AVO INTERNATIONAL

Instruction Manual AVTM653000J

for

SD-3000 Surge Detector

Catalog No. 653000 and 653002

High Voltage Equipment
Aparato de Alto Voltaje

Read the entire manual before operating.
Antes de operar este producto lea este manual enteramente.

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Introduction

Receiving Instructions

Check the equipment received against the packing list to ensure that all materials are present. Notify AVO International of any shortage. Telephone (610) 676-8500.

Examine the instrument for damage received in transit. If any damage is discovered, file a claim with the carrier at once and notify AVO International or its nearest authorized sales representative, giving a detailed description of the damage.

The instrument has been thoroughly tested and inspected to meet rigid specifications before being shipped. It is ready for use when set up as indicated in this manual.

General Information

The SD-3000 Surge Detector is designed to locate faults in shielded, direct buried electric cables by detecting both the electromagnetic and acoustic pulse emitted from an arcing fault when it is surged. The SD-3000 can be used with surge generators manufactured by AVO International or other manufacturers. The detector can easily be carried by the operator to any field location. A sturdy carrying case is provided.

To use the detector, the operator first calibrates the electromagnetic (MAG) level of the SD-3000 by standing over the cable under test and letting the instrument detect an electromagnetic pulse from the surge generator. The operator then places an acoustic pickup on the ground and listens for the characteristic pulse produced by the high energy, electrical discharge at the fault. The SD-3000 displays the relative time delay between the occurrence of the electromagnetic pulse and the reception of the acoustic pulse. Shorter time delays indicate that the acoustic pickup is closer to the fault. The SD-3000 also displays a sound intensity. The operator moves along a line toward the location of the loudest sound and shortest time delay. The final, precise location of the point of maximum sound and minimum time delay is directly over the fault. Faults can be located more quickly and accurately by using a second pickup. With both pickups attached, the instrument indicates a direction to the fault which quickly guides the operator to the fault.

The SD-3000 is contained in a lightweight, compact housing that can be carried by an adjustable strap around the neck, leaving the hands free to operate the instrument. The SD-3000 can be used with Biddle® Power Cable Fault Locating systems, the PFL 3000, PFL 7000 and the DART™. This manual describes the SD-3000; separate instruction manuals describe the operation of Biddle® Surge Generators, dc Test Sets, Arc Reflection Filters and the DART™.

Warning

Procedures described in this manual are designed specifically for Biddle® equipment. If another manufacturer's equipment is used, it is the responsibility of the user, paying careful attention to safety, to verify that grounding and interconnections between the systems are made in accordance with each manufacturerís specific instructions. Incompatible grounding systems may prove hazardous.

Description of Operating Modes

The SD-3000 has the following modes of operation. These modes are automatically selected by the instrument depending on whether one or two pickups are connected or no pickups are connected.

Pulse Mode

The pulse mode is automatically selected when no pickups are plugged into the SD-3000 control unit. The instrument display shows electrical activity in the form of a bar graph. This mode is useful for verifying that you are indeed standing over the cable. The MAG level can be set at any time in any mode of operation. The operator calibrates the MAG level by pressing the MAG SET button while standing over the cable under test. The antenna inside the SD-3000 detects the electromagnetic pulse and normalizes the amplitude to three segments on the bar graph at the top of the screen.

Single Pickup Mode

This mode is automatically selected when one pickup is plugged into the SD-3000 control unit. The operator proceeds to the vicinity of the fault (within 20 ft (7m)) as determined by a prelocation procedure such as arc reflection. It is assumed that the operator knows the path of the cable which can be determined using cable tracing equipment such as the SFL-2000.

The operator can calibrate the MAG level of the instrument by pressing the MAG SET button while standing over the cable under test. The antenna inside the SD-3000 detects the electromagnetic pulse and normalizes the amplitude to three segments on the bar graph at the top of the screen. However, calibrating the MAG level is not required for proper acoustic operation.

The operator places the acoustic pickup on the ground and listens for the fault. When an electromagnetic pulse is detected, the instrument measures the following three quantities:

- The relative strength of the electromagnetic pulse is measured and displayed on a 16-segment bar graph at the top of the screen if the MAG level was previously set.
- The amplitude of the acoustic pulse received by the pickup is measured and displayed as a number between 0 and 999.
- The time delay between the occurrence of the electromagnetic pulse and the arrival of the acoustic pulse at the pickup on the ground is measured and displayed as a number between 0 and 29.9 ms.

The operator patrols along the cable under test until the acoustic amplitude is maximized and the time delay is minimized. The electromagnetic amplitude is used only as an indication that a surge took place; this indication will occur even if the MAG level was not calibrated using the MAG SET button.

Dual Pickup Mode

This mode is automatically selected when two pickups are plugged into the SD-3000 control unit. As in the single pickup mode, the operator proceeds to the vicinity of the fault. If desired the operator can calibrate the MAG level while standing over the cable under test. The SD-3000 detects the electromagnetic pulse and normalizes the amplitude. However, calibrating the MAG level is not required for proper acoustic operation.

The operator then places both acoustic pickups on the ground and listens for the fault. When an electromagnetic pulse is detected, the instrument measures the following five quantities:

- The relative strength of the electromagnetic pulse is measured and displayed on a 16-segment bar graph at the top of the screen if the MAG level was previously set.
- The amplitude of the acoustic pulse received by one pickup is measured.
- The amplitude of the acoustic pulse received by the second pickup is measured.

- The time delay between the occurrence of the electromagnetic pulse and the arrival of the acoustic pulse at one pickup on the ground is measured.

- The time delay between the occurrence of the electromagnetic pulse and the arrival of the acoustic pulse at the second pickup on the ground is measured.

The SD-3000 then displays the measured values for the acoustic pickup closest to the fault, an amplitude between 0 and 999 and a time delay between 0 and 29.9 ms. Arrows at the bottom of the screen point to the pickup closest to the fault. The operator patrols along the cable under test always moving the pickups in the direction of the arrow.

When the two pickups are straddling the fault, two arrows appear that point toward each other. In addition to the arrows, the operator can use the measured values to gain further information. The acoustic amplitude is maximized and the time delay is minimized when the pickups are closest to the fault. The electromagnetic amplitude is used only as an indication that a surge took place; this indication will occur even if the MAG level was not calibrated using the MAG SET button.

