TM9100 mobiles

Service Manual

MMA-00017-01
Issue 1
August 2005

Tait Contact Information

Tait Radio Communications Corporate Head Office

Tait Electronics Ltd
P.O. Box 1645
Christchurch
New Zealand

For the address and telephone number of regional offices, refer to the TaitWorld website:

Website: http://www.taitworld.com

Technical Support

For assistance with specific technical issues, contact Technical Support:

E-mail: support@taitworld.com
Website: http://support.taitworld.com

To our European customers:
Tait Electronics Limited is an environmentally responsible company which supports waste minimization and material recovery. The European Union's Waste Electrical and Electronic Equipment Directive requires that this product be disposed of separately from the general waste stream when its service life is over. Please be environmentally responsible and dispose through the original supplier, your local municipal waste "separate collection" service, or contact Tait Electronics Limited.

Contents

Preface

Scope of Manual

This manual contains information to service technicians for carrying out level-1 and level-2 repairs of TM9100 radios and accessories.

Level-1 repairs entail the replacement of faulty parts and circuit boards; level-2 repairs entail the repair of circuit boards, with the exception of certain special items on the boards. The manual does not cover level-3 repairs, which entail the repair of the special items.

Hardware and Software Versions

This manual describes the following hardware and software versions. The IPNs (internal part numbers) of the boards are listed below; the last two digits in the IPN represent the issue of the board.

- Main board (B1 band) 50W : 220-01723-**02**
- Main board (H5 and H7 bands) 50W/40W : 220-01722-**02**
- Main board (B1 band) 25W : 220-01700-**10**
- Main board (H5 and H6 bands) 25W : 220-01697-**10**
- Control-head board : 220-01718-**01**
- Programming application : version **1.1.0.1**
- Calibration application : version **1.0.0.0**

Enquiries and Comments

If you have any enquiries regarding this manual, or any comments, suggestions and notifications of errors, please contact Technical Support (refer to “Tait Contact Information” on page 2).

Updates of Manual and Equipment

In the interests of improving the performance, reliability or servicing of the equipment, Tait Electronics Ltd reserves the right to update the equipment or this manual or both without prior notice.

Copyright

Disclaimer

There are no warranties extended or granted by this manual.
Tait Electronics Ltd accepts no responsibility for damage arising from use of the information contained in the manual or of the equipment and software it describes. It is the responsibility of the user to ensure that use of such information, equipment and software complies with the laws, rules and regulations of the applicable jurisdictions.

Associated Documentation

The following associated documentation is available for this product:

- MMA-00009-**xx** TM9100 Product Safety and Compliance Information
- MMA-00007-**xx** TM9100 User's Guide
- MMA-00018-**xx** TM9100 Installation Guide
- MMA-00022-**xx** TM9100 Main Board (H5/H6) 25W PCB Information
- MMA-00023-**xx** TM9100 Main Board (B1) 25W PCB Information
- MMA-00024-**xx** TM9100 Main Board (H5/H6) 50W/40W PCB Information
- MMA-00025-**xx** TM9100 Main Board (B1) 50W PCB Information
- MMA-00029-**xx** TM9100 Control-Head Board (Graphical Display) PCB Information
- MMA-00026-**xx** TM9100 PCB Information (printed, pre-punched and shrink wrapped; comprises MMA-00022-**xx** to MMA-00025-**xx** and MMA-00029-**xx**)

The characters **xx** represent the issue number of the documentation.

All available documentation is provided on the TM9100/TP9100 Service CD, product code TMAA24-01.
Updates may also be published on the Tait support website.

Publication Record

Issue	Publication Date	Description
01	August 2005	first release

Alert Notices

Within this manual, four types of alerts are given to the reader: warning, caution, important and note. The following paragraphs illustrate each type of alert and its associated symbol.

Warning!! **This alert is used when there is a potential risk of death or serious injury.**

Caution **This alert is used when there is the risk of minor or moderate injury to people.**

Important This alert is used to warn about the risk of equipment damage or malfunction.

Note This alert is used to highlight information that is required to ensure that procedures are performed correctly.

Abbreviations

Abbreviation	Description
ACP	Adjacent Channel Power
ADC	Analog-to-Digital Converter
AGC	Automatic Gain Control
ALC	Automatic Level Control
APCO	Association of Public Safety Communications Officials
ASC	Accredited Service Center
BOM	Bill of Materials
C4FM	Compatible Four-level Frequency Modulation
CCTM	Computer-controlled Test Mode
CODEC	Coder-Decoder

Abbreviation	Description
CSO	Customer Service Organisation
CTCSS	Continuous-tone-controlled Subaudible Signaling
DAC	Digital-to-Analog Converter
DC	Direct Current
DSP	Digital Signal Processor
DTMF	Dual-Tone Multi-Frequency
EPTT	External PTT (Press-To-Talk)
ESD	Electrostatic Discharge
FCL	Frequency Control Loop
FE	Front-End
FEC	Forward Error Correction
FPGA	Field-Programmable Gate Array
GPIO	General Purpose Input/Output
GPS	Global Positioning System
GUI	Graphical User Interface
IC	Integrated Circuit
IPN	Internal Part Number
IF	Intermediate Frequency
IQ	In-Phase and Quadrature
ISC	International Service Center
LCD	Liquid-Crystal Display
LED	Light-Emitting Diode
LNA	Low-Noise Amplifier
LO	Local Oscillator
LPF	Low-Pass Filter
NPN	Negative-Positive-Negative
P25	Project 25
PA	Power Amplifier
PCB	Printed Circuit Board
PLL	Phase-Locked Loop
PNP	Positive-Negative-Positive

Abbreviation	Description
PSU	Power Supply Unit
PTT	Press-To-Talk
RISC	Reduced Instruction Set Computing
RSSI	Received Signal Strength Indication
SFE	Software Feature Enabler
SMA	Sub Miniature Version A
SMD	Surface-Mount Device
SMT	Surface-Mount Technology
SMPS	Switch-Mode Power Supply
SPI	Serial Peripheral Interface
TCXO	Temperature-compensated Crystal Oscillator
TEL	Tait Electronics Limited
VCO	Voltage-Controlled Oscillator
VCXO	Voltage-Controlled Crystal Oscillator

Chapter 1
Description of the Radio

Chapter 1 – Contents

1 Introduction

The TM9100 series is a range of high-performance microprocessor-controlled radios for digital (APCO project 25-compatible), analog and mixed operation for voice and data communication. The radios are designed for installation in vehicles but can also be used in desktop, remote-monitoring and similar applications.

This manual includes the information required for servicing the radio and its accessories.

Figure 1.1 TM9155 mobile radio

This section describes the different options available for:

- frequency bands
- RF output power
- accessories
- product codes

This section also gives an overview of the labels on the product and the specifications.

1.1 Frequency Bands

The radios are available in the following frequency bands:

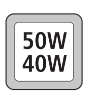
- 136 to 174 MHz (B1)
- 400 to 470 MHz (H5)
- 450 to 530 MHz (H6)
- 450 to 510 MHz (H7)

The frequency bands are implemented by different main boards in the radio body. The control heads are identical for all frequency bands.

1.2 RF Output Power

The radio bodies are available with 50 W/40 W and 25 W RF output power.

The two RF output power options are implemented by different main boards in the radio body, mechanically different radio bodies, and different power connectors. The control heads are identical for all RF output power options.



The 50 W/40 W radio is available in the following frequency bands:

- B1 (50 W)
- H5 (40 W)
- H7 (40 W)

The 25 W radio is available in the following frequency bands:

- B1
- H5
- H6

1.3 Accessories

Tait offers a large variety of audio accessories, installation kits, internal options boards and other accessories such as a desktop power supply.

For more information on these accessories refer to "Chapter 3 Accessories" on page 427.

Audio Accessories

The radios allow for the connection of a comprehensive range of audio accessories:

- rugged microphone (standard)
- keypad microphone
- handset
- high-power remote speaker
- remote PTT kit

Installation Kits

The radio is delivered with a vehicle installation kit with U-cradle. Installation of the radio is described in the installation guide.

Optional installation kits are:

- remote control-head kit for remote installation of the control head
- security bracket for secure and quick-release installation

Internal Options Boards

The radio provides space for an internal options board inside the radio body connecting to an internal options connector. An aperture for an external options connector is also provided.

Desktop Power Supply

A desktop power supply including the parts for mounting the radio is available for desktop installations.

1.4 Product Codes

This section describes the product codes used to identify products of the TM9100 mobile radio product line.

General

The product codes of the TM9100 mobile radio product line have the format:

TMA**abc**–**ddee**

where:

- **a** identifies the product category:
  A = accessory, B = radio body, C = control head, S = software feature
- **b**, **c**, **dd** and **ee** identify specific product features.

Radio Bodies

The product codes of the radio bodies have the format:

TMAB**3c**–**ddee**

where:

- **3** identifies the architecture of the digital board:
  3 = APCO digital
  1 and 2 identify the digital boards of the analog TM8000 product line.
- **c** identifies the RF output power:
  2 = 25W, 4 = 30 to 59W, 5 = 30 to 59W (trigger-base)
- **dd** identifies the frequency band:
  B1 = 136 to 174MHz, H5 = 400 to 470MHz, H6 = 450 to 530MHz, H7 = 450 to 520MHz
  Other characters identify frequency bands of the analog TM8000 product line.
- **ee** identifies any radio options:
  00 = BNC RF connector, 01 = mini-UHF RF connector

Control Head

The product code of the control head has the format:

TMAC**41**–**dd**

where:

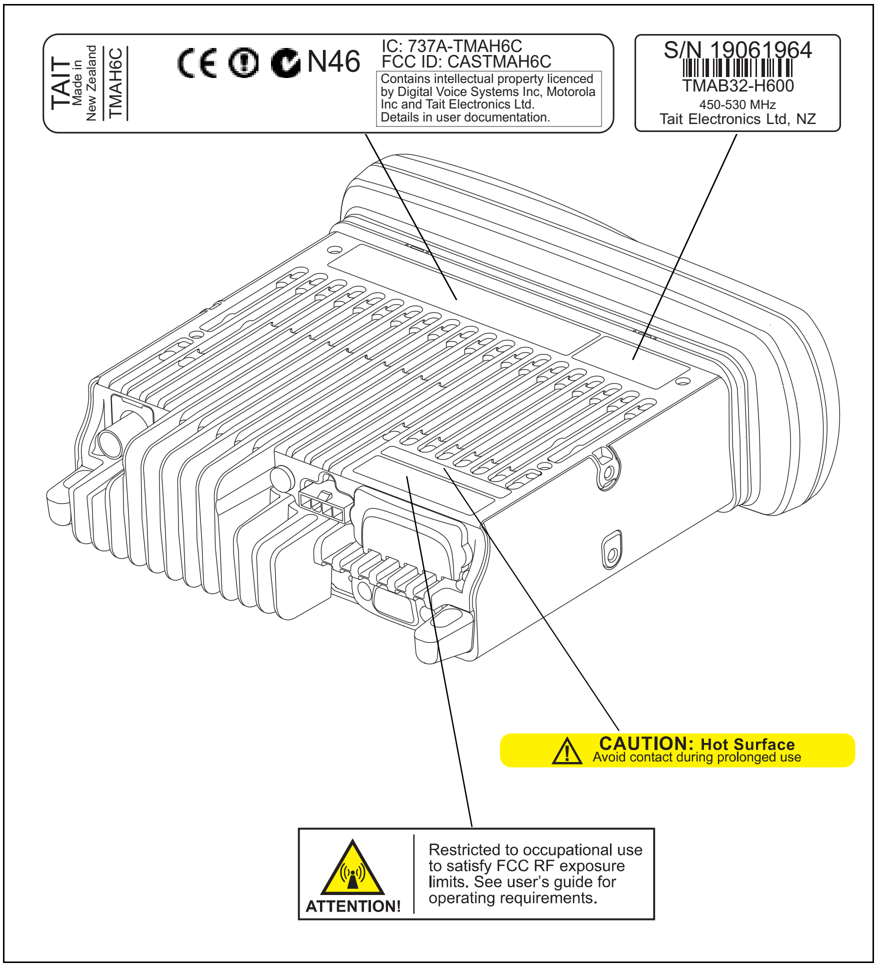
- **4** identifies the control-head type (4 = graphical-display control head)
  Other numbers identify control heads of the analog TM8000 product line.
- **1** identifies the control-head configuration (1 = APCO digital)
  0 identifies the control-head configuration of the analog TM8000 product line.
- **dd** identifies label and branding options.

1.5 Labels

Four external labels are attached to the bottom of the radio body:

- compliance information
- serial number and product code
- hot surface safety warning
- RF exposure safety warning

Figure 1.2 Labels of the TM9100 product line



1.6 Specifications

Introduction

Table 1.1 shows the specifications for the TM9100 radios. The parameter values quoted are minimum values. These specifications are valid for the date of publication only. For up-to-date specifications, refer to the area on the TaitWorld website reserved for TM9100 products.

Table 1.1 Specifications

Parameter	Values	
Basic characteristics	**50 W/40 W radio:**	**25 W radio:**
Frequency ranges: • B1 band • H5 band • H6 band • H7 band	 136 to 174 MHz 400 to 470 MHz not available 450 to 520 MHz	 136 to 174 MHz 400 to 470 MHz 450 to 530 MHz not available
Channel spacing: • B1 band • H5, H6, H7 bands	 12.5 kHz/25 kHz/30 kHz 12.5 kHz/25 kHz	
Channels/talkgroups (simplex or semi-duplex)	512	
Frequency stability	±1.5 ppm	
Zones	26	
Supply current: • receive mode squelched full audio • transmit mode	 100 mA 500 mA <10 A	 110 mA 525 mA <5.5 A
RF connector	50 Ω miniature UHF or BNC (optional)	
Power connector: • Power supply • External speaker	 between 10.8 and 16 V DC maximum power 10 W into 4 Ω balanced load configuration	
Interface connectors: • microphone connector • auxiliary connector • internal options connector	Ports: 1 serial, 1 I/O 1 serial, 3 input, 4 I/O, 1 audio tap in, 1 audio tap out 1 serial, 7 I/O, 1 audio tap in, 1 audio tap out	
Physical characteristics	**50 W/40 W radio:**	**25 W radio:**
Weight	55.87 oz. (1.60 kg)	49.47 oz. (1.40 kg)
Dimensions: • length • width • height	 8.43 in. (214 mm) 7.09 in. (180 mm) 2.68 in. (68 mm)	 7.64 in. (194 mm) 7.09 in. (180 mm) 2.68 in. (68 mm)

Table 1.1 Specifications (continued)

Parameter	Values
Environmental conditions	
Operating temperatures	−22°F to +140°F (−30°C to +60°C)
Standards • IP54 • MIL-STD 810C, D, E and F (for details contact Technical Support)	Meets the requirements for sealing against: • dust • rain Meets the requirements regarding the following aspects: • low pressure • high temperature • low temperature • temperature shock • solar radiation • rain • humidity • salt fog • dust • vibration • shock
Receiver	
Analog sensitivity (12dB SINAD)	<0.25µV (−119dBm)
Digital sensitivity (TIA/EIA) 5% BER#	< 0.20µV (−121dBm)
Intermodulation rejection	>−75dB
Adjacent channel selectivity: • 20kHz/30kHz channel • 12.5kHz channel	 >−75dB >−65dB
Spurious responses rejection	>−75dB
FM hum and noise: • 20kHz/30kHz channel • 12.5kHz channel	 >−43dB >−40dB
Audio distortion at rated audio	<3%
Audio bandwidth	300Hz to3 kHz (flat or with de-emphasis)
Receive detect time (From the time an RF signal is first present at the antenna to the time when the BUSY DETECT line changes state)	< 3ms

Table 1.1 Specifications (continued)

Parameter	Values	
Transmitter	**50 W/40 W radio:**	**25 W radio:**
Output power: • level 1 (very low) • level 2 (low) • level 3 (medium) • level 4 (high)	 10 W 15 W 25 W (VHF), 20 W (UHF) 50 W (VHF), 40 W (UHF)	 1 W 5 W 12 W 25 W
Modulation limiting: • 25 kHz/30 kHz channel • 12.5 kHz channel	 <±5 kHz <±2.5 kHz	
FM hum and noise: • 25 kHz/30 kHz channel • 12.5 kHz channel	 >– 41 dB >– 37 dB	
Conducted and radiated emissions: • up to 1 GHz • between 1 and 4 GHz (for radio operating frequencies below 500 MHz) • between 1 and 12.75 GHz (for radio operating frequencies above 500 MHz)	 <−36 dBm <−30 dBm <−30 dBm	
Audio bandwidth	300 Hz to 3 kHz (flat or with pre-emphasis)	
Audio response	+1/–3 dB	
Audio distortion	<3% at 1 kHz 60% modulation	
Transmit rise time (from the time the external PTT line is asserted to the time when the RF output power reaches 90% of its final value)	<10 ms	

Table 1.2 Typical current consumptions by radio while not transmitting (analog mode) and by control head

Parameter	Value
Radio not operating: • radio off (no links fitted) • radio off (links LK1, LK2, LK3 fitted) (using ignition control to switch radio on and off) • radio on stand-by (links LK1, LK2, LK3 fitted) (using ON/OFF key on control head to switch radio on and off)	 2.2mA 3.3mA 52mA
Receiver: • receiver idle (not scanning) • receiver active, mute on • receiver active, 3W audio into 16Ω • receiver active, 10W audio into 4Ω	 104mA 158mA 585mA 1.6A
Current consumptions by control head only: • no back-lighting, no LEDs • maximum back-lighting, no LEDs • maximum back-lighting and LEDs on • additional current with LCD heating on	 13.3mA 99.9mA 102mA 220mA

Table 1.3 Typical current consumptions by radio body while transmitting (analog mode)

Parameter	Values at different power levels			
	Very low	Low	Medium	High
40W/50W radio: • B1 band • H5 band • H7 band	 4.0A 3.6A 3.5A	 4.8A 4.4A 4.3A	 6.0A 5.1A 5.0A	 9.0A 7.6A 7.6A
25W radio: • B1 band • H5 band • H6 band	 1.1A 1.2 1.2A	 2.0A 2.3A 2.3A	 2.9A 3.3A 3.4A	 4.4A 5.1A 5.2A

2 Description

This section describes the mechanical design and architecture of the radio, explains the operation of the transceiver and the control head, and gives pinouts of the radio connectors.

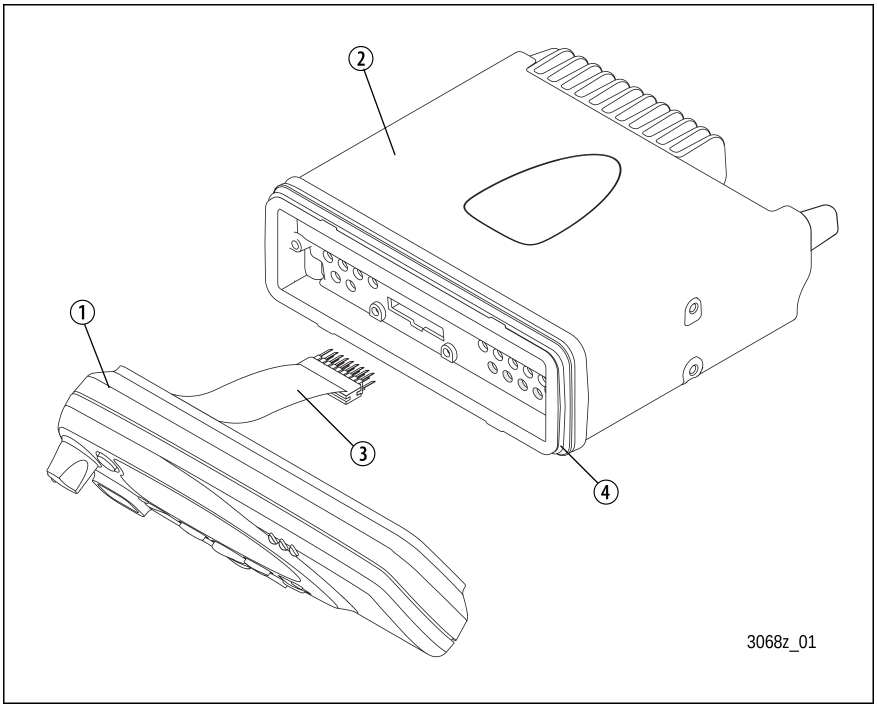
2.1 Mechanical Design

Overview

The radio consists of the following main components:

- control head ①
- radio body ②

Figure 2.1 Components of the radio



The control head ① clips firmly to the front face of the radio body ②, where a seal ④ provides IP54 class protection. A control-head loom ③ connects the control head to the radio body. Two dot-dash-dot marks at the bottom of the radio body indicate the positions where a screwdriver is applied to separate the control head from the radio body.

2.1.1 Radio Body

Overview

The radio body consists of the following main components (see Figure 2.2 on page 25):

- cover ①
- lid ③
- internal options board (optional)
- chassis ⑥
- main-board assembly ⑤

Cover

The black plastic cover ① wraps over the top and sides of the radio body. Apertures in the sides of the cover allow access to the four external screw bosses of the radio body used for mounting the radio to the U-bracket.

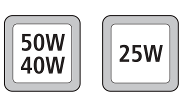
Lid

The aluminum lid ③ is attached to the chassis ⑥ with four M4x16 Torx-head screws ②. A seal fitted inside a groove at the underside of the lid provides for IP54 class protection. The rear of the lid has an aperture for an external options connector, which may be fitted if an internal options board is used. If no external options connector is used, the aperture is sealed with a bung for IP54 class protection. The lid contains two of the four screw bosses to attach the radio to the U-bracket of the installation kit.

Internal Options Board (Optional)

On the inside of the lid, nine screw points are provided for mounting an internal options board, which can be sized and shaped as required.
The internal options board connects to the internal options connector of the main board. Tait offers a range of internal options board, which are described in the accessories section of this manual. For more information on how to create your own internal options board, contact Tait Electronics Limited.

Chassis

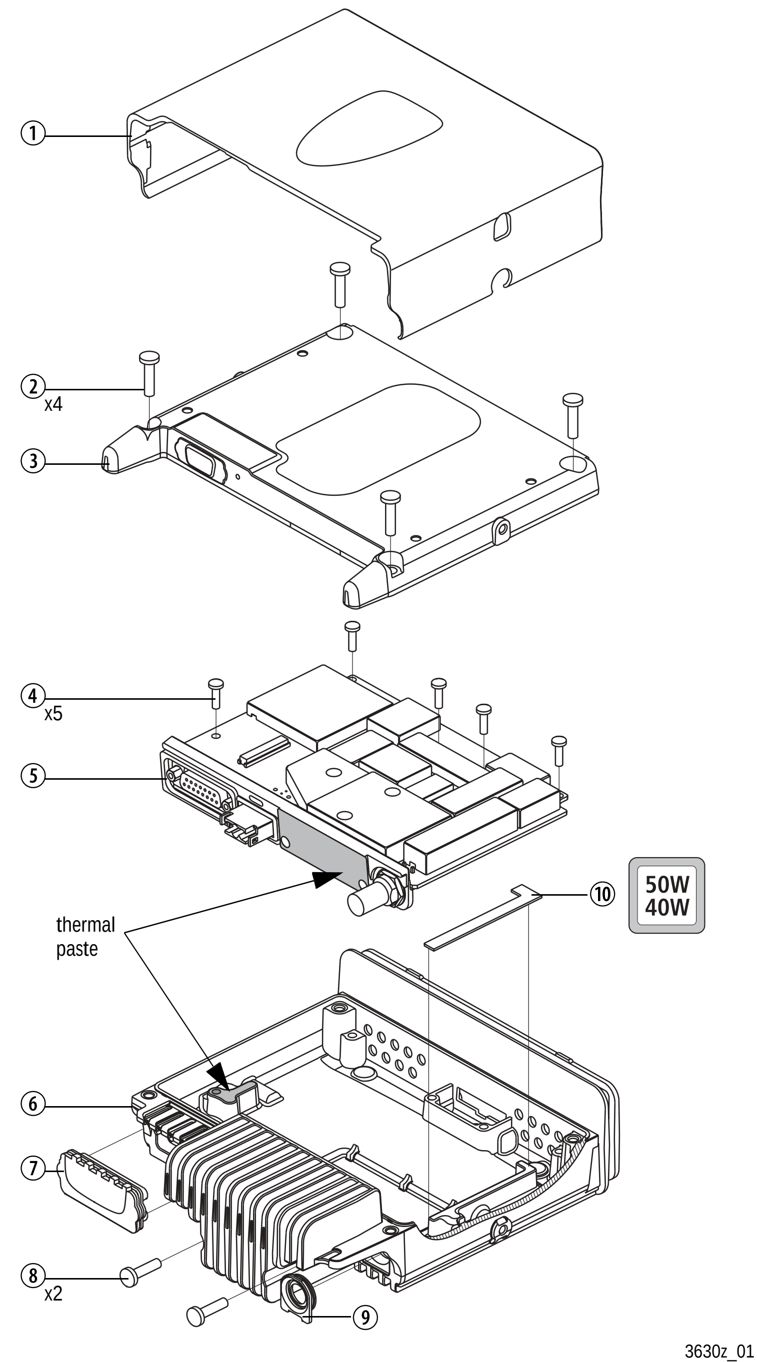


The aluminum chassis ⑥ is the different for the 50W/40W radio and the 25W radio.

The chassis ⑥ houses the main-board assembly ⑤, which is attached with five screws ④ to screw bosses inside the chassis and with two screws ⑧ through the rear of the chassis to the heat-transfer block.

The rear of the chassis has apertures for the RF, power and auxiliary connectors of the main board. If the auxiliary connector is not used, the aperture is sealed with a rubber bung ⑨ for IP54 class protection.
The RF connector has a rubber seal ⑦ which is fitted inside the aperture for the RF connector.

Figure 2.2 Components of the radio body



① cover	⑥ chassis
② screw M4x16 (x4)	⑦ auxiliary connector bung
③ lid assembly	⑧ screws M4x16 (x2)
④ screw M3x10 (x5)	⑨ seal
⑤ main-board assembly	⑩ gap pad (50W/40W radio only)

The front of the chassis has an aperture for the control-head connector. The control-head seal is fitted inside a groove around the flange at the front face of the chassis and provides for IP54 class protection when the control head is fitted. Two dot-dash-dot marks at the underside side of the chassis indicate the leverage points for removing the control head from the radio body.

The sides of the chassis contain two of the four screw bosses to attach the radio to the U-bracket of the installation kit.

For heat dissipation, the chassis has heat fins at the rear, grooves at the bottom, and holes in the front.

50W 40W **25W**

The heat fins at the rear of the 50 W / 40 W radio are longer than those of the 25 W radio. The grooves at the bottom of the 50 W / 40 W radio are deeper than those of the 25 W radio.

50W 40W

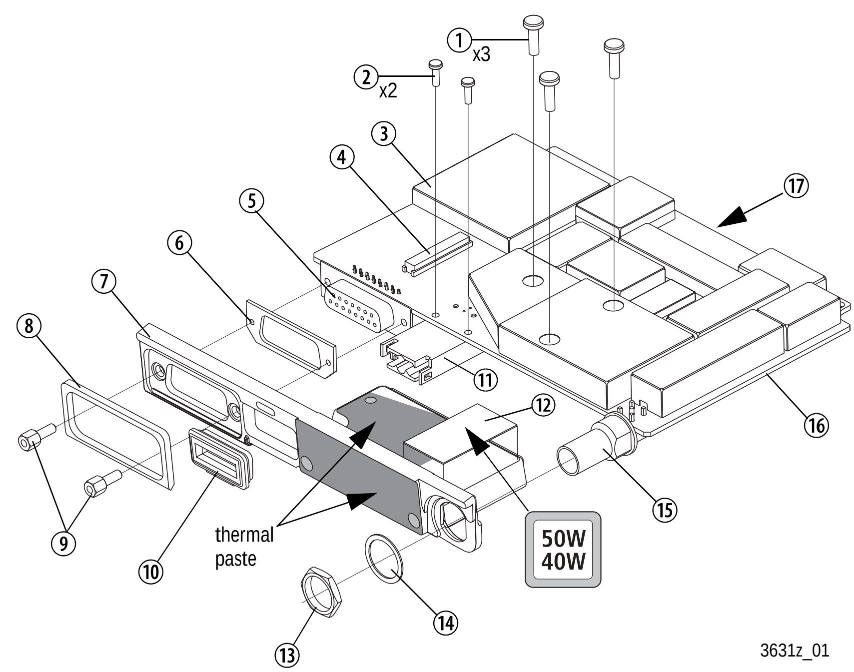
For additional heat dissipation, the 50 W / 40 W radio has an additional L-shaped gap pad ⑩ between the chassis and the main board.

Main-Board Assembly

The main-board assembly consists of the following components (see Figure 2.3):

- main board ⑯ with SMT components, digital board ③, shielding cans, and connectors
- heat-transfer block ⑦
- mounting and sealing elements for the connectors at the rear of the radio body

Figure 2.3 Components of the main-board assembly



① M3x10 screw (x3)

② 50W/40W radios:
M2.2x10 PT screw (x2)
25W radios:
K30x8 PT screw (x2)

③ digital board

④ internal options connector

⑤ auxiliary connector

⑥ inner foam D-range seal

⑦ heat-transfer block

⑧ outer foam seal

⑨ D-range screwlock fastener (x2)

⑩ power connector seal

⑪ power connector

⑫ gap pad (50W/40W radio only)

⑬ hexagonal nut

⑭ lock washer

⑮ RF connector

⑯ main board

⑰ control-head connector

The main board ⑯ is attached to the heat-transfer block ⑦ with three M3x10 Torx-head screws ① and the fastening elements ⑨, ⑬ and ⑭ of the auxiliary and RF connectors.

The inner foam D-range seal ⑥ seals the auxiliary connector against the heat-transfer block. The power connector seal ⑩ seals the power connector against the heat-transfer block.

50W 40W | 25W

The power connector seal ⑩ of the 50 W/40 W radio (blue) is different to the seal of the 25 W radio (black).

Main Board

The main board ⑯ is a printed circuit board in SMT design with components on the top and bottom sides. A digital board ③ is reflow-soldered to the main board. Most components are shielded by metal cans.

There are different main boards for each frequency band and each RF output power configuration.

The internal options connector ④ for connecting an internal options board and the factory connector (not illustrated) for factory use are soldered to the top side of the main board. The control-head connector ⑰ (facing the front of the radio) and the auxiliary ⑤, power ⑪ and RF ⑮ connectors (facing the rear of the radio) are located on the bottom side of the main board.

50W 40W | 25W

The 50 W/40 W radio has a black power connector ⑪ and the 25 W radio has a white power connector.

For more information on the connectors, refer to “Connectors” on page 34.

For heat dissipation, one of the screw bosses inside the chassis is in contact with the underside of the main board. A larger copper plate at the underside of the main board connects to the body of the heat-transfer block.

50W 40W

The 50 W/40 W radio has an additional gap pad between the heat-transfer block and the main board ⑯ which connects to an additional copper plate at the bottom side of the main board.

Heat-Transfer Block

The aluminum heat-transfer block ⑦ dissipates heat from the main board to the heat fins of the chassis. The heat-transfer block has a contact surface to the larger copper plate at the underside of the main board ⑯, and a contact surface to the rear of the chassis. All contact surfaces are coated with thermal paste.

Two self-adhesive foam seals ⑥ and ⑧ around the aperture of the auxiliary connector on either side of the heat-transfer block and the power connector seal ⑩ inside the aperture of the power connector are fitted to the heat-transfer block.

2.1.2 Control Head

Overview

The control head can be divided into the following main areas:

- front panel with control elements, indicators, LCD, speaker, and concealed microphone
- space-frame and seals
- control-head board with SMT components, shielding cans, connectors, and volume potentiometer
- control-head loom with female-female adapter
- adapter flange

The circled numbers in this section refer to the items in Figure 2.4 on page 31.

Front Panel Assembly

The front panel assembly ⑯ consists of an injection-moulded plastic part with an integrated transparent light pipe element for the radio STATUS LEDs, a transparent lens which cannot be replaced, a cloth membrane which is fixed to the speaker grille, and a foam seal inside a rectangular LCD recess behind the lens. A label ⑱ with the radio model number is attached to the front panel assembly with self-adhesive coating and can be replaced for rebranding purposes.

Three clips on the rear side of the front panel assembly snap onto the space-frame to hold the keypads ⑬ and ⑬, the LCD assembly ⑫ and the speaker ⑪ in place. The rear side of the front panel assembly also has four screw bosses to fasten the control-head board ⑤.

Knob for Volume-Control Potentiometer

The knob for the volume-control potentiometer ⑰ is fitted to the shaft of the volume-control potentiometer, which is soldered to the control-head board ⑤.

Keypads

The main keypad ⑬ (for the function, selection, and scroll keys) and the power keypad ⑭ protrude through apertures in the front panel assembly ⑯. The rear sides of these keypads connect directly to the relevant contacts on the control-head board ⑤.

LCD Assembly

The graphical-display LCD assembly ⑫ sits on a foam seal inside a rectangular recess of the front panel assembly ⑯. Another foam seal is attached to the rear of the LCD with self-adhesive coating. The LCD assembly has a loom, which runs through a slot in the space-frame ⑨ and connects to a connector on the rear side of the control-head board ⑤.

Speaker

The speaker ⑪ sits inside a round recess of the front panel assembly, where a cloth membrane is fixed to the speaker grille. The speaker clamp ⑩ holds the speaker in position. The speaker cable plugs into the speaker connector on the rear side of the control-head board ⑤.

Note In some configurations the speaker may be disconnected.

Concealed Microphone

A concealed microphone ⑮ consisting of the microphone capsule and a rubber seal is fitted in a round recess inside the front panel assembly ⑯. The microphone leads are soldered to two pads on the top side of the control-head board.

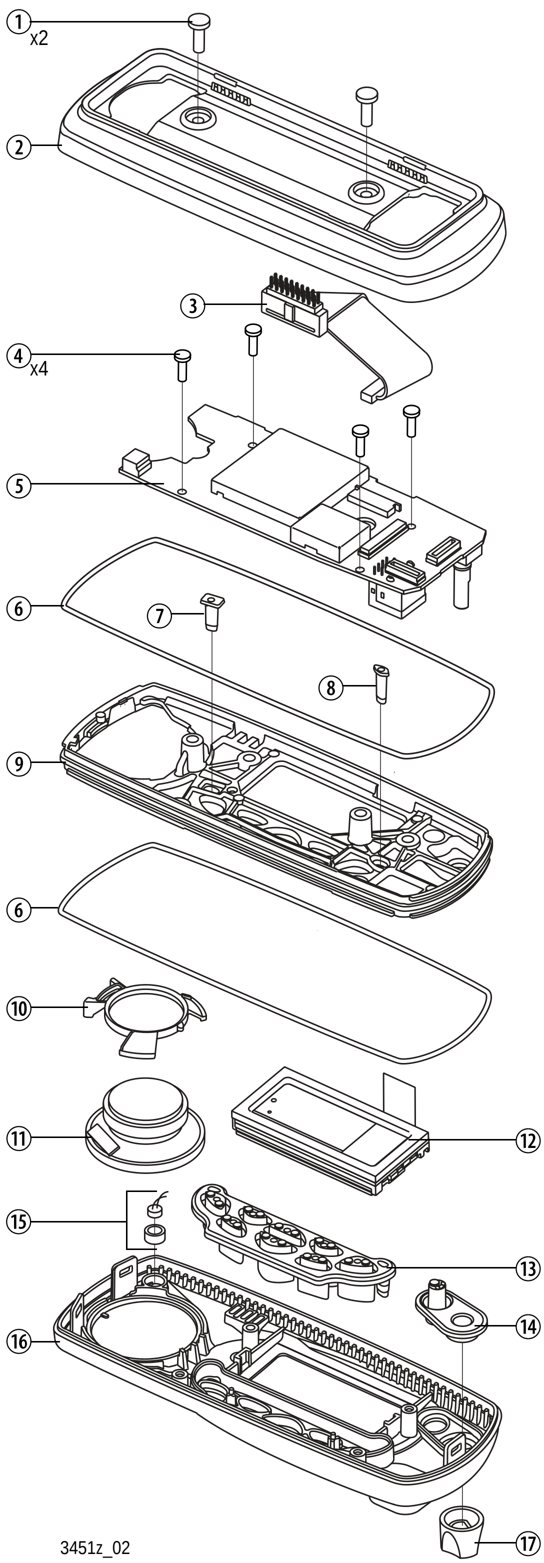
Space-Frame

The aluminum space-frame ⑨ snaps into the three clips of the front panel assembly ⑯. The front side of the space-frame holds the keypads, the LCD assembly, and the speaker in place and at the same time allows access to their electrical contacts. The rear side of the space-frame has four through-holes for the screws ④ of the control-head board ⑤ and two screw bosses to fit the adapter flange ②. Two light pipes ⑦ and ⑧ are fitted in recesses in the space-frame and direct light from LEDs on the control-head board to the front panel. A slot at the top edge of the space-frame allows the loom of the LCD assembly ⑫ to run to the control-head board.

Seals

Two identical ring seals ⑥ fitted to grooves around the perimeter of the space-frame provide for IP54 class protection.

Figure 2.4 Components of the control head



① M4 x 12 Taptite screw (x2)

② adapter flange

③ control-head loom assembly with female-female adapter

④ 3 x 10 PT screw (x4)

⑤ control-head board

⑥ space-frame seal (x2)

⑦ short light pipe

⑧ long light pipe

⑨ space-frame

⑩ speaker clamp

⑪ speaker

⑫ LCD assembly

⑬ main keypad

⑭ power keypad

⑮ concealed microphone

⑯ front panel assembly

⑰ knob for volume-control potentiometer

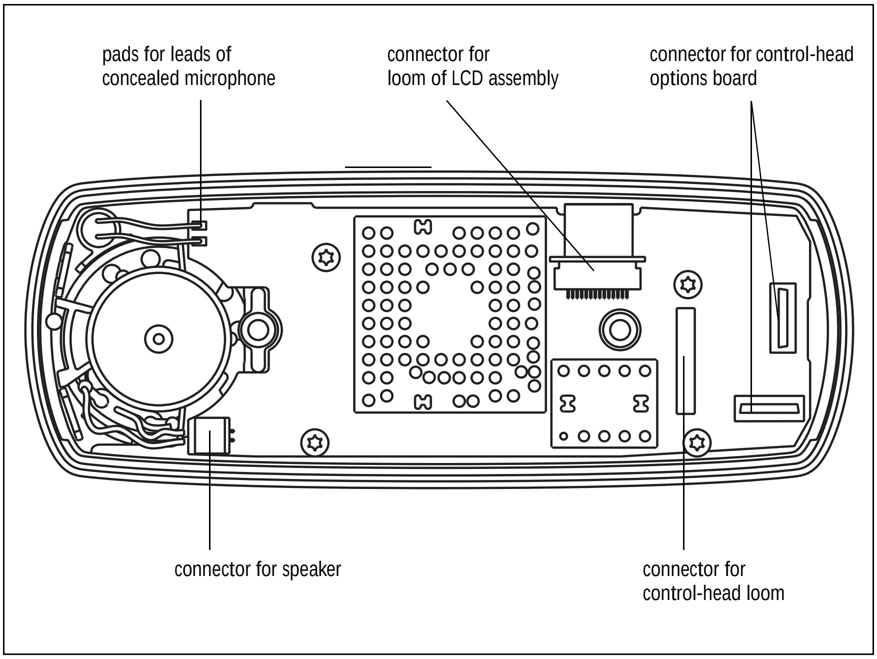
Control-Head Board

The control-head board ⑤ is a printed circuit board in SMT design with components on the top and bottom sides. Some SMT components are shielded by metal cans.

The control-head board is fitted to the front panel assembly ⑯ through the space-frame ⑨ with four 3x10 PT screws ④.

The side facing the radio body has the connectors for the connection of the control-head loom, the LCD loom, the speaker, an optional control-head options board, and pads for the leads of the concealed microphone.

Figure 2.5 Connectors of the control-head board



The side facing the front panel has the volume-control potentiometer, the microphone connector, the indicator and backlight LEDS, and the contacts for the keypads.

Control-Head Loom

The control-head loom ③ connects the connector on the control-head board to the control-head connector of the radio body. For more information refer to “Control-Head Connectors” on page 40.

Adapter Flange

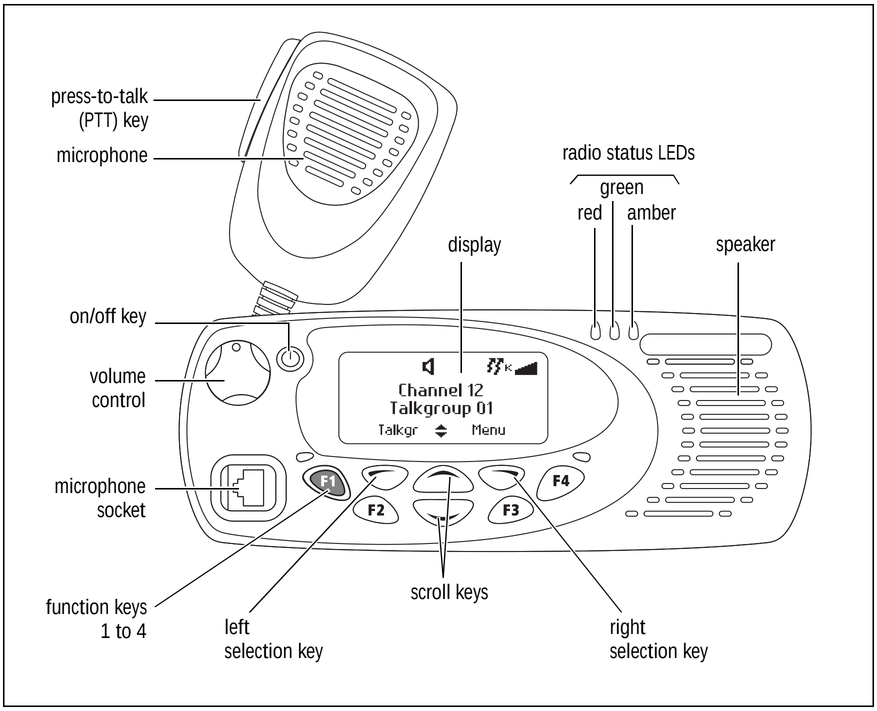
The adapter flange ② is an injection-moulded plastic part, which is fitted to the space-frame with two M4x12 Taptite screws ①.

2.2 User Interface

Figure 2.6 shows the controls and indicators of the user interface. For more information refer to the TM9100 User's Guide.

Some keys have functions assigned to both short and long key presses. A short key press is less than one second, and a long key press is more than one second.

Figure 2.6 User interface



2.3 Connectors

Overview

This section describes the specifications and pinouts of the connectors of the radio body and the control head.

Figure 2.7 provides an overview of the connectors:

Figure 2.7 Connectors

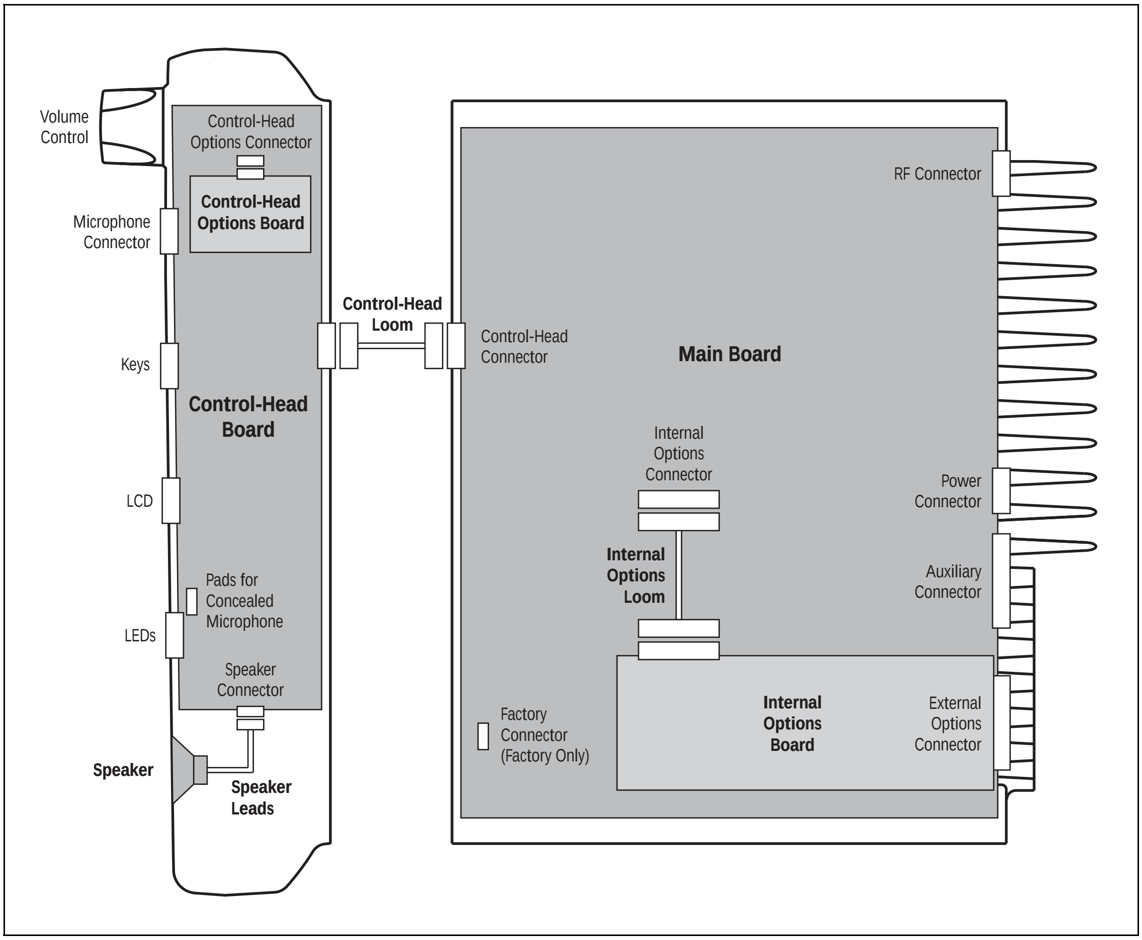


Figure 2.8 shows the connectors of the radio body.
Figure 2.9 shows the connectors of the control head.

For information on the factory connector of the main board and the internal connectors of the control head, refer to the PCB information of the main boards and the control-head board.

Figure 2.8 Connectors of the radio body (25 W radio)

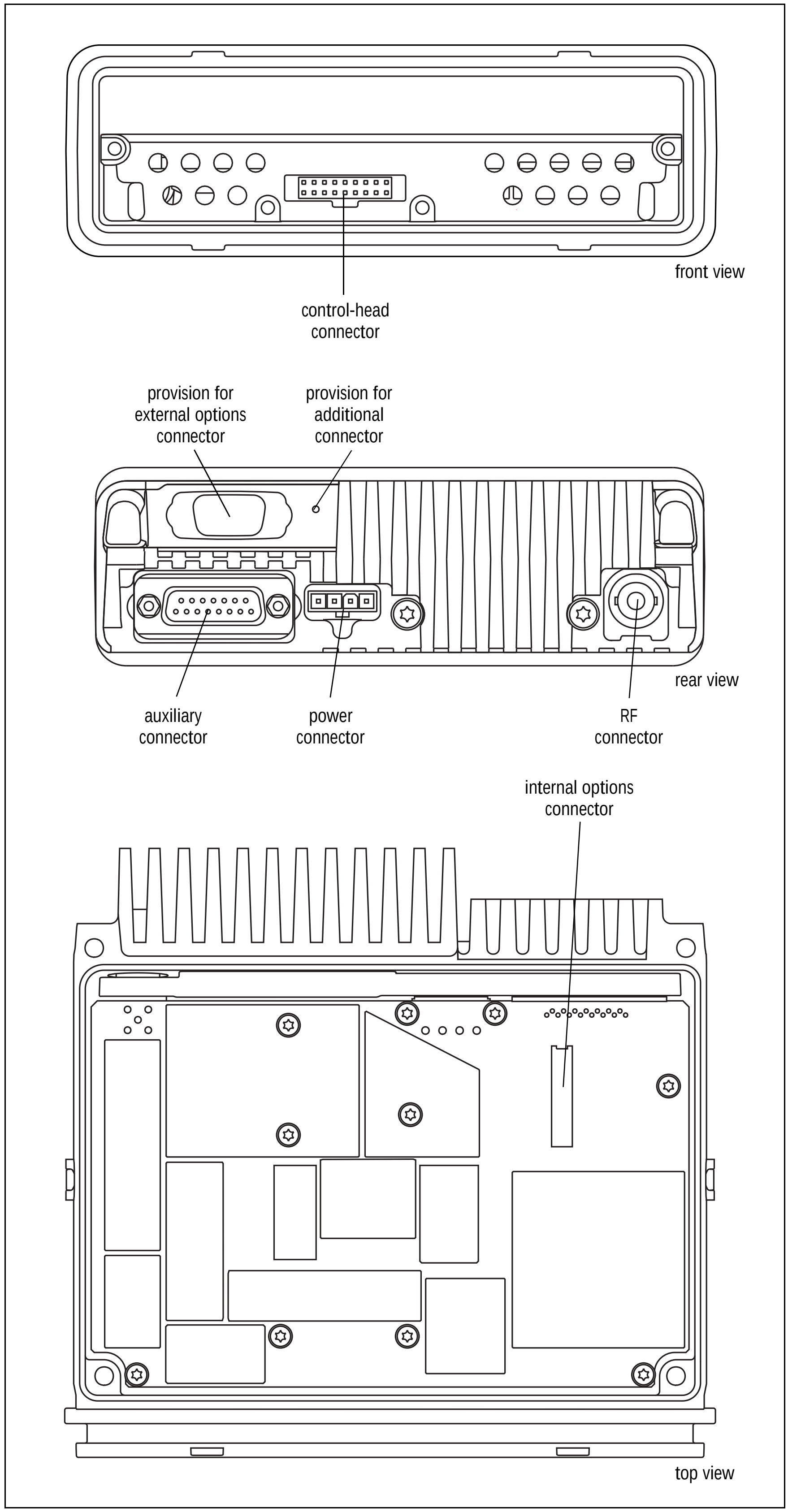
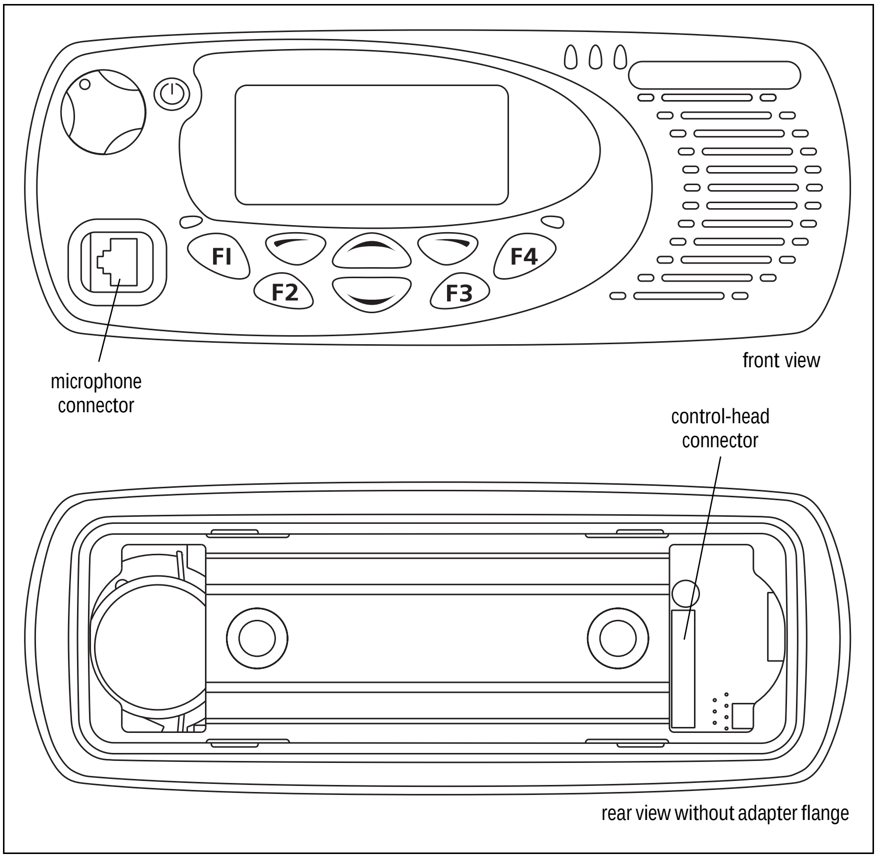


Figure 2.9 Connectors of the control head

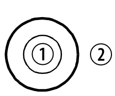


2.3.1 RF Connector

The RF connector is the primary RF interface to the antenna. The RF connector is a standard mini-UHF connector or a BNC connector with an impedance of 50Ω.

Important The maximum RF input level is +27dBm. Higher levels may damage the radio.

Table 2.1 RF connector - pins and signals

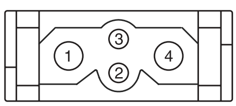
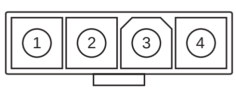
Pinout	Pin	Signal Name	Signal Type
 rear view	1	RF	RF analog
	2	GND	RF ground

2.3.2 Power Connector

The power connector is the interface for the primary 13.8V power source and the external speaker. The primary power source can be the vehicle battery or a mains-fed DC power supply. There are different power connectors for the 50W/40W and 25W radios.

Important The speaker load configuration is balanced; the speaker output lines must **not** be connected to ground. Connecting a speaker output line to ground will cause audio power amplifier shutdown

Table 2.2 Power connector (radio) – pins and signals

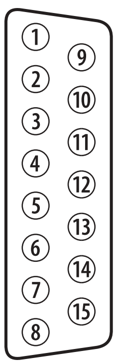
Pinout	Pin	Signal name	Description	Signal type
50W/40W radio  rear view **25W radio**  rear view	1	AGND	Earth return for radio body power source.	Ground
	2	SPK–	External speaker output. Balanced load configuration.	Analog
	3	SPK+	External speaker output. Balanced load configuration.	Analog
	4	13V8_BATT	DC power input for radio body and control head.	Power

2.3.3 Auxiliary Connector

The auxiliary connector is the standard interface for external devices that are typically connected to a radio. The auxiliary connector is a 15-way standard-density D-range socket. The auxiliary connector provides a serial port, three programmable input lines, four programmable digital I/O lines and audio I/O.

The I/O lines can be programmed for a variety of functions, logic levels, and in some cases, direction. Audio lines can also be programmed to tap into, or out of, different points in the audio processing chain. For more information refer to the online help of the programming application.

Table 2.3 Auxiliary connector – pins and signals

Pinout	Pin	Signal name	Description	Signal type
 rear view	12	AUX_GPI1	General purpose digital input. Programmable function.	Digital, 3V3 CMOS
	5	AUX_GPI2	General purpose digital input. Programmable function. With LK3 fitted, GPI2 is an emergency power sense input.[a]	Digital, 3V3 CMOS
	4	AUX_GPI3	General purpose digital input. Programmable function. With LK2 fitted, GPI3 is a power sense input.a	Digital, 3V3 CMOS
	10	AUX_GPIO4	Programmable function and direction. Pads available to fit a higher power driver transistor on GPIO4 line	Digital, 3V3 CMOS input; open collector output with pullup
	2	AUX_GPIO5		
	9	AUX_GPIO6		
	1	AUX_GPIO7		
	11	AUX_TXD	Asynchronous serial port - Transmit data	Digital, 3V3 CMOS
	3	AUX_RXD	Asynchronous serial port - Receive data	Digital, 3V3 CMOS
	7	AUD_TAP_IN	Programmable tap point into the Rx or Tx audio chain. DC-coupled.	Analog
	13	AUD_TAP_OUT	Programmable tap point out of the Rx or Tx audio chain. DC-coupled.	Analog
	14	AUX_MIC_AUD	Auxiliary microphone input. Electret microphone biasing provided. Dynamic microphones are not supported.	Analog
	6	RSSI	Analog RSSI output.	Analog
	8	+13V8_SW[b]	Switched 13.8V supply. Supply is switched off when radio body is switched off.	Power
	15	AGND	Analog ground	Ground

a. For more information on hardware links refer to "Power-Sense Options" on page 82.

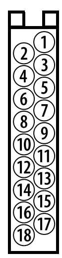
b. Can be switched or unswitched. For more information refer to "Connector Power Supply Options" on page 85.

2.3.4 Internal Options Connector

When installing an internal options board, the internal options connector is the electrical interface to the main board of the radio body.
The internal options connector provides similar I/O to the auxiliary connector. The internal options connector is an 18-pin 0.1 inch pitch Micro-MaTch connector.

Important The digital I/O signals are intended to interface directly with compatible logic signals only. Do not connect these signals to external devices without appropriate signal conditioning and ESD protection.

Table 2.4 Internal options connector – pins and signals

Pinout	Pin	Signal	Description	Signal type
 top view	1	13V8_SW[a]	Switched 13V8 supply. Supply is switched off when the Radio Body is switched off.	Power
	2	AUD_TAP_OUT	Programmable tap point out of the Rx or Tx audio chain. DC-coupled.	Analog
	3	AGND	Analog ground.	Ground
	4	AUX_MIC_AUD	Auxiliary microphone input. Electret microphone biasing provided. Dynamic microphones are not supported.	Analog
	5	RX_BEEP_IN	Receive sidetone input. AC-coupled.	Analog
	6	AUD_TAP_IN	Programmable tap point into the Rx or Tx audio chain. DC-coupled.	Analog
	7	RX_AUD	Receive audio output. Post volume control. AC-coupled.	Analog
	8	RSSI	Analog RSSI output.	Analog
	9…15	IOP_GPIO1…7	General-purpose port for input and output of data. Programmable function and direction. With LK4 fitted, GPIO7 is a power sense input[b].	Digital. 3V3 CMOS
	16	DGND	Digital ground.	Ground
	17	IOP_RXD	Asynchronous serial port - Receive data.	Digital. 3V3 CMOS
	18	IOP_TXD	Asynchronous serial port - Transmit data.	Digital. 3V3 CMOS

a. Can be switched or unswitched. For more information refer to "Connector Power Supply Options" on page 85.

b. For more information on hardware links refer to "Power-Sense Options" on page 82.

2.3.5 Provision for External Options Connector

The radio has a mechanical interface for the external connector of an internal options board. This external options connector can be a 9-way standard-density or 15-way high-density D-range connector. If no internal options board is installed (standard configuration), the hole for the external options connector is sealed by a bung.

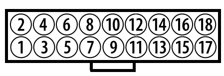
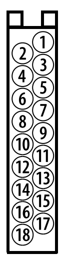
2.3.6 Control-Head Connectors

The control-head loom connects the connector on the front of the radio body to the connector on the rear of the control head.

The connector on the front of the radio body is an 18-way two-row right-angled IDC (insulation displacement connector) SMD header socket.

The connector on the rear of the control head is an 18-way 0.1 inch pitch Micro-MaTch SMD socket.

Table 2.5 Control-head connectors – pins and signals

Pinout	Pin	Signal	Description	Signal type
 front view of radio body	1	RX_AUD	Receive audio output. Post volume control. AC-coupled.	Analog
	2	+13V8[a]	Power supply output from radio body power source.	Power
	3	CH_TXD	Asynchronous serial port - Transmit data.	Digital. 3V3 CMOS.
 top view of control-head board	4	CH_PTT	PTT input from microphone. Also carries the hookswitch signal.	Digital
	5	CH_MIC_AUD	Fist microphone audio input.	Analog
	6	AGND	Analog ground.	Ground
	7	CH_RXD	Asynchronous serial port - Receive data.	Digital. 3V3 CMOS.
	8	DGND	Digital ground.	Ground
	9	CH_ON_OFF	Hardware power on/software-controlled power off input. Active low.	Digital
	10	VOL_WIP_DC	DC signal from volume pot wiper (not used, connected to AGND).	Analog
	11	CH_SPI_DO	Data output signal to control head.	Digital. 3V3 CMOS.
	12	CH_LE	Latch enable output to control head.	Digital. 3V3 CMOS.
	13	CH_GPIO1	General purpose digital input/output.	Digital. 3V3 CMOS input. Open collector output with pullup.
	14	+3V3	Power supply to control head digital circuits.	Power
	15	CH_SPI_DI	Data input from control head.	Digital. 3V3 CMOS.
	16	CH_SPI_CLK	Clock output to control head.	Digital. 3V3 CMOS.
	17	SPK–	Speaker audio output for non-remote control head. Balanced load configuration.	Analog
	18	SPK+	Speaker audio output for non-remote control head. Balanced load configuration.	Analog

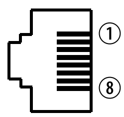
a. Can be switched or unswitched. For more information refer to “Connector Power Supply Options” on page 85.

2.3.7 Microphone Connector

The microphone connector of the control head is an RJ45 socket.

When the control head is connected to the control-head connector of the radio body using the loom provided, the microphone connector uses the following eight control-head connector signals:

Table 2.6 Microphone connector – pins and signals

Pinout	Pin	Signal name	Description	Signal type
 front view	1	MIC_RX_AUD	Receive audio output.	Analog
	2	+13V8[a]	Power supply output. Switched off when radio body is switched off.	Power
	3	MIC_TXD	Asynchronous serial port - Transmit data.	3.3V CMOS
	4	MIC_PTT	PTT input from microphone. Also carries hookswitch signal.	Digital
	5	MIC_AUD	Fist microphone audio input.	Analog
	6	AGND	Analog ground.	Analog ground
	7	MIC_RXD	Asynchronous serial port - Receive data.	3.3V CMOS
	8	MIC_GPIO1	General purpose digital input/output.	Open collector out 3.3V CMOS in

a. Can be switched or unswitched. For more information refer to “Connector Power Supply Options” on page 85.

2.4 Hardware and Software Architecture

Overview

This section describes the hardware and software modules of the radio and their interaction in the functioning of the radio.

2.4.1 Hardware Architecture

The electrical hardware of the radio is implemented on a main board inside the radio body and a control-head board inside the control head.

For a detailed description and block diagrams of individual circuits, refer to "Circuit Descriptions" on page 23.

Main Board

The main board inside the radio body includes the following circuitry:

- transmitter
- receiver
- frequency synthesizer
- digital board with a RISC processor and custom logic (implemented on an FPGA), memory, and a DSP
- CODEC and audio
- interface
- power supply

The main board has an internal options connector which allows internal options boards to access a variety of discrete and programmable signals. For more information refer to "Internal Options Connector" on page 39.

For a basic block diagram of the main board, refer to Figure 2.10 on page 43.

For a more detailed block diagram of the transceiver, refer to Figure 2.12 on page 48 (analog mode) and Figure 2.13 on page 49 (digital mode).

Control-Head Board

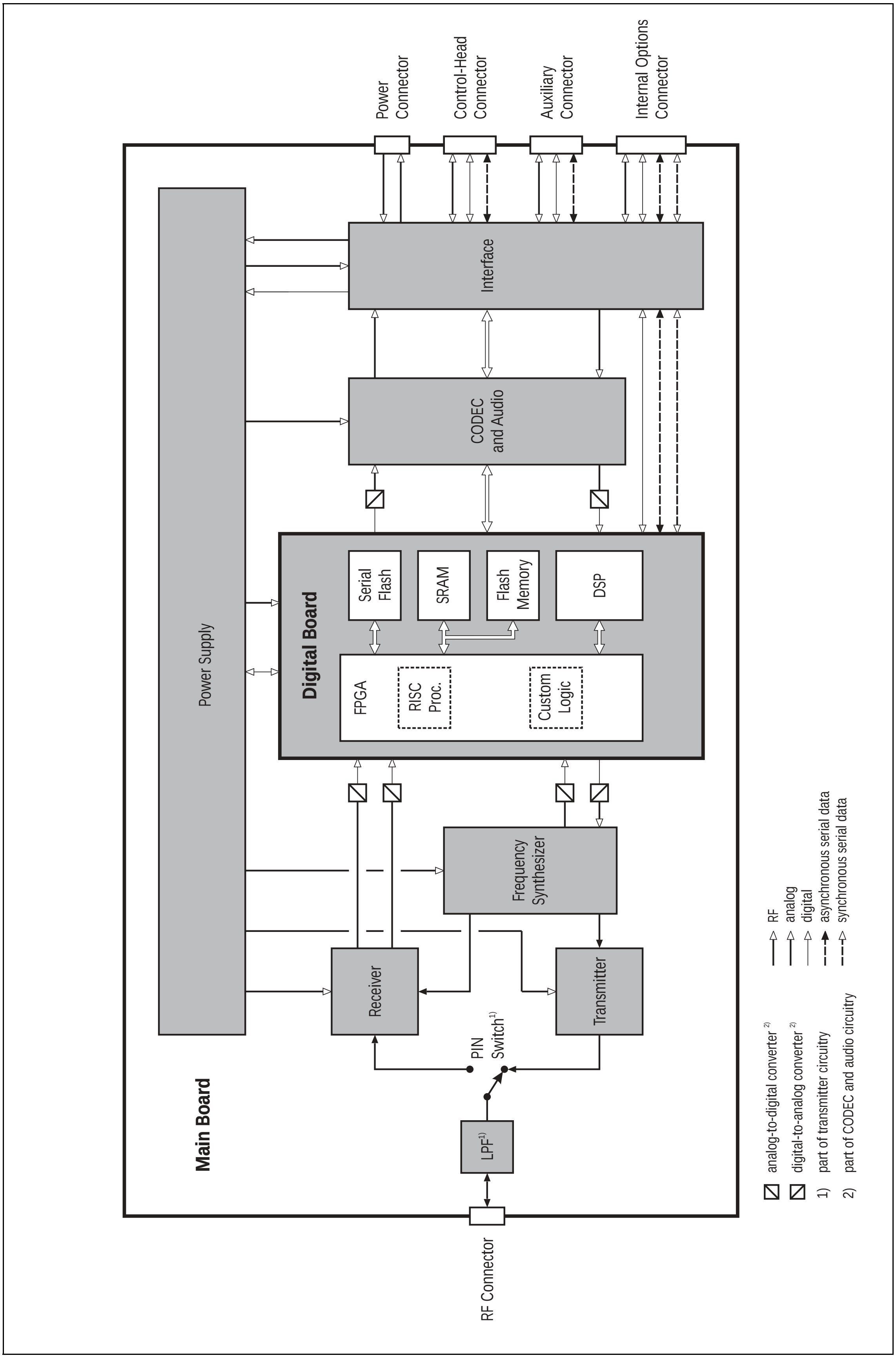
The control-head board includes:

- the circuitry needed for the controls and indicators on the front panel
- with a RISC processor and custom logic (implemented on an FPGA), and memory

For a block diagram of this control-head board, refer to Figure 3.11 on page 91.

The control head has a concealed microphone inside the control head and also has a provision for a separate circuit board that may be designed to perform a variety of tasks including—but not limited to—Bluetooth connectivity. No separate circuit board is required for a dynamic microphone.

Figure 2.10 Hardware architecture of the main board



2.4.2 Software Architecture

Overview

Software plays an important role in the functioning of the radio. Some radio functions such as the graphical user interface, processing of the analog and digital signals, and the implementation of analog and digital radio applications are completely implemented by software.

For a block diagram of the software architecture, refer to Figure 2.11 on page 45.

Software Modules

The following software modules are stored on the digital board of the main board:

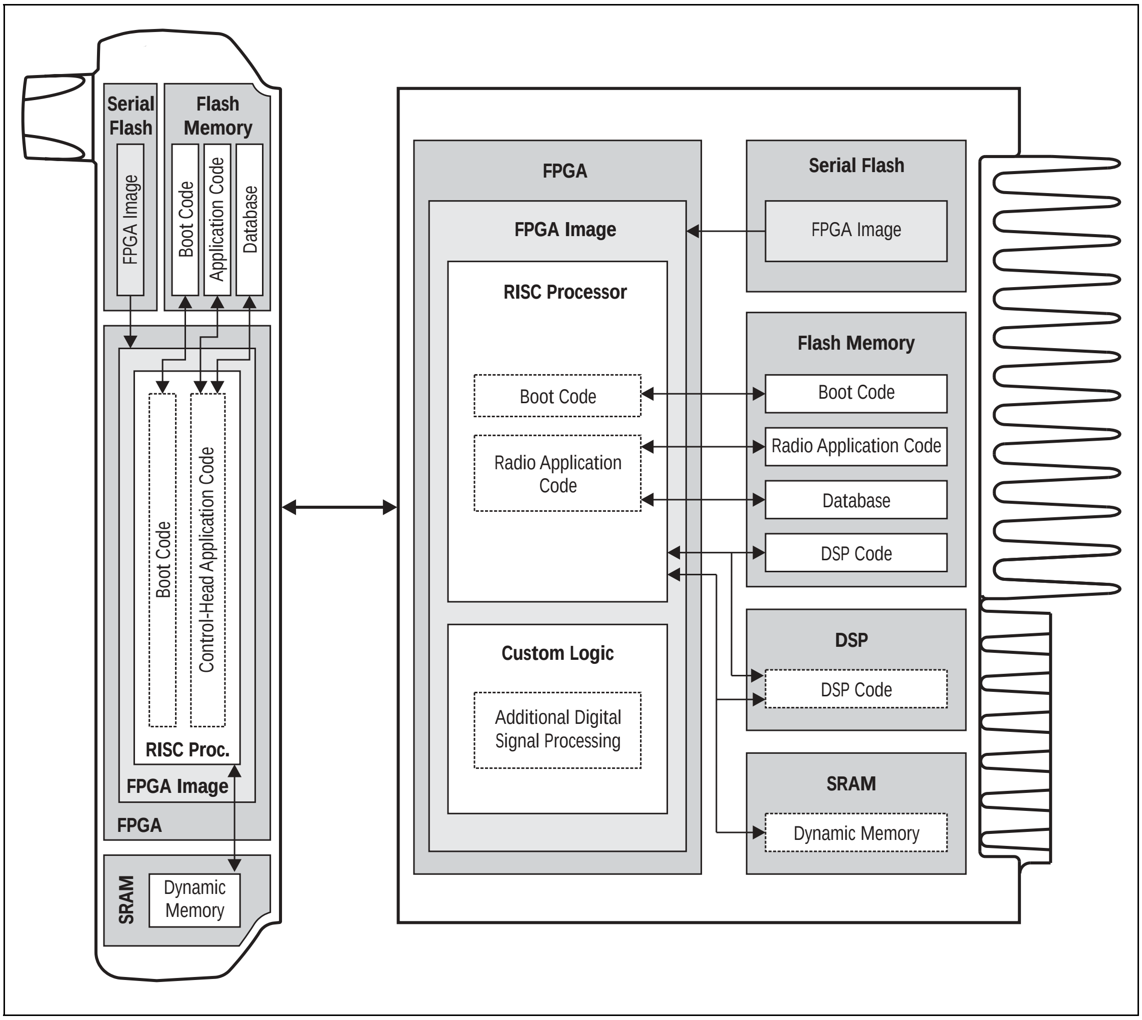
- FPGA image, which includes the software-implemented RISC processor and the custom logic (the custom logic executes additional digital signal processing)
- boot code
- radio application code
- digital signal processing
- radio application database and radio calibration database

The following software modules are stored on the control-head board with:

- FPGA image, which includes the software-implemented RISC processor
- boot code
- control-head application code
- control-head application database

Hardware and interface drivers are part of the boot code, the RISC code, and—in case of the main board—the DSP code.

Figure 2.11 Software architecture



Software Start-Up

When the radio is turned on, the following processes are carried out on the main board:

Note This process describes the normal software start-up into normal radio operation mode.

1. The FPGA image, which includes the RISC processor and the custom logic, is loaded from the serial flash to the FPGA.

2. The RISC processor executes the boot code, which carries out an initialization and auto-calibration, and—in case of a fault—generates an error code for display on the control head.

3. Normal radio operation starts with:
   - the RISC processor executing the radio application code, including application software for the analog and/or digital modes
   - the DSP executing the DSP code for processing of digital signals in analog and digital mode
   - the custom logic executing additional digital signal processing

When the radio is turned on, the following processes are carried out on the control-head board:

1. The FPGA image, which includes the RISC processor, is loaded from the serial flash to the FPGA.

2. The RISC processor executes the boot code, which carries out an initialization, and—in case of a fault—generates an error code for display on the control head.

3. Normal radio operation starts with the RISC processor executing
   - the graphical user interface
   - the I/O processing
   - the user interface processing

During normal radio operation the radio body and control head communicate via interface software, which is part of the radio and control-head application software.

Software Shutdown

On shutdown, the programming and calibration data is stored in the database, and power is removed from the radio.

Important On power loss, any changes made to the programming or calibration data may be lost.

Programming and Calibration Files

One of the servicing tasks is the downloading and uploading of programming and calibration files to the database. For more information, refer to "Servicing Procedures" on page 139 and the online help of the programming and calibration applications.

Software Upgrades

During servicing it may become necessary to upload software to a replacement main board, control head, or control head board using the Tools > Options > Download command of the programming application. For more information, refer to the online help of the programming application and to the technical notes accompanying the software files.

2.5 Operation in Receive Mode

Overview

This section describes the functioning of the transceiver in receive mode.

The operation of the transceiver is illustrated in Figure 2.12 on page 48 (analog mode) and Figure 2.13 on page 49 (digital mode).

These block diagrams show the hardware modules integrated with the software modules:

- hardware (transmitter, receiver, CODEC and audio)
- RISC processor (on FPGA of digital board)
- custom logic (on FPGA of digital board)
- DSP (on digital board)

Note The block diagrams for the analog and digital modes only differ in the operation of the DSP.

The receive path consists of three major functional parts:

- RF hardware
- digital baseband processing
- audio processing and signaling

Note The information flow on a digital radio can be categorized in two forms, signaling (including user data) and voice. Whilst setting up a call, signaling may be the only information transferred across the air interface. Once a call has been established however, both signaling and voice information are transported. The signaling information continues throughout the call for the purpose of maintaining the call and possibly sending data information.

Figure 2.12 Transceiver operation in analog mode

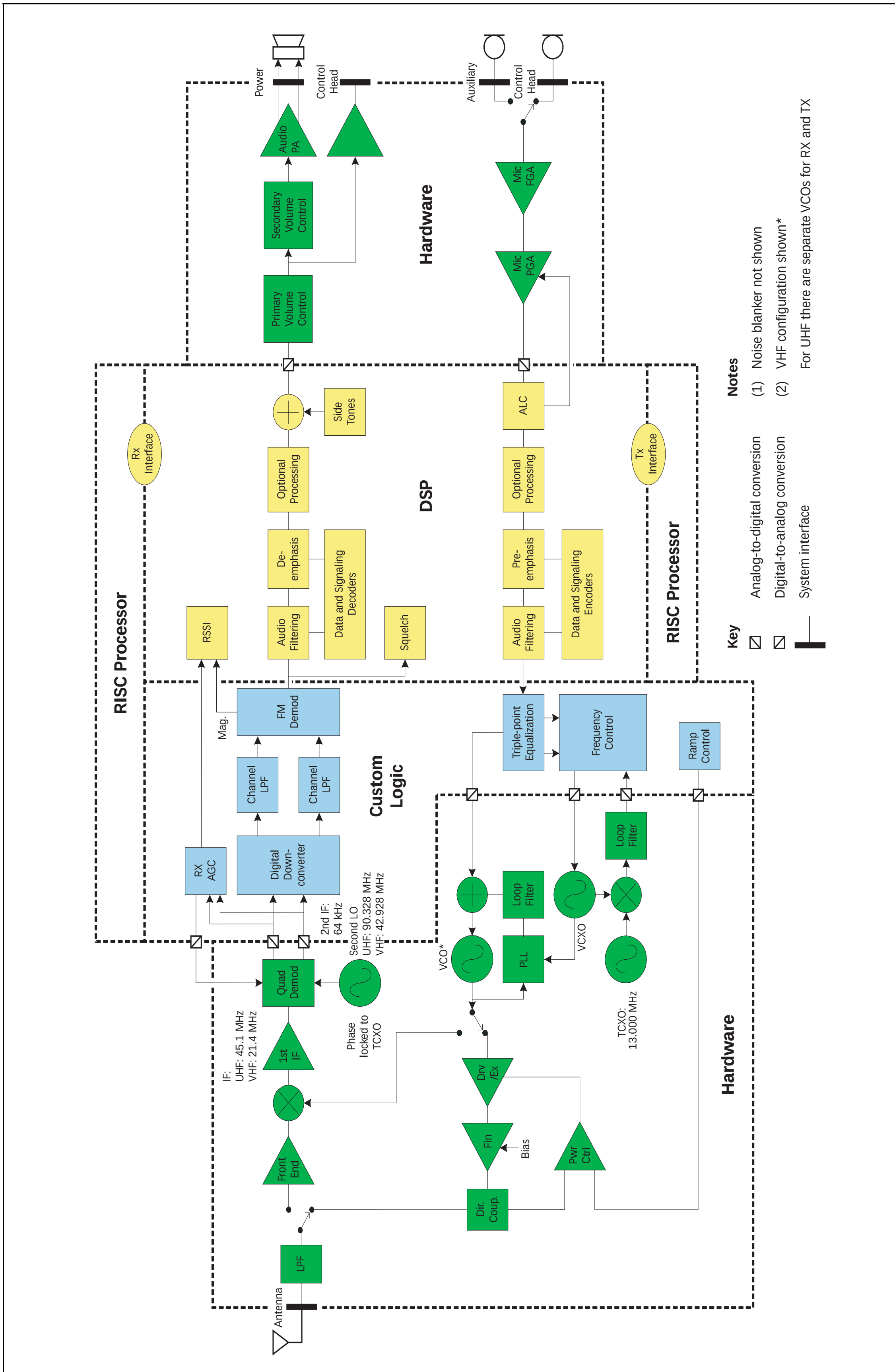
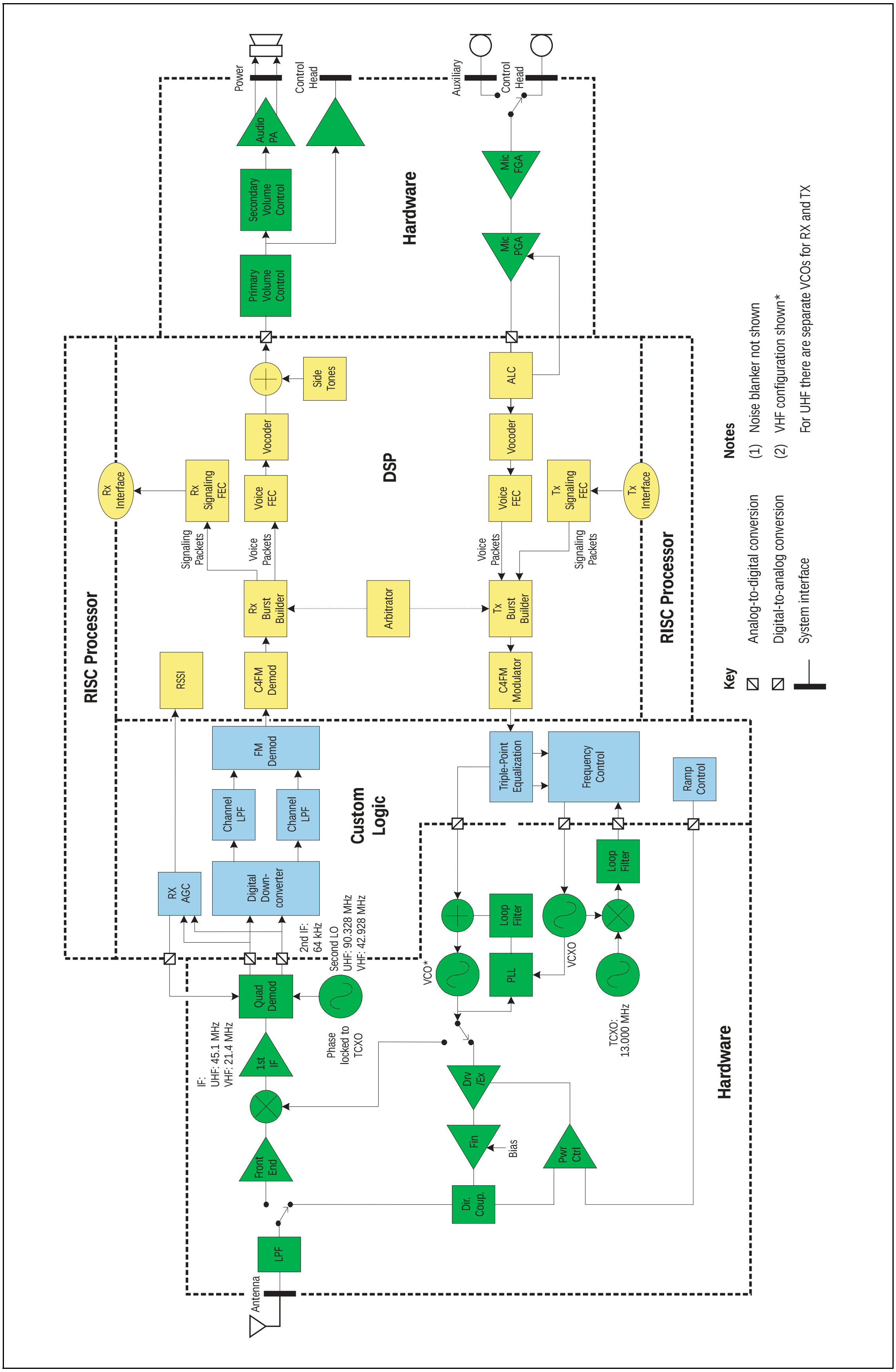


Figure 2.13 Transceiver operation in digital mode



2.5.1 RF Hardware

PIN Switch

The RF PIN switch circuitry selects the RF path to and from the antenna to either the Tx or Rx circuitry of the radio. In addition to the switching functionality, the PIN switch is used to provide attenuation to the Rx front end in high signal-strength locations.

Front End and First IF

The front-end hardware amplifies and image-filters the received RF spectrum, then down-converts the desired channel frequency to a first intermediate frequency IF1 of 45.1MHz (UHF) or 21.4MHz (VHF) where coarse channel filtering is performed. The first LO signal is obtained from the frequency synthesizer and is injected on the low side of the desired channel frequency for all bands. In receive mode, the modulation to the frequency synthesizer is muted. See "Frequency Synthesizer" on page 57 for a description of the frequency synthesizer. The output of the first IF is then down-converted using an image-reject mixer to a low IF of 64kHz.

Quadrature Demodulator

The LO for the image-reject mixer (quadrature demodulator) is synthesized and uses the TCXO as a reference. This ensures good centring of the IF filters and more consistent group-delay performance. The quadrature demodulator device has an internal frequency division of 2 so the second LO operates at 2 x (IF1 + 64kHz). The quadrature output from this mixer is fed to a pair of ADCs with high dynamic range where it is oversampled at 256kHz and fed to the custom logic device.

Automatic Gain Control

The AGC is used to limit the maximum signal level applied to the image-reject mixer and ADCs in order to meet the requirements for intermodulation and selectivity performance. Hardware gain control is performed by a variable gain amplifier within the quadrature demodulator device driven by a 10-bit DAC. Information about the signal level is obtained from the IQ data output stream from the ADCs. The control loop is completed within the custom logic. The AGC will begin to reduce gain when the combined signal power of the wanted signal and first adjacent channels is greater than about -70dBm. In the presence of a strong adjacent-channel signal it is therefore possible that the AGC may start acting when the wanted signal is well below -70dBm.

Noise Blanking (B1 band only)

With the B1 band, a noise blanker can be selected to remove common sources of electrical interference such as vehicle ignition noise. The noise blanker functions by sampling the RF input to the receiver for impulse noise and momentarily disconnecting the first LO for the duration of the impulse. The response time of the noise blanker is very fast (tens of nanoseconds) and is quicker than the time taken for the RF signal to pass through the front-end hardware, so that the LO is disabled before the impulse reaches the IF stage where it could cause crystal filter ring.

2.5.2 Digital Baseband Processing

Custom Logic

The remainder of the receiver processing up to demodulation is performed by custom logic. The digitized quadrature signal from the RF hardware is digitally down-converted to a zero IF and channel filtering is performed at baseband. Different filter shapes are possible to accommodate the various channel spacings and data requirements. These filters provide the bulk of adjacent channel selectivity for narrow-band operation. The filters have linear phase response so that good group-delay performance for data is achieved. The filters also decimate the sample rate down to 48kHz. Custom logic also performs demodulation, which is multiplexed along with AGC and amplitude data and fed via a single synchronous serial port to the DSP. The stream is demultiplexed and the demodulation data used as an input for further audio processing.

Noise Squelch

The noise squelch process resides in the DSP. The noise content above and adjacent to the voice band is measured and compared with a preset threshold. When a wanted signal is present, out-of-band noise content is reduced and, if below the preset threshold, is indicated as a valid wanted signal.

RSSI

Receive signal strength is measured by a process resident in the DSP. This process obtains its input from the demodulator (RF signal magnitude value) and from the AGC (present gain value). With these two inputs and a calibration factor, the RF signal strength at the antenna can be accurately calculated.

Calibration

The following items within the receiver path are factory-calibrated:

- front-end tuning
- AGC
- noise squelch
- RSSI

Information on the calibration of these items is given in the on-line help facility of the calibration application.

2.5.3 Audio Processing and Signaling

Audio Processing (Analog Mode)

Raw demodulated data from the receiver is processed within the DSP. The sample rate at this point is 48kHz with signal bandwidth limited only by the IF filtering. Scaling (dependent on the bandwidth of the RF channel) is then applied to normalize the signal level for the remaining audio processing. The sample rate is decimated to 8kHz and 0.3 to 3kHz bandpass audio filtering is applied. De-emphasis is then applied to cancel out the receive signals pre-emphasized response and improve signal to noise performance. Optional processing such as decryption or companding is then applied if applicable.

Data and Signaling Decoders (Analog Mode)

The data and signaling decoders obtain their signals from various points within the audio processing chain. The point used depends on the decoders' bandwidth and whether de-emphasis is required. Several decoders may be active simultaneously.

Side Tones

Side tones are summed in at the end of the audio processing chain. These are tones that provide some form of alert or give the user confidence an action has been performed. The confidence tones may be generated in receive or transmit mode. The sidetone level is a fixed proportion (in the order of -10dB) relative to full scale in the receive path.

C4FM Demodulator (Digital Mode)

Once the received signal is FM demodulated, it enters the C4FM demodulator. Once synchronization has been acquired, the received signals should exist as four possible frequencies. These frequencies are translated directly into received symbols ready to be passed to the burst builder.

Rx Burst Builder (Digital Mode)

The job of the burst builder is to dismantle the received burst. The burst builder can only receive an incoming burst once synchronization has been achieved by the C4FM modem. The synchronization sequence itself does not contain meaningful signaling payload and is discarded by the burst builder. The payload content of the burst is dismantled and routed to the appropriate signaling FEC or voice FEC task for decoding. The dismantling process is the reverse of the construction process performed by the burst builder.

Rx Signaling FEC (Digital Mode)

Prior to transmission, signaling information such as the network identifier was protected with forward error correction. Upon reception, the signaling may contain errors. If the number of errors is limited they can be corrected to recover the originally transmitted signaling.

Rx Vocoder FEC (Digital Mode)

The 144 bits received from the burst builder are de-interleaved on a frame by frame basis. An attempt is made to decode the 88 vocoder bits using the complementary process to that used in the encoder. An indication of the success of the decoder is produced. If the FEC algorithm is unable to decode correctly, a recommendation is made to the vocoder, depending on the severity of the errors, to either guess what the frame should be, to repeat the last frame, or to mute for this frame.

Rx Vocoder (Digital Mode)

The 88 bits from the FEC are decoded to generate the fundamental frequency of the frame, the voiced/unvoiced decisions for each frequency band, and the spectral amplitudes. 20ms of speech is synthesized from this information, and is interpolated between the previous frame and the next frame to minimize any artefacts due to the transition from one frame to the next.

Arbitration (Digital Mode)

Transmission over the air interface from a radio terminal is governed by channel access procedures. The radio must monitor the Status Symbols on the inbound channel, and wait for the status to indicate that the channel is free to use (idle) before transitioning to transmit mode. The channel access procedures are supervised by various timers. Normally, these procedures must be applied before transitioning from receive mode to transmit mode. However, they may be overridden under emergency conditions.

CODEC

The combined audio and side-tone signal is converted to analog form by a 16-bit DAC with integral anti-alias filtering. This is followed by a programmable-gain amplifier with 45 dB range in 1.5 dB steps, that performs primary volume control and muting. The DAC and primary volume control are part of the same CODEC device (AD6521).

Output to Speakers

The output of the CODEC is fed to an audio power amplifier via a secondary volume control and to the control head via a buffer amplifier. The output configuration of the audio power amplifier is balanced and drives an internal speaker in non-remote control-head configuration and, optionally, an external speaker. The speaker loads are connected in parallel rather than being switched. The power delivered to each speaker is limited by its impedance. The internal speaker has 16Ω impedance whereas the external speaker can be as low as 4Ω.

Volume Control Configurations

There are two volume controls in the radio but only one is active at any time when audio is being output to the speaker(s). The inactive volume control is set to maximum. For non-remote control-head configuration, the primary volume control is active. For remote control-head configuration, the secondary volume control is active. This enables fixed level audio feed to the remote control head, and independent volume control of the external speaker and the speaker of the remote control head.

2.6 Operation in Transmit Mode

Overview

This section describes the functioning of the transceiver in transmit mode.

The operation of the transceiver is illustrated in Figure 2.12 on page 48 (analog mode) and Figure 2.13 on page 49 (digital mode).

These block diagrams show the hardware modules integrated with the software modules:

- hardware (transmitter, receiver, CODEC and audio)
- RISC processor (on FPGA of digital board)
- custom logic (on FPGA of digital board)
- DSP block (on digital board)

Note The block diagrams for the analog and digital modes only differ in the operation of the DSP.

The transmit path consists of three major functional parts:

- audio processing and signaling
- frequency synthesizer
- RF transmitter

Note The information flow on a digital radio can be categorized in two forms, signaling (including user data) and voice. Whilst setting up a call, signaling may be the only information transferred across the air interface. Once a call has been established however, both signaling and voice information are transported. The signaling information continues throughout the call for the purpose of maintaining the call and possibly sending data information.

2.6.1 Audio Processing and Signaling

Microphone Input

The input to the transmitter path begins at the microphone input. There are two microphone sources: a fist microphone connected to the control head and an auxiliary microphone connected via the auxiliary or external options connector. Only electret-type microphones are supported. Support for optional dynamic fist microphones is facilitated by a hardware amplifier and filter in the control head, and must be activated in the programming software.

Analog Processing of the Microphone Input

The CODEC (AD6521) performs microphone selection and amplification. The microphone amplifier consists of a fixed gain amplifier of 16dB followed by a programmable-gain amplifier with 0 to 22dB gain.
The amplified microphone signal is converted to a digital stream by a 16-bit ADC with integral anti-alias filtering (0.1 to 3.2kHz). The digital stream is transported to the DSP for further audio processing.

Automatic Level Control

The ALC follows and is used to effectively increase dynamic range by boosting the gain of the microphone pre-amplifier under quiet conditions and reducing the gain under noisy acoustic conditions. The ALC function resides in the DSP and controls the microphone-programmable gain amplifier in the CODEC. The ALC has a fast-attack (about 10ms) and slow-decay (up to 2s) gain characteristic. This characteristic ensures that the peak signal level is regulated near full scale to maximize dynamic range.

DSP Audio Processing (Analog Mode)

The output of the automatic level control provides the input to the DSP audio processing chain at a sample rate of 8kHz. Optional processing such as encryption or companding is done first if applicable. Pre-emphasis, if required, is then applied. The pre-emphasized signal is hard limited to prevent overdeviation and filtered to remove high frequency components. The sample rate is then interpolated up to 48kHz and scaled to be suitable for the frequency synthesizer.

Data and Signaling Encoders (Analog Mode)

The data and signaling encoders inject their signals into various points within the audio processing chain. The injection point depends on the encoders bandwidth and whether pre-emphasis is required.

Tx Vocoder (Digital Mode)

The IMBE vocoder block takes audio samples in blocks of 20ms, analyses them and compresses them down to 88 bits. If there is no speech content in the segment, the vocoder produces silence. If speech is detected in the segment, the content of the segment is split into a variable number of frequency bands (max. 12) and a voiced/unvoiced decision is made for each band. It also estimates the pitch of the segment of speech and determines the spectral amplitudes of the voiced frequency bands.

Tx Vocoder FEC (Digital Mode)

The 88 bits from the vocoder have 56 bits of parity added to them. Different amounts of protection are afforded to the vocoder parameters, depending on their relative importance. Four blocks of 12 bits are given highest priority and are each encoded by (23,12) Golay codes. Three blocks of 11 bits are afforded less protection and are encoded by (15,11) Hamming codes.
The final 7 bits are unprotected. Finally all 144 bits are interleaved to spread the affect of bursts errors throughout the frame, and sent to the Burst Builder.

Tx Signaling FEC (Digital Mode)

In the same way as voice packets are protected using forward error correction, so too is the signaling information (control and data).
One example is the network identifier which is protected using a powerful BCH (Bose-Chandhuri-Hocquenghem) error code.

Tx Burst Builder (Digital Mode)

It is the nature of a digital radio transmission that the information is structured into bursts. An air interface burst can take several forms. Every burst consists of a frame synchronization sequence and Network identifier, followed by the main body of the burst, the content of which depends upon the type of burst. For a voice burst, it comprises a fixed number of voice packets with control signaling and low speed data interspersed. For a data or control burst, it comprises a variable number of data blocks. Additionally, every air interface burst is expanded with a status symbol after every 70 bits of information. These status symbols are used for channel access procedures.

It is the job of the burst builder to construct the air interface burst using FEC-encoded code words delivered to it by the signaling FEC and voice FEC. The burst is then passed to the C4FM modulator.

Arbitrator (Digital Mode)

Transmission over the air interface from a radio terminal is governed by channel access procedures. The radio must monitor the status symbols on the inbound channel, and wait for the status to indicate that the channel is free to use (idle) before transitioning to transmit mode. The channel access procedures are supervised by various timers. Normally, these procedures must be applied before transitioning from receive mode to transmit mode. However, they may be overridden under emergency conditions.

C4FM Modulator (Digital Mode)

The burst builder creates a symbol stream that must be modulated onto the RF carrier. Four possible symbols can be transmitted. They are passed through a shaping filter defined by the APCO standard which limits the spectral occupancy on air. The four symbols are transmitted at pre-defined frequency deviations from the carrier.

2.6.2 Frequency Synthesizer

Introduction

As shown in Figure 2.12, the frequency synthesizer consists of two main parts:

- FCL
- RF PLL, comprising RF PLL device, loop filter, VCO, and VCO output switch

Frequency Control Loop

The FCL consists of the following:

- TCXO
- mixer
- loop filter
- VCXO
- frequency control block

The FCL provides the reference frequency for the RF PLL. The FCL generates a high-stability reference frequency that can be both modulated and offset in fine resolution steps.

RF PLL

- The RF PLL consists of the following:
- RF PLL device
- loop filter
- VCO
- VCO output switch

The RF PLL has fast-locking capability but coarse frequency resolution. This combination of control loops creates improved frequency generation and acquisition capabilities.

Note that patents are pending for several aspects of the synthesizer design.

Operation of Control Loop

The RF PLL is a conventional integer-N-type design with frequency resolution of 25kHz. In transmit mode, the loop locks to the transmit frequency, whereas in receive mode, it locks to the receive frequency minus the first IF frequency.

Initially, the VCO generates an unregulated frequency in the required range. This is fed to the PLL device (ADF4111) and divided down by a programmed ratio to approximately 25kHz. The reference frequency input from the FCL is also divided down to approximately 25kHz. The phase of the two signals is compared and the error translated into a DC voltage by a programmable charge pump and dual-bandwidth loop filter. This DC signal is used to control the VCO frequency and reduce the initial error. The loop eventually settles to a point that minimizes the phase error between divided down reference and VCO frequencies. The net result is that the loop “locks” to a programmed multiple of the reference frequency.

The FCL generates an output of 13.012 MHz±4 kHz. Initially, a voltage controlled crystal oscillator (VCXO) produces a quasi-regulated frequency in the required range. The VCXO output is fed to a mixer where it is mixed with the 13.000 MHz TCXO frequency. The mixer, after low-pass filtering to remove unwanted products, produces a frequency of 12 kHz nominally. This is converted to digital form and transported to the frequency control block in the custom logic.

The frequency control block compares the mixer output frequency to a reference generated by the digital clock and creates a DC error signal. A programmed offset is also added. This error signal is converted to analog form and used to control the VCXO frequency and reduce the initial error. Once settled, the loop "locks" to the TCXO frequency with a programmed offset frequency. The FCL output therefore acquires the TCXO's frequency stability.

Modulation

The full bandwidth modulation signal is obtained from the DSP in digital form at a sample rate of 48 kHz. In traditional dual-point modulation systems the modulation is applied, in analog form, to both the frequency reference and the VCO in the RF PLL, combining to produce a flat modulation response down to DC. Reference modulation is usually applied directly to the TCXO.

In the system employed in the TM9100 radio, the frequency reference is generated by the FCL, which itself requires dual-point modulation injection to allow modulation down to DC. With another modulation point required in the RF PLL, this system therefore requires triple-point modulation. The modulation signals applied to the FCL are in digital form while for the RF PLL (VCO) the modulation signal is applied in analog form. The modulation cross-over points occur at approximately 30 and 300 Hz as determined by the closed loop bandwidths of the FCL and RF PLL respectively.

Frequency Generation

The RF PLL has a frequency resolution of 25 kHz. Higher resolution cannot be achieved owing to acquisition-time requirements and so for any given frequency the error could be as high as ±12.5 kHz. This error is corrected by altering the reference frequency to the RF PLL. The FCL supplies the reference frequency and is able to adjust it up to ±300 ppm with better than 0.1 ppm resolution (equivalent to better than 50 Hz resolution at the RF frequency). The FCL offset will usually be different for receive and transmit modes.

Fast Frequency Settling

Both the FCL and RF PLL employ frequency-acquisition speed-up techniques to achieve fast frequency settling. The frequency-acquisition process of the FCL and RF PLL is able to occur concurrently with minimal loop interaction owing to the very large difference in frequency step size between the loops.

Frequency Acquisition of RF PLL

In the RF PLL the loop bandwidth is initially set to high by increasing the charge-pump current and reducing time constants in the loop filter. As a result, settling to within 1kHz of the final value occurs in under 4ms. In order to meet noise performance requirements the loop parameters are then switched to reduce the loop bandwidth. There is a small frequency kick as the loop bandwidth is reduced. Total settling time is under 4.5ms.

Frequency Acquisition of FCL

The FCL utilizes self-calibration techniques that enable it to rapidly settle close to the final value while the loop is open. The loop is then closed and settling to the final value occurs with an associated reduction in noise. The total settling time is typically less than 4ms.

Calibration

The following items are calibrated in the frequency synthesizer:

- nominal frequency
- KVCO
- KVCXO
- VCO deviation

Calibration of the nominal frequency is achieved by adding a fixed offset to the FCL nominal frequency; the TCXO frequency itself is not adjusted. The items KVCO and KVCXO are the control sensitivities of the RF VCO (in MHz/V) and VCXO (in kHz/V) respectively. The latter has temperature compensation.

2.6.3 RF Transmitter

RF Power Amplifier and Switching (50W/40W Radio)

50W 40W

The RF power amplifier and exciter of the 50W/40W radio is a five-stage line-up with approximately 40dB of power gain. The output of the frequency synthesizer is first buffered to reduce kick during power ramping. The buffer output goes to a discrete exciter that produces approximately 300 to 400mW output. This is followed by an LDMOS driver producing up to 8W output that is power-controlled. The final stage consists of two parallel LDMOS devices producing enough power to provide 40 to 50W at the antenna.

RF Power Amplifier and Switching (25W Radio)

25W

The RF power amplifier of the 20W radio is a four-stage line-up with approximately 37dB of power gain. The output of the frequency synthesizer is first buffered to reduce kick during power ramping. The buffer output goes to a broad-band exciter IC that produces approximately 200mW output. This is followed by an LDMOS driver producing up to 2W output that is power-controlled. The final stage consists of two parallel LDMOS devices producing enough power to provide 25W at the antenna.

Output of RF Power Amplifier

The output of the RF power amplifier passes through a dual-directional coupler, used for power control and monitoring, to the PIN switch. The PIN switch toggles the antenna path between the receiver and transmitter in receive and transmit modes respectively. Finally, the output is low-pass-filtered to bring harmonic levels within specification.

Power Control

The steady-state power output of the transmitter is regulated using a hardware control loop. With the 50W/40W radio, the sum of the forward power output from the RF power amplifier and reverse power reflected from the load is sensed by the directional coupler and fed back to the power control loop. With the 25W radio, the forward power output from the RF power amplifier is sensed by the directional coupler and fed back to the power control loop. The PA output power is controlled by varying driver gate bias voltage that has a calibrated maximum limit to prevent overdrive. The power control signal is supplied by a 13-bit DAC driven by custom logic.

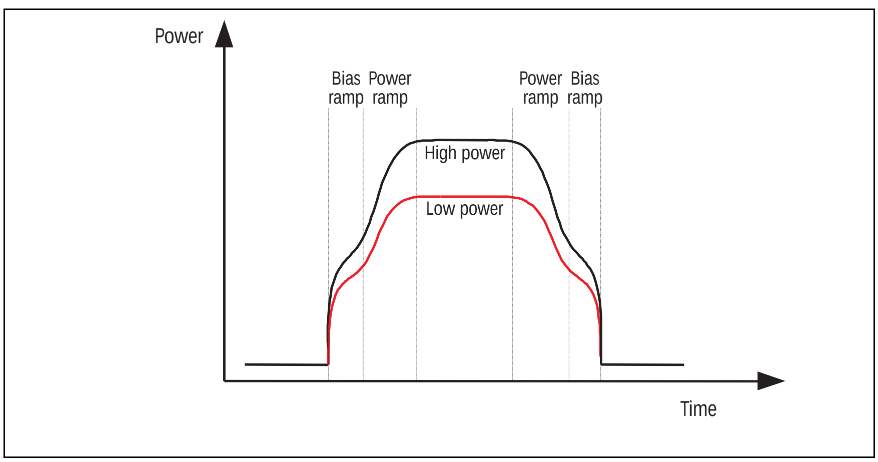
Ramping

Power ramp-up consists of two stages:

- bias
- power ramping

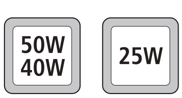
The timing between these two stages is carefully controlled in order to achieve the correct overall wave shape and meet transient ACP specifications. A typical ramping waveform is shown in Figure 2.14.

Figure 2.14 Typical ramping waveforms



The timing between these two stages is critical to achieving the correct overall wave shape in order to meet the specification for transient ACP (adjacent channel power).

Bias Ramp-Up



The steady-state final-stage bias level is supplied by an 8-bit DAC programmed prior to ramp-up but held to zero by a switch on the DAC output under the control of a TX INHIBIT signal. Bias ramp-up begins upon release by the TX INHIBIT signal with the ramping shape being determined by a low-pass filter. Owing to power leakage through the PA chain, ramping the bias takes the PA output power from less than –20dBm for the 50W/40W or –10dBm for the 25W radio to approximately 25dB below steady-state power.

Power Ramp-Up

The power ramp signal is supplied by a 13-bit DAC that is controlled by custom logic. The ramp is generated using a look-up table in custom logic memory that is played back at the correct rate to the DAC to produce the desired waveform. The ramp-up and ramp-down waveforms are produced by playing back the look-up table in forward and reverse order respectively. For a given power level the look-up table values are scaled by a steady-state power constant so that the ramp waveform shape remains the same for all power levels.

PIN Switch

The RF PIN switch circuitry selects the RF path to and from the antenna to either the Tx or Rx circuitry of the radio. In addition to the switching functionality, the PIN switch is used to provide attenuation to the Rx front end in high signal-strength locations.

3 Circuit Descriptions

Introduction

This section describes and illustrates the circuitry of the main board and the control-head board.

The main board is decided into the following circuitry modules:

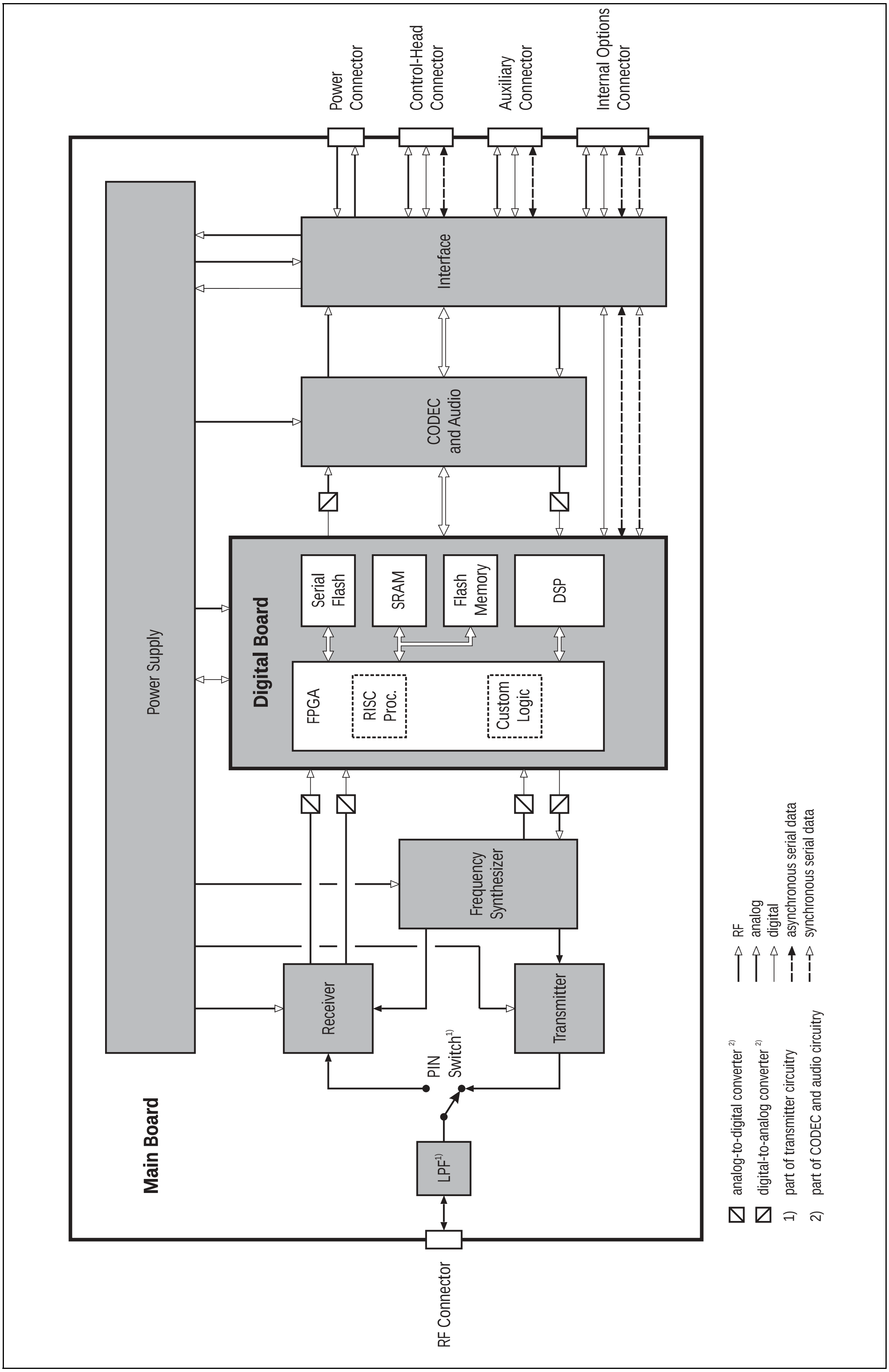
- transmitter
- receiver
- frequency synthesizer (including FCL)
- CODEC and audio
- power supply
- interface
- digital board

Figure 3.1 gives an overview of the of the circuitry modules of the main board and shows how they are interconnected.

Sample Schematics

For up-to-date schematics refer to the relevant PCB information.

Figure 3.1 Main board hardware architecture



3.1 Transmitter Circuitry

Introduction

For a block diagram of the transmitter circuitry, refer to Figure 3.2.

The transmitter circuitry is different for the 50 W/40 W radios and the 25 W radios, and the different bands.

Exciter

With the 50 W/40 W radio, the discrete-component exciter is designed for specific bands (UHF or VHF). It is made up of Q3501, Q3502, and Q3505, which amplify the signal provided by the frequency synthesizer from its level of 7 to 10 dBm up to 24 dBm for the frequency bands 136 to 174 MHz and 400 to 520 MHz.

With the 25 W radio, the broadband exciter is a common element in all the bands, as it operates across all frequencies from 66 to 940 MHz. It is made up of Q300 and Q303, which amplify the signal provided by the frequency synthesizer from its level of 7 to 10 dBm up to 24.5 dBm for the frequency band from 66 to 530 MHz and slightly less than this for the bands covering 530 to 940 MHz.

The exciter operates in full saturation, thereby maintaining a constant output power independent of the varying input power level supplied by the synthesizer.

Power Amplifier

The power amplifier comprises the driver amplifier Q306 and two paralleled final devices Q309 and Q310.

With the 50 W/40 W radio, the signal from the exciter is amplified by Q306 to a power level of approximately 2 W (VHF) using a PD55003 and about 3 W (UHF) using a PD55008. The resulting signal is then amplified by Q309 and Q310 to produce a typical output power of 90 W at 155 MHz and 65 W across the UHF band, when measured after the series capacitors (C348, C349, C350) at the start of the directional coupler.

With the 25 W radio, the 24.5 dBm signal from the exciter is reduced by a band-dependent pi-attenuator and is amplified by Q306. The resulting signal is then amplified a second time by Q309 and Q310 to produce a typical output power of 42 W when measured after the series capacitors (C348, C349, C350) at the start of the directional coupler.

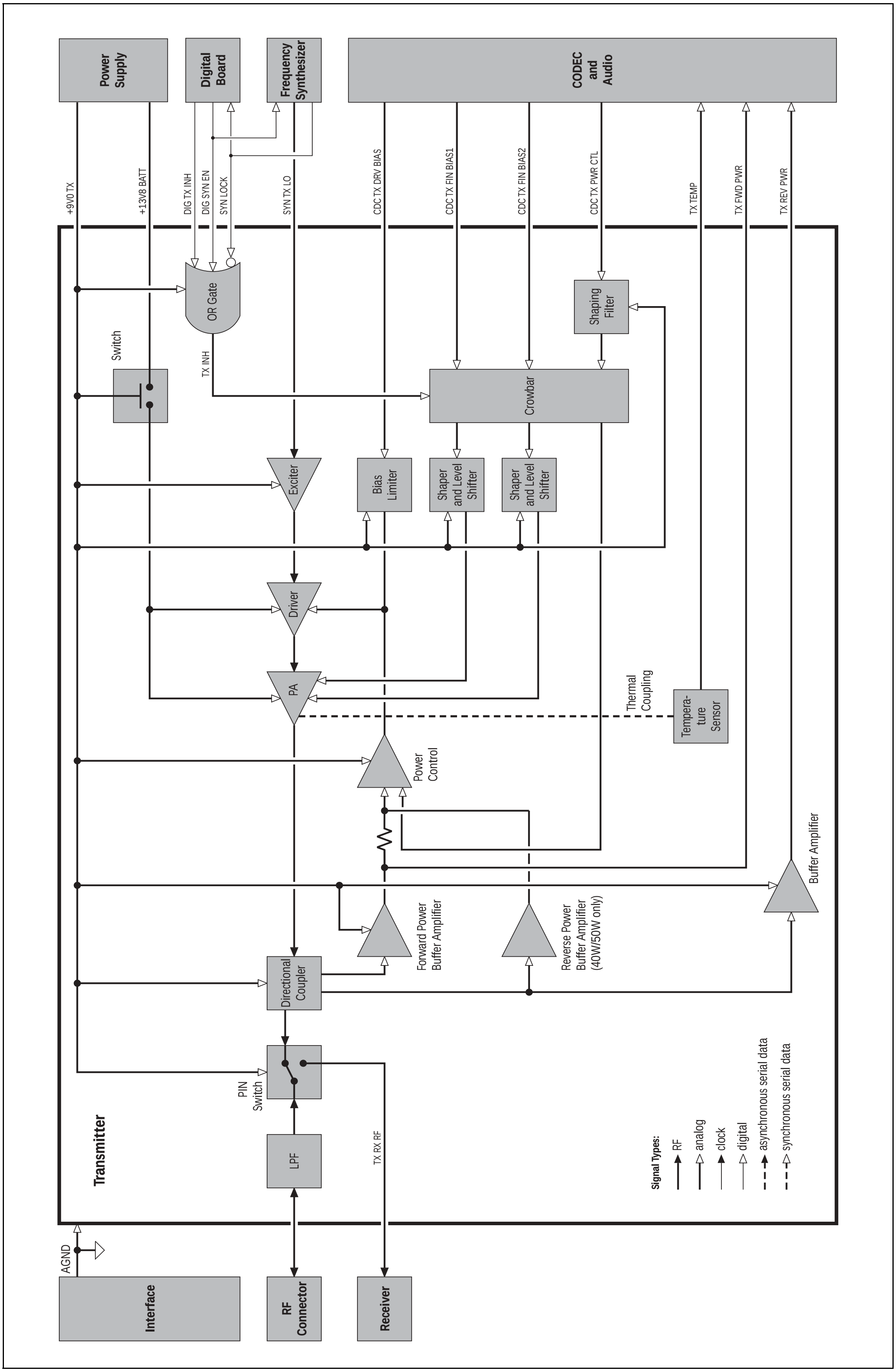
The high-level RF signal passes via the directional coupler, the transmit-receive PIN switch, and the LPF, through to the antenna. The LPF is used to attenuate unwanted harmonic frequencies.

Power Control Loop

Calibration is used to adjust the power control loop, thus setting the output of the transmitter to one of four preferred power levels:

- 10, 15, 25, and 50 watts (VHF), and
  10, 15, 20, and 40 watts (UHF) for 50 W/40 W radios
- 1, 5, 12 and 25 watts (all bands) for 25 W radios

Figure 3.2 Block diagram of the transmitter circuitry



The loop maintains these power settings under changing environmental conditions. The control mechanism for this loop is via the DAC IC204 and one of the operational amplifiers making up IC301. The power control loop will be inhibited if for any reason an out-of-lock signal is detected from the synthesizer. This ensures that no erroneous signals are transmitted at any time.

50W 40W

With the 50 W/40 W radio, the power control loop processes the voltages from the forward and reverse power sensors in the directional coupler. This signal is fed to the buffer and a band-limited operational amplifier back to the gate of Q306. In this way, the transmitter is protected against bad mismatches.

25W

With the 25 W radio, the power control loop senses the forward power by means of the diode D304. This signal is fed to the buffer and a band-limited operational amplifier back to the gate of Q306.

A voltage clamp (one of the operational amplifiers of IC301) for Q306 limits the maximum control-loop voltage applied to its gate.

Directional Coupler

50W 40W

With the 50 W/40 W radio, the directional coupler actively senses the forward power and the reverse power, and feeds them back to the power-control circuit.

25W

With the 25 W radio, the directional coupler actively senses the forward power and feeds it back to the power-control circuit. If the directional coupler detects too much reverse power, indicating a badly matched antenna, the transmitter will be reduced to the lowest power setting.

Temperature Sensor

For added protection, a temperature sensor ensures that the transmitter power is reduced to very low levels should a temperature threshold be exceeded. If the temperature does not decrease, the transmitter is switched off.

3.2 Receiver Circuitry

Introduction

For a block diagram of the receiver circuitry, refer to Figure 3.3.

The receiver is of the triple-conversion superheterodyne type. The first two IF stages are implemented in hardware; the third stage is implemented in the FPGA (field-programmable gate array) of the digital board. The FPGA also carries out the demodulation of the received signals.

Front-End Circuitry

The front-end circuitry is a standard varicap-tuned singlet (band-pass filter), followed by an LNA (low-noise amplifier), and then a varicap-tuned doublet (image filter). The varicap tuning voltage CDC RX FE TUNE is provided by a DAC, with voltages calculated from a calibration table stored in non-volatile memory. The two varicap-tuned filters need to be calibrated to ensure that maximum sensitivity is achieved.

First Mixer

The first mixer is a standard diode-ring mixer with SMD (surface-mount device) baluns and a quadruple SMD diode. For the VHF band the receiver includes a circuit for suppressing ignition noise. This circuit momentarily removes the LO signal from the mixer when an ignition noise pulse is detected. The ignition-noise suppressor is selectable on a per-channel basis when the radio is programmed.

First IF Stage and Second Mixer

The first IF stage consists of a crystal channel filter (BPF1), followed by an IF amplifier, and then another crystal filter (BPF2). The second mixer is an IC quadrature mixer with an internal AGC amplifier. This IC has a divide-by-two function on the LO input in order to provide the quadrature LO frequencies required internally. The second LO frequency is synthesized by an integer PLL (IC403), which uses the TCXO frequency SYN RX OSC (13.0000 MHz) as its reference.

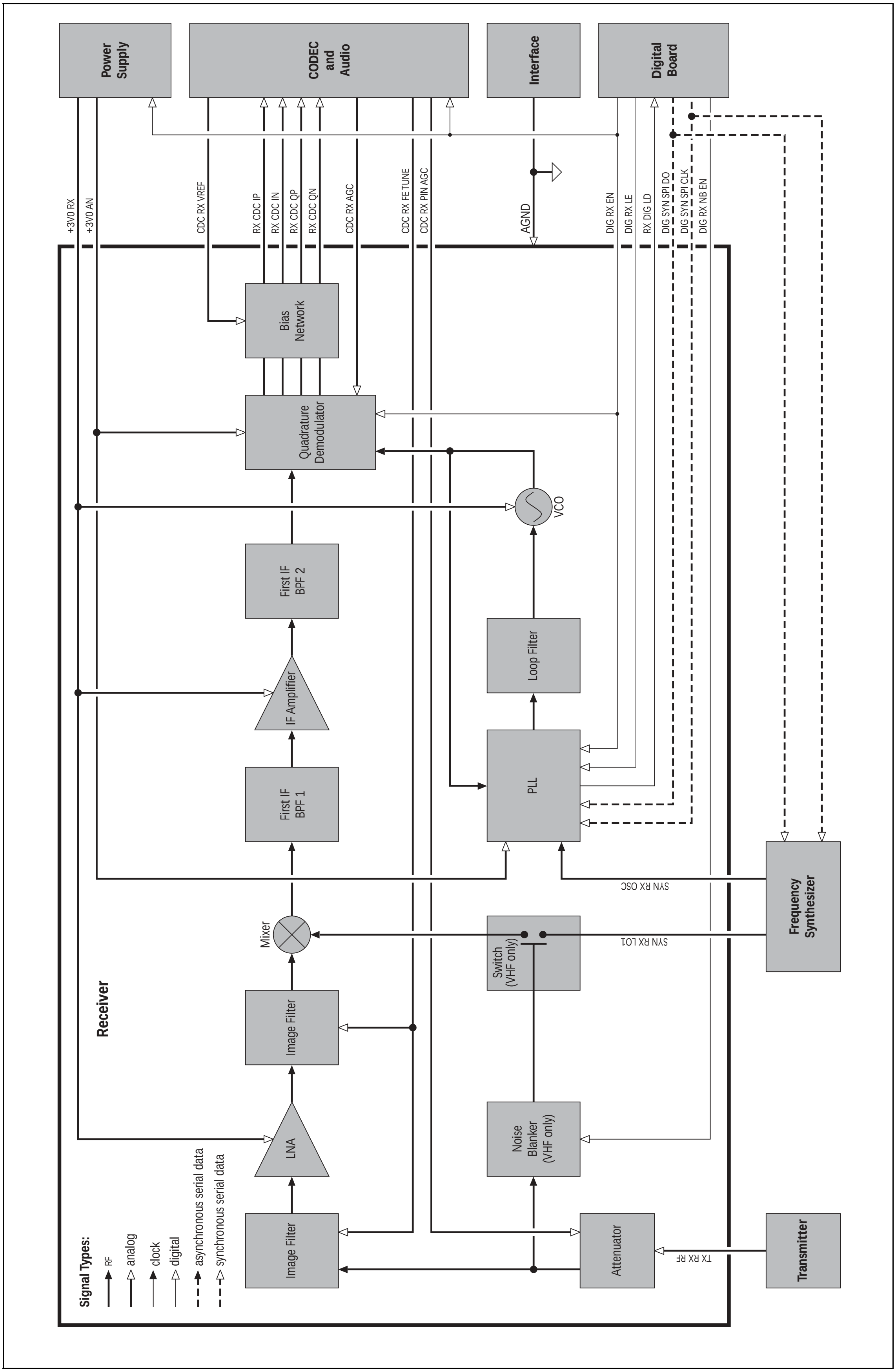
Frequencies of IF Stages

The frequency of the first IF stage depends as follows on the frequency band of the radio:

- B1 band: 21.400029 MHz
- H5, H6, and H7 bands: 45.100134 MHz

The above are nominal values; the actual frequency will differ by a small amount depending on the exact initial frequency of the TCXO.
The frequency of the second IF stage will always be precisely 64.000 kHz once the TCXO calibration has been completed. (The TCXO calibration does not adjust the TCXO frequency, but instead adjusts the VCXO frequency, which in turn adjusts the VCO or first LO frequency as well as the frequency of the first IF stage. The second LO frequency remains fixed.)
The third IF stage is completely within the FPGA and is not accessible.

Figure 3.3 Block diagram of the receiver circuitry



Demodulation

Demodulation takes place within the FPGA. Demodulated audio is passed to the DSP of the digital board for processing of the receiver audio signal. Raw demodulated audio can be tapped out from the DSP for use with an external modem. The modem may be connected to the auxiliary connector or to the external options connector when an internal options board is fitted.

Automatic Gain Control

The receiver has an AGC circuit to enable it to cover a large signal range. Most of the circuit functions are implemented in the FPGA. The FPGA passes the AGC signal to the CODEC IC204 for output from pin 14 (IDACOUT) and thence via IC201 as the signal CDC RX AGC to pin 23 of the quadrature mixer IC400. As the antenna signal increases, the AGC voltage decreases.

Channel Filtering

The channel filtering is split between the first and third IF stages.
The channel filtering circuit in the first IF stage comprises a pair of two-pole crystal filters. The first filter has a 3dB bandwidth of 12kHz, and the second a 3dB bandwidth of 15kHz. Most of the channel filtering, however, is implemented in the FPGA. When the radio is programmed, the different filters are selected as assigned by the channel programming. The selectable filters plus the fixed crystal filters result in the following total IF 3dB bandwidths:

- wide channel spacing : 12.6kHz
- medium channel spacing: 12.0kHz
- narrow channel spacing : 7.8kHz

(The FPGA runs from the DIG SYS CLK signal, which has a frequency of 12.288MHz.) The receiver requires the TCXO calibration to be completed to ensure that the channel filtering is centered, thereby minimizing distortion.

Received Signal Strength Indication

The RSSI is calculated in the FPGA and DSP, and can be passed as an analog voltage to the internal options interface and the external auxiliary interface. To obtain an accurate estimate of the RSSI (over the signal level and frequency), it is necessary to calibrate the AGC characteristic of the receiver and the front-end gain versus the receive frequency.

Front-End AGC Control

The receiver has an FE AGC circuit to enable it to handle large receiver signals with minimal receiver distortion. This is very important for the correct operation of the C4FM modem (P25 modulation). FE AGC is controlled by an algorithm which monitors the RSSI and configures the DAC to turn on the FE attenuation via the receive pin diode of the PIN switch.

3.3 Frequency Synthesizer Circuitry

Introduction

For a block diagram of the frequency synthesizer circuitry, refer to Figure 3.4.

The frequency synthesizer includes an active loop filter, one or two VCOs and buffer amplifiers, and a PLL IC. The last-named uses conventional integer-N frequency division and includes a built-in charge pump. Speed-up techniques ensure a transmit-receive settling time of less than 4.5ms while retaining low noise characteristics in static operation.

Power Supplies

Several power supplies are used by the frequency synthesizer owing to a combination of performance requirements and the availability of suitable components. The PLL IC includes analog and digital circuitry and uses separate power supplies for each section. The digital section is run on 3V, while the analog section is run on approximately 5V. The VCOs and buffer amplifiers run off a supply of about 5.3V. The active loop filter requires a supply of 14 to 15V, and a reference voltage of approximately 2.5V.

Performance Requirements

Low noise and good regulation of the power supply are essential to the performance of the synthesizer. A 6V regulator IC provides good line regulation of the 9V supply and good load regulation. Good regulation of the power-supply line and load is essential for meeting the transient ACP requirements. The regulator output voltage is electrically noisy, however, and filtering is essential. Filtering of the power supply is achieved with two capacitance multipliers (Q508 and C585 for the VCO supply, and Q512 and C579 for the PLL and loop-filter supply). The VCO (or VCOs) use a separate capacitance multiplier because these multipliers have poor load regulation and the VCOs impart sufficient load transients to warrant a separate supply.

Effect of Tuning Range

For reasons of noise performance, the VCOs are designed to be tuned within a range of 2 to 12V. Active tuning circuitry is required. An active loop filter incorporating an IC operational amplifier achieves this range with a suitable power supply voltage. Normal synthesizer switching behavior involves overshoot, which dictates that the tuning voltage range must extend above and below the range of 2 to 12V. The 14V limit is a result of limits on the working supply voltage of the IC operational amplifier.

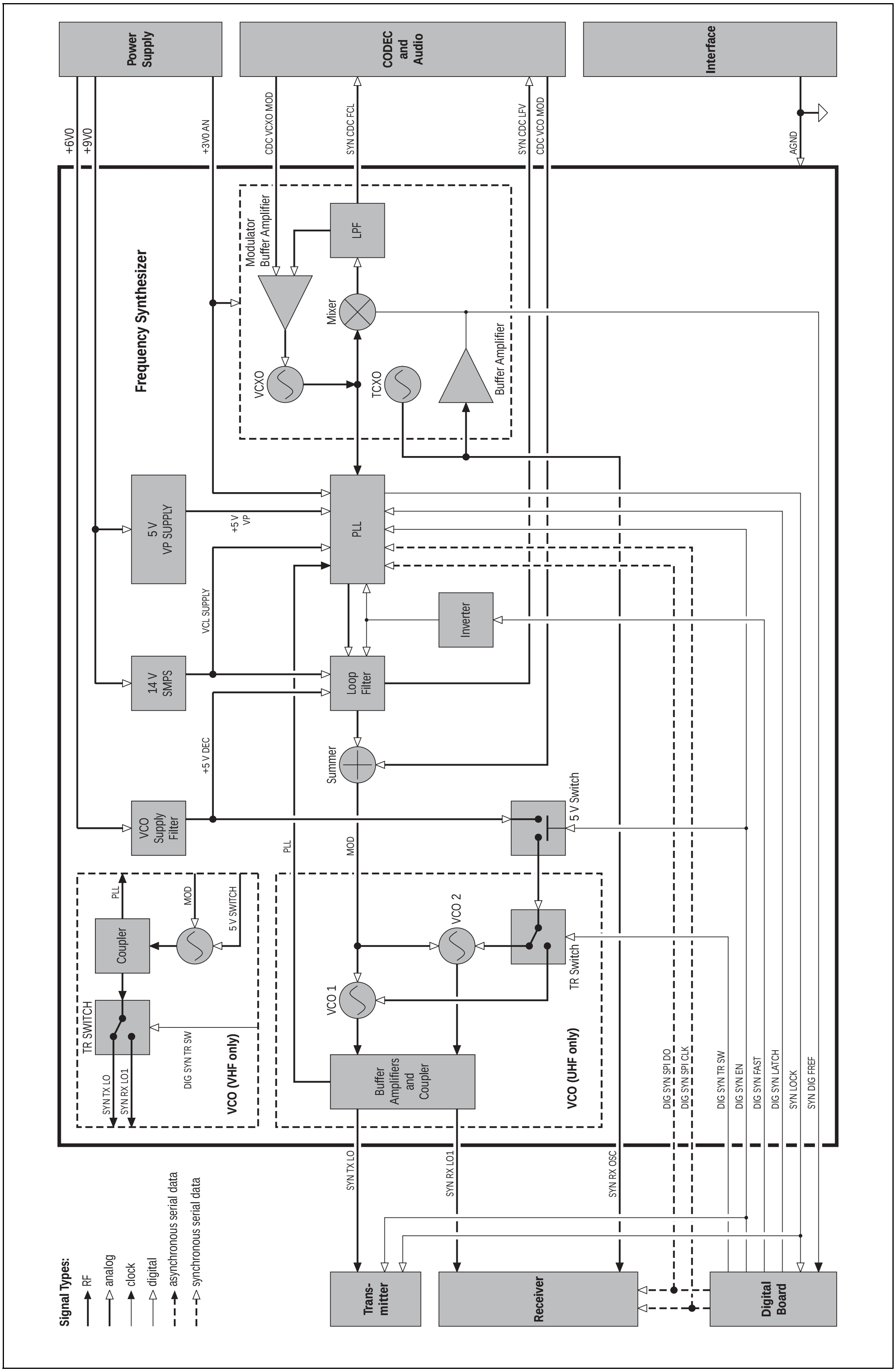
Switch-mode Power Supply

The power supply VCL SUPPLY for the active loop filter is provided by a SMPS, which is in turn powered by 9V. The SMPS consists of an oscillator (switching circuit) and a detector. The output voltage is monitored by a feedback circuit that controls the DC bias of the switching circuit to maintain a constant output voltage.

