OCK-30
SERIES

Operators Manual

Ω-CHECK®

Neutral Resistance Tester

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Warning! **This equipment is intended to be used near energized high voltage equipment. Failure to follow the instructions could result in injury or death. Read this manual carefully and completely prior to using this unit.**

Warning! **Proper grounding of the test equipment must be done prior to connecting this unit to a power source**

Revision History

Version	Comments
1.0	Initial Release
1.1	Updated Terms and Conditions, added example for larger AWG length correction
1.2	Updated Introduction, Test Procedure
1.3	Includes OCK-30F specs, schematics
1.4	Added Data Retrieval section
1.5	Added registered trademark info
1.6	Updated schematics
1.7	Updated Maintenance procedure
1.8	Added OCK-30F Parts List
1.9	Added aluminum neutral example

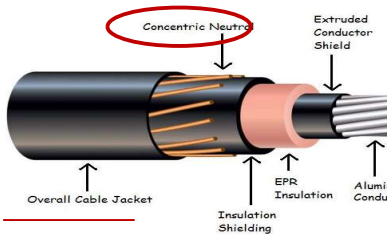
Table of contents

SECTION 1

Introduction

The Ω-CHECK® Concentric Neutral Resistance Tester: How many strands are left?
The Ω-CHECK® is designed to test the degree of degradation, or corrosion, of a cable's concentric neutral wires. The copper or aluminum wire strands of a concentric neutral are known to corrode over time, especially in unjacketed cables and in any cables in moist conditions. The concentric neutral is vital to the stability, reliability, and safety of a distribution system. The **Ω-CHECK®** brings us the best method of measuring the resistance of the neutral to calculate how much of the original remains.

Un-jacketed Cable or Bare Concentric



Precautions

This equipment is intended to be used near energized high voltage equipment and operated only by qualified and properly trained personnel. When performing any work near high voltage equipment, proper safety precautions, such as insulated gloves and insulated overshoes, should be taken. When this equipment is operated near energized facilities, it is essential that all safety procedures, as generally accepted within the electric utility industry or mandated by your company, be strictly observed. No instruction or procedure contained in this manual is intended to specify, modify, or supersede any industry or company mandated safety practices.

The output of the unit is intended to be connected only to grounded conductors, such as cable neutrals. Never connect the output of the unit to any ungrounded conductor unless the system has been de-energized and locked out. Connecting the output of the unit to an energized ungrounded conductor may result in personal injury and/or damage to the unit.

The components of the unit are heavy. Failure to use proper lifting techniques when transporting the unit may result in personal injury.

The current probe should be clamped only around the grounded neutral being tested. Never clamp the current probe around an energized conductor or high current source. Clamping the current probe around a high current source may result in damage to the unit.

The unit should not be operated during periods of inclement weather or when thunderstorms are present in the area, due to the increased probability of a cable fault occurring on or near the cable being tested. Faults occurring on or near the cable during testing may damage the unit. The safety ground cable provided with the unit should be connected to the distribution system ground during all testing to insure operator safety in the event of a cable fault during the test.

Should a situation arise in which the instructions or procedures contained in this manual are not clear or adequately covered, contact High Voltage, Inc. for assistance *before* using the unit.

Theory of Operation

Background: From about 1960 through the 1980s, large quantities of cable with bare concentric neutrals were installed. Many utilities have experienced corrosion of these neutrals. The loss of the cable neutral can result in power quality problems and potentially unsafe conditions for persons near the cable. The **Ω** -Check is an instrument that accurately measures the resistance of an installed cable neutral. The resistance of the cable is then compared with the resistance of a new cable to determine the condition of the neutral.

The **Ω**-Check test system consists of a test box containing a variable power supply and microprocessor-based measurement module, a current probe, and reels of two test leads for connecting to ends of the neutral being tested (see Figure 1 below). The power supply injects an AC current of up to 30 Amperes into the entire grounding system through one pair of conductors of the test lead. Another conductor of the test lead is used as a voltage sensing lead. The relatively high level of output current is primarily to make sure that a minimum level of current flows through the neutral under test even in the presence of extensive leakage current through the ground system. The current probe is then used to detect the portion of the current flowing in the neutral being tested.

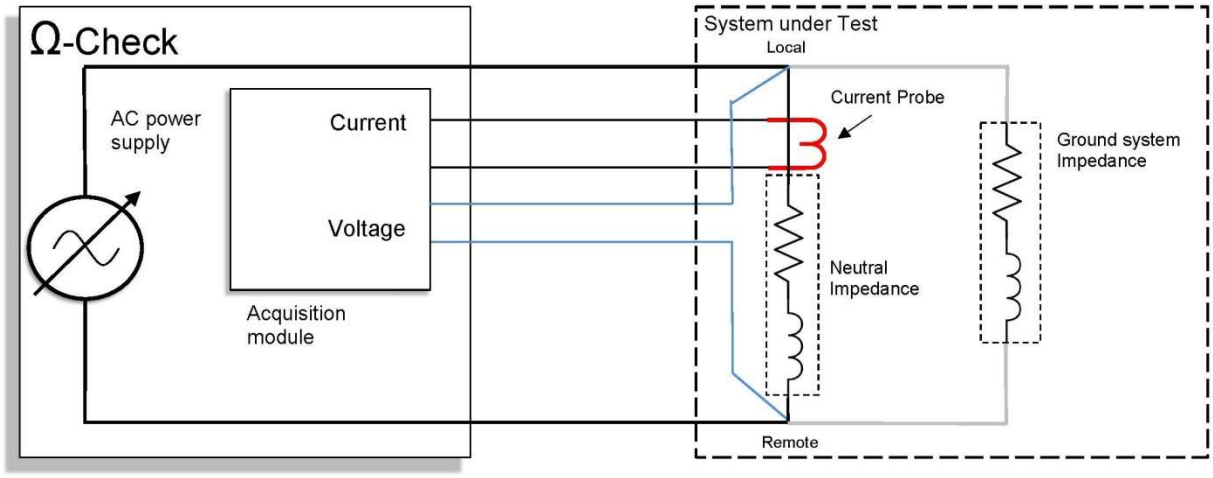


Figure 1

The Acquisition module then measures the voltage across the neutral, the current flowing in the neutral and the phase angle between them and computes the resistance of the neutral per one hundred feet of length:

$$Resistance\ per\ 100\ ft\ =\ \frac{(\ Voltage\ )\ (\ Power\ Factor\ )}{(\ Current\ )\ \frac{Cable\ Length}{100}}$$

The tester is provided with polarity reversing relays which are controlled by the microprocessor. The measurements are made with the test current in each polarity and an average resistance computed. This results in cancellation of the induced effects of adjacent current carrying conductors.

The resistance of a new neutral of the same size is stored in the memory and is used to compute the ratio of the resistance of the neutral under test to the resistance of a new neutral. This resistance ratio then indicates, as a percentage of its 'brand new' condition, the resistance of the neutral.

Test System Components

SECTION 2

Major components of the Ω-Check test system are shown in Figure 2 and are described below.

Figure 2

No.	Name	Description
1	Test Box	The test box consists of a power supply with a maximum excitation current of 30 Amps at 48 Volts and an instrumentation module for processing the neutral measurements.
2	Test conductor clamps	Detachable hot-line clamps for connection to system neutral test points

3	Remote Test Leads	Two (2) Reels each with 500 feet of test lead for connecting the remote end of the cable neutral to the test box. Lead wires consist of two (paralleled) 16AWG conductors to supply excitation (test) current and a third 22AWG for voltage sensing. 3a: Has connectors at 100 foot intervals to facilitate a minimum length (voltage drop) connection to the test box. 3b: is a single 500' length.
4	Local Test Lead	A 10 foot long test lead for connecting the test box to the end of cable neutral nearest the test box. Like the remote leads, the lead wires consist of two (paralleled) 16AWG conductors to supply excitation (test) current and a third 22AWG for voltage sensing.
5	Power Cord	IEC cordset for connecting 120 VAC power to the test box.
6	Safety Ground	A 4AWG flexible grounding cable is provided for connecting the Test Box chassis to local equipment ground.
7	Current Probe	The current probe is used to sense the portion of the test current flowing in the neutral being tested. The probe provides an output of 1 mA/Amp to the instrumentation module in the test box. Includes a 10' test lead

Description of Controls

The controls for the instrument are identified in Figure 3 and described below.

