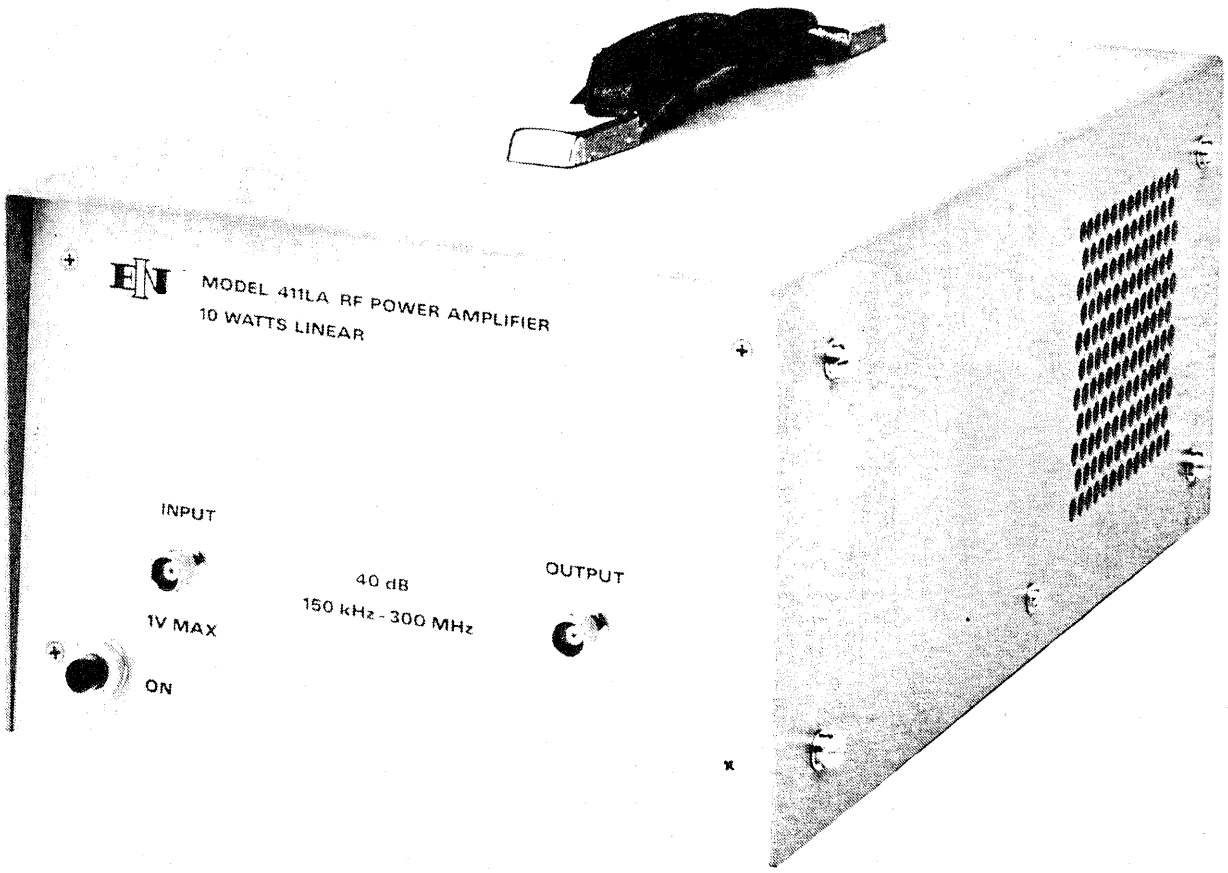
ELECTRONIC NAVIGATION INDUSTRIES, INC.

INSTRUCTION MANUAL

MODEL 411LA

BROADBAND POWER AMPLIFIER



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CHAPTER 1 GENERAL INFORMATION

1.1 INTRODUCTION

The Model 411LA is a general purpose broadband amplifier capable of more than 10 watts of linear power output when driven by any laboratory signal or sweep generator from .15 to 300 MHz.

An ultra linear Class A design, the 411LA will "boost" the output of any signal source by a flat 40 dB (±1.5 dB) and provide its full forward output power into any load impedance (from an open to a short circuit). Its output is a faithful reproduction of the input waveform for AM, FM, SSB, CATV, pulse and other complex modulations. Although specified only over the .15 to 300 MHz frequency range, full power output is typically available from .12 to 320 MHz.

The use of microwave transistors on thin film substrates, microstrip circuitry, and plug-in modules make the 411LA both reliable and easy to service. An integral power supply and cooling system permit operation over a wide range of temperature and AC line conditions.

1.2 DATA SUMMARY

Frequency Coverage:	.15 to 300 MHz
Gain:	40 dB nominal
Gain Variation:	±1.5 dB
Maximum Linear Power Output:	More than 10 watts
Harmonic Distortion:	All harmonics greater than 25 dB below the fundamental at 9.5 watts output. Lower distortion at reduced power.
Input/Output Impedance:	50 ohms
Input VSWR:	1.6 Maximum
Output VSWR:	2.3 Maximum
Stability:	Unconditionally stable

Typical 3rd Order Intermodulation Intercept Point:	+49 dBM
Noise Figure:	10 dB
Power Requirements:	115/230V a.c. ±10% 50-400 Hz, at 120 watts
Size and Weight:	5.7 x 8.7 x 15.4 inches, 18 lbs; 14.4 x 22.1 x 39.1 cm, 8.2 kg
Operating Temperature:	0° to 45°C
Protection:	Unit will withstand a +20 dB overdrive (1 volt RMS) for all output load conditions, including short and open circuits.
Output Connectors:	BNC standard, SMA and type N optional
Rack Mounting:	Optional

CHAPTER 2 OPERATION

2.1 INTRODUCTION

The ENI 411LA RF amplifier is used to increase the r.f. output level of signal sources in the .15 to 300 MHz range. No tuning or any other form of adjustment is required other than the selection of the correct power supply input voltage.