Synthesizer Circuitry

The essential function of the PLL frequency synthesizer is to multiply a 25kHz reference frequency to give any desired frequency that is an integer multiple of 25kHz. There are some constraints imposed by the capabilities of the synthesizer hardware, especially the tuning range of the VCOs.

Figure 3.4 Block diagram of the frequency synthesizer circuitry



Reference Frequency

The 25kHz (approximate) reference is obtained by dividing the 13MHz (approximate) output of the FCL. Any error in the FCL output frequency will be multiplied by the synthesizer. Therefore, if the synthesizer is locked but not the FCL, then the synthesizer output frequency will be wrong. The FCL frequency division is performed by a digital counter inside the PLL IC. The divider setting is constant.

VCO Frequency and Output Power

The output frequency from the synthesizer is generated by a VCO. The VCO frequency is tuned across the frequency range of the radio by means of a DC control voltage, typically between 2V and 12V. The VCO output power is amplified by a buffer amplifier. The power is low and varies from band to band. The buffer output power depends on which mode—receive or transmit—is used. In receive mode the output power should be about 7dBm, whereas in transmit mode it should be about 9dBm.

Dual VCOs

Some variants of the synthesizer use two VCOs: one for receive and one for transmit. Synthesizers with two VCOs share the same tuning signal. Only one VCO is switched on at a time, and so the PLL IC will see only one output frequency to tune. A portion of the RF output from the VCOs is fed to the RF input of the PLL IC. The RF signal is divided by an integer that would give 25kHz if the output frequency were correct.

Phase-locked Loop

The PLL IC compares the 25kHz reference and the divided VCO signal, and the error is used to control the internal charge pump. The charge pump is a current source that can sink or source current in proportion to the frequency or phase error. The output is a series of 25kHz pulses with a width that is dependent on the phase error. When the output frequency of the synthesizer is correct, there is no error and the charge pump output will become open circuit.

Active Loop Filter

The loop filter continuously integrates the current pulses from the charge pump and produces a steady DC output voltage that tunes the VCO (or VCOs). When the VCO frequency is correct, there is no frequency error and therefore no charge-pump output, and so the loop filter's output voltage remains constant. If the frequency is too high or too low, the error will result in the output of charge-pump current pulses (negative or positive depending on the sign of the error). The loop filter's output voltage will change accordingly, causing the VCO frequency to change in proportion. The synthesizer design is such that normally the VCO frequency will be automatically corrected.

Re-tuning of VCO Frequency

When the radio changes channels or switches between receive and transmit, the VCO frequency must be changed. The rate at which the VCO is re-tuned is dependent on many factors, of which the loop filter is the main factor. The loop filter is an integrator built around an operational amplifier. The resistors and capacitors of the filter affect both the switching time and the stability of the synthesizer; the values of these components have been carefully selected to give optimum control characteristics.

Speed-up Techniques

To reduce the change-over time between transmit and receive, part-time speed-up techniques have been implemented. Speed-up involves changing some resistor values while simultaneously changing the PLL IC settings. This process is implemented in hardware under software control in conjunction with use of the synthesized reference input. The result is a transmit-receive settling time of less than 4.5ms. (The switching time is measured for a frequency change equal to the first IF plus 10MHz or 1MHz, depending on the repeater offsets used for the band. This implies a synthesizer transmit-receive change-over plus an offset of 1MHz or 10MHz in less than 4.5ms. The ramp-up and ramp-down of the transmitter, which totals 1ms, extends this change-over time to 5.5ms.)

3.4 Frequency Control Loop

Introduction

The FCL is included in the block diagram of the frequency synthesizer (see Figure 3.4).

The FCL forms part of the frequency-synthesizer module. The basis of the FCL is a VCXO, which generates the reference frequency required by the main PLL of the synthesizer.

Elements of FCL Circuitry

The FCL is a simple frequency-locked loop. The circuitry consists of the following elements:

- VCXO (XL501, Q501, Q503)
- TCXO (XL500)
- buffer amplifier (IC500)
- mixer (IC501)
- low-pass filter (IC502, pins 5 to 7)
- modulator buffer amplifier (IC502, pins 1 to 3)

The TCXO supplies a reference frequency of 13.0000MHz, which is extremely stable, regardless of the temperature. The VCXO runs at a nominal frequency of 13.0000MHz, and is frequency-locked to the TCXO reference frequency.

Circuit Operation

The VCXO output is mixed with the TCXO output to create a nominal difference (or offset) frequency SYN CDC FCL of 12.0kHz. The signal SYN CDC FCL is fed via the CODEC IC502 in the CODEC circuitry to the FPGA on the digital board. The FPGA detects the offset frequency, compares it with the programmed offset frequency, and outputs a corresponding feedback signal CDC VCXO MOD via IC205. The feedback signal is amplified and inverted by the modulator buffer amplifier and output as the loop voltage for the VCXO. With this design the VCXO frequency can be adjusted by very small precise amounts, and because the loop is locked, the VCXO inherits the temperature stability of the TCXO.

Modulation

The FCL modulation is implemented within the FPGA and appears at the output of IC205, and therefore on the VCXO loop voltage. Consequently, the VCXO is frequency modulated directly by the relevant modulation information. The latter may be the microphone audio, an audio tap-in signal, internal modem signals, or any combination of these.

3.5 CODEC and Audio Circuitry

Introduction

For a block diagram of the CODEC and audio circuitry, refer to Figure 3.5.

A/D and D/A Conversion

The analog-to-digital conversion and digital-to-analog conversion is performed by the devices IC203, IC204 and IC205.

Device IC203

IC203 is an eight-channel DAC that provides control of transmitter biasing, front-end tuning, and the output of analog RSSI signals. The digital input data are fed to IC203 in synchronous serial form. Three of the DAC channels are not used.

Device IC205

IC205 contains two CODECs. One is used by the FCL. The second is used for auxiliary audio (input) and VCO modulation (output). The digital section communicates with this device via a four-wire synchronous serial interface.

Device IC204

IC204 contains base-band, voice-band and auxiliary CODECs and some analog signal conditioning. The reference voltage (nominally 1.2V) for these CODECs is provided internally by IC204 but is decoupled externally by C228.

Base-band CODEC

The base-band CODEC handles the I and Q outputs (IRXP, IRXN, QRXP and QRXN balls) of the receiver's second IF stage. The analog signals are differential and biased at 1.2V nominally. The digital section communicates with this CODEC via a two-wire synchronous serial interface (BSDO and BSOFS balls). The digital-to-analog conversion section of the base-band CODEC is not used.

Voice-band CODEC

The voice-band CODEC handles the microphone and speaker signals. The digital section communicates with this CODEC via a three-wire synchronous serial interface (VSFS, VSDO and VSDI balls). IC204 also contains voice-band filtering, pre-amplification and volume control.

Auxiliary CODEC

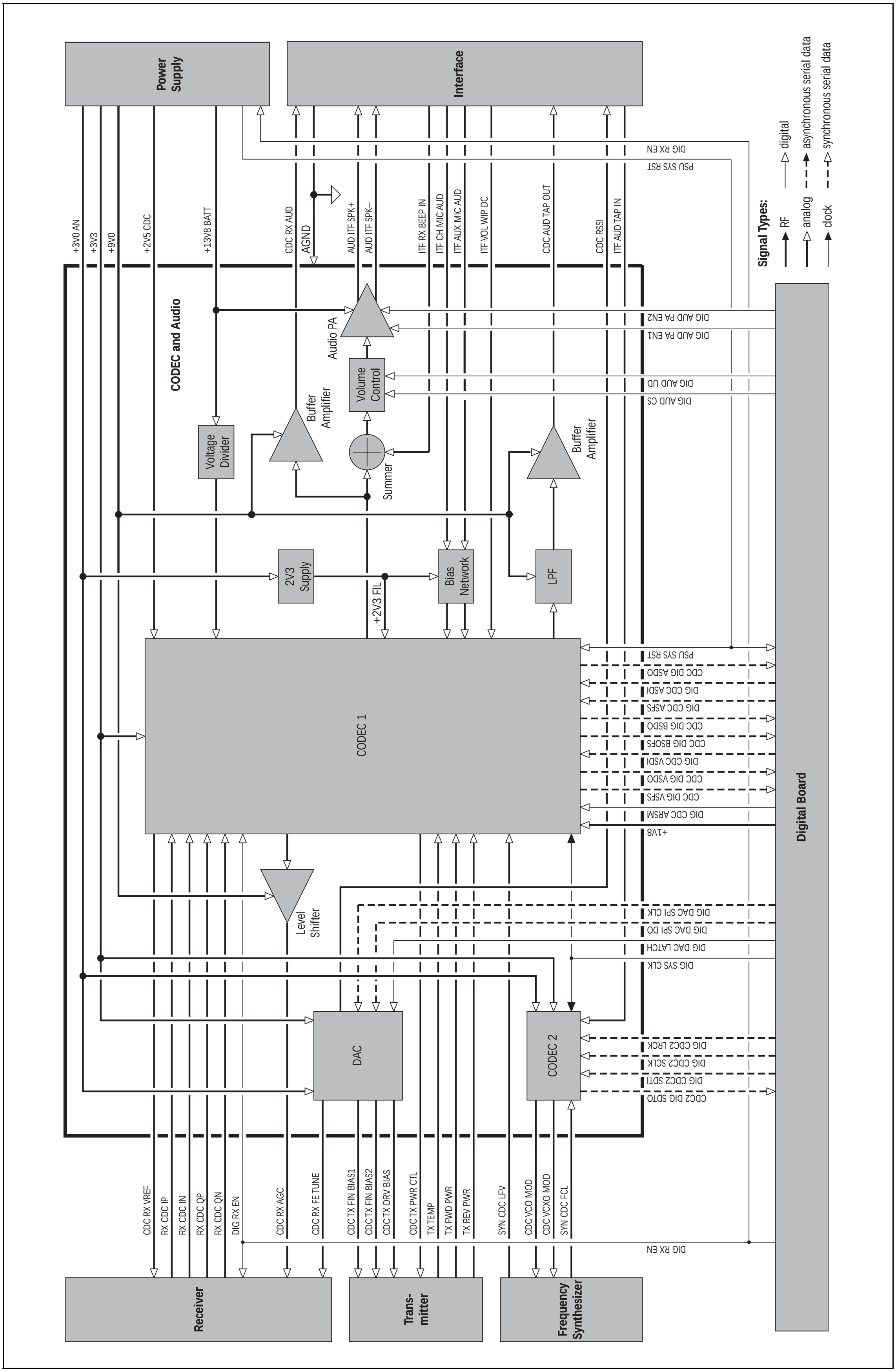
The auxiliary CODEC handles transmitter power control, receiver gain control, auxiliary audio output and general analog monitoring functions. The digital section communicates with this CODEC via a three-wire synchronous serial interface (ASFS, ASDI and ASDO balls). The DAC used for receiver gain control (IDACOUT ball) is a current output type. Current-to-voltage conversion is performed by R238. The full-scale output of 1.2V is amplified by IC201 to approximately 3V as required by the receiver.

Audio Circuitry

The audio circuitry performs four functions:

- output of audio signal for speaker
- input of microphone audio signal
- input of auxiliary audio signal
- output of auxiliary audio signal

Figure 3.5 Block diagram of the CODEC and audio circuitry



The sections of the circuitry concerned with these functions are described below.

Audio Signal for Speaker

The audio signal for the speaker is generated by IC204 (VOUTAUXP ball). This signal is post-volume-control and has a pre-emphasized frequency response. The signal is then processed by R218, R217 and C231 (50W/40W radios) or C205 (25W radios) to restore a flat frequency response and reduce the signal level to that required by the audio power amplifier.

Summing Circuit

The top of C231 (50W/40W radios) or C205 (25W radios) is where side tones are summed in and the CDC RX AUD signal is obtained. C201 and R211 pre-emphasize and attenuate the side-tone signal to give a flat side-tone frequency response and reduce the input to an appropriate level.

Buffer Amplifier

IC201 (pins 8 to 10) amplifies the signal at the top of C231 (50W/40W radios) or C205 (25W radios) by 19dB and drives the CDC RX AUD system interface line via C212 and R225. The capacitor C212 provides AC output coupling and R225 ensures stability. The DC bias for this amplifier is derived from IC204.

Audio Power Amplifier

The signal at the top of C231 (50W/40W radios) or C205 (25W radios) is fed via C204 to the audio power amplifier IC202. IC202 has 46dB of gain and a differential output configuration. C209, C211, R252 and R253 ensure stability of the amplifier at high frequencies. When operational, the output bias voltage for IC202 is approximately half the radio supply voltage. When not operational, the output becomes high impedance.

Control of Audio Power Amplifier

Power up, power down, and muting of IC202 is controlled by two signals from the digital section, DIG AUD PA EN1 and DIG AUD PA EN2. The network consisting of Q200, Q201, R200 to R206, R210 and R250 converts the two digital signals to the single three-level analog signal required by IC202.

Microphone Signals

There are two microphone source signals:

- ITF AUX MIC AUD from auxiliary or internal options connector
- ITF CH MIC AUD from control head

The biasing for electret microphones is provided by a filtered 3.0V supply via R226 and R227. The components R209 and C202 provide the supply filtering. The microphone inputs to IC204 (VINAUXP, VINAUXN, VINNORP, and VINNORN balls) are differential. The negative inputs are decoupled to the filtered 3.0V supply by C215 and C216. The positive inputs are biased to approximately 1.5 V by R229, R232, R230 and R233. AC coupling and DC input protection is provided by C213 and C214.

Auxiliary Audio Input

The auxiliary audio input signal ITF AUD TAP IN is DC-coupled to the ADC input of IC205. R241 combined with internal clamping diodes in IC205 provide DC protection for the ADC input. IC205 provides the input biasing of approximately 1.5V.

Auxiliary Audio Output

The source for the auxiliary audio output signal CDC AUD TAP OUT is provided by IC204 (RAMPDAC ball). The DAC output of IC204 is low-pass filtered to remove high-frequency artefacts. The low-pass filter, formed by IC201 (pins 1 to 3), R219, R220, R221, R224, C206, C208 and C210, is a third-order Butterworth type with a cut frequency of approximately 12kHz.

The output of the low-pass filter is amplified by 6dB by a buffer amplifier, IC201 (pins 5 to 7), and fed via R207 and R208 to drive the CDC AUD TAP OUT interface line. The DC bias for this signal path is provided by IC204 and is approximately 1.2V when operational. The offset at CDC AUD TAP OUT is approximately 2.4V owing to the gain of the buffer amplifier.

3.6 Power Supply Circuitry

Introduction

For a block diagram of the power supply circuitry, refer to Figure 3.6.

The power-supply circuitry consists of the following main sections:

- supply protection
- supervisory circuit
- internal power supplies
- control of internal power supplies
- control of external power supply

Supply Protection

50W 40W | 25W

Electrical protection to the radio is provided by the clamping diode D600 and by 20A fuses (for the 50W/40W radios) and 10A fuses (for the 25W radios) in the positive and negative leads of the power cable. This provides protection from reverse voltages, positive transients greater than 30V, and all negative transients. An ADC monitors the supply and is responsible for the protection of internal devices, which have an operating voltage of less than 30V. The ADC also ensures protection if the radio operates outside its specified voltage range of 10.8V to 16V.

Supervisory Circuit

The supervisory circuit comprises a reset and watchdog timer. The circuit provides the reset signal PSU SYS RST to the digital section, which in turn provides the watchdog signal DIG WD KICK required by the supervisory circuit.

Internal Power Supplies

There are nine internal power supplies:

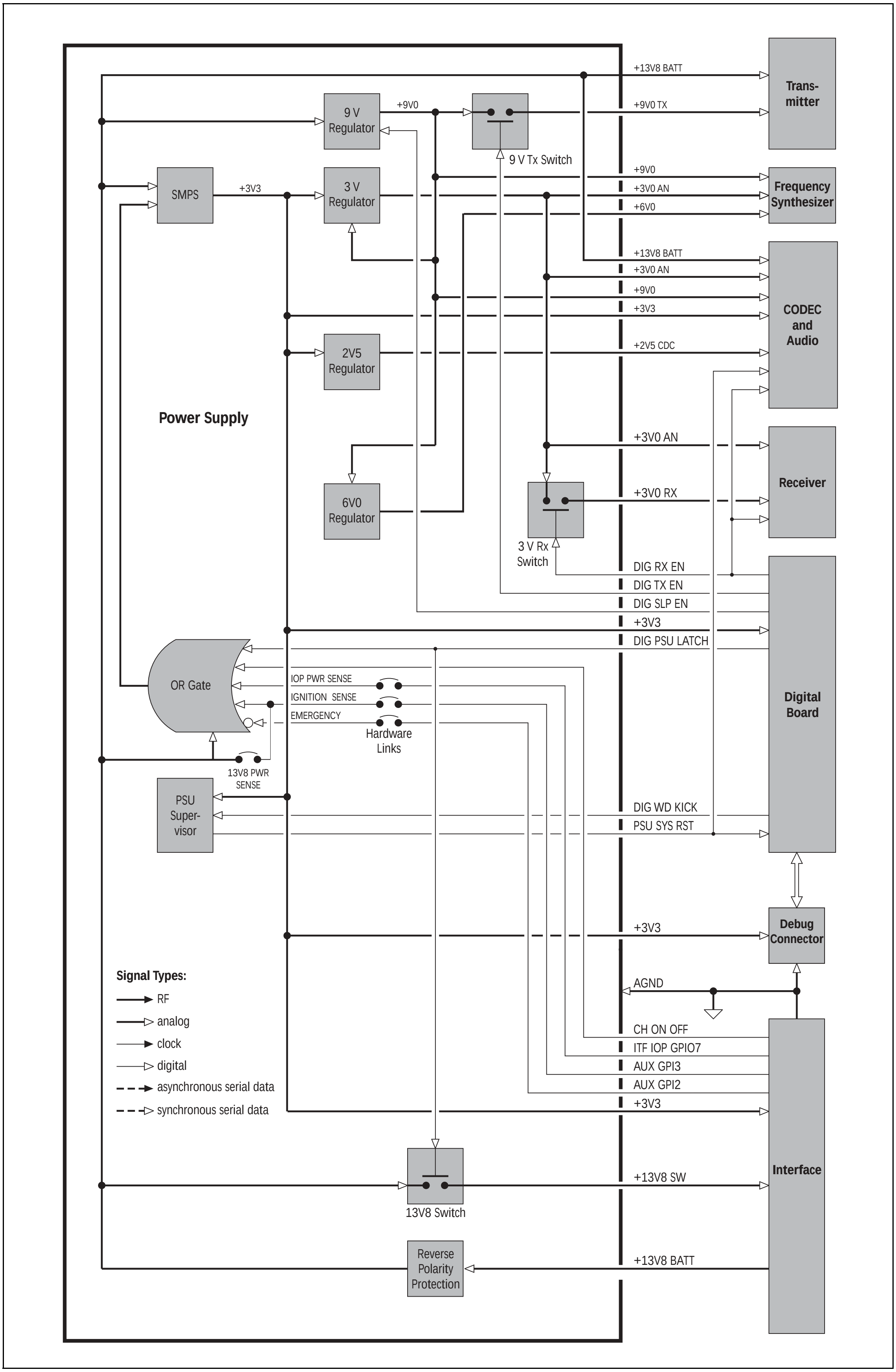
- one SMPS
- five linear regulators (+9V0, +6V0, +3V3, +3V0 AN, +2V5 CDC)
- three switched supplies (+9V0 TX, +3V0 RX, +13V8 SW)

The SMPS is used to regulate to 3.3V from the external supply +13V8 BATT. The four lower voltages required are then further stepped down with linear regulators. These all take advantage of the efficiency gain of the SMPS. The 9V regulator and the 13.8V switched supply are connected to +13V8 BATT. The two remaining switched supplies (9V and 3V) use P-channel MOSFETs.

Control of Internal Power Supplies

The radio can be switched on using the ON/OFF key on the control head or by means of external signals. For the latter case hardware links are required and there are several power-sense options; these are discussed below. Some internal power supplies can be controlled by means of digital lines depending on the mode in which the radio is operating.

Figure 3.6 Block diagram of the power supply circuitry



Power-Sense Options

The radio allows the configuration of different power-sense options to control how the radio is powered up and down:

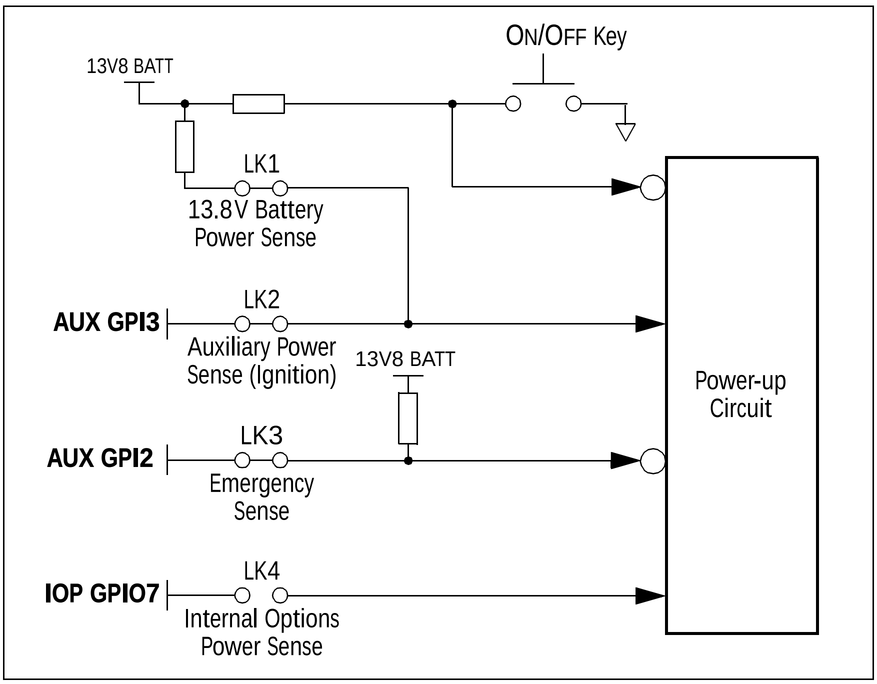
- battery power sense
- auxiliary power sense (ignition sense)
- internal-options power sense
- no power sense
- emergency power sense

The emergency power-sense option can be used in conjunction with any of the other four options.

The different power-sense options have to be facilitated by hardware means, as the software cannot act before it is powered up. The radio provides four hardware links (LK1 to LK4) on the top-side of the main board which can be configured to attain the power-sense option desired.

Figure 3.7 shows a block diagram of the hardware links LK1 to LK4.

Figure 3.7 Block diagram of hardware links LK1 to LK4



The radio can be programmed to be either on, or to return to its previous state when the power sense signal is removed. For information on programming the power-on mode refer to the online help of the programming software.

The ON/OFF key can be used with any of the of the power-sense options to turn the radio on and off.

Table 3.1 shows the configuration of the hardware links LK1, LK2 and LK4 for the individual power-sense options. It also lists the dependence of the power-sense options with respect to the GPI lines, which can or cannot be used.

Table 3.1 Configuration of hardware links and GPI lines for power-sense options

Power-sense option	Links required	Configuration of remaining links and use of AUX GPI3 and IOP GPIO7	Voltages required
13.8V battery power sense	LK1 in LK4 out	LK2 in: AUX GPI3 must be left floating. LK2 out: AUX GPI3 can be used as GPI[a]. IOP GPIO7 can be used as GPIO.	10.8V ≤ supply ≤ 16V
auxiliary power sense	LK2 in LK4 out	LK1 in: Input line must sink <1mA from AUX GPI3 (which is pulled to 13.8V by a 33kΩ resistor). LK1 out: Input line must be active high[b]. IOP GPIO7 can be used as GPIO.	AUX GPI3 ≤ 0.7V off AUX GPI3 ≥ 2.6V high (active) ignition-sense tolerant to 3.3V, 5V and 12V
internal power sense	LK1 out LK2 out LK4 in	 AUX GPI3 can be used as GPI. With LK4 in, the input line must be active high[c].	IOP GPIO7 ≤ 0.7V off IOP GPIO7 ≥ 2.6V high (active) ignition-sense tolerant to 3.3V and 5V only
no power sense	LK1 out LK2 out LK4 out	 AUX GPI3 can be used as GPI. IOP GPIO7 can be used as GPIO.	10.8V ≤ supply ≤ 16V

a. If LK2 is out and AUX GPIO is not used, R775 (33k) should be placed to ensure that AUX GPI3 does not float (R775 is not placed by factory default).

b. If LK1 is out and R775 is placed, AUX GPI3 should be driven low as well.

c. If LK 4 is in and R723 is placed, IOP GPIO7 should be driven low as well. (R723 is placed by factory default.)

Table 3.2 shows the configuration of 'emergency power sense'. 'Emergency power sense' can be configured with any of the above power sense options.

Table 3.2 Configuration of hardware link LK3 and AUX GPI2 for 'emergency power sense'

External push-button or toggle switch required to enter emergency mode	Links required	Implications on AUX GPI2	Voltages required
Yes	LK3 in	AUX GPI2 must be connected to an external (hidden) push-button or toggle switch, which connects it to ground.	≤0.7V active, floating inactive
No	LK3 in LK3 out	AUX GPI2 must be left floating AUX GPI2 can be used as GPI.	

Battery Power Sense

With this option, link LK1 connects +13V8 BATT of the power connector to the power-up circuitry. With this option, when a 13.8V supply is connected to the radio, the radio enters the programmed power-on mode. The ON/OFF key can then be used to switch the radio on and off. This option has the disadvantage that the radio still draws about 50mA after being switched off using the ON/OFF key. The reason is that the radio enters the stand-by mode and does not shut down completely.

Auxiliary Power Sense

This option uses the digital input line AUX GPI3 of the auxiliary connector to power the radio up and down. Link LK2 is required to connect the line to the power-up circuitry. The line is active high; it is on when the level exceeds 2.6V and off when the level falls below 0.7V; the line tolerates maximum inputs equal to the radio supply voltage. When the line becomes active, the radio enters the programmed power-on mode. The ON/OFF key can then be used to switch the radio on and off. With the radio off and the line active, the radio draws about 50mA. When the line becomes inactive, the radio is shut down completely regardless of whether it was on or in stand-by mode. With the line inactive the radio draws less than 1 mA. In a vehicle installation this avoids flattening the battery when the ignition key is off.

Internal-Options Power Sense

This option is similar to the auxiliary power-sense option, except that the IOP GPIO7 line of the internal options connector is used. Link LK4 is required to connect the line to the power-up circuitry. This line is active high; it is on when the level exceeds 2.6V and off when the level falls below 0.7V; the line tolerates maximum inputs of 5V. The behavior of the ON/OFF key is the same as with the auxiliary power-sense option.

No Power Sense

If no power-sense option is selected, the radio can only be powered up and powered down by means of the ON/OFF key. For this option, the links LK1, LK2 and LK4 must be removed. The advantage of this option over the battery power-sense option is that the radio draws less than 1mA when it is switched off.

Emergency Power Sense

This option uses the AUX GPI2 line of the auxiliary connector. Externally, this line is typically connected to a hidden switch. Internally, link LK3 is required to connect the line to the power-up circuitry. The line is active low and has an internal pull-up resistor to the external supply voltage. The line is on when the level falls below 0.7V. When the line becomes active (when the hidden switch is pressed for two seconds) the radio enters the emergency mode. This mode can also be activated by making an emergency call or by pressing a key that has been programmed appropriately. The concealed microphone is typically fitted when the emergency power-sense option is selected.

Operation in Emergency Mode

If the radio is off when the emergency mode is activated, the radio is powered up but the display on the control head is not switched on. If the radio is on when the mode is activated, the display is frozen. In the latter case, if the ON/OFF key is pressed, the display is switched off but the radio remains in the emergency mode. While in this mode the radio cycles between transmit and receive. To exit the emergency mode, the ON/OFF key needs to be pressed again.

Connector Power Supply Options

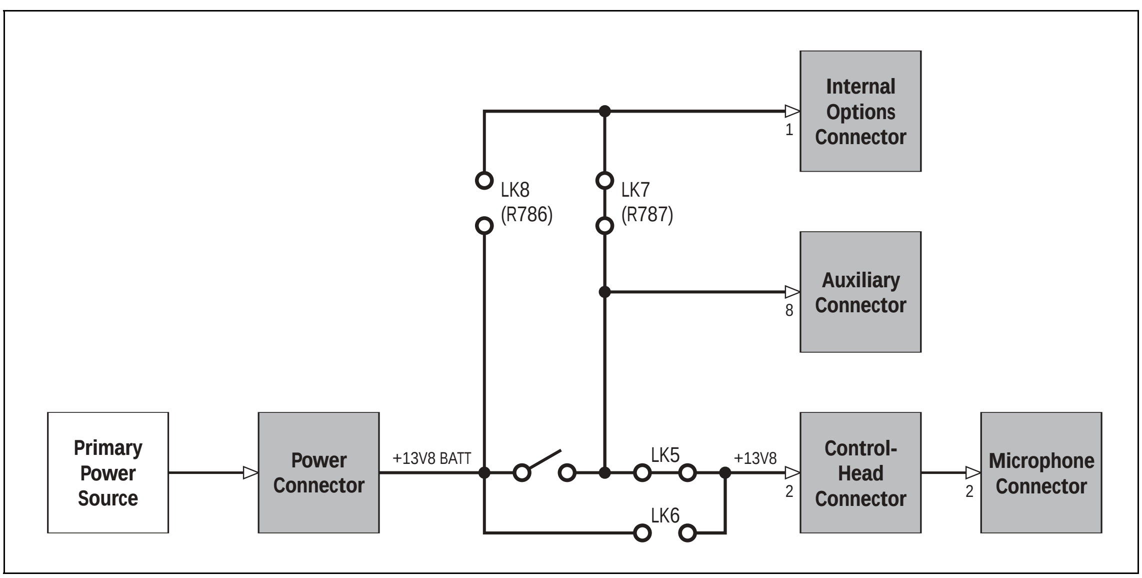
Power from the radio's primary power source is fed to the auxiliary, internal options, control head and microphone connectors. Whether power to these connectors is unswitched, switched or not supplied is determined by hardware links LK5 to LK8 on the top side of the main board, as shown in Figure 3.8 and Table 3.3.

Unswitched power means that power will always be supplied to the connector while the primary power source is connected to the radio and is alive. The supply to the connector is not affected by the state of the radio.

Switched power means that when the radio is off or in standby mode, the power to the connector is switched off. The power will also be switched off if the primary power source voltage is outside the radio's operating range. The switched current drawn by the control-head connector must not exceed 1 A.The switched current drawn by the internal options connector and the auxiliary connector together must not exceed 1 A.

Note The switched output is protected. Short-circuiting the switched power on any connector will not damage the radio. In the event of a short circuit, the current folds back to protect the switch device and connectors.

Figure 3.8 Connector power supply options



Note The links LK7 and LK8 have the alternative designations R787 and R786 respectively. The factory-default setting is with LK5 and LK7 inserted and LK6 and LK8 omitted

Table 3.3 Connector power supply options

Link state				Connector power state			
LK5	LK6	LK7 (R787)	LK8 (R786)	Auxiliary	Internal options	Control head	Microphone
out	out	out	out	switched	no power	no power	no power
in	out	in	out	switched	switched	switched	switched
out	in	in	out	switched	switched	unswitched	unswitched
in	out	out	in	switched	unswitched	switched	switched
out	in	out	in	switched	unswitched	unswitched	unswitched
in	in/out	in	in	unswitched	unswitched	unswitched	unswitched

3.7 Interface Circuitry

Introduction

For a block diagram of the interfaces circuitry, refer to Figure 3.9.

For more on the connector pinouts, refer to "Connectors" on page 34.

Bi-directional Lines

Bi-directional lines are provided on four pins of the auxiliary connector, (AUX GPIO4 to AUX GPIO7) one on the control-head connector (CH GPIO1), and seven on the internal options connector (IOP GPIO1 to IOP GPIO7). Those on the auxiliary and control-head connectors are formed by combining two uni-directional lines. For example, the line AUX GPIO4 at pin 10 of the auxiliary connector is formed from ITF AUX GPI4 and DIG AUX GPO4.
The circuitry is the same in all five cases and is explained below for the case of AUX GPIO4.

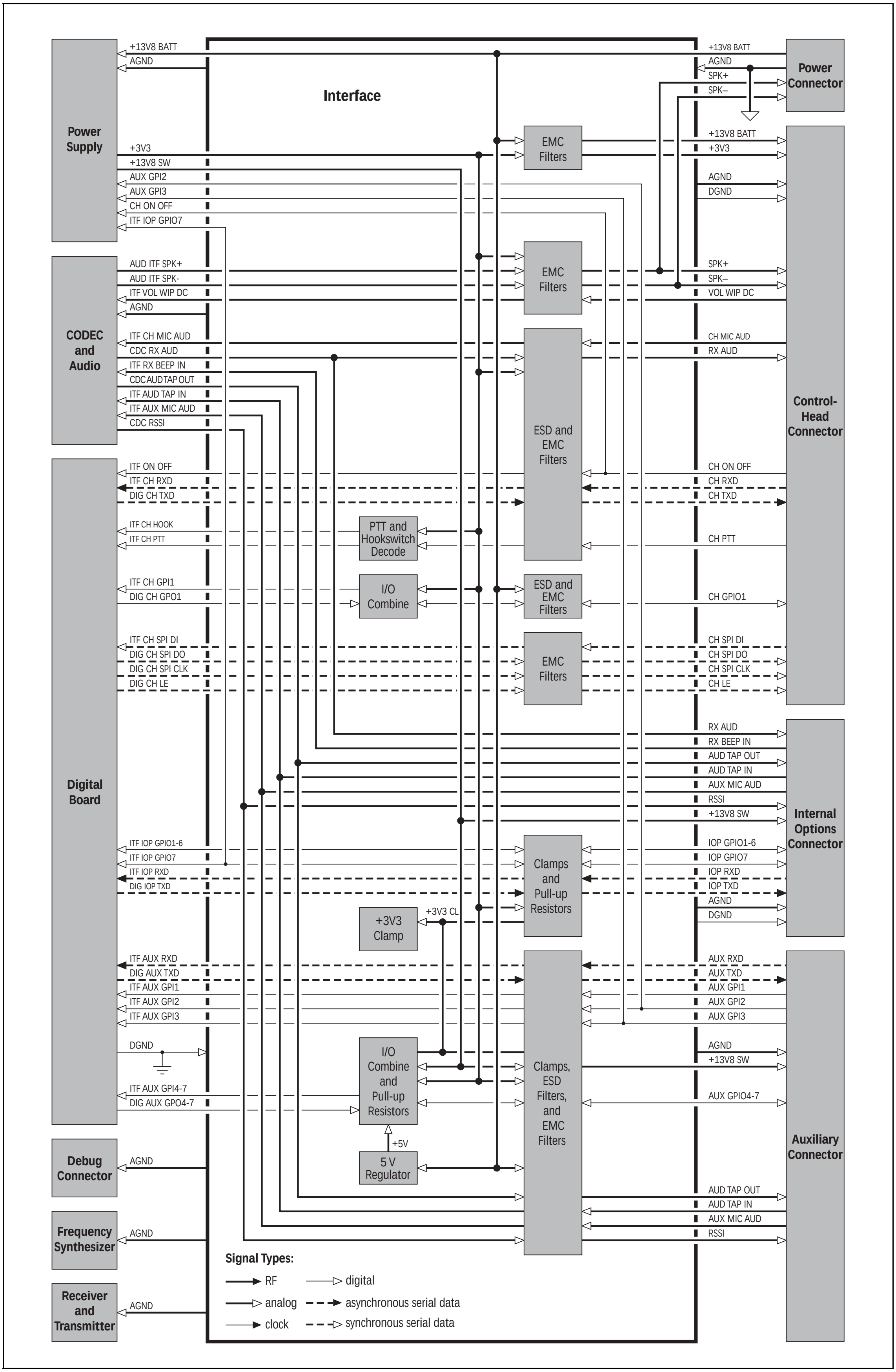
Output Signals (e.g. AUX GPIO4)

An output on the line AUX GPIO4 originates as the 3.3V signal DIG AUX GPO4 from the digital section. The signal is first inverted by Q703 (pins 3 to 5) and the output divided down to 1.6V by R746 and R753 to drive the base of Q703 (pins 1, 2 and 6). When the latter's collector current is low, the base current is a maximum and creates a small voltage drop across R761, causing the collector emitter to saturate. As the collector current increases, the base current decreases proportionally until the voltage across R761 reaches 1V. At this point the base-emitter begins to turn off and the base current diminishes rapidly. The net effect is a current-limiting action. The current limit value is approximately 18mA (the inverse of the value of R761).
The output configuration is open-collector with a pull-up to 3.3V by default. Pull-up options to 5V and 13.8V are also available. On AUX GPIO4 only, the optional MOSFET Q707, which has a high current drive, may be fitted.

5-Volt Regulator

The 5V supply mentioned above is provided by a simple buffered zener regulator formed by Q702, D721, R721 and R722. The resistor R722 limits the current to about 25mA under short-circuit conditions.

Figure 3.9 Block diagram of the interface circuitry



Input Signals (e.g. AUX GPIO4)

An input signal applied to AUX GPIO4 is coupled via R757 to ITF AUX GPI4 and fed to the digital section. As the input signal may exceed the maximum allowed by the digital section, it is clamped by D711 and a shunt regulator. The shunt regulator consists of Q708, R719 and R720 and begins to turn on at approximately 2.7V. In combination with D711, the input to ITF AUX GPI4 is therefore clamped to 3.3V nominally. The value of R757 is made large to minimize the loading effect on the output pull-up resistors.

Input Signals (AUX GPI1 to AUX GPI3)

Dedicated inputs are provided on three pins of the auxiliary connector (AUX GPI1 to AUX GPI3). AUX GPI1 is a general-purpose input with strong protection of the same type used for AUX GPIO4. AUX GPI2 is normally a dedicated emergency input but can be made a general-purpose input like AUX GPI1 by removing the link LK3 in the power supply area. AUX GPI3 is normally a dedicated ignition-sense input but can be made a general-purpose input like AUX GPI1 by removing the link LK2 in the power supply area and fitting the 33kΩ resistor R775.

ESD Protection

On exposed inputs of the auxiliary and control-head connectors ESD (electrostatic discharge) protection is provided by a 470pF capacitor and by clamping diodes to ground and to 13.8V. For example, on AUX GPIO4 this would consist of D713 and C725. The lines IOP GPIO1 to IOP GPIO7 are intended for connection to internal digital devices and so these have relatively light protection.

Hookswitch Detection

Hookswitch detection is performed by Q700, R709, R706 and R712. When the resistance to ground on the PTT line is less than 13.2kΩ, Q700 will turn on and drive the ITF CH HOOK line high; this indicates either that the microphone is on hook or that the PTT (press-to-talk) switch is pressed.

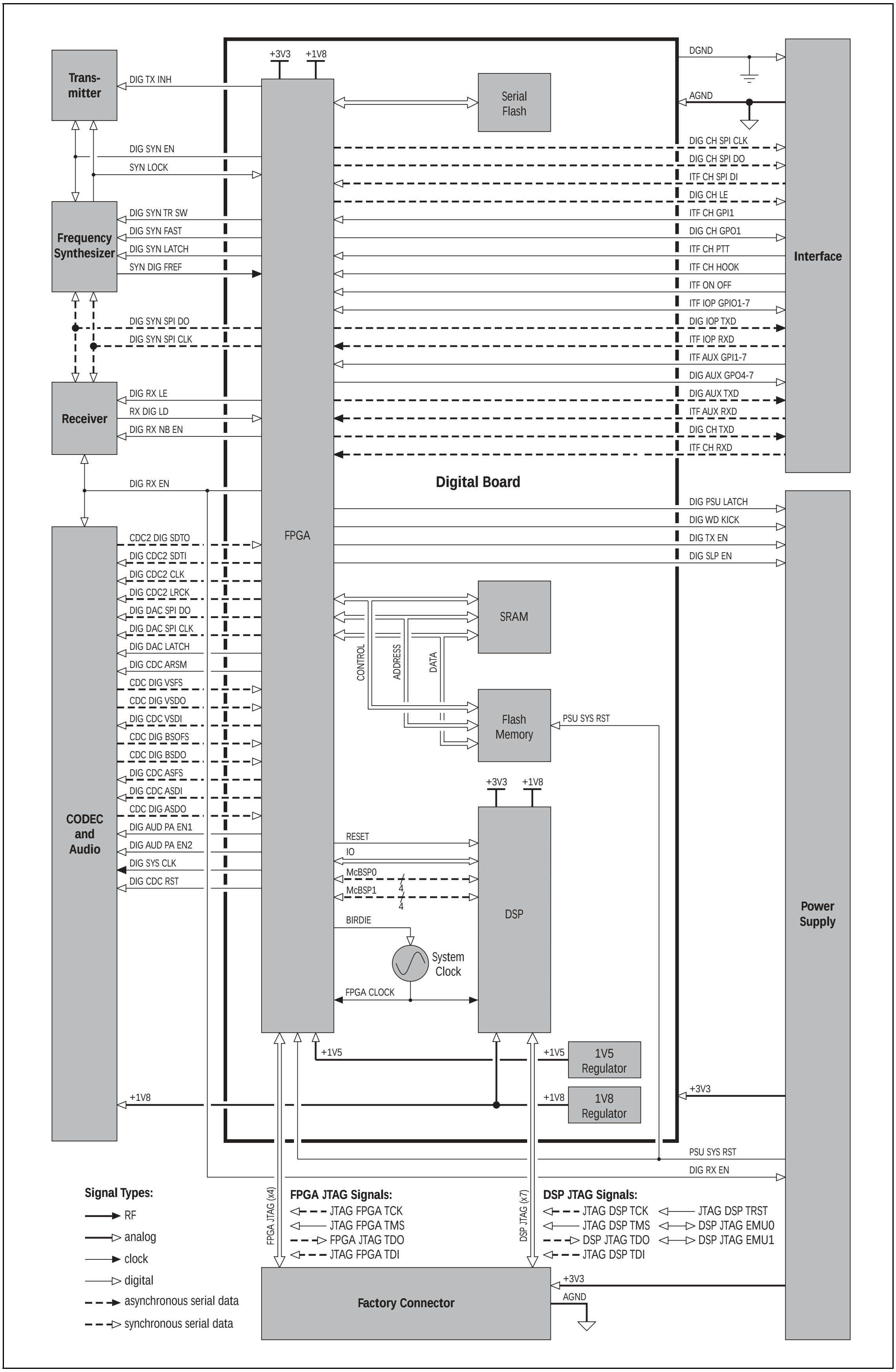
3.8 Digital Board

Introduction

For a block diagram of the digital board, refer to Figure 3.10.

The digital board is not serviceable at level-2 and is not described in this manual.

Figure 3.10 Block diagram of the digital board



3.9 Control-Head Board

Introduction

This section describes the control-head board for the control head with graphical display.

For a block diagram of the digital circuitry, refer to Figure 3.11.

Most signals (except power on/off, speaker and microphone) to and from the radio body are processed by a RISC processor, which is implemented on an FPGA on the control-head board. For more information on the RISC processor and the FPGA, refer to “Software Architecture” on page 44.

User Interface

The control-head board includes the circuitry for the following control elements:

- ON/OFF key
- volume potentiometer
- main keypad (with four functions keys, two scroll keys and two selection keys)
- LCD module (with backlighting and optional heating element)
- three status LEDs
- two function key LEDs (for function keys F1 and F4)
- keypad backlighting LEDs
- speaker

Connectors

The control-head board includes the circuitry for the following connectors:

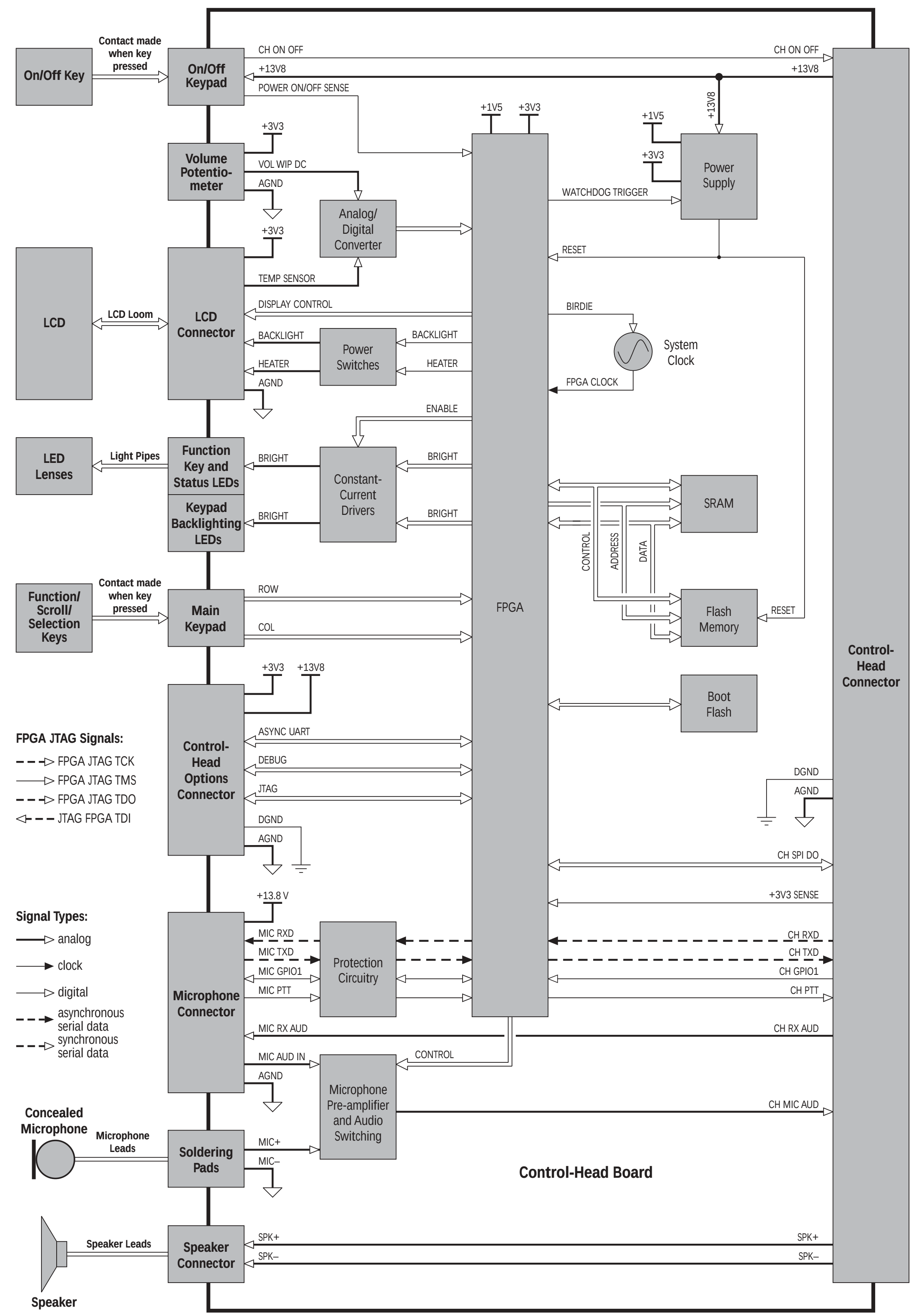
- microphone connector (RJ45 socket)
- control-head connector (18-way MicroMaTch socket)
- LCD connector (for internal connection of LCD module)
- speaker connector (2 leads)
- soldering pads (2 leads) for concealed microphone
- control-head options connector (for optional circuit board)

Protection circuitry is provided for the microphone connector. For pinouts of the control-head connector and the microphone connector, refer to “Connectors” on page 34. For more information on the control-head options connector, please contact Tait Electronics Limited.

ON/OFF Key

When battery power (13.8V) is applied to the radio, a press of the ON/OFF key will create an active low signal (CH ON OFF) back to the radio body to initiate the power-on or power-off sequence. This key-press will also be detected by the FPGA of the control head through Q611 as an active high signal. For more information on the start-up process, refer to “Software Architecture” on page 44.

Figure 3.11 Block diagram of the control-head board



Power Supply

A 3.3V regulator (U1) converts the switched 13.8V supply from the radio body to 3.3V. A 1.5V regulator (U203) converts the 3.3V to 1.5V.
A power-sense module (U202) verifies the outputs of the voltage regulators and—in the case of a fault—creates a power reset signal which is processed by the FPGA.

Volume Control

The voltage level of the volume control potentiometer is converted to a digital signal by an analog/digital converter (U601), processed by the FPGA and transmitted to the radio body.

Main Keypad

The eight keys of the main keypad (function, scroll and selection keys) are connected to the FPGA by an array of 3 columns and 3 rows. During idle operation, the KEY ROW signals are driven low by the FPGA and the KEY COL signals (pulled high by an external resistor) are monitored for activity by the FPGA. A key-press will generate a high-to-low transition on the associated column KEY COL signal. This, in turn, will initiate a sequence of high output levels on the KEY ROW signals to identify which key was pressed.

LCD Module

The LCD module is connected to the control-head board via the LCD connector. The LCD module display is controlled by a serial data link to the FPGA. The backlighting and the optional heating element incorporated in the LCD module are controlled by a data line each from the FPGA, which switch two transistors on MOSFET Q102. A temperature signal from the LCD module is converted to a digital signal by an analog/digital converter (U601) and processed by the FPGA.

Function Key LEDs and Status LEDs

The function key LEDs (F1 and F4) and the red, green and amber status LEDs each are controlled by an FPGA signal and a transistor (Q604 to Q608). The brightness level is controlled by two FPGA signals, resulting in four intensity levels (off, low, medium and high).

Keypad Backlighting

The keypad backlighting LEDs are controlled by two FPGA signals and two transistors (Q2), resulting in four intensity levels (off, low, medium and high). The keypad backlighting LEDs are arranged in two groups for the main keypad and one group for the power button keypad, each group consisting of three LEDs.

Speaker

The two speaker lines (SPK+ and SPK–) are connected to the speaker connector (J104) which is joined to the control-head connector (J103) through two ferrite beads (L105 and L106).

Microphone and Concealed Microphone

The audio signals from the microphone connector or the soldering pads of the concealed microphone are routed to a switching and pre-amplifier circuit. If a dynamic microphone is required, the pre-amplifier is engaged. The switching logic is used to select either the standard microphone input or the concealed microphone signal. The dynamic microphone must be activated in the programming software.

PTT

The PTT signal from the microphone connector is connected to the FPGA via a resistor (R25) and relayed to the radio as a digital command.

Chapter 2
Servicing the Radio

Chapter 2 – Servicing the Radio

4 General Information

Scope of Section

This section discusses the two repair levels covered by the service manual, details concerning website access, the tools, equipment and spares required, and the setting up of the necessary test equipment. General servicing precautions are also given, as well as details of certain non-standard SMT techniques required for level-2 repairs.

4.1 Repair Levels and Website Access

Repair Levels

This manual covers level-1 and level-2 repairs of TM9100 radios. Level-1 repairs comprise the **replacement** of control-head boards, main-board assemblies, and other parts of the radio; level-2 repairs comprise **repairs** of control-head boards and, except for special items, main-board assemblies. The special items are:

- digital board
- RF PAs (Q309 and Q310)
- CODEC 1 (IC204)
- copper plate

Replacements of the connectors and volume-control potentiometer on the control-head board are level-1 repairs. Replacements of the connectors on the main-board assembly, however, are level-2 repairs because these repairs entail the disassembly of the main-board assembly.

Important The circuit boards in the TM9100 radio are complex. They should be serviced only by accredited service centers (ASC). Repairs attempted without the necessary equipment and tools or by untrained personnel might result in permanent damage to the radio.

Accreditation of Service Centers

Service centers that wish to achieve ASC status should contact Technical Support. They will need to provide evidence that they meet the criteria required for accreditation; Technical Support will supply details of these criteria. These centers must then make available suitable staff for training by TEL personnel, allow their service facilities to be assessed, and provide adequate documentation of their processes. They will be accorded ASC status and endorsed for repairs of TM9100 radios after their staff have been trained and their facilities confirmed as suitable. Existing ASCs need to apply for and be granted an endorsement for repairs of TM9100 radios. All ASCs with the necessary endorsements may carry out level-1 and level-2 repairs of these radios, whether under warranty or not.

Skills and Resources for Level-1 Repairs

For level-1 repairs basic electronic repair skills are sufficient. Apart from the standard tools and equipment of any service center, certain torque drivers are required as well as a service kit and, for diagnostic purposes, a spare control head.

Skills and Resources for Level-2 Repairs

For level-2 repairs expertise is required in SMT repairs of circuit boards with a very high complexity and extreme component density. Apart from the tools and equipment needed for level-1 repairs, the standard SMT repair tools are required. A can-removal tool is strongly recommended but not mandatory.

Website Access

To carry out level-1 and level-2 repairs, service centers need access to the secured portion of the Technical Support website. There are different access levels; those required for level-1 and level-2 repairs are:

- level-1 repairs: associate access
- level-2 repairs: ASC and Tait-only access

Log-in passwords are needed for associate and Tait-only access; Technical Support supplies service centers with the necessary log-in information. (The unsecured portion of the Technical Support website is accessible to the general public. This type of access is called public access, and no log-in password is required.)

Items Available on Website

The information available at the different access levels is summarized in Table 4.1. The technical notes mentioned are of different types. Associate technical notes relate to the repair of the radio but not the downloading of firmware; Tait-only technical notes relate to the firmware. The PCB information packs are discussed in more detail below.

Table 4.1 Items relating to TM9100 radios that are available on the Technical Support website

Item	Public access	Associate access	ASC access	Tait-only access
User's guide	•	•	•	•
Installation guide	•	•	•	•
Public technical notes	•	•	•	•
Product safety and compliance information	•	•	•	•
Product release notes		•	•	•
Specifications		•	•	•
Calibration software		•	•	•
Programming software		•	•	•
Programming user manuals		•	•	•
Fitting instructions		•	•	•
Service manual		•	•	•
Associate technical notes		•	•	•
Software release information			•	•
Firmware			•	•
Tait-only technical notes				•
PCB information			•	•

PCB Information

PCB information for a particular circuit board consists of the relevant BOMs, grid reference indexes, PCB layouts, and circuit diagrams. (The grid reference indexes give the locations of components on the PCB layouts and circuit diagrams.) PCB information is compiled whenever there is a **major** change in the layout of the board. All PCB informations are published on the Technical Support website.

Tait FOCUS Database

An additional source of information to service centers is the Tait FOCUS call-logging database. (This is accessible on the Technical Support website also.) All Customer-related technical issues regarding the radios are recorded on this database. These issues may be raised by both Customers and service centers. Technical Support resolves the issues and informs the Customer or service center concerned of the outcome. All issues and their solutions are available for review by all service centers.

4.2 Tools, Equipment and Spares

Torque-drivers

For level-1 and level-2 repairs, excluding SMT repairs of the circuit boards, the following torque-drivers are required.

- For level-1 repairs Torx T6, Torx T10, and Torx T20 driver bits are necessary.
- For level-1 repairs, 3/16 inch and 14mm long-reach sockets are required.

Refer to the illustrations in "Reassembling the Radio Body" on page 131 for the corresponding torque values.

Tools for SMT Repairs

In general only the standard tools for SMT work are required for level-2 repairs of the circuit boards. In addition, a can-removal tool is recommended but if none is available, a hot-air tool may be used instead. However, it should be noted that a hot-air tool affords little control. Even in skilled hands, use of a hot-air tool to remove cans will result in rapid uncontrolled rises in the temperature of components under the can being removed as well as under any adjacent cans. The circuit board might suffer damage as a result.

Test Equipment

The following test equipment is required for servicing the radio:

- test PC (with programming and calibration applications loaded)
- RF communications test set (audio bandwidth of at least 10kHz)
- oscilloscope
- digital current meter (capable of measuring up to 20A)
- multimeter
- 50W 40W | 25W — DC power supply (capable of 13.8V and 20A for the 50W/40W radios, and 10A for the 25W radios)
- spare control head
- service kit

Separate instruments may be used in place of the RF communications test set. These are an RF signal generator, audio signal generator, audio analyzer, RF power meter, and modulation meter.

Service Kit

The service kit contains all the items needed for connecting the radio to the test equipment. The setting up of the equipment is described in "Test Equipment Setup" on page 105. The service kit also includes a service CD and a folder with the necessary service documentation, including this manual. The CD contains the programming application, calibration application, and soft-copies of the service and related documentation. The contents of the service kit are listed in Table 4.2. Note that the TMAA20-04 cable listed is required only if the test PC is to be connected directly to the radio for programming purposes.

Note The characters **xx** below stand for the issue number of the manual. Only the latest issue of each manual will normally be available for ordering.

Table 4.2 Contents of service kit (TMAA24-00)

Product code	Item
TMAA21-01	Cable (DB15 socket to RJ45 plug plus speaker connector)
TMAA23-02	Cable (50W/40W power connector to banana plugs plus speaker connector)
TMAA20-03	Cable (25W power connector to banana plugs plus speaker connector)
TMAA20-04	Cable (RJ12 socket to RJ45 plug)
TPA-SV-006	Programming cable (DB9 socket to RJ12 plug)
T950-001	Cable (USB1.1 to serial DB9 pin)
TOPA-SV-024	Test unit
MMA-00017-**xx**	Service manual
MMA-00026-**xx**	PCB information
TMAA24-01	Service CD
The following components are included in the service kit, but are used for the TP9100 portable radios only:	
TOPA-SV-006	RF cable
TPA-SV-005	Battery eliminator (power supply adaptor)
TPA-SV-007	Programming cable (RJ12 socket to TP9100)
TPA-SV-011	Calibration cable (DB15 socket to TP9100)

4.3 Servicing Precautions

Introduction

This section discusses the precautions that need to be taken when servicing the radios. These precautions fall into the following categories:

- mechanical issues
- compliance issues
- anti-static precautions
- transmitter issues

Service technicians should familiarize themselves with these precautions before attempting repairs of the radios.

Use of Torque-drivers

Apply the correct torque when using a torque-driver to tighten a screw or nut in the radio. Under-torquing can cause problems with microphonics and heat transfer. Over-torquing can damage the radio. The illustrations in “Disassembly and Reassembly” on page 123 show the correct torque values for the different screws and nuts.

Non-scratch Bench Tops

Use workbenches with non-scratch bench tops so that the mechanical parts of the radio are not damaged during disassembly and re-assembly. (The workbench must also satisfy the anti-static requirements specified below.) In addition, use a clear area of the bench when disassembling and re-assembling the radio.

Note The radio is designed to satisfy the applicable compliance regulations. Do not make modifications or changes to the radio not expressly approved by TEL. Failure to do so could invalidate compliance requirements and void the Customer’s authority to operate the radio.

Sealing of Radio

To maintain the sealing of the radio to IP54 standards, ensure that all bungs and seals are fitted after servicing the radio. These are for the auxiliary, RF, external options, and programming connectors:

- bung for auxiliary connector
- rubber seal for RF connector
- bung for aperture for options connector (connector not fitted)
- cover seal for options connector (connector fitted)

In addition, ensure that the grommet sealing the aperture to the microphone connector of the control head is properly fitted.

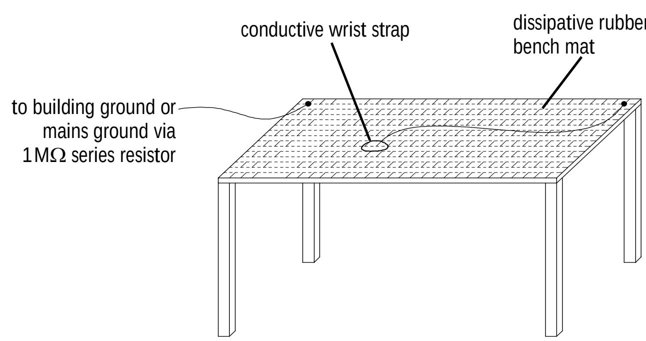
ESD Precautions

Important This equipment contains devices which are susceptible to damage from static discharges. You must handle these devices carefully and according to the procedures described in the manufacturers' data books.

Purchase an antistatic bench kit from a reputable manufacturer and install and test it according to the manufacturer's instructions. Figure 4.1 shows a typical antistatic bench set-up.

You can obtain further information on antistatic precautions and the dangers of electrostatic discharge (ESD) from standards such as ESD S4.1-1997 (revised) or EN 100015-4 1994. The Electrostatic Discharge Association website is http://www.esda.org/.

Figure 4.1 Typical antistatic bench set-up



Storage and Transport of Items

Always observe anti-static precautions when storing, shipping or carrying the circuit boards and their components. Use anti-static bags for circuit boards and anti-static bags or tubes for components that are to be stored or shipped. Use anti-static bags or trays for carrying circuit boards, and foil or anti-static bags, trays, or tubes for carrying components.

Anti-static Workbenches

Use an anti-static workbench installed and tested according to the manufacturer's instructions. A typical installation is shown in Figure 4.1. These benches have a dissipative rubber bench top, a conductive wrist strap, and a connection to the building earth. The material of the bench top must satisfy not only anti-static requirements but also the non-scratch requirements mentioned above.

Transmitter Issues

The following issues relate to the operation of the transmitter:

- RF and thermal burns
- antenna loading
- test transmissions
- accidental transmissions
- distress beacons

The precautions required in each case are given below.

Caution **Avoid thermal burns. Do not touch the cooling fins or underside of the radio body when the transmitter is or has been operating. Avoid RF burns. Do not touch the antenna while the transmitter is operating.**

Important The radio has been designed to operate with a 50Ω termination impedance. Do not operate the transmitter without a suitable load. Failure to do so might result in damage to the power output stage of the transmitter.

Important While servicing the main board, avoid overheating the radio during test transmissions. The following is good practice: Secure the main-board assembly in the chassis with the two external screws and one of the internal screws. The heat-transfer block must be secured to the main board. The lid of the radio body may be left off. After completing any measurement or test requiring activation of the transmitter, immediately return the radio to the receive mode.

Important Under certain circumstances the microprocessor can key on the transmitter. Ensure that all instruments are protected at all times from such accidental transmissions.

Note The frequency ranges 156.8 MHz ± 375 kHz, 243 MHz ± 5 kHz, and 406.0 to 406.1 MHz are reserved worldwide for use by distress beacons. Do not program transmitters to operate in any of these frequency bands.

4.4 Test Equipment Setup

Introduction

This section covers the setting up of the test equipment for servicing the radios, as well as related aspects:

- setting up of test equipment, including test unit
- basic programming and calibration tasks
- invoking CCTM (computer-controlled test mode)
- summary tables of CCTM commands and error codes
- visual and audible indications provided by radio

The last-named aspect applies to control heads with UI, and concerns the STATUS LEDs and LCD screen, and the various alerts and confidence tones emitted from the speaker.

Connect Equipment

Connect the test equipment to the radio as shown in Figure 4.2. Use the test unit, cables and adaptor of the service kit. Refer to "Tools, Equipment and Spares" on page 100 for details of the test equipment and service kit. The test unit is described in "TOPA-SV-024 Test Unit" on page 477.

For testing receive and transmit functions respectively, the switches of the test unit must be set as described below. (When programming or calibrating radios the switches have no effect, although it is good practice to set the MODE switch to "RX".)

Settings for Receive Tests

For receive tests set the switches on the test unit as follows:

- HOOK switch : "OFF HOOK"
- MODE switch : "RX"
- AUDIO IN switch : "OFF"
- AUDIO OUT switch: "SPEAKER" or "LOAD"

In the last-named case, with the switch in the "SPEAKER" position, the received audio is output from the test unit's speaker. In the "LOAD" position a 16Ω load is switched into the circuit in place of the test unit's speaker. Note, however, that the AUDIO OUT switch has no effect on the radio's speaker.

Settings for Transmit Tests

For transmit tests set the switches on the test unit as follows:

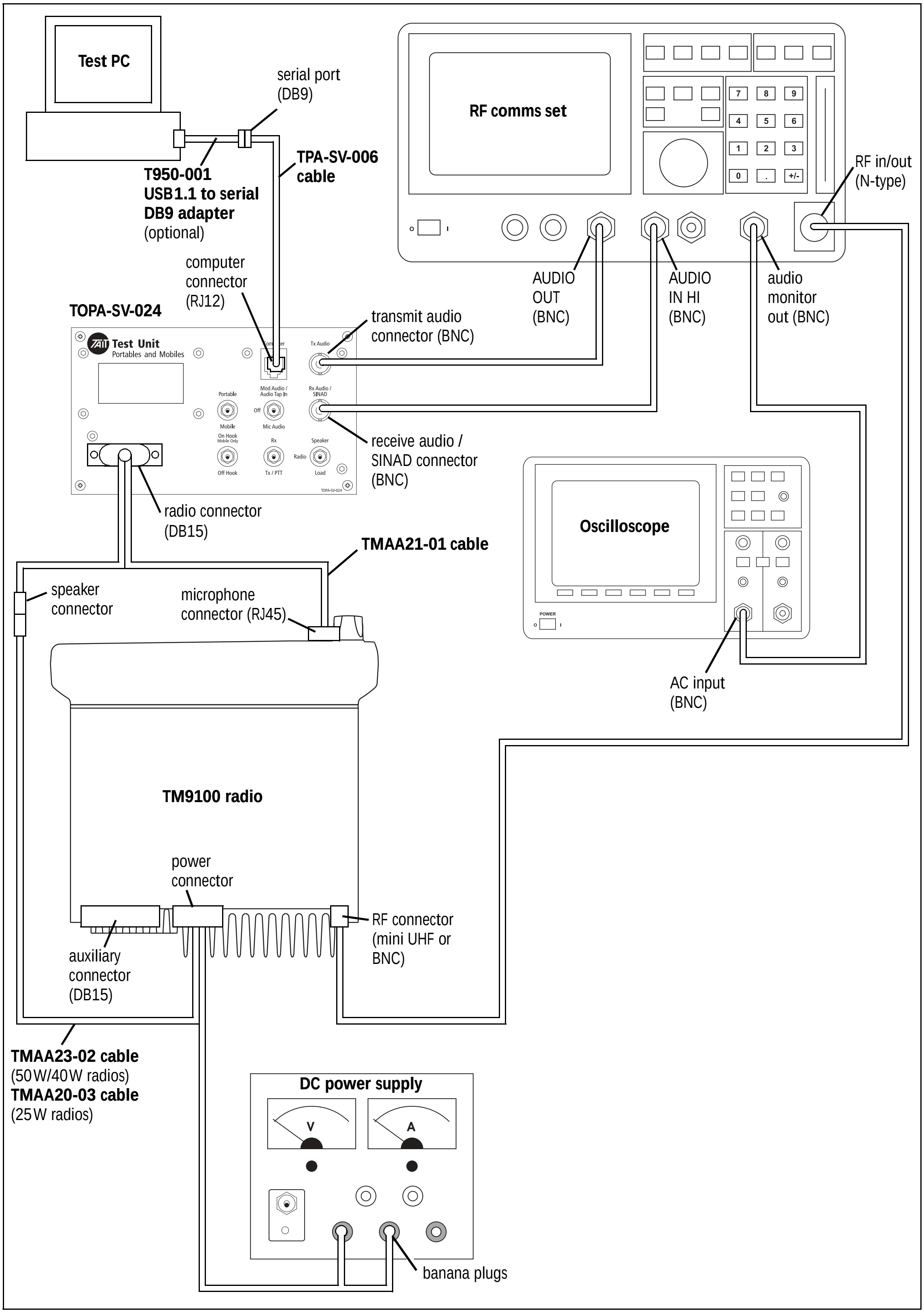
- HOOK switch : "OFF HOOK"
- MODE switch : "RX" initially
- AUDIO IN switch : "MIC AUDIO"
- AUDIO OUT switch: (immaterial)

When ready to transmit, set the MODE switch to the "TX/PTT" position. This switch functions in the same way as the PTT switch on the microphone.

Service CD

Install the programming and calibration applications on the test PC. These applications are included on the service CD supplied with the service kit.

Figure 4.2 Test setup



4.5 Replacing Board Components

This section describes the procedure for obtaining the correct replacement for any faulty component on the boards.

- identify version of PCB information applicable to board
- identify replacement component in BOM of PCB information
- consult technical notes
- obtain replacement component

The technical notes will indicate whether there have been any changes affecting the component in question.

Identify PCB Information

Identify the IPN of the PCB and compare the issue number with that in the PCB information supplied with the service documentation.

Note The IPN is the ten-digit number printed at one corner of the board. The last two digits in the IPN represent the issue number of the PCB.

If the issue numbers match, consult the BOM as described below. If the issue number indicates that the board is either an earlier or a later version, obtain the PCB information for the board under repair from the Technical Support website (support.taitworld.com).

Tip Print and store a copy of every PCB information published on the Technical Support website.

Identify Replacement Component

After locating the correct PCB information for the board, consult the BOM for the board. Identify the component in question in the BOM. Note, however, that a new PCB information is published only whenever there is a major change in the design of the board. A major change normally involves a change in the layout of the PCB, which requires that the issue number in the IPN be incremented. Any minor changes following a major change (and preceding the next major change) normally involve only changes in the components on the board. Such minor changes might affect the component in question. To determine if this is the case, consult any technical notes that might apply to the board as described below.

Consult Technical Notes

A technical note about each major change is published on the Technical Support website (support.taitworld.com). Technical notes giving details of any intervening minor but important changes are also published. It is advisable to print and store a copy of every technical note published.

Obtain Replacement Component

Determine if the required replacement component is included in one of the spares kits. (Check with TEL regarding the availability of the kit.) If the required component is not included in a kit, order the component from a CSO or, in the case of a CSO, from TEL. Always ensure that the replacement component has the identical specification to that given in the BOM. It is particularly important for the tolerances to be the same.

4.6 Shielding Cans and Connectors

The shielding cans on the top- and bottom-side of the main-board assembly are identified in Figure 4.3 and Figure 4.4. The figures also show the locations of the connectors on the board.

Figure 4.3 Shielding cans and connectors (top side of main-board assembly)

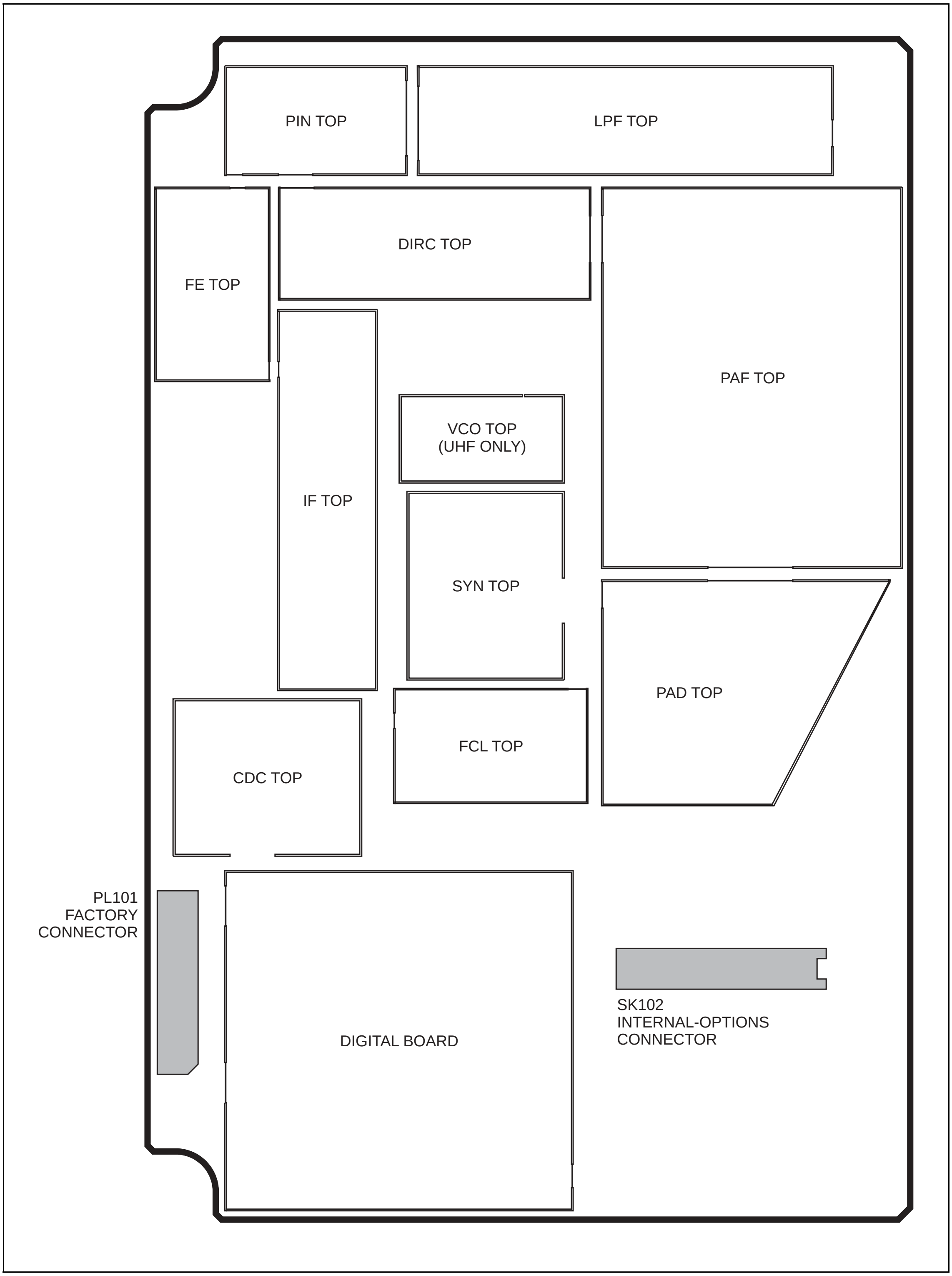
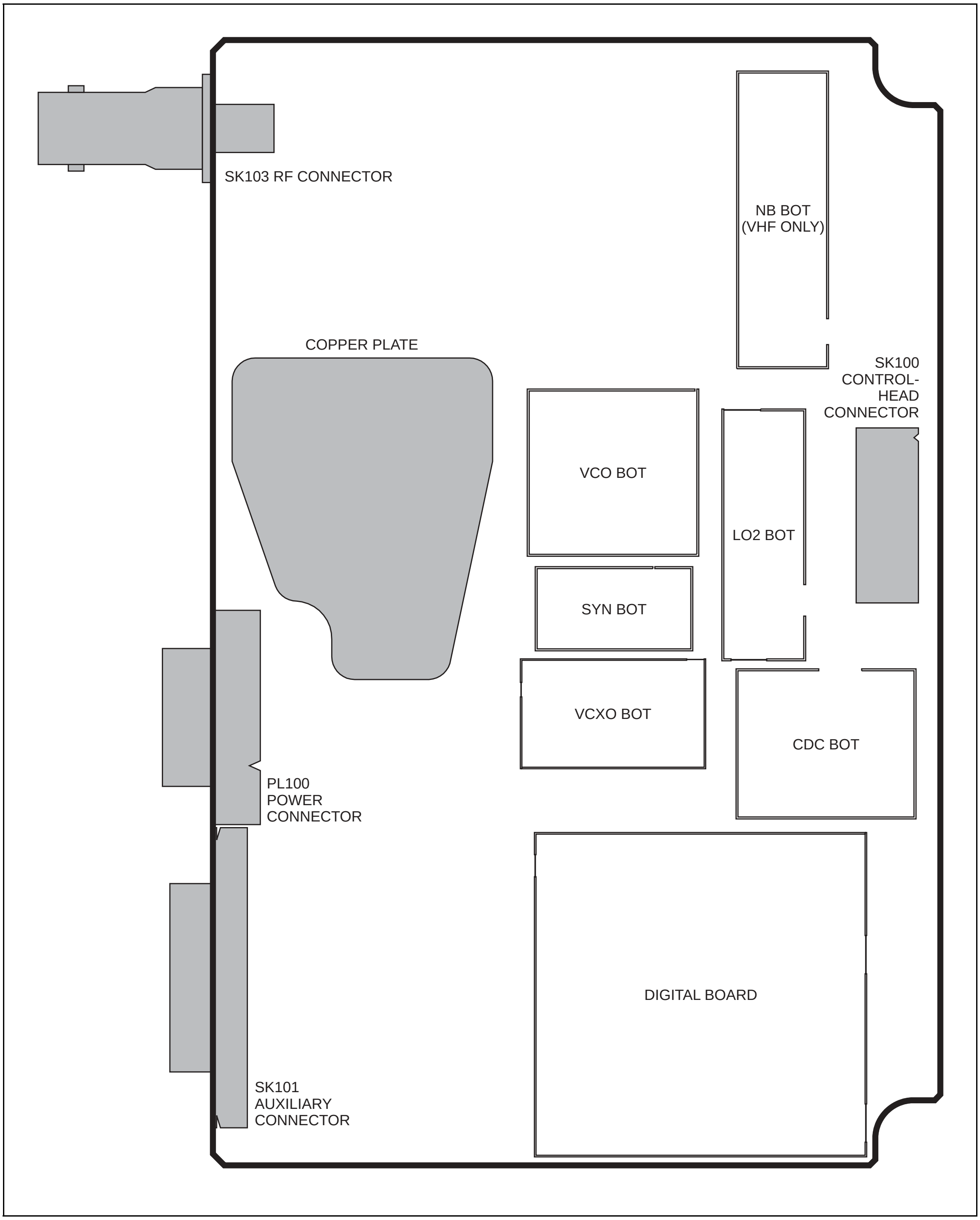


Figure 4.4 Shielding cans and connectors (bottom side of main-board assembly)



Can Removal and Installation

Cans are best removed and installed using a can-removal tool. If this tool is available, technicians should refer to the documentation supplied with the tool for the correct procedures. If the tool is not available, a hot-air tool may be used instead. However, technicians require training in the best techniques to employ in the absence of a can-removal tool. Such training is part of the accreditation process for service centers.

Spare Cans

It is good practice to discard any can that has been removed and replace it with a spare can. If this is not done, special precautions are needed when re-installing the original can. These precautions are discussed as part of the training for accreditation.

4.7 SMT Repair Techniques

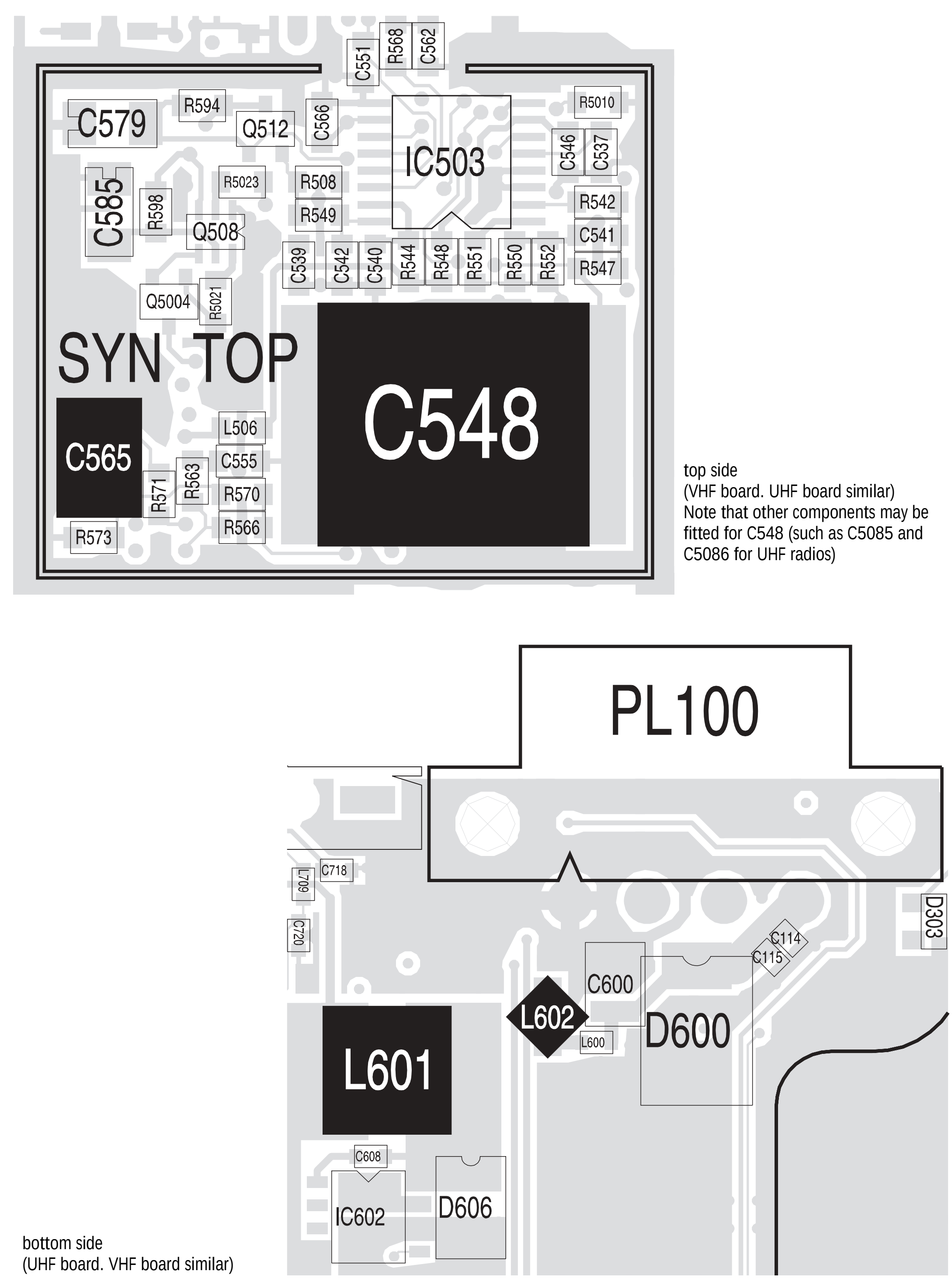
Standard Procedures

Service centers carrying out level-2 repairs are expected to be familiar with the standard techniques for the replacement of SMT components. However, certain components on the main board require non-standard techniques and these are discussed below. Another issue of concern is the procedure for removing and installing cans. A discussion of the issue concludes this section.

Non-standard Procedures

Do not use the standard SMT repair techniques when replacing the capacitors C548 and C565 and the inductors L601 and L602.
The standard techniques tend to produce excessive heat, which will damage these components. Do not use a hot-air tool or heat gun. Instead use solder paste and a standard soldering iron with an iron tip with a specified temperature of 600°F (315°C). The capacitors are part of the frequency-synthesizer circuitry under the SYN TOP can. The inductors are part of the SMPS of the power-supply circuitry on the bottom-side of the board. Figure 4.5 on page 111 shows the locations of the components.

Figure 4.5 Locations of the capacitors C548 and C565 and the inductors L601 and L602



4.8 Computer-Controlled Test Mode (CCTM)

The servicing procedures require a radio to be placed in the computer-controlled test mode. In this mode CCTM commands can be entered at the test PC. These commands are then relayed via the test unit to the radio. Certain CCTM commands cause the radio to carry out particular functions; others read particular settings and parameter values in the radio. The CCTM commands of use in servicing radios are listed in Table 4.3 to Table 4.7, grouped according to category.

Terminal Program for CCTM

Use the calibration application to place the radio in CCTM. To do this, run the calibration application, select *Tools > CCTM*, and click the *CCTM Mode* button. For more information, refer to the online help of the calibration application.

You can also use the HyperTerminal utility which is supplied with Microsoft Windows. As a preliminary, first select the settings for the communications port as follows:

1. Open the terminal program. (In the case of HyperTerminal, click *Start* > *Programs* > *Accessories* > *Communications* > *HyperTerminal*.)
2. In the terminal program first select the COM port to which the radio is connected. Then select the following settings for the port:
   - bits per second : 19 200
   - data bits : 8
   - parity : none
   - stop bits : 1
   - flow control : none
3. Click the *OK* button (or equivalent).
4. Save the file with the port settings under a suitable name. For subsequent sessions requiring the terminal program, open this file.

Invoking CCTM

Using the terminal program, place the radio in CCTM as follows:

1. Enter the character ^ to reset the radio.
2. As soon as the radio is reset, the letter *v* is displayed. (If an uppercase letter *V* appears, this implies a fault.)
3. Immediately the letter *v* is displayed, enter the character *%*. (The character *%* must be entered within half a second of the letter *v* appearing.)
4. If the character *%* is accepted, the character – is displayed in response, and the message *Test Mode* appears on the radio display.

This implies that the radio has entered CCTM. If the attempt fails, repeat Steps 1 to 3.

Table 4.3 CCTM commands in the audio category

Command	Usage	
	Entry at keyboard	**Response on screen**
Audio category		
20 – Mute received audio Forces muting of the received audio signal	*20*	None
21 – Unmute received audio Forces unmuting of the received audio signal	*21*	None
22 – Mute microphone Mutes transmit modulation (effectively mutes microphone audio)	*22*	None
23 – Unmute microphone Unmutes transmit modulation (effectively unmutes microphone audio)	*23*	None
74 – Audio PA Controls the state of the audio PA (and hence enables or disables the speaker)	*74* ***x*** where ***x*** is the required state (0=stand-by, 1=on, 2=mute)	None
110 – Audio volume Sets the level of the audio volume	*110* ***x*** where ***x*** defines the required level (any integer from 0 to 255)	None
138 – Select microphone Selects the microphone required	*138* ***x*** where ***x*** is the required microphone (0=control-head microphone; 1=auxiliary microphone)	None
323 – Audio tap in Generates the audio tone AUD TAP IN at the specified tap point	*323* ***x y*** where ***x*** specifies the tap point (*r2*, *r5, t1* or *t5*) and ***y*** the tap type (A=bypass in, B=combine, E=splice) (the default is A when ***y*** is omitted)	None
324 – Audio tap out Outputs the audio signal at the specified tap point to AUD TAP OUT	*324* ***x y*** where ***x*** specifies the tap point (*r1*, *r2*, *r3*, *r4*, *r5*, *t1*, *t2*, *t3* or *t7*) and ***y*** the tap type (C=bypass out, D=split, E=splice) (the default is D when ***y*** is omitted)	None

Table 4.4 CCTM commands in the radio-information, radio-control and system categories

Command	Usage	
	Entry at keyboard	**Response on screen**
Radio-information category		
94 – Radio serial number Reads the serial number of the radio	*94*	***x*** where ***x*** is the serial number (an eight-digit number)
96 – Firmware version Reads the version number of the radio firmware	*96*	*QMA1F_**x**_**y*** where ***x*** is a three-character identifier and ***y*** is an eight-digit version number
97 – Boot-code version Reads the version number of the boot code	*97*	*QMA1B_**x**_**y*** where ***x*** is a three-character identifier and ***y*** is an eight-digit version number
98 – FPGA version Reads the version number of the FPGA	*98*	*QMA1G_**x**_**y*** where ***x*** is a three-character identifier and ***y*** is an eight-digit version number
133 – Hardware version Reads the product code of the radio body and the hardware version number	*133*	***x*** ***y*** where ***x*** is the product code and ***y*** is the version number (a four-digit number)
134 – FLASH serial number Reads the serial number of the FLASH memory	*134*	***x*** where ***x*** is the serial number (a 16-digit hexadecimal number)
Radio-control category		
400 – Select channel Changes the current channel to that specified	*400 **x*** (alternatively ***x**) where ***x*** is a valid channel number	None
System category		
46 – Supply voltage Reads the supply voltage	*46*	***x*** where ***x*** is the supply voltage in millivolts
203 – Clear system error Clears the last recorded system error	*203*	None
204 – Read system error Reads the last recorded system error and the associated data	*204*	*SysErr:* ***x*** ***y*** where ***x*** is the error number and ***y*** represents the associated data
205 – Erase persistent data Effectively resets the calibration parameters to their default values	*205*	None

Table 4.5 CCTM commands in the frequency-synthesizer and receiver categories

Command	Usage	
	Entry at keyboard	**Response on screen**
Frequency-synthesizer category		
72 – Lock status Reads the lock status of the RF PLL, FCL and LO2 respectively	*72*	***x y z*** where ***x*** is the RF PLL, ***y*** the FCL, and ***z*** the LO2 lock status (0=not in lock, 1=in lock)
101 – Radio frequencies Sets the transmit and receive frequencies to specified values	*101* ***x y*** *0* where ***x*** is the transmit and ***y*** the receive frequency in hertz (any integer from 50 000 000 to 1000 000 000)	None
301 – Calibrate VCXO Calibrates the VCXO of the FCL	*301 0 10*	Four KVCXO control sensitivity values, followed by message with results of calibration attempt
302 – Calibrate VCO(s) Calibrates the VCO(s) of the frequency synthesizer	*302 0 10*	Eight KVCO control sensitivity values, followed by message with results of calibration attempt
334 – Synthesizer power Switches the frequency synthesizer on or off via the DIG SYN EN line	*334* ***x*** where ***x*** is the required state (0=off, 1=on)	None
335 – Synthesizer switch Switches the transmit-receive switch of the frequency synthesizer on or off via the DIG SYN TR SW line	*335* ***x*** where ***x*** is the required state (0=off, 1=on)	None
389 – Synthesizer mode Sets the mode of the frequency synthesizer to fast or slow	*389* ***x*** where ***x*** is the required mode (0=slow, 1=fast)	None
Receiver category		
32 – Receive mode Sets the radio in the receive mode	*32*	None
63 – RSSI level Reads the averaged RSSI level	*63*	***x*** where ***x*** is the averaged level in multiples of 0.1 dBm
376 – Front-end tuning Sets or reads the tuning voltage for the front-end circuitry of the receiver	*376* (to read voltage)	***x*** where ***x*** is the front-end tuning voltage in millivolts
	376 ***x*** (to set voltage) where ***x*** is the front-end tuning voltage in millivolts (any integer from 0 to 3000)	None
378 – Receiver output level Reads the signal power at the output of the channel filter (the square of the amplitude)	*378*	***x*** where ***x*** is the signal power

Table 4.6 CCTM commands in the transmitter category (part 1)

Command	Usage	
	Entry at keyboard	**Response on screen**
Transmitter category		
33 – Transmit mode Sets the radio in the transmit mode	*33*	None
47 – Temperature Reads the temperature in the vicinity of the PAs	*47*	***x*** ***y*** where ***x*** is the temperature in degrees celsius, and ***y*** is the corresponding voltage in millivolts (a value from 0 to 1200 mV)
114 – Transmitter power Sets or reads the transmitter power setting (compare command 326)	*114* (to read value)	***x*** where ***x*** is the current power setting (an integer from 0 to 1023)
	114 ***x*** (to set value) where ***x*** is the required power setting (an integer from 0 to 1023)	None
304 – Driver bias Sets or reads the clamp current at the gate of the PA driver	*304* (to read value)	***x*** where ***x*** is the DAC value of the clamp current (an integer from 0 to 255)
	304 ***x*** (to set value) where ***x*** is the required DAC value of the clamp current (an integer from 0 to 255)	None
318 – Forward power Reads the forward-power level	*318*	***x*** where ***x*** is the voltage in millivolts corresponding to the power level (a value from 0 to 1100 mV)
319 – Reverse power Reads the reverse-power level	*319*	***x*** where ***x*** is the voltage in millivolts corresponding to the power level (a value from 0 to 1100 mV)
326 – Transmitter power Sets the power level of the transmitter	*326* ***x*** where ***x*** specifies the level (0=off, 1=very low, 2=low, 3=medium, 4=high, 5=maximum)	None

Table 4.7 CCTM commands in the transmitter category (part 2)

Command	Usage	
	Entry at keyboard	**Response on screen**
Transmitter category		
331 – Final bias 1 Sets or reads the bias voltage for the first PA	*331* (to read value)	***x*** where ***x*** is the DAC value of the bias voltage (an integer from 0 to 255)
	331 ***x*** (to set value) where ***x*** is the DAC value of the required bias voltage (any integer from 0 to 255)	None
332 – Final bias 2 Sets or reads the bias voltage for the second PA	*332* (to read value)	***x*** where ***x*** is the DAC value of the bias voltage (an integer from 0 to 255)
	332 ***x*** (to set value) where ***x*** is the DAC value of the required bias voltage (any integer from 0 to 255)	None

Table 4.8 CCTM commands for the control-head

Command	Usage	
	Entry at keyboard	**Response on screen**
1000 – Switch all LEDs Switches all the function-key and STATUS LEDs on or off	*1000* ***x*** where ***x*** is the required state (0=off, 1=on)	None
1001 – Switch selected LED Switches a selected function-key or STATUS LED on or off	*1001* ***x y*** where ***x*** identifies the LED (0=F1, 1=F4, 2=yellow, 3=green, 4=red) and ***y*** is the state (0=off, 1=on)	None
1002 – LED intensity Sets the LED intensity	*1002* ***x*** where ***x*** is the intensity level (0=off, 1=low, 2=medium, 3=high)	None
1003 – Keypad back-lighting Activates the keypad back-lighting at a specified intensity	*1003* ***x*** where ***x*** is the intensity level (0=off, 1=low, 2=medium, 3=high)	None
1004 – LCD back-lighting Activates the LCD back-lighting at a specified intensity	*1004* ***x*** where ***x*** is the intensity level (0=off, 1=low, 2=medium, 3=high)	None
1005 – Display contrast Sets the contrast of the display to a specified level	*1005* ***x*** where ***x*** is the contrast level (any integer from 0 to 15)	None
1006 – Display elements Switches all the elements of the display on or off	*1006* ***x*** where ***x*** is the required state (0=off, 1=on)	None
1007 – LCD temperature sensor Reads the output of the LCD temperature sensor	*1007*	***x*** where ***x*** corresponds to the temperature reading (an integer between 00 and FF)
1008 – LCD heating Switches the LCD heating on or off	*1008* ***x*** where ***x*** is the required state (0=off, 1=on)	None
1009 – Key press Switches on or off the facility for detecting if any key is pressed or released	*1009* ***x*** where ***x*** is the required state (0=off, 1=on)	***x*** where ***x*** is the serial output from the detection facility
1010 – Volume control Reads the setting of the volume-control potentiometer	*1010*	***x*** where ***x*** is the potentiometer setting (an integer between 00 and FF)
1011 – Microphone source Selects the microphone input source	*1011* ***x*** where ***x*** is the required source (0=microphone connector, 1=concealed microphone)	None

Table 4.9 CCTM commands of the remote control-head kit

CCTM command	Entry at keyboard	Response on screen
1012 – Remote kit turns the audio amplifier on and off	1012 0 = off 1012 1 = on	none
1013 – Mute audio amplifier mutes and unmutes the audio amplifier	1012 0 = mute 1012 1 =unmute	none
1014 – Digital potentiometer reads the digital potentiometer	1014	value between 0 and 255
1017 – Audio amplifier gain sets the audio amplifier gain (4 levels)	1017 **x** where **x** is the gain (0 to 3)	none

CCTM Error Codes

Once the radio is in CCTM, the CCTM commands may be entered as shown in Table 4.3 to Table 4.7. Depending on the command, a response might or might not be displayed. If an error occurs, an error code will be displayed. Possible error codes are listed in Table 4.10.

Table 4.10 CCTM error codes

Error code	Description
C01	An invalid CCTM command has been received. Enter a valid CCTM command.
C02	A valid CCTM command with invalid parameters has been received. Re-enter the CCTM command with valid parameters.
C03	A valid CCTM command has been received but cannot be processed at this time. Enter the CCTM command again. If the error persists, power the radio down and up again, and re-enter the CCTM command.
C04	An error occurred on entry into CCTM. Power the radio down and up again, and place the radio in CCTM again.
C05	The radio has not responded within the specified time. Re-enter the CCTM command.
X04	The DSP is not responding. Check the DSP pin connections. If the error persists, replace the DSP.
X05	The version of the DSP is incompatible with the version of the radio firmware. Replace the DSP with a later version.
X06	The internal configuration of the MCU is incorrect. Adjust the configuration.
X31	There is an error in the checksum for the model configuration.
X32	There is an error in the checksum for the radio's database.
X35	The radio temperature is above the T1 threshold and a reduction in the transmit power is impending. To avoid damaging the radio, stop transmitting until the radio has cooled down sufficiently.
X36	The radio temperature is above the T2 threshold and the inhibiting of transmissions is imminent.
X37	The supply voltage is less than the V1 threshold.
X38	The supply voltage is less than the V2 threshold and the radio has powered itself down. The radio will not respond to the reset command character ^.

4.9 Visual and Audible Indications

Visual and audible indicators give information about the state of the radio. Visual indications are provided by the STATUS LEDs, function-key LEDs, and LCD display. The information conveyed by the STATUS LEDs is listed in Table 4.11. The behavior of the function-key LEDs depends on the way the function keys are programmed. The LCD display normally displays channel and user information, or error messages. For more information on the LCD display during normal operation, refer to the user's guide. The error messages are listed in Table 6.1 on page 144. Audible indications are provided in the form of different tones emitted from the speaker. The information conveyed by the tones is given in Table 4.12 on page 122.

Table 4.11 Visual indications provided by the STATUS LEDs

LED color	LED name	Indications	Meanings
Red	Transmit	LED is on	The radio is transmitting
		LED flashes	(1) The transmit timer is about to expire (2) The radio has been stunned
Green	Receive and monitor	LED is on	There is activity on the current channel, although it might not be audible
		LED flashes	(1) The radio has received a call with valid special signaling (2) The monitor has been activated (3) The squelch override has been activated
Amber	Scanning	LED is on	The radio is scanning a group of channels for activity
		LED flashes	The radio has detected activity on a certain channel and scanning has halted on this channel

Table 4.12 Audible indications

Type of tone	Meanings
One short beep	(1) After power-up — Radio is locked; PIN is required (2) On power-down — Radio is off (3) On pressing key — Key-press is valid (4) On pressing function key — Function has been initiated
One short low-pitched beep	On pressing function key again — Function has been terminated
One short high-pitched beep	While powered up — Radio has been stunned
One long low-pitched beep	(1) On pressing key — Key-press is invalid (2) On entry of PIN — PIN is invalid (3) On pressing PTT switch — Transmission is inhibited
Two short beeps	(1) On power-up — Radio is ready to use (2) On entry of PIN — PIN has been accepted and radio is ready to use (3) After radio has been stunned — Radio has been revived and is ready to use
Two low-pitched beeps	While powered up — Temperature of radio is high
Two high-pitched beeps	While powered up — Temperature of radio is very high and all transmissions will be at low power; if temperature rises further, transmissions will be inhibited
Three short beeps	While powered up — Previously busy channel is now free
Three beeps	During transmission — Transmit time-out is imminent; transmission will be terminated in 10 seconds
Warble	While powered up — Frequency synthesizer is out of lock on current channel; LCD will usually display *Out of Lock.*
Continuous low-pitched tone	While powered up — System error has occurred and radio might be inoperable; LCD usually displays *E1* or *E2*.

5 Disassembly and Reassembly

This section describes how to:

- remove and mount the control head
- disassemble and reassemble the radio body
- disassemble and reassemble the control head

General

Important Before disassembling the radio, disconnect the radio from any test equipment or power supply.

Disassemble only as much as necessary to replace the defective parts.

Inspect all disassembled parts for damage and replace them, if necessary.

Observe the torque settings indicated in the relevant figures.

For information on spare parts, refer to "Spare Parts" on page 421.

5.1 Removing and Mounting the Control Head

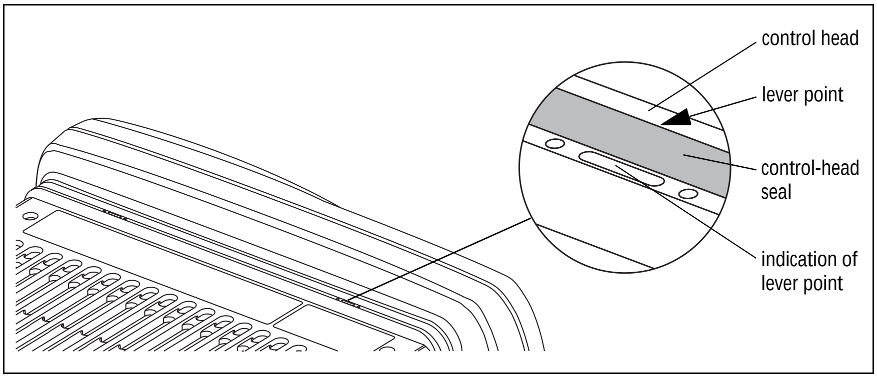
Important Before removing the control head, disconnect the radio from any test equipment or power supply.

Removing the Control Head

1. Note which way up the control head is attached to the radio body in order to return the radio to the customer in its original configuration.

2. On the underside of the radio body, two lever points are indicated on the radio body by a dot-dash-dot pattern (○ ⊂⊃ ○).
The lever point is between the control-head seal and the plastic of the control head.

Figure 5.1 Disconnecting the control head from the radio body



Important When inserting the flat-bladed screwdriver, take care not to damage the control-head seal.

3. At either of the lever points, insert a 3/16 inch (5mm) flat-bladed screwdriver between the control head and the control-head seal.

4. Use the screwdriver to lift the edge of the control head up and off the clip, then repeat in the other position. The control head can now be removed.

5. Disconnect the control-head loom.

6. Inspect the control-head seal for damage, and replace if necessary.

Mounting the Control Head

1. Plug the control-head loom onto the control-head connector.

2. Insert the bottom edge of the control head onto the two clips in the front of the radio body, then snap into place.

5.2 Disassembling the Radio Body

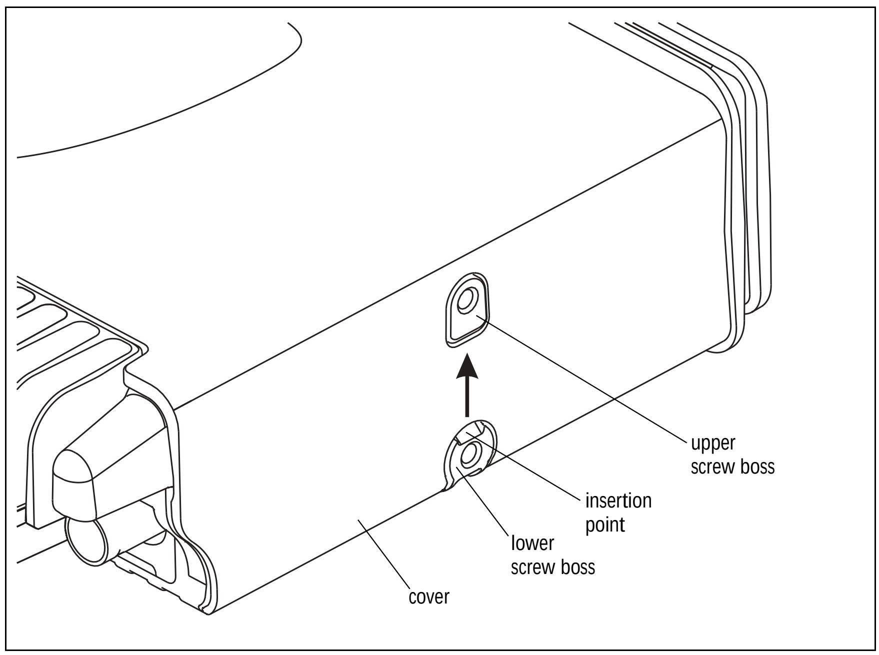
Disassemble only as much as necessary to replace the defective parts.

For reassembly instructions, refer to "Reassembling the Radio Body" on page 131.

Removing the Cover

1. At the upper edge of the lower screw bosses on both sides of the radio body, insert a 1/8 inch (3mm) flat-bladed screwdriver.
2. Push the screwdriver under the cover towards the upper screw boss to release the cover from the upper screw boss.
3. Remove the cover.

Figure 5.2 Removing the cover



Opening the Radio Body

The circled numbers in this section refer to the items in Figure 5.3 on page 127.

1. Use a Torx T20 screwdriver to remove the four screws ②.

Important If an options board is fitted inside the lid, an options loom will connect the options board to the internal options connector on the main board. In this case, carefully fold over the lid and disconnect the loom.

2. Carefully remove the lid assembly ③.

3. Inspect the main seal in the lid for damage, and replace if necessary.

Removing the Main-Board Assembly

The circled numbers in this section refer to the items in Figure 5.3 on page 127.

1. Remove the auxiliary connector bung ⑦ (if fitted).

2. Remove the RF connector seal ⑨ using one of the tabs located at the bottom of the seal—preferably by hand. If necessary, lift up the tap using the blade of a small flat-bladed screwdriver. Do not damage the seal with the screwdriver.

3. Use a Torx T10 screwdriver to remove the screws ④ connecting the main board to the chassis.

4. Use a Torx T20 screwdriver to remove the screws ⑧ connecting the heat-transfer block to the rear of the chassis.

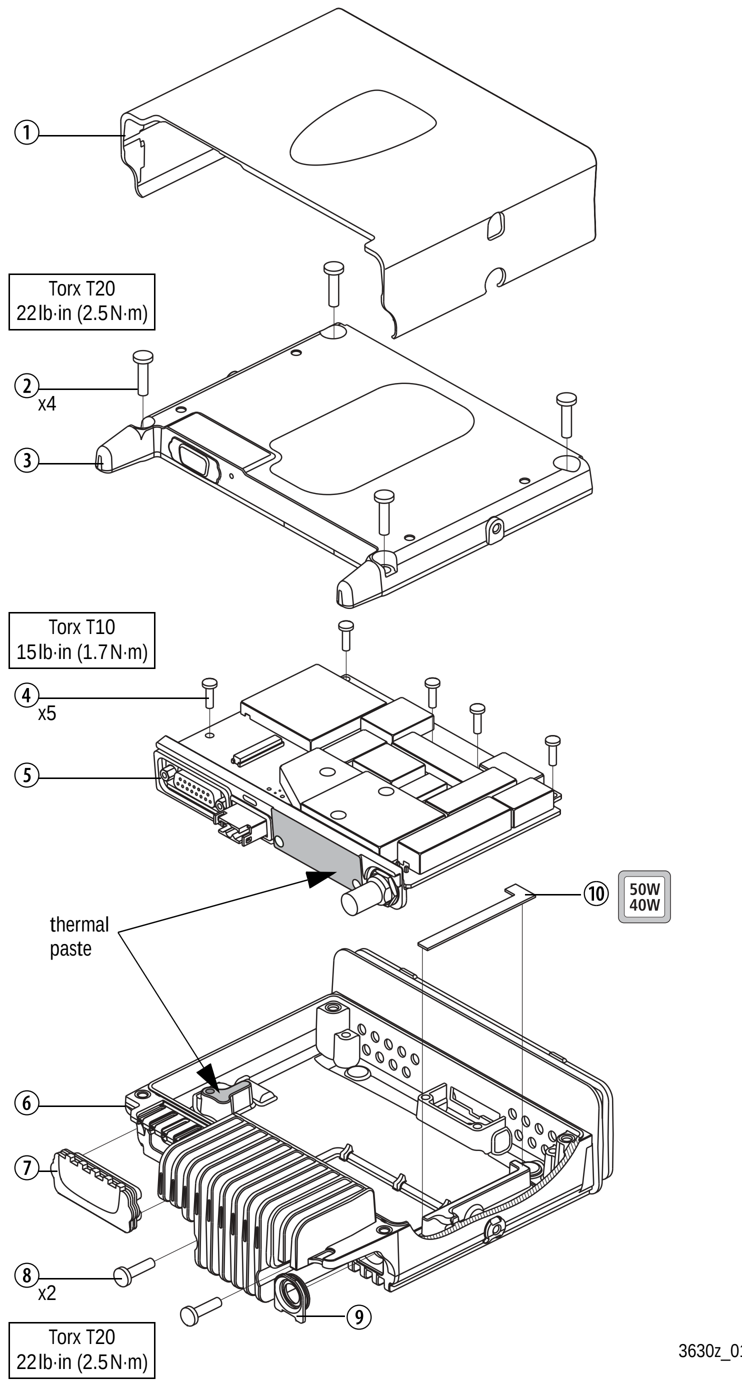
Note Make sure not to touch the thermal paste on the chassis, the heat-transfer block, and the underside of the main board. If the thermal paste is contaminated, you must re-apply thermal paste as described in “Fitting the Main-Board Assembly to the Chassis” on page 133.

5. Holding a hand over the chassis to catch the main-board assembly, turn the chassis upside down and tap its fins on the edge of the workbench. This will release the heat-transfer block from the chassis.

50W 40W

6. With the 50 W/40 W radio, the gap pad ⑩ on the L-shaped ridge must be replaced each time the main board is removed.

Figure 5.3 Components of the radio body



① cover	⑥ chassis
② screw M4x16 (x4)	⑦ auxiliary connector bung
③ lid assembly	⑧ screws M4x16 (x2)
④ screw M3x10 (x5)	⑨ RF connector seal
⑤ main-board assembly	⑩ gap pad (50W/40W radio only)

Disassembling the Main-Board Assembly

The circled numbers in this section refer to the items in Figure 5.4 on page 129. This figure shows the 50 W/40 W configuration.

1. Remove the power connector seal ⑧.

2. Use a torque-driver with a 3/16 inch (5 mm) socket to remove the D-range screwlock fasteners ⑦.

3. Use a torque-driver with a 9/16 inch (14 mm) long-reach socket to remove the RF connector nut ⑪. Also remove the lock washer ⑫.

4. Use a Torx T10 screwdriver to remove the three screws ① securing the main board ⑭ to the heat-transfer block ⑤.

Note Make sure not to touch the thermal paste on the heat-transfer block and the underside side of the main board. If the thermal paste is contaminated, you must re-apply thermal paste as described in "Reassembling the Main-Board Assembly" on page 131.

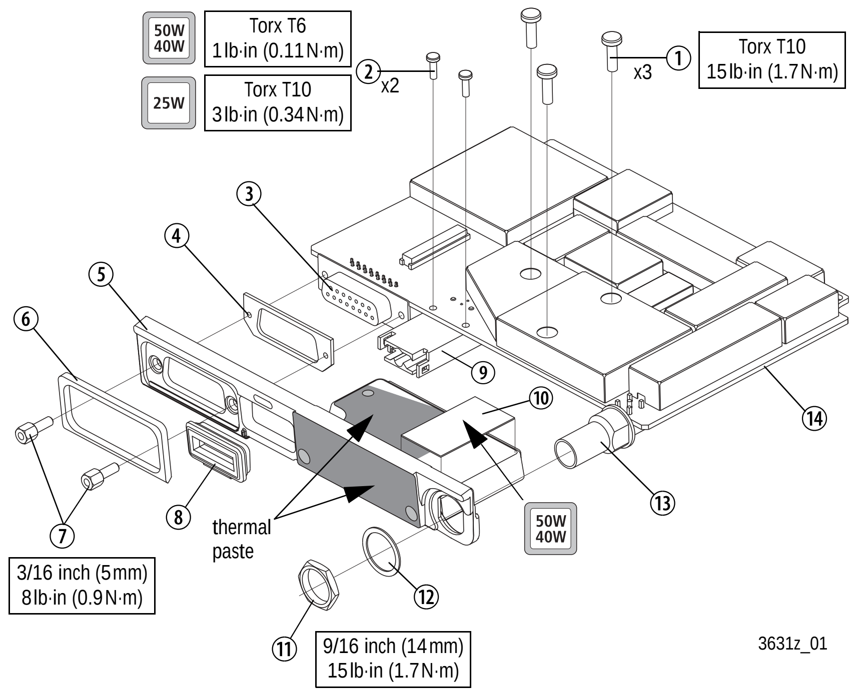
5. Separate the main board ⑭ from the heat-transfer block ⑤.

6. Inspect the inner foam D-range seal ④ and the outer foam seal ⑥, and replace if necessary.

7. The gap pad ⑩ (50 W/40 W radio only) must be replaced each time the heat-transfer block is separated from the main board.

8. To replace the power connector ⑨:
   - With the 50 W/40 W radio, use a Torx T6 screwdriver to undo the two screws ②.
   - With the 25 W radio, use a Torx T10 screwdriver to undo the two screws ②.

Figure 5.4 Components of the main-board assembly



1. M3x10 screw (x3)
2. 50W/40W radios: M2.2x10 PT screw (x2)
   25W radios: K30x8 PT screw (x2)
3. auxiliary connector
4. inner foam D-range seal
5. heat-transfer block
6. outer foam seal
7. D-range screwlock fastener (2x)
8. power connector seal
9. power connector
10. gap pad (50W/40W radio only)
11. RF connector nut
12. RF connector lock washer
13. RF connector
14. main board

Removing an Options Board (Optional)

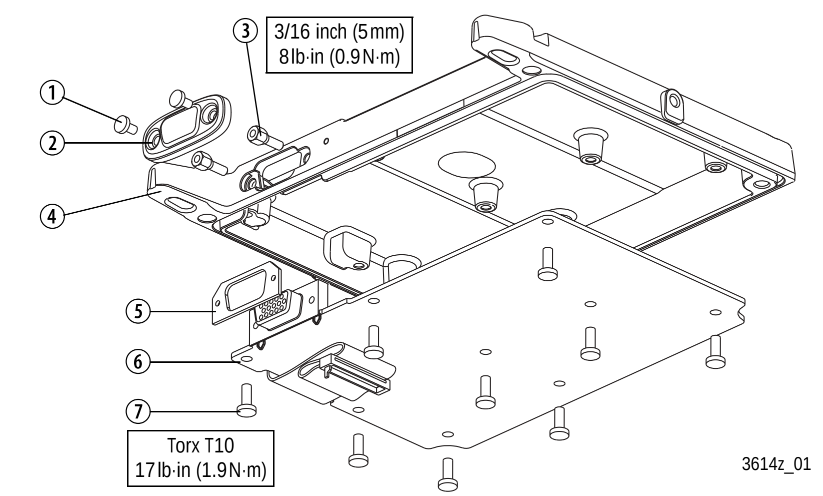
The radio may be fitted with an options board in the lid assembly, which may or may not have an external options connector fitted in a provision in the lid assembly.

The circled numbers in this section refer to the items in Figure 5.5.

1. If an external options connector is fitted:
   - Undo the two screws ① and remove the protective rubber cap ② (if fitted).
   - Undo the two D-range screwlock fasteners ③.
2. Undo up to nine screws ⑦ and remove the options board ⑥ from the lid assembly ④.
3. If an external options connector is fitted, a foam seal for the D-range connector ⑤ is fitted to the inside of the lid. Remove the foam seal only if it is damaged.

Reassembly is carried out in reverse order of the disassembly.

Figure 5.5 Removing an options board



① screw 4-40x3/15 (x2)
② protective rubber cap
③ D-range screwlock fastener 4-40 (x2)
④ lid assembly
⑤ foam seal for D-range connector
⑥ options board (example)
⑦ screw M3x10, self-tapping (x9)

5.3 Reassembling the Radio Body

Inspect all disassembled parts for damage and replace them, if necessary.

Reassembling the Main-Board Assembly

The circled numbers in this section refer to the items in Figure 5.4 on page 129. This figure shows the 50 W / 40 W configuration.

50W 40W | 25W

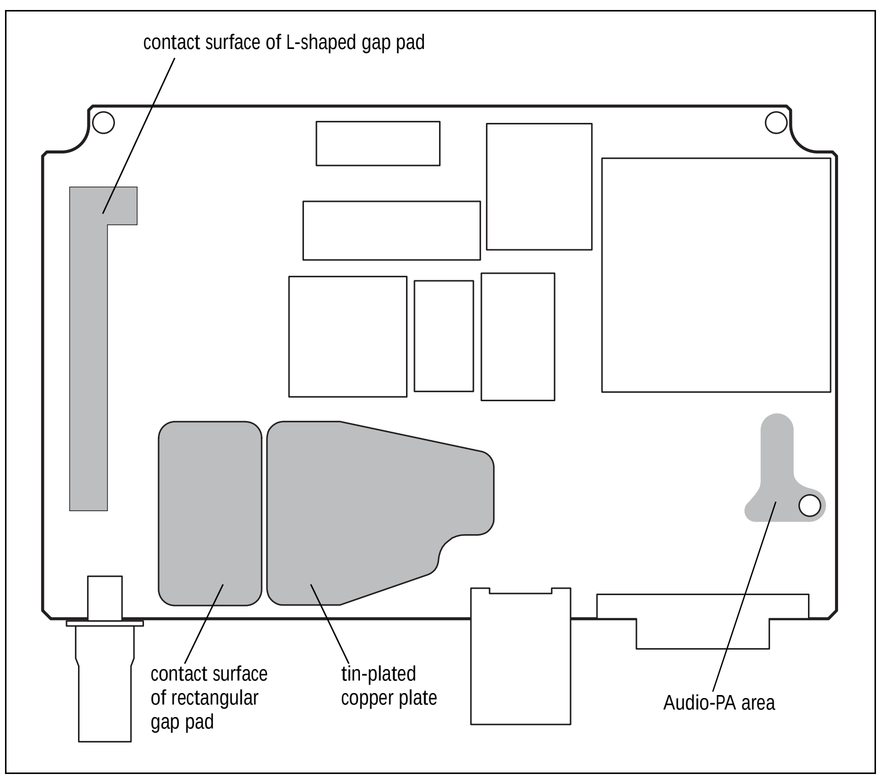
1. If the power connector has been replaced:
   - With the 50 W / 40 W radio, use a Torx T6 torque-driver to tighten the two screws ② to 1 lb·in (0.11 N·m).
   - With the 25 W radio, use a Torx T10 torque-driver to tighten the two screws ② to 3 lb·in (0.34 N·m).

2. If the outer foam seal ④ or the inner foam D-range seal ⑥ have been removed, fit new seals to the heat-transfer block ⑤.

50W 40W

3. With the 50 W / 40 W radio, the rectangular gap pad ⑩ must be replaced each time the heat-transfer block ⑤ is separated from the main board ⑭:
   - Remove any residue of the old rectangular gap pad from the underside of main board and the heat-transfer block.
   - Peel off the transparent film on one side of the gap pad and evenly press the gap pad on the contact surface of main board (refer to Figure 5.6).
   - Peel off the transparent film on other of the gap pad.

Figure 5.6 Contact surfaces on the bottom side of the main board



4. If the thermal paste on the heat-transfer block ⑤ or the tin-plated cooper plate of the main board ⑭ has been contaminated, new thermal paste must be applied:
   - Remove any residue of the old thermal paste from both contact surfaces.
   - Use Dow Corning 340 silicone heat-sink compound (IPN 937-00000-55).

Important Ensure that no bristles from the brush come loose and remain embedded in the paste. The paste needs to be completely free of contaminants.

   - Use a stiff brush to apply 0.1 cm^3 of thermal paste over the complete contact surface on the tin-plated copper plate (refer to Figure 5.6 on page 131).

5. Place the main board ⑭ in position on the heat-transfer block ⑤, and push them together to spread the thermal paste.

Important You must observe the following order of assembly to ensure that the main board and the connectors are not assembled under stress.

6. Use a torque-driver with a 3/16 inch (5mm) socket to fasten the D-range screwlock fasteners ⑦ to 8lb·in (0.9N·m).
7. Fit the RF connector lock washer ⑫. Use a torque-driver with a 9/16 inch (14mm) long-reach socket to fasten the RF connector nut ⑪ to 15lb·in (1.7N·m).
8. Use a torque-driver with a Torx T10 bit to fasten the three screws ① to 15lb·in (1.7N·m).
9. Loosen both the D-range screwlock fasteners ⑦ and the RF connector nut ⑪.
10. Re-tighten both the D-range screwlock fasteners ⑦ and the RF connector nut ⑪ to the torques indicated in steps 7 and 8.
11. Fit the power connector seal ⑧.

Fitting the Main-Board Assembly to the Chassis

The circled numbers in this section refer to the items in Figure 5.3 on page 127. This figure shows the 50 W/40 W configuration.

50W 40W

1. With the 50 W/40 W radio, the L-shaped gap pad ⑩ must be replaced each time the main-board assembly ⑤ is removed from the chassis ⑥:
   - Remove any residue of the old gap pad from the audio-PA area on the underside of the main board (refer to Figure 5.6 on page 131) and the L-shaped ridge of the chassis (refer to Figure 5.3 on page 127).
   - Peel off the transparent film on one side of the gap pad and evenly press the gap pad on the L-shaped ridge of the chassis.
   - Peel off the transparent film on other of the gap pad.

2. If the thermal paste on the heat-transfer block or the underside of the main board has been contaminated, new thermal paste must be applied:
   - Remove any residue of the old thermal paste from both contact surfaces.
   - Use Dow Corning 340 silicone heat-sink compound (IPN 937-00000-55).

Important Ensure that no bristles from the brush come loose and remain embedded in the paste. The paste needs to be completely free of contaminants.

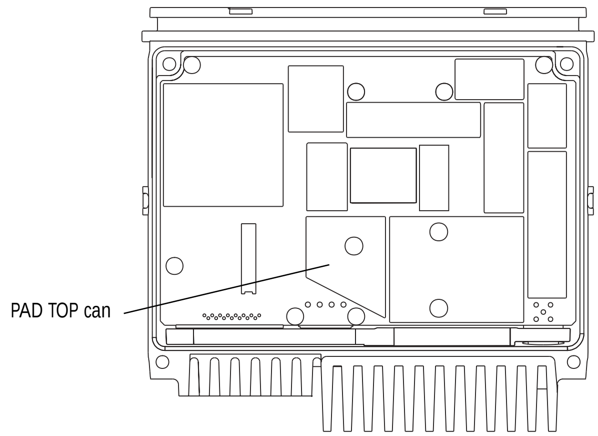
   - Use a stiff brush to apply 0.1 cm^3 of thermal paste on the heat-transfer block (refer to Figure 5.3 on page 127).
   - Use a stiff brush to apply 0.01 cm^3 of thermal paste on the audio-PA heat sink of the chassis (refer to Figure 5.3 on page 127)

3. Place the main-board assembly ⑤ in position in the chassis ⑥.

4. Loosely screw in the two screws ⑧ through the heat-transfer block by hand.

5. While pressing down firmly on the diagonal edge of the PAD TOP can (refer to Figure 5.7), use a Torx T20 torque-driver to tighten the two screws ⑧ to 22 lb·in (2.5 N·m). This will ensure that the main board is seated correctly on the bosses for the five internal screws ④.

Figure 5.7 PAD TOP can on the top side of the main board



6. Clean off any excess thermal paste on the heat-transfer block.

7. Screw in the five screws ④ through the main board by hand as far as possible. Use a Torx T10 torque-driver to tighten the screws to 17 lbf·in (1.9 N·m).

8. Fit the RF connector seal ⑨. Ensure that the seal is properly seated around its entire periphery.

9. If an auxiliary connector bung ⑦ was fitted, fit the bung.

Closing the Radio Body

The circled number in this section refer to the items in Figure 5.3 on page 127.

1. If an internal options board is fitted inside the lid, connect the loom to the internal options connector.

2. Inspect the main seal in the lid for damage, and replace if necessary.

3. Place the lid assembly ③ on the chassis ⑥.

4. Use a Torx T20 torque-driver to tighten the four screws ② to 22 lbf·in (2.5 N·m).

5. Slide the cover ① over the radio body and snap holes in the side of the cover over the screw bosses.

6. Inspect the control-head seal for damage, and replace if necessary.

5.4 Disassembling and Reassembling the Control Head

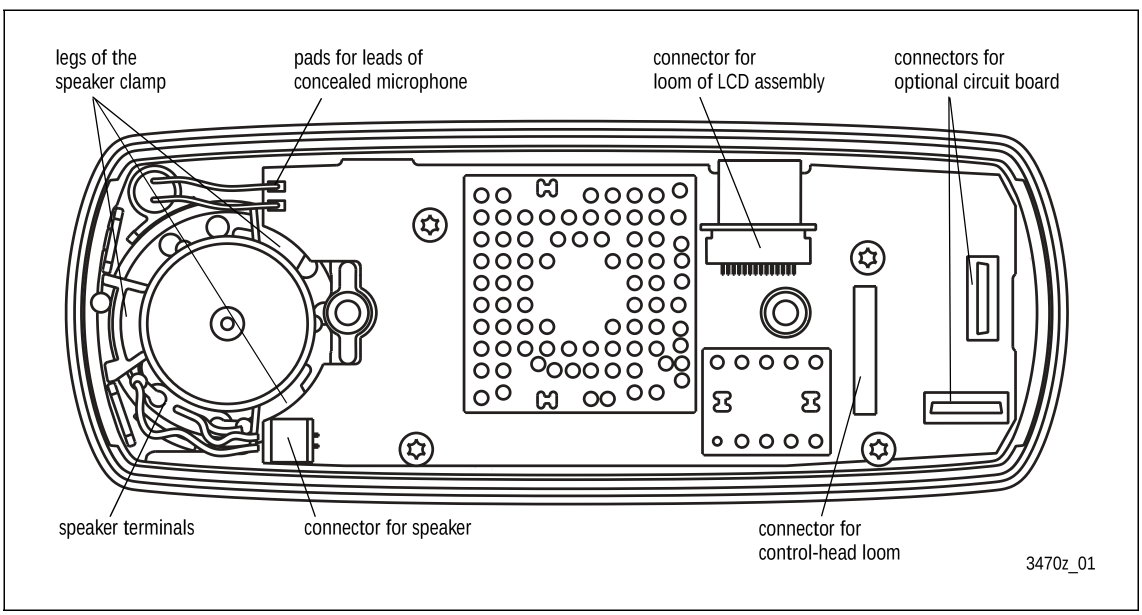
Disassemble only as much as necessary to replace the defective parts. Reassembly is carried out in reverse order of the disassembly.

The circled numbers in this section refer to the items in Figure 5.9 on page 137.

The connectors of the control-head board and the orientation of the speaker and speaker clamp are illustrated in Figure 5.8.

1. With your fingers, pull off the volume control knob ⑰. Do not use any tools as this might cause damage.
2. Unscrew the two screws ① and remove the adaptor flange ②.
3. Disconnect the control-head loom ③.
4. If an optional circuit board is fitted, unplug it from the control-head board ⑤ (refer to Figure 5.8).
5. Note whether the speaker is connected or disconnected. If it is connected, disconnect the speaker cable from the speaker connector of the control-head board ⑤ (refer to Figure 5.8). Note that the radio must be returned to the customer in its original configuration.
6. Release the lock of the LCD connector and unplug the loom of the LCD assembly ⑫ (refer to Figure 5.8). Note that the loom runs through a slot in the space-frame ⑨.

Figure 5.8 Speaker orientation and connectors of the control-head board



7. Unscrew the four screws ④ and remove the control-head board ⑤.

8. Pull the concealed microphone ⑮ capsule out of its rubber seal when removing the control head-board ⑤. If necessary, unsolder the leads from the pads on the control-head board (refer to Figure 5.8).

