Service Manual

Valleylab Force 300 Electrosurgical Generator

Pfizer

Valleylab®

Foreword

This manual and the equipment it describes are for use only by qualified medical professionals trained in the particular technique and surgical procedure to be performed. It is intended as a guide for servicing the Valleylab Force 300 Electrosurgical Generator only.

Caution

Federal (USA) law restricts this device to sale by or on the order of a physician.

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Equipment covered in this manual:
Valleylab Force 300 Electrosurgical Generator

110 - 120 V~ nominal, 220 - 240V~ nominal (auto selected)

Valleylab Part Number: 945 103 007 **Effective Date:** November, 1995

Patents Pending

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How the Service Manual is Organized

The **Force 300 Service Manual** should contain the sections listed below. If any section is missing, please contact Valleylab.

Description	Part Number	Page Count
Foreword Table of Contents Service Centers	225 120 100	10
1 Introduction	225 120 029	6
2 Controls, Indicators, and Receptacles	225 120 030	14
3 Technical Specifications	225 120 101	18
4 Principles of Operation	225 120 032	30
5 Setup, Tests, and Adjustments	225 120 102	32
6 Troubleshooting	225 120 103	30
7 Replacement Procedures	225 120 035	36
8 Repair Policy and Procedures	225 120 036	4
9 Service Parts	225 120 104	14
10 Board Drawings and Schematics	225 120 105	22
Warranty	225 120 070	2

Conventions Used in this Guide

Important
Indicates an operating tip or maintenance suggestion.

Warning

Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

Caution

Indicates a hazardous situation which, if not avoided, may result in minor or moderate injury.

Notice

Indicates a hazard which may result in product damage.

Table of Contents

3 Technical Specifications

4 Principles of Operation

7 Replacement Procedures

8 Repair Policy and Procedure

9 Service Parts

10 Board Drawings and Schematics

Warranty

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Notes

1 Introduction

This manual provides instructions for servicing the Valleylab Force 300 Electrosurgical Generator. This section introduces the features and components of the generator and reviews the precautions associated with generator repair.

Additional information about using the generator is available in the **Force 300 User's Guide**.

General Description

The Valleylab Force 300 is an isolated output electrosurgical generator that provides the power for cutting, desiccating, and fulgurating tissue during electrosurgery. The Force 300 is specifically designed for use in bipolar or monopolar electrosurgery.

The main features of the generator are listed below:

- automatic control of output power in relation to tissue impedance
- *standard* bipolar mode
- two monopolar cut modes: *pure* and *blend*
- two monopolar coag modes: *desiccate* and *fulgurate*
- the Valleylab REM® Contact Quality Monitoring System, which protects patients against burns at the patient return electrode site
- volume control for activation tones

The Force 300 can be used in conjunction with the Valleylab Force GSU® System and the Valleylab Force Argon System. Refer to the **Force GSU User's Guide** and the **Force Argon User's Guide** for more information.

For details about the Force 300 features, see Section 2, *Controls, Indicators, and Receptacles.*

List of Components

The Valleylab Force 300 Electrosurgical Generator is a self-contained unit. It consists of a main enclosure (cover and base) and power cord. The main components of the generator are listed below:

- Front panel components include the power switch; controls for setting the modes and output power; a footswitch receptacle and button for selecting bipolar or monopolar output; receptacles for connecting electrosurgical accessories, and indicators that alert you to the selected modes and the patient return electrode status.
- Rear panel components include the power entry module, volume control, two footswitch receptacles, and equipotential grounding lug.
- Internal components include the Control (microcontroller) Board, Display Board, Footswitch Board, Power Supply/Radio Frequency (RF) Board, low voltage power supply, and heat sinks.

A handle is located on the underside of the chassis.

Details about the interaction of the main components and circuit board descriptions are in Section 4, *Principles of Operation.*

Before servicing the Force 300, it is important that you read, understand, and follow the instructions supplied with the generator and with any other equipment used to install, test, adjust, or repair the generator.

General Precautions

Warning: Use the generator only if the self-test has been completed as described. Otherwise, inaccurate power outputs may result.

Notice: Connect the power cord to a wall receptacle having the correct voltage. Otherwise, product damage may result.

Warning: The *multipin* monopolar output receptacle is designed for connecting either a handswitching (three-pin) or footswitching (one-pin) accessory, but not both at the same time. Connecting more than one accessory to the *multipin* receptacle will activate both accessories simultaneously.

Caution: Do not stack equipment on top of the Force 300 or place the generator on top of electrical equipment (except the Valleylab Force GSU Unit). These configurations are unstable and/or do not allow for adequate cooling.

Caution: Provide as much distance as possible between the electrosurgical generator and other electronic equipment (such as monitors). An activated electrosurgical generator may cause interference with them.

Caution: Do not turn the activation tone down to an inaudible level. The activation tone alerts personnel when an accessory is active.

Notice: If required by local codes, connect the generator to the hospital equalization connector with an equipotential cable.

Active Accessories

Caution: Accessories must be connected to the proper receptacle type. In particular, *bipolar* accessories must be connected to the *bipolar* receptacle only. Improper connection may result in inadvertent generator activation or a REM Contact Quality Monitor alarm.

Patient Return Electrodes

Warning: Using a conventional patient return electrode without the REM safety feature will not activate the Valleylab REM Contact Quality Monitoring System.

Fire/Explosion Hazards

Danger: Explosion Hazard. Do not install the generator in the presence of flammable anesthetics, gases, liquids, or objects.

Warning: Fire Hazard. Do not place active accessories near or in contact with flammable materials (such as gauze or surgical drapes). Electrosurgical accessories that are activated or hot from use can cause a fire. Use a holster to hold electrosurgical accessories safely away from personnel and flammable materials.

Warning: Fire Hazard. Do not use extension cords.

Warning: Fire Hazard. For continued protection against fire hazard, replace fuses only with fuses of the same type and rating as the original fuse.

Electric Shock Hazards

Warning: Connect the generator power cord to a properly grounded receptacle. Do not use power plug adapters.

Warning: Do not connect a wet power cord to the generator or to the wall receptacle.

Warning: Disconnect the power cord before replacing parts. To allow stored energy to dissipate after power is disconnected, wait at least five minutes before replacing parts.

Warning: Always unplug the generator before cleaning.

Warning: Do not touch any exposed wiring or conductive surfaces while the generator is disassembled and energized. Never wear a grounding strap when working on an energized generator.

Warning: When taking measurements or troubleshooting the generator, take appropriate precautions, such as using isolated tools and equipment, using the "one hand rule," etc.

Warning: Potentially lethal AC and DC voltages are present in the AC line circuitry, high voltage DC circuitry, and associated mounting and heat sink hardware described in this manual. They are not isolated from the AC line. Take appropriate precautions when testing and troubleshooting this area of the generator.

Warning: High frequency, high voltage signals that can cause severe burns are present in the RF output stage and in the associated mounting and heat sink hardware described in this manual. Take appropriate precautions when testing and troubleshooting this area of the generator.

Servicing

Caution: Read all warnings, cautions, and instructions provided with the Valleylab Force 300 Electrosurgical Generator before servicing.

Caution: The generator contains electrostatic-sensitive components. When repairing the generator, work at a static-control workstation. Wear a grounding strap when handling electrostatic-sensitive components, except when working on an energized generator. Handle circuit boards by their nonconductive edges. Use an antistatic container for transport of electrostatic-sensitive components and circuit boards.

Notice: After installing a new low voltage power supply, verify that the voltages are correct.

Calibration

Notice: After completing any calibration step, proceed to the next step to save the values from the completed calibration step.

Notice: Do not activate the generator with any load resistor *higher* than 10 ohms while calibrating the current sense gain. Otherwise, product damage will result.

Caution: To avoid inadvertent coupling and/or shunting of RF currents around the resistor elements, keep the resistors at least four inches (10.2 cm) away from any metal surface including tabletops and other resistors. This is especially true if several resistors are connected in series or parallel to obtain a specified value. Do not allow the resistor bodies to touch each other.

Notice: Do not activate the generator with any load resistor *lower* than 750 ohms while calibrating the voltage sense gain for bipolar output. Otherwise, product damage will result.

Notice: Do not activate the generator with any load resistor *lower* than 3000 ohms while calibrating the voltage sense gain for the *pure* cut mode. Do not activate the generator with any load resistor *lower* than 2000 ohms while calibrating the voltage sense gain for the *blend* mode. Otherwise, product damage will result.

Notice: After calibration, the generator will be ready to use only after you initiate the internal self-test by turning the generator off, then on.

Notice: Calibrate the generator after you install a new battery. Calibration values are lost when the battery is replaced.

Notice: Calibrate the generator after you install a new Control Board. Otherwise, the default calibration values are used.

Calibration

Notice: Calibrate the generator after you install a new heat sink or replace components on the heat sink. Otherwise, component differences may affect output waveforms.

Notice: Calibrate the generator after you install a new Power Supply/RF Board. Otherwise, component differences may affect output waveforms.

Cleaning

Notice: Do not clean the generator with abrasive cleaning or disinfectant compounds, solvents, or other materials that could scratch the panels or damage the generator.

2 Controls, Indicators, and Receptacles

The controls, indicators, and receptacles for accessories are located on the front and rear panels of the Force 300. This section describes each component of the generator and its function.

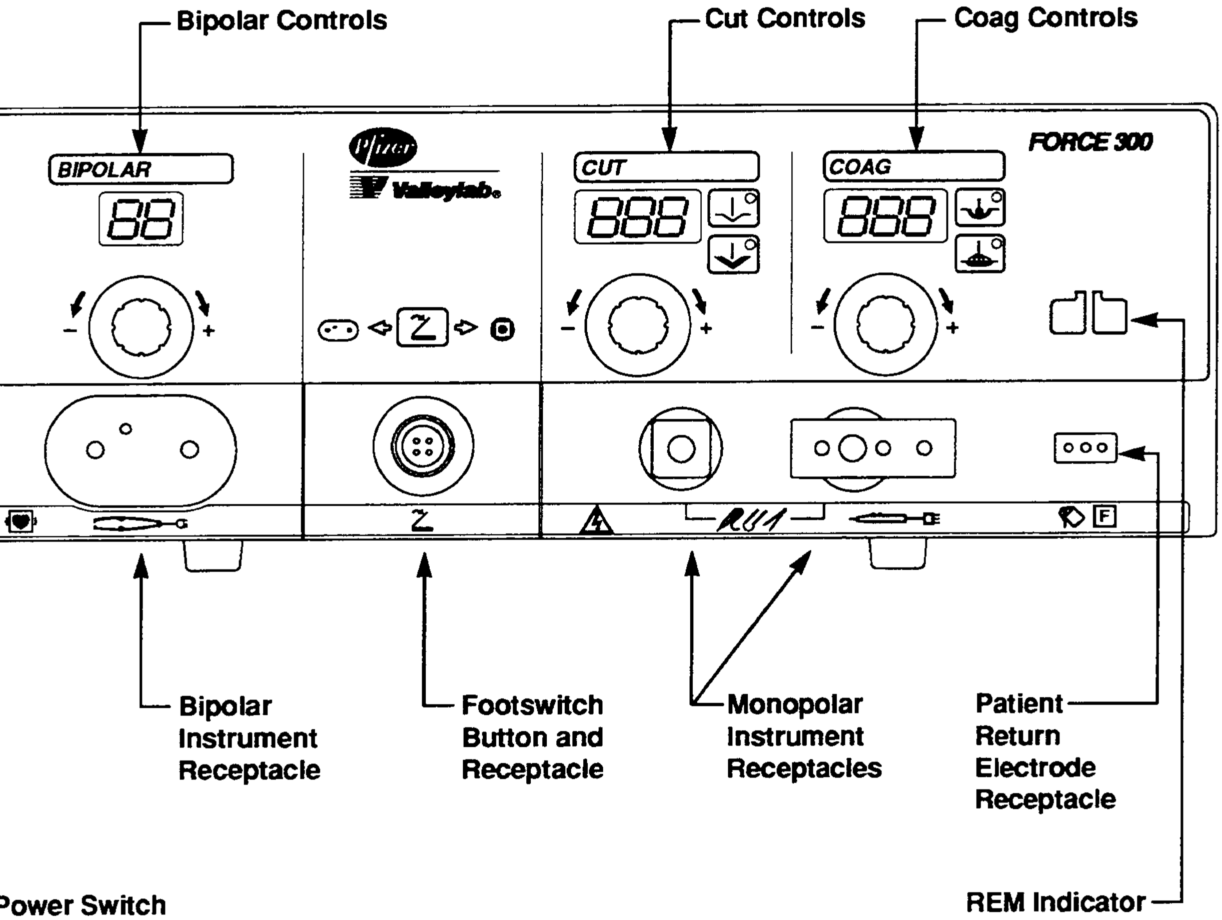
Detailed specifications for the generator are in Section 3.

Caution

Read all warnings, cautions, and instructions provided with the Valleylab Force 300 Electrosurgical Generator before using.

Front Panel

The front panel features are shown below. The bipolar, cut, and coag controls are described in detail on the following pages. Additional information about the footswitch receptacle, bipolar instrument receptacle, monopolar instrument receptacles, and the REM patient return electrode monitoring feature are also provided.

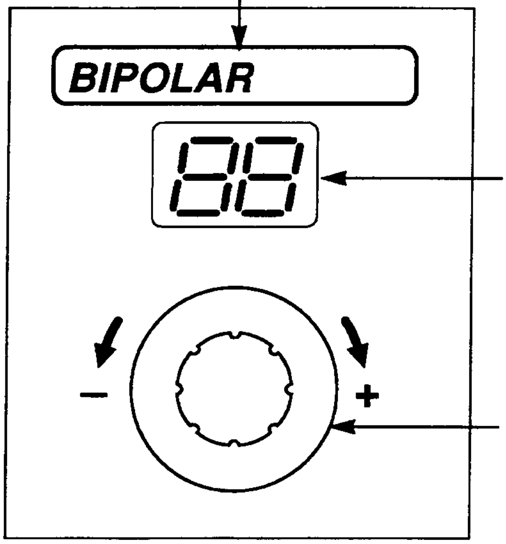


Power Switch

This switch supplies power to the generator.

- To turn on the generator, press (|).
- To turn off the generator, press (O).

When you activate bipolar output, a *standard* bipolar mode is invoked automatically for tissue desiccation. The voltage is kept low to prevent sparking. The power remains constant over a specific range of tissue resistance, allowing a consistent tissue effect.



Bipolar Indicator Bar

When you activate bipolar, this bar illuminates blue and the bipolar activation tone sounds.

Power Display

Shows the power setting, in watts, for bipolar output.

Power Control Knob

To increase (+) the power, turn the knob clockwise.

To decrease (–) the power, turn the knob counterclockwise.

Changing the Bipolar Power Setting

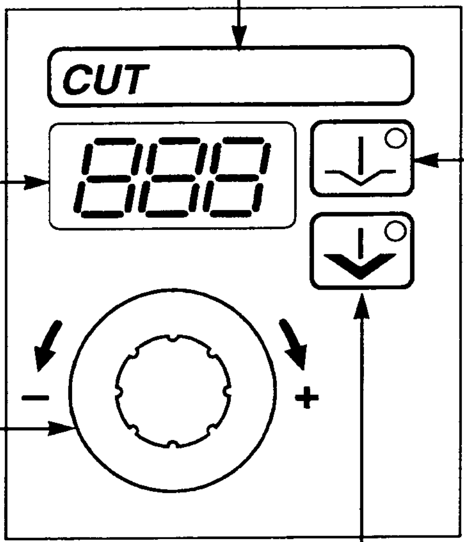
As you turn the power control knob, the power changes by one setting (1 or 5 watts), based on the settings available for bipolar output. The available bipolar power settings are listed in Section 3.

If you turn the knob while the generator is activated, the power changes by one setting *per second* to prevent rapid increases or decreases in power delivered to the surgical site.

If you try to set the power above the maximum setting or below the minimum setting, a warning tone sounds.

Cut Indicator Bar

When you activate cut, this bar illuminates yellow and the cut activation tone sounds.



Power Display

Shows the power setting, in watts, for the selected cut mode.

ower Control Knob

increase (+) the ower, turn the knob ockwise.

decrease (–) the ower, turn the knob unterclockwise.

Pure Mode Button

Select *pure* for an even cut with little or no hemostasis. This mode offers good performance over a wide range of tissue resistance. It provides the maximum output power available from the Force 300. Its waveform is continuous. When you turn on the Force 300, *pure* is selected automatically.

Blend Mode Button

Select *blend* for slower cutting and additional hemostasis. This mode provides a blended waveform.

Changing the Cut Mode and Power Setting

When you press a cut mode button, the indicator on that button illuminates green. You can activate only one cut mode at a time. You cannot change the mode while the generator is activated.

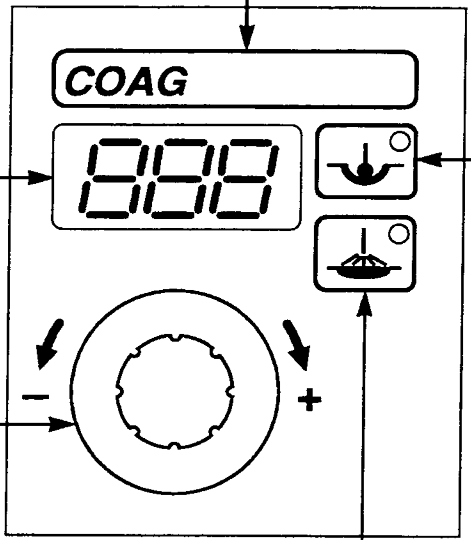
When you change cut modes, the power setting remains the same unless it exceeds the maximum for the new mode. In that case, it reverts to the maximum. For example, if you set the power to 250 for *pure* cut, when you select *blend* the setting changes to 200, the maximum for *blend*.

As you turn the power control knob, the power changes by one setting (1, 5, or 10 watts), based on the settings available for the selected mode. The available cut power settings are listed in Section 3. If you turn the knob while the generator is activated, the power changes by one setting *per second* to prevent rapid increases or decreases in power delivered to the surgical site.

If you try to set the power above the maximum setting or below the minimum setting, a warning tone sounds.

Coag Indicator Bar

When you activate coag, this bar illuminates blue and the coag activation tone sounds.



Power Display

Shows the power setting, in watts, for the selected coag mode.

Power Control Knob

To increase (+) the power, turn the knob clockwise.

To decrease (–) the power, turn the knob counterclockwise.

Desiccate Mode Button

Select *desiccate* to desiccate the area of tissue that is in direct contact with the active electrode. When you turn on the Force 300, *desiccate* is selected automatically.

Fulgurate Mode Button

Select *fulgurate* to fulgurate an area of tissue with a spray of sparks. This mode is useful for general fulguration applications.

Changing the Coag Mode and Power Setting

When you press a coag mode button, the indicator on that button illuminates green. You can activate only one coag mode at a time. You cannot change the mode while the generator is activated.

When you change modes, the power setting remains the same. For example, if you set the power to 65 for *desiccate*, when you select *fulgurate* the power setting does not change.

The power changes by one setting (1, 5, or 10 watts), based on the settings available for coag output. The available coag power settings are listed in Section 3. If you turn the knob while the generator is activated, the power changes by one setting *per second* to prevent rapid changes in power delivered to the surgical site.

If you try to set the power above the maximum setting or below the minimum setting, a warning tone sounds.

Changing the Maximum Voltage for the Desiccate Mode

Initially, the maximum voltage for the *desiccate* coag mode is 300 volts rms. If desired, you can change the maximum voltage to 200 volts rms. For example, a maximum voltage of 200 volts rms may be desired when desiccating delicate tissue or when using small electrodes (needle or laparoscopic electrodes).

You do not need to set the maximum voltage each time you prepare the generator for surgery. The previous setting (300 or 200 volts rms) remains in effect.

If you wish to set the maximum voltage for the *desiccate* mode to 200 volts rms, set the ***Cut*** power to 200. Then, simultaneously press the front panel footswitch button, the *desiccate* button, and the *fulgurate* button. A tone sounds to confirm the new maximum voltage setting.

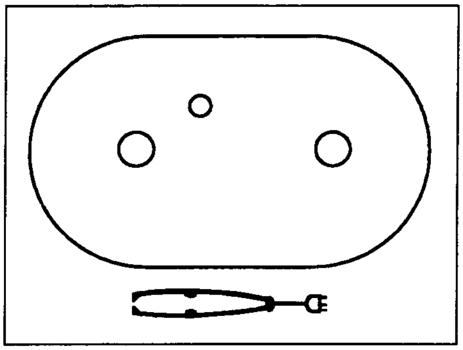
To reset the maximum voltage to 300 volts rms, set the ***Cut*** power to 300. Then, simultaneously press the front panel footswitch button, the *desiccate* button, and the *fulgurate* button. A tone sounds to confirm the new setting.

Bipolar Instrument Receptacle

The bipolar instrument receptacle on the front panel accepts a handswitching bipolar instrument or a footswitching bipolar instrument.

Caution

Accessories must be connected to the proper receptacle type. In particular, *bipolar* accessories must be connected to the *bipolar* receptacle only. Improper connection of accessories may result in inadvertent generator activation or a REM Contact Quality Monitor alarm.



Connect a handswitching instrument with a three-pin connector.

or

Connect a footswitching instrument with a two-pin connector.

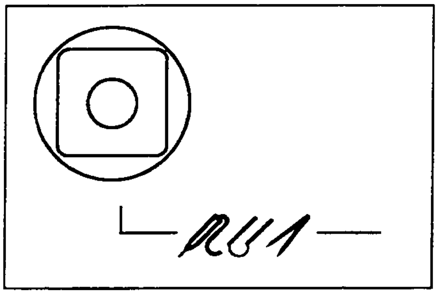
You may use controls on the handset or on a footswitch to activate the handswitching instrument. If you connect a footswitching instrument, you must use a footswitch.

You can use a footswitch to activate bipolar output by connecting a monopolar footswitch to the front panel **or** by connecting a bipolar footswitch to the rear panel.

- To connect a monopolar footswitch to the front panel, refer to *Front Panel Footswitch Receptacle and Button* later in this section.
- To connect a bipolar footswitch to the rear panel, refer to *Rear Panel Footswitch Receptacles* later in this section.

The *single-pin* receptacle on the front panel accepts a footswitching monopolar instrument. The *multipin* receptacle accepts a handswitching or a footswitching monopolar instrument. Some footswitching instruments may require an adapter available from Valleylab.

Single-Pin Monopolar Receptacle



Connect a monopolar footswitching instrument with a single-pin connector to the *single-pin* monopolar receptacle on the front panel.

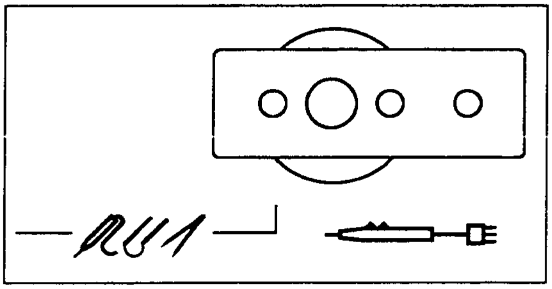
To activate the instrument, connect a monopolar footswitch to the front panel footswitch receptacle. (A footswitch connected to the rear panel does not provide output to the *single-pin* receptacle.) Refer to *Front Panel Footswitch Receptacle and Button* later in this section.

Multipin Monopolar Receptacle

Warning

The *multipin* monopolar output receptacle is designed for connecting either a handswitching (three-pin) or footswitching (one-pin) accessory, but not both at the same time. Connecting more than one accessory to the *multipin* receptacle will activate both accessories simultaneously.

Connect one monopolar instrument to the *multipin* receptacle:



Connect a footswitching instrument with a single-pin connector.

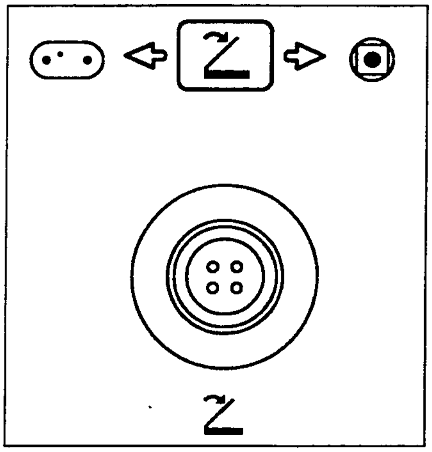
or

Connect a handswitching instrument with a three-pin connector.

To activate a handswitching instrument, use the controls on the handset or on a footswitch. To activate a footswitching instrument, connect a footswitch to the rear panel. (A footswitch connected to the front panel does not provide output to the *multipin* receptacle.) To connect a footswitch, see *Rear Panel Footswitch Receptacles* later in this section.

Front Panel Footswitch Receptacle and Button

The front panel contains a receptacle for connecting a monopolar footswitch. A button above the receptacle lets you choose bipolar or monopolar output for the connected footswitch. When you turn on the Force 300, monopolar output (*single-pin* receptacle only) is selected.



Press the footswitch button to select bipolar or monopolar output.

- Bipolar output is selected when the left (⟵) indicator illuminates green.
- Monopolar output is selected when the right (⟶) indicator illuminates green.

Connect a two-pedal monopolar footswitch to the front panel footswitch receptacle.