Section 2
Safety

The SD-3000 and the recommended operating procedures have been designed with careful attention to safety. AVO International has made formal safety reviews of the initial design and any subsequent changes. This procedure is followed for all new Biddle® products and covers areas in addition to those included in applicable ANSI standards. Regardless of these efforts, it is not possible to eliminate all hazards from electrical test equipment or to foresee every possible hazard which may occur. It is therefore essential that the user, in addition to following the safety rules in this manual, also carefully consider all safety aspects of the test before proceeding. Safety is the responsibility of the user.

This equipment is designed in accordance with safety specifications IEC 1010-1 and ANSI/ISA S82.01 and meets the requirements for Class III equipment. Protection against electric shock from the equipment is provided by the use of extra low-voltage circuits which in themselves are not hazardous. However, the SD-3000 can be used with an arc reflection system or surge generator. The test systems and the cable to which they connect are sources of high-voltage electrical energy. Observe the following safety precautions:

- Observe all safety warnings marked on the high-voltage equipment. These warnings identify areas of immediate hazard which could result in personal injury or loss of life.

- Do not use this equipment for any purpose other than described in this manual.

- Do not use this equipment to locate faults on direct-buried unshielded or secondary cable. Dangerously high differences in potential may be developed in the current return path.

- Do not use this equipment to locate faults on any cable which is likely to be near enough to an energized cable to allow a burn through of the insulation of the energized cable. This situation may occur when the cables are located in a common trench, duct or tray (for example, three-phase systems).

- Use all practical safety precautions to prevent contact with energized parts of the equipment and related circuits.

- Stand clear by at least 3 ft (0.91 m) of all parts of the complete high-voltage circuit, including connections, unless the equipment is de-energized and all parts of the test circuit are grounded. Be aware that signals applied to the cable will be present at the remote end(s) of the cable. To avoid inadvertent contact to hazardous live parts, always ensure that access to any exposed part of the cable or connected equipment is restricted.

- Use suitable barriers, barricades, or warnings to keep persons not directly involved with the work away from test activities.

- Do not leave high-voltage equipment unattended while in operation. One operator must remain with the surge generator while the other patrols the cable with the SD-3000.

- Use the recommended grounding and connection procedures

described in the manuals for the high-voltage equipment (for example, surge generator, arc reflection system).

- Refer to IEEE 510-1983 "IEEE Recommended Practices for Safety in High-Voltage and High-Power Testing" for additional information.

Treat all terminals of high-voltage power equipment as a potential electric shock hazard. There is always the potential of voltages being induced at these terminals because of proximity to energized high-voltage lines or equipment. Any interruption of the grounding connection can create an electric shock hazard.

As a routine safety procedure, some users require that rubber gloves be worn, not only when making connections to the high-voltage terminals but also when manipulating controls. AVO International considers this an excellent safety practice.

Although the SD-3000 does not generate strong electromagnetic fields, it is used in conjunction with high-voltage equipment that does. Users of the high-voltage equipment should note that high-voltage discharges and other sources of strong electric or magnetic fields may interfere with the proper functioning of heart pacemakers. Personnel using heart pacemakers should obtain expert advice on the possible risks before operating this equipment or being close to the equipment during operation. AVO International recommends that a qualified operator be in attendance at all times while the system is in operation.

Warning and caution notices are used in this manual where applicable and should be strictly observed. These notices appear in the format shown below and are defined as follows:

Warning

Warning, as used in this manual, is defined as a condition or practice which could result in personal injury or loss of life.

Caution

Caution, as used in this manual, is defined as a condition or practice which could result in damage to or destruction of the equipment or apparatus under test.

Section 3
Specifications

Operating modes:	Pulse Mode Single Pickup Mode Dual Pickup Mode
Range:	0 to 29.9 ms
Resolution:	0.1 ms
Inputs:	Two (left and right) for acoustic pickups
Outputs:	One jack for stereo headphones, 300 (each side
Volume:	Headphone volume adjustable for comfort Automatic headphone muting while acoustic pickup is moved
Acoustic gain:	Automatic
Electromagnetic gain:	Automatic
Acoustic bands:	125 to 1000 Hz 500 to 1000 Hz
Acoustic pickup:	6-ft (1.82 m) cord with color-coded label

Display:	LCD with automatic backlight
Power:	Ten 3.6 V, AA cell, lithium batteries Automatic shutdown after 60 minutes
Battery life:	> 200 hours (depends how often backlight illuminates)
Operating temperature range:	-4 to 122∞F (-20 to 50∞C)
Storage temperature range:	-40 to 158∞F (-40 to 70∞C) High storage temperatures will degrade battery life.
Humidity:	< 95 percent noncondensing
Climate:	Operation is prohibited in direct rain or snow.
Dimensions and weight:	
Instrument in case:	20 x 13.5 x 7.5 in. (508 x 342.9 x 190.5 mm) 22 lb (10 kg)
Detector:	9 x 3.75 x 4 in. (228.6 x 95.25 x 101.6 mm) 2 lb, 8 oz (1.136 kg)

Accessories supplied:

Acoustic pickup with 6-ft cord labeled with a red band
Acoustic pickup with 6-ft cord labeled with a blue band
Two-piece handle for acoustic pickup (two for C/N 653002)
5-in. threaded spike for acoustic pickup (two for C/N 653002)
Instruction manual
Carrying case
Ten lithium AA batteries (installed)
Stereo headphones

Optional accessories:

Upgrade for C/N 653000 includes:
- Acoustic pickup with 6-ft cord labeled with blue band
- Two-piece handle for acoustic pickup with blue band
- 5-in. threaded spike attachment for acoustic pickup

Section 4
Controls, Indicators, and Connectors

Control Panel

Figure 1 shows the control panel of the SD-3000 and the following controls and indicators:

