Close Interval Potential Surveys (CIPS or CIS) using MCM's Integrated Pipeline Survey Test Equipment and Database Management Package

CIS Training Manual – DA Meter Version

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SECTION I: INTRODUCTION AND BACKGROUND

I. 1   Introduction

This manual is designed to provide individuals who will be performing "Close Interval Potential Surveys" (CIPS or CIS) with a practical knowledge of how to select appropriate test equipment, how to set up and properly connect the test apparatus, how to actually perform close interval potential surveys, and, ultimately, how to transfer (upload) stored survey data from data-loggers to a database management system, after performing such surveys. The equipment and software described here comprise MCM's Integrated Pipeline Survey Test Equipment and Database Management Package.

I. 2   Background on the ECDA methodology and the role of CIS

By way of background, the National Association of Corrosion Engineers (NACE), under a directive from the U.S. Government, recently developed a methodology for assessing and reducing the impact of external corrosion on the integrity of onshore buried pipelines (primarily ferrous pipelines). The methodology is termed an External Corrosion Direct Assessment (ECDA). ECDA is a continuous improvement process designed to not only identify areas where external corrosion is underway, but to also predict potential future corrosion areas, which will assist greatly in future corrosion prevention.

The ECDA methodology is a 4 step process and each step must be performed to fully-satisfy the integrated requirements of an ECDA evaluation. The 4 major steps in the process are summarized below:

Step 1: Pre-Assessment.
This step requires the integration of historical, construction, operations and maintenance records for each ECDA Region.

Step 2: Indirect Inspection.
The objective of this step is to estimate areas of active corrosion by performing above-the-ground measurements.

The results obtained in Step 2 are compared with the information compiled in Step 1 and areas that need to receive "Direct Examination" are identified.

Step 3: Direct Examination.
The objective of this step is to excavate (dig) at least in those areas identified using the complementary steps above (steps 1 and 2) and, by direct inspection, to measure the extent of corrosion in those areas. Typically, wall thickness is measured and other corrosion-related data are collected in this step.

Step 4: Post-Assessment
The objective of this step is to prioritize the repair schedule and to decide on the mitigation approaches to be used based on the results obtained in Step 3. The period of time before the next integrity evaluation is to be undertaken is also decided in this step for each ECDA Region.

The subject of this Training Manual is a measurement process that is applied in Step 2 of the ECDA evaluation process, ie, in the "Indirect Inspection" **Step. The measurement process is known as a close interval potential** survey (CIPS or CIS), the details of which are discussed below.

I. 3   CIS Overview

With regard to "Indirect Inspection" of a buried pipeline, one major technique that is employed is a close interval potential survey (CIS), which involves performing above-the-ground measurements of pipe-to-soil potential (voltage) along the entire length of the pipeline. In a CIS, it is critical that measurements be made in a highly consistent fashion (from individual technician to individual technician) and data (pipe-to-soil potentials) be recorded and analyzed in a consistent fashion in order that such data can be considered an integral part of an ECDA evaluation.

Close interval potential surveys are performed in order to obtain a continuous potential profile along the pipeline.

In the Cathodic Protection industry, it is well known that pipe-to-soil potential (voltage) measurements at test stations, which are typically spaced a considerable distance apart, are insufficient to judge the overall condition of a pipeline and to judge whether or not there is complete protection. As a result, close interval potential surveys involving the measurement of potentials at short intervals along the entire length of a pipeline have become the industry standard. In fact, with regard to the ECDA protocol, pipe-to-soil potential readings are typically recorded at 2.5 feet intervals between test stations. (Test stations are insulated electrodes that are in permanent electrical contact with the pipeline and that can be contacted above ground.)

I. 4   Key Components of a CIS Measurement System

The diagram below (Figure 1) illustrates the essential components of a close interval potential survey measurement apparatus.
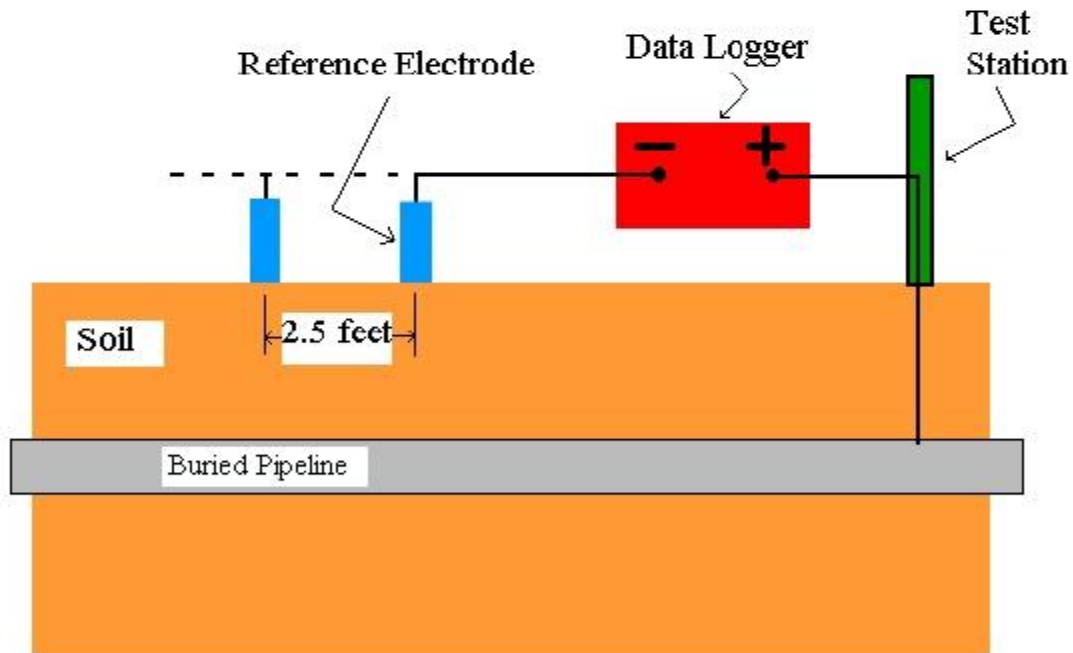
Figure 1:   Key Components of a CIS Test Equipment System

The key components of the CIS apparatus are the reference electrode, connecting the negative terminal of the data-logger to the soil, and the data logger, the positive terminal of which is connected to the test station (and therefore to the pipe). The data-logger is a sophisticated digital voltmeter/data storage unit. Consequently, with this apparatus, the potential difference (voltage difference) between the pipe and the soil (at the reference electrode location) can be measured, and this data point (voltage at a specific location along the length of the pipe with respect to the reference electrode) can be stored for processing by means of the digital voltmeter/data storage unit (data logger). Similarly, data (of pipe-to-soil potential with respect to the reference electrode) can be recorded at intervals of, typically, 2.5 to 5.0 feet along the length of the pipeline.

The ultimate goal of a CIS is to identify locations (if any) along the length of a buried pipeline that are not registering a sufficient potential difference between pipe and soil, which would be indicative of locations that might be experiencing external corrosion. As discussed below in Section II, there is an industry standard (0.85 Volts or 850mV) which is applied in the Cathodic Protection industry and which represents the minimum potential difference (voltage) recorded between the pipe and the soil (with respect to a particular reference electrode (see below in Section II)), that signifies sufficient cathodic protection. Since, on a pipeline that is under cathodic protection (impressed current CP), the pipe is held at negative potential (negative side of the rectifier is connected to the pipe), the minimum potential difference between pipe and soil would be -0.85 Volts. Any more-positive (less-negative) voltages, for example, -0.7 Volts, would suggest insufficient cathodic protection and would indicate a location where external corrosion might be taking place. Actually, a potential difference of greater than -0.85 Volts (for example, -1.0 Volt or higher) might be required to be in the "safe" area with regard to a pipeline being fully cathodically protected under current flow conditions, particularly if the amount of (ionic) current flowing in the soil from the anode to the pipe is large. This situation would result in a significant, so-called, IR drop (voltage drop) due to the current flow in the soil which must be added to the minimum 0.85 Volt potential difference to ensure sufficient cathodic protection. As is discussed in Section III, it is possible to determine the magnitude of this IR drop voltage during the performance of a CIS by conducting the CIS measurements in the "High-Low", or current-interrupted, mode, where the pipe-to-soil potential is sampled as the current is switched ON and OFF in a cyclic fashion (see

Section III). The critical pipe-to-soil potential (with regard to ensuring sufficient cathodic protection) would be the potential measured during the current OFF part of the cycle, since in this case the IR drop would be eliminated.

In any case, once a critical pipe-to-soil potential difference has been established for sufficient cathodic protection of a particular pipeline (taking the IR drop into account), a CIS can be performed to monitor the condition of the pipe, by comparing the pipeline potential profile recorded with the ideal case scenario, which would be a uniform (constant) potential along the length of the pipe.

The following two sections, Sections II and III, describe the setup procedures and operation of the reference electrodes and data-loggers employed in MCM's Integrated CIS Test Equipment Package.

SECTION II: MCM's REFERENCE ELECTRODE FOR CIS

II. 1 Background

As illustrated in Figure 1 in the above section (Section I), the reference electrode makes physical contact with the ground (soil) and is connected electrically to the negative terminal of the data-logger (digital voltmeter/data storage unit). Since the reference electrode is an integral part of the electrical circuit that is allowing the data-logger to measure the potential difference between the pipe and the soil, the reference electrode must make good and consistent electrical contact with the soil at each measurement point during a CIS.

The industry standard reference electrode for pipe-to-soil measurements is the copper-copper sulphate half-cell or, as it's more commonly referred to as, the copper sulphate reference electrode. A schematic illustration of an MCM copper sulphate reference electrode is shown in Figure 2. Also shown in the figure is the reference electrode attached to a push-button cane assembly for use in CIS measurements (see Section III. 3, step 6).
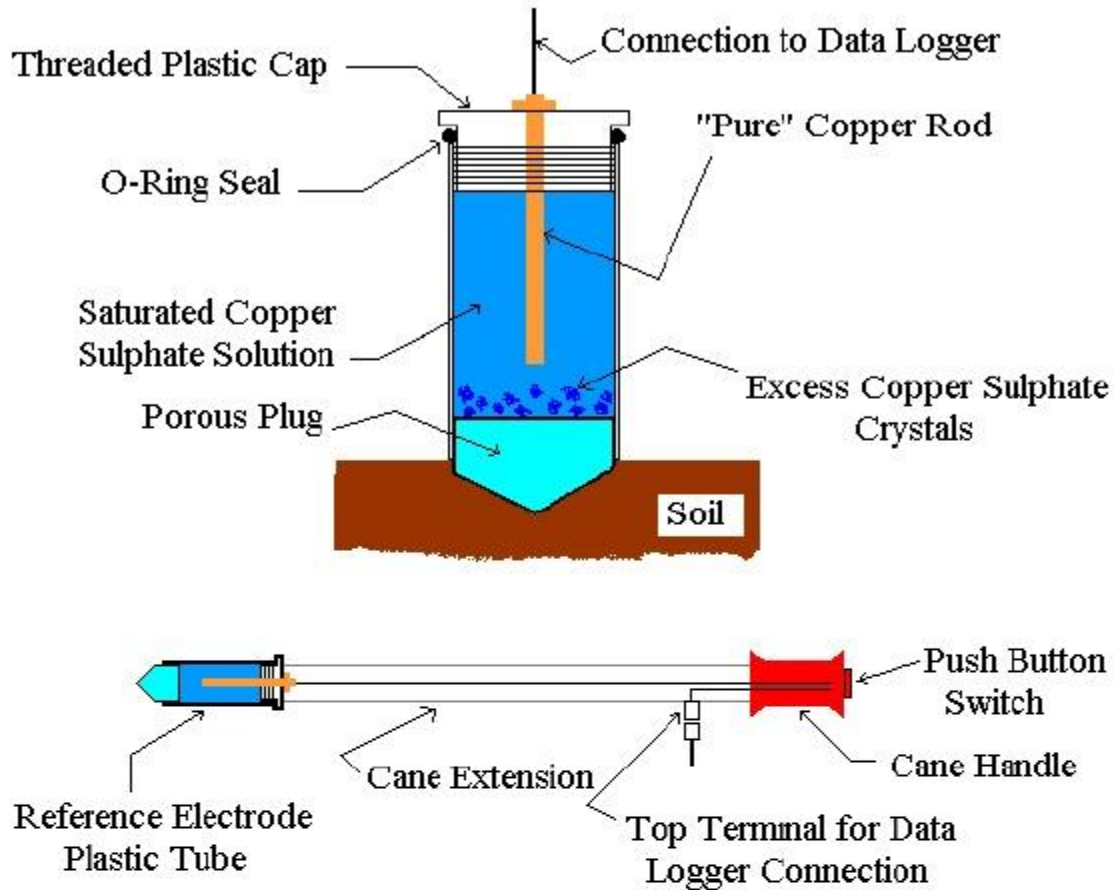
Figure 2:   MCM's Reference Electrode

As can be seen in Figure 2, the reference electrode consists of a pure copper rod that is immersed in a saturated copper sulphate solution within the body of the electrode. The copper rod connects electrically to the negative terminal of the data-logger. During operation, the porous plug is saturated with the copper sulphate solution and it is the solution-saturated plug that makes actual electrical contact with the soil (not the copper rod itself).

It should be noted that the copper/saturated copper sulphate solution combination within the body of the electrode, is actually a half-cell with a built-in half-cell potential (voltage).

Consequently, when the data-logger is connected between the reference electrode and the pipe, as shown in Figure 1 (Section I), the observed voltage reading is actually a combination of two voltages, the copper-copper sulphate half-cell voltage (a constant voltage) and the pipe-to-soil voltage (variable, depending on corrosion conditions).

Therefore, if it can be assumed that the reference electrode half-cell voltage is fixed (a constant value), any variation in the voltage measurements recorded during a CIS can be assumed to be due to variations in pipe-to-soil potential and, therefore, due to the external corrosive condition of the pipe in the various measurement areas. The industry standard voltage value of -0.85 Volts discussed in Section I. 3, which represents a minimum pipe-to-soil potential difference for adequate protection against corrosion, is actually a combination (sum) of the reference electrode half-cell voltage and the pipe-to-soil voltage.

Consequently, since so much emphasis is placed on this critical voltage value, it is imperative that the reference electrode be set up, operated and maintained appropriately so that its half-cell voltage value will, in fact, be fixed.

