WHALETEQ

ESU Neutral Electrodes Impedance Tester

HFPA150

User Manual

Version 2025-07-02
Hardware Version 1.3.x

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1 Introduction

HFPA150 is a unique tester specifically designed for the testing of neutral electrode (NE) impedance in electrosurgical system. The HFPA150 is built to satisfy the testing requirements for contact impedance test as stated in IEC 60601-2-2:2009.

According to IEC 60601-2-2:2009 clause 201.15.101.6, the impedance of the electrical contact between the surface of the NE application site and the NE cord connection shall be low enough to prevent a risk of patient burn due to ohmic heating during the passage of HF surgical current. It is evident that hazard of patient burn during the use of electrosurgical system is present. The main contribution to the risk of patient burn is caused by the high impedance of the NE application site and the NE cord connection. Thus, this safety test is especially important for the neutral electrode manufacturers.

The HFPA150 generates specific NE impedance test signals per requirement of the IEC standard. The built-in generator is capable of generating signals with frequency ranging from 50kHz to 5MHz, producing current over 200mArms, and sine wave with THD < 0.3%. The HFPA150 is built with high stability output, adjustable frequency and gain functions. In addition to neutral electrode test, it could also be used as a measurement tool for general purpose generator where the specifications are appropriate.

Features:

1. A sine wave generator: user may adjust the frequency and gain to meet the needs of high-power sine wave output.
2. Stable frequency output: equipped with DDS (direct digital synthesis) technology, a frequency synthesizer for generating arbitrary waveforms from a single, fixed-frequency reference clock. Together with an embedded DC fan for ventilation and control of the internal temperature, the HFPA150 is not susceptible to temperature fluctuation which facilitates great output stability. Compared to a conventional sine wave generator which creates waveforms based on the charging and discharging of the capacitor, the stability of waveforms is therefore determined by the capacity of the capacitor. However,

the capacity change is proportional to the ambient temperature while inversely to the generated frequency. Thus, a common problem with the conventional sine wave generator occurs with the heat generated from prolong usage and resulted with the lower frequency generated.

3. Compliance with IEC 60601-2-2:2009 testing requirements: the HFPA150 is designed according to the standard of the neutral electrode (Neutral Electrode, NE) contact impedance test.
4. Produce current over 200mArms (~570mApp), compliance with the standard requirement.
5. With the amplified built-in sine wave generator, the output voltage can be up to 10Vrms (at 50Ω impedance).
6. Capability to measure to the upper limit of the contact impedance of the neutral electrode at 50Ω.
7. Frequency is adjustable from 50kHz to 5MHz.

Note:
An oscilloscope shall be used with the HFPA150 to measure the output voltage and current. The HFPA150 is equipped with a built-in conversion circuit, so that no additional current probe is required to measure the current value. User may simply connect the "Current Monitor" port with an oscilloscope to obtain the current value. (For details, please refer to ‘’3.3.2 How to Monitor the HFPA150 Output Voltage and Current’’.)

1.1 Safety Summary

Please review the following safety warnings to avoid injuries and prevent damage to this product or any related products. To avoid potential hazards, only use the product in accordance with this instruction. Only WhaleTeq qualified professionals should repair/adjust the operation program. To avoid fire or personal injuries, only use the original factory-supplied power supply.

- The equipment shall be operated by a qualified electrical engineer or a professional with equivalent qualification and knowledge in the principle of high-frequency insulation and oscilloscope use. **Please read this user manual**

carefully for the working principles and possible risks before first operating the HFPA150.

- If the power output is over 2 watts, pay special attention to the heat and power tolerance while connecting the load. Always use safe work practices when using electrical equipment to avoid the risk of electric shock and fire.

Main applications:

IEC 60601-2-2:2009 Measurement of neutral electrode contact impedance.