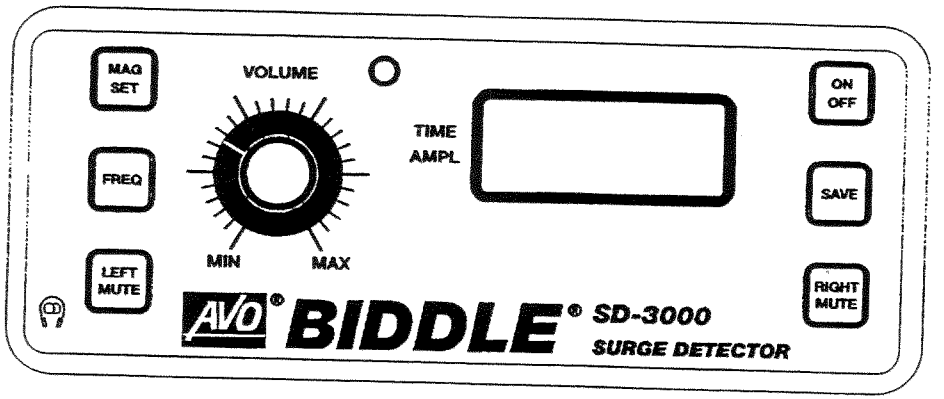


Figure 1: SD-3000 Control Panel

Display

The LCD displays the following information depending upon the operating mode. A photoelectric sensor next to the display senses available light and automatically turns on the display backlight when necessary.

Battery Life

For a few seconds during power up, the instrument displays the number of hours of charge life remaining in the battery.

MAG Level

In the pulse mode, the only quantity that is displayed is the magnitude of the detected electromagnetic pulse. The bar graph across the screen has a total of sixteen possible segments. The bar is approximately logarithmic over two decades and displays the intensity of the electromagnetic pulse detected from the cable. After the MAG level is calibrated, the normalized MAG level (normalized to three segments) is shown at the top of the display as a bar graph with a maximum of 16 segments.

Acoustic Amplitude

The relative amplitude of the acoustic pulse is shown as a number between 0 and 999. As the pickup is moved closer to the fault the number increases. To the left of the LCD, on the control panel is the marking AMPL. The amplitude number (0 to 999) is displayed to the right of AMPL.

Time Delay

The amount of time for the acoustic pulse to travel from the fault to the acoustic pickup is displayed in milliseconds. This quantity is indicative of the relative distance from the acoustic pickup to the

fault. As the pickup is moved closer to the fault, the time delay becomes smaller. It should be noted that the time delay will never be zero since the acoustic pulse takes a finite amount of time to travel to the pickup. The time delay for reception of the acoustic pulse is shown as a number between 0 and 29.9†ms. To the left of the display, on the panel is the marking TIME. The time delay (0 to 29.9†ms) is displayed to the right of TIME.

Memory

The SD-3000 has on-screen memory. The memory locations contain the saved values of amplitude and time. The amplitude and time delay values are displayed to the right of the markings AMPL and TIME, respectively. The left-most position contains the present measurement value and is updated each time the unit detects an electromagnetic pulse. The two positions at the right contain the stored values. The SAVE button is used to update the values stored on the screen. The values on the screen are saved in a first-in-first-out manner and move from left to right on the screen.

Direction

When two pickups are used, the values displayed (amplitude and time) correspond to the pickup that is closest to the fault. Arrows at the bottom of the screen point to the pickup that is closest to the fault. On the front of the instrument, there are right and left audio input jacks. The arrows displayed actually point to the jack on the SD-3000. If the arrow points to the right, then the acoustic pickup plugged into the right input is closer to the fault. If the arrow

points to the left, then the pickup plugged into the left input is closer. In addition to the directional indication by the arrows, the length of the arrows also shows closeness. Longer arrows mean farther away; shorter means closer. When the two pickups straddle the fault (equal distances from the fault), two arrows point to each other. If the arrow appears as three question marks, then the SD-3000 was unable to determine which pickup is closer.

ON/OFF Button

This push button toggles the power on and off. The instrument will automatically turn itself off after sitting idle for 60 minutes. When first turned on, the instrument performs a self-test before entering an operating mode.

FREQ Button

The FREQ push button toggles between two frequency bands used for the acoustic pickups. The default frequency is the 500 to 1000 Hz band. Pressing this button will switch the unit between the 125 to 1000 Hz and 500 to 1000 Hz bands. The different frequency bands are useful for either discriminating against noise or for listening for weak thumps. Pressing FREQ clears any saved readings.

MAG SET Button

The MAG SET push button sets the MAG level. The SD-3000 is calibrated for the correct MAG level by holding it over the cable under test and pressing MAG SET. On the next surge the MAG level is automatically set to a value of 20 percent of full scale (three bar segments).

SAVE Button

The SAVE push button is used to save the present measurement values. The memory locations contain the saved values of amplitude and time. The left-most position contains the present measurement value and is updated each time the unit detects an electromagnetic pulse. The two positions at the right contain the stored values. When SAVE is pressed, the right-most value is replaced by the value in the center position and the present value moves to the center position. In other words, the values are saved in a first-in-first-out manner and move from left to right on the screen. This is convenient when comparing readings while searching for the fault. The memory is cleared by pressing the SAVE button several times. Changing the frequency by pressing the FREQ button will also clear all the saved readings.

RIGHT MUTE Button

The RIGHT MUTE push button turns off the right headphone speaker. This feature is useful when trying to distinguish differences in sounds received by the right pickup and left pickup.

LEFT MUTE Button

The LEFT MUTE push button turns off the left headphone speaker. This feature is used in the same manner as the RIGHT MUTE button.

VOLUME Knob

The VOLUME knob controls the volume of the sound in the headphones and can be adjusted from MIN to MAX for operator comfort. In addition to the MUTE buttons and the VOLUME control, the SD-3000 automatically mutes the headphones when it detects that the acoustic pickups are being moved.

The stereophonic headphones symbol identifies the headphones jack on the left side of the instrument. Be sure that the left earphone is placed over the left ear. The left earphone has the cord extending from it.

Connectors

Headphones Jack

A jack on the left side of the SD-3000 provides for connection of stereophonic headphones with 300-Ω impedance.

Caution

Using monophonic headphones will short-circuit the audio circuit and may damage the instrument. Headphones with an impedance less than 300 Ω may also damage the instrument.