9. Remove the light pipes ⑦ and ⑧.

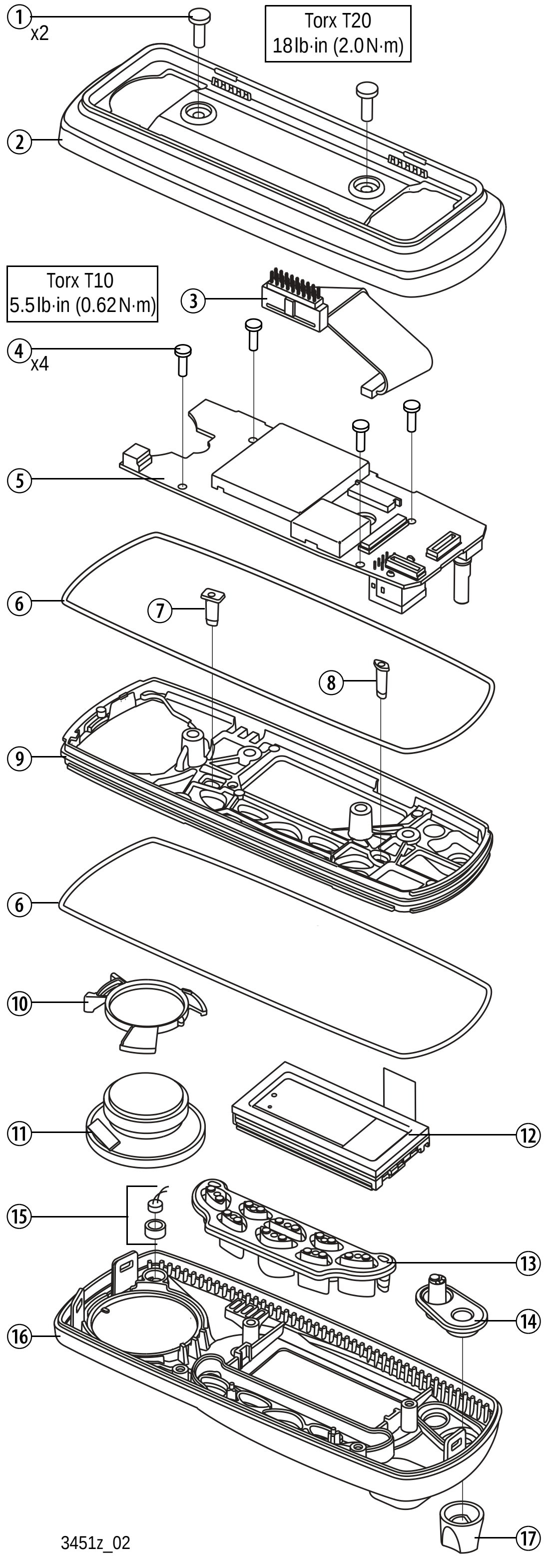
10. The space-frame ⑨ clips into three clips of the front panel. Unclip the spaceframe and remove it along with the two seals ⑥. Check the seals ⑥ and replace them, if necessary.

11. Remove the speaker ⑪ and speaker clamp ⑩.

Important When fitting the speaker and the speaker clamp, observe the orientation of the speaker terminals. Make sure that the larger of the three legs of the speaker clamp is placed between the two clips of the front panel assembly as shown in Figure 5.8 on page 135.

12. Remove the LCD assembly ⑫, main keypad ⑬, and power keypad ⑭.

Figure 5.9 Components of the control head



1. M4 x 12 Taptite screw (x2)
2. adaptor flange
3. control-head loom assembly
4. 3 x 10 PT screw (x4)
5. control-head board
6. space-frame seal (x2)
7. short light pipe
8. long light pipe
9. space-frame
10. speaker clamp
11. speaker
12. LCD assembly
13. main keypad
14. power keypad
15. concealed microphone
16. front panel assembly
17. knob for volume-control potentiometer

6 Servicing Procedures

Scope of Section

This section gives the full sequence of tasks required when servicing a particular radio. These tasks are:

- initial inspection, visual inspection and fault diagnosis
- repair, final inspection, test and administration

For disassembly and reassembly instructions, refer to “Disassembly and Reassembly” on page 123.

6.1 Initial Tasks

List of Tasks

The following tasks need to be carried out for **all** radios:

- initial administration
- visual inspection
- powering up the radio
- reading the programming file
- obtaining the details of the Software Feature Enabler (SFE)
- reading the calibration file
- checking the user interface
- checking any error messages

The following tasks only need to be carried out if they relate to the fault reported:

- checking the transmit and transmit-audio functions
- checking the receive and receive-audio functions

Important Observe the “General Information” on page 97.

Task 1 — Initial Administration

When a radio is received for repair, details of the Customer and the fault will be recorded in a fault database. The fault reported by the Customer might concern damage to or loss of a mechanical part, or the failure of a function of the radio, or both.

Task 2 — Visual Inspection

Check the radio for mechanical loss or damage, even if the fault concerns a function failure only. Inspect the radio as follows:

- knob for volume-control potentiometer
- microphone grommet
- rubber seal for RF connector
- bung for auxiliary connector
- bung for aperture for external options connector

The bung for aperture for external options connector should be replaced by a cover seal if an external options connector is present. All the parts are illustrated in "Spare Parts" on page 421. Except for the microphone grommet, if any of these parts is missing or damaged, replace it as described below. In the case of the microphone grommet, refer to the accessories manual for the repair procedure.

Replace Damaged or Missing Knob

Remove the volume-control knob if it is damaged. Push the replacement knob onto the shaft of the volume-control potentiometer. Ensure that the knob turns freely.

Replace Damaged or Missing Seals and Bungs

Remove any damaged seal or bung. Obtain a replacement seal for the RF connector or a replacement bung from Spares kit 2. Order a replacement cover seal (and screws) from TEL; the IPNs of the parts are listed in "Spare Parts" on page 421. In fitting a replacement bung, ensure that it is not upside down and that it is properly seated. To fit the seal for the RF connector, first fit the upper part of the seal and then press down around the sides of the seal to the bottom. Ensure that the seal is properly seated around its entire periphery.

Check for Additional Damage

Also check for damage to exterior parts that can be replaced only by partly disassembling the radio. These parts are:

- cover assembly for radio body
- keys, lens and LCD of control head
- front panel of control head

In the case of the front panel, inspect particularly the light pipes for the STATUS LEDs and the membrane behind the speaker grille. If the radio is reported to have a functional fault, continue with Task 3. Any additional mechanical damage will be repaired during the course of rectifying the functional fault. If the radio has no functional fault, repair any additional damage as described below; conclude with the tasks of "Final Tasks" on page 147.

Replace Damaged Cover Assembly

Remove a damaged cover assembly. Obtain a replacement assembly from Spares kit 2. The cover assembly comprises a cover and a label; the label is permanently fixed to the cover. The IPNs of both items are given in "Spare Parts" on page 421. If a spares kit is not available, order both items from TEL. Fit the replacement cover assembly to the radio body.

Repair Damaged Control Head

If the control head is damaged, detach it from the radio body as described in "Removing and Mounting the Control Head" on page 124. The procedure includes inspecting the interior of the control head for evidence of other damage. Disassemble the control head and repair all damage as described in "Disassembling and Reassembling the Control Head" on page 135. Obtain replacement parts from Spares kit. Then re-assemble the control head and re-attach it to the radio body.

Task 3 — Power Up the Radio

With the radio connected to the test equipment as described in “Test Equipment Setup” on page 105, attempt to power up the radio.

1. Apply power to the radio. If the radio is programmed not to start on power-on, press the ON/OFF switch.

Note If the radio powers up but keeps resetting itself, check the power-sensing circuitry. If the radio powers up but fails to enter user-mode, or displays an error, refer to Table 6.1 on page 144.

2. If the radio powers up successfully, go to Task 4. If it does not, go to Step 3.

3. Check the fuses, cables, and the power supply.

4. Check whether the control-head loom, the control head or the radio body is faulty by first connecting a spare control-head loom and then a spare control head.

5. If the control head is faulty, check the control-head connector (pin 2: +13V8, pin 14: +3V3, pin 6: AGND), and repair or replace the control-head board.

6. If the repair succeeded without the need for replacing the main-board assembly, go to Task 4. Otherwise continue with Step 7.

7. If the main-board assembly was replaced or if the repair failed, re-assemble the radio as described in “Disassembly and Reassembly” on page 123. Conclude with the tasks of “Final Tasks” on page 147.

Task 4 — Read the Programming File

Given that the radio powers up, the next task is to read the radio's programming file or upload a default file.

1. Use the programming application to read the programming file.
2. If the programming file can be read, save a copy on the test PC, and go to Task 5. If not, go to Step 3.
3. If it seems that the file cannot be read, cycle the power to the radio and again attempt to read the file. First cycling the power is essential if the radio is programmed to power up in transparent-data mode (both 1200 baud FFSK and Tait high-speed data) and if the selected data port is the microphone connector.
4. If the programming file cannot be read, check whether:
   - the radio is connected to the correct serial port of the test PC,
   - the Mode switch of the test unit is set to Rx,
   - the programming application is set-up correctly. Refer to the troubleshooting section of the online help.
5. If the programming file can be read now, save a copy on the test PC, and go to Task 5. If not, go to Step 6.
6. Check whether the control-head loom, the control head or the radio body is faulty by first connecting a spare control-head loom and then a spare control head.
7. If the control head is faulty, check:
   - the control-head connector (pin 3: TXD, pin 7: RXD),
   - the microphone connector,
   - the path between the control-head connector and the microphone connector,

   and repair or replace the control-head board.
8. If the repair succeeded without the need for replacing the main-board assembly, go to Step 9. Otherwise continue with Step 10.
9. If the programming file can be read now, save a copy on the test PC, and go to Task 5. If the file still cannot be read, go to Step 10.
10. Set up a suitable default programming file and attempt to upload it to the radio
11. If the upload succeeds, go to Task 6. If the upload fails, continue with Step 12.
12. If the main-board assembly was replaced or if the repair failed, re-assemble the radio as described in "Disassembly and Reassembly" on page 123. Conclude with the tasks of "Final Tasks" on page 147.

Task 5 — Obtain the Details of the Software Feature Enabler (SFE)

Use the programming application to obtain and record the details of any software-enabled features (*Tools > Optional Features*).

For more information refer to the online help of the programming application.

Task 6 — Read the Calibration File

Use the calibration application to read the calibration file and save it on the test PC. If the calibration file cannot be read, set up a suitable default calibration file and load it to the radio

Task 7 — Check the User Interface

Check the user interface as follows:

1. Use the programming application to activate backlighting, deactivate silent and quiet modes, and view the programmed function keys, channels and scan groups.
2. Turn on the radio, make sure that the volume control is not set to low, and check the start-up sequence:
   - the LEDs light up red briefly
   - the speaker gives two short beeps
   - LCD and keypad backlighting activates
   - the LCD displays a power-up message then a channel number, or an error message.
3. Check for the following elements of the user interface:
   - volume control: Use CCTM command *1010* to read the volume potentiometer. The returned value should be between 0 and 255.
   - LCD: Check visually or use CCTM command *1006 1* to switch on all LCD elements. Power-cycle the radio to reset the LCD to its original state.
   - PTT key: While pressing the PTT key, the transmit symbol or should appear on the radio display (unless transmit is inhibited on the selected channel).
   - scroll and selection keys: Scroll through all settings and observe the radio display.
   - function keys: Check whether the programmed function is activated.
   - keypad: use CCTM command *1009 1* to turn on keypad notification. Check that each keypress returns a different number. CCTM command *1009 1* turns keypad notification off.
   - backlighting (if programmed): Any keypress should activate backlighting.
4. If there is a fault in the user interface, repair the radio as described in "Fault Finding of Control Head" on page 397.
5. If there is no fault, go to Task 8.

Task 8 — Check Error Messages

The radio may display an error message. Carry out the corrective actions described in Table 6.1.

Table 6.1 Error messages

Error message	Corrective action
Error E0001 Unknown	Turn the radio off and then back on.
Error E0002 Unknown	Continue with servicing tasks to locate the problem.
Error E0003 Corrupt FW	Re-download the radio's firmware.
Error E0008 System error 0x*abcdefgh*	Turn the radio off and then back on. If the system error persists, download new radio firmware. To capture details of the system error, use CCTM command *204*.
Temperature threshold exceeded	Wait until the radio has cooled down.
Cannot tx	Go to Task 9 on page 145.
Out of lock	Go to "Frequency Synthesizer Fault Finding" on page 169.
Programming mode, invalid radio ...	Re-program the radio with a new programming database. If the problem persists, update or reload the radio's firmware, and re-program the radio's calibration database.

Task 9 — Check the Transmit and Transmit-Audio Functions

If the radio does not transmit, this can be caused by:

- the synthesizer not being in lock
- no or wrong carrier power
- a faulty speaker
- no modulation

If the cause is already known, go directly to the relevant fault-finding section.

Caution **Observe the servicing precautions for transmitter issues listed on page 104.**

1. Use CCTM command *101 x y 0* to set the transmit frequency to the bottom of the band.
2. Use CCTM command *33* to set the radio to transmit mode.
3. Use CCTM command *72* to read the lock status.
4. If the synthesizer is in lock, go to Step 5. If the synthesizer is not in lock, repair the radio as described in “Frequency Synthesizer Fault Finding” on page 169.
5. Repeat Step 1 to Step 4 with the transmit frequency set to the top of the band.
6. Use CCTM command *326 1* to set the power level to very low.
7. Connect a power meter and measure the transmit power.
8. If the carrier power is correct, go to Step 10. If the carrier power is not correct, try to re-calibrate the radio.
9. If the re-calibration repairs the fault, go to “Final Tasks” on page 147. If it does not, repair the radio as described in “Transmitter Fault Finding (50W/40W Radios)” on page 245 and “Transmitter Fault Finding (25W Radios)” on page 315.
10. Repeat Step 6 to Step 9 with the power level set to high (*326 4*).
11. Check whether the speaker is the source of the fault, as described in “Speaker Faulty” on page 414.
12. If the radio transmits audio now, the original speaker was faulty. Reassemble the radio and go to “Final Tasks” on page 147. If the radio still fails to transmit, reconnect the original speaker and go to Step 13.
13. After having eliminated the synthesizer, the transmitter circuitry, and the speaker as cause for the fault, repair the radio as described in “CODEC and Audio Fault Finding” on page 371.

14. If the main-board assembly was replaced or if the repair failed, reassemble the radio as described in “Disassembly and Reassembly” on page 123. Conclude with the tasks of “Final Tasks” on page 147.

Task 10 — Check the Receive and Receive-Audio Functions

If the radio does not receive, this can be caused by:

- the synthesizer not being in lock
- no carrier detected
- a faulty speaker or volume control
- no modulation

If the cause is already known, go directly to the relevant fault-finding section.

1. Use CCTM command *101 x y 0* to set the receive frequency to the bottom of the band.
2. Use CCTM command *72* to read the lock status.
3. If the synthesizer is in lock, go to Step 5. If the synthesizer is not in lock, repair the radio as described in “Frequency Synthesizer Fault Finding” on page 169.
4. Repeat Step 1 to Step 3 with the receive frequency set to the top of the band
5. Feed a signal without modulation on the receive channel at –47 dBm. Check for maximum RSSI using:
   - the  indicator on the radio display
   - the green status LED
   - CCTM command *63* should return the fed signal strength ±1 dBm.
6. Repeat the check in Step 5 with –117 dBm. The RSSI indicator should show as empty or close to empty.
7. If the carrier is detected correctly, go to Step 9. If the carrier is not detected correctly, try to re-calibrate the radio.
8. If the re-calibration repairs the fault, go to “Final Tasks” on page 147. If it does not, repair the radio as described in “Receiver Fault Finding” on page 227.
9. Check whether the speaker is the source of the fault, as described in “Speaker Faulty” on page 414.
10. If the radio receives audio now, the original speaker was faulty. Reassemble the radio and go to “Final Tasks” on page 147. If the radio still fails to receive, reconnect the original speaker and go to Step 11.
11. Use CCTM command *804* to read the status of the volume potentiometer.

12. If the volume potentiometer is faulty, repair it as described in "Volume Control Faulty" on page 416. If it is not faulty, go to Step 13.

13. After having eliminated the synthesizer, the receiver circuitry, the speaker, and the volume potentiometer as cause for the fault, repair the radio as described in "CODEC and Audio Fault Finding" on page 371.

14. If the main-board assembly was replaced or if the repair failed, re-assemble the radio as described in "Disassembly and Reassembly" on page 123. Conclude with the tasks of "Final Tasks" on page 147.

6.2 Final Tasks

List of Tasks

The following tasks need to be carried out for **all** radios:

- repair
- enable software features (if applicable)
- final inspection
- final test
- final administration

Task 1 — Repair

The fault diagnosis will have resulted in the repair or replacement of the main-board assembly. This section describes the steps after completion of the fault diagnosis:

1. Use the programming and calibration applications to load the programming and calibration files read or set-up in "Initial Tasks".

Note If the radio had to be reprogrammed with a default programming file, the following additional actions are required: If the radio is to be returned direct to a Customer who has **no** programming facilities, the appropriate programming file needs to be obtained and uploaded (or the data obtained to create the file). If the radio is to be returned to a Dealer or direct to a Customer who does have programming facilities, the Dealer or Customer respectively need to be informed so that they can program the radio appropriately.

Note If the main-board assembly has been replaced, certain software features may need to be enabled before the programming file can be loaded. See Task 2 on page 148.

2. Test the radio as described in "Final Test" on page 149.
It may be necessary to also re-calibrate to make the radio functional, in particular if the main-board assembly had to be replaced or if a default calibration file had to be loaded. Refer to the online help of the calibration application.

3. If the main-board assembly has been replaced, level-1 service centers should return the faulty board to the nearest ASC, and level-2 service centers should return the board or assembly to the ISC, if deemed necessary. Supply details of the fault and, if applicable, the attempted repair. Go to step Step 6.

   If the main-board assembly has **not** been replaced, go to Step 4.

4. Replace any cans removed. Refer to "Shielding Cans and Connectors" on page 108.

5. Re-test the radio as described in "Final Test" on page 149.

6. Reassemble the radio as described in "Disassembly and Reassembly" on page 123.

7. Reconnect the radio to the test equipment and carry out a final calibration of the radio. Refer to the online help of the calibration application.

Task 2 — Enable Software Features (SFE)

If the main-board assembly has been replaced, ensure that the correct software features, if any, are enabled for the Customer. If software features need to be enabled, a special licence file is required for the replacement main-board assembly. The file must allow for the enabling of the same software features as in the original assembly. Proceed as follows:

1. If it was possible to read the software features in "Obtain the Details of the Software Feature Enabler (SFE)" on page 143, go to Step 2. If it was not possible, go to Step 3.

2. Reading the software features will have revealed if any software features were enabled for the radio under repair. If there were, go to Step 3. If there were none, go to Task 3.

3. Technicians **not** at a CSO should contact their CSO regarding the radio's software features. Technicians at CSOs should contact Technical Support at TEL.

4. Supply the serial number of the radio under repair, and the serial number of the replacement main-board assembly (located on a label on the main-board assembly).

5. If it is known that the radio had software features enabled, go to Step 6. Otherwise go to Step 7.

6. Ask the CSO (or TEL) for a licence file for the replacement main-board assembly. The CSO will supply the required file. Go to Step 8.

7. Ask the CSO (or TEL) if the radio under repair had any software features enabled, and if so, to send a licence file for the replacement main-board assembly. The CSO (or TEL) will either indicate that the radio had no software features enabled or supply the required file. If the radio had no software features enabled, go to Task 3. If the required file was supplied, go to Step 8.

8. On receiving the licence file, run the programming application on the test PC. On the menu bar click *Tools* > *Optional Features*. The *Software Feature Enabler* dialog appears.

9. Use the licence file to enable the appropriate software features. The procedure is given in the on-line help facility under the heading *Enabling a feature*. Go to Task 3.

Task 3 — Final Inspection

Make a final inspection of the exterior to check that no mechanical parts were damaged during the repair. Repeat the inspection given in "Visual Inspection" on page 139. Rectify any damage.

Task 4 — Final Test

Test the radio to confirm that it is fully functional again. The recommended tests are listed in Table 6.2 to Table 6.4. (The calibration application can be used for many of these tests.) It is good practice to record the test results on a separate test sheet. A copy of the test sheet can be supplied to the Customer as confirmation of the repair.

Task 5 — Final Administration

The final administration tasks are the standard workshop procedures for updating the fault database and returning the repaired radio to the Customer with confirmation of the repair.

If the radio could not be repaired for one of the following reasons:

- fault not located
- repair of fault failed
- required repair is level-3 repair

Level-1 service centers should return the faulty radio to the nearest ASC, and level-2 service centers should return the radio to the ISC. Supply details of the Customer, the fault and, if applicable, the attempted repair.

Table 6.2 Final tests of transmitter function

Test	Limits
Error in transmit frequency	+100 Hz to –100 Hz
Transmit power: • High • Medium • Low • Very low	 23.2 W to 29.2 W 11.1 W to 14.0 W 4.6 W to 5.8 W 0.9 W to 1.2 W
Current at high power: • B1-band radios • H5-band radios • H6-band radios	 < 5.5 A < 6.5 A < 6.5 A
Peak deviation (sweep tone of 300 Hz to 3 kHz): • Narrow-band • Medium-band • Wide-band	 ≤ 2.5 kHz ≤ 4.0 kHz ≤ 5.0 kHz
Distortion: • 1 kHz at 1.5 kHz deviation (narrow-band) • 1 kHz at 3.0 kHz deviation (wide-band)	 < 3% < 3%
CTCSS (continuous-tone-controlled subaudible signaling) deviation: • Narrow-band • Medium-band • Wide-band	 250 to 350 Hz 500 to 560 Hz 580 to 680 Hz

Table 6.3 Final tests of receiver functions

Test	Limits
Receive sensitivity	≤118 dBm for 12 dB SINAD
Mute opening: • Country • City • Hard	 >6 dB and <10 dB SINAD >8 dB and <14 dB SINAD >18 dB and <22 dB SINAD
Audio power (maximum volume at –47 dBm): • At “RX AUDIO/SINAD” connector on test unit • At pins 3 (SPK–) and 4 (SPK+) of power connector on radio	 >500 mV_{rms} >5.00 V_{rms}
Distortion (at –47 dBm, 60% rated system deviation at 1 kHz, with volume set to give 3 W into 16 Ω load)	<3.00%

Table 6.4 Final tests of general radio functions

Test	Description
PTT switch	Check that PTT switch functions.
Microphone	Check operation of microphone. Check operation of hook-switch.
Data communications	Test 1200 baud data transmission (standard). Test Tait high-speed data transmission (if feature is enabled).
Direct-connect GPS (global positioning system)	Check that GPS poll returns correct position (if feature is enabled).
Selcall	Check that radio encodes selcall. Check that radio decodes selcall.
Audio tap points and digital I/O	Check configuration of programmed options and test operation of these lines to confirm that Customer requirements are satisfied.

7 Power Supply Fault Finding

Fault-Diagnosis Tasks

Fault diagnosis of the power-supply circuitry is divided into six tasks:

- check inputs to SMPS
- check 3.3 V supply
- check linear regulators
- check power-up
- check power-up options

The regulators of concern in the third task are those for the 9V, 6V, 3V and 2.5V supplies.

Three Types of Fault

Which of the above tasks are applicable depends on the nature of the fault:

- radio fails to power up
- power-up option has failed
- external power at connector has failed

With the first fault, either the radio fails to power up immediately when power is applied, or it fails to power up when power is applied and the ON/OFF key is pressed. In this case carry out Task 1 to Task 3. With the second fault, the radio powers up when the ON/OFF key is pressed, but not for a power-up option for which it is configured. In this case carry out Task 4 and Task 5. With the third fault, the external power required at a particular connector is no longer present. In this case carry out Task 6.

Task 1 — Check Inputs to SMPS

The test equipment and radio should be set up as described in "Test Equipment Setup" on page 105. If not already done, remove the main-board assembly from the chassis. Connect the control head to the assembly. Then check the SMPS as follows:

1. Use a multimeter to check the supply voltage at pin 7 of **IC602** (see **Figure 7.1**) in the SMPS circuitry; the voltage should be:

pin 7 of IC602: 13.8 V DC

   If it is, go to Step 5. If it is not, go to Step 2.

2. Disconnect the 13.8V supply at the power connector PL100. Check for continuity and shorts to ground in the path between the power connector **PL100** and pin 7 of **IC602** (see **Figure 7.1**). Locate and repair the fault.

3. Reconnect the 13.8V supply. Confirm the removal of the fault by measuring the voltage at pin 7 of **IC602**. If the voltage is correct, continue with Step 4. If it is not, the repair failed; replace the main-board assembly and go to "Final Tasks" on page 147.

4. Press the ON/OFF key. If the radio powers up, return to "Initial Tasks" on page 139. If it does not, go to Step 5.

5. Check the digital power-up signal at pin 5 of **IC602** (see **Figure 7.1**); the signal is active high, namely, when the voltage exceeds 2.0V DC. Measure the voltage at pin 5.

pin 5 of IC602: more than 2.0 V DC

   If it exceeds 2.0V, go to Task 2. If it does not, go to Step 6.

6. Keep the probe of the multimeter on pin 5 of **IC602** and press the ON/OFF key. The voltage should exceed 2.0V DC while the key is depressed. If it does, go to Task 2. If it does not, go to Step 7.

7. Disconnect the 13.8V supply at the power connector PL100. Check for continuity and shorts to ground in the path from pin 5 of **IC602**, via **R600** and via **Q709** in the interface circuitry (see Figure 8.4), to pin 9 of the control-head connector **SK100** (ITF PSU ON OFF line). Locate and repair the fault. Go to Step 8.

8. Reconnect the 13.8V supply. Press the ON/OFF key. If the radio powers up, return to "Initial Tasks" on page 139. If it does not, go to Step 9.

9. With the probe of the multimeter on pin 5 of **IC602** (see Figure 7.1), press the ON/OFF key again. The voltage should exceed 2.0V DC while the key is depressed. If it does, go to Task 2. If it does not, the repair failed; replace the main-board assembly and go to "Final Tasks" on page 147.

Figure 7.1 Important components of the power-supply circuitry (bottom side), including 3.3V regulator IC602

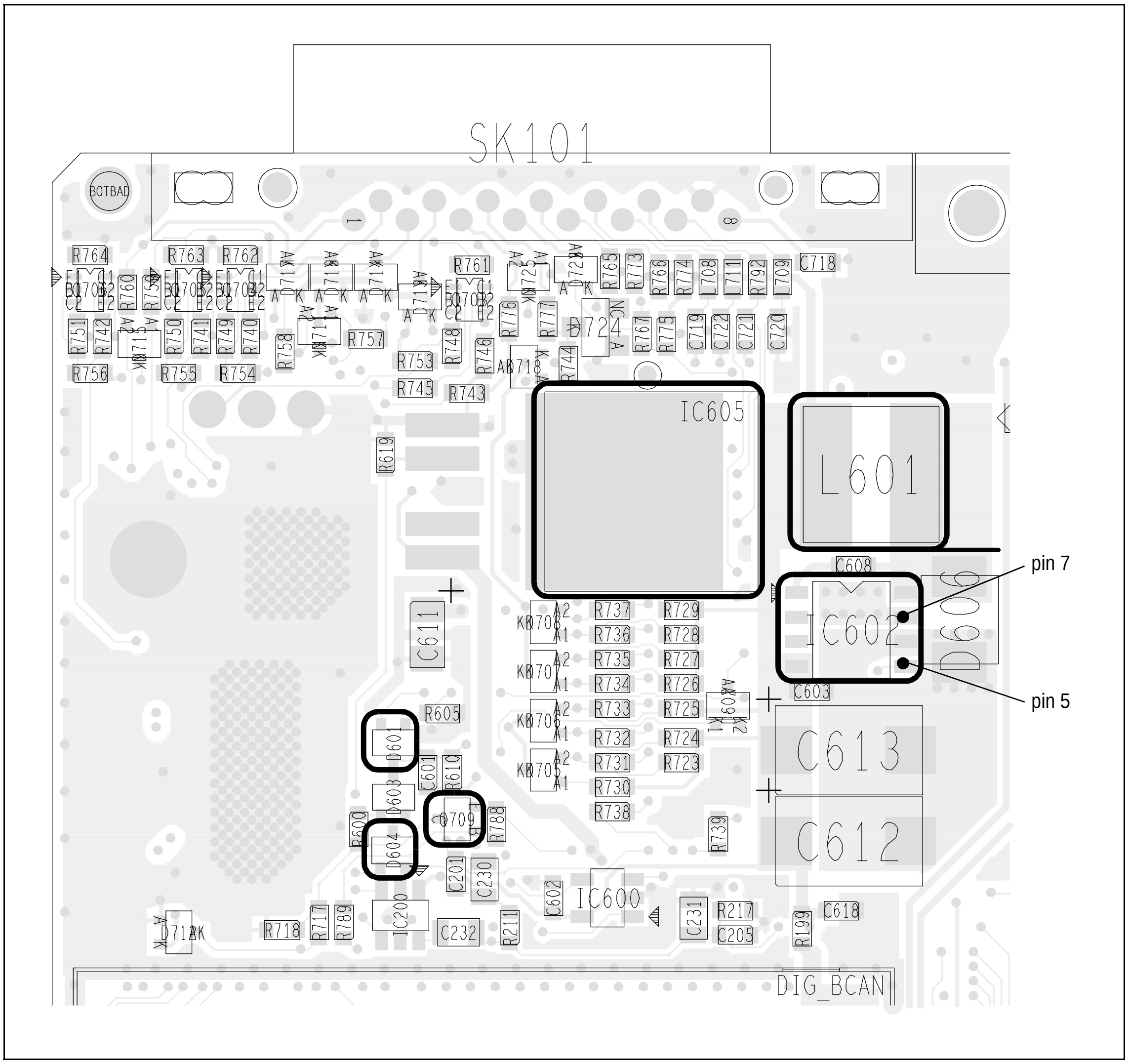
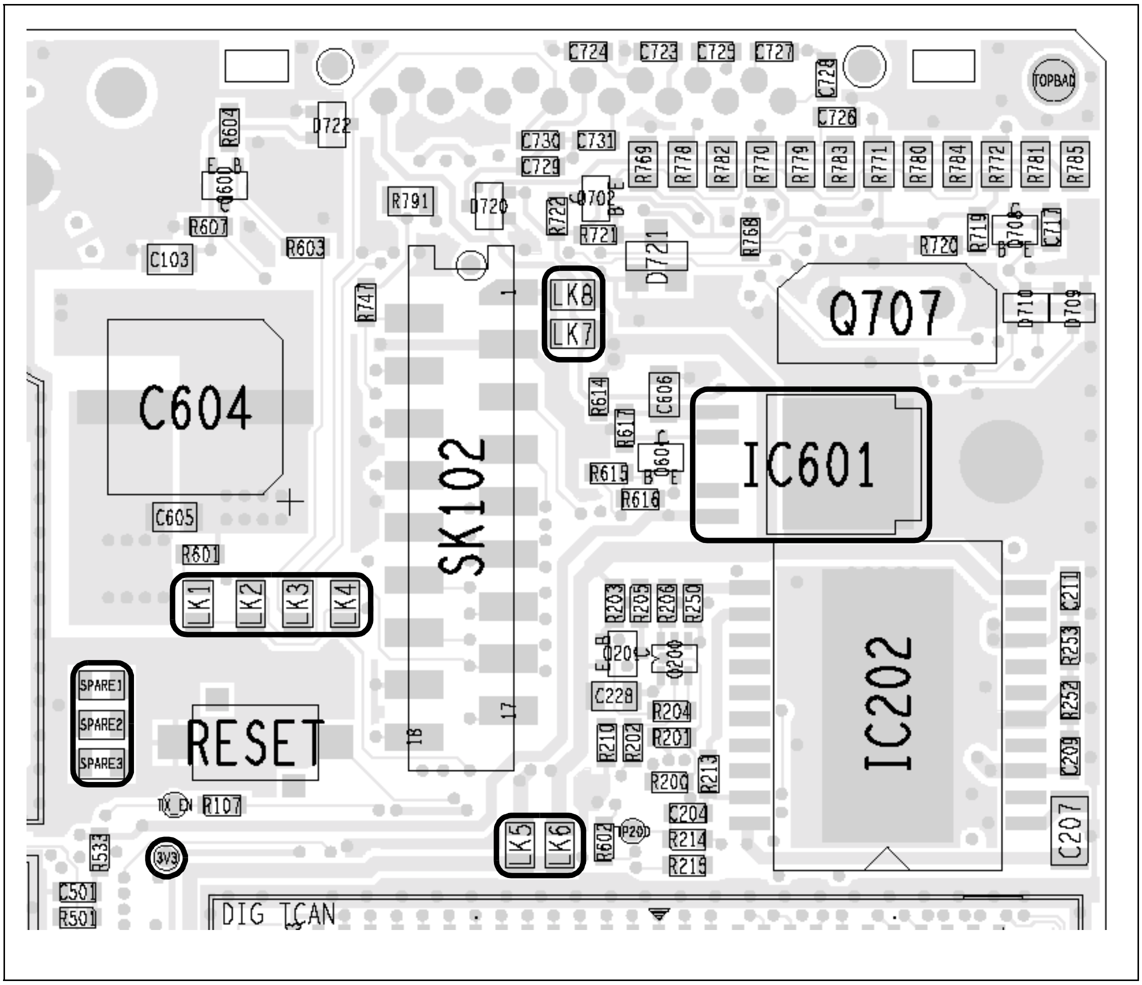


Figure 7.2 **Important components of the power-supply circuitry (top side), including 9 V regulator IC601**



Task 2 — Check 3.3 V Supply

If the inputs at pin 5 and pin 7 of IC602 in the SMPS circuitry are correct, but the radio fails to power up, then the 3.3V DC supply needs to be investigated.

1. First determine as follows if a fault on the digital board is affecting the supply or preventing the radio from powering up: While keeping the ON/OFF key depressed, measure the supply at the **3V3 test point** near the corner of the digital board (see **Figure 7.2**). The voltage is 3.3 V when there is no fault.

3V3 test point: 3.3 ± 0.1 V DC

   If the voltage is correct, the digital board is faulty; replace the main-board assembly and go to “Final Tasks” on page 147. If the voltage is not correct, go to Step 2.

2. Disconnect the 13.8V supply at the power connector. Remove **R199** (see **Figure 7.1**). Reconnect the 13.8V supply.

3. With the probe of the multimeter on the **3V3 test point**, press the ON/OFF key. If the voltage is now 3.3 ± 0.1V, the digital board is faulty; replace the main-board assembly and go to “Final Tasks” on page 147. If the voltage is still not correct, go to Step 4.

4. If the digital board is functional, the fault is on the main board. Replace **R199**. Disconnect the 13.8V supply. Use the multimeter to measure the resistance between the **3V3 test point** and ground. If there is a short circuit, continue with Step 5. If there is no short circuit (but the voltage is wrong), go to Step 7.

5. Search for shorts to ground in the components **C603**, **C612**, **C613**, **C618**, **D606** of the SMPS circuitry (see **Figure 7.1**) as well as in the CODEC and interface circuitry. Repair any fault and repeat the resistance measurement of Step 4 to confirm the removal of the fault. If there is no fault, go to Step 6. If the fault remains, the repair failed; replace the main-board assembly and go to “Final Tasks” on page 147.

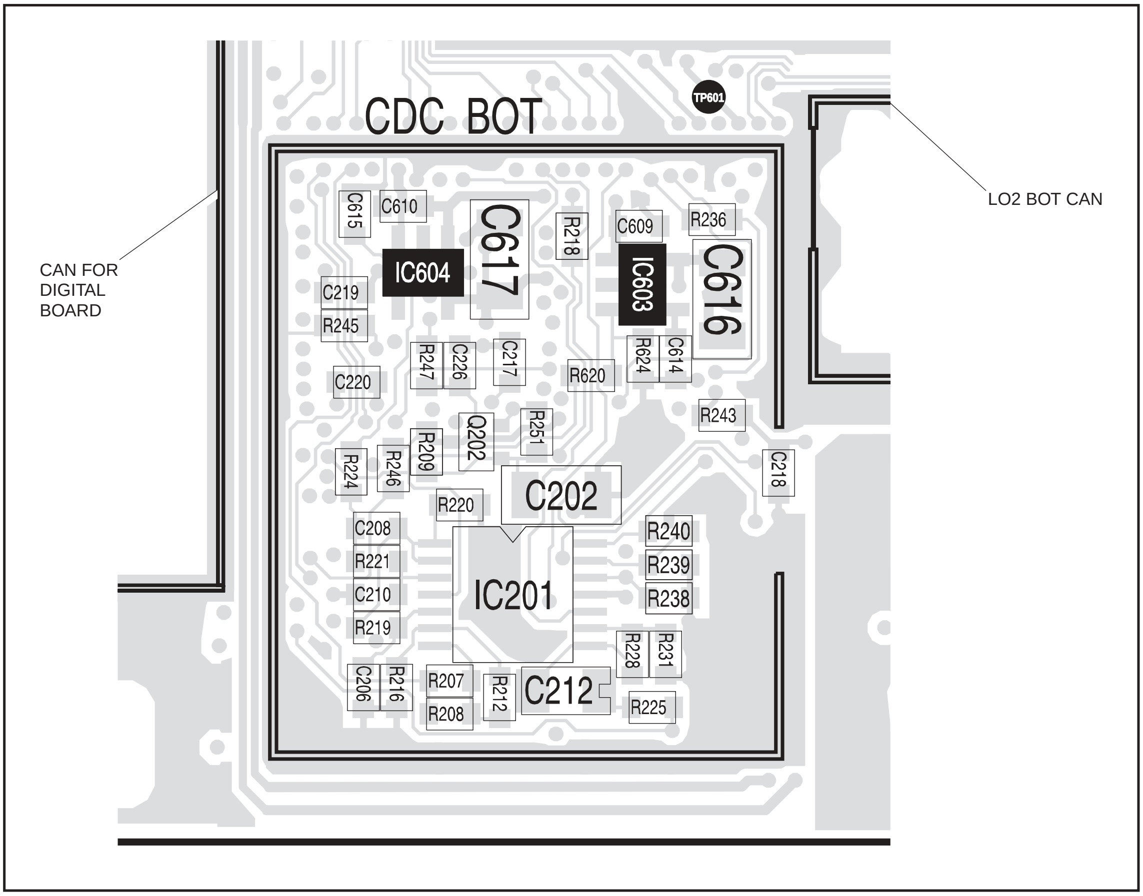
6. Reconnect the 13.8V supply. Press the ON/OFF key. If the radio powers up, return to “Initial Tasks” on page 139. If the radio fails to power up, disconnect the 13.8V supply and go to Step 7.

7. Measure the resistance of **L601** (see **Figure 7.1**). The resistance should be virtually zero. If it is, go to Step 8. If it is not, replace L601. Reconnect the 13.8V supply and press the ON/OFF key. If the radio powers up, return to “Initial Tasks” on page 139. If the radio fails to power up, disconnect the 13.8V supply and go to Step 8.

8. Remove the CDC BOT can. Remove **IC603** (3.0V regulator) and **IC604** (2.5V regulator) (see **Figure 7.3**). Reconnect the 13.8V supply and press the ON/OFF key. If the 3.3V supply is restored, go to Task 3 to check each regulator (3.0V and 2.5V) in turn. If the 3.3V supply is not restored, continue with Step 9.

9. Suspect **IC602**. Disconnect the 13.8V supply. Replace IC602 with a spare (see **Figure 7.1**). Resolder **IC603** and **IC604** in position (see **Figure 7.3**). Reconnect the 13.8V supply and press the ON/OFF key. If the radio powers up, return to “Initial Tasks” on page 139. If the radio fails to power up, the repair failed; replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 7.3 **Power-supply circuitry under the CDC BOT can, including 3V regulator IC603 and 2.5V regulator IC604**



Task 3 — Check Linear Regulators

This task describes the general procedure for checking any linear regulator. There are two possible faults: either the regulator has failed and prevents the radio from powering up, or the regulator voltage is incorrect. (The regulator IC might or might not have been removed during earlier checks.)

1. Disconnect the 13.8 V supply. Check for continuity and shorts to ground (if not already done) on the input, output and control line of the relevant regulator IC. Repair any fault.

2. If the regulator IC has been removed, resolder it in position.

3. Reconnect the 13.8 V supply and press the ON/OFF key. If the radio powers up or the correct regulator voltage is restored, return to "Initial Tasks" on page 139. If the repair failed, go to Step 4.

4. Disconnect the 13.8 V supply. Replace the regulator IC with a spare. Reconnect the 13.8 V supply and press the ON/OFF key. If the radio powers up or the correct regulator voltage is restored, go to "Final Tasks" on page 147. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 4 — Check Power-up Configuration

The radio may be configured for one or more of the following power-up options:

- battery power sense
- auxiliary power sense
- emergency power sense
- internal-options power sense

A particular option is implemented by inserting the link mentioned in Table 7.1. If there is a fault with a power-up option for which the radio is configured, first confirm that the configuration is correct:

1. Confirm that the correct link or links have been inserted for the required power-up options (see **Figure 7.2** and **Table 7.1**). For all except the battery-power-sense option, also check the radio's programming as follows:

2. Open the *"Programmable I/O"* form.

3. Under the *"Digital"* tab, scroll to the relevant digital line listed in the *"Pin"* field:
   - internal-options power sense: IOP GPIO7
   - auxiliary power sense: AUX GPI3
   - emergency power sense: AUX GPI2

4. For the first two lines, confirm that the *"Power Sense (Ignition)"* option has been selected in the *"Action"* field, and *"High"* or *"Low"* in the *"Active"* field. For the third line, confirm that *"Enter Emergency Mode"* has been selected.

5. If the link and programming settings are correct, go to Task 5. If they are not, rectify the settings and check if the fault has been removed. If it has, return to "Initial Tasks" on page 139. If it has not, go to Task 5.

Table 7.1 Implementation of the power-up options

Power-up option	Link to insert	Factory default	Activation mechanism	Connector
Battery power sense	LK1	Link in	Connection of 13.8V supply	Power connector
Auxiliary power sense	LK2	Link in	AUX GPI3 line goes high (If LK1 is in, line floats high; if LK1 is out, line floats low)	Pin 4 of auxiliary connector
Emergency power sense	LK3	Link in	AUX GPI2 line goes low	Pin 5 of auxiliary connector
Internal-options power sense	LK4	Link out	IOP GPIO7 line goes high	Pin 15 of internal-options connector

Task 5 — Check Power-up Options

The functioning of the power-up options may be checked as described in Step 1 to Step 4 below. Carry out the procedure in the appropriate step or steps. In all four cases the procedure involves checking the digital power-up signal at pin 5 of IC602. For a particular option, the activation mechanism is the condition that results in the power-up signal becoming active (the signal is active high).

1. For the battery power-sense option the link **LK1** should be inserted (see **Figure 7.2**). Check the power-up signal at pin 5 of **IC602** (see **Figure 7.1**) while first disconnecting and then reconnecting the 13.8V DC supply at the power connector.

   The power-up signal should go high when the power is reconnected. If it does, conclude with Step 5. If it does not, check for continuity and shorts to ground between the link **LK1** and the +13V8 BATT input at the power connector **PL100**. Repair any fault and go to Step 5.

2. For the auxiliary power-sense option the link **LK2** should be inserted (see **Figure 7.2**). Connect +3.3V DC (more than 2.6V to be precise) from the power supply to the AUX GPI3 line (pin 4 of the auxiliary connector **SK101**). Check that the power-up signal at pin 5 of **IC602** (see **Figure 7.1**) is high.

   Remove the +3.3V supply and ground the AUX GPI3 line (to be precise the voltage on the line should be less than 0.6V). If the power-up signal is now low, conclude with Step 5. If it is not, check for continuity and shorts to ground between **D601** (see **Figure 7.1**) and pin 4 of the auxiliary connector **SK101**. Repair any fault and go to Step 5.

3. For the emergency power-sense option the link **LK3** should be inserted (see **Figure 7.2**). Connect the AUX GPI2 line (pin 5 of the auxiliary connector **SK101**) to ground. Check that the power-up signal at pin 5 of **IC602** (see **Figure 7.1**) is high.

   Remove the connection to ground. If the power-up signal is now low, conclude with Step 5. If it is not, check for continuity and shorts to ground in the path from **D601** (see **Figure 7.1**), via **Q600** (see **Figure 7.2**), to pin 5 of the auxiliary connector **SK101**. Repair any fault and go to Step 5.

4. For the internal-options power-sense option the link **LK4** should be inserted (see **Figure 7.2**). Connect +3.3V DC (more than 2.6V to be precise) from the power supply to the IOP GPIO7 line (pin 15 of the internal-options connector **SK102**). Check that the power-up signal at pin 5 of **IC602** (see **Figure 7.1**) is high.

   Remove the +3.3V supply and ground the IOP GPIO7 line (to be precise the voltage on the line should be less than 0.6V). If the power-up signal is now low, conclude with Step 5. If it is not, check for continuity and shorts to ground between **D604** (see **Figure 7.1**) and pin 15 of the internal-options connector **SK102**. Repair any fault and go to Step 5.

5. After checking all the relevant power-up options, and if necessary repairing any faults, go to "Final Tasks" on page 147. If the fault could not be found or repairs failed, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 6 — Check Provision of External Power

External power is supplied to pin 8 of the auxiliary connector SK101. The power is normally switched, but will be unswitched if all the links LK5 to LK8 are inserted. (With all the links inserted, the power at the other connectors is also unswitched.)

External power, either switched or unswitched, is supplied to pin 2 of the control-head connector SK100. The power is switched or not depending on the links LK5 and LK6:

- switched power: LK5 in, LK6 out
- unswitched power: LK5 out, LK6 in

External power is also supplied to pin 1 of the internal-options connector SK102. The power is switched or not depending on the links LK7 and LK8:

- switched power: LK7 in, LK8 out
- unswitched power: LK7 out, LK8 in

If there is a fault with the supply of external power to any of these connectors, first confirm the link settings required and then carry out the following procedure:

1. With the radio powered up, confirm that 13.8V DC is present at pin 3 of **IC605** (see **Figure 7.1**) and more than 3V DC at pin 2.

2. Check that 13.8 V is present at pin 5 of **IC605**. If there is, go to Step 3. If there is not, go to Step 4.

3. Check for an open circuit between pin 5 of **IC605** and the relevant pin of the connector in question. Repair any fault, confirm the removal of the fault, and go to “Final Tasks” on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 147.

4. Check for continuity between pin 5 of **IC605** and the relevant pin of the connector in question. Check for shorts to ground, check **C718** at the auxiliary connector (see **Figure 7.1**), and check **C715** at the internal-options connector (see **Figure 8.2**).

5. Repair any fault found in the above checks. If no fault could be found, replace **IC605**.

6. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

8 Interface Fault Finding

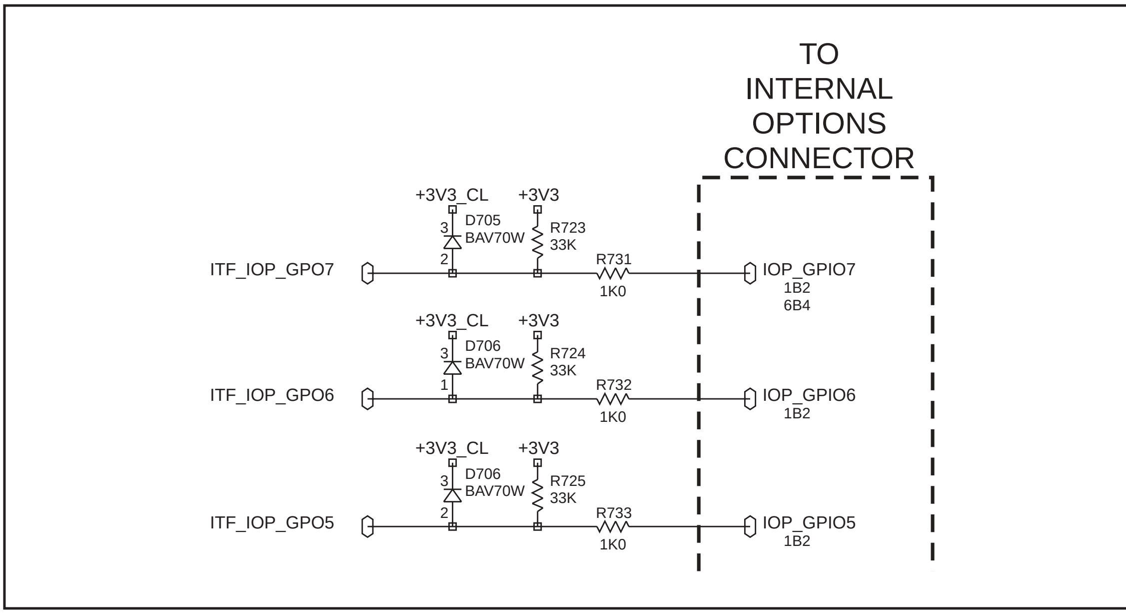
Introduction

This section covers the diagnosis of faults involving signals output from or input to the radio's internal circuitry via the control-head, internal options, power, or auxiliary connectors. For most inputs and outputs, filtering or basic processing is applied between the internal circuitry and the connectors.

Internal and Connector Signals

The signals at the internal circuitry and those at the connectors are distinguished as internal signals and connector signals respectively. On the circuit diagram for the internal circuitry, dashed lines enclose connector signals. Internal signals are all named signals outside these enclosures. In Figure 8.1, which shows part of the internal options connector as an example, IOP GPIO7 is a connector signal and ITF IOP GPIO7 is an internal signal.

Figure 8.1 Example illustrating the convention for internal and connector signals



Types of Signals

The connector and internal signals can be of three types:

- output lines
- input lines
- bi-directional lines

For diagnosing faults in these three cases, carry out Task 1, Task 2 or Task 3 respectively. Where components need to be replaced to rectify faults, refer to Figure 8.3 to Figure 8.4 for the locations of the components. These figures show the three areas of the main board where the components of the interface circuitry are situated.

Figure 8.2 Components of the interface circuitry (top side near the CDC TOP and IF TOP cans)

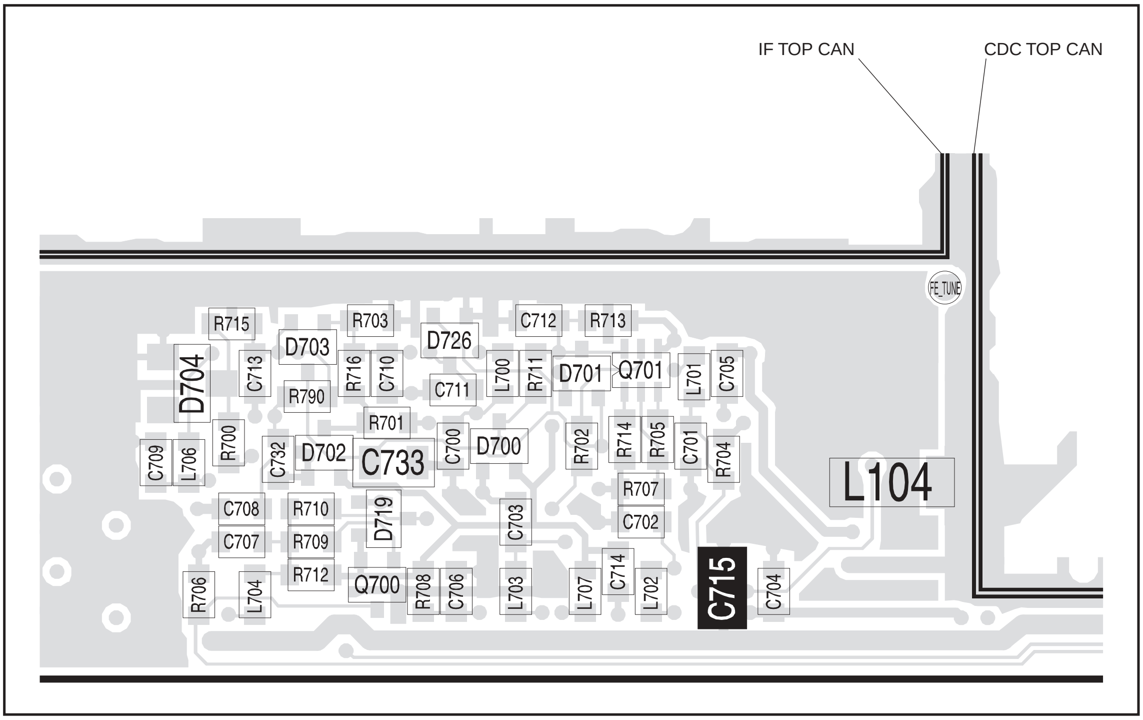
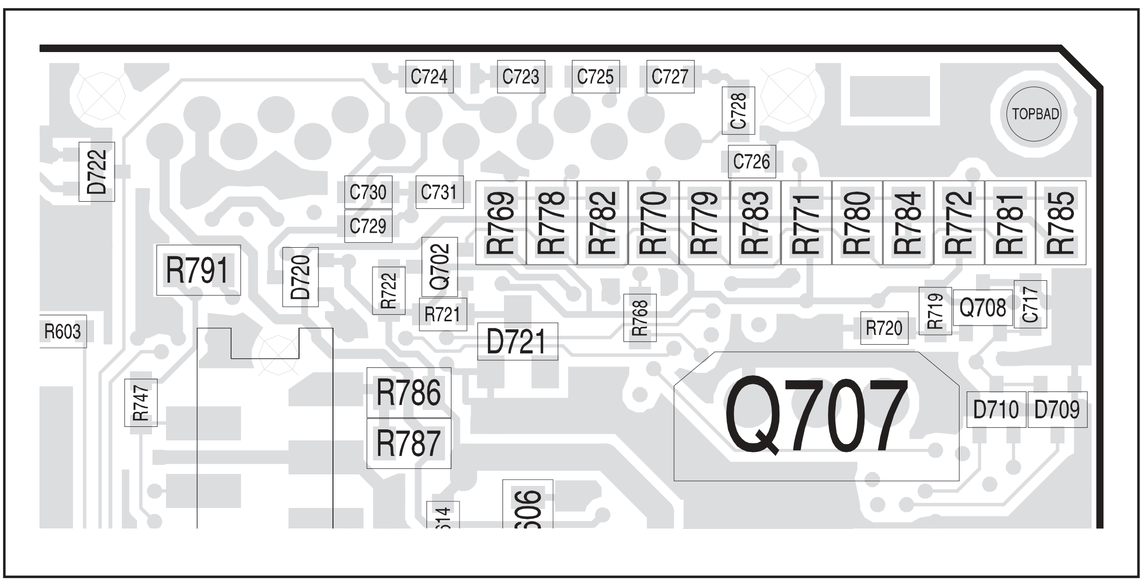


Figure 8.3 Components of the interface circuitry (top side at the corner)



Task 1 — Check Output Lines

For an output line suspected or reported to be faulty, compare actual and expected signals as described below. If necessary, determine what an expected signal should be by copying the faulty radio's programming file into a serviceable radio and measuring the relevant points on the latter.

1. Check the electrical signal at the appropriate pin of a connector mated to the radio connector in question. If the expected connector signal is not present, go to Step 3. If it is, go to Step 2.

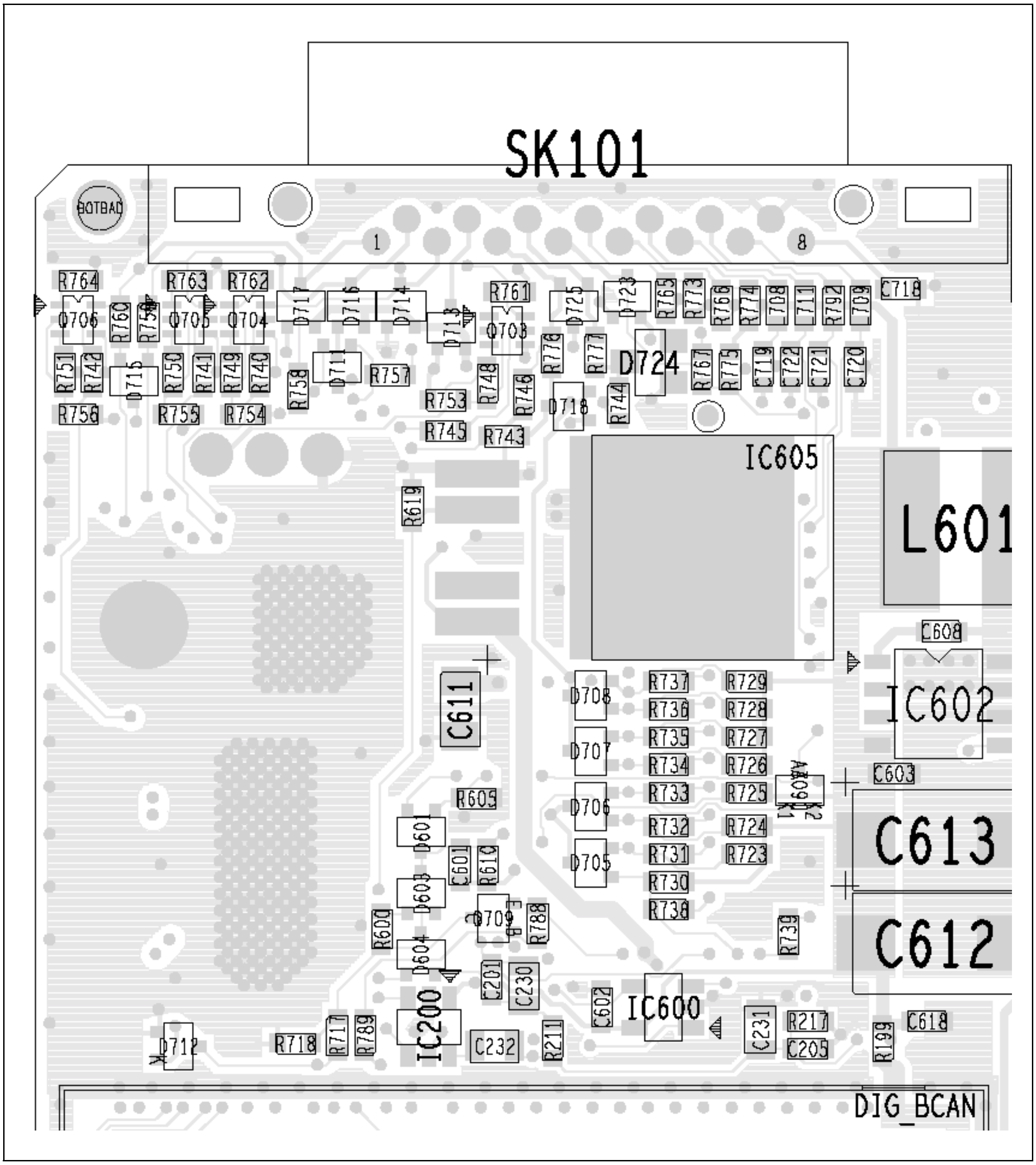
2. If the expected signal is present, there might be no fault on that line or there could be an intermittent fault. Subject the radio to mild mechanical shock or vibration, or to a temperature change. This might expose any intermittent contact, in which case go to Step 3.

3. If the expected signal is not present, check whether the expected internal signal is present. If it is, go to Step 5. If it is not, go to Step 4.

4. The fault lies with the radio's internal circuitry. If the power-supply circuitry or the CODEC and audio circuitry is suspect, continue with the fault diagnosis as in "Power Supply Fault Finding" on page 153 and "CODEC and Audio Fault Finding" on page 371 respectively. If the digital board is suspect, replace the main-board assembly and go to "Final Tasks" on page 147.

5. The fault lies in the filtering, basic processing, or connector for the line under test. Re-solder components or replace damaged or faulty components as necessary. Confirm the removal of the fault and go to "Final Tasks" on page 147. If the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 147.

Figure 8.4 Components of the interface circuitry (bottom side)



Task 2 — Check Input Lines

For an input line suspected or reported to be faulty, proceed as follows:

1. For a suspect CH ON OFF line, go to Step 4. For all other input lines go to Step 2.

2. For the suspect line, apply a 3.3V DC test signal to a connector mated to the radio connector in question.

3. Check the internal signal for the line under test. If 3.3V DC is present, go to Step 7. If it is not, go to Step 8.

4. For the CH ON OFF line, apply a short to ground on pin 5 of a connector mated to the control-head connector. Check that there is 3.9V DC present on the ITF ON OFF line, and that PSU ON OFF is approximately equal to the radio's primary supply voltage, nominally 13.8V DC.

5. Remove the short on the connector. Check that, with CH ON OFF open-circuit, both ITF ON OFF and ITF PSU ON OFF are close to 0.0V.

6. If the voltages given in Step 4 and Step 5 are observed, go to Step 7. If they are not, go to Step 8.

7. The fault lies with the radio's internal circuitry. If the power-supply circuitry or the CODEC and audio circuitry is suspect, continue with the fault diagnosis as in "Power Supply Fault Finding" on page 153 and "CODEC and Audio Fault Finding" on page 371, respectively. If the digital board is suspect, replace the main-board assembly and go to "Final Tasks" on page 147.

8. The fault lies in the filtering, basic processing, or connector for the line under test. Re-solder components or replace faulty com-ponents as necessary. Confirm the removal of the fault and go to "Final Tasks" on page 147. If the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 3 — Bi-directional Lines

For a bi-directional line suspected or reported to be faulty, proceed as described below. In the procedure the direction of the line will need to be configured. For information on this topic consult the on-line help facility on the programming application's *"Programmable I/O"* page.

1. Configure the suspect line as an output, and then carry out the procedure given in Task 1.

2. Configure the suspect line as an input, and then carry out the procedure given in Task 2.

9 Frequency Synthesizer Fault Finding

Introduction

This section covers the diagnosis of faults in the frequency synthesizer. The sections are divided into the following:

- Initial checks
- Fault diagnosis of RF PLL circuitry
- Fault diagnosis of FCL circuitry

The initial checks will indicate whether it is the RF PLL or the FCL that is suspect. Note that the synthesizer is a closed-loop control system. A fault in one area can cause symptoms to appear elsewhere. Locating the fault can therefore be difficult.

Measurement Techniques

The radio must be in CCTM for all the fault-diagnosis procedures of this section. The CCTM commands required are listed in Table 9.1. Full details of the commands are given in “Computer-Controlled Test Mode (CCTM)” on page 112. Use an oscilloscope with a x10 probe for all voltage measurements required. The signals should appear stable and clean. Consider any noise or unidentified oscillations as evidence of a fault requiring investigation. Use a frequency counter for all measurements of high frequencies. The RF power output from the frequency synthesizer will not exceed 10mW. If a probe is used for frequency measurements, use the x1 setting.

Table 9.1 CCTM commands required for the diagnosis of faults in the frequency synthesizer

Command	Description
72	Read lock status of RF PLL, FCL and LO2 — displays **xyz** (0=not in lock, 1=in lock)
101 **x y** 0	Set transmit frequency (**x** in hertz) and receive frequency (**y** in hertz) to specified values
205	Reset calibration parameters to their default values
301 0 10	Calibrate VCXO of FCL
302 0 10	Calibrate VCO(s) of RF PLL
334 **x**	Set synthesizer on (**x**=1) or off (**x**=0) via DIG SYN EN line
335 **x**	Set transmit-receive switch on (**x**=1) or off (**x**=0) via DIG SYN TR SW line
389 **x**	Set synthesizer mode to slow (**x**=0) or fast (**x**=1)
393 1 **x**	Write data **x** to FPGA

9.1 Initial Checks

Types of checks

There are two different types of initial checks, which are covered in the following tasks:

- Task 1: calibration checks
- Task 2: lock status

Which, if any, of these tasks needs to be carried out depends on the symptoms of the fault.

Symptoms of Fault

The symptoms of the fault may be divided into three categories:

- radio fails to power up and *System error* is displayed
- *Out of lock* is displayed
- radio is in lock but exhibits transmit or receive fault

In the first two cases the checks of Task 1 and Task 2 respectively are required. In the last case there are several symptoms; these are listed below.

Transmit and Receive Faults

A transmit or receive fault will be implied by one of the following consequences:

- radio fails to receive or receive performance is degraded
- radio fails to enter transmit mode
- radio exits transmit mode unexpectedly
- radio enters transmit mode but fails to transmit
- radio enters transmit mode but transmit performance is degraded

With a fault of this kind, neither of the initial tasks is required. Fault diagnosis should begin with "Power Supplies" on page 173.

Summary

To summarize, given the nature of the fault, proceed to the task or section indicated below:

- Task 1: system error
- Task 2: lock error
- "Power Supplies": transmit or receive fault

The checks of Task 1 and Task 2 will indicate the section with which the fault diagnosis should continue. Note that there are some differences in the fault-diagnosis procedures, depending on whether the radio is a UHF (H5 and H6 bands) or VHF (B1 band) radio. The product-code label on the radio body will identify the frequency band as described in "Product Codes" on page 16.

Task 1 — System Error

A system error indicates a fault in the calibration of either the FCL or the frequency synthesizer. To determine which is faulty, calibrate the VCXO and the transmit VCO as described below. (Always calibrate the former first, because the latter depends on the former.)

1. Place the radio in CCTM.

2. Enter the CCTM command *301 0 10* to calibrate the VCXO. The response will be one of the following three messages:
   - *"passed sanity check. Cal'd values put into effect"*
   - *"failed sanity check. Cal'd values not in effect"*
   - *"Cal failed: lock error"*

   The first two messages will be preceded by <u>four</u> calibration values.

3. In the case of the first message (passed), go to Step 4. In the case of the second and third messages (failed), the FCL is suspect; go to "Power Supply for FCL" on page 215.

4. Enter the CCTM command *302 0 10* to calibrate the transmit VCO. The response will be one of the three messages listed in Step 2. The first two messages will be preceded by <u>eight</u> calibration values. Reset the radio and re-enter CCTM.

5. If the calibration succeeded but the system error persists, replace the main-board assembly and go to "Final Tasks" on page 147. In the case of the second message (failed sanity check), go to Step 6. In the case of the third message (calibration failed), go to Step 8 (UHF radios) or "Power Supplies" on page 173 (VHF radios).

6. Enter the CCTM command *205* to reset the calibration values to the default values. Then enter the CCTM command *302 0 10* again to calibrate the transmit VCO.

7. If the calibration succeeded, confirm the removal of the fault, and go to "Final Tasks" on page 147. If the calibration failed, go to Step 8 (UHF radios) or "Power Supplies" on page 173 (VHF radios).

8. Program the radio with the <u>maximum</u> frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in hertz.

9. Enter the CCTM command *72* to determine the lock status in receive mode. Note the response.

lock status=**xyz** (**x**=RF PLL; **y**=FCL; **z**=LO2) (0=not in lock; 1=in lock)

10. If the lock status is *111* or *110*, the synthesizer is functioning in the receive mode, and the power supplies and PLL are functioning correctly. Go to “Loop Filter” on page 187 to check the loop filter, VCOs, and buffer amplifiers. If the lock status is *011* or *010*, the synthesizer is faulty in the receive mode. Go to “Power Supplies” on page 173.

Task 2 — Lock Status

A lock error indicates that the frequency synthesizer, FCL or second LO is out of lock. To determine which is faulty, check the lock status as described below.

1. If not already done, place the radio in CCTM.

2. Program the radio with the receive frequency of a channel that is known to be out of lock: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in hertz.

3. Enter the CCTM command *72* to determine the lock status in receive mode. Note the response. The action required depends on the lock status as described in the following steps.

lock status=**xyz** (**x**=RF PLL; **y**=FCL; **z**=LO2) (0=not in lock; 1=in lock)

4. If the lock status is ***x0x***, where ***x*** is *0* or *1*, the FCL is suspect; go to “Power Supply for FCL” on page 215.

5. If the lock status is *011*, the synthesizer is suspect, although the power supplies are functioning correctly; go to “Loop Filter” on page 187.

6. If the lock status is *010*, the synthesizer and second LO are both out of lock. First investigate the synthesizer, excluding the power supplies; go to “Loop Filter” on page 187. If necessary, investigate the receiver later.

7. If the lock status is *110*, the second LO is out of lock. Go to “Receiver Fault Finding” on page 227.

8. If the lock status is *111*, this implies normal operation. But if the lock error persists, replace the main-board assembly and go to “Final Tasks” on page 147.

9.2 Power Supplies

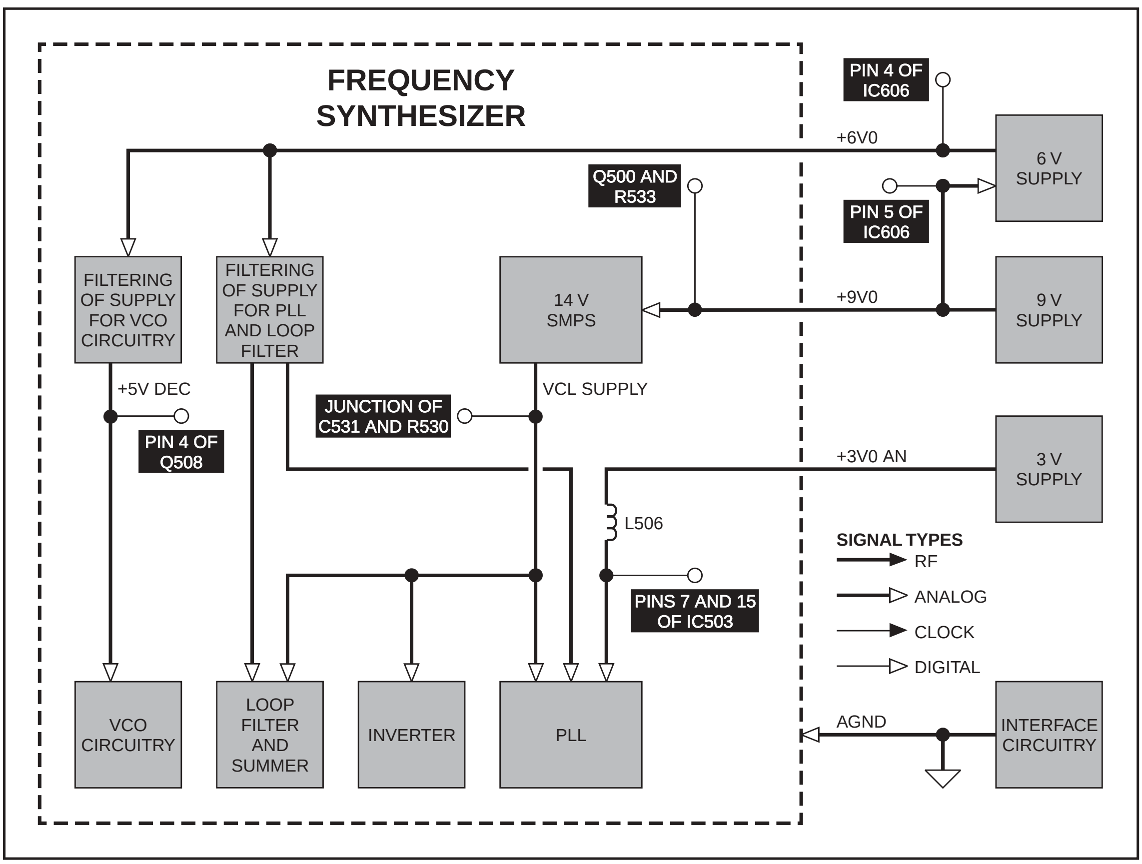
Introduction

First check that a power supply is not the cause of the fault. There are four power supplies for the frequency synthesizer — two are supplied from the PSU (power supply unit) module and two are produced in the synthesizer circuitry itself:

- Task 3: 14 V DC supply from SMPS (VCL SUPPLY)
- Task 4: 6 V DC supply from 6 V regulator in PSU module (+6V0)
- Task 5: 5 V DC supply following filtering of 6 V supply (+5V DEC)
- Task 6: 3 V DC supply from 3 V regulator in PSU module (+3V0 AN)

The measurement points for diagnosing faults in the power supplies are summarized in Figure 9.1.

Figure 9.1 Measurement points for the frequency synthesizer power supply circuitry



Task 3 — 14V Power Supply

First check the output VCL SUPPLY from the SMPS, which is itself provided with a 9V DC supply from a 9V regulator in the PSU module.

1. Remove the main-board assembly from the chassis.

2. Place the radio in CCTM.

3. Measure the SMPS output VCL SUPPLY at the via between **C531** and **R530** (see **Figure 9.2**).

C531: 14.2 V ± 0.3 DC

4. If the SMPS output is correct, go to Task 4. If it is not, go to Step 5.

5. Check the 9 V supply at **Q500** and **R533** (see **Figure 9.3**).

Q500 and R533: 9.0 V ± 0.3 DC

6. If the voltage is correct, go to Step 7. If it is not, the 9V regulator **IC601** is suspect; go to Task 3 of “Power Supply Fault Finding” on page 158.

7. Remove the FCL TOP can and check the SMPS circuit based on **Q500**, **Q502** and **L502** (see **Figure 9.3**).

   Remove the SYN BOT can and check **IC504** and **IC505** for shorts (see **Figure 9.4**); replace any suspect IC.

8. If a fault is found, repair the circuit, confirm the removal of the fault, and go to “Final Tasks” on page 147. If the repair failed or no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 9.2 Synthesizer circuitry under the SYN TOP can and the 6 V regulator IC606 (top side)

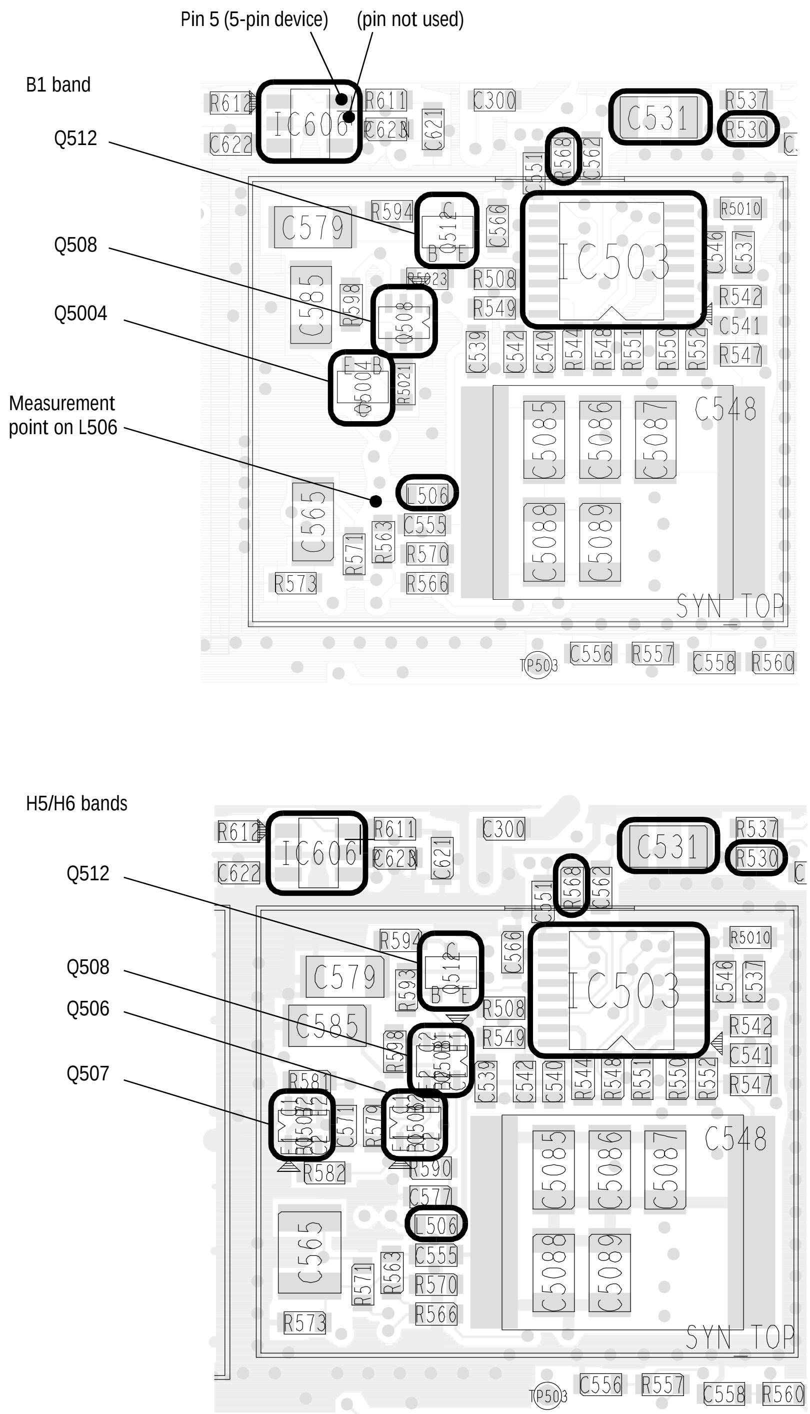
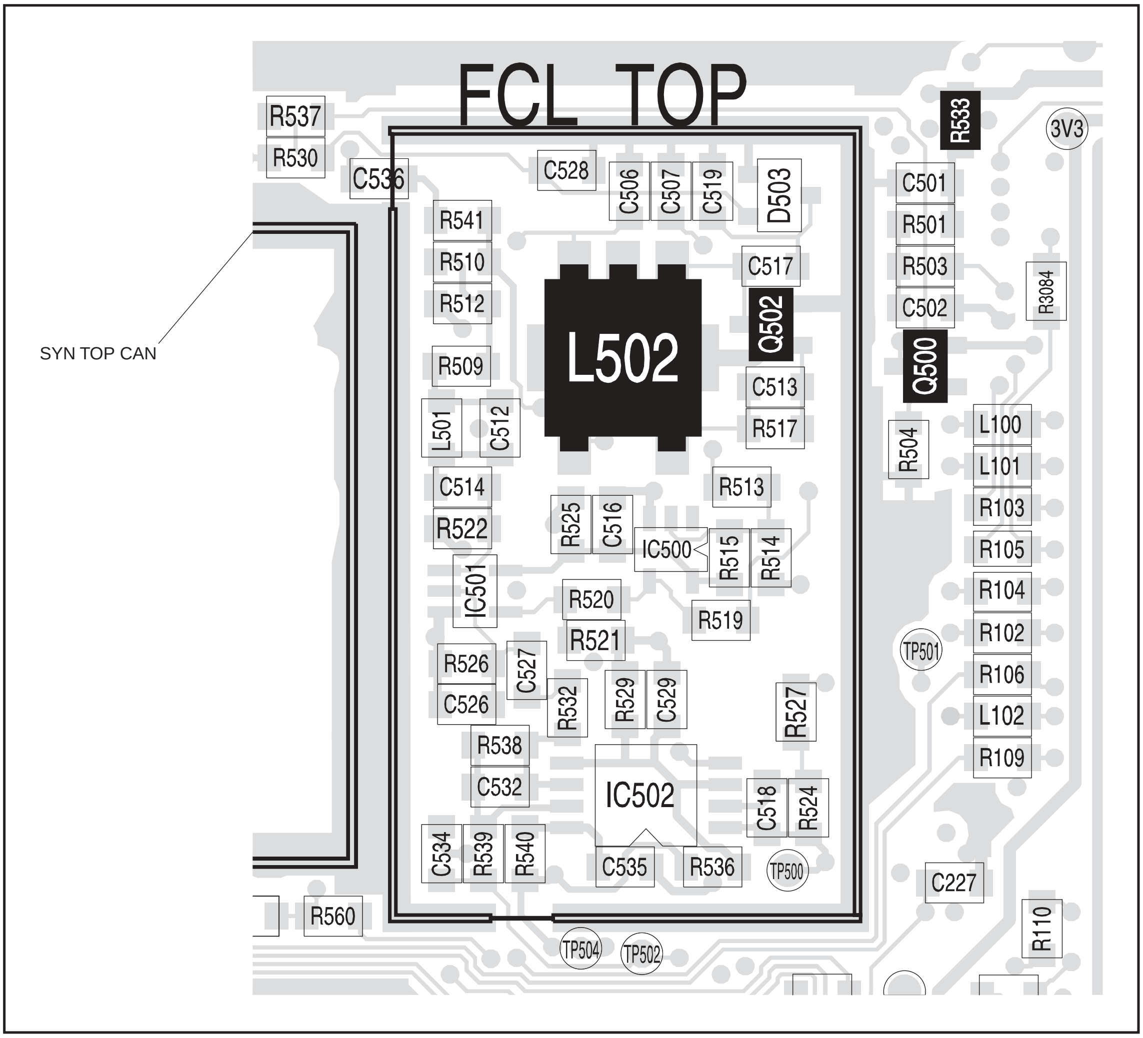


Figure 9.3 Synthesizer circuitry under the FCL TOP can (top side)



Task 4 — 6V Power Supply

If the output of the SMPS is correct, check the 6V DC supply next.

1. Measure the supply +6V0 at pin 4 of **IC606** (see **Figure 9.2**).

pin 4 of IC606: 6.0 ± 0.3V DC

2. If the voltage is correct, go to Task 5. If it is not, measure the 9V input at pin 5 of **IC606** (see **Figure 9.2**).

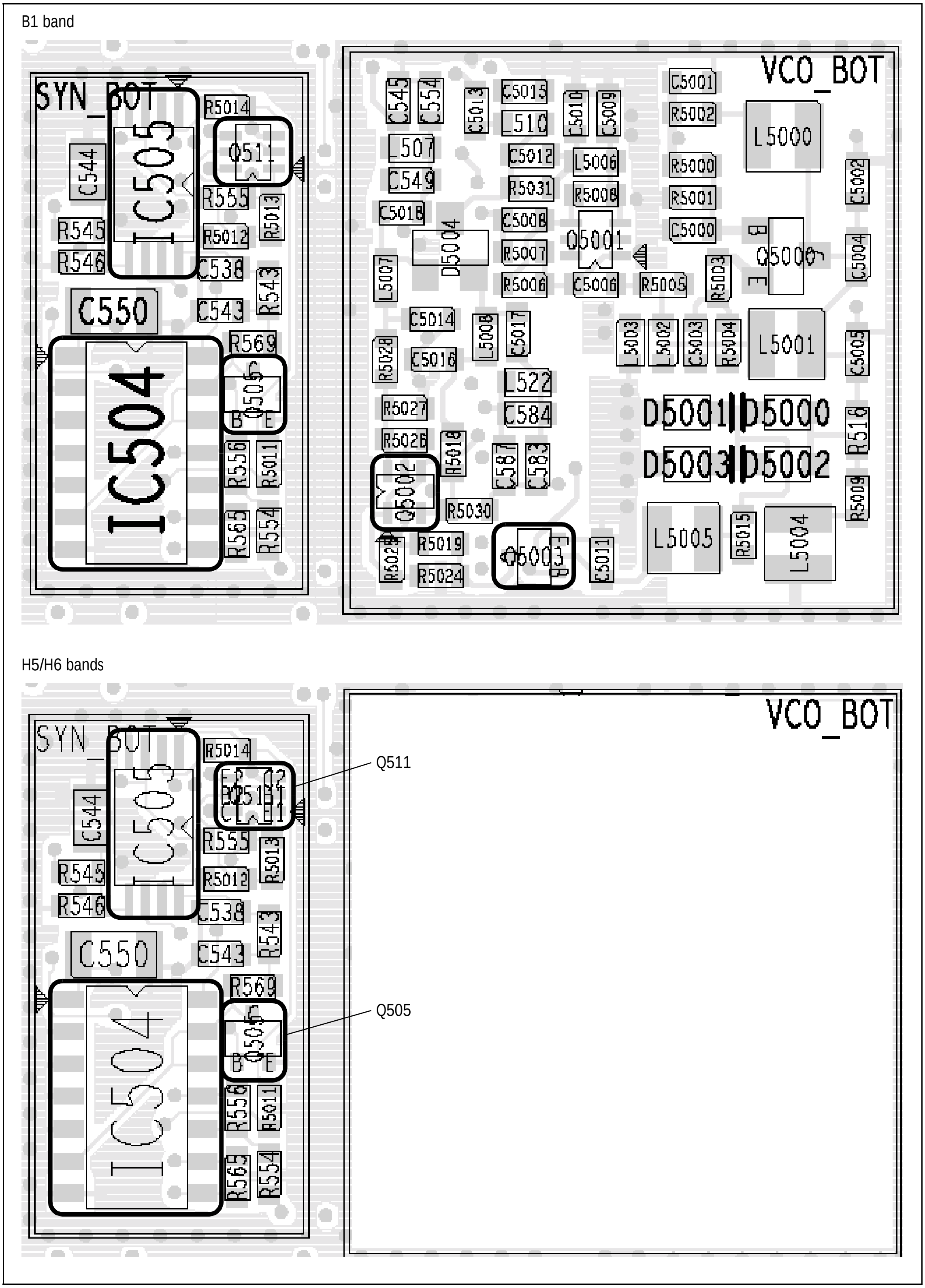
pin 5 of IC606: 9.0 ± 0.3V DC

3. If the voltage is correct, go to Step 4. If it is not, the 9V regulator **IC601** is suspect; go to Task 3 of "Power Supply Fault Finding" on page 158.

4. If the input to the regulator **IC606** is correct but not the output, check IC606 (see **Figure 9.2**) and the associated circuitry; if necessary, replace IC606.

   Remove the SYN TOP can and check the C-multipliers **Q508** (pins 3, 4, 5) and **Q512** for shorts (see **Figure 9.2**); replace any suspect transistor.

5. If a fault is found, repair the circuit, confirm the removal of the fault, and go to "Final Tasks" on page 147. If the repair failed or no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 147.



B1 band
SYN_BOT
VCO_BOT
IC505
IC504
Q511
Q505
C544
C550
R545
R546
R5014
R555
R5012
R5013
C538
C543
R543
R569
R556
R5011
R565
R554
C545
C554
C5013
C5015
L510
C5010
C5009
C5001
R5002
L5000
L507
C549
C5012
L5006
R5000
C5002
R5031
R5008
R5001
C5018
D5004
C5008
Q5001
C5000
Q5000
R5007
C5004
L5007
R5006
C5006
R5005
R5003
C5014
L5008
C5017
L5003
L5002
C5003
R5004
L5001
C5005
R5028
C5016
L522
C584
D5001
D5000
R516
R5027
R5026
R5010
C587
C583
D5003
D5002
Q5002
R5030
R5009
R5019
Q5003
C5011
L5005
R5015
L5004
R5029
R5024
H5/H6 bands

Task 5 — 5V Power Supply

If the SMPS output and 6V DC supply are correct, check the +5V DEC supply next.

1. Remove the SYN TOP can.
2. Measure the supply +5V DEC at pin 4 of **Q508** (see **Figure 9.2**).

pin 4 of Q508: 5.3 ± 0.3V DC

3. If the voltage is correct, go to Task 6. If it is not, go to Step 4 (UHF radios) or Step 5 (VHF radios).
4. With a UHF radio check for faults in the C-multiplier **Q508** (pins 3, 4, 5) and the 5V and transmit-receive switches based on **Q506**, **Q507** and **Q508** (pins 1, 2, 6) (see **Figure 9.2**). Replace any suspect transistor. Conclude with Step 6.
5. With a VHF radio check for faults in the C-multiplier and 5V switch based on **Q508** and **Q5004** (see **Figure 9.2**). Remove the VCO BOT can and check the transmit-receive switch based on **Q5002** and **Q5003** (see **Figure 9.4**). Replace any suspect transistor. Conclude with Step 6.
6. If a fault is found, repair the circuit, confirm the removal of the fault, and go to "Final Tasks" on page 147. If the repair failed or no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 6 — 3V Power Supply

If the SMPS output and the 6V and 5V supplies are correct, the remaining power supply to check is the 3V DC supply.

1. Measure the supply +3V0 AN at pins 7 and 15 of **IC503** (see **Figure 9.2**).

pins 7 and 15 of IC503: 2.9 ± 0.3V DC

2. If the voltage is correct, go to “Phase-locked Loop” on page 181. If it is not, go to Step 3.

3. Check the supply at **L506** (see **Figure 9.2**). The measurement point is the via shown in the figure.

L506: 2.9 ± 0.3V DC

4. If the voltage is correct, go to Step 5. If it is not, the 3 V regulator **IC603** is suspect; go to Task 3 of “Power Supply Fault Finding” on page 158.

5. Check the components in the path from **L506** to **IC503**. Also check IC503; if necessary, replace IC503 (see **Figure 9.2**).

6. If a fault is found, repair the circuit, confirm the removal of the fault, and go to “Final Tasks” on page 147. If the repair failed or no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 147.

9.3 Phase-locked Loop

Introduction

If there is no fault with the power supplies, check the critical output from, and inputs to, the PLL:

- Task 7: supply for charge pump
- Task 8: reference frequency input
- Task 9: DIG SYN EN line input
- Task 10: SYN LOCK line output

The measurement points for diagnosing faults concerning the PLL inputs and output are summarized in Figure 9.5.

Task 7 — Supply for Charge Pump

First check the supply for the charge pump of the PLL.

1. Measure the supply for the charge pump at pin 16 of **IC503** (see **Figure 9.2**).

pin 16 of IC503: 5.0 ± 0.3 V DC

2. If the voltage is correct, go to Task 8. If it is not, go to Step 3.

3. Check the C-multiplier **Q512** (see **Figure 9.2**) and check **IC503** itself; if necessary, replace the transistor or IC.

4. If there is a fault, repair the circuit, confirm the removal of the fault, and go to “Final Tasks” on page 147. If the repair failed or no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 9.5 Test and measurement points for the synthesizer PLL and loop filter

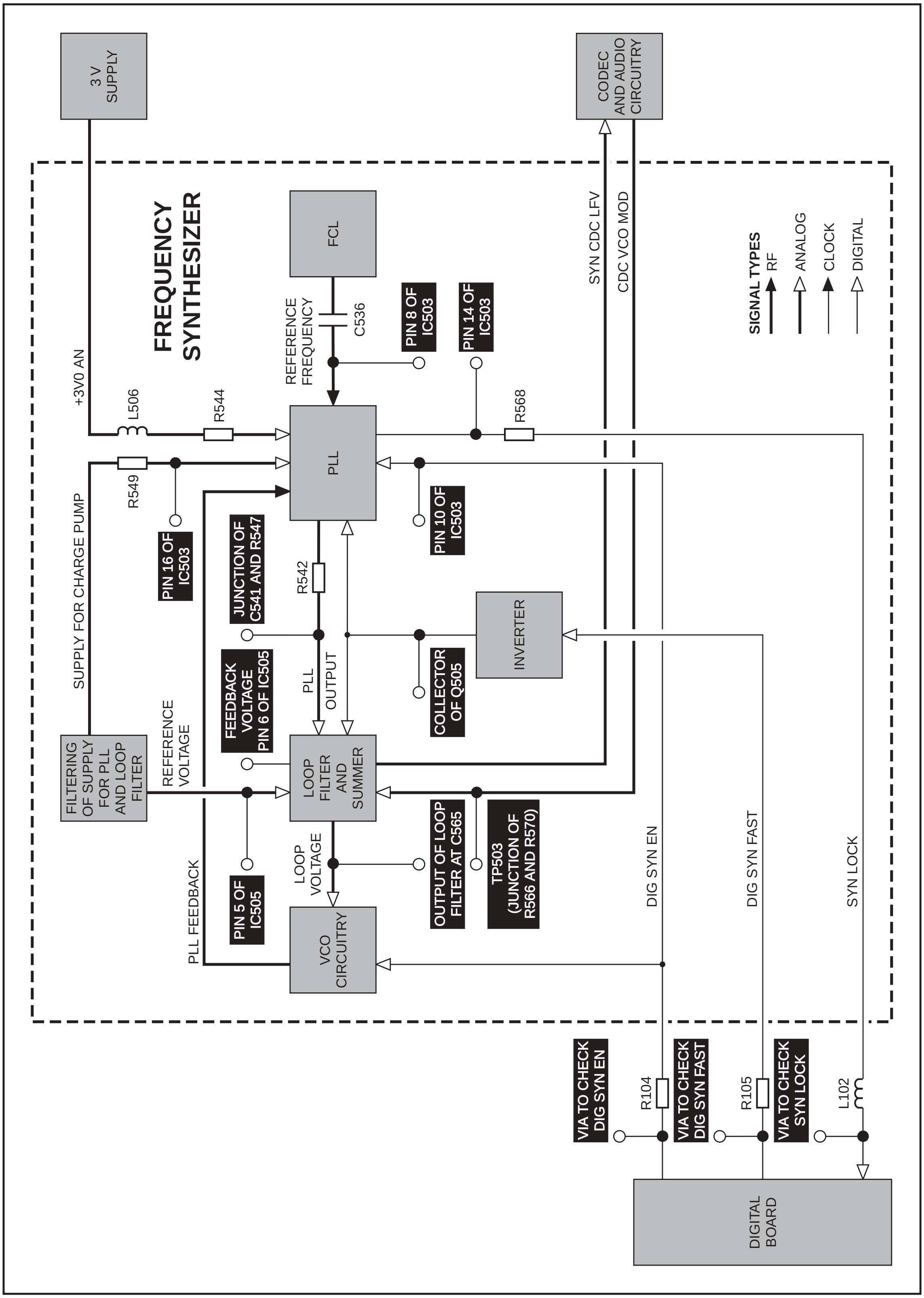
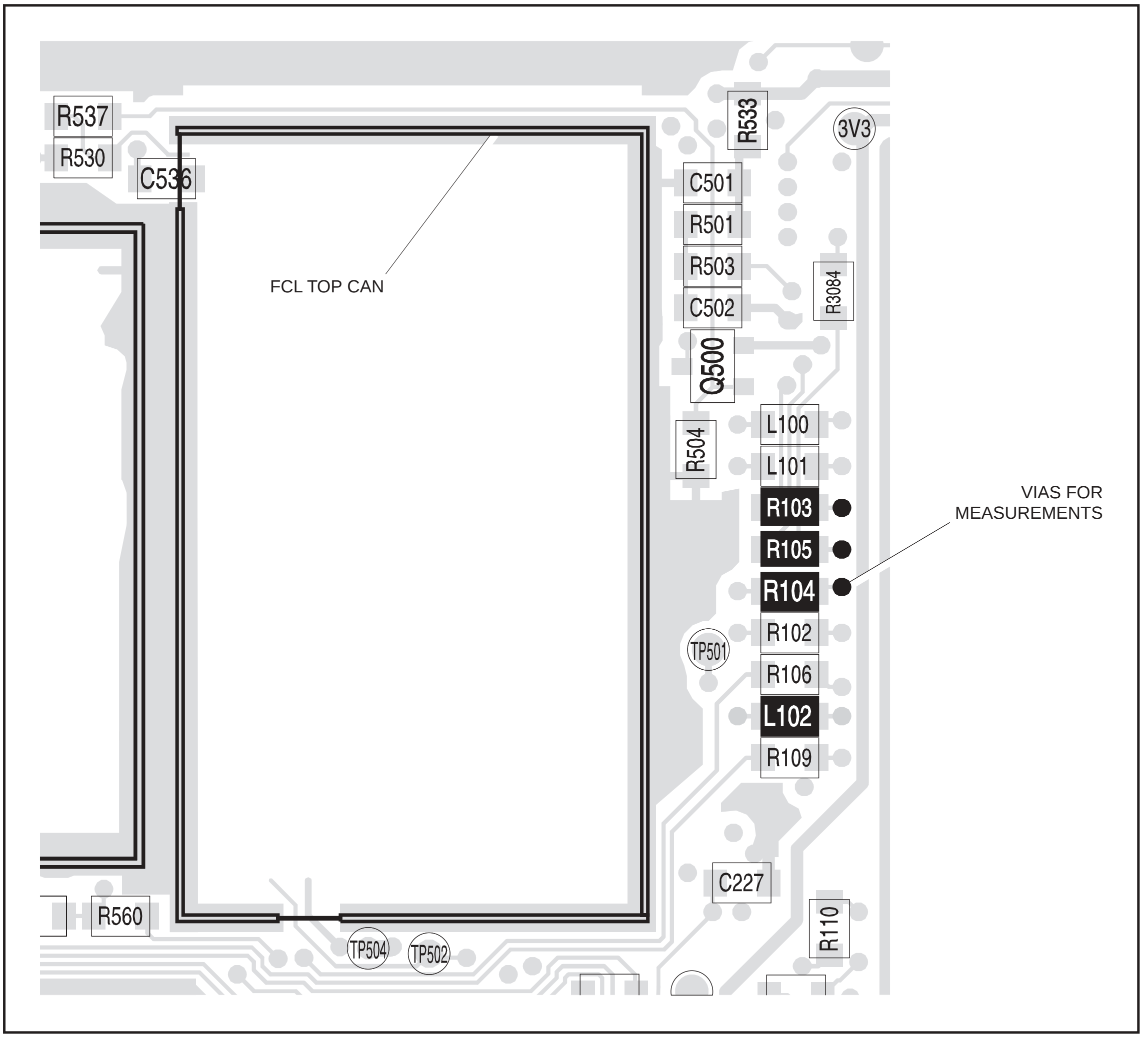


Figure 9.6 Components between the digital board and the frequency synthesizer



Task 8 — Reference Frequency

If the supply for the charge pump is correct, check the reference frequency input from the FCL to the PLL.

1. Measure the reference frequency at pin 8 of **IC503** (see **Figure 9.2**).

pin 8 of IC503: 13.012 ± 0.002 MHz and 1.1 ± 0.2 V_{pp}

2. If the signal is correct, go to Task 9. If it is not, go to Step 3.

3. Check **IC503** (see **Figure 9.2**). Replace IC503 if it is suspect.

4. Determine if the fault has been removed. If it has, go to “Final Tasks” on page 147. If it has not, the FCL is suspect; go to “Power Supply for FCL” on page 215.

Task 9 — DIG SYN EN Line

If the supply for the charge pump and the reference frequency are correct, check the DIG SYN EN line input.

1. Check the DIG SYN EN line at pin 10 of **IC503** (see **Figure 9.2**). Enter the CCTM command *334 0* to switch off the synthesizer, and measure the voltage at pin 10.

pin 10 of IC503: 0 V DC (after entry of CCTM 334 0)

2. Enter the command *334 1* to switch on the synthesizer, and measure the voltage again.

pin 10 of IC503: 2.5 ± 0.3 V DC (after entry of CCTM 334 1)

3. If the voltages measured in Step 1 and Step 2 are correct, go to Task 10. If they are not, go to Step 4.

4. Remove **R104** (see **Figure 9.6**) and repeat the above measurements as follows:

5. Enter the CCTM command *334 0* to switch off the synthesizer, and measure the voltage at the via between **R104** (see **Figure 9.6**) and the digital board.

via at R104: 0 V DC (after entry of CCTM 334 0)

6. Enter the CCTM command *334 1* to switch on the synthesizer, and measure the voltage at the via between **R104** (see **Figure 9.6**) and the digital board.

via at R104: 3.3 ± 0.3 V DC (after entry of CCTM 334 1)

7. If the voltages measured in Step 5 and Step 6 are still not correct, the digital board is faulty; replace the main-board assembly and go to “Final Tasks” on page 147. If the voltages are correct, go to Step 8.

8. There is a fault between the digital board and **IC503**. Locate the fault. Check and resolder **R104** in position (see **Figure 9.6**), and check for continuity between pin 10 of IC503 (see **Figure 9.2**) and the digital board via R104.

9. If there is a fault, repair the circuit, confirm the removal of the fault, and go to “Final Tasks” on page 147. If the repair failed or no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 10 — SYN LOCK Line

If all the critical inputs to the PLL are correct, check the SYN LOCK line output.

1. Enter the CCTM command *72* to determine the lock status in receive mode. Note the status.

lock status=**xyz** (**x**=RF PLL; **y**=FCL; **z**=LO2) (0=not in lock; 1=in lock)

2. Check the SYN LOCK line by measuring the voltage at pin 14 of **IC503** (see **Figure 9.2**). The voltage should depend on the lock status as follows:

lock status 111 or 110: 3.0 ± 0.3 V DC at pin 14 of IC503 lock status 011 or 010: 0 V DC at pin 14 of IC503

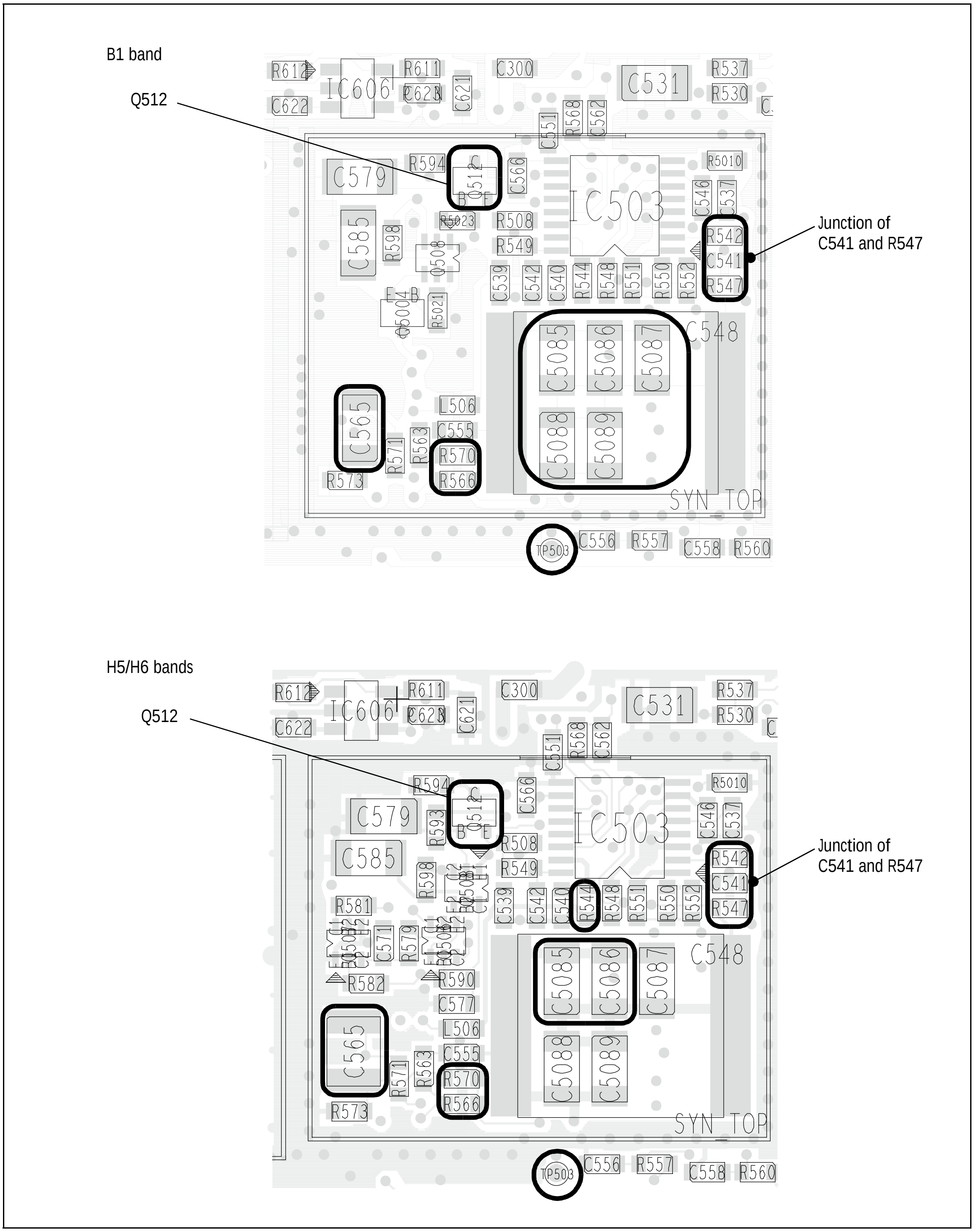
3. If the voltage measured in Step 2 is correct, go to “Loop Filter” on page 187. If it is not, go to Step 4.

4. Check for continuity between pin 14 of **IC503** and the digital board via **R568** (see **Figure 9.2**) and **L102** (see **Figure 9.6**).

5. If there is a fault, go to Step 6. If there is no fault, the digital board is faulty; replace the main-board assembly and go to “Final Tasks” on page 147.

6. Repair the fault. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed or no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 9.7 Synthesizer circuitry under the SYN TOP can (top side)



9.4 Loop Filter

Introduction

If the power supplies for the frequency synthesizer are correct, and the PLL is functioning properly, check the loop filter next:

- Task 11: check loop voltage
- Task 12: VCO fault
- Task 13: check reference voltage
- Task 14: check feedback voltage
- Task 15: check DIG SYN FAST line
- Task 16: check TP503 test point

The test and measurement points for diagnosing faults concerning the loop filter are summarized in Figure 9.5.

Task 11 — Check Loop Voltage

Check whether the loop filter is functioning correctly by measuring the loop voltage at the output of the filter at C565.

1. If not already done, remove the main-board assembly from the chassis, remove the SYN TOP can, and place the radio in CCTM.

2. Remove **R542** (see **Figure 9.7**).

3. Using an oscilloscope, proceed as follows to observe the voltage at **C565** before and after grounding the junction between **C541** and **R547** (see **Figure 9.7**):

   While holding the oscilloscope probe at C565, use a pair of tweezers to momentarily ground the junction. The voltage should change to the following value (if it is not already at this value):

C565: 13.3 ± 0.3 V DC

4. If the loop voltage is correct, go to Step 5. If it is not, the loop-filter circuitry is suspect; go to Task 13.

5. Proceed as follows to observe the voltage at **C565** before and after applying 3 V DC to the junction of **C541** and **R547**; there is a convenient 3 V level at **R544** (see **Figure 9.7**):

   While holding the probe at C565, use the tweezers to momentarily apply 3 V DC to the junction; do not touch the board with your hand, and do not allow the tweezers to touch any cans when you remove them. The voltage should change to:

C565: < 0.5 V DC

6. If the loop voltage is correct, go to Task 12. If it is not, the loop-filter circuitry is suspect; go to Task 13.

Task 12 — VCO Faulty

If the loop voltage is correct, the loop filter is functioning properly. The VCO and related circuitry is therefore suspect. The section to proceed to depends on the type of the radio and the nature of the fault.

1. With a UHF radio go to Step 2. With a VHF radio go to “VCO and Related Circuitry (VHF Radios)” on page 206.

2. If a UHF radio exhibits a lock error or a receive fault. the receive VCO is suspect; go to “Receive VCO and Related Circuitry (UHF Radios)” on page 192.

   If it exhibits a system error or a transmit fault, the transmit VCO is suspect; go to “Transmit VCO and Related Circuitry (UHF Radios)” on page 201.

Task 13 — Check Reference Voltage

If the loop-filter circuitry is suspect, first check the reference voltage for the filter.

1. Remove the SYN BOT can.

2. Measure the reference voltage at pin 5 of **IC505** (see **Figure 9.4**). The result should be:

IC505 pin 5:	2.8 ± 0.1 V DC

3. If the voltage is correct, go to Task 14. If it is not, the reference-voltage circuitry is suspect; go to Step 4.

4. Resolder **R542** in position and check the C-multiplier **Q512** (see **Figure 9.7**).

5. If a fault is found, repair the circuit, and confirm that the reference voltage is now correct. If it is, go to “Final Tasks” on page 147. If it is not, or if no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 14 — Check Feedback Voltage

If the loop filter is suspect but the reference voltage is correct, check the feedback voltage.

1. Measure the feedback voltage at pin 6 of **IC505** (see **Figure 9.4**). The result should be:

IC505 pin 6:	2.8 ± 0.1 V DC

2. If the voltage is not correct, the loop filter is faulty; go to Step 3. If the voltage is correct, resolder **R542** in position (see **Figure 9.7**) and go to Task 15.

3. Check **IC504**, **IC505**, **Q511** (see **Figure 9.4**), **C5085** to **C5089** (B1 band, see **Figure 9.7**) or **C5085** and **C5086** (H5, H6 bands see **Figure 9.7**), and associated components.

4. If a fault is found, repair the circuit, repeat the measurement of the feedback voltage in Step 1, and resolder **R542** in position (see **Figure 9.7**).

5. If the feedback voltage is now correct, go to "Final Tasks" on page 147. If it is not, or if no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 15 — Check DIG SYN FAST Line

If the loop filter is suspect but the reference and feedback voltages are correct, check the DIG SYN FAST line, which is input to the inverter.

1. Enter the CCTM command *389 1* to set the synthesizer mode to fast.

2. Measure the voltage at the collector of **Q505** (see **Figure 9.4**). The result should be:

Q505 collector: 14.2 ± 0.3 V DC (after entry of CCTM 389 1)

3. Enter the CCTM command *389 0* to set the mode to slow.

4. Measure the voltage at the collector of **Q505** (see **Figure 9.4**). The result should be:

Q505 collector: 0 V DC (after entry of CCTM 389 0)

5. If the voltages measured in Step 2 and Step 4 are correct, go to Task 16. If they are not, go to Step 6.

6. Remove **R105** (see **Figure 9.6**).

7. Enter the CCTM command *389 1* to set the mode to fast.

8. Measure the voltage at the via between **R105** and the digital board (see **Figure 9.6**). The result should be:

via at R105: 0 V DC (after entry of CCTM 389 1)

9. Enter the CCTM command *389 0* to set the mode to slow.

10. Measure the voltage at the via between **R105** and the digital board (see **Figure 9.6**). The result should be:

via at R105: 3.3 ± 0.3 V DC (after entry of CCTM 389 0)

11. If the voltages measured in Step 8 and Step 10 are correct, go to Step 12. If they are not, the digital board is faulty; replace the main-board assembly and go to “Final Tasks” on page 147.

12. Check and resolder **R105** in position (see **Figure 9.6**), and check for continuity between the collector of **Q505** (see **Figure 9.4**) and the digital board via R105.

13. If a fault is found, repair the circuit, and confirm that the voltages are now correct. If they are, go to “Final Tasks” on page 147. If they are not, or if no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 16 — Check TP503 Test Point

If the reference voltage, feedback voltage, and DIG SYN FAST line are all correct, check the voltage at the TP503 test point.

1. Measure the voltage at the **TP503 test point** (see **Figure 9.7**). The oscilloscope should show a DC level less than 3.0V with no sign of noise or modulation.

TP503 test point: < 3.0 V DC

2. If the correct result is obtained, go to Step 3. If it is not, go to Step 4.
3. The loop filter is faulty but the above measurements do not provide more specific information. Check **IC504**, **IC505**, **Q511** (see **Figure 9.4**), **C5085** to **C5089** (B1 band, see **Figure 9.7**) or **C5085** and **C5086** (H5, H6 bands see **Figure 9.7**), and associated components. Conclude with Step 9.
4. Remove **R566** and **R570** (see **Figure 9.7**), which provide a modulation path to the VCO(s).
5. Repeat the measurement of Step 1.
6. If the correct result is now obtained, go to Step 7. If the correct result is still not obtained, the CODEC and audio circuitry is suspect; resolder **R566** and **R570** in position (see **Figure 9.7**), and go to "CODEC and Audio Fault Finding" on page 371.
7. Resolder **R566** and **R570** in position (see **Figure 9.7**).
8. Check **IC504** (pins 6, 8, 9) (see **Figure 9.4**) and the associated components in the loop filter.
9. If a fault is found, repair the circuit, and confirm that the voltages are now correct. If they are, go to "Final Tasks" on page 147. If they are not, or if no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 147.

9.5 Receive VCO and Related Circuitry (UHF Radios)

Introduction

If there is no fault with the power supplies, the PLL inputs and output, and the loop filter, check the VCO and related circuitry. The procedures in this section apply only to UHF radios with a lock error or receive fault, and therefore with suspect receive VCO and related circuitry. (The minimum and maximum receive frequencies for the different UHF frequency bands are defined in Table 9.2.) There are six aspects:

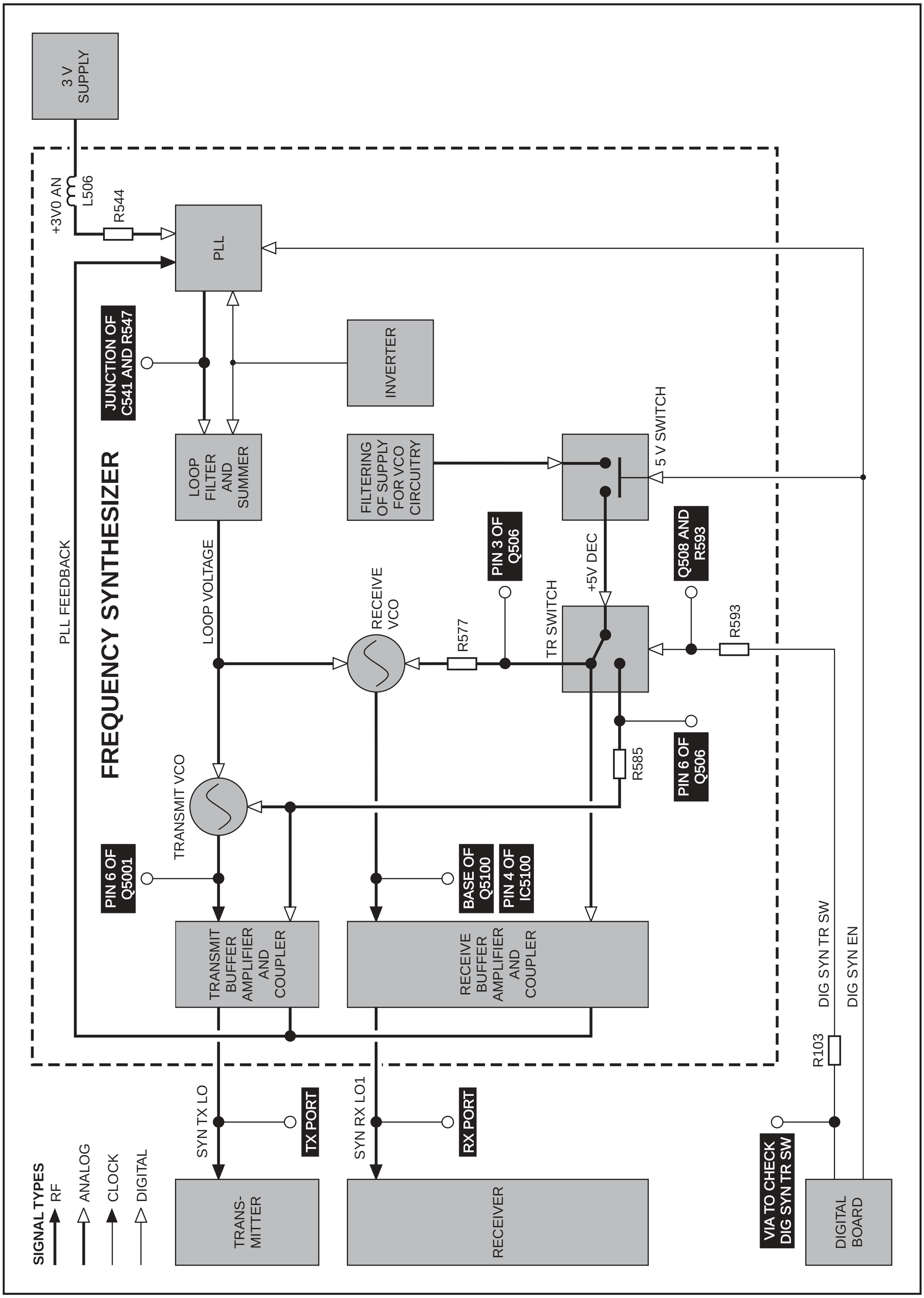
- Task 17: check receive VCO
- Task 18: repair PLL feedback
- Task 19: repair receive VCO
- Task 20: check switching to receive mode
- Task 21: repair switching network
- Task 22: check receive buffer amplifier

The measurement points for diagnosing faults in the VCO and related circuitry are summarized in Figure 9.8.

Table 9.2 Minimum and maximum receive frequencies for the different UHF frequency bands

Frequency band	Receive frequency in MHz	
	Minimum	Maximum
H5	337 ± 5	441 ± 5
H6	378 ± 5	498 ± 5

Figure 9.8 Measurement points for the VCO and related circuitry in UHF radios



Task 17 — Check Receive VCO

Check that the correct receive frequency is synthesized. This is the frequency of the receive VCO output SYN RX LO1 at the RX port shown in Figure 9.9.

1. Enter the CCTM command *335 0* to set the transmit-receive switch off (receive mode).

2. Using a frequency counter, proceed as follows to observe the receive frequency at the RX port before and after grounding the junction between **C541** and **R547** (see **Figure 9.9**):

   While holding the probe from the counter on the RX port, use a pair of tweezers to momentarily ground the junction. The frequency should change to:

RX port: maximum receive frequency (see Table 9.2)

   The loop filter will hold its output steady at 13.3 V. This should result in a frequency equal to the maximum given in **Table 9.2**.

3. If the receive frequency measured in Step 2 is correct, go to Step 4. If it is incorrect, go to Task 19, but if no frequency is detected, go to Task 20.

4. Proceed as follows to observe the receive frequency at the RX port before and after applying 3 V DC to the junction of **C541** and **R547**; there is a convenient 3 V level at **R544** (see **Figure 9.9**):

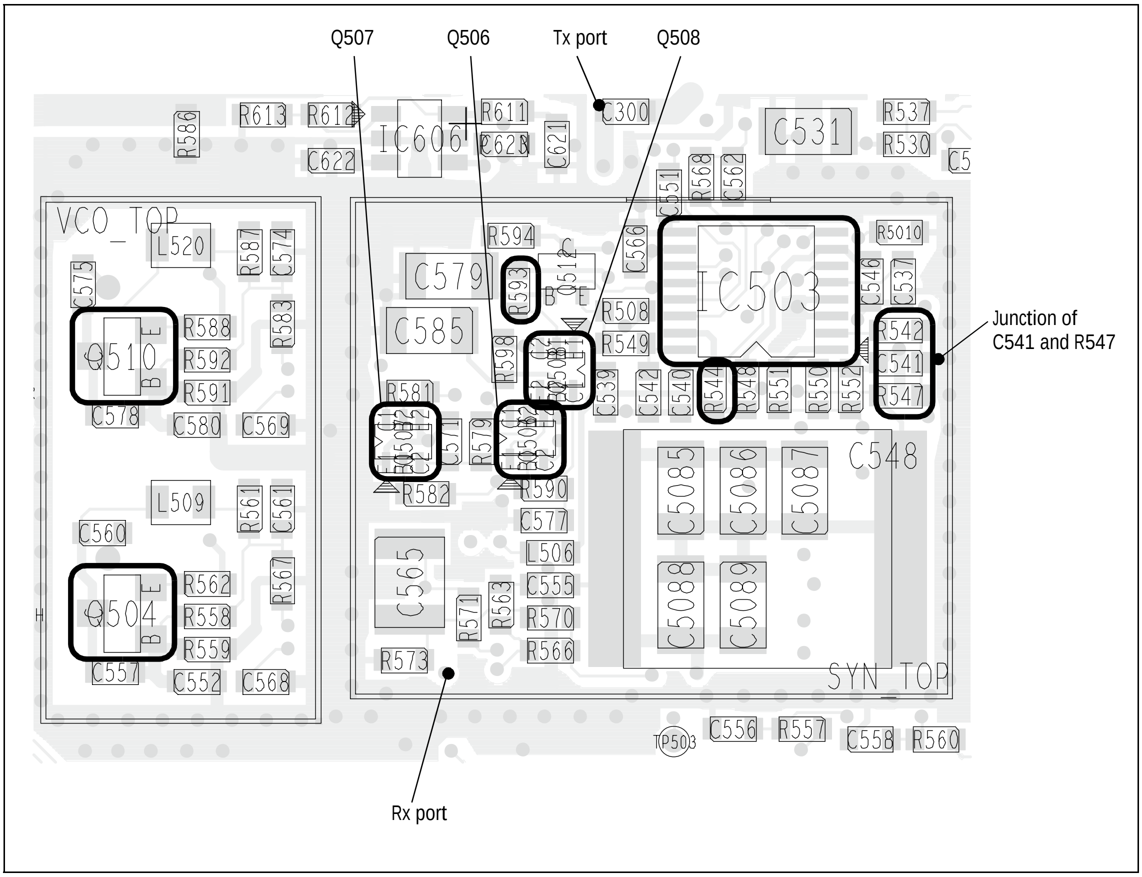
   While holding the probe on the RX port, use the tweezers to momentarily apply 3 V DC to the junction; do not touch the board with your hand, and do not allow the tweezers to touch any cans when you remove them. The frequency should change to:

RX port: minimum receive frequency (see Table 9.2)

   The loop filter will hold its output steady at about 0V. This should result in a frequency equal to the minimum given in **Table 9.2**.

5. If the receive frequency measured in Step 4 is correct, go to Task 18. If it is incorrect, go to Task 19. If no frequency is detected, go to Task 20.

Figure 9.9 Synthesizer circuitry under the SYN TOP and VCO TOP cans (UHF radio, top side)



Task 18 — Repair PLL feedback

If both the minimum and maximum receive frequencies are correct, the PLL feedback is suspect.

1. Resolder **R542** in position (see **Figure 9.9**).

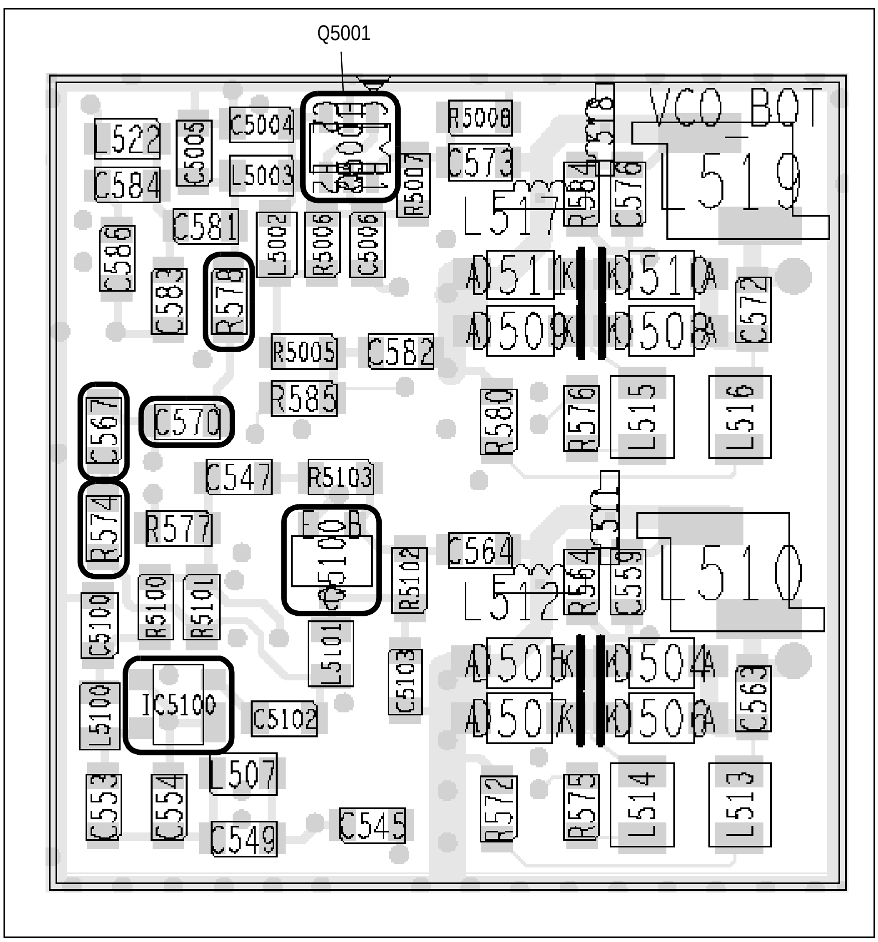
2. Remove the VCO BOT can.

3. Replace the components **C567**, **R574** (see **Figure 9.10**) and **IC503** (see **Figure 9.9**).

4. Also check the second stage of the receive buffer amplifier based on **IC5100** (see **Figure 9.10**). Repair any fault.

5. Confirm that the fault in the radio has been removed. If it has, go to “Final Tasks” on page 147. If it has not, replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 9.10 Synthesizer circuitry under the VCO BOT can (UHF radio, bottom side)



Task 19 — Repair Receive VCO

If either or both the minimum and maximum receive frequencies are incorrect, the receive VCO circuitry is faulty.

1. Remove the VCO TOP can.
2. Check the receive VCO. The circuitry is based on **Q504** (see **Figure 9.9**).
3. If a fault is found, repair it and go to Step 4. If no fault is found, go to Step 6.
4. Repeat the frequency measurements in Step 2 and Step 4 of Task 17.
5. If the frequencies are now correct, resolder **R542** in position (see **Figure 9.9**), and go to “Final Tasks” on page 147. If they are still not correct, go to Step 6.
6. Resolder **R542** in position (see **Figure 9.9**). Replace the main-board assembly and go to “Final Tasks” on page 147.

Task 20 — Check Switching to Receive Mode

If no receive frequency is detected in the check of the receive VCO, first check that the transmit-receive switch is functioning correctly.

1. Resolder **R542** in position (see **Figure 9.9**).

2. Enter the CCTM command *335 0* to switch on the supply to the receive VCO.

3. Measure the voltage at the first collector (pin 3) of **Q506** (see **Figure 9.9**). The voltage should be:

pin 3 of Q506: 5.0 ± 0.3 V DC (after entry of CCTM 335 0)

4. Enter the CCTM command *335 1* to switch off the supply.

5. Again measure the voltage at the first collector of **Q506**.

pin 3 of Q506: 0 V DC (after entry of CCTM 335 1)

6. If the voltages measured in Step 3 and Step 5 are correct, go to Task 22. If they are not, the switching network is suspect; go to Task 21.

Task 21 — Repair Switching Network

If the transmit-receive switch is not functioning correctly, first check the DIG SYN TR SW line to confirm that the digital board is not the cause. If the digital board is not faulty, the switching network is suspect.

1. Enter the CCTM command *335 0* to set the transmit-receive switch off (receive mode). Measure the voltage on the DIG SYN TR SW line between **Q508** and **R593** (see **Figure 9.9**).

R593: 0 V DC (after entry of CCTM 335 0)

2. Enter the CCTM command *335 1* to set the transmit-receive switch on (transmit mode). Again measure the voltage at **R593**.

R593: 2.0 ± 0.5 V DC (after entry of CCTM 335 1)

3. If the voltages measured in Step 1 and Step 2 are correct, go to Step 9. If they are not, remove **R103** (see **Figure 9.6**) and go to Step 4.

4. Enter the CCTM command *335 0* and measure the voltage at the via between **R103** and the digital board (see **Figure 9.6**).

via at R103: 0 V DC (after entry of CCTM 335 0)

5. Enter the CCTM command *335 1* and again measure the voltage at the via between **R103** and the digital board.

via at R103: 3.3 ± 0.3 V DC (after entry of CCTM 335 1)

6. If the voltages measured in Step 4 and Step 5 are correct, go to Step 7. If they are not, the digital board is faulty; resolder **R103** in position (see **Figure 9.6**), replace the main-board assembly and go to “Final Tasks” on page 147.

7. Check and resolder **R103** in position (see **Figure 9.6**), and check for continuity between **Q508** and the digital board via **R593** (see **Figure 9.9**) and R103.

8. If no fault is found, go to Step 9. If a fault is found, repair the circuit, confirm that the voltages are now correct, and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

9. Check the circuitry for the transmit-receive and 5V switches (based on **Q506**, **Q507** and **Q508**) (see **Figure 9.9**).

10. If a fault is found, repair the circuit, confirm that the voltages are now correct, and go to “Final Tasks” on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 22 — Check Receive Buffer Amplifier

If no receive frequency is detected but the switching network is not faulty, check the receive buffer amplifier. If the amplifier is not faulty, there might be a fault in the receive VCO that was not detected earlier.

1. Remove the VCO BOT can.

2. Check the receive buffer amplifier in receive mode: Enter the CCTM command *335 0* to set the transmit-receive switch off.

3. Measure the voltages at the base of **Q5100** and at pin 4 of **IC5100** (see **Figure 9.10**).

base of Q5100:	0.7 ± 0.1V DC (receive mode)
pin 4 of IC5100:	2.0 ± 0.5V DC (receive mode)

4. Then check the receive buffer amplifier in transmit mode: Enter the CCTM command *335 1* to set the transmit-receive switch on.

5. Again measure the voltages of **Q5100** and **IC5100**.

base of Q5100:	0V DC (transmit mode)
pin 4 of IC5100:	0V DC (transmit mode)

6. If the voltages are correct, the receive VCO is suspect; go to Step 7. If they are not, the receive buffer amplifier is suspect; go to Step 9.

7. Remove the VCO TOP can.

8. Check the receive VCO circuitry based on **Q504** (see **Figure 9.9**). Conclude with Step 10.

9. Check the first buffer stage (based on **Q5100**) and the second stage (based on **IC5100**) (see **Figure 9.10**).

10. If a fault is found, repair the circuit, and confirm that the voltages are now correct. If they are, go to “Final Tasks” on page 147. If they are not, or if no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 147.

9.6 Transmit VCO and Related Circuitry (UHF Radios)

Introduction

If there is no fault with the power supplies, the PLL inputs and output, and the loop filter, check the VCO and related circuitry. The procedures in this section apply only to UHF radios with a system error or transmit fault, and therefore with suspect transmit VCO and related circuitry. (The minimum and maximum transmit frequencies for the different UHF frequency bands are defined in Table 9.3.) There are five aspects:

- Task 23: check transmit VCO
- Task 24: repair PLL feedback
- Task 25: repair transmit VCO
- Task 26: check switching to transmit mode
- Task 27: check transmit buffer amplifier

The measurement points for diagnosing faults in the VCO and related circuitry are summarized in Figure 9.8.

Table 9.3 Minimum and maximum transmit frequencies for the different UHF frequency bands

Frequency band	Transmit frequency in MHz	
	Minimum	Maximum
H5	371 ± 5	492 ± 5
H6	419 ± 5	545 ± 5

Task 23 — Check Transmit VCO

Check that the correct transmit frequency is synthesized. This is the frequency of the transmit VCO output SYN TX LO at the TX port shown in Figure 9.9.

