

Instruction Manual  
Portable Fault Locator  
PFL40A

HIGH-VOLTAGE EQUIPMENT

Read this entire manual before operating equipment

**Megger**®

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**Instruction Manual  
Portable Fault Locator  
PFL40A**

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The information presented in this manual is believed to be adequate for the intended use of the product. The products described herein should not be used for purposes other than as specified herein. Specifications are subject to change without notice.

## **WARRANTY**

Products supplied by Megger are warranted against defects in material and workmanship for a period of one year following shipment. Our liability is specifically limited to replacing or repairing, at our option, defective equipment. Equipment returned to the factory for repair must be shipped prepaid and insured. This warranty does not include batteries, lamps, or other expendable items, where the original manufacturer's warranty shall apply. We make no other warranty. The warranty is void in the event of abuse (failure to follow recommended operating procedures) or failure by the customer to perform specific routine maintenance as indicated in this manual.

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## Upon Receipt of Product

Prior to operation, check for loosened hardware or damage incurred during transit. If these conditions are found, a safety hazard is likely, DO NOT attempt to operate equipment. Please contact Megger as soon as possible.



*PFL40A Portable Cable Fault Location System*

**Megger.**

# 1

## GETTING TO KNOW THE PFL

### 1.1 Top Panel Controls

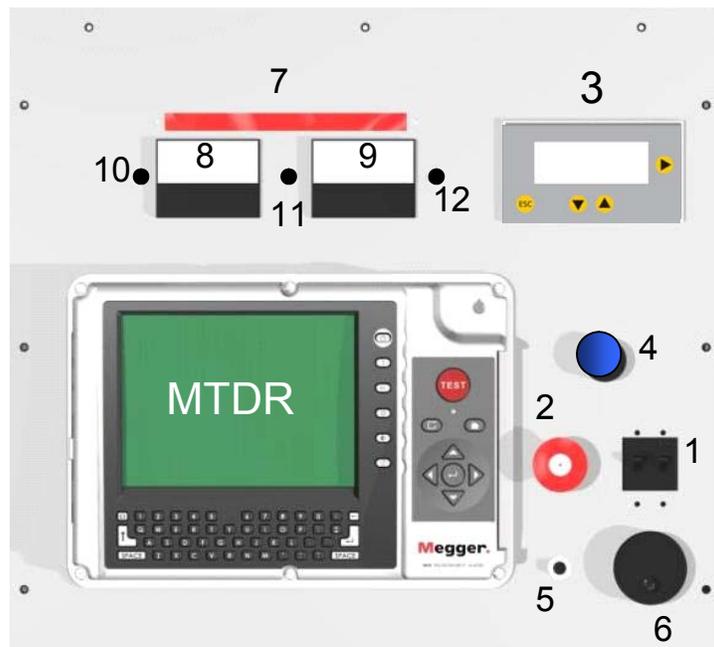


Figure 1-1. Top Panel Controls

1. Power ON/OFF and Circuit Breaker
2. Emergency OFF (available with key option)
3. Main Menu Controller (See Section 4.1)
4. Dielectric Test Current Limit Control (See Proof Section 4.7)
5. Voltage Rate knob (controls the rate at which Voltage Control operates)
6. Voltage Control
7. High Voltage Power Supply ON Indicator
8. Voltage Meter (4/40kV dual range)

- 9. Current Meter (30/300 mA dual range)
- 10. 4kV (Optional module) Range Indicator
- 11. +24V Indicator (illuminates when Circuit Breaker is ON)
- 12. 30 mA Range indicator (active during Proof mode only)

## 1.2 Rear Panel Connections

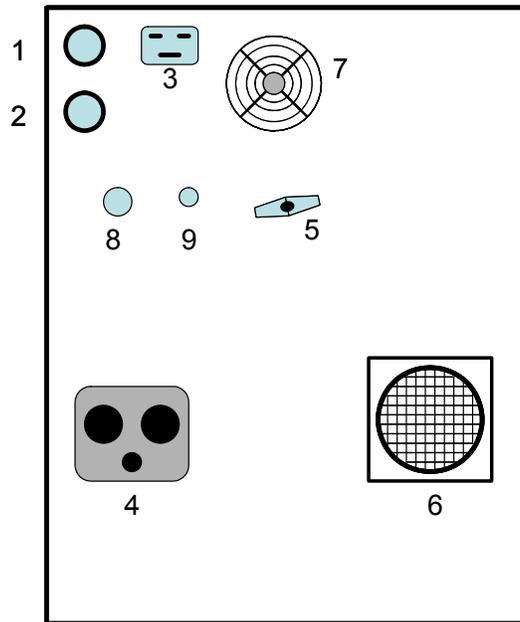


Figure 1-2. Rear Panel Connections

- 1. External Warning Beacon circuit
- 2. Safety Interlock circuit
- 3. Input Power Connector
- 4. High-Voltage Output Receptacle
- 5. Ground Chassis Lug
- 6. Air Intake Fan (DO NOT BLOCK WHILE UNIT IS OPERATING)
- 7. Air Exhaust Fan (DO NOT BLOCK WHILE UNIT IS OPERATING)
- 8. Decay Coupler Input (optional)
- 9. External Ground Monitor Probe Input (optional)

# 2

## SAFETY

### 2.1 ***Safety is the responsibility of the user***

Only qualified and trained operators should operate the PFL40A system. Operator must read and understand this entire Instruction Manual prior to operating the equipment. Operator must follow the instructions of this Instruction Manual and attend the equipment while the equipment is in use. In the event of equipment malfunction, the unit should immediately be de-energized and returned to Megger for repair.

### 2.2 ***General Safety Precautions***

The PFL40A and the Cable Specimen (containing the fault) are both sources of instantaneously lethal levels of electrical energy. Observe the following safety precautions:

- Observe all safety warnings on the equipment. They identify areas of immediate hazard that could result in injury or death.
- Use this equipment only for the purposes described in this manual. Observe strictly the Warning and Caution information provided in this manual
- Treat all terminals of high-voltage power equipment as potential electric shock hazards. Use all practical safety precautions to prevent contact with energized parts of the equipment and related circuits.
- Use suitable barriers, barricades, or warnings to keep persons not directly involved with the work away from test activities.
- Never connect the test equipment to energized cables.
- Do not connect to energized equipment or use in an explosive atmosphere.
- Use the grounding and connection procedures recommended in this manual.
- Personnel using heart pacemakers should obtain expert advice on the possible risks before operating this equipment or being close to the equipment during operation.

## 2.3 *Safety in Using the PFL*

- Never assume that either the PFL40A High-Voltage Output Cable or the Cable Specimen is de-energized. Always treat exposed conductors and connections as potential electric shock hazards
- Do not use this equipment to locate faults on direct-buried unshielded or secondary cable. Otherwise, dangerously high differences in potential may be developed in the Surge Return path.
- Do not use this equipment to locate faults on any cable that may be close enough to an energized cable to allow a burn-through of the insulation of the energized cable.
- Do not operate the equipment without all metal panels securely fastened.
- Do not operate the PFL if it has not first been stabilized in an upright position.
- Remain at least 3 ft (1 m) away from all parts of the High-Voltage circuit, including all connections, unless the equipment is de-energized and all parts of the test circuit are grounded. Be aware that any voltage applied to the Cable Specimen will be present at the remote end(s) and at any other exposed part of the cable, usually out of sight of the operator.
- Use the grounding and connection procedures provided in this Instruction Manual. If other manufacturers' equipment is used with the PFL, the user is responsible for verifying that the grounding and interconnections between the systems comply with each Manufacturer's Instructions.
- Use Industry Accepted practices for making reliable, low-impedance connections, capable of carrying large surge currents.
- Maintain adequate air clearances between the exposed High-Voltage conductor and any adjacent grounds to prevent spark-over. An uncontrolled spark-over can create a safety hazard. Also, ensure the air intake fan filter media (See Figure 1-2, No. 6) is clean and dry before each use.
- Megger recommends the use of appropriately rated rubber gloves when connecting and disconnecting to the High-Voltage terminals.
- An Interlock circuit is provided (and its use is highly recommended) to enable the operator to safely control access to the complete high-voltage circuit.
- An external beacon circuit is provided to enable the operator to install an auxiliary warning beacon which will illuminate whenever the high voltage power supply is energized.

# 3

## PREPARING FOR TEST

### 3.1 *Site Preparation*

Choose a location that meets the following conditions:

- The vehicle (if used) can be safely parked. Set the brakes or block the wheels.
- The location is as dry as possible.
- There is no flammable material stored in the vicinity.
- The test area is adequately ventilated.
- Both the High-Voltage conductor and the Shield of the Cable Specimen are accessible. Be sure all equipment is de-energized. Identify the faulted cables, obtain access to both ends, and erect suitable safety barriers to protect the operator from traffic hazards and to prevent intrusion by unauthorized personnel. Beacon Warning lights are recommended.
- Verify that the station ground is intact and presents an impedance of **LESS** than 100 milliohms to earth.

### 3.2 *Making Circuit Connections*

Connections should be made in the order as listed below and as shown in Figure 3-1.

- 3.2.1 **Vehicle Ground.** If using a vehicle mounted PFL40A, ensure the Vehicle Ground Terminal has less than 100 milliohm impedance to the local station earth ground.
- 3.2.2 **PFL Chassis Ground.** If using a vehicle mounted PFL40A, use the Megger supplied Safety Ground Cable to connect the PFL40A Chassis Ground Terminal directly to the Vehicle Ground Terminal. If using a portable PFL40A, use the Megger supplied Safety Ground Cable to connect the PFL40A Chassis Ground Terminal directly to local station earth ground. In all cases, take great care to ensure that the ground cable connection is as short as possible. If your system is equipped with the optional **Safety Ground Monitor circuit**, then at this time, connect the

External Ground Monitor probe between the PFL and an alternate local station earth ground (outside the vehicle, if used).

- 3.2.3 **Input Power Source Ground.** If using a Vehicle Mounted PFL, ensure the Input Power Source Ground Terminal is less than 100 milliohms impedance to the Vehicle Ground Terminal. If using a portable PFL, ensure the Input Power Source Ground Terminal is less than 100 milliohms of impedance to Local Station Earth Ground.
- 3.2.4 **Cable Specimen Concentric Neutral.** Ensure the Cable Specimen concentric neutral has less than 100 milliohm impedance to Local Station Earth Ground.
- 3.2.5 **De-energize the PFL HV Cable and Cable Specimen, prior to testing (Temporary connection).** NEVER assume that either the PFL High-Voltage Output cable or the Cable Specimen is completely discharged. After ensuring an adequate Ground system (as above) and before making any connections, the PFL40A High-Voltage output cable and Cable specimen's High Voltage conductor should be de-energized by temporarily grounding each (to Local Station Earth Ground) with a Safety Ground Stick (not supplied). Be sure that any stored energy is completely discharged before continuing. Once de-energized, and while wearing rated rubber gloves, connect a temporary Safety Ground Jumper cable between the cable specimen's high voltage conductor and its concentric neutral.
- 3.2.6 **Interlock circuit.** User must provide a closed electrical circuit path across pins B/E of the interlock jack before the PFL40A will function properly. The connection should be made with the mating plug (supplied) using a two-wire twisted pair, 18 gauge or larger, 300 V insulated cable. Megger recommends the User remove the shorting wire from the plug and run the circuit through a suitable test area interlock system. In the event the interlock loop is opened, the test is automatically terminated. When the optional external Decay Module is used, plug the interlock into the Decay Module interlock cable jack and then connect the Decay Module interlock plug into the normal PFL40A interlock connector.
- 3.2.7 **External Warning Beacon.** The User is provided access to an electrical circuit path, which closes only when the High Voltage Output is energized. To utilize this path, using a two-wire twisted pair, 18 gauge or larger and 600 V insulated cable, connect an external high voltage warning beacon circuit across the provided pins A and B on the External Beacon plug. The circuit can handle 3 A, 250 VAC, 60 W, 125 VA.
- 3.2.8 **Surge Return.** Only after the PFL40A has been properly grounded, connect the high voltage output cable to the PFL40A. Then connect the Surge Return Terminal (thin, black lead terminated with a Vise Grip™ style clamp) to the cable specimen concentric neutral.

Do not allow any other conductors (if bundled) to “float” during test. Connect all such conductors, if any, to the cable neutral, making firm, short connections.

The Surge Return is the path that is designed to safely return the Surge Current directly back to the Surge Capacitor through the coaxial shield of the PFL high voltage output cable.

