

# *Fault Wizard*<sup>TM</sup>

## Owner's Manual

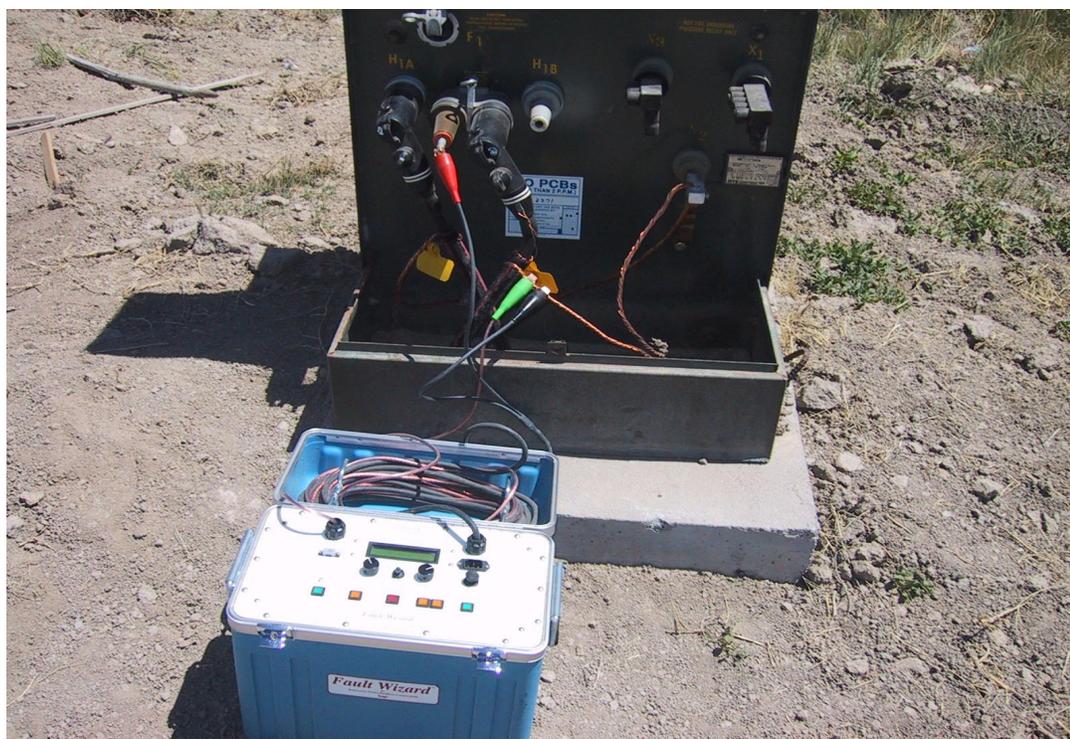
Innovative Utility Products Corporation

Made in the USA

Model No. IUPFW1

Serial Number: \_\_\_\_\_

**Read This Manual Before Operation!**



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# Safety Rules and Issues



## Warnings

**Read the ENTIRE Owner's Manual before operating! Updates to this manual can be found at <http://www.iupcorp.com/iupcorp/downloads.htm>.**

**Failure to follow all instructions may result in electric shock, fire, serious injury or death. Save these instructions with the Fault Wizard for reference by all operators.**

**Follow all local, State, Federal (Country) laws and codes that govern working with High Voltage equipment such as the Fault Wizard. It is highly recommended that a formal Standard Operating Procedure (SOP) be established for the use of the Fault Wizard in your specific environment following all government regulations and your internal company rules and regulations for such use.**

**Danger- HIGH VOLTAGE delivered at output connectors! The *Fault Wizard* produces a high-voltage electrical discharge that is potentially LETHAL. Only personnel trained in the safe handling and operation of high voltage electrical devices should use this device. Do not allow persons unfamiliar with the Fault Wizard to operate.**

**Wearing properly rated high-voltage electrical gloves is mandatory while operating this device!**

**Inspect output cables before use. DO NOT USE if damaged insulation is present.**

**DO NOT USE if the control panel or blue case is cracked or contains holes that will allow potentially combustible material inside the unit such as coal dust. Use of the unit under such conditions could lead to an EXPLOSIVE situation!!!**

**This device creates sparks. Therefore, for environments where explosive or combustible gas is possible, gas checks should be performed before, during, and after using the Fault Wizard.**

**To avoid the possibility of electrical shock, always remember to turn off the Fault Wizard (Power toggle switch) before connecting or disconnecting the cables or handling the clips.**

**High voltage output is from the Red clip. Keep all clips connected to a cable under test, the cable cleats or to each other. High voltage can be present at the red clip and you should always maintain knowledge of all three clips positions and**

connections. Clip boots are for identification purposes only and are NOT rated for high voltage. DO NOT AT ANY TIME attempt to handle the clips or boots while the Fault Wizard is ON.

Before closing the lid, turn the Power toggle switch to off, turn the Voltage knob to zero, and turn the Mode knob to HV TDR. Please clip all three clips to the cable cleats to insure the HV output (red clip) is shorted to HV return (black clip) and chassis ground (green clip).

Inform everybody in the area to avoid body contact with earthed or grounded surfaces such as pipes, transformers, fences, cables, equipment (including the Fault Wizard), etc. to avoid the possibility of electrical shock from step (ground return) currents. For the operator, wearing the mandatory high-voltage electrical gloves while operating the unit will also eliminates this risk. Keep children and bystanders away while operating this device.

Do not expose the Fault Wizard to rain or wet conditions. Water entering or pooling on the unit increases the risk of electric shock or equipment damage.

The Fault Wizard contains high-energy capacitors, electrical shock is possible even if the Fault Wizard is unplugged and off! Only qualified personnel should attempt to repair the Fault Wizard! If service is required, return the unit to the factory only. No field serviceable parts are inside the unit. Danger of electrical shock exists if removed from the case. See return information located elsewhere in this Owner's Manual.

To reduce the possibility of electrical shock, always make sure the Fault Wizard is unplugged and turned off while cleaning (see Maintenance Section).

### Fault Wizard specifications-

Output Voltage	0-10,000 Volts
Output Current	12.5mA for Hi-pot Mode
Output Energy	350 Joules (Max.)
Input Voltage	24 VDC (internal batteries or 24 VDC Input Port)
Input Voltage for battery charger	100-240 VAC
Input Frequency for battery charger	50-60 Hz
Input Current for battery charger	0.80 - 0.35A
Weight	24 kg (53 lbs.)
Size	25.4 x 45.7 x 48.3 cm (10" x 18" x 19")

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## Introduction

Congratulations on your purchase of the *Fault Wizard* primary cable fault locator. The *Fault Wizard* requires no user assembly and is ready for setup and operation. Some of the significant qualities of the *Fault Wizard* in comparison to all other Arc-Reflection (TDR/thumper) fault location systems are its relatively small size, low weight, and ease of operation. These qualities make it easy to hand carry to the needed location for quick and precise fault location. Due to the automated nature of the *Fault Wizard*, training for its operation is quick and easy.

The basic method behind any Arc-Reflection system is to produce an arc at the fault location of a de-energized cable and to bounce a TDR pulse off of the arc in order to calculate how far down the cable the fault is located.

The *Fault Wizard* is designed to thump through multiple transformers on a de-energized circuit where a fault has occurred. You may thump from the open point, switchgear, or an overhead riser. Since the *Fault Wizard* will give you the distance to the fault location, you will be able to quickly identify and isolate the faulted cable between two transformers, thus restoring service quickly. After the cable has been isolated, the Hi-Pot Mode can be used to test the isolated cable to confirm (before re-closure) that the cable contains the fault. Even though the *Fault Wizard* is compact and lightweight it still delivers almost as large a pulse of energy as many thumpers associated with TDR systems. The discharge delivered at the cable fault can be heard above ground with common listening devices used by the electrical utility industry and heard quite often with just your own ears. This gives the *Fault Wizard* a stand-alone capability when pinpointing the location of a fault after the fault's general location has been determined. The Cycle Mode of operation allows repeated thumping (every six seconds at full voltage) for pinpointing the fault.

## Setup

### Initial Inspection

Each *Fault Wizard* has been inspected for its quality of construction and operation. If you have any problems with your *Fault Wizard*, please refer to the Repair and Warranty sections in this manual.

### Operating Conditions

Although the *Fault Wizard* is battery operated, it requires access to 100-240 VAC electrical power for battery recharging. Always place the *Fault Wizard* on a flat stable surface. The *Fault Wizard* will operate properly over normally encountered temperature ranges. **Restrain your *Fault Wizard* while it is in your vehicle to prevent it from sliding into hard objects or being bounced around.** The *Fault Wizard* is constructed to be durable, although, excessively rough handling can damage it and **voids the warranty.**

### *Wet Environment*

Although the *Fault Wizard* is designed to be internally shielded from the outside environment, the *Fault Wizard* is **not** “water proof”. You should think of the *Fault Wizard* as being “splash resistant”. Minimum exposure of the *Fault Wizard* to a wet environment is highly recommended. If your *Fault Wizard* is exposed to a wet environment, then dry the *Fault Wizard* **completely** with a towel as soon as possible. The cables should be unwrapped from the lid and completely dried. **DO NOT** just shut the lid with wet cables and panel because the water will pool on the panel and greatly increase the chance of water entering into the unit. Failure of the unit because of water damage **voids the warranty!**

### **Caution -**

Although the *Fault Wizard* is designed to be internally shielded from the outside environment, to avoid the possibility of electrical shock, never expose the *Fault Wizard* to a wet environment.

### Grounding Instructions

For most electrical products, grounding provides a path of least resistance to prevent the possibility of electrical shock. The *Fault Wizard* is provided with a copper braid "grounding cord" attached to an alligator clip connector (green) at one end and the *Fault Wizard's* internal metal frame at the other end. The alligator clip connector **must** be connected to a solid and stable ground before the *Fault Wizard* is turned on. All local codes and ordinances should be followed when grounding the *Fault Wizard*.

### **Caution -**

Improper grounding of the *Fault Wizard* can result in the risk of electrical shock and improper operation of the instrument! Check with a qualified electrician if you are in doubt as to whether a power source or grounding object is properly grounded.

## **Operation**

The *Fault Wizard* is operated from the panel of the instrument. There are two cables, two knobs, six buttons, a toggle switch, three receptacles, and a LCD display on the *Fault Wizard*. Each of these will be discussed in detail below.

### Cables

The HV Output cable provides the output for both the high voltage and the TDR pulses. The ground cable is used to ground the internal frame of the *Fault Wizard* to an external ground. An alligator clip (green) is provided at the end of the ground cable. **The ground cable must be clipped to a well-grounded object before connecting the HV Output cable or before the *Fault Wizard* is turned on.** Attached to the end of the HV Output

cable is two alligator clips with rubber boots over the clips. **The clip with the red boot should only be attached to the center conductor of the power cable under test. The clip with the black boot should only be attached to the concentric neutrals of the power cable under test.** For ease of storage and use, the cables should be held together when wrapping them around the cable cleats inside the lid and all three clips should be clipped to the cleats.

**Warning-** 

To avoid the possibility of electrical shock, always remember to turn off the *Fault Wizard* before connecting or disconnecting the cables.

### Power Switch

The Power toggle switch is used to turn on the main power to the instrument. Turning the Power switch off returns the *Fault Wizard* to a safe mode. In order to conserve the energy stored in the batteries, turn the Power switch off when the *Fault Wizard* is not in use.