1. Enter the CCTM command *335 1* to set the transmit-receive switch on (transmit mode).

2. Using a frequency counter, proceed as follows to observe the transmit frequency at the TX port before and after grounding the junction between **C541** and **R547** (see **Figure 9.9**):

   While holding the probe from the counter on the TX port, use a pair of tweezers to momentarily ground the junction. The frequency should change to:

TX port: maximum transmit frequency (see Table 9.3)

   The loop filter will hold its output steady at 13.3 V. This should result in a frequency equal to the maximum given in **Table 9.3**.

3. If the transmit frequency measured in Step 2 is correct, go to Step 4. If it is incorrect, go to Task 25. If no frequency is detected, go to Task 26.

4. Proceed as follows to observe the transmit frequency at the TX port before and after applying 3 V DC to the junction of **C541** and **R547**; there is a convenient 3 V level at **R544** (see **Figure 9.9**):

   While holding the probe on the TX port, use the tweezers to momentarily apply 3 V DC to the junction; do not touch the board with your hand, and do not allow the tweezers to touch any cans when you remove them. The frequency should change to:

TX port: minimum transmit frequency (see Table 9.3)

   The loop filter will hold its output steady at about 0 V. This should result in a frequency equal to the minimum given in **Table 9.3**.

5. If the transmit frequency measured in Step 4 is correct, go to Task 24. If it is incorrect, go to Task 25. If no frequency is detected, go to Task 26.

Task 24 — Repair PLL feedback

If both the minimum and maximum transmit frequencies are correct, the PLL feedback is suspect.

1. Resolder **R542** in position (see **Figure 9.9**).
2. Remove the VCO BOT can.
3. Replace the components **C570**, **R578** (see **Figure 9.10**) and **IC503** (see **Figure 9.9**).
4. Confirm that the fault in the radio has been removed. If it has, go to “Final Tasks” on page 147. If it has not, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 25 — Repair Transmit VCO

If either or both the minimum and maximum transmit frequencies are incorrect, the transmit VCO circuitry is faulty.

1. Remove the VCO TOP can.
2. Check the transmit VCO. The circuitry is based on **Q510** (see **Figure 9.9**).
3. If a fault is found, repair it and go to Step 4. If no fault is found, go to Step 6.
4. Repeat the frequency measurements in Step 2 and Step 4 of Task 23.
5. If the frequencies are now correct, resolder **R542** in position (see **Figure 9.9**), and go to “Final Tasks” on page 147. If they are still not correct, go to Step 6.
6. Resolder **R542** in position (see **Figure 9.9**). Replace the main-board assembly and go to “Final Tasks” on page 147.

Task 26 — Check Switching to Transmit Mode

If no transmit frequency is detected in the check of the transmit VCO, first check that the transmit-receive switch is functioning correctly.

1. Resolder **R542** in position (see **Figure 9.9**).

2. Enter the CCTM command *335 1* to switch on the supply to the transmit VCO.

3. Measure the voltage at the second collector (pin 6) of **Q506** (see **Figure 9.9**). The voltage should be:

pin 6 of Q506: 5.0 ± 0.3 V DC (after entry of CCTM 335 1)

4. Enter the CCTM command *335 0* to switch off the supply.

5. Again measure the voltage at the second collector of **Q506**.

pin 6 of Q506: 0 V DC (after entry of CCTM 335 0)

6. If the voltages measured in Step 2 and Step 4 are correct, go to Task 27. If they are not, the switching network is suspect; go to Task 21.

Task 27 — Check Transmit Buffer Amplifier

If no transmit frequency is detected but the switching network is not faulty, check the transmit buffer amplifier. If the amplifier is not faulty, there might be a fault in the transmit VCO that was not detected earlier.

1. Remove the VCO BOT can.

2. Check the transmit buffer amplifier in receive mode: Enter the CCTM command *335 0* to set the transmit-receive switch off.

3. Measure the voltage at pin 6 of **Q5001** (see **Figure 9.10**).

pin 6 of Q5001: 0 V DC (receive mode)

4. Then check the transmit buffer amplifier in transmit mode: Enter the CCTM command *335 1* to set the transmit-receive switch on.

5. Again measure the voltage at **Q5001**.

pin 6 of Q5001: 0.7 ± 0.1 V DC (transmit mode)

6. If the voltages are correct, the transmit VCO is suspect; go to Step 7. If they are not, the transmit buffer amplifier is suspect; go to Step 9.

7. Remove the VCO TOP can.

8. Check the transmit VCO circuitry based on **Q510** (see **Figure 9.9**). Conclude with Step 10.

9. Check the buffer circuitry based on **Q5001** (see **Figure 9.10**).

10. If a fault is found, repair the circuit, and confirm that the voltages are now correct. If they are, go to “Final Tasks” on page 147. If they are not, or if no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 147.

9.7 VCO and Related Circuitry (VHF Radios)

Introduction

If there is no fault with the power supplies, the PLL inputs and output, and the loop filter, check the VCO and related circuitry. The procedures in this section apply only to VHF radios; the VHF frequency bands are defined in Table 9.4. There are six aspects:

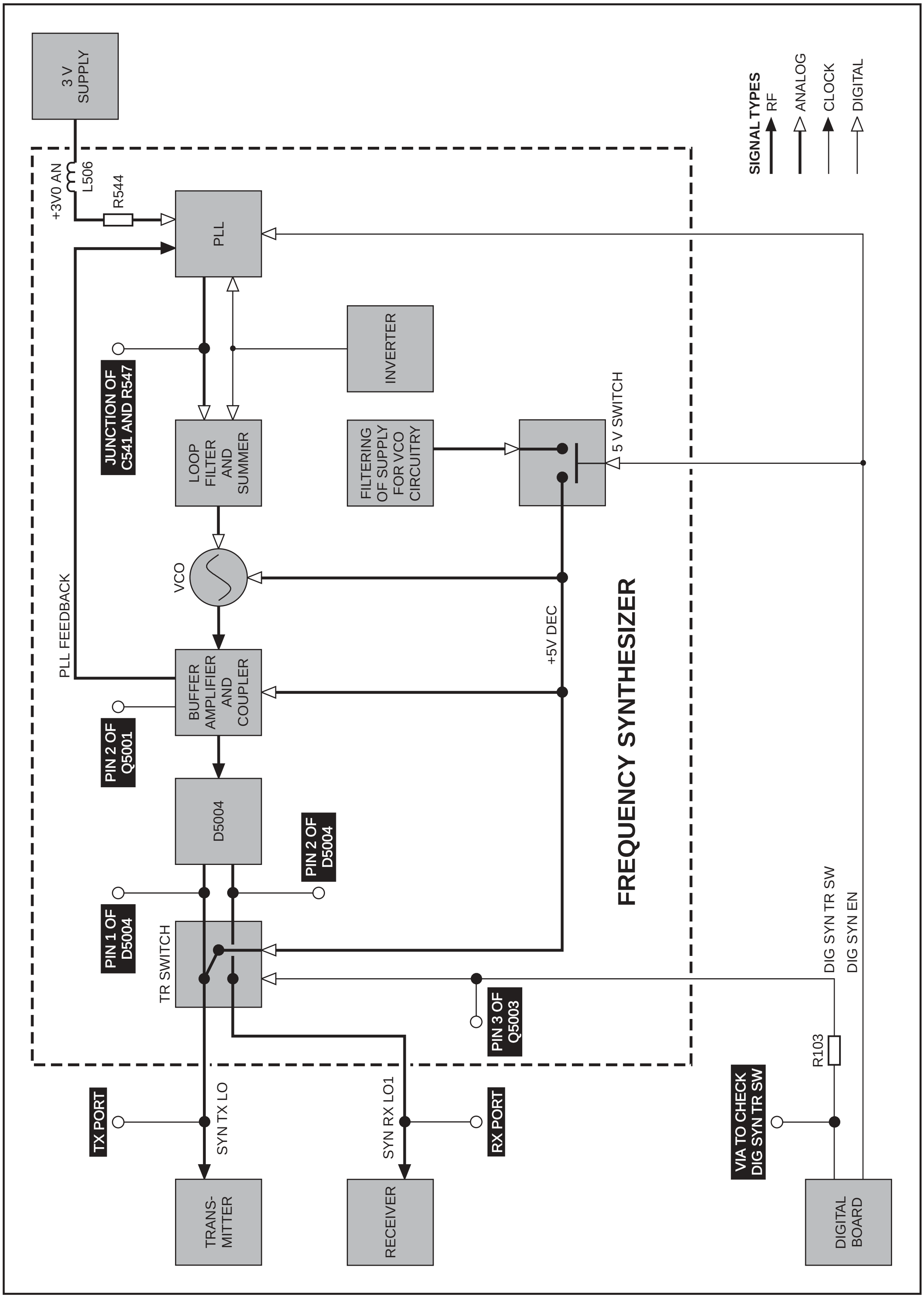
- Task 28: check VCO
- Task 29: repair PLL feedback
- Task 30: repair VCO
- Task 31: check transmit-receive switch
- Task 32: repair switching network
- Task 33: check buffer amplifier

The measurement points for diagnosing faults in the VCO and related circuitry are summarized in Figure 9.11.

Table 9.4 Minimum and maximum frequencies for the different VHF frequency bands

Frequency band	Frequency in MHz	
	Minimum	Maximum
B1	84 ± 5	200 ± 5

Figure 9.11 Measurement points for the VCO and related circuitry in VHF radios



Task 28 — Check VCO

Check that the correct receive and transmit frequencies are synthesized. The receive frequency is that of the VCO output SYN RX LO1 at the RX port shown in Figure 9.12. The transmit frequency is that of the output SYN TX LO at the TX port.

1. Enter the CCTM command *335 1* to set the transmit-receive switch on (transmit mode).

2. Using a frequency counter, proceed as follows to observe the transmit frequency at the TX port before and after grounding the junction between **C541** and **R547** (see **Figure 9.12**):

   While holding the probe from the counter on the TX port, use a pair of tweezers to <u>momentarily</u> ground the junction. The frequency should change to:

TX port: maximum VCO frequency (see Table 9.4)

   The loop filter will hold its output steady at 13.3 V. This should result in a frequency equal to the maximum given in **Table 9.4**.

3. If the maximum frequency measured in Step 2 is correct, go to Step 4. If it is incorrect, go to <u>Task 30</u>, but if no frequency at all is detected, go to <u>Task 31</u>.

4. Enter the CCTM command *335 0* to set the transmit-receive switch off (receive mode).

5. Proceed as follows to observe the receive frequency at the RX port before and after applying 3 V DC to the junction of **C541** and **R547**; there is a convenient 3 V level at **R544** (see **Figure 9.9**):

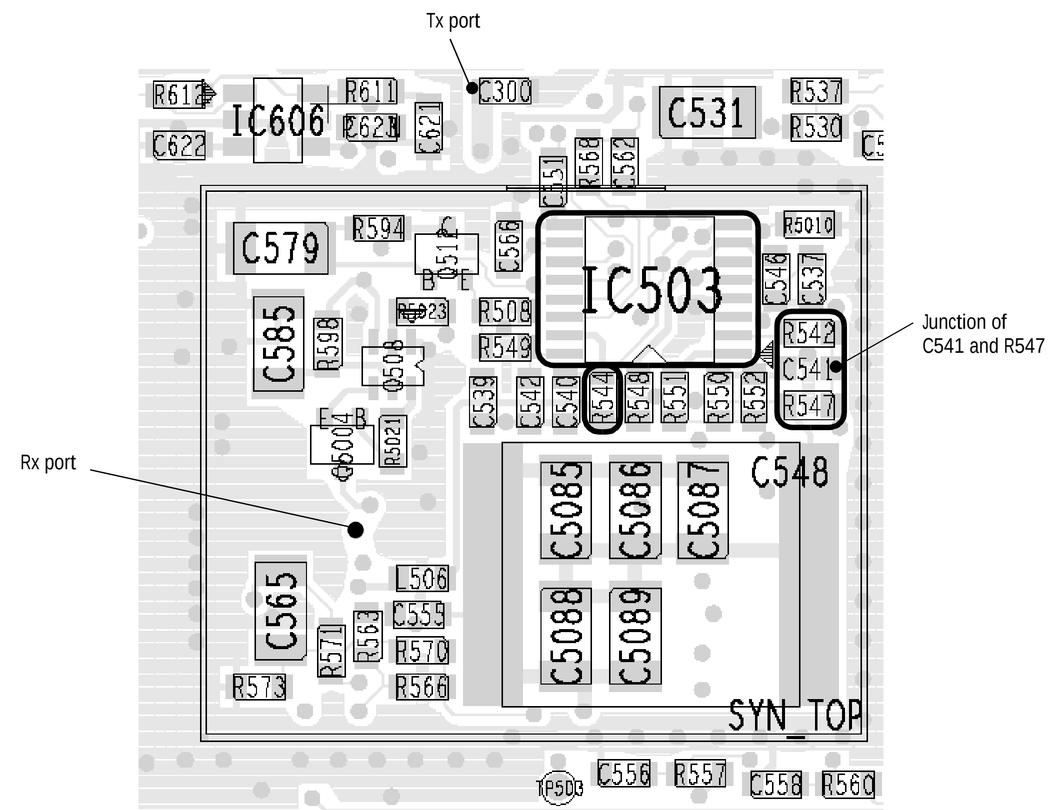
   While holding the probe on the RX port, use the tweezers to <u>momentarily</u> apply 3 V DC to the junction; do <u>not</u> touch the board with your hand, and do <u>not</u> allow the tweezers to touch any cans when you remove them. The frequency should change to:

RX port: minimum VCO frequency (see Table 9.4)

   The loop filter will hold its output steady at about 0 V. This should result in a frequency equal to the minimum given in **Table 9.4**.

6. If the minimum frequency measured in Step 5 is correct, go to <u>Task 29</u>. If it is incorrect, go to <u>Task 30</u>. If no frequency is detected, go to <u>Task 31</u>.

Figure 9.12 Synthesizer circuitry under the SYN TOP can (VHF radio, top side)



Task 29 — Repair PLL feedback

If both the maximum and minimum VCO frequencies are correct, then the PLL feedback is suspect.

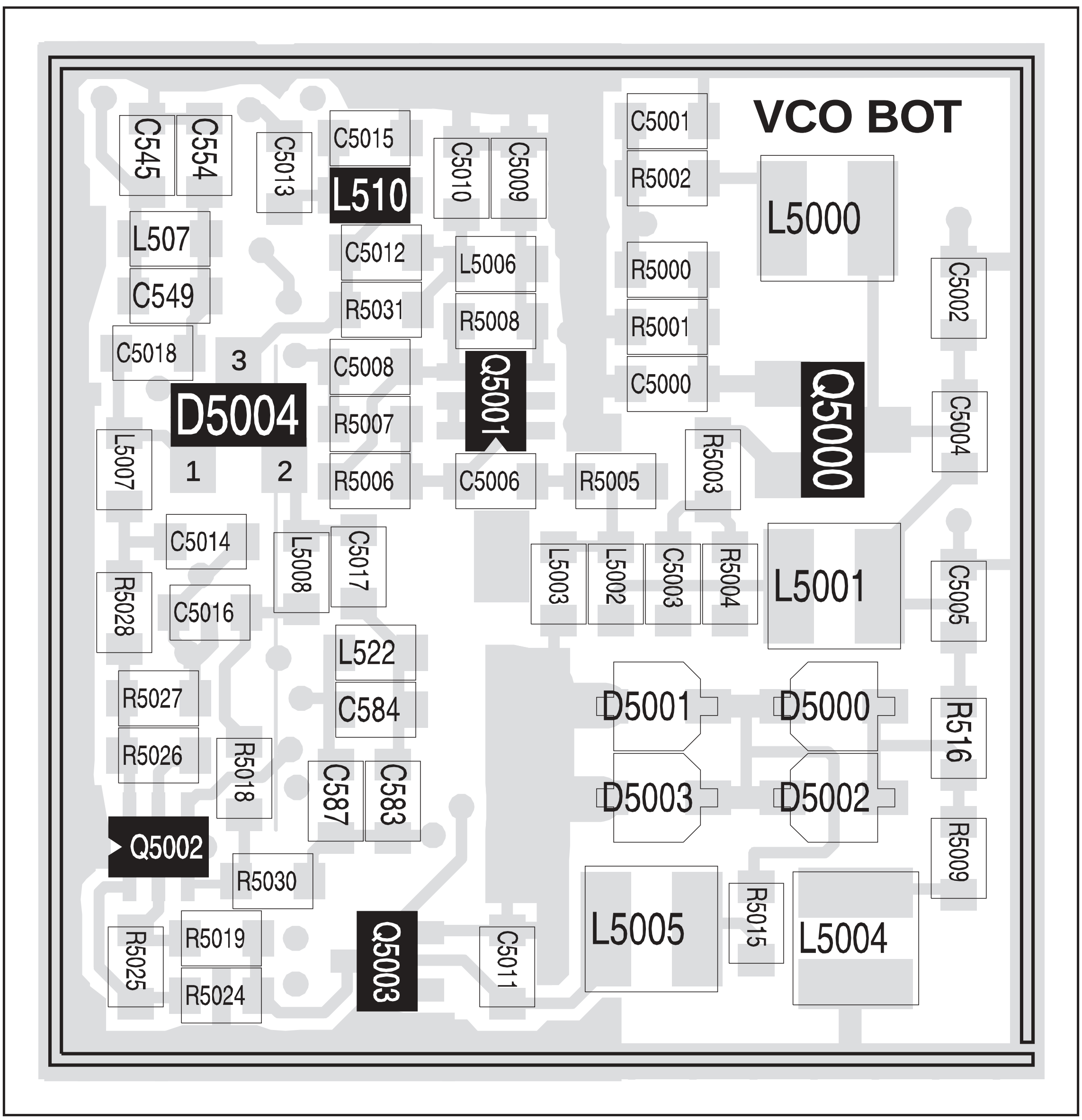
1. Resolder **R542** in position (see **Figure 9.12**).

2. Remove the VCO BOT can.

3. Replace the components **L510** (see **Figure 9.13**) and **IC503** (see **Figure 9.12**).

4. Confirm that the fault in the radio has been removed. If it has, go to “Final Tasks” on page 147. If it has not, replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 9.13 Synthesizer circuitry under the VCO BOT can (VHF radio, bottom side)



Task 30 — Repair VCO

If either or both the maximum and minimum frequencies are incorrect, the VCO circuitry is faulty.

1. Remove the VCO BOT can.
2. Check the VCO. The circuitry is based on **Q5000** (see **Figure 9.13**).
3. If a fault is found, repair it and go to Step 4. If no fault is found, go to Step 7.
4. Repeat Step 1 and Step 2 of Task 28 to measure the maximum VCO frequency.
5. Repeat Step 4 and Step 5 of Task 28 to measure the minimum VCO frequency.
6. If the frequencies are now correct, resolder **R542** in position (see **Figure 9.12**), and go to “Final Tasks” on page 147. If they are still not correct, go to Step 7.
7. Resolder **R542** in position (see **Figure 9.12**). Replace the main-board assembly and go to “Final Tasks” on page 147.

Task 31 — Check Transmit-Receive Switch

If no frequency is detected in the check of the VCO, first check that the transmit-receive switch is functioning correctly.

1. Resolder **R542** in position (see **Figure 9.12**).

2. Remove the VCO BOT can.

3. Enter the CCTM command *335 0* to switch on the supply to the RX port.

4. Measure the voltage at pin 2 of **D5004** (see **Figure 9.13**). (Some RF noise might be observed.) The voltage should be:

pin 2 of D5004: 5.0 ± 0.3 V DC (after entry of CCTM 335 0)

5. Enter the CCTM command *335 1* to switch off the supply.

6. Again measure the voltage at pin 2 of **D5004**.

pin 2 of D5004: 0 V DC (after entry of CCTM 335 1)

7. If the voltages measured in Step 4 and Step 6 are correct, go to Step 8. If they are not, the switching network is suspect; go to Task 32.

8. Enter the CCTM command *335 1* to switch on the supply to the TX port.

9. Measure the voltage at pin 1 of **D5004** (see **Figure 9.13**). (Some RF noise might be observed.) The voltage should be:

pin 1 of D5004: 5.0 ± 0.3 V DC (after entry of CCTM 335 1)

10. Enter the CCTM command *335 0* to switch off the supply.

11. Again measure the voltage at pin 1 of **D5004**.

pin 1 of D5004: 2.1 ± 0.4 V DC (after entry of CCTM 335 0)

12. If the voltages measured in Step 9 and Step 11 are correct, go to Task 33. If they are not, the switching network is suspect; go to Task 32.

Task 32 — Repair Switching Network

If the transmit-receive switch is not functioning correctly, first check the DIG SYN TR SW line to confirm that the digital board is not the cause. If the digital board is not faulty, the switching network is suspect.

1. Enter the CCTM command *335 0* to set the transmit-receive switch off (receive mode). Measure the voltage on the DIG SYN TR SW line at pin 3 of **Q5003** (see **Figure 9.13**).

pin 3 of Q5003: 5.0 ± 0.3 V DC (after entry of CCTM 335 0)

2. Enter the CCTM command *335 1* to set the transmit-receive switch on (transmit mode). Again measure the voltage at **Q5003**.

pin 3 of Q5003: 0 V DC (after entry of CCTM 335 1)

3. If the voltages measured in Step 1 and Step 2 are correct, go to Step 9. If they are not, remove **R103** (see **Figure 9.6**) and go to Step 4.

4. Enter the CCTM command *335 0* and measure the voltage at the via between **R103** and the digital board (see **Figure 9.6**).

via at R103: 3.3 ± 0.3 V DC (after entry of CCTM 335 0)

5. Enter the CCTM command *335 1* and again measure the voltage at the via between **R103** and the digital board.

via at R103: 0 V DC (after entry of CCTM 335 1)

6. If the voltages measured in Step 4 and Step 5 are correct, go to Step 7. If they are not, the digital board is faulty; resolder **R103** in position (see **Figure 9.6**), replace the main-board assembly and go to "Final Tasks" on page 147.

7. Check and resolder **R103** in position (see **Figure 9.6**), and check for continuity between **Q5003** (see **Figure 9.13**) and the digital board via R103.

8. If no fault is found, go to Step 9. If a fault is found, repair the circuit, confirm that the voltages are now correct, and go to "Final Tasks" on page 147. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 147.

9. Check the circuitry for the transmit-receive and 5V switches (based on **Q5002** and **Q5003**) (see **Figure 9.13**).

10. If a fault is found, repair the circuit, confirm that the voltages are now correct, and go to "Final Tasks" on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 33 — Check Buffer Amplifier

If no VCO frequency is detected but the switching network is not faulty, check the buffer amplifier. If the amplifier is not faulty, there might be a fault in the VCO that was not detected earlier.

1. Enter the CCTM command *335 0* to set the transmit-receive switch off.

2. Measure the voltage at pin 3 of **D5004** (see **Figure 9.13**). (Some RF noise might be observed.)

pin 3 of D5004: 4.2 ± 0.2 V DC

3. Measure the voltage at pin 1 of **Q5001** (see **Figure 9.13**).

pin 1 of Q5001: 0.7 ± 0.2 V DC

4. If the voltages measured in Step 2 and Step 3 are not correct, go to Step 5. If they are, check the VCO circuitry based on **Q5000** (see **Figure 9.13**). Conclude with Step 6.

5. The buffer amplifier is suspect. Check the buffer circuitry (based on **Q5001**) (see **Figure 9.13**).

6. If a fault is found, repair the circuit, and confirm that the voltages are now correct. If they are, go to “Final Tasks” on page 147. If they are not, or if no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 147.

9.8 Power Supply for FCL

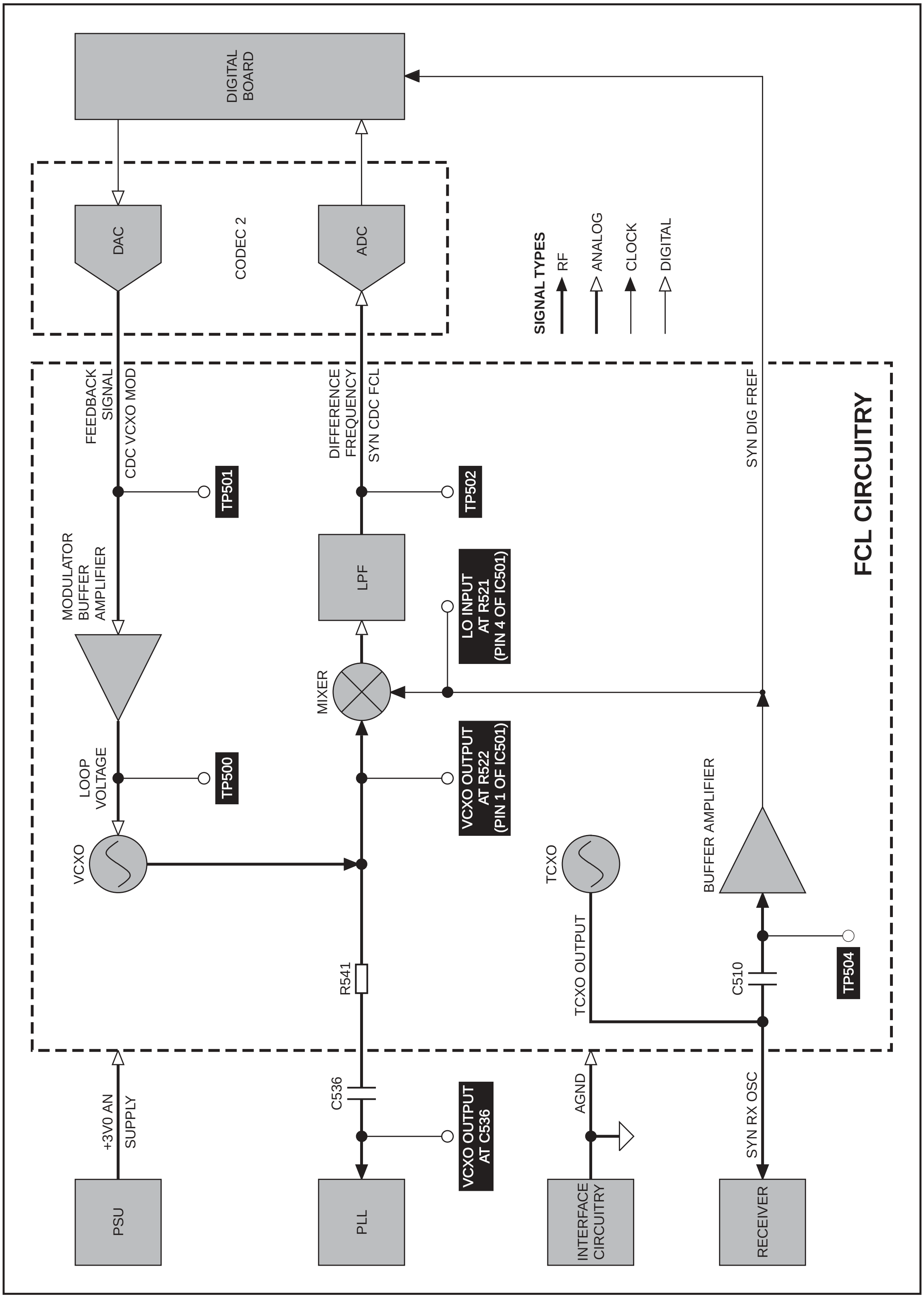
Fault-Diagnosis Stages

Indications of a fault in the FCL will have been revealed by the initial checks in "Initial Checks" on page 170 and the PLL checks in "Phase-locked Loop" on page 181. In the latter case a fault with the reference frequency input from the FCL to the PLL will imply that the FCL is suspect. Fault diagnosis of the FCL is divided into four stages:

- check power supply
- check VCXO and TCXO outputs
- check signals at TP501 and TP502
- check VCXO and CODEC circuitry

The checking of the power supply is given in this section in Task 34 below. The remaining three stages are covered in "VCXO and TCXO Outputs" to "VCXO and CODEC Circuitry" respectively. The test and measurement points for diagnosing faults in the FCL are summarized in Figure 9.14.

Figure 9.14 Test and measurement points the FCL circuitry



Task 34 — Power Supply

If the FCL is suspect, first check that the 3V power supply is not the cause of the fault.

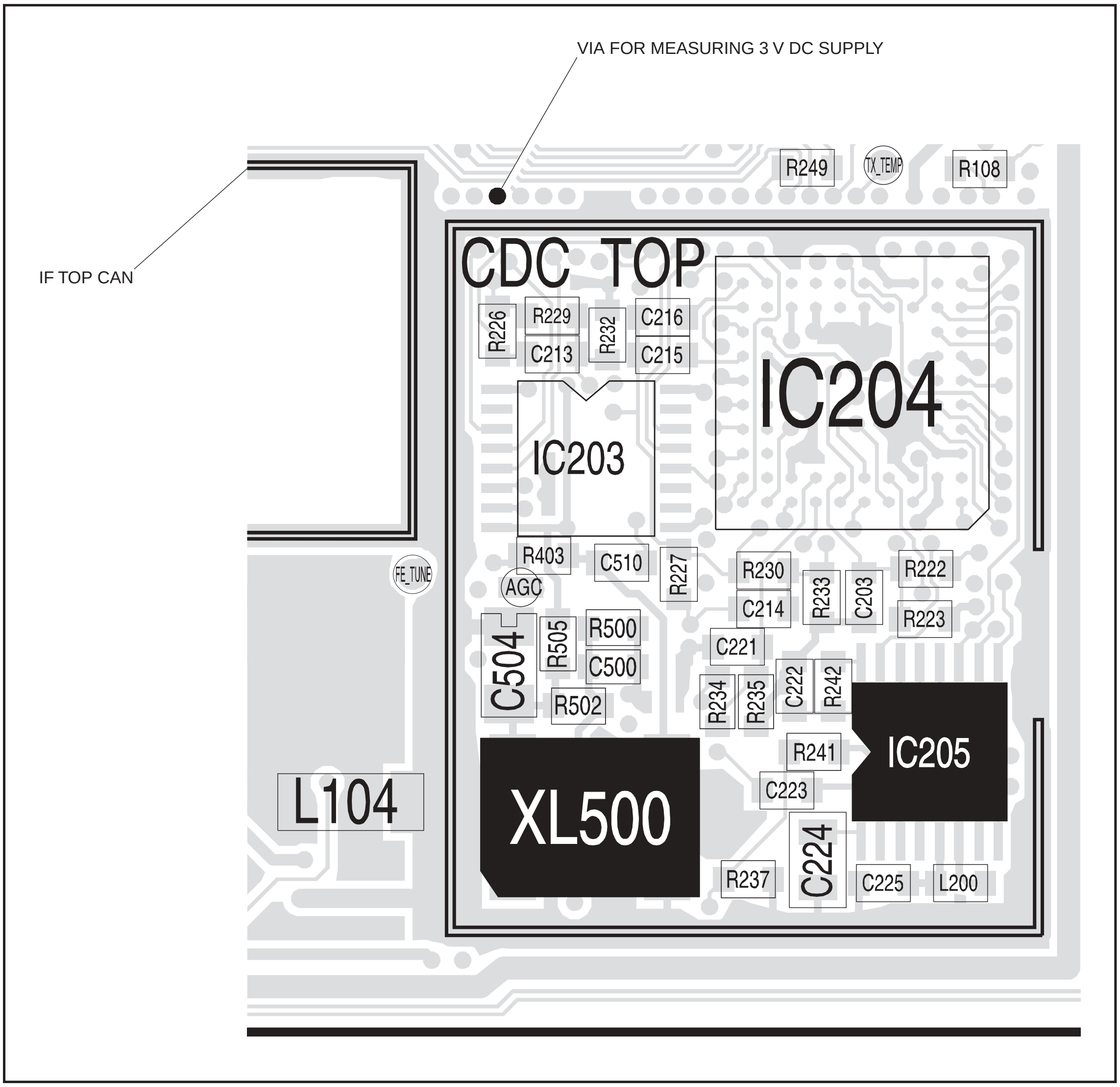
1. If not already done, remove the main-board assembly from the chassis and place the radio in CCTM.

2. Measure the supply +3V0 AN at the via shown in **Figure 9.15**. The via is adjacent to the CDC TOP can.

via adjacent to CDC TOP can: 3.0 ± 0.3 V DC

3. If the voltage is correct, go to “VCXO and TCXO Outputs” on page 218. If it is not, the 3V regulator **IC603** is suspect; go to Task 3 of “Power Supply Fault Finding” on page 158.

Figure 9.15 TCXO circuitry under the CDC TOP can



9.9 VCXO and TCXO Outputs

Task 35 — VCXO Output

If the 3V power supply is not faulty, check the VCXO output as follows:

1. Use an oscilloscope probe to check the VCXO output at **C536** — probe the via next to C536 (see **Figure 9.16**). The signal should be:

VCXO output at C536: sine wave of 1.1 ± 0.2 V_{pp} on 1.4 ± 0.2 V DC

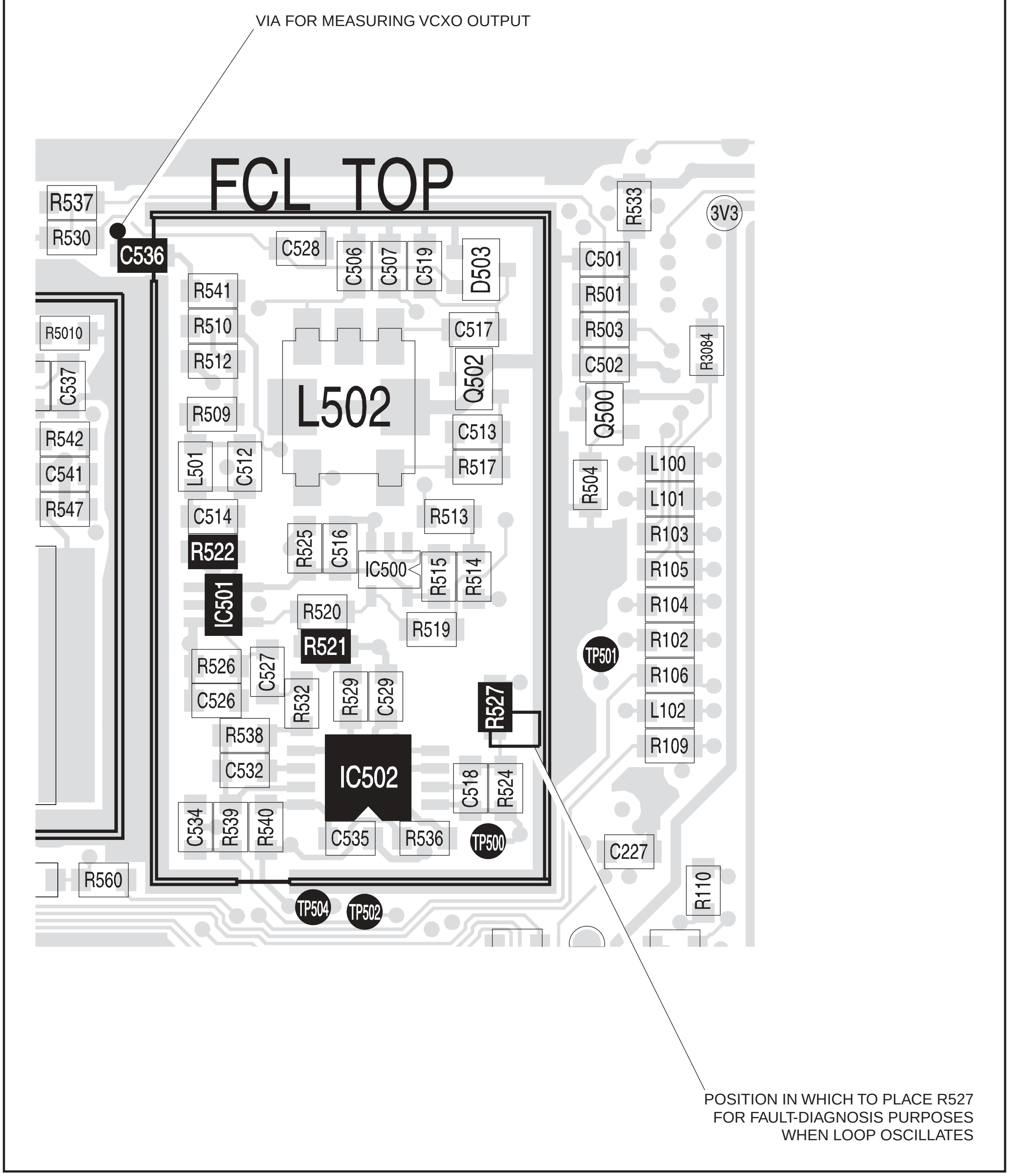
2. If the signal is correct, go to Task 36. If it is not, go to Step 3.

3. The VCXO circuitry under the VCXO BOT can is faulty. Remove the VCXO BOT can.

4. Locate and repair the fault in the VCXO (**Q501**, **Q503**, **XL501** and associated components) (see **Figure 9.17**).

5. Confirm the removal of the fault and go to Task 36. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 9.16 FCL circuitry under and adjacent the FCL TOP can



Task 36 — TCXO Output

If the VCXO output is correct, check the TCXO output as follows:

1. Use the oscilloscope probe to check the TCXO output at the **TP504 test point** (see **Figure 9.16**). The signal is SYN RX OSC and should be:

TCXO output at TP504 test point: clipped sine wave of 1.0 ± 0.2 V_{pp}

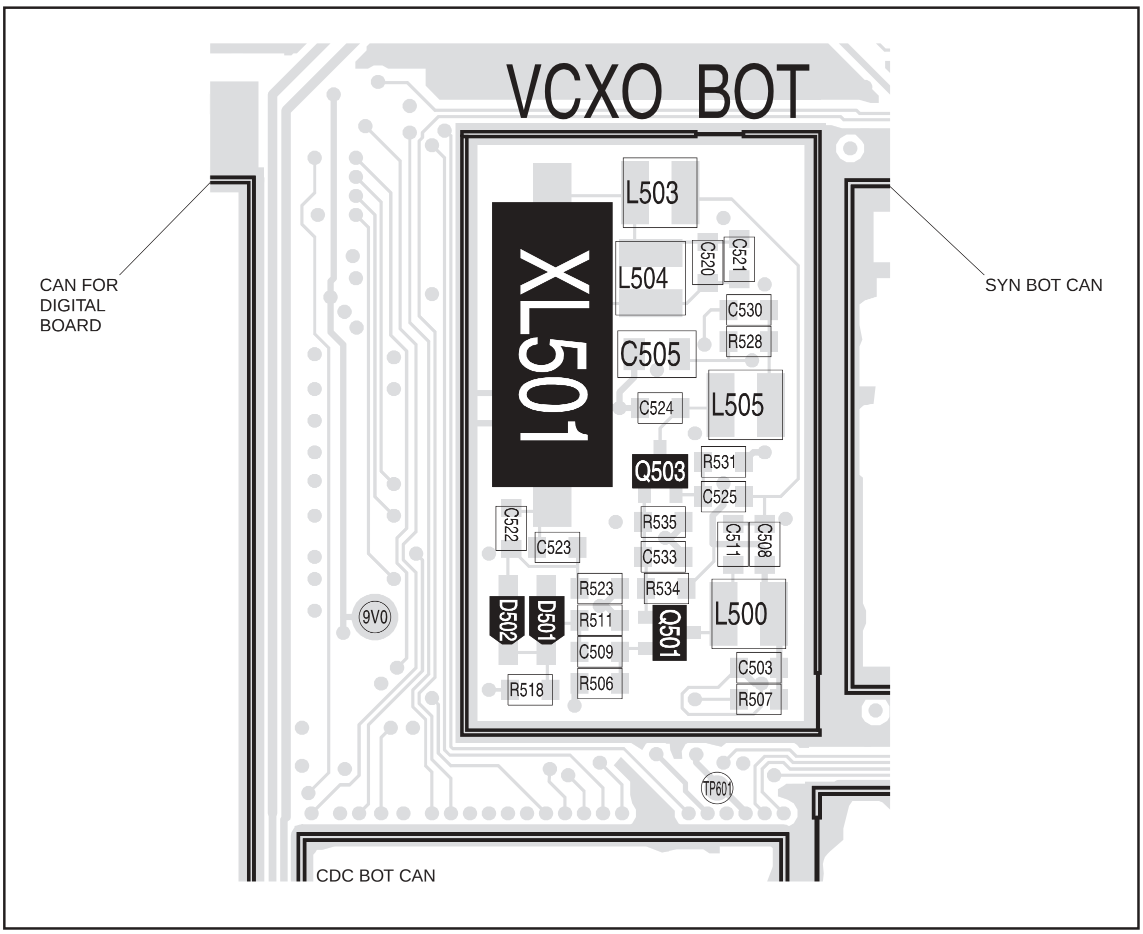
2. If the signal is correct, go to “Signals at TP501 and TP502” on page 221. If it is not, go to Step 3.

3. The TCXO circuitry under the CDC TOP can is faulty. Remove the CDC TOP can.

4. Locate and repair the fault in the TCXO (**XL500** and associated components) (see **Figure 9.15**).

5. Confirm the removal of the fault and go to “Signals at TP501 and TP502” on page 221. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 9.17 FCL circuitry under the VCXO BOT can



9.10 Signals at TP501 and TP502

Introduction

If the VCXO and TCXO outputs are correct, the next stage is to check the signals at the TP501 and TP502 test points. The procedure is divided into three tasks:

- Task 37: check signal at TP502
- Task 38: check signal at TP501 and ground TP501 if loop is oscillating
- Task 39: check signal at TP502 with TP501 grounded

These checks will reveal any faults in the mixer and LPF circuitry, and any additional fault in the VCXO circuitry.

Task 37 — TP502 Test Point

Check the signal at the TP502 test point to determine if there is a fault in the mixer or LPF (low-pass filter) circuitry:

1. Use the oscilloscope probe to check the difference frequency at the **TP502 test point** (see **Figure 9.16**). The signal is SYN CDC FCL and should be:

TP502 test point: sine wave of 1.1 ± 0.2 V_{pp} on 1.5 ± 0.1 V DC

2. If the signal is correct, go to Task 38. If it is not, go to Step 3.

3. The mixer or LPF circuitry under the FCL TOP can is faulty. Remove the FCL TOP can.

4. Locate the fault in the mixer (**IC501** and associated components) or LPF circuitry (**IC502** pins 5 to 7, and associated components) (see **Figure 9.16**).

5. Repair the circuitry. Note that the TCXO input to the mixer at **R521** (pin 4 of IC501) (see **Figure 9.16**) should be:

TCXO input at R521:	square wave with frequency of 13000000 Hz and amplitude of 3.0 ± 0.2 V_{pp}

   Also, the VCXO input to the mixer at **R522** (pin 1 of IC501) (see **Figure 9.16**), although noisy and difficult to measure, should be:

VCXO input at R522:	sine wave of 20 ± 10 mV_{pp}

6. Confirm the removal of the fault and go to Task 38. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 38 — TP501 Test Point

If the signal at the TP502 test point is correct, check the signal at the TP501 test point:

1. With the oscilloscope probe at the **TP501 test point** (see **Figure 9.16**), check the DAC output CDC VCXO MOD. If a triangular wave is present, go to Step 2. Otherwise go to “VCXO and CODEC Circuitry” on page 224.

2. A fault is causing the loop to oscillate. If not already done, remove the FCL TOP can.

3. Check the waveform at the **TP500 test point** (see **Figure 9.16**). The waveform should be an amplified and inverted version of the waveform at the **TP501 test point**.

4. If the waveform is correct, go to Step 5. If it is not, there is a fault in the modulator buffer amplifier (**IC502** pins 1 to 3, and associated components) (see **Figure 9.16**). Rectify the fault and return to Step 1.

5. Connect the **TP501 test point** to ground by resoldering **R527** in the position shown in **Figure 9.16**. This forces the VCXO loop voltage high.

6. Use the oscilloscope probe to check the VCXO output at **C536** — probe the via next to C536 (see **Figure 9.16**). The signal should be:

VCXO output at C536:	sine wave with frequency of 13.017 MHz and amplitude of 1.1 ± 0.2 V_{pp} on 1.4 ± 0.2 V DC

7. If the signal is correct, go to Task 39. If it is not, go to Step 8.

8. The VCXO circuitry is faulty. If not already done, remove the VCXO BOT can.

9. Locate and repair the fault in the VCXO circuitry (**Q501**, **Q503**, **XL501** and associated components) (see **Figure 9.17**).

10. Confirm the removal of the fault, and go to Task 39. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 39 — TP502 Test Point (TP501 Grounded)

If the loop was oscillating, Task 38 will have revealed any fault in the VCXO circuitry. If there was no fault, or if the circuit was repaired, a check at the TP502 test point is now required. This will show if there are any additional faults in the mixer or LPF circuitry.

1. Use the oscilloscope probe to check the difference frequency at the **TP502 test point** (see **Figure 9.16**). The signal is SYN CDC FCL and should be:

TP502 test point:	sine wave with frequency of at least 15 kHz and amplitude of $1.1 \pm 0.2\ V_{pp}$ on 1.5 ± 0.1 V DC

2. If the signal is correct, go to Step 6. If it is not, go to Step 3.

3. The mixer circuitry (**IC501** and associated components) or the LPF circuitry (**IC502** pins 5 to 7, and associated components) under the FCL TOP can is faulty (see **Figure 9.16**). Locate the fault.

4. Repair the circuitry. Note that the TCXO input to the mixer at **R521** (pin 4 of IC501) (see **Figure 9.16**) should be:

TCXO input at R521:	square wave with frequency of 13000000 Hz and amplitude of $3.0 \pm 0.2\ V_{pp}$

   Also, the VCXO input to the mixer at **R522** (pin 1 of IC501) (see **Figure 9.16**), although noisy and difficult to measure, should be:

VCXO input at R522:	sine wave of $20 \pm 10\ mV_{pp}$

5. Confirm the removal of the fault, and go to Step 6. If the repair failed, resolder **R527** in its original position as shown in **Figure 9.16**, replace the main-board assembly and go to “Final Tasks” on page 147.

6. Resolder **R527** in its original position as shown in **Figure 9.16**.

7. Replace all cans.

8. Use the oscilloscope probe to check the difference frequency at the **TP502 test point** (see **Figure 9.16**). The signal is SYN CDC FCL and should be:

TP502 test point: sine wave of $1.1 \pm 0.2\ V_{pp}$ on 1.5 ± 0.1 V DC

9. If the signal is correct, the fault has been removed; go to “Final Tasks” on page 147. If the signal is not correct, the repair failed; replace the main-board assembly and go to “Final Tasks” on page 147.

9.11 VCXO and CODEC Circuitry

Introduction

If the signals at the TP501 and TP502 test points are correct, two CCTM checks will reveal any remaining faults. These possible faults concern the VCXO tank circuit and the CODEC 2 circuitry. There are therefore three aspects, which are covered in Task 40 to Task 42:

- Task 40: CCTM checks
- Task 41: VCXO tank circuit
- Task 42: CODEC 2 circuitry

Following any repairs of the VCXO or CODEC 2 circuitry, Task 40 will need to be repeated to confirm the removal of the fault.

Task 40 — CCTM Checks

If the signals at the TP501 and TP502 test points are correct, or any related faults were rectified, perform the following CCTM checks:

1. Enter the CCTM command *393 1 1900*. Measure the voltage level at the **TP501 test point** (see **Figure 9.16**):

TP501 test point: 1.3 ± 0.2 V DC (after CCTM 393 1 1900)

2. Enter the CCTM command *72* and note the lock status.

lock status=**xyz** (**x**=RF PLL; **y**=FCL; **z**=LO2) (0=not in lock; 1=in lock)

3. Enter the CCTM command *393 1 –1900*. Again measure the voltage level at the **TP501 test point**:

TP501 test point: 2.1 ± 0.2 V DC (after CCTM 393 1 –1900)

4. Enter the CCTM command *72* and note the lock status.

5. If the above voltage levels are not correct or if the FCL is out of lock in either or both of the above cases, investigate the VCXO tank circuit; go to Task 41.

   If the voltage level remains fixed at about 1.5V DC, investigate the CODEC 2 circuitry; go to Task 42.

   If the voltage levels are all correct (following earlier repairs), the fault has been removed; go to “Final Tasks” on page 147.

Task 41 — VCXO Tank Circuit

If the CCTM checks indicate that the VCXO tank circuit is faulty, repair the circuit as follows:

1. If not already done, remove the VCXO BOT can.

2. Locate and repair the fault in the VCXO tank circuit (**Q501**, **D501**, **D502**, **XL501** and associated components) (see **Figure 9.17**).

3. Confirm the removal of the fault and go to Step 4. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

4. Replace all cans.

5. Repeat Task 40 to confirm the removal of the fault. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 42 — CODEC 2 Circuitry

If the CCTM checks indicate a fault in the CODEC 2 circuitry or with the digital signals to and from the circuitry, rectify the fault as follows:

1. Most of the CODEC 2 circuitry is situated under the CDC TOP can. If not already done, remove the CDC TOP can.

2. Check the following digital signals at **IC205** (see **Figure 9.15**):
   - pin 10 : DIG CDC2 LRCK
   - pin 12 : DIG CDC2 SCLK
   - pin 8 : CDC2 DIG SDTO
   - pin 9 : DIG CDC2 SDTI

   These signals to and from the digital board should all be active:

digital signals: 3.3 ± 0.3 V

3. If the digital signals are correct, the CODEC 2 circuitry is suspect; go to Step 6. If they are not, go to Step 4.

4. If any or all digital signals are missing, check the connections between **IC205** and the digital board (see **Figure 9.15**).

5. If there are faults such as open circuits in the connections, repair the circuitry and repeat Task 40.

   If the connections are not faulty, then the digital board is faulty. Replace the main-board assembly and go to "Final Tasks" on page 147.

6. The CODEC 2 circuitry comprises **IC205** and associated components under the CDC TOP can (see **Figure 9.15**) as well as **R246** under the CDC BOT can (see **Figure 7.3 on page 158**). Locate the fault.

7. Repair the circuitry. Note that, if the circuitry is functioning properly, probing the **TP501 test point** (see **Figure 9.16**) during power-up will show a five-step staircase signal followed by a random nine-step staircase signal — this is the expected power-up auto-calibration sequence.

8. Confirm the removal of the fault, and go to Step 9. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 147.

9. Replace all cans.

10. Repeat Task 40 to confirm the removal of the fault. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 147.

10 Receiver Fault Finding

Fault Conditions

This section covers the diagnosis of faults in the receiver. The fault-diagnosis procedures consist of 18 tasks grouped into the following sections.
The symptoms of the fault in the receiver circuitry determine which sections are relevant:

- "Faulty Receiver Sensitivity"
- "Excessive Loss of Sensitivity"
- "Moderate or Slight Loss of Sensitivity"
- "Incorrect RSSI Readings"
- "Faulty Radio Mute"
- "High Receiver Distortion"

If the receiver sensitivity is low, begin with "Faulty Receiver Sensitivity" on page 228 to determine the extent of the loss in sensitivity.

CCTM Commands

The CCTM commands required are listed in Table 10.1. Full details of the commands are given in "Computer-Controlled Test Mode (CCTM)" on page 112.

Table 10.1 CCTM commands required for the diagnosis of faults in the receiver

Command	Description
72	Read lock status of RF PLL, FCL and LO2 — displays **xyz** (0=not in lock, 1=in lock)
101 **x y** 0	Set transmit frequency (**x** in hertz) and receive frequency (**y** in hertz) to specified values
376	Read tuning voltage for front-end circuitry — displays voltage **x** in millivolts
378	Read signal power at output of channel filter — displays power **x** (square of amplitude)

10.1 Faulty Receiver Sensitivity

Introduction

This section covers the determination of the extent of the receiver's loss of sensitivity. Depending on the nature of the fault, a reduction in receiver sensitivity of 1dB is often due to a reduction in receiver gain of many decibels. It is therefore easier to measure gain loss rather than sensitivity loss. Consequently, if the receiver sensitivity is too low, first check the receiver gain. The procedure is given in Task 1 below.

Task 1 — Determine Extent of Sensitivity Loss

Determine the receiver gain as follows. The corresponding loss of sensitivity can then be deduced. Depending on the extent of the loss, continue with "Excessive Loss of Sensitivity" on page 230 or "Moderate or Slight Loss of Sensitivity" on page 234 to rectify the fault.

1. Input an RF signal (not necessarily modulated) of –90 dBm (or –84 dBm with a trigger-base radio) at the RF connector.

2. Enter the CCTM command *378* to measure the receiver output level.

3. Note the value ***x*** returned for the receiver output level. Depending on the frequency band in which the radio operates, the value should be:

receiver output level ***x***: normally between 500 000 and 6000 000

   Note that a change in the input level of 10mdB should result in a ten-fold change in ***x***.

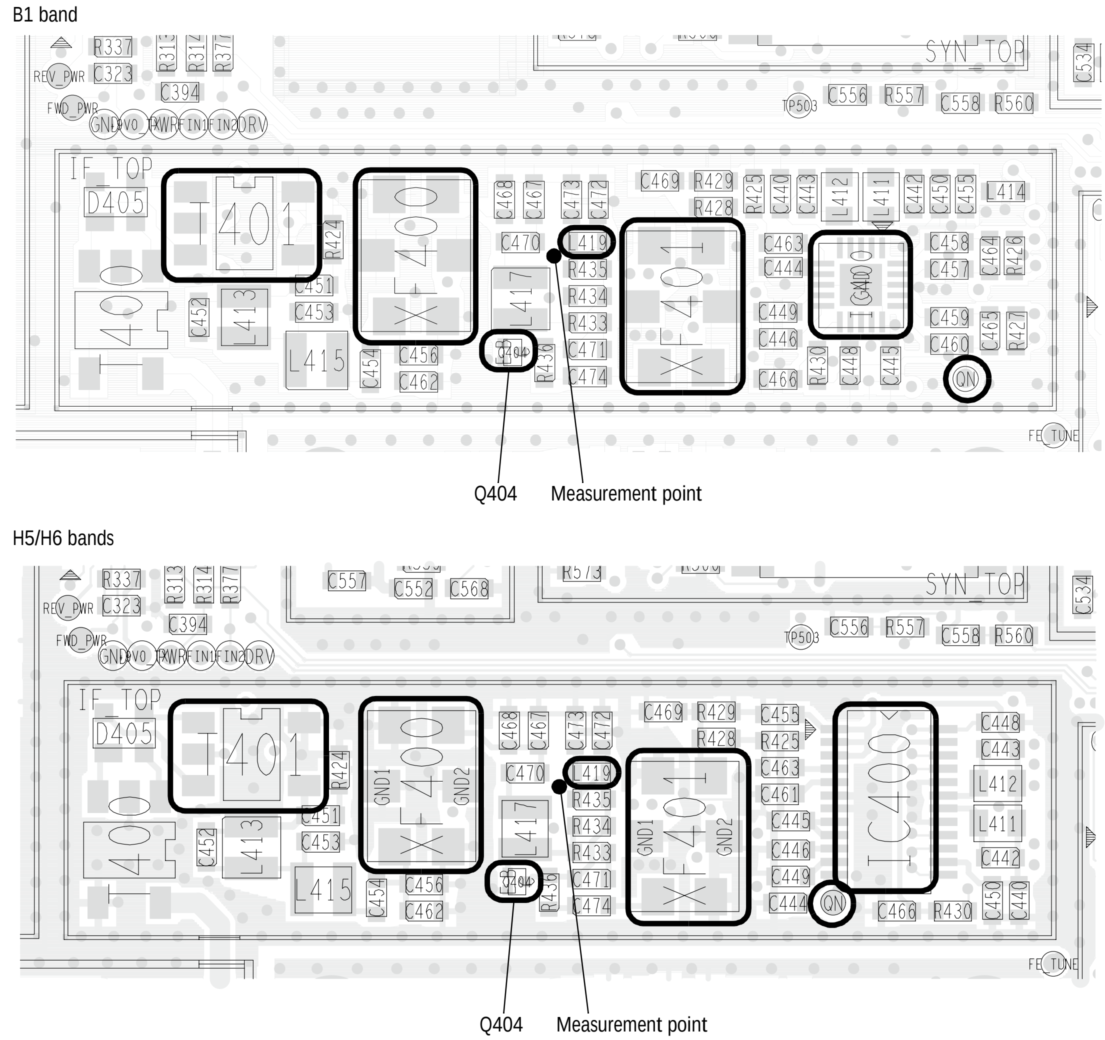
4. If necessary, measure the RF voltage at the **QN test point** (see **Figure 10.1**). (There is access through a hole in the IF TOP can.) For comparison, the voltages corresponding to the above values of ***x*** are:

x = 500 000: 12 mV_{pp} ***x*** = 6000 000: 120 mV_{pp}

   With an unmodulated RF signal the frequency should be 64.000kHz, provided that the LO1, FCL and LO2 are locked and on the correct frequency.

5. Given the value of ***x***, go to the relevant section as follows:
   - ***x*** < 1500, go to "Excessive Loss of Sensitivity" on page 230 (sensitivity is very low)
   - ***x*** < 500 000, go to "Moderate or Slight Loss of Sensitivity" on page 234 (sensitivity is low)

Figure 10.1 Receiver circuitry under the IF TOP can (top side)



10.2 Excessive Loss of Sensitivity

Introduction

This section covers the case where the receiver has suffered an excessive loss of sensitivity. As measured in Task 1, the receiver gain will be less than 1500, which implies a sensitivity that is more than 40 mdB too low. The fault-diagnosis procedure for this case consists of five tasks:

- Task 2: check power supplies
- Task 3: check logic signal
- Task 4: check lock status
- Task 5: check biasing of IF amplifier
- Task 6: check matching circuitry

If the fault does not lie with the power supplies, it is probably in the control, LO, IF1 or IF2 circuitry.

Task 2 — Check Power Supplies

First check the two power supplies 3V0 AN and 3V0 RX for the receiver circuitry.

1. Remove the main-board assembly from the chassis.
2. Check for 3.0 V DC (3V0 AN) at the **TP601 test point** near the LO2 BOT can (see **Figure 10.2**).

TP601 test point: 3.0 V DC

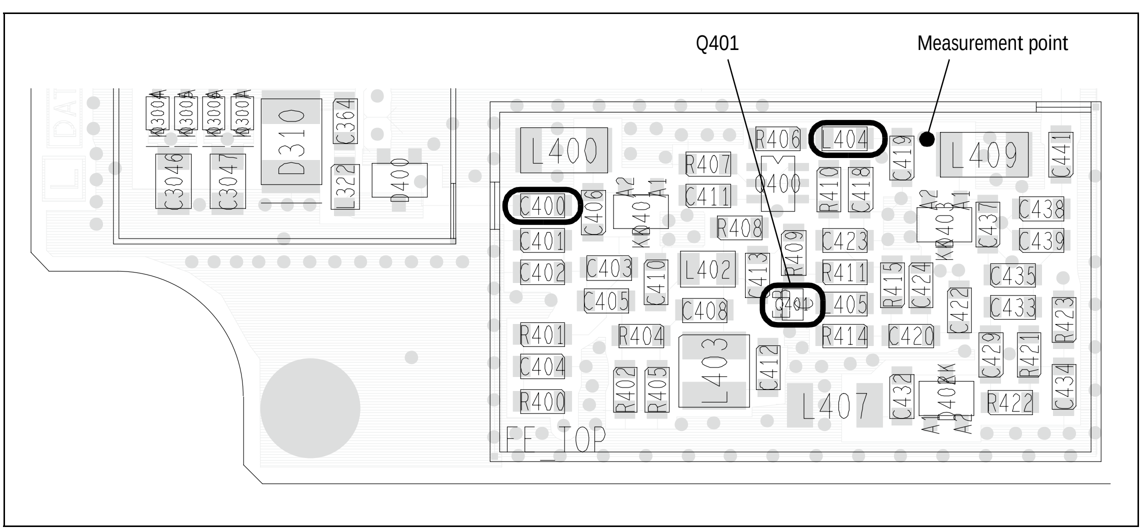
3. If the voltage is correct, go to Step 4. If it is not, the 3 V regulator **IC603** is suspect; go to Task 3 of "Power Supply Fault Finding" on page 158.
4. Remove the LO2 BOT can.
5. Check for 3.0 V DC (3V0 RX) around the collector feed to **Q402** or **Q403** of LO2 (see **Figure 10.2**).

Q402 or Q403 collector: 3.0 V DC

   Alternative measurement points are the collector feed to **Q401** of the RF LNA under the FE TOP can (see **Figure 10.3**) or **Q404** of the IF amplifier under the IF TOP can (see **Figure 10.1**).
6. If the voltage is correct, go to Task 3. If it is not, the 3 V RX switch (based on **Q604** and **Q605**) in the PSU module is suspect; go to Task 3 of "Power Supply Fault Finding" on page 158.

Figure 10.2 Receiver circuitry under the LO2 BOT can (bottom side)

Figure 10.3 Receiver circuitry under the FE TOP can (top side)



Task 3 — Check Logic Signal

If there is no fault with the power supplies, check the logic signal DIG RX EN that is input from the digital board.

1. Check the logic signal DIG RX EN at pin 8 of **IC403** (see **Figure 10.2**). The signal is active high. The required status is active.

pin 8 of IC403: about 3.0V (active)

   An alternative measurement point to the above is pin 24 of **IC400** under the IF TOP can (see **Figure 10.1**).

2. If DIG RX EN is active, go to Task 4. If it is not, go to Step 3.

3. Check the signal continuity from the digital board to the receiver. Repair any fault and go to Step 4. If the digital board itself appears to be faulty, replace the main-board assembly and go to “Final Tasks” on page 147.

4. Recalibrate the receiver using the calibration application.

5. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, go to Task 7.

Task 4 — Check Lock Status

If the logic signal from the digital board is active, as required, check the lock status of the radio.

1. Enter the CCTM command *72* to determine the lock status. The status should be normal:

lock status: 111 (LO1, FCL, LO2 all in lock)

2. If the lock status is normal, go to Task 5. If the LO1 is not in lock, go to “Frequency Synthesizer Fault Finding” on page 169. If the FCL is not in lock, go to “Power Supply for FCL” on page 215. If the LO2 is not in lock, go to Step 3.

3. Check the components around **IC403**, **Q402** and **Q403** (see **Figure 10.2**). Repair any fault.

4. Recalibrate the receiver using the calibration application.

5. Confirm the removal of the fault, and go to “Final Tasks” on page 147. If the repair failed go to Task 7.

Task 5 — Check Biasing of IF Amplifier

If the lock status is normal, check the biasing of the IF amplifier.

1. Remove the IF TOP can.
2. Check all components around **Q404** of the IF amplifier (see **Figure 10.1**).
3. Check the 3V supply voltage at **L419**; use the measurement point shown in **Figure 10.1**.
4. Also check the amplifier bias conditions. First measure V_c between the collector of **Q404** and ground (see **Figure 10.1**).

V_c: 2.0 ± 0.2V

5. Secondly, check I_c. To do so, unsolder and raise one terminal of **L419** (tombstone position) (see **Figure 10.1**), connect a multimeter between this terminal and the pad for the terminal, and measure the current.

I_c: 1.8 ± 0.5mA

6. If the checks in Step 2 to Step 5 reveal no fault, go to Task 6. If there is a fault, repair it and go to Step 7.
7. Recalibrate the receiver using the calibration application.
8. Confirm the removal of the fault, and go to “Final Tasks” on page 147. If the repair failed go to Task 7.

Task 6 — Check Matching Circuitry

Having excluded the IF amplifier, check the matching circuitry for the crystal filters.

1. Check all remaining components between **T401** and **IC400** — these form the matching circuitry for the crystal filters **XF400** and **XF401** (see **Figure 10.1**).
2. If the above check reveals no fault, go to Step 3. If there is a fault, repair it and go to Step 6.
3. Remove the PIN TOP and LPF TOP cans.
4. Make a visual check of the components in the receive path of the PIN switch and LPF circuits.
5. If the visual check reveals an obvious fault, repair it and go to Step 6. If there is no obvious fault, go to Task 7.
6. Recalibrate the receiver using the calibration application.
7. Confirm the removal of the fault, and go to “Final Tasks” on page 147. If the repair failed go to Task 7.

10.3 Moderate or Slight Loss of Sensitivity

Introduction

This section covers the case where the receiver has suffered a moderate or slight loss of sensitivity. As measured in Task 1, the receiver gain will be less than 500 000, but not as low as 1500. With a gain less than 40 000, the loss of sensitivity will be moderate — about 15 mdB too low; otherwise it will be slight — just a few decibels too low. There are three tasks:

- Task 7: front-end calibration and tuning voltages
- Task 8: moderately low receiver sensitivity
- Task 9: slightly low receiver sensitivity

The fault-diagnosis procedures of Task 8 and Task 9 are similar; although the differences are minor they are important.

Task 7 — Front-end Calibration and Tuning Voltages

If the loss of sensitivity is moderate or slight, the fault is probably in the front-end tuning circuitry.

1. Using the calibration application, check the calibration of the front-end tuning circuitry: Open the *"Raw Data"* page and click the *"Receiver"* tab.

2. Record the values listed in the *"Rx FE Tune BPF Settings"* field — these are the DAC values of the FE (front-end) tuning voltages for the five frequencies *FE TUNE0* to *FE TUNE4*.

   (*FE TUNE0* is the lowest frequency and *FE TUNE4* the highest frequency in the radio's frequency band; the values are given in **Table 10.2**.)

3. For each of the frequencies *FE TUNE0* to *FE TUNE4* in turn, carry out the following procedure: Enter the CCTM command *101* ***a a*** *0*, where ***a*** is the frequency in hertz.

   Enter the CCTM command *376* and record the value returned — this is the front-end tuning voltage in millivolts.

4. Compare the values measured in Step 2 and Step 3 with the nominal DAC and voltage values listed in **Table 10.2**.

5. If the DAC and voltage values are correct, go to Step 8. If they are not, go to Step 6.

6. Recalibrate the receiver using the calibration application, and check the DAC and voltage values again.

7. If the DAC and voltage values are now correct, the fault has been rectified; go to "Final Tasks" on page 147. If they are not, go to Step 8.

8. Go to Task 8 if the receiver output level ***x*** measured in Task 1 was less than 40 000; otherwise go to Task 9.

Task 8 — Moderately Low Sensitivity

Following the initial investigation in Task 7, check the circuitry as follows when the sensitivity loss is moderate.

1. Remove the FE TOP can and, if not already done, the IF TOP can.
2. Check the soldering of all the components of the front-end tuning circuitry from **C400** to **T401** (see **Figure 10.1** and **Figure 10.3**).
3. Check the 3V supply voltage at **L404**; use the measurement point shown in **Figure 10.3**.
4. Also check the LNA bias conditions. First measure V_c between the collector of **Q401** and ground (see **Figure 10.3**).

V_c: 2.7 ± 0.1V

5. Secondly, check I_c. To do so, unsolder and raise one terminal of **L404** (tombstone position) (see **Figure 10.3**), connect a multimeter between this terminal and the pad for the terminal, and measure the current.

I_c: 10 ± 1mA

6. If the checks in Step 2 to Step 5 reveal no fault, go to Step 7. If there is a fault, repair it and go to Step 8.
7. Check the signal level at the output of LO1 and continue the fault diagnosis as in “Power Supply for FCL” on page 215.
8. Recalibrate the receiver using the calibration application.
9. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, go to Task 9.

Table 10.2 Front-end tuning voltages and corresponding DAC values

Frequency band	Tuning voltages at five different frequencies				
	FE TUNE0	*FE TUNE1*	*FE TUNE2*	*FE TUNE3*	*FE TUNE4*
B1 band					
Frequency (MHz)	135.9	145.1	155.1	164.1	174.1
DAC value	37 ± 20	88 ± 15	136 ± 15	174 ± 15	210 ± 15
Voltage (V)	0.44 ± 0.24	1.04 ± 0.18	1.60 ± 0.18	2.04 ± 0.18	2.57 ± 0.18
H5 band					
Frequency (MHz)	399.9	417.1	435.1	452.1	470.1
DAC value	0 to 36	94 ± 15	106 ± 15	156 ± 15	191 ± 15
Voltage (V)	0 to 0.43	1.11 ± 0.18	1.25 ± 0.18	1.84 ± 0.18	2.25 ± 0.18
H6 band					
Frequency (MHz)	449.9	470.1	490.1	510.1	530.1
DAC value	41 ± 20	91 ± 15	134 ± 15	176 ± 15	210 ± 15
Voltage (V)	0.48 ± 0.24	1.07 ± 0.18	1.58 ± 0.18	2.07 ± 0.18	2.47 ± 0.18

Task 9 — Slightly Low Sensitivity

Following the initial investigation in Task 7, check the circuitry as follows when the sensitivity loss is slight.

1. Remove the FE TOP can and, if not already done, the IF TOP can.
2. Check the soldering of all the components of the front-end tuning circuitry from **C400** to **T401** (see **Figure 10.1** and **Figure 10.3**).
3. Check the IF-amplifier bias conditions as in Step 4 and Step 5 of Task 5.
4. Check the LNA bias conditions as in Step 4 and Step 5 of Task 8.
5. If the checks of Step 2 to Step 4 reveal no fault, go to Step 6. If there is a fault, repair it and go to Step 7.
6. Check the PIN switch and LPF as in Task 31 to Task 33 of "Transmitter Fault Finding (50W/40W Radios)" on page 245 or "Transmitter Fault Finding (25W Radios)" on page 315.
7. Recalibrate the receiver using the calibration application.
8. Confirm the removal of the fault and go to "Final Tasks" on page 147. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 147.

10.4 Incorrect RSSI Readings

Introduction

If the RSSI readings are incorrect, the receiver calibration is suspect. There are four tasks, which cover the four types of settings concerned:

- Task 10: AGC voltage calibration
- Task 11: FE tune BPF settings
- Task 12: RSSI delta gain
- Task 13: AGC delta gain

If the receiver is properly calibrated but the fault persists, then the receiver sensitivity is suspect.

Task 10 — AGC Voltage Calibration

The first settings to check concern the AGC voltage calibration.

1. In the calibration application open the *"Raw Data"* page and click the *"Receiver"* tab.
2. Note the settings listed in the *"AGC Voltage Cal Pts"* field. The nominal settings should be as listed in **Table 10.3**.
3. If the settings are correct, go to Task 11. If they are not, go to Step 4.
4. Recalibrate the receiver and check the settings again.
5. If the settings are now correct, go to Step 6. If they are not, go to Task 1 and check the receiver sensitivity.
6. Check if the RSSI fault has been removed. If it has, go to "Final Tasks" on page 147. If it has not, go to Task 11.

Table 10.3 Nominal AGC data

Parameter	AGC voltage (mV)	
	B1 band	
AGC0 *AGC1* *AGC2*	1725 ± 40 1850 ± 40 2000 ± 50	
	AGC voltage (mV)	
	H5 band	**H6 band**
AGC0 *AGC1* *AGC2*	1860 ± 40 2040 ± 40 2200 ± 50	1870 ± 40 2050 ± 40 2220 ± 50
	Receiver input power (dBm)	
	Standard radio	**Trigger-base radio**
AGC0 *AGC1* *AGC2*	–50 –60 –68	–44 –54 –62

Task 11 — FE Tune BPF Settings

If the AGC voltage calibration is correct, check the FE tune BPF settings.

1. Note the settings listed in the *"FE Tune BPF Settings"* field. The nominal settings should be as listed in **Table 10.2**.
2. If the settings are correct, go to Task 12. If they are not, go to Step 3.
3. Recalibrate the receiver and check the settings again.
4. If the settings are now correct, go to Step 5. If they are not, go to Task 1 of "Faulty Receiver Sensitivity" on page 228 and check the receiver sensitivity.
5. Check if the RSSI fault has been removed. If it has, go to "Final Tasks" on page 147. If it has not, go to Task 12.

Task 12 — RSSI Delta Gain

If the FE tune BPF settings are also correct, check the RSSI delta gain values.

1. Note the values listed in the *"Rx Delta Gain Values"* field. The values should be between 0mdB and about –3mdB.
2. If the values are as expected, go to Task 13. If they are not, go to Step 3.
3. Recalibrate the receiver and check the values again.
4. If the values are now correct, go to Step 5. If they are not, go to Task 1 and check the receiver sensitivity.
5. Check if the RSSI fault has been removed. If it has, go to "Final Tasks" on page 147. If it has not, go to Task 13.

Task 13 — AGC Delta Gain

If the RSSI delta gain values are also correct, check the AGC delta gain values.

1. Note the values listed in the *"AGC Delta Gain Values"* field. The values should run gradually from 0mdB to about 35mdB.
2. If the values are as expected, go to Step 6. If they are not, go to Step 3.
3. Recalibrate the receiver and check the values again.
4. If the values are now correct, go to Step 5. If they are not, go to Task 1 and check the receiver sensitivity.
5. Check if the RSSI fault has been removed. If it has, go to "Final Tasks" on page 147. If it has not, go to Step 6.
6. In this case all the RSSI calibration settings are correct, but there is still an RSSI fault. Go to Task 1 and check the receiver sensitivity.

10.5 Faulty Radio Mute

Introduction

If the radio mute is faulty, the calibration settings are suspect. There are three tasks:

- Task 14: determine type of muting selected
- Task 15: noise muting selected
- Task 16: RSSI muting selected

The programming application is required for Task 14, and the calibration application for Task 15 and Task 16.

Task 14 — Determine Type of Muting Selected

First use the programming application to determine the type of muting selected.

1. In the programming application click the *“Basic Settings”* page under the *“Channel Profiles”* heading.

2. Click the *“General Settings”* tab.

3. Check the setting in the *“Squelch Detect Type”* field. Ensure that the setting is what the Customer expects.

4. If the setting is *“Noise Level”*, implying that noise muting is selected, go to Task 15. If the setting is *“Signal Strength”*, implying that RSSI muting is selected, go to Task 16.

Task 15 — Noise Muting Selected

With noise muting selected, check the noise mute settings:

1. In the calibration application open the *"Deviation/Squelch"* page and click the *"Squelch and Signaling Thresholds"* tab.
2. Ensure that, under the *"Squelch Thresholds"* label, the settings in the *"Country"*, *"City"* and *"Hard"* fields are what the Customer expects.
3. Open the *"Raw Data"* page and click the *"Mute"* tab.
4. Compare the values in the *"Mute Noise Readings"* field with the required minimum and maximum values listed in **Table 10.4**.
5. If the mute noise readings are correct, go to Task 1 and check the receiver sensitivity. If they are not, go to Step 6.
6. Recalibrate the mute and then check if the mute fault has been removed.
7. If the fault has been removed, go to "Final Tasks" on page 147. If it has not, go to Task 1 and check the receiver sensitivity.

Table 10.4 Mute data

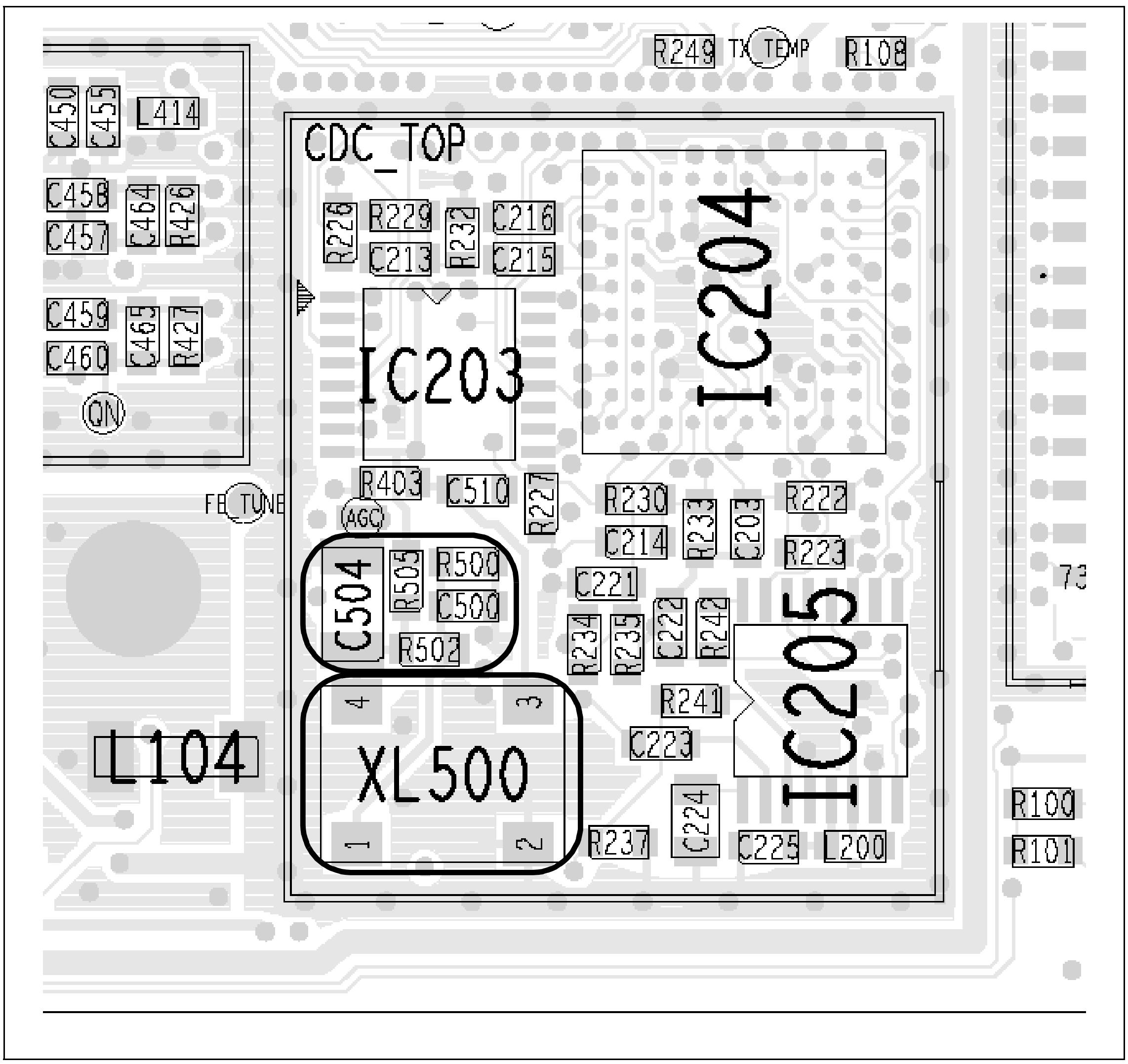
Channel spacing	SINAD (dB)	Mute noise readings	
		Minimum noise value	Maximum noise value
Narrow (12.5 kHz)	8	1900	2300
	20	250	500
Medium (20 kHz)	8	3700	4200
	20	1000	1500
Wide (25 kHz)	8	5500	7300
	20	2200	3700

Task 16 — RSSI Muting Selected

With RSSI muting selected, check the RSSI mute settings.

1. In the calibration application open the *“Deviation/Squelch”* page and click the *“Squelch and Signaling Thresholds”* tab.
2. Check that the values in the *“Opening Pt”* fields and the *“Hysteresis”* fields under the *“Squelch Thresholds”* label are what the Customer expects.
3. If the calibration values are as expected, go to Task 10 and check the RSSI calibration. If they are not, go to Step 4.
4. Adjust the values in the *“Opening Pt”* and *“Hysteresis”* fields. Program the radio with the new values.
5. Check if the mute fault has been removed. If it has, go to “Final Tasks” on page 147. If it has not, go to Task 10 and check the RSSI calibration.

Figure 10.4 TCXO circuitry under the CDC TOP can (top side)



10.6 High Receiver Distortion

Introduction

If there is high receiver distortion, the TCXO is suspect, or alternatively, the matching circuitry for the crystal filters XF400 and XF401. There are two tasks:

- Task 17: TCXO calibration and repair of TCXO
- Task 18: second IF and repair of matching circuitry

Recalibrating the TCXO might often be sufficient to rectify the fault.

Task 17 — TCXO Calibration and Repair of TCXO

First check the TCXO calibration and, if necessary, repair the TCXO.

1. Use the calibration application to check the TCXO calibration: Open the *"Raw Data"* page and click the *"Volt Ref/TCXO/VCO/VCXO"* tab.

2. Note the values listed in the *"Tx TCXO"* and *"Rx TCXO"* fields of the *"TCXO"* group box. The values should be:

Tx TCXO and Rx TCXO values: between +20Hz and –20Hz

3. If the calibration values are correct, go to Step 4. If they are not, recalibrate the TCXO and go to Step 8.

4. Remove the CDC TOP can.

5. Check the components of the TCXO, which is based on **XL500** (see **Figure 10.4**). Repair any fault.

6. Recalibrate the TCXO and check the TCXO calibration values again as in Step 1 and Step 2.

7. If the calibration values are now correct, go to Step 8. If they are not, go to Task 18.

8. Check if the distortion fault has been removed. If it has, go to "Final Tasks" on page 147. If it has not, go to Task 18.

Task 18 — Second IF and Repair of Matching Circuitry

If the TCXO is not faulty, check the second IF and, if necessary, repair the matching circuitry.

1. Input a large unmodulated RF input signal exceeding –90 dBm at the RF connector.

2. Use a needle probe to measure the frequency of the signal at the **QN test point** — access is through the hole in the IF TOP can (see **Figure 10.1**). The frequency is the second IF and should be:

frequency at QN test point: 64.000 kHz

3. If the second IF is correct, go to Step 6. If it is not, go to Step 4.

4. Recalibrate the TCXO.

5. Check if the distortion fault has been removed. If it has, go to “Final Tasks” on page 147. If it has not, go to Step 6.

6. Remove the IF TOP can.

7. Check the components between **T401** and **IC400** — these form the matching circuitry for the crystal filters **XF400** and **XF401** (see **Figure 10.1**).

8. Repair any fault, confirm the removal of the fault, and go to “Final Tasks” on page 147. If the repair failed or no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 147.

11 Transmitter Fault Finding (50 W/40 W Radios)

Introduction

50W 40W

This section covers the diagnosis of faults in the transmitter circuitry of the 50 W/40 W radios. The main indication of a fault in the transmitter is a reduction in range. This implies that the power output is wrong or too low. Another type of fault is manifested when the radio always transmits at full power, even if set otherwise. Regardless of the fault, the lock status should be normal.

Fault-Diagnosis Tasks

The procedure for diagnosing transmitter faults is divided into tasks, which are grouped into the following sections:

- "Power Supplies"
- "Transmitter RF Power"
- "Biasing of PA Driver and PAs"
- "RF Signal Path"

Before beginning the fault diagnosis with "Power Supplies", note the following information regarding CCTM commands, frequency bands, can removal and replacement, and transmit tests.

CCTM Commands

The CCTM commands required in this section are listed in Table 11.1. Full details of the commands are given in "Computer-Controlled Test Mode (CCTM)" on page 112.

Table 11.1 CCTM commands required for the diagnosis of faults in the transmitter

Command	Description
32	Set radio in receive mode
33	Set radio in transmit mode
47	Read temperature near PAs — displays temperature **x** in degrees celsius and voltage **y**
101 **x** **y** 0	Set transmit frequency (**x** in hertz) and receive frequency (**y** in hertz) to specified values
114 **x**	Set DAC value **x** (in range 0 to 1023) of transmit power
304	Read clamp current at gate of PA driver — displays DAC value **x** (in range 0 to 255)
304 **x**	Set DAC value **x** (in range 0 to 255) of clamp current at gate of PA driver
318	Read forward-power level — displays corresponding voltage **x** in millivolts
319	Read reverse-power level — displays corresponding voltage **x** in millivolts
326 **x**	Set transmitter power level **x** (0=off, 1=very low, 2=low, 3=medium, 4=high, 5=maximum)
331	Read bias voltage for first PA — displays DAC value **x** (in range 0 to 255)
331 **x**	Set DAC value **x** (in range 0 to 255) of bias voltage for first PA
332	Read bias voltage for second PA — displays DAC value **x** (in range 0 to 255)
332 **x**	Set DAC value **x** (in range 0 to 255) of bias voltage for second PA
334 **x**	Set synthesizer on (**x**=1) or off (**x**=0) via DIG SYN EN line
335 **x**	Set transmit-receive switch on (**x**=1) or off (**x**=0) via DIG SYN TR SW line

Frequency Bands

Some fault-diagnosis tasks require programming the radio with the lowest, center or highest frequency in the radio's frequency band. The relevant frequencies for the different bands are listed in Table 11.2. Note that the following frequency ranges are reserved worldwide for use by distress beacons:

- B1 band: 156.8MHz ± 375kHz
- H5 band: 406.0 to 406.1MHz

Do not program the radio with any frequency in the above ranges.

Table 11.2 Lowest, center and highest frequencies in MHz

Band	Lowest frequency	Center frequency	Highest frequency
B1	136	155	174
H5	400	435	470
H7	450	485	520

Can Removal

There are five cans shielding the bulk of the transmitter circuitry:

- PAD TOP
- PAF TOP
- DIRC TOP
- PIN TOP
- LPF TOP

To remove any can, first remove the main-board assembly from the chassis. In the case of the PAD TOP and PAF TOP cans, first detach the heat-transfer block from the main board. Secure the block again after removing the cans. Follow the procedures given in "Disassembly and Reassembly" on page 123.

Can Replacement

Replace all cans that have been removed only after repairing the board. An exception is the B1 band, however, where the LPF TOP can must be in place if the transmitter is to operate correctly.

Transmit Tests

The following points need to be borne in mind when carrying out transmit tests:

- secure main-board assembly
- ensure proper antenna load
- limit duration of transmit tests
- protect against accidental transmissions
- avoid thermal and RF burns

These points are discussed in more detail below.

Secure Main-Board Assembly

Before conducting any transmit tests, ensure that the main-board assembly is adequately secured in the chassis. This is essential if overheating of the radio is to be avoided. (As mentioned earlier, the heat-transfer block must already be secured to the main board of the assembly.) It is good practice to secure the assembly by at least the two external screws and one of the internal screws. The screws are labelled ⑧ and ④ in Figure 5.3 on page 127. There is no need, however, to secure the lid of the radio body.

Ensure Proper Antenna Load

The radio has been designed to operate with a 50Ω termination impedance, but will tolerate a wide range of antenna loading conditions. Nevertheless, care should be exercised. Normally the RF connector on the main-board assembly will be connected to the RF communications test set as shown in Figure 4.2 on page 106. But for those tests where this connection is not necessary, a 50Ω load may be used instead. Do not operate the transmitter without such a load or without a connection to the test set. Failure to do so might result in damage to the power output stage of the transmitter.

Limit Duration of Transmit Tests

After setting the frequency and power level (if necessary), enter the CCTM command *33* to perform a transmit test. This command places the radio in transmit mode. After completing the measurement or check required, immediately enter the CCTM command *32*. This command returns the radio to the receive mode. Restricting the duration of transmit tests in this way will further limit the danger of overheating. The reason for this precaution is that the transmit timers do not function in the CCTM mode.

Protect Against Accidental Transmissions

Under certain circumstances the microprocessor can key on the transmitter. Ensure that all instruments are protected at all times from such accidental transmissions.

Avoid Thermal and RF Burns

Avoid thermal burns. Do not touch the cooling fins or underside of the radio body when the transmitter is or has been operating. Avoid RF burns. Do not touch the antenna or the RF signal path on the circuit board while the transmitter is operating.

11.1 Power Supplies

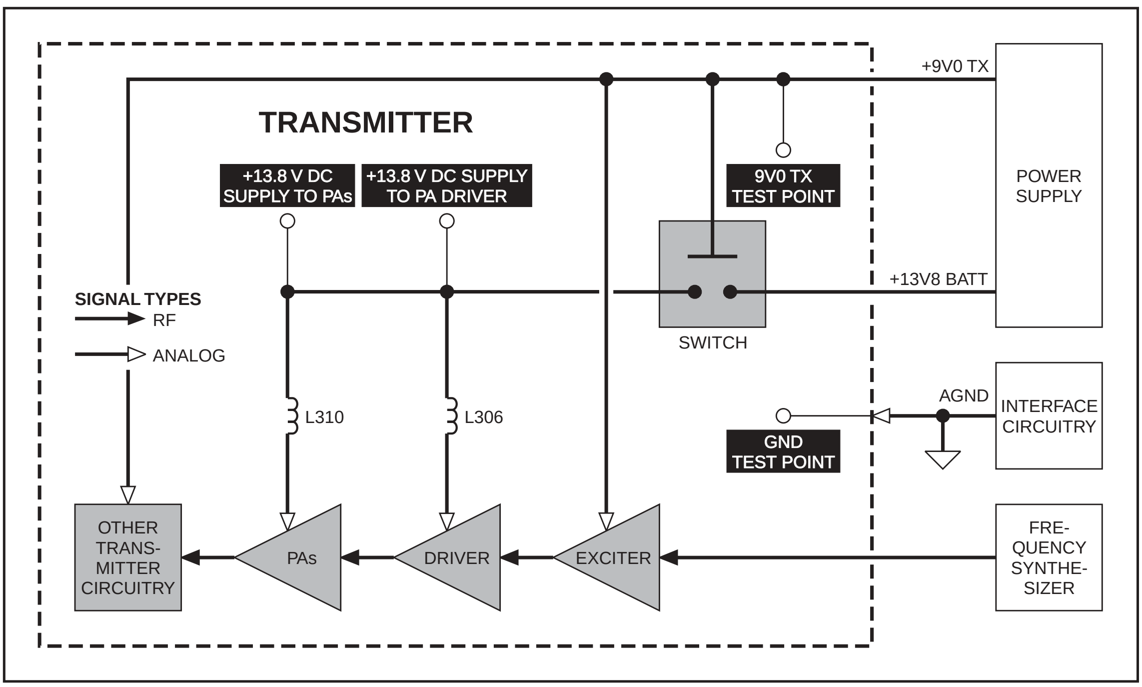
Introduction

First check that a power supply is not the cause of the fault. There are two power supplies and a switch circuit for the transmitter:

- Task 1: 13.8V DC supply from power connector (+13V8 BATT)
- Task 2: switch circuit for 13.8V DC supply
- Task 3: 9V DC supply from 9V regulator in PSU module (+9V0 TX)

The measurement and test points for diagnosing faults in the power supplies are summarized in Figure 11.1.

Figure 11.1 Measurement and test points for diagnosing faults involving the power supplies for the transmitter



Task 1 — 13.8V Power Supply

First check the power supply from the power connector.

1. Obtain a needle probe to use for measurements of the power supply at the PA driver and PAs. If none is available, remove the PAF TOP and PAD TOP cans.
2. Set the DC power supply to 13.8V, with a current limit of 10A.
3. Program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the frequency in hertz. The required values for the different frequency bands are given in **Table 11.2**.
4. Enter the CCTM command *326 5* to set the radio to maximum power.
5. Attempt to place the radio in transmit mode. Enter the CCTM command *33*.
6. If the radio enters the transmit mode, continue with Step 7. If instead a *C03* error is displayed in response to the command *33*, go to Task 7 in "Transmitter RF Power" on page 262.
7. Measure the voltage at the point on **L310** shown in **Figure 11.2** (B1 band) or **Figure 11.3** (H5, H7 bands). This is the supply at the common drain of **Q309** and **Q310**, and should be:

common drain of Q309 and Q310: more than 13V DC

8. Also measure the voltage at the point on **L306** shown in **Figure 11.4** (B1 band) or **Figure 11.5** (H5, H7 bands). This is the supply at the drain of **Q306**, and should be:

drain of Q306: more than 13V DC

9. Enter the CCTM command *32* to place the radio in receive mode.
10. If the power supply measured in Step 7 and Step 8 is not correct, go to Task 2. If it is, go to Task 3.

Figure 11.2 Point for measuring the power supply to the PAs (B1 band)

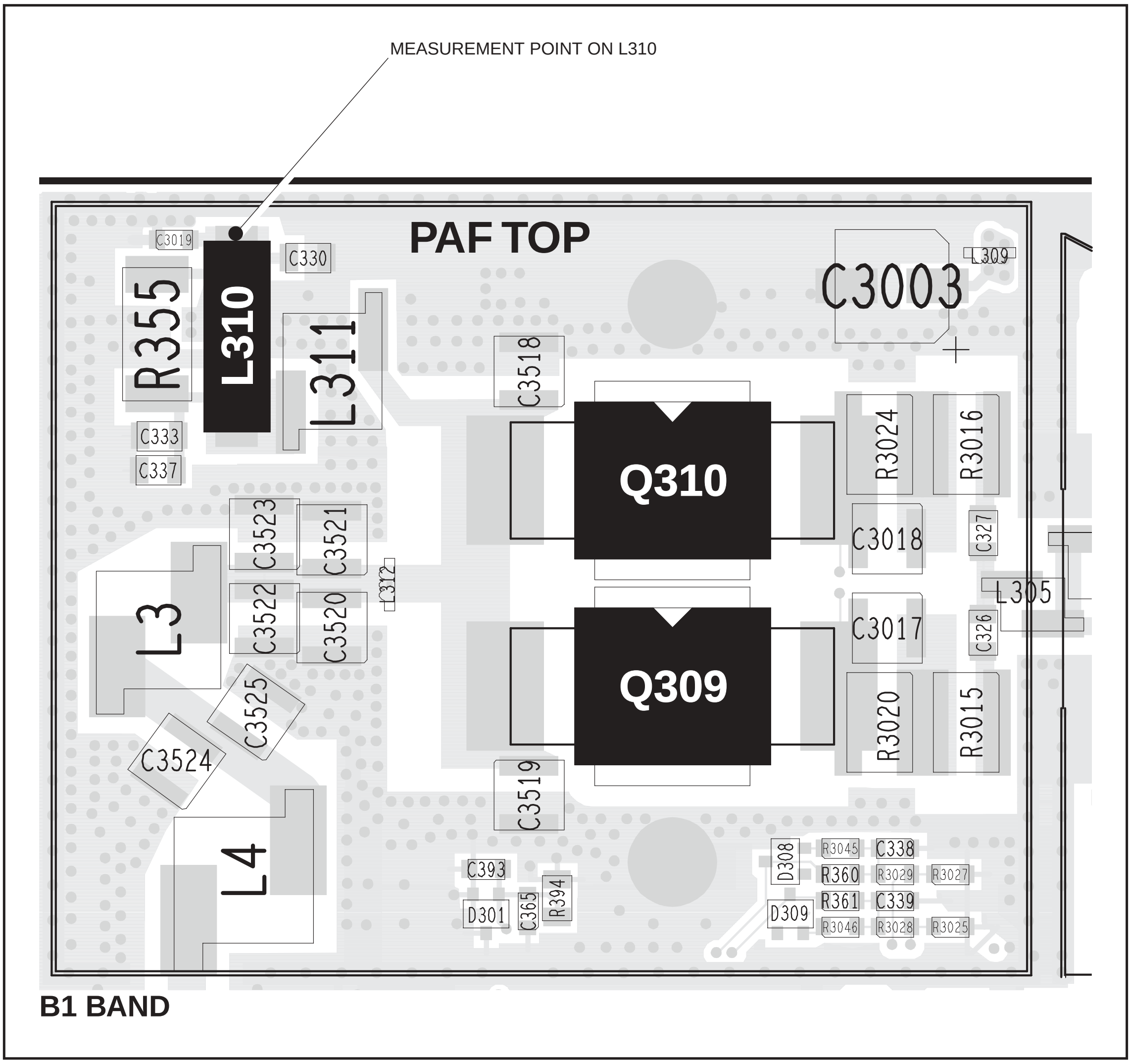


Figure 11.3 Point for measuring the power supply to the PAs (H5 and H7 bands)

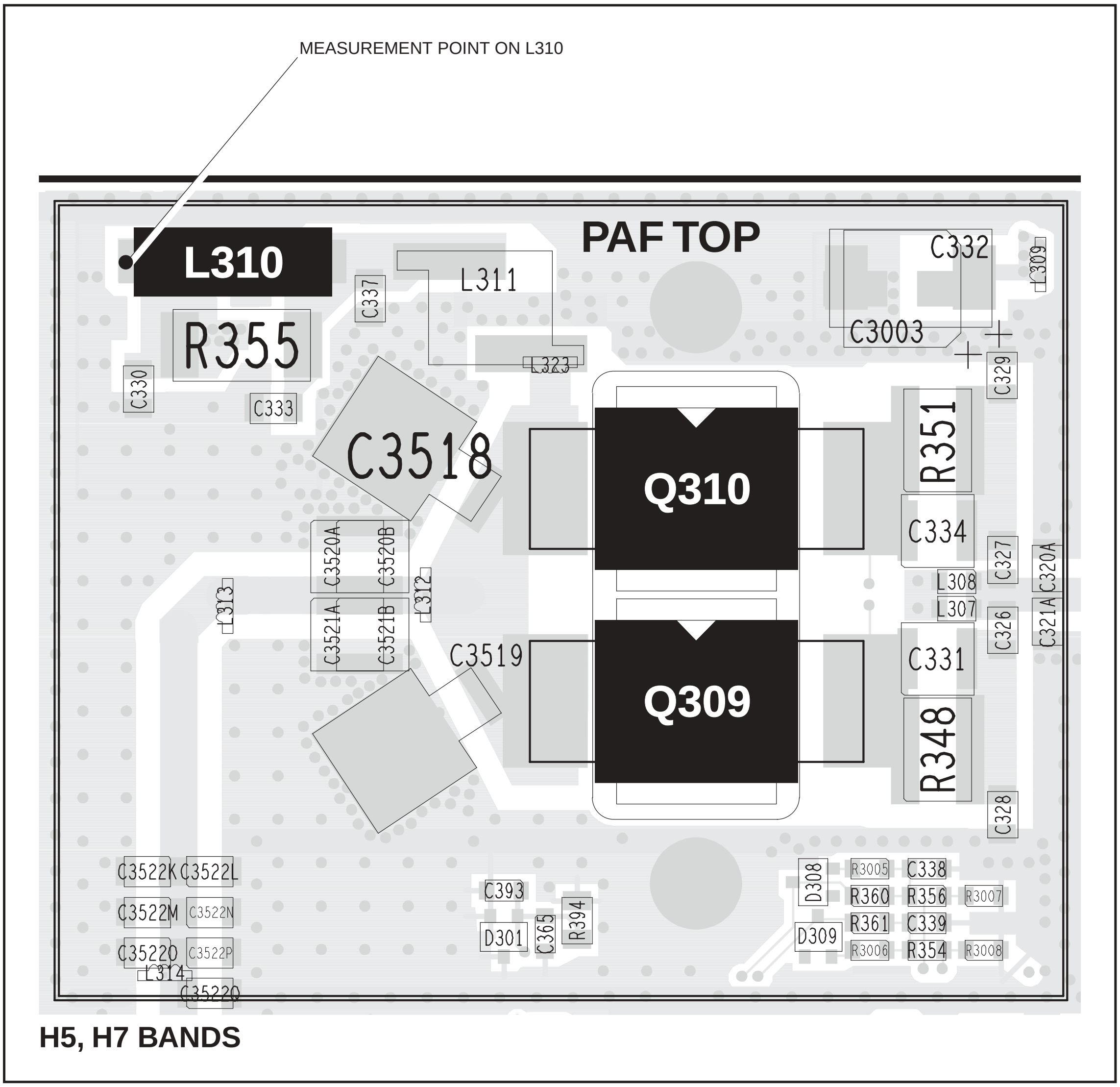


Figure 11.4 Point for measuring the power supply to the PA driver (B1 band)

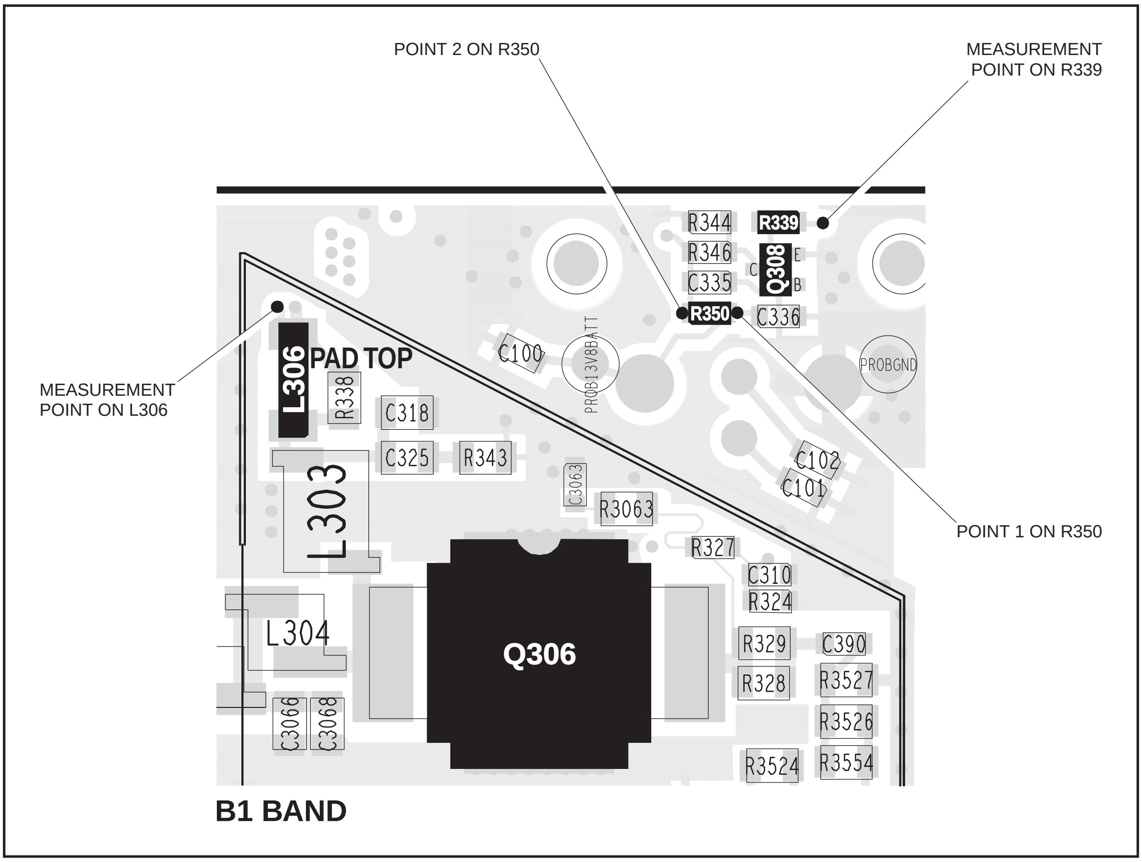
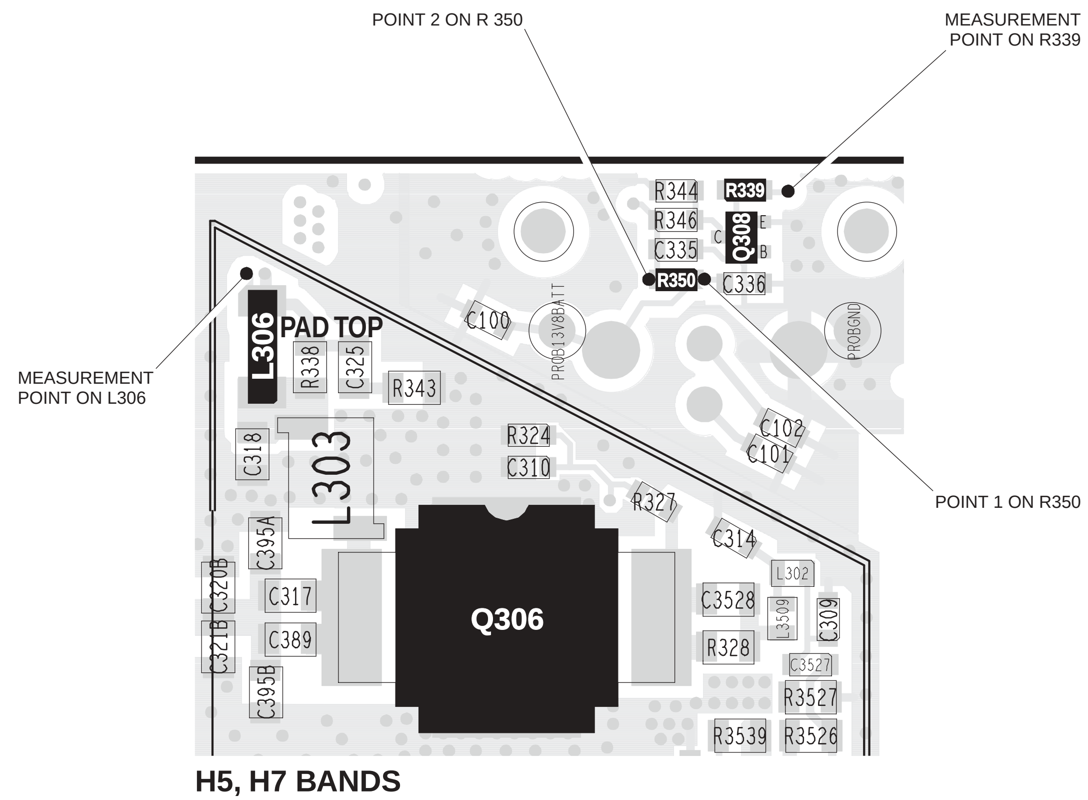


Figure 11.5 Point for measuring the power supply to the PA driver (H5 and H7 bands)



Task 2 — Check Switch Circuit

If the power supply to the drains of the PAs and PA driver is not correct, the switch circuit is suspect. Check the circuit as follows:

1. Measure the voltage at the point 1 on **R350** shown in **Figure 11.4** (B1 band) or **Figure 11.5** (H5, H7 bands). The voltage should be:

point 1 on R350: 13.8V DC

2. If the voltage measured in Step 1 is correct, go to Step 3. If it is not, check for continuity between **R350** and the power connector. Repair any fault and conclude with Step 8.

3. Measure the voltage at **R339** as shown in **Figure 11.4** (B1 band) or **Figure 11.5** (H5, H7 bands). The voltage should be:

R339: 9V DC

4. If the voltage measured in Step 3 is correct, go to Step 5. If it is not, go to Task 3 and check the 9V power supply.

5. Measure the voltage at the point 2 on **R350** shown in **Figure 11.4** (B1 band) or **Figure 11.5** (H5, H7 bands). The voltage should be:

point 2 on R350: < 5V DC

6. If the voltage measured in Step 5 is correct, go to Step 7. If it is not, replace **Q308** — see **Figure 11.4** (B1 band) or **Figure 11.5** (H5, H7 bands) — and conclude with Step 8.

7. Remove the heat-transfer block from the main board. Replace **Q311** (situated on the bottom-side of the main board next to the power connector). Replace the heat-transfer block, and conclude with Step 8.

8. Repeat Task 1 to confirm the removal of the fault, and go to "Final Tasks" on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 3 — 9V Power Supply

If the supply from the power connector is correct, check the 9V DC supply.

1. Enter the CCTM command *326 1* to set the transmitter power level very low.

2. Enter the CCTM command *33* to place the radio in transmit mode.

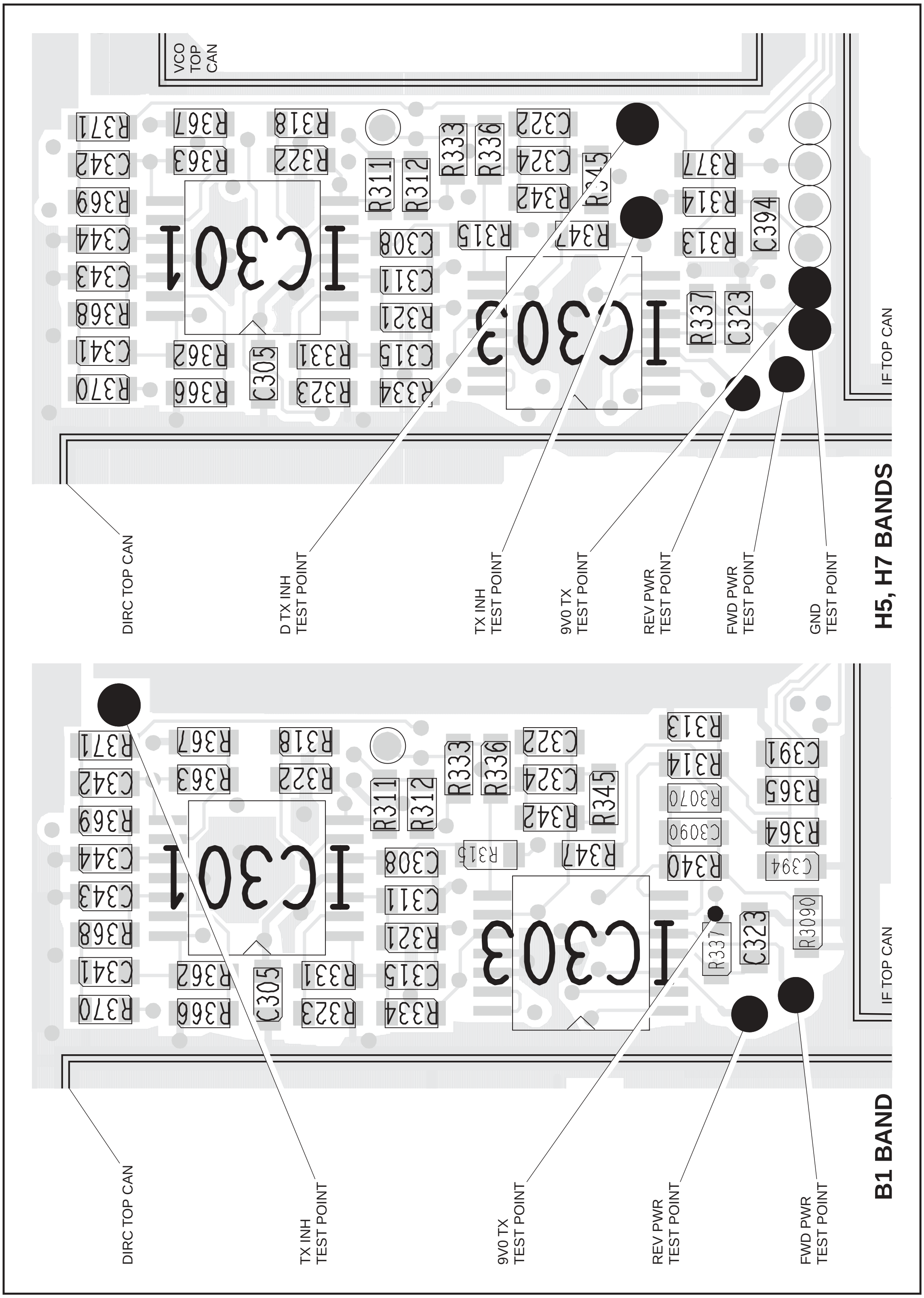
3. Measure the supply voltage between the **9V0 TX test point** and the **GND test point** (see **Figure 11.6**).

supply 9V0 TX: 9.0 ± 0.5V DC

4. Enter the CCTM command *32* to place the radio in receive mode.

5. If the supply measured in Step 3 is correct, go to Task 4 in "Transmitter RF Power" on page 259. If it is not, the 9V regulator **IC601** and the associated switching circuitry **Q603** are suspect; go to Task 3 of "Power Supply Fault Finding" on page 158.

Figure 11.6 Test points for checking the 9V supply, the forward and reverse RF power, and the inhibiting of the transmitter



11.2 Transmitter RF Power

Introduction

If there is no fault with the power supplies, check the transmitter RF power and correct any fault. The procedure is covered in the following eight tasks:

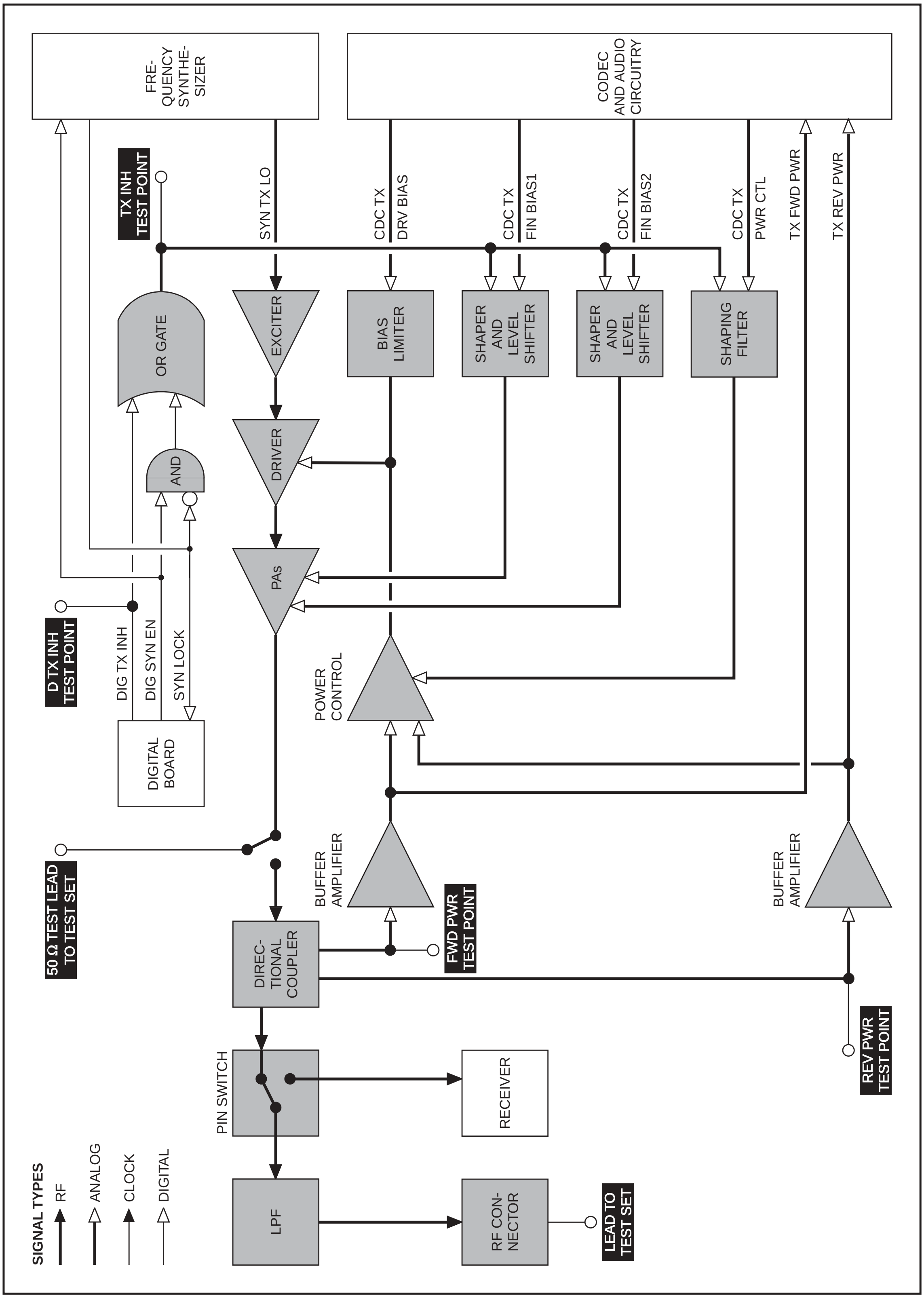
- Task 4: check forward and reverse powers
- Task 5: check RF output power
- Task 6: power unchanged regardless of setting
- Task 7: check for inhibiting of transmitter
- Task 8: check temperature sensor
- Task 9: power and current are skewed
- Task 10: repair output matching circuitry
- Task 11: power and current are low

The measurement points for diagnosing faults concerning the transmitter RF power are summarized in Figure 11.7. Data required for the first task (checking the forward and reverse powers) are supplied in Table 11.3.

Table 11.3 Voltages in millivolts corresponding to nominal forward and reverse powers

Frequency band	Forward power (318 command)	Reverse power (319 command)
B1	2600 to 3400	< 500
H5	3200 to 3900	< 700
H7	3300 to 4000	< 900

Figure 11.7 Measurement and test points for diagnosing faults concerning the transmitter RF power



Task 4 — Check Forward and Reverse Powers

First check the forward and reverse powers for an indication of which part of the circuitry is suspect.

1. Enter the CCTM command *326 4* to set the transmitter power level high.
2. Enter the CCTM command *33* to place the radio in transmit mode.
3. Enter the CCTM command *318* to check the forward power. The value returned is the voltage in millivolts corresponding to the power level, and should be as shown in **Table 11.3**.
4. Confirm the above result by checking the level at the **FWD PWR test point** (see **Figure 11.6**) using an oscilloscope.
5. Enter the CCTM command *319* to check the reverse power. The value returned is the voltage in millivolts corresponding to the power level, and should be as shown in **Table 11.3**.
6. Confirm the above result by checking the level at the **REV PWR test point** (see **Figure 11.6**) using an oscilloscope.

   If the oscilloscope momentarily indicates a very high reverse power, then the most likely scenario is that the antenna VSWR threshold has been exceeded and the PA has shut down to very low power.
7. Enter the CCTM command *32* to place the radio in receive mode.
8. If the values obtained in Step 3 and Step 5 are both correct, and there is no indication of a momentary high reverse power, go to Task 5. If one or both are incorrect, go to Step 9.
9. Check the connection from the RF connector on the radio to the test set.
10. If there is no fault, go to Step 11. If there is, rectify the fault and repeat the above measurements.
11. If the reverse power is momentarily too high, the directional coupler, PIN switch or LPF is suspect; go to Task 31. Otherwise go to Task 5.

Task 5 — Check RF Output Power

If the power supplies are correct, check the RF output power of the transmitter.

1. Enter the CCTM command *326 5* to set the transmitter power level to the maximum value.

2. If not already done, program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the frequency in hertz. The required values for the different frequency bands are given in **Table 11.2**.

3. Enter the CCTM command *33* to place the radio in transmit mode.

4. Note the RF output power measured by the test set, and note the current reading on the DC power supply.

   RF output power: > 60W (VHF), > 52W (UHF)
   current: < 15A (VHF), < 12A (UHF)

5. Enter the CCTM command *32* to place the radio in receive mode.

6. Program the radio with the center frequency in the radio's frequency band: Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the frequency in hertz. The required values for the different frequency bands are given in **Table 11.2**.

7. Repeat Step 3 to Step 5.

8. Program the radio with the lowest frequency in the radio's frequency band: Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the frequency in hertz. The required values for the different frequency bands are given in **Table 11.2**.

9. Repeat Step 3 to Step 5.

10. Depending on the results of the above measurements, proceed to the task indicated in **Table 11.4**. Note that the power and current are considered to be skewed if they are low at one part of the frequency band and high elsewhere.

Table 11.4 Tasks to be performed according to the results of the power and current measurements of Task 5

Power	Current	Task
Correct	Correct	Task 6 — Power unchanged regardless of setting
Correct	Wrong	Task 31 — Check power at directional coupler
Skewed	Skewed	Task 9 — Power and current are skewed
Low (> 0.1W)	Low (> 0.5A)	Task 11 — Power and current are low
None at RF connector (< 0.1W)	Low (> 0.5A)	Task 31 — Check power at directional coupler
None at RF connector (< 0.1W)	None (< 0.5A)	Task 7 — Check for inhibiting of transmitter

Task 6 — Power Unchanged Regardless of Setting

If all the power and current values measured in Task 5 are correct, it is likely that the power remains unchanged regardless of the power setting.

1. Enter the following CCTM commands in turn and measure the RF output power in each case:
   - *326 4*
   - *326 3*
   - *326 2*
   - *326 1*

2. The above measurements should confirm that the power remains unchanged at all settings. Carry out Task 12 and then Task 19.

Task 7 — Check for Inhibiting of Transmitter

If the transmitter is drawing no current or the wrong current, check whether it is being inhibited. This check is also required if a *CO3* error occurs in Task 1.

1. If not already done, enter the CCTM command *33* to place the radio in transmit mode.

2. Check the logic signal at the **TX INH test point** (see **Figure 11.6**). The signal should be:

TX INH test point: about 0V (inactive)

3. If the signal is inactive as required, go to Step 4. If it is active — about 1.1V — the transmitter is being inhibited; go to Step 5.

4. Enter the CCTM command *32* to place the radio in receive mode, and go to Task 12 in "Biasing of PA Driver and PAs" on page 269.

5. Check the logic signal at the **D TX INH test point**; see **Figure 11.18 on page 288** (B1 band) or **Figure 11.6** (H5, H7 bands). The signal should be:

D TX INH test point: about 0V (inactive)

6. If the signal is inactive as required, go to Step 8. If it is active — about 3.2V — the temperature sensor is suspect; go to Step 7.

7. Enter the CCTM command *32* to place the radio in receive mode, and go to Task 8.

8. The lock status is possibly no longer normal. Enter the CCTM command *72* and check the lock status.

9. Enter the CCTM command *32* to place the radio in receive mode.

10. The normal lock status is *110*. If it is not, proceed to the relevant section. If it is, go to Step 11.

11. Check for short circuits on the DIG TX INH line from the **D TX INH test point**.

12. Repair any fault, confirm the removal of the fault, and go to "Final Tasks" on page 147. If the repair failed or no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 8 — Check Temperature Sensor

If the transmitter is being inhibited and the logic signal at the D TX INH test point is active, a fault in the temperature sensor might be the cause.

1. Enter the CCTM command *47* to check the temperature reading.
2. Of the two numbers returned, the first is the temperature in degrees celsius and should be about 25°C. If it is, go to Task 12 in "Biasing of PA Driver and PAs" on page 269. If it is not, go to Step 3.
3. If not already done, remove the PAF TOP can.
4. Check **D301** and the surrounding components — see **Figure 11.8** (B1 band) and **Figure 11.9** (H5 and H7 bands).
5. If there is no fault, go to "CODEC and Audio Fault Finding" on page 371. If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 147. If the repair failed, replace the main-board assembly, and go to "Final Tasks" on page 147.

Figure 11.8 PA circuitry under the PAF TOP can and part of the directional coupler under the DIRC TOP can (B1 band)

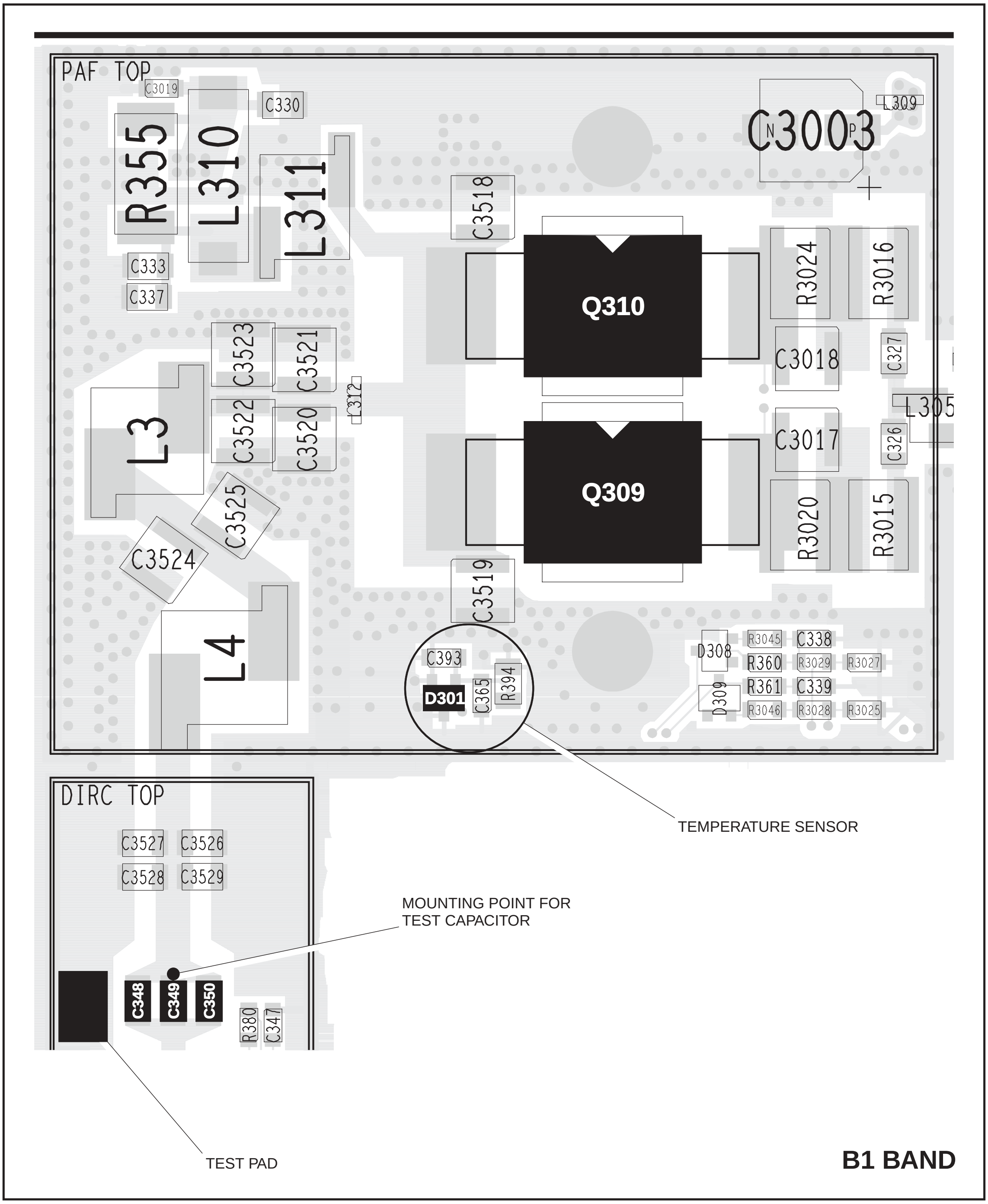
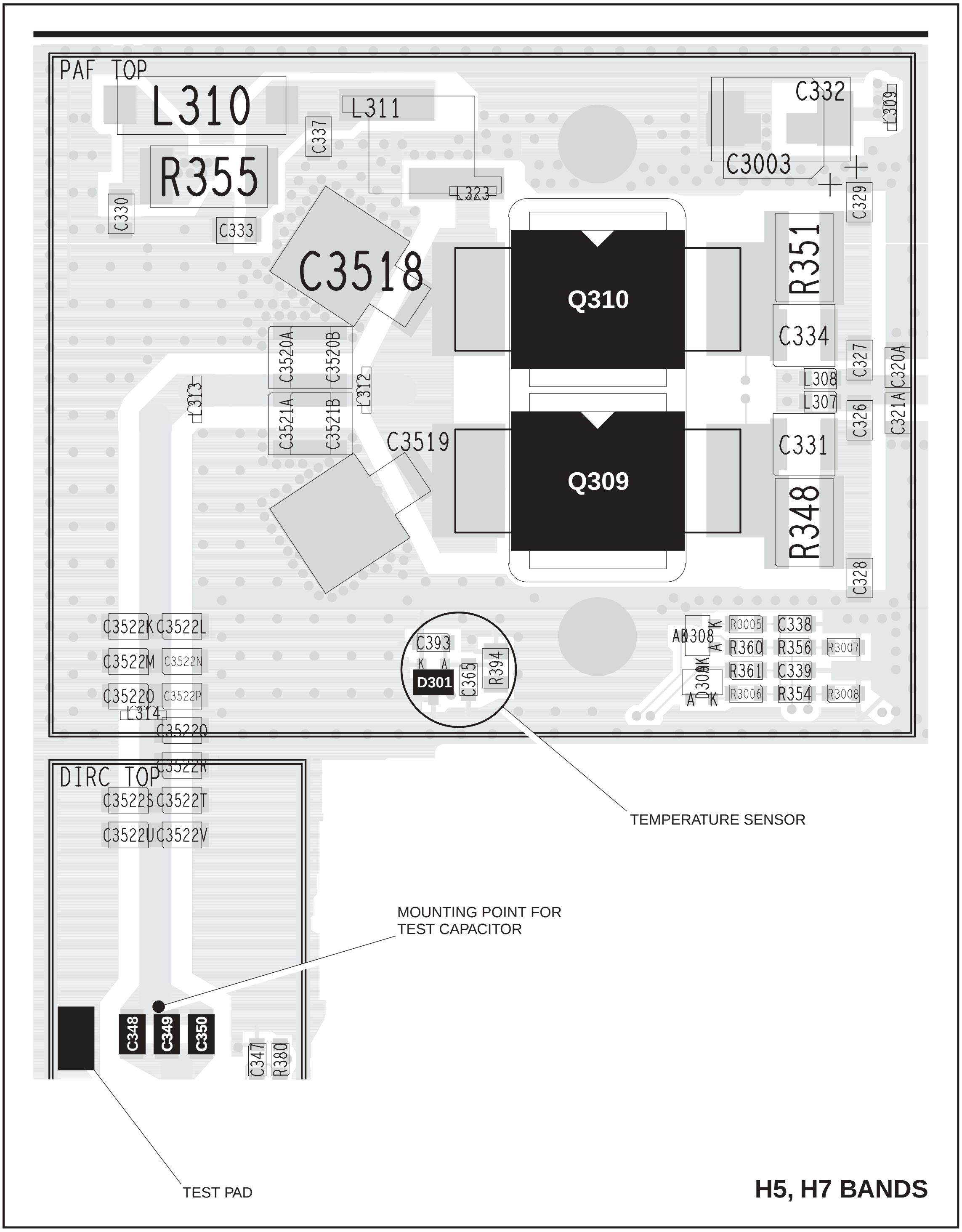


Figure 11.9 PA circuitry under the PAF TOP can and part of the directional coupler under the DIRC TOP can (H5 and H7 bands)



Task 9 — Power and Current Are Skewed

If the RF output power and the supply current are skewed, the output matching is suspect.

