California INSTRUMENTS

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P/N 4847-960

INSTRUCTION MANUAL
MODELS
847T
AND
846CM

Invertron®

NOTE:

ASSEMBLIES, SCHEMATICS AND PARTS LISTS MAY DIFFER FROM THIS MANUAL IF MODEL NUMBER HAS A 3 OR 4 DIGIT SUFFIX. SEE SERIAL NUMBER TAG FOR PROPER IDENTIFICATION.

EXAMPLE

849TA-1-4-2-8-1-3888

MODEL NUMBER — 849TA

OPTIONS (IF APPLICABLE) — 1-4-2-8-1

4 DIGIT SUFFIX — 3888

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SECTION I — GENERAL DESCRIPTION

1.1 INTRODUCTION

This instruction manual contains information relative to the installation, operation, calibration and maintenance of California Instruments' Model 847T Precision Programmable Oscillator and Model 846CM Control Module. A detailed theory of operation is provided as an aid for maintenance personnel. Complete parts lists, schematic diagrams, component location diagrams and assembly diagrams are also supplied.

1.2 GENERAL DESCRIPTION

California Instruments' Model 847T Precision Programmable Oscillator is designed to plug into and obtain power from all of the Invertron® AC Power Sources. Frequency and amplitude are remotely programmable through an IEEE-488 Interface connector or through a parallel interface connector. Both connectors are mounted on the rear of the associated power source and connected to the 847T through a multi-conductor cable. Parallel programming by the parallel interface connector of the 847T is always available when the GPIB relinquishes control or allows the system to go the local control mode. If the 847T GPIB interface is enabled, the parallel interface input at the 846CM is disabled.

The output of the Model 847T provides three-phase variable frequency and amplitude drive for the power source. Remote inputs sense the voltage across the load connected to each leg of the power source. In reponse to the level of these inputs, the servo systems adjust the individual outputs of the 847T to maintain the voltage across the power source load at the programmed value. The 847T employs digital logic techniques for frequency generation with a crystal controlled oscillator serving as the reference for the digital logic circuits. This technique provides long-term frequency stability not obtainable with analog circuits.

The 847T is capable of operating from 45 Hz to 9999 Hz over three ranges; 45 to 99.99 Hz (selectable in 0.01 Hz steps), 45 to 999.9 Hz (selectable in 0.1 Hz steps) and 45 to 9999 Hz (selectable in 1 Hz steps). The low end of the frequency detector is adjusted to shut down the output of the 847T when the selected frequency is below 45 Hz. The high end is factory adjusted to the upper limit of the associated power source. Extending the frequency range beyond 5 KHz requires programming with an internal jumper. A "soft start" feature is incorporated which gradually increases the output amplitude at initial turn-on and when operation resumes after a shut down caused by programming an out-of-limit frequency.

The output voltage range of the oscillator is proportional to the amplitude programmed for the associated power source. When the programmed output voltage for the power source is 135 or 270 volts, the oscillator output will be in the range of 4 to 5 volts rms. The precise level will be dependent upon the voltage level at the sense input. The sense input, when connected directly across the load, increases the oscillator output (and the power source output) to compensate for any drop in the lines connecting the power source to the load.

Relative to the reference phase, Phase A, the angle of the Phase C output may be internally preset to any thirty degree increment. Because of the digital techniques employed, the electrical angle between phases remains constant irrespective of frequency.

1.3 ACCESSORY EQUIPMENT

The optional control module, Model 846CM, plugs into the 36-pin parallel remote connector of the 847T to provide local control and display of frequency and amplitude in the local and remote modes. It is only 1-3/4 inches high and 19 inches wide. It will usually be placed in the same rack as the power source. Four amplitude/frequency selection controls are provided to permit precise adjustment of the output amplitude and frequency with resolution of one part in ten-thousand. Frequency is selectable in steps of 0.01 Hz, 0.1 Hz or 1 Hz over the range of the 847T as shown in paragraph 1.2. The 846CM is equipped with a 37-pin connector identical in function to the remote parallel connector mounted on the rear of the power source. When the IEEE-488 Interface is not used for remote control, parallel remote data may be applied to the 847T through this connector with the local/remote selection accomplished with the LOCAL/REMOTE switch on the 846CM.

To use the parallel remote connector on the 846CM, the 847T A3 board must first be modified. Cut clad jumper E2 to E3. Add jumper from E2 to E1 (W1).

An Extender Assembly, Part No. 4800-703, is available to permit test and adjustment of the 847T external to the associated power source.

1.4 SPECIFICATIONS

Specifications for the Model 847T are listed in Table 1-1. Those for the Model 846CM are listed in Table 1-2.

Table 1-1. Specifications, Model 847T.

AMPLITUDE PROGRAM	
VOLTAGE RANGES:	0 to 135 in 0.1 volt steps 0 to 270 in 0.1 volt steps
VOLTAGE ACCURACY:	±0.2% of full scale from 5% of full scale to full scale (±0.3% above 2 KHz)
LOAD REGULATION:	±0.015% of full scale no-load to full load
LINE REGULATION:	±0.01% of full scale for 10% input change
TEMPERATURE COEFFICIENT:	0.03% of full scale from 25°C
FREQUENCY PROGRAM	
FREQUENCY RANGES:	Standard: 45 to 5000 Hz in 1 Hz steps Optional: 45 to 9999 Hz in 1 Hz steps Optional: 45 to 999.9 Hz in 0.1 Hz steps Optional: 45 to 99.9 Hz in 0.01 Hz steps
FREQUENCY ACCURACY:	±0.001% of programmed value
TEMPERATURE COEFFICIENT:	5 ppm/°C from 25°C
INITIAL FREQUENCY VALUES:	(see below)
PHASE	
TWO-PHASE:	90° separation
THREE-PHASE:	120° separation
PHASE ACCURACY:	±1°; ±0.5° per KHz above 2 KHz

Initial frequency values:

RANGE	INITIAL FREQUENCY
0045 to 9999	0060 (0050, 0400 Optional)
045.0 to 999.9	060.0 (400 Optional)
45.00 to 99.99	60.00

(Continued)

Table 1-1. Specifications, Model 847T (Continued).

PROGRAMMING:	IEEE-488 subsets; SH1, AH1, T6, L3, SR1*, RL1, (with 846CM), DC1 (See Section II for details) or parallel progam
GENERAL	
DATA RETENTION:	All GPIB states and programming data held for more than one second in event of power failure
SLOW START:	Linear one second build-up
DEFAULT CONDITIONS	(At power-up, GPIB, DCL or SDC)
AMPLITUDE:	0000 volts
FREQUENCY:	See above chart
SERVICE REQUEST:	Disabled

SERIAL POLL

STATUS	STATUS BYTE VALUE
Phase A Failure	78
Phase B Failure	77
Phase C Failure	75
Phase A, B Failure	76
Phase A, C Failure	74
Phase B, C Failure	73
Phase A, B, C Failure	72
False Frequency	71
Normal (No Service Request)	15

Table 1-2. Specifications, Model 846CM.

AMPLITUDE RANGE:	Four digits (0000 to 7999). Decimal point internally programmed to match range of associated 847T and power source.*
FREQUENCY RANGE:	Four digits (0000 to 9999). Decimal point internally programmed to match range of associated 847T and power source.*
SELECTORS:	Four dials alternately select amplitude or frequency. Selected data entered by separate FREQ and AMP push buttons.
LOCAL/REMOTE CONTROL:	Panel switch selects local or remote control when remote parallel data input is used. When IEEE-488 interface is used, requests local control only. GPIB retains priority.
OUTPUTS	
DATA:	Parallel, four frequency decades in BCD, four amplitude decades in BCD, positive-true, TTL compatible.
CONTROL:	LOCAL/REMOTE switch, TTL compatible.
INPUTS:	Active HI REMOTE.
INDICATORS	
FREQUENCY:	Four seven-segment LED digits with decimal point.
AMPLITUDE:	Four seven-segment LED digits with decimal point.
LOCAL/REMOTE:	Single LED lights when in local mode.
POWER REQUIREMENTS:	115 VAC at less than 0.25 A or 230 VAC at less than 0.124 A.
SIZE:	19 in. W x 1-3/4 in. H x 8 in. D max. (48.26 cm x 4.45 cm x 20.32 cm)
WEIGHT:	5 lbs. (2.27 Kg) max.

*Usable frequency range will be limited by 847T and amplitude range will be limited by the power source.

SECTION II — INSTALLATION AND OPERATION

2.1 GENERAL

This section of the manual details the installation requirements for the Model 847T Precision Programmable Oscillator and Model 846CM Control Module including unpacking and pre-installation acceptance test procedures.

2.2 UNPACKING

Individual oscillators and control modules are shipped in cardboard containers with protective inner packing. Do not destroy the packing containers until the units have been inspected for possible damage in shipment.

2.3 POWER REQUIREMENTS

The California Instruments Model 847T Precision Programmable Oscillator operates from +25 volts DC and -25 volts DC at 0.1 amperes. In addition, 115 volts AC at 24 volt amperes is required. These power inputs are normally obtained from an associated Invertron® power source. Power for the 846CM is obtained from the commercial sources of 115/230 volts at 50 to 60 Hz.

CAUTION

Voltages up to 500 volts AC are present or available in certain associated Invertrons® and 115 volts AC is present on the Phase A Board, A1, of the 847T. This equipment utilizes potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied. Avoid contact with connector pins C and D of the plug-in oscillator, the primary power circuits and output circuits of the associated Invertron® if the oscillator is tested and/or adjusted when connected to Invertron®.

2.4 FUSE REQUIREMENTS

Separate fusing of the power sources for the 847T is not required. The 846CM requires a 0.5-ampere fuse. The 847T A1 board has a fuse (F1) that is used as a ground fault protection. In the event of any power source malfunction that will cause the analog common to be forced above chassis potential, F1 will blow maintaining digital common at chassis potential.

2.5 POWER SOURCE INTERCONNECTION

Circuit board A3 of the Model 847T has a 60-pin header to which a 60-pin connector attaches. The connectors on the other end of the cable are to be mounted on the rear of the power source and provide the conection to the IEEE-488 GPIB or to the parallel data input. The optional 846CM Control Module will be connected to the parallel data input connector.

2.6 ACCEPTANCE TEST PROCEDURE

Inspect the units for any possible shipping damage immediately on receipt. If damage is evident, notify carrier. DO NOT return an instrument to the factory without prior approval. If the units appear to be in good condition, proceed with the acceptance test procedure of the following paragraphs.

To conduct these tests, the Model 847T must be plugged into an Invertron® which has the appropriate connections. If the 847T is to be used with other power source equipment, it may be necessary to contact the factory for assistance in setting up a test procedure. The 847T must be connected to a computer output that generates, or can simulate, the IEEE-488 control outputs, if that means is to be used to control frequency and amplitude. If the 847T is to be controlled through the 36-pin interface connector, a suitable controller, such as the Model 846M Control Module, must be connected to J2. Operating instructions for the 846CM are provided in paragraph 2.10 and remote programming instructions are provided in paragraph 2.7. The Model 846CM Control Module is an option that provides all necessary functions for checkout through the 36-pin interface connector. However, use of the 846CM for checkout does not provide a checkout of the IEEE-488 interface. If the 847T is to be used with both types of remote control inputs, the tests of this section should be repeated for both. See paragraph 2.7 for interface programming.

To perform the 847T acceptance test procedure, the remote sense inputs must be connected as shown in Figure 2-1. Since the power source with which the 847T will be used will have a full scale output of either 135 volts rms or 270 volts rms, the values for both power sources are shown in this text and are separated by a slash (/). Use the value that is appropriate to the associated power source. If the jumper in the Phase A oscillator has been connected for a lower frequency range, divide the frequency stated in the following procedure by the proper factor, 10 or 100.

CAUTION

Failure to connect the sense inputs across the load or to strap them to the power source outputs will result in power source output voltages in excess of the programmed values by as much as ten percent.

CAUTION

REMOVE POWER FROM THE SOLID STATE INVERTRON® BEFORE REMOVING OR INSERTING THE PLUG-IN OSCILLATOR.

Allowable errors for the complete range of amplitude and frequency are shown in Figure 2-2. Program the 847T for several combinations of amplitude and frequency within the shaded areas and verify that the resultant output from the associated power source is within the specified limits. Next, program the 847T for a frequency below 45 Hz and for a frequency above 5000 Hz and verify that the output goes to zero. Then program the 847T for an amplitude and frequency combination within the shaded area and verify that operation is resumed and that the amplitude increases gradually, indicating that the "soft start" feature is operational.

If the unit fails to perform within the limits stated above, the factory should be notified immediately so that warranty repair may be authorized.

2.7 SYSTEM PROGRAMMING

There are three programming methods that may be used with the Model 847T. One permits operation from a general purpose interface bus (GPIB) which meets the requirements of IEEE Standard 488-1978. The second permits operation from a parallel data bus through the remote parallel connector. The third uses the optional 846CM Control Module which incorporates frequency and amplitude displays. Addition of the 846CM does not affect the ability of the unit to operate using one of the other two methods.

2.7.1 IEEE-488 PROGRAMMING

Programming for the IEEE-488 interface consists of setting the 847T (unit) address and programming the computer to output the proper sequence of ASCII alpha and numercial codes to achieve the frequency and amplitude commands.

2.7.1.1 LISTEN ADDRESS

The unit address switch is shown in Figure mmmmm2-3. Switch A3S1, sections one through five correspond to address bits A1 through A5 respectively. The OFF position of each switch corresponds to the true state as listed in Table 2-1. The switches are initially set to listen address 00001 at the factory. The five lower order bits of the binary equivalent of the listen address correspond to the setting of the address switches (see Table 2-2).

Table 2-1. Unit Address Switch Functions.

SECTION POSITION	FUNCTION	SWITCH TRUE
1	Listen Address A1	OFF
2	Listen Address A2	OFF
3	Listen Address A3	OFF
4	Listen Address A4	OFF
5	Listen Address A5	OFF
6	Listen Only Mode	OFF
7	RSV	OFF
8	Not Used	

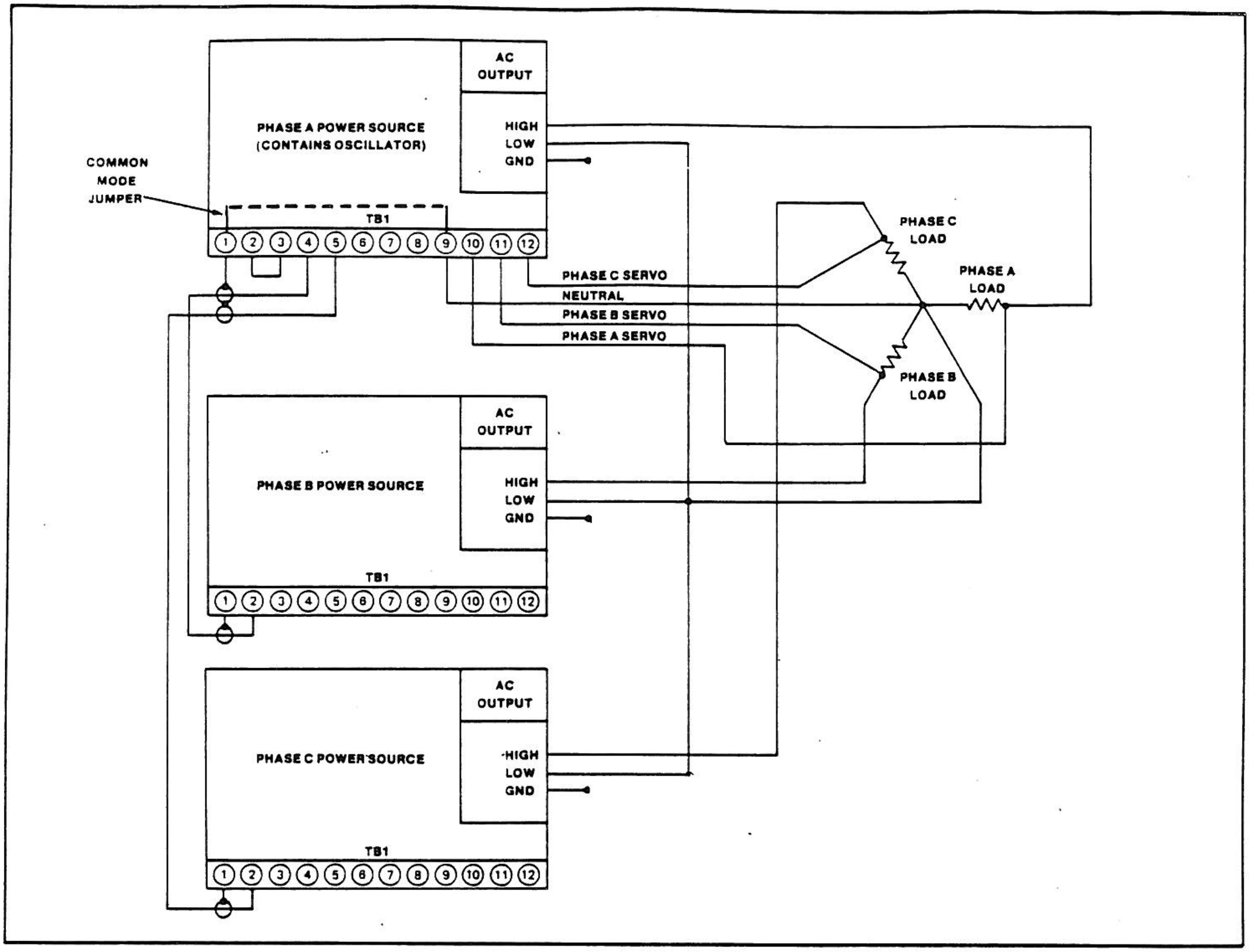


Figure 2-1A. Polyphase Power Source System Connections Using Individual Units.

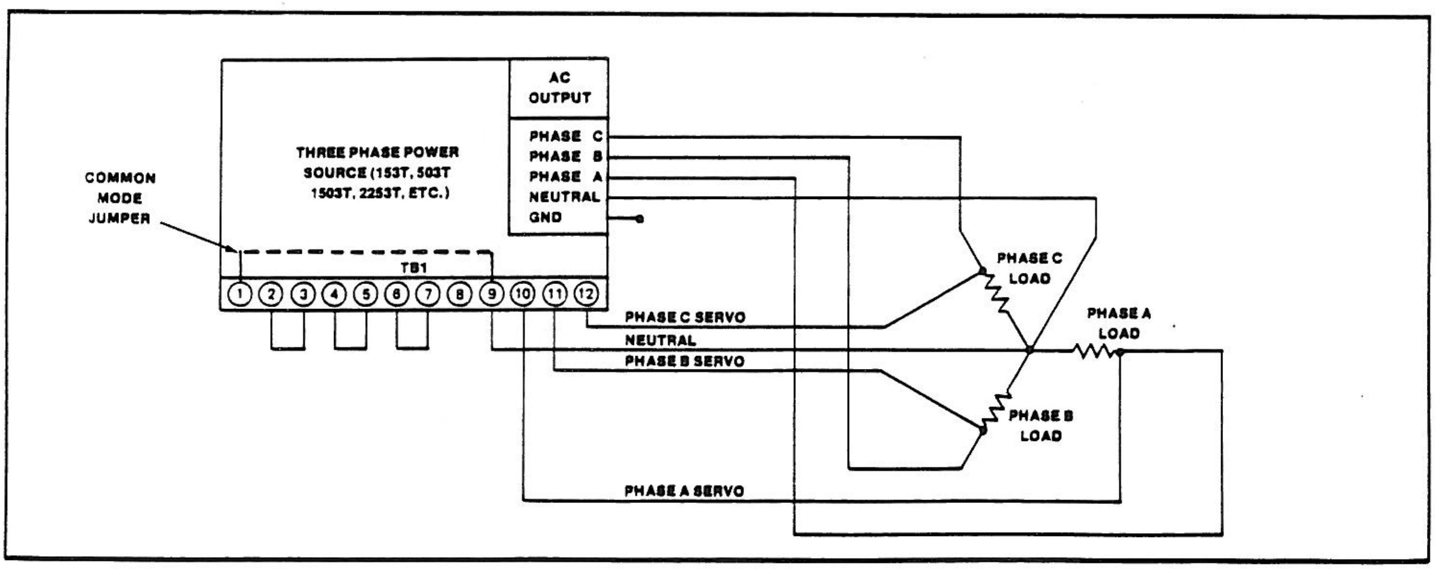


Figure 2-1B. Polyphase Power Source System Connections Using Single Unit.

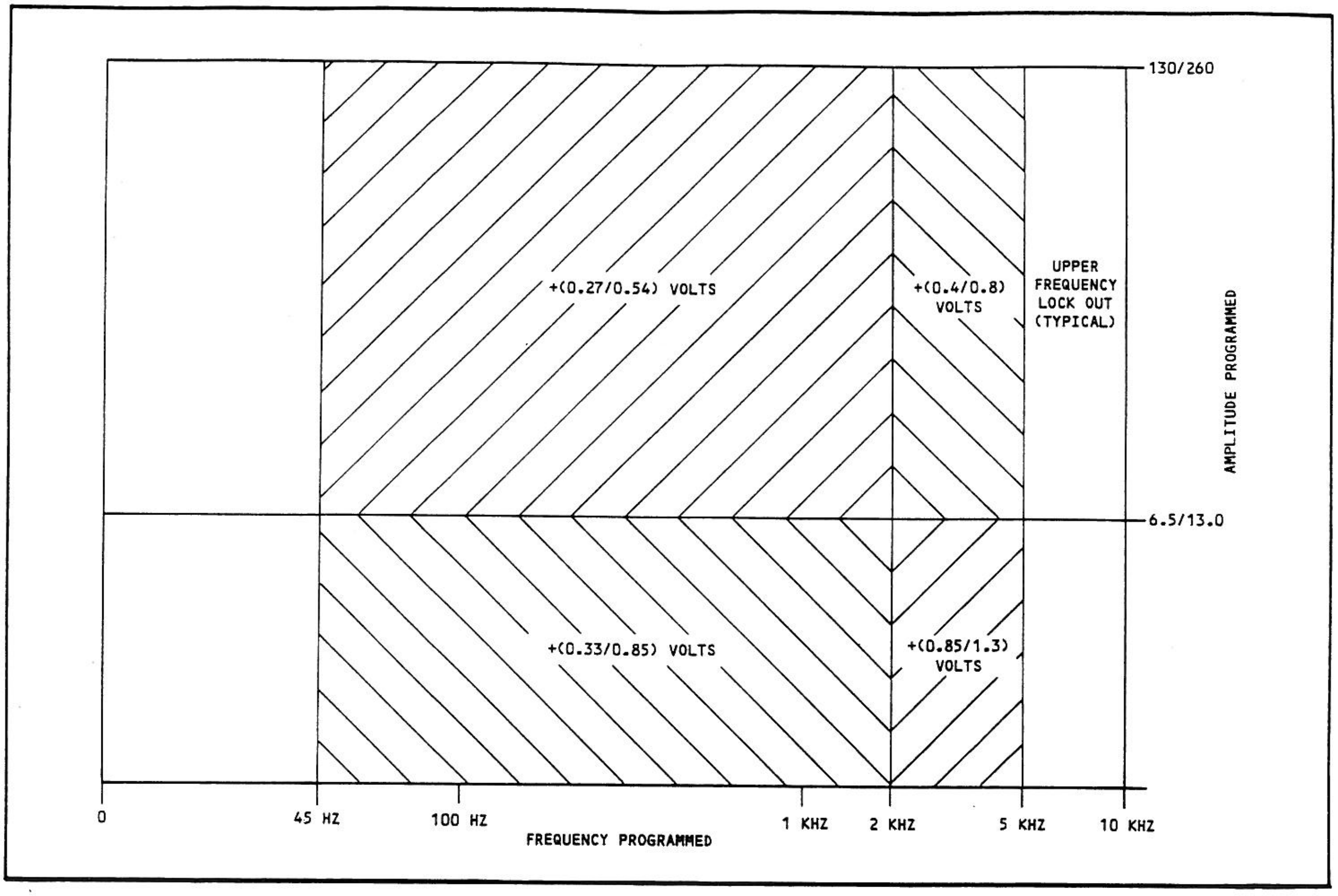


Figure 2-2. Performance Error Limits.

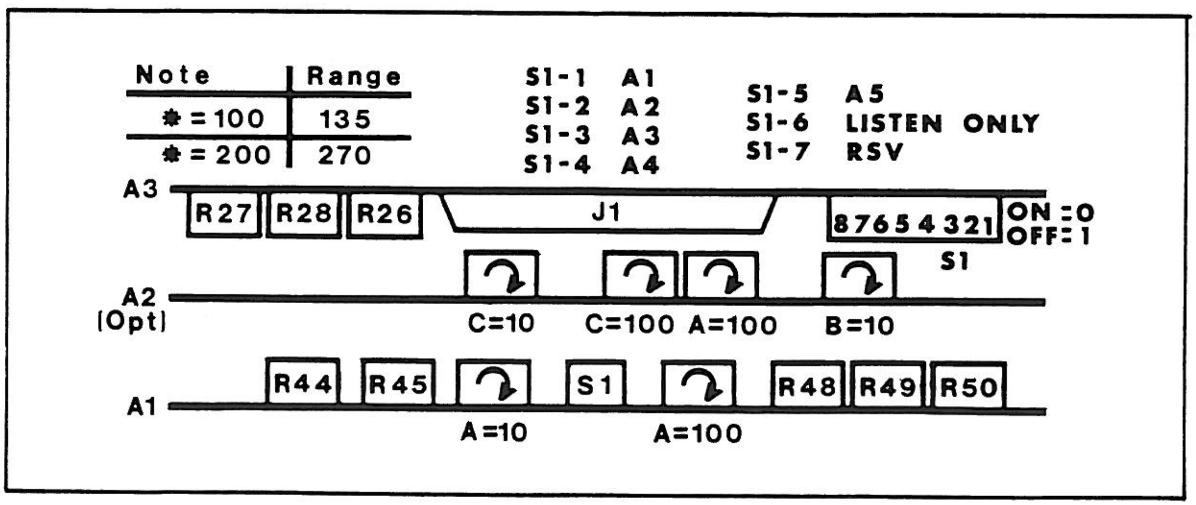


Figure 2-3. 847T Adjustment Locations.

Table 2-2. Listen Address Group.

LISTEN ADDRESS	HEX	BINARY						DECIMAL	ASCII
			A5	A4	A3	A2	A1		
0	20	001	0	0	0	0	0	32	SP
1	21	001	0	0	0	0	1	33	!
2	22	001	0	0	0	1	0	34	"
3	23	001	0	0	0	1	1	35	#
4	24	001	0	0	1	0	0	36	$
5	25	001	0	0	1	0	1	37	%
6	26	001	0	0	1	1	0	38	&
7	27	001	0	0	1	1	1	39	'
8	28	001	0	1	0	0	0	40	(
09	29	001	0	1	0	0	1	41	)
10	2A	001	0	1	0	1	0	42	*
11	2B	001	0	1	0	1	1	43	+
12	2C	001	0	1	1	0	0	44	,
13	2D	001	0	1	1	0	1	45	-
14	2E	001	0	1	1	1	0	46	.
15	2F	001	0	1	1	1	1	47	/
16	30	001	0	0	0	0	0	48	0
17	31	001	1	0	0	0	1	49	1
18	32	001	1	0	0	1	0	50	2
19	33	001	1	0	0	1	1	51	3
20	34	001	1	0	1	0	0	52	4
21	35	001	1	0	1	0	1	53	5
22	36	001	1	0	1	1	0	54	6
23	37	001	1	0	1	1	1	55	7
24	38	001	1	1	0	0	0	56	8
25	39	001	1	1	0	0	1	57	9
26	3A	001	1	1	0	1	0	58	:
27	3B	001	1	1	0	1	1	59	;
28	3C	001	1	1	1	0	0	60	<
29	3D	001	1	1	1	0	1	61	=
30	3E	001	1	1	1	1	0	62	>
UNL	3F	001	1	1	1	1	1	63	?

2.7.1.2 LISTEN ONLY (LON)

The listen only mode allows the 847T to be used without a controller. The normal mode of operation in an ATE system is the addressable mode--LON defeated. The addressable mode is selected by placing switch A3S1, section six, in the ON position.

2.7.1.3 REQUEST SERVICE (RSV)

The 847T has the capability of generating a SERVICE REQUEST (SRQ) if any one of the three power sources goes out of regulation. Additionally it will generate an SRQ if a false frequency is programmed.

Switch A3S1, section seven, must be in the OFF position to allow RSV to be enabled. In addition, an ASCII character U must be transmitted by the controller. The Service Request is disabled when the controller transmits an ASCII character T.

2.7.1.4 AMPLITUDE/FREQUENCY PROGRAMMING

The alpha-numeric data received by the instrument must be coded as ASCII (American Standard For Information Interchange).

Alpha characters are understood to be upper case; A, E, F, W, X, or Y. Numeric characters are assumed to be base ten.

There are two ways of formatting data to the 847T. The first way requires that a string consisting of a maximum of four digits of data be sent. The first digit is understood as the most significant digit (MSD). Refer to Table 2-3 for the numeric weights. The decimal point is fixed by the 847T after the third character sent for amplitude; therefore, it is optional to send the decimal point in the character string.

Table 2-4 and Table 2-5 are examples for programming the 847T.

The programming examples illustrate that the leading zeros must be included in the string.

The second way of programming the 847T allows any digit or digits to be changed without sending the MSD first.

The three LSD's of the frequency or amplitude can be individually selected by the ASCII characters W, X, Y. W selects the LSD.

Table 2-6 contains a set of examples for programming using the selective digit designators.