### Knobs

The Voltage knob adjusts the HV power supply voltage (0-10 kV). The Mode knob selects the *Fault Wizard's* operating mode. There are three modes of operation: (1) HV TDR, (2) Cycle, and (3) Hi-Pot. **It is safe practice to turn the Voltage knob to zero after you are finished using the instrument or before changing into Hi-Pot Mode.**

### *HV TDR Mode*

The *Fault Wizard* is used in HV TDR Mode to activate the automated Arc-Reflection system in order to determine the distance to the fault. By pressing the HV Start button in HV TDR Mode, the HV capacitor in the *Fault Wizard* is charged to the value set by the Voltage adjust knob. Next, by pressing the Thump button, the energy stored in the HV capacitor is discharged into the cable under test while the TDR system is simultaneously activated. In addition, the *Fault Wizard* is returned to an unenergized state. Press the Stop/Ground button at any time to stop the test and return the instrument to an unenergized state.

### *Cycle Mode*

The *Fault Wizard* is used in Cycle mode (with listening equipment) to pinpoint a fault. By pressing the HV Start button in Cycle mode, the *Fault Wizard* starts to charge and discharge in a cyclic fashion. The Voltage knob setting, with a maximum of 6 seconds at full voltage, determines the cycle time. If the cable under test does not break down from a discharge at any time during cycle thumping, the cycle will stop. However, the capacitor will still be at the set charge voltage. If this occurs, either increase the voltage setting on the Voltage adjust knob until the cable breaks down and cycle thumping resumes or press the Stop/Ground button. Press the Stop/Ground button at any time to

stop the cycle thumping and return the instrument to an unenergized state. The energy of the pulse delivered to the power cable is dependent on the charge voltage of the internal capacitor when the *Fault Wizard* is discharged. Energy of 350 J is stored when the capacitor is charged to 10 kV.

### *Hi-Pot Mode*

The *Fault Wizard* is primarily used in Hi-Pot mode to confirm that an isolated section of cable actually has the fault. By pressing the HV Start button in Hi-Pot mode, the DC output voltage will try to rise to the voltage set by the Voltage Adjust knob. Therefore, good practice is to set the Voltage Adjust knob to zero before pressing the Start button. The hold-off voltage of the cable can be determined by raising the DC output voltage gradually by use of the Voltage Adjust knob. The voltage displayed by the LCD meter will not rise above the breakdown voltage of the cable. You will usually see a sudden drop in voltage on the meter when the cable breakdown voltage is reached. When desired, press the Stop/Ground button to stop the test and return the instrument to an unenergized state.

### Buttons

#### *HV Start*

The green HV Start button turns on the HV power supply and illuminates the red LED on the control panel. In HV TDR Mode or Cycle Mode, the capacitor is charged to the voltage level set by the Voltage adjust knob. In Hi-Pot Mode, the DC output voltage tries to rise to the voltage set by the Voltage adjust knob. **(Note: for newer models, a “Zero Start” feature has been added. The Voltage knob must be set to zero before the HV Start button is enabled.)**

#### *Thump*

In HV TDR Mode, the yellow Thump button fires the *Fault Wizard* (HV discharge coupled with a TDR pulse). The *Fault Wizard* is then returned to an unenergized state.

#### *Stop/Ground*

The red Stop/Ground button turns off the HV power supply and internally grounds the HV capacitor through a dump resistor and internally grounds the output (red booted) lead. The red LED also ceases to illuminate. In addition, holding the Stop/Ground button down for three seconds changes the LCD Display to the following:

STORE WAVEFORM IN MEMORY  
CANCEL-GO TO MAIN SCREEN

Pressing the Stop/Ground button a second time chooses the selection made and returns the LCD Display to the Main screen.

### *Cable Vp (Up and Down)*

The two Cable Vp buttons (Up and Down) are used to change the velocity of propagation (Vp) setting for the cable under test. In addition, the Up and Down buttons are used to scroll through the selections in the Store Waveform In Memory mode.

### *LV TDR*

The green LV TDR button is used to fire a low-voltage TDR pulse down the cable (without a HV discharge) to determine the distance to an open (often used to determine the full length of the cable under test). The LV TDR button is deactivated when the HV power supply is on (red LED illuminated).

### Data Port

The Data Port receptacle is used to download waveform data to a computer by utilization of the *Fault Wizard* Software. The receptacle is a standard 9-pin D-Subminiature connector. A compatible communication cable is provided with the *Fault Wizard*.

### Battery Charger

The *Fault Wizard* uses two 12 VDC, 8.5 AH rechargeable lead-acid batteries. On a full charge they should allow the *Fault Wizard* to be charged and discharged hundreds of times before recharging is required. The battery voltage is displayed on the meter. When the voltage reads below 22 volts for more than 3 seconds, the battery voltage will flash on the LCD Display. The batteries will need to be recharged soon. Charging is accomplished using a standard equipment power cord (supplied) and a single-phase 100-240 VAC power outlet. While charging the batteries, the battery voltage on the LCD Display will slowly increase. The *Fault Wizard* does NOT need to be on to charge the batteries. Fully recharging completely depleted batteries takes about 6 hours. Recharging the batteries for long periods of time does not hurt the batteries. **In order to protect the battery charger, the *Fault Wizard* should not be operated while charging the batteries.** A 24 VDC output auxiliary Battery Pack or 24 VDC output AC Pack can be purchased to allow continued field use if the batteries run low or fail. Eventually, the internal batteries, like all batteries, will fail and you will have to send your *Fault Wizard* back to our Repair Center for replacement of the batteries (see Maintenance section). **(Note: for newer models, the Battery Charger is mounted inside the lid between the cable cleats. A cord with a connector at the end runs from the Battery Charger to the input port on the panel. The AC input receptacle for the Battery Charger is mounted on the outside on top of the lid by the handle).**

### *Lead Acid Batteries*

As mentioned earlier, the *Fault Wizard* uses two internal sealed lead-acid batteries. Unlike Ni-Cad batteries, lead-acid batteries **DO NOT** like to be deep discharged. Deep discharging the batteries will decrease the energy storage capacity and life of the batteries. To avoid deep discharging the batteries, do not continue to operate the *Fault Wizard* after

the battery voltage begins flashing on the LCD Display. At this point, the batteries need to be recharged or an external 24 VDC source (Battery or AC Pack) needs to be utilized. Innovative Utility Products Corp. highly recommends purchasing one of the auxiliary packs if the *Fault Wizard* is going to be used for cycle thumping. In addition, if the *Fault Wizard* power is left on for an extended period of time and the batteries completely discharge, the batteries will die and quite often cannot be recharged. If the batteries are dead, plugging in the *Fault Wizard* to recharge the batteries will not accomplish recharging the batteries. For this situation, the battery voltage on the LCD Display will show about 28 volts because the batteries have “opened up” and are not drawing current, therefore, not pulling the charger voltage down. By the way, **batteries are not covered by the warranty! Remember to turn off the power to your *Fault Wizard* when you are finished to avoid killing your batteries!**

### 24 VDC Input

The Aux. 24 VDC Input receptacle is used to provide 24 DC auxiliary power to the *Fault Wizard*. A compatible power cord is provided with the purchase of the auxiliary Battery Pack or AC Pack.

### LCD Display

On power up, the LCD Display shows the following:

STARTUP DIAGNOSTIC TEST  
RESULT: PASS

The result should be PASS. If the result is FAIL, a message stating to contact the factory is shown. The LCD Display then momentarily shows the following:

TDR Version 8.4.2

or what ever version number your *Fault Wizard* contains at present time. The LCD Display then shows momentarily the following:

NORMAL CABLE  
IMPEDANCE SELECTED

or possibly LOW instead of NORMAL, depending on the last setting used. The difference in the two settings will be discussed at the end of this section. Display then shows momentarily the following:

15FTCL

or possibly 40FTCL, depending on whether your *Fault Wizard* has long cable leads or short cable leads. Finally, the LCD Display shows the Main Screen, which looks similar to the following:

CV:00.0KV BV:24.2V  
RD:?????F RT:?? VP.513

where CV, BV, RD, RT, and VP indicate the HV power supply's charge voltage, battery voltage, reflection distance, reflection type, and velocity of propagation setting, respectively.

For typical Arc-Reflection scenarios (HV TDR), the reflection distance (RD) displayed should be the distance to the fault (arc) and the reflection type (RT) should show SH for short (since an arc looks like a short to the TDR system). For resistive arc conditions (not flashing from center to outer conductor), RT will show a blinking RF indicating a resistive fault and RD will give the distance to the open point when operating in Normal Cable Impedance mode. Under Low Cable Impedance mode, HV TDR always tries to yield the distance to the arc or short. If the condition is a pre-short or resistive, then RT will show a blinking SH. LV TDR always looks for an open point and RT always shows OP. The velocity of propagation (VP) is the fraction of the speed of light the signal travels up and down the cable. Typical values for power cables will range between .4 and .6. Refer to the list of Vp values for various cable types found in Table 1 later in this Manual.

Calibration of the Vp for any specific cable type can easily be accomplished by use of the LV TDR function on a length (spool) of cable if the length of cable is known. Hook up the HV Output cable as described above in the Cables section. Next, turn on the Power switch to the Fault Wizard. Now, press the LV TDR button. As you can see on the LCD Display, you should get a value for the reflection distance (RD). Next, press the Up or Down button for the Cable Vp until the reflection distance shows the value of the length of cable under test. The value of the velocity of propagation setting (VP) is the Vp value for that type of cable. You should note that no high voltage was ever applied to the cable under test.

### Waveform Storage

Holding down the Stop/Ground button for three seconds changes the LCD Display to the following: We will refer to this screen as the beginning screen.

STORE WAVEFORM IN MEMORY  
CANCEL-GO TO MAIN SCREEN

Pressing the Up button changes the display to read the following:

MEMORY NUMBERS 01 TO 08

Pressing the up button again changes the display above to the same but with 09 to 16. Since eight waveforms are stored each time the TDR system is activated (Thump or LV TDR), you can select between 01 to 08, 09 to 16, ..., and 105 to 112. Therefore, you can store fourteen activations (eight waveforms per activation) of the TDR system.

You can also press the Down button to move backwards. For example, in order to get to the CLEAR ALL MEMORY NUMBERS screen from the beginning screen, just push the Down button once. The LCD Display will show the following:

CLEAR ALL MEMORY NUMBERS

Pressing the down button one more time changes the display to read the following:

SWITCH TO LOW  
CABLE IMPEDANCE

Pressing the down button one more time changes the display to read the following:

SWITCH UNITS TO METERS

Pressing the down button one more time changes the display to read the following:

MEMORY NUMBERS 105 TO 112

**In order to select any screen and go back to the Main Screen, press the Stop/Ground button once. In order to NOT select anything and go back to the Main Screen, make sure you are on the following screen and press the Stop/Ground button.**

STORE WAVEFORM IN MEMORY  
CANCEL-GO TO MAIN SCREEN

Assuming that you chose to store the next group of waveforms in the first eight memory slots, the Main screen will look something like the following:

CV:00.0KV BV:24.2V M01  
RD:?????F RT:?? VP.513

As you can see, the M01 was added to the screen to indicate that the *Fault Wizard* is armed for waveform storage in the first four non-volatile memory slots. As soon as the TDR system is activated, the M01 will disappear. Non-volatile memory means that the waveforms will not be erased if you turn off the *Fault Wizard*. The only way to erase the memory slots is to choose the CLEAR ALL MEMORY NUMBERS selection. Therefore, selection of any one of the fourteen memory groups (eight waveforms per group) will display one of the following: M01, M09, ..., or M105.