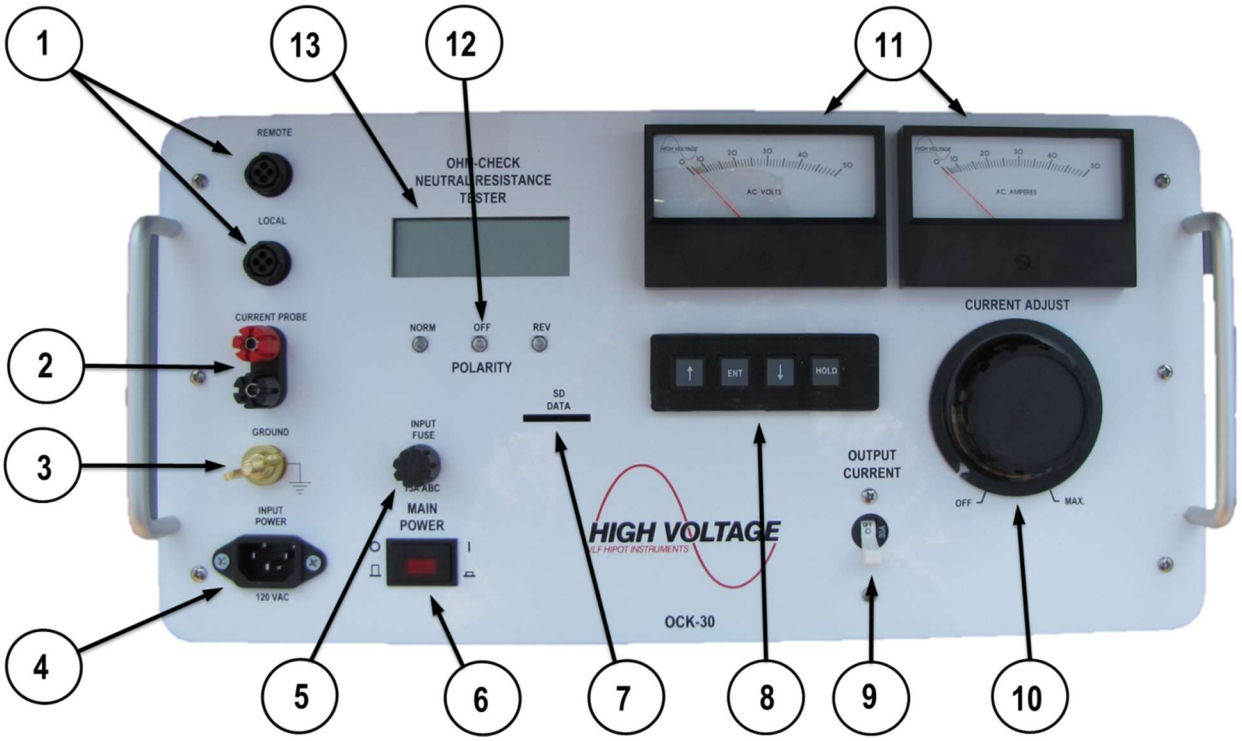


Figure 3

No.	Name	Description
1.	Neutral Connections	Local: Allows connection of the Local Test Lead from the local end of the cable neutral to the unit. Remote : Allows connection of the Remote Test Lead from the remote end of the cable neutral to the unit.
2.	Current Probe	Allows connection of the current probe to the unit.
3.	Equipment ground	Safety ground connection for test box
4.	Power Inlet	IEC-C14 Inlet for connection to 120 VAC source (230VAC for OCK-30F).
5.	AC Input Fuse	Provides overall protection to the unit. Re-fuse only with fast-blo ABC-15 ceramic type of approved equivalent
6.	Power Switch	Energizes the unit.
7.	SD Port	Port for storing test data to a SD flash card.
8.	Keypad	Keypad for input of the cable parameters and control of the measurement module
9.	Test Current Breaker	Energizes test circuit and provides protection to the unit by limiting output current to 30 A.
10.	Current Adjust	Controls the current output of the power supply.
11.	Output meters	Analog meters to indicate the output voltage and current of the power supply.

12.	Polarity	The polarity indicator lights show the polarity of the power supply when measurements are being made. The polarity is controlled by the microprocessor and the indicators are intended for verification of proper operation. When the polarity is in the off position, the power output is disconnected from the Neutral Connections.
13.	Measurements LCD	LCD display for entering the cable parameters and displaying the neutral measurements.

Testing Procedures

SECTION 3

The Ω-Check is normally used to test cable neutrals between distribution transformers or between a transformer and a switching cubicle. The procedure for connecting the instrument and conducting a test are described in this section.

Setup:

1. **Determine the length of the cable** being tested:

This information should be taken from engineering drawings or field measurements. Accuracy of test results are directly proportional to the accuracy of the cable length entered into the instrument so the buried length should be determined as closely as possible. In cases where the routing of the cable is uncertain, it may be prudent to locate the cable prior to field measurement. For most URD installations, measurement with a distance measuring wheel will provide sufficient accuracy.

2. **Determine the size of the neutral** being tested.

Count the number of neutral strands and determine the AWG size of each strand. A wire gage is included with the Ω-Check to measure the strand size if necessary. The Ω -Check is configured for testing neutrals comprised of concentric, round copper wires. Procedures for testing other types of neutrals are described on Page 14.

3**. Connect AC power source** to the Ω-Check.

The Ω-Check must be connected to a utility quality, AC source. For the OCK-30 this is nominally 120VAC and for the OCK-30F 230VAC. The power input is not universal and under no circumstances should a 230V source be connected to the input of an OCK-30. Power for testing is normally taken from the secondary of transformer to which the cable neutral being tested is connected. If 120 VAC is not available at the test location, acceptable results may be obtained using a motor-generator set or an inverter. The unit has been tested with a Brutus Model TB24-12 inverter and found to operate satisfactorily. Before testing with a non-utility power source, verify the proper operation of the unit by comparing the results obtained using the power supply with those obtained using a utility power source.

4. **Connect the local test lead** to the cable neutral being tested:

First, clean the bundle of neutral wires to insure a good connection, using a wire brush or a course cloth. Connect the ten foot local neutral test lead to the LOCAL NEUTRAL CONNECTION socket of the instrument. Connect the test clip of the local test lead to the neutral system at the end nearest the instrument. Accuracy of test results is directly proportional to the accuracy of the # of strands entered into the instrument so be sure that the test clip is in contact with all the neutral strands.

5. **Determine the remote lead route** and connect the REMOTE test lead to the remote cable neutral being tested:

Note:. Measurement accuracy is adversely affected by parasitic inductance in the remote test lead(s). Cable reels should only be used for *storage* of the remote test lead(s) and under no circumstances should the remote test lead setup use cable still coiled onto the reel.

Estimate the length of the remote lead run back to the instrument. Measurements are not affected by the *length* of test lead used so generally this is the shortest distance back to the test box although the lead can also be made longer to avoid obstacles to the cable run. If the total distance is longer than 500' you will need the 'B' type reel in addition to the 'A' type.

a.) Clean the neutral conductors per step 4. above and connect the test clip to the remote end of the neutral system. Accuracy of test results is directly proportional to the accuracy of the # of strands entered into the instrument so be sure that the test clip is in contact with all neutral strands.
b.) If your lead distance is distance is less than 500' skip this step. Connect the end of the 'B' reel to the remote test clip and unspool it back towards the test box. When the end of the reel is reached, couple the 'B' end to the start of the 'A' reel.
c.) Connect the end of the 'A' reel to the remote test clip (or to the end of the 'B' reel if you came from the previous step) and unspool it back towards the test box. The 'A' reel is supplied with connectors at 100 foot intervals. After the test lead is pulled to the test box, unroll enough additional cable to access the next connector, unfasten the remote lead connector from the reel and connect it to the 'REMOTE' connection of the instrument.

The local and remote test leads can be connected to the cable neutral being tested or to any location on the ground system to which the cable neutral is bonded. Care should be taken to insure that the test clip engages all strands of the cable neutral. If a ground loop conductor is available, this is often the most reliable location for connecting the test leads.