## WARNING

**THE SURGE RETURN IS ISOLATED FROM CHASSIS GROUND BY A 2000 OHM RESISTOR. THIS LIMITS CURRENT IN THE CASE OF A FAILED CONCENTRIC NEUTRAL. THE SURGE RETURN CANNOT BE USED AS A SUBSTITUTE SYSTEM GROUND.**



**SAFETY GROUND MUST BE CONNECTED TO THE LOCAL STATION EARTH GROUND. THE IMPEDANCE OF THE LOCAL STATION EARTH GROUND MUST BE VERIFIED AS HAVING AN IMPEDANCE OF LESS THAN 100 MILLIOHM TO GROUND. THE CONNECTION FROM THE STATION GROUND TO THE SPECIMEN CONCENTRIC NEUTRAL MUST BE VERIFIED AS HAVING LESS THAN 100 MILLIOHM OF IMPEDANCE.**

**FAILURE TO FOLLOW THIS PROCEDURE CAN RESULT IN THE DEATH OF THE OPERATOR AND/OR THE DESTRUCTION OF THE EQUIPMENT.**

The operator is isolated from transient voltages along the surge return by the insulation system in the PFL and by the insulated jacket of the high voltage output cable. Tears or breaks in the insulating jacket of the High-Voltage output cable expose the Surge Return to the operator and poses a safety hazard and the cable should be replaced.

DO NOT EXTEND the Surge Return lead of the HV Output Cable must not be extended because this introduces excessive impedance in the Surge Return and could result in exposed hazardous voltages.

**3.2.9 High-Voltage Output Cable – Core Conductor.** Once the Surge Return connection is made as per section 3.2.8, then connect the High-Voltage Output Terminal (white lead with a red band terminated with a Vise Grip™ style clamp) to the high voltage conductor of the cable specimen. Be sure that the exposed conductor and clamp are sufficiently insulated to withstand the test voltage.

**3.2.10 Connect the Input Power Cord.** Before making this connection, Ensure the Input Power Source meets the requirements as listed in Section 3.2.2 and Specifications Section 8. Also make sure that the ON/OFF switch (Figure 1-1, No. 1) is in the OFF position. Connect the input power cable to the PFL40A first, then to the power source.

**3.2.11 Remove the Safety Ground Jumper cable.** Once all of the above connections are made, and while wearing rated rubber gloves, remove the

temporary safety ground jumper cable (applied in Section 3.2.5.) between the cable specimen's high voltage conductor and its concentric neutral. The system is now ready to begin testing.

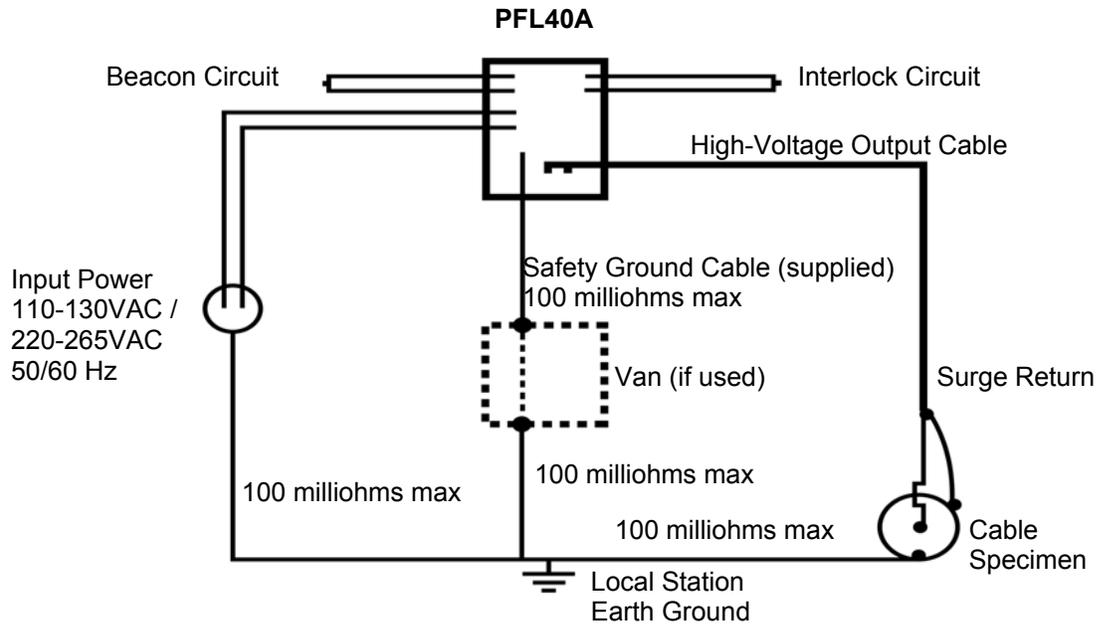


Figure 3-1 PFL40A Connection Diagram

# 4

## CABLE TESTING

### 4.1 Main Menu Operation

The PFL system provides the User with up to six separate test or specimen conditioning modes:

- Arc Reflection
- Impulse Current (surge, IC)
- Pulse Echo (Time Domain Reflectometer, TDR)
- Cable Burn Down
- Dielectric Withstand (Proof)
- Decay

To select any of the options listed, press the Up/Down arrows  until the Selection Arrow  (corresponding to the desired Option) begins to flash.

Then press the Right Arrow button  to activate the desired option.

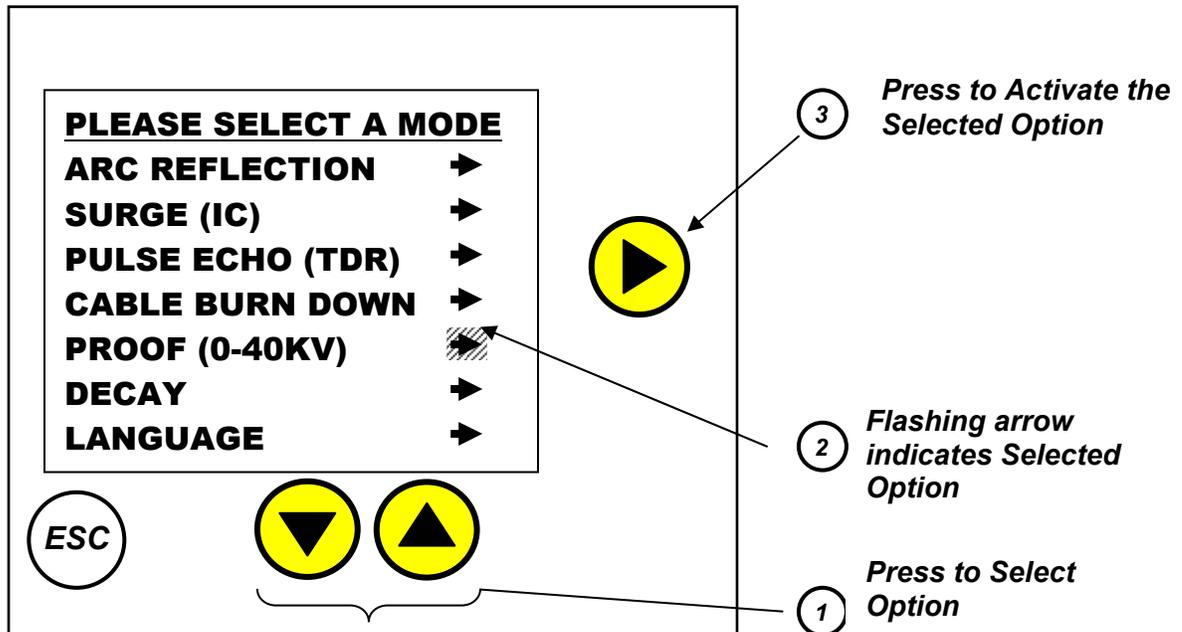


Figure 4 1: Main Control Menu

## 4.2 **Typical Fault Location Strategy**

4.2.1 The most important aspect of locating a cable fault is the development of a strategy that will allow the fault location to be safely and positively identified. The following steps illustrate a typical approach to finding a fault.

1. Deploy equipment, making sure that all company and equipment manufacturers' safety guidelines are followed.
2. Positively identify the faulted cable. If this has not been accomplished by network diagnostics, isolate all of the suspect circuit elements and use the TDR to determine if all of the elements appear to have the same electrical length and the same features (splices, transformers, etc., etc.) at approximately the same distance. (Please see the MTDR operating instructions in Addendum A).
3. If all circuit elements appear to be equal, determine if the electrical length of the circuit elements is in agreement with the known physical length of the circuit. If it does not agree, adjust the TDR propagation velocity accordingly. (Please see the MTDR operating instructions in Addendum A for the propagation velocity adjustment procedure).
4. If the MTDR data is inconclusive, use either the Dielectric Test or Cable Burn Down function to positively identify the faulted phase. Bring each phase up to test voltage individually. Note the breakdown voltage when the faulted phase is found.
5. After the faulted phase has been identified, begin pre-location by engaging the Arc Reflection Test (Please see section 4.3) mode and configuring the MTDR for Arc Reflection Testing. Start testing at the breakdown voltage noted during the previous step. Increase the test voltage slowly. Note that the longer the cable is, the greater the cable capacitance. The Arc Reflection breakdown voltage will be significantly higher than the breakdown voltage observed during step 4 when dealing with very long cables due to capacitive voltage division. If the fault signature seems to be unstable, increase the discharge voltage slightly.
6. If the fault does not consistently breakdown at the maximum allowable voltage, select the Cable Burn Down function. Raise the voltage to either the maximum allowable voltage or until the fault breaks down in a relatively consistent manner as indicated by relatively stable current and voltage. Let the Cable Burn Down function operate until the discharge current is stable. After a few minutes of stable discharge, return to Arc Reflection.
7. Once the fault location has been pre-located by using the Arc Reflection test, the fault can be pinpointed either by acoustic or electroacoustic methods. Set the PFL to Impulse Current and set the discharge voltage to the final voltage noted in step 5. Set the

discharge rate as desired and use the MPP1003 or similar device to pinpoint the exact location of the fault.

## 4.3 **ARC Reflection Method**

- 4.3.1 When the ARC REFLECTION Mode is activated, an Arc Reflection Filter internal to the PFL is switched into the circuit and is connected to the cable specimen. In this mode, the operator can use the MTDR to pre-locate “flashing” or high impedance faults.

The Arc Reflection method is similar to radar in that it uses the transit time of a radio frequency (RF) pulse to calculate the distance to a target. When triggered, a high voltage pulse is applied to the specimen from the PFL’s internal storage capacitor. The specimen voltage rises as the energy is transferred from the capacitor until the fault breaks down and an arc is formed at which point the specimen voltage collapses. The MTDR is able to monitor the start of the discharge via the Arc Reflection Filter and delays the transmission of the RF pulses long enough to allow the arc to stabilize. Because of the impedance mismatch caused by the arc, the RF pulse is reflected by the arc and is displayed on the MTDR screen as a negative reflection. This reflection is used to determine the distance to the fault. (Please see the MTDR operating instructions in Addendum A for Arc Reflection trace interpretation).

- 4.3.2 Follow the instructions and make all connections as described in Section 3. After the cable specimen is de-energized, be sure to remove the temporary Safety Ground Jumper cable as described in Section 3.2.11.
- 4.3.3 Set the POWER circuit breaker on the PFL to ON. The green +24 V indicator will illuminate. Five seconds later, the main menu controller will boot up. **AT THIS POINT THE HIGH VOLTAGE OUTPUT CABLE MUST BE CONSIDERED TO BE AT HIGH VOLTAGE. DO NOT HANDLE THE HIGH VOLTAGE OUTPUT CABLE WITH THE CIRCUIT BREAKER ENGAGED. DO NOT HANDLE THE OUTPUT CABLE AFTER SYSTEM ENERGIZATION UNTIL IT HAS BEEN VERIFIED AS DE-ENERGIZED WITH A SAFETY GROUND STICK.**
- 4.3.4 Set the MTDR to ARC mode (refer to the MTDR operating instructions in Addendum A).
- 4.3.5 If a Burn procedure or Dielectric test has been performed and the desired test voltage is known, then skip to 4.3.6. Otherwise, determine the minimum breakdown level of the fault as follows: Using the up/down arrow keys, select Surge (IC) test mode. This will be indicated by the arrow next to the words SURGE (IC) in the main menu controller blinking. Press the right arrow to enter the selection. At the next prompt select CONTINUOUS operation. Accept the default shot delay by

pressing the right arrow at the following prompt. Select a voltage equal to 10% of the range maximum. Gradually increase the discharge voltage, using the Voltage Control, until the fault breaks down on every discharge as indicated by sound and the voltmeter dip. End Impulse Current mode by pressing the “ESC” button on the main menu controller twice.

- 4.3.6 Using the up/down arrow keys, select Arc Reflection test mode. This will be indicated by the arrow next to the words ARC REFLECTION blinking. At the next prompt select the appropriate test voltage range.
- 4.3.7 Enter desired test voltage using the Voltage Control (Figure 1-1, No. 6). Enter the selection by pressing the right arrow.
- 4.3.8 Set the VELOCITY on the MTDR if a change from the default is required. (Please see the MTDR operating instructions in Addendum A for propagation velocity and range adjustment procedures.)
- 4.3.9 Set the RANGE on the MTDR to a distance greater than the length of the Cable Specimen.
- 4.3.10 Set the SAMPLE mode on the MTDR to ARMED.
- 4.3.11 Press the right arrow on the Main Menu Controller to fire the pulse. You may need to iteratively pulse, observe, increase the test voltage and pulse again.
- 4.3.12 Once a downward reflection is observed on the MTDR screen, adjust the cursor until it is positioned at the front edge of the negative reflection. Read the distance to the fault at the top of the screen. (Please see the MTDR operating instructions in Addendum A for detailed explanation of trace interpretation.)
- 4.3.13 Once testing is complete, refer to “De-energize and System Shutdown” of Section 6.

