OPERATION & SERVICE MANUAL

LPG-6A

RF Power Generator

HIGH RF VOLTAGES MAY BE PRESENT AT THE OUTPUT OF THIS UNIT. *All operating personnel should use extreme caution in handling these voltages and be thoroughly familiar with this manual.*

DO NOT USE ANY CFC (CHLOROFLUOROCARBON) SOLVENT IN THE MAINTENANCE OF THIS PRODUCT. In recognition of our responsibility to protect the environment, this product has been manufactured without the use of CFCs. The no-clean flux now used in all soldering operations may leave a small inert residue that will not affect the performance of the product. The use of CFCs for cleaning or maintenance may result in partial liquification of the no-clean flux residue, which will damage the unit and void the warranty.

This product is manufactured at ENI's Rochester NY plant, an ISO 9001 Quality System Certified Facility.

Notice

Revision Level: B4
Manual Order Number: LPG-6A-TM

Warranty

ENI warrants to the original purchaser for a period of one year from the date of delivery, each instrument to be free from defects in materials and workmanship. For a period of one year, ENI will, at its option, adjust, repair, or replace defective parts, without charge to the original purchaser, so that the instrument performs according to its specifications.

When warranty service is required, the instrument must be returned, transportation prepaid, to the factory or to one of ENI's designated service centers. If, in our opinion, the instrument has been damaged by accident, unreasonable use, buyer-supplied software or interfacing, improper site preparation or maintenance, or abnormal conditions of operation, repairs will be billed at standard rates. In this case, an estimate will be submitted before the work is started.

THIS LIMITED WARRANTY IS EXCLUSIVE AND ENI MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, AND ALL OTHER EXPRESS ORAL OR WRITTEN WARRANTIES AND ALL WARRANTIES IMPLIED BY LAW, INCLUDING ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR OTHER WARRANTY OF QUALITY ARE EXCLUDED AND DISCLAIMED. IN NO EVENT SHALL ENI BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM BREACH OF ANY WARRANTY, WHETHER EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, OR FROM ANY CAUSE WHATSOEVER, INCLUDING NEGLIGENCE. Buyer's sole and exclusive remedy under this warranty shall be repair or replacement as set forth above, or if ENI is unable to repair or replace the defective part within a reasonable time, a refund of the price of the part or goods that give rise to the warranty claim.

Service And Technical Assistance

For Service or Repair contact the closest Customer Service Department with the following information:

- Model and serial number
- Purchase order number
- Detailed description of malfunction
- Your company's "Bill To" and "Ship To" address

You will receive a RMA (Return Materials Authorization) number, the warranty status of the unit to be returned and estimated repair charge, if any. The RMA number is your authorization number. Please type this number on your purchase order and shipping label. After ENI receives the unit, a firm quote and estimated date of completion will be given.

For Technical Assistance for your particular application, contact the nearest ENI Sales and Service Center. The following information will help us provide you with prompt and efficient service:

- All of the information contained on the unit's nameplate.
- Names and telephone numbers of important contacts.
- Detailed description (i.e. physical damage and/or performance anomalies, quantitative and/or qualitative deviation from specifications), including miscellaneous symptoms, dates and times.
- The environment and circumstances under which the issue developed
- Supporting test data and/or records that can be provided.
- Any previous, related conversations and/or correspondence with ENI.

Sales & Service Locations

ROCHESTER, NY	A Division of Emerson Electric Company 100 Highpower Road Rochester, NY 14623 **Toll Free USA Sales Hotline:** **Toll Free USA Service Hotline:**	Tel: (716) 292-7440 Fax: (716) 427-7839 Svc: (716) 292-7478 **1-800-267-5362** **1-800-724-ENI1 (3641)**
FREMONT, CA	48834 Kato Road, Suite 110A Fremont, CA 94538	Tel: (510) 353-4ENI (4364) Fax: (510) 353-4360
AUSTIN, TX	4150 Freidrich Lane Suite J Austin, TX 78744	Tel: (512) 462-2191 Fax: (512) 462-9411
UNITED KINGDOM	Highway House Norreys Drive Maidenhead Berks, SL6 4BN United Kingdom	Tel: 44-1628-775911 Fax: 44-1628-775902
GERMANY	Sielminger Str. 63 D-70771 Leinfelden- Echterdingen (Stetten) Stuttgart, Germany	Tel: 49-711-947700 Fax: 49-711-9477025
JAPAN	541 Aoyogi Kunitachi Tokyo 186 Japan	Tel: 81-42-522-9011 Fax: 81-42-522-2636
TAIWAN	No. 49-1, Lane 2, Sect. 2 Kuang Fu Rd. Hsinchu 300, Taiwan Republic of China	Tel: 886-3-575-1199 Fax: 886-3-575-1022

Product and Applications information also available on the Internet at:

http://www.enipower.com

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Product Manual Revision Control Form

Title:	LPG-6A Operation and Service Manual	Part #:	LPG-6A-TM Rev #: B4	Final Assy #:	LPG-6A-21051 Eff. Date: 01/04/00

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General Information

The ENI Power Systems Model LPG-6A Power Generator is an all solid-state, water-cooled, power source expressly designed for use in gas plasma and sputtering applications. Completely self contained, the LPG-6A provides all of the control and monitoring functions needed in a state-of-the-art power generator. It will provide a maximum continuous power output of 600 W into a 50Ω impedance.

The reliable operation of any solid-state power generator is directly influenced by the sophistication of its power control circuitry. The LPG-6A automatic power control module measures forward RF power, reflected RF power, load RF power, and the current draw of the RF power amplifier module. Should any of these parameters exceed a preset limit, the automatic power control will immediately fold back its RF output power so that the components always remain within their safe operating limits. Besides assuring safe operation of the LPG-6A, the automatic power control module will provide constant RF power output level to within 3% of the matched power setting regardless of the plasma load VSWR. In addition, automatic power control eliminates power-output drift due to line voltage variations, component aging and reduces output hum and ripple to insignificant levels. An external DC voltage or pulse fed into the rear panel connector will permit the power output of the LPG-6A to be accurately controlled by a computer program that includes end-point detection information.

The LPG-6A is provided with an external computer interface. This interface permits RF power to be turned ON or OFF, indicates to the computer when the unit is developing its maximum power and indicates lack of water cooling or RF power. In addition, external differential analog voltages are available at the interface connector for forward, load, and reverse power indications. The forward and load indications are calibrated for 10 V at 600 W, and reflected power indication is calibrated for 10 V at 150 W.

The use of conservatively rated solid-state components and automatic power control ensures the user of reliable and continuous performance with an absolute minimum of maintenance. However, should service be required, all of the plug-in modules are easily removed for replacement or repair.

The very low DC voltages used in the LPG-6A greatly reduce the potential hazards associated with its servicing when compared with vacuum tube equipment.

The LPG-6A may be rack mounted, using the furnished rack-mounting kit, into any 19-inch relay rack, or operated remotely within the plasma system cabinetry.

The LPG-6A is provided with an extremely well shielded and filtered power supply virtually eliminating conducted line leakage. Extensive use of shielding and RF suppression techniques permits the unit to more than meet FCC requirements for ISM equipment at the same time that it eliminates any RF susceptibility problems for associated plasma system circuitry.

The manual contains 7 sections:

Chapter 1 Deals with precautionary details. Please read this section if you are unfamiliar with the LPG-6A or ENI's warranty procedures.

Chapter 2 Tells you how to install and power up the system for the first time.

Chapter 3 Describes the operational details of the LPG-6A.

Chapter 4 Is a technical description of the LPG-6A circuits.

Chapter 5 Describes maintenance procedures.

Chapter 6 Contains the Troubleshooting Guide. Use this section if there is a problem with your LPG-6A.

Appendix Contains a full set of schematics and a parts list for the LPG-6A.

Chapter 1

Safety

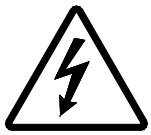
1.1 Labels

Labels are provided to alert operating and service personnel to conditions that may cause personal injury or damage to the equipment from misuse or abuse. Please read the labels and understand their meaning.

1.1.1 Important Operating or Maintenance Cautions

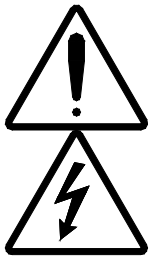
The caution label is used in this manual to caution the reader to important operating or maintenance instructions that could adversely affect equipment reliability.

