

# ARC REFLECTION RADAR Model 1669C

With CIM Option



## OPERATION MANUAL

**SET UP REMINDER:**

**Before using 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.**

**See manual or call factory if questions. Please observe all Safety Rules.**

**Radar Engineers  
503/256-3417**

**1665, 1669C  
11/20/07**

## DIAGNOSTIC MESSAGES

The software in this Radar includes operator alerts if certain abnormal conditions are detected:

1. “CHECK LEFT MARKER” message will appear if the Left Marker is set closer than about 35' from the radar.
2. “APPARENT EQUIPMENT ISSUE” message will appear if a problem is detected in the TDR signal path out to about 40' from the radar. This message can be thought of as a “Check Engine” type alert. If it appears occasionally it may not warrant much concern. If it is seen regularly then things like cable reel connections and the thumper TDR signal path (including all BNC connectors and coupler box) should be checked.
3. “POOR DATA QUALITY” message will appear when the data collected by the TDR is marginal for auto locate to operate properly.

06/01/12

## INSTALLATION INSTRUCTIONS FOR RADAR TDR UPLOADER 2.0

### A. NETWORKS:

If you are on a network, check with the system administrator before installing this program.

### B. COMPATIBILITY:

Radar TDR Uploader 2.0 runs on Windows 95, 98, XP, and Windows 7 operating systems.

### C. INSTALLATION:

- 1) Insert CD into computer.
- 2) Left click the 'Start' button (lower left corner of the screen).
- 3) Select 'Run'.
- 4) In 'Run' box, select 'Browse'
- 5) Choose the drive with the installation CD.
- 6) Click on setup.exe file, then select 'Open'.
- 7) This returns to the 'Run' box-- select 'OK'.
- 8) Installation begins automatically.
- 9) Follow the installation instructions presented by the program.
- 10) In the 'Select Installation Folder' step, there are several options:
  - a. Select 'Browse' to choose a different installation folder. Default is C:\Documents and Settings\All Users\Application Data\Radars\TDR Traces
  - b. Select 'Disk Cost' to find out the available and required drive space.
  - c. Choose the number of users by selecting 'Everyone' or 'Just Me'.
- 11) When installation is complete, a shortcut is created on the desktop.

### D. CONNECTIONS & SAFETY:

Connect factory provided 9-pin cable to com port on computer and to the side of Thumper/Filter Chassis. For Safety and reliability, the 9-pin cable should NOT be connected to the Thumper/Filter while thumping.

### E. TRACE STORAGE INSTRUCTIONS:

- 1) Click on 'Radars TDR Uploader 2.0' shortcut on desktop of computer.
- 2) The center of the display shows the copyright and the bottom shows the marker and trace information boxes.
- 3) At the top of the display are several folders:
  - a. File—There are different options to choose.
    - Open—There are 2 ways to choose a file: 1. Select file from the list that is shown, then open to view the saved file or 2. Click on 'Import Trace from File', select a file location and then a file, and open to view the imported file. All files must have .arc file extension to be opened. Click 'Back' to return to menu.
    - Print—Select to print displayed trace.
    - Print Preview—Shows how the displayed trace will appear when printed.
    - Save—Name the file, add comments, and save the trace that is displayed.
    - Save as Bmp—Saves the trace displayed as a bitmap.
    - Exit—Select to leave file options
  - b. Upload—Select 'Displayed Traces' to upload the trace from the TDR.
  - c. Options—Select 'Set Default Gain from Trace 1' to make the default gain the same value as the gain that is currently displayed for Trace 1.
  - d. Trace Info—Shows available information or comments for the current trace.
  - e. About—Shows the copyright and version information. 12/5/12

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## I. INTRODUCTION

The Model 1669 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 1669 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 1669 applies a low voltage pulse to the cable. The pulse travels down the cable until it encounters a change in electrical characteristics, such as that caused by a splice, short or open. At that point, a reflection of pulse energy occurs. The nature of the reflection depends on the type of change encountered.

The initial output pulse and any impedance caused reflections are shown on the display screen. When viewing the trace, the generated 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 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.

## II. SAFETY PRECAUTIONS

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

Confirm that the ground lug on the rear of the instrument case is grounded to system ground.

Make certain that the cable under test is de-energized and open at both ends before attaching the connecting cables. The cable should be safety grounded for at least one minute immediately before connecting the scope to remove accumulated charges. Safety grounds should be replaced upon completion of the test.

Handle with care, this is a delicate instrument. Never operate when wet. 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.

Use of the Model 1669 together with a "thumper" requires additional safety procedures. This includes the use of a coupler/filter and grounding the radar scope. **NEVER "THUMP" WITH THE MODEL 1669 DIRECTLY CONNECTED TO THE FAULTED CABLE.** Refer to Section VI-A of this manual for additional information. Refer to thumper/filter manufacturers to verify compatibility of the Model 1669 with their systems and for operating procedures.

Only qualified technicians should open the front panel. Disconnect AC power cord before removing front panel. AC line is energized even with power switch off. Never operate the Model 1669 with the front panel removed. Never touch any internal parts when the power is connected. Never touch any internal part until the scope has been unplugged at least five minutes, otherwise severe electric shock could result.

### III. PRODUCT DAMAGE PRECAUTIONS

#### A. DISPLAY

The display in the Model 1669 is a color LCD (Liquid Crystal Display). It is relatively rugged, but should not be subjected to unnecessary shock. Though the LCD is both useable and very visible in sunlight, 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 1669 into an A.C. power source outside the following specifications: 115 to 230 VAC, 50 to 60 Hz. Only use the A.C. cord provided with the instrument.