7. **Connect the current probe.**

Connect the current probe test lead to the CURRENT PROBE connection on the test box and to the sockets on the current probe. Place the current probe around the neutral being tested as close to the cable as possible and always inside of the voltage clamp connection, meaning the current probe must be placed between the voltage clamp connection and the cable neutral being tested. Place the current probe around the neutral being tested. The current probe must be placed between the local test clip and the cable neutral being tested. The current probe should be connected to the instrument before placing it around the neutral being tested. See Figure 4 below

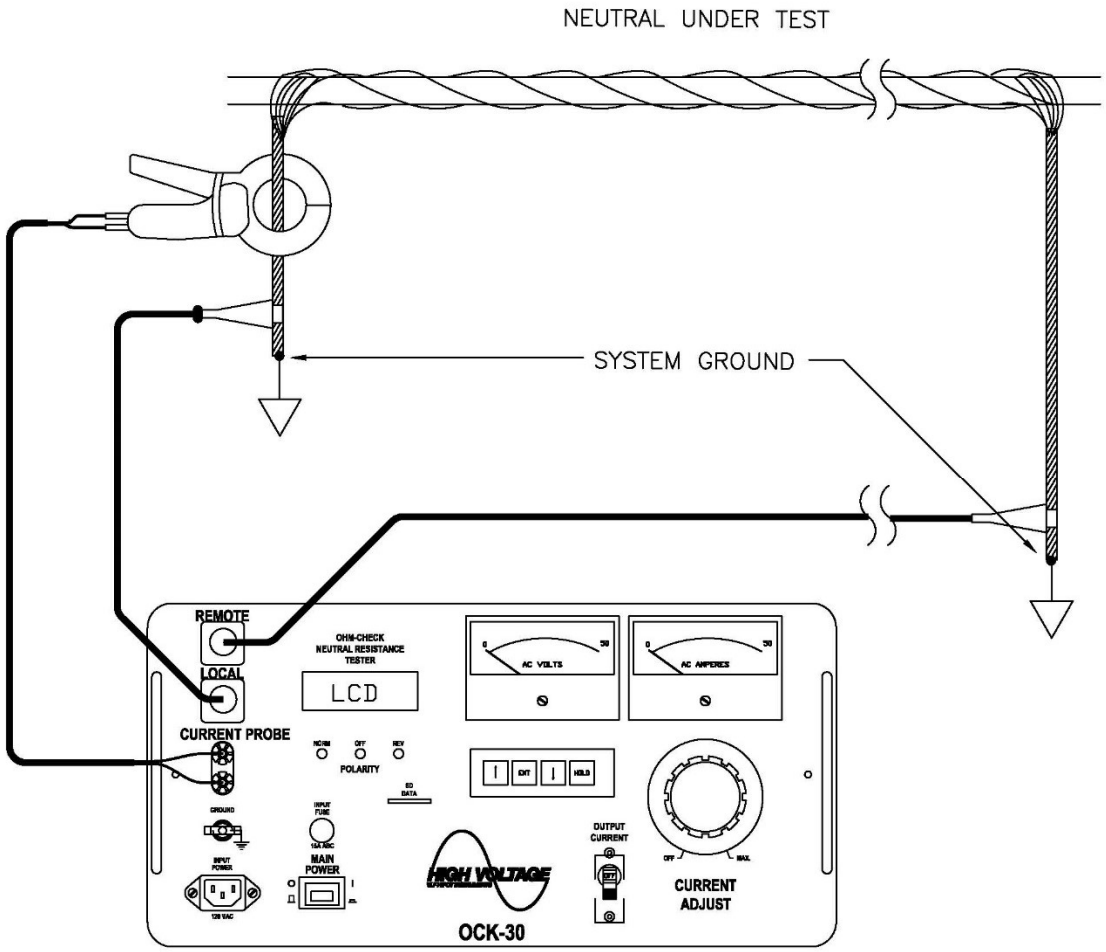


Figure 4: Connection of the Ω-check for testing

Testing:

1. POWERING UP THE UNIT:

Apply power to the unit and press the power switch. The switch indicator should glow red and the following screen displayed on the LCD:

2. THE MAIN MENU:

Press the 'ENT' button and the main menu will appear:

Press the '↑' or '↓' button to move the indicator to the desired menu item and press 'ENT' to select the menu item.

3. RUNNING A TEST.

Selecting the 'Run Test' menu item will display the following data entry screen.

WARNING! Entry of the last digit of the test number on this screen will automatically close the output relay in normal polarity. Make sure the 'Output Current' breaker is in the 'OFF' position before concluding this screen to prevent inadvertently energizing the test leads.

The cursor, shown as a line under the data field, will advance one position when each time 'ENT' is pressed. If an error is made entering the cable data, pressing 'ENT' and 'HOLD' simultaneously will move the cursor backwards to the previous data entry field.

The '↑' or '↓' button increments/decrements the entry in the field where the cursor is displayed. The test cable parameters are entered as follows:

No. of Neutral Strands: The number of strands in the neutral is entered as a right justified number. The display will initially show the number of strands from the previous test. The number of strands entered must be non-zero.

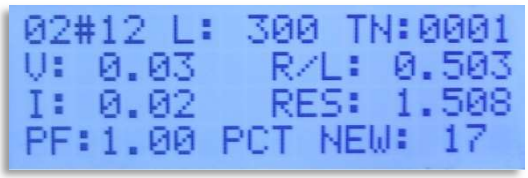
Size of Neutral Strand: The AWG size of the neutral strand is entered. The instrument accepts strand sizes of 10, 12, 14, 16 or 18 AWG. The display will initially show the number of strands from the previous test.

Length: The cable length is entered as a right justified number (a length of 260 Feet, for example, is entered as 0260). The length entered must be non-zero.

Test Number: The test number is a user-selected, four-digit number for identifying the cable being tested. After the last digit of the test number is entered, the polarity relay is set to NORM and the following screen is displayed:

- Turn the CURRENT ADJUST knob fully counterclockwise and turn 'ON' the OUTPUT CURRENT breaker.
- Increase the' CURRENT ADJUST' knob until the AC amperes meter displays 30 Amps. On long cables or cables with poor neutrals, the maximum position of the CURRENT ADJUST knob may indicate less than 30 Amps on the AC ampere meter. In this case, leave the CURRENT ADJUST knob set in its maximum position.

Press 'ENT' and the following measurement screen will be displayed:

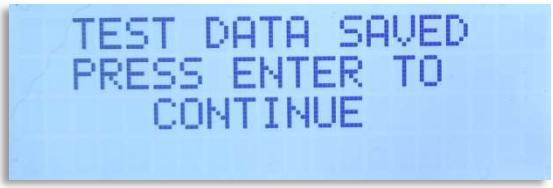


The POLARITY indicator lights will alternate between NORM, OFF and REV as the measurements are made in each polarity. Once the measurements have stabilized, press the HOLD button until the OFF polarity LED is lit and data acquisition stops. Measured values displayed on the screen are:

Neutral Data	The number and AWG size of the neutral strands entered by the user
L:	The cable length in feet entered by the user
TN:	The test number entered by the user
V:	The voltage difference between the local and remote ends of the cable neutral. This voltage is measured with the voltage sense conductors in the test leads
R/L:	The resistance of the neutral being tested in Ohms/100 feet.
I:	The amount of current flowing in the neutral (in A_{RMS}) as detected by the current probe
RES:	Total resistance in Ohms
PF:	The power factor of the neutral conductor being tested. This is determined by measuring the phase angle, φ, between I and V, where PF = Cos φ
PCT NEW:	Conductivity ratio of measured neutral compared to ideal neutral of same length expressed as a percentage. For example, a reading of 75 would mean that the neutral has 75% of its original capacity and that approximately 25% of neutral strands are open

4. STORING TEST RESULTS:

While in the HOLD state the measured values can be stored to the SD card by pressing the '↓' button. The screen will confirm that the data is saved and for you to press 'ENT' to continue.



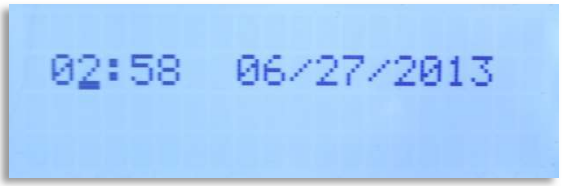
Note: When measurements are completed, be sure to return the CURRENT ADJUST to 0 before turning the power off.

5. RESUMING TESTING

Pressing the 'HOLD' key again will resume testing using the existing settings. Pressing the 'ENT' key will stop the test and return to the entry screen to start another test.

