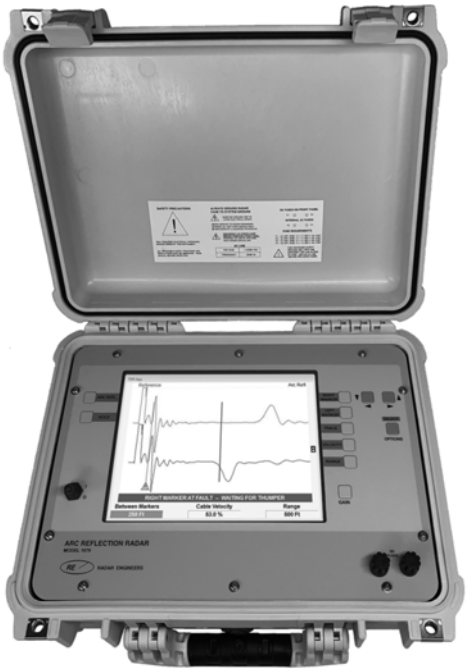
ARC REFLECTION RADAR

Model 1670



OPERATION MANUAL

SET UP REMINDER:

Before using the Radar for the first time be sure to lock in the Left Marker at the end of the connecting cables.
Enter Menu, select Setup, then select Left Marker setting.

DIAGNOSTIC MESSAGES

The software in this Radar includes operator alerts if certain abnormal conditions are detected. The messages appear on an orange background and stay on the screen for a few seconds.

1. "CHECK LEFT MARKER" message will be triggered if the Left Marker appears to be too close to the radar and not set at the connection to the cable under test.
   Action: Reposition the default left marker setting in the options menu.

2. "POSSIBLE OPEN OR FAULT BEFORE CONN. POINT" message appears if there is evidence of an open or fault in the thumper coupler or interconnect cables before the connection point that could interfere with fault location.
   Action: Check radar connecting cable and cable reel connections. If the message repeats and no open is detected, the problem may be inside the thumper.

3. "CHECK THUMPER AND LEADS" message appears if an open is detected before the connection point.
   Action: See #2 above.

4. "POOR CABLE CONN. DETECTED - CHECK HOOKUP" message appears if a high impedance/poor connection to the cable under test is detected such as a corroded vice grip.
   Action: Clean the connection.

5. "LITTLE OR NO FAULT BREAKDOWN - CHECK THUMPER KV" message appears in the event of a weak or no fault breakdown that results in insufficient data for auto locate to identify a fault.
   Action: Try again.

Observe safe work practices at all times.

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APPENDIX

A. CURRENT IMPULSE METHOD (OPTIONAL) A-1

1/25/2024

I. INTRODUCTION

The Model 1670 is specifically designed for use in conjunction with impulse generators ("thumpers") and energy separating coupler/filters in arc reflection systems. It captures and holds the waveform created when a thump causes a fault to arc to ground.

The Model 1670 Digital Storage Radar operates on the principle of pulse reflection to localize the source of power failures in shielded underground cable. This method of cable fault location is simple and fast.

The Model 1670 applies a low voltage pulse to the cable. The pulse propagates on the cable until it encounters a change in the impedance (electrical characteristic), such as that caused by a short, open, splice, tap or transformer, etc. At that point, a full or partial reflection of pulse energy occurs. The shape of the reflection depends on the type of change encountered.

The initial output pulse and any impedance change caused reflections are shown on the display screen. When viewing the trace, the applied pulse is seen on the left of the screen. Everything to the right represents reflections of what the pulse encounters in the cable.

The distance to any reflection of a cable joint or fault along the trace is measured by moving the right marker to the point of interest. The distance to the fault is then shown on the display.

A short glossary of terms used in this manual:

1. TDR stands for time domain reflectometer and is often used interchangeably with radar.
2. Thumpers are impulse generators that discharge capacitors into a cable to break down primary cable faults. The breakdown causes an impedance change in the cable that is detectable by the TDR and shown on the #1670 display.
3. Coupler/Filters (sometimes used interchangeably) refer to the means by which the TDR pulse is imposed on the cable under test when the TDR is connected to a thumper.
4. Arc Reflection refers to the fault location technique where the thumper breaks down a high impedance fault causing an ARC that the TDR pulse reflects off of.
5. Arc Reflection Systems refers to a TDR used together with a thumper and coupler/filter.

II. SAFETY PRECAUTIONS ⚠

Only qualified electrical personnel should operate the model 1670. All applicable safety practices and regulations must be observed. Exercise caution at all times.

This is an instrument. Handle with care. The 1670 is water resistant, not waterproof. Store in a warm dry place. If a problem develops, do not try to repair it yourself. No operator serviceable parts are inside the chassis. Please return the Radar to the factory for repairs.

Prior to connecting to the cable under test, confirm that ground lug on the rear of the 1670 instrument case is grounded to system ground.

TDR MODE

Make certain that the cable under test is de-energized and open at both ends before attaching the connecting cable. The conductor under test should be safety grounded for at least one minute immediately before connecting the model 1670 to remove accumulated charges. Safety grounds should be replaced upon completion of the test. **NEVER THUMP, APPLY HIGH VOLTAGE OR OTHERWISE ENERGIZE A CABLE WITH THE MODEL 1670 DIRECTLY CONNECTED TO THAT CABLE.**

ARC REFLECTION MODE

Use of the Model 1670 together with a “thumper" requires additional safety procedures. This includes the use of a coupler/filter and grounding the radar and the thumper. Refer to Section VI-A of this manual for additional information. Refer to thumper/coupler manufacturer’s manual to verify compatibility of the Model 1670 with their equipment and for operating and safety procedures.

Only qualified technicians should open the front panel. The AC line inside the 1670 is energized even with the 1670 power switch off. Never operate the Model 1670 with the front panel removed. Never touch any internal parts when the power is connected. Never touch any internal part until the 1670 has been unplugged at least five minutes, otherwise severe electric shock could result.

III. PRODUCT DAMAGE PRECAUTIONS

A. DISPLAY

The display in the Model 1670 is a 10.5” TFT enhanced color LCD. It should not be subjected to unnecessary shock. Though the LCD is sunlight readable, it should not be left exposed to direct sunlight for long periods of time. Damage to the display will result.

B. POWER

AC VOLTAGE/FREQUENCY - Do not plug the Model 1670 into an A.C. power source outside the following specifications: 100 VAC to 240 VAC, 50 to 60 Hz.

