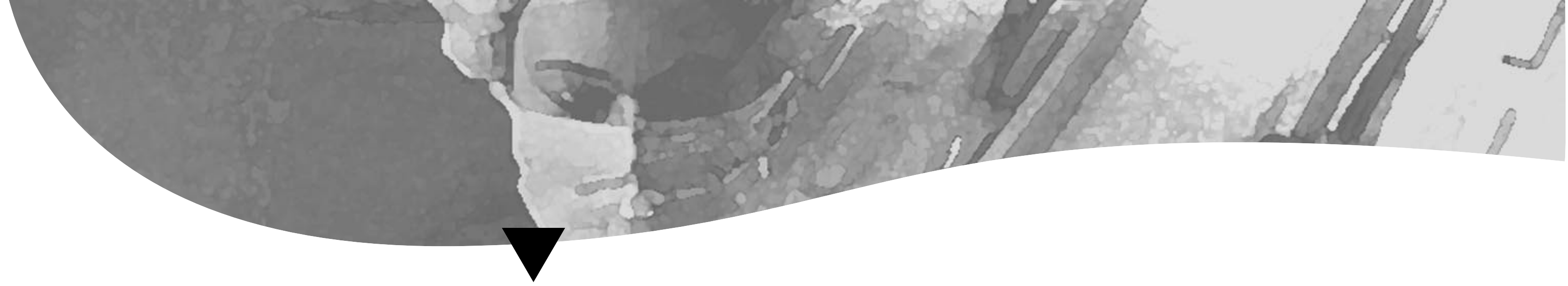


Valleylab™

Service Manual

Force™ 2 Electrosurgical Generator

The following service instructions are for use only by personnel qualified to repair and service the equipment described in this manual.

This service manual covers the installation and basic service instructions for the Force™ 2 Electrosurgical Generator. Also included are sections covering the technical specifications, circuit descriptions, and the testing of the generator. Instructions for use and cautions and warnings concerning electrosurgery are in the ***Force™ 2 Electrosurgical Generator User's Guide*** supplied with the generator.

Caution

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

Equipment covered in this manual:

Electrosurgical Generator	Vac Nominal	Hertz
Force™ 2-2 PCH	110-120	50-60
Force™ 2-8 PCH	220-240	50-60

The ***Force™ 2 Electrosurgical Generator Service Manual*** consists of two parts—the text (part 1 of 2) and a Schematics Supplement (part 2 of 2) which contains the schematics.

Valleylab part number: 945 103 106 (1 of 2)
Effective date: October 2004

Manufactured by
Valleylab, a division of Tyco Healthcare Group LP
Boulder, CO 80301-3299 USA

Tyco Healthcare UK Ltd.
Gosport, PO13 0AS, UK

For information call
1-800-255-8522 / 1-303-530-2300

Made in USA
Printed in USA

Conventions Used in this Guide

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.

▶ ***Important***

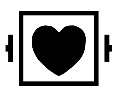
Indicates an operating tip or maintenance suggestion.

Notice

Indicates hazard which may result in product damage.

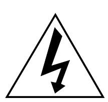
Controls, indicators, and receptacles on the unit appear in bold capital letters like this: **PURE CUT**.

ATTENTION
Refer to the accompanying documents.



Type CF equipment
Low Leakage
Suitable for cardiac use
Defibrillator proof

Drip Proof



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

The generator is high frequency isolated per IEC 601-2-2.

DANGER
Explosion Hazard: Do not use in the presence of flammable anaesthetics.

Valleylab Service Centers

Valleylab
Boulder, Colorado, 80301-3299
USA
Ph: 303-530-2300
Toll Free: 800-255-8522

Tyco Healthcare Nederland B.V.
Technical Service Center
De Beverspijken 37
5221 EE 's-Hertogenbosch
THE NETHERLANDS
Ph: 073-6312412
Fax: 073-6314540

Auto Suture France S.A.
2, rue Denis Diderot
La Clef de Saint Pierre
78990 Elancourt, FRANCE
Ph: 33 (0)1 30 79 80 40
Fax: 33 (0)1 30 79 85 73

Tyco Healthcare Deutschland
Tempelsweg 26
47918 Tonisvorst, GERMANY
Ph: 49 (0)2151 7096 92
Fax: 49 (0)2151 7096 67

For the UK, Europe,
Middle East & Africa:
Tyco Healthcare UK Limited
Valleylab Service Centre
Unit 1a
Corinium Industrial Estate
Raans Road
Amersham
Bucks. HP6 6YJ
UNITED KINGDOM
Ph: 44 (0)1494 789200
FAX: 44 (0)1494 789239

Tyco Healthcare Italia SpA
Via Gaetano Crespi, 12
20134 Milano, ITALY
Ph: 39 02 212181
Fax: 39 02 2640059

Tyco Healthcare Spain S.L.
C/Fructuos Gelabert, 6 – 8 planta 8a,
08970 – Saint Joan DESPI
Barcelona
SPAIN
Ph: 34-93-680-3370
Fax: 34-93-680-2457

Tyco Healthcare Belgium B.V.
Generaal De Wittelaan 9/5
B-2800 Mechelen
BELGIUM
Ph: 32-15-298111
Fax: 32-15-217987

Tyco Healthcare Austria GmbH
Jochen Rindt Str. 37
A-1230 Vienna
AUSTRIA
Ph: 43-1-610-3441
Fax: 43-1-615-3808

Tyco Healthcare Norden AB (Denmark, Finland, Iceland, Norway, Sweden)
Årstaängsvägen 11 B, II
SE-117 43 Stockholm
SWEDEN
Ph. +46 8 585 605 00
Fax +46 8 585 605 06

Tyco Healthcare PTY Ltd
Service & Technical Support
59 - 69 Halstead Street
Hurstville NSW 2220
AUSTRALIA
Ph: 61 2 9579 6066
Toll free hotline: 1800 350 702
Fax: 61 2 9585 1908

Tyco Healthcare Japan
Regulatory Affairs Department
Technical Support Section
Customer Call Center
1-2-20 Heiwajima Ota-ku Tokyo-to JAPAN
Toll Free : 0120-073-008
Ph: 03-3764-0733
Fax: 03-3764-0744

Auto Suture Company, Canada
4490 Garand Street
Ville St. Laurent
Quebec, CANADA H4R 2A2
Ph: 514-334 -7602
Fax: 514-331-5983

Table of Contents

Conventions Used in this Guide **iii**

Valleylab Service Centers **iv**

List of Figures **viii**

Section 1. Service Warnings and Cautions

Section 2. Unpacking and Installation

Unpacking the Force 2 Generator **2-1**

Responsibility of the Manufacturer **2-1**

Preparing the Generator for Use **2-2**

Power Requirements **2-2**

Check the Power Connector **2-2**

Ensure Proper Grounding **2-3**

Perform a System Check **2-3**

Section 3. Description of Controls, Indicators, and Receptacles

Controls **3-3**

Indicators **3-4**

Alarms **3-5**

Receptacles **3-5**

Rear Panel Functions **3-6**

Section 4. Technical Specifications

Standard Conditions of Measurement **4-1**

Operating Parameters **4-1**

Storage and Shipping **4-1**

Output Waveform **4-2**

PCH Generator Output Characteristics **4-2**

Output Configuration **4-2**

Input Power Source **4-3**

- Force 2-2 PCH Generator **4-3**
- Force 2-8 PCH Generator **4-3**

Line Regulation **4-3**

- Force 2-2 PCH Generator **4-3**
- Force 2-8 PCH Generator **4-3**

High Frequency Risk Parameters **4-4**

Low Frequency Leakage (50-60 Hz) **4-4**
- Force 2-2 PCH Generator **4-4**
- Force 2-8 PCH Generator
(per VDE 0750 (IEC601-1), Section 19 for Class 1 Equipment) **4-4**

REM Contact Quality Monitor **4-5**

Audio Volume **4-5**

Approximate Weight **4-5**

Size **4-5**

Classification **4-5**
- Type CF Equipment per IEC 601-1 **4-5**
- Drip Proof per IEC 601-1 **4-5**

Output Power vs. Impedance Graphs **4-6**

Section 5. Circuit Descriptions

Bipolar Display **5-1**

Monopolar Control/Display **5-1**
- Mode Indicators **5-2**
- REM and RMOTE Indicators **5-3**
- RF Indicators **5-3**
- External Memory **5-4**

Interface **5-5**

Power Supply **5-6**

RF Output **5-7**

Section 6. Maintenance Procedures

Routine Maintenance and Inspections **6-1**

Cleaning Instructions **6-1**

General Testing Information **6-2**

Recommended Test Equipment **6-3**

Power Up Self-Test **6-3**

Calibration **6-4**

Calibration Procedure **6-4**

REM Test Procedure **6-7**

Line Frequency (50-60 Hz) Current Leakage Test Procedure **6-8**

Bipolar and Monopolar Output RF Leakage Test Procedures **6-9**

Typical Output Waveforms **6-10**

TT-on Waveforms at TP12 on PSRF Board **6-13**

RF Drive Waveforms at TP7-10 on PSRF Board **6-13**

Clamp Waveform at TP11 on PSRF Board **6-14**

Components Replacement Guidelines **6-15**

Section 7. Manufacturer Service

Returning the Equipment for Service **7-1**

Returning the Force 2 Generator **7-2**

Returning Circuit Boards and Other Subassemblies **7-2**

Section 8. Service Parts List

Ordering Replacement Parts **8-1**

Monopolar Control/Display Board **8-2**

Bipolar Display Board **8-4**

Interface Board **8-5**

Power Supply RF Board **8-8**

Heatsink Assembly **8-13**

- RF Out **8-13**
- HVDC **8-13**
- PS **8-13**
- Clamp **8-13**

Generator Base Assembly **8-14**

Appendix A. Warranty

Schematics Supplement. Assemblies and Schematics

List of Figures

Figure 3-1. PCH Generator Front View **3-2**

Figure 3-2. PCH Generator Rear View **3-2**

Figure 4-1. PCH Generator Typical Output Power vs Load—Monopolar Cut Modes **4-6**

Figure 4-2. PCH Generator Typical Output Power vs Load—Monopolar Cut Modes (continued) **4-7**

Figure 4-3. PCH Generator Typical Output Power vs Load—Monopolar Coag Modes **4-8**

Figure 4-4. PCH Generator Typical Output Power vs Load—Bipolar Mode **4-9**

Figure 6-1. Pure Cut 300 Ω Load
Bipolar 100 Ω Load **6-10**

Figure 6-2. Blend 1 300 Ω Load **6-10**

Figure 6-3. Blend 2 300 Ω Load **6-11**

Figure 6-4. Blend 3 300 Ω Load
Low Voltage Coag 300 Ω Load **6-11**

Figure 6-5. Coag 300 Ω Load **6-12**

Figure 6-6. 1-Cut/Bipolar
2-Blend 1
3-Blend 2
4-Blend 3/LV Coag
5-Coag **6-13**

Figure 6-7. 1-Cut/Bipolar
2-Blend 1
3-Blend 2
4-Blend 3/LV Coag
5-Coag **6-13**

Figure 6-8. Open Circuit 120W Coag **6-14**

Schematics Supplement

Schematic 1. System interconnect diagram **S-4**

Schematic 2. Component/connector locations **S-5**

Schematic 3. Bipolar Display board **S-6**

Schematic 4. Bipolar Display board **S-7**

Schematic 5. Heatsink assembly, RF out **S-8**

Schematic 6. Heatsink assembly, clamp **S-9**

Schematic 7. Heatsink assembly, power supply **S-10**

Schematic 8. Heatsink assembly, HVDC **S-11**

Schematic 9. Monopolar keyboard **S-12**

Schematic 10. Monopolar keyboard **S-12**

Schematic 11. Footswitch board **S-13**

Schematic 12. Power Supply board layout, page 1 of 2 **S-15**
Schematic 13. Power Supply board layout, page 2 of 2 **S-16**
Schematic 14. Power Supply board, page 1 of 6 **S-17**
Schematic 15. Power Supply board, page 2 of 6 **S-18**
Schematic 16. Power Supply board, page 3 of 6 **S-19**
Schematic 17. Power Supply board, page 4 of 6 **S-20**
Schematic 18. Power Supply board, page 5 of 6 **S-21**
Schematic 19. Power Supply board, page 6 of 6 **S-22**
Schematic 20. Interface board layout **S-23**
Schematic 21. Interface board, page 1 of 3 **S-24**
Schematic 22. Interface board, page 2 of 3 **S-25**
Schematic 23. Interface board, page 3 of 3 **S-26**
Schematic 24. Monopolar Control/Display board layout **S-27**
Schematic 25. Monopolar Control/Display board, page 1 of 13 **S-28**
Schematic 26. Monopolar Control/Display board, page 2 of 13 **S-29**
Schematic 27. Monopolar Control/Display board, page 3 of 13 **S-30**
Schematic 28. Monopolar Control/Display board, page 4 of 13 **S-31**
Schematic 29. Monopolar Control/Display board, page 5 of 13 **S-32**
Schematic 30. Monopolar Control/Display board, page 6 of 13 **S-33**
Schematic 31. Monopolar Control/Display board, page 7 of 13 **S-34**
Schematic 32. Monopolar Control/Display board, page 8 of 13 **S-35**
Schematic 33. Monopolar Control/Display board, page 9 of 13 **S-36**
Schematic 34. Monopolar Control/Display board, page 10 of 13 **S-37**
Schematic 35. Monopolar Control/Display board, page 11 of 13 **S-38**
Schematic 36. Monopolar Control/Display board, page 12 of 13 **S-39**
Schematic 37. Monopolar Control/Display board, page 13 of 13 **S-40**

Notes

SECTION 1

Service Warnings and Cautions

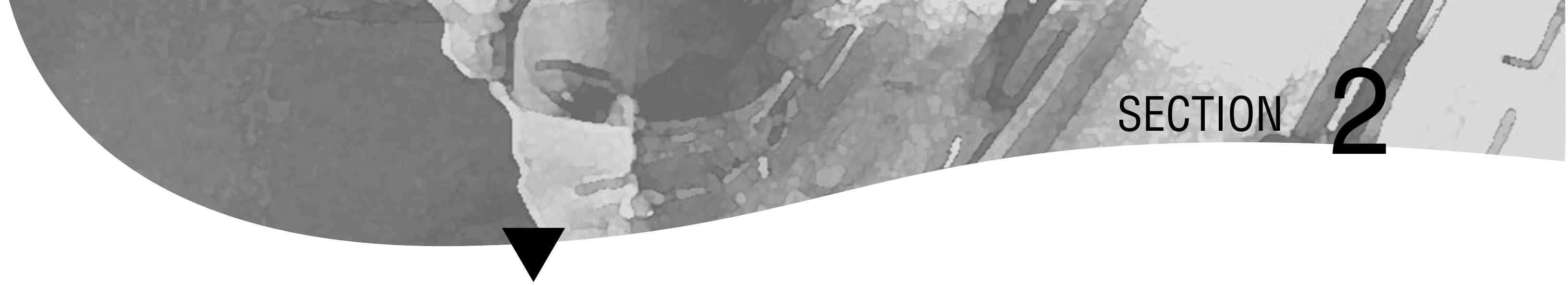
Danger
Explosion Hazard Do not install the Force 2 generator in the presence of flammable anesthetics, gases, liquids, or objects.
For continued protection against fire hazard, replace the fuse with those having the same type and rating as the original fuse.