After a frequency or amplitude command has been received, any digit in that command may be selectively changed by receipt of an alpha character that selects the digit to be changed. However, selective digit changes must not be made to a frequency command after receipt of an amplitude command or vice versa. Although the execution character loads all digits into the command register, the data in the holding register is not erased. Therefore, a partial amplitude command received after a frequency command would load the unchanged digits of the frequency command into the amplitude command register. The selective alpha characters are listed in Table 2-7.

To change the most significant digit (MSD), that digit must be followed by the appropriate execute character. The holding registers retain the last data received, so all remaining digits are unchanged. To change any other digit, the controller must transmit the appropriate ASCII character followed by the new digit value and the appropriate execute character. Digits of less significance may be changed simultaneously by delaying the transmission of the execute character until the additional

Table 2-3. Numeric Weights.

ORDER ASCII NUMBER RECEIVED	AMPLITUDE (VOLTS)	UNDERSTOOD WEIGHT FREQUENCY (HERTZ)		
		9999 RANGE	999.9 RANGE	99.99 RANGE
1	100	1000	100	10
2	10	100	10	1
3	1	10	1	0.1
4	0.1	1	0.1	0.01
5	A or E	F	F	F

Table 2-4. Programming Examples I.

STRING	RESULT
0061F	Programs 61 Hz on the 9999 Hz range
4213F	Programs 421.3 Hz on the 999.9 Hz range
6232F	Programs 63.23 Hz on the 99.99 Hz range
1156A	Programs 115.6 volts
followed by	
116A	Programs 116.6 volts

Table 2-5. Programming Examples II.

ENTRY SEQUENCE	EXAMPLE NUMBER	ASCII CHARACTER	AMPLITUDE	FREQUENCY
↓	1	Power On 1 0 0 0 F	0.000 V 000.0 V	0060 Hz 1000 Hz
↓	2	W 1 F	000.0 V	1001 Hz
↓	3	W 2 F	000.0 V	1002 Hz
↓	4	1 1 5 0 A	115.0 V	1002 Hz
↓	5	X 6 A	116.0 V	1002 Hz
↓	6	X 7 A	117.0 V	1002 Hz
↓	7	X 6 5 A	116.5 V	1002 Hz
↓	8	0 4 0 0 F	116.5 V	0400 Hz
↓	9	DCL	000.0 V	0060 Hz

Table 2-6. Selective Digit Programming Examples.

STRING	RESULT
1150A	115.0 volts
W8A	115.8 volts
W9A	115.9 volts
X60A	116.0 volts
Y250A	125.0 volts
0400F	0400 Hz
X12F	0412 Hz
W1X2Y3	0321 Hz

Table 2-7. ASCII Character Interpretation.

ASCII CHARACTER	847T INTERPRETATION
0-9	0-9
A	Amplitude
E	Amplitude
F	Frequency
W	Digit 4 (LSD)
X	Digit 3
Y	Digit 2

digit values have been transmitted. For example, transmitting the ASCII character sequence "Y, 1, 3, A" loads the two least significant digits, leaving the two most significant digits unchanged.

2.7.1.5 DEFAULT VALUES

During the power-up mode or on receipt of the bus command messages Device Clear (DCL) or Selected Device Clear (SDC), the 847T will default to 000.0 volts and the frequencies listed in Table 2-8. In addition the Service Request will be disabled.

Table 2-8. Program Default Values.

RANGE	FREQUENCY DEFAULT VALUE
9999	*0060, 0050, 0400
999.9	*060.0, 400.0
99.99	*60.00
*The first value given is standard.	

2.8 PROGRAMMING RANGE

The 847T can be programmed over the voltage and frequency ranges given with the configuration listed in Table 2-9.

The voltage range of the 847T must match the voltage range of the associated power source. If the 847T is used with a power source that has a programmable range change feature, the components A1R2, A1R42, A1Q9 are added and A2CR12 is removed. Switch A1S1 must be in the OFF position to allow the programmable range feature to function. An ASCII U will program the 135-volt range. An ASCII T will program the 270-volt range. The 847T will default to the 270-volt range.

2.9 REMOTE PARALLEL PROGRAMMING

The remote programming connector provides for parallel data input directly to the rate multipliers and D/A converters in the frequency and amplitude circuits. Table 2-10 lists the designators for each pin of the remote connector, J2, which is the parallel input connector at the rear of the power source. The first alpha character indicates the digit, the second indicates the function and the third indicates the weight. For example, the line designated FX8 is the 8th bit of digit X of the frequency function.

2.10 MODEL 846CM OPERATING CONTROLS

The 846CM Control Module has four FREQUENCY/AMPLITUDE dials on the front panel with which each digit of the output frequency and amplitude of the 847T and associated power source are selected. Other controls include a REM/LOC (REMOTE/LOCAL) switch, a FREQ ENTER (FREQUENCY ENTER) switch and an AMP ENTER (AMPLITUDE ENTER) switch. Individual four-digit displays show the current frequency and voltage commands. When the REM/LOC switch is in the REM position, the front panel controls are inoperative and the 847T can only be programmed through one of the remote inputs, GPIB or remote parallel. When the switch is in the LOC position, all front panel controls are operative except when a GPIB LOCAL LOCK OUT (LLO) command is received.

When power is first applied to the 846CM, it is preset to zero frequency and amplitude. Those

Table 2-9. Programming Range.

RANGE	CONFIGURATION
0.0 to 135.0 volts	A1S1 ON power source on 135-volt range
0.0.to 270.0 volts	A1S1 OFF power source on 270-volt range
XX.XX Hz to 99.99 Hz	A1W1 installed, A1W2, A1W3 removed
XXX.X Hz to 999.9 Hz	A1W2 installed, A1W1, A1W3 removed
XXXX Hz to 2000 Hz	A1W3 installed, A1W1, A1W2 removed Adjust A1R44 to inhibit above 2000 Hz
XXXX Hz to 5000 Hz	A1W3 installed, A1W1, A1W2 removed Adjust A1R44 to inhibit above 5000 Hz
XXXX Hz to 9999 Hz	A1W3, A1W4 installed, A1W1, A1W2 removed

values will be visible in the panel display if the 847T has not been programmed to other values by the remote input. At that point, frequency should be programmed first. Place the REM/LOC switch in the LOC position and set the desired frequency with the four FREQUENCY/AMPLITUDE dials. Frequency is then entered by depressing the FREQ ENTER switch.

Verification of correct frequency entry is provided by the FREQUENCY display. Amplitude is set by selecting the amplitude with the dials and then pressing the AMP ENTER switch. Verification of correct amplitude entry is provided by the AMPLITUDE display. Either parameter may be changed by following the above procedure.

Table 2-10. Remote Connector, J2, Designators.

PIN NO.	FUNCTION	PIN NO.	FUNCTION
1	100V	11	FY1
20	200V	30	FY2 Frequency Digit Y
21	10V	12	FY4
3	20V	31	FY8
22	40V	13	FX1
4	80V	32	FX2 Frequency Digit X
23	1V	14	FX4
5	2V	33	FX8
24	4V	15	FW1
6	8V	34	FW2 Frequency Digit W (LSD)
25	0.1V	16	FW4
7	0.2V	35	FW8
26	0.4V	36	Logic Ground
8	0.8V	19	$\overline{\text{RTL}}$*
9	FZ1 Frequency Digit Z (MSD)	17	$\overline{\text{REMOTE}}$**
28	FZ2	18	$\overline{\text{LOCAL}}$***
29	FZ4	27	Spare
10	FZ8		

*A low on this input control line will allow the 847T to respond to the data inputs at the parallel input connector (J2) if the GPIB is not in the LOCAL LOCK OUT (LLO) state.

**Active output when jumper A3E3 - A3E2 is removed and A3W1 is installed to activate parallel remote buffers in the 846CM.

***Output to indicate the 847T is under local control of the 846CM. Normally, the GPIB has priority and can take over from local control or transfer control to local. However, the 847T may be programmed so that local control can be acquired by the 846CM or the parallel interface.

SECTION III — THEORY OF OPERATION

3.1 GENERAL

The California Instruments Model 847T Control Module, utilizes a quartz crystal to provide a high degree of frequency stability. A servo system provides excellent overall system (847T and power source) stability. The sense inputs of the control module are connected across the power source loads. The drive from the control module to the power source is changed in response to those inputs to maintain a constant voltage level across the loads. The Phase B and Phase C outputs are developed from the Phase A output through a multiphase converter.

There are two interface connectors on the rear of the unit which enable it to be controlled remotely from a general purpose interface bus (GPIB) meeting IEEE Standard 488-1978 requirements or from a 36-line parallel data bus. The 847T may be controlled locally with the optional Model 846CM Control Module. This unit has frequency and amplitude displays which function when the 847T is controlled locally or remotely. It also has a remote connector to which a parallel remote control may be connected when the IEE-488 Interface is not used. Remote control signals then pass through the 846CM.

3.2 FUNCTIONAL DESCRIPTION

The functional description contained in this section provides an overview of system operation referenced to the block diagram of Figure 3-1. The unit contains a precision three-phase oscillator module with variable output from zero to approximately five volts rms for a 130-volt power source output command. The maximum output level in response to a 130-volt command is dependent on the sense input levels. The oscillator frequency and amplitude are controlled from a GPIB interface within the oscillator module.

3.2.1 IEEE-488 INTERFACE

The IEEE-488 Interface enables a remote controller to provide frequency and amplitude

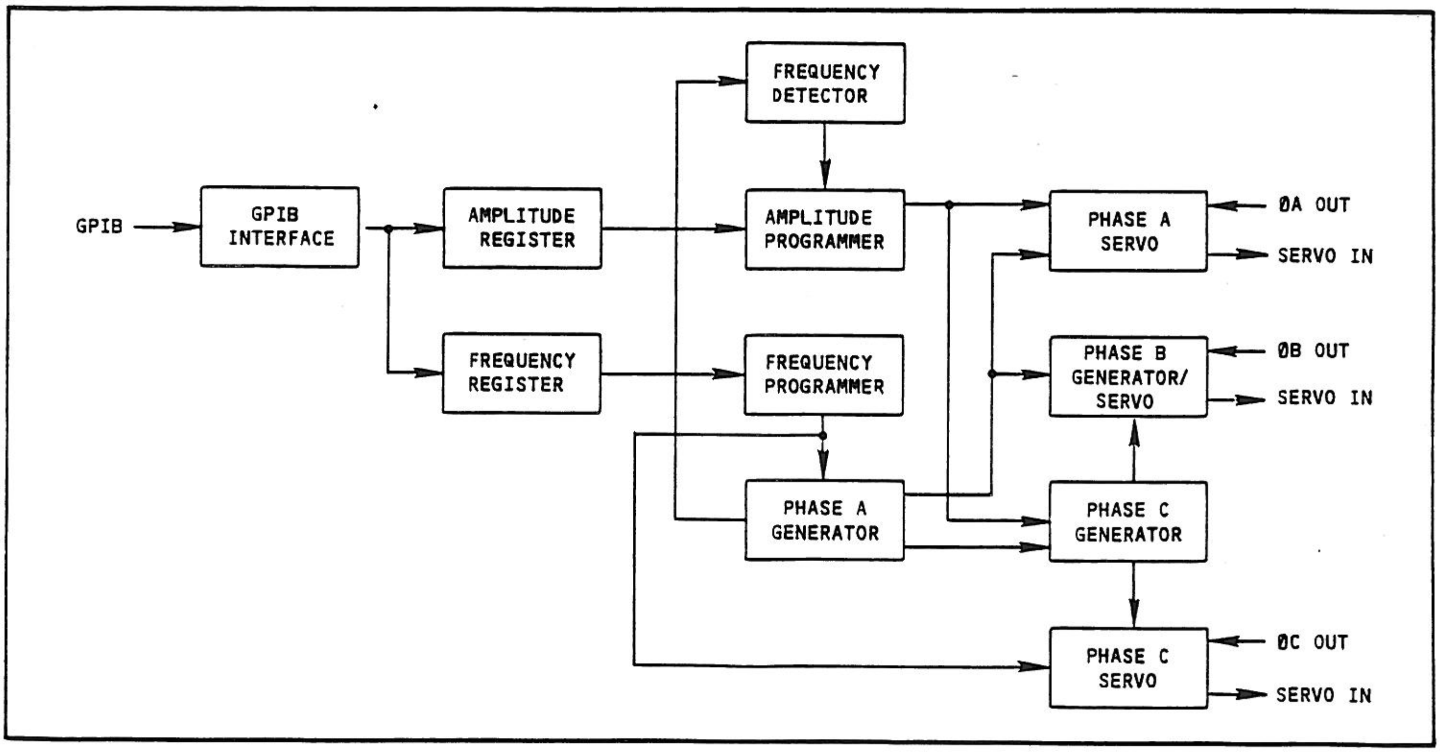


Figure 3-1. Block Diagram, Model 847T.

data over a general purpose interface bus (GPIB) meeting the requirements of IEEE Standard 488-1978. It consists of the interface adapter, data buffers and the frequency and amplitude data registers. It stores the numerical data appearing on the GPIB in the data buffers. It then decodes the frequency or amplitude identifier and loads the contents of the data buffers into the appropriate frequency or amplitude data registers. The interface operates as a listener/talker. In the talker mode, it transmits fault data to the controller. The condition of the decoded GO TO LOCAL (GTL) state from the GPIB determines whether the system is under control of the GPIB or the parallel input. The GPIB is normally in control.

3.2.2 FREQUENCY GENERATOR

The frequency generator produces a series of pulses that have a direct relationship to the 847T output frequency. It consists of the 10.2 MHz clock, rate multipliers and a range counter. The rate multipliers produce a series of pulses that have the width of the crystal controlled clock pulse, but with non-uniform spacing. The number of output pulses per unit time is dependent on the data at the output of the frequency data register. The output of the frequency generator is 1020 times the output frequency of the 847T.

3.2.3 AMPLITUDE PROGRAMMER

The amplitude programmer produces a DC output voltage that is dependent on the data in the amplitude registers. It consists of four digital-to-analog converters (DAC's), one for each decade. The input to the DAC's is provided by the DC reference source. The output of the four DAC's is summed and then buffered to provide the DC input to the Phase A and Phase C generators and the reference input to the servo system.

3.2.4 PHASE A GENERATOR

The Phase A generator produces a sinewave at the output frequency. It contains digital counters, a programmable memory and its own digital-to-analog converter. It combines the outputs of the frequency generator and the amplitude programmer to produce a sinusoidal waveform that is composed of 1020 discrete steps rather than being an analog signal. The output of the Phase A generator is filtered to produce a clean sinusoidal waveform at the output frequency.

3.2.5 PHASE C GENERATOR

The Phase C generator also produces a sinewave at the output frequency. It has inputs and components that are identical to those of the Phase A generator and operates in a similar manner. It is programmed to cause its output to lead the Phase A generator output by 120 degrees.

3.2.6 PHASE B GENERATOR

The Phase B generator sums the Phase A and Phase C generator outputs and inverts the resultant signal to produce the Phase B output.

3.2.7 FREQUENCY DETECTOR

The frequency detector utilizes pulses from the Phase A generator, which are at the output frequency rate, to shut down all 847T outputs if the selected frequency is below the preset limit of 45 Hz, or above the upper limit. In response to input commands, the frequency generator can produce pulse trains for output frequencies below 45 Hz, and above the upper limit. For such frequencies, the frequency detector will inhibit the digital-to-analog converter voltage reference. With a zero DC input, the digital-to-analog converter outputs to the Phase A and Phase C generators are zero.

3.2.8 SERVO

The servo system controls a gain-variable circuit (modulator) situated between the frequency generators and the output. The output level is modified by the sense input.

When the load is located some distance from the power source, the voltage across the load is less than at the power source output due to line voltage drop. The servo compensates for this loss by increasing the output level of the 847T and, thereby, those of the power source. Note that the servo has a reference input from the amplitude programmer. This reference is proportional to the programmed output voltage. It is summed with a DC voltage obtained by rectifying a scaled down level of the sense input voltage, which is proportional to the voltage across the load. The error voltage from the servo controls the phase generator outputs.

3.3 DETAILED CIRCUIT DESCRIPTION

The paragraphs of this section describe in detail the operation of the circuits of the Model 847T Control Module. Unless otherwise specified, all text within this section is referenced to the schematic diagrams of Drawings 4847-070, 4847-071, 4847-072 and the component designators therein. Where components consist of several discrete circuits within a single package, the individual circuits are identified in the text by the component designator and a suffix number, U22-5, for example. The suffix identifies the pin number on which the circuit output appears. The assembly number may be used as a prefix, such as A1U22-5. However, the prefix is used in this text only when necessary to avoid confusion in identification of similarly numbered components located in different assemblies.

3.3.1 IEEE-488 INTERFACE

The Model 847T may be controlled remotely by a computer (controller) that transmits data in accordance with IEEE Standard 488-1978 (IEEE-488) over a general purpose interface bus (GPIB). A complete description of the transmission scheme is beyond the scope of this manual and it is assumed that the servicing technician is familiar with the requirements of IEEE Standard 488-1978. The message organization and the method of processing the messages within the 847T are discussed in this section.

The circuits that interface the 847T with the IEEE-488 data bus are shown in Drawing 4847-072. The data inputs from the bus controller are low-true. These are inverted to high-true by line transmitter/receivers U24 and U25. The control inputs are low-active and are inverted to high-active by line transmitter/receivers U23, U24, U25 and transistors Q7, Q8 and Q9. The outputs of the transmitter/receivers and transistors are the inputs to the IEEE-488 interface device, U16. U16 provides all of the interface functions such as address comparison and processing of handshake data and provides the valid data strobe that clocks hex register U9.

The clock, which consists of U2-2 and associated components, operates at approxmately 2 MHz. It clocks U16 and the associated registers U30 and U22. U16, at the appropriate time, presets shift register U30 to load the address that is determined by the positions of the individual sections of switch S1. The address is then clocked out of U30 through its pin 3, to be stored within U16 where the address comparison is made. Two bits from U22 are clocked through U30 and loaded into U16. These are the REQUEST SERVICE (rsv) bit and the RETURN TO LOCAL (rtl) bit. When switch 7 is in the ON position, U22-1 is low to disable rsv. When rtl at pin 2 of A3J1 is low, $\overline{\text{rtl}}$ at U22-15 is high to return to local. Switch 6, when in the OFF position, puts a binary '1' into U30 and puts the 847T in the LISTEN ONLY MODE. In that mode, the 847T will respond to data on the interface bus without an address being generated by the GPIB controller (reference IEEE Standard 488-1978).

3.3.1.1 COMMAND PROGRAMMING

Complete programming information was provided in Section II. However, a brief review is appropriate here. The command digits for frequency or for amplitude may all be programmed in one serial message. Alternately, one or more sequential digits may be selectively changed in one serial message. When programming all digits, the message consists of five bytes; the first four bytes deliniate the four digit values; the fifth byte is an ASCII alpha character, A, E or F, which is the amplitude or frequency identifier. When a selective change is made beginning with other than the most significant digit, an alpha prefix character, Y, X or W, indicating the digit being changed, is transmitted prior to transmitting the numerical data.

It is optional whether the digits following the first digit to be changed are also changed. As in programming all four digits of the command, the command identifier, A, E or F, must follow the numerical data. However, the selected digit must be of the same command as that previously transmitted as described in paragraph 2.7.1.4. When the Y digit is the first to be changed, the prefix is Y. The next digit prefix is X and the least significant digit prefix is W. How these character transmissions are processed to achieve the desired results is covered in the following paragraph.

3.3.1.2 COMMAND DECODING

The command decoding scheme of the 847T uses programmable read-only memories (PROMs) to direct the message to the proper registers. The command message bytes appear on lines D101 through D107 and provide inputs to the 256 x 4 PROM, U15, and to the four holding registers, U5, U7, U11 and U13. U15 is programmed to output specific codes in response to ASCII code inputs.

Note that the most significant bit input to U15 (pin 15) is not connected to a data input, but to an output of register U9. Also, two outputs of U10 are connected as inputs to U9. These inputs to U9 will be clocked to its outputs to provide part of the next address for U10. They determine what character or characters may next be decoded.

The outputs of U10 on pins 5, 6, 7 and 9 provide the clocks that load the numerical data from the GPIB bus into the individual Z, Y, X and W holding registers, respectively. Pin 3 provides the clock that transfers the data in the Z, Y, X and W holding registers to the outputs of the frequency data registers, U18 and U20. Pin 4 provides the clock that transfers the data from the Z, Y, X and W holding registers to the outputs of the amplitude data registers, U17 and U19.

Register U9 is cleared on power-up to disable rsv, set the voltage command to zero and the frequency (on standard units) to 60 Hz as described in paragraph 3.3.1.4. The first ASCII number received will cause U10 to have logical 11 at its output to load register U13. The second ASCII number received will cause U10 to have logical 22 at its output to load register U7. The third ASCII number received will cause U10 to have logical 43 at its output to load register U11. The fourth ASCII number received will cause U10 to have logical 83 at its output to load register U5.

When the data is frequency, an ASCII F will be transmitted (code 46). The output from U10 is 04. A high is produced on pin 3 of U10 which, through U3-3, clocks the frequency registers, U18 and U20, to transfer the frequency data in the W, X, Y and Z registers to their outputs. When the data is amplitude, an ASCII A will be transmitted (code 41). This produces an output from U10 of 08 and a high on pin 4. This clocks the data in the W, X, Y and Z holding registers to the output of the amplitude data registers, U17 and U19. Note that an ASCII E will produce the same effect as ASCII A. Transmitting another numerical character starts another similar sequence.

3.3.1.3 POWER SHEDDING

To preserve the data in the frequency and amplitude storage registers during short periods of power interruption, a power shedding circuit disconnects all other circuits until power is restored. If power is not restored within approximately 100 milliseconds, the data will be lost and the system reset as described in paragraph 3.3.1.4.

Refer to the schematic diagram of the program board, Drawing 4847-072. VR1 is a programmable zener diode that is adjusted to cutoff when the +5V bus drops to approximately 4.4 volts. This turns off Q2 which turns off Q4, disconnecting C9 from the +5V bus. C9 continues to power the CMOS registers for approximately 100 milliseconds if power is not restored before that time. Q2 being turned off also sets the VLC input to the D/A converters, U26, U27, U28 and U29, high, removing their source of input current. Also, Q6 is turned on, turning on Q3 to discharge C17 and connect the two reference inputs of the D/A converters together. When power is restored, Q6 and Q3 are turned off and C17 charges through FET Q5. The current output of the D/A converters is a function of the difference in their inputs at pins 4 and 15. C17 delays the grounding of the line leading to pin 15 so that the output of the D/A converters is delayed, providing a "soft start" on resumption of power.

3.3.1.4 COMMAND RESET

To prevent random frequency and amplitude output at power-up and after a power interruption, a reset circuit is provided. Refer to the program board schematic diagram, Drawing 4847-072. Note that diodes CR1, CR2 and CR3 are connected in series to the B5 bus. At power-up, or after a prolonged power interruption, C9 will be discharged. Therefore, the level at pin 13 of inverter U2-13 will lag the +5V bus. Its output is then high and forces the output of exclusive OR gate U3-10 high to reset registers U5, U7, U11 and U13. The output of inverter U2-8 is set low, and, through the exclusive OR gates of U3-3 and U3-4, sets the clock inputs of frequency and amplitude registers U17 and U19 low, and the inputs of U18 and U20 to 60 Hz in standard units.

When the input to inverter U2-12 rises to the threshold level, its output goes low, reversing the states of the outputs of U3-10, U2-8 and U2-10. However, the device delays are such that the frequency registers are clocked before the transition of the output of U2-10. Because of the connection of U2-10 to U20 through diodes CR4 through CR7, CR10 and CR11, the 60 Hz weight input to the frequency register is clocked to its output while all other inputs are low due to the reset of U5, U7, U11 and U13.

3.3.2 RATE MULTIPLIERS

The rate multipliers produce a series of pulses that have a fixed relationship to the output frequency (normally 1020 times the output frequency). The number of pulses produced are directly proportional to the frequency command. A rate multiplier is a special type of counter that, during the time of ten clock pulses while enabled, will pass to its output a number of pulses, from 0 to 9, proportional to the BCD code present at its four rate inputs. The output pulses are the same width as the clock pulses, however, pulse spacing is not uniform. A complete explanation of the operation of rate multipliers may be found in material published by the device manufacturers. Therefore, the explanation of the rate multiplier circuits herein is limited to that which is necessary to describe the operation of the 847T.

The rate multipliers are shown in the schematic diagram of the program board, Drawing 4847-072. The outputs of frequency data registers U18 and U20 provide the control inputs to rate multipliers U8, U14, U6 and U12. The rate multipliers are clocked by the output of the crystal oscillator circuit comprised of Q1, Y1 and associated components. The oscillator operates at 10.2 MHz. Rate multiplier U8 (Decade Z), for the most significant digit (MSD), is enabled at all times. The number of pulses appearing at its output (pin 5) during ten oscillator pulses is dependent on data present at the output of U20. Since the clock pulses gate its output, its pulses will have the same width as clock pulses. On the falling edge of the last pulse, pin 7 of U8 goes low, enabling the next rate multiplier, U14, which outputs one pulse if its rate inputs permit, before its enable input again goes high. If its rate inputs are set at five, for example, it will output five pulses for each ten times it is enabled. U6 utilizes the enabling outputs of U14 and U12 utilizes those from U6. The clock pulse provides synchronization and uniformity of pulse widths at the outputs of the mulitipliers. The output pulses from the rate multipliers are then summed through NAND gate U1-6. The number of pulses at the output of U1-6 divided by 1020 provides the desired output frequency.

Refer to Drawing 4847-070. SINE CLOCK, which is the output of the rate multipliers, clocks counter U1. For a range of 45 to 9999 Hz, jumper W3 is installed and U1 is bypassed. For a range of 45 to 999.9 Hz, jumper W2 is installed to provide a division of SINE CLOCK of 10. For a range of 45 to 99.99 Hz, jumper W1 is installed to provide a division of SINE CLOCK of 100.

3.3.3 AMPLITUDE PROGRAMMER

The amplitude programmer consists of a digital-to-analog (D/A) converter array that produces a DC voltage proportional to the amplitude command. The programmer is shown in Drawing 4847-072. There are four D/A converters, U26, U27, U28 and U29. The digital data input is from amplitude data registers U17 and U19. The most significant digit data (hundreds decade) is the input to U29 and the least significant data is input to U26. The reference voltage for the D/A converters is from the 10-volt regulator, A1U12, shown in Drawing 4847-070.

The current supplied to each D/A converter and the output current it furnishes to the summing point (junction of R18, R22 and R20) are scaled by series/parallel resistor combinations. Part of the scaling is accomplished with series input resistors and part with series/parallel resistor combinations at the outputs. The latter are joined at the summing junction which is at the inverting input of amplifier U21-6. The output of U21-6 is a DC voltage level proportional to the digital command at the output of the amplitude registers. R27 and R28 provide tracking adjustments for the units and tens decades, respectively. R26 provides a low level open servo adjustment for U21. The other circuits on the program board are involved in the fault circuits described in paragraph 3.3.8.

3.3.4 PHASE A GENERATOR

The Phase A generator produces a sinewave output with frequency and amplitude corresponding to the frequency and amplitude data stored in the data registers. Its schematic diagram is shown in Drawing 4847-070. It consists of several subsystems that are described in the following paragraphs.

3.3.4.1 ADDRESS AND DIRECTION COUNTERS

Address counters U7, U10 and U13 are clocked by an output of A3U1-6 and provide the digital address to the sinewave programmable read-only memories (PROMs) which are part of the quasi-sinusoid generator described in paragraph 3.3.4.2. The direction counter controls the count reversal that must occur at the end of each 255 counts. The circuits are shown in the schematic diagram of Drawing 4847-070. Address counters U7 and U10 are cascaded to form an 8-stage binary counter. They provide the address for the two programmable read-only memories (PROMs), U11 and U12.

An 8-stage binary counter will normally count 256 clock pulses before its outputs return to their original state. The counter comprised of U7 and U10 must count only 255 steps before being reset to its original state. This is accomplished with the array of exclusive NOR gates, U8 and U9, and direction counter U13. U8 and U9 are open-collector types and their combined outputs go high when all inputs are the same, high or low. This occurs when pin 14 of U13 is high and all stage outputs of U7 and U10 are high, except pin 14 of U7 is low, at counts 254 and 764. It also occurs when pin 14 of U7 is low and all stage outputs of U7 and U10 are low at counts 509 and 1019. This is an input to the multi-phase converter board, A2, Drawing 4847-071, and to counter U13 which is enabled through inverter U3-8. U13 is clocked once simultaneously with U7 and U10 at clock pulses 255, 510, 765 and 1020. U7 and U10 are advanced one count, since their up/-down inputs do not change state until after this clock pulse. The inputs to U9 and U8 are then no longer the same and their combined outputs go low, disabling U13. However, U13 was clocked once, changing the state of its output on pin 14 and the up/down inputs of U7 and U10. The count modes of U7 and U10 are then changed from up to down when pin 14 of U10 goes low or from down to up when it goes high. Thus, U7 and U10 are forced to count up from count 001 to count 255, down from counts 256 to 510, up from counts 511 to 765 and down again from counts 766 to 1020.

Counter U13 has its pin 13 connected to FET Q8. The purpose of this connection is covered in the next paragraph. Its pin 13 and pin 14 outputs are OR'd in U4-11. The output of U4-11 is OR'd with the output of inverter U3-8. This is an input to the multi-phase converter board which is covered in paragraph 3.3.5.