II. 2 How to Prepare Reference Electrode for Use

The reference electrode will arrive from M.C. Miller Co., Inc. (MCM) assembled, but without liquid in the plastic tube. There will, however, be a concentration of blue copper sulphate crystals inside of the transparent plastic tube. To prepare the reference electrode for use, the transparent plastic tube should be unscrewed from the threaded cap/copper rod assembly (by turning the plastic tube counter-clockwise with respect to the threaded cap/copper rod assembly) and the tube (with the copper sulphate crystals at the bottom) should be filled up to about ½ inch from the bottom of the threads with distilled water (or MCM's Electrode Anti-Freeze solution). The plastic tube should then be screwed back on to the threaded cap/copper rod assembly and tightened firmly (do not over-torque) to effectively seal the tube via the compressed O-ring. At this point, the electrode assembly should be shaken a few times to make sure that a saturated solution of copper sulphate is formed inside the tube. Remember that the half-cell is

established, as discussed in (Section II. 1), between the copper rod and a saturated copper sulphate solution. Once the tube is shaken, the liquid will be blue in color and there should always be some excess copper sulphate crystals remaining out of solution at the bottom of the tube. Before using the reference electrode for the first time, a period of at least 5 minutes should be allowed, after filling the tube and establishing the saturated solution, in order that the porous plug on the bottom of the electrode tube can become moist. The protective cap supplied with the electrode assembly should be kept on the porous plug end when the electrode is not being used.

For more details on the preparation and maintenance of copper sulphate reference electrodes, including important safety precautions, please visit the M. C. Miller Co., Inc. website at www.mcmiller.com. On the home page, click on "manuals, data sheets" and then click on "Electrodes – How to use and maintain copper sulphate electrodes".

II. 3 How to Use Reference Electrode in CIS Measurements

In order to proceed with CIS measurements, remove the protective cap from the porous end of a properly setup (prepared) MCM reference electrode [see Section II. 2 for preparation instructions].

Place the reference electrode (porous plug side down) on the ground over the pipe at the first measurement location (typically at a test station electrode). The porous plug of the reference electrode (suitably moist) should be in firm contact with moist soil.

This may require "digging in" where the earth's surface is dry. If the soil is particularly dry, it may be necessary to moisten the soil around the electrode using fresh water to obtain good electrical contact.

The top terminal of the reference electrode is connected to the negative side of the data-logger's voltmeter and the positive side of the voltmeter is **connected to the test station electrode (Note: The specifics on cable hook-ups are provided in Section IV).**

For CIS work, the reference electrode plastic tube assembly is attached to an extension rod (commonly know as a cane) for upright handheld operation. The cane handle houses a push-button switch (for "triggering" voltage recordings and other "events") and the terminal on the cane for electrical connection to the data-logger is a 5-pin connector. As discussed in Section IV, the receiving terminal for the reference electrode on the data-logger is also a 5-pin connector. All electrical cables are provided for these connections in the MCM Integrated CIS Test Equipment Package. A schematic illustration of a reference electrode cane assembly is shown above in Figure 2.

If a matched-pair of reference electrodes (canes) is to be used (see Section II. 4), the top terminals of the two canes are connected to an MCM adapter (dual-probe adapter) and the adapter is connected (effectively) to the negative terminal of the voltmeter (see Section IV for cable hook-ups).

At this point, a voltage reading can be made using the data-logger, establishing the pipe-to-soil potential difference (with respect to the copper sulphate electrode) at the first measurement location. The operating procedures for the data-logger are described in Section III. All subsequent CIS measurements can be made in the same fashion by moving down the length of the pipeline between test stations and placing the reference electrode (or electrodes, if using a matched-pair) in good electrical contact with the soil at intervals of 2.5 feet, or some other distance interval. Since the distance between test stations can be significant, the electrical wire (trail wire) connecting the data-logger to a test station needs to have considerable length.

II. 4 How to Use Matched-Pairs of Reference Electrodes (Canes)

In CIS measurements, it is convenient to use a pair of matched reference electrodes, rather than a single reference electrode. A pair of electrodes is referred to as either a set of "poles" or a set of "canes". As is discussed in Section III, MCM's data-loggers can be set up to accept readings (voltage readings) during the performance of a CIS from two reference electrodes (canes). In this case, the canes would be connected to the data-logger via the dual-probe adapter mentioned above.

Since each cane in the pair has a push-button switch located on the handle section on top of the cane, the individual performing the CIS can determine which of the two canes (reference electrodes) is to be involved in a voltage recording at any given time. As discussed in Section III. 3, these push buttons can also be designated to have other functions, such as registering a survey flag location, for example.

When performing CIS measurements using a pair of canes, one of the canes is held in the operator's right hand (green-colored cane) while the second cane is held in the operator's left hand (red-colored cane). When, for example, the right-hand cane is placed in electrical contact with the soil above the pipe and the push-button switch is activated on the cane, the DA Meter (see Section III. 3) will record the pipe-to-soil potential with respect to the right-hand cane (reference electrode). Similarly, when the left-hand cane is placed in electrical contact with the soil above the pipe and the push-button switch is activated on the cane, the DA Meter will record the pipe-to-soil potential with respect to the left-hand cane (reference electrode), assuming that both canes have been set up to "read" voltages (see Section III. 3, Step 7).

There are several advantages to using a pair of canes (reference electrodes), rather than a single cane (a single reference electrode) for CIS. For example, both canes can be used to record pipe-to-soil voltages in an alternating fashion (one after the other) as the operator walks down the length of the pipeline. In this fashion, the operator can establish a rhythm, very much like a cross-country skier, contacting the soil above the pipe every 2.5 feet by "triggering" the left-hand cane, then the right-hand cane, then the left-hand cane etc., etc.

Also, one of the canes, for example, the left-hand cane could be used to register the location of survey flags, which are typically located every 100 feet down the length of a pipeline. With this arrangement, the right-hand cane would be used to record pipe-to soil voltages every 2.5 feet while the left-hand cane would register survey flags. This methodology has the advantage of periodic "checks" on the operator's location, with the DA Meter's software being able to re-establish starting points every 100 feet (survey flag separation).

A critical requirement with regard to using reference electrode pairs is that the two electrodes (canes) be essentially identical. As discussed in Section II. 1, a copper/copper sulphate reference electrode is a half-cell with a built-in voltage and the half-cell is an integral part of the electrical circuit of Figure 1 (Section I). Consequently, if two reference electrodes (canes) are used to measure pipe-to-soil potential in an alternating fashion, their half-cell voltages need to be essentially identical if any measured pipe-to-soil potential differences are to be attributed to the corrosive condition of the pipe, rather than to any variation in the half-cell voltages of the two reference electrodes.

A pair of canes can be tested for compatibility in the following manner: The two electrodes can be placed end-to-end (with the moist porous plug ends in firm contact) and the voltage difference between them measured using a high-input-impedance voltmeter connected between their top terminals. If a voltage difference (difference in half-cell voltages) of less than 10mV is observed, the two reference electrodes (canes) are matched. The two reference electrodes could also be placed in a plastic bucket containing fresh water and the voltage difference measured again between their top terminals. If this voltage is less than 10mV, the two reference electrodes are matched for use as a cane pair in CIS measurements.

SECTION III: MCM's DA METER (DATA-LOGGER)

III. 1 Introduction

MCM data-loggers are sophisticated high-input-impedance digital voltmeter/data storage units that are used in conjunction with the reference electrodes described above in Section II to perform CIS measurements. When properly connected with reference electrodes (as described in Section IV), a data-logger reads and records pipe-to-soil voltages (with respect to a reference electrode) at each of the measurement locations along the length of the pipeline (typically every 2.5 feet for CIS work).

The particular data-logger described here is the, so-called, DA Meter. This data-logger is a combination of a high-input-impedance digital voltmeter and a handheld Personal Computer (PC). The operating system of the PC is "Windows for Handheld PC 2000" and MCM has designed proprietary application software programs in order that the DA Meter can be employed to run both "Scripted" Site Surveys and Pipeline Surveys (such as CIS, DCVG and Surface Potential Surveys).

Your DA Meter data-logger will arrive from MCM with the Windows operating system and our survey application programs installed. The survey application programs will remain installed unless the main battery pack, and its backup, are allowed to fully-discharge, in which case the application programs will have to be re-installed (see your DA Meter User's Manual). However, your survey data will always be safe, regardless of battery status, as these data are stored in a non-volatile memory (CompactFlash Card).

The particular application software program required to run Close Interval Survey (CIS) applications is called the DA Meter PLS (Pipe Line Survey) program and the use of this program is described below in detail in Section III. 2.

III. 2   How to Set Up the DA Meter for CIS Applications

The following section outlines the steps required to setup the DA Meter to participate in CIS measurement applications. The setup process establishes the conditions of the particular survey about to be performed and identifies the section of pipeline that is about to be examined by the CIS application. The setup process also establishes a file in which the voltage recordings (survey data) will be stored. At the completion of the survey, CIS data can then be retrieved by a PC that is in communication with the DA Meter, by accessing the file in which the survey data are stored. The process of transferring CIS data to a PC following completion of a survey is discussed in Section VI.

Step 1:
Switch on the DA Meter by pressing the power button. Assuming that the battery pack is charged, the screen will light up and will display the Windows Powered (Handheld PC 2000) desktop screen as shown below (assuming that the operating system running your DA Meter is Windows Handheld PC 2000).

Step 2:

Double tap (using the special pen (stylus) provided with the DA Meter) on the "DA Meter PLS" icon. This will open the software program that will run the DA Meter for Pipeline Surveys. The window shown below will appear.

**Note: It may take a few seconds for this window to appear.**
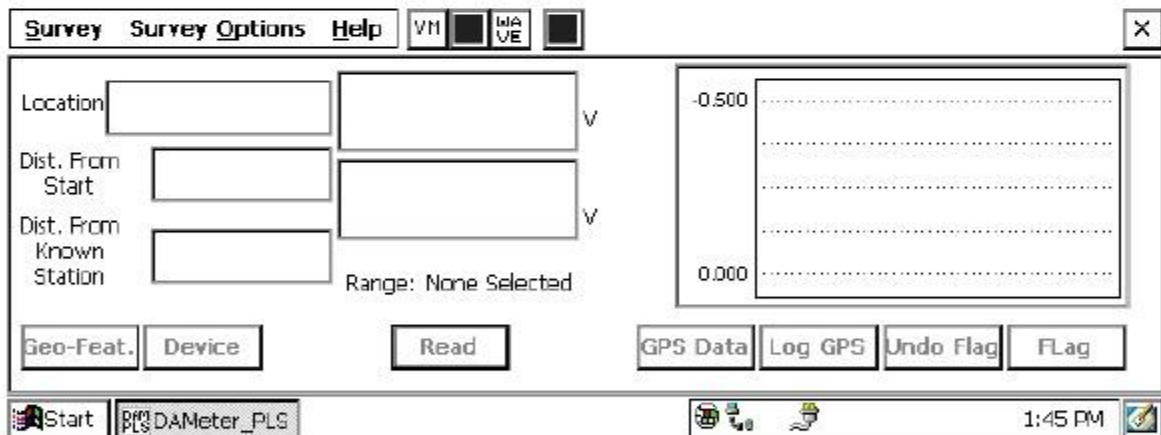
This is the Main Survey Window. At this point, a survey has not been set up (the setup process is what we are going through here) and so no information is currently displayed in this window.
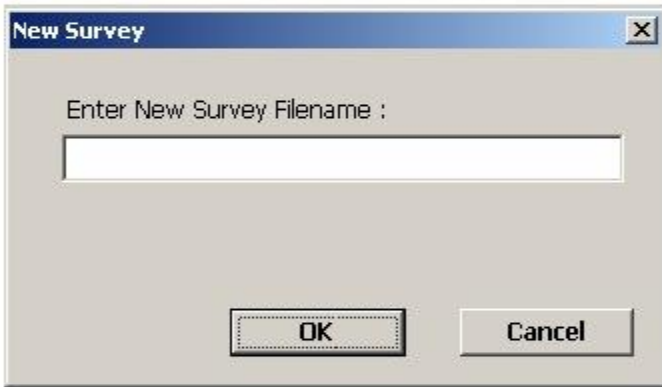
Step 3:

Tap once on the "Survey" button situated in the Menu Bar in the top left-hand corner of the window. The window shown below will appear.
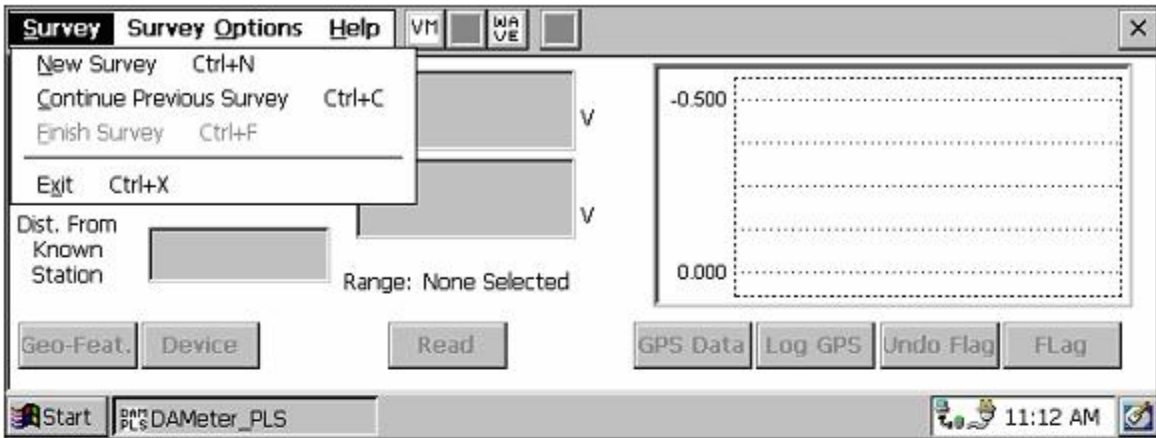
Under "Survey" there are several options. If this is a new survey (not a continuation of a previous survey) tap once on "New Survey". The window shown below will appear.

Step 4:

Enter a "filename" for the Survey using the keyboard.

Note: This is an important step as the filename is used to identify the survey and, also, recorded data (voltages) will be stored in this named file for future retrieval. It is highly recommended that a protocol be established for selecting Survey Filenames. Critical information should be included in the filename, such as pipeline company's name, city or state in which the pipeline is located, pipeline number and section of pipeline number under survey. The protocol developed should be applied consistently for each survey.

For example, let's assume that pipeline company XYZ has a pipeline located in Texas and that the pipeline is identified as pipeline 12 and a survey is being performed on section 085 of this pipeline. A good filename for this survey would be:

XYZ TX 12 085 CIS

When this data file is later accessed, with this filename we know the name of the pipeline owner, we know the state in which the pipeline is located, we know the pipeline number, we know the section number of the pipeline that was surveyed and we know that it was a CIS.