Warning
Electric Shock Hazard Always unplug the generator before cleaning.
Electric Shock Hazard Do not connect a wet power cord assembly into the generator or into the wall outlet.
Electric Shock Hazard Disconnect the power before replacing parts.
Electric Shock Hazard Do not touch any exposed wiring or conductive surface while the generator is disassembled and energized. Never wear a grounding strap when working on an energized generator.
Keep the handset electrode away from personnel. Use the accessory holster to hold the handset safely.
Use the **ACCESSORY** output receptacle for connecting either a handswitch (three-pin) or footswitch (one-pin) accessory, but not both at the same time. Connecting more than one accessory to the **ACCESSORY** output receptacle activates both accessories simultaneously.
Electric Shock Hazard The power FETs and other components on the supply heatsink are at line potential. Use extreme caution when probing this circuitry.
Take appropriate precautions (such as use of isolated tools and equipment; use of the “one hand rule,” etc.) when taking measurements or troubleshooting the generator.

Caution

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

Electric Shock Hazard Special caution should be used when working on the exposed Power Supply board as the heatsinks and many of the components are floating at potentially harmful voltage potentials. Use the footswitching **ACCESSORY** receptacle for generator output on the Force 2-8 PCH and Force 2-2 PCH generators.



SECTION 2

Unpacking and Installation

Unpacking the Force 2 Generator

Notify Valleylab to arrange for repair or replacement of any parts damaged from shipping. All returns must have approval from the Valleylab Customer Service Department. The return authorization number must be displayed on the package label. Refer to Section 7, *Manufacturer Service*, for further information.

Carefully remove the Force 2 generator from the shipping package. Save the carton and packing materials to use when transporting the generator or when returning it for service.

If you have any questions concerning the contents, contact Valleylab Customer Service at 1-800-255-8522 or your Valleylab representative.

Responsibility of the Manufacturer

Valleylab is responsible for the safety, reliability, and performance of the equipment only within the limits of the warranty and other applicable laws if

- Installation procedures in this manual are followed.
- Assembly operations, extensions, re-adjustments, modifications, or repairs are carried out by persons authorized by Valleylab.
- The electrical installation of the relevant room complies with local codes and regulatory requirements such as IEC and BSI.
- The equipment is used in accordance with the Valleylab instructions for use.

Preparing the Generator for Use

The electrosurgical generator may be placed on a mounting cart available from Valleylab or any sturdy table or platform. It is recommended that carts have conductive wheels. Refer to hospital procedures or local codes for detailed information.

Provide at least four to six inches of space around the sides and top of the generator for convection cooling. Under continuous use for extended periods of time, it is normal for the top and rear panel to be warm.

Danger

Explosion Hazard Do not install the Force 2 generator in the presence of flammable anesthetics, gases, liquids, or objects.

Power Requirements

The Force 2-2 PCH Electrosurgical Generator is designed to operate at 110-120 Vac nominal, 50-60 Hz.

The Force 2-8 PCH Electrosurgical Generator is designed to operate at 220-240 Vac nominal, 50-60 Hz.

Check the Power Connector

The Force 2 generator is supplied with a hospital grade power cord and a three-prong power connector. If using the generator in an operating room with another type of receptacle,

- International Only – The Valleylab representative in your country will equip your generator with the proper power cord for your country.
- Domestic Only – The hospital is responsible for replacing the connector on the power cord.

The power connector meets all requirements for safe grounding. Its purpose should not be defeated by using extension cords or three-prong to two-prong adapters. Periodically check the power cord assembly for damaged insulation or connectors. Always grasp cords by the connector. Do not pull on the cord itself.

Ensure Proper Grounding

To ensure patient safety, the Force 2 generator must be properly grounded.

▶ ***Important***

It is the user's responsibility to ensure that the electrical installation of the relevant room complies with local codes and regulatory requirements such as IEC and BSI.

The ground wire in the power cord connects to the unit chassis and ensures that no dangerous currents flow from the cabinet in the event of internal electrical failure. Do not use extension cords or three-prong or two-prong electrical adapters.

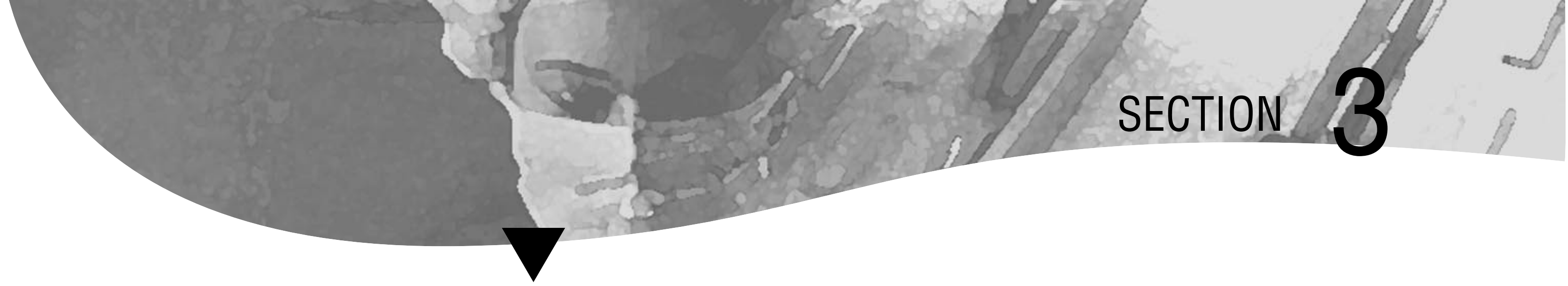
Undesirable leakage currents are affected by the polarization of the 50-60 Hz input power. It is the responsibility of the user to ensure proper polarity and grounding of the power outlets supplying power to the unit.

If required, use the equipotential ground cable supplied with the generator. The equipotential ground connector is located on the rear panel of the generator.

Perform a System Check

Before placing the Force 2 generator into clinical use, perform a system check as described in Section 6, *Power Up Self-Test*.

Notes



SECTION 3

Description of Controls, Indicators, and Receptacles

This section describes the controls, indicators, and receptacles for accessories located on the front panel of the Force 2 generator.

Figure 3-1.
PCH Generator Front View

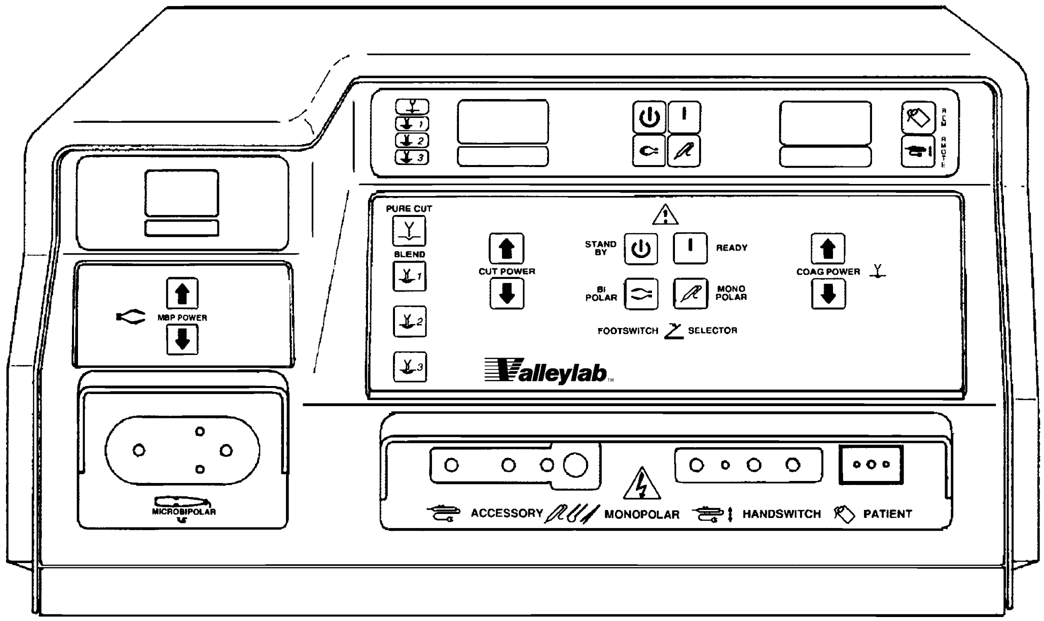
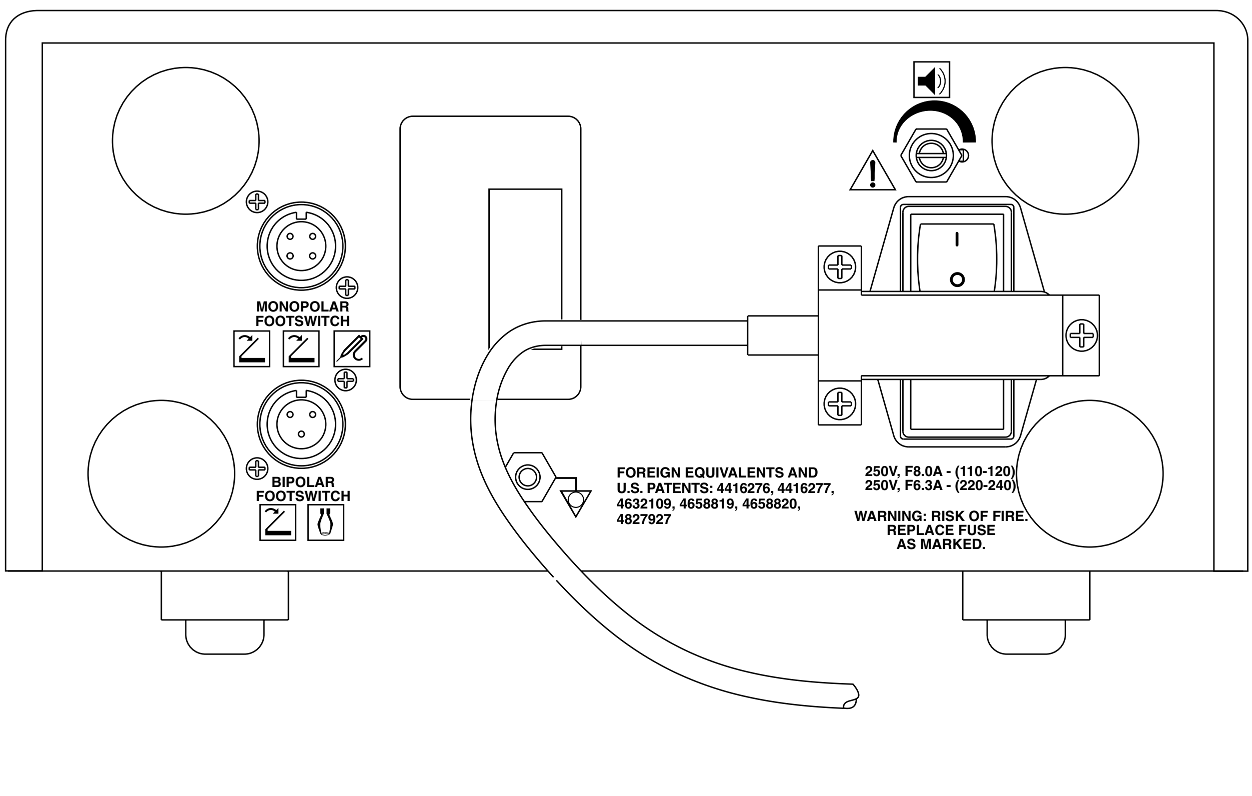


Figure 3-2.
PCH Generator Rear View

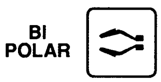


Controls

Standby – Press this button to place the electrosurgical generator in a hold mode. You cannot activate the generator and all audio alarms are silenced. The generator's memory retains the power settings and the display shows dashes.

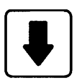
Ready – Press this button to place the generator into service with power outputs, displays, and alarms fully functional.

Monopolar – Press this button to select the monopolar footswitch control for activating the Accessory receptacle.

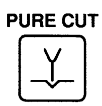


Bipolar – Press this button to select the bipolar output when using the monopolar footswitch.

Power Up –Press this button to increase power in the selected mode. A single press of the button increases the power setting by one watt. Continuously pressing the button gradually increases the power to maximum.

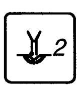


Power Down – Press this button to decrease power in the selected mode. A single press of the button lowers the power setting by one watt. Continuously pressing the button gradually decreases the power to minimum.

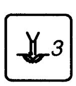


Pure Cut – Press this button to select cut with the lowest level of hemostasis.

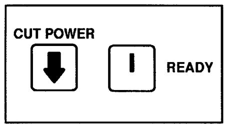
Blend 1 – Press this button to select cut with minimum hemostasis.



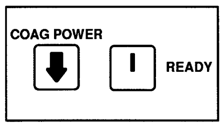
Blend 2 – Press this button to select cut with moderate hemostasis.



Blend 3 – Press this button to select cut with maximum hemostasis.



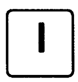
Power Control Pencil Mode – The power control pencil feature does not have a dedicated button to access this mode. Press the **READY** button and while holding it, press the **CUT POWER DOWN** button. The generator sounds a single tone and the **RMOTE** lamp illuminates.



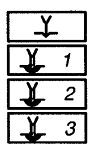
Low Voltage Coag – Low voltage coag does not have a dedicated button to access this mode. Press the **READY** button and while holding it, press the **COAG POWER DOWN** button. The generator displays an L in the hundreds digit of the coag power setting display.

Indicators

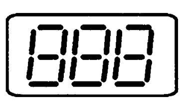
Standby Indicator – Indicates generator is on, but cannot activate outputs.



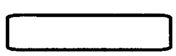
Ready Indicator – Indicates generator is ready for use.



Cut Mode Indicators – One of four cut mode indicators illuminates to show the selected cut mode.

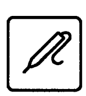


Power Setting Display – The digital power setting display is visible on the generator in the ready mode. The displayed number indicates the nominal power in watts. When you activate the mode, the generator delivers this power to the patient. In the standby mode, the generator display shows dashes.

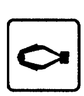


Output Power Indicators – The indicator illuminates when that output power (cut, coag, bipolar) activates. One of the two distinct mode indicator tones sound in conjunction with the visual output power indicator.

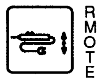
Low Voltage Coag Mode Indicator – An L in the hundreds digit of the coag power setting display indicates the low voltage coag mode selection.



Monopolar Indicator – This indicator illuminates when you select the generator's monopolar footswitch for monopolar accessory activation.



Bipolar Indicator – This indicator illuminates when you select the generator's monopolar footswitch control to activate the bipolar output.

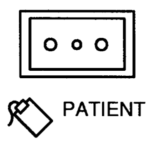


Remote Indicator – This indicator illuminates and the alarm tone sounds once when the power control feature activates. When this indicator illuminates, you can make power changes using the power control handswitching pencil.

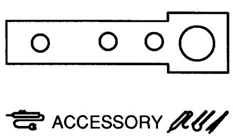
Alarms

REM Alarm Indicator – This indicator illuminates when the REM Contact Quality Monitoring System senses that contact between the patient return electrode and the patient is not adequate. The tone sounds twice when the generator first detects the condition. The generator does not produce monopolar output power when this alarm condition exists. The generator clears the alarm condition when the REM Contact Quality Monitoring System senses that the patient/pad contact resistance is within the acceptance range.

Receptacles



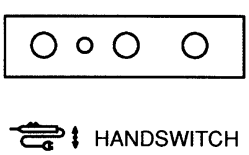
Patient Return Electrode Receptacle – This two-pin receptacle accepts the patient return electrode connector you use in monopolar procedures. The receptacle accepts both REM (dual-section) and conventional patient return electrode connectors.



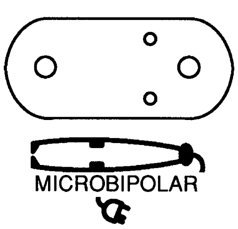
Monopolar Active Receptacle (Accessory) – This receptacle has two output receptacles. It accepts three-pin handswitching active accessories or standard one-pin accessories which you can activate with the monopolar footswitch. You can activate the cut and coag modes at this receptacle. If you connect the handswitching pencil to this output receptacle, you can activate the pencil with the footswitch.