Recommended test instruments:

Table 1: Testing of Neutral Electrode

Testing of Neutral Electrode According to IEC 60601-2-2:2009							
201.15.101 Neutral Electrodes	**HFIT 8.0[1]**	**HFPA150**	**Oscilloscope**	**Heat Induction Meter**	**DC Power Supply**	**Digital Multimeter**	**Remark**
201.15.101.1 General requirements for NEUTRAL ELECTRODES							Not testing required
201.15.101.2 NE code attachment					V	V	
201.15.101.3 NE cord connector, no conductive parts on patient							Use test finger
201.15.101.4 NE cord insulation	V		V				
201.15.101.5 NE thermal performance[2]	V		V	V			Refer to Note 2
201.15.101.6 NE contact impedance		V	V				

Testing of Neutral Electrode According to IEC 60601-2-2:2009							
201.15.101 Neutral Electrodes	**HFIT 8.0[1]**	**HFPA150**	**Oscilloscope**	**Heat Induction Meter**	**DC Power Supply**	**Digital Multimeter**	**Remark**
201.15.101.7 NE adhesion							Non-electrical test
201.15.101.8 NE shelf life							

Note:

1. MEDTEQ HFIT 8.0, High-Frequency Insulation Tester: For insulation and current leakage test of cord and surgical instruments. Visit: https://www.medteq.net/testequipment/hfit8.
2. No current probe is required when the HFIT 8.0 is used as a generator. In the NE thermal performance test, IEC standard stated that the NE under test shall be applied on human skin, surrogate media or test devices with electrical and thermal equivalent properties. Since impedance varies with different contact surfaces, in some cases (especially with high impedance), the HFIT 8.0 is not capable to provide current up to 770mArms (maximum output of HFIT 8.0 is 150W), and in such case, an ESU along with a current probe will be required to conduct the test.

2 Specifications

Table 2: Specifications

Parameters	Specifications
Frequency range	50kHz—5MHz
Maximum voltage	11Vrms (~31Vpp), ≥ 50Ω
Maximum current	>200mArms, ≤ 50Ω
Waveform	Sine
Frequency response	< ±0.8dB, 50Ω
THD	<0.3% (-50.4dB), at 200mArms, 50Ω, 1MHz
Impedance	<3.2Ω + j0.4μH
Auxiliary equipment for contact impedance test	Oscilloscopes (Ch1 connects with voltage probe to measure voltage, Ch2 connects with HFPA150 current monitoring interface to measure the current value)
Current measurement accuracy*	+10% / -0% (Unilateral Tolerance)
Current measurement frequency range	50kHz—5MHz
Current measurement connector type	BNC
Power source	Power Adapter Input: 100—240V, 50/60Hz Output: 12VDC / 2A
Environment	10˚C—40˚C, 30%—90% RH
Dimensions / Weight	18 x 18 x 4.8cm (L x W x H) / 0.7kg (net weight)

*Note: Use with original factory-supplied connection cable (BNC to BNC) and test cables (BNC to alligator clip). See ''3.2 Original Factory-supplied Connection Cables'' for cable specifications.

3 Setup

3.1 Hardware Overview

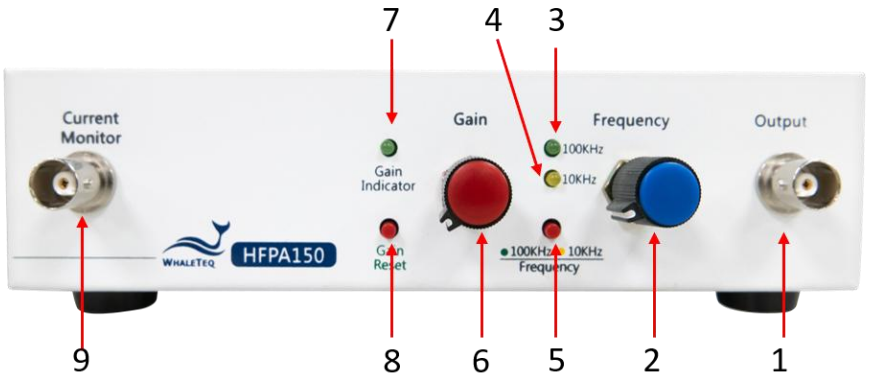

Figure 1: HFPA150 Front View

Table 3: HFPA150 Hardware Overview (Front View)

Item	Label	Name	Description
1	Output	Signal output port	Signal output. BNC connector.
2	Frequency	Frequency adjustment knob	Turn clockwise to increase frequency and turn counterclockwise to decrease frequency.
3	100KHz	100kHz indicator (Green)	Illuminates to indicate for 100kHz selection. Frequency is adjusted to be 100kHz per step.
4	10KHz	10kHz indicator (Yellow)	Illuminates to indicate for 10kHz selection. Frequency is adjusted to be 10kHz per step.
5	100K/10KHz Frequency	100kHz/10kHz switch button	Press for switch between 100kHz and 10kHz.
6	Gain	Gain knob	Turn clockwise to increase amplitude and turn counterclockwise to decrease amplitude. *Read ‘’3.3.3 Parameter Adjustment’’ before operation.