3.3.4.2 QUASI-SINUSOID GENERATION

Digital-to-analog converter (D/A converter) U19 and the two amplifiers of U14 generate a quasi-sinusoidal waveform, consisting of 1020 discrete steps, in response to the inputs from PROMs U11 and U12. The DC input for the D/A converter is provided by the output of U6-8 which combines the DC PROGRAM output of A3U21-6 with that from the Phase A servo. This voltage is variable in amplitude as discussed in paragraph 3.3.3. However, for the purposes of this discussion, the level of the input to the D/A converter is not important.

The PROM outputs provide the digital input codes for the D/A converter. From the previous paragraphs, it should be apparent that the address for the PROMs is repeatedly incremented from 000 to 255 and then decremented from 255 back to 000. Thus, the digital input codes to the D/A converter are, likewise, being incremented and decremented. The PROMs are programmed so that their outputs cause U33 to produce what comprises the first 90 degrees of a quasi-sinusoidal waveform consisting of 255 discrete steps. The amplitude of each step is equivalent to:

$$E = \sin (90/255 \times A)$$

Where A is the discrete digital address (000 to 255).

As the address is decremented from 255 back to 000, U33 produces the opposite waveform which is the second 90 degrees of a quasi-sinusoidal waveform. The process is repetitive. Therefore, in two complete cycles, the current from U19 produces what appears as a sinusoidal waveform after full-wave rectification at the output of U34-7, except that it consists of 1020 discrete steps rather than being a pure analog signal. It is only necessary to invert alternate cycles of U14-7's output to achieve a sinusoidal waveform. This is accomplished in the amplifier circuit of U14-1.

Pin 3 of U14-1 is grounded whenever the gate of FET Q8 is at a TTL high level. This changes U14-1 from an inverting amplifier to a non-inverting amplifier. In a previous paragraph, it was stated that counter U13 was clocked once at counts 255, 510, 765 and 1020. Therefore, its pin 13 will change state at counts 510 and 1020. Pin 13 of U13 is connected to the gate of FET Q8. Whenever it is low, Q8 is turned off and U14-1 does not invert the output of U14-7. When it is high, Q8 is turned on and U14-1's output is inverted. A complete cycle for U14-7 occurs between counts 000 and 510 and between 510 and 1020. Thus, alternate cycles will be inverted to form a sinusoidal waveform at the output of U14-1. The output of U14-1 is then filtered by U17-1, R38, R22, C12 and C15. This is the ϕA REF (Phase A) signal which is a clean sinusoidal waveform. The output of U17-1 goes to the input of the Phase A generator. The signal at pin 3 of U17-1 is sinusoidal and is passed through modulator U17-7 to provide the ϕA output of the oscillator. The output level of U17-7 will be modified by the servo system output as described in paragraph 3.3.6.

3.3.5 MULTI-PHASE CONVERTER

The multi-phase converter produces the Phase C (ϕC) and Phase B (ϕB) outputs that are locked to the ϕA output. It is located on a separate circuit board of which Drawing 4847-071 is the schematic diagram. A vector diagram showing the angular displacement of each phase with respect to the others is shown in Figure 3-2. The following paragraphs explain the functioning of the multi-phase converter.

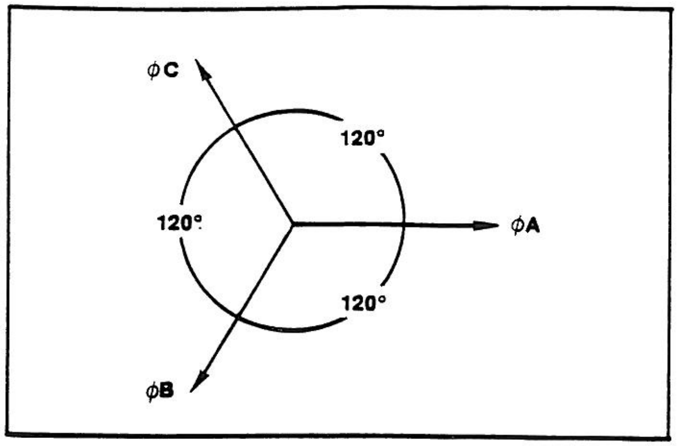


Figure 3-2. Output Phase Relationships.

3.3.5.1 PHASE C GENERATOR

NOTE

All components for the Phase C generator are located on the A2 board. Since reference is made to components on the A1 and A3 boards, the full reference designators are used in the following paragraphs.

The Phase C generator consists of address counters, a directional control counter system, PROMs, a D/A converter and an inverting/non-inverting amplifier which perform the same functions as those on the Phase A generator board. The circuits, comprised of counters A2U2, A2U3 and A2U4, exclusive NOR gates A2U5 and A2U6, PROMs A2U7 and A2U8, D/A converter A2U9 and operational amplifier A2U10-7, are interconnected in the same manner as their counterparts on the Phase A generator board. The counters are clocked by the same signal from A3U1-6. The DC input for the D/A converter is also obtained from amplifier A3U21-6. Therefore, the amplitudes of the ϕA and ϕC outputs are identical.

The counters of the multi-phase converter, unlike those of the Phase A (ϕA) generator, are preset at the instant the ϕA output passes through the 180 degree point on every cycle. The preset causes the waveform generated in this system to be displaced, relative to ϕA, such that it leads ϕA by 120 degrees. The preset is accomplished by the signals at terminal 5 of A1J1 which is from A1U4-3 as shown in Drawing 4847-070. A1U4-3 goes low one clock pulse prior to the 180 degree point of every cycle of the ϕA output.

The outputs of A2U5 and A2U6 go high at counts 254, 509, 764 and 1019. Therefore, they go high at counts 2039, 3059 and 4079. When the output of A1U4-3 is low, the preset mode of counters A2U2, A2U3 and A2U4 are enabled and preset occurs on the rising edge of the next clock pulse. The counters are preset to the count determined by the connections to their pin 3, 4, 5 and 6 inputs. As drawn, the pin 3 and 5 inputs of A2U1 and A2U2 are grounded (low) and the pin 4 and pin 5 inputs are at +5 volts. This produces a preset of AA in hexadecimal or 1010 1010 in binary. This presets the PROM address at 170. The directional control counter, A2U4, is preset so that its pin 14 output is low and its pin 13 output is high. Thus, counters A2U2 and A2U3 will be in the countdown mode and A2U10-1 will be in its inverting mode.

The amplitude of the waveform developed at the output of A2U9 from this point forward will be decreasing from maximum and, since A2U10-1 is in an inverting mode, the output of A2U10-1 will be 120 degrees leading ϕA which is the correct phase angle for ϕC. The signal output of A2U10-1 is filtered by A2U12-7. The connection between the non-inverting inputs of A2U12-7 and A2U12-1 is the ϕC generator output which is combined in A2U12-1 with the ϕC servo input to produce the ϕC OSC OUTPUT at pin 16 of A2J1. The ϕC output is isolated from the ϕB circuit by amplifier A2U12-7. Capacitor A2C7 provides high frequency roll-off for A2U12-7.

3.3.5.2 PHASE B GENERATOR

The Phase B signal is obtained by summing ϕA and ϕC signals of equal amplitudes and then inverting the resultant signal through an operational amplifier. The ϕA input to this board is obtained from amplifier A1U17-1. The ϕC signal is obtained from the output of amplifier A2U12-7. The two signals are summed at the input of amplifier A2U11-1 through the resistor network comprised of two sections of A2R7. The output of A2U11-1 is buffered in A2U11-7 to produce the ϕB output at pin 15 of J1.

3.3.6 SERVO AMPLIFIERS

The servo systems independently increase, or decreases the outputs of the 847T in response to the sense inputs. They adjust the output of the power source to compensate for its output impedance and/or any drop in the cables between the power source outputs and the load. The 847T is equipped with identical servo systems in each of its phase generators. Therefore, only the Phase A servo system is described. The servo system for the Phase A generator is located on the A1 circuit board assembly and is shown in Drawing 4847-070. Those for the Phase B and Phase C generators have their differential sensing amplifiers on the A1 board and the remaining part of the circuit on the A2 board. Thus, all circuits handling HIGH VOLTAGE LEVELS are on the A1 board.

The 847T is designed to operate with 130-volt power sources. Therefore, the Phase A sensing input, which is connected across the power source load, is scaled by the circuit of U6-1, to approximately 5 volts rms for a 130-volt input. The full wave precision rectifier circuit of U16-1 produces a negative DC voltage which is buffered by U16-7 and then integrated by the circuit of U15-6. The output of the integrator affects the gain of the modulator comprised of photo-modulator U18 and amplifier U17-7. The resistive element of U18 will affect the gain of U17-7 in inverse proportion to the level at the input of U6-1. Thus, the output of the ϕA signal will be increased if the level across the ϕA load decreases due to load current and will be increased if the current is decreased. There are adjustments in the servo system for common mode nulling.

Note that when the servo inputs are disconnected, the output of the 847T and associated power source rise approximately ten percent above the programmed level.

3.3.7 FREQUENCY DETECTOR

The purpose of the frequency detector is to prevent production of an output frequency, due to miscommand and/or malfunction, above or below the range of the AC power source that is driven by the 847T. Its circuit is shown in Drawing 4847-070 and is comprised of transistors Q1 and Q2, dual timer U2, dual flip flop U5, NOR gates U4-3 and U4-6 and associated components. Pin 14 of counter U13 transitions from high to low one time for every half-cycle of the output frequency. The falling edge of this pulse triggers the one-shot comprised of U4-3 and inverter U3-4. This momentarily turns on Q1 and Q2 to discharge timing capacitors C9 and C10 and trigger both sections of U2. The section of U2 associated with Q1 is adjusted with R45 so that its time period is greater than one half-cycle of the lowest permissible output frequency (45 Hz). As long as the output frequency of the 847T is greater than this low limit, the timer output will be at a high state when the next trigger pulse from U4-3 occurs. The $\overline{Q}$ output of U5, pin 6, will not change state and the output of U4-6, connected to it, will remain low.

The section of U2 associated with Q2 is adjusted with R44 so that its time period is less than one half-cycle of the highest permissable frequency (normally 5000 Hz). As long as the output frequency of the 847T is less than this high limit, the output of the timer will have transitioned from high to low before the next pulse from U4-3 occurs. The Q output of U2 (pin 9) and the input to U4-6 connected to it will remain low.

When the frequency is within the set limits, the output of U4-6 is low (both inputs low). FAULT is high and $\overline{\text{FAULT}}$ is low. The function of the fault circuits is discussed in other paragraphs. When a frequency is selected that is lower than the preset limit, the pin 5 output of U2 goes high before the next pulse. The $\overline{Q}$ output of U5, pin 6, is then clocked high, the output of U4-6 goes high, setting FAULT low and $\overline{\text{FAULT}}$ high.

The function of FAULT is discussed in paragraph 3.3.8. FAULT is carried through to the program board A3 which is shown schematically in Drawing 4847-072. When FAULT goes high, it turns on transistor Q6 which, in turn, turns on transistor Q3, discharging capacitor C17 and connecting the current input of the D/A converters together. The current output of the D/A converters is a function of the difference between their current inputs. Since the difference with FAULT high is then zero, DC PROGRAM and the output of the ϕA and ϕC generators is zero.

When an acceptable frequency is then programmed, FAULT goes low, turning off Q6 and Q3. C17 will slowly charge through FET Q5 so that the amplitude builds slowly after being shut down. This is how the "slow start" feature, mentioned in Section I, is implemented.

Note that the base of Q6 is also connected, through a section of Z1, to the collector of Q2. When a power failure occurs, the +5V bus drops below 4.5 volts, turning off Q2. Q6 will then be turned on through R30 to shut down the D/A converters. If the failure is of short duration, C9 will maintain the data in the frequency and amplitude registers. When power is restored, Q6 and Q3 will be turned off and the "slow start" circuit will function as previously described.

3.3.8 FAULT SYSTEM

The fault system functions to shut down the 847T if a frequency outside the preset limit is programmed or if either the Phase A, Phase B or Phase C generators fail. The generation of the fault signal from the frequency detector was detailed in paragraph 3.3.7. The circuit that produces the fault signal for the Phase A frequency generator is shown in Drawing 4847-070.

Note that if the ϕA output should fail, the output of servo integrator U19-6 would shift toward -12 volts. Through zener diode VR3, transistor Q3 would be turned on, pulling SB1 low. Identical circuits in Drawing 4847-071, comprised of CR5 and Q2 and CR6 and Q3, pull SB3 and SB2 low for Phase C and Phase B, respectively.

The $\overline{\text{FAULT}}$ signal from the frequency detector is carried to the program board, A3, Drawing 4847-072, and provides talker signal SB4 to the GPIB controller through A3U25. SB1, SB2 and SB3 are also passed to the A3 board and are connected to the inputs of NAND gate U1. When a fault occurs, this will load a "1" into register U22 which will be clocked into U16. This will force U16 to generate a service request (SRQ) to the GPIB controller. The GPIB controller will then poll the various devices on the bus. When it determines that the 847T has generated the SRQ, it will interrogate the 847T. The 847T will then communicate the fault data to the GPIB.

3.3.9 POWER SUPPLY

The power supply circuits for the 847T are shown in the left center area of Drawing 4847-070. DC at +25 volts and -25 volts is obtained from the associated power source. The +25V input is regulated to +15 volts through series pass transistor Q6 which has its base voltage set by VR1. A similar circuit, comprised of Q7 and VR2, regulates the -25V input to -15 volts. The +5-volt supply is obtained by rectification of the AC voltage appearing across the secondary of transformer T1, filtering it with C21 and regulating it at +5 volts through VR5.

3.4 DETAILED CIRCUIT DESCRIPTION-846CM

The 846CM is an optional equipment item that provides local control for the 847T. It contains BCD switches, storage registers, BCD-to-seven-segment decoders and seven-segment LED numerical displays for selecting and displaying frequency and amplitude commands. Its schematic diagram is shown in Drawing 4846-070. The connections between the 846CM and the program board (A3) of the 847M are listed in Drawing 4847-072.

3.4.1 LOCAL/REMOTE TRANSFER

The GPIB normally has priority and can assume control at any time irrespective of the position of the LOC/REM (LOCAL/REMOTE) switch of the 846CM. However, the GPIB cannot place the 847T in local control until the switch on the 846CM is placed in the LOC position. This becomes apparent when the LOC/REM switch common connection is traced back to the A3 board of the 847T, Drawing 4847-072. When the switch is in the REMOTE position, it generates a low at the input of inverter A3U2-2. The high on A3U2-2 is the RTL signal. When $\overline{\text{LOC}}$ from the 847T goes low, it completes the current path for CR4 causing it to light, indicating that the 846CM has control.

When the 846CM is used in conjunction with a remote parallel input connected to it, jumper A3W1 at the output of A3U2-6 is installed, and the clad from E2 to E3 is removed. The LOC/REM switch on the 846CM is then in complete control of local/remote selection. $\overline{\text{REM}}$ at the output of A3U2-6 goes low when the switch is in the REM position, enabling buffers U1 through U6 of the 846CM to connect the external remote data lines to the 847T frequency generator and amplitude programmer. $\overline{\text{LOC}}$ at the output of A3U4-12 goes high to disable registers U16, U17, U18 and U19 in the 846CM, preventing local operation. When the switch is in the LOC position, the parallel data buffers are disabled and registers U16, U17, U18 and U19 are enabled.

3.4.2 FREQUENCY/AMPLITUDE ENTRY

Frequency and amplitude are selected with a single set of four BCD switches, S1 through S4. The lines from each switch are connected to amplitude registers U16 and U17 and to frequency registers U18 and U19. The registers are 8-bit latches and each switch is connected to four of the inputs. Each selected bit opens the path between the low end of a pull-up resistor and ground, placing +5 volts at the inputs of the registers.

Entry of amplitude is made with AMP ENTER switch A6. The switch is a momentary toggle switch. When closed, amplitude registers U16 and U17 are clocked to place the states of the BCD switch lines on their outputs and on the amplitude data lines. When FREQ ENTER switch S7 is closed, frequency registers U18 and U19 are clocked, placing the states of the BCD switches on their outputs and on the frequency data lines. The outputs of U16, U17, U18 and U19 are connected to the terminals on J1 which, through the mating connector, connects the outputs of U16 and U17 to the inputs of the 847T amplitude programmer and U18 and U19 to the inputs of the frequency programmer. Note, however, that the registers are tri-state devices enabled by a low on pin 1. When the system is in the remote mode, the line connected to pin 1 of the registers is in a high state, placing their outputs in a high impedance state and they no longer control frequency and amplitude.

3.4.3 FREQUENCY/AMPLITUDE DISPLAY

The inputs to seven-segment decoder/drivers U8 through U15 are connected to the frequency and amplitude data lines of J2. Frequency and amplitude data are present on these lines in either remote mode (GPIB or remote parallel) and in the local mode so that frequency and amplitude are displayed at all times. Their outputs drive seven-segment display devices DS1 through DS8. DS1 through DS4 display four digits of amplitude data and DS5 through DS8 display four digits of frequency data. The individual resistors of R10 will be connected such that the decimal point is displayed in the correct location depending on the frequency and amplitude range of the 847T.

3.4.4 POWER-UP CLEAR

When power is applied, the frequency and amplitude data registers are cleared. Positive 5 volts is applied to C4, through R8, making the outputs of inverters U20-4 and U20-6 momentarily low for the time constant R8 times C3. When U20-2 is high, it is inverted by U20-12 to pull all the lines of switches S1 through S4 low. The circuit time constants are such that C4 will charge, forcing the output of U20-6 and U20-4 high, before U20-12 goes high. The latches in the registers are enabled at all times, though their output buffers may be in the high impedance (remote control) state. Thus, when U20-6 goes high, it clocks the frequency and amplitude registers at a time when low states exist at all inputs, making their outputs low.

3.4.5 POWER SUPPLY

The 846CM obtains its power not from the associated power source, but from local commercial power of 115/230 volts at 50/60 Hz. It has its own POWER switch which connects the power source to transformer T1. The power supply is a simple full-wave rectifier comprised of CR1 and CR2. Its output is filtered by C1 and regulated to +5 volts by U7. C2 provides high-frequency by-passing and CR3 provides transient suppression.

SECTION IV — ADJUSTMENT PROCEDURES

4.1 GENERAL

The following adjustment procedure, or any part of it, may be performed on a routine basis to insure that the oscillator remains within the specified performance limits. Paragraphs 4.3 through 4.10 only need to be performed if a related component has been replaced. Paragraphs 4.11 through 4.12 need to be performed on a periodic interval.

Calibration of the 847T Programmable Precision Oscillator requires a compatible power source(s) as shown in Figure 2-1.

4.2 RECOMMENDED TEST EQUIPMENT

The items listed in Table 4-1 are recommended for performing the adjustments outlined in this section.

4.3 PRELIMINARY STEPS

1. Connect the servo inputs as shown in Figure 2-1.
2. Apply Power and allow at least fifteen minutes for the oscillator to stabilize.
3. Monitor the programmed AC voltage with a digital AC voltmeter at TB1 on the rear of the power source. The Phase A output is monitored across terminals 9 and 10, the Phase B output across terminals 9 and 11 and the Phase C output across terminals 9 and 12. The voltage may be monitored at the power source front panel terminals if the source is unloaded.

4.4 SINE CLOCK ADJUSTMENT

1. Connect the frequency counter between test point A3TP1 and digital ground.
2. Adjust A3C8 for a counter reading of 10,200,000 Hz ±100 Hz.

4.5 GPIB CLOCK ADJUSTMENT

1. Connect the frequency counter between test point A3TP2 and digital ground.
2. Adjust A3R7 for a counter reading of 2.0 MHz ±0.1 MHz. Seal A3R7.

4.6 FREQUENCY DETECTOR LOW LIMIT ADJUSTMENT

1. Program the 846CM to 44 Hz and 100.0 volts.
2. Adjust the LOW adjustment (A1R45) until the output is inhibited.
3. Retard the adjustment just to the point where the output reappears. Seal A1R45.

4.7 FREQUENCY DETECTOR HIGH LIMIT ADJUSTMENT

1. Program the 846CM to the highest frequency compatible with the power source being used and to 100.0 volts.
2. Adjust the HIGH adjustment (A1R44) to the point where the output is inhibited.
3. Retard the adjustment just to the point the output reappears. Seal A1R44.

4.8 OPEN SERVO ADJUSTMENT

1. Open the Phase A, B and C sense lines by removing all connection to TB1 terminals 10, 11 and 12.
2. Program the 846CM to 010.0 volts and 60 Hz.
3. Attach the voltmeter to the power source Phase A output and adjust A3R26 for 11.3 volts ±0.1 volts.

Table 4-1. Recommended Test Equipment.

Digital Voltmeter	Calibration accuracy of 0.1% on the 200-volt range
Distortion Analyzer	Krohn-Hite Model 6800 or equivalent
Control Module	California Instruments Model 846CM
Phase Meter	Dranetz Series 331

4. Program the 846CM to 100 volts. Adjust the power source GAIN control for 110.0 volts ±0.1 volts.
5. Attach the voltmeter to the Phase B power source output. Adjust the Phase B power source GAIN control for 110.0 volts ±0.1 volts.
6. Attach the voltmeter to the Phase C power source output. Adjust the Phase C power source GAIN control for 110.0 volts ±0.1 volts.
7. Repeat steps 2 through 6 above.
8. Seal A3R26 on the 847T and lock the power source front panel GAIN controls.

4.9 COMMON MODE ADJUSTMENT

Refer to Figure 2-1 and connect the remote sense leads. Initially insure that there is no connection between CIRCUIT GND (TB1, terminal 1) and either terminal 9, 10, 11 or 12.

4.9.1 PHASE A COMMON MODE ADJUSTMENT

1. Short TB1, terminal 10, to CIRCUIT GND (terminal 1).
2. Monitor the power source Phase A output voltage with the digital AC voltmeter across TB1, terminals 9 and 10.
3. Program the 846CM for 60 Hz and 100.0 volts. Record the voltmeter reading to within ±10 millivolts.
4. Remove the short from TB1, terminal 10, and connect it to TB1, terminal 9.
5. Adjust A1R49 for the same voltage recorded in step 3, ±10 millivolts. Seal A1R49.
6. Remove the short from TB1, terminal 9.

4.9.2 PHASE B COMMON MODE ADJUSTMENT

1. Short TB1, terminal 11, to CIRCUIT GND (terminal 1).
2. Monitor the power source Phase B output voltage with the digital AC voltmeter across TB1, terminals 9 and 11.
3. Program the 846CM for 60 Hz and 100.0 volts. Record the voltmeter reading to within ±10 millivolts.
4. Remove the short from TB1, terminal 11, and connect it to TB1, terminal 9.
5. Adjust A1R48 for the same voltage recorded in step 3, ±10 millivolts. Seal A1R48.
6. Remove the short from TB1, terminal 9.

4.9.3 PHASE C COMMON MODE ADJUSTMENT

1. Short TB1, terminal 12, to CIRCUIT GND (terminal 1).
2. Monitor the power source Phase C output voltage with the digital AC voltmeter across TB1, terminals 9 and 12.
3. Program the 846CM for 60 Hz and 100.0 volts. Record the voltmeter reading to within ±10 millivolts.
4. Remove the short from TB1, terminal 12, and connect it to TB1, terminal 9.
5. Adjust A1R50 for the same voltage recorded in step 3, ±10 millivolts. Seal A1R50.
6. Remove the short from TB1, terminal 9.

4.10 DECADE TRACKING ADJUSTMENT

1. Connect the remote sense lines as shown in Figure 2-1.
2. Connect the AC voltmeter to Phase A output.
3. Program the 846CM to 100.0 volts and 90 Hz. Adjust **A1R47** (A=100) for 100.00 volts ±0.01 volts.
4. Program the 846CM to 90.0 volts and adjust A3R27 for 90.00 volts +0.01 volts. Seal A3R27.
5. Program the 846CM to 99.0 volts and adjust A3R28 for 99.0 volts ±0.01 volts. Seal A3R28.

NOTE

Paragraphs 4.4 through 4.10 are the non-routine adjustments. The following paragraphs describe adjustments that are of a periodic nature and are summarized in Table 4-2.

4.11 10-VOLT ADJUSTMENT

1. Verify that the remote sense lines are connected as shown in Figure 2-1.
2. Program the 846CM for 10.0 volts and 60 Hz.
3. Monitor the Phase A output. Adjust A1R46 (A=10V) for 10.00 volts ±0.01 volts.
4. Monitor the Phase B output. Adjust A2R34 (B=10V) for 10.00 volts ±0.01 volts.
5. Monitor the Phase C output. Adjust A2R32 (C=10V) for 10.00 volts ±0.01 volts.

Table 4-2. Periodic Adjustments.

STEP	AMPLITUDE	FREQUENCY	ADJUSTMENT	OUTPUT
1	10.0	90	A = 10	Phase A = 010.0 ±0.01V
2	10.0	90	B = 10	Phase B = 010.0 ±0.01V
3	10.0	90	C = 10	Phase C = 010.0 ±0.01V
4	100.0 or 200.0	90	A = 100	Phase A = 100.0 or 200.0 ±0.01V
5	100.0 or 200.0	90	B = 100	Phase B = 100.0 or 200.0 ±0.01V
6	100.0 or 200.0	90	C = 100	Phase C = 100.0 or 200.0 ±0.01V
7	Repeat steps 1 through 6			

4.12 100-VOLT/200-VOLT ADJUSTMENT

NOTE

This adjustment is made at either 100 volts on the 135-volt range or 200 volts on the 270-volt range.

1. Program the 846CM to either 100 volts or 200 volts.
2. Monitor the Phase A output. Adjust A1R47 (A=100) for the programmed value ±0.01 volts.
3. Monitor the Phase B output. Adjust A2R18 (B=100) for the programmed value ±0.01 volts.
4. Monitor the Phase C output. Adjust A2R15 (C=100) for the programmed value ±0.01 volts.
5. Repeat the steps of paragraphs 4.11 and 4.12.

SECTION V — MAINTENANCE

5.1 GENERAL

This section of the manual contains information to assist in troubleshooting the Model 847T Precision Programmable Oscillator. A table of power supply voltages and 'logic tree' types of troubleshooting charts, Figures 5-1 through 5-5, are included. A review of the Theory of Operation contained in Section III and the calibration and alignment procedures of Section IV is recommended prior to attempting to troubleshoot either unit. The technician will then have a good understanding of the circuit operation which will further assist in the troubleshooting task.

5.2 REQUIRED TEST EQUIPMENT

The test equipment required to perform the tests outlined in this section are listed in Table 5-1.

5.3 TEST PROCEDURE

1. Connect the 847T and the power sources as shown in Figure 2-1.
2. Remove the oscillator module from the 847T and separate the three circuit boards for easy access to their test points.
3. Install the extender board and connect the oscillator module to it.
4. Proceed with the tests of the following paragraphs.

5.3.1 POWER SUPPLY TEST

NOTE

Before conducting any tests, verify continuity of fuse F1. This can be checked with an ohmmeter connected between pins 1 and 3 of connector A1J1.

1. Apply power to the equipment and program the 846CM for 000.0 volts and 400.0 Hz.
2. Measure the +15V, -15V and +5V supply lines. Verify that they are within the limits shown in Table 5-2.

Adjust any power supply output that is outside limits. Then proceed with the tests in the following paragraphs.

5.3.2 CLOCK GENERATOR TEST

Check the clock generator signal with the oscilloscope at A3TP1. The clock signal should be a square wave at 10.2 MHz with an amplitude of 3 volts or more, peak-to-peak. If there is no clock signal, refer to the clock generator troubleshooting chart of Figure 5-3. If the clock signal is present, but the oscillator output is absent or highly distorted, refer to the waveform synthesizer troubleshooting chart of Figure 5-2.

5.3.3 INTERFACE CLOCK TEST

Check the clock frequency at test point A3TP2. Verify that it is a 2 MHz ±0.1 MHz square wave.

Table 5-1. Required Test Equipment.

Digital Multimeter	Calibration accuracy of 0.1% on the 200-volt range
Control Module	California Instruments Model 846CM
Frequency Counter	20 MHz, or better, response
Calibrated Oscilloscope	20 MHz, or better, response
GPIB Analyzer	Model ZT488 or equivalent
Extender Board Assembly	California Instruments Part No. 4800-703

Table 5-2. Power Supply Voltage Limits.

SUPPLY	TEST POINT	LIMITS
+15V	A1TP1	+14.6 to 16.2 VDC
-15V	A1TP2	-14.6 to 16.2 VDC
+5V		+4.75 to 5.25 VDC

Operation of the oscillator breaks down to four major functions. Each function has a separate troubleshooting 'logic tree' type of chart. This chart provides the preliminary steps to determine which of the four major functions requires further troubleshooting.