Using the Front Panel Footswitch for Bipolar Output

When the left (⟵) indicator is illuminated, the footswitch activates the instrument (handswitching or footswitching) that is connected to the bipolar receptacle. (See *Footswitch Activation Diagram* at the end of this section.) Press either footswitch pedal to activate bipolar output.

If you also connect a bipolar footswitch to the rear panel, the footswitch you use first activates bipolar output. Instructions for connecting a bipolar footswitch to the rear panel are provided in *Rear Panel Footswitch Receptacles* later in this section.

Using the Front Panel Footswitch for Monopolar Output

When the right (⟶) indicator is illuminated, the footswitch activates the footswitching instrument connected to the adjacent *single-pin* monopolar receptacle only. (See *Footswitch Activation Diagram* at the end of this section.)

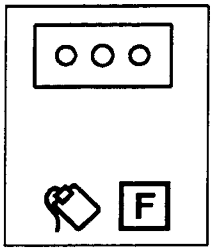
The front panel footswitch does not activate an instrument connected to the *multipin* monopolar receptacle. For information about connecting a footswitch to activate an instrument connected to the *multipin* receptacle, refer to *Rear Panel Footswitch Receptacles* later in this section.

If you also connect a monopolar footswitch to the rear panel (and connect two monopolar instruments to the front panel), the footswitch you use first activates monopolar output to the appropriate instrument. Simultaneous activation of instruments will not occur.

A patient return electrode is required for monopolar electrosurgery. When you activate monopolar output, the generator connects the patient return electrode path. If you activate bipolar output when a return electrode is applied to the patient, the generator disconnects the return electrode path to eliminate the possibility of current dispersal.

Warning

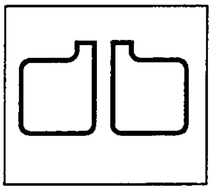
Using a conventional patient return electrode without the REM safety feature will not activate the Valleylab REM Contact Quality Monitoring System.



Valleylab recommends the use of REM patient return electrodes to maximize patient safety.

For monopolar electrosurgery, connect a Valleylab REM patient return electrode to the patient return electrode receptacle.

REM Alarm Indicator



The REM alarm indicator illuminates red until you apply a REM patient return electrode to the patient and connect it to the generator. Then the indicator illuminates green. (When you connect an electrode without the REM safety feature, the indicator light is extinguished. It does not illuminate green.)

If the REM system senses an alarm condition, the indicator flashes red, a tone sounds twice, and the generator disables RF output. The indicator illuminates red until you correct the alarm condition.

When you correct the REM alarm condition, RF output is enabled and the REM alarm indicator illuminates green. If you are using a return electrode without the REM safety feature, the red indicator light is extinguished when you correct the alarm condition.

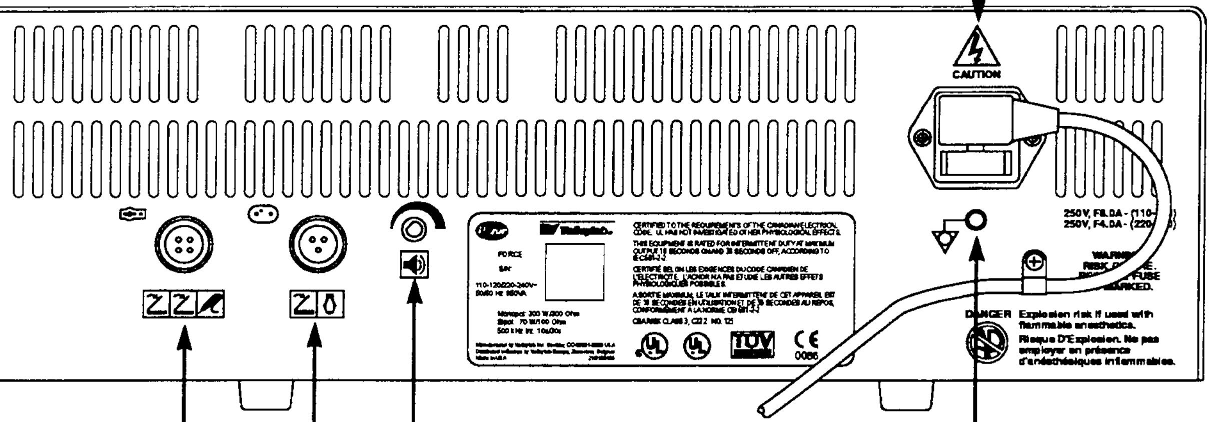
For additional information, refer to *The REM Contact Quality Monitoring System* in Section 4.

The rear panel features are illustrated below. The footswitch receptacles are described on the following pages.

Power Entry Module

The power cord provided with the Force 300 connects to the receptacle on the power entry module.

The fuse drawer in the power entry module contains two fuses. Instructions for changing the fuses are provided in Section 7.



Monopolar Footswitch Receptacle

Bipolar Footswitch Receptacle

Grounding Lug

Some institutions require that electrosurgical generators be connected to protective earth ground. The grounding lug is provided for this purpose.

Volume Control

You can adjust the volume of the tones that sound when the generator is activated. The alarm tone volume is not adjustable. To ensure that the surgical team is alerted to inadvertent activation, the activation tones cannot be silenced.

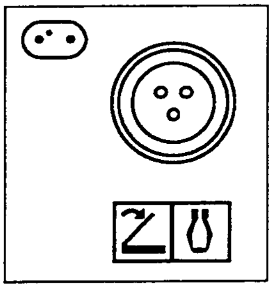
- To increase the volume of activation tones, turn the volume knob clockwise.
- To decrease the volume, turn the knob counterclockwise.

The rear panel contains two footswitch receptacles: one for a bipolar footswitch and one for a monopolar footswitch.

Bipolar Footswitch Receptacle

If you connect a footswitching instrument to the bipolar receptacle on the front panel, you must connect a footswitch to the generator.

- You can connect a monopolar footswitch to the front panel as described earlier in *Front Panel Footswitch Receptacle and Button.*
- You can connect a bipolar footswitch to the receptacle on the rear panel, as described below.

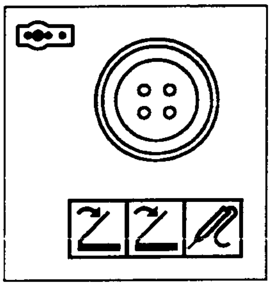


Connect a single-pedal bipolar footswitch to the bipolar footswitch receptacle on the rear panel.

The connected footswitch activates bipolar output for the instrument (handswitching or footswitching) that is connected to the bipolar receptacle on the front panel. (See *Footswitch Activation Diagram* at the end of this section.)

Monopolar Footswitch Receptacle

You must connect the monopolar footswitch to this receptacle if you connect a footswitching instrument to the *multipin* receptacle on the front panel. (See *Footswitch Activation Diagram* at the end of this section.)



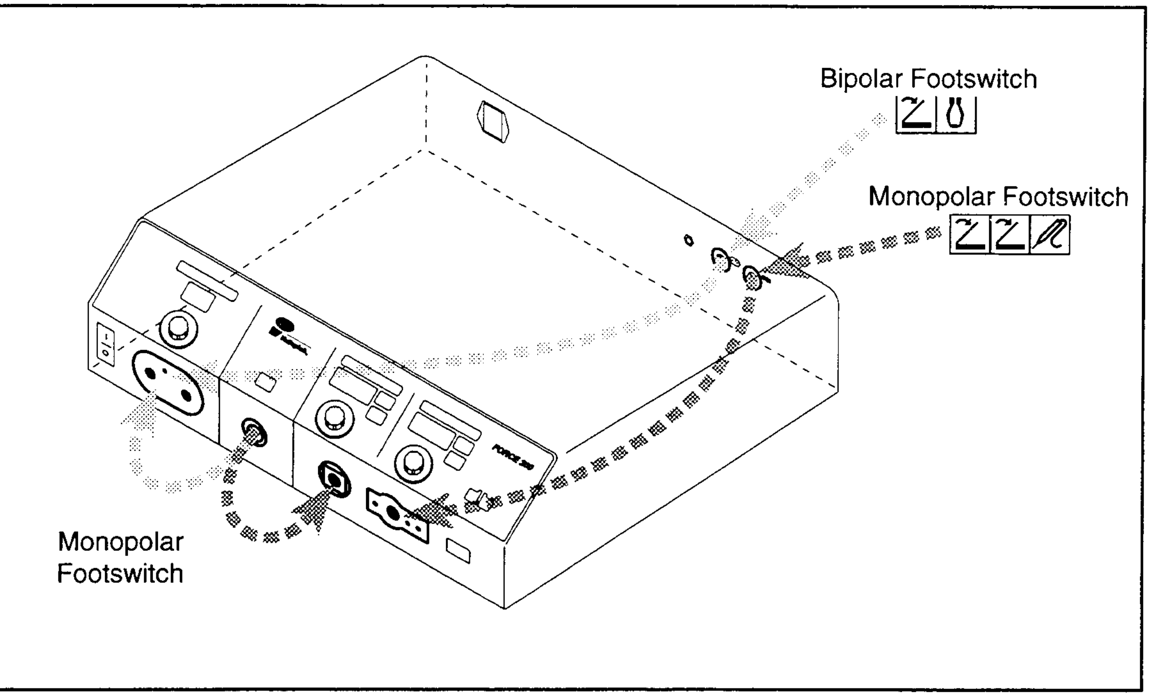
Connect a two-pedal monopolar footswitch to the rear panel monopolar footswitch receptacle.

The connected footswitch activates monopolar output for the instrument that is connected to the *multipin* monopolar receptacle. The footswitch will not activate instruments connected to the bipolar receptacle or to the *single-pin* monopolar receptacle.

For information about using a monopolar footswitch to activate instruments connected to the bipolar receptacle and the *single-pin* monopolar receptacle, see *Front Panel Footswitch Receptacle and Button* earlier in this section.

Footswitch Activation Diagram

This diagram illustrates how to connect and use footswitches to activate instruments connected to the bipolar, *single-pin* monopolar, and *multipin* monopolar receptacles on the front panel.



3 Technical Specifications

All specifications are nominal and subject to change without notice. A specification referred to as "typical" is within ± 20% of a stated value at room temperature of 25° C (77° F) and a nominal input power voltage.

Performance Characteristics

General

Output configuration: isolated output

Cooling: natural convection; side and rear panel vents

Display: eight digital seven-segment displays: 1.9 cm (0.75 in.) each

Mounting: Valleylab cart (E8006 or E8008), Force GSU Unit, or any stable flat surface

Dimensions and Weight

Width: 40.6 cm (16 in.)

Depth: 39.5 cm (15.6 in.)

Height: 12.7 cm (5 in.)

Weight: < 8.2 kg (< 18 lbs.)

Operating Parameters

Ambient temperature range: 10° to 40° C (50° to 104° F)

Relative humidity: 30% to 75%, noncondensing

Atmospheric pressure: 700 to 1060 millibars

Warm-up time: If transported or stored at temperatures outside the operating temperature range, allow one hour for the generator to reach room temperature before use.

Transport and Storage

Ambient temperature range: – 40° to 70° C (– 40° to 158° F)

Relative humidity: 0% to 75%, noncondensing

Atmospheric pressure: 500 to 1060 millibars

Duration of storage: If stored longer than one year, the battery for battery-backed RAM must be replaced (see *Battery Replacement* in Section 7) and a full checkout, including calibration, must be completed before use (refer to Section 5 for instructions).

Duty Cycle

Under maximum power settings and rated load conditions (*pure* cut, 300 watt setting, 300 ohm load) the Force 300 is suitable for activation times of 15 seconds on, 45 seconds off for one hour. With lesser settings and loads, you can activate the Force 300 for greater durations without generating excessive internal temperatures.

If the internal temperature of the Force 300 is too high, an alarm tone sounds and a number (451) flashes in the ***Cut*** display alternately with the power settings. You can activate the generator and change the power settings while this condition exists.

Check the generator for blocked cooling vents or stacking on hot equipment. Limit the activation time.

Internal Memory

Nonvolatile, battery-backed RAM

Battery type: 3 V lithium button cell

Battery life: 5 years

Storage capacity:

- the last twenty error codes detected by the generator
- the number of times and length of activation for each mode
- the average power setting used for each mode
- the total time the generator is on
- other service related information

Audio Volume

The stated audio level is for activation tones (bipolar, cut, and coag) and alarm tones (REM and system alarms) at a distance of one meter. Alarm tones meet the requirements for prEN 475 and IEC 601-2-2.

Activation Tone

Volume (adjustable): 45 to 65 dB

Frequency: bipolar = 554 Hz; cut = 440 Hz; coag = 554 Hz

Duration: continuous while the generator is activated

Alarm Tone

Volume (not adjustable): 65 dB

Frequency: 440 Hz

Duration: 250 to 500 ms. The pulse train is repeated for REM and dosage error alarms at 30 second intervals.

REM Contact Quality Monitor

REM current is measured according to IEC 601-1, Ed. 1988, Figure 15.

Measurement frequency: 80 kHz ± 10 kHz

Measurement current: < 10 μA

Acceptable Resistance Range

REM resistance measurements are ± 10% during RF activation and ± 5% when RF output is not activated.

REM patient return electrode: 5 to 135 ohms or up to a 40% increase in the initial measured contact resistance (whichever is less)

Patient return electrode without the REM safety feature (single-section electrode): 0 to 20 ohms

If the measured resistance is outside the acceptable range(s) noted above, a REM fault condition occurs. For more information, refer to *The REM Contact Quality Monitoring System* in Section 4.

Low Frequency (50-60 Hz) Leakage Current

Enclosure source current, ground open: < 300 μA

Source current, patient leads, all outputs:

Normal polarity, intact ground: < 10 μA

Normal polarity, ground open: < 50 μA

Reverse polarity, ground open: < 50 μA

Sink current at high line, all inputs: < 20 μA

High Frequency (RF) Leakage Current

Bipolar RF leakage current: < 60 mA_{rms}

Monopolar RF leakage current: < 150 mA_{rms}

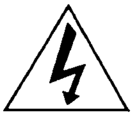
Input Power

110 Volt	220–240 Volt
Maximum VA input: Idle: 40 VA Bipolar: 500 VA Cut: 850 VA Coag: 500 VA	Maximum VA input: Idle: 40 VA Bipolar: 500 VA Cut: 850 VA Coag: 500 VA
Full regulation range: 90–135 Vac	Full regulation range: 186–264 Vac
Operating range: 85–140 Vac	Operating range: 170–280 Vac
Maximum mains current: Idle: 0.4 A Bipolar: 4.2 A Cut: 8.0 A Coag: 4.2 A	Maximum mains current: Idle: 0.2 A Bipolar: 2.1 A Cut: 4.0 A Coag: 2.1 A
Mains line frequency range (nominal): 60 Hz	Mains line frequency range (nominal): 50 Hz
Mains fuse: 8.0 A	Mains fuse: 4.0 A
Power plug: 3-prong hospital grade connector	Power plug: 3-prong locally approved connector

ATTENTION
Consult accompanying documents.

The generator output is floating (isolated) with respect to ground.

Danger
Explosion risk if used with flammable anesthetics.



Caution

To reduce the risk of electric shock, do not remove the cover. Refer servicing to qualified service personnel.

Class I Equipment (IEC 601-1)

Accessible conductive parts cannot become live in the event of a basic insulation failure because of the way in which they are connected to the protective earth conductor.

Type CF Equipment (IEC 601-1)

The Force 300 provides a high degree of protection against electric shock, particularly regarding allowable leakage currents. It is type CF isolated (floating) output and may be used for procedures involving the heart.

Drip Proof (IEC 601-2-2)

The Force 300 enclosure is constructed so that liquid spillage in normal use does not wet electrical insulation or other components which, when wetted, are likely to affect adversely the safety of the generator.

Electromagnetic Interference

When placed on or beneath an activated Valleylab electrosurgical generator, the Force 300 operates without interference. The generator minimizes electromagnetic interference to video equipment used in the operating room.

Caution

Do not stack equipment on top of the Force 300 or place the generator on top of electrical equipment (except the Valleylab Force GSU Unit). These configurations are unstable and/or do not allow for adequate cooling.

Electromagnetic Compatibility (IEC 601-1-2 and IEC 601-2-2))

The Force 300 meets IEC 601-1-2 and IEC 601-2-2 requirements for electromagnetic compatibility.

Voltage Transients (Emergency Generator Mains Transfer)

The Force 300 operates in a safe manner when the transfer is made between line AC and an emergency generator voltage source.

Defibrillator Proof

The Force 300 patient return electrode terminal is protected from defibrillator discharge according to ANSI/AAMI HF18 and IEC 601-2-2.

Available Power Settings in Watts

Bipolar

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
45	50	55	60	65	70				

Monopolar Cut: *Pure*

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
45	50	55	60	65	70	75	80	85	90
95	100	110	120	130	140	150	160	170	180
190	200	210	220	230	240	250	260	270	280
290	300								

Monopolar Cut: *Blend*

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
45	50	55	60	65	70	75	80	85	90
95	100	110	120	130	140	150	160	170	180
190	200								

Monopolar Coag: *Desiccate* and *Fulgurate*

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
45	50	55	60	65	70	75	80	85	90
95	100	110	120						

Maximum Output for Force 300 Modes

Note: Power readouts agree with actual power into rated load to within 15% or 5 watts, whichever is greater.

Mode	Open Circuit P–P Voltage (max)	Rated Load (max)	Power (max)	Crest Factor *
Bipolar				
Standard	300 V	100 Ω	70 W	1.5
Monopolar Cut				
Pure	2000 V	300 Ω	300 W	1.5
Blend	3400 V	300 Ω	200 W	2.1
Monopolar Coag				
Desiccate	660 V	300 Ω	120 W	1.5
	1100 V	300 Ω	120 W	1.5
Fulgurate	6000 V	500 Ω	120 W	4.5

* Crest factor is an indication of a waveform's ability to coagulate bleeders without a cutting effect.

Initially, the maximum voltage for the *desiccate* mode is 300 volts rms. You can change the maximum voltage for this mode to 200 volts rms (and reset it to 300 volts rms) according to your preference. Instructions for changing the maximum voltage for the *desiccate* mode are in Section 2.

Output Waveforms

Effect mode, an automatic adjustment, is applied to all modes except *fulgurate*. For more information, refer to *Effect Mode* in Section 4.

Bipolar

Standard 470 kHz sinusoid with effect mode. 100% duty cycle.

Monopolar Cut

Pure 394 kHz sinusoid with effect mode. 100% duty cycle.

Blend 394 kHz bursts of sinusoid recurring at 27.1 kHz intervals. 50% duty cycle.

Monopolar Coag

Desiccate 394 kHz sinusoid with effect mode. 100% duty cycle. Similar to the *pure* cut mode except the maximum voltage is limited to a lower value.

Fulgurate 480 kHz damped sinusoidal bursts with a repetition frequency of 57 kHz.

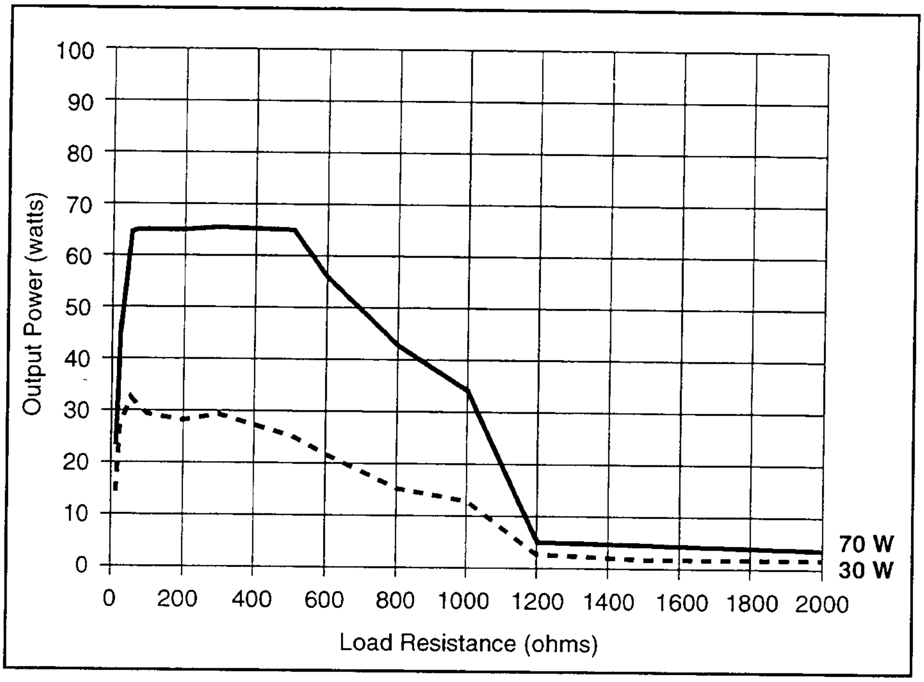
Output Power vs. Resistance Graphs

The graphs that follow depict the changes for each mode at certain power settings.

Bipolar Graph

The insulating surface described in IEC 601-2-2 and full-length leads were used to obtain the bipolar output measurements.

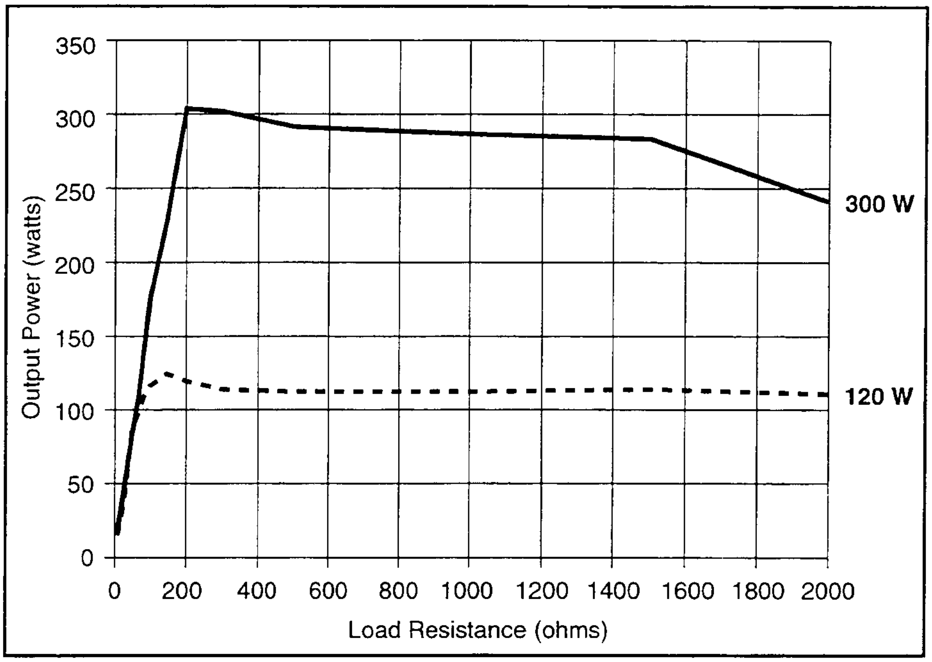
Standard



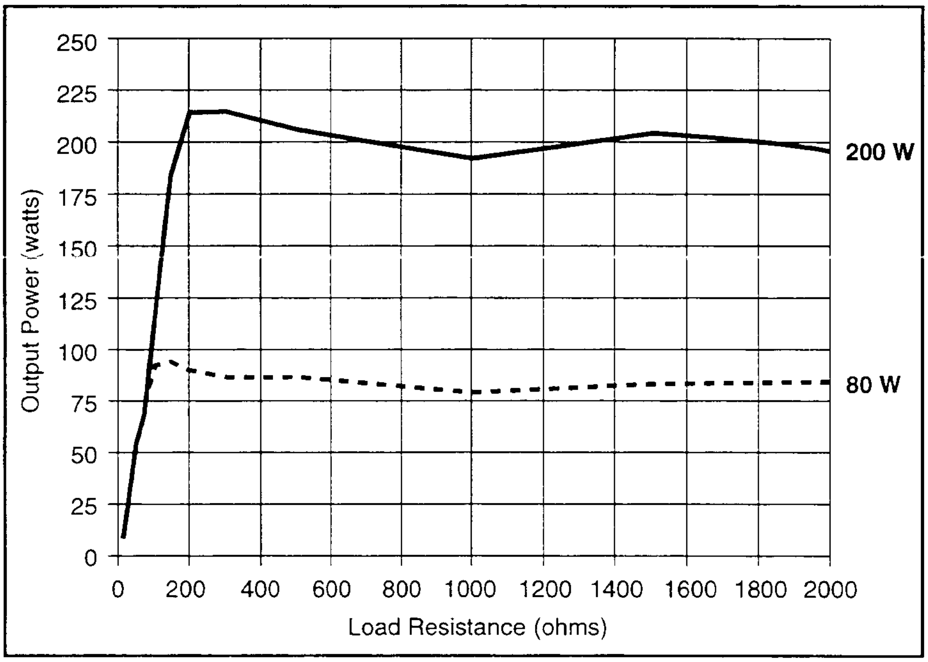
Monopolar Cut Graphs

The procedures described in IEC 601-2-2 and full-length leads were used to obtain the monopolar cut output measurements.