The 411LA produces rated power output at its output connector, regardless of load impedance. Any power reflected due to output load mismatch is absorbed in the amplifier. Therefore, although the output impedance is 50 ohms (typical VSWR: 2:1), the amplifier will work into any load impedance.

2.2 OPTIONAL RACK INSTALLATION

To install the 411LA into a nineteen inch relay rack, a rack panel and two rack panel brackets are required. To install the panel and associated brackets remove the two no. 8-32 screws on each side of the cover nearest the front panel. Verify left and right brackets by positioning them next to the cover screw holes and noting that the bottom of each bracket is flush with the base of the chassis. Attach the rack panel brackets firmly using the hardware removed above. Then take the rack panel and slide it over the front of the amplifier until it is flush against the rack panel brackets and attach it with the hardware supplied. The rubber feet may be unscrewed and removed if the minimum vertical usage of the relay rack is necessary.

2.2.1 Mains Voltage Setting

The supply voltage selection switch is located at the rear of the instrument and is normally set for 115 V a.c. operation.

CAUTION

Before connecting the unit to the mains supply, check that the supply voltage selection switch is correctly set. Extensive damage will result if the Amplifier is connected to the wrong supply voltage. Under no circumstances should this switch be operated while the supply is connected.

2.2.2 Mains Fuse Rating

The mains fuse F1 is located on the rear panel. The replacement part number details are:

3 amp	Slow Blow	ENI Part No. 313003

The 3 amp rating is correct for both 115 and 230 volts a.c.

2.2.3 Mains Lead Connection

For 230 V a.c. operation, a suitable mains supply plug must be fitted to the mains lead attached to the instrument. The three conductors are coded as follows:

BLACK - Live
WHITE - Neutral
GREEN - Earth

2.3 OPERATION

Determine and adjust the voltage setting and fuse rating as described in the previous sections 2.2.1 and 2.2.2 then proceed as follows:

(i) Ensure input voltage is not excessive

The 1 V rms indicated maximum input voltage is 5 times the level of the input signal required to achieve maximum output. Input voltages in excess of 2 volts peak may permanently damage the instrument.

(ii) Connect the input signal via a 50 ohm coaxial lead and BNC plug to the input connector.

(iii) Connect the output via a 50 ohm coaxial lead and BNC plug to the load.

CHAPTER 3 TECHNICAL DESCRIPTION

3.1 GENERAL DESCRIPTION

The ENI Model 411LA is designed to amplify signals by 40 dB in the frequency band of .15 to 300 MHz. The signal from the front panel BNC input connector is fed via a length of 50 ohm coaxial cable to the input of the preamplifier module (411LA-4682). The signal is amplified by low noise transistor Q1 and split into two equal amplitude and phase channels by transformer T2 (See Figure 5.1). Transistors Q2 and Q3 provide equal amounts of power gain and their outputs are recombined in transformer T3. Transformers T4, T5, T6, and T7 split the output of the preamplifier into four equal phase and amplitude signals appearing at J3, J4, J5 and J6. These signals are distributed by 50 ohm coaxial cables to form the inputs of four identical power amplifier modules (400AP-4641) mounted on the side plate heatsinks.

Each input signal is matched and attenuated by resistors R1, R2, R3 and capacitor C1 and coupled to be base of transistor Q1. The output at the collector of Q1 is matched and split into four equal phase and amplitude signals by transformers T1, T2, T3 and T4. Each of the four drive channels is coupled to a final transistor amplifier (Q2, Q3, Q4, and Q5). The outputs of each transistor are combined and impedance matched at the output jack J11, by transformers T5, T6, T7 and T8.

The outputs of the four power amplifier modules J11, J12, J13, and J14 are fed via 50 ohm cables to the inputs of the output combiner module (411LA-4684). Hybrid transformers T3, T4, and T2 vectorially sum the power outputs of the power amplifier modules. Transformer T1 and capacitors C1, C2 and C3 match the output impedance of the combiner to 50 ohms. Resistors R1, R2, and R3 will dissipate power only if the power amplifiers are unmatched or a failure has occurred. The output of the combiner module is sent to the output BNC connector on the front panel via a length of coaxial cable and connector module 510L-4445.

The amplifier power requirements are 115V or 230 V a.c. at 120 watts. The power supply regulator (411LA-3684) provides a 22 V d.c. 4 ampere source. The 22 V d.c. source is regulated by series pass transistors Q2 and Q3 driven by transistor Q1 in a Darlington arrangement. Voltage control and feedback is provided by integrated circuit regulator IC1. Resistor R4 adjusts the power supply voltage to 22 volts. The front panel light located in the front panel push button assembly is connected to the 22 V d.c. supply and will indicate when the power supply is operating.

CHAPTER 4 MAINTENANCE

4.1 INTRODUCTION

The ENI 411LA RF amplifier requires no periodic maintenance. The instrument is unconditionally stable and is failsafe under all load conditions. Damage can only be externally caused by the incorrect selection of the supply voltage or by an input signal in excess of the specified 1 volt rms maximum.

