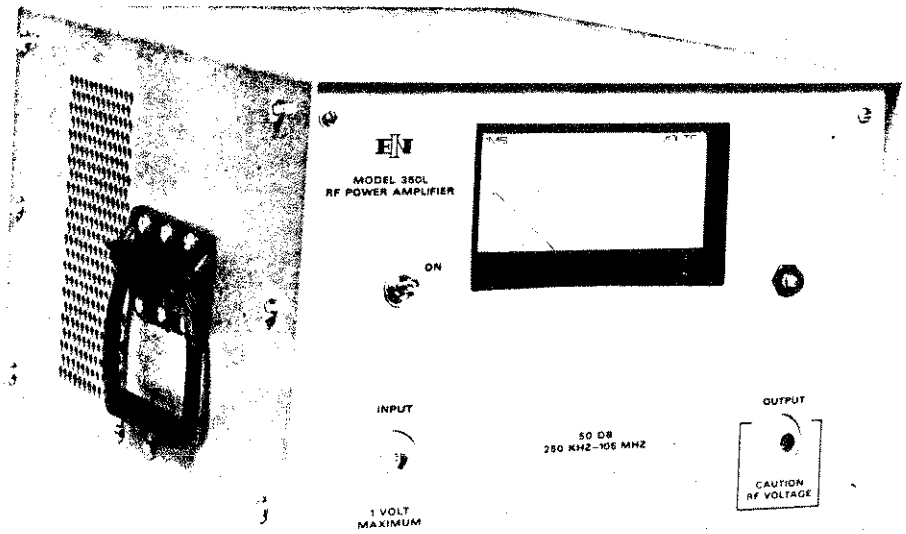
OPERATION AND SERVICE MANUAL

FAILURE TO RETURN THIS MANUAL WILL RESULT IN A MINIMUM OF A $25.00 CHARGE.



350 L BROADBAND POWER AMPLIFIER

ELECTRONIC NAVIGATION INDUSTRIES Inc.

ROCHESTER, NEW YORK, U. S. A.

WARRANTY

Electronic Navigation Industries, Inc. warrants each instrument to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing and replacing any defective parts for a period of one (1) year after delivery to the original purchaser.

When warranty service is required, the instrument must be returned transportation charges prepaid to the factory or our authorized service facility. If, in our opinion, the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before work is started.

There are no other warranties expressed or implied, including any warranty of merchantibility or fitness. Seller shall not be responsible for any incidental or consequential damages arising from any breach of warranty.

FACTORY SERVICE

When Factory Service is required, the following steps should be taken:

(1) Notify ENI, giving full details of the difficulty. Include the instrument's serial number.

(2) Upon receipt of shipping instructions, forward the instrument, transportation prepaid, to the factory or to the authorized repair station indicated on the instructions.

If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the warranty.

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CHAPTER 1
INTRODUCTION

1.1 GENERAL DESCRIPTION

The ENI Model 350L is an all solid state amplifier which has a flat frequency response from 250 kHz to 105 MHz. It provides 50 watts of linear power with low harmonic and intermodulation distortion. Gain is 50 dB nominal, with a variation of less than $\pm$1.5 dB over the entire frequency range. Input and output impedance are 50 ohms and the unit may be driven to full power output by most RF synthesizers, signal generators and swept signal sources.

The ENI Model 350L will deliver its rated power output into any load impedance, regardless of match. Built-in protection circuitry will absorb the power reflected from a mismatched load without causing failure or oscillation.

Output RF voltage is displayed on the front panel meter. The Model 350L is packaged for bench mounting and is shipped with rack mounting adapters. Its integral power supply and cooling operate from a 115 or 230 VAC 50/60Hz main supply.

The Model 350L will raise the power level of signal sources and generators without requiring tuning or band-switching. The Class A linear circuitry will amplify signals of AM, FM, SSB, TV and complex modulations limited only by their peak input and bandwidth with minimum distortion.