## **4.4 Impulse Current (Surge)**

- 4.4.1 The Impulse Current method is usually an effective method for pre-locating a high-resistance fault (arc resistance greater than  $200\Omega$ ) as the Arc Reflection method does not work effectively in this regime. The Impulse Current method is similar to the Arc Reflection method in that both methods send high energy pulses down the cable which are used to break down the fault. The difference is that the Arc Reflection method observes the voltage waves caused by the reflection of RF pulses from the arc at the fault. The Impulse Current method observes the current waves that are caused by the injection of the main pulse and its subsequent reflection from the fault.

When using the Impulse Current method, a current coupler is switched into the surge return circuit and is used to measure the high frequencies in the transient as a series of spikes each separated by the round-trip travel time from the fault back to the PFL.

The MTDR has dual cursors that allow the operator to measure the distance, in feet (or meters), to the fault. In general, the left and right cursors are positioned on two consecutive reflections from the fault. The first one or two impulses in the transient are due to the outgoing Current Impulse used to energize the cable and may not be related to the fault location. Therefore, the third and later pulses should be used to locate the fault. (Please see the MTDR operating instructions in Addendum A for interpretation of Impulse Current traces and MTDR operational specifics.)

The Impulse Current method can normally be performed at any voltage higher than the breakdown voltage that was developed in the Proof or Burn testing. The output voltage is slowly raised to the test level without exceeding the recommended proof test rating of the cable. Once breakdown is achieved, the Voltage Meter will momentarily dip and the Current Meter will momentarily rise with each Impulse, indicating that there is an energy transfer (via the arc) with each Impulse.

- 4.4.2 Follow the instructions and make all connections as described in Section 3. After the cable specimen is de-energized, be sure to remove the temporary Safety Ground Jumper cable as described in Section 3.2.11.
- 4.4.3 Set the POWER circuit breaker on the PFL to ON. The green +24 V indicator will illuminate. Five seconds later, the main menu controller will boot up. **AT THIS POINT THE HIGH VOLTAGE OUTPUT CABLE MUST BE CONSIDERED TO BE AT HIGH VOLTAGE. DO NOT HANDLE THE HIGH VOLTAGE OUTPUT CABLE WITH THE CIRCUIT BREAKER ENGAGED. DO NOT HANDLE THE OUTPUT CABLE AFTER SYSTEM ENERGIZATION UNTIL IT HAS BEEN VERIFIED AS DE-ENERGIZED WITH A SAFETY GROUND STICK.**
- 4.4.4 Set the MTDR to Impulse Current (Surge) mode. (Refer to the MTDR operating instructions in Addendum A).
- 4.4.5 Using the down/up arrow keys, select SURGE (IC). This will be indicated by the arrow next to the words SURGE (IC) in the main menu controller blinking. Press the right arrow to enter the selection. You will then be asked to select the appropriate voltage range.
- 4.4.6 For pre-location, select SINGLE SHOT and go to section 4.4.8. If the fault breakdown voltage has not been determined then go to section 4.4.7.

- 4.4.7 Select Surge (IC) test mode and select CONTINUOUS operation. Accept the default shot delay by pressing the right arrow. Select a voltage equal to 10% of the range maximum. Gradually increase the discharge voltage, using the Voltage Control, until the fault breaks down on every discharge as indicated by sound and the voltmeter dip. End Impulse Current mode by pressing the “ESC” button on the main menu controller twice. Again select SURGE (IC), the appropriate voltage range and SINGLE SHOT.
- 4.4.8 On the MTDR select a range that is at least twice the known length of the cable specimen.
- 4.4.9 Set the MTDR sample mode to ARMED. (Please see the MTDR operating instructions in Addendum A).
- 4.4.10 After each shot you will be asked if you wish to continue. If YES is selected, you will be asked if you wish to use the same range. If Yes is answered, the voltage of the last shot will be displayed. If NO is selected, the voltage range selection page will be displayed.
- 4.4.11 Take care not to exceed the authorized test voltage for the specimen.
- 4.4.12 Once a transient is observed, adjust the left cursor on the MTDR until it is positioned at the peak of a well-defined pulse.
- 4.4.13 Adjust the right cursor on the MTDR until it is positioned at the peak of the next pulse.
- 4.4.14 Read the distance to the fault at the top of the MTDR screen.
- 4.4.15 If testing is complete, refer to “De-energize and System Shutdown” of Section 6. Otherwise, continue in this section.

#### **4.4.16 Impulse Surge – Trace and Pinpoint Fault**

After pre-location (determining distance to fault), the operator may find it useful to pinpointing the precise location of the fault. The operator patrols the land above of the Cable Specimen, near the pre-location site, while holding a detector such as the MPP1003. The PFL40A repeatedly applies Impulse Surges. Each time the fault breaks down, electromagnetic and acoustic transients are detected by the detector. Rapid delivery of Impulse Surges intensifies the acoustic disturbances and makes it easier to locate the fault site.

- 4.4.17 Select SURGE (IC) mode and the appropriate voltage range. Select CONTINUOUS and at the next prompt press the right arrow to accept the default shot cycle delay. On the next page, select the desired voltage. Press the right arrow to begin firing. You may change the voltage at any

time using the Voltage Control and the delay may be adjusted anywhere from 0 to 30 seconds at any time by using the down/up arrows.

- 4.4.18 Once testing is complete, refer to “De-energize and System Shutdown” of Section 6.

### **4.5 Pulse Echo (Time Domain Reflectometry, TDR)**

- 4.5.1 When the Pulse Echo (TDR) Mode is selected, the High Voltage generation capability of the PFL System is disabled allowing the MTDR exclusive access to the de-energized Cable Specimen. The TDR method of fault location uses low-voltage pulses to locate impedance discontinuities (faults) along a defective cable. From these low-voltage pulses, a small amount of energy is reflected back any impedance discontinuity of sufficient size and is displayed on the TDR screen, as either a positive or negative blip, depending on the fault characteristic (negative blip for low impedance to shield faults and positive blip for high resistance faults). By knowing the speed (velocity) of the traveling pulses along the Cable Specimen, the time interval associated with the outgoing voltage pulses and the incoming energy reflections can then be used to calculate distance to fault, which is then displayed on the MTDR in feet (or meters).
- 4.5.2 Follow the instructions and make all connections as described in Section 3. After the cable specimen is de-energized, be sure to remove the temporary Safety Ground Jumper cable as described in Section 3.2.11.
- 4.5.3 Set the POWER circuit breaker on the PFL to ON. The green +24 V indicator will illuminate. Five seconds later, the main menu controller will boot up. **AT THIS POINT THE HIGH VOLTAGE OUTPUT CABLE MUST BE CONSIDERED TO BE AT HIGH VOLTAGE. DO NOT HANDLE THE HIGH VOLTAGE OUTPUT CABLE WITH THE CIRCUIT BREAKER ENGAGED. DO NOT HANDLE THE OUTPUT CABLE AFTER SYSTEM ENERGIZATION UNTIL IT HAS BEEN VERIFIED AS DE-ENERGIZED WITH A SAFETY GROUND STICK.**
- 4.5.4 Using the down/up arrow keys, select PULSE ECHO (TDR). This will be indicated by the arrow next to the words PULSE ECHO (TDR) in the main menu controller blinking. Press the right arrow to enter the selection
- 4.5.5 Set VELOCITY on the MTDR if a change from the default is required. (Please see the MTDR operating instructions in Addendum A for propagation velocity and range setting procedures.)
- 4.5.6 Set the range on the MTDR to a distance greater than the total length of the Cable Specimen.

- 4.5.7 To locate the fault, adjust the cursor until it is positioned at the beginning of the negative reflection for a low-resistance fault or at the beginning of the positive reflection for a high Resistance fault. The distance to the fault is displayed at the top of the screen.
- 4.5.8 Once testing is complete, refer to “De-energize and System Shutdown” of Section 6.

## **4.6 Cable Burn Down (Fault Conditioning)**

- 4.6.1 The Cable Burn Down Mode is selected in order to reduce the breakdown voltage of the fault to a level within the selected Surge or Arc Reflection test voltage range. Cable Burn Down Mode, reduces the breakdown voltage of the fault by creating a continuous arc across the fault. The heat from the arc creates carbon and metal tracks on the walls of the fault, reducing the fault’s impedance permanently.

However, in some instances, excessive burning is counterproductive. For some materials with low melting temperatures, excessive burning causes the material surrounding the fault to become molten. The molten material begins to flow, in effect removing any charred material from the fault channel. This could serve to create the undesirable effect of increasing the fault impedance and thus increasing the fault breakdown voltage.

- 4.6.2 Follow the instructions and make all connections as described in Section 3. After the cable specimen is de-energized, be sure to remove the temporary Safety Ground Jumper cable as described in Section 3.2.11.
- 4.6.3 Set the POWER circuit breaker on the PFL to ON. The green +24 V indicator will illuminate. Five seconds later, the main menu controller will boot up. AT THIS POINT THE HIGH VOLTAGE OUTPUT CABLE MUST BE CONSIDERED TO BE AT HIGH VOLTAGE. DO NOT HANDLE THE HIGH VOLTAGE OUTPUT CABLE WITH THE CIRCUIT BREAKER ENGAGED. DO NOT HANDLE THE OUTPUT CABLE AFTER SYSTEM ENERGIZATION UNTIL IT HAS BEEN VERIFIED AS DE-ENERGIZED WITH A SAFETY GROUND STICK.
- 4.6.4 Using the down/up arrow keys, select CABLE BURN DOWN. This will be indicated by the arrow next to the words CABLE BURN DOWN in the main menu controller blinking. Press the right arrow to enter the selection. You will then be asked to select the appropriate voltage range.
- 4.6.5 When ready, start the process by pressing the right arrow.
- 4.6.6 Increase the output voltage by using the VOLTAGE CONTROL. Gradually increase the output voltage until either the proof test voltage

level is reached or the output current becomes stable, Then, keeping the current stable, decrease the output voltage until it falls within the desired voltage range. At this point, you may choose to discontinue testing, or continue in an attempt to further reduce the breakdown voltage.

- 4.6.7 Once testing is complete, refer to “De-energize and System Shutdown” of Section 6.

### **4.7 Dielectric Test (Proof)**

- 4.7.1 When the Dielectric Test mode is selected, the unit operates as a DC Dielectric tester. This test is performed to determine whether the cable insulation is good or bad. In this mode, the PFL40A can provide a timed “soak” test as well as minimize the energy delivered to the fault if the specimen fails.
- 4.7.2 Follow the Instructions and make all connections as described in Section 3. After the Cable Specimen is de-energized, be sure to remove the temporary Safety Ground Jumper cable as described in Section 3.2.11.
- 4.7.3 Set the POWER circuit breaker on the PFL to ON. The green +24 V indicator will illuminate. Five seconds later, the main menu controller will boot up. **AT THIS POINT THE HIGH VOLTAGE OUTPUT CABLE MUST BE CONSIDERED TO BE AT HIGH VOLTAGE. DO NOT HANDLE THE HIGH VOLTAGE OUTPUT CABLE WITH THE CIRCUIT BREAKER ENGAGED. DO NOT HANDLE THE OUTPUT CABLE AFTER SYSTEM ENERGIZATION UNTIL IT HAS BEEN VERIFIED AS DE-ENERGIZED WITH A SAFETY GROUND STICK.**
- 4.7.4 Using the up/down arrow keys, select DIELECTRIC (PROOF). This will be indicated by the arrow next to the words DIELECTRIC (PROOF) in the main menu controller blinking. Press the right arrow to enter the selection.
- 4.7.5 The PFL40A will configure itself into the 0 – 40 kV configuration automatically. There are no other ranges available for the Dielectric Test.
- 4.7.6 Next, you will be advised to set the Over Current Trip level (blue knob). The range extends from 2 – 9 mA in increments of 1 mA and then there are two higher levels, 10 mA and 50 mA. In Dielectric Test Mode the PFL40A power supply is configured for a maximum current of 25 mA. The power supply ramps up slowly to this level, so while adjusting the unit to the desired test voltage, the trip level should be set to at least 50 mA. After specimen is at the test voltage level, set the Over Current Trip selector to the desired sensitivity. Note that during normal operation the power supply will turn on for short periods of time in order to maintain the specimen voltage. The greater the leakage current the more frequently

the power supply turns on and for longer durations. If the leakage current is sufficient, the power supply will be on long enough that the power supply ramp will equal the overcurrent trip point and the test will be immediately terminated.

