



Electrosurgical Unit Analyzer



ESU-2300

USER MANUAL

**BC BIOMEDICAL
ESU-2300
TABLE OF CONTENTS**

WARNINGS, CAUTIONS, NOTICES	ii
DESCRIPTION.....	1
OVERVIEW.....	4
SCREENS.....	11
POWER UP SETTINGS	19
TEST SETUPS.....	21
ERROR MESSAGES	43
DFA™ TECHNOLOGY.....	46
COMMUNICATION PROTOCOL	47
COMMUNICATION COMMAND SUMMARY	51
MANUAL REVISIONS.....	52
WARRANTY	52
SPECIFICATIONS	53
NOTES.....	55

WARNING - USERS

The ESU-2300 Analyzers are for use by skilled technical personnel only.

WARNING - USE

The ESU-2300 Analyzers are intended for testing only and they should never be used in diagnostics, treatment or any other capacity where they would come in contact with a patient.

WARNING - MODIFICATIONS

The ESU-2300 Analyzers are intended for use within the published specifications. Any application beyond these specifications or any unauthorized user modifications may result in hazards or improper operation.

WARNING - CONNECTIONS

All connections to patients must be removed before connecting the Device Under Test (DUT) to the Analyzer. A serious hazard may occur if the patient is connected when testing with the Analyzer.
Do not connect any leads from the patient directly to the Analyzer or DUT.

WARNING - TEST LEADS

There are retractable ends on the test leads for use with the ESU to avoid possible electric shock, skin burns or personal injury.
Do not touch any metal on the banana plugs or probes.

WARNING - POWER SUPPLY

Unplug the Power Supply before
cleaning the surface of the Analyzer.

WARNING - LIQUIDS

Do not submerge or spill liquids on the Analyzer.

Do not operate the Analyzer if internal
components not intended for use with fluids may
have been exposed to fluid, as the internal
leakage may have caused corrosion and be a
potential hazard.

CAUTION - SERVICE

The ESU-2300 Analyzers are intended to be serviced only by authorized service personnel. Troubleshooting and service procedures should only be performed by qualified technical personnel.

CAUTION - ENVIRONMENT

The ESU-2300 Analyzers are intended to function between 15 and 30 °C. Exposure to temperatures outside this range can adversely affect the performance of the Analyzer.

CAUTION - VENTILATION

The ESU-2300 Analyzers include ventilation grills on either side of the units to help prevent overheating during operation. These grills and internal fan should not be blocked. Continuing to apply a high-level ESU signal after an Error Message, can result in damage to the unit.

CAUTION - CLEANING

Do not immerse. The Analyzer should be cleaned by wiping gently with a damp, lint-free cloth. A mild detergent can be used if desired.

CAUTION - INSPECTION

The ESU-2300 Analyzers should be inspected before each use for wear and the Analyzer should be serviced if any parts are in question.



NOTICE – CE



The ESU-2300 Analyzers bear the  mark
Based on the following testing standards:

ELECTROMAGNETIC COMPATIBILITY DIRECTIVE
**EMC – Directive 89/336/EEC and 2004/108/EC as amended by
92/31/EEC, 93/68/EEC and Directive 91/263/EEC [TTE/SES]**

EN 61326-1:1997 + A1:1998 + A2:2001 + A3:2003
**“Electrical equipment for measurement, control and
laboratory use – EMC requirements”**

This equipment has been type tested by an independent, accredited testing laboratory
and compliance was demonstrated to the above standard to the extent applicable.

EMISSIONS Radiated and Line Conducted Emissions

EN 61000-3-2	Harmonic Current Emissions
EN 61000-3-3	Voltage Fluctuation and Flicker

IMMUNITY– CLASS C

EN 61000-4-2	Electrostatic Discharge
EN 61000-4-3	Radiated Electric Field Immunity
EN 61000-4-4	Electrical Fast Transients / Bursts
EN 61000-4-5	Surge Voltage
EN 61000-4-6	Conducted Disturbance
EN 61000-4-11	Voltage Dips and Short Interrupts

LOW VOLTAGE DIRECTIVE **EC – Directive 73/23/EC**

EN 61010-1:2001
**“Safety requirements for electrical equipment for measurement, control, and
laboratory use – General requirements”**

This equipment has been type tested and compliance was demonstrated
to the above standard to the extent applicable.

NOTICE – SYMBOLS

Symbol

Description



Caution
(Consult Manual for Further Information)



RF Current Transformer



Per European Council Directive
2002/95/EC, do not dispose of this
product as unsorted municipal waste.

NOTICE – ABBREVIATIONS

A/D		#	Number
c	centi- (10^{-2})	Ω	Ohm
CF	Crest Factor	PC	Personal Computer
DFA	Digital Fast Acquisition	Pk	Peak
DUT	Device Under Test	%	Percentage
ESU	Electrosurgical Unit	RF	Radio Frequency
Ext	External	RMS	Root Mean Square
Hz	hertz	sec	seconds
Int	Internal	sec.	section
k	kilo- (10^3)	US	United States
kg	kilograms	V	Volt
kHz	kilohertz	VDC	Direct Current Voltage
lbs	pounds		
Max	Maximum		
M	Mega- (10^6)		
MHz	Megahertz		
μ	micro- (10^{-6})		
μ A	microampere		
m	Milli- (10^{-3})		
mA	milliampere		
mHz	millihertz		
mm	millimeter		
ms	millisecond		
mV	millivolts		
Min	Minimum		

NOTICE – DISCLAIMER

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NOTICE – CONTACT INFORMATION

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**BC BIOMEDICAL
ESU-2300
ELECTROSURGICAL UNIT ANALYZER**

The Model ESU-2300 is a high-accuracy Electrosurgical Analyzer. The “measurement engine” of the ESU-2300 is a specially-engineered True-RMS RF Ammeter and Wattmeter, particularly suited to measuring the complex RF waveforms produced by electrosurgical generators. The ESU-2300 has been designed to comply with electrosurgical manufacturer industry standard current sensing technology, and thus utilizes an internal precision RF Current Transformer. The analyzer utilizes a precision internal test load resistor network. The ESU-2300 is intended to be routinely used to measure the various parameters relating to the testing and performance validation of electrosurgical generators. The Patent Pending DFA™ Technology allows the ESU-2300 to aggressively digitize the complex electrosurgical generator waveform, analyze its components and provide highly accurate and stable results. It may be used as a stand-alone meter or in conjunction with a PC utilizing the optional software.

The following are highlights of some of the main features:

- TRUE RMS READINGS USING PATENT PENDING DFA™ TECHNOLOGY
- INDUSTRY STANDARD CURRENT SENSING TECHNOLOGY
- MV, MV PEAK, CREST FACTOR AND POWER (WATTAGE) RANGES
- RF CURRENT (mA) AND POWER (WATTS) CAN BE DISPLAYED
- INTERNAL PRECISION LOAD RESISTOR NETWORK: 50 Ω TO 750 Ω OHMS IN 50 Ω INCREMENTS
- EXTERNAL LOAD RESISTOR CAPABILITY – USES THE EXTERNAL RESISTOR VALUE AS A DISCRETE VALUE OR ADD IT TO ANY INTERNAL LOAD RESISTOR VALUE
- 2.5% OF READING ACCURACY ON RF CURRENT (mA)
- 4% OF READING ACCURACY ON RF POWER (WATTS)
- INTERNAL LOAD RESISTOR NETWORK IS COOLED WITH TEMPERATURE AND POWER CONTROLLED COOLING FAN
- USES AN INTERNAL 0.1:1 RATIO PRECISION RF CURRENT TRANSFORMER
- INDEPENDENT CQM (REM/ARM) RESISTOR NETWORK: 1 Ω TO 500 Ω IN 1 Ω INCREMENTS
- RF LEAKAGE MEASUREMENTS THROUGH 200 Ω TEST LOAD
- INTERNAL RECHARGEABLE BATTERY ALLOWS OPERATION INDEPENDENT OF LINE POWER
- LARGE GRAPHICS DISPLAY WITH CURSOR SELECTION OF OPTIONS AND SETUP OF PARAMETERS
- DIGITAL DATA OUTPUT VIA USB
- REMOTE CAPABILITIES USING RS232 AND USB
- PC BASED INTERFACE PROGRAM OPTIONAL
- DIGITAL CALIBRATION – NO POTS TO TURN
- SELECTABLE DISPLAY OPTIONS
- TACTILE KEYS WITH AUDIO FEEDBACK

STANDARD ACCESSORIES:

BC20 – 00125	ACCESSORY KIT (TEST LEADS)
BC20 – 21105	UNIVERSAL POWER SUPPLY
BC20 – 41352	COMMUNICATIONS CABLE (USB)
BC20 – 41341	COMMUNICATIONS CABLE (RS232)
BC20 – 205XX	STANDARD POWER ADAPTER (International Options, see Page 15 for details)

OPTIONAL ACCESSORIES:

