OPERATING AND SERVICING MANUAL

BAUER BROADCAST PRODUCTS DIVISION

MODEL 660

FM EXCITER

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GENERAL INFORMATION

1-1. INTRODUCTION

This manual contains information required to install, operate, and maintain the Bauer Model 660 FM Exciter. Section I describes the exciter and lists its specifications, Section II provides installation instructions, Section III contains operating procedures, and Section IV describes the principles of operation. Maintenance procedures and troubleshooting diagrams are contained in Section V and replaceable parts are identified and listed in Section VI.

1-2. GENERAL DESCRIPTION

The Model 660 FM Exciter (figure 1-1) is an all-solid-state unit that provides monaural, stereo, and Subsidiary Communications Authorization (SCA) modes of operation in accordance with FCC and international standards. The modulation method is "direct FM" with no mixers or multipliers after the modulated oscillator. The unit is equipped with relay circuitry that enables remote switching to the monaural mode if one of the two stereo program lines is impaired.

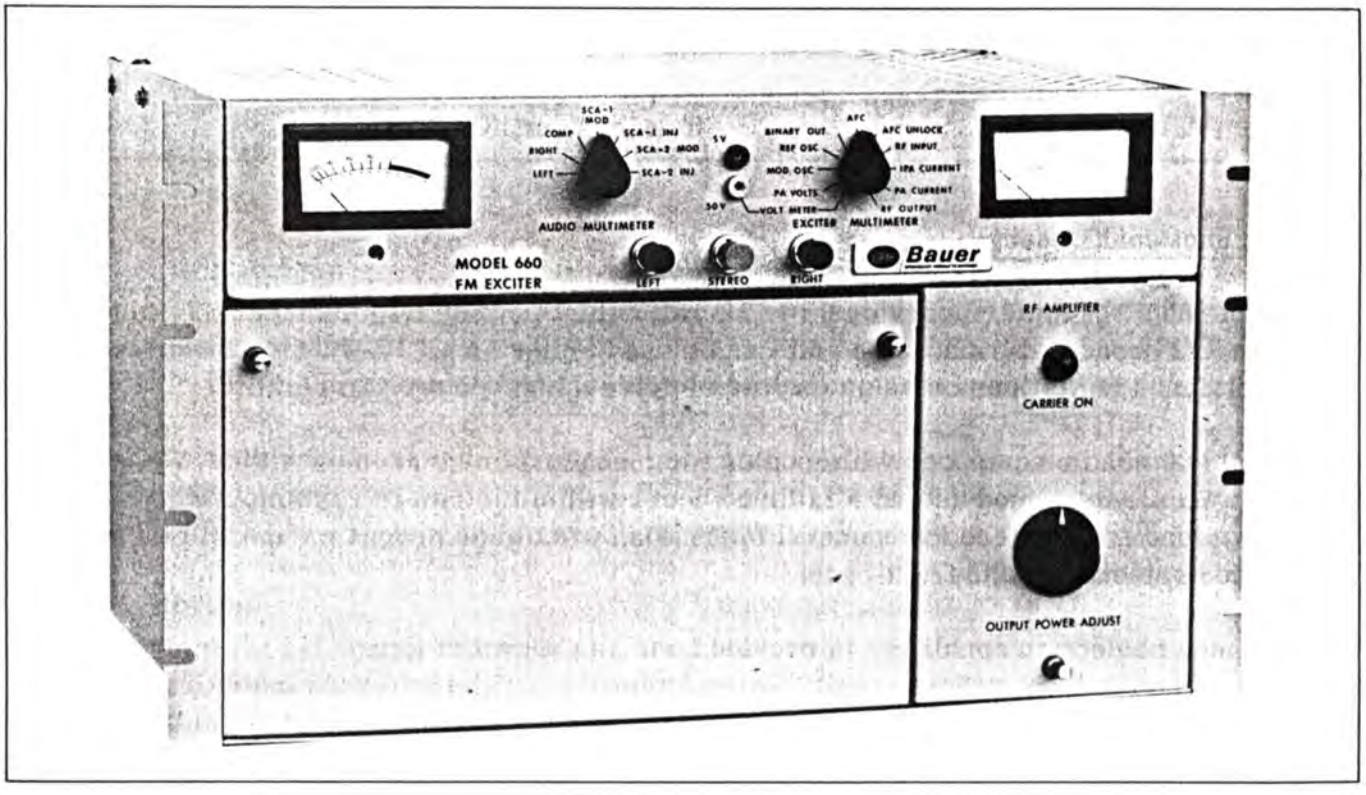


Figure 1-1. Bauer Model 660 FM Exciter

1-2.1. Physical Description

The Model 660 consists of a main frame assembly and plug-in functional modules. The main frame contains the power supplies, metering circuits, and the main operating controls. Stereo, monaural, FM, and SCA circuitry are mounted on printed circuit boards. The RF amplifier plug-in module is contained in a shielded chassis with the components wired to standoff terminals. Physical characteristics of the Model 660 are listed in table 1-1.

Table 1-1. Physical Characteristics

Dimensions:	10-1/2 inches high, 12 inches deep, 17 inches wide across chassis, and 19 inches wide across mounting flanges.
Weight:	42 pounds, fully equipped with modules.
Construction Style:	Alodine aluminum and cadmium steel; flush-fitting front panel with mounting flanges notched to mate with standard 19-inch equipment rack.
Maximum Altitude:	7500 feet
Maximum Humidity:	95%
Connectors	
RF Output:	BNC type
All Others:	Standard barrier strip

1-2.2. Functional Description

The Model 660 FM Exciter provides 5 to 12 watts output power into a matched 50-ohm load within the FM broadcast band. The unit can be used either as a 10-watt broadcast transmitter for educational FM stations or as an exciter to drive a high-power transmitter.

The Model 660 can be equipped with modules for monaural or stereo operation. When equipped with a stereo module and a failure occurs within the stereo system, the Model 660 can be switched from stereo to monaural operation over either program channel by push-button mode selection at the front panel.

Remote mode selection capability is provided and, as shown in figure 1-1, two multimeters are mounted on the front panel to facilitate maintenance. The left-hand meter is used for monitoring the audio and the right-hand meter is used for monitoring electrical parameters

during operation. A module extender and probe are furnished with the exciter to be used in conjunction with the multimeters for fault isolation. The exciter has SCA capabilities and separate modules are available for 41-kHz and 67-kHz operation. Exciter design permits the use of one or both SCA channels when operating in the monaural mode. SCA operation is limited to 67 kHz when the exciter is in the stereo mode.

Electrical characteristics of the Model 660 are listed in table 1-2.

Table 1-2. Electrical Characteristics

Power Requirements:	115, 208, or 230 vac, 50 to 60 Hz, single phase; 120 watts maximum.
Frequency Range:	87 to 109 MHz; channelized to frequency specified by customer.
Power Output:	5 to 12 watts (adjustable)
Load Impedance:	50 ohms
Load VSWR:	2:1 maximum
Modulation:	F3 and F9
Modulation Capability:	±150 kHz (±75 kHz = 100% modulation)
Harmonic Attenuation:	>56 db below carrier
Frequency Stability:	±750 Hz after 5-minute warmup
Ambient Temperature Range (monaural operation):	0°F to 120°F (-20°C to +50°C)
Altitude Range:	Sea level to 7500 feet
MONAURAL OPERATION	
Frequency Response:	Within ±1 db from 50 Hz to 15 kHz (referred to 75-μsec preemphasis)
Distortion:	0.5% maximum (50 Hz to 15 kHz)
FM Noise:	65 db below 100% modulation at 400 Hz
Incidental AM Noise:	>60 db below 100% equivalent AM

Table 1-2. Electrical Characteristics (Continued)

MONAURAL OPERATION (Continued)	
Synchronous AM:	>50 db below 100% equivalent AM (100% modulation at 400 Hz)
Input Impedances	
Monaural Audio:	600 ohms (±10%), balanced
Composite Baseband:	4.7 kilohms, unbalanced
Subcarrier Injection:	15 kilohms, unbalanced
Input Levels	
Monaural Audio:	±10 dbm ±2 db (not adjustable) at 400 Hz
Baseband (Stereo or Monaural):	2-volts peak-to-peak for 100% modulation
Subcarriers:	2-volts peak-to-peak for 30% injection
SCA OPERATION	
Ambient Temperature Range:	40°F to 120°F (+5°C to +50°C)
Frequency Stability:	±500 Hz
Subcarrier Frequencies:	41 kHz and 67 kHz
Frequency Response:	±2 db from 50 Hz to 7.5 kHz (referred to 75-μsec preemphasis)
Distortion:	<1.5% at 10% deviation (50 Hz to 7.5 kHz)
Modulation Method:	Direct FM
Modulation Capability:	±15% of subcarrier frequency (10% deviation = 100% modulation)
Injection Range:	Subcarrier injection adjustable from 0 to 30%
Audio Input Impedance:	600 ohms (±10%), balanced

Table 1-2. Electrical Characteristics (Continued)

SCA OPERATION (Continued)	
Audio Input Level:	±10 dbm ±2 db for 100% modulation at 400 Hz
FM Noise:	65 db below 15% deviation
Muting:	Selectable at front panel
Muting Sensitivity:	Subcarrier gate opens at -10 dbm at 400 Hz
Muting Delay:	Adjustable from 0.6 to 4 seconds, nominal
STEREOPHONIC OPERATION	
Ambient Temperature Range:	32°F to 120°F (0°C to +50°C)
Pilot Frequency Stability:	±1 Hz
Audio Input Impedance:	600 ohms (±10%), balanced
Audio Input Level:	+10 dbm ±2 db at 400 Hz for 90% modulation
Frequency Response:	±1 db from 50 Hz to 15 kHz (referred to 75-μsec preemphasis)
Distortion:	<0.75% of composite waveform
FM Noise:	>65 db below 100% modulation
AM Noise:	>60 db below 100% equivalent AM
Stereo Separation:	>35 db from 50 Hz to 15 kHz
Carrier Suppression:	>45 db below 100% modulation
Crosstalk (main channel to subchannel and subchannel to main channel):	>42 db below 100% modulation

1-3. MODULE EQUIPMENT

The Model 660 FM Exciter is equipped with the following modules, which provide the capability of monaural FM operation:

a. One FM Exciter Module (001-7560-01)

b. One Monaural Module (001-7565-01)

c. One RF Amplifier Module (001-7559-01)

d. Two Dummy SCA Modules (001-7569-01)

The following modules, which are available from Granger Associates, provide the Model 660 with the capability of stereo and SCA operation:

a. One Stereo Generator Module (001-7562-01)

b. One 41-kHz SCA Module (001-7563-01)

c. One 67-kHz SCA Module (001-7566-01)

When operating in the monaural mode, the 41-kHz and 67-kHz SCA modules may be used individually or simultaneously. When operating in the stereo mode, the 41-kHz and 67-kHz generators are automatically muted. However, the 67-kHz SCA module can be used in combination with the stereo generator in any mode of operation without program interruption if an optional 5-kHz filter kit is installed.

A 5-kHz filter kit (091-5971-01) may be specified for initial installation by Granger Associates, or it can be added to the SCA module at a later date. The kit consists of a low-pass filter which limits the SCA input bandwidth to 5 kHz. In addition to the input filter, the subcarrier deviation should be limited to 6% to avoid interference with the stereo channel.

1-4. ACCESSORIES

The Model 660 is supplied with the following accessories:

a. One Module Extender (001-7570-01)

b. One DC Probe (001-0015-01)

The module extender permits any module to be withdrawn from the exciter main frame for voltage checks and maintenance. The dc probe extends the use of the right-hand multimeter to allow point-to-point voltage checks of the extended modules. Extensive circuit checking can therefore be accomplished without additional test equipment.

SECTION II
INSTALLATION

2-1. INSTALLATION PLANNING

Dimensions essential to know for proper installation of the Model 660 FM Exciter are shown in figure 2-1.

2-1.1 Environmental Requirements

Location of the Model 660 must be within the following environmental limitations:

a. Maximum altitude: 7500 feet

b. Maximum temperature: +50°C

c. Minimum temperature: 0°C

d. Maximum humidity: 95%

2-1.2. Power Requirements

Requirements for input power and power consumption are provided in Section I, table 1-2.

2-1.3. Cooling Requirements

The Model 660 is convection cooled and considerations for panel mounting should include adequate space around the unit to permit free flow of air. Most of the heat is generated in the RF amplifier at the upper right-hand side of the unit; therefore, the installation should be made such that adequate circulation of air at that point is ensured.

2-2. INPUT AND OUTPUT CONNECTIONS

All input and output connections for the Model 660 are made at terminal boards TB3, TB4, and TB5, and the RF OUT connector at the rear of the unit. (See figure 2-2.) The silk-screened terminal board nomenclature of each connection is listed and briefly described in table 2-1.

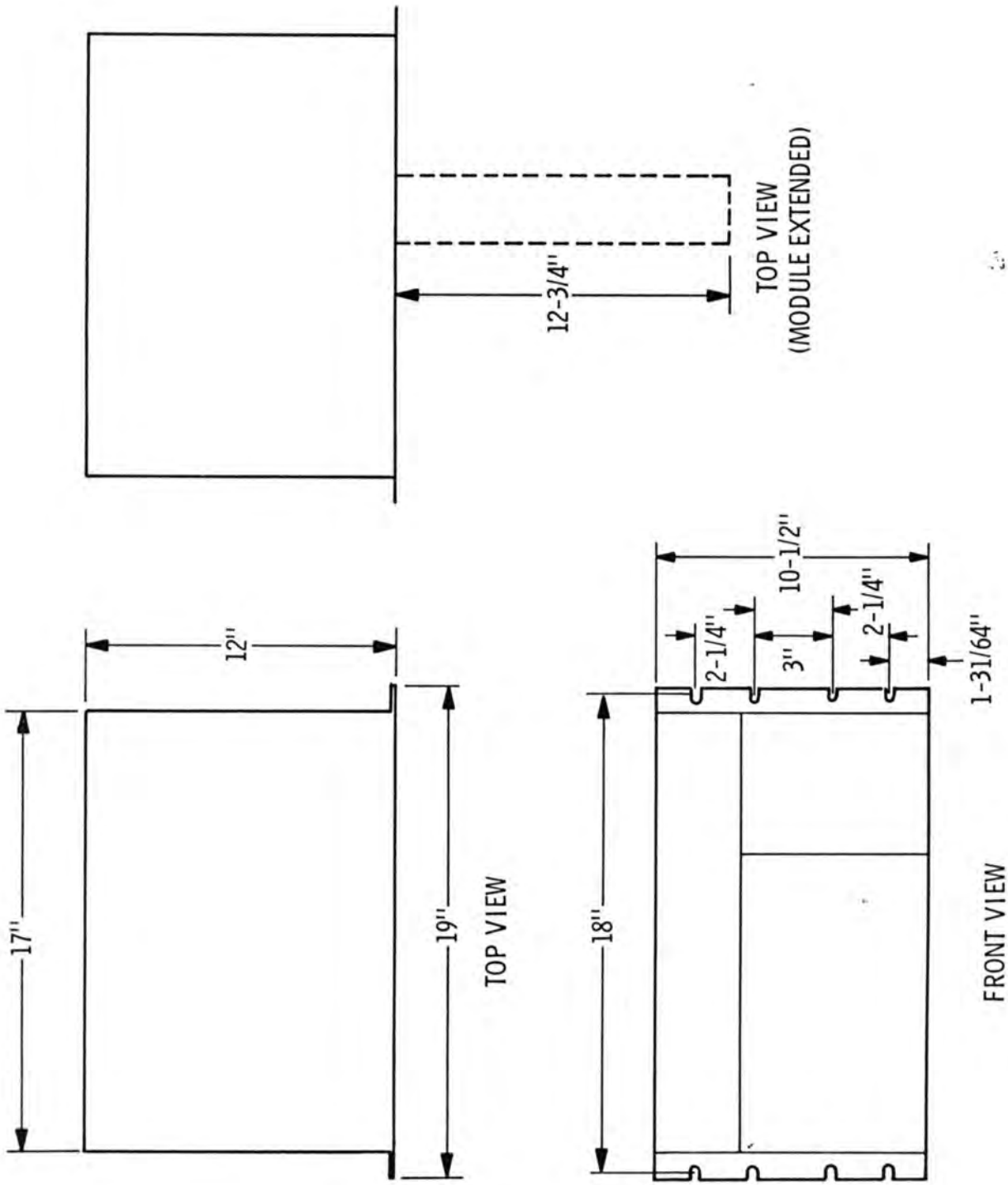


Figure 2-1. Model 660 FM Exciter Outline and Installation Dimensions

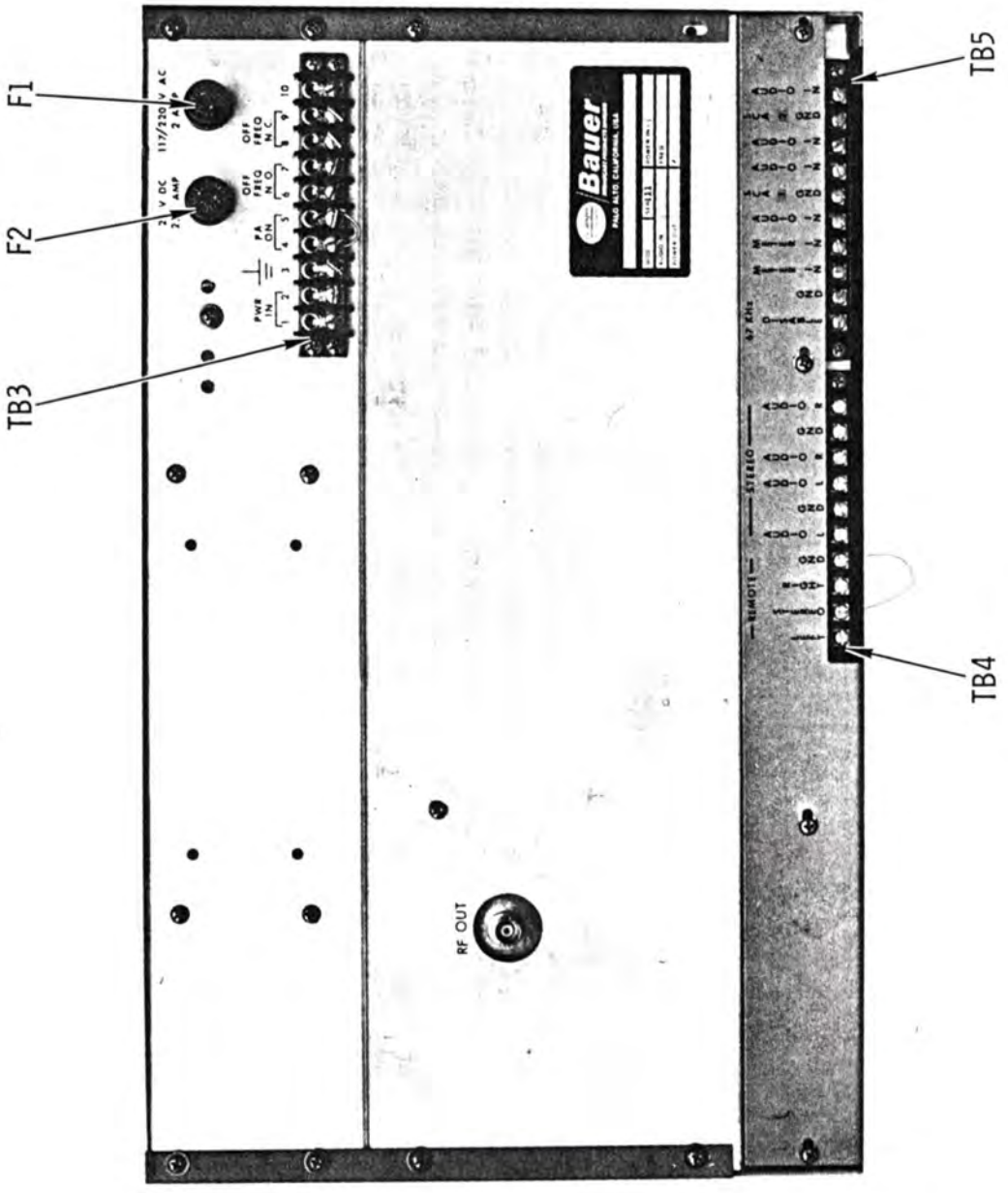


Figure 2-2. Model 660 FM Exciter Rear View

Table 2-1. Input and Output Terminal Board Connections

TB	No.	Terminal Nomenclature	Function
TB3	1-2	PWR IN	115/208/230 vac line input
	3	⏚ (chassis ground)	Station or transmitter ground system common
	4-5	PA ON	RF amplifier B+ OFF/ON switch
	6-7	OFF FREQ N.O.	AFC alarm; normally open contact for off-frequency alarm
	8-9	OFF FREQ N.C.	AFC alarm; normally closed contact for transmitter interlock
	10		Not connected
TB4	1	REMOTE - LEFT	Left channel select; momentary closure
	2	REMOTE - STEREO	Stereo select; momentary closure
	3	REMOTE - RIGHT	Right channel select; momentary closure
	4	REMOTE - GND	Remote mode select common return
	5-7	STEREO - AUDIO L	Audio input - stereo left channel shielded pair
	6	STEREO - GND	Shield ground for stereo left channel shielded pair
	8-10	STEREO - AUDIO R	Audio input - monaural or stereo right channel shielded pair
	9	STEREO - GND	Shield ground for monaural or stereo right channel shielded pair
TB5	1	67 KHz DISABLE	Switch/jumper to GND for 67-kHz SCA operation
	2	GND	67-kHz disable and telemeter common return
	3	METER IN	No. 1 SCA telemetering
	4	METER IN	No. 2 SCA telemetering
	5-7	AUDIO IN	No. 2 SCA input shielded pair
	6	SCA 2 GND	Shield ground for shielded pair
	8-10	AUDIO IN	No. 1 SCA input - shielded pair
	9	SCA 1 GND	Shield ground for SCA shielded pair

2-2.1. Primary Power Connections

CAUTION

Verify that the primary connections to transformer T1 have been made to agree with the available mains voltage. These connections and jumpers are made on terminal board TB2. (See figures 5-3 and 6-1.)

Connect the single-phase power to TB3-1 and TB3-2. Connect TB3-3 to station ground. Do not apply primary power to the exciter until directed to do so in the initial turn-on procedure given in paragraph 2-3.

2-2.2. Control Connections

Exciter control connections are made at terminal board TB3 on the rear panel. Three sets of terminals on TB3 provide connections to three sets of contacts on off-frequency alarm relay K1 located on the upper inside rear wall of the exciter. (See figure 6-1.) The control functions for the exciter enabled through these connections are as follows:

a. RF amplifier module power (TB3-4 and TB3-5)

b. Off-frequency alarm (TB3-6 and TB3-7)

c. Off-frequency alarm interlock (TB3-8 and TB3-9)

Terminals 4 and 5 of TB3 (PA ON) must be jumpered in order for the exciter to operate. Terminals 6 and 7 of TB3 (OFF FREQ N.O.) provide an alarm function in case of off-frequency operation.

When the exciter output is used to drive a high-power transmitter, terminals TB3-8 and TB3-9 (OFF FREQ N.C.) provide an interlock function to remove operating power from the transmitter during off-frequency operation.

2-2.3. Input/Output Signal Connections

Connect the input and output signal lines to the exciter at TB4, and use twisted-pair shielded cable for all audio and SCA input connections.

For monaural operation, connect audio signal leads to TB4-5 and TB4-7 (STEREO AUDIO L) and connect line shield to TB4-6 (GND).

For stereo operation, connect left audio line to TB4-5 and TB4-7 (STEREO AUDIO L) and line shield to TB4-6 (GND). Connect right audio line to TB4-8 and TB4-10 (STEREO AUDIO R) and line shield to TB4-9 (GND).

For SCA operation, connect balanced audio line to TB5-5 and TB5-7 (SCA 1 AUDIO IN) and line shield to TB5-6 (GND).

For the second SCA, connect balanced audio line to TB5-8 and TB5-10 (SCA 2 AUDIO IN) and line shield to TB5-9 (GND).

NOTE

If the 67-kHz SCA is to be controlled locally, connect a jumper from TB5-1 (67 KHz DISABLE) to TB5-2 (GND). For remote 67-kHz SCA operation, refer to paragraph 2-2.4.

The RF output connection is made at the BNC connector (RF OUT) on the rear panel. Use RG-58/U cable with matching connector to feed the exciter output to an antenna or a transmitter.

2-2.4. Remote Control Connections

Remote control connections are made at TB4 and TB5. The four REMOTE terminals on TB4 are used in stereo operation and provide duplicate remote functions of the LEFT, STEREO, and RIGHT pushbutton switches on the exciter front panel. These remote control functions require the use of three momentary-contact pushbutton switches at the remote control point.

To connect the pushbutton switches for remote stereo control, use three twisted pair conductors. Connect one wire of each twisted pair to its related terminal (TB4-1, -2, or -3) and connect the common return wire of each twisted pair to TB4-4 (REMOTE GND).

Four terminals on TB5 provide remote metering of the SCA mode of operation when one or both SCA modules are installed. Terminals TB5-1 (67 KHz DISABLE) and TB5-2 (GND) are used to remotely disable the 67-kHz SCA mode of operation. A remote switch connected to these terminals provides normal SCA operation when in the closed position. When the switch is in the open position, the SCA module is disabled.

NOTE

If remote control of the 67-kHz SCA mode is not desired, connect a jumper between TB5-1 and TB5-2.

Subaudible telemetry tones can be applied to the SCA modules by making connections to TB5-3 and TB5-4 (METER IN). Use coaxial cable such as RG58A/U for this function and ground the shield to TB5-2 (GND). The 41-kHz SCA module telemetering function connects to TB5-3 and the 67-kHz SCA module telemetering function connects to TB5-4.

2-3. INITIAL TURN-ON PROCEDURE

Perform the following preliminary adjustments and checks before placing the Model 660 in operation:

a. Verify that proper fuses are installed in the two fuseholders on rear panel. Fuse F1 has a rating of 2 amperes for 117-vac operation and a rating of 1 ampere for 230-vac operation. Fuse F2 has a rating of 2.5 amperes.

b. Verify that all modules are seated firmly and locked in place.

c. Verify that input power connections have been made in accordance with paragraph 2-2.1.

d. Verify that external power control switch for RF amplifier module is in open position (paragraph 2-2.2).

e. Remove fuse F2 from fuseholder and apply power to exciter.

f. Rotate EXCITER MULTIMETER switch to following positions and verify and record meter indications in accordance with final test data:

Switch Position	Meter Indication
(1) MOD OSC	_____
(2) REF OSC	_____
(3) BINARY OUT	_____
(4) RF INPUT	_____

g. Rotate EXCITER MULTIMETER switch to AFC UNLOCK and set AFC ADJUST screwdriver adjustment on FM exciter module to produce zero indication on multimeter.

h. Allow 15 minutes for exciter warmup.

i. Connect 50-ohm nonreactive load to RF OUT connector; jumper terminals 4 and 5 on TB3 and replace fuse F2.

j. Rotate EXCITER MULTIMETER switch to PA VOLTS and PA CURRENT and record multimeter indications for future reference.

k. Rotate EXCITER MULTIMETER switch to RF OUT and observe power output indication on multimeter. (Full-scale indication of 100% is equivalent to 10 watts RF output.)

m. Connect electronic counter or calibrated frequency monitor to exciter output through a 20 db pad or to a "sniffer" in transmission line.

n. Set FREQUENCY ADJUST control on FM exciter module for precise center frequency. Rotate EXCITER MULTIMETER switch to AFC and set AFC ADJUST control for midscale indication on multimeter.

o. Verify that all multimeter indications are in reasonable agreement with final test data.

p. Disconnect jumper wire between terminals 4 and 5 of TB3. Connect exciter RF OUT connector to antenna or power amplifier. Reconnect jumper wire between terminals 4 and 5 of TB3.

q. Rotate EXCITER MULTIMETER to RF OUT and withdraw RF amplifier module from main frame. Adjust capacitors C18 and C19 (Figure 6-2) for maximum RF output as observed on multimeter. Reinsert RF amplifier into main frame and lock in place.

