TB7100 base station

Service Manual

MBB-00005-01
Issue 1
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Tait Contact Information

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To our European customers:
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Contents

Preface

Scope of Manual

This manual contains information to service technicians for carrying out level-1 and level-2 repairs of the TB7100 base station.

Level-1 repairs entail the replacement of faulty parts and circuit boards; level-2 repairs entail the repair of the transmitter and receiver modules, 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.

For more information on repair levels and serviceable parts, refer to "General Information" on page 75.

Hardware and Software Versions

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

- B1 band, 25W : 220-01700-**10**
- H5 and H6 bands, 25W : 220-01697-**10**
- B1 band, 50W : 220-01723-**02**
- H5 and H7 bands, 50W/40W : 220-01722-**02**
- Programming application : version **1.06**
- Calibration application : version **1.03**

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.

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:

- MBB-00001-**xx** TB7100 Installation and Operation Manual
- MBB-00002-**xx** TB7100 Specifications Manual
- MBB-00003-**xx** TB7100 Installation Guide

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

All available documentation is provided on the CD (406-00047-**xx**) supplied with the base station. Updates may also be published on the Tait support website.

Publication Record

Issue	Publication Date	Description
01	October 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
ASC	Accredited Service Centre
BOM	Bill of Materials
CCTM	Computer-Controlled Test Mode
CODEC	Coder-Decoder
CSO	Customer Service Organisation
DAC	Digital-to-Analog Converter
DC	Direct Current
DSP	Digital Signal Processor
ESD	Electrostatic Discharge
FCL	Frequency Control Loop
FE	Front-End

Abbreviation	Description
FPGA	Field-Programmable Gate Array
IC	Integrated Circuit
IPN	Internal Part Number
IF	Intermediate Frequency
IQ	In-Phase and Quadrature
ISC	International Service Centre
LCD	Liquid-Crystal Display
LED	Light-Emitting Diode
LNA	Low-Noise Amplifier
LO	Local Oscillator
LPF	Low-Pass Filter
PA	Power Amplifier
PCB	Printed Circuit Board
PLL	Phase-Locked Loop
PTT	Press-To-Talk
RISC	Reduced Instruction Set Computing
RSSI	Received Signal Strength Indication
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

1 Introduction

The TB7100 is a software and hardware link-configured base station which is designed for operation in large variety of standard frequency ranges. It makes extensive use of digital and DSP technology. Many operating parameters such as channel spacing, audio bandwidth and signalling are controlled by software.

This manual includes the information required for servicing the base station.

This section describes the different options available for:

- frequency bands
- RF output power
- product codes

For specifications, refer to the specifications manual or the area on the TaitWorld website reserved for TB7100 products.

Figure 1.1 TB7100 base station

1.1 Frequency Bands

The base station is available in the following frequency bands:

- 136 to 174 MHz (B1)
- 400 to 470 MHz (H5)
- 450 to 530 MHz (H6)
- 450 to 520 MHz (H7)

The RF band of the base station is implemented by the frequency band of the transmitter and receiver modules.

1.2 RF Output Power

The base station is available with 25 W and 50 W/40 W RF output power. The RF output power options are implemented by different transmitter and receiver modules.

The 25 W base station is available in the following frequency bands:

- B1
- H5
- H6

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

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

1.3 Product Codes

This section describes the product codes used to identify products of the TB7100 base station product line.

The product codes of the TB7100 base station product line has the format:

TBB**aabb-cdd-ee**

where:

- **aa** identifies the frequency band of the transmitter:
  B1 = 136 to 174 MHz, H5 = 400 to 470 MHz, H6 = 450 to 530 MHz, H7 = 450 to 520 MHz
- **bb** identifies the frequency band of the receiver:
  B1 = 136 to 174 MHz, H5 = 400 to 470 MHz, H6 = 450 to 530 MHz, H7 = 450 to 520 MHz
- **c** identifies the RF output power:
  A = 25 W, B = 50 W/40 W
- **dd** identifies the power supply option:
  00 = DC power supply
- **ee** identifies base station options:
  00 = no options

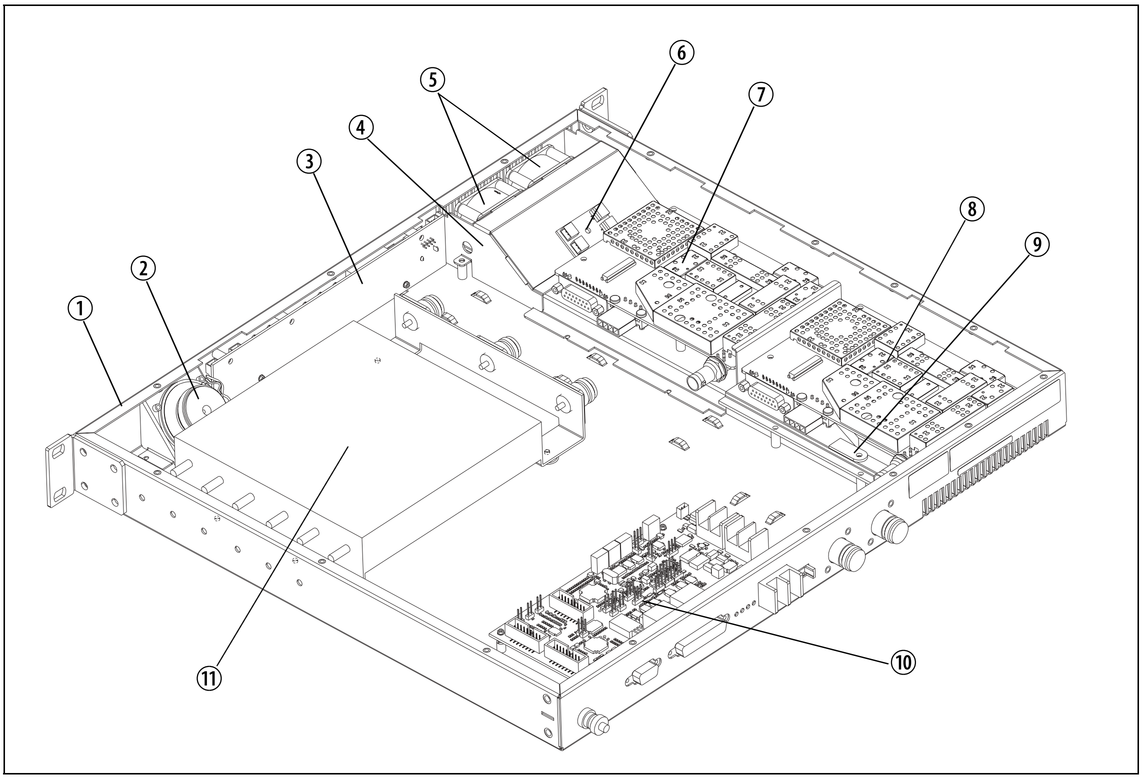
2 Mechanical Design

Overview

The base station consists of the following main modules:

- tray ①
- UI board (user interface) ③
- receiver module ⑦
- transmitter module ⑧
- SI board (system interface) ⑩
- duplexer (optional) ⑪.

Figure 2.1 Parts of the base station



All modules and boards are mounted from above into the 1U tray ①. The modules are secured by screws or clips into standoffs on the tray chassis, and are easily removed for replacement.

The base station also includes two cooling fans ⑤ and a fan duct ④ in front of the receiver and transmitter modules, a speaker ② mounted behind the front panel, a fan power board ⑥ mounted on the fan duct, and a temperature sensor board ⑨ mounted on the heatsink of the transmitter module ⑧.

The modules and components are interconnected by looms and cables.

2.1 Tray

The 1U tray consists of a mild steel folded chassis and a flat cover (not shown) which is fastened to the chassis with 15 Torx T10 screws. The tray can be fitted into a standard 19 inch rack or cabinet using the two rack mounting brackets.

The front panel has holes to accommodate the controls and the microphone/programming connector of the UI board.
The rear panel has holes to accommodate the connectors and the fuse holder of the SI board, the antenna connectors, and a ground terminal.

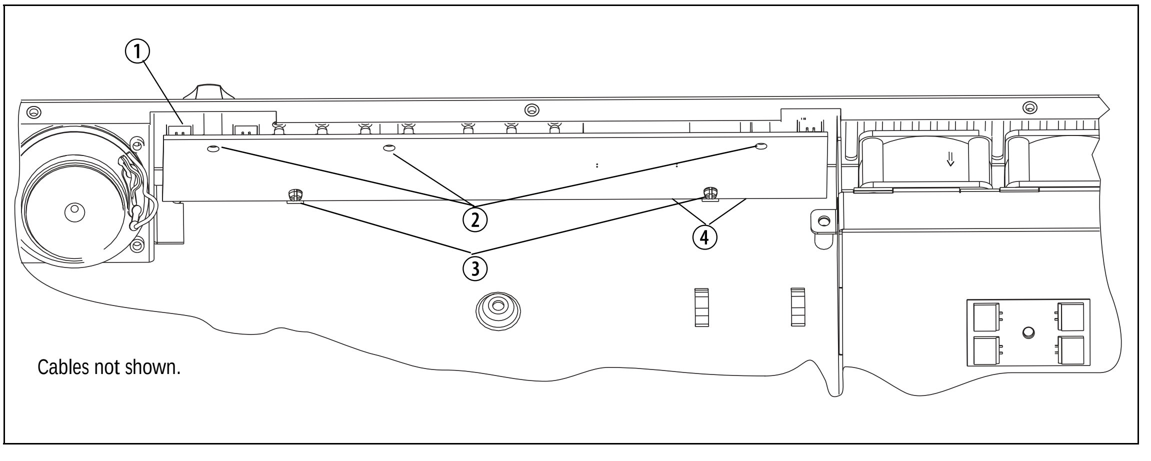
For more information on the connections, refer to "Connections" on page 63.

2.2 UI Board

The UI board is mounted behind the front panel with three Torx T10 screws ② and two spring clips ③. The UI board is connected to the transmitter and receiver modules via the two Micro-MaTch connectors ④ and the two UI cables (not shown). The UI board also has a speaker connector ①.

A volume knob is fitted to the shaft of the volume-control potentiometer.

Figure 2.2 UI board



2.3 Receiver Module

The receiver module is mounted in the front left of the tray with five Torx T10 screws ⑥.

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

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

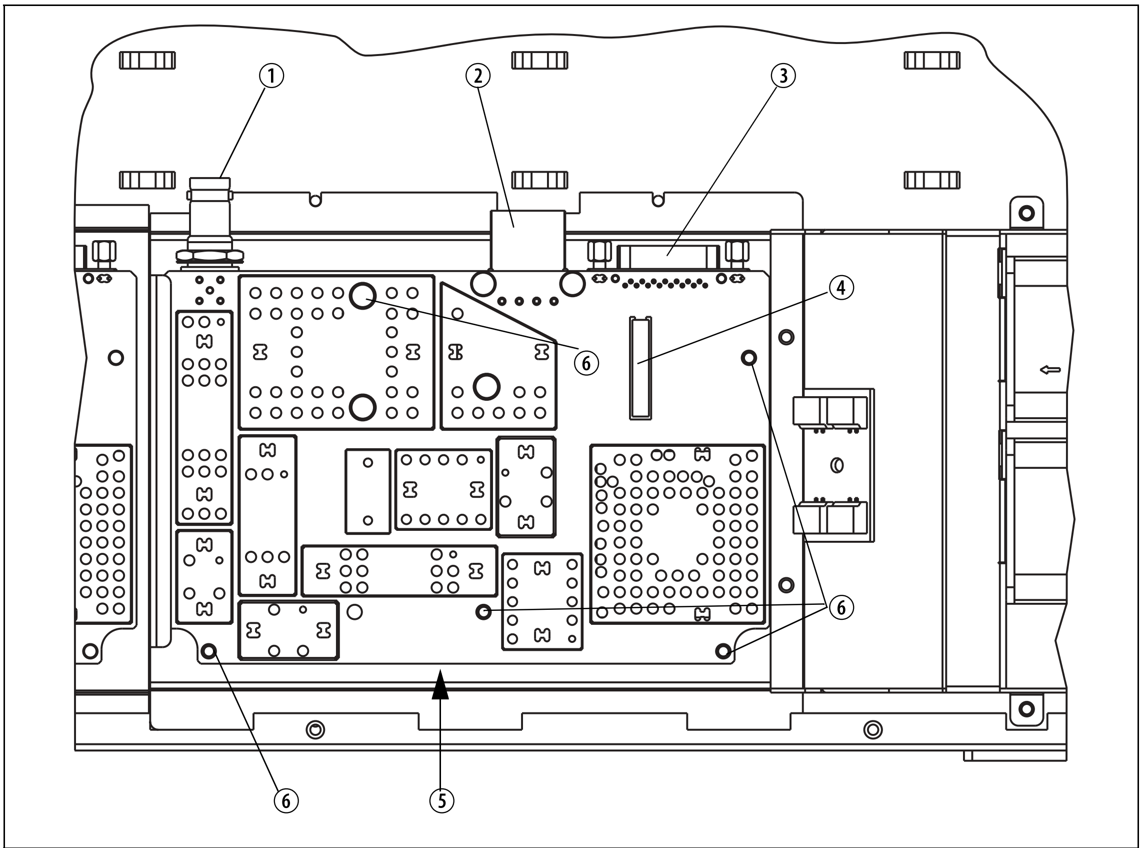
The RF ①, DC power ②, auxiliary ③, and user interface ⑤ connectors are located on the bottom side of the board. The internal options connector ④ and a factory connector (not shown) for factory use are located on the top side of the board.

25W | 50W 40W

For compliance reasons, there are different variants of the receiver module for use in the 25 W and 50 W/40 W base stations. The 25 W version has a white DC power connector ② and the 50 W/40 W version has a black DC power connector.

For more information on the connectors, refer to “Connections” on page 63.

Figure 2.3 Receiver module



2.4 Transmitter Module

The transmitter module consisting of a transmitter board ⑤ mounted on a purpose-designed heatsink ⑩ is mounted in the left rear of the tray with four Torx T10 screws (not shown).

The transmitter board is a printed circuit board in SMT design with components on the top and bottom sides. A digital board is reflow-soldered to the board. Most components are shielded by metal cans. There are different boards for each frequency band and each RF output power configuration.

The RF ①, DC power ②, auxiliary ③, and user interface ⑤ connectors are located on the bottom side of the board. The internal options connector ④ and a factory connector (not shown) for factory use are located on the top side of the board.

25W 50W 40W

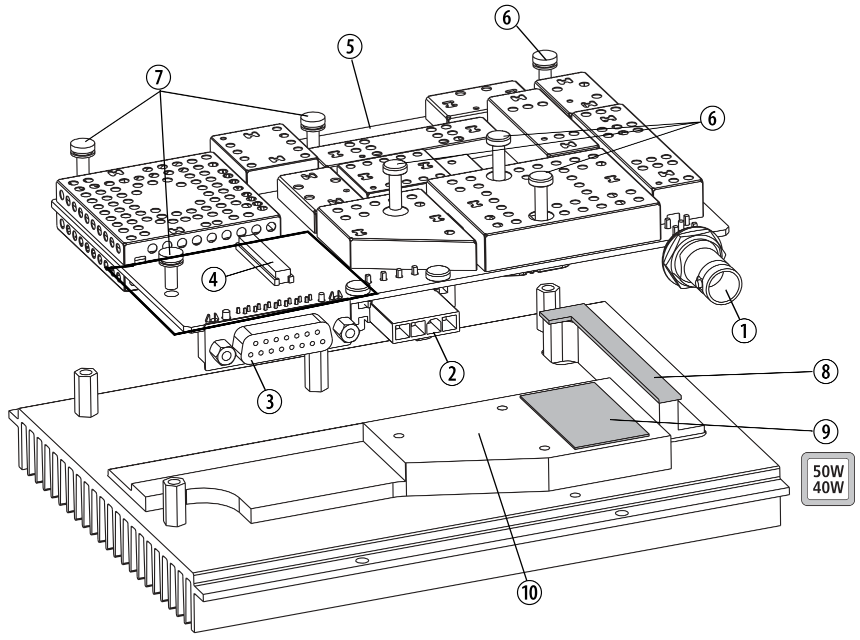
The 50 W/40 W version has a black DC power connector ② and the 25 W version has a white DC power connector. For more information on the connectors, refer to “Connections” on page 63.

The board ⑤ is mounted to the heatsink ⑩ with seven Torx T10 screws ⑤ and ⑥.

25W 50W 40W

An L-shaped gap pad ⑧ and (with the 50 W/40 W version) a rectangular gap pad ⑨ are fitted between the board ⑤ and the heatsink ⑩ to improve heat transfer.

Figure 2.4 Transmitter module



2.5 SI Board

The SI board is mounted in the rear right of the tray with two Torx T10 screws ⑨, one Pozidriv screw ⑧, and two spring clips ⑩.

The SI board has the following external connectors:

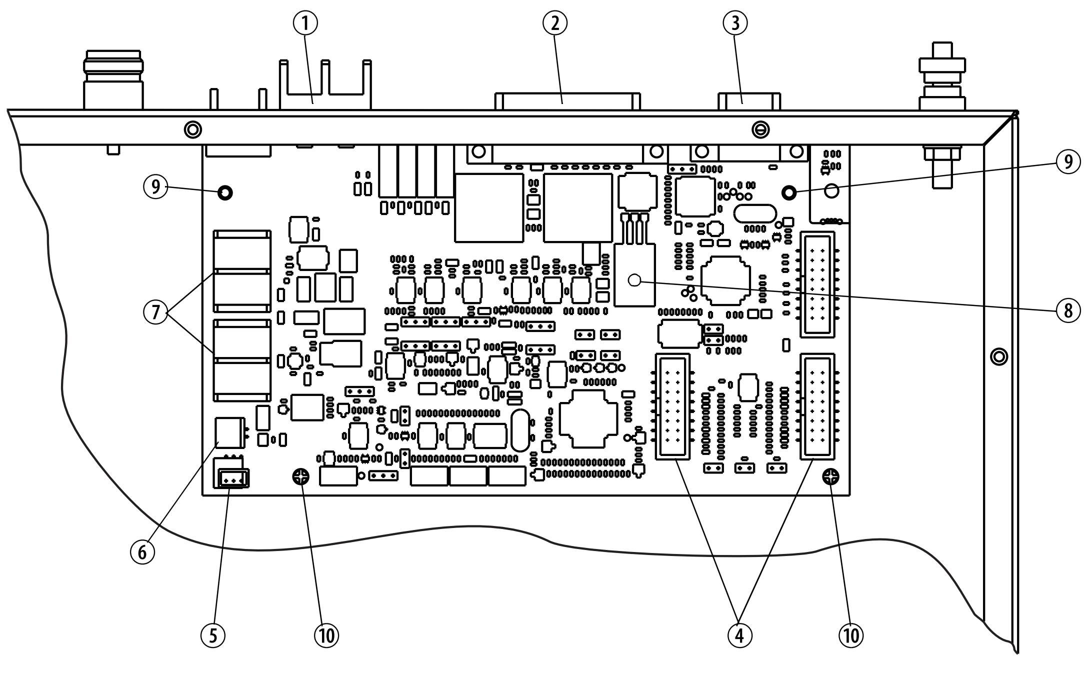
- 13.8V DC power connector (labelled 12V DC) ①
- system connector (labelled SYSTEM) ②
- serial data connector (labelled IOIOI) ③.

The SI board has the following internal connectors:

- two system interface connectors ④ (to transmitter and receiver)
- two DC power output connectors ⑦ (to transmitter and receiver)
- fan control connector ⑤ (to fan power board on fan duct)
- temperature control connector ⑥ (to temperature sensor on transmitter heatsink).

For more information on the connectors, refer to "Connections" on page 63.

Figure 2.5 SI board



3 Functional Description

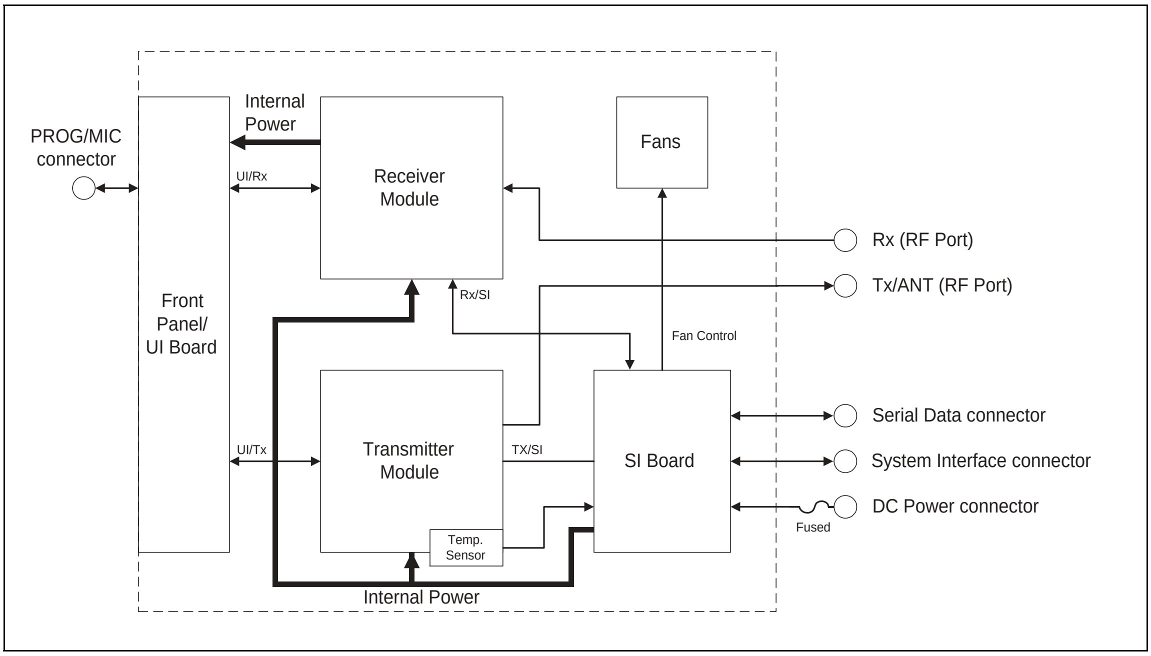
This section describes some principles of the base station operation. The descriptions are based on a 25W base station.

Figure 3.1 below shows the high-level block diagram of the base station. It illustrates the main inputs and outputs for power, RF and control signals, as well as the interconnection between modules.

- program data and audio from the PROG/MIC socket on the UI board to and from the transmitter and receiver modules
- audio and signalling from the SYSTEM connector to and from the transmitter and receiver modules
- RS-232 data from the serial data connector (IOIOI) to and from the transmitter and receiver modules
- fan power and control from the SI board
- power distribution from the DC power input connector to the transmitter and receiver modules, and from the receiver module to the UI board.

The circuitry of the individual modules that make up the base station is described in more detail in the following sections.

Figure 3.1 Base station high-level block diagram



Frequency Bands and Sub-bands

The circuitry in the base station modules is common to all frequency bands, and is therefore covered by a single description in this manual. Where the circuitry differs between bands, separate descriptions are provided for each frequency band. For more information refer to "Frequency Bands" on page 11.

RS-232 Signals

External data communications all occur directly between the connected computer (or other electrical equipment) and the transmitter and receiver modules over the RS-232 serial lines.

Fan Signals

The power and ground signals for the fans are routed from the SI board to the fans behind the front panel. These signals are electrically isolated from all other system signals to ensure fan noise is not transferred to other sensitive system components.

If there is a fault in the fan circuitry, the transmitter module is protected from overheating by its internal foldback circuitry.

Speaker Signal

Received audio is sent from the receiver module to the UI board.
The volume is controlled by the volume potentiometer on the UI board.
The audio signal is then passed to the speaker for monitoring purposes.

Power and Ground

The SI board provides power to the transmitter and receiver modules.
The receiver modules provides power to the UI board.

3.1 Receiver Operation

Parts of Receiver Board

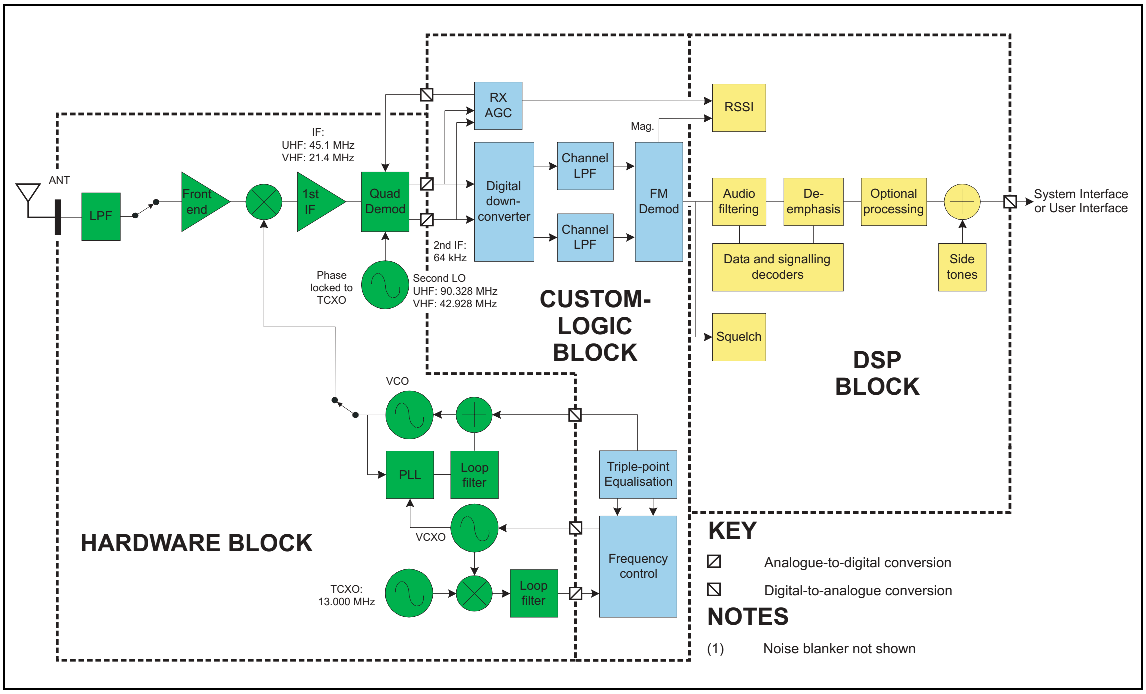
The main circuit parts of the receiver modules are:

- receiver
- frequency synthesizer
- CODEC (coder-decoder) and audio circuitry
- power supply
- interface circuitry

Software plays a prominent role in the functioning of the radio.
When describing the operation of the radio the software must be included with the above. This is considered further below.

These functional parts are described in detail below.

Figure 3.2 Receiver high-level block diagram



3.1.1 RF Hardware

Front End Circuitry 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 (local oscillator) signal is obtained from the frequency synthesizer and is injected on the low side of the desired channel frequency for all bands. When receiving the modulation to the frequency synthesizer is muted. The output of the first IF (intermediate frequency) stage 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 (temperature-compensated crystal oscillator) 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 (analog-to-digital converters) with high dynamic range where it is oversampled at 256kHz and fed to the custom logic device.

Automatic Gain Control

The AGC (automatic gain control) 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 (digital-to-analog converter). Information about the signal level is obtained from the IQ (in-phase and quadrature) data output stream from the ADCs. The control loop is completed within 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.

3.1.2 Digital Baseband Processing

Custom Logic

The remainder of the receiver processing up to demodulation is performed by custom logic. The digitised quadrature signal from the RF hardware is digitally down-converted to a zero IF, and channel filtering is performed at base-band. 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.

Received Signal Strength Indication

Received signal strength is measured by a process resident in the DSP. This process obtains its input from the demodulator (value of RF signal magnitude) and from the AGC (value of present gain). 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 calibrated in the Factory:

- front-end tuning
- AGC
- noise squelch
- RSSI (received signal strength indication)

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

3.1.3 Audio Processing and Signalling

Audio Processing

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 normalise the signal level for the remaining audio processing. The sample rate is decimated to 8kHz and bandpass audio filtering (0.3 to 3kHz) is applied. The base station takes the audio from the receiver mode at Tap R4, this point has no de-emphasis.

Data and Signalling Decoders

The data and signalling decoders obtain their signals from various points within the audio processing chain. The point used depends on the bandwidth of the decoders 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 the receiver. The side-tone level is a fixed proportion (in the order of –10dB) relative to full scale in the receive path.

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 a range of 45dB in 1.5dB steps. The amplifier performs muting. The DAC is part of the same CODEC device (AD6521).

Output to Speakers

The output of the CODEC is fed to an audio power amplifier and to the UI board via a buffer amplifier. The output configuration of the audio power amplifier is balanced and drives an internal speaker. The power delivered to the speaker is limited by its impedance. The speaker has 16Ω impedance.

3.2 Transmitter Operation

Parts of Transmitter Board

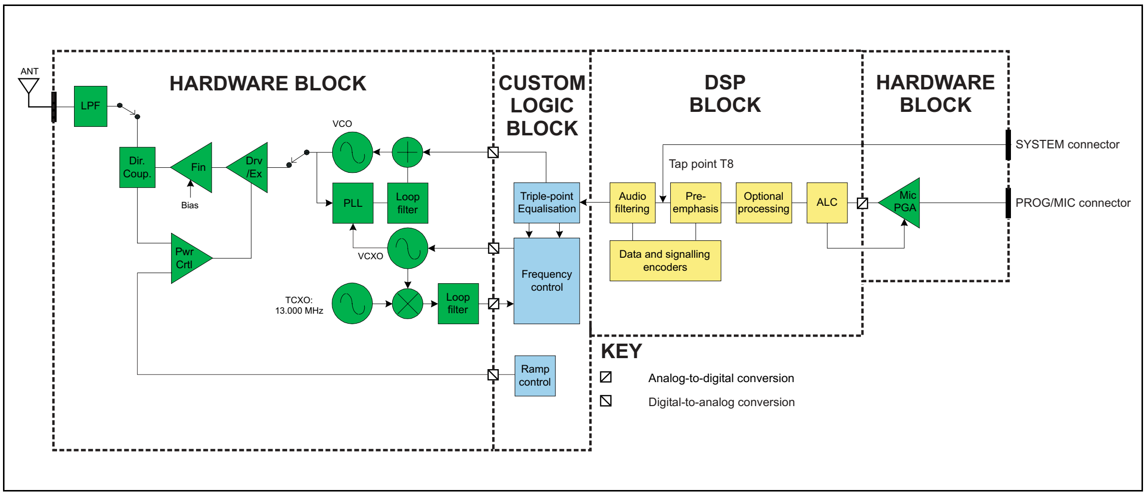
The main circuit parts of the transmitter board are:

- transmitter
- frequency synthesizer
- CODEC (coder-decoder) and audio circuitry
- power supply
- interface circuitry

Software plays a prominent role in the functioning of the board. When describing the operation of the radio the software must be included with the above. This is considered further below.

These functional parts are described in detail below.

Figure 3.3 Transmitter high-level block diagram



3.2.1 Audio Processing and Signalling

Microphone Input

The input to the transmitter path begins at either the SI board or the PROG/MIC connector of the UI board. Only electret-type microphones are supported. The audio input is then applied to tap point T8 on the transmitter board (the tap point is user-selectable).

Analog Processing of Microphone Signal

The CODEC (AD6521) performs microphone selection and amplification. The microphone amplifier consists of an amplifier with a fixed gain of 16dB followed by a programmable-gain amplifier with 0dB 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 (automatic level control) 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) characteristic. This characteristic ensures that the peak signal level is regulated near full scale to maximise dynamic range.

DSP Audio Processing

The output of the automatic level control provides the input to the DSP audio-processing chain at a sample rate of 8 kHz. Optional processing such as encryption or companding is done first if applicable. Pre-emphasis, if required, is then applied. The pre-emphasised signal is hard limited to prevent over deviation, 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 Signalling Encoders

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

3.2.2 Frequency Synthesizer

Main Parts of Synthesizer

The frequency synthesizer consists of two main parts:

- FCL (frequency control loop)
- RF PLL (phase-locked loop)

The FCL and RF PLL are described briefly below. Note that patents are pending for several aspects of the synthesizer design.

Frequency Control Loop

The FCL consists of the following:

- TCXO
- mixer
- loop filter
- VCXO (voltage-controlled crystal oscillator)
- frequency control block

The FCL provides the reference frequency for the RF PLL. It 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 (voltage-controlled oscillator)
- VCO output switch

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

Operation of Control Loop

The RF PLL is a conventional integer-N design with frequency resolution of 25 Hz. In transmit mode the loop locks to the transmit 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 minimises 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 ± 0.004MHz. Initially a VCXO produces a quasi-regulated frequency in the required range. The VCXO output is fed to a mixer where it is mixed with the 13.000MHz TCXO frequency. The mixer, after low-pass filtering to remove unwanted products, produces a nominal frequency of 12kHz. This is converted to digital form and transported to the frequency-control block in custom logic.

The frequency-control block compares the mixer output frequency with 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 48kHz. 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 transmitter board, 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, whereas 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).

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 high by increasing the charge pump current and reducing time constants in the loop filter. As a result settling to within 1 kHz of the final value occurs in under 4 ms. 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 4.5 ms.

Frequency Acquisition of FCL

The FCL utilises 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 4 ms.

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.

3.2.3 RF Power Amplifier

RF Power Amplifier and Switching

The RF PA (power amplifier) is a four-stage line-up with approximately 42 dB 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 200 mW output. This is followed by an LDMOS driver producing up to 2 W output that is power-controlled. The final stage consists of two parallel LDMOS devices producing enough power to provide 25 W at the RF connector.

Output of RF Power Amplifier

The output of the RF PA passes through a dual-directional coupler, used for power control and monitoring. 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. The forward power output from the RF PA is sensed by the directional coupler and fed back to the power control loop. The PA output power is controlled by varying the 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.

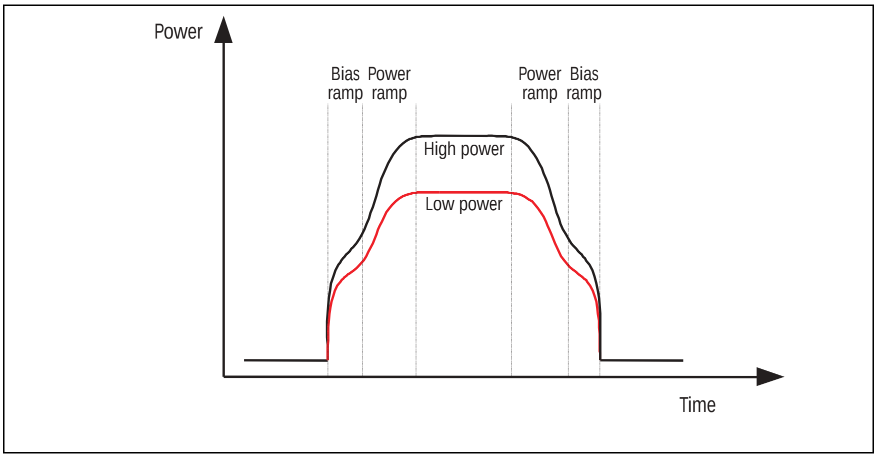
Ramping

Power ramp-up consists of two stages:

- bias
- power ramping

The timing between these two stages is critical to achieving the correct overall wave shape in order to meet the specification for transient ACP (adjacent channel power). A typical ramping waveform is shown in Figure 3.4.

Figure 3.4 Typical ramping waveforms



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 –10 dBm to approximately 25 dB below steady-state power.

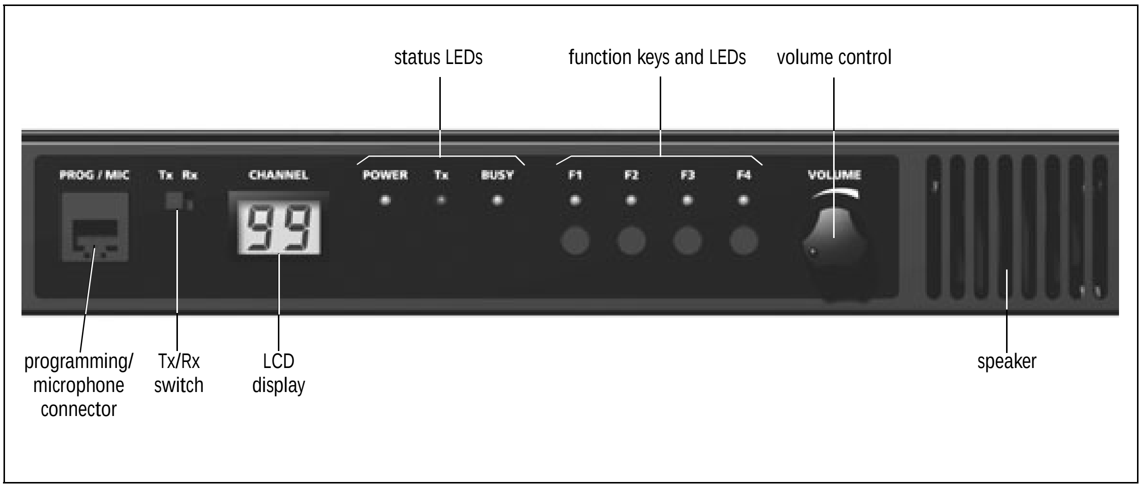
Power Ramp-up

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.

3.3 User Interface Operation

This section describes the functioning of the user interface. Figure 3.5 shows the controls and indicators of the user interface.

Figure 3.5 User interface



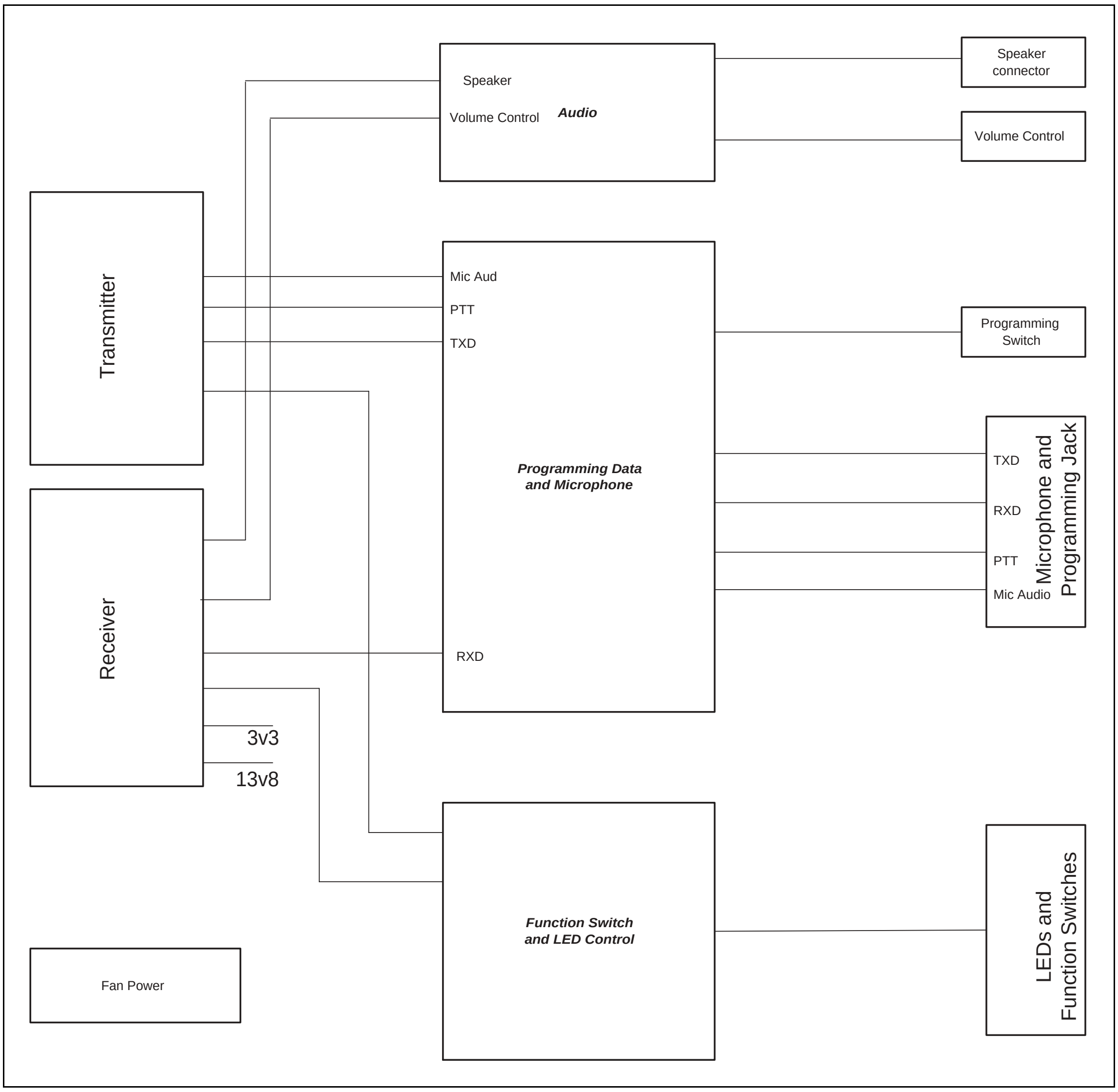
The user interface provides a panel consisting of:

- two digit, seven-segment LCD display
- four programmable function keys
- LED indicators
- volume control
- internal speaker
- PROG/MIC connector
- TX/RX switch

The PROG/MIC connector may be used for the connection of a handset or programming lead. The TX/RX switch changes the LCD display to transmitter or receiver, it also determines which board will be programmed by the programming or calibration applications.

The function keys may 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 3.6 UI board high-level block diagram



Connectors and Circuit Boards

There is an 18-way electrical interface between the UI board and the transmitter module, and another from the UI board to the receiver module. The physical connection is via two 18-way ribbon cables. The internal speaker is connected to the UI board via a lead with a mating connector so that it can be easily disconnected.

UI Board

The UI board does not include a microprocessor. A synchronous bi-directional serial interface provides communication of key status, LCD and LED-indicator data between the transmitter/receiver boards and the UI board. The serial data is converted to or from a parallel form by a number of shift registers for the function keys and indicators. For the LCD, the serial data is fed to a driver IC that converts the serial data to a form suitable for the LCD. The keys are scanned and the LCD and LED indicators updated approximately every 50 ms. The TX/RX switch controls what is displayed on the LCD and also whether the transmitter board or the receiver board will be programmed.

Programming Application

The programming application is a program on a PC that is connected to the base station via the PROG/MIC connector on the user interface.

The programming application enables the user to program the base station with the required channels and subaudible signalling settings.

The transmitter and receiver modules are programmed individually according to the setting of the TX/RX switch on the front panel.

Calibration Application

The calibration application is a program on a PC that is connected to the base station via the PROG/MIC connector on the user interface.

The transmitter and receiver modules are designed to be totally electronically tuned. No physical tuning is required, as all tuning is done by electronic trimming. The calibration application can assist in the tuning of:

- AD6521 CODEC voltage reference
- TCXO frequency
- receiver front end
- transmitter driver and final gate bias limit
- transmitter power control
- deviation and squelch.

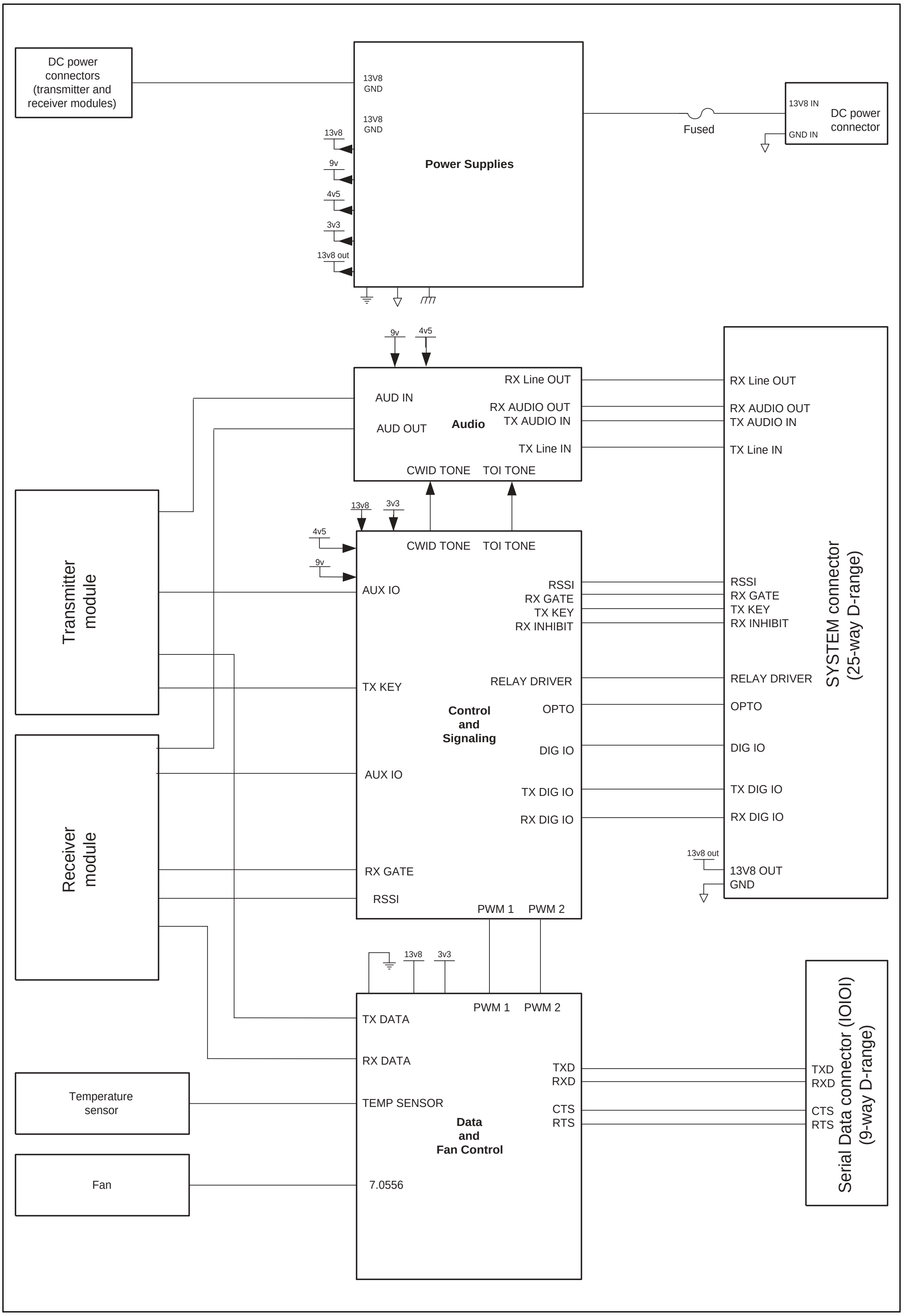
3.4 System Interface Operation

This section describes the functioning of the system interface. The system interface provides:

- internal power distribution
- serial data connection (THSD or FFSK)
- fan control
- general purpose IO
- receiver audio processing
- transmitter audio processing
- opto-isolated keying
- relay output
- received signal strength indication (RSSI)
- receiver gate output
- receiver inhibit input
- 13.8V DC (1.5A) output
- tone on idle (TOI).

These functional parts are described in detail below.

Figure 3.7 SI board high-level block diagram



3.4.1 Internal Power Distribution

This section details how the input power feed is distributed throughout the base station to power its various sub-systems. Refer to Figure 3.8 for more information.

13.8V DC

The DC input is on the rear panel of the base station. The base station power input is protected by a rear panel fuse. The 13.8V is distributed directly to the receiver and transmitter boards and to the 13.8VDC output on the SYSTEM connector, rated at 1.5A. The 13.8VDC is also used to power the fans, via control circuitry.

Note The UI board obtains 13.8V and 3.3V from the receiver module and outputs 13V8_SW to the PROG/MIC connector.

3.3V, 4.5V, 9V, 13.8V

The other voltages derived on the SI board are used only on the SI board.

3.4.2 Serial Data

THSD

Tait High Speed Data (THSD) is a Tait Electronics Ltd. proprietary protocol that can be used with the base station. This allows the base station configured in either data repeater or data modem modes to pass data speeds up to 12kbps on a narrow-band channel and 19.2kbps on a wide-band channel. 1200-baud Fast Frequency Shift Keyed (FFSK) data is also available as an option.

3.4.3 General Purpose IO

The transmitter and receiver boards can be programmed to act upon signals from the SI board and also outputs signals for certain conditions.
These settings are discussed in the installation and operation manual.

3.4.4 Receiver Audio Processing

The SI board provides an external 600Ω balanced 4-wire line for connecting 4-wire circuits.

The SI board provides an unbalanced audio output for connecting to other devices. Output levels can be set via the rear panel.

3.4.5 Tone On Idle

The tone-on-idle (TOI) frequency is generated by the SI board and fed directly to the receiver line out. It is enabled using links on the SI board. These settings are discussed in installation and operation manual. If enabled, the output of the TOI is switched by the receiver gate.

3.4.6 Transmitter Audio Processing

The SI board provides an external 600Ω balanced 4-wire line for connecting 4-wire circuits.

The SI board provides an unbalanced audio input and output for connecting to other devices.

3.4.7 Opto Isolated Keying

External keying of the base station can be achieved using the current regulated optically isolated keying connections.

3.4.8 Relay Output

The SI board can provide a relay output with a load voltage of 350 V or load current of 120 mA continuous. The SI board can also provide a relay driver output. Both these options are configurable and these settings are discussed in the installation and operation manual.

3.4.9 Fan Control

There are three modes of operation for the fans. The modes are:

- on continuous
- on when transmitting
- on at a pre-defined temperature.

The modes of operation are selected by links on the SI board. These settings are discussed in the installation and operation manual.

3.4.10 RSSI

A received signal strength indication (RSSI) voltage is developed by the receiver module and applied directly to the SI board rear panel.

3.4.11 Receiver Gate

The receiver gate signal is used by the SI board to control TOI and a relay output. The receiver gate output on the SYSTEM connector can be used for external equipment such as TaitNet trunking controllers.

3.4.12 Receiver Inhibit

The receiver inhibit input on the SYSTEM connector is used to control the receiver gate signal. This may be used in linking applications to prevent unwanted receiver audio signals from appearing at the SI board output connector.

3.5 Fan Operation

The cooling fans are mounted behind the front panel. Both fans in the chassis must be of the same type.

Dissipation of Heat

Heat needs to be dissipated from a number of components on the transmitter and receiver boards, including the following:

- 9V regulator
- RF PA
- driver for RF PA
- audio PA.

The mechanisms by which the heat is conducted away in each case are described below.

Dissipation of Heat from Transmitter

The transmitter board is mounted directly onto a heatsink through which the forced air from the fans is ducted.

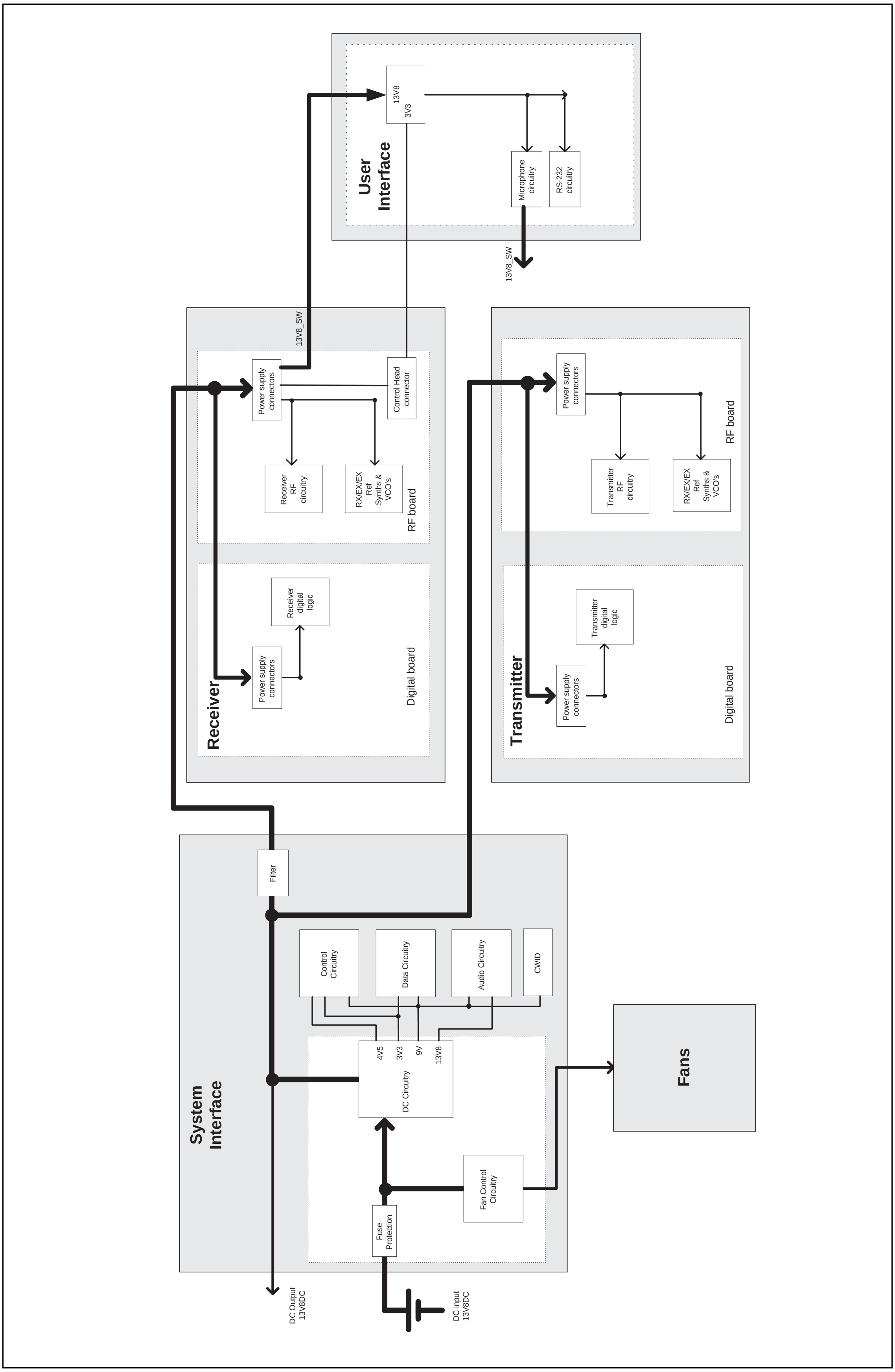
Dissipation of Heat from Regulator and Audio PA

Heat from the audio PA and 9V regulator on the receiver board id conducted away by a small aluminium heatsink and mounting boss. The heatsink and boss contact the underside of the board where the components are mounted and thermal paste ensures a good thermal transfer between the two surfaces.

Dissipation of Heat from RF PAs and Driver

Heat from the RF PAs and driver is conducted to the heatsink through a copper separator plate. The copper plate is fixed to the underside of the board and the components soldered directly to it. The copper plate is mounted directly to the main heatsink boss and a coating of thermal paste ensures good thermal transfer between these two surfaces.

Figure 3.8 Power distribution



4 Circuit Descriptions

Introduction

This section describes and illustrates the circuitry of the transmitter and receiver modules.

The transmitter and receiver modules are divided into the following circuitry:

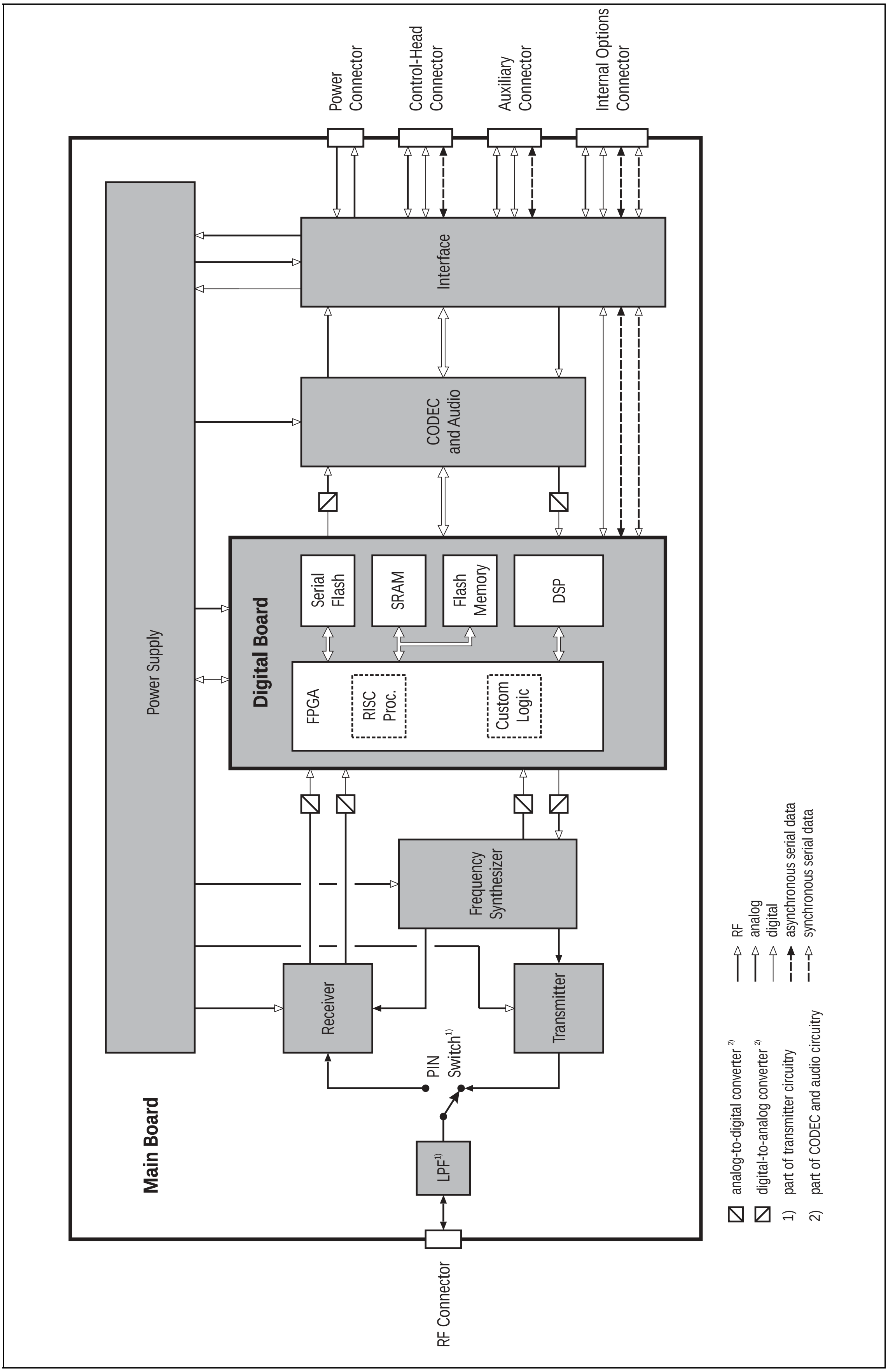
- transmitter
- receiver
- frequency synthesizer (including FCL)
- CODEC and audio
- power supply
- interface
- digital board

Figure 4.1 gives an overview of the of the circuitry of the transmitter and receiver boards and shows how they are interconnected.

Sample Schematics

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

Figure 4.1 Transmitter and receiver boards hardware architecture



4.1 Transmitter Circuitry

Introduction

For a block diagram of the transmitter circuitry, refer to Figure 4.2.

50W 40W | 25W

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

Exciter

50W 40W

With the 50 W / 40 W boards, 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.

25W

With the 25 W boards, the broadband exciter is a common element in all the bands, as it operates across all frequencies from 66 to 530 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.

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.

50W 40W

With the 50 W / 40 W boards, 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.

25W

With the 25 W boards, 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:

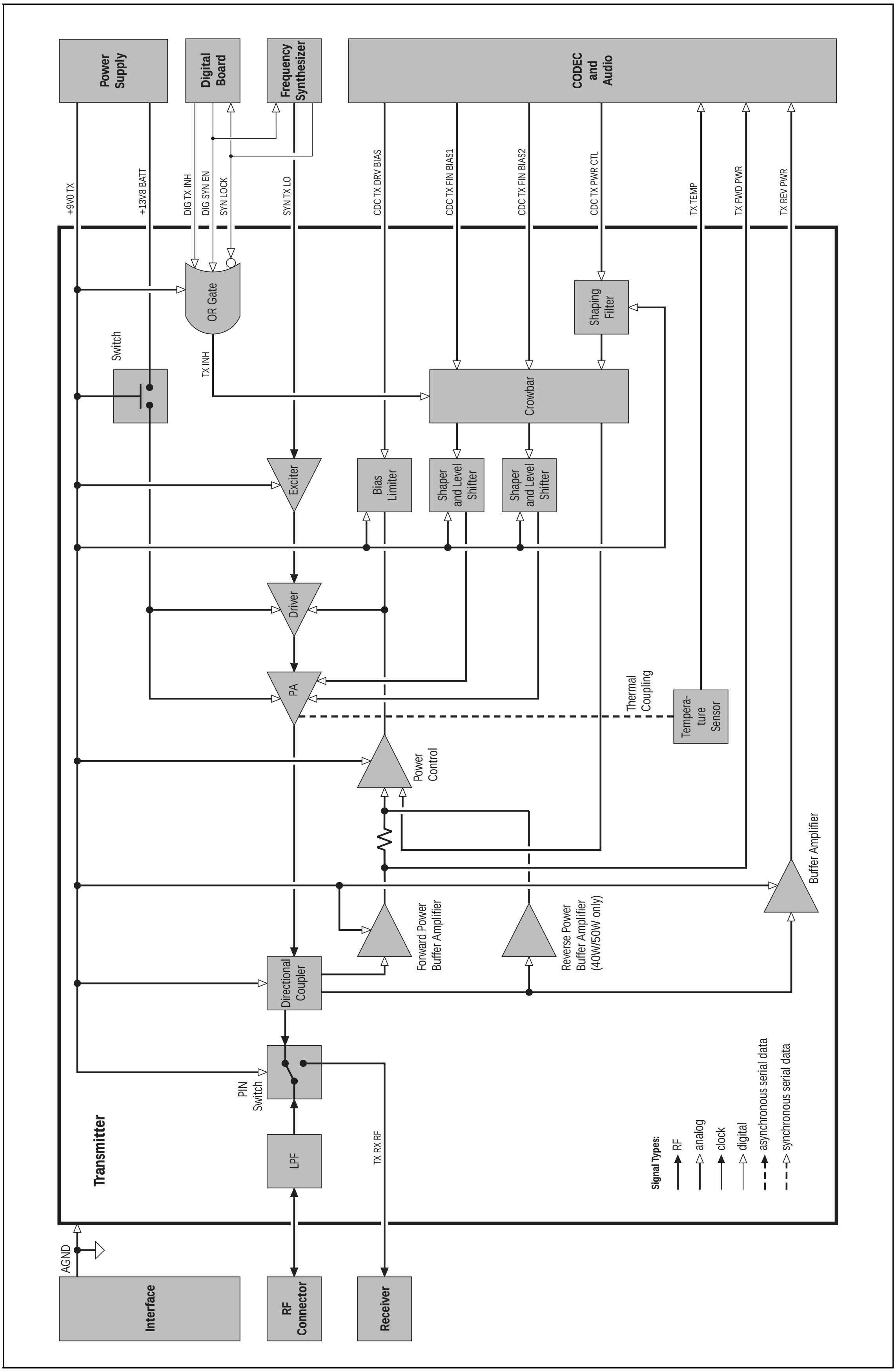
50W 40W

- 10, 15, 25, and 50 watts (VHF), and
  10, 15, 20, and 40 watts (UHF) for 50 W / 40 W boards

25W

- 1, 5, 12 and 25 watts (all bands) for 25 W boards

Figure 4.2 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 boards, 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 boards, 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 boards, 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 boards, 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.

4.2 Receiver Circuitry

Introduction

For a block diagram of the receiver circuitry, refer to Figure 4.3.

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:

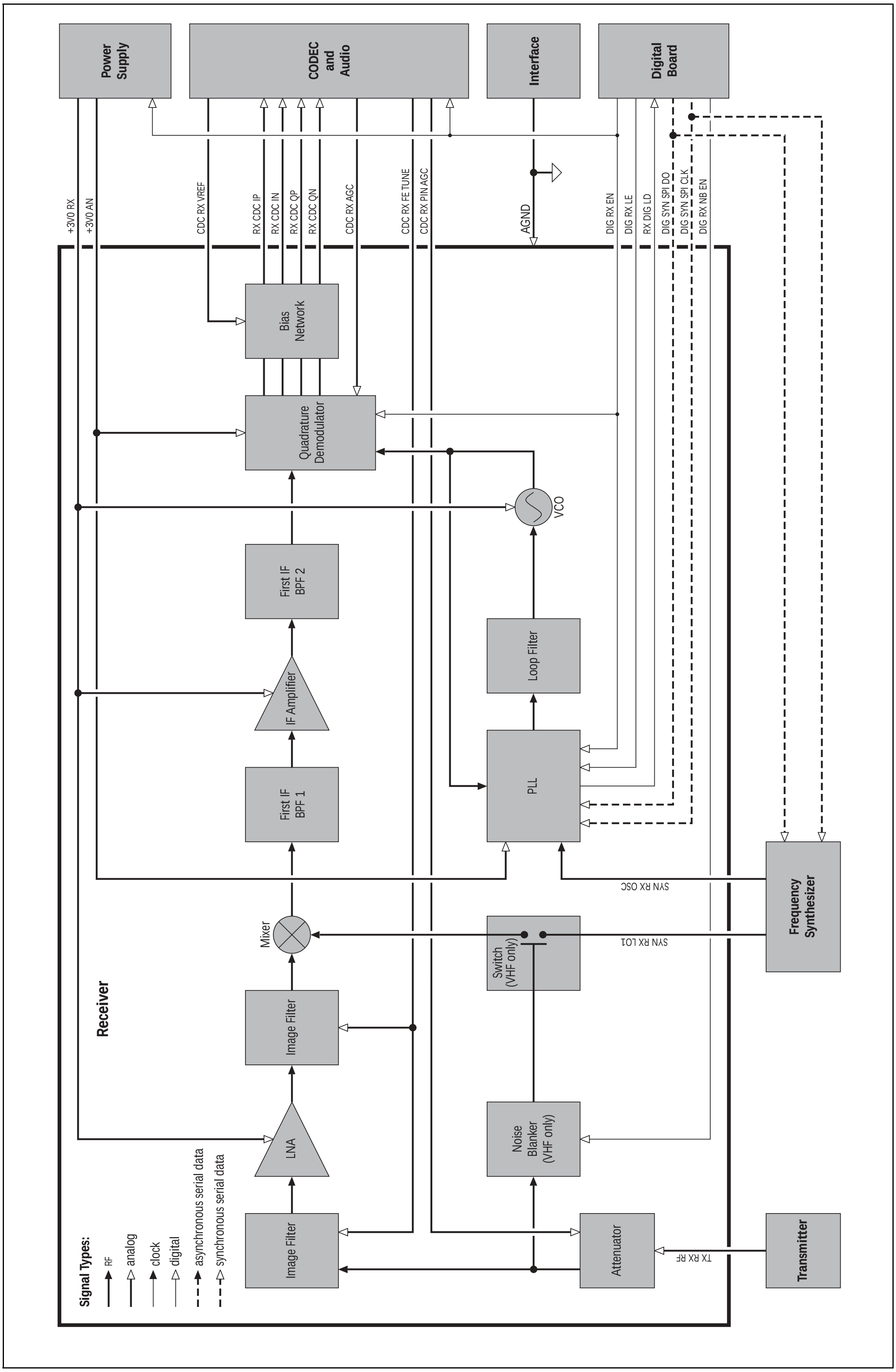
- B1 band: 21.400029 MHz
- H5, H6, and H7 bands: 45.100134 MHz

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.