Pure



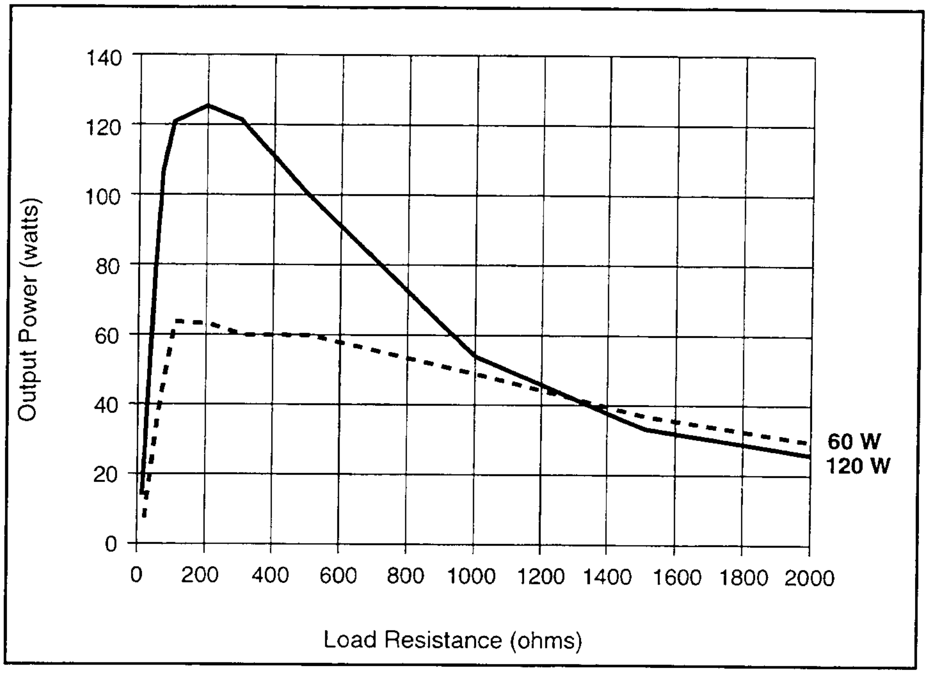
Blend



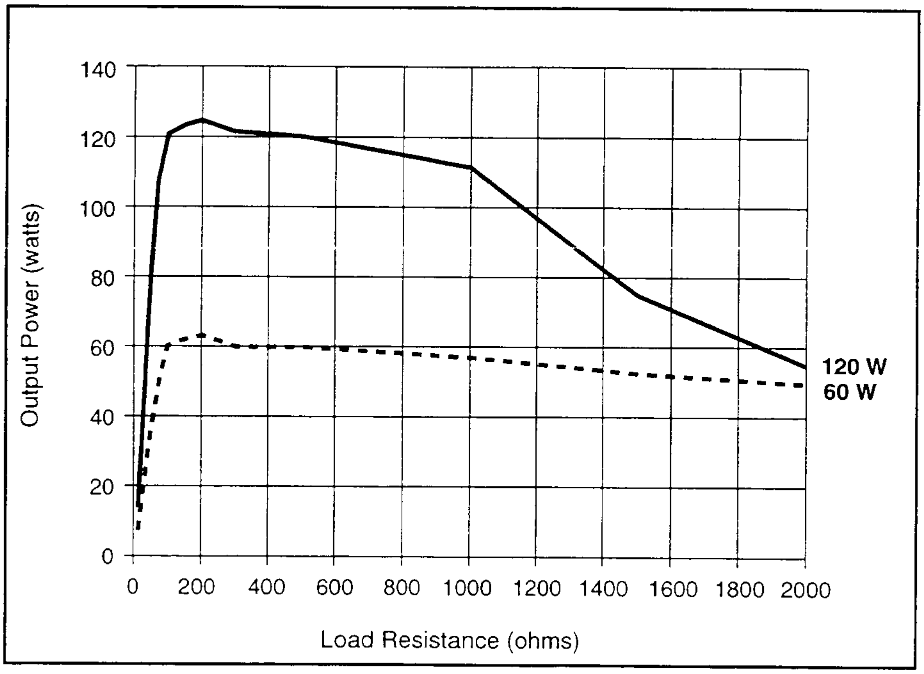
Monopolar Coag Graphs

The procedures described in IEC 601-2-2 and full-length leads were used to obtain the monopolar coag output measurements.

Desiccate (200 V)



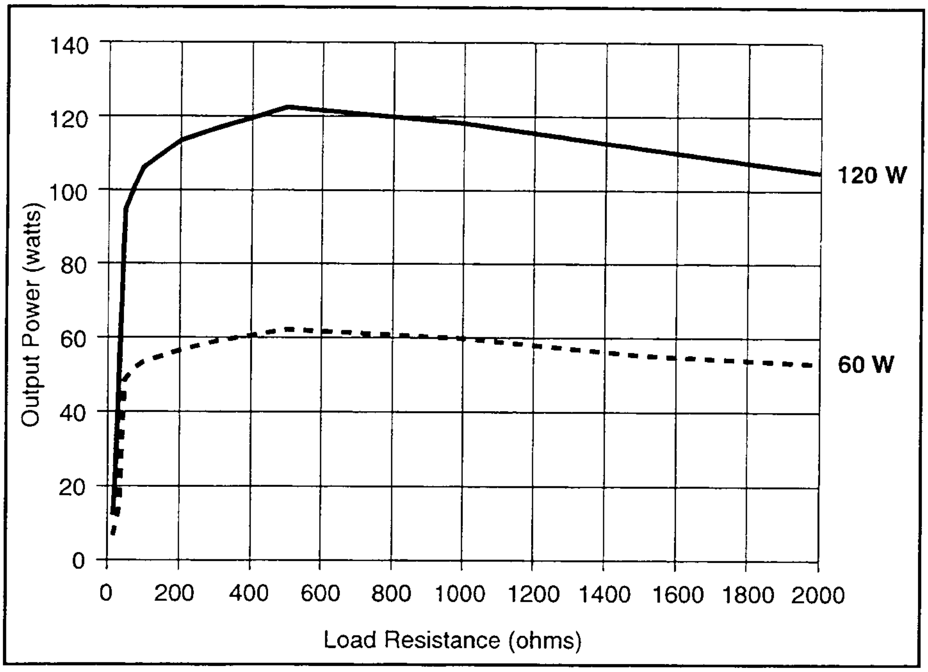
Desiccate (300 V)



Output Power vs. Resistance Graphs

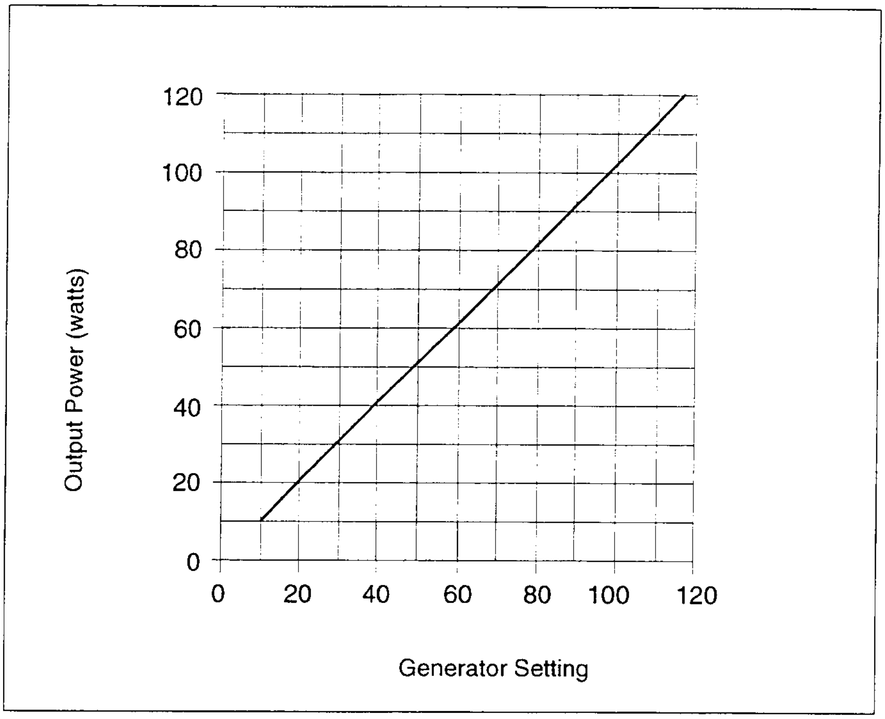
Monopolar Coag Graphs

Fulgurate

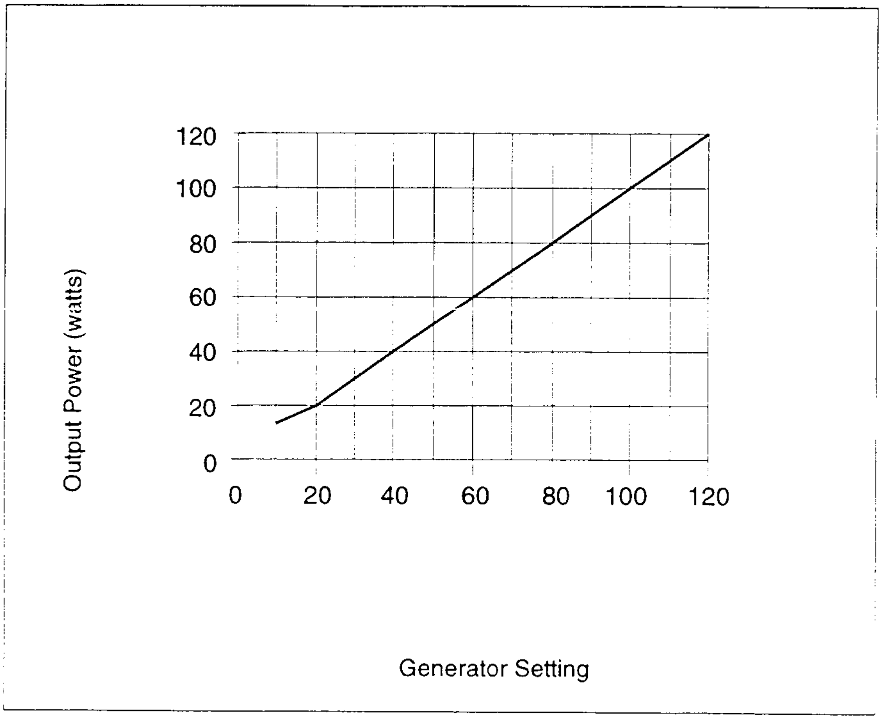


Output Power vs. Generator Settings

200V Desiccate @ 300 Ohms

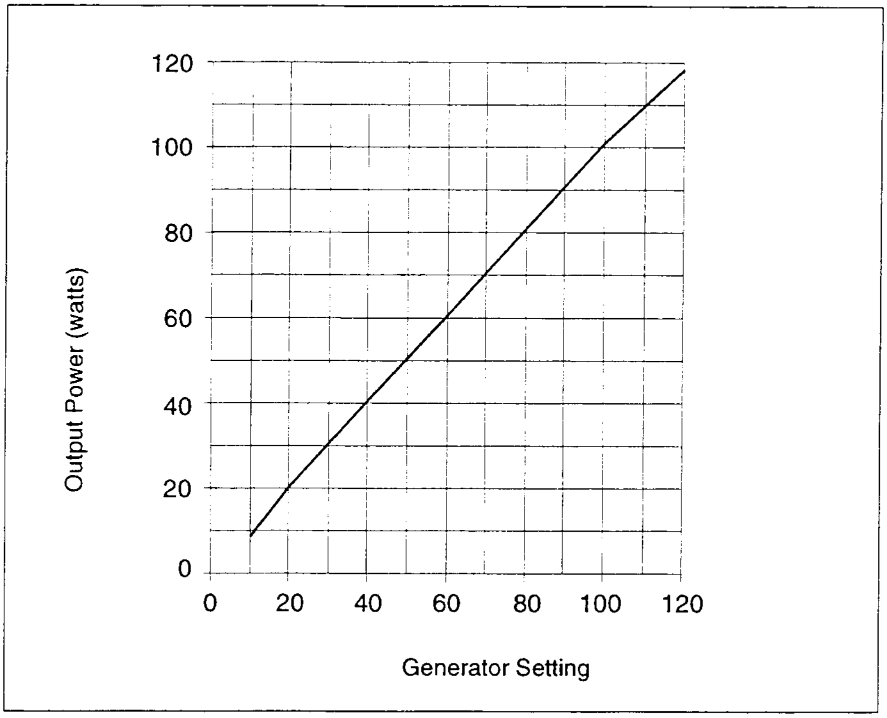


300V Desiccate @ 300 ohms

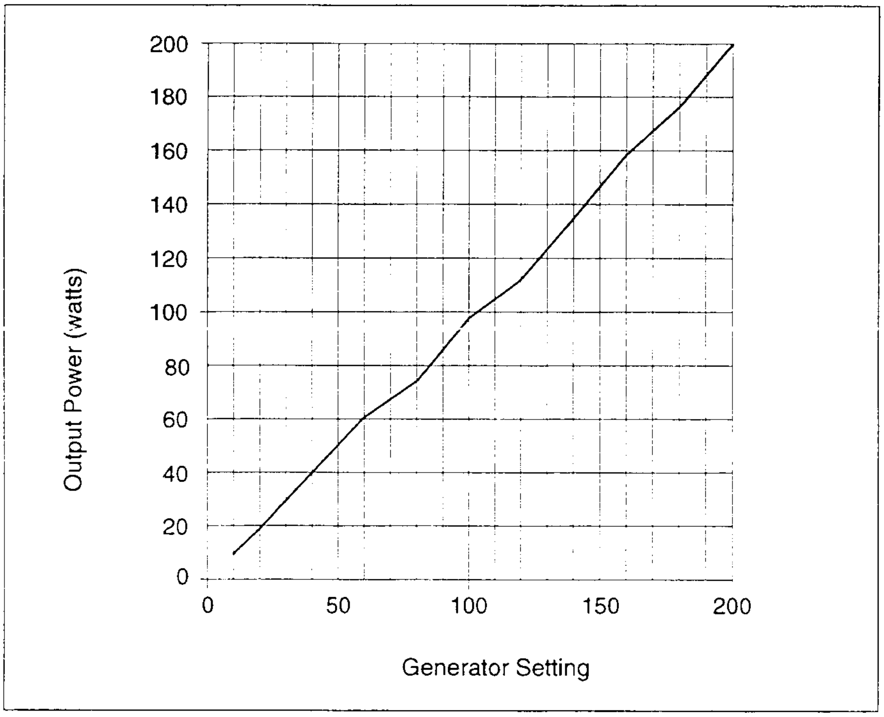


Output Power vs. Generator Settings

Fulgurate @ 500 ohms

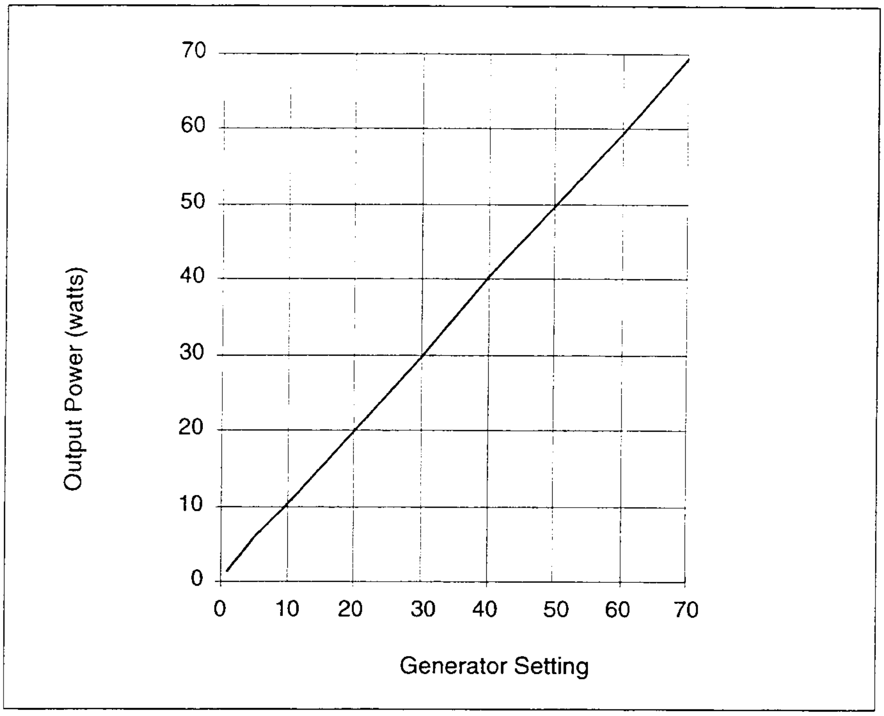


Blend @ 300 ohms

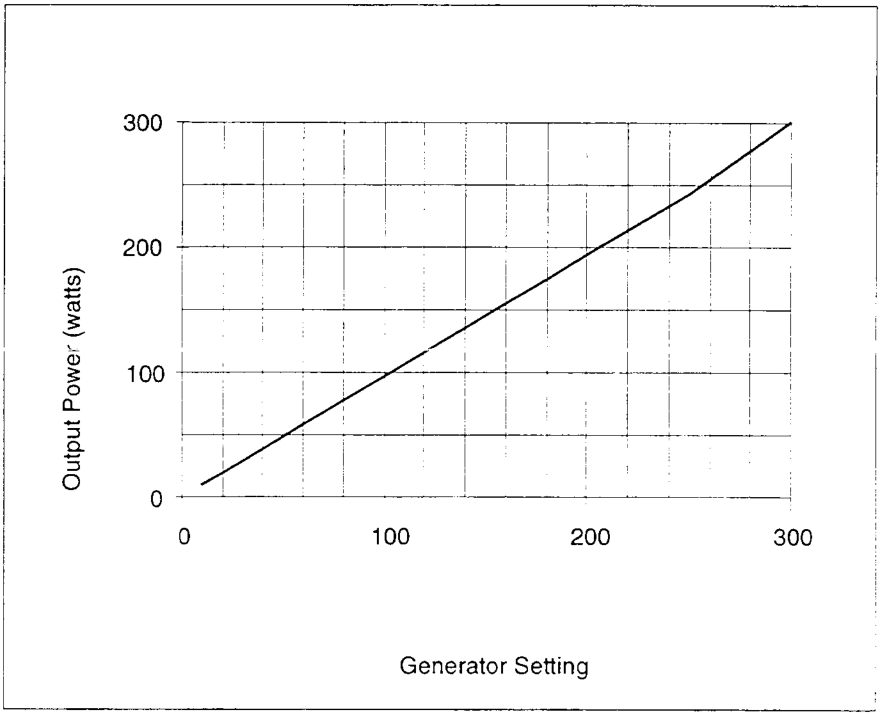


Output Power vs. Generator Settings

Bipolar @ 100 ohms



Pure Cut @ 300 ohms



Notes

4 Principles of Operation

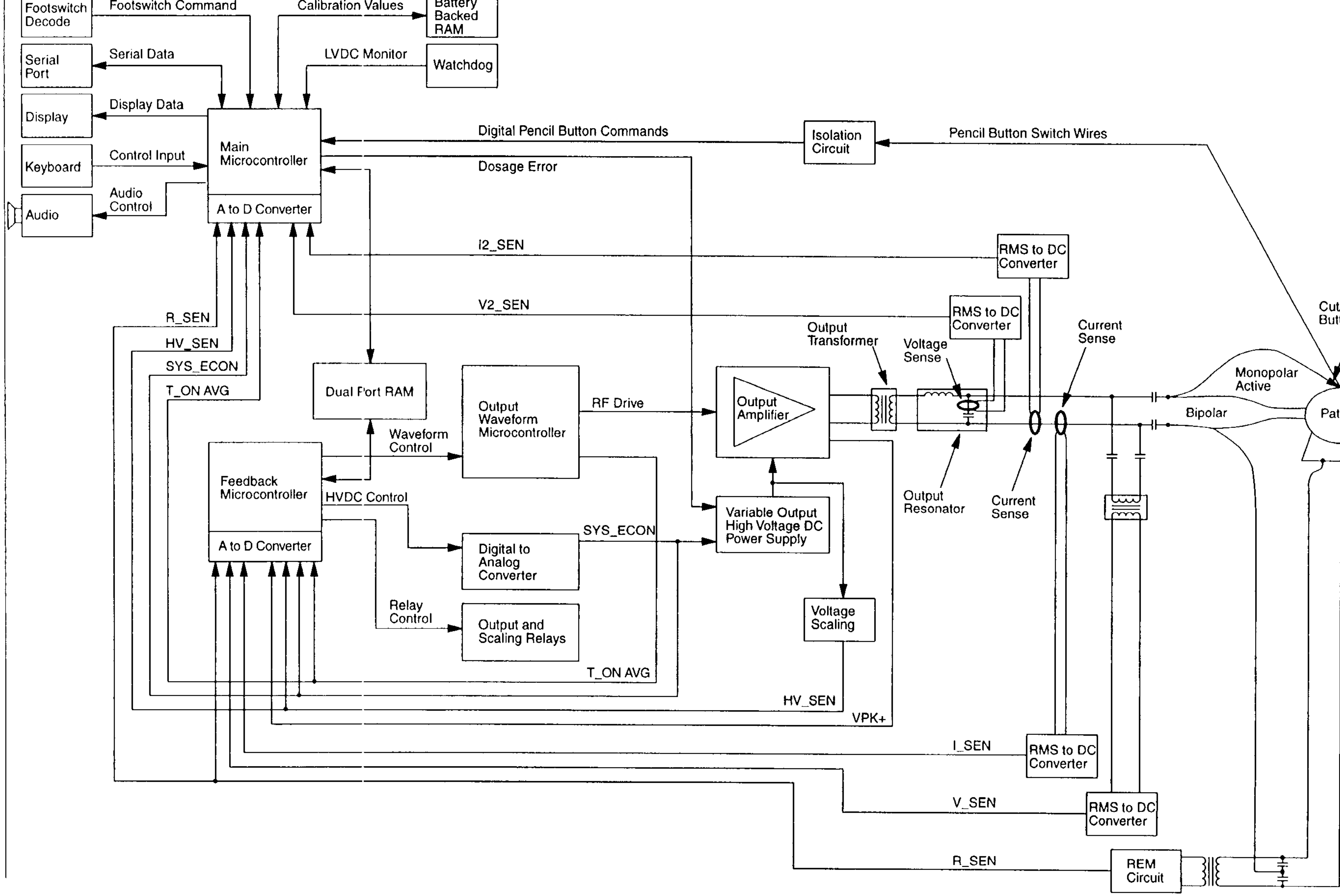
This section provides detailed information about how the Force 300 Electrosurgical Generator functions and how the internal components of the generator interact.

The Force 300 circuitry is housed on four printed circuit boards: the Control Board, the Display Board, the Footswitch Board, and the Power Supply/RF (Radio Frequency) Board.

This section includes the following:

- a block diagram that illustrates how the generator functions
- an overview in which the functionality of the generator is described in general terms
- detailed descriptions of the circuitry for each printed circuit board

Block Diagram



The Valleylab Force 300 is specifically designed for use in bipolar or monopolar electrosurgery to cut and coagulate (desiccate and fulgurate) tissue. In electrosurgery, radio frequency (RF) current flows from the generator to an active electrode, which delivers the current to the patient. The resistance to the current, provided by the patient's tissue and/or the air between the active electrode and the tissue, produces the heat that is necessary for the surgical effect. The RF current flows from the active electrode, through the patient's body tissue to the return electrode, which recovers the current and returns it to the generator.

Effect Mode

The Force 300 maintains constant output power over a specific range of tissue resistances. The generator senses resistance and automatically adjusts the output voltage to maintain a consistent tissue effect across different tissue types. The adjustment, or *effect mode*, is based on the selected mode, the power setting, and the level of tissue resistance. For details, refer to *Effect Mode Algorithm* later in this section.

The REM Contact Quality Monitoring System

The Force 300 uses the Valleylab REM Contact Quality Monitoring System to monitor the quality of electrical contact between the patient return electrode and the patient. The REM system eliminates the hazard of burns at the return electrode site during monopolar electrosurgery.

When you connect a REM patient return electrode to the patient return electrode receptacle, you activate the REM system. When you activate monopolar output, the generator connects the patient return electrode path. If you activate bipolar output while a patient return electrode is connected, the generator disconnects the patient return electrode path to eliminate the possibility of current dispersal.

The REM system measures resistance continuously. It compares the resistance at the return electrode site to a standard range of safe resistance (5 to 135 ohms). This built-in acceptance range eliminates intermittent false alarms that could result from small changes in resistance. The REM system also adapts to individual patients by measuring the initial contact resistance between the patient and the patient return electrode.

When the measured resistance exceeds the standard range of safe resistance (below 5 ohms or above 135 ohms) or when the initial measured contact resistance increases by 40% (whichever is less), the REM alarm indicator flashes red, a tone sounds twice, and RF output is disabled. The REM alarm indicator remains illuminated red until you correct the condition causing the alarm. Then, the indicator illuminates green and RF output is enabled.

Electrodes Without the REM Safety Feature

When you use a patient return electrode that does not have the REM safety feature, the REM system does not monitor the patient contact area. It monitors only the pin-to-pin resistance at the connector and can detect broken wires or connectors in the return electrode cord.