Most of the time, you will want to operate the *Fault Wizard* under the NORMAL CABLE IMPEDANCE mode. However, for some cable types such as “mining cable” and “feeder cable” (such as 750 or 1000 MCM), the LOW CABLE IMPEDANCE mode will work better. Low impedance cable attenuates the waveforms to the point that this special mode of operation is sometimes necessary.

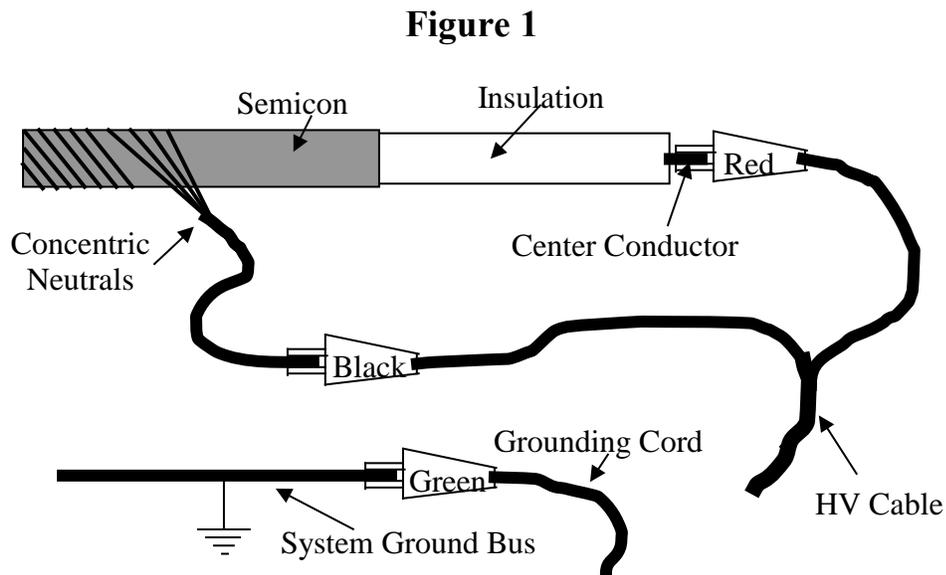
## Test Procedure

### Faulted Cable Section Isolation

1. Open the top of the *Fault Wizard* case in order to gain access to the control panel.
2. Ground the *Fault Wizard* as described in the Setup section in this manual.
3. Connect the *Fault Wizard* to the de-energized cable as shown in Figure 1. The red alligator clip attaches to the center conductor and the black clip to the concentric neutrals. The case ground should be connected to the system neutral. **Note:** The cable you are connecting the *Fault Wizard* to should be tested for voltage to insure the cable is de-energized.

**Warning -** 

**High voltage output is from the Red clip. Keep all clips connected to a cable under test, the cable cleats or to each other. High voltage can be present at the red clip and you should always maintain knowledge of all three clips positions and connections.**



4. Turn on the power to the *Fault Wizard*.
5. If the battery voltage is low (<22 volts) an auxiliary pack can be used. The *Fault Wizard* batteries should be charged as soon as possible.
6. Set the Mode knob to HV TDR.

- 7 Turn the Voltage knob to “Zero”
8. Press the HV Start button.
9. Set the Voltage knob to at least 7 kV. Although a good starting voltage for the charge voltage, you may require higher voltage settings to get consistent readings.
10. Press the Thump button on the *Fault Wizard* to discharge the *Fault Wizard* into the test cable. **Note:** The sound you here inside the *Fault Wizard* when you press the thump button can tell you important information about the system under test. Refer to the “Helpful Facts” section for more information.
11. Wait for the *Fault Wizard* to display the distance to the fault.
12. Repeat steps 7 through 11 to see the consistency in the results. You may want to adjust the *Fault Wizard*'s discharge voltage to obtain consistent *Fault Wizard* readings. The more consistent the readings are, the more confident you will be on the accuracy of the distance to the fault.
13. Based on the fault distance reading from the *Fault Wizard*, isolate the section of cable that contains the fault. You may want to confirm that the isolated section of cable is actually faulted by use of the *Fault Wizard*'s Hi-Pot mode. This is described in steps 14 through 22. Note: You can only use the Hi-Pot mode on isolated sections of cable **not** connected to any transformers.

#### Verifying Isolated Cable Section Is Faulted

14. Connect the *Fault Wizard* to the isolated cable to test.
15. Turn on the power to the *Fault Wizard*.
16. Turn the Voltage knob to zero.
17. Set the Mode knob to Hi-Pot mode.
18. Press the Start button.
19. Turn the Voltage knob to raise the voltage on the cable.
20. Note the hold-off voltage of the cable.
21. Press the Stop/Ground button to stop the test.
22. If the cable held-off the full 10 kV of voltage, then you probably have isolated an unfaulted section of cable. Therefore, isolate and hi-pot the closest sections of cable to determine which one contains the fault.

### Fault Pinpointing on Isolated Cable Section

1. Follow steps 1 through 5 above.
2. Turn the Voltage Adjust knob to zero.
3. Set the Mode knob to Hi-Pot mode. Note: you can only use the Hi-Pot mode on isolated sections of cable not connected to any transformers.
4. Press the HV Start button.
5. Turn the Voltage knob to raise the voltage on the cable.
6. Note the hold-off voltage of the cable.
7. Press the Stop/Ground button to stop the test.
8. Set the Mode knob to HV TDR.
9. Turn the Voltage knob to “Zero”
10. Press the Start button.
11. Set the Voltage knob to at least 7 kV. Although a good starting voltage for the charge voltage, you may require higher voltage settings to get consistent readings.
12. Press the Thump button on the *Fault Wizard* to discharge the *Fault Wizard* into the test cable. **Note:** The sound you here inside the *Fault Wizard* when you press the thump button can tell you important information about the system under test. Refer to the “Helpful Facts” section for more information.
13. Wait for the *Fault Wizard* to display the distance to the fault.
14. Repeat steps 9 through 13 to see the consistency in the results. You may want to adjust the *Fault Wizard*'s charge voltage to obtain consistent *Fault Wizard* readings. The more consistent the readings are, the more confident you will be on the accuracy of the distance to the fault.
15. Set the *Fault Wizard* mode to Cycle mode.
16. Turn the Voltage knob to “Zero”
17. Press the Start button.
18. Set the Voltage knob to at least 7 kV (note: loudest sound at the fault is produced at 10 kV)
19. While the *Fault Wizard* is cycle thumping, go to the general location of the fault by measuring off the distance determined by the *Fault Wizard* to the fault.
20. By using proper listening equipment, you should be able to pinpoint the fault location.

## Helpful Facts

This section has been included to help you better utilize your *Fault Wizard* locating system.

1. The *Fault Wizard* must produce an arc at the fault from the center conductor to the concentric neutrals before it can obtain the distance to the arc (fault). However, some cable failures may involve arcing to earth and/or semicon. Like all arc-reflection systems, the *Fault Wizard* can't "lock in" on the distance to the fault for these situations. Increasing the charge (discharge) voltage may help produce an arc from the center conductor to the concentric neutrals.
2. Listening to the internal thump sound the *Fault Wizard* makes in HV TDR mode is very important. If there is a fault and the cable arcs from the center conductor to the neutrals (metal to metal) when the thump button is pressed, you should hear a solid "whack" sound from the *Fault Wizard*, itself. We refer to this situation as "hitting hard". This is because the energy is quickly rushing out of the unit. If there is **not** a fault or a **resistive fault** (arc to semi-con or dirt or gaps in the neutrals from corrosion), you will not hear the "whack" sound but a "dull" sound or just a clicking sound of the internal relay. We refer to this situation as "hitting soft". Note: unless you hear the "whack" sound in HV TDR (hitting hard), you will **not** get the correct distance reading.
3. Some cable failures may involve open-fault scenarios such as pull-apart splices or the center conductor burning apart. Under these circumstances, using the low voltage TDR feature of the *Fault Wizard* will give the distance to the fault. Thumping the cable under HV TDR mode will confirm the fault distance for the situation of the center conductor having burned apart.
4. If the fault is within 20 to 30 feet of the *Fault Wizard*, it is difficult for the *Fault Wizard* to see the fault distance. This is true for all arc-reflection systems. On the display (RD), you should get all question marks. However, on rare occasion, you might get a false distance out a few hundred feet. If this occurs, then test from the other end.

## Maintenance

The internal lead-acid batteries will eventually have to be replaced. Therefore, you will eventually have to send your *Fault Wizard* back to our Repair Center for replacement of the batteries. If you want to replace the internal batteries yourself, please call Innovative Utility Products Corp. for guidance (see Repair section).

### Calibration

Your *Fault Wizard* was calibrated during the manufacturing process. It can be sent back to our Repair Center for calibration (see Repair section).

### Cleaning

The *Fault Wizard* can be cleaned externally with a damp (not wet) rag containing a mild solution of soap and water or a typical household glass cleaner.

Do not use harsh cleaning solutions, such as organic solvents (e.g., acetone), that may mar the surfaces. Like most electrical items, do not immerse the *Fault Wizard* in any type of liquid.

**Warning-** 

In order to avoid the possibility of electrical shock, always make sure the *Fault Wizard* is unplugged and turned off while cleaning it!

**Warning -** 

**NEVER** operate or turn on the *Fault Wizard* without the Red clip connected to a cable under test or the cable cleats. High voltage can be present when unit is on and Class I or better High Voltage rated gloves must be worn whenever handling the Red clip.

## Repair

Your *Fault Wizard* can be sent back to our Repair Center for repair. Before sending it back, please call our Repair Center at (479) 410-2098 for shipping instructions. If you decide to repair or modify your *Fault Wizard* by any other means than shipping it to our Repair Center, Innovative Utility Products Corp. assumes no liability for injury (or death) resulting from your *Fault Wizard*. In addition, any attempt to repair or modify your *Fault Wizard* (without IUP approval) **voids the warranty**.

**Warning-** 

Since the *Fault Wizard* contains high-voltage capacitors, electrical shock is possible even if the *Fault Wizard* is unplugged! Only qualified personnel should attempt to repair the *Fault Wizard*.

## Warranty

Innovative Utility Products Corporation (IUP) warrants its products to be free from defects in material and workmanship under normal and proper use for a period of one year from date of shipment from IUP's factory. Any products purchased from IUP that upon inspection at IUP's factory prove to be defective will be repaired (at IUP's option) without charge. This limited warranty shall be void in regard to (1) any product or part without IUP's previous written consent or (2) any product or part thereof that has been subjected to unusual electrical, physical or mechanical stress or upon which the original identification marks have been removed or altered. Transportation charges for shipping any product or part thereof that the buyer claims is covered by this limited warranty shall be paid by the buyer. With the express warranty set out above, IUP does not grant any warranties either expressed or implied, including implied warranties of merchantability or fitness for use.

The obligations or liabilities of IUP specifically shall not be liable for damages, IUP specifically shall not be liable for reinstalling any product or part thereof repaired or replaced under the limited warranty set out above. IUP expressly excludes all liability for any indirect or consequential damages the buyer may sustain in connection with the delivery, use, or performance of IUP's products.