6. SETTING THE TIME AND DATE.

Selecting the 'Set Time/Date' menu item displays the following screen for setting the time and date:



- Time/date fields are incremented/decremented by using the '↑" and '↓' keys, respectively.
- Press 'ENT' to advance to the next field or ENT+HOLD to return to the previous field. Time format is 24 hour (military style).

7. THE INFORMATION DISPLAY.

Selecting the Information menu item displays the following information about the Ω-Check:

8. TIMED SHUT DOWN.

In order to reduce the weight of the unit, some components are not sized for continuous operation. The unit is designed for operation at full power for up to 5 minutes. After 5 minutes of operation the unit must be allowed to cool for 5 minutes. After test current has been applied for 5 minutes, the polarity will be set to off inhibiting any further testing and the unit will require power being cycled in order to resume.

Interpreting the test results

The resistance ratio is used to access the integrity of the cable neutral. The data presented is based on research conducted by the Georgia Power Company Research Center and is intended to assist the user in establishing a cable replacement criteria. The replacement criteria should be based on the neutrals ability to carry anticipated currents under both normal and fault conditions. It may also be influenced by the location of the cable, i.e. exposure to the public and other facilities, the age of the cable, and the users risk management philosophy.

As part of the research, several hundred feet of bare concentric neutral cable was buried and the corrosion accelerated by application of a DC current. The neutral resistance was monitored and the cables were removed at selected resistance levels. The cables were inspected and fault tests were conducted on selected samples.

The tests indicated that the corrosion occurred in localized areas along the cable. The corrosion began reducing the strand diameter in ¼ to ½ inch long sections of the neutral strand and continued until the stand eventually opened.

The measurements showed that there was no significant increase in the overall resistance of the neutral because of the reduced strand diameters in localized areas. The neutral resistance increases dramatically once strands begin to open. The resistance ratio was found to be a reliable indicator of the number of open strands in the neutral. The expected ratio can be calculated as:

$$Ratio = \frac{Total\ No.\ of\ Strands}{Total\ No.\ of\ Stands - No.\ of\ Open\ Strands}$$

The percent of new value provided on the LCD display is the reciprocal of the ratio and can be used as a indication of the percentage of strands remaining intact. For example: **PCT NEW: 50** means that there is a 2:1 ratio of ideal to measured resistance, meaning 50% of the neutral remains.

The fault tests consisted of one instantaneous and two timed reclosures and were performed with the cable buried. As expected, the neutral failed at locations where the strand diameter was reduced by localized corrosion. Thus, the fault current capability of a corroded cable with all strands intact will likely be less than that of a new cable even though the ratio is near one. The test data was used to develop the relationship between the resistance ratio and fault current capacity shown in Figure 5. The tests indicate that for a neutral with a resistance ratio of 1.0, the fault capacity may be reduced to about 75 percent of a new cable. During the fault tests, often the fault successfully cleared, but resulted in damage to the neutral with many burned or open strands. This indicates that it may be prudent to test the neutral following a cable fault. The voltage gradient (step voltage) measurements were also made on the surface over the cable while passing the test current through the neutral. The intent was to locate the areas where the neutral was open. At locations were most or all of the strands were open, significantly higher voltage gradients were measured. In some cases it may be possible to determine the location of an open neutral by measuring the step voltage along the cable using a digital voltmeter.

The data presented is intended only to provide general guidance for the user in establishing an appropriate replacement criterion. In establishing a criterion, careful consideration should be given to your individual system requirements. Generally, a replacement criterion would range between a resistance ratio of 1.25 and 2.00, depending on your individual requirements.

Practical Testing Suggestions

The following suggestions for testing are based on experience gained during development and subsequent field application of the instrument. These suggestions may be helpful in resolving some of the problems that may be encountered in using the instrument.

- **Check for missing strands**.

On many cable terminations, one neutral strand is used as drain wire for the cable termination. If this is not connected to the rest of the neutral strands, it may not carry the test current. In this case, the test results would indicate that this strand is open, when in fact it may not be. Since this can occur on different strands on each end of the cable, two strands may not carry test current. This may yield overly pessimistic results. If possible, insure that all neutral strands are twisted together so that the test current passes through all strands. In many instances, a short length of wire with alligator clips is useful for bonding stray strands to the bundle of neutral strands.

- **Connecting the test leads**.

It is important to insure that the test leads make good contact with all the strands of the neutral. Where the neutral strands are tightly twisted, this is generally not a problem. Where the strands are loosely twisted, it can be difficult to make contact between the test lead connector and all the strands.

- **Testing three phase cables.**

When testing three phase cables, the most reliable results are obtained by placing the current probe around the neutrals of all three phases and measuring the resistance ratio based on the total number of strands in all phases. For example, a three phase circuit of cables with 8 no. 14 AWG neutral strands would be entered as 24 no. 14 strands. Measurement of the phases individually can provide an indication of the integrity of each phase, however contact between the strands of adjacent cables and the effects of test current flowing in adjacent cables may provide unexpected results.

- **Testing different types of neutrals.**

The instrument and its database were designed for testing concentric, round, copper wire neutrals. To test other types of neutrals, it is necessary to determine the resistance per 100 feet of a new neutral of that type. This can be done by calculation, reference to manufacturer's data, or by measuring the resistance of a 100 foot length of cable using the **Ω**-Check. The **Ω**-Check provides test results in resistance per 100 feet and the resistance ratio can be calculated manually. It is also possible to determine the number and size of round concentric wire that will provide a resistance that is equivalent to the neutral being tested. The **Ω** -Check calculates the reference resistance as follows:

$$R_{ref} = \frac{Resistance\ of\ 1\ strand}{Total\ no.\ of\ strands} \quad (1.1)$$

Where the constant of 1.1 is a lay factor that accounts for the increased neutral length due to spiral wind of the concentric neutral. The strand resistances per 100 feet used by the **Ω** -Check are as follows:

AWG	**Ω per 100 feet**
10	0.0999
12	0.1588
14	0.2525
16	0.4016
18	0.6385

Once the equivalent neutral size is calculated, it can be entered as test data and the resistance ratio read directly. Using this method, the **Ω**-Check can be used to test virtually any type of neutral.

Example 1: If the strands of a 500' concentric neutral were 22AWG copper an 'equivalent length' of 18AWG neutral (same strand count) may be calculated thus:

$L_{entered}$ = (1.614/.6385)*500' = 1264' where:

1.614 = **Ω per 100 feet of 22AWG Cu**
0.6385 = **Ω per 100 feet of 18AWG Cu**
500' = actual concentric neutral length

The length compensation factors for smaller gauge wires relative to 18AWG appear in Table 1 below

Actual neutral gauge	Copper resistance (**Ω/100'**)	Equivalent 18AWG entered length multiplier
20	1.015	1.5897
22	1.614	2.5278

Table 1

Example 2: If the strands of a 250' concentric neutral were 18AWG aluminum instead of copper the 'equivalent length' may be calculated by multiplying the actual length by the relative resistivity of aluminum to copper (1.647)

$L_{entered}$ = (1.647)*250' = 412'

• Testing cables with mid span taps.

It is not possible to accurately measure the resistance of cables with mid span taps because the portion of the current flowing in each cable segment from the tap point cannot be determined. However, by measuring the resistance across each of the three terminal, it often can be determined if the neutral is open or severely impaired in one cable segment.

- **Very low neutral test current**.

When the neutral test current is very low (less than 1 Amperes), reliable resistance measurements are not possible. When the neutral test current is very low, particularly when accompanied by high neutral voltages, it is a positive indication that the neutral is open. In this case the neutral should be presumed open and the resistance ratio disregarded.

- **Testing long cables.**

Additional lengths of Reel "B" test lead may be used to test cables longer than 1000 feet. Field experience has shown that cables up to 2000 feet can generally be tested with the neutral connected to the system. At lengths beyond 2000 feet, the voltage drop in the test lead will not allow adequate current to be passed through the neutral. In order to insure reliable measurements, at least 1 Ampere of neutral current is required. Considerably longer lengths of cable could be tested by disconnecting the neutral from the ground system. It is also possible to test longer lengths of cable by excavating the cable, applying the remote test lead at the mid point of the cable and testing the two sections separately.

