Service Manual

System 2450™

ELECTROSURGICAL GENERATOR

ConMed® CORPORATION

LIMITED WARRANTY

For a period of two years following the date of delivery, CONMED Corporation warrants the CONMED System 2450™ Electrosurgical Generator against any defects in material or workmanship and will repair or replace (at CONMED's option) the same without charge, provided that routine maintenance as specified in this manual has been performed using replacement parts approved by CONMED. This warranty is void if the product is used in a manner or for purposes other than intended.

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U.S. Patent Numbers 6,830,569 - 6,875,210 - 6,948,503 - D552241 and other patents pending.

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& List of Illustrations

Theory of Operation

Section 3.0

System 2450™ functions and essential circuit information are provided in this section. This section begins with a description of the key parameters for each mode. This is followed by an overview of how the system functions and some key operational information for the modules within the system.

3.1 Mode Descriptions

The key functional parameters for each mode are presented here. Nominal mode specifications are provided in section 1.2.11 of the System 2450 Operators Manual.

3.1.1 Cut Major Modes

Major Mode	Minor Mode	Nominal RF Frequency	Modulation (Number of Pulses, Nominal Time On/Off	Modulation (Normal Frequency & Period)
Cut	Pure	400 KHz	None	None
	Blend	400 KHz	11 pulses, 28μs / 12μs	25 KHz / 40μs
	Hi Blend*	400 KHz	9 pulses, 23μs / 17μs	25 KHz / 40μs

*Hi Blend can be set by a Hospital Qualified Biomedical Technician – see Section 4.8.

3.1.2 Coag Major Modes

Major Mode	Minor Mode	Nominal RF Frequency	Modulation (Number of Pulses, Nominal Time On/Off	Modulation (Normal Frequency & Period)
Coag	Standard	495 KHz	Single pulse	40 KHz / 25μs
	Spray	495 KHz	Single pulse	20 KHz / 50μs

Standard and Spray Coag modes are fundamentally different from the Cut modes in that the resonant circuit of the RF Amplifier and Transformer combination is excited by the energy of a single pulse, causing the resonant circuit to ring until the energy is dissipated. Spray Coag provides the maximum open circuit voltage for which the system is rated.

3.1.3 Bipolar Major Modes

Major Mode	Minor Mode	Nominal RF Frequency	Modulation (Number of Pulses, Nominal Time On/Off	Modulation (Normal Frequency & Period)
Bipolar	Macro	400 KHz	None	None
	Micro	400 KHz	None	None

3.2 System Overview

Mains power is converted to electrosurgical output power through the RF Power Supply (RFPS), the RF Amplifier, and the Transformer and Output sections of the system.

Mains power is converted to high voltage direct current power in the RFPS to supply the RF Amplifier. This is essentially a power transformer with a power factor corrected regulator. The power factor correction can be enabled or disabled under software control.

Pulses generated in the RF Controller are amplified to electrosurgical power and voltage levels in the RF Amplifier and Transformer portions of the power train. Three high-voltage bipolar transistors and a single MOSFET make up the hybrid-cascode RF Amplifier. The hybrid-cascode amplifier is a fast, high-voltage amplifier that can be controlled by the combination of DC voltage (VBASE_PWM) and a fixed amplitude, variable pulse width signal (RFGATE). This amplifier is combined through a relay with either the Monopolar output transformer or the Bipolar output transformer to generate electrosurgical power.

Electrosurgical power flows from the RF Amplifier / Transformer section to the Output section where the power is switched to the specific electrosurgical outputs. The Output section also has circuitry to detect activations from accessories and the circuitry to perform the Automatic Return Monitor (A.R.M.) function to ensure the integrity of the dispersive electrode connection.

The power section also includes a number of output voltage and current sensors that are used by the RF Controller for control of power delivery and by the Monitor to detect errant output conditions. Windings on the Monopolar output transformer and the Bipolar output transformer are the means for sensing output voltage. Separate primary-side current transformers are shared by the bipolar and monopolar channels for control and monitoring of the current. There are also separate current sensors on the monopolar outputs that are used to detect stuck output relays.

The RF Controller is a Field Programmable Gate Array (FPGA) that generates the RFGATE and VBASE_PWM RF Amplifier drive signals based upon a comparison of measured parameters and settings-based parameters. The pulse train sequence is a settings-based parameter that is dependent on the selected mode. Target power, current limit, and voltage limit are all settings-based parameters derived from a load curve that is specific to the selected mode and front panel power setting. The RF Controller samples electrosurgical output current and output voltage from sensors at a 20 Megahertz rate and uses these sampled values to calculate sensed current, sensed voltage, and output power. This high sample rate allows control of the real power delivered to the active accessory and also allows the System 2450 to rapidly adapt to changing loads. The output current, output voltage, and output power are compared with corresponding settings based parameters of current limit, voltage limit, and target power, respectively, and the RF Controller adjusts value of VBASE_PWM in a closed-loop fashion to control these parameters. The RF Controller also provides fixed pulses for RFGATE within each mode-based pulse train sequence.

The RF Monitor is a Digital Signal Processor (DSP) that is used to monitor the system for safety problems that can result from a variety of conditions.

- The Monitor has independent sensors for output voltage and current, which it uses to calculate power for comparison with the power that the RF Controller senses and for comparison with the generator power setting.
- To ensure that the correct outputs are activated, the Monitor also independently senses current at each of the outputs, looking for current flow that would indicate electrosurgical power at outputs other than the selected output.
- The Monitor senses the audio output to ensure that a tone occurs whenever electrosurgical outputs are active.
- The RF Amplifier drive signal is sensed by the Monitor to detect improper frequencies or improper pulse sequences for the selected mode.
- The Monitor independently compares the activation signal with that seen by the System Controller to ensure that the activation signal is consistent.

The Monitor has the capability to independently disable the electrosurgical output if a problem is detected.

The System Controller provides the primary control interface to the user and other outside systems, including the serial interface, the activation relay, tone generation, and displays.

Finally, the Display accepts all user input and provides all user feedback. The Display is controlled by the System Controller through a serial interface and illuminates the LED display elements in a time division multiplexed fashion; the illuminated LED display elements are actually on less than half the time. The Display also provides for user input through the buttons on the control panel, including switch de-bouncing and conditioning.

Figure 3.2 illustrates the key elements of the system in block diagram form.

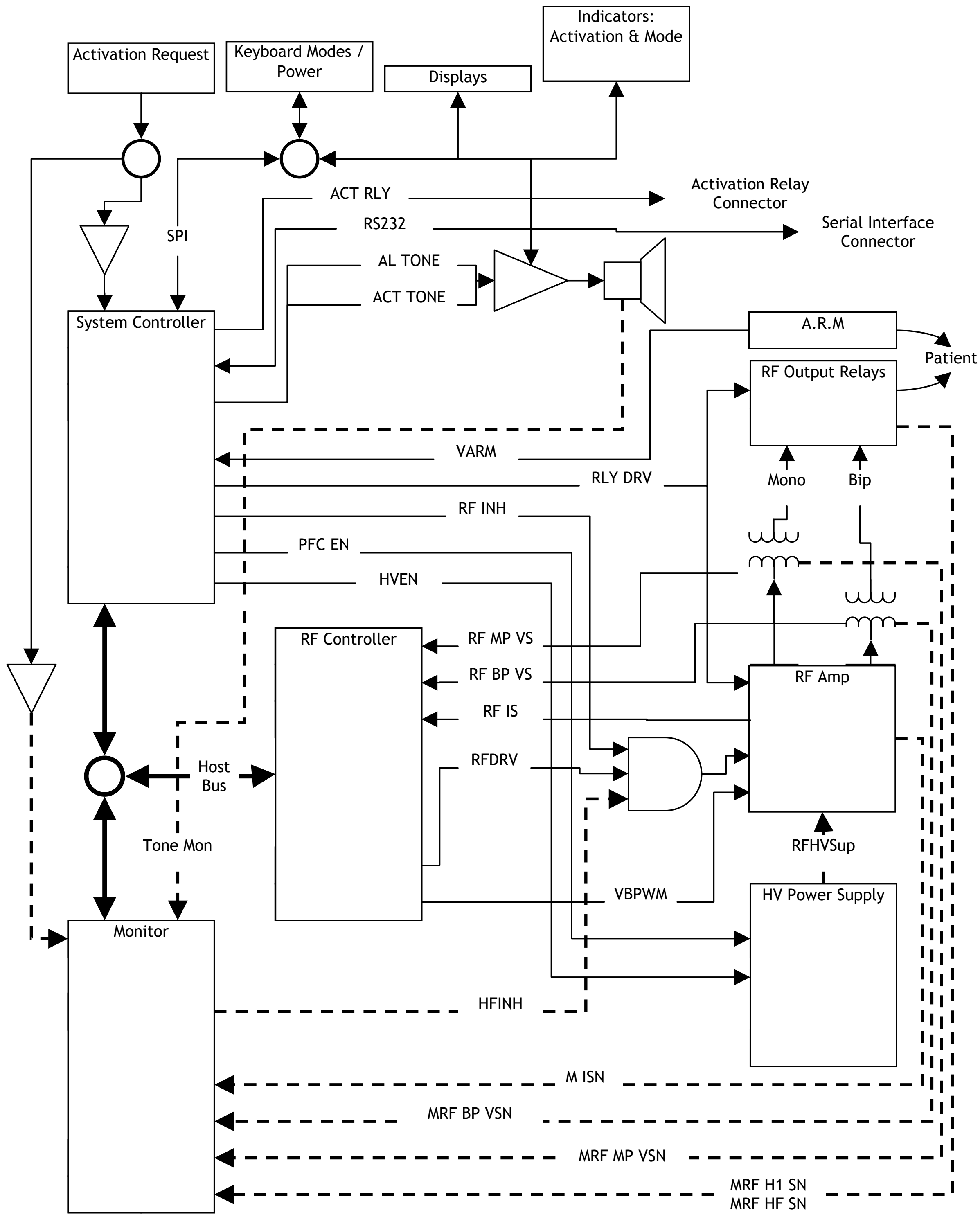


Figure 3.2 System Block Diagram

3.2.1 RF Power Supply (RFPS)

The RFPS is comprised a line transformer and a Power Factor Control (PFC) section. The PFC converts Mains power from the transformer to approximately 95 volts D.C. using techniques that ensure the mains current into the supply is sinusoidal and in phase with the mains voltage. By doing so, RMS current and harmonic distortion are reduced. Jumpers on the power board are used to select input line voltage range. A graphic on the power board and on the schematic indicate which jumpers are used for each input voltage range.

WARNING: THE RFPS VOLTAGE TAKES SEVERAL SECONDS TO DECAY AFTER THE POWER IS SWITCHED OFF. TO WARN THE SERVICE TECHNICIAN, A RED LED (DS1) ON THE POWER BOARD INDICATES WHEN VOLTAGE IS STILL ON THE BOARD.

The System Controller can enable or disable the PFC section of the RFPS. The PFC is normally enabled during operation to ensure a resistive load is presented to the Mains.