SECTION III
OPERATION

3-1. OPERATING CONTROLS AND INDICATORS

As shown in Figure 3-1, all operating controls and indicators are located on the front panel of the exciter main frame. The controls on the optional plug-in modules are not used during routine operation of the Model 660. Table 3-1 lists the Model 660 operating controls and indicators and gives the reference designator and a brief functional description of each.

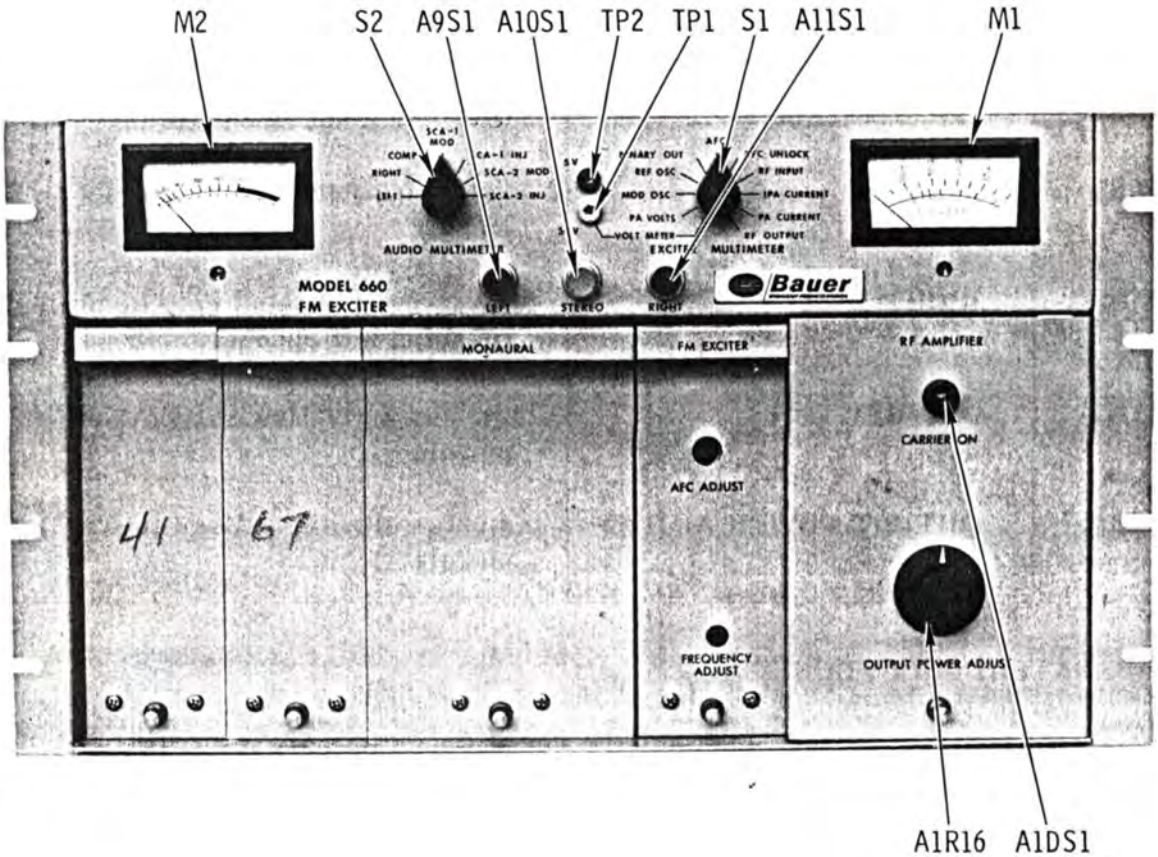


Figure 3-1. Model 660 FM Exciter Front Panel Controls and Indicators

Table 3-1. Operating Controls and Indicators

Ref. Des.	Panel Nomenclature	Function
M1	None	Provides indication of functions selected by EXCITER MULTIMETER switch S1: external metering, power amplifier voltage, basic oscillator, reference oscillator, binary out, AFC, and RF amplifier input/output and current conditions.
M2	None	As selected by switch S2, provides indication of modulation levels fed into exciter.
S1	EXCITER MULTIMETER	Selects functions for application to meter M1.
S2	AUDIO MULTIMETER	Selects audio functions for application to meter M2.
A9S1	LEFT	Selects left channel only (monaural). Disables right channel.
A10S1	STEREO	Selects and indicates activation of stereo mode.
A11S1	RIGHT	Selects right channel only (monaural). Disables left channel.
A1DS1	CARRIER ON	Indicates activation of RF Amplifier module.
A1R16	OUTPUT POWER ADJUST	Adjusts collector voltage in RF Amplifier module.

3-2. OPERATING PROCEDURES

When operating power is initially applied, the crystal oven in the FM exciter module begins to warm up and the modulated oscillator circuit searches for phase lock; after a short interval, the oscillator will lock to the crystal reference frequency. The phase-locked condition can be verified by rotating the EXCITER MULTIMETER switch to AFC UNLOCK and observing a zero indication on meter M1. If necessary, slightly adjust the AFC ADJUST control on FM exciter module A2 to produce zero indication.

Operating power should be applied continuously to the exciter. At the end of a broadcast period, remove operating power to the RF amplifier module by disconnecting the jumper (or opening the switch) between terminals 4 and 5 of TB3. To resume operation, simply apply power to the RF amplifier; no warmup period is required.

3-2.1. Mode Selection

Monaural operation is enabled with the use of either the monaural or stereo modules installed in the exciter. For monaural operation with either module installed, audio signals are connected to the STEREO AUDIO L input terminals 5 and 7 of TB4. If the stereo module is in place, press the LEFT pushbutton on the upper panel to provide monaural operation. If the monaural module is in place, switching is not required for monaural operation.

Either one or both 41-kHz and 67-kHz SCA modules may be installed and used simultaneously when the exciter is operating in the monaural mode; thus, full-time operation of all three modes is permitted.

The exciter must be equipped with a stereo generator module to produce the stereo mode of operation. When the module is in place, either left channel, right channel, or stereo operation is available as selected by the LEFT, RIGHT, or STEREO pushbutton switches on the upper front panel. When the 41-kHz SCA module is used in the exciter equipped for stereo operation, it is automatically disabled when the stereo mode is selected. This does not apply to the use of the 67-kHz SCA module if it is equipped with a 5-kHz filter. This filter prevents interference between the SCA and stereo subchannels.

3-2.2. Monitoring

Complete monitoring of the exciter operating functions is enabled by the use of two multimeters (M1 and M2) located on the control panel. Monitoring functions of both meters are selected by adjacent rotary switches. The left-hand meter is used to measure modulation levels and the right-hand meter is used to evaluate the electrical parameters of the exciter. The EXCITER MULTIMETER switch is related to the right-hand meter and provides an additional function of allowing the multimeter to be used for dc measurements in maintenance procedures.

3-2.3. Channelization

The exciter is crystal controlled and completely adjusted for operation on a specific frequency at the factory. The crystal is contained plug-in oven HR1, which mates with XHR1 located at the rear of the FM exciter module. (See figure 5-5.)

Compute the crystal frequency for a specific allocation as follows:

$$F_{xtal} = \frac{F_{carrier}\ (kHz)}{1024}$$

When ordering a spare or replacement crystal for the exciter, state the required crystal frequency and specify G/A part number 166-0006-01. Table 3-2 contains a reference listing of FM broadcast frequency allocations and the required crystal frequency for each allocation.

Table 3-2. FM Frequency Allocations/Crystal Frequencies

CARRIER FREQUENCY (MHz)	CRYSTAL FREQUENCY (kHz)	CARRIER FREQUENCY (MHz)	CRYSTAL FREQUENCY (kHz)	CARRIER FREQUENCY (MHz)	CRYSTAL FREQUENCY (kHz)
88.1	86.0352	94.9	92.6758	101.5	99.1211
88.3	86.2305	95.1	92.8711	101.7	99.3165
88.5	86.4258	95.3	93.0665	101.9	99.5118
88.7	86.6211	95.5	93.2618	102.1	99.7071
88.9	86.8165	95.7	93.4571	102.3	99.9024
89.1	87.0118	95.9	93.6524	102.5	100.0977
89.3	87.2071	96.1	93.8477	102.7	100.2930
89.5	87.4024	96.3	94.0430	102.9	100.4883
89.7	87.5977	96.5	94.2383	103.1	100.6836
89.9	87.7930	96.7	94.4336	103.3	100.8790
90.1	87.9883	96.9	94.6290	103.5	101.0743
90.3	88.1836	97.1	94.8243	103.7	101.2696
90.5	88.3790	97.3	95.0196	103.9	101.4649
90.7	88.5743	97.5	95.2149	104.1	101.6602
90.9	88.7696	97.7	95.4102	104.3	101.8555
91.1	88.9649	97.9	95.6055	104.5	102.0508
91.3	89.1602	98.1	95.8008	104.7	102.2461
91.5	89.3555	98.3	95.9961	104.9	102.4415
91.7	89.5508	98.5	96.1915	105.1	102.6368
91.9	89.7461	98.7	96.3868	105.3	102.8321
92.1	89.9415	98.9	96.5821	105.5	103.0274
92.3	90.1368	99.1	96.7774	105.7	103.2227
92.5	90.3321	99.3	96.9727	105.9	103.4180
92.7	90.5274	99.5	97.1680	106.1	103.6133
92.9	90.7227	99.7	97.3633	106.3	103.8086
93.1	90.9180	99.9	97.5586	106.5	104.0040
93.3	91.1133	100.1	97.7540	106.7	104.1993
93.5	91.3086	100.3	97.9493	106.9	104.3946
93.7	91.5040	100.5	98.1446	107.1	104.5899
93.9	91.6993	100.7	98.3399	107.3	104.7852
94.1	91.8946	100.9	98.5352	107.5	104.9805
94.3	92.0899	101.1	98.7305	107.7	105.1758
94.5	92.2852	101.3	98.9258	107.9	105.3711
94.7	92.4805				

SECTION IV
PRINCIPLES OF OPERATION

4-1. INTRODUCTION

This section describes the principles of operation of the Model 660 FM Exciter. An overall description of the exciter is given, followed by a detailed description of the operation of each module or other operational assembly contained in the exciter. The unit descriptions apply to the basic modules and to other modules which may be optionally supplied.

4-2. EXCITER CIRCUIT DESCRIPTION

The Model 660 FM Exciter (figure 4-1) comprises a modulated oscillator, audio input circuits, frequency control circuits, an RF amplifier, and a multivoltage power supply.

The modulated oscillator generates the carrier frequency, and the frequencies shown in figure 4-1 are nominal and are given for reference only. The oscillator accepts modulating signals from as many as three modules. The modulated RF output signal of the oscillator is amplified and isolated by a buffer stage before application to the RF power amplifier.

The center frequency of the modulated oscillator is held fixed by a phase-lock system of automatic frequency control. A sample of the oscillator output signal is divided and compared with the divided output of the crystal reference oscillator. The resulting error signal output of the NOR gate phase detector is used to activate an automatic frequency control (AFC) circuit, which provides frequency stability for the modulated oscillator. The error signal circuitry is also used to deactivate a transmitter in the event the oscillator falls out of phase lock. A fine-tuning adjustment (FREQ. ADJUST) on the front panel permits precise adjustment of the exciter to the authorized frequency.

The following paragraphs describe the operation of the phase-lock AFC system used in the exciter. The nominal frequencies shown in figure 4-1 are used only in the description as a reference.

The 100-MHz oscillator carrier frequency is fed to a series of binary dividers for division by a factor of 16,384 to a frequency of nearly 6 kHz. The output of the 100-kHz reference oscillator is divided by a factor of 16 to produce a signal closely related to the 6-kHz signal derived from the carrier frequency division process.

The two signals are compared in a phase detector and the error signal is used to stabilize the carrier frequency and to offset the effects of temperature change and aging components. The AFC system must also permit modulation over the entire range of 50 Hz to 75 kHz while

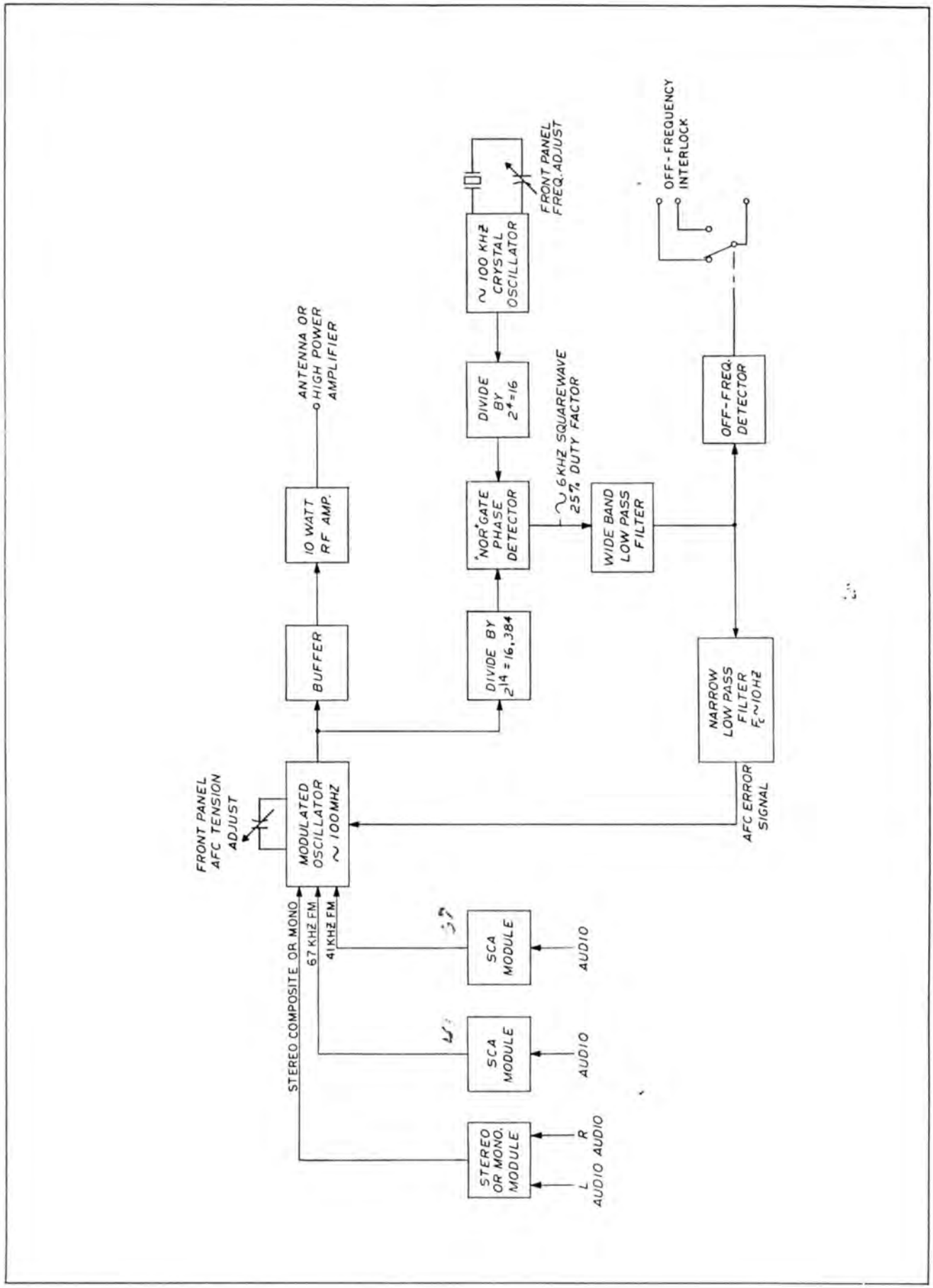


Figure 4-1. Model 660 Exciter Functional Block Diagram

holding the center carrier frequency within tolerance. The wide range of modulation is necessary to accommodate transmission in the monaural, stereophonic, and SCA modes.

Figure 4-2(a) is a simplified block diagram of the AFC control circuit. The phase detector is a form of OR gate, which has a high output when the input from either the reference oscillator chain or the modulated oscillator chain is high. When both inputs are low, the output of the OR gate is low. A buffer stage inverts the output waveform of the OR gate and, during quiescent conditions, the buffer output consists of a train of square waves that have a peak amplitude of 15 volts and a duty factor of 25%.

With the exception of the phase detector in the feedback loop, this AFC system behaves much like an ordinary feedback control system. The phase detector is characterized by the function ϕ shown in figure 4-2(b), which resembles that of an amplifier having a linear output in volts-per-degree of error for excursions that do not exceed ±90 degrees. For excursions that exceed ±90 degrees, the detector acquires a negative resistance characteristic which would normally produce instability.

In the following simplified analysis of the AFC loop, it is assumed that the divider chains are integral parts of the phase detector and that the effects of phase shift introduced by the divider chains are negligible. See figure 4-3(a). When referred to the carrier frequency, the phase detector characteristic is stable over ±1,474,560 degrees of phase excursion at that frequency. This wide latitude of phase stability is shown in figure 4-3(b).

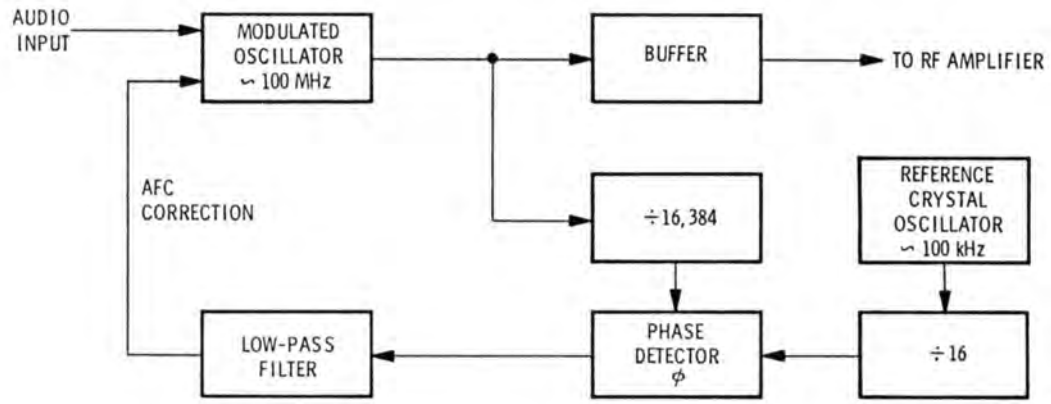
The nonlinear nature of the AFC system requires separate consideration of perturbations of varying intensity. Exciter modulation at 100% represents a ±75-kHz frequency deviation, and the peak phase deviation is a function of the modulation frequency, as stated by the formula:

$$\text{peak carrier phase deviation} = \frac{75{,}000 \times 360^\circ}{2\pi f \text{ mod (Hz)}} \text{ at 100\% modulation.}$$

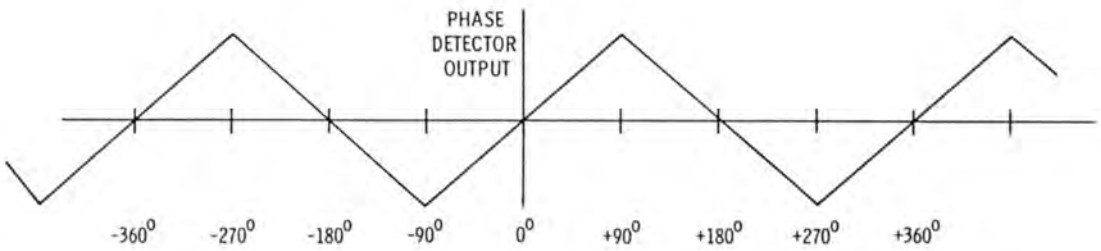
Thus, 100% modulation in the region of 2.5 Hz or lower will cause oscillation in the AFC system.

Smaller perturbations caused by temperature variations and mild mechanical shock have negligible effect on this circuit stability, and during these disturbances the phase detector remains a stable, linear device, permitting analysis of the AFC circuit based on conventional feedback theory. The system behavior is thus determined by the loop gain and filter response in the feedback loop. These parameters are affected by component tolerances, and the loop gain is affected by the varicap diode sensitivity, which is a function of the operating frequency.

The typical AFC loop response should be approximately as shown in figure 4-4. Transient response should be damped sufficiently to avoid excessive ringing or overshoot. The low-pass filter in the feedback loop prevents the AFC system from being influenced by modulating frequencies above a nominal 20 Hz. Below 20 Hz, the AFC system opposes carrier modulation, so the action of the AFC system limits the lower audio transmission frequencies.

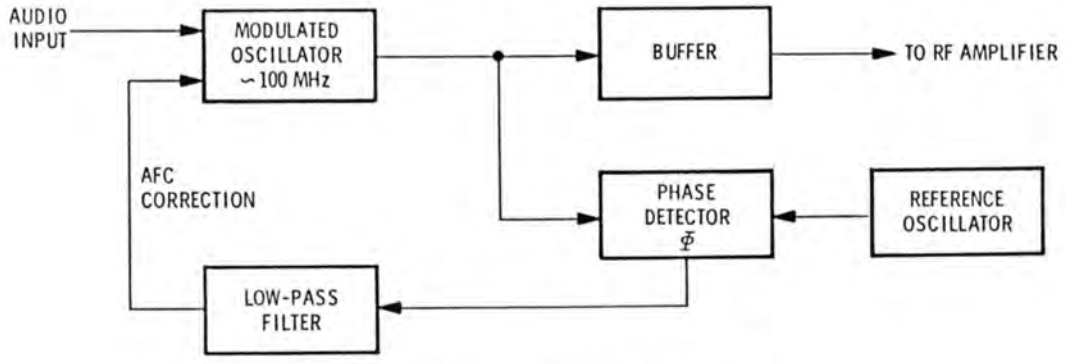


a. AFC System Basic Block Diagram

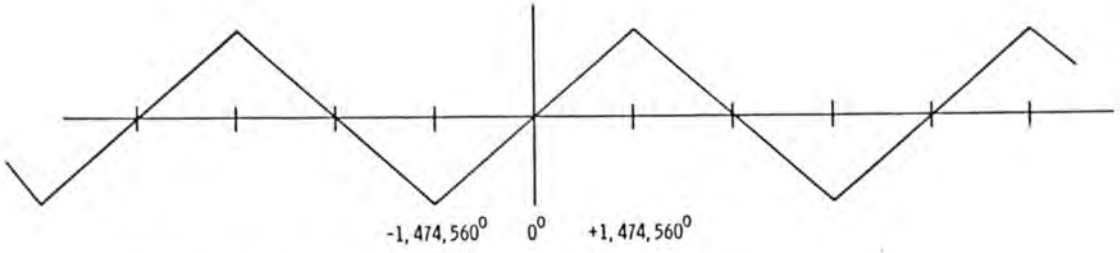


b. Phase Detector Characteristic -- φ

Figure 4-2. AFC System Basic Block Diagram and Phase Detector Characteristic --φ



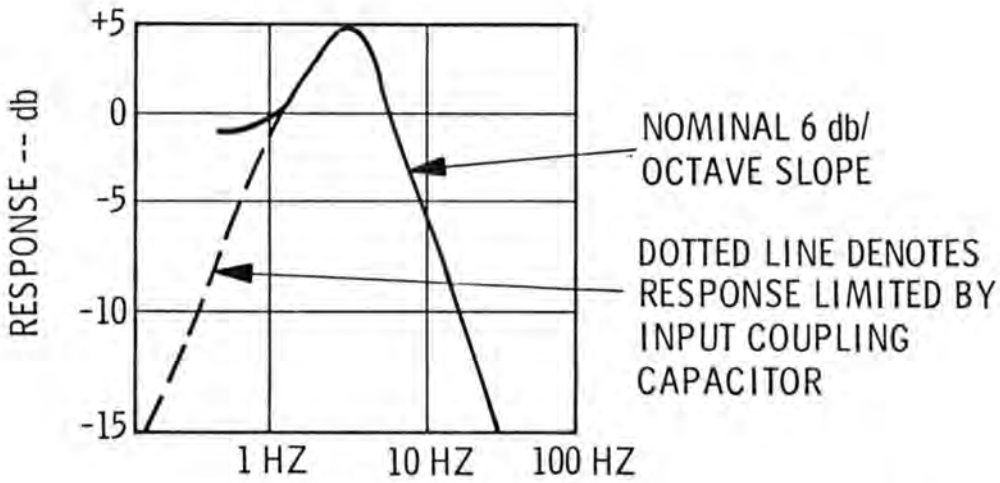
a. AFC System Reduced Block Diagram



PHASE ERROR AT CARRIER FREQUENCY

b. Phase Detector Characteristic --Φ

Figure 4-3. AFC System Reduced Block Diagram and Phase Detector Characteristic -- Φ



NOTE: 1-VOLT p-p CONNECTED BETWEEN PINS 5 AND 1 ON MODULATED OSCILLATOR ASSEMBLY. OUTPUT MEASURED ACROSS C6 ON SAME ASSEMBLY.

Figure 4-4. Typical AFC Loop Response Vs. Frequency

Perturbations of medium intensity may move the operation of the phase detector from its stable region and cause the AFC circuit to lose phase lock. It is difficult to predict the precise response of the AFC circuit under such conditions as momentary power failure and similar problems, due to the nonlinear behavior of the circuit. After such a disturbance, the phase detector quickly locks into a stable operating region and normal exciter operation is resumed immediately.

For a major perturbation such as encountered during initial equipment warmup, the modulated oscillator may be considerably off the assigned frequency and the circuits may search for one or two minutes before acquiring phase lock. As the oscillator frequency approaches the lock point, a low-frequency phase-error beat note appears. The low-pass filter rejects the beat note, but as the frequency becomes lower, the modulated oscillator tends slightly toward lock each time the phase detector passes through the stable part of a cycle. As the frequency of the beat note becomes lower than 10 Hz in its approach to zero, the modulated oscillator is drawn into lock during a stable part of a cycle. The phase-lock circuits have a pull-in capability from 100 kHz to 150 kHz at the carrier frequency.

4-2.1. RF Amplifier Module A1

The RF amplifier is a three-stage VHF amplifier of conventional design. All three stages use overlay transistors operating class C. (See figure 5-4.) A 6 db resistive pad at the input provides proper termination for the coaxial line between the exciter module and the

amplifier input. The pad also provides extra isolation between the modulated oscillator and subsequent stages.

The RF amplifier is designed to feed a 50-ohm nonreactive load. An SWR of up to 2:1 can be accommodated by adjusting the output stage tuning and loading controls, C18 and C19. Access to these controls is provided through two holes adjacent to the output connector on the left side of the chassis as it is removed from the exciter main frame.

The amplifier can withstand load faults ranging from open to short circuit without damage; however, prolonged operation under such conditions should be avoided, since the output stage is forced to dissipate the additional power that would normally be fed to the load.

4-2.2. FM Exciter Module A2

As shown in figure 5-5, the FM exciter module consists of two printed circuit board assemblies. Assembly A2A1 contains the modulated oscillator and buffer amplifier and assembly A2A2 contains the reference oscillator and AFC circuits. The module includes a receptacle for plug-in crystal oven HR1.