- 4.7.7 After the reminder screen, you will be asked if you want a manual or timed test. If manual mode is selected, the high voltage power supply is engaged and the voltage selection screen is presented. Increase voltage to the desired level by using the Voltage Control knob. To terminate the test, press the “ESC” key.
- 4.7.8 If a timed test is selected, you will be prompted for the required test interval. This can be set from one to 60 minutes in increments of one minute. Press the right arrow to advance to the next screen and engage the high voltage power supply.
- 4.7.9 Adjust the voltage to the desired level using the Voltage Control knob. When the test voltage has been achieved and the over current trip point has been set, press the right arrow to start the count down timer. After the time is set, you will not be able to adjust the voltage. A new screen will announce the successful completion of the test.
- 4.7.10 If the specimen fails, a warning will be displayed on the main menu controller and the test will be immediately terminated. Press “ESC” to return to the main menu.
- 4.7.11 Once testing is complete, refer to “De-energize and System Shutdown” of Section 6.

## **4.8 Decay Test (Optional Accessory)**

- 4.8.1 In this test the specimen is charged through a high impedance Decay Coupler. When the fault breaks down, a traveling wave is launched back toward the Decay Coupler in the PFL and is reflected back to the fault (in reverse polarity) where it will be reflected again, until the energy fully dissipates. This reversal of polarity creates the condition such that the Distance to Fault (as measured between the two cursors on the MTDR) will be between a peak and the adjacent valley.
- 4.8.2 Only the Safety Ground should be connected at this point with the circuit breaker in the off position. Connect the Decay Coupler directly to the PFL40A. Connect the Decay Coupler interlock plug to the PFL40A interlock jack using the provided cable. Connect the External Interlock circuit to the jack provided on the interlock cable.
- 4.8.3 Connect the coaxial cable provided between the BNC jack on the Decay Coupler and the Decay Input jack on the PFL40A.

- 4.8.4 Connect the high voltage output cable to the output connector on the Decay Coupler.
- 4.8.5 Following all safety procedures described in Section 3, as well as any local safety requirements, connect the high voltage output cable to the specimen. First, connect the input power line to the unit, then to the power source.
- 4.8.6 Set the POWER circuit breaker on the PFL to ON. The green +24 V indicator will illuminate. Five seconds later, the main menu controller will boot up. **AT THIS POINT THE HIGH VOLTAGE OUTPUT CABLE MUST BE CONSIDERED TO BE AT HIGH VOLTAGE. DO NOT HANDLE THE HIGH VOLTAGE OUTPUT CABLE WITH THE CIRCUIT BREAKER ENGAGED. DO NOT HANDLE THE OUTPUT CABLE AFTER SYSTEM ENERGIZATION UNTIL IT HAS BEEN VERIFIED AS DE-ENERGIZED WITH A SAFETY GROUND STICK.**
- 4.8.7 Using the down/up arrow keys, select DECAY. This will be indicated by the arrow next to the word DECAY in the main menu controller blinking. Press the right arrow to activate the selection.
- 4.8.8 The Voltage Decay Ready screen will now be displayed. Select Decay Mode on the MTDR. Set range and propagation velocity. (Please see the MTDR operating instructions in Addendum A for range and propagation velocity setting procedures.)
- 4.8.9 Configure the MTDR for Decay Mode. Please see the MTDR operating instructions in Addendum A for the configuration procedure.
- 4.8.10 Press the right arrow on the PFL40A main menu controller. This will engage the high voltage power supply and bring up the voltage control page. Adjust the output voltage to the required level using the Voltage Control knob. Adjust the output voltage slowly, while watching the current meter. Allow the current meter to settle so the output voltage is known. Remember, the voltmeter is showing the output voltage from the PFL40A, not the Decay coupler.
- 4.8.11 When configured for Decay method testing, the PFL40A automatically configures itself for the 0 – 40 kV range.
- 4.8.12 Once the transient is observed, adjust the left and right cursors at 2 consecutive zero crossings.
- 4.8.13 Read the distance to the fault at the top of the MTDR screen.
- 4.8.14 **NOTE:** This test will not terminate after specimen breakdown. The power supply will continue to charge the specimen until the operator terminates the test.

- 4.8.15 If testing is complete, refer to “De-energize and System Shutdown”.
- 4.8.16 Disconnect the Decay Module upon completion of decay testing.

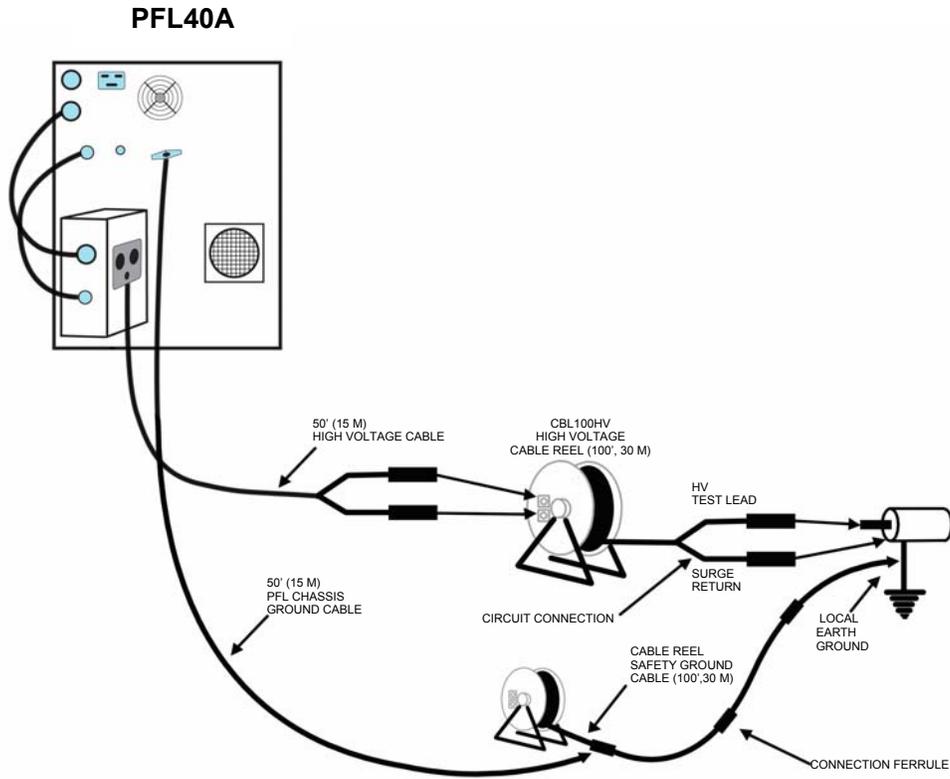


Figure 4-2. Decay Coupler Connections

# 5

## SYSTEM WARNINGS

- 5.1 While in operation, the PFL continuously monitors a number of circuit elements within the system and, in the event either a failure or Safety concern is discovered, operation will automatically be halted and an appropriate Warning message will be displayed. The Warning message will inform the User as to the nature of the failure and what action would be required in order to overcome the failure mode.

### ***Warning Messages:***

- **EMERGENCY STOP**

This is displayed if the Emergency Stop button is set at start-up. Reset the Emergency Stop by twisting the button. Depending on which option you have selected, you may need a key to reset the Emergency Stop.

- **SYSTEM INTERLOCK**

This is displayed when the External Interlock circuit is not satisfied. Check the External Interlock jack and plug.

- **SYSTEM OVERHEATING**

This is displayed when the power supply heatsink temperature reaches 80 degrees C. You must shut down and wait for the unit to cool off.

- **HV TEST LEAD INTERLOCK**

The output cable is either missing or loose. Insert or push the high voltage output cable.

- **CONFIGURATION SWITCH FAILURE**

This will appear if energizing the high voltage power supply was attempted when the main configuration switch is not in the correct position. All operations with the unit must be immediately halted and the unit must be returned to Megger for repair.

- **DECAY COUPLER CONNECTED (if equipped)**

Operation other than Decay was attempted while Decay Coupler is installed. Remove Decay Coupler and restart unit.

- **MUST CONNECT DECAY COUPLER (if equipped)**

Decay test attempted without Decay Coupler. Connect Decay Coupler.

- **OVER CURRENT TRIP**

Power supply current exceeds limit set by Over Current Trip Selector during Dielectric Testing. Press “ESC” to return to the main menu.

- **GROUND SAFETY MONITOR (if equipped)**

Operation is terminated in the event of high impedance ground connection, excessive safety ground current, or excessive voltage level on external Ground Monitor circuit.

# 6

## DE-ENERGIZE AND SYSTEM SHUTDOWN

- 6.1 Upon completion of testing, for Safety reasons, it is necessary to completely discharge any High Voltage stored energy within both the cable specimen and the PFL40A. **Be sure to perform the steps below in the order as listed.**
- 6.2 Using the Main Menu Controller, exit out of all test modes, going back to the Main Menu screen. If exiting from continuous Impulse Current (Surge) mode, allow the unit to complete at least one cycle before discharge and shutdown.
- 6.3 **OBSERVE VOLTMETER. Make sure that it reads ZERO** before proceeding. If it does not, the unit has malfunctioned. Go to step 6.4 and then observe the meter again. If it still shows voltage, use a Safety Discharge Stick to discharge system. **DO NOT RE-ENERGIZE UNIT.** Return the unit to Megger for repair.
- 6.4 Switch the MAIN CIRCUIT BREAKER to the OFF position. The green +24V indicator will no longer be illuminated.
- 6.5 After completing step 6.4 use an adequately grounded Safety Ground Stick to positively ground all exposed high voltage connections. Then, while wearing the appropriately rated rubber gloves, connect Safety Ground Jumpers from all exposed high voltage cable terminals to Local Station Earth Ground. It is a good idea to leave the jumpers in place for at least as long as the specimen was at test voltage.
- 6.6 Remove the PFL High-Voltage Output and Surge Return clamps from the Cable Specimen, leaving the Safety Ground Jumper in place to drain any stored charge.
- 6.7 Disconnect the high voltage output cable.
- 6.8 Prior to switching the circuit breaker off, press the  (Power Suspend) button on the MTDR to prepare the MTDR for shutdown.
- 6.9 Disconnect the Power Cord from the Input Power Source.
- 6.10 Lastly, disconnect the safety ground cable.

**Megger.**

# 7

## MAINTENANCE

### 7.1 *Pre-Maintenance Precautions*

- 7.1.1 Before performing any maintenance on the PFL, be sure to read the entire contents of this Instruction Manual and observe all Safety precautions.

To maintain the PFL in proper condition, it is suggested a program of routine maintenance be carried out every six months. In abnormally dirty areas or in difficult environments, routine maintenance may be required more often.

This is a high-voltage system that can produce and contain instantaneously lethal voltages. Any Maintenance or repair of this equipment should be performed only by qualified persons who are aware of high-voltage hazards and the necessary precautions routinely taken to prevent injury.

- 7.1.2 De-energized and Shutdown in accordance with Section 6.
- 7.1.3 Using the Safety Ground Cable (provided), connect the PFL Chassis to Local Station Earth Ground.
- 7.1.4 Plug the High Voltage Cable connector into the PFL and connect both the High-Voltage vise-clamp and the Surge Return vise-clamp to Local Station Earth Ground.
- 7.1.5 Remove front and side panels.
- 7.1.6 **Use a safety grounding stick and touch all visible terminals. Certain malfunctions can leave a lethal level of charge in the capacitors, even for MONTHS at a time.**

### 7.2 *Inspection and Maintenance*

- 7.2.1 Examine all cables and connectors for loose or damage. Check for evidence of corrosion, fracture, or burning.
- 7.2.2 Inspect and clean the outer jackets of the High-Voltage Cable; check for breaks in these jackets.

- 7.2.3 Clean the outside of the IMPULSE SWITCH with a soft dry rag. Remove the cover of the impulse switch, taking care not to drop any of the screws into the equipment. **Touch all of the electrodes with the safety grounding stick.** Clean the interior of the Impulse Switch with a soft dry rag and low-pressure air. Also using low-pressure air, blow out any dust from inside the equipment. Replace the Impulse Switch lid and front and side panels.

## 7.3 *Repairs*

Even when disconnected from the Input Power Source, the PFL can produce and contain dangerous voltages. Any service or repair of this equipment should be performed only by qualified persons who are aware of High-Voltage hazards and the necessary precautions required to prevent injury.

Megger offers a complete Repair and Calibration Service and recommends that its customers take advantage of this service for routine maintenance or in the event of any equipment malfunction.

In the event Service is required, contact your Megger representative for instructions, a product Return Authorization (RA) number, and shipping instructions.

Ship the product prepaid and insured and marked for the attention of the Repair Department. Please indicate all pertinent information, including catalog number, serial number, and problem symptoms.