1.1.2 Shock Hazard Warnings



The warning label is used in this manual to warn the reader of a procedure or practice that could result in personal injury if not followed carefully.

1.1.3 Service

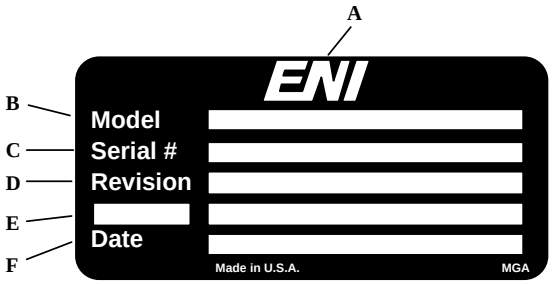


ENI is responsible for safety, reliability, and performance of the equipment only if:

- *Assembly operations, extensions, readjustments, modifications, or repairs are carried out by authorized personnel.*
- *The electrical installation is made in accordance with the installation instructions provided and the room in which the equipment is installed complies with the environmental requirements.*
- *The equipment is used in accordance with the instructions for use.*

1.1.4 Nameplate

The LPG-6A can be identified by a nameplate at the rear of the unit that has the following information:



A. Manufacturer:

   ENI

   Rochester, NY USA

B. Model

   The assembly number that uniquely identifies product configuration.

C. Serial #:

   A number that is sequentially assigned as the product is manufactured.

D. Revision:

   The revision letter that identifies the product configuration. The initial revision is A.

E. Customer name and customer identification number.

F. Date:

   The date of manufacture.

Chapter 2

System Installation

2.1 Initial Inspection

2.1.1 Mechanical Inspection

If damage to the shipping carton is evident, request the carrier's agent be present when the unit is unpacked. Check the equipment for damage and inspect the cabinet and panels for dents and scratches.

2.1.2 Claim for Damage

If the LPG-6A is mechanically damaged or fails to meet specification upon receipt, notify ENI or our representative immediately. Retain the shipping carton and packing material for the carrier's inspection, as well as for subsequent use in returning the unit if necessary.

2.1.3 Packaging for Reshipment

Whenever possible, the original shipping carton and packing material should be used for reshipment. If the original 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 wall on each side. Protect the front panel by means of cardboard spacers inserted between the front panel and the shipping carton. Make sure that the instrument cannot move in the container during shipping. Seal the carton with a good grade of shipping tape and mark the container:

FRAGILE! ELECTRONIC INSTRUMENT

Drain water before shipment.

2.2 LPG-6A Installation Requirements

2.2.1 Bench Operation

The unit has plastic feet and can be placed onto a secure flat surface.

2.2.2 Cooling and Ventilation

Water Cooling

Connect fittings for water cooling. Connections are provided to accept ¼-inch NPT male pipefittings. The unit is designed to operate normally with not less than 0.8 gallons per minute. If in doubt or the available process water flow is near this flow rate, the actual flow should be checked.

Note: *The LPG-6A is protected against damage caused by lack of coolant flow. However, inadequate coolant flow will result in an OVERHEAT condition and the generator will turn off its RF power until normal internal temperatures are restored. The water used for cooling should be clean and free of any contaminants that may cause a build-up of corrosion or scale inside the heat sink tubing. This condition would reduce the electrical ruggedness of the LPG-6A by reducing the amount of cooling to the power transistors.*

DO NOT apply torque to the water inlet and outlet pipes on the rear of the LPG-6A. Place a wrench on the pipefittings on the LPG-6A while the mating fittings are being tightened.

Note: *Distilled water should be used if possible to eliminate lime or other mineral build-up in the copper heat exchanger. If tap water with a high mineral content is used for cooling, it may be necessary to periodically flush the unit by pumping through a commercial lime- or scale-removing agent. Typically, this agent is a household or industrial product. The unit should be flushed for approximately 5 minutes or until the scale is totally removed. For further recommendations, consult the factory.*

If conditions exist where the water coolant temperature is below the ambient dew point temperature, ENI recommends that either 1.) in-line solenoid valves be installed on the water connections to the generator and be closed when generator RF has been disabled or 2.) coolant water temperature be adjusted to prevent condensation.

Follow this recommendation to prevent condensation from forming when the generator is off; failure to do so may result in extensive damage to the generator! Contact ENI Service for more information.

2.2.3 Remote Control Connector Assembly

Supplied with each LPG-6A generator is a 17-20250 connector. The 17-20250 connector mates with the accessories jack. To make connections to this connector, it must first be disassembled as follows:

a) Unscrew the rear cable clamp and put the accessories wires through it.

b) Remove the two screws in the split shell and remove the two halves to expose the terminals.

c) Connect the wires as explained in section 3.2.

d) Replace the two halves of the shell and tighten the two screws.

e) Screw on the cable clamp and tighten the two screws to hold the cable securely.

2.3 Power Requirements

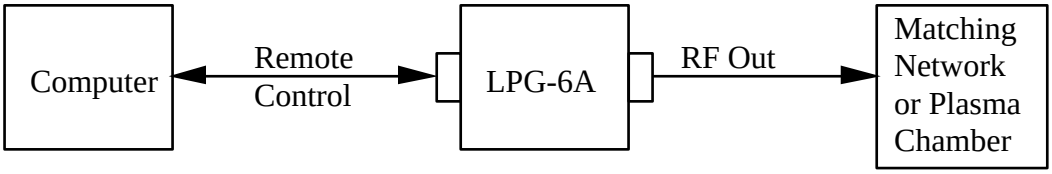
The LPG-6A is designed for operation from either a 100-120 VAC 50/60 Hz single-phase or a 200-240 VAC 50/60 Hz single-phase line. The unit is factory set for 208 VAC.

2.3.2 Power Cable

To protect operating personnel, the Model LPG-6A is equipped with a three-conductor cable consisting of a black hot line, a white common line, and a green chassis ground. For U.S. delivery, the Model LPG-6A is supplied with a three-wire, 20 ampere, 250 V plug NEMA L6-20P. This plug must be inserted into a properly wired 20 ampere, three-wire grounding receptacle NEMA L6-20R.

2.4 System Interconnection

The following diagram shows the normal interconnection of an LPG-6A to a system:



The remote control connection allows a computer or external control unit to adjust and read back power via the accessories connector (see section 3.2). The RF OUT connection is made to either a load (often a plasma chamber) or a matching network.

2.5 System Check

The following items should be checked before applying power for the first time:

1. Check for any physical damage that could affect safety, for instance, a dent that could indicate that internal components could have shifted and cause a short circuit.

2. Make sure that the front panel AC power switch is in the OFF position (down).

3. Rotate the POWER ADJUST control fully CCW and be sure the RF POWER switch is in the OFF/REMOTE position.

4. Plug connector with jumper between Pins 10 and 23 into the accessories connector located on the rear panel.

5. Connect the output of the power generator to a suitable 1000 W, 50Ω load.

6. Finally, check all cables making sure that they are correctly installed and firmly inserted.

2.6 Initial Turn-on Procedure

The following procedure outlines how the LPG-6A should react as power is applied for the first time.

1. Ensure that proper coolant flow has been established.

2. Turn ON the AC LINE switch. The AC ON light and the INTERLOCK ENABLE light should be on; all others should be off. There should be no meter reading. The internal cooling fan should be operating.

3. Turn ON the RF POWER switch. The RF ON light should be ON. The MAXIMUM POWER and OVERHEAT lights should be OFF. There should be no meter reading.

4. Rotate the POWER ADJUST CW to obtain at least 600 W with the front panel METER switch in the FORWARD position. The MAXIMUM POWER light may be on at 600 W if the AC line voltage is at or near its lower limit. This is normal.

5. Set the METER switch on the front panel to the LOAD position. The meter should read the same as in the FORWARD position.

6. Return the METER switch to the FORWARD position and turn off the RF POWER switch.

7. Disconnect the LPG-6A output connector from the 50Ω load and turn on the RF POWER switch. Observe that with the METER switch in the FORWARD position the meter reading should be 150 W, and in the LOAD position the meter should read zero. The MAXIMUM POWER light should be ON to indicate that the LPG-6A is being limited by the internal protection circuit and is no longer controlled by the front panel POWER ADJUST.

8. Rotate the POWER ADJUST CCW to reduce the output power below 150 W. The MAXIMUM POWER lamp will be OFF as power control and leveling is restored.