BC20 – 00232	BNC TO BNC CABLE
BC20 – 41356	CD, ESU2300 INTERFACE SOFTWARE

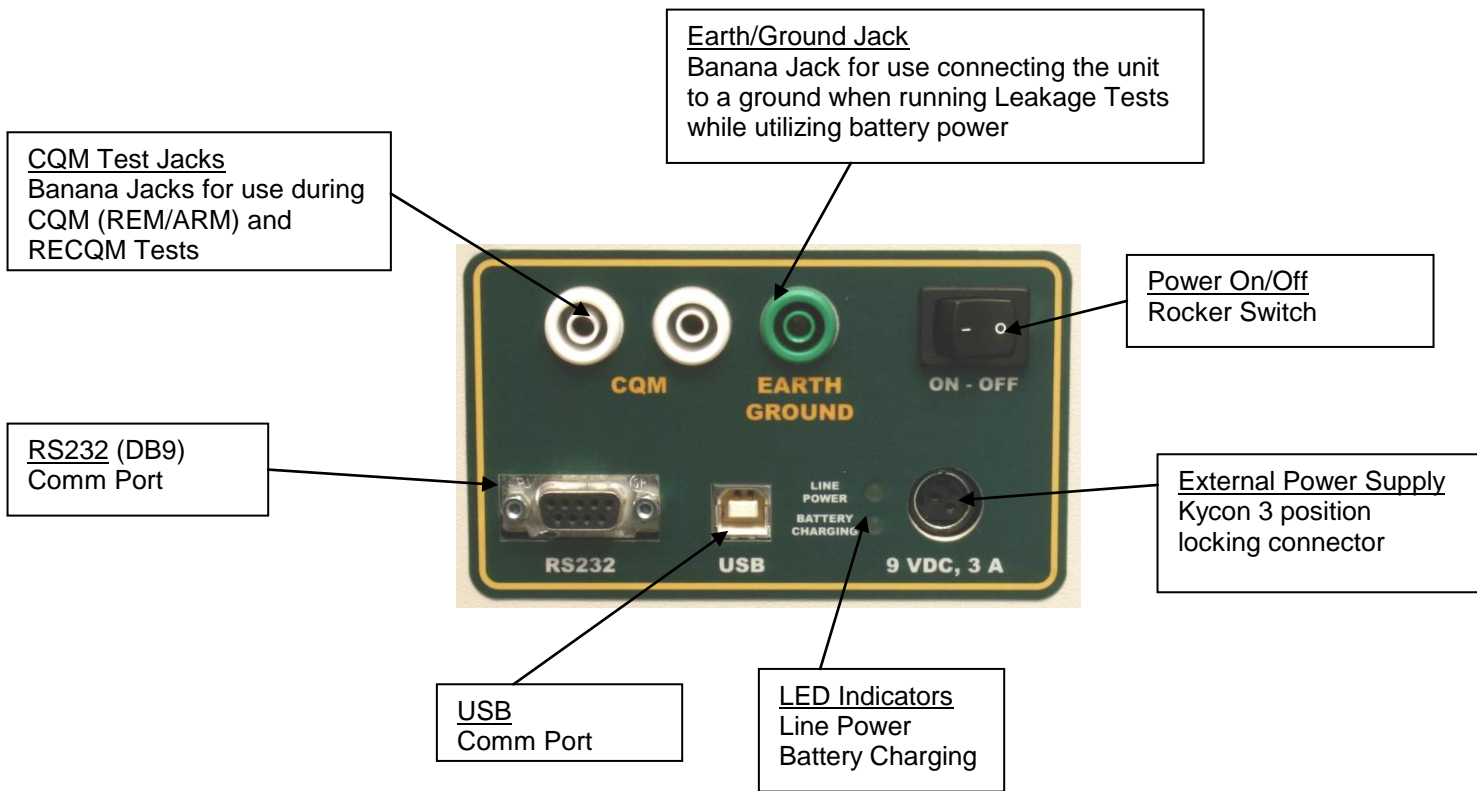
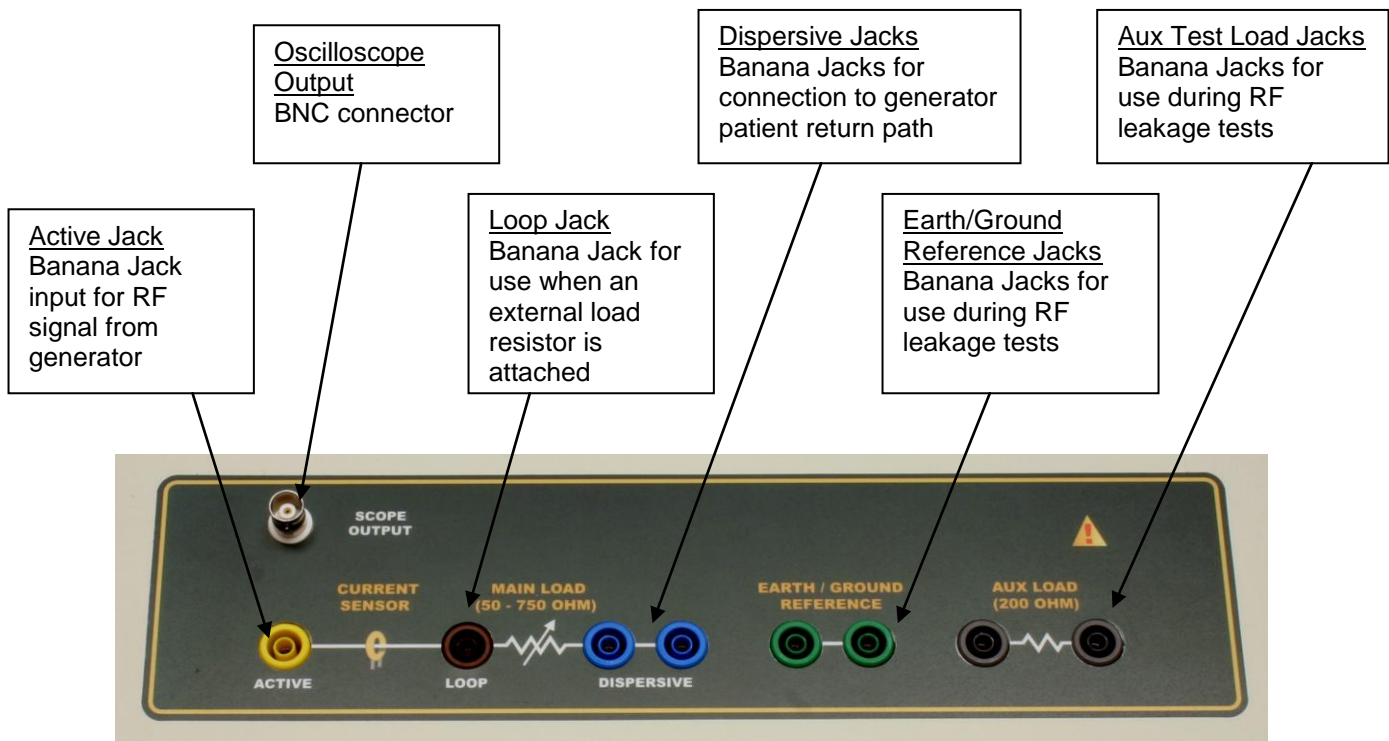
VISHAY-DALE NH-250 PRECISION 1% TOLERANCE NON-INDUCTIVE LOAD RESISTORS:

BC20-00200	5 Ω , 250 WATT RESISTOR
BC20-00201	10 Ω , 250-WATT RESISTOR
BC20-00202	20 Ω , 250-WATT RESISTOR
BC20-00203	30 Ω , 250-WATT RESISTOR
BC20-00204	50 Ω , 250-WATT RESISTOR
BC20-00205	100 Ω , 250-WATT RESISTOR
BC20-00206	200 Ω , 250-WATT RESISTOR
BC20-00207	300 Ω , 250-WATT RESISTOR
BC20-00208	500 Ω , 250-WATT RESISTOR
BC20-00209	1000 Ω , 250-WATT RESISTOR
BC20-00210	2000 Ω , 250-WATT RESISTOR
BC20-00211	3000 Ω , 250-WATT RESISTOR
BC20-00212	4000 Ω , 250-WATT RESISTOR
BC20-00213	5000 Ω 250-WATT RESISTOR
BC20-00240	POWER RESISTOR BANANA JACK ADAPTER (2 PER SET)

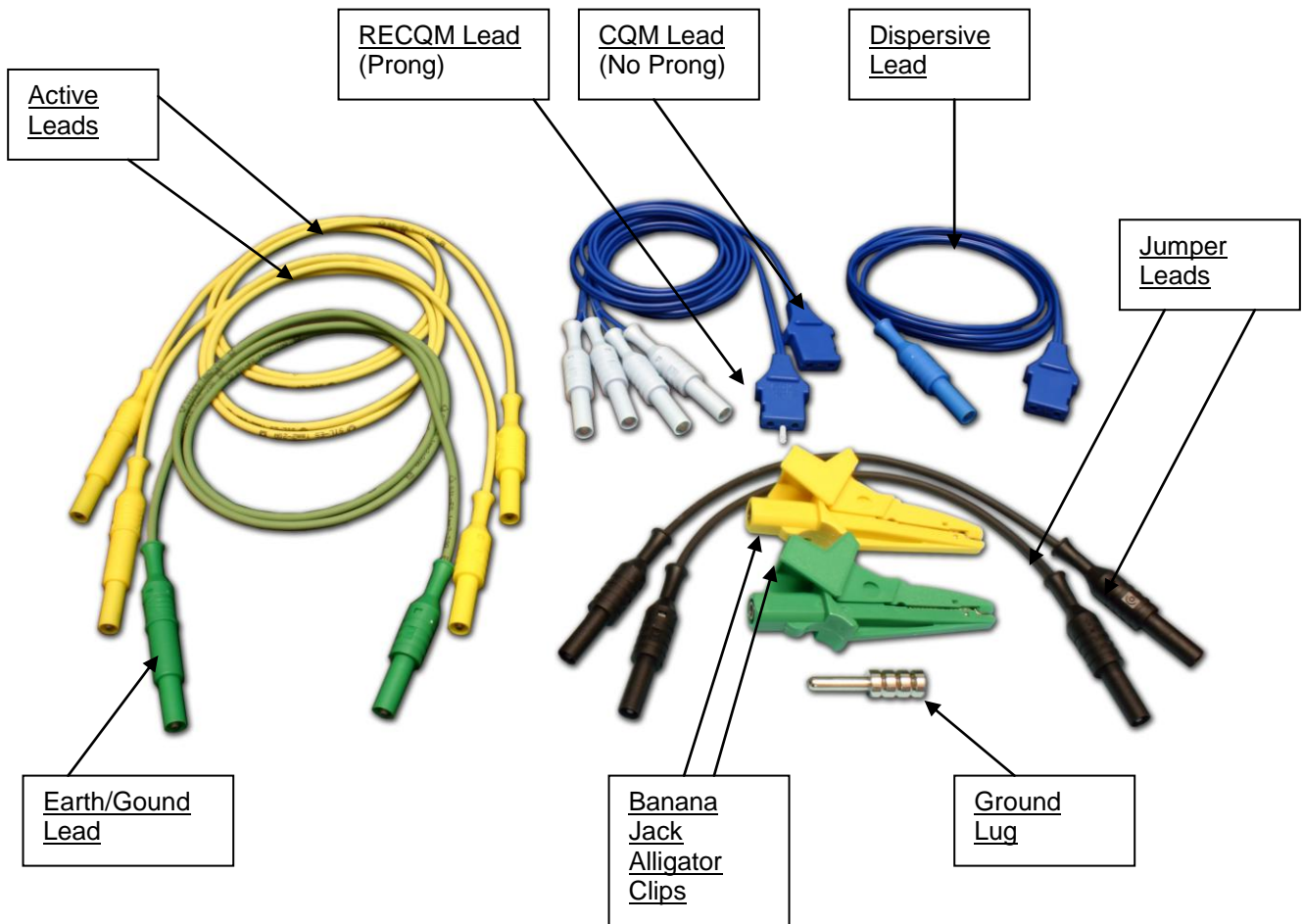
OVERVIEW

This section looks at the layout of the ESU-2300 and gives descriptions of the elements that are present.





Accessory Kit, BC20 – 00125:




GENERAL OPERATION

The ESU-2300 is controlled by 5 light touch keys for navigation, plus 1 light touch key for LCD display backlight control. The navigation keys allow the user to move around within the displayed parameters, select the desired options, choose a specific category and control the setup for the unit. When a key is depressed there is an audio click when it is accepted, or a “Razz” tone if the key is invalid.

A large LCD graphics display with high intensity white backlight provides the user with information about the current status of the device configuration options, test results and more. The display identifies the function of each key on a dynamic basis. As the operation mode changes, the key functions change to suit the operating mode.


BACKLIGHT KEY

The Graphic LCD display may be viewed with or without the backlight. Depressing any key will activate the backlight. However, since the backlight will drain the internal rechargeable battery at an accelerated rate if left on, it will automatically be shut off after a user programmable delay when running the ESU-2300 on battery power.

The  key is provided to toggle the backlight on or off at any time.

NOTE: The backlight parameter in the System Setup screen may be set to Off, 1-20 sec or Always On.

FUNCTION KEYS

There are five  keys that are used to provide general operational control. The functions of the keys vary depending on the current screen. The section of the screen just above the key indicates its current meaning.

NOTE: Only functions that are available to the user will be visible at any given time.

63		0.5		Load	
mA		Watts		Int	50
				Ext	100
				Sum	150
				Int/Ext	
DISPLAY	CHANGE	HOLD	RECOM	SETUP	



Sample Function Key Labeling

SERIAL COMMUNICATION

There are two serial ports on the side panel. One is a standard USB port and the other is a DB9 RS232 port. Both ports can be used to connect to a PC to get measurements and remotely configure the ESU-2300. The RS232 port is also used to update the ESU-2300 firmware. For more details on remote operation see the Communication Protocol section on page 53.

OSCILLOSCOPE OUTPUT

A BNC connector is provided to connect an oscilloscope to the unit. This output is an uncalibrated attenuated version of the ESU Generator output waveform.

POWER SWITCH

The main power switch for the Analyzer is located on the side panel.