Warning

Use the **ACCESSORY** output receptacle for connecting either a handswitch (three-pin) or footswitch (one-pin) accessory, but not both at the same time. Connecting more than one accessory to the **ACCESSORY** output receptacle activates both accessories simultaneously.

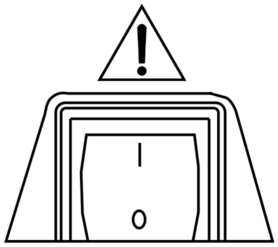


Monopolar Active Receptacle (Handswitch) – This receptacle accepts the three-pin handswitching active accessories and the Valleylab power control pencil. You can only activate the power output from this receptacle by using the handswitch mechanism. No power is available through use of the footswitch. You can activate the cut and coag modes at this receptacle. Note that the power control pencil is only functional through this receptacle.



Microbipolar Active Receptacle – This receptacle accepts three-pin handswitching bipolar accessories. You can also activate these accessories with the footswitch. This receptacle also accepts two-pin bipolar footswitching accessories.

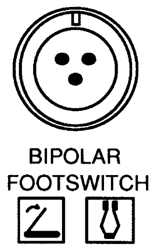
Rear Panel Functions



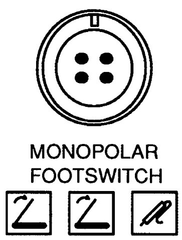
On/Off Switch – Press the toggle up to turn power on and down to shut power off.

The Force 2 generator uses a universal type power entry module but is not voltage selectable. Line fuse replacement is the following:

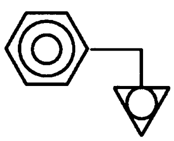
250V	8A	110-120V generators (-2 PCH)
250V	6.3A	220-240V generators (-8 PCH)



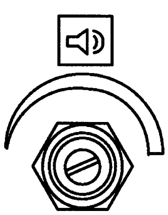
Bipolar Footswitch Receptacle – This three-pin receptacle accepts a single-pedal bipolar footswitch connector.



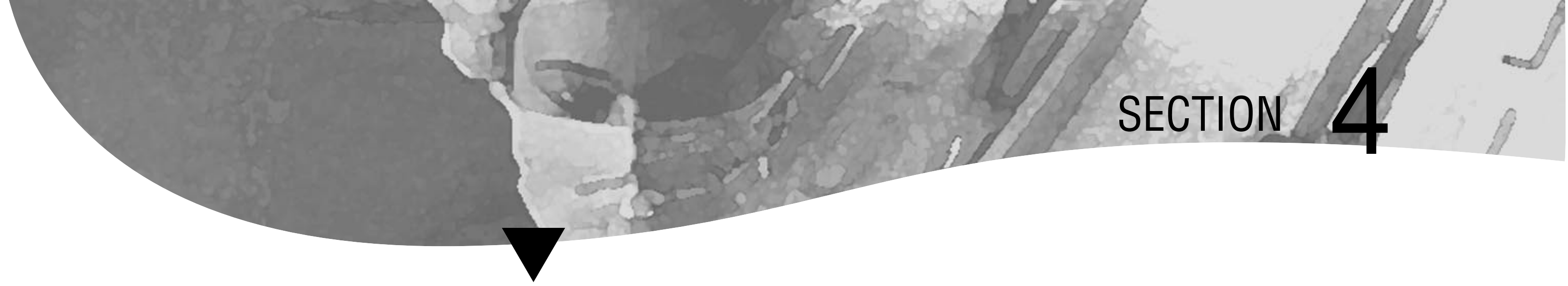
Monopolar Footswitch Receptacle – This four-pin receptacle accepts a two-pedal monopolar footswitch connector.



Equipotential Lug – You can connect this lug to earth ground with an equipotential grounding cable.



Audio Volume Control – When the generator activates, it produces cut, coag, and bipolar mode indicator tones. You adjust the volume of the tones with this control. The volume of the audio alarm is not adjustable.



SECTION 4

Technical Specifications

In this section “typical” refers to a specification that is within 20% of a stated value. Specifications subject to change without notice.

Standard Conditions of Measurement

Unless otherwise specified, all measurements are specified at an ambient temperature of 21° C (70° F) and 760 torr.

Operating Parameters

Temperature Range	10° C (50° F) to 40° C (104° F)
Humidity Range	30 to 75%, noncondensing
Atmospheric Pressure	500 to 1060 millibar

Storage and Shipping

Temperature Range	-18° C (0° F) to 70° C (158° F)
Humidity Range	10 to 100%, noncondensing
Atmospheric Pressure	500 to 2500 millibar

Output Waveform

Cut	510 kHz sinusoid
Blend 1	510 kHz bursts of sinusoid at 50% duty cycle recurring at 31 kHz
Blend 2	510 kHz bursts of sinusoid at 37.5% duty cycle recurring at 31 kHz
Blend 3	510 kHz bursts of sinusoid at 25% duty cycle recurring at 31 kHz
Coag	510 kHz damped sinusoidal bursts with a repetition frequency of 31 kHz
Low Volt Coag	510 kHz bursts of sinusoid at 25% duty cycle recurring at 31 kHz
Bipolar	510 kHz sinusoid, unmodulated

PCH Generator Output Characteristics

	Maximum (open circuit) P-P voltage	Rated Load (ohms)	Nominal Power at rated load (watts)	Crest Factor* at rated load (typical)
Cut	3500	300	300	2.1 @ 100W
Blend 1	3800	300	250	3.4 @ 100W
Blend 2	4000	300	200	3.9 @ 100W
Blend 3	4000	300	150	4.7 @ 100W
Coag	7000	300	120	8.5 @ 50W
Low Voltage Coag	4000	300	99	4.7 @ 99W
Bipolar	1200	100	70	2.0 @ 40W

** An indication of a waveform's ability to coagulate bleeders without a cutting effect*

Output Configuration

Isolated output.

Input Power Source

Force 2-2 PCH Generator

Maximum Operating Range	85-135 Vac
Nominal Operating Range	110-120 Vac

The line frequency may vary between 45 and 65 Hz

Current:	Idle - 0.7A, max	Power:	Idle - 60W, max
	Cut - 7.0A, max		Cut - 600W, max
	Coag - 2.9A, max		Coag - 250W, max
	Bipolar - 2.6A, max		Bipolar - 220W, max

Force 2-8 PCH Generator

Maximum Operating Range	170-270 Vac
Nominal Operating Range	220-240 Vac

The line frequency may vary between 45 and 65 Hz

Current:	Idle - 0.4A, max	Power:	Idle - 60W, max
	Cut - 2.9A, max		Cut - 500W, max
	Coag - 1.5A, max		Coag - 250W, max
	Bipolar - 1.3A, max		Bipolar - 220W, max

Line Regulation

Force 2-2 PCH Generator

Between 85 and 135 volts input, output power into nominal load will vary no more than 15% or 5 watts, whichever is greater.

Force 2-8 PCH Generator

Between 170 and 270 volts input, output power into nominal load will vary no more than 15% or 5 watts, whichever is greater.

High Frequency Risk Parameters

Bipolar RF leakage current	< 150 mA, per IEC 601-2-2.
Monopolar RF leakage current	< 150 mA, per IEC 601-2-2.

Low Frequency Leakage (50-60 Hz)

Force 2-2 PCH Generator

All patient connected terminals tied together:

Source current normal polarity, intact chassis ground	< 10 µA
Source current normal polarity, ground open	< 25 µA
Source current reverse polarity, ground open	< 25 µA
Sink current, 135V applied, all inputs	< 150 µA
Chassis source current, ground open	< 100 µA

Force 2-8 PCH Generator
(per VDE 0750 (IEC601-1), Section 19 for Class 1 Equipment)

Measured with radio frequency output inactive:

	Type CF	
Current Path	**Normal Condition**	**Single Fault Condition**
Earth Leakage Current	0.5 mA	1.0 mA
Enclosure Leakage Current	0.01 mA	0.5 mA
Patient Leakage Current	0.01 mA	0.05 mA
Patient Leakage Current (mains on the applied part)	0.01 mA	0.05 mA
Patient Auxiliary Current	0.01 mA	0.05 mA

REM Contact Quality Monitor

Measurement Frequency	140 kHz ± 20 kHz
Measurement Current	3.0 mA, maximum
Acceptable Resistance Ranges	Single area pad - nominally < 24 ohms Dual area REM - nominal range 5 - 135 ohms

If impedance measured is outside the acceptance range, a REM alarm will occur. In the REM mode, if resistance increases by more than 40% above the reference value, or above 135 ohms, an alarm will be generated.

Audio Volume

The mode indicator tones are adjustable from 45 to > 65 dBA at 1 meter. The alarm tones are set to a level of > 65 dBA at 1 meter and are not adjustable.

Approximate Weight

10 kg (22 lbs)

Size

20 x 33 x 53 cm (8 x 13 x 21 in.)

Classification

Type CF Equipment per IEC 601-1

The Force 2 generator provides a high degree of protection against electrical shock, particularly regarding allowable leakage current and has a CF type isolated (floating) applied part. The applied part may be used on the heart. Defibrillator protected.

Drip Proof per IEC 601-1

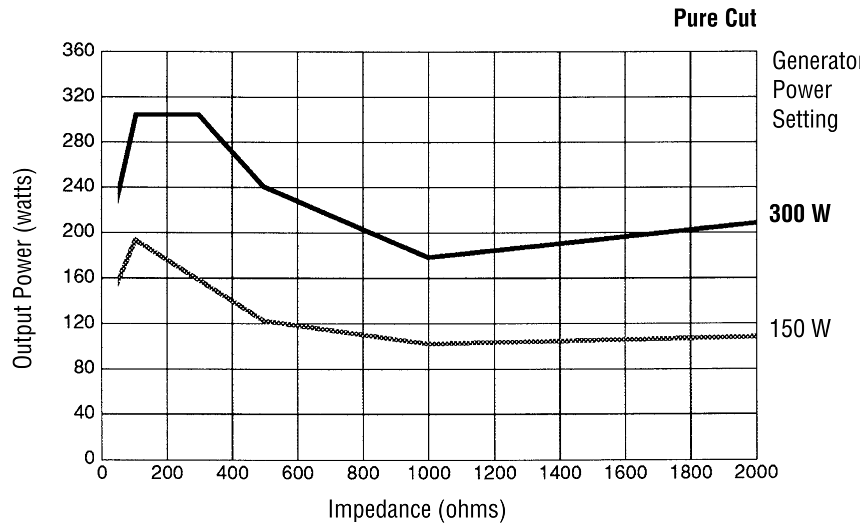
The Force 2 generator enclosure will prevent reasonable amounts of falling liquid from interfering with the generator's safe and satisfactory operation.

All monopolar output measurements are made using the setup referred to in IEC 601-2-2, Figure 104.

Output Power vs. Impedance Graphs

All monopolar output measurements are made using the setup referred to in IEC 601-2-2, Figure 104.

Figure 4-1.
PCH Generator Typical Output Power vs Load—Monopolar Cut Modes



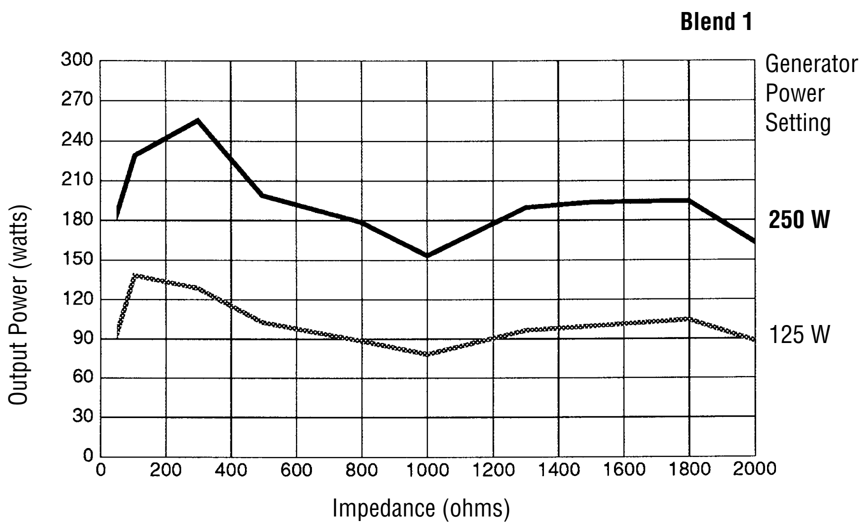
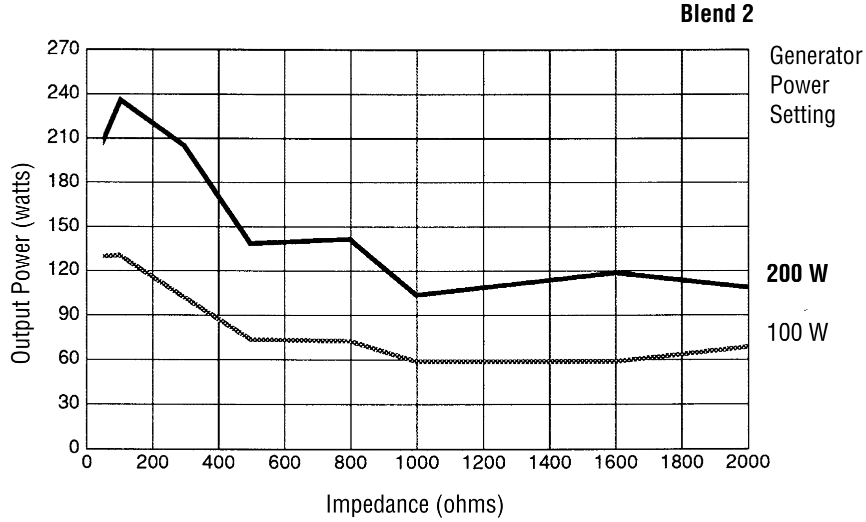


Figure 4-2.
PCH Generator Typical Output Power vs Load—Monopolar Cut Modes (continued)