Under no circumstances shall any liability for which IUP is held responsible exceed the selling price to the buyer of IUP's products that are proven to be defective. This limited warranty applies exclusively to IUP's manufactured products. Any legal action for breach of any IUP warranty must be commenced within one year of the date on which the breach is or should have been discovered.

## Technical Support

Innovative Utility Products Corporation believes in providing technical support in order for you to best utilize the *Fault Wizard*. In order to serve the needs of our customers we welcome all comments and suggestions regarding the *Fault Wizard*. Technical Support can be reached at (479) 410-2098. Technical Support's Fax number is (479) 410-3260.

## Specifications

Max Charge Voltage:	10 kV
Max Hi-Pot Voltage:	10 kV
Max Energy Storage:	350 Joules
Max Cycle Time:	6 seconds for 10 kV charge
Weight:	24 kg (53 lbs.)
Size:	25.4 cm x 45.7 cm x 48.3 cm (10" x 18" x 19")
Battery Capacity:	8.5 AH at 24 V
Battery Charger Input Voltage:	100-240 VAC, 50/60 Hz, single phase

**Table 1**

Typical velocity of propagation values that can be used if needed. Values may vary depending on the number of transformers and splices in the circuit. If you are not sure, then try using a velocity of propagation that is about .520.

KV Class	Mils	Cable Size	Type	Vp
15	175	#1CU	XLPE	.554
15	175	#2AL	XLPE	.495
15	175	#2CU	XLPE	.514
15	175	#4CU	XLPE	.516
15	175	1/0	XLPE	.522
15	175	1/0	TRXLPE	.510
15	175	2/0	XLPE	.486
15	175	4/0	XLPE	.472
15	175	500MCM	XLPE	.526
15	175	750MCM	XLPE	.536
15	175	1000MCM	TRXLPE	.430
15	175	#2AL	EPR	.544
15	175	1/0	EPR	.508
15	175	4/0	EPR	.572
15	220	1/0AL	TRXLPE	.550
25	260	1/0AL	TRXLPE	.540
25	260	1/0AL (CU Ribbon)	TRXLPE	.570
35	345	1/0	XLPE	.565
--	---	2/0 Mining Trailing	---	.430
--	---	4/0 MPF	---	.540
--	---	2/0 MPF	---	.520
--	---	2/0 GGC Round	---	.500
--	---	#2 GGC Round	---	.540
--	---	#4 -4/c W Round	---	.530
--	---	Pilot Wireless Avg.	---	.600

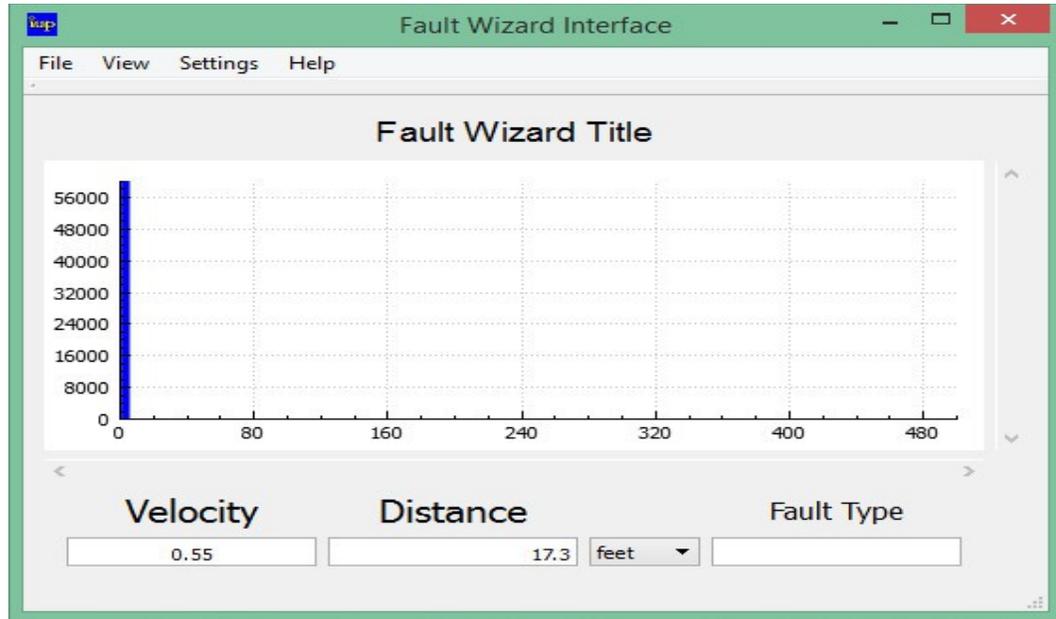
## ***Fault Wizard Software***

### **Installation**

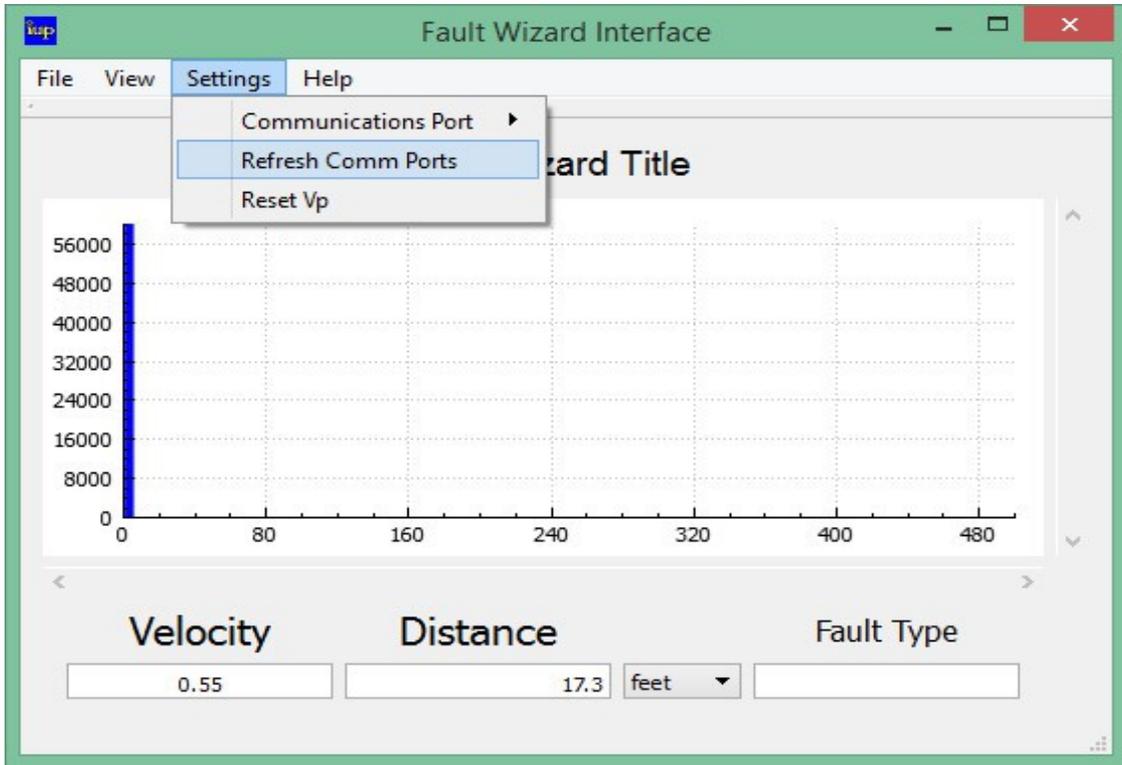
1. Insert the *Fault Wizard* Software CD into your CD Drive on your computer.
2. Open the CD and run Setup.exe.
3. Follow the on-screen instructions provided by the installation software.
4. For uninstalling the *Fault Wizard* Software from your computer, follow steps 1-3. At a specific window provided to you, you can select to remove the software.
5. Hook up the computer cable (provided) from the *Fault Wizard's* Data Port to your computer's com port (com 1-5). If your computer does not have a com port but does have a USB port, you can use the *Fault Wizard* Software but you will need to buy a USB to serial cable (which you should be able to find on the internet or possibly from a local computer store).

## Using the *Fault Wizard* Software

Turn on the Power (toggle) switch on your Fault Wizard. Open the *Fault Wizard* Software by double clicking on the icon. The following graph window is displayed.

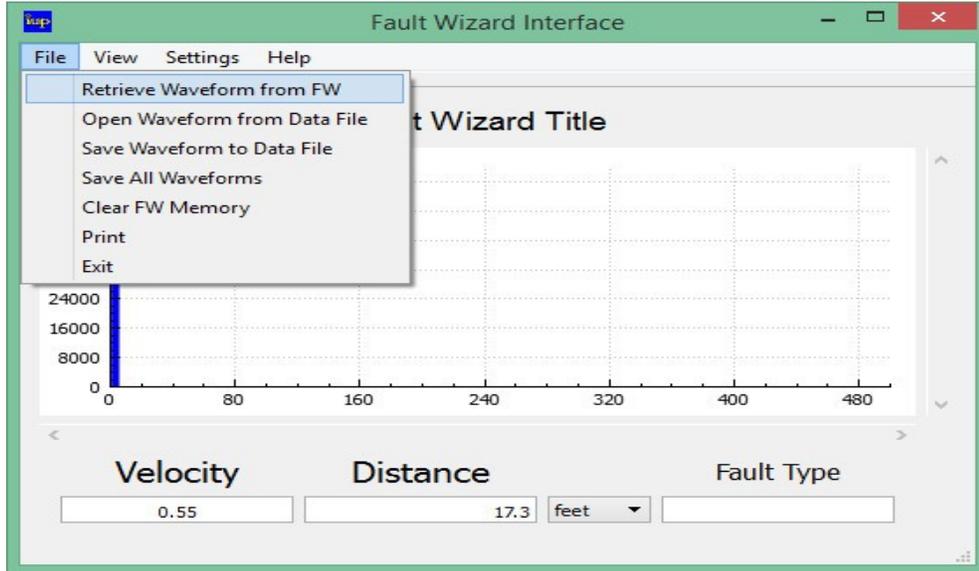


Next, choose **Refresh Comm Ports** submenu under the Settings menu. Then choose the **Communications Port** option under the Settings menu and a side menu will appear. Choose the computer port that you want to use.

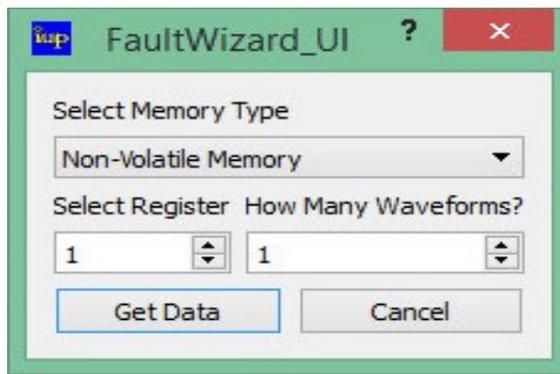


The most common problem encountered during the attempt to download waveforms from the *Fault Wizard* is communication between your computer and the *Fault Wizard*. If such a problem occurs, make sure that you have selected the proper port. In addition, if some other application on your computer has been using that port, then that application may not have released it for use by the *Fault Wizard* Software. A remedy of the problem is to open that application and have that application choose a different port. You may (not always) have to reboot your computer for the port selection to take effect.

