INSTRUCTION MANUAL

for

AEL MODEL FM-15QE

FM EXCITER

April 1977

AEL

American Electronic Laboratories, Inc.

A Subsidiary of AEL Industries, Inc.

Richardson Road, Colmar, PA 18915

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FM-15QE

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AMERICAN ELECTRONIC LABORATORIES, INC.

A DIVISION of AEL INDUSTRIES, INC.

Richardson Road

Colmar, PA 18915

MODEL ______________ DATE ______________

SERIAL NO. ______________

TO: ____

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Seller warrants the products of this contract, manufactured and sold by Seller, against failure due to defects in material and workmanship under normal use and service for a period of ______________ from the date of original delivery when operated in accordance with Seller's operating instructions. This warranty shall not apply to tubes, fuses, bulbs, semiconductors, motors, meters and relays; however, the warranties extended by the original manufacturers apply. All warranties whether expressed or implied (hereinafter collectively called "warranties") shall extend only to the Buyer and no others.

Warranties are valid only when and if (a) Seller receives prompt written notice of the breach within the period of the warranty, (b) the defective product is properly packed and returned by the Buyer (transportation and insurance prepaid), and (c) Seller determines, in its sole judgment, that the product is defective and not subject to any misuse, neglect, improper installation, negligence, accident, or (unless authorized in writing by Seller) repair or alteration. Seller's exclusive obligation under all warranties, and Seller's exclusive liability for any personal and/or property damages (including direct, consequential or incidental) caused by the breach of any or all warranties, shall be limited to the following: (a) repairing or replacing (in Seller's sole discretion) any defective parts free of charge (f.o.b. Seller's plant), and/or (b) crediting (in Seller's sole discretion) all or a portion of the purchase price to the Buyer.

SELLER DOES NOT WARRANT MERCHANTABILITY OF GOODS OR-PARTS THEREOF NOT MANUFACTURED BY SELLER THERE ARE NO WARRANTIES THAT EXTEND BEYOND THE DESCRIPTION ON THE FACE HEREOF OR BEYOND THE TERMS AND CONDITIONS CONTAINED HEREIN.

GUARANTEE

American Electronic Laboratories, Inc. also agrees to make available for purchase by Buyer the replaceable parts for the transmitters and exciters, and stereo generators sold hereunder for a period of ten (10) years at the price charged by AEL to others for said parts.

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SECTION I

GENERAL DESCRIPTION

1-1. INTRODUCTION.

This manual contains information for installation, operation, and maintenance of the AEL FM-15QE FM exciter (figure 1-1). The necessary drawings are included with, but not bound into, the manual.

The FM-15QE was designed and built for the professional FM broadcaster and is an all solid-state, on-carrier, direct FM, phase locked, frequency synthesized exciter. The FM-15QE was designed to meet or exceed FCC requirements for use in the standard FM broadcast band (88 to 108 MHz).

1-2. PHYSICAL DESCRIPTION.

The exciter is housed in a 3-1/2 X 19 X 14 in. enclosure for mounting in a standard equipment rack. All operator controls and indicators are located on the front panel. The rear panel contains signal input and output connectors, the ac power line cord and fuse, and the switch for selecting mono or stereo input signals.

The exciter is identified by a model number and serial number located on the rear panel. All correspondence in regard to this unit should reference the complete model and serial numbers.

1-3. ELECTRICAL DESCRIPTION.

The exciter is all solid-state, employing silicon transistors, diodes, and integrated circuits and featuring phase-locked stability and on-carrier direct FM for full multiplex operation with freedom from spurious responses. The exciter can withstand any VSWR phase or magnitude and provides a power output adjustable from less than 5 to greater than 20 watts. Also, the exciter may be programmed to operate on any 100 kHz increment in the FM band by using the internal 8 MHz crystal as a reference.

1-4. SPECIFICATIONS.

Table 1-1 lists the electrical and mechanical specifications for the FM-15QE exciter.

Figure 1-1. FM-15QE FM Exciter.

Table 1-1. Specifications

Parameter	Specification
MECHANICAL	
Dimensions	3-1/2 in. H X 19 in. W X 14 in. D
Mounting Dimensions	Standard 19 in. rack
Net Weight	12 lb.
Shipping Weight	16 lb.
Maximum Operating Temp.	131°F (55°C) ambient
Environmental	0°C to +55°C operating (-15°C to +55°C with 30 min. warm up)
ELECTRICAL	
Primary Power	105-125/210/250 Vac, 50/60 Hz
Power Consumption	Approx 50 watts max.
Power Output	Adjustable from less than 5 to greater than 20 watts
Frequency Range	88 to 108 MHz (programmable)
Type of Emission	180F3 or 300F9
Modulation Capability (less than 1 percent THD)	150 kHz peak
Frequency Stability	± 500 Hz (-10°C to +55°C)
Output Impedance	50 ohms
VSWR Protection	Any magnitude or phase
AM Noise	Better than -55 dB
Stereo Separation	Better than 40 dB from 30 Hz to 15 kHz with AEL Model FM-15QE/SG Stereo Generator

Table 1-1. Specifications (Cont'd)

Parameter	Specification
Crosstalk (Main to SCA)	-55 dB
Crosstalk (SCA to Main)	-65 dB
Harmonic and Spurious Suppression	Better than 80 dB (with optional harmonic filter)
Mono Input:	
a. Impedance	600 ohms (balanced)
b. Level	+10 dBm for 75 kHz dev. at 400 Hz
c. Pre-emphasis	75 usec $\pm$ 1 dB (50 usec optional)
Stereo Input:	
a. Impedance	10k ohms
b. Level	4Vpp for 75 kHz deviation
SCA Inputs (2):	
a. Impedance	10k ohms
b. Level	1Vpp for 10 percent injection
Distortion	0.35 percent max. THD at 75 kHz dev.
FM Noise (below 75 kHz dev. with 75 usec de-emphasis)	Better than -70 dB

SECTION II

INSTALLATION

2-1. UNPACKING AND INSPECTION.

After receipt, carefully unpack the equipment and check items received against the shipping invoice. Inspect all items received for completeness and damage. Notify the shipment carrier involved in cases of loss or damage.

2-2. MECHANICAL INSTALLATION.

The following paragraphs provide the information needed to accomplish mechanical installation of the exciter.

2-3. ENVIRONMENTAL REQUIREMENTS. Locate the exciter in an environment that satisfies the following conditions:

a. Maximum altitude: 10,000 ft.

b. Maximum temperature: 131°F (55°C)

c. Minimum temperature: 5°F (-15°C)

2-4. MOUNTING REQUIREMENTS. The exciter is designed for mounting in a standard 19 in. rack. Provide sufficient air space above and below the exciter to allow for dissipation of heat generated by the circuitry. If the exciter is placed above equipment that generates substantial quantities of heat, forced air cooling may be required to keep the ambient temperature of the exciter within the specified range.

Secure the exciter to the rack using four (4) each no. 10 oval head screws and finishing washers.

2-5. ELECTRICAL INSTALLATION.

The following paragraphs provide the information needed to accomplish electrical installation of the exciter.

2-6. AC POWER. The exciter is supplied wired for either 105 to 125 Vac, single phase, 50 to 60 Hz power or 210 to 250 Vac, single phase, 50 to 60 Hz power as noted on the rear panel identification plate (figure 2-1). If any doubt exists as to the voltage for which the exciter is wired, or if it is desired to change the operating voltage, refer to drawing 4051139 for power transformer connections. Clearly mark the equipment to indicate the voltage for which it is wired. Plug the line cord into a suitable receptacle.

2-7. LOW OUTPUT POWER OPERATION. If the exciter is to be used for only 12 watts or less output, it may be modified as follows to reduce heat generation:

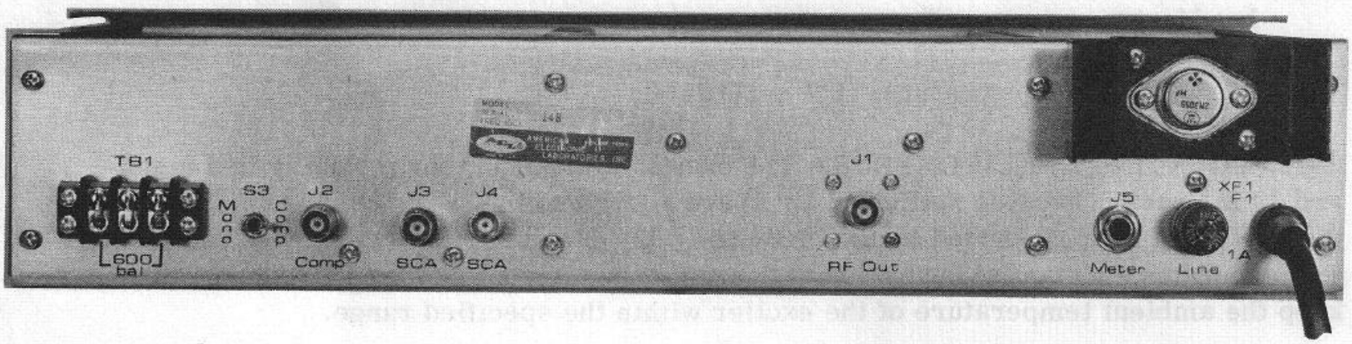

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Figure 2-1. FM-15QE Exciter Rear Panel.

1. Remove power transformer yellow lead from CR1.

2. Connect power transformer red/yellow lead to CR1.

3. Change A4R10 from 820 ohms to 1.5 k ohms.

4. Clearly mark the equipment to indicate the low-power modification.

2-8. MONAURAL TRANSMISSION. If monaural transmission is to be used, connect the monaural audio line to TB1. The exciter requires a 600 ohm balanced audio input having a level of +10 ($\pm$ 1) dBm for 75 kHz deviation at 400 Hz. This input provides 75 μsec pre-emphasis. The center terminal of TB1 is connected to chassis ground.

Set Mono/Comp switch S3 to Mono.

2-9. STEREO TRANSMISSION. If stereo transmission is to be used, connect the stereo generator to Comp jack J2 using a type BNC connector and RG-58/U cable or its equivalent. This input requires 4 V peak-to-peak across 10 k ohms for 75 kHz deviation.

Set Mono/Comp switch S3 to Comp.

2-10. SCA TRANSMISSION. If SCA transmission is to be used, connect an SCA generator to SCA jack J3 or J4 using a type BNC connector and RG-58/U cable or its equivalent.

2-11. EXTERNAL METER. Meter jack J5 is provided on the rear panel to allow remote monitoring of the PA collector current. Use a 0 to 3 Amp meter connected to J5 using a three-wire stereo phone plug.

2-12. RF OUTPUT. Connect RF Out jack J1 to a transmitter or other load having a 50 ohm input impedance using a type BNC connector and RG-58/U cable or its equivalent.

CAUTION

Never operate the exciter without an RF load.

2-13. INSTALLATION CHECKOUT

Proceed as follows to ensure proper installation and operation of the exciter:

1. Recheck all installation details for conformance to requirements.

2. Ensure that all connections are properly made and tight.

3. Review Section III of this manual to gain familiarity with the location and function of all controls and indicators.

4. Connect RF Out jack J1 to a 50 ohm, 20 watts (min.) RF load using a signal sampler having a -20 to -30 dB output.

5. Connect a frequency counter to the signal sampler low level output.

6. Accomplish operating procedure of paragraph 3-2.

SECTION III

OPERATION

3-1. CONTROLS AND INDICATORS.

All operator's controls and indicators are mounted on the exciter's front panel. Table 3-1 lists the controls and indicators, describes their functions, and locates them by reference to figure 3-1.

3-2. OPERATING PROCEDURE.

1. Set MULTIMETER switch to RF.
2. Set POWER switch to on (up). Observe that POWER on indicator lights.
3. Verify that AFC LOCKED indicator lights and RF output is indicated on meter within a few seconds.

NOTE

The RF reading will vary somewhat depending on the RF load connected to the exciter.