The REM indicator does not illuminate green when you connect a patient return electrode without the REM safety feature. Instead, the indicator light is extinguished. If the generator detects a break in continuity between the electrode and the generator, the REM alarm indicator illuminates red.

When resistance between the patient return electrode receptacle pins exceeds 20 ohms, the REM alarm indicator flashes red, a tone sounds twice, and RF output is disabled. The REM alarm indicator remains illuminated red until you correct the condition causing the alarm. Then, the red indicator light is extinguished and RF output is enabled.

See Section 9 for components and Section 10 for board drawing and schematics.

The Control Board contains the circuitry that controls the generator, including the indicators and switches on the Display Board and the RF output stage on the Power Supply/RF Board. Firmware on the Control Board performs many diagnostic and initialization routines. Errors are reported as alarm numbers on the front panel. For a complete list of alarm numbers, refer to *Responding to System Alarms* in Section 6.

The Control Board interfaces with the Power Supply/RF Board through a 96-pin card edge connector. It interfaces with the Display Board through a 64-pin ribbon cable.

Microcontrollers

Two microcontrollers on the Control Board (the main microcontroller and the feedback microcontroller) work together to control the Force 300. They communicate with each other through a shared RAM. The main microcontroller (U5) performs all system functions, except the time-critical real time feedback control of generator RF output. This is handled by the feedback microcontroller (U11), which is a separate, dedicated microcontroller. All system analog signals are available to these microcontrollers.

A third microcontroller (U9) functions as an application-specific integrated circuit, or ASIC. It generates the RF drive waveforms (T_ON\) for the RF output stage.

Main Microcontroller

The main microcontroller (U5) is an 80C562 that incorporates an 8-input multiplexed 8-bit A/D converter. The main microcontroller monitors all dosage error functions and safety circuits. It implements the user interface, including activation control. It communicates with the feedback microcontroller. It is primarily responsible for these functions:

- segment display drivers and LED update
- power control knob, mode buttons, and the activation interface
- serial port interface
- alarm handling
- REM
- audio control
- memory control and storage (system alarms with time stamps, calibration values)
- real-time clock control and interface
- internal self-tests
- dosage error monitoring

A PSD413 programmable peripheral (U3) provides program memory (128K x 8 external EPROM) and data memory (2K x 8 external battery-backed static RAM) for the main microcontroller. Additional data memory is available from these sources:

- 256 x 8 microcontroller internal RAM
- 4K x 8 external static RAM (U4) shared with the feedback microcontroller

Battery-Backed RAM

A socket on the Control Board contains a 3.0 V lithium button cell battery (BT1) that provides backup power for the 2K x 8 external RAM on the PSD413 device (U3) used by the main microcontroller. The battery-backed RAM stores calibration constants, last setup parameters, and temporary data.

Feedback Microcontroller

The feedback microcontroller (U11) is an 80C562. It receives commands from the main microcontroller and, when the generator is activated, establishes the appropriate relay closures and activates RF output. The feedback microcontroller continually adjusts the output signal of the generator by controlling the high voltage DC power supply and the RF clock circuitry. The primary functions of the feedback microcontroller are listed below:

- scaling relay control and output relay control
- T_ON ASIC waveform control
- leakage control (coag)
- constant voltage, current, and power feedback control
- ECON initialization
- real-time information update (actual voltage, current, power, impedance, effect mode)
- memory tests

Feedback Microcontroller Memory

A PSD412 (U6) provides program memory (64K x 8 external EPROM) and data memory (2K x 8 external static RAM) for the feedback microcontroller. Additional data memory is available from these sources:

- 256 x 8 microcontroller internal RAM
- 4K x 8 external static RAM (U4) shared with the main microcontroller

Shared RAM

The 4K x 8 external shared static RAM is provided by an IDT 713425A device (U4) with semaphore flags. The shared RAM allows the main microcontroller (U5) and the feedback microcontroller (U11) to share common variables. It functions as a communications interface between the main and feedback microcontrollers. It also provides these microcontrollers with additional general purpose RAM.

I/0 Expansion

Three devices provide I/O expansion capabilities: the PSD413 programmable peripheral (U3), the PSD412 programmable peripheral (U6), and an 82C55 expansion port (U2).

The PSD413 and PSD412 each incorporate forty individually programmable I/O pins divided into five 8-bit ports. Twenty-four of the general I/O pins can alternatively be used as I/O for two PLDs, featuring a total of 59 inputs, 126 product terms, and 24 macrocells.

The PSD413 and PSD412 also contain128K x 8 of EPROM (PSD413) or 64K x 8 of EPROM (PSD412). Both contain 2K x 8 of static RAM and a power management unit for battery backup. The I/O expansion capabilities of the devices are configured as outputs for relay control, lamp control, keyboard scanning, and chip selects.

The expansion port 82C55 (U2) is a generic I/O expander that incorporates twenty-four I/O pins divided into three 8-bit ports. It is configured as all inputs. It reads the keyboard, activation signals, accessory switches, and system status flags.

Keyboard Interface and Activation Inputs

The keyboard interface is a simple row and column matrix between three bank select output lines (BANK0–BANK2) on port A of the PSD413 (U3) used by the main microcontroller and eight keyboard (KBD_D0–KBD_D7) input lines on port A of the 82C55 expansion port (U2).

Port B of the 82C55 expansion port reads activation inputs from the IsoBloc® decoding circuits on the Power Supply/RF Board.

Power Supply Supervisor Circuit

The power supply supervisor circuit (U14), a MAX691, generates a Reset signal and a Reset\ signal for the main microcontroller (U5) if the power supply voltage to the Control Board drops below 4.65 V. Reset\ also places the PSD413 (U3) and the PSD412 (U6) in sleep mode and disables the 2K x 8 external static RAM.

Each 80C562 microcontroller (U5 and U11) contains an 8-channel multiplexed 8-bit A/D converter. Resolution of voltage and current sense inputs is enhanced by incorporating gain scaling relays in the sense circuits on the Power Supply/RF Board and prescaling based on the expected input voltage or current values.

The main microcontroller senses redundant RF output current and voltage from additional sense circuits located on the Power Supply/RF Board. This information is not gain scaled since it is for dosage monitoring only.

An MP7226 quad D/A converter (U15) provides 4-channel 8-bit D/A capabilities for the feedback microcontroller to output 0 to 5 Vdc analog voltages.

Waveform Generation (T_ON ASIC)

A dedicated 87C750 microcontroller (U9) generates the RF waveforms (T_ON\) for the RF output amplifier on the Power Supply/RF Board. The microcontroller functions as an application-specific integrated circuit, or ASIC, performing an endless series of repetitive tasks while enabled.

The feedback microcontroller (U11) holds the T_ON ASIC (U9) in a reset state until the feedback microcontroller detects a valid activation request. After validating the request, the feedback microcontroller releases the T_ON ASIC from reset and communicates a 4-bit code that represents the generator mode to be activated. The acceptable activation codes are listed below:

0: bipolar

2: *pure* and *desiccate*

3: *blend*

8: *fulgurate*

Codes 1, 4, 5, 6, 7, 9 and A–F are unused on the Force 300.

Each code generates a unique waveform pattern to be delivered to the RF output stage of the generator. The T_ON ASIC reads and evaluates the code and, if the code value is acceptable, repetitively generates the appropriate waveform until the activation request ends. After the request ends, the feedback microcontroller places the T_ON ASIC back into reset.

If the code received by the T_ON ASIC is not valid, the internal program sets an error flag, deactivates all output signals, and remains in an error state until the system is reset.

T_ON Average Check

The T_ON waveform generator output waveform is integrated in hardware and returned to the main microcontroller as an analog value called T_ON average. The T_ON average is different for each distinct output mode of the T_ON waveform generator. The main microcontroller continually checks the T_ON average for compliance with the calibrated value to ensure that the T_ON waveform generator is operating properly.

The T_ON average signal rests at 5 V when the generator is not activated and drops to the calibrated value when activation occurs. The main microcontroller checks to make sure the T_ON average signal is within ± 15 counts of the calibrated value.

During spark control in the cut modes or wak control in the coag modes, the T_ON average rises an indeterminate amount. Due to this unknown, the T_ON average is allowed to rise to 253 counts, which guarantees the T_ON waveform generator is still operating. The T_ON average is still not allowed to drop below the lower limit of 15 counts mentioned above.

Audio Alarm

The audio alarm circuit is located on the Power Supply/RF Board. The audio alarm is controlled by software and hardware.

- Software control is provided by the UP_TONE\ and LO_TONE signals generated by the main microcontroller in response to activation inputs, alarms, and at power-up.
- Hardware control is provided by the RF_TONE\ signal generated in the RF output stage by RF sensing circuitry on the Power Supply/RF Board.

Serial Interface

The RS-232 serial port is a software-polled interface to the main microcontroller (U5). It is used for diagnostics and calibration. Transmission and receipt of command strings do not stop real time processing, except as single characters are read from or written to the serial port. The serial port is configured to 9600 baud, 8 data bits, 1 stop bit, with no parity. This timing is derived from the main microcontroller oscillator frequency of 11.0592 MHz.

The dosage error algorithm for the closed loop modes (bipolar and cut) is based on a comparison between the backup current and voltage sensors, read by the main microcontroller (U5), and the primary current and voltage sensors, read by the feedback microcontroller (U11). Each microcontroller monitors one set of sensors and calculates real-time output current, voltage, and power. While the feedback microcontroller is operating the generator, the main microcontroller checks the values to make sure the main and feedback microcontroller calculations agree.

In a closed loop mode, there is a 500 ms delay before the dosage error algorithm monitors the rms output of the generator. After the delay, the algorithm first checks to see that the voltage and current calculated by the backup sensors are less than 125% of the value calculated by the primary sensors. On passing this test, the feedback mode of the generator is taken into account.

- In current control mode, the current calculated by the backup sensors is not allowed to deviate from the current calculated by the primary sensors by more than 50% of the value calculated by the primary sensors.
- In power control mode, the power calculated by the backup sensors is not allowed to be greater than 125% of the value calculated by the primary sensors.
- In voltage control mode, the voltage calculated by the backup sensors is not allowed to deviate from the voltage calculated by the primary sensors by more than 50% of the value calculated by the primary sensors.

During closed loop activation, the main microcontroller continually checks for broken backup sensors. The current and voltage sensor analog values are compared to the previous readings to ensure that the sensor values are not constant or falling while ECON is rising.

The dosage error algorithm for the open loop mode (*fulgurate*) is based on the ECON calculated for the mode. The main microcontroller calculates an ECON that represents 125% of the front panel power setting and verifies that SYS_ECON and HV_SEN do not exceed this value while the generator is activated.

When the generator is not activated, the main microcontroller monitors the inputs to the high voltage power supply (ECON and SYS_ECON) and the output (HV_SEN) to verify that no power is generated.

These tests detect power output while not activated, stuck or aberrant sensors, and improper delivered power. The dosage error firmware executes in less than one second.

Effect Mode Algorithm

The Force 300 effect mode is a closed loop control algorithm that is implemented in microcontroller firmware. It is applied to bipolar, the monopolar cut modes, and the *desiccate* coag mode. It is not applied to the *fulgurate* mode.

As tissue impedance increases from short circuit to open circuit, the algorithm implements first constant current, then constant power, and finally, constant voltage. The maximum output voltage is controlled to reduce capacitive coupling, reduce video interference, and eliminate sparking. At low impedances, constant current protects output circuitry. At high impedances, constant voltage control limits arcing and electromagnetic interference (EMI).

Constant current: output voltage is held at constant output current according to

$$I = (P/R)^{(1/2)}$$

where I is the output current, P is the power set by the user, and R is the constant current to constant power impedance switchpoint.

Constant power: the power set by the user is maintained.

Constant voltage: the output voltage is maintained according to

$$V = (P*R)^{(1/2)}$$

where V is the output voltage, P is the power set by the user, and R is the constant power to constant voltage impedance switchpoint.

High Impedance Effect Mode Operation

The firmware algorithm clamps the output voltage to specific levels for high impedance conditions. The clamp level is a function of the mode that is activated. This helps prevent arcing and EMI.

Analog to Digital Saturation

If the analog to digital converter is saturated, the effect mode feedback loop reduces the output voltage to allow for an unsaturated operating condition. The feedback loop switches the control function to maintaining the analog to digital converter in the linear operating range.

See Section 10 for schematics.

The Display Board is located in the front panel assembly. It contains LED displays, seven-segment power setting displays, and RF indicator lamps. The Display Board switch circuitry includes mode selection switches, encoders for changing power settings, the REM switch circuit, and a footswitch decoding circuit for the front panel footswitch jack.

Bipolar, Cut, and Coag Power Setting Encoders

Three mechanical encoders (S1, S3, and S6) change the current power settings for bipolar (S1), cut (S3), and coag (S6). The encoders effectively contain two switches that open and close as the knob is turned, either shorting the encoder output to DGND or letting the encoder output be pulled high by pull-up resistors on the Control Board. The switches open and close 90 degrees out of phase. The direction the knob is turned can be determined by looking at which switch is leading the other. The result seen by the main microcontroller is a 2-bit binary code in which only one bit changes for each state change. When the knob is turned clockwise, the switches cycle through states 00, 10, 11, 01, 00, etc. When turned counterclockwise, the cycle reverses (00, 01, 11, 10, 00, etc.).

RF Indicator Lamps

The RF indicator lamps illuminate during RF activation to visually indicate the presence of RF power. Each of the three indicator bars (bipolar, cut, and coag) on the front panel is illuminated by four incandescent bulbs (LP1–LP12).

- LP1–LP4 illuminate the bipolar bar, changing its color from white to blue to indicate bipolar activation.
- LP5–LP8 illuminate the yellow bar, indicating cut activation.
- LP9–LP12 illuminate the blue bar, indicating coag activation.

FETs Q1, Q4, and Q5 turn the RF indicator lamps on and off. Resistors R2, R3, R4, R10, R39, R40, R42, R44, R49, R50, R52, and R54 set the amount of current flowing through the lamps when they are turned on. The value of these resistors varies for each indicator bar, depending on the color of the bar, to make the different colors of the bars illuminate with equal intensities. Pull-down resistors R1, R47, and R48 are attached to gates Q1, Q4, and Q5 to reduce the input impedance of Q1, Q4, and Q5 as seen by the main microcontroller on the Control Board. This rounds off the edges of these digital signals, reducing high frequency emissions. The lowered impedance also reduces the susceptibility of the circuit to noise from other circuits.

LED and Seven-Segment Display Drivers

This circuit contains two display drivers: the LEDs and the seven-segment displays The LEDs indicate modes of operation, REM condition, and the selected footswitch mode. The seven-segment displays indicate bipolar, cut, and coag power settings.

Each display driver (U5 and U6) can drive up to eight banks of eight LEDs by multiplexing the time that each bank is turned on. The banks can be wired together to increase the time that a group of LEDs is on, effectively increasing the brightness of that group.

U6 drives the discrete LEDs. These include green indicators for the cut modes (*pure* and *blend*), the coag modes (*desiccate* and *fulgurate*), the bipolar and monopolar footswitch selection arrows, and eight red/green bicolor LEDs for the REM indicator. The anode of the mode and footswitch selection LEDs (D1–D6) are tied to driver U6, pin 16 (digit 2) and pin 23 (digit 3). By using two of eight digit lines of the driver, the duty ratio for these LEDs is effectively 1/4.

- The red anodes of the REM LEDs are connected to U6, pins 17 and 20 (digits 4 and 5) for a 1/4 duty cycle.
- The green anodes of the REM LEDs are connected to U6, pins 18, 21, and 22 (digits 6-8) for a 3/8 duty cycle.

U5 drives the seven-segment displays that indicate power settings. DS1 and DS2 indicate the bipolar power setting, DS3–DS5 indicate the cut power setting, and DS6–DS8 indicate the coag power setting. The anodes of these displays are each tied to only one digit line of the driver. The effective duty cycle is 1/8 for each seven-segment display.

Some filtering components are associated with U5 and U6. Bypass capacitors C19, C20, C21, and C22 are connected between + 5V and DGND. C19 and C21 have a relatively small capacitance value of 0.1 µF to filter higher frequency noise. C20 and C22 have a relatively large capacitance value of 47 µF to supply the large spikes of current for the LEDs generated by the multiplexing action of the drivers, which typically occurs at 250 Hz.

R18, R20, R22, R24, R26, R28, R30, R32, R34, R36, and R38 reduce the input impedance of the display driver inputs as seen by the main microcontroller on the Control Board. This rounds off the edges of these digital signals, reducing high frequency emissions. The lowered impedance also reduces the susceptibility of the circuit to noise from other circuits.

Mode Selection Switches

The mode selection switch circuitry uses five discrete switches (S2, S4, S5, S7, and S8). S2 toggles the front panel footswitch control between bipolar output or *single-pin* monopolar output. S4 and S5 select the *pure* and *blend* cut modes. S7 and S8 select the *desiccate* or *fulgurate* coag modes.

FETs Q2, Q3, and Q6 select a bank of switches to be read by the main microcontroller. When one of the digital signals (BANK0–BANK2) is set high, the corresponding FET pulls its output low and any switch closure in that bank can be read by the main microcontroller as a logic low. If a switch is not pressed, the corresponding output (KBD_D6 or KBD_D7) is pulled high by a pull-up resistor on the Control Board and read as a logic high. Resistors R16, R43, and R53 pull the outputs of Q2, Q3, and Q6 high when they are turned off. Pull-up resistors R15, R41, and R51 are attached to gates Q2, Q3, and Q6 to reduce the input impedance as seen by the main microcontroller on the Control Board. This rounds off the edges of these digital signals, reducing high frequency emissions. The lowered impedance also reduces the susceptibility of the circuit to noise from other circuits.

Schottky diodes (Z1–Z5) prevent false switch readings should multiple switches be pressed. For example, when S4, S5, and S7 are all closed and the BANK2 signal is set high, Q6 pulls KBD_D6 low through S7. If Z2 is not placed in line with S4, the output of Q3 is pulled low through S4, and KBD_D7 is pulled low through S5. To the main microcontroller, S7 and S8 appear to be pressed, however, since S8 is not pressed, this reading is false. Schottky diodes are used because the logic low level placed on KBD_D6 or KBD_D7 must be below 0.8 volts to be read correctly.

REM Switch Circuit

The REM switch circuit determines when a REM patient return electrode is plugged into the patient return electrode receptacle. When a REM electrode is used, a mechanical lever senses the center plastic pin on the REM plug and opens S9. This allows R55 to pull REM_SW high, telling the main microcontroller that a REM patient return electrode is connected to the generator.

When an electrode without the REM safety feature is used, S9 remains closed and REM_SW is pulled low. Capacitor C23 filters noise on REM_SW. Resistor R56 limits the amount of current that flows through S9 when it closes and C23 discharges.

The footswitch circuit on the Display Board provides a means of activating the bipolar instrument receptacle or the *single-pin* monopolar instrument receptacle, depending on which is selected. This circuit consists of a footswitch receptacle, an isolated DC/DC converter, two optoisolators, and associated circuitry.

The footswitch connector (P1) provides the connecting point for the footswitch. The common mode choke (L1) and capacitors (C1–C3, C16–C18, and C24–C26) provide filtering that blocks high frequency noise from exiting the generator on the footswitch cable. Note that C16–C18 decouple the footswitch outputs to DGND and then C1–C3 and C24–C26 decouple DGND to CHGND. This is done in two stages in order to use the DGND plane on the board as a low impedance path from the footswitch circuit to the edge of the board, where chassis ground can be picked up more readily.

- When a footswitch **coag** pedal is pressed, the corresponding signal (FRONT_FSW_COAG_FIL) is pulled high by +V_ISO_5_FIL pulling MON1_COAG\ low through U1 .
- When a footswitch **cut** pedal is pressed, the corresponding signal (FRONT_FSW_CUT_FIL) is pulled high by +V_ISO_5_FIL pulling MON1_CUT\ low through U2.

Resistors R5 and R6 set the amount of current flowing through optoisolators U1 and U2. An isolated DC/DC converter (U3) provides the power source for the footswitch circuit via isolated power (+V_ISO_5) and ground (ISO5). Capacitors C6, C10, and C15 provide high frequency filtering to reduce emissions. Capacitor C12 supplies a source for current spikes flowing into the switching input of U3.

See Section 9 for components and Section 10 for board drawing and schematic.

The Footswitch Board contains circuitry for the footswitch connectors on the rear panel, a speaker, and the volume control potentiometer for the audio circuit. The board interfaces to the Power Supply/RF Board.

The monopolar footswitch connector (J1) provides footswitching capability for the *multipin* monopolar instrument receptacle located on the front panel. The bipolar footswitch connector (J4) provides footswitching capability for the bipolar instrument receptacle located on the front panel. Capacitors C1–C5 provide filtering that blocks high frequency noise from exiting the generator on the footswitch cables.

The audio circuit on the Power Supply/RF Board uses the speaker (SP1) on the Footswitch Board to enunciate the presence of RF output and to provide an auditory indication of alarm conditions. The potentiometer (R1) adjusts the volume of RF output activation tones. The speaker volume cannot be turned off entirely. The volume used during alarm conditions is not adjustable.

See Section 9 for components and Section 10 for board drawing and schematics.

The Power Supply/RF Board is the main board of the Force 300. It contains the high voltage power supply and the RF output stage. Other functions performed by circuitry on this board are listed below:

- output voltage monitoring (spark control circuit)
- leakage current sensing (RF leakage sensing and reduction circuits)
- REM impedance monitoring (REM circuit)
- switch closure detection (IsoBloc circuit)
- rear panel footswitch control (footswitch decode circuit)
- audio tone generation (audio circuit)
- thermal monitoring (temperature sense circuit)

Power Supply/RF Board Interfaces

The Power Supply/RF Board interfaces to other boards and components of the Force 300 as noted below:

- Control Board
- Footswitch Board
- RS-232 interface
- EKG blanking contact closure
- heat sink components (RF damping resistors and the RF MOSFET)
- a series of single wire attachment points for connecting the sense transformers
- low voltage power supply (AC input and output)

A series of fuse clips connect the RF outputs and other front panel interfaces (i.e., REM and handswitching signals). The fuse clips mate to lugs located in the output portion of the front panel assembly.

Warning

Potentially lethal AC and DC voltages are present in the AC line circuitry, high voltage DC circuitry, and associated mounting and heat sink hardware described in this manual. They are not isolated from the AC line. Take appropriate precautions when testing and troubleshooting this area of the generator.

The high voltage power supply section contains the power entry circuitry, auto mains switching circuitry, AC/DC conversion circuitry, and a DC/DC switching regulator.

Power Entry Circuit

The power entry circuit consists of an integral three-wire power cord receptacle, fuse drawer, EMI filter, and a separate power switch. The receptacle/filter is mounted on the rear panel of the generator. The power switch is mounted on the front panel. AC line fuses are changeable from the rear of the generator.

Auto Mains Switching Circuitry

The auto mains switching circuit detects the AC line voltage level and controls the triac (D3). This triac controls the topology of the AC/DC converter. For 120 Vac operation, the triac is on, which connects the AC neutral to the center of the AC/DC converter capacitor bank (C58–C61). In this configuration, the circuit acts as a doubler using the right hand half of the bridge rectifier (CR80). For 240 Vac operation the triac is off and CR80 is used as a full wave rectifier.

The control IC (U10) functions as follows: The series circuit (CR6, R59, R64, and C57) provides power for U10. Pin 1 (Vss) is a shunt regulator that provides a –9 V (nominal) output. The divider (R65 and R66) measures the input line voltage. Since the voltage at pin 8 varies with the line, it can sense the line voltage zero crossing as well as the peak voltage. Pins 2 and 3 are inputs to an oscillator used for triac triggering timing. R67 and C50 set the oscillator frequency. Pin 7 is tied to Vss, which places the circuit in the fail-safe mode. Thus, once the circuit enters full bridge mode it remains in that mode until input power is recycled. A power dropout cannot cause the circuit to accidentally act as a doubler when the higher input voltage range is used.

The AC/DC converter uses CR80 as either a doubler or full wave rectifier, depending on the input voltage. In either case, an unregulated nominal 300 Vdc is provided to the DC/DC switching regulator. Thermistors R68 and R70 provide inrush current limiting, and fuse F1 provides protection against faults in the DC/DC switcher.

Capacitors C58–C61 are an energy storage reservoir for the DC/DC switcher. C70 is a high frequency bypass filter. Bleeder resistors R69 and R71 discharge the capacitors when the AC line is disconnected or the power switch is turned off.

DC/DC Switching Regulator

The DC/DC switching regulator is a buck-derived, pulse width modulated (PWM) transformer. It is an isolated, fixed frequency, full bridge converter. The PWM IC (U3) is used in the voltage mode. The output of the regulator is adjustable from approximately zero (0) to 180 Vdc.

The full bridge consists of four power MOSFETs (Q2, Q4, Q5, and Q7) that operate at AC line potential. Transistors Q2 and Q5 are on while Q4 and Q7 are off, and the reverse. In this manner, power signals to the power transformer are bidirectional, or push-pull. This allows full utilization of the transformer core magnetization capability. Regulation is achieved by modulating the time that each MOSFET pair is on. Capacitor C67, in series with the power transformer T3 primary, prevents DC flux imbalance. A snubber circuit (C66 and R79) absorbs leakage energy spikes. Another snubber circuit (C91 and R121) reduces spikes due to reverse recovery of the output bridge rectifier.