Choose **Retrieve Waveform from FW** submenu under the File menu.



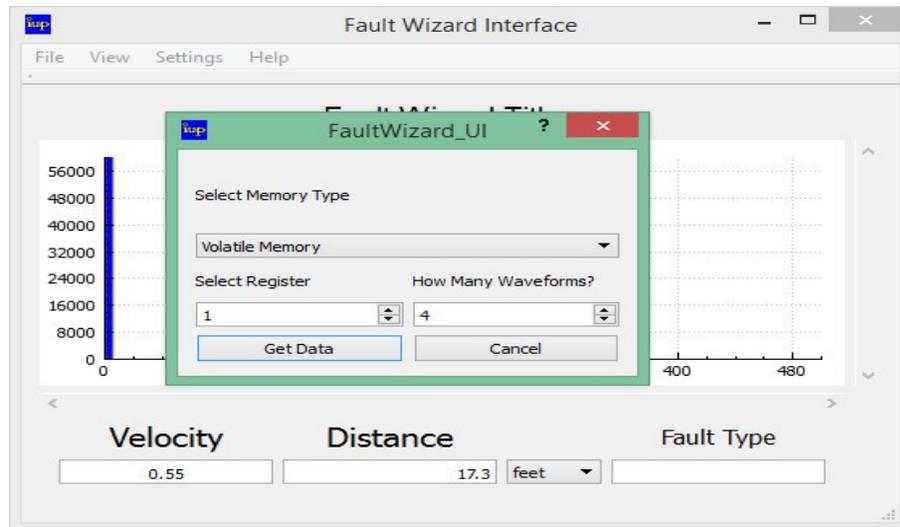
The following dialog box will appear.



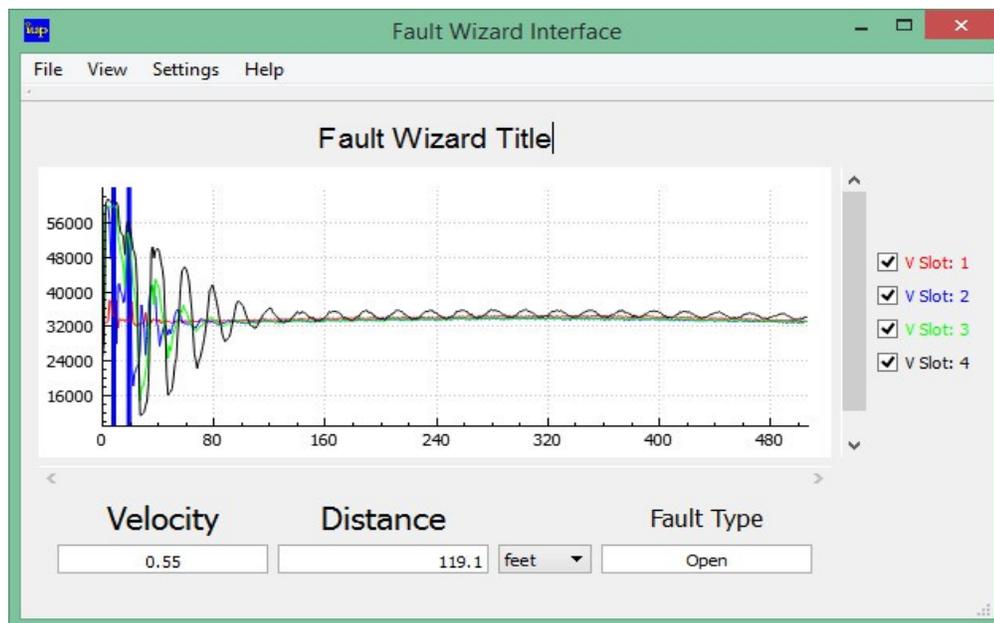
Eight waveforms are stored in the *Fault Wizard's* volatile or non-volatile memory each time the HV TDR system is activated (four waveforms are stored for LV TDR with the remaining four left blank). Volatile Memory holds the last HVTDR or LVTDR activation while the unit is on. Once the unit has been switched off the data in Volatile Memory is no longer valid. Non-Volatile Memory holds waveform data that has been saved to specific memory locations and is retained through power cycles.

By the way, the *Fault Wizard* must be on in order for your computer to communicate with the *Fault Wizard*.

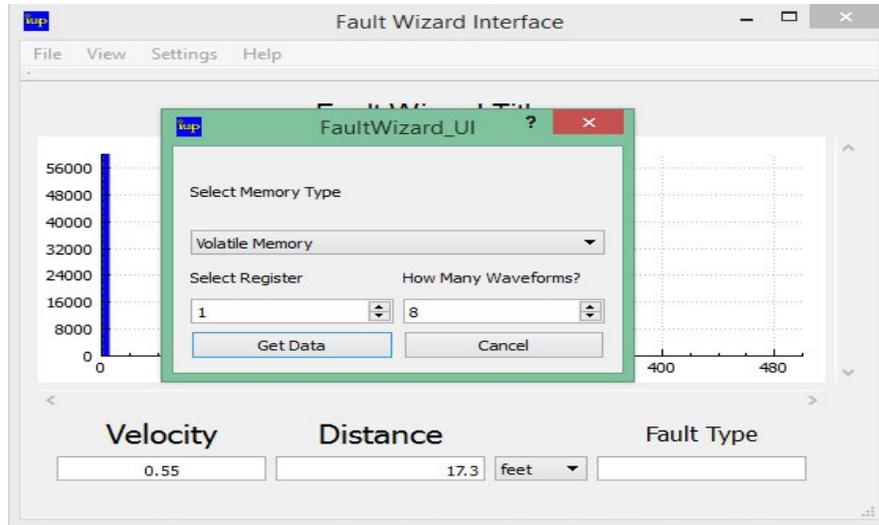
To retrieve LVTDR data from Volatile Memory select Volatile Memory in the Select Memory Type drop down list. Next select a Register, for Volatile Memory there are only 8 registers (or memory locations). Then you can select the consecutive number of waveforms to retrieve at once. Retrieval of LVTDR waveforms settings shown below.



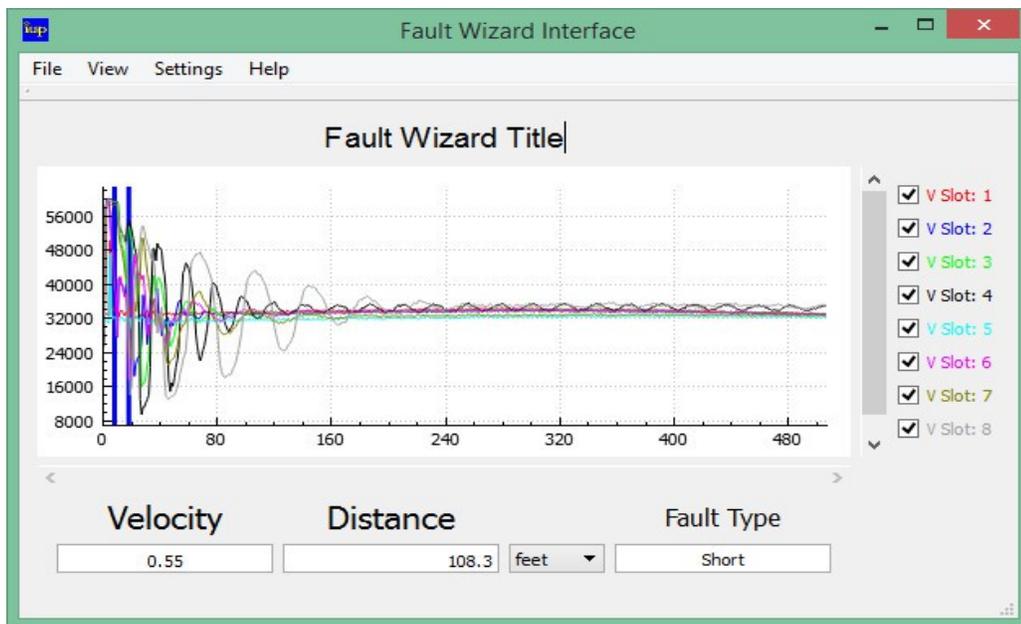
Since the LVTDR waveform data consists of only 4 valid waveforms it is only necessary to retrieve the first 4 registers as registers 5-8 will have only invalid noise. After entering appropriate numbers in the entry boxes, the graph window will be updated to look like something shown below.



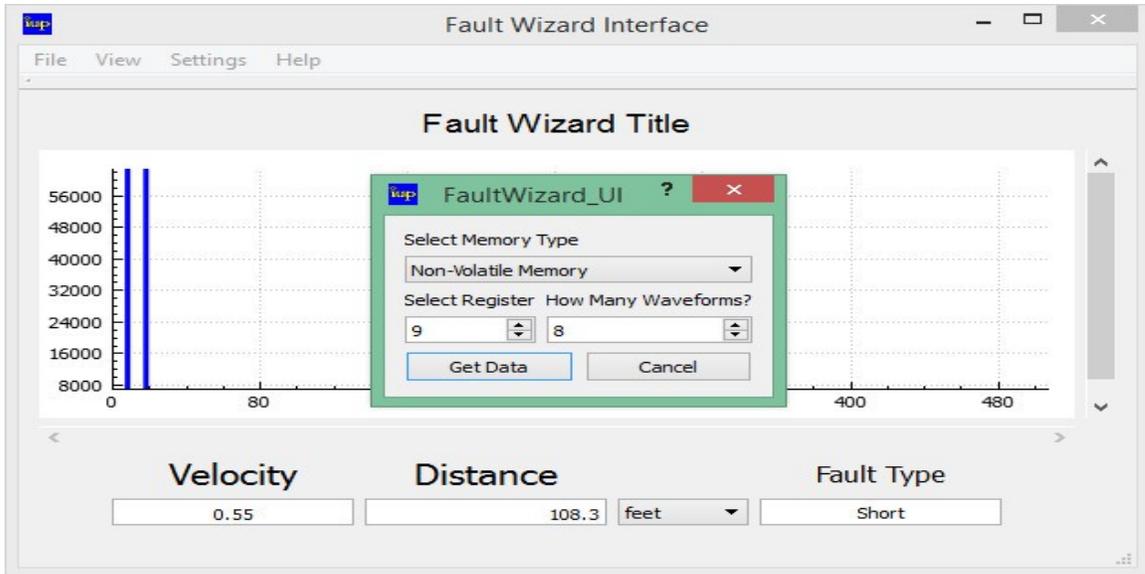
To retrieve HVTDR data from Volatile Memory select Volatile Memory in the Select Memory Type drop down list. Next select a Register. Then you can select the consecutive number of waveforms to retrieve at once. Retrieval of HVTDR waveforms settings shown below.



After entering appropriate numbers in the entry boxes, the graph window will be updated to look like something shown below.



To retrieve LVTDR or HVTDR data from Non-Volatile Memory select Non-Volatile Memory in the Select Memory Type drop down list. Next select a Register. Then you can select the consecutive number of waveforms to retrieve at once. Retrieval of waveforms in Non-Volatile memory shown below.



Non-Volatile (saved) waveform data starts at register 1 and goes to 112. You can see from the example above that we are pulling data from the Fault Wizard starting at register 9 and pulling in 8 registers. This would correspond with the second TDR activation saved in Fault Wizard memory.