Note: You will not be permitted to use invalid characters, such as slashes(/ or \ ), as part of a filename. You will be alerted if you try to use any invalid characters.
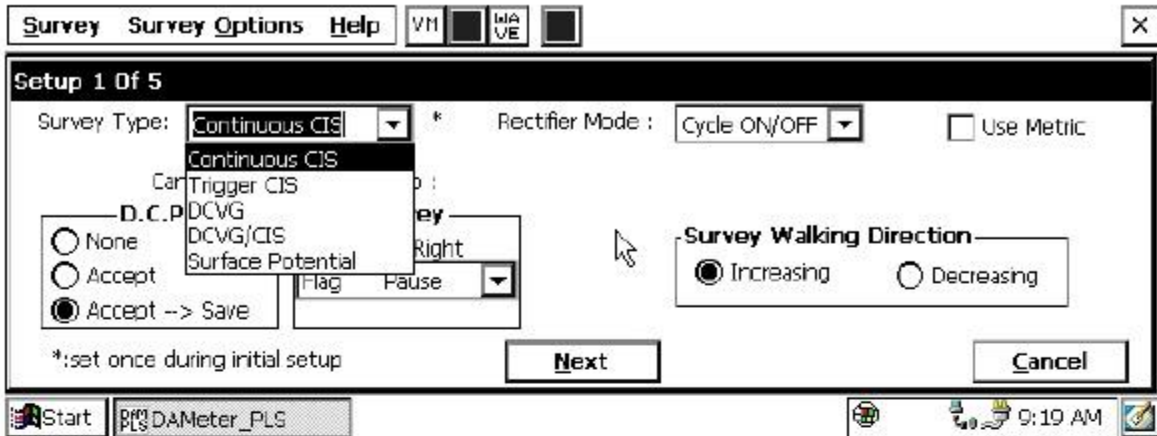
Step 5:

Tap once on the OK button. The window shown below will appear. This is the first of 5, so-called, setup windows.
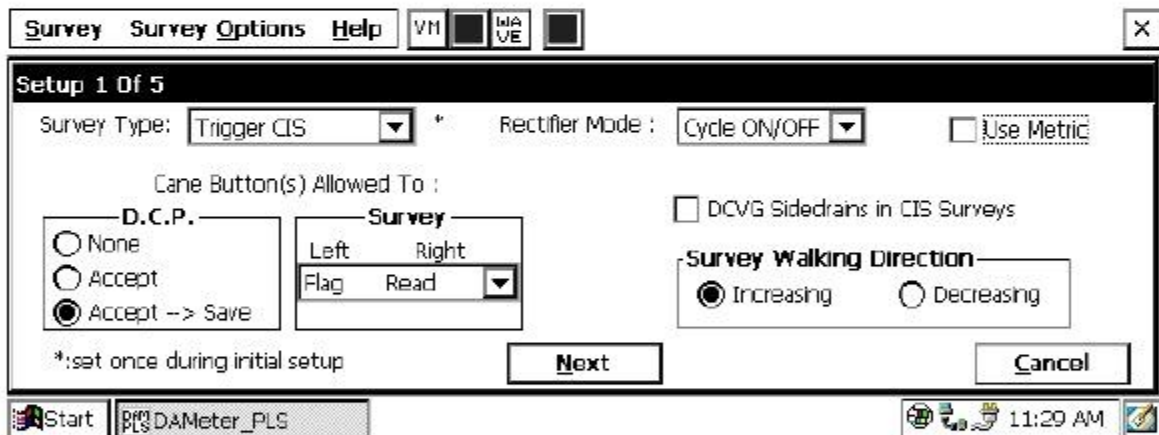
Step 6:

Select "Survey Type".
For CIS measurements there are 2 options for "type of survey": Trigger CIS and Continuous CIS. Other survey types are available as can be seen by tapping once on the pull-down list arrow button in the "Survey Type" field, as shown below.

As can be seen from the above screen, DCVG, combined DCVG/CIS and Surface Potential Surveys are available for selection, however, for CIS-Only surveys, either Continuous CIS or Trigger CIS should be selected by tapping once on the selection.

In Trigger CIS mode, voltage recordings are "triggered" by the operator pressing on the push-button switch located on top of a reference electrode cane (data probe) while making electrical contact with the soil above the pipe with the copper/copper sulphate half-cell end of the cane. **Consequently, in this survey mode, the operator is in control of the timing** of when voltage recordings are made as a CIS is conducted.

Note: The "Trigger CIS" mode should also be selected when using the trigger cable (part # SIN024) for automatic triggering of readings in conjunction with the wire chainer/counter unit.

In contrast, with the Continuous CIS mode, the timing of when voltage recordings will be made is preset. For instance, if you select 1 second intervals, voltage recordings will be made every second. Consequently, the operator must synchronize his cane repositioning pace to match the preset voltage recording timing.

Step 7:
Select the function (operating mode) of the cane buttons associated with the two reference electrodes (canes) to be used in the CIS. Selections are made by tapping choices in the D.C. P. and Survey fields shown in the Step 5 screen above.

The function of the cane buttons during regular survey measurements is determined by the selection made in the "survey" field while the selection made in the "D.C.P." field determines the function of the cane buttons when measurements are made at specially-identified locations (devices).

Cane Button Functions – During Regular Survey (Between "Devices")

The functionality available for the cane buttons depends on the survey mode selected in Step 6 [Trigger mode or Continuous (automatic) mode].

If the Trigger CIS mode is selected, the screen will appear as shown below.
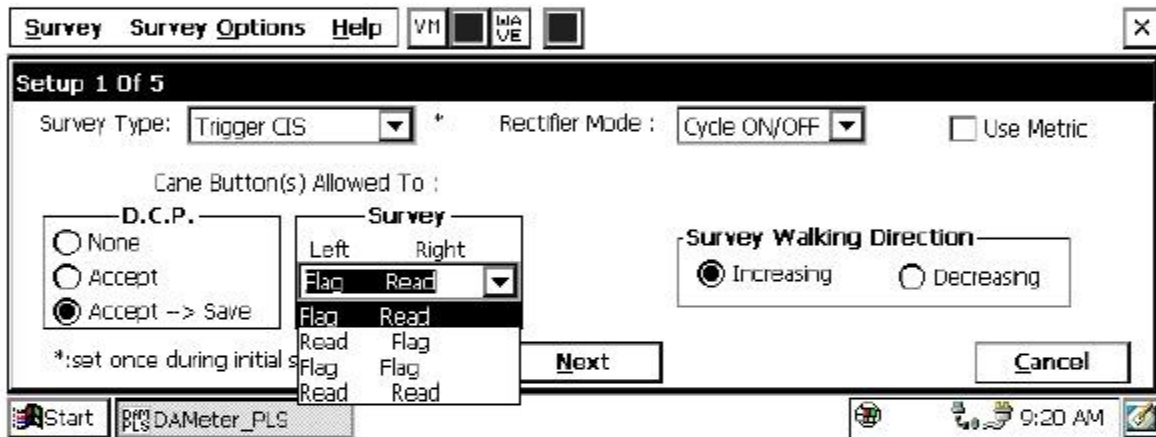
For the above screen, the pull-down-list arrow button in the Survey field was tapped to reveal the 4 choices for the push buttons on the pair of canes to be used in the Trigger CIS (the left cane, held in the left hand with the left thumb operating the left cane button and the right cane, held in the right hand with the right thumb operating the right cane button) .

Manual Triggering of Readings:
The left and right cane buttons can both be selected to read voltages (read read) meaning that as the operator walks down the pipeline alternately contacting the soil with the left and right canes, a voltage recording will be made when either cane is triggered. Alternatively, one of

the canes can be selected to read voltages while the other is selected to register the location of a survey flag (survey flags are typically located every 100 feet down the length of a pipeline). This would be the (flag read) or (read flag) choice. In this case, the push button on the cane selected to register flags would only be pressed at each survey flag location. Finally, the (flag flag) choice can be selected and, in this case, both canes would only be used to register survey flags. Pressing the push-button on the "read" designated cane or pressing the cane button on the "flag" designated cane has the same affect as tapping the read button (and saving the reading) or the flag button, respectively.

Automatic Triggering of Readings:

When the trigger cable (part # SIN024) is used in conjunction with the wire chainer/counter unit, the trigger cable signal simulates the action of the left-hand (red-handled) data probe push button, while the right-hand (green-handled) data probe push button is disabled (has no effect). Consequently, in this case, it is important that the left-hand data-probe push button be designated as a read button, while the right-hand push button can be designated as either read or flag (again, the right-hand data probe push button is not a factor). The appropriate selections would be read read, or, read flag. In this case, survey flags can be designated by tapping the "Flag" button on the survey screen.

If Continuous CIS mode is selected, the screen will be as shown below.
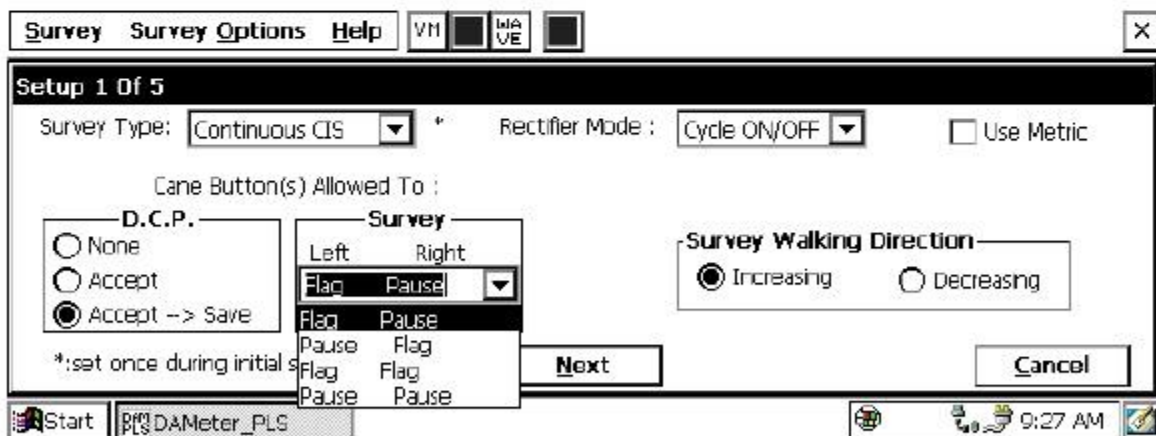
The 4 choices for the set of two canes in the Continuous CIS mode are revealed in the Survey field by tapping once on the pull-down-list arrow. The 4 choices are shown in the screen above. In this case, one of the cane buttons can be selected to effect a pause in the continuous (automatic every so many seconds as prescribed) voltage recordings while the other cane button is selected to register survey flag locations [(flag pause) or (pause flag)]. Alternatively, both cane buttons can be selected to register flags or to **affect pauses. The pause cane would also act as the start or restart cane.**

Cane Button Functions – At "Device" Locations
"Devices" are defined as specially-identifiable entities that exist along the length of the pipeline. Examples of "Devices" include, rectifiers, test stations, valves, etc.

For both CIS modes (Trigger and Continuous), a cane button function selection (selection will apply to both left and right canes) has to be made with regard to Data Collection Points (see D.C.P. field in above screen). A Data Collection Point is a "Device" location point.

In this case there are 3 choices: "None", "Accept" and "Accept and Save". Your selection is made by tapping once in the circle beside your choice.

If "none" is selected: Pressing a cane button will do nothing. In this case, you would have to tap the "accept" and then "save" buttons on the screen, having previously tapped the "device" button, if you wished to read and record the voltage data at the "Device" location.

If "accept" is selected: Pressing a cane button has the same effect as tapping the accept button on the "Device Readings" screen.
If "accept and save" is selected: Pressing a cane button has the same effect as tapping the accept button and then tapping the save button on the "Device Readings" screen.

For the most part, selecting the "accept and save" choice will be preferable, since voltage recordings at special data collection points (such as rectifiers, test stations, valves, etc.) are important and should be saved as part of the overall CIS and the most convenient way to do this is to use the push-button on one of the canes, having tapped on the "Device" button on the screen when a "Device" is encountered.

Step 8a:

Make "Survey Walking Direction" selection

The "Survey Walking Direction" field is shown in the screen above as part of the Setup 1 of 5 screen. There are only 2 selection choices: Increasing and Decreasing.

This selection establishes the walking direction during the survey. If the survey is going to entail walking from a low-numbered test station to a higher-numbered test station, for example, select "Increasing" by tapping once on the circle beside "Increasing". Select "Decreasing" if the opposite is true.

## Step 8b:

Make selection of "Metric" units if required.

By checking off the box labeled "Metric", the reading interval (distance between voltage recordings) and the flag internal (flag spacing) will be displayed on the Setup 3 of 5 screen in meters, as opposed to feet.

Step 8c:

Check-off "DCVG Sidedrains in CIS Survey" if you plan to log DCVG sidedrain readings at previously located anomalies during the course of a CIS.