4. Set MULTIMETER switch to all positions. Verify that meter indicates within $\pm$ 10 percent of factory-supplied information.
5. Use PWR ADJ control to set power output to level required.
6. Use FREQ ADJ control to fine-tune exciter to exact frequency.
7. To de-energize the exciter, set the POWER switch to off (down).

Table 3-1. Exciter Controls and Indicators

Item	Control or Indicator	Function
1	Power switch	Applies ac power to exciter when set to the up position.
2	POWER on indicator	Indicates, when lit, that ac power is applied to exciter
3	MULTIMETER meter	Indicates, on a scale of 0 to 1, the relative levels of functions selected by MULTIMETER switch.
4	MULTIMETER switch, having positions as follows:	Selects various exciter functions for display on meter:
	Vcc	Power to integrated circuits
	+15 V	Output of 15 Volt power supply.
	+5 V	Output of 5 Volt power supply.
	Ref	Reference oscillator level.
	Fmo	FM oscillator RF level.
	IPA	IPA power output (IPA collector current)
	PA	PA power output (PA collector current)
	RF	Exciter RF output.
5	PWR ADJ control	Screwdriver adjustment to set level of exciter RF output over a range of approx 5 to 20 watts.
6	FREQ ADJ control	Screwdriver adjustment to fine-tune exciter output RF output over a range of approx ± 500 Hz.
7	AFC LOCKED indicator	Indicates, when lit, that exciter output frequency is locked to the internal reference oscillator.

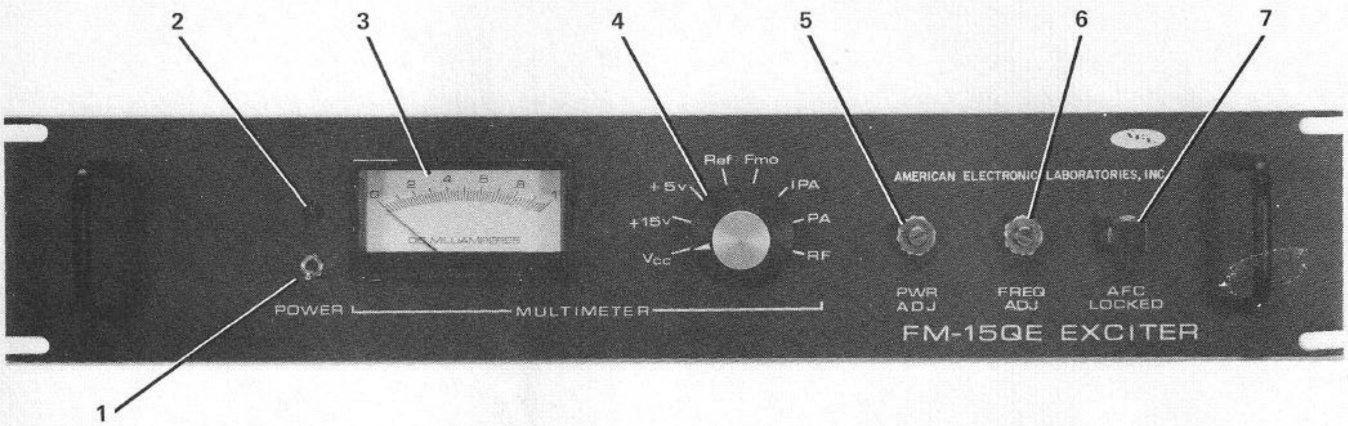


Figure 3-1. FM-15QE Exciter Controls and Indicators.

SECTION IV

THEORY OF OPERATION

4-1. OVERALL THEORY.

Refer to drawing 3050688 for a block diagram of the exciter. The exciter is divided into three functional areas:

a. Frequency Modulation Oscillator (FMO) and Phase Lock - A2 assembly

b. Intermediate Power Amplifier (IPA) and Power Amplifier (PA) - A3 assembly

c. Power Supply and Regulator - A4 assembly.

4-2. FMO AND PHASE LOCK ASSEMBLY. The FMO receives pre-emphasized monaural audio, a composite (comp) audio signal from a stereo generator, or up to two SCA inputs. The FMO produces the basic frequency modulated signal which is amplified by the FMO buffer and control amplifier to approximately 100 mw. This signal is then sent to the IPA and PA assembly.

A sample of the signal from the FMO buffer is fed to a high speed divider which reduces the frequency to nominally 5 MHz (Fc/20). This 5 MHz signal is then processed by the programmable divider which has an output of 5 kHz regardless of the selected frequency. The output of an 8 MHz crystal controlled oscillator is digitally divided to 5 kHz. This signal is phase compared with the output of the programmable divider; the resulting signal is filtered and used to control the FMO subassembly. Thus, the programmable divider allows the use of the same high stability 8 MHz reference crystal regardless of channel assignment.

Note that this phase locked loop requires a phase error, not a frequency error, to generate its correction signal. Because of this, the output of a phase locked exciter exhibits long term phase coherence with the reference oscillator without the frequency drift associated with frequency locked loop exciters.

The lock detector senses loss of phase coherence and provides a signal that cuts off the control amplifier thereby shutting off the RF output until lock is established.

4-3. IPA AND PA. The IPA and PA assembly contains a two-stage power amplifier which raises the 100 mw output of the FMO and Phase Lock assembly to a maximum level of approximately 20 watts.

4-4. POWER SUPPLY - REGULATOR. The Power Supply - Regulator assembly contains a power supply-regulator for the IPA and PA, for the FMO (+15 Vdc), and for the FMO logic circuits (+5 Vdc). These supplies are short circuit protected. The supply-regulator for the IPA and PA can be continuously varied from 14 Vdc to 24 Vdc by using the front panel PWR ADJ control. This allows control over the power output of the IPA and PA assembly.

4-5. DETAILED THEORY.

These paragraphs provide detailed theory for the following areas of the exciter:

a. FMO and Phase Lock Assembly

b. IPA and PA Assembly

c. Power Supply-Regulator

d. Power and Signal Distribution.

4-6. FMO AND PHASE LOCK ASSEMBLY. The FMO and Phase Lock assembly receives comp audio, two SCA inputs, or monaural audio. Refer to drawing 5051277. The monaural audio is applied through transformer T2, switch A1S3, and then directly to the FMO subassembly. If stereo operation is used, the comp input is applied to the FMO through network R34, R35, and C18, and through A1S3; R34 is used to set the input level to the FMO. The two SCA inputs are capacitively coupled to the input of the FMO.

The output of the FMO subassembly is fed to the base of Q1, the FMO buffer. This stage drives Q3, the control amplifier and U1, a high speed emitter coupled logic (ECL) flip-flop. Q3 raises the power level to approximately 100 mw, a level sufficient to drive the IPA. If an unlocked condition is sensed, a signal is developed which causes Q2 to conduct thereby shorting the base of Q3 to ground and shutting off the RF output. The Ref Mtr output provides a voltage representative of FMO RF level for use by the front panel meter. The Shut Down output is not used.

Q4 provides level matching between the output of U1 (fc ÷ 2) and the input of U2. U2 is a high speed divide by 10 circuit. The output of U2 is therefore fc ÷ 20. U3, U4, U5 and U6 make up the programmable divider. By grounding the appropriate points (refer to table 2-1), this circuit can be made to divide by any whole number from 2 to 2000. For operation in the FM band, the circuit is made to divide by a number between 881 and 1079. When this is done, the output frequency of the programmable divider is 5 kHz when the FMO is operating on the assigned channel.

Q7, Y1 and associated circuitry form a stable 8 MHz crystal oscillator which provides the reference frequency for the system. C27 is the coarse tune capacitor and Q8 (a transistor used as a varicap) provides the voltage controlled fine tuning. Q8 is controlled by the FREQ ADJ pot on the front panel. Q9 buffers the output of the reference oscillator and provides level matching to drive U7. U7, U8 and U9 are TTL integrated circuits. The output of U9 is 8 MHz ÷ 1600 or 5 kHz. This 5 kHz square wave is differentiated and applied to Q7. When Q7 conducts, it discharges C21. C21 is charged through constant current source Q6, R46 and R47. The result of this action is to convert the 5 kHz square wave to a linear 5 kHz sawtooth. R47 is an amplitude and linearity adjustment.

The 5 kHz output of the programmable divider drives pulse amplifier Q5. The output of Q5 and the sawtooth converter are coupled to U12. This IC and associated circuitry form a sample hold phase detector. U12 is a gated Operational Transconductance Amplifier. This device has a high impedance (constant current) output. R39 and C20 form a storage circuit. U12 charges this storage circuit to the point on the input sawtooth which is coincident with the pulse from Q5. Therefore, as the phase angle between the reference derived and the FMO derived 5 kHz signals changes, the voltage on C20 rides up or down. However, since the voltage can change only when the pulse from Q5 is present, the filter required to eliminate the reference frequency is greatly reduced. U11 is a high input impedance voltage follower which eliminates any loading of the storage circuit. The low impedance output of U11 is filtered and applied to the AFC control port of the FMO subassembly thereby closing the control loop.

Q10 buffers the output of U9 (reference 5 kHz) and drives the REF position on the MULTIMETER.

U10, Q11 and Q12 form the circuit that senses lock. A 5 kHz square wave from U9 and a 5 kHz pulse from the programmable divider are fed to U10. If the two inputs are not locked, a square wave will appear at pin 6 of U10. This signal is converted to a DC level by Q11 and this level is applied to Q12 which drives the other half of U10. The output of U10 is then fed to Q2 where it shuts down the RF output and to Q13 which turns off the AFC LOCKED lamp.

4.7. IPA AND PA. The output of the FMO and Phase Lock assembly (approximately 100 mw) is applied to T1. Refer to drawing 4051142. T1 and T2 provide impedance matching to the base of Q1, the IPA. C2 stabilizes the amplifier throughout the power adjust range. C7, C8 and L2 provide impedance matching between the collector of Q1 and the base of Q2, the PA. L5, C14 and C15 provide impedance matching between the collector of Q2 and the load. CR1 and associated circuitry drives the RF position on the MULTIMETER. Parallel bypass capacitors are used on both stages to ensure that the power supply is bypassed for all frequencies. This precaution is necessary due to the extremely high low frequency gain of RF power transistors. If adequate bypassing is not used, low frequency oscillations of a sufficient magnitude to destroy the transistor can occur.

4-8. POWER SUPPLY - REGULATOR. The Power Supply-Regulator receives unregulated dc voltage from a chassis mounted rectifier. This unregulated voltage is distributed to the IPA-PA regulator, the 15 volt regulator, and the 5 volt regulator. Refer to drawing 4051141.

IPA-PA Regulator. A 12 volt zener diode, CR4, is the reference for this supply. The PWR ADJ control R1 (front panel control, across pins H and S) supplies all or part of the 12 volts across CR4 to the base of Q2. Q2 and Q3 form a DC amplifier with a gain of approximately 2. This raises the voltage supplied to the base of pass transistor A1Q1 (mounted on heat sink at rear of unit) to approximately 24.7 volts max. The emitter of the pass transistor supplies the load through R12. If the current drawn through R12 is excessive, the voltage drop across R12 will exceed the forward voltage necessary to cause Q4 to conduct. When Q4 conducts, it fires SCR CR3 which shorts out the reference thereby causing the supply to shut down. When this occurs, C1 starts to charge through R11. When the voltage at the junction of R11 and C1 becomes more negative than the gate voltage of SCR CR1, CR1 fires discharging C1. The resulting pulse causes Q1 to momentarily interrupt the holding current through CR3 thereby cutting off CR3. This action resets the supply automatically. R27 provides unregulated dc to the front panel AFC LOCKED indicator; R28 provides a +24 Vdc output to the front panel POWER on indicator.

15 Volt Regulator. Zener diode CR6 is the reference for this regulator. Q5 and Q7 amplify the voltage across this diode to approximately 15 volts. Q6 acts similar to Q4 if the current drawn from the supply exceeds approximately 100 ma.