In addition to the RFPS winding, there is also another secondary winding on the Mains transformer that is rectified and filtered to provide unregulated +25VDC voltage as the input for a +12V switching regulator. The +12V output is then used to supply input voltage to a variety of low-voltage regulators on the controller board.

3.2.2 RF Amplifier and Transformer

The RF Amplifier and Transformer portions use a switch-mode resonant hybrid-cascode amplifier to convert the power from the RFPS to the RF energy necessary for electrosurgery. One may think of the amplifier as a high-speed switch that pulses current through a resonant circuit, which is formed by the monopolar or bipolar transformer together with capacitors that are connected to the transformer primary and secondary windings. The transformers are designed with a good deal of leakage inductance in order to provide inductance for resonating with the capacitors. One Metal-Oxide-Semiconductor Field Effect Transistor (MOSFET) is connected in series with three parallel bipolar transistors to provide the switching. The pulses to drive the gate on the MOSFET in this arrangement come from the RF Controller (RFGATE). The base connections of the three parallel bipolar transistors are also driven by a signal that originates from the RF Controller (Vbase_PWM).

The RFGATE drive pulses provide the basic pulse pattern that is used to form the electrosurgical waveform, and have a set pulse-pattern and pulse-width for each mode. A drive of several pulses at a frequency that closely matches the resonant frequency of the amplifier characterize Cut and Blend modes, and the output pulses substantially correspond to the drive. Spray and Standard Coag modes, however, are characterized by pulses that occur less frequently where the amplifier is allowed to "ring" at its resonant frequency.

Rapid regulation of the output power in this arrangement is provided by VBASE_PWM; as VBASE_PWM is increased, the output power increases. As noted in the RF Controller discussion, the RF Controller compares the output power with the desired power and adjusts the VBASE_PWM to minimize the difference. VBASE_PWM enters the amplifier as a 312 KHz Pulse-Width-Modulated (PWM) signal that is filtered to become a variable DC base drive signal.

Finally, the RF Amplifier and Transformer provide capabilities for sensing RF output current and voltage. The voltage sensors that are used for power control and power monitoring are independent windings on the output transformers. The current is also measured on the primary side of the transformers. With proper characterization of the transformer, the controller obtains an accurate representation of the voltage, current, and thus the output power of the system.

3.2.3 Electrosurgical Outputs

Relays are provided to isolate electrosurgical outputs and select which outputs are active. The System Controller selects the appropriate output relays based upon activation command inputs.

The Monitor utilizes current sensors implemented on each monopolar electrosurgical output to determine whether current is flowing only to the correct outputs. In the event that current flows in an output that is not selected, the Monitor can independently disable RF. The monitor uses the bipolar primary voltage to sense that the bipolar relay has been activated.

3.2.4 Activation Command Sensing

Each of the Hand Controlled Accessory receptacles incorporate inputs that are used to sense an activation command from the user. Each monopolar hand controlled accessory receptacle has an input for Cut and an input for Coag. The bipolar receptacle incorporates a single activation input. Each of these five inputs is isolated from the other electrosurgical outputs and from other low-level circuitry in the system. All are powered by a multiple output isolated power supply. The footswitch activation inputs on the back panel are configured in a similar way and share one of the isolated power supply outputs.

3.2.5 Automatic Return Monitor (A.R.M.)

The patient return connector interfaces to single and dual dispersive electrodes using a two-pin connector. A.R.M. circuitry uses an actively driven impedance measurement circuit, which allows the System Controller to detect the type of dispersive electrode connected and verify its integrity.

3.2.6 System Controllers and Monitor

Two processors and an FPGA are used for system interface & control, RF control, and system monitor functions. The RF control section consists of a dual-channel architecture with two independent channels where one is used exclusively for RF output control and the other is used for safety monitoring. All of these elements are located on the Control board, along with circuitry for interface with the user.

- System Controller (System Microcontroller): A dedicated Microcontroller that handles the entire user interface, Serial Interface, and enables/disables the power factor control section of the RFPS using the PFC_EN signal. The System Controller can also disable the signal used to drive the RF Amplifier and can terminate RF drive at any time without interaction from either the RF Controller or the Monitor. The System Controller is comprised of a standard architecture microprocessor together with portions of the FPGA, which provides interface logic to a variety of signals, independent voltage regulators, a processor supervisory reset circuit, and other interface logic.
- RF Controller: An FPGA implementing digital signal processing elements for control of RF power using the VBASE_PWM and RFGATE outputs. To reduce the effects on the microprocessor circuits on the Control/Display Board from RF noise at the output, VBASE_PWM and RFGATE are both differential mode signals running between the Control/Display Board and the power section. The RF Controller is capable of disabling RF output power and putting the system into a safe state without any interaction from the Monitor or the System Controller. The RF Controller independently monitors the RF output voltage and current for control purposes through several scaled inputs. The RF Controller is comprised of the major portion of the FPGA, together with circuitry necessary for converting the control signals between analog and digital form.
- RF Monitor: A DSP that is dedicated to safety monitoring activities. The Monitor is capable of disabling RF output power and putting the system into a safe state without any interaction from the RF Controller or the System Controller. To ensure that the Monitor can correctly perform its function, the Monitor is resistively isolated from the System Controller and the RF Controller and has independent voltage regulation. The RF Monitor independently monitors a variety of inputs to detect safety problems and has control of disable signals for RF Amplifier drive. The Monitor is comprised of a DSP, together with circuitry necessary for converting the signals monitored between analog and digital form, an FPGA to provide interface logic, independent voltage regulators, isolation resistors and other interface logic.

3.2.7 Low Voltage Power Monitoring

The low voltage power supply is monitored in hardware and resets the processors if it is out of range. The microprocessor supervisory device on the Control/Display Board monitors +3.3V and +1.8V and will reset the system should the levels drop approximately 0.3V. The Control/Display Board has the circuit that will reset the system should the 3.3V supply exceed 3.6V.

3.2.8 Operator Control Panel

• Keyboard: The main operator input device for choosing operating modes and settings is the membrane keyboard panel. Tactile-feedback mechanical switches allow the operator to set modes and adjust power settings.

• Display Panel: Consists of 7-segment displays and discrete dual colored LED's that will display all controls and settings. LED display elements are illuminated in a time division multiplexed fashion; the illuminated LED display elements are actually on less than half the time.

3.2.9 Activation Tones

Tone is generated for all activation requests, fault detection and changes made on the Control Panel. The System Controller generates the tone signal (TONE_DRV), which is amplified by a driver. The activation tone is adjustable and controlled by an output from the System Controller, but alarm tones are not adjustable and are set to generate a tone greater than 65 dB.

There is circuitry to permit the Monitor to verify the oscillation from voltage measured across the speaker, which provides confirmation that the speaker is indeed generating audible tones during activation. RF output is inhibited should the speaker drive current be absent or too low.

3.2.10 Activation Relay Connector

There is an Accessory Relay Connector, which provides a relay closure (SPST switch) that may be used for activating external accessories such as smoke evacuation units.

3.3 Optional System Configurations

An eight-position configuration dipswitch (S2), located on the Control/Display Board Assembly (A4) allows a qualified service technician to change some of the factory default settings. With the exception of the DACview switch, which is only effective in Test Mode, the configuration dipswitch settings are only detected when power is initialized, so any changes to the switch positions will not be detected until power is cycled. Each switch is OFF in the Down position and ON in the UP position. (The system detects changes in the DACview switch while power is on, so it is treated differently.) Relevant information for the configuration dipswitches appears in Section 4.8.

Maintenance

Section 4.0

This section contains information useful in the maintenance and repair of the System 2450.

WARNING: High voltages are present at the connections and within the System 2450. Maintenance personnel should take precautions to protect themselves. Read the safety summary in Section 1.1.4 of the System 2450 Operators Manual before working on the ESU.

4.1 General Maintenance Information

Although the System 2450 has been designed and manufactured to high industry standards, it is recommended that periodic inspection and performance testing be performed to ensure continual safe and effective operation.

Ease of maintenance was a primary consideration in the design of the System 2450. Maintenance features of this unit include microprocessor aided troubleshooting aids and push button calibration, built in fault detection, circuit protection, and easy access to circuitry while the unit is operational.

These features, coupled with the warranty, local support, loaner equipment, factory support, toll free phone service to the factory and available factory training ensure a minimal maintenance effort with extensive support available.

4.2 Maintenance Personnel

Only Hospital Qualified Biomedical Technicians or ConMed factory technicians should perform service on the System 2450. Refer all servicing to a Hospital Qualified Biomedical Technician.

If necessary, your CONMED sales representative will be happy to assist you in getting your equipment serviced.

4.3 Cleaning

The interior of the unit may be vacuumed or blown out as required. The exterior of the unit may be cleaned by wiping it with a cloth that has been dampened (not dripping) with a mild detergent such as Windex® or Formula 409®.

(Windex® is a registered trademark of the S.C. Johnson Company. Formula 409® is a registered trademark of the Clorox Company.)

4.4 Periodic Inspection

The System 2450 should be visually inspected at least every six months. This inspection should include checks for the following:

1) Damage to the power cord and plug.
2) Proper mating and absence of damage to the accessory connectors.
3) Any obvious external or internal damage to the unit.
4) Any accumulation of lint or debris within the unit or heatsink.
5) Control Panel cuts, punctures, or dents.

4.5 Periodic Performance Testing

The System 2450 should be tested for correct performance at least once every year. Every unit is supplied with a serialized Production Test Data Sheet that tabulates the results of the factory tests that were performed on the unit. This data is supplied so that it may be used as a reference for subsequent tests.

Recommended periodic performance tests are listed in the following sections.

4.5.1 Chassis Ground Integrity

Connect a standard ohmmeter between the earth ground prong on the power plug and the Equipotential Ground Connection. Compensate for lead resistance. Confirm less than 0.2 ohms resistance is measured.

4.5.2 Displays, Alarms and Commands

Perform the Preliminary Functional Test procedure described in section 2.3.1 of the System 2450 Operators Manual to verify proper operation of displays, alarms and commands.

4.5.3 Output Power

1) Equipment Requirements:
   a) Monopolar Footswitch
   b) Bipolar Footswitch
   c) Commercial ESU Tester (e.g. Fluke 454A or equivalent) with non-inductive 50 and 300 ohm loads for bipolar modes and a non-inductive 500 ohm load for monopolar modes.

Note: Micro Bipolar is particularly sensitive to the load resistance. A 50 ohm load should be used for checking power to obtain the best results.

2) Use test leads to connect the ESU tester to the unit's return electrode output and the footswitch controlled active output. Set the Load resistance per mode as indicated in Tables 4.1 and 4.2.
3) Perform the monopolar power tests indicated in Tables 4.1 and 4.2. The acceptance range is given in both Watts and Amps to accommodate available test equipment. It is not necessary to test for both power and current.