The gate driver circuitry for each MOSFET is transformer-coupled through T1 to provide AC line isolation. It consists of a dual MOSFET driver (U1) and various damping resistors. Resistors R40, R58, R63, and R78 minimize turn-off oscillations. Resistors R17 and R41 damp ringing due to parasitic inductances in T1. Blocking capacitors C12 and C26 prevent DC flux imbalance in T1.

Note: T1 consists of two transformers electrically and magnetically isolated from each other but assembled into the same package. T1A and T1B form one transformer; T1C and T1D form the other.

The output of the power transformer is full wave rectified by a high voltage diode bridge (CR17, CR22, CR23, and CR36). The rectified power signal is filtered by L1, C89, and C108. The regulated DC output from this supply is the input to the RF stage of the generator.

The SYS_ECON signal from the microcontroller controls the output voltage level. This 0 to 5 Vdc signal sets the reference for the PWM control loop. An external op-amp (U4A) is used for gain and integration, since common mode voltage limitations in U3's internal op-amp preclude its use over the full range of 0 to 5 V. The internal op-amp is connected as a follower. SYS_ECON is compared to the feedback voltage from the output divider (R21 and R22) and an error signal (ECON) is sent to the PWM microcontroller. In addition to the error signal, U4A and the associated R-C networks provide lead-lag loop compensation to increase the bandwidth of the regulator beyond that of the output L-C filter.

The output of U3 is a pair of 180° out-of-phase signals that are pulse width modulated by comparing ECON with the internal oscillator ramp waveform. At the start of an oscillator cycle, an output is turned on. It turns off when the ramp voltage crosses the ECON level. The two output signals from U3 (pins 11 and 14) feed the MOSFET drivers (U1A and U1B).

The U3 oscillator frequency is set by R42 and C27. C29 controls the ramp-up of the pulse width at power on for slow start control. Transformer T2 limits the power transformer primary current, protecting against faults in the DC/DC switcher power stage and faults in circuitry downstream of the switcher. The secondary of T2 is rectified (CR2–CR5), filtered (R47 and C30), and fed to the current limit pin (pin 9 of U3). During an overcurrent condition the U3 current limit function resets the slow start circuit, resulting in the output cycling from on to off until the current falls. Pin 9 of U3 is also used for remote shut down of the DC/DC switcher through Q1 and CR1. The shut down signal comes from the main microcontroller on the Control Board.

The resister divider formed by R88 and R89 is used for dosage error sensing.

Low Voltage Power Supply

The low voltage power supply is rated for 40 watts. It delivers a regulated +5 Vdc and ±12 Vdc output. This power supply has a universal input and works for both input voltage ranges. It has internal current limiting, overvoltage, and thermal shutdown protection. The pinouts between the low voltage power supply and the Power Supply/RF Board are listed below:

PIN	Voltage
1	+5 Vdc
2	–12 Vdc
3	+12 Vdc
4	GROUND

The significant specifications of the low voltage power supply compared to estimated loads are as follows:

Output Voltage	Output Current	Output Power	Estimated Load
+5 Vdc	4000 mA	20.0 W	1000 mA
–12 Vdc	400 mA	4.8 W	160 mA
+12 Vdc	2000 mA	24.0 W	1400 mA

Warning

High frequency, high voltage signals that can cause severe burns are present in the RF output stage and in the associated mounting and heat sink hardware described in this manual. Take appropriate precautions when testing and troubleshooting this area of the generator.

The RF stage consists of a single MOSFET power switch with associated gate drive circuitry, an RF power transformer, tuning capacitors, an RF output L-C filter, output directing relays, and topology selecting relays. Also included in this section are the RF voltage and current sense circuits and a switched damping network for certain operational modes.

The MOSFET gets its gating signal from the T_ON ASIC (U9) on the Control Board. The T_ON ASIC also provides the gating signal for the switched damping network.

When the topology selecting relays (K1 and K15) are unenergized, the RF stage is in the coag mode; when energized, the RF stage is in the cut and bipolar mode. Note that *desiccate* is considered a cut mode from the topology standpoint.

Primary Sense Circuits

The primary voltage and current sense circuits provide feedback information to the feedback microcontroller in the bipolar and cut modes.

For voltage sensing, the two 10 k ohm resistors in series with the primary of T12 work in concert with the 100 ohm resistor across the secondary to divide the output voltage down to a manageable level. Depending on the front panel power setting, one of the three relays (K2–K4) is switched in to give optimum scaling. The four op-amps (U18 and U23), along with the associated resistors, capacitors, and diodes, form a precision full wave rectifier circuit. U23B is a high input impedance follower to prevent the rectifier circuit from loading down the resistive divider. U23A is a follower that adds phase delay, which improves balance in the rectified waveform between positive and negative half cycles of the input signal. The actual rectification is done with U18A and U18B. The rectified waveform is converted to DC by the R-C filter after the last op-amp, with the full scale at 5 Vdc.

The current sense circuit, which uses current transformers T5 and T6, works the same as the voltage sense circuit. T6 senses bipolar current and T5 senses monopolar current. Relay K9 selects the appropriate current. Note that the current scaling relays (K5–K7) switch at different power settings than the voltage scaling relays.

The primary sense circuits are functionally in parallel to redundant sense circuits for the dosage error monitoring function performed by the main microcontroller on the Control Board.

For redundant voltage sensing, a current sense transformer (T8) is placed in series with the capacitor ladder. This voltage is then rectified through a bridge rectifier (CR24, CR25, CR27, and CR28), divided, and limited before being filtered and buffered by op-amp circuit U31A.

For redundant current sensing, another current sense transformer (T7) senses current flow in both the bipolar output leads and the monopolar output leads. A circuit identical to the redundant voltage sensing circuit follows for rectification, division, limiting, buffering, and filtering.

The signals produced from the redundant sense circuits are scaled for zero to 5 Vdc operation for use by the analog-to-digital channels of the main microcontroller on the Control Board.

Output Relays

In all monopolar modes, K12 is closed and routes patient return current through the REM receptacle. K10 routes active current through the *single-pin* (footswitch activated) output receptacle. K11 routes the active current through the *multipin* (handswitch or footswitch activated) receptacle.

In bipolar mode, the REM receptacle relay is open. Relays K13 and K14 route bipolar current to the bipolar receptacle.

All output relays are open when the generator is not being activated.

Bipolar Mode

The bipolar mode circuit topology is essentially the same as the cut modes, except the output voltage is tapped off C159 and the switching frequency is 470 kHz. These differences allow for the higher currents and lower voltages required in bipolar surgery while still maintaining the advantages of zero voltage switching in the MOSFET. The T_ON\ signal is a continuous pulse train.

In the cut modes, K1 is set so that diode CR7 is in parallel with the MOSFET body drain diode, C62 and C65 are across the MOSFET, and the transformer primary consists of windings 1-2 and 3-4 in series. K15 is closed so the series capacitor bank (C143, C154, C159, C165, and C166) is across the output.

In the *pure* cut mode, the T_ON\ signal is a continuous pulse train with a frequency of 394 kHz. In this case, essentially two resonant circuits operate in tandem. The output L-C filter is tuned just slightly higher than the RF switching frequency, achieving a high degree of filtering. The output is very sinusoidal over the full range of load impedances. Capacitors C62 and C65 are tuned with the RF transformer primary so that the flyback voltage appearing across the MOSFET at turn off is a half sine pulse and returns to zero volts before the next cycle begins. The T_ON\ pulse width is chosen to support this tuning. This zero voltage switching improves the efficiency of the RF stage and is effective over a wide range of load impedances.

The circuit topology of the *blend* cut mode is the same as the *pure* cut mode. In *blend* mode, however, the T_ON\ signal is an interrupted pulse train with a 50% duty cycle and a frequency of 27.1 kHz. For a given power setting, *blend* gives a higher peak current, providing better hemostasis than *pure.* To minimize ringing at the beginning of the off period of the *blend* waveform envelope, the damping resistor is switched on just before switching ends and stays on for part of the off period.

Coag Modes

In the *fulgurate* mode, K1 is set so that diode CR7 blocks reverse current in the power MOSFET, C100 as well as C62 and C65 are across the MOSFET, and the transformer primary consists of winding 1-2 only. K15 is open, keeping the series capacitor bank (C143, C154, C159, C165, and C166) out of the circuit.

The T_ON\ signal is a continuous pulse train with a pulse width of 1.69 µsec and a frequency of 57 kHz. When the MOSFET turns on, some energy is delivered to the output and some is stored in the T4 core. When the MOSFET is turned off, the energy stored in the core rings out with a frequency of 580 kHz. The frequency is set by C62, C65, C100 and the inductance of winding 1-2 of T4. CR7 blocks reverse current in the body drain diode of the MOSFET so that the power waveform can ring negative. This allows high peak voltages to be achieved at the output. In most cases, all the energy stored in the transformer core during one switching cycle is delivered to the load before the next cycle begins.

To minimize ringing on the output voltage waveform at light loads, transistor Q8 switches in the 50 watt, 50 ohm heat sink mounted resistor in series with the transformer primary for part of the RF switching cycle.

The *desiccate* coag mode is treated by the microcontroller as a feedback controlled cut mode. Its operation is the same as *pure* cut described above, except the power curve is different.

Spark Control Circuit

The spark control circuit uses the voltage sense circuit to monitor the output voltage. It interrupts the delivery of power if the output voltage exceeds a preset threshold. This greatly reduces sparking when an activated accessory is removed from tissue. The sparking occurs because the RF stage tuning results in a higher natural gain at light loads than at heavy loads. Thus, during sudden transitions from heavy to light loads, the output voltage rises faster than the microcontroller can respond. This analog circuit works outside the microcontroller loop at a much greater speed.

The rectified but unfiltered waveform from the output voltage sense circuit is fed into a peak detector (U13A, CR8, and C76). This input signal is called VSEN_SCC. A high impedance buffer (U13B) maintains the integrity of the peak detected signal. The output of this buffer is divided and fed to a comparator. The other input to the comparator is an analog threshold level (VMAX_CLP) that is set by the feedback microcontroller on the Control Board and depends on the mode and power setting.

When the peak detected sample of the output voltage exceeds the threshold, one-shot U15A is fired and generates a 3 msec pulse (SPARK_CON) that is sent to the T_ON ASIC on the Control Board. This pulse is ignored if it occurs during the first 0.2 seconds of activation. Otherwise, SPARK_CON causes the T_ON\ signal to stop. The feedback microcontroller on the Control Board senses this and realizes that a spark has been suppressed. The feedback microcontroller waits either 10 msec in *desiccate* or 100 msec in *pure* cut, then re-initiates T_ON\ with a frequency of 470 kHz. The frequency returns to 394 kHz after one second of continuous activation or when the generator is reactivated.

For the *fulgurate* mode, the high voltage RF output pulse repetition period varies with changes in spark and patient tissue impedance to limit the RF leakage current to a desired level. The VSENSE signal is obtained from the divider (R90, R94) located on the primary side of T4. VSENSE is input to a negative peak detector (U20A) that generates the analog signal (VPEAK–). Then U21A amplifies and inverts the signal.

The averaged signal (now called VPK+) is input to the feedback microcontroller on the Control Board and added to the ECON value at the selected power setting. The sum of these signals, with the proper gain factors, varies linearly with load impedance at the patient site. This sum is input into a pulse width modulator (also part of U11) on the Control Board which sends its output (WAK\) to the NAND gate (U10) on the Control Board. Thus, the T_ON\ signal is inhibited for up to four consecutive cycles.

REM Circuit

The REM transformer (T10) provides isolated reflected impedance sensing for tissue impedance across the REM patient return electrode terminals (connected to J17 and J19). In addition to tuning the REM circuit, capacitors C149–C151 and C157 provide a return path for high frequency RF signals to the RF output transformer.

The REM transformer (T10) and capacitors C149–C151 and C157 form a resonant circuit with a nominal operating frequency of 80 kHz. This frequency is positioned between RF output harmonics to prevent electrosurgical RF noise from corrupting the impedance measurement. The resonant characteristics of the REM circuit are similar to those of a band pass filter. Spectral components outside the 80 kHz pass band are heavily attenuated while the 80 kHz components are allowed to pass. When the resonant circuit is perfectly tuned, the primary voltage and current are exactly in phase.

REM Oscillator

The REM oscillator is a stable adjustable ceramic oscillator. It is temperature compensated with R125, a temperature dependent resistor. The REM_CLK signal from driver U29A actually provides the REM current to the REM transformer (T10). The REM_DRV signal is an inverted version of this signal that correctly times the REM voltage sensing. The main microcontroller on the Control Board uses digital potentiometer U26 to calibrate the REM circuit during calibration.

IsoBloc Circuit

The IsoBloc circuit provides a means of detecting a switch closure in an output accessory while maintaining electrical isolation between the generator output and ground referenced circuitry. The IsoBloc circuit consists of an isolated DC power supply and an optoisolator link from the output connected circuitry to the ground referenced low voltage circuitry. Each handswitching output of the generator (*multipin* monopolar and bipolar) is associated with its own IsoBloc power source and isolated signal paths.

Oscillator

The oscillator circuit consists of a 74HCT4060 oscillator/divider (U30) using a 5 MHz ceramic resonator as the frequency determining element. The output of the oscillator is connected internally to the input of a counter/divider chain. The Q6 output of the divider yields a 78.13 kHz square wave that is applied to the input of two 4081 AND gates (U27A and U34A) for buffering and gating with the ISO_TST\ signal. The software system uses the ISO_TST\ signal to shut off the IsoBloc supplies for safety testing.

Power Supply

The two 4081 AND gates drive two VN10KM FETs (Q9 and Q10) that are connected to transformers T9 and T11. The transformers are operated in a flyback mode with their associated 6800 pF capacitors (C133 and C139). The voltages at the secondaries of the two transformers are half-wave rectified and referenced to two separate isolated grounds to provide –8 V for operating the isolated activation circuitry.

Optoisolators

The isolated power supply voltages produced by the IsoBloc power supplies are connected to the Active output terminals of the generator (J15, J22, and J24). Handswitch activation is accomplished by sensing Active-to-Cut or Active-to-Coag switch closure in a handswitching accessory. Current limiting resistors, in series with LEDs in the optoisolators, cause the LEDs to light to a controlled degree while not excessively loading the IsoBloc power supply. This light is detected by the photo-transistor in the optoisolator. The photo-transistor, which is connected to an input to an 82C55 expansion port in the main microcontroller circuit, turns on, pulling the associated input low. This is interpreted by the software as an activation request, and the generator is activated after using ISO_TST\ to verify the validity of the activation request.

Audio Circuit

The audio system enunciates the presence of RF output and provides an auditory indication of alarm conditions. This system consists of an audio oscillator, tone control signals, a volume control potentiometer, an audio amplifier, and a speaker.

The audio oscillator is enabled when UP_TONE\ (from the Control Board) or RF_TONE\ (from the Power Supply/RF Board) is pulled low. Diodes D1 and D2 provide a wired-OR function for the two signals. Since UP_TONE\ and RF_TONE\ are +5 V (logic level) signals, resistors R24 and R49 divide the +12 V audio power supply down to about 4.85 V to prevent D1 and D2 from sourcing current into their logic level drive signals. R25 and C31 provide filtering for the resultant wired-OR output.

With either UP_TONE\ or RF_TONE\ enabled low, the voltage at the noninverting input of U5B is pulled below the Vref threshold present at U5B's inverting input. Under this condition, the output transistor of U5B (open collector) is turned on, grounding R31 and allowing U6A to oscillate. Vref is used throughout the audio circuit and is generated by dividing the +12 V power supply down to about 2 volts through R50 and R54 while C33 provides low pass filtering for Vref.

U6A is a relaxation oscillator whose frequencies are determined by the RC time constants of R29, C11, and C42. This design allows the oscillator to produce two distinct frequencies that can be selected by the state of the LO_TONE signal.

- When LO_TONE is asserted (+5 V), the voltage at the inverting input of U5A exceeds the 2 volt Vref signal at its noninverting input, thus turning on its output transistor. This effectively connects C11 in parallel with C42 to produce a higher RC time constant for the oscillator, which results in a lower audio frequency.
- Conversely, when LO_TONE is not asserted, the output transistor of U5A (open collector) is allowed to float, thus removing C11 from the circuit.

The ALARM signal from the Control Board selects the user-controlled audio volume or the fixed alarm level volume. U5C and U5D are configured in an exclusive OR arrangement in which the state of the output transistor of U5C or U5D is complementary. In other words, the output transistor of one of these two devices is always on, but both cannot be on simultaneously. Under normal operating conditions, the ALARM signal is low, allowing the U5C output to float while the U5D output transistor is turned on. The output of U5D creates a voltage divider through R1 (the volume control potentiometer on the Footswitch Board), R27, and R28 to attenuate the audio signal to levels acceptable for input to the audio amplifier. R27 determines the minimum audio volume. R55 provides an alternate audio signal path in the event of an open volume potentiometer.

Audio Circuit

When the ALARM signal is high, the U5C output transistor is turned on while the output of U5D floats. When the U5C output transistor is on, R26 is pulled to ground and creates a fixed voltage divider with R28 to produce the alarm volume level at the input to audio amplifier U8.

Meanwhile, the output of U5D is allowed to float, thus removing the variable resistor divider from the circuit. In this case, the volume control potentiometer becomes a small resistance in series with the high impedance input from the audio amplifier, negating the effect of the volume setting.

Audio amplifier U8 and speaker SP1 (on the Footswitch Board) comprise the final stage in the audio system. The audio signal is AC coupled to the amplifier by C43 to eliminate the need for well-controlled input biasing. The U8 voltage gain is set to about 20 by floating its gain select pins. Because the U8 output signal is internally biased to Vcc/2, it is necessary to AC couple the speaker through C51 to prevent the amplifier from DC biasing the speaker.

The LO_TONE signal drives Q3 to change the gain of U8 to compensate (equalize) the volume for low frequency operation. This is required because the speaker (SP1) does not have flat frequency response between the cut tone and the coag tone.

Footswitch Decode Circuit

The Footswitch Board is mounted inside the rear panel of the Force 300. The 3-pin bipolar footswitch jack (J4) and the 4-pin monopolar footswitch jack (J1) are mounted on the board and extend through the rear panel. The footswitch decode circuit is located on the Power Supply/RF Board.

Footswitch activation causes current to flow through the LED section of an optical isolator (ISO1, ISO2, and ISO3). This current generates an IR beam that causes the corresponding photo-transistor to conduct. The signals from the collectors of the transistors are sent to the microcontroller where they activate the desired mode of operation.

As required by the IEC, the footswitch circuit is isolated from patient connected circuits and able to withstand a potential of 500 V rms (50/60 Hz). To obtain this isolation, the footswitch side of the circuitry is powered from an isolated power supply (U11). The isolated power supply, an HPR-107, operates from the ground referenced +12 V supply on the Power Supply/RF Board. Its output is an isolated 12 volts called +V_ISO_4.

The Control Board fault tests this circuit using the ISO_TST\ signal. The main microcontroller asserts ISO_TST\ to shut down U11 and discharge +V_ISO_4. Using comparators U7A, U7B, and U9A to gate Vref2 allows loopback testing of the footswitch activation circuits.

Since the Force 300 does not use a fan to cool the internal components, monitoring the internal air temperature is important. Under worst case conditions, it may be necessary to dissipate as much as 180 watts of heat via the convection cooling slots and surface areas.

A thermistor device (R13) in the temperature sense circuit measures the internal air temperature at the left rear corner of the Power Supply/RF Board. If the temperature exceeds 65° C, the main microcontroller receives a signal to indicate an over-temperature condition.

An error code displays on the front panel display that is not in use or in the *Cut* display. When the air temperature decreases to 60° C, operation returns to normal.

Thermal Sensing

A reference voltage is applied to the noninverting input of U2B (LM 393). The reference voltage is determined by R5, R6, R15, and R16. It is designed to be equal to the voltage at the inverting input of U2B when the thermistor is at 65° C.

At temperatures below 65° C, the output of U2B pin 7 is LOW. When the thermistor temperature exceeds the threshold, the voltage comparator changes state causing the output at U2B pin 7 to go HIGH (+5 Vdc). The HIGH is transmitted to the main microcontroller.

5

Setup, Tests, and Adjustments

After unpacking or after servicing the Valleylab Force 300, set it up and verify that it functions correctly.

If the generator does not satisfactorily complete the self-test, calibrate the generator to ensure its accuracy.

1. Turn off the generator by pressing the front panel off (O) switch.

Caution

Do not stack equipment on top of the Force 300 or place the generator on top of electrical equipment (except the Valleylab Force GSU Unit). These configurations are unstable and/or do not allow for adequate cooling.

2. Place the generator on any stable flat surface, such as a table, platform, or Valleylab cart.
   - Carts with conductive wheels are recommended. Refer to the procedures for your institution or to local codes for details.
   - Provide at least four to six inches of space from the sides and top of the generator for cooling. Normally, the top, sides, and rear panel are warm when the generator is used continuously for extended periods of time.
3. Ensure that the generator rests securely on the cart or platform. If necessary, adjust the placement of the feet on the Force 300.

   On the underside of the generator are four rubber feet and additional holes that allow you to reposition the feet to ensure stability. Use a Phillips screwdriver to remove the rubber feet from the generator. Then, reinstall the feet in the preferred location.

Notice

If required by local codes, connect the generator to the hospital equalization connector with an equipotential cable.

4. According to the procedures used by your institution, connect an equipotential grounding cable to the grounding lug on the rear panel of the generator. Then, connect the cable to earth ground.
5. Plug the generator power cord into the rear panel receptacle. Secure the cord to the rear panel using the screw and C clamp provided.

Warning

Electric Shock Hazard. Connect the generator power cord to a properly grounded receptacle. Do not use power plug adapters.

Warning

Fire Hazard. Do not use extension cords.

Notice

Connect the power cord to a wall receptacle having the correct voltage. Otherwise, product damage may result.

6. Plug the generator power cord into a grounded receptacle. Grasp the plug, not the power cord. Do not pull on the cord itself.

Periodic Safety Check

Perform the following safety check every six months to verify that the Force 300 Generator is functioning properly. Record the test results for reference in future tests. If the generator fails to meet any of the checks, refer to Section 6, *Troubleshooting*.

Important

When testing RF equipment, follow these test procedures to duplicate manufacturer test data. Keep test leads to the minimum length usable; lead inductance and stray capacitance can adversely affect readings. Carefully select suitable ground points to avoid ground loop error in measurements.

The accuracy of most RF instruments is approximately 1-5% of full scale. Using uncompensated scope probes causes large errors when measuring high voltage RF waveforms.

Warning

Electric Shock Hazard—When taking measurements or troubleshooting the generator, take appropriate precautions, such as using isolated tools and equipment, using the "one hand rule," etc.

Electric Shock Hazard—Do not touch any exposed wiring or conductive surfaces while the generator is disassembled and engerized. Never wear a grounding strap when working on an energized generator.

Caution

The generator contains electrostatic-sensitive components. When repairing the generator, work at a static-control workstation. Wear a grounding strap when handling electrostatic-sensitive components, except when working on an engerized generator. Handle circuit boards by their nonconductive edges. Use an antistatic container for transport of electrostatic-sensitive components and circuit boards.

The summary of safety checks are summarized below.

- Inspect the generator and accessories
- Inspect the internal components
- Test the generator
- Verify REM Function
- Confirm outputs
- Check leakage current and ground resistance

Recommended Test Equipment

- Digital voltmeter—Fluke 77 or 87, or equivalent
- True RMS voltmeter—Fluke 8920, or equivalent
- Oscilloscope—Tektronix 2445, or equivalent
- Leakage current tester—Use UL load device or commercially available leakage tester
- Leakage table—per IEC specifications

Inspecting the Generator and Accessories

Equipment

- bipolar footswitch or monopolar footswitch
- bipolar instrument cords (handswitching and footswitching)
- monopolar instrument cords (handswitching and footswitching)

1. Turn off (O) the generator by pressing the front panel power switch.
2. Disconnect the power cord from the wall receptacle.

Rear Panel

1. Check the rear panel footswitch receptacles for obstructions or damage. Check for a secure fit by inserting the bipolar footswitch or monopolar footswitch connector into the appropriate receptacle.
2. Remove the fuse and verify correct voltage and current rating. See *Performance Characteristics* in Section 3.

If either connection is loose, replace the footswitch board assembly. See *Footswitch Board Replacement* in Section 7.

Front Panel

1. Check the footswitch receptacle for obstructions or damage. Check for a secure fit by inserting the monopolar footswitch connector into the receptacle.

   If the connection is loose, replace the receptacle. See *Front Panel Footswitch Receptacle Replacement* in Section 7.

2. Check the bipolar instrument receptacle for obstructions or damage. Insert the bipolar instrument connector (footswitching and handswitching) into the appropriate receptacle to verify a secure fit.

   If the connection is loose, replace the front panel assembly. See *Front Panel Replacement* in Section 7.

6. Check the monopolar instrument receptacles for obstructions or damage. Insert the monopolar instrument connector (footswitching and handswitching) into the appropriate receptacle to verify a secure fit.

   If any of the connections are loose, replace the front panel assembly. See *Front Panel Replacement* in Section 7.

7. Check the patient return electrode receptacle for a broken pin or an obstruction. If the receptacle is damaged or obstructed, replace the front panel assembly. See *Front Panel Replacement* in Section 7.