By doing so, a special "Device" selection , named "Mark DCVG" will be made available in the "Device" list, which has a sidedrain prompt associated with it, as indicated in the screens shown below.
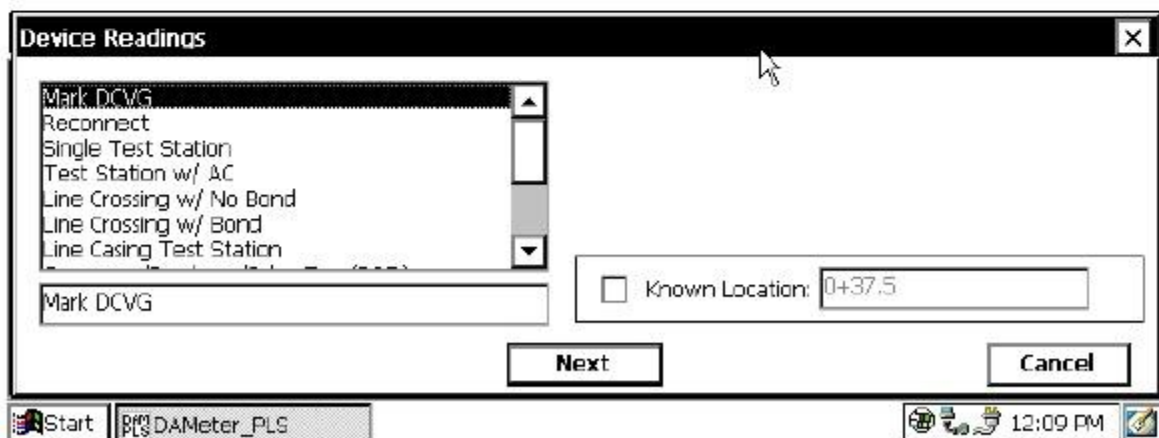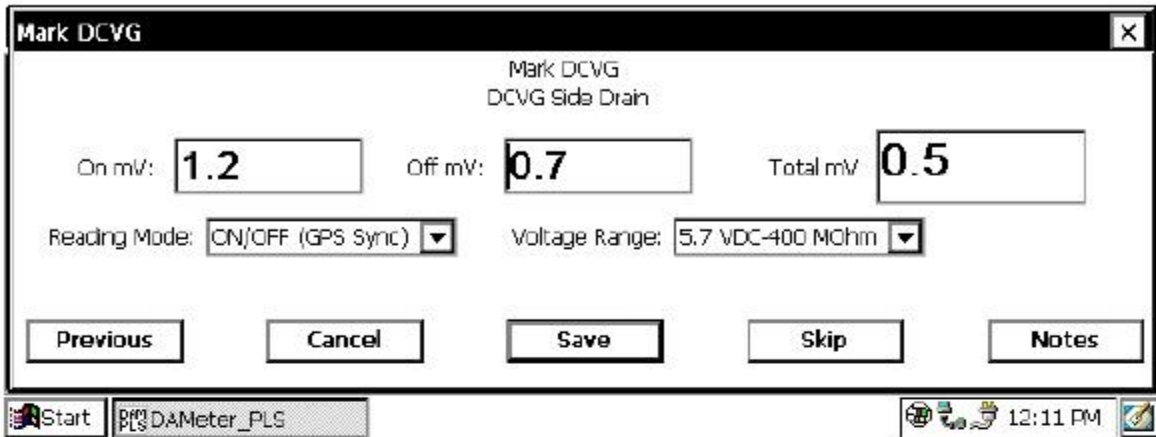
The "Mark DCVG" device will not appear in the Device list if this box is not checked, which would be the case if you were conducting a regular CIS.
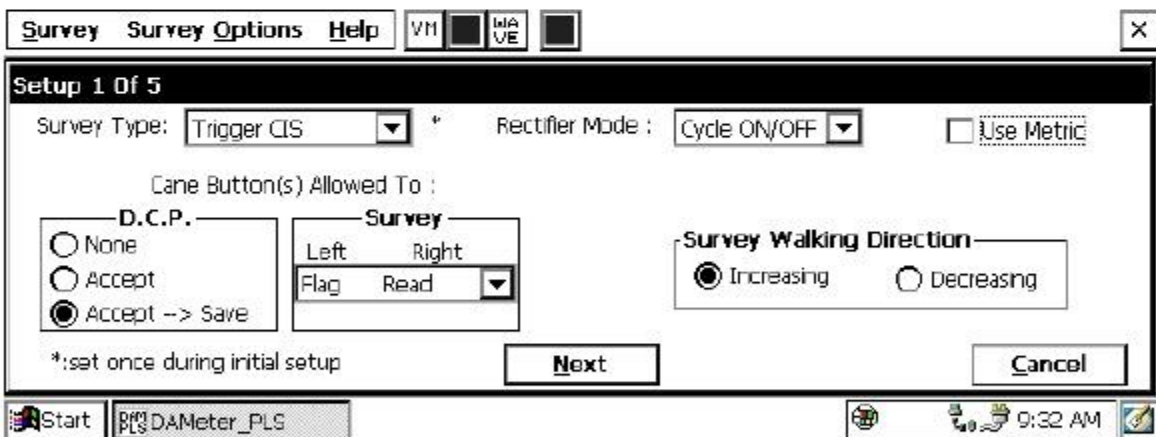
If the following selections have been made so far, the Setup 1 of 5 screen will appear as shown below:

Survey Type: Trigger CIS

Survey: Flag Read

D.C.P.:   Accept   Save

Survey Walking Direction: Increasing;   Metric: NOT selected

Step 9:
Make "Rectifier Mode" selection.

In the case where a pipeline is cathodically-protected via an impressed current (current flow to the pipe from a sacrificial anode driven by an external DC voltage source), the rectifier (DC voltage source) is typically always ON, so that the line is continuously protected. However, with current flowing in the soil to the pipe, the "pipe-to-soil" voltages being measured during a CIS will include any voltage drop (IR drop) occurring in the soil itself.

If a large amount of current is flowing in the soil and/or the soil has a high-resistivity, the magnitude of the voltage drop (IR drop) could be significant. Consequently, it is important to measure the actual pipe-to-soil potential (voltage) with no current flowing in the soil, with a view to establishing that the pipe is at a sufficiently negative potential (at least -0.85 Volts with respect to copper sulphate reference electrodes). The problem is that the rectifiers (DC voltage sources) cannot be switched OFF for the duration of CIS measurements, since the pipeline would lose its cathodic protection while the CIS measurements were being performed.

The solution to this problem is to only "interrupt" the current flow for very short periods of time (typically less than a second) and to be able to record the pipe-to-soil voltages (with respect to the reference electrode) during the "current OFF" periods. If pipe-to-soil voltages are also recorded during the "current ON" periods, the magnitude of the IR drop can be determined, which would just be the difference between the "current ON" and current OFF" voltages.

In terms of CIS measurements, a convenient way to "sample" or "capture" "current ON" and "current OFF" pipe-to-soil voltages is to employ a "Current Interrupter" which is a current-switching device that is connected to a Rectifier. The Current Interrupter can be programmed to switch the rectifier current ON and OFF in a predetermined cyclic fashion.
In this case, when a cane is in contact with the soil and the push button on the cane is pressed, in the process of a CIS, the DA Meter will record the High and Low voltages taken over at least one current ON/OFF cycle.

Such a "Current Interrupted" method is known as a High/Low CIS mode.

It should be noted that all rectifiers that might have an affect on a pipeline under survey (ie, might generate current in the line) need to simultaneously be switched ON and OFF in an identical cyclic fashion and, in addition, all current-interrupter waveforms (ON/OFF) cycles need to be synchronized with each other. In other words, all rectifiers need to be ON at the same time and for the same length of time, and all rectifiers need to OFF at the same time and for the same length of time. One way to accomplish such synchronization, is to have GPS receivers integrated with current-interrupter switches and to employ a GPS satellite's timing system to control the current switching timing on all participating rectifiers simultaneously.

Such GPS Receiver/Current Interrupter Switches are available through MCM. This type of current-interrupted method is known as a GPS **Satellite-Synchronized High/Low CIS mode.**

Figure 2 shows an illustration of a CIS being performed using GPS satellite-synchronization of rectifier current-interrupter switches. Again, the ON/OFF current switching cycle would be synchronized for all rectifiers having an affect on the pipeline section being surveyed.
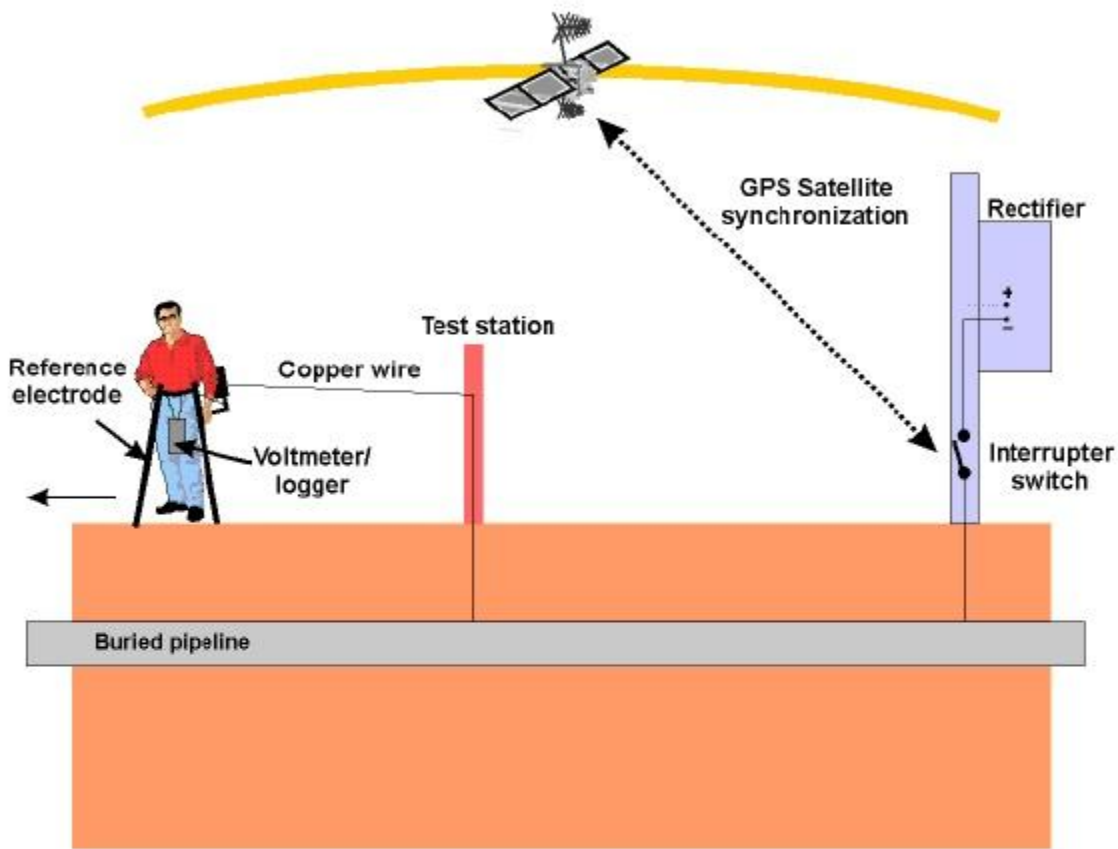
Figure 2: A GPS satellite-synchronized high/low CIS mode illustration

Of course, a CIS can be performed with rectifiers permanently ON (current permanently flowing in the soil during measurements) and this method is known as a Non-Interrupted CIS mode, since, in this case, the rectifier current is non-interrupted.

Finally, a CIS can be performed with rectifiers permanently OFF, which could be the case, for example, if a potential profile is desired of a depolarized pipeline, ie, a pipeline whose polarization potential has had a chance to fully dissipate. Under such conditions, however, the pipeline would not be cathodically-protected.

"Rectifier Mode" Selection:

By tapping once on the pull-down list arrow button in the "Rectifier Mode" field on the Setup 1 of 5 screen, the screen shown below will appear.
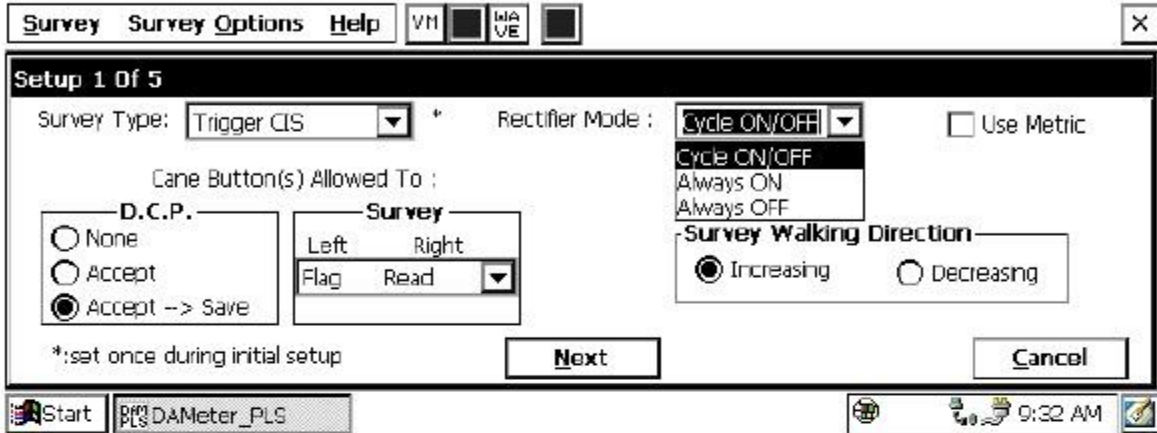
As can be seen on the above screen, there are 3 choices for "Rectifier **Mode": Cycle ON/OFF, Always ON and Always OFF.**

If Always ON is selected, it will be assumed that the rectifiers affecting the line will be permanently ON, which would be the case, for example, for a **non-interrupted CIS.**

If Always OFF is selected, it will be assumed that all rectifiers having an affect on the line will be permanently OFF (at least for the duration of the CIS).

If Cycle ON/OFF is selected, it will be assumed that all rectifiers having an affect on the line have current-interrupters installed and that their switching **waveforms will be synchronized. This would be the case for a High/Low CIS.**

Step 10:

Tap once on the Next button.

The screen shown below will appear (Setup 2 of 5).
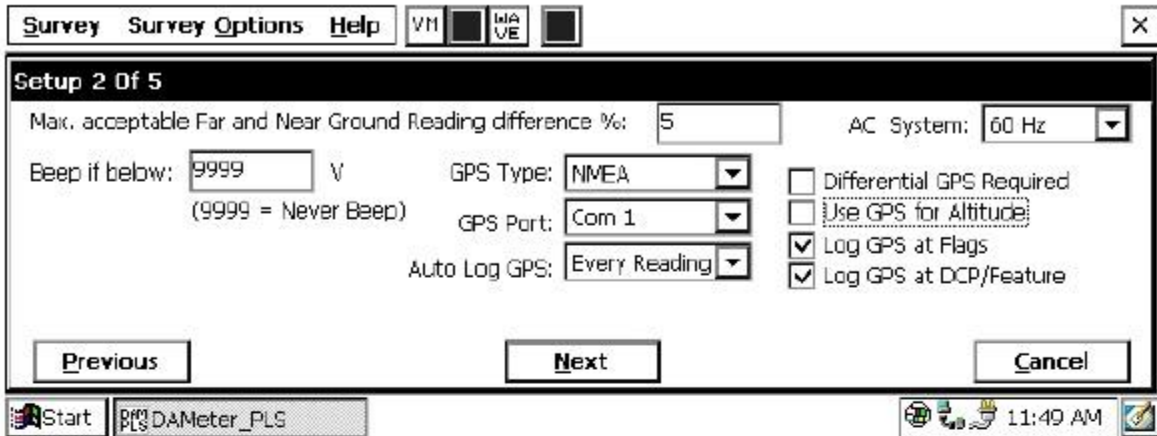
Step 11:
Make Selection of "Maximum Acceptable % Difference between Far and Near Ground Readings".