LINE POWER

A Kycon 3 position locking connector is provided for the 9 VDC external universal power supply for using the ESU-2300 with line power. When connected to line power, this connection provides a connection for Earth/Ground.

NOTE: While operating the ESU-2300 on battery power, a Jumper Lead must be run from the Earth/Ground Jack to an Earth/Ground point for all of the RF leakage tests.

(See Leakage Tests for more information.)

The Universal Power Supply takes a Standard Power Adapter Cable with Small Standard Product Plug and Required International Connector (See Options Below).

Typical Power Cord Options Available for the ESU-2300



BC20-20500
North America
Hospital Grade



BC20-20501
Japan



BC20-20502
United Kingdom



BC20-20503
Schuko-
Continental
Europe



BC20-20509
India/
South Africa



BC20-20510
Switzerland



BC20-20512
Italy



BC20-20516
Australia

Pick Your Country's
Connector from Above

to Connect to the
Universal Power Supply



Standard Power Cord

Standard Product Plug

POWER UP SETTINGS

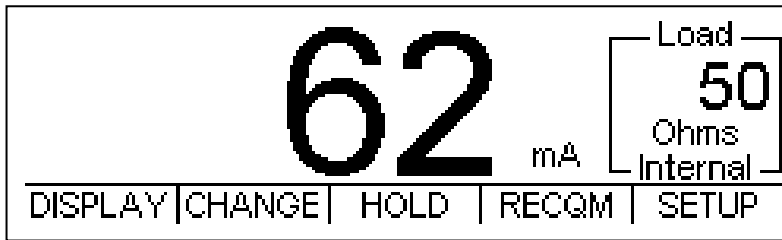
The unit may be setup to turn on using either the factory default settings or a custom set of parameters as previously saved by the user (See Power Up Settings section for details).

SCREENS

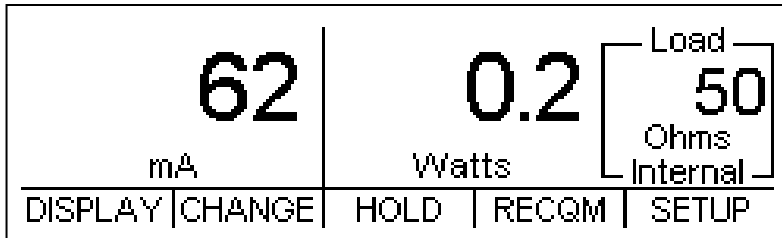
DISPLAY SCREEN

When the ESU-2300 is first powered up, the DISPLAY SCREEN will be shown. This screen contains one, two or five parameter DISPLAY ZONES, the LOAD SETTING and the available FUNCTION KEYS. Each Display Zone can be customized to show the desired parameter of RF RMS Current in mA, RF RMS Voltage in mV, RF RMS Power in Watts, RF RMS Peak Voltage in mV, RF RMS Peak to Peak Voltage in mV or Crest Factor (CF). The Load Mode Setting can be set to show the desired Internal, External and Internal/External loads. The Load Selection can be set to change the internal, external, or internal plus external load resistances.

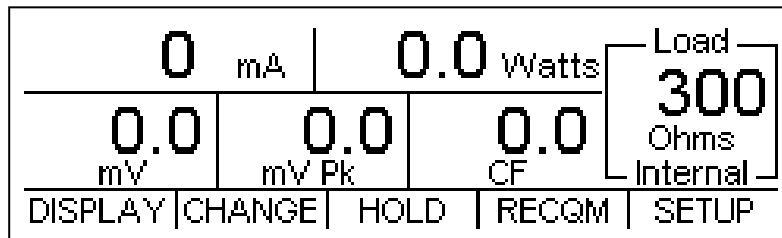
DISPLAY ZONES



Sample Display Screen with one Display Zone



Sample Display Screen with two Display Zones



Sample Display Screen with five Display Zones

The Display Zones can be toggled through using **DISPLAY** .

The parameters can be changed using the **CHANGE** key to enter the Display Parameters Configuration Screen.

LOAD SETTING

The Load Setting portion of the Display Screen shows the load selection and value that will be used in testing. There are three load set up choices for testing with the ESU-2300: Internal, External and Internal/External.

```
┌ Load ─┐
│        │
│  50    │
│ Ohms   │
│└ Internal ┘
```

```
┌ Load ─┐
│        │
│ 100    │
│ Ohms   │
│└ External ┘
```

```
┌ Load ─┐
│ Int    │ 50
│ Ext    │ 100
├───┬───┤
│ Sum   │ 150
│└ Int/Ext ┘
```

The Load Setting and value can be toggled through using the CHANGE key to enter the Display Parameters Configuration Screen.

In Internal mode, the user applies the Active Lead to the Active Jack and the Dispersive Lead to the Dispersive Jack. The RF current is routed through the selected internal loads and through the RF Current Transformer to measure the current and power.

In External mode, the user applies the Active Lead to the Active Jack and then connects another lead from the Loop Jack to whichever external load resistor is in use. The Dispersive Lead then goes to the other side of the external load resistor. In this mode, the only component that sees the ESU Generator output in the ESU-2300 is the RF current transformer. It is important to make sure that the external load resistance parameter in the ESU-2300 is set to the real value of the external load(s) as this is what is used to calculate Power.

In Internal/External mode, the user applies the Active Lead to the Active Jack and then connects another lead from the Dispersive Jack to whichever external load resistor is in use. The Dispersive Lead then goes to the other side of the external load resistor. It is important to make sure that the external load resistance parameter in the ESU-2300 is set to the real value of the external load(s) as this is what is used to calculate Power.

FUNCTION KEYS



DISPLAY – This key will toggle between one parameter, two parameter or five parameter Display Zones.

CHANGE – This key will enter the Display Parameters Configuration Screen where parameters can be selected and changed.

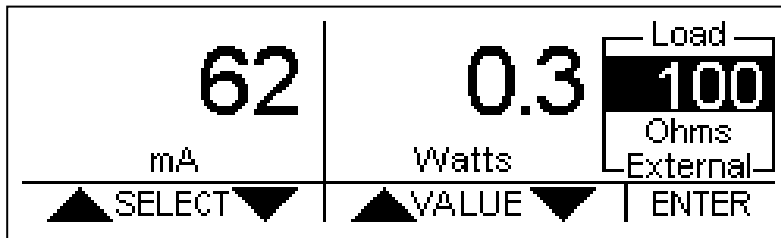
HOLD – This key will freeze the current reading in the Display Zone.

RECQM – This key will enter the RECQM Test Screen.

SETUP – This key will enter the System Setup Screen.

DISPLAY PARAMETERS CONFIGURATION SCREEN

The parameters on the DISPLAY SCREEN can be changed by using the **CHANGE** key to enter the DISPLAY PARAMETERS CONFIGURATION SCREEN. This screen adds a highlight line to the DISPLAY SCREEN and changes the FUNCTION KEYS.



Sample Display Parameters Configuration Screen with the load value highlighted

Use the **SELECT** keys to highlight the parameter to change. The last FUNCTION KEY will be **EXIT**. Use this key to return to the DISPLAY SCREEN.

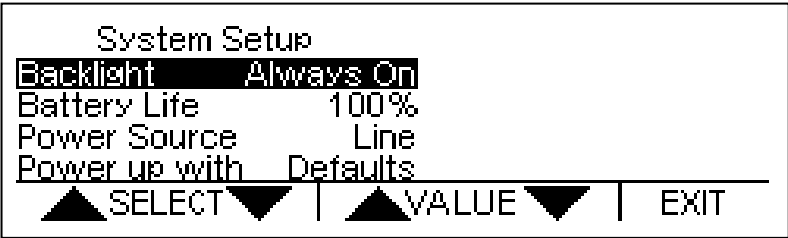
Use the **VALUE** keys to sequence through the available values of the highlighted parameter. The last FUNCTION KEY will be **ENTER**. Use this key to save the current value.

NOTE: Using the **SELECT** keys to highlight the next parameter will also save the current value.

NOTE: To save a custom configuration, see Power Up Settings section.

SYSTEM SETUP SCREEN

The SETUP Mode allows the user to adjust the configuration of the unit. The SETUP SCREEN can be entered using the SETUP key.



Sample System Setup Screen

Use the ▲ SELECT ▼ keys to highlight the parameter to change. The last FUNCTION KEY will be EXIT. Use this key to return to the DISPLAY SCREEN.

Use the ▲ VALUE ▼ keys to sequence through the available values of the highlighted parameter. The last FUNCTION KEY will be ENTER. Use this key to save the current value.

NOTE: Using the ▲ SELECT ▼ keys to highlight the next parameter will also save the current value.

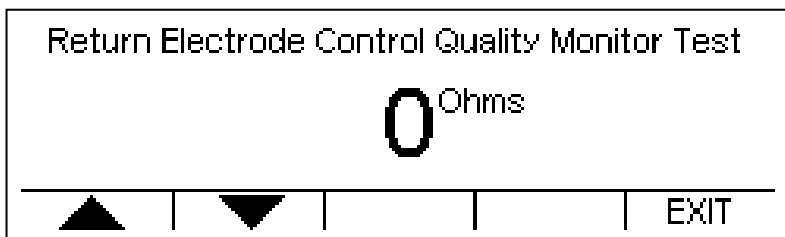
NOTE: To save a custom configuration, see Power Up Settings section.

The following is a breakdown of the parameters available in the configuration of the unit and their available options:


System Setup Configuration		
Parameter	Description	Range
Backlight	Controls whether the backlight is on or off or how long to wait for user input before automatically turning off the backlight in battery powered mode.	Off, 0-20 sec, Always on (Factory Default = 10)
Battery Life	Displays remaining battery life (charge) in percent	0-100% (Read Only)
Power Source	Displays whether the unit is on battery power or line powered	Battery or Line (Read Only)
Power up with	Determines the power up mode of the ESU-2300. The default mode shows a single mA parameter display. Set this parameter to custom to display the saved startup mode. Set this parameter to Save current as custom to save the settings for the next time power is cycled.	Defaults Custom Set Current as Custom
Num A/D Samples	Sets the number of A/D converter readings used in each mA RMS computation. A higher setting requires more computation and is slower, but results in a more stable reading.	1024 2048 4096 8192 16384 32768 (Factory Default = 32768)
Display Averaging	Sets the number of mA RMS readings that are averaged. A higher number will cause the display to update slower, but will give a more stable reading.	1-30 Readings (Factory Default = 11)
Software	Displays current software program.	(Read Only)

CQM/RECQM (REM/ARM) TEST SCREEN

The RECQM TEST SCREEN can be entered using the **RECQM** key from the DISPLAY SCREEN.



Sample RECQM Test Screen

Use the  keys to change the value of the resistance setting. This setting ranges from 1 Ω to 500 Ω in 1 Ω increments. The last FUNCTION KEY will be **EXIT**. Use this key to return to the DISPLAY SCREEN.

POWER UP SETTINGS

The ESU-2300 allows the user to customize the settings that the unit will have on Power Up. The “Power up with” parameter in the System Setup Menu allows for the selection of either Default or Custom selections.

Use to enter the SETUP SCREEN. Use the keys to highlight the “Power up with” parameter.

Use the keys to change the parameters to Default, Custom or Set Current as Custom. The last FUNCTION KEY will be . Use this key to save the current value.

NOTE: Using the keys to highlight the next parameter will also save the current value.

The last FUNCTION KEY will then be . Use this key to return to the DISPLAY SCREEN.

Default

If this option is selected, the unit will power up to the dual display zone screen, which will:

- Show the mA and Watts readings
- Put the ESU-2300 into Internal Load mode
- Use 300 ohms as the default internal load

Custom

If this option is selected, the unit will Power Up using the unique sets of parameters that were last customized and saved by the user. The DISPLAY SCREEN will use the parameters in the Display Zones that were last configured and saved by the user.