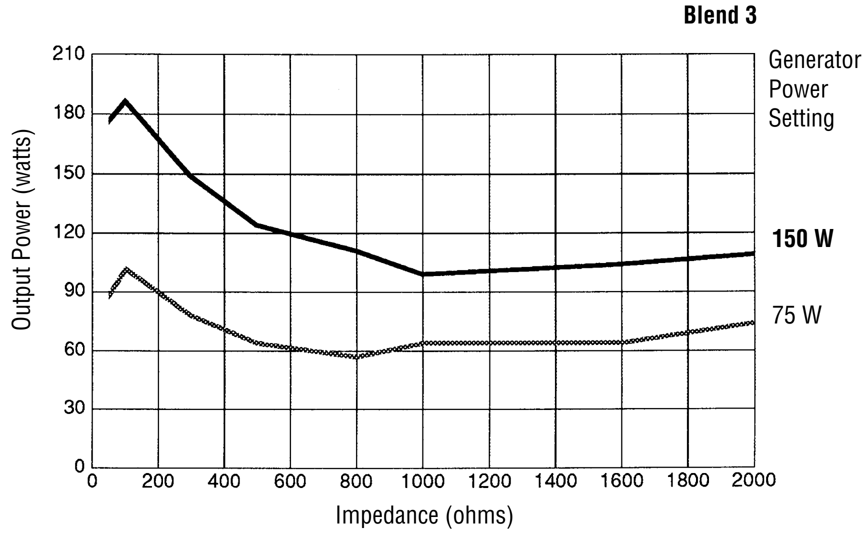
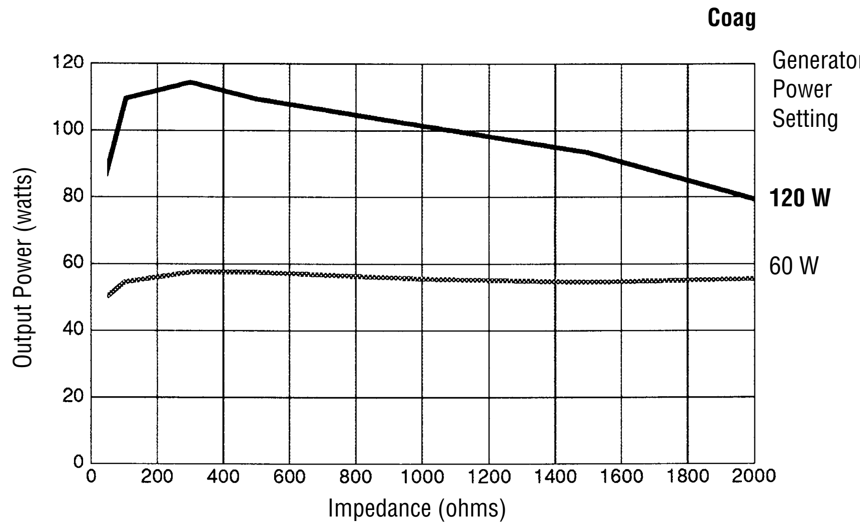
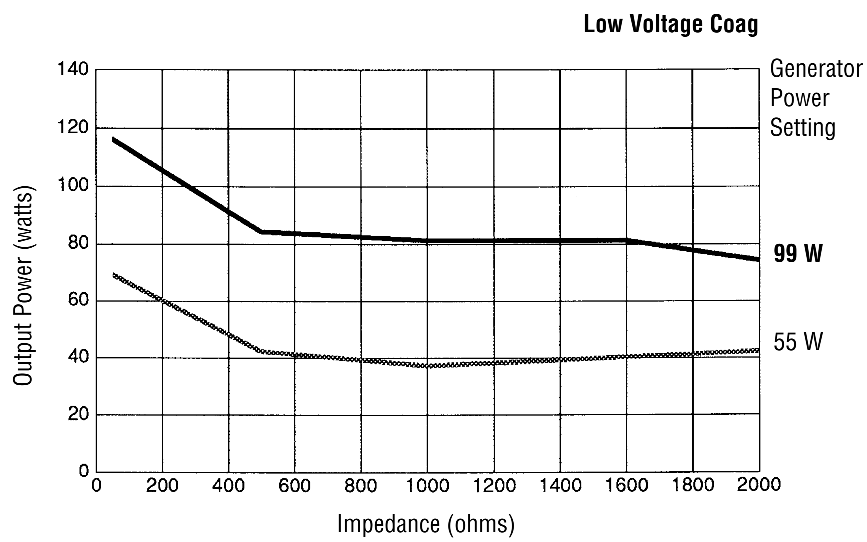


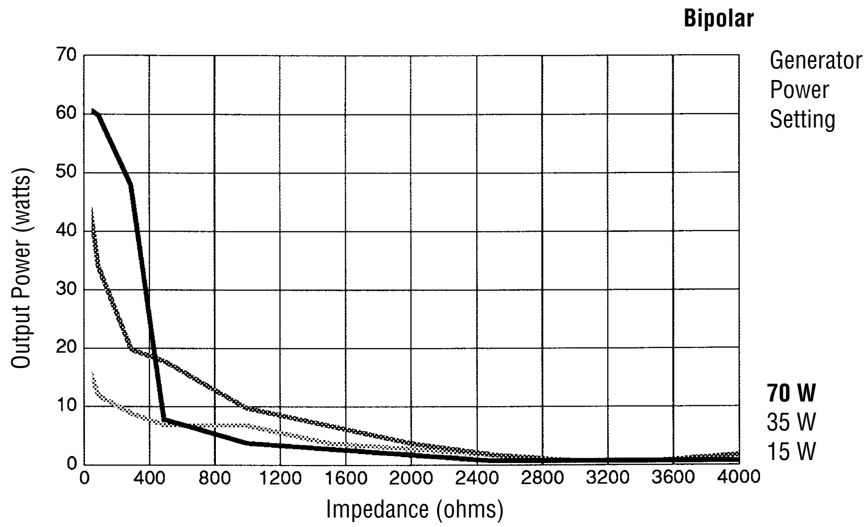
Figure 4-3.
PCH Generator Typical Output Power vs Load—Monopolar Coag Modes



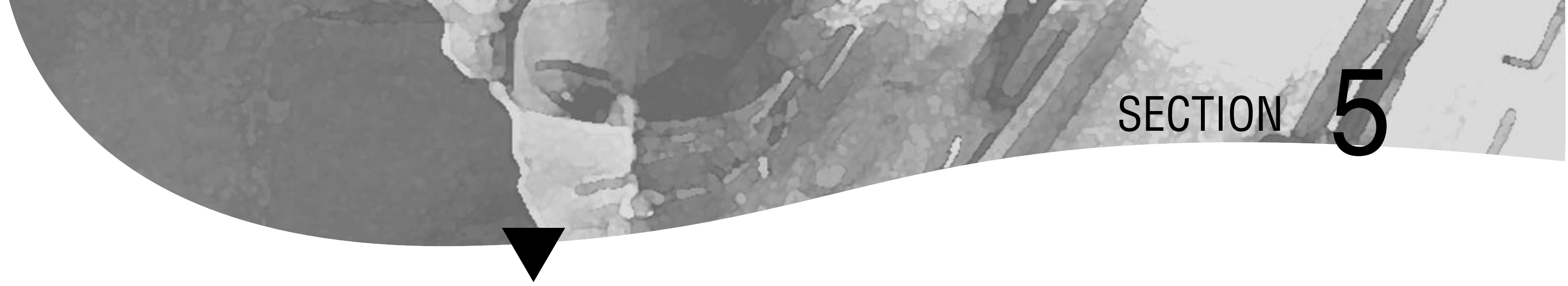


Bipolar measurements are made using bipolar forceps on the insulating surface referred to in IEC 601-2-2, Figure 104.

Figure 4-4.
PCH Generator Typical Output Power vs Load—Bipolar Mode



Notes



SECTION 5

Circuit Descriptions

Bipolar Display

The Bipolar Display board is the numeric display for the mode's power set point, and the signals for these indicators derive from the multiplexed display driver on the Monopolar Control/Display board. The Bipolar Display board displays the bipolar RF indicator and the RF circuitry generates the signals.

An audio alarm is also present on this board. Circuitry on the Microprocessor board performs the frequency select for the alarm. A potentiometer on the rear panel controls the volume. In the case of an alarm condition, the board bypasses the volume potentiometer and a full volume alarm sounds. The Monopolar Control/Display board contains this circuitry.

Monopolar Control/Display

The Monopolar Control/Display board (also known as the CPU board) has two major functions:

- Serve as the main control element of the generator
- Provide the user interface.

As part of its control function, the CPU board supports REM monitoring. The board also supports adaptive REM monitoring, but only when RF is inactive.

When functioning as the operator/generator interface, the CPU board receives all operator keyboard inputs and performs the proper functional response (e.g., increment power register and display, change mode, and so forth). Further, it accepts all activation signals after the Interface board decodes them and performs the necessary steps to produce the desired RF output.

When functioning as the main control element of the generator, the Monopolar Control/Display board produces the proper RF drive according to the mode selected. It calculates and generates the required power supply control voltage. It also calculates and sets the current limit for the RF output stage.

The main control element on the CPU board is an 89C54, a single chip microcontroller with 16k of on-board electronically programmable read-only memory (EPROM). The firmware residing within the 89C54 implements the performance requirements of the Monopolar Control/ Display board. This section provides a description of the Monopolar Control/Display board hardware.

An Intersil ICM7218C display multiplexer (U8) performs the major display functions of the Monopolar Control/Display board. The device is a universal, eight digit, LED driver system. It contains all the circuitry necessary to interface a microcontroller to a multiple seven segment LED display:

- An 8 x 8 static memory array with storage for the displayed information
- Seven segment decoders
- All multiplex scan circuitry
- The high power digit and segment drivers.

Mode Indicators

The ICM7218C is not capable of driving the mode indicators with enough power to make them fully visible through the translucent display windows. The microcontroller writes a bit pattern on the ICM7218C digit drive bus; the pattern corresponds to the mode displays to be illuminated. Segment H, the decimal point drive output of the ICM7218C, gates each of the eight digit drive lines through U28 and U29 to provide external multiplexing for the mode indicator information. A ULN2803A, U27, boosts the resultant mode indicator drive current.

REM and RMOTE Indicators

The ICM7218C does not control the REM and RMOTE indicators. Microcontroller port lines P12 and P16, buffered by U5B and U5A, drive the REM and RMOTE indicators directly. Pull-up resistors R45 and R47 ensure that the outputs of the open collector driver pull high when its inputs are low.

An additional circuit in parallel with the REM LED is transistor Q1, which turns on when the REM indicator illuminates. This transistor shorts out the volume control potentiometer causing the alarm tone to sound at full volume.

Two digit drive lines and seven segment drive lines, bused from the Monopolar Control/Display board to the Bipolar Display board, control the bipolar display seven segment digits.

Integrated circuit U11C, configured as a single gate oscillator, R22, and C26 serve as the principal frequency determining elements. R23 and CR8 change the duty cycle of the oscillator and help to fine tune the final audio output. Port lines of the 89C54, P10 and P11, control the audio enable and tone frequency respectively. These two control lines activate an on/off analog switch which gates the audio drive signal to the audio amplifier stage comprised of U5F and U5G. A second analog switch, when enabled, increases the net capacitance of the audio oscillator timing elements, thereby lowering the frequency. A filter consisting of R7 and C4 rolls off the high frequency components of the audio signal reducing the harshness of the audio tone. A large R-C filter, R19 and C20, on the power input to U1, provides decoupling from the 5V supply.

RF Indicators

The display driver does not control the RF indicators. Port lines P24 through P27, buffered by U5D, U5C, and U5E, drive the Cut, Coag, and Bipolar RF power indicators. Q5 further controls the indicators. For the RF indicators to illuminate, the presence of either the LMPTST or RF_SENSE signals must turn on this transistor.

When you turn on the generator, LMPTST performs a display test that turns on all of the display digits and indicators. RF_SENSE, coming from the PSRF board, activates whenever the ECON voltage reaches a level to provide usable output.

The 89C54 communicates directly with the ICM7218C; that is, the display driver is a device on the CPU's data bus. For the CPU to read from or write to its peripherals, the system must generate chip selects external to the CPU. The falling edge of the address latch enable (ALE) line on the CPU indicates that a valid address is present on the data bus. A 74LS374 octal D-type latch (U9) latches the external memory address of the selected peripherals.

External Memory

There are eight external memory locations. To ensure accessing only one peripheral at a time, all external memory locations have addresses with all bits high except one. The address latch, U9, is continuously active with addresses on the address/data bus latched with every negative transition of ALE. When it accesses an external device, it qualifies the latched address byte with a RD\ or WR\ signal as appropriate, causing the selected device to be strobed with a negative true read or write signal.

Three of the external memory locations are read only and five are write only. Previously, the text described one of the write only locations, U8, the ICM7218C display controller. The following text covers the other seven locations, starting with the read locations.

Three Read-Only Locations

The three read locations enter the 22 user inputs:

- Fourteen are the keyboard inputs
- Eight are decoded activation inputs.

The signals are grouped logically into activation inputs, mode selection, and power UP/DOWN control. Tri-state inverting buffers U2, U15, and U17 gate these signals onto the CPU data bus.

Four Write-Only Locations

There are two 8-bit digital/analog converters (DACs) on the data bus, U21 and U19. These are write only devices. The U21 DAC generates the power supply control voltage ECON. The U19 DAC generates the RF current limit analog voltage ICON.

The buffered outputs of the two DACs are further amplified by a gain of 2.4. The final output range of the two analog signals is approximately 0V to 5V. An LM324 quad op amp, U23, contains all of the amplifiers. Capacitors C39 and C44 limit RF interference.

If the ECON and ICON signals do not track within a 10% "window," the Power Alarm circuit on the PSRF board enables an alarm signal; the generator emits a constant audio tone and disables the RF output. The REM indicator also comes on. This alarm warns of possible CPU or DAC problems.

The third write memory location, U6, is a 74LS165 8-bit, parallel-in, serial-out shift register. this register gates the principal RF clock frequency to generate the final RF drive envelope.

A 74LS374 octal D-type latch (U4) in the activation circuitry uses the fourth write location. When the Force 2 is activated, the microcontroller reads data on the bus. The data identify which device is activate and in what mode. It then writes this data to latch U4. Two 74LS85 digital comparators, U7 and U10, compare this stored pattern to the ongoing activation input. Any change in the activation input will cause the digital comparators to respond to the difference in inputs and, subsequently, to deactivate the RF output and to begin to respond to the new activation (or de-activation) input. R27 and C29 provide time delay and moderate RF filtering to this line.

An 8.192 MHz crystal oscillator generates the required clock signal for 89C54. This oscillator also provides the clock drive for the RF waveform drive circuitry, giving a stable RF output frequency.

During RF T-on and T-off drive generation, U26 divides the crystal frequency from 8.192 MHz to 510 KHz. One half of U18 serves as a toggle flip-flop to divide the clock further to 255 KHz. Two analog gates of U20, controlled by the microcontroller port P15, select the frequency of the RF drive pulse trains. The microcontroller loads a 74LS165 parallel in serial out shift, U6, with a pattern that corresponds to the grouping of RF drive pulses for the desired mode of activation. Since the 8 bit shift register cyclically loads itself while data shifts out, the drive frequency of modulation is 255/8 = 31.88 KHz. An AND gate (U22) processes the selected clock frequency with the serial output of the shift register U6 to produce RFT0, the RF on drive. This generator does not use RFT1, the RF off drive. R36-C41 compensate for timing skews on the clock generation circuitry and provide a means for adjusting the RF output power.

To avoid RF interference problems, the microprocessor goes into an idle mode when the generator is activated. A latch, U18A, sets when the generator is activated and resets when the activation ends. The Q\ output of this latch goes to an interrupt input, Port 33, of the microcontroller. Resetting this latch awakens the microcontroller from its idle mode state, allowing it to respond to the change in the activation status. The occurrence of a REM alarm (except when Bipolar mode is activated) also resets the latch. Enabling the generation of RF drive pulses requires the inverse of the signal that awakens the microcontroller, RF_EN/WAKEUP\. Consequently, RF drive trains and RF output can only occur when the microcontroller is in the idle state.

A 74LS374 latch, U1, buffers Port 2 of the 89C54 microcontroller. Port 2 controls the RF enable and RF relay signals. The latch has an asynchronous reset that forces the output signals to an inactive state during the power up reset period.

Interface

The Interface board mounts vertically at the front panel shield. It contains the patient circuit module functions: activation, output receptacle selection and patient return contact quality monitoring. This board has isolated, high voltage, patient connected circuitry, and you must use exactly equivalent parts for component replacement.

The activation circuits comprise an isolated power source, comparators to detect switch closure and optical couplers. The power source is two flyback converters and toroid transformers. The handswitch circuits use three comparators to sense active to cut, active to coag, cut to coag, and active to cut to coag connections. These codes for cut and coag increase power and reduce power, respectively. The remaining activation circuits simply have resistors in series with the opto couplers to limit current. There are four isolated circuits, each with its own transformer winding for power.

This generator has three possible RF output receptacles. Single pole, normally open, high voltage relays make the selection of the receptacle. The CPU turns on the relays through bipolar drivers on the Interface board. A CPU controlled delay between relay closure and initiation of RF drive reduces contact wear. Note the 0.0047 µF capacitors in series with the RF output and return. These are the primary patient protection against electrocution and must be high voltage parts.

The REM circuitry measures the pad to pad resistance of dual-pad patient return electrodes or the wiring resistance of single pad electrodes. A microswitch in the connector opens for dual-pad patient return electrodes and selects one of two alarm signal paths in the alarm logic string. The load on the REM transformer secondary is the measured resistance. The secondary resonates by two 0.22 µF capacitors, and a synchronous detector senses the reflected primary load. Four clocked CMOS switches perform synchronous detection. A potentiometer tunes the oscillator to the transformer. The detector output amplifies and inputs to four comparators. Two comparators provide hard wired alarm limits at 5 ohm and 135 ohm alarm limit for dual-pad patient return electrodes. The third comparator provides a hard wired alarm limit at 20 ohms for single pad electrodes.