GENERATORS/INVERTERS - The 1670 will run off generators and inverters that provide AC power in the above specified range. These devices, particularly generators, may have start up and turn off transients during which the output voltage is not in the specified range for the 1670. The 1670 is designed to tolerate these transients for a well-regulated generator or inverter in good operating condition. However, to protect the 1670 from malfunction in these external power sources, the 1670 should not be plugged in until the external source is on and stabilized. The 1670 should be unplugged before the external source is turned off.

SPIKES/SURGES - The 1670 has internal power line spike protection. However, if the 1670 is to be connected repeatedly to various AC power sources that may have surges, spikes, and brown-out conditions, it is recommended that further external protection be provided, such as a voltage regulating transformer with spike/surge protection.

C. RAIN

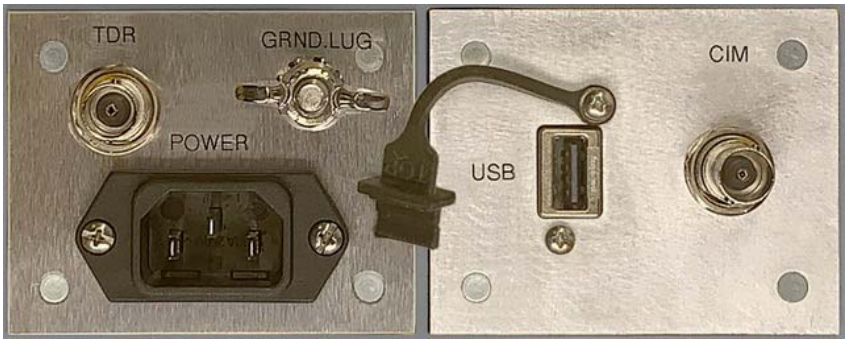
When the lid is open avoid exposure to rain, snow, etc. The Model 1670 is water resistant but not waterproof.

D. STORAGE/OPERATION TEMPERATURES

Do not store this instrument where temperatures are below 10°F or above 140°F. Damage to the instrument may occur below or above those temperatures. The operating temperature range for the Model 1670 is 20°F to 120 °F.

IV. FRONT & BACK PANEL LAYOUT

Front Panel



Back Panel

V. MODEL 1670 CONNECTIONS AND CONTROLS

A. INPUT

On the back of the model 1670 there is a BNC input marked TDR. Attach one end of the coax connecting cable there. Attach the other end to the corresponding input on a thumper equipped with an energy separating filter designed for ARC reflection. If the optional CIM mode was also purchased there will be a second BNC input marked CIM. Connect that CIM input with a separate BNC cable to the CIM input on the thumper. Do not use the CIM input for TDR/ARC REFLECTION. See Appendix A for CIM capable instruments.

B. GROUND LUG

For connecting the Model 1670 to system ground. Any time the instrument is used, and especially as part of an arc reflection system, the Model 1670 must be grounded, preferably to system ground.

C. THE CORD & RECEPTACLE

AC: The unit is supplied with a grounded cable appropriate for standard 120 VAC U.S. three prong outlets. For 220 VAC operation, use a three wire (grounded) cable appropriate for the outlet used.

D. POWER ON SWITCH

The instrument is on and the display screen lights up when the power switch for Model 1670 is turned on.

E. DISPLAY SCREEN

Signal traces, equipment status and modes, distance marker and trace analysis are displayed on the LCD. The screen has two halves. The lower half displays "Live" waveforms while the top half displays "Memory" waveforms and "Reference" waveforms for arc reflection comparison.

F. SET UP

Each function key just to the right of the LCD is activated by pushing it once. A small icon will appear on the display, indicating which function button has been selected and is active.

1. RIGHT MARKER – Allows the operator to move the right vertical line or marker. The vertical line on the right of the display indicates the end point for all measurements. It also sets the center point for the horizontal zoom.
2. LEFT MARKER - Allows the operator to move the left vertical line or marker. The vertical line on the left of the display indicates the beginning point for all measurements. When the Model 1670 is turned on, the left marker resumes the last position to which it was "locked in". The left marker is set in the OPTIONS menu. At the bottom of the left marker is a triangle with initials “CP” for “connection point”, sometimes also referred to as “zero” point.
3. TRACE - Allows the operator to move the bottom waveform up and down. This can

be particularly useful in the arc reflection mode to compare the reference trace (captured before the thump) with the arc reflection trace captured during the thump.

4. VELOCITY - Allows the operator to change the propagation velocity factor to match the specific cable under test. The selected velocity is shown at the bottom of the LCD in the center of the display when the velocity key is pressed. The factory set default value is 53%. The default value can be changed in the OPTIONS menu. See section VII for additional information.
5. RANGE - Ranges of 500, 1500, 3000, 6000, 12000, 25000 and 50000 feet are available. The factory default range is 3000 feet.
6. GAIN - Controls the vertical amplitude of the trace on the display. The gain level appears at the bottom of the LCD when the gain key is pressed
7. ARROWS - To change a selected function up/down or left/right, the ARROW keys are used.

G. MODE

When a function to the left of the LCD is chosen and is active, an icon appears on the display next to it.

1. ARC REFL. - This key allows the operator to toggle between the default live trace TDR mode and the Arc Reflection mode. The Arc reflection mode is used when the operator is connected to an arc reflection system and wishes to capture a cable breakdown following a "thump". To enter ARC REFL mode, press the ARC REFL. key. To exit Arc Reflection, press the ARC REFL key, again.
2. HOLD - In the default mode, the screen is constantly being updated. To stop the updating of the display, press the hold key. A small icon will then appear next to the key. Ordinarily this key will only be used when the ARC REFL. mode has also been selected and it is desired to "hold" the thumped waveform that has appeared on the lower part of the display. Once the Hold key is pressed the lower waveform will not update until released. To release the HOLD function, press the Hold key. (When in the HOLD mode, the ARC REFL. and RANGE keys will not respond.)

H. OPTIONS

To enter the options menu, press Options. The arrow keys are used to highlight the desired option and the dual function OPTIONS/SELECT key is pressed again to enter the choice. Press any key to exit or select EXIT in the menu. More details about specific functions can be found in Section VI, Operation Guide.

1. SETUP - This option is used to change the DEFAULT settings. Follow the instructions on the screen exactly.
    a. L MKR - Change the default or “zero point” location of the left marker.
    b. AUTO F. - Auto functions available for Range and Locate. Toggle on or off with the SELECT key.
    c. VEL. - Change the default velocity factor. Factory default is 53%.

d. RANGE - Change the default range. Factory default is 3,000 ft.

e. MORE

i. METRIC - Toggle between metric and feet with the SELECT key.

ii. VEL. NOT. - Toggle between the velocity notations of Vp (Ft/µS) and VF (%) with the SELECT key.

iii. ABOUT - Identifies the version of software.

iv. FACTORY - Restores factory defaults.

f. EXIT - Select to leave the SETUP menu.