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.

Figure 4.3 Block diagram of the receiver circuitry



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 then 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 base station 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 centred, 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 a front-end 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). The front-end AGC is controlled by an algorithm which monitors the RSSI and configures the DAC to turn on the front-end attenuation via the receive pin diode of the PIN switch.

Noise Blanker (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.

4.3 Frequency Synthesizer Circuitry

Introduction

For a block diagram of the frequency synthesizer circuitry, refer to Figure 4.4.

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 behaviour 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.

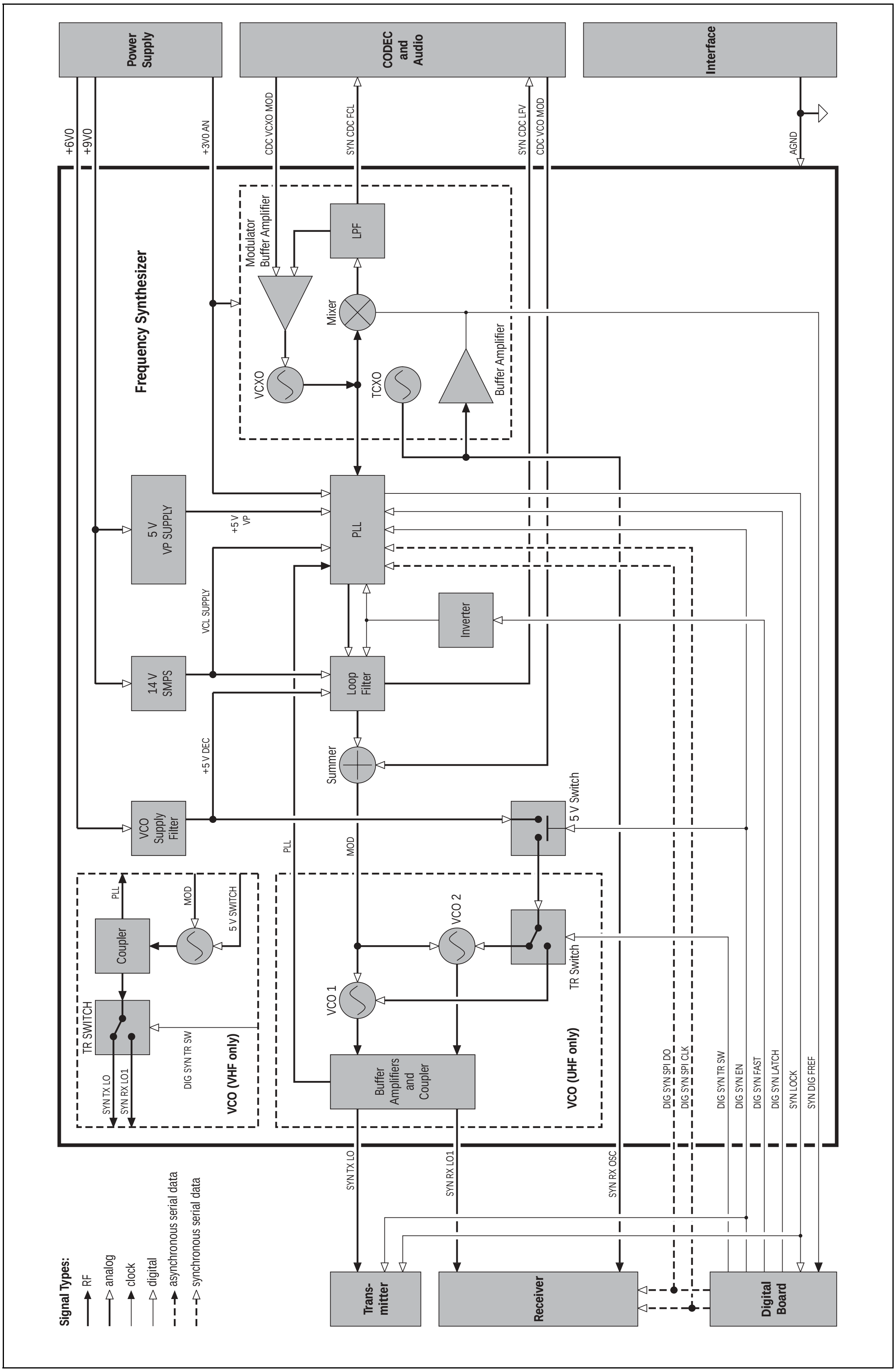
Switch-mode Power Supply

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 4.4 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 base station 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 base station 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.)

4.4 Frequency Control Loop

Introduction

The FCL is included in the block diagram of the frequency synthesizer (see Figure 4.4).

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 13.0000 MHz, which is extremely stable, regardless of the temperature. The VCXO runs at a nominal frequency of 13.0120 MHz, 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 12.0 kHz. 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.

4.5 CODEC and Audio Circuitry

Introduction

For a block diagram of the CODEC and audio circuitry, refer to Figure 4.5.

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 AGC, 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

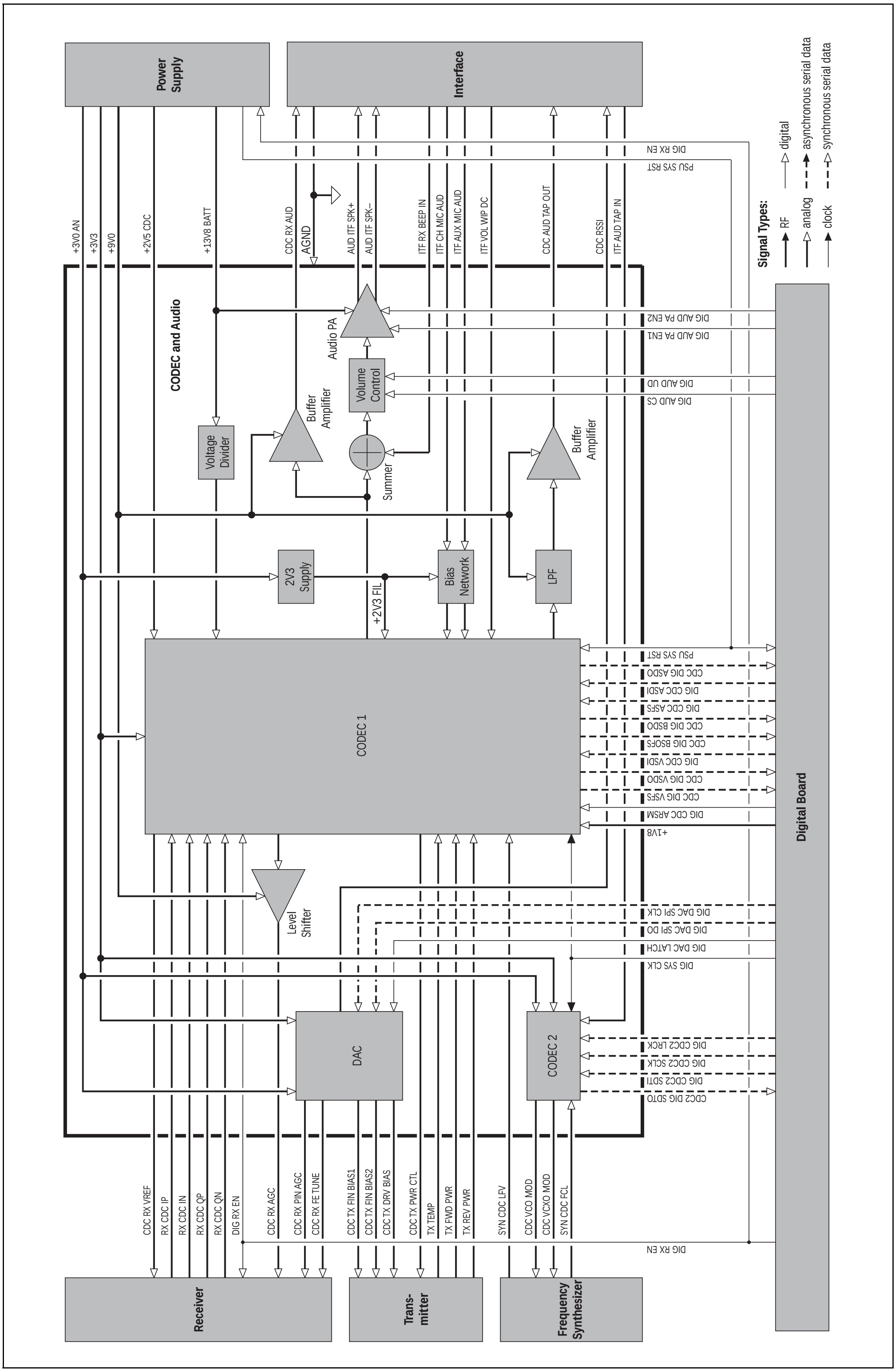
The auxiliary CODEC handles transmitter power control, receiver gain control, auxiliary audio output and general analog monitoring functions. The digital section communicates with this CODEC via a three-wire synchronous serial interface (ASFS, ASDI and ASDO balls). The DAC used for receiver gain control (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 4.5 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 (C205) 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 (C205) 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 (C205) 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 (C205) 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 base station 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 microphone connector

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.

4.6 Power Supply Circuitry

Introduction

For a block diagram of the power supply circuitry, refer to Figure 4.6.

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 base station is provided by the clamping diode D600 and by 20A fuses (for the 50W/40W boards) and 10A fuses (for the 25W boards) 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 base station 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.

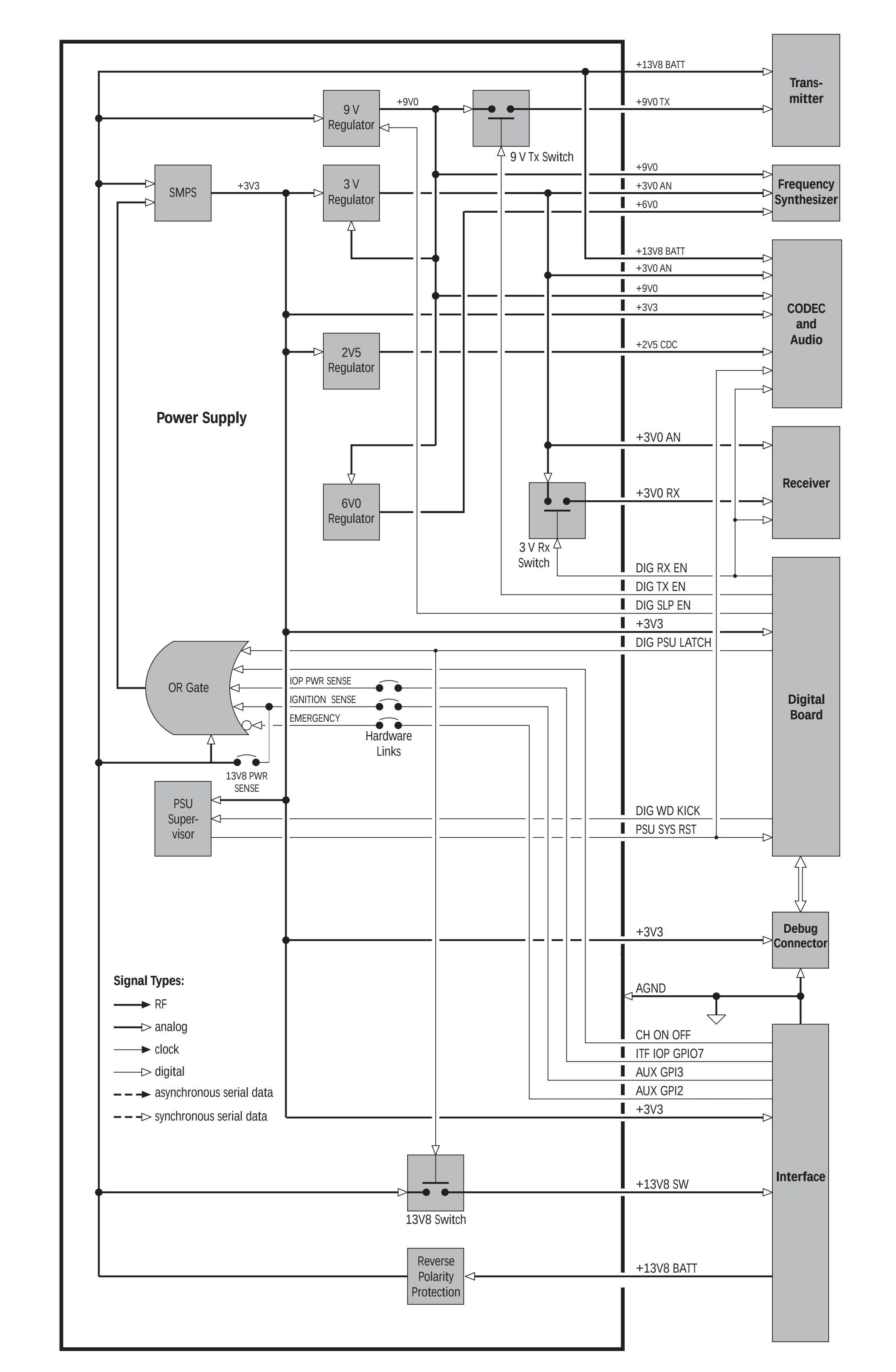
Internal Power Supplies

There are eight internal power supplies:

- one SMPS (+3V3)
- four linear regulators (+9V0, +6V0, +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.

Figure 4.6 Block diagram of the power supply circuitry



4.7 Interface Circuitry

Introduction

For a block diagram of the interfaces circuitry, refer to Figure 4.7.

For more on the connector pinouts, refer to "Connections" on page 63.

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 R748 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. If Q707 is fitted, R768 must be removed.

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.

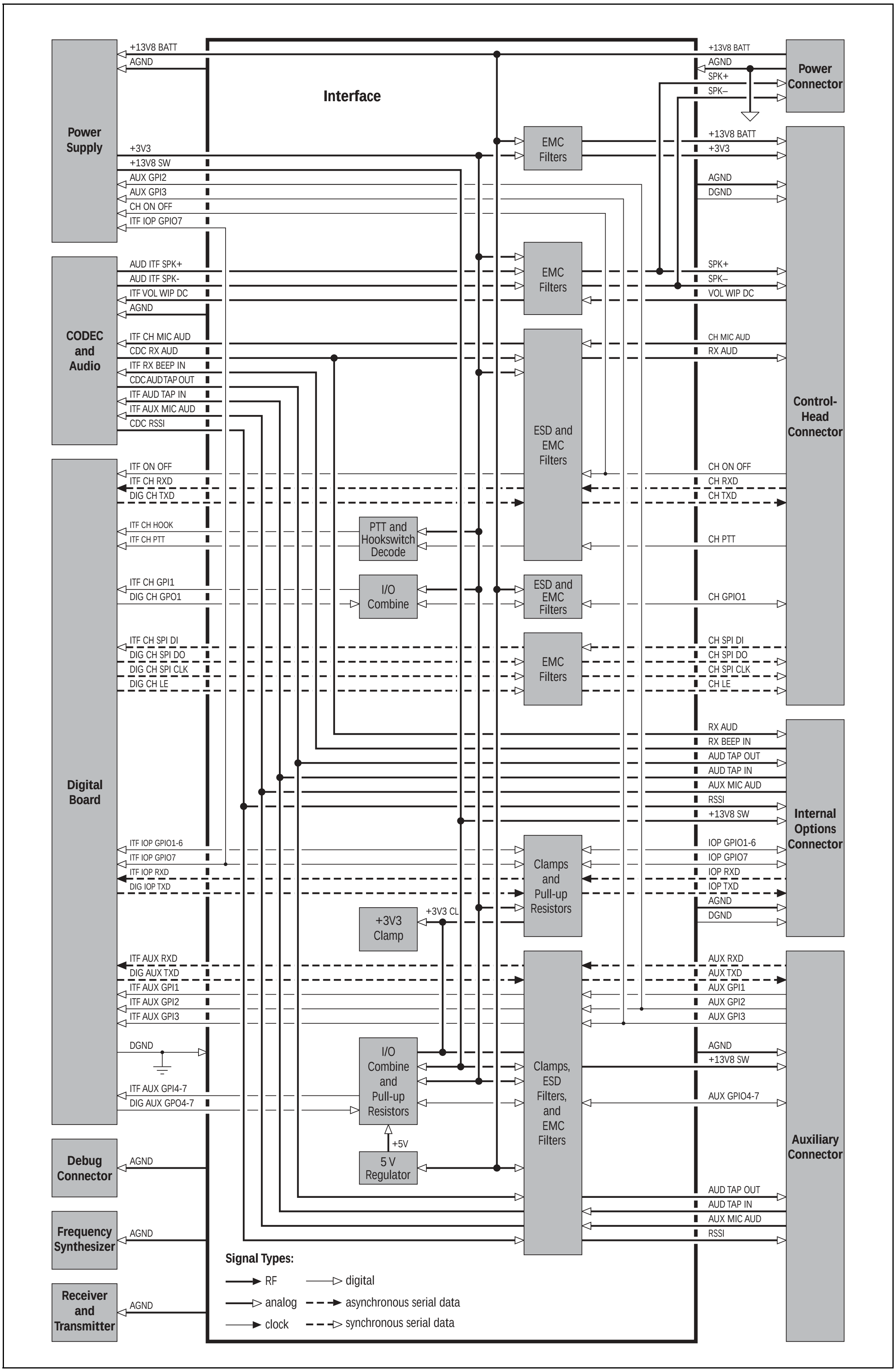
Input Signals (e.g. AUX GPIO4)

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.

Figure 4.7 Block diagram of the interface circuitry



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.

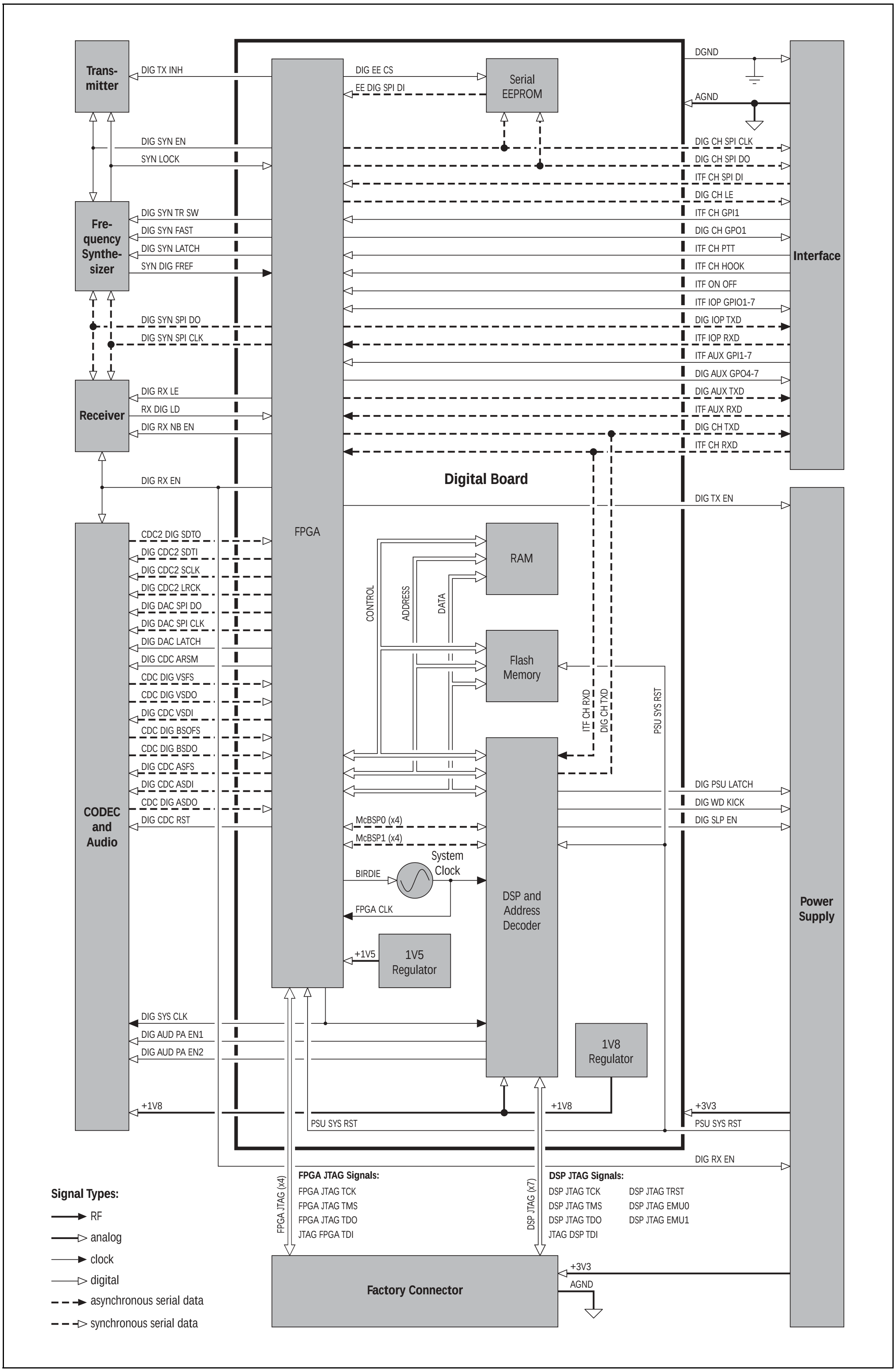
4.8 Digital Board

Introduction

For a block diagram of the digital board, refer to Figure 4.8.

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

Figure 4.8 Block diagram of the digital board



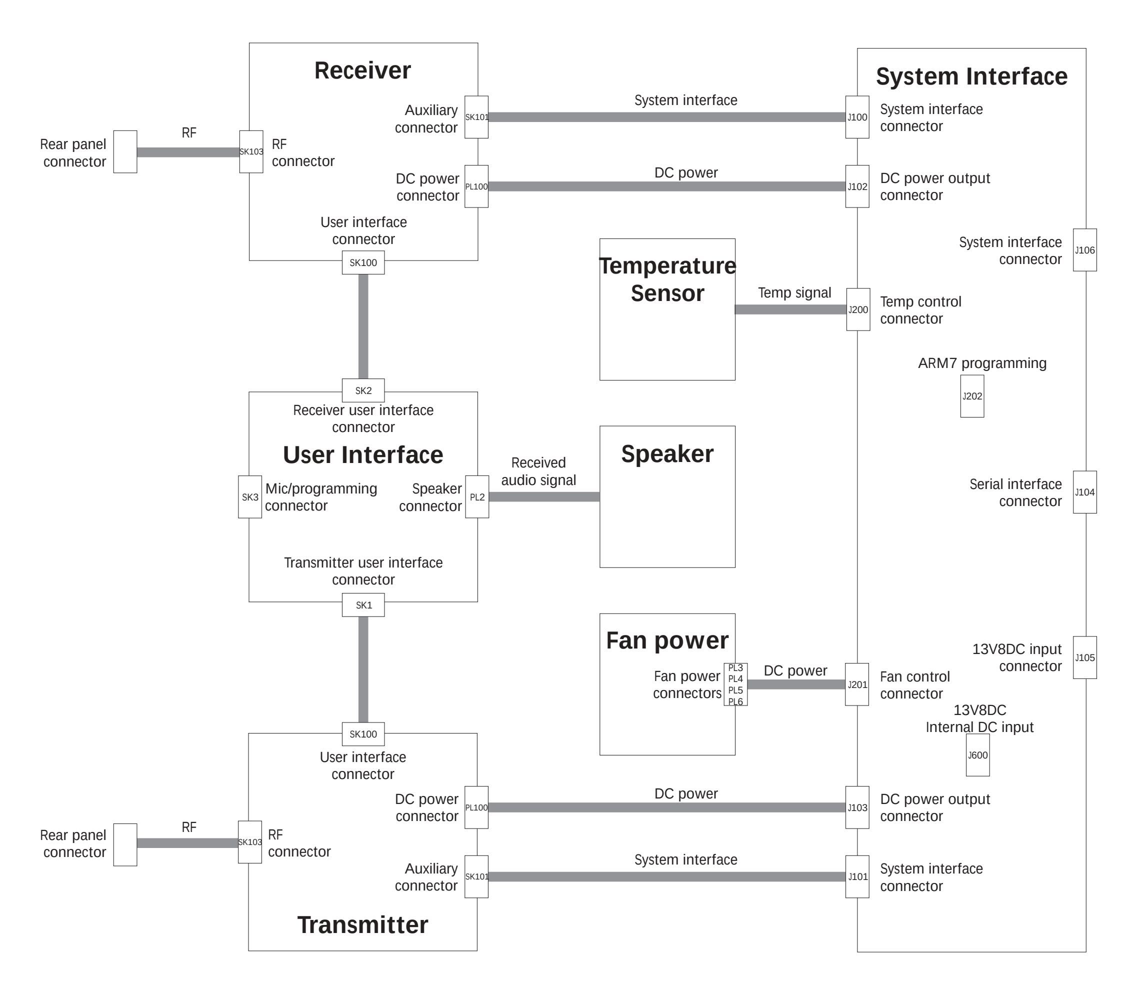
5 Connections

Overview

This section gives an overview of looms and cables, and describes the specifications and pinouts of the external and internal connectors.

Figure 5.1 provides an overview of the connections.

Figure 5.1 Connectors, looms and cables

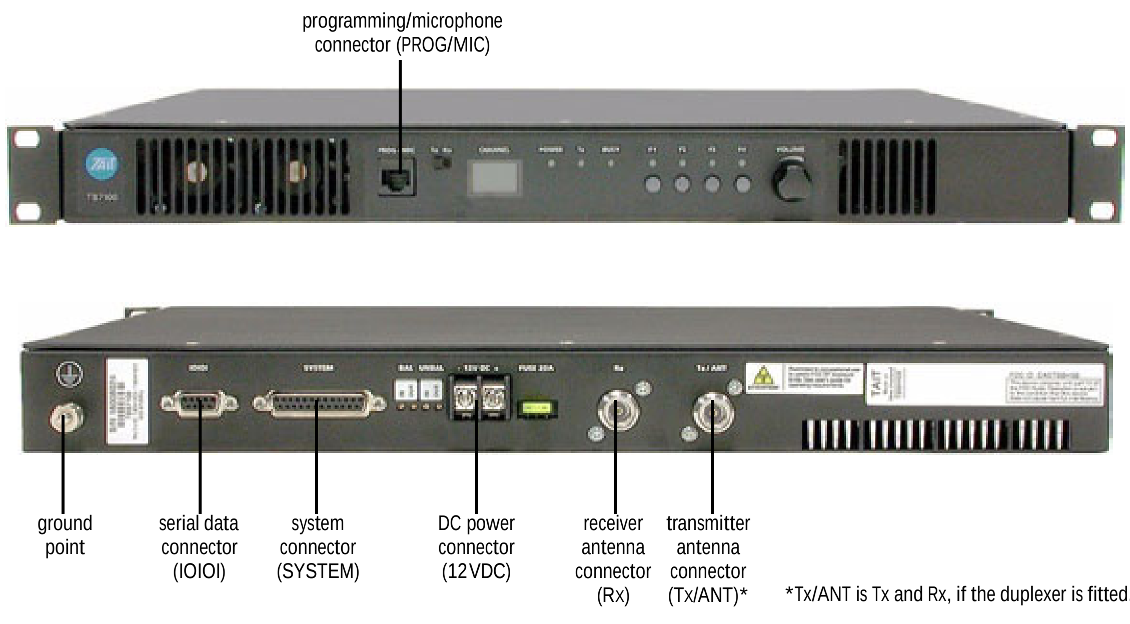


For information on the factory connector and the internal options connector of the transmitter and receiver, refer to the PCB information.

5.1 External Connectors

Figure 5.2 shows the external connectors:

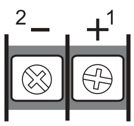
Figure 5.2 External connectors



DC Power Connector (12V DC)

The base station is designed to accept a nominal 13.8V DC, with negative ground.

The DC power connector (J105) at the rear of the base station is a heavy-duty M4 screw terminal connector suitable for many forms of connection.

	Pin	Signal Name	Signal Type	Notes
 external view	1	13.8VDC	input	
	2	ground	input	

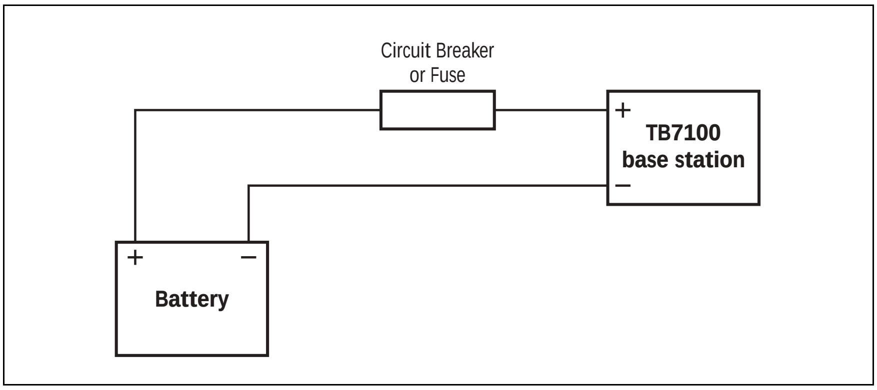
You must connect the DC supply from the battery to the base station via a readily accessible disconnect device such as a fuse or DC-rated circuit breaker with the appropriate rating, as shown in the table below. The DC input leads should be of a suitable gauge to ensure less than 0.2V drop at maximum load over the required length of lead.

Nominal Supply Voltage	Input Voltage Range	Circuit Breaker/ Fuse Rating	Recommended Wire Gauge[a]
13.8 VDC	10 VDC to 16 VDC	20 A	8 AWG / 8.35 mm^2

a. For a length of 1.5 m to 2 m (5 ft to 6.5 ft) (typical).

Terminate the DC input leads with a suitable crimp connector for attaching to the J105 M4 screws.

Figure 5.3 Recommended DC power connection



Ground Point

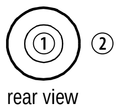
The ground point is a terminal for grounding the tray to the mounting rack.

Receiver and Transmitter Antenna Connectors (Rx and Tx/ANT)

The RF input to the base station is via the Rx connector (N-type) on the rear panel of the base station. The RF output is via the Tx/ANT connector (N-type) on the rear panel of the base station.

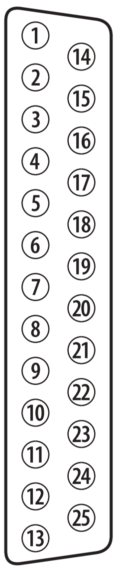
The RF connector is an N-type connector with an impedance of 50Ω.

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

	Pin	Signal Name	Signal Type	Notes
	1	RF	RF analog	
	2	GND	RF ground	

System Connector (SYSTEM)

The system connector (J106) at the rear of the base station is a 25-way standard-density D-range socket.

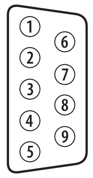


external view

Pin	Signal Name	Signal Type	Notes
1	Rx line output +	audio output	transformer isolated line
2	Tx/Rx digital input 1	input	high ≥1.7 V, low ≤0.7 V
3	Tx/Rx digital input 2		
4	Rx line output –	audio output	transformer isolated line
5	Tx line input +	audio input	transformer isolated line
6	Tx/Rx digital input 3	input	high ≥1.7 V, low ≤0.7 V
7	Tx/Rx digital input 4	input	output: high ≥3.1 V (no load), low <0.6 V (10mA sink) input: high ≥1.7 V, low ≤0.7 V
8	Tx line input –	audio input	transformer isolated line
9	RSSI	output	DC signal
10	Tx digital in/out 1	input/output	output: high ≥3.1 V (no load), low <0.6 V (10mA sink) input: high ≥1.7 V, low ≤0.7 V
11	Tx audio input	audio input	
12	Tx digital in/out 2	input/output	output: high ≥3.1 V (no load), low <0.6 V (10mA sink) input: high ≥1.7 V, low ≤0.7 V
13	ground	ground	
14	Rx gate	output	open collector
15	Tx key	input	active low
16	Rx relay (comm)	output	
17	Rx relay (NO or NC)	output	
18	Rx Inhibit	input	
19	Rx digital in/out 1	input/output	output: high ≥3.1 V (no load), low <0.6 V (10mA sink) input: high ≥1.7 V, low ≤0.7 V
20	Tx Opto input +	input	input voltage range 10VDC to 60VDC
21	Tx Opto input –	input	
22	Rx digital in/out 2	input/output	output: high ≥3.1 V (no load), low <0.6 V (10mA sink) input: high ≥1.7 V, low ≤0.7 V
23	Digital output/Tx relay	output	
24	Rx audio output	output	
25	13.8 volt output	power output	resetable SMD fuse 1.5A

Serial Data Connector (IOIOI)

The serial data connector (J1054) labelled IOIOI is a 9-way female D-range connector, which provides a data connection to the base station.



external view

Pin	Signal Name	Signal Type	Notes
1	not connected	not used	
2	receive data	output	data transmitted by TB7100
3	transmit data	input	data received by TB7100
4	not connected	not used	
5	ground	ground	
6	not connected	not used	
7	ready to transmit	output	request to send
8	clear to send	input	clear to send
9	not connected	not used	

Programming/ Microphone (PROG/MIC)

5.2 Internal Connectors

5.2.1 Transmitter and Receiver Connectors

The internal connectors of the transmitter and receiver are the same for both modules.

Note The signals on the user interface connectors are different for the transmitter and the receiver.

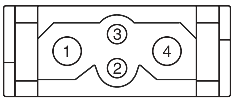
RF Connectors

The RF connectors of the transmitter and the receiver are N-type connectors with an impedance of 50Ω.

DC Power Connectors

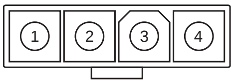
The DC power connectors of the transmitter and the receiver are the interface for the primary 13.8V power source. There are different DC power connectors for the 50W/40W and 25W versions.

50W/40W



external view

25W

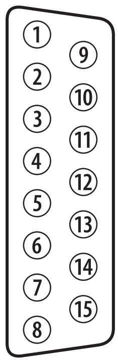


external view

Pin	Signal name	Signal type	Notes
1	AGND	ground	
2	SPK–	analog output	not connected
3	SPK+	analog output	not connected
4	13.8VDC	DC power input	

Auxiliary Connectors

The auxiliary connectors of the transmitter and receiver are 15-way standard-density D-range sockets.

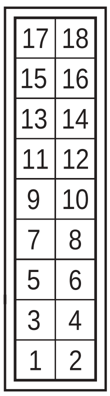


external view

Pin	Signal Name	Signal Type	Notes
1	AUX GPIO7		
2	AUX GPIO4		
3	AUX RXD	input	
4	AUX GPI3		
5	AUX GPI2		
6	RSSI	output	
7	AUX TAP IN	input	
8	13.8VDC SW	output	
9	AUX GPIO6		
10	AUX GPIO4		
11	AUX TXD	output	
12	AUX GPI1		
13	AUD TAP OUT	output	
14	AUX MIC AUD	input	
15	AGND	ground	

User Interface Connector

The user interface connectors (SK100) of the transmitter and the receiver is a 15-way moulded plastic connector.



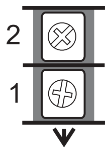
external view
pin 1 closest to PCB

Pin	Signal Name	Signal Type		Notes
		Transmitter	Receiver	
1	RX AUD	no connection	no connection	no connection
2	13.8VDC	no connection	output	+13V8DC for UI board
3	CH TXD	input	input	programming data
4	CH PTT	input	no connection	microphone PTT
5	CH MIC AUD	input	output	audio from microphone
6	AGND	ground	ground	analog ground
7	CH RXD	output	output	programming data
8	DGND	ground	ground	digital ground
9	CH ON OFF	output	output	digital ground
10	VOL WIP DC	input	input	volume control
11	CH SPI D0	output	output	
12	CH LE	output	output	
13	CH GPIO1	output	output	digital ground
14	3.3VDC	no connection	output	+3V3DC for UI board
15	CH SPI D1	input	input	
16	CH SPI CLK	output	output	
17	SPK-	no connection	output	speaker audio
18	SPK+	no connection	output	speaker audio

5.2.2 SI Board Connectors

DC Power Output Connectors

The two DC power output connectors (J102 and J103) on the SI board are heavy-duty M4 screw terminals. J102 distributes the DC power (13.8V DC) to the transmitter, and J103 distributes the DC power to the receiver.

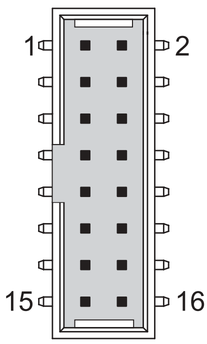


external view

Pin	Signal Name	Signal Type	Notes
1	Tx and Rx 13.8VDC	output	
2	Tx and Rx ground	output	

System Interface Connector to Transmitter

The system interface connector (J101) to the transmitter is a 16-way surface-mounted connector.

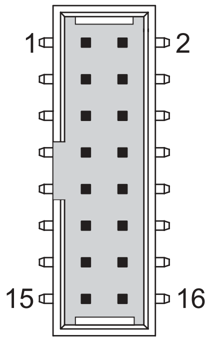


external view

Pin	Signal Name	Signal Type	Notes
1	TX_AUX_GPIO7	output	Tx key signal
2	TX_AUX_GPIO6	bidirectional	digital input/output
3	TX_AUX_GPIO5	bidirectional	digital input/output
4	TX_AUX_GPIO4	bidirectional	digital input/output
5	TX_AUX_RXD	input	data
6	TX_AUX_TXD	output	data
7	TX_AUX_GPI3	input	digital input
8	TX_AUX_GPI1	input	digital input
9	TX_AUX_GPI2	input	digital input
10	TX_AUD_TAP_OUT	no connection	
11	TX_RSSI	no connection	
12	TX_MIC_AUD	output	
13	TX_AUD_TAP_IN	output	Tx audio
14	TX_GND	ground	ground
15	TX_13V8	no connection	
16	N/C	no connection	

System Interface Connector to Receiver

The system interface connector (J100) to the receiver is a 16-way surface-mounted connector.



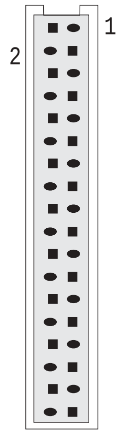
external view

Pin	Signal Name	Signal Type	Notes
1	RX_AUX_GPIO7	input	gate signal
2	RX_AUX_GPIO6	bidirectional	digital input/output
3	RX_AUX_GPIO5	bidirectional	digital input/output
4	RX_AUX_GPIO4	bidirectional	digital input/output
5	RX_AUX_RXD	input	data
6	RX_AUX_TXD	output	data
7	RX_AUX_GPI3	input	digital input
8	RX_AUX_GPI1	input	digital input
9	RX_AUX_GPI2	input	digital input
10	RX_AUD_TAP_OUT	input	receive audio
11	RX_RSSI	input	RSSI
12	RX_MIC_AUD	no connection	
13	RX_AUD_TAP_IN	no connection	
14	RX_GND	ground	ground
15	RX_13V8	no connection	
16	N/C	no connection	

5.2.3 UI Board Connectors

User Interface Connector to Transmitter

The user interface connector (SK1) to the transmitter is a 16-way MicroMaTch connector.

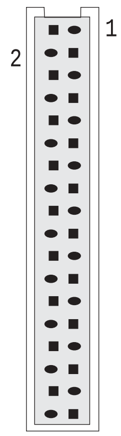


external view

Pin	Signal Name	Signal Type	Notes
1	TX_RX_AUD	no connection	no connection
2	TX_+13V8_SW	no connection	no connection
3	TX_CH_TXD	output	programming data
4	TX_CH_PTT	output	microphone PTT
5	TX_MIC_AUD_OUT	output	audio from microphone
6	TX_AGND	ground	analogue ground
7	TX_CH_RXD	input	programming data
8	TX_DGND	ground	digital ground
9	TX_CH_ON_OFF	input	digital ground
10	TX_VOL_WIP_DC	output	no connection
11	TX_CH_SPI_D0	input	
12	TX_CH_LE	input	
13	TX_CH_SPIO1	input	digital ground
14	TX_+3V3	no connection	no connection
15	TX_CH_SPI_DI	output	
16	TX_CH_SPI_CLK	input	
17	TX_CH_SPK-	no connection	no connection
18	TX_CH_SPK+	no connection	no connection

User Interface Connector to Receiver

The user interface connector (SK2) to the receiver is a 16-way MicroMaTch connector.



external view

Pin	Signal Name	Signal Type	Notes
1	RX_RX_AUD	no connection	no connection
2	RX_+13V8_SW	input	+13V8DC for PCB
3	RX_CH_TXD	output	programming data
4	RX_CH_PTT	no connection	no connection
5	RX_MIC_AUD_OUT	input	no connection
6	RX_AGND	ground	analogue ground
7	RX_CH_RXD	input	programming data
8	RX_DGND	ground	digital ground
9	RX_CH_ON_OFF	input	digital ground
10	RX_VOL_WIP_DC	output	volume control
11	RX_CH_SPI_D0	input	
12	RX_CH_LE	input	
13	RX_CH_GPIO1	input	digital ground
14	RX_+3V3	input	+3V3DC for PCB
15	RX_CH_SPI_DI	output	
16	RX_CH_SPI_CLK	input	
17	RX_CH_SPK-	input	speaker audio
18	RX_CH_SPK+	input	speaker audio

6 General Information

This section discusses the two repair levels covered by the service manual, details concerning website access, the tools and equipment 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. This section also describes the use of computer-controlled test mode (CCTM).

6.1 Repair Levels and Website Access

Repair Levels

This manual covers level-1 and level-2 repairs of the base station.

Level-1 repairs comprise the **replacement** of:

- transmitter module
- receiver module
- SI board
- UI board
- speaker
- fans
- fan power board
- temperature sensor board
- volume-control potentiometer on the UI board.

Level-2 repairs comprise the **repair** of:

- transmitter module
- receiver module

except for special items. The special items are:

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

Level-2 repairs also comprise the **replacement** of the connectors on the transmitter and receiver modules, and the external connectors of the UI and SI boards.

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

Accreditation of Service Centres

Service centres 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 centres 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 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. All ASCs with the necessary endorsements may carry out level-1 and level-2 repairs, 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 centre, special test equipment and certain torque drivers are required.

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 centres 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 centres 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 6.1. The technical notes mentioned are of different types. Associate technical notes relate to the repair of the base station but not the downloading of firmware; Tait-only technical notes relate to the firmware. The PCB information is discussed in more detail below.

Table 6.1 Items available on the Technical Support website

Item	Public access	Associate access	ASC access	Tait-only access
Installation guide	•	•	•	•
Installation instructions	•	•	•	•
Public technical notes	•	•	•	•
Installation and operation manual		•	•	•
Specifications manual		•	•	•
Calibration software		•	•	•
Programming software		•	•	•
Programming user manual		•	•	•
PCB information		•	•	•
Service manual		•	•	•
Application notes		•	•	•
Associate technical notes		•	•	•
Release notes		•	•	•
Firmware			•	•
Tait-only technical notes				•

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. PCB information is published on the Technical Support website.

Tait FOCUS Database

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

6.2 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.

- Philips #2 bit
- PZ1 and PZ2 Pozidriv bit
- Torx T10 bit
- 50W 40W — With the 50W/40W board, a Torx T6 bit is required to replace the DC power connector.

Refer to the illustrations in “Disassembly and Reassembly” on page 99 for the corresponding torque values.

Card Remover Tool

To remove the UI board, it is recommended to use the card remover tool (220-02034-**xx**) included in the TBA0ST2 tool kit.

Tuning Tool

To tune the transmitter and receiver modules, it is recommended to use the tuning tool (937-00013-**xx**) included in the TBA0ST2 tool kit.

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:

- test PC
- calibration and test unit (TBA0STU or TBA0STP)
- TB7100 CTU adapter (TBB0STU-TBB, included in TBA0STU)
- TMAA20-04 cable (RJ12 socket to RJ45 plug, included in TBB0P00)
- T2000-A19 cable (included in TBB0P00)
- RF communications test set (audio bandwidth of at least 10kHz)
- oscilloscope
- digital current meter (capable of measuring up to 20A)
- multimeter
- 25W 50W 40W — DC power supply (capable of 13.8V and 10A for 25W base stations, and 20A for 50W/40W base stations)

The standard test setup is illustrated in Figure 6.2. Separate instruments may be used in place of the RF communications test set. These are an RF signal generator, audio signal generator, audio analyser, RF power meter, and modulation meter.

An alternative test setup for testing the transmitter and receiver modules, using the TOPA-SV-024 test unit and cables included in the TMAA21-00 kit and a TMAC20-0T control head is illustrated in Figure 6.3.

Product CD

Install the TB7100 programming and calibration applications on the test PC. These applications are included on the CD (406-00047-**xx**) supplied with the base station.

6.3 Servicing Precautions

Introduction

This section discusses the precautions that need to be taken when servicing the base station. 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 base station.

Use of Torque-drivers

Apply the correct torque when using a torque-driver to tighten a screw or nut in the base station. Under-torquing can cause problems with microphonics and heat transfer. Over-torquing can damage the base station. The illustrations in "Disassembly and Reassembly" on page 99 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 base station 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 base station.

Compliance Issues

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

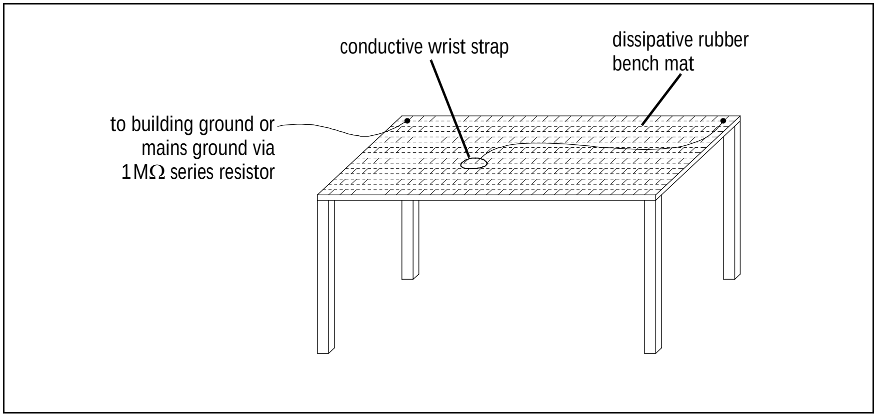
ESD Precautions

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 6.1 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 6.1 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 6.1. 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 heatsink when the transmitter is or has been operating. Avoid RF burns. Do not touch the antenna while the transmitter is operating.**

Important The base station 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 transmitter module, avoid overheating during test transmissions. The heatsink must be secured to the transmitter board. After completing any measurement or test requiring activation of the transmitter, immediately return the base station 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.

Important When the transmitter module is not connected to the SI board, the transmitter will transmit continuously. To overcome this, connect pins 1 and 13 of a 15-way D-range plug and connect the plug to the auxiliary connector of the transmitter module.

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.

6.4 Test Equipment Setup

This section describes how to set up of the test equipment for servicing the base station. Refer to "Tools, Equipment and Spares" on page 78 for details of the test equipment.

Important For testing, the base station must be linked as a line-controlled base station and not as a repeater. Table 6.2 shows the link settings of the SI board. The optional duplexer must be removed before testing.

Table 6.2 Link settings of the SI board

Link	Pins	Name	Default Position	Function
J400	3	Tx Key Source	1-2	External PTT signal to transmitter
J500	3	Line Out Frequency Response	2-3	De-Emphasis
J501	3	Line In Frequency Response	2-3	Pre-Emphasis
J502	3	Tx Audio Source	1-2	External audio line in to transmitter
J503	3	Rx Audio Destination	2-3	Received audio sent to balanced and unbalanced external outputs
J507	3	Line In Destination	2-3	AUDIO_TAP_IN. The Tx audio tap point

Test Setup with CTU

The standard test setup using the CTU is shown in Figure 6.2.

Note The CTU is described in the TBA0STU/TBA0STP Calibration & Test Unit Operation Manual (MBA-00013-**xx**).

1. Connect the test PC to the PROG/MIC connector on the front of the base station using the T2000-A19 and TMAA20-04 cables.

2. Connect the 25-pin SYSTEM INTERFACE connector of the CTU to the SYSTEM connector of the base station using the TB7100 CTU adapter and the 25-way D-range ribbon cable. Audio connections between the CTU and test equipment are described in the relevant test steps.

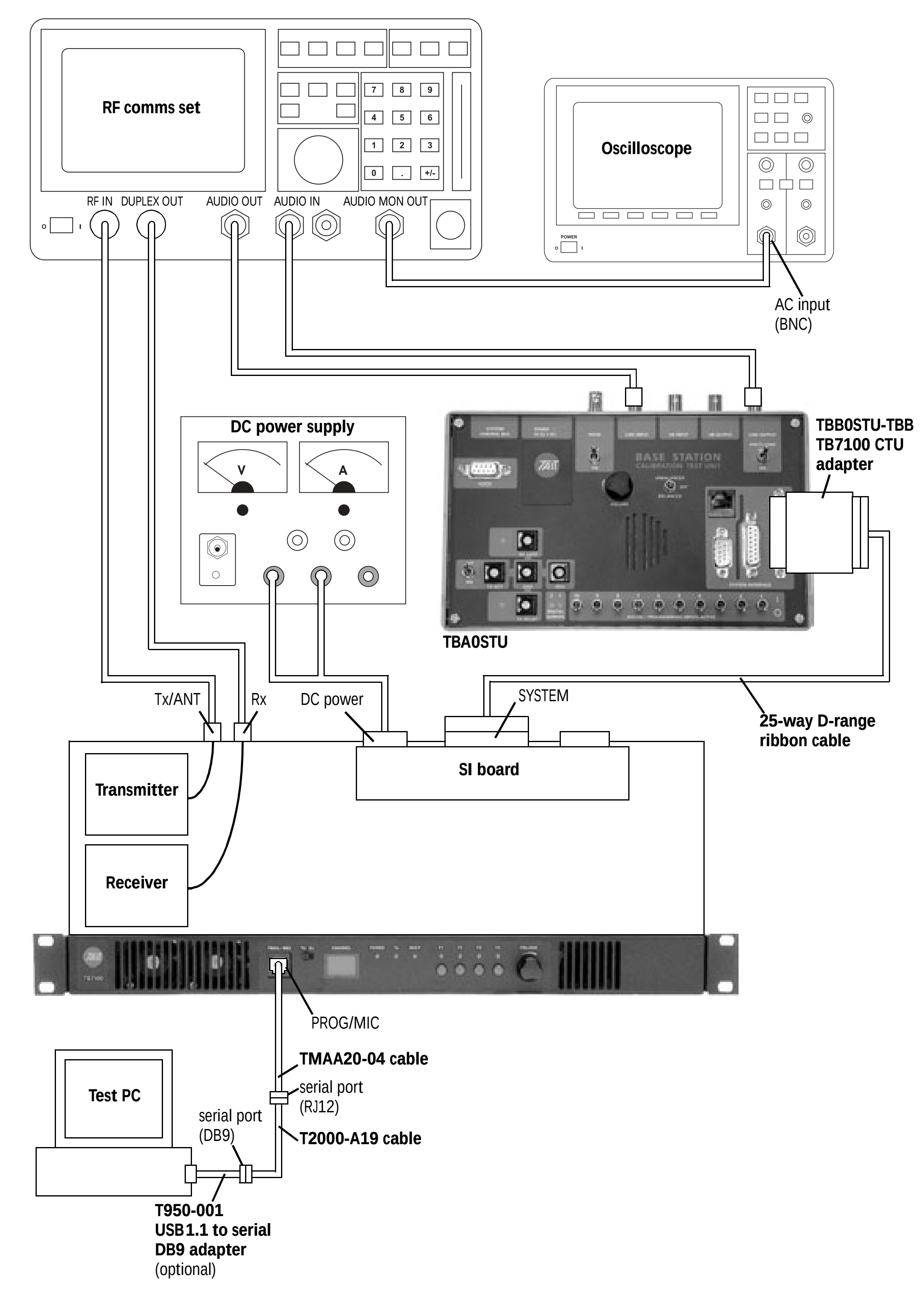
3. Set all switches on the CTU to the off position.

4. Connect the RX N-type connector of the base station to the output port of the RF test set (DUPLEX OUT).

5. Connect the TX/ANT N-type connector of the base station to the input port of the RF test set (RF IN).

6. Connect the 13.8V DC power supply to the DC power connector (labelled 12VDC) of the base station.

Figure 6.2 Test setup with CTU (TBA0STU)



Alternative Test Setup with TOPA-SV-024 Test Unit and TMAC20-0T Control Head

An alternative test setup using the TOPA-SV-024 test unit and cables of the TMAA21-00 kit and a TMAC20-0T control head used for testing the transmitter and receiver modules is shown in Figure 6.3.

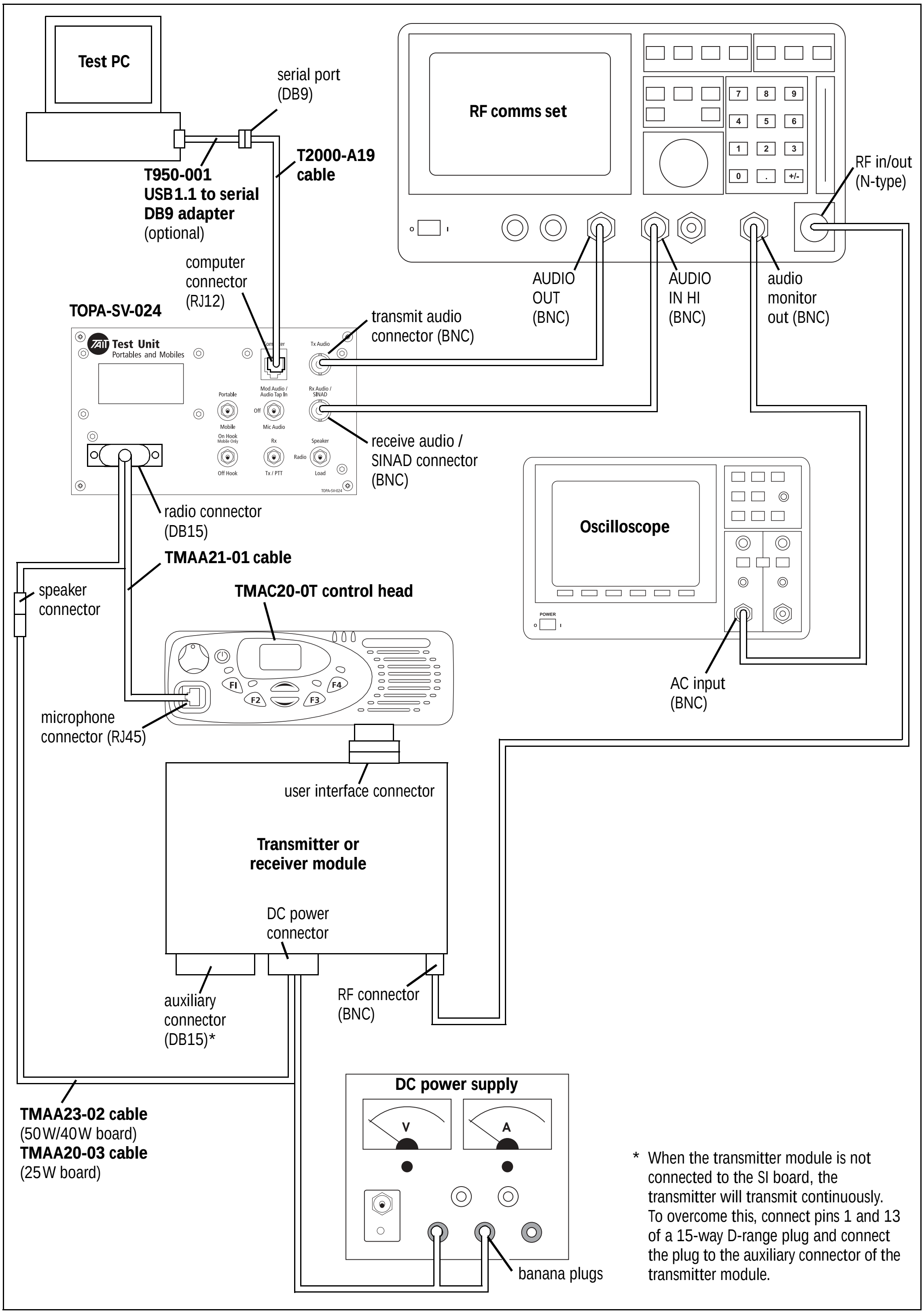
When using the alternative test setup, the switches of the test unit must be set as described below. (When programming or calibrating the base station, the switches have no effect, although it is good practice to set the MODE switch to "RX".)

Transmit tests		Receive tests	
Switch	**Position**	**Switch**	**Position**
HOOK	OFF HOOK	HOOK	OFF HOOK
MODE	RX initially[a]	MODE	RX
AUDIO IN	MIC AUDIO	AUDIO IN	OFF
AUDIO OUT	(immaterial)	AUDIO OUT	SPEAKER or LOAD[b]

a. 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.

b. 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 speaker.

Figure 6.3 Test setup with TOPA-SV024 test unit and TMAC20-0T control head



6.5 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.

6.6 Shielding Cans and Connectors

The shielding cans on the top- and bottom-side of the transmitter and receiver boards are identified in Figure 6.4 and Figure 6.5. The figures also show the locations of the connectors.

Figure 6.4 Shielding cans and connectors (top side)

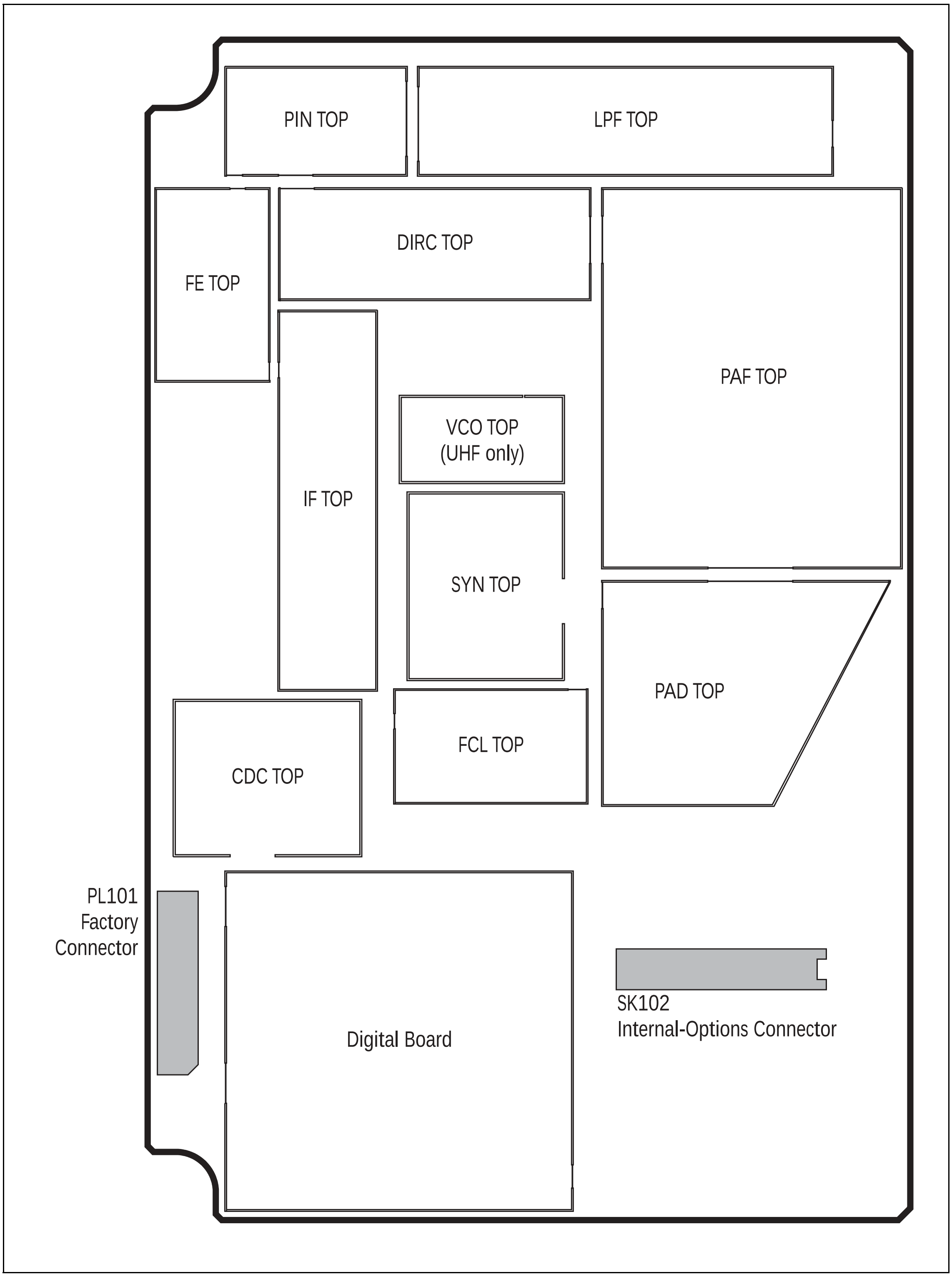
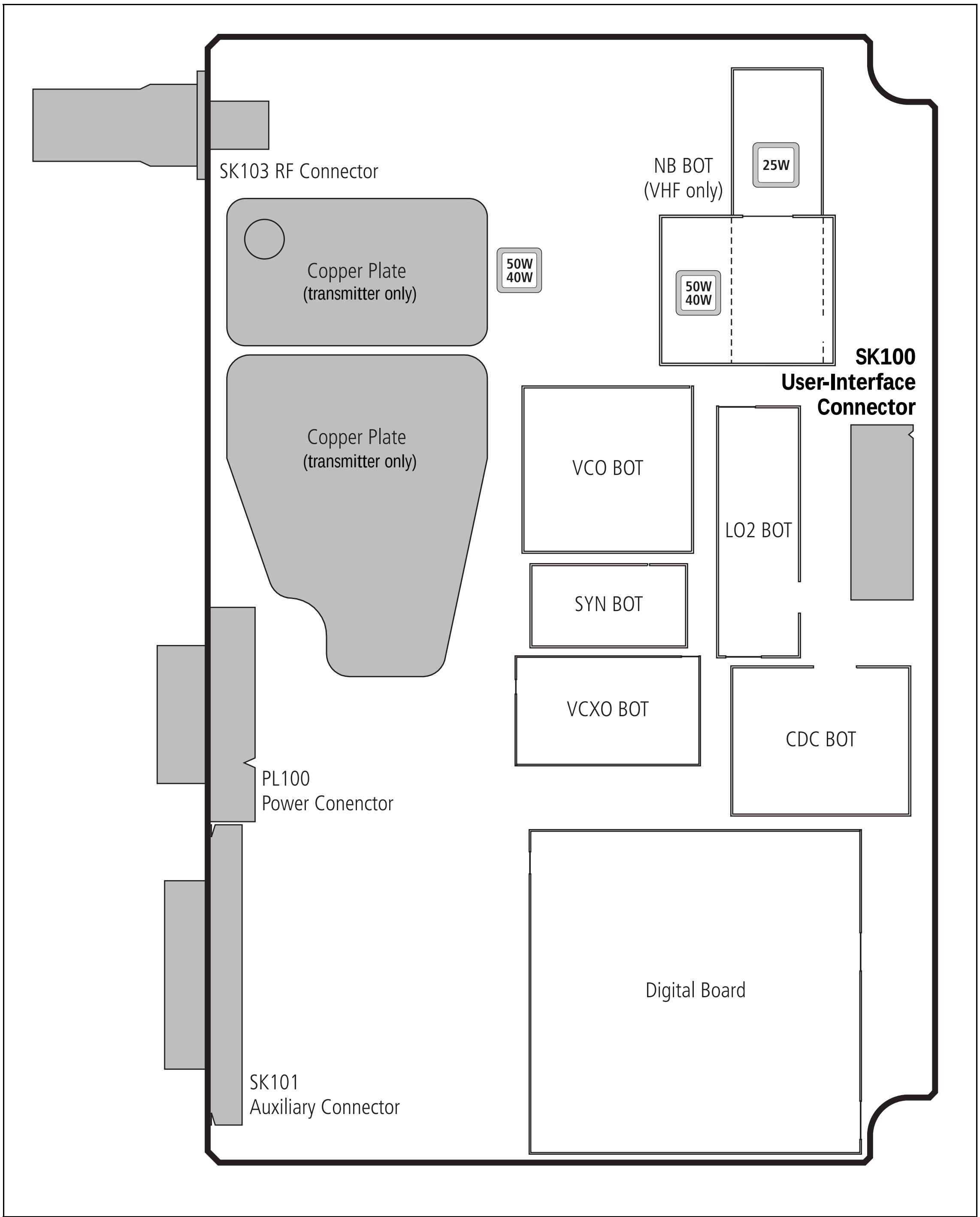


Figure 6.5 Shielding cans and connectors (bottom side)



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 centres.

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.

6.7 SMT Repair Techniques

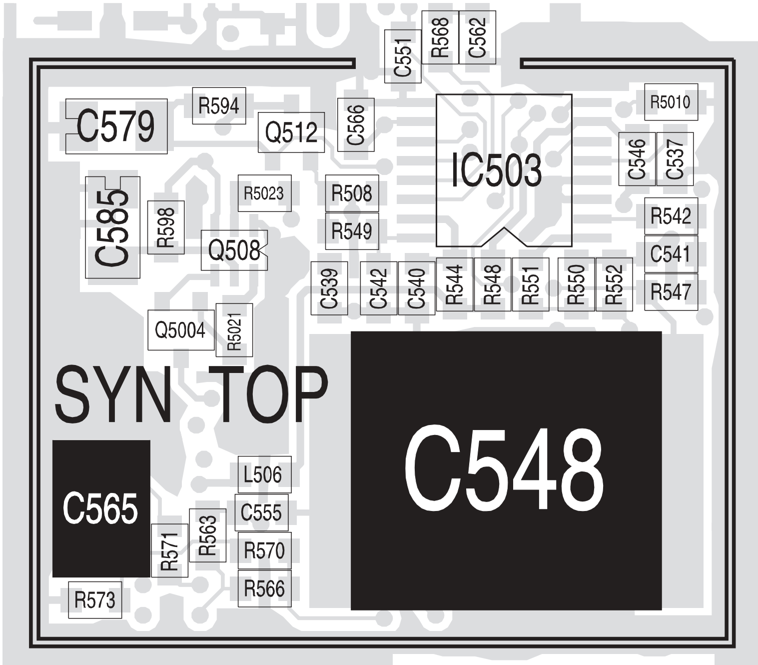
Standard Procedures

Service centres 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.

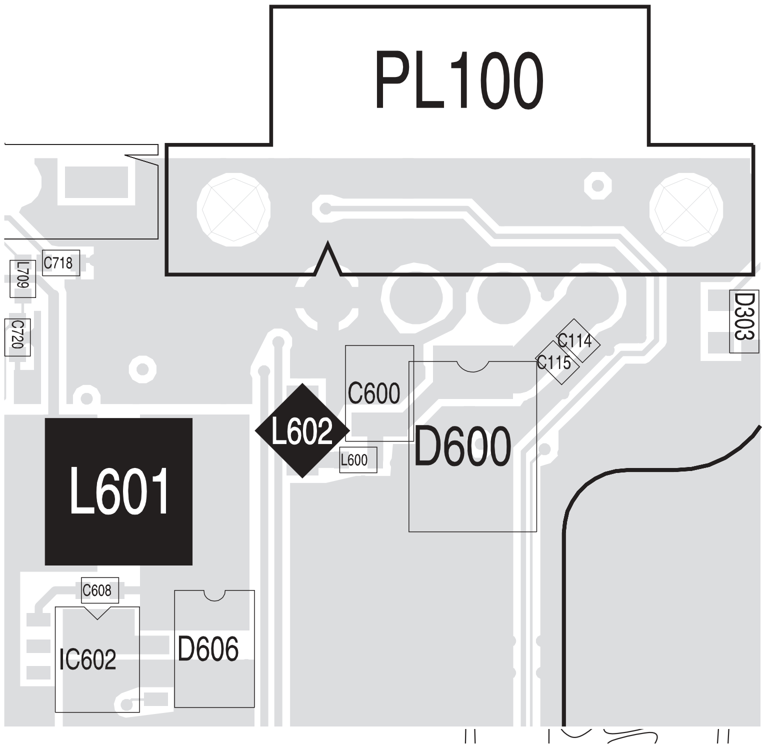
Non-standard Procedures

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 6.6 on page 90 shows the locations of the components.