- **Testing with the test lead on the reel.**

Testing with test lead on the reel will provide inaccurate results due to uncompensated parasitic inductance. Always unroll the test lead to the next connector and separate the connector to connect to the instrument.

Data Retrieval

Test data stored on the SD card is saved as a tab-delimited text file (.txt) that may be retrieved using any text editor or Microsoft Excel on any PC equipped with an SD card reader.

Procedure:

Insert SD card into slot on PC/external reader. Card should be displayed in Explorer window similar to Fig.5 below

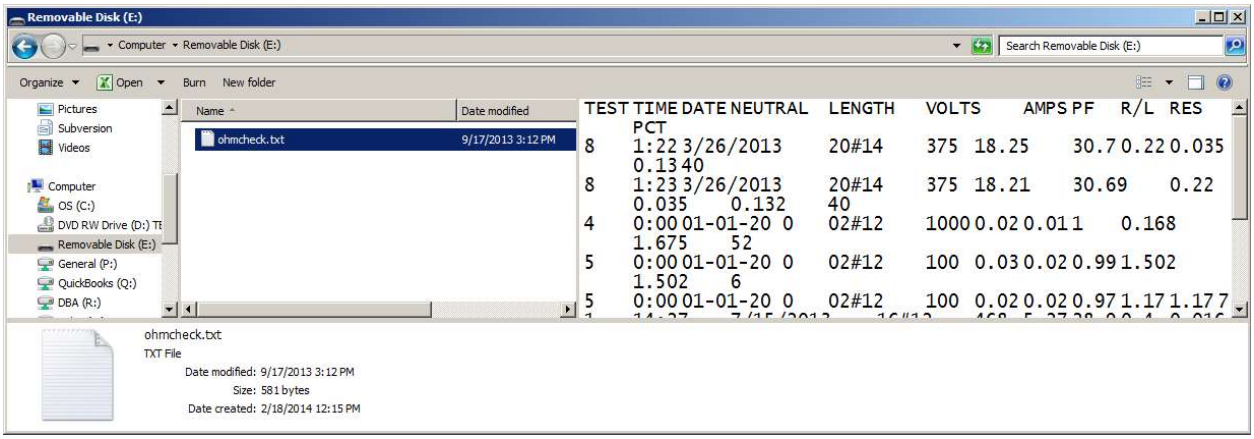


Figure 5

9. OPENING THE FILE USING MS EXCEL

1. Open MS Excel
2. Select File-Open-Removable Disk(E:)
3. Select down-arrow in righthand dropbox and select 'All files (*.*)'. Ohmcheck.txt should appear in file window as shown in Fig6. below.

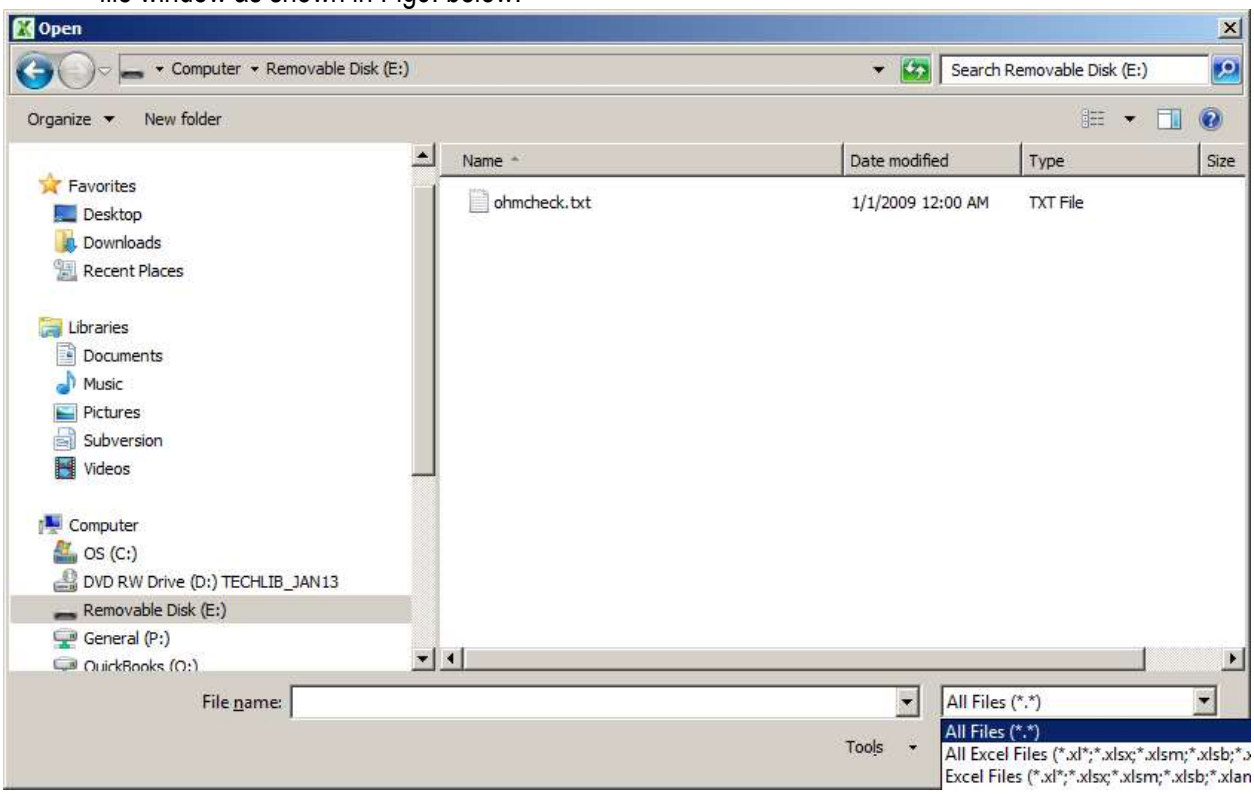


Figure 6

Select ohmcheck.txt and Open it. The Text Import Wizard of Fig.7 should appear.
Under 'Original data type' select 'Delimited' and then click 'Next'