1.2 SPECIFICATIONS.

Physical and electrical specifications are listed in table 1-1.

1.3 INSTRUMENT IDENTIFICATION

Each amplifier is identified by a serial number tag on the back panel of the unit. Both the model number and the serial number should be given in any correspondence with the company.

Table 1-1. 350L Specifications

FREQUENCY COVERAGE:	120 kHz to 120 MHz
GAIN:	50 dB nominal
GAIN VARIATION:	±1.5 dB from 250 kHz to 105 MHz
MAXIMUM POWER OUTPUT:	More than 50 watts from 250 kHz to 105 MHz. 46.99dBm More than 25 watts from 120 kHz to 250 kHz and 105 MHz to 120 MHz 43.98dBm
HARMONIC DISTORTION:	All harmonics 25 dB or more, below fundamental, at 40 watts output; 250 kHz to 105 MHz.
2nd ORDER DISTORTION	More than 30 dB down, at full output
TYPICAL 3rd ORDER INTERMODULATION INTERCEPT POINT:	+56 dBM
INPUT/OUTPUT IMPEDANCE:	50 ohms
INPUT VSWR:	Less than 1.5
OUTPUT VSWR:	Less than 2.0, 250 kHz to 80 MHz; less than 3.0, 80 MHz to 120 MHz (typical)
NOISE FIGURE:	Less than 10 dB
STABILITY:	Unconditionally stable, unit will not oscillate for any condition of load and source impedance
PROTECTION:	Unit will withstand up to 16 dB of overdrive (input signal of 1 volt RMS) for all output load conditions, including short and open circuit loads
OUTPUT METERING:	Average reading voltmeter calibrated in RMS volts for a sine wave, with an accuracy of ±3% of full scale (0-80 volts): also calibrated in watts into 50 ohms (0-120 watts)
POWER REQUIREMENTS:	115/230 VAC ± 10%, 50-60 Hz, 550 watts
OPERATING TEMPERATURE:	0° to +45°C
SIZE:	8-3/4 x 12 x 17 inches
WEIGHT:	42.5 Lbs.
CONNECTORS:	BNC Standard, Type N Optional

CHAPTER 2

PREPARATION

2.1 INITIAL INSPECTION

2.1.1 Mechanical Check

If damage to the shipping carton is evident, request the carriers agent be present when the instrument is unpacked. Check the equipment for damage and inspect the cabinet and panel surfaces for dents and scratches.

2.1.2 Claim for Damage

If the Model 350L is mechanically damaged or fails to meet specifications upon receipt, notify ENI or our representative immediately. Retain shipping carton and packing material for the carriers inspection as well as for subsequent use in returning the unit if necessary.

2.1.3 Performance Check

The electrical performance of the Model 350L should be verified as soon as possible after receipt. The following is a performance check that is suitable for incoming inspection.

a. Check that the 115/230 switch on the rear panel is in the correct position.

b. Set the amplifier front panel power switch to the ON position, and check that the pilot light illuminates and the fan motor is operating normally.

c. Perform RF Output Power Test, section 5.1.4.

2.2 PREPARATION FOR USE

2.2.1 Power Requirements

The Model 350L amplifier requires a power source of 115 or 230 volts AC $\pm$10%, 47 to 63 Hz, single phase, which can supply 550 watts.

The two-position slide switch mounted on the rear panel permits operation from either the 115 or 230 volt power source. The screwdriver slot in the slider must be pushed toward the 115 or 230 volt label depending upon which line voltage is to be connected.

Failure to have the switch in the correct position may result in damage to the instrument. Do not adjust the line-voltage switch when the power cable is connected to the AC line.

2.2.2 Power Cable Ground Protection

To protect operating personnel, the ENI Model 350L is equipped with a three conductor cable and plug which, when inserted in a three terminal receptacle, grounds the panel and cabinet. The offset pin on the power cable three prong-connector is the ground pin. When using a two prong adapter connect the green pigtail on the adapter to ground.