2. MEMORY - This function is used to manually store up to 100 traces in memory.

a. STORE - Press the SELECT key to store the current trace that is displayed.

b. DISPLAY - Use the SELECT key to toggle the active memory display on or off.

c. PREVIEW - Use the arrow keys to preview specific stored traces (#1 - #15) in active memory and check the status. The number of the memory register will appear followed by the status description, which will indicate if the memory register is open or has a trace stored in it.

d. CLEAR - Choose single to clear the current memory only or choose ALL to clear all stored traces.

e. USB – Allows the user to upload data to a thumb drive via a USB output connection.

f. EXIT -- Select to exit the MEMORY menu.

3. RECENTS –The model 1670 automatically stores the last 30 thumped traces for easy reference. Recents are retained for 30 days. This function can be accessed in the Options menu only when in ARC Refl. or CIM.

4. ZOOM - This option is available when the distance is >3000 ft. It enlarges the area around the right marker. Move right marker to the area of interest before selecting the ZOOM feature. See Section VI. C., Advanced Operating Instructions.

5. AUTO R. - Performs a new auto range of cable without the need to turn the radar off and back on.

6. MORE - Additional functions are available which are accessed by selecting the MORE function.

a. CIM – This function enables the current impulse method (“CIM”) when that optional mode is available.

b. ABC -- This function permits the operator to view, overlay and obtain differential readings from up to 3 phases. The first step is to store the trace from each phase on the screen. Connect to any phase then press select to

lock it on the screen. Next connect to the second phase and lock it. Repeat for third phase. Finally, select the overlay or differential mode for evaluation. When you exit the 3 phase mode the traces are erased.

c. P/W - This option allows the user to change the pulse width using the arrow keys.

d. UPLOAD - Allows the user to upload data to a computer via a USB output connection.

e. EXIT - Select to leave the MORE menu.

I. USB PORT

This port permits attachment to a thumb drive.

J. DC LINE FUSES

DC line fuses are operator accessible:

a. 3A FB ceramic fuse for the right fuse on the front panel (F2). See lid label.

b. 4A FB ceramic fuse for the left fuse on the front panel (F1). See lid label.

K. BEEPER

Each time the Model 1670 is turned on, a beep will sound. Any time a key is pressed or when an auto locate or auto range operation is completed a beep will sound.

VI. OPERATION GUIDE

A. PRELIMINARY STEPS

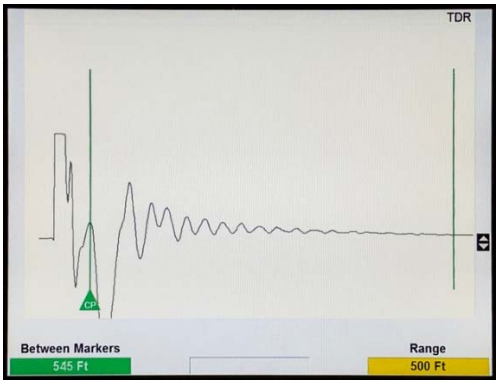
1. RESISTANCE TEST - First check the resistance of the cable under test with an ohmmeter to determine the resistance of the fault. If it is a low resistance fault (less than 200 ohms) the Radar Engineers Model 1670 alone will help you quickly locate it. If it is a high resistance fault, then the Model 1670 should be used as part of an arc reflection system.
2. POWER - Plug the power cord into 115 or 230 volts AC, 50 or 60 Hz AC.
3. BOOT-UP - It takes about 40 seconds after turn on for the model 1670 to be operational. At temperatures below freezing the display in Model 1670 may be sluggish when first turned on.
4. CONNECTING CABLE - The Model 1670 may be hooked up directly to a conductor. Or it may be connected to an impulse generator (thumper) with energy separating coupler/filter. In each case make sure that the cable under test is de-energized and open at both the near and far ends before attaching the connecting cables. The cable must be grounded for at least one minute immediately before connection to remove accumulated charges. This is particularly important if a megger, impulse generator, or proof tester was previously connected. Follow all utility safety procedures.
   If the Model 1670 is connected directly to the cable under test (and if you are using a factory supplied 50 ft. BNC coax connecting cable), the black lead of the 50 ft. cable is attached to the faulted cable's shield or concentric neutral. The red lead is attached to the center conductor. **NEVER THUMP, APPLY HIGH VOLTAGE OR OTHERWISE ENERGIZE A CABLE WITH THE MODEL 1670 HOOKED UP DIRECTLY TO THAT CABLE.**
   If the Model 1670 is to be connected through a thumper with a coupler/"filter" for arc reflection read the thumper manufacturer's manual carefully for safety, hook up and thumping procedures. Always ground the chassis of the Model 1670 and the thumper, preferably to system ground.
5. THUMPER VOLTAGE LEVELS - The Model 1670 only needs a thumping voltage sufficient to cause an arc to ground. Higher voltages do not necessarily improve waveform capture or presentation
6. GAIN SETTINGS - The 1670 automatically sets the gain for the best algorithm performance. Vertical gain can also be manually adjusted. If you set the gain manually, it is recommended that the gain be increased until the peak of the outgoing pulse begins to flatten out. Increase or decrease as necessary.

B. BASIC OPERATION

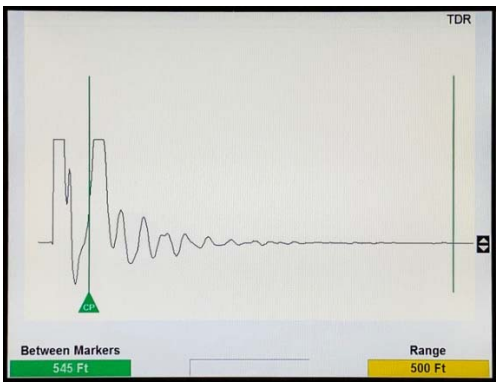
1. SETTING THE LEFT MARKER - The Left Marker setting must be confirmed before using the radar. All distance measurements depend on the location of the Left Marker. Default left Marker zero point changes are accessed through the OPTIONS menu. Follow the instructions on the screen exactly for locking in the Left Marker. Ordinarily,

the Left Marker should be set or locked in at the point where the end of the test cable connects to the conductor under test. This point is usually on the first distinct blip in the trace after the outgoing pulse. If there is any doubt about the location of the connecting point, it can be located by alternately shorting and opening the end of the test leads while observing the display. Set the marker where the trace “pivots” as the cable is shorted. See photo sequence below. Follow safe work practices when shorting the connecting cable leads.