The fourth comparator generates a pulse width modulated waveform by comparing the return electrode monitor resistance to a triangle wave that an oscillator generates. The CPU decodes this pulse width to implement the adaptive REM feature for dual-pad resistances between 5 ohms and 135 ohms.

Power Supply

The high voltage DC power supply on the Power Supply board is an off-line DC-DC switching converter operating at 80 kHz. A bridge rectifier, two hold-up capacitors and four power FETs in a bridge configuration supply the input power. The FETs drive the power transformer T2 primary at 320V peak and varying duty cycles. A 0.75 mH inductor and two 15 µF capacitors filter the power transformer rectified secondary voltage which convert a constant amplitude variable duty cycle input to a variable DC output. A 3526 IC regulator with emitter followers performs duty cycle control and drives the transformer T3, that switches the power FETs. The IC contains a sawtooth oscillator, pulse steering logic, and a comparator. The error voltage on pin 1 varies from 0.5V to 3.5V to change the output duty cycle. The power transformer has snubber networks to limit voltage spikes.

Power supply control uses an op amp within the 3526 to amplify the difference between a feedback fraction of the DC output and a reference voltage ECON. The CPU generates the reference and the reference scales as the square root of the front panel power setting. There is a DC current limit implemented with a comparator and pulse stretcher. The pulse stretcher shuts down the supply's control IC for about 1/3 of a second and then soft starts the supply. The R-C network on the 3526 pin 7 provides a power on reset.

A separate switching power supply on the rear of the chassis supplies the low voltages. It supplies regulated +5Vdc, +12Vdc, and -12Vdc to the Power Supply board where all voltages filter with 10 µF capacitors. The -12Vdc voltage converts to -5Vdc using a LM336 regulator. The supply voltages transfer to the Interface board and Monopolar Control/Display board through the 40-pin ribbon cable.

Warning

The power FETs and other components on the supply heatsink are at line potential. Use extreme caution when probing this circuitry.

RF Output

This circuitry resides on the Power Supply board and amplifies the CPU signal T-on, RFT (0) to the level the front panel power setpoint requires.

T-off, RFT (1) is not a requirement and therefore terminates at the ribbon cable with a 10k ohm resistor. Current limiting and peak voltage limiting circuits prevent damage under extreme load conditions. Varying the supply voltage controls the power. Both DC supply and RF current limit levels calibrate for each mode - cut, coag, blend and bipolar. The output tuning and transformer turns ratio is different for cut and coag waveforms and a relay performs the selection. Eight power FETs act as RF switching elements. A current sampling resistor at the sources provides input to a current limit circuit. Gate drive is direct at a 12V level. The drains have diodes in series to allow the output transformer primary voltage to swing negative in coag. The cut waveform drive is at a 50% duty cycle with a 1 µs ON time. Turning on the FETs for 2 µs every 32 µs generates the coag drive waveform.

RF control uses a RS flip-flop to control the T-on pulse to the output stage. The RS flip-flop can be reset by feedback circuits to reduce output drive pulses for control of RF output. Excessive output current compared to ICON or excessive negative going voltage compared to the ECON setting can generate this pulse reduction, pulse wacking.

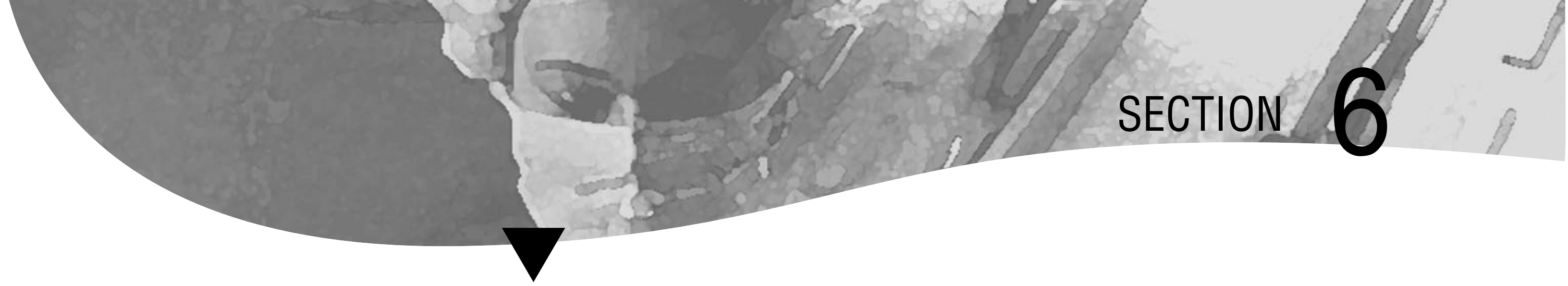
Comparing output transformer primary voltage to ECON controls the RF leakage and high impedance power. The signal from the primary attenuates and then compares to a reference level proportional to the ECON setting. This attenuation is mode specific for cut, blend, and coag. When the negative going voltage from the primary exceeds the reference level, this removes (wacks) the RF drive pulses and adds a resistive load in parallel to the primary to dampen the output waveform.

The CPU supplies the current limit reference, ICON, and varies as the square root of power with an offset at low powers. When peak voltage limiting occurs, the reference voltage to the LM306 current limit comparator reduces which in turn reduces the output pulse width. At high load impedances a one shot triggers by transformer primary voltages below -100V. This one shot places a resistive load across the output and reduces high frequency risk currents.

The FET output is rather low impedance, and the choice of DC supply voltage as the power control parameter limits its voltage compliance.

Above 300 ohms load, the output resembles a constant voltage source. Below 300 ohms load, the current limit circuitry enforces a constant current characteristic. All eight output FETs must be the same type.

The bipolar control adds an op amp to the power supply feedback path. This amplifies the difference between the RF output peak voltage and the power supply set point voltage. The difference is summed with the feedback supply voltage by injecting current into the feedback divider to reduce the supply under high impedance load conditions. Current injection enables only in the bipolar mode.



SECTION 6

Maintenance Procedures

Routine Maintenance and Inspections

Valleylab recommends that qualified service personnel inspect the Force 2 generator every six months. Check the power cord assembly periodically for damaged insulation or connectors.

This service manual describes the recommended maintenance, inspection, testing, and calibration procedures. Return the generator to Valleylab for major repairs. Repair parts and information are available from Valleylab. Refer to Section 8, *Service Parts List*, for additional information.

Cleaning Instructions

Clean the Force 2 generator using standard hospital procedures. Use a mild detergent and damp cloth to clean the cover, control panel, footswitch, and cord. Do not allow fluids to enter the chassis. Do not use caustic, corrosive, or abrasive cleaning materials. The generator and all components must be completely dry before use.

Do not sterilize the Force 2 generator.

Warning

Electric Shock Hazard Do not install a wet power cord assembly into the generator or into the wall outlet.

General Testing Information

Warning

Take appropriate precautions (such as use of isolated tools and equipment; use of the "one hand rule," etc.) when taking measurements or troubleshooting the generator.

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

Notice

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. Handle the circuit boards by their nonconductive edges. Use an antistatic container for transport of electrostatic sensitive components and circuit boards.

▶ ***Important***

When removing the Power Supply board, please refer to Schematic 1 for proper hardware installation. Use a star washer in the location indicated, for grounding. The Force 2 generator rating is not for continuous duty operation. The recommended duty cycle is 50% (15 seconds on, 15 seconds off). (Maximum ON time at a power setting of 100 is two minutes.)

When testing, follow proper testing procedures in order to duplicate manufacturer test data. Keep test leads as short as possible. Lead inductance and stray capacitance can affect meter readings adversely. Use of uncompensated scope probes may cause large errors in measurements. When measuring microampere leakage currents, accidental capacitive or inductive coupling may cause order-of-magnitude error in the observed values.

Perform the leakage current and ground resistance tests before returning the generator to clinical use.

Recommended Test Equipment

You will need the following equipment to perform the checks and calibration described in this section. If you use substitute equipment, it must meet or exceed the specifications of the recommended equipment.

- Tektronix type 465 Oscilloscope, or equivalent, with 50 MHz or greater band width
- Tektronix type P6015A High Voltage Probe
- Tektronix type P6009 100X Probe
- Simpson Model 1339 RMS RF Ammeter, 0-250 mA
- Wattmeter, 0-500 W 300 ohm load and 100 ohm load with reactive phase angle of less than 20 degrees at 500 kHz
- Variable Resistor 0 to 150 ohms
- Fluke Model 8920A True RMS Meter
- Pearson Model 411 Wideband Current Transformer
- Dale NH250 1% Noninductive Load Resistors
- Line Frequency Leakage Current Test Load (1k ohm parallel 0.15 µF)
- 30 pF ± 20%, 6kV Ceramic Capacitor.

Power Up Self-Test

Plug the generator into a grounded receptacle (do not use extension cords and/or adapter plugs). Turn the power on using the On/Off switch on the rear panel.

The generator will conduct an internal self test during which a tone sounds, digital displays show “8”s, and indicators illuminate. Ensure that all digit segments, mode, alert, and power indicators illuminate. If any of these indicators do not illuminate, return the generator for service.

In five to seven seconds following the self test, the generator enters the standby mode with the digital displays showing dashes.

Press the **READY** button to place the generator into service. The power setting displays indicate one watt, and the **MONOPOLAR FOOTSWITCH** indicator illuminates.

Calibration

You obtain the best performance if each adjustment is made to the exact setting. If you use substitute equipment, it must meet or exceed the specifications of the recommended equipment. Also, the manufacturer makes all calibrations in the procedure before Quality Assurance accepts the generator. If you only need to recalibrate RF output power, proceed directly to step 4 of the procedure.

Take special care in step 3. Calibrate the 100X probe and the oscilloscope together before using.

Calibration Procedure

1. Remove the cover from the Force 2 generator to expose the internal controls and test points.
2. +12 V Supply: Connect the digital multimeter between pins 5 or 6 and pins 1 or 2 on the 40-pin interconnect cable. The meter should read +12 V ± 0.3 V.

   +5 V Supply: Connect the digital multimeter between pins 3 or 4 and pins 1 or 2 on the 40-pin interconnect cable. The meter should read +5 V ± 0.25 V.

   -5 V Supply: Connect the digital multimeter between pin 7 and pins 1 or 2 on the 40-pin interconnect cable. The meter should read -4.75 V ± 0.2 V.

Caution

Special caution should be used when working on the exposed Power Supply board as the heatsinks and many of the components are floating at potentially harmful voltage potentials. Use the footswitching **ACCESSORY** receptacle for generator output on the Force 2-8 PCH and Force 2-2 PCH generators.

3. Adjust the High Voltage Clamp
   a. Set the coag power setting display to 30 W.
   b. Attach a 300 ohm load from the generator output to the **PATIENT** receptacle.
   c. Activate the generator in coag. Output power should be 30 W ± 5 W.
   d. Remove the 300 ohm load.
   e. Adjust the coag power setting display to 1.
   f. Attach an oscilloscope with a 100X probe between the anode of CR1, TP11, and ground. Activate the generator in coag. Slowly increase the coag power setting display and observe the peak positive voltage. Adjust R19 on the Power Supply board so that the maximum peak voltage is 440 V ± 15 V.

4. Adjust the Pure Cut Output Calibration

   a. Attach a 300 ohm load to the generator output.

   b. Set cut power setting display at 300 W and adjust R74 for 300 W output.

   c. Attach a 100 ohm load to the generator output.

   d. Verify that cut output is 290 W - 325 W. If not, adjust R70 for the correct output. R70 is the cut ICON adjustment.

5. Blend Modes Output Calibration

   a. Attach a 300 ohm load to the generator output.

   b. Set the blend 2 power setting display at 200 W and adjust R75 for 200 W output. R75 is the blend ECON adjustment.

   c. Attach a 100 ohm load to the generator output.

   d. Set the blend 1 power setting display at 250 W.

   e. Verify that blend 1 output is 210 W - 260 W. If not, adjust R71 for correct output. R71 is the blend ICON adjustment.

6. Coag Output Calibration

   a. Adjust R61, R62, R63, and R101 fully clockwise.

   b. Attach a 300 ohm load to the generator output.

   c. Set coag power setting display to 30 W, activate and adjust R76 (ECON) for approximately 37 W (350 mA).

   d. Press the **READY** and **COAG POWER DOWN** buttons at the same time to enter the low voltage coag mode, set low voltage coag power setting display to 30 W and adjust R101 for approximately 32 W (330 mA).

   e. Verify the output power for coag at 30 W is 32 W (330 mA) and low voltage coag at 30 W is approximately 32 W (330 mA). Adjust R76 and R101 as needed.

   f. Set coag power setting display to 120 W and verify output power for approximately 112 W (610 mA). Ensure that R72 (COAG ICON) is adjusted fully clockwise.

7. Bipolar Output Calibration

   a. Attach a 100 ohm load to the generator output.

   b. Set R73 to mid setting. Turn R69 fully clockwise.

   c. Set the bipolar power setting display at 70 W and adjust R73 for 70 W (836 mA) output.

   d. Turn R69 counterclockwise until it affects bipolar output in part 7b. Then, turn R69 clockwise one turn.

8. High Impedance Power

a. Attach a 4000 ohm load between the **ACCESSORY** and **PATIENT** receptacles. Activate cut at maximum power setting and adjust R61 to achieve approximately 35 W (93 mA). Verify the 3000 ohm output is above 170 W (238 mA).

b. Attach a 4000 ohm load between the **ACCESSORY** and **PATIENT** receptacles. Activate blend 2 at maximum power setting and adjust R62 to obtain approximately 36 W (95 mA). Verify the 3000 ohm output is above 120 W (190 mA).

c. Attach a 4000 ohm load between the **ACCESSORY** and **PATIENT** receptacles. Activate coag at maximum power setting and adjust R63 until power increases from approximately 20 W (70 mA) to 58 W (120 mA). Discontinue activation and adjust R63 1/4 turn counterclockwise. Activate the generator and observe output reading. Continue this inactivated/activated calibration in 1/4 turn increments until the output is approximately 20 W-26 W (70 mA-80 mA). Verify the 3000 ohm output is above 60 W (141 mA).

▶ ***Important***

Use short leads on all connections. Adjust R61, R62, or R63 if any reading exceeds 150 mA in the cut, blend, or coag modes, respectively. If you need to make an adjustment, recheck the High-Impedance power.

9. High Frequency Leakage

Bipolar RF Leakage

a. Connect the 200 ohm load and RMS voltmeter in series from the right **MICROBIPOLAR** receptacle to chassis ground.

b. Connect a 30 pF capacitor between the left **MICROBIPOLAR** receptacle and chassis ground.

c. Activate **MICROBIPOLAR** at 70 W and note the results for the right **MICROBIPOLAR** receptacle.

d. Reverse the load and capacitor connections at the **MICROBIPOLAR** receptacles.

e. Activate **MICROBIPOLAR** at 70 W and note the results for the left **MICROBIPOLAR** receptacle.

Monopolar Patient Return RF Leakage

Connect the 200 ohm load and RMS voltmeter in series from **PATIENT** receptacle to chassis ground, connect a 30 pF capacitor between active accessory and chassis ground.

a. Activate cut at 15 W and note leakage current. Increment the setting by 5 W until 25 W is reached and ensure that the hot spot between the incremental settings is less than 150 mA. Adjust R61 as needed to control leakage. Increase power settings to maximum power.

b. Select blend 3 and activate to 25 W and note leakage current. Increment setting by 5 W until 45 W is reached and ensure that the hot spot between the incremental settings is less than 150 mA.

c. Select coag and activate at 10 W and note leakage current. Increment setting by 5 W until 25 W is reached and ensure that the hot spot between the incremental settings is less than 150 mA. Increase to maximum power.