5 Volt Regulator. A 6.3 volt zener diode CR5 is the reference for this regulator. Q8 buffers the voltage across this diode and drives the chassis mounted pass transistor A1Q2. Q9 and R25 provide the current limit function for this supply. The limit point is approximatley 500 ma. A 6 Vac input from the chassis-mounted power transformer drives diode bridge CR7 through CR10. This bridge provides collector voltage for A1Q2.

4-9. POWER AND SIGNAL DISTRIBUTION. The FMO and Phase Lock, IPA and PA, and Power Supply-Regulator assemblies are mounted on the main chassis of the exciter. Refer to drawing 4051139. The chassis also provides signal interconnections, Multimeter and switching functions, and unregulated dc power.

Signal Interconnections. The chassis provides audio input connections (TB1 and J2), SCA input connections (J3 and J4), and the RF output connection (J1). J6 is an internal connector for connecting FMO RF to the IPA and PA assembly. J5 provides a convenient means of remotely monitoring collector current for the IPA and PA.

Multimeter Function. The front panel mounter meter (M1) receives +24 Vdc, +15 Vdc, and +5 Vdc from the Power Supply-Regulator via contacts 1, 2, and 3 respectively on switch S2. This allows monitoring of all power supply functions. S2 contacts 4 and 5 provide to M1 dc levels proportional to the RF levels of the reference 5 kHz and FMO, respectively. S2 contacts 6 and 7 provide for the monitoring of Vcc for the IPA and PA, respectively; for these functions M1 is returned to +24 Vdc. M1 also monitors exciter RF output via contact 8 of S2.

Unregulated DC Power. Ac power is applied to power transformer T1 through POWER switch S1 and fuse F1. The transformer may be wired for operation on either 120 or 240 Vac. The ac output from T1 drives rectifier CR1 which provides the unregulated dc voltage required by the Power Supply-Regulator. Front panel PWR ADJ control R1 sets the level of the dc voltage to the IPA and PA.

SECTION V

MAINTENANCE

5-1. PREVENTIVE MAINTENANCE.

Frequently check all MULTIMETER positions to ensure proper operation of all exciter circuits. Other than this, and the normal care to be exercised with electronic instruments, there are no specific preventive maintenance procedures required for the exciter.

5-2. ACCESS TO COMPONENTS.

Access to all exciter internal components can be gained by removing the top and bottom cover plates. Figures 5-1 through 5-5 locate all components by reference designation. For the complete reference designation, prefix the given reference by:

a. A1 for the chassis

b. A2 for the FMO and Phase Lock assembly

c. A3 for the IPA and PA assembly

d. A4 for the Power Supply-Regulator assembly.

5-3. TEST EQUIPMENT.

Table 5-1 lists the test equipment required for alignment and adjustment of the exciter.

5-4. INTRODUCTION TO TROUBLESHOOTING.

Troubleshooting the exciter is greatly simplified by using the front panel MULTIMETER. If a malfunction should occur, use the following general guidelines to isolate the fault:

1. Check the line fuse.

2. Use the MULTIMETER to isolate the fault to the FMO and Phase Lock assembly, the IPA and PA assembly, the Power Supply-Regulator assembly, or to chassis components.

3. Use the troubleshooting chart (table 5-2).

5-5. TROUBLESHOOTING CHART.

Table 5-2 is the troubleshooting chart for the exciter. The table lists a selected number of malfunctions based on front panel indications and provides for these malfunctions one or more probable causes and corrective actions.

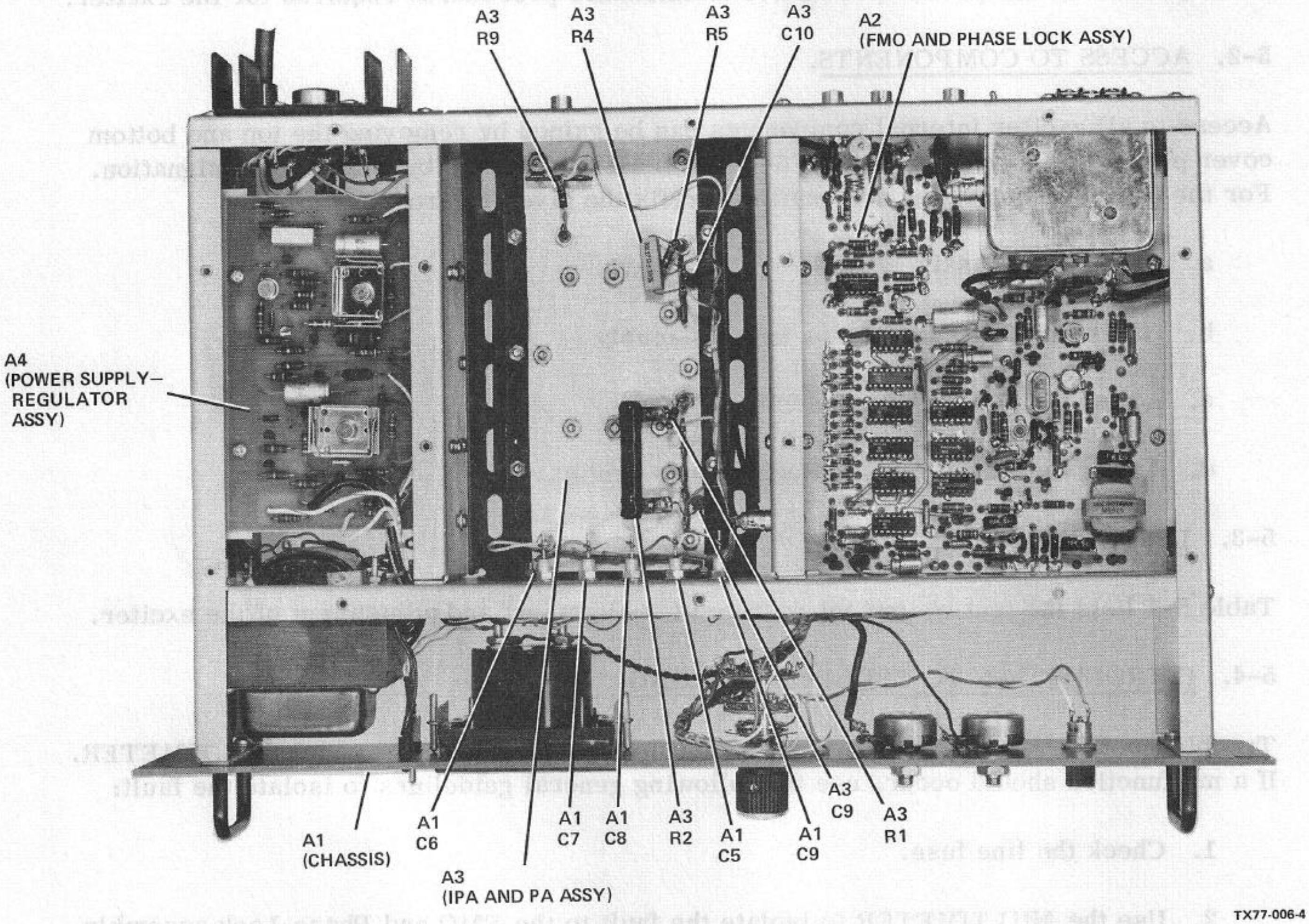
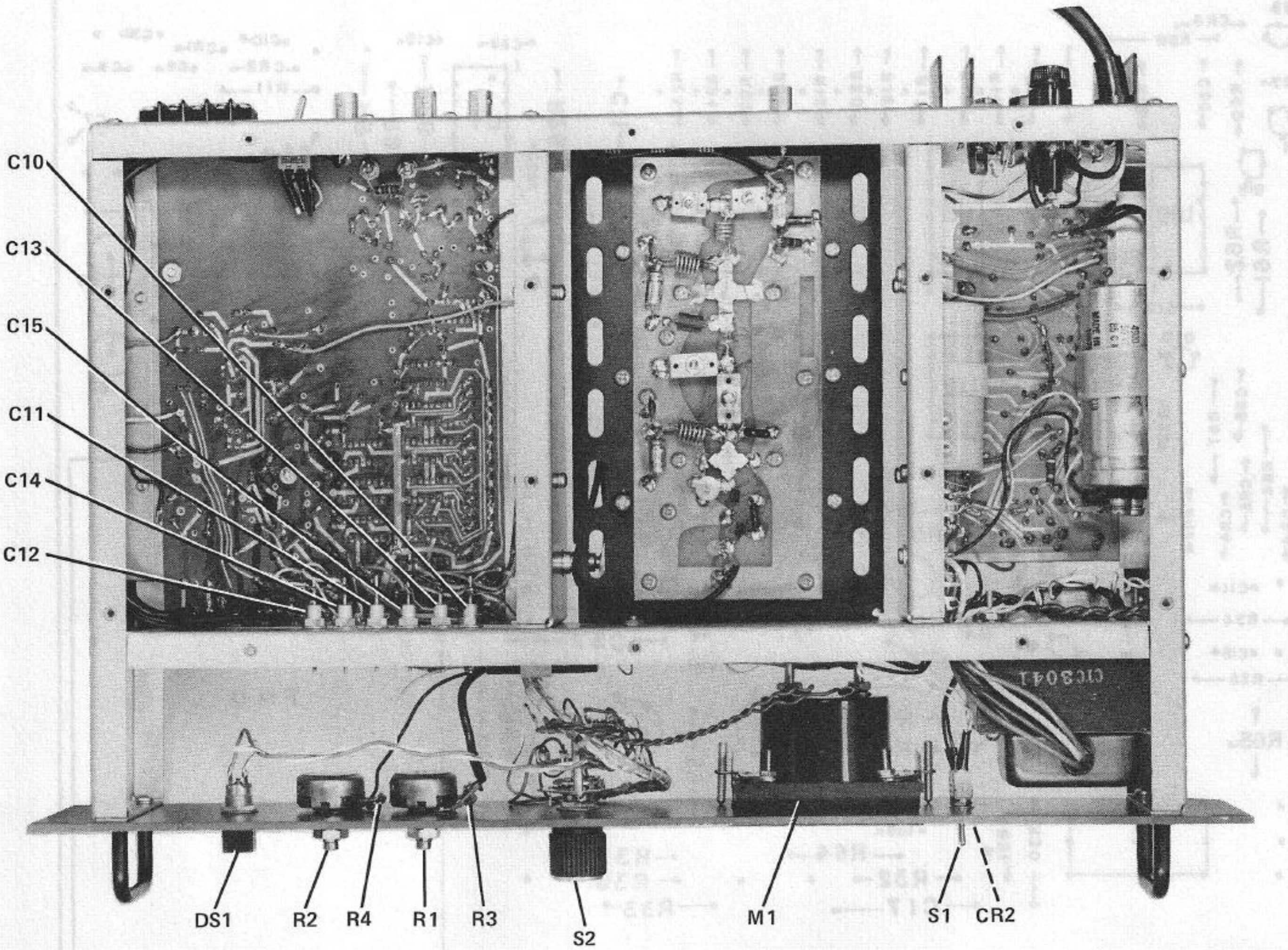


Figure 5-1. FM-15QE Exciter Top View with Cover Removed.



NOTE: PREFIX ALL REFERENCE DESIGNATIONS WITH A1.

Figure 5-2. FM-15QE Exciter Bottom View with Cover Removed.