2.2.3 Cooling

When the 350L is enclosed by an external cabinet, provision must be made to insure an adequate flow of cooling air to the unit. Ambient temperature of the air must not exceed 45^{o}C.

2.3 RACK MOUNTING

In order to install the Model 350L in a standard 19 inch relay rack, rack mounting brackets must be attached to the cover, as follows:

a. Remove 6 (six) 8-32 screws from 350L cover just behind the front panel.

b. Verify left and right rack mounting brackets by holding them next to screw holes. Mounting bracket overhang should be at bottom of unit.

c. Attach mounting brackets to sides of unit using same screws and hardware.

d. Tighten all screws carefully, assuring that unit is held firmly in place.

e. The four rubber feet on the bottom plate may be unscrewed and removed if the minimum vertical usage of the relay rack is necessary.

2.4 PACKAGING FOR RESHIPMENT

Whenever possible, the original shipping carton and packing material should be used for reshipment. If the orginal packing material is not available, wrap the instrument

in heavy paper or plastic. Use a strong shipping container. If a cardboard carton is used, it should be at least 200 lb. test material. Use shock absorbing material around all sides of the instrument to provide a firm cushion and to prevent movement inside the container. A minimum of two inches should be between the instrument and the container wall on each side. Protect the front panel and meter by means of cardboard spacers inserted between the front panel and the shipping carton. Make certain that the instrument cannot move in the container during shipment. Seal the carton with a good grade of shipping tape and mark the container FRAGILE ELECTRONIC INSTRUMENT.

CHAPTER 3
OPERATION

3.1 FUNCTIONAL DESCRIPTION

The ENI Model 350L is a linear Class A amplifier capable of increasing the output of any signal generator, frequency synthesizer, sweep generator or laboratory signal source from 250 kHz to 105 MHz.

Less than 200 millivolts of signal is required from the output of the signal source into the 50 ohm input of the amplifier to extract maximum power output. The output power of the 350L is directly proportional to the input signal and therefore, the attenuator of the signal generator will serve as the attenuator for the overall output.

The Model 350L is completely protected against damage due to load mismatch provided that the input RF level does not exceed 1 volt RMS or 1.4 volts peak. If the attached signal source is capable of generating substantially more than this input voltage, please use caution in adjusting it. The Model 350L will saturate well before the maximum input voltage and there will be no increase in output power at that point.

The 350L is unconditionally stable. Any impedance can be connected to the input and output of the amplifier, without causing oscillation.

The 350L will deliver its rated power to any load impedance regardless of match. Load mismatch will cause RF power to reflect back to the amplifier. The unit is designed to withstand 100 percent reflected power (a pure reactance, open or short circuit load will cause 100 percent reflected power) continuously without damage.

An output meter is provided to indicate the average output voltage (calibrated in RMS) as well as the power output when the unit is connected to a 50 ohm load. Since the meter responds only to average output, the modulation characteristics of the input signal must be taken into account when interpreting the meter readings. For example, the amplifier may be in saturation during the on portion of a pulse yet the meter reading will be low due to the low duty cycle of the pulse input.

3.2 CONTROLS, INDICATORS AND CONNECTORS

Front and rear panel devices are described in table 3-1.

3.3 OPERATING PROCEDURE

Refer to the following procedure as a guide to operating the Model 350L.

a. The input and output are connected via the front panel BNC connectors to the signal source and load respectively.

b. The input signal should be increased gradually while observing the output voltage on the output RF voltmeter. Input signal voltage should never be allowed to exceed 1 volt (RMS) or 1.4 volts (peak).

c. When the Model 350L is connected to a 50 ohm load, the CW power output of the unit may be read directly from the meter scale.

d. When the amplifier is connected to an arbitrary or unknown load impedance, the following procedure will insure low distortion power output.

   1. Disconnect the output load cable from the output BNC connector of the Model 350L.

   2. If the CW output voltage is less than 80 volts RMS, the unit is operating at low distortion regardless of the load impedance.