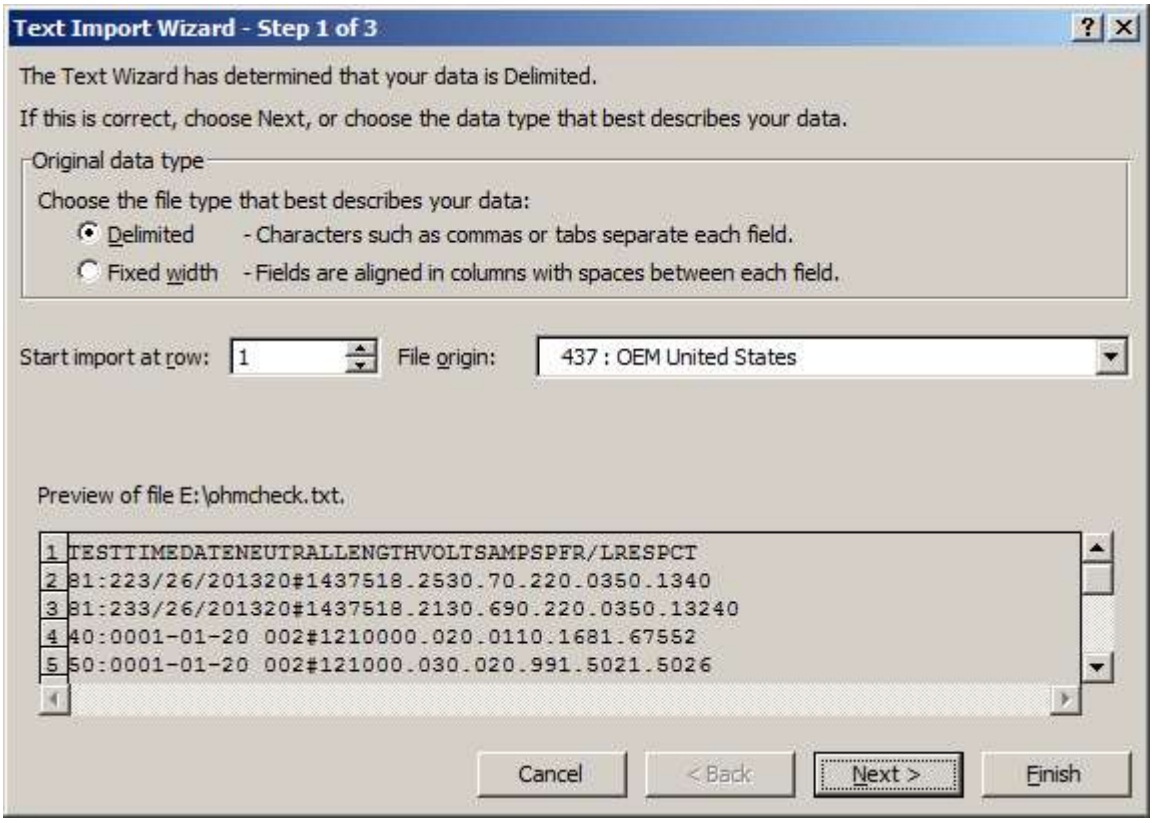
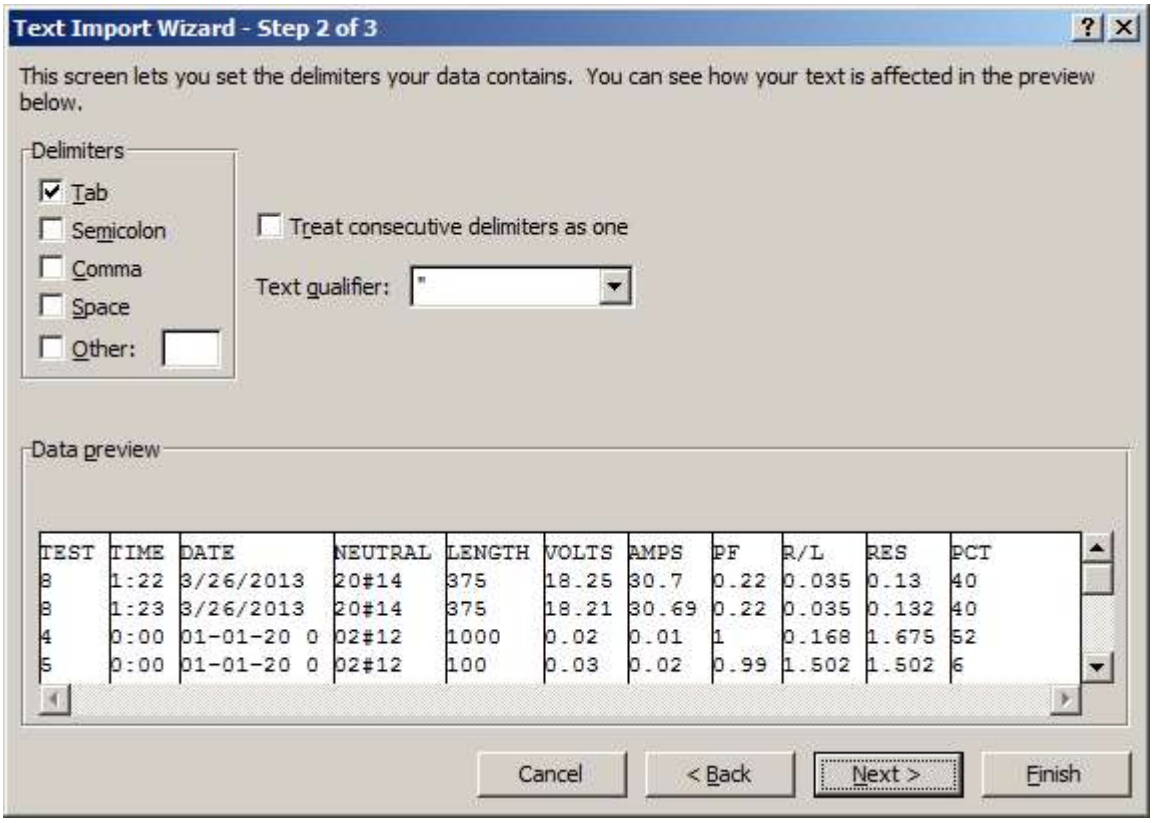


Figure 7

Under the Delimiters tab, select 'Tab' and then click 'Finish'



File is now imported and should look similar to the one in Fig. 8 below. It is recommended that the imported file be saved as a standard Excel file (.xls or .xlsx) to allow easier data manipulation and graphing.

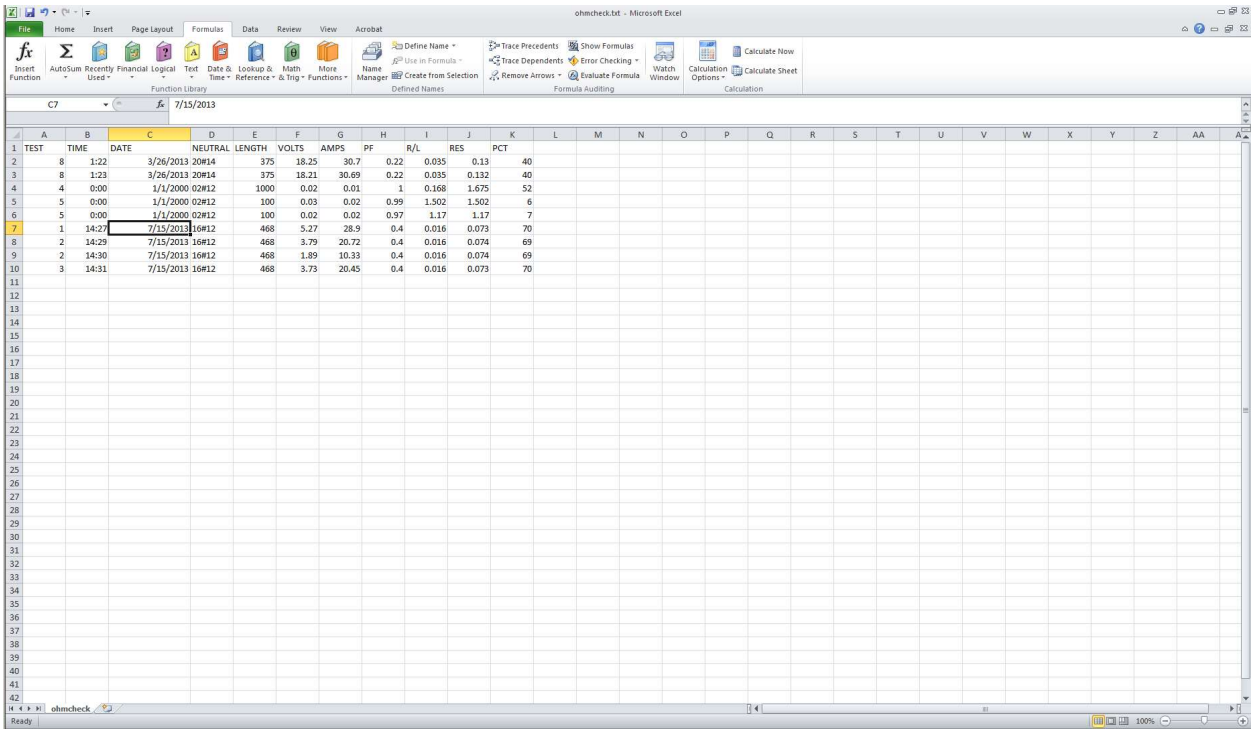


Figure 8

Maintenance Procedures

Prior to testing with the Ω-Check, the magnetic mating surfaces of the current probe should be inspected. These surfaces should be free of dirt, rust or other foreign matter. If these surfaces are rusted, they should be cleaned gently with a soft, oiled cloth.

The panel may be cleaned with damp, soft cloth. Take care not to scratch the meter or display faces. Do not use a cleaning agent of any kind.

Periodically, proper operation of the Ω-Check should be verified by comparison of the POWER SUPPLY OUTPUT with the NEUTRAL MEASUREMENTS display as follows.

1. Connect the Hot-line clamp to the local test lead (10') and connect the other end to the LOCAL NEUTRAL CONNECTION

2. Connect the Hot-line clamp to second 10' lead to the REMOTE NEUTRAL CONNECTION.

3. With the clamps separated, setup a test (strands, AWG and length can be arbitrary for this test) and increase the OUTPUT ADJUST until the panel voltmeter indicates 25 Volts and start the test. The voltage shown in the LCD display should agree with the panel voltmeter.