Item	Label	Name	Description
7	Gain Indicator	Gain indicator (Green)	The flashing light indicates signal output. The light will be solid green when there is no signal output or when the reset button is pressed.
8	Gain Reset	Gain reset	Press to reset gain to zero.
9	Current Monitor	Current monitoring port	Connect the oscilloscope with the original factory-supplied BNC cable to monitor the current value. (The oscilloscope shows 1mV is equivalent to 1mA of current flowing through the DUT.)

Figure 2: HFPA150 Rear View

Table 4: HFPA150 Hardware Overview (Rear View)

Item	Label	Name	Description
1	On/Off	Power switch	On/Off Switch.
2	DC IN	Power jack	12V DC power input connecting to the power supply.

3.2 Original Factory-supplied Connection Cables

HFPA150 is capable to measure the output current value through a current monitor port with direct connection to the oscilloscope using the BNC to BNC cable. This unique design saves cost and the need of an expensive current probe. A BNC to alligator clip cable is supplied for the connection to the signal output port in order to pass the test signal to the connection points and metallic plate of NE.

To control the accuracy of monitoring the current to ±5%, the HFPA150 measures the current by means of a 1Ω shunt together with the frequency compensation circuit. According to IEC 60601-2-2 clause 201.15.101.6, NE contact impedance test frequency shall range from 200kHz to 5MHz. As the frequency changes, the small capacitance of the test cable with the HFPA150 resistor results in noticeable RC effect, leading to significant deviation of frequency response.

The original factory-supplied cables with the HFPA150 are designed to resolve the above described issues. It is strongly recommended to use the original factory-supplied cables for measurements. The specifications of the cables are as follows:

1. BNC to BNC Cable

Exclusively designed for HFPA150 current monitoring, the BNC to BNC cable connects the current monitoring port with the oscilloscope. The indication of 1mV is equivalent to 1mA current flowing through the DUT.

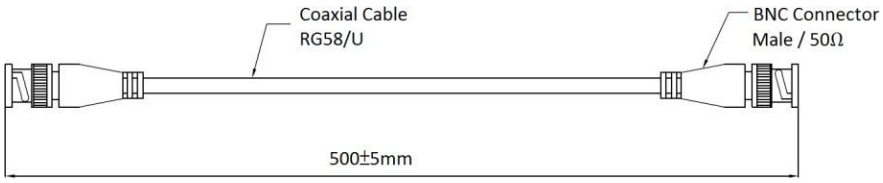

Figure 3: BNC to BNC Cable

Table 5: BNC to BNC Cable Specifications

Length	50cm
Cable capacitor	50pF ± 5pF
Impedance	50Ω
Type of cable	RG58U

2. BNC to Alligator Clip Cable

The BNC and alligator clips on the short cable are specifically designed for NE tests. It connects the HFPA150 with the DUT. Each of the alligator clip connects the wire connection port of the DUT (neutral electrode) and the metallic plate/prosthesis.

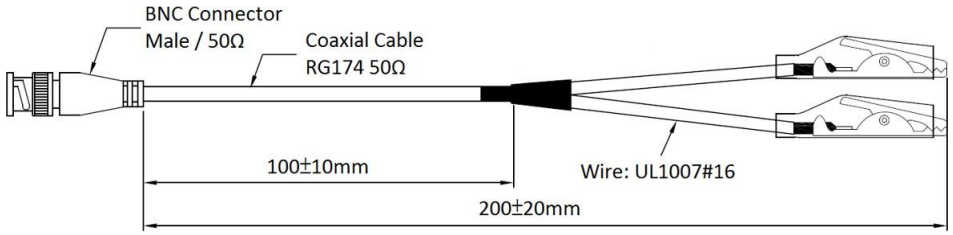

Figure 4: BNC to Alligator Clip Cable

Table 6: BNC to Alligator Clip Cable Specifications

Length	20cm
Cable capacitor	≤20pF
Impedance	50Ω
Type of cable	RG58U

Note: When using the BNC to alligator clip cable, avoid contacting the two alligator clips together. Contacting the two alligator clips under no-load condition can cause output short circuit, equipment damage, and possible risk of fire and electric shock.