Figure 6.6 Locations of the capacitors C548 and C565 and the inductors L601 and L602



top side
(VHF board. UHF board similar)
Note that other components may be fitted for C548 (such as C5085 and C5086 for UHF board)



bottom side
(UHF board. VHF board similar)

6.8 Computer-Controlled Test Mode (CCTM)

The servicing procedures require the transmitter or receiver modules 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 module. Certain CCTM commands cause the module to carry out particular functions; others read particular settings and parameter values in the module. The CCTM commands of use in servicing the modules are listed in Table 6.3 to Table 6.6, grouped according to category.

Terminal Program for CCTM

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 module 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 module in CCTM as follows:

1. Enter the character ^ to reset the module.

2. As soon as the module 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 *CL* appears on the base station display. This implies that the module has entered CCTM. If the attempt fails, repeat Step 1 to Step 3.

Table 6.3 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
24 – Let squelch control received audio mute Lets the base station control muting and unmuting of the received audio signal	*24*	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
322 – Generate audio tone Generates an audio signal	*322* ***x y z*** where ***x*** specifies the tap point (*r1*, *r2*, *r3*, *r4*, *r5*, *t1*, *t2*, *t3* or *t7*), ***y*** specifies the frequency × 10 (e.g. 10000=1kHz), and ***z*** specifies the amplitude (5000 is approx. 60% FSD or 1V_{pp})	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 6.4 CCTM commands in the radio-information, radio-control and system categories

Command	Usage	
	Entry at keyboard	**Response on screen**
Radio-information category		
94 – Module serial number Reads the serial number of the module	*94*	***x*** where ***x*** is the serial number (an eight-digit number)
96 – Firmware version Reads the version number of the module 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 module 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 6.5 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 6.6 CCTM commands in the transmitter category

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 6.6 CCTM commands in the transmitter category

Command	Usage: Entry at keyboard	Usage: Response on screen
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

CCTM Error Codes

Once the module is in CCTM, the CCTM commands may be entered as shown in Table 6.3 to Table 6.6. 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 6.7.

Table 6.7 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 module down and up again, and re-enter the CCTM command.
C04	An error occurred on entry into CCTM. Power the module down and up again, and place the module in CCTM again.
C05	The module 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 module 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 module's database.
X35	The module temperature is above the T1 threshold and a reduction in the transmit power is impending. To avoid damaging the module, stop transmitting until the module has cooled down sufficiently.
X36	The module 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 module has powered itself down. The module will not respond to the reset command character ^.

6.9 Visual Indicators

Visual indicators give information about the state of the base station. Visual indications are provided by the status LEDs, function key LEDs, and LCD display. The information conveyed by the LEDs is listed in Table 6.8. The behaviour 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 installation and operation manual. Audible indications are provided in the form of different tones emitted from the speaker.

Table 6.8 Visual indications provided by the LEDs

LED color	LED name	Indications	Meanings
Red	Tx	LED is on	The base station is transmitting
		LED flashes	(1) The transmit timer is about to expire (2) The base station has been stunned
Green	Busy	LED is on	There is activity on the current channel, although it might not be audible
		LED flashes	(1) The base station has received a call with valid special signaling (2) The monitor has been activated (3) The squelch override has been activated
Green	Power	LED is on	Power is supplied to the base station (through the receiver module)
		LED is off	No power is supplied to the base station

Note The base station does not generate audible signals.

7 Disassembly and Reassembly

This section describes how to:

- remove and open and close the base station
- remove and fit the modules and components
- disassemble and reassemble the transmitter module

General

Important Before disassembling the base station, disconnect the base station 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 369.

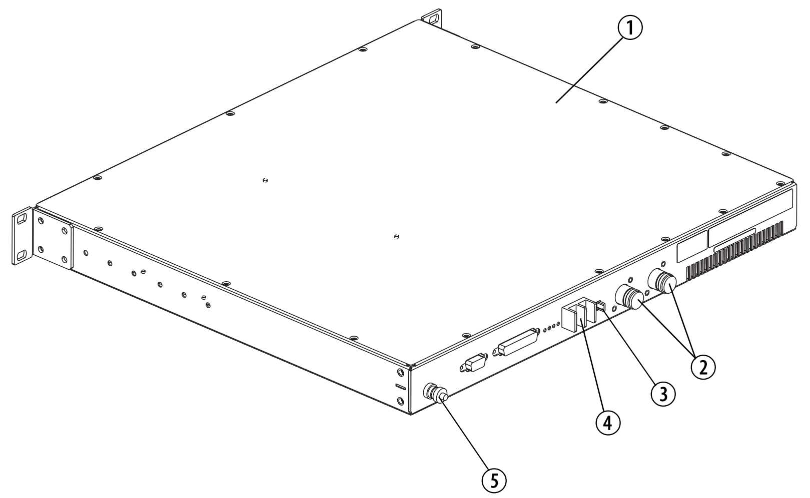
Important To ensure adequate airflow through the base station, do not cover the fan intake grill on the front panel. Do not operate for more than a few minutes with the fan intake covered.

Important The transmitter and receiver modules can only be replaced with base station modules. The transmitter module can be identified by the heat transfer plate fitted to the underside, whereas the receiver does not have a heat transfer plate.

7.1 Removing the Base Station and Opening the Tray

Important The modules in the base station are **not** hot-pluggable. It is recommended the tray is removed from the rack before any modules are replaced.

Figure 7.1 Opening the tray



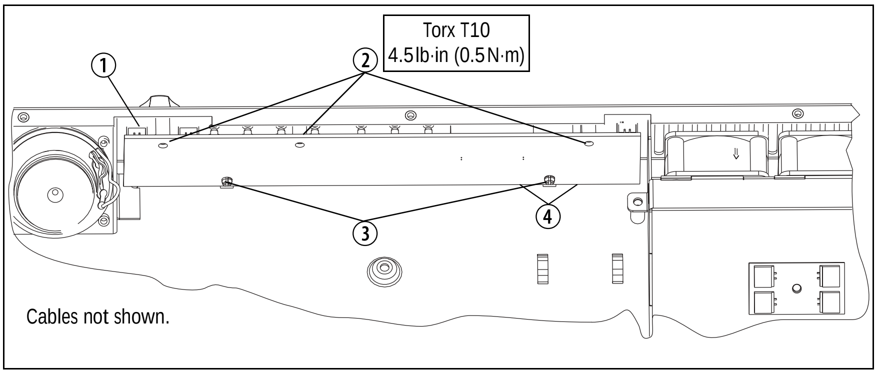
1. Remove the fuse ③ at the rear of the base station to disconnect the base station from DC power.
2. Use a Philips #2 screwdriver to disconnect the cables from the DC power connector ④.
3. Disconnect the antenna connectors for transmit and receive ②.
4. Disconnect any other connectors.
5. Disconnect the ground cable from the ground point ⑤.
6. Use a PZ2 Pozidriv screwdriver to remove the four M6 screws, and remove the base station from the rack.
7. Use a Torx T10 screwdriver to remove the 15 countersunk screws. Remove the tray cover ①.

7.2 Replacing the UI Board

Removal

1. Remove the volume knob by pulling slowly but firmly. The knob is a friction fit and can leave the collet behind on the shaft. If this happens, remove the collet from the shaft and place inside the knob.
2. Disconnect the speaker connector ①.
3. Use a Torx T10 screwdriver to remove the three screws ② together with the spring washers and flat washers.
4. Insert the card remover tool (220-02034-xx) from the tool kit (TBA0ST2), or a small flat-bladed screwdriver into the two small holes at the bottom of the UI board. Lever the board completely off the spring clips ③.
5. Carefully slide the UI board towards the rear of the base station until the volume-control shaft clears the front panel. Lift the UI board clear of the chassis.
6. Disconnect the two Micro-MaTch connectors ④.

Figure 7.2 Removing the UI board



Fitting

1. Plug the two Micro-MaTch connectors ④ into the UI board. The Micro-MaTch connector for the transmitter is closest to the edge of the UI board.
2. Align the volume-control shaft with the hole in the front panel, also align the programming/microphone connector and function buttons as the board is slid into place.
3. Gently slide the UI board into position so that the spring clips ③ are engaged. Press firmly around the spring clips to ensure they are engaged fully.
4. Use a Torx T10 screwdriver to fasten the three screws ② to 4.5lb·in (0.5N·m).
5. Plug the speaker connector ① into the UI board.
6. Fit the volume knob onto the shaft and press firmly until fully seated.

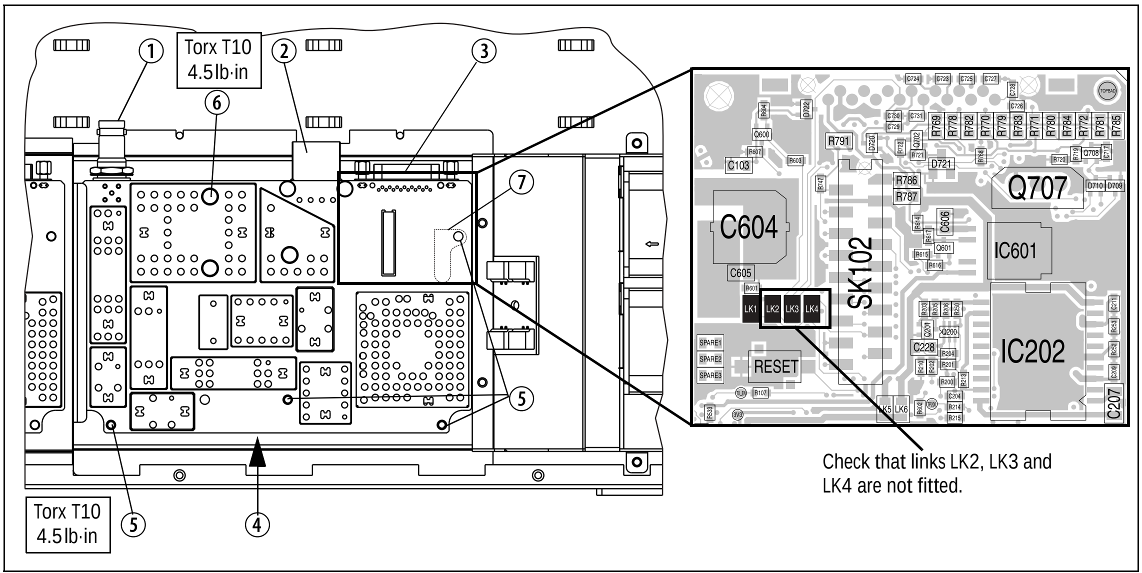
7.3 Replacing the Receiver Module

Removal

Note Release the latch underneath the DC power connector before attempting to disconnect it.

1. Disconnect the cables to the RF ①, DC power ②, system interface ③, and the user interface ④ connectors.
2. Use a Torx T10 screwdriver to remove the five screws ⑤ and ⑥ together with the spring washers and flat washers.
3. Lift the receiver module clear of the chassis.
4. Make sure not to lose the metal heatsink ⑥ for the audio PA.

Figure 7.3 Replacing the receiver module



Note Although the transmitter and receiver modules look alike, a transmitter module can not replace a receiver module. There is no heat transfer plate on the receiver. Check that the replacement module has links, LK2, LK3 and LK4 not fitted as shown above.

Fitting

Note Before fitting the receiver module, make sure that the metal heatsink ⑦ for the audio PA is fitted to the tray chassis.

1. Place one screw ⑥ into the hole above the metal heatsink plate by:
   a. holding the module at a 60° angle
   b. fitting the screw on the Torx driver
   c. slipping it through the shield hole and into the board hole.
2. Position the receiver module inside the tray chassis.
3. Use a Torx T10 torque-driver to tighten the screws ⑤ and ⑥ to 4.5lbf·in (0.5N·m).
4. Connect the cables to the RF ①, DC power ②, system interface ③, and user interface ④ connectors.

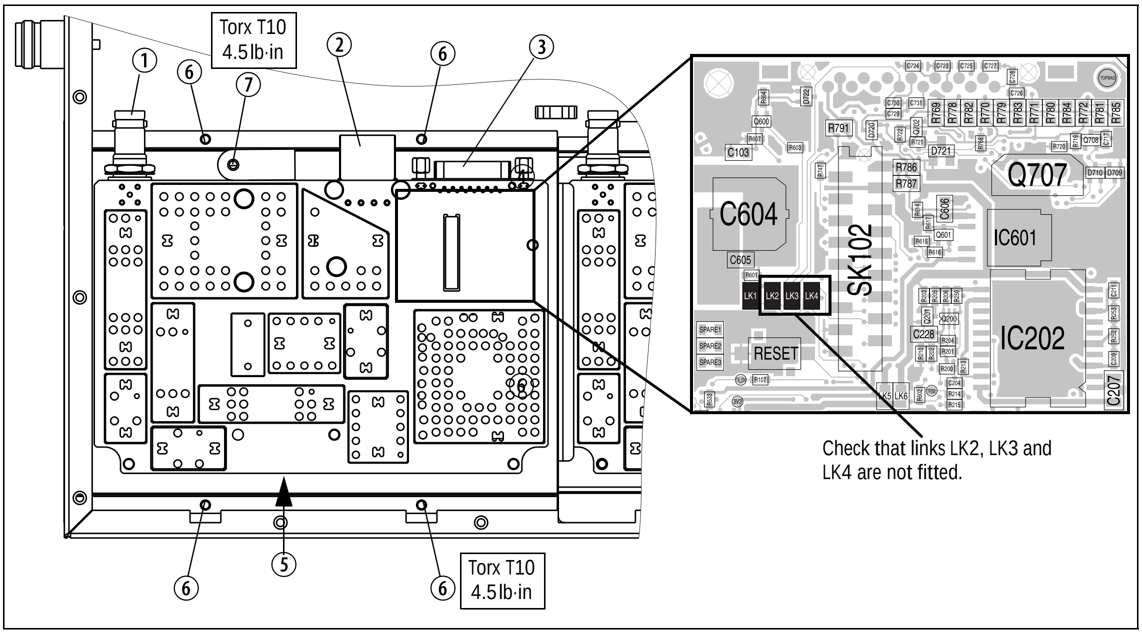
7.4 Replacing the Transmitter Module

Removal

Note Release the latch underneath the DC power connector before attempting to disconnect it.

1. Disconnect the cables to the RF ①, DC power ②, system interface ③, and the user interface ⑤ connectors.
2. Use a Torx T10 screwdriver to remove the screw ⑦ fastening the temperature sensor to the heatsink.
3. Use a Torx T10 screwdriver to remove the four screws ⑥ fastening the heatsink to the tray chassis.
4. Lift the transmitter module clear of the tray chassis.

Figure 7.4 Replacing the transmitter module



Fitting

Note Although the transmitter and receiver modules look alike, a transmitter module can not replace a receiver module. There is no heat transfer plate on the receiver. Check that the replacement module has links, LK2, LK3 and LK4 not fitted as shown below.

1. Position the transmitter module inside the tray chassis.
2. Use a Torx T10 torque-driver to fasten the four screws ⑥ to 4.5 lbf·in (0.5 N·m).
3. Use a Torx T10 torque-driver to fasten the temperature sensor with the screw ⑦ to 4.5 lbf·in (0.5 N·m).
4. Connect the cables to the RF ①, DC power ②, system interface ③, and the user interface ⑤ connectors.

7.5 Disassembling the Transmitter Module

Important Disassembling the transmitter module is a level-2 repair and must only be performed by accredited service centres (ASC). For more information, refer to “Repair Levels and Website Access” on page 75.

1. Remove the transmitter module as described in “Replacing the Transmitter Module” on page 103.

2. Use a Torx T10 screwdriver to unscrew the seven screws ⑤ and ⑥ together with the spring washers and flat washers.

3. Lift the transmitter module clear of heat sink.

25W 50W 40W

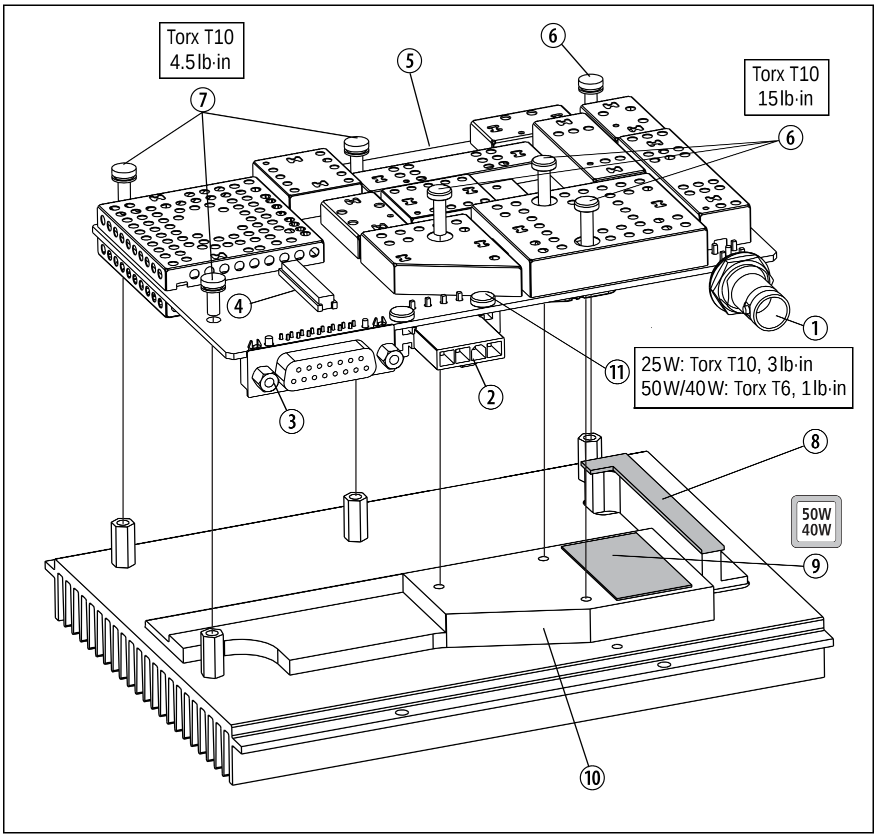
4. Remove and discard the gap pad ⑧ and (with the 50 W / 40 W boards) the gap pad ⑨.

5. To replace the power connector ②:

25W 50W 40W

- With the 50 W / 40 W board, use a Torx T6 screwdriver to undo the two screws ⑪.
- With the 25 W board, use a Torx T10 screwdriver to undo the two screws ⑪.

Figure 7.5 Removing and fitting the transmitter board



7.6 Reassembling the Transmitter Module

The circled numbers in this section refer to the items in Figure 7.5 on page 104.

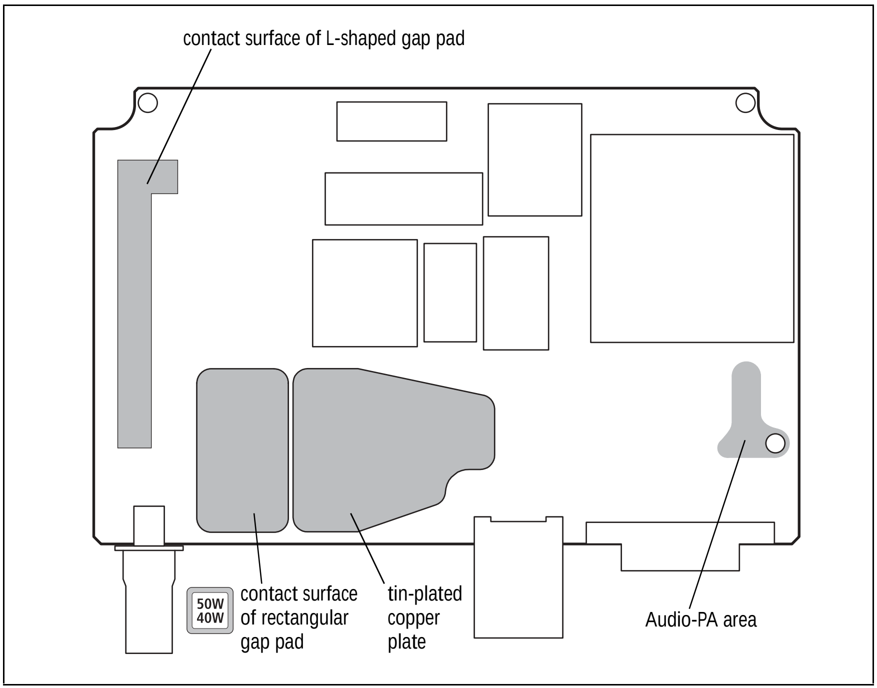
1. If the power connector has been replaced:
   - With the 25 W board, use a Torx T10 torque-driver to tighten the two screws ⑪ to 3 lb·in (0.34 N·m).
   - With the 50 W / 40 W board, use a Torx T6 torque-driver to tighten the two screws ⑪ to 1 lb·in (0.11 N·m).

2. The L-shaped gap pad ⑧ and (with the 50 W / 40 W board) the rectangular gap pad ⑨ must be replaced each time the board is separated from the heatsink ⑩:
   - Remove any residue of the gap pad(s) from the underside of the board and the heatsink.
   - Make sure that the heatsink and the heat plates are free of any dust.
   - Peel off the transparent film on one side of the L-shaped gap pad ⑧ and evenly press the gap pad on the contact surfaces of the heatsink.

Important With the 50 W / 40 W board, the rectangular gap pad ⑨ must not overlap the edge of the tin-plated copper plate (refer to Figure 7.6).

   - Peel off the transparent film on one side of the rectangular gap pad and evenly press the gap pad on the contact surfaces of the board.
   - Peel off the transparent film on other of the gap pad(s).

Figure 7.6 Contact surfaces on the bottom side of the board



3. If the thermal paste on the heatsink ⑪ or the tin-plated cooper plate of the 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 over the complete contact surface on the tin-plated copper plate (refer to Figure 7.6 on page 105).

Important With the 50 W/40 W board, the rectangular gap pad ⑨ must not overlap the edge of the tin-plated copper plate (refer to Figure 7.6 on page 105).

4. Place the board in position on the heatsink ⑪, and push them together to spread the thermal paste.

5. Place three screws ⑥ into the holes above the metal heatsink plate by:

   a. holding the module at a 60° angle

   b. fitting the screw on the Torx driver

   c. slipping it through the shield hole and into the PCB hole

6. Use a Torx T10 torque-driver to fasten the three screws ⑥ to 15 lbf·in (1.7 N·m).

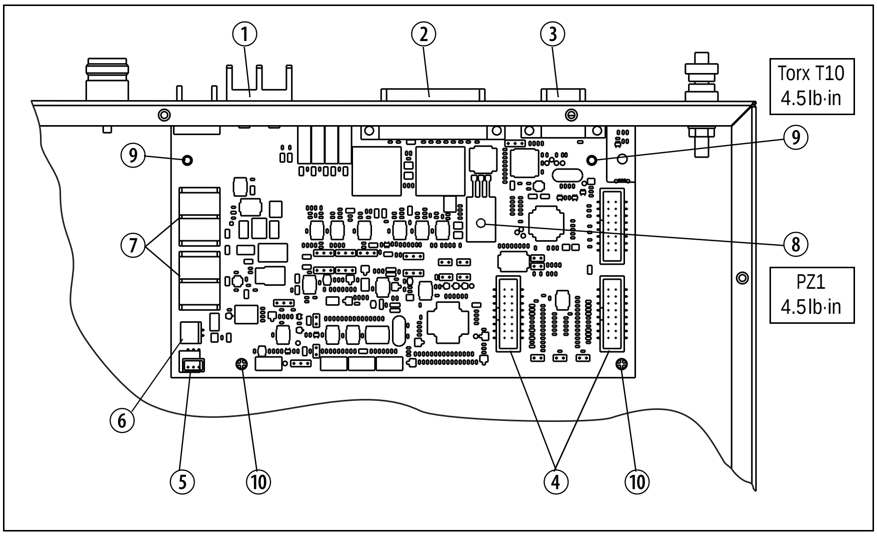
7. Use a Torx T10 torque-driver to fasten the four screws ⑤ to 4.5 lbf·in (0.5 N·m).

7.7 Replacing the SI Board

Removal

1. Disconnect the system interface cables ④ to the transmitter and the receiver, the fan control cable ⑤, and the temperature sensor cable ⑥, and move them to one side.
2. Remove the DC power cables ⑦ and move them to one side. Note the connection positions.
3. Use a Torx T10 screwdriver to remove the two screws ⑨. Use a PZ1 Pozidriv screwdriver to remove the screw ⑧ on the heatsink of U406.
4. Carefully lift the front of the SI board off the spring clips ⑩.
5. Carefully slide the SI board towards the front of the base station until the connectors ①, ② and ③ clear the rear panel. Lift the SI board clear of the chassis.

Figure 7.7 Replacing the SI board



Fitting

1. Slide the SI board into the tray chassis by fitting the connectors ①, ② and ③ into the rear panel.
2. Press down firmly on the front of the SI board to engage the two spring clips ⑨.

Important Make sure that the thermal pad is fitted under and the plastic insulating washer is fitted on U406.

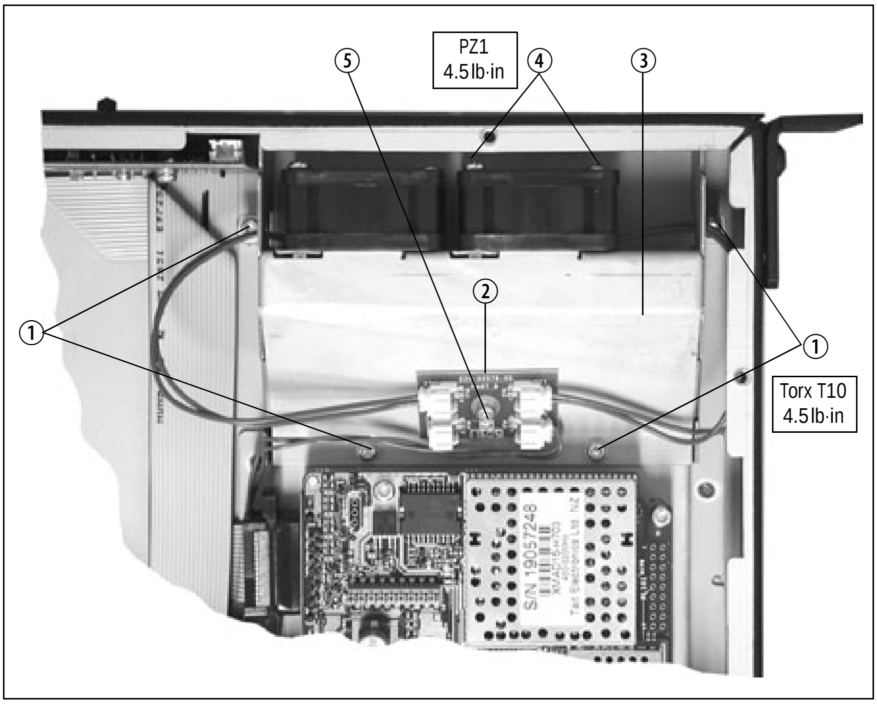
3. Use a torque-driver to fasten the two screws ⑨ (Torx T10) the screw ⑧ (PZ1) on the heatsink of U406 to 4.5lb·in (0.5N·m).
4. Connect the system interface cables ④ to the transmitter and the receiver, the fan control cable ⑤, the temperature sensor cable ⑥, and the DC power cables ⑦.

7.8 Replacing the Fans

Removal

1. Use a Torx T10 screw driver to remove the four screws ① securing the fan duct ③ in the tray chassis.
2. Disconnect the fan control loom from the fan power board ②. Slide back the fan duct ③ and lift clear.
3. Unplug the fan to be replaced from the fan power board ② on the fan duct ③.
4. Use a PZ1 Pozidriv screwdriver to remove the two M3 × 25mm screws ④ and remove the fan.

Figure 7.8 Replacing the fans



Fitting

1. Place the fan into position on the fan duct ④ and use a PZ1 screwdriver to fasten the two M3 × 25 screws ④ to 4.5 lb·in (0.5 N·m).
2. Thread the fan cable through the hole in the side of the fan duct. Plug the fan into the fan power board ②.
3. Slide the fan duct ③ into the chassis. Plug the fan control loom into the fan power board ②.
4. Use a Torx T10 screwdriver to fasten the four screws ① to 4.5 lb·in (0.5 N·m).

7.9 Replacing the Fan Power Board

Note The fan power board is manufactured as part of the UI board and cannot be ordered separately. For more information, refer to “Spare Parts” on page 369.

The circled numbers in this section refer to the items in Figure 7.8 on page 108.

1. Disconnect the fan control cable and the fan cables from the fan power board ②.
2. Use a Torx T10 screwdriver to remove the screw ⑤ attaching the fan power board ② to the fan duct ③.
3. Fitting is carried out in reverse order.

7.10 Replacing the Temperature Sensor Board

Note The temperature sensor board is manufactured as part of the SI board and cannot be ordered separately. For more information, refer to “Spare Parts” on page 369.

1. Disconnect the temperature sensor cable from the SI board (Figure 7.7, ⑥).
2. Use a Torx T10 screwdriver to remove the screw (Figure 7.4, ⑦) attaching the temperature sensor board to the transmitter module.
3. Fitting is carried out in reverse order.

7.11 Replacing the Speaker

Removal

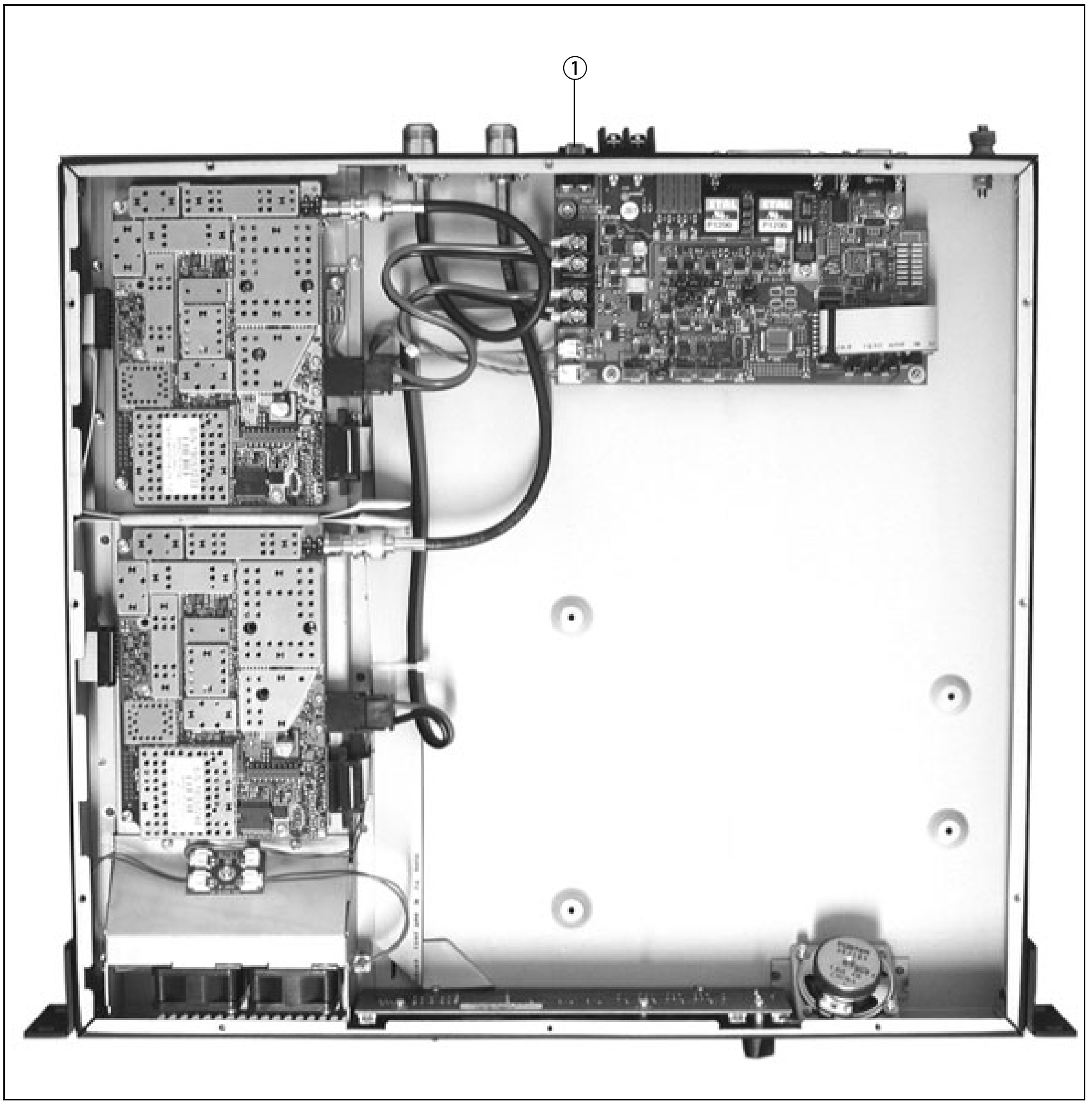
1. Use a Torx T10 screw driver to remove the two screws securing the speaker to the tray chassis.
2. Fitting is carried out in reverse order.

7.12 Final Reassembly

1. Ensure all internal cables are connected correctly as shown below.
2. Place the tray cover onto the chassis.
3. Use a Torx T10 torque-driver to fasten the tray cover with the 15 countersunk screws to 4.5 lb·in (0.5 N·m).
4. Fit the fuse ① at the rear of the base station.

Note Installation of the base station is described in the installation and operation manual.

Figure 7.9 Final reassembly



8 Servicing Procedures

This section gives the full sequence of tasks required when servicing this base station. These tasks fall into the following categories:

- Initial tasks: initial administration, visual inspection and fault diagnosis
- Final tasks: repair, final inspection, test and administration

For disassembly and reassembly instructions, refer to "Disassembly and Reassembly" on page 99.

Note The UI and SI boards are not serviceable items.

8.1 Initial Tasks

List of Tasks

The following tasks need to be carried out:

- initial administration
- visual inspection
- power up the base station
- read the programming files
- read the calibration files
- check any error messages.
- check the transmit power and frequency
- check the transmit deviation and audio distortion
- check the transmitter module
- check the receive and receive-audio functions
- check the receiver module
- check the user interface
- check the fans

Important Observe the "General Information" on page 75.

Task 1 — Initial Administration

When a base station 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, or both.

Task 2 — Visual Inspection

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

- fuse
- ventilation (refer to the installation and operation manual)
- tray and mounting brackets
- knob for volume-control potentiometer
- missing function buttons

If the base station is reported to have a functional fault, continue with Task 3. If the base station has no functional fault, repair any mechanical damage; conclude with the tasks of "Final Tasks" on page 123.

Task 3 — Power Up the Base Station

With the base station linked as a Line Controlled Base Station and connected to the test equipment as described in "Test Equipment Setup" on page 82, attempt to power up the base station following the steps below.

Note The RX switch position is tested first because the UI board is powered from the receiver module. If the receiver module is faulty and does not power up then there will be no indication that the transmitter module has powered up correctly.

If during these tests the LCD indicates that the module has powered up but fails to enter user-mode or displays an error code, the module is faulty. Refer to Table 8.1 on page 115.

If the LCD indicates that the receiver or transmitter module keeps resetting itself, check the voltage at the power connector on the module. If the voltage is correct, check the module's power-sensing circuitry. If the voltage is not correct, replace the SI board and return to Step 3.

1. Before turning on the base station, check that:
   - all looms and cables at the front and rear of the base station and the links are fitted correctly
   - all connectors are secure
   - the 20A fuse is fitted.
2. Switch the TX/RX switch to the RX position.
3. Apply power to the base station and check that the base station powers up correctly.
   - The POWER LED on lights up.
   - The LCD indicates the current channel number.

   If the receiver module powers up successfully, go to Step 4. If it does not, go to Step 5.

4. Switch the Tx/Rx switch to the Tx position and check that the base station powers up correctly.

   - The LCD indicates the current channel number.

   If the transmitter module powers up successfully, go to Task 4. If it does not, go to Step 10.

Check the Receiver Power Supply

5. Check the fuses, cables, DC power connector (labelled 12VDC) and the power supply. A blown fuse must be replaced with exactly the same type of fuse.

6. Check whether there is power at the DC power connector of the receiver module. If there is, go to Step 8.

7. Check whether there is power at the DC power output connector to the receiver on the SI board (J102). If there is, replace the receiver power cable and return to Step 3. If not, replace the SI board and return to Step 3.

8. Check whether the UI board and cable or the receiver module is faulty by connecting a UI board and cable to the receiver.

Note Only the UI cable to the receiver needs to be connected, but ensure the Tx/Rx switch is set to Rx.

Tip Instead of the spare UI board, a TMAC20-0T control head can be connected to the receiver module.

9. If the receiver module is faulty, go to “Power Supply Fault Finding” on page 127. Then return to Step 3.

Check the Transmitter Power Supply

10. Check whether there is power at the DC power connector of the transmitter module. If there is, go to Step 12.

11. Check whether there is power at the DC power output connector to the transmitter on the SI board (J103). If there is, replace the transmitter power cable and return to Step 4. If not, replace the SI board and return to Step 4.

12. Check whether the UI board and cable or the transmitter module is faulty by connecting a UI board and cable to the receiver and transmitter.

Note **Both** UI cables (to the transmitter and the receiver) need to be connected, and ensure the Tx/Rx switch is set to Tx.

Tip Instead of the spare UI board, a TMAC20-0T control head can be connected to the transmitter module only.

13. If the transmitter module is faulty, go to “Power Supply Fault Finding” on page 127. Then return to Step 4.

Task 4 — Read the Programming File

Given that the base station powers up, the next task is to use the programming application to read the programming files of the receiver and transmitter modules and save the customer data. If the programming file can be read but is corrupted, upload a default file.

Note Many problems can be caused by the customer incorrectly programming the base station. Once the customer's programming file has been read and saved load a default file that is known to work for the testing. If the base station works correctly with the default file then load the customer's file and retest. If it no longer works base station has been programmed incorrectly.

1. Switch the Tx/Rx switch to the Rx position and read the programming file.

2. If the programming file can be read, save a copy on the test PC before going to Step 3.

3. Switch the Tx/Rx switch to the Tx position and read the programming file.

4. If the programming file can be read, save a copy on the test PC before going to Step 5.

5. If both programming files could be read, load default test files to the receiver and transmitter modules and go to Task 5.

6. If none of the programming files could be read, go to Step 8.

7. If one of the programming files could not be read, go to Step 11

None of the Modules Could be Read

8. Switch the Tx/Rx switch to the Rx position.

9. Check whether:
   - the base station is connected to the correct serial port of the test PC,
   - the programming application is set-up correctly. Refer to the troubleshooting section of the online help.

10. If the programming file can now be read, return to Step 1. If not, go to Step 11.

One of the Modules Could Not be Read

11. Switch the Tx/Rx switch to the correct position.

12. Cycle the power to the base station and immediately attempt to read the file. First cycling the power is essential if the module 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. Using the microphone as the transparent-mode data port is not a valid base station configuration.

13. If the module can now be read, reprogram the data port to Aux and return to Step 1 (receiver) or Step 3 (transmitter). If not, go to Step 14.

Note Reprogramming the data port to Aux will make further programming easier. However, it is important to confirm with the customer whether this configuration is acceptable before returning the base station.

14. Check whether the UI board and cables or the receiver or transmitter module is faulty by connecting a spare UI board and cables to the receiver and transmitter.

Note When checking the receiver module, only the UI cable to the receiver needs to be connected, but ensure the TX/RX switch is set to RX. When checking the transmitter module, both UI cables need to be connected.

Tip Instead of the spare UI board, a TMAC20-0T control head can be connected to the module.

15. If the module can now be read, return to Step 1 (receiver) or Step 3 (transmitter). If not, go to Step 16.

16. Replace the receiver or transmitter module, load a default file, verify that the module can be read and return to Step 1 (receiver) or Step 3 (transmitter).

Task 5 — Read the Calibration File

Use the calibration application to read the calibration files of both the receiver and the transmitter module and save them on the test PC. If the calibration files cannot be read, set up suitable default calibration files and load them to the base station.

Note Loading a default calibration file into a module will allow fault basic tracing to take place. However once the faults are repaired the module must be correctly calibrated using the calibration application before being sent back to the customer.

Task 6 — Check Error Messages

The base station may display an error message. Carry out the corrective actions described in Table 8.1.

Table 8.1 Error messages

Error message	Corrective action
E1 (error 1)	Turn the base station off and then back on. If the error persists, read the last system error using CCTM command 204.
E2 (error 2)	
OL (out of lock)	Go to "Frequency Synthesizer Fault Finding" on page 143.

Task 7 — Check Tx Power and Frequency

This task only needs to be carried out if it relates to the fault reported or if the reported fault is not sufficiently specific to identify the faulty module.

Caution **Observe the servicing precautions for the transmitter listed in "Transmitter Issues" on page 81.**

1. Set up the test set to measure frequency and power level.

2. Activate the TX KEY switch on the CTU. (After completing the measurement, deactivate the TX KEY switch.)

3. If the transmitter keys up and the measured power level and frequency match the programmed settings (within the expected accuracy of the test set and taking into account cable losses), go to Step 6. If it does not, go to Step 4.

4. If the transmitter does not key up, check whether the SI board and cable or the transmitter module is faulty by connecting a spare transmitter module. If the transmitter keys up but the power level or frequency is incorrect, go to Task 9.

Tip It is not required to remove the original transmitter module from the tray chassis. Just unplug the connectors.

5. If the transmitter keys up now, the original transmitter module is faulty. Reconnect the original transmitter module and go to Task 9. Then continue with Step 6.

6. Connect a fist microphone to the PROG/MIC connector and press the PTT key.

7. If the transmitter keys up and the measured power level and frequency match the programmed settings (within the expected accuracy of the test set and taking into account cable losses), go to Step 10. If it does not, go to Step 8.

8. If the transmitter does not key up, check whether the UI board and cable or the transmitter module is faulty by connecting a spare UI board and cable to the transmitter and receiver. If the transmitter keys up but the power level or frequency is incorrect, go to Task 9.

Note When checking the transmitter module, both UI cables need to be connected.

Tip Instead of the spare UI board, a TMAC20-0T control head can be connected to the module.

9. If the transmitter does not key up, the original transmitter module is faulty. Reconnect the original UI board and cable and go to Task 9. Then continue with Step 10.

10. Activate the TX KEY switch on the CTU or the PTT key on the fist microphone. The TX LED should light up.

11. If the TX LED does not light up, replace the UI board.

Task 8 — Check Transmit Deviation and Audio Distortion

This task only needs to be carried out if it relates to the fault reported or if the reported fault is not sufficiently specific to identify the faulty module.

Caution **Observe the servicing precautions for the transmitter listed in "Transmitter Issues" on page 81.**

1. Connect the audio output from the test set to the Line Input on the CTU.

2. Set up the modulation analyser in the test set to measure the distortion and deviation of the modulated audio signal.

3. Set up the test set audio generator output to be 1 kHz and at the level required by the customer's system to produce 60% full system deviation (providing this is within the specified limits of the base station).

4. Activate the TX KEY switch and verify that the measured deviation is 60% of full system deviation and that the measured distortion level is within the transmitter specifications as detailed in the specifications manual.

5. If the measured value agrees with the programmed settings, go to Step 8, If it does not, attempt to complete the required transmitter audio level adjustment as described in the installation and operation manual.

6. If this rectifies the fault, go to Step 8. If it does not, check whether the SI board and cable or the transmitter module is faulty by connecting a spare transmitter module.

Tip It is not required to remove the original transmitter board from the tray chassis. Just unplug the connectors.

7. If this rectifies the fault, the original transmitter module is faulty. Reconnect the original transmitter module and go to Task 9. Then continue with Step 8.

8. Repeat from Step 1 using the Unbalanced Line Input.

9. Connect a fist microphone to the PROG/MIC connector, and whistle into the microphone while pressing the PTT key. Verify whether close to full system deviation is measured.

Note For a more accurate measurement, the TOPA-SV-024 test unit can be used to connect the microphone input of the base station to an audio source.

10. If the deviation is correct, go to Step 12. If there is no deviation or very low deviation, check whether the UI board and cable or the transmitter module is faulty by connecting a spare UI board and cables to **both** transmitter and receiver.

Note Ensure the TX/RX switch of the spare UI board is set to TX. When checking the transmitter module, **both** UI cables need to be connected.

Tip Instead of the spare UI board, a TMAC20-0T control head can be connected to module.

11. If this rectifies the fault, go to Step 12. If it does not, go to Task 9. Return to Step 9.

12. If the reported fault was only with the transmitter and has now been repaired, go to "Final Tasks" on page 123. Otherwise go to Task 10.

Task 9 — Check the Transmitter Module

If the fault is with the transmitter module, this can be caused by:

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

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

Caution **Observe the servicing precautions for the transmitter listed in "Transmitter Issues" on page 81.**

Synthesizer Out of Lock

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 base station 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 transmitter module as described in "Frequency Synthesizer Fault Finding" on page 143.

5. Repeat Step 1 to Step 3 with the transmit frequency set to the top of the band

No or Wrong Carrier Power

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 transmitter module.

9. If the re-calibration does not repair the fault, repair the transmitter module as described in "Transmitter Fault Finding (50 W/40 W)" on page 273 and "Transmitter Fault Finding (25 W)" on page 219.

10. Repeat Step 7 to Step 9 with the power level set to high (*326 4*).

No Modulation

11. If the base station transmits, the synthesizer and transmitter circuitry are operating correctly. Repair the transmitter module as described in "CODEC and Audio Fault Finding" on page 343.

Task 10 — Check the Receive and Receive-Audio Functions

This task only needs to be carried out if it relates to the fault reported or if the reported fault is not sufficiently specific to identify the faulty module.

1. Set up the test set to generate a signal at –70dBm, modulated at 60% full system deviation, on the test channel.

Note Ensure that the test channel does not use sub-audible signalling, the base station is not in TSHD transparent mode, and the Rx Inhibit line (SW6 on the CTU) is not active.

2. Turn up the volume and verify that audio can be heard from the speaker.

3. If no audio can be heard, check whether the user interface or the receiver module is faulty by connecting a spare speaker, UI board and UI cable to the receiver module.

Note When checking the receiver module, only the UI cable to the receiver needs to be connected, but ensure the TX/RX switch is set to RX.

4. If this rectifies the fault, go to Task 12. If not, go to Task 11. Then go to Step 5.

5. Verify whether the volume potentiometer works correctly. If not, go to Task 12. Then go to Step 6.

6. Connect the Line Output from the CTU to the audio input on the test set.

7. Set up the audio meter to measure audio level and SINAD.

8. Verify that the measured value agrees with the customer's requirements (providing this is with in the specified limits of the base station).

9. If the measured value is correct, go to Step 12. If not, attempt to complete the required receiver audio level adjustment as described in the installation and operation manual.

10. If this rectifies the fault, go to Step 12. If not, check whether the SI board and cable or the receiver module is faulty by connecting a spare receiver module.

Tip It is not required to remove the original receiver module from the tray, just unplug the connectors.

11. If this rectifies the fault, the original receiver module is faulty. Reconnect the original receiver module and go to Task 11. Then go to Step 12.

12. Repeat from Step 6 using the Unbalanced Line output.

13. Check whether the BUSY LED on the front of the base station is lit up. If not, replace the UI board or cable.

14. Verify the Rx Gate LED on the CTU is lit. If not, check whether the SI board and cable or the receiver module is faulty by connecting a spare receiver module.

Tip It is not required to remove the original receiver module from the tray, just unplug the connectors.

15. If this rectifies the fault, the original receiver module is faulty. Reconnect the original receiver module and go to Task 11. Then go to Task 12.

Task 11 — Check the Receiver Module

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

- the synthesizer not being in lock
- no carrier detected

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

No Receive or Receive Audio

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 receiver module as described in “Frequency Synthesizer Fault Finding” on page 143.

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 BUSY LED
   - CCTM command *63* should return the fed signal strength ±1 dBm.

6. If the carrier is detected correctly, try to re-calibrate the receiver module. If not, load a default calibration file into the receiver module and then attempt to re-calibrate.

7. If re-calibration does not the repair the fault, repair the receiver module as described in “Receiver Fault Finding” on page 201.

Receive Audio but No Rx Gate Signal

The receiver is working but there is a fault in the interface circuitry of the receiver module. Repair the receiver module as described in “Interface Fault Finding” on page 137.

Audio Faults

After having eliminated the synthesizer, the receiver and interface circuitry, the speaker, and the volume potentiometer as cause for the fault, repair the receiver module as described in "CODEC and Audio Fault Finding" on page 343.

Task 12 — Check the User Interface

This task only needs to be carried out if it relates to the fault reported or if the reported fault is not sufficiently specific to identify the faulty module.

1. Use the programming application to view the functions assigned to the function keys and whether LCD backlighting is turned on or off.

Note Faults of the LCD, TX LED, BUSY LED, speaker and volume potentiometer can also be caused by the transmitter and receiver modules, respectively. Refer to the relevant tasks in this section.

2. Check the user interface for any of the following faults:
   - LCD (with the TX/RX switch in both positions)
   - function key LEDs
   - function keys
   - TX LED (go to Task 7)
   - BUSY LED (go to Task 10)
   - speaker and volume potentiometer (go to "Speaker or Volume Potentiometer Faulty" below).

3. Replace the UI board, if necessary.

Speaker or Volume Potentiometer Faulty

If the speaker functions only intermittently, the audio level is low or the audio level can not be changed, and connecting a spare UI board, cable and speaker has eliminated the receiver module as the source of the fault, carry out the steps below.

1. Connect a spare speaker to the original UI board and cable.

2. If there is still a fault, reconnect the original speaker and then disconnect the UI cable from the receiver module.

3. Check the continuity from the speaker connector PL2 to pin 17 (SPKR-) and pin 18 (SPKR+) of the UI cable. If there is a fault, replace the UI cable and retest. If there is still a fault replace the UI Board.

4. If there was no fault check the resistance between pins 10 (VOL WIP DC) and 6 (GND) of the UI cable varies linearly between 0 and 10kΩ. Then test the resistance between pin 10 (VOL WIP DC) and pin 14 (+3V3) varies linearly between 32 and 42kΩ.

5. If there is a fault, test the resistance between pins 1 and 3 of the volume potentiometer is about 10kΩ and the resistance between pin 1 and pin 2 varies linearly between about 0 and 10kΩ.

6. If there was a fault, replace the volume potentiometer RV1. If not replace the UI cable and retest. If there is still a fault replace the UI board.

7. Confirm the removal of the fault.

Task 13 — Check the Fans

These tests assume that Tasks 1 to 5 were successful.

1. Set the jumpers on the SI board to match the settings below.
   - J206 = 2-3

2. Check that both fans turn on. If they do, go to Step 4. If one fan turns on, go to Step 3. If no fans turn on, check that there is 12V between pins 1 and 2 of J201. If not, replace the SI board.

3. Check for 12VDC between pins 1 and 2 on all connectors on the fan power board. If there is, replace the faulty fan(s). If not, replace the fan power board.

4. Set the jumpers on the SI board to match the settings below.
   - J206 = 1-2
   - J207 = 1-2

5. With the transmitter module connected to a suitable load, check that fans activate only when the TX Key line is activated.

6. If they do, go to Step 7. If not, replace the SI board.

7. Set the jumpers on the SI board to match the settings below.
   - J206 = 1-2
   - J207 = 2-3

8. Attempt to turn RV200 clockwise until the fans turn on and then anticlockwise until fans just turn off. If successful, go to Step 10. If not, go to Step 9

9. Connect a spare temperature sensor and repeat Step 8. If the fault is still present, replace the SI board.

10. Use a hot air tool to gently heat the temperature sensor. If the fans turn on, the temperature sensor and fans are operating correctly. Reset RV200 to the correct turn-on temperature. If the fans do not turn on, replace the temperature sensor and repeat from Step 8.

8.2 Final Tasks

List of Tasks

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

- repair
- final test
- final administration

Task 1 — Repair

The fault diagnosis will have resulted in the repair or replacement of a module. This section describes the steps after completion of the fault diagnosis:

1. If the transmitter or receiver module has been replaced, level-1 service centres should return the faulty module to the nearest ASC, and level-2 service centres should return the module to the ISC, if deemed necessary. Supply details of the fault and, if applicable, the attempted repair. (The replacement module will have been factory-calibrated.) Go to Step 5.

2. If the transmitter or receiver module has **not** been replaced, but was repaired then replace any cans removed and reinstall the module into the base station.

3. Reconnect the module to the test equipment and re-calibrate the module. Refer to the online help of the calibration application.

4. Use the programming and application to load the programming and files read or set-up in "Initial Tasks".

5. Use the calibration application to load the calibration files read or set-up in "Initial Tasks".

Note If the base station had to be reprogrammed with a **default** programming file, the following additional actions are required:

- If the base station 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 base station 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 base station appropriately.
- If the fault was with the customer's data file, the customer needs to be informed of this and the changes that were made.

6. Test the base station as described in "Final Test" on page 124. It may be necessary to also carry out the audio level adjustments as described in the installation and operation manual.

Task 2 — Final Test

Test the base station to confirm that it is fully functional again. The recommended tests are listed in Figure 8.1. 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 3 — Final Administration

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

If the base station 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 centres should return the faulty base station to the nearest ASC, and level-2 service centres should return the base station to the ISC. Supply details of the Customer, the fault and, if applicable, the attempted repair.

Figure 8.1 Test sheet

TB7000 base stations

TB7100 Base Station - Single Channel Test Sheet

Product Code: TBB__________-_________-________

Serial Number: __________________

Job Number: ___________________ **Quantity:** ______/_______

Test Set-up Details	
Test Equipment	HP8920
Test Equipment S/N	ID _ _ _ _
Programming App version	
Rx Configuration file	
Tx Configuration file	

Module details	Product code	DB Version	Serial number	F/W version	H/W version
RX Board					
TX Board					
SI Board					
UI Board					
Power Supply					

Channel		RX Frequency	Sensitivity (W/B) (12dB SINAD <-115 dBm) De-Emph, Balanced O/P	TX Frequency	Deviation @ TD (W/B Limit =3 ±0.25 kHz) Pre-Emph, Balanced I/P	Tx Power (-13)= 21-32W (-15H)= 33-50W (-15B1)= 42-65W
		MHz	dBm	MHz	KHz	W

Balanced output Level (Limit = -10dBm ±0.5 dB)	Z_L=600 :@ *TL*	_____ dBm	Audio Distortion (<2%) Balanced @ TD	_____ %
Balanced output audio distortion (< 2.0%) @ *TL*		_____ %		
			Limiter (4.0 kHz to 5.0 kHz) Max. deviation	_____ kHz
Un-balanced output Level (Limit = 1 ±0.15 V_{PP})	Z_L> 10k :@ *TL*	_____ Vp-p	(20dB step balanced input) @ audio freq.	_____ kHz
Mute Gating (RF levels)	Mute	_____ dBm	Unbalanced deviation @ TD, 1Vpp I/P level (3 kHz ±0.25 kHz)	_____ kHz
	Un-mute	_____ dBm		
			Microphone deviation (whistle) (4.4 kHz ±0.4 kHz)	_____ kHz

Power Supply

Input power type used for tests: DC AC

AC o DC o AC changeover operation: OK

Comments

Software Features (SFE) =

Rack frame

RX_GATE & TX_KEY	OK
Speaker operation	OK
Fan operation @40°C (J222=1.40V)	OK
F1, F2, F3, F4 keys	OK
LED functionality	OK
Digital I/P & LCD RX	OK
Digital I/P & LCD TX	OK
Digital O/P RX	OK
Digital O/P TX	OK
TOI (Links w401, w402); Default =disabled	OK

Test sheet completed by: ________________________ Date: ____________

Assembled by: ________________________ Date: ____________

Notes

1. All performance tests are at TF unless otherwise stated.
2. Software settings on next page used to generate test results.

Test tone settings

TL RF Test Level = -70dBm, 1kHz modulation @ 60% max deviation.

TD RF Test Deviation = 60% max, 1kHz test tone.

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9 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 82. 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 9.1**) 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 9.1**). 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 123.

4. Press the ON/OFF key. If the radio powers up, return to "Initial Tasks" on page 111. If it does not, go to Step 5.

5. Check the digital power-up signal at pin 5 of **IC602** (see **Figure 9.1**); 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 10.4), 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 111. If it does not, go to Step 9.

9. With the probe of the multimeter on pin 5 of **IC602** (see Figure 9.1), 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 123.

Figure 9.1 Important components of the power-supply circuitry (bottom side), including 3.3V regulator IC602

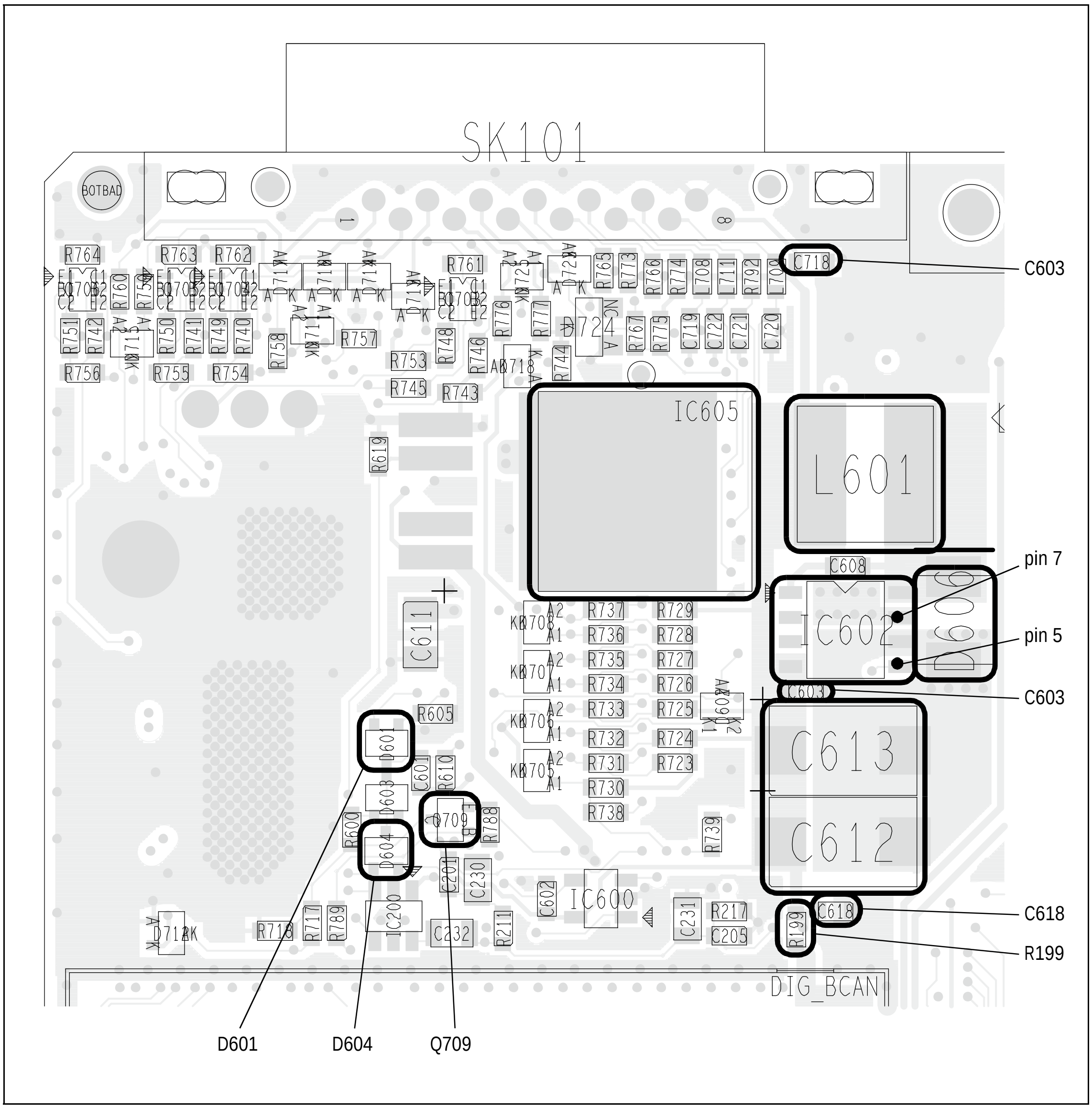
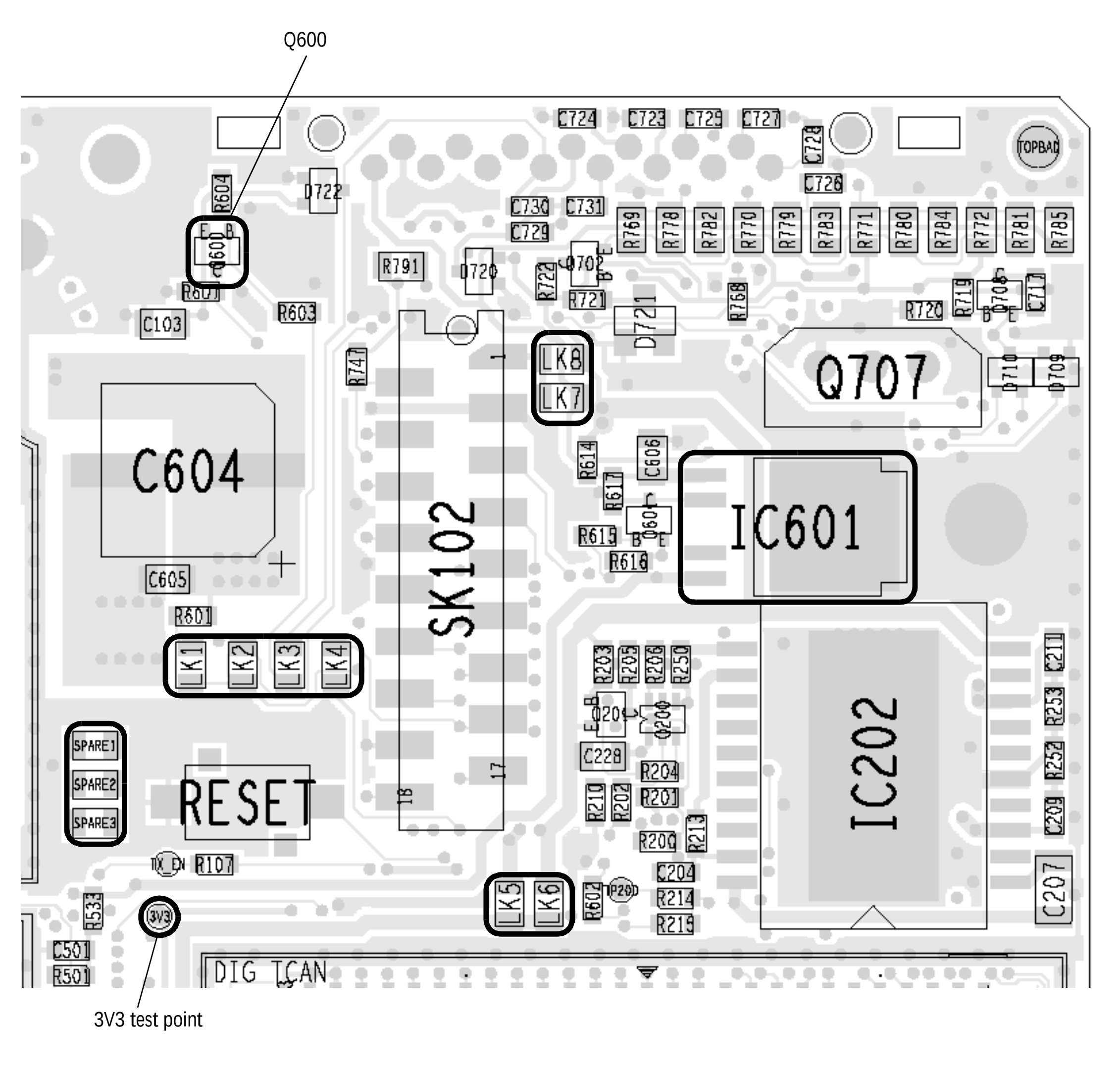


Figure 9.2 Important components of the power-supply circuitry (top side), including 9V regulator IC601



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 9.2**). The voltage is 3.3V 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 123. If the voltage is not correct, go to Step 2.

2. Disconnect the 13.8V supply at the power connector. Remove **R199** (see **Figure 9.1**). 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 123. 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 9.1**) 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 123.

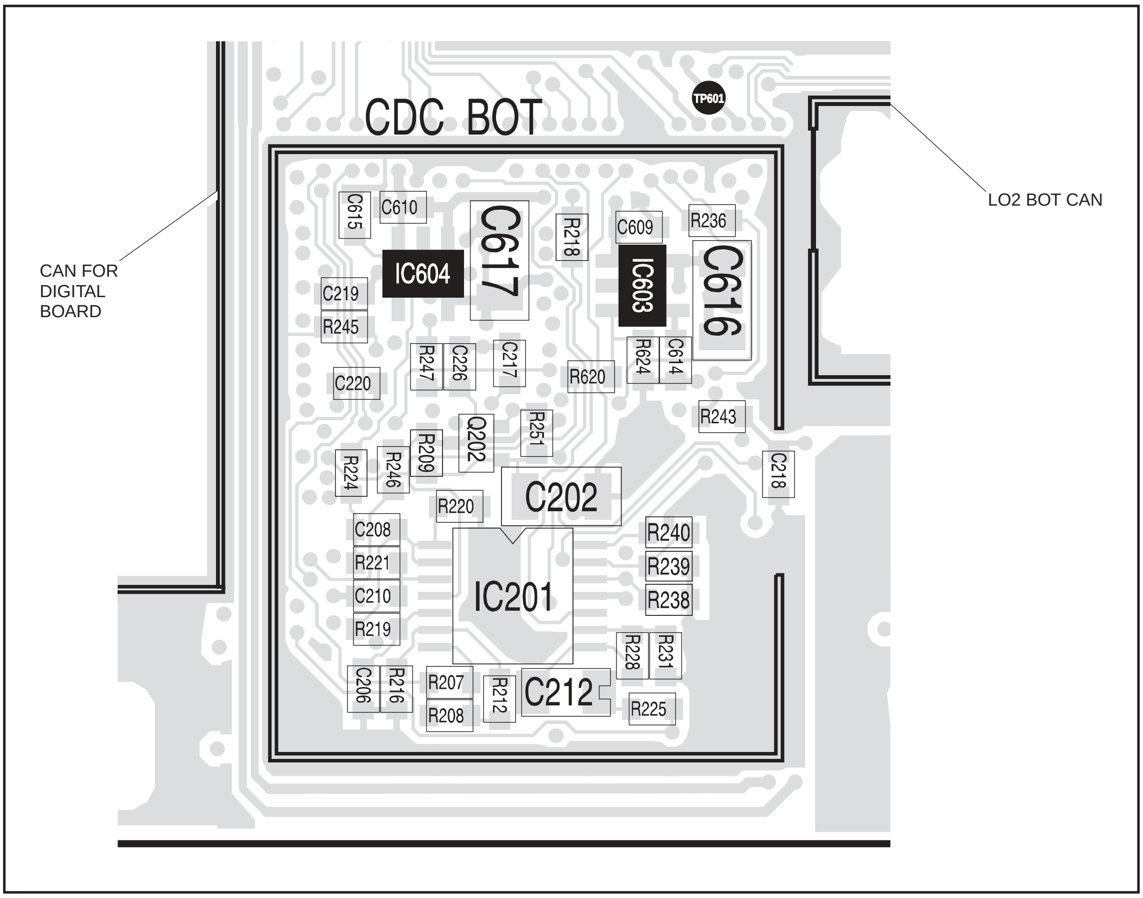
6. Reconnect the 13.8V supply. Press the ON/OFF key. If the radio powers up, return to "Initial Tasks" on page 111. If the radio fails to power up, disconnect the 13.8V supply and go to Step 7.