Footswitch

1. Remove the footswitch from the generator.
2. Disassemble the footswitch connector. Inspect the connector for damage or corrosion.
3. Reassemble the footswitch connector.
4. Inspect the footswitch for damage.
5. Reconnect the footswitch to the generator.

Power Cord

1. Remove the power cord from the unit and ensure that it is unplugged from the wall receptacle.
2. Inspect the power cord for damage.
3. Reconnect the power cord to the generator and wall receptacle.

Inspecting the Internal Components

Equipment

- Phillips screwdriver

Caution

The generator contains electrostatic-sensitive components. When repairing the generator, work at a static-control workstation. Wear a grounding strap when handling electrostatic-sensitive components, except when working on an energized generator. Handle circuit boards by their nonconductive edges. Use an antistatic container for transport of electrostatic-sensitive components and circuit boards.

1. Turn off (O) the generator by pressing the front panel power switch.
1. Loosen the 4 screws that secure the cover to the chassis. Lift the cover off the chassis. Set the cover aside for reinstallation.
2. Verify that all connectors are firmly seated.
3. Inspect each board for damaged components, wires, cracks, and corrosion.
    - If you find evidence of damage on the Control Board, Display Board, or Footswitch Board, replace the board. See *Control Board Replacement*, *Display Board Replacement*, or *Footswitch Board Replacement* in Section 7.
    - If you find evidence of damage on the Power Supply/RF Board, replace the board only if the damage is severe. Refer to *Power Supply/RF Board Replacement* in Section 7.
4. Reinstall the cover on the generator. Position the cover above the chassis and slide it down. Tighten the four screws that secure the cover to the chassis.

Testing the Generator

Turning on the generator initiates an internal self-test to verify the calibration. The self-test also checks the operation of the speaker, all indicators, and the displays.

Important

When testing RF equipment, follow these test procedures to duplicate manufacturer test data. Keep test leads to the minimum length usable; lead inductance and stray capacitance can adversely affect readings. Carefully select suitable ground points to avoid ground loop error in measurements.

The accuracy of most RF instruments is approximately 1-5% of full scale. Using uncompensated scope probes causes large errors when measuring high voltage RF waveforms.

Warning

Use the generator only if the self-test has been completed as described. Otherwise, inaccurate power outputs may result.

1. Turn on the generator by pressing the front panel on (I) switch. Verify the following:
   - All visual indicators and displays on the front panel illuminate.
   - Activation tones sound to verify that the speaker is working properly.

Caution

Do not turn the activation tone down to an inaudible level. The activation tone alerts personnel when an accessory is active.

2. If the test is successful, a tone sounds. Verify the following:
   - Indicators on the selected mode buttons (*pure* and *desiccate*) illuminate green.
   - The right (→) footswitch button indicator illuminates green.
   - Each digital display shows a power setting of 1 watt.

3. If the test is not successful, an alarm tone sounds. A number may momentarily appear in the ***Cut*** display and, in most cases, RF output is disabled.

   If the generator is <u>not</u> calibrated, calibrate it and retest the generator.

   If the generator is calibrated, note the number and refer to *Responding to System Alarms* in Section 6.

Verifying REM Function

Equipment

- REM Patient Return Electrode

1. Plug the REM connector into the REM patient return electrode receptacle on the front panel.
2. Plug a monopolar handswitching instrument to ***multipin*** receptacle on the front panel.
3. Activate the generator at maximum power.
4. Remove the REM connector from the front panel, and verify that REM alarm sounds.
5. Repeat for each monopolar output and mode.
6. If the REM alarm does not sound for each monopolar output and mode, then calibrate the generator as described in calibration step 4.

Confirming Outputs

Equipment

- two small test cables (less than 24 inches long) with banana plugs
- current transformer
- true RMS voltmeter (such as the Fluke 8920 or equivalent)
- 100, 300, and 500 ohm 1% noninductive power resistors
- bipolar footswitch and monopolar footswitch

Checking the Bipolar Output

1. Verify that the generator successfully completes the self-test as described in *Testing the Generator*.
2. Connect the test equipment for bipolar output.
   a. Connect the two test cables to the ***Bipolar*** receptacle.
   b. Pass one test cable through the current transformer and connect the current transformer to the voltmeter.
   c. Connect the **100 ohm** power resistor across the output jacks at the end of the test cables.
   d. Connect the bipolar footswitch to the ***Bipolar Footswitch*** receptacle on the rear panel.
3. Set the bipolar power to 10.
4. Test the output current for the selected bipolar mode.
   a. Press the footswitch pedal and, while activating the generator, note the output on the voltmeter.
   b. Release the footswitch pedal.
   c. Based on the voltmeter setting and the current transformer you are using, calculate and record the output current.
5. Verify that the generator output for each mode is **316 ± 32 mA rms**.

   If the output is outside the specified range, calibrate the generator as described in calibration steps 5, 6, 7, and 8. Then repeat this procedure. If the output remains outside the specified range, call the Valleylab Service Center.

Checking the Monopolar Output

Step 1 – Check the output for the cut modes.

1. Verify that the generator successfully completes the self-test as described in *Testing the Generator.*
2. Connect the test equipment for monopolar output.
   a. Connect one test cable to the left receptacle in the ***Multipin*** receptacle. Pass the test cable through the current transformer and connect the current transformer to the voltmeter.
   b. Connect the second test cable to both pins of the Patient Return Electrode receptacle.
   c. Connect the **300 ohm** resistor across the output receptacles at the end of the test cables.
   d. Connect the monopolar footswitch to the footswitch receptacle on the front panel of the generator.
3. Press the pure mode button.
4. Set the cut power to 80 watts.
5. Test the monopolar cut output.
   a. Press the footswitch cut pedal and, while activating the generator, note the output on the voltmeter.
   b. Release the footswitch pedal.
   c. Based on the voltmeter setting and the current transformer you are using, calculate and record the output current.
7. Press the blend mode button and repeat step 5.
8. Verify that the generator output for each mode is **516 ± 52 mA rms**.

   If the output is outside the specified range, calibrate the generator as described in calibration steps 5, 6, 7, and 8. Then repeat this procedure. If the output for one or more cut modes remains outside the specified range, call the Valleylab Service Center.

Checking the Monopolar Output

Step 2 – Check the output for the coag modes.

1. Press the desiccate mode button.
2. Set the coag power to 80 watts.
3. Test the monopolar coag output.
   a. Press the footswitch coag pedal and, while activating the generator, note the output on the voltmeter.
   b. Release the footswitch pedal.
   c. Based on the voltmeter setting and the current transformer you are using, calculate and record the output current.
4. Verify that the generator output for desiccate is **516 ± 52 mA rms**.
5. Connect the **500 ohm** resistor across the output receptacles at the end of the test cables.
6. Press the fulgurate mode button.
7. Repeat step 3.
8. Verify that the generator output for fulgurate is **400 ± 40 mA rms**

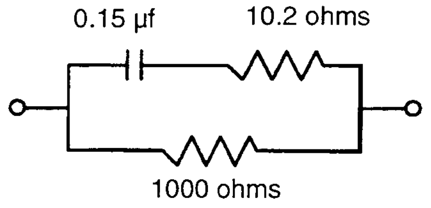
   If the outputs are outside the specified ranges, calibrate the generator as described in calibration steps 5, 6, 7, and 8. Then repeat this procedure. If the output for one or more coag modes remains outside the specified range, call the Valleylab Service Center.

Checking Leakage Current and Ground Resistance

Check the leakage current and ground resistance before returning the Force 300 generator to clinical use.

Equipment Required

- DVM
- Leakage current tester



Leakage Current Test Circuit

Output Receptacles and REM Source Current

1. Set the DVM to AC volts (200 mV) and connect the leakage current test circuit.
2. Turn on the generator.
3. Measure between all the output receptacles (including the REM Patient Return Electrode receptacle) and earth ground. Record the largest reading.
4. Determine the leakage current using the conventional 1 microamp per 1 millivolt.
5. Verify under normal conditions (ground closed, normal polarity) the leakage current is less than 10 microamps. If the leakage current is greater than 10 microamps, call the Valleylab Service Center.
6. Verify single fault conditions (ground open) the leakage current is less than or equal to 50 microamps. If the leakage current is greater then 50 microamps, call the Valleylab Service Center.

Chassis or Earth Leakage

1. Set the DVM to AC volts (200 mV) and connect the leakage current test circuit.
2. Turn on the generator.
3. Measure between between the chassis and earth ground.
4. Determine the leakage current using the conventional 1 microamp per 1 millivolt.
5. Verify under normal conditions (ground closed, normal polarity) the leakage current is less than 100 microamps. If the leakage current is greater than 100 microamps, call the Valleylab Service Center.
6. Verify single fault conditions (ground open) the leakage current is less than or equal to 300 microamps. If the leakage current is greater than 300 microamps, call the Valleylab Service Center.

Output Receptacles and REM Sink Current

1. Set the DVM to AC volts (200 mV) and connect the leakage current test circuit.
2. Turn on the generator at 220 Vac and connect the end of the leakage current test circuit to 220 volts through a 120 kΩ resistor.
3. Connect the other side of the IEC leakage load to all of the output receptacles (including the REM Patient Return Electrode receptacle)
4. Determine the leakage current using the conventional 1 microamp per 1 millivolt.
5. Verify the leakage current is less than or equal to 20 microamps. If the leakage current is greater than 10 microamps, call the Valleylab Service Center.

The calibration procedure consists of nine steps. During calibration you verify information specific to the Force 300, adjust the calendar, and adjust the clock. You also adjust the REM circuit and several values, or factors, that ensure the proper operation of the generator.

The calibration steps and the values you can adjust are summarized below. Certain values are not adjustable, but must be verified.

Notice

After completing any calibration step, proceed to the next step to save the values from the completed calibration step.

Calibration Step and Description		Adjustable?
1	Force 300 data	
	Generator model number	No (verify value)
	Master microcontroller software version	No (verify value)
	Feedback microcontroller software version	No (verify value)
2	Calendar	
	Day	Yes
	Month	Yes
	Year	Yes
3	Clock	
	Hour	Yes
	Minute	Yes
4	REM impedance	No (verify values)
5	Current sense gain factor	Yes
6	Voltage sense gain factor	Yes
7	Reactance gain factor	Yes
8	ECON factor	No
9	Coag leakage	Yes

Preparing for Calibration

You will need the equipment listed below to calibrate the Force 300:

- bipolar footswitch and monopolar footswitch
- REM plug and resistor substitution box
- two small test cables (less than 24 inches long) with banana plugs
- current transformer (such as the Pearson Model 411 or equivalent)
- true RMS voltmeter (such as the Fluke 8920A or equivalent)
- noninductive power resistors (such as a Dale NH-250) with these values (in ohms): 10, 30, 50, 100, 200, 300, 500, 1000, and 2000.

  If these exact values are not available, you may substitute series or parallel combinations of other values.
- X1000 high voltage scope probe (TEK P6015A or equivalent)
- oscilloscope (Tek 2445B or equivalent)

Entering Calibration Mode

When you are in calibration mode, the calibration step number appears in the ***Bipolar*** display. The value(s) associated with each calibration step appear in the ***Cut*** and ***Coag*** displays. You use the cut and coag power control knobs to adjust the displayed values.

1. If the generator is off, turn it on.

   If you removed and/or replaced the battery, alarm number 212 will appear in the ***Cut*** display the first time you turn on the generator.
2. To enter calibration mode, simultaneously press the *footswitch*, *pure*, and *desiccate* buttons.

   The first calibration step number (1) appears in the ***Bipolar*** display. For instructions on completing this step, refer to *Calibration Step 1 – Verify the Force 300 data.*

If an error occurs during calibration, an alarm number will appear in the *Cut* display. Note the number and refer to *Responding to System Alarms* in Section 6 for the appropriate action to take.

Notice

After completing any calibration step, proceed to the next step to save the values from the completed calibration step.

Exiting Calibration Mode

You can exit calibration mode at any time. If you want to save the new values for a particular calibration step, you must turn the bipolar knob to the next step before exiting calibration mode. Calibration values are saved one step at a time.

For example, if you only want to adjust the clock, first enter calibration mode and turn the bipolar knob until calibration step number 3 is displayed. Next, change the hour and minute values. Then, turn the bipolar knob clockwise once (to the next step). This saves the changes for step 3 and displays the next calibration step number (4). After saving the changes, turn off the generator to exit calibration mode.

If you do not want to save the changes you make for a particular calibration step, turn off the generator (do not turn the bipolar knob at the end of the step). The values that were in effect before you started that step remain in effect.

Notice

After calibration, the generator will be ready to use only after you initiate the internal self-test by turning the generator off, then on.

To save the changes for the present calibration step, turn the bipolar knob clockwise until the next calibration step number appears in the *Bipolar* display. Then, turn off the generator to exit calibration mode.

or

To exit calibration mode without saving the changes for the present calibration step, turn off the generator.

Calibration Step 1 – Verify the Force 300 data.

In calibration step 1, you verify the Force 300 model number and the software version numbers for the main and feedback microcontrollers. You cannot adjust these values.

- The generator code (model number) for the Force 300 is *300*.
- The software version number for the main microcontroller may vary among manufacturing lots, but should *never* be zero (0).
- The software version number for the feedback microcontroller may vary among manufacturing lots, but should *never* be zero (0).

If one or more of the values that appear as you proceed through this calibration step are not correct, call the Valleylab Service Center.

1. In the ***Bipolar*** display, verify that the calibration step number is 1.
2. In the ***Cut*** display, verify that the Force 300 model number (300) is displayed.
3. In the ***Coag*** display, verify that the main microcontroller version number is a value other than zero (0).
4. To display the feedback microcontroller version number, press the *fulgurate* button. Verify that the version number in the ***Coag*** display is a value other than zero (0).
5. To proceed to the next calibration step, turn the bipolar knob clockwise until 2 is shown in the ***Bipolar*** display.

   At the end of each calibration step, turn the bipolar knob clockwise to advance to the next step. If you need to return to a previous calibration step, turn the bipolar knob counterclockwise.

Next, check the month, day, and year values as described in *Calibration Step 2 – Adjust the calendar.*

Calibration Step 2 – Adjust the calendar.

The month, date (day of the month), and year values are stored in the real-time clock on the Control Board. Use the coag knob on the front panel to adjust these values.

- To increase the displayed value, turn the coag knob clockwise.
- To decrease the value, turn the coag knob counterclockwise.

1. Verify that the ***Bipolar*** display shows calibration step number 2.
2. To select the day, turn the coag knob until the correct value (1–31) appears in the ***Coag*** display.
3. To display the month value, press the *desiccate* button once. (The *desiccate* button cycles through the day, month, and year values.)

   To select the month, turn the coag knob until the correct value (1–12) appears in the ***Coag*** display.

4. To display the year value, press the *desiccate* button once.

   To select the year, turn the coag knob until the correct value (0–99) appears in the ***Coag*** display.

   Examples:

   - For 1997, set the year value to 97.
   - For 2001, set the value to 1.

5. To save the day, month, and year values and go to the calibration step 3, turn the bipolar knob clockwise.

Next, check the hour and minute values as described in *Calibration Step 3 – Adjust the clock.*

Calibration Step 3 – Adjust the clock.

The hour and minute values are stored in the real-time clock on the Control Board. The clock was originally set for Mountain Standard Time at Boulder, Colorado, USA. The clock is configured to the 24-hour (i.e., military time) format.

1. Verify that the ***Bipolar*** display shows calibration step number 3.
2. To select the hour, turn the coag knob until the correct value (0–23) appears in the *Coag* display.

   Examples:
   - For 2 AM, set the hour value to 2.
   - For 2 PM, set the value to 14.

3. To display the minute value, press the *desiccate* button once. (The *desiccate* button cycles through the hour and minute values.)

   To select the minute value, turn the coag knob until the correct value (0–59) appears in the *Coag* display.

4. To save the hour and minute values and go to calibration step 4, turn the bipolar knob clockwise.

Next, check the REM impedance as described in *Calibration Step 4 – Check the REM impedance.*

Calibration Step 4 – Check the REM impedance.

Equipment

- two short test cables (less than 24 inches long) with banana plugs
- REM plug
- resistor substitution box

1. Verify that the ***Bipolar*** display shows calibration step number 4.
2. Connect the REM plug and the resistor substitution box to the REM patient return electrode receptacle on the front panel.
3. Verify that the ***Coag*** display shows 135.
4. Set the resistor substitution box to 135 ohms.
   a. Turn the coag knob clockwise once. The display will flash 135 for a few seconds while the REM frequency is adjusted.
   b. After the flashing stops, verify that 70 appears in the ***Coag*** display.
5. Set the resistor substitution box to 70 ohms.
   a. Turn the coag knob clockwise once.
   b. Verify that 10 appears in the ***Coag*** display.
6. Set the resistor substitution box to 10 ohms.
   a. Turn the coag knob clockwise once.
   b. Verify that **OP** appears in the ***Coag*** display.
7. Set the resistor substitution box to the **open** position.
8. To save the REM calibration values and go to calibration step 5, turn the bipolar knob clockwise.
9. Remove the REM plug and resistor substitution box.

Next, check the current sense gain factor as described in *Calibration Step 5 – Check and adjust the current sense gain.*

Calibration Step 5 – Check and adjust the current sense gain.

Equipment

- two short test cables (less than 24 inches long) with banana plugs
- current transformer (such as the Pearson Model 411 or equivalent)
- true RMS voltmeter (such as the Fluke 8920 or equivalent)
- 10 ohm noninductive power resistor (such as the Dale NH-250)
- bipolar footswitch and monopolar footswitch

Checking the Current Sense Gain for Bipolar Output

mportant

When testing RF equipment, follow these test procedures to duplicate manufacturer test data. Keep test leads to the minimum length usable; lead inductance and stray capacitance can adversely affect readings. Carefully select suitable ground points to avoid ground loop error in measurement.

The accuracy of most RF instruments is approximately 1-5% of full scale. Using uncompensated scope probes causes large errors when measuring high voltage RF waveforms.

Caution

To avoid inadvertent coupling and/or shunting of RF currents around the resistor elements, keep the resistors at least four inches (10.2 cm) away from any metal surface including tabletops and other resistors. This is especially true if several resistors are connected in series or parallel to obtain a specified value. Do not allow the resistor bodies to touch each other.

Notice

Do not activate the generator with any load resistor *higher* than 10 ohms while calibrating the current sense gain. Otherwise, product damage will result.

1. Verify that the ***Bipolar*** display shows calibration step number 5.

   The ***Cut*** and ***Coag*** displays show the I (current) factor. If it is four or more digits, the most significant digits appear in the ***Cut*** display.

2. Connect the test equipment for bipolar output.

   a. Connect the two test cables to the bipolar instrument receptacle.

   b. Pass one test cable through the current transformer and connect the current transformer to the voltmeter.

   c. Connect the **10 ohm** resistor across the output jacks at the end of the test cables.

   d. Connect the bipolar footswitch to the rear panel.
   or
   Connect the monopolar footswitch to the front panel and press the footswitch button to select bipolar (←) output.

Calibration Step 5 – Check and adjust the current sense gain.

Checking the Current Sense Gain for Bipolar Output

3. Check and adjust the I factor for bipolar output.

   a. Verify the left (←) footswitch button indicator illuminates green.

   b. Press the footswitch pedal and check the voltmeter for a reading equivalent to 1.50 +0/–.03 A_{rms} **(1.47 to 1.50 A_{rms})**.

   c. Stop activation. If the output current was not within the stated range, adjust the I factor. Use the coag knob for small adjustments and the cut knob for larger adjustments.

      Approach the value from the low side to give consistent calibration results. Adjust the I factor until the current is as close as possible to 1.50 A_{rms}, but not over 1.50 A_{rms}.

   Repeat 3a and 3c until the output current is within the stated range.

4. Disconnect the test cables from bipolar output.

Calibration Step 5 – Check and adjust the current sense gain.

Checking the Current Sense Gain for Monopolar Output

1. Connect the test equipment for monopolar output.
   a. Connect the test cables to the *multipin* monopolar receptacle.
   b. Verify that the **10 ohm** resistor is connected to the test cables through the current transformer.
   c. Connect a monopolar footswitch to the monopolar footswitch receptacle on the rear panel.
2. Check and adjust the I factor for the *pure* mode.
   a. Press the *pure* button.
   b. Press the footswitch cut pedal and check the voltmeter for a reading equivalent to 1.25 +0/–.025 Arms **(1.225 to 1.25 Arms)**.
   c. Stop activation. If the output current was not within the stated range, use the cut and coag knobs to adjust the I factor.

      Approach the value from the low side. Adjust until the current is as close as possible to 1.25 Arms, but not over 1.25 Arms.

   Repeat 2b and 2c until the output current is within the stated range.
3. Check and adjust the I factor for the *blend* mode.
   a. Press the *blend* button.
   b. Press the footswitch cut pedal and check the voltmeter for a reading equivalent to 1.0 +0/–.02 Arms **(0.98 to 1.0 Arms)**.
   c. Stop activation. If the output current was not within the stated range, use the cut and coag knobs to adjust the I factor.

      Approach the value from the low side. Adjust until the current is as close as possible to 1.0 Arms, but not over 1.0 Arms.

   Repeat 3b and 3c until the output current is within the stated range.
4. Disconnect the test cables and the 10 ohm resistor from monopolar output.
5. To save the current sense gain calibration and go to calibration step 6, turn the bipolar knob clockwise.

Next, check the voltage sense gain factor as described in *Calibration Step 6 – Check and adjust the voltage sense gain.*

Calibration Step 6 – Check and adjust the voltage sense gain.

Equipment

- two short test cables (less than 24 inches long) with banana plugs
- current transformer (such as the Pearson Model 411 or equivalent)
- true RMS voltmeter (such as the Fluke 8920 or equivalent)
- 750, 3000, and 2000 ohm noninductive power resistors (such as the Dale NH-250)
- bipolar footswitch and monopolar footswitch

Checking the Voltage Sense Gain for Bipolar Output

Notice

Do not activate the generator with any load resistor *lower* than 750 ohms while calibrating the voltage sense gain for bipolar output. Otherwise, product damage will result.

1. Verify that the ***Bipolar*** display shows calibration step number 6.

   The ***Cut*** and ***Coag*** displays show the V (output voltage) factor. If it is four or more digits, the most significant digits are in the ***Cut*** display.

2. Connect the test equipment for bipolar output.

   a. Connect the two test cables to the bipolar instrument receptacle.

   b. Pass one test cable through the current transformer and connect the current transformer to the voltmeter.

   c. Connect the resistors in series to achieve a **750 ohm** load across the output jacks at the end of the test cables.

   d. Connect the bipolar footswitch to the rear panel.
   or
   Connect the monopolar footswitch to the front panel and press the footswitch button to select bipolar (⟵) output.

3. Check and adjust the V factor for bipolar output.

   a. Verify the left (⟵) footswitch button indicator illuminates green.

   b. Press the footswitch pedal and check the voltmeter for a reading equivalent to 0.252 +0/–.005 Arms **(0.247 to 0.252 Arms)**.

   c. Stop activation. If the output current was not within the stated range, adjust the V factor. Use the coag knob for small adjustments and the cut knob for larger adjustments.

   Approach the value from the low side to give consistent calibration results. Adjust until the current is as close as possible to 0.252 Arms, but not over 0.252 Arms.

   Repeat 3a and 3c until the output current is within the stated range.

4. Disconnect the test cables and remove the resistors.

Calibration Step 6 – Check and adjust the voltage sense gain.

Checking the Voltage Sense Gain for Monopolar Output

Notice

Do not activate the generator with any load resistor *lower* than 3000 ohms while calibrating the voltage sense gain for the *pure* cut mode. Do not activate the generator with any load resistor *lower* than 2000 ohms while calibrating the voltage sense gain for the *blend* mode. Otherwise, product damage will result.

1. Connect the test equipment for monopolar output.
   a. Connect the test cables to the *multipin* monopolar receptacle.
   b. Connect the resistors in series to achieve a **3000 ohm** load. Ensure that one test cable passes through the current transformer.
   c. Connect a monopolar footswitch to the monopolar footswitch receptacle on the rear panel.

2. Check and adjust the V factor for the *pure* mode.
   a. Press the *pure* button.
   b. Press the footswitch cut pedal and check the voltmeter for a reading equivalent to 0.217 +0/–.004 Arms **(0.213 to 0.217 Arms)**.
   c. Stop activation. If the output current was not within the stated range, use the cut and coag knobs to adjust the V factor.

      Approach the value from the low side. Adjust until the current is as close as possible to 0.217 Arms, but not over 0.217 Arms.

   Repeat 2b and 2c until the output current is within the stated range.

3. Replace the 3000 ohm load with the **2000 ohm** resistor.
4. Check and adjust the V factor for the *blend* mode.
   a. Press the *blend* button.
   b. Press the footswitch cut pedal and check the voltmeter for a reading equivalent to 0.300 +0/–.006 Arms **(0.294 to 0.300 Arms)**.
   c. Stop activation. If the output current was not within the stated range, use the cut and coag knobs to adjust the V factor.

      Approach the value from the low side. Adjust until the current is as close as possible to 0.300 Arms, but not over 0.300 Arms.

   Repeat 4b and 4c until the output current is within the stated range.