   3. Reconnect the output of the amplifier to the load.

e. If the output of the amplifier is monitored by a high frequency oscilloscope or spectrum analyzer, the input signal may be increased until the point of maximum undistorted power output is observed.

Table 3-1 Front and Rear Panel Devices

DEVICE	FUNCTION
Power Switch	Throwing toggle to "on" position connects fan and power supply to main power source.
Meter	Indicates output voltage and also power for a 50 ohm load. The meter circuit responds to the average RF voltage and is calibrated in RMS volts for a sine wave. The voltage pick-off is mounted directly behind the front panel at the output connector.
Input Connector	BNC type for connection of the driving generator. Input impedance is 50 ohms. No more than 0.2 volts is required to obtain saturated output. Up to 1.4 volts peak can be applied without causing damage; however, no additional power output can be expected.
Output Connector	BNC type for connection of amplifier output to load.
Fuse	Holder requires 3AG size, slow-blow type fuse. Rating is marked on the rear panel.
Line Cord	Three prong type plug with safety ground pin connected to cabinet.
115/230 Voltage Selector	Slide switch operated by using flat blade screw driver as a key to select available line voltage.

3.4 PRECAUTIONS

a. The Model 350L output is at DC ground potential through the final combining transformer (see schematic diagram Figure 7-2). Therefore, the output should not be directly connected to a load on which there is a DC potential. A series capacitor with the appropriate DC voltage breakdown rating (.1 mfd is the recommended value) should be inserted between the output connector and the load.

b. The input and output of the Model 350L should not be connected together. This will cause oscillation and may damage the input preamplifier.

c. The Model 350L should not remain connected to an antenna when the unit is not in use. If thunderstorms are likely, it would be prudent to earth ground the unit's case.

d. When the input signal voltage of the signal source is unknown, insert an attenuator between it and the Model 350L input.

CHAPTER 4
PRINCIPLES OF OPERATION

4.1 GENERAL

The Model 350L achieves it high level of power output by combining the power outputs of a number of individual transistor amplifiers. The hybrid combining technique permits each amplifier to operate independently of all the others and to supply its power output contribution without regard to the other amplifier stages. This isolation is afforded by ferrite loaded transformer hybrids connected at the input and output of each transistor pair.

Each amplifier module (either power amplifier or preamplifier) is designed to have an input and output impedance of 50 ohms. Therefore, the individual modules can be disconnected and tested independently.

Highly linear Class A transistors are used throughout the amplifier. Their linearity is augmented by negative feedback networks connected to each stage. The high power output transistors have nichrome resistors deposited at their emitter terminals to increase linearity and reliability.

The amplifier is powered by a low noise DC regulator of dissipative design. Over temperature protection is built into the power supply and cooling fan.

4.2 BLOCK DIAGRAM DESCRIPTION

A block diagram of the entire Model 350L is shown in figure 4-1.

Input signal from the front panel BNC connector is fed to the preamplifier module (A22). The preamplifier has four equal amplitude and phase outputs. These are fed via coaxial cables to the inputs of four driver amplifier modules (A1). Each preamplifier channel has an overall gain of 16 dB and a maximum power output of 100 milliwatts. The driver amplifier modules are push-pull units capable of supplying up to 3 watts of output, with 20 dB gain. Signal supplied by each driver amplifier is fed to its respective power amplifier module (A21).

Each power amplifier has a gain of 8 dB and is capable of producing more than 15 watts of power at its output. The combiner module (A23) sums the outputs of the power amplifiers while maintaining isolation between them. RF output signal is fed to the output BNC connector and to the RF voltmeter module (A12). The RF voltmeter module provides a DC signal to the front panel meter, proportional to the output level.

The power distribution 350L-2181 provides cooling and DC power to the entire unit. The regulated power supply is capable of supplying 27.5 volts at a current of 16 amperes.