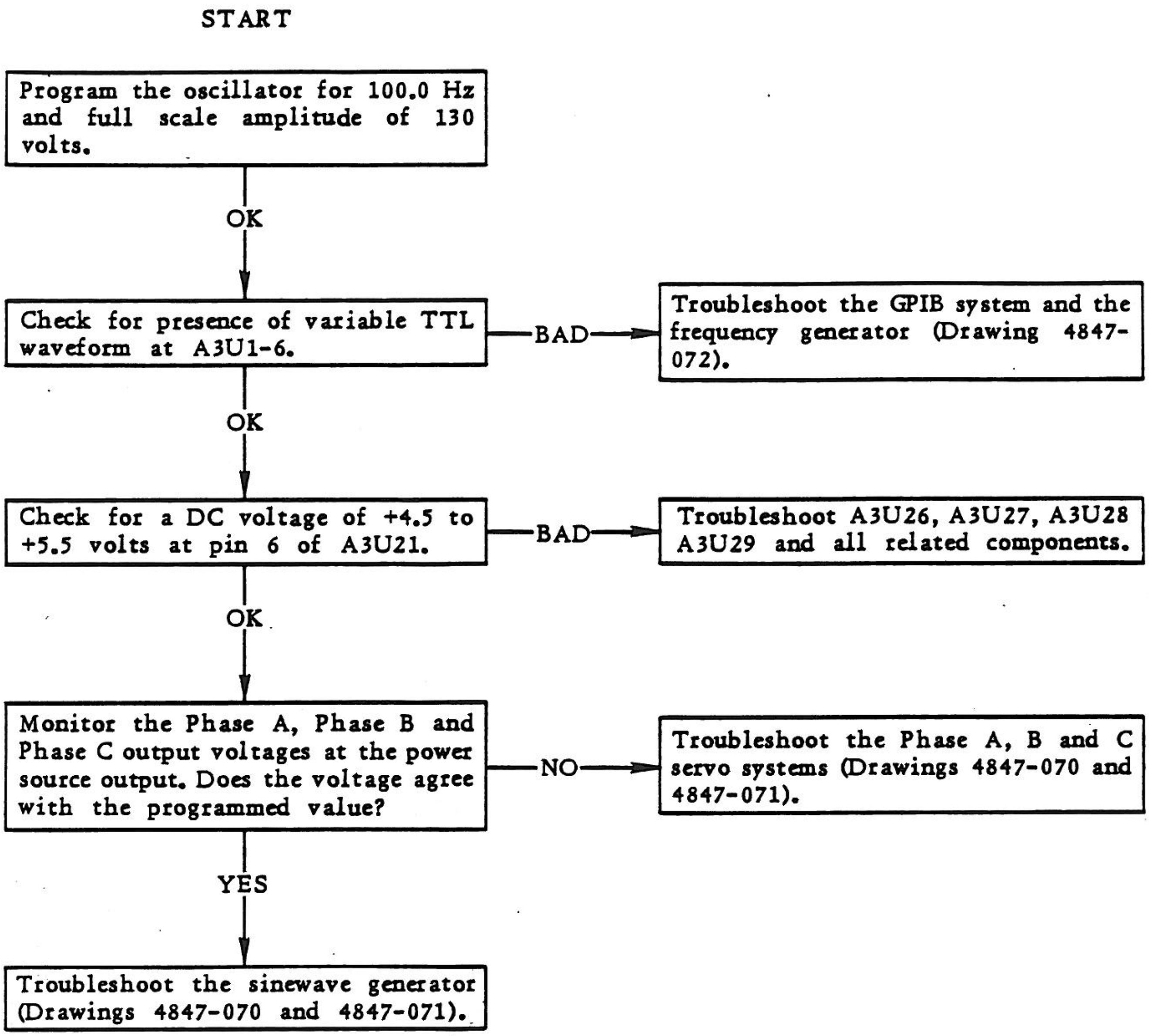


Figure 5-1. Troubleshooting Chart I, Preliminary Checks.

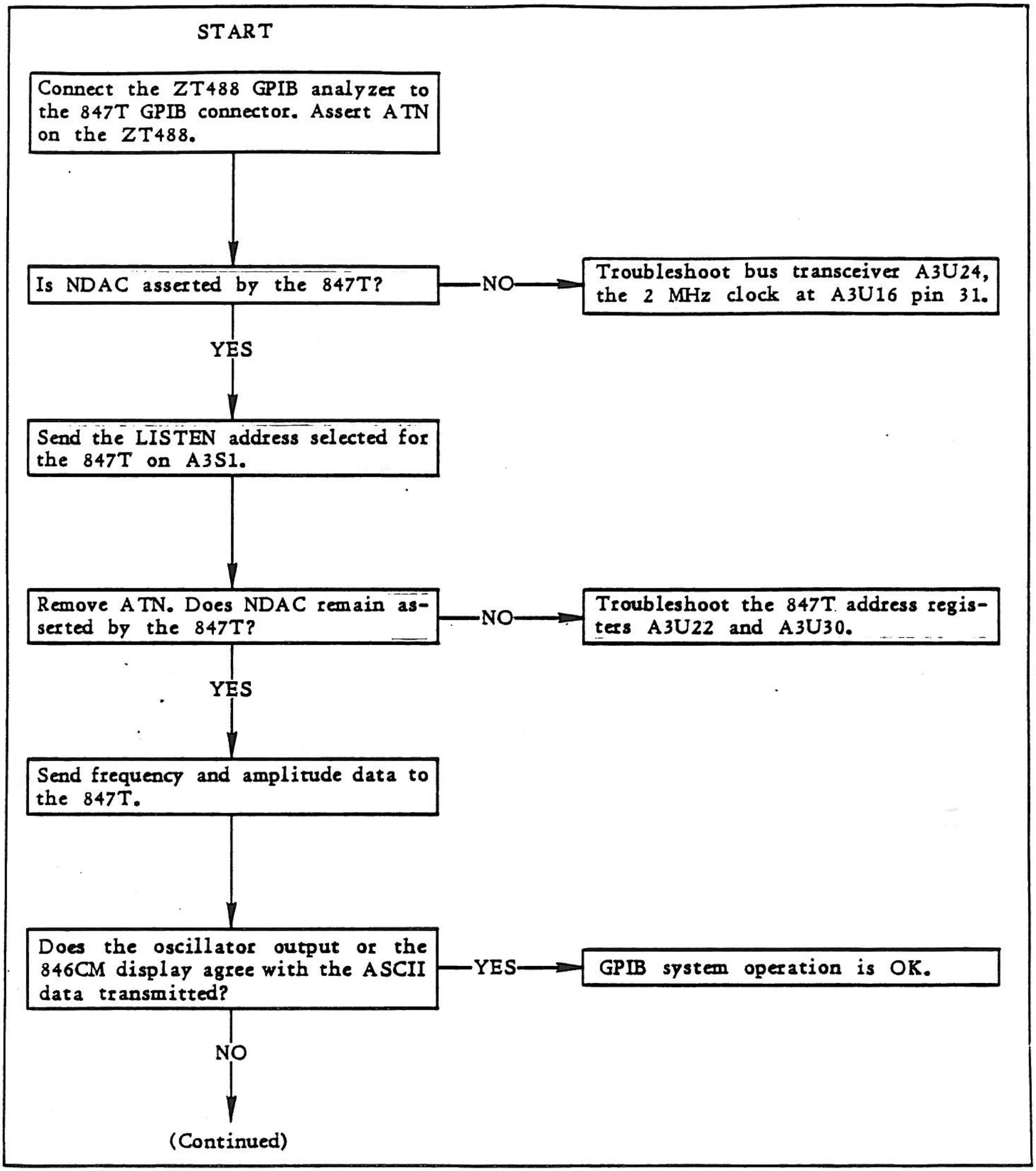


Figure 5-2. Troubleshooting Chart II, GPIB System.

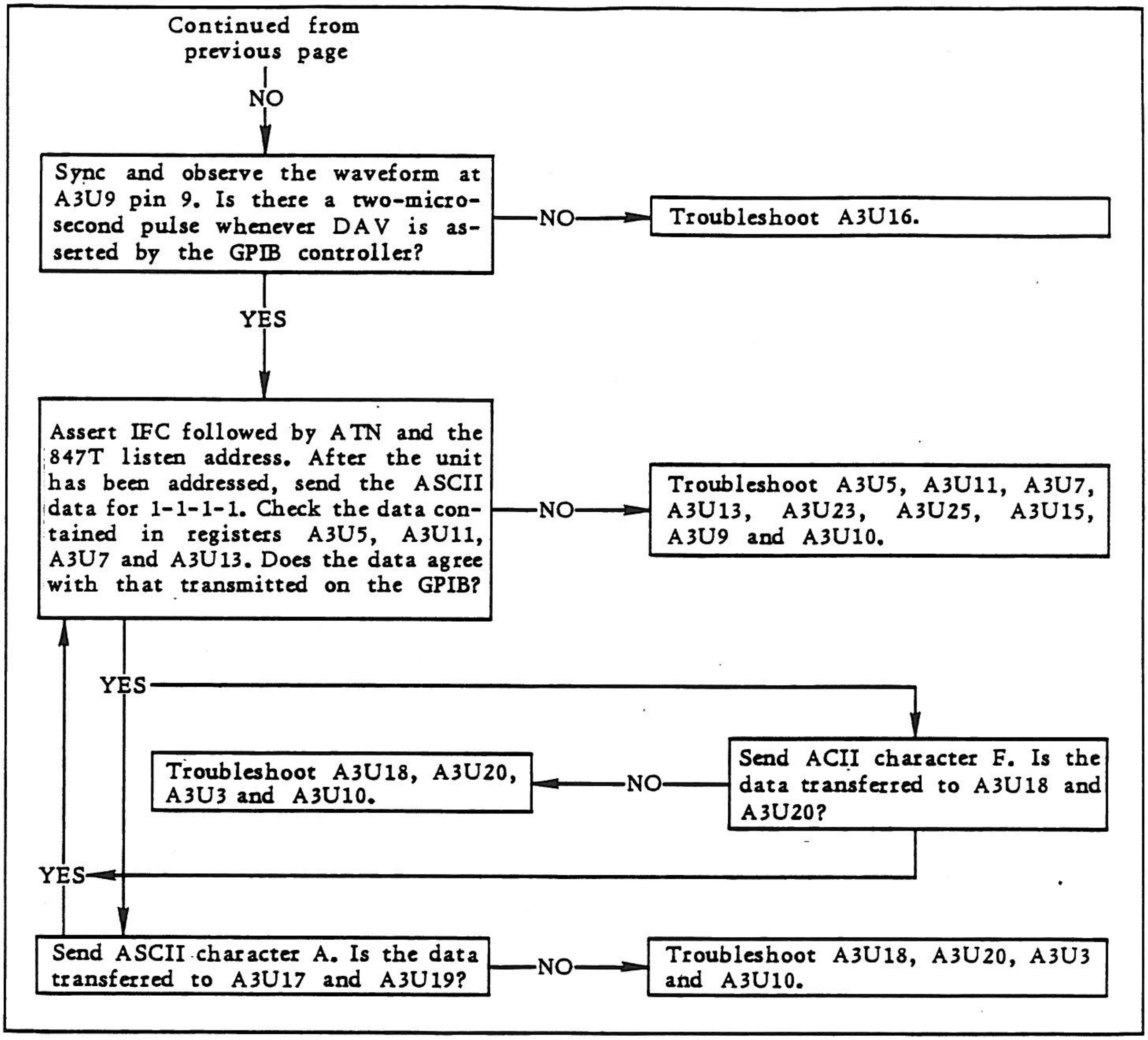


Figure 5-2. Troubleshooting Chart II, GPIB System (Continued).

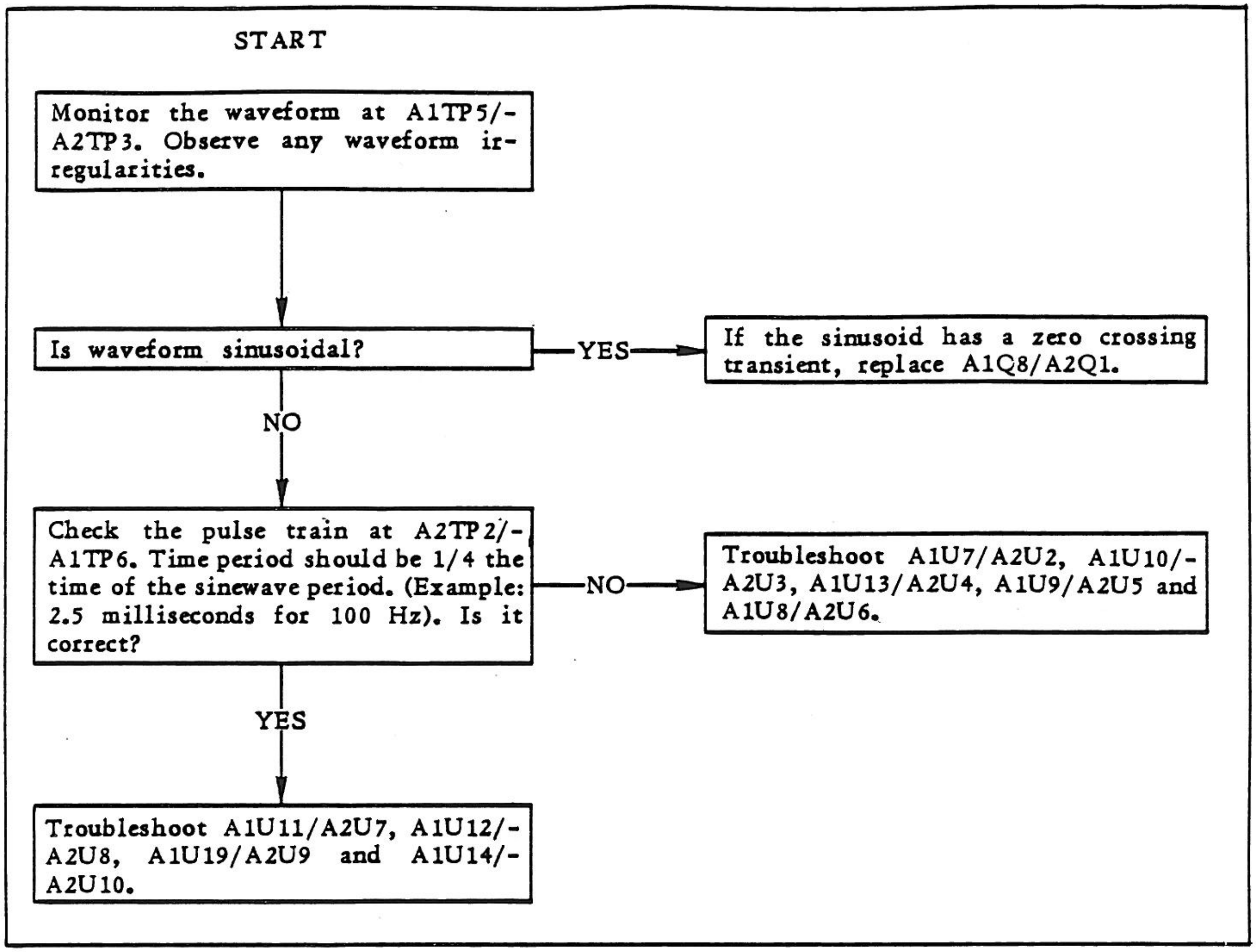


Figure 5-3. Troubleshooting Chart III, Waveform Synthesizer.

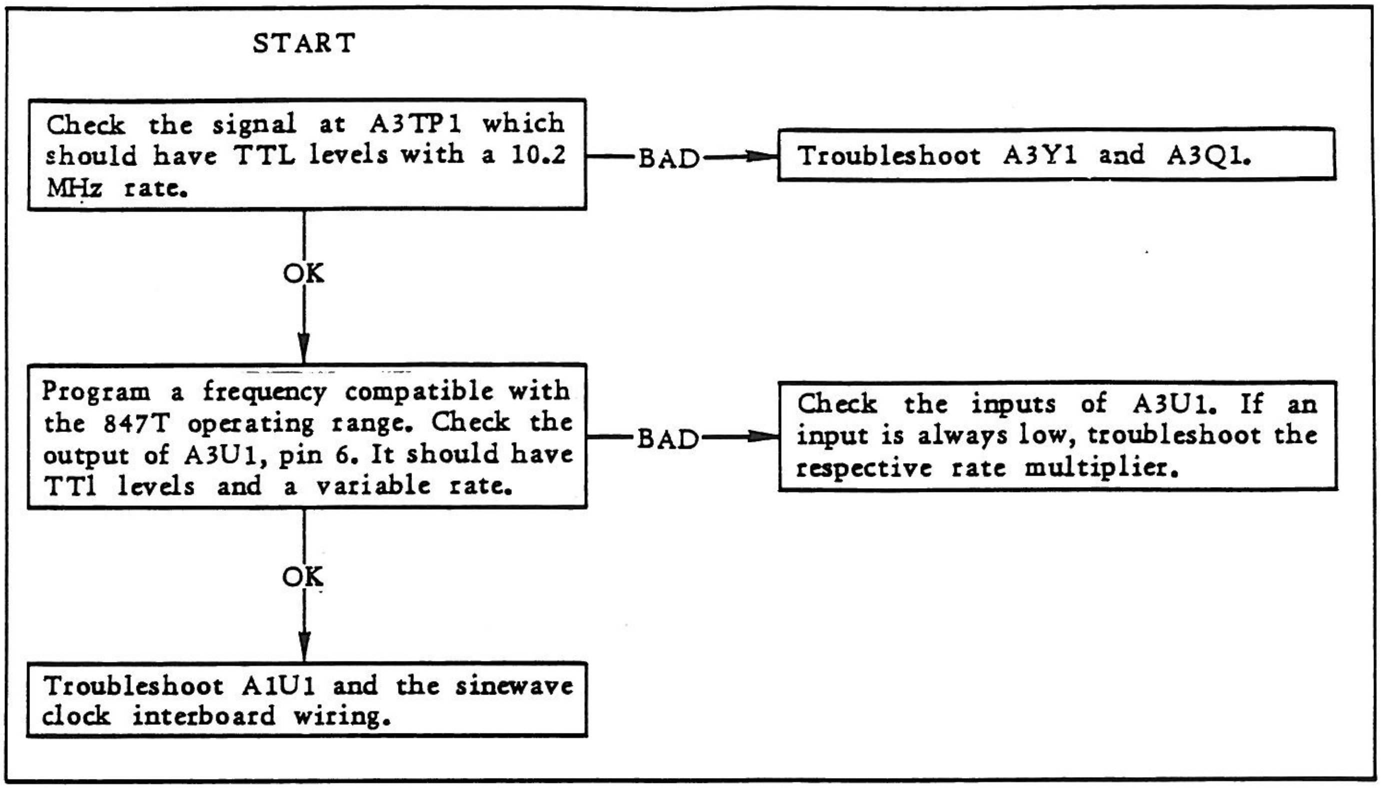


Figure 5-4. Troubleshooting Chart IV, Frequency Generator.

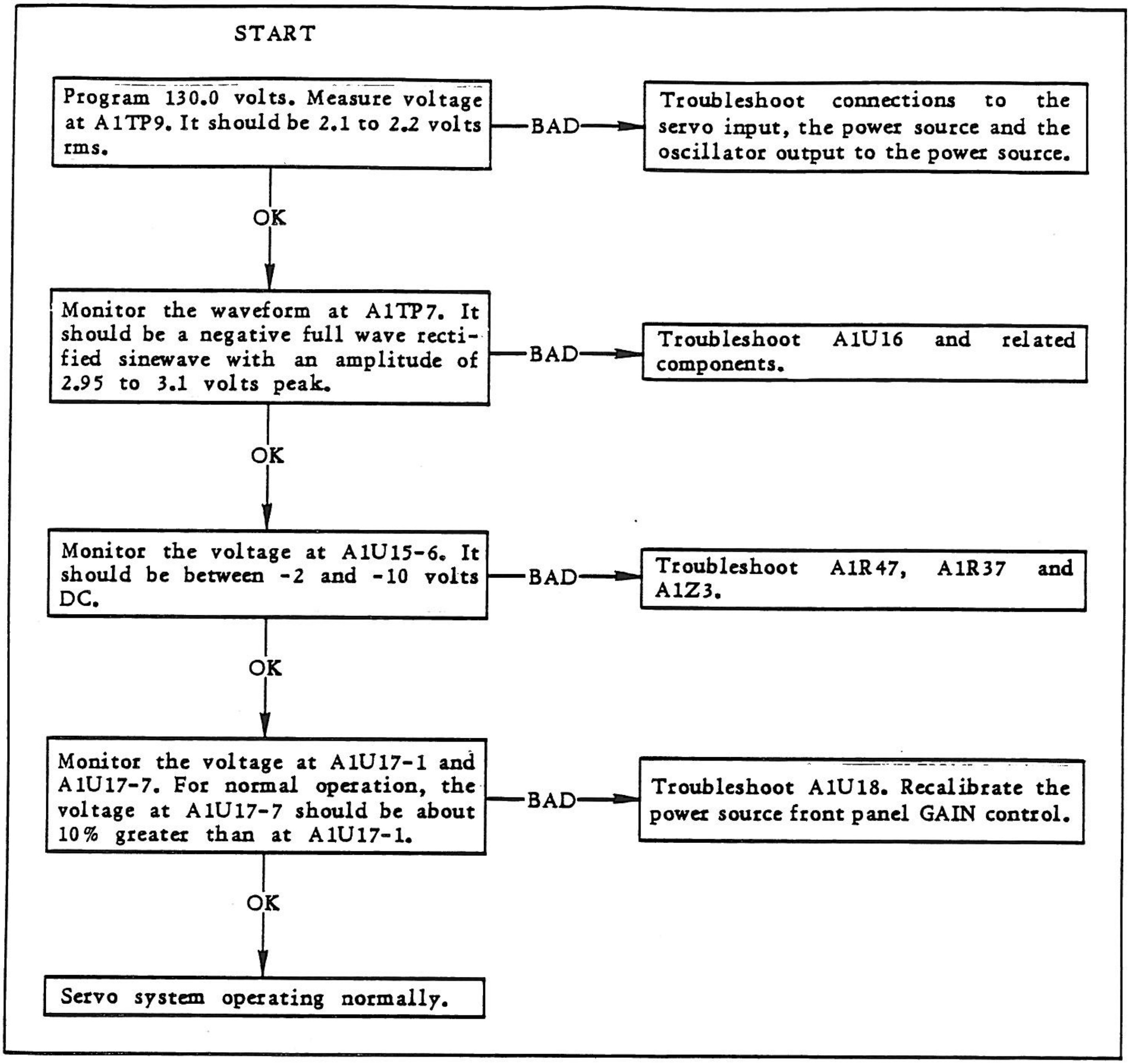


Figure 5-5. Troubleshooting Chart V, Servo System.

SECTION VI — DIAGRAMS

6.1 GENERAL

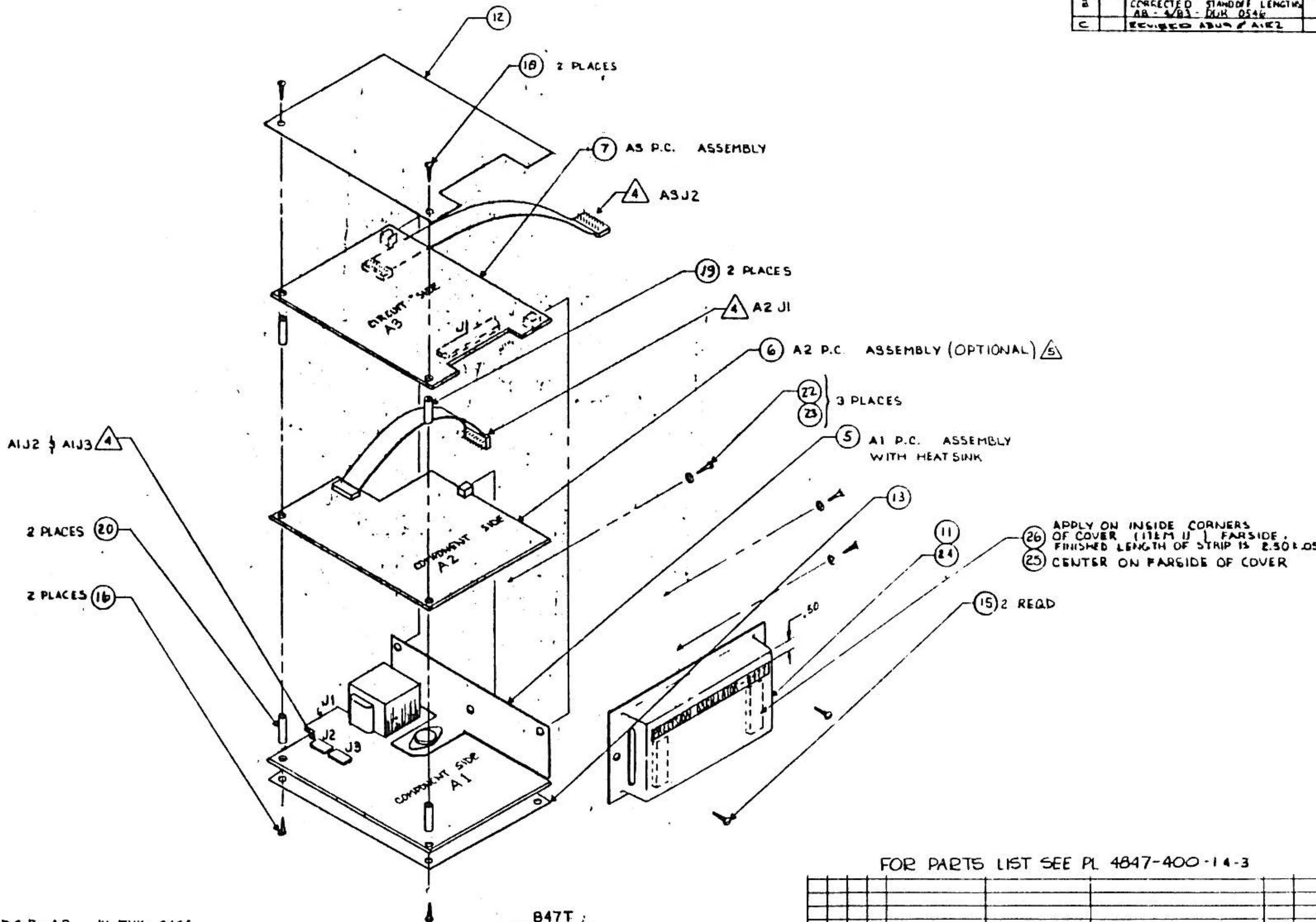
This section of the manual contains schematic and mechanical diagrams necessary for the operation and maintenance of the Model 847T Control Module. The schematic diagrams illustrate the circuits while the circuit board assembly diagrams indicate component locations.

6.2 REFERENCE DESIGNATORS

Partial reference designators are shown on schematic diagrams and circuit board assembly diagrams. Prefix these numbers with assembly and/or subassembly designations for the complete reference designator. Examples follow:

Assembly/Sub-Assembly	Component	Component Designator
None	T1	T1
A1	U6	A1U6
A2	R44	A2R44
A3	C7	A3C7
A4	Q2	A4Q2

REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APPD
A		INITIAL RELEASE				
B		CORRECTED STANDOFF LENGTHS AB - 1/83 - DUK 0546				
C		REVISED ABU... A1E2				



847T ASSEMBLY 5

FOR PARTS LIST SEE PL 4847-400-14-3

5. SOME ASSEMBLIES DO NOT INCLUDE P.C.B. A2. IN THIS CASE, USE TWO #6 WASHERS (FS1080) TO TAKE A2's PLACE BETWEEN ITEMS 19 & 20.