▶ ***Important***

Use short leads on all connections. Record readings at maximum power settings in cut and coag.

Monopolar Accessory Active RF Leakage

Connect the 200 ohm load and RMS voltmeter in series from accessory active to chassis ground and connect a 30 pF capacitor between **PATIENT** receptacle and chassis ground.

REM Test Procedure

1. Connect a variable resistance across the two pins within the Patient receptacle using a REM-type connector.
2. Set the resistance to 135 ohms and adjust R11 for the highest possible voltage on TP3.
3. Turn R15 counterclockwise until EREM is below 4 V. Turn R15 clockwise until REMFT (TP5) goes high (5 V).
4. Monitor REM PW (TP2) and adjust R16 until one period of square wave is 10 ms ± 0.5 ms. Decrease the resistance to 50 ohms.
5. Increase the resistance gradually and record the value at which the REM alarm turns on (70 ohms ± 10 ohms). Decrease the resistance and note that the REM alarm again turns off.
6. Decrease the resistance and record the value at which the REM alarm again turns on (5 ohms ± 2 ohms).

Repeat above test setup not using a REM-type connector. Set the variable resistance to 5 ohms. Note that the REM alarm is off. Gradually increase resistance and record value at which the REM alarm turns on (less than 24 ohms). The REM alarm should remain off below this value and turn on again if above this value.

Line Frequency (50-60 Hz) Current Leakage Test Procedure

This test measures potentially dangerous 50-60 Hz leakage currents.

The Force 2 generator is left on but not active.

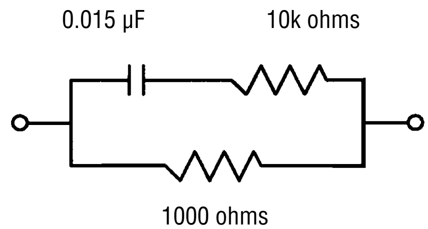
To indirectly measure the current, observe the voltage across a 1k ohm resistor to ground from each front panel receptacle. A 0.015 µF capacitor connects in series with the 10k ohm resistor to remove any trace of oscillator high frequency noise inside the generator. This capacitor has little effect on the 50-60 Hz leakage current.

▶ ***Important***

When you activate the generator, it is difficult to make a 50-60 Hz leakage measurement because of the extreme difference in magnitude of the 50-60 Hz leakage current in the RF signals. When you activate the generator, there can be as much as 7000 V peak to peak of RF compared to 20 mV of 50-60 Hz. This ratio (110 db) of voltages would require the use of sophisticated measuring techniques. In practice, the 50-60 Hz leakage currents do not change significantly when you activate the generator.

To calculate the leakage current, use the formula I = E/R, where R = 1k ohms and E is the voltage across the resistor. The maximum acceptable voltage across the 1k ohm resistor for 10 µA leakage is 0.010 V (10m V).

Input Circuit:



Measure third wire leakage current by opening the green grounding wire at the plug and connecting the 1k ohm resistor from chassis to ground. The maximum voltage across the 1k ohm resistor for 350 µA leakage would be 350mV. You may use commercially available leakage testers for this test.

The typical value of 50 µA is valid for manufacturer installed 3 m, 1.0 mm 2 line cords. Do not use longer line cords or extension cords. They increase the third wire leakage. With the Force 2 generator power off, the third wire leakage should be less than 10 µA.

The line frequency sink leakage is the current that passes into the **PATIENT** leads when there is a 120 V, 50-60 Hz potential between a **PATIENT** lead and the chassis. The voltage source should be a 120 V isolation transformer with a 120k ohm current limiting resistor in series with a secondary.

To calculate the current, measure the voltage across a 1k ohm resistor in series with the AC volt source and the **PATIENT** or active receptacles. This current should be less than 10 µA.

Bipolar and Monopolar Output RF Leakage Test Procedures

▶ ***Important***

The following procedure is meant to approximate the test procedure found in the IEC Standard 601-2-2 Sub-Clause 19.101b). In applications where you perform the IEC test, do not use this procedure as a direct substitute.

Test Setup

1. Place the Force 2 generator on a wooden table with no exposed metal on the surface or within one meter of the table surface.
2. When testing the Force 2-8 PCH generator, use active accessory and activate it using the footswitch.

Bipolar Procedure

1. Set Microbipolar to 70 W. Connect a 200 ohm load and the isolated RF milliammeter between the left **MICROBIPOLAR** receptacle and ground.
2. Attach a 30 pF capacitor between the right **MICROBIPOLAR** receptacle and ground.
3. Activate Microbipolar output and note results.
4. Repeat process by attaching a meter to the right **MICROBIPOLAR** receptacle, and attaching the 30 pF to the left **MICROBIPOLAR** receptacle. No reading shall exceed 150 mA.

▶ ***Important***

Use short leads.

Monopolar Procedure

1. Connect the 200 ohm load and an isolated RF milliammeter between **PATIENT** receptacle and ground.
2. Attach a 30 pF capacitor between active accessory and ground.
3. Activate the generator at 5 W in pure cut and note results.
4. Increase settings at 10 W increments until you reach 35 W. Verify that no reading exceeds 150 mA.
5. Increase settings at 20 W increments until you reach 195 W. Subsequently, increase to maximum output. Verify that no reading exceeds 150 mA.
6. Connect the 200 ohm load and an isolated RF milliammeter between the active accessory and ground.
7. Attach a 30 pF capacitor between the **PATIENT** receptacle and ground. Record readings at maximum settings in cut and coag only.
8. Select the coag mode selected and repeat steps 1 through 5. Increments of 20 W will continue to 115 W only. Verify that no reading exceeds 150 mA.
9. If any readings exceeds 150 mA, check the RF leakage calibration (steps 11 and 12 in the calibration section), and repeat the test.

Typical Output Waveforms

Figure 6-1.
Pure Cut 300 Ω Load
Bipolar 100 Ω Load

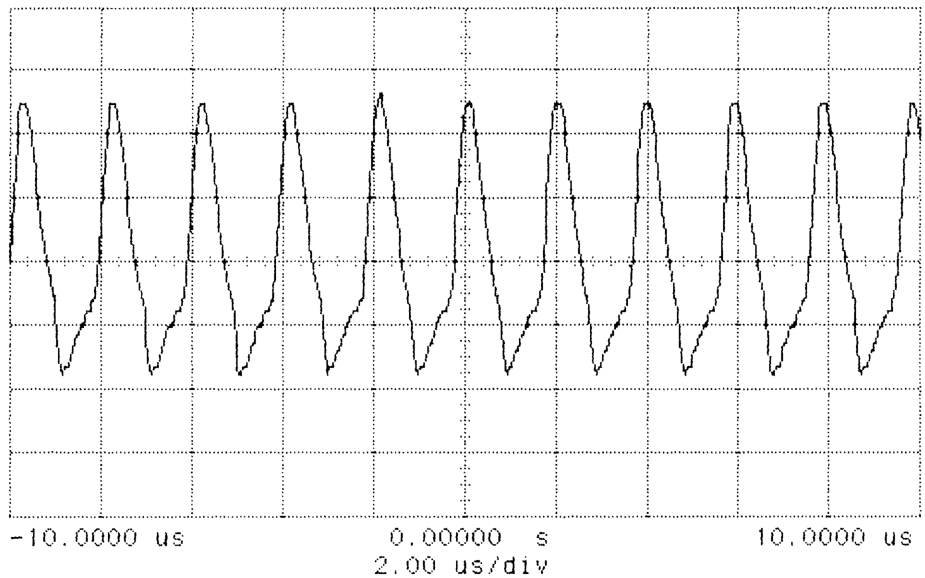


Figure 6-2.
Blend 1 300 Ω Load

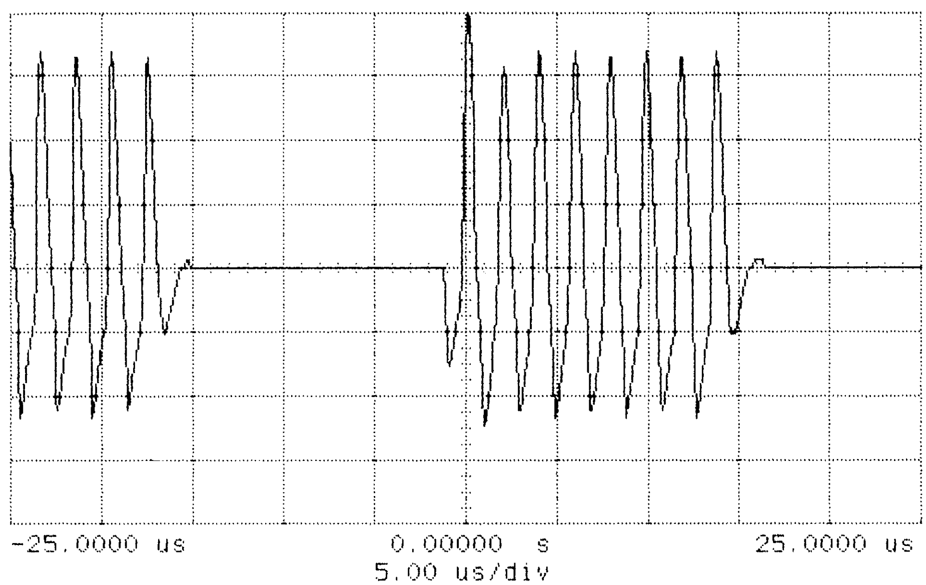


Figure 6-3.
Blend 2 300 Ω Load

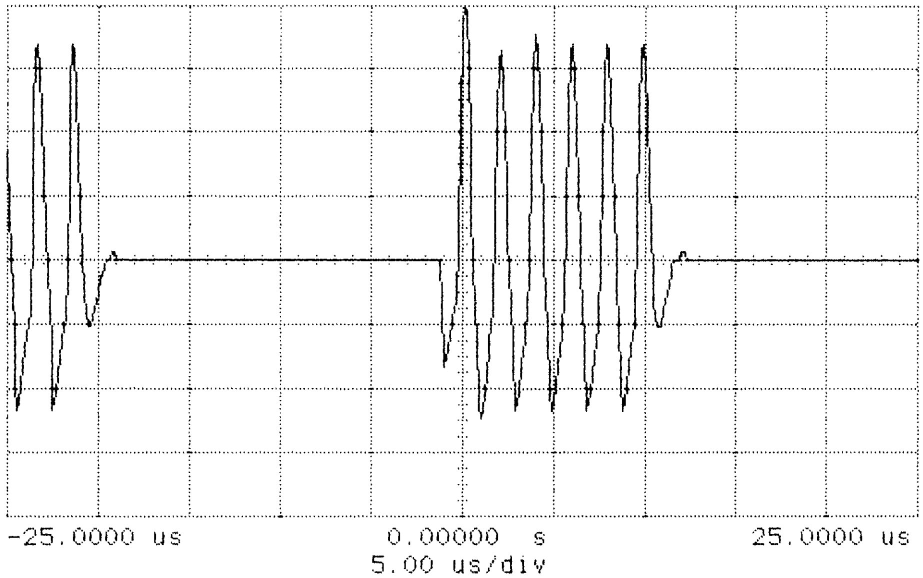


Figure 6-4.
Blend 3 300 Ω Load
Low Voltage Coag 300 Ω Load

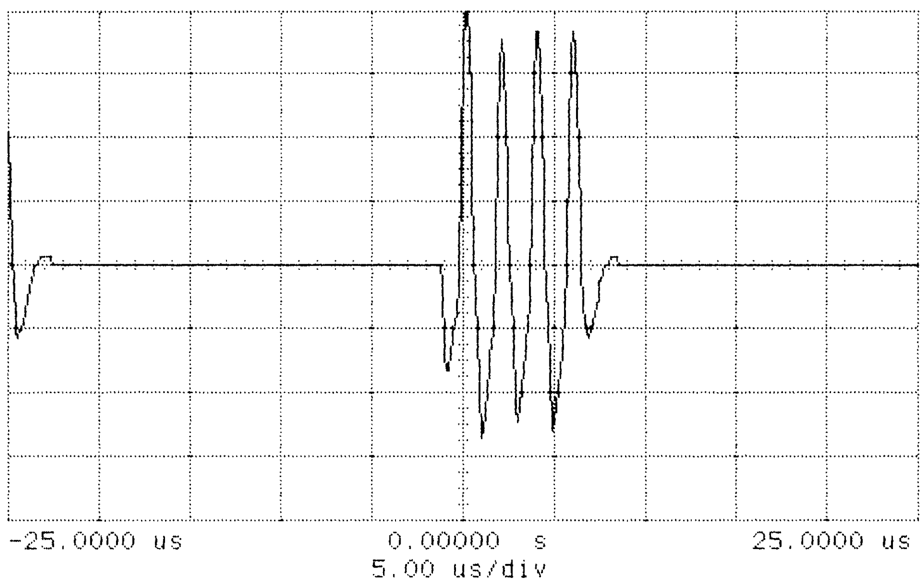
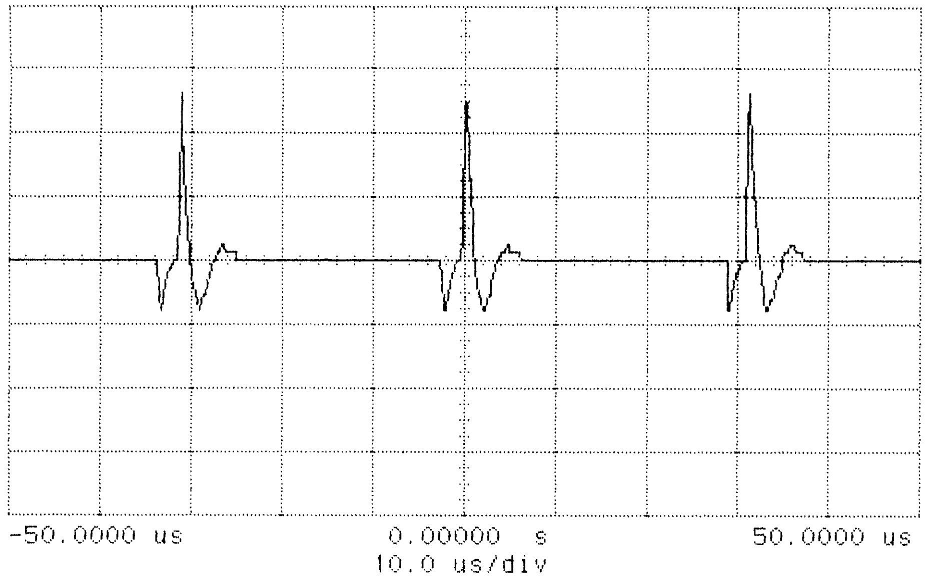
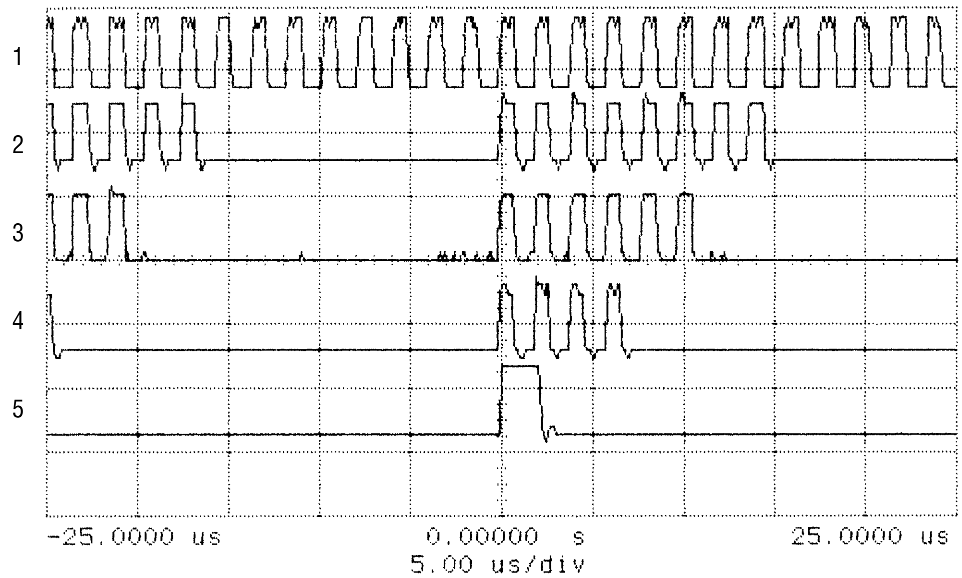