7. Measure the resistance of **L601** (see **Figure 9.1**). 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 111. 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 9.3**). 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 9.1**). Resolder **IC603** and **IC604** in position (see **Figure 9.3**). Reconnect the 13.8V supply and press the ON/OFF key. If the radio powers up, return to "Initial Tasks" on page 111. If the radio fails to power up, the repair failed; replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 9.3 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 111. 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 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

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 9.1. 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 9.2** and **Table 9.1**). 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 111. If it has not, go to Task 5.

Table 9.1 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 9.2**). Check the power-up signal at pin 5 of **IC602** (see **Figure 9.1**) 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 9.2**). 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 9.1**) 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 9.1**) 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 9.2**). 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 9.1**) 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 9.1**), via **Q600** (see **Figure 9.2**), 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 9.2**). 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 9.1**) 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 9.1**) 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 123. If the fault could not be found or repairs failed, replace the main-board assembly and go to "Final Tasks" on page 123.

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 9.1**) 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 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 123.

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 9.1**), and check **C715** at the internal-options connector (see **Figure 10.2**).

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 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

10 Interface Fault Finding

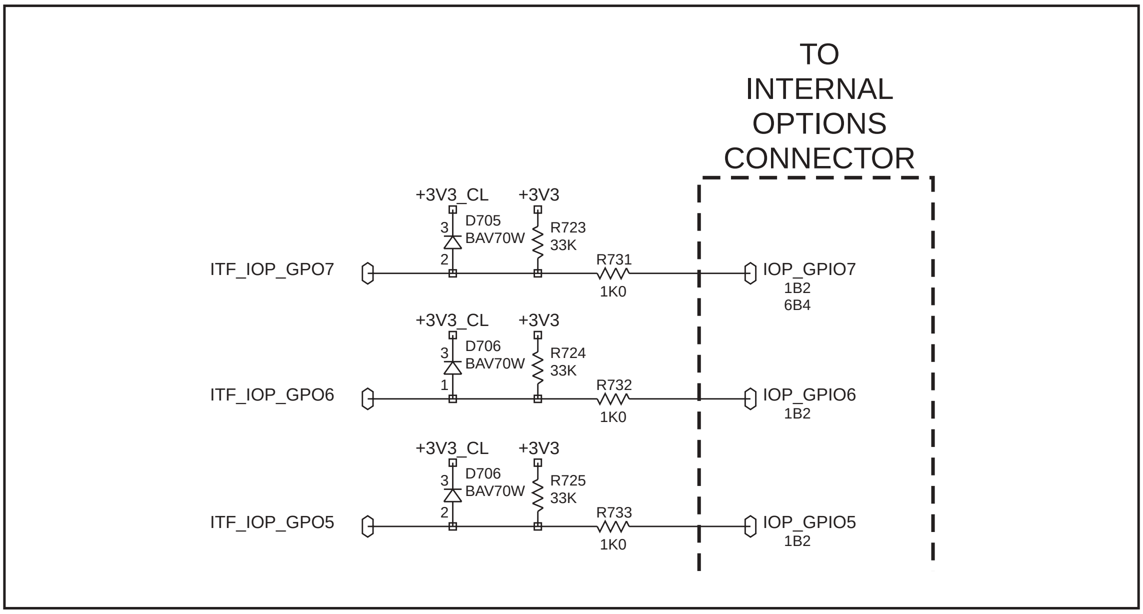
Introduction

This section covers the diagnosis of faults involving signals output from or input to the radio's internal circuitry via the user interface, 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 10.1, 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 10.1 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 10.3 to Figure 10.4 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 10.2 Components of the interface circuitry (top side near the CDC TOP and IF TOP cans)

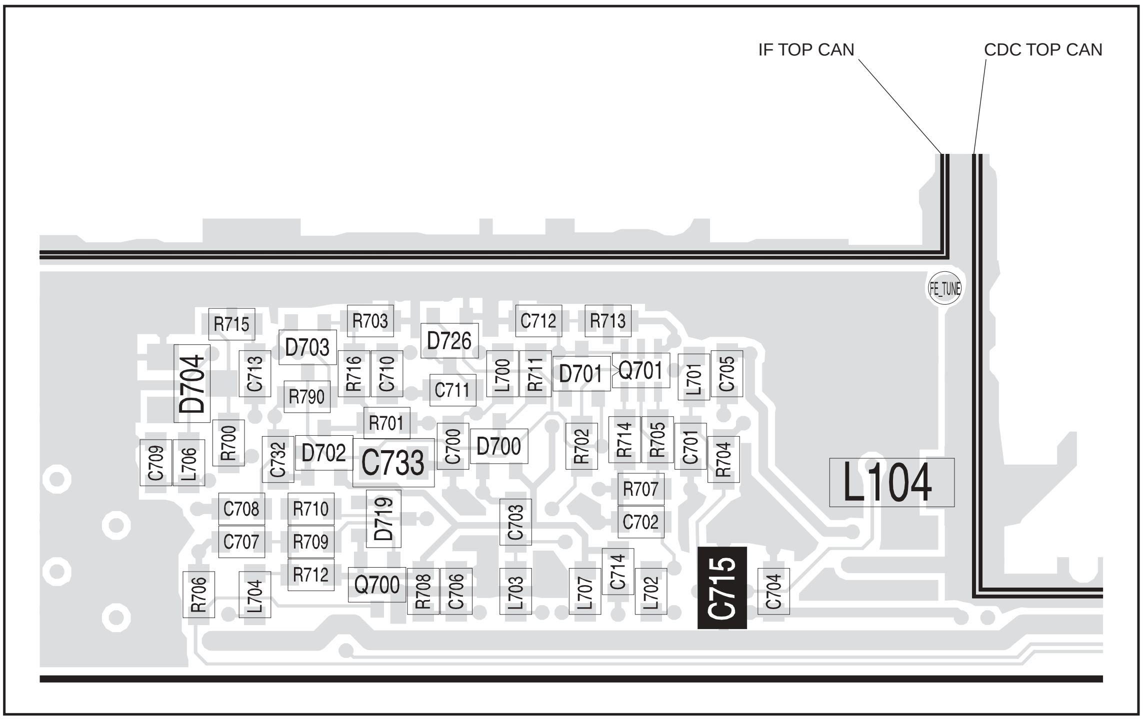
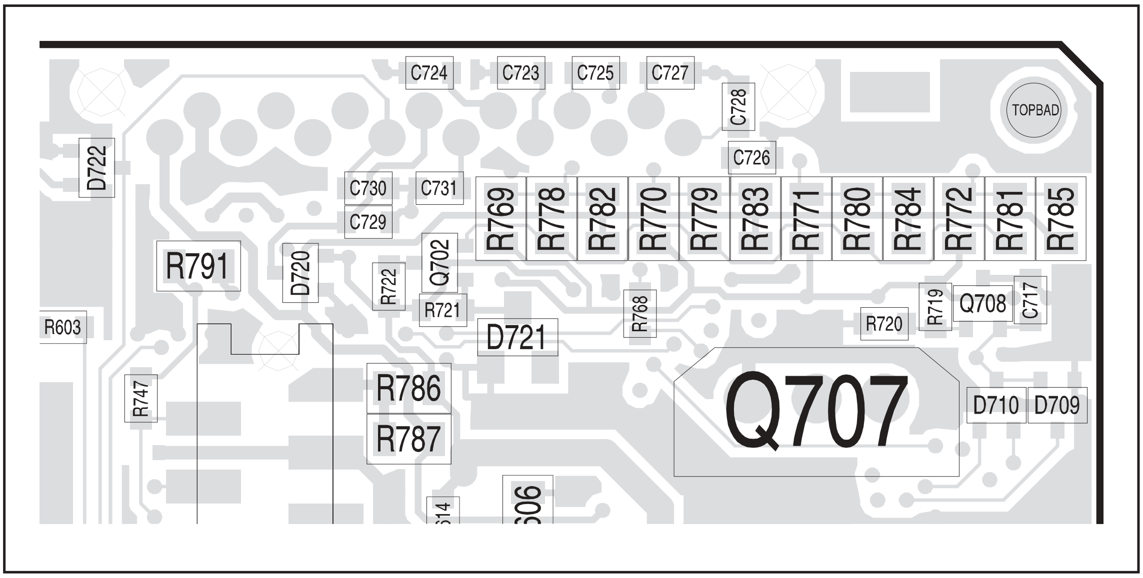


Figure 10.3 Components of the interface circuitry (top side at the corner)



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.

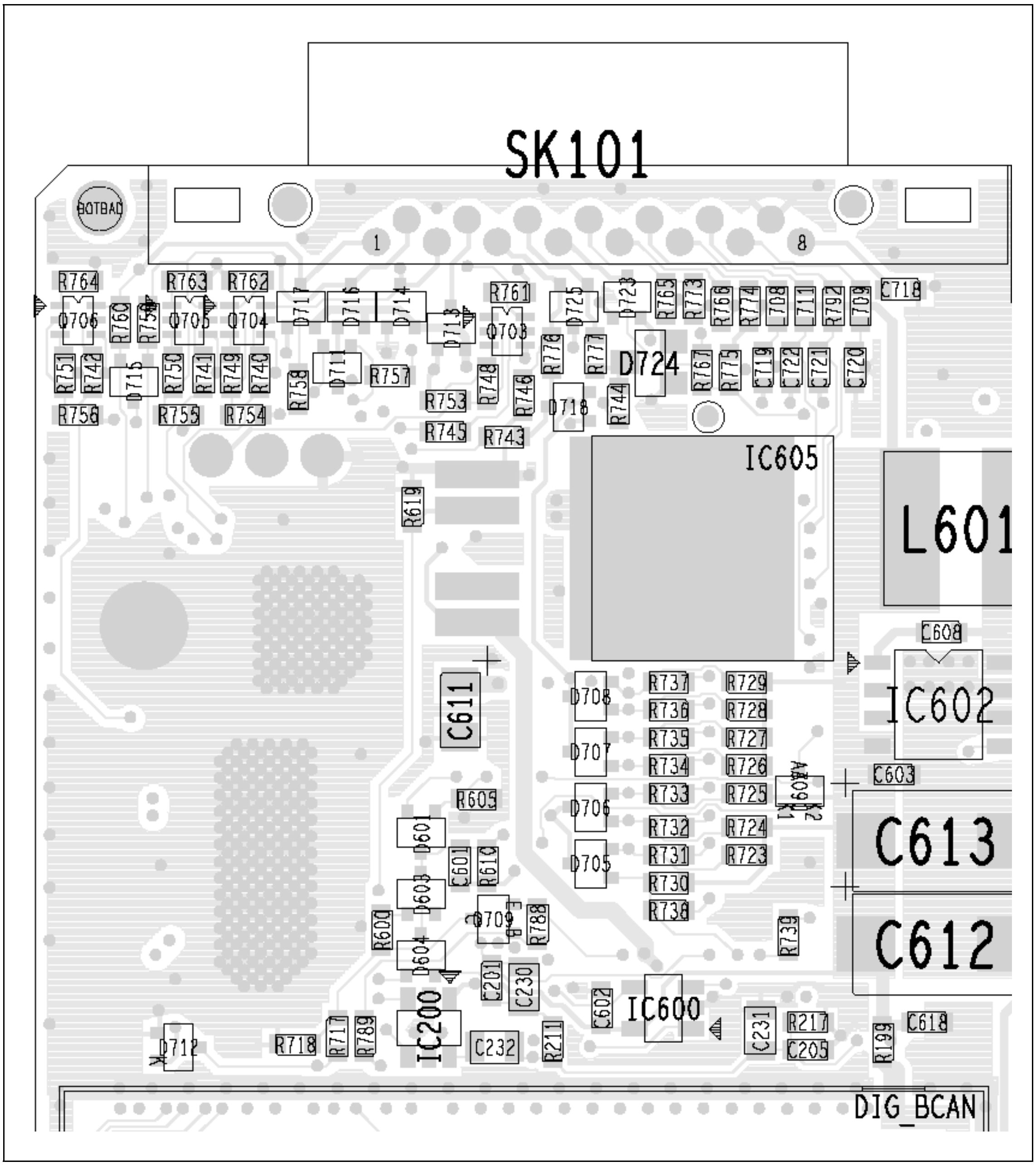
2. If the expected signal is present, there might be no fault on that line or there could be an intermittent fault. Subject the radio to mild mechanical shock or vibration, or to a temperature change. This might expose any intermittent contact, in which case go to Step 3.

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 127 and "CODEC and Audio Fault Finding" on page 343 respectively. If the digital board is suspect, replace the main-board assembly and go to "Final Tasks" on page 123.

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 123. If the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 10.4 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 127 and "CODEC and Audio Fault Finding" on page 343, respectively. If the digital board is suspect, replace the main-board assembly and go to "Final Tasks" on page 123.

8. The fault lies in the filtering, basic processing, or connector for the line under test. Re-solder components or replace faulty components as necessary. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 123.

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.

11 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 11.1. Full details of the commands are given in "Computer-Controlled Test Mode (CCTM)" on page 91. 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 11.1 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

11.1 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 147.

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 "Introduction" on page 11.

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 four 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 189.

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 eight 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 123. 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 147 (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 123. If the calibration failed, go to Step 8 (UHF radios) or "Power Supplies" on page 147 (VHF radios).

8. Program the radio with the maximum 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 161 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 147.

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 189.

5. If the lock status is *011*, the synthesizer is suspect, although the power supplies are functioning correctly; go to "Loop Filter" on page 161.

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 161. 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 201.

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 123.

11.2 Power Supplies

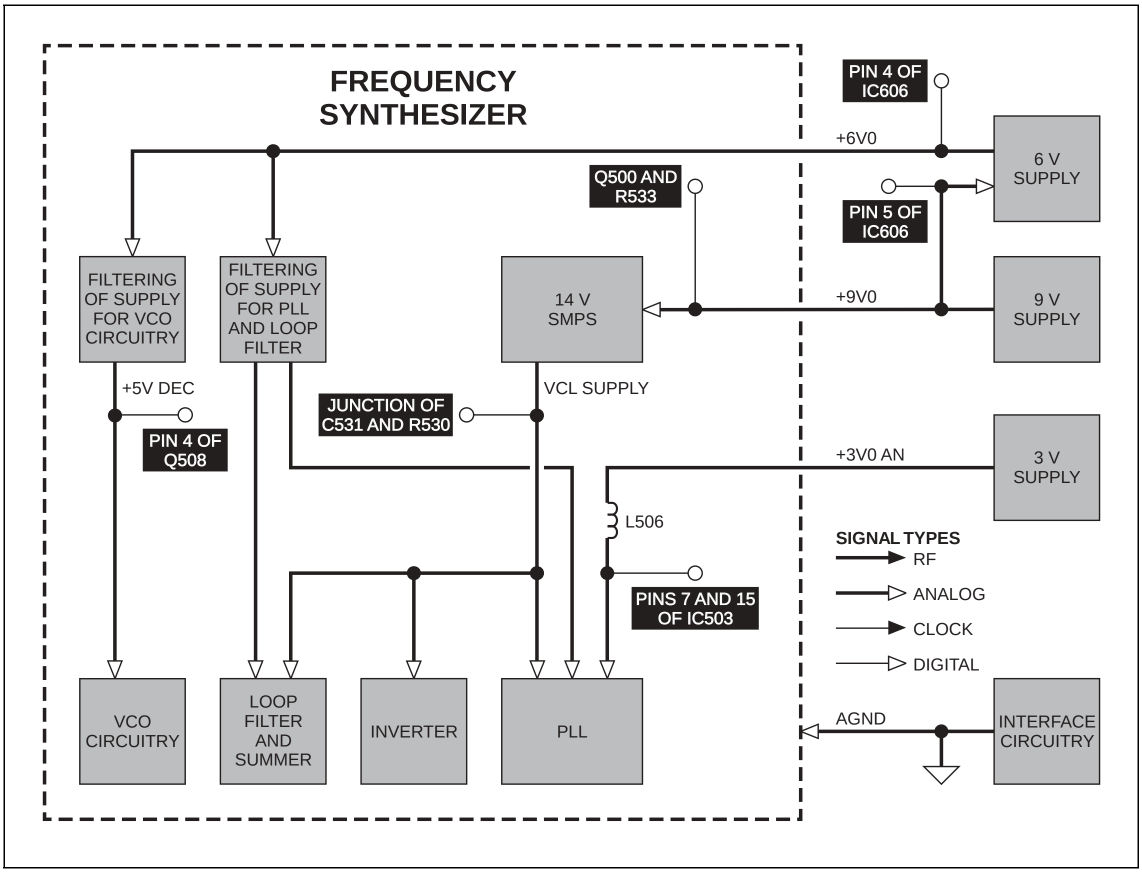
Introduction

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 11.1.

Figure 11.1 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 11.2**).

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 11.3**).

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 132.

7. Remove the FCL TOP can and check the SMPS circuit based on **Q500**, **Q502** and **L502** (see **Figure 11.3**).

   Remove the SYN BOT can and check **IC504** and **IC505** for shorts (see **Figure 11.4**); 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 123. If the repair failed or no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 11.2 Synthesizer circuitry under the SYN TOP can and the 6 V regulator IC606 (top side)

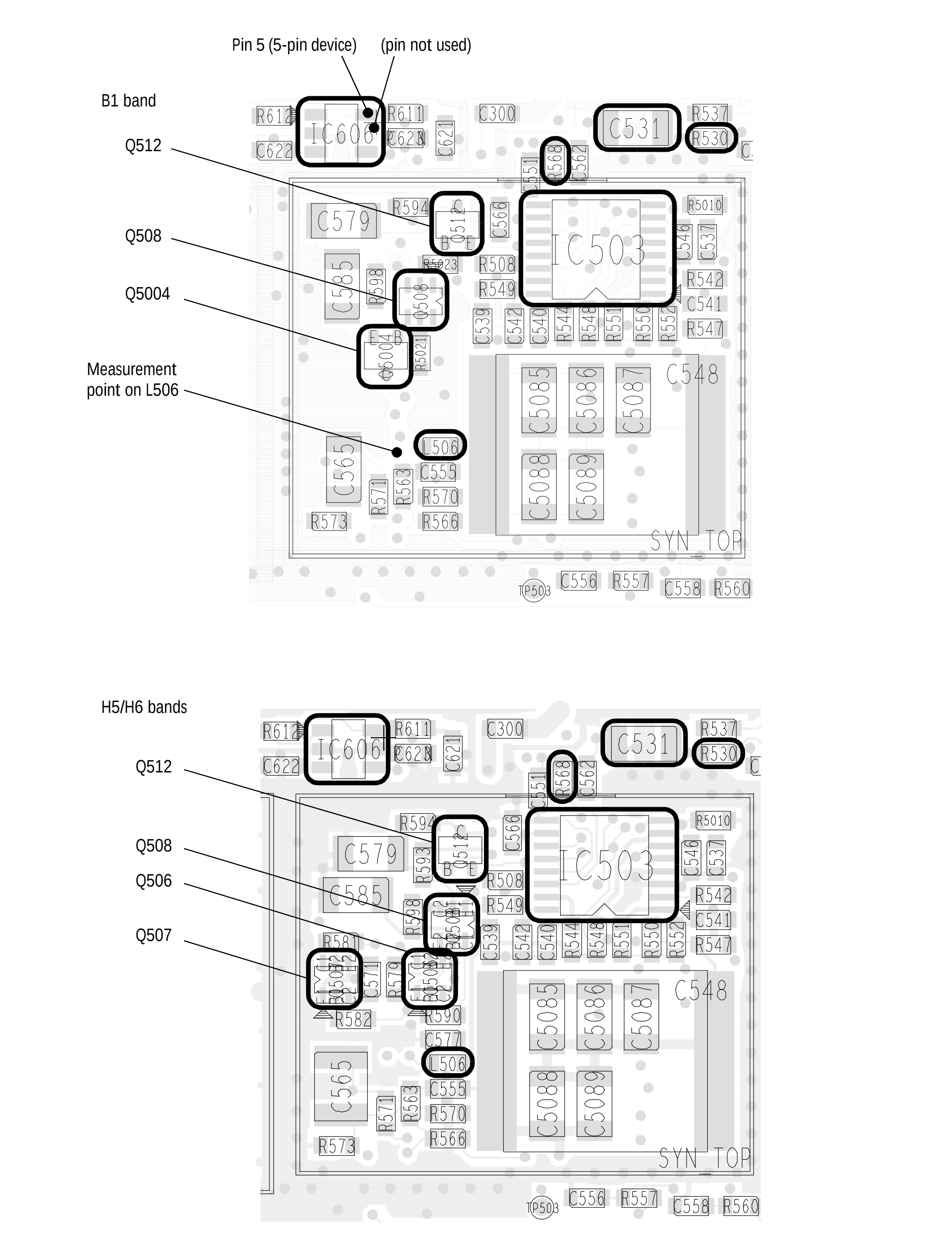
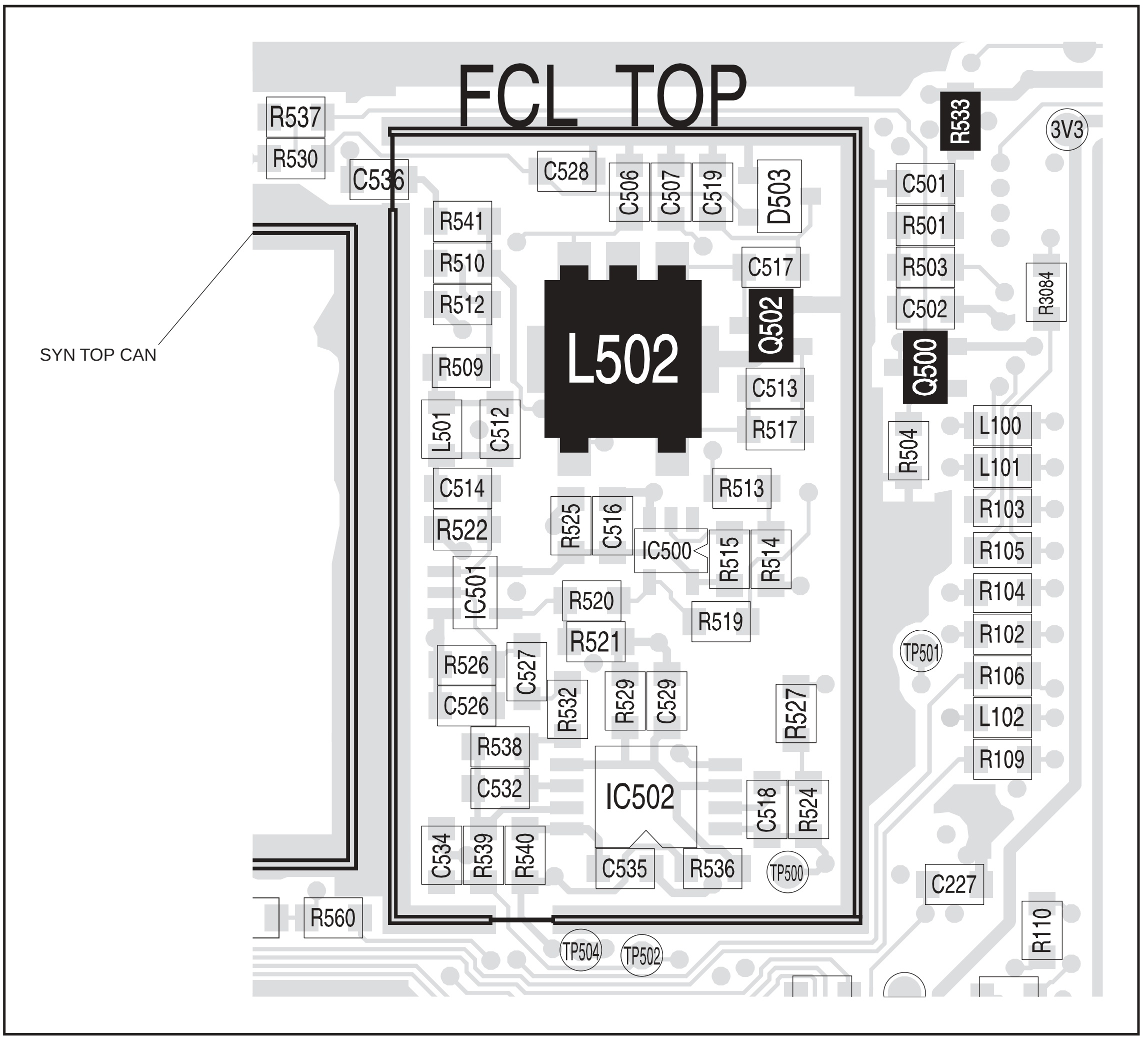


Figure 11.3 Synthesizer circuitry under the FCL TOP can (top side)



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 11.2**).

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 11.2**).

pin 5 of IC606: 9.0 ± 0.3V DC

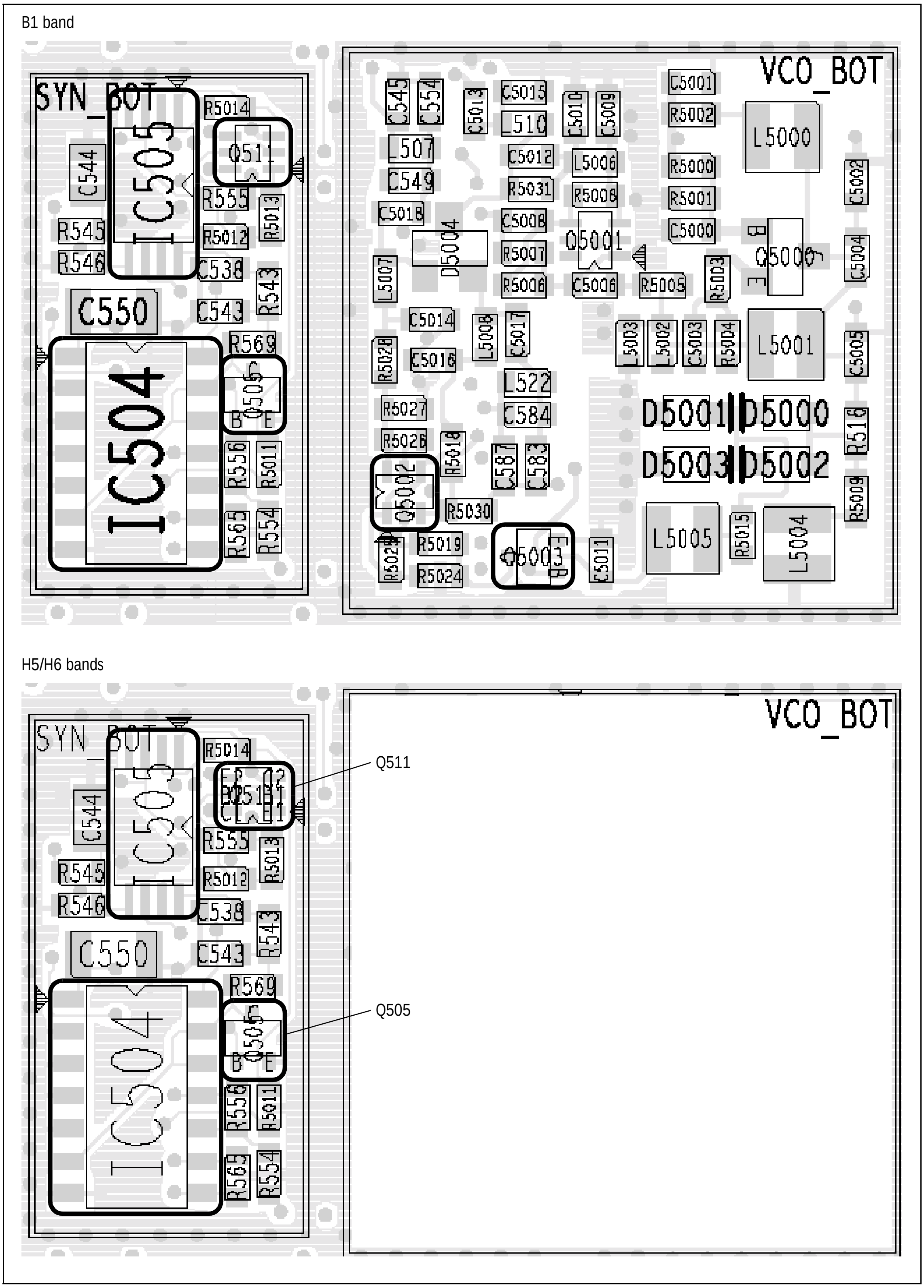
3. If the voltage is correct, go to Step 4. If it is not, the 9V regulator **IC601** is suspect; go to Task 3 of "Power Supply Fault Finding" on page 132.

4. If the input to the regulator **IC606** is correct but not the output, check IC606 (see **Figure 11.2**) 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 11.2**); 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 123. If the repair failed or no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 11.4 Synthesizer circuitry under the SYN BOT and VCO BOT cans (bottom side)



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 11.2**).

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 11.2**). 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 11.2**). Remove the VCO BOT can and check the transmit-receive switch based on **Q5002** and **Q5003** (see **Figure 11.4**). 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 123. If the repair failed or no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 123.

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 11.2**).

pins 7 and 15 of IC503: 2.9 ± 0.3V DC

2. If the voltage is correct, go to “Phase-locked Loop” on page 155. If it is not, go to Step 3.

3. Check the supply at **L506** (see **Figure 11.2**). 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 132.

5. Check the components in the path from **L506** to **IC503**. Also check IC503; if necessary, replace IC503 (see **Figure 11.2**).

6. If a fault is found, repair the circuit, confirm the removal of the fault, and go to “Final Tasks” on page 123. If the repair failed or no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 123.

11.3 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 11.5.

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 11.2**).

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 11.2**) 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 123. If the repair failed or no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 11.5 Test and measurement points for the synthesizer PLL and loop filter

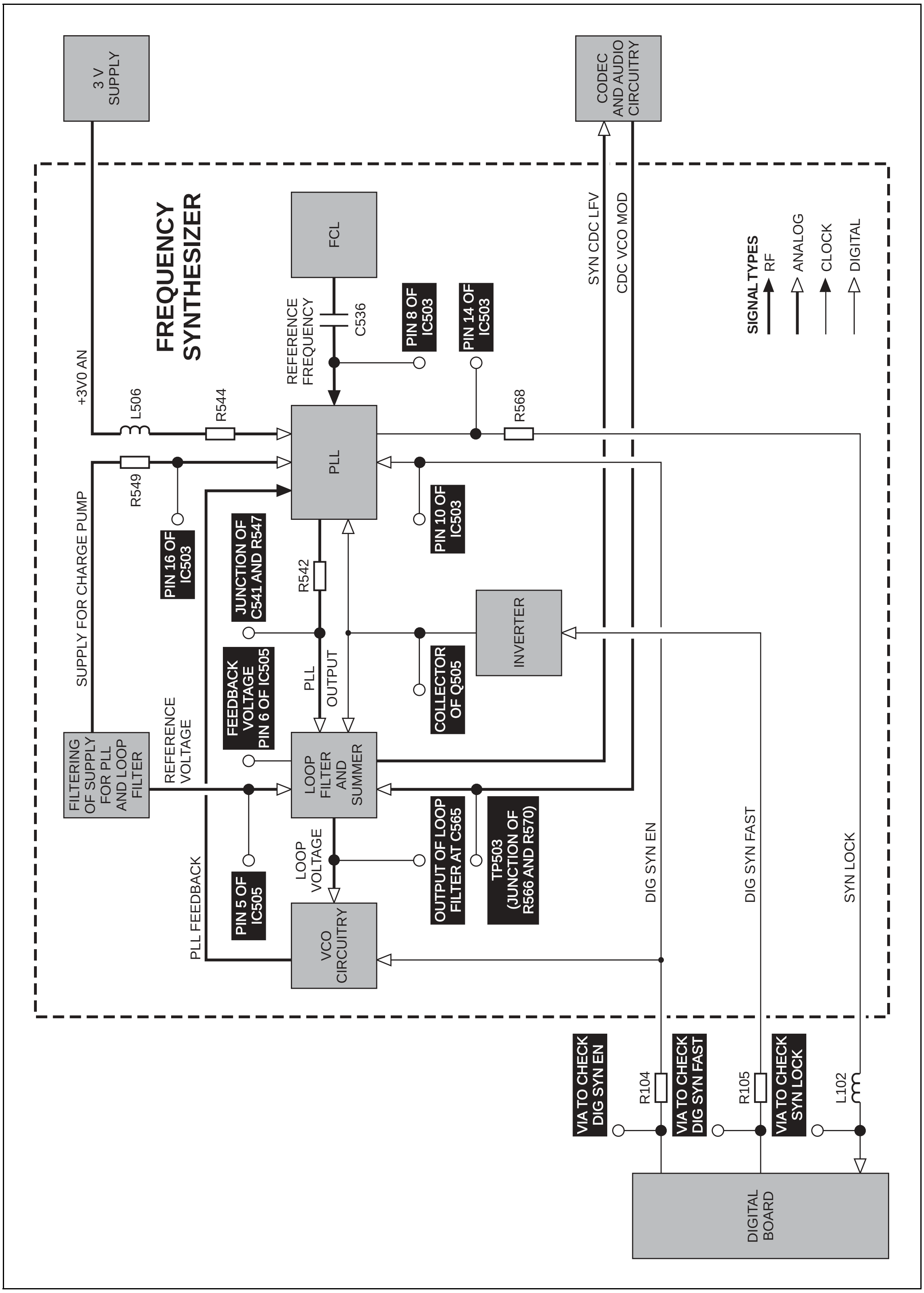
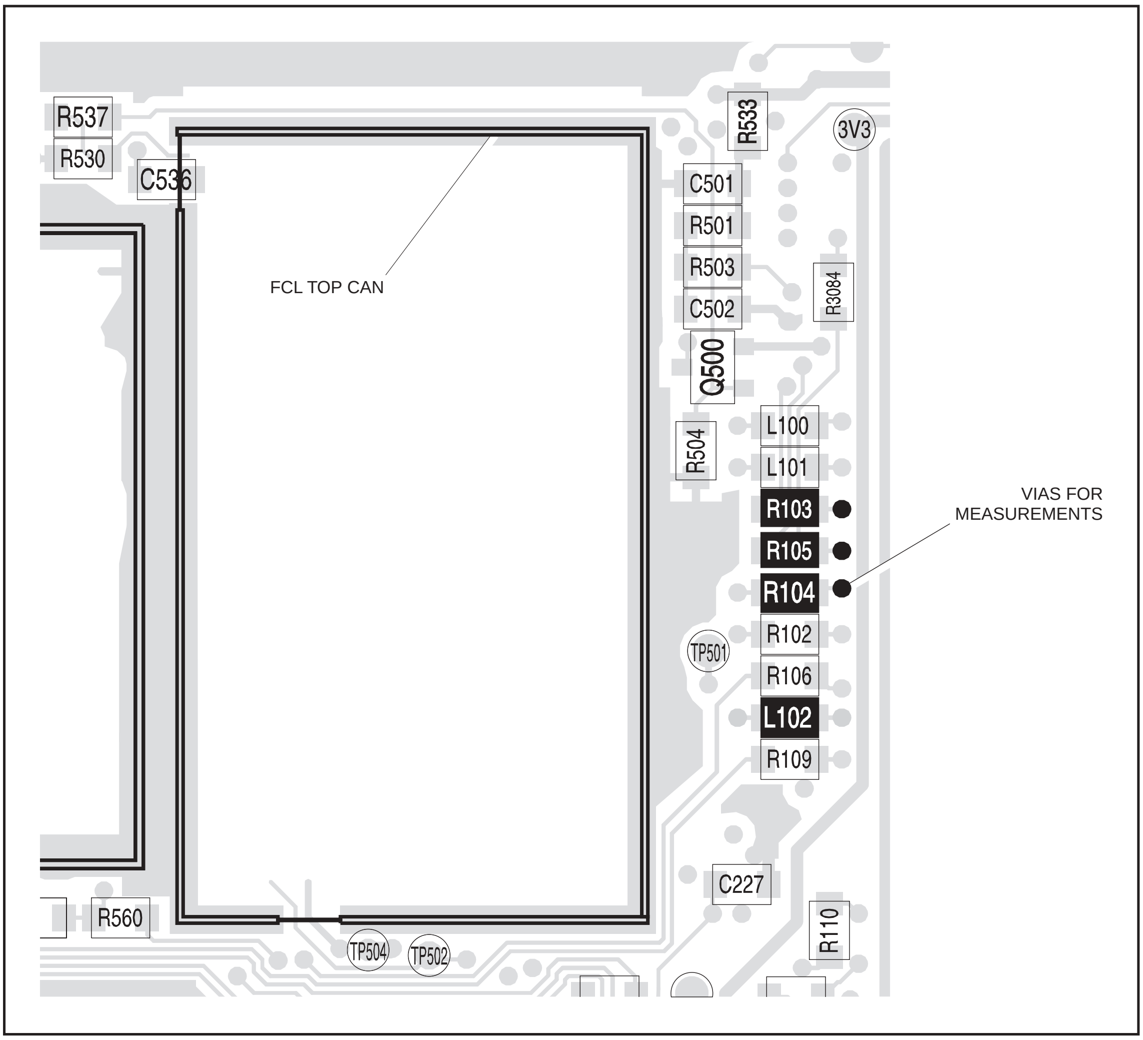


Figure 11.6 Components between the digital board and the frequency synthesizer



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 11.2**).

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 11.2**). Replace IC503 if it is suspect.

4. Determine if the fault has been removed. If it has, go to "Final Tasks" on page 123. If it has not, the FCL is suspect; go to "Power Supply for FCL" on page 189.

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 11.2**). 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 11.6**) 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 11.6**) 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 11.6**) 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 123. 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 11.6**), and check for continuity between pin 10 of IC503 (see **Figure 11.2**) 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 123. If the repair failed or no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 123.

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 11.2**). 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

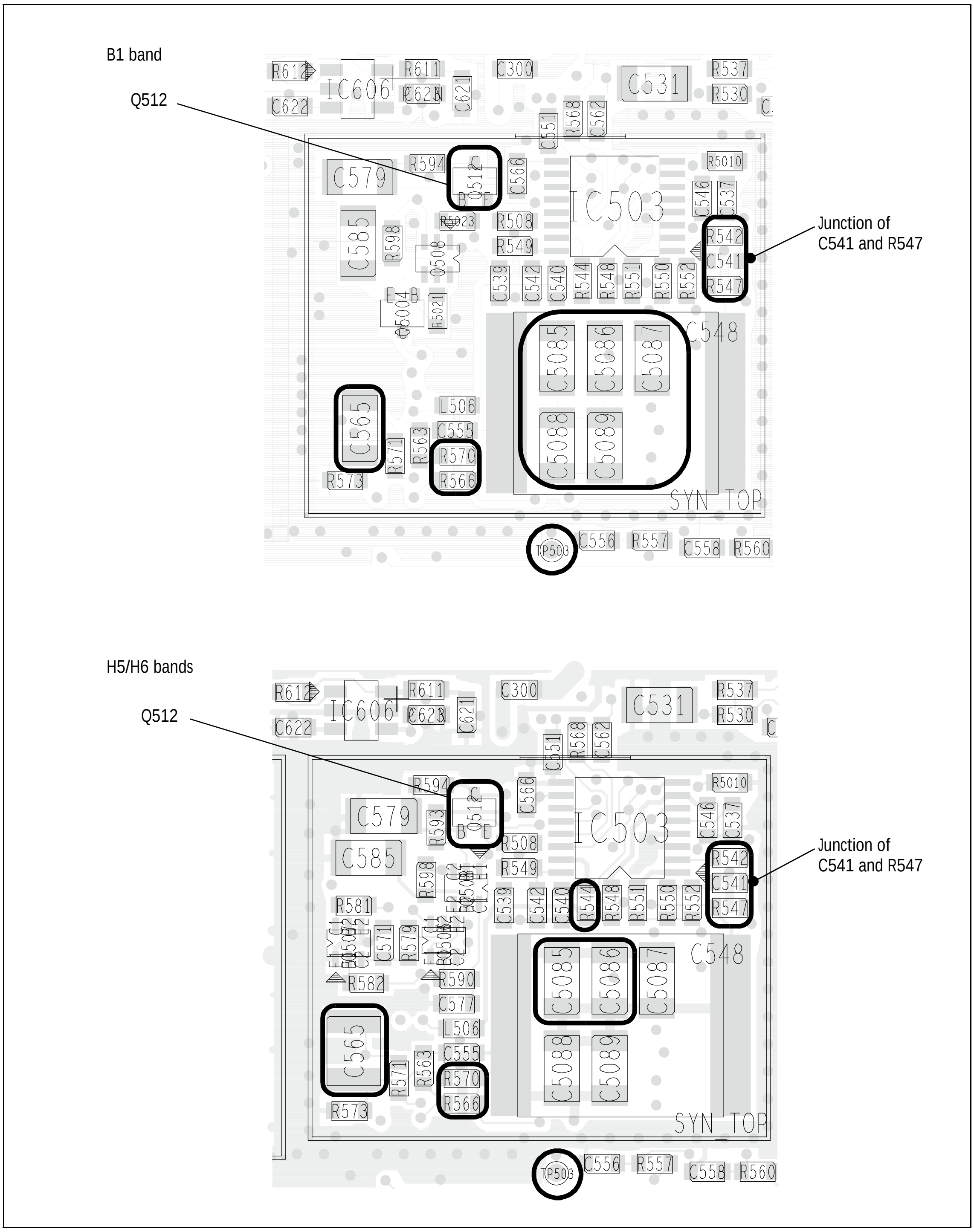
3. If the voltage measured in Step 2 is correct, go to "Loop Filter" on page 161. If it is not, go to Step 4.

4. Check for continuity between pin 14 of **IC503** and the digital board via **R568** (see **Figure 11.2**) and **L102** (see **Figure 11.6**).

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 123.

6. Repair the fault. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed or no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 11.7 Synthesizer circuitry under the SYN TOP can (top side)



11.4 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 11.5.

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 11.7**).

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 11.7**):

   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 11.7**):

   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 180.

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 166.

   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 175.

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 11.4**). 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 11.7**).

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 123. If it is not, or if no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 123.

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 11.4**). 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 11.7**) and go to Task 15.

3. Check **IC504**, **IC505**, **Q511** (see **Figure 11.4**), **C5085** to **C5089** (B1 band, see **Figure 11.7**) or **C5085** and **C5086** (H5, H6 bands see **Figure 11.7**), 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 11.7**).

5. If the feedback voltage is now correct, go to "Final Tasks" on page 123. If it is not, or if no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 123.

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 11.4**). 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 11.4**). 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 11.6**).

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 11.6**). 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 11.6**). 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 123.

12. Check and resolder **R105** in position (see **Figure 11.6**), and check for continuity between the collector of **Q505** (see **Figure 11.4**) 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 123. If they are not, or if no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 123.

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 11.7**). The oscilloscope should show a DC level less than 3.0 V 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 11.4**), **C5085** to **C5089** (B1 band, see **Figure 11.7**) or **C5085** and **C5086** (H5, H6 bands see **Figure 11.7**), and associated components. Conclude with Step 9.

4. Remove **R566** and **R570** (see **Figure 11.7**), 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 11.7**), and go to "CODEC and Audio Fault Finding" on page 343.

7. Resolder **R566** and **R570** in position (see **Figure 11.7**).

8. Check **IC504** (pins 6, 8, 9) (see **Figure 11.4**) 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 123. If they are not, or if no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 123.

11.5 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 11.2.) There are six aspects:

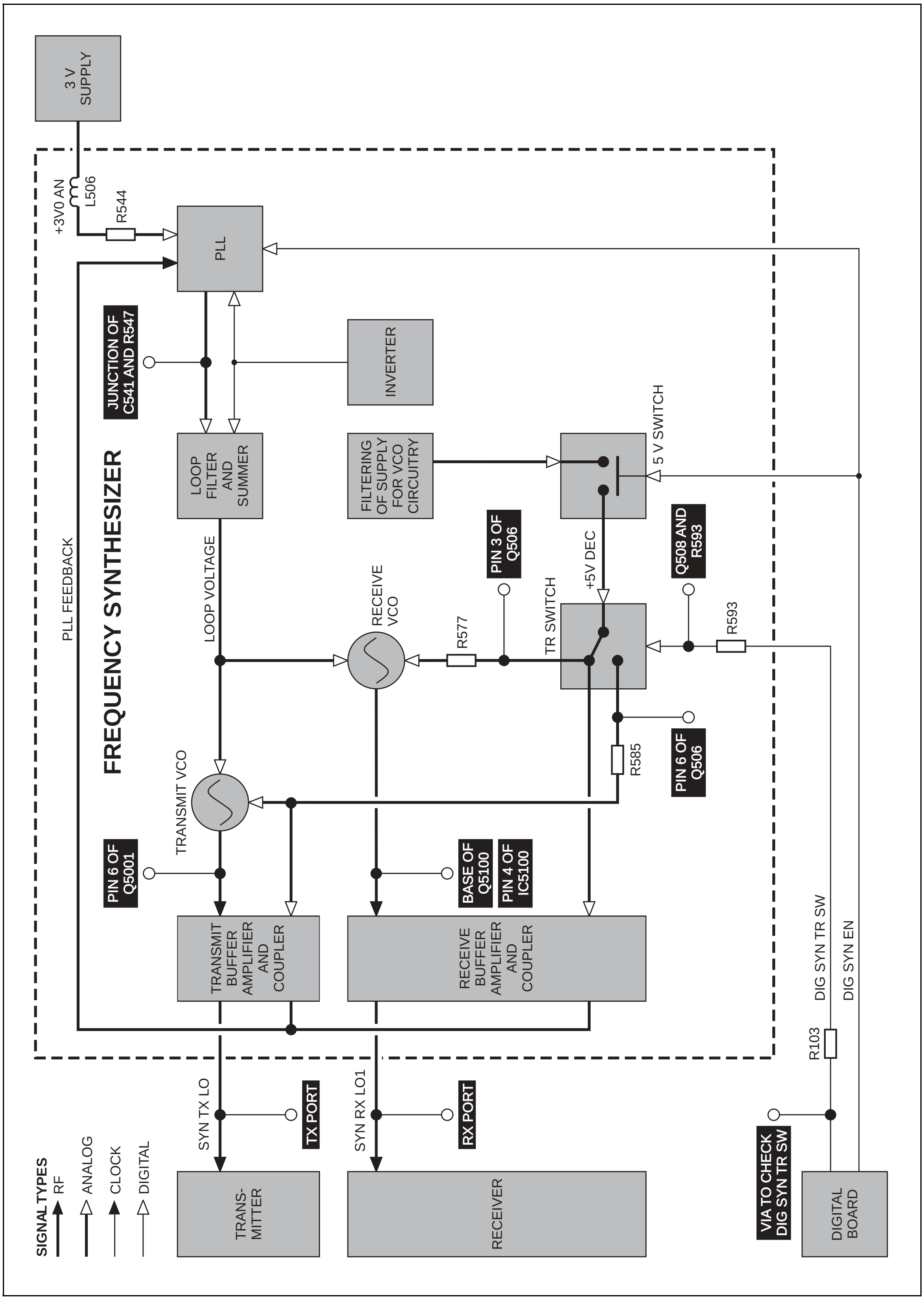
- Task 17: check receive VCO
- Task 18: repair PLL feedback
- Task 19: repair receive VCO
- Task 20: check switching to receive mode
- Task 21: repair switching network
- Task 22: check receive buffer amplifier

The measurement points for diagnosing faults in the VCO and related circuitry are summarized in Figure 11.8.

Table 11.2 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 11.8 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 11.9.

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 11.9**):

   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 11.2)

   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 11.2**.

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 11.9**):

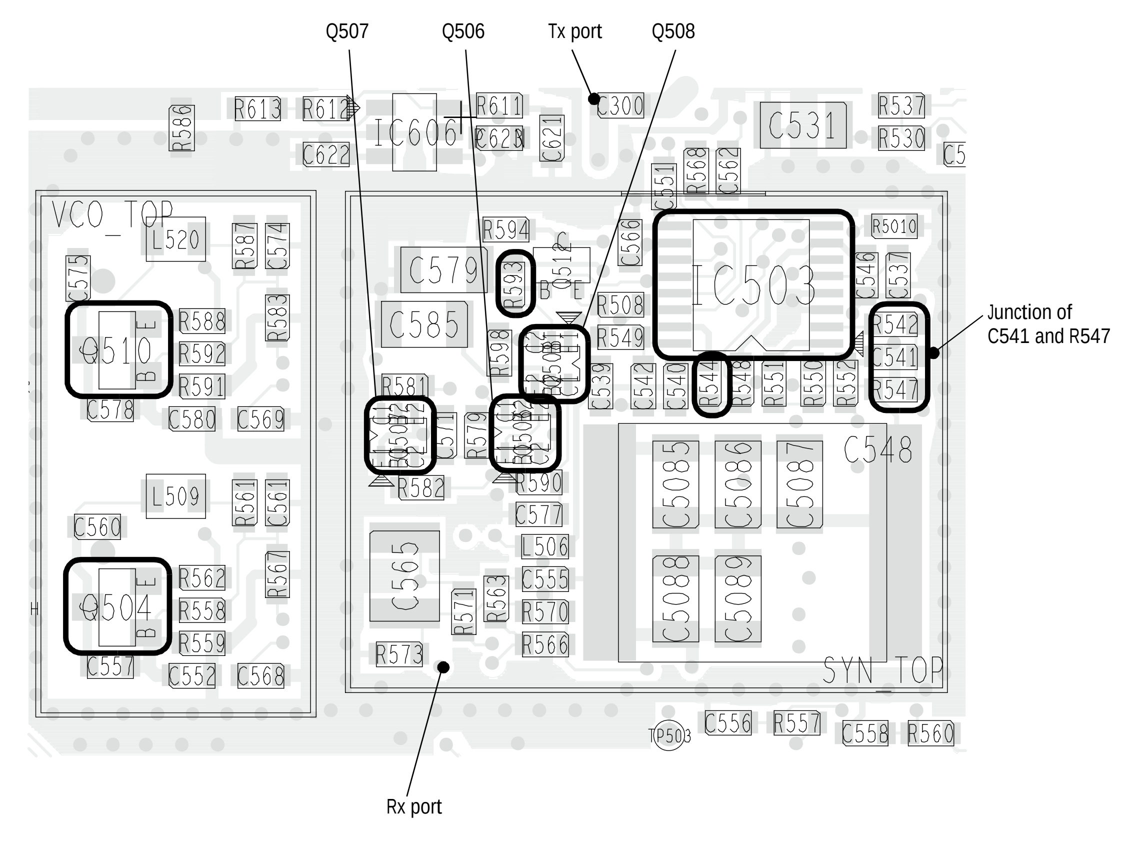
   While holding the probe on the RX port, use the tweezers to momentarily apply 3 V DC to the junction; do not touch the board with your hand, and do not allow the tweezers to touch any cans when you remove them. The frequency should change to:

RX port: minimum receive frequency (see Table 11.2)

   The loop filter will hold its output steady at about 0V. This should result in a frequency equal to the minimum given in **Table 11.2**.

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 11.9 Synthesizer circuitry under the SYN TOP and VCO TOP cans (UHF radio, top side)

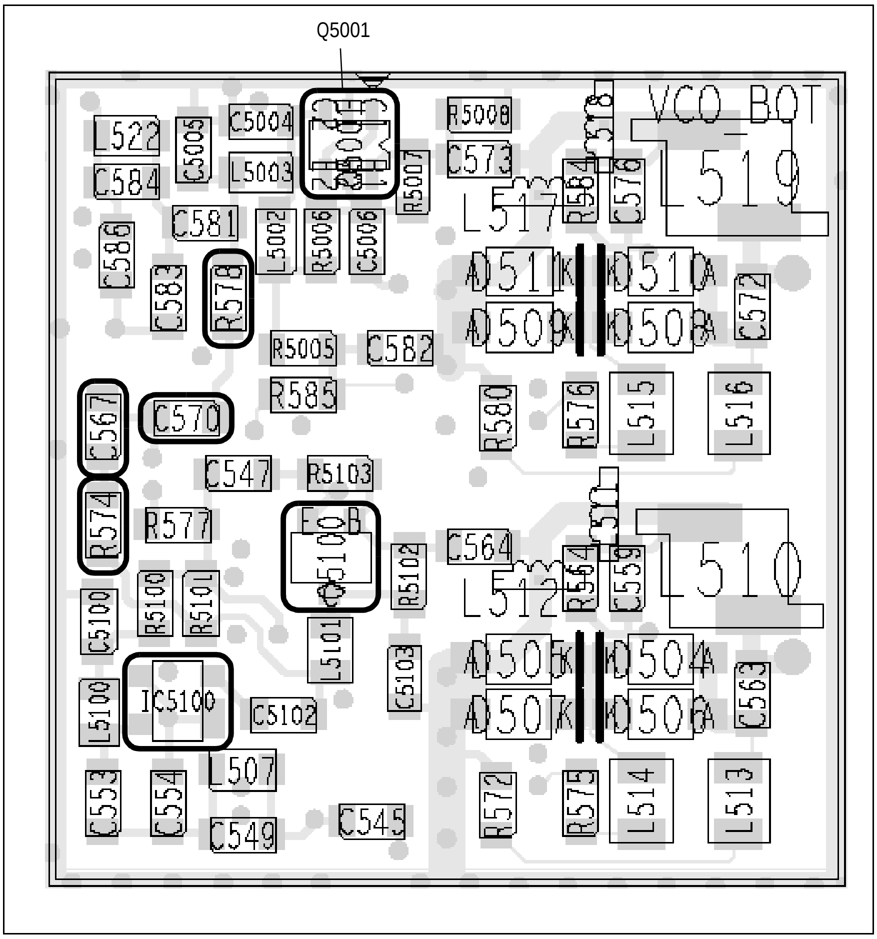


Task 18 — Repair PLL feedback

If both the minimum and maximum receive frequencies are correct, the PLL feedback is suspect.

1. Resolder **R542** in position (see **Figure 11.9**).
2. Remove the VCO BOT can.
3. Replace the components **C567**, **R574** (see **Figure 11.10**) and **IC503** (see **Figure 11.9**).
4. Also check the second stage of the receive buffer amplifier based on **IC5100** (see **Figure 11.10**). Repair any fault.
5. Confirm that the fault in the radio has been removed. If it has, go to “Final Tasks” on page 123. If it has not, replace the main-board assembly and go to “Final Tasks” on page 123.

Figure 11.10 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 11.9**).

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 11.9**), and go to “Final Tasks” on page 123. If they are still not correct, go to Step 6.

6. Resolder **R542** in position (see **Figure 11.9**). Replace the main-board assembly and go to “Final Tasks” on page 123.

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 11.9**).
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 11.9**). 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 11.9**).

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 11.6**) 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 11.6**).

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 11.6**), replace the main-board assembly and go to “Final Tasks” on page 123.

7. Check and resolder **R103** in position (see **Figure 11.6**), and check for continuity between **Q508** and the digital board via **R593** (see **Figure 11.9**) 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 123. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 123.

9. Check the circuitry for the transmit-receive and 5V switches (based on **Q506**, **Q507** and **Q508**) (see **Figure 11.9**).

10. If a fault is found, repair the circuit, confirm that the voltages are now correct, and go to “Final Tasks” on page 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 123.

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 11.10**).

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 11.9**). Conclude with Step 10.

9. Check the first buffer stage (based on **Q5100**) and the second stage (based on **IC5100**) (see **Figure 11.10**).

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 123. If they are not, or if no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 123.

11.6 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 11.3.) 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 11.8.

Table 11.3 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 11.9.

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 11.9**):

   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 11.3)

   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 11.3**.

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 11.9**):

   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 11.3)

   The loop filter will hold its output steady at about 0V. This should result in a frequency equal to the minimum given in **Table 11.3**.

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 11.9**).
2. Remove the VCO BOT can.
3. Replace the components **C570**, **R578** (see **Figure 11.10**) and **IC503** (see **Figure 11.9**).
4. Confirm that the fault in the radio has been removed. If it has, go to "Final Tasks" on page 123. If it has not, replace the main-board assembly and go to "Final Tasks" on page 123.

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 11.9**).
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 11.9**), and go to "Final Tasks" on page 123. If they are still not correct, go to Step 6.
6. Resolder **R542** in position (see **Figure 11.9**). Replace the main-board assembly and go to "Final Tasks" on page 123.

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 11.9**).

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 11.9**). 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 11.10**).

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 11.9**). Conclude with Step 10.

9. Check the buffer circuitry based on **Q5001** (see **Figure 11.10**).

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 123. If they are not, or if no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 123.

11.7 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 11.4. There are six aspects:

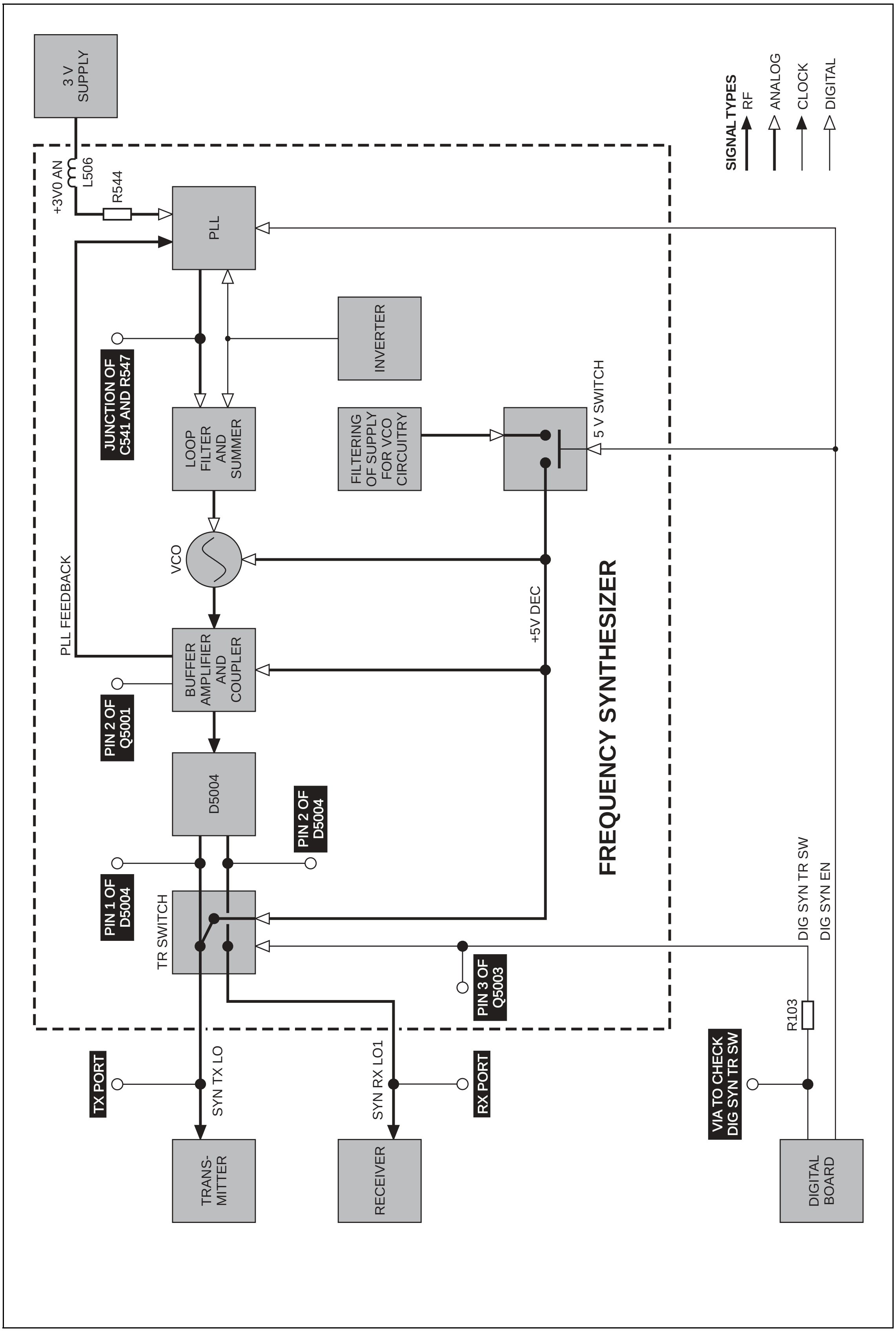
- Task 28: check VCO
- Task 29: repair PLL feedback
- Task 30: repair VCO
- Task 31: check transmit-receive switch
- Task 32: repair switching network
- Task 33: check buffer amplifier

The measurement points for diagnosing faults in the VCO and related circuitry are summarized in Figure 11.11.

Table 11.4 Minimum and maximum frequencies for the different VHF frequency bands

Frequency band	Frequency in MHz	
	Minimum	**Maximum**
B1	84 ± 5	200 ± 5

Figure 11.11 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 11.12. 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 11.12**):

   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 VCO frequency (see Table 11.4)

   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 11.4**.

3. If the maximum frequency measured in Step 2 is correct, go to Step 4. If it is incorrect, go to Task 30, but if no frequency at all is detected, go to Task 31.

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 11.9**):

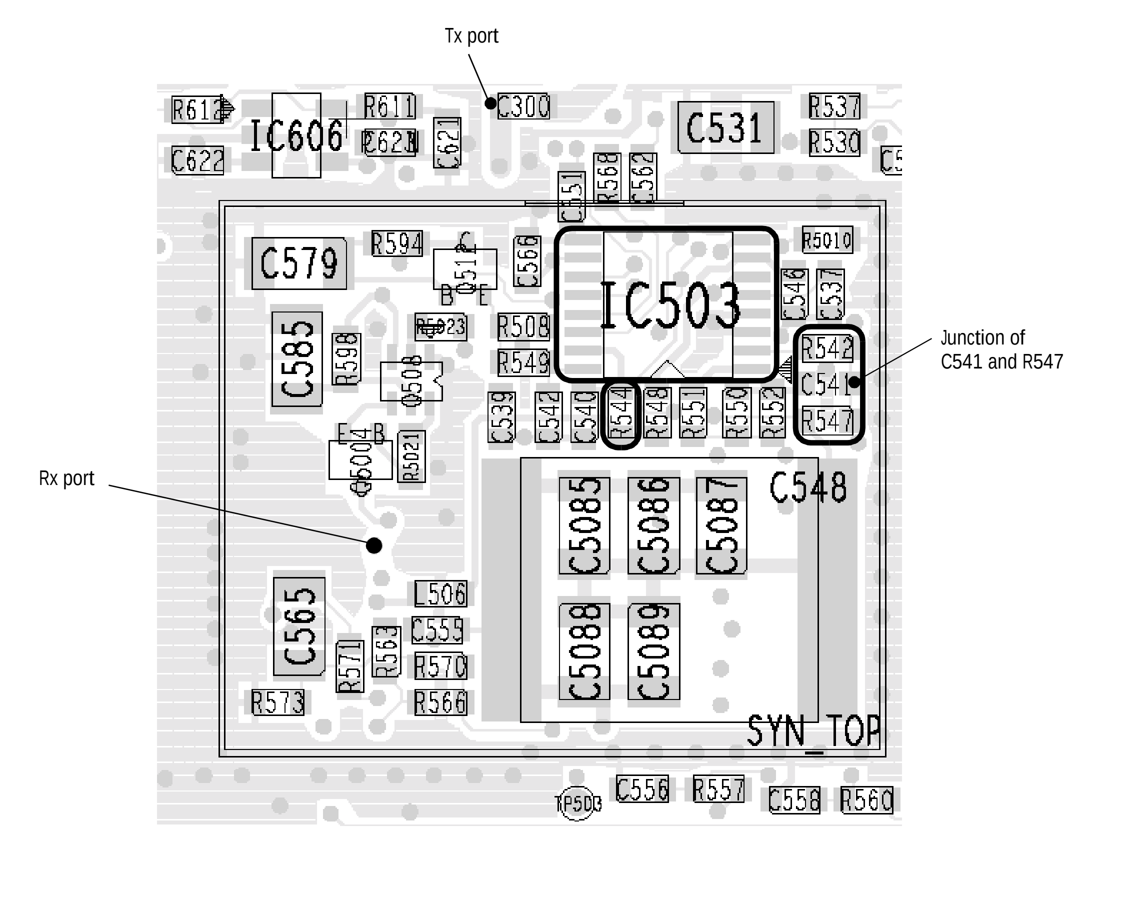
   While holding the probe on the RX port, use the tweezers to momentarily apply 3 V DC to the junction; do not touch the board with your hand, and do not allow the tweezers to touch any cans when you remove them. The frequency should change to:

RX port: minimum VCO frequency (see Table 11.4)

   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 11.4**.

6. If the minimum frequency measured in Step 5 is correct, go to Task 29. If it is incorrect, go to Task 30. If no frequency is detected, go to Task 31.

Figure 11.12 Synthesizer circuitry under the SYN TOP can (VHF radio, top side)

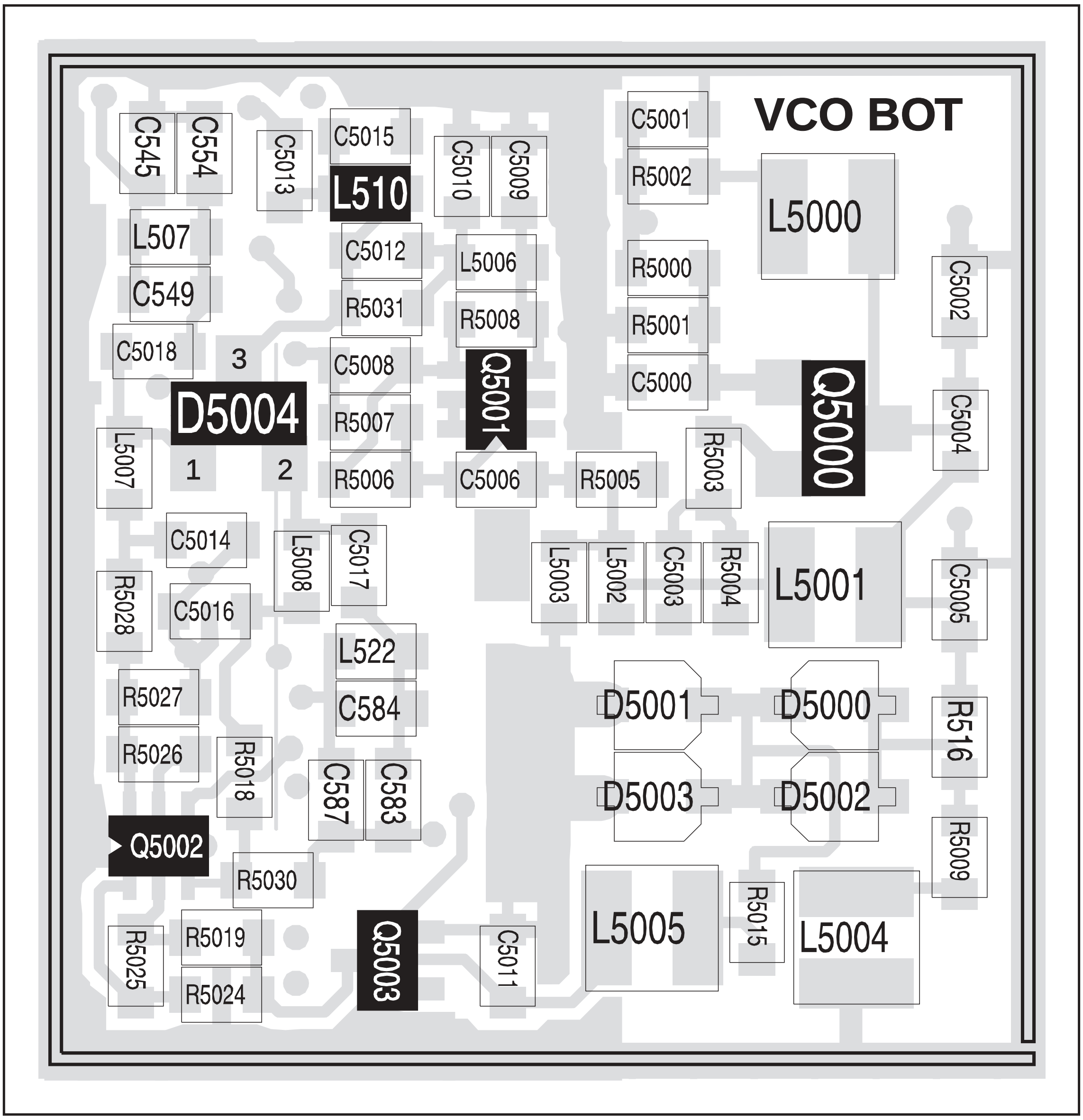


Task 29 — Repair PLL feedback

If both the maximum and minimum VCO frequencies are correct, then the PLL feedback is suspect.