1. Remove the DIRC TOP can.
2. Remove the coupling capacitors **C348**, **C349** and **C350** — see **Figure 11.8** (B1) and **Figure 11.9** (H5, H7).
3. Solder one terminal of an 82 pF (H5, H7 bands) or 680 pF (B1) test capacitor to the PCB at the point shown in **Figure 11.8** and **Figure 11.9**. Mount the capacitor vertically. Use a test capacitor of the type GRM111, DLI C17, Murata 1210, or the equivalent.
4. Solder a 50 Ω test lead to the PCB. Solder the outer sheath to the test pad shown in **Figure 11.8** and **Figure 11.9**, and solder the central wire to the other terminal of the test capacitor.
5. Connect the test lead to the test set.
6. Program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101* ***x*** *x 0*, where ***x*** is the frequency in hertz.
7. Enter the CCTM command *33* to place the radio in transmit mode.
8. Note the RF output power measured by the test set, and note the current reading on the DC power supply.

RF output power: > 70W (VHF), > 60W (UHF) current: < 15A (VHF), < 12A (UHF)

9. Enter the CCTM command *32* to place the radio in receive mode.
10. Program the radio with the center frequency in the band: Enter the CCTM command *101* ***x*** *x 0*, where ***x*** is the frequency in hertz.
11. Repeat Step 7 to Step 9.
12. Program the radio with the lowest frequency in the band: Enter the CCTM command *101* ***x*** *x 0*, where ***x*** is the frequency in hertz.
13. Repeat Step 7 to Step 9.
14. If the power and current are still skewed, go to Task 10. If the power and current are correct, remove the test lead and test capacitor, resolder the coupling capacitors in position, and go to Task 33 — the PIN switch and LPF require checking.

Task 10 — Repair Output Matching Circuitry

If the checks in Task 9 show that the power and current are still skewed, there is a fault in the output matching circuitry.

1. If not already done, remove the PAF TOP can.

2. Check for faulty, shorted or misplaced components in the circuit between the test capacitor and the common drain of **Q309** and **Q310** (see **Figure 11.8** and **Figure 11.9**). Repair any fault.

3. Program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101 **x** x 0*, where ***x*** is the frequency in hertz.

4. Enter the CCTM command *33* to place the radio in transmit mode.

5. Note the RF output power measured by the test set, and note the current reading on the DC power supply.

RF output power: > 70W (VHF), > 60W (UHD) current: < 15A (VHF), < 12A (UHF)

6. Enter the CCTM command *32* to place the radio in receive mode.

7. Program the radio with the center frequency in the band: Enter the CCTM command *101 **x** x 0*, where ***x*** is the frequency in hertz.

8. Repeat Step 4 to Step 6.

9. Program the radio with the lowest frequency in the band: Enter the CCTM command *101 **x** x 0*, where ***x*** is the frequency in hertz.

10. Repeat Step 4 to Step 6.

11. Remove the test lead and test capacitor, and resolder the coupling capacitors **C348**, **C349** and **C350** in position (see **Figure 11.8** and **Figure 11.9**).

12. If the power and current are now correct at all three frequencies, the fault has been rectified; go to "Final Tasks" on page 147. If they are not, go to Task 26 in "RF Signal Path" on page 293.

Task 11 — Power and Current Are Low

If the RF output power and the supply current are uniformly low at all frequencies, one of the PAs is suspect or the input to the PAs is reduced. Check each PA in turn:

1. For the first PA (Q310), enter the CCTM command *331* to check the DAC value of final bias 1 (CDC TX FIN BIAS 1). Record the value ***x*** returned.
2. Note the current reading on the DC power supply.
3. Enter the CCTM command *331 1* to turn off final bias 1.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Note the RF output power measured at the test set. This should be as shown in **Table 11.5**.
6. If the RF power is correct, go to Step 7 to repeat the check with the second PA. If it is not, enter the CCTM command *32* to place the radio in receive mode, and carry out Task 12 and then Task 13.
7. For the second PA (Q309), enter the CCTM command *332* to check the DAC value of final bias 2 (CDC TX FIN BIAS 2). Record the value ***y*** returned.
8. Note the current reading on the DC power supply.
9. Enter the CCTM command *332 1* to turn off final bias 2.
10. With the radio still in transmit mode, note the RF output power measured at the test set. This should be as shown in **Table 11.5**.
11. Enter the CCTM command *32* to place the radio in receive mode.
12. If the RF power measured in Step 10 is correct, go to "RF Signal Path" on page 292. If it is not, carry out Task 12 and then Task 16.

Table 11.5 RF output power of individual RF power amplifiers at different frequencies

Frequency band	Frequency within band		
	Lowest frequency	Center frequency	Highest frequency
B1	38 ± 5W	48 ± 5W	33 ± 5W
H5	16 ± 5W	17 ± 5W	21 ± 5W
H7	25 ± 5W	32 ± 5W	40 ± 5W

11.3 Biasing of PA Driver and PAs

Introduction

The measurements of the transmitter RF output power in "Transmitter RF Power" might indicate a need to check the biasing of the two PAs and the PA driver. The procedure is covered in this section. There are thirteen tasks grouped as follows:

- Task 12: prepare to check biasing
- Task 13 to Task 15: check biasing of first PA
- Task 16 to Task 18: check biasing of second PA
- Task 19 and Task 20: check biasing of PA driver
- Task 21 to Task 24: repair circuitry

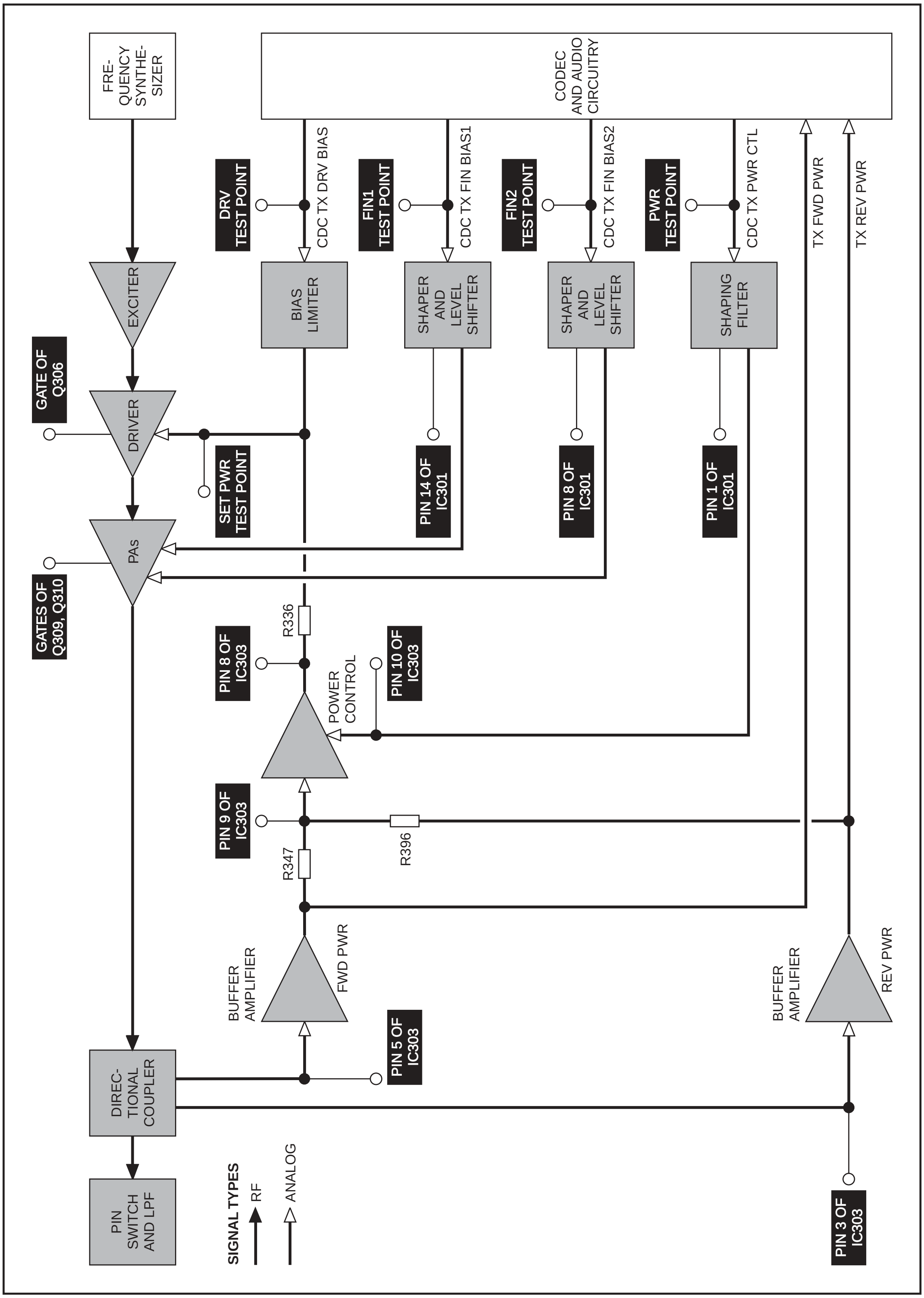
The test and measurement points for diagnosing faults in the biasing of the PAs and PA driver are summarized in Figure 11.10.

Task 12 — Prepare to Check Biasing

If the transmitter is not being inhibited, check the biasing of the two PAs and the PA driver. First make the following preparations:

1. Set the current limit on the DC power supply to 3A.
2. Enter the CCTM command *331* to check the DAC value of final bias 1 (CDC TX FIN BIAS 1) at maximum power. Record the value ***x*** returned.
3. Enter the CCTM command *332* to check the DAC value of final bias 2 (CDC TX FIN BIAS 2) at maximum power. Record the value ***y*** returned.
4. Enter the CCTM command *304* to check the DAC value of the clamp current at the driver gate. Record the value ***z*** returned.
5. Enter the CCTM command *33* to place the radio in transmit mode.
6. Switch off all biases by entering the following CCTM commands in sequence:
   - *331 1*
   - *332 1*
   - *304 1*
   - *114 1023*
   - *334 0*
   - *335 0*
7. Note the current reading on the DC power supply. This will be less than 500mA.
8. With the radio still in transmit mode, check the biasing of the PAs and PA driver, beginning with Task 13.

Figure 11.10 Measurement and test points for diagnosing faults in the biasing of the PAs and PA driver



Task 13 — Check Biasing of First PA

Check the biasing of the first PA (Q310).

Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *331 **x***, do not specify a value ***x*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. Use a multimeter to measure the voltage at pin 14 of **IC301** (see **Figure 11.11** and **Figure 11.12**). The voltage should be:

pin 14 of IC301: < 100mV (initially)

2. Note the current reading on the DC power supply. As mentioned in Step 7 of Task 12, this will be less than 500mA.

3. Enter the CCTM command *331 **x*** (where ***x*** was recorded in Task 12).

4. Check that the voltage changes to:

pin 14 of IC301: 2 to 5V (after entry of CCTM 331 **x**)

5. Also note the current reading. This should increase by an amount approximately equal to the offset given in **Table 11.6**.

6. If the voltage and current are both correct, go to Step 7. If the voltage is correct but not the current, go to Task 14. If neither the current nor the voltage is correct, go to Task 15.

7. Enter the CCTM command *331 1* to switch off final bias 1, and go to Task 16.

Table 11.6 Gate biases for the PAs and PA driver at high power

Frequency band	Offset currents in mA		
	First PA	**Second PA**	**PA driver**
B1	1690	1690	150
H5	1800	1800	400
H7	1800	1800	600

Figure 11.11 Test points and components of the shaping filter (B1 band)

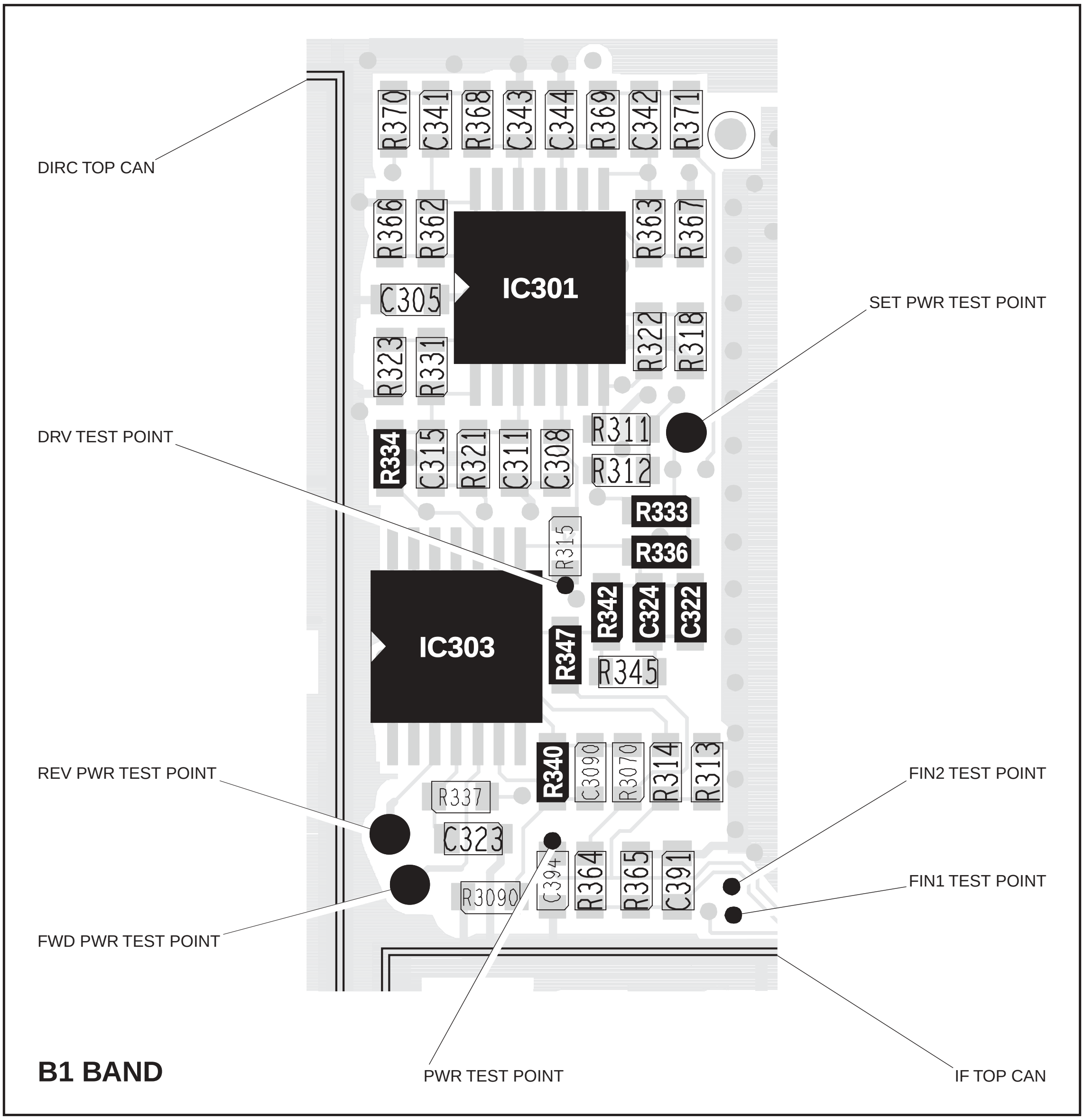
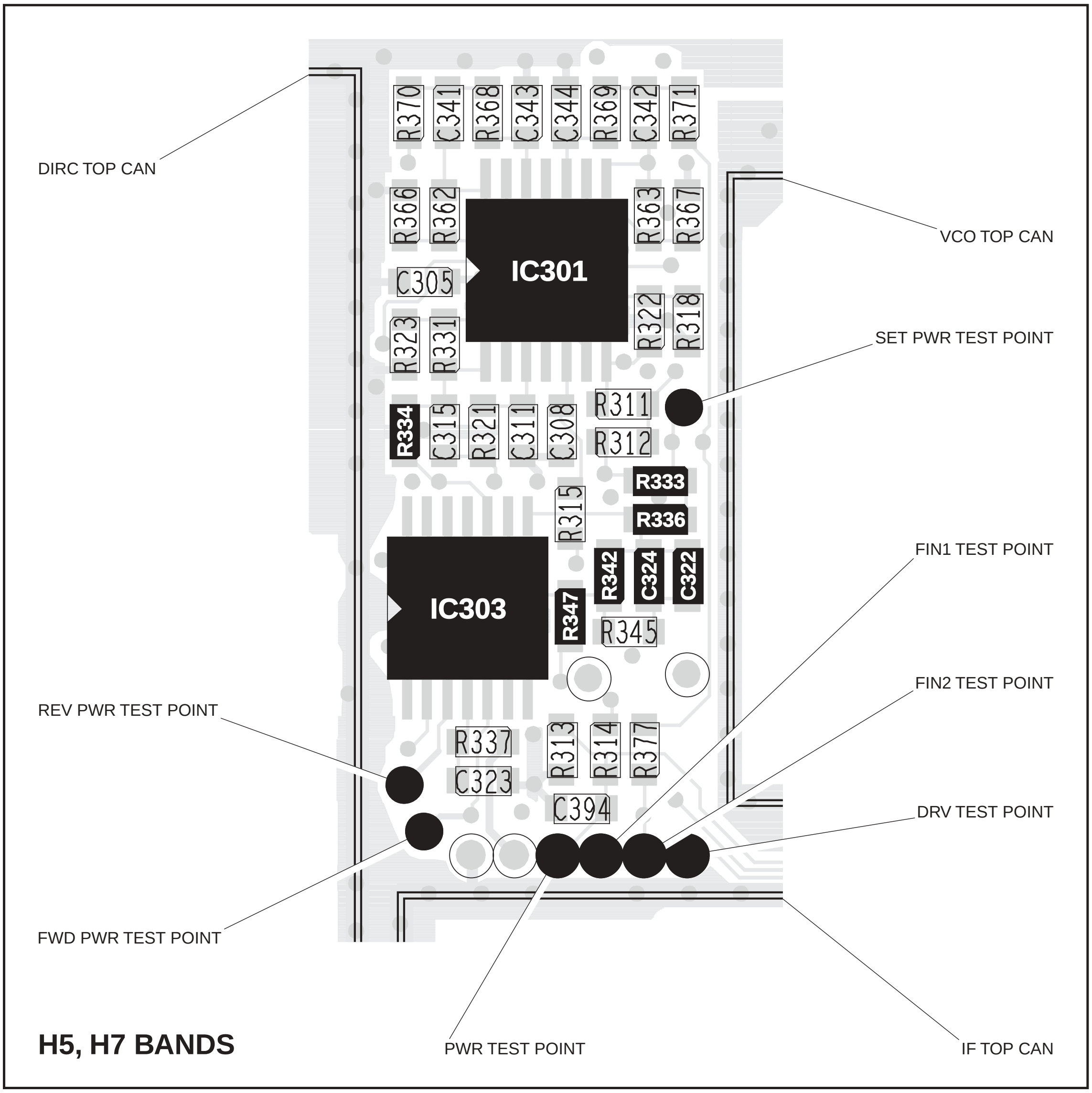


Figure 11.12 Test points and components of the shaping filter (H5 and H7 bands)



Task 14 — Shaper and Level Shifter

If the voltage measured in Task 13 is correct but not the current, either the first PA or the shaper and level shifter for the PA is suspect.

Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *331 x*, do not specify a value *x* higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. If the PAF TOP can has already been removed, go to Step 5 If it has not, go to Step 2.
2. Enter the CCTM command *32* to place the radio in receive mode.
3. Remove the PAF TOP can.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Enter the CCTM command *331 x* (where *x* was recorded in Task 12).
6. Check that the voltage at the gate of **Q310** is (see **Figure 11.13** and **Figure 11.14**):

gate of Q310: 2 to 5V

7. Enter the CCTM command *32* to place the radio in receive mode.
8. If the voltage measured above is correct, **Q310** is faulty; replace the main-board assembly and go to “Final Tasks” on page 147. If it is not correct, go to Step 9.
9. Check the circuitry between pin 14 of **IC301** and the gate of **Q310** (see **Figure 11.13** and **Figure 11.14**). If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 147. If the repair failed or Q310 itself is faulty, replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 11.13 PA circuitry under the PAF TOP can (B1 band)

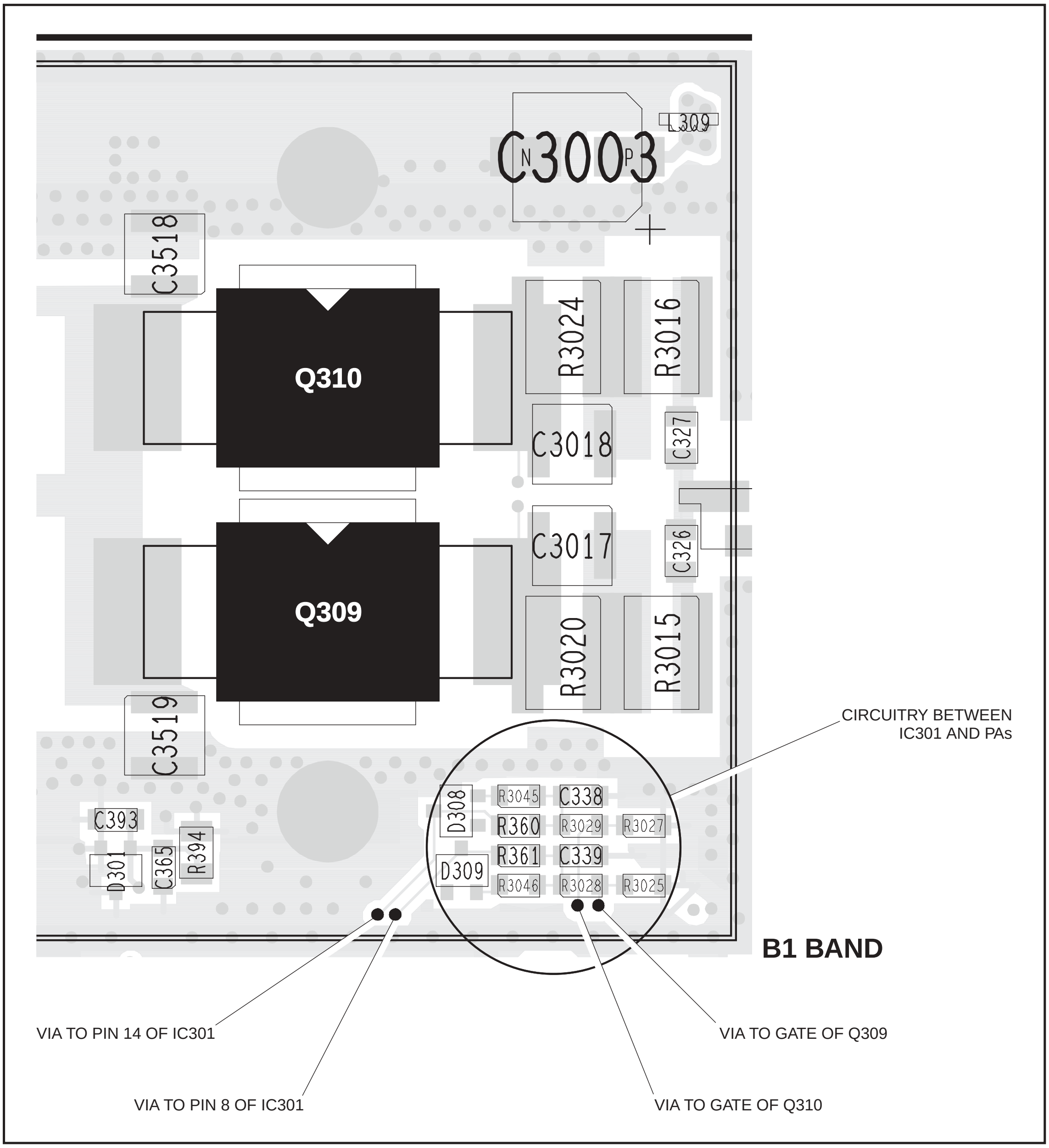
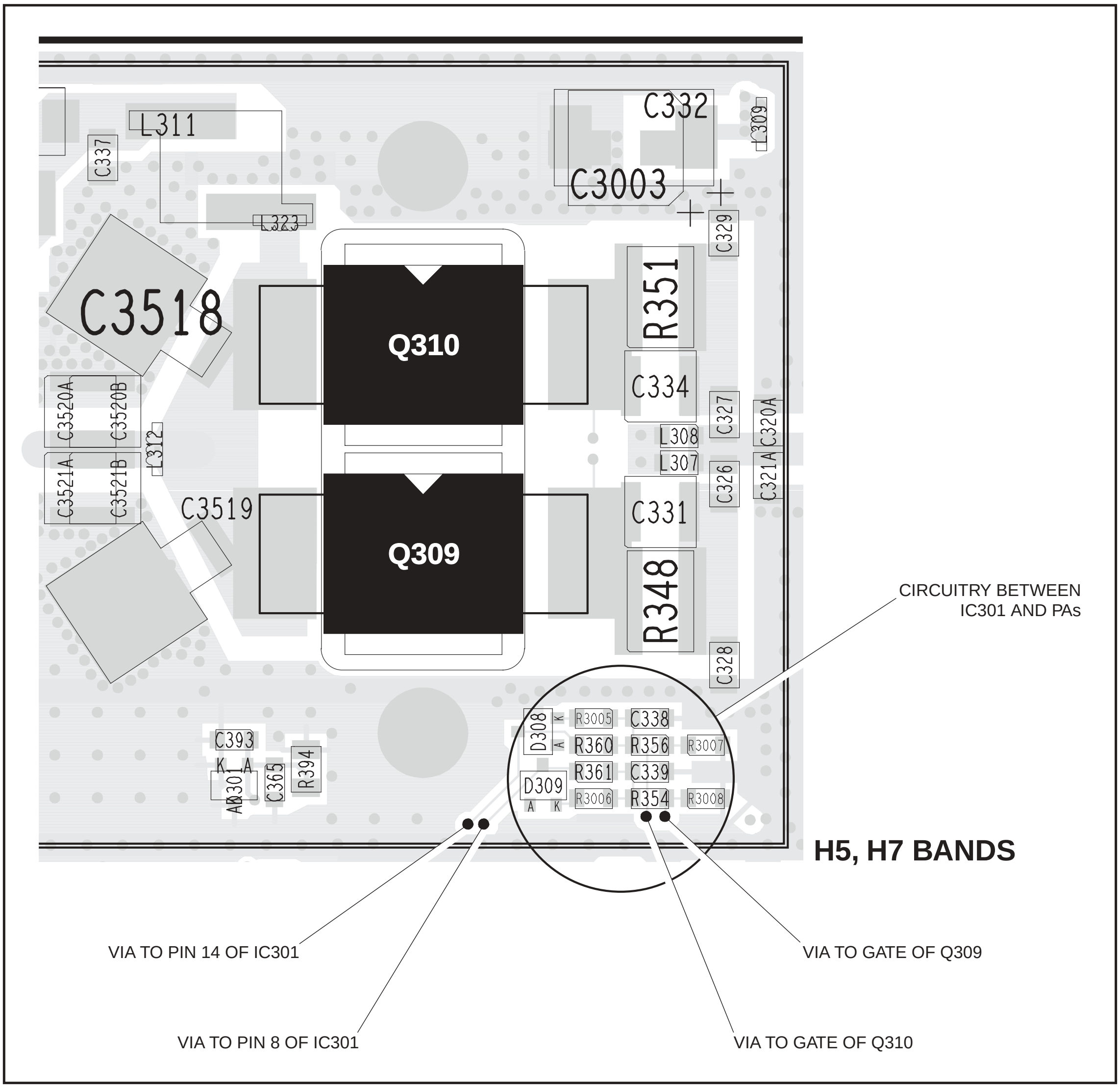


Figure 11.14 PA circuitry under the PAF TOP can (H5 and H7 bands)



Task 15 — Shaping Filter for Power Control

If neither the voltage nor the current measured in Task 13 is correct, then the shaping filter for the power-control circuitry or the CODEC and audio circuitry is suspect.

Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *331* ***x***, do not specify a value ***x*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. Use the multimeter to measure the voltage at the **FIN1 test point** (see **Figure 11.11** and **Figure 11.12**). The voltage should be:

FIN1 test point: 18 ± 2mV (initially)

2. Enter the CCTM command *331* ***x*** (where ***x*** was recorded in Task 12).

3. Check that the voltage changes to:

FIN1 test point: 1.1 to 2.7V (after entry of CCTM 331 **x**)

4. Enter the CCTM command *32* to place the radio in receive mode.

5. If the voltage measured above is correct, go to Step 6. If it is not, go to "CODEC and Audio Fault Finding" on page 371.

6. Check **IC301** and the surrounding shaping-filter circuitry (see **Figure 11.11** and **Figure 11.12**). If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 147. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 16 — Check Biasing of Second PA

If the biasing of the first PA is correct, check that of the second PA (Q309).

Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *332* ***y***, do not specify a value ***y*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. Use the multimeter to measure the voltage at pin 8 of **IC301** (see **Figure 11.11** and **Figure 11.12**). The voltage should be:

pin 8 of IC301: < 100 mV (initially)

2. Note the current reading on the DC power supply. As mentioned in Step 7 of Task 12, the current will be less than 500 mA.

3. Enter the CCTM command *332* ***y*** (where ***y*** was recorded in Task 12).

4. Check that the voltage changes to:

pin 8 of IC301: 2 to 5V (after entry of CCTM 332 **y**)

5. Also note the current reading. This should increase by an amount approximately equal to the offset given in **Table 11.6**.

6. If the voltage and current are both correct, go to Step 7. If the voltage is correct but not the current, go to Task 17. If neither the current nor the voltage is correct, go to Task 18.

7. Enter the CCTM command *332 1* to switch off final bias 2, and go to Task 19.

Task 17 — Shaper and Level Shifter

If the voltage measured in Task 16 is correct but not the current, either the second PA or the shaper and level shifter for the PA is suspect.

Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *332* ***y***, do not specify a value ***y*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. If the PAF TOP can has already been removed, go to Step 5. If it has not, go to Step 2.
2. Enter the CCTM command *32* to place the radio in receive mode.
3. Remove the PAF TOP can.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Enter the CCTM command *332* ***y*** (where ***y*** was recorded in Task 12).
6. Check that the voltage at the gate of **Q309** is (see **Figure 11.13** and **Figure 11.14**):

gate of Q309: 2 to 5V

7. Enter the CCTM command *32* to place the radio in receive mode.
8. If the voltage is correct, **Q309** is faulty; replace the main-board assembly and go to "Final Tasks" on page 147. If it is not, go to Step 9.
9. Check the circuitry between pin 8 of **IC301** and the gate of **Q309** (see **Figure 11.13** and **Figure 11.14**). If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 147. If the repair failed or Q309 itself is faulty, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 18 — Shaping Filter for Power Control

If neither the voltage nor the current measured in Task 16 is correct, then the shaping filter for the power-control circuitry or the CODEC and audio circuitry is suspect.

Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *332* ***y***, do not specify a value ***y*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. Use the multimeter to measure the voltage at the **FIN2 test point** (see **Figure 11.11** and **Figure 11.12**). The voltage should be:

FIN2 test point: 18 ± 2V (initially)

2. Enter the CCTM command *332* ***y*** (where ***y*** was recorded in Task 12).

3. Check that the voltage changes to:

FIN2 test point: 1.1 to 2.7V (after entry of CCTM 332 **y**)

4. Enter the CCTM command *32* to place the radio in receive mode.

5. If the voltage measured above is correct, go to Step 6. If it is not, go to "CODEC and Audio Fault Finding" on page 371.

6. Check **IC301** and the surrounding shaping-filter circuitry (see **Figure 11.11** and **Figure 11.12**). If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 147. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 19 — Biasing of PA Driver — DRV test point

If there is no fault in the biasing of the PAs, investigate the biasing of the PA driver (Q306). First check the DRV test point.

Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *304* ***z***, do not specify a value ***z*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PA driver.

1. Note the current reading on the DC power supply. As mentioned in Step 7 of Task 12, the current will be less than 500mA.

2. Enter the CCTM command *304* ***z*** (where ***z*** was recorded in Task 12) to switch on the clamp current.

3. Note the current reading on the DC power supply.

4. Compare the above current readings. The current should increase by an amount approximately equal to the offset given in **Table 11.6**. If it does, go to Task 21. If it does not, go to Step 5.

5. Check as follows that the voltage from the DAC is changing: First enter the CCTM command *304 1* to switch off the bias.

6. Measure the voltage at the **DRV test point** (CDC TX DRV BIAS) (see **Figure 11.11** and **Figure 11.12**). The voltage should be:

DRV test point: < 0.1V (after entry of CCTM 304 1)

7. Enter the CCTM command *304* ***z*** (where ***z*** was recorded in Task 12) to change the DAC value of the clamp current.

8. The voltage should increase to:

DRV test point: 0.8 to 2.5V (after entry of CCTM 304 **z**)

9. If the voltage does change, go to Task 20. If it does not, go to Step 10.

10. Enter the CCTM command *32* to place the radio in receive mode, and go to “CODEC and Audio Fault Finding” on page 371.

Task 20 — Biasing of PA Driver— SET PWR test point

If the voltage at the DRV test point is correct, check that at the SET PWR test point.

1. Check the voltage at the **SET PWR test point** (see **Figure 11.11** and **Figure 11.12**):

SET PWR test point: 2 to 5V

2. If the voltage is correct, go to Step 3. If it is not, go to Task 21.
3. If the PAD TOP can has already been removed, go to Step 7. If it has not, go to Step 4.
4. Enter the CCTM command 32 to place the radio in receive mode.
5. Remove the PAD TOP can.
6. Enter the CCTM command 33 to place the radio in transmit mode.
7. Check the voltage on the gate of **Q306** (see **Figure 11.15** and **Figure 11.16**):

gate of Q306: 2 to 5V

8. Enter the CCTM command 32 to place the radio in receive mode.
9. If the voltage is correct, replace **Q306**; confirm the removal of the fault and go to "Final Tasks" on page 147. If it is not, go to Task 23.

Figure 11.15 PA driver circuitry under the PAD TOP can (B1 band)

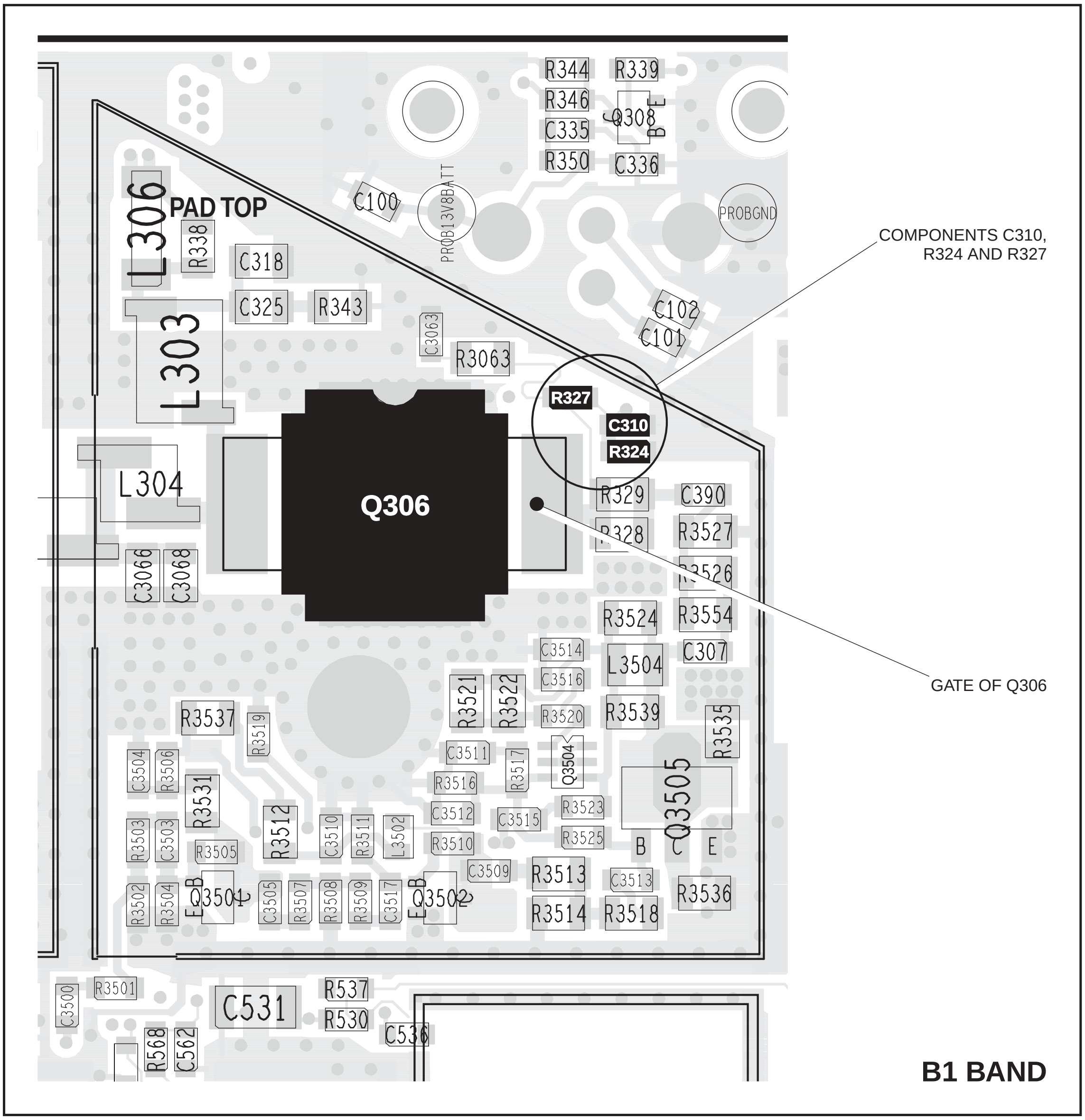
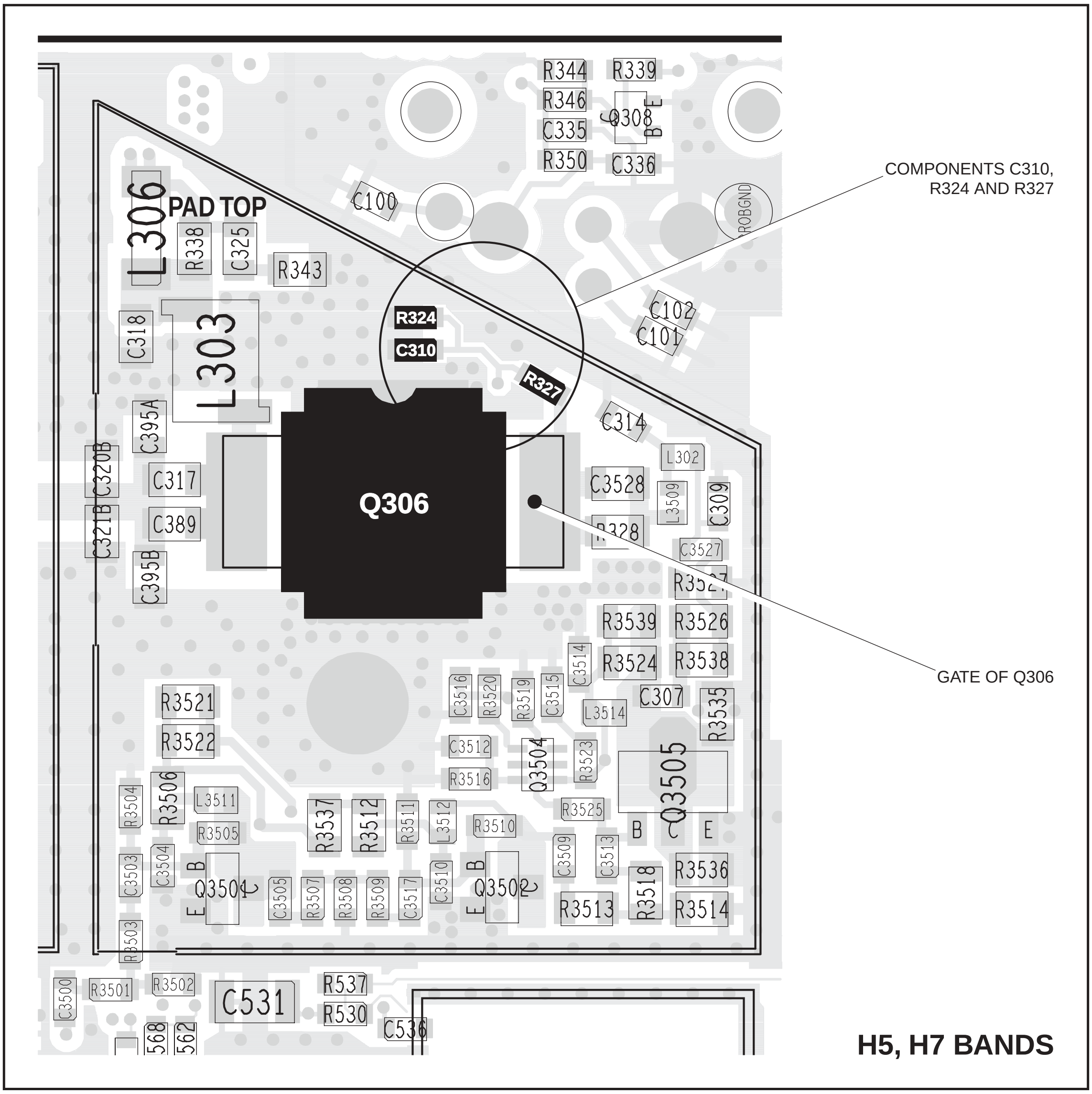


Figure 11.16 PA driver circuitry under the PAD TOP can (H5 and H7 bands)



Task 21 — Check Power Control

Check the power-control circuitry if the clamp current for the PA driver is correct or if the voltage at the SET PWR test point is incorrect.

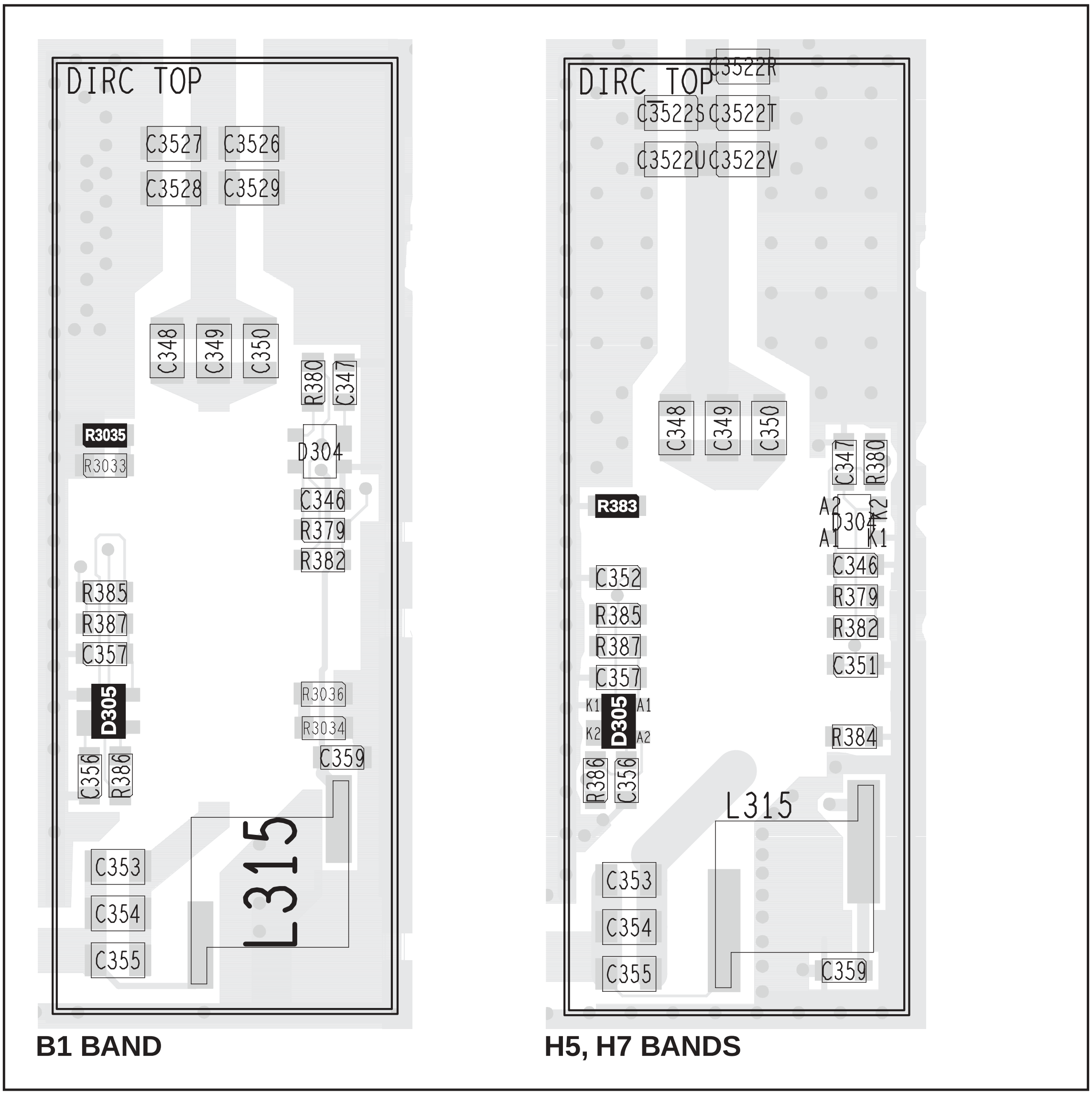
Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *304* ***z***, do not specify a value ***z*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PA driver.

1. Enter the CCTM command *304* ***z*** (where ***z*** was recorded in Task 12).
2. Note the current reading on the DC power supply.
3. Enter the CCTM command *114 0* to switch off the power.
4. Note the current reading on the DC power supply.
5. Compare the above current readings. The current should decrease by an amount approximately equal to the offset given in **Table 11.6**. If it does, go to Task 26 in "RF Signal Path" on page 293. If it does not, go to Step 6.
6. Check that the voltage from the DAC is changing. Measure the voltage at the **PWR test point** (CDC TX PWR CTL) (see **Figure 11.11** and **Figure 11.12**).
7. Enter the CCTM command *114 1023*. The voltage should increase to:

PWR test point: 2.4 ± 0.1V

8. Enter the CCTM command 32 to place the radio in receive mode.
9. If the voltage at the **PWR test point** increases as required, go to Task 22. If it does not, go to "CODEC and Audio Fault Finding" on page 371.

Figure 11.17 Circuitry under the DIRC TOP can



Task 22 — Directional Coupler and Buffer Amplifiers

Following the checks in Task 19 to Task 21, locate the fault and repair the circuitry as described in the remaining tasks of the section. In this task any faults in the directional coupler or the buffer amplifiers will be located.

1. Cycle the power.
2. Enter the CCTM command *326 5* to set the transmitter to maximum power. Enter the CCTM command *33* to place the radio in transmit mode.
3. Measure the voltage at pin 9 of **IC303** in the power-control circuit (see **Figure 11.11** and **Figure 11.12**).
4. The above voltage should be as given in **Table 11.7**. If it is, go to Task 24. If it is not, go to Step 5.
5. Check the voltage at the FWD PWR **test point** (pin 5 of **IC303**) and at the REV PWR **test point** (pin 3 of IC303) (see **Figure 11.11** and **Figure 11.12**). Note that the probe impedance might affect these measurements.
6. Enter the CCTM command 32 to place the radio in receive mode.
7. The voltages measured in Step 5 should be as given in **Table 11.7**. If they are, go to Step 10. If the FWD PWR voltage is incorrect, go to Step 8. If the REV PWR voltage is incorrect, go to Step 9.

Table 11.7 Voltages at IC303 at maximum power (70 W for B1 band, and 60 W for H5 and H7)

Frequency band	Frequency (MHz)	Voltage (V)		
		Pin 9	Pin 3 (REV PWR)	Pin 5 (FWD PWR)
B1	136 155 174	2.6 ± 0.5 2.9 ± 0.5 3.2 ± 0.5	0.4 ± 0.3 0.4 ± 0.3 0.5 ± 0.3	3.1 ± 0.5 3.4 ± 0.5 3.9 ± 0.5
H5	400 435 470	2.8 ± 0.5 3.0 ± 0.5 3.3 ± 0.5	0.6 ± 0.4 0.6 ± 0.4 0.5 ± 0.4	3.3 ± 0.5 3.7 ± 0.5 3.9 ± 0.5
H7	450 485 520	3.9 ± 0.5 4.1 ± 0.5 4.4 ± 0.5	0.6 ± 0.4 0.8 ± 0.4 0.8 ± 0.4	4.4 ± 0.5 4.6 ± 0.5 5.0 ± 0.5

8. Remove the DIRC TOP can. Check the components of the directional coupler (see **Figure 11.17**) and go to Step 11.
9. Remove the DIRC TOP can. Check **D305** and **R3035** (B1) or **R383** (H5, H7) (see **Figure 11.17**). If there is no fault, the PIN switch or LPF or both are suspect; go to Task 33. If there is a fault, go to Step 11.
10. In the buffer amplifiers, check **R340** and **R341** (see **Figure 11.11**, **Figure 11.18** and **Figure 11.19**).

11. Repair any fault revealed by the above checks. Replace **IC303** if none of the other components is faulty (see **Figure 11.11** and **Figure 11.12**).

12. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 23 — Power Control for PA Driver

In this task any faults in the path between the power-control circuit and the PA driver will be located, as well as any fault with the PA driver.

1. Check for short circuits at the gate of the PA driver **Q306**. Check **R333**, **R336** (see **Figure 11.11** and **Figure 11.12**), **C310**, **R324** and **R327** (see **Figure 11.15** and **Figure 11.16**) between the power-control circuit and Q306.

2. Repair any fault revealed by the checks in Step 1. If none of the above-mentioned components is faulty, replace **Q306** (see **Figure 11.15** and **Figure 11.16**).

3. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 11.18 Components of concern on the bottom-side of the main board (B1 band)

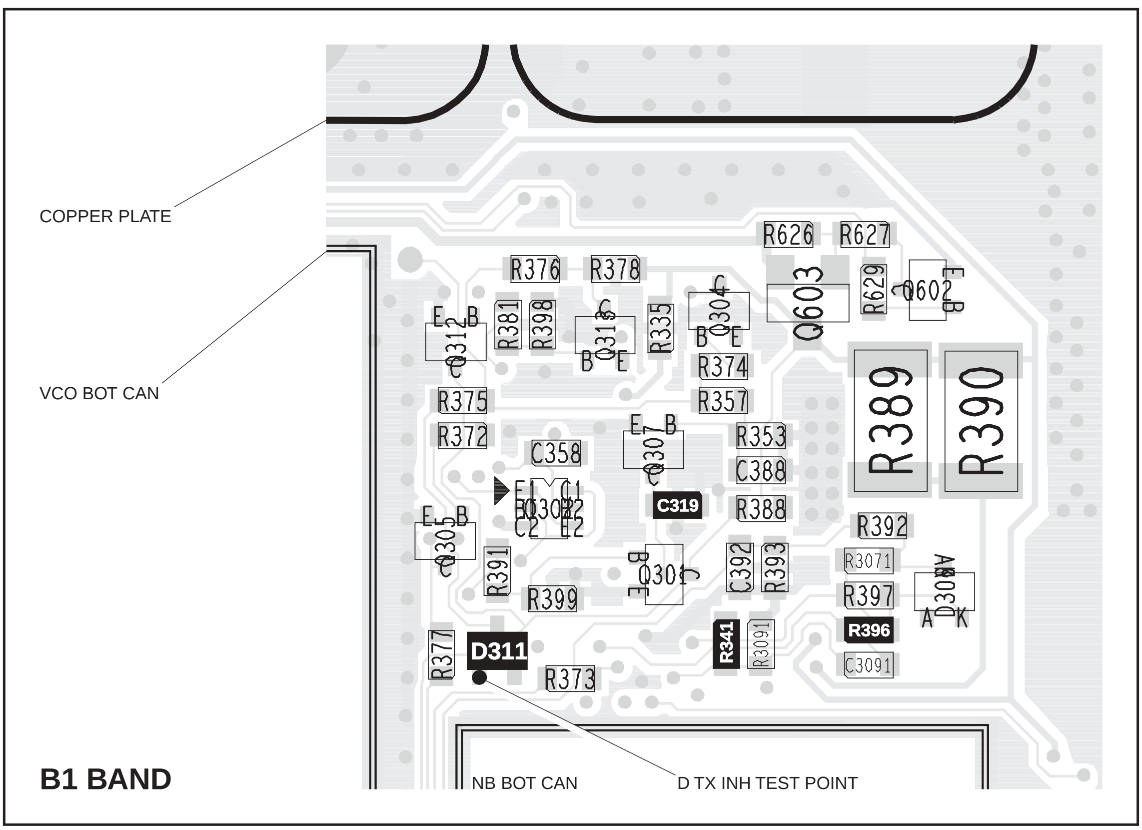
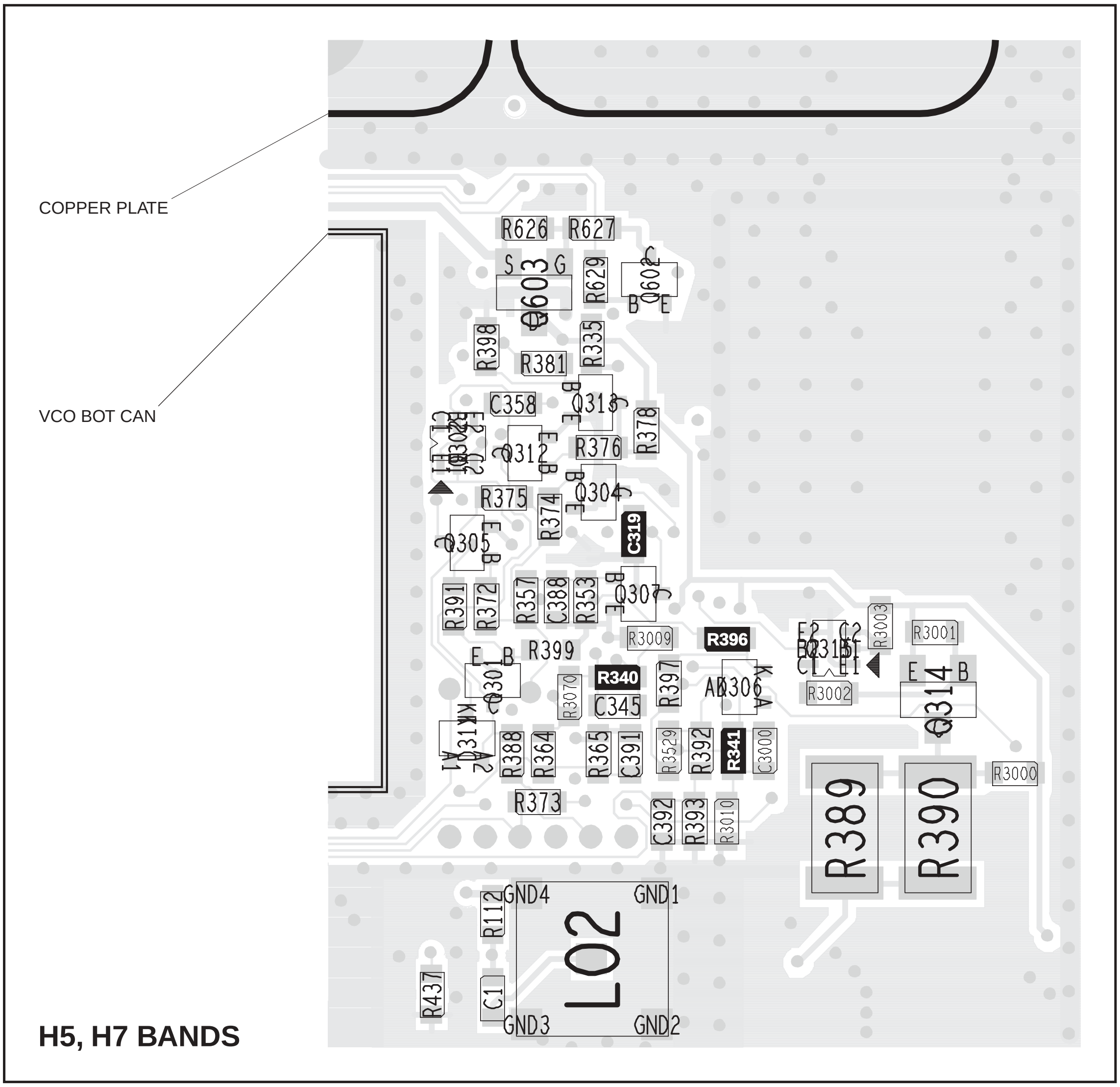


Figure 11.19 Components of concern on the bottom-side of the main board (H5 and H7 bands)



Task 24 — Power Control

In this task any faults in the power-control circuitry will be located:

1. Measure the voltage at pin 8 of **IC303** (see **Figure 11.11** and **Figure 11.12**) in the power-control circuit. The voltage should be:

pin 8 of IC303: 7.4 ± 0.5V

2. If the voltage is correct, go to Step 3. If it is not, enter the CCTM command *32* and return to Task 23.

3. Measure the voltage at pin 10 of **IC303** in the power-control circuit. The voltage should be:

pin 10 of IC303: 4.8 ± 0.5V

4. If the voltage is correct, go to Step 5. If it is not, go to Task 25.

5. Enter the CCTM command *32* to place the radio in receive mode.

6. Check **C322**, **C324**, **R342**, **R347** (see **Figure 11.11** and **Figure 11.12**) and **R396** (see **Figure 11.18** and **Figure 11.19**) in the power-control circuit. Repair any fault. Replace **IC303** if none of the other components is faulty.

7. Confirm the removal of the fault and go to "Final Tasks" on page 147. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 25 — Shaping Filter

In this task any faults in the shaping-filter circuitry will be located.

1. With the radio still in transmit mode, measure the voltage at pin 1 of **IC301** (see **Figure 11.11** and **Figure 11.12**) in the shaping-filter circuit. The voltage should be:

pin 1 of IC301: 4.8 ± 0.5V

2. Enter the CCTM command *32* to place the radio in receive mode.

3. If the voltage measured in Step 1 is correct, go to Step 4. If it is not, go to Step 5.

4. Check the components **R334** (see **Figure 11.11** and **Figure 11.12**) and **C319** (see **Figure 11.18** and **Figure 11.19**) and go to Step 6.

5. Check the components between the **PWR test point** and pin 1 of **IC301** (see **Figure 11.11** and **Figure 11.12**) and go to Step 6.

6. Repair any fault revealed by the checks in Step 4 and Step 5. Replace **IC301** if none of the other components is faulty.

7. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

11.4 RF Signal Path

Introduction

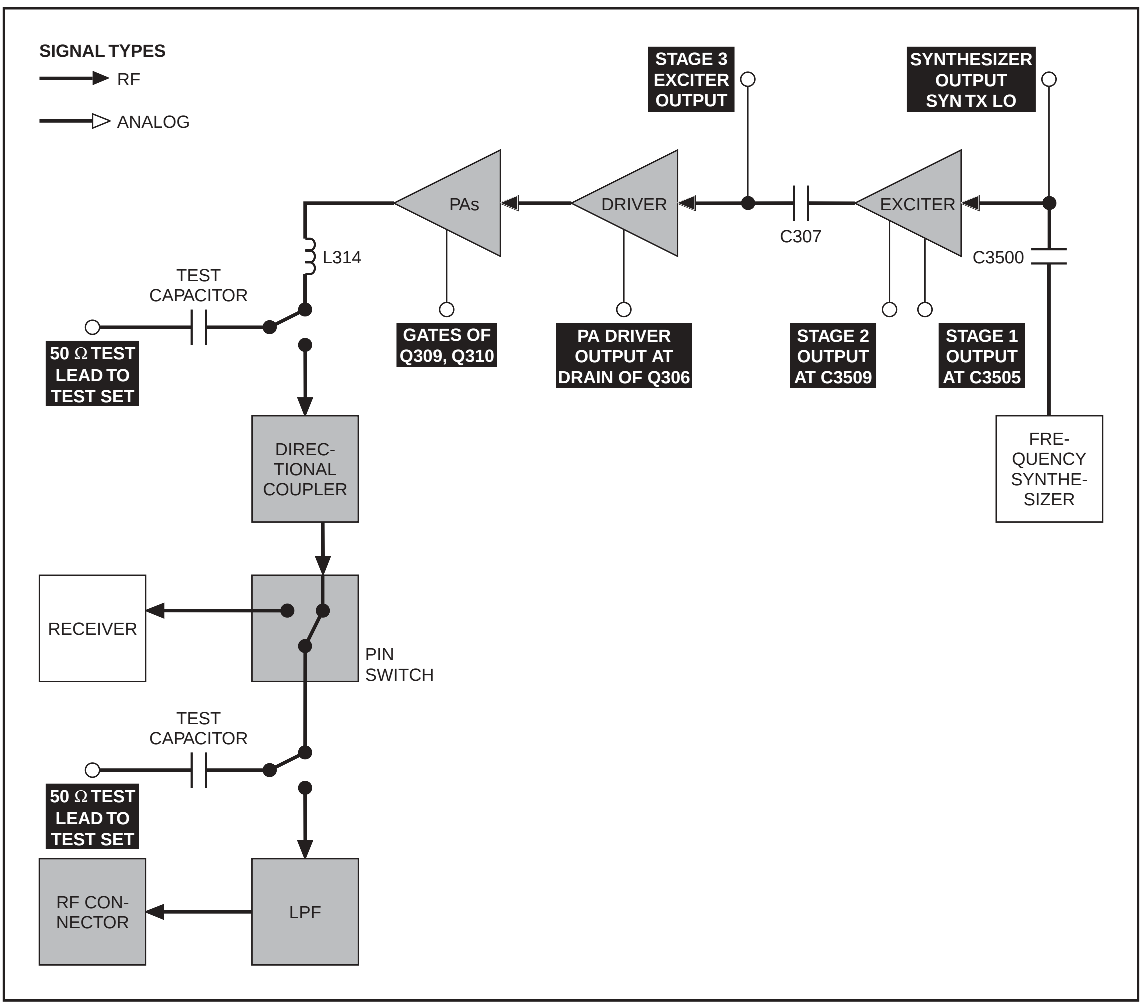
The RF signal path extends from the output of the frequency synthesizer to the LPF. This section of circuitry will require investigation either following certain checks in "Transmitter RF Power" or if the biasing checks of "Biasing of PA Driver and PAs" reveal no fault. The procedure is divided into ten tasks grouped as follows:

- Task 26 to Task 30: initial RF signal path
- Task 31 and Task 32: directional coupler
- Task 33 and Task 34: PIN switch
- Task 35: LPF

The initial signal path includes the exciter and PA driver. The directional coupler, PIN switch, and LPF make up the final signal path.

The measurement points for diagnosing faults in the signal path are summarized in Figure 11.20.

Figure 11.20 Measurement points for diagnosing faults in the RF signal path



Task 26 — Output of Frequency Synthesizer

The first point to check in the initial RF signal path is the output SYN TX LO from the frequency synthesizer. This signal is input to the exciter at C300.

1. For test purposes select a representative power level and frequency from **Table 11.8** (B1 band), **Table 11.9** (H5) or **Table 11.10** (H7). (Note that the data for these tables were obtained using an RFP5401A RF probe.)

2. To set the power level, enter the CCTM command *326* ***x***, where ***x*** defines the level. To set the frequency, enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in hertz.

3. Enter the CCTM command *33* to place the radio in transmit mode.

4. Use an RFP5401A RF probe or the equivalent to measure the RF voltage after **C3500** (see **Figure 11.21** and **Figure 11.22**). Earth the probe to the FCL TOP can adjacent to the PA driver circuitry.
   The required voltage should be as given in **Table 11.8** (B1 band), **Table 11.9** (H5) or **Table 11.10** (H7).

5. Enter the CCTM command *32* to place the radio in receive mode.

6. If the voltage measured above is correct, go to Task 27. If it is not, go to Step 7.

7. Check **C3500** (see **Figure 11.21** and **Figure 11.22**). If C3500 is not faulty, go to “Frequency Synthesizer Fault Finding” on page 169.
   If C3500 is faulty, replace it and return to Step 2.

Figure 11.21 PA driver circuitry under the PAD TOP can (B1 band)

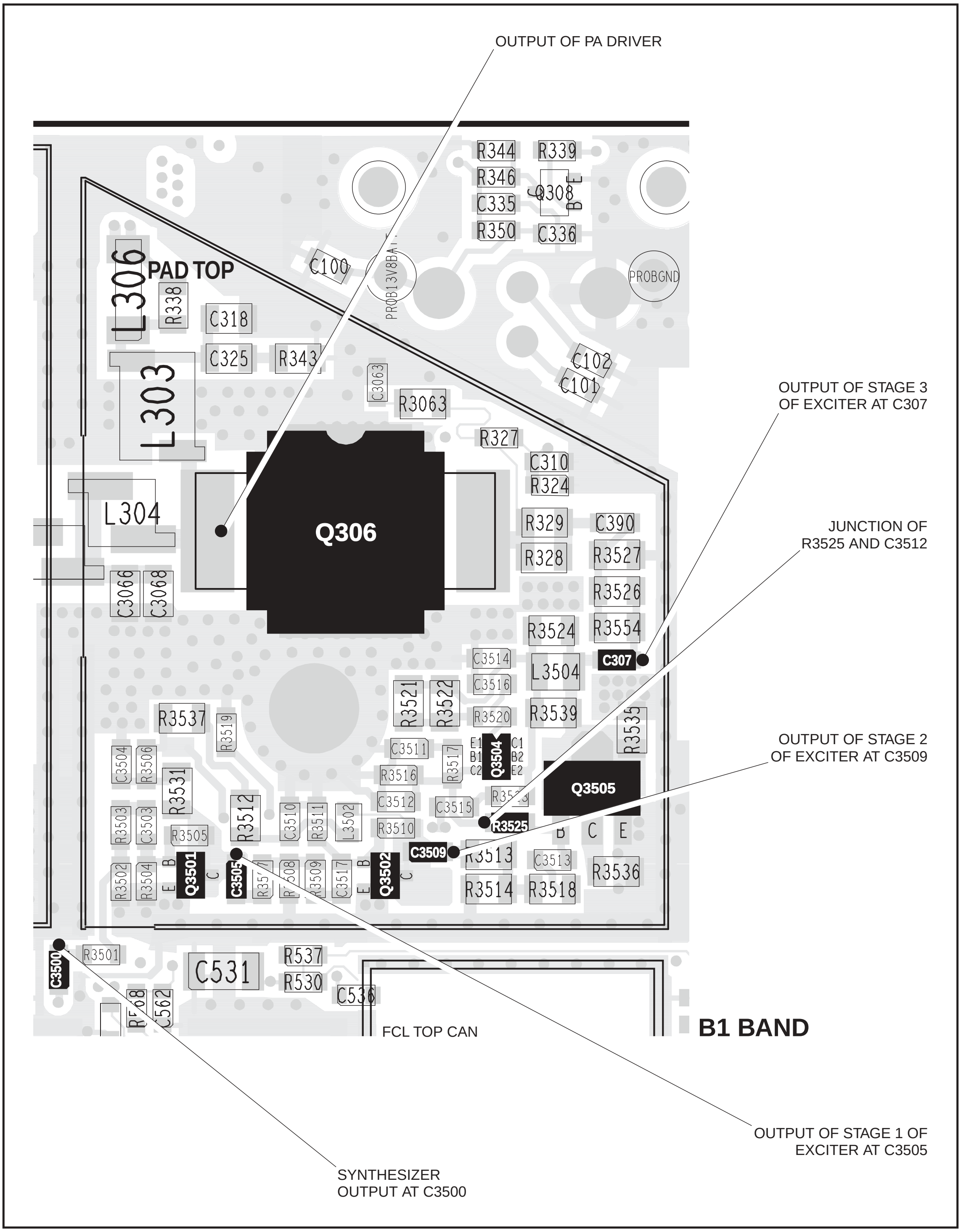


Figure 11.22 PA driver circuitry under the PAD TOP can (H5 and H7 bands)

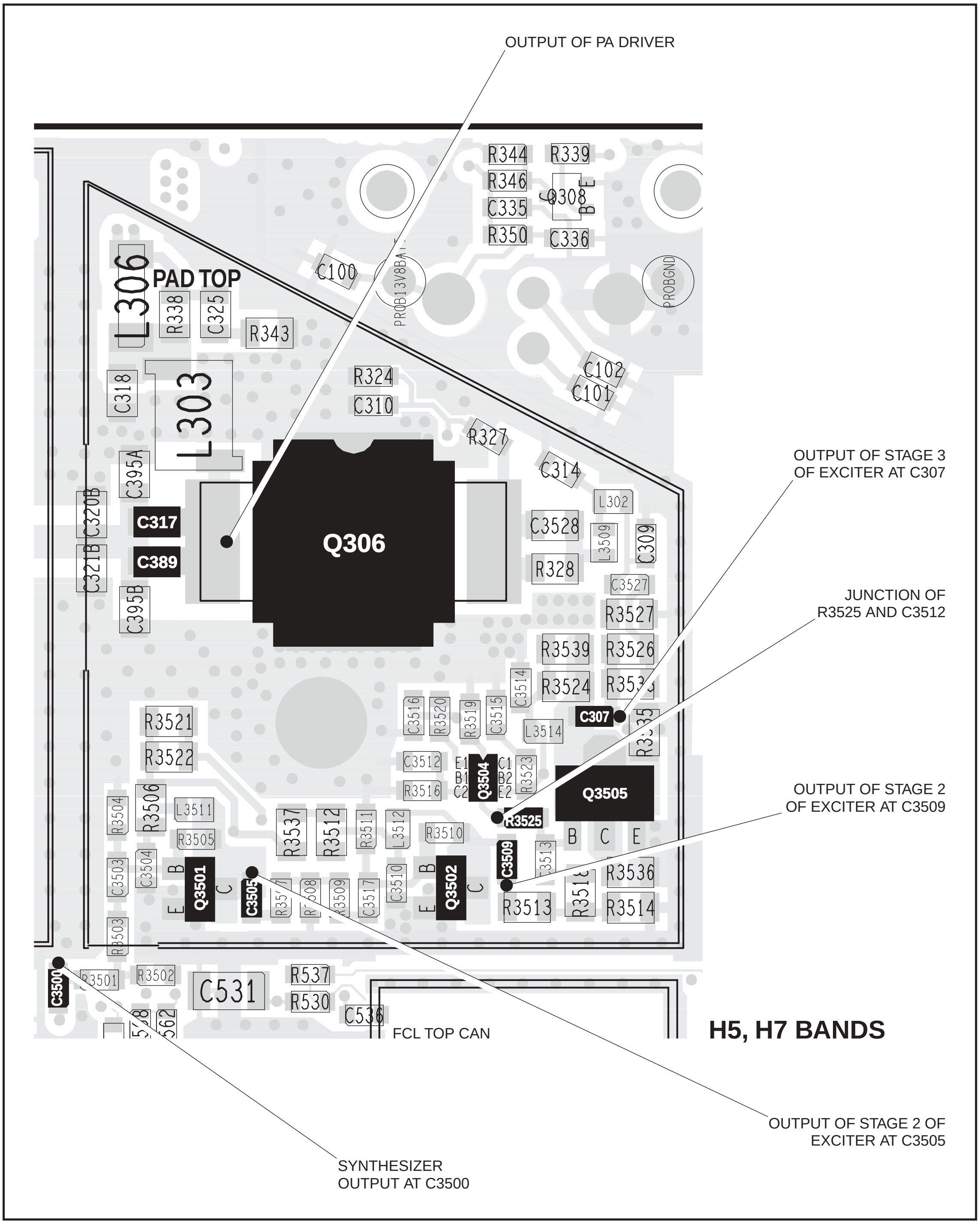


Table 11.8 RF voltages along the initial RF signal path of the VHF radio (B1 band)

Power level (W)	Frequency (MHz)	RF voltages (V)				
		Synthesizer output	Exciter stage 1	Exciter stage 2	Exciter stage 3	Driver output
10	136 155 174	0.3 ± 0.1 0.3 ± 0.1 0.2 ± 0.1	0.6 ± 0.2 0.6 ± 0.2 0.7 ± 0.2	2.7 ± 0.5 2.2 ± 0.5 1.7 ± 0.5	4.0 ± 0.5 3.7 ± 0.5 4.0 ± 0.5	9.9 ± 0.5 8.4 ± 0.5 8.4 ± 0.5
15	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.6 ± 0.2 0.6 ± 0.2 0.7 ± 0.2	2.7 ± 0.5 2.2 ± 0.5 1.7 ± 0.5	4.0 ± 0.5 3.7 ± 0.5 4.0 ± 0.5	11.8 ± 0.5 10.0 ± 0.5 10.0 ± 0.5
25	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.6 ± 0.2 0.6 ± 0.2 0.7 ± 0.2	2.7 ± 0.5 2.2 ± 0.5 1.7 ± 0.5	4.0 ± 0.5 3.7 ± 0.5 4.0 ± 0.5	14.3 ± 0.5 13.5 ± 0.5 14.7 ± 0.5
50	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.6 ± 0.2 0.6 ± 0.2 0.7 ± 0.2	2.7 ± 0.5 2.2 ± 0.5 1.7 ± 0.5	4.0 ± 0.5 3.7 ± 0.5 4.0 ± 0.5	15.6 ± 0.5 15.0 ± 0.5 15.6 ± 0.5
70	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.3 ± 0.1	0.6 ± 0.2 0.6 ± 0.2 0.7 ± 0.2	2.7 ± 0.5 2.2 ± 0.5 1.7 ± 0.5	4.0 ± 0.5 3.7 ± 0.5 4.0 ± 0.5	24.5 ± 0.5 29.0 ± 0.5 22.0 ± 0.5

Table 11.9 RF voltages along the initial RF signal path of the UHF radio (H5 band)

Power level (W)	Frequency (MHz)	RF voltages (V)				
		Synthesizer output	Exciter stage 1	Exciter stage 2	Exciter stage 3	Driver output
10	400 435 470	0.3 ± 0.1 0.4 ± 0.1 0.3 ± 0.1	1.2 ± 0.2 2.4 ± 0.2 1.1 ± 0.2	4.2 ± 0.5 2.7 ± 0.5 2.1 ± 0.5	9.2 ± 0.5 6.8 ± 0.5 4.8 ± 0.5	3.0 ± 0.5 2.9 ± 0.5 2.0 ± 0.5
15	400 435 470	0.3 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	1.2 ± 0.2 2.4 ± 0.2 1.1 ± 0.2	4.2 ± 0.5 2.7 ± 0.5 2.1 ± 0.5	9.2 ± 0.5 6.8 ± 0.5 4.8 ± 0.5	4.1 ± 0.5 3.8 ± 0.5 2.5 ± 0.5
20	400 435 470	0.4 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	1.2 ± 0.2 2.4 ± 0.2 1.1 ± 0.2	4.2 ± 0.5 2.7 ± 0.5 2.1 ± 0.5	9.2 ± 0.5 6.8 ± 0.5 4.8 ± 0.5	4.8 ± 0.5 4.2 ± 0.5 3.0 ± 0.5
40	400 435 470	0.3 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	1.2 ± 0.2 2.4 ± 0.2 1.1 ± 0.2	4.2 ± 0.5 2.7 ± 0.5 2.1 ± 0.5	9.2 ± 0.5 6.8 ± 0.5 4.8 ± 0.5	4.6 ± 0.5 4.0 ± 0.5 2.9 ± 0.5
60	400 435 470	0.3 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	1.2 ± 0.2 2.4 ± 0.2 1.1 ± 0.2	4.2 ± 0.5 2.7 ± 0.5 2.1 ± 0.5	9.2 ± 0.5 6.8 ± 0.5 4.8 ± 0.5	8.1 ± 0.5 7.3 ± 0.5 5.3 ± 0.5

Table 11.10 RF voltages along the initial RF signal path of the UHF radio (H7 band)

Power level (W)	Frequency (MHz)	RF voltages (V)				
		Synthesizer output	Exciter stage 1	Exciter stage 2	Exciter stage 3	Driver output
10	450 485 520	0.2 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	1.1 ± 0.2 1.0 ± 0.2 1.2 ± 0.2	2.2 ± 0.5 1.9 ± 0.5 0.9 ± 0.5	5.7 ± 0.5 3.4 ± 0.5 2.4 ± 0.5	2.5 ± 0.5 2.0 ± 0.5 0.9 ± 0.5
15	450 485 520	0.2 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	1.1 ± 0.2 1.0 ± 0.2 1.2 ± 0.2	2.2 ± 0.5 1.9 ± 0.5 0.9 ± 0.5	5.7 ± 0.5 3.4 ± 0.5 2.4 ± 0.5	3.1 ± 0.5 2.4 ± 0.5 1.1 ± 0.5
20	450 485 520	0.2 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	1.1 ± 0.2 1.0 ± 0.2 1.2 ± 0.2	2.2 ± 0.5 1.9 ± 0.5 0.9 ± 0.5	5.7 ± 0.5 3.4 ± 0.5 2.4 ± 0.5	3.6 ± 0.5 2.9 ± 0.5 1.4 ± 0.5
40	450 485 520	0.2 ± 0.1 0.1 ± 0.1 0.1 ± 0.1	1.1 ± 0.2 1.0 ± 0.2 1.2 ± 0.2	2.2 ± 0.5 1.9 ± 0.5 0.9 ± 0.5	5.7 ± 0.5 3.4 ± 0.5 2.4 ± 0.5	3.8 ± 0.5 3.2 ± 0.5 1.5 ± 0.5
60	450 485 520	0.2 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	1.1 ± 0.2 1.0 ± 0.2 1.2 ± 0.2	2.2 ± 0.5 1.9 ± 0.5 0.9 ± 0.5	5.7 ± 0.5 3.4 ± 0.5 2.4 ± 0.5	7.8 ± 0.5 4.8 ± 0.5 2.8 ± 0.5

Task 27 — Output of First Stage of Exciter

If the synthesizer output is correct, check the output at C3505 of the first stage of the exciter circuit.

1. If not already done, remove the PAD TOP can.
2. Enter the CCTM command *326 **x***, where ***x*** defines the power level selected in Task 26.
3. Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the frequency selected in Task 26.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Measure the RF voltage after **C3505** (see **Figure 11.21** and **Figure 11.22**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 11.8** (B1 band), **Table 11.9** (H5) or **Table 11.10** (H7).
6. Enter the CCTM command *32* to place the radio in receive mode.
7. If the voltage measured above is correct, go to Task 29. If it is not, go to Step 8.
8. Check the components around **Q3501** (see **Figure 11.21** and **Figure 11.22**).
9. Repair any fault revealed by the above checks. Replace **Q3501** (see **Figure 11.21** and **Figure 11.22**) if none of the other components is faulty.
10. Confirm the removal of the fault and go to "Final Tasks" on page 147. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 28 — Output of Second Stage of Exciter

If the output of the first stage of the exciter circuit is correct, check that of the second stage at C3509:

1. With the radio still in transmit mode, measure the RF voltage after **C3509** (see **Figure 11.21** and **Figure 11.22**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 11.8** (B1 band), **Table 11.9** (H5) or **Table 11.10** (H7).

2. If the voltage is correct, go to Task 30. If it is not, go to Step 3.

3. Enter the CCTM command *32* to place the radio in receive mode.

4. Check the components around **Q3502** (see **Figure 11.21** and **Figure 11.22**).

5. Repair any fault revealed by the above checks. Replace **Q3502** (see **Figure 11.21** and **Figure 11.22**) if none of the other components is faulty.

6. Confirm the removal of the fault and go to "Final Tasks" on page 147. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 29 — Output of Third Stage of Exciter

If the output of the second stage of the exciter circuit is correct, check that of the third and final stage at C307.

1. With the radio still in transmit mode, measure the RF voltage after **C307** (see **Figure 11.21** and **Figure 11.22**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 11.8** (B1 band), **Table 11.9** (H5) or **Table 11.10** (H7).

2. If the voltage is correct, go to Task 30. If it is not, go toStep 3.

3. With the radio still in transmit mode, measure the RF voltage at the junction of **R3525** and **C3512** (see **Figure 11.21** and **Figure 11.22**). The voltage should be:

junction of R3525 and C3512:	1.3 ± 0.2V (B1)
	1.8 ± 0.2V (H5, H7)

4. Enter the CCTM command *32* to place the radio in receive mode.

5. If the voltage measured in Step 3 is correct, go to Step 7. If it is not, go to Step 6.

6. Check the components around **Q3504** (see **Figure 11.21** and **Figure 11.22**). Repair any fault. Replace Q3504 if none of the other components is faulty. Conclude with Step 8.

7. Check the components around **Q3505** (see **Figure 11.21** and **Figure 11.22**). Repair any fault. Replace Q3505 if none of the other components is faulty.

8. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 30 — Output of PA Driver

If the exciter output is correct, check the output of the PA driver at the drain of Q306. If necessary, also check the signal at the gates of the PAs Q309 and Q310. This is the last point in the initial RF signal path.

1. With the radio still in transmit mode, measure the RF voltage at the drain of **Q306** (B1 — see **Figure 11.21**) or after **C317** and **C389** (H5, H7 — see **Figure 11.22**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 11.8** (B1), **Table 11.9** (H5) or **Table 11.10** (H7).
2. Enter the CCTM command *32* to place the radio in receive mode.
3. If the voltage measured above is correct, go to Step 7. If it is not, go to Step 4.
4. Check the components between **C307** and **Q306** (see **Figure 11.21** and **Figure 11.22**).
5. If the above checks reveal a fault, go to Step 6. If they do not, go to Task 12 in “Biasing of PA Driver and PAs” on page 269.
6. Repair the fault. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.
7. If not already done, remove the PAF TOP can.
8. Enter the CCTM command *326 5* to set the power level to the maximum, and then the command *33* to place the radio in transmit mode.
9. Measure the RF voltage at the gates of the PAs **Q309** and **Q310** (see **Figure 11.23** and **Figure 11.24**).
10. Enter the CCTM command *32* to place the radio in receive mode.
11. If an RF voltage is present, there is no fault in the initial RF signal path; go to Task 31. If there is no RF voltage, go to Step 12.
12. Check the components of the interstage matching circuitry between the PA driver **Q306** and the gates of the PAs **Q309** and **Q310** (see **Figure 11.23** and **Figure 11.24**).
13. If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 11.23 Components of the interstage matching circuitry between the PA driver Q306 and the PAs Q309 and Q310 (B1 band)

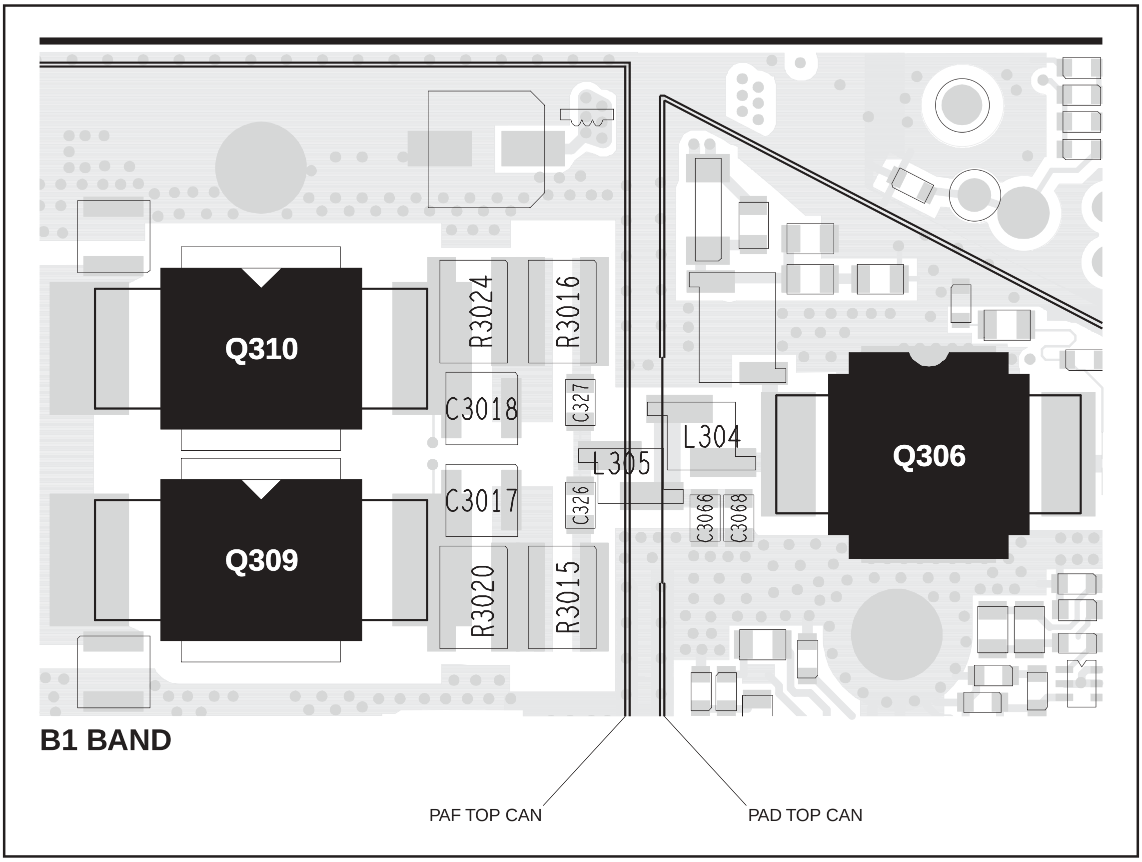
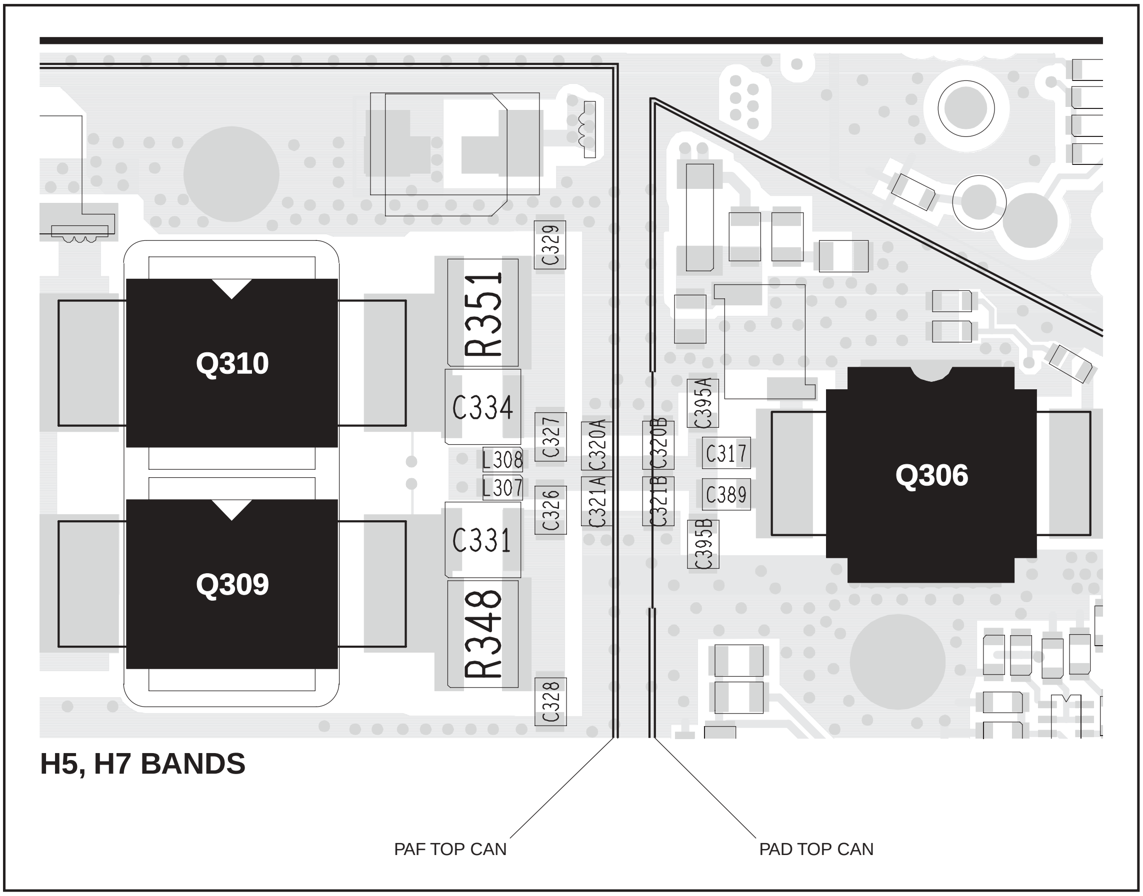


Figure 11.24 Components of the interstage matching circuitry between the PA driver Q306 and the PAs Q309 and Q310 (H5 and H7 bands)



Task 31 — Check Power at Directional Coupler

If, as determined in Task 26 to Task 30, there is no fault in the initial RF signal path, investigate the final signal path. This part of the circuitry may also require investigation following certain checks in "Transmitter RF Power". Begin by checking the directional coupler as follows:

1. If not already done, remove the DIRC TOP can.
2. Remove the coupling capacitors **C348**, **C349**, **C350** (see **Figure 11.25** and **Figure 11.26**).
3. Solder one terminal of an 82pF (H5, H7 bands) or 680pF (B1) test capacitor to the PCB at the point shown in **Figure 11.25** and **Figure 11.26**. Mount the capacitor vertically. Use a test capacitor of the type GRM111, DLI C17, Murata 1210, or the equivalent.
4. Solder a 50Ω test lead to the PCB: Solder the outer sheath to the test pad shown in **Figure 11.25** and **Figure 11.26**, and solder the central wire to the other terminal of the test capacitor.
5. Connect the test lead to the test set.
6. Enter the CCTM command *326 5* to set the transmitter power level to the maximum.
7. Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the lowest frequency (in hertz) for maximum power, as given in **Table 11.8** (B1 band), **Table 11.9** (H5) or **Table 11.10** (H7).
8. Enter the CCTM command *33* to place the radio in transmit mode.
9. Measure the RF output power. This should be:

RF output power:	more than 70W (B1 band) more than 60W (H5, H7 bands)

10. Enter the CCTM command *32* to place the radio in receive mode.
11. Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the highest frequency (in hertz) for maximum power, as given in **Table 11.8** (B1 band), **Table 11.9** (H5) or **Table 11.10** (H7).
12. Repeat Step 8 to Step 10.
13. If the power measured in both the above cases exceeds 70W (B1) or 60W (H5, H7), go to Step 14. If it does not, go to Task 32.
14. Remove the test lead and test capacitor, resolder the coupling capacitors in position, and go to Task 33.

Figure 11.25 Circuitry under the DIRC TOP can, and the points for attaching the test lead and test capacitor (B1 band)

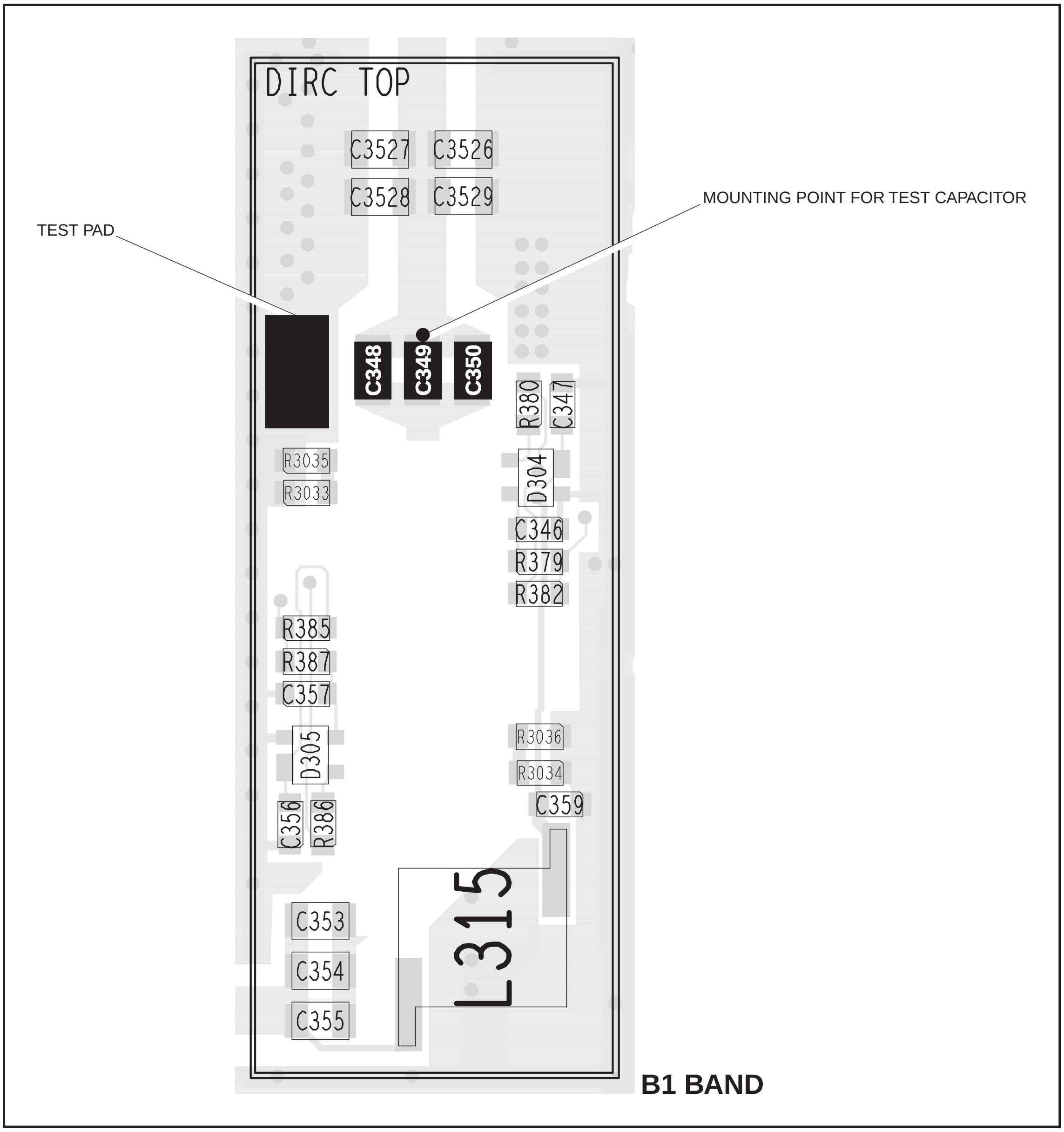
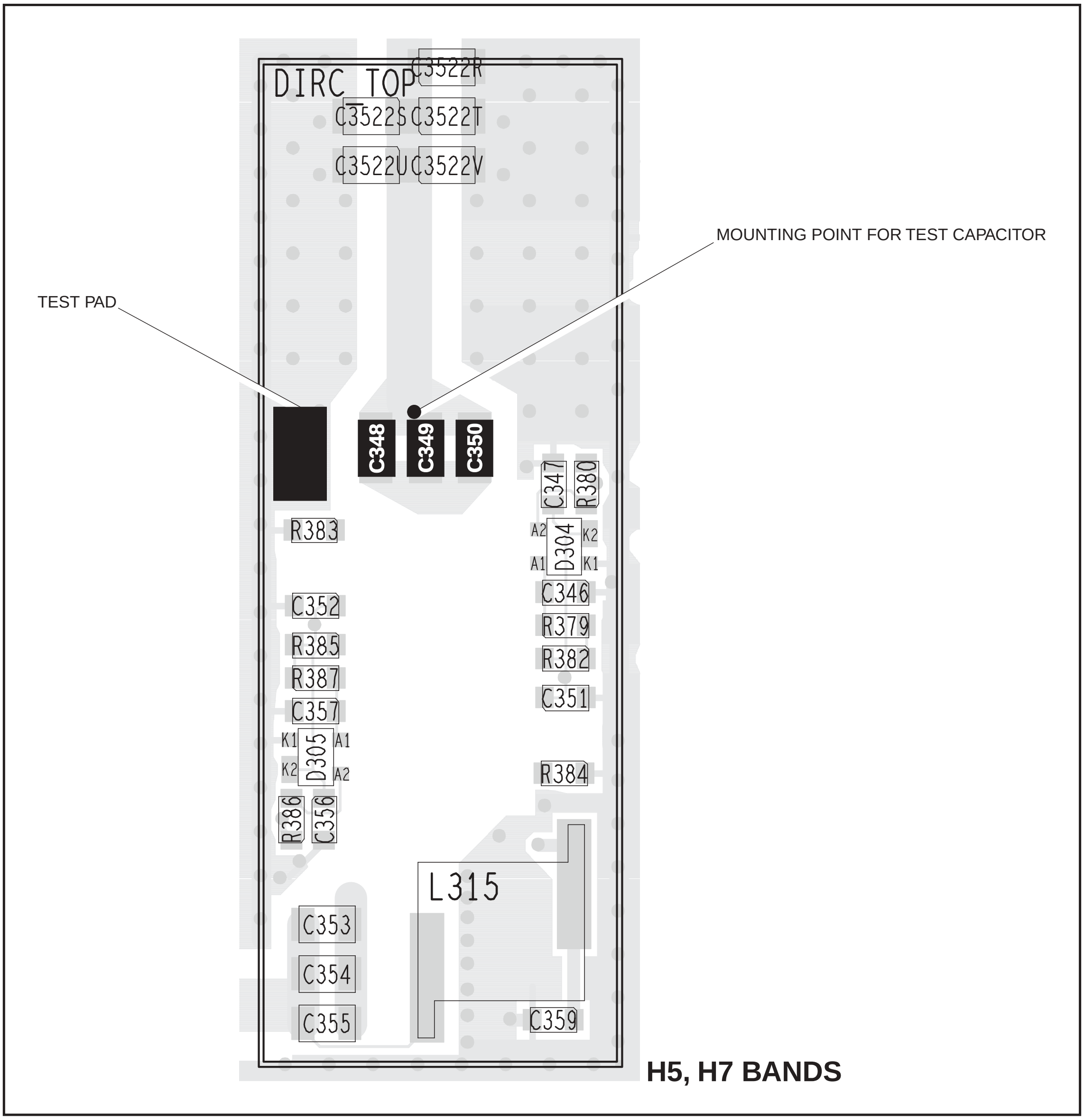


Figure 11.26 Circuitry under the DIRC TOP can, and the points for attaching the test lead and test capacitor (H5 and H7 bands)



Task 32 — Repair Circuitry

If the RF output power measured in Task 31 is low, there is a fault in the circuit between the common drain of the PAs and the test capacitor.

1. If not already done, remove the PAF TOP can.
2. Check for faulty, shorted or misplaced components in the circuit between the test capacitor and the common drain of **Q309** and **Q310** (see **Figure 11.8** and **Figure 11.9**).
3. Repair any fault revealed by the above checks and go to Step 5. If no fault could be found, go to Step 4.
4. Remove the test lead and test capacitor, resolder the coupling capacitors **C348**, **C349** and **C350** in position (see **Figure 11.25** and **Figure 11.26**), and go to Task 26.
5. With the test lead still connected to the test set, enter the CCTM command *326 5* to set the transmitter power level to the maximum.
6. Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the lowest frequency (in hertz) for maximum power, as given in **Table 11.8** (B1 band), **Table 11.9** (H5) or **Table 11.10** (H7).
7. Enter the CCTM command *33* to place the radio in transmit mode.
8. Measure the RF output power. This should be:

RF output power:	more than 70W (B1 band) more than 60W (H5, H7 bands)

9. Enter the CCTM command *32* to place the radio in receive mode.
10. Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the highest frequency (in hertz) for maximum power, as given in **Table 11.8** (B1 band), **Table 11.9** (H5) or **Table 11.10** (H7).
11. Repeat Step 7 to Step 9.
12. Remove the test lead and test capacitor, and resolder the coupling capacitors **C348**, **C349** and **C350** in position (see **Figure 11.25** and **Figure 11.26**).
13. If the power in both the above cases is now correct, the fault has been rectified; go to “Final Tasks” on page 147. If it is not, the repair failed; replace the main-board assembly and go to “Final Tasks” on page 147.

Task 33 — Check PIN Switch

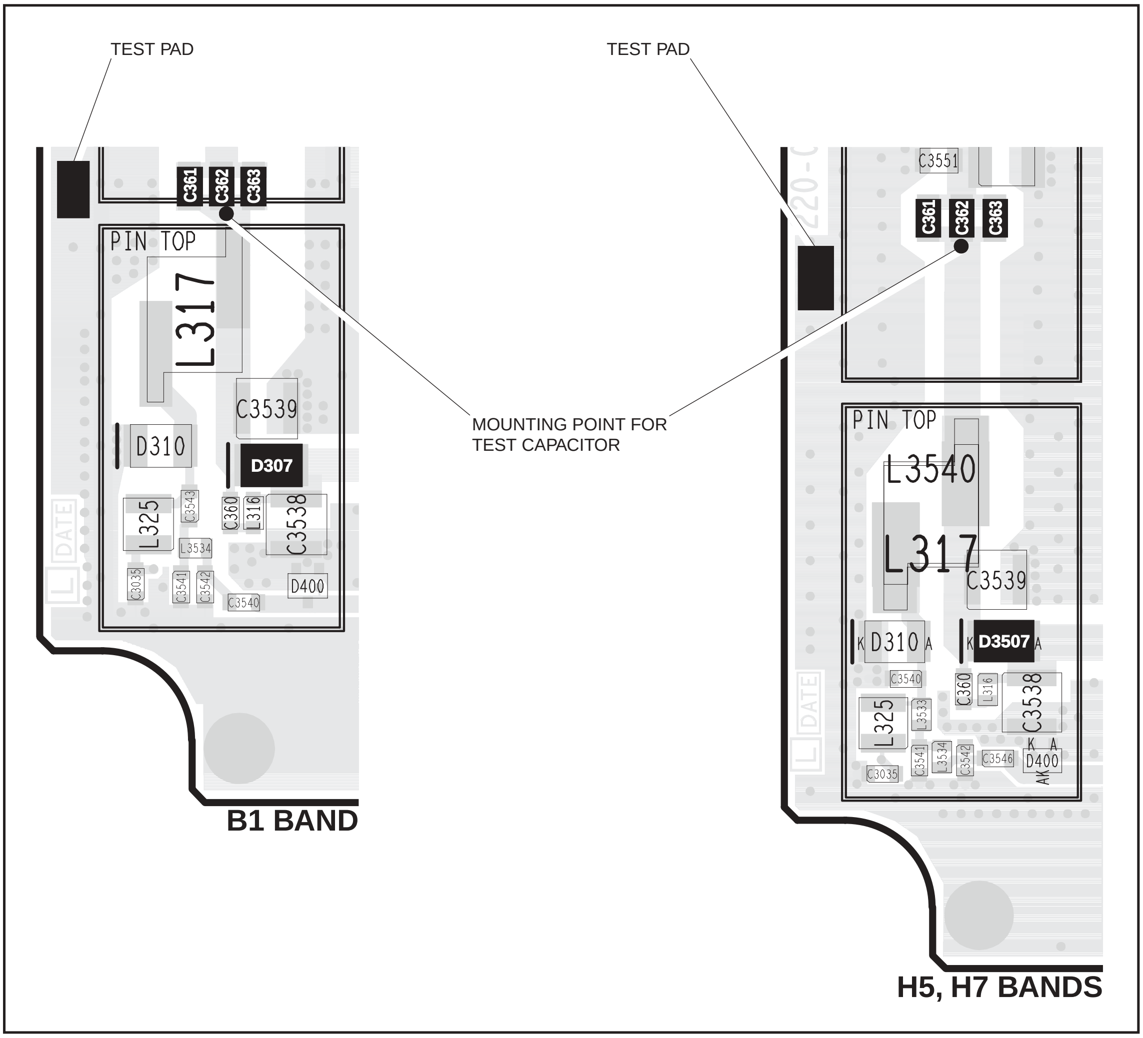
In checking the final RF signal path, if no fault is found in the directional coupler, then check the PIN switch next. The PIN switch may also require investigation following certain checks in "Transmitter RF Power".

1. Remove the LPF TOP can.
2. Remove the three blocking capacitors **C361**, **C362** and **C363** (see **Figure 11.27**).
3. Solder one terminal of a 56 pF (B1 band) or 18 pF (H5, H7) test capacitor to the PCB at the point shown in **Figure 11.27**. Mount the capacitor vertically. Use a test capacitor of the type GRM111, DLI C17, Murata 1210, or the equivalent.
4. Solder a 50 Ω test lead to the PCB. Solder the outer sheath to the test pad shown in **Figure 11.27**, and solder the central wire to the other terminal of the test capacitor.
5. Connect the test lead to the test set.
6. Enter the CCTM command *326 5* to set the transmitter power level to the maximum.
7. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the lowest frequency (in hertz) for maximum power, as given in **Table 11.8** (B1 band), **Table 11.9** (H5) or **Table 11.10** (H7).
8. Enter the CCTM command *33* to place the radio in transmit mode.
9. Measure the RF output power. This should be:

RF output power:	more than 70W (B1 band) more than 60W (H5, H7 bands)

10. Enter the CCTM command *32* to place the radio in receive mode.
11. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the highest frequency (in hertz) for maximum power, as given in **Table 11.8** (B1 band), **Table 11.9** (H5) or **Table 11.10** (H7).
12. Repeat Step 8 to Step 10.
13. If the power in both the above cases exceeds 70W (B1) or 60W (H5, H7), go to Step 14. If it does not, the circuitry of the PIN switch is suspect; go to Task 34.
14. Remove the test lead and test capacitor, resolder the blocking capacitors in position, and go to Task 35.

Figure 11.27 Circuitry under the PIN TOP can, and points for attaching the test lead and test capacitor



Task 34 — Repair PIN switch

If the RF power at the PIN switch is low, the switch is not drawing the expected current or the diode is faulty. Check the circuit as follows:

1. Remove the PIN TOP can.

2. Perform a diode check of **D307** (B1 band) or **D3507** (H5, H7 bands) (see **Figure 11.27**). If it is not faulty, go to Step 3. If it is, replace D307 or D3507, and go to Step 4.

3. Check the +9V0_TX supply to the PIN switch via the following resistors on the bottom-side of the PCB (see **Figure 11.28** and **Figure 11.29**):
   - B1 band: **R389** and **R390**
   - H5, H7 bands: **R3000**, **R389** and **R390**

   If any resistor is faulty, replace the resistor as well as **D307** (B1) or **D3507** (H5, H7). (A faulty resistor is likely to have resulted in damage to D307 or D3507.)

4. With the test lead still connected to the test set, enter the CCTM command *326 5* to set the transmitter power level to the maximum.

5. Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the lowest frequency (in hertz) for maximum power, as given in **Table 11.8** (B1 band), **Table 11.9** (H5) or **Table 11.10** (H7).

6. Enter the CCTM command *33* to place the radio in transmit mode. Again measure the RF output power. This should be:

RF output power:	more than 70W (B1 band)
	more than 60W (H5, H7 bands)

7. Enter the CCTM command *32* to place the radio in receive mode.

8. Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the highest frequency (in hertz) for maximum power, as given in **Table 11.8** (B1 band), **Table 11.9** (H5) or **Table 11.10** (H7).

9. Repeat Step 5 to Step 7.

10. Remove the test lead and test capacitor, and resolder the blocking capacitors **C361**, **C362** and **C363** (see **Figure 11.27**) in position.

11. If the power in both the above cases is now correct, the fault has been rectified; go to “Final Tasks” on page 147. If it is not, the repair failed; replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 11.28 Components of concern on the bottom-side of the main board (B1 band)

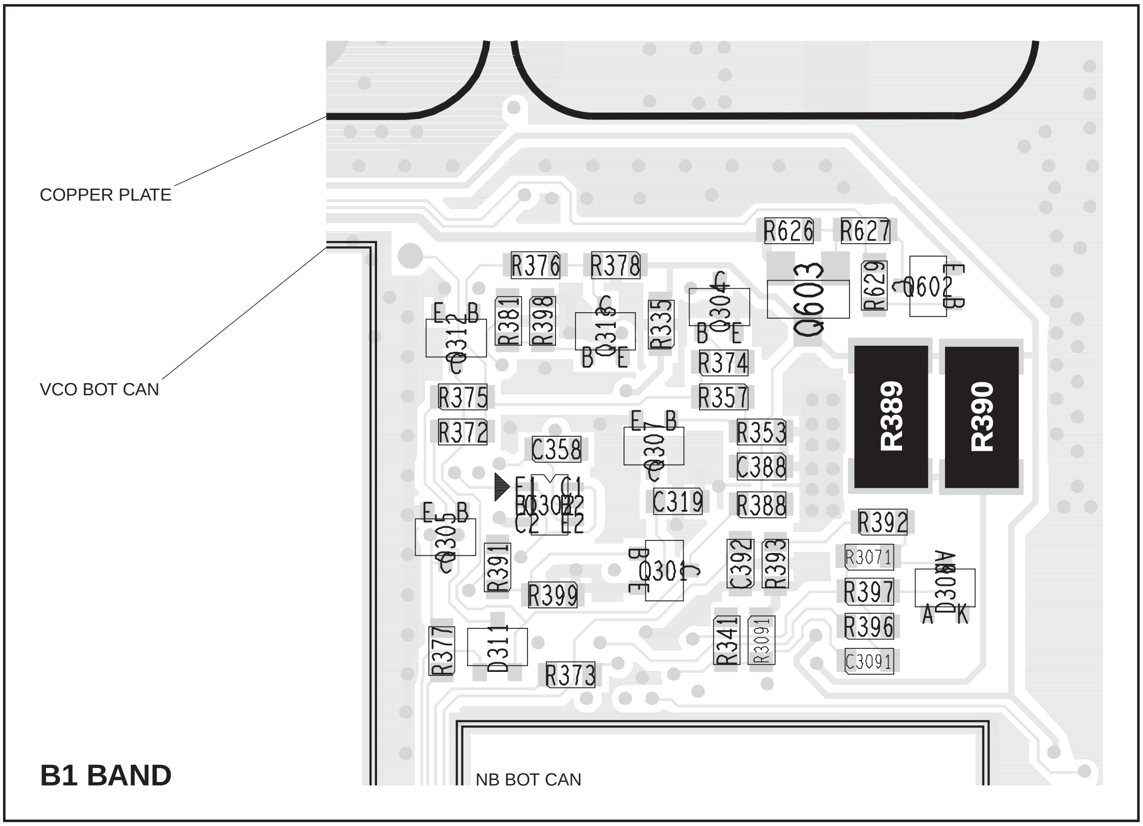


Figure 11.29 Components of concern on the bottom-side of the main board (H5 and H7 bands)

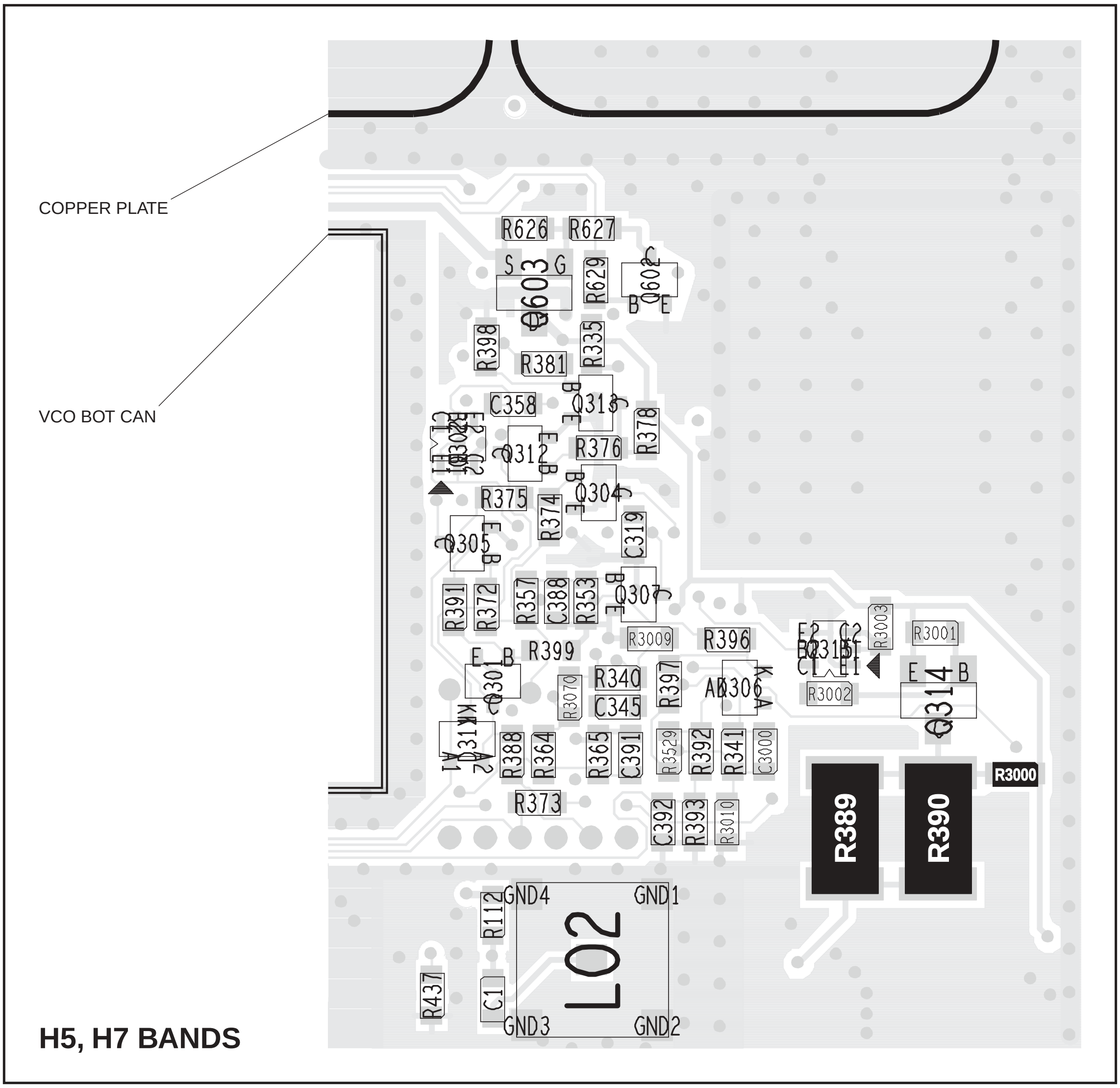
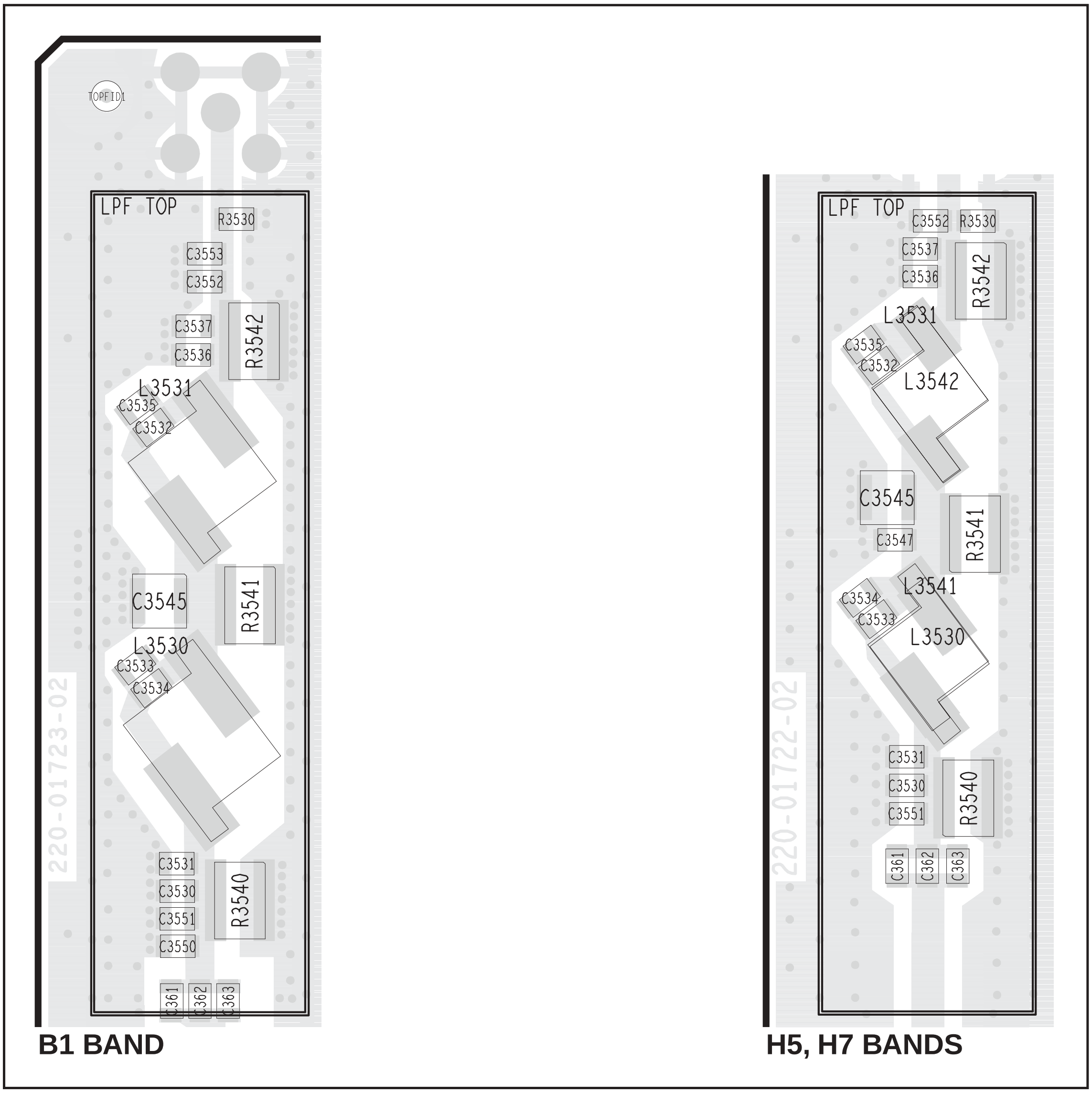


Figure 11.30 Circuitry under the LPF TOP can



Task 35 — Check Components of LPF

If there are no faults in the final RF signal path up to and including the PIN switch, then the fault should lie in the LPF. Check the LPF as follows:

1. If not already done, remove the LPF TOP can.
2. Connect the RF connector to the test set.
3. Check the capacitors and inductors of the LPF between the PIN switch and the RF connector. See **Figure 11.30**. Check for shorts, open circuits, and faulty components. Repair any fault.
4. In the case of the B1 band, replace the LPF TOP can before continuing.
5. Enter the CCTM command *326 5* to set the transmitter power level to the maximum.
6. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the lowest frequency (in hertz) for maximum power, as given in **Table 11.8** (B1 band), **Table 11.9** (H5) or **Table 11.10** (H7).
7. Enter the CCTM command *33* to place the radio in transmit mode.
8. Measure the RF output power. This should be:

RF output power:	more than 70W (B1 band) more than 60W (H5, H7 bands)

9. Enter the CCTM command *32* to place the radio in receive mode.
10. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the highest frequency (in hertz) for maximum power, as given in **Table 11.8** (B1 band), **Table 11.9** (H5) or **Table 11.10** (H7).
11. Repeat Step 7 to Step 9.
12. If the power in both the above cases exceeds 70W (B1) or 60W (H5, H7), the fault has been rectified; go to “Final Tasks” on page 147. If it does not, the repair failed; replace the main-board assembly and go to “Final Tasks” on page 147.

12 Transmitter Fault Finding (25 W Radios)

Introduction

This section covers the diagnosis of faults in the transmitter circuitry for the 25 W radios. The main indication of a fault in the transmitter is a reduction in range. This implies that the power output is wrong or too low. Another type of fault is manifested when the radio always transmits at full power, even if set otherwise. Regardless of the fault, the lock status should be normal.

Fault-Diagnosis Tasks

The procedure for diagnosing transmitter faults is divided into tasks, which are grouped into the following sections:

- “Power Supplies”
- “Transmitter RF Power”
- “Biasing of PA Driver and PAs”
- “RF Signal Path”

Before beginning the fault diagnosis with “Power Supplies”, note the following information regarding CCTM commands, frequency bands, can removal and replacement, and transmit tests.

CCTM Commands

The CCTM commands required in this section are listed in Table 12.1. Full details of the commands are given in “Computer-Controlled Test Mode (CCTM)” on page 112.

Table 12.1 CCTM commands required for the diagnosis of faults in the transmitter

Command	Description
32	Set radio in receive mode
33	Set radio in transmit mode
47	Read temperature near PAs — displays temperature **x** in degrees celsius and voltage **y**
101 **x** **y** 0	Set transmit frequency (**x** in hertz) and receive frequency (**y** in hertz) to specified values
114 **x**	Set DAC value **x** (in range 0 to 1023) of transmit power
304	Read clamp current at gate of PA driver — displays DAC value **x** (in range 0 to 255)
304 **x**	Set DAC value **x** (in range 0 to 255) of clamp current at gate of PA driver
318	Read forward-power level — displays corresponding voltage **x** in millivolts
319	Read reverse-power level — displays corresponding voltage **x** in millivolts
326 **x**	Set transmitter power level **x** (0=off, 1=very low, 2=low, 3=medium, 4=high, 5=maximum)
331	Read bias voltage for first PA — displays DAC value **x** (in range 0 to 255)
331 **x**	Set DAC value **x** (in range 0 to 255) of bias voltage for first PA
332	Read bias voltage for second PA — displays DAC value **x** (in range 0 to 255)
332 **x**	Set DAC value **x** (in range 0 to 255) of bias voltage for second PA
334 **x**	Set synthesizer on (**x**=1) or off (**x**=0) via DIG SYN EN line
335 **x**	Set transmit-receive switch on (**x**=1) or off (**x**=0) via DIG SYN TR SW line

Frequency Bands

Some fault-diagnosis tasks require programming the radio with the lowest, center or highest frequency in the radio's frequency band. The relevant frequencies for the different bands are listed in Table 12.2. Note that the following frequency ranges are reserved worldwide for use by distress beacons:

- B1 band: 156.8MHz ± 375kHz
- H5 band: 406.0 to 406.1MHz

Do not program the radio with any frequency in the above ranges.

Table 12.2 Lowest, center and highest frequencies in MHz

Band	Lowest frequency	Center frequency	Highest frequency
B1	136	155	174
H5	400	435	470
H6	450	490	530

Can Removal

There are five cans shielding the bulk of the transmitter circuitry:

- PAD TOP
- PAF TOP
- DIRC TOP
- PIN TOP
- LPF TOP

To remove any can, first remove the main-board assembly from the chassis. In the case of the PAD TOP and PAF TOP cans, first detach the heat-transfer block from the main board. Secure the block again after removing the cans. Follow the procedures given in "Disassembly and Reassembly" on page 123.

Can Replacement

Replace all cans that have been removed only after repairing the board. This applies to the B1, H5 and H6 bands. For certain other bands the transmitter will not operate correctly unless all the cans are fitted.

Transmit Tests

The following points need to be borne in mind when carrying out transmit tests:

- secure main-board assembly
- ensure proper antenna load
- limit duration of transmit tests
- protect against accidental transmissions
- avoid thermal and RF burns

These points are discussed in more detail below.

Secure Main-Board Assembly

Before conducting any transmit tests, ensure that the main-board assembly is adequately secured in the chassis. This is essential if overheating of the radio is to be avoided. (As mentioned earlier, the heat-transfer block must already be secured to the main board of the assembly.) It is good practice to secure the assembly by at least the two external screws and one of the internal screws. The screws are labelled ⑧ and ④ in Figure 5.3 on page 127. There is no need, however, to secure the lid of the radio body.

Ensure Proper Antenna Load

The radio has been designed to operate with a 50Ω termination impedance, but will tolerate a wide range of antenna loading conditions. Nevertheless, care should be exercised. Normally the RF connector on the main-board assembly will be connected to the RF communications test set as shown in Figure 4.2 on page 106. But for those tests where this connection is not necessary, a 50Ω load may be used instead. Do not operate the transmitter without such a load or without a connection to the test set. Failure to do so might result in damage to the power output stage of the transmitter.

Limit Duration of Transmit Tests

After setting the frequency and power level (if necessary), enter the CCTM command *33* to perform a transmit test. This command places the radio in transmit mode. After completing the measurement or check required, immediately enter the CCTM command *32*. This command returns the radio to the receive mode. Restricting the duration of transmit tests in this way will further limit the danger of overheating. The reason for this precaution is that the transmit timers do not function in the CCTM mode.

Protect Against Accidental Transmissions

Under certain circumstances the microprocessor can key on the transmitter. Ensure that all instruments are protected at all times from such accidental transmissions.

Avoid Thermal and RF Burns

Avoid thermal burns. Do not touch the cooling fins or underside of the radio body when the transmitter is or has been operating. Avoid RF burns. Do not touch the antenna or the RF signal path on the circuit board while the transmitter is operating.

12.1 Power Supplies

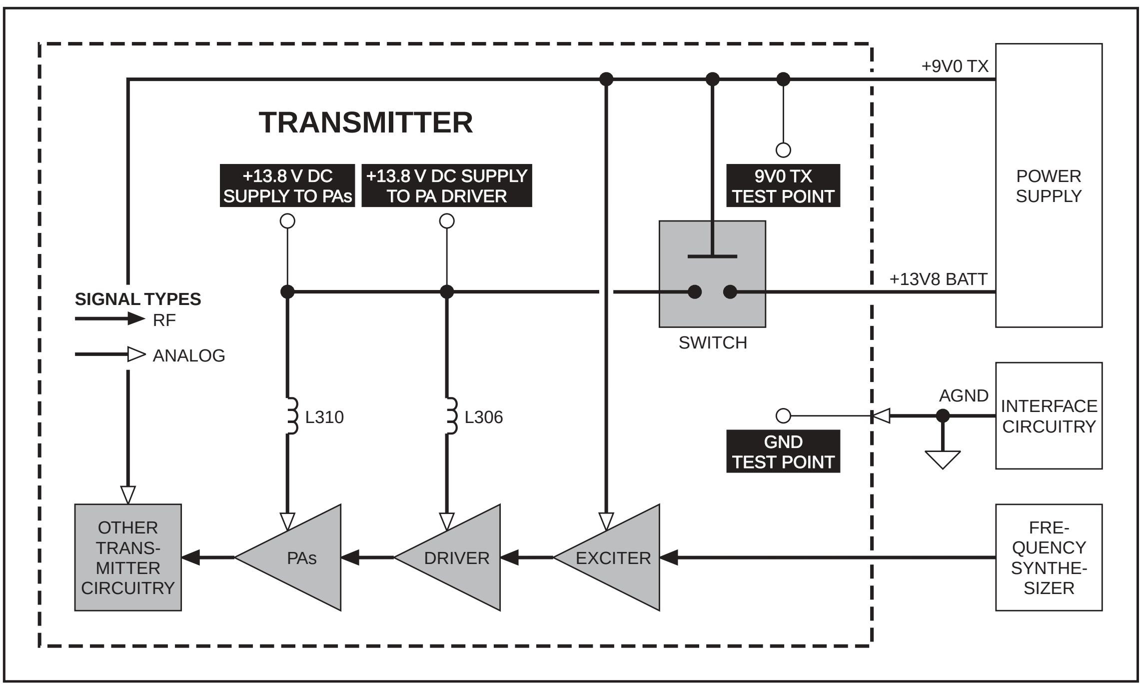
Introduction

First check that a power supply is not the cause of the fault. There are two power supplies and a switch circuit for the transmitter:

- Task 1: 13.8V DC supply from power connector (+13V8 BATT)
- Task 2: switch circuit for 13.8V DC supply
- Task 3: 9V DC supply from 9V regulator in PSU module (+9V0 TX)

The measurement and test points for diagnosing faults in the power supplies are summarized in Figure 12.1.

Figure 12.1 Measurement and test points for diagnosing faults involving the power supplies for the transmitter



Task 1 — 13.8V Power Supply

First check the power supply from the power connector.

1. Obtain a needle probe to use for measurements of the power supply at the PA driver and PAs. If none is available, remove the PAF TOP and PAD TOP cans.

2. Set the DC power supply to 13.8V, with a current limit of 9A.

3. Program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the frequency in hertz. The required values for the different frequency bands are given in **Table 12.2**.