The left marker above is <u>not</u> set at the end of the test leads/connection point (CP) to the cable under test.



The photo above shows the test lead shorted, and the left marker moved to the pivot/ connection point.



The Left marker above is correctly set at the connection point. Cycle the radar off and back on to confirm the new default setting is locked in.

2. <u>AUTO RANGE</u> - The 1670 is factory set to default to Auto Range and Auto Locate

(these features may be disabled in the OPTIONS menu). When the Model 1670 is turned on, it will Auto Range or search for the end of the cable, which will be an upward blip. When the open is located, the Right Marker will automatically change the range to allow viewing the end of the cable and it will move the Right Marker to the open.

a. Open “faults” versus open “terminations” (end of cable) - The Radar cannot distinguish between an open fault and an open termination. You must make that determination. To verify that a given upward blip is the cable end, alternately ground and open the far end while observing the display. The blip will be downward when the end is grounded and upward when open. If no change is seen when the end is shorted, then the open on the screen is an open fault, not an open cable end.

b. Override - If you disagree with range selected by the Auto Function, you can override it by pushing the RANGE key and then an arrow key to obtain the range you want.

c. Disable -The Auto Range function may be disabled by entering the options menu, then select SETUP and follow instructions on the screen.

3. AUTO LOCATE - This function automatically sets the Right Marker at the fault (short) after each thump during which the fault breaks down. The user is reminded that while every effort has been made to ensure the reliability of the “Auto” functions they should not replace the user’s own personal judgment. If a case is found where the “Auto” functions fail to work, the user should revert to using their own experience to find the end of the cable as well as the fault.

   a. Override: The Auto-Locate marker placement may be overridden by moving the Right Marker to the preferred location.

   b. Disable: The unit is shipped with the "Auto" functions enabled. In order to disable/enable the "Auto" functions, press the OPTIONS button, then go to SETUP, and then select AUTO F. from the menu. Toggle on/off by pressing the OPTIONS/SELECT key.

   c. Training: We recommend that any training in the operation of the Radar first be done without the Auto functions. There is no substitute for operator judgment.

   d. Use Lower Range Message: If the Range is set for 3000 feet or more and a fault is located within about the first 10% of the range, a message will appear:

FAULT CLOSE IN - USE LOWER RANGE

   Exit arc reflection mode. Set to a lower range. Reenter arc reflection and “thump” again. This will improve fault location accuracy. If you are on the 500 or 1500 foot range and the fault is close in the operator can overlay the traces and mark the fault manually or go to the far end of the cable and shoot back from there.

   e. Unmarked Faults: In some cases, the auto-locate functions cannot determine where the fault Is. When that happens, a message will appear:

NO FAULT MARKED - PRESS SELECT TWICE FOR HELP

The Help screen will appear:

POSSIBLE REASONS NO FAULT MARKED	SUGGESTIONS TO TRY
Inadequate Fault Break Down…	• Increase Thumper KV, Or • Test From Far End Of Cable
Fault Is An "Open" And Cannot Be Broken Down or Cable is Shorted...	• Confirm Right Marker Is At Open End Or Fault, Or • Test From Far End Of Cable
Fault Is Beyond Displayed Range…	• Increase Range
Open Or Fault At Or Before Connection Point…	• Check Thumper And Cable Reel Connections
PRESS SELECT TO CLEAR	

4. DETERMINE DISTANCE WITH THE MARKERS - Distance measurements are displayed in the lower left portion of the display. The distance shown there represents the distance between the Left Marker and the Right Marker. See Figure 1. (If Auto Range were enabled the right marker would automatically move to the open upward blip.)

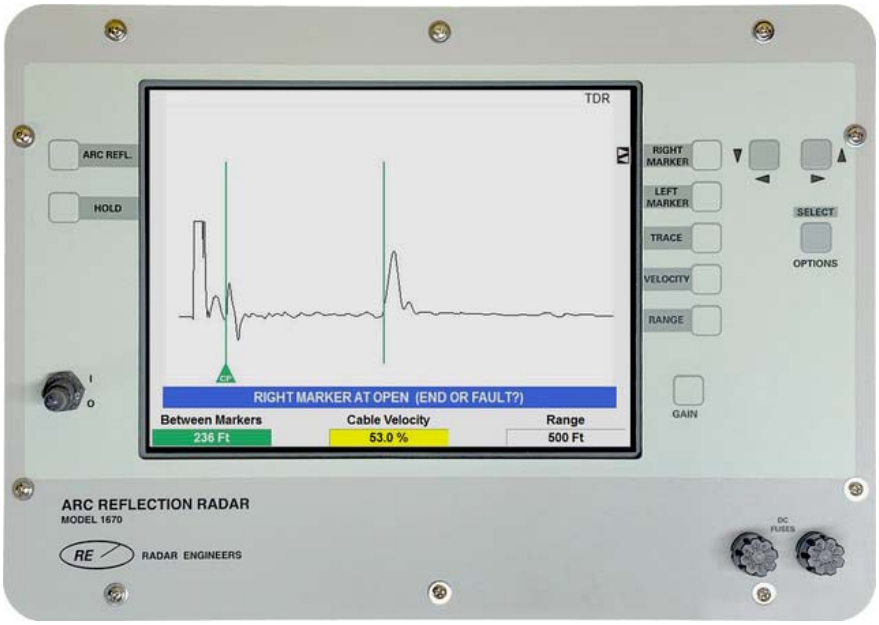


Figure 1

The distance readout changes automatically with the movement of either marker. The markers will move and the distance readout will change under the following circumstances:

a. The Auto-Range or Auto-Locate Feature Is Enabled. Whenever the 1670 performs the Auto-Range function, the Right Marker will automatically move to the “open” and result in a distance change. Whenever the 1670 performs the Auto-Locate function, the Right Marker will automatically move to the “short” and result in a distance change.

b. The Markers Are Moved Manually. This is accomplished by pressing a Marker key, then an Arrow key. In this fashion, the operator can measure between any two points on the waveform. If the left marker is moved it will leave behind a “ghost” image of dotted lines.

c. The Range Is Changed. If the range is changed, the Right Marker will automatically move to the right side of the display. The Left Marker will either stay at the “zero point” or return to the “zero point” if it had been moved manually.

d. The Velocity Factor Is Changed. The velocity factor affects distance measurements. Changes in the Velocity setting will result in automatic changes in the Distance readouts.