Audio Jacks

Two audio input jacks are situated on the front of the instrument. If only one pickup is used, it will work equally well in either input. However,

for the sake of convention, we recommend using the right audio input jack when using one pickup. Pickups are color coded for easy identification, but it does not matter which pickup is plugged into which jack when using two pickups. All that is important is that the operator be able to see where each pickup is plugged in. Identification of which pickup is plugged into which jack is important when two pickups are used since the SD-3000 indicates which direction to move the pickups. The SD-3000 automatically switches to the dual pickup mode when it detects the presence of a second pickup plugged into the left audio input jack. Sounds detected by the left pickup are amplified through the left headphone speaker, and sounds detected by the right pickup are amplified through the right headphone speaker in dual pickup mode. In single pickup mode, the headphones automatically become monophonic and the same sound is heard in both ears.

Section 5
Operation

Single Pickup Mode

Perform the following steps to connect and configure the SD-3000 for operation in the single pickup mode. Read and understand Section 2, Safety, before operating the SD-3000.

Warning

Do not leave the high-voltage equipment unattended while in operation. One operator must remain with the surge generator while the other patrols the cable under test with the SD-3000.

1. Proceed to the vicinity of the fault.

   Use the approximate location determined by a prelocation test such as arc reflection. It is assumed that the operator knows the path of the cable, which can be determined by using cable tracing equipment such as the Biddle® SFL-2000.

2. Assemble the SD-3000 as shown in Figure 2.

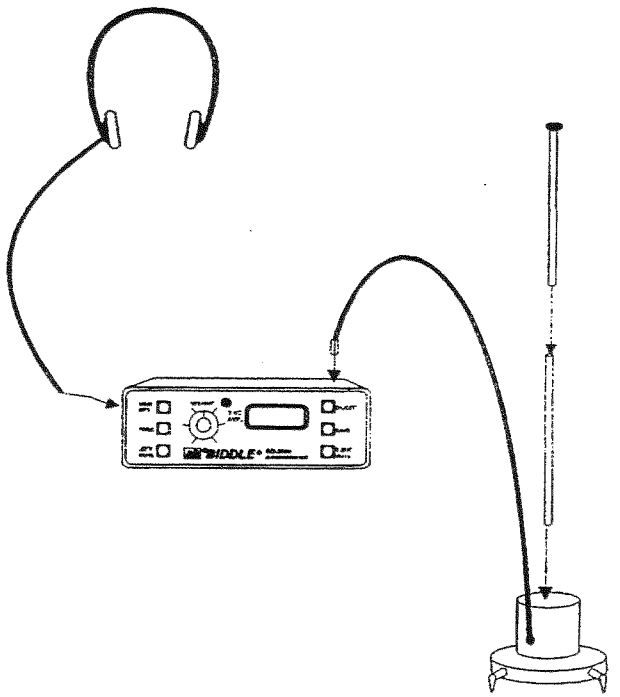


Figure 2: Assemble and Connect One Pickup

Assemble the handle for the acoustic pickup by screwing the two sections together.

Screw the assembled handle into the threaded insert in the top of the acoustic pickup.

Plug the stereo headphones into the headphones jack on the left side of the SD-3000. The left earphone has the cord extending from it.

Warning

Refer to and observe the connection and operating instructions supplied by the manufacturer of the surge generator being used before commencing the test. Figure 3 is incomplete concerning connections to ground and the cable under test; it is intended to show concepts only.

3. Begin surging the cable.

   Turn on the surge generator and begin surging the faulted cable at a voltage great enough to cause the fault to breakdown. See Figure 3.

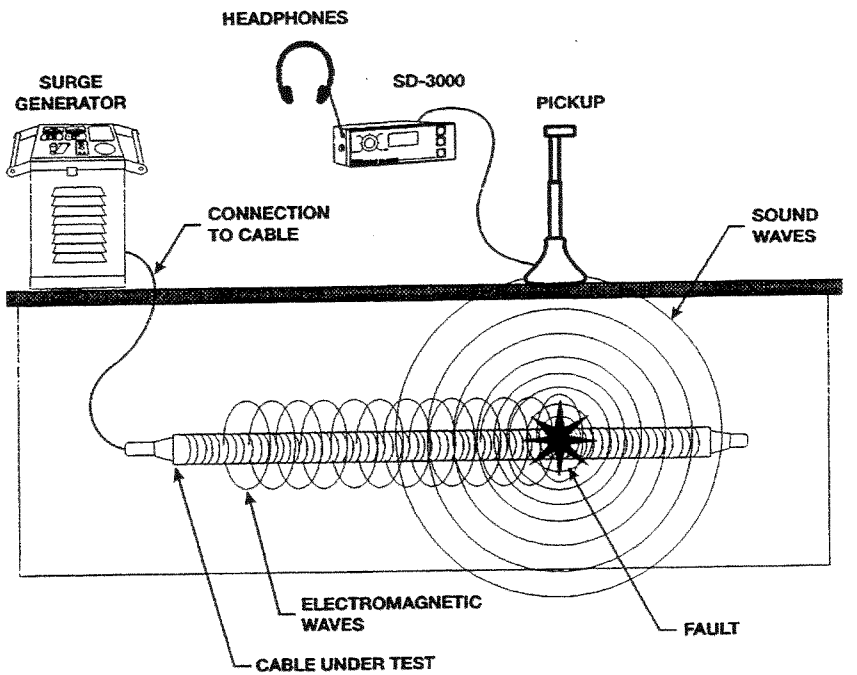


Figure 3: Use of the SD-3000 in Single Pickup Mode

4. Calibrate the MAG level.

   Turn the SD-3000 power on by pressing the ON/OFF button on the control panel. A message similar to the following is displayed:

BIDDLE SD-3000

Battery > 100 hrs

After a momentary display of the battery life message, the next display requests the operator to press the MAG SET button.

-Magnetic Cal-
Hold over cable
Press SET button
Pulse Mode

Stand over the cable path and press the MAG SET button. This button calibrates the MAG level when the SD-3000 detects the next surge. The MAG level will be normalized to 20 percent (three segments on the bar graph at the top of the display). Each time the surge generator surges the cable, the bar graph shows a momentary bar indicating the magnitude of the electromagnetic pulse.

■■■

Pulse Mode

If the response to the electromagnetic pulse weakens too much (only one segment shows), calibrate the MAG level again by pressing the MAG SET button. The MAG level bar graph is a con-

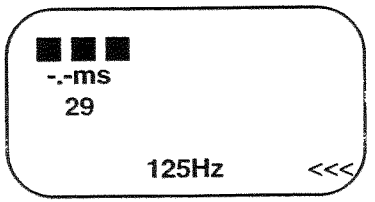
venient way to confirm that the surge generator is ionizing the fault. After the SD-3000 MAG level is calibrated, start to locate the fault.