4. Enter the CCTM command *326 5* to set the radio to maximum power.

5. Attempt to place the radio in transmit mode. Enter the CCTM command *33*.

6. If the radio enters the transmit mode, continue with Step 7. If instead a *C03* error is displayed in response to the command *33*, go to Task 7 in "Transmitter RF Power" on page 328.

7. Measure the voltage at the point on **L310** shown in **Figure 12.2**. This is the supply at the common drain of **Q309** and **Q310**, and should be:

common drain of Q309 and Q310: more than 13V DC

8. Also measure the voltage at the point on **L306** shown in **Figure 12.3**. This is the supply at the drain of **Q306**, and should be:

drain of Q306: more than 13V DC

9. Enter the CCTM command *32* to place the radio in receive mode.

10. If the power supply measured in Step 7 and Step 8 is not correct, go to Task 2. If it is, go to Task 3.

Figure 12.2 Point for measuring the power supply to the PAs

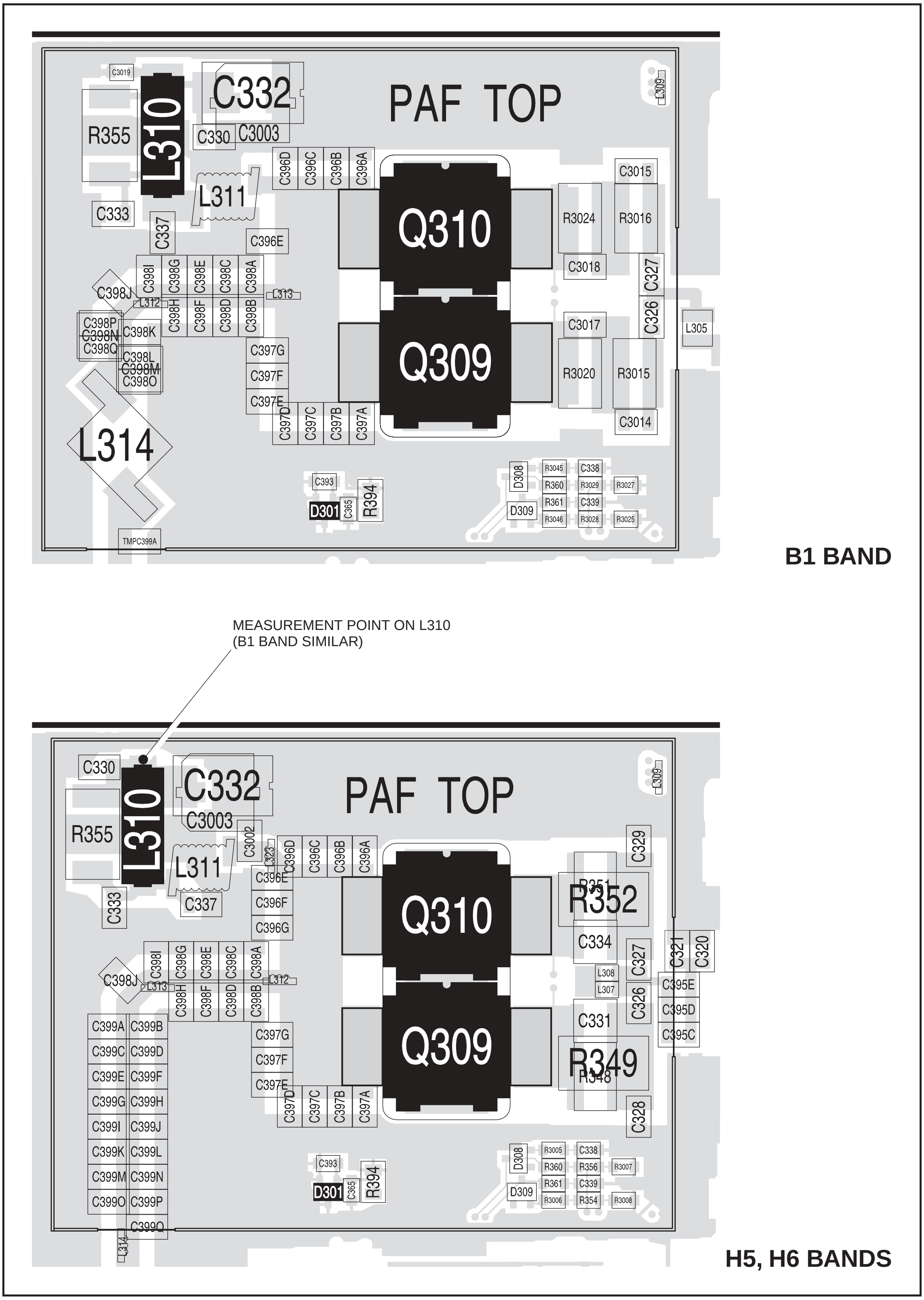
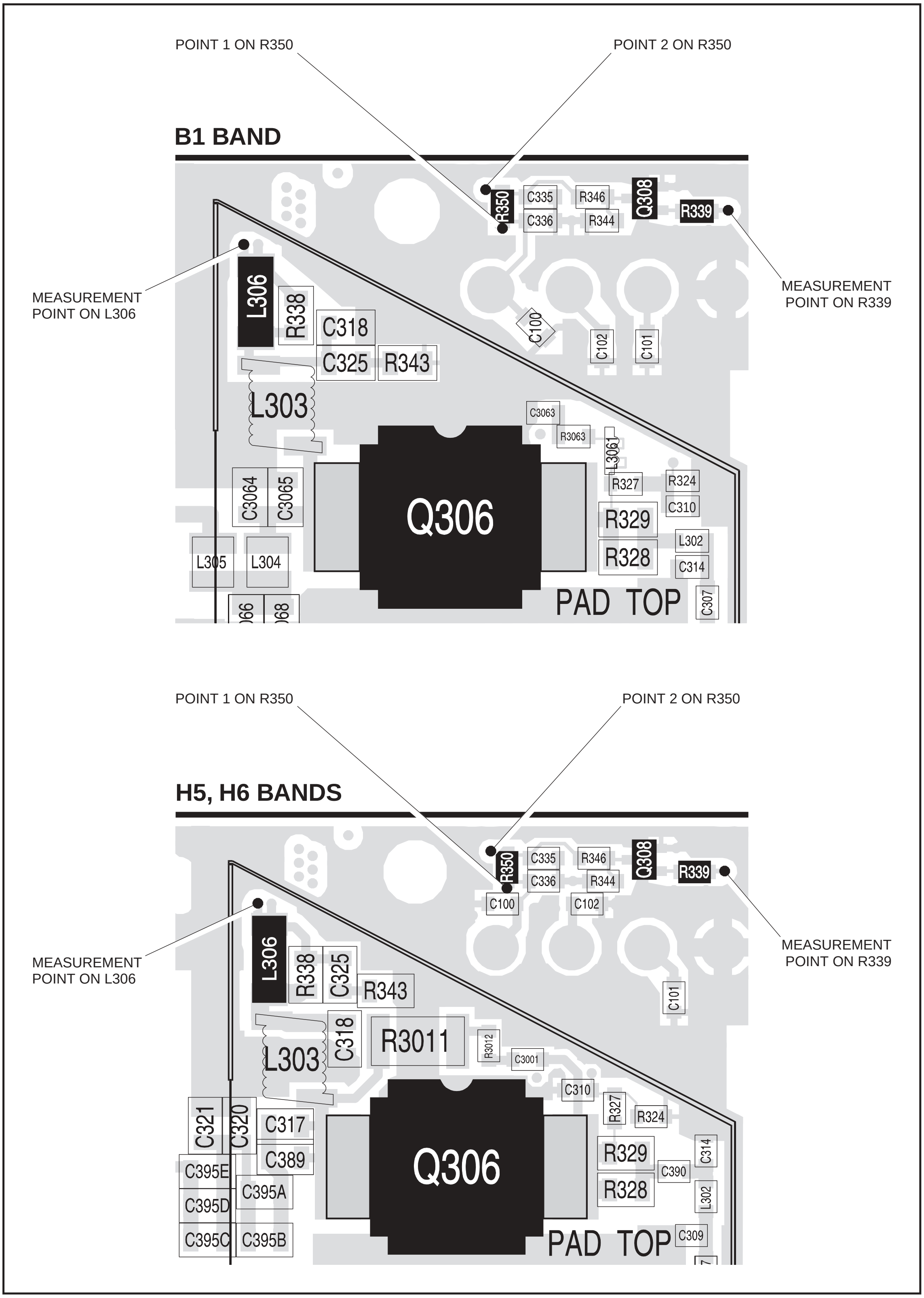


Figure 12.3 Point for measuring the power supply to the PA driver



Task 2 — Check Switch Circuit

If the power supply to the drains of the PAs and PA driver is not correct, the switch circuit is suspect. Check the circuit as follows:

1. Measure the voltage at the point 1 on **R350** shown in **Figure 12.3**. The voltage should be:

point 1 on R350: 13.8V DC

2. If the voltage measured in Step 1 is correct, go to Step 3. If it is not, check for continuity between **R350** and the power connector. Repair any fault and conclude with Step 8.

3. Measure the voltage at **R339** as shown in **Figure 12.3**. The voltage should be:

R339: 9V DC

4. If the voltage measured in Step 3 is correct, go to Step 5. If it is not, go to Task 3 and check the 9V power supply.

5. Measure the voltage at the point 2 on **R350** shown in **Figure 12.3**. The voltage should be:

point 2 on R350: < 5V DC

6. If the voltage measured in Step 5 is correct, go to Step 7. If it is not, replace **Q308** — see **Figure 12.3** — and conclude with Step 8.

7. Remove the heat-transfer block from the main board. Replace **Q311** (situated on the bottom-side of the main board next to the power connector). Replace the heat-transfer block, and conclude with Step 8.

8. Repeat Task 1 to confirm the removal of the fault, and go to "Final Tasks" on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 3 — 9V Power Supply

If the supply from the power connector is correct, check the 9V DC supply.

1. Enter the CCTM command *326 1* to set the transmitter power level very low.

2. Enter the CCTM command *33* to place the radio in transmit mode.

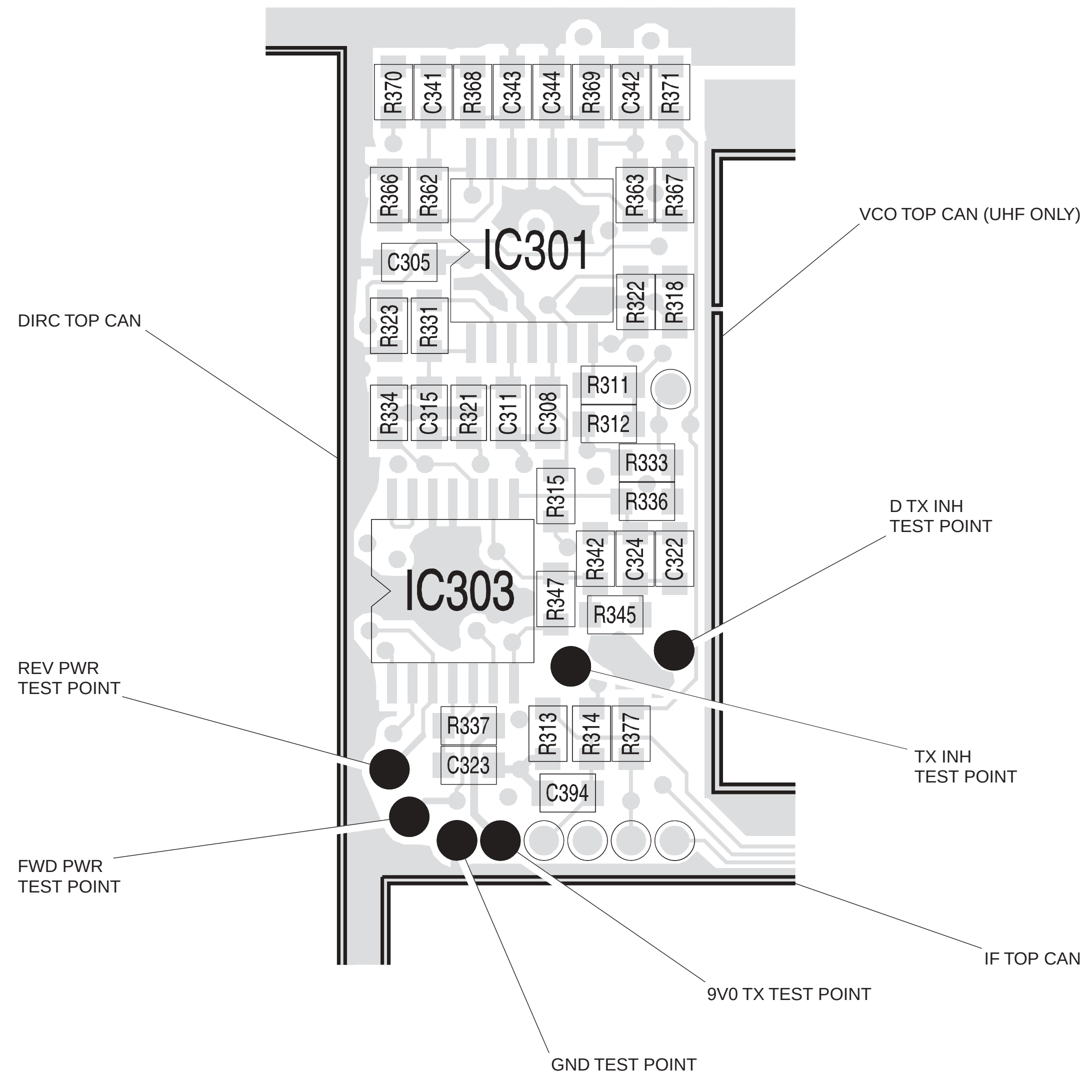
3. Measure the supply voltage between the **9V0 TX test point** and the **GND test point** (see **Figure 12.4**).

supply 9V0 TX: 9.0 ± 0.5V DC

4. Enter the CCTM command *32* to place the radio in receive mode.

5. If the supply measured in Step 3 is correct, go to Task 4 in "Transmitter RF Power" on page 326. If it is not, the 9V regulator **IC601** and the associated switching circuitry **Q603** are suspect; go to Task 3 of "Power Supply Fault Finding" on page 158.

Figure 12.4 Test points for checking the 9V supply, the forward and reverse RF power, and the inhibiting of the transmitter



12.2 Transmitter RF Power

Introduction

If there is no fault with the power supplies, check the transmitter RF power and correct any fault. The procedure is covered in the following eight tasks:

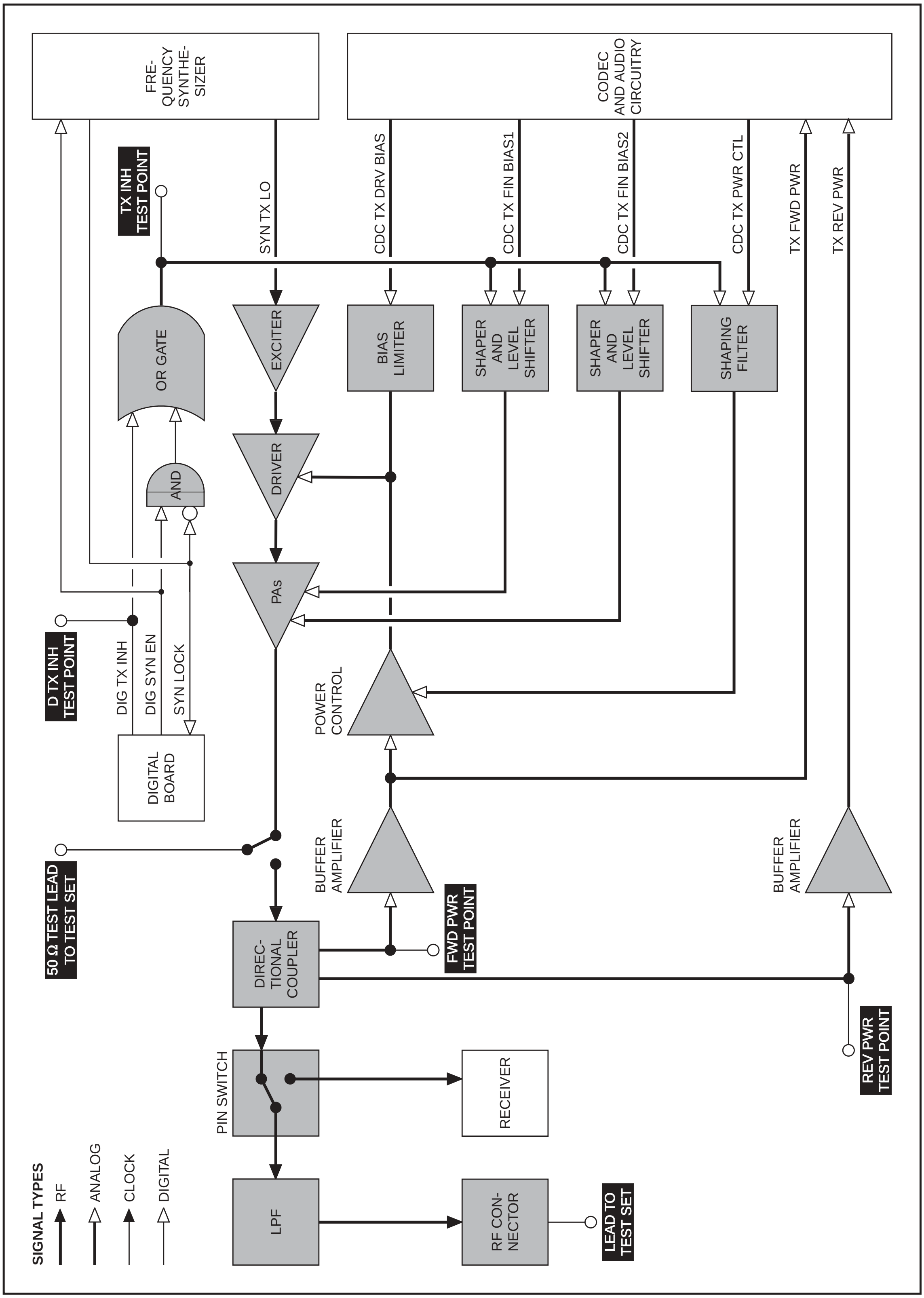
- Task 4: check forward and reverse powers
- Task 5: check RF output power
- Task 6: power unchanged regardless of setting
- Task 7: check for inhibiting of transmitter
- Task 8: check temperature sensor
- Task 9: power and current are skewed
- Task 10: repair output matching circuitry
- Task 11: power and current are low

The measurement points for diagnosing faults concerning the transmitter RF power are summarized in Figure 12.5. Data required for the first task (checking the forward and reverse powers) are supplied in Table 12.3.

Table 12.3 Voltages in millivolts corresponding to nominal forward and reverse powers

Frequency band	Forward power (318 command)	Reverse power (319 command)
B1	1100 to 2000	< 500
H5	2500 to 3500	< 1000
H6	2800 to 3900	< 1000

Figure 12.5 Measurement and test points for diagnosing faults concerning the transmitter RF power



Task 4 — Check Forward and Reverse Powers

First check the forward and reverse powers for an indication of which part of the circuitry is suspect.

1. Enter the CCTM command *326 4* to set the transmitter power level high.
2. Enter the CCTM command *33* to place the radio in transmit mode.
3. Enter the CCTM command *318* to check the forward power. The value returned is the voltage in millivolts corresponding to the power level, and should be as shown in **Table 12.3**.
4. Confirm the above result by checking the level at the **FWD PWR test point** (see **Figure 12.4**) using an oscilloscope.
5. Enter the CCTM command *319* to check the reverse power. The value returned is the voltage in millivolts corresponding to the power level, and should be as shown in **Table 12.3**.
6. Confirm the above result by checking the level at the **REV PWR test point** (see **Figure 12.4**) using an oscilloscope.

   If the oscilloscope momentarily indicates a very high reverse power, then the most likely scenario is that the antenna VSWR threshold has been exceeded and the PA has shut down to very low power.
7. Enter the CCTM command *32* to place the radio in receive mode.
8. If the values obtained in Step 3 and Step 5 are both correct, and there is no indication of a momentary high reverse power, go to Task 5. If one or both are incorrect, go to Step 9.
9. Check the connection from the RF connector on the radio to the test set.
10. If there is no fault, go to Step 11. If there is, rectify the fault and repeat the above measurements.
11. If the reverse power is momentarily too high, the directional coupler, PIN switch or LPF is suspect; go to Task 29. Otherwise go to Task 5.

Task 5 — Check RF Output Power

If the power supplies are correct, check the RF output power of the transmitter.

1. Enter the CCTM command *326 5* to set the transmitter power level to the maximum value.

2. If not already done, program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101* ***x*** ***x*** *0*, where ***x*** is the frequency in hertz. The required values for the different frequency bands are given in **Table 12.2**.

3. Enter the CCTM command *33* to place the radio in transmit mode.

4. Note the RF output power measured by the test set, and note the current reading on the DC power supply.

RF output power: > 30W current: < 8A (VHF), < 9A (UHF)

5. Enter the CCTM command *32* to place the radio in receive mode.

6. Program the radio with the center frequency in the radio's frequency band: Enter the CCTM command *101* ***x*** ***x*** *0*, where ***x*** is the frequency in hertz. The required values for the different frequency bands are given in **Table 12.2**.

7. Repeat Step 3 to Step 5.

8. Program the radio with the lowest frequency in the radio's frequency band: Enter the CCTM command *101* ***x*** ***x*** *0*, where ***x*** is the frequency in hertz. The required values for the different frequency bands are given in **Table 12.2**.

9. Repeat Step 3 to Step 5.

10. Depending on the results of the above measurements, proceed to the task indicated in **Table 12.4**. Note that the power and current are considered to be skewed if they are low at one part of the frequency band and high elsewhere.

Table 12.4 Tasks to be performed according to the results of the power and current measurements of Task 5

Power	Current	Task
Correct	Correct	Task 6 — Power unchanged regardless of setting
Correct	Wrong	Task 29 — Check power at directional coupler
Skewed	Skewed	Task 9 — Power and current are skewed
Low (> 0.1W)	Low (> 0.5A)	Task 11 — Power and current are low
None at RF connector (< 0.1W)	Low (> 0.5A)	Task 29 — Check power at directional coupler
None at RF connector (< 0.1W)	None (< 0.5A)	Task 7 — Check for inhibiting of transmitter

Task 6 — Power Unchanged Regardless of Setting

If all the power and current values measured in Task 5 are correct, it is likely that the power remains unchanged regardless of the power setting.

1. Enter the following CCTM commands in turn and measure the RF output power in each case:
   - *326 4*
   - *326 3*
   - *326 2*
   - *326 1*

2. The above measurements should confirm that the power remains unchanged at all settings. Carry out Task 12 and then Task 19.

Task 7 — Check for Inhibiting of Transmitter

If the transmitter is drawing no current or the wrong current, check whether it is being inhibited. This check is also required if a *CO3* error occurs in Task 1.

1. If not already done, enter the CCTM command *33* to place the radio in transmit mode.

2. Check the logic signal at the **TX INH test point** (see **Figure 12.4**). The signal should be:

TX INH test point: about 0V (inactive)

3. If the signal is inactive as required, go to Step 4. If it is active — about 1.1V — the transmitter is being inhibited; go to Step 5.

4. Enter the CCTM command *32* to place the radio in receive mode, and go to Task 12 in "Biasing of PA Driver and PAs" on page 335.

5. Check the logic signal at the **D TX INH test point** (see **Figure 12.4**). The signal should be:

D TX INH test point: about 0V (inactive)

6. If the signal is inactive as required, go to Step 8. If it is active — about 3.2V — the temperature sensor is suspect; go to Step 7.

7. Enter the CCTM command *32* to place the radio in receive mode, and go to Task 8.

8. The lock status is possibly no longer normal. Enter the CCTM command *72* and check the lock status.

9. Enter the CCTM command *32* to place the radio in receive mode.

10. The normal lock status is *110*. If it is not, proceed to the relevant section. If it is, go to Step 11.

11. Check for short circuits on the DIG TX INH line from the **D TX INH test point**.

12. Repair any fault, confirm the removal of the fault, and go to "Final Tasks" on page 147. If the repair failed or no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 8 — Check Temperature Sensor

If the transmitter is being inhibited and the logic signal at the D TX INH test point is active, a fault in the temperature sensor might be the cause.

1. Enter the CCTM command *47* to check the temperature reading.

2. Of the two numbers returned, the first is the temperature in degrees celsius and should be about 25°C. If it is, go to Task 12 in "Biasing of PA Driver and PAs" on page 335. If it is not, go to Step 3.

3. If not already done, remove the PAF TOP can.

4. Check **D301** and the surrounding components — see **Figure 12.6** (B1 band) and **Figure 12.7** (H5 and H6 bands).

5. If there is no fault, go to "CODEC and Audio Fault Finding" on page 371. If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 147. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 147.

Figure 12.6 PA circuitry under the PAF TOP can and part of the directional coupler under the DIRC TOP can (B1 band)

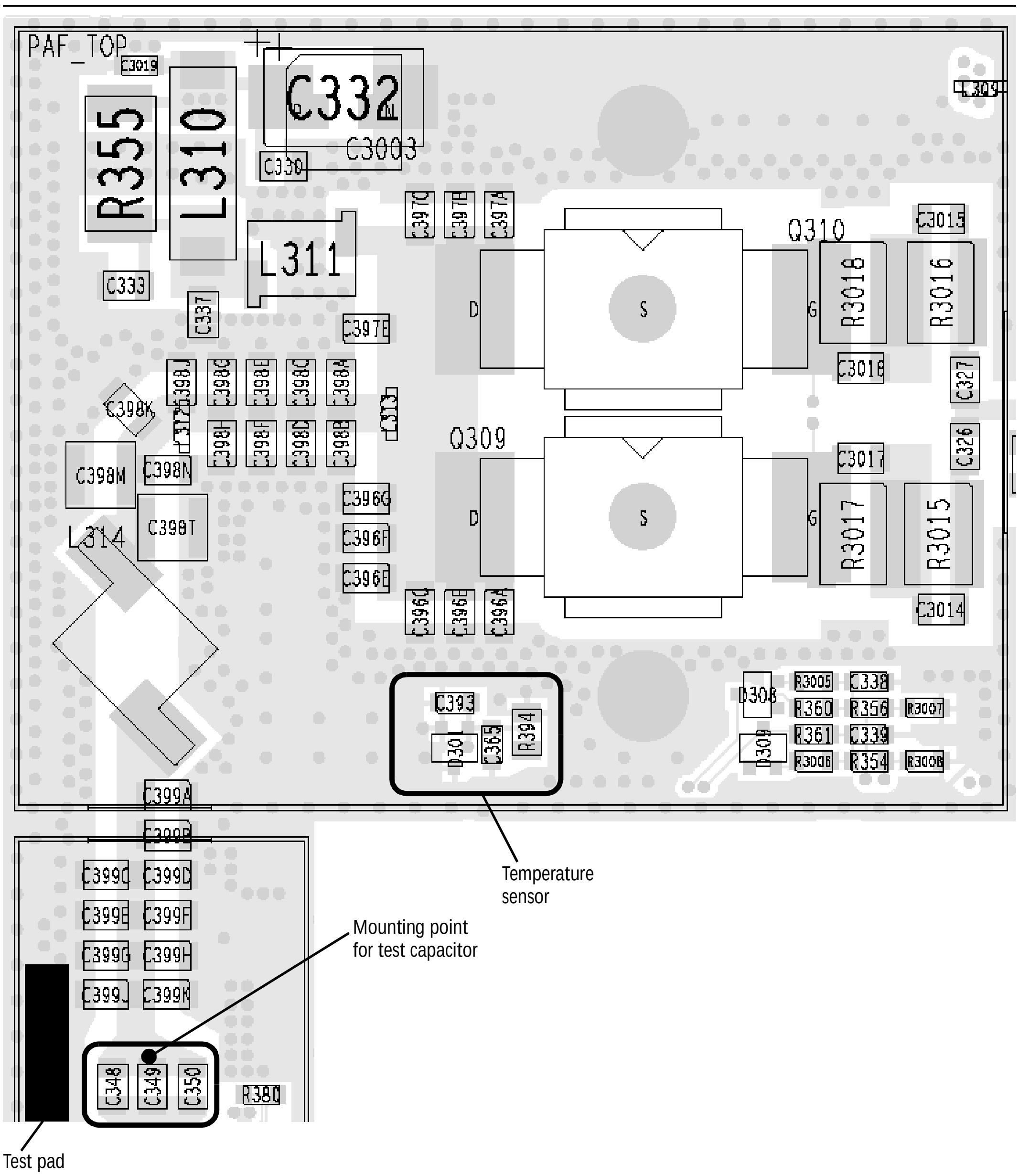
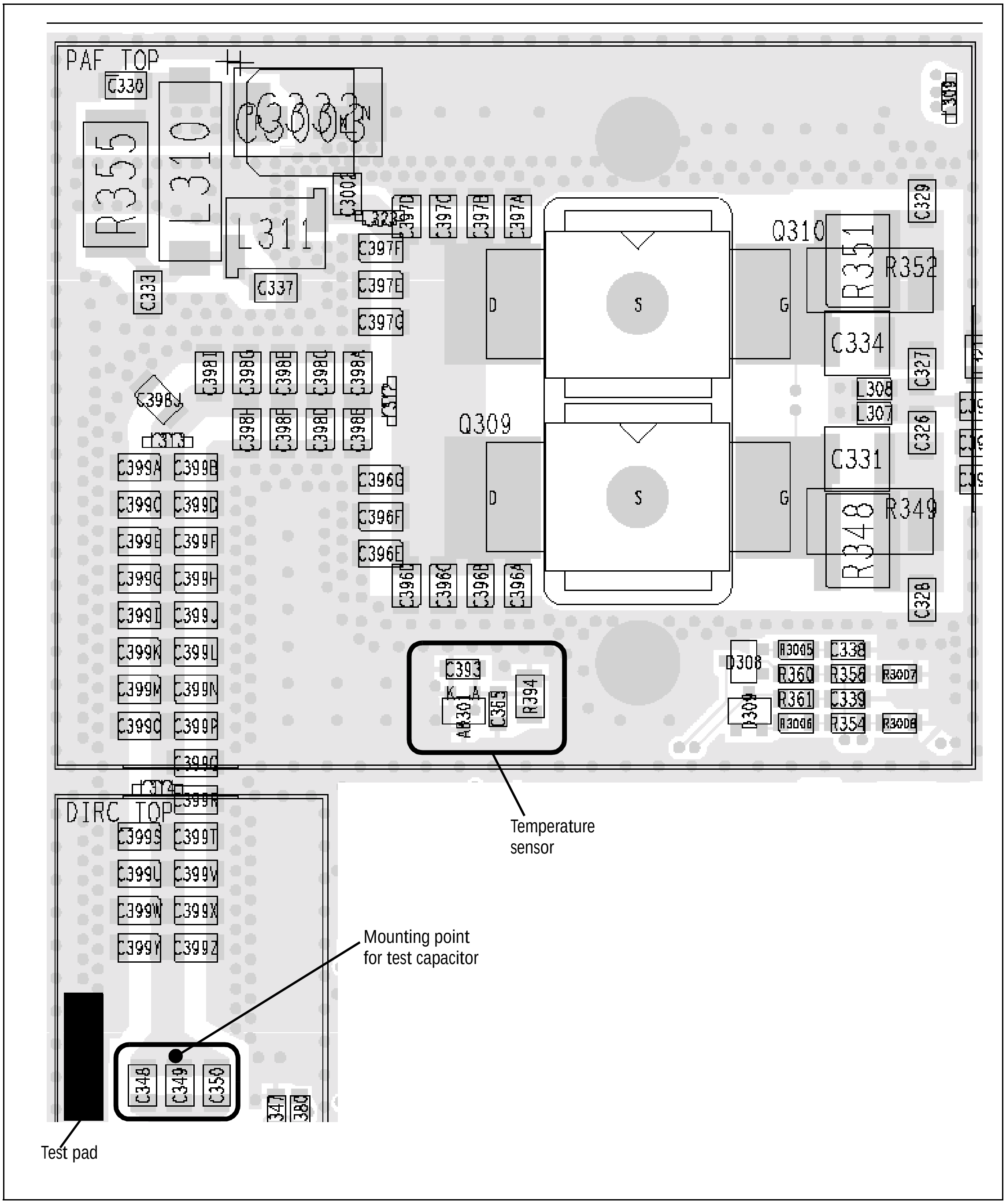


Figure 12.7 PA circuitry under the PAF TOP can and part of the directional coupler under the DIRC TOP can (H5 and H6 bands)



Task 9 — Power and Current Are Skewed

If the RF output power and the supply current are skewed, the output matching is suspect.

1. Remove the DIRC TOP can.
2. Remove the coupling capacitors **C348**, **C349** and **C350** — see **Figure 12.6** (B1), and **Figure 12.7** (H5, H6).
3. Solder one terminal of an 82pF (H5, H6 bands) or 680pF (B1) test capacitor to the PCB at the point shown in **Figure 12.6** to **Figure 12.7**. Mount the capacitor vertically. Use a test capacitor of the type GRM111, DLI C17, Murata 1210, or the equivalent.
4. Solder a 50Ω test lead to the PCB. Solder the outer sheath to the test pad shown in **Figure 12.6** to **Figure 12.7**, and solder the central wire to the other terminal of the test capacitor.
5. Connect the test lead to the test set.
6. Program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101 x x 0*, where ***x*** is the frequency in hertz.
7. Enter the CCTM command *33* to place the radio in transmit mode.
8. Note the RF output power measured by the test set, and note the current reading on the DC power supply.

RF output power: > 35W current: < 8A (VHF), < 9A (UHF)

9. Enter the CCTM command *32* to place the radio in receive mode.
10. Program the radio with the center frequency in the band: Enter the CCTM command *101 x x 0*, where ***x*** is the frequency in hertz.
11. Repeat Step 7 to Step 9.
12. Program the radio with the lowest frequency in the band: Enter the CCTM command *101 x x 0*, where ***x*** is the frequency in hertz.
13. Repeat Step 7 to Step 9.
14. If the power and current are still skewed, go to Task 10. If the power and current are correct, remove the test lead and test capacitor, resolder the coupling capacitors in position, and go to Task 31 — the PIN switch and LPF require checking.

Task 10 — Repair Output Matching Circuitry

If the checks in Task 9 show that the power and current are still skewed, there is a fault in the output matching circuitry.

1. If not already done, remove the PAF TOP can.

2. Check for faulty, shorted or misplaced components in the circuit between the test capacitor and the common drain of **Q309** and **Q310** (see **Figure 12.6** to **Figure 12.7**). Repair any fault.

3. Program the radio with the highest frequency in the radio's frequency band: Enter the CCTM command *101 **x** x 0*, where ***x*** is the frequency in hertz.

4. Enter the CCTM command *33* to place the radio in transmit mode.

5. Note the RF output power measured by the test set, and note the current reading on the DC power supply.

RF output power: > 35W current: < 8A (VHF), < 9A (UHF)

6. Enter the CCTM command *32* to place the radio in receive mode.

7. Program the radio with the center frequency in the band: Enter the CCTM command *101 **x** x 0*, where ***x*** is the frequency in hertz.

8. Repeat Step 4 to Step 6.

9. Program the radio with the lowest frequency in the band: Enter the CCTM command *101 **x** x 0*, where ***x*** is the frequency in hertz.

10. Repeat Step 4 to Step 6.

11. Remove the test lead and test capacitor, and resolder the coupling capacitors **C348**, **C349** and **C350** in position (see **Figure 12.6** to **Figure 12.7**).

12. If the power and current are now correct at all three frequencies, the fault has been rectified; go to "Final Tasks" on page 147. If they are not, go to Task 25 in "RF Signal Path" on page 355.

Task 11 — Power and Current Are Low

If the RF output power and the supply current are uniformly low at all frequencies, one of the PAs is suspect or the input to the PAs is reduced. Check each PA in turn:

1. For the first PA (Q310), enter the CCTM command *331* to check the DAC value of final bias 1 (CDC TX FIN BIAS 1). Record the value ***x*** returned.
2. Note the current reading on the DC power supply.
3. Enter the CCTM command *331 1* to turn off final bias 1.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Note the RF output power measured at the test set. This should be as shown in **Table 12.5**.
6. If the RF power is correct, go to Step 7 to repeat the check with the second PA. If it is not, enter the CCTM command *32* to place the radio in receive mode, and carry out Task 12 and then Task 13.
7. For the second PA (Q309), enter the CCTM command *332* to check the DAC value of final bias 2 (CDC TX FIN BIAS 2). Record the value ***y*** returned.
8. Note the current reading on the DC power supply.
9. Enter the CCTM command *332 1* to turn off final bias 2.
10. With the radio still in transmit mode, note the RF output power measured at the test set. This should be as shown in **Table 12.5**.
11. Enter the CCTM command *32* to place the radio in receive mode.
12. If the RF power measured in Step 10 is correct, go to “RF Signal Path” on page 354. If it is not, carry out Task 12 and then Task 16.

Table 12.5 RF output power of individual RF power amplifiers at different frequencies

Frequency band	Frequency within band		
	Lowest frequency	Center frequency	Highest frequency
B1	29 ± 5W	34 ± 5W	29 ± 5W
H5	5 ± 5W	12 ± 5W	27 ± 5W
H6	13 ± 5W	19 ± 5W	28 ± 5W

12.3 Biasing of PA Driver and PAs

Introduction

The measurements of the transmitter RF output power in "Transmitter RF Power" might indicate a need to check the biasing of the two PAs and the PA driver. The procedure is covered in this section. There are thirteen tasks grouped as follows:

- Task 12: prepare to check biasing
- Task 13 to Task 15: check biasing of first PA
- Task 16 to Task 18: check biasing of second PA
- Task 19 and Task 20: check biasing of PA driver
- Task 21 to Task 24: repair circuitry

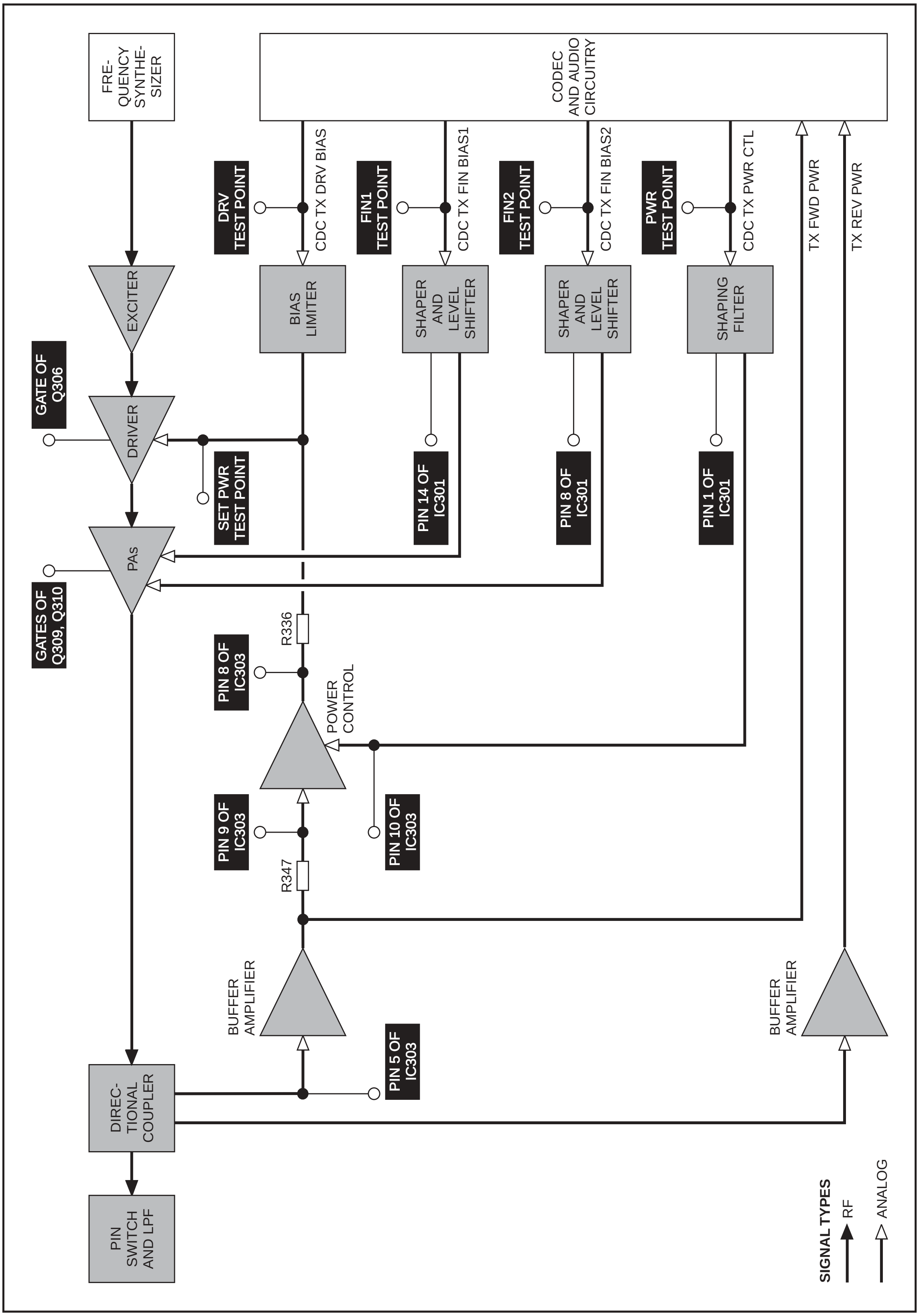
The test and measurement points for diagnosing faults in the biasing of the PAs and PA driver are summarized in Figure 12.8.

Task 12 — Prepare to Check Biasing

If the transmitter is not being inhibited, check the biasing of the two PAs and the PA driver. First make the following preparations:

1. Set the current limit on the DC power supply to 2A.
2. Enter the CCTM command *331* to check the DAC value of final bias 1 (CDC TX FIN BIAS 1) at maximum power. Record the value ***x*** returned.
3. Enter the CCTM command *332* to check the DAC value of final bias 2 (CDC TX FIN BIAS 2) at maximum power. Record the value ***y*** returned.
4. Enter the CCTM command *304* to check the DAC value of the clamp current at the driver gate. Record the value ***z*** returned.
5. Enter the CCTM command *33* to place the radio in transmit mode.
6. Switch off all biases by entering the following CCTM commands in sequence:
   - *331 1*
   - *332 1*
   - *304 1*
   - *114 1023*
   - *334 0*
   - *335 0*
7. Note the current reading on the DC power supply. This will be less than 500mA.
8. With the radio still in transmit mode, check the biasing of the PAs and PA driver, beginning with Task 13.

Figure 12.8 Measurement and test points for diagnosing faults in the biasing of the PAs and PA driver



Task 13 — Check Biasing of First PA

Check the biasing of the first PA (Q310).

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *331 **x***, do not specify a value ***x*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. Use a multimeter to measure the voltage at pin 14 of **IC301** (see **Figure 12.9**). The voltage should be:

pin 14 of IC301: < 100mV (initially)

2. Note the current reading on the DC power supply. As mentioned in Step 7 of Task 12, this will be less than 500mA.
3. Enter the CCTM command *331 **x*** (where ***x*** was recorded in Task 12).
4. Check that the voltage changes to:

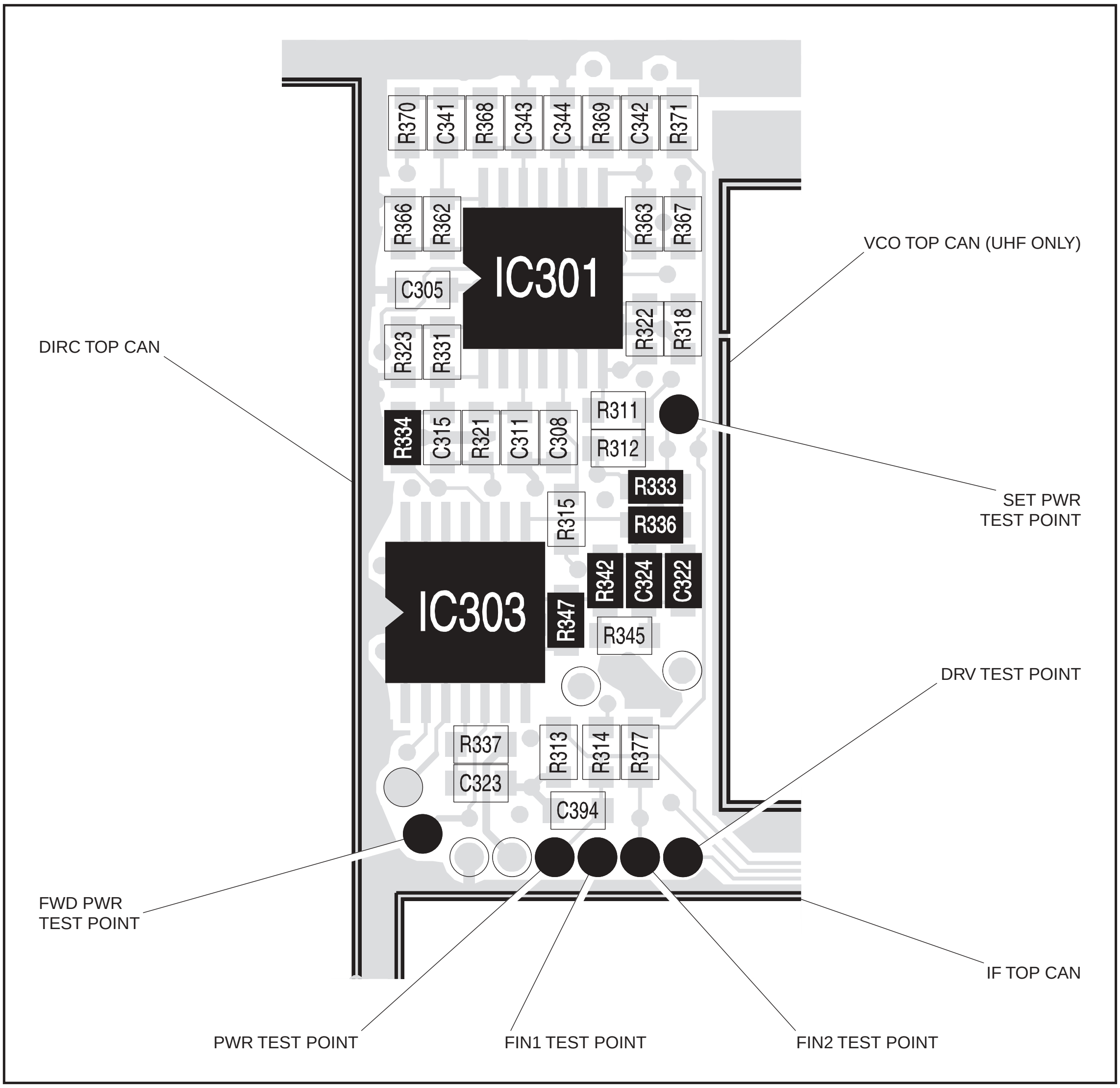
pin 14 of IC301: 2 to 5V (after entry of CCTM 331 **x**)

5. Also note the current reading. This should increase by an amount approximately equal to the offset given in **Table 12.6**.
6. If the voltage and current are both correct, go to Step 7. If the voltage is correct but not the current, go to Task 14. If neither the current nor the voltage is correct, go to Task 15.
7. Enter the CCTM command *331 1* to switch off final bias 1, and go to Task 16.

Table 12.6 Gate biases for the PAs and PA driver at high power

Frequency band	Offset currents in mA		
	First PA	Second PA	PA driver
B1	750	750	300
H5	1000	1000	450
H6	1000	1000	450

Figure 12.9 Test points and components of the shaping filter



Task 14 — Shaper and Level Shifter

If the voltage measured in Task 13 is correct but not the current, either the first PA or the shaper and level shifter for the PA is suspect.

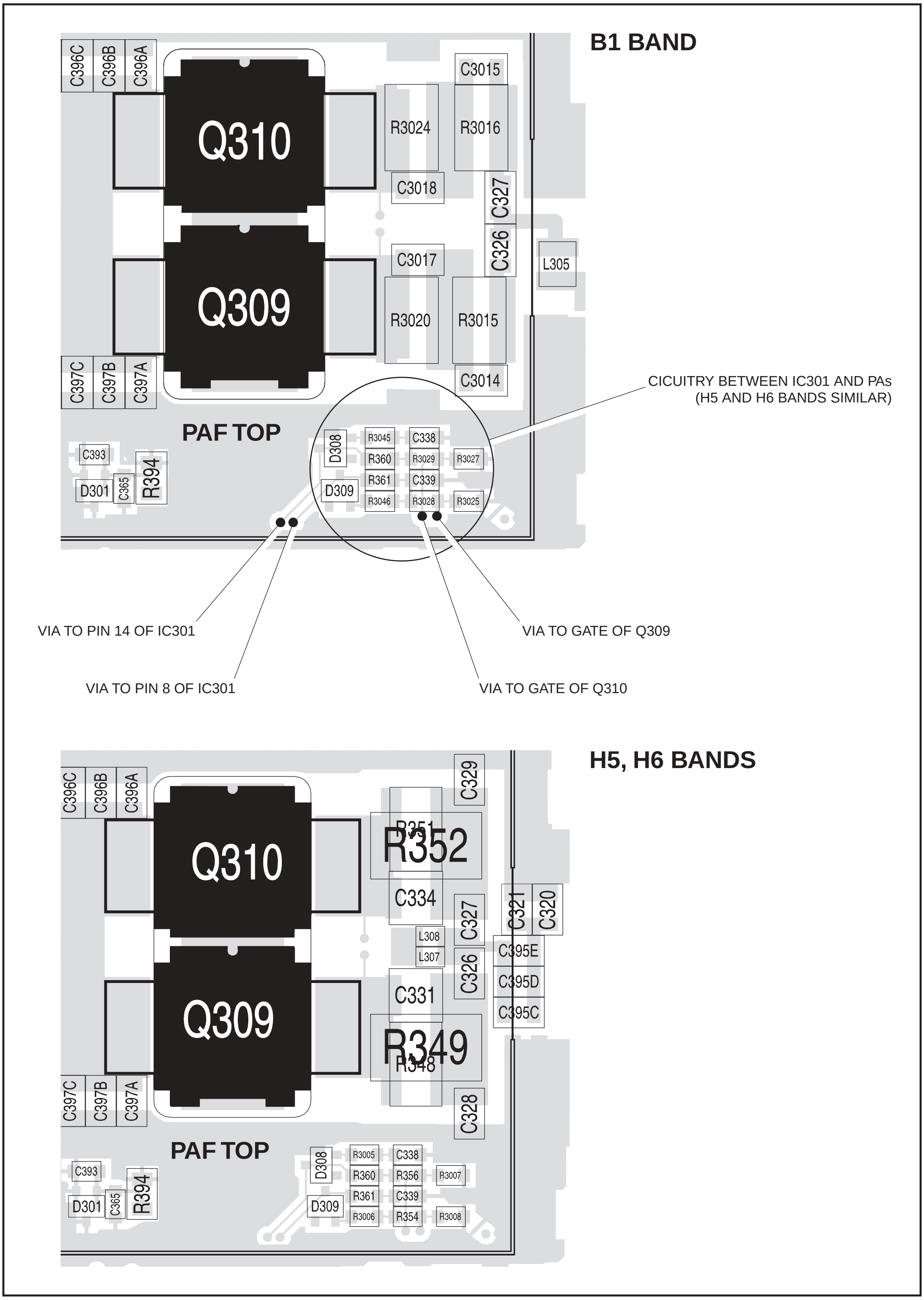
Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *331* ***x***, do not specify a value ***x*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. If the PAF TOP can has already been removed, go to Step 5. If it has not, go to Step 2.
2. Enter the CCTM command *32* to place the radio in receive mode.
3. Remove the PAF TOP can.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Enter the CCTM command *331* ***x*** (where ***x*** was recorded in Task 12).
6. Check that the voltage at the gate of **Q310** is (see **Figure 12.10**):

gate of Q310: 2 to 5V

7. Enter the CCTM command *32* to place the radio in receive mode.
8. If the voltage measured above is correct, **Q310** is faulty; replace the main-board assembly and go to "Final Tasks" on page 147. If it is not correct, go to Step 9.
9. Check the circuitry between pin 14 of **IC301** and the gate of **Q310** (see **Figure 12.10**). If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 147. If the repair failed or Q310 itself is faulty, replace the main-board assembly and go to "Final Tasks" on page 147.

Figure 12.10 PA circuitry under the PAF TOP can



Task 15 — Shaping Filter for Power Control

If neither the voltage nor the current measured in Task 13 is correct, then the shaping filter for the power-control circuitry or the CODEC and audio circuitry is suspect.

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *331* ***x***, do not specify a value ***x*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. Use the multimeter to measure the voltage at the **FIN1 test point** (see **Figure 12.9**). The voltage should be:

FIN1 test point: 18 ± 2mV (initially)

2. Enter the CCTM command *331* ***x*** (where ***x*** was recorded in Task 12).

3. Check that the voltage changes to:

FIN1 test point: 1.1 to 2.7V (after entry of CCTM 331 **x**)

4. Enter the CCTM command *32* to place the radio in receive mode.

5. If the voltage measured above is correct, go to Step 6. If it is not, go to “CODEC and Audio Fault Finding” on page 371.

6. Check **IC301** and the surrounding shaping-filter circuitry (see **Figure 12.9**). If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 16 — Check Biasing of Second PA

If the biasing of the first PA is correct, check that of the second PA (Q309).

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *332* ***y***, do not specify a value ***y*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. Use the multimeter to measure the voltage at pin 8 of **IC301** (see **Figure 12.9**). The voltage should be:

pin 8 of IC301: < 100 mV (initially)

2. Note the current reading on the DC power supply. As mentioned in Step 7 of Task 12, the current will be less than 500 mA.

3. Enter the CCTM command *332* ***y*** (where ***y*** was recorded in Task 12).

4. Check that the voltage changes to:

pin 8 of IC301: 2 to 5 V (after entry of CCTM 332 **y**)

5. Also note the current reading. This should increase by an amount approximately equal to the offset given in **Table 12.6**.

6. If the voltage and current are both correct, go to Step 7. If the voltage is correct but not the current, go to Task 17. If neither the current nor the voltage is correct, go to Task 18.

7. Enter the CCTM command *332 1* to switch off final bias 2, and go to Task 19.

Task 17 — Shaper and Level Shifter

If the voltage measured in Task 16 is correct but not the current, either the second PA or the shaper and level shifter for the PA is suspect.

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *332* ***y***, do not specify a value ***y*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. If the PAF TOP can has already been removed, go to Step 5. If it has not, go to Step 2.

2. Enter the CCTM command *32* to place the radio in receive mode.

3. Remove the PAF TOP can.

4. Enter the CCTM command *33* to place the radio in transmit mode.

5. Enter the CCTM command *332* ***y*** (where ***y*** was recorded in Task 12).

6. Check that the voltage at the gate of **Q309** is (see **Figure 12.10**):

gate of Q309: 2 to 5V

7. Enter the CCTM command *32* to place the radio in receive mode.

8. If the voltage is correct, **Q309** is faulty; replace the main-board assembly and go to "Final Tasks" on page 147. If it is not, go to Step 9.

9. Check the circuitry between pin 8 of **IC301** and the gate of **Q309** (see **Figure 12.10**). If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 147. If the repair failed or Q309 itself is faulty, replace the main-board assembly and go to "Final Tasks" on page 147.

Task 18 — Shaping Filter for Power Control

If neither the voltage nor the current measured in Task 16 is correct, then the shaping filter for the power-control circuitry or the CODEC and audio circuitry is suspect.

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *332* ***y***, do not specify a value ***y*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

1. Use the multimeter to measure the voltage at the **FIN2 test point** (see **Figure 12.9**). The voltage should be:

FIN2 test point: 18 ± 2V (initially)

2. Enter the CCTM command *332* ***y*** (where ***y*** was recorded in Task 12).

3. Check that the voltage changes to:

FIN2 test point: 1.1 to 2.7V (after entry of CCTM 332 **y**)

4. Enter the CCTM command *32* to place the radio in receive mode.

5. If the voltage measured above is correct, go to Step 6. If it is not, go to “CODEC and Audio Fault Finding” on page 371.

6. Check **IC301** and the surrounding shaping-filter circuitry (see **Figure 12.9**). If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 19 — Biasing of PA Driver— DRV test point

If there is no fault in the biasing of the PAs, investigate the biasing of the PA driver (Q306). First check the DRV test point.

Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *304* ***z***, do not specify a value ***z*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PA driver.

1. Note the current reading on the DC power supply. As mentioned in Step 7 of Task 12, the current will be less than 500mA.

2. Enter the CCTM command *304* ***z*** (where ***z*** was recorded in Task 12) to switch on the clamp current.

3. Note the current reading on the DC power supply.

4. Compare the above current readings. The current should increase by an amount approximately equal to the offset given in **Table 12.6**. If it does, go to Task 21. If it does not, go to Step 5.

5. Check as follows that the voltage from the DAC is changing: First enter the CCTM command *304 1* to switch off the bias.

6. Measure the voltage at the **DRV test point** (CDC TX DRV BIAS) (see **Figure 12.9**). The voltage should be:

DRV test point: < 0.1V (after entry of CCTM 304 1)

7. Enter the CCTM command *304* ***z*** (where ***z*** was recorded in Task 12) to change the DAC value of the clamp current.

8. The voltage should increase to:

DRV test point: 0.8 to 2.5V (after entry of CCTM 304 **z**)

9. If the voltage does change, go to Task 20. If it does not, go to Step 10.

10. Enter the CCTM command *32* to place the radio in receive mode, and go to “CODEC and Audio Fault Finding” on page 371.

Task 20 — Biasing of PA Driver— SET PWR test point

If the voltage at the DRV test point is correct, check that at the SET PWR test point.

1. Check the voltage at the **SET PWR test point** (see **Figure 12.9**):

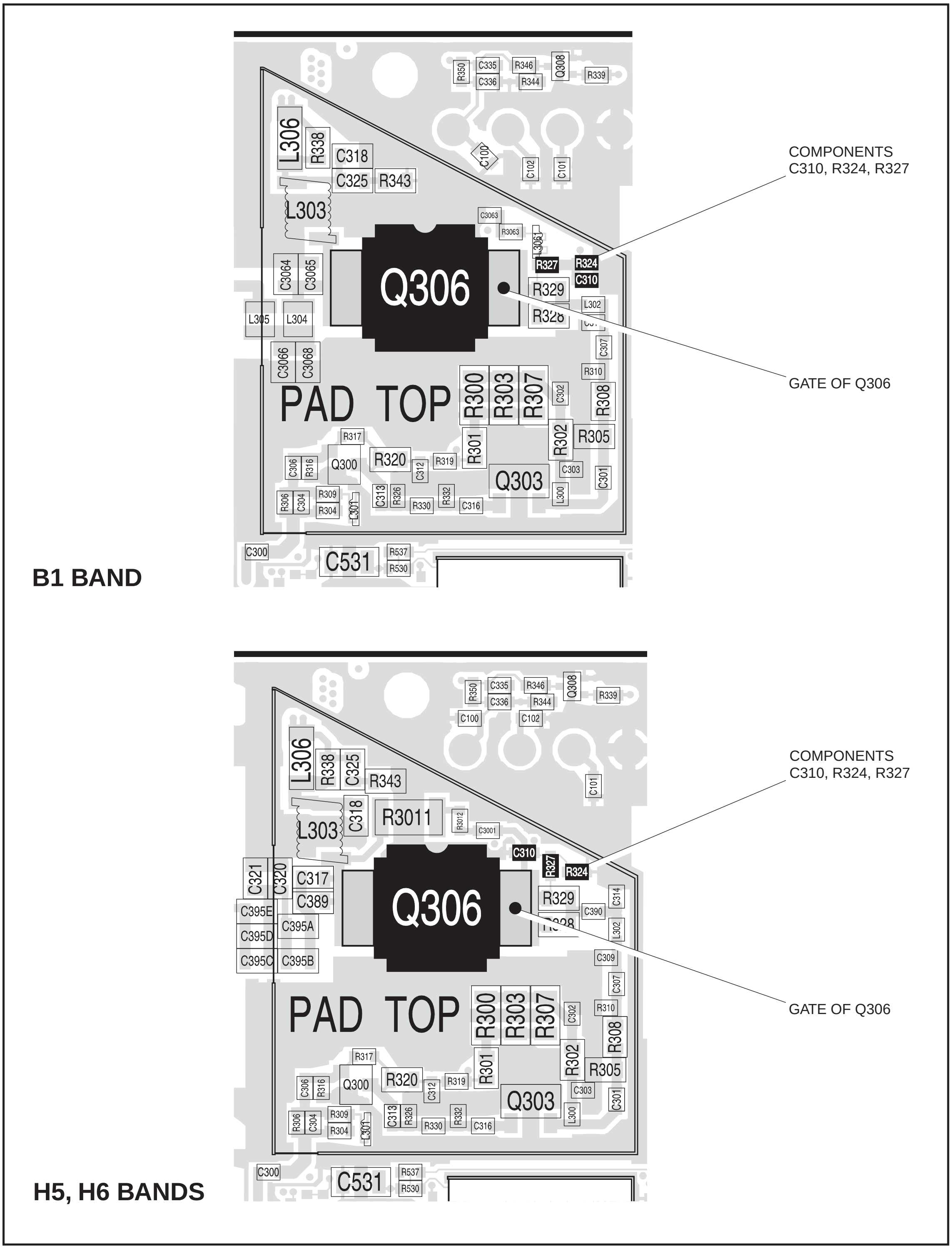
SET PWR test point: 2 to 5V

2. If the voltage is correct, go to Step 3. If it is not, go to Task 21.
3. If the PAD TOP can has already been removed, go to Step 7. If it has not, go to Step 4.
4. Enter the CCTM command 32 to place the radio in receive mode.
5. Remove the PAD TOP can.
6. Enter the CCTM command 33 to place the radio in transmit mode.
7. Check the voltage on the gate of **Q306** (see **Figure 12.11**):

gate of Q306: 2 to 5V

8. Enter the CCTM command 32 to place the radio in receive mode.
9. If the voltage is correct, replace **Q306**; confirm the removal of the fault and go to "Final Tasks" on page 147. If it is not, go to Task 23.

Figure 12.11 PA driver circuitry under the PAD TOP can



Task 21 — Check Power Control

Check the power-control circuitry if the clamp current for the PA driver is correct or if the voltage at the SET PWR test point is incorrect.

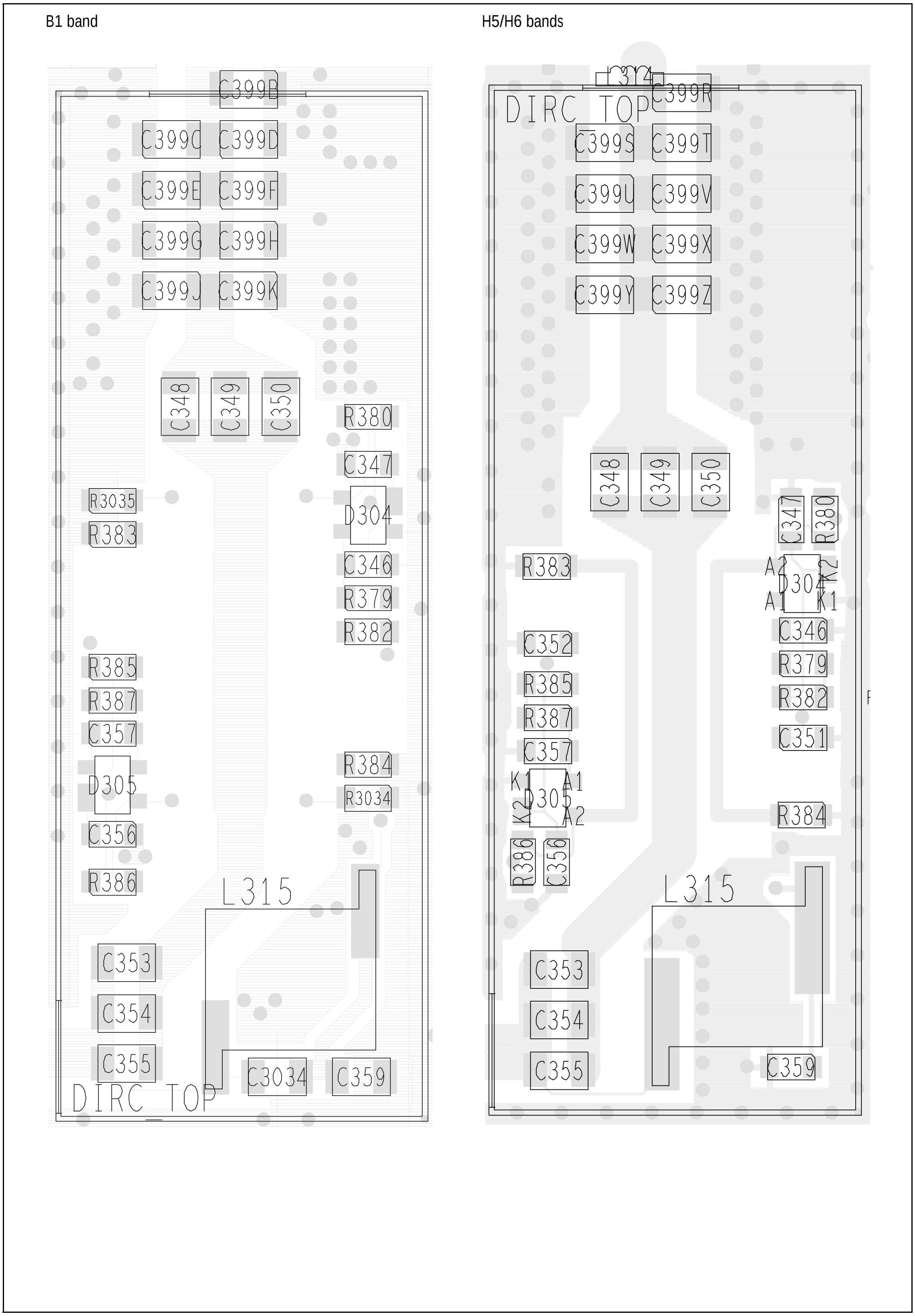
Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *304 **z***, do not specify a value ***z*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PA driver.

1. Enter the CCTM command *304 **z*** (where ***z*** was recorded in Task 12).
2. Note the current reading on the DC power supply.
3. Enter the CCTM command *114 0* to switch off the power.
4. Note the current reading on the DC power supply.
5. Compare the above current readings. The current should decrease by an amount approximately equal to the offset given in **Table 12.6**. If it does, go to Task 25 in "RF Signal Path" on page 355. If it does not, go to Step 6.
6. Check that the voltage from the DAC is changing. Measure the voltage at the **PWR test point** (CDC TX PWR CTL) (see **Figure 12.9**).
7. Enter the CCTM command *114 1023*. The voltage should increase to:

PWR test point: 2.4 ± 0.1V

8. Enter the CCTM command 32 to place the radio in receive mode.
9. If the voltage at the **PWR test point** increases as required, go to Task 22. If it does not, go to "CODEC and Audio Fault Finding" on page 371.

Figure 12.12 Circuitry under the DIRC TOP can



Task 22 — Directional Coupler and Buffer Amplifier

Following the checks in Task 19 to Task 21, locate the fault and repair the circuitry as described in the remaining tasks of the section. In this task any faults in the directional coupler or buffer amplifier will be located.

1. Cycle the power.
2. Enter the CCTM command *326 5* to set the transmitter to maximum power.
3. Enter the CCTM command *33* to place the radio in transmit mode.
4. Measure the voltage at pin 9 of **IC303** in the power-control circuit (see **Figure 12.9**).
5. The above voltage should be as given in **Table 12.7**. If it is, go to Task 24. If it is not, go to Step 6.
6. Check the voltage at pin 5 of **IC303** (or use the FWD PWR **test point**) (see **Figure 12.9**). Note that the probe impedance might affect the measurement.
7. Enter the CCTM command 32 to place the radio in receive mode.
8. The voltage measured in Step 6 should be as given in **Table 12.7**. If it is not, go to Step 9. If it is, go to Step 11.

Table 12.7 Voltages at IC303 at maximum power (40 W)

Frequency band	Frequency (MHz)	Voltage (V)	
		Pin 9	Pin 5 (FWD PWR)
B1	136 155 174	2.2 ± 0.5 2.3 ± 0.5 2.5 ± 0.5	1.9 ± 0.5 2.1 ± 0.5 2.3 ± 0.5
H5	400 435 470	3.4 ± 0.5 3.8 ± 0.5 4.0 ± 0.5	3.3 ± 0.5 3.7 ± 0.5 3.9 ± 0.5
H6	450 490 530	3.9 ± 0.5 4.2 ± 0.5 4.7 ± 0.5	3.8 ± 0.5 4.1 ± 0.5 4.6 ± 0.5

9. Remove the DIRC TOP can.
10. Check the components of the directional coupler (see **Figure 12.12**) and go to Step 12.
11. Check **R340** between pins 6 and 7 of **IC303** in the buffer amplifier (see **Figure 12.13**), and then go to Step 12.
12. Repair any fault revealed by the above checks. Replace **IC303** if none of the other components is faulty (see **Figure 12.9**).

13. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 23 — Power Control for PA Driver

In this task any faults in the path between the power-control circuit and the PA driver will be located, as well as any fault with the PA driver.

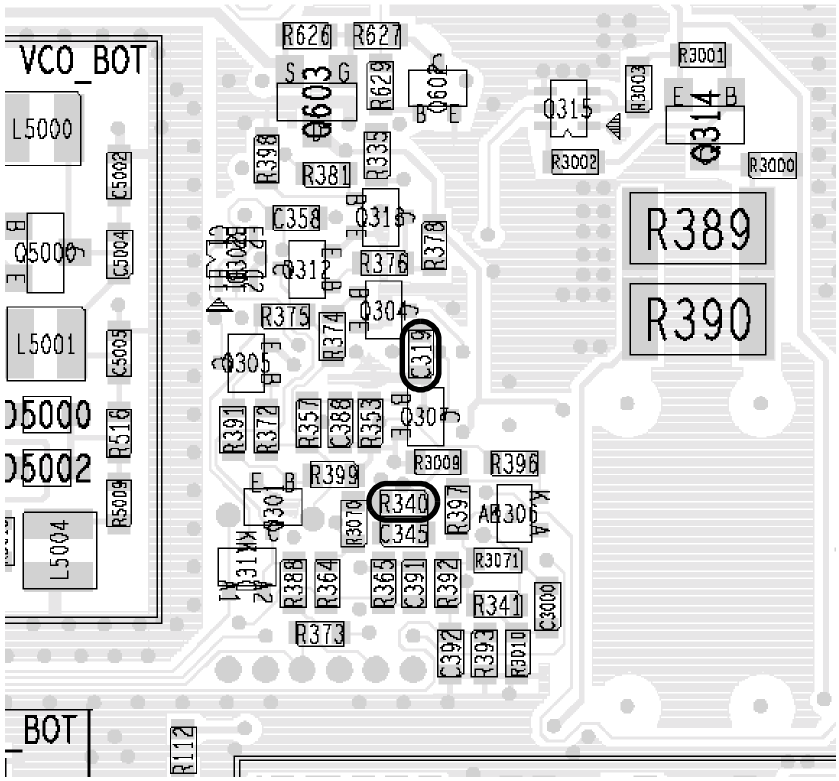
1. Check for short circuits at the gate of the PA driver **Q306**. Check **R333**, **R336** (see **Figure 12.9**), **C310**, **R324** and **R327** (see **Figure 12.11**) between the power-control circuit and Q306.

2. Repair any fault revealed by the checks in Step 1. If none of the above-mentioned components is faulty, replace **Q306** (see **Figure 12.11**).

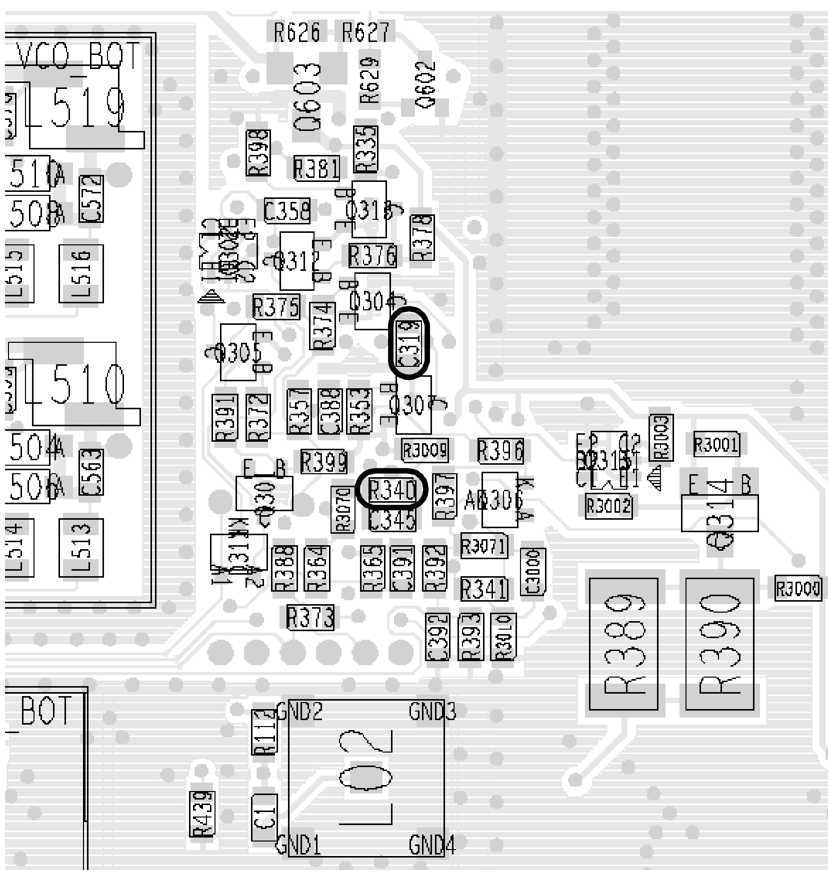
3. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 12.13 Components of concern on the bottom-side of the main board

B1 band



H5/H6 bands



Task 24 — Power Control and Shaping Filter

In this task any faults in the power-control and shaping-filter circuitry will be located:

1. Measure the voltage at pin 8 of **IC303** (see **Figure 12.9**) in the power-control circuit. The voltage should be:

pin 8 of IC303: 7.4 ± 0.5V

2. If the voltage is correct, go to Step 3. If it is not, enter the CCTM command *32* and return to Task 23.

3. Measure the voltage at pin 10 of **IC303** (see **Figure 12.9**) in the power-control circuit. The voltage should be:

pin 10 of IC303: 4.8 ± 0.5V

4. If the voltage is correct, go to Step 5. If it is not, go to Step 8.

5. Enter the CCTM command *32* to place the radio in receive mode.

6. Check **C322**, **C324**, **R342**, **R347** (see **Figure 12.9**) in the power-control circuit.

7. Repair any fault revealed by the checks in Step 5. Replace **IC303** (see **Figure 12.9**) if none of the other components is faulty. Confirm the removal of the fault and go to "Final Tasks" on page 147. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 147.

8. Measure the voltage at pin 1 of **IC301** (see **Figure 12.9**) in the shaping-filter circuit. The voltage should be:

pin 1 of IC301: 4.8 ± 0.5V

9. Enter the CCTM command *32* to place the radio in receive mode.

10. If the voltage measured in Step 8 is correct, go to Step 11. If it is not, go to Step 12.

11. Check the components **R334** (see **Figure 12.9**) and **C319** (see **Figure 12.13**) and go to Step 13.

12. Check the components between the **PWR test point** and pin 1 of **IC301** (see **Figure 12.9**) and go to Step 13.

13. Repair any fault revealed by the checks in Step 11 and Step 12. Replace **IC301** (see **Figure 12.9**) if none of the other components is faulty. Confirm the removal of the fault and go to "Final Tasks" on page 147. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 147.

12.4 RF Signal Path

Introduction

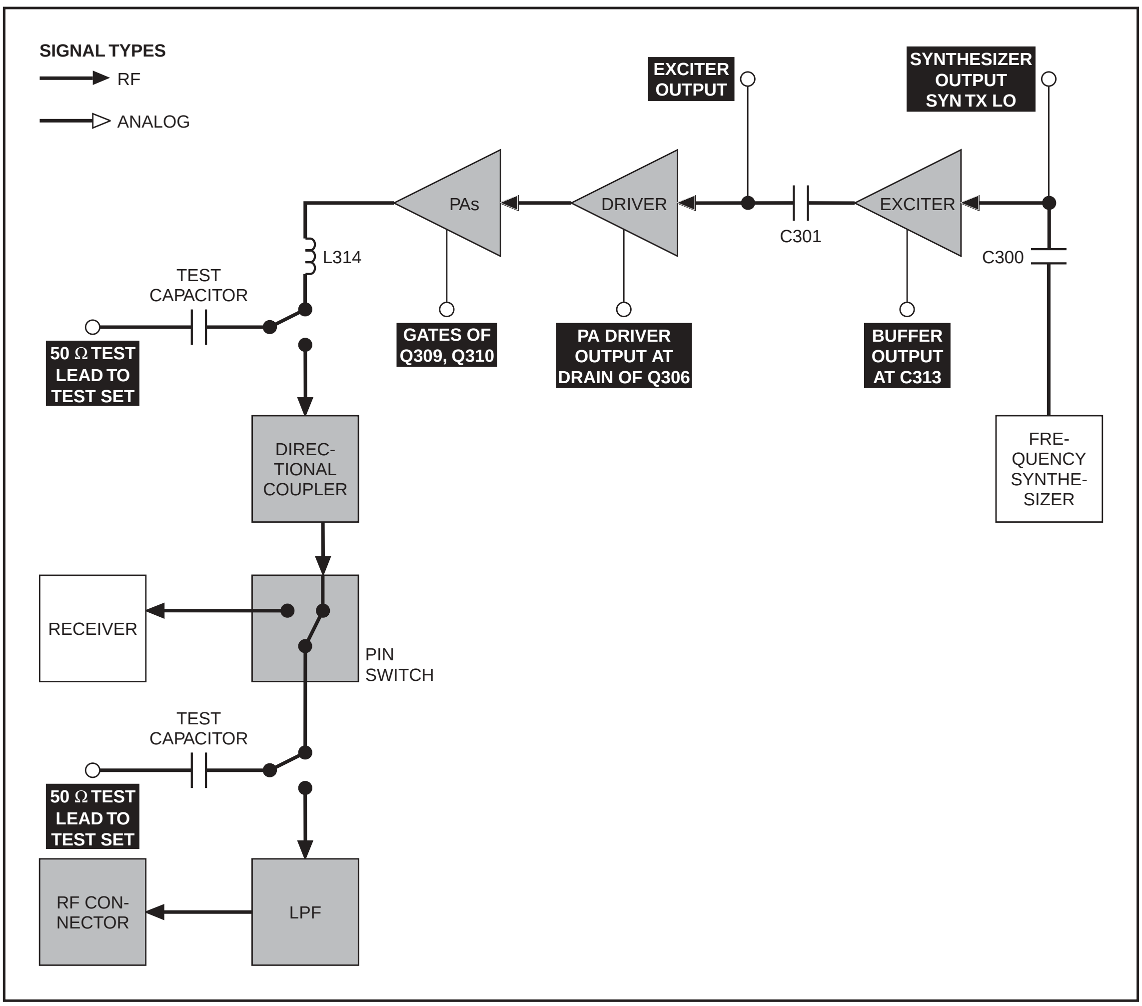
The RF signal path extends from the output of the frequency synthesizer to the LPF. This section of circuitry will require investigation either following certain checks in "Transmitter RF Power" or if the biasing checks of "Biasing of PA Driver and PAs" reveal no fault. The procedure is divided into nine tasks grouped as follows:

- Task 25 to Task 28: initial RF signal path
- Task 29 and Task 30: directional coupler
- Task 31 and Task 32: PIN switch
- Task 33: LPF

The initial signal path includes the exciter and PA driver. The directional coupler, PIN switch, and LPF make up the final signal path.

The measurement points for diagnosing faults in the signal path are summarized in Figure 12.14.

Figure 12.14 Measurement points for diagnosing faults in the RF signal path



Task 25 — Output of Frequency Synthesizer

The first point to check in the initial RF signal path is the output SYN TX LO from the frequency synthesizer. This signal is input to the exciter at C300.

1. For test purposes select a representative power level and frequency from **Table 12.8** (B1 band) or **Table 12.9** (H5, H6). (Note that the data for these tables were obtained using an RFP5401A RF probe.)

2. To set the power level, enter the CCTM command *326* ***x***, where ***x*** defines the level. To set the frequency, enter the CCTM command *101* ***x*** ***x*** *0*, where ***x*** is the frequency in hertz.

3. Enter the CCTM command *33* to place the radio in transmit mode.

4. Use an RFP5401A RF probe or the equivalent to measure the RF voltage after **C300** (see **Figure 12.15**). Earth the probe to the FCL TOP can adjacent to the PA driver circuitry. The required voltage should be as given in **Table 12.8** (B1 band) or **Table 12.9** (H5, H6).

5. Enter the CCTM command *32* to place the radio in receive mode.

6. If the voltage measured above is correct, go to Task 26. If it is not, go to Step 7.

7. Check **C300** (see **Figure 12.15**). If C300 is not faulty, go to “Frequency Synthesizer Fault Finding” on page 169. If C300 is faulty, replace it and return to Step 2.

Figure 12.15 PA driver circuitry under the PAD TOP can

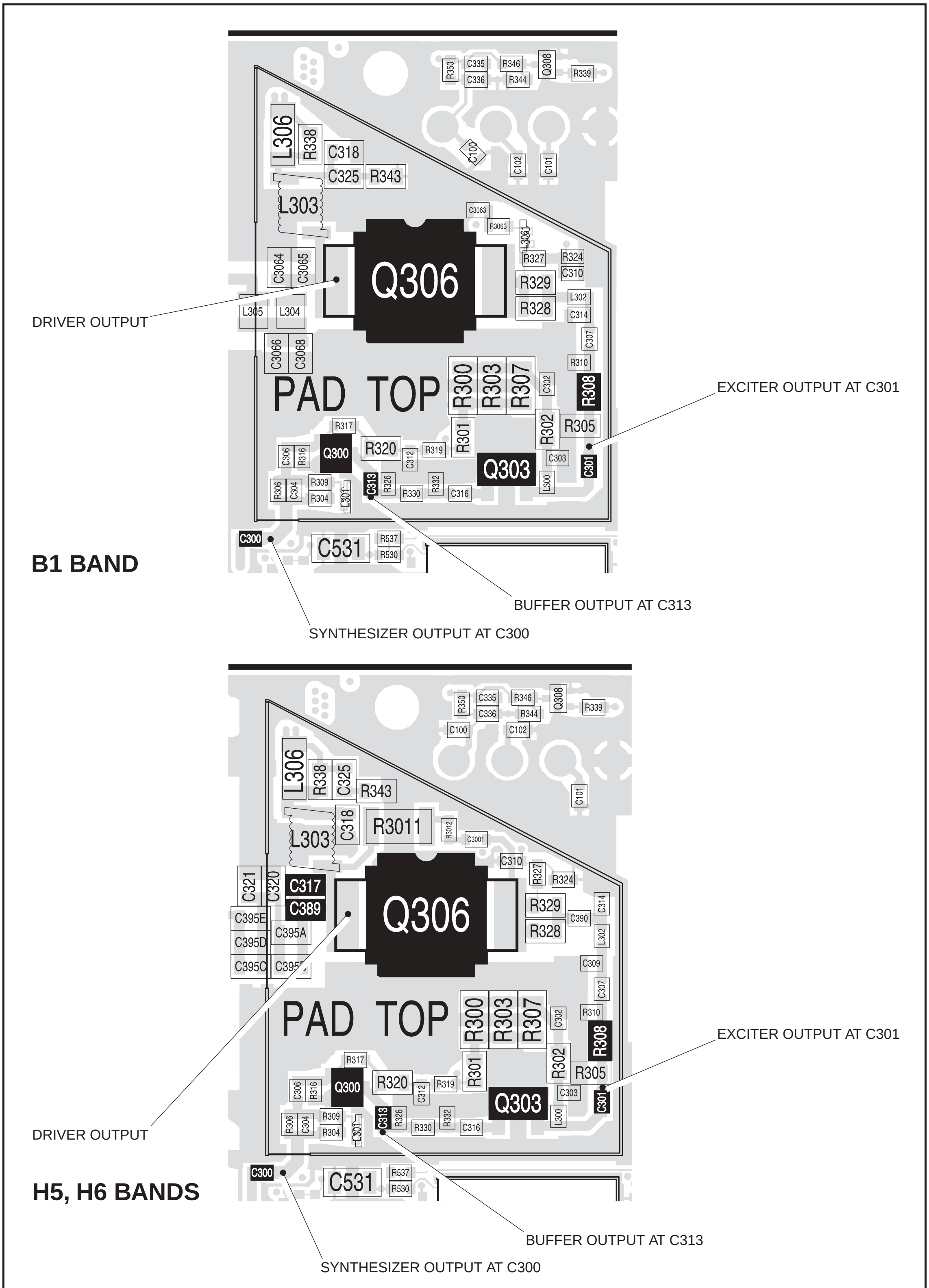


Table 12.8 RF voltages along the initial RF signal path of the VHF radio (B1 band)

Power level (W)	Frequency (MHz)	RF voltages (V)			
		Synthesizer output	Buffer output	Exciter output	Driver output
1	136 155 174	0.3 ± 0.1 0.3 ± 0.1 0.2 ± 0.1	0.2 ± 0.1 0.3 ± 0.1 0.2 ± 0.1	2.4 ± 0.5 2.5 ± 0.5 2.6 ± 0.5	1.8 ± 0.5 1.0 ± 0.5 1.5 ± 0.5
5	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.2 ± 0.1 0.3 ± 0.1 0.2 ± 0.1	2.5 ± 0.5 2.6 ± 0.5 2.6 ± 0.5	3.0 ± 0.5 1.5 ± 0.5 2.6 ± 0.5
12	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.2 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	2.5 ± 0.5 2.6 ± 0.5 2.7 ± 0.5	4.2 ± 0.5 2.0 ± 0.5 3.8 ± 0.5
26	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.2 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	2.4 ± 0.5 2.4 ± 0.5 2.5 ± 0.5	3.3 ± 0.5 1.7 ± 0.5 4.5 ± 0.5
40	136 155 174	0.3 ± 0.1 0.2 ± 0.1 0.3 ± 0.1	0.4 ± 0.1 0.4 ± 0.1 0.3 ± 0.1	2.5 ± 0.5 2.5 ± 0.5 2.5 ± 0.5	8.2 ± 0.5 5.5 ± 0.5 7.7 ± 0.5

Table 12.9 RF voltages along the initial RF signal path of the UHF radio (H5 and H6 bands)

Power level (W)	Frequency (MHz)		RF voltages (V)			
	H5 band	H6 band	Synthesizer output	Buffer output	Exciter output	Driver output
1	400 435 470	450 490 530	0.2 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.3 ± 0.1 0.3 ± 0.1 0.4 ± 0.1	4.5 ± 0.5 4.6 ± 0.5 3.9 ± 0.5	2.3 ± 0.5 1.5 ± 0.5 0.8 ± 0.5
5	400 435 470	450 490 530	0.2 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.3 ± 0.1 0.4 ± 0.1 0.4 ± 0.1	4.6 ± 0.5 4.6 ± 0.5 3.6 ± 0.5	3.6 ± 0.5 2.6 ± 0.5 1.2 ± 0.5
12	400 435 470	450 490 530	0.2 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.2 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	3.9 ± 0.5 4.0 ± 0.5 3.4 ± 0.5	4.5 ± 0.5 3.9 ± 0.5 1.7 ± 0.5
26	400 435 470	450 490 530	0.2 ± 0.1 0.1 ± 0.1 0.1 ± 0.1	0.2 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	3.8 ± 0.5 3.6 ± 0.5 3.0 ± 0.5	4.6 ± 0.5 4.5 ± 0.5 1.8 ± 0.5
40	400 435 470	450 490 530	0.2 ± 0.1 0.2 ± 0.1 0.2 ± 0.1	0.3 ± 0.1 0.3 ± 0.1 0.3 ± 0.1	4.2 ± 0.5 3.6 ± 0.5 3.2 ± 0.5	8.6 ± 0.5 8.2 ± 0.5 2.5 ± 0.5

Task 26 — Output of Buffer in Exciter Circuit

If the synthesizer output is correct, check the output at C313 of the buffer amplifier in the exciter circuit.

1. If not already done, remove the PAD TOP can.
2. Enter the CCTM command *326 **x***, where ***x*** defines the power level selected in Task 25.
3. Enter the CCTM command *101 **x x** 0*, where ***x*** is the frequency selected in Task 25.
4. Enter the CCTM command *33* to place the radio in transmit mode.
5. Measure the RF voltage after **C313** (see **Figure 12.15**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 12.8** (B1 band) or **Table 12.9** (H5, H6).
6. Enter the CCTM command *32* to place the radio in receive mode.
7. If the voltage measured above is correct, go to Task 27. If it is not, go to Step 8.
8. Check the components around **Q300** (see **Figure 12.15**).
9. Repair any fault revealed by the above checks. Replace **Q300** (see **Figure 12.15**) if none of the other components is faulty.
10. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 27 — Output of Exciter

If the output of the buffer amplifier is correct, check that of the exciter at C301.

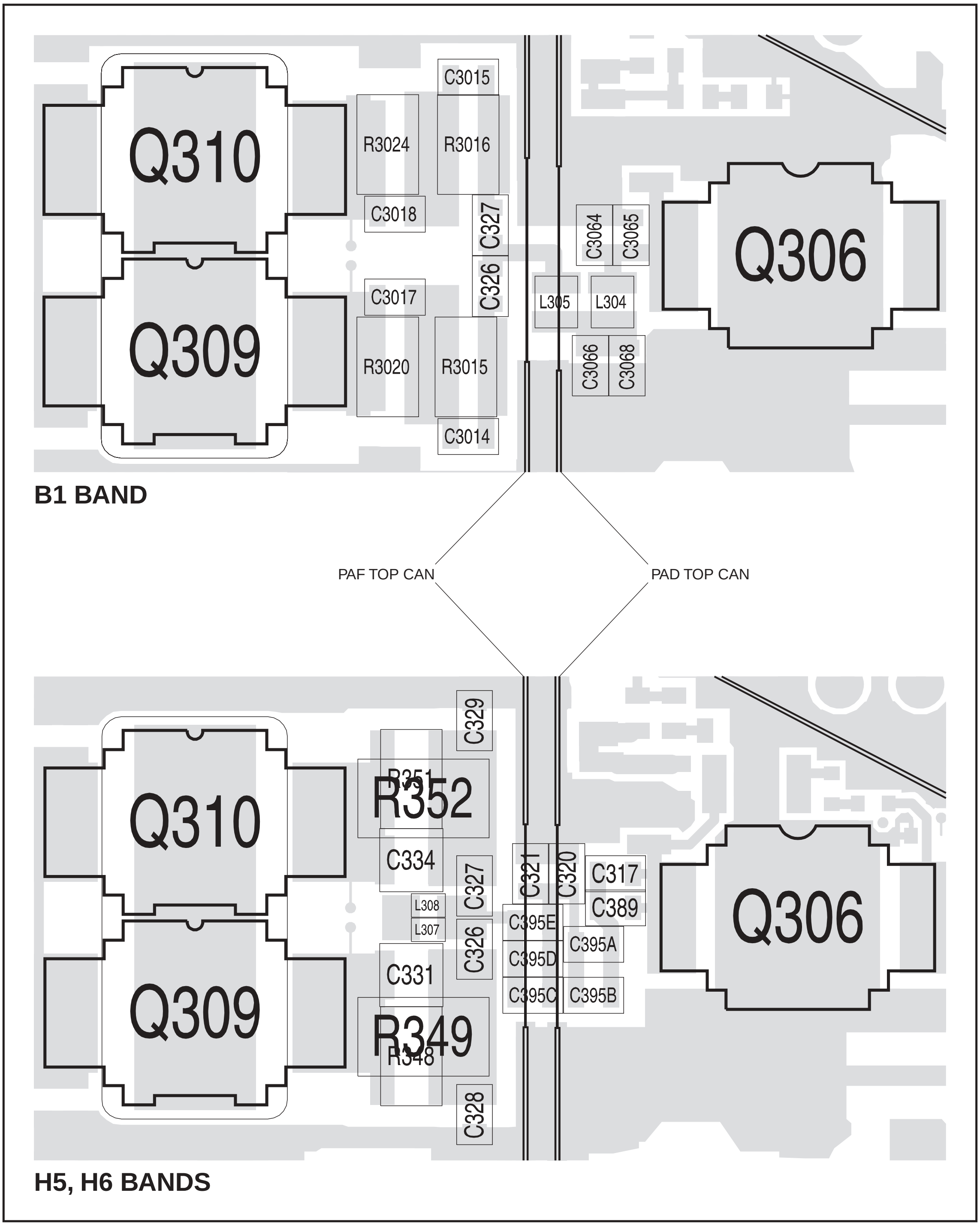
1. With the radio still in transmit mode, measure the RF voltage after **C301** (see **Figure 12.15**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 12.8** (B1 band) or **Table 12.9** (H5, H6).
2. If the voltage is correct, go to Task 28. If it is not, go to Step 3.
3. Enter the CCTM command *32* to place the radio in receive mode.
4. Check the components between **C313** and **Q303**, and between Q303 and **R308** (see **Figure 12.15**).
5. Repair any fault revealed by the above checks. Replace **Q303** (see **Figure 12.15**) if none of the other components is faulty.
6. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 28 — Output of PA Driver

If the exciter output is correct, check the output of the PA driver at the drain of Q306. If necessary, also check the signal at the gates of the PAs Q309 and Q310. This is the last point in the initial RF signal path.

1. With the radio still in transmit mode, measure the RF voltage at the drain of **Q306** (B1) or after **C317** and **C389** (H5, H6) (see **Figure 12.15**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 12.8** (B1) or **Table 12.9** (H5, H6).
2. Enter the CCTM command *32* to place the radio in receive mode.
3. If the voltage measured above is correct, go to Step 7. If it is not, go to Step 4.
4. Check the components between **C301** and **Q306** (see **Figure 12.15**).
5. If the above checks reveal a fault, go to Step 6. If they do not, go to Task 12 in “Biasing of PA Driver and PAs” on page 335.
6. Repair the fault. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.
7. If not already done, remove the PAF TOP can.
8. Enter the CCTM command *326 5* to set the power level to the maximum, and then the command *33* to place the radio in transmit mode.
9. Measure the RF voltage at the gates of the PAs **Q309** and **Q310** (see **Figure 12.16**).
10. Enter the CCTM command *32* to place the radio in receive mode.
11. If an RF voltage is present, there is no fault in the initial RF signal path; go to Task 29. If there is no RF voltage, go to Step 12.
12. Check the components of the interstage matching circuitry between the PA driver **Q306** and the gates of the PAs **Q309** and **Q310** (see **Figure 12.16**).
13. If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 12.16 Components of the interstage matching circuitry between the PA driver Q306 and the PAs Q309 and Q310



Task 29 — Check Power at Directional Coupler

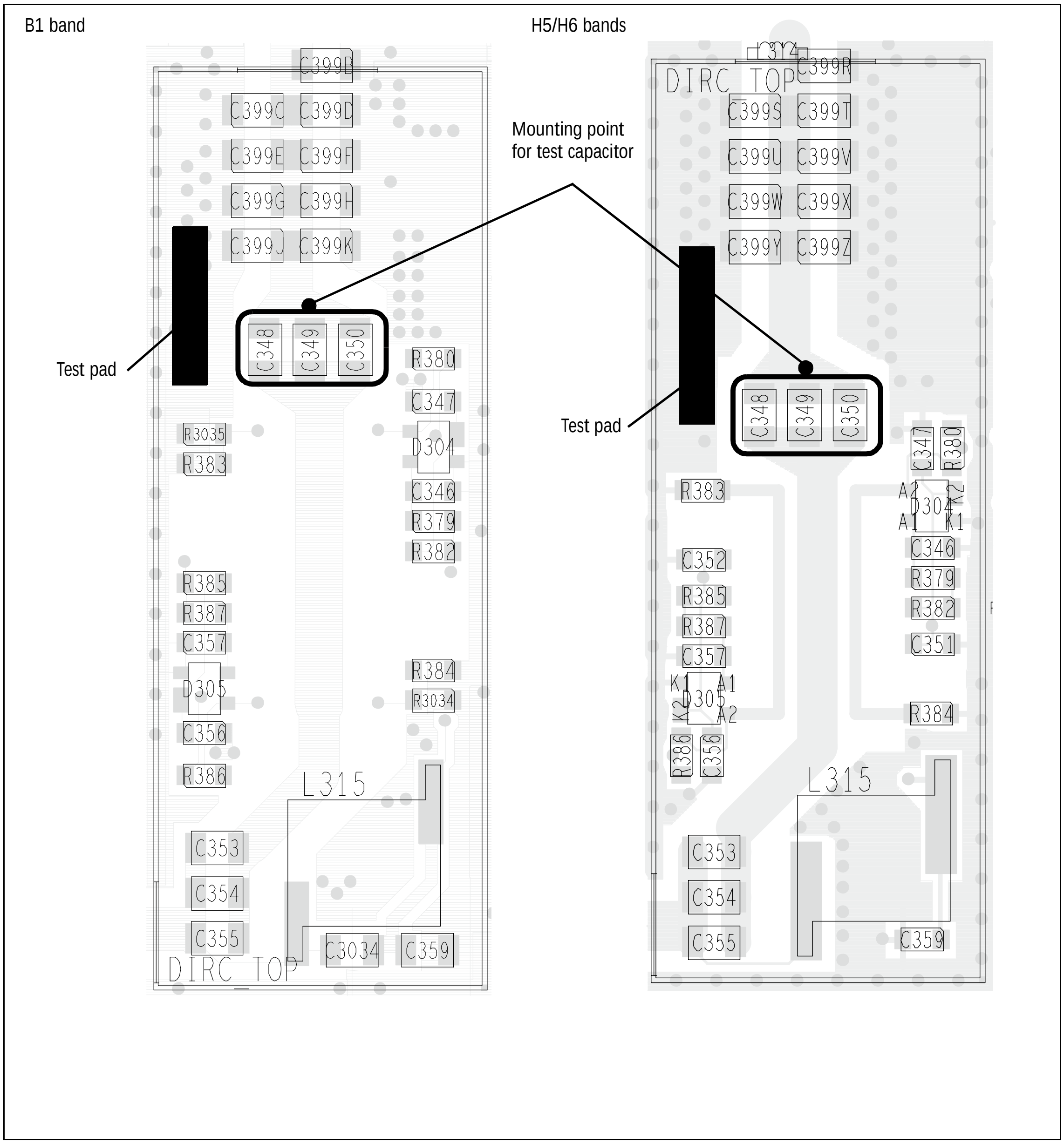
If, as determined in Task 25 to Task 28, there is no fault in the initial RF signal path, investigate the final signal path. This part of the circuitry may also require investigation following certain checks in "Transmitter RF Power". Begin by checking the directional coupler as follows:

1. If not already done, remove the DIRC TOP can.
2. Remove the coupling capacitors **C348**, **C349**, **C350** (see **Figure 12.17**).
3. Solder one terminal of an 82pF (H5, H6 bands) or 680pF (B1) test capacitor to the PCB at the point shown in **Figure 12.17**. Mount the capacitor vertically. Use a test capacitor of the type GRM111, DLI C17, Murata 1210, or the equivalent.
4. Solder a 50Ω test lead to the PCB: Solder the outer sheath to the test pad shown in **Figure 12.17**, and solder the central wire to the other terminal of the test capacitor.
5. Connect the test lead to the test set.
6. Enter the CCTM command *326 5* to set the transmitter power level to the maximum.
7. Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the lowest frequency (in hertz) for maximum power, as given in **Table 12.8** (B1 band) or **Table 12.9** (H5, H6).
8. Enter the CCTM command *33* to place the radio in transmit mode.
9. Measure the RF output power. This should exceed 35 W.

RF output power: more than 35W

10. Enter the CCTM command *32* to place the radio in receive mode.
11. Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the highest frequency (in hertz) for maximum power, as given in **Table 12.8** (B1 band) or **Table 12.9** (H5, H6).
12. Repeat Step 8 to Step 10.
13. If the power measured in both the above cases exceeds 35W, go to Step 14. If it does not, go to Task 30.
14. Remove the test lead and test capacitor, resolder the coupling capacitors in position, and go to Task 31.

Figure 12.17 Circuitry under the DIRC TOP can, and the points for attaching the test lead and test capacitor



Task 30 — Repair Circuitry

If the RF output power measured in Task 29 is low, there is a fault in the circuit between the common drain of the PAs and the test capacitor.

1. If not already done, remove the PAF TOP can.
2. Check for faulty, shorted or misplaced components in the circuit between the test capacitor and the common drain of **Q309** and **Q310** (see **Figure 12.6** to **Figure 12.7**).
3. Repair any fault revealed by the above checks and go to Step 5. If no fault could be found, go to Step 4.
4. Remove the test lead and test capacitor, resolder the coupling capacitors **C348**, **C349** and **C350** in position (see **Figure 12.17**), and go to Task 25.
5. With the test lead still connected to the test set, enter the CCTM command *326 5* to set the transmitter power level to the maximum.
6. Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the lowest frequency (in hertz) for maximum power, as given in **Table 12.8** (B1 band) or **Table 12.9** (H5, H6).
7. Enter the CCTM command *33* to place the radio in transmit mode.
8. Measure the RF output power. This should exceed 35 W.

RF output power: more than 35W

9. Enter the CCTM command *32* to place the radio in receive mode.
10. Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the highest frequency (in hertz) for maximum power, as given in **Table 12.8** (B1 band) or **Table 12.9** (H5, H6).
11. Repeat Steps Step 7 to Step 9.
12. Remove the test lead and test capacitor, and resolder the coupling capacitors **C348**, **C349** and **C350** in position (see **Figure 12.17**).
13. If the power in both the above cases is now correct, the fault has been rectified; go to “Final Tasks” on page 147. If it is not, the repair failed; replace the main-board assembly and go to “Final Tasks” on page 147.

Task 31 — Check PIN Switch

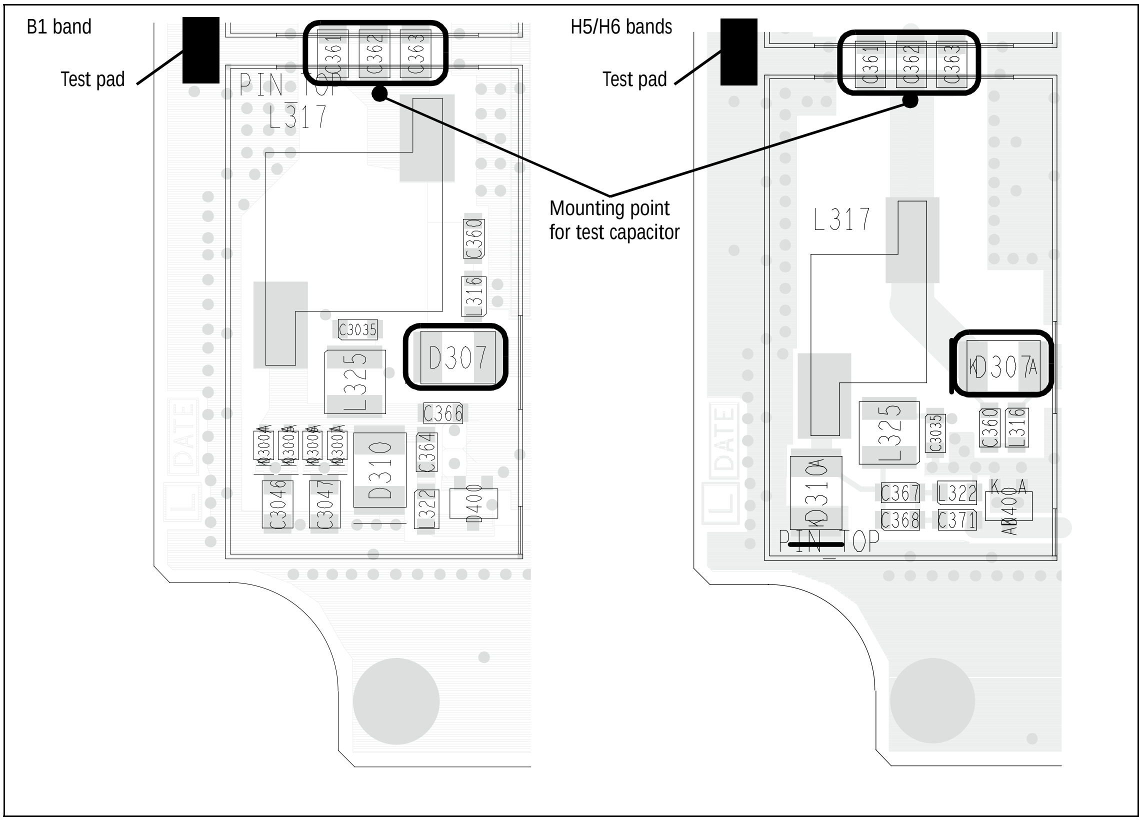
In checking the final RF signal path, if no fault is found in the directional coupler, then check the PIN switch next. The PIN switch may also require investigation following certain checks in "Transmitter RF Power" on page 324.

1. Remove the PIN TOP can.
2. Remove the three blocking capacitors **C361**, **C362** and **C363** (see **Figure 12.18**).
3. Solder one terminal of a 22pF test capacitor to the PCB at the point shown in **Figure 12.18**. Mount the capacitor vertically. Use a test capacitor of the type GRM111, DLI C17, Murata 1210, or the equivalent.
4. Solder a 50Ω test lead to the PCB. Solder the outer sheath to the test pad shown in **Figure 12.18**, and solder the central wire to the other terminal of the test capacitor.
5. Connect the test lead to the test set.
6. Enter the CCTM command *326 5* to set the transmitter power level to the maximum.
7. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the lowest frequency (in hertz) for maximum power, as given in **Table 12.8** (B1 band) or **Table 12.9** (H5, H6).
8. Enter the CCTM command *33* to place the radio in transmit mode.
9. Measure the RF output power. This should exceed 35W.

RF output power: more than 35W

10. Enter the CCTM command *32* to place the radio in receive mode.
11. Enter the CCTM command *101* ***x x*** *0*, where ***x*** is the highest frequency (in hertz) for maximum power, as given in **Table 12.8** (B1 band) or **Table 12.9** (H5, H6).
12. Repeat Step 8 to Step 10.
13. If the power in both the above cases exceeds 35 W, go to Step 14. If it does not, the circuitry of the PIN switch is suspect; go to Task 32.
14. Remove the test lead and test capacitor, resolder the blocking capacitors in position, and go to Task 33.

Figure 12.18 Circuitry under the PIN TOP can, and points for attaching the test lead and test capacitor



Task 32 — Repair PIN switch

If the RF power at the PIN switch is low, the switch is not drawing the expected current or the diode is faulty. Check the circuit as follows:

1. Perform a diode check of **D307** (see **Figure 12.18**). If it is not faulty, go to Step 2. If it is, replace D307 and go to Step 3.
2. Check the +9V0_TX supply to the PIN switch via the following resistors on the bottom-side of the PCB (see **Figure 12.19**):
   - B1 band: **R3080**, **R389** and **R390**
   - H5, H6 bands: **R3000** and **R389**

   If any resistor is faulty, replace the resistor as well as **D307**. (A faulty resistor is likely to have resulted in damage to D307.)
3. With the test lead still connected to the test set, enter the CCTM command *326 5* to set the transmitter power level to the maximum.
4. Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the lowest frequency (in hertz) for maximum power, as given in **Table 12.8** (B1 band) or **Table 12.9** (H5, H6).
5. Enter the CCTM command *33* to place the radio in transmit mode.
6. Again measure the RF output power. This should exceed 35W.

RF output power: more than 35W

7. Enter the CCTM command *32* to place the radio in receive mode.
8. Enter the CCTM command *101 **x** **x** 0*, where ***x*** is the highest frequency (in hertz) for maximum power, as given in **Table 12.8** (B1 band) or **Table 12.9** (H5, H6).
9. Repeat Step 5 to Step 7.
10. Remove the test lead and test capacitor, and resolder the blocking capacitors **C361**, **C362** and **C363** (see **Figure 12.18**) in position.
11. If the power in both the above cases is now correct, the fault has been rectified; go to “Final Tasks” on page 147. If it is not, the repair failed: replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 12.19 Components of concern on the bottom-side of the main board

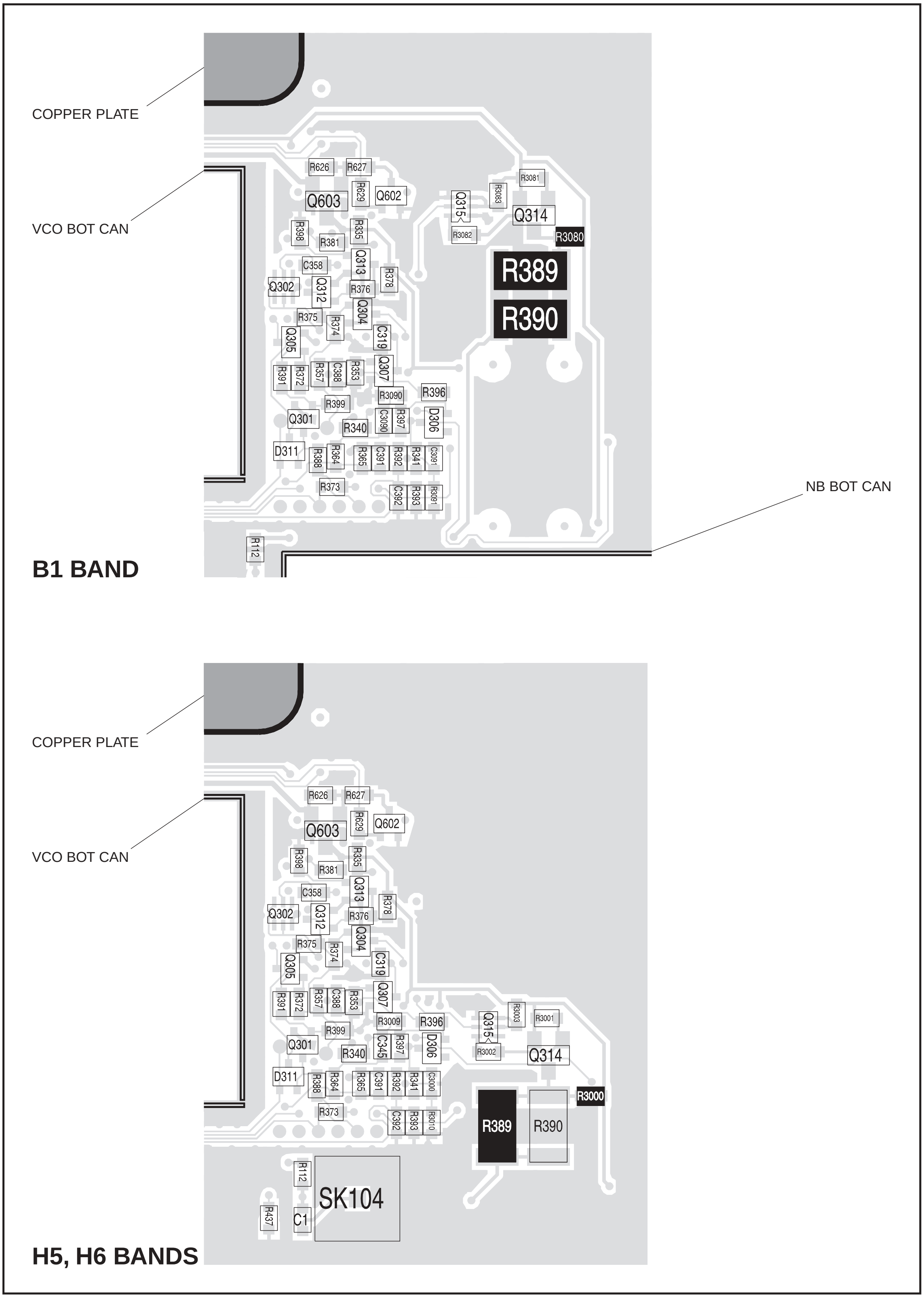
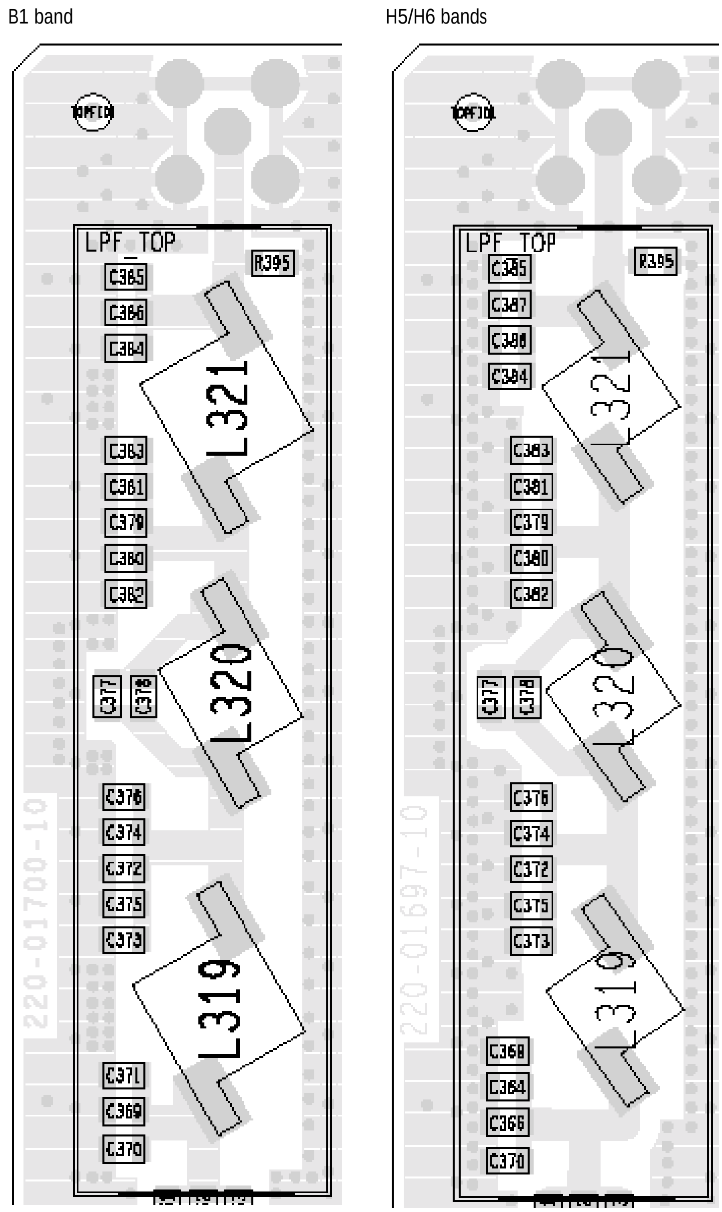


Figure 12.20 Circuitry under the LPF TOP can (top side)



Task 33 — Check Components of LPF

If there are no faults in the final RF signal path up to and including the PIN switch, then the fault should lie in the LPF. Check the LPF as follows:

1. Remove the LPF TOP can.
2. Connect the RF connector to the test set.
3. Check the capacitors and inductors of the LPF between the PIN switch and the RF connector. See **Figure 12.20**. Check for shorts, open circuits, and faulty components. Repair any fault.
4. Enter the CCTM command *326 5* to set the transmitter power level to the maximum.
5. Enter the CCTM command *101* ***x*** *x 0*, where ***x*** is the lowest frequency (in hertz) for maximum power, as given in **Table 12.8** (B1 band) or **Table 12.9** (H5, H6).
6. Enter the CCTM command *33* to place the radio in transmit mode.
7. Measure the RF output power. This should exceed 35W.

RF output power: more than 35W

8. Enter the CCTM command *32* to place the radio in receive mode.
9. Enter the CCTM command *101* ***x*** *x 0*, where ***x*** is the highest frequency (in hertz) for maximum power, as given in **Table 12.8** (B1 band) or **Table 12.9** (H5, H6).
10. Repeat Steps Step 6 to Step 8.
11. If the power in both the above cases exceeds 35 W, the fault has been rectified; go to “Final Tasks” on page 147. If it does not, the repair failed; replace the main-board assembly and go to “Final Tasks” on page 147.

13 CODEC and Audio Fault Finding

Fault Conditions

This section covers the diagnosis of faults in the CODEC and audio circuitry. There are five conditions that indicate a possible fault in the circuitry:

- no speaker audio or speaker audio is distorted
- no speaker audio at auxiliary connector
- receiver does not operate
- no transmit modulation or modulation is distorted
- no transmit modulation despite modulation at auxiliary connector

In the first case regarding the speaker audio, the green STATUS LED will be operating correctly and all unmute criteria will be satisfied. In the second case the receiver will be operating normally. In the third case the assumption is that the receiver and power-supply circuitry were checked and no faults were found. In the fourth case regarding the transmit modulation, the radio will be transmitting the correct amount of RF power. In the fifth case the transmitter will be operating normally.

Fault-Diagnosis Procedures

The procedures for diagnosing the above faults are given below in the following sections. In each case, however, first carry out the tasks of "Power Supplies" on page 372. Also note that the conditions concerning the auxiliary connector can both occur at the same time. In this case carry out both "No Speaker Audio at Auxiliary Connector" on page 382 and "Faulty Modulation Using Auxiliary Connector" on page 394.

CCTM commands

The CCTM commands required in this section are listed in Table 13.1. Full details of the commands are given in "Computer-Controlled Test Mode (CCTM)" on page 112.

Table 13.1 CCTM commands required for the diagnosis of faults in the CODEC and audio circuitry

Command	Description
21	Unmute received audio
32	Set radio in receive mode
33	Set radio in transmit mode
110 **x**	Set level **x** (in range 0 to 255) of audio volume
323 **x y**	Generate audio tone AUD TAP IN at tap point **x** of tap type **y**
324 **x y**	Output audio signal at tap point **x** of tap type **y** to AUD TAP OUT
400 **x**	Select channel with channel number **x**

13.1 Power Supplies

Introduction

First check that a power supply is not the cause of the fault. Of these supplies, the 3.3V DC supply (+3V3) will already have been checked in “Power Supply Fault Finding” on page 153. The remaining supplies that need to be checked are:

- Task 1: 9V DC supply from 9V regulator (+9V0)
- Task 2: 3V DC supply from 3V regulator (+3V0 AN)
- Task 3: 2.5V DC supply from 2.5V regulator (+2V5 CDC)

Two other supplies used in the CODEC and audio circuitry are a 1.8V DC supply (+1V8) from the digital board and the 13.8V DC supply (+13V8 BATT) from the power connector. Faults in these supplies are dealt with elsewhere.

Task 1 — 9V Power Supply

First check the 9V DC supply (+9V0), which is required by IC201.

1. Remove the main-board assembly from the chassis.
2. Remove the CDC BOT can.
3. Measure the voltage +9V0 at pin 4 of **IC201** (see **Figure 13.1**).

pin 4 of IC201: 9.0 ± 0.3V DC

4. If the voltage is correct, go to Task 2. If it is not, go to Step 5.
5. The fault will be at **IC201** (see **Figure 13.1**), since any fault with the 9V regulator in the PSU module will already have been rectified. Therefore, check the soldering of IC201. Repair any fault.
6. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 2 — 3V Power Supply

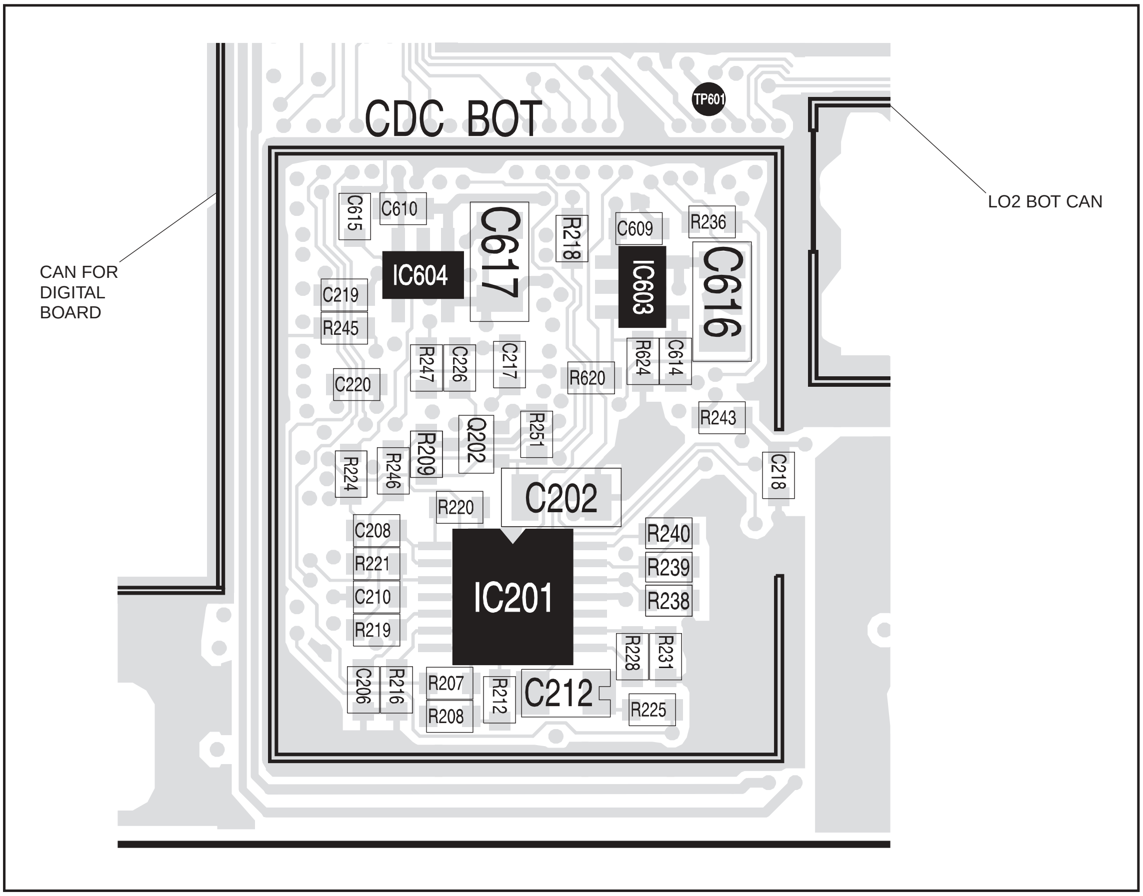
If the 9V supply is correct, check the 3V DC supply (+3V0 AN) next.

1. Measure the voltage +3V0 AN at the **TP601 test point** (see **Figure 13.1**).

TP601 test point: 2.9 ± 0.3V DC

2. If the voltage is correct, go to Task 3. If it is not, go to Step 3.
3. The 3V regulator **IC603** is suspect (see **Figure 13.1**). Check the regulator as described in Task 3 of “Power Supply Fault Finding” on page 158.

Figure 13.1 Power-supply circuitry for the CODEC and audio circuitry under the CDC BOT can



Task 3 — 2.5V Power Supply

If the 9V and 3V supplies are correct, the remaining power supply to check is the 2.5V DC supply (+2V5 CDC).

1. Measure the voltage +2V5 CDC at pin 5 of **IC604** (see **Figure 13.1**).

pin 5 of IC604: 2.5 ± 0.3V DC

2. If the voltage is correct, go to Step 4. If it is not, go to Step 3.

3. The 2.5V regulator **IC604** is suspect (see **Figure 13.1**). Check the regulator as described in Task 3 of “Power Supply Fault Finding” on page 158.

4. Proceed to the section relevant to the fault exhibited:
   - “Faulty Speaker Audio” (distorted or no speaker audio)
   - “No Speaker Audio at Auxiliary Connector” (no speaker audio at auxiliary connector)
   - “Faulty Receiver” (receiver does not operate)
   - “Faulty Modulation” (distorted or no transmit modulation)
   - “Faulty Modulation Using Auxiliary Connector” (modulation at auxiliary connector only)

   Further details are given in the introduction to the section.

13.2 Faulty Speaker Audio

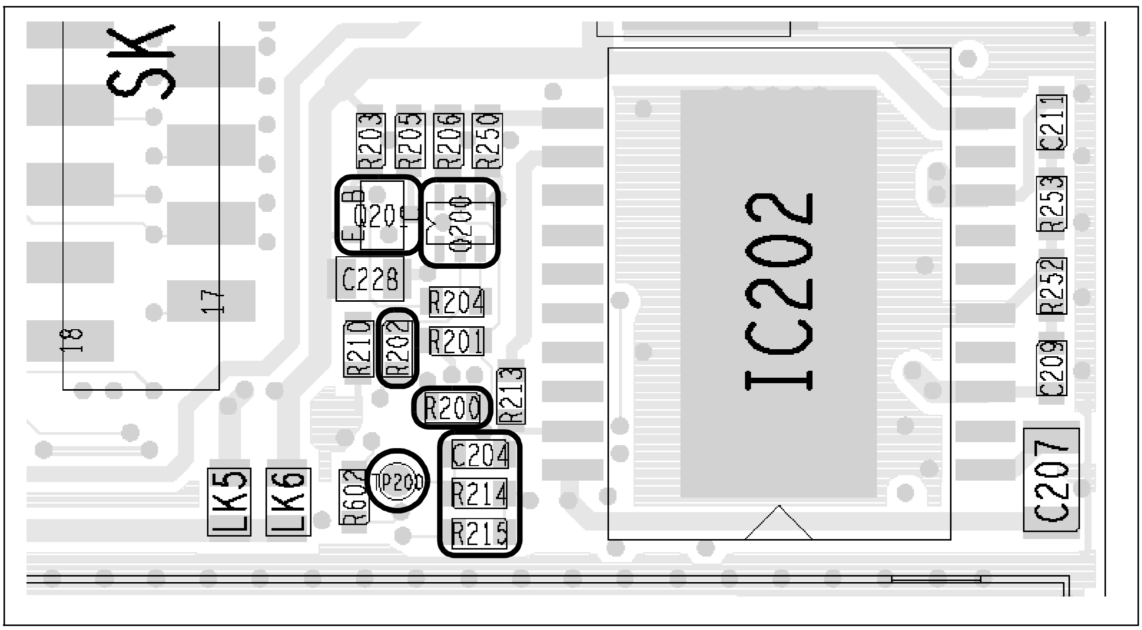
Introduction

This section covers the case where the green STATUS LED is operating correctly and all unmute criteria are satisfied, but there is either no speaker audio or the speaker audio is distorted. There are four tasks:

- Task 4: check audio power amplifier
- Task 5: check speaker outputs
- Task 6: check ITF VOL WIP DC input signal
- Task 7: check ITF RX BEEP IN input signal

The next section deals with the case where there is no speaker audio at the auxiliary connector.

Figure 13.2 Circuitry in the vicinity of IC202 (top side)



Task 4 — Check Audio Power Amplifier

If there is no fault with the power supplies, check the inputs to the audio PA as follows. This check is only applicable, however, if the output of the voice-band CODEC is correct and the signal level varies as the volume is varied.

1. Use the programming application to find the frequency selected for channel 1.

2. In user mode apply an on-channel RF signal of –47 dBm with 60%, 1 kHz deviation. The channel must not have signaling enabled. Set the volume to maximum.

3. Use an oscilloscope probe to check the output of the voice-band CODEC at the **TP200 test point** (see **Figure 13.2**). The signal should be:

TP200 test point: sine wave of 100 mV_{pp} with 0.6 V DC offset

4. If the above signal is correct, go to Step 5. If it is not, go to Task 7.

5. Vary the volume control. This should cause the signal level at the **TP200 test point** (see **Figure 13.2**) to vary. If it does, go to Step 6. If it does not, go to Task 6.

6. Check the voltage at pin 11 of **IC202** (see **Figure 13.2**):

pin 11 of IC202: at least 8 V DC

7. If the voltage is correct, go to Step 9. If it is not, check for and repair any faults in the level-translation circuits incorporating **Q200** and **Q201** (see **Figure 13.2**).

8. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

9. Check the digital signals DIG AUD PA EN1 at **R200** and DIG AUD PA EN2 at **R202** (see **Figure 13.2**):

R200 (DIG AUD PA EN1): 3.3 V DC R202 (DIG AUD PA EN2): 0.0 V DC

10. If the signals are correct, go to Task 5. If they are not, check the programming and test set-up; otherwise the digital board is faulty; replace the main-board assembly and go to “Final Tasks” on page 147.

Task 5 — Check Speaker Outputs

If the inputs to the audio PA are not faulty, check the speaker outputs from the PA.