3.3 Operation

3.3.1 Power

- **DC Power Jack**

Connect the power adapter (100V – 240V, 50/60Hz).

Note: Always use the original factory-supplied power supply.

Figure 5: DC Power Jack

- **Power Switch**

1. Switch the HFPA150 on.
2. Upon powering on the HFPA150, the green “Gain Indicator” and the yellow “10KHz” indicators illuminate. Frequency initiates at 50kHz with no voltage through “Output” port.

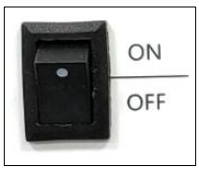

Figure 6: Power Switch

3.3.2 How to Monitor the HFPA150 Output Voltage and Current

HFPA150 measures the output voltage and current through two connecting ports of the oscilloscope:

1. Connect the original factory-supplied BNC to BNC cable* with the "Current Monitoring” port and oscilloscope CH2.
2. Connect the “Output” port with the BNC to alligator clip cable. Connect the other end of this cable to the analytes (DUT) and voltage probes connect with the oscilloscope CH1 (as shown in Figure 7)
3. Power up the HFPA150, turn the "Gain" knob clockwise to read a 50kHz signal

from CH1/CH2. The HFPA150 is working properly when amplitude increases with gain increase. The 1mVrms at CH2 is equivalent to 1mArms current. CH1 voltage and frequency indicates the output voltage and frequency.

*Note: To achieve HFPA150 current monitoring accuracy (<± 5%), use the original factory-supplied connection cables.

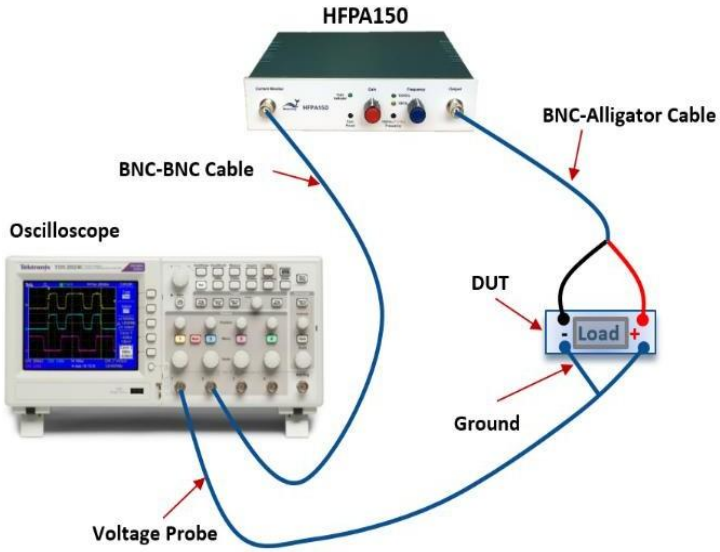

Figure 7: Test Wiring Diagram

3.3.3 Parameter Adjustment

- **Gain**

1. "Gain" knob: use for gain output adjustment. Monitor the oscilloscope to adjust the desired voltage/current. Turing the knob clockwise to increase the gain; counterclockwise to reduce the gain.
2. A flashing "Gain Indicator": indicates signal being output. The light will be solid green when there is no signal output or the reset button is pressed.

3. “Gain Reset”: Press to reset gain to zero. For safety reason, always reset gain when replacing analytes.