This chapter therefore, deals only with certain fundamental procedures for fault location and with the subsequent re-alignment procedures.

Performance limits quoted are for guidance only and should not be taken for guaranteed performance specifications unless they are also quoted in the Data Summary Section 1.2.

4.2 ACCESS AND LAYOUT

The ENI Model 411LA RF amplifier is housed in an aluminum chassis. The cover can be removed by releasing the ten screws on the side of the unit and lifting the handle.

The lamp indicator in the on-off switch may be replaced by unscrewing the knurled bezel on the switch and removing the lamp assembly.

The rear panel supports the mains fuse holders, the mains input voltage selector switch (S2) and the cooling fan.

The preamplifier module, four power amplifier modules, and the output combiner module are all attached to the "U" shaped RF heatsink which in turn is mounted to the amplifier baseplate. The power supply module (411LA-3684) contains the regulator module the bridge rectifier (CR1) two current handling transistors (Q2 and Q3) and a filter capacitor (C1) and is located in front of the fan and in the center of the baseplate. To gain access to the power supply module the RF heatsink must first be removed. To remove the RF heatsink, first disconnect the appropriate power leads from the terminal block located on the baseplate in the front of the unit. Remove the coaxial cables connected to it and the eight no. 4-40 mounting screws holding the heatsink to the chassis.

4.3 PERFORMANCE CHECKS

To determine the amplifier's performance carry out the following procedure.

4.3.1 Initial Check

The following check can be made after repair and adjustments or whenever the condition of the unit is in question.

(i) Connect power supply. Switch on power and observe that the supply lamp (DS1) illuminates.

(ii) Connect a sweep generator (Wavetek 2001 or similar) capable of sweeping the frequency range 1 to 300 MHz to the input connector.

(iii) Adjust the output level of the sweep generator so that a 50 ohm video detector connected at the output of the unit will not be damaged by excessive power output.

(iv) Observe the gain versus frequency ripple on an oscilloscope calibrated in decibels. The gain variation must be not more than ± 1.5 dB over the frequency range.

(v) Connect a calorimetric power meter (HP434 or equivalent) through a short length of 50 ohm cable to the output connector. Adjust the input CW signal to any frequency between 1 and 300 MHz for 9.5 watts output.

(vi) Observe the harmonic distortion of the output on a spectrum analyzer. The harmonic components contributed by the amplifier should be at least 25 dB down from the fundamental.

If the requirements of this check are not met, verify that:

(a) The mains supply switch and fuse are correctly selected and that DS1 is illuminated.

(b) The preamplifier and power amplifier voltage is set for 22 volts by R4.

If the above checks are found to be correct, then normal fault location procedures, with reference to the circuit diagram Figure 5.1 should be followed to determine the correct operation of the preamplifier and power amplifier modules.

4.4 RE-ALIGNMENT PROCEDURE

Before any adjustment is made to the unit, first

(i) Ensure that the mains switch and fuse are correctly selected and that DS1 is illuminated.

(ii) Measure the power supply voltages and adjust per section 4.3.1(b).

4.4.1 Measurement of Gain

Equipment required:

(a) Oscilloscope - Telequipment Model S54A
(b) Sweep/Signal Generator - Wavetek 2001
(c) 50 ohm Detector - Wavetek D151
(d) Attenuator, 10 dB, 20 watts - Narda 766-10
(e) Sweep/Signal Generator-HP8601A