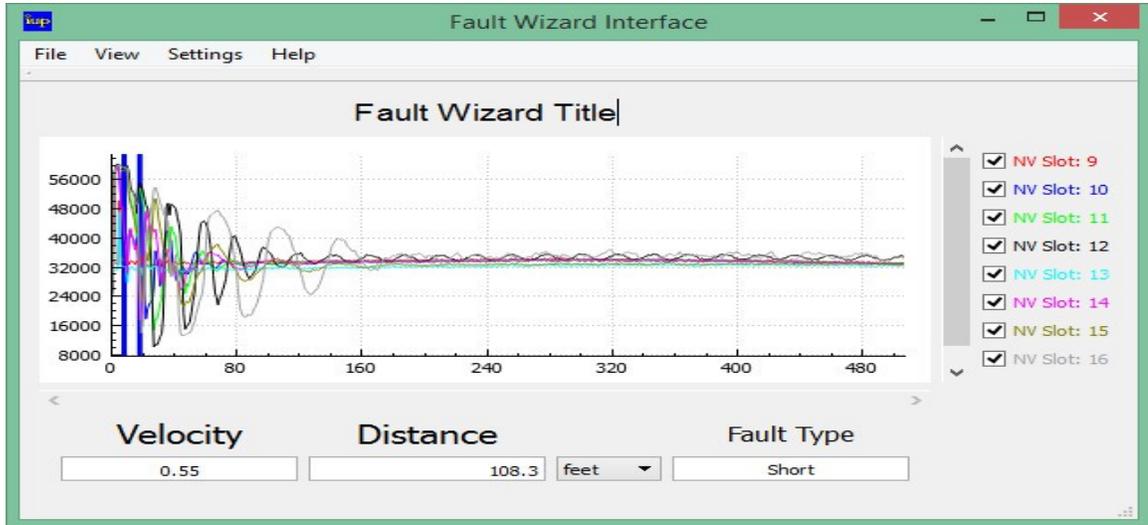
Memory locations in Non-volatile memory for the first TDR activation saved.



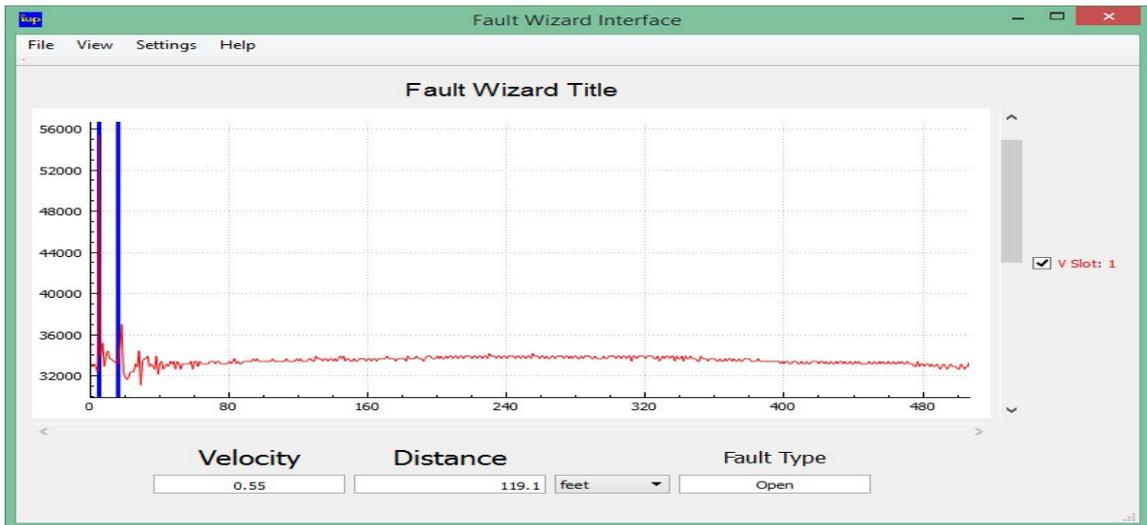
Memory locations in Non-volatile memory for the second TDR activation saved.



Memory locations in Non-volatile memory for the 14th TDR activation saved. After entering appropriate numbers in the entry boxes, the graph window will be updated to look like something shown below.



Of course you also have the ability to pull in one single waveform at a time by selecting the register (memory location) and then selecting 1 on the number of waveforms. That allows the user to view one particular waveform or pull in waveforms from different TDR activations for comparison.



As you can see, a red waveform is shown in the graph. You should also note that two vertical blue lines (cursors) appear in the graph and the values for the Distance Between Cursors and Velocity of Propagation shown at the bottom of the graph have changed. The Velocity of Propagation ( $V_p$ ) is stored in the waveform data and is displayed for the first waveform loaded into the graph. The position of the alligator clips is represented by the left cursor. The position of the open point (for LV TDR) or the arc (for HV TDR) is represented by the right cursor. The distance between these two cursor lines based on the given  $V_p$  is displayed for the first waveform loaded into the graph. Loading additional waveforms into the graph does not change the position of the cursors or the  $V_p$ .

### Change Cursor Position

You can change the position of the cursors by clicking on the graph with the left mouse button (for left cursor) or the right mouse button (for right cursor). Changing the cursor positions does change the distance displayed.

### Hide/Show Waveforms

When there are waveforms displayed on the graph there is a legend displayed on the right-hand side. To hide waveforms shown in the graph, uncheck the appropriate “slot” on the right-hand side legend. To show it again, check it. The following example shows a graph with some of the waveforms hidden. Notice the check boxes on the right hand side.



Two waveforms visible and two waveforms hidden.

### Zoom Functions

To zoom in on part of the waveform, select the **Zoom In** submenu under the **View** menu. Next, click and hold your left mouse button while you drag your mouse. A blue rectangle will appear in the drag area. The area within the rectangle will be the area of the graph redisplayed.

Alternatively, you can use the mouse wheel to zoom the waveform/s along the horizontal axis.

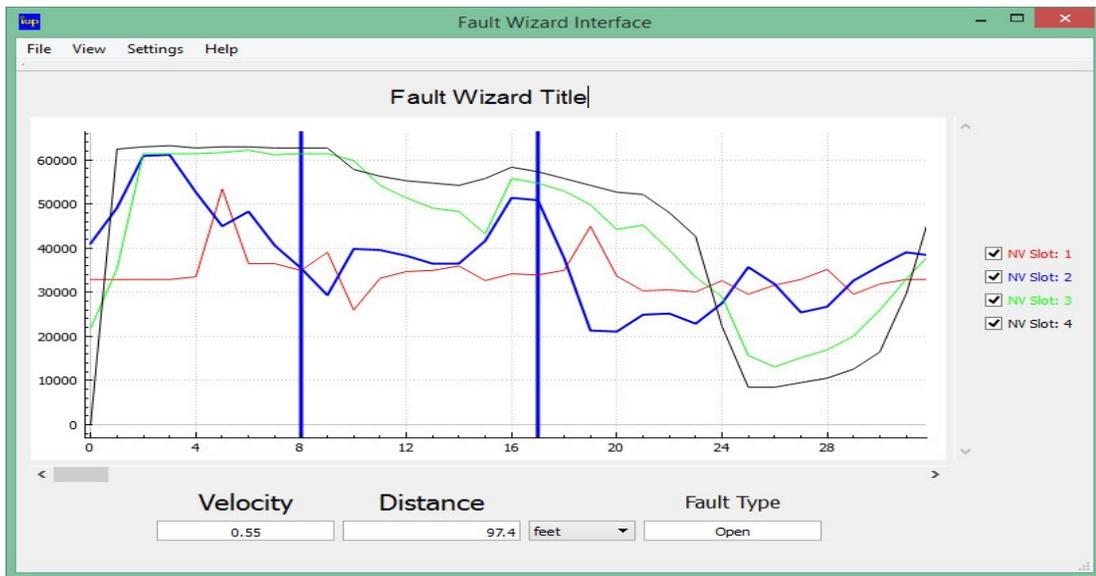
You can return the graph to the un-zoomed view by selecting the **Full Size** submenu under the **View** menu.

### Remove waveform from plot / Clear Waveforms

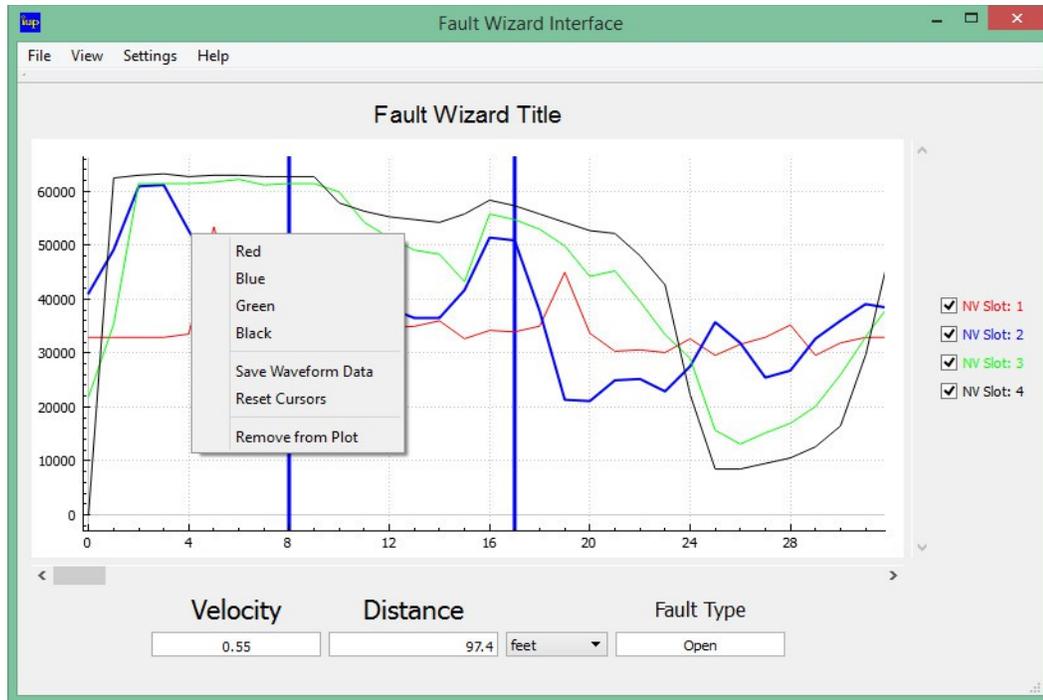
It is frequently necessary or desired to remove one or more waveform/s from the graph. Below is a graph that we would like to remove a waveform from.



We want to remove the second (blue) waveform from the graph above so, first we'll need to left-click on the waveform to highlight it. Shown below is the highlighted blue waveform.