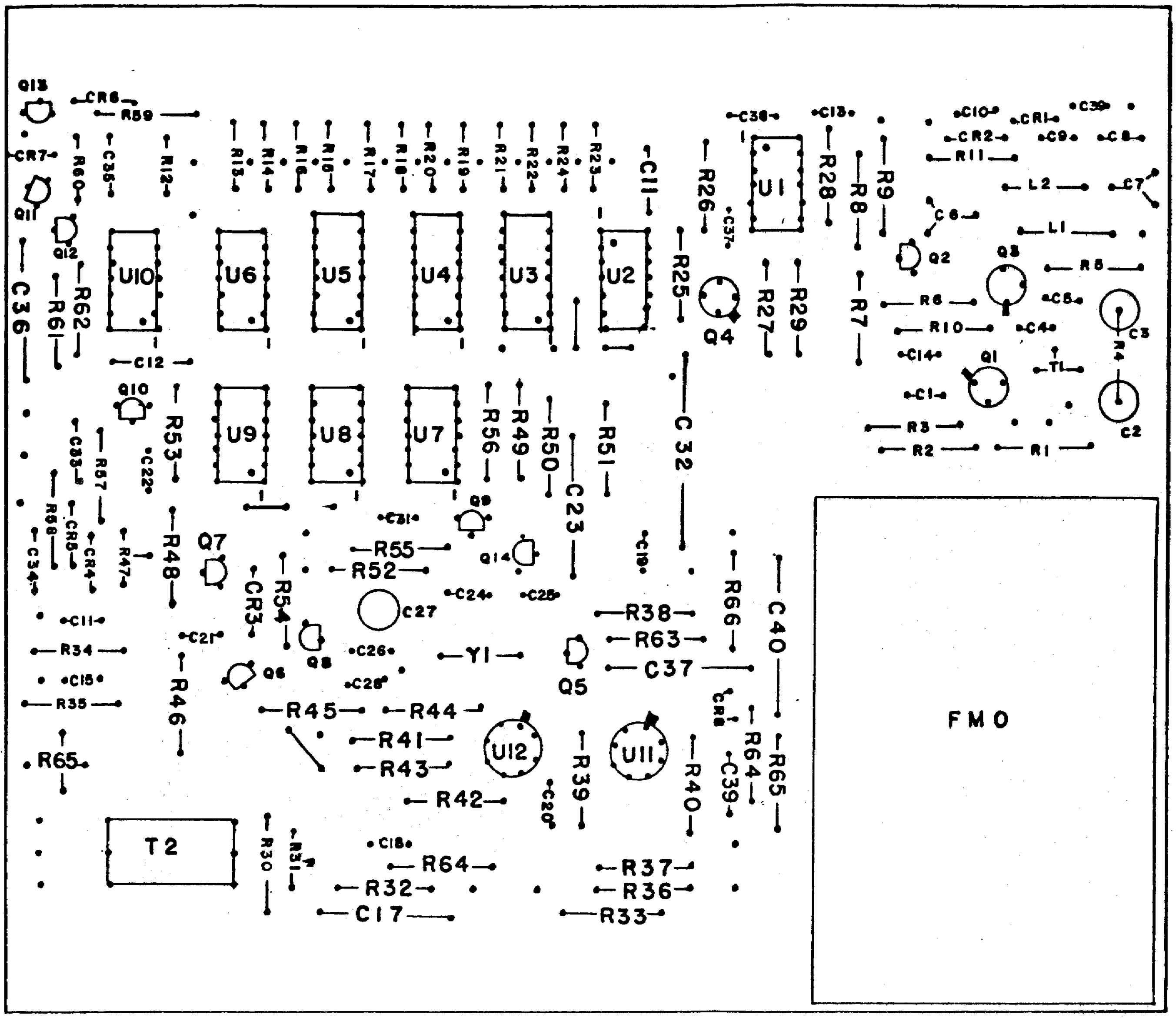


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Figure 5-3. FMO and Phase Lock Assembly, Location of Parts.

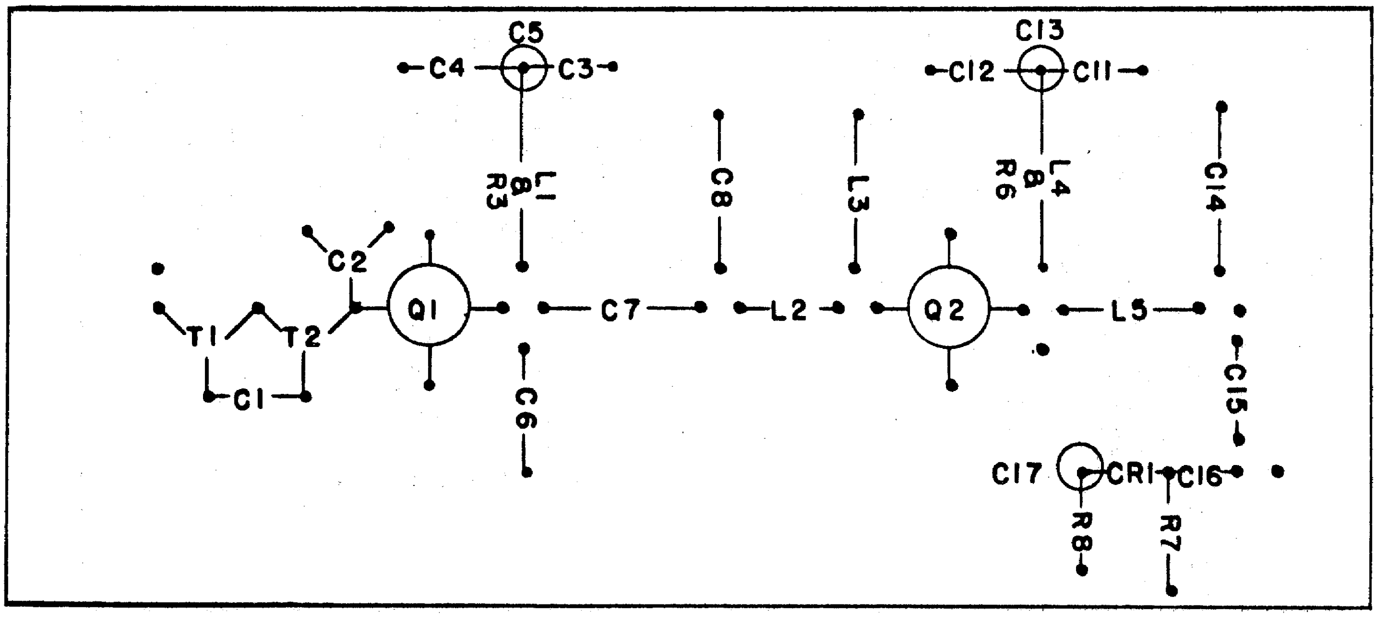

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Figure 5-4. IPA and PA Assembly, Location of Parts.

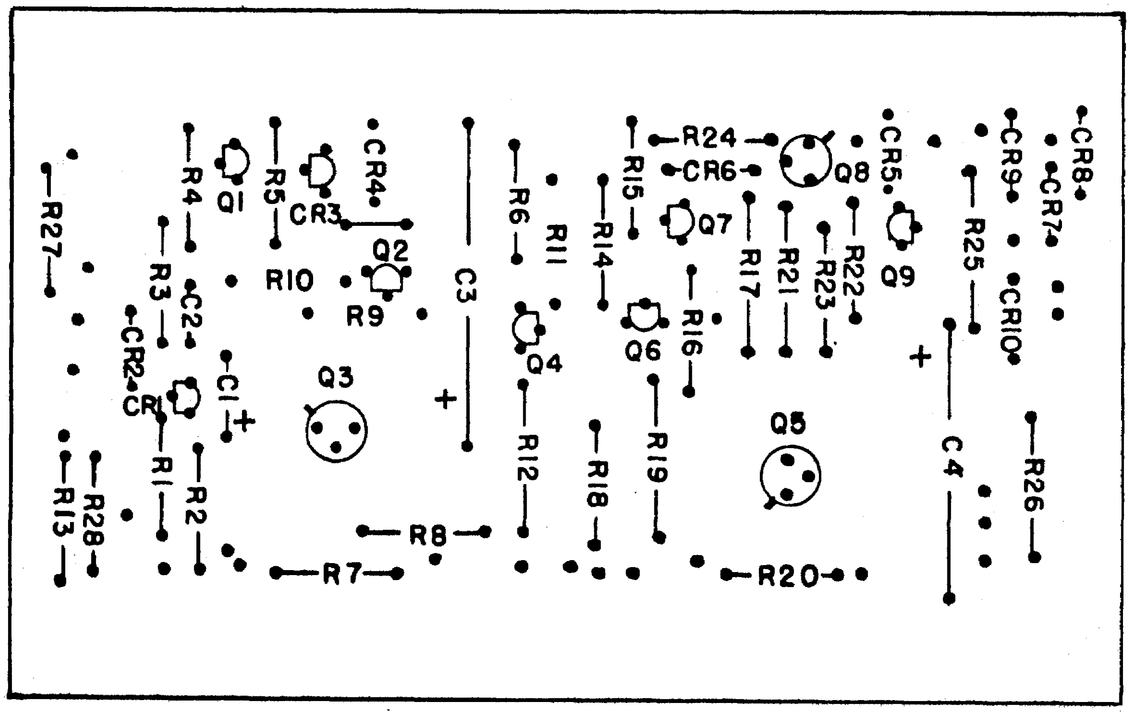

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Figure 5-5. Power Supply - Regulator Assembly, Location of Parts.

Table 5-1. Recommended Test Equipment

Test Equipment	Type (or equivalent)
RF Load and Wattmeter (50 ohms, 20 Wmin.)	Bird 611
FM Modulation Monitor	QEI 671
Audio Generator (less than 0.1% distortion)	Hewlett-Packard 200CD
Dual Trace 10 MHz Oscilloscope	Telequipment D54
110 MHz Counter (Stability greater than 1 part in 10^6)	Hewlett-Packard 5245L with 5253 Plug-in
Signal Sampler (-20 to -30 dB output)	Emco M-201N
Spectrum Analyzer	Hewlett-Packard 8553B/8552A
Distortion Analyzer	Hewlett-Packard 331

Table 5-2. Troubleshooting Chart

Malfunction	Probable Cause	Corrective Action
POWER on indicator does not light; unit does not function.	1. Unregulated dc power missing.	1. Check A1F1 and A1CR1; replace if defective.
	2. A4CR1 or A4CR2 defective.	2. Replace A4CR1 or A4CR2.
POWER on indicator does not light; unit functions correctly.	1. A1CR2 defective.	1. Replace A1CR2.
	2. A4R28 open.	2. Replace A4R28.
Vcc reading on MULTIMETER is incorrect.	1. IPA and PA supply-regulator defective.	1. Check A1Q1, through A4Q4, A1Q1, and A4CR1 through A4CR4; replace if defective.
	2. PWR ADJ control A1R1 defective.	2. Replace A1R1.
+15 V reading on MULTIMETER is incorrect.	+15 Vdc supply-regulator defective.	Check A4Q5 through A4Q7 and A4CR6, replace if defective.
+5 V reading on MULTIMETER is incorrect.	+5 Vdc supply-regulator defective.	Check A4Q8, A4Q9, A1Q2, A4CR5, and A4CR7 through A4CR10; replace if defective.
Ref reading on MULTIMETER is incorrect.	1. Reference oscillator defective.	1. Check A2Q7 through A2Q9 and A2Y1; replace if defective.
	2. Divide-by-1600 counter defective.	2. Check A2U7 through A2U9; replace if defective.
	3. 6 kHz buffer defective.	3. Check A2Q10; replace if defective.

Table 5-2. Troubleshooting Chart (Cont'd)

Malfunction	Probable Cause	Corrective Action
Fmo reading on MULTIMETER is incorrect.	1. FMO circuit defective.	1. Check FMO subassembly; replace if defective.
	2. FMO buffer or amplifier defective.	2. Check A2Q1 or A2Q3; replace if defective.
	3. FMO-unlocked circuit defective.	3. Check A2Q2; replace if defective.
IPA reading on MULTIMETER is incorrect.	IPA circuit defective.	Check A3Q1; replace if defective.
PA reading on MULTIMETER is incorrect.	PA circuit defective.	Check A3Q2; replace if defective.
RF reading on MULTIMETER is incorrect.	1. PA defective.	1. Check A3Q2; replace if defective.
	2. Improper RF load.	2. Check RF load; ensure that exciter is working into a 50 ohm load.
AFC LOCKED indicator does not light; output frequency is stable.	1. AFC LOCKED indicator defective.	1. Check A1DS1; replace if defective.
	2. A4R27 open.	2. Check A4R27; replace if defective.
AFC indicator does not light; output frequency unstable.	1. FMO circuits defective; Fmo reading on MULTIMETER is incorrect.	1. Proceed as for incorrect FMO reading on MULTIMETER.
	2. Reference oscillator circuits defective; Ref reading on MULTIMETER is incorrect.	2. Proceed as for incorrect Ref reading on MULTIMETER.
	3. Divider circuits defective.	3. Check U1 through U6; replace if defective.