The modulated oscillator on A2A1 uses an RCA type 2N4427 transistor in an emitter-coupled Hartley configuration. The tuned oscillator circuit uses inductor L3 and the combination of capacitors C7 and C12 and varicaps CR1 to CR4 as capacitive elements. Capacitor C7 is used as a coarse frequency control. Trimmer C12 is used to adjust the tension in the AFC loop. Varicaps CR1 and CR3 are connected back-to-back to provide excellent linearity over the required frequency swing. Varicaps CR2 and CR4 are part of the AFC loop.

Resistors R3, R4, and R5 are used in conjunction with L2 to establish the proper operating point for varicaps CR1 and CR3. Potentiometer R4 is set at the factory to provide a 2.5-vdc potential at the junction of CR1 and CR3.

The output power of approximately 200 milliwatts is fed to the attenuator pad composed of R22, R23, and R24 to isolate the modulated oscillator from succeeding stages. The pad provides an RF feed for the AFC network.

Transistor Q2 is also a type 2N4427, and is operated as a conventional collector-tuned amplifier. The amplifier provides approximately 200 to 300 milliwatts of power to drive RF amplifier module A1. Audio is fed from a monaural amplifier or stereo generator to pin W of input connector P1. SCA signals are applied to pins V and T of the connector. Potentiometer R2, which controls the modulation sensitivity, is adjusted at the factory so that 2 volts peak-to-peak at pin W will cause 100% modulation. Input impedance at pin W is approximately 5000 ohms.

The AFC circuit on assemlby A2A2 is a phase-lock type of automatic frequency control in which the phase of the modulated oscillator on assembly A2A1 is compared with the phase of a temperature-stabilized crystal reference oscillator. The resultant phase error signal is used to correct the frequency of the modulated oscillator. The AFC action is described in

paragraph 4-2; therefore, the following description is limited to an analysis of the binary counting circuits and their related components.

The first four integrated circuits (IC-1, IC-2, IC-3, and IC-5) on assembly A2A2 are high-speed binary dividers connected in cascade to produce an output that is 1/16 the carrier frequency. The output of IC-3 is fed to level shifter and buffer transistor Q1, which drives a series of low-speed integrated circuits connected as divide-by-four binary circuits. Integrated circuits IC-6 through IC-10 divide the signal from 1/16 the carrier frequency to 1/16,384 the carrier frequency. The output of IC-10, which is a square wave with a period inversely proportional to the mean frequency of the modulated oscillator, is fed to one input of OR gate IC-13.

Integrated circuit IC-4 and crystal Y1 form the reference crystal oscillator circuit. The crystal oven is internally heated and contains a thermostat which is connected to power transistor Q1 for even temperature control. The crystal frequency is in the nominal range from 85 to 105 kHz. (Refer to paragraph 3-2.3.) The output of IC-4 is fed to buffer Q2, which drives IC-11. Integrated circuits IC-11 and IC-12 each divide by four, and together in cascade divide the crystal frequency by 16. The output of IC-12 is a square wave with a period inversely proportional to the reference oscillator frequency. This output is fed to the second input of IC-13.

The output of IC-13 is a train of pulses, the width of which is proportional to the phase relationship of the two input signals. The pulses are fed to Q3 for amplification sufficient to drive the integrator network composed of R13, C11, R16, and C14. The integrator network removes the 6-kHz component of the pulse train and leaves a dc voltage which is proportional to the pulse width, and hence proportional to the relative phase of the two signals. This voltage is fed to AFC varicaps CR2 and CR4 in assemlby A2A1 for control of the modulated oscillator center frequency. A steady-state frequency error will develop a beat note signal at the output of integrator network R13 and C11. This signal is fed to off-frequency detector circuit board A4.

4-2.3. Meter Amplifier Circuit Board A3

Meter amplifier board A3 (figure 5-6) comprises seven calibrating potentiometers, a three-stage direct-coupled amplifier, and a peak-reading voltmeter circuit. The potentiometers are used to calibrate meter M2 to external references. The potentiometers for LEFT, RIGHT, and COMP (composite) functions are calibrated for a meter indication of 100% with a 2-volt peak-to-peak input to FM exciter module A2. Both SCA MOD inputs should produce a meter reading of 100% at 10% subcarrier deviation. Both SCA INJ inputs should produce a meter reading of 30% with a 2-volt peak-to-peak subcarrier input to module A2.

Voltage amplifier transistor Q1 has a gain of approximately five. The following two current amplifier stages develop sufficient power at low impedance to drive the peak detector and meter M2. The audio signal is fed through C2 to diode CR1, from which the rectified output voltage charges C3 to peak signal value. Capacitor C4 is connected in parallel with R16 to

accelerate the slow response time of meter M2. Diode CR5 protects the meter from transient voltages.

4-2.4. Off-Frequency Detector Board A4

During normal operation, the oscillator in FM exciter module A2 (figure 5-5) is locked to the frequency of the crystal reference oscillator. The output of buffer amplifier Q3 on assembly A2A2 is a train of 6-kHz square wave pulses having a peak value of 15 volts and a duty factor of 25%. This waveform is fed to the network composed of R13 and C11, which produces a nominal 3.5-vdc signal containing a negligible amount of residual ripple.

If the FM oscillator becomes unlocked, the duty factor of the square wave output of the buffer amplifier Q3 varies cyclically as the AFC circuit attempts to regain phase lock. The variation appears as a beat note, which is amplified by Q1 on off-frequency detector board A4, after which it is rectified and filtered by diodes CR2 and CR3 and capacitor C4. (See figure 5-7.) The resulting dc voltage drives amplifier Q4-Q5 to actuate off-frequency relay K1, which is mounted on the main frame of the exciter.

The off-frequency relay can be actuated by circuit malfunctions other than loss of phase lock: the reference oscillator may fail or one of the dividers may be stalled. Either event is sufficient to cause a high or low output to appear at Q3 instead of a beat note. A stalled condition in either divider chain in the high-output condition produces a 0-volt output at Q3 on assemlby A2A2. A stall in the lower condition produces a symmetrical square wave.

A 0-volt output at Q3 causes the collector of Q1 on off-frequency board A4 to be high, turning on the following Q3, which turns on the relay amplifier Q4-Q5. The symmetrical square wave output causes the emitter of Q1 to be high, turning on Q2, which turns on relay amplifier Q4-Q5.

The condition of the divider chains can be determined by rotating the EXCITER MULTIMETER selector to the BINARY OUT and REF OSC positions. In either position the meter should indicate between 50 and 80 on the linear scale of multimeter M2. The actual meter indications depend on component tolerances but should remain constant during the operation of the exciter. Failure of an oscillator or divider chain produces either a 0 or 100 meter indication at the BINARY OUT or REF OSC positions, respectively.

4-2.5. Monaural Module A5

Monaural module A5 (see figure 5-8) comprises a resistive input pad, an input transformer, a low-pass filter, and a low-distortion audio amplifier.

The audio input line is connected to a pad which provides a resistive termination at all audio frequencies and prevents interaction with other audio equipment connected to the exciter. The pad is followed by a balanced-line input transformer. A 15-kHz low-pass filter is inserted between the input transformer and the audio amplifier to remove all undesired audio content which might interfere with SCA operation.

The amplifier section consists of a two-stage, high-gain amplifier with negative feedback. The transfer function of the feedback network is adjusted to provide the 75-μsec preemphasis curve required for FM broadcast service. The preemphasis may be removed by restrapping two terminals on the circuit baord and may be changed to 50 μsec by replacing C4 with a 0.022 μF capacitor.

4-2.6. Stereo Generator Module A5

The stereo generator module (figures 4-5 and 5-9) is also designated A5, as either monaural module A5 or stereo generator module A5 may be inserted into J3 in the main frame of the exciter, depending on the type of operation required. (See figure 5-2.)

The stereo generator comprises three assemblies: an input pad-transformer-filter assembly and two etched-circuit board assemblies. Assembly A5A1 contains the subcarrier oscillator, modulator, and pilot injection circuitry. Assemlby A5A2 contains both the left and right channel audio amplifiers, the composite output amplifier, and the relay switching and control circuitry.

Audio from separate sources is fed to the left and right channels of the module. Each line feeds a 10-db pad which is followed by a transformer so the input circuit is balanced and presents a 600-ohm resistive characteristic over the entire audio frequency range. The right channel circuitry is equipped with filter-terminating potentiometer R46 and gain potentiometer R47. These controls are used to match the right channel filter gain and phase characteristics to those of the left channel. A two-stage negative feedback amplifier follows the input circuits in each channel, with the frequency response of the amplifiers governed by their feedback networks. Terminals on assembly A5A2 may be strapped to provide a choice of 75-μsec preemphasis or flat frequency response. The 75-μsec preemphasis time constant is provided in the left channel by capacitor C5 and the parallel combination of R10 and R11; the 75-μsec preemphasis time constant is provided in the right channel by C16, R36, R37, and R38. If preemphasis is provided in the audio equipment feeding the exciter, both channels should be strapped in the FLT (flat) position. For the left channel, this change involves moving the jumper from C3 and C5 to connecting C3 to C6. For the right channel, remove jumper from R34 and connect to C17.

In the left channel, the impedance of L1 and R7 controls the response at the higher frequencies, so that the gain does not continue to increase indefinitely as the signal frequency is increased beyond 15 kHz. The right channel contains three additional balancing adjustments: R50 sets the nominal 75-μsec break point to match that of the left channel, R33 sets the high-frequency rolloff to match that of the left channel, and R37 is a gain control to match the gain of the right channel against that of the left channel. The preemphasis break-point time constant may be changed to 50 μsec by replacing C5 and C16 with 0.022 μF capacitors.

Assembly A5A1 contains the 76-kHz crystal oscillator circuit which includes transistors Q1 and Q2. The oscillator frequency may be adjusted precisely by PILOT FREQUENCY control C1 on the front of the module. The oscillator output waveform is "squared" by buffer Q3, and the steep falling edge of the square wave triggers bistable flip-flop Q4-Q5.

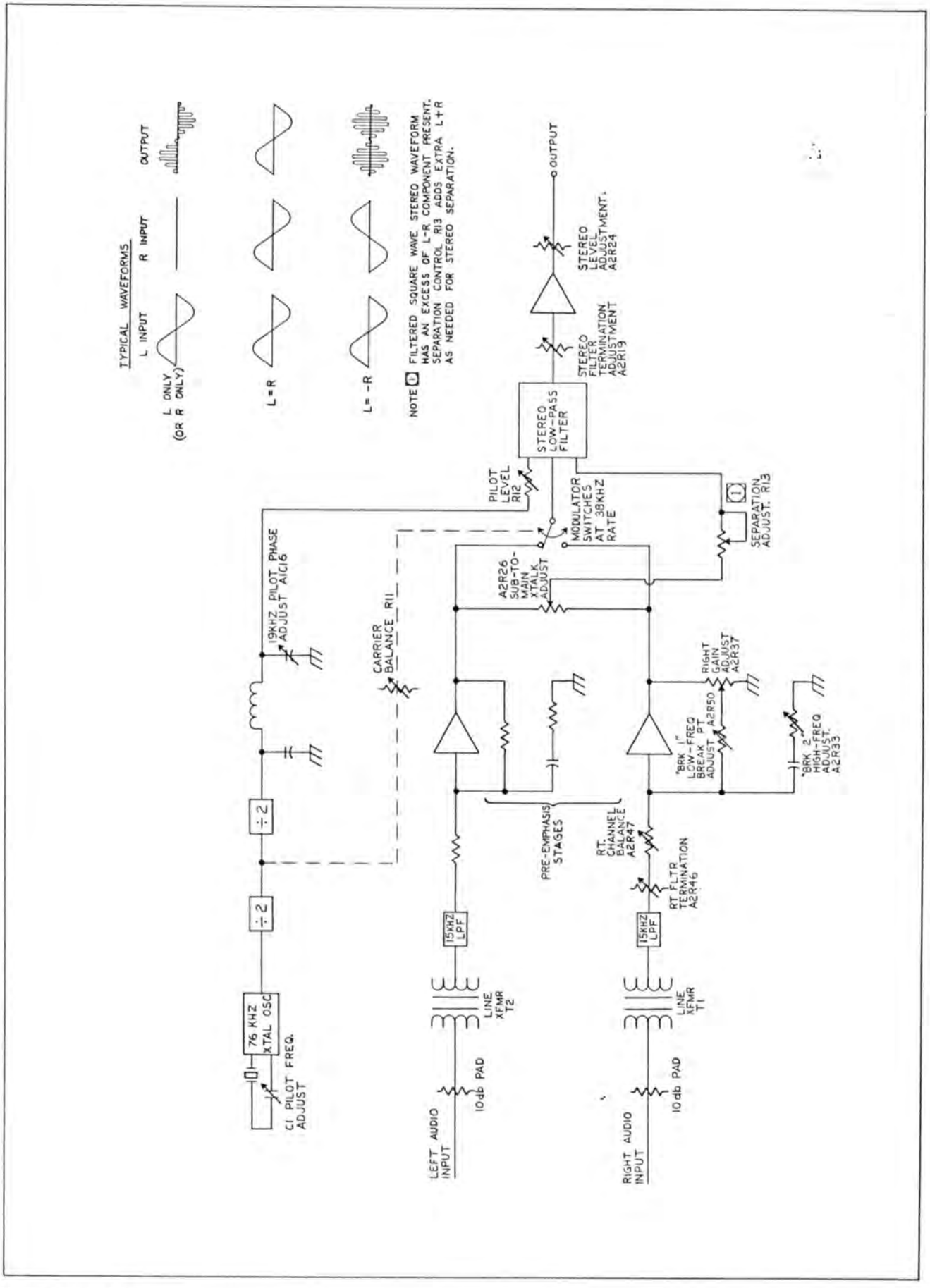


Figure 4-5. Stereo Generator Module A5 Simplified Block Diagram

The symmetrical 38-kHz square wave from the flip-flop drives the balanced modulator formed by CR7 through CR10. CARRIER BALANCE control R11 is used to null out the 38-kHz carrier. The switching action of the modulator gates audio first from the left channel, and then from the right channel. When there is no audio modulation, the modulator output at the junction of CR8 and CR9 on assembly A5A1 is a steady dc pedestal.

The output of the modulator is fed to buffer Q9 for amplification before being fed to composite low-pass filter FL3. A 19-kHz pilot tone is also injected into FL3. The 38-kHz output of Q4-Q5 drives bistable flip-flop Q6-Q7, which yields a 19-kHz square wave. This is fed to buffer Q8, which is followed by a tuned circuit consisting of L1, C14, C15, and C16, which provides low-pass filtering of the square wave signal. The phase of the pilot tone is adjustable by the use of PILOT PHASE capacitor C16, which is mounted on assembly A5A1.

All circuits following the balanced modulator must have wide bandwidth and very good phase linearity for effective stereo channel separation. Filter FL3 removes all spurious frequencies above 53 kHz to avoid interference with SCA subchannel operation. The operation of the filter is simplified by the symmetrical nature of the 38-kHz switching waveform, which contains no even-order harmonics. Filter FL3 is followed by composite amplifier Q5 on assembly A5A2. Best phase response is provided by the adjustment of STEREO FLTR potentiometer R19; STEREO LEVEL potentiometer R24 controls the amplitude of the composite waveform. Both of these controls are located on assembly A5A2. The single composite output waveform of Q5 contains all the information required for stereo transmission. The composite signal is fed to emitter-follower Q10 before application to the modulated oscillator in module A2.

SEPARATION control R13 on the lower front panel of the stereo generator is used to add extra left-plus-right to the composite waveform for good stereo separation, and is adjusted to correct the minor amplitude error that is inherently produced by the action of the low-pass filter.

Control relays K1 and K2 enable the selection of either left or right monaural, or stereo composite, and provide mode indication by lighting the appropriate front panel lamps.

4-2.7. 41-kHz and 67-kHz SCA Modules A6 and A7

Inasmuch as the 41-kHz SCA module and the 67-kHz SCA module have similar circuitry, the following discussion applies equally to both units. The difference table in figure 5-10 specifies those components used for operation at either frequency.

Incoming audio is fed to a 10 db resistive pad that is followed by transformer T1. The circuit board contains provision for an optional 5-kHz low-pass filter for use with the 67-kHz SCA module when the exciter is equipped with a stereo generator. The filter connects to terminals 20, 21, and 22, and the jumper should be removed from between terminals 20 and 21.

The emitter circuit of Q1 contains the preemphasis and rolloff networks. The 75-μsec preemphasis network consists of R12 and C4, and high-frequency rolloff is provided by the network of L1 and R10. The preemphasis time constant may be changed to 150 μsec by

changing the value of C4 to 0.33 μF. Telemetry tones can be injected into the emitter of Q1 from terminals on the rear panel of the exciter. Emitter-follower Q2 is used to drive the muting amplifier, the exciter multimeter, and the subcarrier modulated oscillator.

Modulated oscillator Q10-Q11 is a free-running multivibrator, the frequency of which is proportional to its bias voltage. Transistor Q9 regulates the bias to compensate for temperature drift.

The modulated oscillator is followed by diode gate CR5-CR6, buffer amplifier Q12, and a low-pass filter which removes harmonics of the oscillator waveform. The output of the filter is fed to emitter-follower Q13 before application to FM exciter module A2.

Subcarrier control switch S1 is mounted on the front panel of the SCA module. This switch provides a choice of three operating conditions: ON, OFF, and AUTO. These designations relate to muting the subcarrier. In the AUTO position, the subcarrier is automatically muted when there is no audio input into the SCA module. The muting amplifier composed of Q3 through Q8 gates the subcarrier on with normal audio inputs of 20 db or less below peak deviation capability. The subcarrier remains on for a short period (nominally between 0.6 and 4 seconds) after the audio input is removed; the duration of the period is adjustable by muting delay control R41.

4-3. POWER SUPPLY CIRCUIT DESCRIPTION

The Model 660 Exciter main frame contains a power supply which provides four dc output voltages to the modules as follows: +24 volts regulated to RF amplifier A1 and off-frequency detector A4; +15 volts regulated to FM exciter module A2, monaural module A5, stereo module A5, and SCA modules A6 and A7; -15 volts regulated to stereo module A5; and +3.5 volts regulated to the AFC circuits. Unregulated +40 volts is also available for the crystal oven HR1 in FM exciter module A2. One power transformer with three secondary windings is used in the power supply. (See figure 5-11.)

The +24-volt and the +3.5-volt circuits use conventional full-wave bridge rectifiers. The +15-volt and -15-volt circuits share a common center-tapped primary and full-wave bridge rectifier.

The +24-volt circuit uses cascaded emitter followers in series with the load. The output voltage is controlled by an error-amplifier transistor and a zener diode voltage reference. The output voltage is adjustable by potentiometer R4 mounted on TB1 in the exciter main frame.

The +24-volt supply section provides a thoroughly filtered output voltage which is also used as a reference for the +15-volt and +3.5-volt output circuits. Both the +15-volt and the +3.5-volt circuits use single series-pass transistors controlled by zener reference diodes. Their output voltages have very low ripple content because of the stable reference voltage from the +24-volt supply.

The -15-volt supply uses a single series-pass transistor controlled by a single zener reference diode.

4-4. POWER DISTRIBUTION

The Model 660 can be used with supply voltages from 105 to 125 volts, or from 200 to 250 volts, at 50 to 60 Hz. The transformer primary is adapted to local supply voltage by a combination of split and tapped windings. Refer to figure 5-3 for proper primary connections to power transformer T1. The dc power supply output voltages are wired to the module plug-in sockets and to the frame-mounted modules. The power supply sources and their destinations are also shown in figure 5-3.

SECTION V
MAINTENANCE

5-1. PERIODIC MAINTENANCE

Periodic inspection, cleaning, and maintenance requirements for the Model 660 FM Exciter are in accordance with standard practice for maintaining any communications equipment.

5-2. PRINTED CIRCUIT BOARD COMPONENT REPLACEMENT

To replace a circuit board component, proceed as follows:

a. Brush a coating of rosin flux over both leads of component to be replaced and on circuit board copper. Coat a piece of 1/32-to 1/4-inch-wide flat shielding braid (tinned copper wire woven into a flat braid) with rosin flux. Lay end of braid over lead of component to be removed. Apply heated soldering iron to braid in such a manner that braid absorbs all solder as it melts from copper and around component lead.

b. Repeat for all leads holding component onto printed circuit board.

c. After all component leads are loose in their mounting holes, straighten out leads that have been bent over to secure component during soldering. Remove component carefully so as not to damage or break copper tracings on printed circuit board.

d. Replace component in mounting holes on printed circuit board. Bend leads over to secure component and cut off excess length. Be extremely careful not to damage traces on board. Remove any excess rosin flux from soldered area with clean alcohol.

5-3. OPERATIONAL CHECK

Correct operation of the Model 660 FM Exciter can be verified by performing the operational check described in the following paragraph. This check is general in scope and is intended to verify adequate modulation capability and signal power output. If inadequate operation is indicated, or if a change of operating frequency is required, perform the alignment and adjustment procedures in this section for remedial action.

The following test equipment (or equivalent) is required in the performance of this check and for subsequent tests and alignment procedures:

VOM	Tripplett Model 630
Low-Distortion Audio Oscillator	HP Model H20−200CD

FM Monitor	Belar Models FMM-1 and FMS-1
SCA Monitor	Belar Model SCM-1
Oscilloscope	Tektronix Model 504
RF Power Meter	Sierra Model 164
Electronic Counter	HP Model 5245-L
50-Ohm Load or 20-db Pad	Sierra Model 661A-20

5-3.1. General Performance Check

The following check is performed to determine the general operating characteristics of the exciter:

a. With power off, remove lower front panel cover and remove FM exciter module A2. Place module in extender board and reconnect to exciter receptacle.

b. Connect jumper wire between terminals 4 and 5 of TB3.

c. Note setting of OUTPUT POWER ADJUST control on front panel of RF AMPLIFIER and turn control fully counterclockwise.

d. Apply power to exciter and allow short warmup period.

e. Using VOM, verify +24 vdc at TB3 terminals 4-5 to ground.

f. Feel outside of crystal oven on FM exciter module A2 to verify oven heater operation.

g. Verify application of 40 vdc across terminals 3 and 4 of crystal oven socket, with voltage recurring intermittently at approximately 1-minute intervals.

h. Rotate EXCITER MULTIMETER switch to AFC UNLOCK. Exciter multimeter should indicate 0.

i. Using low-distortion audio oscillator, feed 1-kHz signal at +10 dbm into each active channel input and verify output at studio monitors.

j. If exciter contains stereo generator module, feed 1-kHz signal at 2.5 volts rms to paralleled right and left inputs. Verify output signals as in step i.

k. Connect RF power meter to exciter RF OUT jack J2. Restore OUTPUT POWER ADJUST control to original setting noted in step c. Rotate EXCITER MULTIMETER switch to RF OUTPUT and compare indications of RF power meter with exciter multimeter.

NOTE

The output indication of the exciter multimeter is adjusted at the factory to indicate 10-watts RF output at the 100% mark.

5-4. ALIGNMENT AND ADJUSTMENT PROCEDURES

CAUTION

If the exciter requires alignment or adjustment it should be performed only by experienced personnel having an adequate understanding of the exciter and who are thoroughly familiar with test instruments, monitors, etc.

The test equipment specified in paragraph 5-3 is used in the following procedures. The use of the module extender permits access to all controls for the plug-in modules under the front cover panel. Reference to figures 6-1 through 6-12 in Section VI may be helpful in locating specific components and test points.

The following alignment and adjustment procedures apply to: (1) the dc power supply and its relation to the modules, (2) the individual modules and their circuit board assemblies, and (3) the complete interconnection of the circuit board assemblies and modules comprising the exciter.

5-4.1. DC Power Supply Assembly Alignment and Adjustment

The alignment and adjustment of the power supply assembly is conducted as follows:

a. Check line and power supply fuses and verify correct connections to the primary of power transformer T1 under top cover of exciter. Apply power.

b. Refer to figure 5-11 for power supply schematic diagram. Measure 40 vdc (±10%) at positive terminal of capacitor C1 in power supply.

c. Place test probe at junction of R3, R7, and R9 in power supply. Adjust voltage control potentiometer R4, if necessary, to obtain +24-vdc (±10%) indication.

d. Verify +15 vdc (±5%) at the emitter of Q4.

e. Verify -15 vdc (±10%) at the emitter of Q5.

f. Verify +3.5 vdc at the emitter of Q6.

5-4.2. RF Amplifier Module A1 Alignment and Adjustment

For minor realignment of RF amplifier module A1 after component replacement, leave all capacitors in their preset positions and use this procedure as a guide. When changing to a new operating frequency, follow this procedure exactly. Refer to figures 5-4 and proceed as follows:

a. With power off, unlock and withdraw the RF amplifier module from exciter main frame. Do not disconnect RF cables from module connectors.

b. Remove the six screws holding RF amplifier to side panel of module. Invert amplifier on work surface to rest on heat sink.

c. Set capacitors C1, C2, and C17 to maximum capacitance.

d. Set capacitors C5, C7, C11, C12, C16, and C18 to minimum capacitance.

e. Set C19 to half capacitance.

f. Connect RF power meter to RF OUT jack J2 on rear panel of exciter. Connect 20 db pad to RF power meter output.

g. Rotate OUTPUT POWER ADJUST control R16 fully counterclockwise.

h. Apply power to exciter.

i. Rotate EXCITER MULTIMETER switch to IPA CURRENT. Connect external VOM between TP1 and chassis ground.

j. Adjust C7 for peak indication on VOM.

k. Increase capacitance of C5 in small increments and readjust C7 for peak readings of approximately 0.5 volt. The peak should occur at peak indication on multimeter M1.

m. Connect VOM between TP2 and ground. Rotate EXCITER MULTIMETER switch to PA CURRENT. Tune C12 and C11 for peak VOM indication of approximately 1.5 volts coinciding with peak indication on multimeter M1.

n. Rotate EXCITER MULTIMETER switch to RF OUT. Adjust C16 and C18 in sequence for peak RF power meter indication coinciding with peak indication on multimiter M1. The RF power meter should be set on the 1-watt scale for finding the initial tuning point.

o. Rotate OUTPUT POWER ADJUST control R16 to maximum clockwise position for maximum power output. Adjust PA tuning and loading controls C16 through C19 for maximum. Carefully readjust all tuning capacitors for maximum power output.

p. Press LEFT pushbutton on exciter front panel and connect FM monitor to output of 20 db pad. Feed 400-Hz signal into AUDIO L terminals on rear panel of exciter at sufficient level to produce 100% modulation indication on FM monitor. Set reference input level on FM monitor and measure AM noise. Carefully readjust interstage and output tuning for at least -50 db AM noise while maintaining the required power output.

q. Remove modulating signal and read AM noise. Noise indication should be at least 60 db below 100% modulation.

r. Rotate OUTPUT POWER ADJUST potentiometer R16 to produce 10-watt indication on RF power meter. Adjust R1 on RF amplifier chassis to produce 100% indication on multimeter M1.

s. Reassemble RF amplifier by replacing the six screws to fasten RF amplifier to module. Rotate EXCITER MULTIMETER switch to AFC UNLOCK.

t. Disconnect primary power for five or six seconds and then reconnect primary power. Exciter should quickly regain phase lock. If not, slightly detune C17 in FM exciter module A2. If necessary, set AFC ADJUST C12 on FM exciter module for phase lock. Repeat this procedure several times to ensure that exciter will always regain phase lock after a power interruption.