4. Reduce the OUTPUT ADJUST to zero and stop the test. Connect the hot-line clamps together and setup another test (as with the previous step, strand, AWG and length are arbitrary). Increase the OUTPUT ADJUST until the panel ammeter indicates 28 Amperes and start the test. The current shown in the LCD DISPLAY should agree with the panel ammeter.

If these measurements do not agree, repair and or calibration of the unit may be required.

Periodically the test leads should be inspected and tested with an ohm-meter. Verify continuity of each conductor as well as isolation between conductors and from the connector shell.

There are no internal, user serviceable components in the unit.

Troubleshooting

If a problem develops during the operation of the Ω-Check, refer to the following troubleshooting information.

1. NEUTRAL MEASUREMENTS display does not light.

- Check POWER ON/OFF switch.
- Check FUSE.
- Check input power source.

Service Instructions

If factory service is required or desired, contact High Voltage, Inc. for return instructions.

Provide High Voltage, Inc. with the serial number, nature of the problem or service desired, return address, your name, and where you can be reached should the factory need to contact you.

Pack the equipment appropriately to prevent damage during shipment. It is suggested that the packaging material the unit is shipped in from the factory be retained for use in shipping the unit to the factory should the need arise.

SECTION 4

OCK-30 Specifications

Electrical:

Input power:	OCK-30: 1800VA, 120V@60Hz, 15A max. OCK-30F:1800VA, 230V@50-60Hz, 8A max.
Output power:	0-48VAC, 30A max.
Current probe input:	1000:1, 0-140mA ($140A_{RMS}$)max
Accuracy(V, I):	±1%
Accuracy (phase)	±1.5°

Environmental:

Temperature (operating):	0 to 45°C
(storage):	-20 to 70°C
Humidity:	0-85% (non-condensing)

Dimensions:

Test box:	20" W x 12" D x 19" H
Cable reel (ea.):	12" W x 11.5" D x 14.75" H

Weight:

Test box:	OCK-30: 55 lbs. OCK-30F: 69 lbs
Cable reel (ea.):	23 lbs

Warranty

TERMS AND CONDITIONS AND LIMITED WARRANTY Rev. 102113

High Voltage, Inc., 31 County Route 7A, Copake, NY USA 12516
Phone: (518) 329-3275 Fax (518) 329-3271 E-mail: factory@hvinc.com

THESE TERMS AND CONDITIONS OF SALE AND LIMITED WARRANTY OF HIGH VOLTAGE, INC. ("High Voltage") SHALL BE GOVERNED BY AND CONSTRUED ACCORDING TO THE INTERNAL LAWS OF THE STATE OF NEW YORK, USA, WITHOUT GIVING EFFECT TO ITS CONFLICT OF LAWS PROVISIONS. THE RIGHTS AND OBLIGATIONS OF ALL PARTIES AND ALL PERSONS OR ENTITIES CLAIMING HEREUNDER SHALL NOT BE GOVERNED BY THE PROVISIONS OF THE 1980 U.N. CONVENTION ON CONTRACTS FOR THE INTERNATIONAL SALE OF GOODS.

1. **ACCEPTANCE.** All orders become effective only when accepted by High Voltage's written order acknowledgment at Copake, New York, USA. Unless modified in writing by an authorized representative of High Voltage, or modified in High Voltage's Quotation or order Acknowledgment, these Terms and Conditions and Limited Warranty shall solely control Purchaser's order. High Voltage expressly rejects any additional or different provisions, terms or conditions proposed by Purchaser at any time.

2. **SCHEDULING.** High Voltage's shipping date specified in High Voltage's quotation or purchase order acknowledgment is approximate and High Voltage shall use reasonable commercial efforts to effect timely shipment. Furthermore, High Voltage shall not be liable for any delay in the performance of orders or contracts or in the delivery or shipment of goods or for any damages suffered by Purchaser by reason of such delay when such delay is, directly or indirectly, caused by, or in any manner arising from Purchaser's fault, fires, floods, accidents, riots, acts of God, war, governmental interference or, embargoes, strikes, labor difficulties, shortage of labor, fuel, power, materials or supplies, transportation delays, or any other cause or causes (whether or not similar in nature to any of these hereinbefore specified) beyond the control of High Voltage.

3. **CANCELLATIONS.** Prior to shipment, Purchaser may request cancellation or delayed delivery of an order or part thereof, but such shall be conditioned upon written consent of High Voltage and upon payment to High Voltage of cancellation or delayed delivery charges to be determined by High Voltage.

4. **SALE AND DELIVERY.** Unless otherwise agreed in writing, sale and delivery of the goods hereunder shall be made EXW or FCA (Incoterms® 2010) at High Voltage's option, High Voltage's dock at Copake, New York, USA, at which time all risk of loss or damage shall pass to Purchaser. All shipments and packaging shall be made in the manner determined by High Voltage, unless otherwise requested by Purchaser, in which case any resultant additional changes and expenses shall be paid by Purchaser.

5. **TAXES.** Any and all sales, use, excise and similar taxes, and duty and all other charges levied or imposed by governmental authority, foreign and domestic, upon any goods sold or contracted to be sold shall be paid by Purchaser and added to the purchase price unless appropriate tax exemption certificates are supplied to High Voltage in form satisfactory to High Voltage.

6. **PAYMENTS.**

a. All payments shall be in US Dollars without discount unless otherwise specified in High Voltage's order acknowledgment. Credit card payments are accepted only if specified in High Voltage's order acknowledgment.

b. Terms of payment are net thirty (30) days from date of invoice, unless otherwise agreed by High Voltage in its order acknowledgment. Delinquent payments are subject to a service charge on the unpaid balance from invoice date equal to the lower of 1-1/2% per month or the maximum rate permitted by law until all amounts are paid in full. If the financial responsibility of Purchaser becomes unsatisfactory to High Voltage for any reason, or if Purchaser has been in default to High Voltage under any order, High Voltage may require full payment in cash before shipment of goods.

c. If Purchaser so requests and makes arrangements prior to shipment which meet High Voltage's full satisfaction, High Voltage in its discretion may accept irrevocable letters of credit in its favor issued by a United States bank which is satisfactory to High Voltage.

7. **INFRINGEMENT, ETC.** On goods manufactured to Purchaser's specifications, Purchaser shall and does indemnify and hold High Voltage harmless against any claims, damages, liabilities, costs and expenses (including attorneys' fees) arising out of or resulting from actual or alleged infringement of patent, copyright, trademark or other proprietary rights, or claim of unfair trade or unfair competition arising from or occasioned by the use, possession, sale or delivery of any such goods sold by High Voltage.

8. **REPRODUCTION RIGHTS.** Drawings, specifications, reports, photographs and other data relating to all orders and all proprietary rights and interests therein and the subject matter thereof shall be and remain the property of High Voltage. Purchaser agrees that it shall not use High Voltage's drawings, specifications or other materials covered by this order, or any similar article from any other source, or reproduce the same or otherwise appropriate them, without the prior written authorization of High Voltage.

9. **LIMITED WARRANTY.**

a. High Voltage warrants to the original Purchaser of any new goods that the goods are free from defects in material and workmanship under normal use and service for a period of one (1) year from the date of shipment by High Voltage. The obligation of High Voltage under this Limited Warranty is limited, in High Voltage's exclusive option, to repair, replace with new or reconditioned parts or issue credit for goods, parts or materials which prove to be defective. Costs incurred by Purchaser for labor or other expenses to repair or replace such goods, parts and/or materials shall be the sole responsibility of Purchaser. High Voltage shall not be responsible for any damage or lack of performance resulting from: (i) defects due to accident, negligence, alteration, modification, faulty installation, abuse or misuse, whether by Purchaser, Purchaser's agents or employees, or by others than High Voltage (ii) attempted or actual dismantling, disassembly, service or repair by any person, firm or corporation not specifically authorized in writing by High Voltage, or (iii) defects caused by or due to handling by carrier, or incurred during shipment, transshipment or other move.

b. High Voltage expressly disclaims any warranty whatsoever of (i) consumables, and of (ii) parts, components, software (including but not limited to object code and source code and software user instructions), accessories, and materials not prepared, compiled or manufactured by High Voltage, and Purchaser must deal directly with such other supplier. High Voltage may elect to assist Purchaser in settling such claim against such other supplier, but any such assistance shall not prejudice High Voltage's position as to its own liability.