Table 5-2. Troubleshooting Chart (Cont'd)

Malfunction	Probable Cause	Corrective Action
	4. Phase comparator and lock detector defective.	4. Check U10, Q11, and Q12; replace if defective.

5-6. REMOVAL AND REPLACEMENT PROCEDURES.

All exciter components are easily replaced without the use of special tools or special techniques. Observe, however, the following general precautions when making repairs to the exciter:

a. Solid-state components are susceptible to heat damage during soldering operations. Therefore, always use a low capacity soldering iron (25 W or less) and heat sink solid-state component leads to prevent thermal damage to the item.

b. Use only 60/40 rosin core solder.

c. Always use a "solder sucker" or "solder wick" when unsoldering components.

d. When removing a diode always note the location of the band on the diode (cathode end). Observe this polarity when replacing the diode.

e. When removing a component having multiple leads, always tag the leads to ensure correct reinstallation.

5-7. ALIGNMENT AND ADJUSTMENT.

NOTE

Do not attempt troubleshooting or alignment of this unit without adequate tools and test equipment

Before starting alignment of this unit, verify that three supply voltages are present and correct. Connect the Exciter to a 50 ohm, 20 watt RF load through the signal sampler.

The following adjustments may be accomplished on the FMO and Phase Lock assembly:

a. Frequency programming

b. AFC adjustment - A2R47

c. Modulation level adjustment - A2R31, A2R34

d. Coarse frequency adjustment - A2C27.

The following adjustments may be accomplished on the IPA and PA assembly:

a. Coarse alignment - A3C2, A3C7, A3C8, A3C14, A3C15

b. Final alignment - A3C2, A3C7, S3C8, A3C14, A3C15.

5-8. FREQUENCY PROGRAMMING. The exciter can be reprogrammed to operate on any odd tenth-MHz frequency from 88.1 to 107.9 MHz. To accomplish this, the programmable counter must be configured with a program unique to each frequency. Proceed as follows:

1. Refer to drawing 5051277.

2. Locate the following programming points on the drawing and the FMO and Phase Lock assembly.

    a. X1 - X2

    b. A1, B1, C1, D1

    c. A2, B2, C2, D2

    d. A3, B3, C3, D3.

3. Refer to table 5-3. For the frequency to be programmed, tie to ground those programming points indicated by X, short together those programming points indicated by *, and leave open those points indicated by o.

4. Accomplish paragraphs 5-9 through 5-15 in the sequence given to check exciter alignment.

5-9. FMO AND PHASE LOCK AFC ADJUSTMENT.

1. Connect oscilloscope to junction of A2C21 and A2R43. Adjust A2R47 for the greatest amplitude linear 5 kHz sawtooth obtainable.

2. Connect oscilloscope to pin 6 of A2U11. Adjust trimmer accessible through hole in FMO can until pin 6 shows a dc level. Either side of lock will give a sawtooth signal whose frequency becomes lower as lock is approached.

5-10. FMO AND PHASE LOCK COARSE FREQUENCY ADJUSTMENT.

NOTE

Be sure of the accuracy and stability of the frequency counter.

1. Connect a frequency counter to the low level output of the signal sampler.

2. Remove all modulation from the exciter. If any modulation is present, it is necessary for the counter to have a gate time of at least four seconds in order to obtain a correct reading.

3. Set FREQ ADJ pot R2 to the center of its range.

Table 5-3. Frequency Programming

Freq. MHz	Programming Points												
	X1-X2	A1	B1	C1	D1	A2	B2	C2	D2	A3	B3	C3	D3
88.1	o		X	X					X	X	X	X	
88.3	o		X	X	X	X	X	X		X	X	X	
88.5	o			X	X	X	X	X		X	X	X	
88.7	o		X		X	X	X	X		X	X	X	
88.9	o				X	X	X	X		X	X	X	
89.1	o		X	X		X	X	X		X	X	X	
89.3	o		X	X	X		X	X		X	X	X	
89.5	o			X	X		X	X		X	X	X	
89.7	o		X		X		X	X		X	X	X	
89.9	o				X		X	X		X	X	X	
90.1	o		X	X			X	X		X	X	X	
90.3	o		X	X	X	X	X	X	X		X	X	
90.5	o			X	X	X	X	X	X		X	X	
90.7	o		X		X	X	X	X	X		X	X	
90.9	o				X	X	X	X	X		X	X	
91.1	o		X	X		X	X	X	X		X	X	
91.3	o		X	X	X		X	X	X		X	X	
91.5	o			X	X		X	X	X		X	X	
91.7	o		X		X		X	X	X		X	X	
91.9	o				X		X	X	X		X	X	
92.1	o		X	X			X	X	X		X	X	
92.3	o		X	X	X	X		X	X		X	X	
92.5	o			X	X	X		X	X		X	X	
92.7	o		X		X	X		X	X		X	X	
92.9	o				X	X		X	X		X	X	
93.1	o		X	X		X		X	X		X	X	
93.3	o		X	X	X			X	X		X	X	
93.5	o			X	X			X	X		X	X	
93.7	o		X		X			X	X		X	X	
93.9	o				X			X	X		X	X	
94.1	o		X	X				X	X		X	X	
94.3	o		X	X	X	X	X		X		X	X	
94.5	o			X	X	X	X		X		X	X	
94.7	o		X		X	X	X		X		X	X	
94.9	o				X	X	X		X		X	X	

Table 5-3. Frequency Programming (Cont'd)

Freq. MHz	Programming Points												
	X1-X2	A1	B1	C1	D1	A2	B2	C2	D2	A3	B3	C3	D3
95.1	o		X	X		X	X		X		X	X	
95.3	o		X	X	X		X		X		X	X	
95.5	o			X	X		X		X		X	X	
95.7	o		X		X		X		X		X	X	
95.9	o				X		X		X		X	X	
96.1	o		X	X			X		X		X	X	
96.3	o		X	X	X	X			X		X	X	
96.5	o			X	X	X			X		X	X	
96.7	o		X		X	X			X		X	X	
96.9	o				X	X			X		X	X	
97.1	o		X	X		X			X		X	X	
97.3	o		X	X	X				X		X	X	
97.5	o			X	X				X		X	X	
97.7	o		X		X				X		X	X	
97.9	o				X				X		X	X	
98.1	o		X	X					X		X	X	
98.3	o		X	X	X	X	X	X			X	X	
98.5	o			X	X	X	X	X			X	X	
98.7	o		X		X	X	X	X			X	X	
98.9	o				X	X	X	X			X	X	
99.1	o		X	X		X	X	X			X	X	
99.3	o		X	X	X		X	X			X	X	
99.5	o			X	X		X	X			X	X	
99.7	o		X		X		X	X			X	X	
99.9	o				X		X	X			X	X	
100.1	*	X	X	X	X	X	X	X	X	X	X	X	X
100.3	*	X		X	X	X	X	X	X	X	X	X	X
100.5	*	X	X		X	X	X	X	X	X	X	X	X
100.7	*	X			X	X	X	X	X	X	X	X	X
100.9	*	X	X	X		X	X	X	X	X	X	X	X
101.1	*	X	X	X	X		X	X	X	X	X	X	X
101.3	*	X		X	X		X	X	X	X	X	X	X
101.5	*	X	X		X		X	X	X	X	X	X	X
101.7	*	X			X		X	X	X	X	X	X	X
101.9	*	X	X	X			X	X	X	X	X	X	X

Table 5-3. Frequency Programming (Cont'd)

Freq. MHz	Programming Points												
	X1-X2	A1	B1	C1	D1	A2	B2	C2	D2	A3	B3	C3	D3
102.1	*	X	X	X	X	X		X	X	X	X	X	X
102.3	*	X		X	X	X		X	X	X	X	X	X
102.5	*	X	X		X	X		X	X	X	X	X	X
102.7	*	X			X	X		X	X	X	X	X	X
102.9	*	X	X	X		X		X	X	X	X	X	X
103.1	*	X	X	X	X			X	X	X	X	X	X
103.3	*	X		X	X			X	X	X	X	X	X
103.5	*	X	X		X			X	X	X	X	X	X
103.7	*	X			X			X	X	X	X	X	X
103.9	*	X	X	X				X	X	X	X	X	X
104.1	*	X	X	X	X	X	X		X	X	X	X	X
104.3	*	X		X	X	X	X		X	X	X	X	X
104.5	*	X	X		X	X	X		X	X	X	X	X
104.7	*	X			X	X	X		X	X	X	X	X
104.9	*	X	X	X		X	X		X	X	X	X	X
105.1	*	X	X	X	X		X		X	X	X	X	X
105.3	*	X		X	X		X		X	X	X	X	X
105.5	*	X	X		X		X		X	X	X	X	X
105.7	*	X			X		X		X	X	X	X	X
105.9	*	X	X	X			X		X	X	X	X	X
106.1	*	X	X	X	X	X			X	X	X	X	X
106.3	*	X		X	X	X			X	X	X	X	X
106.5	*	X	X		X	X			X	X	X	X	X
106.7	*	X			X	X			X	X	X	X	X
106.9	*	X	X	X		X			X	X	X	X	X
107.1	*	X	X	X	X				X	X	X	X	X
107.3	*	X		X	X				X	X	X	X	X
107.5	*	X	X		X				X	X	X	X	X
107.7	*	X			X				X	X	X	X	X
107.9	*	X	X	X					X	X	X	X	X

X - Tie to ground
o - Open
* - Short together.

4. Adjust A2C27 until exciter is on frequency.

5. Vary FREQ ADJ pot R2 from end to end. Frequency should bary approximately ± 500 Hz. Reset exciter on frequency.

5-11. IPA AND PA COARSE ALIGNMENT.

1. Using the signal sampler, connect the RF load/Wattmeter to RF Out jack J1. Connect a spectrum analyzer to the low level output of the signal sampler.

2. Apply power to the unit and observe POWER on indicator CR2 and AFC LOCKED indicator DS1. If indicators do not light refer to FMO alignment procedures (paragraphs 5-9, 5-10, and 5-13).

3. Set PWR ADJ control R1 full clockwise. Set the MULTIMETER switch S2 to the IPA position. Set A3C2 to mid-range.

4. Observe an indication of IPA collector current on the MULTIMETER. Maximize this indication by adjusting A2C6 and A2C7 of the A2 board.

5. Set the MULTIMETER switch to the PA position. Adjust A3C7 and A3C8 for a maximum reading in this position.

6. Set the MULTIMETER switch to the RF position. Adjust A3C14 and A3C15 for a maximum reading in this position. The coarse alignment is now complete. Accomplish final alignment.

5-12. IPA AND PA FINAL ALIGNMENT.

1. Connect low level output of signal sampler to spectrum analyzer.

2. Set MULTIMETER switch S2 to the RF position. Adjust A3C14 and A3C15 for a maximum reading on the multimeter. If the Power Amplifier draws excessive current and trips the power supply overload circuitry, adjust A3C15 clockwise until this condition is corrected. When this condition appears, the output power is in excess of 20 watts. Adjust A3C15 clockwise to reduce the output power to 20 watts. Readjust A3C14 for a maximum reading on the MULTIMETER.

3. Adjust A3C7 and A3C8 for a maximum reading on the MULTIMETER.

4. Turn the PWR ADJ control R1 to the max. CCW position.

5. Adjust A3C2 for stability as observed on the spectrum analyzer.

6. Turn the PWR ADJ control to the max. CW position. Readjust A3C2 if necessary to stabilize the display.

5-13. FMO AND PHASE LOCK MODULATION LEVEL ADJUSTMENT.