5-4.3. FM Exciter Module A2 Alignment and Adjustment

To align and adjust FM exciter module A2, or to change frequency, refer to figure 5-5 and proceed as follows:

a. With power removed, insert module extender into FM exciter module socket.

b. Remove top cover from FM exciter module and insert module into extender socket.

c. Apply power to exciter and allow 10-minute warmup.

d. Connect electronic (frequency) counter by means of a 50-ohm attenuator to exciter module output jack J1. Set AFC ADJ control C12 to midrange position. Adjust capacitor C7 while observing counter to ensure oscillator coil L3 will tune to the required frequency. If necessary, carefully squeeze or stretch L3 to raise or lower its inductance.

e. Rotate EXCITER MULTIMETER switch to AFC UNLOCK. If zero indication is not observed on multimeter M1, carefully adjust C7 for the required zero indication.

f. Adjust MOD BIAS control R4 for 2.5 vdc as measured across R5.

g. Remove monaural or stereo module and connect FM monitor to module RF OUT jack J1. Feed a 1-kHz, 2-volts peak-to-peak signal to terminals 5 on assembly A2A1, and adjust BASEBAND LEVEL control R2 for 100% modulation indication on FM monitor.

5-4.4. Monaural Module A5 Alignment and Adjustment

To align and adjust monaural module A5, refer to figure 5-8. The only adjustment on the monaural module is accomplished by a choice of strapping terminals C-P or C-F to determine either the preemphasis mode or flat mode of operation. The only alignment required is setting the related calibration resistor on meter amplifier board A3 to calibrate meter M2 to agree with a test standard. For this alignment, proceed as follows:

a. Connect FM monitor to RF OUT jack J2 at the rear of exciter.

b. Feed 400-Hz input signal into STEREO AUDIO L terminals at level sufficient to produce 100% indication on FM monitor.

c. Rotate AUDIO MULTIMETER switch to LEFT and adjust R1 on meter amplifier board for indication of 100 on meter M2.

5-4.5. Stereo Generator Module A5 Alignment and Adjustment

The PILOT FREQUENCY, PILOT LEVEL, CARRIER BALANCE, and SEPARATION controls on the front panel of the stereo generator may be touched up occasionally as required during routine maintenance. If alignment and adjustment is required, refer to figure 5-9 and proceed as follows:

CAUTION

The following procedure should only be performed by experienced personnel having an adequate understanding of the stereo generator and who are thoroughly familiar with test instruments.

a. With power removed from exciter, connect test equipment as shown in figure 5-1.

b. On assembly A5A2, disconnect preemphasis jumpers connecting C3 to C5 and C14 to R34.

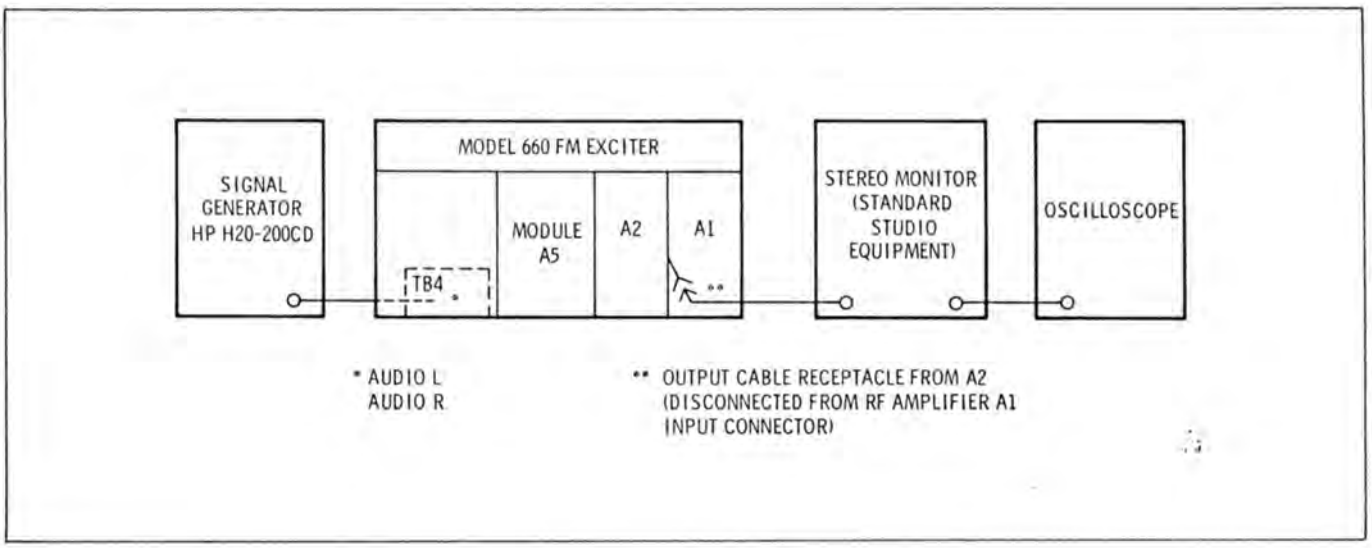


Figure 5-1. Stereo Generator Module Test Setup

c. Preset trimming controls on board A5A2 as follows:

SUB/MN/XTLK R26:	Mid-range
BRK 1 R50:	Mid-range
RT GAIN R37:	Fully clockwise
STEREO LEVEL R24:	Mid-range

RT FLTR R46:	Fully counterclockwise
BRK 2 R33:	Mid-range
STEREO FLTR R19:	Mid-range
RT BAL R47:	Fully clockwise

d. Disconnect input from audio oscillator. Apply operating power to equipment. Set FM monitor function switch to 38-kHz position and allow 10-minute warmup.

e. Adjust CARRIER BALANCE control on front panel for null indication. Observe minimum carrier suppression of 60 db or better.

f. Connect audio oscillator output in phase to left and right channels. Feed 500-Hz signal to inputs. Press STEREO pushbutton on exciter upper front panel and adjust oscillator level to indicate 100% modulation on FM monitor.

g. Make reference measurement of audio level required (2.5 ±0.5 volts rms) for 100% modulation.

h. Press RIGHT and LEFT channel pushbuttons in sequence and observe approximately equal indications before making adjustments. Observe that nominal 2.5 volts at inputs provides approximately 100% modulation on left channel, right channel, and stereo modes.

i. Set FM monitor function switch to L - R position and adjust RT BAL control R47 for minimum L - R indication.

j. Turn RT FLTR control R46 fully clockwise and adjust RT GAIN control R37 for minimum L - R indication.

k. Set audio oscillator to 13 kHz with level adjusted to produce 100% modulation and adjust RT FLTR R46 for minimum L - R indication.

m. Vary audio frequency over range of 5 kHz to 15 kHz. Verify L - R indication to be a minimum of 42 db below 100% indication. If necessary, trim RT BAL and RT FLTR controls to produce required indication.

n. Reverse one of the audio feed lines at audio input terminals to feed L and R out of phase.

o. Adjust audio frequency to 7.5 kHz and adjust level for 100% modulation.

p. Adjust SUB/MN XTLK control R26 for minimum L + R indication.

q. Vary audio frequency over range of 5 kHz to 15 kHz. Verify L + R indication to be a minimum of 42 db below 100% over the range. If necessary, trim SUB/MN/XTLK adjustment to produce required indication.

r. Connect temporary jumpers at preemphasis terminals associated with C3 and C5, and with C14 and R34.

s. Again reverse one of the audio lines to produce in-phase condition. Set oscillator frequency to 2 kHz and adjust level for 100% modulation. Adjust BRK 1 control R50 for minimum L - R indication.

t. Set audio oscillator to 15 kHz and adjust level for 100% total modulation. Adjust BRK 2 control R33 for minimum L - R indication. Trim BRK 1, BRK 2, and RT BAL controls to produce an L - R indication at least 42 db below 100% modulation at 50 Hz, 400 Hz, 1 kHz, 2 kHz, 5 kHz, 10 kHz, and 15 kHz.

u. Reverse one of the audio feed lines to produce out-of-phase condition. Set audio level for 100% total modulation. Check crosstalk into L + R channel for better than 42 db indication below 100% at frequencies specified in step t. Trim the SUB/MN/XTLK control if necessary to produce required results.

v. Set FM monitor function switch to PILOT position. Adjust exciter module front panel PILOT LEVEL control R12 for 9% pilot injection.

w. Feed 1-kHz signal into left and right channels. Push LEFT and STEREO pushbuttons while observing total modulation indicator. Adjust stereo LEVEL control R24 so that modulation indicator does not change when switching between LEFT, RIGHT, and STEREO, then set PILOT LEVEL control R12 to minimum output position.

x. Feed a 12.5-kHz signal into left channel input and adjust level for 100% total modulation. Connect oscilloscope to wideband output of FM monitor. Place oscilloscope vertical amplifier in dc-coupled mode on the 10 mv/cm scale. Trim STEREO FLTR control R19 and panel-mounted SEPARATION control R13 for a flat baseline display on oscilloscope.

y. Set audio oscillator to 1.25 kHz and adjust level for 100% modulation. Adjust front-panel SEPARATION control R13 for flattest baseline.

NOTE

Channel separation can be measured by connecting the oscilloscope to the COMPOSITE OUTPUT jack on the FM monitor and using the following formula:

$$\text{Separation} = 20 \log_{10} \frac{\text{V total p-p}}{\text{V baseline p-p}}$$

z. With modulation remaining at 100%, check minimum separation of 35 db or better at frequencies of 50 Hz, 100 Hz, 1 kHz, 5 kHz, 10 kHz, and 15 kHz.

aa. Feed audio oscillator into right channel and adjust for 100% modulation. Without further adjustment, check separation as in step z, using same frequencies. If further trimming adjustments are necessary to obtain correct separation, repeat steps e through z.

ab. Set PILOT LEVEL control R12 for 9% injection. Adjust FM monitor PHASE CONTROL in accordance with monitor instruction manual. Feed 1-kHz signal into right or left channel with level adjusted to produce 100% modulation. Adjust panel-mounted PILOT FREQUENCY control C1 for 19-kHz output. Adjust PILOT PHASE control C16 for best separation as read on the appropriate L or R meter.

ac. Remove temporary jumper leads from preemphasis terminals and solder jumpers in place.

ad. On exciter front panel, press LEFT pushbutton and set oscillator for 100% modulation at 400 Hz. Rotate AUDIO MULTIMETER switch to LEFT and adjust potentiometer R1 on meter amplifier board A3 for 100% indication on audio multimeter M2.

ae. Press RIGHT pushbutton and rotate AUDIO MULTIMETER switch to RIGHT. Adjust potentiometer R2 on meter amplifier board A3 for 100% indication on audio multimeter M2.

af. Press STEREO pushbutton and rotate AUDIO MULTIMETER switch to COMP. Adjust potentiometer R3 on meter amplifier board A3 so that audio multimeter M2 is in reasonable agreement with indication on FM monitor.

5-4.6. SCA Modules A6 and A7 Alignment and Adjustment

To align and adjust SCA module A6 or A7, refer to figure 5-10 and proceed as follows:

a. Insert module extender into exciter receptacle J1 or J2, as appropriate, and insert SCA module in extender. Set FREQUENCY adjust potentiometer R42 on front panel of SCA module to mid-range position.

b. Connect SCA monitor to wideband output of FM monitor; connect input of FM monitor to exciter RF OUT jack J2 through a 20 db pad. Set subcarrier control switch S1 to ON.

c. Adjust coarse frequency control R43 to produce 41-kHz or 67-kHz indication, as appropriate, on SCA monitor.

d. Connect low-distortion audio oscillator to terminals 1 and 2 of SCA module circuit board. Set audio oscillator for 400-Hz output and verify that an audio input level between +8 and +12 dbm yields a 10% frequency deviation.

e. Set subcarrier control switch S1 to AUTO. Decrease oscillator output to approximately -10 dbm and verify muting function. Verify correct setting of MUTING DELAY control R41 to ensure muting turnoff time between 0.5 and 4 seconds.

f. Connect oscilloscope to wiper terminal of OUTPUT LEVEL control R76. Set subcarrier control switch S1 to ON and verify that OUTPUT LEVEL control R76 produces variation of from 0 to 2 volts peak-to-peak (0.7 volt rms).

5-5. FREQUENCY CHANNELIZATION AND ALIGNMENT

When a new operating frequency is required, a new reference frequency oscillator crystal must be obtained and minor physical adjustments to the modulated oscillator inductor may be required. The RF amplifier will also require realignment.

Specify the required crystal frequency and provide all pertinent information when ordering replacement crystals from the factory. Refer to paragraph 3-2.3 and table 3-2 for precise ordering information.

To channelize a new specific operating frequency, refer to figure 5-5 and proceed as follows:

a. With power removed, insert module extender into FM exciter module socket.

b. Remove top cover from FM exciter module A2 and remove crystal oven from socket. Remove crystal and replace with new crystal to be used.

c. Replace crystal oven in socket, insert FM exciter module in extender socket.

d. Apply power to exciter unit and allow a 10-minute warmup period.

e. Refer to paragraph 5-4.3 and perform alignment procedure steps d through g.

f. Refer to paragraph 5-4.2 and perform entire alignment procedure for RF amplifier module A1.

5-6. TROUBLESHOOTING

Table 5-1 lists possible trouble symptoms. The source of other troubles can be localized by observing indications on monitor meters on the front panel, then using standard trouble-shooting procedures to isolate the defective part.

Table 5-1. Troubleshooting Guide

SYMPTOM	POSSIBLE CAUSE
Intermediate power amplifier (IPA) and power amplifier (PA) not operating; CARRIER ON lamp not lighted.	Off-frequency alarm relay.
IPA and PA not operating; AFC UNLOCK indication above zero.	Modulated oscillator not locked to reference oscillator.
IPA and PA not operating; AFC UNLOCK at zero, but REF OSC or BINARY OUT indication either zero or full scale.	Reference oscillator or divider chain.
IPA or PA not operating; CARRIER ON lamp illuminated and MOD OSC indication normal.	Broken connection between exciter module and RF amplifier.
Drive input to transmitter power amplifier lacking or inadequate; exciter operation appears normal.	Check connections between exciter output and power amplifier input; adjust exciter tuning and load controls C18 and C19 of RF amplifier.
AFC indication does not remain steady; high reading (over 80) or low reading (below 40) on REF OSC or BINARY position; MOD OSC does not remain locked to reference.	Check all power supply voltages; check socket connections for integrated circuits and transistors in FM exciter module A2. Verify correct seating of FM exciter module in main frame.

Table 5-1. Troubleshooting Guide (Continued)

SYMPTOM	POSSIBLE CAUSE
Excessive AM noise.	Check 24-volt power supply.
Excessive FM noise.	Check all power supplies. Verify exciter not subject to excessive vibration, and that modules are seated firmly in main frame.
CARRIER ON lamp flashes on and off repeatedly.	Interaction between modulated oscillator and following stages. On modulated oscillator assembly, slightly detune C17.
Carrier frequency drifts out of tolerance.	Check crystal oven; should feed warm. Oven heater should cycle on and off about once per minute.
No modulation; exciter audio multimeter M2 indication normal.	Verify that modules are firmly seated in main frame.
No modulation; exciter audio multimeter M2 indication abnormal.	Check program lines.

5-7. MAINTENANCE AND TROUBLESHOOTING DIAGRAMS

The maintenance and troubleshooting schematic diagrams for the Model 660 FM Exciter are as follows:

Figure 5-2. Signal Distribution Diagram

Figure 5-3. Power Distribution Diagram

Figure 5-4. RF Amplifier Module A1 Schematic Diagram

Figure 5-5. FM Exciter Module A2 Schematic Diagram

Figure 5-6. Meter Amplifier Board A3 Schematic Diagram

Figure 5-7. Off-Frequency Detector Board A4 Schematic Diagram

Figure 5-8. Monaural Module A5 Schematic Diagram

Figure 5-9. Stereo Module A5 Schematic Diagram

Figure 5-10. SCA Modules A6 and A7 Schematic Diagram

Figure 5-11. Power Supply Schematic Diagram.

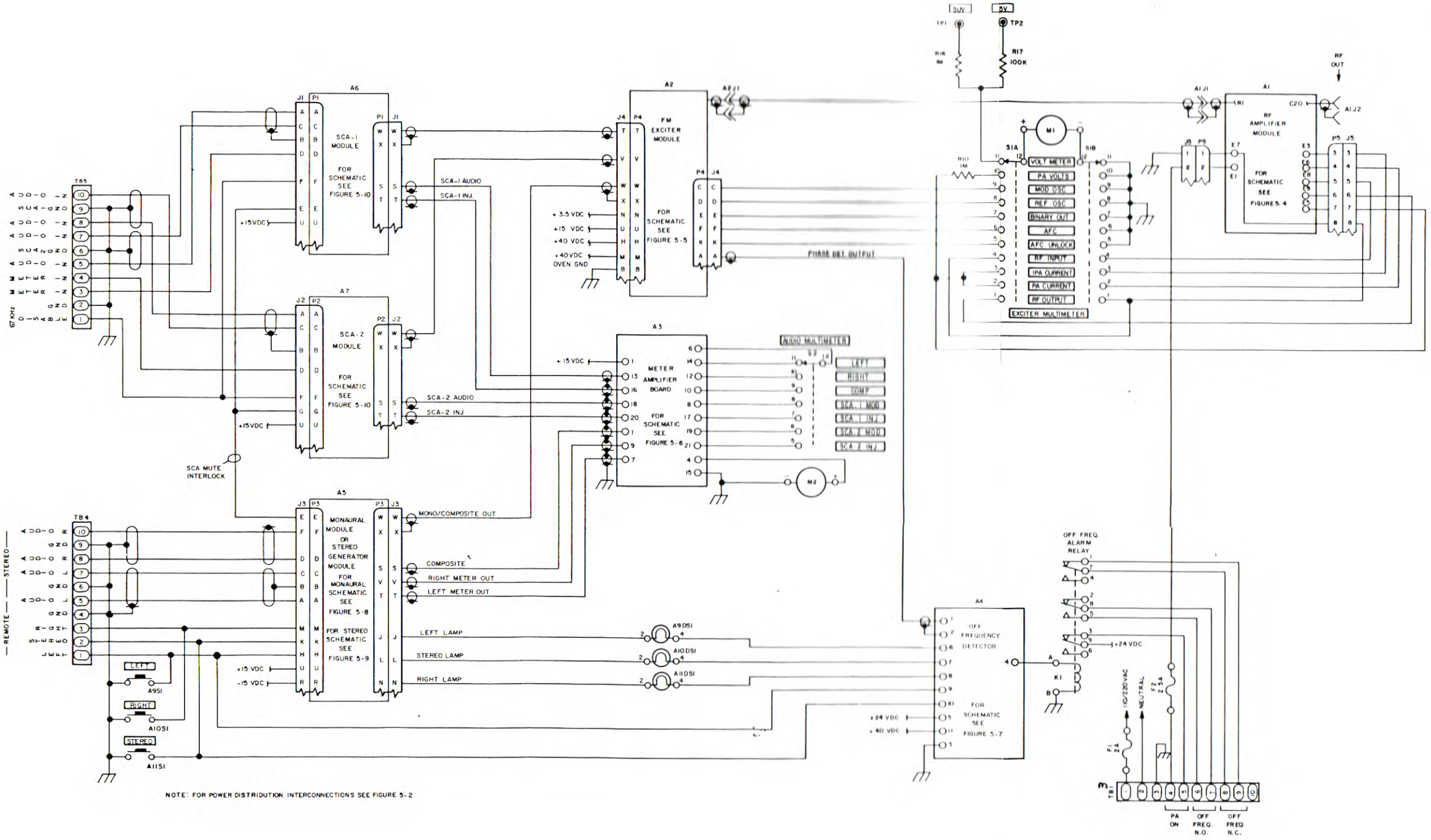


Figure 5-2. Signal Distribution Diagram

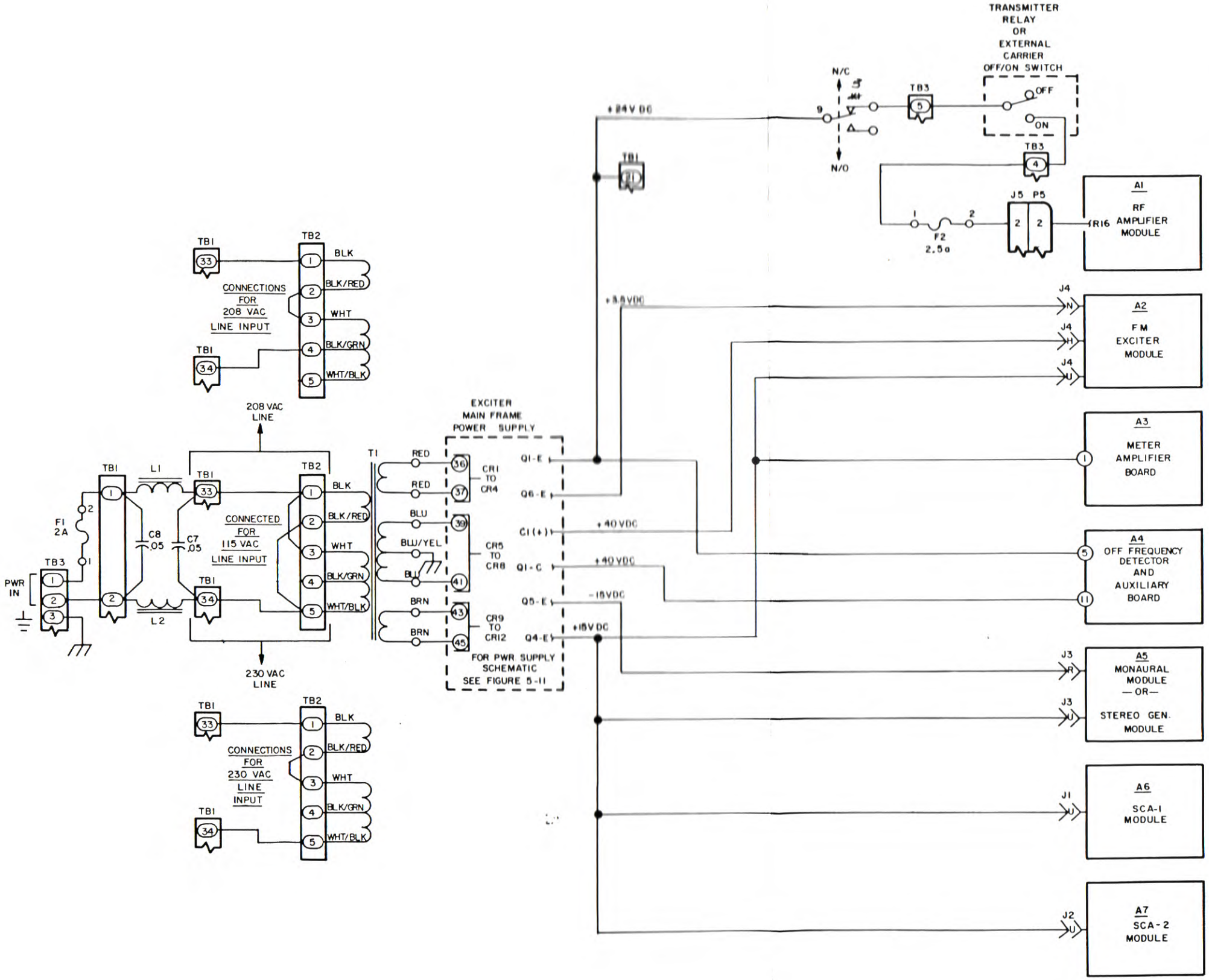
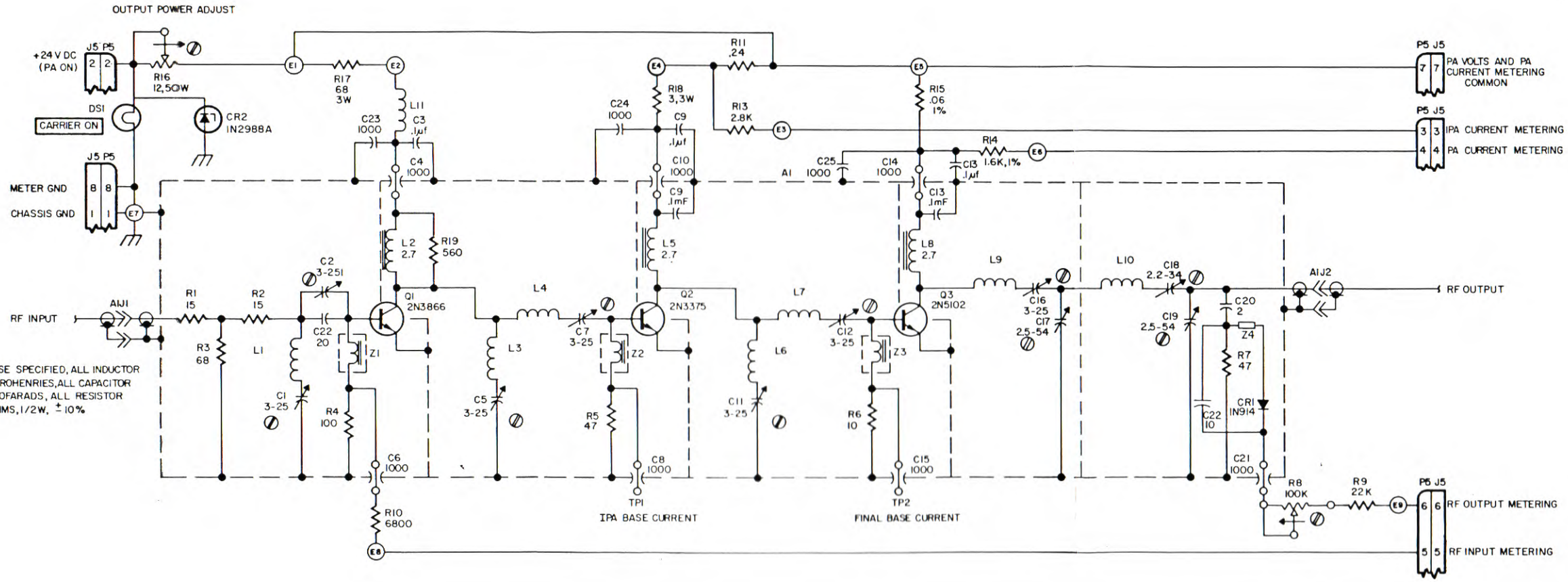


Figure 5-3. Power Distribution Diagram



NOTES:
1. UNLESS OTHERWISE SPECIFIED, ALL INDUCTOR VALUES ARE IN MICROHENRIES, ALL CAPACITOR VALUES ARE IN PICOFARADS, ALL RESISTOR VALUES ARE IN OHMS, 1/2W, ±10%