1. Resolder **R542** in position (see **Figure 11.12**).
2. Remove the VCO BOT can.
3. Replace the components **L510** (see **Figure 11.13**) and **IC503** (see **Figure 11.12**).
4. Confirm that the fault in the radio has been removed. If it has, go to "Final Tasks" on page 123. If it has not, replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 11.13 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 11.13**).
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 11.12**), and go to "Final Tasks" on page 123. If they are still not correct, go to Step 7.
7. Resolder **R542** in position (see **Figure 11.12**). Replace the main-board assembly and go to "Final Tasks" on page 123.

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 11.12**).
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 11.13**). (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 11.13**). (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 11.13**).

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 11.6**) 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 11.6**).

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 11.6**), replace the main-board assembly and go to "Final Tasks" on page 123.

7. Check and resolder **R103** in position (see **Figure 11.6**), and check for continuity between **Q5003** (see **Figure 11.13**) 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 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

9. Check the circuitry for the transmit-receive and 5V switches (based on **Q5002** and **Q5003**) (see **Figure 11.13**).

10. If a fault is found, repair the circuit, confirm that the voltages are now correct, and go to "Final Tasks" on page 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 123.

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 11.13**). (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 11.13**).

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 11.13**). Conclude with Step 6.

5. The buffer amplifier is suspect. Check the buffer circuitry (based on **Q5001**) (see **Figure 11.13**).

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 123. If they are not, or if no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 123.

11.8 Power Supply for FCL

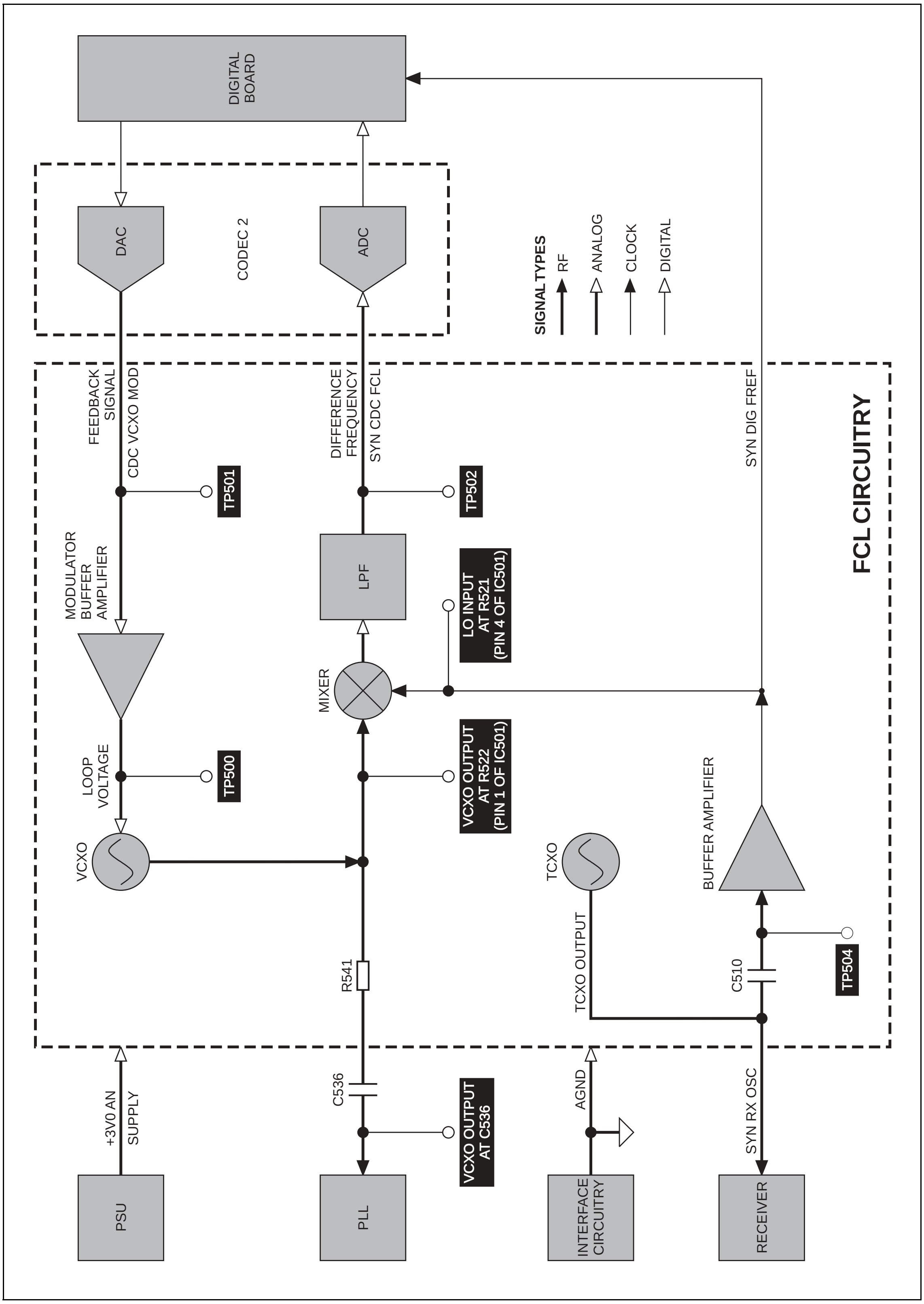
Fault-Diagnosis Stages

Indications of a fault in the FCL will have been revealed by the initial checks in "Initial Checks" on page 144 and the PLL checks in "Phase-locked Loop" on page 155. 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 11.14.

Figure 11.14 Test and measurement points the FCL circuitry



Task 34 — Power Supply

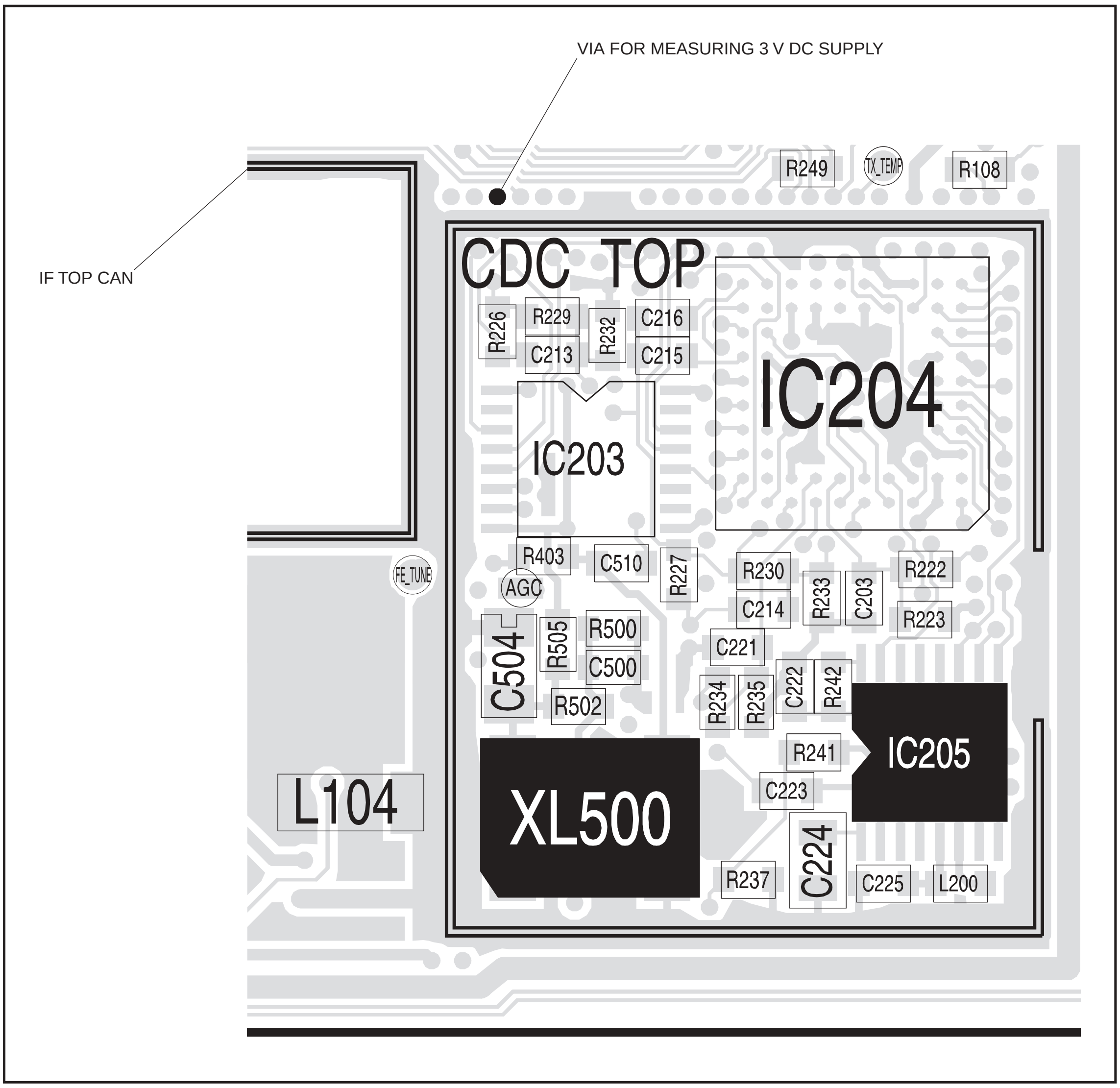
If the FCL is suspect, first check that the 3V power supply is not the cause of the fault.

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 11.15**. 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 192. If it is not, the 3V regulator **IC603** is suspect; go to Task 3 of "Power Supply Fault Finding" on page 132.

Figure 11.15 TCXO circuitry under the CDC TOP can



11.9 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 11.16**). The signal should be:

VCXO output at C536: sine wave of 1.1 ± 0.2 V_{pp} on 1.4 ± 0.2 V DC

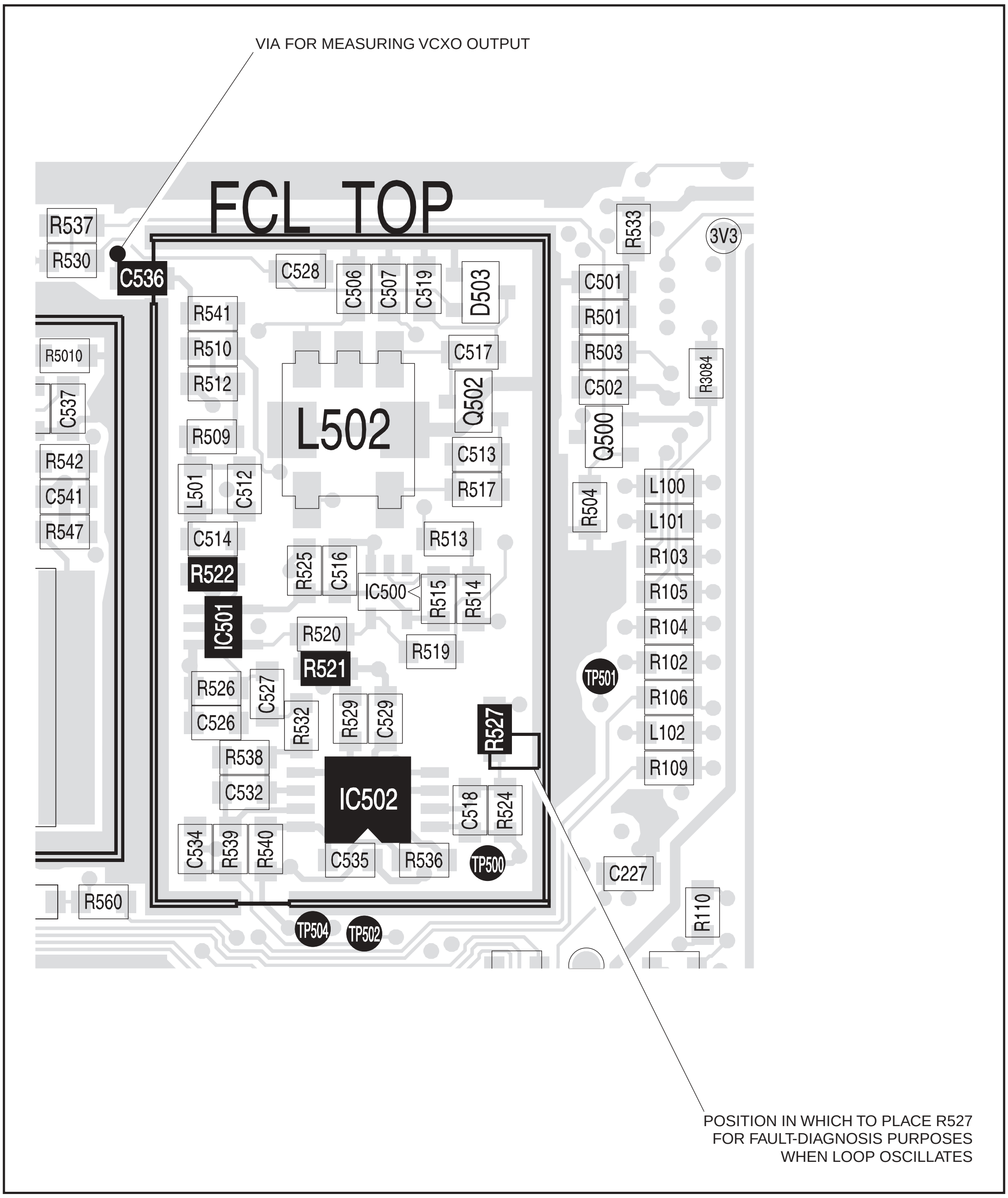
2. If the signal is correct, go to Task 36. If it is not, go to Step 3.

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 11.17**).

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 123.

Figure 11.16 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 11.16**). 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}

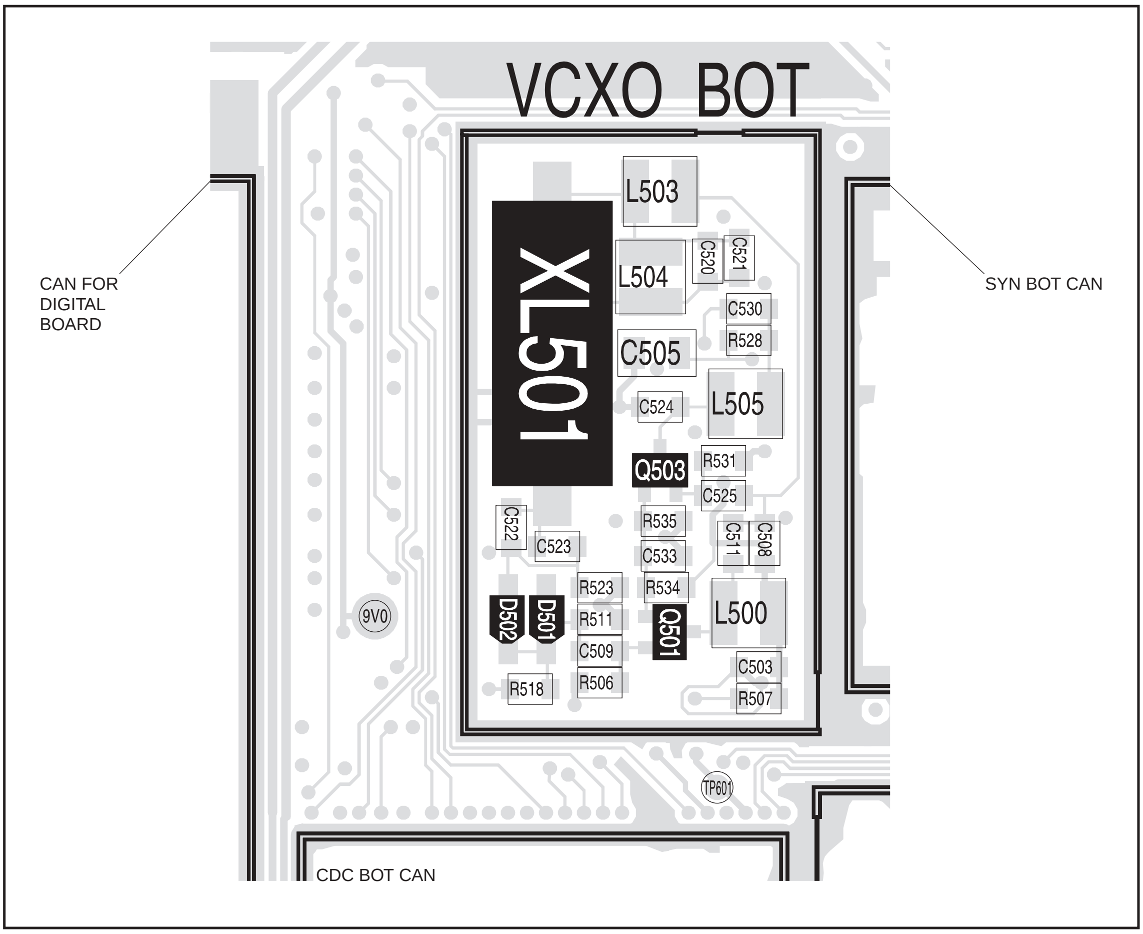
2. If the signal is correct, go to “Signals at TP501 and TP502” on page 195. If it is not, go to Step 3.

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 11.15**).

5. Confirm the removal of the fault and go to “Signals at TP501 and TP502” on page 195. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 123.

Figure 11.17 FCL circuitry under the VCXO BOT can



11.10 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 11.16**). 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 11.16**).

5. Repair the circuitry. Note that the TCXO input to the mixer at **R521** (pin 4 of IC501) (see **Figure 11.16**) 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 11.16**), 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 123.

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 11.16**), 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 198.

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 11.16**). 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 11.16**). 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 11.16**. 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 11.16**). 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 11.17**).

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 123.

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 11.16**). 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 ± 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 11.16**). Locate the fault.

4. Repair the circuitry. Note that the TCXO input to the mixer at **R521** (pin 4 of IC501) (see **Figure 11.16**) 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 11.16**), although noisy and difficult to measure, should be:

VCXO input at R522:	sine wave of 20 ± 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 11.16**, replace the main-board assembly and go to "Final Tasks" on page 123.

6. Resolder **R527** in its original position as shown in **Figure 11.16**.

7. Replace all cans.

8. Use the oscilloscope probe to check the difference frequency at the **TP502 test point** (see **Figure 11.16**). 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

9. If the signal is correct, the fault has been removed; go to "Final Tasks" on page 123. If the signal is not correct, the repair failed; replace the main-board assembly and go to "Final Tasks" on page 123.

11.11 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 11.16**):

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 123.

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 11.17**).
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 123.
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 123.

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 11.15**):
   - 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 11.15**).

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 123.

6. The CODEC 2 circuitry comprises **IC205** and associated components under the CDC TOP can (see **Figure 11.15**) as well as **R246** under the CDC BOT can (see **Figure 9.3 on page 132**). Locate the fault.

7. Repair the circuitry. Note that, if the circuitry is functioning properly, probing the **TP501 test point** (see **Figure 11.16**) 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 123.

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 123.

12 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 202 to determine the extent of the loss in sensitivity.

CCTM Commands

The CCTM commands required are listed in Table 12.1. Full details of the commands are given in "Computer-Controlled Test Mode (CCTM)" on page 91.

Table 12.1 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)

12.1 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 204 or "Moderate or Slight Loss of Sensitivity" on page 208 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 10dBm should result in a ten-fold change in ***x***.

4. If necessary, measure the RF voltage at the **QN test point** (see **Figure 12.1**). (There is access through a hole in the IF TOP can.) For comparison, the voltages corresponding to the above values of ***x*** are:

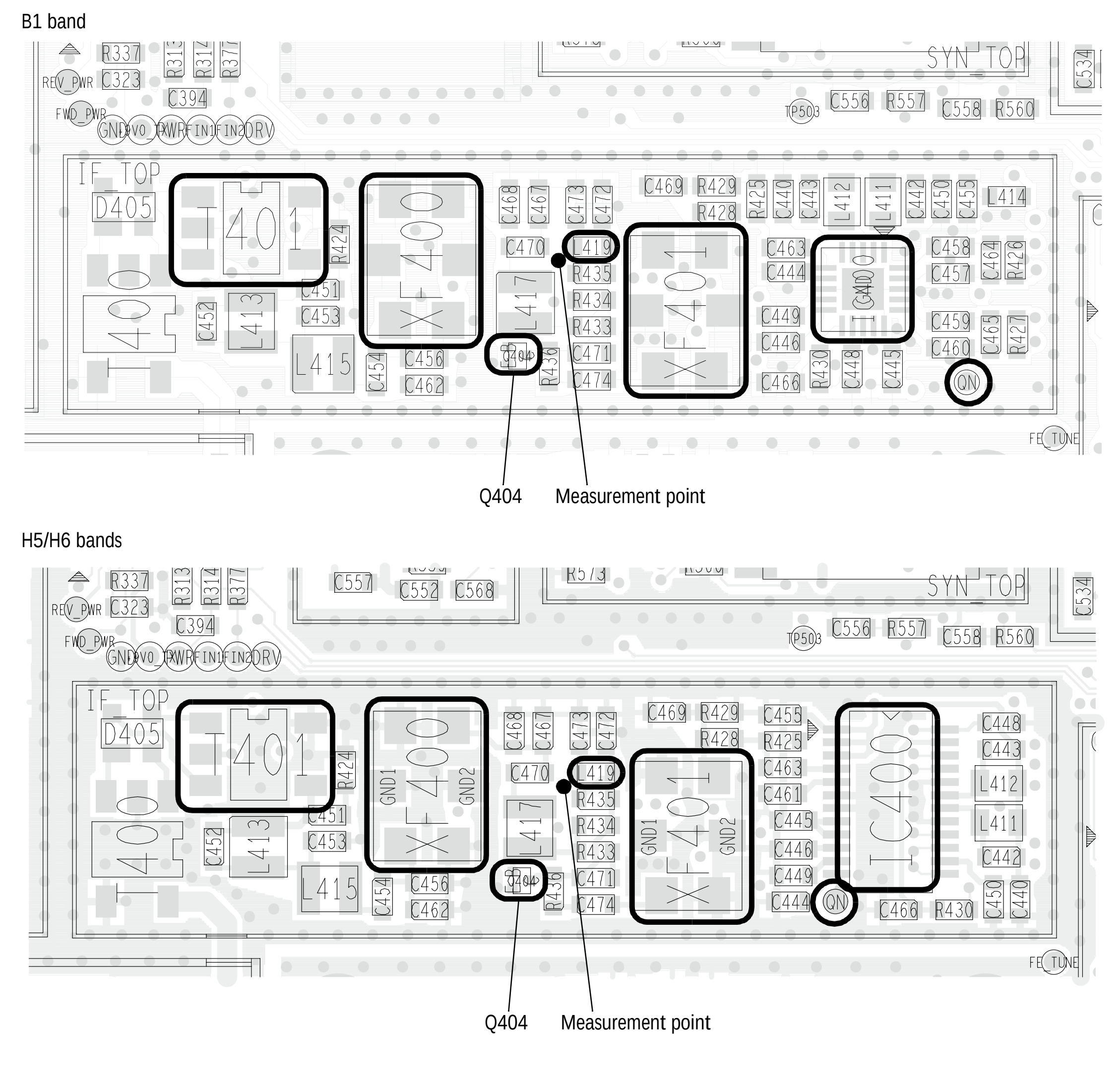
x = 500 000: 12 mV_{pp} ***x*** = 6000 000: 120 mV_{pp}

   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 204 (sensitivity is very low)
   - ***x*** < 500 000, go to "Moderate or Slight Loss of Sensitivity" on page 208 (sensitivity is low)

Figure 12.1 Receiver circuitry under the IF TOP can (top side)



12.2 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 dBm 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 3.0V DC (3V0 AN) at the **TP601 test point** near the LO2 BOT can (see **Figure 12.2**).

TP601 test point: 3.0V DC

3. If the voltage is correct, go to Step 4. If it is not, the 3V regulator **IC603** is suspect; go to Task 3 of "Power Supply Fault Finding" on page 132.

4. Remove the LO2 BOT can.

5. Check for 3.0V DC (3V0 RX) around the collector feed to **Q402** or **Q403** of LO2 (see **Figure 12.2**).

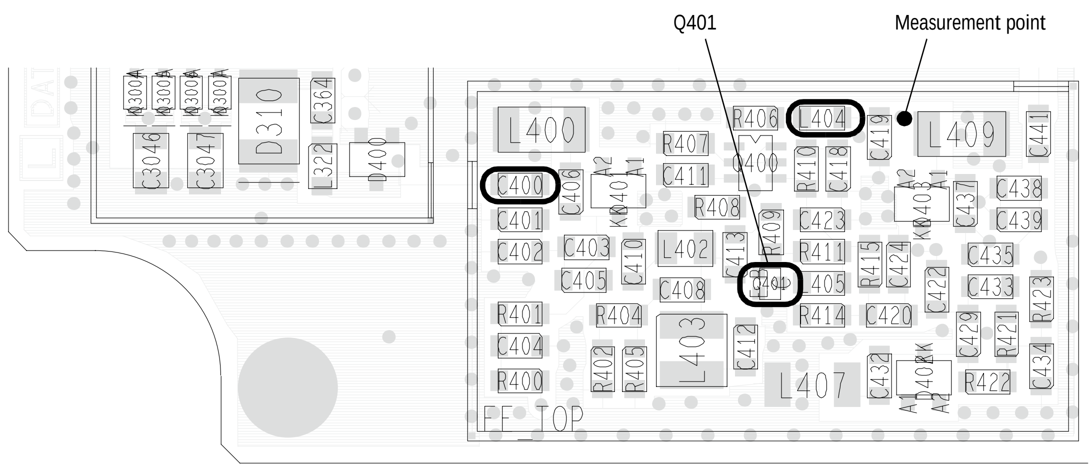
Q402 or Q403 collector: 3.0V DC

Alternative measurement points are the collector feed to **Q401** of the RF LNA under the FE TOP can (see **Figure 12.3**) or **Q404** of the IF amplifier under the IF TOP can (see **Figure 12.1**).

6. If the voltage is correct, go to Task 3. If it is not, the 3V RX switch (based on **Q604** and **Q605**) in the PSU module is suspect; go to Task 3 of "Power Supply Fault Finding" on page 132.

Figure 12.2 Receiver circuitry under the LO2 BOT can (bottom side)

Figure 12.3 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 12.2**). 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 12.1**).

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 123.

4. Recalibrate the receiver using the calibration application.

5. Confirm the removal of the fault and go to “Final Tasks” on page 123. 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 143. If the FCL is not in lock, go to “Power Supply for FCL” on page 189. If the LO2 is not in lock, go to Step 3.

3. Check the components around **IC403**, **Q402** and **Q403** (see **Figure 12.2**). 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 123. 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 12.1**).
3. Check the 3V supply voltage at **L419**; use the measurement point shown in **Figure 12.1**.
4. Also check the amplifier bias conditions. First measure V_c between the collector of **Q404** and ground (see **Figure 12.1**).

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 12.1**), 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 123. 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 12.1**).
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 123. If the repair failed go to Task 7.

12.3 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 15dBm 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 12.2**.)

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 12.2**.

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 123. 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 12.1** and **Figure 12.3**).
3. Check the 3V supply voltage at **L404**; use the measurement point shown in **Figure 12.3**.
4. Also check the LNA bias conditions. First measure V_c between the collector of **Q401** and ground (see **Figure 12.3**).

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 12.3**), 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 189.
8. Recalibrate the receiver using the calibration application.
9. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed, go to Task 9.

Table 12.2 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) DAC value Voltage (V)	135.9 37 ± 20 0.44 ± 0.24	145.1 88 ± 15 1.04 ± 0.18	155.1 136 ± 15 1.60 ± 0.18	164.1 174 ± 15 2.04 ± 0.18	174.1 210 ± 15 2.57 ± 0.18
H5 band Frequency (MHz) DAC value Voltage (V)	399.9 0 to 36 0 to 0.43	417.1 94 ± 15 1.11 ± 0.18	435.1 106 ± 15 1.25 ± 0.18	452.1 156 ± 15 1.84 ± 0.18	470.1 191 ± 15 2.25 ± 0.18
H6 band Frequency (MHz) DAC value Voltage (V)	449.9 41 ± 20 0.48 ± 0.24	470.1 91 ± 15 1.07 ± 0.18	490.1 134 ± 15 1.58 ± 0.18	510.1 176 ± 15 2.07 ± 0.18	530.1 210 ± 15 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 12.1** and **Figure 12.3**).
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 (25 W)" on page 219 or "Transmitter Fault Finding (50 W/40 W)" on page 273.
7. Recalibrate the receiver using the calibration application.
8. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

12.4 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 12.3**.
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 123. If it has not, go to Task 11.

Table 12.3 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 12.2**.
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 202 and check the receiver sensitivity.
5. Check if the RSSI fault has been removed. If it has, go to "Final Tasks" on page 123. 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 0dBm and about –3dBm.
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 123. 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 0dBm to about 35dBm.
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 123. 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.

12.5 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 *"Networks"* heading.
2. Click the *"Basic Network 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 12.4**.
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 123. If it has not, go to Task 1 and check the receiver sensitivity.

Table 12.4 Mute data

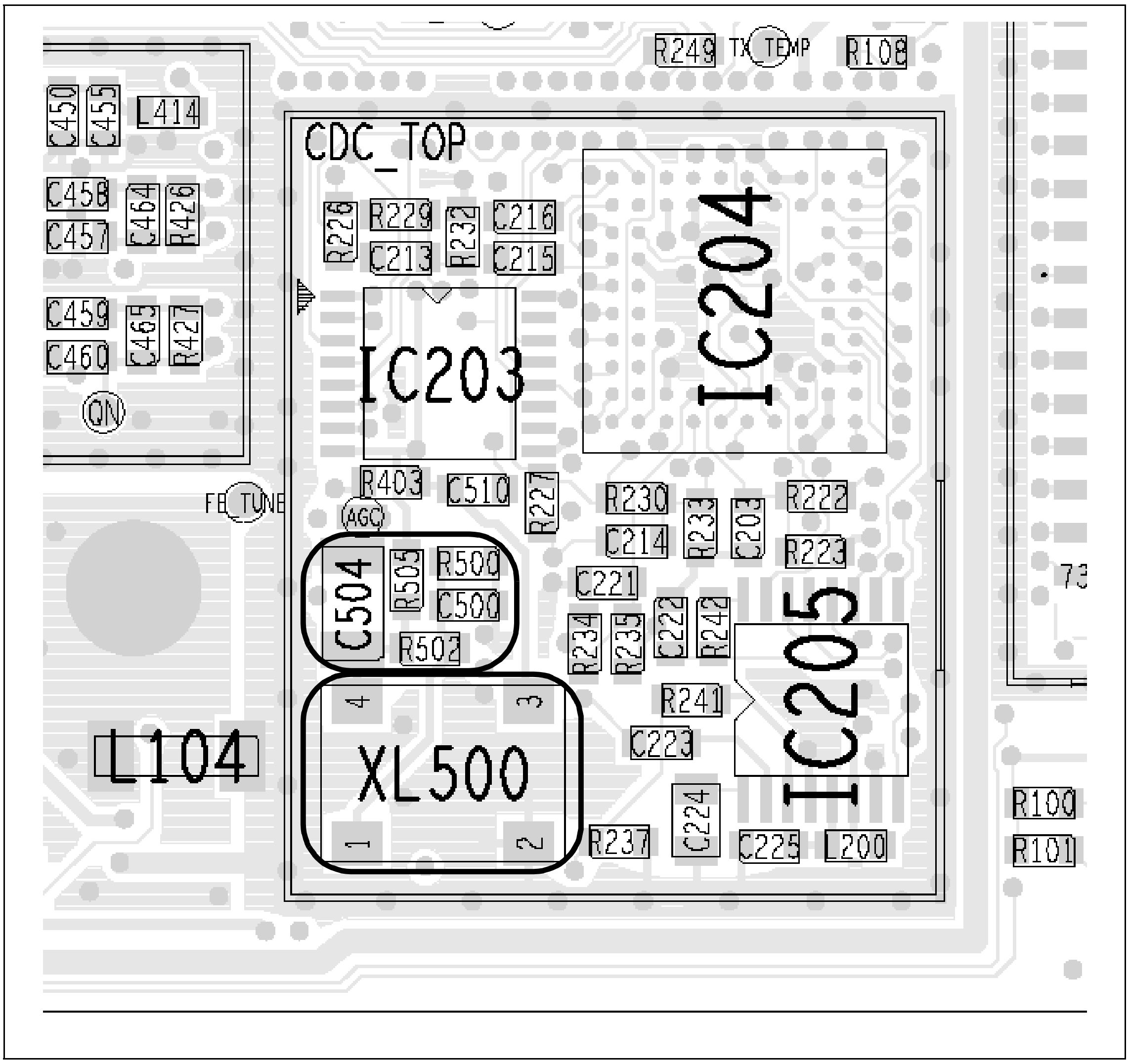
Channel spacing	SINAD (dB)	Mute noise readings	
		Minimum noise value	Maximum noise value
Narrow (12.5 kHz)	8	1900	2300
	20	250	500
Medium (20 kHz)	8	3700	4200
	20	1000	1500
Wide (25 kHz)	8	5000	7300
	20	2200	3700

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 123. If it has not, go to Task 10 and check the RSSI calibration.

Figure 12.4 TCXO circuitry under the CDC TOP can (top side)



12.6 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 12.4**). 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 123. 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 –90dBm 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 12.1**). The frequency is the second IF and should be:

frequency at QN test point: 64.000kHz

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 123. 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 12.1**).

8. Repair any fault, confirm the removal of the fault, and go to “Final Tasks” on page 123. If the repair failed or no fault could be found, replace the main-board assembly and go to “Final Tasks” on page 123.

13 Transmitter Fault Finding (25 W)

Introduction

25W

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 13.1. Full details of the commands are given in "Computer-Controlled Test Mode (CCTM)" on page 91.

Table 13.1 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, centre or highest frequency in the radio's frequency band. The relevant frequencies for the different bands are listed in Table 13.2. Note that the following frequency ranges are reserved worldwide for use by distress beacons:

- B1 band: 156.8 MHz ± 375 kHz
- H5 band: 406.0 to 406.1 MHz

Do not program the radio with any frequency in the above ranges.

Table 13.2 Lowest, centre and highest frequencies in MHz

Band	Lowest frequency	Centre 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 99.

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 XREF. 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 50 Ω 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 on page 82. But for those tests where this connection is not necessary, a 50 Ω 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.

13.1 Power Supplies

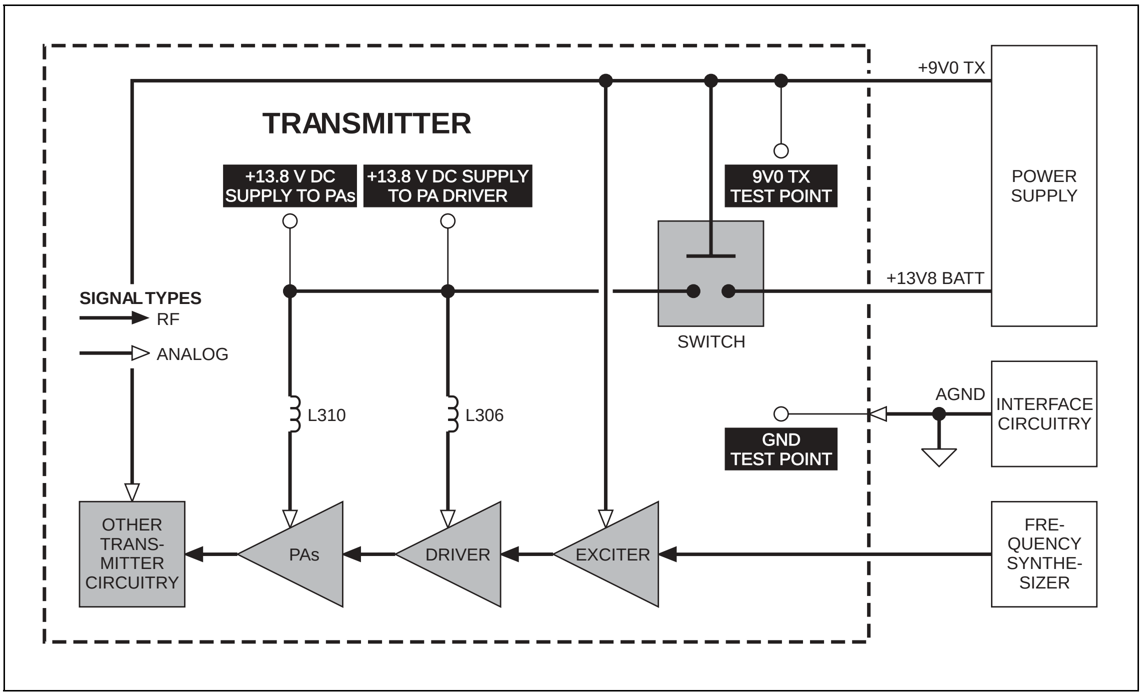
Introduction

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 13.1.

Figure 13.1 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 13.2**.
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 232.
7. Measure the voltage at the point on **L310** shown in **Figure 13.2**. 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 13.3**. 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 13.2 Point for measuring the power supply to the PAs

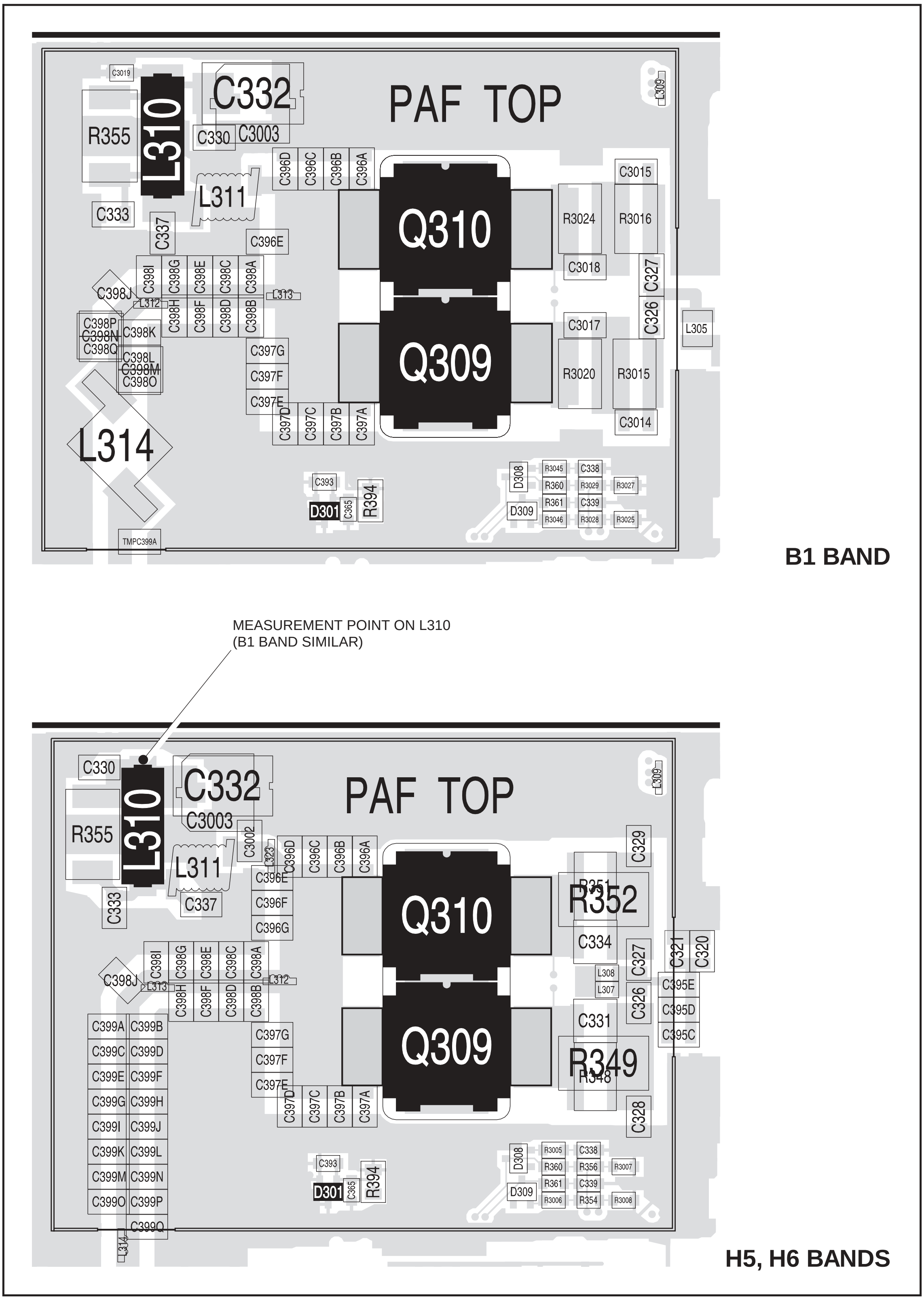
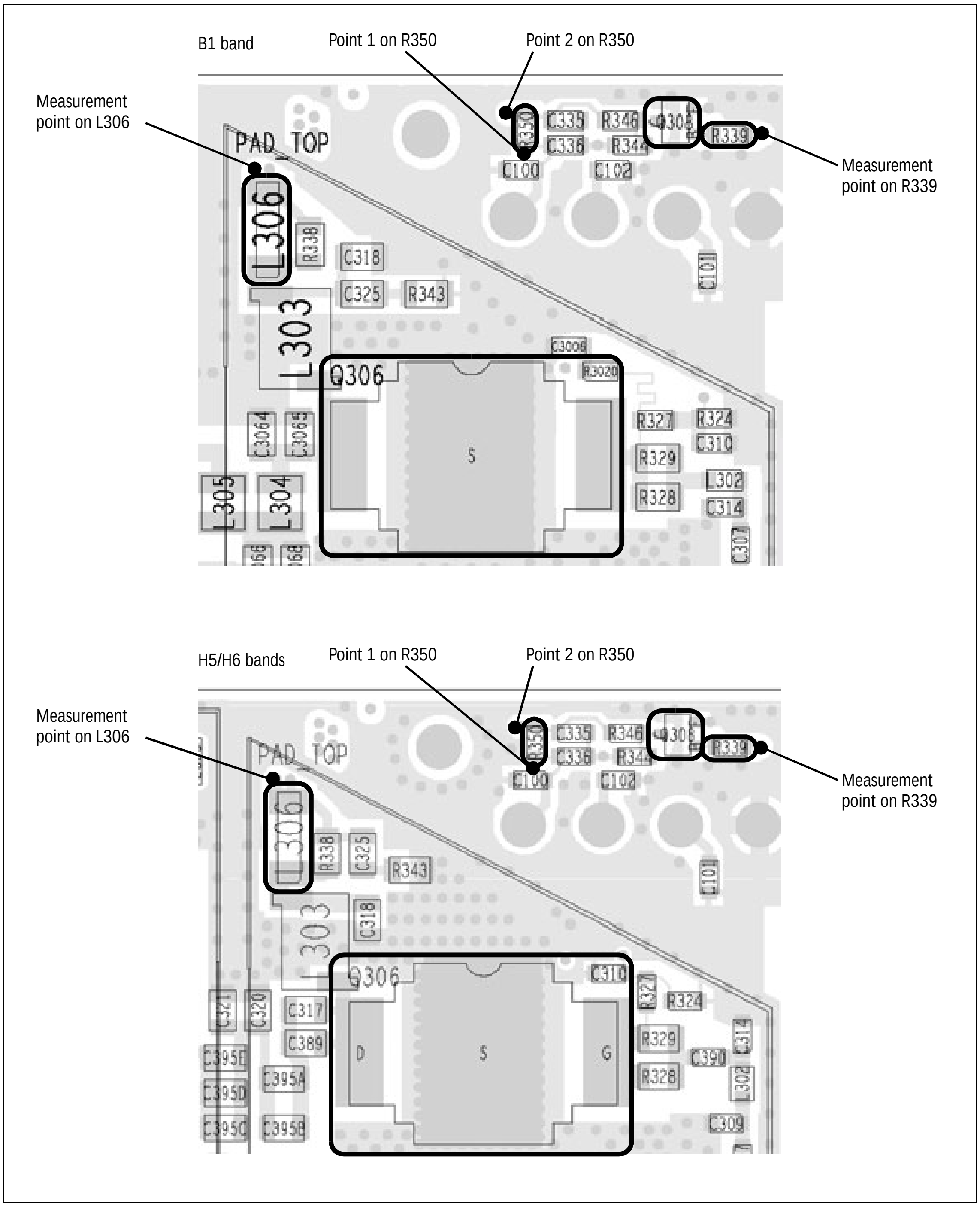


Figure 13.3 Point for measuring the power supply to the PA driver



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 13.3**. 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 13.3**. 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 13.3**. 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 13.3** — 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 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 123.

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.

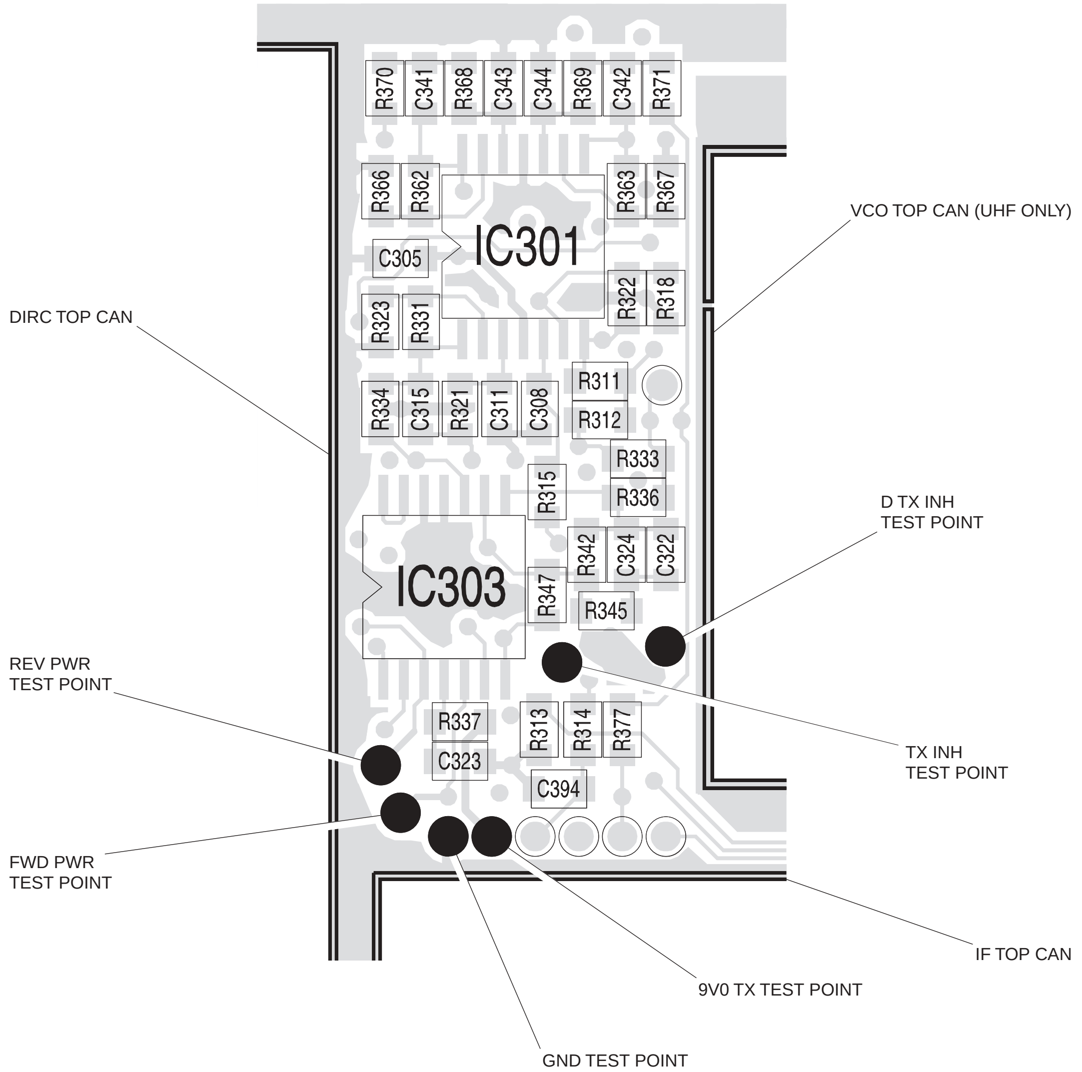
3. Measure the supply voltage between the **9V0 TX test point** and the **GND test point** (see **Figure 13.4**).

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 230. 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 132.

Figure 13.4 Test points for checking the 9V supply, the forward and reverse RF power, and the inhibiting of the transmitter



13.2 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:

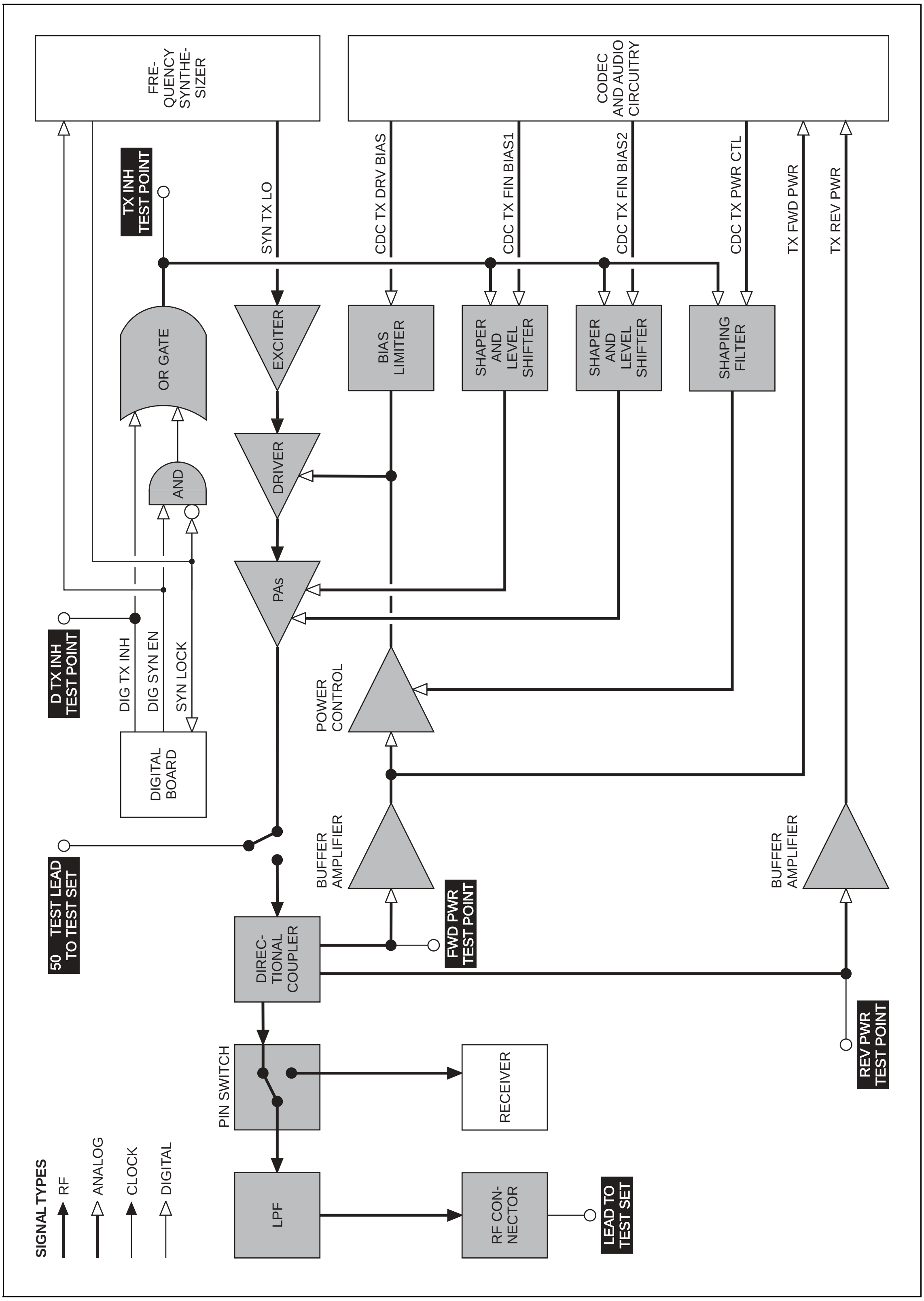
- Task 4: check forward and reverse powers
- Task 5: check RF output power
- Task 6: power unchanged regardless of setting
- Task 7: check for inhibiting of transmitter
- Task 8: check temperature sensor
- Task 9: power and current are skewed
- Task 10: repair output matching circuitry
- Task 11: power and current are low

The measurement points for diagnosing faults concerning the transmitter RF power are summarized in Figure 13.5. Data required for the first task (checking the forward and reverse powers) are supplied in Table 13.3.

Table 13.3 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 13.5 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 13.3**.
4. Confirm the above result by checking the level at the **FWD PWR test point** (see **Figure 13.4**) 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 13.3**.
6. Confirm the above result by checking the level at the **REV PWR test point** (see **Figure 13.4**) 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 13.2**.
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 centre 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 13.2**.
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 13.2**.
9. Repeat Step 3 to Step 5.
10. Depending on the results of the above measurements, proceed to the task indicated in **Table 13.4**. 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 13.4 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 *C03* 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 13.4**). 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 239.
5. Check the logic signal at the **D TX INH test point** (see **Figure 13.4**). 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 123. If the repair failed or no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 123.

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 239. 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 13.6** (B1 band) and **Figure 13.7** (H5 and H6 bands).

5. If there is no fault, go to "CODEC and Audio Fault Finding" on page 343. If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 13.6 PA circuitry under the PAF TOP can and part of the directional coupler under the DIRC TOP can (B1 band)

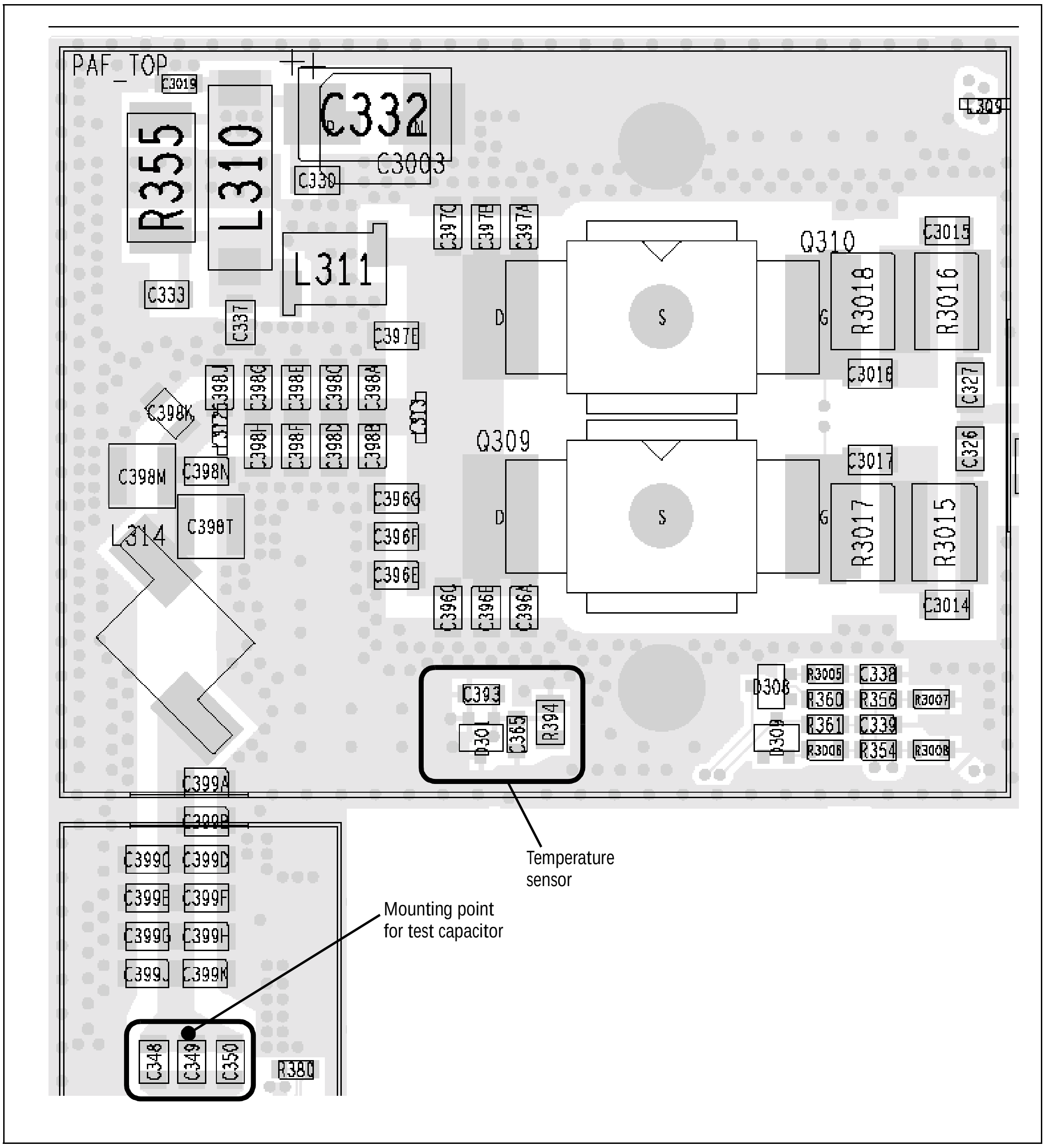
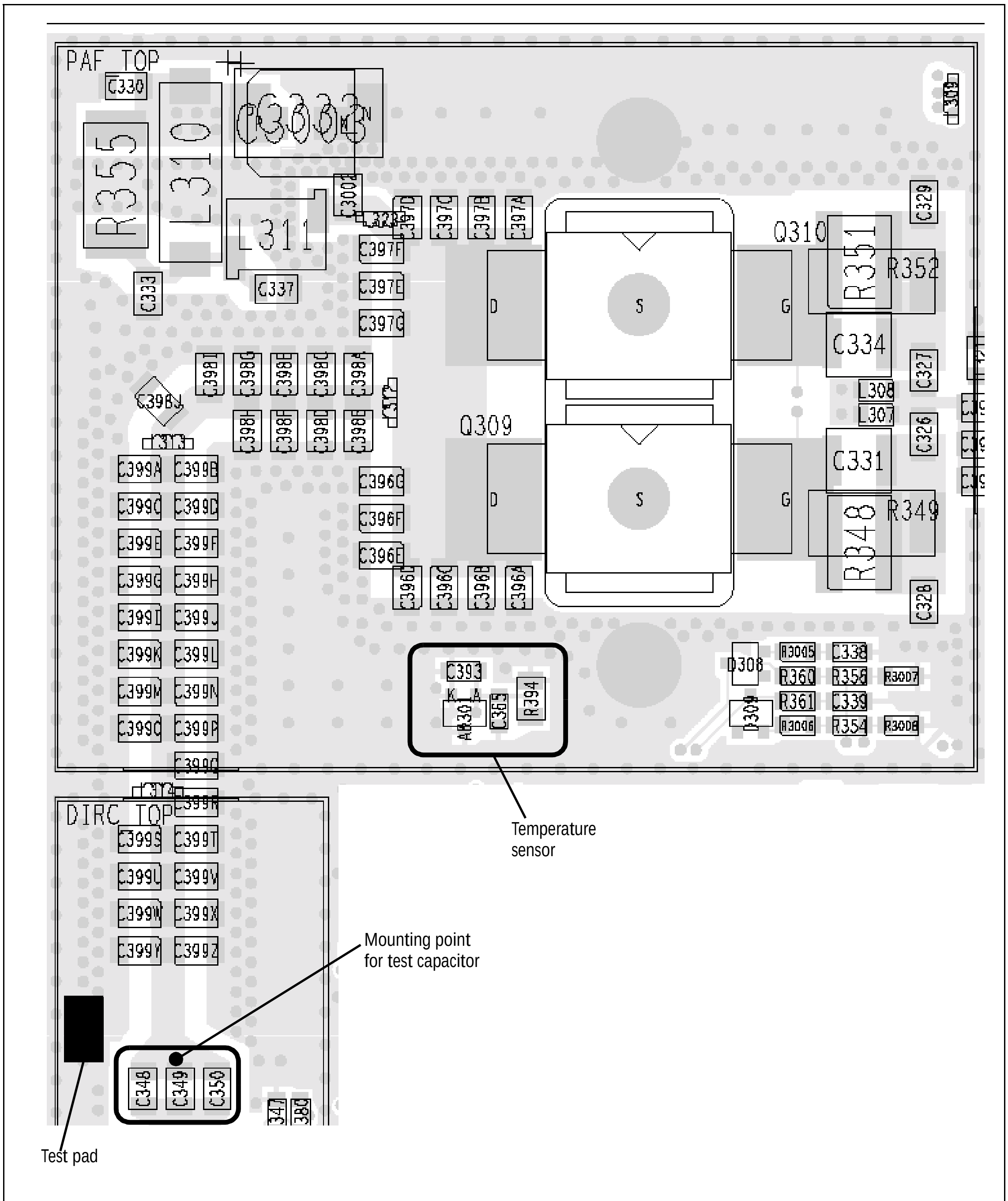


Figure 13.7 PA circuitry under the PAF TOP can and part of the directional coupler under the DIRC TOP can (H5 and H6 bands)



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 13.6** (B1), and **Figure 13.7** (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 13.6** to **Figure 13.7**. 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 13.6** to **Figure 13.7**, 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 centre 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 13.6** to **Figure 13.7**). 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 centre 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 13.6** to **Figure 13.7**).

12. If the power and current are now correct at all three frequencies, the fault has been rectified; go to "Final Tasks" on page 123. If they are not, go to Task 25 in "RF Signal Path" on page 259.

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 13.5**.
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 13.5**.
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 258. If it is not, carry out Task 12 and then Task 16.

Table 13.5 RF output power of individual RF power amplifiers at different frequencies

Frequency band	Frequency within band		
	Lowest frequency	Centre frequency	Highest frequency
B1	29 ± 5W	34 ± 5W	29 ± 5W
H5	5 ± 5W	12 ± 5W	27 ± 5W
H6	13 ± 5W	19 ± 5W	28 ± 5W

13.3 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

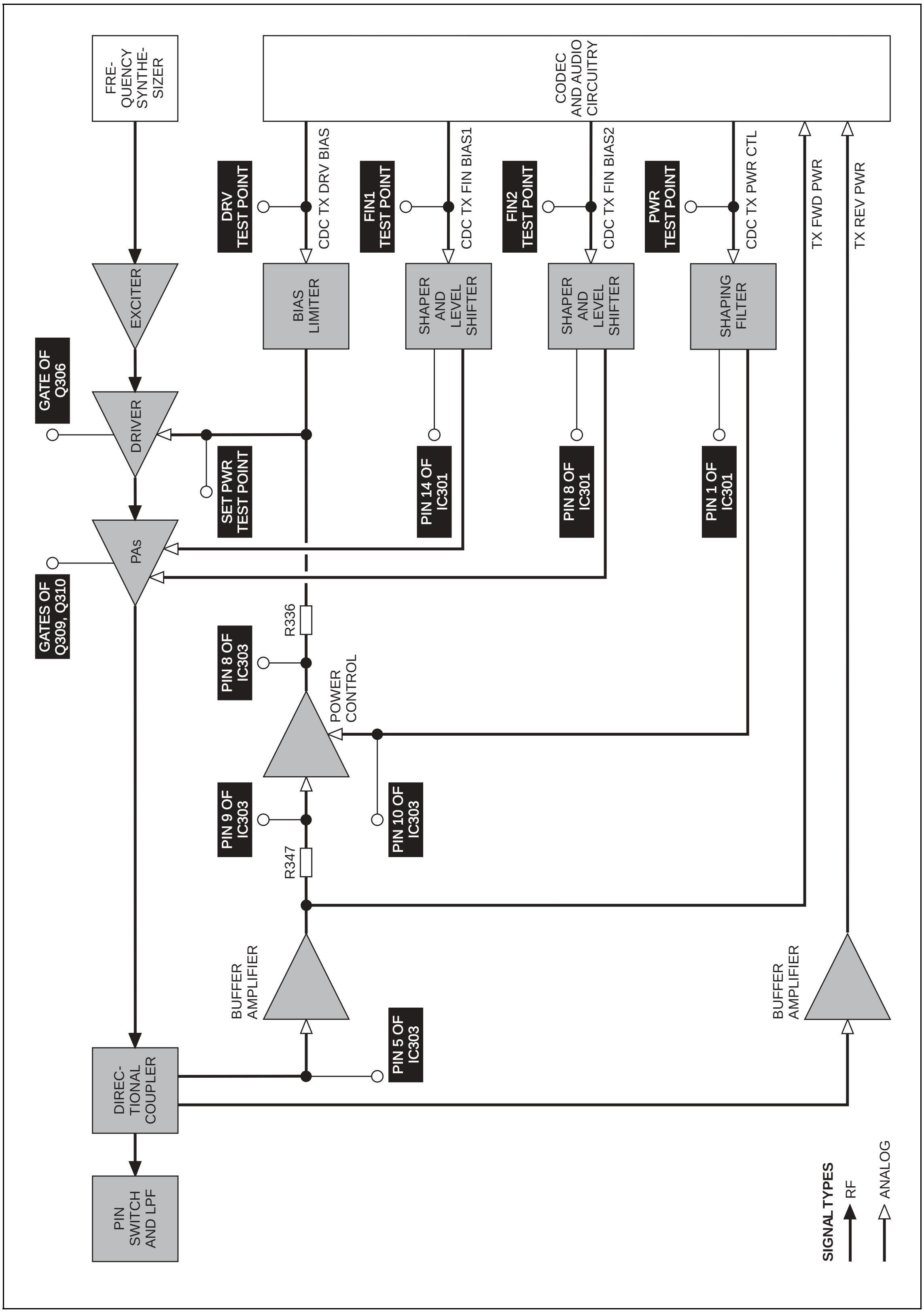
The test and measurement points for diagnosing faults in the biasing of the PAs and PA driver are summarized in Figure 13.8.