1. Connect an FM Modulation Monitor to the low level output of the signal sampler.

2. Using an audio generator, connect a 400 Hz +10 dBm signal to TB1. Place S3 in MONO position. Adjust A2R31 until monitor reads 100 percent.

3. Using a 400 Hz 4 Vpp (1.41 Vrms) signal to Comp jack J2. Place S3 in position. Adjust A2R34 until monitor reads 100 percent.

5-14. RECHECK COARSE FREQUENCY ADJUSTMENT. Repeat step 5-10; readjust if necessary.

5-15. PROOF OF PERFORMANCE TEST. Accomplish a proof of performance test using the Distortion Analyzer.

SECTION VI

PARTS LISTS

6-1. ORDERING INFORMATION.

To order parts for the FM-15QE Exciter, write:

American Electronic Laboratories, Inc.
P. O. Box 552
Lansdale, PA 19446

or call:

(215) 822-2929, extension 355.

Provide the following information:

a. Station call

b. Model and serial no.

c. Reference designation of part if applicable (i.e., A4R10)

d. AEL part no. or manufacturer's part no.

e. Desired method of shipment.

6-2. PARTS LISTS.

The parts lists for the exciter are found, unbound, at the back of this manual.

SECTION VII

DIAGRAMS

The following diagrams are supplied, unbound, with this technical manual:

Title	Drawing No.
Block Diagram, FM Exciter	3050688
Schematic Diagram, FM Exciter Chassis	4051139
Schematic Diagram, Power Supply	4051141
Schematic Diagram, FM Exciter Power Amplifier	4051142
Schematic Diagram, FMO and Phase Lock	5051277

AMERICAN ELECTRONIC LABORATORIES, INC.

EXCITER PROOF OF PERFORMANCE

MODEL FM-15QE

Freq. (Hz)	INPUT LEVEL (dB)	MAX.	MIN.	DIST. (%)
50	+10	12.2	8.2	.14
100	+10	11.7	8.7	.11
400	+10	10.0		.12
1000	+9.4	10.8	7.8	.13
5000	+2.0	3.3	0.3	.12
7500	-1.0	0.2	-2.8	.15
10,000	-3.1	-1.6	-5.4	.19
15,000	-6.0	-4.4	-9.4	.26

PANEL METER READINGS

VCC	.43
+15V	58
+5V	.50
REF	.48
FMO	.72
IPA	.36
PA	.31
RF	.26

FM NOISE -72 dB

AM NOISE > - 70 dB

EXCITER SR. NO. 145

FREQUENCY 93.7 MHz

STATION WAYL

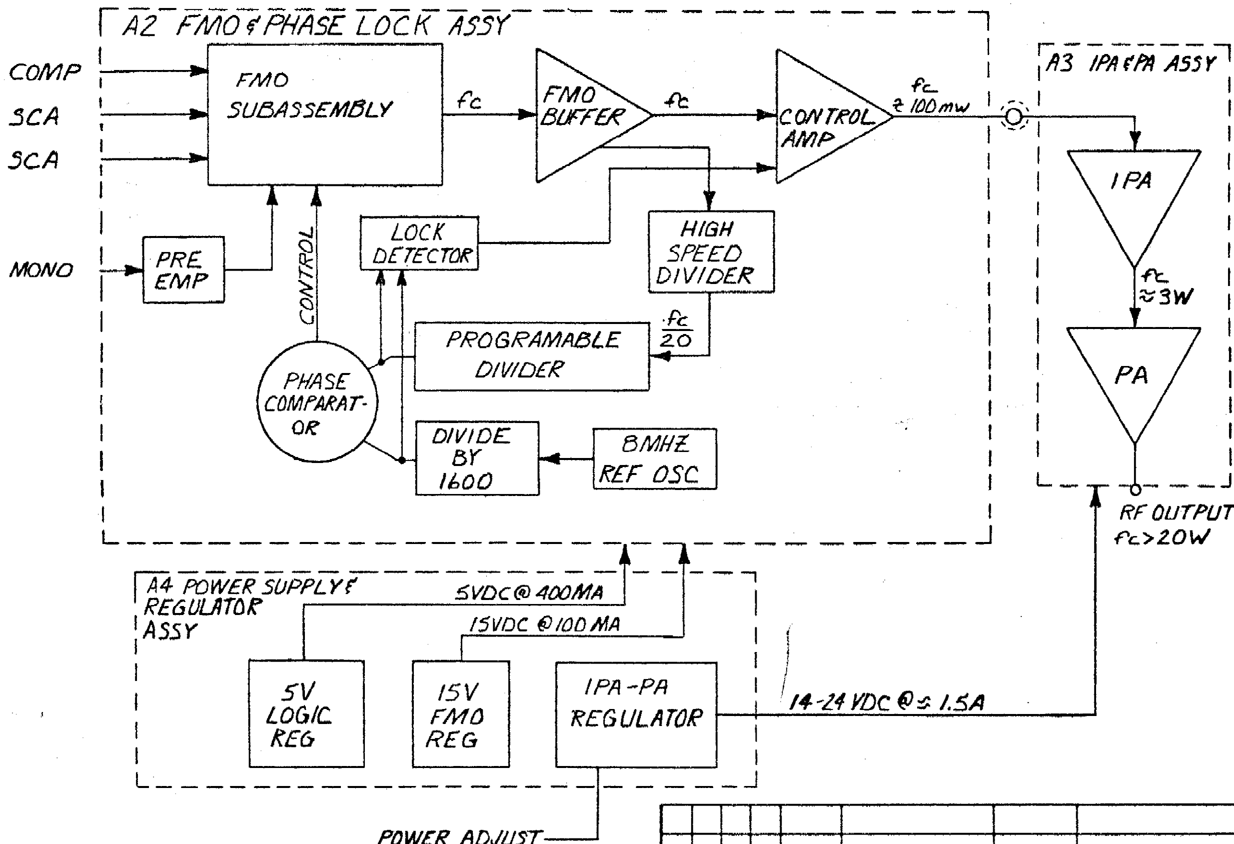
MODULATION MONITOR QEI 1671

DISTORTION METER HP 334A

DATE 9/12/77

TESTER Paul Alcoff

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED



504	503	502	501	ITEM OR REF DESIG.	PART NUMBER	CODE IDENT †	DESCRIPTION	MATERIAL/FINISH	SPECIFICATION	NOTE
QTY REQD										

PARTS LIST

INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-D-1000.
DO NOT SCALE DRAWING.
UNLESS OTHERWISE SPECIFIED;
DIMENSIONS ARE IN INCHES AND INCLUDE PLATING THICKNESS WHEN SPECIFIED.
ALL THREADS ARE UNIFIED NATIONAL SERIES, CLASS 2.
REMOVE ALL BURRS AND SHARP EDGES.
MANUFACTURE IN ACCORDANCE WITH MFG SPEC NO.
* VENDOR ITEM–SEE SPECIFICATION OR SOURCE CONTROL DRAWING.
† VENDORS IDENTIFIED BY CODE IDENT NO. ARE LISTED IN FEDERAL CATALOGING HANDBOOK H4-2.

ASSY OR PART	NEXT ASSY	USED ON
REF		12406
APPLICATION		

UNLESS OTHERWISE SPECIFIED TOLERANCES ON:

BASIC DIMENSIONS	2 PLACE DECIMALS	3 PLACE DECIMALS
UP TO 10	±.02	±.005
ABOVE 10 TO 36	±.03	±.010
ABOVE 36	±.06	±.015
ANGULAR DIMENSIONS ± 1/2°		

UNLESS OTHERWISE SPECIFIED ALL HOLE TOLERANCES PER 1610123

CONTRACT OR ORDER NO

		DATE
DRAWN	John Ross	9-11-75
CHECKED	R. Shuies	9-15-75
MECH ENGR		
ELEC ENGR	R. L. Se...	9-15-75
APPROVAL (PROJECT)		
APPROVAL (CUSTOMER)		

AMERICAN ELECTRONIC LABORATORIES, INC.
COLMAR, PA.

BLOCK DIAGAM
FM EXCITER

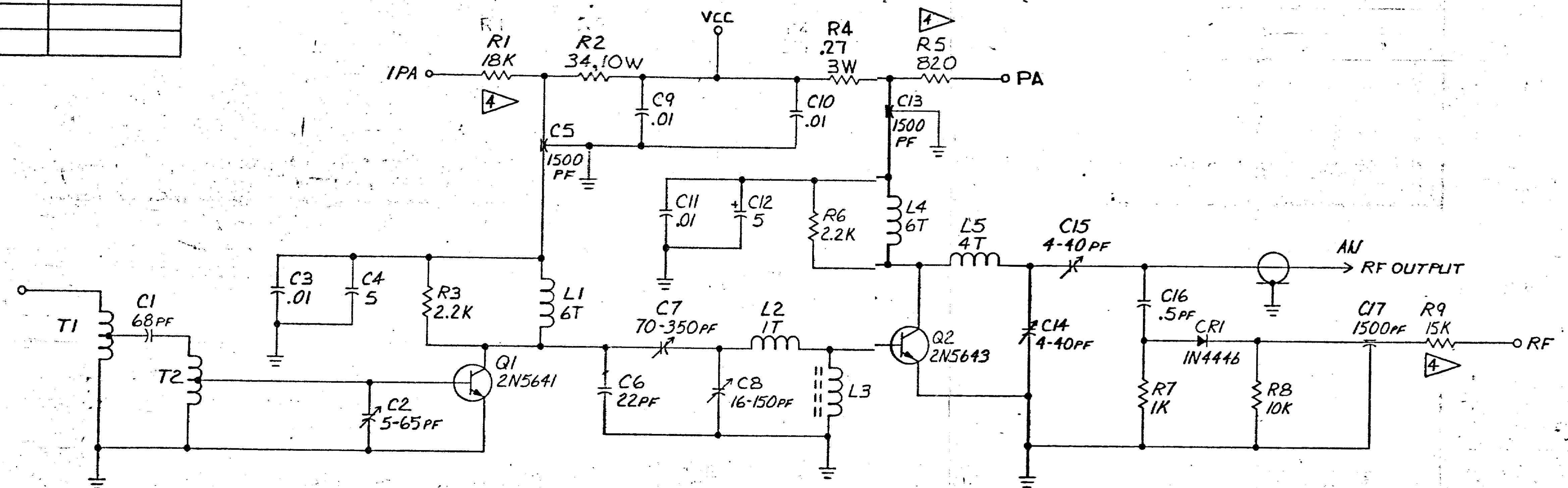
DWG SIZE	CODE IDENT	DRAWING NO.	REV
C	93346	3050688	

SCALE NONE WEIGHT N/A SHEET 1 OF 1

3050688

COMPONENT REFERENCE DESIGNATIONS	
LAST USED	NOT USED
A1J	
C17	
CR1	
L5	
Q2	
R9	
T2	

REVISIONS		
ZONE	LTR	DESCRIPTION
	A	GENERAL REVISIONS



NOTES:

UNLESS OTHERWISE SPECIFIED:

1. REFERENCE DESIGNATIONS ARE ABBREVIATED. FOR COMPLETE DESIGNATION, PREFIX WITH UNIT NUMBER AND/OR SUBASSEMBLY DESIGNATION(S) AS APPLICABLE.
2. ALL RESISTANCE VALUES ARE IN OHMS.
3. ALL CAPACITANCE VALUES ARE IN UF.

4 FACTORY SELECT ITEM.

INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-STD-100.
DO NOT SCALE DRAWING.
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES AND INCLUDE PLATING THICKNESS WHEN SPECIFIED.
ALL THREADS ARE UNIFIED NATIONAL SERIES, CLASS 2.
REMOVE ALL BURRS AND SHARP EDGES.
MANUFACTURE IN ACCORDANCE WITH MFG. SPEC.
* VENDOR ITEM—SEE SPECIFICATION OR SOURCE CONTROL DRAWING.
† VENDORS IDENTIFIED BY CODE IDENT. NO. ARE LISTED IN FEDERAL CATALOGING HANDBOOK H4-2.