1. Check the positive and negative speaker outputs AUD ITF SPK+ and AUD ITF SPK– at pins 3 and 8 respectively of **IC202** (see **Figure 13.2**):

pin 3 of IC202 (AUD ITF SPK+): approximately half-rail bias pin 8 of IC202 (AUD ITF SPK–): approximately half-rail bias

2. If the speaker outputs are correct, go to Step 5. If they are not, go to Step 3.

3. Check for and repair any soldering faults around **IC202** (see **Figure 13.2**), or else replace IC202.

4. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

5. With the volume at maximum, check each speaker output at pins 3 and 8 of **IC202** (see **Figure 13.2**):

pin 3 of IC202 (AUD ITF SPK+): approximately 9.5V_{pp} AC pin 8 of IC202 (AUD ITF SPK–): approximately 9.5V_{pp} AC

6. If the speaker outputs are correct, the fault is unknown (it could be intermittent); replace the main-board assembly and go to “Final Tasks” on page 147. If there is no AC, go to Step 7.

7. Check that **C204** and **R214** (see **Figure 13.2**) are not faulty and are correctly soldered. Repair any fault.

8. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 13.3 Circuitry under the CDC TOP can, and adjacent interface circuitry

Task 6 — Check ITF VOL WIP DC Input Signal

If the output of the voice-band CODEC is correct, but the signal level does not vary as the volume control is varied, check the ITF VOL WIP DC signal.

1. Check the voltage on the VOL WIP DC line at the junction of **R708** and **C706** (see **Figure 13.3**). As the volume varies, the voltage should vary as follows.

junction of R708 and C706: 0.0 to 1.2V as volume varies

2. If the voltage varies as expected, go to Step 5. If it does not, go to Step 3.

3. Check the control-head connector **SK100**. Repair or replace the connector if necessary.

4. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 147.

5. Remove the CDC TOP can.

6. Check the voltage at the junction of **R234** and **R235** (see **Figure 13.3**). As the volume varies, the voltage should vary as follows.

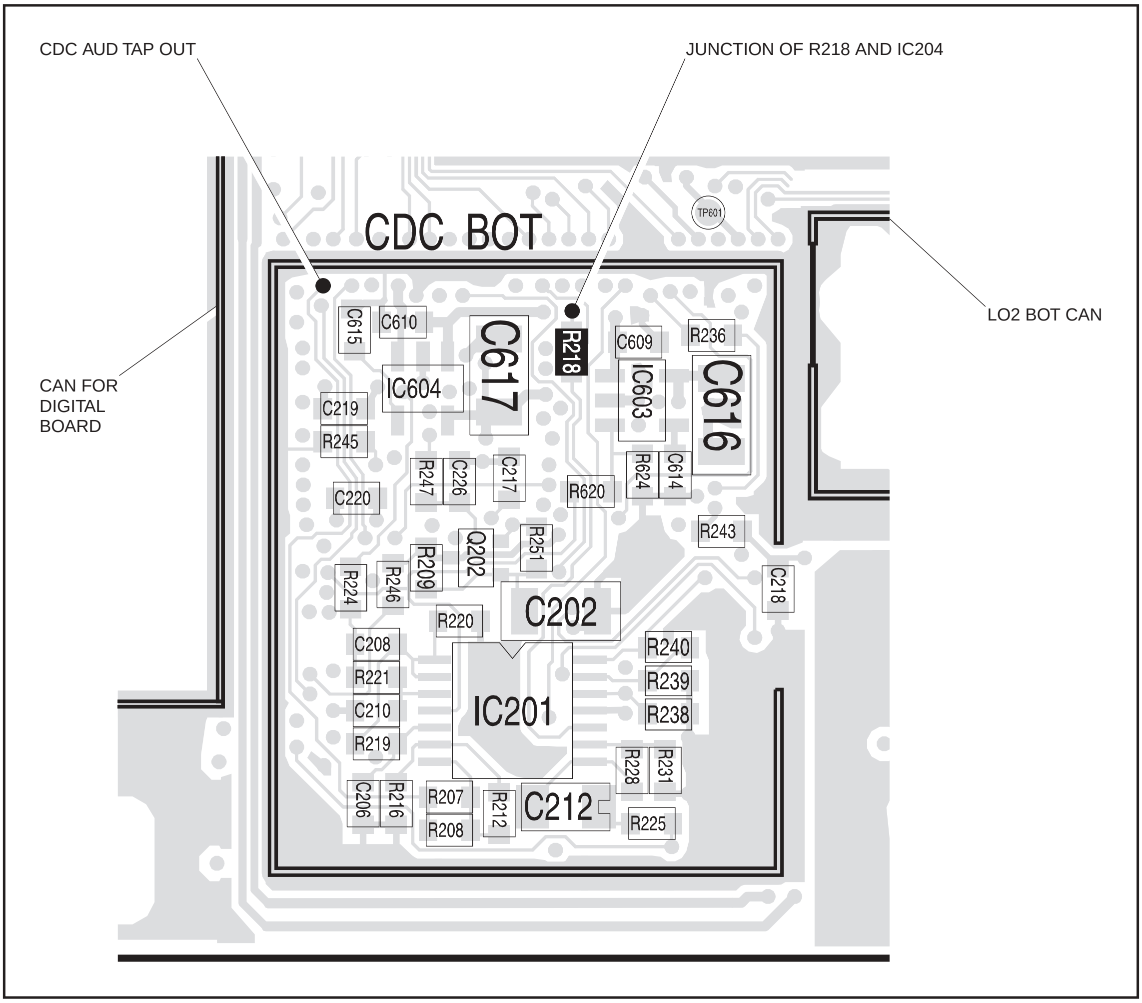
junction of R234 and R235: 0.0 to 0.6V as volume varies

7. If the voltage varies as expected, CODEC 1 (**IC204**) is suspect; replace the main-board assembly and go to “Final Tasks” on page 147. If it does not, go to Step 8.

8. Check for continuity across **R234**, and check that **R235** is properly soldered (see **Figure 13.3**). Repair any fault.

9. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 13.4 Circuitry under the CDC BOT can



Task 7 — Check ITF RX BEEP IN Input Signal

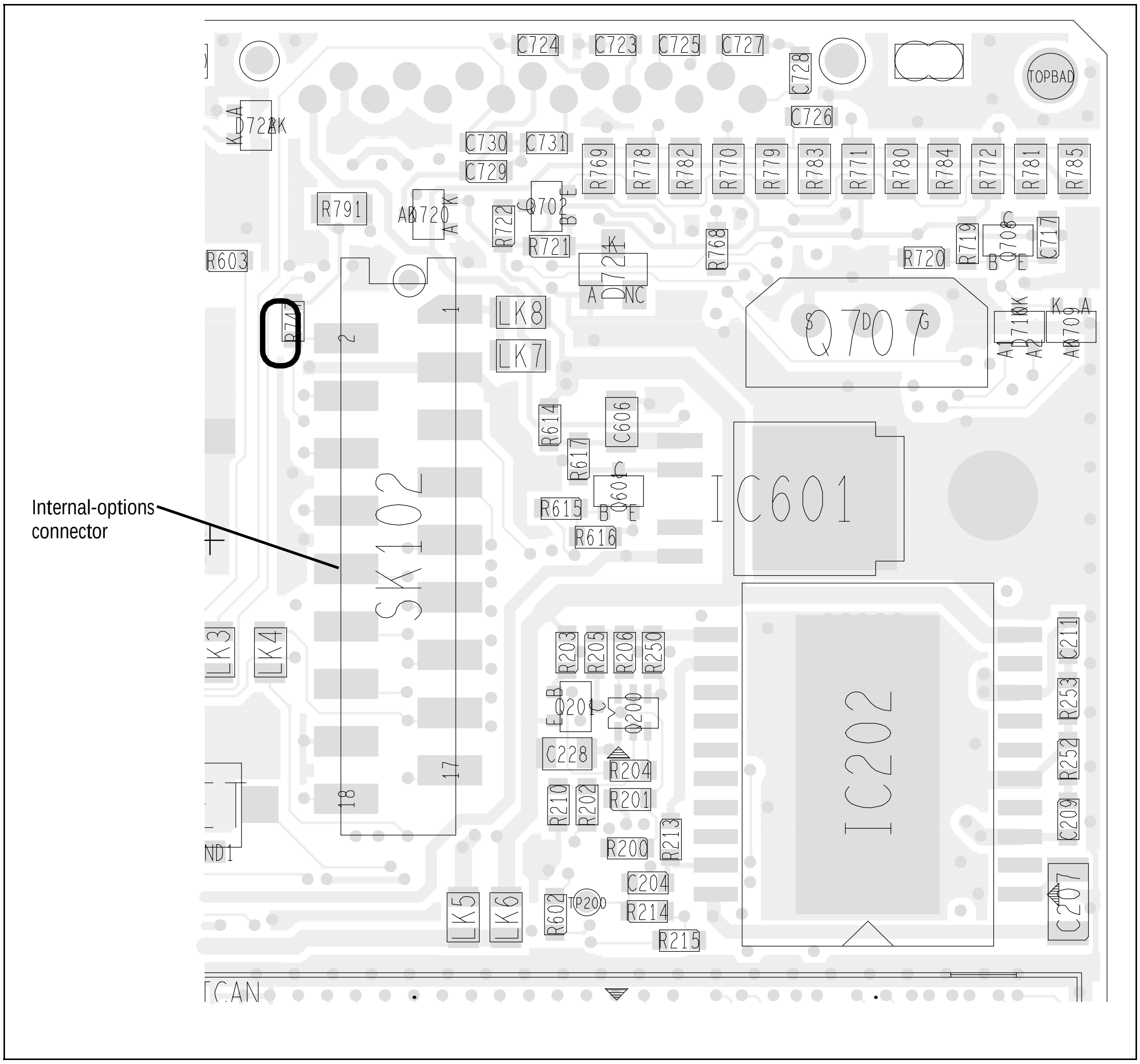
If the output of the voice-band CODEC is not correct, check the ITF RX BEEP IN signal.

1. If not already done, remove the CDC BOT can.
2. Check the signal at the junction of **R218** and **IC204** (see **Figure 13.4**). The signal should be:

junction of R218 and IC204: sine wave about $1V_{pp}$ with 1.2V DC offset

3. If the signal is correct, go to Step 4. If it is not, either CODEC 1 (**IC204**) or the digital board is faulty; replace the main-board assembly and go to "Final Tasks" on page 147.
4. Check for continuity between the **TP200 test point** and **IC204** via **R214**, **R215** (see **Figure 13.2**) and **R218** (see **Figure 13.4**). Repair any fault; if necessary, replace R214, R215 or R218.
5. Confirm the removal of the fault and go to "Final Tasks" on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 147.

Figure 13.5 Circuitry in the vicinity of the internal-options connector SK102 (top side)



13.3 No Speaker Audio at Auxiliary Connector

Introduction

This section covers the case where the receiver operates normally but there is no speaker audio at the auxiliary connector. In other words, there is no signal at pin 13 (AUD TAP OUT) of the connector. The fault-diagnosis procedure comprises two tasks:

- Task 8: check signal from CODEC
- Task 9: check LPF and buffer amplifier in CODEC circuitry

These tasks need to be followed by those of “Faulty Modulation Using Auxiliary Connector” on page 394 if there is also a fault with the transmit modulation using the auxiliary connector.

Task 8 — Check Signal from CODEC

First generate an appropriate audio test signal and check whether the signal is present at the output of the CODEC circuitry.

1. Enter the CCTM command *400 x*, where *x* is a valid channel number. (A suitable channel will depend on the programming of the radio.)

2. Enter the CCTM command *21* to force unmuting of the received audio signal.

3. Enter the CCTM command *110 128* to set the audio level at its midpoint.

4. At the test set apply 60%, 1kHz modulation to the RF signal. Reduce the volume to a minimum.

5. Enter the CCTM command *324 r5*.

6. Check that the received signal is present at pin 2 (AUD TAP OUT) of the internal-options connector **SK102** (see **Figure 13.5**) (alternatively, the measurement point for CDC AUD TAP OUT shown in **Figure 13.4**). The signal should be:

pin 2 of internal-options connector: received signal with 2.4V DC offset

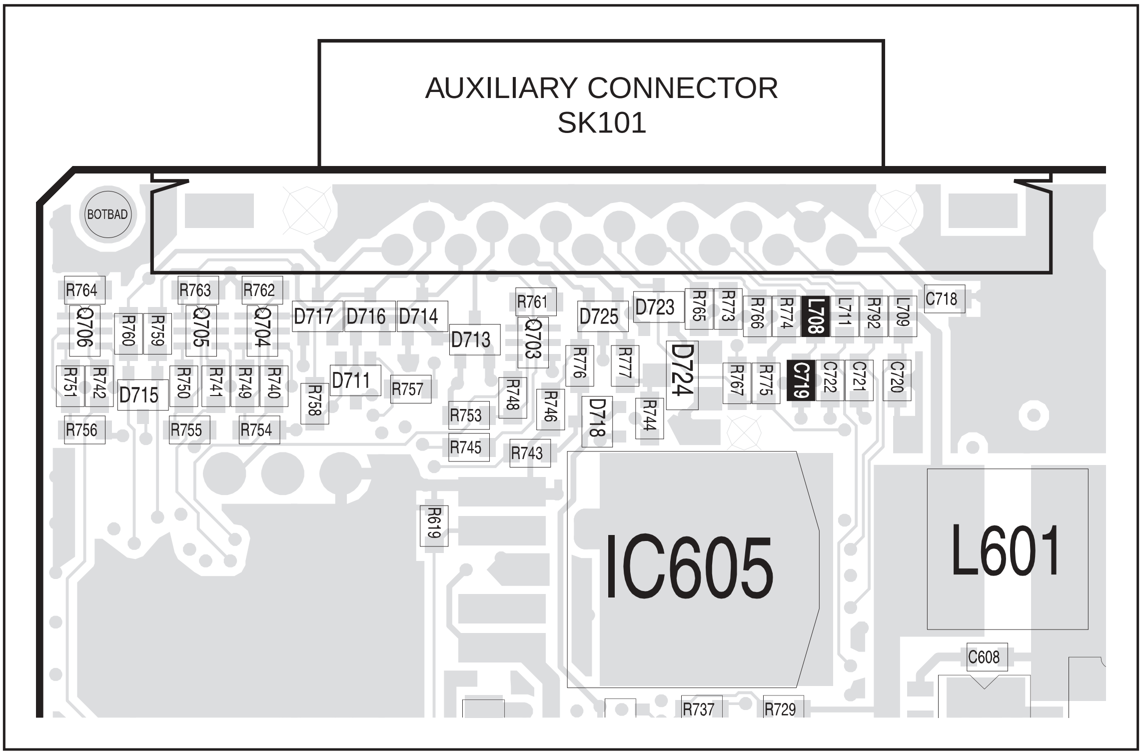
7. If the above signal is correct, go to Step 8. If it is not, go to Task 9.

8. Check the components in the path from pin 13 of the auxiliary connector **SK101** to the CODEC and audio circuitry. These are **C719** and **L708** (see **Figure 13.6**) and the link **R747** (see **Figure 13.5**). Also check the auxiliary connector itself. Repair any fault.

9. Confirm the removal of the fault and go to Step 10. If the repair failed or the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 147.

10. If there is also a fault with the transmit modulation, notwithstanding modulation at the auxiliary connector, go to Task 15 of "Faulty Modulation Using Auxiliary Connector" on page 394. If there is no other fault, go to "Final Tasks" on page 147.

Figure 13.6 Circuitry in the vicinity of the auxiliary connector (bottom side)



Task 9 — Check LPF and Buffer Amplifier

If there is no test signal at the internal-options connector, then either CODEC 1 is faulty or there is a fault in the LPF or buffer amplifier.

1. Remove the CDC BOT can.

2. Check the signal at the junction between **R224** and **IC204** (see **Figure 13.7**). This should be:

junction of R224 and IC204: 0.7V_{pp} with 2.4V DC offset

3. If the above signal is correct, go to Step 4. If it is not, CODEC 1 (**IC204**) is faulty; replace the main-board assembly and go to “Final Tasks” on page 147.

4. Check the voltage at pin 1 of **IC201** (see **Figure 13.7**).

pin 1 of IC201: 1.2V

5. If the voltage is correct, go to Step 6. If it is not, check the LPF circuit based on **IC201** (pins 1 to 3) (see **Figure 13.7**). Repair any fault and conclude with Step 9.

6. Check the voltage at pin 7 of **IC201** (see **Figure 13.7**).

pin 7 of IC201: 2.4V

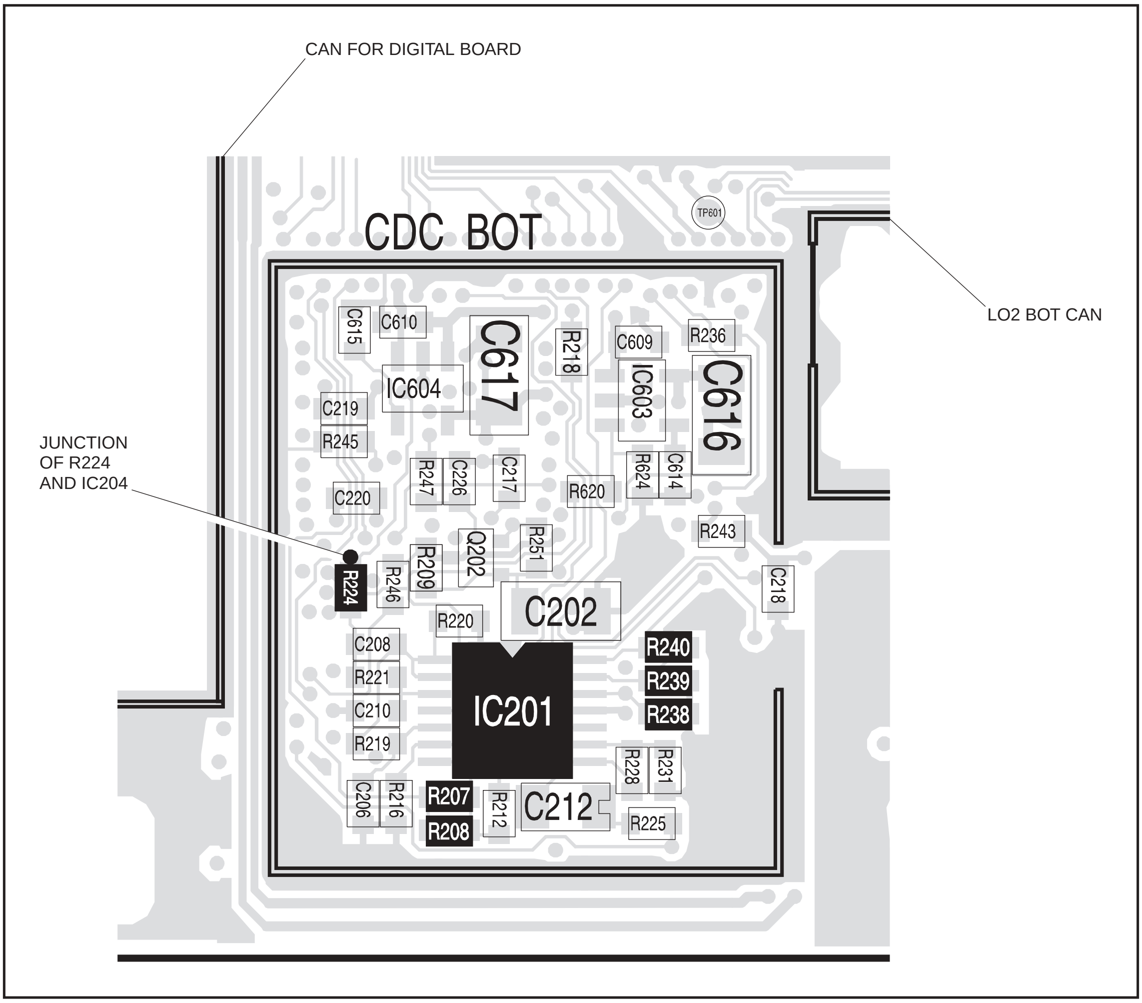
7. If the voltage is correct, go to Step 8. If it is not, check the buffer amplifier based on **IC201** (pins 5 to 7) (see **Figure 13.7**). Repair any fault and conclude with Step 9.

8. Check **R207** and **R208** (see **Figure 13.7**). Repair any fault and conclude with Step 9.

9. Confirm the removal of the fault and go to Step 10. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 147.

10. If there is also a fault with the transmit modulation, notwithstanding modulation at the auxiliary connector, go to “Faulty Modulation Using Auxiliary Connector” on page 394. If there is no other fault, go to “Final Tasks” on page 147.

Figure 13.7 Circuitry under the CDC BOT can



13.4 Faulty Receiver

Introduction

This section covers the case where the receiver does not operate, although there is no apparent fault in the receiver circuit itself. There are two tasks:

- Task 10: check level shifter
- Task 11: check QN test point

The latter check will isolate the module at fault if the level shifter is not the cause of the problem.

Task 10 — Check Level Shifter

Check the operation of the base-band CODEC and receiver AGC as described below. This concerns the level-shifter circuit. It is assumed that the receiver and power-supply circuitry were checked and no faults were found.

1. If not already done, remove the CDC BOT can.
2. With no RF signal applied, check the voltage at pin 14 of **IC201** (see **Figure 13.7**):

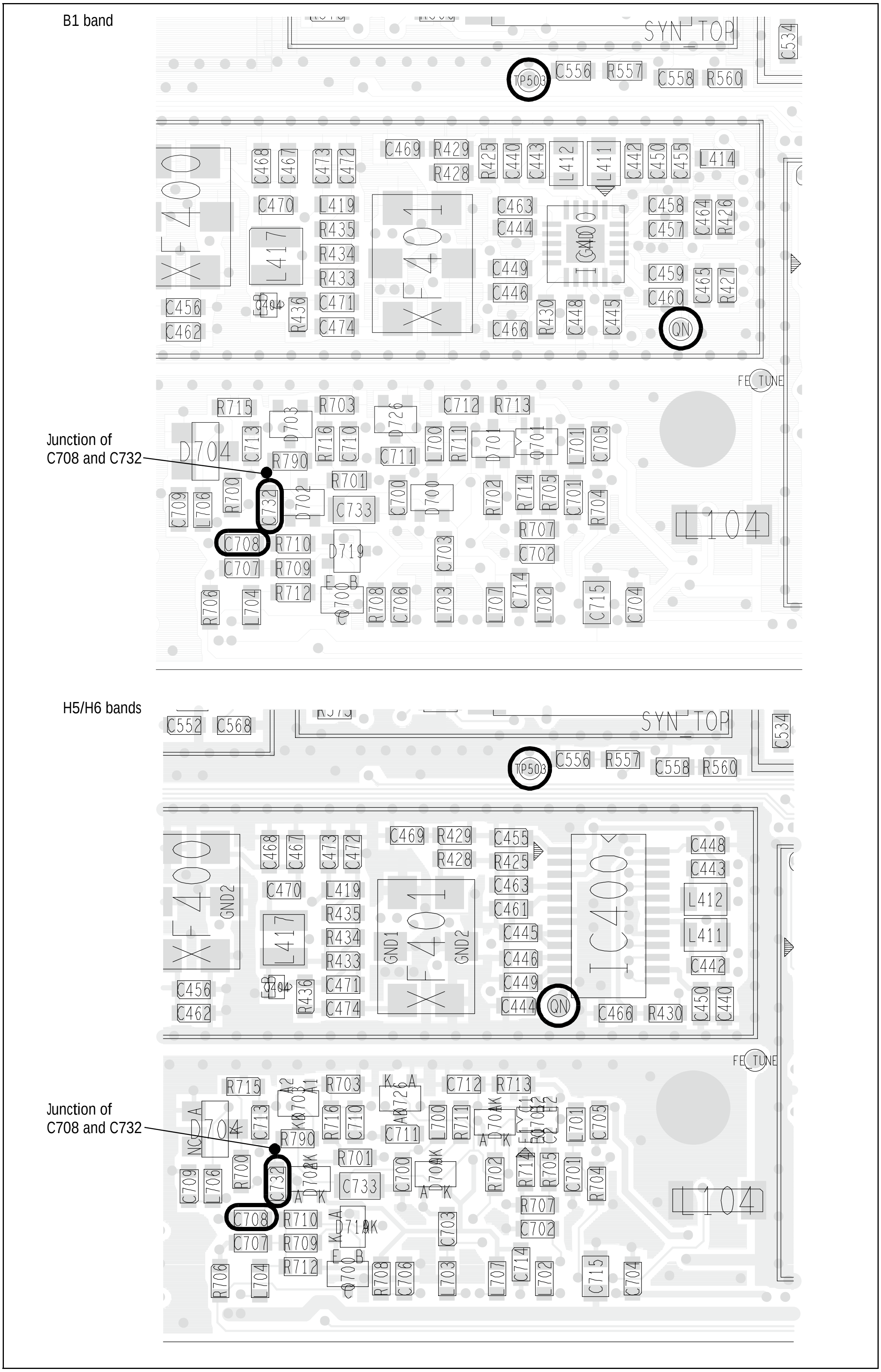
pin 14 of IC201: more than 2.5V DC

3. If the above voltage is correct, go to Task 11. If it is not, go to Step 4.
4. Check the voltage at pin 12 of **IC201** (see **Figure 13.7**):

pin 12 of IC201: more than 1V DC

5. If the above voltage is correct, go to Step 8. If it is not, go to Step 6.
6. Check for and repair any shorts to ground at the junction of **R238** and pin 12 of **IC201** (see **Figure 13.7**).
7. Confirm the removal of the fault and go to "Final Tasks" on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 147.
8. Check the circuitry (**R238**, **R239**, **R240**) around pins 12, 13 and 14 of **IC201** (see **Figure 13.7**). Repair any fault.
9. Confirm the removal of the fault and go to "Final Tasks" on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 147.

Figure 13.8 Circuitry in the vicinity of the CDC TOP can



Task 11 — Check QN Test Point

If the level shifter is not faulty, check the signal at the QN test point. This will ascertain whether the digital board, CODEC 1, or the receiver is at fault.

1. Use the programming application to find the frequency selected for channel 1.
2. Apply a strong on-channel signal.
3. Check that a sine wave is present at the **QN test point** (there is access through a hole in the IF TOP can — see **Figure 13.8**).

QN test point: sine wave

4. If there is a sine wave present, go to Step 5. If there is not, go to "Receiver Fault Finding" on page 227.
5. Either the digital board or CODEC 1 (**IC204**) is faulty; replace the main-board assembly and go to "Final Tasks" on page 147.

13.5 Faulty Modulation

Introduction

This section covers the case where the radio transmits the correct amount of RF power, but there is either no modulation or the modulation is distorted. There are three tasks:

- Task 12: initial checks
- Task 13: check 2.3V DC supply
- Task 14: check bias network

The initial checks will determine whether the frequency synthesizer, the 2.3V supply, or the bias network is at fault.

Task 12 — Initial Checks

Carry out the following checks to isolate the part of the circuitry that is faulty.

1. Apply a 1kHz audio signal of 20 mV_{pp} at the microphone input on the control head.

2. Enter the CCTM command *33* to place the radio in transmit mode. (The frequency is that of channel 1.)

3. Check that the 1kHz signal appears at the **TP503 test point** (see **Figure 13.8**).

TP503 test point: 1kHz signal

4. Enter the CCTM command *32* to place the radio in receive mode.

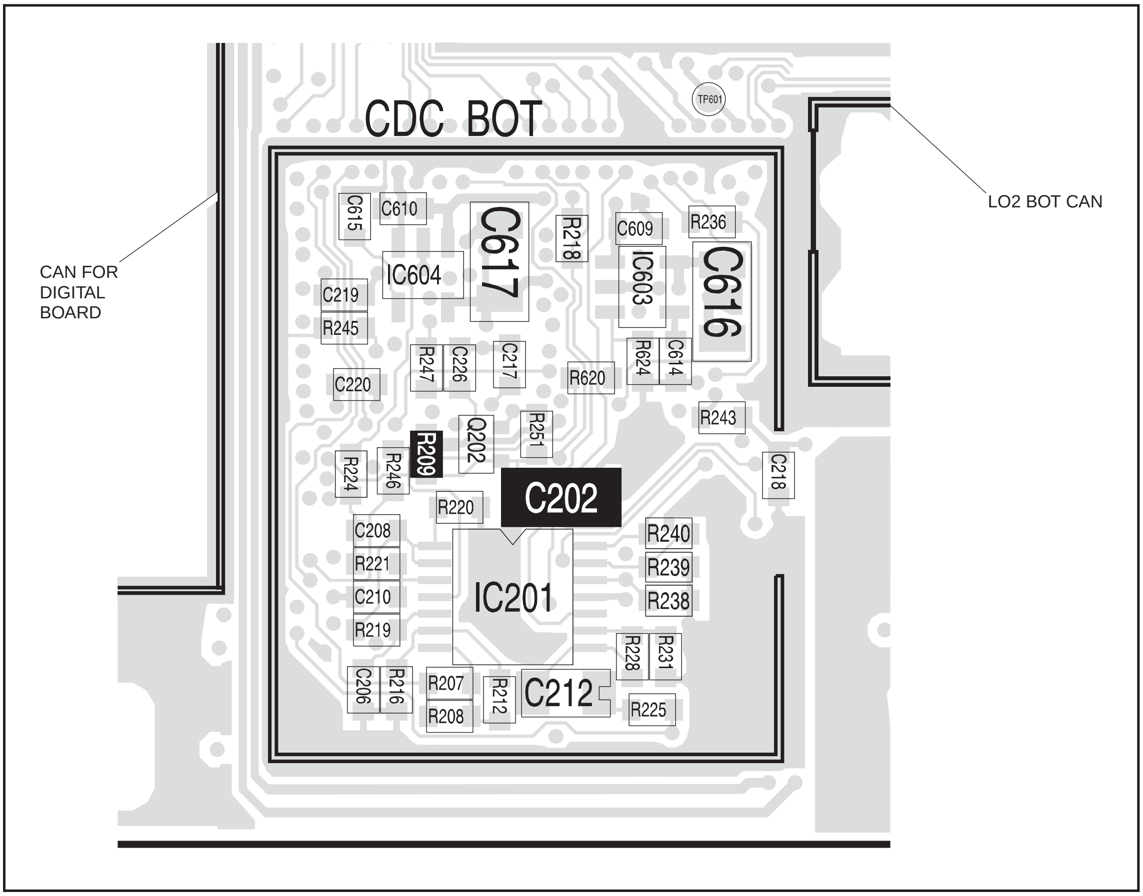
5. If the 1kHz signal is present, go to "Frequency Synthesizer Fault Finding" on page 169. If it is not, go to Step 6.

6. With no microphone connected, check the voltage at the junction of **C708** and **C732** (CH MIC AUD) (see **Figure 13.8**):

junction of C708 and C732: approximately 3V

7. If the above voltage is correct, go to Task 14; the bias network is suspect. If it is not, go to Task 13; the 2.3V supply is suspect.

Figure 13.9 Circuitry in under the CDC BOT can



Task 13 — Check 2.3V Supply

If the CH MIC AUD signal is not as expected, the 2.3V supply needs to be checked.

1. If not already done, remove the CDC BOT can.
2. Check the voltage across **C202** (see **Figure 13.9**):

voltage across C202: 3V

3. If the above voltage is correct, go to Task 14. If it is not, go to Step 4.
4. Check the soldering of **R209**, and check for shorts to ground at **C202** (see **Figure 13.9**). Repair any fault.
5. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 14 — Check Bias Network

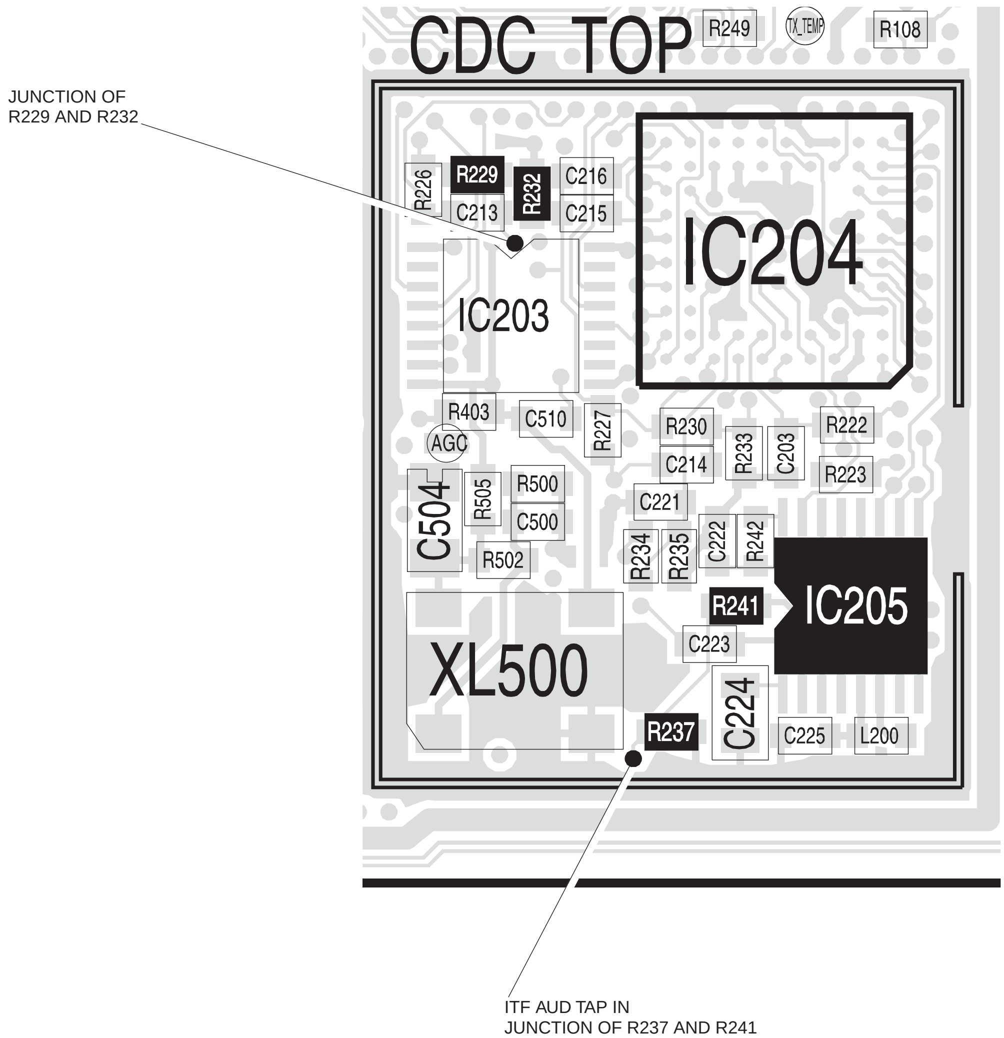
If the signal at the TP503 test point is incorrect, but the other checks in the above tasks reveal no fault, check the bias network.

1. Remove the CDC TOP can.
2. Check the voltage at the junction of **R229** and **R232** (see **Figure 13.10**):

junction of R229 and R232: 1.5V DC

3. If the voltage is correct, go to Step 4. If it is not, go to Step 5.
4. CODEC 1 (**IC204**) is faulty; replace the main-board assembly and go to “Final Tasks” on page 147.
5. Check the soldering of **R229** and **R232**, and check for shorts across R232 (see **Figure 13.10**). Repair any fault.
6. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 147.

Figure 13.10 Circuitry under the CDC TOP can



13.6 Faulty Modulation Using Auxiliary Connector

Introduction

This section covers the case where the transmitter operates normally but there is no modulation (although there is modulation at the auxiliary connector). There are two tasks:

- Task 15: apply AUD TAP IN signal
- Task 16: check CODEC 2 device

If there was also a fault with the speaker audio at the auxiliary connector, it is assumed that this has now been rectified.

Task 15 — Apply AUD TAP IN Signal

First check the modulation and, if necessary, the DC offset.

1. Enter the CCTM command *33* to place the radio in transmit mode. (The frequency is that of channel 1.)
2. Check the modulation via the microphone input.
3. Enter the CCTM command *32* to place the radio in receive mode.
4. If the modulation is correct, go to Step 5. If it is not, go to Task 12 of “Faulty Modulation” on page 390.
5. Apply a 1kHz AC-coupled signal of 0.7V_{pp} at pin 7 (AUD TAP IN) of the auxiliary connector (alternatively, as ITF AUD TAP IN at the junction of **R237** and **R241** — see **Figure 13.10**).
6. Enter the CCTM command *323 t5*.
7. Check the DC offset voltage at pin 7:

pin 7 of auxiliary connector: approximately 1.5V DC offset

8. If the above DC offset is correct, go to Step 9. If it is not, go to Step 11.
9. Remove the CDC TOP can.
10. Check for and repair any soldering faults around **IC205**, or else replace IC205 (see **Figure 13.10**). Conclude with Step 12.
11. Check for shorts at pin 7 of the auxiliary connector. If there are none, go to Task 16. If there are, repair the fault and conclude with Step 12.
12. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

Task 16 — Check CODEC 2 Device

If the DC offset measured in Task 15 is incorrect but there is no fault with the auxiliary connector, check the CODEC 2 device.

1. Remove the CDC TOP can.
2. Check the voltage at both ends of **R241** (see **Figure 13.10**):

R241: 1.5V DC at both ends

3. If the voltages are correct, go to Step 4. If they are not, go to Step 6.
4. Check for and repair any soldering faults around **IC205**, or else replace IC205 (see **Figure 13.10**).
5. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.
6. Remove **R241**.
7. Check the voltage at pin 3 of **IC205** (see **Figure 13.10**):

pin 3 of IC205: 1.5V DC

8. If the above voltage is correct, go to Step 9. If it is not, replace the main-board assembly and go to “Final Tasks” on page 147.
9. Check for and repair any soldering faults around **R241** and **IC205** (see **Figure 13.10**).
10. Confirm the removal of the fault and go to “Final Tasks” on page 147. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 147.

14 Fault Finding of Control Head

Overview

This section describes the fault finding of the control head for the following faults:

- power supply faulty (initial check)
- LCD display faulty
- LCD backlighting faulty
- LCD contrast faulty
- LCD heating faulty
- function key LEDs or status LEDs faulty
- keypad backlighting faulty
- ON/OFF key faulty
- function, scroll, or selection keys faulty
- speaker faulty
- volume control faulty
- PTT faulty

The faults can be detected by visual inspection (refer to "Visual Inspection" on page 128) or using the CCTM commands in Table 14.1 on page 398.

General

The following applies for all fault finding procedures:

Important Do not disconnect or connect the control head while power is supplied to the radio.

- To connect to ground use one of the screw bosses of the metal spaceframe or the screw bosses of the radio body.
- If the radio does not switch on when power is supplied, the radio may be programmed to go into the status it was in when powered down. Connect a known good control head, power up the radio, and change the relevant setting in the programming application. Remember to program the original setting before returning the radio to the customer.
- For disassembly and re-assembly instructions, refer to "Disassembling and Reassembling the Control Head" on page 135.
- If the repair fails or no fault could be found, replace the control-head board.
- After completing the repair, carry out the tasks in "Final Tasks" on page 147.

14.1 CCTM Commands

The following CCTM commands are used during the fault finding of the control head:

Table 14.1 CCTM commands for fault finding of the control head

CCTM command	Entry at keyboard	Response on screen
1000 – All function key LEDs and status LEDs sequentially switches the function key LEDs and the status LEDs on and off	1000 0 = off 1000 1 = on	none
1001 – Individual function key LEDs and status LEDs switches individual LEDs on and off	1001 **x y** where **x** is the LED number (0=F1, 1=F4, 2=yellow, 3=green, 4=red), and **y** is the state (0=off, 1=on)	none
1002 – LED intensity sets the LED intensity	1002 0 = off 1002 1 = low 1002 2 = medium 1002 3 = high	none
1003 – Keypad backlighting Activate keypad backlighting at specified intensity	1003 0 = off 1003 1 = low 1003 2 = medium 1003 3 = high	none
1004 – LCD backlighting Activate LCD backlighting at specified intensity	1004 0 = off 1004 1 = low 1004 2 = medium 1004 3 = high	none
1005 – LCD contrast sets the LCD contrast (16 levels)	1005 **x** where **x** is the contrast level (0 to 15)	none
1006 – LCD elements switches all LCD elements on and off	1006 0 = off 1006 1 = on	none
1007 – LCD temperature sensor Reads the LCD temperature sensor	1007	value between 00 (0) and FF (255)
1008 – LCD heating switches the LCD heating on and off	1008 0 = off 1008 1 = on	
1009 – Key press detects and notifies individual key press and release events	1009 0 = off 1009 1 = on	serial output
1010 – Volume potentiometer reads and notifies the volume potentiometer setting	1010	value between 00 (0) and FF (255)
1011 – Microphone selects the microphone input source	1011 0 = microphone connector 1011 2 = covert microphone	none

The following CCTM commands are used during the fault finding of the remote control-head kit:

Table 14.2 CCTM commands for fault finding of the remote control-head kit

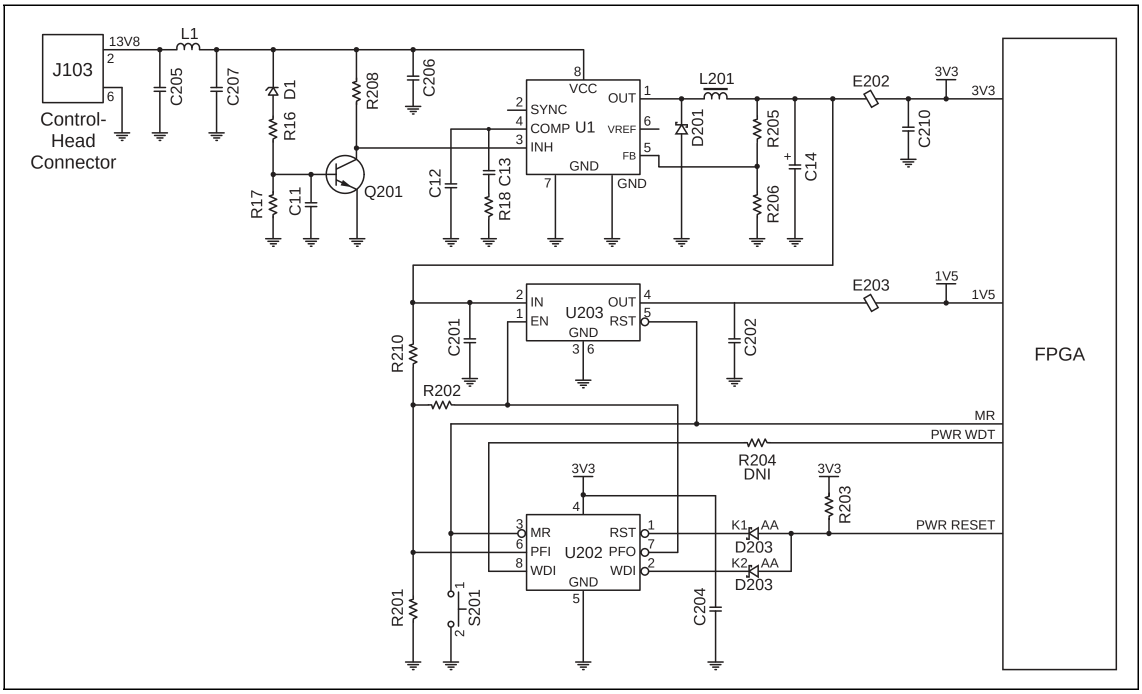
CCTM command	Entry at keyboard	Response on screen
1012 – Remote kit turns the audio amplifier on and off	1012 0 = off 1012 1 = on	none
1013 – Mute audio amplifier mutes and unmutes the audio amplifier	1012 0 = mute 1012 1 =unmute	none
1014 – Digital potentiometer reads the digital potentiometer	1014	value between 0 and 255
1017 – Audio amplifier gain sets the audio amplifier gain (4 levels)	1017 **x** where **x** is the gain (0 to 3)	none

14.2 Power Supply Faulty

A 3.3V regulator (U1) converts the switched 13.8V supply from the radio body to 3.3V. A 1.5V regulator (U203) converts the 3.3V to 1.5V.

A power-sense module (U202) verifies the outputs of the voltage regulators and—in the case of a fault—creates a power reset signal which is processed by the FPGA. If the start-up of the control head fails, the radio body reduces the switched 13.8V supply shortly after power is supplied.

Figure 14.1 Circuit diagram of the power supply circuitry



For all faults, check that the supply voltages are correct:

1. Check the 3.3V supply voltage between E202 and C210.

E202/C210: 3.3V

If the signal is correct, continue with step 4.

If the signal is not correct, visually inspect the components E202, D201, L201, R205, and R206 for open or shorted contacts. Replace if necessary. Continue with step 2.

2. Check the 13.8V supply voltage (9.7V to 17.2V) between pin 2 of the control-head connector J103 and pin 8 of U1.

J103 pin 2: 13.8V (V_S=9.7V…17.2V) U1 pin 8: 13.8V (V_S=9.7V…17.2V)

If the signal is correct, continue with step 3.

Note A fault in the control head can cause the radio body to reduce the switched 13.8V supply shortly after power is supplied. In this case, the control head must be supplied directly through pin 2 of connector J103.

If the signal is not correct, check the 13.8V supply voltage from the radio body. Return to step 1.

3. Check the inhibit signal at pin 3 of U1.

   U1 pin 3: high: >2.2V, low: < 0.7V
   D1: V_S – 5.1V

   If the signal is above 2.2V, visually inspect the components D1, R16, R17, R208, and Q201 for open or shorted contacts. Replace if necessary. Return to step 1.

   If the signal is low, replace U1. Return to step 1.

4. Check the 1.5V supply voltage at pin 4 of U203.

   U203 pin 4: 1.5V

   If the signal is correct, continue with step 6.

   If the signal is not correct, continue with step 5.

5. Check E203 for continuity.

   E203: 1.5V

   If E203 is correct, continue with step 6

   If E203 is faulty, replace E203 and return to step 4.

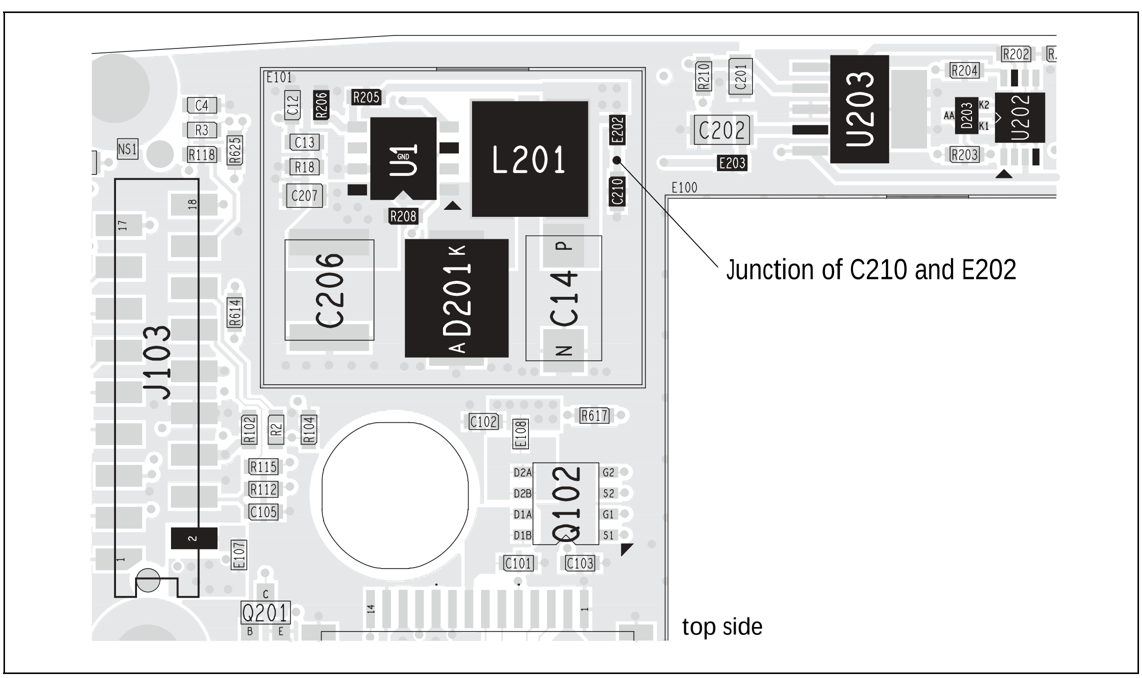
6. U202 detects a possible power failure and generates an output signal on pin 7. Check whether this signal is low.

   U202 pin 4: 3.3V
   U202 pin 7: 3.3V

   If pin 4 measures 3.3V and pin 7 is low, replace U202.

   If pin 4 measures 3.3V and pin 7 is high, replace U203.

Figure 14.2 PCB layout of the power supply circuitry



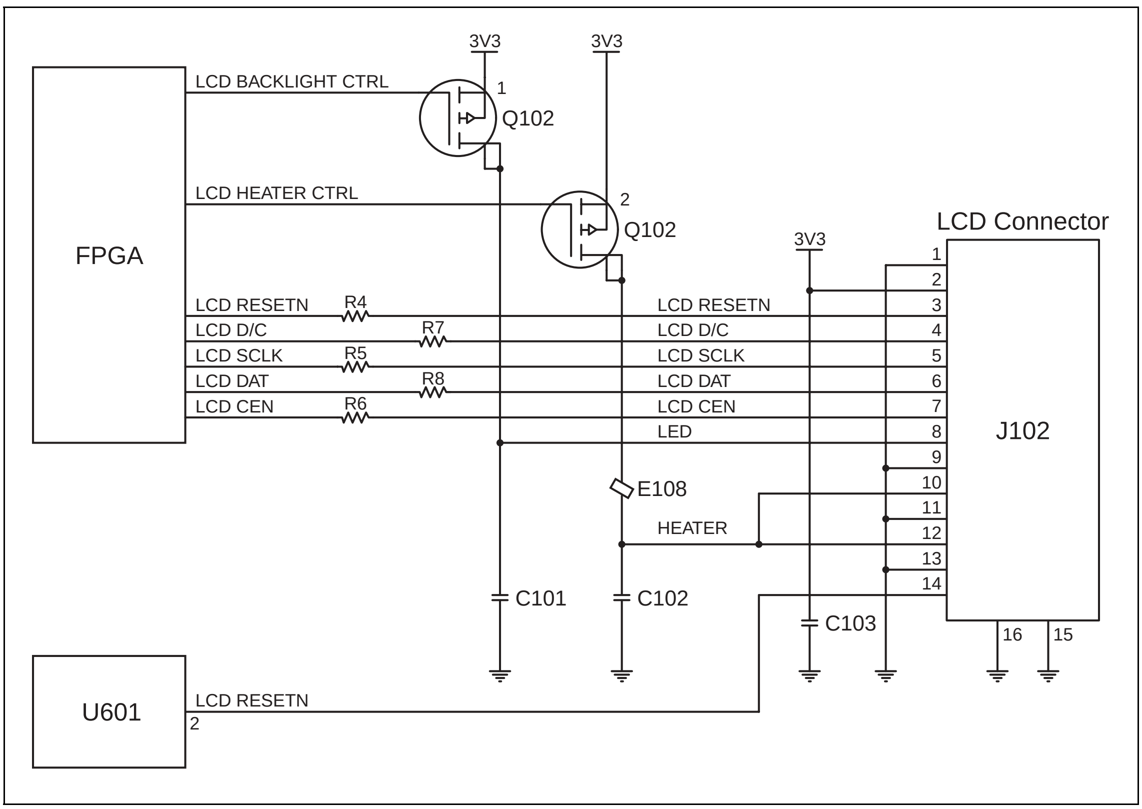
14.3 LCD Display Faulty

The LCD module is connected to the control-head board via the LCD connector. The LCD module display is controlled by a serial data link to the FPGA. A faulty LCD display can be caused by the following:

- a loose or dirty LCD loom connection,
- a faulty LCD, or
- a fault on the control-head board

Note This section only deals with the display of the LCD. For faults of the LCD backlighting, refer to "LCD Backlighting Faulty" on page 404.

Figure 14.3 Circuit diagram of the LCD circuitry



Note If some of the LCD pixels are faulty (usually complete rows or lines), send CCTM command **1006 1** to activate all LCD pixels. If some of the LCD pixels are faulty, replace the LCD.

If the LCD display is faulty:

1. Disconnect the LCD loom, visually inspect and clean the contacts, and reconnect the LCD loom. Visually inspect connector J102 for open or shorted contacts.

2. Check the 3.3V supply voltage at pin 2 of the LCD connector J102.

J102 pin 2: 3.3V

If the signal is not correct, refer to “Power Supply Faulty” on page 400.

Tip For a quick check of the LCD without having to disassemble the control head, connect a good LCD to the control head, or disconnect the LCD loom and connect it to a good control head.

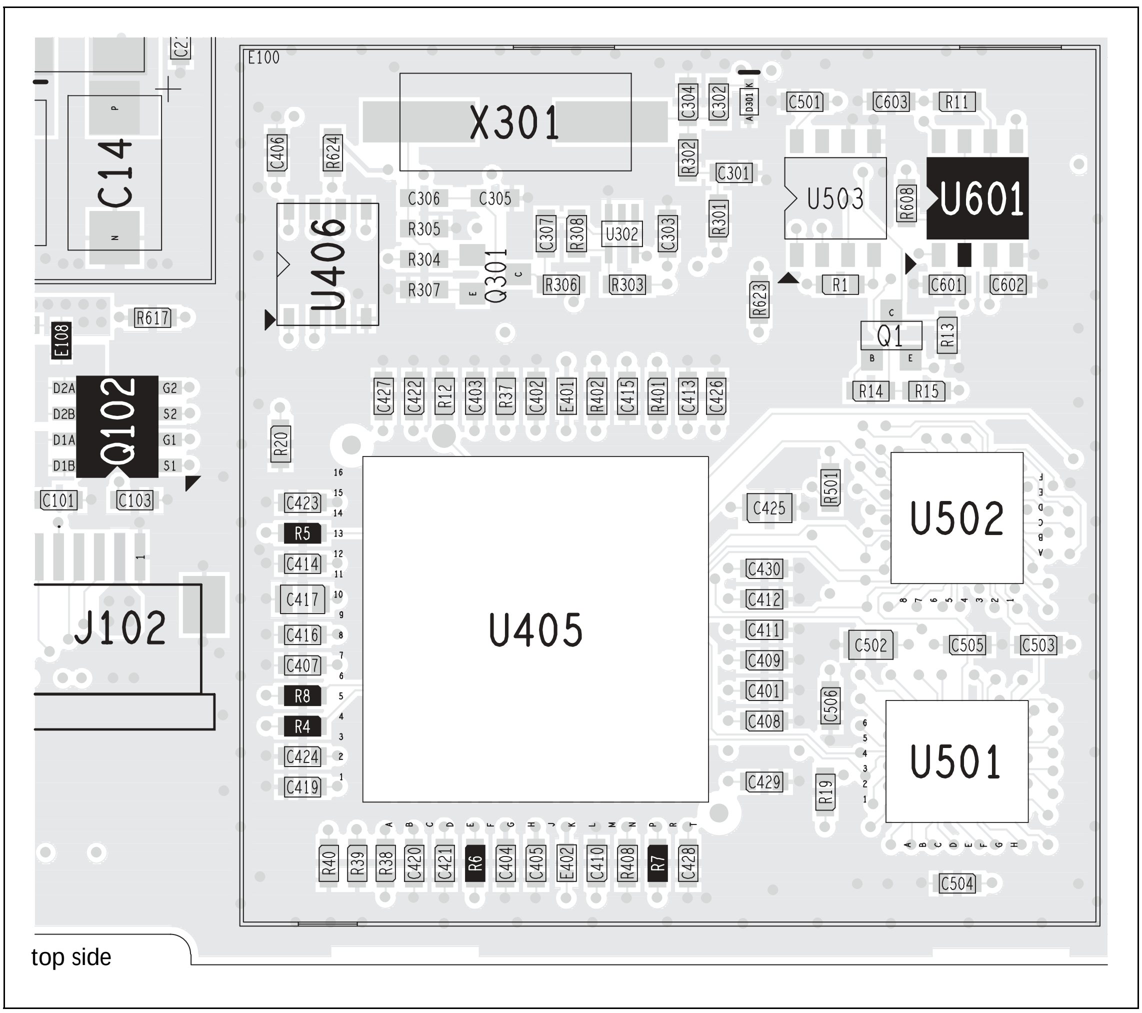
3. Replace the LCD. Take care not to scratch the soft polarizer material on the top side of the LCD.

4. Use an oscilloscope to check the signals of pins 3 to 7 of connector J102.

J102 pins 3 to 7:	The signals should be switching 0 to 3.3V in bursts of 0.125ms at approximately 1s intervals.

If any of the signals are missing or distorted, remove can E100 and check for continuity between the FPGA and the LCD connector. If necessary, replace the corresponding 100Ω resistor R4 to R8.

Figure 14.4 PCB layout of the LCD circuitry



14.4 LCD Backlighting Faulty

The backlighting incorporated in the LCD module is controlled by a data line from the FPGA, which switches a transistor on MOSFET Q102.

Note The LCD backlighting has four brightness settings: off = GND, on=3.3V, and two intermediate settings which are implemented by pulse-width modulation.

For a circuit diagram and PCB layout, refer to Figure 14.3 on page 402 and Figure 14.4 on page 403.

If the LCD backlighting is faulty:

1. Make sure that LCD backlighting has been enabled in the programming application.

2. Check the 3.3V supply voltage at pin 1 (S1) of Q102.

Q102 pin 1 (S1): 3.3V

   If the signal is correct, continue with step 3.

   If the signal is not correct, refer to "Power Supply Faulty" on page 400

3. Send CCTM command **1004 3** to switch on LCD backlighting.

4. Check the signal at pin 2 (G1) of Q102.

Q102 pin 2 (G1): GND (with backlighting switched on)

   If the signal is correct, continue with step 5.

   If the signal is not correct, visually inspect pin 2 for open contact. Otherwise the FPGA is faulty and the control-head board must be replaced.

5. Check the signal at pin 7 (DA1) of Q102.

Q102 pin 7 (D1A): 3.3V (with backlighting switched on)

   If the signal is correct, continue with step 6.

   If the signal is not correct, replace Q102.

6. Visually inspect whether the contact of pin 8 of connector J102 is open or shorted. Check the signal at pin 8 of connector J102.

J102 pin 8: 3.3V (with backlighting switched on)

   If the signal is correct, replace the LCD.

14.5 LCD Heating Faulty

The heating incorporated in the LCD module is controlled by a data line from the FPGA, which switches a transistor on MOSFET Q102.
A temperature signal from the LCD module is converted to a digital signal by an analog/digital converter (U601) and processed by the FPGA.

Note The temperature sensor signal is independent from the heating and is also used to control the LCD contrast.

For a circuit diagram and PCB layout, refer to Figure 14.3 on page 402 and Figure 14.4 on page 403.

If the LCD heating is faulty:

1. Check the temperature sensor signal at pin 14 of J102.

   J102 pin 14: 1.52V at 30°C, 1.58V at 25°C, 1.64V at 20°C, 1.69V at 15°C

   If the signal is below 0.7V (low) or above 2.5V, (high), the LCD temperature sensor is faulty.

2. Send CCTM command **1007** to read the temperature sensor value.

   If the value does not correspond to the ambient temperature, U601 is faulty.

3. Check the 3.3V supply voltage at pin 3 (S2) of Q102.

   Q102 pin 3 (S2): GND

   If the signal is not correct, refer to "Power Supply Faulty" on page 400.

4. Check the signal at pin 4 (G2) of Q102.

   Q102 pin 4 (G2): GND (with heating switched on)

   If the signal is not correct, visually inspect pin 4 for open contact. Otherwise the FPGA is faulty and the control-head board must be replaced.

5. Check the signal at pin 5 (DA2) of Q102.

   Q102 pin 5 (D2A): 3.3V (with heating switched on)

   If the signal is missing, replace Q102.

6. Visually inspect pins 10 and 12 of connector J102 for open or shorted contacts.

7. Check the signal at pins 10 and 12 of connector J102.

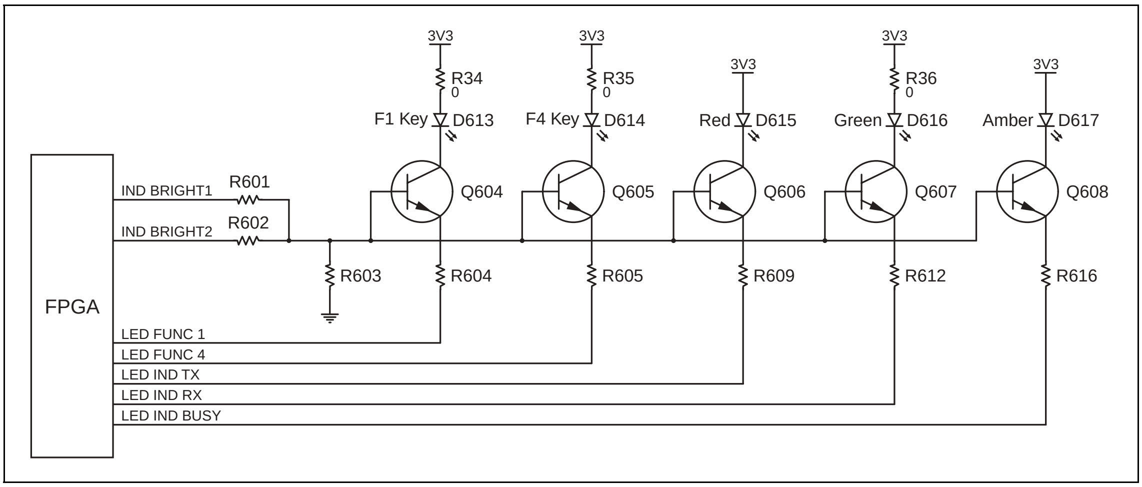
   J102 pins 10 and 12: 3.3V (with heating switched on)

   If the signal is not correct, replace the LCD.

14.6 Function Key LEDs or Status LEDs Faulty

The function key LEDs (F1 and F4) and the red, green and amber status LEDs each are controlled by an FPGA signal and a transistor (Q604 to Q608). The brightness level is controlled by two FPGA signals, resulting in four intensity levels (off, low, medium and high).

Figure 14.5 Circuit diagram of the function key LEDs and status LEDs



LED Faulty

If one of the function key LEDs or status LEDs is faulty:

1. Send CCTM command **1001 x 1** (where **x** is the LED number: 0 = F1, 1 = F4, 2 = amber, 3 = green, 4 = red) to activate the relevant LED.

2. Check the resistors R34, R35, and R36 in the paths of the green LEDs.

R34: 0Ω
R35: 0Ω
R36: 0Ω

3. Measure the voltage at the point between the LED and the transistor.

D613/Q604 (F1 key LED):	1.87V (on)	1.40V (off)
D614/Q605 (F4 key LED):	1.87V (on)	1.40V (off)
D615/Q606 (red status LED):	1.92V (on)	1.57V (off)
D616/Q607 (green status LED):	1.87V (on)	1.40V (off)
D617/Q608 (amber status LED):	1.89V (on)	1.48V (off)

If the voltage is incorrect, replace the LED.

4. Replace the corresponding transistor.

LED Intensity Faulty

If the intensity of the LEDs is faulty:

1. Send CCTM command **1001 0 1** to activate the LED of the F1 key.

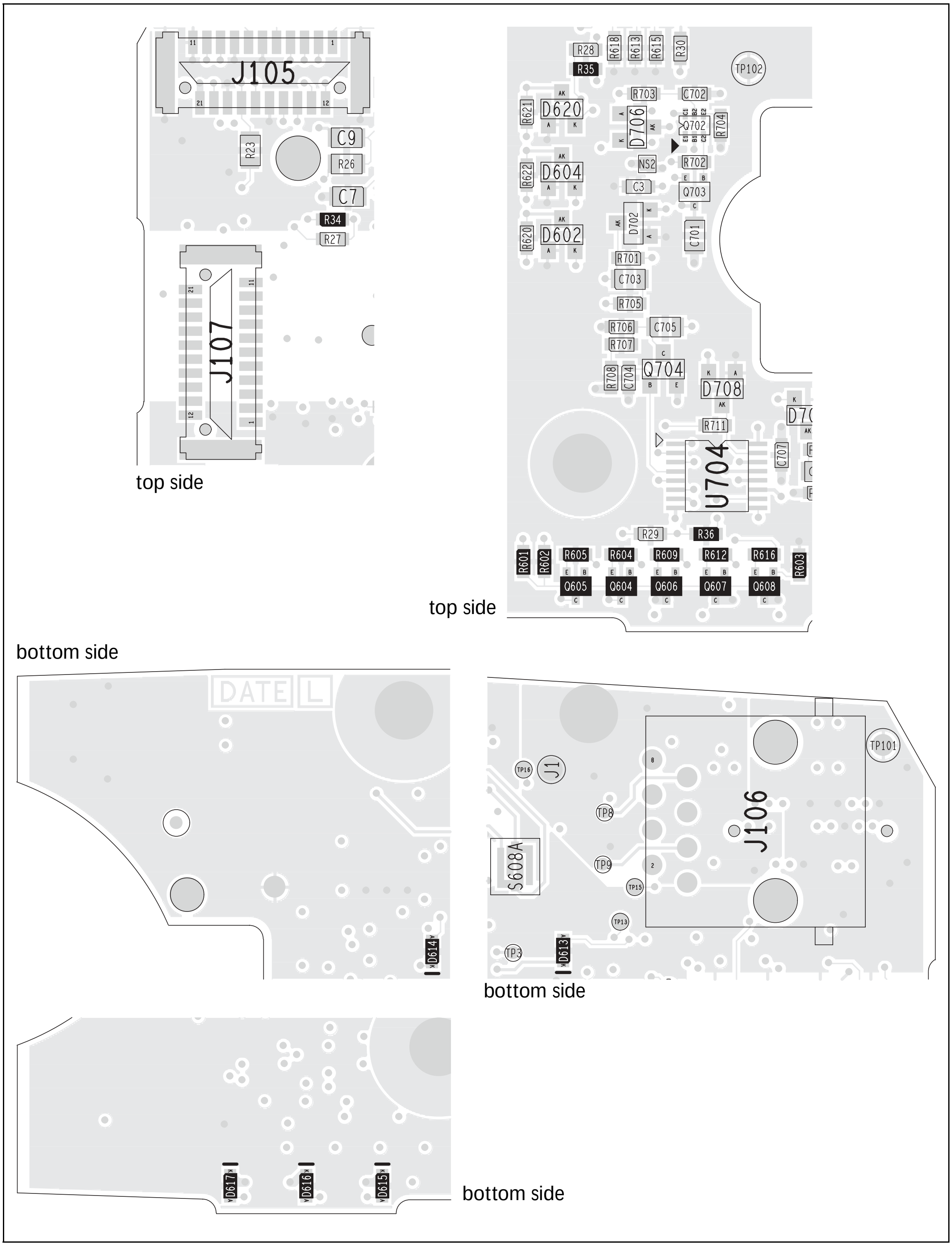
2. Send CCTM command **1002 3** to set the LED intensity level to high.

3. Check the resistors R601 and R602, and replace if necessary.

R601: 2.2kΩ R602: 5.62kΩ

If the resistors are okay, the FPGA is faulty and the control-head board must be replaced.

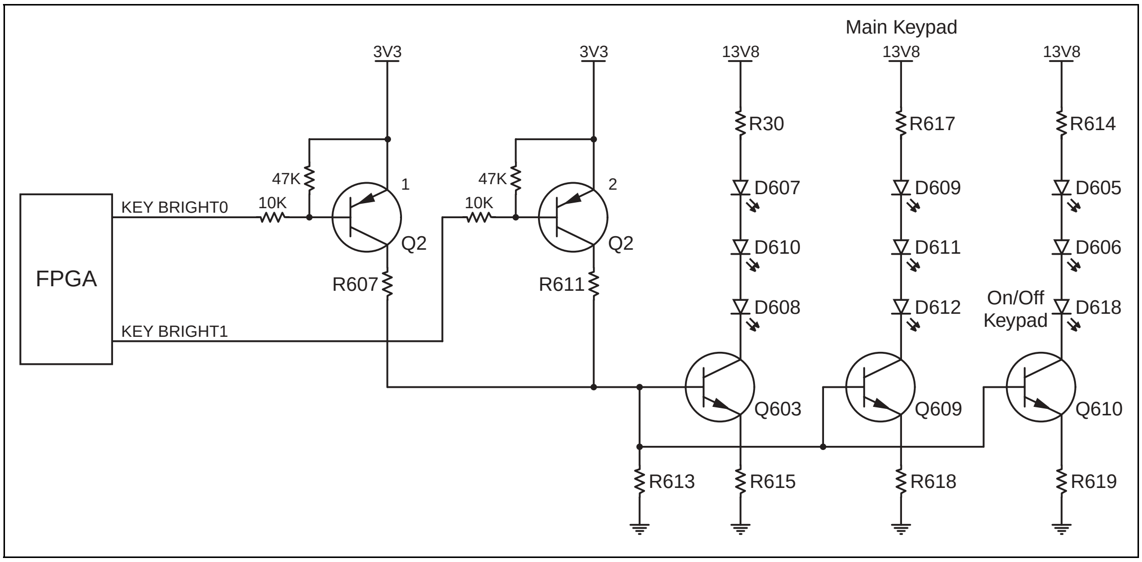
Figure 14.6 PCB layout of the function key LED and status LED circuitry



14.7 Keypad Backlighting Faulty

The keypad backlighting LEDs are controlled by two FPGA signals and two transistors (Q2), resulting in four intensity levels (off, low, medium and high). The keypad backlighting LEDs are arranged in two groups for the main keypad and one group for the on/off keypad, each group consisting of three LEDs.

Figure 14.7 Circuit diagram of the keypad backlighting circuitry



One LED or One Group of LEDs Faulty

If one LED or one group of three LEDs is faulty:

1. Send CCTM command **1003 x** (where **x** is the intensity: 0 = off, 1 = low, 2 = medium, 3 = high) to switch on keypad backlighting.

2. Check the 13.8V supply voltage of the relevant branch.

3. From top to bottom, check the resistor, the three LEDs, and the transistor of the relevant branch for continuity.

R30: 4.7Ω D607: 1.9V (on) D610: 1.9V (on) D608: 1.9V (on) Q603: 1.9V (on) R615: 56Ω	R617: 4.7Ω D607: 1.9V (on) D609: 1.9V (on) D611: 1.9V (on) Q609: 1.9V (on) R618: 56Ω	R614: 4.7Ω D605: 1.9V (on) D606: 1.9V (on) D618: 1.9V (on) Q610: 1.9V (on) R619: 56Ω

All LEDs Faulty or Intensity Faulty

If all LEDs are faulty or the intensity is faulty:

1. Send CCTM command **1003 x** (where **x** is the intensity: 0 = off, 1 = low, 2 = medium, 3 = high) to switch on keypad backlighting.

2. With the intensity set to high, check the signals at pins 2 (B1) and 5 (B2) of Q2.

Q2 pin 2 (B1): GND Q2 pin 5 (B2): GND

If any of these signals are incorrect, the FPGA is faulty and the control-head board must be replaced.

3. Check the signals at pins 6 (C1) and 3 (C2) of Q2. Check the signals at pins 1 (E1) and 4 (E2) of Q2.

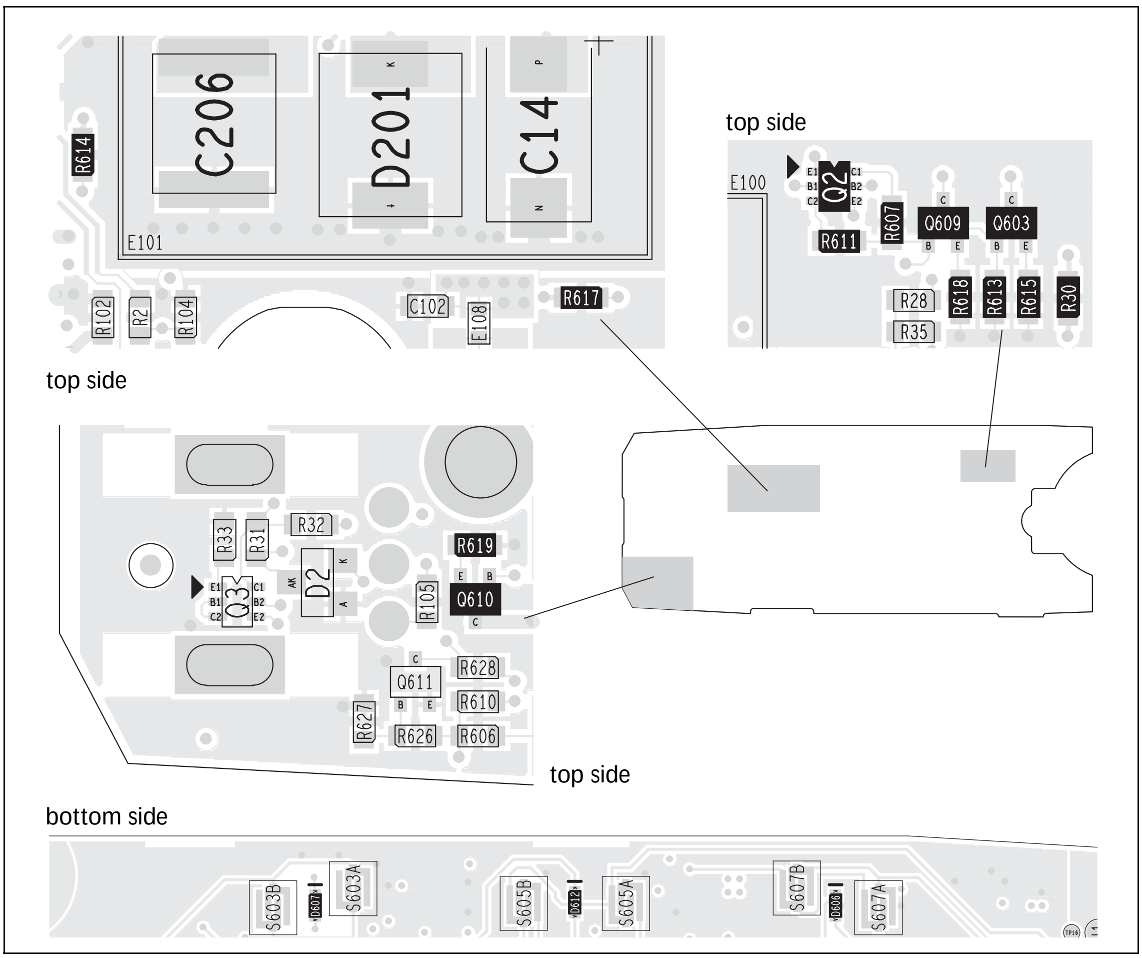
Q2 pin 6 (C1): 3.3V Q2 pin 3 (C2): 3.3V Q2 pin 1 (E1): 3.3V Q2 pin 4 (E2): 3.3V

If any of these signals are incorrect, Q2 is faulty.

4. Check the resistors R607, 611, and R613 for shorted or open circuits.

R607: 3.3kΩ R611: 2.2kΩ R613: 1kΩ

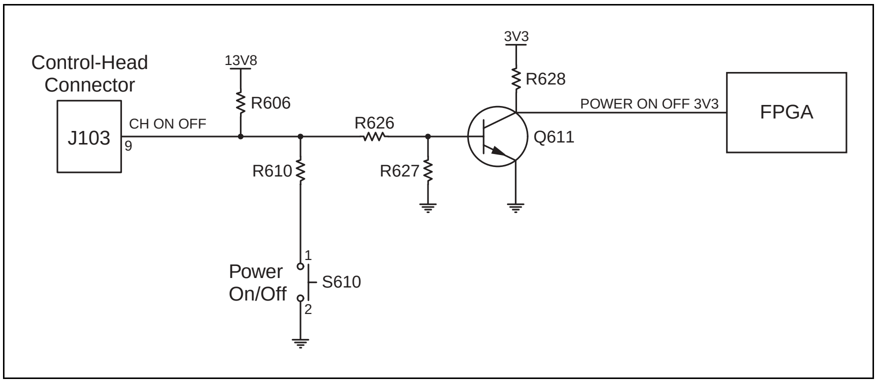
Figure 14.8 PCB layout of the keypad backlighting circuitry



14.8 On/Off Key Faulty

When battery power (13.8V) is applied to the radio, a press of the ON/OFF key will create an active low signal (CH ON OFF) back to the radio body to initiate the power-on or power-off sequence. This key-press will also be detected by the FPGA of the control head through Q611 as an active high signal (POWER ON OFF 3V3). For more information on the start-up process, refer to "Software Architecture" on page 44.

Figure 14.9 Circuit diagram of the ON/OFF key



If the ON/OFF key is faulty:

1. Use isopropyl alcohol and a soft lens-cleaning cloth to clean the pads S610 on the control-head board for the ON/OFF key.

2. Check the CH ON OFF signal level from the radio at pin 9 of the control-head connector J103.

J103 pin 9: 13V

   If the signal is approx. 13V, continue with step 5.

   If near or at ground, continue with step 3.

3. Visually inspect pin 9 of connector J103 for open or shorted contacts.

4. Verify the source of the signal to pin 9 of connector J103 from the radio (without the control-head connector).

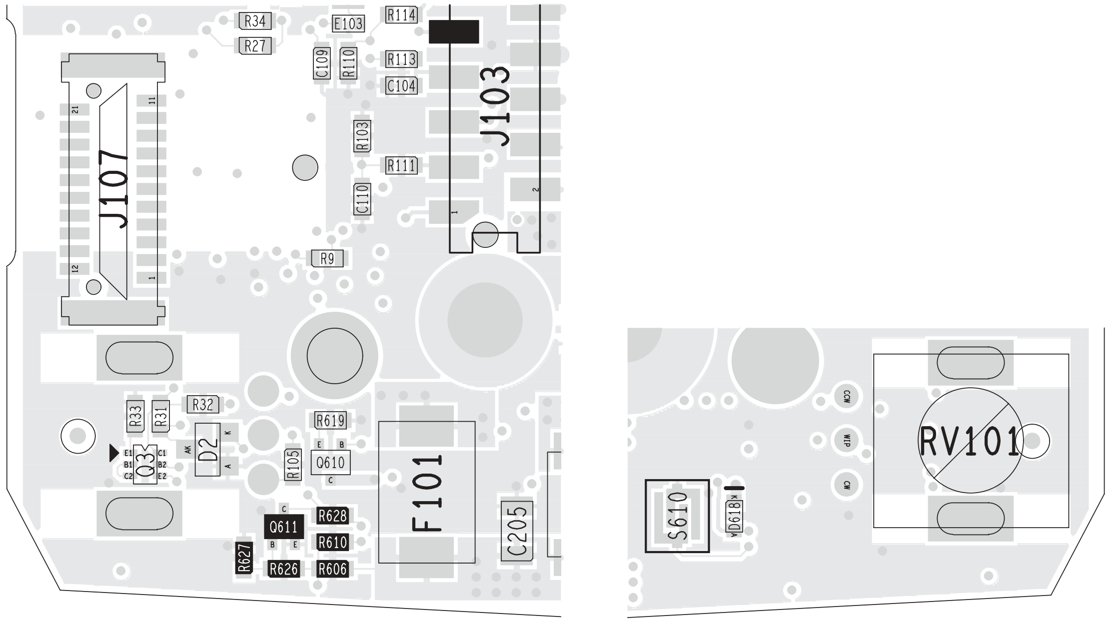
5. Visually inspect R610, R606, and R624 for short-circuit to adjacent components. Replace if necessary. Return to step 2.

6. Visually inspect R610 for shorted or open circuits. Repair if necessary. Retest switch.

7. Verify continuity between R610 and switch S610, and continuity between switch S610 and ground.

   If the continuity cannot be restored, replace the control-head board.

Figure 14.10 PCB layout of the power on/off key circuitry



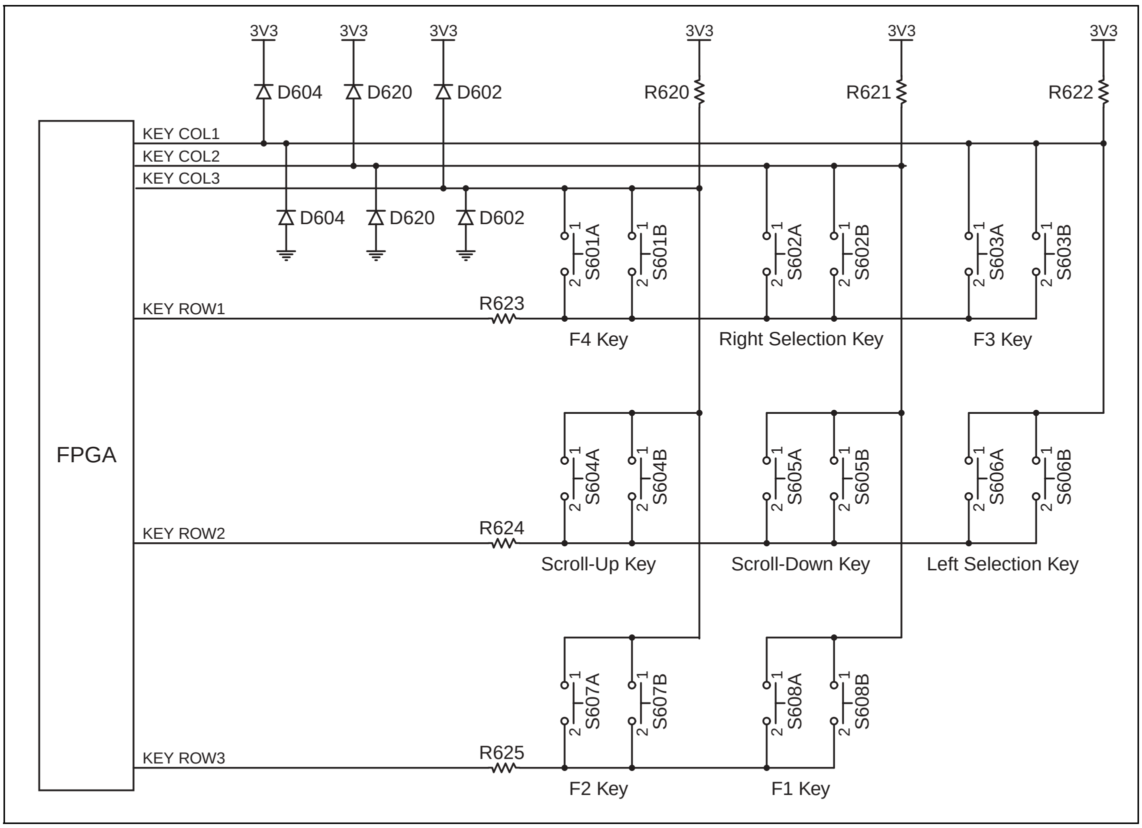
top side

bottom side

14.9 Function, Scroll, or Selection Keys Faulty

The eight keys of the main keypad (function, scroll, and selection keys) are connected to the FPGA by an array of three columns and three rows. During idle operation, the KEY ROW signals are driven low by the FPGA and the KEY COL signals (pulled high by an external resistor) are monitored for activity by the FPGA. A key-press will generate a high-to-low transition on the associated column KEY COL signal. This, in turn, will initiate a sequence of high output levels on the KEY ROW signals to identify which key was pressed.

Figure 14.11 Circuit diagram of the function, scroll, and selection keys



The signal at the column side of the switch should be 3.3V. The row side of the switch should be GND. A successful press will cause transition on associated KEY_COL signal to low.

Note CCTM command **1009** can be used to monitor keypad press and release events.

One Key Faulty

If an individual key is faulty:

1. Use isopropyl alcohol and a soft lens-cleaning cloth to clean the pad of the tact switch.

2. Visually inspect both tact switches (A and B) of a key for short-circuits. Repair if necessary.

Several Keys Faulty

The keys can be grouped into columns and rows of three or two keys, as illustrated in Figure 14.11.

If one column of keys is faulty:

1. Visually inspect the associated resistor and diodes for open or shorted circuits.

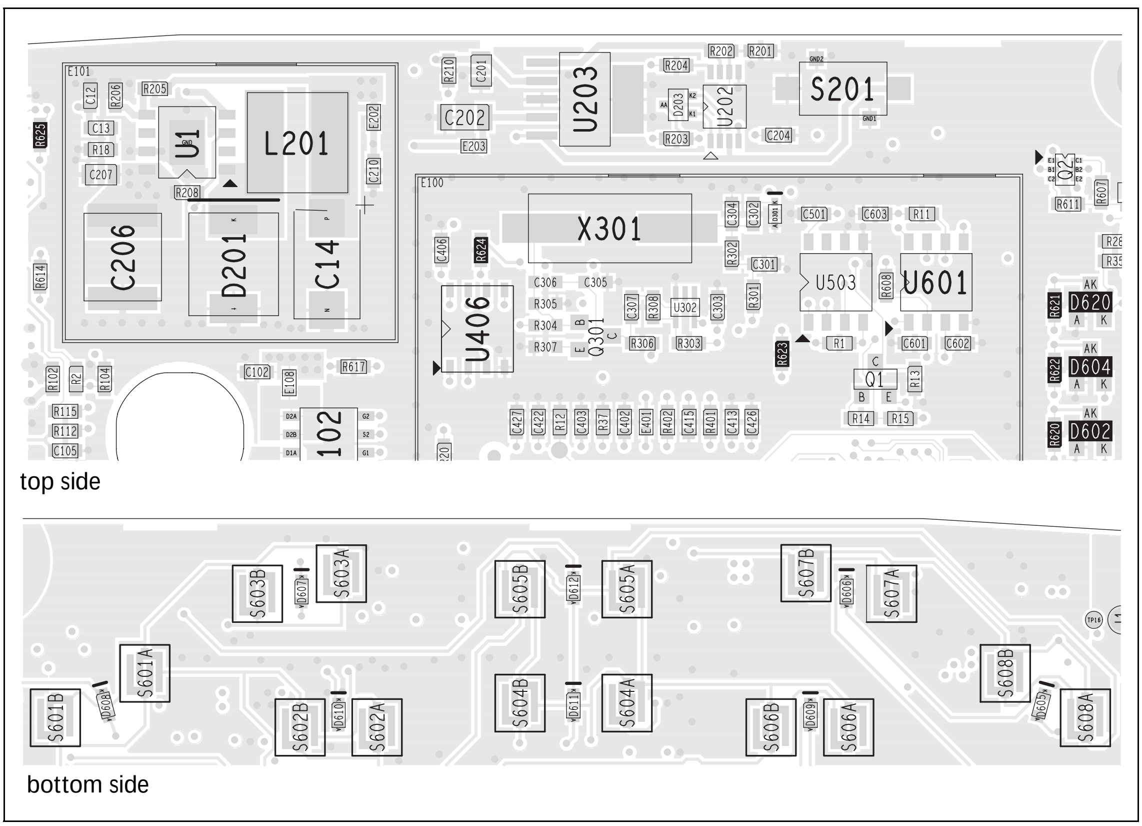
F2 key	R620	F1 key	R621	F3 key	R622
F4 key	D602	right selection key	D620	left selection key	D604
scroll-up key		scroll-down key			

If one row of keys is faulty:

1. Visually inspect the associated resistor for open or shorted circuits.

F3 key	R623	scroll-up key	R624	F1 key	R625
F4 key		scroll-down key		F2 key	
right selection key		left selection key			

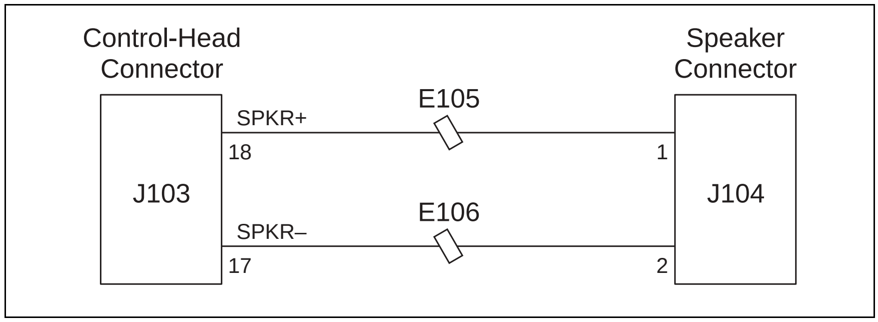
Figure 14.12 PCB layout of the function, scroll, and selection key circuitry



14.10 Speaker Faulty

The two speaker lines (SPK+ and SPK–) are connected to the speaker connector (J104) which is connected to the control-head connector (J103) through two ferrite beads (L105 and L106).

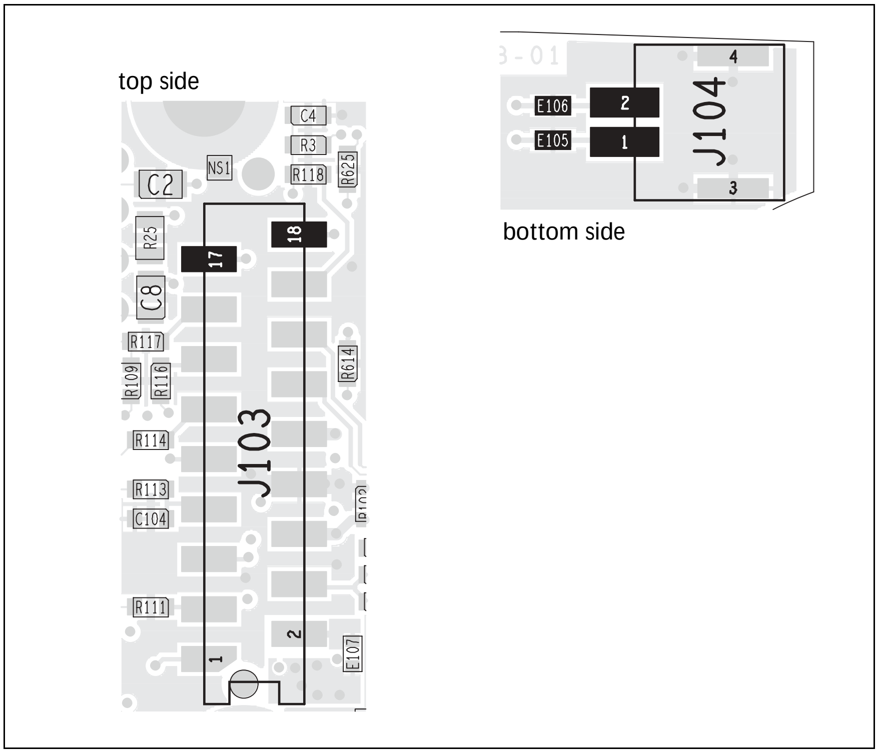
Figure 14.13 Circuit diagram of the speaker circuitry



If the speaker functions only intermittently or the audio level is low:

1. Check the continuity from the speaker connector J104 to pin 18 (SPK+) and pin 17 (SPK–) of the control-head connector J103.
2. Inspect E105 and E106.
3. Replace the speaker.
4. If there is still a fault, go to "Volume Control Faulty" on page 416.

Figure 14.14 PCB layout of the speaker circuitry

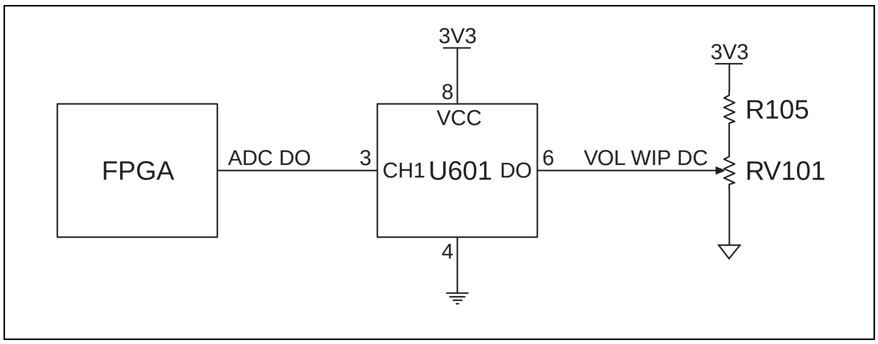


14.11 Volume Control Faulty

The voltage level of the volume control potentiometer is converted to a digital signal by an analog/digital converter, processed by the FPGA and transmitted to the main board.

Note This section only describes faults to the volume control caused by the control head, which has been established during the initial servicing tasks by means of elimination test. For fault finding of the amplifier circuitry of the main board, refer to xxx on page yyy.

Figure 14.15 Circuit diagram of the volume control circuitry



If the volume control works only intermittently, works only at full volume, or does not work at all:

1. Check that the voltage between pins CW and WIP of the volume-control potentiometer RV1 varies linearly between about 0V and 3.3V.

RV1: 0 to 3.3V

   If the voltage is not correct, replace the potentiometer RV1

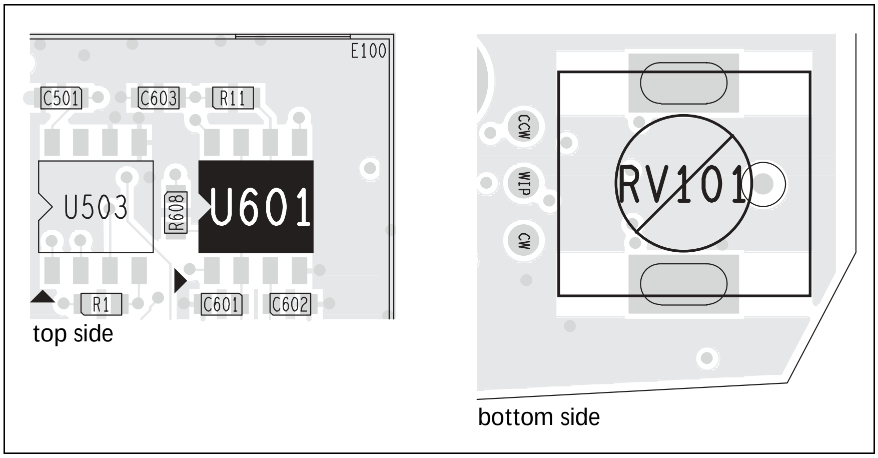
2. Send CCTM command **1010** to read the volume potentiometer.

No volume: reading 0 (1V) Full volume: reading 255 (3.3V)

   If the signal is not correct, remove can E100 and replace the analog/digital converter U601.

   If the signal is correct, replace the speaker.

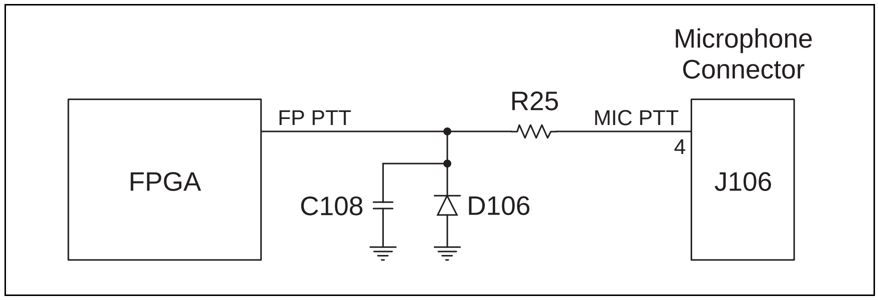
Figure 14.16 PCB layout of the volume control circuitry



14.12 PTT Faulty

The PTT signal from the microphone connector is connected to the FPGA via a resistor (R25) and relayed to the radio as a digital command.

Figure 14.17 Circuit diagram of the PTT circuitry



Note This section only describes faults to the PTT caused by the control head, which has been established during the initial servicing tasks by means of elimination test. For fault finding of the ??? circuitry of the main board, refer to xxx on page yyy.

If the PTT is faulty:

1. With no PTT switch and hookswitch operated, check whether pin 4 of J106 is 4V.

J106 pin 4: 4V

   If the signal is correct, continue with step 2.

   If the signal is incorrect, inspect R25 for open or shorted contacts. Repair if necessary. Repeat step 1.

2. With the PTT switch operated, check whether the same 4V are pulled to ground on the other side of R25.

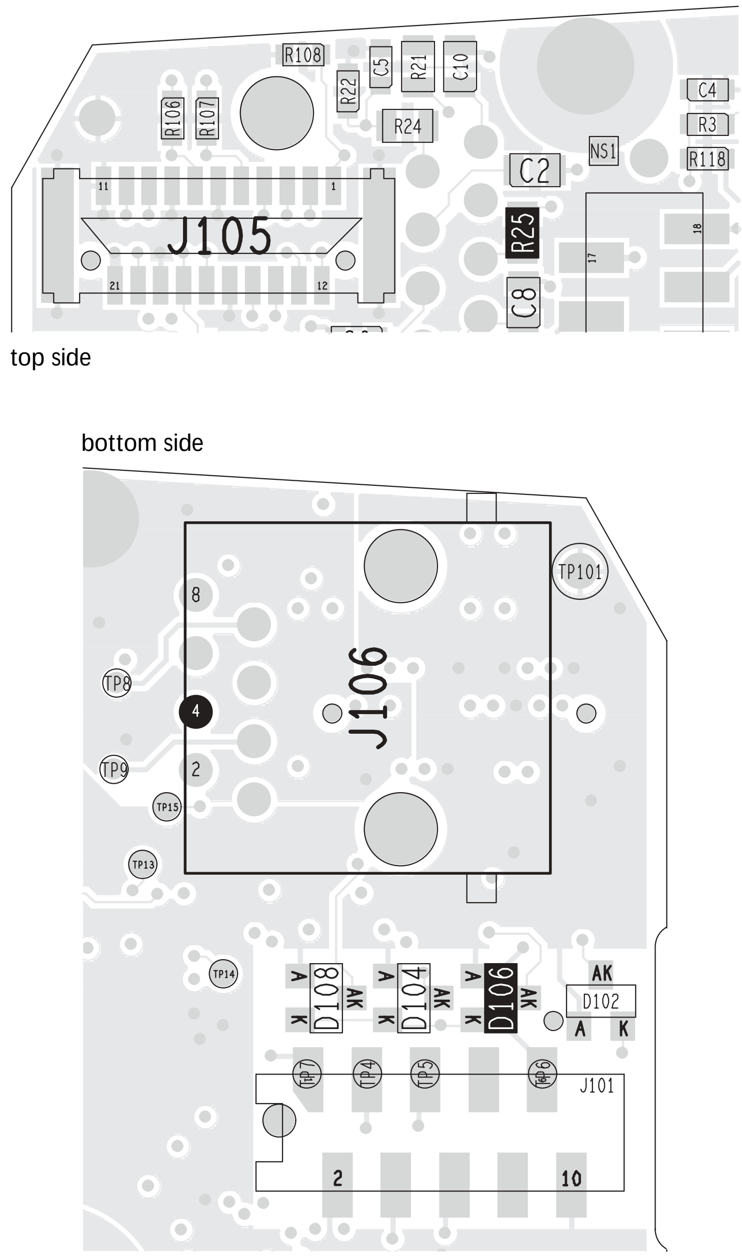
   If the signal is correct, continue with step 3.

R25: GND

   If the signal is incorrect, inspect D106 and C108 for short-circuits. Repair if necessary.

3. Verify continuity between R25 and the FPGA. Repair PCB track if possible.

Figure 14.18 PCB layout of PTT circuitry



15 Spare Parts

Introduction

This section lists all serviceable parts (except PCB components) of the

- radio body (Figure 15.1, Figure 15.2, and Table 15.1)
- control head (Figure 15.3 and Table 15.2)

Figure 15.1 Spare parts of the radio body (sheet 1 of 2)

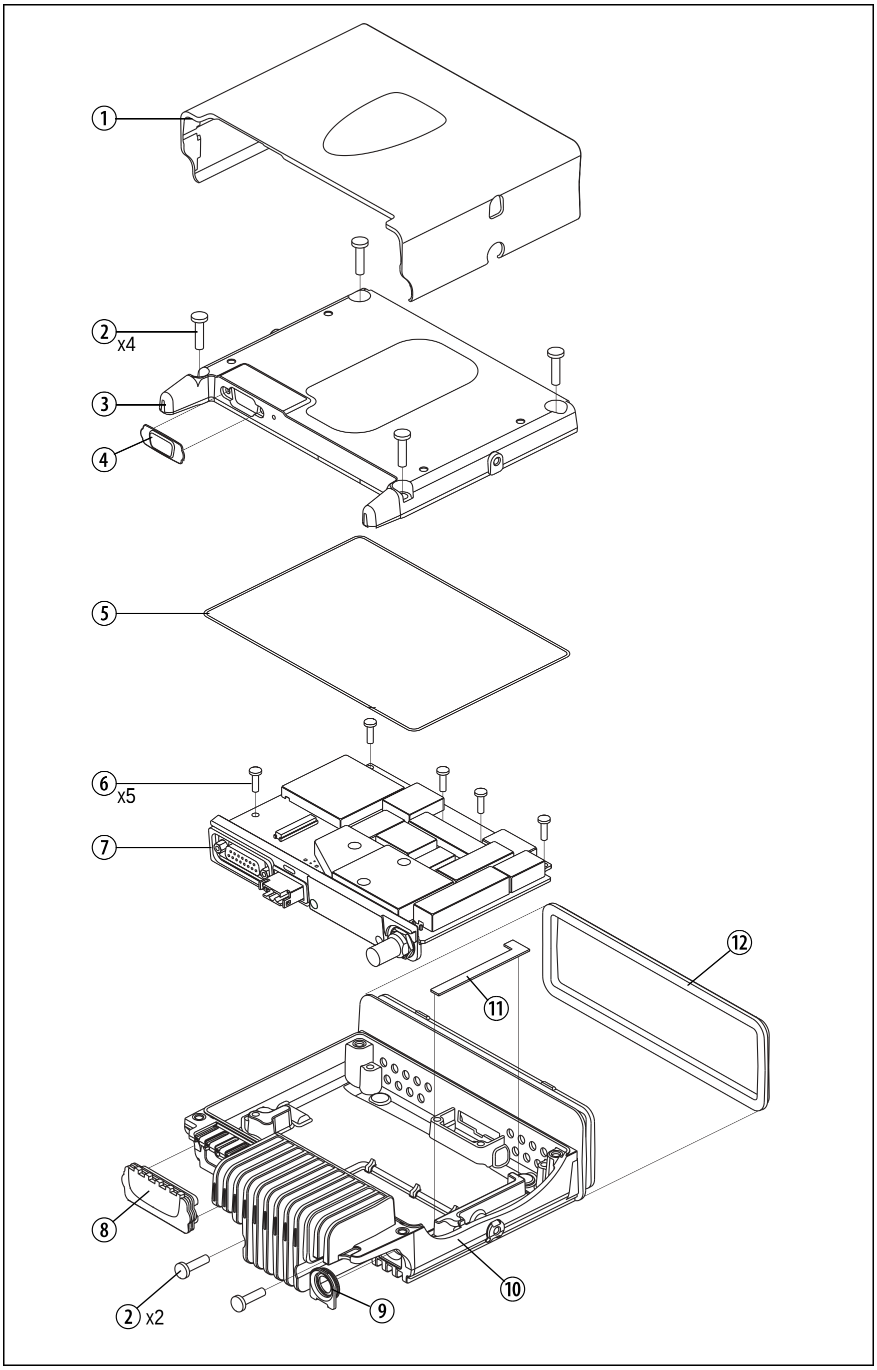


Figure 15.2 Spare parts of the radio body (sheet 2 of 2)

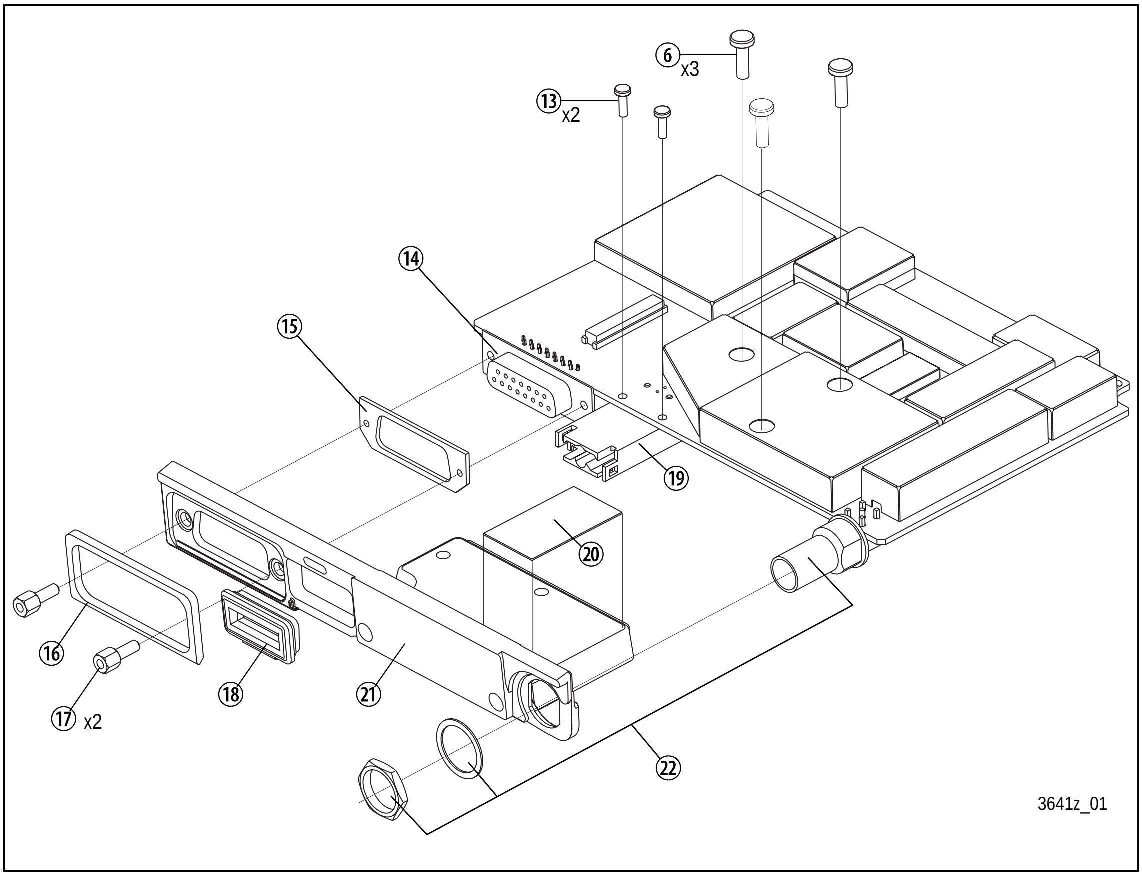


Table 15.1 Spare parts of the radio body

Pos.	Description	Qty.	IPN	Spares Kit
①	Cover	1	–	TMAA22-02 mech. kit
②	Screw M4 x 16	6	349-02067-**xx**	TMAA22-02 mech. kit
③	Lid	1	312-01091-**xx**	–
④	Bung for aperture for external options connector	1	302-50000-**xx**	TMAA22-02 mech. kit
⑤	Main seal	1	362-01109-**xx**	TMAA22-02 mech. kit
⑥	Screw M3 x 10	8	349-02066-**xx**	TMAA22-02 mech. kit
⑦	Main-board assembly (50W/40W radios) Main-board assembly (25W radios)	1 1	XMAB34-**yyzz** XMAB32-**yyzz**	TMAA22-34**yyzz** TMAA22-32**yyzz**
⑧	Bung for auxiliary connector	1	302-50001-**xx**	TMAA22-02 mech. kit
⑨	Seal for RF connector	1	362-01113-**xx**	TMAA22-02 mech. kit
⑩	Chassis (50W/40W radio) Chassis (25W radio)	1 1	303-11301-**xx** 303-11225-**xx**	– –
⑪	Gap pad for chassis (50W/40W radio only)	1	369-01048-**xx**	TMAA22-02 mech. kit TMAA22-98 gap pad kit
⑫	Control-head seal	1	362-01115-**xx**	TMAA22-02 mech. kit TMAA22-07 seals kit
⑬	Screw for power connector (50W/40W radio) Screw for power connector (25W radio)	2 2	346-10022-07 346-10030-08	–
⑭	Auxiliary connector [SK101]	1	240-02022-**xx**	–
⑮	Inner foam seal for auxiliary connector	1	362-01110-**xx**	TMAA22-02 mech. kit
⑯	Outer foam seal for auxiliary connector	1	362-01112-**xx**	TMAA22-02 mech. kit
⑰	Lock-nut for auxiliary connector	1	354-01043-**xx**	TMAA22-02 mech. kit
⑱	Rubber seal for power connector (50W/40W radio) Rubber seal for power connector (25W radio)	1 1	362-01127-**xx** 362-01114-**xx**	TMAA22-02 mech. kit
⑲	Power connector [PL100] (50W/40W radio) Power connector [PL100] (25W radio)	1 1	240-00040-**xx** 240-00027-**xx**	–
⑳	Gap pad for copper plate (50W/40W radio only)	1	369-01049-**xx**	TMAA22-02 mech. kit TMAA22-98 gap pad kit
㉑	Heat-transfer block	1	308-13147-**xx**	–
㉒	Antenna connector [SK103] (mini-UHF), or Antenna connector [SK103] (BNC) (both incl. lock washer and hexagonal nut)	1 1	240-00029-**xx** 240-00028-**xx**	–

The characters **xx** in an IPN stand for the issue number. Items will always be the latest issue at the time the radio is manufactured.
The characters **yy** in an IPN or spares kit number stand for the abbreviated frequency band.
For more information, refer to "Frequency Bands" on page 14.
The characters **zz** in an IPN or spares kit number stand for the type of RF connector (00=BNC, 01=mini-UHF).

Figure 15.3 Spare parts of the control head

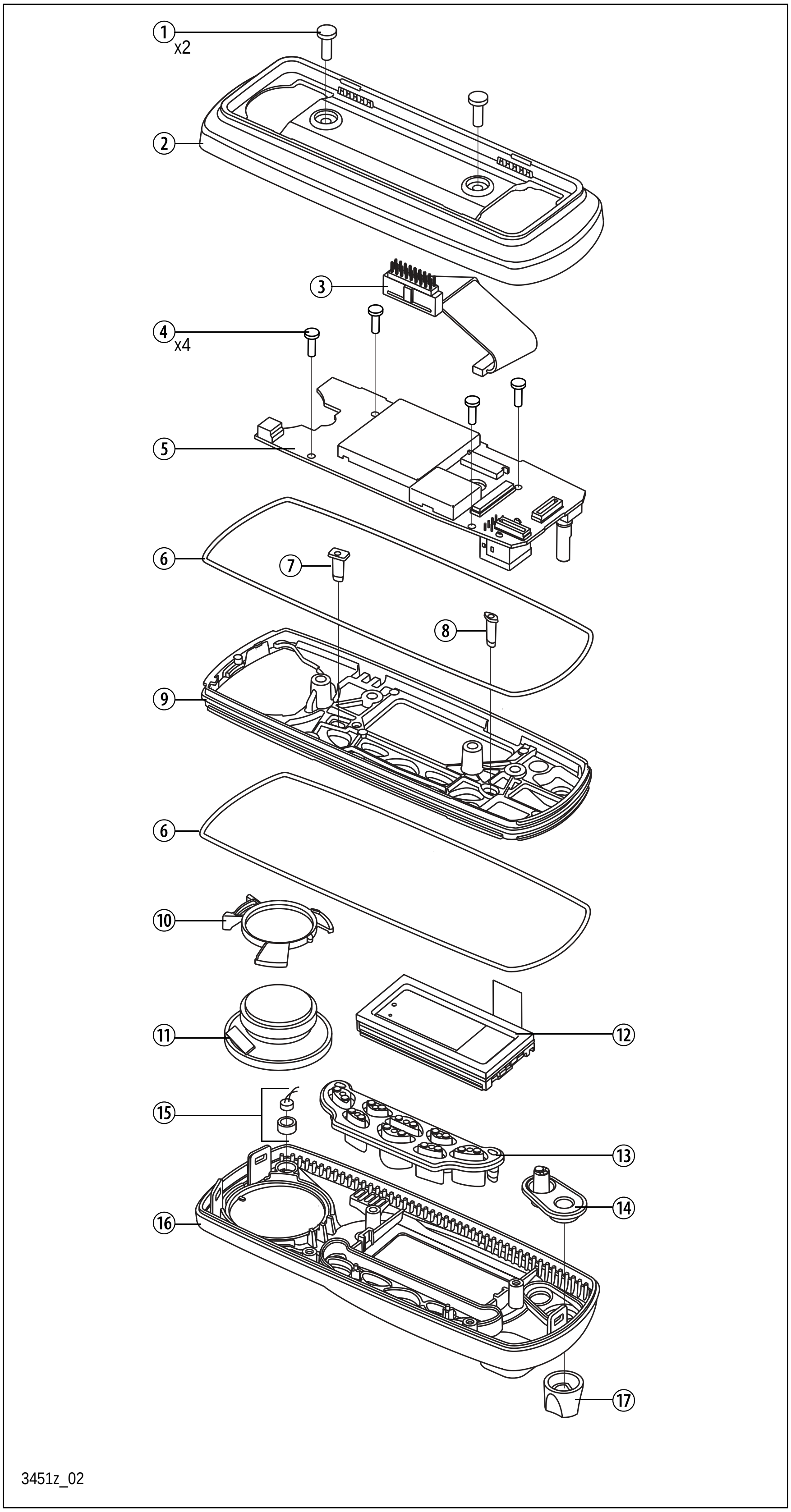


Table 15.2 Spare parts of the control head

Pos.	Description	Qty.	IPN	Spares Kit[a]
①	M4 x 12 Taptite screw	2	349-02058-**xx**	TMAA22-97
②	Adaptor flange	1	349-02067-**xx** 301-00020-**xx**	TMAA22-97
③	Control-head loom (with female-female adaptor) – female-female adaptor	1	219-02882-**xx** 240-00021-41	TMAA22-97
④	3 x 10 PT screw	4	346-10030-**xx**	TMAA22-97
⑤	Control-head board	1	–	TMAA22-96 (x3)
⑥	Seal	2	362-01124-**xx**	TMAA22-97
⑦	Short light pipe	1	262-00003-**xx**	TMAA22-97
⑧	Long light pipe	1	262-00004-**xx**	TMAA22-97
⑨	Space-frame	1	319-30077-**xx**	TMAA22-97
⑩	Speaker clamp	1	303-50111-**xx**	TMAA22-97
⑪	Speaker	1	252-00011-**xx**	TMAA22-97
⑫	LCD assembly	1	–	TMAA22-94 (x3)
⑬	Main keypad	1	311-03124-**xx**	TMAA22-97
⑭	Power keypad	1	311-03120-**xx**	TMAA22-97
⑮	Concealed microphone	1	–	TMAA02-07
⑯	Front panel assembly	1	–	TMAA22-97
⑰	Knob for volume-control potentiometer	1	311-01054-**xx**	TMAA22-97
The characters **xx** in an IPN stand for the issue number. Items will always be the latest issue at the time the radio is manufactured.				

a. Spares kit TMAA22-97 contains an assembled control head without control-head board, concealed microphone and LED assembly.

Chapter 3
Accessories

Chapter 3 – Contents

16 TMAA02-08 Keypad Microphone

The TMAA02-08 keypad microphone plugs into the microphone socket on the graphical-display radio control head, and enables users to make calls to other radios, groups, or to a PABX or PSTN. The types of call that you can make depends on the way your radio has been programmed.

As well as the PTT key, there are twelve alphanumeric keys, two scroll keys, and a left and right selection key on the keypad microphone. The selection keys and scroll keys duplicate the keys on the control head.

The microphone button operates a hookswitch, which is closed when the microphone is connected to the microphone clip, and open when the microphone is removed from the microphone clip. The function of the hookswitch is determined by the radio programming.

16.1 Operation

16.1.1 Using the Keypad

The 12 alphanumeric keys on the keypad microphone are used to dial call strings and enter text.

The left selection key , right selection key and scroll keys or have the same functions as the left and right selection keys and scroll keys on the control head.

Pressing an alphanumeric key enters the first character on the key into the control head display. Subsequent quick presses toggle through the other characters on the key. Pausing for longer than one second moves the cursor on to the next place in the dialled string or text message on the control head display, ready for the next key press.

If the wrong number or character has been selected, use the left selection key on either the microphone keypad or control head to clear it and move back one.

16.1.2 Using the PTT Key

The PTT key is used for voice transmission.

1. Select the required channel or group.

2. Check that the channel is clear. If the green LED is glowing, the channel is busy and you may not be able to transmit.

3. Once the channel is clear (the green LED is off), lift the microphone off the microphone clip.

4. Hold the microphone about 5cm (2 inches) from your mouth and press the PTT key to transmit.

5. Speak clearly into the microphone and release the PTT key when you have finished talking.

   While you are transmitting, the red LED glows and the transmit icon appears in the icon bar.

16.1.3 Using the Keypad Microphone to Make a Local or Address-Book Call

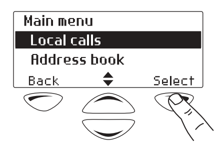
There are two ways of making a local call or address-book call:

- you can either dial the number for the call you want to make,
- you can use the radio’s Main menu, or
- you can use a combination of the two methods, as in the following example.

Example: Making a local call to your Dispatcher

1. Select the required channel.

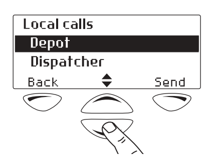
2. Select Menu > Local Calls.



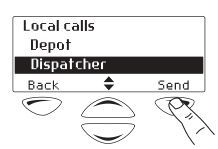
3. Press the key corresponding to the first letter of the name of the person you want to call.

   You will have to use short presses to toggle through the characters on the key until you get the correct one (see “Using the Keypad” on page 431).

4. The first name in the Local Calls menu starting with the keyed letter is displayed.

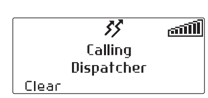


5. Scroll through the list of local calls until the call you want appears.



6. Press **Send**.

   The call details appear in the display, the red LED glows and the transmit icon appears in the icon bar.



7. When the called party responds, lift the microphone off the microphone clip.

8. Hold the microphone about 5cm (2 inches) from your mouth and press the PTT key to transmit.

9. Speak clearly into the microphone and release the PTT key when you have finished talking.

16.2 Installation

16.2.1 Installing the Microphone

Important The keypad microphone grommet must be installed whenever the microphone is plugged into the microphone socket. When installed, the grommet has two functions:

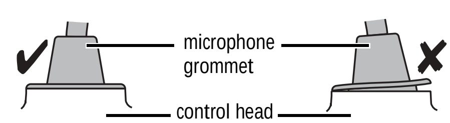
- to prevent damage to the microphone socket when there is movement of the microphone cord, and
- to ensure that the control head is sealed against water, dust and other environmental hazards.

1. Make sure the radio is turned off, then plug the keypad microphone cord into the microphone socket on the radio control head.

Important The radio will only recognize the presence of the keypad microphone when the radio is powered on, so that if the microphone is plugged in after the radio has been powered on, it will not recognize the keypad microphone. Also, if the keypad microphone is plugged in on power up but is later unplugged, then plugged back in, the radio will not recognize it again until the next power cycle.

2. Slide the microphone grommet along the microphone cord and push two adjacent corners of the grommet into the microphone socket cavity.
3. Squeeze the grommet and push the remaining corners into position.
4. Check that the grommet is seated correctly in the cavity.

Figure 16.1 Correct keypad microphone grommet seating



16.2.2 Installing the Microphone Clip

Install the microphone clip in the most convenient location for the radio user. It must be within easy reach of the user, but in such a position that the microphone PTT key cannot be inadvertently activated or jammed on.

16.3 Radio Programming

The radio does not need to be programmed to recognize the presence of a keypad microphone, as this is automatically done when the radio is powered on.

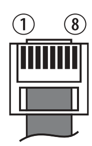
However, there are a few related fields that should be configured, as required, to enable the keypad microphone to be used effectively. For example, in conventional mode there are check boxes called “Selcall Call Dialling”, “DTMF Call Dialling” and “Phone Patch Call Dialling”. There is also an option “Conventional Dialling Type” field, where you can program the radio to dial labels or channels from the default display.

Refer to the online help of the programming application for more information about these programming options.

16.4 Interface Specification

The following table and diagram summarizes the signals used for the keypad microphone on the radio’s microphone connector and shows the interface between the keypad microphone and the radio.

Table 16.1 Keypad microphone connector - pins and signals

	Pin	Signal	Colour	Description
	1	RX audio	—	not connected
	2	13.8V	black	power supply
	3	TXD	green	transmit serial data
	4	PTT	white	PTT and hookswitch
	5	MIC	blue	audio from the microphone
	6	GND	red	ground
	7	RXD	yellow	receive serial data
	8	IO	—	not connected

16.5 Circuit Description

The microphone has a standard 12-key telephone keypad which is connected to a micro-processor. The micro-processor performs the keypad scanning using eight GPIO lines. When a valid keypress is detected, a serial command is sent from the microphone.

16.6 PCB Information

Note The IPN number on the actual PCB for the keypad microphone may differ to that shown in the following information.