Figure 5-4. RF Amplifier Module A1 Schematic Diagram

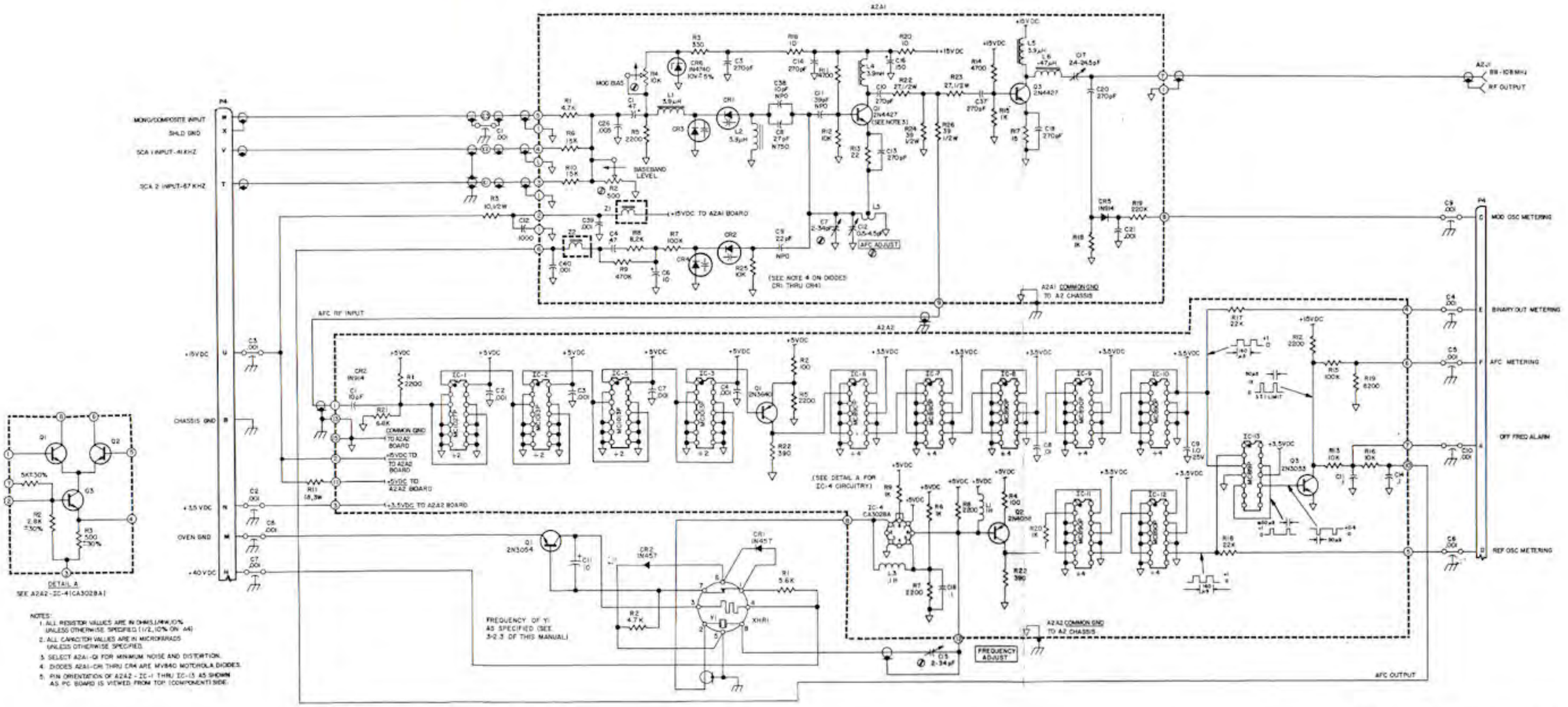
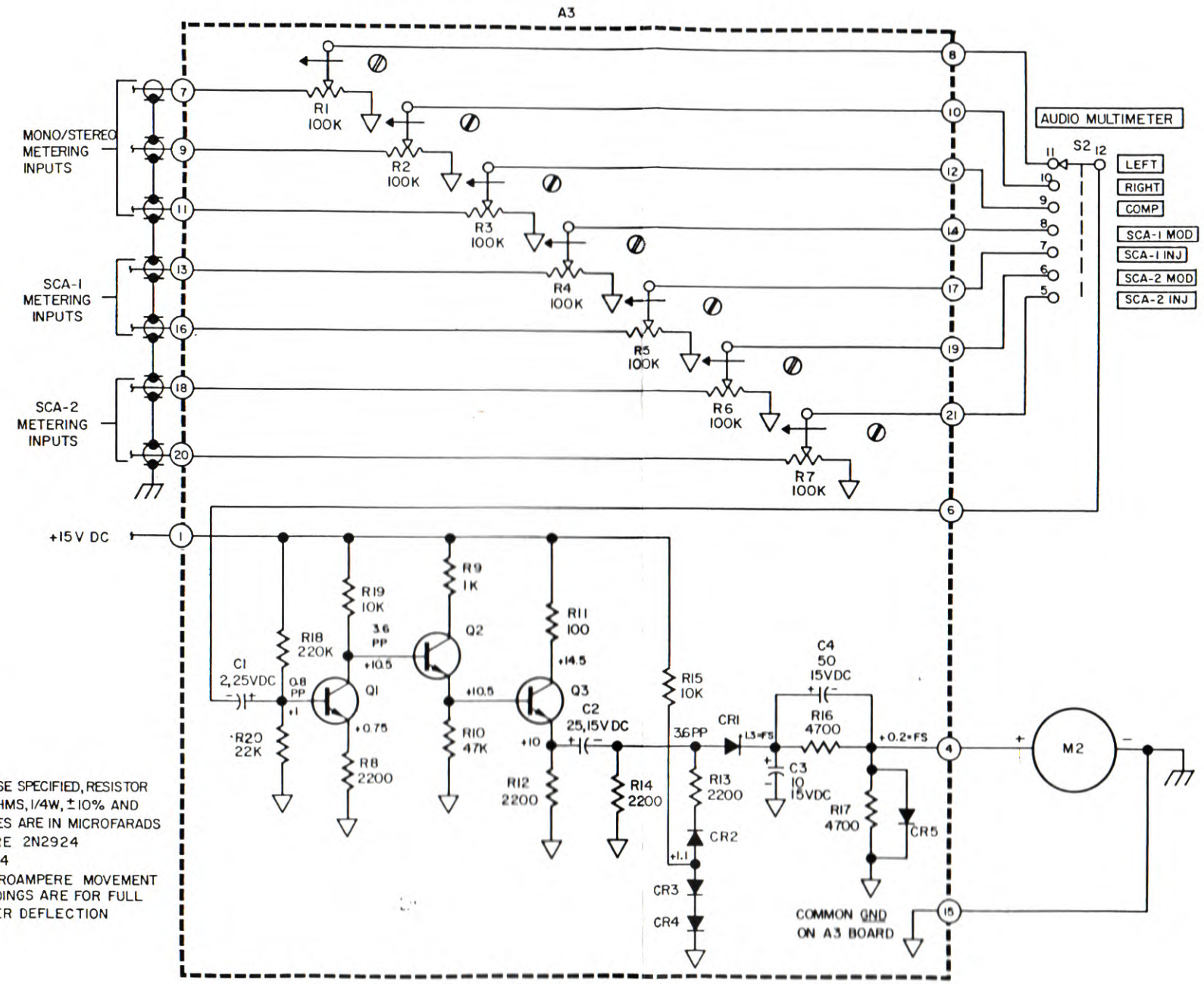


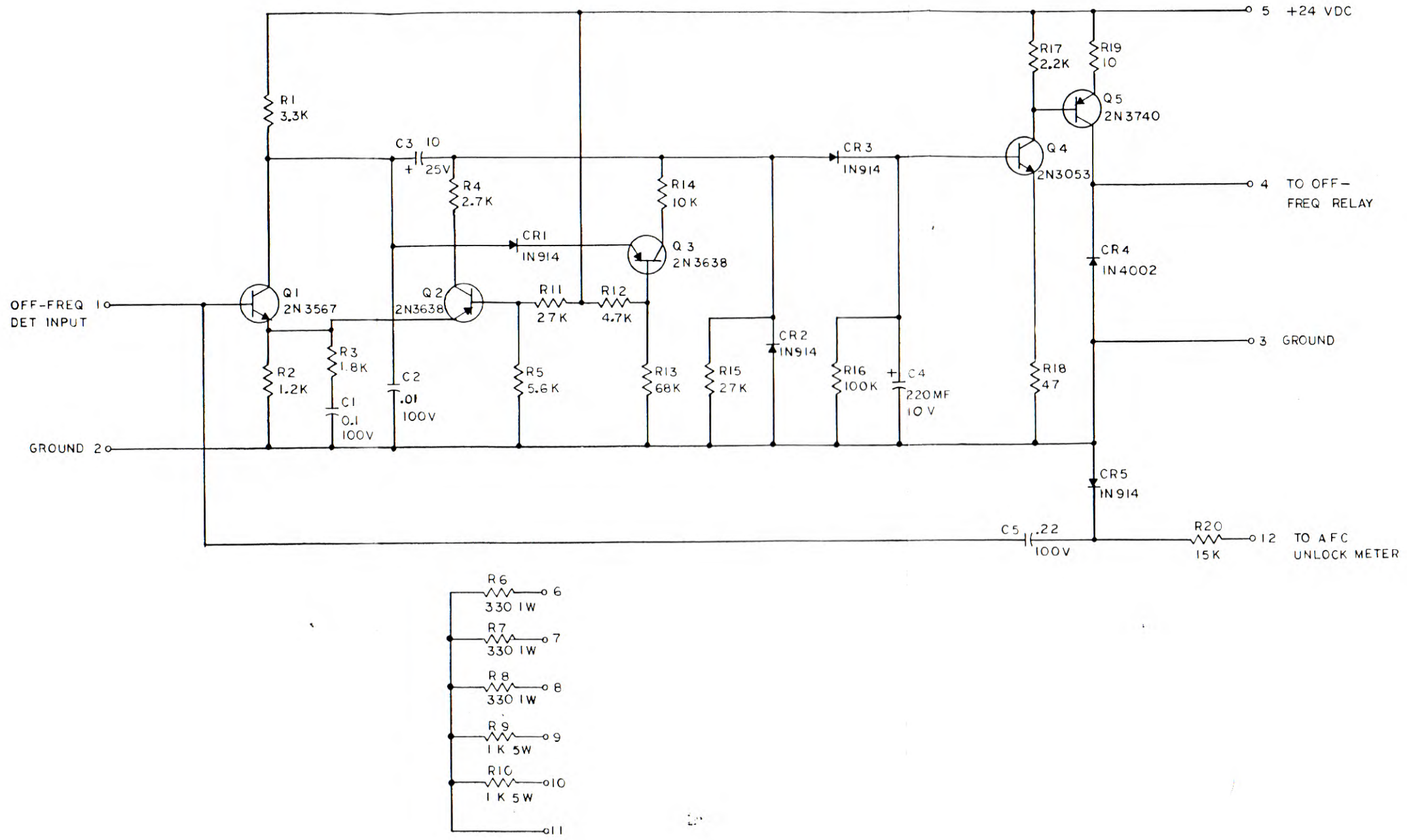
Figure 5-5. FM Exciter Module A2 Schematic Diagram



NOTES:

1. UNLESS OTHERWISE SPECIFIED, RESISTOR VALUES ARE IN OHMS, 1/4W, ±10% AND CAPACITOR VALUES ARE IN MICROFARADS
2. TRANSISTORS ARE 2N2924
3. DIODES ARE IN914
4. M2 HAS 200 MICROAMPERE MOVEMENT
5. PP VOLTAGE READINGS ARE FOR FULL SCALE (FS) METER DEFLECTION

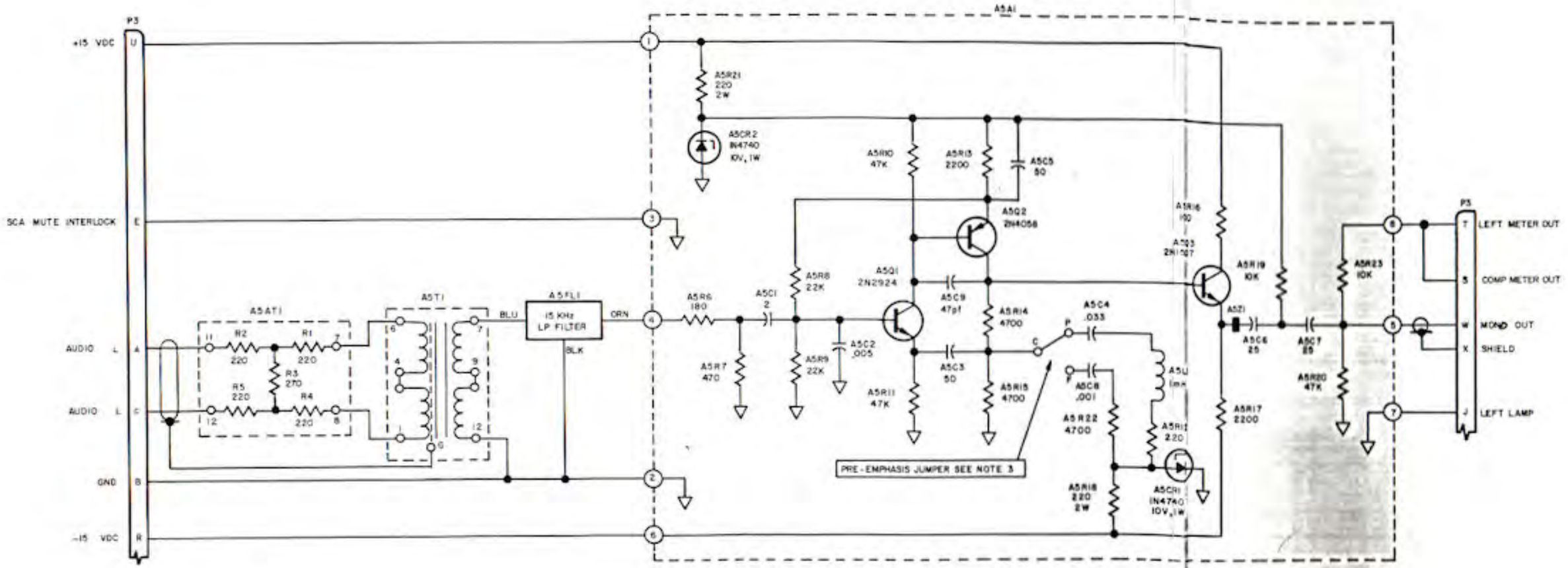
Figure 5-6. Meter Amplifier Board A3 Schematic Diagram



NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   RESISTORS ARE IN OHMS 1/2W, ±10%
   CAPACITORS ARE IN MICROFARADS

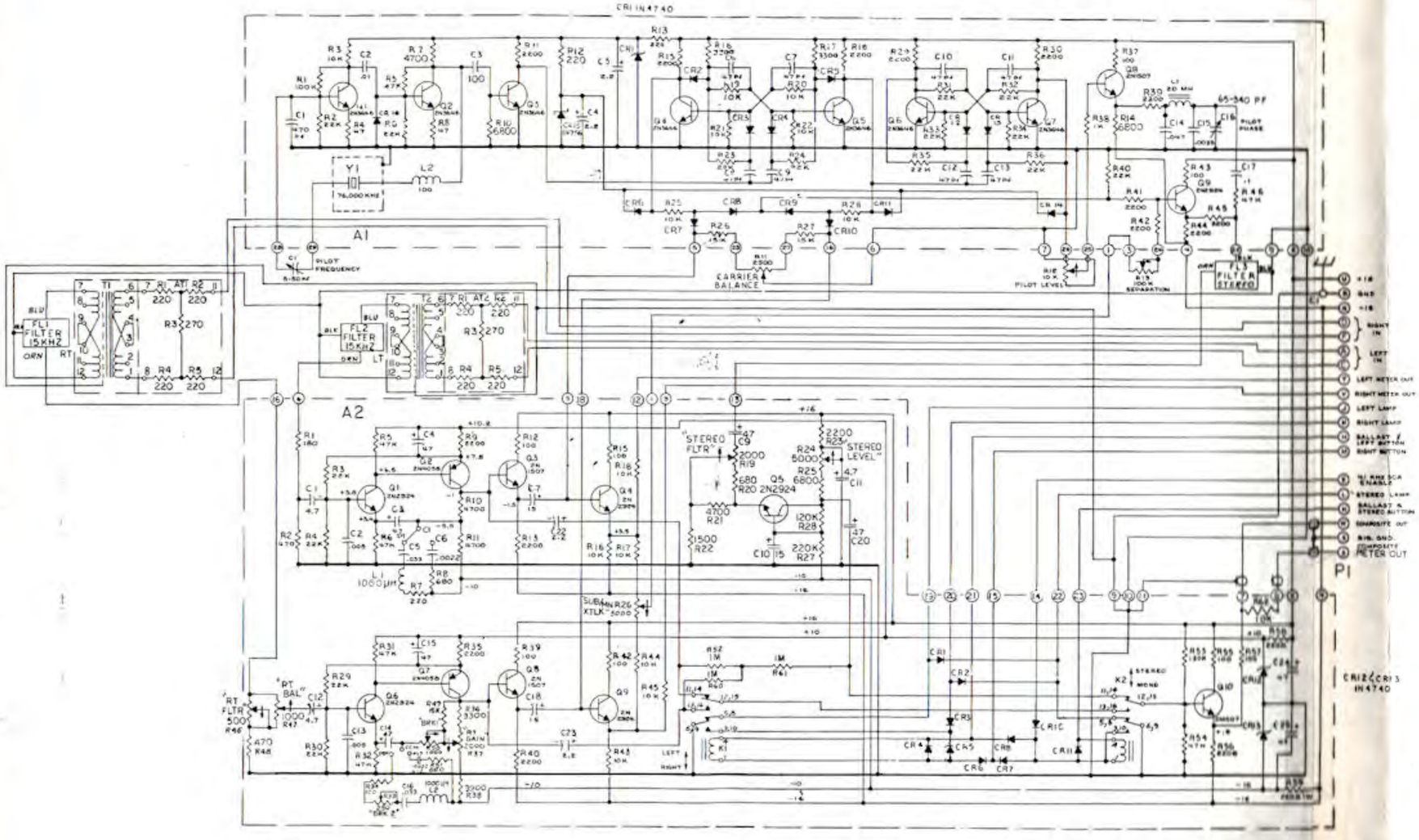
Figure 5-7. Off-Frequency Detector Board A4 Schematic Diagram



NOTES:

1. ALL RESISTORS ARE IN OHMS 1/2W, 10% UNLESS OTHERWISE SPECIFIED
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED
3. FOR PRE-EMPHASIS: CONNECT JUMPER BETWEEN C AND P (AS SHOWN)
   FOR FLAT-EMPHASIS: CONNECT JUMPER BETWEEN C AND F

Figure 5-8. Monaural Module A5 Schematic Diagram

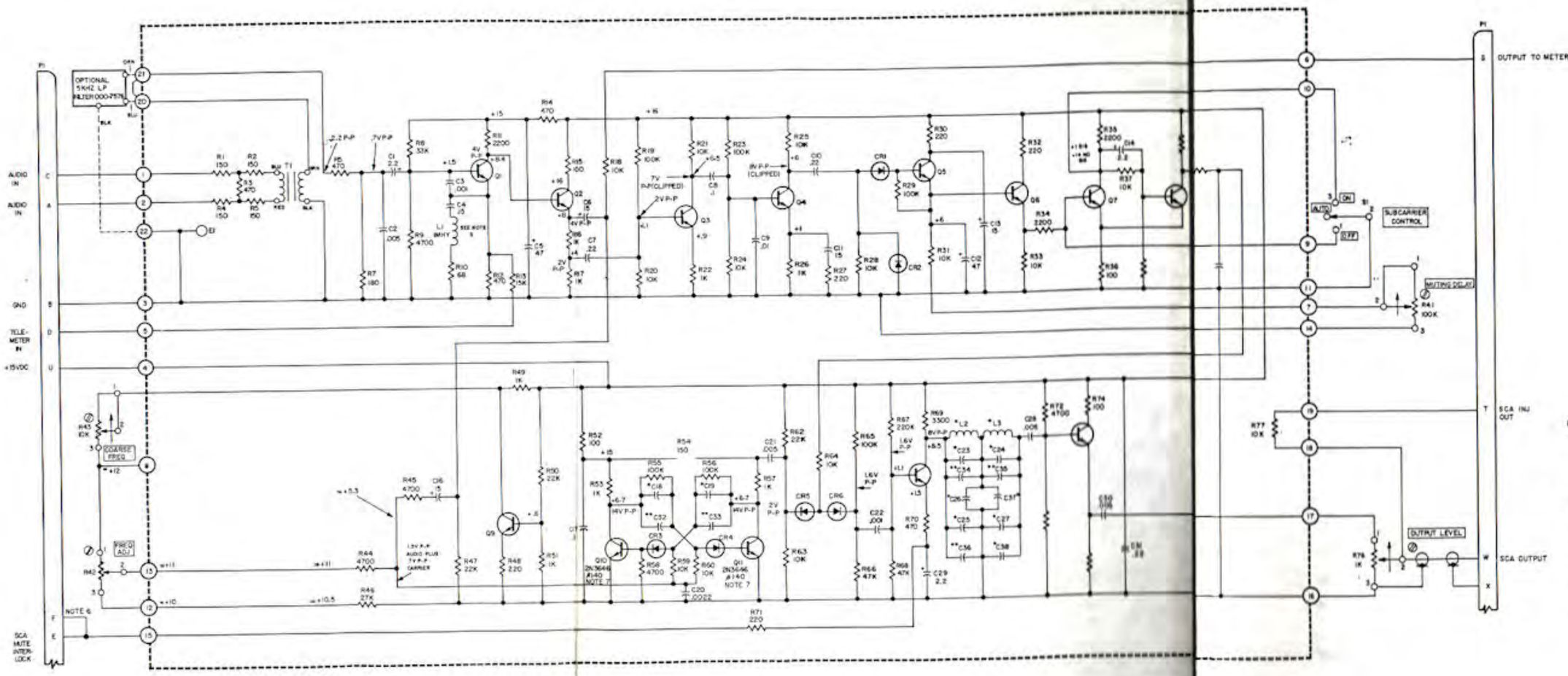


3. ADJUSTMENT ON ANY CONTROL ON BOARD 2 REQUIRES THAT ENTIRE REALIGNMENT PROCEDURE BE FOLLOWED SEE INSTRUCTION MANUAL 098-1241-01

2. ENCIRCLED NUMBERS ARE PC BOARD PINS ENCIRCLED LETTERS ARE CONNECTOR PLUG PINS

NOTES: UNLESS OTHERWISE SPECIFIED RESISTOR VALUE ARE IN OHMS, 1/2W, 10%. CAPACITOR VALUE ARE IN MICROFARADS. DIODES ON A1 ARE IN914 OR EQUIV; DIODES ON A2 ARE IN4005 OR EQUIV.

Figure 5-9. Stereo Module A5 Schematic Diagram



NOTES: UNLESS OTHERWISE SPECIFIED:

1. RESISTOR VALUES ARE IN OHMS, 1/2 WATT, 10%. CAPACITOR VALUES ARE IN MICROFARADS. TRANSISTORS ARE 2N2924. DIODES ARE IN914.
2. ⊘ INDICATES SCREWDRIVER ADJUSTMENT.
3. ENCIRCLED NUMBERS ARE PRINTED CIRCUIT BOARD CONNECTIONS.
4. R10 CONTROLS RESPONSE AT 12 KHz. C4 CONTROLS RESPONSE AT 2 KHz.
5. CAPACITORS IN CHART IN PICOFARADS. INDUCTORS IN CHART IN MICROHENRYS.
6. EXTERNAL MUTING WHEN TUNED FOR 67 KHz AND PROVIDED WITH 5 KHz INPUT FILTER.
7. Q10 & Q11 SELECTED FOR BETA BETWEEN 80 & 100 AT I_C = 10MA, V_{CE} = 5 VOLT.

46/67 KHZ COMPONENT CONVERSION CHART

	L2	L3	C18	C19	C23	C24	C25	C26	C27	C32	C33	C34	C35	C36	C37	C38
67KHZ	4700	5900	510	510	120	430	470	820	820	—	—	—	—	—	—	—
46 KHZ	10000	4700	820	820	150	820	750	820	820	—	—	—	—	—	—	—
67TO 46 KHZ CONVERSION	10000	4700	510	510	120	430	470	820	820	300	300	30	390	470	820	560

Figure 5-10. SCA Modules A6 and A7 Schematic Diagram

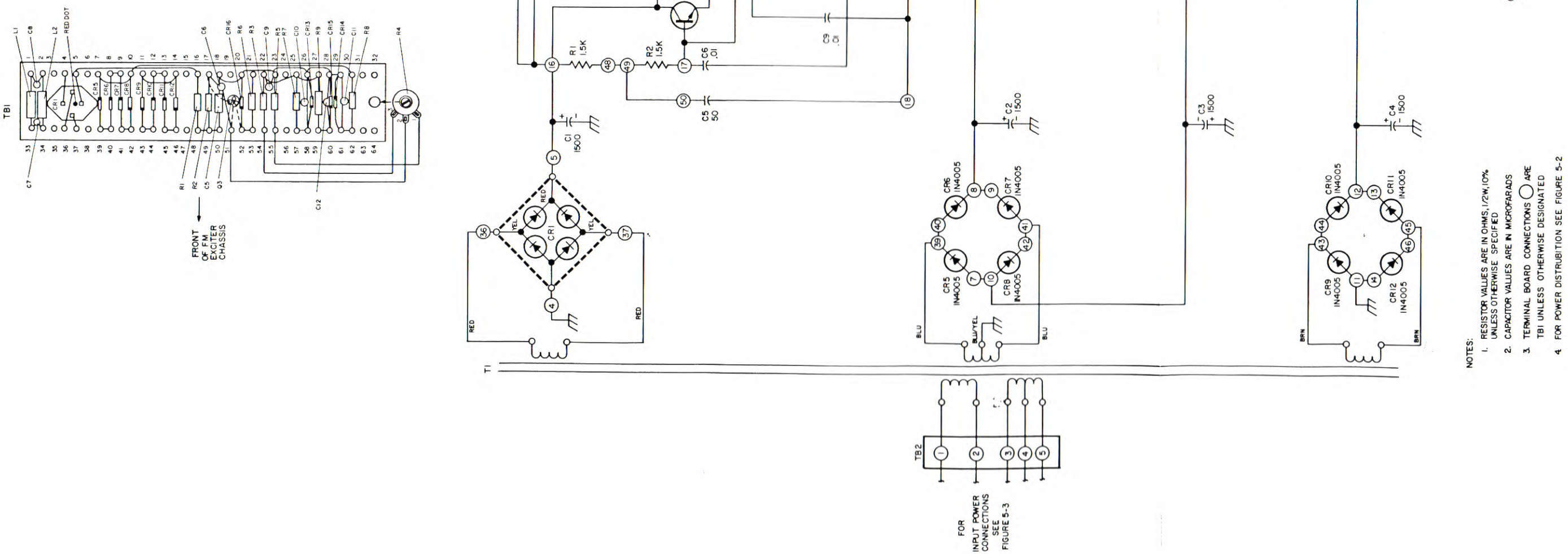


Figure 5-11. Power Supply Schematic Diagram

SECTION VI
REPLACEABLE PARTS

6-1. ORDERING INFORMATION

When ordering parts for the Model 660 FM Exciter give the model number and the serial number of the equipment and the reference designation, G/A part number, manufacturer's part number, and name of manufacturer. To order a part not listed in paragraph 6-3 of this section, give a complete description of the part including function and location.

All parts may be ordered from either of the following offices:

For North and South America, the Pacific area, Australia, and most of the Far East, communicate with:

Granger Associates, Marketing Department
1601 California Avenue, Palo Alto, California
Telephone: 415-321-4175
TWX: 910-373-1291, Cable: RADCOM

For European, African, and Eastern Mediterranean countries, communicate with:

Granger Associates Limited
Granger Corner, 1 Brooklands Road
Weybridge, Surrey, England
Telephone: BYFLEET 44261-2, -3, or -4
Telex: 851-261780 Answerback ANSOUND WALTON
Cable: ANSOUND-Walton-on-Thames

6-2. PARTS LOCATION

The location of parts listed in tables 6-2 through 6-17 are shown in figures 6-1 through 6-12. Wherever possible, individual components are identified in these figures in relationship to their subassemblies. Components mounted directly to the exciter enclosure are identified by their location on the enclosure assembly.

6-3. TABLES OF REPLACEABLE PARTS

Table 6-1 lists the manufacturers of the component parts of the Model 660 FM Exciter. These manufacturers are referenced for each component by a 5-digit code number which appears in the column headed "Mfr" in tables 6-2 through 6-17.

When ordering a replaceable part, provide all the data listed in the replaceable parts table as well as the name and address of the manufacturer and the code number indicated in table 6-1.