Set Current as Custom

This choice is provided to create the set of custom startup screen parameters. The user simply configures each screen to show the desired parameters and then enters the Set Current as Custom choice in the SETUP SCREEN. The current configuration is saved as the Custom Power Up values and will be used when the “Power up with” parameter is set to Custom. This configuration will remain the Custom configuration until it is written over using the Set Current as Custom option in the “Power up with” parameter.

TEST SETUPS

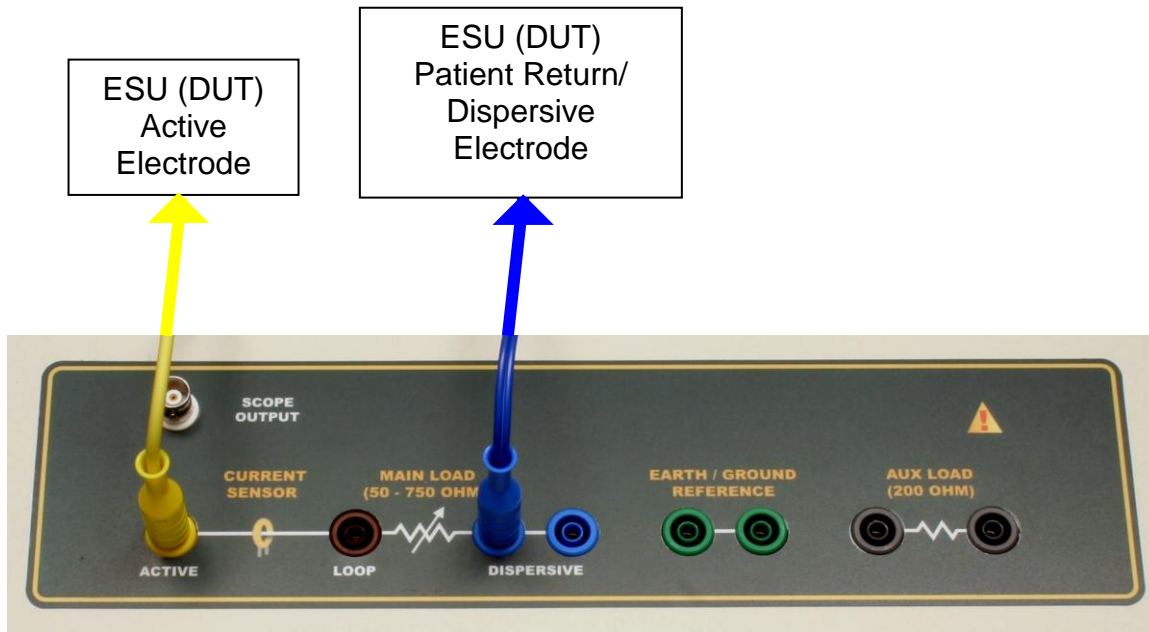
GENERATOR OUTPUT TESTS USING INTERNAL LOADS

The purpose of this test is to verify the output accuracy of the Electrosurgical Generator Device Under Test (DUT) at a given RF power setting, based on the selected internal precision test load (50 Ω to 750 Ω in 50 Ω increments) from the ESU-2300 resistor network. The ESU-2300 should always be set to match the electrosurgical generator manufacturer's specified test load for the mode and output waveform selected.

Connections

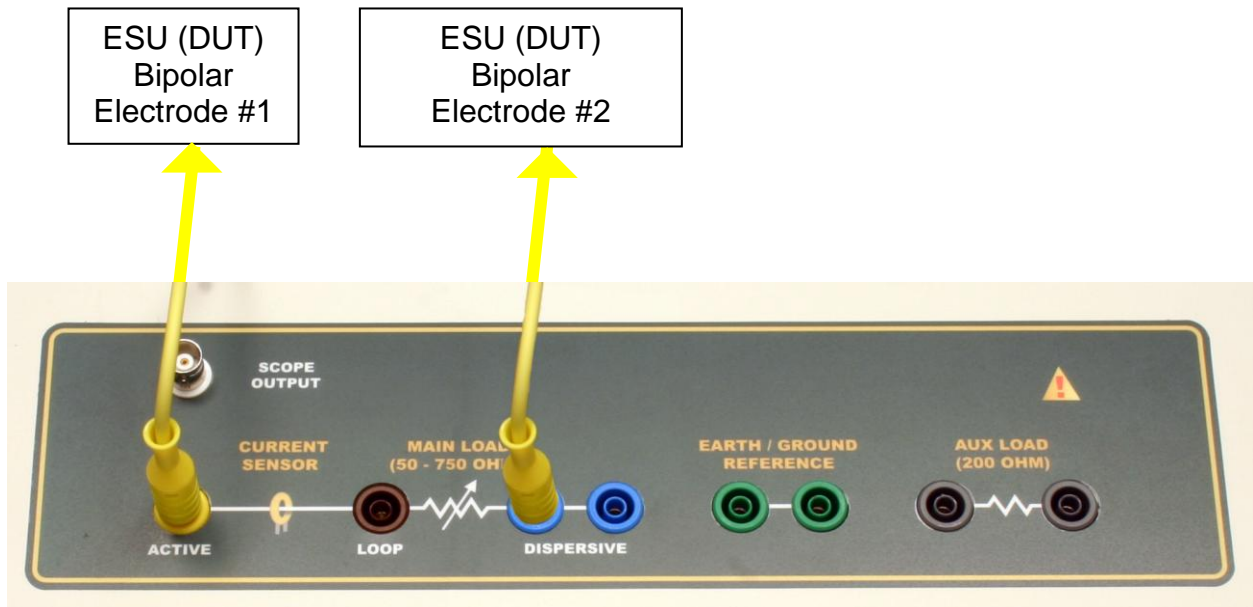
Monopolar outputs:

1. Yellow Active Lead from Active Jack on ESU-2300 to DUT Output.
2. Blue Dispersive Lead from Dispersive Jack on ESU-2300 to DUT Dispersive.



Bipolar outputs:

1. Yellow Active Lead from Active Jack on ESU-2300 to DUT Bipolar Output Electrode #1.
2. Second Yellow Active Lead from Dispersive Jack on ESU-2300 to DUT Bipolar Output Electrode #2.



ESU-2300 Screen

DISPLAY SCREEN with LOAD SETTING set to Internal and Load Value set to the desired number.

Results

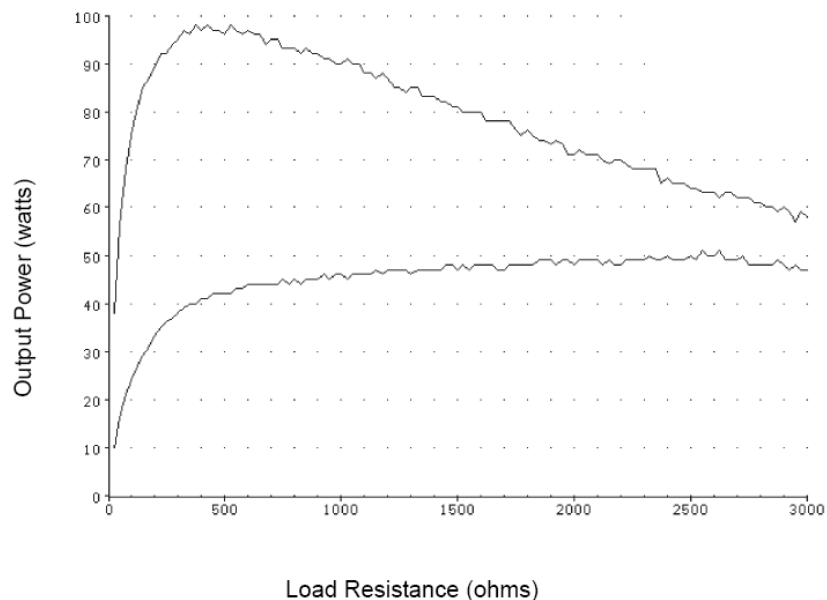
Watts reading on DISPLAY SCREEN will display the measured power through the currently selected load resistance. The DUT specs should be verified based on this information.

Information

Many electrosurgical generators vary their output power based on the measured load impedance (the resulting electrical impedance of the human tissue being cut or coagulated). One such trade-name for this functional characteristic is “Tissue Response Technology” (which was originally offered by Covidien Valleylab, Boulder, Colorado). They start out by applying a lower power signal to measure the load, and then adjust the final output to match what is set on the front panel control setting.

When testing electrosurgical generators that utilize this level of technology, it is advisable to give the ESU-2300 analyzer a few seconds to accurately measure the final power of the generator. There is almost always a specified power curve that plots output power to load resistance. Many electrosurgical generators have a peak power at around 300-500 ohm range, with decreased delivered power to the actual load at lower and higher impedances.

A typical power output vs. test load impedance “load curve” for an electrosurgical generator is as follows:



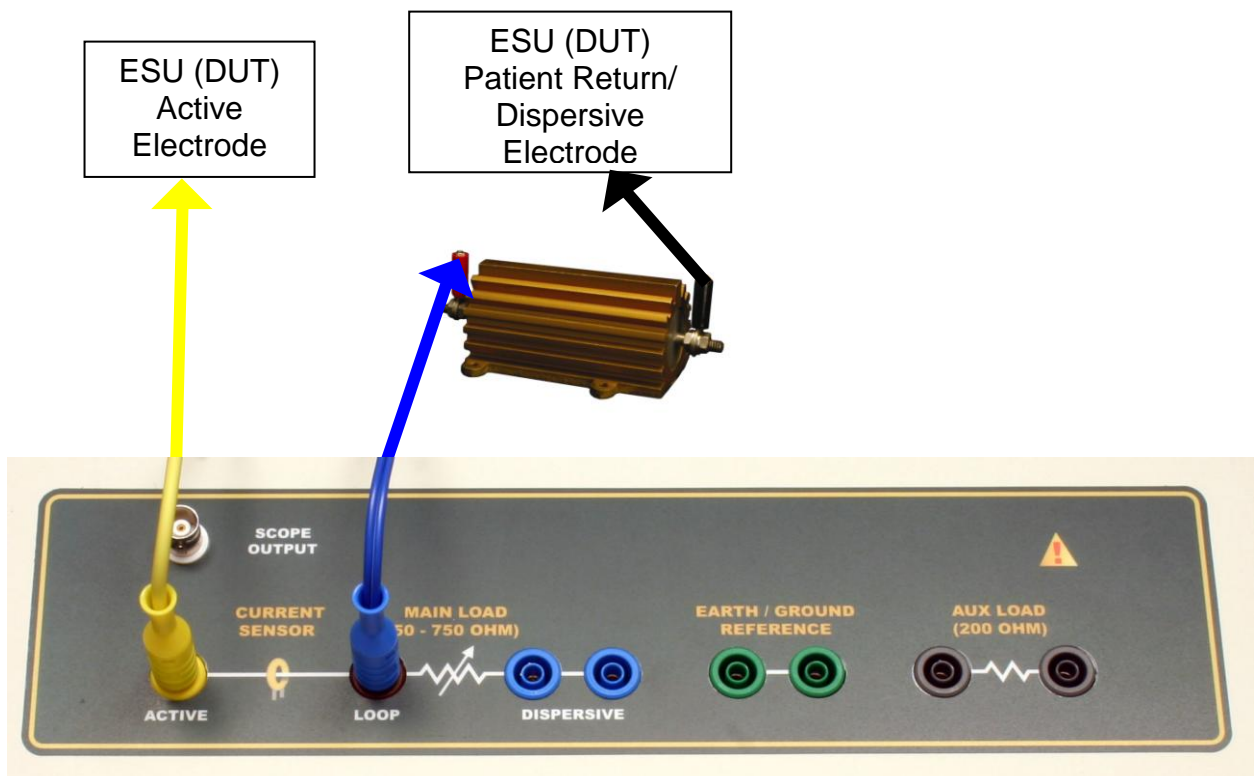
GENERATOR OUTPUT TESTS WITH EXTERNAL LOADS

The purpose of this test is to verify the output accuracy of the Electrosurgical Generator Device Under Test (DUT) at a given RF power setting, based upon an attached external load resistor. The external load resistor attached to the ESU-2300 should always be set to match the electrosurgical generator manufacturer's specified test load for the mode and output waveform selected.