GENERATORS/INVERTERS - The 1669 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 1669. The 1669 is designed to tolerate these transients for a well regulated generator or inverter in good operating condition. However, to protect the 1669 from malfunction in these external power sources, the 1669 should not be plugged in until the external source is on and stabilized. The 1669 should be unplugged before the external source is turned off.

SPIKES/SURGES - The 1669 has internal power line spike protection. However, if the 1669 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. A voltage regulating transformer with spike/surge protection, such as the Sola 63-13-070-6 works adequately.

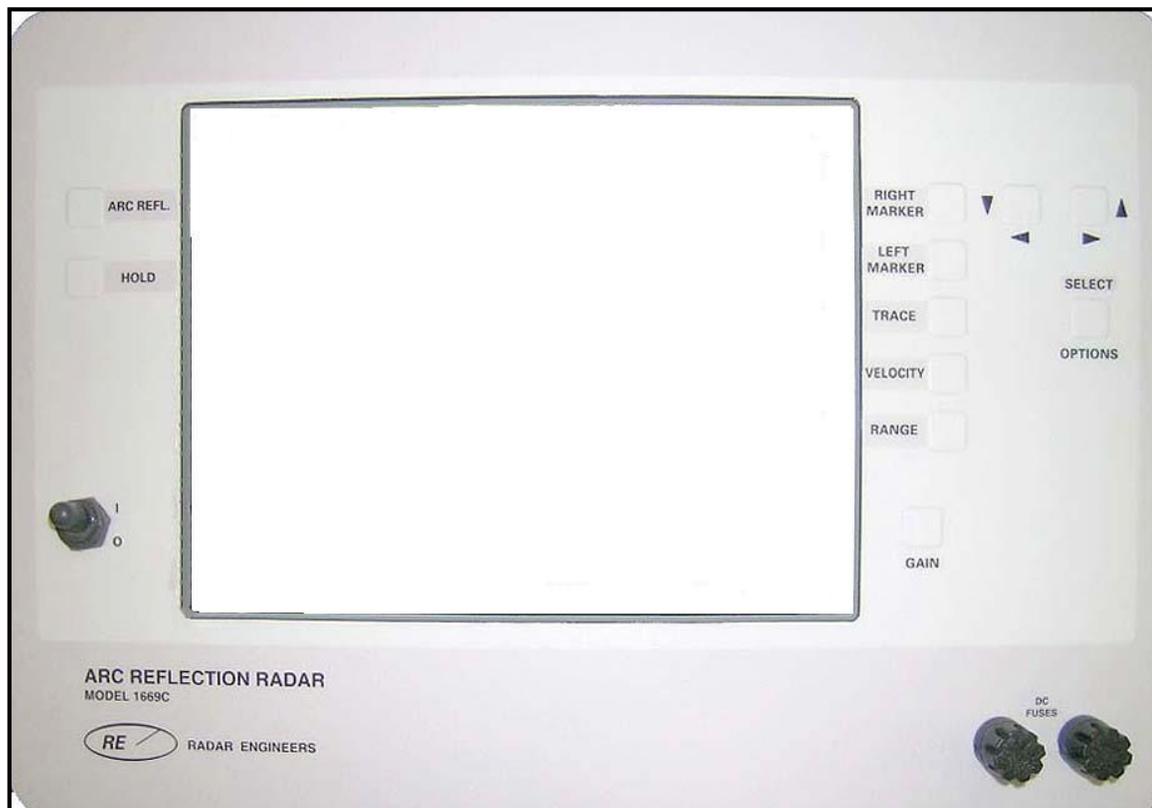
#### C. RAIN

Do not operate the Model 1669 in the rain. The Model 1669 with the yellow plastic Pelican cover open is not shielded from water entering the enclosure, and the external AC cable connection is not water tight.

#### 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 1669 is 20°F to 110°F.

## IV. FRONT & BACK PANEL LAYOUT



Front Panel



Back Panel

## V. MODEL 1669 CONTROLS

### A. INPUT

Hook up point for the BNC connecting cable. For TDR and ARC REFLECTION use, connect the BNC cable to the TDR input on the radar and the corresponding input on the filter/coupler. Do not use the CIM input for TDR/ARC REFLECTION. See Appendix A below for CIM enabled units.

### B. GROUND LUG

For connecting the Model 1669 to system ground. Any time the unit is used with a "thumper" and "filter" the Model 1669 must be grounded, preferably to system ground.

### C. THE CORD & RECEPTACLE

AC: Only use the three wire grounded plug provided with the unit for A.C. operation.

### D. POWER ON SWITCH

Display screen is on when power switch for Model 1669 is on.

### E. DISPLAY SCREEN

The Model 1669 uses a 10.5" diagonal color liquid crystal display ("LCD"). Opens, shorts, and spikes in the cable under test 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 triangle will appear on the display, indicating which function button has been selected and is active.

1. RIGHT MARKER - The vertical line on the right of the display that indicates the end point for all measurements. It also sets the center point for the horizontal zoom.
2. LEFT MARKER - The vertical line on the left of the display that indicates the beginning point for all measurements. When the Model 1669 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.
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 before and after Arc reflection traces.
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. 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, 24000 and 48000 feet are available. The default range is 500 feet.
6. GAIN - Controls the vertical amplitude of the trace on the display.
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, a "brick" appears on the display next to it. There is no "brick" in the default mode.

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". In these instances, the ARC REFL. mode is selected. To exit Arc reflection, press the Arc reflection key.
2. HOLD - In the default mode, the screen is constantly being updated. To stop the updating of the display, press the hold 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 change. (When in the HOLD mode, the ARC REFL. and RANGE keys will not respond.) To release the HOLD function, press the hold key.