4.2.1 Preamplifier Module (A22) 350L-4185

The schematic of the preamplifier module is shown in figure 7-1. Input signal is amplified by a low noise transistor stage, Q-1. Its output is split into two equal phase signals by transformer T2 and fed to transistors Q3 and Q4. Signal boost capacitors C6 and C8 compensate for the gain roll-off of the succeeding amplifier stages. The hybrid network consisting of transformers T4, T5, T6, T7 splits the output of the preamplifier into four equal phase and amplitude signals at P1A, P2A, P3A, and P4A.

4.2.2 Driver Amplifier Module (A1) 350L-4181

The schematic of the driver amplifier module is shown in figure 7-1. Input signal fed to J1A is matched, split and inverted by transformers T1 and T2. Two equal amplitude, phase reversed, signals are fed to the inputs of transistors Q1 and Q2. The output of transistors Q1 and Q2 are coupled to the base of power output transistors Q3 and Q4 through matching transformers T3 and T4. Reversing hybrid transformer T5 combines the power output of Q3 and Q4 and couples even order harmonics to resistor R2. Transformer T6 matches the output impedance to 50 ohms.

4.2.3 Power Amplifier Module (A21) 350L-4184

The schematic of the power amplifier module is shown in figure 7-2. Input signal impressed at connector J5A is divided into two equal phase and amplitude signals by transformer T1. Each signal is fed to two identical power amplifier channels. The top channel signal is fed to a phase reversing hybrid consisting of transformers T2 and T3. Transistors Q1 and Q2 amplify the signal by 8 dB and feed their outputs to reversing hybrids T6 and T7. Transformer T10 sums the power outputs of the top and bottom channel