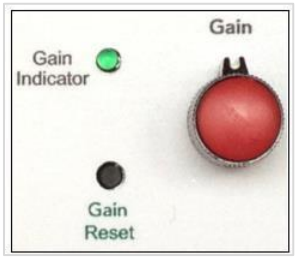

Figure 8: Gain Parameter Adjustment

Notes:

1. While doing gain adjustment, always monitor the current/voltage by an oscilloscope. Overcurrent will activate the protection circuit. See ‘’3.4 Overcurrent Protection’’.
2. When replacing the analyte, press "Gain Reset" to avoid hazard to operators or damage to HFPA150 unit due to sudden load reduction and current increase.
3. While turning the “Gain” knob to increase gain, the power output also increases accordingly. If the power output is over 2W, pay special attention to the heat and power tolerance while connecting the load. Always use safe work practices every time electrical equipment is used to avoid the risk of electric shock or fire.

While using the BNC to alligator clip cable, avoid contacting the two alligator clips together. Contacting the two alligator clips under no-load condition can cause output short circuit, equipment damage, and possible risk of fire and electric shock.

- **Frequency**

1. "Frequency" knob: use for frequency output adjustment. Monitor the oscilloscope to adjust the desired frequency. Turning the knob clockwise to increase the frequency; counterclockwise to reduce frequency.
2. “100KHz” indicator: Illuminates to indicate for 100kHz selection. Frequency is

adjusted to be 100kHz per step.

3. “10KHz” indicator: Illuminates to indicate for 10kHz selection. Frequency is adjusted to be 10kHz per step.
4. "100KHz/10KHz Frequency" switch button: Press for switch between 100kHz and 10kHz.

Figure 9: Frequency Parameter Adjustment

3.4 Overcurrent Protection

To ensure the safety operation and avoid the risk of damage to equipment due to improper use, the HFPA150 is built with a set of overcurrent protection circuit.

When “Detected circuits” detects an overcurrent, it will target the “Power Amp (Turn Off)” to reduce immediately. In case the limit is reached, the “MCU” receives the signal and subsequently adjusts the “Variable Amp” of the gain value to “0”.

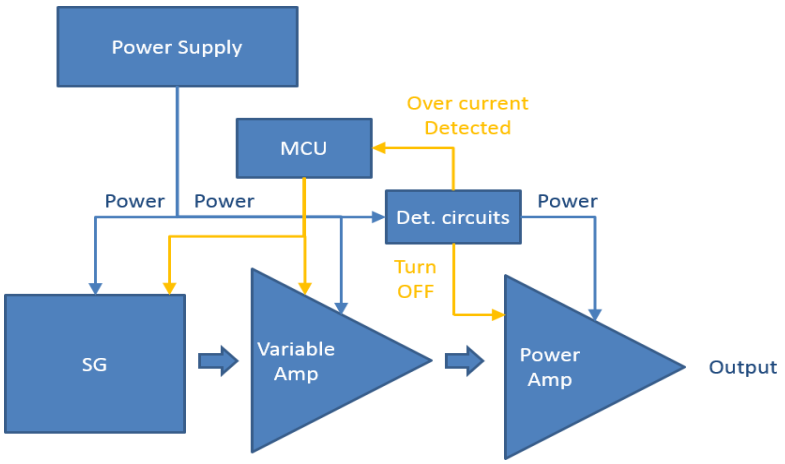

Figure 10: Protective Circuit Block Diagram

Instant current rise will result in an event that the impedance of the analyte is very low or even short circuit. In such case, using firmware to control “*MCU*” and further adjusting the gain value is not going to be responsive enough. The protection circuit works in the way of turning on the hardware as soon as overcurrent is being detected so that the “*Power Amp*” is reduced immediately. At this point, waveforms will distort (Figure 12) due to the current decrease. There could also be no waveforms (Figure 13) when the “*MCU*” adjusts the “*Variable Amp*” to Low gain “0.”

Both waveform distortion (Figure 12) and no waveform (Figure 13) indicate the protection circuit is activated. Readjust the gain value (increase or decrease) as needed.