## 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 500 ft.
  - e. MORE
    - i. METRIC - Toggle between metric and feet with the SELECT key.
    - ii. VEL. NOT. - Toggle between the velocity notations of  $V_p$  (Ft/ $\mu$ S) and  $V_f$  (%) 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 store up to 30 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. **EXIT** -- Select to exit the **MEMORY** menu.
3. **ZOOM** - This option is available when the distance is >3000 ft. It enables the user to enlarge 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.
4. **AUTO R.** - Permits auto range of cable without turning radar off.
5. **MORE** - There are 3 additional functions available which are accessed by selecting the **MORE** function.
- a. **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 (deenergized, of course) 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.
  - b. **P/W** - This option allows the user to change the pulse width using the arrow keys.
  - c. **DELAY** - This option allows the user to temporarily change delay times for the period of time between when the thump is detected and the active trace is captured. See Section VI. C. Advanced Operating Instructions.
  - d. **UPLOAD** - Allows the user to upload data to a computer via a serial output connection.
  - e. **EXIT** - Select to leave the **MORE** menu.

## **I. SERIAL PORT**

This standard 9 Pin male connector permits attachment to the serial port of a computer or printer.

## J. FUSES/FUSE HOLDERS

1. AC line fuses: Use 2A FB ceramic fuses for F3 and F4 which are located inside the instrument. (Disconnect AC before opening the front panel).
2. DC line fuses:
  - a. 3A FB ceramic fuse for the left fuse on the front panel (F1). See lid label.
  - b. 4A FB ceramic fuse for the right fuse on the front panel (F2). See lid label.

## K. BEEPER

Each time the Model 1669 is turned on, 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 500 ohms) the Radar Engineers Model 1669 alone will help you quickly locate it. If it is a high resistance fault, then the Model 1669 should be used together with an arc reflection system (thumper and energy separating filter).
2. POWER - Plug the power cord into 115 or 230 volts AC, 50 or 60 Hz AC.
3. WARM-UP - Under normal circumstances no warm up is necessary. However, at temperatures below freezing the display in Model 1669 may be sluggish when first turned on.
4. CONNECTING CABLE/THUMPER-FILTER - The Model 1669 may be hooked up directly to a conductor or through most arc reflection systems (energy separating filter and impulse generator or "thumpers"). 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 1669 is connected directly to the cable under test (and you are using a factory supplied 50 ft. connecting cable), the black lead of the 50 ft. connecting cable is attached to the faulted cable's shield or concentric neutral. The red lead is attached to the center conductor. **NEVER "THUMP" A CABLE WITH THE MODEL 1669 HOOKED UP DIRECTLY TO THE FAULTED CABLE.** If the Model 1669 is connected through a "filter", read the manufacturer's manual carefully for hook up and thumping procedures. Always ground the chassis of the Model 1669, preferably to system ground if it is connected through a filter.

5. THUMPER VOLTAGE LEVELS - The Model 1669 only needs a thumping voltage sufficient to cause an arc to ground. Higher voltages do not necessarily improve waveform capture or presentation and in fact can cause a deterioration of waveform

presentation.

6. GAIN SETTINGS - The 1669 automatically sets the gain for the best algorithm performance. Vertical gain can also be manually adjusted between approximately 0 and 20 db. If you set the gain manually, it is recommended that the gain be set at until the peak 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. 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 test cable connects to the conductor under test. This is often called the "zero point". This point is usually 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 precisely located by alternately shorting and opening the end of the test leads while observing the display.
2. AUTO RANGE - The 1669 is factory set to default to Auto Range and Auto Locate (these features may be disabled in the OPTIONS menu). When the Model 1669 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). 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 his own experience to find the end of the cable as well as the fault.

Blind Zone: For faults within about 25 feet of the connection point on the 500 foot range and 50 feet on all other ranges, auto locate will not mark faults. This is due to the high level of reflections near the connecting point.

- 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: 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 decide where the fault is. When that happens a message will appear:

NO FAULT MARKED - PRESS SELECT TWICE FOR HELP

The Help screen will appear:

IF FAULT NOT MARKED CHECK THESE POSSIBILITIES:

- 1. Fault did not break down..... Increase thumper Kv.
- 2. Distorted arc trace..... Lower thumper Kv or increase delay.
- 3. Fault "downer" is small.....Overlay traces.
- 4. Fault near connecting point.....Lower range or overlay traces:
  - 0-25 ft. on 500' range
  - 0-50 ft. on other ranges.
- 5. Fault on longer range.....Increase range.

Press select to exit

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.)