5. Disconnect the test cables and remove the 2000 ohm resistor from monoploar output.

6. To save the voltage sense gain calibration and go to calibration step 7, turn the bipolar knob clockwise.

Next, check the reactance gain factor as described in *Calibration Step 7 – Check and adjust the reactance gain.*

Calibration Step 7 – Check and adjust the reactance gain.

Equipment

- two short test cables (less than 24 inches long) with banana plugs
- current transformer (such as the Pearson Model 411 or equivalent)
- true RMS voltmeter (such as the Fluke 8920 or equivalent)
- 50 and 200 ohm noninductive power resistors (such as the Dale NH-250)
- bipolar footswitch and monopolar footswitch

Checking the Reactance Gain for Bipolar Output

1. Verify that the ***Bipolar*** display shows calibration step number 7.

   The ***Cut*** and ***Coag*** displays show the Z (reactance) factor. If it is four or more digits, the most significant digits appear in the ***Cut*** display.

2. Connect the test equipment for bipolar output.

   a. Connect the two test cables to the bipolar instrument receptacle.

   b. Pass one test cable through the current transformer and connect the current transformer to the voltmeter.

   c. Connect the **50 ohm** resistor across the output jacks at the end of the test cables.

   d. Connect the bipolar footswitch to the rear panel.
   or
   Connect the monopolar footswitch to the front panel and press the footswitch button to select bipolar (←) output.

3. Adjust the Z factor for bipolar output.

   Note: Start with a low Z factor and increase it only until you obtain the the desired current. Do not continue to increase it beyond where you first note the correct output current.

   a. Press the footswitch pedal and check the voltmeter for a reading equivalent to 1.15 +0/–.023 Arms **(1.127 to 1.150 Arms)**.

   b. Stop activation. If the output current was not within the stated range, adjust the Z factor. Use the coag knob for small adjustments and the cut knob for larger adjustments.

   Start with a low value. Adjust until the current is as close as possible to 1.15 Arms, but not over 1.15 Arms.

Repeat 3a and 3b until the output current is within the stated range.

4. Disconnect the test cables and remove the 50 ohm resistor.

Calibration Step 7 – Check and adjust the reactance gain.

Checking the Reactance Gain for Monopolar Output

1. Connect the test equipment for monopolar output.
   a. Connect the test cables to the *multipin* monopolar receptacle.
   b. Connect the **200 ohm** resistor to the test cables through the current transformer.
   c. Connect a monopolar footswitch to the monopolar footswitch receptacle on the rear panel.

2. Adjust the Z factor for the *pure* mode.

   Note: Start with a low Z factor and increase it only until you obtain the the desired current. Do not continue to increase it beyond where you first note the correct output current.

   a. Press the *pure* button.
   b. Press the footswitch cut pedal and check the voltmeter for a reading equivalent to 0.94 +0/–.02 Arms **(0.92 to 0.94 Arms)**.
   c. Stop activation. If the output current was not within the stated range, use the cut and coag knobs to adjust the Z factor.

      Start with a low value. Adjust until the current is as close as possible to 0.94 Arms, but not over 0.94 Arms.

   Repeat 2b and 2c until the output current is within the stated range.

3. Adjust the Z factor for the *blend* mode.

   Note: Start with a low Z factor and increase it only until you obtain the the desired current. Do not continue to increase it beyond where you first note the correct output current.

   a. Press the *blend* button.
   b. Press the footswitch cut pedal and check the voltmeter for a reading equivalent to 1.000 +0/–.02 Arms **(0.98 to 1.00 Arms)**.
   c. Stop activation. If the output current was not within the stated range, use the cut and coag knobs to adjust the Z factor.

      Start with a low value. Adjust until the current is as close as possible to 1.00 Arms, but not over 1.00 Arms.

   Repeat 3b and 3c until the output current is within the stated range.

4. Disconnect the test cables and remove the 200 ohm resistor from monopolar output.

5. To save the reactance gain calibration and go to calibration step 8,

turn the bipolar knob clockwise.

Next, go to *Calibration Step 8 – Check and adjust the ECON factor.*

Calibration Step 8 – Check and adjust the ECON factor.

Equipment

- two short test cables (less than 24 inches long) with banana plugs
- current transformer (such as the Pearson Model 411 or equivalent)
- true RMS voltmeter (such as the Fluke 8920 or equivalent)
- 30, 100, and 500 ohm noninductive power resistors (such as the Dale NH-250)
- bipolar footswitch and monopolar footswitch

Checking Bipolar Output

1. Verify that the ***Bipolar*** display shows calibration step 8.
2. Connect the test equipment for bipolar output.
   a. Connect the two test cables to the bipolar instrument receptacle.
   b. Connect the **30 ohm** resistor across the output jacks at the end of the test cables.
   c. Connect the bipolar footswitch to the rear panel.
   or
   Connect the monopolar footswitch to the front panel and press the footswitch button to select bipolar (⟵) output.
3. Check the bipolar output.
   a. Verify that the ***Coag*** display shows 30 watts.
   b. Using the bipolar footswitch, activate bipolar output for 2 to 5 seconds.
   c. Stop activation. Verify that the ***Coag*** display changed to 70 watts.
   d. Activate bipolar output again for 2 to 5 seconds. Stop activation. Verify that the ***Coag*** display changed to 30 watts.
4. Disconnect the test cables and remove the 30 ohm resistor.

Calibration Step 8 – Check and adjust the ECON factor.

Checking Monopolar Cut Output

1. Connect the test equipment for monopolar output.
   a. Connect the test cables to the *multipin* monopolar receptacle.
   b. Connect the **100 ohm** resistor to the test cables.
   c. Connect a monopolar footswitch to the monopolar footswitch receptacle on the rear panel.

2. Check the pure output.
   a. Press the *pure* cut button.
   b. Verify that the *Coag* display shows 30 watts.
   c. Press the cut pedal to activate monopolar output for 2 to 5 seconds.
   d. Stop activation. Verify that the *Coag* display changed to 300.
   e. Press the cut pedal again for 2 to 5 seconds. Stop activation. Verify that the *Coag* display changed to 30.

3. Check the blend output.
   a. Press the *blend* button.
   b. Verify that the *Coag* display shows 30 watts.
   c. Press the cut pedal to activate monopolar output for 2 to 5 seconds.
   d. Stop activation. Verify that the *Coag* display changed to 200.
   e. Press the cut pedal again for 2 to 5 seconds. Stop activation. Verify that the *Coag* display changed to 30.

Checking Monopolar Coag Output

1. Verify that the **100 ohm** resistor is connected to the test cables for monopolar output from the *multipin* receptacle.
2. Check the desiccate output.
   a. Press the *desiccate* button.
   b. Verify that the *Coag* display shows 10 watts.
   c. Press the coag pedal and activate monopolar output for 2 to 5 seconds.
   d. Stop activation. Verify that the *Coag* display changed to 300.
   e. Press the coag pedal again for 2 to 5 seconds. Stop activation. Verify that the *Coag* display changed to 10.
3. Remove the 100 ohm resistor from the test cables and set up the equipment to check the output current.
   a. Verify that the test cables are connected to the *multipin* receptacle.
   b. Pass one test cable through the current transformer and connect the current transformer to the voltmeter.
   c. Connect the **500 ohm** resistor to the test cables.
4. Press the *fulgurate* button. Verify that the *Coag* display shows 10 watts.
5. Adjust the ECON factor.
   a. Press the coag pedal and, while activating the generator, use the coag knob to adjust the output current to 0.141 +0/–.003 Arms **(0.138 to 0.141 Arms)**. Do not exceed 0.141 Arms.
   b. Stop activation. Verify that the *Coag* display changed to 120.
   c. Press the coag pedal again and, while activating the generator, use the coag knob to adjust the output current to 0.489 +0/–.010 Arms **(0.479 to 0.489 Arms)**. Do not exceed 0.489 Arms.
   d. Stop activation. Verify that the *Coag* display changed to 10.
6. Remove the 500 ohm resistor and disconnect the test equipment.
7. To save the ECON calibration values and go to calibration step 9, turn the bipolar knob clockwise.

Next, go to *Calibration Step 9 – Check and adjust the coag leakage.*

Calibration Step 9 – Check and adjust the coag leakage.

Equipment

- two short test cables (less than 24 inches long) with banana plugs
- X1000 high voltage scope probe (TEK P6015A or equivalent)
- oscilloscope (Tek 2445B or equivalent)
- 2000 and 300 ohm noninductive power resistors (such as the Dale NH-250)
- monopolar footswitch

1. Verify that the ***Bipolar*** display shows calibration step 9.

   The coag leakage value appears in the ***Coag*** display.

2. Set up the test equipment to monitor the coag waveform.
   a. Connect the test cables to the *multipin* monopolar receptacle.
   b. Connect the **2000 ohm** resistor to the test cables.
   c. Connect the high voltage probe to the resistor and to the oscilloscope. Set the oscilloscope timebase to 20 µsec/division.
   d. Connect a monopolar footswitch to the monopolar footswitch receptacle on the rear panel.

3. Press the footswitch coag pedal and, while activating the generator, observe the *fulgurate* waveform on the oscilloscope for a damped 480 kHz sinusoid at a 57 kHz repetition rate.

   Turn the coag knob to adjust the value in the ***Coag*** display until there is no evidence of missing pulses. Select the lowest value that gives the desired result.

4. Replace the 2000 ohm resistor with the **300 ohm** resistor. Check the oscilloscope to verify that there is still no evidence of missing pulses.
5. Open circuit the output. Verify that there are missing fulgurate pulses and bursts of 2 to 3 pulses during an 86 microsecond period.

   If necessary, turn the coag knob to adjust the value in the ***Coag*** display. Increase the value for fewer missing pulses. Decrease the value for more missing pulses. Select the lowest value that gives the desired result.

6. If necessary, replace the 300 ohm resistor with the **2000 ohm** resistor and repeat steps 3–5 until you achieve the desired result.
7. Turn the bipolar knob clockwise until number 1, which represents the first calibration step, appears in the ***Bipolar*** display.

To leave calibration mode, refer to *Exiting Calibration Mode* earlier in this section.

Notes

6 Troubleshooting

If the generator is not functioning properly, use the information in this section to perform the following:

- Identify and correct the malfunction.
- If a system alarm number was displayed, take the appropriate action to correct the alarm condition.

Inspecting the Generator

If the generator malfunctions, first check for obvious conditions that may have caused the problem.

- Check the generator for visible signs of physical damage.
- Verify that all accessory cords are properly connected.
- Check the power cord. Replace the power cord if you find exposed wires, cracks, frayed insulation, or a damaged connector.
- Open the fuse drawer and inspect the fuse housing and fuses for damage and corrosion. Verify that the fuses are firmly seated.

An internal component malfunction in the generator can damage the fuses. You may need to replace the fuses if the generator fails the self-test or stops functioning. See *Fuse Replacement* in Section 7.

If the solution is not readily apparent, use the table below to help you identify and correct specific malfunctions. After taking action to correct the malfunction, verify that the generator completes the self-test as described in Section 5

Situation	Possible Cause	Recommended Action
Generator does not respond when turned on.	1. Disconnected power cord, faulty wall receptacle, or faulty power cord.	1. Check power cord connections (generator and wall receptacle). Connect the power cord to a functional receptacle. If necessary, replace the power cord.
	2. Fuse drawer is open or fuses are blown.	2. Close the fuse drawer. If necessary, replace the fuse(s). Fuses should be 4.0 A (220–240 V operation) or 8.0 A (110 V operation). Refer to *Fuse Replacement* in Section 7.
	3. Loose or disconnected internal cables.	3. Check all internal connections.
	4. Faulty power entry module or connections.	4. Check the power entry module and its cable connections.
	5. Faulty low voltage power supply.	5. Check the low voltage power supply.
	6. Damaged Control Board connectors and/or malfunctioning Control Board.	6. Remove the Control Board and inspect the connectors to the Power Supply/RF Board and to the Display Board for damage, poor seating, etc. If the problem persists, replace the Control Board. For instructions, see *Control Board Replacement* in Section 7.
	7. Shorts or disconnects on Power Supply/RF Board.	7. Check the Power Supply/RF Board for shorts or disconnects.
	8. Faulty power switch.	8. Replace the power switch. See *Front Panel Power Switch Replacement* in Section 7.
	9. Malfunctioning front panel components.	9. Replace the front panel assembly. See *Front Panel Replacement* in Section 7.

Situation	Possible Cause	Recommended Action
Generator is on, but did not complete the self-test.	1. Software malfunction.	1. Turn off, then turn on the generator.
	2. Loose or disconnected internal cables.	2. Check and correct all internal connections.
	3. Faulty low voltage power supply.	3. Check the low voltage power supply.
	4. Damaged Control Board connectors and/or malfunctioning Control Board.	4. Remove the Control Board and inspect the connectors to the Power Supply/RF Board and to the Display Board for damage, poor seating, etc. If the problem persists, replace the Control Board. For instructions, see *Control Board Replacement* in Section 7.
	5. Shorts or disconnects on Power Supply/RF Board.	5. Check the Power Supply/RF Board for shorts or disconnects.
	6. Malfunctioning front panel components.	6. Replace the front panel assembly. See *Front Panel Replacement* in Section 7.

Situation	Possible Cause	Recommended Action
Alarm number 188 or alarm number 212 appears in the ***Cut*** display during the self-test.	1. The battery was removed and/or replaced, but the generator was not calibrated.	1. Turn off, then turn on the generator to clear the number. Calibrate the generator. Refer to *Calibrating the Force 300* in Section 5 for instructions.
	2. Faulty battery on Control Board causing loss of battery-backed memory.	2. Replace the battery and check the battery-backed RAM device. See *Correcting Battery-Backed RAM Malfunctions* later in this section.
	3. Loss of battery-backed RAM due to faulty component on the Control Board (other than the battery).	3. Replace the Control Board. See *Control Board Replacement* in Section 7.

Situation	Possible Cause	Recommended Action
Activation and/or alarm tones do not sound; speaker is malfunctioning.	1. Poor connection or damaged Footswitch Board ribbon cable.	1. Check/correct connection. If indicated, replace the Footswitch Board. See *Footswitch Board Replacement* in Section 7.
	2. Faulty connections or speaker on Footswitch Board.	2. Replace the Footswitch Board. See *Footswitch Board Replacement* in Section 7.
	3. Audio signal malfunction on Control Board.	3. Replace the Control Board. See *Control Board Replacement* in Section 7.
	4. Audio circuitry malfunction on Power Supply/RF Board.	4. Troubleshoot Power Supply/RF Board components, particularly U8 and associated components.

Situation	Possible Cause	Recommended Action
Blank or confusing LED display.	1. Faulty ribbon cable between Control Board and Display Board.	1. Check/connect ribbon cable that connects the Display Board to the Control Board.
	2. Incorrect display modes communicated through the Control Board.	2. Replace the Control Board. See *Control Board Replacement* in Section 7.
	3. Display Board malfunction.	3. Replace the Display Board. See *Display Board Replacement* in Section 7.

Situation	Possible Cause	Recommended Action
Mode buttons do not function correctly when pressed.	1. Faulty ribbon cable between Control Board and Display Board.	1. Check/connect ribbon cable that connects the Display Board to the Control Board.
	2. Incorrect modes communicated through the Control Board.	2. Replace the Control Board. See *Control Board Replacement* in Section 7.
	3. Display Board malfunction.	3. Replace the Display Board. See *Display Board Replacement* in Section 7.

Situation	Possible Cause	Recommended Action
Footswitch connected to front panel is not functioning correctly.	1. Front panel footswitch provides output only to *single-pin* receptacle and you want output to the *multipin* receptacle.	1. Connect the footswitching instrument to the *single-pin* receptacle. To use a footswitch for the *multipin* receptacle, connect the footswitch to the the rear panel.
	2. Front panel footswitch button is set to incorrect output.	2. Press the footswitch button to select the output: the left (←) indicator illuminates for bipolar; the right (→) indicator illuminates for monopolar.
	3. Damaged front panel footswitch receptacle.	3. Replace the front panel footswitch receptacle. See *Front Panel Footswitch Receptacle Replacement* in Section 7.
	4. Control Board is losing or not processing signal.	4. Replace the Control Board. See *Control Board Replacement* in Section 7.
	5. Circuitry malfunction on Display Board or faulty ribbon cable.	5. Replace the Display Board (including the ribbon cable). See *Display Board Replacement* in Section 7.

Situation	Possible Cause	Recommended Action
Rear panel footswitch will not activate output.	1. Rear panel monopolar footswitch activates only handswitching instrument connected to *multipin* receptacle.	1. Use a handswitching instrument or connect the footswitching instrument to a universal adapter. Then connect the adapter to the *multipin* receptacle for handswitching output.
	2. Faulty connection from Footswitch Board to Power Supply/RF Board.	2. Check the ribbon cable and its connections.
	3. Malfunctioning or damaged rear panel footswitch receptacle.	3. Replace the Footswitch Board. See *Footswitch Board Replacement* in Section 7.
	4. Footswitch activation signal lost on Control Board.	4. Replace the Control Board. See *Control Board Replacement* in Section 7.
	5. Malfunctioning footswitch interface circuitry on Power Supply/RF Board.	5. Troubleshoot components on the Power Supply/RF Board: • Check the DC/DC converter (U11). • Check optical isolators ISO1, ISO2, and ISO3.

Situation	Possible Cause	Recommended Action
Generator is on and accessory is activated, but generator does not deliver output.	1. Malfunctioning handswitching instrument or footswitch.	1. Turn off the generator. Check and correct all accessory connections. Turn on the generator. Replace the instrument or footswitch if it continues to malfunction.
	2. Front panel footswitch is being used, but footswitch button is set to incorrect output.	2. Verify the footswitch and surgical instrument connections. Press the footswitch button to select the desired output: the left (←) indicator illuminates for bipolar; the right (→) indicator illuminates for monopolar (output from *single-pin* receptacle only).
	3. Front panel footswitch is being used to activate instrument in *multipin* monopolar receptacle.	3. Connect the footswitch to the monopolar receptacle on the rear panel. **or** If a footswitching instrument is being used, connect it to the *single-pin* receptacle.
	4. Rear panel footswitch is being used to activate instrument in *single-pin* monopolar receptacle.	4. Connect the footswitch to the front panel footswitch receptacle. **or** Connect the instrument to the *multipin* receptacle.
	5. Power set too low.	5. Increase the power setting.
	6. An alarm condition exists.	6. Check the ***Cut*** display for an alarm number. Note the number and see *Responding to System Alarms* in this section.

Continued on the next page ...

Situation	Possible Cause	Recommended Action
...Continued Generator is on and accessory is activated, but generator does not deliver output.	7. Control Board malfunction.	7. If the activation bar does not illuminate and the tone does not sound, replace the Control Board. See *Control Board Replacement* in Section 7. If the activation bar illuminates and the tone sounds, the malfunction is likely to be on the Power Supply/RF Board.
	8. Blown fuse on Power Supply/RF Board.	8. Check the high voltage power supply fuse (F1) and replace if necessary. See *Fuse Replacement* in Section 7.
	9. High voltage power supply malfunction (high voltage is not present during activation).	9. If high voltage is not present during activation at TP20 on the Power Supply RF/Board, troubleshoot the high voltage power supply as described below: Check the voltages after bridge rectifier CR80 and line filter capacitors at TP10, TP13, and TP14. Check switching transistors (Q2, Q4, Q5, and Q7) for failure (typically fail shorted) at TP7, TP11, TP18, and TP19 to respective drain and source pins. Check high voltage rectifiers CR17, CR22, CR23, CR36. Troubleshoot the pulse-width modulator circuit (U3 and surrounding components). Check SYS_ECON circuit from TP3 to U3. Perform further detailed component troubleshooting as needed.

Continued on the next page ...

Situation	Possible Cause	Recommended Action
...Continued Generator is on and accessory is activated, but generator does not deliver output.	10. RF output stage malfunction (high voltage is present during activation).	10. If high voltage is present during activation at TP20 on the Power Supply RF/Board, troubleshoot the generator as described below: On the Power Supply/RF Board, verify T_ON\ pulses during activation at U22 (TP33). • If pulses are not present at TP33, replace the Control Board. See *Control Board Replacement* in Section 7. • If pulses are present at TP33, but are not present after U22, replace U22. On the right heat sink, check the power MOSFET at J13 for failure (typically fail shorted). Check all output relays to verify that they are toggling during activation. The problem could be on the Control Board at the relay driver (U16) or K10, K11, K12, K13, or K14. Perform further detailed component troubleshooting as needed. Check for shorting of the output tuning inductors (L2 and L3) and failure of the output tuning capacitors C143, C154, C159, C165, C166, etc.

Situation	Possible Cause	Recommended Action
Continuous monitor interference.	1. Faulty chassis-to-ground connections.	1. Check and correct the chassis ground connections for the monitor and, if applicable, for the generator. Check other electrical equipment in the room for defective grounds.
	2. Electrical equipment is grounded to different objects rather than a common ground. The generator may respond to the resulting voltage differences between grounded objects.	2. Plug all electrical equipment into line power at the same location.
	3. Malfunctioning monitor.	3. Replace the monitor.

Situation	Possible Cause	Recommended Action
Interference with other devices only when generator is activated.	1. Metal-to-metal sparking.	1. Check all connections to the generator, patient return electrode, and accessories.
	2. High settings used for fulguration.	2. Use lower power settings for fulguration or select the *desiccate* mode.
	3. Electrically inconsistent ground wires in the operating room.	3. Verify that all ground wires are as short as possible and go to the same grounded metal.
	4. If interference continues when the generator is activated, the monitor is responding to radiated frequencies.	4. Check with the manufacturer of the monitor. Some manufacturers offer RF choke filters for use in monitor leads. The filters reduce interference when the generator is activated and minimize the potential for an electrosurgical burn at the site of the monitor electrode.

Situation	Possible Cause	Recommended Action
Pacemaker interference.	1. Intermittent connections or metal-to-metal sparking.	1. Check all connections to the generator. It may be necessary to reprogram the pacemaker prior to surgery.
	2. Current traveling from active to return electrode during monopolar electrosurgery is passing too close to pacemaker.	2. Use bipolar instruments, if possible. If you must use a monopolar instrument, place the patient return electrode as close as possible to the surgical site. Make sure the current path from the surgical site to the patient return electrode does not pass through the vicinity of the heart or the site where the pacemaker is implanted. Always monitor patients with pacemakers during surgery and keep a defibrillator available. Consult the pacemaker manufacturer or hospital Cardiology Department for further information when use of electrosurgical appliances is planned in patients with cardiac pacemakers.

Situation	Possible Cause	Recommended Action
Abnormal neuromuscular stimulation (*stop surgery immediately*).	1. Metal-to-metal sparking.	1. Check all connections to the generator, patient return electrode, and active electrodes.
	2. Can occur during coag. It is more likely when fulgurating than when cutting, and is unlikely when desiccating.	2. Use a lower power setting for fulguration or select the *desiccate* mode.
	3. Abnormal 50-60 Hz leakage currents.	3. Inside the generator, carefully inspect for damage that may cause shorting between the AC line voltage and connected patient components.

Responding to System Alarms

An alarm tone sounds and a number flashes in the *Cut* display when a system alarm condition exists. The generator is disabled until the condition is cleared. Most system alarms require some action on your part to correct the condition. Some are corrected automatically.

Use the table below to determine how to respond to the alarm. After correcting an alarm condition, verify that the generator completes the self-test as described in Section 5.

Number	Description	Recommended Action
0	Master microcontroller failed to hold feedback microcontroller in reset.	See *Correcting IC U3 Malfunctions* in this section.
1	Master microcontroller failed to power up feedback microcontroller.	
2	Feedback microcontroller failed to power up and initialize RAM in time allotted.	See *Correcting IC U6 Malfunctions* in this section.
3	Feedback microcontroller failed to checksum battery-backed RAM data in dual-port RAM in time allotted.	
4	Internal diagnostics. Master microcontroller CPU test failed.	1. Replace the Control Board. See *Control Board Replacement* in Section 7. 2. Calibrate the generator. Refer to Section 5 for instructions. If the alarm number reappears, record the number and call the Valleylab Service Center.
5	Master microcontroller unable to access FEEDBACK_SEM semaphore.	See *Correcting IC U6 Malfunctions* in this section.
6	Master microcontroller unable to access ECON_SEM semaphore.	
7	Master microcontroller unable to access KEY_ACTIVE_SEM semaphore.	
10	Software malfunction. Invalid alarm number.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.

Number	Description	Recommended Action
11	Internal diagnostics. Invalid activated power, function, mode, or key request mode echoed by feedback microcontroller.	See *Correcting IC U6 Malfunctions* (steps 1–7) and *Correcting IC U3 Malfunctions* (steps 4–11) in this section.
12	Diagnostics/microcontroller malfunction. TON_ERR test failed.	See *Correcting IC U6 Malfunctions* (steps 1–7) and *Correcting T_ON ASIC Malfunctions* (steps 4–11) in this section.
13	Master microcontroller unable to access GEN_SEM semaphore.	See *Correcting IC U6 Malfunctions* in this section.
14	Internal diagnostics. Calibration data checksum error on master microcontroller.	See *Correcting IC U3 Malfunctions* in this section.
16	Diagnostics/microcontroller malfunction. T_ON average test failed.	Calibrate the ECON factor. Refer to Section 5 for instructions. If the alarm number reappears, see *Correcting T_ON ASIC Malfunctions* in this section.
17	Isns and/or Vsns voltage detected without activation.	Do not attempt to use the generator. Record the number and call the Valleylab Service Center.
18	REM circuit failure. REM oscillator frequency outside acceptable operating range.	
19	Overvoltage detected on +5 V power supply.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
30	Software malfunction. **audio_state** value outside *state* range.	
31	Software malfunction. Invalid alarm.	
32	Software malfunction. **alarm_state** value outside *state* range.	
40	Software malfunction. **selection_state [button_num]** value outside *state* range.	
50	Software malfunction. **encoder_state [which_encoder]** value outside *state* range.	