504	503	502	501	ITEM OR REF DESIG.	PART NUMBER	CODE IDENT †	DESCRIPTION	MATERIAL/FINISH	SP
QTY REQD					PARTS LIST				

ASSY OR PART	NEXT ASSY	USED ON
REF		12406
APPLICATION		

UNLESS OTHERWISE SPECIFIED, TOLERANCES ON:		
BASIC DIMENSIONS	2 PLACE DECIMALS	3 PLACE DECIMALS
UP TO 10	±.02	±.005
ABOVE 10 TO 36	±.03	±.010
ABOVE 36	±.06	±.015
ANGULAR DIMENSIONS ±½°		

UNLESS OTHERWISE SPECIFIED ALL HOLE TOLERANCES PER 1610123

CONTRACT OR ORDER NO.	
DRAWN John Ross	DATE 9-11-75
CHECKED R. [illegible]	9-15-75
MECH ENGR	
ELEC ENGR R. E. [illegible]	9-15-75
APPROVAL (PROJECT)	
APPROVAL (CUSTOMER)	

AMERICAN ELECTRONIC LA[B]
COLMAR, PA

SCHEMATIC DIAGRA[M]
FM EXCITER
POWER AMPLIFIER

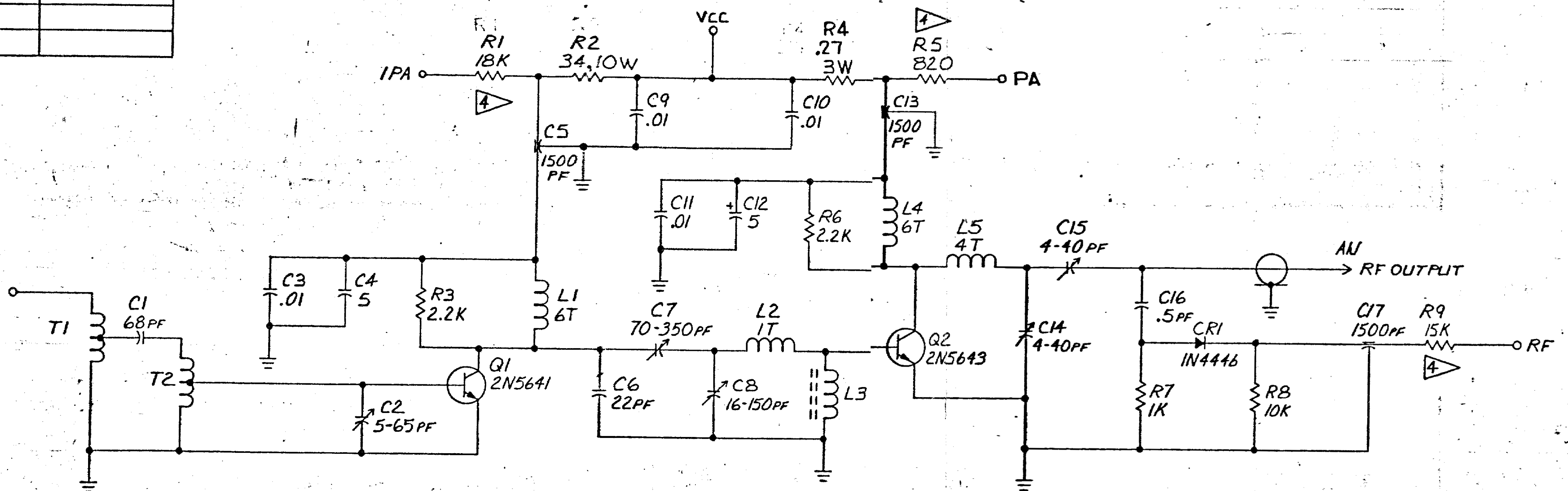
DWG SIZE	CODE IDENT	DRAWING NO.
D	93346	405114
SCALE NONE	WEIGHT N/A	SHE[ET]

COMPONENT REFERENCE DESIGNATIONS

LAST USED	NOT USED
A1J	
C17	
CR1	
L5	
Q2	
R9	
T2	

REVISIONS

ZONE	LTR	DESCRIPTION
	A	GENERAL REVISIONS



NOTES:

UNLESS OTHERWISE SPECIFIED:

1. REFERENCE DESIGNATIONS ARE ABBREVIATED. FOR COMPLETE DESIGNATION, PREFIX WITH UNIT NUMBER AND/OR SUBASSEMBLY DESIGNATION(S) AS APPLICABLE.
2. ALL RESISTANCE VALUES ARE IN OHMS.
3. ALL CAPACITANCE VALUES ARE IN UF.

4 FACTORY SELECT ITEM.

INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-STD-100.
DO NOT SCALE DRAWING.
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES AND INCLUDE PLATING THICKNESS WHEN SPECIFIED.
ALL THREADS ARE UNIFIED NATIONAL SERIES, CLASS 2.
REMOVE ALL BURRS AND SHARP EDGES.
MANUFACTURE IN ACCORDANCE WITH MFG. SPEC.
* VENDOR ITEM—SEE SPECIFICATION OR SOURCE CONTROL DRAWING.
† VENDORS IDENTIFIED BY CODE IDENT. NO. ARE LISTED IN FEDERAL CATALOGING HANDBOOK H4-2.

504	503	502	501	ITEM OR REF DESIG.	PART NUMBER	CODE IDENT †	DESCRIPTION	MATERIAL/FINISH	SP
QTY REQD					PARTS LIST				

ASSY OR PART	NEXT ASSY	USED ON
REF		12406
APPLICATION		

UNLESS OTHERWISE SPECIFIED, TOLERANCES ON:

BASIC DIMENSIONS	2 PLACE DECIMALS	3 PLACE DECIMALS
UP TO 10	±.02	±.005
ABOVE 10 TO 36	±.03	±.010
ABOVE 36	±.06	±.015

ANGULAR DIMENSIONS ±1/2°

UNLESS OTHERWISE SPECIFIED ALL HOLE TOLERANCES PER 1610123

CONTRACT OR ORDER NO.	DATE
DRAWN John Ross	9-11-75
CHECKED R. [illegible]	9-15-75
MECH ENGR	
ELEC ENGR R. [illegible]	9-15-75
APPROVAL (PROJECT)	
APPROVAL (CUSTOMER)	

AMERICAN ELECTRONIC LA[illegible]
COLMAR, P[illegible]

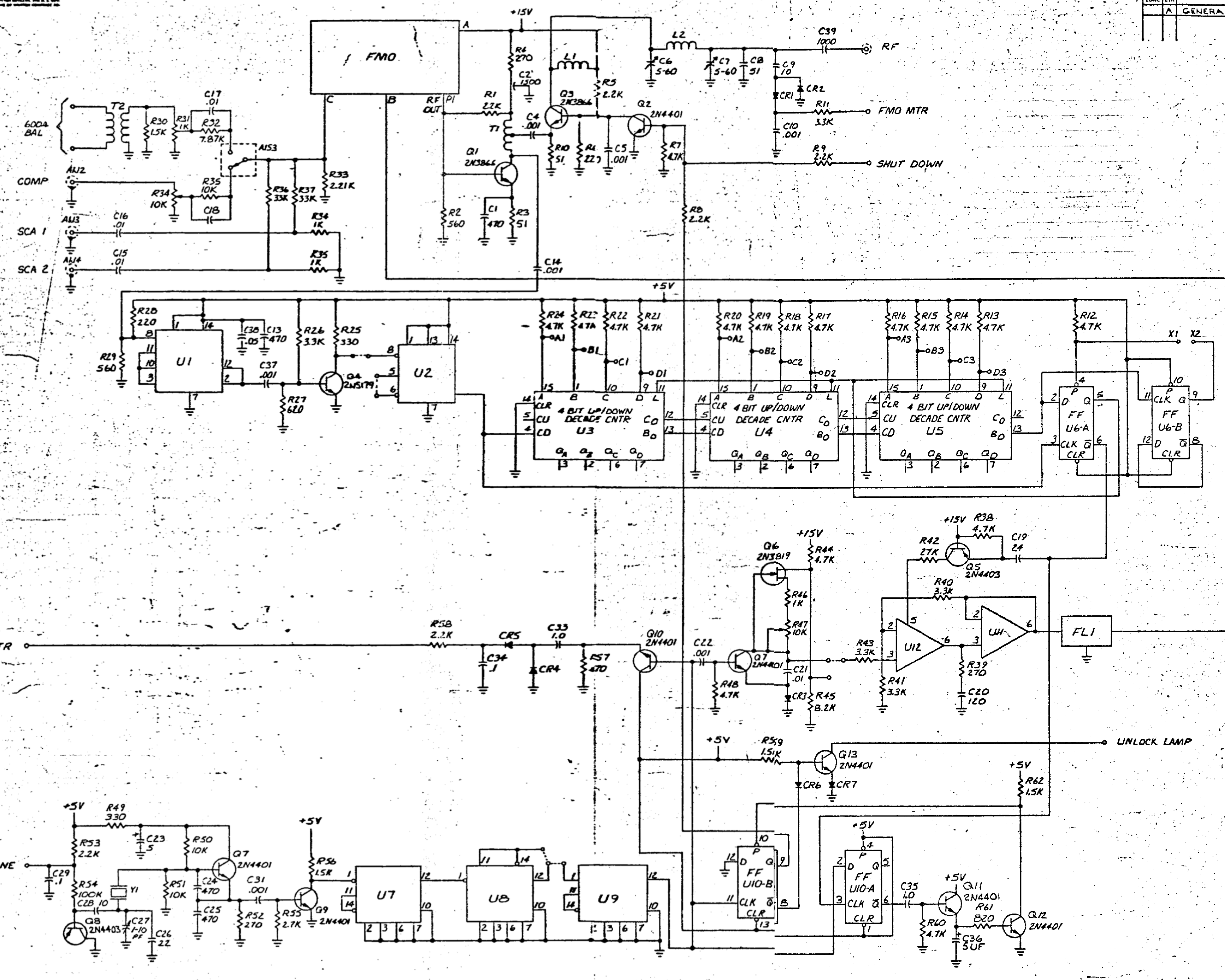
SCHEMATIC DIAGRA[illegible]
FM EXCITER
POWER AMPLIFIER

DWG SIZE	CODE IDENT	DRAWING NO.
D	93346	405114

SCALE NONE WEIGHT N/A SHE[illegible]

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPR
	A	GENERAL REVISIONS		

COMPONENT REFERENCE DESIGNATIONS	
LAST USED	NOT USED
	A1J1

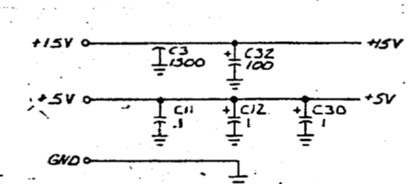


LOGIC SYMBOL	COMMERCIAL DEVICE TYPE	+15V PIN	+5V PIN
U1	1034	–	14
U2	745196	–	14
U3	74192	–	16
U4	74192	–	16
U5	74192	–	16
U6	7474	–	14
U7	7493	–	5
U8	7490	–	5
U9	7490	–	5
U10	7474	–	14
U11	741	7	–
U12	3080	7	–
U13			
U14			
U15			

NOTES:

UNLESS OTHERWISE SPECIFIED:

1. REFERENCE DESIGNATIONS ARE ABBREVIATED. FOR COMPLETE DESIGNATION, PREFIX WITH UNIT NUMBER AND/OR SUBASSEMBLY DESIGNATION(S) AS APPLICABLE.
2. ALL RESISTANCE VALUES ARE IN OHMS.
3. ALL CAPACITANCE VALUES ARE IN UF.



PARTS LIST

QTY REQD				ITEM OR REF DESIG	PART NUMBER	CODE IDENT	DESCRIPTION	MATERIAL/FINISH	SPECIFICATION
504	503	502	501						

UNLESS OTHERWISE SPECIFIED ALL HOLE TOLERANCES PER 1610123

ASSY OR PART	NEXT ASSY	USED ON
REF		12406

APPLICATION

CONTRACT OR ORDER NO.