Table 6-2 lists the replaceable parts of the Model 660 FM Exciter down to the chassis-mounted component and major subassembly level. Tables 6-3 through 6-17 list the replaceable parts for each of the major subassemblies down to the component level. The parts lists are organized as follows:

Chassis-Mounted Components	Table 6-2
RF Amplifier Module A1	Table 6-3
FM Exciter Module A2	Table 6-4
Modulated Oscillator Assembly A2A1	Table 6-5
AFC Assembly A2A2	Table 6-6
Meter Amplifier Assembly A3	Table 6-7
Off-Frequency Detector Assembly A4	Table 6-8
Monaural Module A5	Table 6-9
Monaural Module Assembly A5A1	Table 6-10
Stereo Generator Module A5	Table 6-11
Stereo Generator Module Assembly A5A1	Table 6-12
Stereo Generator Module Assembly A5A2	Table 6-13
41-kHz SCA Module A6	Table 6-14
41-kHz SCA Module Assembly A6A1	Table 6-15
67-kHz SCA Module A7	Table 6-16
67-kHz SCA Module Assembly A7A1	Table 6-17

Table 6-1. List of Manufacturers

Code No.	Manufacturer	Address
MOLEX	Molex Products Company	Brookfield, Ill.
SCHMI	Schmidt Electronics	Sonoma, Calif.
01121	Allan-Bradley Company	Milwaukee, Wisc.
01295	Texas Instruments Inc. Semiconductor-Components Division	Dallas, Tex.
02114	Ferroxcube Corporation of America	Saugerties, N.Y.
02660	Amphenol Corporation	Broadview, Ill.
02735	Radio Corporation of America Solid State and Receiving Tube Division	Somerville, N.J.
03508	General Electric Company Semiconductor Products Department	Syracuse, N.J.
04713	Motorola Semiconductor Products Incorporated	Phoenix, Ariz.
07263	Fairchild Camera & Instrument Corporation Semiconductor Division	Mountain View, Calif.
08806	General Electric Company Miniature Lamp Dept.	Cleveland, Ohio
08935	Granger Associates	Palo Alto, Calif.
13934	Midwec Corporation	Oshkosh, Nebr.
17117	Electronic Molding Corporation	Pawtucket, R.I.
24759	Lenox-Fugle Electronics Inc.	Watchung, N.J.
44655	Ohmite Manufacturing Company	Skokie, Ill.
56289	Sprague Electric Company	North Adams, Mass.
71400	Bussman Manufacturing Division of McGraw-Edison	Lt. Louis, Mo.
71590	Centralab Division of Globe-Union Inc.	Milwaukee, Wisc.
71785	Cinch Manufacturing Co. & Howard B. Jones Div.	Chicago, Ill.
72136	Electro Motive Manufacturing Company Inc.	Willimantic, Conn.
72619	Dialight Corporation	Brooklyn, N.Y.
73445	Amperex Electronic Corporation	Hicksville, L.I., N.Y.
73899	JFD Electronics Co. A Division of Stratford Retreat House	Brooklyn, N.Y.
74970	EF Johnson Company	Waseca, Minn.
76493	JW Miller Company	Los Angeles, Calif.
80089	Essex Wire Corp. Controls Division	Logansport, Ind.
80223	United Transformer Company	New York, N.Y.
80294	Bourns Incorporated	Riverside, Calif.
80740	Beckman Instruments Inc.	Fullerton, Calif.
81312	Winchester Electronics Division Litton Industries	Oakville, Conn.
81349	Military Specification	
83330	Herman H. Smith Inc.	Brooklyn, N.Y.
88245	Litton Industries USECO Division	Van Nuys, Calif.
94990	Motorola Inc. Government Electronics Division	Scottsdale, Ariz.
95146	Alco Electronics Products Inc.	Lawrence, Mass.
98291	Sealectro Corporation	Mamaroneck, N.Y.

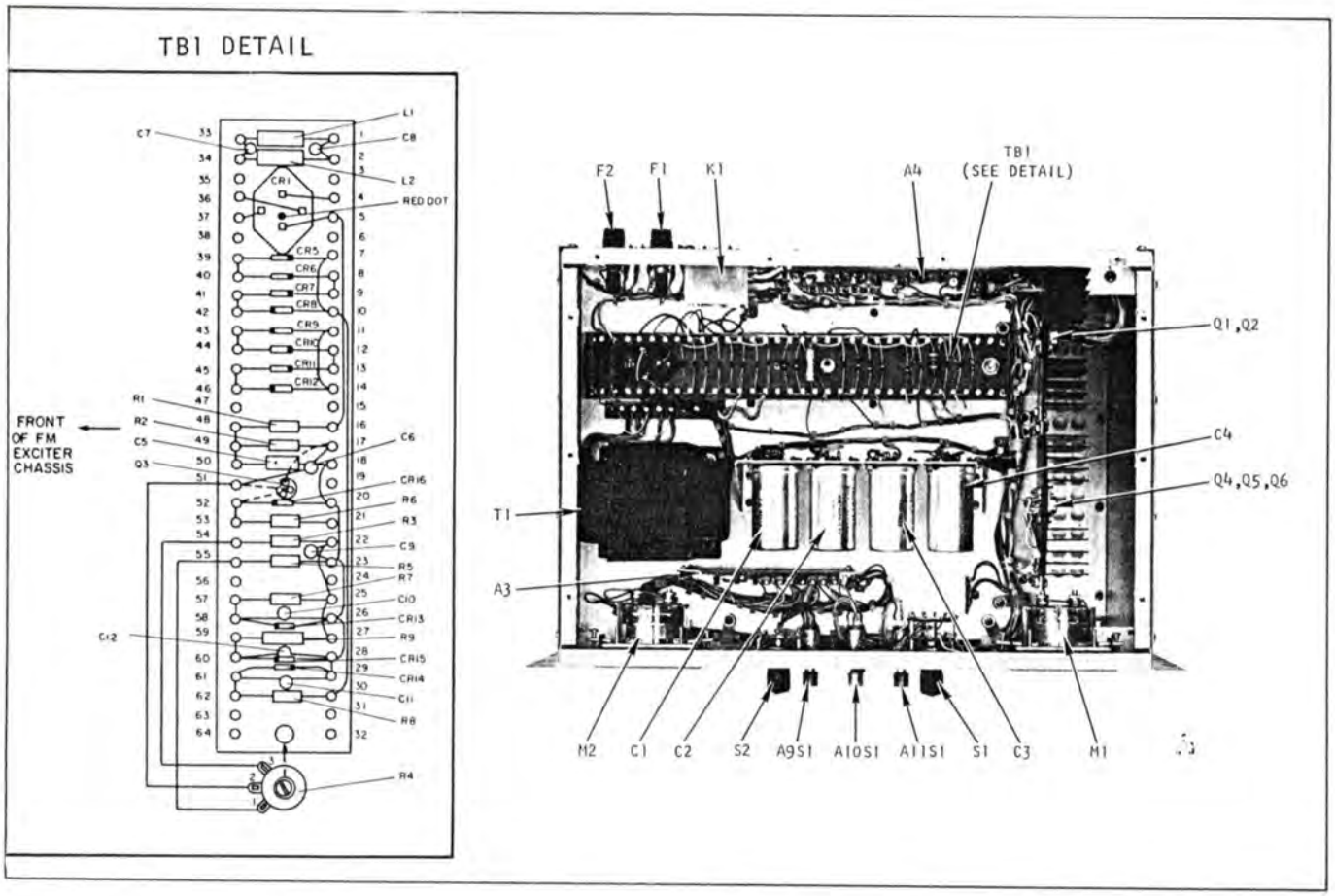


Figure 6-1. Model 660 FM Exciter Top View

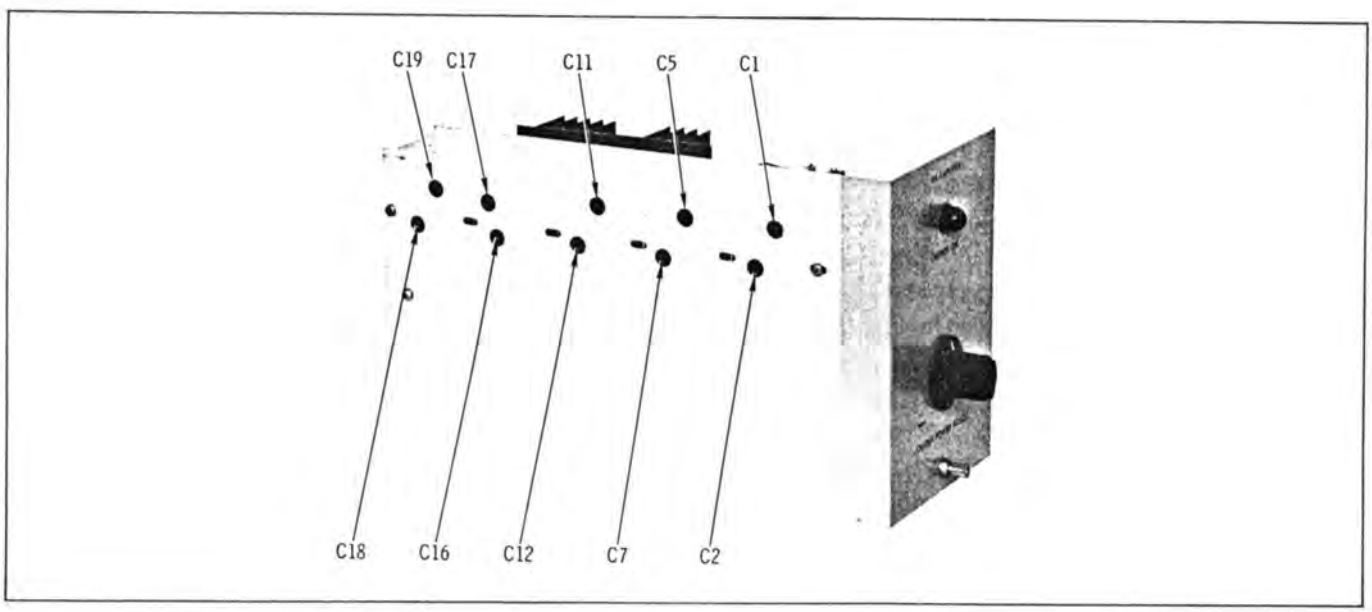


Figure 6-2. RF Amplifier Module Side View

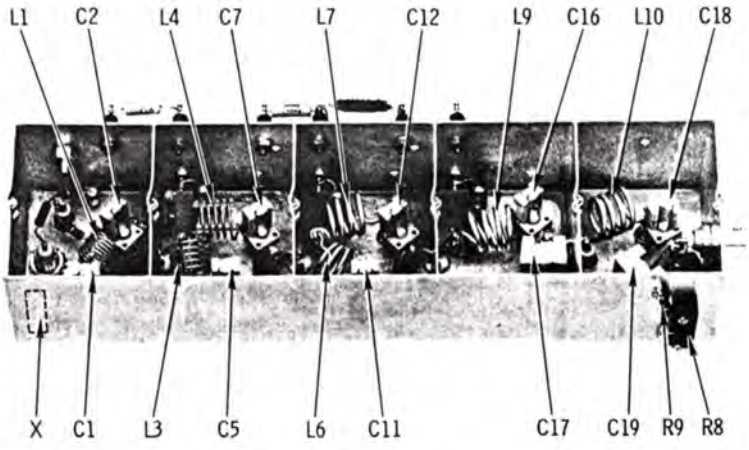


Figure 6-3. RF Amplifier Assembly Top View (Cover Removed)