Plug the acoustic pickup plug into the right input jack on the front of the SD-3000.

5. Adjust the SD-3000.

   Put on the headphones and adjust the volume to midscale or a comfortable level.

   Set the SD-3000 to the 125 Hz band by pressing the FREQ button. The frequency band is displayed at the bottom of the LCD.



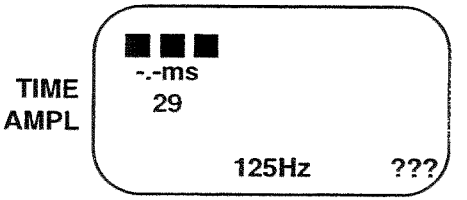
6. Measure the surge.

Warning

To avoid hazards due to damage to underground objects, such as electric cables or gas pipes, always determine the location and depth of these objects before piercing the soil with the spike.

Gently press the three tines of the acoustic pickup into the earth by stepping on its edge. Do not disturb the position of the pickup once it is pressed into the earth because this will lessen its contact with the soil and result in a weaker sound. If the surface is paved, place the acoustic pickup on a level surface so that all three tines contact the surface. If the surface is not paved and it is not possible to press the three tines into the soil, then the 5-in. spike might be most appropriate. Screw the spike into the threaded insert in the bottom of the pickup. Pierce the soil with the spike to make contact.

Wait for the next surge through the fault. When the surge occurs, the bar graph at the top of the display indicates its strength. The magnitude of the acoustic pulse appears next to the marking AMPL (0-999). The time delay to the fault appears next to the marking TIME (0-29.9 ms). If the time delay was not able to be determined properly then the display shows:



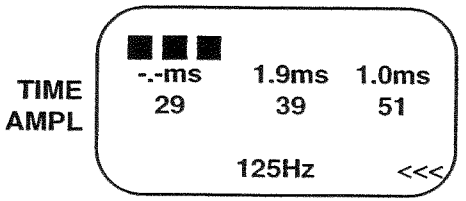
In situations where the background noise is high, it is often best to observe a few readings to see if the measurement repeats.

Note: Restrict operator movement during the surge since acoustic noise from this movement can disturb the readings.

7. Save the reading and repeat.

Press the SAVE button. Then move along the route of the cable and repeat the measurement.

Moving closer to the fault causes the amplitude reading to be greater and the time delay to be shorter. Continue taking readings until the amplitude is maximized and the time delay is minimized; this is the position of the fault.



Operational Notes

It should be noted that the amplitude, while a good indicator, is subject to unusual variations. Even though the operator may have moved closer to the fault the amplitude could actually decrease. This could happen for a number of reasons. The most important reason is the tines of the acoustic pickup may not be making as good contact as during the previous reading. Another reason is that the acoustic pulse may have traveled through a different medium that does not transmit sound as well (soil conditions can change drastically within a small distance).

Since the amplitude of the acoustic pulse is subject to change, the time delay measurement must also be considered a valuable indicator of the fault position. The velocity through different soil types varies so it can

be expected that the time delay might change depending on where the acoustic pickup is placed. Significant changes should not be expected; however, in practice, large variations are sometimes seen. These variations are due to background acoustic disturbances such as road noise from vehicles or pedestrian traffic. The computer in the SD-3000 determines the time delay to fault by detecting the presence of the acoustic pulse. Noise that superposes with the actual surge pulse make its apparent arrival time change. To combat this problem:

- Limit movement during the measurement.
- Change the acoustic frequency band.
- Observe multiple readings and use the most frequent reading.

Changing the frequency band for the acoustic pulse can have certain advantages. Selecting the lower band, 125 Hz, allows more low frequency energy to be received by the SD-3000. Lower frequencies travel through the earth with less attenuation, so it is easier to detect surge pulses from a greater distance. This frequency band is the best choice when first starting the location process since even weak sound is more readily detected. However, since sound travels further at lower frequencies, any interfering sound will corrupt the measurement. In other words, if road noise is a problem, then selecting the lower frequency band only exasperates the problem since the road noise will be measured along with the surge pulse.

To eliminate the problem with low frequency interference corrupting the measurement, a second frequency band is provided. The alternate frequency band is the 500 Hz band and can be used to eliminate most of the low frequency interference. The principle that makes the higher

frequency band eliminate the interference is that high frequency sound attenuates rapidly as it travels through the soil. Any high frequency interference in this band is in effect filtered out by the soil. The downside of this interference filtering is that the surge pulse also attenuates rapidly as the acoustic pulse travels away from the fault. For this reason, switching to the higher frequency band is only effective when the acoustic pickups are close to the fault, otherwise the surge pulse cannot be heard.

One important point to remember is that acoustic propagation in soil is frequency dependent. This means that both the time delay and amplitude readings are influenced by the choice of frequency bands. For this reason, whenever the frequency band is changed, the stored readings are cleared since it is not possible to compare the readings from different frequency bands. Placing the acoustic pickup at a single location and making two measurements using different frequency bands can result in two radically different readings.

Dual Pickup Mode

Perform the following steps to operate the SD-3000 in the dual pickup mode. Read and understand Section 2, Safety, before operating the SD-3000.

Warning

Do not leave the high-voltage equipment unattended while in operation. One operator must remain with the surge generator while the other patrols the cable under test.

1. Proceed to the vicinity of the fault.

   Use the approximate location determined by a prelocation test such as arc reflection.
   It is assumed that the operator knows the path of the cable which can be determined by locating the cable using cable tracing equipment such as the Biddle® SFL-2000.

2. Assemble the SD-3000 as shown in Figure 4.

   Assemble the handle for both the acoustic pickups by screwing the two sections together.

   Screw the assembled handles into the threaded inserts in the tops of the acoustic pickups.