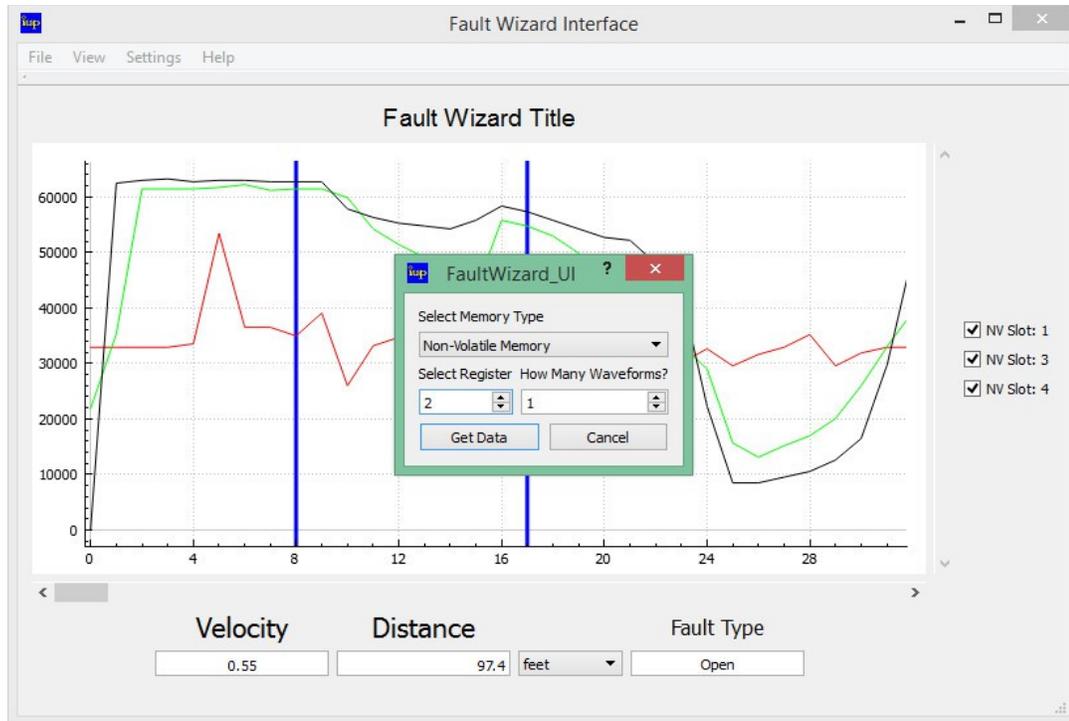
With the blue waveform selected next right-click the waveform and you should see the options pictured below.



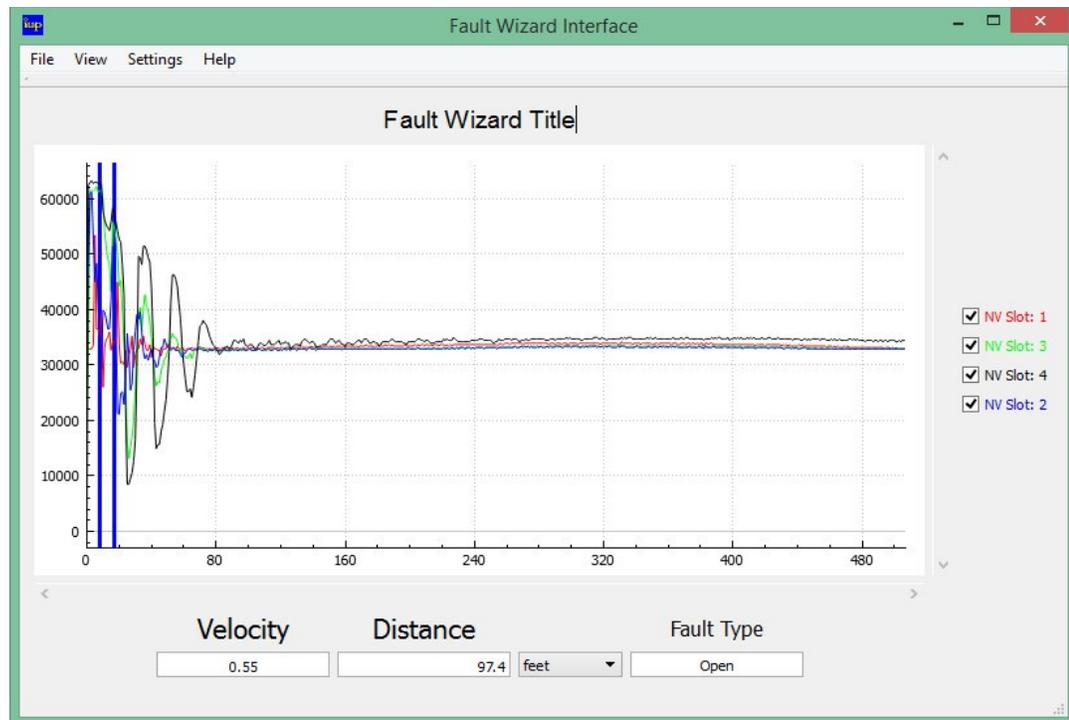
Simply locate and click the **Remove from Plot** option and the highlighted waveform is removed from the graph along with the corresponding check box in the right hand legend (pictured below).



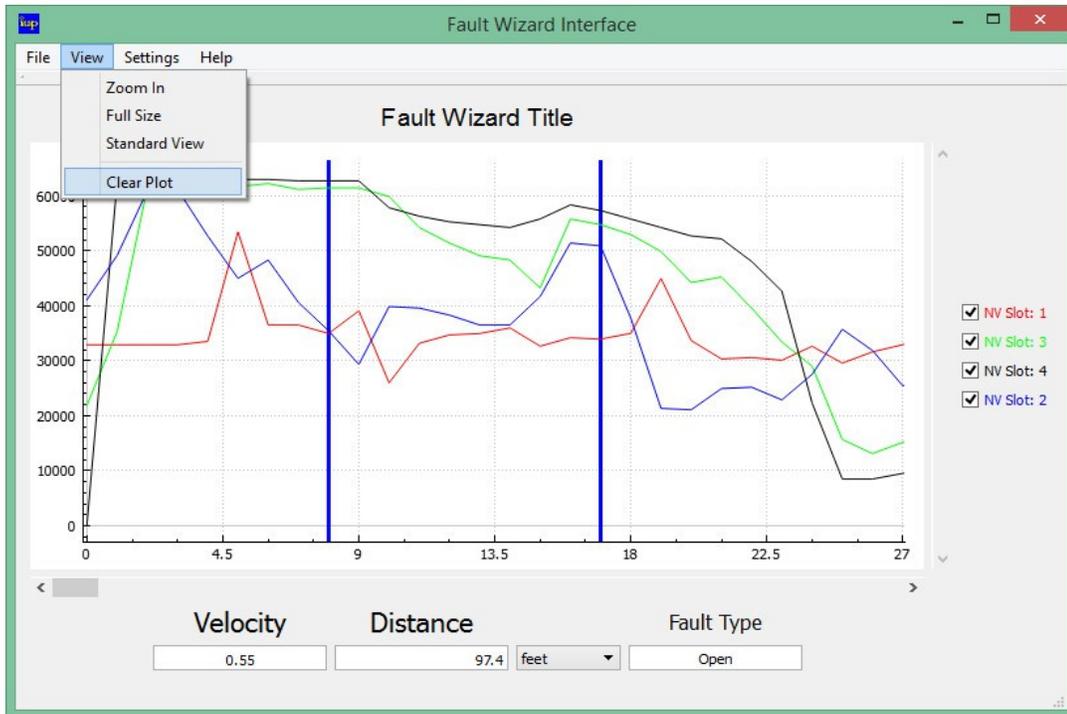
We will now retrieve the previously removed waveform again.



Now that the waveform has been brought back in you should note that the blue waveform and legend has been repopulated however it is at the bottom of the list. See below.



If you are simply trying to clear all the waveforms to retrieve a new set then go to the **View** menu and select **Clear Plot**. See below.



Below is the graph from above after the plot has been cleared.



**Save Waveform to File**

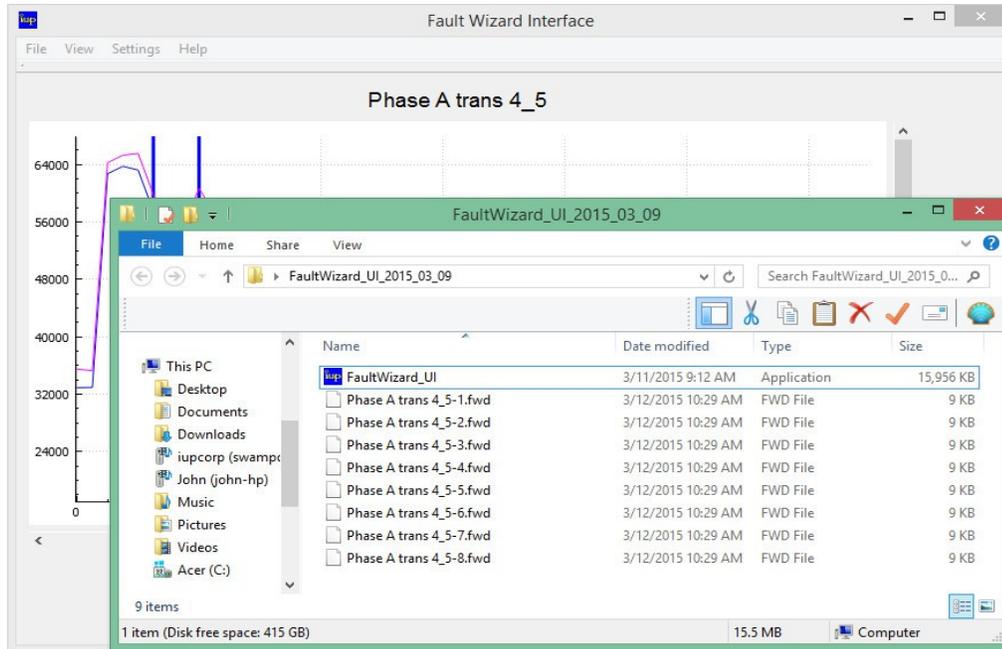
You can save a single loaded waveform to a file by clicking on the waveform in the graph highlighting it and selecting the **Save Waveform to Data File** submenu under the **File** menu or right-clicking the waveform and selecting **Save Waveform to Data File** in the right-click options. The data is saved as a file with the Fault Wizard Data file extension (.fwd). You can reload any saved file by selecting the **Open Waveform from Data File** sub menu under the **File** menu.

### Save all Waveforms

Alternately, the user has the ability to save all waveforms in the graph all at the same time. To do this first give the graph a new Title by clicking the title above the graph that says “Fault Wizard Title”, or it may also say “Main Title”, and simply typing in a new title. It is suggested to use a title that is descriptive. In the example we have changed the title to “Phase A trans 4\_5”.



After giving your graph a new title you then select **Save All Waveforms**. A save file dialog will ask for a location to save to. Then when you click OK all of the waveforms on the graph will be saved with the graph title and number (1-8). Shown in the next example is the saved files from above with the filenames generated by the graph title.