9. Rotate the POWER ADJUST CCW to its zero position. There should be no power reading. Turn OFF the RF Power Switch and AC Line Switch.

10. The initial test is now complete. Disconnect the unit from the AC line, 50Ω load, and water outlets.

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Chapter 3

LPG-6A Operation

3.1 Front Panel

The LPG-6A front panel is provided with 5 indicators for status, monitoring, 1 analog meter for power monitoring, 4 switches for primary control, and 2 potentiometers for manual control of generator frequency and output power.

3.1.1 Indicators

AC ON LIGHT:	Indicates when AC power is being applied to the generator.
RF ON LIGHT:	Indicates when RF can be supplied by the generator. This light is OFF in the case of an OVERHEAT fault.
MAXIMUM POWER LIGHT:	This LED indicates a lack of Forward/Load Power Control Leveling. This is usually caused by conditions of high VSWR where either the Reverse Power Sensing or the Power Amplifier Current Sensing has reduced the output power to protect the generator.
OVERHEAT LIGHT:	This LED indicates that the thermostat located on the RF heat sink has closed due to excessive heat sink temperature. All RF power is removed from the generator output, and the driver Class-A bias is removed until the unit cools. The function is self-resetting and no maintenance is needed.
INTERLOCK ENABLE LIGHT:	This LED indicates when the cover interlock switches are closed and the Accessories connector Pins 10 and 23 are shorted. The generator AC voltage will not be ON if the cover interlock switches are open and the RF power will not turn ON if the Accessories connector Pins 10 and 23 are not short circuited.

3.1.2 Switches

AC ON CIRCUIT BREAKER: Turns on +42 V to +48 V DC power supply and control circuits.

RF ON SWITCH: In the ON position the +25.6 volt DC power supply is enabled providing power and bias through the Driver Amplifier, which provides the input to the RF power amplifiers. In the OFF/REMOTE position, the +25.6 volt DC power supply will only be activated when the remote control function (Pins 4 and 17) located on the rear panel accessories connector is at +20 to +24 V.

METER SWITCH: The meter indicates the forward power output (watts) of the generator when the meter switch is in the FORWARD position. The meter indicates the power absorbed in the load when the METER switch is in the LOAD position. The difference between the forward and the load power is equal to the power reflected from the load back to the generator.

POWER CONTROL SWITCH: In the FORWARD position the generator will level on the forward power. In the LOAD position the generator will level on the load power.

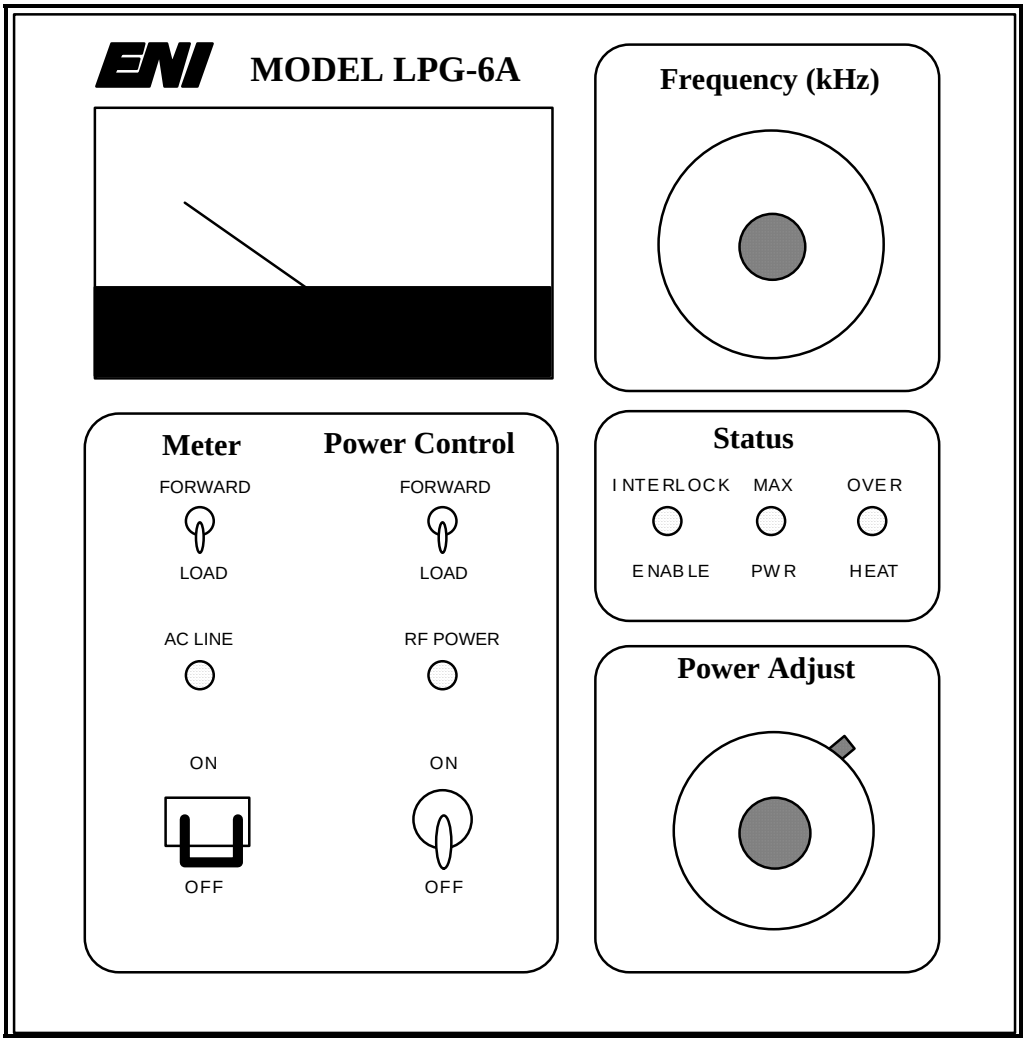
3.1.3 Potentiometers and Metering

METER: Indicates either load or forward power depending on the position of the meter switch.

RF POWER ADJUST: The RF adjust varies the output of the generator from <0.5 to 600 W. The 10-turn dial has a logging scale and a dial lock for repeatability of any power setting. To operate the lock, press down on the lever. To break the lock, push the lever to the up position.

FREQUENCY: The FREQUENCY (kHz) dial varies the output frequency of the generator from 90 to 460 kHz.

LPG-6A Front Panel



3.2 Rear Panel

The rear of the LPG-6A contains one connector for RF output, one connector for remote control, and a pair of water fittings. Note that a circuit breaker is included to protect the interlock transformer.

3.2.1 RF Output Connector

The RF output of the generator is delivered through this BNC connector. The "Caution High RF Voltage" indicates that an AC potential of up to 175 V may exist between the center pin of the connector and ground. Normal caution should be exercised when working with these voltages.

A Chassis Ground Stud is provided to allow a firm connection to be made to system ground.

3.2.2 Accessories Connector

The Accessories Connector allows remote control and monitoring of the LPG-6A generator functions.

PIN #	Function	Description
1 & 14	MAXIMUM POWER	This **output** is a collector-emitter junction: closed = Maximum, open = Normal operation.
2 & 15	REVERSE POWER	This **output** is between 1 V and 10 V per kW, depending on the setting of the Reverse Power Cal. potentiometer (R124), to allow reverse power reading on any external voltmeter having an input impedance of 250 kΩ or more. This differential output is originally set for 10 V at 150 W reverse power.
3 & 16	FORWARD POWER	This **output** is between 1 V and 10 V per kW, depending on the setting of the Forward Power Cal. potentiometer (R91), to allow forward power reading on any external voltmeter having an input impedance of 250 kΩ or more. The output is originally set for 10 V at 600 W of forward power.
4 & 17	RF ON INPUT	This **input** is to allow control of the RF ON function: +20 V to +24 V = RF ON, 0 V = RF OFF.
5 & 18	EXTERNAL CONTROL	This differential **input** voltage may be DC or pulse, and any power level from 1 to 600 W may be controlled by this input. In addition, the generator may be calibrated to accept an input of 1 V per kW or any voltage up to 10 V corresponding to full power output. For pulse operation, rise time is less than 0.2 ms. Overdrive limiting is provided such that 680 W cannot be exceeded regardless of pulse amplitude. ***Note:*** *In order to use this function, EXTERNAL CONTROL SELECT must be enabled.*
6	24 VDC	Unregulated +24 V is available at this pin. 50 ma max.