Number	Description	Recommended Action
51	Software malfunction. **which_encoder** value outside *state* range.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
60	Software malfunction. **which_display** value outside *state* range.	
61	Software malfunction. **which_led** value outside *state* range.	
62	Software malfunction. **Key_req_mode** value outside *state* range.	
63	Software malfunction. **direction** value outside *state* range.	
64	Software malfunction. **msg.action_code** value outside *state* range.	
65	Software malfunction. **flash_state** value outside *state* range.	
66	Software malfunction. Unable to find alarm number to display.	
67	Internal diagnostics. Settings data corrupted.	
68	Master microcontroller unable to access GEN_SEM semaphore.	See *Correcting IC U6 Malfunctions* in this section.
69	Software malfunction. **flash_power_state** value outside *state* range.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
70	Software malfunction. **Key_req_mode** value outside *state* range.	
71	Software malfunction. **request+1** value outside *state* range.	
80	Software malfunction. ***input[i].p_state** value outside *state* range.	
81	Internal component malfunction. Optoisolator test failed.	Do not attempt to use the generator. Record the number and call the Valleylab Service Center.
90	Generator model in master microcontroller ROM not Force 300 model number.	See *Correcting IC U6 Malfunctions* (steps 1–7) and *Correcting IC U3 Malfunctions* (steps (4–11) in this section.

Number	Description	Recommended Action
95	Generator model number in feedback microcontroller ROM not Force 300 model number.	See *Correcting IC U6 Malfunctions* (steps 1–7) and *Correcting IC U3 Malfunctions* (steps 4–11) in this section.
100	Software malfunction. **rem_update_state** value outside *state* range.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
101	Software malfunction. **rem_pad_state** value outside *state* range.	
102	Software malfunction. **rem_state** value in **re_rem_control( )** outside *state* range.	
103	Software malfunction. **rem_state** value in **re_non_rem_control( )** outside *state* range.	
104	Software malfunction. **rem_flash_state** value outside *state* range.	
105	Software malfunction. **rem_led_state** value outside *state* range.	
110	Software malfunction. **cal_state** value in **ca_generator_setup( )** outside *state* range.	
111	Software malfunction. **cal_state** value in **ca_clock_date_setup( )** outside *state* range.	
112	Software malfunction. **cal_mode** value in **ca_clock_date_setup( )** outside *state* range.	
113	Software malfunction. **cal_state** value in **ca_clock_time_setup( )** outside *state* range.	
114	Software malfunction. **cal_mode** value in **ca_clock_time_setup( )** outside *state* range.	
115	Software malfunction. **cal_state** value in **ca_coag_leakage_cal( )** outside *state* range.	
116	Software malfunction. **cal_state** value in **ca_econ_cal( )** outside *state* range.	
117	Software malfunction. **econ_cal_state** value outside *state* range.	

Number	Description	Recommended Action
118	Software malfunction. **cal_state** value in **ca_rem_cal( )** outside *state* range.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
119	Software malfunction. **rem_cal_state** value outside *state* range.	
120	Calibration malfunction. Calibration value(s) outside acceptable range.	Repeat the failing calibration step. If the alarm number reappears, record the number and call the Valleylab Service Center.
121	Software malfunction. **cal_mode** value in **ca_generator_setup( )** outside *state* range.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
122	Open circuit REM sense failure.	Repeat the failing calibration step. If the alarm number reappears, record the number and call the Valleylab Service Center.
123	Master microcontroller unable to access GEN_SEM semaphore.	See *Correcting IC U6 Malfunctions* in this section.
124	Master microcontroller unable to access FEEDBACK_SEM semaphore.	
125	Master microcontroller unable to access ECON_SEM semaphore.	
126	Master microcontroller unable to access KEY_ACTIVE_SEM semaphore.	
127	REM circuit malfunction. REM oscillator frequency cannot be set to 100 kHz.	Do not attempt to use the generator. Record the number and call the Valleylab Service Center.
128	REM circuit malfunction. REM oscillator frequency cannot be set within operating range.	
129	Software malfunction. **rem_cal_pot_state** value outside *state* range.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
130	Software malfunction. **convert_this** value outside *state* range.	

Number	Description	Recommended Action
131	Software malfunction. **Settings[COAG] .mode_setting** value for **CLOCK_DATE_SETUP** outside *state* range.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
132	Software malfunction. **Settings[COAG] .mode_setting** value for **CLOCK_TIME_SETUP** outside *state* range.	
133	Software malfunction. **Cal_settings.cal_value** value in **cd_rem_value_conversion( )** outside *state* range.	
134	Software malfunction. **cal_step** value outside *state* range.	
136	Software malfunction. **button_function** value outside *state* range.	
137	Software malfunction. **which_display** value outside *state* range.	
138	Software malfunction. **update_this** value outside *state* range.	
139	Software malfunction. **value_displayed** value for **valid_selection**[COAG_DN_SELECTION] and **CLOCK_DATE_SETUP** outside state range.	
140	Software malfunction. **value_displayed** value for **valid_selection**[COAG_DN_SELECTION] and **CLOCK_TIME_SETUP** outside state range.	
150	Software malfunction. **cal_state** value in **cs_v_sns_cal( )** outside *state* range.	
151	Master microcontroller unable to access GEN_SEM semaphore.	See *Correcting IC U6 Malfunctions* in this section.
152	Software malfunction. **cal_state** value in **cs_i_sns_cal( )** outside *state* range.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
154	Master microcontroller unable to access FEEDBACK_SEM semaphore.	See *Correcting IC U6 Malfunctions* in this section.

Number	Description	Recommended Action
160	Internal component malfunction. Dosage error test failed.	Calibrate the ECON factor. Refer to Section 5 for instructions. If the alarm number reappears, see *Correcting T_ON ASIC Malfunctions* in this section.
161	Dosage error while generator was activated, where Vsns and Isns stay the same or decrease while the ECON increases consistently for about 150 ms.	Do not attempt to use the generator. Record the number and call the Valleylab Service Center.
162	Dosage error while generator was not activated, where an ECON voltage was detected.	
163	Dosage error while activating *fulgurate*.	
164-166	Dosage error while activating the bipolar mode, a cut mode, or *desiccate*.	Repeat the failing calibration step. If the number reappears, record the number and call the Valleylab Service Center.
170	Watchdog malfunction. Correct value not sent from feedback microcontroller.	See *Correcting IC U6 Malfunctions* in this section.
171	Watchdog malfunction. Correct value not sent from master microcontroller.	See *Correcting IC U3 Malfunctions* in this section.
172	Watchdog malfunction. Master microcontroller unable to access watchdog semaphore.	
173	Watchdog malfunction. Feedback microcontroller unable to access watchdog semaphore.	See *Correcting IC U6 Malfunctions* in this section.
174	Software malfunction. **which_errors** value outside *state* range.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
180	Internal diagnostics. Master microcontroller WSI RAM check failed.	See *Correcting IC U3 Malfunctions* in this section.
181	Internal diagnostics. Feedback microcontroller WSI RAM check failed.	See *Correcting IC U6 Malfunctions* in this section.

Number	Description	Recommended Action
182	Internal diagnostics. Master microcontroller dual-port RAM check failed.	See *Correcting IC U3 Malfunctions* in this section.
183	Internal diagnostics. Master microcontroller Page 0 (zero) ROM CRC test failed.	
184	Internal diagnostics. Master microcontroller Page F ROM CRC test failed.	
185	Internal diagnostics. Feedback microcontroller ROM CRC test failed.	See *Correcting IC U6 Malfunctions* in this section.
188	Internal diagnostics. Battery-backed RAM data checksum error.	Calibrate the generator. Refer to Section 5 for instructions. If the alarm number reappears, see *Correcting Battery-Backed RAM Malfunctions* in this section.
189	Software malfunction. **display_state** value outside *state* range.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
191	Internal diagnostics. Cut mode buttons (*pure* and/or *blend*) may be stuck.	1. Turn off, then turn on the generator. Do not press buttons or accessory activation devices during the self-test. 2. If the alarm number reappears, disconnect all accessories. Turn off, then turn on the generator again. If the alarm number reappears, record the number and call the Valleylab Service Center.
192	Internal diagnostics. Coag mode buttons (*desiccate* and/or *fulgurate)* may be stuck.	
193	Internal diagnostics. Front panel footswitch button may be stuck.	
194	Internal diagnostics. Handswitch or cut pedal may be stuck.	
195	Internal diagnostics. Handswitch or coag pedal may be stuck.	
196	Internal diagnostics. Handswitch or cut key may be stuck.	
197	Internal diagnostics. Handswitch or coag key may be stuck.	
198	Internal diagnostics. Handswitch or bipolar footswitch pedal may be stuck.	

Number	Description	Recommended Action
199	Internal diagnostics. Master and feedback microcontrollers are not compatible.	See *Correcting IC U6 Malfunctions* (steps 1–7) and *Correcting IC U3 Malfunctions* (steps 4–11) in this section.
200	Internal diagnostics. Master microcontroller SEML line may be stuck.	1. Replace the Control Board. See *Control Board Replacement* in Section 7 for instructions. 2. Calibrate the generator. Refer to Section 5 for instructions. If the alarm number reappears, record the number and call the Valleylab Service Center.
201	Internal diagnostics. Feedback microcontroller SEMR line may be stuck.	
202	Internal diagnostics. Master microcontroller watchdog test failed.	See *Correcting IC U3 Malfunctions* in this section.
203	Internal diagnostics. Feedback microcontroller watchdog test failed.	See *Correcting IC U6 Malfunctions* in this section.
206	Software malfunction. **doserr_test_state** value in **st_m_doserr_test** outside *state* range.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
207	Software malfunction. **doserr_test_state** value in **st_fb_doserr_test** outside *state* range.	
208	Master microcontroller timer interrupt failed.	1. Replace the Control Board. See *Control Board Replacement* in Section 7 for instructions. 2. Calibrate the generator. Refer to Section 5 for instructions. If the alarm number reappears, record the number and call the Valleylab Service Center.
209	Feedback microcontroller timer interrupt failed.	
210	Software malfunction. **data_type** value outside *state* range.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
211	Software malfunction. **which_data** value outside *state* range.	

Number	Description	Recommended Action
212	Internal diagnostics. Battery-backed RAM data not initialized.	Calibrate the generator. Refer to Section 5 for instructions. If the alarm number reappears, see *Correcting Battery-Backed RAM Malfunctions* in this section.
213	Internal diagnostics. Firmware not compatible with hardware.	See *Correcting IC U6 Malfunctions* (steps 1–7) and *Correcting IC U3 Malfunctions* (steps 4–11) in this section.
214	REM circuit malfunction. REM oscillator frequency cannot be set to calibrated frequency.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
220	Feedback microcontroller unable to access KEY_REQ_SEM semaphore.	See *Correcting IC U6 Malfunctions* in this section.
221	Feedback microcontroller unable to access GEN_SEM semaphore.	
222	Master microcontroller failed to copy battery-backed RAM data to dual-port RAM in time allotted.	See *Correcting IC U3 Malfunctions* in this section.
223	Master microcontroller failed to complete initialization in time allotted.	
224	Internal diagnostics. Calibration data checksum error on feedback microcontroller.	See *Correcting IC U6 Malfunctions* in this section.
225	Internal diagnostics. Feedback microcontroller CPU test failed.	1. Replace the Control Board. See *Control Board Replacement* in Section 7. 2. Calibrate the generator. Refer to Section 5 for instructions. If the alarm number reappears, record the number and call the Valleylab Service Center.
226	Feedback microcontroller unable to access FEEDBACK_SEM semaphore.	See *Correcting IC U6 Malfunctions* in this section.

Number	Description	Recommended Action
230	Software malfunction. **keyed_state** value outside *state* range.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
231	Software malfunction. **Key_req_mode** value outside *state* range.	
232	Feedback microcontroller unable to access KEY_ACTIVE_SEM semaphore.	See *Correcting IC U6 Malfunctions* in this section.
240	Software malfunction. **activation_seq** value outside *state* range.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
241	Software malfunction. **Feedback** value in **do_feedback( )** outside *state* range.	
242	Software malfunction. **Feedback** value in **do_cal_feedback( )** outside *state* range.	
243	Software malfunction. **Mode** value outside *state* range.	
244	Software malfunction. **disable_seq** value outside *state* range.	
245	Software malfunction. **spark_state** value outside *state* range.	
246	Feedback microcontroller unable to access FEEDBACK_SEM semaphore.	See *Correcting IC U6 Malfunctions* in this section.
247	Feedback microcontroller unable to access ECON_SEM semaphore.	
260	Internal diagnostics. A/D conversion did not complete in allowed time.	1. Replace the Control Board. See *Control Board Replacement* in Section 7. 2. Calibrate the generator. Refer to Section 5 for instructions. If the alarm number reappears, record the number and call the Valleylab Service Center.
261	Software malfunction. **ti_check_times** value outside *state* range.	Turn off, then turn on the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.

Number	Description	Recommended Action
451	The internal temperature limit was exceeded due to length of activation time.	Check the location of the generator for adequate cooling. Use the lowest power setting that achieves the desired effect. Limit activation times, if possible.

Correcting IC U3 Malfunctions

Equipment:

- Phillips screwdriver
- surface mount, quad pack chip extractor

Warning

Electric Shock Hazard. Disconnect the power cord before replacing parts. To allow stored energy to dissipate after power is disconnected, wait at least five minutes before replacing parts.

Caution

The generator contains electrostatic-sensitive components. When repairing the generator, work at a static-control workstation. Wear a grounding strap when handling electrostatic-sensitive components, except when working on an energized generator. Handle circuit boards by their nonconductive edges. Use an antistatic container for transport of electrostatic-sensitive components and circuit boards.

1. Turn off the generator. Disconnect the power cord from the wall receptacle. To allow stored energy to dissipate after power is disconnected, wait at least five minutes before replacing parts.
2. Loosen the 4 screws that secure the cover to the chassis. Lift the cover off the chassis.
3. Remove the Control Board.
   a. Remove the screw that secures the retention bracket to the left rear heat sink.
   b. Unlock the connector on the Control Board and disconnect the Display Board ribbon cable from the Control Board.
   c. Carefully slide the Control Board straight up to disconnect it from the Power Supply/RF Board.
4. On the Control Board, verify that the pins for programmable IC U3 are properly seated in their socket.
   a. Grip IC U3 with the chip extractor and lift it out of its socket.
   b. Align the notch on IC U3 above the notch on the socket and gently press the chip back into the socket.
5. Reinstall the Control Board.
   a. Position the Control Board over the Power Supply/RF Board, fitting the edge of the board into the slot on the right heat sink. Slide the board down, carefully fitting the edge connector into the matching connector on the Power Supply/RF Board.
   b. Place the retention bracket on the left rear heat sink and install the screw that secures the bracket to the heat sink.
   c. Connect the Display Board ribbon cable to the Control Board and lock the connector.

Warning

Electric Shock Hazard. Do not touch any exposed wiring or conductive surfaces while the generator is disassembled and energized. Never wear a grounding strap when working on an energized generator.

6. Calibrate the generator. Refer to Section 5 for instructions. If the calibration is successful, reinstall the cover (see step 11).
7. If the alarm number reappears, replace IC U3.
   a. Turn off the generator.
   b. Remove the Control Board (see step 3).
   c. Grip IC U3 with the chip extractor and lift it out of its socket.
   d. Align the notch on the new chip above the notch on the socket and gently press the chip into the socket.
   e. Reinstall the Control Board (see step 5).
8. Recalibrate the generator. If the calibration is successful, reinstall the cover (see step 11).
9. If the alarm number reappears, replace the Control Board.
   a. Turn off the generator.
   b. Remove the Control Board (see step 3).
   c. Install the new Control Board (see step 5).
10. Recalibrate the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
11. To reinstall the cover, position the cover above the chassis and slide it down. Tighten the 4 screws that secure the cover to the chassis.

Correcting IC U6 Malfunctions

Equipment:

- Phillips screwdriver
- surface mount, quad pack chip extractor

Warning

Electric Shock Hazard. Disconnect the power cord before replacing parts. To allow stored energy to dissipate after power is disconnected, wait at least five minutes before replacing parts.

Caution

The generator contains electrostatic-sensitive components. When repairing the generator, work at a static-control workstation. Wear a grounding strap when handling electrostatic-sensitive components, except when working on an energized generator. Handle circuit boards by their nonconductive edges. Use an antistatic container for transport of electrostatic-sensitive components and circuit boards.

1. Turn off the generator. Disconnect the power cord from the wall receptacle. To allow stored energy to dissipate after power is disconnected, wait at least five minutes before replacing parts.
2. Loosen the 4 screws that secure the cover to the chassis. Lift the cover off the chassis.
3. Remove the Control Board.
   a. Remove the screw that secures the retention bracket to the left rear heat sink.
   b. Unlock the connector on the Control Board and disconnect the Display Board ribbon cable from the Control Board.
   c. Carefully slide the Control Board straight up to disconnect it from the Power Supply/RF Board.
4. On the Control Board, verify that the pins on programmable IC U6 are properly seated in their socket.
   a. Grip IC U6 with the chip extractor and lift it out of its socket.
   b. Align the notch on IC U6 above the notch on the socket and gently press the chip back into the socket.
5. Reinstall the Control Board.
   a. Position the Control Board over the Power Supply/RF Board, fitting the edge of the board into the slot on the right heat sink. Slide the board down, carefully fitting the edge connector into the matching connector on the Power Supply/RF Board.
   b. Place the retention bracket on the left rear heat sink and install the screw that secures the bracket to the heat sink.
   c. Connect the Display Board ribbon cable to the Control Board and lock the connector.

Warning

Electric Shock Hazard. Do not touch any exposed wiring or conductive surfaces while the generator is disassembled and energized. Never wear a grounding strap when working on an energized generator.

6. Turn on the generator. If the self-test completes successfully, reinstall the cover (see step 12).
7. If the alarm number reappears, replace IC U6.
   a. Turn off the generator.
   b. Remove the Control Board (see step 3).
   c. Grip IC U6 with the chip extractor and lift it out of its socket.
   d. Align the notch on the new chip above the notch on the socket and gently press the chip into the socket.
8. Reinstall the Control Board (see step 5).
9. Turn on the generator. If the self-test completes successfully, reinstall the cover (see step 12).
10. If the alarm number reappears, replace the Control Board.
    a. Turn off the generator.
    b. Remove the Control Board (see step 3).
    c. Install the new Control Board (see step 5).
11. Calibrate the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
12. To reinstall the cover, position the cover above the chassis and slide it down. Tighten the 4 screws that secure the cover to the chassis.

Equipment:

- Phillips screwdriver
- surface mount, quad pack chip extractor

Warning

Electric Shock Hazard. Disconnect the power cord before replacing parts. To allow stored energy to dissipate after power is disconnected, wait at least five minutes before replacing parts.

Caution

The generator contains electrostatic-sensitive components. When repairing the generator, work at a static-control workstation. Wear a grounding strap when handling electrostatic-sensitive components, except when working on an energized generator. Handle circuit boards by their nonconductive edges. Use an antistatic container for transport of electrostatic-sensitive components and circuit boards.

Note: If you are responding to a specific alarm number, first calibrate the ECON factor as described in Section 5. If the alarm number reappears after calibration, complete this procedure.

1. Turn off the generator. Disconnect the power cord from the wall receptacle. To allow stored energy to dissipate after power is disconnected, wait at least five minutes before replacing parts.
2. Loosen the 4 screws that secure the cover to the chassis. Lift the cover off the chassis.
3. Remove the Control Board.
   a. Remove the screw that secures the retention bracket to the left rear heat sink.
   b. Unlock the connector on the Control Board and disconnect the Display Board ribbon cable from the Control Board.
   c. Carefully slide the Control Board straight up to disconnect it from the Power Supply/RF Board.
4. On the Control Board, verify that the pins on programmable IC U9 are properly seated in their socket.
   a. Grip IC U9 with the chip extractor and lift it out of its socket.
   b. Align the notch on IC U9 above the notch on the socket and gently press the chip back into the socket.

5. Reinstall the Control Board.
   a. Position the Control Board over the Power Supply/RF Board, fitting the edge of the board into the slot on the right heat sink. Slide the board down, carefully fitting the edge connector into the matching connector on the Power Supply/RF Board.
   b. Place the retention bracket on the left rear heat sink and install the screw that secures the bracket to the heat sink.
   c. Connect the Display Board ribbon cable to the Control Board and lock the connector.

Warning

Electric Shock Hazard. Do not touch any exposed wiring or conductive surfaces while the generator is disassembled and energized. Never wear a grounding strap when working on an energized generator.

6. Turn on the generator. If the generator successfully completes the self-test, reinstall the cover (see step 11).
7. If the alarm number reappears, replace programmable IC U9.
   a. Turn off the generator.
   b. Remove the Control Board (see step 3).
   c. Grip IC U9 with the chip extractor and lift it out of its socket.
   d. Align the notch on the new chip above the notch on the socket and gently press the chip into the socket.
   e. Reinstall the Control Board (see step 5).
8. Turn on the generator. If the generator successfully completes the self-test, reinstall the cover (see step 11).
9. If the alarm number reappears, replace the Control Board.
   a. Turn off the generator.
   b. Remove the Control Board (see step 3).
   c. Install the new Control Board (see step 5).
10. Calibrate the generator. Refer to Section 5 for instructions. If the alarm number reappears, record the number and call the Valleylab Service Center.
11. To reinstall the cover, position the cover above the chassis and slide it down. Tighten the 4 screws that secure the cover to the chassis.

Correcting Battery-Backed RAM Malfunctions

Equipment:

- Phillips screwdriver
- surface mount, quad pack chip extractor

Warning

Electric Shock Hazard. Disconnect the power cord before replacing parts. To allow stored energy to dissipate after power is disconnected, wait at least five minutes before replacing parts.

Caution

The generator contains electrostatic-sensitive components. When repairing the generator, work at a static-control workstation. Wear a grounding strap when handling electrostatic-sensitive components, except when working on an energized generator. Handle circuit boards by their nonconductive edges. Use an antistatic container for transport of electrostatic-sensitive components and circuit boards.

Note: If you are responding to a specific alarm number, first calibrate the generator as described in Section 5. If the alarm number reappears after calibration, complete this procedure.

1 Turn off the generator. Disconnect the power cord from the wall receptacle. To allow stored energy to dissipate after power is disconnected, wait at least five minutes before replacing parts.

2. Loosen the 4 screws that secure the cover to the chassis. Lift the cover off the chassis.

3. Remove the Control Board.

   a. Remove the screw that secures the retention bracket to the left rear heat sink.

   b. Unlock the connector on the Control Board and disconnect the Display Board ribbon cable from the Control Board.

   c. Carefully slide the Control Board straight up to disconnect it from the Power Supply/RF Board.

4. Replace the battery.

   a. Grasp the battery and snap it out of the socket.

   b. Position the new 3 V button-cell battery so that the *positive* side of the battery is facing out (visible).

   c. Snap the new battery into the socket so it is firmly seated.

5. On the Control Board, verify that the pins on programmable IC U3 are properly seated in their socket.

   a. Grip IC U3 with the chip extractor and lift it out of its socket.

   b. Align the notch on IC U3 above the notch on the socket and gently press the chip back into the socket.

6. Reinstall the Control Board.
   a. Position the Control Board over the Power Supply/RF Board, fitting the edge of the board into the slot on the right heat sink. Slide the board down, carefully fitting the edge connector into the matching connector on the Power Supply/RF Board.
   b. Place the retention bracket on the left rear heat sink and install the screw that secures the bracket to the heat sink.
   c. Connect the Display Board ribbon cable to the Control Board and lock the connector.

Warning

Electric Shock Hazard. Do not touch any exposed wiring or conductive surfaces while the generator is disassembled and energized. Never wear a grounding strap when working on an energized generator.

7. Calibrate the generator. Refer to Section 5 for instructions. If the calibration is successful, reinstall the cover (see step 12).
8. If the alarm number reappears, replace IC U3.
   a. Turn off the generator.
   b. Remove the Control Board (see step 3).
   c. Grip IC U3 with the chip extractor and lift it out of its socket.
   d. Align the notch on the new chip above the notch on the socket and gently press the chip into the socket.
   e. Reinstall the Control Board (see step 6).
9. Recalibrate the generator. If the calibration is successful, reinstall the cover (see step 12).
10. If the alarm number reappears, replace the Control Board.
    a. Turn off the generator.
    b. Remove the Control Board (see step 3).
    c. Install the new Control Board (see step 6).
11. Recalibrate the generator. If the alarm number reappears, record the number and call the Valleylab Service Center.
12. To reinstall the cover, position the cover above the chassis and slide it down. Tighten the 4 screws that secure the cover to the chassis.