Table 4.1 Monopolar Cut Mode RF Output Power Accuracy

Mode	Load (ohms)	Power Setting	Watts (min)	Watts (max)	Amps (min)	Amps (max)
Pure	500	20	17	23	0.184	0.214
	500	100	90	110	0.424	0.469
	500	300	270	330	0.735	0.812
Blend	500	20	17	23	0.184	0.214
	500	100	90	110	0.424	0.469
	500	200	180	220	0.600	0.663

Table 4.2 Monopolar Coag Mode RF Output Power Accuracy

Mode	Load (ohms)	Power Setting	Watts (min)	Watts (max)	Amps (min)	Amps (max)
Standard	500	20	17	23	0.184	0.214
	500	50	45	55	0.300	0.332
	500	120	108	132	0.465	0.514
Spray	500	20	17	23	0.184	0.214
	500	50	45	55	0.300	0.332
	500	80	72	88	0.379	0.420

4) Disconnect the ESU tester from the unit.
5) Use test leads to connect the ESU tester to the Bipolar Accessory outputs.
6) Perform the bipolar power tests indicated in Table 4.3. This table only provides the minimum number of points to be tested.

Table 4.3 Bipolar Mode RF Output Power Accuracy

Mode	Load (ohms)	Power Setting	Watts (min)	Watts (max)	Amps (min)	Amps (max)
Macro	300	20	17	23	0.238	0.277
	300	50	45	55	0.387	0.428
	300	70	63	77	0.458	0.507
Spray	50	20	17	23	0.583	0.678
	50	50	45	55	0.949	1.049
	50	70	63	77	1.122	1.241

4.5.4 RF Leakage Measurement

NOTE: To ensure accuracy when making leakage measurements, perform all leakage testing using methods and instruments that are compliant with the prcedures outlined in Section 19 of IEC60601-2-2 (Particular Requirements for the Safety of High Frequency Surgical Equipment).

RF Leakage can present a hazard in the operating room because electrosurgical currents can flow to the patient and operating room staff through unintended paths, which can cause injury. RF leakage occurs because the total energy in the output voltage waveform is provided with a conductive path through stray parasitic capacitance distributed within the generator and along the length of the leads.

Table 4.4 presents the allowed RF leakage currents to ground.

Table 4.4 Allowable RF Leakage Current to Ground

MEASURED TERMINAL	ACTIVATED ACCESSORY	MODE	RF LEAKAGE (Ma)
Dispersive Electrode	Coag Combination Monopolar	Standard Coag	< 100
Dispersive Electrode	Cut Combination Monopolar	Pure Cut	< 100
Dispersive Electrode	Hand Controlled	Standard Coag	< 100
Combination Monopolar Active	Coag Combination Monopolar	Standard Coag	< 100
Hand Controlled Active	Left Hand Controlled	Standard Coag	< 100
Bipolar Right	Bipolar Footswitch	Bipolar Macro	< 67
Bipolar Left	Bipolar Footswitch	Bipolar Macro	< 67

Equipment:

- ESU Tester with RF Leakage function -OR-
- 0-250 is RF Ammeter with a 200 ohm 10 W Non-inductive Resistor
- Patient Plate Adapter Plug
- 2 - Test leads, 1 m max. Length
- 3 - Test leads, 10 cm max. Length
- Wooden table approximately 1 m from floor.

NOTE: Use a measuring device that meets IEC specification for RMS measured over one second.

Procedure:

1) Ensure that the unit is fully assembled and all fasteners are tight.
2) Place the ESU tester or meter with resistor on the table so that they are at least 0.5m away from the unit under test and any other conductive surface.
3) Set the unit for full power for the modes noted in the table. Connect the ESU tester in accordance with the manufacturer's instructions -OR- connect the 200-ohm non-inductive resistor in series with the 250 mA RF ammeter to the Equipotential Ground Connection on the Rear Panel. Also make sure there are no connections to any output other than the one you are measuring.

WARNING: HAND CONTROL ACTIVATIONS SHOULD BE KEYED USING 3" OR LESS WELL-INSULATED JUMPER. USE OF AN INSULATING ROD TO INSERT THE JUMPER IS ADVISED TO PREVENT RF BURNS.

3) One at a time, connect test setup to each RF output terminal indicated in Table 4.4 and activate the unit using the corresponding command. Confirm no meter readings exceed the specified maximum. Hand controlled Coag activations are accomplished by connecting a jumper between the left jack and center jack of the desired hand switched accessory jack.

RF leakage should also be measured between inactive outputs and the Dispersive Electrode connection. The procedure is as follows:

1) Set the unit for full power for the modes noted in Table 4.5. Connect the ESU tester according to manufacturer's instructions - OR- the 200-ohm non-inductive resistor in series with the 250 mA RF ammeter to the Dispersive Electrode connection on the front panel. Also make sure there are no connections to any output other than the one you are measuring.

2) One at a time, connect this series combination to each RF output terminal indicated in Table 4.5 and activate the unit using the corresponding command. Confirm that no meter readings exceed the specified maximum.

Table 4.5 Allowable RF Leakage Current - Inactive Monopolar Outputs

MEASURED TERMINAL	ACTIVATED ACCESSORY	MODE	RF LEAKAGE (Ma)
Combination Monopolar Active	Hand Controlled	Standard Coag	< 50
Combination Monopolar Active	Bipolar Footswitched	Macro	< 20
Hand Controlled Active	Combination Monopolar	Standard Coag	< 50
Hand Controlled Active	Bipolar Footswitched	Macro	< 20
Bipolar Left	Right Hand Controlled Standard	Coag	< 48

Finally, RF leakage should be measured between the inactive bipolar outputs while a monopolar accessory is activated. Do the following:

1) Set the unit for full power for the bipolar mode noted in Table 4.6. Connect ESU tester according to manufacturer's instructions -OR the 200-ohm non-inductive resistor in series with the 250 mA RF ammeter between the two bipolar output connections.
2) Activate and verify the limit in Table 4.6.

Table 4.6 Allowable RF Leakage Current - Inactive Bipolar Outputs

MEASURED TERMINAL	ACTIVATED ACCESSORY	MODE	RF LEAKAGE (Ma)
Bipolar Right to Left	Hand Controlled	Standard Coag	< 48

4.5.5 Line Frequency Leakage

CAUTION: To prevent RF current from destroying the test equipment and/or affecting leakage readings, set all power settings to zero.

WARNING: ELECTROCUTION HAZARD. USE OF AN ISOLATED MAINS POWER SOURCE IS RECOMMENDED WHEN OPENING THE MAINS GROUND DURING THE FOLLOWING SAFETY TESTS.

Circuit ground and Neutral (Low Mains) must be connected together for Mains leakage testing.

Equipment:

These tests are performed most conveniently using any good quality biomedical electrical safety tester.

Procedure:

1) Connect the electrical safety analyzer to make the measurements indicated in Table 4.7.
2) Mode: Measure leakage for Bipolar to Neutral and Chassis to Neutral.

Table 4.7 Line Frequency Allowable Leakage - Inactive

RF output to Neutral	LINE	GND	LIMIT max
Equipotential Ground	Normal	Closed	30 μA
Equipotential Ground	Reversed	Closed	30 μA
Equipotential Ground	Normal	Open	270 μA
Equipotential Ground	Reversed	Open	270 μA
Dispersive Electrode	Normal	Closed	15 μA
Dispersive Electrode	Reversed	Closed	15 μA
Dispersive Electrode	Normal	Open	15 μA
Dispersive Electrode	Reversed	Open	15 μA
Bipolar Output*	Normal	Closed	15 μA
Bipolar Output*	Reversed	Closed	15 μA
Bipolar Output*	Normal	Open	15 μA
Bipolar Output*	Reversed	Open	15 μA

*Measure the Bipolar Output with Bipolar connections shorted together.

5) Since the System 2450 monopolar active outputs are disconnected by relays when the unit is not activated, active-to-neutral leakage tests must be performed with the unit activated in order to be valid.
6) With all power controls set to zero, measure the leakage current as in step 1 from each of the three active output terminals to neutral; see Table 4.8; while that output is activated in Cut by the appropriate footswitch or hand control jumper. Hand control cut activations are accomplished by connecting a jumper between the two outer jacks of where the handcontrolled accessory is plugged into the unit.

Table 4.8 Line Frequency Allowable Leakage - Active

RF output to Neutral	LINE	GND	ACTIVATION	LIMIT max
Combination Monopolar Active	Normal	Closed	Combination Monopolar Cut	15 μA
Combination Monopolar Active	Reversed	Closed	Combination Monopolar Cut	15 μA
Combination Monopolar Active	Normal	Open	Combination Monopolar Cut	15 μA
Combination Monopolar Active	Reversed	Open	Combination Monopolar Cut	15 μA
Hand Controlled Active	Normal	Closed	Hand Controlled Cut	15 μA
Hand Controlled Active	Reversed	Closed	Hand Controlled Cut	15 μA
Hand Controlled Active	Normal	Open	Hand Controlled Cut	15 μA
Hand Controlled Active	Reversed	Open	Hand Controlled Cut	15 μA

4.5.6 Automatic Return Monitor (A.R.M.) Check

A.R.M. has two specific ranges that will be tested initially and then the circuit will be tested to verify that the circuit measures dispersive electrode resistance correctly. For this testing, only a Decade Resistance Box (DRB) and a dispersive electrode cable adapter are required. Connect the DRB to the Dispersive Electrode Receptacle using the dispersive electrode cable adapter.

A.R.M. may be reset by disconnecting the dispersive electrode connector or adjusting the DRB above 10K Ohms until the Single and Dual Dispersive Electrode Status/Alarm Indicators flash red in alternating fashion. Allow approximately two seconds after the DRB is changed before proceeding to the next step in the procedure. A.R.M. indicators not mentioned in the procedure must be off for each test.

1) Dual Electrode Alarm Limit: Set the DRB to 158 Ohms, then connect it to the Dispersive Electrode Receptacle and verify that the Single and Dual Dispersive Electrode Status/Alarm Indicators flash red in alternating fashion.
2) Dual Electrode Upper Limit: Set DRB to 140 Ohms and verify that the Dual Dispersive Electrode Status/Alarm Indicator is Green.
3) Dual Electrode Lower Limit: Set the DRB to 15 Ohms and verify the Dual Dispersive Electrode Status/Alarm Indicator is Green.
4) Single Electrode Upper Limit: Set the DRB to 7 Ohms, then reset A.R.M. and verify the Single Dispersive Electrode Status/Alarm Indicator is Green.

4.5.7 Output Coupling Capacitor Check

WARNING: ENSURE ALL POWER SETTINGS ARE AT 0 WATTS BEFORE CONDUCTING THIS TEST TO PREVENT INJURY TO PERSONNEL AND DAMAGE TO TEST EQUIPMENT.

NOTE: Not all capacitance meters will read properly for this test. The test frequency should be at or below 1 kHz for best accuracy. The following meters have been tried successfully: Fluke 189, Extech 285, Sencor LC75 and HP4284A (1 kHz setting or below).

1) Connect shorting plug to banana adapter to the two pin Dispersive Electrode Receptacle. Use 6” or shorter test leads to connect a capacitance meter between the shorting plug adapter and the footswitched ReadiPlug Universal Accessory Receptacle.
2) Measure capacitance and confirm it is less than 0.2 nF.