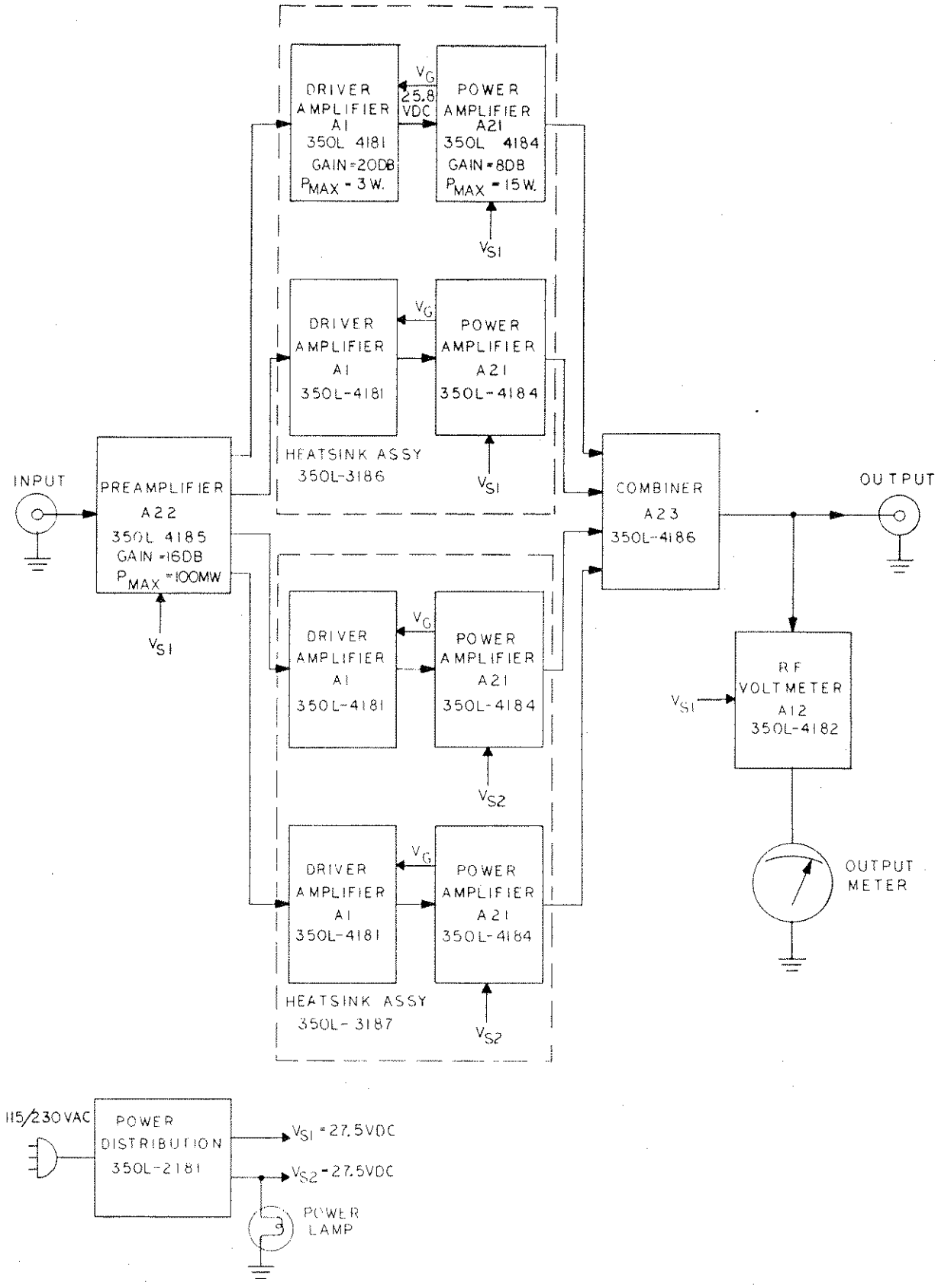

Figure 4-1. 350L Block Diagram

and transformer T11 matches the outputs to a 50 ohm load at connector J5B.

4.2.4 Combiner Module (A23) 350L-4186

The schematic of the combiner module is shown in figure 7-2. RF power impressed at connectors P5B, P6B, and P7B, P8B, is summed by hybrid transformers T1 and T2. Out of phase power is absorbed in resistors R1 and R2. Capacitors C1, C2, C3 and C4 compensate for the winding reactance in transformer T3 which sums the outputs of T1 and T2. Capacitors C5, C6 and transformer T4 match the summed RF output to the 50 ohm output at connector J12.

4.2.5 RF Voltmeter Module (A12) 350L-4182

The schematic of the RF voltmeter module (A12) is shown in figure 7-2. Resistors R1, R2, R3, R4, and R5 make up a high impedance voltage divider and are connected to the RF output voltage at the 350L output connector. A fast switching hot carrier diode CR1 rectifies the RF voltage from the divider. Capacitor C3 compensates for the high frequency roll-off of the diode CR1. Resistors R5, R6, R7 and capacitor C1 filter the rectified RF and convert it to DC which is fed to the front panel meter.

4.2.6 Power Distribution 350L-2181

A schematic of the power distribution is shown in figure 7-3. The 115/230 volts AC is distributed from terminal block TB1 to power transformer T1 and to the 115/230 volt switch. The secondary of T1 supplies voltage to two full wave bridge rectifiers CR1 and CR2. The output of each rectifier is connected to capacitors C1, C2 and the collectors of Q1, Q2, Q3, Q4 and Q5 located on the transistor assemblies (350L-4188). These transistors form a series pass regulator of the dissipative type. The output of each rectifier is also connected to separate integrated circuit voltage regulators IC-1 and IC-2 located on the power supply regulator board (A31) 350L-4187. The output voltage of each supply is adjusted by potentiometer A31R2 and A31R7.

CHAPTER 5
PERFORMANCE TEST PROCEDURES

5.1 PERFORMANCE TESTS

5.1.1 General

There are three tests required to check the operation and performance of the Model 350L. These tests are as follows: the gain and gain variation test, the RF output power test and the RF output distortion test.