Figure 6-5.
Coag 300 Ω Load



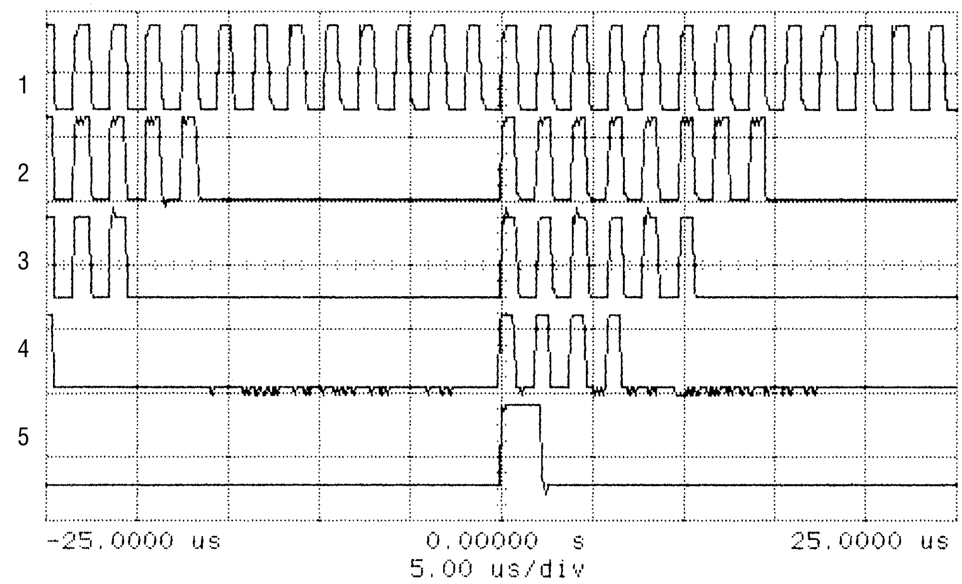
TT-on Waveforms at TP12 on PSRF Board

Figure 6-6.
1-Cut/Bipolar
2-Blend 1
3-Blend 2
4-Blend 3/LV Coag
5-Coag



RF Drive Waveforms at TP7-10 on PSRF Board

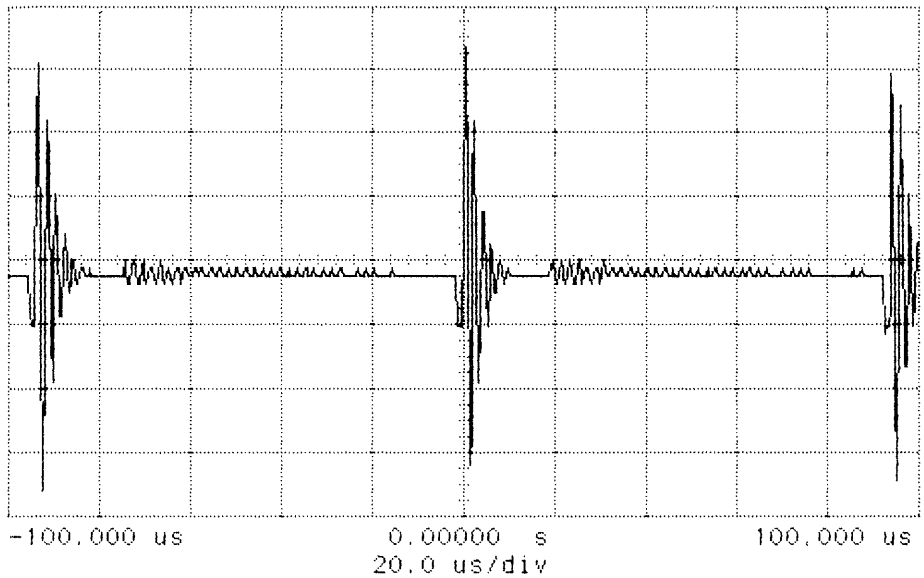
Figure 6-7.
1-Cut/Bipolar
2-Blend 1
3-Blend 2
4-Blend 3/LV Coag
5-Coag



Maintenance Procedures

Clamp Waveform at TP11 on PSRF Board

Figure 6-8.
Open Circuit 120W Coag

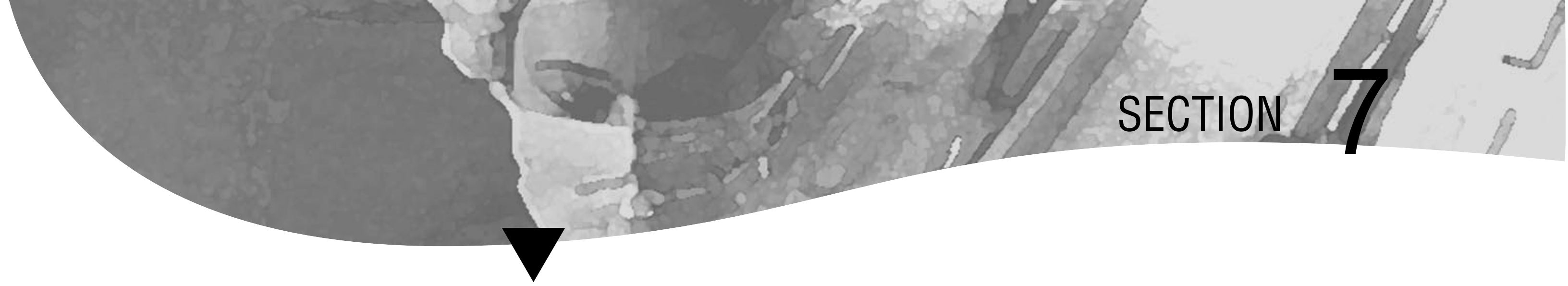


Components Replacement Guidelines

Follow these guidelines when installing and mounting components on circuit boards.

1. Install all nonpolarized components so that the value, tolerance, and part number are visible.
2. Install polarized components correctly so that the positive symbol (+), negative symbol (-), or other polarization markings are visible.
3. Do not remove coatings beyond the point where the lead enters the component body. For example, use a soldering iron to remove coating on the leads.
4. Center the component body between bends (except for miniature diodes, where it is desirable to leave the cathode lead longer than the anode lead for identification). Line up the leads, where required, with the mounting holes prior to installation.
5. Position lead-mounted components so that the major axis of the component is parallel to any two of the three major planes (sides) of the unit. Mechanically support any component having a weight in excess of 14.18 g (1/2 oz.) by means other than the leads.
6. Properly insulate all component leads which are, or could be, forced into a shorting condition with another component lead or circuit.
7. Do not stress component leads between mounting pins. Provide an adequate strain relief to prevent damage to the component and solder pins.
8. When installing components on circuit boards with the circuitry on the component side of the board, insulate the metallic bodies of the components with sleeving.
9. Mount resistors rated at 2 W or less flush to the circuit board (0.0–0.15 cm [0.0 - 0.06 in.] clearance).
10. Mount resistors greater than 2 W 0.635 cm ± 0.15 cm (0.25 in. ± 0.06 in.) from the surface of the board.
11. Radial lead capacitors: if installation requires bending the lead, the bend should be no closer to the body than 0.15 cm (0.06 in.) Mounting height should be 0.08–0.64 cm (0.032–0.25 in.) from the board surface to the potting material.
12. Soldered surfaces should be clean and free of contaminants that would result in poor soldering.
13. Control soldering temperature to prevent damage to components or circuitry.
14. Use no clean wire solder for general soldering on circuit boards.

Notes



SECTION 7

Manufacturer Service

Returning the Equipment for Service

Before you return the generator to Valleylab, call the Valleylab Service Department for a Return Authorization Number, or call your Valleylab representative for assistance. Have the following information ready:

- Hospital/clinic name/customer number
- Telephone number
- Department/address
- City, state, and ZIP code
- Model number
- Serial number
- Description of problem
- Type of repair to be done.

Attach a tag with this same information to the generator when shipping it for service.

Returning the Force 2 Generator

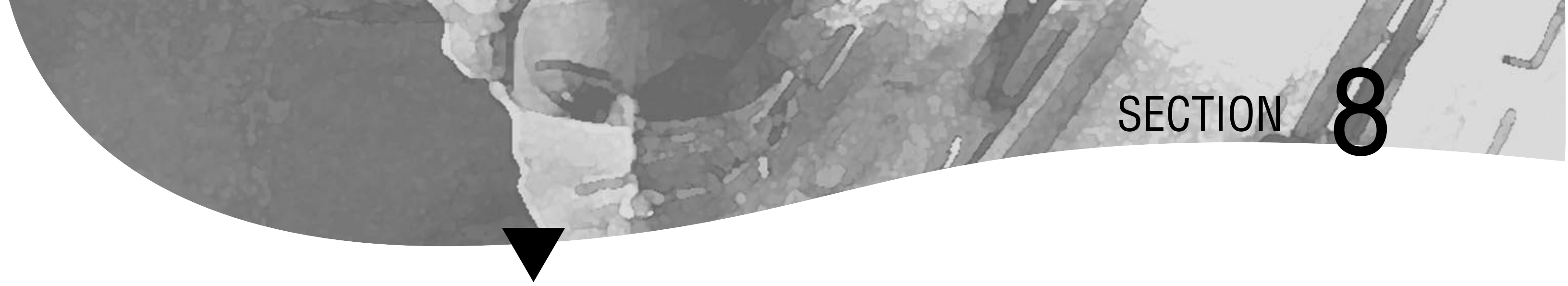
Package the generator in the original packaging container, if available. If the original packaging is not available, use the following guidelines for packaging:

- Remove and retain the footswitch.
- Use a packing container with double wall construction.
- Place a plastic bag over the generator.
- Use nonabrasive packing material that will not damage the surface of the unit.
- Use four crossed straps to secure the box.

Returning Circuit Boards and Other Subassemblies

When packaging circuit boards or other subassemblies, use the following guidelines:

- Place each board or subassembly in an ESD (Electrostatic Discharge) bag or container.
- Provide a separate packing container for each board or subassembly.



SECTION 8

Service Parts List

Ordering Replacement Parts

When ordering replacement parts for the generator, include this information:

- Model number (located on the rear of the generator)
- Serial number (located on the rear of the generator)
- Valleylab part number.

All components must be replaced with parts of identical construction and value. Replacement part ratings and tolerances must be equal or better than original. Generator performance can be adversely affected by substitution of lower grade parts.

All items referenced in this section are found in the Schematics Supplement.

Monopolar Control/Display Board

201 496 000

Reference Designator	Description	Valleylab Part Number
Resistors		
R24, 27, 39, 44	10k Ω ± 5%, 1/4W	234 024 087
R2, 8, 22	100k Ω ± 5%, 1/4W	234 024 111
R5, 21, 31, 34	1k Ω ± 5%, 1/4W	234 024 063
R7	51 Ω ± 5%, 1W	234 204 112
R9, 46, 48	330 Ω ± 5%, 1/4W	234 024 051
R1, 3, 4, 6, 10, 13, 14, 25, 26, 45, 47	3.3k Ω ± 5%, 1/4W	234 024 075
R11	750 Ω ± 5%, 1/4W	234 024 060
R12	1.6k Ω ± 5%, 1/4W	234 024 068
R14	33k Ω ± 5%, 1/4W	234 024 099
R15-18	75 Ω ± 5%, 1/2W	234 014 086
R19	100 Ω ± 5%, 1/4W	234 024 039
R23	130k Ω ± 5%, 1/4W	234 024 114
R20, 29, 49	4.7k Ω ± 5%, 1/4W	234 024 079
R32, 33, 37, 41	51 Ω ± 5%, 1/2W	234 014 083
R35, 43	1.8M Ω ± 5%, 1/4W	234 024 141
R36	10k Ω ± 10%, 5W Trimpot	236 200 091
R40	24k Ω ± 5%, 1/4W	234 024 096
R42	20k Ω ± 5%, 1/4W	234 024 094
RA1-4	10k Ω resistor array	234 100 171
Capacitors		
C1, 3	10 µF ± 20%, 25V	204 600 067
C5, 6, 10, 12, 13, 15, 18, 19, 21-24, 27, 28, 30-33, 35, 36,40, 45, 46, 48-51	0.1 µF ± 20%, 50V	204 200 460
C4, 8, 17, 29, 42	1 µF ± 20%, 50V	204 200 464
C2, 16, 25	1000 pF ± 10%, 100V	204 200 454
C9	22 pF ± 5%, 100V	204 200 450
C14, 41	33 pF ± 5%, 100V	204 200 451

Reference Designator	Description	Valleylab Part Number
C7, 11	100 pF ± 5%, 100V	204 200 454
C20	68 μF ± 20%, 20V	204 600 068
C26	0.033 μF ± 20%, 50V	204 200 459
C34, 38, 39, 43, 44	0.01 μF ± 20%, 50V	204 200 456
Integrated Circuits		
U4, 9	74LS374	210 520 374
U2, 15, 17	74LS240	210 520 240
U3	89C54, Programmed	210 730 211
U5, 27	2803A	210 800 002
U6	74LS165	210 520 165
U7, 10	74LS85	210 520 085
U8	ICM7218	210 700 001
U11, 24	MC14584B	210 212 106
U12	4068B	210 210 068
U13, 30	4071B	210 210 071
U14	4011B	210 210 011
U16	4001B	210 210 001
U18, 25	4013B	210 027 000
U19, 21	DAC0832	210 750 001
U20	4066	210 200 022
U22	4073	210 210 073
U23	LM324N	210 022 000
U26	74HC161	210 230 017
U28, 29	4081	210 210 081
U1	74LS273	210 520 273
Q6	DS1833-5	210 760 026

Reference Designator	Description	Valleylab Part Number
Transistors		
Q1	2N2907A	239 100 012
Q2, 3, 7	VN10KM FET	239 200 012
Q4	2N3904	239 015 000
Q5	MPS6651	239 300 039
Diodes		
CR1-6, 8	1N4148	239 014 000
CR12, 13	LM336	210 300 016
LED's		
D1	HLMP2720	239 750 022
D2, 3, 4, 9, 10, 11	HDSP7501	239 750 119
D5, 6, 8	HLMP2755	239 750 033
D7, 13	HLMP2855	239 750 039
D12	HLMP2655	239 750 042
Miscellaneous		
Y1	Oscillator, 8.192 MHz	250 010 025
L1, 2	EMI Ferrite Bead	251 100 106
DS1, DS2	RF Indicator, 12 Vdc	215 200 077

Bipolar Display Board

201 302 001

Reference Designator	Description	Valleylab Part Number
LP1	RF Indicator, 12 Vdc	215 200 077
LS1	Speaker Assembly, 8 Ω, 1/2W	202 701 765
D1, 2	HDSP7501	239 750 119