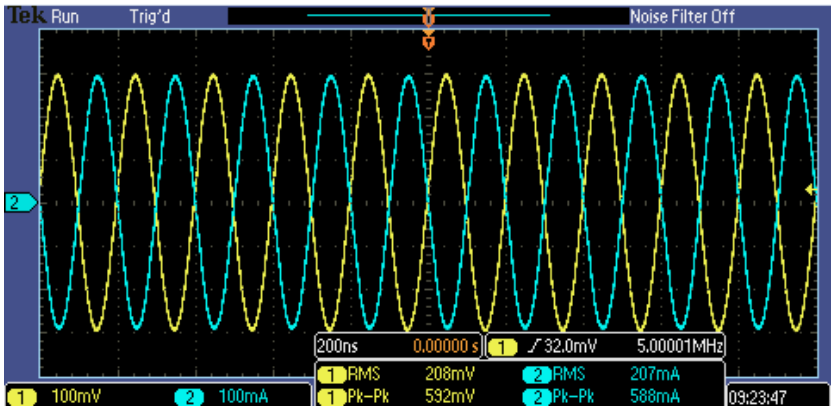

Figure 11: Normal Waveforms on the Oscilloscope Display Before Protection Circuit is Activated

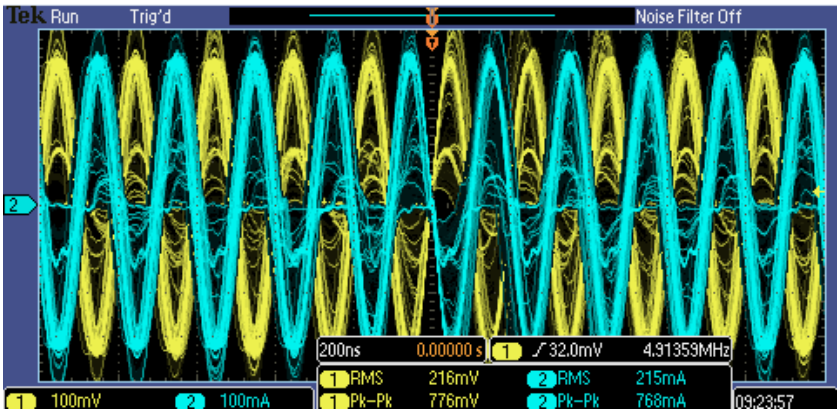

Figure 12: Distorted Waveforms After Protection Circuit Shuts Down the "Power Amp"

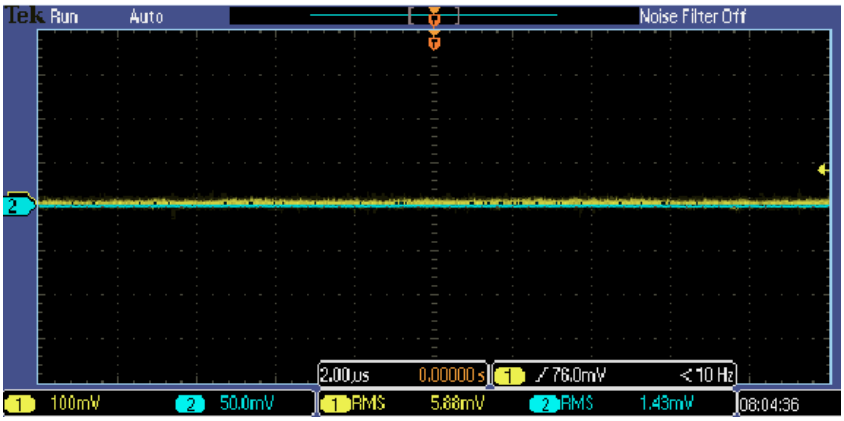

Figure 13: No Waveform Displayed After "MCU" Adjusts the "Variable Amp" to Low Gain "0"

3.5 Test Example

ESU Neutral Electrodes Impedance Test.