DRAWN John Ross DATE 9-9-75

CHECKED 9-15-75

MECH ENGR

ELEC ENGR 9-15-75

APPROVAL (PROJECT)

APPROVAL (CUSTOMER)

AMERICAN ELECTRONIC LABORATORIES COLMAR, PA.

SCHEMATIC DIAGRAM FMO & PHASE LOCK

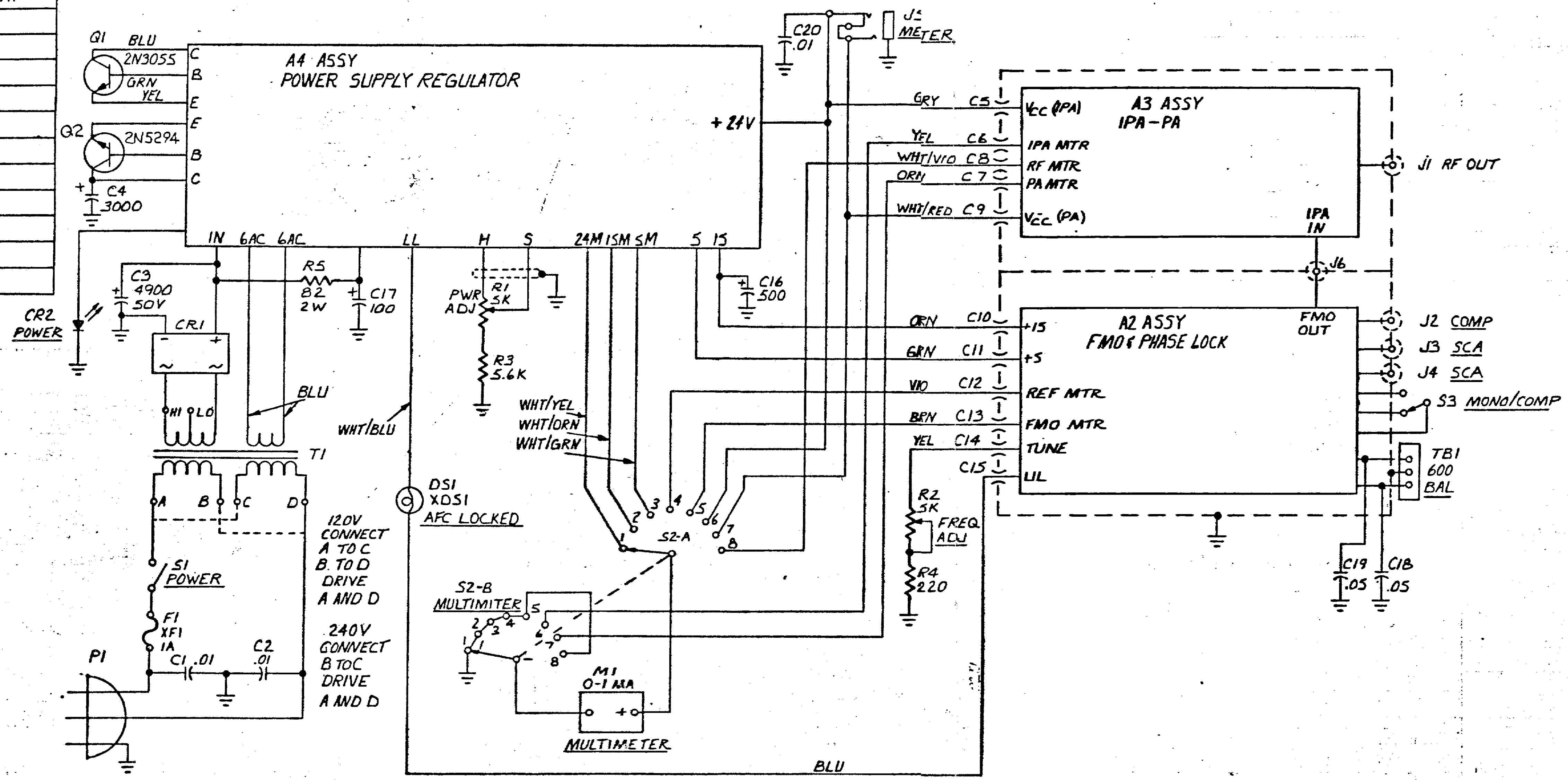
DWG SIZE E | CODE IDENT 93346 | DRAWING NO. 5051277

SCALE | WEIGHT | SHEET 1 OF

CATEGORY

REVISIONS			
ZONE	LTR	DESCRIPTION	DATE
	A	GENERAL REVISIONS JWZ	1/7?

COMPONENT REFERENCE DESIGNATIONS	
LAST USED	NOT USED
A4	A1
C19	
CR2	
DS1	
J5	
P1	
Q2	
R5	
S3	
T1	
XDS1	
XF1	



NOTES:

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3. ALL CAPACITANCE VALUES ARE IN

INTERPRET DRAWING IN ACCORDANCE WITH STANDARDS PRESCRIBED BY MIL-STD-100.
DO NOT SCALE DRAWING.
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES AND INCLUDE PLATING THICKNESS WHEN SPECIFIED.
ALL THREADS ARE UNIFIED NATIONAL SERIES, CLASS 2.
REMOVE ALL BURRS AND SHARP EDGES.
MANUFACTURE IN ACCORDANCE WITH MFG. SPEC.
* VENDOR ITEM-SEE SPECIFICATION OR SOURCE CONTROL DRAWING.
† VENDORS IDENTIFIED BY CODE IDENT. NO. ARE LISTED IN FEDERAL CATALOGING HANDBOOK H4-2.

504	503	502	501	ITEM OR REF DESIG.	PART NUMBER	CODE IDENT †	DESCRIPTION	MATERIAL/FINISH	SPECIFICA
QTY REQD					PARTS LIST				

REF		12406
ASSY OR PART	NEXT ASSY	USED ON
	APPLICATION	

UNLESS OTHERWISE SPECIFIED ALL HOLE TOLERANCES PER 1610123

CONTRACT OR ORDER NO.	
DRAWN John Ross	DATE 9-10-75
CHECKED	9-15-75
MECH ENGR	
ELEC ENGR	9-15-75
APPROVAL (PROJECT)	
APPROVAL (CUSTOMER)	

AMERICAN ELECTRONIC LABORA
COLMAR, PA.

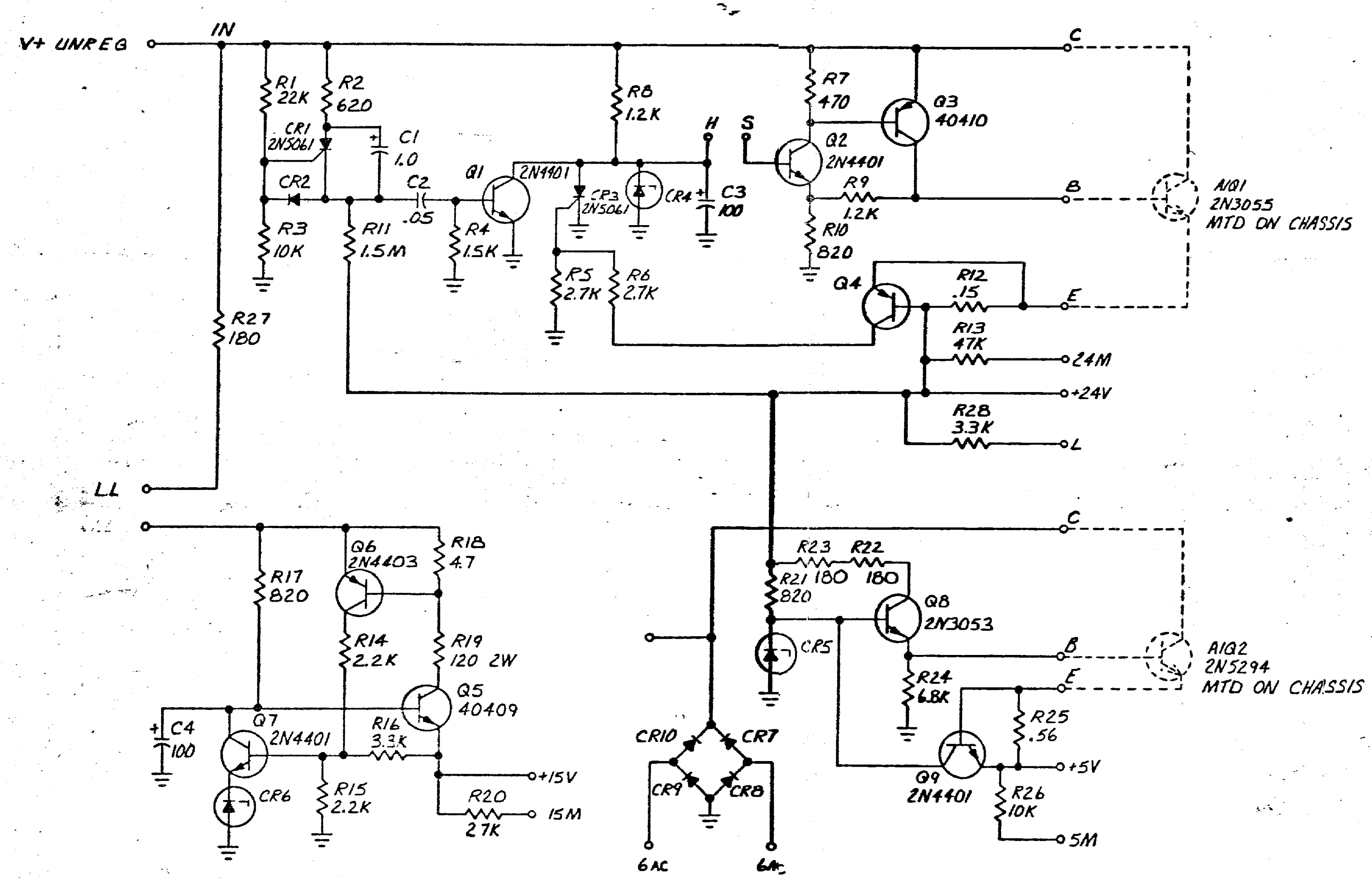
SCHEMATIC DIAGRAM
FM EXCITER CHASSIS

DWG SIZE	CODE IDENT	DRAWING NO.
D	93346	4051139

SCALE N/A WEIGHT N/A SHEET 1

COMPONENT REFERENCE DESIGNATIONS	
LAST USED	NOT USED
A1Q2	
C4	
CR10	
R28	
Q9	

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	GENERAL REVISIONS	6/7/73	



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504	503	502	501	ITEM OR REF DESIG.	PART NUMBER	CODE IDENT †	DESCRIPTION	MATERIAL/FINISH	SPECIFICATION
QTY REQD					PARTS LIST				

ASSY OR PART	NEXT ASSY	USED ON
REF		12406
	APPLICATION	

UNLESS OTHERWISE SPECIFIED TOLERANCES ON:		
BASIC DIMENSIONS	2 PLACE DECIMALS	3 PLACE DECIMALS
UP TO 10	±.02	±.005
ABOVE 10 TO 36	±.03	±.010
ABOVE 36	±.06	±.015
ANGULAR DIMENSIONS ±1°		

UNLESSS OTHERWISE SPECIFIED ALL HOLE TOLERRANCES PER 16610123

CONTRACT OR ORDER NO.

		DATE
DRAWN	JOHN ROSS	9-11-75
CHECKED		9-15-75
MECH ENGR		
ELEC ENGR		9-15-75
APPROVAL (PROJECT)		
APPROVAL (CUSTOMER)		

AMERICAN ELECTRONIC LABORATORIES, INC.
COLMAR, PA.

SCHEMATIC DIAGRAM
POWER SUPPLY

DWG SIZE	CODE IDENT	DRAWING NO.
D	93346	4051141

SCALE N/A WEIGHT N/A SHEET 1 OF 1

CATEGORY