4. AT ASSEMBLY PLUG A1J2 INTO A2 J1 PLUG A1J3 INTO A3J2. PLUG THEM SUCH THAT PIN 1 IS ALIGNED WITH PIN 1, ETC.

3. FOR SCHEMATIC OF A3 SEE D4847-072
2. FOR SCHEMATIC OF A2 SEE D4847-071
1. FOR SCHEMATIC OF A1 SEE D4847-070

NOTES (UNLESS OTHERWISE SPECIFIED)

REQD PER ASSY	ITEM NO	PART NUMBER	PART NAME	MATERIAL – SPECIFICATION	CODE IDENT	FINISH	REF DES	ZONE

DIM IN INCHES TOLERANCES .XXX = .010 .XX = .03 X° = 30'

BREAK ALL SHARP CORNERS & EDGES MACH SURFACES √

DWG SIZE D

TITLE: TOP ASSEMBLY, 847 T

MODEL 847T

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DASH NO	QTY	NEXT ASSY	USED ON
-3		END ITEM	847T-3#
-1		END ITEM	847T-1#

DRAFTSMAN: PEACH

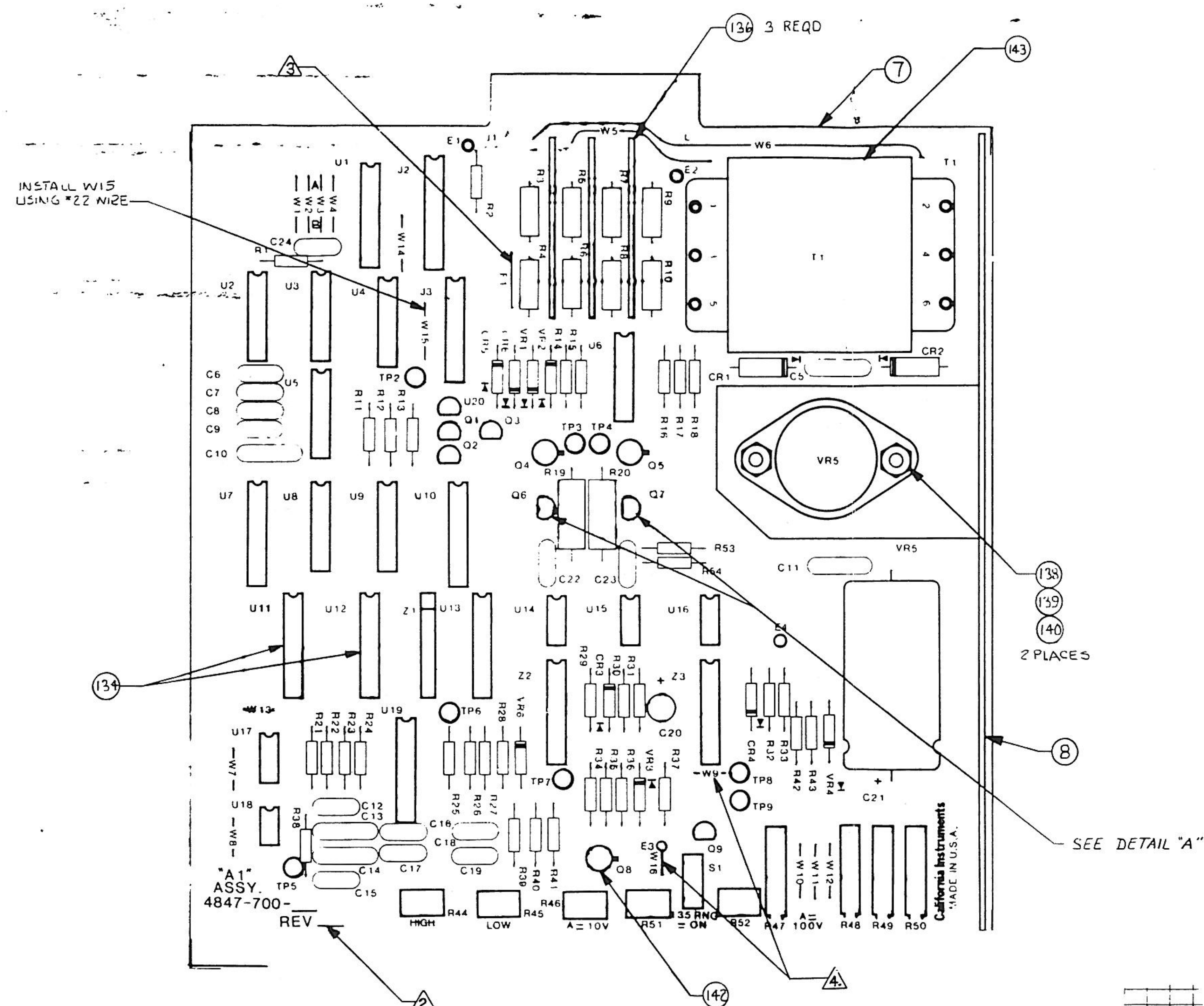
CALICO CALIFORNIA INSTRUMENTS CORP SAN DIEGO CALIFORNIA

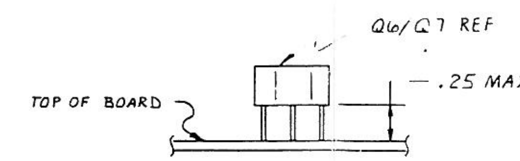
CODE IDENT 16067

DWG NO 4847-400 REV C

SHEET 1 OF 1

REV	AUTH	DESCRIPTION
A		INITIAL RELEASE
B		SEE ECO 1134 & 1136 3-24-83 TED
C		DELETED BALLOON 135 AE 4/83
D		ADDED ITEM # 143 4-14-83 TED
E		ECO 1144 AB 6/83
F		ECO 1243 AB 5-84
G		ECO 1160 & 1165
H		UPDATE REV LTR TO MATCH -2 PART





DETAIL "A"
SCALE: NONE

4847-700

4847-700 H

FOR PARTS LIST SEE PL 4847-700-1 & -2

4. CLAD JUMPERS W9 & W16 TO BE CUT FOR -2 ASSEMBLY.

3. INSTALL ONE STRAND OF #24 11/36 WIRE. SLEEVE WITH #24 TEFLON TUBING.

2. PERMANENTLY MARK REV LTR AND APPROPRIATE DASH NO. OF ASSY WHERE SHOWN.

1. FOR SCHEMATIC SEE 4847-070.

NOTES: UNLESS OTHERWISE SPECIFIED

DASH NO.	QTY REQD	NEXT ASSEMBLY	EFF ON
-2	1	4847-401	847T-1-3085
-1	1	4847-400	847 T

DIM IN INCHES TOLERANCES .XXX .010 .XX .03 .X 30'

BREAK ALL SHARP CORNERS & EDGES MACH SURFACES √

DWG SIZE D

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TITLE: PRINTED CIRCUIT A... PHASE A GENERAT...

MODEL: 847

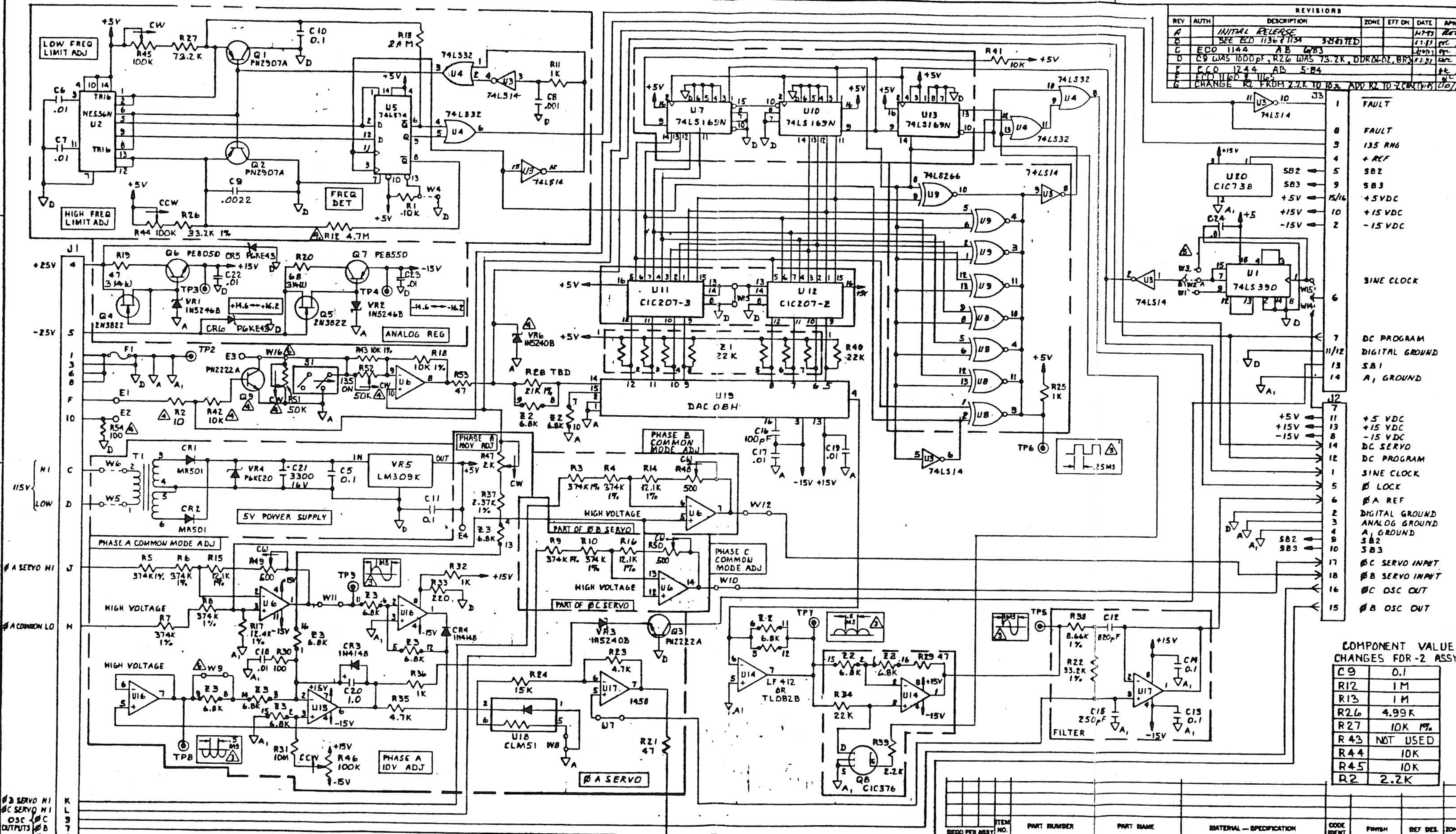
CHECKER — PURCHASING

DESIGN — PROJ ENGR

DRFTSMN: BEATH 11/82 CHF ENGR

4847-700 H

2/1



REVISIONS

REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD
A		INITIAL RELEASE				
B		SEE ECO 1136 & 1134 SORTED				
C		ECO 1144 AB 6/83				
D		C9 WAS 1000pF, R26 WAS 73.2K, DDR0602, 8R3				
E		ECO 1244 AB 5-84				
F		ECO 1160 & 1165				
G		CHANGE R2 FROM 2.2K TO 10Ω ADD R2 TO -2 CONFIG				

COMPONENT VALUE CHANGES FOR -2 ASSY

C9	0.1
R12	1M
R13	1M
R26	4.99K
R27	10K 1%
R43	NOT USED
R44	10K
R45	10K
R2	2.2K

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL CAPACITORS IN MICROFARADS
2. ALL RESISTORS ARE IN OHMS, 5%
3. ALL WAVEFORMS SHOWN WITH FREQUENCY PROGRAMMED TO 1KHz AND MAX FULL SCALE OUTPUT 130 OR 260 VRMS
4. CLAD JUMPERS W9 & W6 TO BE CUT FOR -2 ASSY.
5. INSTALL: W3 AND W4 FOR 45-9999 HZ; W3 FOR 45-5000 Hz; W2 FOR 45-999.9 HZ; W1 FOR 45-99.99 HZ
6. PART NOT NORMALLY INSTALLED IN -1 ASSY.

ITEM NO.	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES.	ZONE

DIM IN INCHES TOLERANCES .XXX = .010 .XX = .03 X° = 30'
BREAK ALL SHARP CORNERS & EDGES
DWG SIZE D

EXCEPT AS OTHERWISE PROVIDED BY CONTRACT, THESE DRAWINGS AND SPECIFICATIONS ARE THE PROPERTY OF CALICO AND SHALL NOT BE REPRODUCED OR COPIED OR USED AS THE BASIS FOR THE MANUFACTURE OR SALE OF APPARATUS WITHOUT WRITTEN PERMISSION

DASH NO	QTY REQD	NEXT ASSEMBLY	USED ON
-2	REF	4847-700-2	847T-1-3015
-1	REF	4847-700-1	847T

TITLE: SCHEMATIC DIAGRAM, PHASE A GENERATOR A1

MODEL 847T

DRAFTSMAN T. DONAHUE 7/9/82
PROJ ENGR D. McFayden

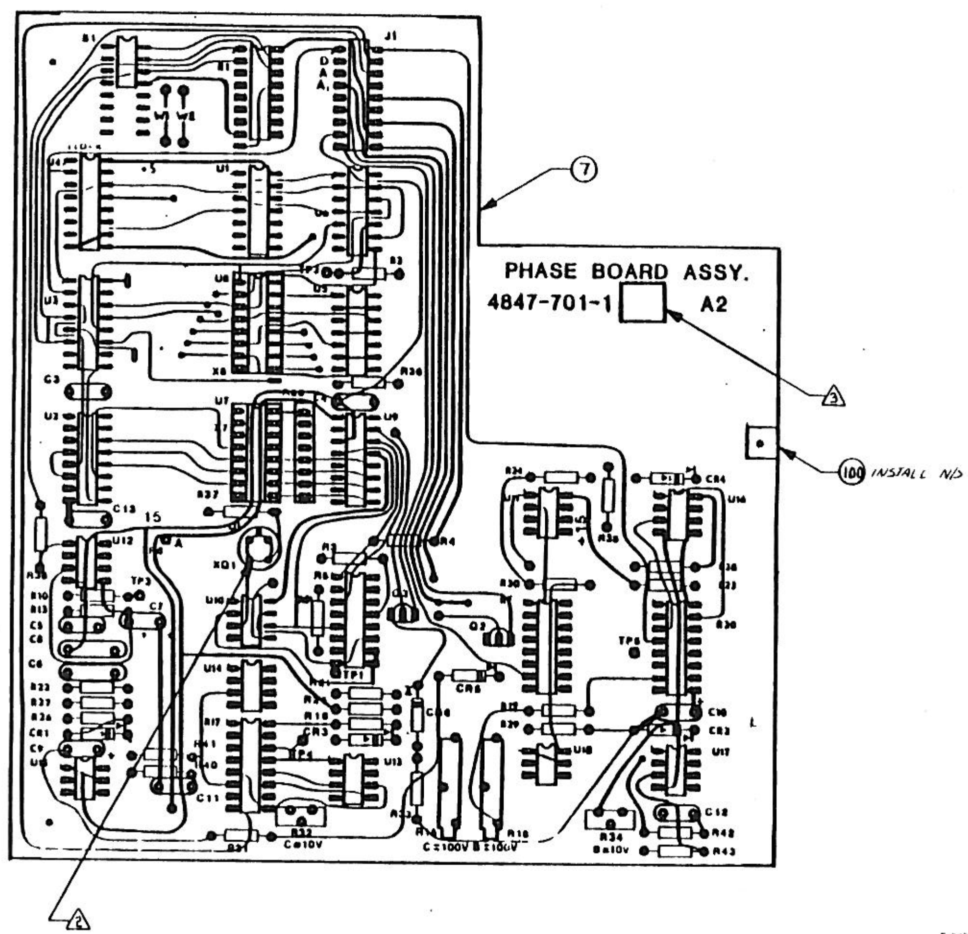
CALICO — CALIFORNIA INSTRUMENTS CORP. SAN DIEGO, CALIFORNIA

CODE IDENT 16067

DWG NO 4847-070 REV G

SCALE NONE SHEET 1 OF 1

REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APPD
A		INITIAL RELEASE				
B		ECO 1145 AB SH1				



FOR PARTS LIST SEE PL 4847-701

⚠3 PERMANENTLY MARK WITH REV LTR WHERE SHOWN.

⚠2 RUBBER SHORTING STRAP IS TO REMAIN ON LEADS OF Q1 UNTIL AFTER INSTALLATION.

1. FOR SCHEMATIC SEE 4847-071

PRINTED CIRCUIT ASSY, PHASE B AND C SERVO A2

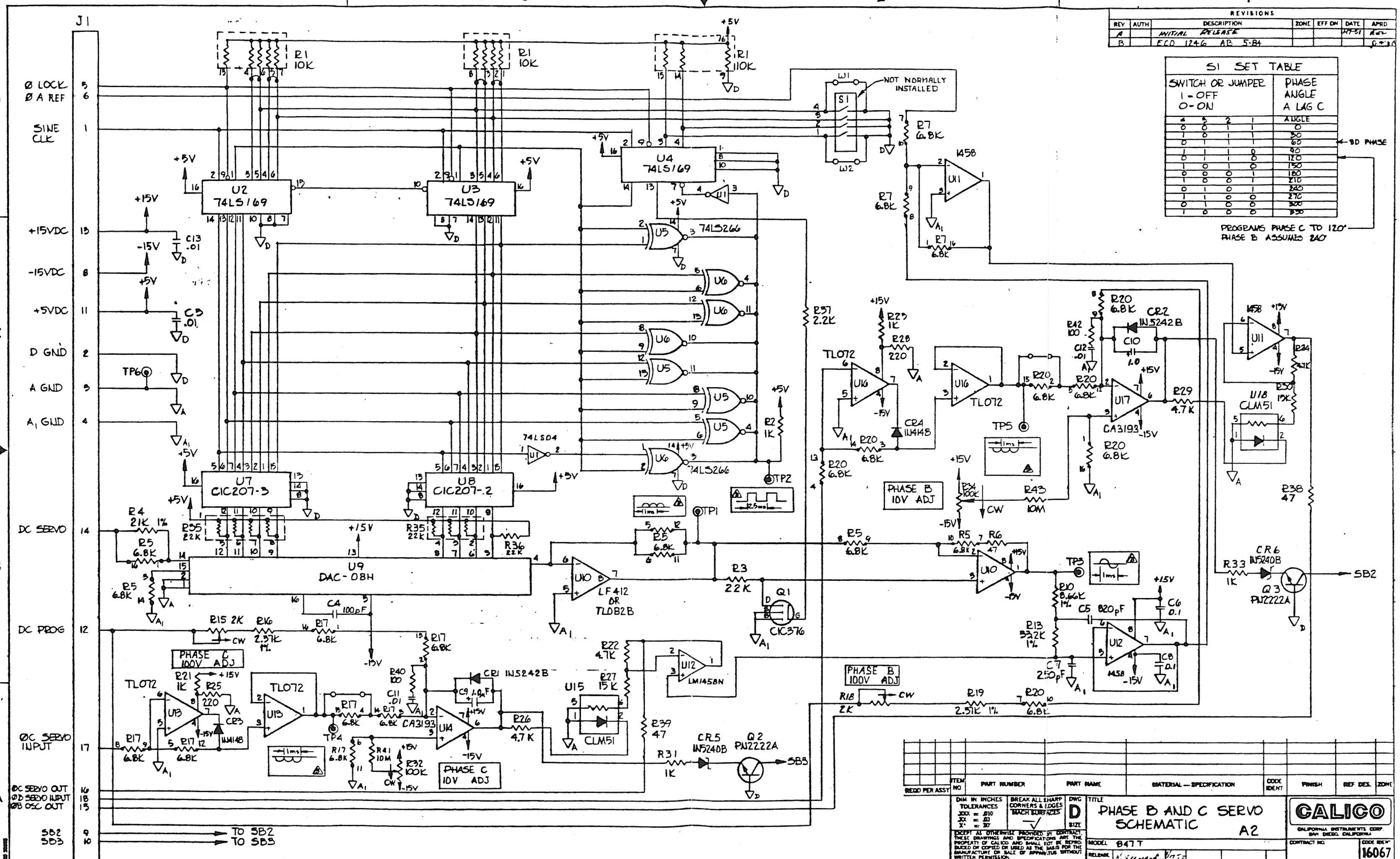
MODEL 847 T

CALICO

16067

4847-701 B

REVISIONS						
REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD
A		INITIAL RELEASE				
B		ECO 1246 AB 5-84				



S1 SET TABLE				
SWITCH OR JUMPER 1 - OFF 0 - ON				PHASE ANGLE A LAG C
4	3	2	1	ANGLE
0	0	1	1	0
1	0	1	1	30
0	1	1	1	60
1	1	1	0	90
0	1	1	0	120
1	0	1	0	150
0	0	0	1	180
1	0	0	1	210
0	1	0	1	240
1	1	0	0	270
0	1	0	0	300
1	0	0	0	330

← 3D PHASE (60)

PROGRAMS PHASE C TO 120° PHASE B ASSUMES 240° (120)

NOTES: (UNLESS OTHERWISE SPECIFIED)
1. ALL RESISTORS IN OHMS ARE 5%.
2. ALL CAPACITORS ARE IN MICROFARADS.

⚠ ALL WAVEFORMS SHOWN WITH FREQ AND AMP PROGRAMMED TO 100Hz AND MAX FULL SCALE AMPLITUDE (135V OR 270V).

REQD PER ASSY	ITEM NO	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES.	ZONE

DIM IN INCHES TOLERANCES .XXX = .010 .XX = .03 X° = 30'

BREAK ALL SHARP CORNERS & EDGES MACH SURFACES √

DWG SIZE D

TITLE: PHASE B AND C SERVO SCHEMATIC A2

MODEL 847T

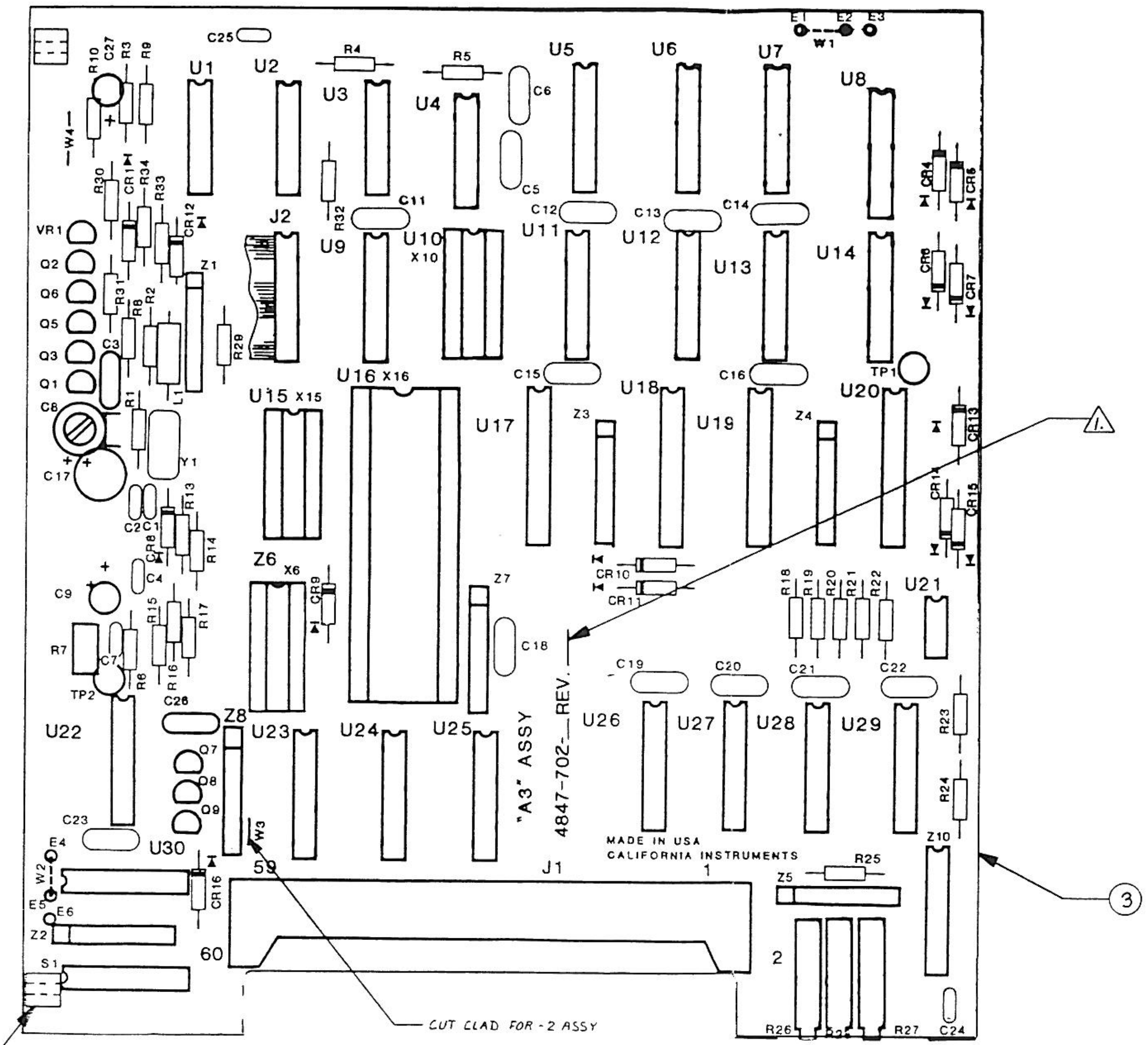
REF 847T

CALICO
CALIFORNIA INSTRUMENTS CORP. SAN DIEGO, CALIFORNIA

CODE IDENT 16067

DWG NO 4847-071 REV B.

REVISIONS						
REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD
A		INITIAL RELEASE			1-17-83	KE
B		SEE ECO 1137, 1138 3-25-83 TED				
C		REVERSED ORIENTATION OF CAB ON J2 S.T. 7-26-83				
D		ADDED X6 TO PARTS LIST -1 & -2				
E	CHANGE U9 FROM 40174 TO 74HC174					



4 2 REQD

FOR PARTS LIST SEE PL 4847-702-1 & -2.

REQD PER ASSY	ITEM NO	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES	ZONE

DIM IN INCHES TOLERANCES .XXX = .010 .XX = .03 X = 30'	BREAK ALL SHARP CORNERS & EDGES MACH SURFACES √	DWG SIZE D
EXCEPT AS OTHERWISE PROVIDED BY CONTRACT THESE DRAWINGS AND SPECIFICATIONS ARE THE PROPERTY OF CALICO AND SHALL NOT BE REPRODUCED OR COPIED OR USED AS THE BASIS FOR THE MANUFACTURE OR SALE OF APPARATUS WITHOUT WRITTEN PERMISSION		
-2	1	4847-400-2 847T-1-30F5
-1	1	4847-400-1 847T
DASH NO	QTY REQD	NEXT ASSEMBLY EFF ON AUTH

TITLE: PRINTED CIRCUIT ASSEMBLY, FREQUENCY PROGRAMMER

MODEL 847 SERIES
RELEASE R. LEDYARD 12/82
CHECKER R. CHASE 12/82 PURCHASING
DESIGN R. CHASE 12/82 PROJ ENGR D. McFADDEN 12-82
DRFTSMN T. DONAHUE 1-25-83 CHF ENGR

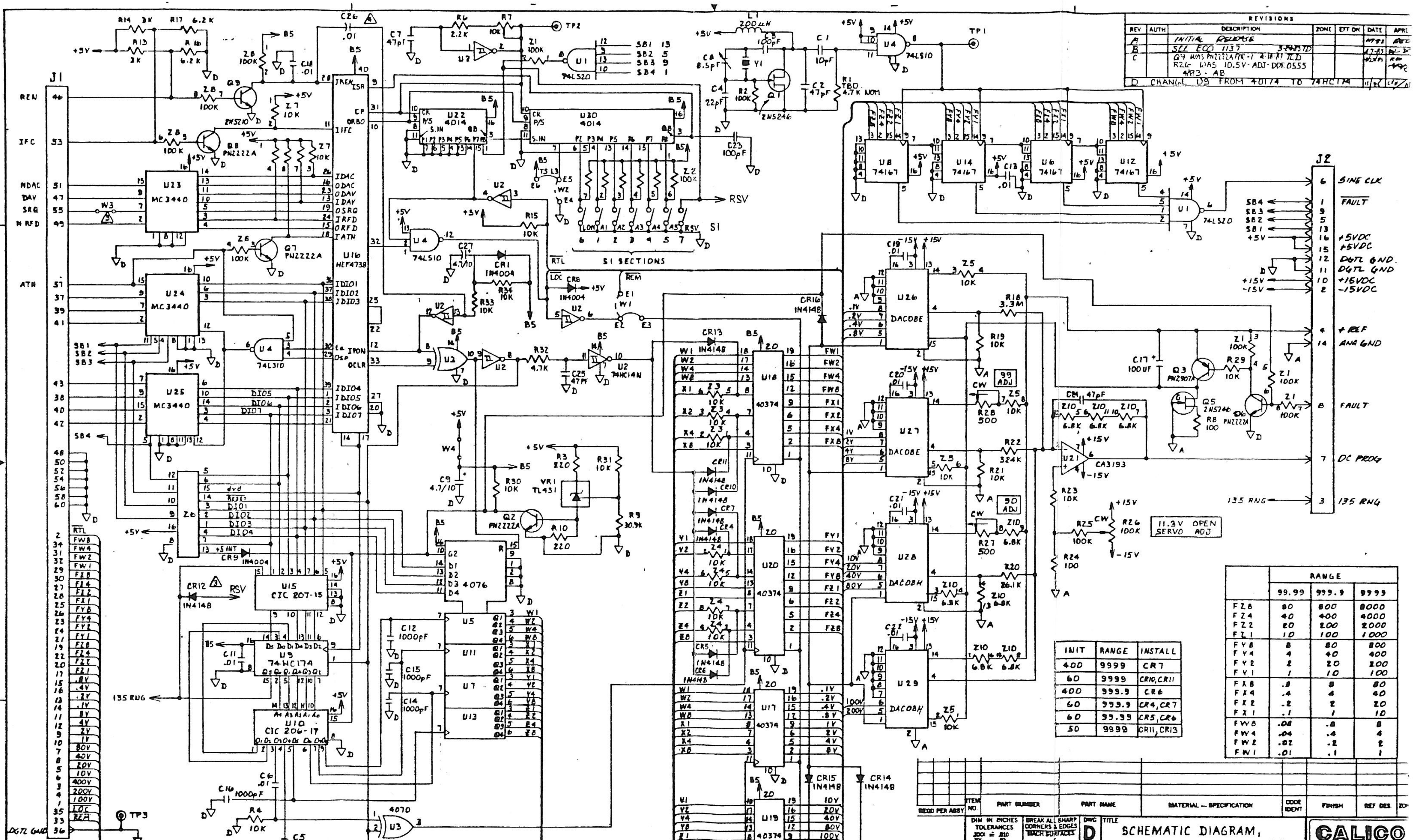
CALICO
CALIFORNIA INSTRUMENTS CORP.
SAN DIEGO, CALIFORNIA

CONTRACT NO
CODE IDENT 16067
DWG NO 4847-702 REV E
SCALE 2/1 SHEET 1 OF 1

4847-702

4847-702 F

2. FOR SCHEMATIC SEE DWG 4847-072.
1. ⚠ PERMANENTLY MARK REV LTR AND APPROPRIATE DASH NO. OF ASSY WHERE SHOWN.
NOTES: UNLESS OTHERWISE SPECIFIED)



INIT	RANGE	INSTALL
400	9999	CR7
60	9999	CR10, CR11
400	999.9	CR6
60	999.9	CR4, CR7
60	99.99	CR5, CR6
50	9999	CR11, CR13

	RANGE		
	99.99	999.9	9999
FZ8	80	800	8000
FZ4	40	400	4000
FZ2	20	200	2000
FZ1	10	100	1000
FY8	8	80	800
FY4	4	40	400
FY2	2	20	200
FY1	1	10	100
FX8	.8	8	80
FX4	.4	4	40
FX2	.2	2	20
FX1	.1	1	10
FW8	.08	.8	8
FW4	.04	.4	4
FW2	.02	.2	2
FW1	.01	.1	1

4. FOR USE ON -2 ASSY ONLY.
3. FOR USE ON -1 ASSY ONLY.
2. ALL RESISTORS ARE IN OHMS, 5%.
1. ALL CAPACITORS ARE IN MICROFARADS

NOTES: (UNLESS OTHERWISE SPECIFIED)