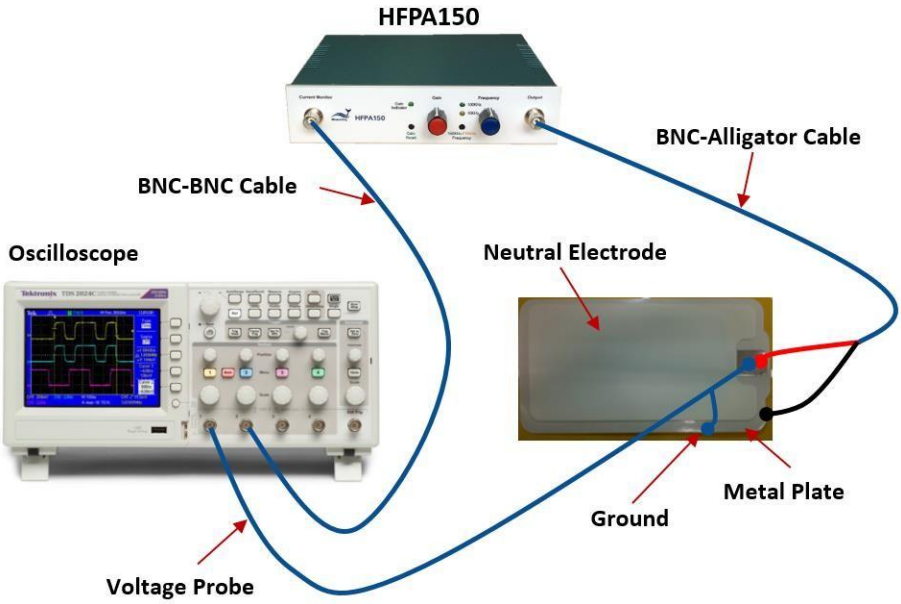

Figure 14: HFPA150 Connection for Neutral Electrode Contact Impedance Test

1. Connect the original factory-supplied BNC to alligator clip cable from the "Output" port to the neutral electrode (NE) plates. Connect the red alligator clip to the NE connector and the black alligator clip to the adhesive metallic plate.
2. Connect the oscilloscope probe (CH1) to the same point as the red alligator clip on the NE connector, and connect the ground end of the probe to the adhesive metallic plate.
3. Connect the HFPA150 “Current Monitor” port and the oscilloscope CH2 using the original factory-supplied BNC to BNC cable.
4. Adjust HFPA150 "Gain" and "Frequency" to CH2 200kHz, Vrms=200mVrms. (This indicates 1rms=200mArms).
5. Measure Vrms voltage of CH1. Use the equation Z=V/I to get the contact impedance value.

Note: Turning the “Gain” Knob clockwise will increase gain and output power

accordingly. When the output voltage exceeded 10Vrms while the output current does not reach 200mArms, this is an indication that the neutral contact impedance of tested negative plate is more than 50Ω. (IEC 60601-2-2:2009 clause 201.15.101.6 stated that the neutral electrode impedance shall not exceed 50Ω). Stop increasing the gain in such event and record the rms voltage and current. Calculate the contact impedance value for the neutral electrode.

6. Adjust the frequency to 500kHz, 1MHz, 2MHz, 5MHz and repeat step 4 and 5.

4 Cautions

1. Warranty void if QC PASS label is removed or tampered with.
2. The professional testing instrument, not a medical device, is for testing only, and will not involve human or clinical use.

5 Ordering Information

5.1 Standard Package

Table 7: Standard Package

Part No.	Description	Quantity
100-HF00103	**Model No.**: HFPA150 **Model Name**: NE Contact Impedance Tester Package contents: • HFPA150 x 1 • Power supply x 1 • BNC to BNC cable x 1 • BNC to alligator clip cable x 1	1

5.2 Optional Accessories and Services

- **Optional Accessories**

Table 8: Optional Accessories

Part No.	Description	Quantity
300-HFPA15D	1Ω/50Ω power resistor load for HFPA150 calibration	1

- **Optional Calibration Service and Warranty Extension**

Table 9: Optional Calibration Service and Warranty Extension

Part No.	Description
YY0007	**Model No.**: C3 Provides (3) years of calibration service coverage. WhaleTeq equipment can be calibrated to original performance on the basis of (1) year interval.
YY0008	**Model No.**: R3 Extends the limited warranty from (1) year to (3) years.

6 Revision History

Table 10: Revision History

Version	Modified Contents	Issued Date
2021-03-31	Change appearance drawing Add 5 Ordering Information 6 Version Information	2021-03-31
2021-06-18	Add 4 Cautions	2021-06-18
2025-07-02	Update 2 Specifications	2025-07-14

7 Contact WhaleTeq

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