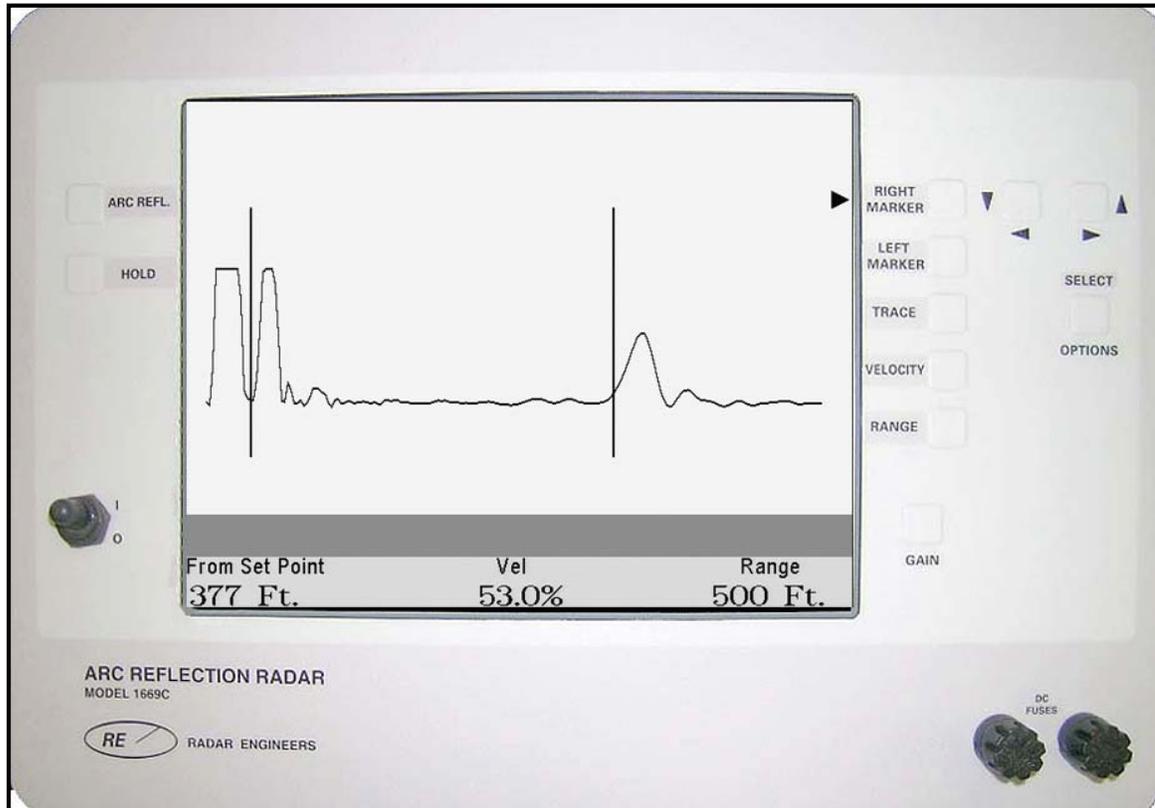


Figure 1

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 1669 performs the Auto-Range function, the Right Marker will automatically move to the “open” and result in a distance change. Whenever the 1669 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.
- 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 will show no sign of the fault using the Model 1669 alone. However, when a high voltage pulse is applied with a thumper and the Model 1669 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 1669 has the ability to "capture" the momentary fault and freeze the display so that measurements can be made as if the fault were an ordinary low resistance type fault.

After identifying the end of the cable and measuring the length as described previously, select the Arc Reflection Mode by pushing the ARC REFL key. The Model 1669 will then automatically copy and display the active trace to the upper half of the screen for a reference trace of what the cable looked like before thumping. (See Figure 2)

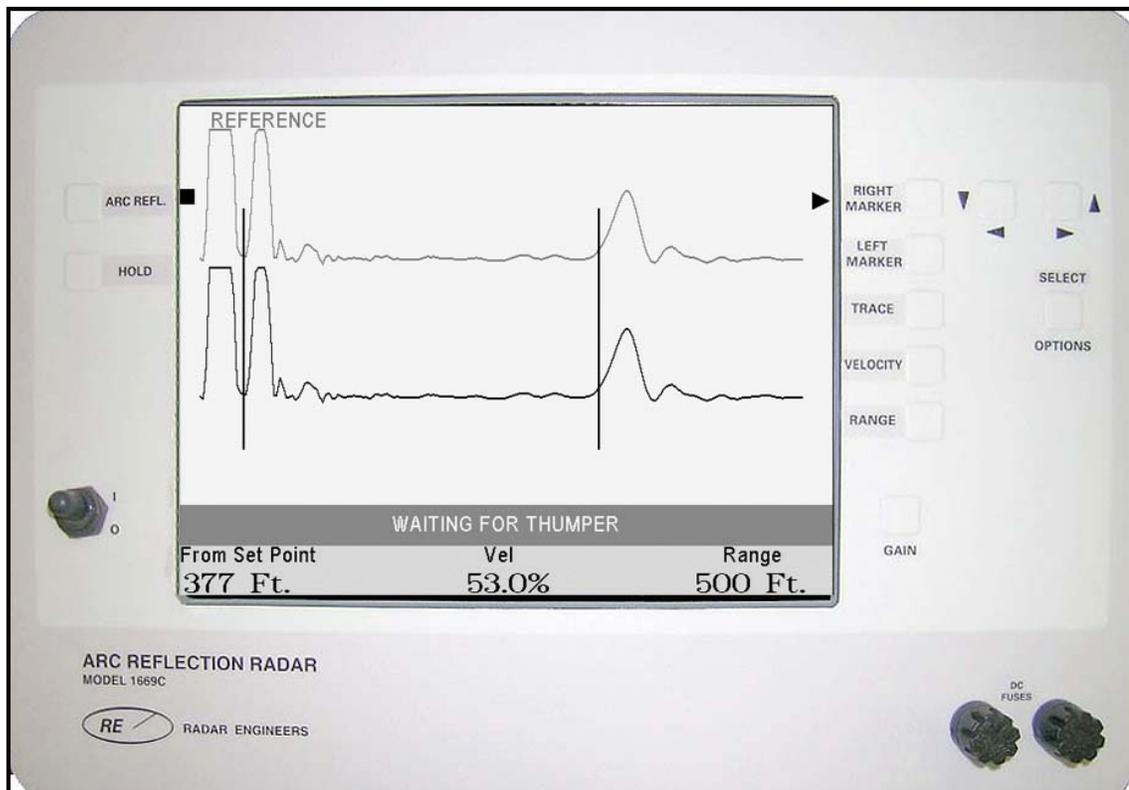


Figure 2

The Model 1669 now waits until a thump is detected and captures a trace while the fault is arcing. This trace is 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 should immediately push the HOLD key and turn off the thumper. (See Figure 3)