REVISIONS

REV	AUTH	DESCRIPTION	ZONE	EFT ON	DATE	APRL
A		INITIAL RELEASE				
B		SEE ECO 1137				
C		Q9 WAS PN2222A ... R26 WAS 10.5V-ADJ-DDF 0555 4/83 - AB				
D		CHANGE U9 FROM 40174 TO 74HC174				

REQD PER ASSY	ITEM NO.	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES	ZONE

DIM IN INCHES
TOLERANCES
.XXX = .010
.XX = .03
X° = 30'

BREAK ALL SHARP CORNERS & EDGES
MACH SURFACES

DWG SIZE D

EXCEPT AS OTHERWISE PROVIDED BY CONTRACT THESE DRAWINGS AND SPECIFICATIONS ARE THE PROPERTY OF CALICO AND SHALL NOT BE REPRODUCED OR COPIED OR USED AS THE BASIS FOR THE MANUFACTURE OR SALE OF APPARATUS WITHOUT WRITTEN PERMISSION

DASH NO	QTY REQD	NEXT ASSEMBLY	EFT ON	AUTH
-1	REF	4847-702-2		
-1	REF	4847-702-1		

TITLE: SCHEMATIC DIAGRAM, PROGRAM BOARD A3

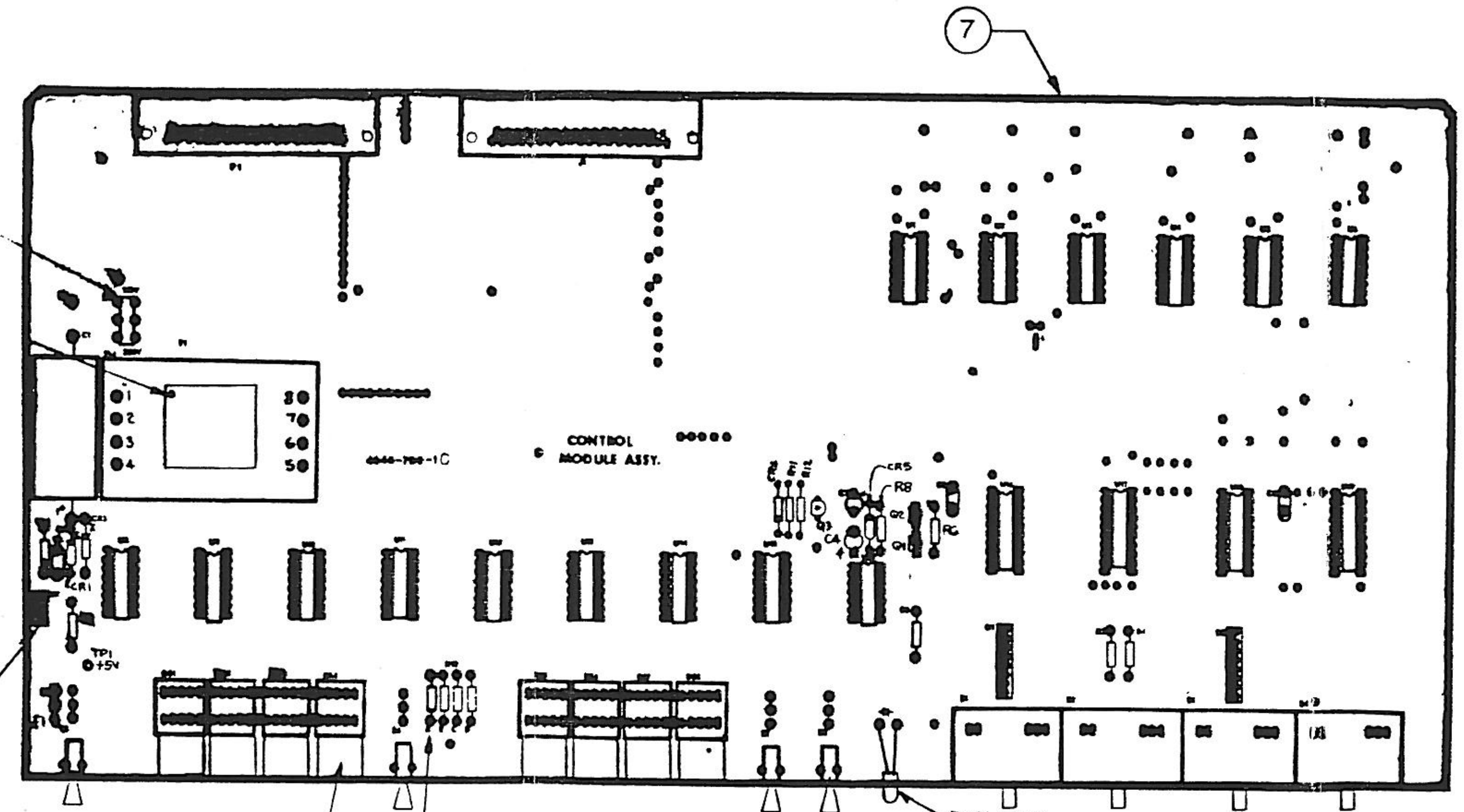
MODEL: 847 SERIES

RELEASE
CHECKER
DESIGN
DRFTSMN: T. DONAHUE
PURCHASING
PROJ ENGR: D. McFadden
CHF ENGR

CALICO
CALIFORNIA INSTRUMENTS CORP.
SAN DIEGO, CALIFORNIA

CONTRACT NO.
CODE IDENT: 1606
DWG NO. 4847-072
REV: D
SCALE: NONE
SHEET 1 OF 1

REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD
A		REDESIGNED & REDRAWN				
B		PROTOTYPE CLEANUP			5/14/80	



-1 ASSEMBLY

TOP CLAD DELETED FOR CLARITY

FOR PARTS LIST SEE PL 4846-700

REQD PER ASSY			ITEM NO.	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES.	ZONE

DIM IN INCHES TOLERANCES .XXX = .010 .XX = .03 X° = 30'

BREAK ALL SHARP CORNERS & EDGES MACH SURFACES ✓

DWG SIZE D

EXCEPT AS OTHERWISE PROVIDED BY CONTRACT, THESE DRAWINGS AND SPECIFICATIONS ARE THE PROPERTY OF CALICO AND SHALL NOT BE REPRODUCED OR COPIED OR USED AS THE BASIS FOR THE MANUFACTURE OR SALE OF APPARATUS WITHOUT WRITTEN PERMISSION.

DASH NO.	QTY REQD	NEXT ASSEMBLY	EFF ON	AUTH
-1	1	4846-400		

TITLE: PC BOARD ASSEMBLY— CONTROL MODULE

MODEL 846

RELEASE		5-15-80			
CHECKER			PURCHASING		
DESIGN			PROJ ENGR		5/14/80
DRFTSMN	MARCO	3-80	CHF ENGR	W. DUCHEK	

CALICO — CALIFORNIA INSTRUMENTS CORP. SAN DIEGO, CALIFORNIA

CONTRACT NO.

CODE IDENT 16067

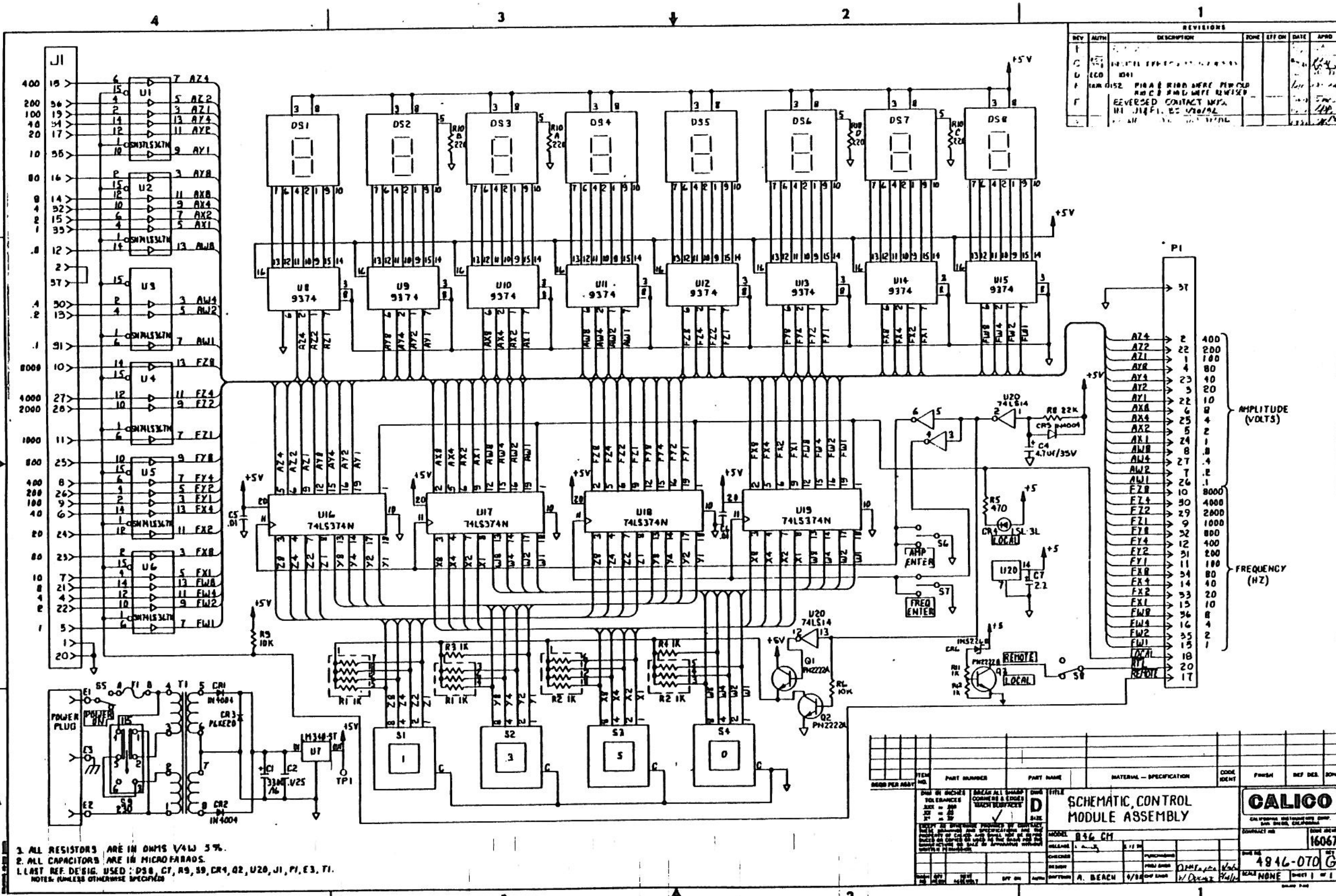
DWG NO. 4846-700 REV E

SCALE 1 : 1 SHEET 1 OF 2

4846-700 E

1. FOR SCHEMATIC, SEE DWG 4846-070

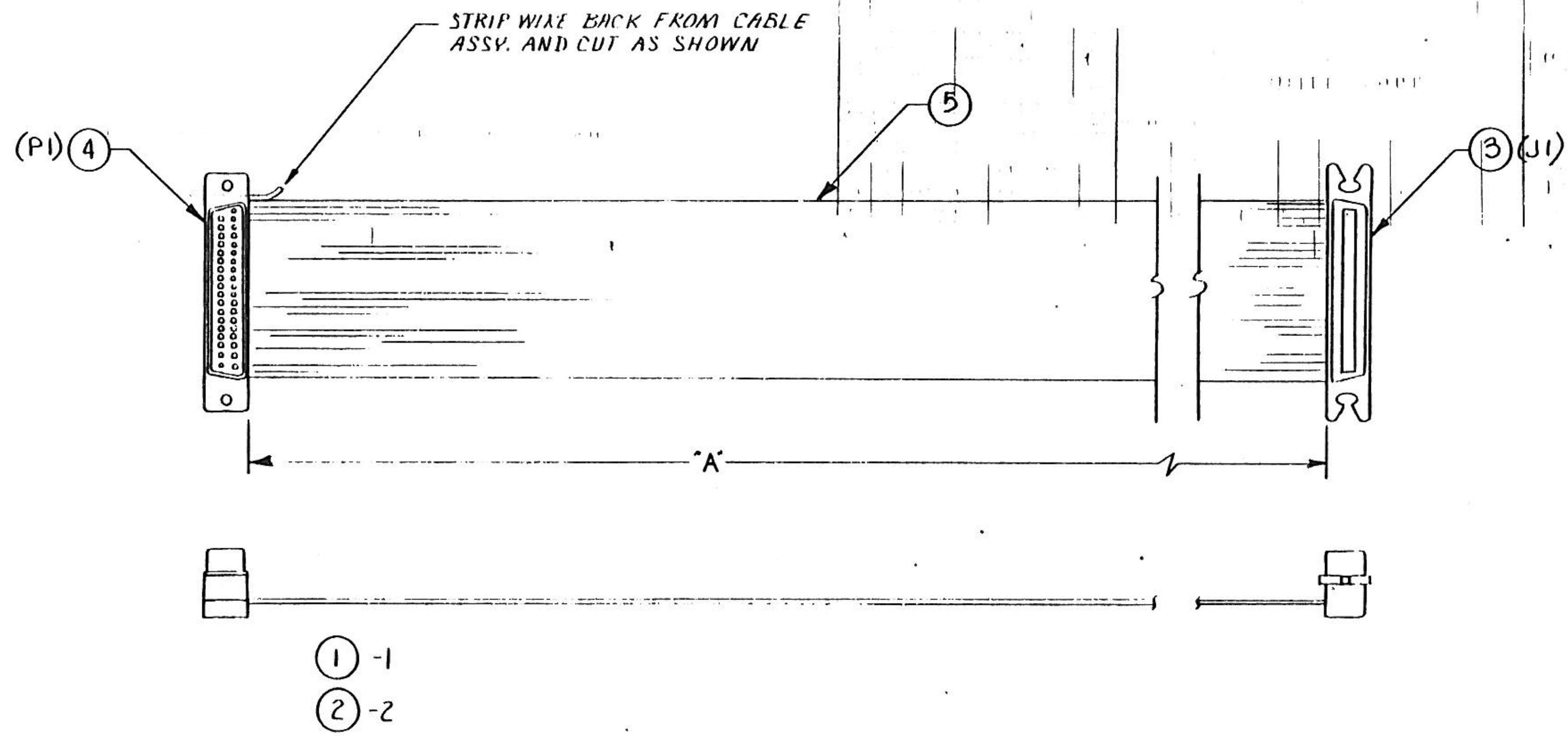
NOTES: (UNLESS OTHERWISE SPECIFIED)



REVISIONS
REV AUTH DESCRIPTION ZONE EFF ON DATE APPD
J1
P1
AMPLITUDE (VOLTS)
FREQUENCY (HZ)
DS1 DS2 DS3 DS4 DS5 DS6 DS7 DS8
U8 9374
U9 9374
U10 9374
U11 9374
U12 9374
U13 9374
U14 9374
U15 9374
U16 74LS374N
U17 74LS374N
U18 74LS374N
U19 74LS374N
U20 74LS14
AMP ENTER
FREQ ENTER
LOCAL
REMOTE
POWER PLUG
POWER ON
LM340-5T
U7
TP1
PN2222A
IN4004
3. ALL RESISTORS ARE IN OHMS 1/4W 5%.
2. ALL CAPACITORS ARE IN MICROFARADS.
1. LAST REF. DESIG. USED: DS8, C7, R9, S9, CR4, Q2, U20, J1, P1, E3, T1.
NOTES: (UNLESS OTHERWISE SPECIFIED)
SCHEMATIC, CONTROL MODULE ASSEMBLY
CALICO
MODEL 846 CM
A. BEACH
16067
4846-070 G
SCALE NONE
SHEET 1 OF 1

REVISIONS

REV	AUTH	DESCRIPTION	ZONE	EFF ON	DATE	APRD
A		INITIAL RELEASE			3/20/02	RRL
B	BW.	J1 WAS 3366-1002			8/5/02	RRL



CABLE LENGTH	
ASSY DASH NO.	DIM "A" ±.50
-1	4'-0"
-2	7'-0"

-2	-1	ITEM NO.	PART NUMBER	PART NAME	MATERIAL — SPECIFICATION	CODE IDENT	FINISH	REF DES.	ZONE
AR	AR	5	3365-37	RIBBON CABLE		04963			
1	1	4	3503-1000	CONNECTOR 37 PIN		04963		P1	
1	1	3	3366-1001	CONNECTOR 36 PIN		04963		J1	
/		2	-2	CABLE ASSY	4846-402-2	16067			
	/	1	-1	CABLE ASSY	4846-402-1	16067			

REQD PER ASSY

DIM IN INCHES TOLERANCES .XXX = .010 .XX = .03 X° = 30'

BREAK ALL SHARP CORNERS & EDGES — MACH SURFACES √

DWG SIZE C

EXCEPT AS OTHERWISE PROVIDED BY CONTRACT, THESE DRAWINGS AND SPECIFICATIONS ARE THE PROPERTY OF CALICO AND SHALL NOT BE REPRODUCED OR COPIED OR USED AS THE BASIS FOR THE MANUFACTURE OR SALE OF APPARATUS WITHOUT WRITTEN PERMISSION.

DASH NO	QTY REQD	NEXT ASSEMBLY	USED ON
-2	1		846CM
-1	1	4846-400	846CM

TITLE: CABLE ASSY, 846CM INTERCONNECT

MODEL 846CM

RELEASE	[illegible]	3/1/2			
CHECKER	RRL	3/1/02	PURCHASING		
DESIGN	RRL	3/1/02	PROJ ENGR	[illegible]	3/1/2
DRFTSMN	BJunk	1/15/02	CHF ENGR		

CALICO — CALIFORNIA INSTRUMENTS CORP. SAN DIEGO, CALIFORNIA

CONTRACT NO. — CODE IDENT 16067

DWG NO. 4846-402 — REV B

SCALE 1/1 — SHEET 1 OF 1

1. CABLE TO BE IDENTIFIED WITH 4846-402, APPROPRIATE DASH NUMBER, AND REVISION

NOTES: (UNLESS OTHERWISE SPECIFIED)

4846-402 B

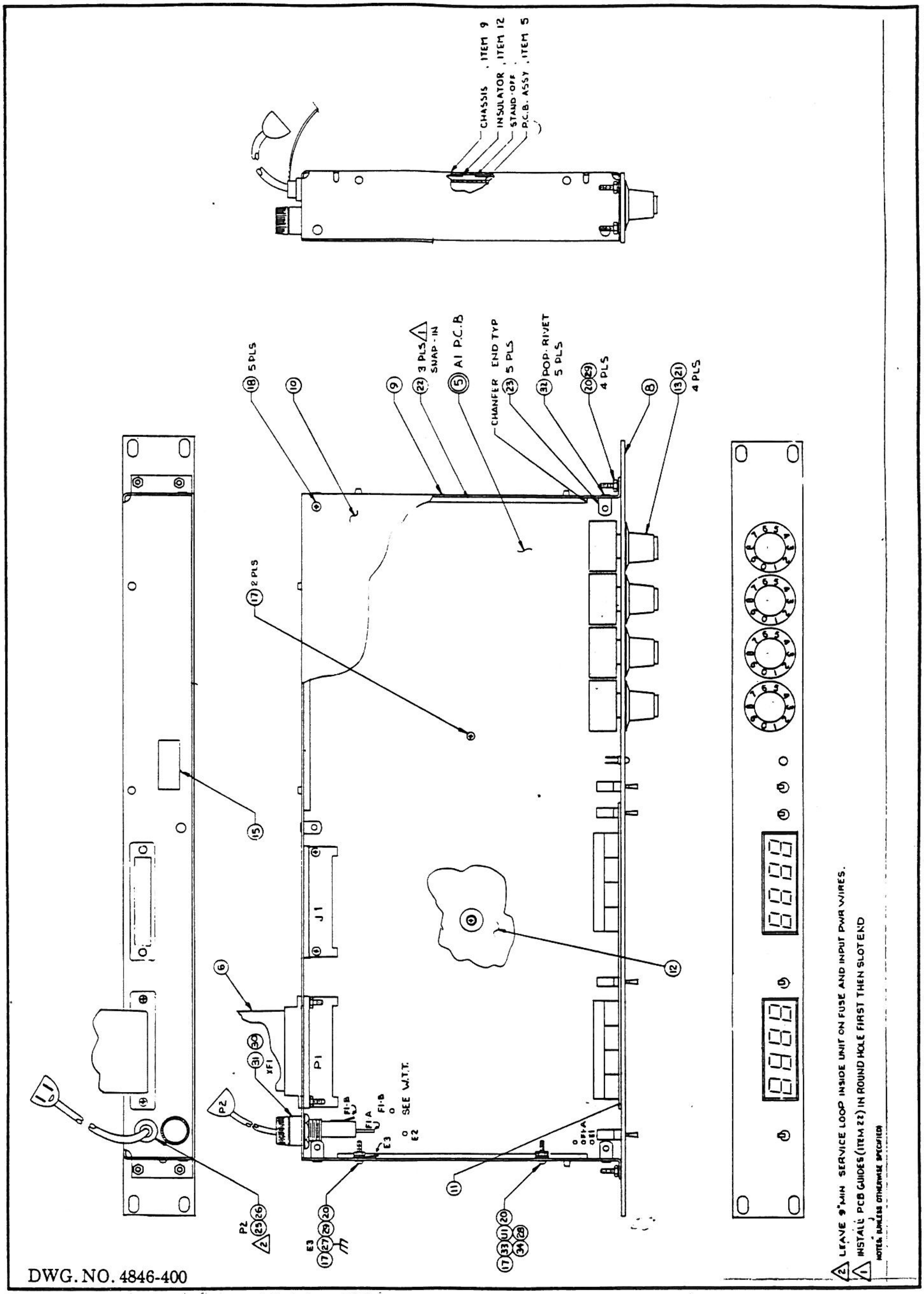


Figure 6-10. Assembly Diagram, Model 846CM.

SECTION VII — REPLACEABLE PARTS

7.1 GENERAL

This section contains ordering information and complete lists of replaceable parts. Parts are listed by major assembly in alphanumerical order of their reference designators. Description, manufacturer's part number, manufacturer's code identification number (see Appendix A for list of manufacturers), and California Instruments' stock numbers are indicated.

7.2 ORDERING INFORMATION

In order to provide our customers with prompt service on replacement parts, please provide the following information, when applicable, for each part ordered.

a) Model number and serial number of the instrument.

b) California Instruments' part number of the subassembly where the component is located.

c) Component reference designator (see Section VI).

d) Component description.

e) Component manufacturer's number and code identification.

f) California Instruments' stock number.

All replacement parts orders should be placed with California Instruments, Division of Amstar Technical Products Co., Inc., San Diego, California, 92111-1266.

7.3 COMPUTER GENERATED PARTS LISTS

The following information is included as an explanation of the computer formatted parts lists columns.

"Seq. No." -- Sequence number; the reference designator or the component, or (if there is no reference designator) the balloon number (bubble or "find" number) on the face of the assembly drawing. They are listed in alphanumerical order.

"Component Item No." -- This is California Instruments' part number. Please use this number when ordering spares.

"Engineering Drawing No." -- This is used for the follwing:

a) The document/specification number generated by California Instruments to control the part.

b) The generic part number (military specification or industry accepted standards).

c) The primary vendor's catalog part number. An asterisk at the end of the number indicates number is longer than that shown (contact California Instruments if the full number is required).

"Vendor" -- This is the FSCM code identification (see Appendix A).

"Quan" and "U/M" -- The requirements per unit of measure such as:
"2 each"; "1 lb."; "4 oz."; or "6 SI" (square inches).

PARENT ITEM NO. 4847-400-1

TOP ASSY,847T-1PH
ENGR DRAW NO. 4847-400 REV C

5/16/88

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
A1	4847-700-1	PC ASSY,POWER SUPPLY	4847-700 REV H	16067	1.0	EA
A3	4847-702-1	PC ASSY,FREQUENCY PROG	4847-702 REV E	16067	1.0	EA
10	FS1158	SCREW,PNH,S/S,6-32X1-1/4	MS51957-35	96906	2.0	EA
11	210674	COVER,FRONT	4845-200-7	16067	1.0	EA
12	210690	INSULATOR,PWB	4845-206-7	16067	1.0	EA
13	210691	INSULATOR,PWB	4845-207-7	16067	1.0	EA
15	FS1032	SCREW,PNH,S/S,6-32X1/2	MS51957-30	96906	2.0	EA
16	FS1031	SCREW,PNH,S/S,6-32X7/16	MS51957-29	81349	2.0	EA
19	210749	SPACER, #6 X 3/4",NYLON	4031	83330	2.0	EA
20	210748	STANDOFF,6-32 X 1",PHEN	8697	83330	2.0	EA
22	FS1013	SCREW,PNH,S/S,4-40X3/8	MS51957-15	96906	3.0	EA
23	FS1072	WASHER,SPLT,S/S,#4	MS35338-135	96906	3.0	EA
24	4847-100-1	DECAL,CALIBRATON	4847-100	16067	1.0	EA
25	4847-101-1	DECAL,FRONT PANEL	4847-101	16067	1.0	EA
26	FS4007	RUBBER STRIP,ADHESIVE	1/2WIDEX1/8DEEP	.81349	2.0	IN

PARENT ITEM NO. 4847-400-3

TOP ASSY,847T-3PH
ENGR DRAW NO. 4847-400 REV C

5/16/88

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
A1	4847-700-1	PC ASSY,POWER SUPPLY	4847-700 REV H	16067	1.0	EA
A2	4847-701-1	PC ASSY,A&B SERVO SENSE	4847-701 REV B	16067	1.0	EA
A3	4847-702-1	PC ASSY,FREQUENCY PROG	4847-702 REV E	16067	1.0	EA
10	FS1158	SCREW,PNH,S/S,6-32X1-1/4	MS51957-35	96906	2.0	EA
11	210674	COVER,FRONT	4845-200-7	16067	1.0	EA
12	210690	INSULATOR,PWB	4845-206-7	16067	1.0	EA
13	210691	INSULATOR,PWB	4845-207-7	16067	1.0	EA
15	FS1032	SCREW,PNH,S/S,6-32X1/2	MS51957-30	96906	2.0	EA
16	FS1031	SCREW,PNH,S/S,6-32X7/16	MS51957-29	81349	2.0	EA
19	210749	SPACER, #6 X 3/4",NYLON	4031	83330	2.0	EA
20	210748	STANDOFF,6-32 X 1",PHEN	8697	83330	2.0	EA
22	FS1013	SCREW,PNH,S/S,4-40X3/8	MS51957-15	96906	3.0	EA
23	FS1072	WASHER,SPLT,S/S,#4	MS35338-135	96906	3.0	EA
24	4847-100-1	DECAL,CALIBRATON	4847-100	16067	1.0	EA
25	4847-101-1	DECAL,FRONT PANEL	4847-101	16067	1.0	EA
26	FS4007	RUBBER STRIP,ADHESIVE	1/2WIDEX1/8DEEP	81349	2.0	IN

PC ASSY,POWER SUPPLY
ENGR DRAW NO. 4847-700 REV H

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
CR1	310244	DIODE,RECT,3A,200V	MR502	04713	1.0	EA
CR2	310244	DIODE,RECT,3A,200V	MR502	04713	1.0	EA
CR3	310206	DIODE,ZNR,12V.5W,5%	1N5242B	04713	1.0	EA
CR4	310227	DIODE,SWNG,75V,.5W,DO35	1N4148	81349	1.0	EA
CR5	310276	DIODE,SUPPR,34.8VR,600W	P6KE43	24444	1.0	EA
CR6	310276	DIODE,SUPPR,34.8VR,600W	P6KE43	24444	1.0	EA
C5	610916	CAP,MYLAR,.1UF,250V	C280AE/A100K	80031	1.0	EA
C6	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C7	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C8	610730	CAP,CER,1000PF,1000V	DD102	71590	1.0	EA
C9	610956	CAP,MYLAR,.0022UF,250V	* 713A1BB222PK*	80031	1.0	EA
C10	610916	CAP,MYLAR,.1UF,250V	C280AE/A100K	80031	1.0	EA
C11	610916	CAP,MYLAR,.1UF,250V	C280AE/A100K	80031	1.0	EA
C12	610050	CAP,MICA,820PF,300V	CM05F821J03	81349	1.0	EA
C13	610916	CAP,MYLAR,.1UF,250V	C280AE/A100K	80031	1.0	EA
C14	610916	CAP,MYLAR,.1UF,250V	C280AE/A100K	80031	1.0	EA
C15	610620	CAP,MICA,250PF,500V	CM05F251J03	81349	1.0	EA
C16	610475	CAP,CER,100PF,1000V	DD101	71590	1.0	EA
C17	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C18	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C19	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C20	610796	CAP,TANT,1UF,35V	T362A105M035AS	05397	1.0	EA
C21	611056	CAP,AL,3300UF,16V	16T3300	30039	1.0	EA
C22	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C23	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C24	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
J2	360346	SOCKET,DIP,18 PIN	ICO-183-S8-T	06776	1.0	EA
J3	230057	SOCKET,DIP,16 PIN	ICO-163-S8-T	06776	1.0	EA
Q1	330285	TRANSISTOR,SS,PNP,TO92	PN2907A	07263	1.0	EA
Q2	330285	TRANSISTOR,SS,PNP,TO92	PN2907A	07263	1.0	EA
Q3	330284	TRANSISTOR,SS,NPN,TO92	PN2222A	07263	1.0	EA
Q4	330319	TRANSISTOR,FET,N,JFET	2N3822	81349	1.0	EA
Q5	330319	TRANSISTOR,FET,N,JFET	2N3822	81349	1.0	EA
Q6	330289	TRANSISTOR,SS,NPN,TO92	PE8050	07263	1.0	EA
Q7	330288	TRANSISTOR,SS,PNP,TO92	PE8550	07263	1.0	EA
Q8	330308	TRANSISTOR,FET,N,DMOS	CIC376	16067	1.0	EA
R1	510076	RES,CARB,1/4W,10K OHM	RC07GF103J	81349	1.0	EA
R3	560484	RES,FILM,1/4W,374K,1%	RN60C3743F	81349	1.0	EA
R4	560484	RES,FILM,1/4W,374K,1%	RN60C3743F	81349	1.0	EA
R5	560484	RES,FILM,1/4W,374K,1%	RN60C3743F	81349	1.0	EA
R6	560484	RES,FILM,1/4W,374K,1%	RN60C3743F	81349	1.0	EA
R7	560484	RES,FILM,1/4W,374K,1%	RN60C3743F	81349	1.0	EA
R8	560484	RES,FILM,1/4W,374K,1%	RN60C3743F	81349	1.0	EA
R9	560484	RES,FILM,1/4W,374K,1%	RN60C3743F	81349	1.0	EA
R10	560484	RES,FILM,1/4W,374K,1%	RN60C3743F	81349	1.0	EA
R11	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
R13	510151	RES,CARB,1/4W,2.4M OHM	RC07GF245J	81349	1.0	EA