It should be noted that when the zoom function is active, the Left Marker will remain visible on the display either at the "zero point" (if that is a part of the zoomed waveform) or at the far left side of the display (if it is not part of the zoomed waveform). In either case the Distance displayed when zoom is first activated is the distance from the "zero point" to the right marker.

5. ARC REFLECTION

a. Using The Arc Reflection And Hold Keys - Frequently the cable under test will show no sign of the fault using the Model 1670 alone. However, when a high voltage pulse is applied with a thumper and the Model 1670 is connected through an arc reflection filter, the arc at the fault appears momentarily as a low resistance fault and is clearly indicated by a downward deflection in the trace. The Model 1670 "captures” the momentary fault and freezes the display.

Select the Arc Reflection Mode by pushing the ARC REFL key. The Model 1670 automatically copies the active trace to the upper half of the screen. It will save this as a “reference” trace of what the cable looked like before thumping. The “live” trace remains on the bottom of the half of the display waiting for a thump. (See Figure 2 below)

Figure 2

When a “thump” is detected the fault is captured and displayed in the lower half of the screen. If it is a clean trace and shows the typical downward deflection of the fault the operator can push the HOLD key to preserve the “thumped” trace or wait for an update when the thumper is discharged again. (See Figure 3) Pressing the Hold key a second time releases the hold.

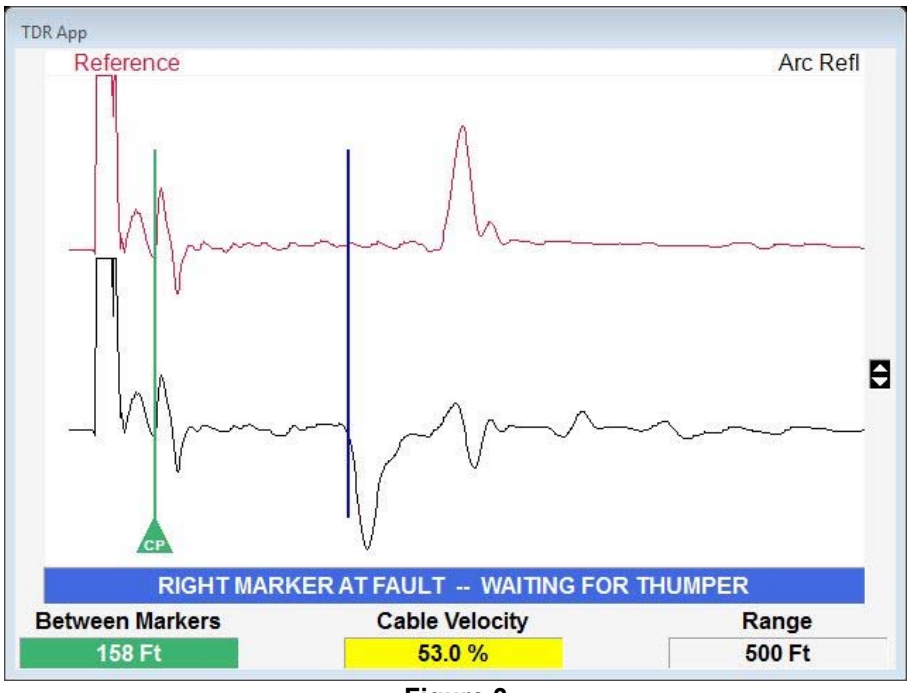


Figure 3

b. Distance to the Fault - If the “auto locate” feature is enabled the distance to the fault is automatically measured by the Radar which sets the Right Marker at the leading edge of the downward deflection. (See Figure 3)

c. Manual Override - If not satisfied with the automatic fault locate placement, the operator may override the auto feature by pressing Right Marker, then an arrow key.

The accuracy of the manual fault location can be optimized by a careful comparison of the fault trace with the Reference trace. For this reason the markers extend through both traces. Also the lower trace can be moved closer to, or superimposed on, the reference trace to provide the most accurate location of the left edge of the downward deflection. (See Figure 4)

To raise the lower trace:

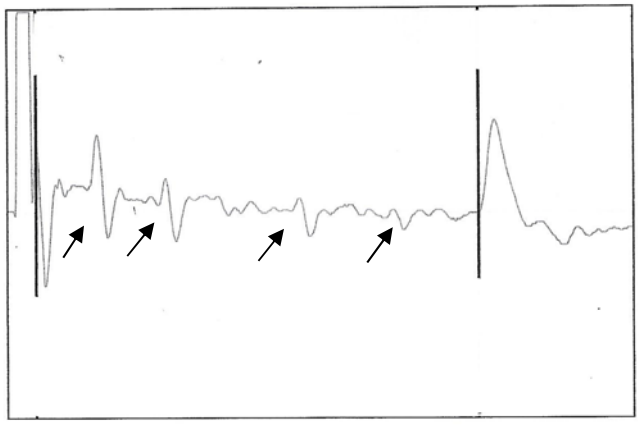
Push the TRACE key, then

Push the UP ARROW key.

Figure 4

The above procedures begin with the range set to show the full length of the cable under test because the fault may be anywhere along the cable. If it is seen that the fault is in the first half of the cable, the accuracy can be increased by using a lower range.

6. CABLE JOINTS – Splices, transformers and other connections cause an impedance change in the cable. Those changes in turn cause a partial reflection of the radar pulses that are then seen on the display. While it is often difficult to tell the difference between a splice and a transformer, connections can often be distinguished from the background noise in the cable trace. See the transformer reflections below marked with an arrow.



7. DIFFICULT FAULTS - Because of the extraordinary voltages involved when locating faults in the arc reflection mode, the Model 1670 will occasionally capture an unusual waveform. This is not abnormal. In other cases the thumper will be unable to break down a fault. In either case thump the cable again and capture a better trace. If you continue to have problems capturing a satisfactory trace, change the thumper voltage up or down. Generally the lowest thumper voltage setting which will cleanly break down the fault is best. In some cases the solution is to move to the far end of the cable and try to locate the fault from there.

C. ADVANCED OPERATING INSTRUCTIONS

1. ZOOM FUNCTION

To improve the display resolution on the higher ranges, the Model 1670 includes a zoom function in the OPTIONS menu. Zoom only works on ranges of 3000 feet and above. Before zooming, move the Right Marker to the area of interest.

Pushing the ZOOM key causes the active trace to be "expanded" horizontally. The position of the right marker at the time zoom is entered becomes the center of the zoomed trace. The zoom factor is 2X in the 3000 foot range and 4X on all other ranges. The zoomed trace nominal lengths are as follows:

RANGE	NOMINAL ZOOM TRACE LENGTH
3000 FT	1500 FT
6000	1500
12000	3000
24000	6000
50000	12,000

Ordinarily it is helpful to store and display the trace to be zoomed before pressing the Zoom key. The memory trace provides a reference for landmarks on the zoomed trace.