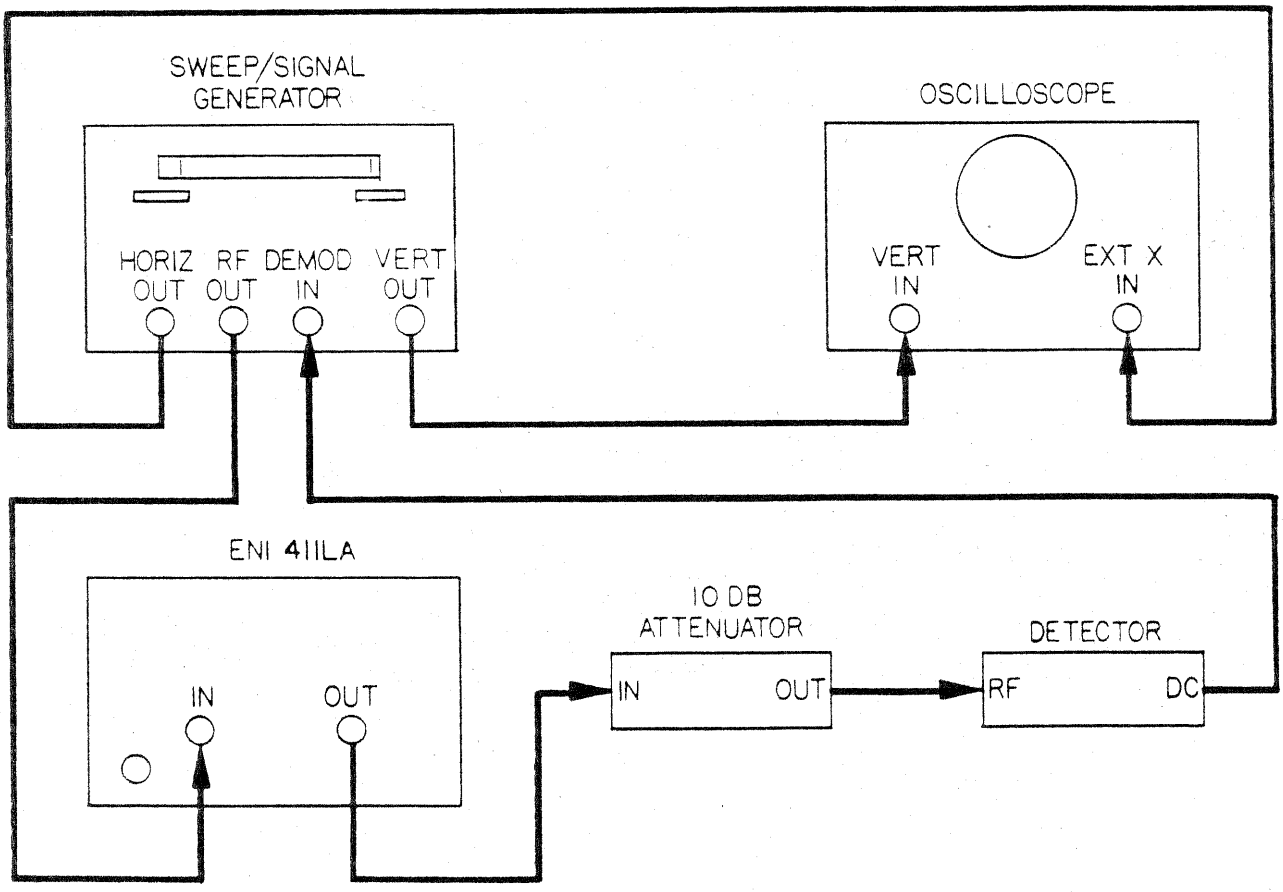


Figure 4-1 Gain Measurement

Connect the equipment as shown in Figure 4.1, then proceed as follows:

(a) Set the oscilloscope to DC, time/CM to Ext. X, and vertical gain to 10MV/CM.

(b) Set the sweep/generator to the S/S mode with the start frequency at 1 MHz and The stop frequency at 300 MHz.

(c) Disconnect the ENI 411LA from the set-up and connect the sweep/generator RF output directly to the 10 dB attentuator.

(d) Adjust the output level of the sweep/generator for full vertical deflection on the oscilloscope face.

(e) Calibrate the scope face to show 3 dB in 1 dB steps by attenuating the sweep/generator in 1 dB steps and marking the traces with a grease pencil.

(f) Return sweep/generator output level to full deflection. Rotate the step attenuator on the sweep/generator (CCW) so that the output is reduced by 40 dB.

(g) Reconnect the 411LA into the test set-up of Figure 4.1.

(h) Push the 411LA power swtich to the "on" position.

(i) Observe the gain versus frequency sweep on the oscilloscope. Adjust the output of sweep/signal generator so that trace is centered.

1. The average gain should be 40 dB (within 1.5 dB).

2. The gain variation should be within the 3 dB markings as shown on the oscilloscope.

(j) If the gain versus frequency sweep is out of specification, adjust R4 located in the power supply regulator module ($\pm$.5V max) until the sweep observed on the oscilloscope is within the 3 dB markings.

(k) Repeat steps (a) through (j) using the HP8601A sweep generator with start frequency at 150 kHz and stop frequency at 1 MHz.

4.4.2 Measurement of Harmonics

Equipment required:

(a) Sweep/Signal generator - Wavetek 2001
(b) Attenuator, 30 dB-Bird 8321
(c) Calorimetric Power Meter-HP434A

(d) Spectrum Analyzer - HP140T Display Unit
HP8554L Spectrum Analyzer
RF Section
HP8552A Spectrum Analyzer
IF Section