Connections

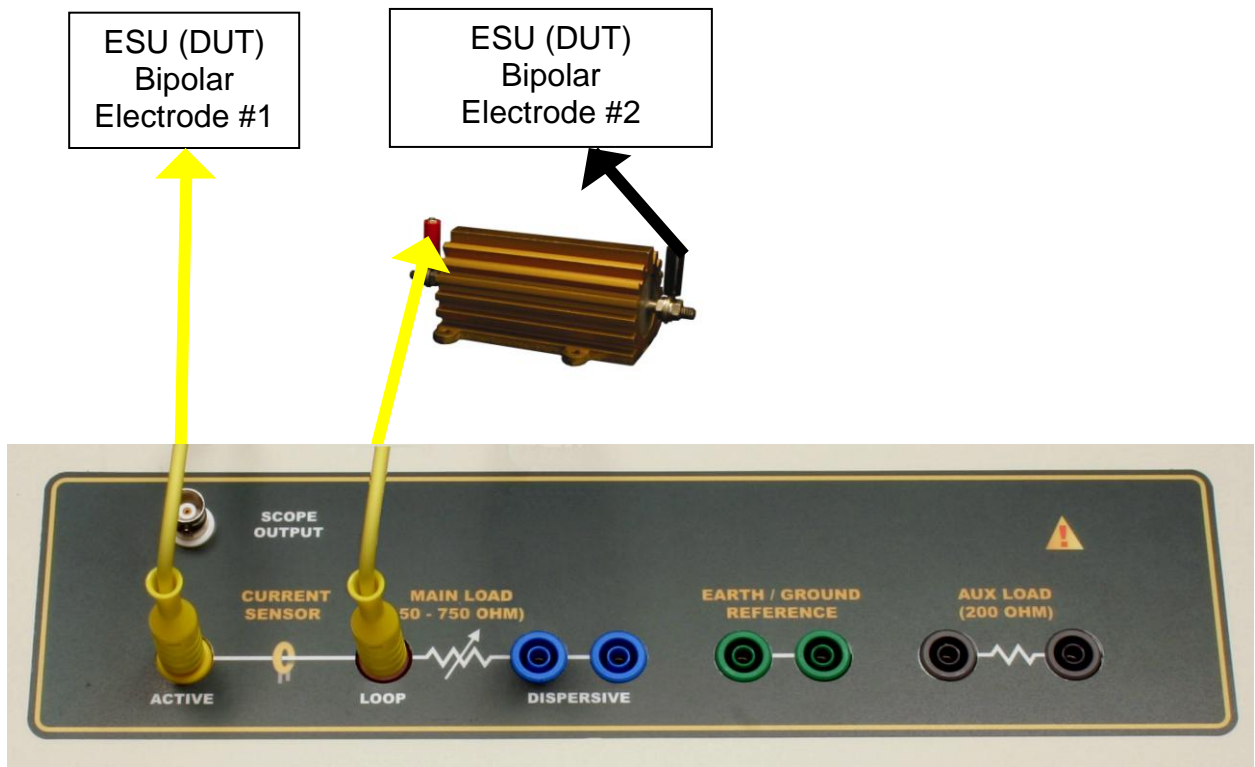
Monopolar:

1. Yellow Active Lead from Active Jack on ESU-2300 to DUT Output.
3. Blue Dispersive Lead from Loop Jack on ESU-2300 to External Load.
4. External Load to DUT Dispersive.



Bipolar:

1. Yellow Active Lead from Active Jack on ESU-2300 to DUT Bipolar Output Electrode #1.
2. Second Active Lead from Loop Jack on ESU-2300 to External Load.
3. External Load to DUT Bipolar Output Electrode #2.



ESU-2300 Screen

DISPLAY SCREEN with LOAD SETTING set to External and Load Value set to the desired number.

Results

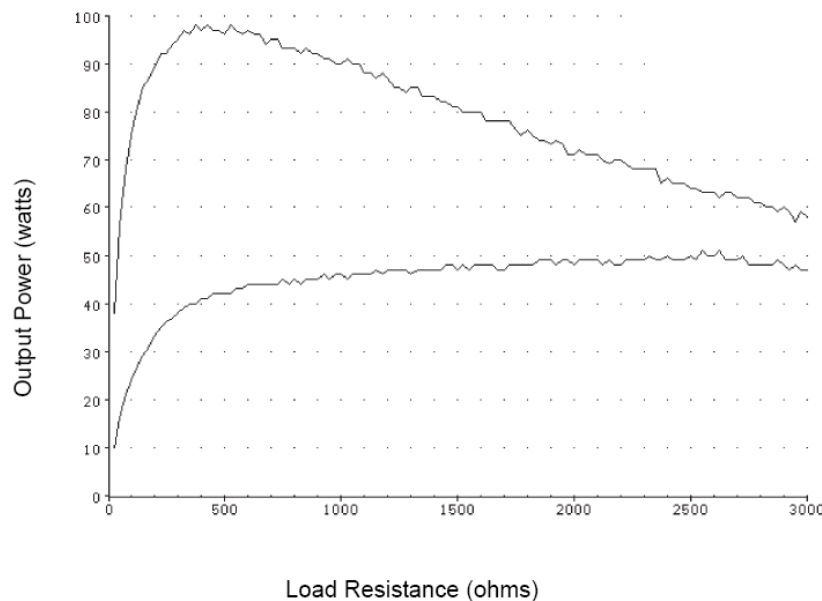
Watts reading on DISPLAY SCREEN will display the measured power through the external load resistance(s). The DUT specs should be verified based on this information.

Information

Many electrosurgical generators vary their output power based on the measured load impedance (the resulting electrical impedance of the human tissue being cut or coagulated). One such trade-name for this functional characteristic is “Tissue Response Technology” (which was originally offered by Covidien Valleylab, Boulder, Colorado). They start out by applying a lower power signal to measure the load, and then adjust the final output to match what is set on the front panel control setting.

When testing electrosurgical generators that utilize this level of technology, it is advisable to give the ESU-2300 analyzer a few seconds to accurately measure the final power of the generator. There is almost always a specified power curve that plots output power to load resistance. Many electrosurgical generators have a peak power at around 300-500 ohm range, with decreased delivered power to the actual load at lower and higher impedances.

A typical power output vs. test load impedance “load curve” for an electrosurgical generator is as follows:



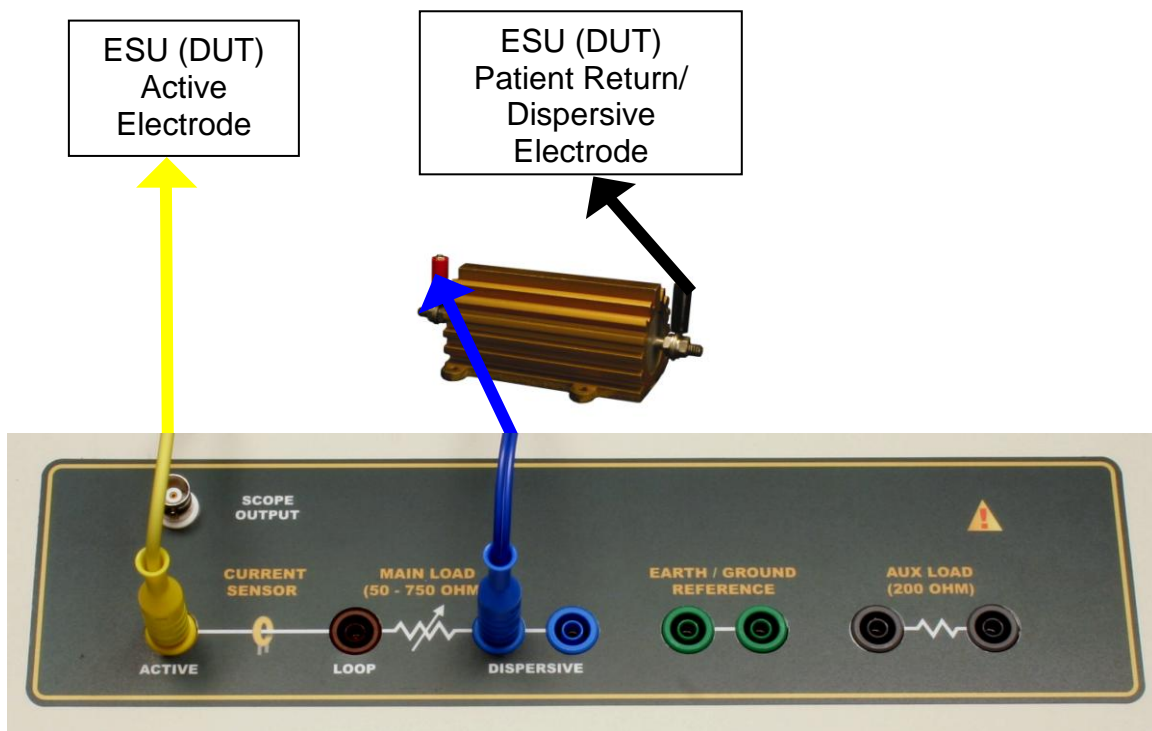
GENERATOR OUTPUT TESTS WITH INTERNAL / EXTERNAL TEST LOADS

The purpose of this test is to verify the output accuracy of the Electrosurgical Generator Device Under Test (DUT) at a given RF power setting, based on the selected internal precision test load (50 Ω to 750 Ω in 50 Ω increments) from the ESU-2300 resistor network, in addition to series-connected external load resistor. The resulting test load (the ESU-2300 internal load + the external load) should always be set to match the electrosurgical generator manufacturer's specified test load for the mode and output waveform selected.