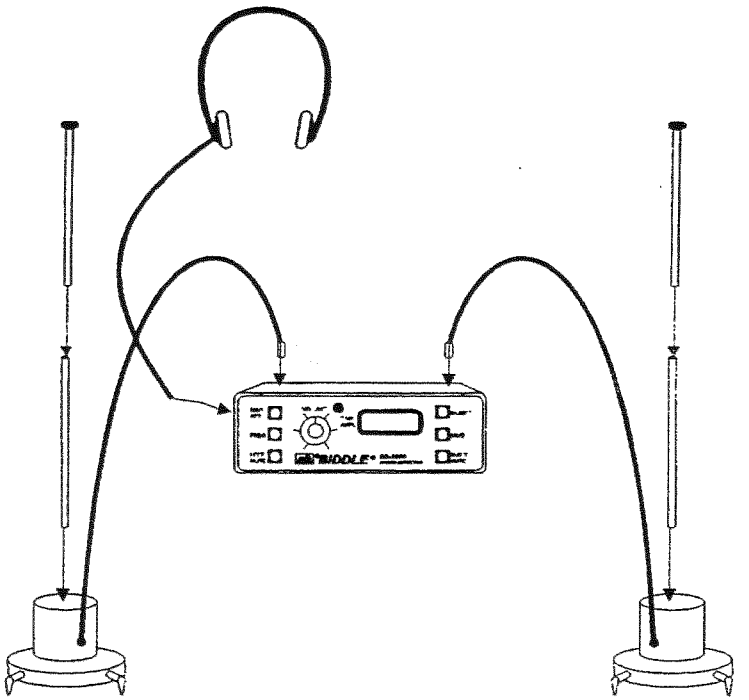


Figure 4: Assemble and Connect Two Pickups

Plug the stereo headphones into the headphones jack on the left side of the SD-3000. The left earphone has the cord extending from it.

Warning

Refer to and observe the connection and operating instructions supplied by the manufacturer of the surge generator being used before commencing the test. Figure 5 is incomplete concerning connections to ground and the cable under test; it is intended to show concepts only.

3. Begin surging the cable.

   Turn on the surge generator and begin surging the faulted cable at a voltage great enough to cause the fault to break down. See Figure 5.

4. Calibrate the MAG level.

   Turn the SD-3000 power on by pressing the ON/OFF button on the control panel. A display similar to the following is shown:

BIDDLE SD-3000

Battery > 100 hrs

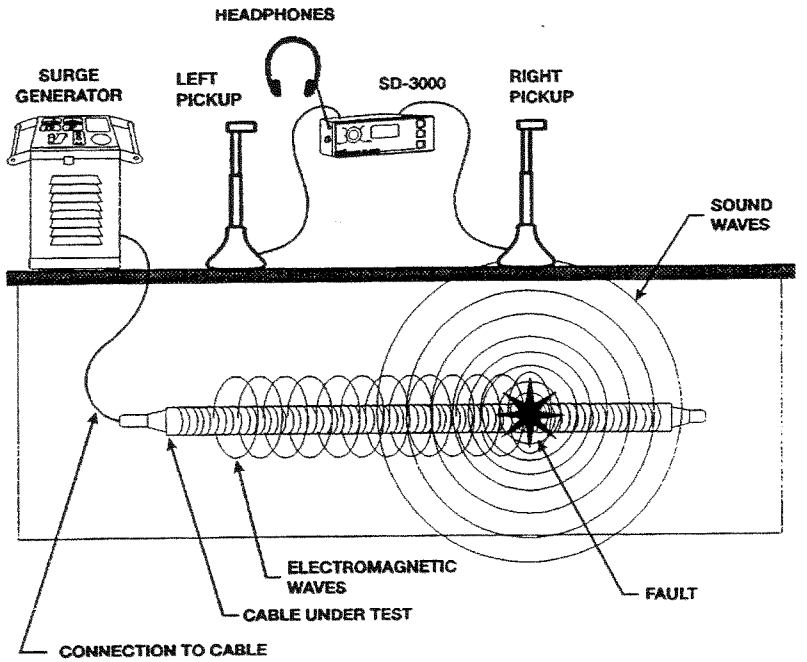
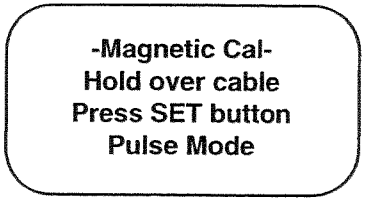


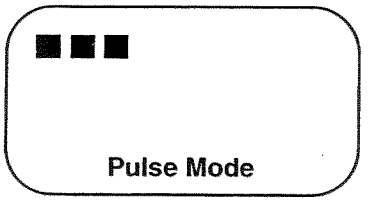
Figure 5: Use of the SD-3000 in Dual Pickup Mode

After a momentary display of the battery life message, the next display requests the operator to press the MAG SET button.



Stand over the cable path and press the MAG SET button. This button calibrates the MAG level when the SD-3000 detects the next surge. The MAG level is normalized to 20 percent (three segments on the bar graph at the top of the display). Each time the surge generator surges the cable, the bar graph shows a momentary bar indicating the magnitude of the electromagnetic pulse.

If the response to the electromagnetic pulse weakens too much (only one segment shows), calibrate the MAG level again by pressing the MAG SET button while standing over the cable. The MAG level bar graph is a convenient way to confirm that the surge generator is ionizing the fault. After the SD-3000 MAG level is calibrated, start to locate the fault.



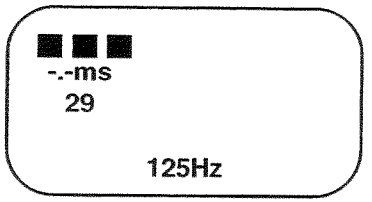
Plug the red acoustic pickup plug into the right input jack on the front of the SD-3000.

Plug the blue acoustic pickup plug into the left input jack on the front of the SD-3000.

5. Adjust the SD-3000.

Put on the headphones and adjust the volume to midscale or a comfortable level.

Set the SD-3000 to the 125 Hz band by pressing the FREQ button. The frequency band is displayed at the bottom of the LCD.



6. Measure the surge.

Warning

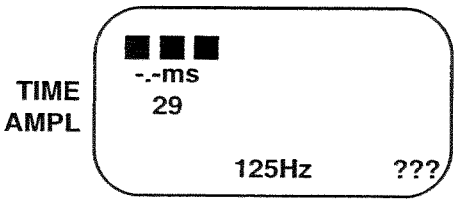
To avoid hazards due to damage to underground objects, such as electrical cables or gas pipes, always determine the location and depth of these objects before piercing the soil with the spike.