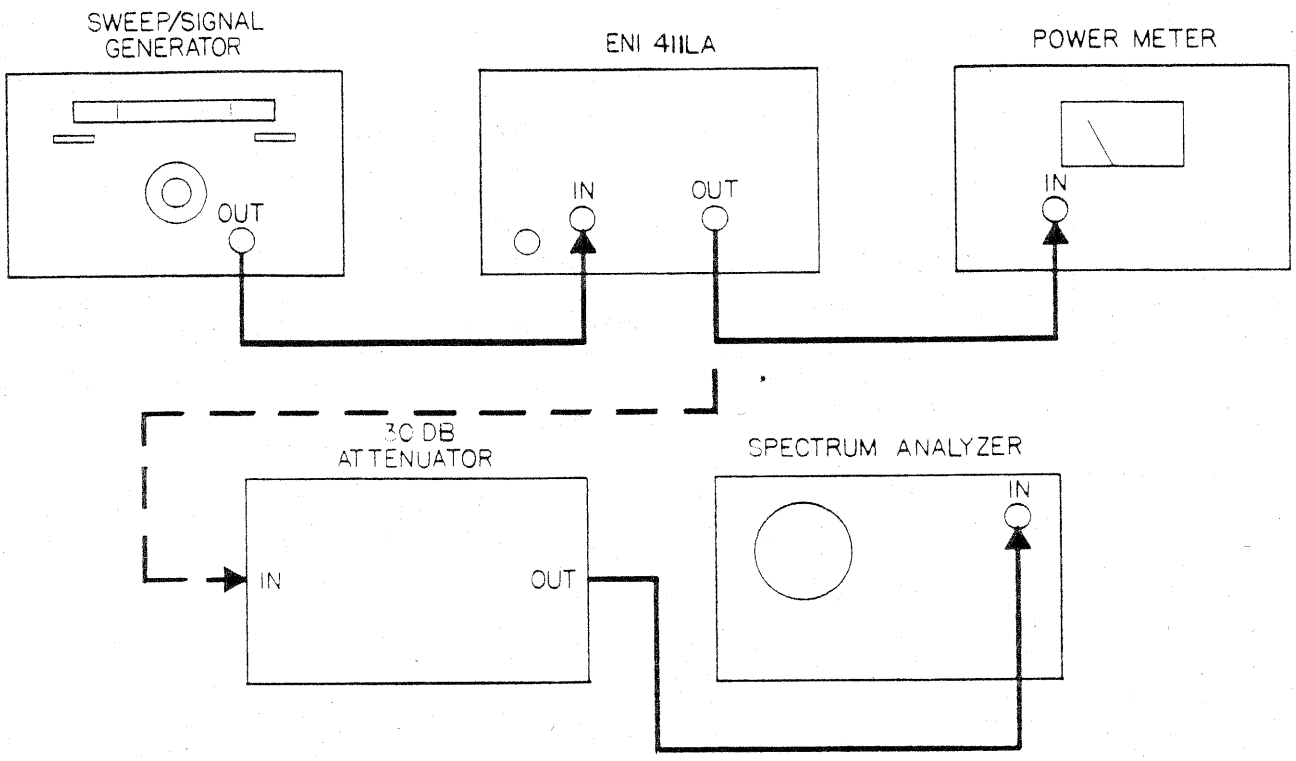


Figure 4-2 Harmonic Measurement

Connect the equipment as shown in Figure 4.2 then proceed as follows:

(a) Adjust the sweep/signal generator at a CW center frequency of 150 MHz for an indicated output of 9.5 watts on the power meter.

(b) Using the spectrum analyzer, check that the level of the carrier harmonics are less than -25 dB with respect to the carrier.

(c) If the above specification is not met, the 22 volt d.c. supply may be varied up to ±.5V to reduce the harmonic level.

4.5 PACKAGING FOR RESHIPMENT

In the event of the equipment being returned for servicing it should be packed in the original shipping carton and packing material. If this is not available wrap the instrument in heavy paper or plastic and place in a rigid outer box of wood, fiberboard