3) Confirm cut power is set to 0, then activate and confirm capacitance is between 0.6 and 0.9 nF.
4) Do not activate for this bipolar test. Move test leads to Bipolar Output Accessory Receptacles. Confirm capacitance is between 2.2 and 2.5 nF.

4.6 System Calibration

The System 2450 is calibrated during manufacture using equipment traceable to National Institute of Standards & Technology (NIST) standards and should retain its accuracy for a long period of time. Recalibrate the generator after repair or if it performs out of specification. Check the calibration in normal operating mode and only perform calibration if errors are identified.

The System 2450 stores its calibration in nonvolatile semiconductor memory, so the calibration will be retained without any action on the part of the user or maintenance staff. Calibration should be checked in normal operating mode during annual preventative maintenance to ensure there is no change.

Calibration is required when:

- "Err 138", "Err 139", or "Err 140" occurs: An error is detected with the stored calibration values.
- "Err 143" or "Err 321" occurs: One or more modes require calibration.
- "Err 135" occurs: An error is detected with stored ARM calibration values.
- Either the Control/Display Board assembly (Conmed P/N 61-6991) or the Power Board assembly (Conmed P/N 61-6981) is replaced.
- Calibration differences are found during preventative maintenance.

Refer to Figure 4.1 for calibration process flow.

4.6.1 Calibration Preliminaries

System 2450 calibration occurs in Calibration Operating Mode, which is entered by setting the system configuration DIP switches on the Control/Display Board. Set the Calibration system configuration DIP switch (Control/Display Board SW2.2) to the ON (UP) position and the Test system configuration DIP switch (Control/Display Board SW2.1) to the OFF (DOWN) position. Other configuration DIP switch settings positions will not affect this. See Section 4.8 for system configuration DIP switch details.

With this configuration set, turn on power while pressing and holding both Bipolar Mode Select Keys. Release these Keys when CAL appears in the Monopolar Cut Power Digital Display and the software revision appears in the Monopolar Coag Power Digital Display. CAL and the software revision may persist in the displays for a few seconds after the Bipolar Mode Select Keys are released. The display will then provide an indication of the calibration status:

- "ALL" will appear in the Monopolar Cut Power Digital Display if the calibration memory is empty.
- "nEr" will appear in the Monopolar Cut Power Digital Display, where "n" indicates how many major modes require calibration, will be displayed if only particular modes require calibration. All of the minor mode indicators will be illuminated and the minor modes needing calibration will flash.
- "CU", "COA", "bP", or "PAd" will appear in the Monopolar Cut Power Digital Display to indicate the major mode when only minor modes under that major mode require calibration. All of the minor mode indicators will be illuminated and the minor modes needing calibration will flash.
- "CU" will appear in the Monopolar Cut Power Digital Display with the Pure Cut Mode Indicator illuminated if all modes are calibrated.

For all except the last of these, a single Press and release of the Tone Loudness Adjustment Down Key is required to proceed past this point on the menu. After pressing this key, "CU" will appear in the Monopolar Cut Power Digital Display with the Pure Cut Mode Indicator illuminated.

4.6.2 Selecting the Mode to Calibrate

Press the Monopolar Cut Power Adjustment Keys to select the major mode to calibrate as displayed in the Monopolar Cut Power Digital Display. The selections are "CU" for Cut, "COA" for Coag, "bP" for Bipolar, or "PAd" for the Dispersive Electrode A.R.M. connection. If any of the minor modes under these major modes are not calibrated, the displayed major mode will flash.

Select the monopolar minor mode by pressing the appropriate Mode Select Key.

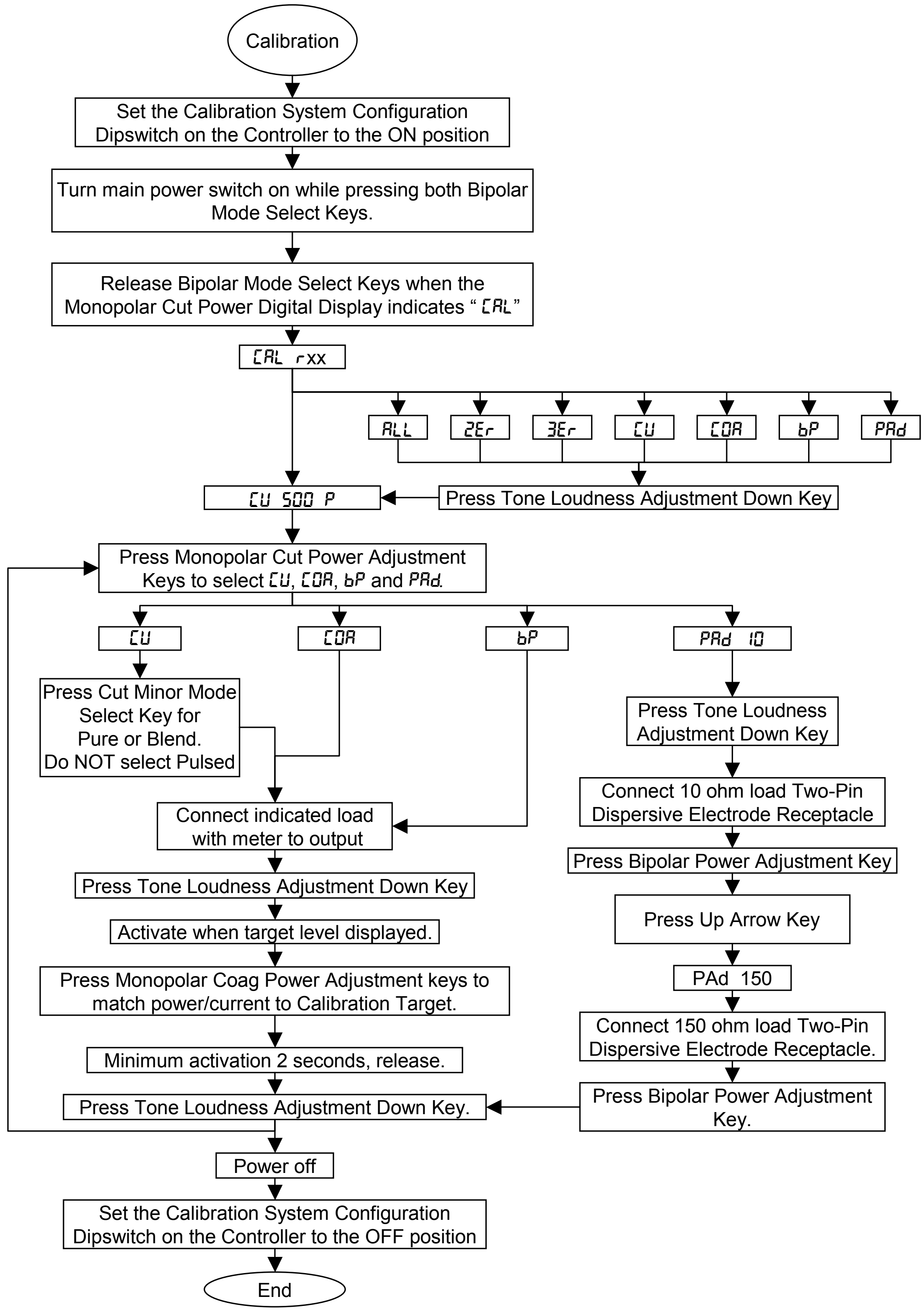


Figure 4.1 Calibration Procedure Flow Chart

4.6.3 Calibrating a Monopolar Mode

This section applies to the Pure Cut, Blend, Standard Coag, and Spray Coag modes.

Calibration may be performed by measuring current or by measuring power. To select between calibration using measured current and measured power, press the Bipolar Power Adjustment Keys to set the calibration units to either "A" for current or "P" for power.

The resistance to be used for calibration will appear in the Monopolar Coag Power Digital Display. Connect a resistor of this value between the output connection that is being used for calibration and both pins on the Two-Pin Dispersive Electrode Receptacle.

Press and release the Tone Loudness Adjustment Down Key to begin calibration. After this key is pressed, the target level appears in the Monopolar Coag Power Digital Display.

Activate using the appropriate Handswitch or Footswitch. Power will now flow to the resistor. While monitoring either the current or the power, adjust the power up or down using the Monopolar Coag Power Adjustment Keys until the measured value is as close to the target level as possible. The activation must be maintained for a minimum of 2 seconds to ensure the calibration is valid. After the power is properly adjusted, release the activation. Press and release the Tone Loudness Adjustment Down Key to complete the calibration sequence for the selected minor mode.

*Blend mode only: Both the default Lo Blend mode and the optional Hi Blend mode must be calibrated. After Lo Blend is calibrated, the system will return to the step where the target power is displayed for Hi Blend calibration. Note that the target value for Hi Blend is different from the target value for Lo Blend. To complete the Hi Blend calibration, activate again using the appropriate Handswitch or Footswitch. Power will now flow to the resistor. While monitoring either the current or the power, adjust the power up or down using the Monopolar Coag Power Adjustment Keys until the measured value is as close to the target level as possible. The activation must be maintained for a minimum of 2 seconds to ensure the calibration is valid. After the power is properly adjusted, release the activation. Press and release the Tone Loudness Adjustment Down Key to complete the Hi Blend calibration sequence.

After a minor mode has been calibrated, the associated minor mode indicator will quit flashing. When all of the minor modes within a major mode have been calibrated, the major mode indicated in the Monopolar Cut Power Digital Display will quit flashing.

4.6.4 Calibrating Bipolar Modes

The Bipolar modes are calibrated using a method that is very similar to the Monopolar modes.

Calibration may be performed by measuring current or by measuring power. To select between calibration using measured current and measured power, press the Bipolar Power Adjustment Keys to set the calibration units to either "A" for current or "P" for power.

The resistance to be used for calibration will appear in the Monopolar Coag Power Digital Display. Connect a resistor of this value between the two active connections in the Bipolar Accessory Receptacle.

Press and release the Tone Loudness Adjustment Down Key to begin calibration. After this key is pressed, the target level appears in the Monopolar Coag Power Digital Display.

Activate using the Bipolar Footswitch. Power will now flow to the resistor. While monitoring either the current or the power, adjust the power up or down using the Monopolar Coag Power Adjustment Keys until the measured value is as close to the target level as possible. The activation must be maintained for a minimum of 2 seconds to ensure the calibration is valid. After the power is properly adjusted, release the activation. Press and release the Tone Loudness Adjustment Down Key to complete the calibration sequence for the bipolar mode.

After a Bipolar minor mode has been calibrated, the associated Bipolar minor mode indicator will quit flashing. When all of the Bipolar minor modes have been calibrated, the major mode indicated in the Monopolar Cut Power Digital Display will quit flashing.

4.6.5 Calibrating A.R.M.

A.R.M. is calibrated against a pair of known resistances.

Press and release the Tone Loudness Adjustment Down Key to begin calibration. The resistance to be used for calibration will appear in the Monopolar Coag Power Digital Display. Connect a resistor of this value ±1% between the two active connections in the Two-Pin Dispersive Electrode Receptacle.