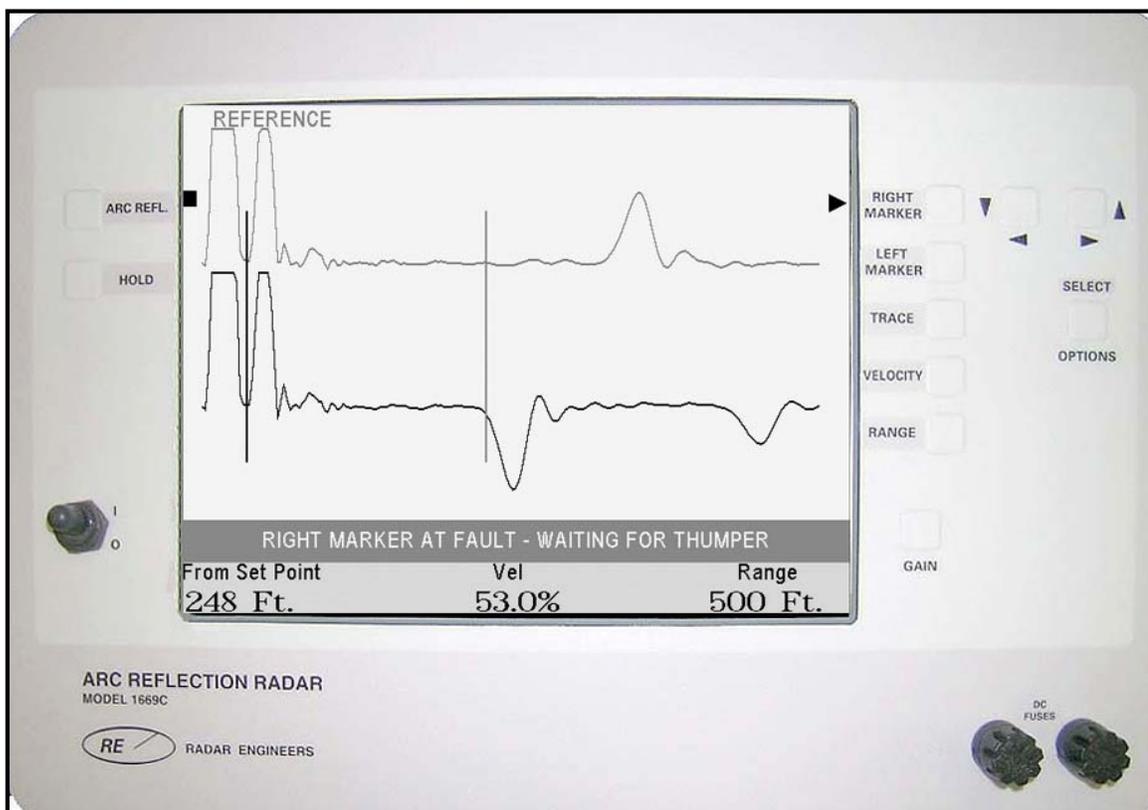


Figure 3

- b. Auto Fault Locate - The distance to the fault is then automatically measured by the Radar which sets the Right Marker at the leading edge of the downward deflection. If the captured trace is not satisfactory, wait until the thumper discharges again. When a satisfactory trace is captured, push the HOLD key and turn off the thumper.
- c. Manual Override - If you are not satisfied with the automatic fault locate placement, you 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 upper 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.