c. Compliance with the following Limited Warranty Claim Procedure is a condition precedent to the obligation of High Voltage under this Limited Warranty:

i. Purchaser must notify High Voltage in writing as soon as is reasonably

possible, but within the applicable warranty period, of any alleged defect in material, workmanship, or operation of any goods covered under this Limited Warranty. Such notice must describe in detail the defect, any and all defective parts, and the alleged cause of the defect. No goods may be returned to High Voltage without High Voltage's prior written permission, which permission may be withheld by High Voltage in its sole discretion.

ii. At the exclusive option of High Voltage, Purchaser may be directed in writing to dismantle the goods at the Purchaser's cost and expense and ship the goods prepaid to High Voltage (refer to "Returns" Section 10 for provisions regarding the return of any goods to High Voltage). If High Voltage elects to inspect the goods at Purchaser's site, and to repair, replace, or ship the defective goods to High Voltage's factory, Purchaser, at its own cost and expense, shall provide the facilities for such work as needed to inspect and evaluate and possibly repair/replace the goods. If inspection discloses that the defect is not one for which High Voltage is liable, then Purchaser shall promptly reimburse High Voltage for all expenses incurred.

iii. Upon receipt of the defective goods, or following access to the same, High Voltage shall inspect and evaluate the goods and determine the validity of Purchaser's claim.

iv. The validity of any warranty claim, Purchaser's compliance with the Limited Warranty and Limited Warranty Claim Procedure, and the obligation to replace, repair, or issue credit for any goods are solely and exclusively to be determined by High Voltage and any determination shall be final and binding.

d. THIS WARRANTY IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES, STATUTORY OR EXPRESSED OR IMPLIED ON THE PART OF HIGH VOLTAGE, INCLUDING THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT; FURTHERMORE, HIGH VOLTAGE MAKES NO WARRANTY REGARDING NON-INTERRUPTION OF USE OR SOFTWARE FREEDOM FROM BUGS. HIGH VOLTAGE NEITHER ASSUMES NOR AUTHORIZES ANY OTHER PERSON, FIRM, OR CORPORATION TO ASSUME ANY LIABILITY OR OBLIGATION IN CONNECTION WITH THIS SALE OR LIMITED WARRANTY ON HIGH VOLTAGE'S BEHALF AND PURCHASER ACKNOWLEDGES THAT NO REPRESENTATION EXCEPT THOSE MADE HEREIN HAS BEEN MADE TO PURCHASER.

10. **RETURNS.** No goods may be returned to High Voltage without High Voltage's prior written permission, which permission may be withheld by High Voltage in its sole discretion. Any request for return authorization must be in writing and include, as applicable, model number, serial number, part number, reason for return, alleged defect, and apparent cause of alleged defect. Except as specifically provided in Section 9 Limited Warranty, if High Voltage consents to return of goods: (a) all return shipments are to be via prepaid freight and with all other charges prepaid, (b) if goods are returned to High Voltage within sixty (60) days from the date of original shipment for reasons other than an error by High Voltage in filling the Purchaser's order, Purchaser shall only be entitled to receive a credit in an amount equal to the payment received by High Voltage for the goods minus (i) handling charges, and (ii) a restocking fee determined solely by High Voltage which shall not exceed twenty five percent (25%) of the invoiced amount, and (c) if goods are returned to High Voltage after sixty (60) days from the date of original shipment for reasons other than an error by High Voltage in filling the Purchaser's order, Purchaser shall only be entitled to receive a credit in the amount equal to the payment received by High Voltage for the goods minus (x) a handling fee, and (y) a restocking fee in excess of twenty five percent (25%) which shall be determined by High Voltage.

11. **SECURITY INTEREST.** In order to induce High Voltage to ship goods without full payment, Purchaser grants a security interest to High Voltage in any and all of Purchaser's right, title and interest in the goods, and Purchaser agrees to comply with any reasonable request of High Voltage to perfect such security interest. Purchaser hereby further authorizes High Voltage to perfect High Voltage's security interest in said goods and consents to filing one or more financing statements without the signature of Purchaser.

12. **ARBITRATION.** Any controversy arising out of or relating to this document, or any breach thereof, including, without limitation, any claim that this document is voidable or void, shall be submitted to final and binding arbitration before, and in accordance with, the Commercial Rules of the American Arbitration Association then in effect, and judgment upon the award may be entered in any court have jurisdiction thereof; provided, however, that this clause shall not be construed to limit any rights which High Voltage may have to apply to any court of competent jurisdiction for equitable, injunctive or provisional relief. This arbitration provision shall be deemed self-executing, and in the event that either party fails to appear at any properly noticed arbitration proceeding, an award may be entered against such party notwithstanding said failure to appear. Such arbitration shall be conducted before a single arbitrator under the aegis of the American Arbitration Association in Columbia County, State of New York. The arbitrator shall have the authority to award expenses to the successful party.

13. **LIMITATION OF LIABILITY.** TO THE MAXIMUM EXTENT PERMITTED UNDER APPLICABLE LAW, AND NOTWITHSTANDING ANYTHING ELSE IN THIS DOCUMENT OR OTHERWISE, INCLUDING THAT HIGH VOLTAGE WAS WARNED THAT DAMAGES WOULD OCCUR OR WERE LIKELY TO OCCUR, HIGH VOLTAGE SHALL NOT BE LIABLE WITH RESPECT TO ANY SUBJECT MATTER OF THIS DOCUMENT UNDER ANY CONTRACT, NEGLIGENCE, STRICT LIABILITY OR OTHER LEGAL OR EQUITABLE THEORY FOR (i) ANY AMOUNTS IN EXCESS IN THE AMOUNT PAID TO HIGH VOLTAGE FOR THE PARTICULAR GOODS OR PART THEREOF WHICH GAVE RISE TO THE APPLICABLE CAUSE OF ACTION OR CLAIM, OR (ii) ANY INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, LOST PROFITS OR LOST OR CORRUPTED DATA, OR (iii) COST OF PROCUREMENT OF SUBSTITUTE GOODS, SOFTWARE, TECHNOLOGY OR SERVICES. HIGH VOLTAGE SHALL HAVE NO LIABILITY FOR ANY FAILURE OR DELAY DUE TO MATTERS BEYOND ITS REASONABLE CONTROL.

14. **SEVERABILITY.** These Terms and Conditions and Limited Warranty are the entire understanding between Purchaser and High Voltage with respect to the subject matter hereof and supersede all prior agreements, dealings and negotiations. No modification, alteration or amendment shall be effective unless made in writing and signed by a duly authorized representative of High Voltage. No waiver of any breach hereof shall be held to be a waiver of any other or subsequent breach. Nothing contained in this document shall be construed as requiring the commission of any act contrary to law. Whenever there is any conflict between any provision of this document and any present or future statute, ordinance or regulation contrary to which the parties have no legal right to contract, the latter shall prevail, but in such event the provision of this document thus affected shall be curtailed and limited only to the extent necessary to bring it within the requirements of the law. In the event that any part, article, section, paragraph, sentence or clause of this document shall be held to be indefinite, invalid or otherwise unenforceable, the entire document shall not fail on account thereof, and the balance of the document shall continue in full force and effect. If any arbitration tribunal or court of competent jurisdiction deems any provision hereof (other than for the payment of money) unreasonable, said arbitration tribunal or court may declare a reasonable modification thereof, and this document shall be valid and enforceable, and the parties hereto agree to be bound by and perform the same as thus modified.

15. **BASIS OF BARGAIN**. Each party recognizes and agrees that the warranty disclaimers and liability and remedy limitations in this document are material, bargained for bases of their agreement and that they have been taken into account and reflected in determining the respective obligations of the parties.

[End]

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Returned Material

If for any reason it becomes necessary to return any equipment or materials to High Voltage, Inc., the Service Department of High Voltage, Inc. must be notified, and authorization received, prior to the shipment of the equipment. When notified, the following information must be provided:

MODEL:
SERIAL NO:
PART NO:
REASON FOR RETURN:
SUSPECTED DEFECT:
CAUSE OF DEFECT:

With the above information provided, High Voltage, Inc. will determine if the return of the equipment is appropriate. If deemed appropriate, a Return Authorization Number will be issued. At that time, the Purchaser will be instructed how to mark and return the equipment.

The above procedure must be adhered to in order to ensure prompt service. No equipment should be returned without the prior knowledge and authorization of High Voltage, Inc.