Calibrate the particular value connected by pressing one of the Bipolar Power Adjustment Keys. When the value is accepted, a two-tone sequence will sound and the resistance in the Monopolar Coag Power Digital Display will quit flashing.

Now scroll to the other of the pair of known resistances using the Monopolar Coag Power Adjustment Keys. The resistance to be used for calibration will appear in the Monopolar Coag Power Digital Display. Connect a resistor of this value ±1% between the two active connections in the Two-Pin Dispersive Electrode Receptacle.

Calibrate the particular value connected by again pressing one of the Bipolar Power Adjustment Keys. When the value is accepted, a two-tone sequence will sound and the resistance in the Monopolar Coag Power Digital Display will quit flashing.

Press and release the Tone Loudness Adjustment Down Key to complete A.R.M. calibration.

After A.R.M. has been calibrated, the major mode "PAd" indicated in the Monopolar Cut Power Digital Display will quit flashing.

4.6.6 Completing Calibration

Turn power off and set the Calibration system configuration DIP switch (Control/Display Board SW2.2) to the OFF (DOWN) position. See Section 4.8 Displaying Optional System Configuration for system configuration DIP switch details. The ESU will be ready for normal operation the next time the power is turned on.

4.7 Last Fault Code Retrieval & Clear

Up to 50 error (Err) and accessory (ACC) codes can be stored in memory for retrieval. When retrieving the error codes, it is also possible to retrieve the system settings when the error occurred.

4.7.1 Last Fault Code Retrieval

1) Turn on power while pressing and holding both Bipolar Mode Select Keys. Release these Keys when LFC appears in the Monopolar Cut Power Digital Display and the software revision appears in the Monopolar Coag Power Digital Display. LFC and the software revision may persist in the displays for a few seconds after the Bipolar Mode Select Keys are released. This action will place the system in the Last Fault Code Mode (LFC). Electrosurgical outputs cannot be activated while the system is in LFC.
2) If any errors are stored in memory, the Cut Window will next display "Err"; the Coag window will display the error code (a numeric value); and the Bipolar Window will display the storage location of that error code.

   Last Fault display example:

Err	381	1

3) Scroll through the stored error codes using the Bipolar Power Adjustment Keys. The error codes are stored Last in, First out. A "1" in the Bipolar Display shows the last error that occurred. Press the Bipolar Up key and a "2" will be displayed if more than one error occurred.
4) To retrieve the settings when the error occurred, it is necessary to have a Handcontrol accessory connected. Press both Cut and Coag activation switches and the Display Panel will show the system settings when the error occurred.

4.7.2 Clearing Last Fault Codes

As errors occur, fault codes from earlier errors are erased in a last-in-first-out fashion. While it is not absolutely necessary to clear the older codes, clearing the codes may be desirable in some situations.

- Pressing the Monopolar Cut Power Adjustment down Key followed by the Tone Loudness Adjustment Down Key will clear the entire fault code memory. The cut window will display "CLr" when codes are cleared.
- Pressing the Tone Loudness Adjustment Down Key again will display the optional system configuration settings.

4.8 Displaying Optional System Configuration

The optional system configuration DIP switch settings can be checked without removing the top cover.

- Access Last Fault Code retrieval as described in the preceding section.

- Press the Tone Loudness Adjustment Down Key again and the configuration DIP switch settings will be displayed. "0" is for OFF and a "1" is for ON.

The eight-position configuration DIP switch (S2), located on the Control/Display Board Assembly allows a qualified service technician to change some of the factory default settings. The default switch is only read during Power on Self Test (POST) or when the system is powered on, so any changes to the switch positions should be made with the main power off. Each switch is OFF in the down position and ON in the up position. Relevant information for each switch is described in Table 4.9 and the positions are illustrated in Figure 4.2.

Table 4.9 DIP Switch Settings

Config. Switch Position	Title / Display Element	Default	Description for Off	Description for On
1	TEST / Cut 100's	Off	Run Mode. Required position for surgery.	Activates Test Mode, which inhibits most of the system level monitoring for trouble-shooting purposes. When this switch is ON, both Bipolar Mode Select Keys on the Display Panel must be pressed until 888 appears in the Monopolar Cut Power Digital Display and the software revision appears in the Monopolar Coag Power Digital Display. 888 and the software revision may persist in the displays for a few seconds after the Bipolar Mode Select Keys are released. If both Bipolar Mode Select Keys are not pressed, and Err 100 is displayed and the power must be cycled.
2	CAL/ Cut 10's	Off	Run Mode. Required position for surgery.	Required for calibration of output power and A.R.M. When this switch is ON, both Bipolar Mode Select Keys on the Display Panel must be pressed until CAL appears in the Monopolar Cut Power Digital Display and the software revision appears in the Monopolar Coag Power Digital Display. CAL and the software revision may persist in the displays for a few seconds after the Bipolar Mode Select Keys are released. If both Bipolar Mode Select Keys are not pressed, and Err 100 is displayed and the power must be cycled.
3	SCOAG / Cut 1's	On	Allows activation of only one accessory at a time in Coagulation modes.	Allows simultaneous activation of two accessories for Coagulation modes.
4	DCUT / Coag 100's	Off	Allows activation of only one accessory at a time in Cut modes.	Allows simultaneous activation of two accessories for Cut modes.

Config. Switch Position	Title / Display Element	Default	Description for Off	Description for On
5	LAST / Coag 10's	On	Defaults to Pure Cut, Standard Coag, and Micro Bipolar and sets all power levels to zero (0W) each time the system is initialized.	Defaults all modes and power levels to the last activated settings from the last time the system was powered down.
6	Not used / Coag 1's	Off	Not used.	Not used.
7	Blend Mode Selection / Bipolar 10's	Off	Lo Blend is selected when the Blend Mode Select Key is pressed.	Hi Blend is selected when the Blend Mode Select Key is pressed.
8	DACview / Bipolar 1's	NA	DACview - See below.	DACview - See below.

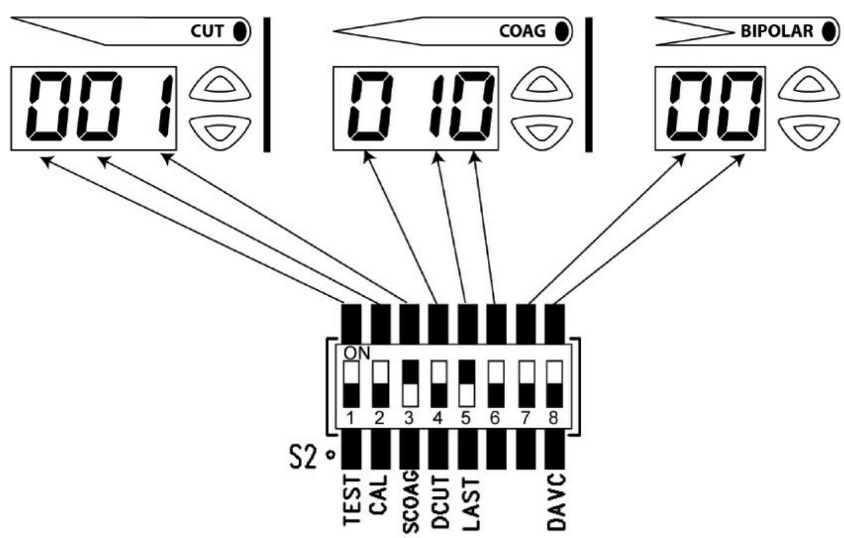


Figure 4.2 DIP Switch Positions

4.9 DACview

DACview is a troubleshooting aid that allows access to internal readings. The feature allows output voltage, current and power that the system reads to be output to a DVM or oscilloscope.
To use DACview, the system must be in the Test Mode.

1) Set the system for operation in Test Mode as described in the preceding section.
2) Connect a DVM to the Control/Display Board test point labeled TP60 – DACV and any GND test point (e.g. TP61).
3) Turn on power while pressing and holding both Bipolar Mode Select Keys. Release these Keys when 888 appears in the Monopolar Cut Power Digital Display and the software revision appears in the Monopolar Coag Power Digital Display. 888 and the software revision may persist in the displays for a few seconds after the Bipolar Mode Select Keys are released.
4) Move the DACview switch (Control/Display Board S2 position 8 – the change is recognized, not whether the switch is on or off).
5) The Monopolar Cut Power Digital Display is used to display the selected DACview channel. Since power was just initialized, the Monopolar Cut Power Digital Display will display "0" at this point. Select the desired channel using the Monopolar Cut Power Adjustment Keys.
6) Move the DACview switch (again, the change is recognized, not whether the switch is on or off). The cut power setting will be displayed.
7) To select a different location to monitor with a DVM, simply move the DACview switch and the memory locations will be displayed instead of the cut power. Select the desired selection and then move the DACview switch again.

Table 4.10 DACview Channels

Channel	Source	Function	Scaling
0		No channel selected	
1	Monitor	RF RMS Power (300mS running average)	0.01 V / 1 W

4.10 Troubleshooting

Listed in Table 4.11 are potential errors that may occur and problem solving ideas for each. All error codes (Err xxx) can only be cleared by cycling power.

When an error code is displayed, reset the system to determine if the error can be cleared with a System Reset or if further service is required.

Error codes are stored as Last Fault Codes (See Last Fault Codes).

CAUTION: Activation of unit with the collector fuses (F2,6, & 7 on power board) removed and the base fuses (F1,4, & 5) in place can result in damage to U3 on power board. Activation with base fuses removed and collector fuses in place is acceptable.

Table 4.11 Troubleshooting

Problem	Possible Cause
Display Panel Blank when System is Powered on	Verify the power cord is fully seated in the power receptacle on the back of the System.
	With the power cord disconnected, verify fuses are good and are installed properly in the receptacles on the back panel of the generator.
	Remove the top cover and verify that the Control/Display Board and all harnesses are properly seated.
	Check that power appears on the Control/Display Board by measuring +12 V at TP66 and +5V at TP54. Check other power supply test points as necessary to characterize the problem.
	Check that J17 and J8 on power board are connected. Check fuses F3 and F11 on power board.