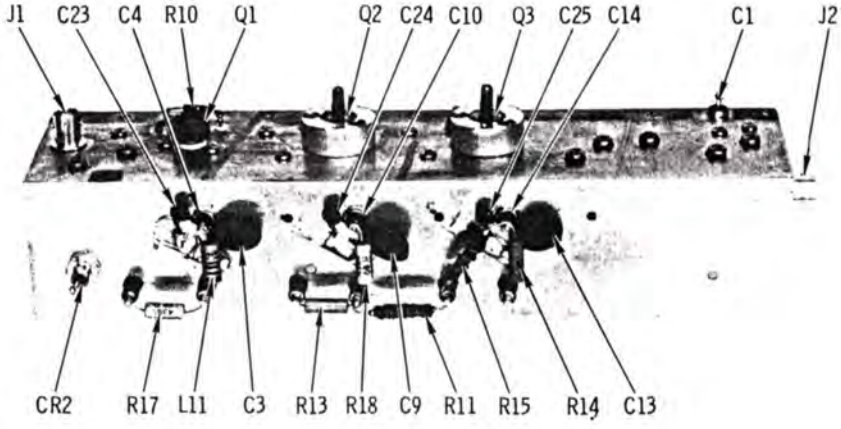


Figure 6-4. RF Amplifier Assembly Bottom View

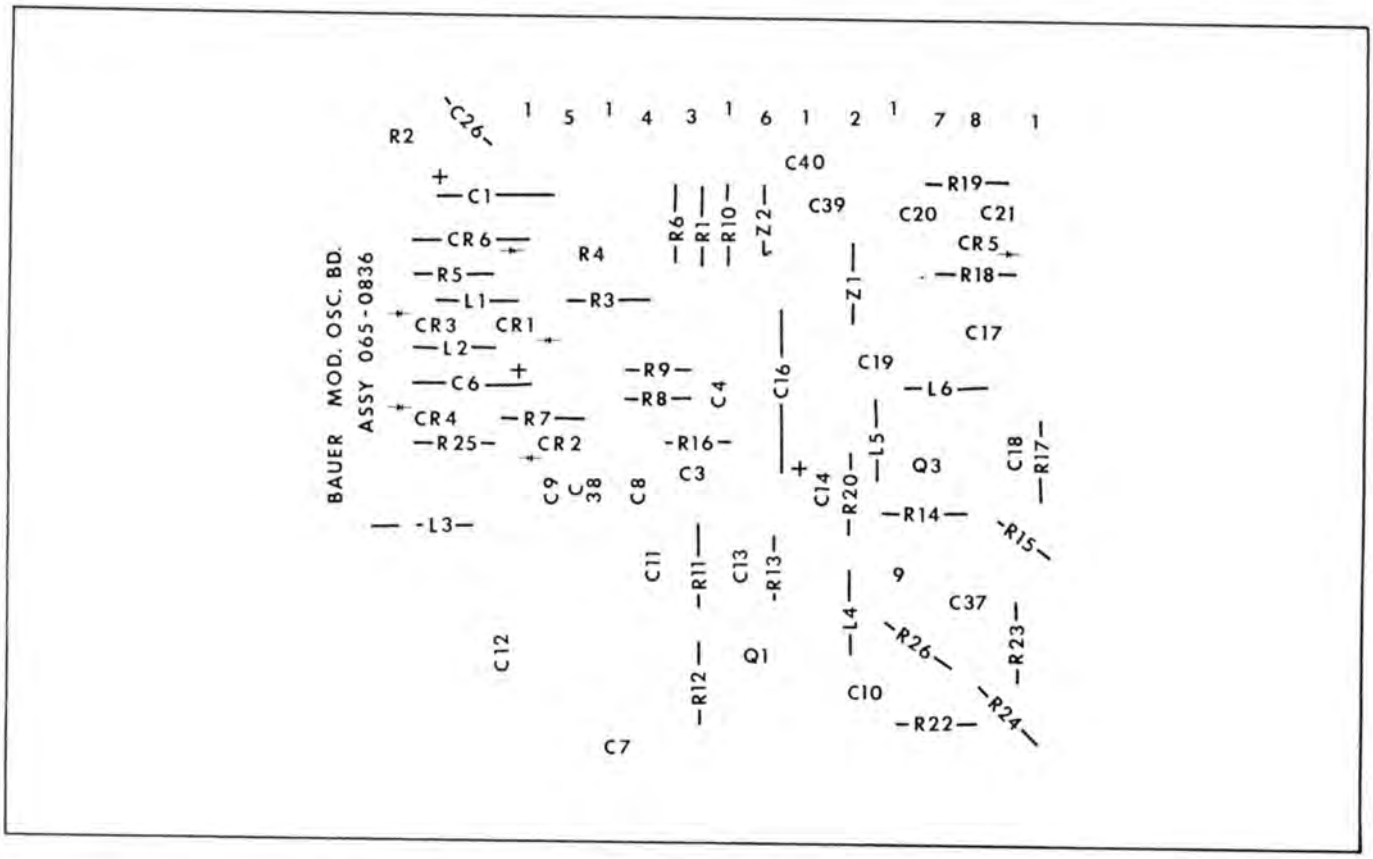


Figure 6-5. Modulated Oscillator Assembly A2A1

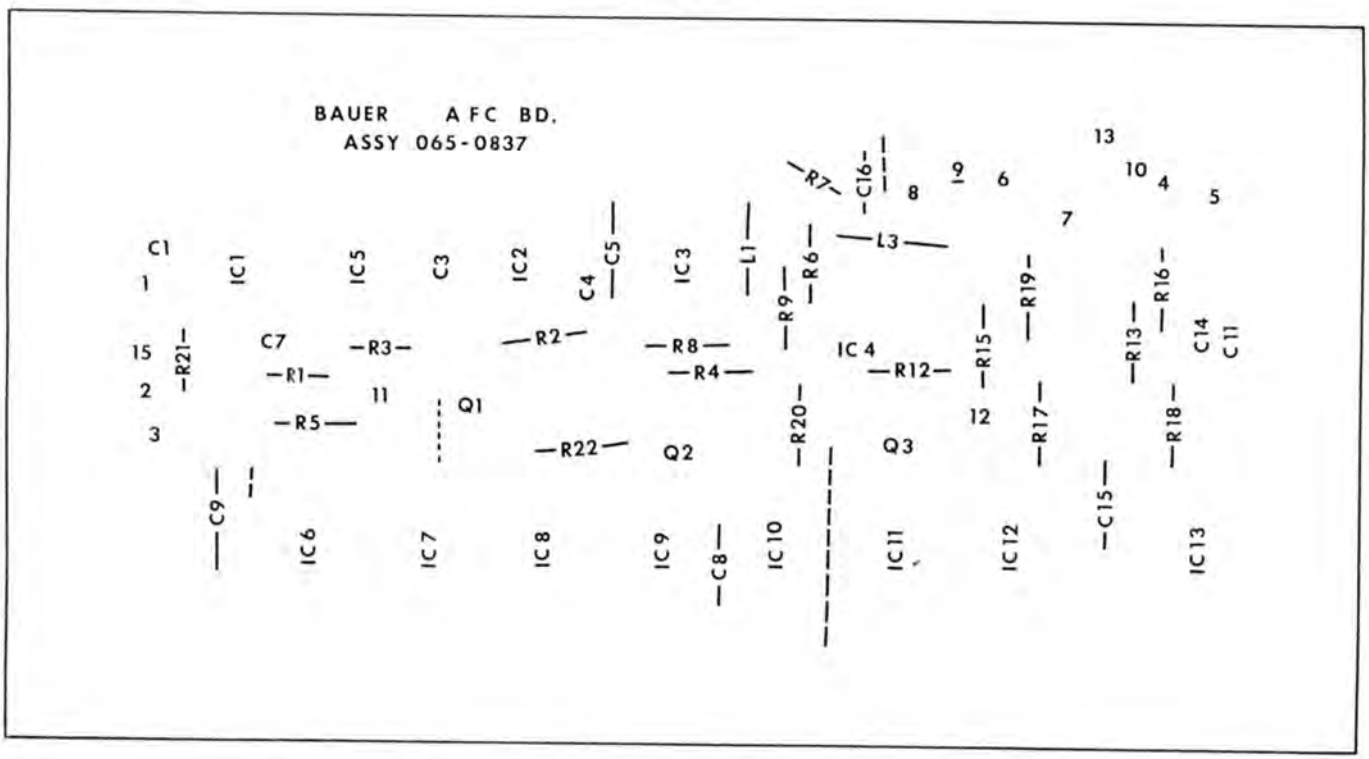


Figure 6-6. AFC Module Assembly A2A2

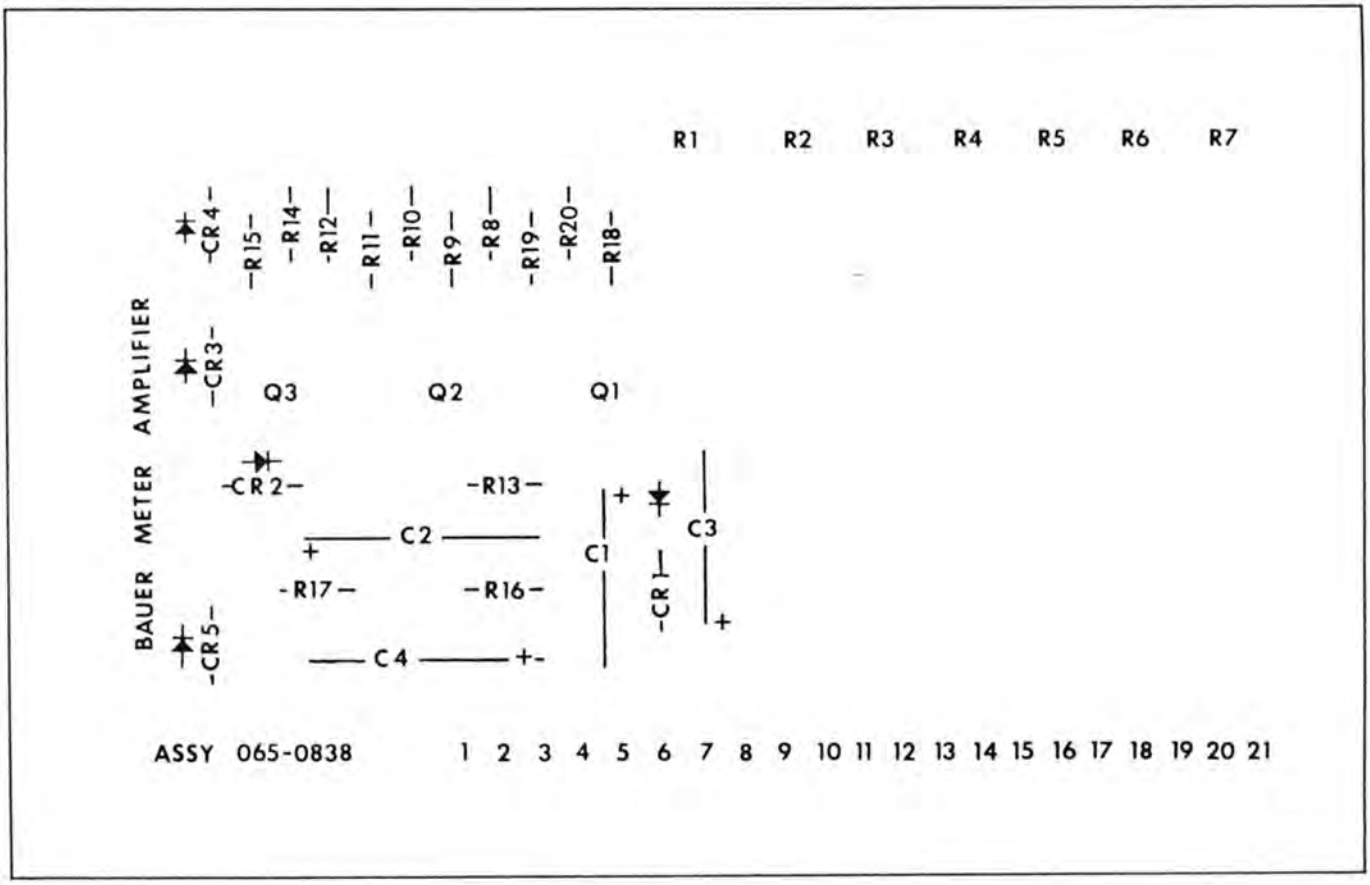


Figure 6-7. Meter Amplifier Assembly A4

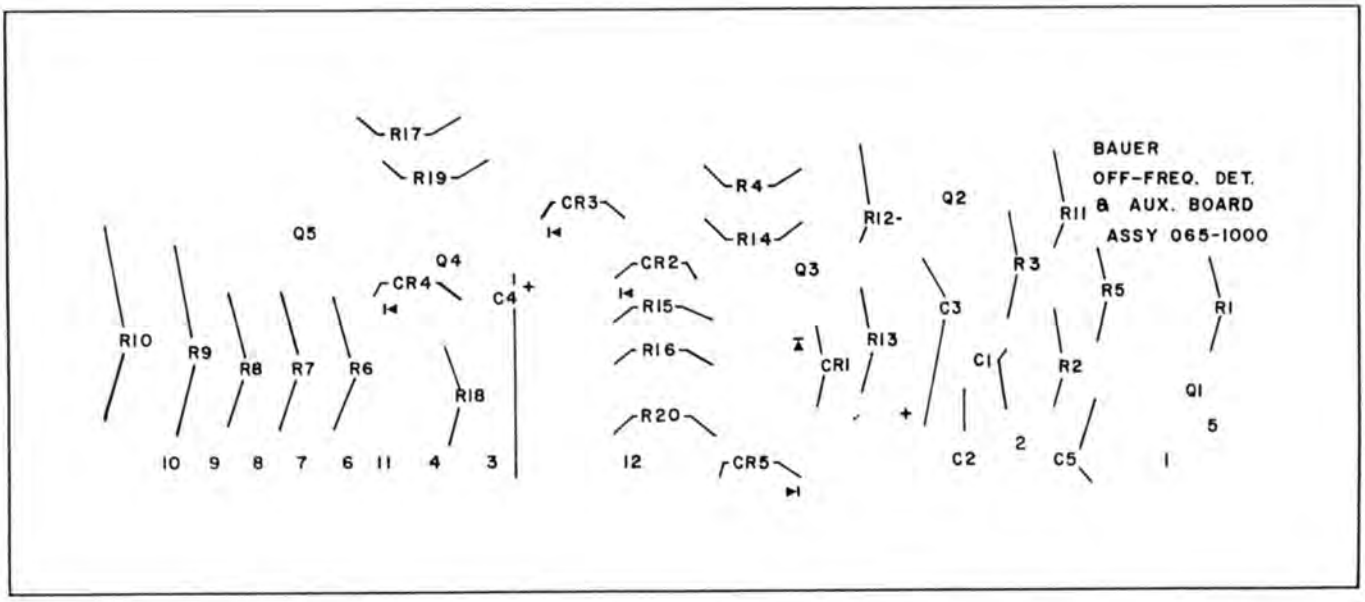


Figure 6-8. Off-Frequency Detector Assembly A5

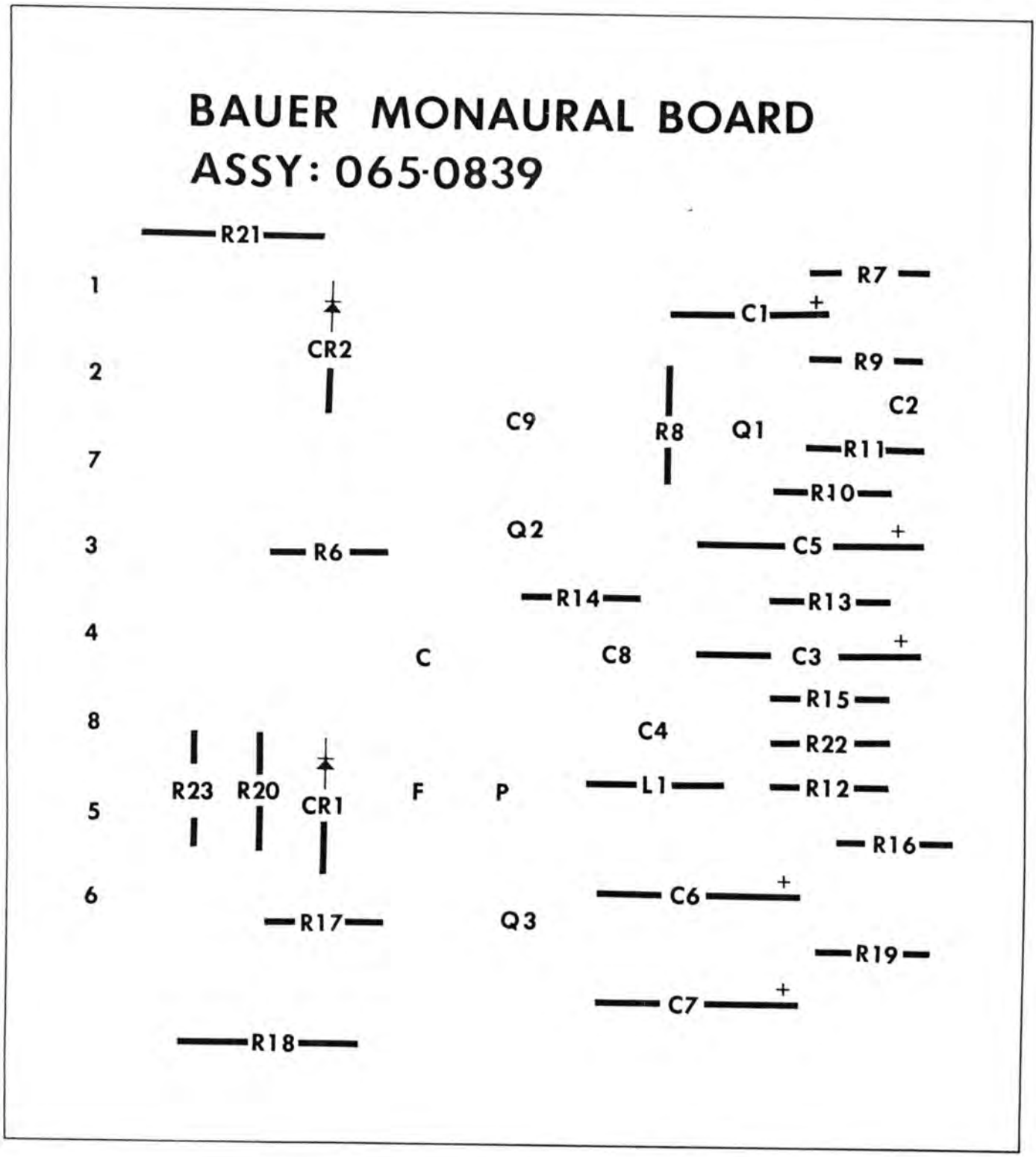


Figure 6-9. Monaural Module Assembly A5A1

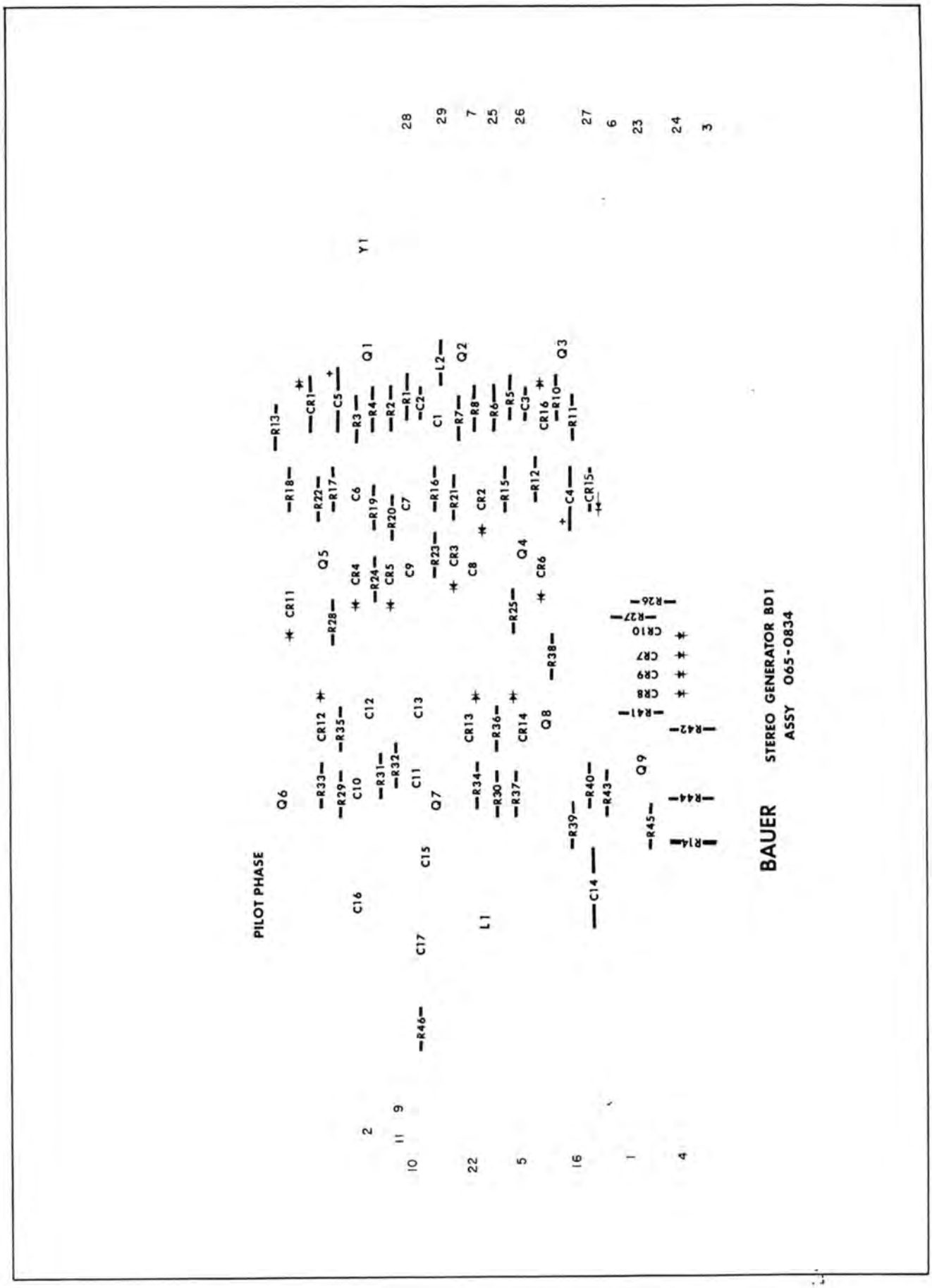


Figure 6-10. Stereo Generator Assembly A5A1

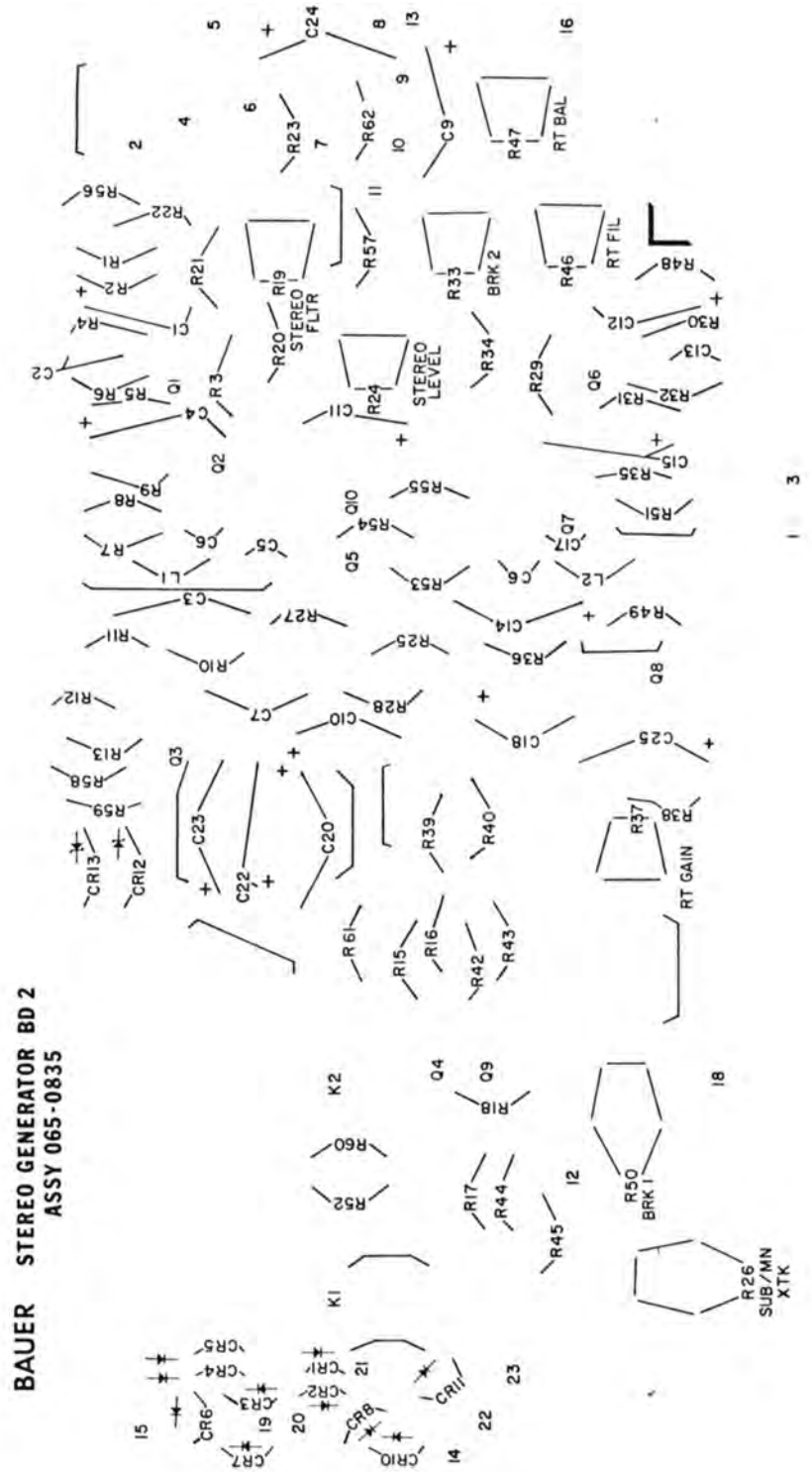


Figure 6-11. Stereo Generator Assembly A5A2

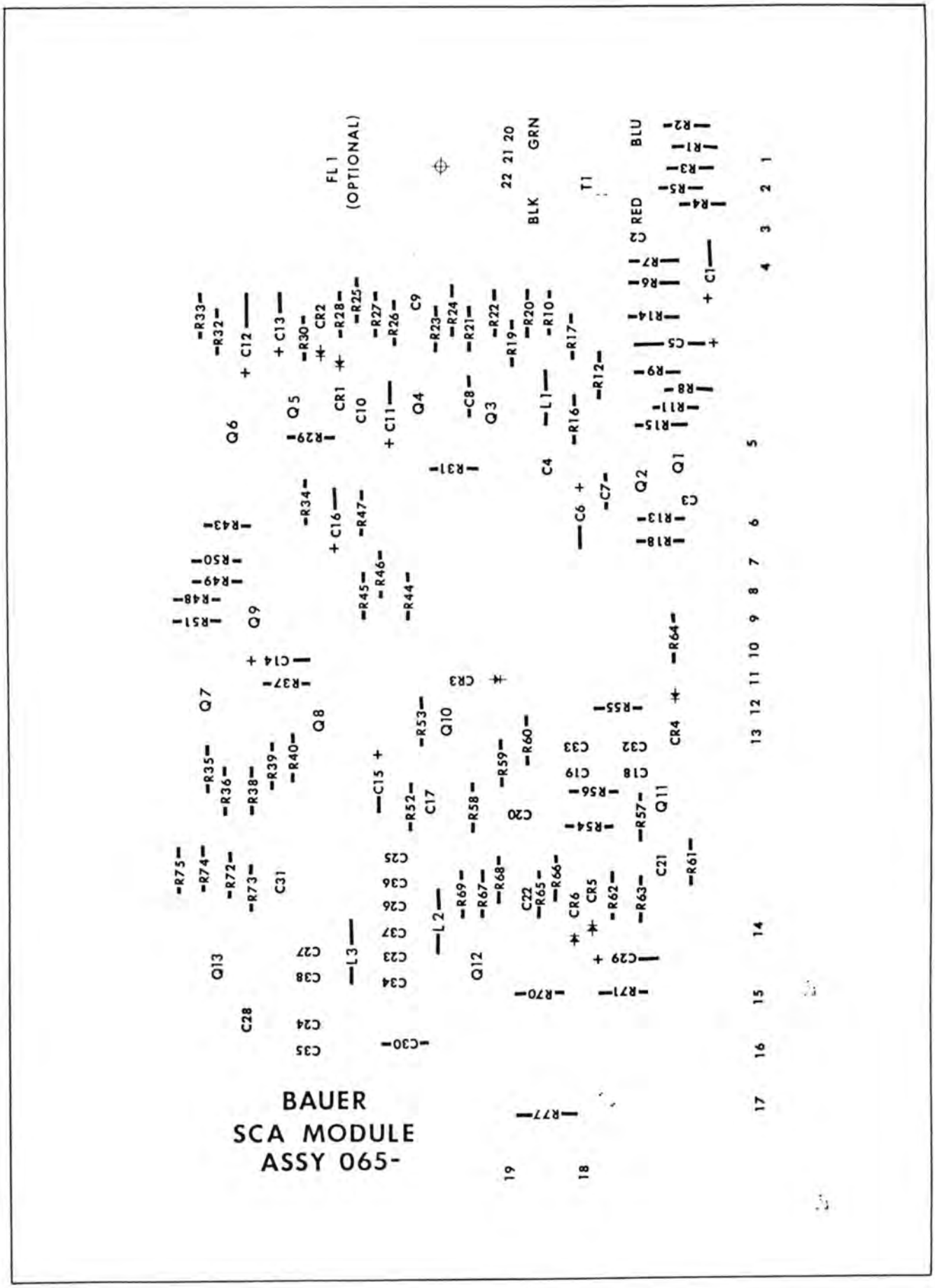


Figure 6-12. SCA Module Assemblies A6 and A7

Table 6-2. Chassis-Mounted Components (Part 1 of 3)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
A1	RF Amplifier Module	001-7559-01	08935		1
A2	FM Exciter Module	001-7560-01	08935		1
A3	Meter Amplifier Assy	065-0838-01	08935		1
A4	Off-Frequency Detector Assy	065-1000-01	08935		1
A5	Monaural Module	001-7565-01	08935		1
A5	Stereo Generator Module	001-7562-01	08935		option
A6	41-kHz SCA Module	001-7568-01	08935		option
A7	67-kHz SCA Module	001-7566-01	08935		option
A9DS1	Lamp, type 327	244-0033-01	08806	327	3
A10DS1	Same as A9DS1				
A11DS1	Same as A9DS1				
A9S1	Lampholder/switch	247-1414-01	72619	513-0101-604	3
A10S1	Same as A9S1				
A11S1	Same as A9S1				
C1-C4	Capacitor, 1500μf, 50v	112-0060-01	08935		4
C5	Capacitor, 50μf, 50v	112-1389-01	56289	30D506G050DD4	1
C6	Capacitor, .005μf, 100v	110-1060-01	56289	TG-D50	1
C7-C8	Capacitor, .05μf, 500v	110-0037-01	56289	33C58	2
C9-C12	Capacitor, .01μf, 100v	110-0006-01	08935		4
CR1	Rectifier, bridge	161-0332-01	94990	MDA-952-3	1

Table 6-2. Chassis-Mounted Components (Part 2 of 3)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
CR5-CR12	Diode, 1N4005	161-0269-01	04713	1N4005	8
CR13-CR14	Diode, 1N4745	161-0243-01	04713	1N4745	2
CR15	Diode, 1N4731A	161-0241-01	04713	1N4731A	1
CR16	Diode, 1N4740	161-0242-01	04713	1N4740	1
F1	Fuse, 2A, 125v	261-0080-01	71400	MDL2	1
F2	Fuse, 2-1/2A, 125v	261-0081-01	71400	MDL2-1/2	1
J1-J4	Connector	286-4031-17	81312	MRE20SG7	4
J5	Connector	286-1378-01	MOLEX	1375R	1
K1	Relay, 24v	180-0051-01	80089	93Q-951	1
L1-L2	Choke, 8.8μh	186-1313-01	76493	5220	2
M1	Meter, 50μA	368-9130-01	08935		1
M2	Meter, 200μA	368-9131-01	08935		1
Q1	Transistor, 2N3055	149-0129-01	02735	2N3055	1
Q2	Transistor, 2N3054	149-0128-01	02735	2N3054	3
Q3	Transistor, 2N2924	149-0180-01	03508	2N2924(TO-5)	1
Q4	Same as Q2				
Q5	Transistor, 2N3740	149-0179-01	04713	2N3740	1
Q6	Same as Q2				
R1-R2	Resistor, 1.5K, 10%, 1/2w	136-1152-01	81349	RC20GF152K	2
R3	Resistor, 10K, 10%, 1/2w	136-1172-01	81349	RC20GF103K	1

Table 6-2. Chassis-Mounted Components (Part 3 of 3)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
R4	Resistor, var, 5K, 10%, 2w	130-0091-01	81349	RV4NAYSD502A	1
R5	Resistor, 6.8K, 10%, 1/2w	136-1168-01	81349	RC20GF682K	1
R6	Resistor, 1.8K, 10%, 1/2w	136-1154-01	81349	RC20GF182K	1
R7-R8	Resistor, 470, 10%, 1/2w	136-1140-01	81349	RC20GF471K	2
R9	Resistor, 470, 10%, 2w	136-1540-01	81349	RC42GF471K	1
R10	Resistor, 1M, 1%, 1/4w	134-2786-01	81349	RN60D1004F	2
R11-R15	N/A				
R16	Same as R10				
R17	Resistor, 100K, 1%, 1/4w	134-0195-01	81349	RN60D1003F	1
S1	Switch, rotary	295-0027-01	71590	PA-1005	1
S2	Switch, rotary	295-0025-01	71590	PA-1001	1
T1	Transformer, power	326-0372-01	08935		1
TB1	Terminal board, main	022-0105-01	08935		1
TB2	Terminal board, auxiliary	022-0111-01	08935		1
TB3	Terminal board	477-0010-01	71785	10-164	1
TB6-TB7	Terminal strip	477-0137-01	71785	10-174	2
TP1	Jack, test, yellow	407-0057-01	74970	105-607	1
TP2	Jack, test, red	407-0053-01	74970	105-602	1
XF1-XF2	Fuseholder	261-0043-01	71400	HKP[illegible]	2

Table 6-3. RF Amplifier Module A1 Parts List (Part 1 of 3)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
C1-C2	Capacitor, var, 3-25pf	109-0020-02	74970	189-509-4	7
C3	Capacitor, .1μf	110-0007-01	08935		3
C4	Capacitor, feedthru, .001μfd	110-0613-01	01121	FA5C-102W	7
C5	Same as C1				
C6	Same as C4				
C7	Same as C1				
C8	Same as C4				
C9	Same as C3				
C10	Same as C4				
C11-C12	Same as C1				
C13	Same as C3				
C14-C15	Same as C4				
C16	Same as C1				
C17	Capacitor, var, 2.5-54pf	109-0052-01	74970	194-8-4	2
C18	Capacitor, var, 2.2-34pf	109-0019-01	74970	193-10-5	1
C19	Same as C17				
C20	Capacitor, 2pf	101-0142-01	72136	DM15C020M0500WV4CR	1
C21	Same as C4				
C22	Capacitor, 20pf	110-0435-01	71590	TCZ-20	1
C23-C25	Capacitor, .001μf	110-0204-01	08935		3

Table 6-3. RF Amplifier Module A1 Parts List (Part 2 of 3)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
CR1	Diode, 1N914	161-0096-01	01295	1N914	1
CR2	Diode, 1N2988A	161-0246-01	04713	1N2988A	1
DS1	Lamp	244-0033-01	08806	MS23277-327	1
E1-E6	Terminal, standoff	484-0048-01	17117	2574-91-1	6
E7	N/A				
E8-E9	Terminal, standoff	484-0071-01	98291	ST-SM-1TUR	2
J1-J2	Connector, RF, BNC	287-0034-01	02660	UG1094A/U	2
L1	Coil, inductor	022-0655-01	08935		1
L2	Choke, 2.7μh	186-0183-01	81349	LT4K006	3
L3-L4	Coil, inductor	022-0156-01	08935		2
L5	Same as L2				
L6	Coil, inductor	022-0653-01	08935		1
L7	Coil, inductor	022-0654-01	08935		3
L8	Same as L2				
L9-L10	Same as L7				
L11	Choke, 100μh	186-0207-01	81349	MS75052-5	1
Q1	Transistor, 2N3866	149-0121-01	02735	2N3866	1
Q2	Transistor, 2N3375	149-0178-01	02735	2N3375	1
Q3	Transistor, 2N5102	149-0181-01	02735	2N5102	1
R1-R2	Resistor, 15, 10%, 1/2w	136-1104-01	81349	RC20GF150K	2

Table 6-3. RF Amplifier Module A1 Parts List (Part 3 of 3)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
R3	Resistor, 68, 10%, 1/2w	136-1120-01	81349	RC20GF680K	1
R4	Resistor, 100, 10%, 1/2w	136-1124-01	81349	RC20GF101K	1
R5	Resistor, 47, 10%, 1/2w	136-1116-01	81349	RC20GF470K	2
R6	Resistor, 10, 10%, 1/2w	136-1100-01	81349	RC20GF100K	1
R7	Same as R5				
R8	Resistor, var, 100K	130-0331-01	80294	3068P1-104	1
R9	Resistor, 22K, 10%, 1/2w	136-1180-01	81349	RC20GF223K	1
R10	Resistor, 6.8K, 10%, 1/2w	136-1168-01	81349	RC20GF682K	1
R11	Resistor, .24, 1%	131-1375-02	SCHMI	.24Ω, ±1%	1
R13	Resistor, 2.8K, 1%, 1/2w	134-2808-01	81349	RN65D2801F	1
R14	Resistor, 1.6K, 1%, 1/2w	134-2809-01	81349	RN65D1601F	1
R15	Resistor, .06, 1%	131-1375-01	SCHMI	.06Ω, ±1%	1
R16	Resistor, var, 12, 50w	137-0229-01	44655	0314	
R17	Resistor, 68, 3w	131-0629-01	56289	450E6805	1
R18	Resistor, 3, 3w	131-0604-01	56289	450E3R05	1
R19	Resistor, 560, 1/2w	136-1142-01	81349	RC20GF561K	1
Z1-Z3	Bead, shielding	599-0115-01	02114	VK200 20/4B	3

Table 6-4. FM Exciter Module A2 Parts List

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
A2A1*	Modulated Oscillator Assy	065-0836-01	08935		1
A2A2**	AFC Assy	065-0837-01	08935		1
C1-C10	N/A				
C11	Capacitor, 10μf, 50v	112-1380-01	56289	30D106G050CB4	1
C12	Capacitor, 1000μf, 16v	112-1451-01	73445	C437AR/E1000	1
E1-E3	Terminal, insulated	484-0103-01	88245	4448B	3
HR1	Oven, crystal	165-0400-01	08935		1
J1	Connector, receptacle	287-0065-01	02660	31-318	1
P1	Connector	286-4031-16	81312	MRE20PG7	1
Q1	Transistor, 2N3054	149-0128-01	02735	2N3054	1
R1	Resistor, 470, 10%, 1/2w	136-1140-01	81349	RC20GF685K	1
R2	Resistor, 47K, 10%, 1/2w	136-1188-01	81349	RC20GF473K	1
R3	Resistor, 10, 10%, 1/2w	136-1100-01	81349	RC20GF270K	1
R11	Resistor, 68, 5%, 3w	131-0629-01	56289	450E6805	1
XHR1	Socket, octal	396-0062-01	71785	8AM	1

* See table 6-5
** See table 6-6

Table 6-5. Modulated Oscillator Assembly A2A1 Parts List (Part 1 of 3)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
C1	Capacitor, 47μf, 6v	104-0125-01	08935		1
C2	N/A				
C3	Capacitor, 270pf	101-0183-01	72136	DM15F271J0500WV4CR	8
C4	Capacitor, .47μf, 25v	110-0040-01	56289	5C023474X0250B3	1
C5	N/A				
C6	Capacitor, 10μf, 20v	104-0119-01	08935		1
C7	Capacitor, var, 2-34pf, 650v	109-0019-01	74970	193-10-5	1
C8	Capacitor, 27pf, 500v	110-0486-01	71590	TCN-27	1
C9	Capacitor, 22pf, 600v	110-0436-02	71590	TCZ-22	1
C10	Same as C3				
C11	Capacitor, 39pf, 600v	110-0433-01	71590	TCZ-39	1
C12	Capacitor, var, 0.5-4.5pf	113-0018-01	73899	NVC25G	1
C13-C14	Same as C3				
C15	N/A				
C16	Capacitor, 150μf, 15v	104-0131-01	08935		1
C17	Capacitor, var, 2.4-24.5pf	109-0078-01	74970	189-509-5	1
C18-C20	Same as C3				
C21	Capacitor, .001μf	110-0204-01	08935		3
C22-C25	N/A				
C26	Capacitor, .005μf	110-1060-01	56289	TG-D50	1

Table 6-5. Modulated Oscillator Assembly A2A1 Parts List (Part 2 of 3)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
C27-C36	N/A				
C37	Same as C3				
C38	Capacitor, 10pf, 600v, 2%	110-0436-03	71590	TCZ-10	1
C39-C40	Same as C21				
CR1-CR4	Diode, MV840	161-0245-01	04713	MV840	4
CR5	Diode, 1N914	161-0096-01	01295	1N914	1
CR6	Diode, 1N4740	161-0242-01	04713	1N4740	2
L1-L2	Choke, RF, 3.9μh	186-0014-01	81349	MS18130-15	4
L3	Coil, mod oscillator	022-0123-01	08935		1
L4-L5	Same as L1				
L6	Choke, RF, 4.7μh	186-0004-01	81349	MS18130-4	1
Q1	Transistor, 2N4427	149-0183-01	02735	2N4427	2
Q2	N/A				
Q3	Same as Q1				
R1	Resistor, 4.7K, 10%, 1/4w	136-1040-01	81349	RC07GF472K	3
R2	Resistor, var, 500	137-0876-01	80740	62PR500	1
R3	Resistor, 330, 10%, 1/4w	136-1026-01	81349	RC07GF331K	1
R4	Resistor, var, 10K	137-0880-01	80740	62PR10K	1
R5	Resistor, 2.2K, 10%, 1/4w	136-1036-01	81349	RC07GF222K	1
R6	Resistor, 15K, 10%, 1/4w	136-1046-01	81349	RC07GF153K	2

Table 6-5. Modulated Oscillator Assembly A2A1 Parts List (Part 3 of 3)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
R7	Resistor, 100K, 10%, 1/4w	136-1056-01	81349	RC07GF104K	1
R8	Resistor, 8.2K, 10%, 1/4w	136-1043-01	81349	RC07GF822K	1
R9	Resistor, 470K, 10%, 1/4w	136-1064-01	81349	RC07GF474K	1
R10	Same as R6				
R11	Same as R1				
R12	Resistor, 10K, 10%, 1/4w	136-1044-01	81349	RC07GF103K	2
R13	Resistor, 22, 10%, 1/4w	136-1012-01	81349	RC07GF220K	1
R14	Same as R1				
R15	Resistor, 1K, 10%, 1/4w	136-1032-01	81349	RC07GF102K	2
R16	Resistor, 10, 10%, 1/4w	136-1008-01	81349	RC07GF100K	2
R17	Resistor, 15, 10%, 1/4w	136-1010-01	81349	RC07GF150K	1
R18	Same as R15				
R19	Resistor, 220K, 10%, 1/4w	136-1060-01	81349	RC07GF224K	1
R20	Same as R16				
R21	N/A				
R22-R23	Resistor, 27, 10%, 1/2w	136-1110-01	81349	RC20GF270K	2
R24	Resistor, 39, 10%, 1/2w	136-1114-01	81349	RC20GF390K	2
R25	Same as R12				
R26	Same as R24				
Z1-Z2	Bead, shielding	599-0115-01	02114	VK200 20/4B	2