Gently press the three tines of the two acoustic pickups into the earth by stepping on their edges. Maintain a separation of approximately 3 feet (0.91 m) between the two acoustic pickups.

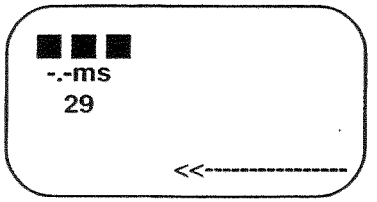
Do not disturb the position of the pickups once they are pressed into the earth because this will lessen their contact with the soil

and result in a weaker sound. If the surface is paved, place the pickups on a level surface so that all three tines contact the surface. If the surface is not paved and it is not possible to press the three tines into the soil, then the 5-in. spike might be most appropriate. Screw the spike into the threaded insert in the bottom of the acoustic pickup. Pierce the soil with the spike to make contact. It is important that both pickups contact the surface in the same manner; best time delays are measured this way. So both pickups must have their three tines pressed into soil, or placed on pavement, or use the spike.

Wait for the next surge through the fault. When the surge occurs, the bar graph at the top of the display indicates its strength. The magnitude of the acoustic pulse appears next to the marking AMPL (0-999). The time delay to the fault appears next to the marking TIME (0-99.9 ms). If the time delay was not able to be determined properly, then the display shows:



In addition, an arrow will appear at the bottom of the display and will point to the acoustic pickup that is closest to the fault; three question marks appear instead of an arrow if the time delay cannot be determined. The values shown on the display correspond to the acoustic pickup that the arrow points to. The length of the arrow shaft is an additional indicator; longer arrow shafts mean further away.



In situations where the background noise is high, it is often best to observe a few readings to see if the measurement repeats.

Note: Restrict operator movement during the surge since the acoustic noise from this movement can disturb the readings.

7. Save the reading and move.

Press the SAVE button. Then move along the route of the cable in the direction of the arrow and repeat the measurement. The spacing between the two pickups should be kept about the same.

Moving in the direction of the arrow can become confusing if the two pickups are not positioned properly. If the SD-3000 points to the right pickup and the pickup connected to the right input is positioned on the right then both pickups should be moved to the right. On the other hand, if the SD-3000 points to the right pickup and the pickup connected to the right input is positioned on the left, then both pickups should be moved to the left. To avoid confusion, always keep the pickup connected to the right input positioned to the right side.

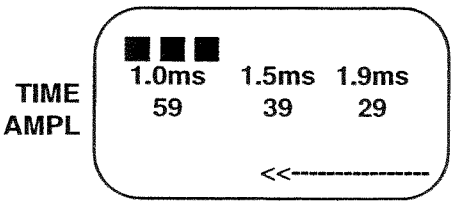
As the fault is approached, the amplitude reading becomes greater and the time delay becomes shorter. The same interpretation of the

readings holds true for the dual pickup mode; the amplitude is maximized and the time delay is minimized when the pickups are positioned over the fault.

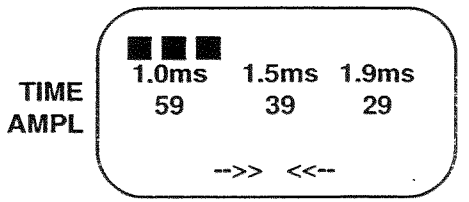
8. Continue following the direction of the arrow.

Save the present reading and move along the route of the cable in the direction of the arrow and repeat the measurement. The spacing between the two pickups should be kept about the same.

As the fault is approached, the shaft of the arrow become shorter, the amplitude becomes greater and the time delay becomes shorter. Continue moving in the direction of the arrow.



As the fault is passed, the direction of the arrow will reverse and point to the other pickup. Move the pickups in small increments in the opposite direction, keeping the spacing about the same until the pickups straddle the fault. When the pickups straddle the fault, the time delays to both pickups will be the same and a special double arrow will appear with the arrowheads pointing toward each other. This means that the fault is positioned between the two pickups.



Note: If the arrow suddenly turns into several question marks and a time delay does not register, then the instrument could not determine the time delay properly.

Section 6
Theory

Fault Process

To understand how faults are located, it is necessary to discuss the properties of the breakdown process and the propagation of acoustic pulses through the earth. All faults can be represented electrically by a gap shunted by a resistance as shown in Figure 6. Although the electrical circuit is simple, variations in the conditions of the two paths can cover an extremely wide range, the resistance ranging from a dead short to many megohms, and the gap breakdown voltage varying from zero to many thousands of volts.

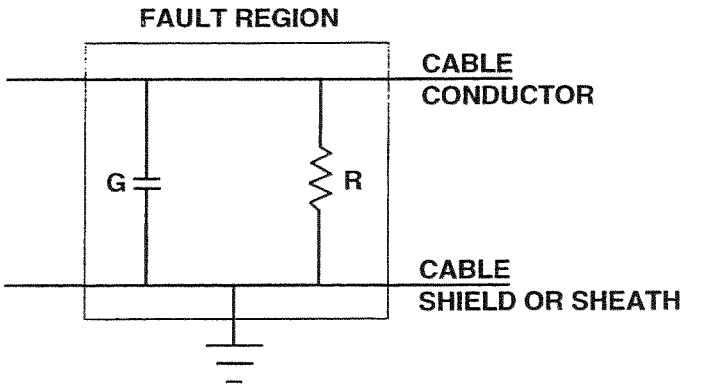


Figure 6: Typical Fault Diagram

Sparkover is determined by three factors: the nature of the fault, the capacitance of cable, and the capacitance of the surge generator. If the capacitance of the surge generator is similar to the capacitance of the cable under test, the fault may not break down on every closure of the discharge switch. This is a result of a capacitive voltage division between the cable capacitance and the surge generator capacitance that prevents sufficient voltage from being applied to the cable.

While modeling the fault itself is important, so is modeling the faulted cable. When a cable fails, portions of the cable are destroyed. Depending on the cable type and the available fault current in the circuit, the damage at the fault site can vary anywhere from a small pinhole to damage that destroys both the center conductor and neutrals. A classification scheme for faults is:

- Shunt fault: a faulted cable in which both the center conductor and neutrals are still intact. If time domain reflectometry (TDR) is used to test the cable, the cable appears to be in operable condition. However, when high voltage is applied, the cable fails. This fault is one type of high-resistance fault. This type of fault produces an adequate acoustic pulse to be found using the SD-3000.