Problem	Possible Cause
Display Panel Blank when System is Powered on (continued)	Confirm Jumpers JP1-5 are configured correctly for line voltage. Refer to power board schematic for details.
	Unplug J8 and J17, and check continuity of transformer windings. Refer to power board schematic for details.
Display: ACC xxx	Accessory error – Faulty accessory is connected, a hand controlled accessory is erroneously actuated, or a footswitch is erroneously actuated. Ensure that footswitches are not stacked on top one another. ACC rh and ACC Lh indicate problems with the accessories connected to the Hand Controlled and Combination Monopolar Accessory Receptacles, respectively. ACC FS indicates a problem with the footswitch connected to either of the Monopolar or Bipolar Footswitch Connectors.
Display: CP xx	Control Panel error – Check for a faulty push button on the front control panel, a control panel push button that has been pushed while the unit is being turned on, or a faulty cable connection between the front panel and the display board.
Display: LFc xxx	Last Fault Codes – the Tone Loudness Adjustment Down Key was pressed while power was initialized. The generator must be reset to clear this condition. See section 4.7.
Display: CAL	The system is in the Calibration Mode. Calibration Mode is selected when the configuration DIP switch in the second position on the Control/Display Board is in the ON (Up) position and the Tone Loudness Adjustment Down Key is pressed and held while power is turned on. See section 4.8.
Display: Err xxx	Refer to Table 4.12 for list of Err codes and possible causes. If an Err code appears, try cycling power. If it reappears, the unit should be taken out of service until a qualified biomedical engineer can diagnose the problem.
Single and Dual Dispersive Electrode Status / Alarm Indicators flash alternating red.	A Dispersive Electrode is not connected to the system.
	A Dual Dispersive Electrode is connected but is not properly applied to patient.
	A Dispersive Electrode is connected but is not properly seated. Ensure the connector is fully seated in the Two-Pin Dispersive Electrode Receptacle.
Flashing Decimal Points on the Display	The system is in the Test Mode. Test Mode is selected when the configuration DIP switch in the first position on the Control/Display Board is in the ON (Up) position and the Tone Loudness Adjustment Down Key is pressed and held while power is turned on. Note: When the Test Mode is active, most of the internal safety monitoring is inhibited. See section 4.8.
No output power	One or more connections inside the system are bad. Check: • J5, Control/Display Board • J12, Power board • Faulty accessory – blade not seated fully • Output board jacks not making contact
	Low voltage power supplied to the Control/Display Board is bad. Check +12V and +5V on the Control/Display Board.
	Shorted RF Amplifier power MOSFET Q5. (Note: A better indication of the problem will be provided by cycling power, which will allow the generator to find a fault during POST.) • Remove F1, F2, F4, F5, F6, and F7 on the Power board • Using an ohmmeter measure between drain and ground on Q2, Q3, and Q4 for low resistance. • Using an ohmmeter measure between gate and ground on Q2, Q3, and Q4 for low resistance. • If either exhibit low resistance, either replace the faulty MOSFET or replace the Power board.

Problem	Possible Cause
No output power (continued)	HVPS output too low. • Configure system for test mode operation. • Set the system for Pure cut at 1 watt. • Activate and confirm RFSUP at TP8 is approximately 95Vdc.
	Improper gate drive. • Configure system for test mode operation. • Verify that RFGATE (TP11) and BGATE (TP5) are correct.
	Improper VBASE_PWM. • Check VB_PWM for 312 Khz signal • Check VBASE_PWM (TP9) for dc voltage corresponding to duty cycle of VB_PWM. VBASE_PWM is approximately linear with the percentage duty cycle between 0.6 volts and 10 volts.
Incorrect monopolar output	Bad calibration – Recalibrate
	Ensure the load resistor is correct when checking output power.Bad voltage or current feedback. Check: • C_MVSNS, monopolar voltage sense • C_ISNS, monopolar current sense • These signals should match the Monitor voltage and current sense, M_MVSNS and M_ISNS, respectively.
Incorrect bipolar output	Bad calibration – Recalibrate Ensure the load resistor is correct when checking output power.
	Bad voltage or current feedback. Check: • C_BVSNS, bipolar voltage sense • C_ISNS, bipolar current sense • These signals should match the Monitor voltage and current sense, M_BVSNS and M_BISNS, respectively.

4.10.1 HVPS Troubleshooting Hints

WARNING: LOSS OF POWER SUPPLY ISOLATION CAN CAUSE ELECTRICAL SHOCK. WHEN SERVICING THE HIGH VOLTAGE POWER SUPPLY, ASSUME INTERNAL ISOLATION IS COMPROMISED UNTIL VERIFIED OTHERWISE.

WARNING: MAKE SURE THE LED FOR THE CIRCUIT YOU'RE WORKING ON IS OFF WHEN MAKING CONNECTIONS OR TOUCHING CIRCUITRY.

• The PFC LED should always be on when power is on. It will become momentarily and slightly brighter during POST.

• If fuse F3 is blown, Q1 is probably shorted. Also check surrounding components for failure if Q1 is found to be bad.

• Check the clock frequency and reference voltage on the PFC controller integrated circuit. The PFC clock must have PFC enabled to function correctly.

• At low output current, the PFC will cycle on and off. This is normal.

• When replacing a MOSFET, check all the gate drive components.

4.11 Parts Ordering Information

To obtain replacement parts or additional information regarding your unit, write or telephone according to the contact information as listed on the inside front cover of this manual, or contact your CONMED distributor. To ensure prompt service, please provide the following information:

- Model Number
- Serial Number
- Reference Designator and Description of Part
- CONMED Part Number (if known)
- Quantity Desired
- Mailing or Shipping Address
- Preferred Shipping Means (if any)
- Purchase Order Number (if applicable)
- Your Name

When returning a unit, obtain a Return Authorization (R.A.) Number from CONMED Technical Services. Please mark the R.A. number on the outside of the carton for prompt service. Please enclose a brief note with the unit describing all of the symptoms found.

4.12 Assembly Breakdown/Parts Access

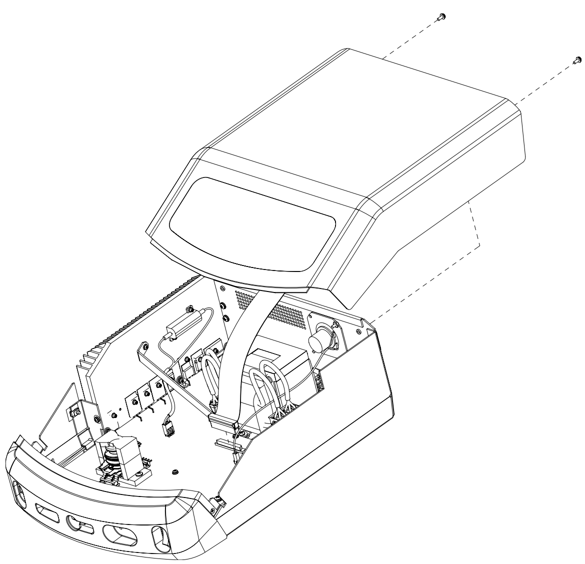
CAUTION: This device contains components that can be damaged by static electricity. Proper handling by grounding of personnel during servicing is mandatory.

Following are instructions for unit disassembly and reassembly instructions.

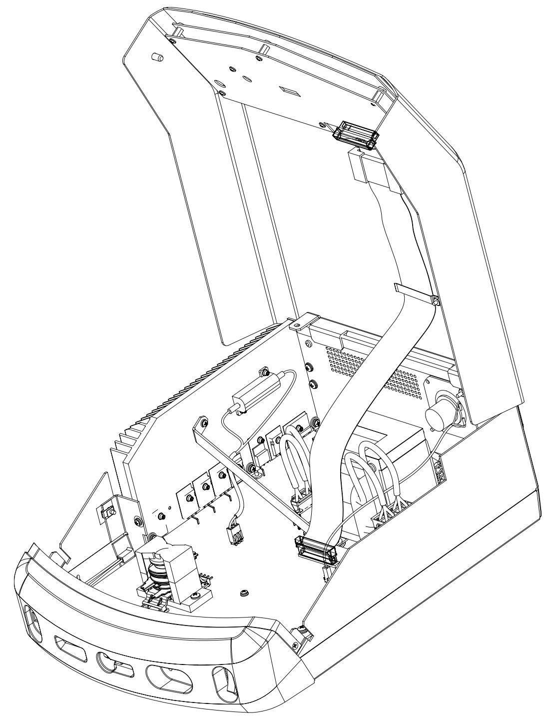
4.12.1 Top Cover Removal & Replacement

Top Removal:

1) Remove the two screws located on rear of unit as shown.



2) Pull back and up to disengage the top.
3) Open the top by lifting the front edge. A bracket is provided at the back edge of the top to support the top in its service position as shown.



4) To completely remove the top, disconnect the ribbon cable at its Power Board connection point.

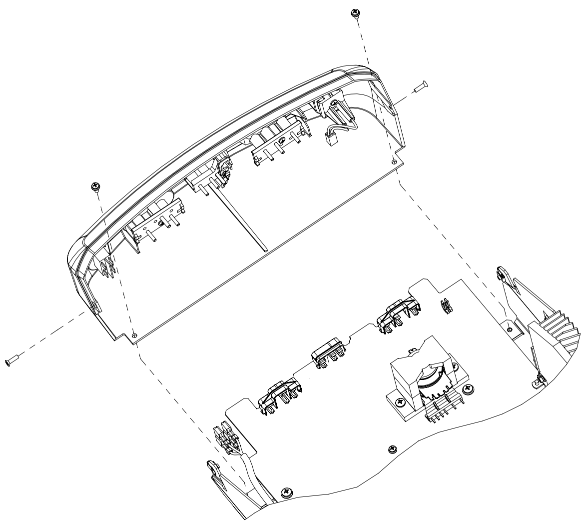
Top Replacement:

1) Reconnect the ribbon cable to its Power Board connection point.
2) Place top approximately ¾” from front bezel on top of unit.
3) Press forward, aligning lip of front bezel with groove in top.
4) Re-install screws.

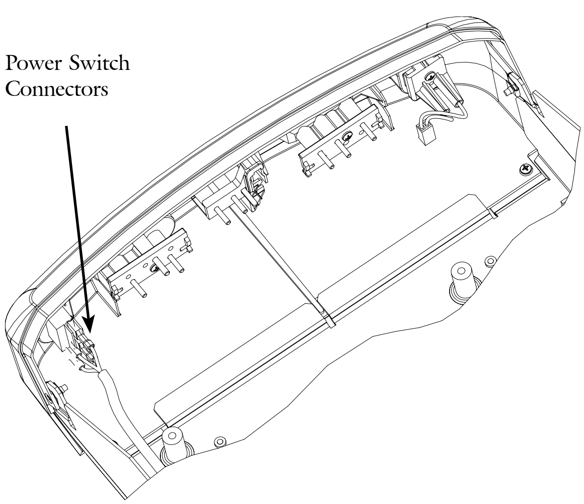
4.12.2 Bezel Removal & Replacement

Bezel Removal:

1) Remove Top.
2) Remove two flat-head screws on side of bezel and two pan-head screws on bottom of bezel as shown.

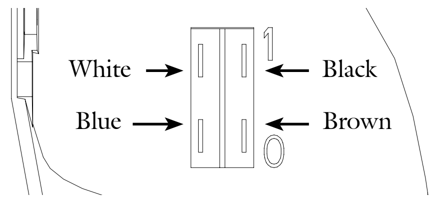


3) Unlatch dispersive electrode connector.
4) In most situations, it is not necessary to remove the four power switch connectors. The bezel can be rotated off to the right side for power board removal. To fully remove the bezel, these connectors must be disconnected.



Bezel Replacement:

1) Connect power switch connectors as shown, if required.