Connections

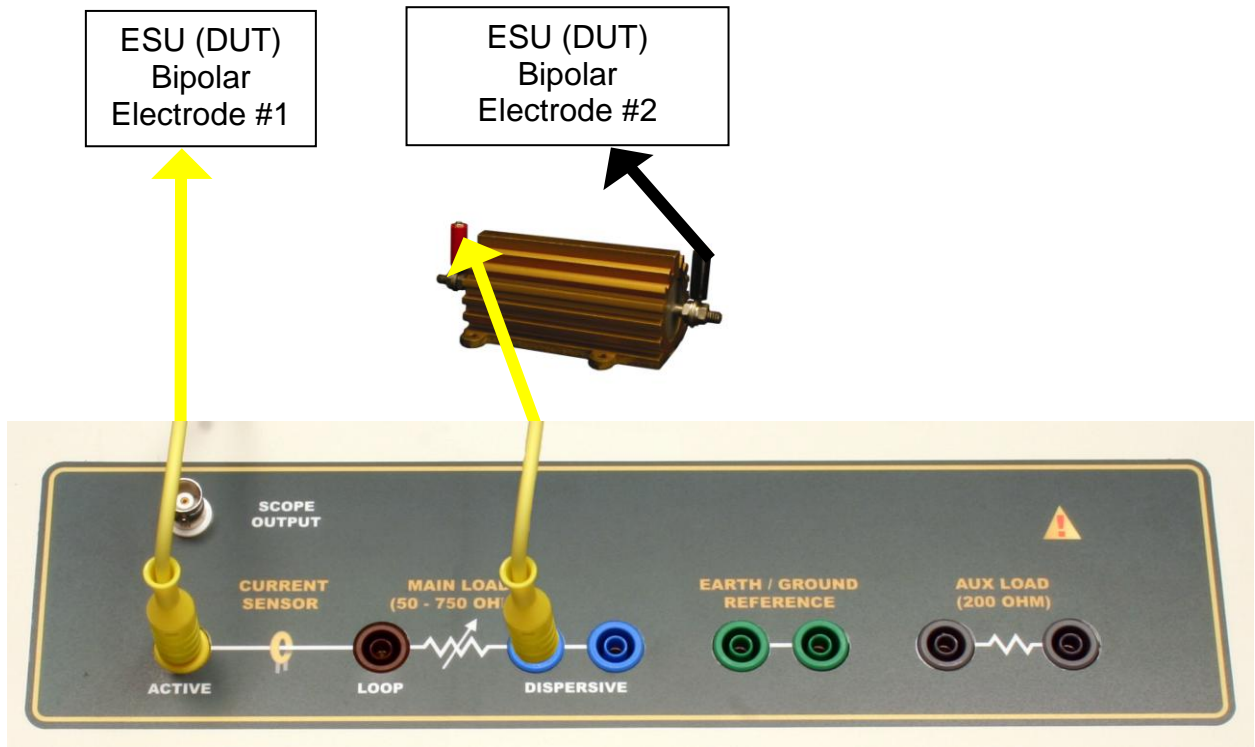
Monopolar:

1. Yellow Active Lead from Active Jack on ESU-2300 DUT Output.
2. Blue Dispersive Lead from Dispersive Jack on ESU-2300 to External Load.
3. External Load to DUT Dispersive Lead



Bipolar:

1. Yellow Active Lead from Active Jack on ESU-2300 to DUT Bipolar Output Electrode #1.
2. Second Yellow Active Lead from Dispersive Jack on ESU-2300 to External Load.
3. External Load to DUT Bipolar Output Electrode #2.



ESU-2300 Screen

DISPLAY SCREEN with LOAD SETTING set to Internal/External and Load Value set to the desired number.

Results

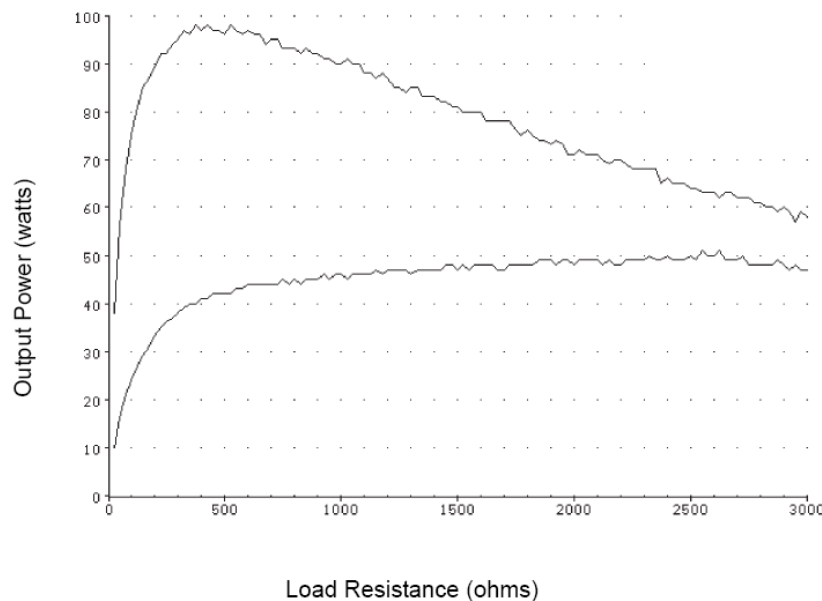
Watts reading on DISPLAY SCREEN will display the measured power through the internal load resistance(s) and the external load resistance(s). The DUT specs should be verified based on this information.

Information

Many electrosurgical generators vary their output power based on the measured load impedance (the resulting electrical impedance of the human tissue being cut or coagulated). One such trade-name for this functional characteristic is “Tissue Response Technology” (which was originally offered by Covidien Valleylab, Boulder, Colorado). They start out by applying a lower power signal to measure the load, and then adjust the final output to match what is set on the front panel control setting.

When testing electrosurgical generators that utilize this level of technology, it is advisable to give the ESU-2300 analyzer a few seconds to accurately measure the final power of the generator. There is almost always a specified power curve that plots output power to load resistance. Many electrosurgical generators have a peak power at around 300-500 ohm range, with decreased delivered power to the actual load at lower and higher impedances.

A typical power output vs. test load impedance “load curve” for an electrosurgical generator is as follows:



CQM (REM/ARM) TEST

The Return Electrode Control Quality Monitor Test Mode allows the user to test the CQM/RECQM (REM/ARM) safety feature available on most electrosurgical generators. This feature exists mainly to prevent high frequency burns caused when the dispersive electrode contact with the patient degrades to a high impedance connection, resulting in increased current density at the electrode site. To prevent this, electrosurgical generators typically employ a dual-sided pad, with independent electrical connections from each side of the pad to the generator. The generator utilizes special electronic circuitry that circulates a small current flow at a specific frequency through this circular electrical path to monitor the contact impedance between the pad and the patient.

There are two basic types of this safety feature:

1. A basic continuity type test, where the ESU is looking for a very low resistance (usually < 20 ohms) between the two dispersive pads
2. A more advanced RECQM test where the generator usually tests for a resistance between the two dispersive pads to be greater than 5 ohms and less than 135 ohms, as well as testing whether the measured resistance has changed by a certain percentage over the initial measured resistance.

The usual way to test these two safety features of the electrosurgical generators is to use a separate decade box and go through the ranges, checking when the generator alarms out. In the ESU-2300, however, a digitally adjustable resistor, separate from the internal test load resistor network, gives the user the ability to do all testing with one device.

In this feature, the resistance across the two white CQM Jacks can be varied from 0 Ω to 500 Ω in 1 Ω increments.

WARNING – CQM TEST
Do not connect the Electrosurgical Generator
Active Electrode while conducting this test.
Do not enable the Electrosurgical Output at any time.

Connections

For CQM (continuity type):

1. CQM Lead (without prong) from CQM Jacks on side of ESU-2300 to DUT Dispersive.

For RECQM (resistance type):

1. RECQM Lead (with prong) from CQM Jacks on side of ESU-2300 to DUT Dispersive



ESU (DUT)
Patient Return/
Dispersive
Electrode

ESU-2300 Screen

RECQM SCREEN with OHMS SETTING set to the desired value.

Results

The DUT should be checked for appropriate alarms in both safety modes (CQM and RECQM).

NOTICE – MANUFACTURER’S SPECS

The user must consult the manufacturer’s manual for each DUT to determine the correct test procedures and alarm specifications to follow.

RF LEAKAGE TEST #1

This leakage test, specified by the IEC as Active (or Dispersive) Electrode to Ground, is for testing the RF leakage to Earth/ Ground of an Isolated Output type CF electrosurgical generator from a single active or dispersive lead. The test complies with IEC 601.2.2, sec. 19.101b, fig, 104 and sec. 19.102, adopted by ANSI/AAMI HF18-2001. The purpose of this test is to verify that open circuit RF leakage of the Device Under Test (DUT) meets or exceeds the IEC specification.

NOTE: DO NOT TEST A EARTH REFERENCED TYPE BF ELECTROSURGICAL GENERATOR WITH THIS TEST, THE RESULTING MEASUREMENT WILL BE ERRONEOUS.

WARNING – ONE LEAD AT A TIME
Only test one lead of the ESU Generator at a time,
either Active or Dispersive, not both.

Connections

1. Either Active Lead from Active Jack on ESU-2300 to DUT Active Output.
or
Dispersive Lead from Active Jack on ESU-2300 to DUT Dispersive
2. Jumper Lead from Dispersive Jack on ESU-2300 to Earth/Ground on ESU-2300.



NOTE: When the ESU-2300 is being operated on battery power (not connected to line power through the external power supply and consequently not connected to an Earth/Ground reference), it is necessary to supply an Earth/Ground reference the unit prior to performing any RF Leakage Tests.

To accomplish this, simply connect the Ground Lead from the Earth/Ground Jack on the right side panel of the ESU-2300 to a Ground Alligator Clip. Attach this clip to a Ground Lug that is plugged into an Earth/Ground in any standard wall outlet.



ESU-2300 Screen

DISPLAY SCREEN with LOAD SETTING set to Internal and Load Value set to 200 ohm.

Results

Activate the Electrosurgical Generator Output and read the RF leakage measurement as the mA leakage readings on the DISPLAY SCREEN. These readings should be verified against the appropriate electrosurgical generator standards.

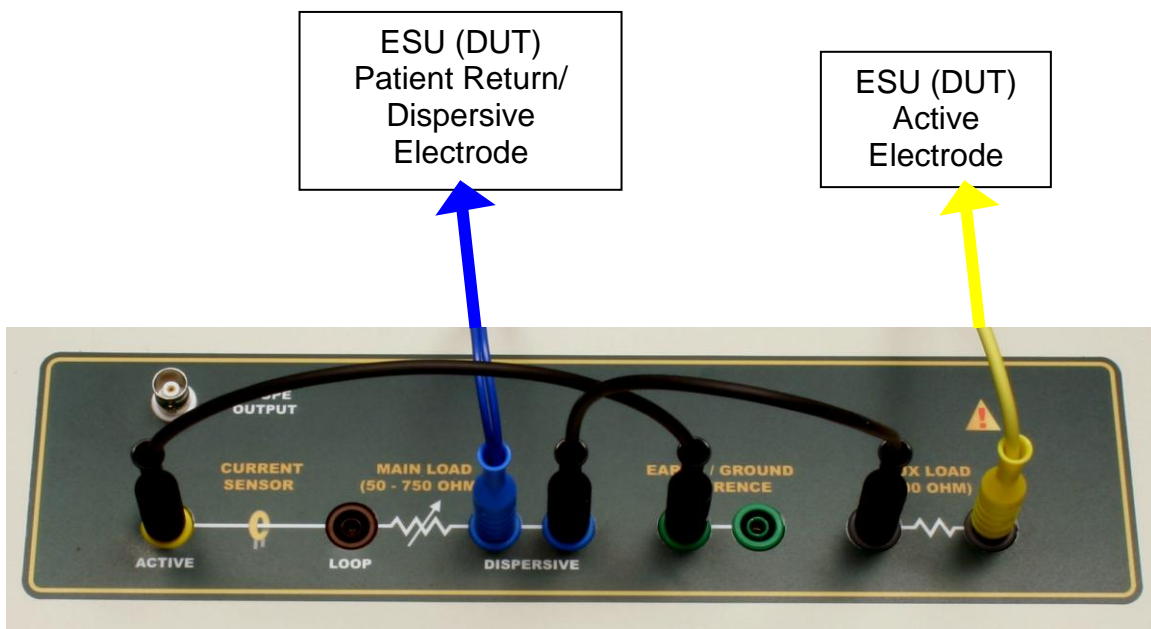
NOTE: Remember to disable the Electrosurgical Generator Output when testing is completed.