Before the zoom mode is activated, the Right Marker is moved to the center of the area of interest. The trace will be expanded horizontally on each side of the Right Marker.

This position represents the location of the right marker before the zoom. The Left Marker continues to refer to the zero point of the normal trace unless the zero point is off-screen to the left. When this occurs, the Left Marker moves to the left margin of the display. IN EITHER CASE, THE DISTANCE DISPLAY SHOWS THE DISTANCE FROM THE ZERO POINT TO THE RIGHT MARKER ON THE ZOOMED TRACE. Once the Zoom Mode is entered, all distance measurements relate to the zoomed trace only.

While in the Zoom Mode, IF THE LEFT MARKER IS MOVED, the distance display changes to show the distance between the markers at the zoomed resolution. To exit the Zoom Mode, press the OPTIONS key.

2. ZOOM WITH ARC REFLECTION MODE

   To make a valid comparison of the active and Reference trace while in the Arc Refl. Mode, both traces should be zoomed or not be zoomed. Using zoom while in the Arc Refl. mode can improve fault location accuracy.

   The Arc Reflec. mode can be entered when zoom is on. The Reference trace will then be a copy of the zoomed active trace. Operation is normal, as described above, except that the traces are zoomed.

3. PULSE WIDTH

   When the OPTIONS menu is displayed, select the MORE function, then select P/W. Each increase in the PULSE WIDTH will double the width of the transmitted TDR pulse up to a maximum of 8 times the normal width for the range selected. The values of the pulse width can vary from 1/2 to 8. The amount the pulse width can be increased depends upon the range selected. For example, in the 24,000 ft range a factor of 8 is the maximum. This option may allow the expert operator to find faults in very long cables with low transmission efficiency where the normal pulse width does not provide adequate reflection. The expert user may also use the trailing edge of the wider pulses to examine very short cables using the step technique.

   The pulse width status is shown in the message bar near the bottom of the display. During normal operation, when the range is changed the pulse width will return to the normal value for that range.

   The amount the pulse width can be decreased depends on the range (for example, no decrease is possible in the 500 ft range). This option may allow the operator to identify more detail in the cable, such as closely spaced splices or transformers.

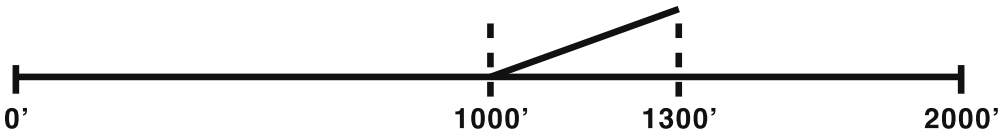
4. UPLOAD MEMORY FILES

   To upload .JPG images of the memory files, first connect a thumb drive to the USB Port. In the OPTIONS menu select the MEMORY function, then select USB to transfer memory files to the thumb drive.

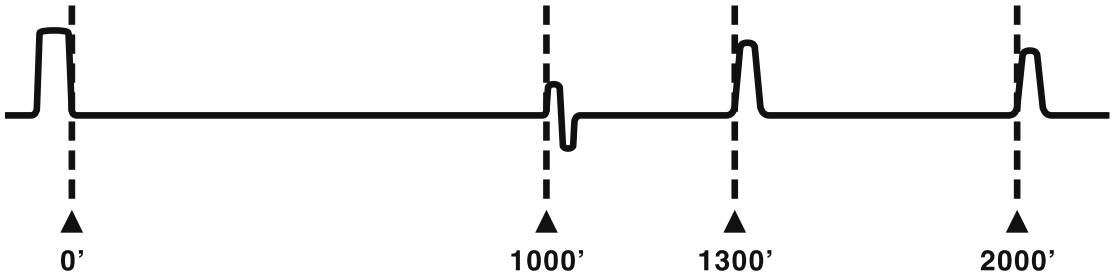
D. TAPS

The Model 1670 functions best in a URD environment where there are no Taps or T's. However, if your conductor does have a Tap there is a technique available to help you determine which leg of your conductor contains the fault.

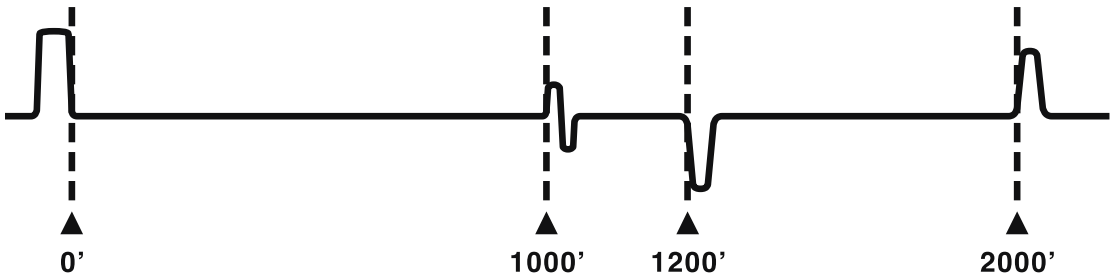
Assume a conductor configured as follows:



The unfaulted display representation of that cable would appear as follows:



During fault locating, the open at the end of the leg of the conductor with a fault on it will change visually on the trace. Generally, the open on the faulted leg will disappear or be substantially reduced in size. For example, if the fault was at 1200 ft. and the fault was on the short leg, the open at 1300 ft. would disappear.



VII. DETERMINING THE VELOCITY FACTOR

The velocity factor setting directly affects distance measurements with the Model 1670. It is, therefore, important to be as accurate in its setting as possible. Experience is usually the best source of velocity factor values. Cable manufacturers can also be useful sources of information. In addition, as seen below, there are ranges of velocity factor values for different types of insulation.

There are several parameters that affect the propagation velocity factor. These include dielectric constant of the insulation, shielding, concentric neutral, corrosion, cable age, etc. If the cable has a solid shield, the dielectric constant is the determining factor in calculating VF.

The following tabulation is a general guide to the propagation velocity factor settings for the Model 1670.

PROPAGATION VELOCITY FACTOR SETTINGS

TYPE CABLE	INSULATION	VF FACTOR RANGE
Overhead	AIR	.98
Communication	PIC	.65-.68
Power	EPR	.52-.58
Power	HMWP	.52-.56
Power	XLPE	.50-.60
Power	PILC	.43-.53

Power cable with cross-linked polyethylene insulation and one-third concentric neutral usually has a VF equal to .51. The VF for the same cable with full concentric neutral is closer to .53. Since this cable type is common, the Model 1670 defaults to 53%. However, it can be changed by the operator up to 99% or down to 25%.