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 13.8 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 13.9**). 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:

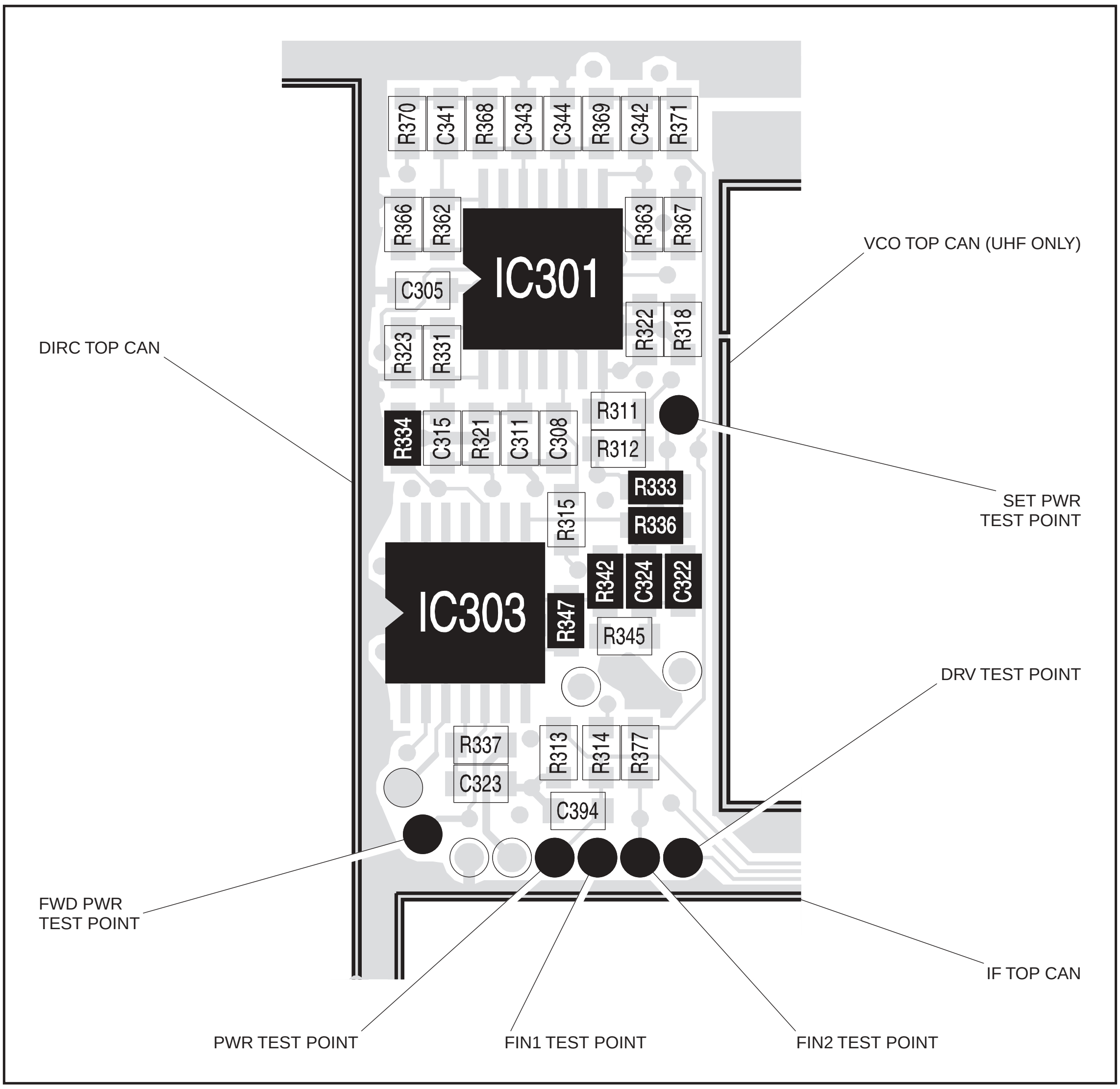
pin 14 of IC301: 2 to 5V (after entry of CCTM 331 **x**)

5. Also note the current reading. This should increase by an amount approximately equal to the offset given in **Table 13.6**.
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 13.6 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 13.9 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.

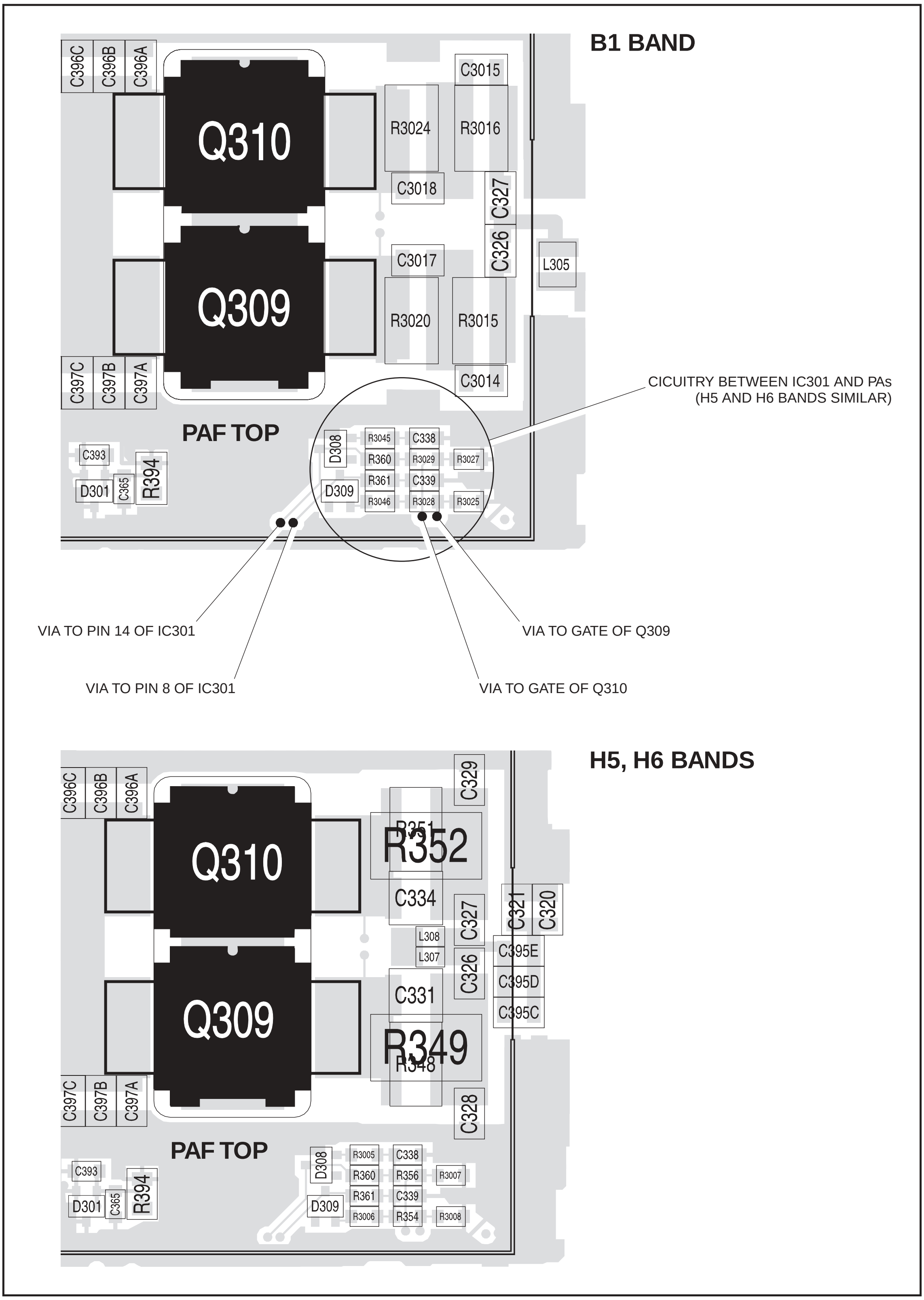
Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *331 **x***, do not specify a value ***x*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PAs.

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 13.10**):

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 123. 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 13.10**). If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 123. If the repair failed or Q310 itself is faulty, replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 13.10 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 13.9**). 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 343.

6. Check **IC301** and the surrounding shaping-filter circuitry (see **Figure 13.9**). If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 123. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 123.

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 13.9**). The voltage should be:

pin 8 of IC301: < 100mV (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 500mA.

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 13.6**.

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 13.10**):

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 123. If it is not, go to Step 9.
9. Check the circuitry between pin 8 of **IC301** and the gate of **Q309** (see **Figure 13.10**). If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 123. If the repair failed or Q309 itself is faulty, replace the main-board assembly and go to “Final Tasks” on page 123.

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 13.9**). 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 343.

6. Check **IC301** and the surrounding shaping-filter circuitry (see **Figure 13.9**). If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 123. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 123.

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 13.6**. 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 13.9**). 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 343.

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 13.9**):

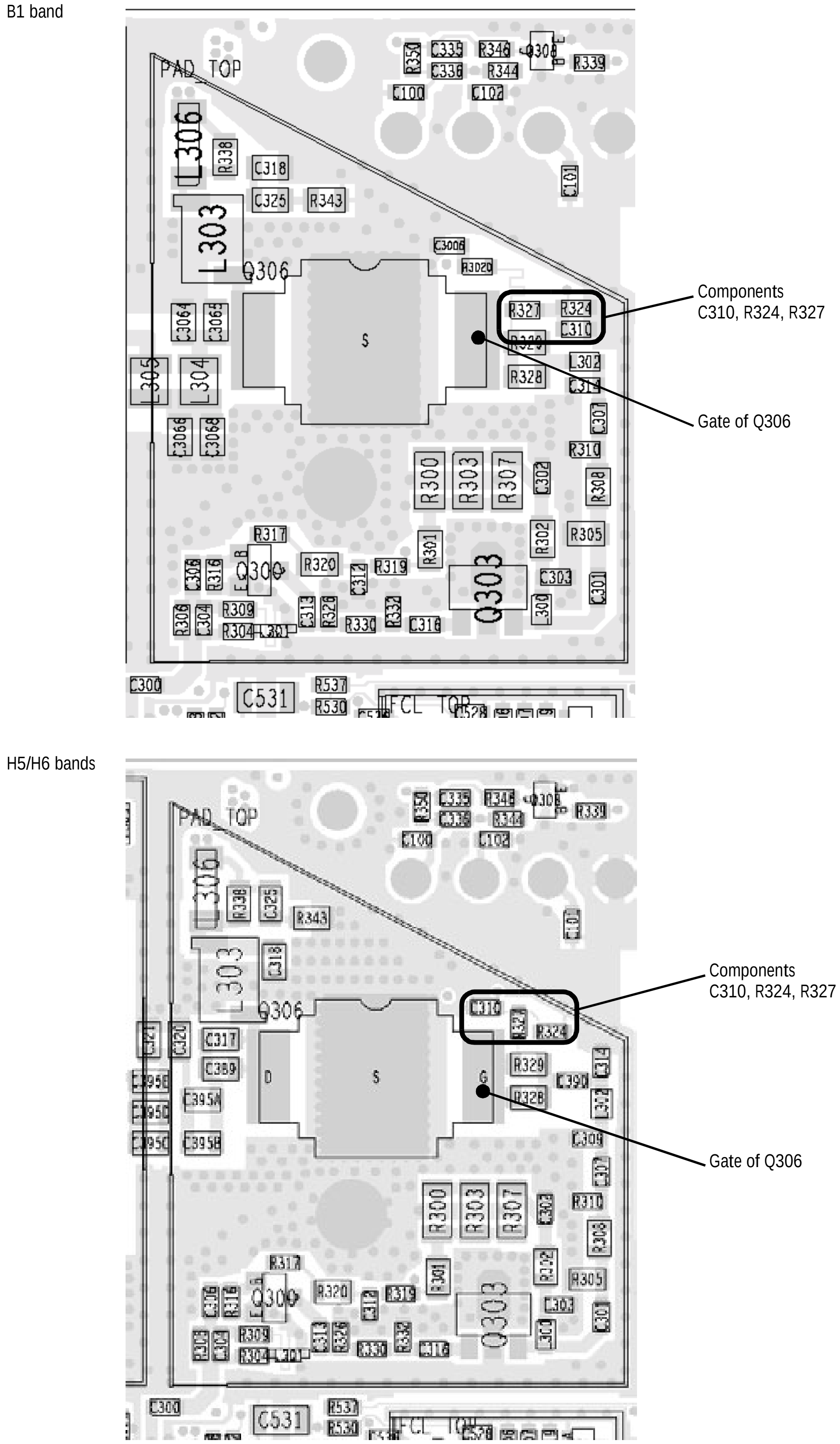
SET PWR test point: 2 to5V

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 13.11**):

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 123. If it is not, go to Task 23.

Figure 13.11 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.

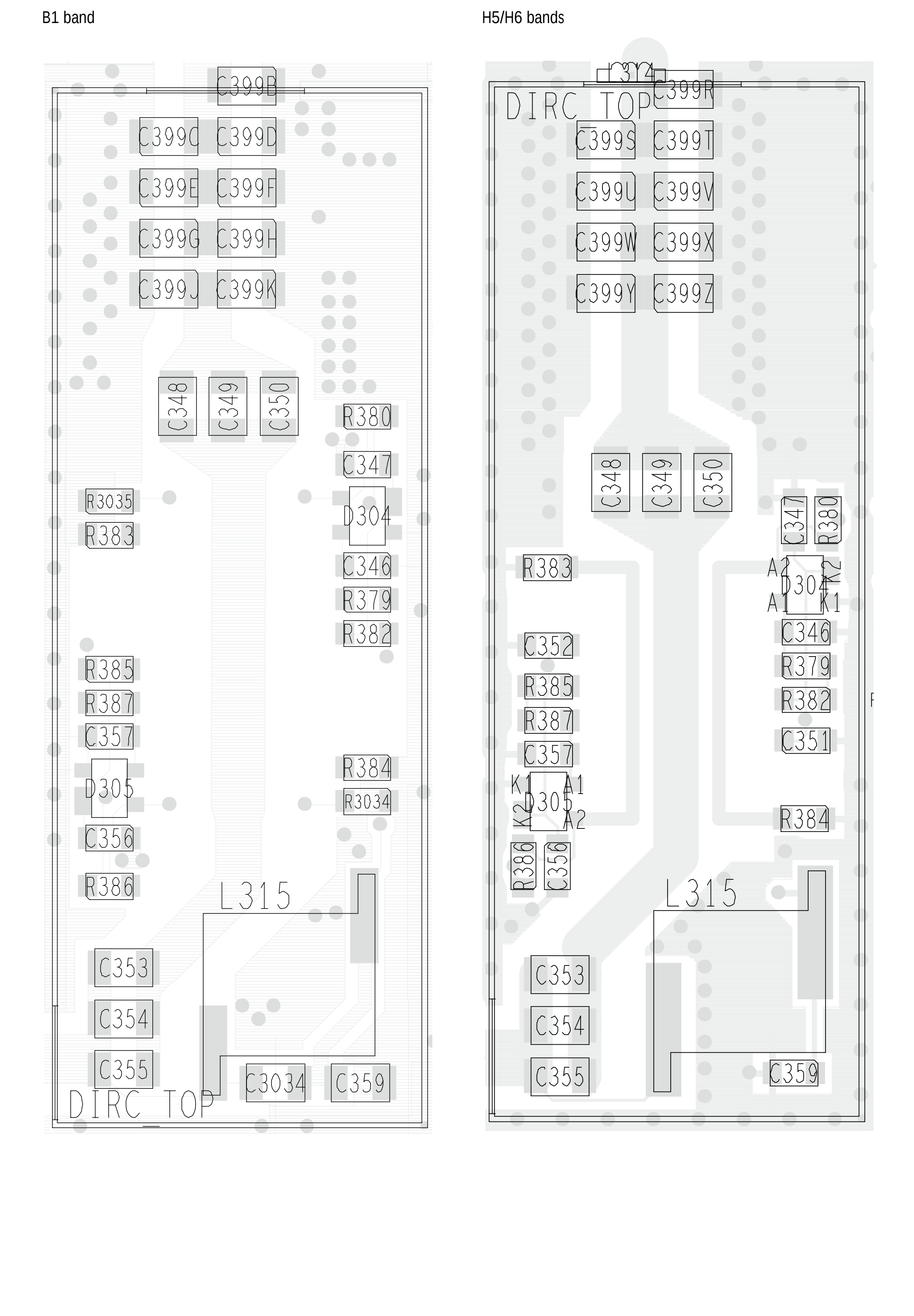
Important Ensure that the current limit on the DC supply is 2A. And, when entering the CCTM command *304* ***z***, do not specify a value ***z*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PA driver.

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 13.6**. If it does, go to Task 25 in “RF Signal Path” on page 259. 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 13.9**).
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 343.

Figure 13.12 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 13.9**).
5. The above voltage should be as given in **Table 13.7**. 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 13.9**). 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 13.7**. If it is not, go to Step 9. If it is, go to Step 11.

Table 13.7 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 13.12**) and go to Step 12.
11. Check **R340** between pins 6 and 7 of **IC303** in the buffer amplifier (see **Figure 13.13**), 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 13.9**).

13. Confirm the removal of the fault and go to “Final Tasks” on page 123. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 123.

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.

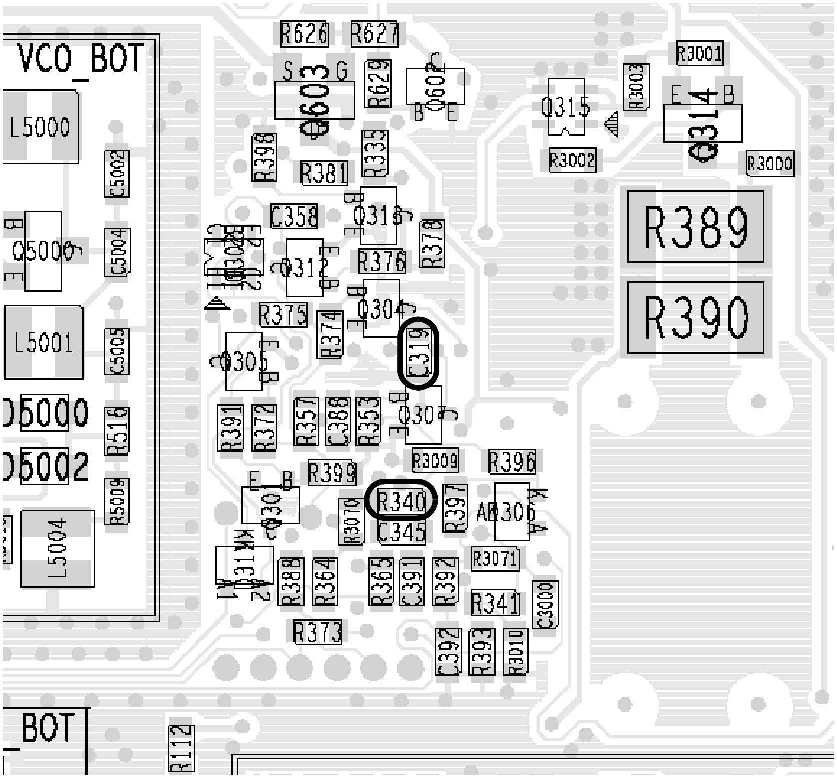
1. Check for short circuits at the gate of the PA driver **Q306**. Check **R333**, **R336** (see **Figure 13.9**), **C310**, **R324** and **R327** (see **Figure 13.11**) between the power-control circuit and Q306.

2. Repair any fault revealed by the checks in Step 1. If none of the above-mentioned components is faulty, replace **Q306** (see **Figure 13.11**).

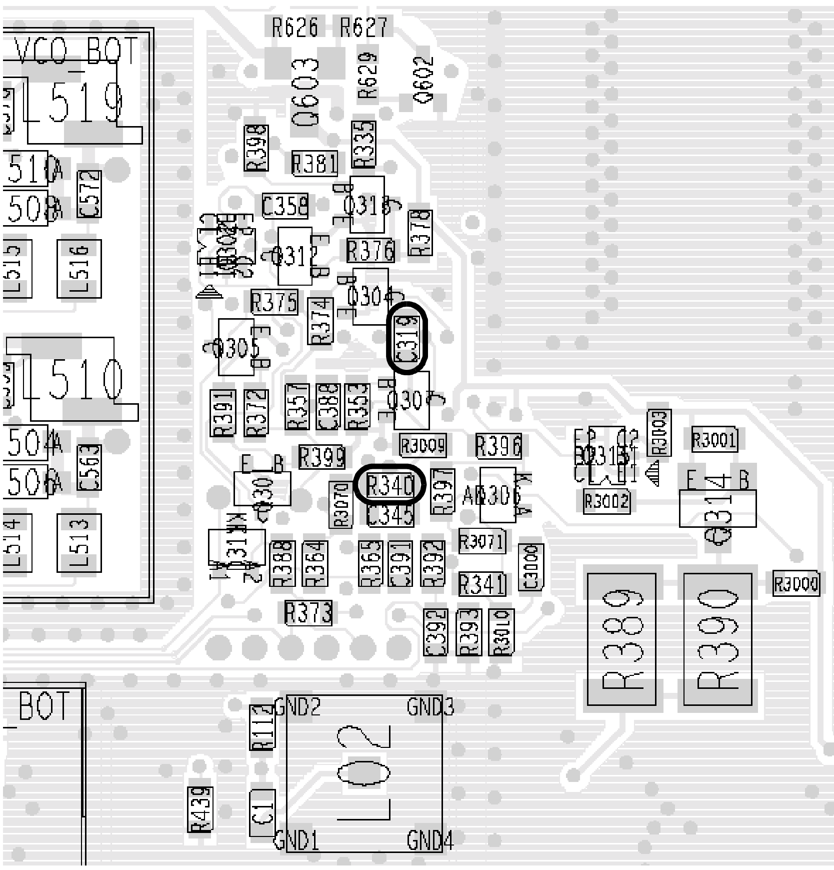
3. Confirm the removal of the fault and go to “Final Tasks” on page 123. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 123.

Figure 13.13 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 13.9**) 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 13.9**) 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 13.9**) in the power-control circuit.

7. Repair any fault revealed by the checks in Step 5. Replace **IC303** (see **Figure 13.9**) if none of the other components is faulty. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

8. Measure the voltage at pin 1 of **IC301** (see **Figure 13.9**) 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 13.9**) and **C319** (see **Figure 13.13**) and go to Step 13.

12. Check the components between the **PWR test point** and pin 1 of **IC301** (see **Figure 13.9**) and go to Step 13.

13. Repair any fault revealed by the checks in Step 11 and Step 12. Replace **IC301** (see **Figure 13.9**) if none of the other components is faulty. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

13.4 RF Signal Path

Introduction

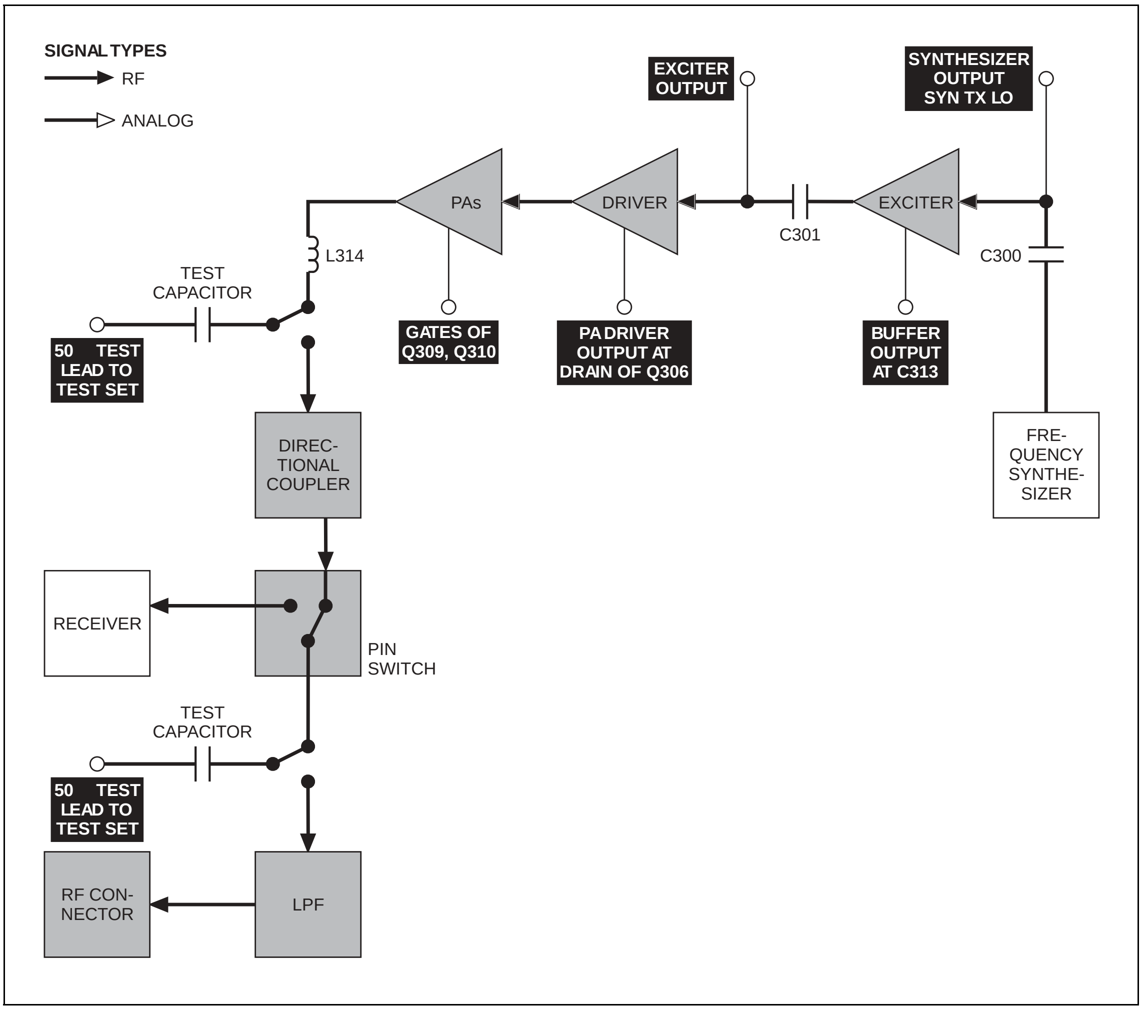
The RF signal path extends from the output of the frequency synthesizer to the LPF. This section of circuitry will require investigation either following certain checks in "Transmitter RF Power" or if the biasing checks of "Biasing of PA Driver and PAs" reveal no fault. The procedure is divided into 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 13.14.

Figure 13.14 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 13.8** (B1 band) or **Table 13.9** (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 13.15**). Earth the probe to the FCL TOP can adjacent to the PA driver circuitry. The required voltage should be as given in **Table 13.8** (B1 band) or **Table 13.9** (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 13.15**). If C300 is not faulty, go to “Frequency Synthesizer Fault Finding” on page 143. If C300 is faulty, replace it and return to Step 2.

Figure 13.15 PA driver circuitry under the PAD TOP can

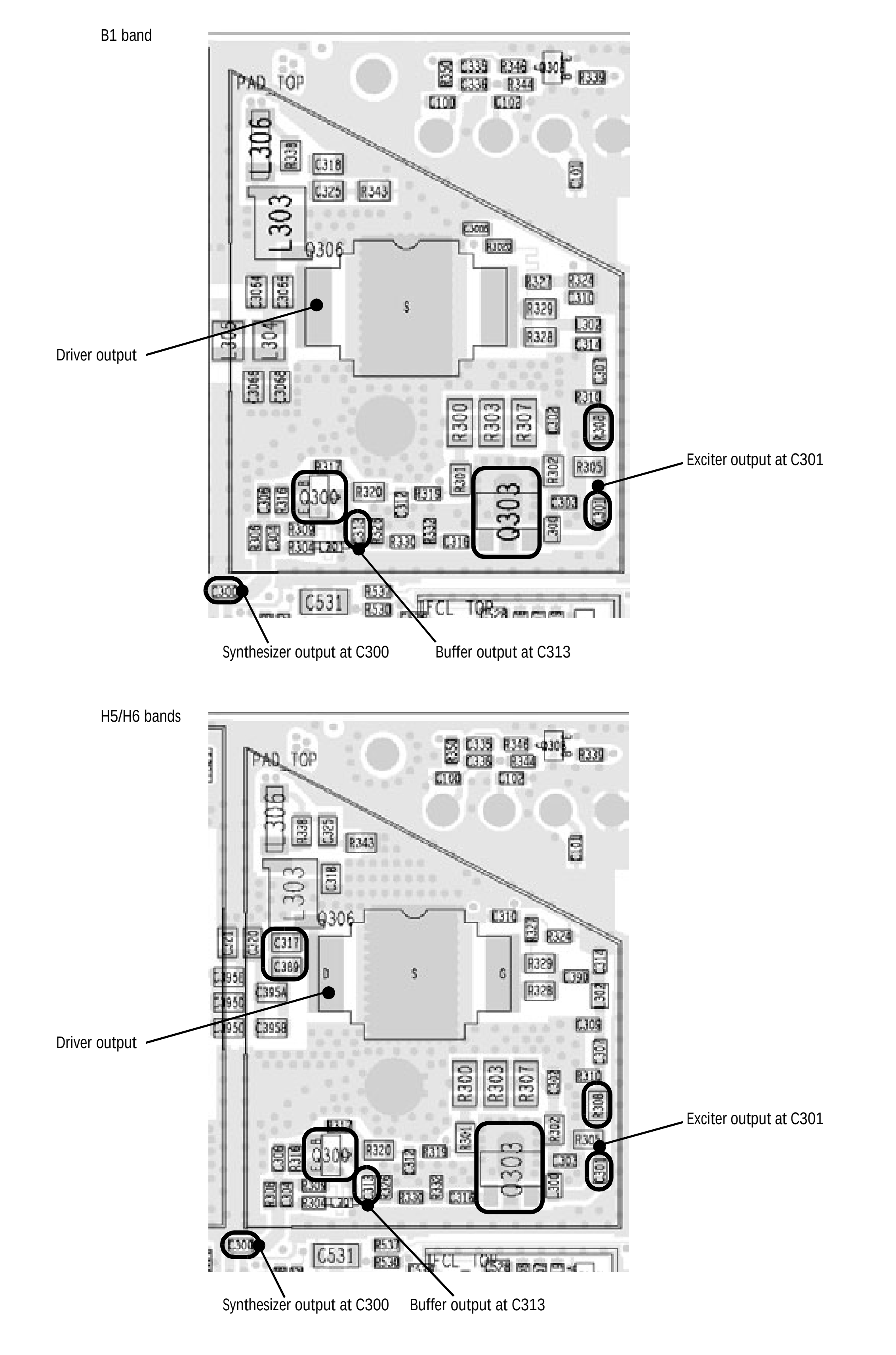


Table 13.8 RF voltages along the initial RF signal path of the VHF radio (B1 band)

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 13.9 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 13.15**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 13.8** (B1 band) or **Table 13.9** (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 13.15**).
9. Repair any fault revealed by the above checks. Replace **Q300** (see **Figure 13.15**) if none of the other components is faulty.
10. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

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 13.15**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 13.8** (B1 band) or **Table 13.9** (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 13.15**).
5. Repair any fault revealed by the above checks. Replace **Q303** (see **Figure 13.15**) if none of the other components is faulty.
6. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

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 13.15**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 13.8** (B1) or **Table 13.9** (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 13.15**).

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 239.

6. Repair the fault. Confirm the removal of the fault and go to “Final Tasks” on page 123. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 123.

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 13.16**).

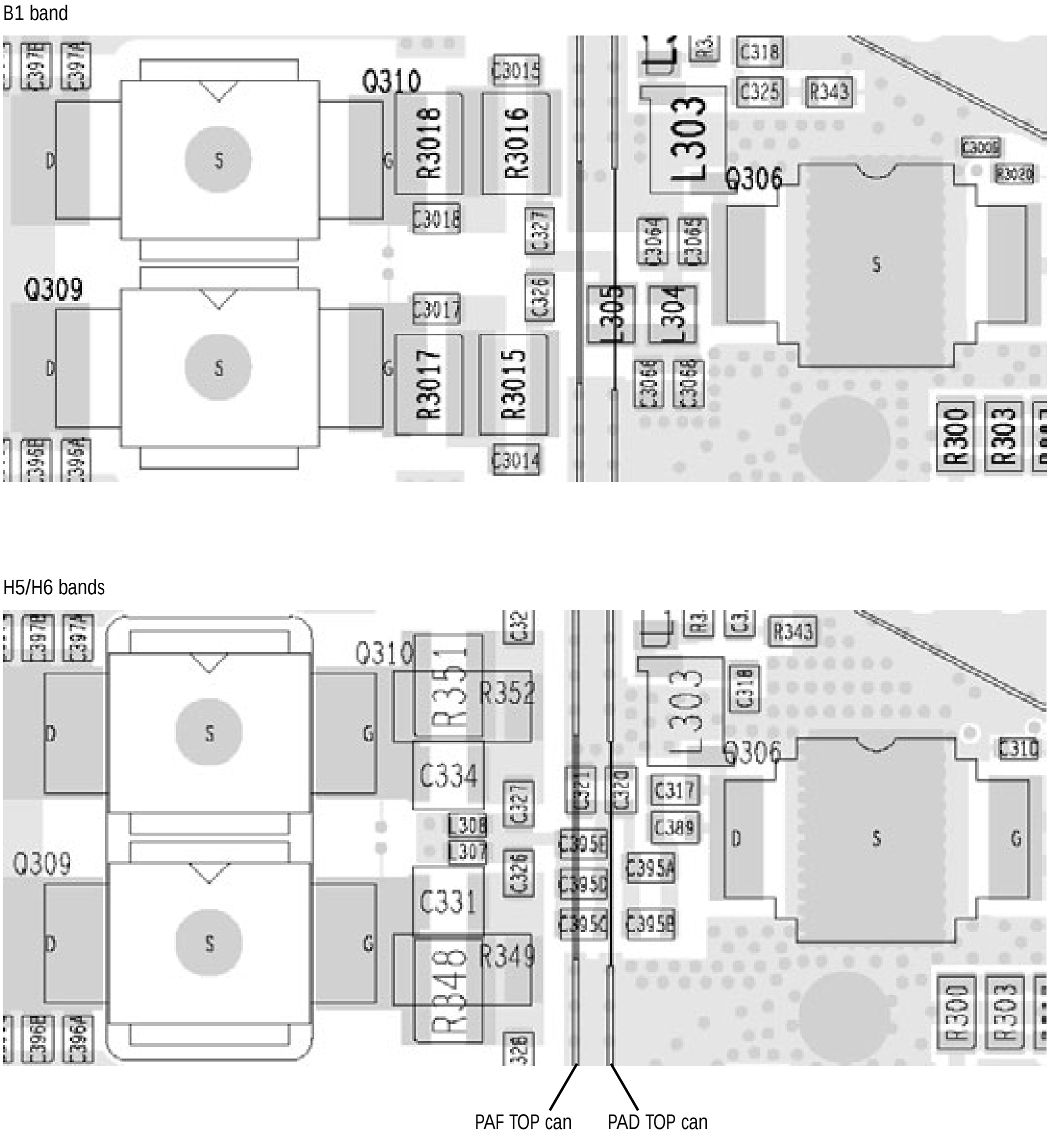
10. Enter the CCTM command *32* to place the radio in receive mode.

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 13.16**).

13. If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 123.

Figure 13.16 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 13.24**).
3. Solder one terminal of an 82pF (H5, H6 bands) or 680pF (B1) test capacitor to the PCB at the point shown in **Figure 13.24**. 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 13.24**, 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 13.8** (B1 band) or **Table 13.9** (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 13.8** (B1 band) or **Table 13.9** (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.

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 13.6** to **Figure 13.7**).

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 13.24**), 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 13.8** (B1 band) or **Table 13.9** (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 13.8** (B1 band) or **Table 13.9** (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 13.24**).

13. If the power in both the above cases is now correct, the fault has been rectified; go to "Final Tasks" on page 123. If it is not, the repair failed; replace the main-board assembly and go to "Final Tasks" on page 123.

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 228.

1. Remove the PIN TOP can.

2. Remove the three blocking capacitors **C361**, **C362** and **C363** (see **Figure 13.17**).

3. Solder one terminal of a 22pF test capacitor to the PCB at the point shown in **Figure 13.17**. 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 13.17**, 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 13.8** (B1 band) or **Table 13.9** (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.

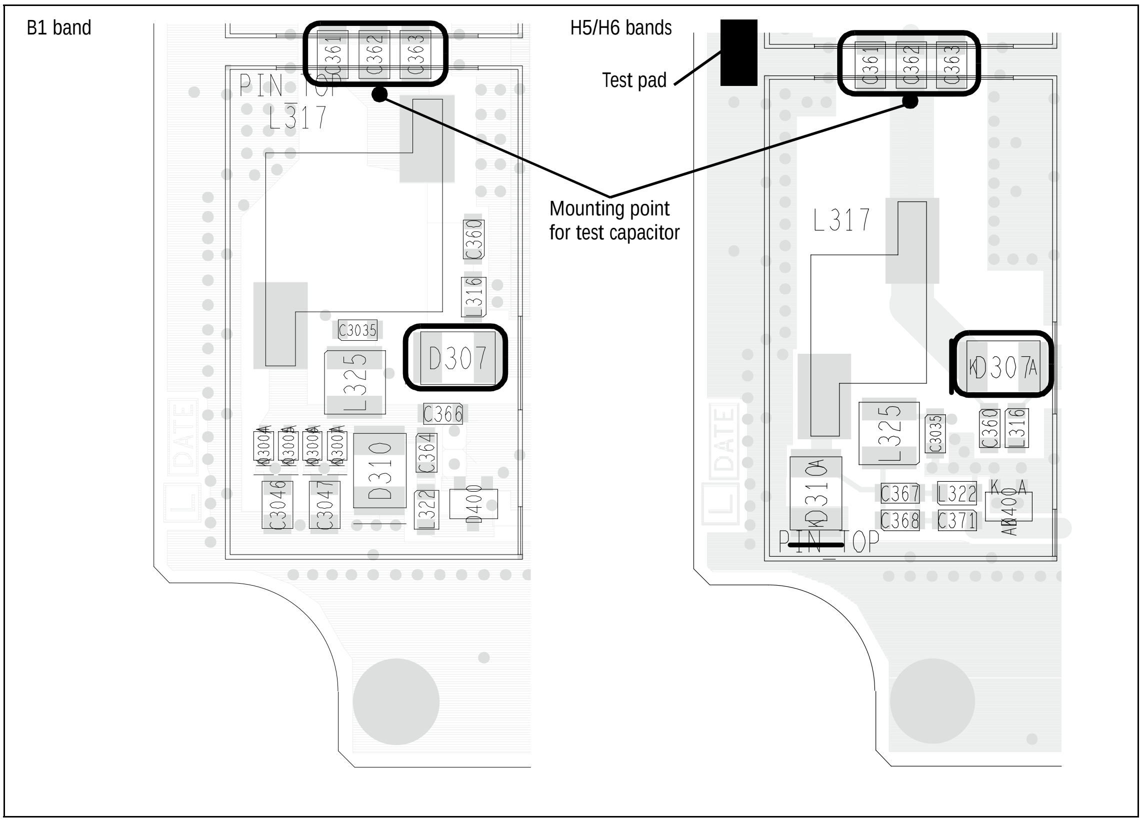
11. Enter the CCTM command *101 x x 0*, where *x* is the highest frequency (in hertz) for maximum power, as given in **Table 13.8** (B1 band) or **Table 13.9** (H5, H6).

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 13.17 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 13.17**). 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 13.18**):
   - 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 13.8** (B1 band) or **Table 13.9** (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 35 W.

RF output power: more than 35 W

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 13.8** (B1 band) or **Table 13.9** (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 13.17**) 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 123. If it is not, the repair failed: replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 13.18 Components of concern on the bottom-side of the main board

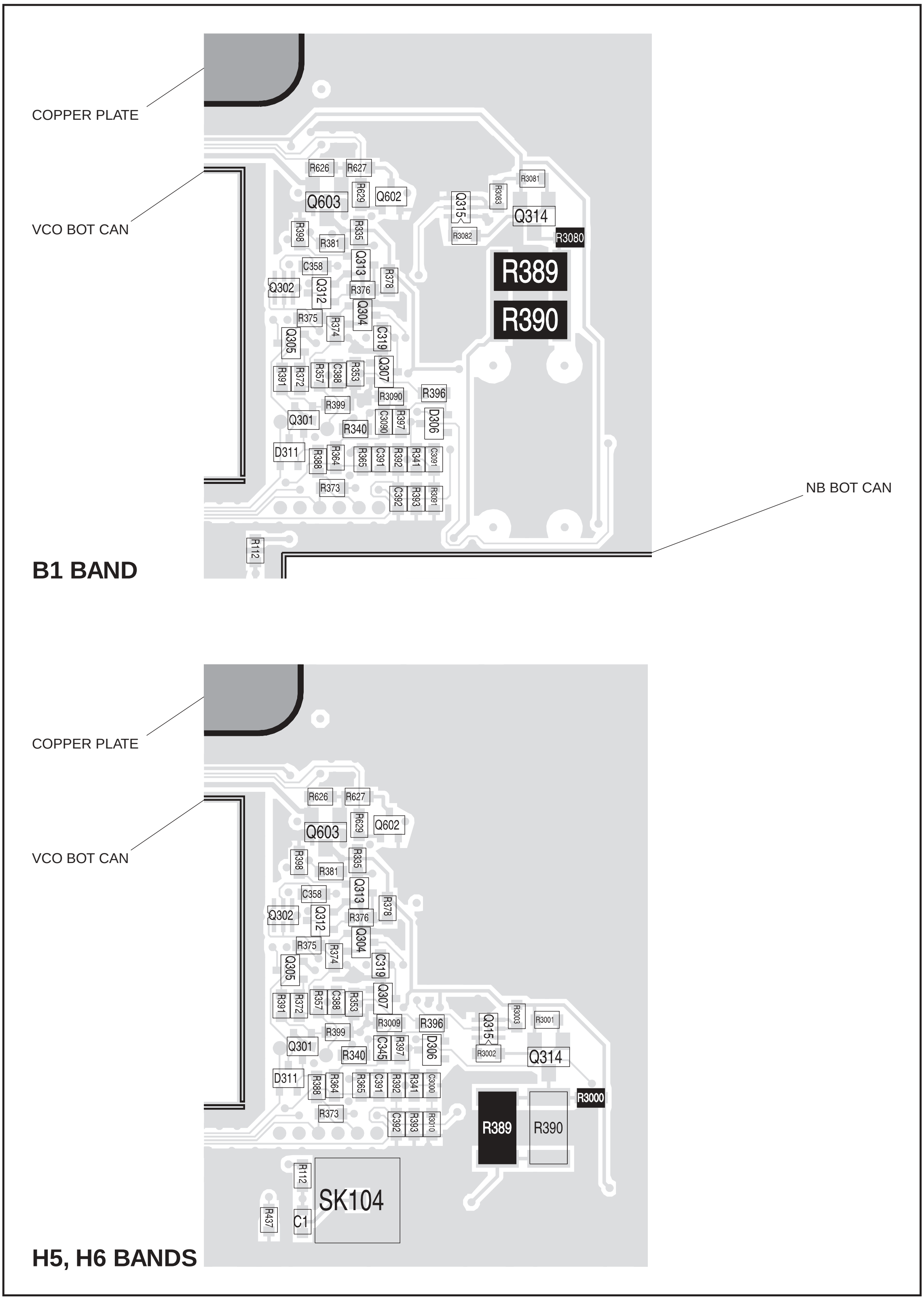
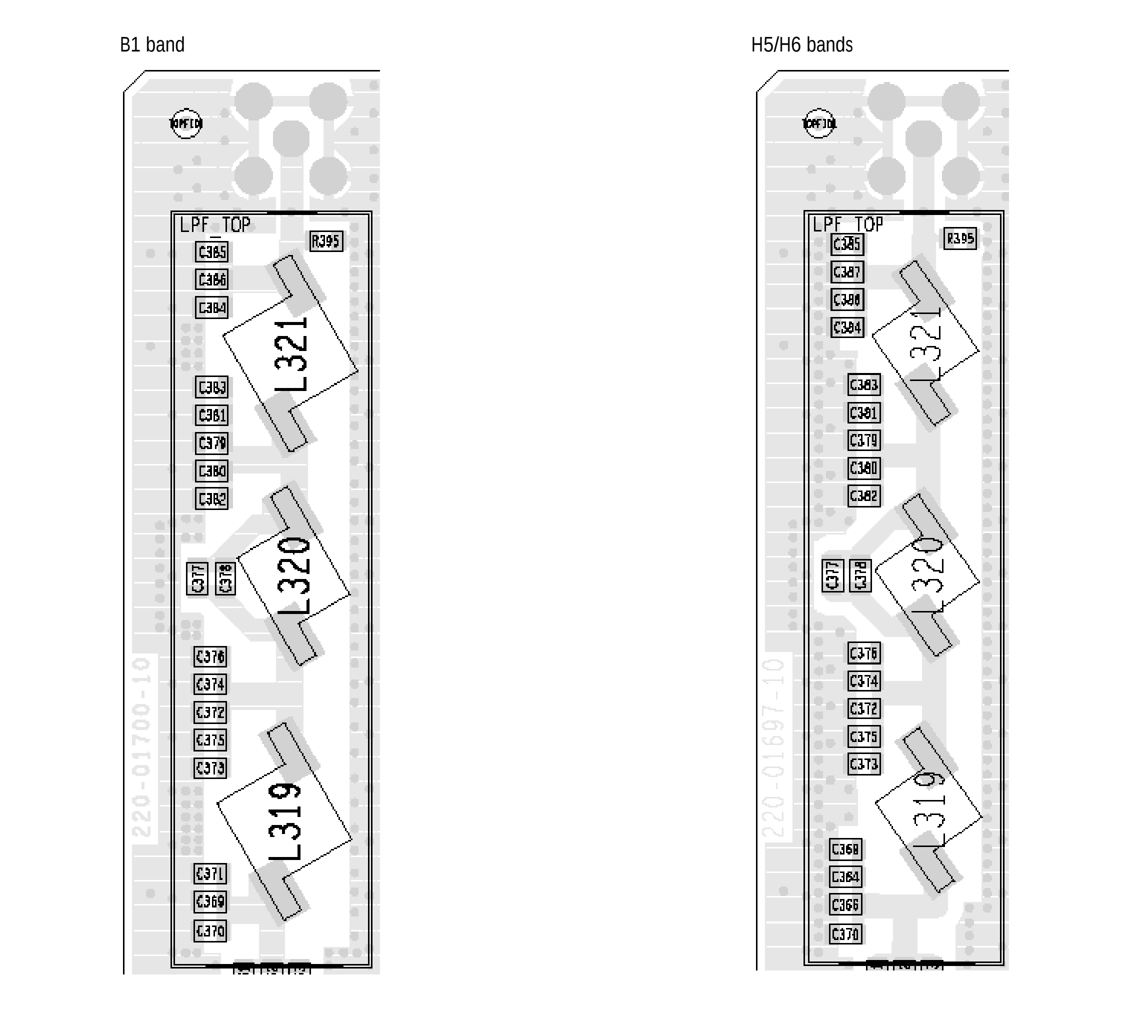


Figure 13.19 Circuitry under the LPF TOP can (top side)



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 13.19**. 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 13.8** (B1 band) or **Table 13.9** (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 13.8** (B1 band) or **Table 13.9** (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 123. If it does not, the repair failed; replace the main-board assembly and go to “Final Tasks” on page 123.

14 Transmitter Fault Finding (50 W/40 W)

Introduction

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 14.1. Full details of the commands are given in “Computer-Controlled Test Mode (CCTM)” on page 91.

Table 14.1 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, centre or highest frequency in the radio's frequency band. The relevant frequencies for the different bands are listed in Table 14.2. 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 14.2 Lowest, centre and highest frequencies in MHz

Band	Lowest frequency	Centre 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 99.

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 XREF. 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 6.2 on page 83. 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.

14.1 Power Supplies

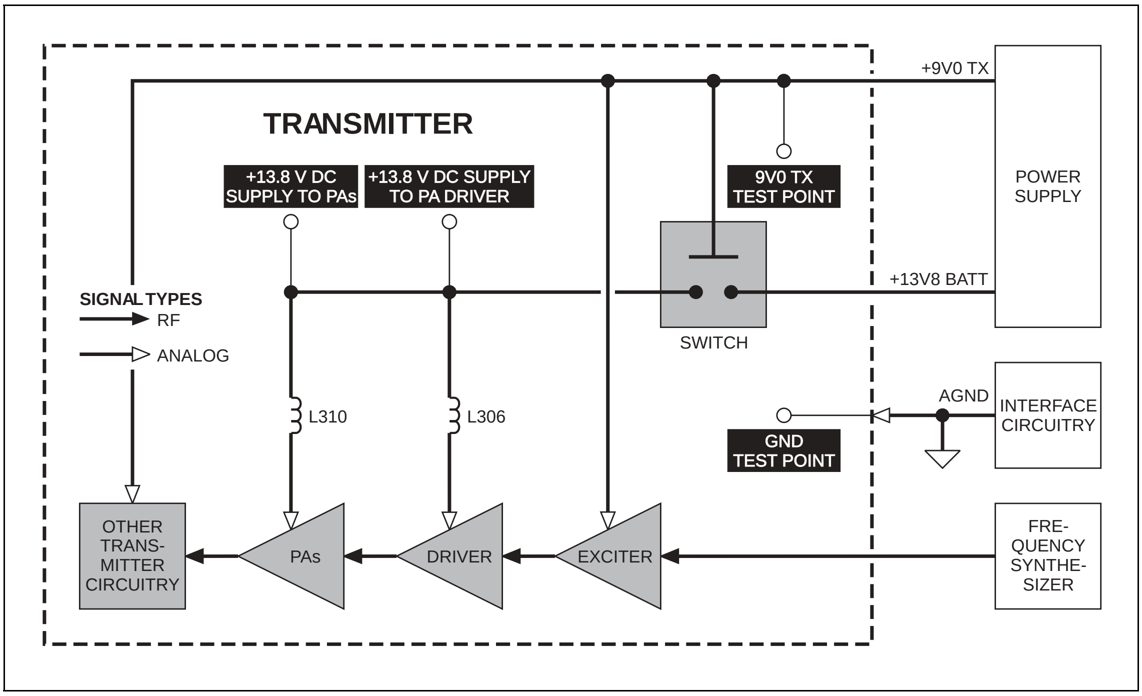
Introduction

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 14.1.

Figure 14.1 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 14.2**.

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 290.

7. Measure the voltage at the point on **L310** shown in **Figure 14.2** (B1 band) or **Figure 14.3** (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 14.4** (B1 band) or **Figure 14.5** (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 14.2 Point for measuring the power supply to the PAs (B1 band)

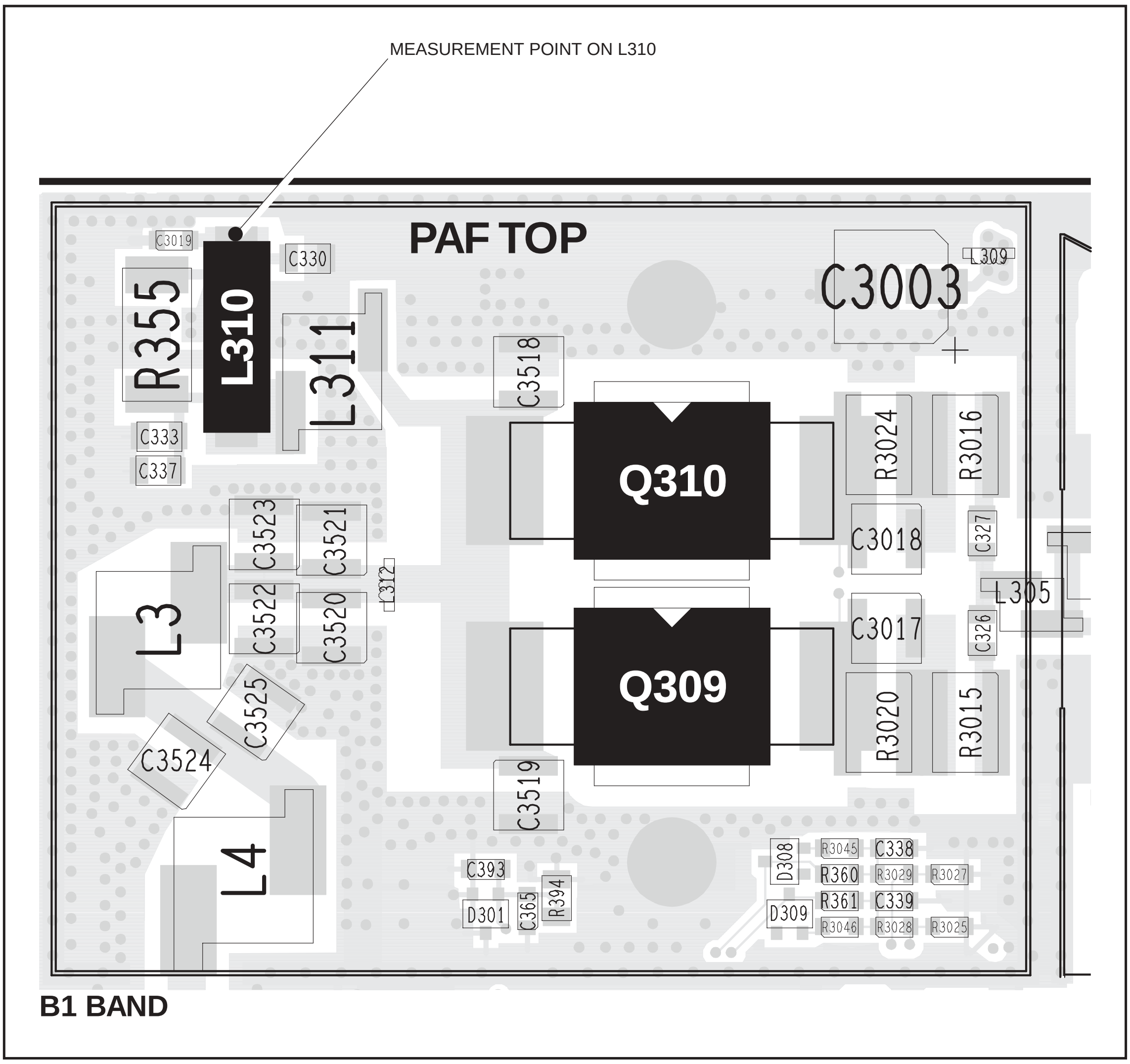


Figure 14.3 Point for measuring the power supply to the PAs (H5 and H7 bands)

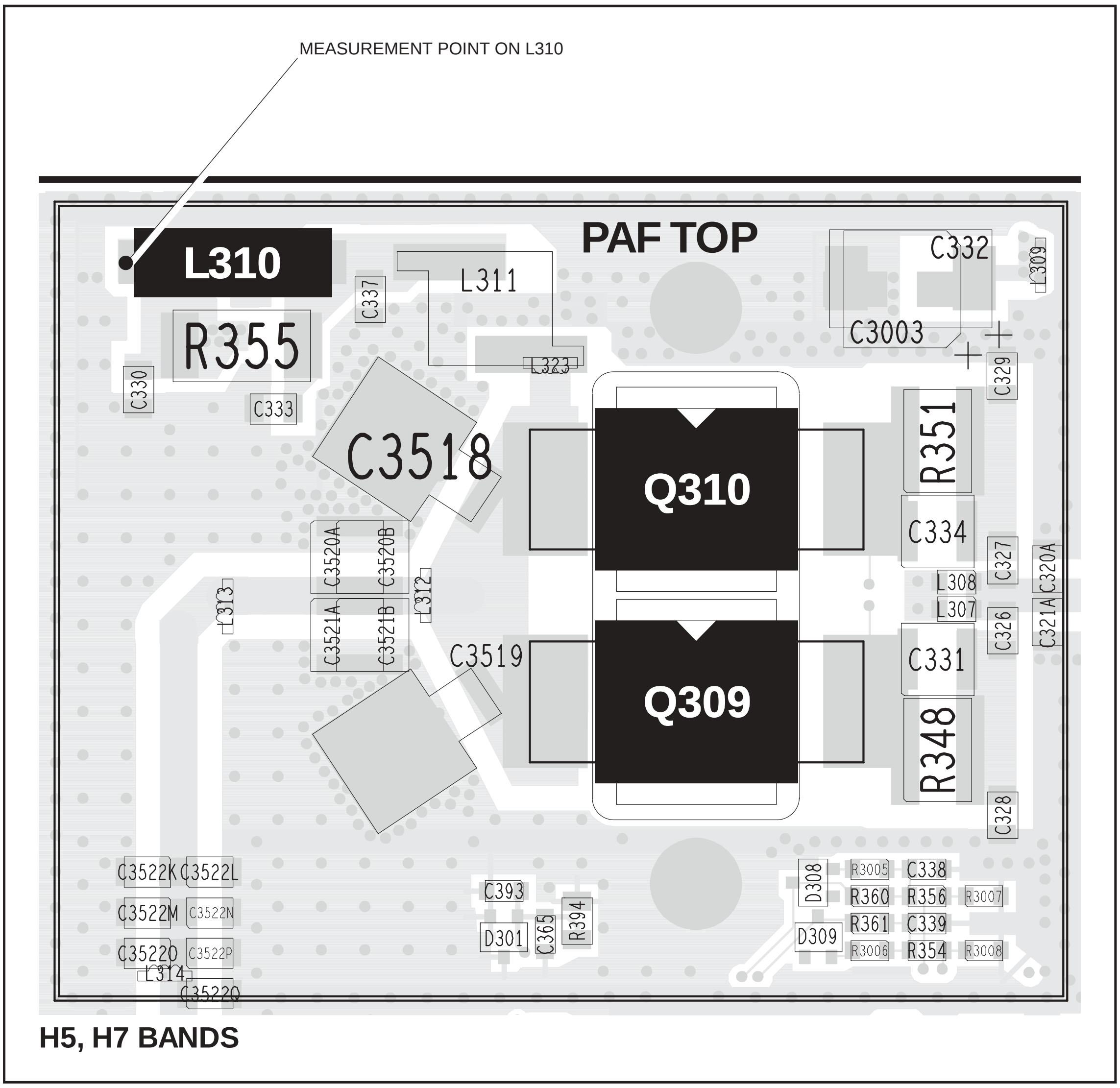


Figure 14.4   Point for measuring the power supply to the PA driver (B1 band)

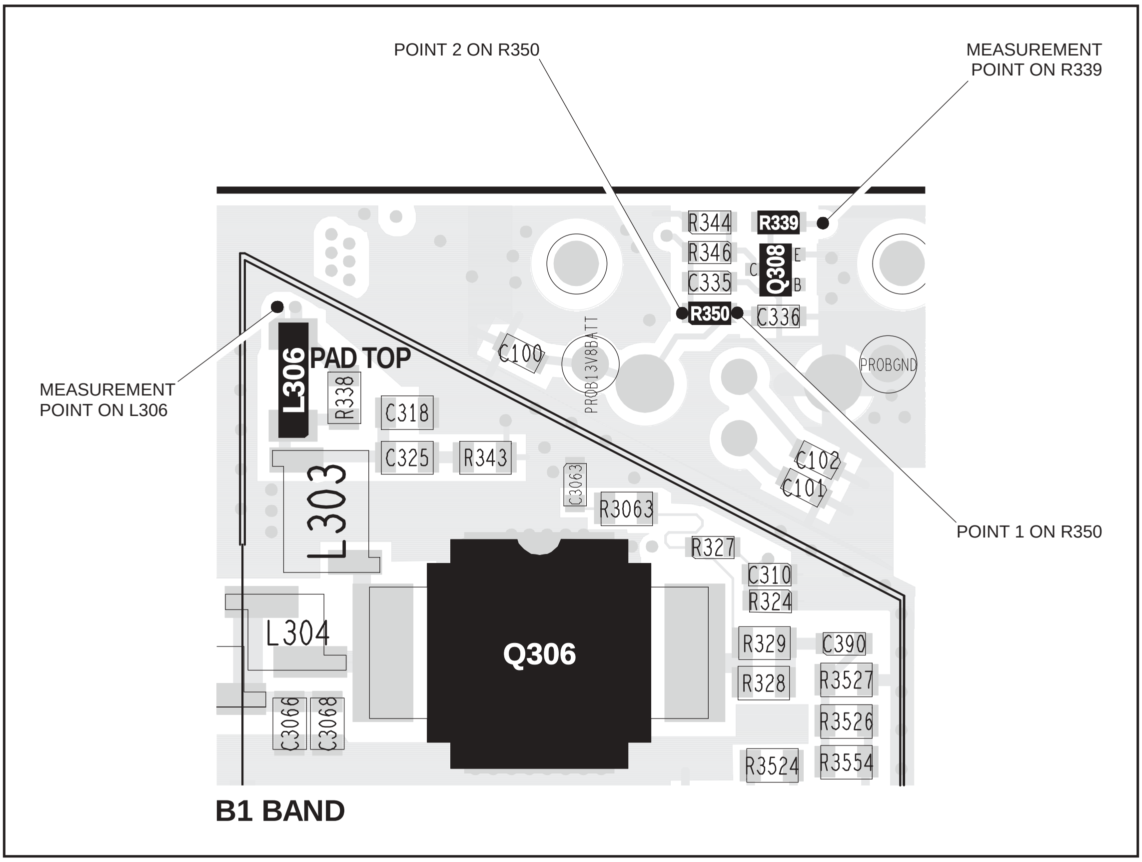
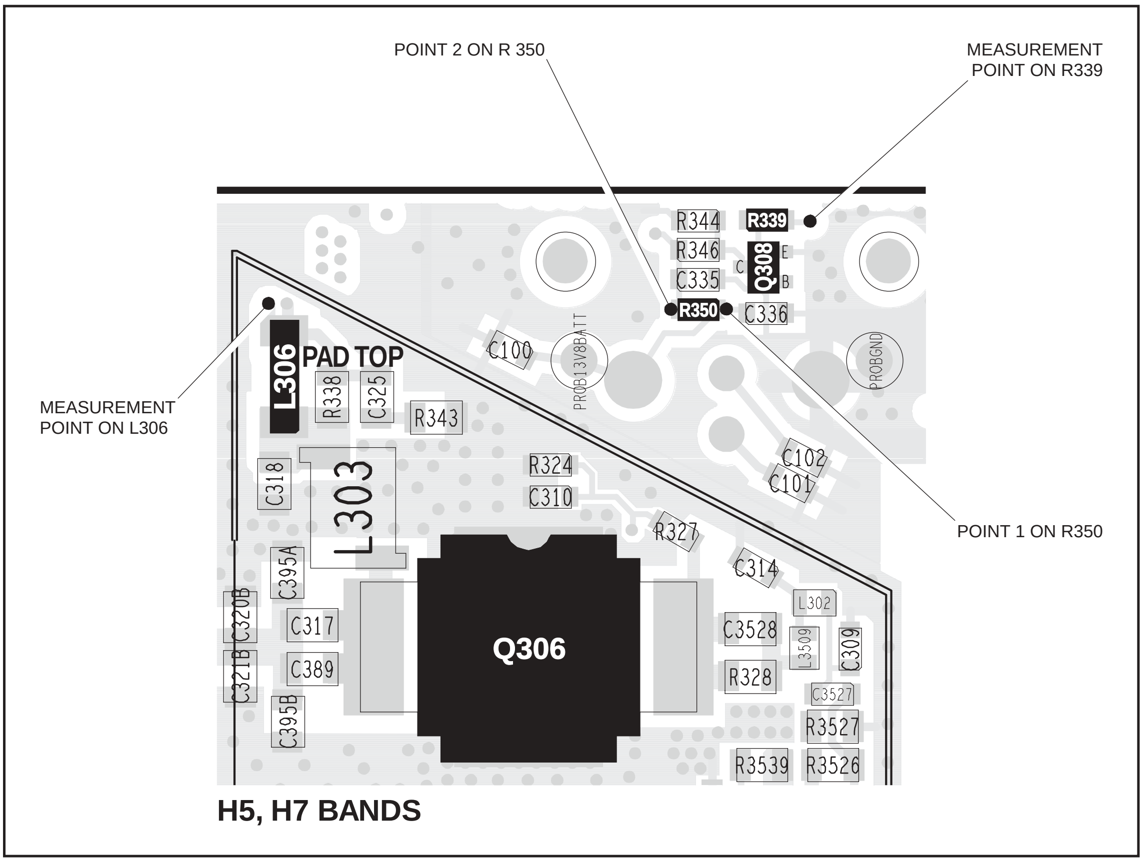


Figure 14.5 Point for measuring the power supply to the PA driver (H5 and H7 bands)



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 14.4** (B1 band) or **Figure 14.5** (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 14.4** (B1 band) or **Figure 14.5** (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 14.4** (B1 band) or **Figure 14.5** (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 14.4** (B1 band) or **Figure 14.5** (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 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 123.

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.

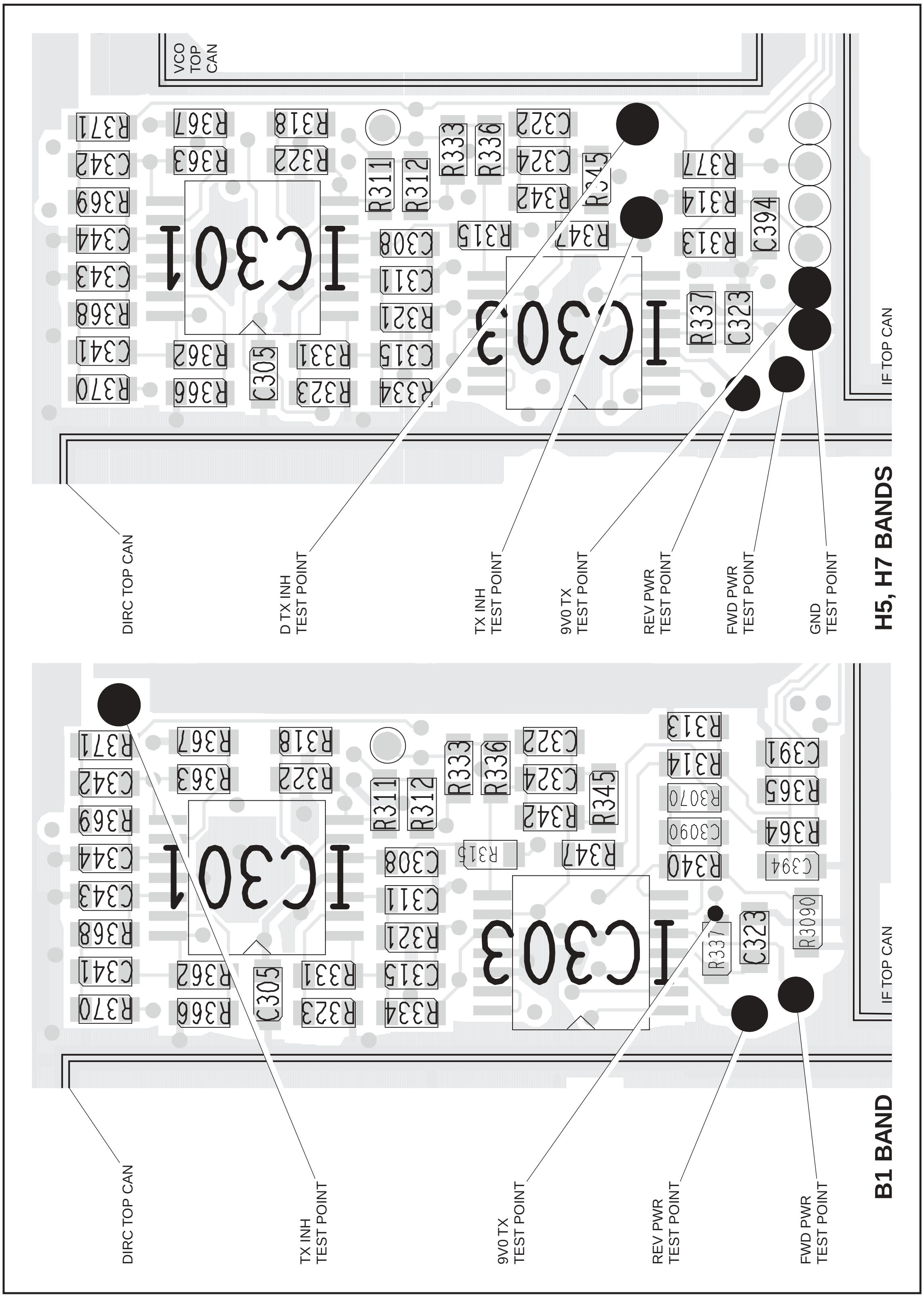
3. Measure the supply voltage between the **9V0 TX test point** and the **GND test point** (see **Figure 14.6**).