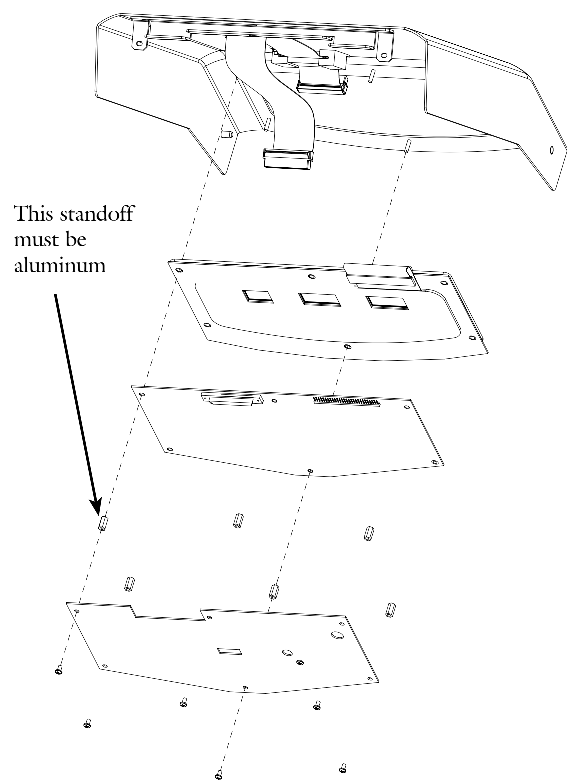


2) Connect dispersive electrode connector.
3) Align bezel between chassis flanges and center slot. Slide bezel into unit as shown in figure.
4) Replace and tighten screws.

4.12.3 Control/Display Board Removal & Replacement

Control/Display Board Removal:

1) Remove Top.
2) Remove the six screws and remove sheet metal shield.
3) Disconnect the ribbon cable.
4) Remove the one aluminum and five plastic hex standoffs, noting location of aluminum standoff. Lift board off the threaded standoffs.



5) Disconnect display flex connector, being careful not to damage it.

Control/Display Board Replacement:

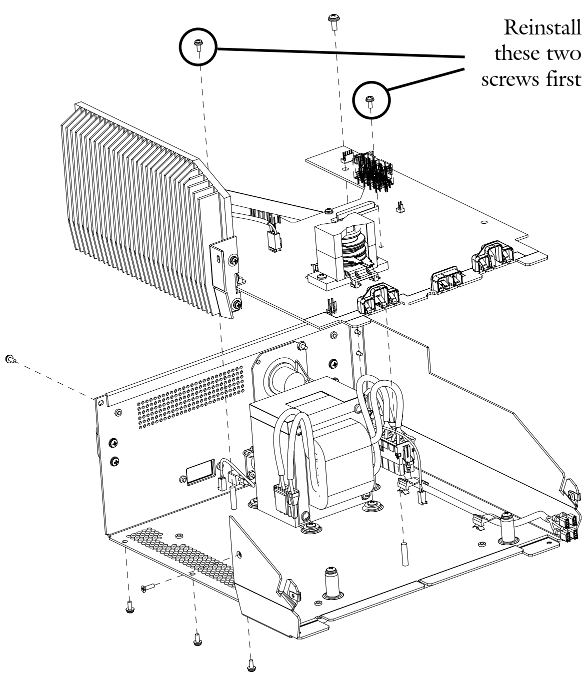
1) Connect display flex connector and place board back onto threaded standoffs.
2) Replace aluminum standoff in its previous location and tighten all hex standoffs.

   NOTE: The aluminum standoff provides a ground and must be located as shown below.
3) Connect ribbon cable.
4) Replace sheet metal shield and tighten six screws into hex standoffs.

4.12.4 Power Board Removal & Replacement

Power Board Removal:

1) Remove Top.
2) Remove Bezel.
3) Remove the five screws mounted to the heat sink in the rear, bottom and side of chassis.
4) Remove the five screws mounted to the chassis standoffs. **Do not** remove the screws that secure the angle bracket between the Power PWB and the heat sink.



5) Disconnect all cable connectors – Transformer, speaker, footswitch, AC power, and 3.5mm jack.
6) Pull board slightly forward to remove it from the chassis.

Power Board Replacement:

1) Reverse board removal operation.

   NOTE: Install the noted two, smaller screws first, to assure Power Board alignment in chassis.

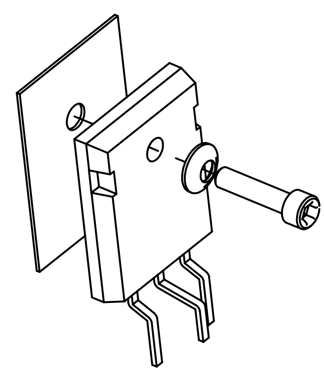
4.12.5 Power Transistor Replacement

CAUTION: This device contains components that can be damaged by static electricity. Proper handling by grounding of personnel during servicing is mandatory.

All Power Board components mounted to the heat sink may be replaced. Use only components supplied by CONMED.

Follow these instructions for replacement:

1) No thermal compound is necessary, but the mating surfaces of the transistor, insulator pad and surface of heat sink should be clean. Always replace the insulator pad associated with the transistor. Always fasten or clamp the part to the heat sink surface prior to soldering it to the board. This will assure good thermal contact is maintained.
2) In order to maintain alignment with the heat sink surface, the leads of these parts have been bent to the proper shape. They should be purchased from CONMED with bent leads.
3) When installing these parts, be sure to orient the Bellville washer as shown, with the convex surface next to the head of the screw. Tighten screws to 5-7 inch pounds.



4.13 Fault Codes

This section of the manual contains a table of fault codes. Each numeric fault code is listed along with a description of the fault, possible causes and things to check, and corrective actions.

Table 4.12 Fault Codes

Err Code	Description	Possible Cause	Things to check	Correction
100	Test or CAL mode dip switch without both Bipolar Mode Select Keys pressed when power is turned on.	When either of these DIP switches are ON, both Bipolar Mode Select Keys on the Display Panel must be pressed until the Blend mode appears in the Monopolar Power Digital Displays – i.e. either “bL LO” or “bL HI”. The Blend mode may persist in the displays for a few seconds after the Bipolar Mode Select Keys are released.	Cycle system power while pressing both Bipolar Mode Select Keys and determine if this error is repeated.	Replace the Control/ Display Board.
101	Controller/ Monitor DIP switch mismatch	The System Controller and the Monitor do not detect the same settings for the Configuration Dipswitches.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
102	Corrupted communications between the System Controller and Monitor	The data transmitted from the System Controller to the Monitor through the HPI port is faulty. This could be caused by damage to components associated with the HPI bus on the Controller, permitting electromagnetic interference to upset one of the processors.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
103	Corrupted communications between the System Controller and RF Controller	The data transmitted from the System Controller to the RF Controller through the HPI port is faulty. This could be caused by damage to components associated with the HPI bus on the Controller, permitting electromagnetic interference to upset one of the processors.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
104	Monitor TOKEN not incremented, monitor program corrupted	The data transmitted from the System Controller to the Monitor through the HPI port is faulty. This could be caused by damage to components associated with the HPI bus on the Controller, permitting electromagnetic interference to upset one of the processors.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
105	Controller failed RAM test	The System Controller memory errors have been detected during POST.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.

Err Code	Description	Possible Cause	Things to check	Correction
107	Monitor boot-load program does not match controller ROM table	The program transmitted from the System Controller to the Monitor through the HPI port at startup is faulty. This could be caused by damage to components associated with the HPI bus on the Controller, permitting electromagnetic interference to upset one of the processors.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
108	RF TOKEN not incremented, RF controller program corrupted	The program transmitted from the System Controller to the RF Controller through the HPI port at startup is faulty or has been corrupted after initialization. This could be caused by damage to components associated with the HPI bus on the Controller, permitting electromagnetic interference to upset one of the processors.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
109	Communications lost during POST tests	Communications through the HPI port are faulty. This could be caused by damage to components associated with the HPI bus on the Controller, permitting electromagnetic interference to upset one of the processors.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
112	Pre-activation handshake, monitor does not read an activation signal	The activation signals detected by the System Controller and the Monitor do not match.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
113	Pre-activation handshake, monitor does not read a tone signal	Prior to enabling electrosurgical output power, the Monitor ensures that an activation tone is present. This error occurs if the activation tone is not present when the Monitor checks prior to enabling electrosurgical output power.	Increase the tone volume by adjusting the Volume Control on the back panel of the generator. Cycle system power and determine if this error is repeated. Configure system for test mode operation. Check the tone drive signal from the Control/Display Board while the unit is activated. Lack of a signal indicates a problem with the Control/Display Board. Check for a proper TONE_ MON signal to the controller. Lack of a signal indicates a problem with the Power Board.	Replace the Control/ Display Board. Replace the Power Board.

Err Code	Description	Possible Cause	Things to check	Correction
114	Display or keyboard SPI communication failure	Communication between the Control/Display Board and the Display assembly over the SPI bus is faulty.	Cycle system power and determine if this error is repeated. Check SPI_SCK, SPI_MOSI, and SPI_MISO to see signals toggle.	Replace the cable between the Display and the Controller. Replace the Control/Display Board. Replace the Display assembly.
122	System Controller flash program CRC does not match the calculated CRC	The self-check CRC for the System Controller is not internally consistent, indicating an error in the stored software.	Cycle system power and determine if this error is repeated.	Replace the Control/Display Board.
135	A.R.M. calibration (10/150 Ohm) EPROM CRC failed	The CRC for the calibration coefficient memory is not self consistent, indicating an error in the stored calibration coefficients.	Recalibrate the A.R.M. system. See section 4.6.	Check J1 connector on the Power Board. Repair ARM circuitry on Power Board or replace Power Board if necessary. Replace the Control/Display Board if the system will not calibrate.
136	A.R.M. circuit dropped below .4V (circuit failed)	The A.R.M. circuit on the Output assembly or the A.R.M. sensing circuit on the Control/Display Board has failed.	Verify proper voltage on the VARM signal entering the Control/Display Board.	Repair or replace the Power Board if VARM entering the Controller is faulty. Replace the Control/Display Board if VARM appears correct.
138	Monitor calibration EEPROM CRC failed	The CRC for the calibration coefficient memory is not self consistent, indicating an error in the stored calibration coefficients.	Recalibrate the entire system.	Replace the Control/Display Board if the system will not calibrate.
139	During calibration, not all points were entered for the mode	The calibration was not completed in the correct manner.	Recalibrate any uncalibrated modes. See Section 4.6.	Replace the Control/Display Board if the system will not calibrate.
140	A calibration EEPROM CRC failed (POST ERROR)	The CRC for the calibration coefficient memory is not self consistent, indicating an error in the stored calibration coefficients.	Recalibrate any un-calibrated modes. See Section 4.6.	Replace the Control/Display Board if the system will not calibrate.
141	Test and cal dip switches are both turned on	The Calibration and Test Configuration Dipswitches are both in the ON position. At least one of these must be in the OFF position.	Change the Calibration and Test Configuration Dipswitches to the desired state, cycle system power, and determine if this error is repeated.	Replace the Control/Display Board.