# 8

## SPECIFICATIONS

### ***Available Modes***

ARC REFLECTION  
PULSE ECHO (TDR)  
IMPULSE CURRENT (SURGE)  
CABLE BURN DOWN  
DIELECTRIC TEST (PROOF)  
DECAY

### ***Voltage Output***

Impulse Voltage ranges:	0 – 4 (optional), 0 - 8, 0 - 16, 0 - 34 kV
Surge Interval:	Single Shot <i>or</i> Repetitive: Variable, 2 seconds - minimum
DC Mode:	Proof mode: 0 to 40 kV Burn mode: 0 to 34 kV
Duty Cycle:	Continuous
Polarity:	Negative with respect to ground

### ***Current Output***

Proof Mode:	25 mA continuous, with trip points to 50mA
Burn Mode:	30 mA @ 34kV 60 mA @ 16 kV 120 mA @ 8 kV

## **Energy**

Capacitance:	1.5 kJ basic system: 2.9, 11.7, 46.8 $\mu\text{F}$ 2.0 kJ basic system: 3.91, 15.6, 62.5 $\mu\text{F}$  With 4 kV 1.5 kJ optional capacitor: 186.7 $\mu\text{F}$ With 4 kV 2.0 kJ optional capacitor: 250 $\mu\text{F}$
Peak Energy:	1.5 kJ system at 34 kV - 1.7 kJ 2.0 kJ system at 34 kV - 2.3 kJ

## **Coupling**

Arc Reflection Filter/Surge Current Coupler:	Internally Integrated
--	-----------------------

## **Metering**

Voltmeter:	0 to 4/40 kV dual range display with lighted range indicator
Ammeter:	0 to 30/300 mA dual range display with lighted range indicator

## **Environmental**

Operating temperature range:	-4 to 120°F (-20 to 50°C)
Storage temperature range:	-22 to 131°F (-30 to 55°C)
Elevation:	6500 ft (2000 m) max. (Call factory for altitude derating)
Humidity:	5 to 95% RH non-condensing (operating)
Climate:	Operation is prohibited in direct rain or snow

## ***Physical***

Height :	With Wheel kit: 44.6 inches (1133 mm) Without Wheel kit: 35.0 inches (89 mm)
Width:	30.6 inches (777 mm)
Depth:	27.6 inches (701 mm)
Weight:	390 lbs (177 kg)

## ***Input Voltage Source (User supplied)***

Single phase, 110 – 130 VAC; fused at 15 A, 50/60 Hz,

or

Single phase, 220 – 265 VAC; fused at 7.5 A, 50/60 Hz

two-pole, three-terminal grounding type connector (IEC compliant)

## ***Standard Accessories***

Integrated MTDR Analysis System

- High-Voltage Output Cable: 50-ft (15-m), with Center Conductor and Surge Return (Shield), each with an attached clamp
- Safety Ground Cable: 50-ft (15-m), flexible with clamp
- Input Power Cord: 25-ft (8-m) 3-wire, with IEC 320 cap
- Wheel Kit
- One Interlock Shorting Plug
- One Beacon Warning Light Plug

## ***Optional Modules/Accessories***

- CBL100HV output cable reel in a portable configuration with 100 ft (30 m) High Voltage *and* Safety Ground extension cables, Cat. No. CBL100HV
- Megger Pin Pointer (used for Tracing), Cat. No. MPP1000 Series
- Decay Module
- Ground Safety Monitor, includes 50' (15m) Earth Monitor Cable
  - 100' (30m) Earth Monitor on reel , also available
- External Battery System
- External 4kV capacitor
- High Voltage Discharge Stick
- Cooling Fan Filters

# Addendum A

## *MTDR Analyzer*

### *Specifications*

Operating modes:	ARC Reflection, SURGE, voltage Decay and TDR
Ranges:	U.S.: 200, 500, 1000, 2000, 5000, 10,000, 20,000, 50,000, 100,000, 200,000 ft  Metric: 60, 150, 300, 600, 1500, 3000, 6000, 15,000, 30,000, 60,000 m  Time: 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100 $\mu$ s
TDR pulse widths:	40, 80, 160, 320, 640 ns, 1, 2, 5, 10 $\mu$ s
Cursors:	Selectable format: feet, meters, $\mu$ s  Dual, independent cursors with both positions displayed  Differential cursor position displayed
Resolution:	5 ft (1.50 m), depending on range and mode
Horizontal zoom:	Selectable via front panel controls
Velocity selectable:	0 to 99%  0 to 983.6 ft/ $\mu$ s  0 to 299.8 m/ $\mu$ s  0 to 491.8 ft/ $\mu$ s ( $V_p/2$ )
Inputs:	Input 1: channel one acquisition (TDR and ARC)  Input 2: channel two acquisition (SURGE)
TDR pulse amplitude:	10 V nominal, into 50 $\Omega$

Gain:	1, 2, 3, 4, 5, 10, 20, 50, 100
Input impedance:	50 $\Omega$ , all inputs
Max. signal input:	250 V peak for transients
Display:	Transflective, daylight viewable color LCD
Operating system:	Windows® XP Embedded
External interfaces:	Dual USB ports Serial port
Printer support:	Hewlett Packard or others printers supporting standard HP- PCL (Printer Control Language)
Memory:	Stores up to 200 waveforms internally
Power:	Power is 100 to 240V AC 50/60 Hz self configuring for standalone unit, or for integrated unit, the Power is supplied by PFL40A
Temperature range:	-4 to 122°F (-20 to 50°C) operating -22 to 158°F (-30 to 70°C) storage
Humidity:	<95 percent non-condensing
Dimensions:	Integrated into the top panel of PFL40A
Weight:	Included in PFL40A system
Accessories supplied:	software to download and upload traces to and from a PC and to emulate MTDR operation on a PC for trace analysis and viewing

## Top Panel Controls

**Test Button:**



Initiates and Terminates all Tests.

**Navigation Keys:**



Use Arrow keys to highlight a desired Selection. Use Enter button (in center) to Activate the Selection.

**Home Key:**



Returns to Home Screen. Press twice to ignore.

**Change Area Key:**



Allows User to select Active area of the screen. Selected area outlined in blue.



**QWERTY Keys:**

Provides the operator a full QWERTY key board for entering notes and data.

**Power Suspend:**



Prepares the Instrument for Shutdown. A message will indicate when Input Power can be safely removed.

**Help Function:**



Provides on screen Help to assist operator.

**Function Key:**



Displays the options available for any highlighted Selection.

## Communications ports



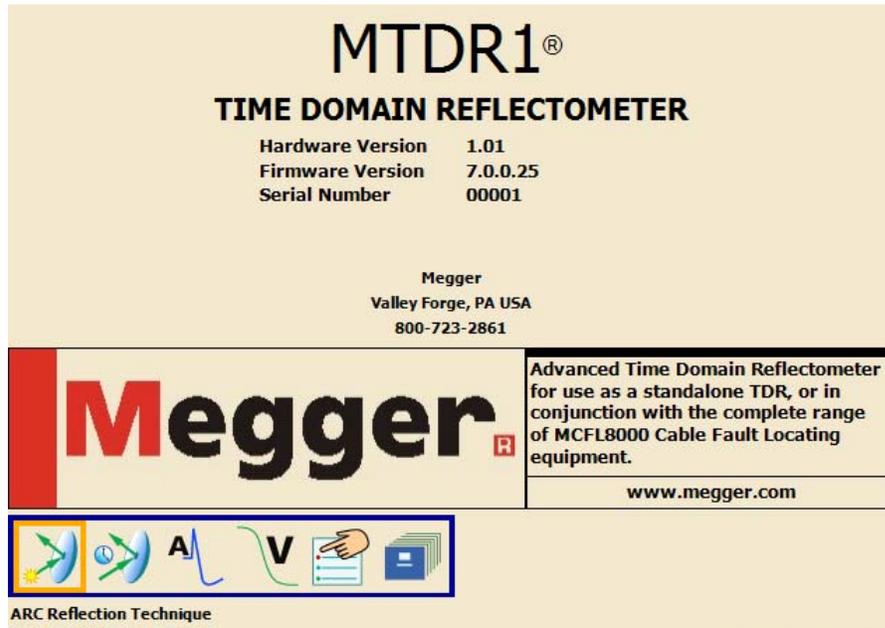
**USB Ports:**

USB Connectors; For printer cable and USB memory stick.

**SERIAL Port**

Nine-pin Serial COMMs Connector; For PC interface.

## Home Screen



## Home Screen - Mode Options



Select for ARC Reflection Mode



Select for TDR Mode



Select for Current Impulse Mode (Surge)



Select for Voltage Decay Mode (optional)



Select to input Preferences



Select to enter File Manager

## Utilities



**Save Icon.** Used to Save Preferences or, when selected from any Test Mode screen, will bring up the Save File screen. Default File name is the Date and Time.



**Recall Test Icon.** Select from any Test Mode screen to bring up the File Recall screen. Default is the first File name.



**File Manger Icon.** Select from any Test Mode screen to manage Files stored in either the MTDR or on a USB Memory Stick. This screen is also used for creating and printing Reports, as below.



**Report Icon.** Select on the File Manager Screen to bring up a Create a Report. Reports can either be printed or saved for later use.



**Cancel Icon.** Select to Cancel without Saving.



**Delete Icon.** Deletes the Selected File or Report.



**Print Icon.** Prints the Selected Report. Printer must be standard USB supporting HP PCL protocol.



**USB Icon.** Select to Transfer Files or Reports from the MTDR to the external USB Memory Stick.

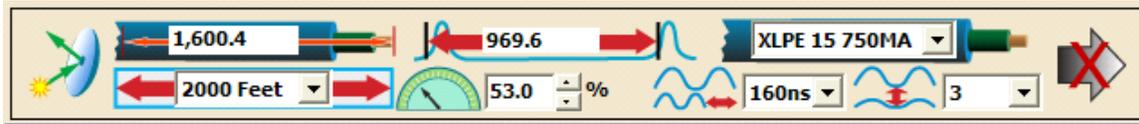


**Zoom Icon.** Select to Zoom in on specific areas of displayed Trace.

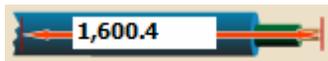


**Pan Icon.** Select to Pan (left and right) across displayed Trace.

## Test Parameters – Display Header



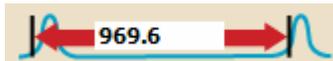
Indicates selected **Test Mode**. Arc Reflection Test Mode shown here.



Indicates **Cable Length** which is set during the TDR mode with automatic placement of the cursors.



Indicates **Display Range** (as shown on screen). This Display Range can be changed by User.



Indicates **Distance** between cursors.



Indicates **Velocity** of Propagation. The velocity normally comes from the Cable Type selected, but can be changed by User.



Indicates **Cable Type**. Default type is that selected in the Preferences screen.



Indicates **Pulse Width** which is automatically set based on range. This Width can be changed by User.

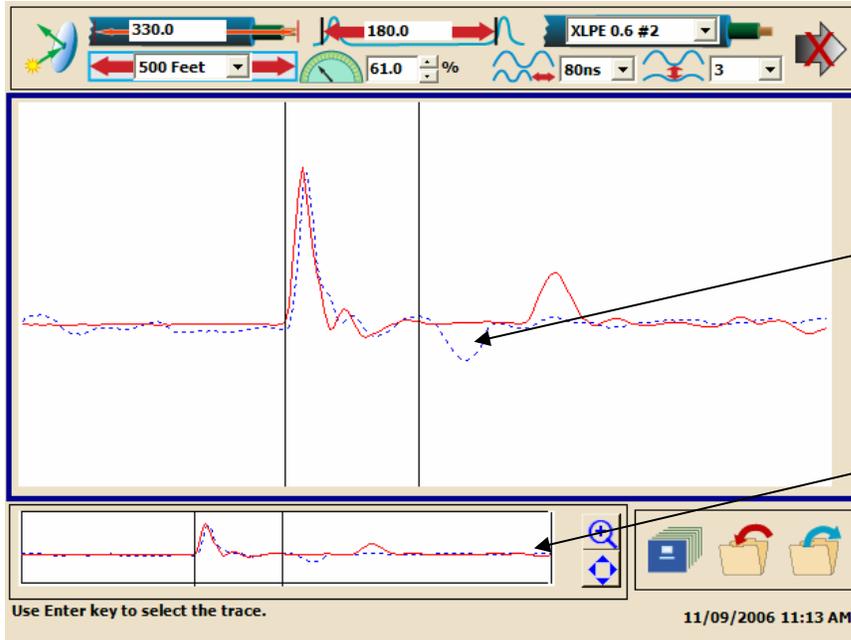


Indicates **Pulse Amplitude** which is automatically set based on range. This Amplitude can be changed by User.



Indicates **Testing Status**: Stopped, Continuous Sampling, or Armed.