- Series fault: a faulted cable in which the center conductor, neutrals, or both are burned open. If TDR is used to test the cable, the cable appears to have an open circuit at the fault site. When high voltage is applied, the cable fails. This fault is another type of high-resistance fault. This type of fault produces an adequate acoustic pulse to be found using the SD-3000.

- Bolted fault: a faulted cable in which the center conductor and neutrals are shorted (low resistance) together. If TDR is used to test the cable, the cable appears to have a short circuit at the fault site. When high voltage is applied, the cable fails. This fault, also called a low-resistance fault, may not produce an adequate acoustic pulses since most of the surge is conducted through the resistor in the fault model rather than through the gap.

The first step performed in the fault locating procedure is to identify the type of fault. The insulation resistance test determines whether the fault is a high-resistance fault or a low-resistance fault. It is recommended that this test be performed at both ends of the cable; it is possible that the type of fault may be different on either side of the fault location.

To determine whether the fault is a shunt fault or series fault, measure the resistance of the conductors. Short one end of the cable (connect the high-voltage conductor to the neutral). Measure the resistance from the other end of the cable. The resistance should be reasonably low (a few ohms). If it is not within the expected range, then there is either a series fault or significant neutral corrosion.

If the fault resistance is greater than 200 W, the fault is a high-resistance fault and the SD-3000 will work successfully since the surge will be conducted through the gap and will produce an acoustic pulse. If the fault resistance is less than 200 W, the fault is a low-resistance fault and most of the surge will be conducted through the resistor in the fault model. In this case, the fault will produce little or no sound as the surge is conducted through it. These types of faults cannot usually be found using acoustic pinpointing methods.

Velocity of Propagation

The velocity of propagation in the earth helps the operator to interpret the measurement results in terms of the distance to the fault. By definition, the velocity of propagation is the speed at which the acoustic pulse travels through the earth. When the surge is applied to the cable an electromagnetic pulse is produced along with an acoustic pulse. The electromagnetic pulse is detected almost immediately by the SD-3000 (within microseconds). The acoustic pulse is detected later, usually within milliseconds of the discharge. Since the electromagnetic pulse is detected 1000 times sooner than the acoustic pulse, the occurrence of the electromagnetic pulse is assumed to have occurred at the instance of the creation of the acoustic pulse. Therefore, the time of arrival of the acoustic pulse can be considered as a measure of the distance to the fault. Soil properties vary tremendously so it is difficult to assign a specific velocity of propagation. The SD-3000 is best used in a relative manner; shorter times mean closer to the fault. The speed of sound through soil is faster than 1 ft/ms and can vary widely; dense wet soils will be much faster.

Soil Losses

An important property affecting fault location measurements is the attenuation of the acoustic pulse as it travels through the earth. High frequency pulses suffer high attenuation in the earth. The high frequency band should be used when close to the fault. The low frequency band should be used when far away from the fault because low frequency signals suffer less attenuation than high frequency signals.

Losses are exponentially related to the distances to the fault. For example, doubling the distance causes the losses to be squared and tripling the length causes the losses to be cubed.

The high frequency band should be used to eliminate noise and interference when close to the fault. The low frequency band should be used to prelocate the fault since the low frequency band is effective at farther distances.

Dispersion

In addition to the high attenuation suffered by the acoustic transient as it propagates through the earth, its phase also becomes distorted. This means that different sound frequencies travel at different velocities. The implication is that time delay measurements made at the same place, using different frequency bands will give different results.

Overstressing the Cable

Indiscriminate use of a surge generator can place sound insulation at risk. Overstressing the insulation by surging the cable at voltages that are too high or for extended periods may cause premature failure. For this reason it is important to limit the voltage and number of surges while fault locating. Use a sensitive listening device, such as the SD-3000, to locate faults quickly and accurately at the lowest possible voltage.

Section 7
Maintenance

Cleaning

Clean the exterior of the case using a clean dry cloth, being careful to prevent the ingress of foreign material. Clean the display screen as necessary using a soft cloth dampened with water or window cleaner.

Caution

Abrasives and solvents will damage the screen and make it cloudy.

Service

With the exception of battery replacement, the SD-3000 has no user-serviceable internal adjustments and requires no routine service or calibration. Due to the nature of the instrument and the use of custom-built elements, it is recommended that the instrument be returned to the factory for repair or replacement if found to be defective in form or function.

Battery Replacement

Replace all 10 batteries when the battery life displayed is 1 hour. Use only 3.6 V, AA lithium batteries, as specified in Section 8, Replaceable Parts List. Other type batteries do not have the proper voltage. To replace the batteries, perform the following procedure:

1. Loosen, but do not remove, the two screws on either side of the SD-3000.

2. Lift off the top panel of the SD-3000 to access the batteries inside.

3. Remove the batteries and dispose of them in an environmentally safe way.

Warning

Do not expose to temperatures above 150°C, incinerate, puncture, crush, recharge, overdischarge, or short circuit

4. Install the new batteries, ensuring proper polarity. Polarity is marked in the holders and on the batteries.

5. Reassemble the SD-3000.

Repairs

AVO International offers a complete repair service and recommends that its customers take advantage of this service in the event of any equipment malfunction. Please indicate all pertinent information, including problem symptoms. The serial number and catalog number of the instrument should also be specified. Equipment returned for repair must be shipped prepaid and insured and marked for the attention of the Repair Department.

Section 8
Replaceable Parts List

Description	Part No.
Stereo headphones	34303
Acoustic pickup with 6-ft cord (red label)	34292
Acoustic pickup with 6-ft cord (blue label)	34292-1
Two-piece handle (top) for acoustic pickup (two required for C/N 653002)	34298-1
Two-piece handle (bottom) for acoustic pickup (two required for C/N 653002)	34298-2
5-in. threaded spike attachment for acoustic pickup (two required for C/N 653002)	34302
Carrying case	34310
Instruction Manual	AVTM653000J
3.6 V, AA lithium batteries (10 required)	34274

Warranty

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