When you are reconnecting the trailing wire from one test station to another test station further down the pipeline, the last voltage recorded prior to breaking the connection with the first test station should be recorded as a "Device" voltage. After tapping on the "Device" button on the survey screen and selecting "Reconnect", follow the predetermined voltage recording procedures for a "Reconnect". The specific procedures for a given "Device", such as a "Reconnect", will have been "scripted" via the software.

The voltage recorded prior to disconnecting the trailing wire will be considered the FAR-Ground reading, since you will be FAR (perhaps a mile) from the first test station. Once the reconnect has been made at the second test station, you will be prompted to make a new voltage recording. **This new voltage recording will be considered the Near-Ground reading,** since you are standing very NEAR to the second test station.
By tapping once inside the field marked "Max. acceptable Far and Near Ground Reading Difference %", the number indicated (in the above case the number shown is 5) can be changed to any % value desired by pressing the "delete" (DEL) key on the keyboard and typing in a new number.

If, for example, the number (5) is entered in this field, it means that the maximum allowable difference between FAR and NEAR voltage recordings has been set at 5%, otherwise an error window will be displayed on the screen. If the FAR and NEAR voltage recordings are within 5% (in this case) of each other, there will be no error message. If, on the other hand, the recordings differ by more than 5%, an error window will appear on the screen. The error window will indicate 2 options:

Option 1:   Retake Near Reading
Option 2:   Accept This Error

By selecting Option 1, you have the chance to make another recording at the second test station which would be compared to the stored FAR-Ground recording. If this voltage difference is <5% there will be no error message.

By selecting Option 2, you will be choosing to ignore the difference in the recordings and move on with the survey.

Step 11:
Set Local Electricity AC Frequency

By tapping once on the "AC System" field pull-down arrow button on the Setup 2 of 5 screen shown above, you will have the choice of 60Hz or 50Hz AC. Select 60Hz for all U.S. applications.

Step 12:
Select "Beeping" (or Alarm) Voltage:

By tapping once in the "Beep if below" field on the Setup 2 of 5 screen, a voltage value can be entered, for example -0.850. With this value entered, the DA Meter will beep to alert you to the fact that a voltage reading lower than -0.850 Volts has been made. This would be a location that you might want to check again and mark if the lower reading persists.

Step 13:
Select the GPS Receiver Being Used (If Any).

By tapping once on the "GPS Type" field pull-down-list arrow button on the Setup 2 of 5 screen, the screen shown below will appear.
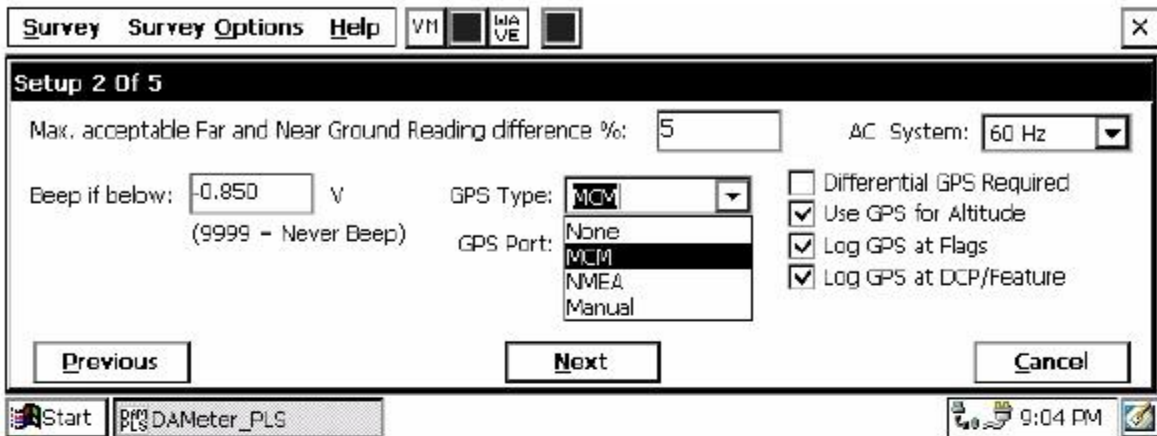
This selection pertains to a GPS receiver that can be connected to the DA Meter. The GPS receiver can be called upon to log the precise location of "Devices" or "Geographical Features" that are encountered during a CIS.

As can be seen from the screen, there are 4 choices for "GPS Type":

None: This means that a GPS receiver is not being used
MCM: This means that an MCM GPS receiver is being used
NMEA: This means that a GPS receiver (other than the MCM receiver)
               that is capable of outputting NMEA data is being used
Manual: This means that location data will be entered manually when
               the GPS button is pressed on the survey screen during a CIS.

Select the appropriate choice by tapping once on your selection.

Step 14:
Select GPS Options.

On the far right-hand side of the Setup 2 of 5 screen as shown above, there is a group of boxes associated with a GPS accessory. If a GPS accessory has been selected for use with the DA Meter for a particular CIS, all, or some of the functions available can be enabled (boxes ticked). A box can be "ticked" or "unticked" by tapping once on the box.

The options available are as follows:

Differential GPS Required:
This box should be ticked if you only want differentially-corrected (real-time corrected) GPS data to be logged by the DA Meter. If this box is ticked, only GPS data that has been derived using a correction message signal (in real-time) will be logged by the DA Meter. If this box is left unticked, it means that you will allow the DA Meter to log either standard GPS data or differentially-corrected GPS data, depending upon what is being output by your receiver at any given time. Please note that if this box is checked (ticked), GPS data will not be logged unless a real-time correction signal has been received by the correction message receiver component of your GPS unit. In most instances, logging standard (ie, uncorrected) GPS data would be preferable to not logging any GPS data.

Use GPS Altitude:
If this box is ticked, altitude data will be included with the position data whenever GPS data is logged. (Note: Altitude data on some GPS units is not particularly accurate in CIS applications).

Log GPS at Flags:
If this box is ticked, GPS location data will be logged automatically at flags when either the flag button is tapped (directly on the survey screen) or when the push-button on the designated "flag cane" is pressed.

Log GPS at DCP/Feature:
If this box is ticked, GPS position data will be logged automatically at "Devices" or "Geo-Features" when either the "Device" button is tapped on the survey screen and a "Device" reading is logged or when the "Geo-Feat." button is tapped on the survey screen and a geo-feature is noted.

Auto Log GPS:
By tapping on the drop down menu button in the "Auto Log GPS" field, the selections available will be displayed as indicated below.
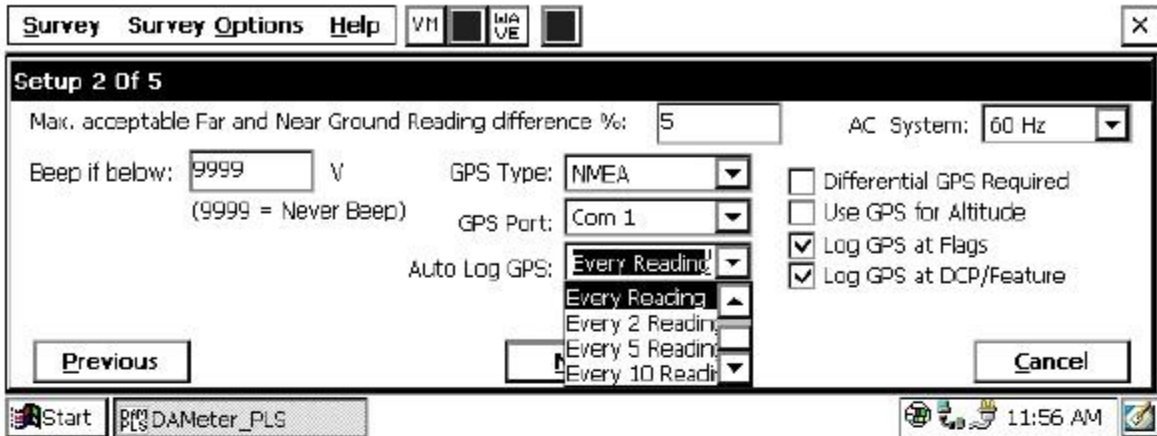
By selecting one of these options, you can elect to have the GPS position data logged automatically at every survey reading, at every second reading, at every fifth reading, at every tenth reading, or not at all (never) at survey readings.
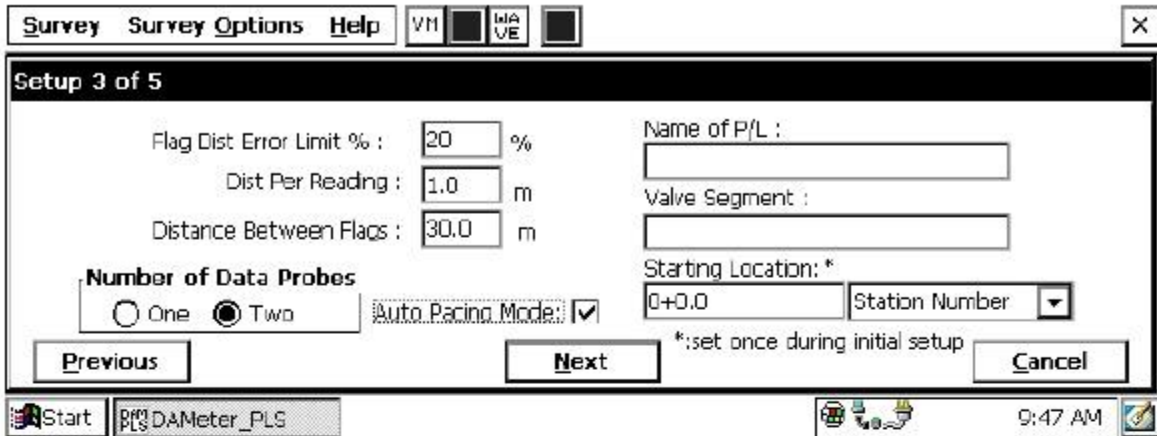
Step 15:
Tap once on the Next button

The specific screen that will appear (Setup 3 of 5 screen) will depend on if you selected "Trigger CIS" mode or "Continuous CIS" mode back at Step 6 and whether or not you selected "Metric" units.

If Trigger CIS mode was selected, for example, the screens shown below will appear for the non-metric and the metric cases.
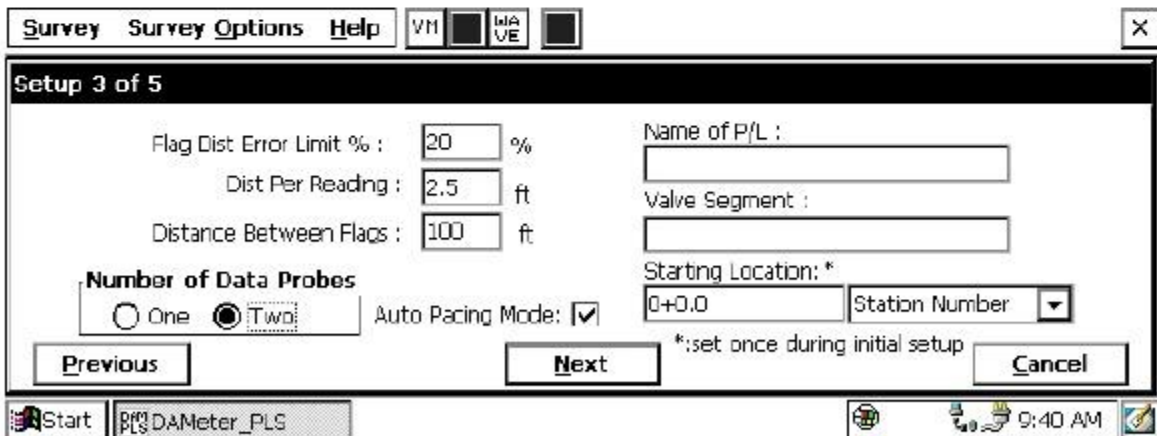
Step 16:
Select Voltage Reading Interval (Distance Between Recordings)

By tapping once in the field in the Setup 3 of 5 screen labeled "Distance Per Reading" you can type in the voltage reading interval (distance in feet (or meters) expected between recordings) for the CIS. Typically, in CIS work this expected interval distance is 2.5 feet (or 1 meter).

Step 17:
Select Survey Flag Interval (Distance Between Survey Flags)

By tapping once in the field in the Setup 3 of 5 screen labeled "Distance Between Flags", you can type in the survey flag interval (distance between survey flags) for the section of pipeline being measured. Typically, survey flags are located at 100 feet intervals (or around 30 meter intervals).

Step 18:
Select the maximum permissible error between the actual number of recordings made between 2 survey flags and the expected number of recordings.

By tapping in the field labeled "Flag Dist Error Limit %" you can type in the maximum permissible error. For example, the maximum permissible error is indicated as 20% on the above screens. If the recording interval is expected to be 2.5 feet and the survey flag separation is 100 feet, it means that 40 recordings are expected. If, however, only 30 recordings are actually made between survey flags, an error window will appear on the screen, since there is a 25% difference between the expected and actual number of recordings made. No error window will appear if the difference is less than 20% for this example, ie, you could have a minimum of 32 recordings and a maximum of 48 recordings between survey flags to stay within the 20% (max.) error allowance.

Step 19:

Select whether or not you would like the recordings to be uniformly spaced between survey flags in cases where the actual number of recordings made between flags deviates from the projected number (flag separation ÷ recording interval).

By tapping in the box labeled "Auto Pacing Mode", and inserting a tick in the box, you will enable the DA Meter to automatically adjust the actual recordings and space them evenly over a 100 feet span (distance between survey flags), regardless of the actual number of recordings made. This selection is highly recommended.

Step 20:

Select the number of reference electrodes (canes) that will be used in the CIS

The number of reference electrodes (also known as data probes) that will be used in the CIS can be selected by tapping on either the "one" or "two" circle in the box labeled "Number of Data Probes".

Step 21:

Provide the Name of the Pipeline:

By tapping once in the field labeled "Name of P/L", you can type in the pipeline name. Note: This is not the same as the filename for the CIS that was selected back in Step 4. This is the actual name of the pipeline.

Step 22:

Provide the Valve Segment Identification Number (or Name)

By tapping once in the field labeled "Valve Segment", you can type in the valve segment number, or name (if known).

Step 23:

Provide the Starting Location for the Survey

Tap the pull-down list arrow button in the "Starting Location" field, which will reveal the options available regarding how you would like location information to be displayed. The Setup 3 of 5 screen will be as shown below for the non-metric case.