or very strong corrugated cardboard. Use ample soft packing to prevent movement. Provide additional support for projecting parts to relieve these of unnecessary shock. Close the carton securely and seal with durable tape. Mark the

CHAPTER 5 SCHEMATIC AND PARTS LIST

5.1 SCHEMATIC DIAGRAM

A complete schematic diagram appears in figure 5.1.

5.2 PARTS LIST

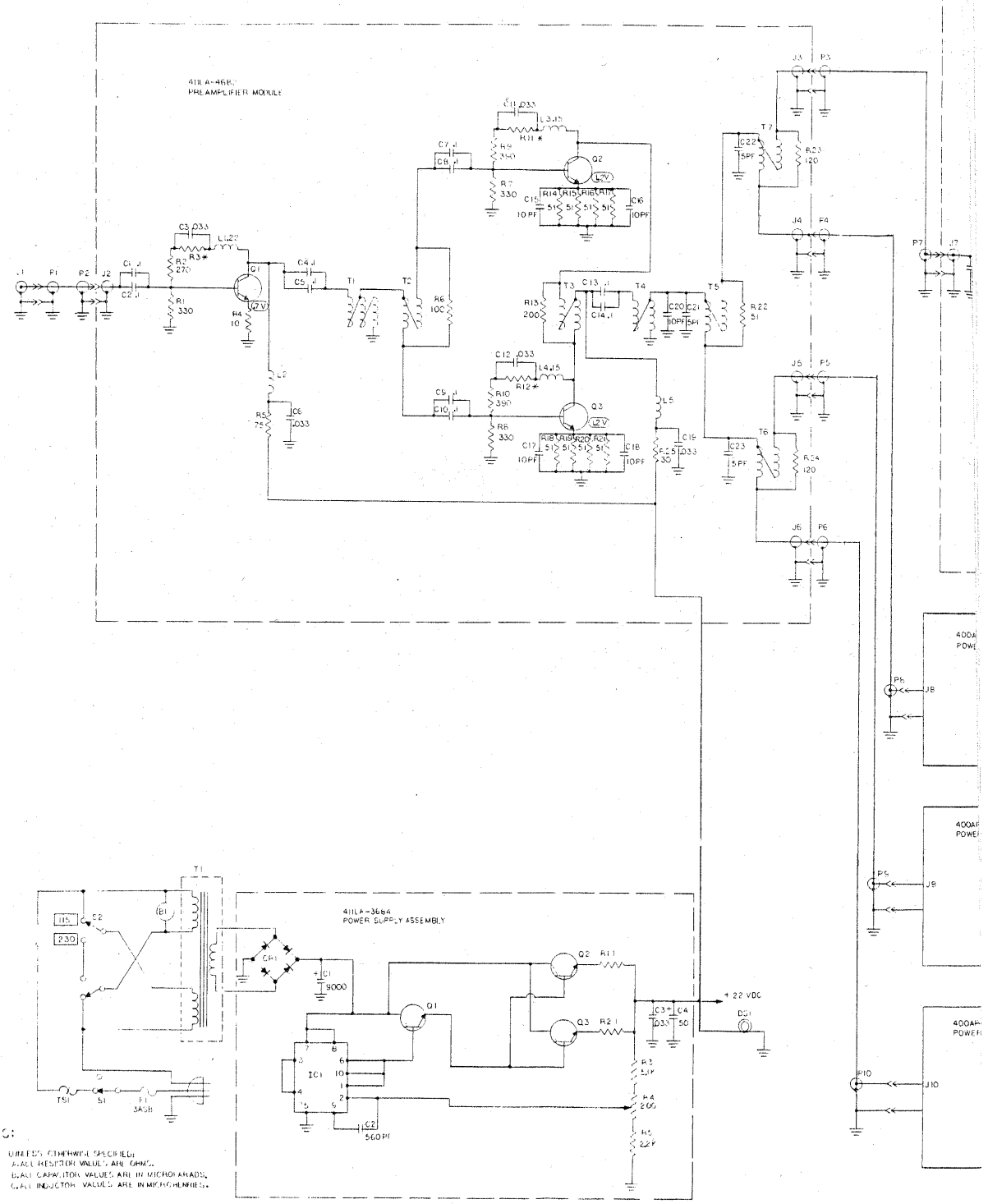
Table 5.1 provides a listing of all electrical parts and those mechanical parts which may be required for replacement. Electrical parts are listed by module number and by reference designations as indicated on the schematic diagrams. Parts list includes a description, part number and manufacturers federal supply code number. Table 5.2 provides a reference glossary of abbreviations used in the parts list.