RF LEAKAGE TEST #2

This leakage test, specified by the IEC as Earth Reference Leakage Type BF (Load Between Electrodes), is for testing the leakage to Earth/Ground of a Ground Referenced Output type BF electrosurgical generator from the active output. This test complies with IEC 601.2.2, sec. 19.101a, test 1, fig. 102, and sec. 19.102, adopted by ANSI/AAMI HF18-2001. The purpose of this test is to verify that the RF leakage of the Device Under Test (DUT) meets or exceeds the IEC specification.

Connections

1. Active Lead from Aux Jack on ESU-2300 to DUT Active Output.
2. Jumper Lead from Earth/Ground on ESU-2300 to Active Jack on ESU-2300.
3. Jumper Lead from Aux Jack on ESU-2300 to Dispersive Jack on ESU-2300.
4. Dispersive Lead from Dispersive Jack on ESU-2300 to DUT Dispersive.



NOTE: When the ESU-2300 is being operated on battery power (not connected to line power through the external power supply and consequently not connected to an Earth/Ground reference), it is necessary to supply an Earth/Ground reference the unit prior to performing any RF Leakage Tests.

To accomplish this, simply connect the Ground Lead from the Earth/Ground Jack on the right side panel of the ESU-2300 to a Ground Alligator Clip. Attach this clip to a Ground Lug that is plugged into an Earth/Ground in any standard wall outlet.



ESU-2300 Screen

DISPLAY SCREEN with LOAD SETTING set to Internal and Load Value set to 200 ohm.

Results

Activate the Electrosurgical Generator Output and read the RF leakage measurement as the mA leakage readings on the DISPLAY SCREEN. These readings should be verified against the appropriate electrosurgical generator standards.

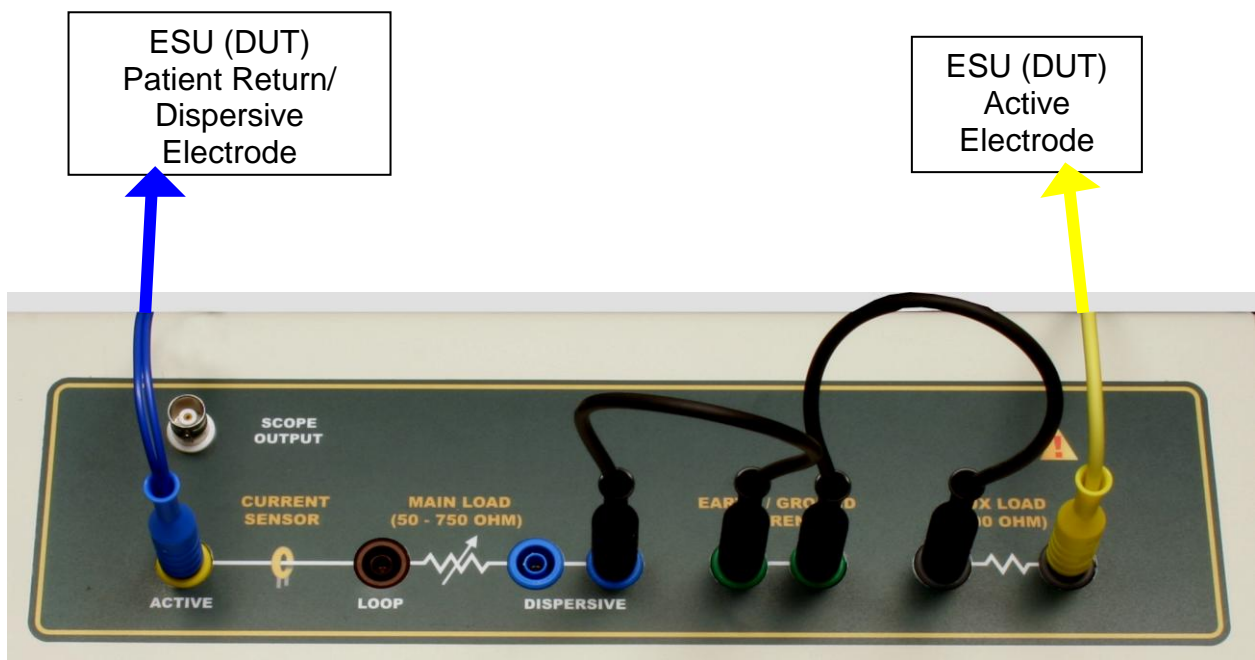
NOTE: Remember to disable the Electrosurgical Generator Output when testing is completed.

RF LEAKAGE TEST #3

This leakage test, specified by the IEC as Earth Reference Leakage Type BF (Load from Active Electrode to Earth) is for testing the leakage to Earth/Ground of a Ground Referenced Output type BF electrosurgical generator from the active output. This test complies with IEC 601.2.2, sec. 19.101a, test 2, fig. 102, and sec. 19.102, adopted by ANSI/AAMI HF18-2001. The purpose of this test is to verify that the RF leakage of the Device Under Test (DUT) meets or exceeds the IEC specification.

Connections

1. Active Lead from Aux Jack on ESU-2300 to DUT Active Output.
2. Jumper Lead from Earth/Ground on ESU-2300 to Aux Jack on ESU-2300.
3. Jumper Lead from Earth/Ground on ESU-2300 to Dispersive Jack on ESU-2300.
4. Dispersive Lead from Active Jack on ESU-2300 to DUT Dispersive.



NOTE: When the ESU-2300 is being operated on battery power (not connected to line power through the external power supply and consequently not connected to an Earth/Ground reference), it is necessary to supply an Earth/Ground reference the unit prior to performing any RF Leakage Tests.

To accomplish this, simply connect the Ground Lead from the Earth/Ground Jack on the right side panel of the ESU-2300 to a Ground Alligator Clip. Attach this clip to a Ground Lug that is plugged into an Earth/Ground in any standard wall outlet.



ESU-2300 Screen

DISPLAY SCREEN with LOAD SETTING set to Internal and Load Value set to 200 ohm.

Results

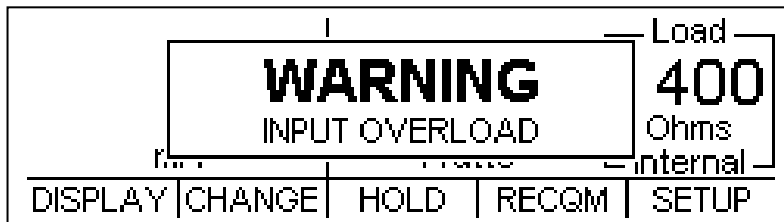
Activate the Electrosurgical Generator Output and read the RF leakage measurement as the mA leakage readings on the DISPLAY SCREEN. These readings should be verified against the appropriate electrosurgical generator standards.

NOTE: Remember to disable the Electrosurgical Generator Output when testing is completed.

ERROR MESSAGES

Several error messages are provided to indicate invalid operating conditions.

Input Overload

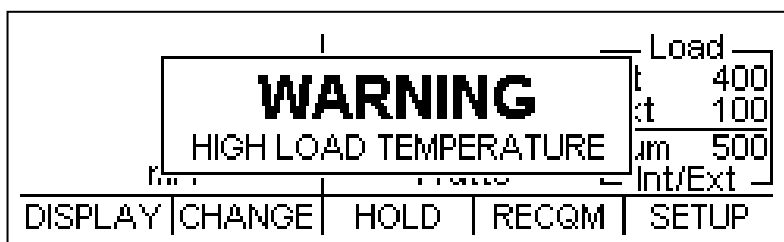


Sample Input Overload Screen

When the input signal rises above the range that is measurable by the system, the “WARNING Input Overload” message will be shown.

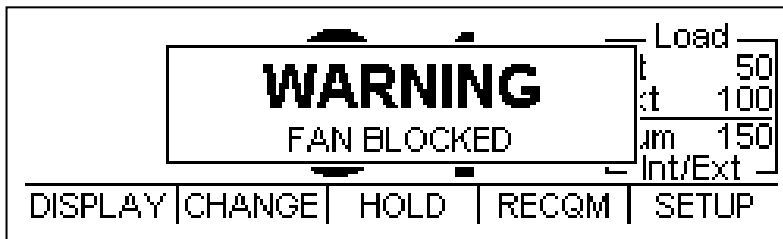
NOTE: Although the input is protected from damage at these levels, the user should immediately remove any input signal when this message is shown.

High Load Temperature



When the measured load bank temperature goes over the Warning Temperature the “WARNING High Load Temperature” message will be shown. The user should disable the electrosurgical generator output immediately and let the ESU-2300 cool down for a period of time.

Fan Blocked

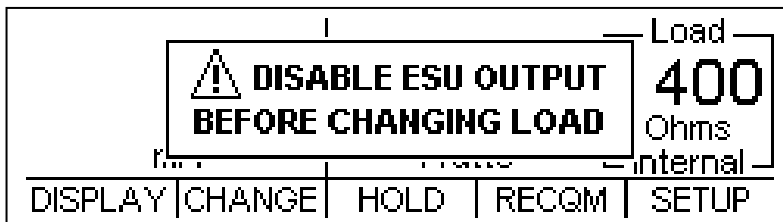


Sample Fan Blocked Screen

If there is a mechanical problem with the internal fan, such as a locked bearing or some physical item blocking the path of the fan blades, the “Warning Fan Blocked” message will be shown. The user should check the unit for any obvious protrusions. The user should not use the unit for any electrosurgical generator testing and should return the ESU-2300 to the factory for immediate servicing.

WARNING – FAN BLOCKED WARNING
Do not activate the electrosurgical generator to the internal loads of the ESU-2300, as there will be no way for the internal loads to cool down.

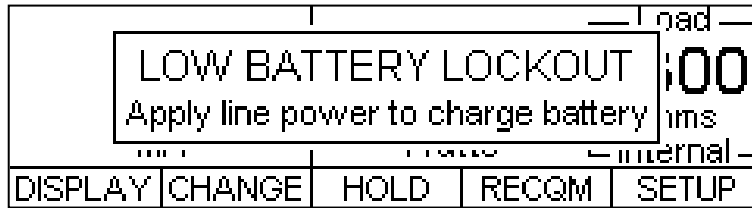
Disable Electrosurgery Generator Output Before Changing Load



Sample Disable Output Screen

This message will warn the user not to switch internal load resistances while the electrosurgical generator output is active.

Low Battery Lockout



This message will be shown when the battery voltage is too low for proper operation.

When this message is displayed, the keys are locked out. Line power should be applied as soon as possible to recharge the system battery.

DFA™ TECHNOLOGY

Our Patent Pending DFA™ (Digital Fast Acquisition) Technology is a revolutionary new method of measuring electrosurgical generator output power. A high-speed analog to digital converter is used to digitize the high frequency, high power output of the electrosurgery generator. An RF Current Transformer is used to convert the current signal to a voltage signal, which is read by the A/D converter. By digitizing the signal, a more accurate, frequency independent measurement can be made.

COMMUNICATION PROTOCOL

The communication protocol provides a means to completely configure and use the ESU-2300 from a PC. All of the functions available through the front panel can be performed through the communication ports. All of the measurements made by the ESU-2300 are accessible as well. This provides for hands free or automated operation of the ESU-2300.

Communication Ports

The ESU-2300 has two communication ports. Both ports use the same command format. The Serial port is configured as 115,200 Baud Rate, 8 Data Bits, 1 Stop Bit, and No Parity. The USB port appears to a PC as a serial port and is configured for 748,800 Baud Rate, 8 Data Bits, 1 Stop Bit, and No Parity.

Command Syntax

The command description is broken into 3 columns; the KEYWORD, the PARAMETER FORM and COMMENTS.

Keyword

The KEYWORD column provides the name of the command. The actual name of the command consists of one or more keywords since SCPI commands are based on a hierarchical structure, also known as a **tree system**.