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
R14	560756	RES,FILM,1/8W,12.1K,1%	RN55C1212F	81349	1.0	EA
R15	560756	RES,FILM,1/8W,12.1K,1%	RN55C1212F	81349	1.0	EA
R16	560756	RES,FILM,1/8W,12.1K,1%	RN55C1212F	81349	1.0	EA
R17	560760	RES,FILM,1/8W,12.4K,1%	RN55C1242F	81349	1.0	EA
R18	560762	RES,FILM,1/8W,10K,1%	RN55D1002F	81349	1.0	EA
R19	530068	RES,CARB,1W,47 OHM	RC32GF470J	81349	1.0	EA
R20	530004	RES,CARB,1W,68 OHM	RC32GF680J	81349	1.0	EA
R21	510021	RES,CARB,1/4W,47 OHM	RC07GF470J	81349	1.0	EA
R22	560575	RES,FILM,1/8W,33.2K,1%	RN55D3322F	81349	1.0	EA
R23	510068	RES,CARB,1/4W,4.7K OHM	RC07GF472J	81349	1.0	EA
R24	510080	RES,CARB,1/4W,15K OHM	RC07GF153J	81349	1.0	EA
R25	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
R26	560575	RES,FILM,1/8W,33.2K,1%	RN55D3322F	81349	1.0	EA
R27	560753	RES,FILM,1/8W,73.2K,1%	RN55D7322F	81349	1.0	EA
R28	560788	RES,FILM,1/8W,21K,1%	RN55D2102F	81349	1.0	EA
R29	510021	RES,CARB,1/4W,47 OHM	RC07GF470J	81349	1.0	EA
R30	510029	RES,CARB,1/4W,100 OHM	RC07GF101J	81349	1.0	EA
R31	510135	RES,CARB,1/4W,10M OHM	RC07GF106J	81349	1.0	EA
R32	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
R33	510037	RES,CARB,1/4W,220 OHM	RC07GF221J	81349	1.0	EA
R34	510084	RES,CARB,1/4W,22K OHM	RC07GF223J	81349	1.0	EA
R35	510068	RES,CARB,1/4W,4.7K OHM	RC07GF472J	81349	1.0	EA
R36	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
R37	560759	RES,FILM,1/8W,2.37K,1%	RN55C2371F	81349	1.0	EA
R38	560747	RES,FILM,1/8W,8.66K,1%	RN55D8661F	81349	1.0	EA
R39	510060	RES,CARB,1/4W,2.2K OHM	RC07GF222J	81349	1.0	EA
R40	510084	RES,CARB,1/4W,22K OHM	RC07GF223J	81349	1.0	EA
R41	510076	RES,CARB,1/4W,10K OHM	RC07GF103J	81349	1.0	EA
R43	560762	RES,FILM,1/8W,10K,1%	RN55D1002F	81349	1.0	EA
R44	570270	POT,1T,PC,100K	63X104	02111	1.0	EA
R45	570270	POT,1T,PC,100K	63X104	02111	1.0	EA
R46	570270	POT,1T,PC,100K	63X104	02111	1.0	EA
R47	570140	POT,MT,PC,2K,1/4W,20%	ET34X202	30983	1.0	EA
R48	570134	POT,MT,PC,500 OHM,1/4W	ET34X501	30983	1.0	EA
R49	570134	POT,MT,PC,500 OHM,1/4W	ET34X501	30983	1.0	EA
R50	570134	POT,MT,PC,500 OHM,1/4W	ET34X501	30983	1.0	EA
R53	510021	RES,CARB,1/4W,47 OHM	RC07GF470J	81349	1.0	EA
S1	240494	SWITCH,DIP,2 SECT	CTS 206-2	71450	1.0	EA
TP2	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
TP3	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
TP4	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
TP5	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
TP6	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
TP7	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
TP8	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
TP9	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
T1	710338	TRANSFORMER	PC16-1500	08779	1.0	EA

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
U1	360226	IC,TTL,COUNTER,DEC,DUAL	SN74LS390N	81349	1.0	EA
U2	360234	IC,TIMER,DUAL	NE556N	18324	1.0	EA
U3	360267	IC,TTL,INVERT,SCHMITT,HEX	SN74LS14N	81349	1.0	EA
U4	360099	IC,TTL,OR,2-IN,QUAD	SN74LS32N	81349	1.0	EA
U5	360161	IC,TTL,FF,DUAL	SN74LS74N	81349	1.0	EA
U6	360353	IC,OP-AMP,FET,QUAD	MC34004P	04713	1.0	EA
U7	360378	IC,TTL,COUNTER,BIN,UP/DN	SN74ALS169N	81349	1.0	EA
U8	360239	IC,TTL,EXCL NOR,2-IN,OC	SN74LS266N	81349	1.0	EA
U9	360239	IC,TTL,EXCL NOR,2-IN,OC	SN74LS266N	81349	1.0	EA
U10	360378	IC,TTL,COUNTER,BIN,UP/DN	SN74ALS169N	81349	1.0	EA
U11	CIC207-3	IC,TTL,PROM,256X4	CIC207-3	16067	1.0	EA
U12	CIC207-2	IC,TTL,PROM,256X4	CIC207-2	16067	1.0	EA
U13	360378	IC,TTL,COUNTER,BIN,UP/DN	SN74ALS169N	81349	1.0	EA
U14	360530	IC,OP-AMP,FET,DUAL	UPC812	33297	1.0	EA
U15	360237	IC,OP-AMP,PREC	CA3193E	18722	1.0	EA
U16	360530	IC,OP-AMP,FET,DUAL	UPC812	33297	1.0	EA
U17	360530	IC,OP-AMP,FET,DUAL	UPC812	33297	1.0	EA
U18	360256	IC,OPTO,MODULATOR	CLM51	03911	1.0	EA
U19	360265	IC,DAC,8-BIT,.1%	DAC-08HN	18324	1.0	EA
U20	360278	IC,REF,+10	CIC738	16067	1.0	EA
VR1	310173	DIODE,ZNR,16V,.5W,5%	1N5246B	04713	1.0	EA
VR2	310173	DIODE,ZNR,16V,.5W,5%	1N5246B	04713	1.0	EA
VR3	310169	DIODE,ZNR,10V,.5W,5%	1N5240B	04713	1.0	EA
VR4	310267	DIODE,SUPPR,16.2VR,600W	P6KE20	24444	1.0	EA
VR5	360007	IC,VOLTAGE REG,+5,1A	LM309K	27014	1.0	EA
W3	FS5118	WIRE,BUS,AWG 24,QQ-W-343E	QQW343S24S2B	81348	1.0	IN
W5	FS5004	WIRE,BU,MIL-W-16878/4	AWG 24,WHT	81349	4.0	IN
W6	FS5004	WIRE,BU,MIL-W-16878/4	AWG 24,WHT	81349	4.0	IN
Z1	360154	RES,ARRAY,SIP,22K	108A223	01121	1.0	EA
Z2	360232	RES,ARRAY,TFLM,DIP,6.8K	698-3-R6.8K-F	73138	1.0	EA
Z3	360232	RES,ARRAY,TFLM,DIP,6.8K	698-3-R6.8K-F	73138	1.0	EA
7	4847-750-1	PWB,POWER SUPPLY	4847-750-1	16067	1.0	EA
8	110736	HEATSINK	4845-201-7	16067	1.0	EA
134	230057	SOCKET,DIP,16 PIN	ICO-163-S8-T	06776	2.0	EA
136	250391	BUS BAR *	B5206-.750-2-T*	29593	3.0	EA
138	FS1030	SCREW,PNH,S/S,6-32X3/8	MS51957-28	96906	2.0	EA
139	FS1073	WASHER,SPLT,S/S,#6	MS35338-136	96906	2.0	EA
140	FS1064	NUT,HEX,S/S,6-32	MS35649-264	96906	2.0	EA
142	240294	SOCKET,XSTR,4 PIN,TO5/18	05-3308	83486	1.0	EA
143	120027	DECAL,HIGH VOLTAGE 2X.7"	DANGER	16067	1.0	EA

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
CR1	310206	DIODE,ZNR,12V.5W,5%	1N5242B	04713	1.0	EA
CR2	310206	DIODE,ZNR,12V.5W,5%	1N5242B	04713	1.0	EA
CR3	310227	DIODE,SWNG,75V,.5W,DO35	1N4148	81349	1.0	EA
CR4	310227	DIODE,SWNG,75V,.5W,DO35	1N4148	81349	1.0	EA
CR5	310169	DIODE,ZNR,10V,.5W,5%	1N5240B	04713	1.0	EA
CR6	310169	DIODE,ZNR,10V,.5W,5%	1N5240B	04713	1.0	EA
C3	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C4	610475	CAP,CER,100PF,1000V	DD101	71590	1.0	EA
C5	610050	CAP,MICA,820PF,300V	CM05F821J03	81349	1.0	EA
C6	610916	CAP,MYLAR,.1UF,250V	C280AE/A100K	80031	1.0	EA
C7	610620	CAP,MICA,250PF,500V	CM05F251J03	81349	1.0	EA
C8	610916	CAP,MYLAR,.1UF,250V	C280AE/A100K	80031	1.0	EA
C9	610796	CAP,TANT,1UF,35V	T362A105M035AS	05397	1.0	EA
C10	610796	CAP,TANT,1UF,35V	T362A105M035AS	05397	1.0	EA
C11	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C12	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C13	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
J1	250388	CABLE ASSY,RIBBON,7"	* CAD-18PO2-281C*	08261	1.0	EA
Q1	330308	TRANSISTOR,FET,N,DMOS	CIC376	16067	1.0	EA
Q2	330284	TRANSISTOR,SS,NPN,TO92	PN2222A	07263	1.0	EA
Q3	330284	TRANSISTOR,SS,NPN,TO92	PN2222A	07263	1.0	EA
R1	360241	RES,ARRAY,DIP,10K	898-1-R10K-F	73138	1.0	EA
R2	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
R3	510084	RES,CARB,1/4W,22K OHM	RC07GF223J	81349	1.0	EA
R4	560788	RES,FILM,1/8W,21K,1%	RN55D2102F	81349	1.0	EA
R5	360232	RES,ARRAY,TFLM,DIP,6.8K	698-3-R6.8K-F	73138	1.0	EA
R6	510021	RES,CARB,1/4W,47 OHM	RC07GF470J	81349	1.0	EA
R7	360232	RES,ARRAY,TFLM,DIP,6.8K	698-3-R6.8K-F	73138	1.0	EA
R10	560747	RES,FILM,1/8W,8.66K,1%	RN55D8661F	81349	1.0	EA
R13	560575	RES,FILM,1/8W,33.2K,1%	RN55D3322F	81349	1.0	EA
R15	570140	POT,MT,PC,2K,1/4W,20%	ET34X202	30983	1.0	EA
R16	560759	RES,FILM,1/8W,2.37K,1%	RN55C2371F	81349	1.0	EA
R17	360232	RES,ARRAY,TFLM,DIP,6.8K	698-3-R6.8K-F	73138	1.0	EA
R18	570140	POT,MT,PC,2K,1/4W,20%	ET34X202	30983	1.0	EA
R19	560759	RES,FILM,1/8W,2.37K,1%	RN55C2371F	81349	1.0	EA
R20	360232	RES,ARRAY,TFLM,DIP,6.8K	698-3-R6.8K-F	73138	1.0	EA
R21	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
R22	510068	RES,CARB,1/4W,4.7K OHM	RC07GF472J	81349	1.0	EA
R23	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
R24	510068	RES,CARB,1/4W,4.7K OHM	RC07GF472J	81349	1.0	EA
R25	510037	RES,CARB,1/4W,220 OHM	RC07GF221J	81349	1.0	EA
R26	510068	RES,CARB,1/4W,4.7K OHM	RC07GF472J	81349	1.0	EA
R27	510080	RES,CARB,1/4W,15K OHM	RC07GF153J	81349	1.0	EA
R28	510037	RES,CARB,1/4W,220 OHM	RC07GF221J	81349	1.0	EA
R29	510068	RES,CARB,1/4W,4.7K OHM	RC07GF472J	81349	1.0	EA
R30	510080	RES,CARB,1/4W,15K OHM	RC07GF153J	81349	1.0	EA
R31	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
R32	570270	POT,1T,PC,100K	63X104	02111	1.0	EA
R33	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
R34	570270	POT,1T,PC,100K	63X104	02111	1.0	EA
R35	360154	RES,ARRAY,SIP,22K	108A223	01121	1.0	EA
R36	510084	RES,CARB,1/4W,22K OHM	RC07GF223J	81349	1.0	EA
R37	510060	RES,CARB,1/4W,2.2K OHM	RC07GF222J	81349	1.0	EA
R38	510021	RES,CARB,1/4W,47 OHM	RC07GF470J	81349	1.0	EA
R39	510021	RES,CARB,1/4W,47 OHM	RC07GF470J	81349	1.0	EA
R40	510029	RES,CARB,1/4W,100 OHM	RC07GF101J	81349	1.0	EA
R41	510135	RES,CARB,1/4W,10M OHM	RC07GF106J	81349	1.0	EA
R42	510029	RES,CARB,1/4W,100 OHM	RC07GF101J	81349	1.0	EA
R43	510135	RES,CARB,1/4W,10M OHM	RC07GF106J	81349	1.0	EA
TP1	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
TP2	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
TP3	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
TP4	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
TP5	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
TP6	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
U1	360159	IC,TTL,INVERT,HEX	SN74LS04N	81349	1.0	EA
U2	360378	IC,TTL,COUNTER,BIN,UP/DN	SN74ALS169N	81349	1.0	EA
U3	360378	IC,TTL,COUNTER,BIN,UP/DN	SN74ALS169N	81349	1.0	EA
U4	360378	IC,TTL,COUNTER,BIN,UP/DN	SN74ALS169N	81349	1.0	EA
U5	360239	IC,TTL,EXCL NOR,2-IN,OC	SN74LS266N	81349	1.0	EA
U6	360239	IC,TTL,EXCL NOR,2-IN,OC	SN74LS266N	81349	1.0	EA
U7	CIC207-3	IC,TTL,PROM,256X4	CIC207-3	16067	1.0	EA
U8	CIC207-2	IC,TTL,PROM,256X4	CIC207-2	16067	1.0	EA
U9	360265	IC,DAC,8-BIT,.1%	DAC-08HN	18324	1.0	EA
U10	360530	IC,OP-AMP,FET,DUAL	UPC812	33297	1.0	EA
U11	360530	IC,OP-AMP,FET,DUAL	UPC812	33297	1.0	EA
U12	360530	IC,OP-AMP,FET,DUAL	UPC812	33297	1.0	EA
U13	360530	IC,OP-AMP,FET,DUAL	UPC812	33297	1.0	EA
U14	360237	IC,OP-AMP,PREC	CA3193E	18722	1.0	EA
U15	360256	IC,OPTO,MODULATOR	CLM51	03911	1.0	EA
U16	360530	IC,OP-AMP,FET,DUAL	UPC812	33297	1.0	EA
U17	360237	IC,OP-AMP,PREC	CA3193E	18722	1.0	EA
U18	360256	IC,OPTO,MODULATOR	CLM51	03911	1.0	EA
XQ1	240294	SOCKET,XSTR,4 PIN,TO5/18	05-3308	83486	1.0	EA
X7	230057	SOCKET,DIP,16 PIN	ICO-163-S8-T	06776	1.0	EA
X8	230057	SOCKET,DIP,16 PIN	ICO-163-S8-T	06776	1.0	EA
7	4847-751-1	PWB,PH A&B SERVO SENSE	4847-751-1	16067	1.0	EA
100	210416	FSTNR,CHASSIS,BLOCK	159-BLK	88245	1.0	EA

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
CR1	310062	DIODE,RECT,1A,400V,DO41	1N4004	81349	1.0	EA
CR8	310062	DIODE,RECT,1A,400V,DO41	1N4004	81349	1.0	EA
CR9	310062	DIODE,RECT,1A,400V,DO41	1N4004	81349	1.0	EA
CR10	310227	DIODE,SWNG,75V,.5W,DO35	1N4148	81349	1.0	EA
CR11	310227	DIODE,SWNG,75V,.5W,DO35	1N4148	81349	1.0	EA
CR12	310227	DIODE,SWNG,75V,.5W,DO35	1N4148	81349	1.0	EA
CR16	310227	DIODE,SWNG,75V,.5W,DO35	1N4148	81349	1.0	EA
C1	611088	CAP,CER,10PF,25V	CN15C100K	71590	1.0	EA
C2	611089	CAP,CER,47PF,25V	CN15C470K	71590	1.0	EA
C3	610475	CAP,CER,100PF,1000V	DD101	71590	1.0	EA
C4	611091	CAP,CER,22PF,25V	CN15C220J	71590	1.0	EA
C5	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C6	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C7	611089	CAP,CER,47PF,25V	CN15C470K	71590	1.0	EA
C8	611092	CAP,VAR,.8-8.5PF	EF9	18736	1.0	EA
C9	610750	CAP,TANT,4.7UF,10V	T362A475M010AS	05397	1.0	EA
C11	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C12	610730	CAP,CER,1000PF,1000V	DD102	71590	1.0	EA
C13	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C14	610730	CAP,CER,1000PF,1000V	DD102	71590	1.0	EA
C15	610730	CAP,CER,1000PF,1000V	DD102	71590	1.0	EA
C16	610730	CAP,CER,1000PF,1000V	DD102	71590	1.0	EA
C17	611093	CAP,AL,100UF,25V	SM25VB100MC	57640	1.0	EA
C18	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C19	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C20	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C21	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C22	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C23	610475	CAP,CER,100PF,1000V	DD101	71590	1.0	EA
C24	611089	CAP,CER,47PF,25V	CN15C470K	71590	1.0	EA
C25	611089	CAP,CER,47PF,25V	CN15C470K	71590	1.0	EA
C27	610750	CAP,TANT,4.7UF,10V	T362A475M010AS	05397	1.0	EA
J1	410316	CONN,PC HDR,60 PIN,90D	816-6022-435	08261	1.0	EA
J2	410277	CABLE ASSY,RIBBON,7"	5242-007	08261	1.0	EA
L1	590005	INDUCTOR,RF,200UH	1537-90	99800	1.0	EA
Q1	330245	TRANSISTOR,FET,N,JFET	2N5246	81349	1.0	EA
Q2	330284	TRANSISTOR,SS,NPN,TO92	PN2222A	07263	1.0	EA
Q3	330285	TRANSISTOR,SS,PNP,TO92	PN2907A	07263	1.0	EA
Q5	330245	TRANSISTOR,FET,N,JFET	2N5246	81349	1.0	EA
Q6	330284	TRANSISTOR,SS,NPN,TO92	PN2222A	07263	1.0	EA
Q7	330284	TRANSISTOR,SS,NPN,TO92	PN2222A	07263	1.0	EA
Q8	330284	TRANSISTOR,SS,NPN,TO92	PN2222A	07263	1.0	EA
Q9	330295	TRANSISTOR,SS,NPN,TO92	2N5210	81349	1.0	EA
R1	510068	RES,CARB,1/4W,4.7K OHM	RC07GF472J	81349	1.0	EA
R2	510100	RES,CARB,1/4W,100K OHM	RC07GF104J	81349	1.0	EA
R3	510037	RES,CARB,1/4W,220 OHM	RC07GF221J	81349	1.0	EA
R4	510076	RES,CARB,1/4W,10K OHM	RC07GF103J	81349	1.0	EA

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
R5	510076	RES,CARB,1/4W,10K OHM	RC07GF103J	81349	1.0	EA
R6	510060	RES,CARB,1/4W,2.2K OHM	RC07GF222J	81349	1.0	EA
R7	570271	POT,1T,PC,10K	63X103	02111	1.0	EA
R8	510029	RES,CARB,1/4W,100 OHM	RC07GF101J	81349	1.0	EA
R9	560783	RES,FILM,1/8W,30.9K,1%	RN55D3092F	81349	1.0	EA
R10	510037	RES,CARB,1/4W,220 OHM	RC07GF221J	81349	1.0	EA
R13	510063	RES,CARB,1/4W,3.0K OHM	RC07GF302J	81349	1.0	EA
R14	510063	RES,CARB,1/4W,3.0K OHM	RC07GF302J	81349	1.0	EA
R15	510076	RES,CARB,1/4W,10K OHM	RC07GF103J	81349	1.0	EA
R16	510071	RES,CARB,1/4W,6.2K OHM	RC07GF622J	81349	1.0	EA
R17	510071	RES,CARB,1/4W,6.2K OHM	RC07GF622J	81349	1.0	EA
R18	510129	RES,CARB,1/4W,3.3M OHM	RC07GF335J	81349	1.0	EA
R19	510076	RES,CARB,1/4W,10K OHM	RC07GF103J	81349	1.0	EA
R20	560764	RES,FILM,1/8W,26.1K,1%	RN55C2612F	81349	1.0	EA
R21	560762	RES,FILM,1/8W,10K,1%	RN55D1002F	81349	1.0	EA
R22	560763	RES,FILM,1/8W,324K,1%	RN55D3243F	81349	1.0	EA
R23	510076	RES,CARB,1/4W,10K OHM	RC07GF103J	81349	1.0	EA
R24	510029	RES,CARB,1/4W,100 OHM	RC07GF101J	81349	1.0	EA
R25	510100	RES,CARB,1/4W,100K OHM	RC07GF104J	81349	1.0	EA
R26	570138	POT,MT,PC,100K,1/4,20%	ET34X104	30983	1.0	EA
R27	570134	POT,MT,PC,500 OHM,1/4W	ET34X501	30983	1.0	EA
R28	570134	POT,MT,PC,500 OHM,1/4W	ET34X501	30983	1.0	EA
R29	510076	RES,CARB,1/4W,10K OHM	RC07GF103J	81349	1.0	EA
R30	510076	RES,CARB,1/4W,10K OHM	RC07GF103J	81349	1.0	EA
R31	560762	RES,FILM,1/8W,10K,1%	RN55D1002F	81349	1.0	EA
R32	510068	RES,CARB,1/4W,4.7K OHM	RC07GF472J	81349	1.0	EA
R33	510076	RES,CARB,1/4W,10K OHM	RC07GF103J	81349	1.0	EA
R34	510076	RES,CARB,1/4W,10K OHM	RC07GF103J	81349	1.0	EA
S1	240500	SWITCH,DIP,8 SECT, 90D	BT8	000AS	1.0	EA
TP1	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
TP2	FS2046	TERMINAL,QCK CLP,PC,MALE	835	79963	1.0	EA
U1	360235	IC,TTL,NAND,4-IN,DUAL	SN74LS20N	81349	1.0	EA
U2	360355	IC,MOS,INVERT,HEX,HS	74HC14N	27014	1.0	EA
U3	360163	IC,MOS,EXCL OR,2-IN,QUAD	CD4070BE	18722	1.0	EA
U4	360143	IC,TTL,NAND,3-IN,TRIPLE	SN74LS10N	81349	1.0	EA
U5	360351	IC,MOS,FF,QUAD D	HEF4076BP	18324	1.0	EA
U6	360360	IC,MOS,RATE MULT,BCD	74HCT167	16067	1.0	EA
U7	360351	IC,MOS,FF,QUAD D	HEF4076BP	18324	1.0	EA
U8	360360	IC,MOS,RATE MULT,BCD	74HCT167	16067	1.0	EA
U9	360511	IC,MOS,FF,HEX	CD74HC174E	18722	1.0	EA
U10	CIC206-17	IC,TTL,PROM,32X8	CIC206-17	16067	1.0	EA
U11	360351	IC,MOS,FF,QUAD D	HEF4076BP	18324	1.0	EA
U12	360360	IC,MOS,RATE MULT,BCD	74HCT167	16067	1.0	EA
U13	360351	IC,MOS,FF,QUAD D	HEF4076BP	18324	1.0	EA
U14	360360	IC,MOS,RATE MULT,BCD	74HCT167	16067	1.0	EA
U15	CIC207-15	IC,TTL,PROM,256X4	CIC207-15	16067	1.0	EA
U16	360259	IC,MOS,INTERFACE,GPIB	HEF4738	18324	1.0	EA

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
U17	360512	IC,MOS,FF,3-STATE,OCTAL	74HC374	81349	1.0	EA
U18	360512	IC,MOS,FF,3-STATE,OCTAL	74HC374	81349	1.0	EA
U19	360512	IC,MOS,FF,3-STATE,OCTAL	74HC374	81349	1.0	EA
U20	360512	IC,MOS,FF,3-STATE,OCTAL	74HC374	81349	1.0	EA
U21	360237	IC,OP-AMP,PREC	CA3193E	18722	1.0	EA
U22	360258	IC,MOS,SHIFT REG,8-BIT	CD4014	02335	1.0	EA
U23	360176	IC,TTL,TRANSCEIVER,GP1B	MC3440P	04713	1.0	EA
U24	360176	IC,TTL,TRANSCEIVER,GP1B	MC3440P	04713	1.0	EA
U25	360176	IC,TTL,TRANSCEIVER,GP1B	MC3440P	04713	1.0	EA
U26	360240	IC,DAC,8-BIT,.19%	DAC-08EN	18324	1.0	EA
U27	360240	IC,DAC,8-BIT,.19%	DAC-08EN	18324	1.0	EA
U28	360265	IC,DAC,8-BIT,.1%	DAC-08HN	18324	1.0	EA
U29	360265	IC,DAC,8-BIT,.1%	DAC-08HN	18324	1.0	EA
U30	360258	IC,MOS,SHIFT REG,8-BIT	CD4014	02335	1.0	EA
VR1	310269	IC,VOLTAGE REG,+VAR	TL 431 CLP	01295	1.0	EA
X6	230057	SOCKET,DIP,16 PIN	ICO-163-S8-T	06776	1.0	EA
X10	230057	SOCKET,DIP,16 PIN	ICO-163-S8-T	06776	1.0	EA
X15	230057	SOCKET,DIP,16 PIN	ICO-163-S8-T	06776	1.0	EA
X16	360186	SOCKET,DIP,40 PIN	C85-40-01	01295	1.0	EA
Y1	250386	CRYSTAL,10.2M,.005%	HC18 PARALLEL*	54363	1.0	EA
Z1	360206	RES,ARRAY,SIP,100K	108B104	01121	1.0	EA
Z2	360326	RES,ARRAY,SIP,100K	108A104	73138	1.0	EA
Z3	360207	RES,ARRAY,SIP,10K	108B103	01121	1.0	EA
Z4	360207	RES,ARRAY,SIP,10K	108B103	01121	1.0	EA
Z5	360207	RES,ARRAY,SIP,10K	108B103	01121	1.0	EA
Z6	360241	RES,ARRAY,DIP,10K	898-1-R10K-F	73138	1.0	EA
Z7	360139	RES,ARRAY,SIP,10K	108A103	01121	1.0	EA
Z8	360206	RES,ARRAY,SIP,100K	108B104	01121	1.0	EA
Z10	360232	RES,ARRAY,TFLM,DIP,6.8K	698-3-R6.8K-F	73138	1.0	EA
3	4847-752-1	PWB,FREQUENCY PROG	4847-752-1	16067	1.0	EA
4	210416	FSTNR,CHASSIS,BLOCK	159-BLK	88245	2.0	EA

PARENT ITEM NO.
4846-400-1

TOP ASSY,846CM
ENGR DRAW NO. 4846-400 REV C1

3/02/87

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED		ENGINEERING DRAWING NO.	VENDOR	QTY	UM
A1	4846-700-1	PC ASSY,CONTROL		4846-700 REV E1	16067	1.0	EA
F1	270079	FUSE,1/4A,250V		312.250	75915	1.0	EA
P2	250203	PWR CORD,115V,18-3,6'		17237	70903	1.0	EA
XF1	240264	FUSE HOLDER,PANEL,1/4"		345-001	75915	1.0	EA
6	4846-402-1	CABLE ASSY,PARALLEL		4846-402 REV 0	16067	1.0	EA
8	110739-1	PANEL,FRONT W/4846-200		4846-200-1	16067	1.0	EA
9	110740-1	ENCLOSURE W/4846-201		4846-201-1	16067	1.0	EA
10	110741	COVER,TOP		4846-202-7	16067	1.0	EA
11	210680	POLARIZER		4846-203-7	16067	1.0	EA
12	210697	INSULATOR,PWB		4846-204-7	16067	1.0	EA
13	210650	KNOB,BLK,CLR SKT	*-CL	PS-70TSL-2-BLK*	21604	4.0	EA
15	210677	DECAL,FRONT PANEL		4845-204-7	16067	1.0	EA
17	FS1011	SCREW,PNH,S/S,4-40X1/4		MS51957-13	96906	1.0	EA
18	FS1014	SCREW,FLH,S/S,4-40X1/4		MS24693-C2	96906	5.0	EA
19	FS1079	WASHER,FLAT,S/S,#4		MS15795-804	96906	3.0	EA
20	FS1066	NUT,HEX,S/S,4-40		MS35649-244	96906	5.0	EA
21	210187	NUT,HEX,NKL,3/8-32		1199	83330	4.0	EA
22	210694	GUIDE,PWB,6"		E-600	32559	3.0	EA
23	210693	BRACKET,ANGLE		741	79963	5.0	EA
26	210480	STRAIN RELIEF		SR-5L-1	28520	1.0	EA
27	250359	LUG,RING,SOLDER,#6		809	79963	1.0	EA
28	FS4001	THERMAL COMPOUND		351	13103	.1	OZ
29	FS1072	WASHER,SPLT,S/S,#4		MS35338-135	96906	5.0	EA
32	210695	FSTNR,RVT,POP,1/8X.222		AD42ABS	07707	5.0	EA
33	210474	INSULATOR,RECT,MICA		4673	91833	1.0	EA
34	210076	INSULATOR,SHLDR,NYL,#4		NY04-040	08289	1.0	EA