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 287. 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 132.

Figure 14.6 Test points for checking the 9V supply, the forward and reverse RF power, and the inhibiting of the transmitter



14.2 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:

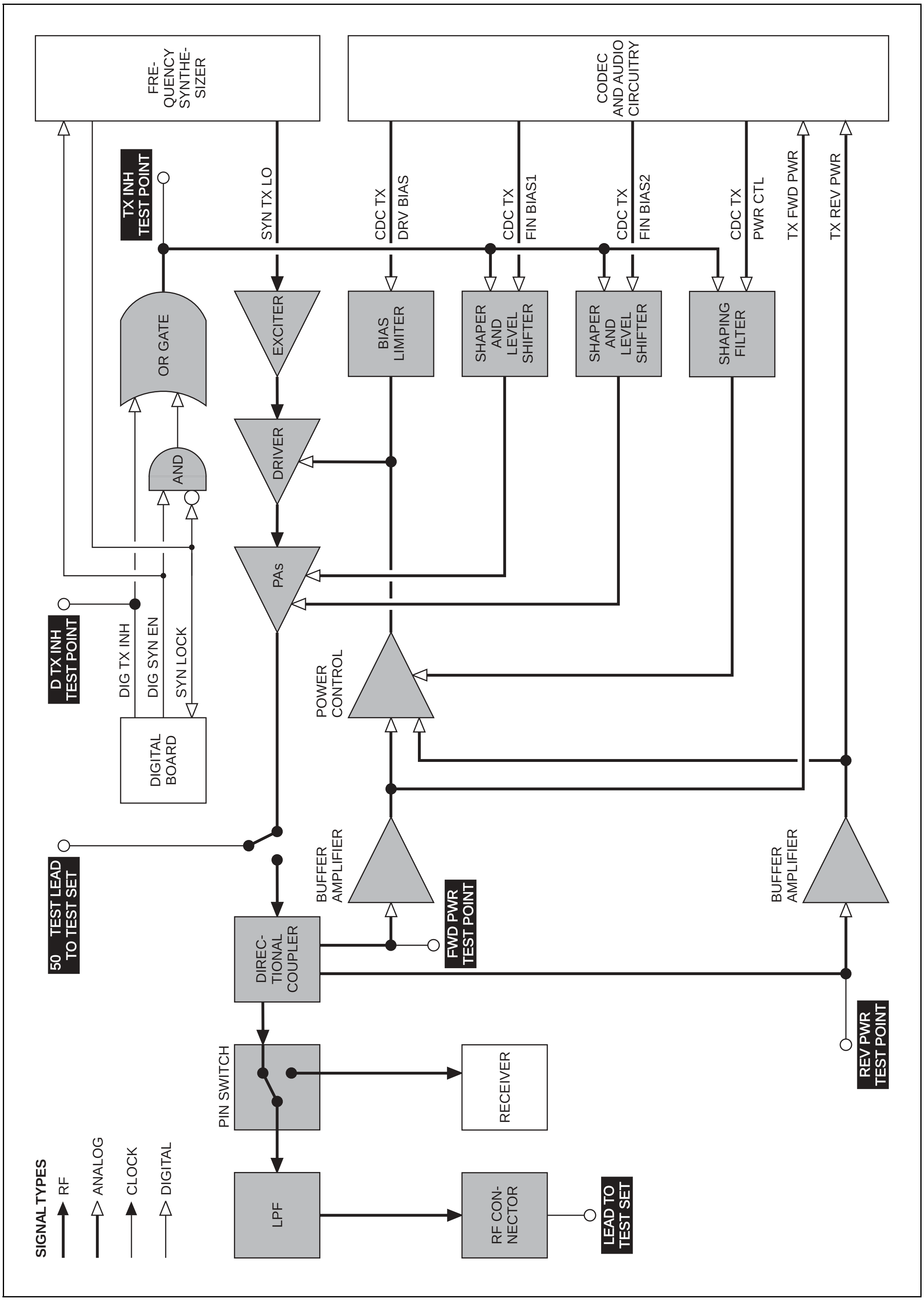
- Task 4: check forward and reverse powers
- Task 5: check RF output power
- Task 6: power unchanged regardless of setting
- Task 7: check for inhibiting of transmitter
- Task 8: check temperature sensor
- Task 9: power and current are skewed
- Task 10: repair output matching circuitry
- Task 11: power and current are low

The measurement points for diagnosing faults concerning the transmitter RF power are summarized in Figure 14.7. Data required for the first task (checking the forward and reverse powers) are supplied in Table 14.3.

Table 14.3 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 14.7 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 14.3**.
4. Confirm the above result by checking the level at the **FWD PWR test point** (see **Figure 14.6**) 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 14.3**.
6. Confirm the above result by checking the level at the **REV PWR test point** (see **Figure 14.6**) 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 14.2**.

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 centre 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 14.2**.

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 14.2**.

9. Repeat Step 3 to Step 5.

10. Depending on the results of the above measurements, proceed to the task indicated in **Table 14.4**. 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 14.4 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 14.6**). 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 297.
5. Check the logic signal at the **D TX INH test point**; see **Figure 14.18 on page 316** (B1 band) or **Figure 14.6** (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 123. If the repair failed or no fault could be found, replace the main-board assembly and go to "Final Tasks" on page 123.

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 297. 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 14.8** (B1 band) and **Figure 14.9** (H5 and H7 bands).
5. If there is no fault, go to "CODEC and Audio Fault Finding" on page 343. If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 123. If the repair failed, replace the main-board assembly, and go to "Final Tasks" on page 123.

Figure 14.8 PA circuitry under the PAF TOP can and part of the directional coupler under the DIRC TOP can (B1 band)

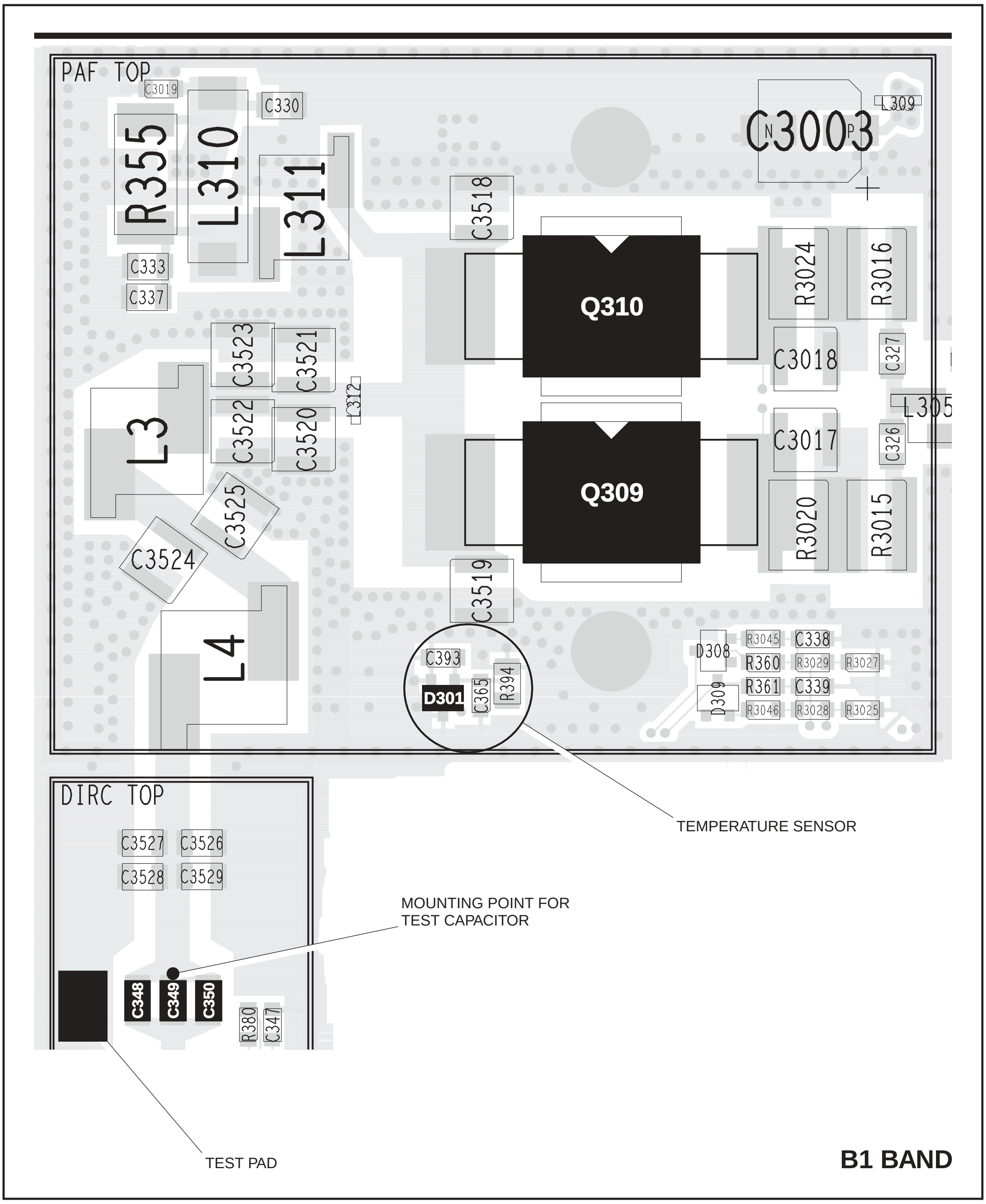
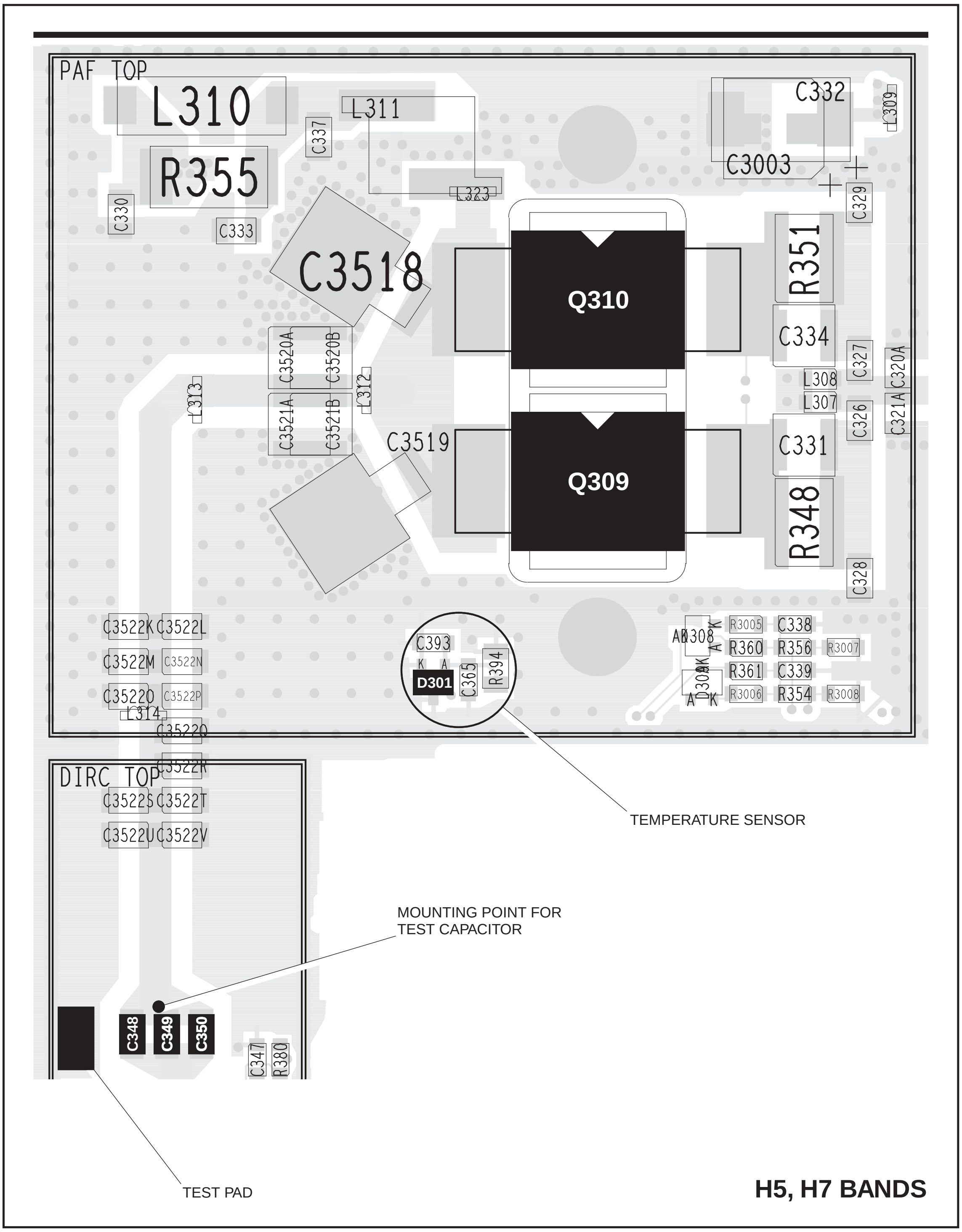


Figure 14.9 PA circuitry under the PAF TOP can and part of the directional coupler under the DIRC TOP can (H5 and H7 bands)



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 14.8** (B1) and **Figure 14.9** (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 14.8** and **Figure 14.9**. 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 14.8** and **Figure 14.9**, 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 centre 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 14.8** and **Figure 14.9**). 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 centre 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 14.8** and **Figure 14.9**).
12. If the power and current are now correct at all three frequencies, the fault has been rectified; go to "Final Tasks" on page 123. If they are not, go to Task 26 in "RF Signal Path" on page 321.

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 14.5**.
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 14.5**.
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 320. If it is not, carry out Task 12 and then Task 16.

Table 14.5 RF output power of individual RF power amplifiers at different frequencies

Frequency band	Frequency within band		
	Lowest frequency	Centre frequency	Highest frequency
B1	38 ± 5W	48 ± 5W	33 ± 5W
H5	16 ± 5W	17 ± 5W	21 ± 5W
H7	25 ± 5W	32 ± 5W	40 ± 5W

14.3 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

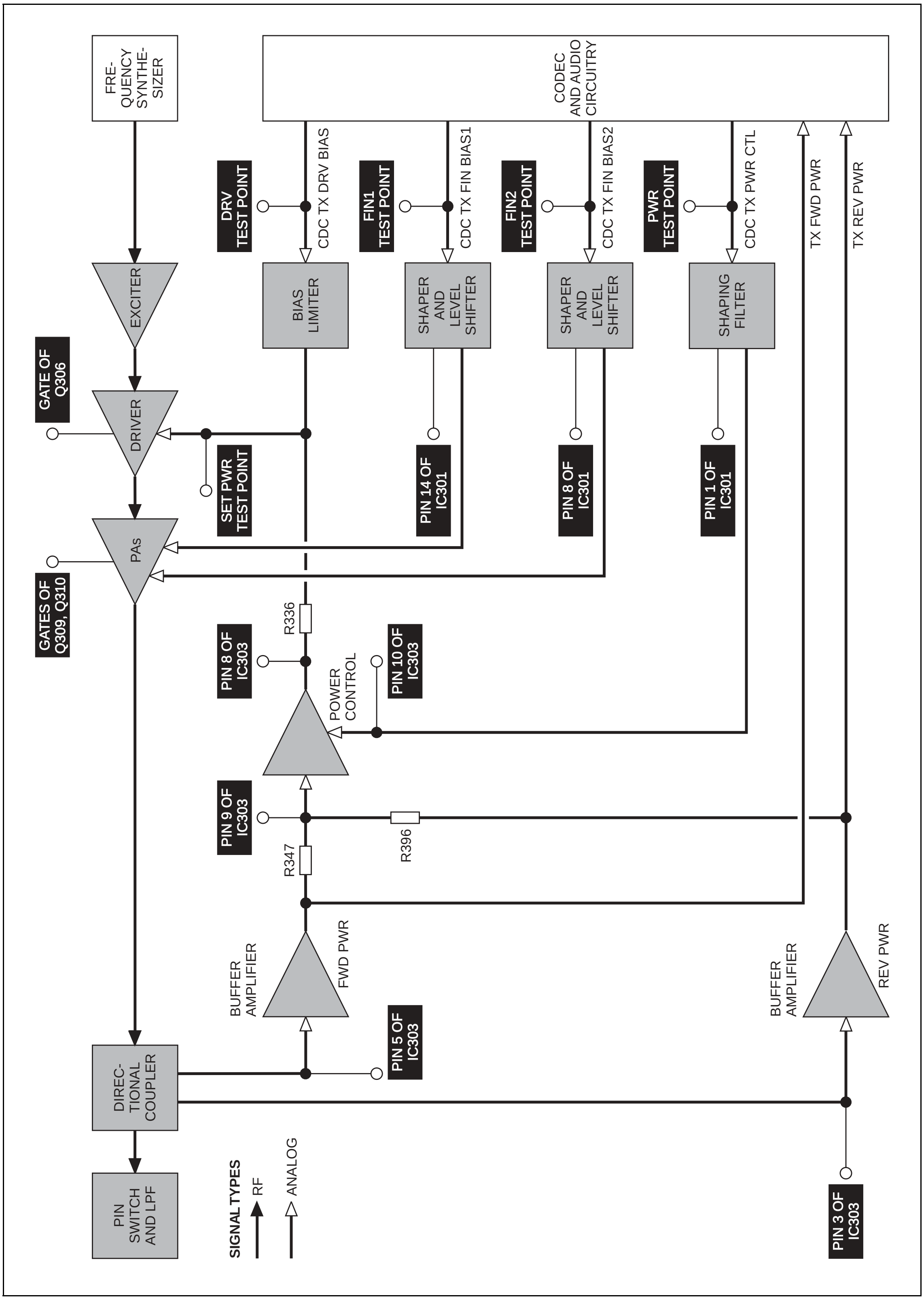
The test and measurement points for diagnosing faults in the biasing of the PAs and PA driver are summarized in Figure 14.10.

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 14.10 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 14.11** and **Figure 14.12**). 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 14.6**.

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 14.6 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 14.11 Test points and components of the shaping filter (B1 band)

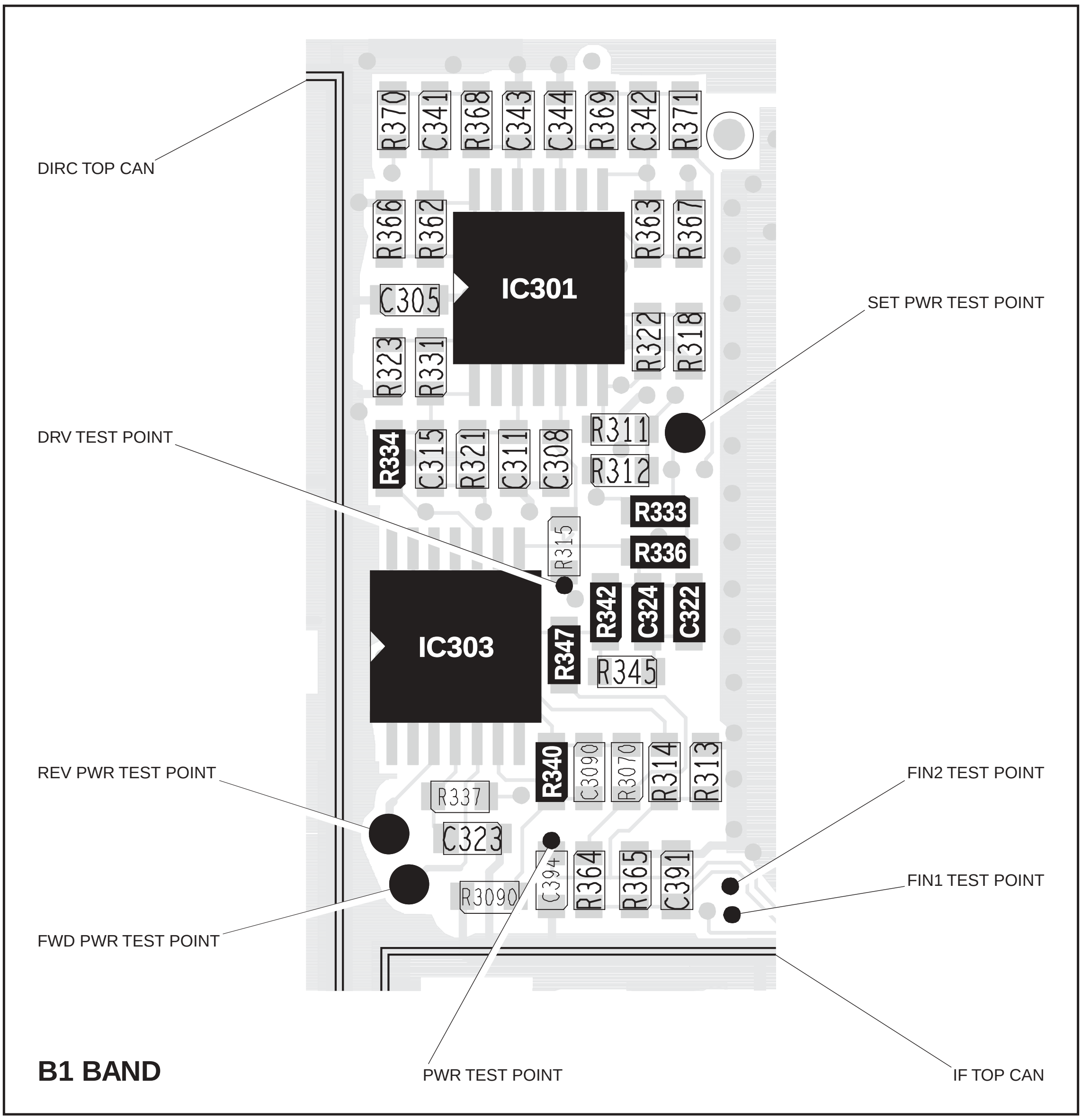
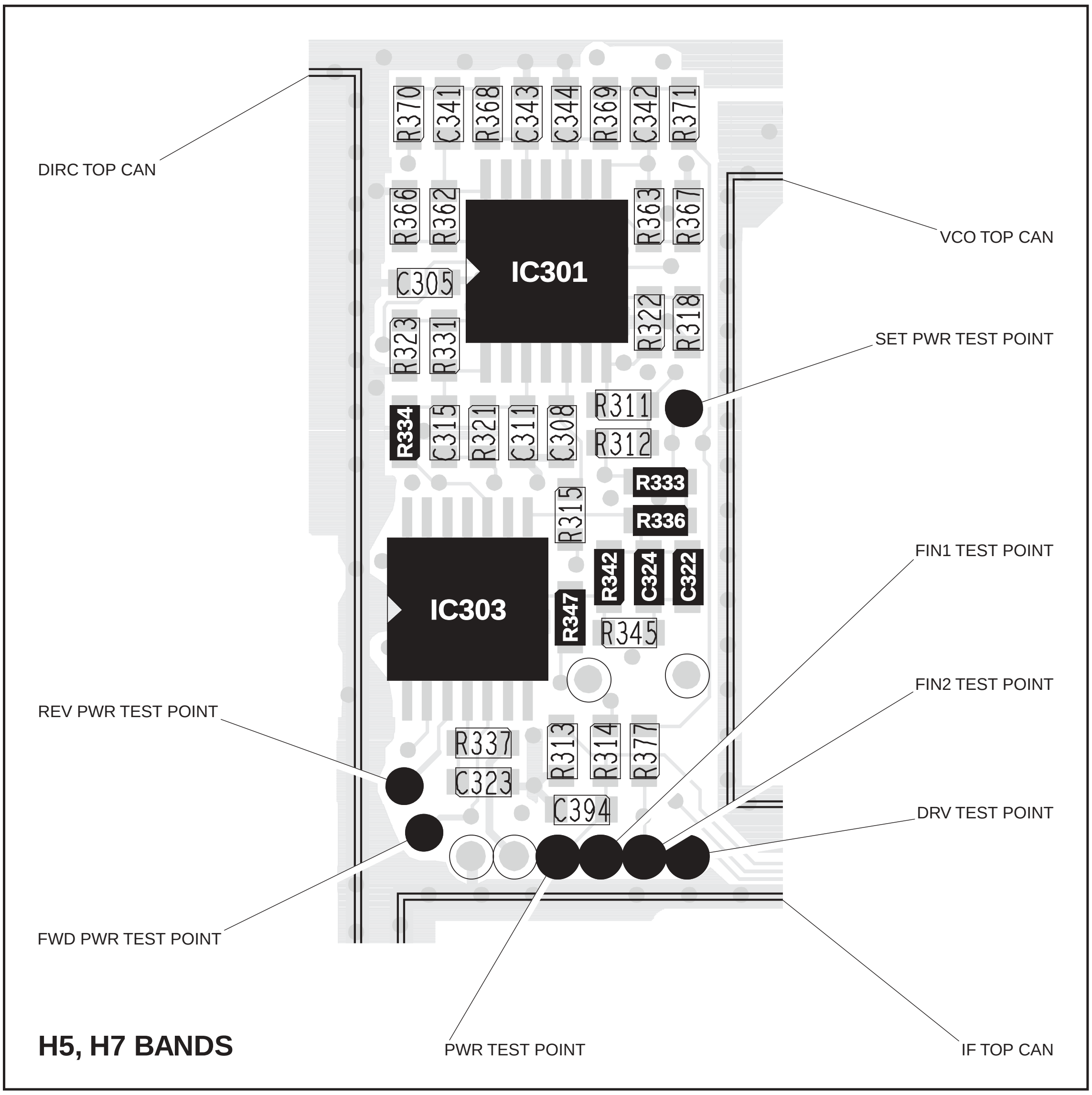


Figure 14.12 Test points and components of the shaping filter (H5 and H7 bands)



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 14.13** and **Figure 14.14**):

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 123. 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 14.13** and **Figure 14.14**). If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 123. If the repair failed or Q310 itself is faulty, replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 14.13 PA circuitry under the PAF TOP can (B1 band)

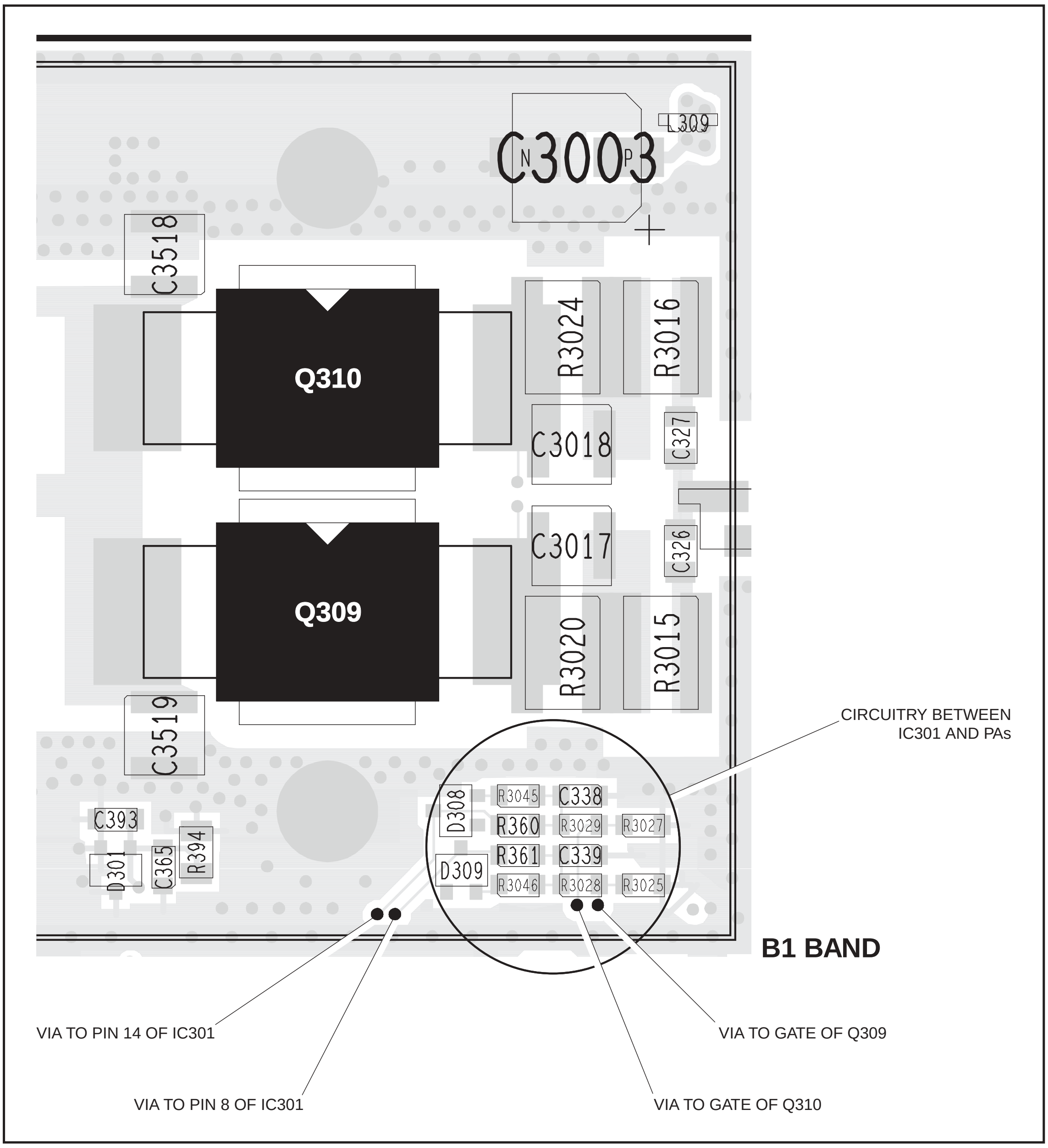
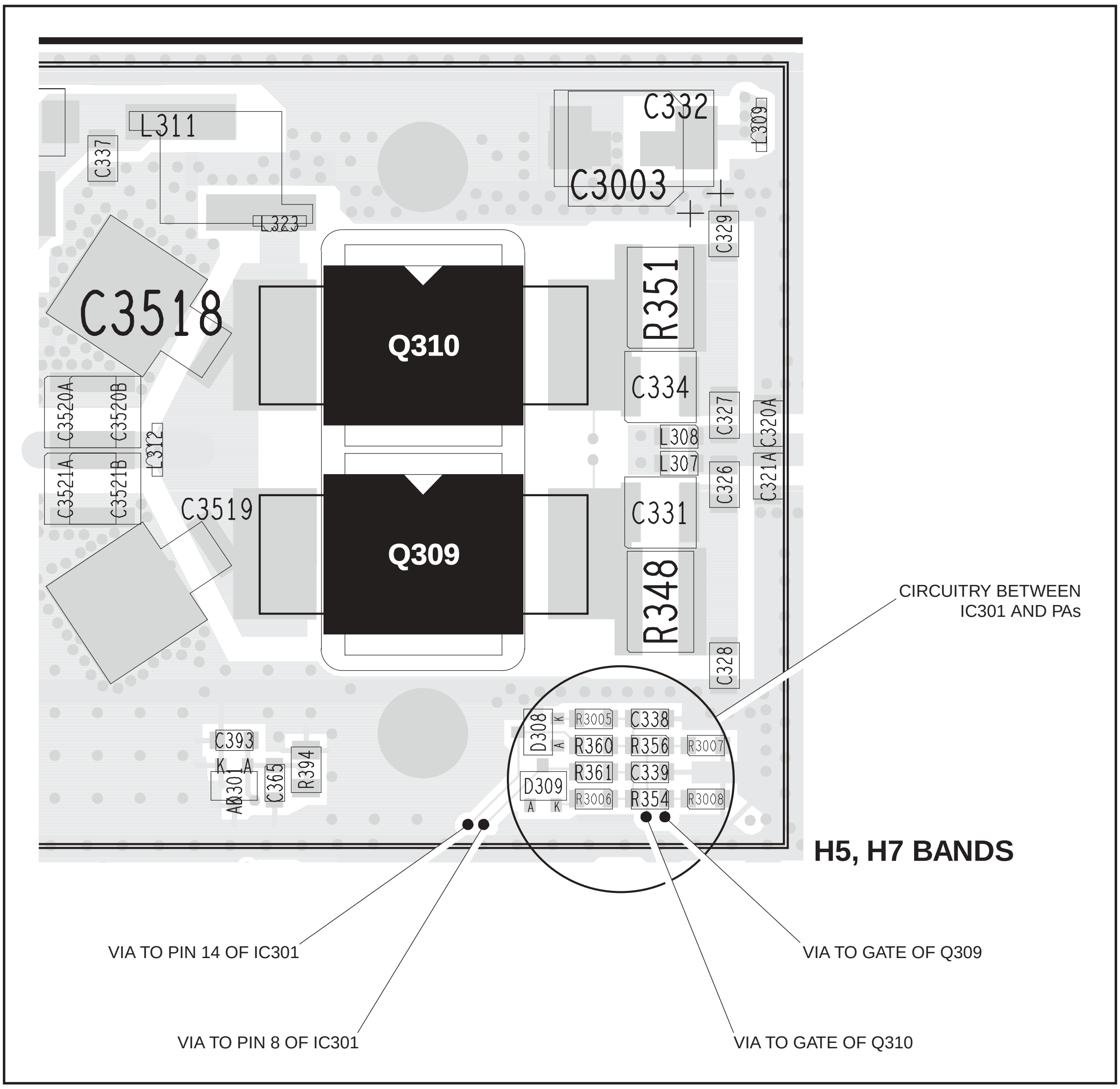


Figure 14.14 PA circuitry under the PAF TOP can (H5 and H7 bands)



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 14.11** and **Figure 14.12**). 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 343.

6. Check **IC301** and the surrounding shaping-filter circuitry (see **Figure 14.11** and **Figure 14.12**). If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 123. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 123.

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 14.11** and **Figure 14.12**). The voltage should be:

pin 8 of IC301: < 100mV (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 500mA.

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 14.6**.

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 14.13** and **Figure 14.14**):

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 123. If it is not, go to Step 9.

9. Check the circuitry between pin 8 of **IC301** and the gate of **Q309** (see **Figure 14.13** and **Figure 14.14**). If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 123. If the repair failed or Q309 itself is faulty, replace the main-board assembly and go to "Final Tasks" on page 123.

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 14.11** and **Figure 14.12**). 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 343.

6. Check **IC301** and the surrounding shaping-filter circuitry (see **Figure 14.11** and **Figure 14.12**). If a fault is found, repair it, confirm the removal of the fault, and go to "Final Tasks" on page 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

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 14.6**. 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 14.11** and **Figure 14.12**). 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 343.

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 14.11** and **Figure 14.12**):

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 14.15** and **Figure 14.16**):

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 123. If it is not, go to Task 23.

Figure 14.15 PA driver circuitry under the PAD TOP can (B1 band)

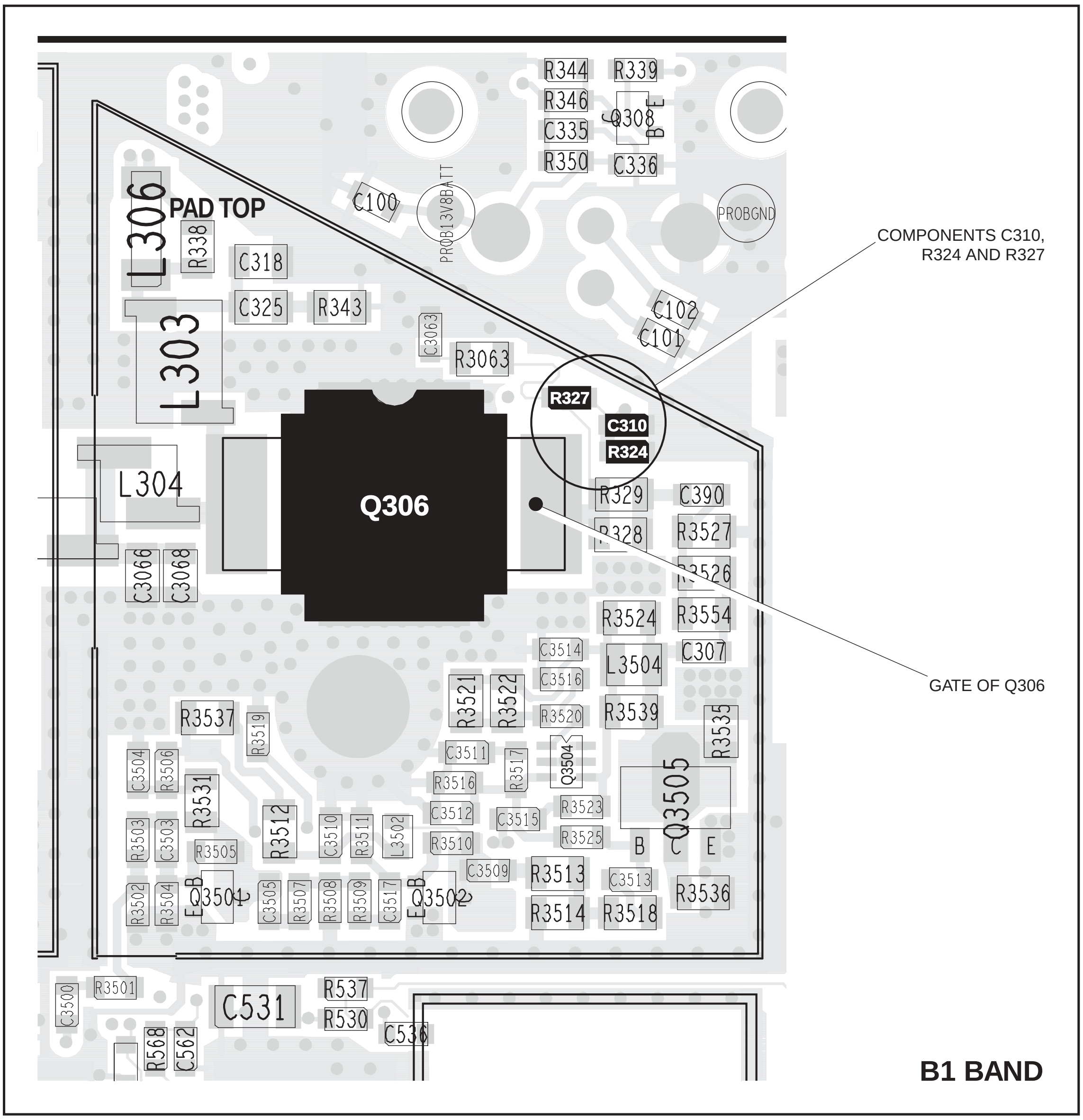
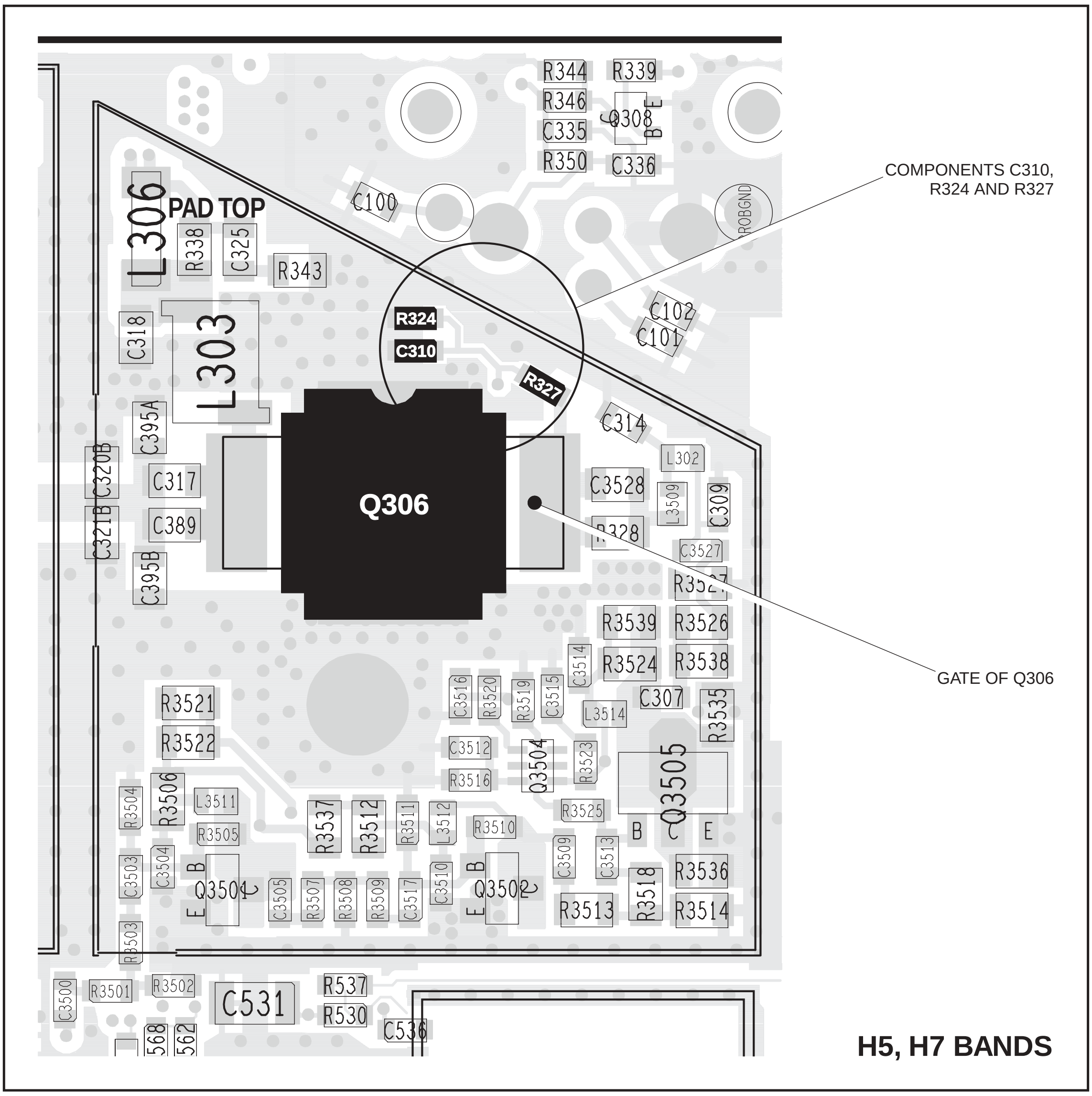


Figure 14.16 PA driver circuitry under the PAD TOP can (H5 and H7 bands)



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.

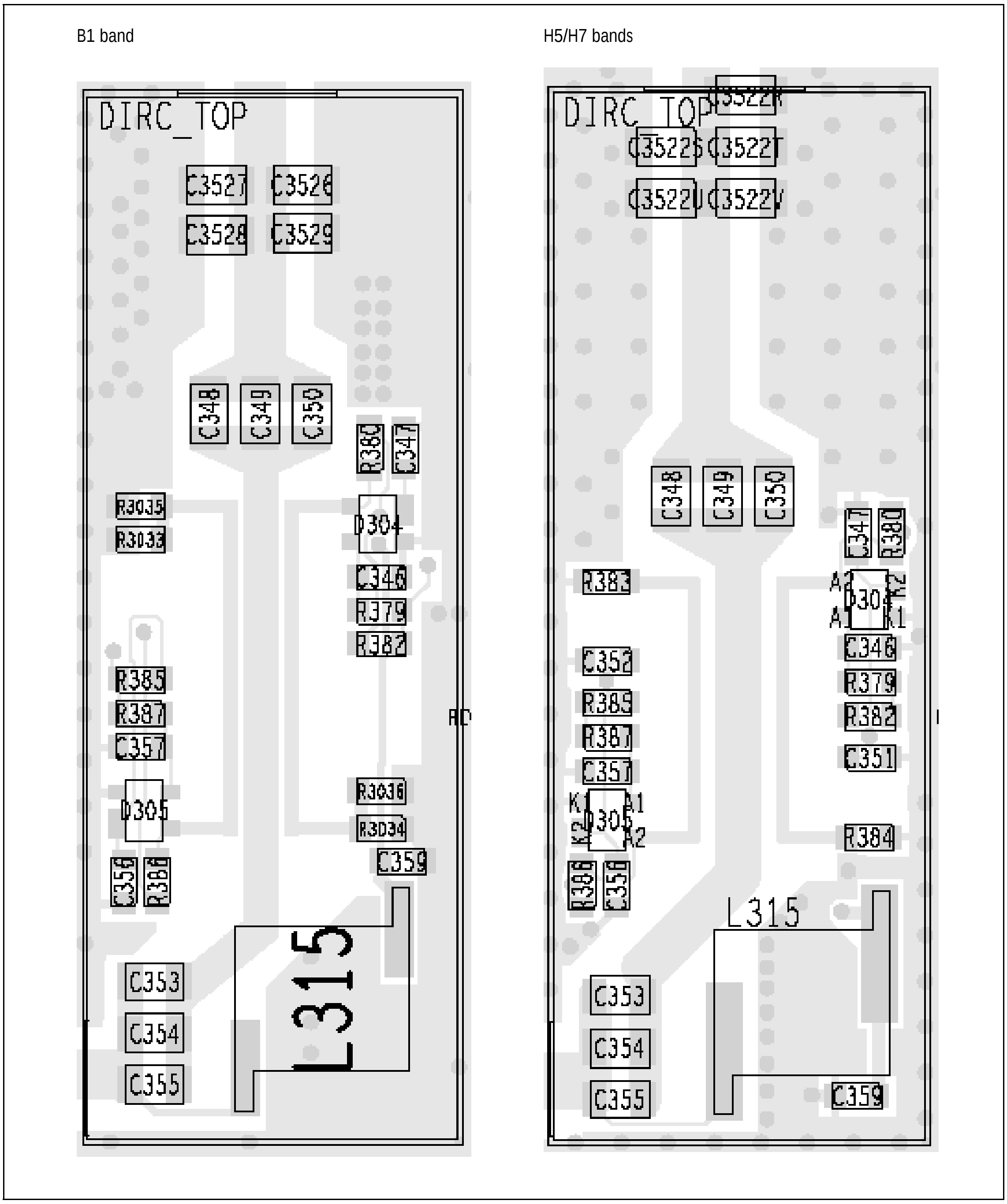
Important Ensure that the current limit on the DC supply is 3A. And, when entering the CCTM command *304* ***z***, do not specify a value ***z*** higher than that recorded in Task 12. Failure to do so might result in the destruction of the PA driver.

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 14.6**. If it does, go to Task 26 in "RF Signal Path" on page 321. 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 14.11** and **Figure 14.12**).
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 343.

Figure 14.17 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 14.11** and **Figure 14.12**).
4. The above voltage should be as given in **Table 14.7**. 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 14.11** and **Figure 14.12**). 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 14.7**. 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 14.7 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 14.17**) and go to Step 11.
9. Remove the DIRC TOP can. Check **D305** and **R3035** (B1) or **R383** (H5, H7) (see **Figure 14.17**). 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 14.11**, **Figure 14.18** and **Figure 14.19**).

11. Repair any fault revealed by the above checks. Replace **IC303** if none of the other components is faulty (see **Figure 14.11** and **Figure 14.12**).

12. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

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 14.11** and **Figure 14.12**), **C310**, **R324** and **R327** (see **Figure 14.15** and **Figure 14.16**) 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 14.15** and **Figure 14.16**).

3. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 14.18 Components of concern on the bottom-side of the main board (B1 band)

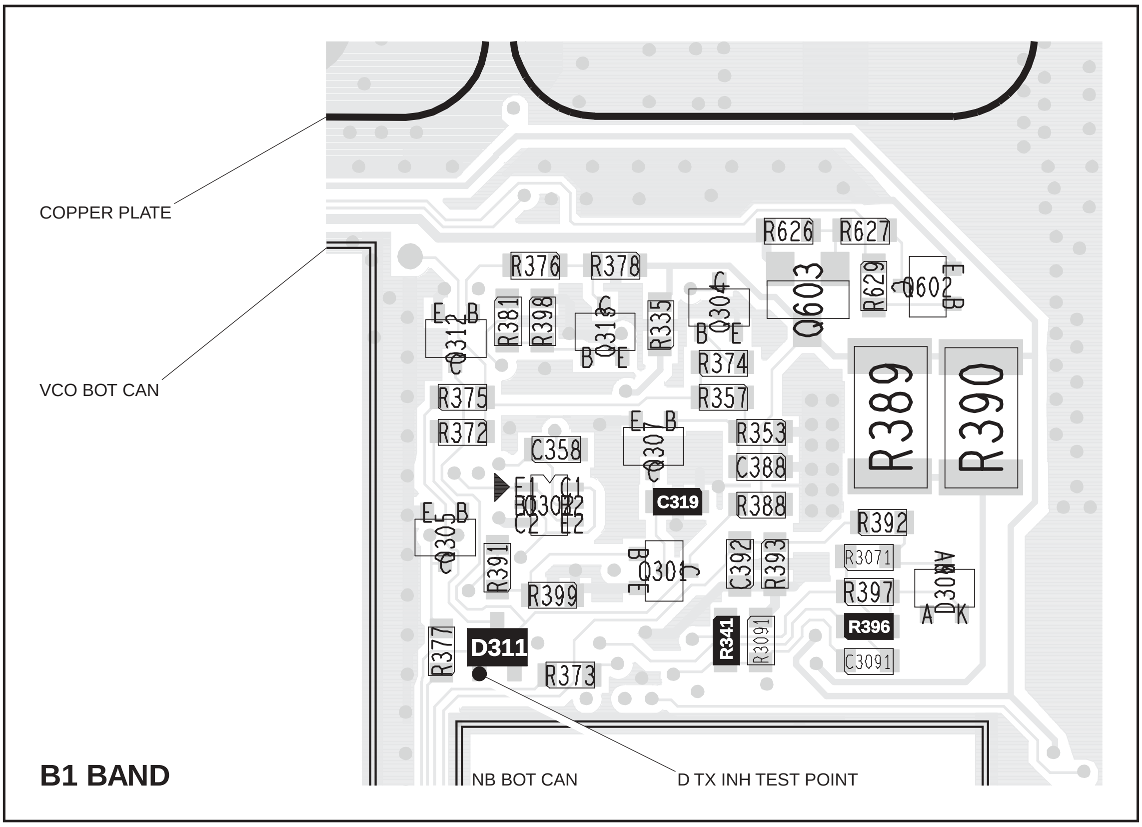
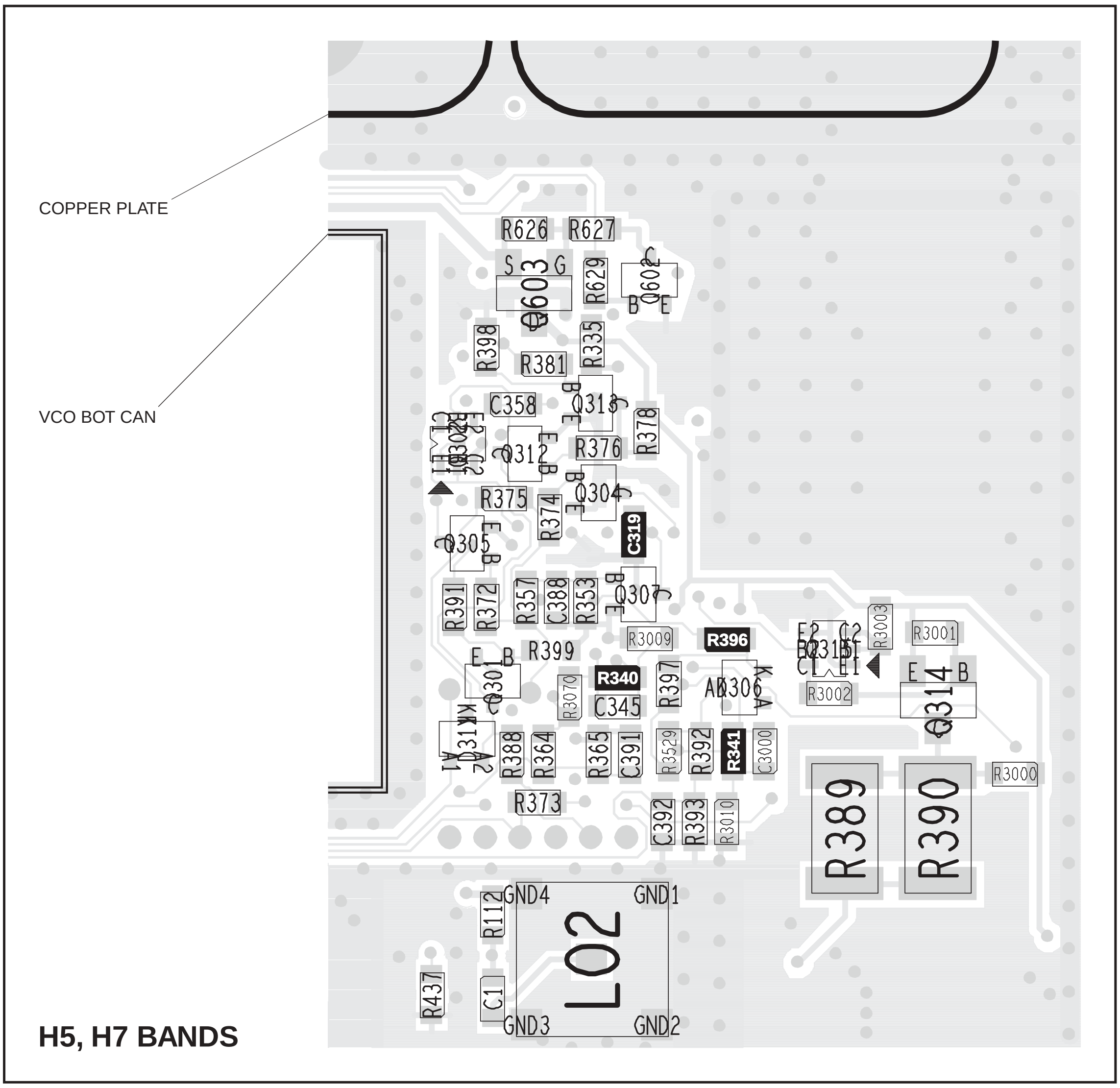


Figure 14.19 Components of concern on the bottom-side of the main board (H5 and H7 bands)



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 14.11** and **Figure 14.12**) 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 14.11** and **Figure 14.12**) and **R396** (see **Figure 14.18** and **Figure 14.19**) 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 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

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 14.11** and **Figure 14.12**) 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 14.11** and **Figure 14.12**) and **C319** (see **Figure 14.18** and **Figure 14.19**) and go to Step 6.

5. Check the components between the **PWR test point** and pin 1 of **IC301** (see **Figure 14.11** and **Figure 14.12**) 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 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

14.4 RF Signal Path

Introduction

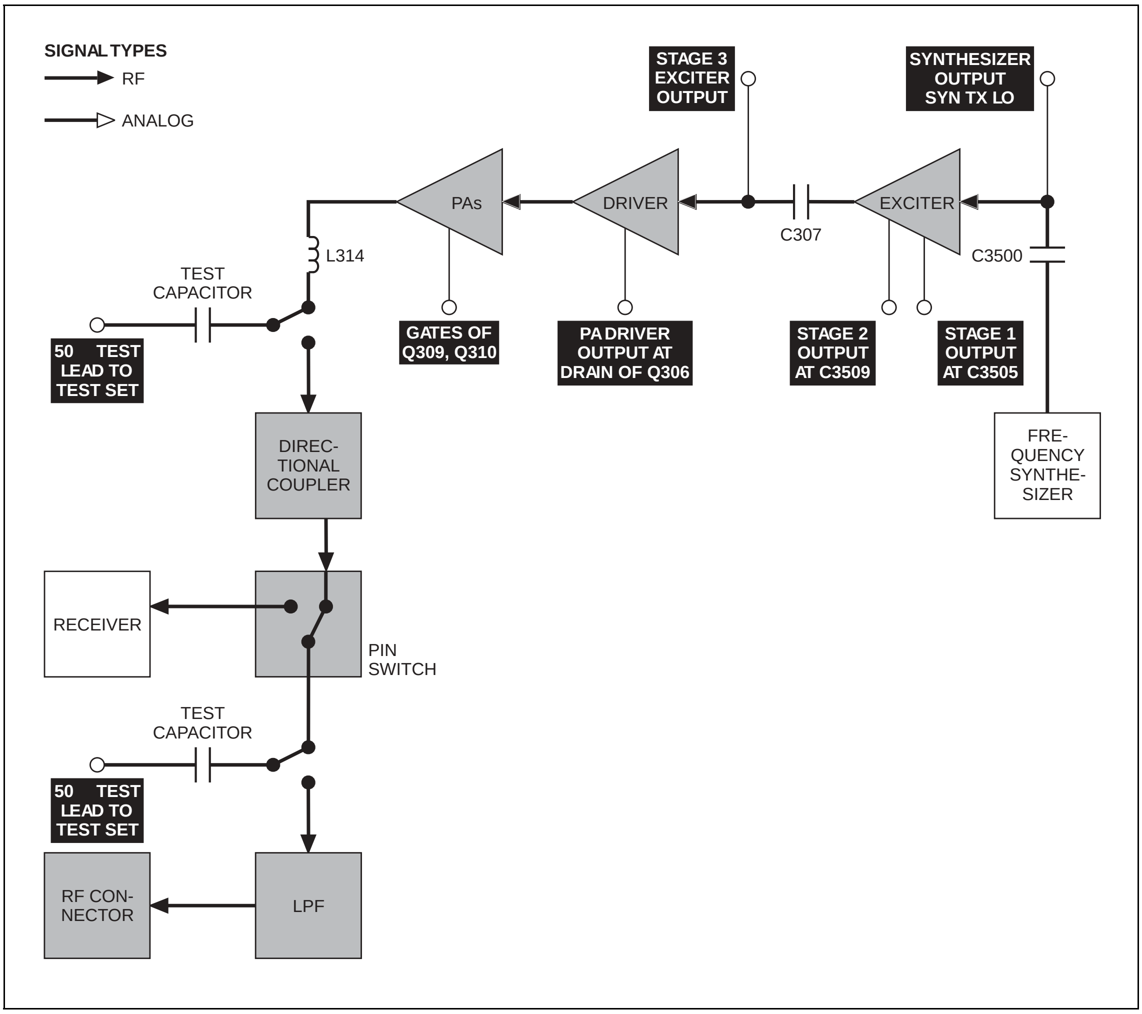
The RF signal path extends from the output of the frequency synthesizer to the LPF. This section of circuitry will require investigation either following certain checks in "Transmitter RF Power" or if the biasing checks of "Biasing of PA Driver and PAs" reveal no fault. The procedure is divided into 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 14.20.

Figure 14.20 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 14.8** (B1 band), **Table 14.9** (H5) or **Table 14.10** (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 14.21** and **Figure 14.22**). Earth the probe to the FCL TOP can adjacent to the PA driver circuitry. The required voltage should be as given in **Table 14.8** (B1 band), **Table 14.9** (H5) or **Table 14.10** (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 14.21** and **Figure 14.22**). If C3500 is not faulty, go to “Frequency Synthesizer Fault Finding” on page 143. If C3500 is faulty, replace it and return to Step 2.

Figure 14.21 PA driver circuitry under the PAD TOP can (B1 band)

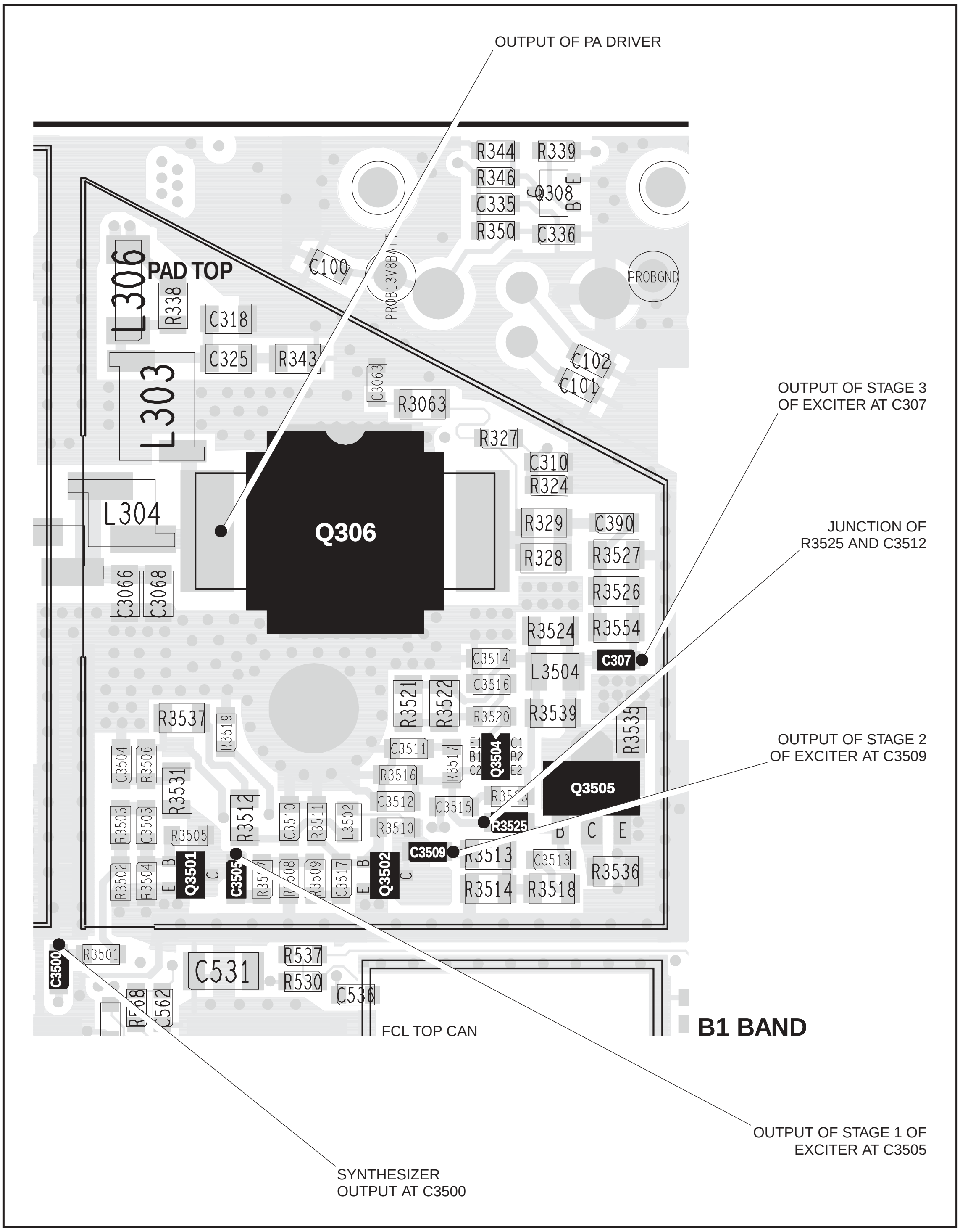


Figure 14.22 PA driver circuitry under the PAD TOP can (H5 and H7 bands)

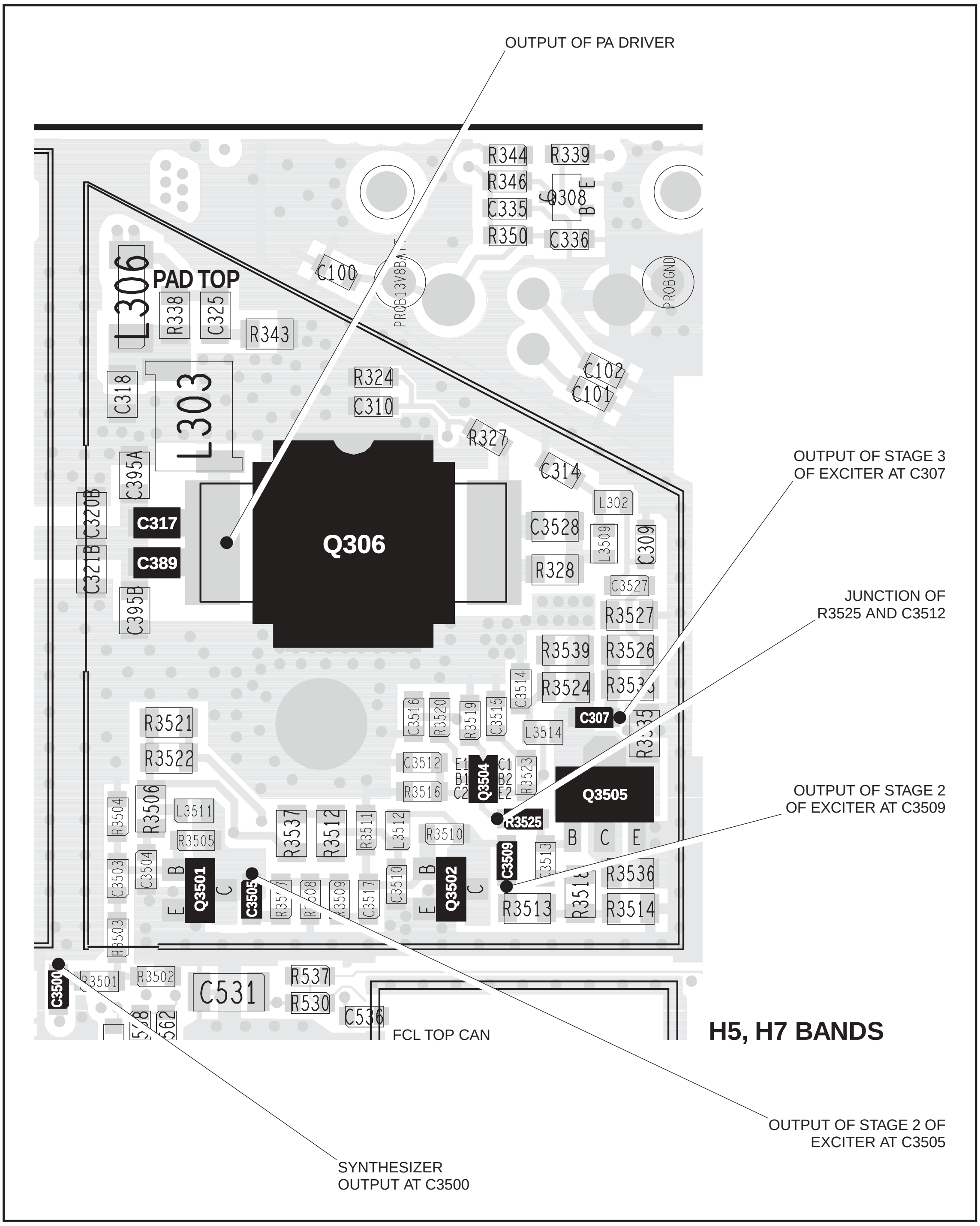


Table 14.8 RF voltages along the initial RF signal path of the VHF radio (B1 band)

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 14.9 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 14.10 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 14.21** and **Figure 14.22**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 14.8** (B1 band), **Table 14.9** (H5) or **Table 14.10** (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 14.21** and **Figure 14.22**).
9. Repair any fault revealed by the above checks. Replace **Q3501** (see **Figure 14.21** and **Figure 14.22**) if none of the other components is faulty.
10. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

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 14.21** and **Figure 14.22**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 14.8** (B1 band), **Table 14.9** (H5) or **Table 14.10** (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 14.21** and **Figure 14.22**).