Table 6-6. AFC Assembly A2A2 Parts List (Part 1 of 3)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
C1	Capacitor, 100pf, 5%, 500v	101-0172-01	72136	DM15F101J0500WV4CR	1
C2-C4	Capacitor, .001μf, 1000v	110-0204-01	08935		3
C5	Capacitor, 1μf, 10%, 35v	104-0108-01	08935		2
C6-C7	N/A				
C8	Capacitor, .01μf, 20%, 100v	110-0006-01	08935		1
C9	Same as C5				
C10	N/A				
C11	Capacitor, .1μf, 5%, 100v	105-3226-10	13934	E3XFR.1	2
C12-C13	N/A				
C14	Same as C11				
C15	Capacitor, var, 2-34pf, 650v	109-0021-02	74970	193-10-1	1
C16	Capacitor, .1μf, 100v	110-0007-01	08935		1
IC1	IC MC1027P	425-0014-01	04713	MC1027P	1
IC2-IC3	IC MC1013P	425-0015-01	04713	MC1013P	2
IC4	IC CA3028A	425-0018-01	02735	CA3028A	1
IC5	Same as IC2				
IC6-IC12	IC MC890P	425-0016-01	04713	MC890P	7
IC13	IC MC819P	425-0017-01	04713	MC819P	1
L1	Inductor 100mh	186-0094-05	24759	MR-100,000	2
L2	N/A				

Table 6-6. AFC Assembly A2A2 Parts List (Part 2 of 3)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
L3	Same as L1				
Q1	Transistor, 2N3640	149-0097-01	07263	2N3640	1
Q2	Transistor, 2N4058	149-0184-01	03508	2N4058(TO-5)	1
Q3	Transistor, 2N3053	149-0169-01	02735	2N3053	1
R1	Resistor, 2.2K, 10%, 1/4w	136-1036-01	81349	RC07GF222K	5
R2	Resistor, 120, 10%, 1/4w	136-1021-01	81349	RC07GF121K	1
R3	Resistor, 390, 10%, 1/4w	136-1027-01	81349	RC07GF391K	2
R4	Resistor, 100, 10%, 1/4w	136-1020-01	81349	RC07GF101K	1
R5	Same as R1				
R6	Resistor, 1K, 10%, 1/4w	136-1032-01	81349	RC07GF102K	2
R7-R8	Same as R1				
R9	Same as R6				
R10	N/A				
R11	Resistor, 68, 5%, 3w	131-0629-01	56289	450E6805	1
R12	Same as R1				
R13	Resistor, 10K, 10%, 1/4w	136-1044-01	81349	RC07GF103K	2
R14	N/A				
R15	Resistor, 100K, 10%, 1/4w	136-1056-01	81349	RC07GF104K	1
R16	Same as R13				
R17-R18	Resistor, 22K, 10%, 1/4w	136-1048-01	81349	RC07GF223K	2

Table 6-6. AFC Assembly A2A2 Parts List (Part 3 of 3)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
R19	Resistor, 8.2K, 10%, 1/4w	136-1043-01	81349	RC07GF822K	1
R20	Same as R6				
R21	Resistor, 6.8K, 10%, 1/4w	136-1042-01	81349	RC07GF682K	1
R22	Same as R3				

Table 6-7. Meter Amplifier Assembly A3 Parts List

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
C1	Capacitor, 2μf, 25v	112-1370-01	56289	30D205G025BAL	1
C2	Capacitor, 25μf, 15v	112-1383-01	56289	30D256G015BB4	1
C3	Capacitor, 10μf, 15v	112-1378-01	56289	30D106G015BAL	1
C4	Capacitor, 50μf, 15v	112-1387-01	56289	30D506G015CB4	1
CR1-CR5	Diode 1N914	161-0096-01	01295	1N914	5
Q1-Q3	Transistor, 2N2924	149-0180-01	03508	2N2924(TO-5)	3
R1-R4	Resistor, var, 100K	130-0331-01	80294	3068P1-104	7
R5	Resistor, 220K, 10%, 1/4w	136-1060-01	81349	RC07GF224K	1
R6	Resistor, 22K, 10%, 1/4w	136-1048-01	81349	RC07GF223K	1
R7	Resistor, 10K, 10%, 1/4w	136-1044-01	81349	RC07GF103K	2
R8	Resistor, 2.2K, 10%, 1/4w	136-1036-01	81349	RC07GF222K	4
R9	Resistor, 1K, 10%, 1/4w	136-1032-01	81349	RC07GF102K	1
R10	Resistor, 47K, 10%, 1/4w	136-1052-01	81349	RC07GF473K	1
R11	Resistor, 100, 10%, 1/4w	136-1020-01	81349	RC07GF101K	1
R12-R14	Same as R8				
R15	Same as R7				
R16-R17	Resistor, 4.7K, 10%, 1/4w	136-1040-01	81349	RC07GF472K	2
R18-R20	Same as R1				

Table 6-8. Off-Frequency Detector Assembly A4 Parts List (Part 1 of 2)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
C1	Capacitor, disc, .1, 100v	110-0007-01	08935		1
C2	Capacitor, disc, .01, 100v	110-0006-01	08935		1
C3	Capacitor, 10μf, 25v	112-1379-01	56289	30D106G025BB4	1
C4	Capacitor, elec, 220μf, 10v	104-0132-01	08935		1
C5	Capacitor, .22, 100v	105-3226-12	13934	E3XFR, .22, ±5%, 100v	1
CR1-CR3	Diode, 1N914	161-0096-01	01295	1N914	4
CR4	Diode, 1N4002	161-0293-01	94990	1N4002	1
CR5	Same as CR1				
Q1	Transistor, 2N3567	149-0140-01	07263	2N3567	1
Q2-Q3	Transistor, 2N3638	149-0125-01	07263	2N3638A	2
Q4	Transistor, 2N3053	149-0169-01	02735	2N3053	1
Q5	Transistor, 2N3740	149-0179-01	04713	2N3740	1
R1	Resistor, 3.3K, 10%, 1/2w	136-1160-01	81349	RC20GF332K	1
R2	Resistor, 10K, 10%, 1/2w	136-1100-01	81349	RC20GF100K	2
R3	Resistor, 1.8K, 10%, 1/2w	136-1154-01	81349	RC20GF182K	1
R4	Resistor, 2.7K, 10%, 1/2w	136-1158-01	81349	RC20GF272K	1
R5	Resistor, 5.6K, 10%, 1/2w	136-1166-01	81349	RC20GF562K	1
R6-R8	Resistor, 330, 10%, 1w	136-1337-01	81349	RC32GF331K	3
R9-R10	Resistor, 1K, 5%, 5w	131-0748-01	44655	4623	2
R11	Resistor, 27K, 10%, 1/2w	136-1182-01	81349	RC20GF273K	2

Table 6-8. Off-Frequency Detector Assembly A4 Parts List (Part 2 of 2)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
R12	Resistor, 4.7K, 10%, 1/2w	136-1164-01	81349	RC20GF472K	1
R13	Resistor, 68K, 10%, 1/2w	136-1192-01	81349	RC20GF683K	1
R14	Resistor, 10K, 10%, 1/2w	136-1172-01	81349	RC20GF103K	1
R15	Same as R11				
R16	Resistor, 100K, 10%, 1/2w	136-1196-01	81349	RC20GF104K	1
R17	Resistor, 2.2K, 10%, 1/2w	136-1156-01	81349	RC20GF222K	1
R18	Resistor, 47, 10%, 1/2w	136-1116-01	81349	RC20GF470K	1
R19	Same as R2				
R20	Resistor, 15K, 10%, 1/2w	136-1176-01	81349	RC20GF153K	1

Table 6-9. Monaural Module A5 Parts List

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
A5A1	Monaural Module Assy*	065-0839-01	08935		1
AT1	Pad, input	065-0923-01	08935		1
E1	Lug, solder, #4	475-0134-01	83330	1413-4	1
FL1	Filter, 15 kHz	001-7563-01	08935		1
P1	Connector	286-4031-16	81312	MRE20PG7	1
T1	Transformer, audio	318-0116-01	80223	A-20	1

*See table 6-10.

Table 6-10. Monaural Module Assembly A5A1 Parts List (Part 1 of 2)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
C1	Capacitor, 2μf, 25v	112-1370-01	56289	30D205G025BA4	1
C2	Capacitor, .005μf, 100v	110-1060-01	56289	TG-D50	1
C3	Capacitor, 50μf, 25v	112-1388-01	56289	30D506G025CC4	2
C4	Capacitor, .033μf, 5%, 100v	105-3226-06	13934	E3XFR, .033, 5%, 100v	1
C5	Same as C3				
C6-C7	Capacitor, 25μf, 25v	112-1384-01	56289	30D256G025CB4	2
C8	Capacitor, .001μf	110-0204-01	71590	DD-102G	1
C9	Capacitor, 47pf	101-0163-01	72136	DM15E470J0500WV4CR	1
CR1-CR2	Diode, Zener, 1N4740	161-0242-01	04713	1N4740	2
L1	Inductor, 1mh	186-0094-01	24759	MR1000	1
Q1	Transistor, 2N2924	149-0180-01	03508	2N2924(TO-5)	1
Q2	Transistor, 2N4058	149-0184-01	03508	2N4058(TO-5)	1
Q3	Transistor, 2N1507	149-0037-01	01295	2N1507	1
R6	Resistor, 180, 10%, 1/2w	136-1130-01	81349	RC20GF181K	1
R7	Resistor, 470, 10%, 1/2w	136-1140-01	81349	RC20GF471K	1
R8-R9	Resistor, 22K, 10%, 1/2w	136-1180-01	81349	RC20GF223K	2
R10-R11	Resistor, 47K, 10%, 1/2w	136-1188-01	81349	RC20GF473K	3
R12	Resistor, 220, 10%, 1/2w	136-1132-01	81349	RC20GF221K	1
R13	Resistor, 2.2K, 10%, 1/2w	136-1156-01	81349	RC20GF222K	2
R14-R15	Resistor, 4.7K, 10%, 1/2w	136-1164-01	81349	RC20GF472K	3

Table 6-10. Monaural Module Assembly A5A1 Parts List (Part 2 of 2)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
R16	Resistor, 100, 10%, 1/2w	136-1124-01	81349	RC20GF101K	1
R17	Same as R13				
R18	Resistor, 220, 10%, 1/2w	136-1532-01	81349	RC42GF221K	2
R19	Resistor, 10K, 10%, 1/2w	136-1172-01	81349	RC20GF103K	2
R20	Same as R10				
R21	Same as R18				
R22	Same as R14				
R23	Same as R19				
Z1	Bead, shielding	599-0113-01	02114	56-590-65-3B	1

Table 6-11. Stereo Generator Module A5 Parts List

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
A5A1	Stereo Generator Module Assy No. 1*	065-0834-01	08935		1
A5A2	Stereo Generator Module Assy No. 2**	065-0835-01	08935		1
C1	Capacitor, var, cer, 8-50pf	108-0041-01	71590	822AN	1
E1	Lug, solder, #4	475-0134-01	83330	1413-4	1
P1	Plug	286-4031-16	81312	MRE20PG7	1
R11	Resistor, var, 5.0K	130-0355-01	08935		1
R12	Resistor, var, 10K	130-0356-01	08935		1
R13	Resistor, var, 100K	130-0357-01	08935		1

*See table 6-12.
**See table 6-13.

Table 6-12. Stereo Generator Module Assembly A5A1 Parts List (Part 1 of 3)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
C1	Capacitor, 470pf	101-0189-01	72136	DM19E471J0500WV4CR	1
C2	Capacitor, .01μf	110-0006-01	08935		1
C3	Capacitor, 100pf	101-0172-01	72136	DM15E101J0500WV4CR	1
C4-C5	Capacitor, 2.2μf	104-0112-01	08935		2
C6-C13	Capacitor, 47pf	101-0163-01	72136	DM15E470J0500WV4CR	8
C14	Capacitor, .047μf	105-0402-01	08935		1
C15	Capacitor, .0035μf	105-3226-40	13934	E3FR, .0035, 2%, 100v	1
C16	Capacitor, var, 65-340pf	108-1013-02	84171	303	1
C17	Capacitor, .1μf	105-3226-10	13934	E3XFR, .0082, 5%, 100v	1
CR1	Diode, 1N4740	161-0242-01	04713	1N4740	1
CR2-CR14	Diode, 1N914	161-0096-01	01295	1N914	13
CR15	Diode, Zener, 1N756	161-0093-01	01295	1N756	1
L1	Inductor, 20mh	186-0522-01	81095	EM-020A	1
L2	Inductor, 100μh	186-0039-01	99800	1537-76	1
Q1-Q7	Transistor, 2N3646	149-0182-01	07263	2N3646	7
Q8	Transistor, 2N1507	149-0037-01	01295	2N1507	1
Q9	Transistor, 2N2924	149-0180-01	03508	2N2924(TO-5)	1
R1	Resistor, 100K, 1/2w	136-1196-01	81349	RC20GF104K	1
R2	Resistor, 22K, 1/2w	136-1180-01	81349	RC20GF223K	11
R3	Resistor, 10K, 1/2w	136-1172-01	81349	RC20GF103K	9

Table 6-12. Stereo Generator Module Assembly A5A1 Parts List (Part 2 of 3)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
R4	Resistor, 47, 1/2w	136-1116-01	81349	RC20GF470K	2
R5	Resistor, 47K, 1/2w	136-1188-01	81349	RC20GF473K	2
R6	Same as R2				
R7	Resistor, 4700, 1/2w	136-1164-01	81349	RC20GF472K	1
R8	Same as R4				
R9	N/A				
R10	Resistor, 6.8K, 1/2w	136-1168-01	81349	RC20GF682K	2
R11	Resistor, 2.2K, 1/2w	136-1156-01	81349	RC20GF222K	10
R12-R13	Resistor, 220, 1/2w	136-1132-01	81349	RC20GF221K	2
R14	Same as R10				
R15	Same as R11				
R16-R17	Resistor, 3.3K, 1/2w	136-1160-01	81349	RC20GF332K	2
R18	Same as R11				
R19-R22	Same as R3				
R23-R24	Same as R2				
R25-R28	Same as R3				
R29-R30	Same as R11				
R31-R36	Same as R2				
R37	Resistor, 100, 1/2w	136-1124-01	81349	RC20GF101K	2
R38	Resistor, 1K, 1/2w	136-1148-01	81349	RC20GF102K	1

Table 6-12. Stereo Generator Module Assembly A5A1 Parts List (Part 3 of 3)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
R39	Same as R29				
R40	Same as R2				
R41-R42	Same as R11				
R43	Same as R37				
R44-R45	Same as R11				
R46	Same as R5				
Y1	Crystal, 76 kHz	165-0019-01	08935		1

Table 6-13. Stereo Generator Module Assembly A5A2 Parts List (Part 1 of 4)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
C1	Capacitor, 4.7μf, 35v	104-0115-01	08935		3
C2	Capacitor, .005μf, 100v	110-0076-01	56289	5HK-D50	2
C3-C4	Capacitor, 47μf, 20v	104-0126-01	08935		7
C5	Capacitor, .003μf, 100v	105-3226-06	13934	E3XFR, .033, 5%, 100v	2
C6	Capacitor, .0022μf, 1%, 100v	105-3226-20	13934	E3RF, .0022, 1%, 100v	2
C7	Capacitor, 15μf, 20v	104-0119-01	08935		3
C8	N/A				
C9	Same as C3				
C10	Same as C7				
C11-C12	Same as C1				
C13	Same as C2				
C14-C15	Same as C3				
C16	Same as C5				
C17	Same as C6				
C18	Same as C7				
C19	N/A				
C20	Same as C3				
C21	N/A				
C22-C23	Capacitor, 2.2μf, 35v	104-0112-01	08935		2
C24-C25	Same as C3				
CR1-CR11	Diode, 1N4005	161-0269-01	04713	1N4005	11

Table 6-13. Stereo Generator Module Assembly A5A2 Parts List (Part 2 of 4)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
CR12-CR13	Diode, Zener, 1N4740	161-0242-01	04713	1N4740	2
K1-K2	Relay, 2500 ohms, 4C	180-0416-01	08935		2
L1-L2	Inductor, 1000mh, shield	186-0094-02	24759	MR-1000	2
Q1	Transistor, 2N2924	149-0180-01	03508	2N2924(TO-5)	5
Q2	Transistor, 2N4058	149-0184-01	03508	2N4058(TO-5)	2
Q3	Transistor, 2N1507	149-0037-01	01295	2N1507	3
Q4-Q6	Same as Q1				
Q7	Same as Q2				
Q8	Same as Q3				
Q9	Same as Q1				
Q10	Same as Q3				
R1	Resistor, 180, 10%, 1/2w	136-1130-01	81349	RC20GF181K	1
R2	Resistor, 470, 10%, 1/2w	136-1140-01	81349	RC20GF471K	2
R3-R4	Resistor, 22K, 10%, 1/2w	136-1180-01	81349	RC20GF223K	4
R5-R6	Resistor, 47K, 10%, 1/2w	136-1188-01	81349	RC20GF473K	5
R7	Resistor, 220, 10%, 1/2w	136-1132-01	81349	RC20GF221K	3
R8	Resistor, 4.7K, 10%, 1/2w	136-1164-01	81349	RC20GF472K	4
R9	Resistor, 2.2K, 10%, 1/2w	136-1156-01	81349	RC20GF222K	6
R10-R11	Same as R8				
R12	Resistor, 100, 10%, 1/2w	136-1124-01	81349	RC20GF101K	7
R13	Same as R9				

Table 6-13. Stereo Generator Module Assembly A5A2 Parts List (Part 3 of 4)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
R14	N/A				
R15	Same as R12				
R16	Resistor, 10K, 10%, 1/2w	136-1172-01	81349	RC20GF103K	7
R17-R18	Same as R16				
R19	Resistor, var, 2K, 30%, 1/4w	130-0040-01	37942	MTC23L4	1
R20	Resistor, 680, 10%, 1/2w	136-1144-01	81349	RC20GF681K	2
R21	Same as R8				
R22	Resistor, 1.5K, 10%, 1/2w	136-1152-01	81349	RC20GF152K	1
R23	Same as R9				
R24	Resistor, var, 5K, linear	130-0041-01	37942	MTC53L4	2
R25	Resistor, 6.8K, 10%, 1/2w	136-1168-01	81349	RC20GF682K	1
R26	Same as R24				
R27	Resistor, 220K, 10%, 1/2w	136-1204-01	81349	RC20GF224K	1
R28	Resistor, 120K, 10%, 1/2w	136-1198-01	81349	RC20GF124K	1
R29-R30	Same as R3				
R31-R32	Same as R5				
R33	Resistor, var, 250, linear	130-0042-01	37942	MTC251L4	1
R34	Same as R12				
R35	Same as R9				
R36	Resistor, 3.3K, 10%, 1/2w	136-1160-01	81349	RC20GF332K	1
R37	Same as R19				

Table 6-13. Stereo Generator Module Assembly A5A2 Parts List (Part 4 of 4)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
R38	Resistor, 3.9K, 10%, 1/2w	136-1162-01	81349	RC20GF392K	1
R39	Same as R12				
R40	Same as R9				
R41	N/A				
R42	Same as R12				
R43-R45	Same as R16				
R46	Resistor, var, 500, 30%, 1/4w	130-0043-01	37942	MTC52L4	1
R47	Resistor, var, 1K, linear	130-0044-01	37942	MTC13L4	2
R48	Same as R2				
R49	Resistor, 15K, 10%, 1/2w	136-1176-01	81349	RC20GF153K	1
R50	Same as R47				
R51	Same as R20				
R52	Resistor, 1M, 10%, 1/2w	136-1220-01	81349	RC20GF105K	3
R53	Resistor, 150K, 10%, 1/2w	136-1200-01	81349	RC20GF154K	1
R54	Same as R5				
R55	Same as R12				
R56	Same as R9				
R57	Same as R12				
R58-R59	Same as R7				
R60-R61	Same as R52				
R62	Same as R16				

Table 6-14. 41-kHz SCA Module A6 Parts List

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
A6A1	41-kHz SCA Module Assembly*	065-1012-01	08935		1
E1	Lug, solder, #4	475-0134-01	83330	1413-4	1
P1	Connector	286-4031-16	81312	MRE20PG7	1
R41	Resistor, var, 100K	130-0357-01	08935		1
R42-R76	Resistor, var, 1K	130-0358-01	08935		2
S1	Switch, SPDT, center off	299-0052-01	95146	MST-115E	1

*See table 6-15.

Table 6-15. 41-kHz SCA Module Assembly A6A1 Parts List (Part 1 of 6)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
C1	Capacitor, 2.2μf, 35v	104-0112-01	08935		3
C2	Capacitor, .005μf, 1kv	110-0076-01	56289	5HK-D50	4
C3	Capacitor, .001μf, 1kv	110-0204-01	08935		2
C4	Capacitor, .15μf, 100v	105-3226-11	13934	E3XFR, .15, 5%, 100v	1
C5	Capacitor, 47μf, 20v	104-0126-01	08935		2
C6	Capacitor, 15μf, 20v	104-0119-01	08935		5
C7	Capacitor, .22μf, 100v	105-3226-12	13934	E3XFR, .22, 5%, 100v	3
C8	Capacitor, .1μf, 100v	105-3226-10	13934	E3XFR, .1, 5%, 100v	2
C9	Capacitor, .01μf, 100v	110-0006-01	08935		1
C10	Same as C7				
C11	Same as C6				
C12	Same as C5				
C13	Same as C6				
C14	Same as C1				
C15-C16	Same as C6				
C17	Same as C8				
C18	Capacitor, 820pf	101-0039-01	72136	DM15E821J0300WV4CR	6
C19	Same as C18				
C20	Capacitor, .0022μf, 100v	105-3226-20	13934	E3FR, .0022, 1%, 100v	1
C21	Same as C2				

Table 6-15. 41-kHz SCA Module Assembly A6A1 Parts List (Part 2 of 6)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
C22	Same as C3				
C23	Capacitor, 150pf	101-0176-01	72136	DM15F151J0500WV4CR	1
C24	Same as C18				
C25	Capacitor, 750pf	101-0038-01	72136	DM15E751J0300WV4CR	1
C26-C27	Same as C18				
C28	Same as C2				
C29	Same as C1				
C30	Same as C2				
C31	Same as C7				
C32-C36	N/A				
C37	Same as C18				
C38	Capacitor, 560pf	101-0035-01	72136	DM15E561J0300WV4CR	1
CR1-CR6	Diode, 1N914	161-0096-01	01295	1N914	6
L1	Inductor, 1mh	186-0094-02	24759	MR-1000	1
L2	Inductor, 10mh	186-0094-06	24759	MR-10,000	1
L3	Inductor, 4.7mh	186-0094-04	24759	MR-4700	1
Q1-Q9	Transistor, 2N2924	149-0180-01	03508	2N2924(TO-5)	11
Q10	Transistor, 2N3646	149-0303-01	08935		2
Q11	Same as Q10				
Q12-Q13	Same as Q1				

Table 6-15. 41-kHz SCA Module Assembly A6A1 Parts List (Part 3 of 6)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
R1-R2	Resistor, 150, 10%, 1/2w	136-1128-01	81349	RC20GF151K	5
R3	Resistor, 470, 10%, 1/2w	136-1140-01	81349	RC20GF471K	5
R4-R5	Same as R1				
R6	Same as R3				
R7	Resistor, 180, 10%, 1/2w	136-1130-01	81349	RC20GF181K	1
R8	Resistor, 33K, 10%, 1/2w	136-1184-01	81349	RC20GF333K	1
R9	Resistor, 4.7K, 10%, 1/2w	136-1164-01	81349	RC20GF472K	7
R10	Resistor, 68, 10%, 1/2w	136-1120-01	81349	RC20GF680K	1
R11	Resistor, 2.2K, 10%, 1/2w	136-1156-01	81349	RC20GF222K	5
R12	Same as R3				
R13	Resistor, 15K, 10%, 1/2w	136-1176-01	81349	RC20GF153K	1
R14	Same as R3				
R15	Resistor, 100, 10%, 1/2w	136-1124-01	81349	RC20GF101K	4
R16-R17	Resistor, 1K, 10%, 1/2w	136-1148-01	81349	RC20GF102K	8
R18	Resistor, 10K, 10%, 1/2w	136-1172-01	81349	RC20GF103K	16
R19	Resistor, 100K, 10%, 1/2w	136-1196-01	81349	RC20GF104K	6
R20-R21	Same as R18				
R22	Same as R16				
R23	Same as R19				
R24-R25	Same as R18				

Table 6-15. 41-kHz SCA Module Assembly A6A1 Parts List (Part 4 of 6)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
R26	Same as R16				
R27	Resistor, 220, 10%, 1/2w	136-1132-01	81349	RC20GF221K	5
R28	Same as R18				
R29	Same as R19				
R30	Same as R27				
R31	Same as R18				
R32	Same as R27				
R33	Same as R18				
R34-R35	Same as R11				
R36	Same as R15				
R37	Same as R18				
R38	Same as R9				
R39	Same as R11				
R40	Same as R18				
R41-R42	N/A				
R43	Resistor, var, 10K	137-0837-01	80294	3067P1-103	1
R44-R45	Same as R9				
R46	Resistor, 27K, 10%, 1/2w	136-1182-01	81349	RC20GF273K	1
R47	Resistor, 22K, 10%, 1/2w	136-1180-01	81349	RC20GF223K	3
R48	Same as R27				

Table 6-15. 41-kHz SCA Module Assembly A6A1 Parts List (Part 5 of 6)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
R49	Same as R16				
R50	Same as R47				
R51	Same as R16				
R52	Same as R15				
R53	Same as R16				
R54	Same as R1				
R55-R56	Same as R19				
R57	Same as R16				
R58	Same as R9				
R59-R60	Same as R18				
R61	Same as R9				
R62	Same as R47				
R63-R64	Same as R18				
R65	Same as R19				
R66	Resistor, 47K, 10%, 1/2w	136-1188-01	81349	RC20GF473K	2
R67	Resistor, 220K, 10%, 1/2w	136-1204-01	81349	RC20GF224K	1
R68	Same as R66				
R69	Resistor, 3.3K, 10%, 1/2w	136-1160-01	81349	RC20GF332K	1
R70	Same as R3				
R71	Same as R27				

Table 6-15. 41-kHz SCA Module Assembly A6A1 Parts List (Part 6 of 6)

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
R72	Same as R9				
R73	Same as R18				
R74	Same as R15				
R75	Same as R11				
R76	N/A				
R77	Same as R18				
T1	Transformer, audio	318-0115-02	08935		1

Table 6-16. 67-kHz SCA Module A7 Parts List

Desig	Description	G/A Part No.	Mfr	Mfr Part No.	Total
A6A1	67-kHz SCA Module Assembly*	065-1011-01	08935		1
E1	Lug, solder, #4	475-0134-01	83330	1413-4	1
P1	Connector	286-4031-16	81312	MRE20PG7	1
R41	Resistor, var, 100K	130-0357-01	08935		1
R42-R76	Resistor, var, 1K	130-0358-01	08935		2
S1	Switch, SPDT, center off	299-0052-01	95146	MST-115E	1

*See table 6-17