### **Print**

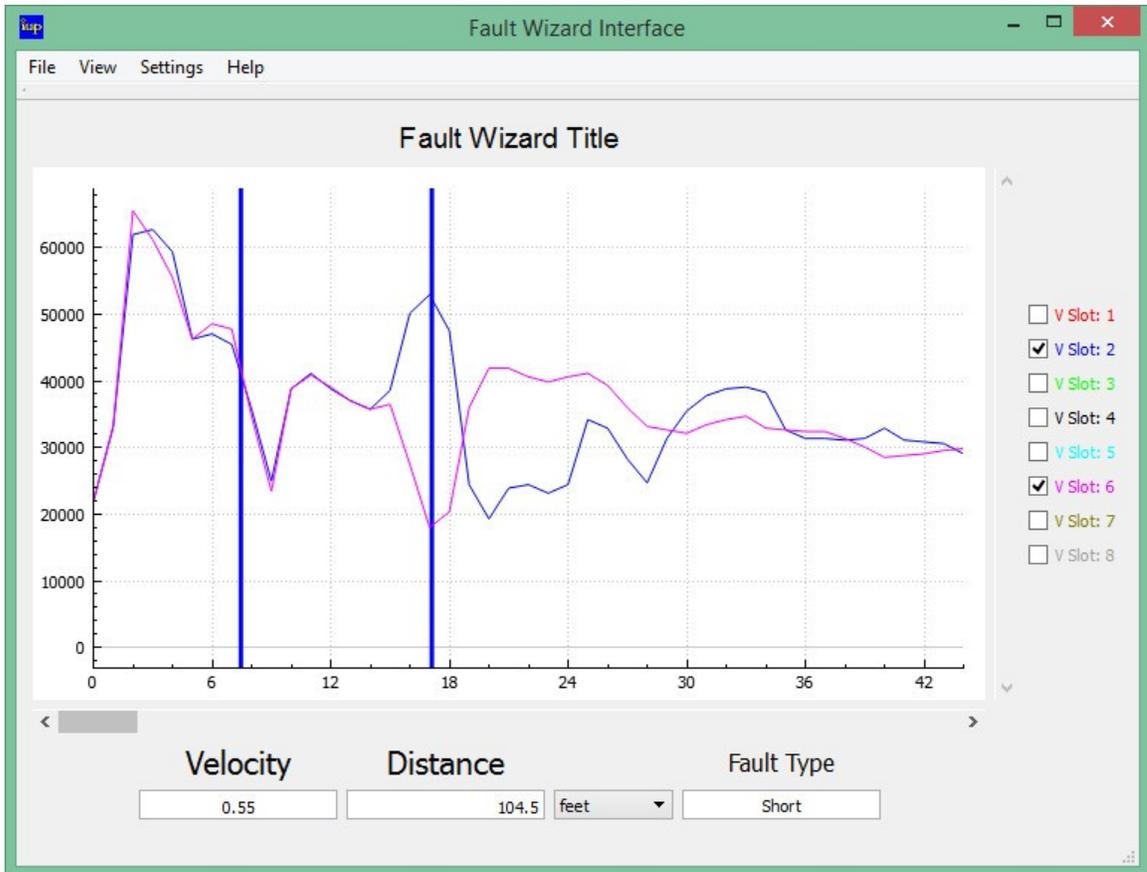
You can also print the displayed graph by selecting the **Print** submenu under the File menu.

### **Exit**

To quit the program, select the **Exit** submenu under the File menu or click the close box located in the top right corner of the graph window.

### **Understanding Waveforms**

Each activation of the TDR system (LV TDR or HV TDR) produces multiple waveforms.. Each waveform is unique. There are three different TDR output pulse widths (narrow, medium, and wide). The four waveforms produced by the LV TDR are the following: (1) narrow, (2) medium, (3) wide, and (4) wide looked at with higher amplitude resolution. The eight waveforms produced by the HV TDR are the following: (1-4) same as the four LV TDR waveforms, (5) narrow during the arc, (6) medium during the arc, (7) wide during the arc, and (8) wide during the arc looked at with higher amplitude resolution. The 2<sup>nd</sup> and 6<sup>th</sup> waveforms from a HV TDR activation are the medium pulse widths before the arc and during the arc, respectively. The data was taken from a 105 ft power cable. The end of the cable was flashed for this HV TDR data. Now, by zooming in on the waveform data, you get the graph below.



As you can see in the graph, there is a large positive output pulse followed by the “up & down” reflection of the alligator clips (both blue and purple waveforms). The left blue cursor is positioned in the center of the alligator clip reflection. Next, you see a positive reflection (blue waveform) from the open point at the end of the cable and a negative reflection (purple waveform) from the arc at the end of the cable. The right blue cursor is positioned at the end of the cable. The remaining part of the graph shows “oscillations” from the reflections. If the cable had actually been flashed in the middle of the cable instead of at the end, the negative reflection from the arc would have been closer to the alligator clip reflection than the open point reflection.

## Battery Pack

An auxiliary Battery Pack can be purchased for use with the *Fault Wizard*. The Battery Pack is highly recommended for several reasons. The Battery Pack is a great “backup” in case the *Fault Wizard's* internal batteries become depleted of energy or if the batteries fail. Also, lead-acid batteries **DO NOT** like to be deep discharged. When the *Fault Wizard's* internal batteries become depleted, the battery voltage (BV) on the display will blink. Although continued operation can be performed, the result is deep discharging of the internal batteries. This can decrease the life and energy storage capacity of the internal batteries. The Battery Pack gives the user an alternative to continuing the use of the internal batteries after the battery voltage (BV) on the display begins to blink. The Battery Pack consists of the following components: (1) grey polycarbonate Battery Box with chrome handle and black connector port, (2) black Battery Charger with 115 VAC equipment cord, and (3) grey Hookup Cord with black connector at each end.



### Using the Battery Box with the *Fault Wizard*

To use the Battery Pack with the *Fault Wizard*, connect one end of the grey Hookup Cord to the connector port on the Battery Box and the other end to the 24 VDC Input port on the *Fault Wizard* panel. If the battery voltage from the Battery Box is greater than the battery voltage from the internal batteries in the *Fault Wizard*, then the battery voltage (BV) on the display will go up when you connect the two. If the battery voltage (BV) on the display is blinking, then you need to turn the *Fault Wizard's* power off and then back

on to reset the unit so the battery voltage (BV) will not blink. The *Fault Wizard's* internal batteries and the batteries in the Battery Box can not “back feed” each other. In other words, the energy from each will only flow to the *Fault Wizard*. Therefore, you can not use the charger that comes with the Battery Pack to charge the *Fault Wizard's* internal batteries. Likewise, plugging the 120 VAC equipment cord into the Battery Charger port on the *Fault Wizard's* panel while the Battery Box is connected to the *Fault Wizard* will not charge the batteries in the Battery Box. However, it will obviously charge the internal batteries in the *Fault Wizard*.

### Charging the Batteries in the Battery Box

The batteries in the Battery Box are charged using the Battery Charger and 120 VAC equipment cord that came with the Battery Pack. Plug the 120 VAC equipment cord into the Battery Charger and a 120 VAC outlet. Actually, the input voltage to the Battery Charger can be 100-240 VAC, 50-60 Hz, single-phase (see back of Battery Charger). The green “power” LED on the Battery Charger will illuminate to indicate it has power. Next, plug the connector from the Battery Charger to the connector port on the Battery Box. The yellow “charge” LED on the Battery Charger will illuminate to indicate that charging of the batteries is occurring. When the batteries are fully charged, the charger goes into “trickle mode” and the yellow LED turns off indicating that your batteries are fully charged. It does not hurt the batteries to leave them hooked up to the Battery Charger after the batteries are fully charged. It takes about 6 hours to fully charge depleted batteries. **If the yellow “charge” LED on the Battery Charger does NOT turn off after about 8 hours of charging your Battery Box, then please disconnect the charger from the Battery Box and replace your batteries. There is a possibility of an internal short in one of the batteries and overheating of the Battery Box and Battery Charger can occur.** The Battery Charger does not have enough power to power the *Fault Wizard*. **DO NOT connect the Battery Charger to the 24 VDC Input port on the *Fault Wizard's* panel or damage to both devices may occur and voids the warranty.**

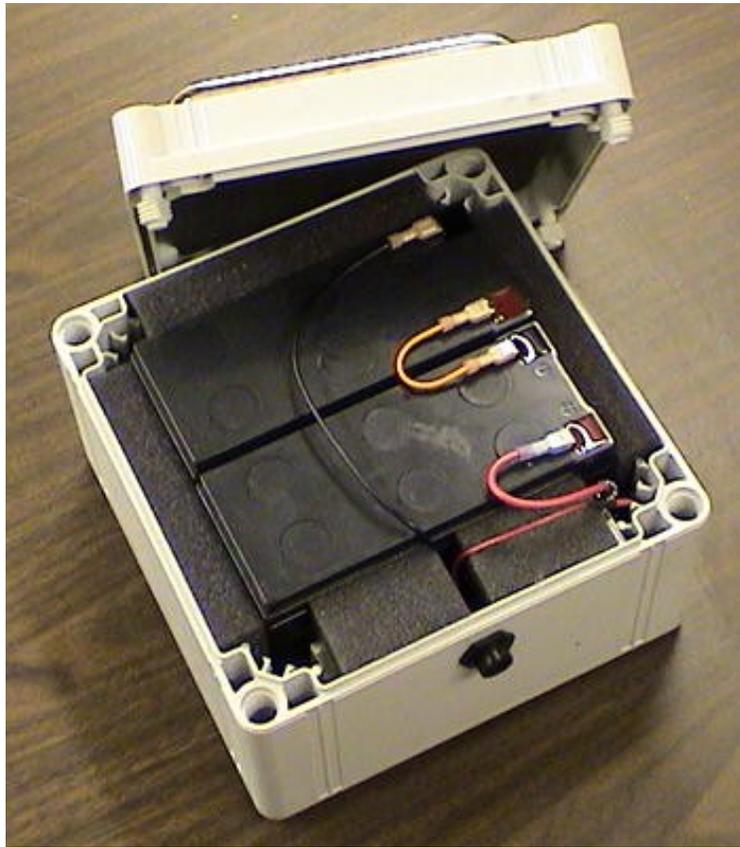
### Replacing the Batteries in the Battery Box

It is quite easy to replace the batteries in your Battery Box. Unscrew the four plastic bolts from the four top corners of the Battery Box lid with a large flathead screwdriver. The four plastic bolts remain in the lid. Lift the lid off of the Battery Box. The picture below shows the inside of the Battery Box.

Next, remove the four “quick connect” connectors from the batteries’ terminals by pulling on the connectors (not the wires!). The use of needle-nose pliers makes removing and attaching the connectors quite easy. You can now remove and replace the batteries. After you are finished replacing the batteries, reconnect the connectors to the terminals. Place the lid back onto the Battery Box and tighten the four plastic screws at the four corners of the lid.

Note: Tucked away in the front right corner of the Battery Box is an inline fuse holder attached to the red wires. The fuse holder contains an 8 amp slow-blow fuse. If the

Battery Box does not output voltage, then check the fuse to see if it has been blown. If it has been blown, then check the wiring (including the wires attached to the back of the output port) to see if an electrical short has occurred.



## AC Pack

The use of the Fault Wizard AC Pack is quite straightforward. Use the grey cable with connectors on both ends to attach the AC Pack to the 24 Volt Input on the Panel of the Fault Wizard. The Equipment Cord is used to plug the AC Pack to an electrical outlet. The AC Pack accepts 100-240 VAC, 50-60 Hz.



### Caution-

The Fault Wizard and AC Pack will heat up during normal use. This especially occurs during cycle thumping. Therefore, the Fault Wizard and AC Pack should not be operated for more than 1 hour continuously in cycle mode. It is important to allow the Fault Wizard and AC Pack time to cool down (about 1 hour) after 1 hour of continuous use in cycle mode. If you do not, the Fault Wizard and AC Pack can be damaged. Overheating of the Fault Wizard and AC Pack voids the warranty.