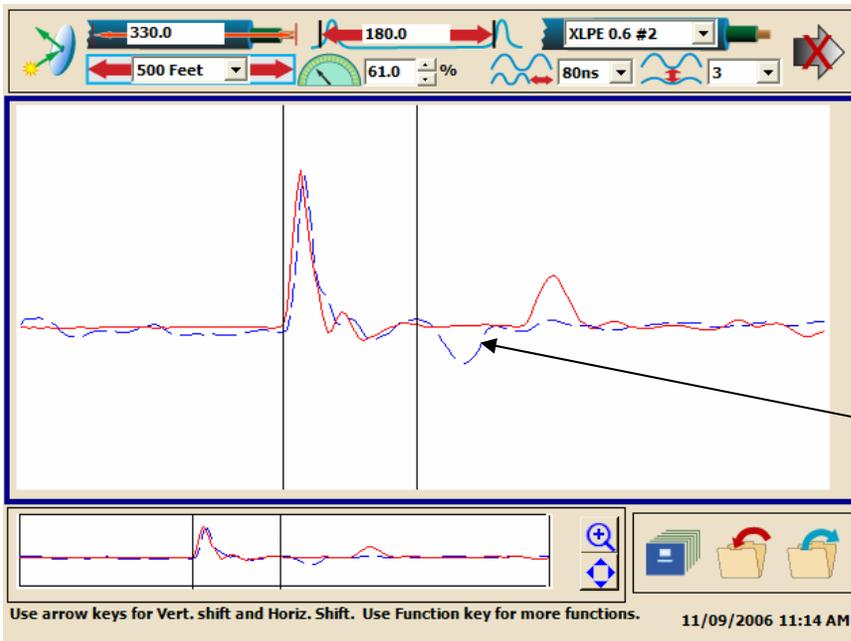
## Trace Viewer Control



Blue perimeter indicates Active area

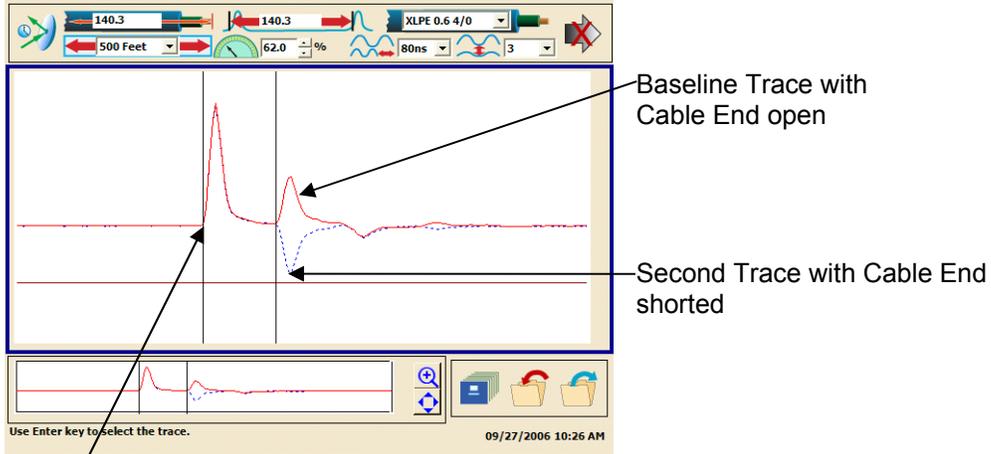
Dotted line indicates Trace is ready for Selection

Small World view of large Display



Dashed line indicates Trace is selected

## TDR - Multiple Trace Capture



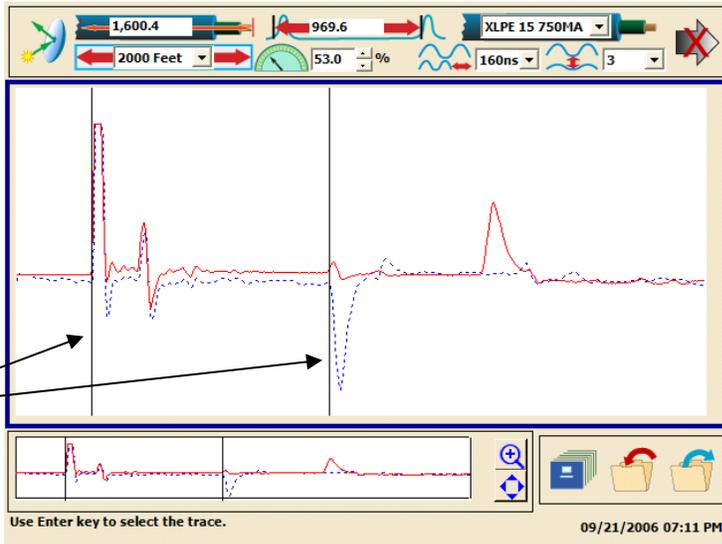
Baseline Trace to automatically identify the start of the Test Lead.

**Note:** If the Cable length is known, then **Velocity** can be verified. Place the right cursor at the Cable end and begin adjusting the Velocity. When the Distance shown for the right cursor matches the known Cable length, the velocity is set to its correct value.

## Arc Reflection – Test Control



Distance between cursors indicates Distance to Fault



**Trace Options**

Scroll Waveforms

Average Waveforms

Enable D.A.R.T.

Reset Trace

Delay (msec)

Trace Color

Reset to Factory Color

Clear Recall Trace

Scroll through waveforms with arrow keys. Use Enter to select waveform.

**Scroll Waveforms.** Allows operator to scroll through up to 16 waveforms captured for each test.

**Average Waveforms.** Displays the average of those 16 waveforms.

**D.A.R.T. Mode:** Differential Arc Reflection technique to view the difference between the TDR and ARC reflection traces

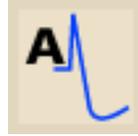
**Reset.** Resets the Trace options to factory defaults

**Delay (msec)** sets the TDR Delay used to before sampling (after the surge is detected).

**Trace color** sets the color of Traces.

Pressing  will bring up Options available for Selected item. Arc Reflection Options shown at left.

## Impulse Current (Surge)



The Impulse Current method is usually an effective method for pre-locating a high-resistance fault (arc resistance greater than 200 ohms). The Impulse Current method is similar to the Arc Reflection method in that both methods send high energy pulses down the cable which are used to break down the fault. The difference is that the Arc Reflection method observes the voltage waves caused by the reflection of the MTDR pulses from the arc at the fault. The Impulse Current method observes the current waves that are caused by the injection of the PFL pulse and its subsequent reflection from the fault. .

When using the Impulse Current method, a current coupler is switched into the surge return circuit and is used to measure the high frequencies in the transient as a series of spikes each separated by the round-trip travel time from the fault back to the PFL.

In general, the left and right cursors are positioned on the peaks of two consecutive reflections from the fault. The first one or two impulses in the transient are due to the outgoing Current Impulse used to energize the cable and may not be related to the fault location. Therefore, the third and later pulses should be used to locate the fault.

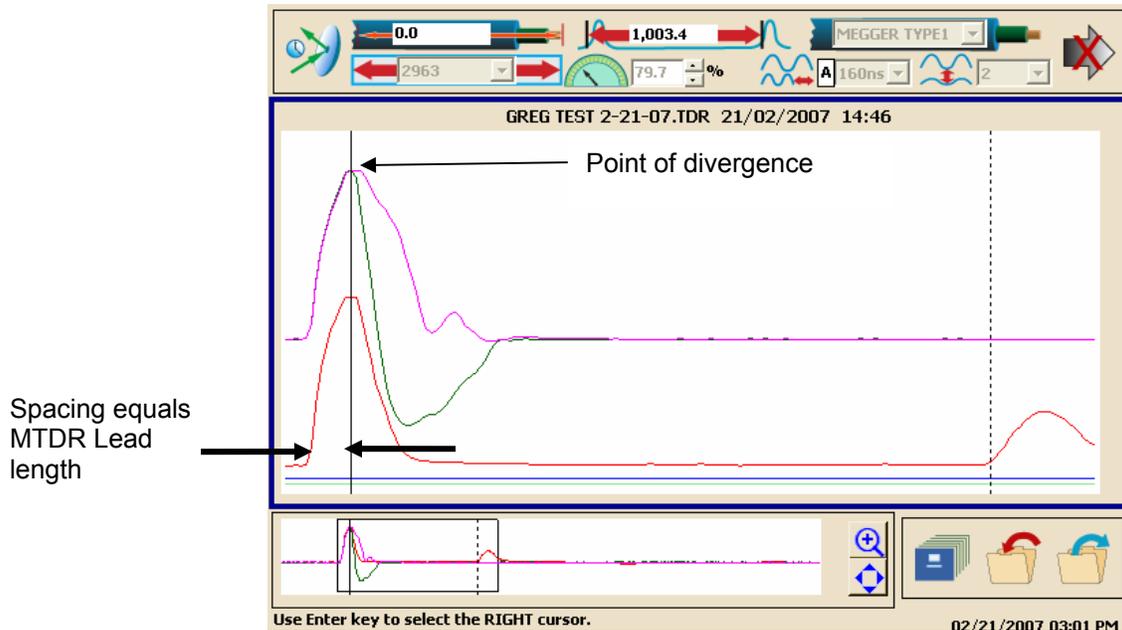
## Decay Method



Use of the Decay method of fault locating is normally used when the voltage required to sustain an arc at the fault exceeds the normal Surge capability of the PFL system. In this case, a dc dielectric test set is used to charge the cable under test, through a high-impedance Decay Coupler, to a voltage that should cause a breakdown at the fault location. The PFL is able to put out up to 40kV in Decay mode.

The capacitive charge build up on the cable, eventually causes the fault to break down, and a traveling wave is then launched back toward the Decay Coupler in the PFL and is reflected back to the fault (in reverse polarity) where it will be reflected again, until the energy fully dissipates. This reversal of polarity creates the condition such that the Distance to Fault (as measured between the two cursors on the MTDR) will be between a strong peak and an adjacent valley (half-period point).

## MTDR Lead length Calibration - Left Cursor Offset



1. With the test leads in place and open, use the TDR mode to capture a trace. Left cursor will be automatically placed at the start of the outgoing Pulse (left side of first blip).
2. Select and freeze the first Trace. Then, select the second Trace while also temporarily shorting the end of the test leads. The point at which the first and second Traces begin to diverge represents the end of the test leads. Select and freeze the second trace and then move the left cursor to this point of divergence. This change in position (of the left cursor) is referred to as the Left Cursor Offset.
3. To save this offset, use the  function select, and check the save offset. This offset will be saved, and will continue to be used until reset.

## Troubleshooting

<b>Problem</b>	<b>No reflected pulses</b>
<b>Indications</b>	No reflected pulses are observed
<b>Possible Cause</b>	<p>The fault is beyond the range of the instrument</p> <p>The fault is beyond the sensitivity of the instrument.</p> <p>The CFL system or arc reflection filter is not in the arc reflection mode.</p> <p>The connections are not correct.</p> <p>In arc reflection mode:</p> <p>The voltage may not be producing a breakdown at the fault</p> <p>The current through the fault may not be great enough</p> <p>The arc may not last long enough to cause the downward deflection.</p> <p>These conditions occur when</p> <p>The fault is a bolted fault (low impedance).</p> <p>Voltage of the test set is not great enough to cause the fault to breakdown.</p> <p>The fault is underwater and an arc cannot be established.</p> <p>The fault is filled with oil and an arc cannot be established. This occurs when testing PILC type cable.</p> <p>The fault path is too long to establish an arc for the time necessary to see the downward deflection. This can occur when the fault is at an elbow or splice.</p> <p>The neutrals in the cable are corroded preventing the creation of an adequate arc.</p>

<b>Problem</b>	<b>Open circuits</b>
<b>Indications</b>	No reversing deflection observed when the cable end is opened and shorted
<b>Possible Cause</b>	<p>Corrosion has eroded the neutrals so that there is an open circuit.</p> <p>The conductor of the cable has burned open.</p> <p>The neutrals of the cable have burned open.</p>
<b>Remedy</b>	Place a short circuit between phase and neutral at the far end of the cable. Use an ohmmeter to measure the resistance between the center conductor and the neutral. If it is greater than expected (a few ohms), then there is an open somewhere.

<b>Problem</b>	<b>Echoes</b>
<b>Indications</b>	Multiple (ghost) reflections
<b>Possible Cause</b>	Often, the TDR reflects back and forth several times in the cable system until it becomes so attenuated that it can no longer be observed on the screen
<b>Remedy</b>	To distinguish an echo from a fault, measure the distance from the initial pulse to the first reflection and then from the initial pulse to the second reflection (suspected echo). If the distance to the second reflection is exactly double the distance to the first reflection, it is probably an echo because echoes are evenly spaced.