5.1.2 Test Equipment Required

The following test equipment is required for accomplishing the Model 350L performance tests. Equivalent substitutes for recommended models may be used.

a. Oscilloscope - Telequipment Model S54A
   - or Telequipment Model D67
   - or Tektronix Model D10 with 5A23N and 5A24N plug in units.

b. RF Generator/Sweeper - HP-8601A

c. 50 ohm Detector - HP 8471A
   - or Wavetek D151

d. Attenuator, 30 dB, 50 watts - Bird 8321

e. Attenuator, 30 dB - HP-8491A

f. Attenuator, 10 dB, 20 watts - Narda 766-10

g. Calorimetric Power Meter - HP 434A

h. Spectrum Analyzer - HP 140T Display Unit
   - HP 8554L Spectrum Analyzer-RF section
   - HP 8552A Spectrum Analyzer-IF section

5.1.3 Gain and Gain Variation Test

The purpose of this test is to verify the gain and gain flatness versus frequency of the Model 350L.

5.1.3.1 CALIBRATION OF SET UP

a. Set-up the test equipment as shown in figure 5.1.

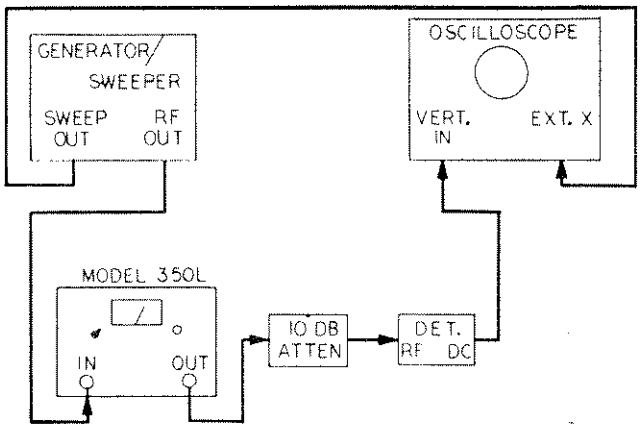

Figure 5-1. Gain and Gain Variation Test Set Up

b. Set oscilloscope to DC, Time/CM to Ext. X, and vertical gain to 10MV/CM.

c. Set the RF Generator/Sweeper to video sweep and frequency to 105 MHz.

d. Disconnect the Model 350L from the set-up and connect the Generator/Sweeper RF output directly to the 10dB attenuator.

e. Adjust the output level of the Generator/Sweeper for full vertical deflection on the oscilloscope face.

f. Calibrate the scope face to show 3 dB in 1 dB steps by attenuating the Generator/Sweeper in 1 dB steps and marking the traces with a grease pencil.

g. Return Generator/Sweeper output level to full deflection. Rotate the step attenuator on the Generator/Sweeper (CCW) so that the output is reduced by 50 dB.

h. Reconnect Model 350L into the test set up of figure 5-1.

5.1.3.2 MEASUREMENT PROCEDURE

a. Turn on the Model 350L power switch.

b. Observe the gain versus frequency sweep on the oscilloscope.

1. The average gain should be 50 dB (within 1 dB).

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

5.1.4 RF Output Power Test

The purpose of the RF output power test is to verify that the Model 350L will deliver more than 50 watts of RF power over the frequency range of 250 kHz to 105 MHz.

5.1.4.1 MEASUREMENT PROCEDURE

a. Set-up the test equipment as shown in figure 5-2.

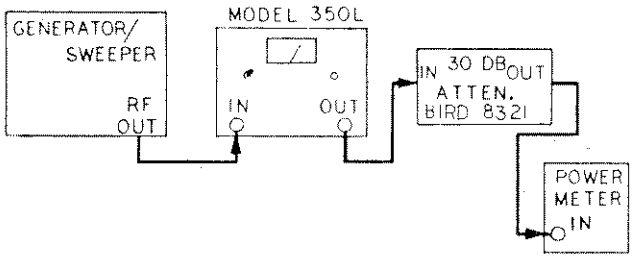

Figure 5-2. RF Output Power Test Set Up

b. Set the calorimetric power meter to .10 watt range. With the 30 dB series attenuator, this corresponds to a full scale deflection of 100 watts.

c. Set the Generator/Sweeper to CW, output level to 0 dBm and frequency to 250 kHz.

d. Slowly increase frequency while observing the power meter. Note that at every frequency up to 105 MHz, the power output is in excess of 50 watts.