16.6.1 TMAA02-08 Parts List (PCB IPN 226-00145-04)

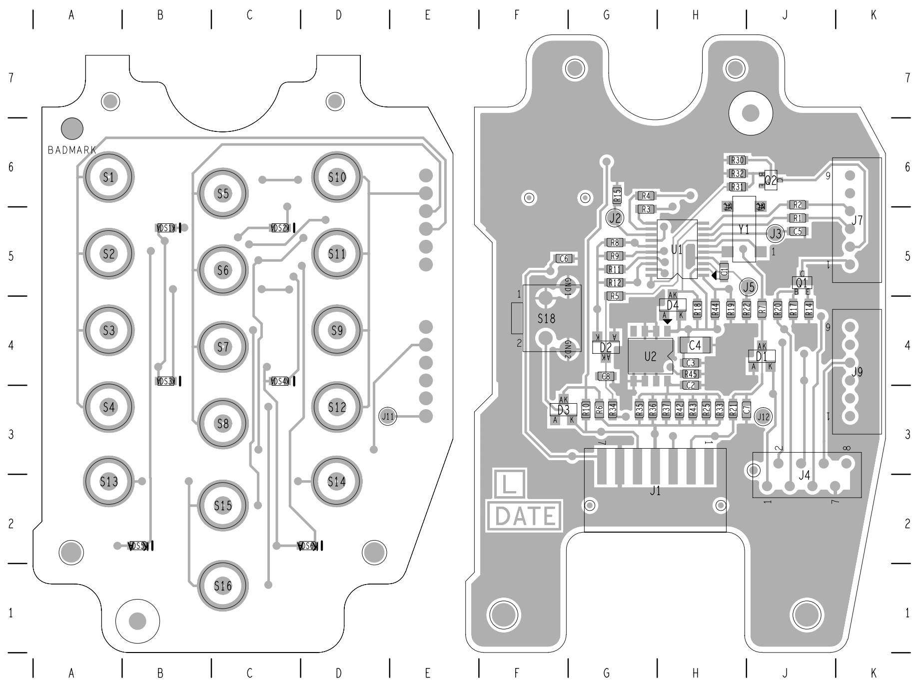
Ref.	IPN	Description
C1	018-16100-00	Cap 0603 100n 16vx7r±10%
C2	018-16100-00	Cap 0603 100n 16vx7r±10%
C3	018-16100-00	Cap 0603 100n 16vx7r±10%
C4	015-07220-08	Cap Cer 1206 2u2 16v X7r
C5	018-16100-00	Cap 0603 100n 16vx7r±10%
C6	018-15100-00	Cap 0603 10n 50v X7r ±10%
C7	018-15100-00	Cap 0603 10n 50v X7r ±10%
C8	018-15100-00	Cap 0603 10n 50v X7r ±10%
D1	001-10054-00	Diode SMD BAT54s
D2	001-10054-00	Diode SMD BAT54s
D3	001-10054-00	Diode SMD BAT54s
D4	001-10054-00	Diode SMD BAT54s
DS1	008-10004-00	LED SMD 0603 Green Ultrabright
DS2	008-10004-00	LED SMD 0603 Green Ultrabright
DS3	008-10004-00	LED SMD 0603 Green Ultrabright
DS4	008-10004-00	LED SMD 0603 Green Ultrabright
DS5	008-10004-00	LED SMD 0603 Green Ultrabright
DS6	008-10004-00	LED SMD 0603 Green Ultrabright
J4	240-04020-50	Skt 8w 2x4 Pcb Mtg M/Match
Q2	000-10084-71	Xstr BC847BW NPN SOT323
R1	038-14220-00	Res 0603 2k2 1/16w +-5%
R2	038-14220-00	Res 0603 2k2 1/16w +-5%
R3	038-14220-00	Res 0603 2k2 1/16w +-5%
R4	038-14220-00	Res 0603 2k2 1/16w +-5%
R5	038-13100-10	Res 0603 100e 1/16w ± 1%
R7	038-13100-10	Res 0603 100e 1/16w ± 1%
R8	038-15470-10	Res 0603 47k 1/16w +-1%
R9	038-15470-10	Res 0603 47k 1/16w +-1%
R10	038-15100-10	Res 0603 10k 1/16w +-1%
R11	038-15470-10	Res 0603 47k 1/16w +-1%
R12	038-15470-10	Res 0603 47k 1/16w +-1%
R13	038-13180-00	Res 0603 180e 1/16w ± 5%
R14	038-12100-10	Res 0603 10e 1%
R15	038-15470-10	Res 0603 47k 1/16w +-1%
R16	038-13180-00	Res 0603 180e 1/16w ± 5%
R17	038-13470-00	Res 0603 470e 1/16w +-5%
R18	038-17100-00	Res 0603 1m 1/16w +-5%
R19	038-15120-00	Res 0603 12k 1/16w +-5%
R20	038-14120-10	Res 0603 1K2 1%
R21	038-14100-10	Res 0603 1k0 1/16w +-1%
R22	038-15470-10	Res 0603 47k 1/16w +-1%
R23	038-13180-00	Res 0603 180e 1/16w ± 5%
R24	038-13180-00	Res 0603 180e 1/16w ± 5%
R25	038-13680-00	Res 0603 680e 1/16w +-5%
R26	038-13180-00	Res 0603 180e 1/16w ± 5%
R27	038-13180-00	Res 0603 180e 1/16w ± 5%
R28	038-13180-00	Res 0603 180e 1/16w ± 5%
R29	038-13180-00	Res 0603 180e 1/16w ± 5%
R30	038-10000-00	Res 0603 Zero 0hm 1/16w ± 5%
R31	038-14120-10	Res 0603 1K2 1%
R32	038-13470-00	Res 0603 470e 1/16w +-5%
R33	038-13680-00	Res 0603 680e 1/16w +-5%
R34	038-14100-10	Res 0603 1k0 1/16w +-1%
R35	038-13680-00	Res 0603 680e 1/16w +-5%
R36	038-13680-00	Res 0603 680e 1/16w +-5%
R37	038-13680-00	Res 0603 680e 1/16w +-5%
R38	038-13180-00	Res 0603 180e 1/16w ± 5%
R39	038-13180-00	Res 0603 180e 1/16w ± 5%
R40	038-13180-00	Res 0603 180e 1/16w ± 5%
R41	038-13180-00	Res 0603 180e 1/16w ± 5%
R42	038-13680-00	Res 0603 680e 1/16w +-5%
R43	038-13680-00	Res 0603 680e 1/16w +-5%
R45	038-14180-00	Res 0603 1k8 1/16w
S18	232-00010-29	Sw Tact 3.85 Stem Red Pcb
U1	002-43010-11	IC SMD MSP430F1011AIPW Microc
U2	002-14931-00	IC L4931CD33 3.3v 250Ma Regso8
Y1	274-10010-05	Xtal SMD 32.768KHz Plstc 2MMh
	226-00145-04	PCB TMAA-08 K/Pad Micph

16.6.2 TMAA02-08 Grid Reference List (PCB IPN 226-00145-04)

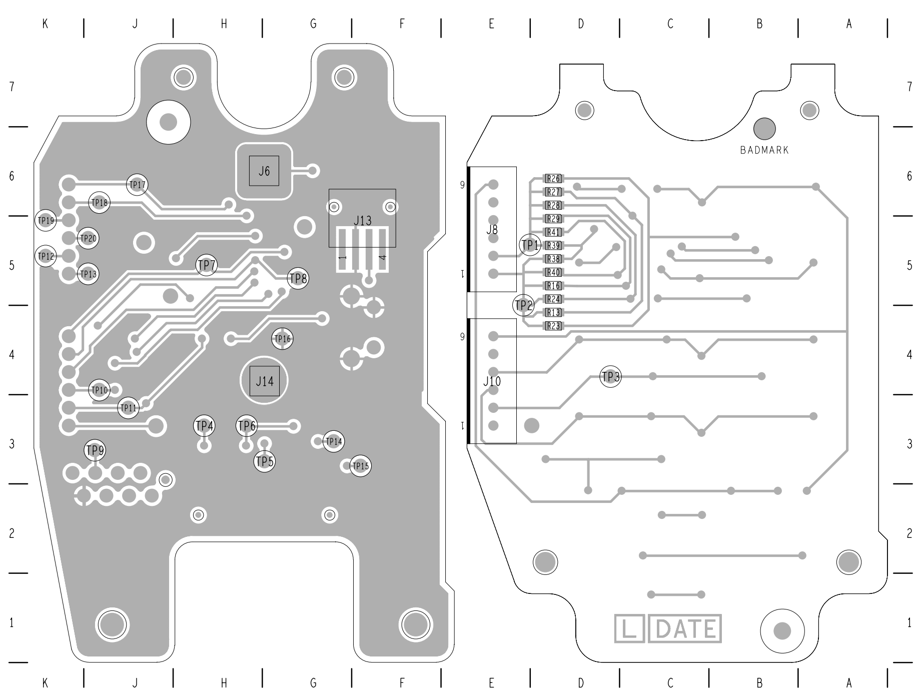
Ref.	PCB	Circuit
Top Side Components		
Y1	H5	1G10
U2	G4	1K13
U1	H5	1G9
S9	D4	1F3
S8	C3	1E2
S7	C4	1F2
S6	C5	1F2
S5	C6	1G2
S4	A3	1E1
S3	A4	1F1
S2	A5	1F1
S18	F4	1J7
S16	C1	1E4
S15	C2	1F4
S14	D2	1F4
S13	A2	1G4
S12	D3	1E3
S11	D5	1F3
S10	D6	1G3
S1	A6	1G1
R9	G5	1G6
R8	G5	1G6
R7	J4	1H6
R6	G3	1K6
R5	G5	1H8
R45	H4	1J8
R44	H4	1G7
R43	H3	1J12
R42	H3	1J12
R4	G6	1D7
R37	H3	1J12
R36	G3	1J12
R35	G3	1K12
R34	G3	1H6
R33	H3	1K12
R32	H6	1B9
R31	H6	1B9
R30	H6	1B8
R3	G5	1D7
R25	H3	1K12
R22	J4	1F11
R21	H3	1H5
R20	J4	1B7
R2	J6	1D7
R19	H4	1G7
R18	H4	1F8
R17	J4	1B7
R15	G6	1G8
R14	J4	1B6
R12	G5	1G6
R11	G5	1G6
R10	G3	1K6
R1	J5	1D7
Q2	J6	1B8
Q1	J5	1B7
J9	K3	1F5 1E5 1G5
J7	K5	1D5 1B5
J5	J5	1F11
J4	J2	1E12
J3	J5	1F7
J2	G5	1G8
J12	J3	1E5
J11	D3	1E4
J1	G2	1J4

Ref.	PCB	Circuit
DS6	D2	1C3
DS5	B2	1C3
DS4	C4	1C3
DS3	B4	1C2
DS2	C5	1C2
DS1	B5	1C1
D4	H4	1F8
D3	F3	1K6 1K7
D2	G4	1J7 1H6
D1	J4	1H5
C8	G4	1H6
C7	J3	1H5
C6	F5	1J6
C5	J5	1F8
C4	H4	1J14
C3	H4	1J14
C2	H4	1J12
C1	H5	1H10
Bottom Side Components		
TP9	J3	1F5
TP8	G5	1G5
TP7	H5	1G5
TP6	H3	1K5
TP5	G3	1K5
TP4	H3	1K5
TP3	D4	1E5
TP20	J5	1D6
TP2	E5	1B4
TP19	K5	1D6
TP18	J6	1D6
TP17	J6	1D5
TP16	G4	1J13
TP15	F3	1J6
TP14	G3	1J6
TP13	J5	1B5
TP12	K5	1B5
TP11	J3	1E5
TP10	J4	1E5
TP1	E5	1B4
R41	D5	1B4
R40	D5	1B3
R39	D5	1C3
R38	D5	1B3
R29	D5	1C3
R28	D6	1C2
R27	D6	1C2
R26	D6	1C1
R24	D5	1B2
R23	D4	1B1
R16	D5	1B3
R13	D4	1B2
J8	E5	1D5 1B5
J6	G6	1K8
J14	G4	1K8
J13	F5	1J6
J10	E3	1E5 1G5 1F5

16.6.3 Keypad Microphone Board Layout

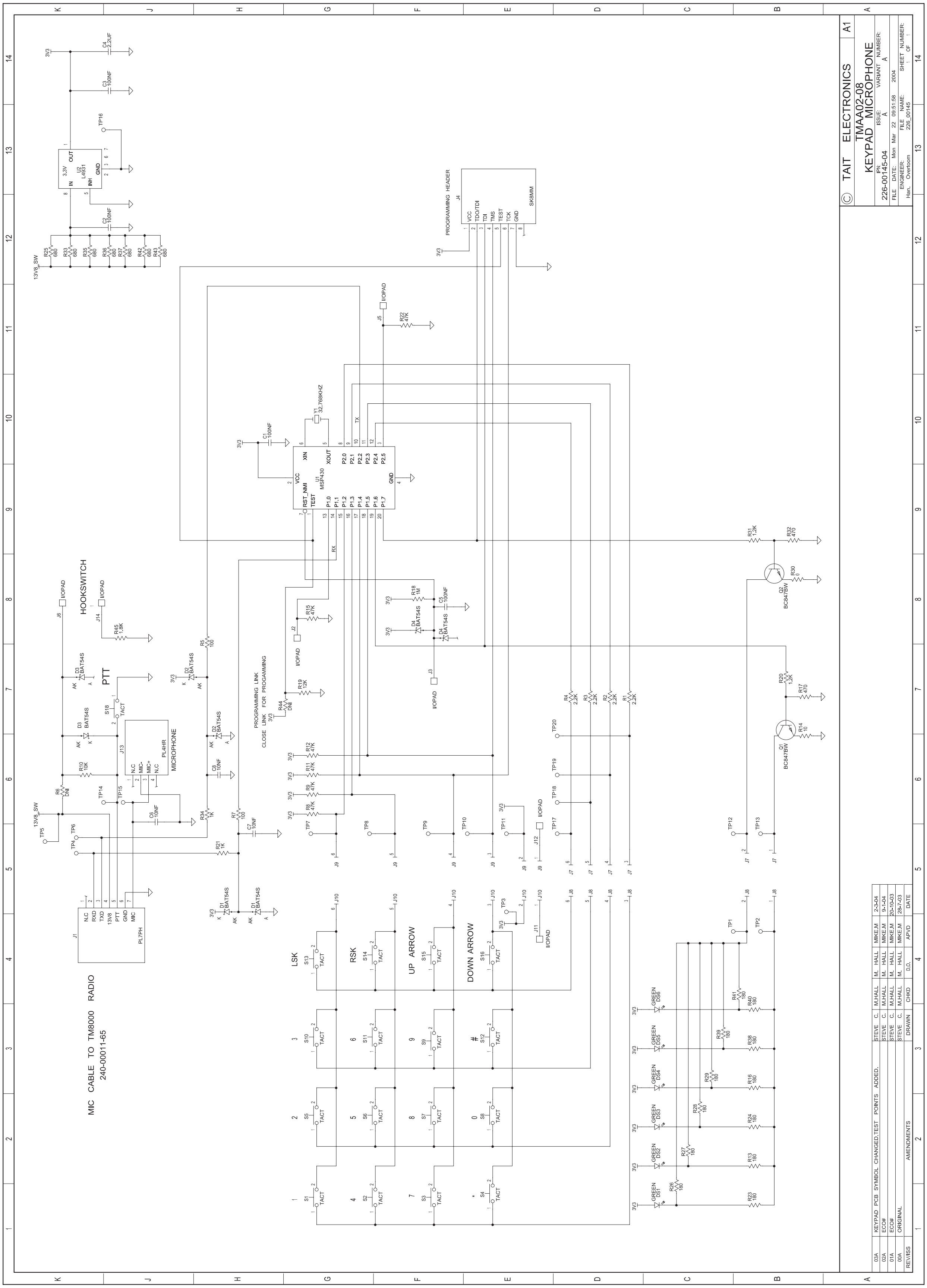


IPN 226-00145-04 (top side)



IPN 226-00145-04 (bottom side)

16.6.4 Keypad Microphone Board Circuit Diagram

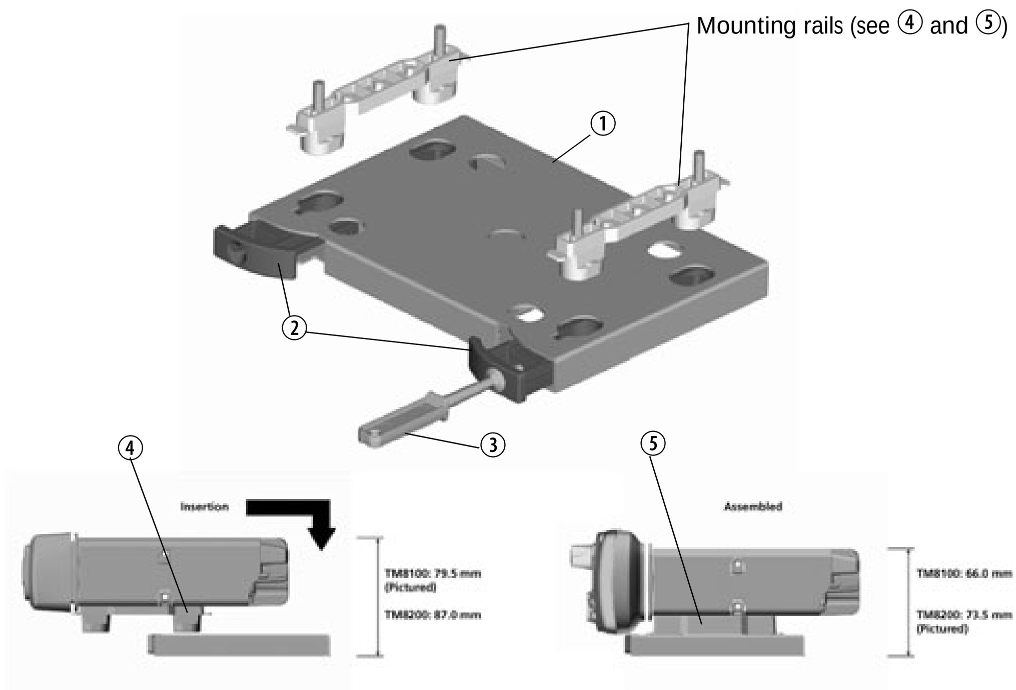


17 TMAA03-02 Security Bracket

The TMAA03-02 security bracket can be used in place of the standard U-bracket in locations where you want to stop opportunistic removal of the radio by a third party, or where you want to have a quick release setup that allows you to swap over radios (e.g. leasing situation). The security bracket also provides electrical isolation to the radio.

The parts of the TMAA03-02 security bracket are illustrated in Figure 17.1.

Figure 17.1 Parts of the TMAA03-02 security bracket



Description	Quantity		
① security bracket cradle base	1	④ short mounting rails for TM8100	2
		screws (M4x25 T/T P/T ContiR) - for attaching short mounting rails to TM8100 radio (not pictured)	4
② slide locks	1 left 1 right		
③ slide lock key	2	⑤ tall mounting rails for TM8200	2
self-tapping screws (10Gx20 hex/poz) - for fixing security bracket in place (not pictured)	4	screws (M4x30 T/T P/T ContiR) - for attaching tall mounting rails to TM8200 (not pictured)	4
anti-vibration washers for self-tapping screws (not pictured)	4		

Note: ① and ② are pre-assembled

17.1 Installing the Security Bracket and Radio

17.2 Installation Planning

Before installing the security bracket, make sure that the site you have chosen for the installation meets the following criteria:

1. The site has enough height for the radio to be easily installed and removed.

   The measurements given at the bottom of Figure 17.1 are the heights of the radios and base only. Allow extra space for manipulation.

Note You will need more space if you are installing a TM8200 radio.

2. The site has enough depth for the radio.

   Check that the front and rear overhang of the radios will fit where you are mounting the security bracket.

3. The site allows for good air circulation, particularly at the rear of the radio.

17.2.1 Installation Procedure

Important The security bracket must be securely installed. Otherwise there is a risk that the whole assembly of the radio and security bracket may become loose over time, or as a result of serious impact.

Note Because the some model control heads are taller than others, each security bracket kit comes with two different heights of mounting rail and mounting screws, depending on the radio type you are installing.

Once you have identified a suitable site for the security bracket and radio, installation is as follows:

1. Use the four self-tapping screws and washers to fix the security bracket base in place. The base actually has five screw holes available, but the center screw hole does not need to be used.
2. Depending on whether you are installing a TM8100 or TM8200 radio, select the correct height mounting rails and screws, and attach a rail to each side of the bottom of the radio body (two screws per rail, minimum torque 20in.lbf [2.26N.m]).
3. To insert the radio, with the mounting rails attached, into the security bracket base, check that the left and right slide locks are open.

4. If the slide locks are closed, open them by inserting the slide lock key into the keyhole. Rotate the key 90° (it will slip into a detent), and pull.

   Two slide lock keys are supplied so that you can either use them both at once, or so that you can keep one as a spare.

5. Place the radio over the security bracket base so that the feet of the mounting rails fit securely into the base.

6. Close the slide locks by pressing them into the base. You should hear an audible click as the internal spring lock mechanism engages.

Warning!! **For continued safe operation, replace and do not re-use Security Bracket once it has been involved in a crash greater than 50km/h.**

17.3 Removing a Radio from the Security Bracket

Remove the radio from the security bracket as follows:

1. Open the slide locks by inserting the slide lock key into the keyhole. Rotate the key 90° (it will slip into a detent), and pull. The pull will be need to be quite firm to open each slide lock.

2. Remove the radio and its mounting rails by lifting it up and out of the security bracket base.

3. If required, remove the mounting rails from the radio body base by unscrewing them.

17.4 Replacing the Radio in the Security Bracket

To replace the radio in a security bracket, first follow the steps in “Removing a Radio from the Security Bracket” on page 441, and then follow from step 2 in “Installing the Security Bracket and Radio” on page 440.

17.5 Disassembling the Security Bracket

Disassemble the security bracket as follows:

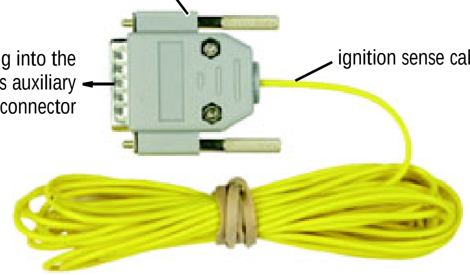
1. Remove the radio from the security bracket by following the steps in "Removing a Radio from the Security Bracket" on page 441.
2. Unscrew the four self-tapping screws holding the security bracket base in place.

17.6 Ordering Extra Parts

The following parts can be ordered separately in case of loss, or in situations where, for example, one security bracket is installed where several different radios may be installed at different times.

Part	Part Number	Quantity
Security Crdl Key TM8 (slide lock key)	319-60004-XX	2
Security Crdl Mtg Short TM8 (short mounting rails for TM8100)	319-60002-XX	2
Scrw M4*25 T/T P/T ContiR (for attaching short mounting rails to TM8100 radio)	349-02063-XX	4
Security Crdl Mtg Tall TM8 (tall mounting rails for TM8200)	319-60003-XX	2
Scrw M4*30 T/T P/T ContiR (for attaching tall mounting rails to TM8200 radio)	349-02068-XX	4

18 TMAA04-05 Ignition Sense Kit



The TMAA04-05 ignition sense kit provides a mating plug for the radio's auxiliary connector. The four metre length of cable from pin 4 of the plug connects to the vehicle's ignition signal.

Once the kit is installed, the ignition signal is used to power up and power down the radio, so that the radio turns off when the vehicle ignition is off. This avoids any possibility that the radio may flatten the vehicle's battery. When the vehicle ignition is turned on, the radio either turns on, or returns to the state that it was in when the vehicle ignition was turned off.

Important The radio does not meet the IP54 protection standard once the bung for the auxiliary connector is removed. Therefore, once the TMAA04-05 ignition sense kit is installed, mount the radio in areas where it is not exposed to water, dust or other environmental hazards.

18.1 Installation

1. Connect the auxiliary connector plug to the radio's auxiliary connector
2. Connect the ignition sense cable to the 13.8V signal controlled by the vehicle's ignition key.

18.2 Radio Programming

Program the AUX GPI3 line to 'Power Sense (Ignition)' and active to 'High'.

Refer to the online help of the programming application for more information.

19 TMAA10-01 Desktop Microphone

The TMAA10-01 desktop microphone is an omnidirectional dynamic microphone which can be used in dispatch situations, where the microphone is positioned on a flat surface. The desktop microphone plugs into the microphone socket on the radio control head.

The desktop microphone has an internal pre-amplifier and an adjustable sensitivity control on the underside of the desktop microphone base.

19.1 Operation

Hold down the monitor key and check whether the channel is clear.

If the channel is clear, press the PTT key to transmit. Speak clearly into the microphone and release the PTT key when you have finished talking.

Note The monitor key can be locked in the ‘on’ position. To do this, hold the monitor key down and slide the monitor key towards you. The monitor key should now be locked on.

19.2 Installation

Important The desktop microphone grommet must be installed whenever the desktop microphone is plugged into the microphone socket. When installed, the grommet has two functions:

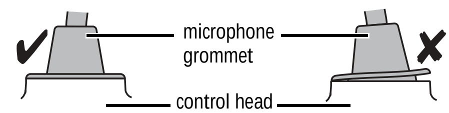
- to prevent damage to the microphone socket when there is movement of the microphone cord, and
- to ensure that the control head is sealed against water, dust and other environmental hazards.

1. Plug the microphone cord into the microphone socket on the radio control head.
2. Slide the grommet along the cord and push two adjacent corners of the grommet into the microphone socket cavity.

3. Squeeze the grommet and push the remaining corners into position.

4. Check that the grommet is seated correctly in the cavity.

Figure 19.1 Correct desktop microphone grommet seating



19.3 Adjustment

Adjust the output sensitivity of the desktop microphone using R5. R5 is accessible from the underside of the desktop microphone, as shown.

The microphone sensitivity is set to maximum by rotating R5 counterclockwise.

19.4 Interface Specification

The following table and diagram summarizes the signals used for the desktop microphone on the radio's microphone connector and shows the interface between the desktop microphone and the radio.

Table 19.1 Desktop microphone connector - pins and signals

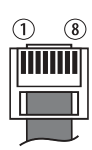
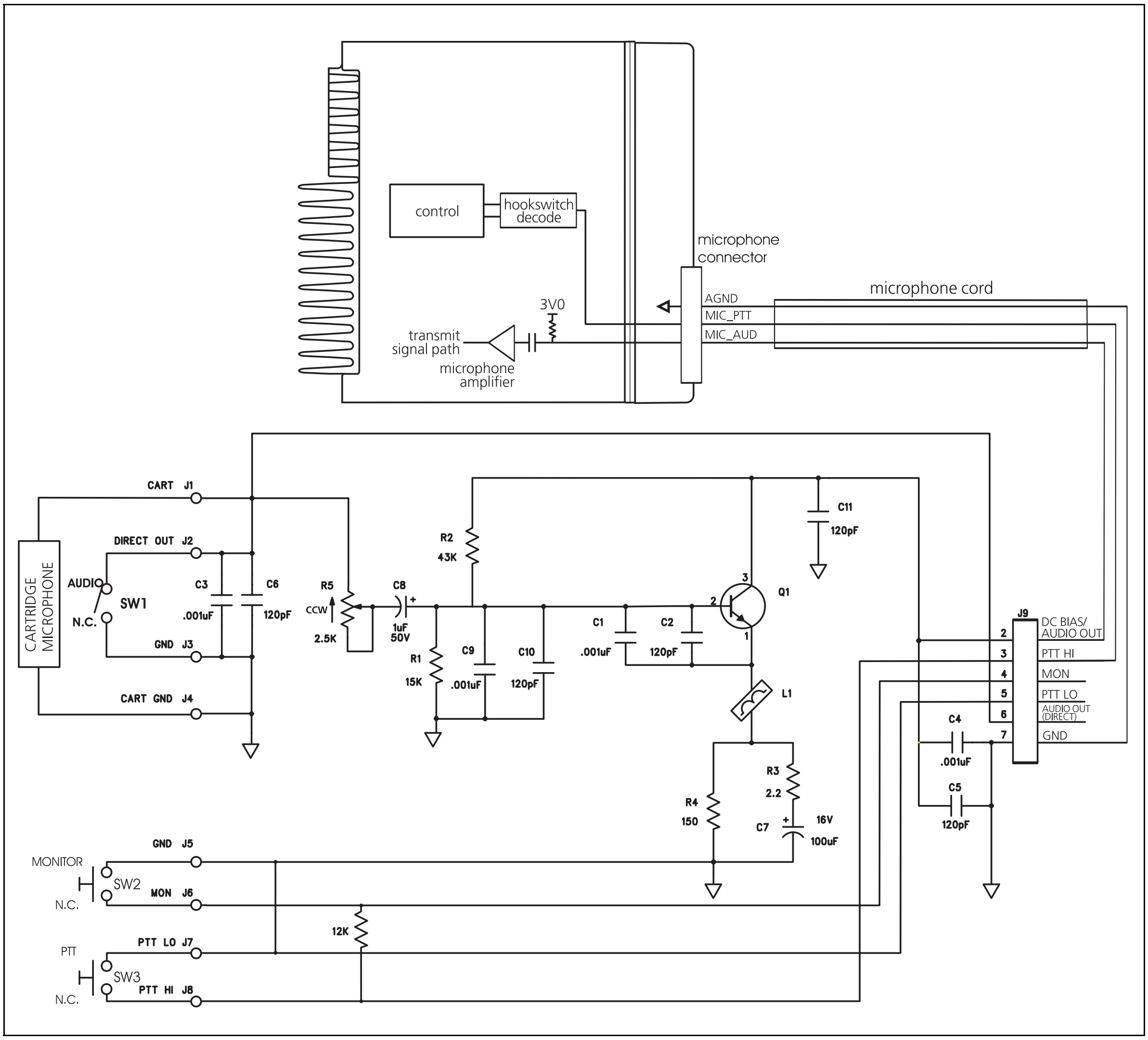
	Pin	Signal	Colour	Description
	1	—	—	not connected
	2	—	—	not connected
	3	—	—	not connected
	4	MIC_PTT	yellow	PTT
	5	MIC_AUD	red	audio from the microphone
	6	AGND	bare	analog ground
	7	—	—	not connected
	8	—	—	not connected

Figure 19.2 Desktop microphone to radio interface



19.5 Circuit Description

The desktop microphone uses a dynamic microphone capsule and contains a pre-amplifier (Q1) to boost the microphone level to that required by the radio. Power for the pre-amplifier is provided by the electret microphone bias circuit within the radio. R5 is used to adjust the gain.

PTT and hookswitch signals are combined onto one line and fed to the control head PTT input of the radio.

20 TMAA10-02 Handset

The TMAA10-02 handset provides the user with privacy and also improves the audio quality in noisy environments. The handset uses a dynamic microphone capsule, so for TM8100 radios, the TMAA02-06 support kit for concealed and dynamic microphones needs to be installed.

When your radio receives a call and the handset is mounted in its locking cradle, the radio unmutes and you can hear the call from your radio's internal speaker and from any connected remote speaker.

If you remove the handset from its cradle when you receive a call, the radio unmutes and you can hear the call from your radio's internal speaker, from any connected remote speaker and from the handset earpiece.

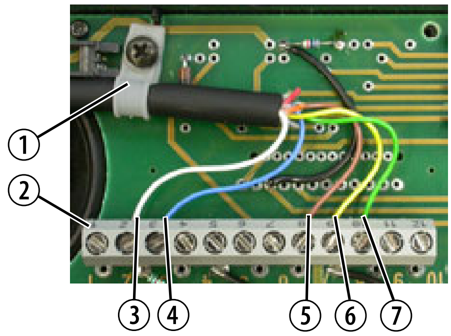
Using private handset mode, the radios internal and external speakers are muted and the call can only be heard from the handset earpiece.

20.1 Installation

20.1.1 Handset Wiring

1. Drill a hole in the chosen mounting surface for the radio to handset cord and pass the cord through the hole.
2. Prepare the radio to handset cord, as follows.
   - Cut the radio to handset cord to the required length.
   - Strip away about 60 mm (2 inches) of the cable outer sheath on the end without a connector.
   - Cut off the exposed orange, red, black and bare wires.
   - Strip about 6 mm (0.2 inches) of the coating off each of the five remaining wires.
3. Secure the radio to handset cord in the handset PCB P-clip ①, as shown in the diagram.
4. Connect the five wires to the handset PCB connector ②.

Table 20.1 Handset PCB connector wiring

	Handset PCB Connector	Colour	Reference
	2	white or violet	③
	3	blue	④
	8	brown	⑤
	9	yellow	⑥
	10	green	⑦

20.1.2 Handset Installation

1. Press the pushbutton and remove the handset from the locking cradle.
2. Disassemble the locking cradle by removing the four locking cradle screws.
3. Screw the handset mounting plate to the required mounting surface. Note that mounting screws are not provided in this kit.
4. Clamp the top part of the locking cradle onto the mounting plate, and secure it with the four locking cradle screws.

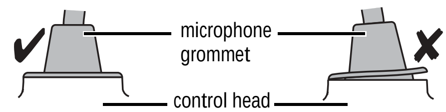
20.1.3 Connecting the Handset to the Radio

Important The handset microphone grommet must be installed whenever the handset to radio cord is plugged into the microphone socket. When installed, the grommet has two functions:

- to prevent damage to the microphone socket when there is movement of the microphone cord, and
- to ensure that the control head is sealed against water, dust and other environmental hazards.

1. Plug the radio to microphone cord into the microphone socket on the radio control head.
2. Slide the grommet along the cord and push two adjacent corners of the grommet into the microphone socket cavity.
3. Squeeze the grommet and push the remaining corners into position.
4. Check that the grommet is seated correctly in the cavity.

Figure 20.1 Correct handset microphone grommet seating



20.1.4 Radio Programming

Dynamic Microphone Support

Dynamic microphone support must be enabled in the UI Preferences form of the radio's programming application, so that audio is optomized for dynamic microphones. Refer to the online help of the programming application for more information.

Table 20.2 Handset settings in the UI Preferences form (TM8100 Programming Application)

Field	Setting	Selected/Cleared
Audio Setup	Enable Options Board Preamp	selected

Table 20.3 Handset settings in the UI Preferences form (TM8200, TM9000/TP9000 Programming Application)

Field	Setting	Selected/Cleared
Audio>Audio Setup	Dynamic Mic Support	selected

Private Handset Mode

If private handset mode is required, the radio needs to be programmed to mute the audio power amplifier when the handset is out of the cradle. The audio path is then only through the RX AUDIO line to the handset earpiece.

The following table shows the settings required in the Programmable I/O form of the radio's programming application. Refer to the online help of the programming application for more information.

Note If private handset mode is programmed, then no audio will be heard from the speakers if the handset is unplugged.

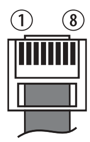
Table 20.4 Handset settings in the Programmable I/O form

Pin	Direction	Label	Action	Active	Debounce	Signal State	Mirrored To
CH_GPIO1	Input	None	Force Audio PA Off	High	25	None	None

20.2 Interface Specification

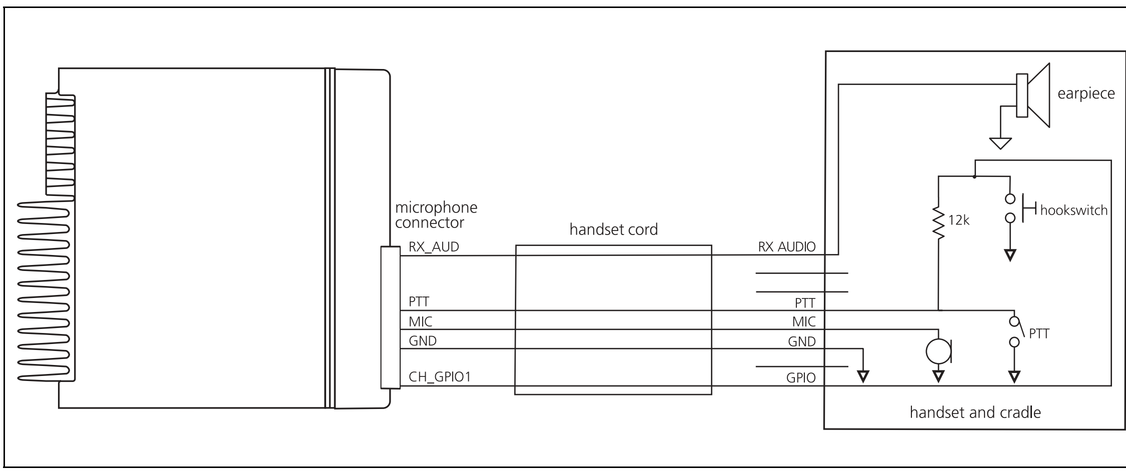
The following table and diagram summarizes the signals used for the handset on the radio's microphone connector and shows the interface between the handset and the radio.

Table 20.5 Handset microphone connector - pins and signals



Pin	Signal	Handset PCB Connector	Colour	Description
1	RX_AUD	8	brown	receive audio to handset
2	—	—	—	not connected
3	—	—	—	not connected
4	PTT	2	white	PTT and hookswitch
5	MIC	9	yellow	audio from the handset to dynamic-mic support board
6	GND	10	green	analog ground
7	—	—	—	not connected
8	CH_GPIO1	3	blue	programmable line controlling private mode

Figure 20.2 Handset to radio interface



21 TMAA10-03 and TMAA10-06 High-Power Remote Speakers

The TMAA10-03 remote speaker (for the 25W radio) and the TMAA10-06 remote speaker (for the 50W/40W radio) are installed in parallel with the radio's existing internal speaker. The remote speaker can then be installed at some distance from the radio, or it can be used to increase the volume of the audio from the radio's existing internal speaker.

The remote speaker cable is terminated with two receptacles. These receptacles are different between the TMAA10-03 and the TMAA10-06 remote speakers.

Two spare receptacles are included with the remote speaker, along with four mounting screws and washers.

21.1 Installation

21.1.1 Remote Speaker Mounting

1. Choose a mounting position for the remote speaker where it will not interfere with the operation of any of the vehicle controls.

2. Remove the remote speaker from the mounting bracket and use the screws and washers provided to fix the mounting bracket securely in the chosen location.

Important Check before drilling that the drill will not damage any components or wiring behind the mounting location.

- If mounting the bracket onto a metal surface, drill two 3.5mm (0.14 inch) holes in the appropriate locations and secure the bracket with the supplied self tapping screws.
- If mounting the bracket to any other material, such as plastic, drill two 4.5mm (0.18 inch) holes and attach the bracket with screws and captive nuts, or similar.

3. Attach the speaker to the mounting bracket using the thumbscrews.

4. Run the free end of the speaker cable to the radio power cable and install the two receptacles in the power connector, as described in the "Power Connector Wiring" procedure.

Important Check that the speaker cable is protected from engine heat, sharp edges and from being pinched or crushed.

21.1.2 Power Connector Wiring

Insert the remote speaker receptacles into the power connector socket, as shown in the diagrams below.

Note The positive remote speaker wire has a white stripe.
With the TMAA10-03 remote speaker (25 W radio), insert the the positive remote speaker wire into the position nearest to the red wire.
With the TMAA10-06 remote speaker (50 W/40 W radio), insert the positive remote speaker wire into the upper position (marked "3").

Figure 21.1 Power connector wiring of the TMAA10-03 remote speaker

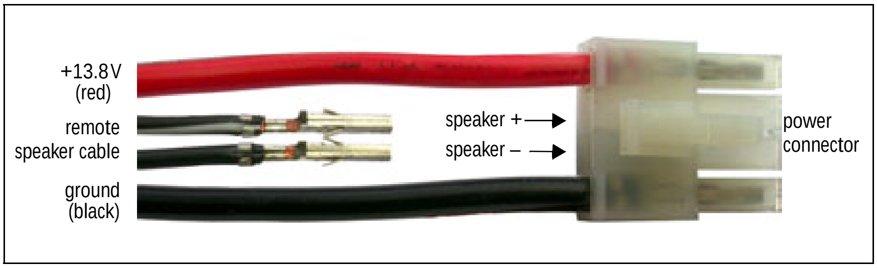
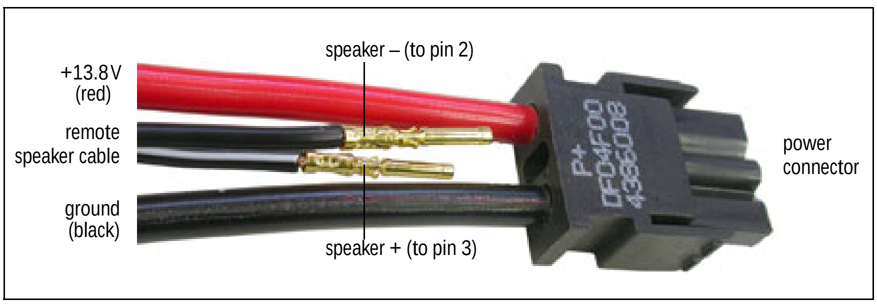


Figure 21.2 Power connector wiring of the TMAA10-06 remote speaker



22 TMAA10-04 Remote PTT Kit

The TMAA10-04 remote PTT kit plugs into the radio's auxiliary connector. This kit uses the remote electret microphone to replace communication through the usual rugged microphone. The rugged microphone can still provide hookswitch operation, if this is required.

The TMAA10-04 kit uses a conveniently mounted remote PTT key for PTT operation. When the remote PTT is activated, the remote microphone is used for communication.

There are three mounting options for the remote microphone and an extension lead is provided for the remote PTT in the TMAA10-04 kit.

Important This kit does not meet the IP54 protection standard. Care must be taken when a radio with a TMAA10-04 kit installed is being operated in an environment where there is water, dust or other environmental hazards.

22.1 Installation

Important Care should be taken to avoid routing any cables near vehicle pedal controls, steering column and other moving parts.

22.1.1 Installing the Remote Microphone

1. Choose one of the three mounting options provided for the remote microphone and determine its most appropriate location.

   The mounting position of the microphone should be no more than 50 cm (20 inches) from the user's mouth.

2. Route the remote microphone cable so as not to distract the driver.

3. Mount the remote microphone in the chosen location and check that the microphone and cable are clear of all the usual movements performed by the user.

22.1.2 Installing the Remote PTT

Important The remote PTT must be operable from a normal driving position.

1. Secure the remote PTT in position using the velcro strap and plug the remote PTT cord into the remote PTT extension lead.

   A common position for the remote PTT is on the gear lever of the vehicle.

2. Check that the cord and lead do not interfere with the safe operation of the vehicle.

22.2 Radio Programming

22.2.1 Remote PTT Settings in the PTT Form

The following table shows the settings required in the PTT form of the programming application. Some of these settings are default settings and may not need to be changed. Refer to the online help of the programming application for more information.

Note If hookswitch operation is programmed for the rugged microphone and the Inhibit PTT Transmission When Mic On Hook field is selected in the PTT tab of the PTT form, then the hands-free remote PTT cannot transmit when the rugged microphone hookswitch is closed (the microphone is on the microphone clip).

Table 22.1 Remote PTT settings in the PTT form, External PTT (1) tab

Field		Setting
Advanced EPTT1	PTT Transmission Type	Voice
	Audio Source	AUX MIC

22.2.2 Remote PTT Settings in the Programmable I/O Form

Note The Programmable I/O form setting for AUX_GPIO4 must have the default programming settings and the AUX_GPIO4 pullup resistor on the radio main PCB must be set for the factory default of 3.3V (R769 fitted).

Table 22.2 Remote PTT settings in the Programmable I/O form, Digital tab

Pin	Direction	Label	Action	Active	Debounce	Signal State	Mirrored To
AUX_GPI1	Input	None	External PTT 1	Low	25	None	None
AUX_GPIO4	None	None	No Action	None	None	None	None

22.3 Interface Specification

The following table and diagram summarizes the signals used for the remote PTT and hands-free kits on the radio's auxiliary connector and shows the interface between the kits and the radio.

Table 22.3 Auxiliary connector - pins and signals

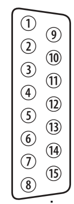
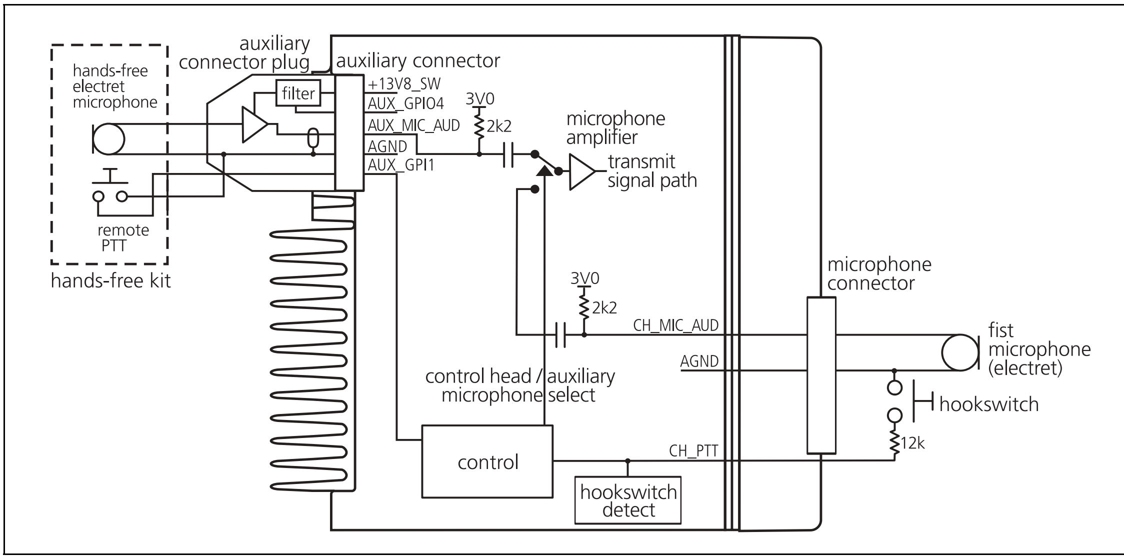
	Pin	Signal name	Description
	8	+13V8_SW	power to hands-free microphone pre-amplifier
	10	AUX_GPIO4	reference voltage to pre-amplifier regulator
	12	AUX_GPI1	PTT signal from hands-free kit
	14	AUX_MIC_AUD	microphone audio to the radio
	15	AGND	analog ground

Figure 22.1 TMAA10-04/TMAA10-05 to radio interface



22.4 Circuit Description

The remote microphone signal is amplified by a pre-amplifier in the auxiliary connector plug. The power supply to this amplifier is provided by the +13.8V supply on the auxiliary connector. This supply is filtered and regulated down to approximately 3.3V. The reference voltage for the regulator is provided by AUX_GPIO4 line.

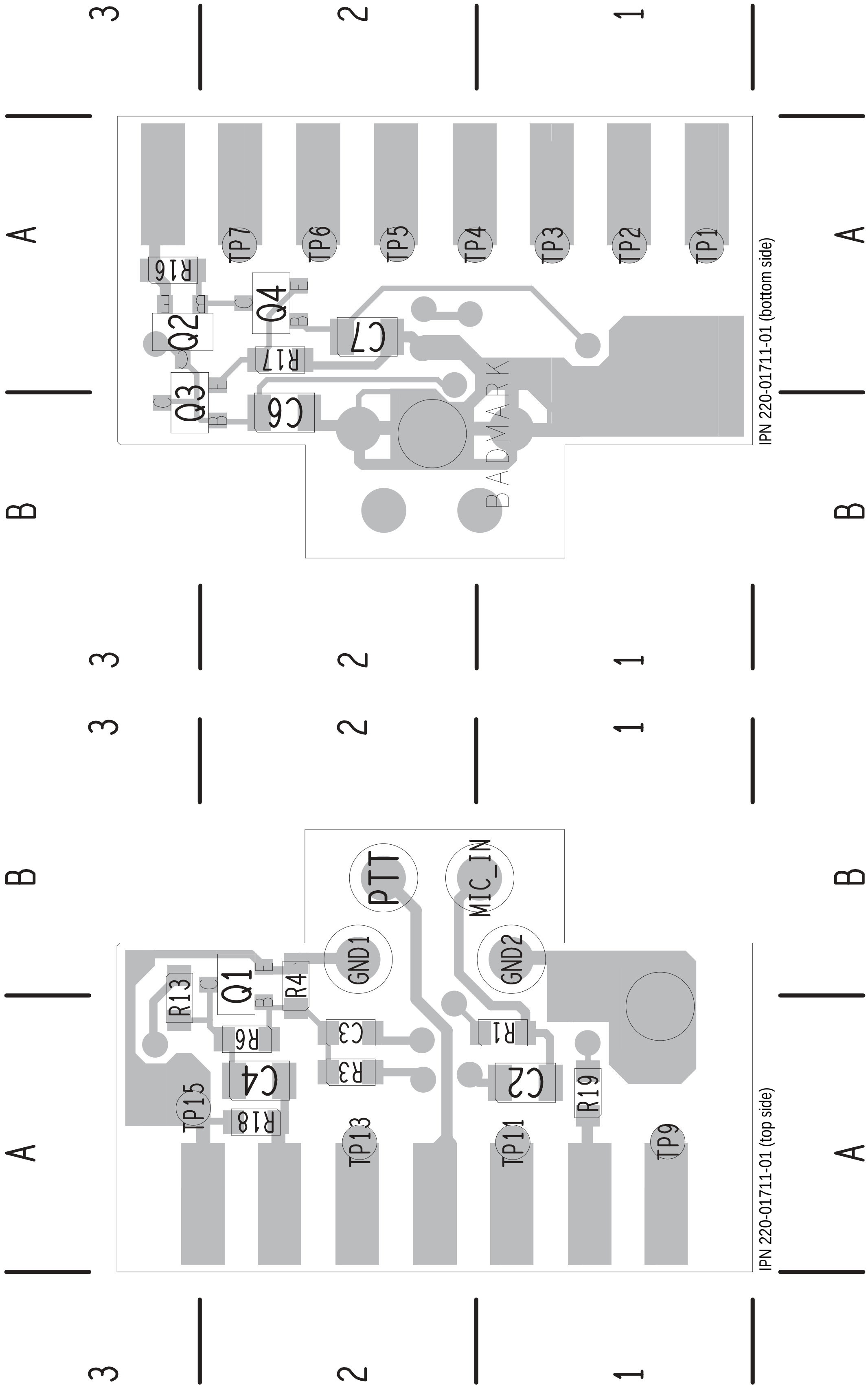
The remote microphone signal is fed via AUX_MIC_AUD and an input selector to the radio's internal microphone amplifier. The microphone input selected depends on the PTT source used to make the call. If the remote PTT is used, then AUX_MIC_AUD is selected. If the control head microphone PTT is used, then CH_MIC_AUD is selected. Test points for all other auxiliary connections are provided on the auxiliary connector plug PCB to facilitate the connection of other devices or signals e.g ignition switch signal.

22.5 PCB Information

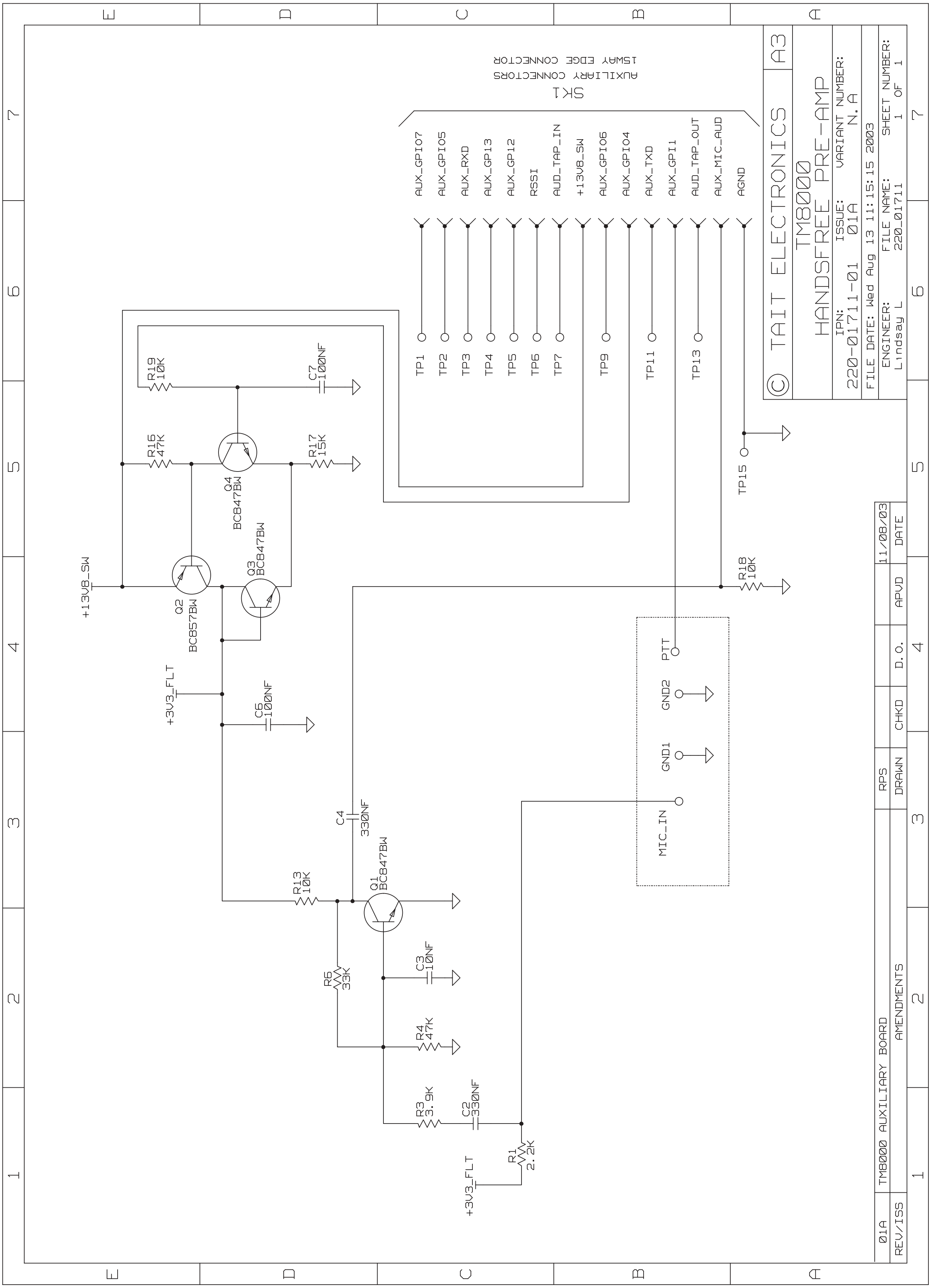
22.5.1 TMAA10-04 Parts List (PCB IPN 220-01711-01)

Ref.	IPN	Description
C2	015-26330-08	Cap Cer 0805 330n 5% 10v X7r
C3	018-15100-00	Cap 0603 10n 50v X7r +-10%
C4	015-26330-08	Cap Cer 0805 330n 5% 10v X7r
C6	015-26100-08	Cap Cer 0805 100n 10% X7r 50v
C7	015-26100-08	Cap Cer 0805 100n 10% X7r 50v
Q1	000-10084-71	Xstr BC847BW NPN SOT323
Q2	000-10085-71	Xstr SMD BC857BW PNP SOT323
Q3	000-10084-71	Xstr BC847BW NPN SOT323
Q4	000-10084-71	Xstr BC847BW NPN SOT323
R1	038-14220-00	Res 0603 2k2 1/16w +-5%
R3	038-14390-10	Res 0603 3k9 1%
R4	038-15470-10	Res 0603 47k 1/16w+-1%
R6	038-15330-10	Res 0603 33k 1%
R13	038-15100-10	Res 0603 10k 1/16w +-1%
R16	038-15470-10	Res 0603 47k 1/16w+-1%
R17	038-15150-00	Res 0603 15k 1/16w +-5%
R18	038-15100-10	Res 0603 10k 1/16w +-1%
R19	038-15100-10	Res 0603 10k 1/16w +-1%
	219-00305-00	cable
	220-01711-01	Pcb HFree
	236-00001-00	Sw Ptt W/Cbl & Strap
	240-06010-18	Conn 15w Hood/Cvr Drng MDJ15
	252-00010-72	Mic Electret Unidir 2.5mm Plg
	402-00006-01	F/Inst TMAA10-04/TMAA10-05 Eng

22.5.2 Pre-Amplifier Board Layout

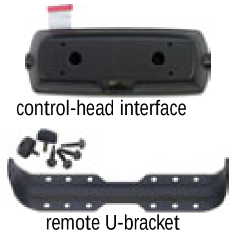


22.5.3 Pre-Amplifier Board Circuit Diagram



23 Installing an Enhanced Remote Kit

The control head of a graphical-display radio can be installed remotely from the radio body. The diagram below shows the parts used for this installation.

		
TMAA03-03 remote control-head back (includes remote U-bracket)	TMAA04-01 remote cable	TMAC34-0T (TM8200) or TMAC34-1T(TM9100) torso interface

Note Although the torso interface is similar in appearance to the dual-RJ45 on the telemetry radio, the control head on the telemetry radio cannot be used for remote installation.

23.1 Installation

Warning!! **Mount the remote U-bracket with the remote control-head assembly and the U-bracket with the radio body securely. These units must not break loose in the event of a collision. Unsecured radio units are dangerous to the vehicle occupants.**

Caution **Observe the installation warnings and safety regulations in the installation procedures of the radio.**

Important This equipment contains devices which are susceptible to damage from static discharges. Refer to "ESD Precautions" on page 103 for more information.

Note Torx T10 and T20 screwdrivers are required for most of the screws in this installation.

The circled numbers in the following sections refer to the items in Figure 23.1 on page 462.

23.1.1 Overview

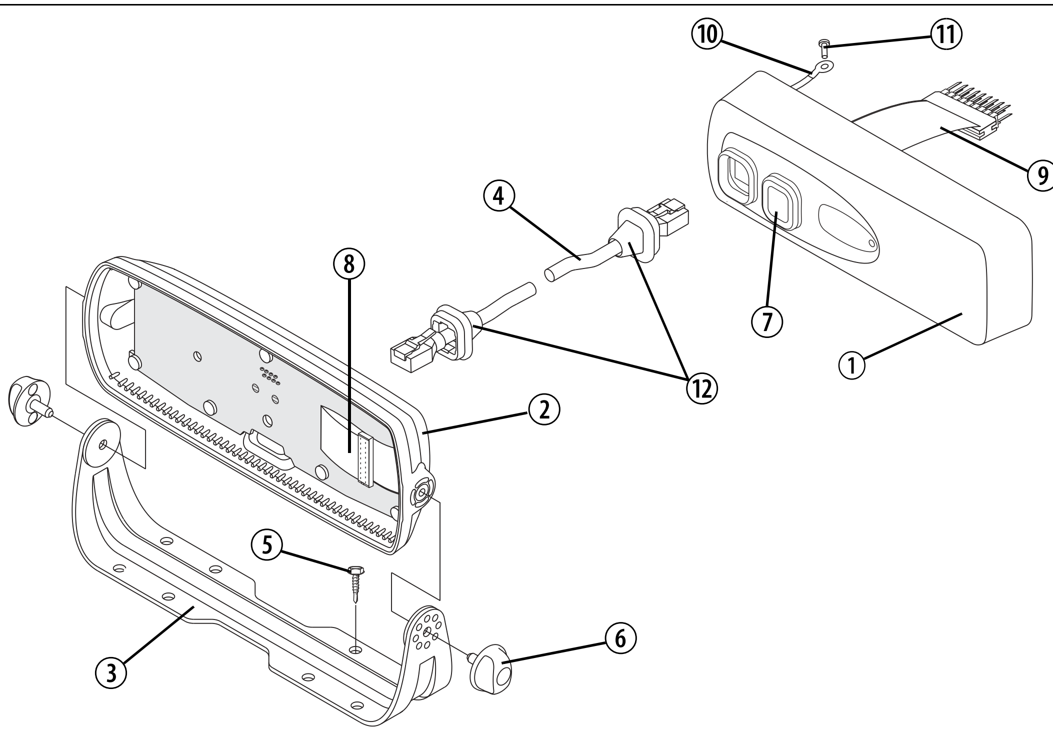
Installing the control head remotely is done in six steps:

1. Remove the control head from the radio body, if necessary.
2. Install the torso interface ① onto the radio body.
3. Mount the remote U-bracket ③ in the required position.
4. Install the control-head interface ② onto the control head and install the remote control-head assembly in the remote U-bracket.
5. Mount the U-bracket in the required position and install the radio body in the U-bracket.
6. Route the remote cable ④ between the remote control-head assembly and the radio body.

23.1.2 Parts Required

The following diagram identifies the parts for remote control-head installation and shows how they fit together.

Figure 23.1 Parts for remote control-head installation



① torso interface

② control-head interface

③ remote U-bracket

④ remote cable

⑤ self-drilling screw

⑥ thumb screw

⑦ RJ45 bung

⑧ control-head interface loom

⑨ torso-interface loom

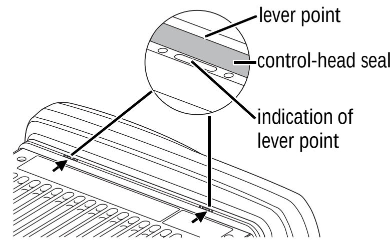
⑩ earthing tag

⑪ earthing-tag screw

⑫ remote cable grommets

23.1.3 Removing the Control Head from the Radio Body (if necessary)

Caution **During this procedure, take care that the control-head seal is not damaged. Damage to this seal reduces environmental protection.**



1. On the underside of the radio, insert a 5mm (3/16 inch) flat-bladed screwdriver between the control head and the control-head seal, in the positions shown.

   Insertion points and are lever points and are indicated on the radio chassis by a dot-dash-dot pattern (•▬•).

2. Use the screwdriver to lift the control head off the chassis clip, then repeat in the other position.

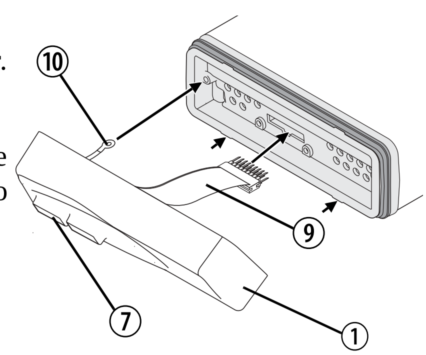
3. Unplug the control-head loom from the radio body.

   The control head is now separate from the radio body.

23.1.4 Installing the Torso Interface

The torso interface must be installed onto the radio body, in place of the control head.

1. Screw the solder tag ⑩ onto one of the screw bosses on the radio chassis.



2. Plug the torso-interface loom ⑨ onto the control-head connector.

3. Insert the bottom edge of the remote control head ① onto the two clips in the front of the radio chassis, then snap into place.

4. Remove one of the bungs ⑦ covering the RJ45 connectors. The remote cable ④ will plug into this connector once the installation is complete.

If the remote cable is not installed in the RJ45 cavity, then the RJ45 bung must be installed. This ensures that the torso interface is sealed against water, dust and other environmental hazards.

23.1.5 Mounting the Remote U-Bracket

The remote U-bracket with its self-drilling screws, is used to install the remote control-head assembly on the dashboard or on any sufficiently flat surface.

Caution **When drilling holes in the vehicle, check that drilling at the selected points will not damage existing wiring.**

Important Check that the remote U-bracket is not distorted when the screws are tightened.

1. Drill any holes required for cables and install suitable grommets or bushings in the holes.

2. If precise positioning is required, predrill ∅ 3mm (1/8 inch) pilot holes for the self-drilling screws. Reduce the hole size in metal that is less than 1mm (1/32 inch) thick.

3. Screw the remote U-bracket in the chosen mounting position using the self-drilling screws provided. Use all four screws provided.

23.1.6 Installing the Control-Head Interface

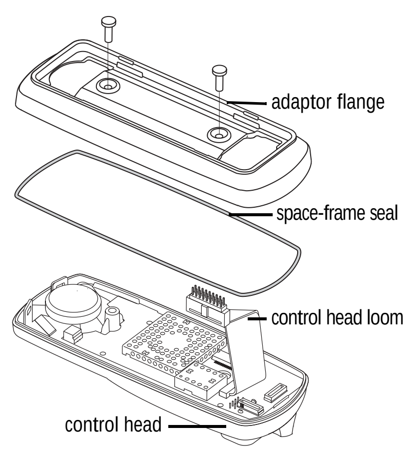
With the control head separated from the radio body, the control-head interface ② must be installed on the rear of the control head.

1. Undo the two Torx T-20 screws on the adaptor flange of the control head, and remove the adaptor flange.

2. Unplug the control-head loom.

   The adaptor flange and control-head loom are not used for the remote control-head installation. Keep the two screws for step (4).

3. Plug the control-head interface loom ⑧ into the connector on the control head.



Important When fitting the control-head interface to the control-head, be careful not to damage the space-frame seal.

4. Use the two screws from step (2) to fit the control-head interface to the control head through the two screw holes at the rear of the control-head interface.

Changing the Remote U-Bracket Orientation

The control-head interface is configured for installation with the RJ45 socket facing downwards (U-bracket below control head, as in Figure 23.1). If the RJ45 socket is required to face upwards (control head hanging from

U-bracket), the control-head interface loom ⑧ must be moved, so that it can reach the control head connector.

To move the control-head interface loom:

1. Undo the seven Torx T-10 screws on the control-head board, and remove the control-head interface board from the control-head interface.

2. Change the control-head interface loom ⑧ to the opposite connector.

3. Reinstall the control-head interface board.

Installing the Remote Control-Head Assembly in the Remote U-Bracket

1. Position the control-head assembly in the remote U-bracket and position it for a good viewing angle.

Note Adjusting the contrast on the control-head display may also improve its readability.

2. Screw the remote control-head assembly into position using the two thumb screws provided.

23.1.7 Mounting the U-Bracket and Installing the Radio Body

Mounting the U-Bracket

Install the U-bracket on any sufficiently flat surface, using self-drilling screws and washers.

Caution **When drilling holes in the vehicle, check that drilling at the selected points will not damage existing wiring, petrol tanks, fuel lines, brake pipes or battery cables.**

Important When mounting the U-bracket, check whether the mounting surface needs to be reinforced.

Important Install the U-bracket using at least four screws.

1. If the U-bracket is being mounted over a curved surface, bend the U-bracket tabs slightly, to match the surface shape.

2. Drill any holes required for cables and install suitable grommets or bushings in the holes.

Important Check that the U-bracket is not distorted when the screws are tightened.

3. If precise positioning is required, predrill ∅ 3mm (1/8 inch) pilot holes for the self-drilling screws. Reduce the hole size in metal that is less than 1mm (1/32 inch) thick.

4. Screw the U-bracket in the chosen mounting position using the self-drilling screws washers.

Installing the Radio Body in the U-Bracket

1. Connect the antenna and power cables to the rear of the radio.
2. Position the radio body in the U-bracket so that the holes in the U-bracket line up with the holes in the radio chassis.
3. Screw the radio into position using the four thumb screws.

23.1.8 Connecting the Remote Cable

Caution **When drilling holes in the vehicle, check that drilling at the selected points will not damage existing wiring, petrol tanks, fuel lines, brake pipes or battery cables.**

1. Drill any holes required for cables and install suitable grommets or bushings in the holes.
2. Plug one end of the remote cable into the control-head interface.
3. Run the remote cable to the torso interface and plug it into the RJ45 connector without a bung.

Installing the Remote-Cable Grommets

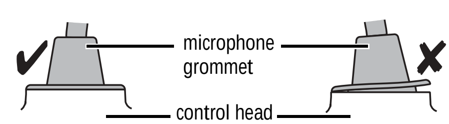
Install both the remote cable grommets, using the following procedure.

Important The remote cable grommets must be installed whenever the remote cable is plugged into the RJ45 sockets. When installed, the grommets have two functions:

- to prevent damage to the RJ45 sockets when there is movement of the remote cable, and
- to ensure that the radio and remote control-head assembly is sealed against water, dust and other environmental hazards.

1. Slide the grommet along the remote cable and push two adjacent corners of the grommet into the RJ45 socket cavity.
2. Squeeze the grommet and push the remaining corners into position.
3. Check that the grommet is seated correctly in the cavity.

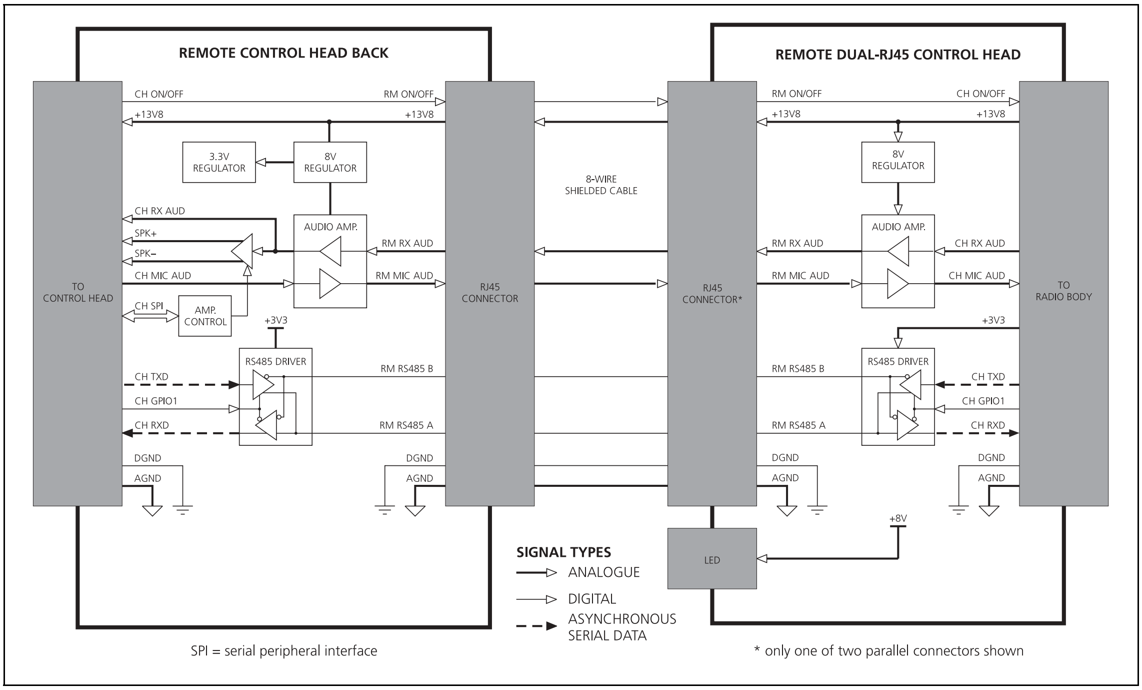
Figure 23.2 Correct remote cable grommet seating



23.2 Circuit Description

Figure 23.3 shows a block diagram of the remote control-head installation. Both control heads contain a circuit board with audio amplifiers and RS-485 driver components.

Figure 23.3 Block diagram of remote control-head installation



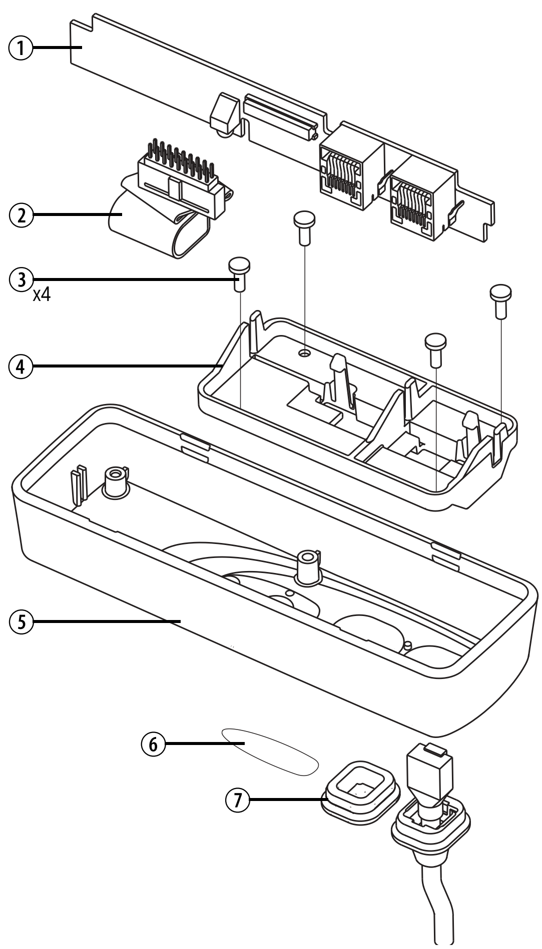
23.3 Servicing the Remote Control-Head Installation Parts

23.3.1 Disassembling the Torso Interface

Disassemble only as much as is necessary to replace the defective parts. Re-assembly is carried out in reverse order of disassembly.

1. Release the clip of the PCB bracket ④ and remove the control-head board ①.
2. Disconnect the torso-interface loom ②.
3. Unscrew the four PT type screws ③ and remove the PCB bracket ④.

Figure 23.4 Parts of the torso interface



	Description	IPN
①	control-head board	
②	torso-interface loom	219-02882-XX[a]
③	3 x 8 PT screw (x4)	346-10030-XX[a]
④	PCB bracket	302-10063-XX[a]
⑤	front panel	316-06843-XX[a]
⑥	label	365-01751-XX[a]
⑦	RJ45 bung	302-50002-XX[a]

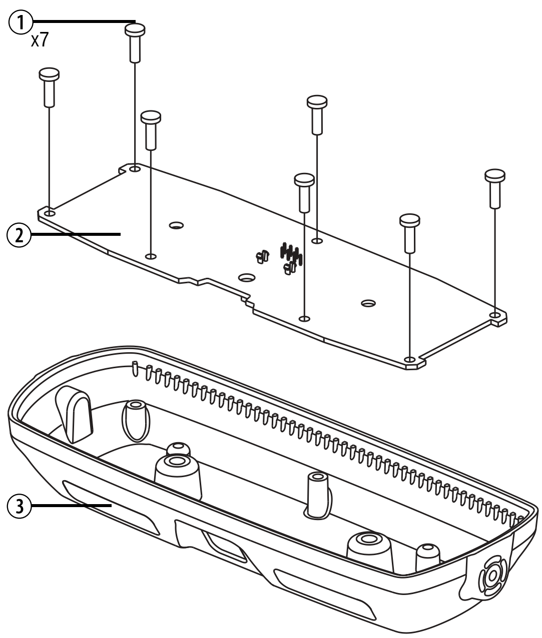
[a] Contact Technical Support for the exact IPN.

23.3.2 Disassembling the Control-Head Interface

Disassemble only as much as necessary to replace the defective parts or to swap the Micromatch connector loom. Re-assembly is carried out in reverse order of disassembly.

1. Unscrew the seven PT type screws ① and remove the PCB ②.
2. Remove the control-head interface loom (not illustrated).

Figure 23.5 Parts of the control-head interface



	Description	IPN
①	3 x 8 PT screw (x7)	346-10030-XX[a]
②	control-head interface PCB	
③	control-head interface	316-06842-XX[a]
	control-head interface loom	219-02914-XX[a]

[a] Contact Technical Support for the exact IPN.

23.4 PCB Information

23.4.1 TMAA03-03 Control-Head Interface (PCB IPN 220-01721-02)

Parts List

Ref.	IPN	Description
C100	018-14101-00	Cap 0603 1n 50v NPO ±5%
C101	018-14101-00	Cap 0603 1n 50v NPO ±5%
C102	015-02470-06	Cap Cer 1210 47p NPO 500v
C103	015-02470-06	Cap Cer 1210 47p NPO 500v
C110	018-16100-00	Cap 0603 100n 16v x7r + - 10%
C300	015-06470-01	Cap Cer 1206 470n X7r 20% 50v
C301	015-07220-08	Cap Cer 1206 2u2 16v X7r
C310	015-26100-08	Cap Cer 0805 100n 10% X7r 50v
C311	015-07220-08	Cap Cer 1206 2u2 16v X7r
C320	016-09100-07	Cap Elec SMD 100u 35v Loesr
C400	018-16100-00	Cap 0603 100n 16v x7r + - 10%
C401	015-07220-08	Cap Cer 1206 2u2 16v X7r
C410	018-16100-00	Cap 0603 100n 16v x7r + - 10%
C411	018-13100-00	Cap 0603 100p 50v NPO ±5%
C420	018-16100-00	Cap 0603 100n 16v x7r + - 10%
C421	018-13100-00	Cap 0603 100p 50v NPO ±5%
C422	015-07220-08	Cap Cer 1206 2u2 16v X7r
C423	015-07220-08	Cap Cer 1206 2u2 16v X7r
C430	015-07220-08	Cap Cer 1206 2u2 16v X7r
C500	015-26100-08	Cap Cer 0805 100n 10% X7r 50v
C600	015-26100-08	Cap Cer 0805 100n 10% X7r 50v
C601	015-26100-08	Cap Cer 0805 100n 10% X7r 50v
C610	015-26100-08	Cap Cer 0805 100n 10% X7r 50v
C611	015-07220-08	Cap Cer 1206 2u2 16v X7r
C612	015-07220-08	Cap Cer 1206 2u2 16v X7r
C700	015-26100-08	Cap Cer 0805 100n 10% X7r 50v
C701	015-07220-08	Cap Cer 1206 2u2 16v X7r
C702	015-07220-08	Cap Cer 1206 2u2 16v X7r
C703	015-06470-01	Cap Cer 1206 470n X7r 20% 50v
C704	018-16100-00	Cap 0603 100n 16v x7r + - 10%
C705	018-16100-00	Cap 0603 100n 16v x7r + - 10%
C706	018-13220-00	Cap 0603 220p 50v NPO±5%
C707	015-06470-01	Cap Cer 1206 470n X7r 20% 50v
C708	015-07220-08	Cap Cer 1206 2u2 16v X7r
C710	015-07220-08	Cap Cer 1206 2u2 16v X7r
C711	015-07220-08	Cap Cer 1206 2u2 16v X7r
C712	015-07220-08	Cap Cer 1206 2u2 16v X7r
C730	015-26220-18	CAP CER 0805 220N 10% X7R 50V
C731	015-26220-18	CAP CER 0805 220N 10% X7R 50V
C732	018-14100-00	Cap 0603 1n 50v X7r ±10%
C733	018-14100-00	Cap 0603 1n 50v X7r ±10%
C734	015-07220-08	Cap Cer 1206 2u2 16v X7r
C735	015-07220-08	Cap Cer 1206 2u2 16v X7r
D100	001-10000-99	Diode SMD BAV99 D-Sw SOT23
D101	001-10000-99	Diode SMD BAV99 D-Sw SOT23
D102	001-10000-99	Diode SMD BAV99 D-Sw SOT23
D103	001-10000-99	Diode SMD BAV99 D-Sw SOT23
D104	001-10000-99	Diode SMD BAV99 D-Sw SOT23
D110	001-10084-91	Diode SMD BZX84C9V1 Zen SOT23
D201	001-10000-99	Diode SMD BAV99 D-Sw SOT23
D211	001-10000-99	Diode SMD BAV99 D-Sw SOT23
D300	001-10000-99	Diode SMD BAV99 D-Sw SOT23
D720	001-10841-10	Diode SMD BZX84C11v ZEN SOT23
D730	001-10014-03	Diode SMD MBRS140T3 Sch
D731	001-10014-03	Diode SMD MBRS140T3 Sch
E100	057-10081-06	Ind 1806 Blm41p750s Emi Supr

Ref.	IPN	Description
E101	057-10081-06	Ind 1806 Blm41p750s Emi Supr
E102	057-10600-05	Ind 0603 Blm11p600s .5a F/Bead
E103	057-10600-05	Ind 0603 Blm11p600s .5a F/Bead
E105	057-10081-06	Ind 1806 Blm41p750s Emi Supr
E710	057-10600-05	Ind 0603 Blm11p600s .5a F/Bead
E711	057-10081-06	Ind 1806 Blm41p750s Emi Supr
E730	057-10081-06	Ind 1806 Blm41p750s Emi Supr
E731	057-10081-06	Ind 1806 Blm41p750s Emi Supr
J100	240-00016-00	Conn RJ45 Shld 8P8C LP RA TH
J200	240-10000-11	Conn SMD 18w Skt M/Match
J201	240-10000-11	Conn SMD 18w Skt M/Match
L712	057-10100-65	Ind SMD Pwr Cdrh6D38 100UH .65
L730	057-10010-02	Ind SMD Pwr CDRH74 10UH 1.8A
L731	057-10010-02	Ind SMD Pwr CDRH74 10UH 1.8A
Q610	000-10084-71	Xstr BC847BW NPN SOT323
Q720	000-10084-71	Xstr BC847BW NPN SOT323
Q721	000-10442-70	Xstr SI4427DY PCH Pwr MFET SO8
R100	038-13100-00	Res 0603 100e 1/16w ± 5%
R110	038-15100-00	Res 0603 10k 1/16w +-5%
R200	038-13100-00	Res 0603 100e 1/16w ± 5%
R201	038-13100-00	Res 0603 100e 1/16w ± 5%
R202	038-13100-00	Res 0603 100e 1/16w ± 5%
R210	038-13100-00	Res 0603 100e 1/16w ± 5%
R211	038-13100-00	Res 0603 100e 1/16w ± 5%
R212	038-13100-00	Res 0603 100e 1/16w ± 5%
R300	038-14120-00	Res 0603 1k2 1/16w +-5%
R301	038-13220-00	Res 0603 220e 1/16w +-5%
R320	036-00000-00	Res 1206 0e 5% 0.125w
R401	038-14470-00	Res 0603 4k7 1/16w +-5%
R402	038-14470-00	Res 0603 4k7 1/16w +-5%
R410	038-15150-00	Res 0603 15k 1/16w +-5%
R411	038-16150-00	Res 0603 150k 1/16w +-5%
R412	038-13100-00	Res 0603 100e 1/16w ± 5%
R420	038-15330-00	Res 0603 33k 1/16w +-5%
R421	038-15220-00	Res 0603 22k 1/16w +-5%
R422	038-12470-00	Res 0603 47e 1/16w ± 5%
R430	038-14220-00	Res 0603 2k2 1/16w +-5%
R431	038-14220-00	Res 0603 2k2 1/16w +-5%
R441	038-14470-00	Res 0603 4k7 1/16w +-5%
R442	038-14470-00	Res 0603 4k7 1/16w +-5%
R501	038-15100-00	Res 0603 10k 1/16w +-5%
R510	038-13120-00	Res 0603 120e 1/16w ± 5%
R511	038-10000-00	Res 0603 Zero 0hm 1/16w ± 5%
R600	038-15100-00	Res 0603 10k 1/16w +-5%
R601	038-16470-00	Res 0603 470k 1/16w ± 5%
R602	038-10000-00	Res 0603 Zero 0hm 1/16w ± 5%
R603	038-10000-00	Res 0603 Zero 0hm 1/16w ± 5%
R604	038-10000-00	Res 0603 Zero 0hm 1/16w ± 5%
R605	038-10000-00	Res 0603 Zero 0hm 1/16w ± 5%
R606	038-15100-00	Res 0603 10k 1/16w +-5%
R607	038-15100-00	Res 0603 10k 1/16w +-5%
R608	038-15100-00	Res 0603 10k 1/16w +-5%
R609	038-15100-00	Res 0603 10k 1/16w +-5%
R611	038-15100-00	Res 0603 10k 1/16w +-5%

Ref.	IPN	Description
R612	038-14470-00	Res 0603 4k7 1/16w +-5%
R701	038-16120-00	Res 0603 120k 1/16w +-5%
R710	036-13100-00	Res M/F SMD 0805 100e 5%
R720	038-15100-00	Res 0603 10k 1/16w +-5%
R721	038-14220-00	Res 0603 2k2 1/16w +-5%
R722	038-14470-00	Res 0603 4k7 1/16w +-5%
R730	038-12470-00	Res 0603 47e 1/16w ± 5%
R731	038-12470-00	Res 0603 47e 1/16w ± 5%
U300	002-12523-17	IC LM317l Reg T0252 0.5a
U310	002-14931-00	IC L4931CD33 3.3v 250Ma Regso8
U400	002-19120-00	IC TS912ID Cmos R2R Opamp
U500	002-13483-00	IC XCVR RS485 LTD SLEW RATE 3V
U600	002-15595-00	IC 74AHC595 8bit Shiftreg Tsop
U610	002-10126-71	IC SMD DS1868 Dgtl Pot Tsop20
U700	002-13001-00	IC TPA3001 20W Mono PA TSSOP24
	220-01721-02	PCB MFX Head Remote

Ref.	IPN	Description
	219-02914-00	Loom MFX Remote Head
	302-10062-00	Brkt Remote Head TM8200
	302-05263-00	Brkt U Thumb Scrw TMA
	316-06842-00	Pnl Rear TM8200 MF2
	346-10030-08	Scrw P/T Wn1412 Kc30x08 Zbc
	349-00060-00	Scrw 10GX20 SLFDRL Hex/Poz TMA
	353-05007-00	Wshr Rubber M4*19*1.0 S/A
	354-01052-00	Fsnr Bush PSM SHK-B-M4 Ins

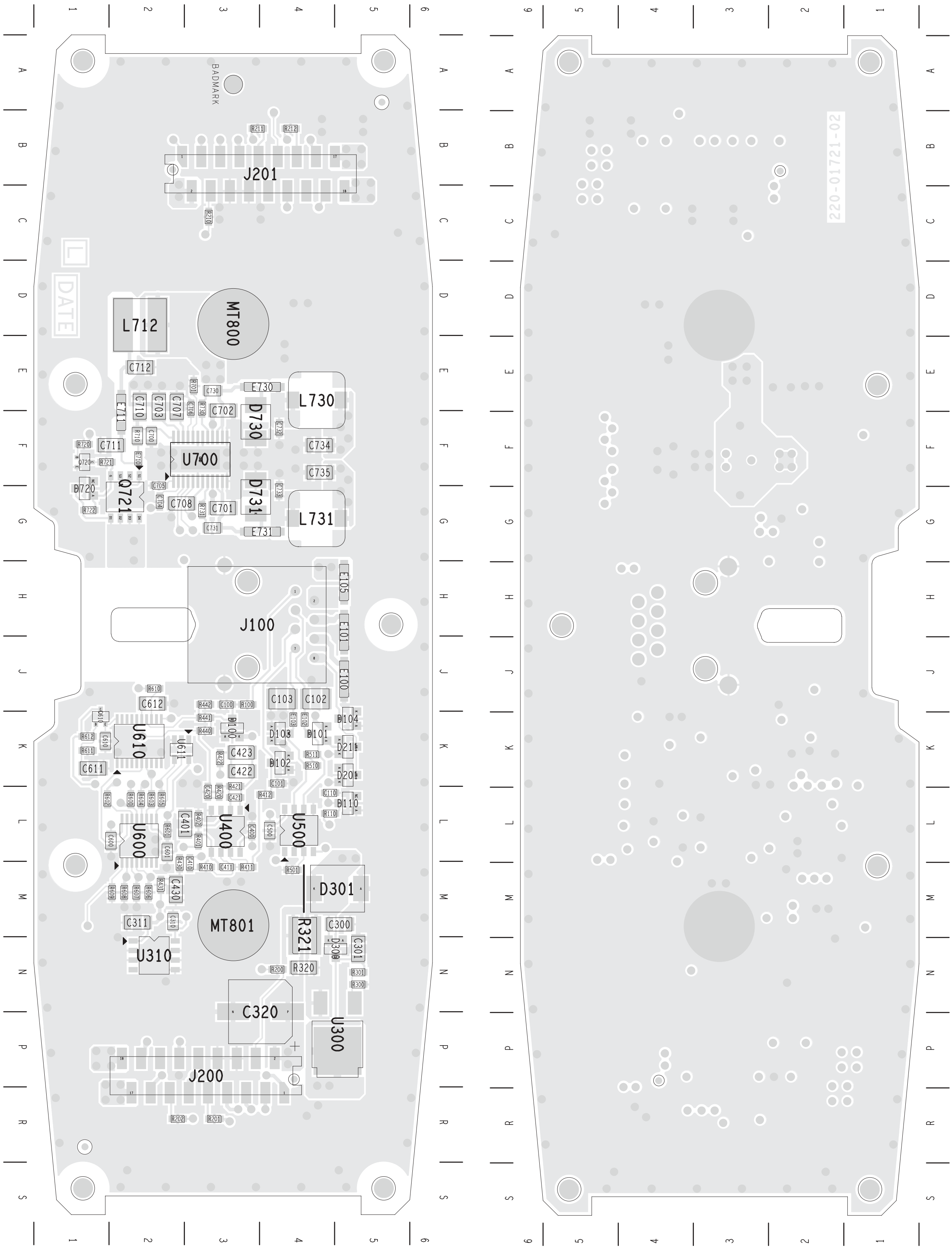
TMAA-4-01 Remote Cable Parts

219-02918-00	**Cbl Rmt Ctrl Hd Kit, comprising:**
240-02158-00	Conn Shld RJ45 Shortbody Plg
360-02022-00	Grommet Mic TMA

Grid Reference List

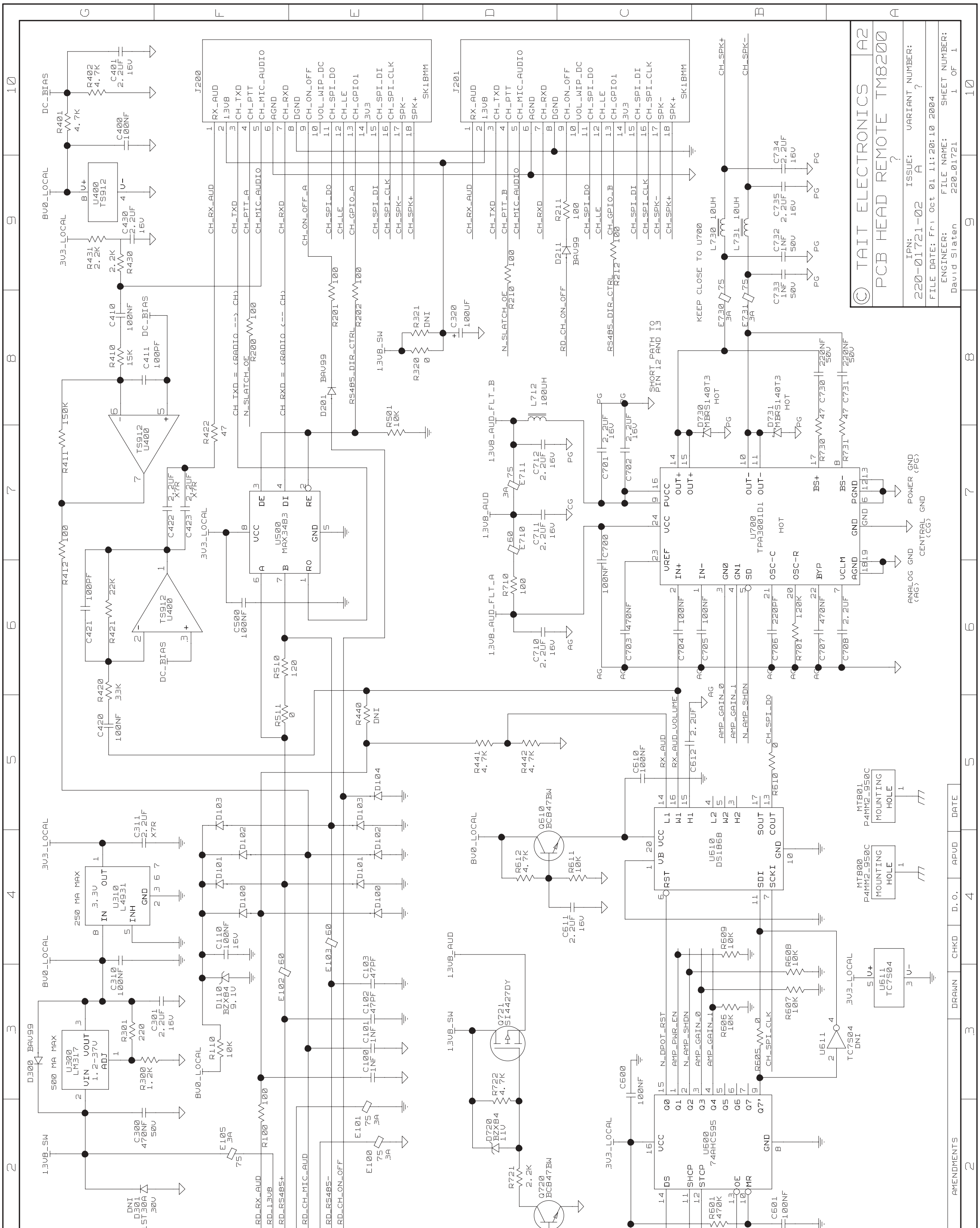
Ref.	PCB	Circuit
C100	J3	1E3
C101	K4	1E3
C102	J4	1E3
C103	J4	1E3
C110	L4	1F4
C300	M5	1G2
C301	N5	1F3
C310	M2	1G4
C311	M2	1G4
C320	P4	1D8
C400	L3	1G10
C401	L3	1G10
C410	M3	1G8
C411	M3	1G8
C420	L3	1G5
C421	L3	1G6
C422	K3	1F7
C423	K3	1F7
C430	M2	1G9
C500	L4	1F6
C600	L2	1C3
C601	L2	1B2
C610	K1	1C5
C611	K1	1C4
C612	J2	1C5
C700	F2	1C6
C701	G3	1C7
C702	F3	1C7
C703	E2	1C6
C704	G2	1C6
C705	G2	1B6
C706	E3	1B6
C707	E2	1B6
C708	G2	1A6
C710	E2	1D6
C711	F2	1D7
C712	E2	1D7
C730	E3	1B8
C731	G3	1A8
C732	F4	1B9
C733	G4	1B9
C734	F4	1B9
C735	F4	1B9
D100	K3	1E4 1F4
D101	K4	1F4 1E4
D102	K4	1F4 1E4
D103	K4	1E5 1F5
D104	K5	1E5
D110	L5	1F3
D201	K5	1E8
D211	K5	1C9
D300	N5	1G3
D301	M5	1G2
D720	G1	1D2
D730	F3	1B7
D731	G3	1B7
E100	J5	1E2
E101	H5	1E2
E102	K4	1F3
E103	K4	1E4
E105	H5	1F2
E710	F2	1D7
E711	F2	1D7
E730	E4	1B8
E731	G4	1B8
J100	H4	1E1
J200	P3	1E10
J201	B4	1C10
L712	D2	1D8
L730	E4	1B9
L731	G4	1B9
MT800	D3	1A4
MT801	M3	1A5
Q610	K1	1D4
Q720	F1	1D2
Q721	G2	1D3
R100	J3	1F2
R110	L4	1F3
R200	N4	1F8
R201	R3	1E8
R202	R2	1E8
R210	C3	1D9
R211	B3	1C9
R212	B4	1C9
R300	N5	1G3
R301	N5	1G3
R320	N4	1E8
R321	M4	1E8
R401	L3	1G10
R402	L3	1G10
R410	M3	1G8
R411	M3	1G7
R412	L4	1G7
R420	L3	1G6
R421	L3	1G6
R422	K3	1F7
R430	M2	1G9
R431	M2	1G9
R440	K3	1E5
R441	K3	1D5
R442	J3	1D5
R501	M4	1E7
R510	K4	1F6
R511	K4	1F5
R600	L2	1B1
R601	L2	1B2
R602	L1	1C1
R603	L2	1C1
R604	L2	1B1
R605	L2	1B3
R606	M2	1B3
R607	M2	1B3
R608	M2	1B3
R609	M2	1B4
R610	J2	1B5
R611	K1	1C4
R612	K1	1D4
R701	E3	1B6
R710	F2	1D6
R720	F1	1D1
R721	F1	1D2
R722	G1	1D2
R730	E3	1B7
R731	G3	1A7
U300	P5	1G3
U310	N2	1G4
U400	L3	1F6 1G9 1G7
U500	L4	1F7
U600	L2	1B2
U610	K2	1B4
U611	K2	1A3
U700	F3	1B7

Board Layout



IPN 220-01721-02

Circuit Diagram



23.4.2 TMAC34-0T Torso Interface (PCB IPN 220-01720-01)

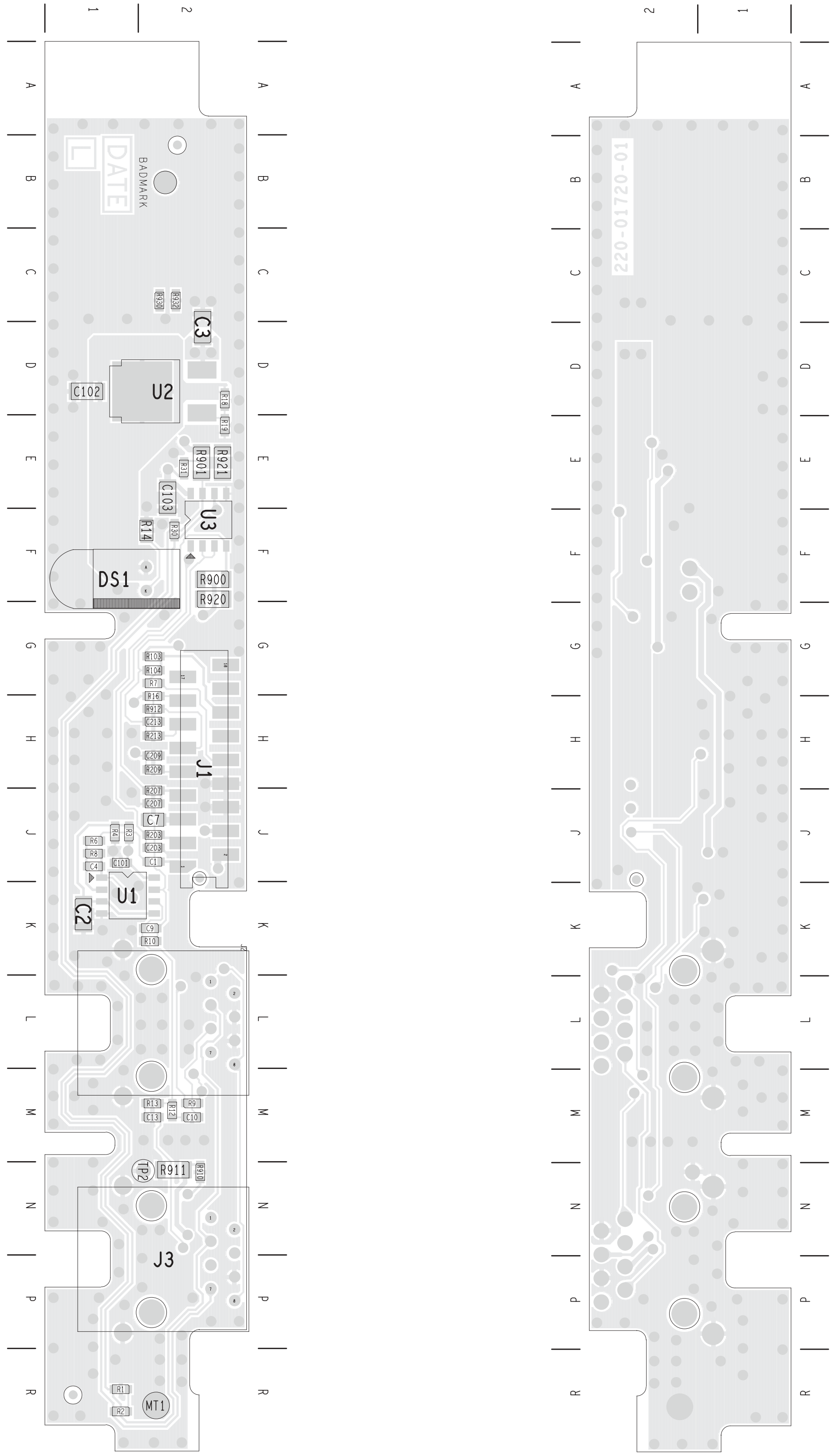
Parts List

Ref.	IPN	Description
C1	018-16100-00	Cap 0603 100n 16v x7r + - 10%
C2	015-07470-10	Cap Cer 1206 4u7 X7r 16v
C3	015-06470-01	Cap Cer 1206 470n X7r 20% 50v
C4	018-13100-00	Cap 0603 100p 50v NPO ±5%
C7	015-27100-08	Cap Cer 0805 X7R 1uF 16V 10%
C9	018-13100-00	Cap 0603 100p 50v NPO ±5%
C10	018-16100-00	Cap 0603 100n 16v x7r + - 10%
C13	018-16100-00	Cap 0603 100n 16v x7r + - 10%
C101	018-16100-00	Cap 0603 100n 16v x7r + - 10%
C102	015-07470-10	Cap Cer 1206 4u7 X7r 16v
C103	015-07470-10	Cap Cer 1206 4u7 X7r 16v
C203	018-13270-00	Cap 0603 270p 50v NPO±5%
C207	018-13270-00	Cap 0603 270p 50v NPO±5%
C209	018-13270-00	Cap 0603 270p 50v NPO±5%
C213	018-13270-00	Cap 0603 270p 50v NPO±5%
DS1	008-00014-73	LED Hp Grn Rang PCB Mtg
J1	240-10000-11	Conn SMD 18w Skt M/Match
J2	240-00016-00	Conn RJ45 Shld 8P8C LP RA TH
J3	240-00016-00	Conn RJ45 Shld 8P8C LP RA TH
R1	038-13120-00	Res 0603 120e 1/16w ± 5%
R2	038-10000-00	Res 0603 Zero 0hm 1/16w ± 5%
R3	038-14470-00	Res 0603 4k7 1/16w +-5%
R4	038-14470-00	Res 0603 4k7 1/16w +-5%
R6	038-15220-00	Res 0603 22k 1/16w +-5%
R7	038-15100-00	Res 0603 10k 1/16w +-5%
R8	038-15820-00	Res 0603 82k 1/16w +-5%
R9	038-13100-00	Res 0603 100e 1/16w ± 5%
R10	038-15100-00	Res 0603 10k 1/16w +-5%
R12	038-16100-00	Res 0603 100k 1/16w +-5%
R13	038-16100-00	Res 0603 100k 1/16w +-5%
R14	036-13560-00	Res M/F SMD 0805 560e 5%
R16	038-15100-00	Res 0603 10k 1/16w +-5%
R18	038-13220-00	Res 0603 220e 1/16w +-5%
R19	038-14120-00	Res 0603 1k2 1/16w +-5%
R30	038-13390-00	Res 0603 390e 1/16w +-5%
R31	038-13390-00	Res 0603 390e 1/16w +-5%
R103	038-12100-00	Res 0603 10e 1/16W ± 5%
R104	038-15100-00	Res 0603 10k 1/16w +-5%
R203	038-13100-00	Res 0603 100e 1/16w ± 5%
R207	038-13100-00	Res 0603 100e 1/16w ± 5%
R209	038-13100-00	Res 0603 100e 1/16w ± 5%
R213	038-13100-00	Res 0603 100e 1/16w ± 5%
R911	036-00000-00	Res 1206 0e 5% 0.125w
U1	002-19120-00	IC TS912ID Cmos R2R Opamp
U2	002-12523-17	IC LM317l Reg T0252 0.5a
U3	002-13483-00	IC XCVR RS485 LTD SLEW RATE 3V
	220-01720-01	PCB MFX Radio Remote
	219-02882-00	Loom Control Head TMA
	302-10063-00	Brkt PCB Remote TM8200 Body
	302-50002-00	Bung RJ45 MFO
	316-06843-00	Pnl Frt Remote TM8200 MF0
	346-10030-08	Scrw P/T Wn1412 Kc30x08 Zbc
	349-02062-00	Scrw M3*8 T/T P/T ContiR
	365-01762-00	Lbl TM8200 Branding Bullet

Grid Reference List

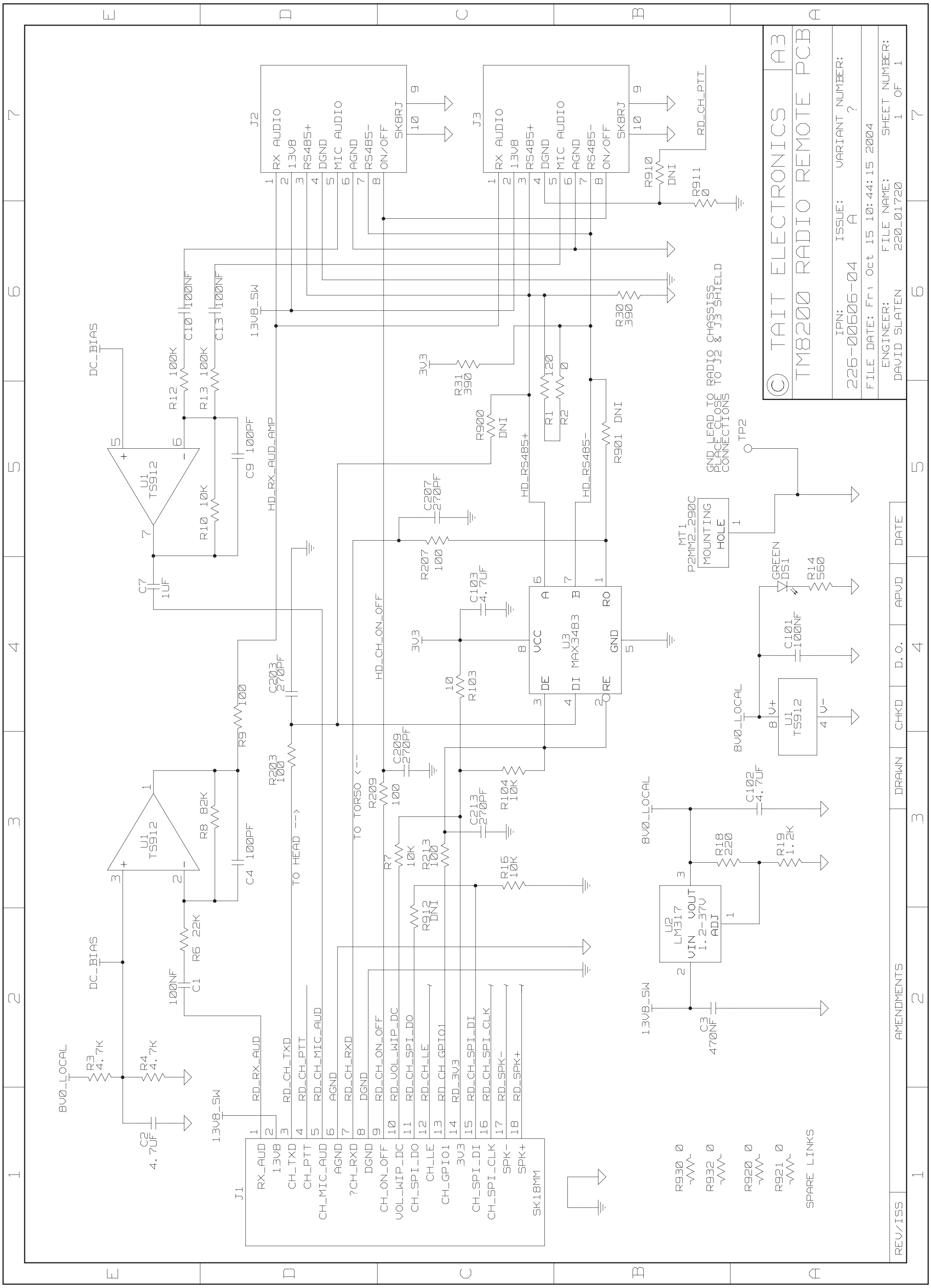
Ref.	PCB	Circuit
C1	J2	1E2
C10	M2	1E6
C101	J1	1A4
C102	D1	1A3
C103	E2	1C4
C13	M2	1D6
C2	K1	1E1
C203	J2	1D4
C207	J2	1C5
C209	H2	1C3
C213	H2	1C3
C3	D2	1B2
C4	J1	1D3
C7	J2	1E4
C9	K2	1D5
DS1	F2	1A4
J1	H2	1C1
J2	L2	1D7
J3	N2	1C7
MT1	R2	1B5
R1	R1	1C5
R10	K2	1D5
R103	G2	1C4
R104	G2	1C3
R12	M2	1E6
R13	M2	1D6
R14	F2	1A4
R16	H2	1C3
R18	D2	1B3
R19	E2	1A3
R2	R1	1B5
R203	J2	1D3
R207	J2	1C5
R209	H2	1C3
R213	H2	1C3
R3	J1	1E2
R30	F2	1B6
R31	E2	1C6
R4	J1	1E2
R6	J1	1E2
R7	G2	1C3
R8	J1	1D3
R9	M2	1D4
R900	F2	1C5
R901	E2	1B5
R910	N2	1B7
R911	N2	1B7
R912	H2	1C2
R920	F2	1A1
R921	E2	1A1
R930	C2	1B1
R932	C2	1B1
TP2	N2	1A5
U1	K1	1E5 1E3 1A4
U2	D2	1B2
U3	F2	1B4

Board Layout



IPN 220-01720-01

Circuit Diagram

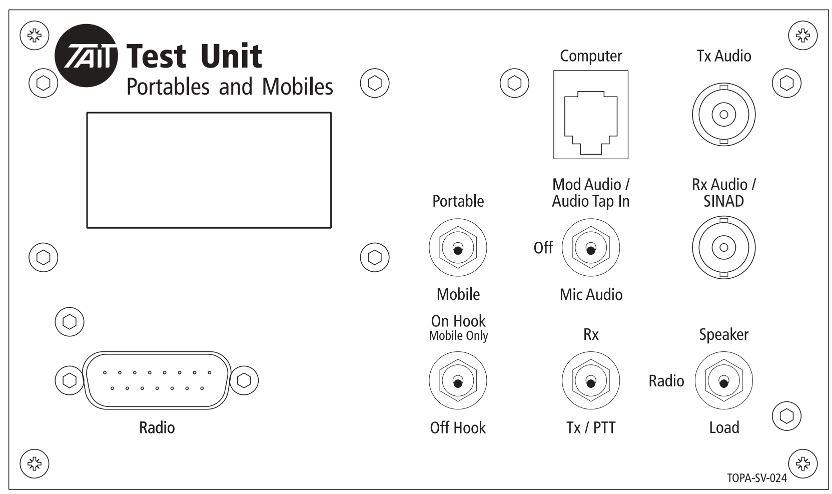


24 TOPA-SV-024 Test Unit

The TOPA-SV-024 test unit is used to test and maintain Tait portable and mobile radios by providing an interface between the radio, a test PC, and an RF communications test set.

The diagram below shows the front panel of the test unit.

Figure 24.1 TOPA-SV-024 test unit

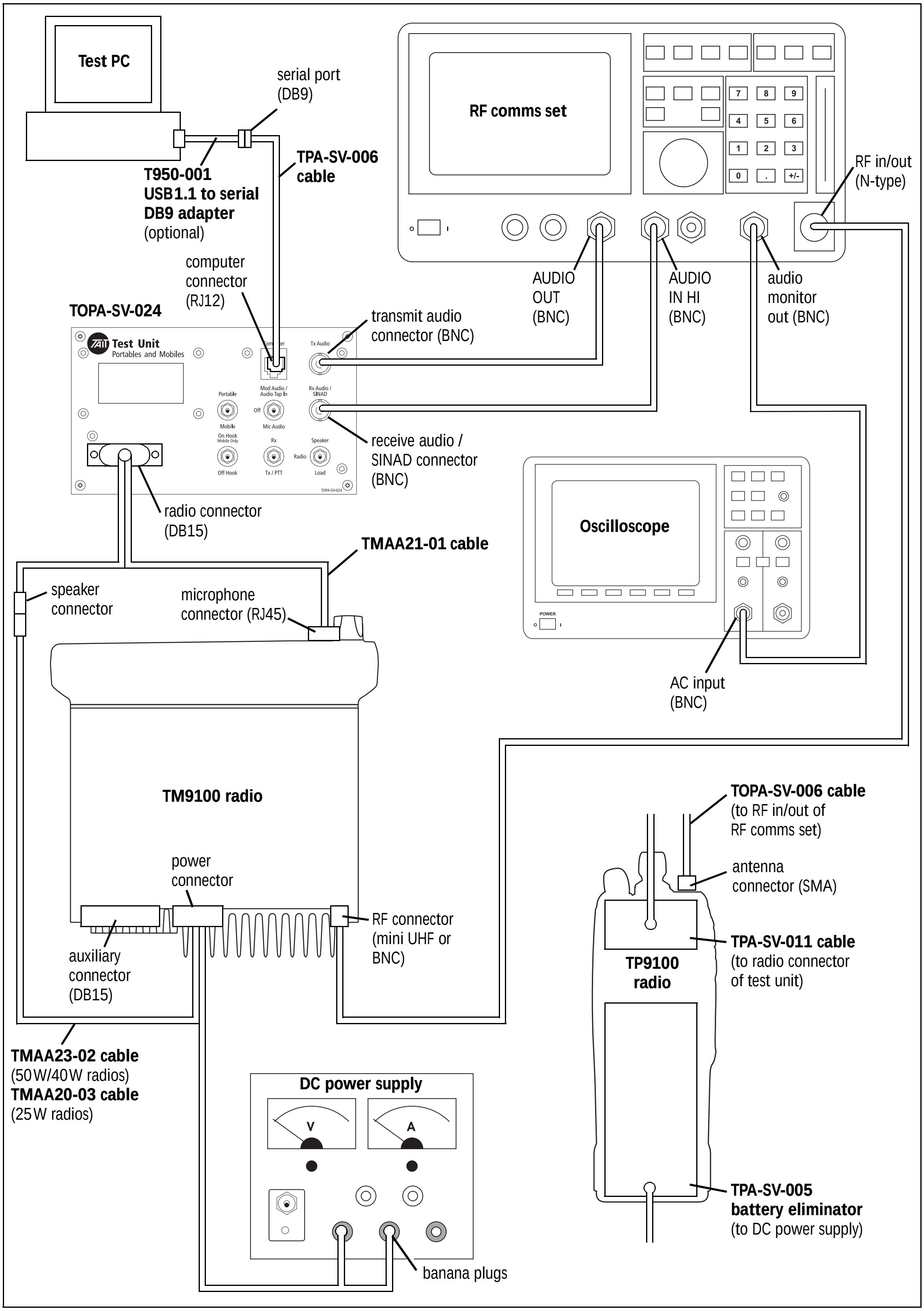


24.1 Test Setup

The diagram on the following page shows how the test unit is connected to the radio, the test PC, and the RF communications test set.

Note The test unit can also be connected to a Tait Orca portable radio (TOP) using the TOPA-SV-007 cable, or to a T2000 radio using the T2000-11 cable. Use with Tait Orca and T2000 radios is not described in this document.

Figure 24.2 Test setup



24.2 Operation

This section explains the function of the TOPA-SV-024 test unit controls. The procedure for using the test unit is described in the relevant section on test equipment setup.

24.2.1 Portable / Mobile Switch

This 2-way toggle switch is used to switch attenuation resistors (R4, R5, R6) in and out of the line from the radio’s positive speaker output to the positive receive audio/SINAD output of the test unit (before the isolating transformer).

- When set to **Portable**, the attenuation resistors are switched out.
- When set to **Mobile**, the attenuation resistors are switched in (attenuation 10:1).

Important Selecting the wrong switch position may result in incorrect SINAD readings and damage to the test unit.

24.2.2 Mod Audio/Audio Tap In / Off / Mic Audio Switch

This 3-way toggle switch is used to switch between **Mod Audio/Audio Tap In**, **Mic Audio**, and **Off** (no audio signal).

- With the Tait Orca portables, this switch can be used for setting up dual point modulation by applying modulation to different parts of the radio.
- For normal transmit deviation tests (other portables and mobiles), this switch is set to **Mic Audio**.

24.2.3 On Hook / Off Hook Switch

Important When using the test unit with portables, the **On Hook** / **Off Hook** toggle switch **must** be set to **Off Hook**. Portables do not have a hookswitch, and if the switch is set to **On Hook**, the accessory function key of the portable is activated.

This 2-way toggle switch is used to simulate the microphone hookswitch opening (“hook off”) and closing (“hook on”). This is done by switching a 12kΩ resistor (R3) in or out of the MIC_PTT line.

- When set to **Off Hook**, the 12kΩ resistor (R3) is switched out of the MIC_PTT line. This simulates the microphone being removed from the microphone clip.
- When set to **On Hook**, a 12kΩ resistor (R3) is switched into the MIC_PTT line. This simulates the microphone being placed on the microphone clip.

24.2.4 Rx / Tx/PTT Switch

This 2-way toggle switch is used to switch between receive and transmit mode.

- When set to **Rx**, the PTT line is switched to high impedance.
- When set to **Tx/PTT**, the PTT line is pulled to ground.

24.2.5 Speaker / Radio / Load Switch

This 3-way toggle switch is used during receive audio tests to switch the audio to the test unit speaker (**Speaker**), to the radio's internal speaker (**Radio**) or to a dummy load consisting of R1 and R2 (**Load**).

Note This switch does not disconnect the radio's internal speaker on mobiles. If the switch is set to **Speaker** or **Load**, this simulates an external speaker being connected in parallel to the radio's internal speaker.

With all settings, a low level audio signal is available for testing through the SINAD port.

Portable

- When set to **Speaker**, only the speaker of the test unit is active.
- When set to **Radio**, only the speaker of the portable is active.
- When set to **Load**, no speaker is active. The audio signal is terminated in the test unit dummy load.

Mobile

- When set to **Speaker**, the speakers of the test unit and the mobile are both active. The speaker of the mobile cannot be disconnected.
- When set to **Radio**, only the speaker of the mobile is active.
- When set to **Load**, the speaker of the mobile remains active.

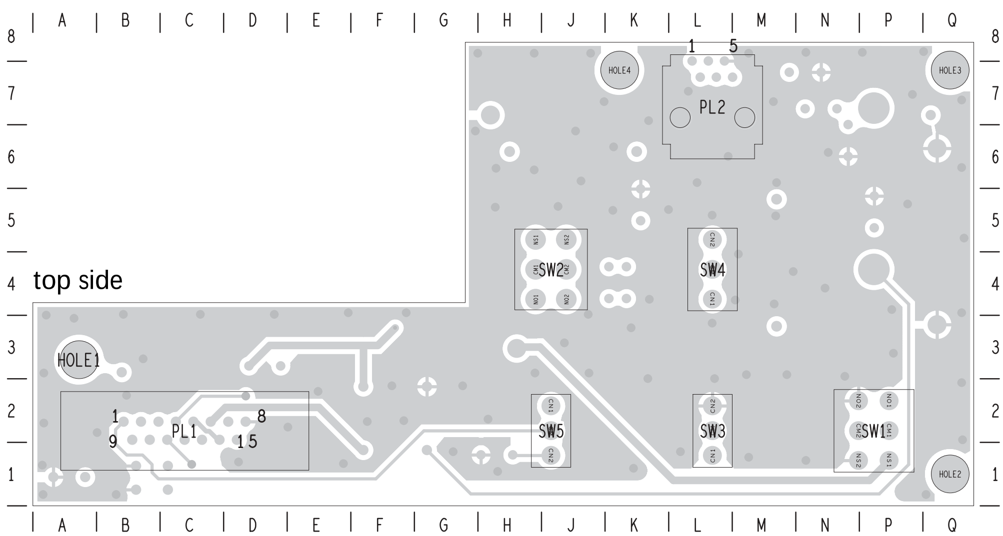
24.3 PCB Information (PCB IPN 220-01418-02A)

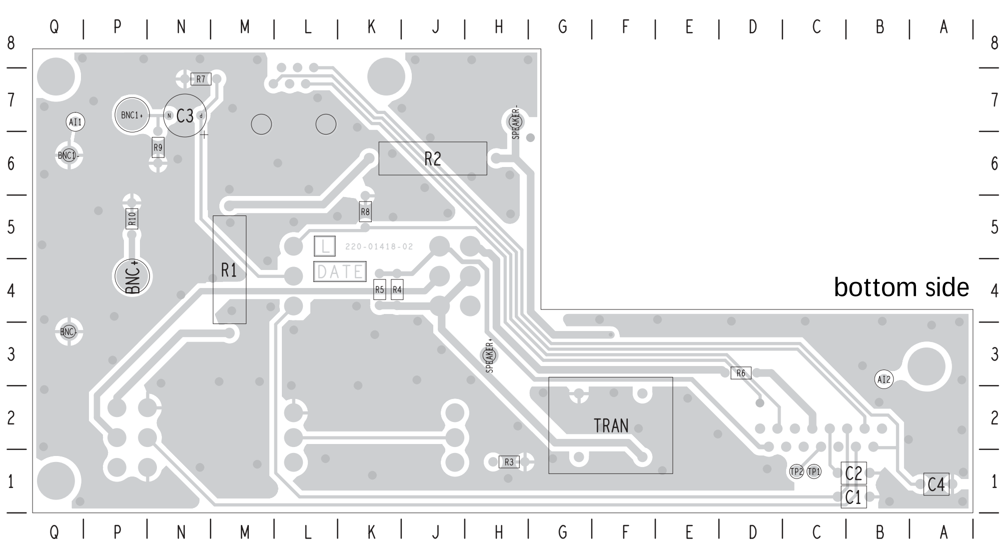
24.3.1 Parts List (Rev. 4)

Ref.	IPN	Description
BNC1	240-02100-11	Skt Coax BNC 3.5mm Pnl N/Tag
BNC2	240-02100-11	Skt Coax BNC 3.5mm Pnl N/Tag
C1	011-54100-01	Cap Cer Al 1n 10% T/C B 50v
C2	011-54100-01	Cap Cer Al 1n 10% T/C B 50v
C3	020-59100-06	Cap Elec Rdl 100m 16v 6.3x11
C4	011-54100-01	Cap Cer Al 1n 10% T/C B 50v
PL1	240-00010-55	Plg 15w Drng W-Wrap Pnl Mtg
PL2	240-04021-60	Skt 6w Modr Ph Vrt T-Ent
R1	032-31820-01	Res M/F Pwr 17x5 8e2 5% 2.5w
R2	032-31820-01	Res M/F Pwr 17x5 8e2 5% 2.5w
R3	030-55120-20	Res Flm 4x1.6 12k 5% 0.4w
R4	030-53560-20	Res Flm 4x1.6 560e 5% 0.4w
R5	030-54270-20	Res Flm 4x1.6 2k7 5% 0.4w
R6	030-52560-20	Res Flm 4x1.6 56e 5% 0.4w
R7	030-55100-20	Res Flm 4x1.6 10k 5% 0.4w

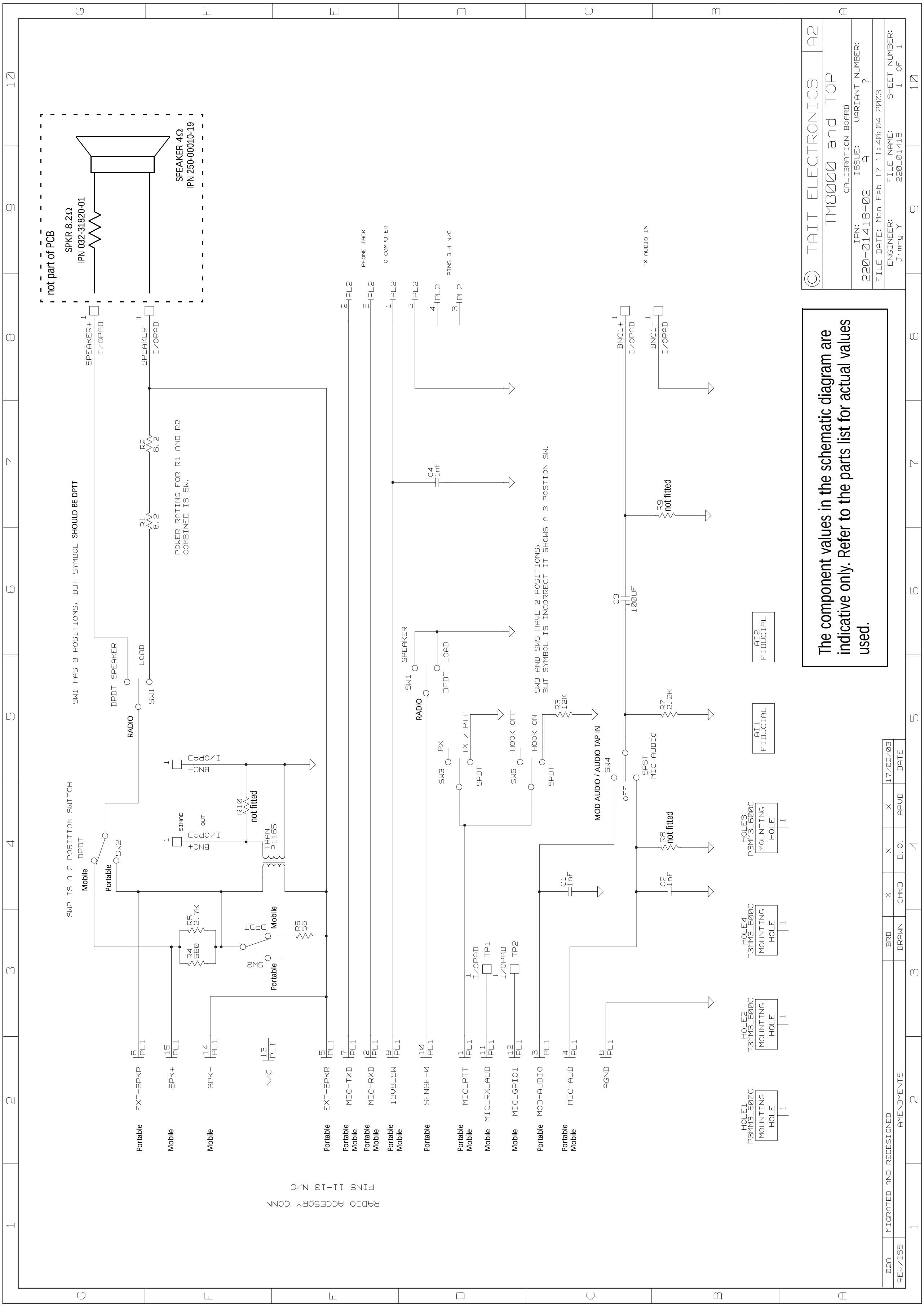
Ref.	IPN	Description
SW1	230-00010-42	Sw Tgl On Off On Dpdt Ms500hb
SW2	230-00010-57	Sw Tgl Dpdt On-On Pnl Mtg
SW3	230-00010-03	Sw Tgl Spst Mini Pnl Mtg
SW4	230-00010-16	Sw Tgr Spst 3-Pos Pnl Mtg
SW5	230-00010-03	Sw Tgl Spst Mini Pnl Mtg
TRAN	054-00010-17	Xfmr Line 600 Ohm 1:1
Not part of the PCB:		
SPKR	032-31820-01	Res M/F Pwr 17x5 8e2 5% 2.5w
	250-00010-19	Spkr C/W Rubber Sealing Ring

24.3.2 PCB Layout





24.3.3 Circuit Diagram



Tait General Software Licence Agreement

This legal document is an Agreement between you (the "Licensee") and Tait Electronics Limited ("Tait"). By using any of the Software or Firmware items prior-installed in the related Tait product, included on CD or downloaded from the Tait website, (hereinafter referred to as "the Software or Firmware") you agree to be bound by the terms of this Agreement. If you do not agree to the terms of this Agreement, do not install and use any of the Software or Firmware. If you install and use any of the Software or Firmware that will be deemed to be acceptance of the terms of this licence agreement.

The terms of this Agreement shall apply subject only to any express written terms of agreement to the contrary between Tait and the Licensee.

Licence

TAIT GRANTS TO YOU AS LICENSEE THE NON-EXCLUSIVE RIGHT TO USE THE SOFTWARE OR FIRMWARE ON A SINGLE MACHINE PROVIDED YOU MAY ONLY:

1. COPY THE SOFTWARE OR FIRMWARE INTO ANY MACHINE READABLE OR PRINTED FORM FOR BACKUP PURPOSES IN SUPPORT OF YOUR USE OF THE PROGRAM ON THE SINGLE MACHINE (CERTAIN PROGRAMS, HOWEVER, MAY INCLUDE MECHANISMS TO LIMIT OR INHIBIT COPYING, THEY ARE MARKED "COPY PROTECTED"), PROVIDED THE COPYRIGHT NOTICE MUST BE REPRODUCED AND INCLUDED ON ANY SUCH COPY OF THE SOFTWARE OR FIRMWARE; AND / OR

2. MERGE IT INTO ANOTHER PROGRAM FOR YOUR USE ON THE SINGLE MACHINE (ANY PORTION OF ANY SOFTWARE OR FIRMWARE MERGED INTO ANOTHER PROGRAM WILL CONTINUE TO BE SUBJECT TO THE TERMS AND CONDITIONS OF THIS AGREEMENT).

THE LICENSEE MAY NOT DUPLICATE, MODIFY, REVERSE COMPILE OR REVERSE ASSEMBLE ANY SOFTWARE OR FIRMWARE IN WHOLE OR PART.

Important Notice

THE SOFTWARE OR FIRMWARE MAY CONTAIN OPEN SOURCE SOFTWARE COMPONENTS ("OPEN SOURCE COMPONENTS"). OPEN SOURCE COMPONENTS ARE EXCLUDED FROM THE TERMS OF THIS AGREEMENT EXCEPT AS EXPRESSLY STATED IN THIS AGREEMENT AND ARE COVERED BY THE TERMS OF THEIR RESPECTIVE LICENCES WHICH MAY EXCLUDE OR LIMIT ANY WARRANTY FROM OR LIABILITY OF THE DEVELOPERS AND/OR COPYRIGHT HOLDERS OF THE OPEN SOURCE COMPONENT FOR THE PERFORMANCE OF THOSE OPEN SOURCE COMPONENTS. YOU AGREE TO BE BOUND BY THE TERMS AND CONDITIONS OF EACH SUCH LICENCE. FOR MORE INFORMATION SEE: http://support.taitworld.com/go/opensource

Title to Software

THIS AGREEMENT DOES NOT CONSTITUTE A CONTRACT OF SALE IN RELATION TO THE SOFTWARE OR FIRMWARE SUPPLIED TO THE LICENSEE. NOT WITHSTANDING THE LICENSEE MAY OWN THE MAGNETIC OR OTHER PHYSICAL MEDIA ON WHICH THE SOFTWARE OR FIRMWARE WAS ORIGINALLY SUPPLIED, OR HAS SUBSEQUENTLY BEEN RECORDED OR FIXED, IT IS A FUNDAMENTAL TERM OF THIS AGREEMENT THAT AT ALL TIMES TITLE AND OWNERSHIP OF THE SOFTWARE OR FIRMWARE, WHETHER ON THE ORIGINAL MEDIA OR OTHERWISE, SHALL REMAIN VESTED IN TAIT OR THIRD PARTIES WHO HAVE GRANTED LICENCES TO TAIT.

Term and Termination

THIS LICENCE SHALL BE EFFECTIVE UNTIL TERMINATED IN ACCORDANCE WITH THE PROVISIONS OF THIS AGREEMENT. THE LICENSEE MAY TERMINATE THIS LICENCE AT ANY TIME BY DESTROYING ALL COPIES OF THE SOFTWARE OR FIRMWARE AND ASSOCIATED WRITTEN MATERIALS. THIS LICENCE WILL BE TERMINATED AUTOMATICALLY AND WITHOUT NOTICE FROM TAIT IN THE EVENT THAT THE LICENSEE FAILS TO COMPLY WITH ANY TERM OR CONDITION OF THIS AGREEMENT. THE LICENSEE AGREES TO DESTROY ALL COPIES OF THE SOFTWARE OR FIRMWARE AND ASSOCIATED WRITTEN MATERIALS IN THE EVENT OF SUCH TERMINATION.

Limited Warranty

THE SOFTWARE OR FIRMWARE (INCLUDING OPEN SOURCE COMPONENTS) IS SUPPLIED BY TAIT AND ACCEPTED BY THE LICENSEE "AS IS" WITHOUT WARRANTY OF ANY KIND EITHER EXPRESSED OR IMPLIED, INCLUDING BUT NOT BEING LIMITED TO ANY IMPLIED WARRANTIES AS TO MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. THE LICENSEE ACKNOWLEDGES THAT THE SOFTWARE OR FIRMWARE (INCLUDING OPEN SOURCE COMPONENTS) IS USED BY IT IN BUSINESS AND ACCORDINGLY TO THE MAXIMUM EXTENT PERMITTED BY LAW NO TERMS OR WARRANTIES WHICH ARE IMPLIED BY LEGISLATION SHALL APPLY TO THIS AGREEMENT. TAIT DOES NOT WARRANT THAT THE FUNCTIONS CONTAINED IN THE SOFTWARE OR FIRMWARE (INCLUDING OPEN SOURCE COMPONENTS) WILL MEET THE LICENSEE'S REQUIREMENTS OR THAT THE OPERATION OF THE SOFTWARE OR FIRMWARE (INCLUDING OPEN SOURCE COMPONENTS) WILL BE UNINTERRUPTED OR ERROR FREE.

Exclusion of Liability

IN NO CIRCUMSTANCES SHALL TAIT BE UNDER ANY LIABILITY TO THE LICENSEE, OR ANY OTHER PERSON WHATSOEVER, WHETHER IN TORT (INCLUDING NEGLIGENCE), CONTRACT (EXCEPT AS EXPRESSLY PROVIDED IN THIS AGREEMENT), EQUITY, UNDER ANY STATUTE, OR OTHERWISE AT LAW FOR ANY LOSSES OR DAMAGES WHETHER GENERAL, SPECIAL, EXEMPLARY, PUNITIVE, DIRECT, INDIRECT OR CONSEQUENTIAL ARISING OUT OF OR IN CONNECTION WITH ANY USE OR INABILITY OF USING THE SOFTWARE OR FIRMWARE (INCLUDING OPEN SOURCE COMPONENTS).

THE LICENSEE'S SOLE REMEDY AGAINST TAIT WILL BE LIMITED TO BREACH OF CONTRACT AND TAIT'S SOLE AND TOTAL LIABILITY FOR ANY SUCH CLAIM SHALL BE LIMITED AT THE OPTION OF TAIT TO THE REPAIR OR REPLACEMENT OF THE SOFTWARE OR FIRMWARE OR THE REFUND OF THE PURCHASE PRICE OF THE SOFTWARE OR FIRMWARE.

General

THE LICENSEE CONFIRMS THAT IT SHALL COMPLY WITH THE PROVISIONS OF LAW IN RELATION TO THE SOFTWARE OR FIRMWARE.

Law and Jurisdiction

THIS AGREEMENT SHALL BE SUBJECT TO AND CONSTRUED IN ACCORDANCE WITH NEW ZEALAND LAW AND DISPUTES BETWEEN THE PARTIES CONCERNING THE PROVISIONS HEREOF SHALL BE DETERMINED BY THE NEW ZEALAND COURTS OF LAW. PROVIDED HOWEVER TAIT MAY AT ITS ELECTION BRING PROCEEDINGS FOR BREACH OF THE TERMS HEREOF OR FOR THE ENFORCEMENT OF ANY JUDGEMENT IN RELATION TO A BREACH OF THE TERMS HEREOF IN ANY JURISDICTION TAIT CONSIDERS FIT FOR THE PURPOSE OF ENSURING COMPLIANCE WITH THE TERMS HEREOF OR OBTAINING RELIEF FOR BREACH OF THE TERMS HEREOF.

No Dealings

THE LICENSEE MAY NOT SUBLICENSE, ASSIGN OR TRANSFER THE LICENCE OR THE PROGRAM EXCEPT AS EXPRESSLY PROVIDED IN THIS AGREEMENT. ANY ATTEMPT OTHERWISE TO SUBLICENSE, ASSIGN OR TRANSFER ANY OF THE RIGHTS, DUTIES OR OBLIGATIONS HEREUNDER IS VOID.

No Other Terms

THE LICENSEE ACKNOWLEDGES THAT IT HAS READ THIS AGREEMENT, UNDERSTANDS IT AND AGREES TO BE BOUND BY ITS TERMS AND CONDITIONS. THE LICENSEE FURTHER AGREES THAT SUBJECT ONLY TO ANY EXPRESS WRITTEN TERMS OF AGREEMENT TO THE CONTRARY BETWEEN TAIT AND THE LICENSEE THIS IS THE COMPLETE AND EXCLUSIVE STATEMENT OF THE AGREEMENT BETWEEN IT AND TAIT IN RELATION TO THE SOFTWARE OR FIRMWARE WHICH SUPERSEDES ANY PROPOSAL OR PRIOR AGREEMENT, ORAL OR WRITTEN AND ANY OTHER COMMUNICATIONS BETWEEN THE LICENSEE AND TAIT RELATING TO THE SOFTWARE OR FIRMWARE.