The velocity factor is the speed of the pulse in the cable, expressed as a percent of the speed of light in space. The Model 1670 appears to measure distance, but it actually measures the time it takes the pulse to go out to a point in the cable and come back. Using this measured time the Model 1670 then calculates the distance using the basic relationship:

distance traveled = speed X time

However, since the distance traveled is both ways, out and back, the Model 1670 divides the calculated distance by 2 before showing it on the display. The speed in the above equation is:

speed of light in space X (velocity factor/100)

Accurate measurements to points along a cable can be made without knowing the velocity factor if the length of the cable under test or a parallel conductor is known. If a cable length is known, then the velocity can be determined as follows. First, move the Right Marker to the leading edge of the upward deflection representing the end of the cable. If the readout distance does not equal the known length of the cable, press the Velocity key and appropriate Arrow key until the known length of the cable appears as the Distance in the lower left of the screen. The velocity setting shown at the known cable length is the appropriate velocity for the cable.

VIII. 1670 SPECIFICATIONS

A. OPERATIONAL

Ranges:	500 to 50,000 ft.
Cable Velocity:	VF: 25.0% - 99.9%, adjustable. Default can be set through menus, Factory set to 53.0% Ft/μsec and M/μsec selectable.
Position/Distance Markers:	2 moveable vertical lines, right and left. The displayed distance always refers to the distance between the two markers.
Distance Resolution:	1 foot on 500 ft range, with Vf set to 53.0%. Increases to about 200 ft at 100,000 ft.
Zoom:	Horizontal zoom is available on ranges 3000 ft and above. Zoom is 2x on 3000 ft. range and 4x over 3000 ft.
Trace Vertical Gain:	Vertical Gain is adjustable with a gain range of about 41 dB.
Sampling speed:	240 mega samples per second.
Pulse Width:	50 nanoseconds to 10.0 microseconds, automatically increases with range and is also adjustable in steps through the OPTIONS menu.
Pulse Voltage:	Nominal 40 volts at the BNC with no cable connected.
Signal Input:	BNC. Nominal I/O impedance, 50 ohms.
Display:	TYPE: TFT Enhanced Color LCD, 10.5” Diag, (800 x 600 pixels) TRACES: TDR mode, active, +memory optional. Arc Refl. Mode: reference and active. ABC mode, A,B,C traces TEXT: Distance between markers, Velocity factor, Range, Gain, messages to operator
Memory:	100 waveform memory.
Recents:	30 most recent thumped traces auto saved for 30 days

B. ENVIRONMENTAL

Power:	AC power: 100-240 .VAC / 50 – 60 Hz. Operates with most inverters.
Temp Range:	Operating: 20°F to 120°F. Storage: 10°F to +140°F.

Moisture:	When case is open avoid direct exposure to rain, snow, sleet, etc. The 1670 is water resistant not water proof.

IX. WARRANTY AND NOTICE TO PURCHASER

All TDR's manufactured by Radar Engineers 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. THIS WARRANTY IS MADE IN LIEU OF ANY OTHER WARRANTY, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OF FITNESS FOR A PARTICULAR PURPOSE. Neither seller nor manufacturer shall be liable for any injury, loss or damage, direct or consequential, arising out of the use of this product.

All statements, technical information and recommendations contained herein are based on information believed to be reliable, but the accuracy or completeness thereof is not guaranteed. Before using, the user shall determine the suitability of the product for his intended use, and user assumes all risk and liability whatsoever in connection therewith.

The Model 1670 collects data to aid in product development.

All statements or recommendations not contained herein shall have no force or effect unless in an agreement signed by officer of seller and manufacturer.

X. REPAIRS AND CUSTOMER SERVICE

Radar Engineers Inc maintains a complete instrument repair service. Should the instrument ever require repairs, we recommend it be returned to:

RADAR ENGINEERS INC
9535 N.E. Colfax St.
Portland, Oregon 97220

When returning the instrument for repairs, it should be shipped prepaid and insured. A note should be included describing the defect and the name and phone number of the person to contact in case additional information is needed.

If you have questions regarding the operation of this instrument, call Radar Engineers Inc at: (503) 256-3417.

APPENDIX

CURRENT IMPULSE METHOD (OPTIONAL)

The current impulse method (CIM) is particularly useful on difficult to break down faults. Since an inductor is not needed for CIM, the thumper pulse shape is not stretched and peak voltage is not reduced as it is when using Arc reflection. As a consequence, when using the CIM mode, higher voltage will be applied to the fault, for a given voltage setting, thus making it more probable that a flashover will occur.

Once established, an arc will cause current surges in the cable that appear as “oscillations” on the radar screen. By measuring the time between oscillations the distance to the fault can be prelocated. The “CIM” program is available as an option at the time of purchase.

CIM OPERATION

A. SAFETY: OBSERVE SAFE WORK PRACTICES AT ALL TIMES. READ THUMPER MANUFACTURER’S MANUAL. ONLY QUALIFIED ELECTRICAL PERSONNEL SHOULD OPERATE THIS INSTRUMENT. CONFIRM THAT THE RADAR HAS A GROUND ATTACHED. CONFIRM THE CABLE UNDER TEST IS DE-ENERGIZED BEFORE CONNECTING OR DISCONNECTING THE THUMPER LEADS TO IT.

B. Attach BNC cable between the “CIM” BNC input on the back of the radar and the CIM input on the thumper.

C. Enter Options Menu. Scroll to “MORE” on the menu bar. Select “MORE”. Scroll to “CIM”. Select “CIM”.
The screen will appear with a flat line intersected by the left and right markers.