5.1.5 RF Output Distortion Test

The purpose of this test is to verify that the harmonic distortion of the Model 350L and hence, its linearity is within specified limits.

5.1.5.1 MEASUREMENT PROCEDURE

a. Set-up the test equipment as shown in figure 5-3.

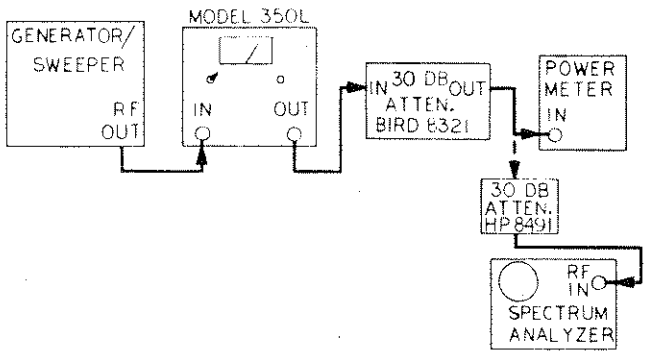

Figure 5-3. RF Output Distortion Test Set Up

b. Set the calorimetric power meter to .10 watt range. With the 30 dB series attenuator, this corresponds to a full scale deflection of 100 watts.

c. Set Generator/Sweeper to CW and frequency to 250 kHz.

d. Adjust the Generator/Sweeper output level so that the output power indicated on the calorimetric power meter is 50 watts.

e. Disconnect the cable from the power meter and connect it to the Spectrum Analyzer through a 30 dB attenuator.

f. Observe that the 3rd harmonic is at least 20 dB below the fundamental and the 2nd harmonic is at least 30 dB below fundamental signal.

g. Repeat steps d. through f with the generator frequency set at 1MHz, 10MHz, 40MHz, and 105 MHz in succession.

CHAPTER 6
TROUBLESHOOTING AND REPAIR

6.1 TROUBLESHOOTING

The first step in isolating a malfunction is to review the conditions under which the symptoms were observed and check that it was not caused by the external cabling or associated test equipment. Before proceeding to the detailed test procedures, a complete visual inspection of the 350L should be accomplished. Check for burnt or discolored components, loose cable connectors and broken wires and note any details which might localize the malfunction.

Commonly found symptoms together with their probable cause and troubleshooting recommendations are listed in the Troubleshooting Guide, Table 6-1.

Table 6-1. Troubleshooting Guide

SYMPTOM	PROBABLE CAUSE	RECOMMENDATION
Power lamp does not light	Burned out bulb	Check for 27.5 volts across bulb.
	Defective Power Supply	Perform test in section 6.3.1.1.
	Thermal Switch Open	If TS1 contacts do not close after unit has cooled, replace thermal switch.
	Defective Power Switch	Replace switch (S1).
	Blown Fuse	Replace fuse with 8 amp. 3AG S.B.
Power Lamp dim	Power supply out of adjustment	Perform Power Supply Adjustment Section 6.3.1.2.
	115/230 volt line switch in wrong position	Check for correct position of switch (S2).
Blown Fuse	Defective Power Supply	Perform test in section 6.3.1.1.
	Wrong Fuse	Check to see that 8 amp. 3AG S.B. is installed.
	Defective line cord or AC wiring	Visually inspect for signs of insulation breakdown.
No RF Output or Gain	Broken Input or Output BNC Connector	Visually inspect connectors for broken pins.
	Defective Input or Output internal cables	Visually inspect cables at input and output connectors.
	Defective Preamplifier Module	Replace Q1 in the preamplifier module (A22) 350L-4185