5. Repair any fault revealed by the above checks. Replace **Q3502** (see **Figure 14.21** and **Figure 14.22**) if none of the other components is faulty.

6. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

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 14.21** and **Figure 14.22**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 14.8** (B1 band), **Table 14.9** (H5) or **Table 14.10** (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 14.21** and **Figure 14.22**). 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 14.21** and **Figure 14.22**). 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 14.21** and **Figure 14.22**). 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 123. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 123.

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 14.21**) or after **C317** and **C389** (H5, H7 — see **Figure 14.22**). (Use an RFP5401A RF probe or the equivalent.) The required voltage should be as given in **Table 14.8** (B1), **Table 14.9** (H5) or **Table 14.10** (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 14.21** and **Figure 14.22**).
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 297.
6. Repair the fault. Confirm the removal of the fault and go to “Final Tasks” on page 123. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 123.
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 14.23** and **Figure 14.24**).
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 14.23** and **Figure 14.24**).
13. If a fault is found, repair it, confirm the removal of the fault, and go to “Final Tasks” on page 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 123.

Figure 14.23 Components of the interstage matching circuitry between the PA driver Q306 and the PAs Q309 and Q310 (B1 band)

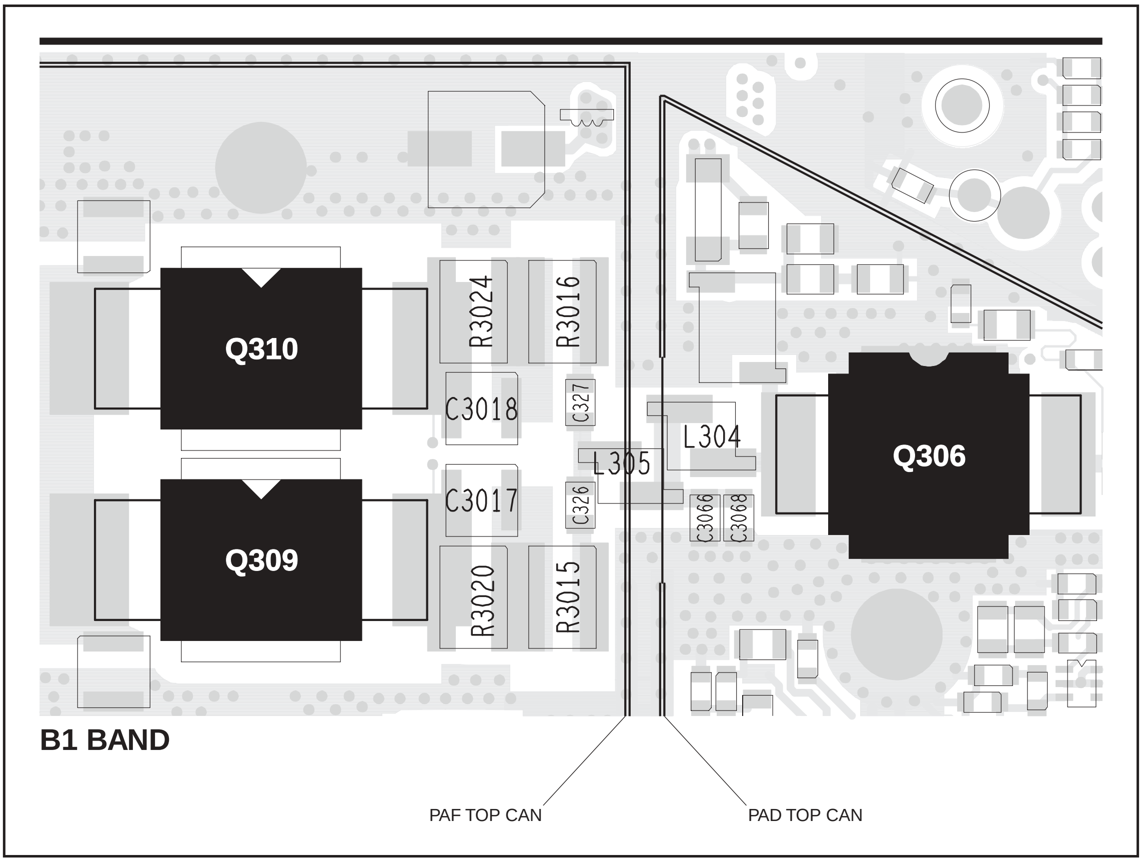
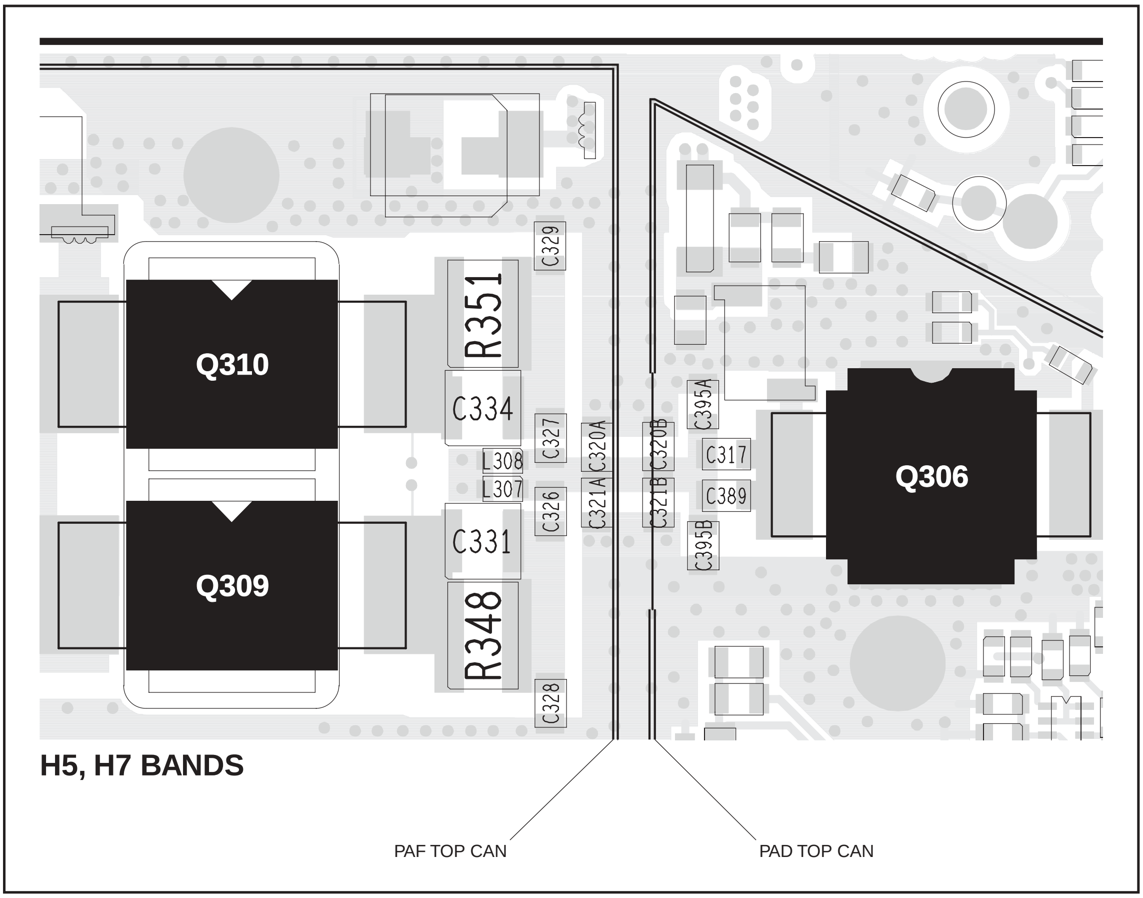


Figure 14.24 **Components of the interstage matching circuitry between the PA driver Q306 and the PAs Q309 and Q310 (H5 and H7 bands)**



Task 31 — Check Power at Directional Coupler

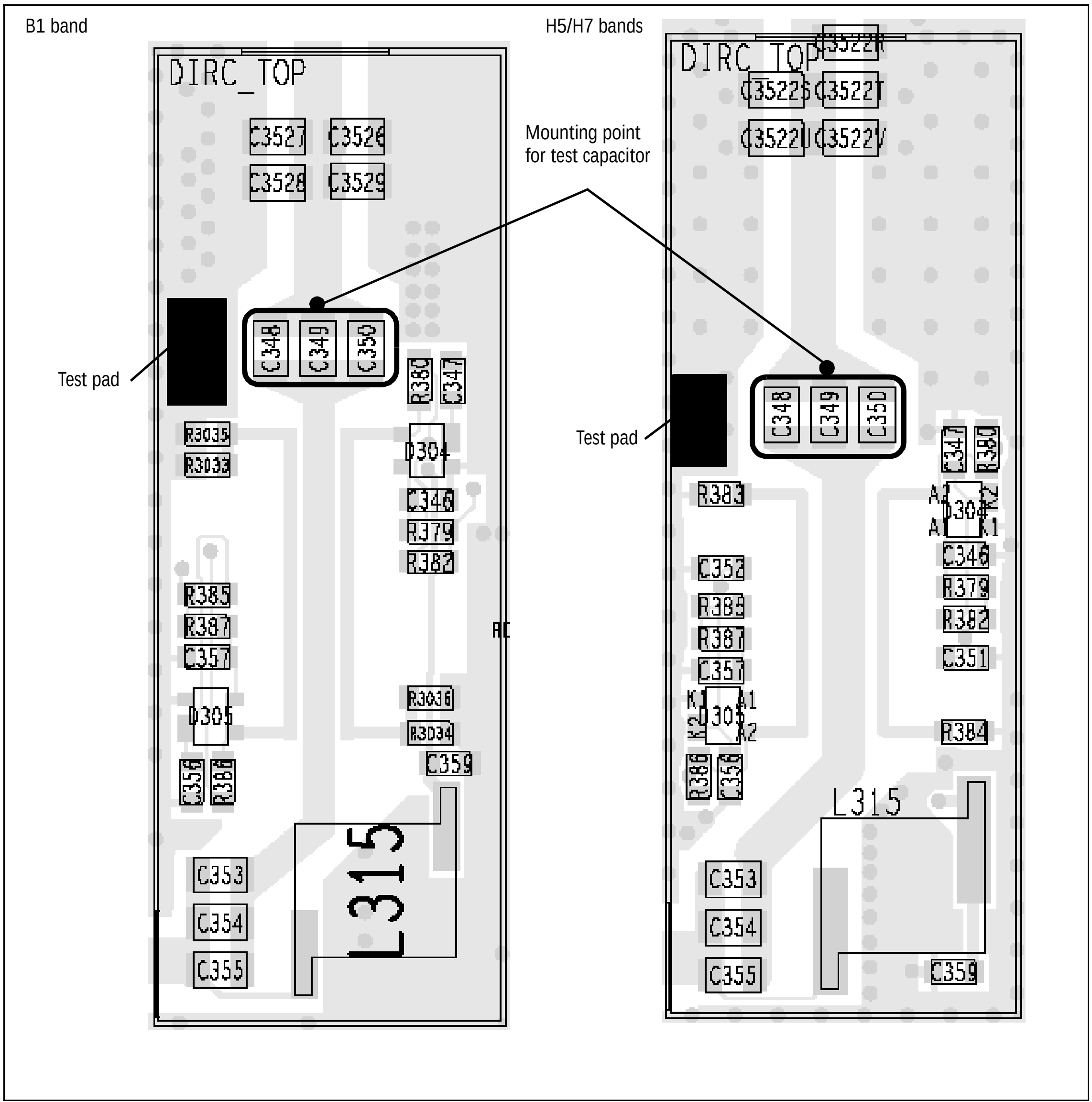
If, as determined in Task 26 to Task 30, there is no fault in the initial RF signal path, investigate the final signal path. This part of the circuitry may also require investigation following certain checks in "Transmitter RF Power". Begin by checking the directional coupler as follows:

1. If not already done, remove the DIRC TOP can.
2. Remove the coupling capacitors **C348**, **C349**, **C350** (see **Figure 14.25**).
3. Solder one terminal of an 82pF (H5, H7 bands) or 680pF (B1) test capacitor to the PCB at the point shown in **Figure 14.25**. 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 14.25**, 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 14.8** (B1 band), **Table 14.9** (H5) or **Table 14.10** (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 14.8** (B1 band), **Table 14.9** (H5) or **Table 14.10** (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 14.25 Circuitry under the DIRC TOP can, and the points for attaching the test lead and test capacitor



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 14.8** and **Figure 14.9**).

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 14.25**), 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 14.8** (B1 band), **Table 14.9** (H5) or **Table 14.10** (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 14.8** (B1 band), **Table 14.9** (H5) or **Table 14.10** (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 14.25**).

13. If the power in both the above cases is now correct, the fault has been rectified; go to "Final Tasks" on page 123. If it is not, the repair failed; replace the main-board assembly and go to "Final Tasks" on page 123.

Task 33 — Check PIN Switch

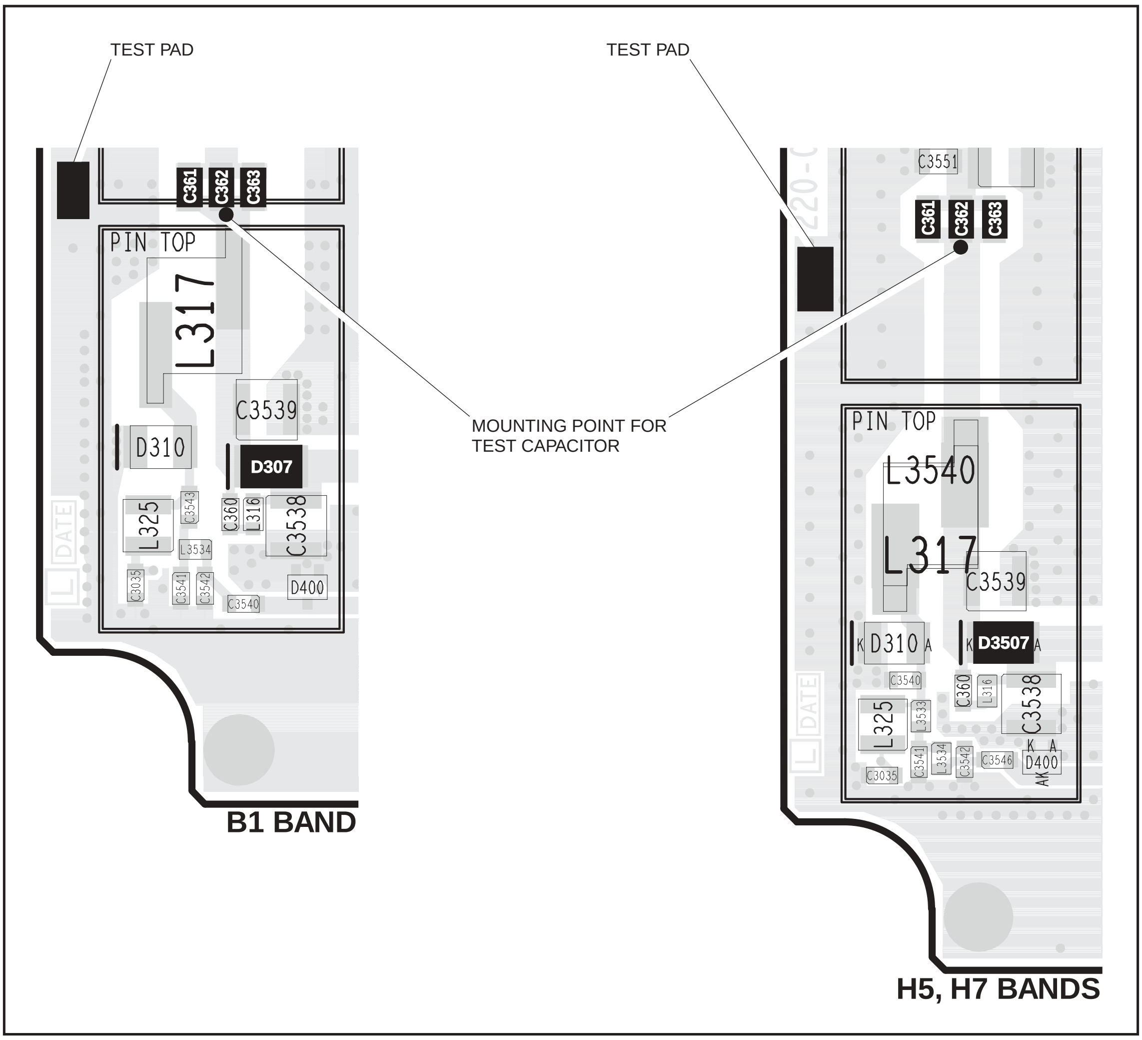
In checking the final RF signal path, if no fault is found in the directional coupler, then check the PIN switch next. The PIN switch may also require investigation following certain checks in "Transmitter RF Power".

1. Remove the LPF TOP can.
2. Remove the three blocking capacitors **C361**, **C362** and **C363** (see **Figure 14.26**).
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 14.26**. 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 14.26**, 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 14.8** (B1 band), **Table 14.9** (H5) or **Table 14.10** (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 14.8** (B1 band), **Table 14.9** (H5) or **Table 14.10** (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 14.26 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 14.26**). 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 14.27** and **Figure 14.28**):

   - 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 14.8** (B1 band), **Table 14.9** (H5) or **Table 14.10** (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 14.8** (B1 band), **Table 14.9** (H5) or **Table 14.10** (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 14.26**) 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 123. If it is not, the repair failed; replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 14.27 Components of concern on the bottom-side of the main board (B1 band)

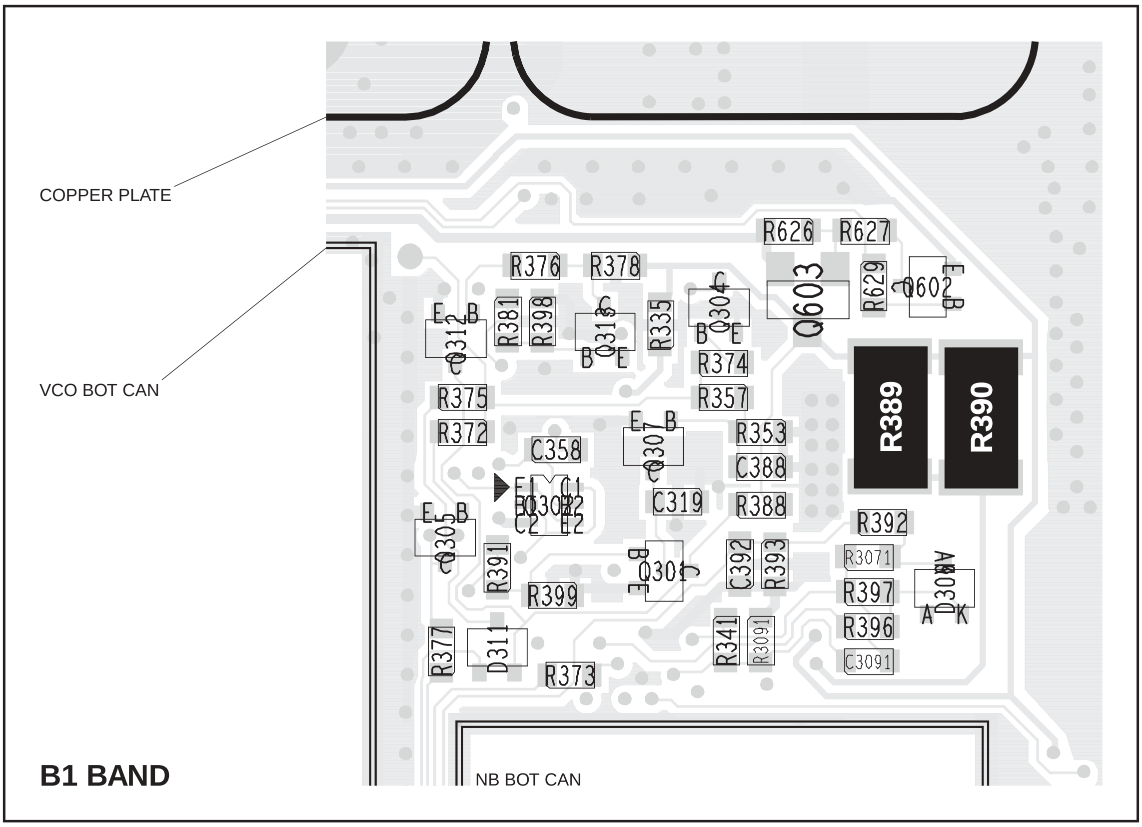


Figure 14.28 Components of concern on the bottom-side of the main board (H5 and H7 bands)

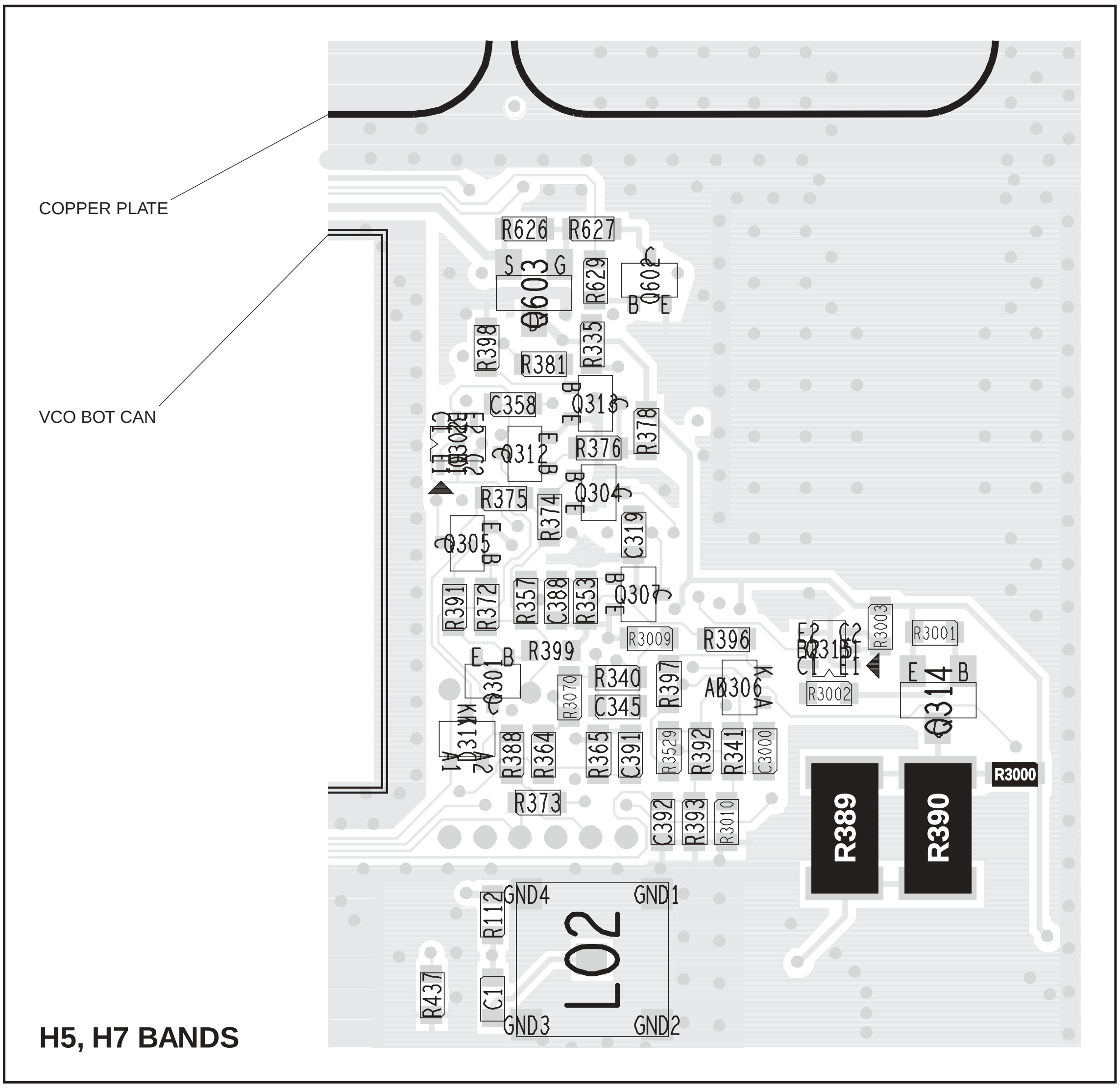
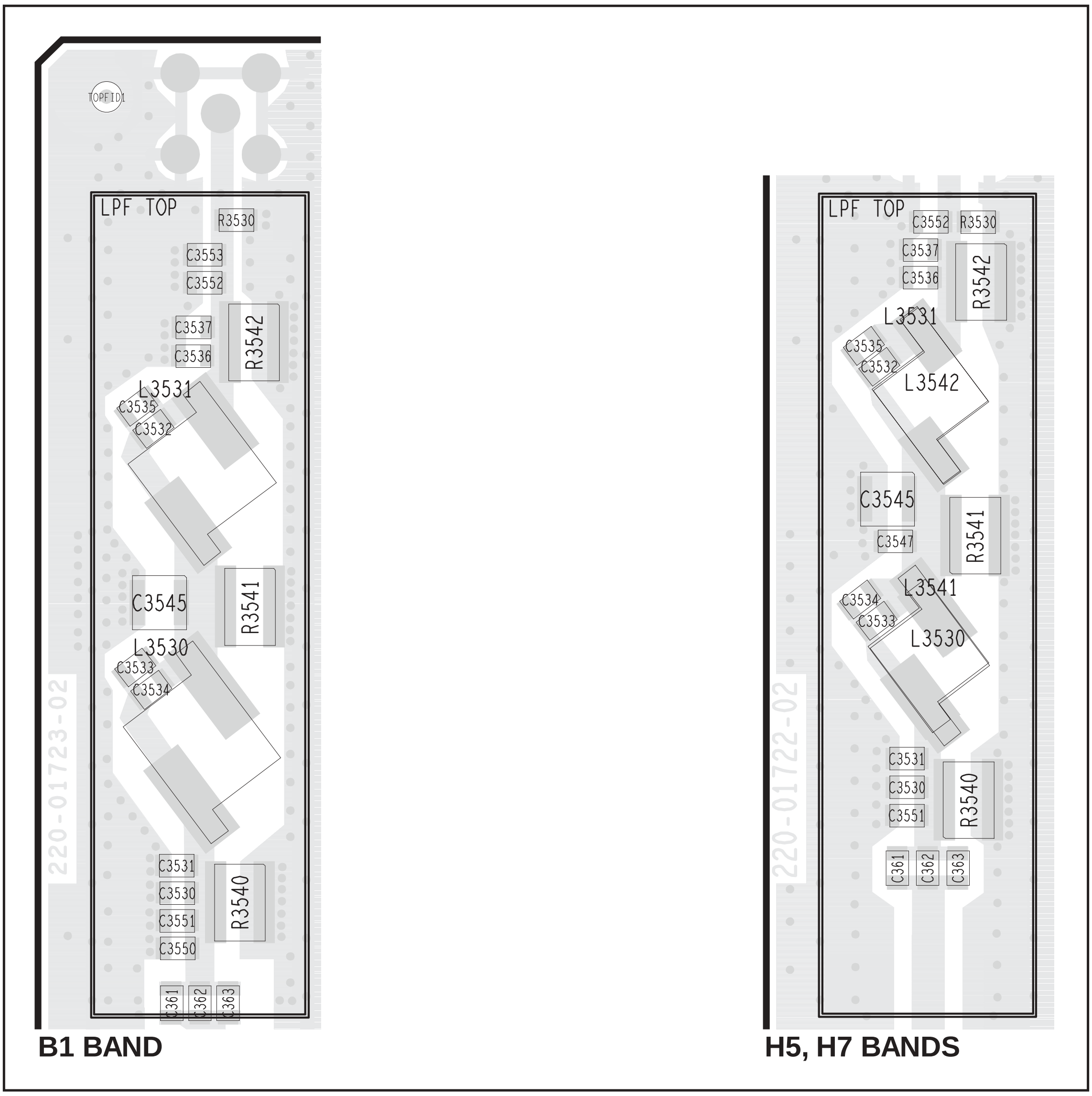


Figure 14.29 Circuitry under the LPF TOP can



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 14.29**. 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 14.8** (B1 band), **Table 14.9** (H5) or **Table 14.10** (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 14.8** (B1 band), **Table 14.9** (H5) or **Table 14.10** (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 123. If it does not, the repair failed; replace the main-board assembly and go to “Final Tasks” on page 123.

15 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 344. 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 354 and "Faulty Modulation Using Auxiliary Connector" on page 366.

CCTM commands

The CCTM commands required in this section are listed in Table 15.1. Full details of the commands are given in "Computer-Controlled Test Mode (CCTM)" on page 91.

Table 15.1 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**

15.1 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 127. 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 15.1**).

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 15.1**), 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 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 123.

Task 2 — 3V Power Supply

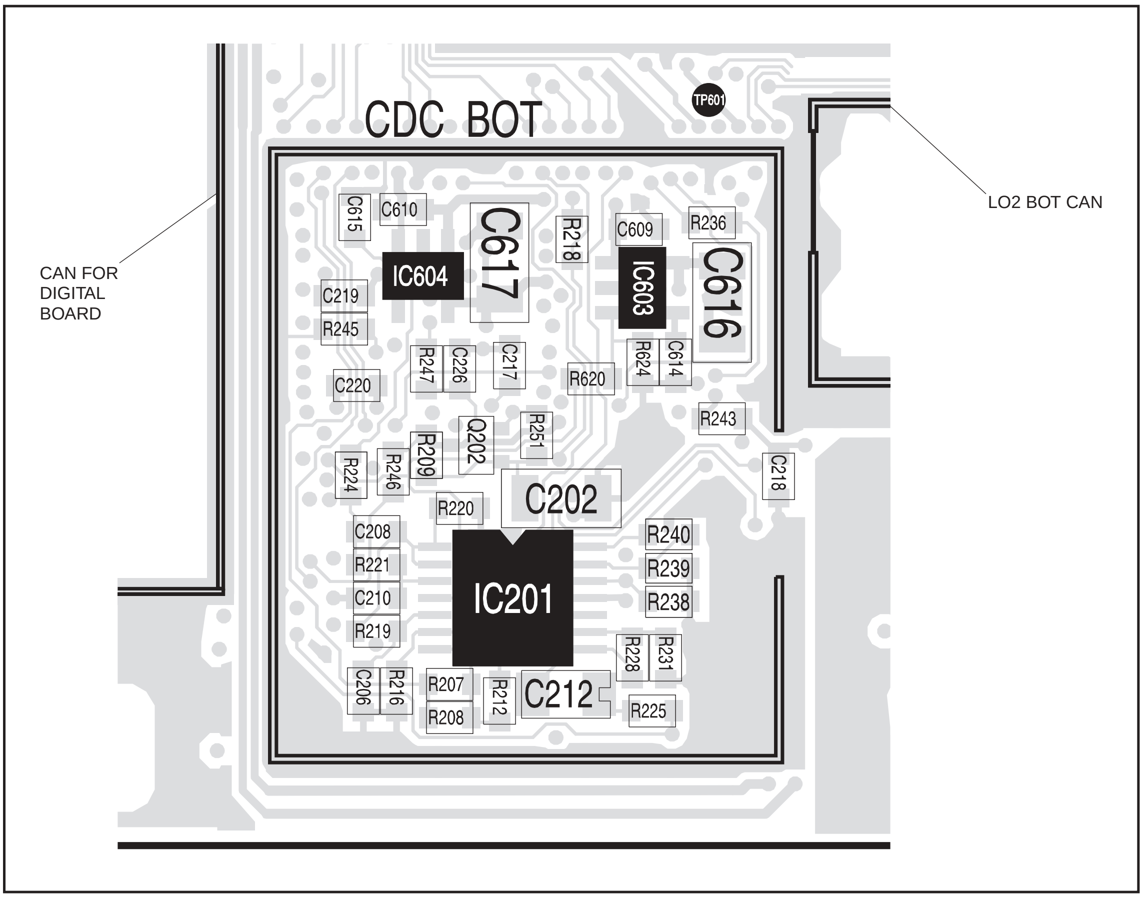
If the 9V supply is correct, check the 3V DC supply (+3V0 AN) next.

1. Measure the voltage +3V0 AN at the **TP601 test point** (see **Figure 15.1**).

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 15.1**). Check the regulator as described in Task 3 of "Power Supply Fault Finding" on page 132.

Figure 15.1 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 15.1**).

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 15.1**). Check the regulator as described in Task 3 of “Power Supply Fault Finding” on page 132.

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.

15.2 Faulty Speaker Audio

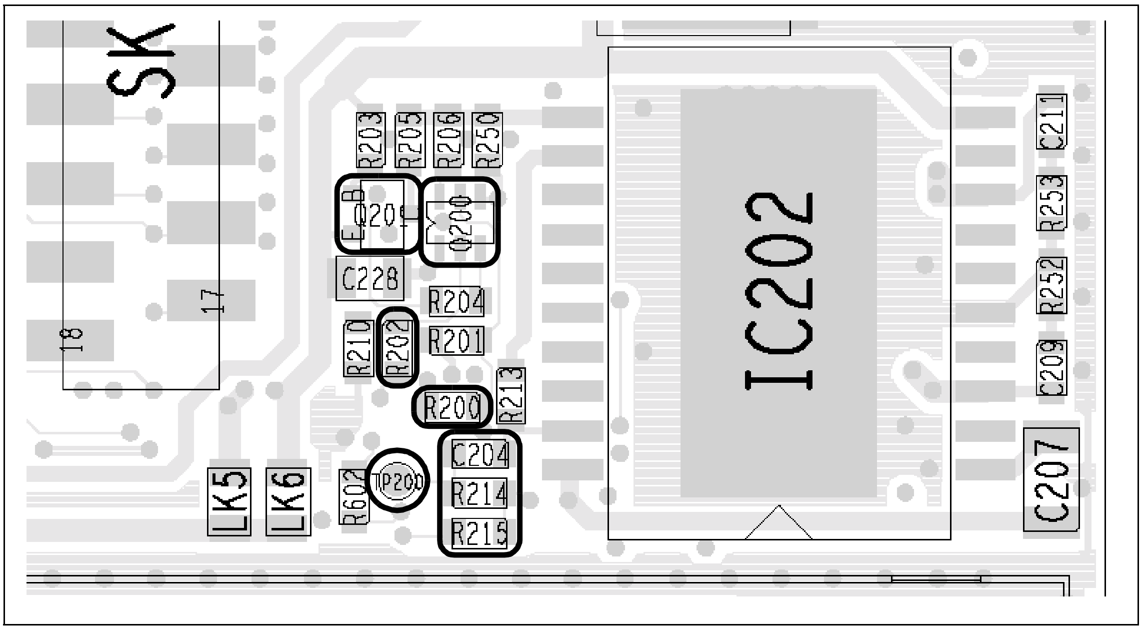
Introduction

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 15.2 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 signalling 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 15.2**). 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 15.2**) 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 15.2**):

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 15.2**).

8. Confirm the removal of the fault and go to “Final Tasks” on page 123. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 123.

9. Check the digital signals DIG AUD PA EN1 at **R200** and DIG AUD PA EN2 at **R202** (see **Figure 15.2**):

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 123.

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 15.2**):

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 15.2**), or else replace IC202.

4. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

5. With the volume at maximum, check each speaker output at pins 3 and 8 of **IC202** (see **Figure 15.2**):

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 123. If there is no AC, go to Step 7.

7. Check that **C204** and **R214** (see **Figure 15.2**) are not faulty and are correctly soldered. Repair any fault.

8. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 15.3 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 15.3**). 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 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 123.

5. Remove the CDC TOP can.

6. Check the voltage at the junction of **R234** and **R235** (see **Figure 15.3**). As the volume varies, the voltage should vary as follows.

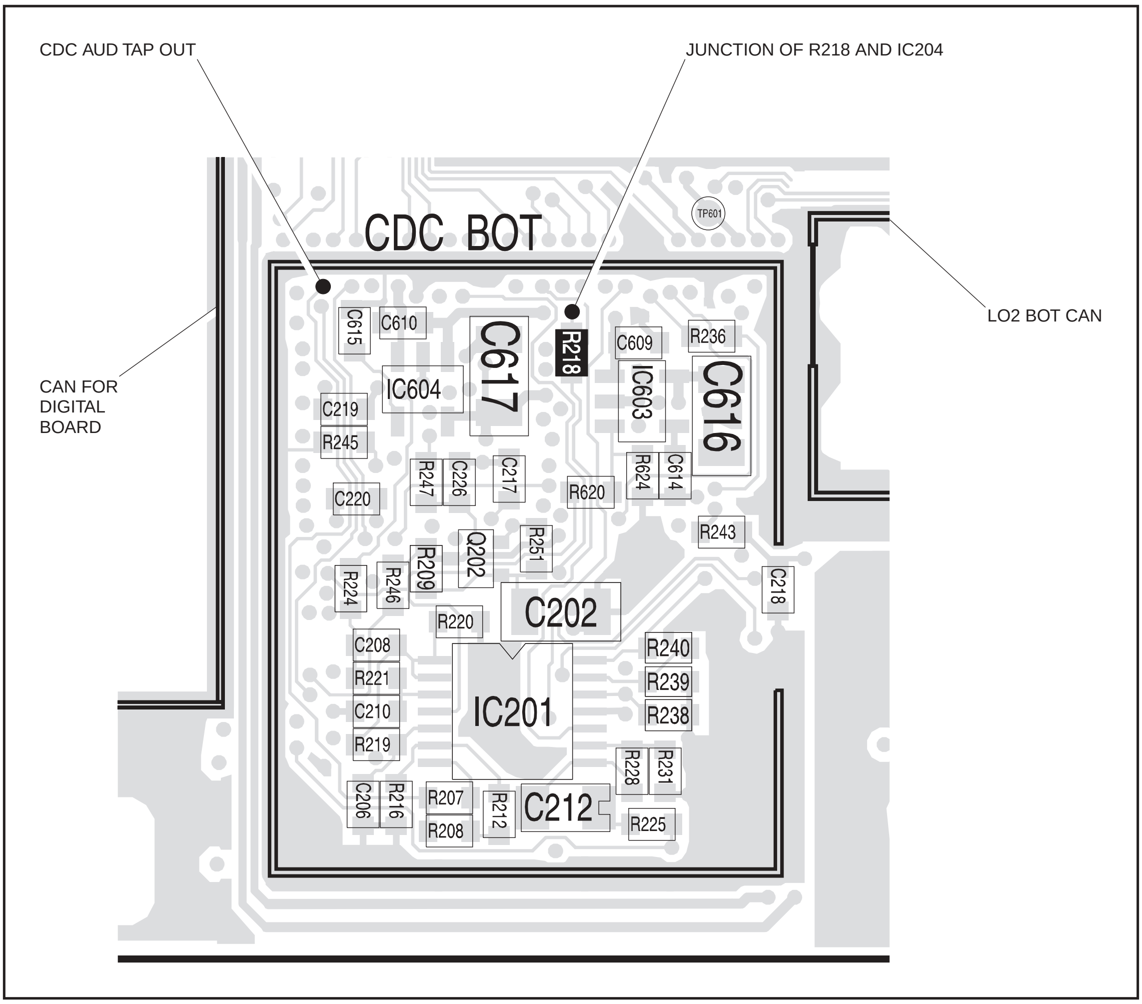
junction of R234 and R235: 0.0 to 0.6V as volume varies

7. If the voltage varies as expected, CODEC 1 (**IC204**) is suspect; replace the main-board assembly and go to “Final Tasks” on page 123. If it does not, go to Step 8.

8. Check for continuity across **R234**, and check that **R235** is properly soldered (see **Figure 15.3**). Repair any fault.

9. Confirm the removal of the fault and go to “Final Tasks” on page 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 123.

Figure 15.4 Circuitry under the CDC BOT can



Task 7 — Check ITF RX BEEP IN Input Signal

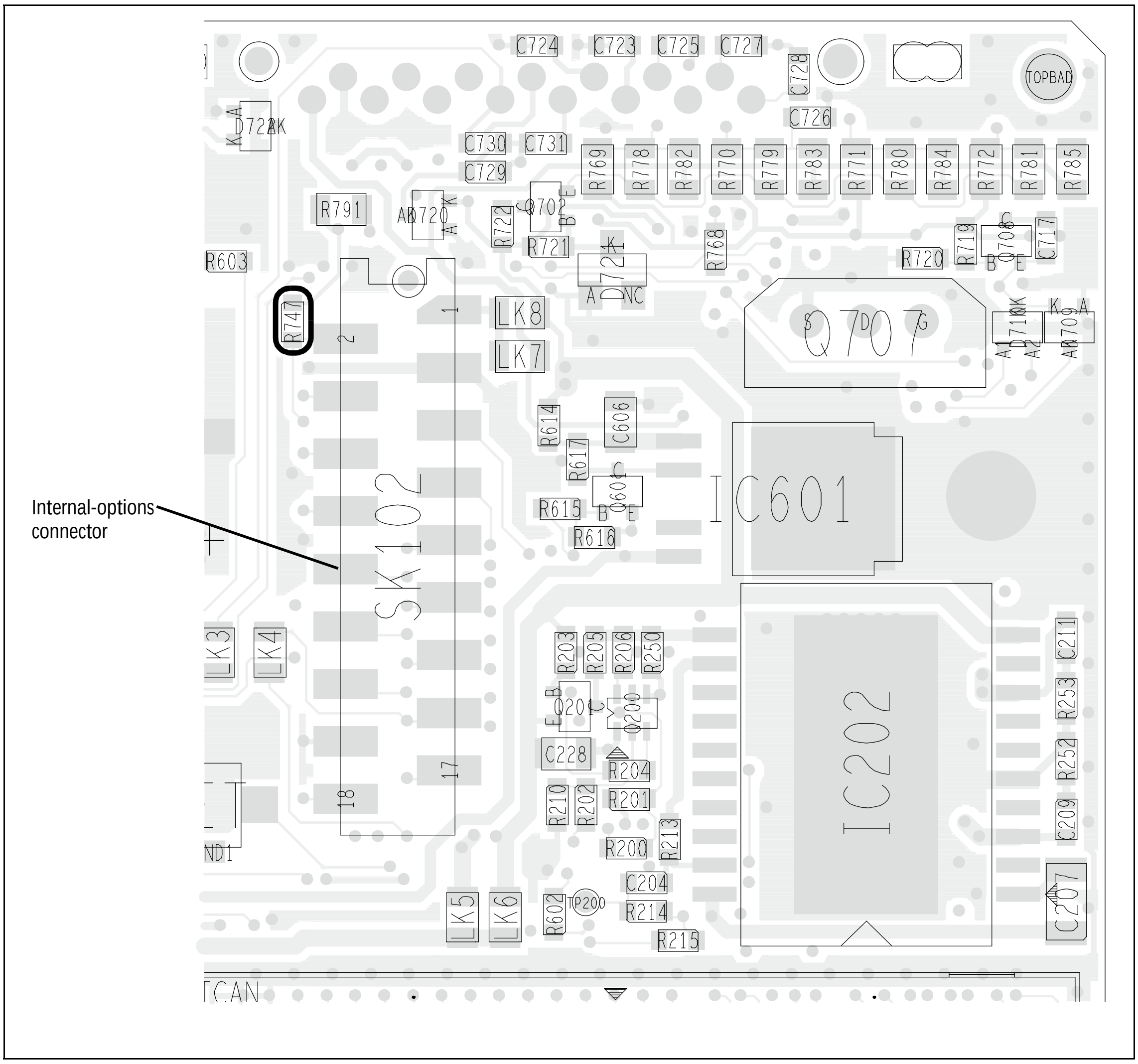
If the output of the voice-band CODEC is not correct, check the ITF RX BEEP IN signal.

1. If not already done, remove the CDC BOT can.
2. Check the signal at the junction of **R218** and **IC204** (see **Figure 15.4**). 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 123.
4. Check for continuity between the **TP200 test point** and **IC204** via **R214**, **R215** (see **Figure 15.2**) and **R218** (see **Figure 15.4**). Repair any fault; if necessary, replace R214, R215 or R218.
5. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 15.5 Circuitry in the vicinity of the internal-options connector SK102 (top side)



15.3 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 366 if there is also a fault with the transmit modulation using the auxiliary connector.

Task 8 — Check Signal from CODEC

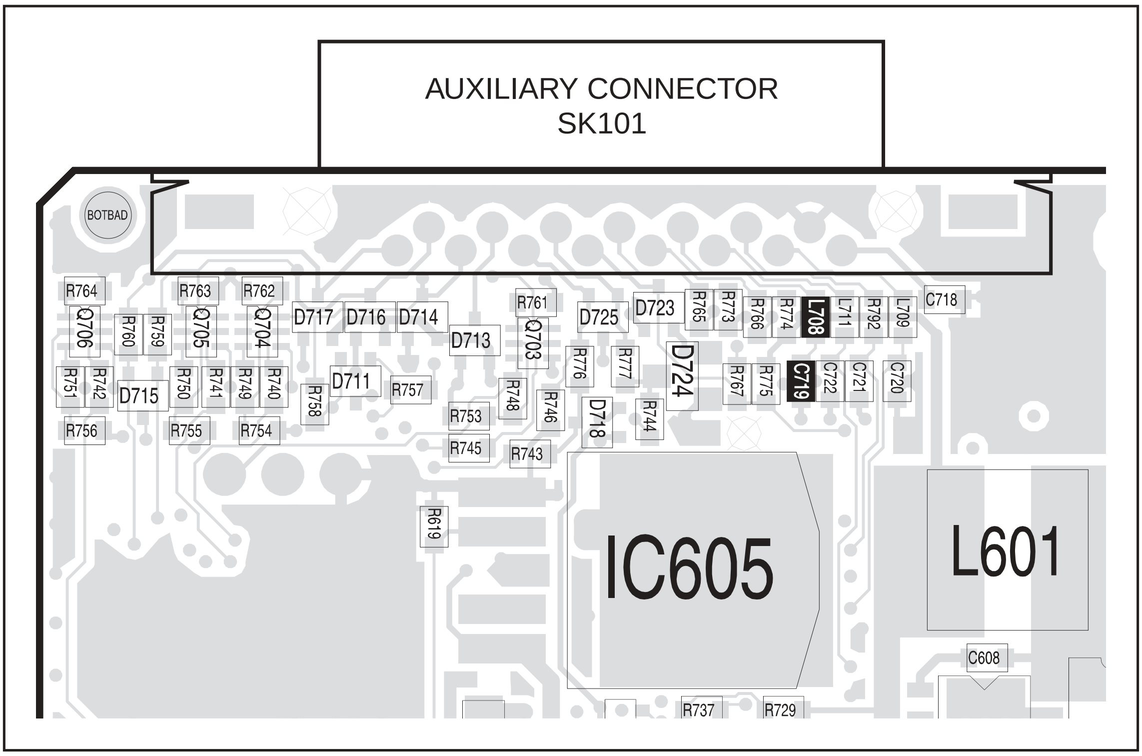
First generate an appropriate audio test signal and check whether the signal is present at the output of the CODEC circuitry.

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%, 1 kHz 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 15.5**) (alternatively, the measurement point for CDC AUD TAP OUT shown in **Figure 15.4**). The signal should be:

pin 2 of internal-options connector: received signal with 2.4 V 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 15.6**) and the link **R747** (see **Figure 15.5**). 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 123.
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 366. If there is no other fault, go to “Final Tasks” on page 123.

Figure 15.6 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 15.7**). 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 123.

4. Check the voltage at pin 1 of **IC201** (see **Figure 15.7**).

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 15.7**). Repair any fault and conclude with Step 9.

6. Check the voltage at pin 7 of **IC201** (see **Figure 15.7**).

pin 7 of IC201: 2.4V

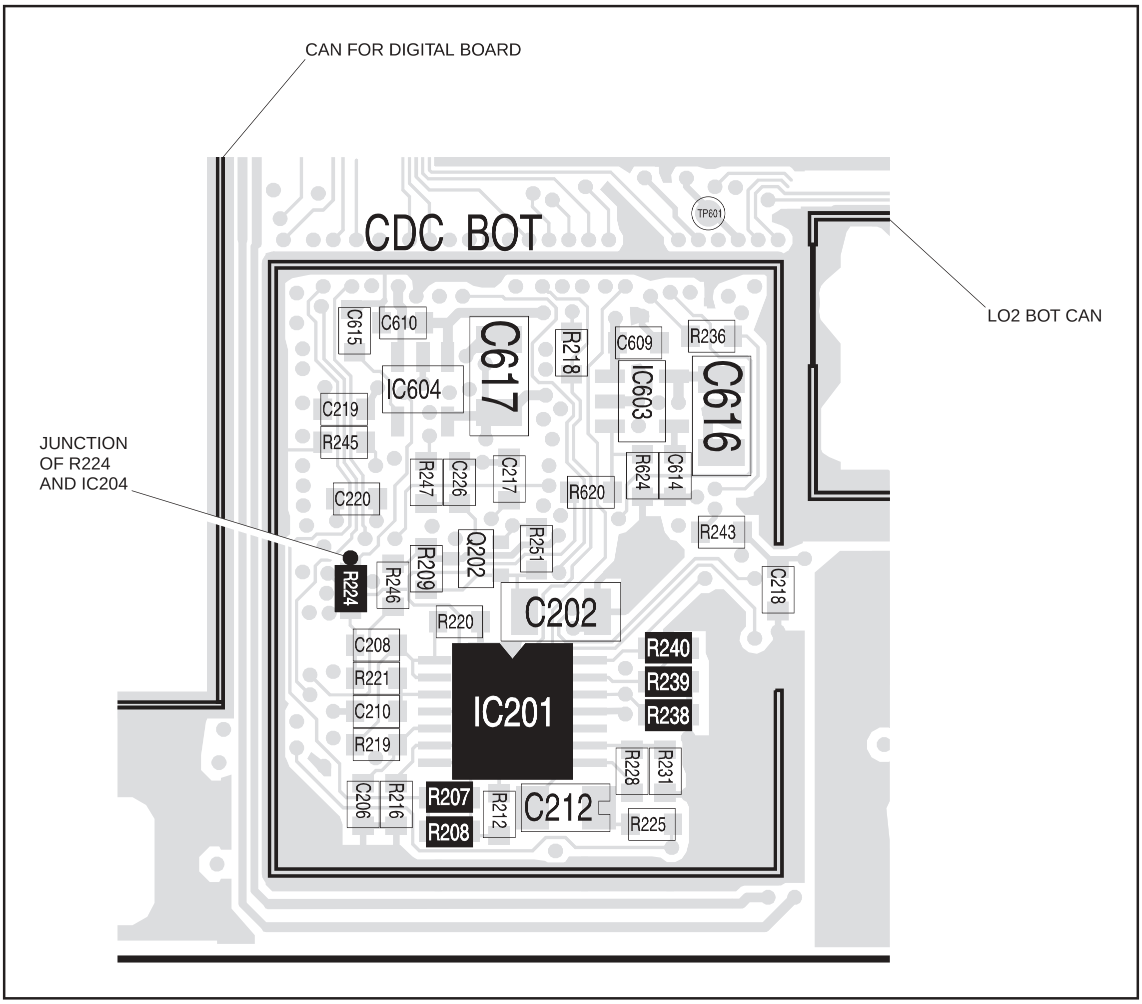
7. If the voltage is correct, go to Step 8. If it is not, check the buffer amplifier based on **IC201** (pins 5 to 7) (see **Figure 15.7**). Repair any fault and conclude with Step 9.

8. Check **R207** and **R208** (see **Figure 15.7**). 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 123.

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 366. If there is no other fault, go to "Final Tasks" on page 123.

Figure 15.7 Circuitry under the CDC BOT can



15.4 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 15.7**):

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 15.7**):

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.

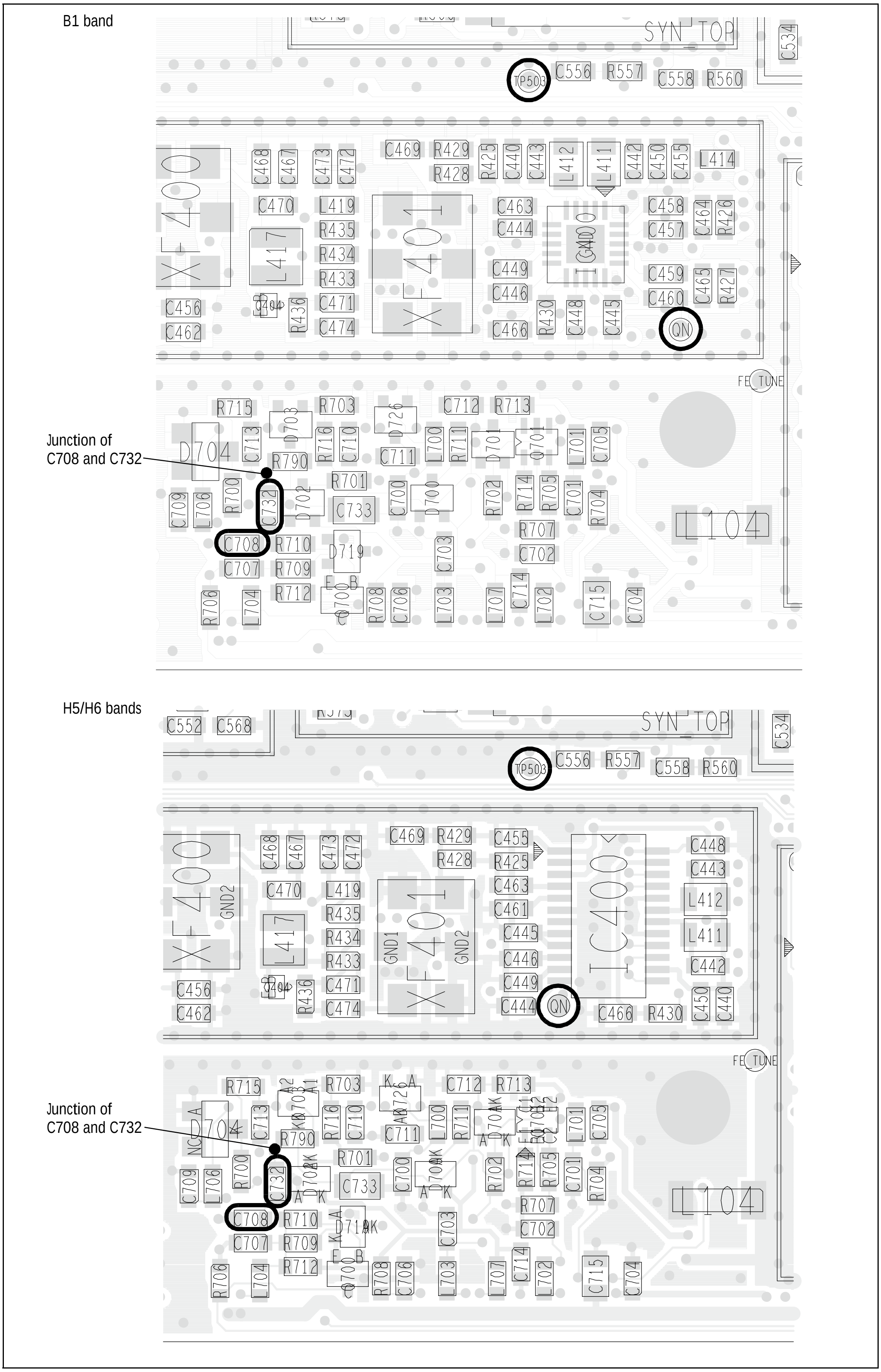
6. Check for and repair any shorts to ground at the junction of **R238** and pin 12 of **IC201** (see **Figure 15.7**).

7. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 123.

8. Check the circuitry (**R238**, **R239**, **R240**) around pins 12, 13 and 14 of **IC201** (see **Figure 15.7**). Repair any fault.

9. Confirm the removal of the fault and go to "Final Tasks" on page 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to "Final Tasks" on page 123.

Figure 15.8 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 15.8**).

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 201.

5. Either the digital board or CODEC 1 (**IC204**) is faulty; replace the main-board assembly and go to “Final Tasks” on page 123.

15.5 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.

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 15.8**).

TP503 test point: 1kHz signal

4. Enter the CCTM command *32* to place the radio in receive mode.

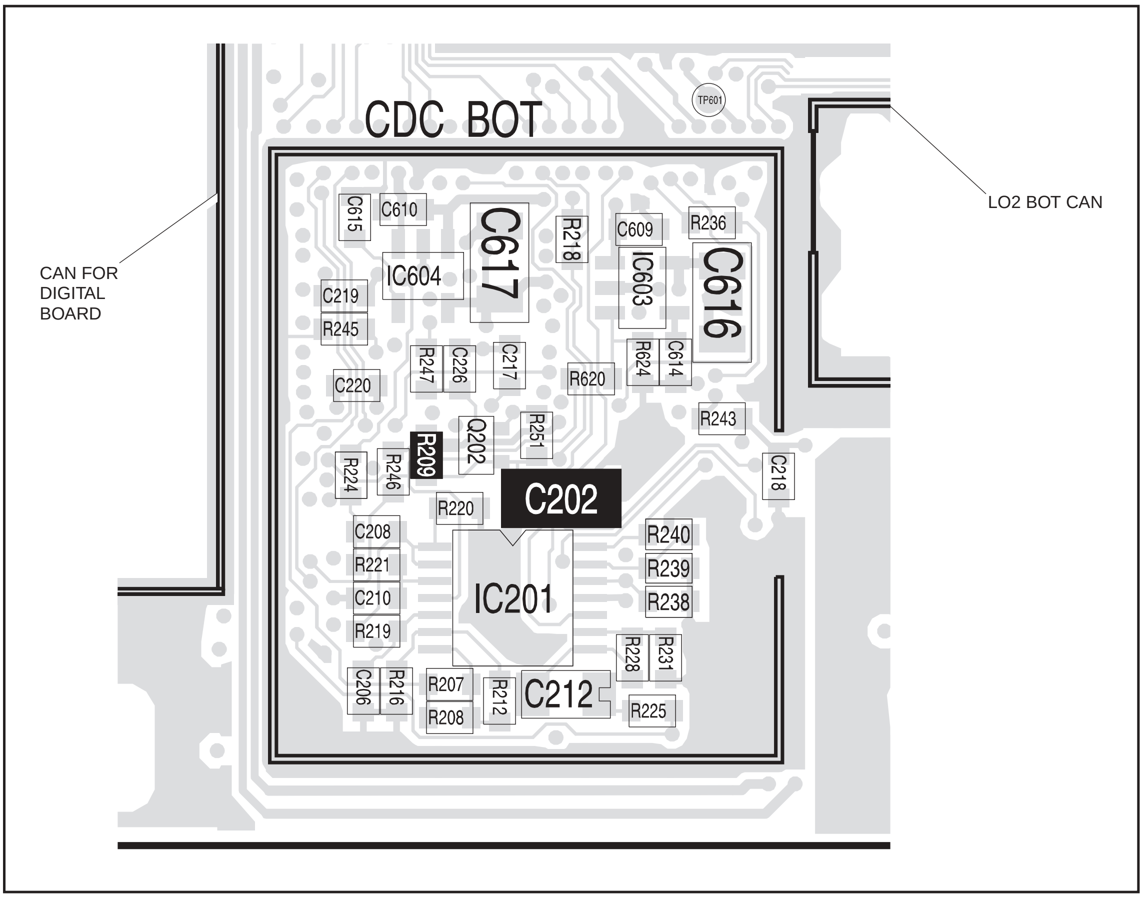
5. If the 1kHz signal is present, go to “Frequency Synthesizer Fault Finding” on page 143. If it is not, go to Step 6.

6. With no microphone connected, check the voltage at the junction of **C708** and **C732** (CH MIC AUD) (see **Figure 15.8**):

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 15.9 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 15.9**):

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 15.9**). Repair any fault.
5. Confirm the removal of the fault and go to “Final Tasks” on page 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 123.

Task 14 — Check Bias Network

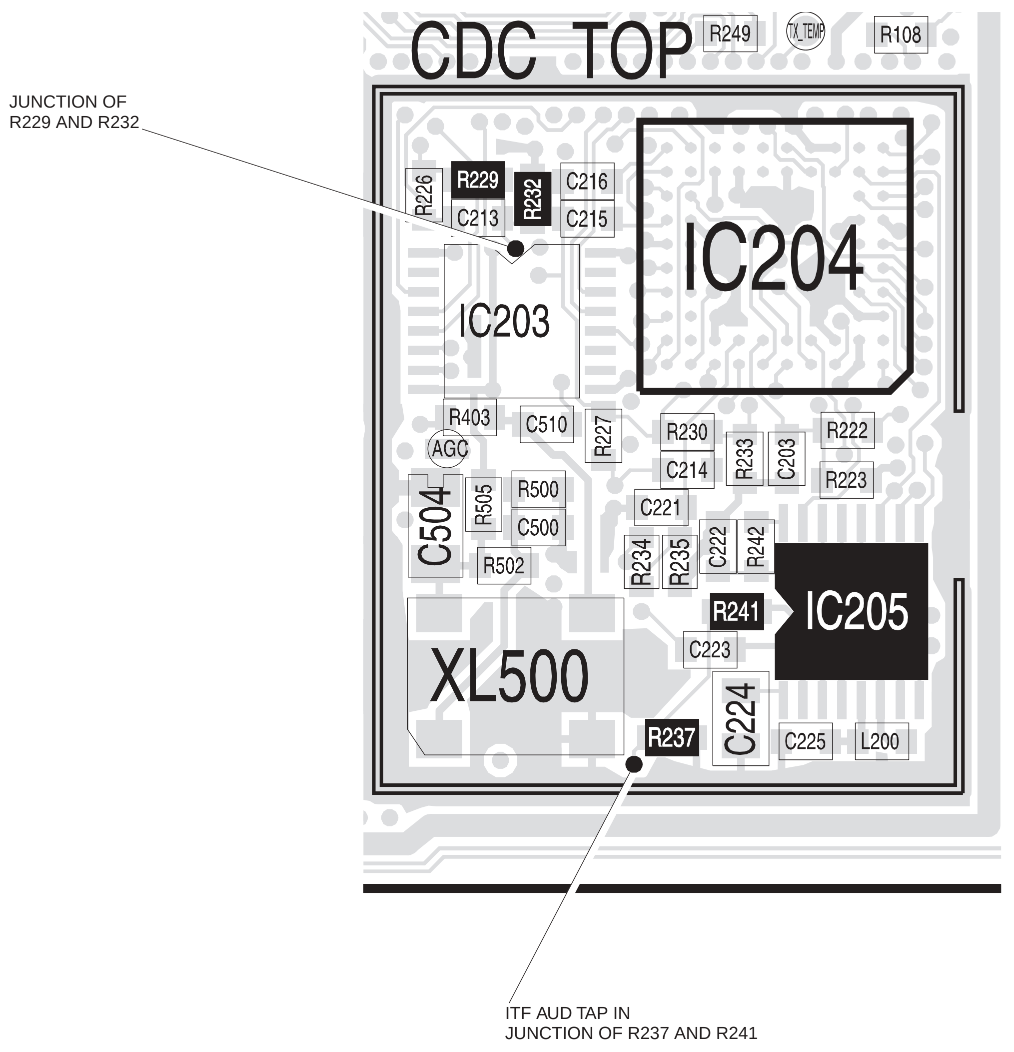
If the signal at the TP503 test point is incorrect, but the other checks in the above tasks reveal no fault, check the bias network.

1. Remove the CDC TOP can.
2. Check the voltage at the junction of **R229** and **R232** (see **Figure 15.10**):

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 123.
5. Check the soldering of **R229** and **R232**, and check for shorts across R232 (see **Figure 15.10**). Repair any fault.
6. Confirm the removal of the fault and go to “Final Tasks” on page 123. If the repair failed or the fault could not be found, replace the main-board assembly and go to “Final Tasks” on page 123.

Figure 15.10 Circuitry under the CDC TOP can



15.6 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 362.

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 15.10**).

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 15.10**). 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 123. If the repair failed, replace the main-board assembly and go to "Final Tasks" on page 123.

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 15.10**):

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 15.10**).

5. Confirm the removal of the fault and go to “Final Tasks” on page 123. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 123.

6. Remove **R241**.

7. Check the voltage at pin 3 of **IC205** (see **Figure 15.10**):

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 123.

9. Check for and repair any soldering faults around **R241** and **IC205** (see **Figure 15.10**).

10. Confirm the removal of the fault and go to “Final Tasks” on page 123. If the repair failed, replace the main-board assembly and go to “Final Tasks” on page 123.

16 Spare Parts

This section lists all serviceable parts (except PCB components).

Table 16.1 Spare parts

Description	Qty.	IPN	Figure
Tray chassis	1	303-11302-**xx**	Figure 7.1
Tray cover	1	303-23169-**xx**	Figure 7.1
Screw M3x6 (cover)	15	345-40460-**xx**	Figure 7.1
Rack mounting bracket	2	302-05279-**xx**	Figure 7.1
Screw M5x8 (rack mounting bracket)	4	346-00005-**xx**	Figure 7.1
Fuse, 20A, 32V, mini-blade	1	265-00011-**xx**	Figure 7.1
Volume control knob	1	311-01054-**xx**	Figure 7.2
UI board (includes fan power board)	1	XBBU100	Figure 7.2
Receiver module (50W/40W version) Receiver module (25W version)	1	XMAD15-**yy**03 XMAD13-**yy**03	Figure 7.3
Transmitter module (50W/40W version) Transmitter module (25W version)	1	XMAD15-**yy**02 XMAD13-**yy**02	Figure 7.4
SI board (includes temperature sensor board)	1	XBBS103	Figure 7.7
Transmitter power cable (4-way to M3.5 spade) (50W/40W version) Transmitter power cable (4-way to M3.5 spade) (25W version)	1	219-02975-**xx** 219-02976-**xx**	Figure 7.9
Receiver power cable (4-way to M3.5 spade) (50W/40W version) Receiver power cable (4-way to M3.5 spade) (25W version)	1	219-02973-**xx** 219-02974-**xx**	Figure 7.9
SI cable (16-way IDC to 15-way D-range)	2	219-02972-**xx**	Figure 7.9
UI cable (18-way IDC to Micro-MaTch)	2	219-02977-**xx**	Figure 7.9
Angled adapter for UI connector	2	240-00021-**xx**	Figure 7.9
Coaxial cable (N-type to BNC)	2	219-02978-**xx**	Figure 7.9
Fan power cable	1	219-02982-**xx**	Figure 7.9
Label for front panel	1	365-01764-**xx**	Figure 3.5
Label Tait TB7100	1	365-01765-**xx**	Figure 3.5
Speaker	1	252-00011-**xx**	Figure 2.1
Screw M3x8 (speaker)	24	345-40470-**xx**	Figure 2.1
Washer M3 (speaker)	2	353-00010-**xx**	Figure 2.1
Fuse 20A, 32V, mini blade	1	265-00011-**xx**	Figure 7.1
Hexagonal screwlock fastener (D-range connectors)	4	354-01043-**xx**	Figure 7.1
Nut M3 Nyloc (N-type connectors)	4	352-00010-**xx**	Figure 7.1
Earthing terminal	1	356-00010-**xx**	Figure 7.1
Heatsink for audio PA	1	303-13152-**xx**	Figure 7.3

Table 16.1 Spare parts

Description	Qty.	IPN	Figure
L-shaped gap pad	1	369-01048-**xx**	Figure 7.5
Rectangular gap pad (50W/40W version only)	1	369-01049-**xx**	Figure 7.5
Insulating rubber (under regulator on SI board)	1	362-00010-21	Figure 7.7
Insulating washer M3 (for screw through regulator on SI board)	1	353-00010-18	Figure 7.7
Screw M3x10 (through regulator on SI board)	1	345-00040-**xx**	Figure 7.7
Fan	2	219-02993-**xx**	Figure 7.8
Fan duct	1	319-01269-**xx**	Figure 7.8
Screw M3x25 (fans)	4	345-00040-**xx**	Figure 7.8
Cable tie	5	369-00010-**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 11.			

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