# Addendum B

## CBL100HV CABLE REELS

### Connections

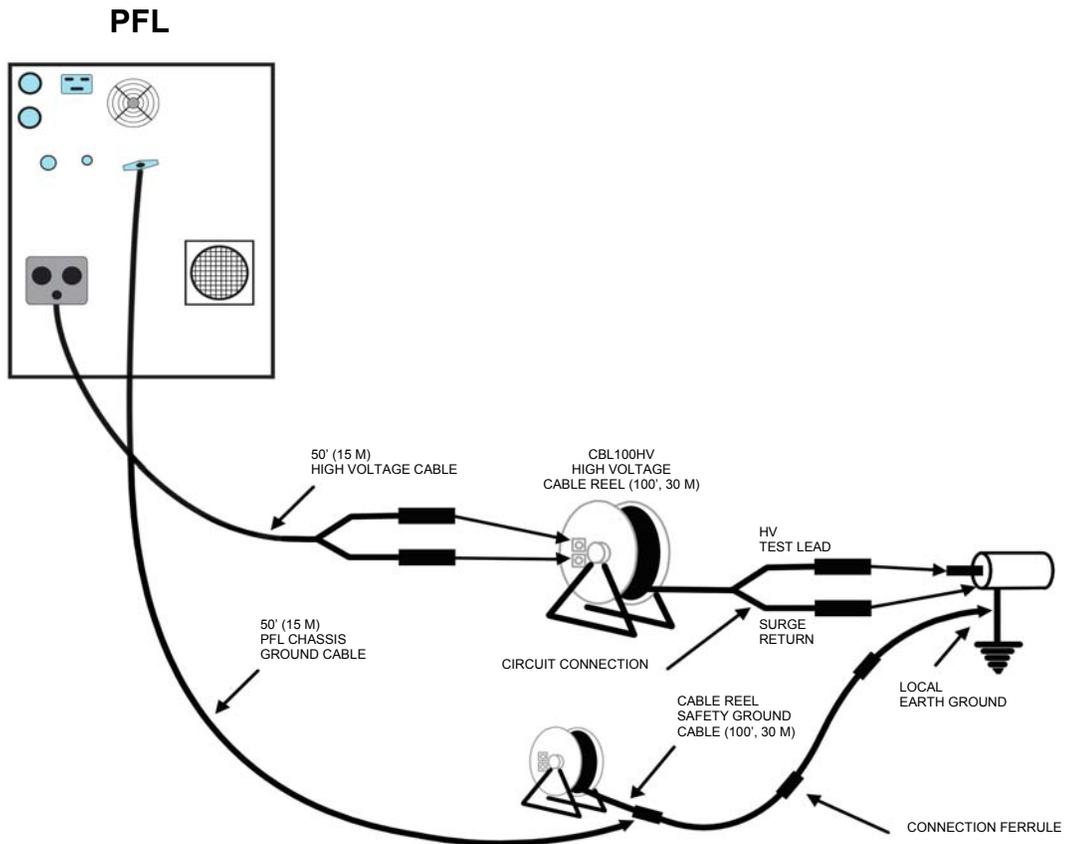


Figure B-1. High-Voltage and Ground Cable Reel connections.

## Specifications

Voltage: 40 kV dc maximum

HV cable reel containing 100 ft (30 m) cable

Dimensions: 9.25 x 16.5 x 19 in. (23.5 x 42 x 48 cm) (D x W x H)

Weight: 47.5 lb (21.6 kg)

Gauge: 12 AWG

Ground cable reel containing 100 ft (30 m) cable

Dimensions: 12 x 12 x 15 in. (30.5 x 30.5 x 38.1 cm) (D x W x H)

Weight: 26.5 lb (12 kg)

Gauge: 8 AWG

### WARNING



**The high-voltage cable reel is part of the high-voltage circuit. Do NOT touch while energized. Shut down and ground all parts of the system before connecting or disconnecting cables.**

### WARNING



**Lethal voltages can be present at the ends of the HV output cable. Before connecting or disconnecting HV cables at the reel, ensure that the POWER switch is set to OFF and the CBL100HV HV cable is disconnected from the specimen and that the ends of the HV cable have been grounded.**

## Connecting the Cable Reels

Perform the following procedure to connect the CBL100HV cable reels. Figure B-1 shows connections to the PFL40A.

1. Remove the detachable vise grips from the HV output cable of the PFL40A by pressing the connector firmly into the receptacle to unlock the connector, then pulling the plug from the receptacle. Attach the vise grips to the output end of the CBL100HV HV cable by pressing the plug firmly into the receptacle.
2. Place the CBL100HV cable reel within 50 ft (15 m) of the PFL40A. Unwind the amount of HV cable and ground cable required to reach and connect to cable under test. Make connections as follows:

## CBL100HV CABLE REELS

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- a. Connect the SAFETY GROUND lead to the LOCAL EARTH GROUND.
- b. Connect the SURGE RETURN test lead to the SPECIMEN GROUND (grounded shield of the cable under test). This is the black lead terminated with a vise-grip clamp.

### WARNING



**The low-voltage lead of the output cable must not be extended because this introduces excessive impedance in the SURGE RETURN and could result in hazardous voltages being present on the low-voltage lead.**

- c. Connect the high-voltage test lead to the faulted conductor of the cable under test. This is the red lead with red band terminated with a vise-grip clamp. Be sure that the exposed conductor and clamp are sufficiently insulated to withstand the test voltage.
3. Attach the 50 ft (15 m) PFL CHASSIS SAFETY GROUND cable to a convenient connection ferrule on the CABLE REEL SAFETY GROUND.
  4. Plug the connectors on the 50 ft (15 m) HV output cable (of the Portable Fault Locator) into the HIGH VOLTAGE and SURGE RETURN receptacles on the HV cable reel.
  5. At the completion of the test, discharge the cable and shut down. Refer to the manual for the surge generator you are using for the recommended procedure.

**NOTE:** *To remove the HV connectors from the receptacles on the HV cable reel, firmly press the connectors into the receptacle to unlock the connector and then pull the plug from the receptacle.*

**Megger.**

# Addendum C

## COMLink (Version 1.08)

### *Introduction*

COMLink is Megger's software program for use with your MTDR Analyzer.

COMLink allows the bi-directional transfer of test data (waveforms) between the MTDR and a Personal Computer (PC).

COMLink software consists of two programs—COMLink, which provides the interface to the MTDR, and COM32, which provides the communication to the MTDR. COMLink takes care of starting and terminating COM32. Your COMLink installation CD will install both COMLink and COM32.

Data is transferred via either a USB memory stick or through an RS232 serial cable, which connects the MTDR to the PC. If using the serial cable, the MTDR and the PC must operate with the same communication parameters.

### **System Requirements for PC**

<b>Operating system:</b>	Windows NT 3.1 or later; Windows 95 or later
<b>Processor:</b>	80386 or higher
<b>Monitor resolution:</b>	VGA or higher
<b>Display properties:</b>	600 x 800 and small fonts
<b>RAM:</b>	16 M
<b>Communications port:</b>	9600 baud or better
<b>Storage</b>	USB stick, 3½-inch inch floppy disk drive, or CD-ROM

## Software Installation

*NOTE: COMLink uses DART/MTDR interchangeably.*

To install COMLink, load the COMLink CD into your CD-ROM drive and follow the on-screen instructions.

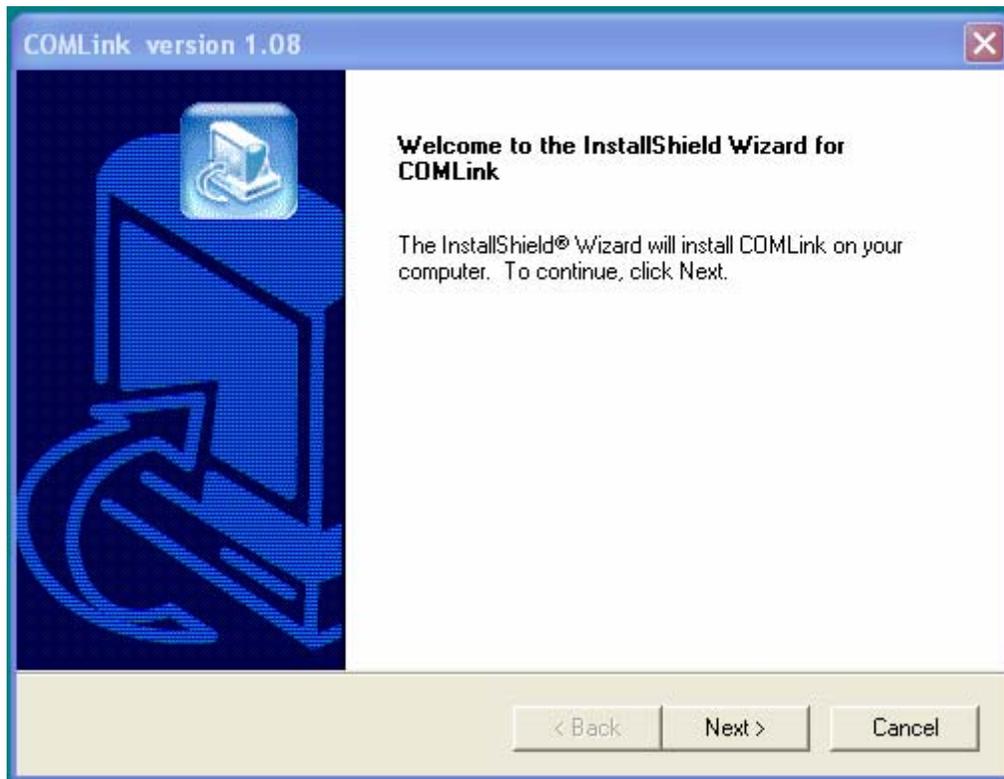


Figure C-1. COMLink Installation screen

## Connecting the PC to the MTDR

You may power up the MTDR before or after connection to the PC, however be sure the MTDR is properly and securely connected to the PC (via RS232 serial cable) before starting COMLink. Refer to Addendum A for the location of the RS232 serial port.

1. Access the COMLink program by clicking on **Start**.
2. From the Programs menu, select **COMLink** and then, from the submenu, **COMLink**.
3. COMLink automatically sets the communication parameters at 19200 baud, 8 data bits, 1 stop bit and no parity. The MTDR uses 19200 band for communication.

## COMLink Home Screen

When opening the COMLink program, the Home Screen is displayed. From the Select Device drop down menu, select the **DART (MTDR)** device.

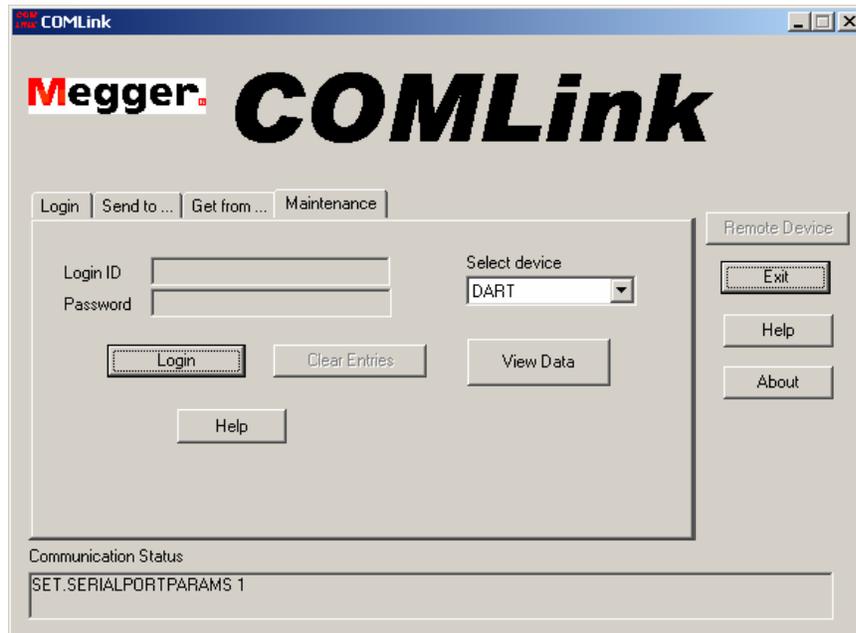


Figure C-2. COMLink Home Screen

## Select Device

After selecting **DART (MTDR)** as the remote device, the COMLink program initially displays the Login tab. Login ID and Password are not required to use COMLink with the MTDR Analyzer. Next, click on **Login**.

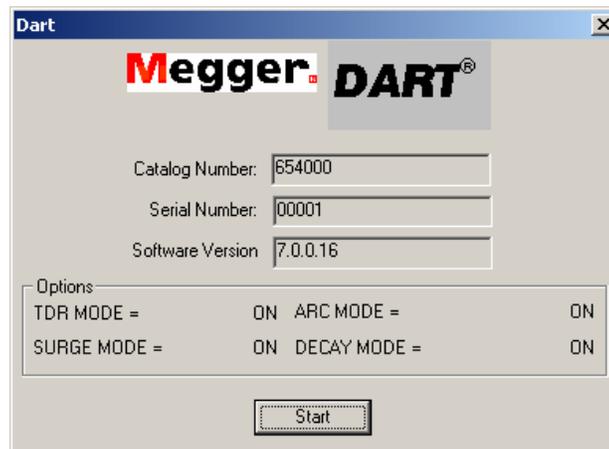


Figure C-3. Successful Connection Confirmation Screen

If your login is successful, the screen will display the Catalog number 654000, the MTDR Serial Number, and software version. Also, the name of the **Login** tab will change to **Logout**. If your login is unsuccessful, the **Remote Device** button will remain disabled.

Click on **Start** and the **Select Operating Mode** screen will open.