Interface Board

201 304 002

Reference Designator	Description	Valleylab Part Number
Resistors		
R1, 4, 6, 8, 9, 12, 14, 18 19, 29, 32,39, 58, 59, 61	1k Ω ± 5%, 1/4W	234 024 063
R2	10 Ω ± 5%, 1/4W	234 024 015
R3	4.3k Ω ± 5%, 1/4W	234 024 078
R7	3k Ω ± 5%, 1/4W	234 024 074
R5, 43, 45, 56	5.1k Ω ± 5%, 1/4W	234 024 080
R73	11k Ω ± 1%, 1/8W	234 201 389
R10, 13, 20, 28, 33, 63	3.6k Ω ± 5%, 1/4W	234 024 076
R42, 48-52	820 Ω ± 5%, 1/4W	234 024 061
R60, 62	2.4k Ω ± 5%, 1/4W	234 024 072
R21, 41, 53, 68	10k Ω ± 5%, 1/4W	234 024 087
R40	3.3k Ω ± 5%, 1/4W	234 024 075
R22, 54, 76	100k Ω ± 5%, 1/4W	234 024 111
R31, 35, 64, 75	15k Ω ± 5%, 1/4W	234 024 091
R30	6.04 Ω ± 1%, 1/8W	234 201 364
R65, 74	5.6k Ω ± 5%, 1/4W	234 024 081
R11	20k Ω trimpot	236 010 008
R26, 34, 71	10k Ω ± 1%, 1/8W	234 201 385
R55, 57	470k Ω ± 5%, 1/4W	234 024 127
R72	51.1k Ω ± 1%, 1/8W	234 014 453
R77	220 Ω ± 5%, 1/4W	234 024 047
R38	27k Ω ± 5%, 1/4W	234 024 097
R37	24k Ω ± 5%, 1/4W	234 024 096

Reference Designator	Description	Valleylab Part Number
R15	5k Ω trimpot	236 010 006
R44	68k Ω ± 5%, 1/4W	234 024 107
R23	560k Ω ± 5%, 1/4W	234 024 129
R16	100k Ω trimpot	236 010 011
R24	910k Ω ± 5%, 1/4W	234 024 134
R17	200k Ω ± 5%, 1/4W	234 024 118
R25	160k Ω ± 5%, 1/4W	234 024 116
R47	10.2k Ω ± 1%, 1/8W	234 201 386
R67	390k Ω ± 5%, 1/4W	234 024 125
R27, 36	200k Ω ± 1%, 1/8W	234 201 510
R46, 66	887 Ω ± 1%, 1/8W	234 201 284
R69	19.1k Ω ± 1%, 1/8W	234 201 412
R70	33k Ω ± 5%, 1/4W	234 024 099
Capacitors		
C58, 61	0.22 µF ± 10%, 250V	204 400 120
C16, 17, 59	0.0047 µF ± 20%, 10kV	204 200 243
C60	0.0047 µF ± 20%, 6kV	204 025 050
C2-5, 10, 11, 18, 19, 21, 23, 24, 31-33, 36, 38, 41, 43, 48-53, 56, 64, 69	0.1 µF ± 20%, 50V	204 200 460
C1, 6-9, 12-14, 20, 25-29, 37, 39, 40, 42, 47, 54, 57, 65, 68	1 µF ± 20%, 50V	204 200 464
C34, 55	240 pF ± 5%, 500V	204 300 331
C62, 66, 67	1000 pF ± 10%, 100V	204 200 454
C63, 71	3300 pF ± 10%, 100V	204 200 455
C30, 35, 70	10 µF ± 20%, 25V	204 600 067

Reference Designator	Description	Valleylab Part Number
C22, 44	0.01 µF ± 10%, 100V	204 600 457
C15	10 µF ± 10%, 20V	204 600 064
Integrated Circuits		
U6, 7, 9, 10	4049B	210 210 049
U1, 8	LM339AN	210 300 015
U3	4013B	210 027 001
U2	79LO5AC	210 300 071
U4	4011B	210 210 011
U11	4066	210 200 022
U5	LM358AN	210 300 013
Transistors		
Q6, 7	VN10KM	239 200 012
Q1, 3-5	2N3904	239 015 000
Q2	2N2907A	239 100 012
Diodes		
CR1, 3-5, 8-11, 13-15	1N4148	239 014 000
CR2, 6, 7, 16	1N5240B	239 600 001
CR12	1N5233B	239 600 000
Optoisolators		
OPT1-6	OPI1264C	239 750 019
OPT7-9	4N35	239 750 002
Miscellaneous		
T3	Transformer, RF Input	251 200 078
T1, 2	IsoBloc Toroid	251 300 019

Reference Designator	Description	Valleylab Part Number
K1, 2	Reed Relay, 10kV	230 007 007
K3	Double Pole Relay	230 012 000

Power Supply RF Board

(-8 PCH) 202 701 918
(-2 PCH) 202 701 917

Reference Designator	Description	Valleylab Part Number
Resistors		
R12	47k Ω ± 5%, 1/2W	234 014 115
R42	82k Ω ± 5%, 1/2W	234 014 120
R43	120k Ω ± 5%, 1/2W	234 014 124
R16	3.9 Ω ± 5%, 1/4W	234 024 005
R86	10 Ω ± 5%, 1/4W	234 024 015
R1, 2, 4, 5, 7-11, 125	22 Ω ± 5%, 1/4W	234 024 023
R120	36 Ω ± 5%, 1/4W	234 024 028
R109, 110	10 Ω ± 5%, 1/2W	234 014 068
R134, 138, 139, 141	51 Ω ± 5%, 1/4W	234 024 032
R81	360 Ω ± 5%, 1/4W	234 024 052
R118	560 Ω ± 5%, 1/4W	234 024 057
R20, 23, 27, 30, 32, 41, 46, 48, 49, 79, 96, 108, 114, 127, 135-137, 140	1k Ω ± 5%, 1/4W	234 024 063
R26, R83, R126	1.5k Ω ± 5%, 1/4W	234 024 067
R21	1.8k Ω ± 5%, 1/4W	234 024 069
R3, 22*, 95, 107	2k Ω ± 5%, 1/4W	234 024 070
R17, 29, 60, 80, 84, 100	2.7k ± Ω 5%, 1/4W	234 024 073

**For -2 PCH only, change R22 to 1 kΩ ± 5% 1/4W 234 024 063*

Reference Designator	Description	Valleylab Part Number
R35	3k Ω ± 5%, 1/4W	234 024 074
R33, 34, 37, 39	3.3k Ω ± 5%, 1/4W	234 024 075
R111	3.6k Ω ± 5%, 1/4W	234 024 076
R36	3.9k Ω ± 5%, 1/4W	234 024 077
R40	4.7k Ω ± 5%, 1/4W	234 024 079
R94	4.75k Ω ± 1%, 1/8W	234 201 354
R31, 119	5.1k Ω ± 5%, 1/4W	234 024 080
R121	7.5k Ω ± 5%, 1/4W	234 024 084
R28, 38, 47, 50, 53, 55-58, 66, 87, 90, 91, 93, 103, 115, 128-132, 143, 144	10k Ω ± 5%, 1/4W	234 024 087
R24, 105	24k Ω ± 5%, 1/4W	234 024 096
R18	30k Ω ± 5%, 1/4W	234 024 098
R77	33k Ω ± 5%, 1/4W	234 024 099
R106	43k Ω ± 5%, 1/4W	234 024 102
R104, 117	47k Ω ± 5%, 1/4W	234 024 103
R85	82k Ω ± 5%, 1/4W	234 024 109
R67, 68, 82, 102, 113, 116, 122	100k Ω ± 5%, 1/4W	234 024 111
R92	107k Ω ± 1%, 1/8W	234 201 484
R25	220k Ω ± 5%, 1/4W	234 024 119
R112	330k Ω ± 5%, 1/4W	234 024 123
R65, 97	1M Ω ± 5%, 1/4W	234 024 135
R123, 124	20k Ω ± 5%, 8W	234 000 017
R44, 45	.1 Ω ± 3%, 3W	234 028 001
R13-15	.2 Ω ± 5%, 7W	234 300 060
R19	1k Ω trimpot	236 200 076

Reference Designator	Description	Valleylab Part Number
R69-76	10k Ω trimpot	236 200 079
R61-63	20k Ω trimpot	236 200 080
R101	50k Ω trimpot	236 200 082
R89	20k Ω ± 5%, 1/4W	234 024 094
J11, 13	0 Ω jumper	234 300 080
J6 (Force 2-2 PCH only)	0 Ω jumper	234 300 080
J7 (Force 2-8 PCH only)	0 Ω jumper	234 300 080
Capacitors		
C13, 34	100 pF ± 5%, 100V	204 200 452
C2, 4, 9, 11, 15, 18, 19, 21, 23-25, 27, 28, 35, 36, 39-43, 45, 47, 50, 51, 58, 61, 66-71, 77, 80, 82-84	.1 µF ± 20%, 50V	204 200 460
C7, 16, 17, 37, 38, 44, 52, 53, 55-57, 62, 65	1 µF ± 20%, 50V	204 200 464
C54, 59	.033 µF ± 10%, 100V	204 200 503
C60	47 pF ± 5%, 100V	204 200 533
C1, 3, 8, 10	22 µF ± 20%, 25V	204 600 063
C20, 26, 32, 33, 81	10 µF ± 20%, 25V	204 600 067
C14	.01 µF ± 10%, 100V	204 200 457
C64	.0022 µF ± 20%, 6KV	204 025 044
C74	1500 pF ± 5%, 500V	204 300 350
C49	2200 pF ± 5%, 500V	204 300 354
C29	470 pF ± 5%, 500V	204 106 027
C22	12000 pF ± 5%, 500V	204 300 130
C6	15000 pF ± 5%, 500V	204 300 132
C76	1200 pF ± 5%, 500V	204 300 348

Reference Designator	Description	Valleylab Part Number
C72	2 µF ± 10%, 400V	204 400 001
C73	1 µF ± 10%, 250V	204 400 138
C30, 31	15 µF ± 10%, 200V	204 400 150
C63, 75	1000 µF ± 20%, 200V	204 500 103
C46, 48	.0015 µF ± 10%, 1KV	204 079 059
C12	1000 pF ± 10%, 100V	204 200 454
C5	2700 pF ± 5%, 500V	204 105 036
Integrated Circuits		
U8	LM306	210 016 002
U17	LM 324N	210 022 000
U10, 12, 14, 18	4066	210 200 022
U13	4001B	210 210 001
U7	4011B	210 210 011
U9, 15	LM339AN	210 300 015
U20	3526	210 300 062
U5	74F10	210 520 090
U11	74LS126	210 520 091
U6, 19	1427	210 800 012
U1-4	4429	210 800 014
U16	LM358AN	210 300 013
Transistors		
Q10-14, 16, 17, 23, 24, 29-31	VN10KM	239 200 012
Diodes		
CR1-5	MUR8100E	239 850 033

Reference Designator	Description	Valleylab Part Number
CR6	1N5817	239 700 005
CR7, 8, 10, 11, 13, 15-20, 25-28	1N4148	239 014 000
CR9	1N5233B	239 600 000
CR12	LM336-5	210 300 018
CR14	LM336-2.5	210 300 016
Miscellaneous		
F1 (Force 2-2 PCH)	Fuse 6A, 250V	215 005 039
F1 (Force 2-8 PCH)	Fuse 6.3A, 250V	215 100 041
K1	4 pole relay	230 007 002
RT1	Thermistor 5 Ω, 6A	240 003 005
L2	Inductor 0.75 mH	251 100 107
L1	Cut Inductor	251 100 108
T1	Output Transformer	251 200 060
T2	Switching Transformer	251 200 061
T3	Dual Pulse Transformer	251 300 014

Heatsink Assembly

RF Out

202 701 789

Reference Designator	Description	Valleylab Part Number
Q1-4	Transistor FET BUZ80A	239 200 020
R6	500 Ω, 500W TO-220	234 400 271

HVDC

202 701 790

Reference Designator	Description	Valleylab Part Number
CR21-24	MUR 8100E	239 850 033
R142	150 Ω, 20W TO-220	234 400 251

PS

202 701 791

Reference Designator	Description	Valleylab Part Number
CR25-28	FET N-Channel 500V 8A	239 200 022
R133	50 Ω, 20W TO-220	234 400 272
	Bridge 400V 35A	239 700 067

Clamp

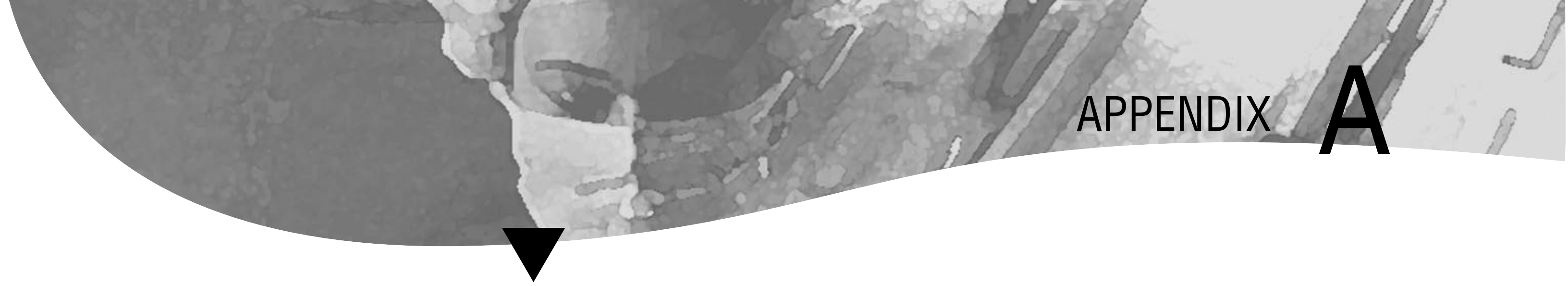
202 701 792

Reference Designator	Description	Valleylab Part Number
Q5	FET N-Channel 500V 8A	239 200 022
Q6-9	Transistor FET BUZ80A	239 200 020
	Resistor Assembly F2-PCH	207 500 198

Generator Base Assembly

202 701 448

Reference Designator	Description	Valleylab Part Number
	REM Adapter	202 701 063
	Monopolar Keyboard	207 500 147
	Bipolar Keyboard	207 500 148



APPENDIX A

Warranty

Valleylab warrants each product manufactured by it to be free from defects in material and workmanship under normal use and service for the period(s) set forth below. Valleylab's obligation under this warranty is limited to the repair or replacement, at its sole option, of any product, or part thereof, which has been returned to it or its Distributor within the applicable time period shown below after delivery of the product to the original purchaser, and which examination discloses, to Valleylab's satisfaction, that the product is defective. This warranty does not apply to any product, or part thereof, which has been repaired or altered outside Valleylab's factory in a way so as, in Valleylab's judgment, to affect its stability or reliability, or which has been subjected to misuse, neglect or accident.

The warranty periods for Valleylab's products are as follows:

Electrosurgical Generators	One Year from date of shipment.
Mounting Fixtures (all models)	One Year from date of shipment.
Footswitches (all models)	One Year from date of shipment.
Patient Return Electrodes	Shelf life only as stated on packaging.
Sterile Disposables	Sterility only as stated on packaging.

This warranty is in lieu of all other warranties, express or implied, including, without limitation, the warranties of merchantability and fitness for a particular purpose, and of all other obligations or liabilities on the part of Valleylab. Valleylab neither assumes nor authorizes any other person to assume for it any other liability in connection with the sale or use of any of Valleylab's products. Notwithstanding any other provision herein or in any other document or communication, Valleylab's liability with respect to this agreement and products sold hereunder shall be limited to the aggregate purchase price for the goods sold by Valleylab to customer. There are no warranties which extend beyond the terms hereof. Valleylab disclaims any liability hereunder or elsewhere in connection with the sale of this product, for indirect or consequential damages.

This warranty and the rights and obligations hereunder shall be construed under and governed by the laws of the State of Colorado, USA. The sole forum for resolving disputes arising under or relating in any way to this warranty is the District Court for the County of Boulder, State of Colorado.

Valleylab, its dealers and representatives, reserve the right to make changes in equipment built and/or sold by them at any time without incurring any obligation to make the same or similar changes on equipment previously built and/or sold by them.