In such a system, associated commands are grouped together under a common node in the hierarchy, analogous to the way leaves at a same level are connected at a common branch. This and similar branches are connected to fewer and thicker branches, until they meet at the root of the tree. The closer to the root, the higher a node is considered in the hierarchy. To activate a particular command, the full path to it must be specified.

This path is represented in the following tables by placing the highest node in the left-most position. Further nodes are indented one position to the right, below the parent node.

The highest level node of a command is called the Keyword, followed by the Node, Subnode, and then the value.

Not all commands require the complexity of the full command path. For example, the Status? command doesn't have a Node or Subnode.

Some commands allow for reading and writing data and some commands are Read Only. To indicate a read function, a question mark (?) is placed at the end of the command path. For example, a write command to change the internal load resistance to 100 ohms would be "CONFigure:LOAD:INTernal 100<cr>", where <cr> indicates a carriage-return. For example, a mArms read command would be "READ:MArms?<cr>", which would return a value of "xxx.x<cr><lf>" where <cr> is a carriage-return and <lf> is a linefeed.

Lowercase letters indicate the **long-form** of the command (for example, **CONFigure:INPut:RANGe?**) and can be omitted for simplification. Uppercase letters indicate the abbreviated, or **short-form**, of the commands and must be included (for example, **CONF:INP:RANG?**).

All commands sent to the unit are terminated with a Carriage Return.

NOTE: Commands can be entered in either upper or lowercase or a mixture of the two, uppercase and lowercase. Commands sent to the ESU –2050 are not case sensitive. Upper and lower cases are only used when documenting the commands.

Parameter Form

The PARAMETER FORM column indicates the number and order of parameters in a command and their legal values. Parameter formats are listed in angle brackets (<>) while string parameters are simply listed.

Square brackets ([]) are used to enclose one or more parameters that are optional.

The vertical bar (|) can be read as "or" and is used to separate alternative parameter options.

The query form of a command is generated by appending a question mark (?) to the last keyword. However, not all commands have a query form, and some commands exist only in the query form. The COMMENTS column is used to indicate this.

Comments

The COMMENTS column indicates any notes.

CONFigure Subsystem

This group allows the user to setup the display and operational settings for the unit.

KEYWORD **PARAMETER FORM** **COMMENTS**

CONFigure
:DISPlay :SxZy S<display_screen_number> Z<zone_number> nn

display_screen_number = 1-3
1 = One Parameter
2 = Two Parameters
3 = Five Parameters

nn = Parameter for selected Zone
0 = mA RMS
1 = Watts RMS
2 = mV RMS
3 = mV Peak
4 = Crest Factor
5 = mV Pk-Pk

:SCReen < numeric_value >

Range 1-4
1-3 = Display zones
4=RECQM Display

:HOLD ON | OFF

:LOAD

:MODE INTernal, EXTernal, or INT/EXTernal

:INTernal < numeric_value >

50-750 ohms in 50 ohm steps

:EXTernal < numeric_value >

External Load Resistance, 0-5200 ohms.

INPut:

AVERaging: 1-30

Number of readings averaged

NUMsamples: 1024 | 2048 | 4096 | 8192 | 16384 | 54768

RECqm < numeric_value >

Set CQM load to 0-500 ohms

SYSTEM Subsystem

This group allows the user to setup the startup mode for the unit, as well as directly control the unit, as if pressing the keys on the front panel.

KEYWORD	PARAMETER FORM	COMMENTS
SYSTEM: POWER BACKlight	DEFaults CUStom SETCurrent < numeric_value >	0-21 Seconds 0=Off, 21=ON
KEY	BKLT KEY1 KEY2 KEY3 KEY4 KEY5	
VERsion		Read only, returns firmware rev

READ Subsystem

This group allows the user to get measurements from the unit.

KEYWORD	PARAMETER FORM	COMMENTS
READ:	MVrms MArms WArms MVPeak MVPP CF FANspeed TEMPerature	Read only

STATUS Sub-system

This subsystem provides status on the operating mode of the unit including messages that would normally be seen on the display.

KEYWORD	PARAMETER FORM	COMMENTS																																																			
STATus?	<table border="1"> <thead> <tr> <th>Bit</th> <th>Value</th> <th>Definition</th> </tr> </thead> <tbody> <tr><td>0</td><td>1</td><td>Hold Mode</td></tr> <tr><td>1</td><td>2</td><td></td></tr> <tr><td>2</td><td>4</td><td>Low Battery</td></tr> <tr><td>3</td><td>8</td><td>Fan Blocked</td></tr> <tr><td>4</td><td>16</td><td>Load Bank Overtemp</td></tr> <tr><td>5</td><td>32</td><td></td></tr> <tr><td>6</td><td>64</td><td></td></tr> <tr><td>7</td><td>128</td><td></td></tr> <tr><td>8</td><td>256</td><td>Error Present</td></tr> <tr><td>9</td><td>512</td><td>mV Out of Range</td></tr> <tr><td>10</td><td>1024</td><td>mA Out of Range</td></tr> <tr><td>11</td><td>2048</td><td>Watts Out of Range</td></tr> <tr><td>12</td><td>4096</td><td>mV Peak Out of Range</td></tr> <tr><td>13</td><td>8192</td><td>Crest Factor Out of Range</td></tr> <tr><td>14</td><td>16384</td><td>mV Peak to Peak Out of Range</td></tr> <tr><td>15</td><td>32768</td><td></td></tr> </tbody> </table>	Bit	Value	Definition	0	1	Hold Mode	1	2		2	4	Low Battery	3	8	Fan Blocked	4	16	Load Bank Overtemp	5	32		6	64		7	128		8	256	Error Present	9	512	mV Out of Range	10	1024	mA Out of Range	11	2048	Watts Out of Range	12	4096	mV Peak Out of Range	13	8192	Crest Factor Out of Range	14	16384	mV Peak to Peak Out of Range	15	32768		Read Only
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ESU-2300 Communication Command Summary

Keywords	Nodes	Subnodes	Values	
CONFigure	DISPlay	SxZy nn	x is the Screen # (1-3) and y is the Zone # (1-5). nn=0 to 5: 0= mA RMS 1= Watts RMS 2= mV RMS 3= mV Peak 4= Crest Factor 5= mV Pk-Pk	
		SCReen	Range: 1-4 1-3 = # display zones 4=RECQM Display	
	HOLD	ON,OFF		
	LOAD	MODE	INTernal, EXTernal, INT/EXTernal	
		INTernal	Internal load resistance, 50-750 ohms in 50 ohm steps	
		EXTernal	External load resistance, 0 to 5200 ohms	
	RECqm	0-500 ohms		
	INPut	AVERaging	1-30 readings	
		NUMsamples	1024, 2048, 4096, 8192, 16384, 32768	
	SYSTEM	POWerup	DEFaults, CUSTom, SETCurrent	
BACKlight		0-21 (special cases: 0 = always off, 21=always on, otherwise inaction timeout)		
KEY		BKLT, KEY1-KEY5		
VERsion?		[read only]		
READ	MVrms?	Returns: mV RMS [read only]		
	MARms?	Returns: mA RMS [read only]		
	WARms?	Returns: Watts RMS [read only]		
	MVPeak?	Returns: mV Peak [read only]		
	MVPP?	Returns: mV Peak to Peak [read only]		
	CF?	Returns: CF [read only]		
	FANspeed?	Returns: Fanspeed [read only]		
STATus?		<u>Bit</u> <u>Value</u>	Definition	
		0 1	Hold Mode	
		1 2	Calibration Mode	
		2 4	Low Battery	
		3 8	Fan Blocked Rotor	
		4 16	Load Bank Overtemp	
		5 32		
		6 64		
		7 128		
		8 256	Error Present	
		9 512	mV Out of Range	
		10 1024	mA Out of Range	
		11 2048	Watts Out of Range	
		12 4096	mV Peak Out of Range	
		13 8192	Crest Factor Out of Range	
	14 16384	mV Peak to Peak Out of Range		
	15 32768			

MANUAL REVISIONS

<u>Revision #</u>	<u>Program #</u>	<u>Revisions Made</u>
Rev 01	DT7377A	Origination
Rev 02	DT7377D	Added 5 zone display screen, added 3 parameters
Rev 03	DT7377E	Added Communications, Revised External Load
Rev 04	DT7377CE	Miscellaneous Edits
Rev 05	DT7377CF	Modify Battery Measurement

LIMITED WARRANTY

WARRANTY: BC GROUP INTERNATIONAL, INC. WARRANTS ITS NEW PRODUCTS TO BE FREE FROM DEFECTS IN MATERIALS AND WORKMANSHIP UNDER THE SERVICE FOR WHICH THEY ARE INTENDED. THIS WARRANTY IS EFFECTIVE FOR TWELVE MONTHS FROM THE DATE OF SHIPMENT.

EXCLUSIONS: THIS WARRANTY IS **IN LIEU OF** ANY OTHER WARRANTY EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF **MERCHANTABILITY** OR FITNESS FOR A PARTICULAR PURPOSE.

BC GROUP INTERNATIONAL, INC. IS NOT LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES.

NO PERSON OTHER THAN AN OFFICER IS AUTHORIZED TO GIVE ANY OTHER WARRANTY OR ASSUME ANY LIABILITY.

REMEDIES: THE PURCHASER'S SOLE AND EXCLUSIVE REMEDY SHALL BE: (1) THE REPAIR OR REPLACEMENT OF DEFECTIVE PARTS OR PRODUCTS, WITHOUT CHARGE. (2) AT THE OPTION OF **BC GROUP INTERNATIONAL, INC.**, THE REFUND OF THE PURCHASE PRICE.

SPECIFICATIONS

INPUT RANGE	
Current (RMS)	20 – 2500.0 mA RMS
Input Resolution	1 mA RMS
Frequency	10 kHz – 10 MHz
Accuracy	2.5% of Reading on RF Current or ± 15 mA, whichever is greater 4% of Reading on RF Power or ± 3 Watts, whichever is greater

CALCULATED RANGES	
Voltage	2.0 – 700.0 mV
Resolution	.1 mV
Wattage	400.0 Watts
Resolution	0.1 Watt
Voltage (Peak)	1000.0 mV
Resolution	.1 mV
Voltage (Peak to Peak)	0.0 – 1.0 mV
Resolution	.1 mV
Crest Factor	1.4 to 500
Resolution	.1

DISPLAY	LCD Graphical 240x64 Pixels
SETUP MEMORY	EEPROM, All Parameters
MEMORY RETENTION	10 Years w/o Power
OPERATING RANGE	15 to 30 Degrees C
STORAGE RANGE	-20 to 60 Degrees C
HUMIDITY RANGE	20 to 80 %, Non-Condensing
CONSTRUCTION	Enclosure – Kydex Face – Lexan, Back Printed
SIZE	6 x 13.5 x 12 inches 152.4 x 342.9 x 304.8mm (H x W x D)
WEIGHT	≤ 17 lbs. (7.7 kg)
CONNECTIONS	Input: Safety Jacks Output: Serial DB-9 or USB BNC oscilloscope output
FAN	120 mm Internal Fan
CQM/RECQM TEST FEATURE	0-500 Ω Independent Digitally Controlled Resistance in 1 Ω Increments Accuracy: 2% of range or 2 Ω, whichever is greater
POWER SUPPLY ADAPTER	9 VDC, 5 A
POWER CONSUMPTION	ON: less than 3 A OFF: less than 250 μA
BATTERY	Type: 6V, 7.2 Amp Hour Sealed Lead Acid
CHARGER	2-state internal independent charger with float mode

NOTES

NOTES