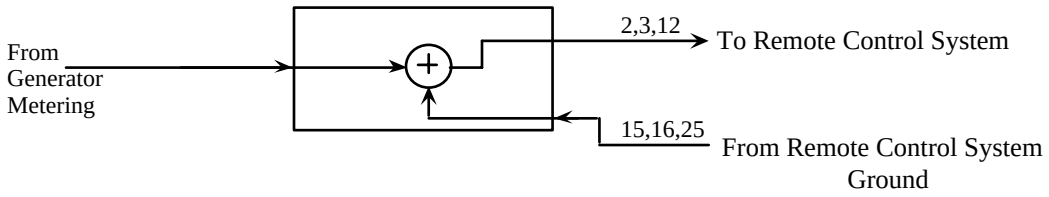
PIN #	Function	Description
7 & 20	RF ON OUTPUT	This **output** is a collector-emitter junction: closed = RF ON, open = RF OFF. The junction is open in the event of an OVERHEAT fault.
8	INT/EXT CONTROL	With no connection to this **input**, the generator is in internal mode; the power output is controlled from the RF POWER ADJUST potentiometer, located on the front panel. With this **input** grounded, the generator is in the external mode; the power output of the generator is controlled by the external differential input to the Accessories connector Pins 5 and 18.
9 & 22	OVERHEAT OUTPUT	This **output** is a collector-emitter junction: closed = OVERHEAT.
10 & 23	INTERLOCK	These pins must be connected in series with any safety interlock switches. The interlock switch should be closed for safe operation. If this circuit should be interrupted, the RF power from the generator will turn off instantly. If no safety switches are used, a jumper must be connected between Pins 10 and 23 in order to operate the generator.
11 & 24	FWD/LOAD POWER LEVELING	With no connection to this **input** (Pin 11), the generator power leveling is controlled from the front panel Power Control Switch (S4). With this pin at +5 VDC, the generator is in Load Power Leveling. Pin 24 is provided to give +5 VDC for this purpose.
12 & 25	LOAD POWER	**Output**, between 1 V and 10 V per kW, depending on the setting of the Load Power Cal. potentiometer (R108), to allow load power reading on any external voltmeter having an input impedance of 250 kΩ or more. The output is originally set for 10 V at 600 W of load power.
13	+15 V	Regulated +15 V is available at this pin. 10 ma max.
19 & 21	GROUND	Chassis ground is available at this pin.

Connection of Remote Control

In order to obtain the best performance from the analog input and output signals, the following connection procedure should be used.

Connection to Forward, Reverse, and Load Power Outputs

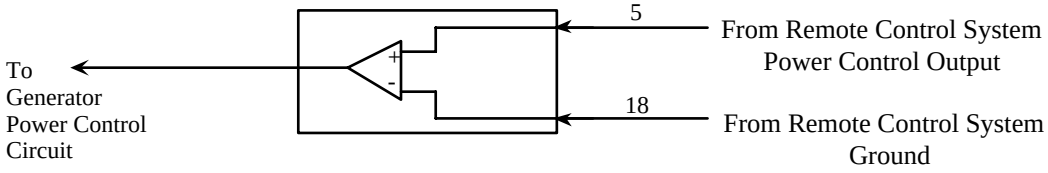
Each of these outputs has an accompanying input that is designed to eliminate the difference between the generator ground potential and the remote control system ground potential.



Any voltage applied to the compensation input is summed to the output voltage. Therefore, if, for instance, the remote control system ground is 1 V above the generator ground, the output to the remote control system will be raised by 1 V and will provide a correctly calibrated metering voltage at the remote control system relative to its ground.

Connection to External Control Input

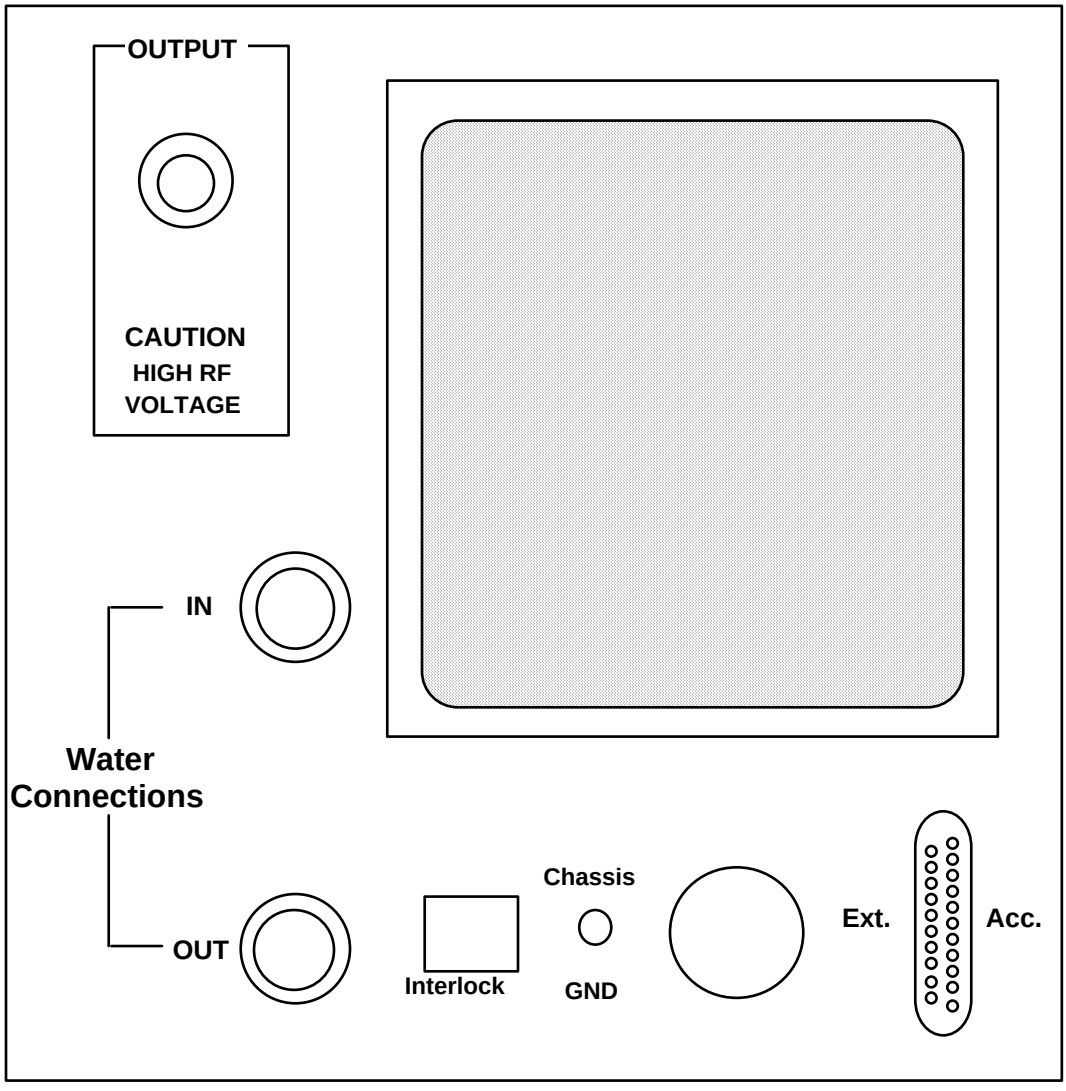
This is a differential input. Best performance is obtained by connecting one input to the remote control system ground and the other input to the remote control system power control output. If a connection is not made to the remote control system ground, the control accuracy will be reduced by an amount proportional to the difference in potential between the remote control system and generator grounds.



3.2.3 Water Input/Output Connectors

The water inlet and outlet connectors are provided for attachment of a water-cooling system having a minimum flow rate of 0.8 gal./min. The connections provided accept a ¼-inch male (NPT) pipe thread. The water inlet temperature must not exceed +35°C.

LPG-6A Rear Panel



3.3 Internal Meter Select Switch

The Meter Select switch is located inside the generator. To access the switch, it is necessary to remove the cover.