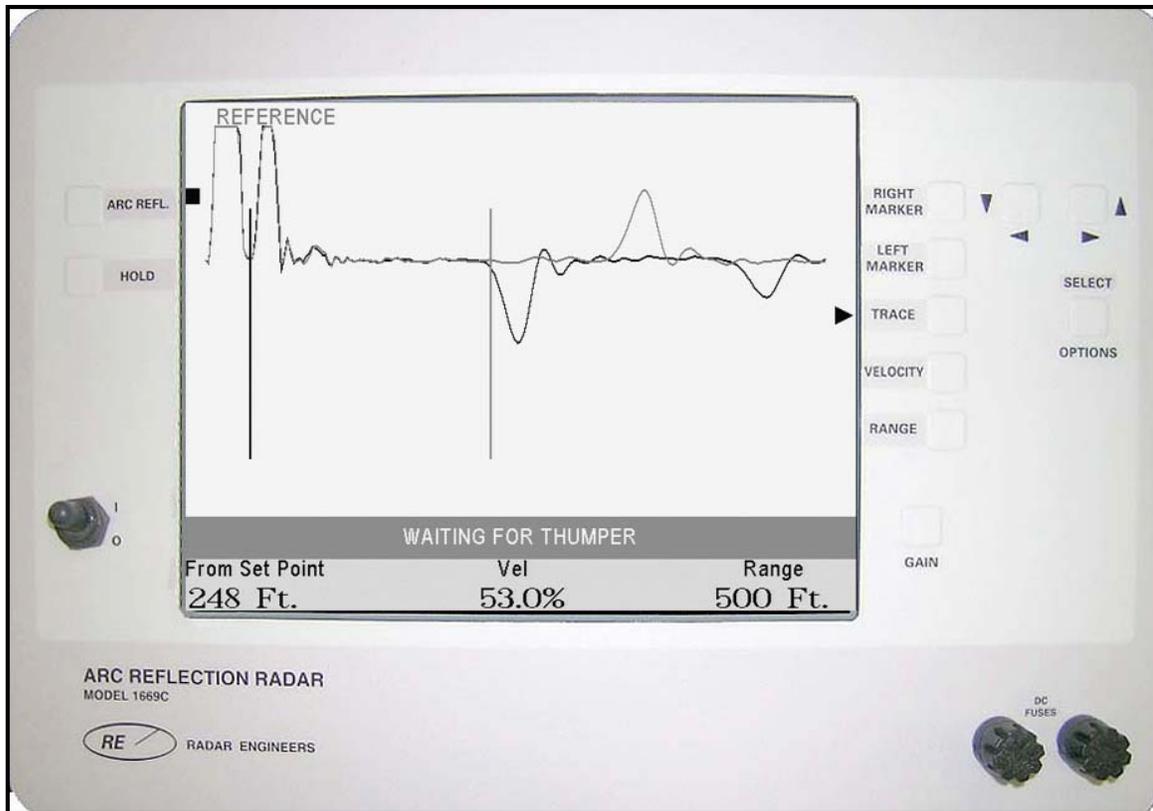


Figure 4

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. UNUSUAL WAVEFORMS - Because of the extraordinary voltages involved when locating faults in the arc reflection mode, the Model 1669 will occasionally capture an unusual waveform. This is not abnormal. 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 break down the fault is best. Unnecessarily high voltages often interfere with trace capture.
7. ARCHIVING - Data may be collected for product improvement purposes.

## C. ADVANCED OPERATING INSTRUCTIONS

### 1. ZOOM FUNCTION

To improve the display resolution on the higher ranges, the Model 1669 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:

<u>RANGE</u>	<u>NOMINAL ZOOM TRACE LENGTH</u>
3000 FT	1500 FT
6000	1500
12000	3000
24000	6000

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 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 1/8 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 4 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 bottom right hand corner 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 SCREEN DATA

When the OPTIONS menu is displayed, select the MORE function, then press UPLOAD to transfer a screen data file to a computer attached to the serial output connector. The user may receive this data file with any of the many available communications program for computers. The user may also examine the data by reading the file, or may make a special program to display the data.

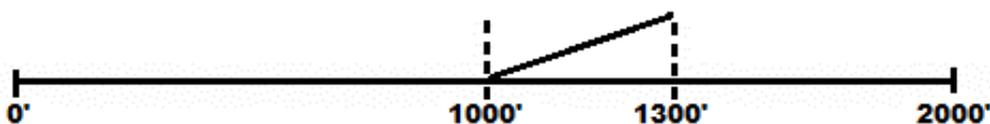
#### 5. CHANGING THE DELAY

When the OPTIONS menu is displayed, select the MORE function, then select DELAY to change the delay time. The delay function controls the time between when the thump is detected and the active trace is captured. The delay time can range between 0 – 20. When turned on, the Model 1669 always starts with a default delay value. This delay value will be adequate for almost all conditions. If difficulty is encountered in capturing a fault trace, there is some chance that better results can be obtained by changing the delay. This is particularly true if the fault is very close to the connecting point. In that case, try increasing or decreasing the delay value.

### D. TAPS

The Model 1669 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.

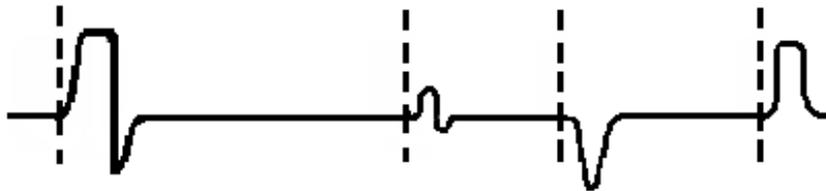
Assume a conductor configured as follows:



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 1669. 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, 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 1669.

### PROPAGATION VELOCITY FACTOR SETTINGS

<u>TYPE CABLE</u>	<u>INSULATION</u>	<u>VF FACTOR RANGE</u>
Overhead	AIR	.98
Communication	PIC	.65-.68
Power	EPR	.52-.58
Power	HMWP	.52-.56
Power	XLPE	.50-.60

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 1669 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 1669 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 1669 then calculates the distance using the basic relationship:

$$\text{distance traveled} = \text{speed} \times \text{time}$$

However, since the distance traveled is both ways, out and back, the Model 1669 divides the calculated distance by 2 before showing it on the display. The speed in the above equation is:

$$\text{speed of light in space} \times (\text{velocity factor}/100)$$

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. SPECIFICATIONS

Ranges:	500 to 48000 ft (Can be set up in feet or meters)			
Velocity Factor:	25.0% - 99.9%			
Markers:	2 moveable vertical lines, right and left.			
Pulse Width:	50 nanoseconds to 3.0 micro seconds. Pulse width automatically increases with range and is also adjustable in steps.			
Pulse Voltage:	14 volts into 50 ohms			
Temp Range:	Operating:	20°F to 120°F		
	Storage:	10°F to +140°F		
Resolution:	SAMPLING DISPLAY	Approximately 3 feet <u>Range</u> 500 Ft. 1500 3000 6000 12000 24000 48000	<u>Normal</u> 1 Ft. 3 6 12 24 48 96	<u>w/Zoom</u> N/A N/A 3 3 6 12 24
Display:	TFT Enhanced Color LCD 10.5" Diag (640 x 480 pixels) Dual Trace			
Text Readout:	Distance (can be set up in feet or meters) Velocity Factor Range Messages and operator menus			
Power:	AC power supply 115 – 230 VAC / 50 – 60 Hz			
Pulse Output/ Filter Input:	BNC, 50 ohms			
Memory:	30 waveform memory			
Zoom Mode:	2x on 3000 ft. range 4x over 3000 ft.			
Vertical Gain:	Adjustable, 0 to 20 dB			
Screen Update:	Low voltage TDR mode, 4 per second Arc Reflection mode, 1 per high voltage impulse			

## **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.

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

RADAR ENGINEERS  
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 at: (503) 256-3417.