5.3 LIST OF MANUFACTURERS

Table 5.3 provides a correlation of the manufacturers federal supply code numbers used in the parts list with the names and addresses of the manufacturers. If ENI's manufacturer code number (10226) appears, that part must be obtained directly from Electronic Navigation Industries, Inc.

5.4 ORDERING REPLACEMENT PARTS

To obtain replacement parts, address order or inquiry to Electronic Navigation Industries, Inc. or its authorized service facility. Identify parts by number as listed in the parts list.



NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   A. ALL RESISTOR VALUES ARE OHMS.
   B. ALL CAPACITOR VALUES ARE IN MICROFARADS.
   C. ALL INDUCTOR VALUES ARE IN MICROHENRIES.
2. VOLTAGE MEASUREMENTS TAKEN WITH NO SIGNAL APPLIED USING A VOLTMETER WITH A HIGH INPUT IMPEDANCE. (10 MEG. OR GREATER.)
3. * INDICATES VARIABLE VALUE.

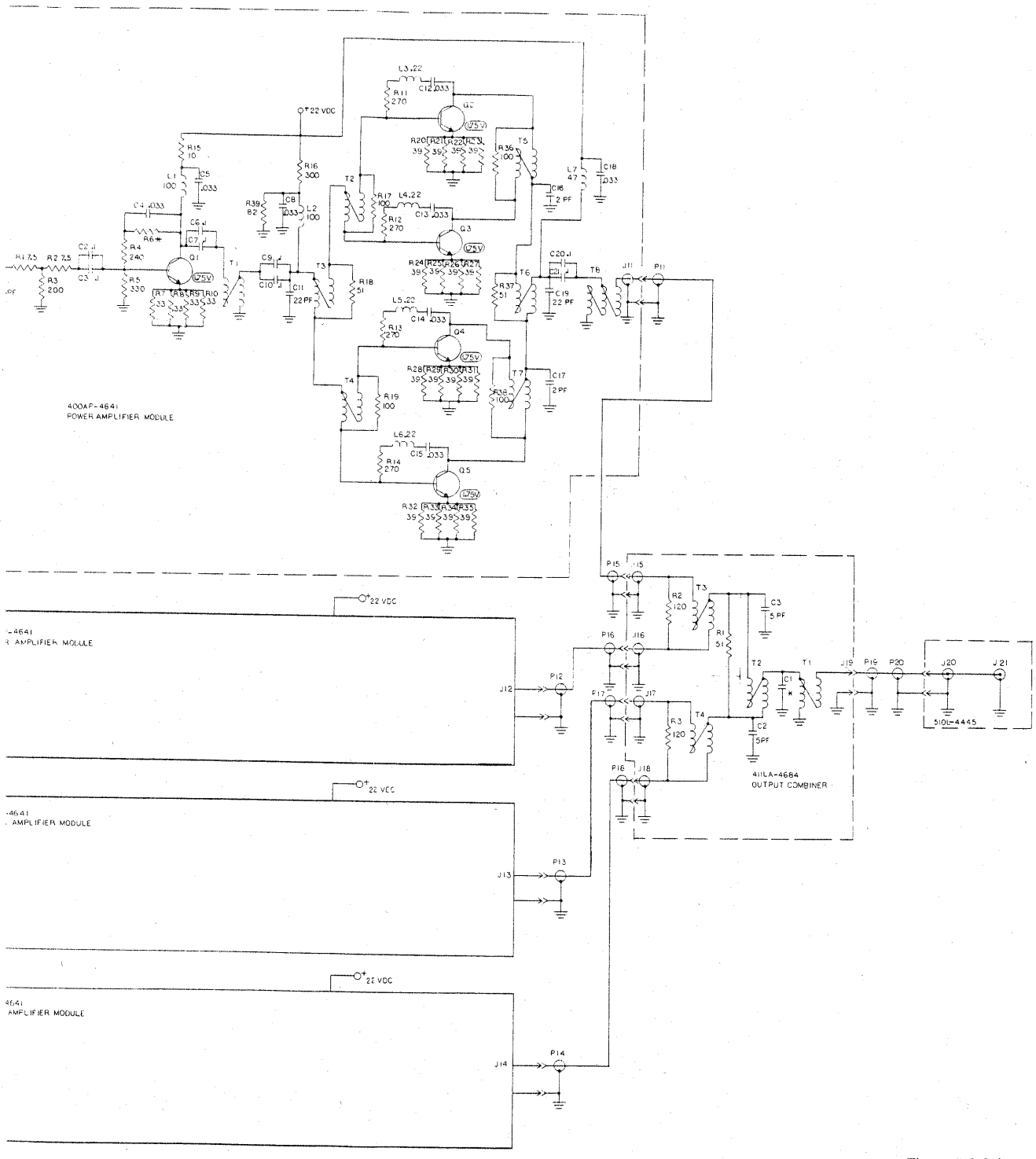


Figure 5.1 Schematic Diagram

MODEL 411LA

REF. DESIGN.	DESCRIPTION	MFG. CODE	PART NO.
	POWER DISTRIBUTION ASSEMBLY		
T1	Transformer, Power	12715	AM7849
S1	Switch, Illuminated	87034	616-6-1
B1	Fan	28875	WS2107FL
F1	Fuse Type 3AG3ASB	75915	313003
FX	Fuseholder	75915	342001
CR1	Bridge Rectifier	04713	MDA 990-2
C1	Cap., Elect., 9000UF 50VDCW	56289	360902G050BC2A
Q2,Q3	Transistor	84411	2N3772
A95	Power Supply Regulator Board	10226	411LA-4683
A95IC1	I.C. Regulator	49956	RC723CT
A95Q1	Transistor	04713	2N1613
A95R1,R2	Resistor, 1 ohm 5W	44655	4530
A95R3	Resistor, Film, 5.1K Ω 5% ½W	16299	HC-5-5.1KΩ
A95R4	Pot, 200 ohm, 5%	32997	3389T-1-201
R95R5	Resistor, Film, 2.2K Ω 5% ½W	16299	HC-5-2.2K
A95C2	Cap., Mica, 560PF, 5%	02023	CM05EC561J03
A95C3	Cap., Cer., .033UF 50VDCW	72982	8121-050-651-104Z
A95C4	Cap., Elect., 50UF 50VDCW	56289	500D506G050BC2A
	RF ASSEMBLY		
A-88	Power Amplifier Board	10226	400AP-4641
A88R1,R2	Resistor, Comp. 7.5 ohm 5% ¼W	01121	RC07GF7R5J
A88R3	Resistor, Comp. 200 ohm 5% ¼W	01121	RC07GF201J
A88R4	Resistor, Comp. 240 ohm 5% ½W	01121	RC20GF241J
A88R5	Resistor, Comp. 330 ohm 5% ¼W	01121	RC07GF331J
A88R6	Variable	01121	
A88R7-R10	Resistor, Comp. 33 ohm 5% ¼W	01121	RC07GF330J
A88R11-R14	Resistor, Comp. 270 ohm 5% ¼W	01121	RC07GF271J
A88R15	Resistor, Comp. 10 ohm 5% 1W	01121	RC32GF100J
A88R16	Resistor, Comp. 300 ohm 5% 2W	01121	RC426F301J
A88R17	Resistor, Comp. 100 ohm 5% ¼W	01121	RC07GF101J
A88R18	Resistor, Comp. 51 ohm 5% ¼W	01121	RC07GF510J
A88R19	Resistor, Comp. 100 ohm 5% ¼W	01121	RC07GF101J
A88R20-R35	Resistor, Comp. 39 ohm 5% ¼W	01121	RC07GF390J
A88R36	Resistor, Comp. 100 ohm 5% ¼W	01121	RC07GF101J
A88R37	Resistor, Comp. 51 ohm 5% ¼W	01121	RC07GF510J