Err Code	Description	Possible Cause	Things to check	Correction
143	The unit or a mode was never calibrated	The system or a mode was never calibrated. The Controller was replaced but not calibrated.	Calibrate any modes that need calibration.	Replace the Control/ Display Board if the system will not calibrate.
144	RF controller and Monitor power levels do not match	The Monitor and RF Controller and constantly checking to ensure they see the same electrosurgical output power during activation. This error occurs if the power they sense does not match. This typically results from differences between the independent Monitor and RF Controller sensing circuits.	Use DACView to troubleshoot the Monitor. Verify that the output power is consistent with displayed power setting. Check voltage and current sensing channels for both the RF Controller and the Monitor.	Replace the Control/ Display Board. Troubleshoot the RF voltage (Vsense) and current (Isense) feedback circuits for the activated mode.
145	Inter-processor communications error	The data transmitted from the System Controller through the HPI port is faulty. This could be caused by damage to components associated with the HPI bus on the Controller, permitting electromagnetic interference to upset one of the processors.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
150	2.5 volt too low	2.5-volt power on the Control/ Display Board is too low.	Check for proper connection of the ribbon cable.Check the +12V entering Control/Display Board (TP66). Check the +2.5V power on the Control/Display Board (TP36). Verify that the System Controller ADC reference voltage (C_2.5V) on the Control/Display Board is 2.5 volts.	If +12V is out of limits, replace or repair the Power Board. If either +2.5V or the ADC reference is out of limits, replace the Control/Display Board.
151	2.5 volt too high	2.5-volt power in the system is too high.	Check for proper connection of the ribbon cable. Check the +12V entering Control/Display Board (TP66). Check the +2.5V power on the Control/Display Board (TP36). Verify that the System Controller ADC reference voltage (C_2.5V) on the Control/Display Board is 2.5 volts.	If +12V is out of limits, replace or repair the Power Board. If either +2.5V or the ADC reference is out of limits, replace the Control/Display Board.
152	1.2 volt too low	1.2-volt power on the Control/ Display Board is too low.	Check for proper connection of the ribbon cable. Check the +12V entering Control/Display Board (TP66). Check the +1.2V power on the Control/Display Board (TP15). Verify that the System Controller ADC reference voltage (C_2.5V) on the Control/Display Board is 2.5 volts.	If +12V is out of limits, replace or repair the Power Board. If either +1.8V or the ADC reference is out of limits, replace the Control/Display Board.

Err Code	Description	Possible Cause	Things to check	Correction
153	1.2 volt too high	1.2-volt power in the system is too high.	Check for proper connection of the ribbon cable. Check the +12V entering Control/Display Board (TP66). Check the +1.2V power on the Control/Display Board (TP15). Verify that the System Controller ADC reference voltage (C_2.5V) on the Control/Display Board is 2.5 volts.	If +12V is out of limits, replace or repair the Power Board. If either +1.8V or the ADC reference is out of limits, replace the Control/Display Board.
154	1.8 volt too low	1.8-volt power on the Control/ Display Board is too low.	Check for proper connection of the ribbon cable. Check the +12V entering Control/Display Board (TP66). Check the +1.8V power on the Control/Display Board (TP39). Verify that the System Controller ADC reference voltage (C_2.5V) on the Control/Display Board is 2.5 volts.	If +12V is out of limits, replace or repair the Power Board. If either +1.8V or the ADC reference is out of limits, replace the Control/Display Board.
155	1.8 volt too high	1.8-volt power in the system is too high.	Check for proper connection of the ribbon cable. Check the +12V entering Control/Display Board (TP66). Check the +1.8V power on the Control/Display Board (TP39). Verify that the System Controller ADC reference voltage (C_2.5V) on the Control/Display Board is 2.5 volts.	If +12V is out of limits, replace or repair the Power Board. If either +1.8V or the ADC reference is out of limits, replace the Control/Display Board.
160	POST has determined that the RF Controller voltage sense is faulty.	RF Controller voltage sense is open or shorted. This can result from a disconnected wire terminal or bad A/D converter.	Cycle system power and determine if this error is repeated. Verify that all internal connectors are properly seated. Check for loose wires on Power board T3.	Replace the Control/ Display Board. Replace the Power Board.
170	Controller waveform inhibit failed (will not disable RF) (POST ERROR)	The Monitor has detected that the System Controller cannot disable the RF Drive signal during POST.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
311	POST Monitor memory failure.	Errors found in Monitor microprocessor memory during power initialization.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
314	POST Monitor or RF Controller clock failure	Monitor or RF Controller clock oscillator failure detected during POST.	Check for 10 MHz clock frequency input to Monitor processor and or RF Controller.	Replace the Control/ Display Board.
315	POST Monitor activation circuitry failure	The states of the activation request signals detected by the Monitor do not match the states detected by the System Controller.	Check for active high activation request on lines running to the Monitor.	Replace the Control/ Display Board.

Err Code	Description	Possible Cause	Things to check	Correction
320	Monitor failed program CRC test	Errors found in software downloaded from the System Controller to the Monitor during initialization.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
321	Monitor failed calibration data CRC test	Monitor calibration data is corrupted.	Recalibrate all system modes.	Replace the Control/ Display Board.
322	Monitor or RF controller did not return to IDLE state	Activation continues after activation command ceases.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
330	POST RF AC voltage cut feedback too low	Monitor senses electrosurgical voltage output too low during POST, indicating insufficient voltage from HVPS, insufficient drive from the RF Controller, failed RF Amplifier, or a failed voltage sensing channel. The limits for this comparison are set when the system enters calibration mode.	Configure the system for Calibration mode operation and initialize power. Configure the system for test mode operation and cycle power. Measure HVPS output, RF Amplifier drive, RF Amplifier output, and voltage sensing channel.	Replace the Control/ Display Board or the Power Board depending on the specific cause of the failure.
331	POST RF AC voltage cut feedback too high	Monitor senses electrosurgical voltage output too low during POST test, indicating insufficient voltage from HVPS, insufficient drive from the RF Controller, failed RF Amplifier, or a failed voltage sensing channel. The limits for this comparison are set when the system enters calibration mode.	See 330 above.	Confirm proper connection of J3 on the Power Board.See above.
340	Monitor Timer0 interrupt failed	One of the timers internal to the Monitor is failed.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
341	Monitor Timer0 interrupt failed POST	Failure of one of the timers internal to the Monitor detected during POST.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
342	Monitor Timer1 interrupt failed POST	Failure of one of the timers internal to the Monitor detected during POST.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
343	Monitor has lost communications - controller TOKENS not incremented	Reset machine and if error repeats, then replace Control/ Display Board.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.

Err Code	Description	Possible Cause	Things to check	Correction
350	Monitor output channel current sensor failure	Current detected through the output channel current sensor that is used to detect a stuck output relay does not match the current sensed by the power monitoring sensor. This typically indicates that there is a problem with the output channel current sensing circuit.	Configure the system for test mode operation and cycle power. Use DACview to compare the output channel current with the output current while activating at constant power into a fixed load.	Repair or Replace the Power board. Replace the Control/ Display Board.
351	Monitor sensed over power condition for 300mS running average	Over power at the electrosurgical output has persisted for more than 300 ms.	Configure the system for test mode operation and cycle power. Measure the actual power into a fixed load. If power is correct, verify proper operation of the Monitor voltage and current sensing circuits. If power is correct, verify proper operation of the RF Controller voltage and current sensing circuits, the HVPS, and the RF Amplifier.	Repair or Replace the Power board. Replace the Control/ Display Board.
357	Monitor sensed power @ 0W dial power setting	The Monitor has sensed electrosurgical output power during activation while the power is set to zero.	Recalibrate the system. Configure the system for test mode operation and cycle power. Measure the actual power into a fixed load. If power is correct, verify proper operation of the Monitor voltage and current sensing circuits. If power is correct, verify proper operation of the RF Controller voltage and current sensing circuits, the HVPS, and the RF Amplifier.	Repair or Replace the Power board. Replace the Control/ Display Board.
358	Monitor sensed gate drive in idle @ 0W dial power setting	The Monitor has detected a drive signal while the system is not activated.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
360	Monitor program counter landed on an unused interrupt vector	Monitor processor anomaly.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
371	Monitor will not disable RF waveform on the Control/Display Board during POST	POST has determined that the Monitor cannot disable the RF waveform.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
375	Monitor activation I/O failed POST	POST has determined that activation commands sensed by the System Controller do not match the activation commands sensed by the Monitor.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.

Err Code	Description	Possible Cause	Things to check	Correction
379	RF calibration failed POST	System calibration required on one or more modes.	Recalibrate the system. Configure the system for test mode operation and cycle power. Measure the actual power into a fixed load. If power is correct, verify proper operation of the Monitor voltage and current sensing circuits. If power is correct, verify proper operation of the RF Controller voltage and current sensing circuits, the HVPS, and the RF Amplifier.	Replace the Control/ Display Board if the system will not calibrate.
381	No tone feedback during POST	The Monitor did not detect tones during POST. This typically occurs because of a problem in the tone generation circuitry.	Listen for tones during POST. Verify that all internal cables are properly connected. Increase the tone volume by adjusting the Volume Control on the control panel. Cycle system power and determine if this error is repeated. Configure system for test mode operation. Check the tone drive signal from the Control/Display Board while the unit is activated. Lack of a signal indicates a problem with the Control/Display Board. Check for a proper TONE_ MON signal to the controller. Lack of a signal indicates a problem with the Power Board assembly.	Replace the Control/ Display Board. Repair or replace the Back Panel assembly.
382	Activation without a tone	The Monitor did not detect a tone during activation. This typically occurs because of a problem in the tone generation circuitry.	Listen for a tone during activation. Verify that all internal cables are properly connected. Increase the tone volume by adjusting the Volume Control on the control panel. Cycle system power and determine if this error is repeated. Configure system for test mode operation. Check the tone drive signal from the Control/Display Board while the unit is activated. Lack of a signal indicates a problem with the Control/Display Board. Check for a proper TONE_ MON signal to the controller. Lack of a signal indicates a problem with the Power Board.	Replace the Control/ Display Board. Repair or replace the Power Board.
383	RF Current sensed at an unselected output.	The Monitor has sensed current flowing at an output that has not been selected. This may indicate a faulty or stuck output relay.	Arrange the system with fixed loads connected to all outputs. Activate each output in turn while monitoring all outputs for current.	Replace or repair the Output assembly. Replace the Control/ Display Board.

Err Code	Description	Probable Cause	Things to check	Correction
388	POST monitor timed out- did not respond to a POST command	Reset machine and if error repeats, then replace Control/ Display Board	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
389	Dial setting over maximum limit	The front panel power setting exceeds the limit for the selected mode.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
391	Monitor detected the wrong RF waveform	The Monitor has detected an improper RF Amplifier drive waveform or frequency for the selected mode.	Cycle system power and determine if this error is repeated.	Replace the Control/ Display Board.
395	Maximum peak voltage was exceeded for a given mode.	Disconnected wire terminal or bad A/D converter.	Check for loose wires on the Power board T3.Cycle system power. Test each mode open circuit at maximum power and determine if this error is repeated.	Replace the Control/ Display Board. Replace the Power Board.
396	The monopolar-bipolar selection relay is stuck in the bipolar position.	TBD		