The Rotary switch allows a service technician to change the meaning of the front panel meter to one of the following functions:

POSITION	FUNCTION	DESCRIPTION
1	RF POWER	The forward or load power is read on the front panel meter in this position. Power selection is made with the METER switch located on the front panel. The Diagnostic switch is normally left in this position.
2,3	PA 1 CURRENT, PA 2 CURRENT	When the switch is in either of these two positions, the front panel meter will read the DC current draw of the corresponding power amplifier. The meter has a full scale of 15 A.
4	PA VOLTAGE	When the switch is in this position, the front panel meter will read the DC voltage of the unregulated power supply feeding the power amplifier module. The meter has a full scale of 75 V.
5	DRIVER CURRENT	When the switch is in this position, the front panel meter will read the DC current draw of the driver amplifier. The meter has a full scale of 7.5 A.
6	DRIVER VOLTAGE	When the switch is in this position, the front panel meter will read the DC voltage of the driver power supply. The meter has a full-scale reading of 75 V.

3.4 Sequence of Control Operation

It is recommended for best generator operation that the following sequence of control actuation take place. Following these steps will improve the performance and increase the reliability of the generator:

1. Turn the AC line ON with the front panel circuit breaker. Be sure any external interlocks connected to the generator are closed.

2. Select LOCAL or REMOTE control mode. See section 3.2.1

3. Enable RF ON with the front panel switch, or with remote control. See section 3.2.1, part (D).

4. Increase RF POWER output level from zero using front panel control or remote control. See section 3.2.1, part (E). For PULSE operation, best results are achieved when the FORWARD POWER CONTROL input is pulsed from 0 to +10 VDC peak.

5. Reverse this order to turn generator off.

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Chapter 4

Technical Description

4.1 System Overview

The diagram on the following page shows the basic structure of the LPG-6A. This section briefly describes the way in which each of the following blocks works:

1) The Power Supply

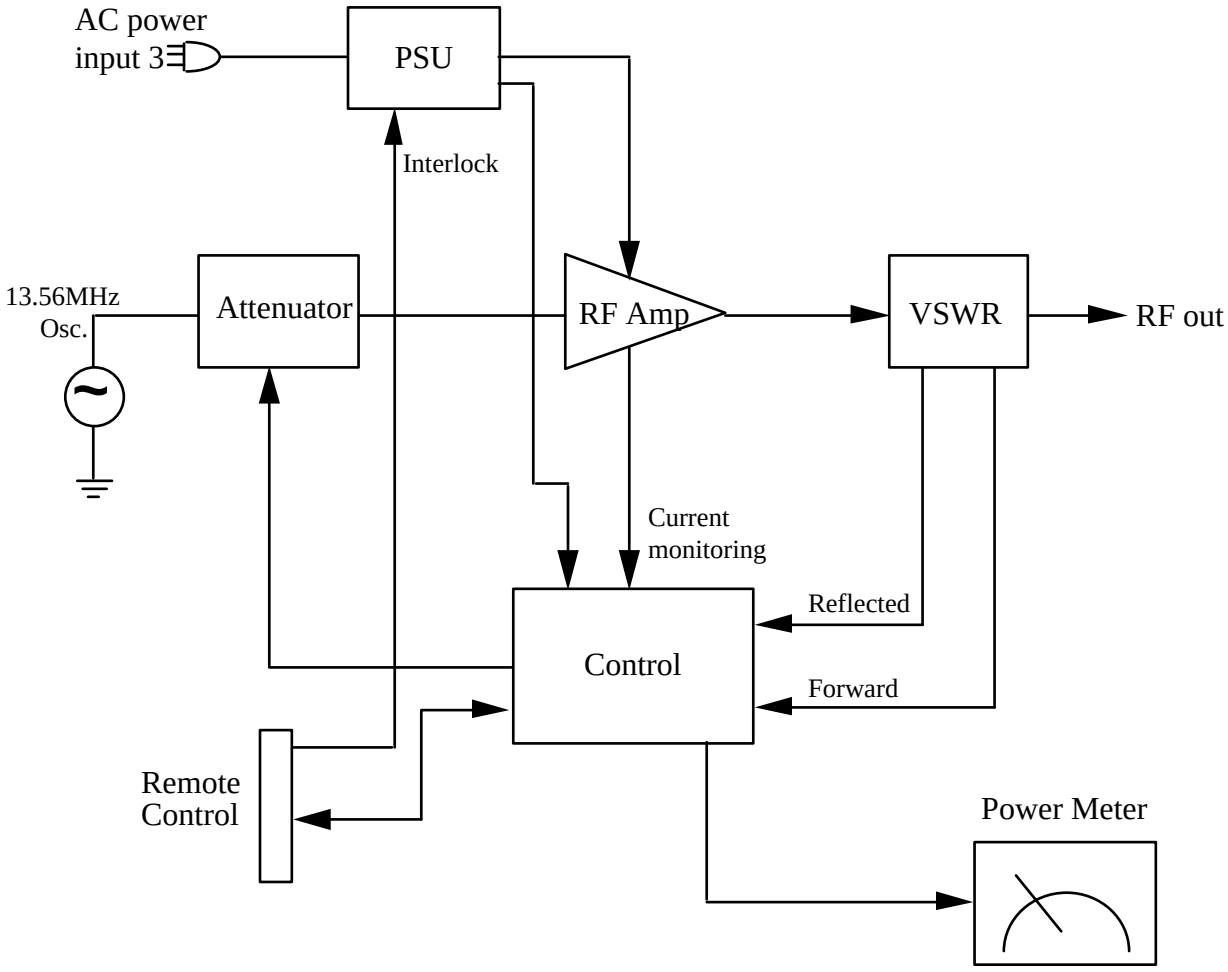
2) The RF Amplifier Module

3) The Control Board Assembly

4) Local and Remote Control Interface Circuits

During the following discussions it will be necessary to refer to the schematics in the rear of this manual.

System Block Diagram



4.2 The Power Supply

The Power Supply provides unregulated DC Voltage (approximately 40-48 V) to the RF Chassis Assembly. The circuit is a single-phase, full-wave bridge rectifier, capable of an output current of 30 A. Both sides of the AC line are protected by a circuit breaker, and a double-pole contactor provides disconnection from the mains within the unit. Initial set-up is aided by a line-voltage test that allows the unregulated DC voltage to be read on the power output meter.

A +40 V regulator is located on the RF Assembly for powering the last stage of the driver amplifier. This regulator is fed from the unregulated supply voltage. An ENI-1 transistor regulator is used for high reliability.

A +25 V regulator is located on the RF Assembly for biasing of the driver amplifier. This regulator is fed from the unregulated supply voltage. An ENI-1 transistor regulator is used for high reliability. Bias to the driver is present only when the "RF ON" function is enabled, either locally or through the external accessories connector.

4.3 The RF Amplifier Module

The RF Amplifier Module consists of a driver amplifier assembly, two power amplifiers, a combiner, and the meter control assembly.

The driver amplifies the RF output from the control board to about 15 W to drive the power amplifier. This is a Class A, linear driver with the first stage operating from regulated +25 V. The output stage uses the regulated 40 VDC for the collector supply while the base bias is taken from the regulated +25 V.

The Power Amplifier consists of two pairs of push-pull amplifier stages each operating in a Class C mode and feedback stabilized for operation into high VSWR loads without spurious oscillations. The output of each pair is about 300 W at 100Ω. The collector bias is unregulated DC at 12.5 A maximum (limited by circuitry on the control board). Resistors used for current sensing are located on each power amplifier pair.

The output combiner combines the outputs of the two power amplifier pairs and gives a 50Ω output impedance.

The Meter Control Assembly senses the forward and reverse power simultaneously and provides output to the control board for monitoring and protection functions. These outputs are applied to a voltage-squaring circuit on the control board so that all control and interface functions are linear and directly proportional to power outputs.

4.4 The Control Board Assembly

The control board contains the following functions:

- Rectifiers and voltage regulators for the ground-referenced and DC-referenced ±15 V bias supplies.
- Current-sensing protection circuits.
- Reverse power protection and metering circuits.
- Forward power control and metering circuitry.
- Load power control and metering circuits.
- Maximum power indicating circuits.
- RF ON Control Logic and indicating circuits.
- Thermostat-control interface.
- Diagnostic Self-test Circuits.
- Oscillator and buffer circuits.

4.4.1 15-volt Power Supplies

The dual +15 V supplies operate from center-tapped windings on the main transformer mounted on the base plate assembly. The supply used with the current sensing is referenced to the unregulated DC (44 to 48 V). The voltage regulator is IC1, MC1468. These voltages are used only with IC2 and Q1. The other supply is referenced to DC ground and uses 3-terminal IC8 (MC7915CT) and IC9 (LM317). These voltages are used for all other circuitry on the control board except where +25 V is used on Q2, Q3, Q5 and Q6.