8/25/15

# APPENDIX

# APPENDIX A. CURRENT IMPULSE METHOD ("CIM")

## I. INTRODUCTION

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 or rounded as it is when using Arc reflection. As a consequence, when using the CIM mode, it is easier to cause an arc at the fault.

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, available as an option at the time of purchase, allows for these measurements.

## II. SAFETY PRECAUTIONS

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

Never operate the Model 1669 with the front panel removed. Never touch any internal parts when the unit is plugged into AC. No user serviceable parts inside. Do not remove the front panel. Return to factory for repairs.

Confirm that the ground lug on the rear of the instrument case is grounded to system ground.

Make certain that the cable under test is de-energized and open at both ends before attaching the connecting cables. The cable should be safety grounded for at least one minute immediately before connecting the scope to remove accumulated charges. Safety grounds should be replaced upon completion of the test.

Handle with care, this is a delicate instrument. Never operate when wet. Store in a warm dry place. If a problem develops, do not try to repair it yourself. Please return the Radar to the factory.

Use of the Model 1669 together with a "thumper" requires additional safety procedures. This includes grounding the radar scope. **NEVER "THUMP" WITH THE MODEL 1669 DIRECTLY CONNECTED TO THE FAULTED CABLE.** Refer to Section VI-A of this manual for additional information. Refer to thumper/filter manufacturers to verify compatibility of the Model 1669 with their system and for their operating procedures.

### III. PRODUCT DAMAGE PRECAUTIONS

See Section III above (Arc Reflection)

- A. Display
- B. Power
- C. Rain
- D. Storage/Operation Temperature

### IV. FRONT & BACK PANEL LAYOUT

See Section IV above (Arc Reflection)

### V. MODEL 1669 CIM CONTROLS

- A. Input: Use the factory provided BNC coaxial cable to connect between the radar CIM BNC input and the thumper/filter CIM input.
- B. Ground Lug: For connecting the Model 1669 to system ground. Any time the Model 1669 is used it must be grounded, preferably to system ground.
- C. Cord & Receptacle: Only use the three wire grounded plug provided with the unit for A.C. operation.
- D. Power On Switch: The display screen will turn on when the switch for the 1669 is on.
- E. Display Screen: The Model 1669 uses a sunlight readable 10.5" diagonal color liquid crystal display (LCD).
- F. Set Up: Each function key just to the right of the LCD is activated by pushing it once. A small triangle will appear on the display, indicating which function button has been selected and is active.
  - 1. Right Marker: The vertical line on the right of the display indicates the end point for all measurements.
  - 2. Left Marker: The vertical line on the left of the display indicates the beginning point of all measurements.
  - 3. Trace: Allows the operator to move the waveform up and down.
  - 4. Velocity: 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. In general terms the CIM pulse is slower. 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. This can be changed temporarily by pressing the velocity button and

an arrow key. A different default velocity can be chosen through the CIM options menu.

RANGE: Ranges of 1500, 3000, 6000, 12,000, 24,000, 48,000, 96,000 and 192,000 feet are available. The default range is 3000 ft. This can be changed temporarily by pressing the range key and an arrow button.

CIM measurements require the operator to view several oscillations of the current impulse created by the fault arc. This means that it is usually a good idea to set the range at three times (3x) the actual length of the cable under test.

GAIN: Controls the vertical amplitude of the trace on the display.

ARROWS: To change a selected function up/down or left/right, the ARROW keys are used.

- G. CIM Option: To enter the CIM options menu press OPTIONS/SELECT: 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 options or select EXIT in the menu. More detail about specific functions can be found in Section VI below, CIM Operation Guide.
- H. Set Up: This option is used to change the CIM DEFAULT settings. Follow the instructions on the screen exactly.
1. VEL. - Change default velocity factor. Factory default is 50%
  2. RANGE - Change default range. Factory default is 3000 feet.
  3. MORE –
    - a. Metric - Toggle between metric and feet with the SELECT key.
    - b. Vel. Not - Toggle between velocity notations of Vp (Ft/uS) and Vf (%) with the SELECT key.
    - c. About - Identifies the version of the software.
    - d. Factory - Restores factory default settings.
- I. MEMORY: This function is used to store up to 30 traces in memory.
1. STORE - Press the SELECT key to store the current trace that is displayed.
  2. DISPLAY - Use the SELECT key to toggle the active memory display on or off.
  3. PREVIEW - Use the arrow keys to preview specific stored traces (#1-#30) 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.
  4. CLEAR - Choose SINGLE to clear the current memory only or choose ALL to clear all stored traces.
  5. EXIT - Select to exit the MEMORY menu.

J. **MORE:**

TDR: Select TDR to return to Arc Reflection.

CIM+: Select CIM+ to permit the overlay of two CIM type Traces.

EXIT: Select EXIT to exit CIM options menu and return to CIM.