PARENT ITEM NO. 4846-700-1

PC ASSY,CONTROL
ENGR DRAW NO. 4846-700 REV E1

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
CR1	310062	DIODE,RECT,1A,400V,DO41	1N4004	81349	1.0	EA
CR2	310062	DIODE,RECT,1A,400V,DO41	1N4004	81349	1.0	EA
CR3	310267	DIODE,SUPPR,16.2VR,600W	P6KE20	24444	1.0	EA
CR4	250352	LAMP,LED,RED	5082-4850	28480	1.0	EA
CR5	310062	DIODE,RECT,1A,400V,DO41	1N4004	81349	1.0	EA
CR6	310129	DIODE,ZNR,3.3V,.5W,5%	1N5226B	04713	1.0	EA
C1	611056	CAP,AL,3300UF,16V	16T3300	30039	1.0	EA
C2	610916	CAP,MYLAR,.1UF,250V	C280AE/A100K	80031	1.0	EA
C4	610802	CAP,TANT,4.7UF,25V	T362B475M025AS	05397	1.0	EA
C5	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C6	610094	CAP,CER,.01UF,50V	CK103	71590	1.0	EA
C7	610798	CAP,TANT,2.2UF,25V	T362B225M025AS	05397	1.0	EA
DS1	230077	DISPLAY,LED,RED,.5,DGTL	HDSP5501	28480	1.0	EA
DS2	230077	DISPLAY,LED,RED,.5,DGTL	HDSP5501	28480	1.0	EA
DS3	230077	DISPLAY,LED,RED,.5,DGTL	HDSP5501	28480	1.0	EA
DS4	230077	DISPLAY,LED,RED,.5,DGTL	HDSP5501	28480	1.0	EA
DS5	230077	DISPLAY,LED,RED,.5,DGTL	HDSP5501	28480	1.0	EA
DS6	230077	DISPLAY,LED,RED,.5,DGTL	HDSP5501	28480	1.0	EA
DS7	230077	DISPLAY,LED,RED,.5,DGTL	HDSP5501	28480	1.0	EA
DS8	230077	DISPLAY,LED,RED,.5,DGTL	HDSP5501	28480	1.0	EA
J1	410312	CONN,RCPT,RECT,37 SOCKET	DCP-37SAC	71468	1.0	EA
P1	410313	CONN,PLUG,RECT,37 PIN	DCP37PAC	71468	1.0	EA
Q1	330284	TRANSISTOR,SS,NPN,TO92	PN2222A	07263	1.0	EA
Q2	330284	TRANSISTOR,SS,NPN,TO92	PN2222A	07263	1.0	EA
Q3	330284	TRANSISTOR,SS,NPN,TO92	PN2222A	07263	1.0	EA
R1	360263	RES,ARRAY,SIP,1K	108A102	01121	1.0	EA
R2	360263	RES,ARRAY,SIP,1K	108A102	01121	1.0	EA
R3	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
R4	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
R5	510045	RES,CARB,1/4W,470 OHM	RC07GF471J	81349	1.0	EA
R6	510076	RES,CARB,1/4W,10K OHM	RC07GF103J	81349	1.0	EA
R8	510084	RES,CARB,1/4W,22K OHM	RC07GF223J	81349	1.0	EA
R9	510076	RES,CARB,1/4W,10K OHM	RC07GF103J	81349	1.0	EA
R10	510037	RES,CARB,1/4W,220 OHM	RC07GF221J	81349	1.0	EA
R11	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
R12	510053	RES,CARB,1/4W,1K OHM	RC07GF102J	81349	1.0	EA
S1	240477	SWITCH,RTRY,10 POS	11975MP/REL-10	82104	1.0	EA
S2	240477	SWITCH,RTRY,10 POS	11975MP/REL-10	82104	1.0	EA
S3	240477	SWITCH,RTRY,10 POS	11975MP/REL-10	82104	1.0	EA
S4	240477	SWITCH,RTRY,10 POS	11975MP/REL-10	82104	1.0	EA
S5	240491	SWITCH,TGL,SPDT	7101P3D9AV2QE	08353	1.0	EA
S6	240492	SWITCH,TGL,SPDT	7105P3D9AV2QE	08353	1.0	EA
S7	240492	SWITCH,TGL,SPDT	7105P3D9AV2QE	08353	1.0	EA
S8	240491	SWITCH,TGL,SPDT	7101P3D9AV2QE	08353	1.0	EA
S9	240495	SWITCH,SLIDE,DPDT	24-441-020	10389	1.0	EA
TP1	250303	TERMINAL,MINIWRAP POST	T44	82893	1.0	EA
T1	710339	TRANSFORMER	DPC16-1500	08779	1.0	EA

PARENT ITEM NO. 4846-700-1

PC ASSY,CONTROL
ENGR DRAW NO. 4846-700 REV E1

3/02/87

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION TRUNCATED	ENGINEERING DRAWING NO.	VENDOR	QTY	UM
U1	360189	IC,TTL,BUFFER,HEX	SN74LS367N	81349	1.0	EA
U2	360189	IC,TTL,BUFFER,HEX	SN74LS367N	81349	1.0	EA
U3	360189	IC,TTL,BUFFER,HEX	SN74LS367N	81349	1.0	EA
U4	360189	IC,TTL,BUFFER,HEX	SN74LS367N	81349	1.0	EA
U5	360189	IC,TTL,BUFFER,HEX	SN74LS367N	81349	1.0	EA
U6	360189	IC,TTL,BUFFER,HEX	SN74LS367N	81349	1.0	EA
U7	360032	IC,VOLTAGE REG,+5,1A	LM340-5T	27014	1.0	EA
U8	360229	IC,TTL,DECODER,LATCH	9374	07263	1.0	EA
U9	360229	IC,TTL,DECODER,LATCH	9374	07263	1.0	EA
U10	360229	IC,TTL,DECODER,LATCH	9374	07263	1.0	EA
U11	360229	IC,TTL,DECODER,LATCH	9374	07263	1.0	EA
U12	360229	IC,TTL,DECODER,LATCH	9374	07263	1.0	EA
U13	360229	IC,TTL,DECODER,LATCH	9374	07263	1.0	EA
U14	360229	IC,TTL,DECODER,LATCH	9374	07263	1.0	EA
U15	360229	IC,TTL,DECODER,LATCH	9374	07263	1.0	EA
U16	360257	IC,TTL,FF,3STATE,OCTAL	SN74LS374N	81349	1.0	EA
U17	360257	IC,TTL,FF,3STATE,OCTAL	SN74LS374N	81349	1.0	EA
U18	360257	IC,TTL,FF,3STATE,OCTAL	SN74LS374N	81349	1.0	EA
U19	360257	IC,TTL,FF,3STATE,OCTAL	SN74LS374N	81349	1.0	EA
U20	360267	IC,TTL,INVERT,SCHMITT,HEX	SN74LS14N	81349	1.0	EA
XDS1	230074	SOCKET,DIP,10 PIN	10-6823-90	51167	1.0	EA
XDS2	230074	SOCKET,DIP,10 PIN	10-6823-90	51167	1.0	EA
XDS3	230074	SOCKET,DIP,10 PIN	10-6823-90	51167	1.0	EA
XDS4	230074	SOCKET,DIP,10 PIN	10-6823-90	51167	1.0	EA
XDS5	230074	SOCKET,DIP,10 PIN	10-6823-90	51167	1.0	EA
XDS6	230074	SOCKET,DIP,10 PIN	10-6823-90	51167	1.0	EA
XDS7	230074	SOCKET,DIP,10 PIN	10-6823-90	51167	1.0	EA
XDS8	230074	SOCKET,DIP,10 PIN	10-6823-90	51167	1.0	EA
7	160325	PWB,CONTROL	4846-700-7	16067	1.0	EA
83	230057	SOCKET,DIP,16 PIN	ICO-163-S8-T	06776	14.0	EA
84	360260	SOCKET,DIP,20 PIN	ICO-203-S8-T	06776	4.0	EA

MANUAL ADDENDUM

Model 847T-1-3016

1.0 GENERAL:

The Model 847T-1-3016 Oscillator is identical to the standard Model 847T-1-2-2-1 Oscillator except the frequency of operation is from 15.0 to 999.9 Hz in .1 Hz steps.

2.0 SPECIFICATIONS:

The specifications for the Model 847T -1-3016 Oscillator are identical to the standard model except for the following:

AMPLITUDE PROGRAMMING:

Programming Time:	From $\geq$0.5 volts to full scale limited only by response of associated power source. From 0 to 0.5 volts $\geq$1.0 seconds to 1% of programmed value.

FREQUENCY PROGRAMMING:

Range:	15.00 to 999.9 Hz in 0.1 Hz steps

3.0 THEORY OF OPERATION:

The Model 847T-1-3016 Oscillator has been modified to allow the frequency to be programmed over the new range.

The low frequency limit is set to 15 Hz by changing the value of A1C10 to .22μF.

Intergrator capacitor A1C20 has been increased to 4.7μF for proper servo operation at 15 Hz.

The middle frequency range is enabled by removing jumper A1W3 and adding A1W2.

4.0 ADJUSTMENT PROCEDURES:

The adjustment of the Model 847T-1-3016 Oscillator is identical to the standard unit except for the following:

4.1 Frequency Detector Low Limit Adjustment (Refer to paragraph 4.6).

1. Program the Model 847T-1-3016 to 15.00 Hz and 100.0 volts.

2. Adjust A1R45 until the oscillator is inhibited.

3. Retard A1R45 to the point where the output reappears. Seal A1R45.

Appendix A

Number	Vendor Name	City	State
0000A	Electricord	Westfield	PA
0000C	Jackson Bros.	Waddon,Surrey	GB
0000S(28564)	OPCDA (Retac Elect. Corp.)	Winsted	CT
0000W	Milton Ross Co.	Southampton	PA
0000X(52745)	Timco	Los Angeles	CA
000AC	Itac	Santa Clara	CA
000AD(55112)	Plessey (Westlake Cap. Inc.)	Westlake Village	CA
000AG	LaFrance	Philadelphia	PA
000AH(54363)	Jan Crystal	Ft. Myers	CA
000AL(53495)	Data Components, Inc.	Gardena	CA
000AM	Kraus & Naimer	Santa Monica	CA
000AN	Ritz Instrument Transformer	Redondo Beach	CA
000AS	Switches Incorporated	Mt. View	CA
000AT(62643)	United Chemi-Con	Rosemont	IL
000AU	JMJ Technical Prod. Inc.	Kendall Park	NJ
000AV(61637)	Semi Processes, Inc.	San Jose	CA
000AW	Hirose	Chatsworth	CA
000AX(63878)	Aptronics	Mentor	OH
000AY	Silicon Power Cube Corp.	Long Beach	CA
000AZ(61271)	Fujitsu	Santa Clara	CA
000BA(61964)	Omron Electronics, Inc.	Schaumburg	IL
000BB	Hallmark Metals, Inc.	Glendora	CA
000BC	Toshiba America, Inc.	Tustin	CA
000BD(55982)	Electronic Essentials	Woodside	NY
000BE(57856)	Kel-Am	Eldon	MO
000BF(55285)	Berquist	Minneapolis	MN
000BG	Panasonic	Secaucus	NY
000BH	Century Components	Canyon Country	CA
000BI(54186)	Micro Power Systems	Santa Clara	CA
000BJ(06776)	Robinson Nugent	New Albany	IN
000BL(13150)	Beau Products (Vernitron)	Laconia	NH
000BM(91725)	Coromindor (Gerrard AJ & Co.)	Des Plaines	IL
000BO	Mitsubishi Electronics Amer.	Sunnyvale	CA
000BP	Silicon Power Cube	Long Beach	CA
000BR	Secmo	Bagnolet	France
000BS	Panel Components Corp.	Santa Rosa	CA
00544	Metal-Cal Div., Avery Prod.	Inglewood	CA
00779	AMP Inc.	Harrisburg	PA
00853	Sangamo Electronic Co.	Pickens	SC
00866	Goe Eng. Co., Inc.	City of Industry	CA
01002	G.E. Co., Ind. & Pwr. Cap. Dept.	John St. Hudson Falls	NY
01121	Allen-Bradley Co.	Milwaukee	WI
01139	G.E. Co., Silicone Prod.	Waterford	NY
01295	Texas Instruments	Dallas	TX
01961	Pulse Engineering, Inc.	San Diego	CA
02111	Spectrol Electronics	City of Industry	CA
02113	Coilcraft, Inc.	Cary	IL
02335	Fairchild Controls Corp.	Hicksville,LI	NY
02375	American Insulating Mach. Co.	Philadelphia	PA
02538	Texas Electronics Co.	Dallas	TX
02660	Amphenol Corporation	Broadview	IL
02768	Illinois Tool Works, Inc.	Des Plains	IL
02799	Use Code #72136		
03507	General Electric Company	Syracuse	NY
03508	General Electric Company	Syracuse	NY
03797	Eldema Corporation	Compton	CA
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls	NJ
03911	Clairex Corporation	New York	NY
04009	Arrow-Hart and Hegeman Elec.	Hartford	CT
04099	Capco, Inc.	Grand Junction	CO
04713	Motorola Semiconductor Prod.	Phoenix	AZ
04729	Universal Components Corp.	Green Brook	NJ
04963	3-M	St. Paul	MN
05245	Corcom Inc.	Chicago	IL
05276	Pomona Electronics., Inc.	Pomona	CA
05397	Kemet, Union Carbide Corp.	Cleveland	OH
05791	Lyn-Tron, Inc.	Burbank	CA
05820	Wakefield Engineering, Inc.	Wakefield	MA
05972	Loctite Corp.	Newington	CT
06383	Panduit Corp.	Tinley Park	IL
06514	Stanctron, Wyco Metal Prod.	N. Hollywood	CA
06540	Amatom Elect. Hardware	New Rochelle	NY
06665	Precision Monolithics Inc.	Santa Clara	CA
06776	Robinson Nugent, Inc.	New Albany	IN
06915	Richco Plastics, Co.	Chicago	IL
07088	Kelvin Electric Company	Van Nuys	CA
07263	Fairchild Camera & Instr.	Mt. View	CA
07387	Birtcher Corporation	Los Angeles	CA
07556	Unitrack Calabro Plastics	Upper Darby	PA
07633	Epoxy Prod. Co., Allied Prod. Corp.	New Haven	CT
07707	USM Corp. (USM Fastener Div)	Shelton	CT
07716	IRC Incorporated	Burlington	IA
07910	Use Code #15818		
08028	Loctite (Auto & Consumer Grp)	Mtn View	CA
08057	Spang Ind. (Magnetics Div)	Sandy Lake	PA
08065	Accurate Rubber and Plastics	San Diego	CA
08261	Spectra Strip (Amphenol)	Garden Grove	
08289	Bliss Delbert Co.	Pomona	CA
08353	Bristol Co. of Canada	Toronto, Ont	Canada
08730	Oatby & Barton (Vemaline Prod. Div.)	Warwick	RI
08779	Signal Transformer	Brooklyn	NY
09214	GE (Semiconductor Prod. Div)	Auburn	NY
09353	C & K Components	Newton	MA
09922	Burndy Corp.	Norwalk	CT
10389	Chicago Switch	Chicago	IL
11815	Cherry/Textron (Fastener Div)	Santa Ana	CA
12406	Elpac Electronics	Santa Ana	CA
12697	Clarostat Mfg.	Dover	NH
13103	Thermalloy Company	Dallas	TX
13150	Vernitron Corp (Beau Prod.)	Laconia	NH
13604	Sperry Corp. Elec. Systems	Great Neck	NY
13919	Burr-Brown	Tucson	AZ
14099	Semtech Corporation	Newbury Park	CA
14604	Elmwood Sensors Inc.	Cranston	RI
14655	Cornell-Dubilier Elect. Corp.	Newark	NJ
14726	Hollingsworth Co.	Phoenixville	PA
14752	Electro Cube, Inc.	San Gabriel	CA
14908	Electronic Instrument and Specialty Corp.	Stoneham	MA
15238	ITT Semiconductors	Lawrence	MA
15454	Ametek Emk (Rodan Div)	Anaheim	CA
15636	Elec-trol	Northridge	CA
15801	Fenwall Electronics	Framingham	MA
15818	Amelco Teledyne, Inc.	Mt. View	CA
15912	Ansley	Los Angeles	CA
16067	California Instruments Co.	San Diego	CA
16758	Delco Radio Div., Gen. Mtrs.	Kokomo	IN
16956	Dennison	Framingham	MS
17856	Siliconix, Inc.	Santa Clara	CA
18076	Gopco	City of Industry	CA
18178	Vactec, Inc.	Maryland Heights	MO
18310	Concord Electronics Corp.	New York	NY
18324	Signetics	Sunnyvale	CA
18612	Vishay Instruments, Inc.	Malvern	PA
18677	Scanbe Mfg. Co. (Zero Corp.)	Monterey Park	CA
18722	RCA	Mountaintop	PA
18736	Voltronics Corp.	Hanover	NJ
19080	Robison Company	Hawthorne	CA
21604	Buckeye Stamping Company	Columbus	OH
21845	Solitron Devices (Semi-conductor Group)	Riviera Beach	FL
22599	Elastic Stop Nut Corp.	Van Nuys	CA
23050	Product Components Corp.	Hastings-on-Hudson	NY
23936	Pamotor, Inc.	San Francisco	CA
24011	ECC	Burlington	MA
24355	Analog Devices, Inc.	Norwood	MA
24444	General Semiconductor Inc.	Tempe	AZ
24796	Parelco, Inc.	Paramount	CA
24931	Specialty Connector Co., Inc.	Greenwood	IN
24972	AEG-Telefunken Corp.	Summerville	NJ
25403	Amperex Electronic Corp.	Slatersville	RI
25497	Meter Master	Los Angeles	CA
26405	Marathon Electric Mfg. Corp.	Bowling Green	OH
26806	American Zettler, Inc.	Costa Mesa	CA
27014	National Semi-Conductor Crp.	Santa Clara	CA
27191	Cutler-Hammer, Inc.	Milwaukee	WI
27264	Molex	Downers Grove	IL
27335	B & B Motor & Control Corp.	New York	NY
27556	IMB Electronic Products	Santa Fe Springs	CA
27683	Varo, Inc.	St. Garland	TX
27735	F-Dyne Electronics	Bridgeport	CT
27832	Hughes Aircraft	Newport Beach	CA
28480	Hewlett-Packard Co.	Palo Alto	CA
28520	Heyman Mfg. Company (Heyco)	Kenilworth	NJ
28606	Schlin Ltd.	Rexdale Ont.	Canada
29372	Resnord Inc. Tridair Ind.	Torrance	CA
29593	Bussco Eng. Inc.	El Segundo	CA
30039	International Components Crp.	Asbury Park	NJ
30161	Aavid Engineering, Inc.	Laconia	NH
30897	Derenn Company	Sylmar	CA
30983	Electra/Midland (Mepco/Electra)	San Diego	CA
31827	Budwig Mfg. Co.	Ramona	CA
31951	Triridge, Inc.	Pittsburg	PA
32293	Intersil	Cupertino	CA
32559	Bivar, Inc.	Santa Ana	CA
32997	Bourns Inc. (Trimpot Div)	Riverside	CA
33005	Jewell Electrical Inst. Inc.	Manchester	NH
33335	Logic Dynamics, Inc.	Gardena	CA
33716	Kingsbacher Murray Co.	Los Angeles	CA
33855	Ducommun, Inc.	Los Angeles	CA
33901	Colber Corp.	Irvington	NJ
34238	Mills Resistor Co.	Los Alamitos	CA
34333	Silicon General	Westminster	CA
34649	Intel Corporation	Santa Clara	CA
35007	Aerovox Canada Ltd.	Amherst NS	Canada
37964	Linear Technology, Inc.	Burlington, Ont	CAN
44655	Ohmite Manufacturing Co.	Skokie	IL
45722	Parker-Kalon	Clifton	NJ
46384	Penn. Eng. and Mfg. Corp.	Doylestown	PA
50157	Midwest Components, Inc.	Muskegon	MI
50522	Monsanto, Electronic Special Products	Cupertino	CA
50558	Electronic Concepts, Inc.	Eatontown	NJ
50811	Mouser Corp.	Santee	CA
51167	Aries Electronics, Inc.	Frenchtown	NJ
51506	Accurate Screw Machine Co.	Nutley	NJ
51705	ICO/Rally	Palo Alto	CA
52072	Circuit Assembly Corp.	Costa Mesa	CA
52745	Timco	Los Angeles	CA
53076	Kintex, Inc.	Buffalo	NY
53495	Data Components, Inc.	Gardena	CA
54361	Edwards Sheet Metal Works	Fredericktown	OH
54407	Power-One Co.	Camarillo	CA
55322	Samtec, Inc.	New Albany	NY
55566	RAF Electronic Hardware, Inc.	Seymour	CT
56289	Sprague Electric Company	North Adams	MA
56637	RCD Components, Inc.	Manchester	NH
57640	United Chem-Con Corp.	Philadelphia	PA
57856	Kel-Am, Inc.	Eldon	MO
58474	Superior Electric Company	Bristol	CT
59730	Thomas and Betts Company	Elizabeth	NJ
59993	International Rectifier Semiconductor Div.	El Segundo	CA
60395	Xicor, Inc.	Milpitas	CA
61394	Seeq Technology, Inc.	San Jose	CA
61441	Saronix	Palo Alto	CA
61529	Aromat Corp.	Mountainside	NJ
61735	Pulse Engineering, Inc.	College Park	MD
62483	Densitron Corp. of America	Torrance	CA
62643	United Chemicon, Inc.	Rosemont	IL
62786	Hitachi America Ltd.	San Jose	CA
63743	Ward Leonard Electric Co.	Mt. Vernon	NY
63791	Star Micronics, Inc.	New York	NY
70318	Allmetal Screw Prod. Co.	Garden City	NY
70903	Belden Manufacturing Co.	Chicago	IL
71218	Bud Industries, Inc.	Willoughby	OH
71279	Cambridge Thermionic Corp.	Cambridge	MA
71400	Bussman Mfg. Div. McGraw-Edison Co.	St. Louis	MO
71450	CTS Corporation	Elkhart	IN
71468	ITT Cannon Electric, Inc.	Los Angeles	CA
71590	Centralab Div. Globe-Union	Milwaukee	WI
71707	Coto-Coil	Providence	RI
71744	Chicago Miniature Lampworks	Chicago	IL
71785	Cinch Manufacturing Company	Chicago	IL
71984	Dow Corning Corp.	Midland	MI
72136	Elmenco (Electro Motive)	Willimantic	CT
72619	Dialight Corporation	Brooklyn	NY
72699	General Instruments	Newark	NJ
72982	Erie Technological Prod. Inc.	Erie	PA
73138	Beckman Instruments, Inc.	Fullerton	CA
73612	Consolidated Electronic Wire and Cable Corp.	Chicago	IL
73734	Federal Screw Products, Inc.	Chicago	IL
74193	Heinemann Electric Company	Trenton	NJ
74545	Harvey Hubbell, Inc.	Bridgeport	CT
74840	Illinois Condenser Co.	Chicago	IL
74970	E.F. Johnson Company	Waseca	MN
75042	TRW Electronic Components	Philadelphia	PA
75382	Kulka Electric Corporation	Mt. Vernon	NY
75582	Leviton Mfg. Co.	Little Neck	NY
75915	Littlefuse, Inc.	Des Plaines	IL
76385	Minor Rubber Co., Inc.	Bloomfield	NJ
77062	Pabst Eng. Equipment Co.	Elizabeth	NJ
77132	United-Carr Inc., Patvin Div	Waterbury	CT
77342	Potter and Blumfield Div. AMF	E. Princeton	IN
78189	Shakeproof Div, IL Tool Works	Chicago	IL
78553	Tinnerman Products, Inc.	Cleveland	OH
79130	Johns-Manville Products Corp	Chicago	IL
79136	Waldes Kohinoor Inc.	Long Island City	NY
79963	Zierick Mfg. Corp.	New Rochelle	NY
80031	Mepco/Electra	Morristown	NJ
80223	United Transformer Co.	New York	NY
80294	Bourns, Inc.	Riverside	CA
80495	High Voltage Engineering Corp (Anderson Pwr Prod. Div)	Brighton	MA
81095	Triad Transformer Corp.	Venice	CA
81312	Winchester Electronics	Oakville	CT
81348	(Fed. Specs) Promulgated by General Services Administration Washington DC		
81349	Military Specification or Commercial Generic Number		
81541	Airpax Corp.	Cambridge	MD
81683	Raco Products Co.	Chicago	IL
81851	Bentley-Harris Mfg Co.	Lionville	PA
82104	Standard Grigsby	Aurora	IL
82389	Switchcraft, Inc.	Chicago	IL
82877	Rotron Mfg. Co., Inc.	Woodstock	NY
82893	Vector Electronics, Inc.	Sylmar	CA
83330	Herman H. Smith, Inc.	Brooklyn	NY
83486	Elco Tool & Screw Corp.	Rockford	IL
85480	Brady W.H. Co.	Milwaukee	WI
86684	RCA	Harrison	NJ
86928	Seastrom Mfg. Co., Inc.	Glendale	CA
87034	Marco-Oak Industries	Anaheim	CA
88245	Useco Div., Litton Ind.	Van Nuys	CA
90201	Mallory Capacitor Co.	Indianapolis	IN
91506	Augat, Inc.	Attleboro	MA
91637	Dale Electronics, Inc.	Columbus	NE
91662	Elco Corporation	Willow Grove	PA
91802	Industrial Devices, Inc.	Edgewater	NJ
91833	Keystone Electronics Corp.	New York	NY
91967	National Tel-Tronics	Meadville	PA
92194	Alpha Wire Corp.	Elizabeth	NJ
93303	Pentagon Products Co.	Washington	DC
94222	Southco, Inc.	Lester	PA
94696	Magnecraft Electric Co.	Chicago	IL
95146	Alco Electronic Prod., Inc.	No. Andover	MA
95303	RCA	Cincinnati	OH
95354	Methode Manufacturing Corp.	Rolling Meadows	IL
95566	Arnold Engineering Co.	Marengo	IL
95987	Weckesser Company, Inc.	Chicago	IL
96906	Military Std		
97525	Electronic Engineering Co.	Santa Ana	CA
98159	Rubber Teck, Inc.	Gardena	CA
98291	Sealectro Corp.	Mamaroneck	NY
98376	Zero Mfg. Co. (West)	Burbank	CA
98978	IERC	Burbank	CA
99017	Protective Closures Co., Inc. (Caplugs Div)	Buffalo	NY
99217	Bell Industries, Inc.	Delevan	NY
99742	Permacel	New Brunswick	NJ
99743	IMC	Haywood	CA
99800	Delevan Electronics Corp.	Aurora	NY

ONE YEAR WARRANTY

CALIFORNIA INSTRUMENTS, Division of Amstar Technical Products Co., Inc., warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are tubes, fuses, and batteries which carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS will service, replace, or adjust any defective part or parts, free of charge, when the instrument is returned freight prepaid, and when examination reveals that the fault has not occurred because of misuse, abnormal conditions of operation, user modification, or attempted user repair. Equipment repaired beyond the effective date of warranty or when abnormal usage has occurred will be charged at applicable rates. CALIFORNIA INSTRUMENTS will submit an estimate for such charges before commencing repair, if so requested.

PROCEDURE FOR SERVICE

If a fault develops, notify CALIFORNIA INSTRUMENTS or its local representative, giving full details of the difficulty, and including the model number and serial number. On receipt of this information, service data or a Return Material Authorization (RMA) number will be given. Fill in RMA No. blank on shipping label attached opposite these instructions, pack instrument carefully to prevent transportation damage, affix label to shipping container, and ship freight prepaid to the factory. CALIFORNIA INSTRUMENTS shall not be responsible for repair of damage due to improper handling or packing. Instruments returned without RMA No., or freight collect will be refused. Instruments repaired under Warranty will be returned by prepaid surface freight. Instruments repaired outside the Warranty period will be returned freight collect, F.O.B. CALIFORNIA INSTRUMENTS, San Diego, CA. If requested, an estimate of repair charges will be made before work begins on repairs not covered by the Warranty.

DAMAGE IN TRANSIT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed immediately with the carrier. A full report of the damage should be obtained by the claim agent, and a copy of this report should be forwarded to us. CALIFORNIA INSTRUMENTS will prepare an estimate of repair cost, and repair the instrument when authorized by the claim agent. Please include model number and serial number when referring to the instrument.