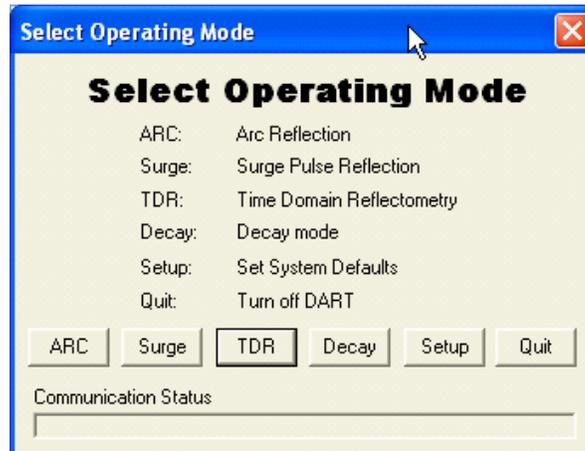


Figure C-4. Select Operating Mode Screen

To start the MTDR Wave Form Viewer, click on the **TDR**, **ARC**, **Surge**, or **Decay** mode buttons. Click **Setup** to set the units-of-measure (for both Distance and Velocity of propagation).

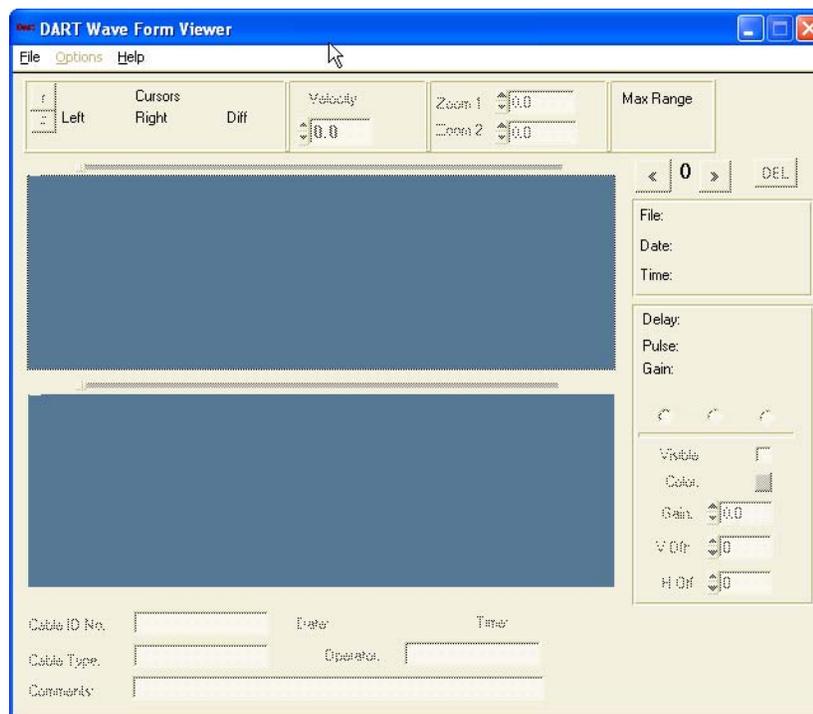


Figure C-5. MTDR Waveform Viewer

## Transferring Wave Forms from the MTDR

With COMLink you can transfer Waveforms to the PC (Get from DART (MTDR)) or to the DART (MTDR) (Send to DART (MTDR)). This can be done via a USB Memory stick or via a serial cable as below.

Minimize DART (MTDR) Viewer and click on either the **Get from DART (MTDR)** or **Send to DART (MTDR)** tabs. Then specify the path and file name to transfer.

If you need to stop the file transfer, select the **STOP Getting Files** button.

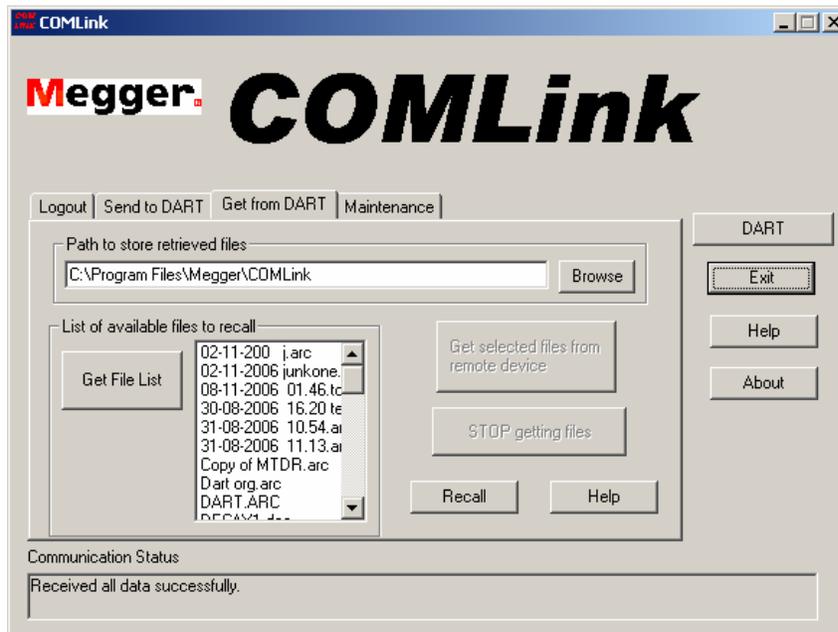


Figure C-6. File Transfer Menu

The MTDR Wave Form Viewer

To view a wave form that is stored on the PC, click on **File** in the menu bar at the top of the screen, then click on **Load**.

The **Select Wave Form** dialog box displays. Browse to the folder containing the wave form you want to view and double-click on the desired **.arc**, **.srg**, **.tdr**, or **.dec** file. (The default location is C:\COMLink\MTDRdata.). Arc Reflection wave forms are stored with an **.arc** extension, Surge Impulse with **.srg**, TDR with **.tdr**, and Decay with **.dec**.

The Viewer displays the selected wave form. The section on the right side of the viewer displays the filename for the wave form shown as well as the date and time it was saved in the MTDR (DART).

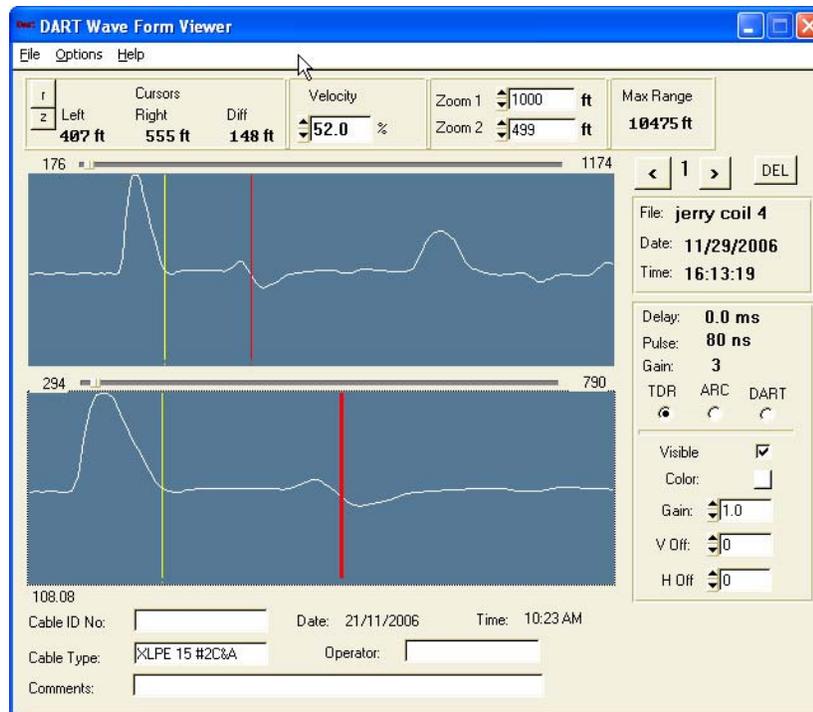


Figure C-7. MTDR Waveform Viewer

The controls across the top of the viewer allow you to alter the view by adjusting a number of variables.

The left cursor (yellow) and right cursor (red) can be moved by either clicking and dragging or by clicking and using the left and right arrow keys on your keyboard. If the left cursor is moved, clicking on the **1** box will reset it to its zero position. To set a new left cursor zero position, click on **2**. The **Cursors Left** and **Right** display the absolute distance measurements of the left and right cursors from the zero set point. The **Diff** measurement is the differential distance between the left and right cursors.

To adjust the velocity of propagation, click on the **Velocity** spin box.

The **Zoom 1** spin box is provided to allow changes to the total distance displayed in the upper window. The **Zoom 2** spin box allows distance changes to the lower window.

You can click and drag the slider bars located above the upper and lower windows to view different sections of the cable.

You may also view the TDR, ARC or DART (MTDR) traces, if available, for the wave form, individually or all at once. Click on the Options tab for the desired method, and then click the Visible checkbox to display the trace.

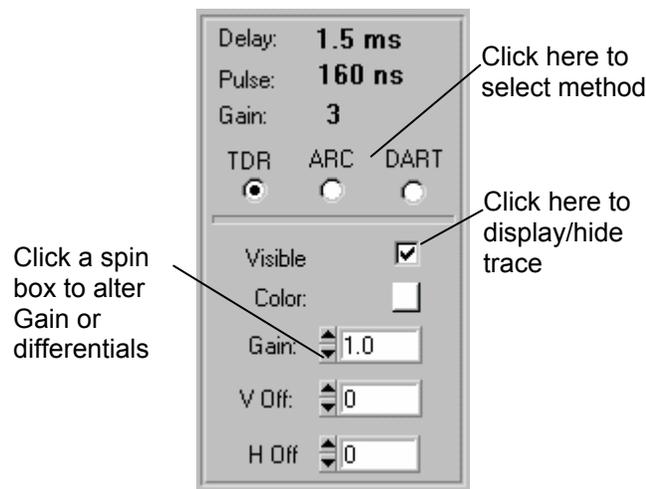


Figure C-8. MTDR Waveform Viewer – Control Box

The Gain and Offsets of the individual TDR, ARC or DART (MTDR) traces can be altered by selecting a value in the spin box. A color pallet is also provided to color the various displayed traces.

## Multiple Waveform viewing

Up to three files can be loaded into the Viewer at one time. If the Velocity used was identical for all three traces, the arrows above the file name toggle through each of the three traces and display the appropriate file name, date, time, pulse width and gain for each trace.

Click on **DEL** only if you want to discard the wave form from the Viewer.

*Note: this will not delete the file from its saved location.*

## Print Waveform

To print the Waveform display, click on **File** and then **Print** and follow the on-screen instructions.

## Communications functions

The MTDR and the COMLink software must always operate with the same communications parameters. If you find it necessary to change the communications parameters for COMLink, you can do so from the Maintenance tab.

Click on **Maintenance** to display the Maintenance tab, and then select **DART (MTDR)** from the **Select Device** drop-down list.

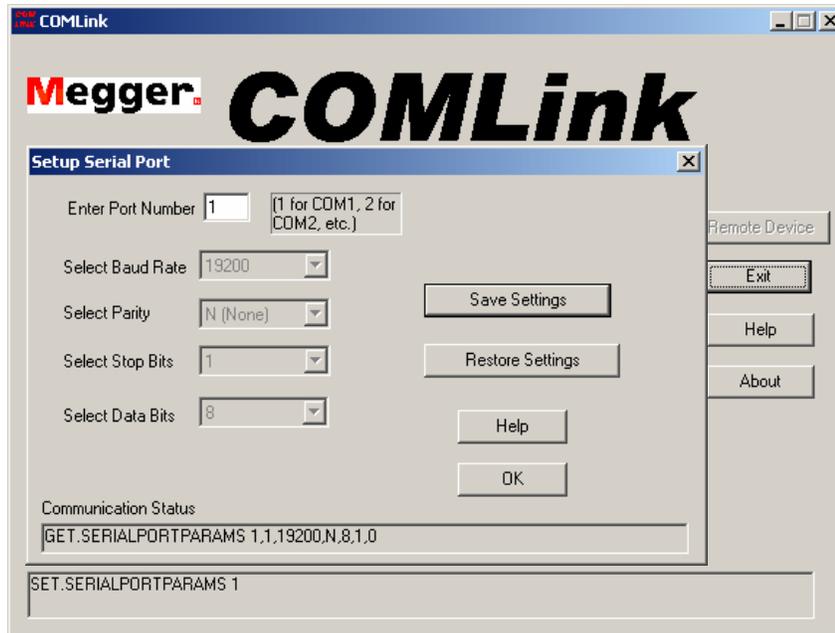


Figure C-9. Serial Port Set Screen

## Setup Serial Port

When necessary, use this feature to adjust the communications parameters.

Click on **Setup Serial Port**. Select either COM1 or COM2.

To save the new settings and initialize the serial port, click **Save Settings**.

To Exit without saving, click the **Restore Settings** button.

## COM32

COM32 provides the communication to the remote device. COMLink takes care of starting and terminating COM32. If you need to view the communication status, click on **START, PROGRAMS, COMLink, COM32**. The resulting window shows all commands and responses to commands going between COMLink, COM32 and the remote device. The following abbreviations indicate where the commands and responses are coming from:

- RI:           Response to command came from the remote device
- RO:           Command was sent to the remote device
- CO:           Response to a command was sent to the client (COMLink)

Other items in the window, which are generated by COM32, may or may not be preceded by one of the above indicators.