You can select to have location information displayed on the survey screen as station number, feet or milepost (station number, meters or kilometers for the metric case).

Whichever selection you make here will determine how you enter your starting location information.

For example, if your pipeline locations are represented by station numbers, you would select "Station Number" from the drop down list and you would enter a starting location for the survey in the form of a station number. [If you do not know the station number where you're beginning your survey, enter 0+0.0].

As an example, if you are working on pipeline ABC within valve segment 45 and you are about to begin a CIS at station number 12+0.0, your Setup 3 of 5 screen would be as shown below.

Step 24:

Tap once on the Next button on Setup 3 of 5 screen

The screen shown below will appear (Setup 4 of 5 screen).

Step 25:

Provide the Work Order Number for the CIS

By tapping once in the field labeled "Work Order #", you can type in the work order number for the CIS if appropriate.

Step 26:
Provide Your Name

By tapping once in the field labeled "Technician Name" you can type in your name.

Step 27:
Provide Comments

By tapping once in the field labeled "Comments/Description", you can enter any comments you might have regarding the survey (perhaps weather conditions, soil conditions etc.).

Also shown on the Setup 4 of 5 screen are the File Name and the date/time.

Note: Do not attempt to change the File Name indicated here as this identification will be required by the ProActive software to transfer your CIS data to your PC or server.

Step 28:
Make Voltmeter Read Mode Selection

Tap once on the Next button on the Setup 4 of 5 screen
The Setup 5 of 5 screen will appear as shown below.
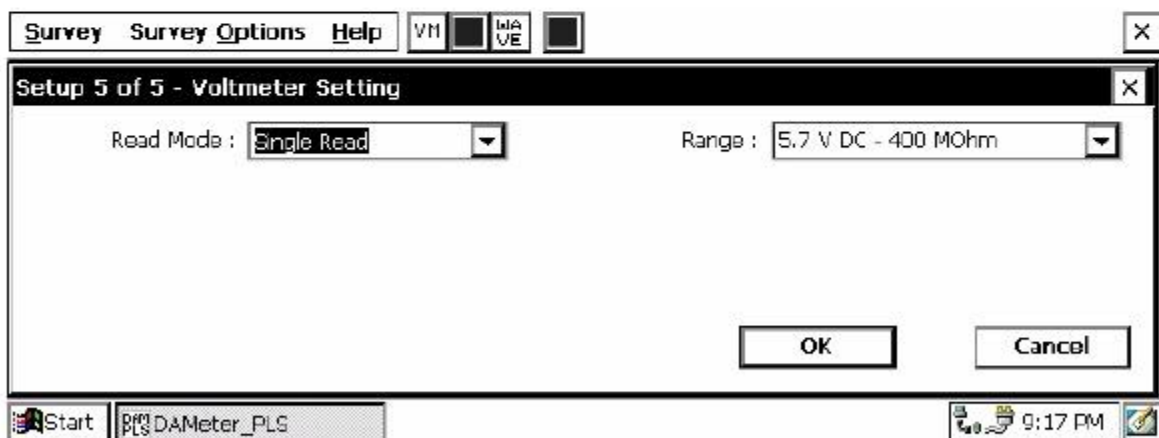
The above screen is used to establish the mode in which the digital voltmeter will be operating during the CIS measurements. Remember, the data being logged by the DA Meter are actually voltages that are measured by a voltmeter.

The 5 choices available for the voltmeter's reading mode are observed by tapping once on the pull-down-list arrow button in the "Read Mode" field. The screen will appear as shown below.
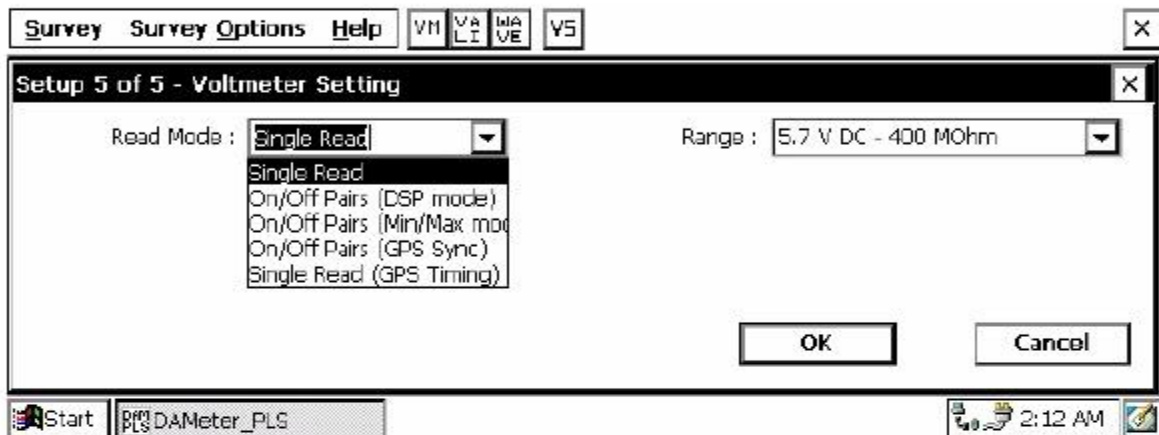
The 5 choices for voltmeter mode are as follows:
Note: Selection of voltmeter mode should be made with reference to your selection of "Rectifier Mode" back at Step 9 and your selection of GPS Accessory back at Step 13.

Single Read:
This voltmeter mode would be selected if you were performing a non-interrupted CIS, with either the rectifiers ON continuously [Always ON] or OFF continuously [depolarized pipeline].

On/Off Pairs (DSP mode):
This voltmeter mode would be selected if you were performing a High/Low CIS (current-interrupted CIS). In this mode, the voltmeter uses digital signal processing to determine the voltage during the ON portion of the rectifier-current cycle and the voltage during the OFF portion of the current cycle. A measurable difference between the High and the Low voltage readings is required for this mode, ie, a measurable IR drop is required.

With this voltmeter reading mode selected, after tapping on the "OK" button, the screen shown below will appear.
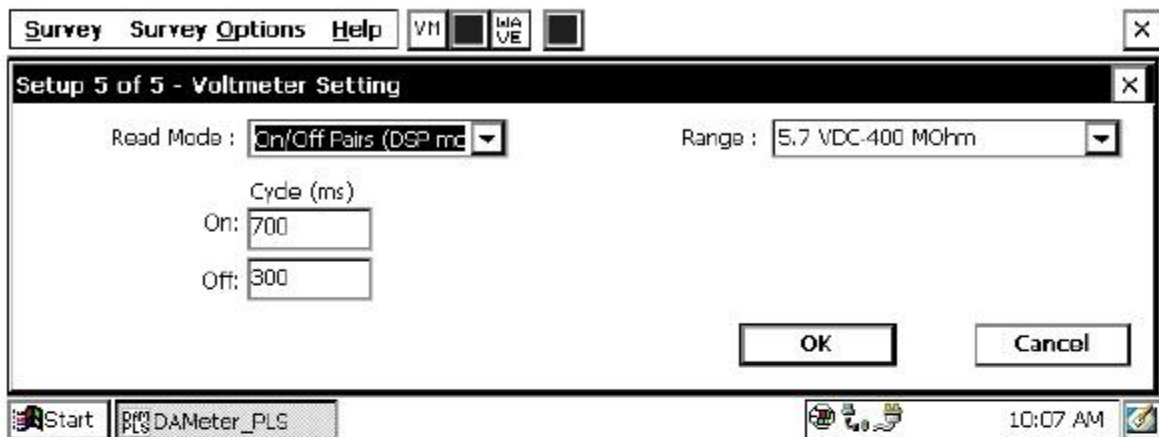
The specific On and Off times for the particular current-interruption waveform cycle that will be employed during your CIS should be entered in the "Cycle (ms)" fields. The On and the Off times should be entered in milli-seconds.

Note: Ideally, the interruption waveform period (which is the On time plus the Off time) should be less than the time between triggered voltage recordings on a CIS. For short waveform periods (< 1 second, for example) this is not a concern, as a typical walking pace would translate to a time between triggered voltage recordings of greater than 1 second.

However, care should be taken if longer waveform periods are in effect (for example, several seconds long waveform periods), in which case a slower than normal walking (and triggering) pace would have to be employed to avoid recording several same value readings until such times as a new waveform cycle has occurred.

On/Off Pairs (Min/Max mode):
This voltmeter mode would be selected if you were performing a High/Low CIS but the DA Meter was having trouble distinguishing between the High and the Low voltage readings. This would be the case, for example, if the IR drop was very small (remember that the difference between High and Low voltage readings in a current-interrupted CIS is just the magnitude of the IR drop). In this case, the voltmeter would determine the average of the maximum and minimum voltages read during each rectifier-current cycle.

With this voltmeter reading mode selected, the screen shown below will appear.
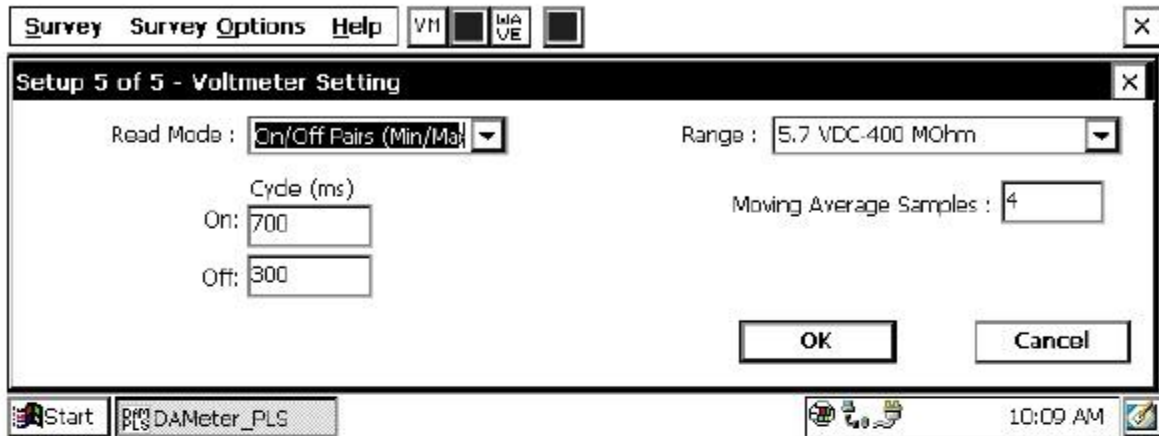
Again, you would make your selection of ON and OFF cycle times. In this case, you would also provide a number for the "Moving Average Samples". In the above case, since the number 4 has been entered, 4 sample readings would be used to compute an average value for the Minimum (Min) voltage reading during each OFF portion of the cyclic waveform and, also, 4 sample readings would be used to compute an average value for the Maximum (Max) voltage reading during each ON portion of the waveform.

On/Off Pairs (GPS Sync):
This voltmeter mode can be selected if you are using the MCM GPS unit on your DA Meter and current-interrupter switches equipped with GPS units were being employed on your rectifiers. In this case, voltage readings (High/Low readings) are synchronized with the current-interrupter switching timing.

With this voltmeter reading mode selected, the screen shown below will appear.
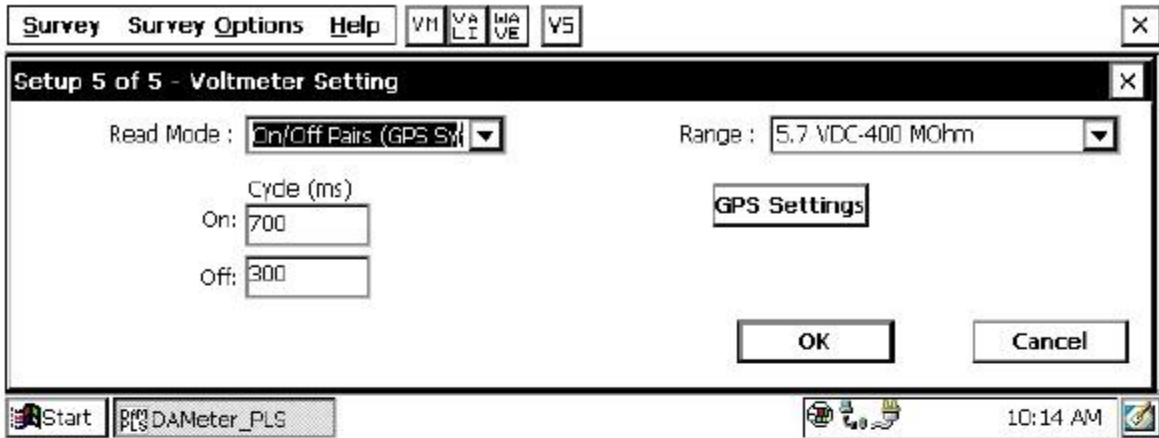
Again, you would make your selection of ON and OFF cycle times.

Also, in this case, you would tap on the "GPS Settings" button, which would bring up the screen shown below.
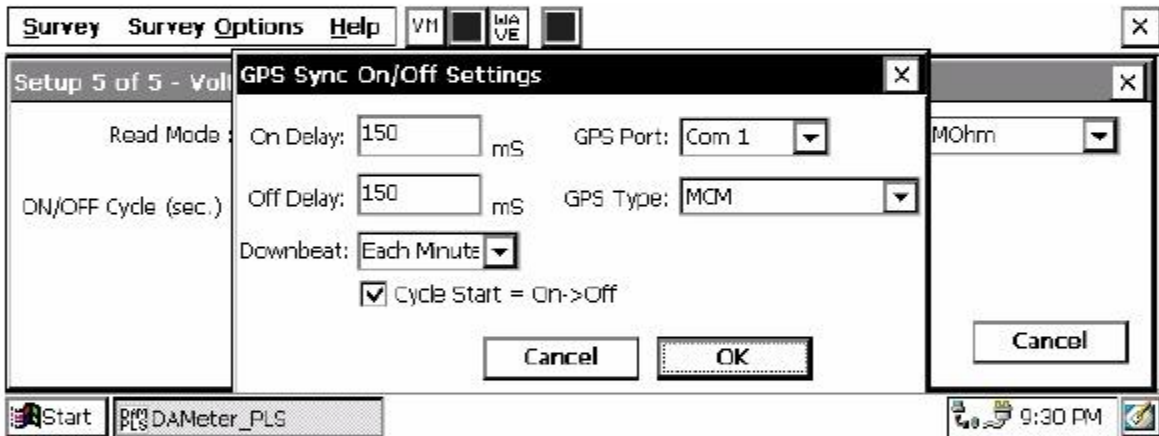
You are being asked here to make several selections.