4.4.2 Current Sensing

The current sensing and protection operates from the voltage drop across the current sense resistors located on the power amplifier module. The power supply side (high side) of the resistor is connected to the inverting input of an op-amp through a voltage divider. The power amplifier (low side) of the resistor is connected to the non-inverting input. When the current through the sense resistor is less than 12.5 A, the output of the op-amp will be high and allow Q1 to remain off. When 12.5 A is exceeded, the voltage to the non-inverting input will be less than that to the inverting input and the op-amp output will be driven low, thus turning on Q1.

This, in turn, turns on Q2, which pulls the attenuator bias line down toward ground, thus reducing the RF output of the attenuator. The net effect is to reduce the drive to the RF module, which reduces the output power sufficiently to limit current to the power amplifier module to 12.5 A per pair.

4.4.3 Reverse Power Sensing

The Reverse Power Sensing and Protection operates from the output of the Meter Control Assembly. The control signal is first linearized with respect to power by a squaring circuit IC4. It is then applied to the control amplifier for comparison to the internal reference voltage.

If the reverse power signal exceeds this reference, the control amplifier output goes high, which turns on Q3 and pulls the attenuator control line toward ground. The net effect is the same as for current limiting: The drive to the RF module is reduced sufficiently to limit the reverse power to a safe level. This level is normally set to 150 W. The output of the squaring circuit (IC4) is also applied to the linear power meter on the front panel and to the Accessories connector on the rear panel. This accessories output is 0 to 10 V depending on the volts/kilowatt range set by R124. The output of the squaring circuit is also applied to the difference amp (IC7-C) for calculation of the load power.

4.4.4 Forward Power Sensing

The Forward Power Sensing and leveling operates from the forward output of the Meter Control Assembly. As in the case of the reverse power, the control signal is first linearized by a squaring circuit (IC5). It is then applied to the control amplifier (IC6-A), via the analog switch (IC10), for comparison to a reference voltage. This reference can be either the front panel power control (10-turn potentiometer) or an external voltage applied through the accessories connector on the rear panel. This external voltage is applied to an amplifier/limiter circuit such that calibration for 1 volt per 600 W can be done. It can be adjusted by R72 for 600 W maximum limited output. Additionally, this voltage may be pulsed to any peak power level up to 600 W with a pulse as narrow as 100 μs. The remainder of the circuitry is the same as for the reverse power sensing. The output of the control amplifier turns on Q3, the net effect being to reduce the drive to the RF module and thereby limit the RF output to that set by the variable reference voltage. At 0 V control voltage, the RF output will be less than 1 milliwatt.

4.4.5 Load Power Sensing

The Load Power Sensing and leveling operates from the output of the load power difference amplifier (IC7-C). It is then applied to the control amplifier (IC6-A), via the analog switch (IC10), for comparison to a reference voltage. The remainder of the circuitry is the same as for the forward power sensing.

4.4.6 Maximum Power Indicator

The Maximum Power Indicating Circuit operates in the absence of forward power leveling control. It indicates that the generator is not able to produce the output called for by the controlling signal. This situation will occur under high VSWR conditions where either the current sense limiting or the reverse power limiting circuits are operating to protect the unit. The circuit operates from the output of the forward or load control amplifier (IC6-A). When this amplifier is not controlling forward power, its output is a negative voltage. This is fed to a threshold detector. The output of the detector then goes high, thus enabling the LED indicator on the front panel. An output in the form of collector-emitter junction is also provided to the rear panel accessories connector (closed = Maximum Power, open = Normal Operation). Diode-control logic prevents a false indication by sensing the condition of the RF ON line.

4.4.7 RF ON Control

The RF ON Control logic and indicating circuits act upon the +25 VDC regulated supply. When the RF ON line is low (less than 1 volt), the +25 VDC supply is turned off. When the RF ON line is high (4.0 to 5.0 V), the +25 VDC supply is turned on. For local control operation, this line is opened by the switch on the front panel for RF ON. For remote operation, the front panel switch must be in the down (OFF/REMOTE) position where the line is grounded through a 680Ω resistor. When a +20 to +24 volt signal is supplied through the accessories connector Pins 4 and 17, it appears across this resistor thus enabling the RF ON function. The thermostat on the RF module is diode coupled to the RF ON line to turn off the RF drive in case of an overheat fault. The RF ON indicator is supplied from the +25 VDC supply through a 2.4 kΩ resistor. The RF ON output to the rear panel accessories connector Pins 7 and 20 is a collector-emitter junction (closed = RF ON, open = RF OFF).

4.4.8 Thermostat Control

The thermostat is located on the RF Assembly Heat Sink and has an operating temperature of +50°C. This is sufficient to allow a cooling water temperature of +35°C maximum. When the thermostat closes, it grounds the RF ON line, the bias to the driver is turned off and the red overheat LED on the front panel will light. Diode logic is used to isolate the above functions.

4.4.9 Oscillator and Buffer Circuits

The 90-460 kHz voltage-controlled oscillator circuit with the attenuator and buffer amplifier is similar to that used in other high-reliability ENI Power Systems equipment. The oscillator generates a sine wave from 90 to 460 kHz, depending on the DC voltage at Pin 8 of IC12, at an output of approximately 3.3 V peak to peak. This output is fed into one side of a multiplier IC3, and the other input receives a DC voltage of 0 to 2.6 V. The output of the multiplier is fed into the buffer amplifier Q5 and Q6 and then to the driver amplifier module.

Chapter 5

Maintenance and Calibration

5.1 Recommended Test Equipment

The following test equipment is recommended to aid in maintenance and calibration of the LPG-6A.

DESCRIPTION	RECOMMENDED TYPE	USE
Power Meter	EMB2K250 or HP435B	Power measurement and meter calibration.
50Ω Load 2000 W	Bird #8329	50Ω load
Digital VOM	Textronix 2213A or equivalent.	Output voltage measurement.
Oscilloscope Probe	Textronix 10:1, P6120 or equivalent.	Voltage measurements
Oscilloscope	Textronix T922 or equivalent.	AC Signal Measurement

5.2 Periodic Maintenance

For optimum performance, the LPG-6A calibration should be checked once per year.

Before making any adjustments to the unit, first check that it performs to the specification. If this is the case, adjustment is unnecessary.

Cooling and reliability of the LPG-6A is dependent on the cleanliness of the water supply. Problems with the water supply normally show up as frequent overheat indications on the front panel. If this is the case, check water flow rate and look for obstructions in the water inlet and outlet connectors on the rear of the LPG-6A.

5.3 LPG-6A Calibration

5.3.1 RF SECTION Calibration

The RF Section of the LPG-6A consists of:

1) Driver Amplifier

2) Power Amplifier

3) +25 volt and +40 volt Regulator

4) Meter Control

Problems in these circuits can be isolated with a systematic test procedure. The test equipment shown in section 5.1 will be needed for a thorough checkout of the LPG-6A.

Driver Amplifier

The Driver Amplifier consists of two amplifier stages. The bias voltages of the stages are as follows:

	EMITTER	BASE	COLLECTOR
Q1	0.50 to 0.70 V	1.0 to 1.4 V	25.0 V
Q2	2.5 to 2.9 V	3.5 to 3.9 V	48.0 V

Refer to the schematic diagrams in the back of this manual. The outputs of the voltage regulators are 25 ±5% and 48 ±5%. The regulator assembly is mounted to the heat sink just above the Power Amplifier module.

To verify proper operation of the driver amplifier, disconnect its output from the power amplifier and the input from the Control Board. Apply an input signal of 1.0 V peak-to-peak to the input connector and connect the output to a 50Ω load. The output power should be at least 15 W when read on the power meter. Most of the driver components can be replaced from the top of the driver amplifier board. This includes Q2 and most resistors and capacitors. Q1 is a stud-mounted transistor and cannot be replaced without access to the rear of the RF Module. See section 5.4 for instructions on removing the RF module, as well as for instructions on replacing the RF power transistors.