K. Serial Port: See Section V above (Arc Reflection.)

L. Fuses/Fuse Holder: See Section V above (Arc Reflection.)

M. Beeper: See Section V above (Arc Reflection.)

## VI. CIM OPERATION

A. Confirm you have a BNC cable attached between the “CIM” BNC input on the back of the radar and the CIM input on the thumper or filter. Confirm that the radar has a ground attached. Follow All Utility and Thumper Manufacturer’s Safety Procedures.

B. Enter Options Menu. Scroll to “MORE” on the menu bar. Select “MORE”. Scroll to “CIM”. Select “CIM”.

C. The screen will appear with a flat line intersected by the left and right markers.

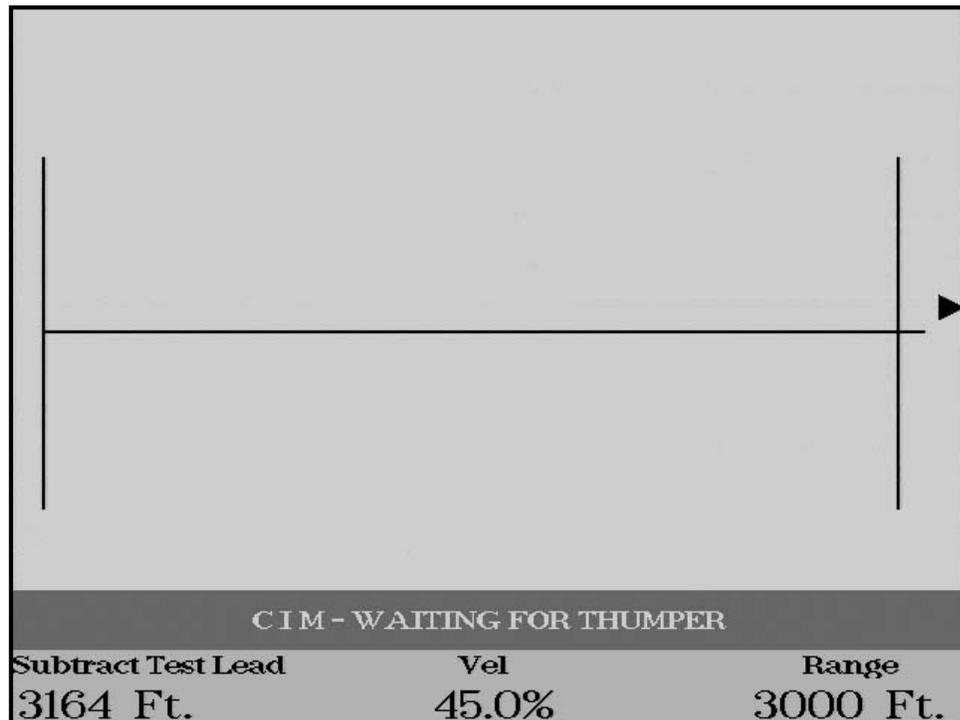


Figure A-1

D. Set the range to three times (3x) cable length.

- E. Velocity will default to 50%. This value can be changed temporarily by pressing the velocity key and then an arrow key.
- F. Discharge the impulse generator (thumper). When the fault breaks down the flat line will become a series of oscillations.

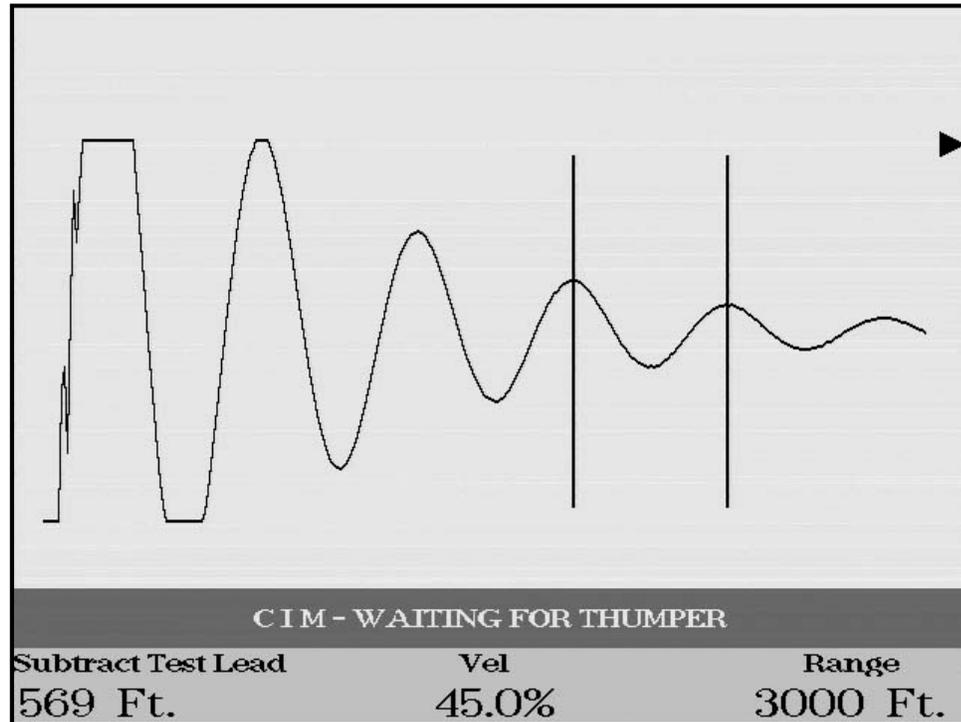


Figure A-2

These oscillations are the current surges created by the arcing fault. 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 oscillations. (It is usually best to not use the first oscillation for this measurement.) That distance is displayed in the lower left corner of the LCD.
- H. 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.
- I. 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.
- J. 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.