First, select the type of GPS unit you will be using (currently, only the MCM GPS unit can be used in the "GPS Sync" voltage reading mode).

Next, enter your "On Delay" and your "Off Delay" selections by tapping in the appropriate field and typing in the requested delay time in milliseconds. These delay times are employed so that any spiking in the voltage waveform that might occur as the rectifier-current is switched from ON to OFF and from OFF to ON does not become a factor in the voltmeter's determination of the "true" ON and OFF voltage values for each CIS measurement. For example, if 150 ms was selected for the "Off Delay", the data logger would record the voltage value sampled 150 ms after the rectifier-current was switched from the ON to the OFF state. Also, if 150 ms was selected for the "On Delay" the data logger would record the voltage value sampled 150 ms after the rectifier-current was switched from the OFF to the ON state.

Finally, select your current-interrupter's "Downbeat" frequency. As indicated by tapping on the pull-down-list arrow button in the "Downbeat" field, there are 3 selection choices; Each Minute, Each Hour and Midnight. If "Each Minute" is an option for your current-interrupter, we suggest making this selection. Also, if your interruption cycle starts with the current in the ON state (the first transition is from ON to OFF), place a tick in the "Start Cycle" box (remove the tick if the opposite is true).

Single Read (GPS Timing):
This voltmeter mode is similar to the "Single Read" mode except that in this case the data logger uses the GPS clock signal to associate voltage recordings with the actual time they were made.

With this voltmeter reading mode selected, the screen shown below will appear.
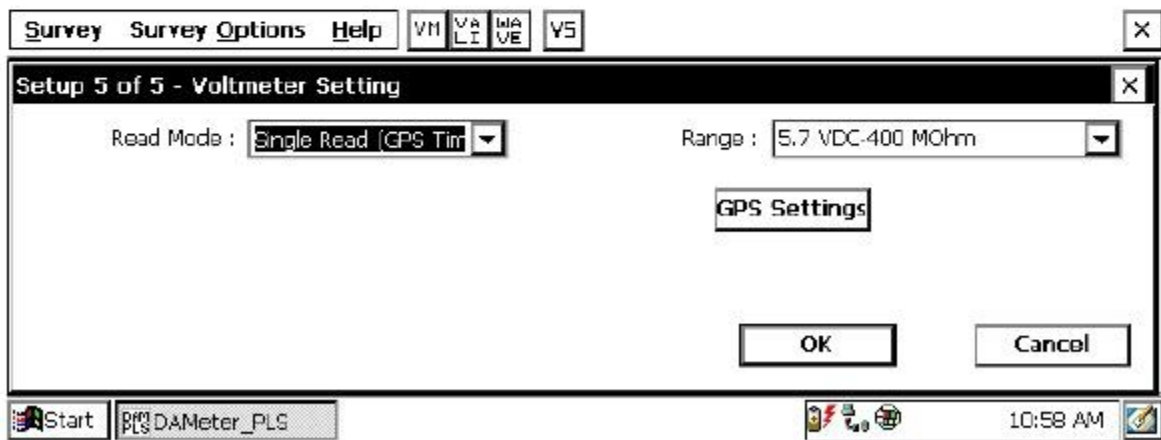
The only additional information that needs to be supplied here is the type of GPS unit you will be using, which you can select by tapping on the "GPS Settings" button. Currently, only the MCM GPS unit can be used in this voltmeter reading mode application.

Step 29:
Select Voltmeter Range and Input Impedance

By tapping on the pull-down list arrow button in the "Range" field, you can select the voltmeter range and input impedance settings for your application.

The recommended settings for the voltmeter for CIS are 5.7 Volts DC (full-scale) and an input impedance value of 400MOhm, These settings provide a relatively-fast response time (~80 ms), which is important in rectifier-current-interrupted applications. Also, a 400MOhm input impedance setting eliminates reading errors associated with any high source resistance measurements.

Note: Caution has to be exercised if any of the ranges beginning with the number 4 (for example, 4V, 400mV or 40mV) are selected for CIS applications, since these represent relatively-slow response settings. Such settings provide a higher level of AC filtering, but at the expense of speed of response. Rather than the response time of 80ms for the 5.7V range, these settings have a response time greater than 1 second. Consequently, such settings are not appropriate for fast current-interruption cycles, ie, interruption On and Off times shorter than 1 second, as true On and Off potentials would not be recorded.

Step 30:
Pull Up "Active" Survey Screen.

Tap once on the OK button on the Voltmeter Setting screen (or the GPS Settings" screen), which will pull up the Survey screen shown below.
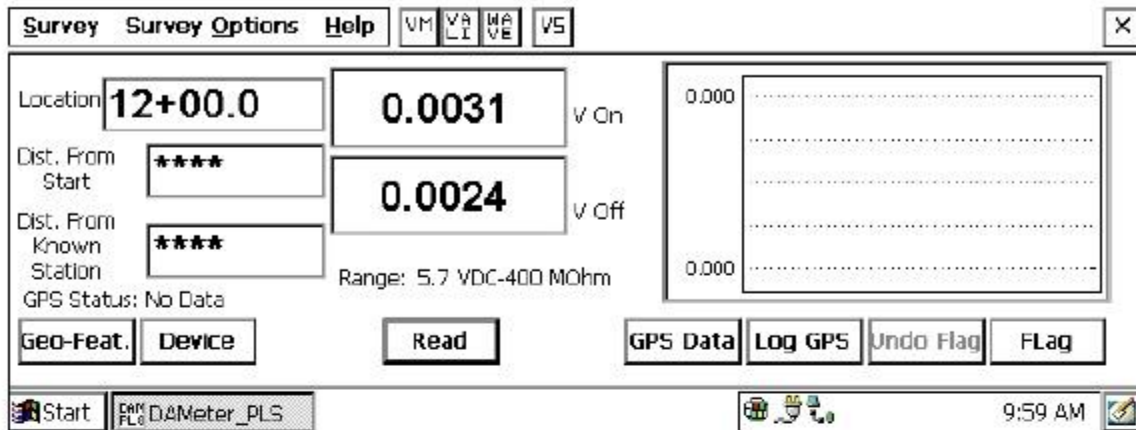
As voltages are recorded by the DA Meter (by either tapping on the "Read button on the Survey screen or by pressing the appropriate cane push button, the "Distance From Start" (total distance from the start of the survey) parameter will increase in increments of 2.5 feet, or whatever the "Distance Per Reading" value was that was entered back at Step 16. (Distances will be in meters, if the metric option was selected).

Also, the "Distance From Know Station" parameter will increase in the same increments as voltages are recorded. The difference in this case, however, will be that when each known station is registered, this distance parameter will begin again at zero. In other words, this will show the distance you are assumed by the DA Meter to have traveled from the last known station that you encountered (and registered).

You are now ready to perform a close interval survey using the DA Meter.

III. 3   How to Make Changes to Your Set Up Selections

Once you've setup the DA Meter for a particular Close Interval Survey, as described in the above Section, you can make changes to your setup selections with the exception of your "Survey Type" selection and the currently indicated "Location". If you have selected a Trigger Mode CIS, for example, you cannot change to a Continuous Mode CIS, without setting up a "new" survey.

You can, however, make other selection changes. For example, if you examine the pipe-to-soil voltage waveform prior to beginning a survey (highly recommended) and discover that the IR drop magnitude is quite small, or there is considerable noise on the waveform, you might decide to switch the voltmeter reading mode from On/Off Pairs (DSP mode) to On/Off Pairs (Min/Max mode). Or, in another case, you might decide to change the "Distance Per Reading" interval from 2.5 feet to 5.0 feet, for example.

To make setup selection changes, tap on "Survey Options" at the top of the screen. The screen will appear as shown below.
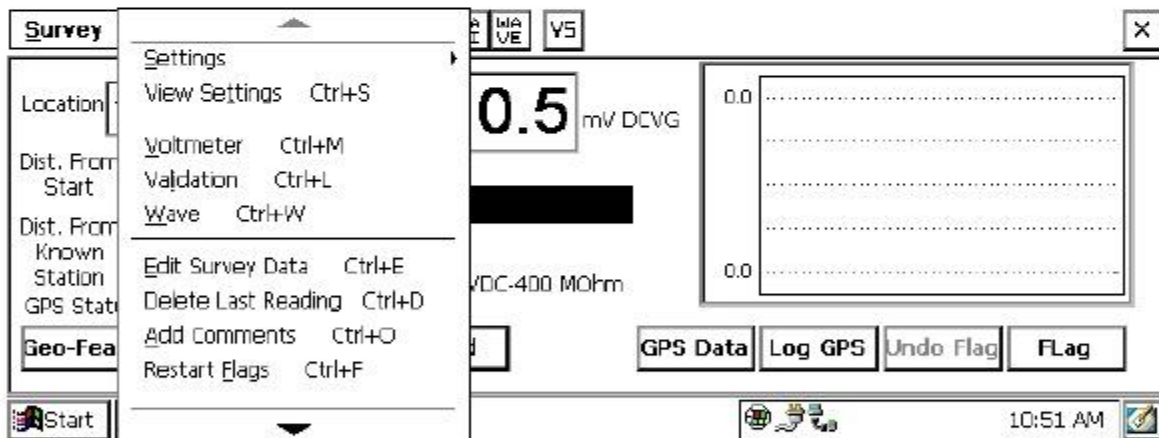
To make (allowed) changes, tap on "Settings" on the above menu, tap on "Change Global Settings" and proceed to make any desired changes.
To simply view your Set Up selections, you can tap on "View Settings" on the above menu (after tapping on "Survey Options").

SECTION IV: TEST EQUIPMENT HOOK-UPS FOR CIS

IV. 1   How to make Cable Hook-Ups for CIS Measurements

The connections for CIS measurements employing MCM test equipment are illustrated in Figure 4.
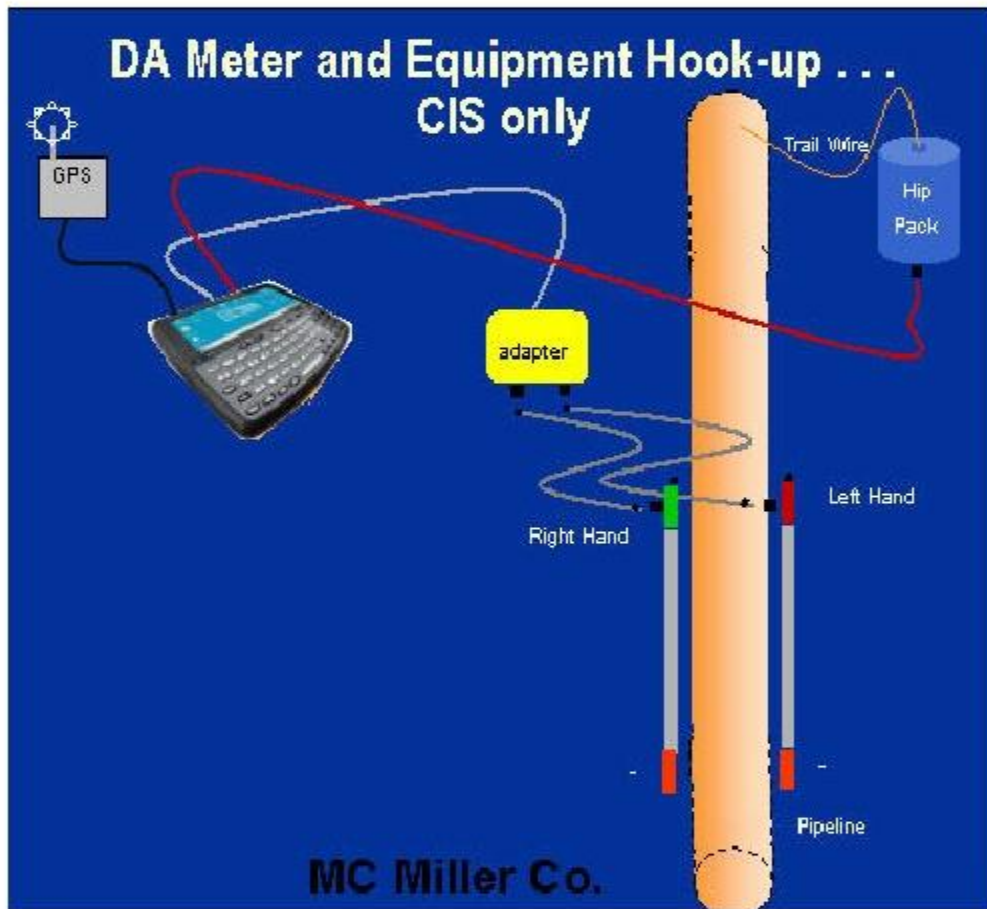
Figure 4: Cable Connections for Hook-Up of MCM's CIS Test Equipment

As can be seen from Figure 4, a pair of canes (reference electrodes – see Section II. 4) is illustrated, the left-hand cane (red cane) and the right-hand cane (green cane). These canes, which will be placed on the soil above the pipeline in an alternating fashion, have push buttons on top of the handles so that the operator can "trigger" voltage recordings on his command at each of the CIS measurement locations as well as at "Devices". See Section III. 2 for a discussion on cane button functionality (Step 7 of the Set Up Process).

The canes (data probes) are connected as shown to the "input" terminals of the dual-probe adapter and the "output" terminal of the adapter is connected to a 5-pin Data Probe Connector socket on the top side of the DA Meter. This effectively connects the canes (reference electrodes) to the negative terminal of the data-logger (DA Meter). For CIS, the cables connecting the data probes to the dual-probe adapter are both "black band" cables.

In order that the DA Meter will record "pipe-to-soil" voltages when the canes are triggered, the positive (red) banana plug terminal on the back of the DA Meter is connected as shown to the pipe via a spool of wire contained in a Hip Pack. The connection to the pipe is made by hooking a cable from the red terminal on the DA Meter (banana plug terminal) to the banana plug terminal on the underside of the Hip Pack and connecting the trail wire coming out of the topside of the Hip Pack to the Test Station Electrode (and therefore to the pipe).

A GPS receiver unit is also illustrated in Figure 4. Such a unit can be connected to the DA Meter in order that the position of items such as flags, devices and geo-features can be recorded during the performance of a CIS, either manually by tapping on the "log GPS" button on the survey screen at each critical location or automatically by pre-programming the DA Meter as described in Section III. 2 (Steps 13 and 14).

IV. 2   How to Attach Cables and Accessories to the DA Meter

The terminals on the back of the DA Meter for the various connections described above are illustrated in Figure 5.