Power Amplifier

The Power Amplifier operates in a Class C mode with the base bias at the DC ground. The RF gain of the Power Amplifier is approximately 17 dB. A faulty module can be isolated by first checking that there is +48 VDC on the collectors of Q3, Q4, Q5 and Q6 on the Power Amplifier module. If the 48 V is available, turn off the AC LINE switch and connect a 50Ω load and power meter. Turn the unit on and check for 0 to 600 W output when the POWER ADJUST is turned from 0.0 to 10.0. If there is no power output, turn the unit off and check the driver per section 5.3.1.1. If the driver is putting out 0 to 15 W, then the Power Amplifier module is faulty and the transistors must be changed. See section 5.4.

+25 Volt and +40 Volt Regulator

Measure the voltage between Pin 1 of P13 and chassis ground. It should be 48 VDC. The voltage between Pin 7 of P13 and chassis should be the same. The voltage at Pin 3 of P13 should be about .1 volt lower than that at Pins 1 and 7. If the 48 VDC is not present at Pin 3, check transistors Q5 and Q6 and replace if necessary. See section 5.4.

Meter Control

The Meter Control board is a directional coupler located on the RF Assembly. Its function is to provide outputs proportional to the forward and reflected power on the transmission line to the metering and leveling circuits on the control board.

To check the directional coupler, use the following procedure:

1. Connect the output of the LPG-6A into a 50Ω load, 2000 W and an external wattmeter.
2. Turn on the LPG-6A and set the POWER ADJUST for 600 W of forward power as indicated on the external wattmeter.
3. Connect an oscilloscope to the IC5-1 on the Control Board and check for 16 V peak-to-peak. If it is not 16 V P-P, adjust R5 on the METER CONTROL Board.
4. Check that the front panel meter indicates 600 W. If it does not, adjust (R95) Forward Meter potentiometer located on the Control Board.

5. Turn the POWER ADJUST down to 0.0 and disconnect the 50Ω load from the output of the unit. Increase the POWER ADJUST so that 100 W of FORWARD power is indicated on the front panel meter. Connect an oscilloscope to IC4-1 on the Control Board and check that the peak-to-peak voltage is the same as IC5-1. If it is not, adjust R6 on the METER CONTROL Board until IC4-1 equals IC5-1.

6. Turn the POWER ADJUST down to 0.0 and reconnect the 50Ω load to the output of the unit. Increase the POWER ADJUST so that 600 W FORWARD power is indicated on the front panel meter. Set the METER switch to the LOAD position and check that the front panel meter indicates 600 W. If it does not, adjust (R107) Load Meter potentiometer until it does.

5.3.2 Control Board Calibration

The Control Board Assembly contains all the control and protection circuitry and logic functions used in the LPG-6A. These functions can be grouped as follows:

1) Power Supplies for the Control Functions

2) Current-Sensing Protection

3) Reverse-Power Protection and Metering

4) Forward-Power Control and Metering

5) Load-Power Control and Metering

6) Maximum-Power Indicating Circuit

7) RF ON Control logic and indicating

8) 90-460 kHz Oscillator and Buffer

Power Supplies for Control Functions

There are two +15 volt power supplies on the control board. One is referenced to DC ground and provides ±15 V for all circuits except current sensing. The output of this supply is nominal and a tolerance of +10% is acceptable. There are no adjustments provided. If the voltages are outside of the 10% tolerance, check for 40 Vrms AC across the control transformer secondary (Pins 3 and 21). Then check for approximately +23 VDC across C7 and C8. If voltages are nominal, replace IC8 or IC9 for the –15 V and +15 V supplies, respectively.

The other power supply on the control board is also +15 V, but is referenced to the unregulated +40 V to the Power Amplifiers. As a result, this supply floats with changes in the actual +40 to 48 V depending upon the line voltage and RF power output. This power supply is used only to bias the current-sensing circuits comprised of IC2 and associated components. Measurements made in this circuit, as well as this power supply, are best referenced to the +40 V supply on P1 Pin 4 of the control board connector or Pin 1 of IC1. Voltage readings of ±15 V ±5% are nominal for the output of IC1 Pins 4 and 11 respectively. As in the paragraph above, check for 40 Vrms across the other control transformer secondary (Pins 1 and 20). If these voltages are nominal and the outputs of IC1 are faulty, replace IC1.

Current-Sensing Protection

Current sensing is accomplished by measuring the voltage drops across the 0.01Ω ±1% resistors located on the Power Amplifier Board. This voltage is supplied to IC2 via the control board connector wiring. At IC2 it is compared with a reference voltage of 0.125 V set by R1 and R9. If the current-sense voltage drop exceeds 0.125 V, the output of IC2 immediately pulls the base of Q1 low, turning on Q1 and Q2, which pulls the attenuator bias low and reduces the RF output, thus effectively limiting the current to each Power Amplifier section.

The current limit is set to limit each P.A. section to 12.5 ±2 amperes. To set this limit, use the following procedure:

1. Disconnect T3 from the bases of Q5 and Q6 located near the rear of the Power Amplifier board by unsoldering the two leads from the printed circuit board.

2. Turn the METER SELECT switch to PA 1 CURRENT position. The front panel meter will read the current draw of PA 1, with an indication of a full-scale reading of 15 amps. 12.5 amps will read 625 W.

3. Connect the output of the LPG-6A to a 50Ω load.

4. Turn the POWER ADJUST fully CCW and turn on the LPG-6 AC LINE and RF POWER switches. Slowly increase the forward power while monitoring the current. Increase the power until the front panel meter shows 12.5 amps (625 W on the front panel meter).

5. Adjust R1 on the control board until the current limit LED on the control board lights. Turn down the POWER ADJUST and then recheck that the LED turns on at 12.5 amps and that, if the POWER ADJUST is increased further, the current remains at 12.5 amperes.

6. Turn off the LPG-6A and re-solder the T3 transformer back to the bases of Q5 and Q6. Unsolder the T2 transformer from the bases of Q3 and Q4, located closest to the Driver board.

7. Repeat the above procedure for PA 2. Control board adjustment is made with R9. Turn the METER SELECT switch to read PA 2 CURRENT.

Reverse-Power Protection and Metering

This circuit obtains its input from the METER BOARD directional coupler. Verify that this is operating properly before troubleshooting the reverse-power circuits on the control board. Refer to section 5.3.1.4. Also refer to the schematics at the rear of this manual and the theory of operation in section 4.4.3. If alignment is necessary, use the following procedure:

1. Connect the LPG-6A to the 50Ω load Power Meter. Verify that a flow of coolant is present through the unit.
2. Connect a digital voltmeter to the reverse power output Pins 2 and 15 of the rear panel accessories connector. Zero the front panel meter using the zero adjust screw just below the center of the meter. Turn on the AC LINE switch and adjust REV NULL control R119 until the voltage at Pins 2 and 15 of the rear panel accessories connector reads 0.00 V.
3. Turn on the LPG-6A RF ON Switch and set the output power to 100 W on the external Power Meter.
4. Turn off the RF ON Switch and open circuit the RF output of the LPG-6A. Turn on the RF ON Switch and set the front panel meter to indicate 150 W of forward power. Pins 2 and 15 of the rear panel accessories connector should read 10.00 V. If it does not, adjust R124 REV CAL until it does.
5. With the output still open circuit, adjust R110 REV LEVEL SET for limiting at this level. Increase the POWER ADJUST to verify limiting action. If necessary, re-adjust R110 for limiting to 150 W.

Forward-Power Control and Metering

This circuit obtains its input from the METER BOARD directional coupler. Verify that this is operating properly before troubleshooting the forward power circuits on the Control Board. Refer to section 5.3.1.4. Also refer to the schematics at the rear of this manual and the theory of operation in section 4.4.4. If alignment is necessary, use the following procedure:

1. Connect the LPG-6A to the 50Ω load and an RF Power Meter. Verify that an adequate flow of coolant is present through the unit.
2. Connect a digital voltmeter to the forward power output Pins 3 and 16 of the accessories connector. Zero the front panel meter using the zero adjust screw just below center of the meter. Turn on the AC LINE circuit breaker and adjust FWD NULL control R83 until the

front panel meter indicates 0 W in the forward power position. Set the POWER ADJUST fully CCW.

3. Turn on the LPG-6A RF POWER Switch and connect an oscilloscope to the output of the unit. The output voltage should be less than .2 V peak-to-peak. If it is not, adjust R29 LOW POWER NULL until it is.