REF. DESIGN.	DESCRIPTION	MFG.CODE	PART NO.
	RF ASSEMBLY (cont.)		
A88R38	Resistor, Comp. 100 ohm 5% ¼W	01121	RC07GF101J
A88R39	Resistor, Comp. 82 ohm 5% ½W	01121	RC206F820J
A88C1	Cap., Mica, 5PF 5%	09023	DM5CC050A
A88C2,C3	Cap., Cer., .1UF 50VDCW	72982	8131-050-651-104Z
A88C4	Cap., Cer., .033UF 50VDCW	72982	8121-050-651-333Z
A88C6,C7	Cap., Cer., .1UF 50VDCW	72982	8131-050-651-104Z
A88C8	Cap., Cer., .033UF 50 VDCW	72982	8121-050-651-333Z
A88C9,C10	Cap., Cer., .1UF 50VDCW	72982	8131-050-651-104Z
A88C11	Cap., Mica, 22PF, 5%	09023	CM05E0220J03
A88C12-C15	Cap., Cer., .033UF 50VDCW	72982	8121-050-651-333Z
A88C16,C17	Cap., Cer., 2PF 5%	09023	DM5CC020A
A88C18	Cap., Cer., .033UF 50VDCW	72982	8121-050-651-333Z
A88C19	Cap., Mica, 22PF 5%	09023	CM05ED270J03
A88C20,C21	Cap., Cer., .1UF 50VDCW	72982	8131-050-651-104Z
A88L1,L2	Choke, RF, 100UH	99800	2890-42
A88L3-L6	Choke, RF, .22UH	99800	1025-04
A88L7	Choke, RF, 47UH	99800	2890-36
A88T1-T7	Transformer	10226	
A88T8	Transformer	10226	
A88Q1-Q5	Transistor	10226	2240
A96	Preamplifier Board	10226	411LA-4682
A96R1	Resistor, Comp. 330 ohm 5% ¼W	01121	RC07GF331J
A96R2	Resistor, Comp. 270 ohm 5% ¼W	01121	RC07GF271J
A96R3	Variable	01121	
A96R4	Resistor, Comp. 10 ohm 5% ¼W	01121	RC07GF270J
A96R5	Resistor, Comp. 75 ohm 5% 1W	01121	RC326GF750J
A96R6	Resistor, Comp. 100 ohm 5% ¼W	01121	RC07GF101J
A96R7,R8	Resistor, Comp. 330 ohm 5% ¼W	01121	RC07GF331J
A96R9,R10	Resistor, Comp. 390 ohm 5% ¼W	01121	RC07GF391J
A96R11,R12	Variable	01121	
A96R13	Resistor, Comp. 200 ohm 5% ¼W	01121	RC07GF201J
A96R14-R22	Resistor, Comp. 51 ohm 5% ¼W	01121	RC07GF510J
A96R23,R24	Resistor, Comp. 120 ohm 5% ½W	01121	RC20GF121J
A96R25	Resistor, Comp. 30 ohm 5% 2W	01121	RC42GF300J
A96C1,C2	Cap., Cer., .1UF 50VDCW	72982	8131-050-651-104Z
A96C3	Cap., Cer., .033UF 50VDCW	72982	8121-050-651-333Z
A96C4-C10	Cap., Cer., .1UF 50VDCW	72982	8131-050-651-104Z
A96C11,C12	Cap., Cer., .033UF 50VDCW	72982	8121-050-651-333Z
A96C13,C14	Cap., Cer., .1UF 50VDCW	72982	8131-050-651-104Z
A96C15-C18	Cap., Mica, 10PF 5%	09023	CM05ED100J03
A96C19	Cap., Cer., .033UF 50VDCW	72982	8121-050-651-333Z

REF. DESIGN.	DESCRIPTION	MFG.CODE	PART NO.
	RF ASSEMBLY (cont.)		
A96C20	Cap., Mica, 10PF, 5%	09023	CM05ED100J03
A96C21-C23	Cap., Mica, 5PF, 5%	09023	DM5CC050A
A96L1	Choke, RF, .22UH	99800	1025-04
A96L2	Choke, RF	10226	
A96L3,L4	Choke, RF, .15UH	99800	MS18130-1
A96L5	Choke, RF	10226	
A96Q1	Transistor	10226	
A96Q2,Q3	Transistor	01281	LT2001
A97	Output Combiner Board	10226	411LA-4684
A97R1	Res., Comp. 51 ohm 5% ¼W	01121	RC07GF510J
A97R2,R3	Res., Comp. 120 ohm 5% ½W	01121	RC20GF121J
A97C1	Cap., Variable		
A97C2,C3	Cap., Mica, 5PF, 5%	09023	DM5CC050A
A97T1	Transformer	10226	
A97T2	Transformer	10226	
A97T3,T4	Transformer	10226	

TABLE 5-2. GLOSSARY OF ABBREVIATIONS

AMP	AMPERES	PF	PICOFARAD
AMPL	AMPLIFIER	POT	POTENTIOMETER
BKT	BRACKET	REF	REFERENCE
CAP	CAPACITOR	RES	RESISTOR
CER	CERAMIC	SIL	SILICON
COMP	COMPOSITION CARBON	UF	MICROFARADS
DPDT	DOUBLE-POLE THROW	UH	MICROHENRY
ELECT	ELECTROLYTIC	V	VOLTS
IN	INCHES	VAR	VARIABLE
K	KILOHMS	VDCW	DC WORKING VOLTS
MTG	MOUNTING	W	WATTS
MW	MILLIWATTS	WW	WIRE WOUND

TABLE 5-3. LIST OF MANUFACTURERS

FEDERAL SUPPLY CODE NUMBER	MANUFACTURER	ADDRESS
01121	Allen-Bradley Co.	Milwaukee, WI.
04713	Motorola, Inc. Semiconductor Prod. Div.	Phoenix, AZ.
09023	Cornell-Dubilier Electronics	Sanford, N.C.
10226	ELECTRONIC NAVIGATION INDUSTRIES,INC.	Rochester, N.Y.
12715	American Magnetics Corp.	Carterville, IL.
13511	Amphenol Corp. Inc.	Los Gatos, CA.
14604	Elmwood Sensors, Inc.	Cranton, R.I.
16299	Corning Glass	Raleigh, N.C.
22753	U I D Electronics Corp.	Hollywood, FL.
32997	Bourns, Inc.	Riverside, CA.
49956	Raytheon Co.	Lexington, MA.
56289	Sprague Electric Co.	N.Adams, MA.
72982	Erie Technological Products, Inc.	Erie, PA.
75042	I R C Div. of TRW, Inc.	Philadelphia, PA.
75915	Littlefuse, Inc.	Des Plaines, IL.
79089	RCA	Harrison, N.Y.
99800	Delevan Electronics Corp.	E. Aurora, N.Y.
72619	Dialight Corp.	Brooklyn, N.Y.
28875	IMC Magnetics	Rochester, N.H.
32159	West-Cap Arizona	Tucson, AZ.
71590	Centralab Electronics	Milwaukee, WI.
83003	Varo, Inc.	Garland, TX.
87034	Marco Oak Industries	Anaheim, CA.
91293	Johanson Manufacturing Co.	Boonton, N.J.