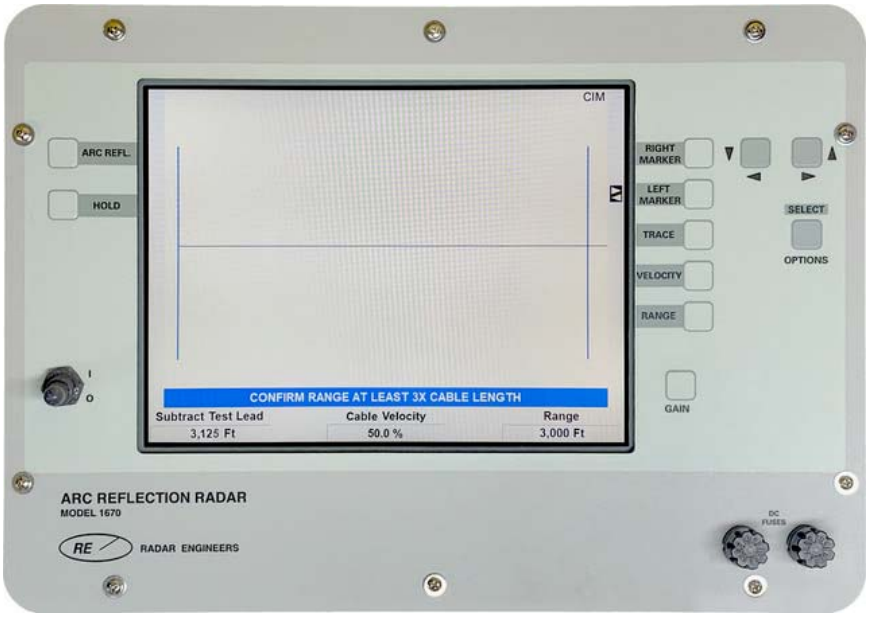


Figure A-1

D. Set the range to three times (3x) cable length. CIM measurements require viewing several oscillations of the current impulse created by the Arc fault.

E. Velocity will default to 50%. This value can be changed temporarily by pressing the velocity key and then an arrow key. The velocity settings used for CIM will usually be different from those used in Arc Reflection. The reason is that in CIM the velocity setting calibrates for the speed of the current pulse created at the time a fault break breaks down. In Arc Reflection the velocity calibration is for the TDR pulse. The speed of each type of pulse is different. The CIM velocity setting will normally be somewhat lower than the velocity setting used for Arc reflection by about 5-15%. The default factory CIM velocity setting is 50% which would be ballpark for most XLPE cable. A different default velocity can be chosen through the CIM options menu.

F. Discharge the impulse generator (thumper). When the fault breaks down the flat line will become a series of oscillations.

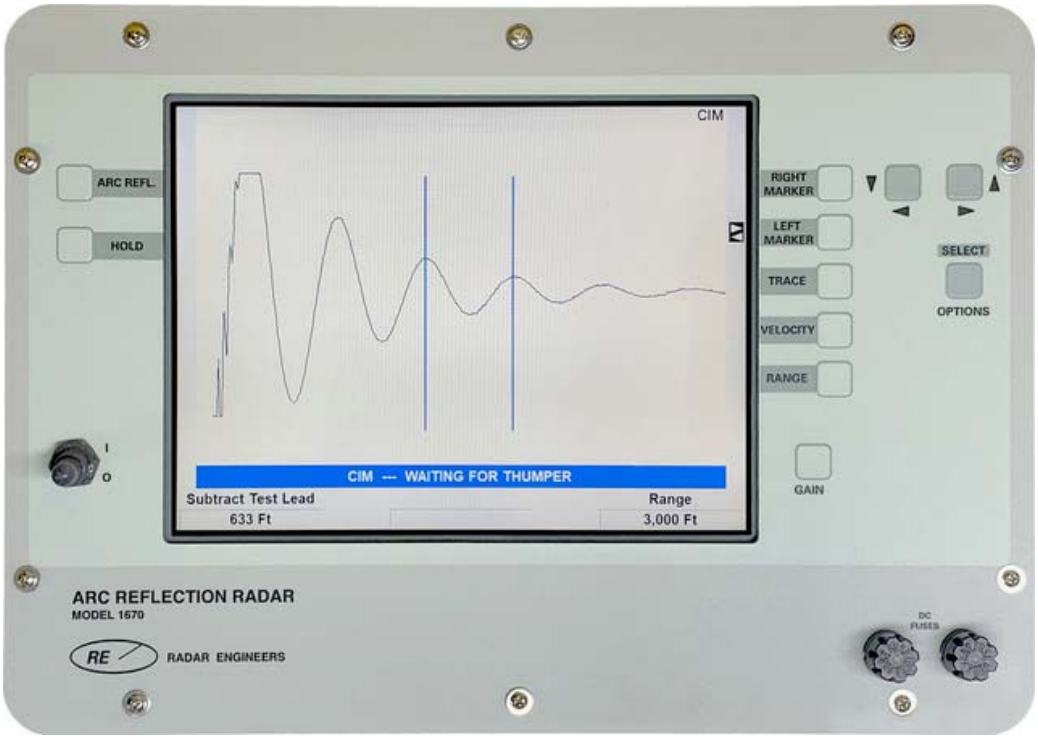


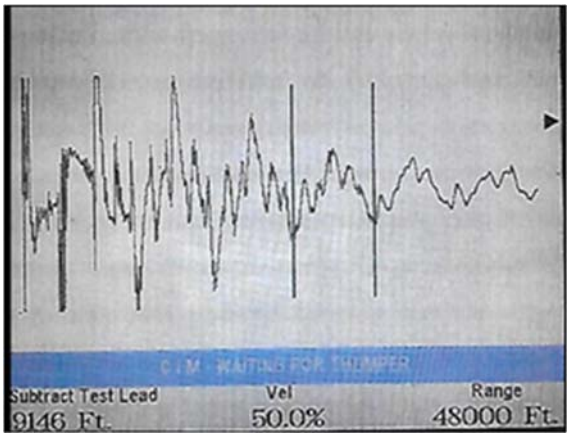
Figure A-2

The surges bounce back and forth between the fault and the impulse generator. If you cannot see at least three clear oscillations, increase the range.

G. Distance: The distance to the fault is determined by placing the left marker at some point (usually the peak) on one of the oscillations and the right marker at the same location on the next oscillation. (It is usually best to not use the first oscillation for this

measurement.) The fault distance is displayed in the lower left corner of the LCD.

H. CIM oscillations can be somewhat busy with reflections caused by splices or joints, particularly on longer cables. See the example below. Here the operator placed the markers at the bottom (instead of the peak) on two adjacent oscillations to obtain the distance to the fault.



I. Subtract Connecting Cables: When the CIM sensor is located in the thumper/filter, the connecting cables must be subtracted from the fault distance measurement shown in the lower left corner of the display.

J. Prelocate: The CIM fault distance indicated is a good ballpark or prelocate distance. The exact location of the fault should be confirmed with acoustic techniques.

K. CIM+: CIM+ is an advanced fault locating technique that combines ARC Reflection and CIM. CIM+ facilitates the overlay of two CIM traces: one taken at low thumper voltage and the other at higher fault breakdown voltage. The operator can then use Arc Reflection Analysis to prelocate the fault. This technique can be useful on very difficult faults. However, only very experienced operators should try this technique. Contact the factory for additional information.