4. Increase the POWER ADJUST to indicate 600 W on the external power meter.

5. Check at Pins 3 and 16 of the rear panel accessories connector for 10.00 V on the digital voltmeter. If it is not 10.00 V, adjust R91 FWD METER CAL until it is. Check the front panel meter; it should indicate 600 W of Forward Power. If it does not, adjust R95 FWD METER ADJ until it does.

6. Increase the POWER ADJUST to 10.0 (FULL CW) and check that the forward power is not greater than 650 W. If it is, adjust R39 MAX FWD POWER until 650 W is indicated on the front panel meter.

7. Turn off the RF POWER Switch. Ground Pin 8 of the rear panel accessories connector. Provide a DC control voltage to Pins 5 and 18 of the rear panel accessories connector at the level desired for a given peak RF output. (This procedure will describe a set-up of 10 V for 600 W output; other calibrations can be used such as 1 volt per kilowatt.)

8. Turn on the RF POWER Switch. Check that with +10 VDC between Pins 5 and 18 of the rear panel accessories connector, the output power is 600 W. If it is not, adjust R68 REM LEVEL until 600 W is indicated on the front panel meter.

9. Adjust R72 MAX REMOTE POWER ADJ for 650 W maximum power. Verify control voltage vs. output power tracking by reducing the control voltage to 5.0 V. The output power should be 300 W. This completes the calibration of the forward-power control and metering circuits.

Load-Power Control and Metering

This circuit obtains its inputs from the forward-power multiplier IC5 and the reverse-power multiplier IC4. Verify that these circuits are operating properly before troubleshooting the load power circuits on the control board. Refer to the schematics at the rear of the manual and the theory of operation in section 4.4.5. If alignment is necessary, use the following procedure:

1. Connect the LPG-6A to a 50Ω load and an RF Power Meter.

2. Connect a digital voltmeter to the load-power output Pins 12 and 13 of the rear panel accessories connector. Zero the front panel meter

using the zero adjustment screw just below center of the meter. Turn on the AC LINE circuit breaker and adjust R142 LOAD NULL until the front panel meter indicates 0 in the load-power position. Set the POWER ADJUST to 0.0.

3. Turn on the LPG-6A RF POWER Switch and set the output power to 600 W of forward power. Place the METER Switch to LOAD position and check that the meter indicates 600 W. If it does not, adjust R107 LOAD POWER ADJUST until it indicates 600 W. Check digital voltmeter on Pins 12 and 13 of the rear panel accessories connector; it should indicate 10.00 V. If it does not, adjust R108 LOAD CAL until it does.

4. The following calibration is for LOAD-Power leveling. With 600 W output, set the POWER CONTROL Switch to LOAD and check that the forward power still indicates 600 W. If it does not, adjust R97 600 W TRACKING until it does. This completes the calibration of the load-power control and metering circuits.

Maximum-Power Indicating Circuit

Refer to section 4.4.6 and the schematics at the rear of this manual for a description of this circuit. Disconnect the 50Ω load from the output of the LPG-6A. Set the POWER ADJUST to 0.0 and turn on the AC LINE Switch and the RF POWER Switch. Increase the POWER ADJUST until 150 W of forward power is indicated on the front panel meter. Check the MAX PWR LED until it lights. This circuit is activated when IC7"B" functions as an inverting switch that drives the buffer amplifier IC7"A." Troubleshooting should be done with a voltmeter having an input impedance of at least 1 MΩ.

RF-ON Control Logic and Indicating Circuit

Refer to section 4.4.7 and the schematics at the rear of this manual for a description of this circuit. Diode logic is used to interface with the Oscillator, Driver Amplifier, Maximum Power Circuit and Thermostat. There are no adjustments, and no calibration is needed. The RF ON LED is driven by the +25 VDC power supply.

90-460 kHz Oscillator and Buffer Amplifier

The 90-460 kHz Oscillator and Buffer Amplifier provide a low- level RF signal to the driver amplifier. Refer to the Control Board schematic. The RF Output, when the attenuator bias is 3.0 V or greater, should be at least 1.0 V peak-to-peak into the driver amplifier.

5.3.3 DC Power Supply Calibration

The DC Power Supply consists of the power transformer, rectifiers, and filter capacitors. Refer to section 4.2. The output voltage of this power supply is adjusted by changing the tap on the power

transformer. See section 2.3. No other adjustments are provided. The rectifiers are located on the water-cooled heat sink on the RF Heat Sink Assembly. Use caution while measuring voltages on the power supply; voltages of up to 240∅ VAC are present on the transformer primary circuit. The transformer secondary windings should read approximately 35 V when the DC voltage is 44 V.

5.4 RF Power Transistor Replacement

REMOVAL

Power transistor removal is accomplished without removing the Printed Wiring Board (PWB).

1. Carefully unsolder overhanging components (e.g., Feedback Resistors) taking care to allow solder to liquefy before lifting components. Note and record the orientation of the power transistor and the length and pre-bend conditions of the transistor leads. Unsolder and lift the four power-transistor leads. Carefully bend each lead towards the transistor body while solder is liquefied. Inspect for solder bridges between each lead and the PWB removing any solder bridges with solder wick.
2. Remove the two fastening screws holding the power transistor to the heat sink and remove it from the cavity. With solder wick, carefully remove excess solder from the PWB.
3. With a swab or lint-free cloth, carefully remove silicone grease from the heat sink surface within the cavity, followed by gently vacuuming the cavity and surrounding area.

INSTALLATION

1. Inspect the new power transistor for flange damage (e.g., scratches or nicks). Shorten and pre-bend the transistor leads to reflect the leads of the transistor being replaced.
2. Apply a very thin layer of silicone grease to the heat sink within the PWB cavity, being sure to avoid contamination of the grease. Apply a very thin layer of silicone grease to the transistor flange, orient device and place into the PWB cavity. Carefully press and rotate against the transistor flanges to set the transistor in the silicone grease. Do not press against the top of the ceramic cover of the power transistor. Check the orientation of the transistor before proceeding.
3. Install mounting hardware and hand-tighten only. Torque each fastening screw to 5-6 in./lbs.
4. Solder the four transistor leads and replace overhanging components.

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Chapter 6

Troubleshooting

If for any reason you believe that the LPG-6A is not functioning correctly, the following Troubleshooting Guide may help. The guide includes the problems most frequently found when operating an LPG-6A.

The first step in isolating a malfunction is to review the conditions under which the symptoms were observed. Determine that the problem was not due to external cabling or abnormal line voltages. If the equipment is being operated by remote control, verify that proper commands are being received by the LPG-6A. After the problem has been definitely attributed to the LPG-6A, refer to the Troubleshooting Flowchart and Guide. Note that many of the circuits can be checked without the application of RF Power. A systematic fault localizing procedure is mandatory for rapid trouble shooting. When the problem has been isolated to a particular circuit, refer to the Theory of Operation for an explanation of the circuit and a simplified schematic diagram.

Troubleshooting Guide

Symptoms	Probable Cause	Recommendations
Power Lamp does not light.	Burned out LED.	Check for voltage to LED.
	Faulty 40 V or 24 V Power Supply.	Check per sections 5.3.1.1 and 5.3.3.
	Defective power relay.	Replace relay.
	Defective circuit breaker.	Replace circuit breaker.
No RF Output.	Broken output connector.	Visually inspect connector for broken pin.
	Defective output cable.	Visually inspect cable at output connector.
	Generator operating in opposite control mode (int./ext.).	Check/select proper operating mode.
The circuit breaker keeps turning off.	Defective RF oscillator or RF ON control circuit.	Connect the unit to a voltage supply the unit was set for by the manufacturer.
	Defective line cord or AC wiring.	Visually inspect for sign of insulation breakdown.
RF ON Lamp dim.	Defective RF amplifier.	Perform procedure for locating faulty RF module per section 5.3.2.6.
Low RF Output.	Defective RF amplifier.	Perform procedure for locating faulty RF module per section 5.3.1.2.
Power generator overheating.	Inadequate intake/outlet coolant.	Check that the coolant is circulating properly.
	Defective internal fan.	Check for proper operation.
	Coolant temperature excessive.	Reduce coolant temperature.

Troubleshooting Guide		
Symptoms	Probable Cause	Recommendations
Incorrect front panel meter calibration.	Improper calibration of the meter or the directional coupler.	Perform adjustments per sections 5.3.2.3, 5.3.2.4, 5.3.2.5
	Defective meter.	Replace meter.
	Meter select switch in wrong position.	Place Meter Select switch into RF power position.

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