1. 5 Pin Data Probe Connector
2. GPS Connector
3. Positive Terminal
4. Negative Terminal
5. 9 Pin Communication
Port
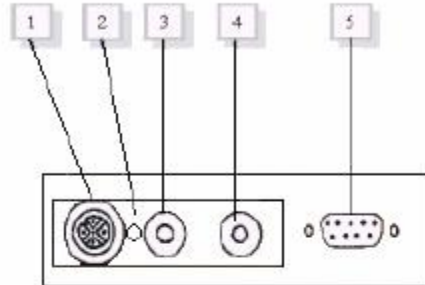
Figure 5: Connection terminals on rear of the DA Meter

The 5-pin Data Probe Connector is shown above as Terminal 1. As discussed above, the reference electrode canes are connected to this terminal via the dual probe adapter. Again, the reference electrodes are effectively connected to the negative terminal of the voltmeter with this connection. (Consequently, the black banana plug terminal (Terminal 4) is not used when push button canes are employed)

The red (positive) banana plug terminal (for connection to the hip pack) is shown as Terminal 3. This will establish connection to the positive terminal of the voltmeter.

Terminal 5 is a GPS Accessory terminal. A GPS receiver capable of outputting NMEA data (such as a Trimble Pathfinder unit or the MCM unit) would be connected to Terminal 5 (9-pin terminal). Terminal 2 is currently earmarked for future use.

Finally, Terminal 5 is also used (after performing a CIS and removing the NMEA GPS receiver, if used) to connect a serial data communication cable to a PC in order that the survey data recorded by the DA Meter can be uploaded to a PC. See Section VI for a discussion on how to transfer (upload) CIS data to a PC for data management.

SECTION V: HOW TO PERFORM CLOSE INTERVAL SURVEYS

V. 1 How to Carry the Test Equipment During a CIS

With the equipment connected as shown in Figure 4, and the DA Meter "set up" as described in Section III. 2, you are now ready to perform a Close Interval Survey.

To make a pipeline survey more manageable, MCM has developed a special harness which allows the DA Meter and the trail-wire Hip Pack to be carried around the waist area in a "hands-free" fashion, allowing the individual to be able to position the reference electrodes (canes) over the pipeline (every 2.5 feet, or so, in an alternating manner) and to be able to "trigger" the push button canes when appropriate to do so.

With the harness assembly, the DA Meter sits on a tray at waist level allowing the operator to view the screen at all times and to make any selections required by tapping on the screen. Also, the dual-probe adapter shown in Figure 4, is attached to the underside of the tray, allowing convenient (5 pin cable) connection of the adapter's "output" to the DA Meter. [Again, this will effectively connect both data-probes (reference electrode canes) to the negative terminal of the voltmeter].

The Hip Pack, which contains a spool of copper wire (trail wire) [typically 1 mile or 3 miles in length], is attached to the waist belt of the harness and, as described in Section IV. 1, a cable connects the banana plug terminal on the underside of the Hip Pack to the red (positive) banana plug terminal on the DA Meter. Typically, the Hip Pack sits on the operator's left-hand side at waist level.

In addition, a GPS receiver unit (together with its battery pack and antenna) can also be attached to the waist band of the harness, typically on the operator's back at waist level, with the antenna rising to above-head height.

## V. 2 How to Examine and Record a High/Low Voltage Waveform

When you are performing a High/Low (current-interrupted) CIS, it is recommended that you examine the pipe-to-soil voltage waveform at your starting location (starting test station) and it is suggested that you make a recording of this voltage waveform using your DA Meter. The nature of the voltage waveform that you are examining will reflect the nature of the rectifier-current waveform that is currently in-effect on your pipeline.

With at least one of the two reference electrodes making good electrical contact with the soil above the pipe at the first test station and a test cable connected from the test station to the red banana plug terminal on the DA Meter (the cable connection to the Hip Pack will be temporarily disconnected), you will see voltage readings displayed for the "ON" and the "OFF" portions of the current-interrupted waveform cycle for each cycle – see screen shown below for a "snap-shot".

To examine the ON/OFF pipe-to-soil voltage waveform, tap once on the WAVE button on the menu bar at the top of the Survey screen. Alternatively, tap on the "Survey Options" button and then tap on "Wave". The screen shown below will appear.
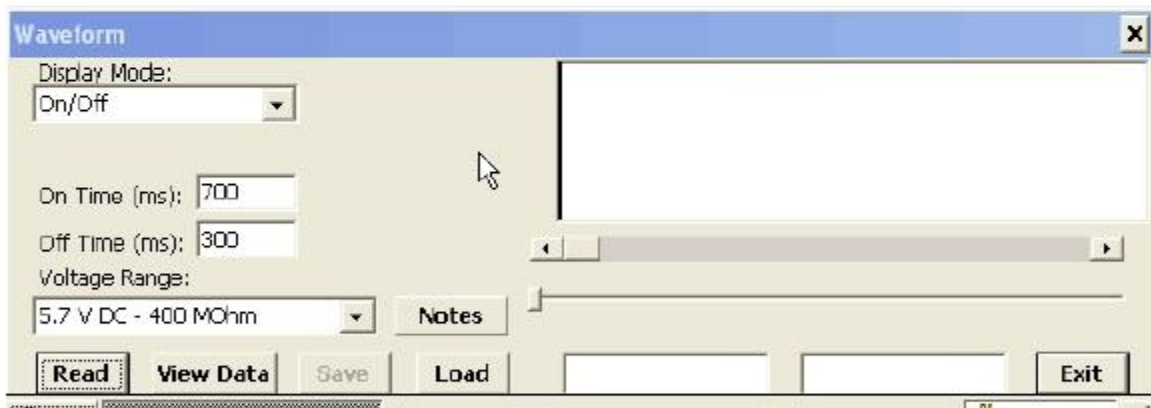
By tapping once on the "Read" button on the above screen, you can view the actual ON/OFF voltage waveform. A typical waveform would be as shown in the following screen.
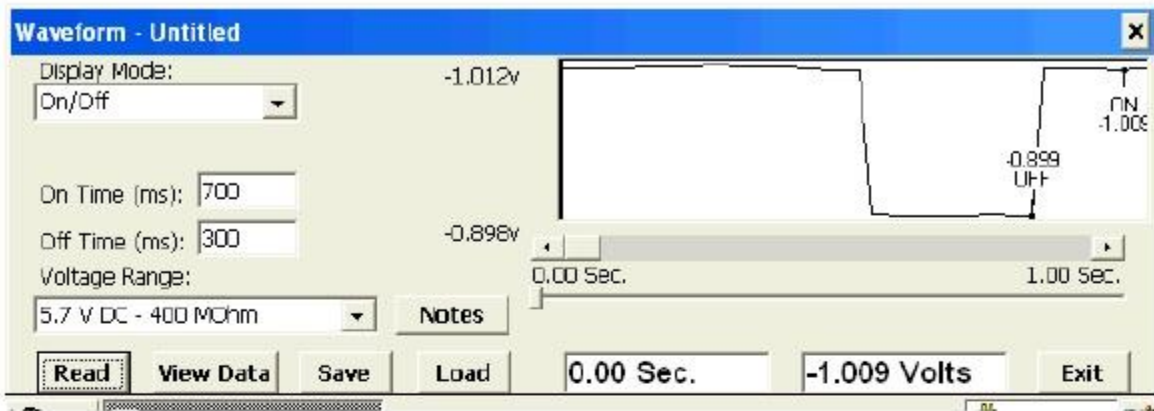
As can be seen from the above screen, the voltage reading is "High" for 0.7 sec. and "Low" for 0.3 sec. which was the prescribed cycle for the rectifier-current in our example.

It can also be noted by examining the above pipe-to-soil voltage waveform that the transitions from High-to-Low and from Low-to-High readings are **quite sharp (as opposed to being step-like). This means that all rectifiers** having an affect on this section of pipe are being switched ON and OFF in a synchronized fashion, which is the ideal case.

To record this waveform, tap once on the "save" button on the above screen.

The "Save As" window shown below will appear on the screen.
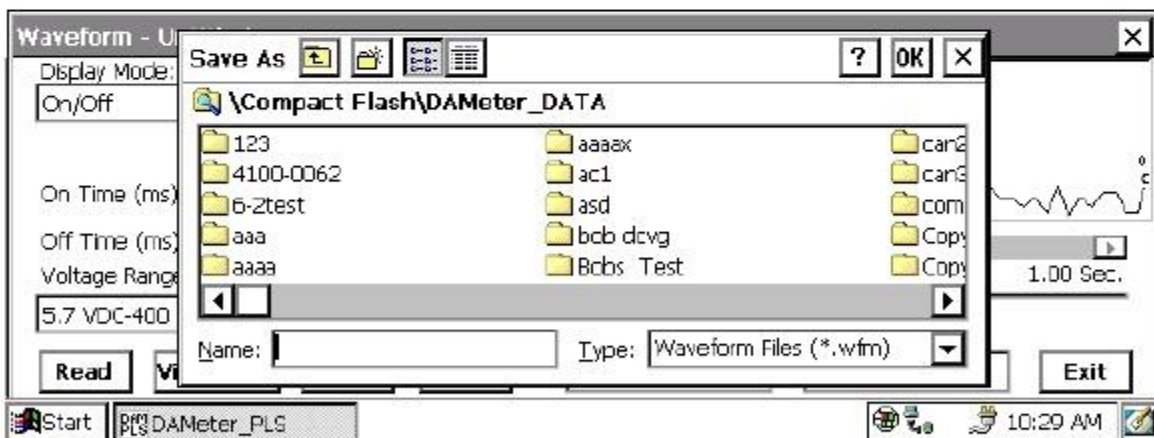
You are being asked here to establish a file in which the waveform data will be stored (saved). The name of this file will be the name you type into the "Name" box on the above screen. For ease of future retrieval when you have uploaded your survey data to the Data Management software package (ProActive) [see Section VI], it is recommended that you use the same name as your survey filename with the addition of something like "Wave TS 1" to the file name. This would represent the waveform data recorded at Test Station 1 at the beginning of your survey.

You should then tap once on the OK button. This process will "save" the waveform data in the DA Meter's CompactFlash memory in the DA Meter_DATA folder for future reference.

Tap once on the "Exit" button on the waveform screen and this will bring you back to the survey screen.

V. 3 How to Record the Voltages at a Starting Test Station:

At this point, it is recommended that you record the ON/OFF voltages at the starting test station. This will represent the first "Device" on this survey.

To do so, tap once on the "Device" button on the survey screen. The "Device Readings" screen shown below will appear.

Note: An additional device, named "Mark DCVG" will be available for selection if the box labeled, "DCVG Sidedrains in CIS Survey" was checked-off during initial survey set up.
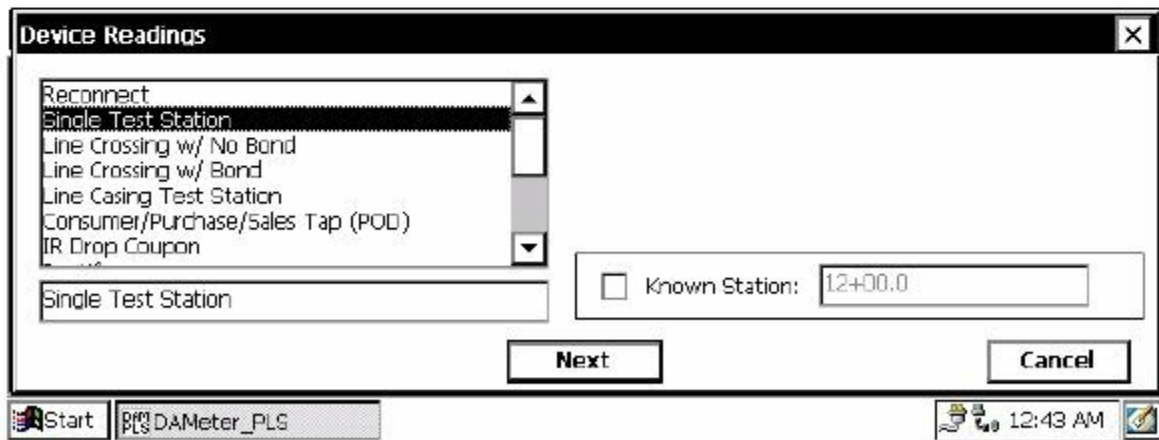
As can be seen from the above screen, you can choose from a number of "Devices". In this case, you would tap once on "Single Test Station" to highlight this selection. You should then tap once on the "Next" button. The screen shown below will appear.
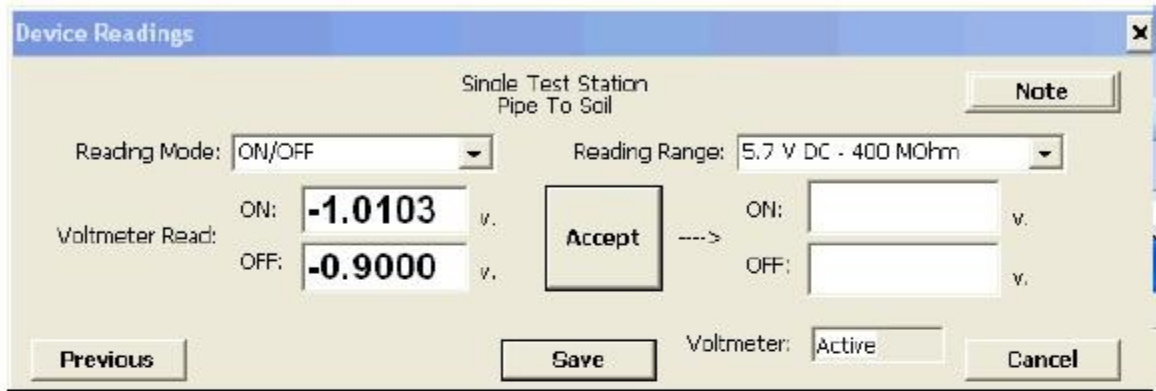

As shown above, the High and Low voltage readings measured at the starting test station will be displayed on this screen. You have the option at this point to tap once on the "Accept" button and then once on the "Save" button to record the data at the first test station. As an alternative, you could press the trigger button on either your right-hand or left-hand cane (reference electrode) to record the data, assuming that you selected the "accept save" option for the canes at D.C.P.s (see Section III. 3, Step 7).

Saving the first test station voltages will bring you back again to the Survey **screen. You are now ready to proceed with the CIS.**

V. 4 How to Perform a CIS

In order to illustrate some of the important processes associated with performing a CIS, we have designed a fictitious section of pipeline and the steps outlined below with regard to conducting a CIS pertain to this fictitious section. Our 350 feet long section of pipeline is shown below in Figure 6.
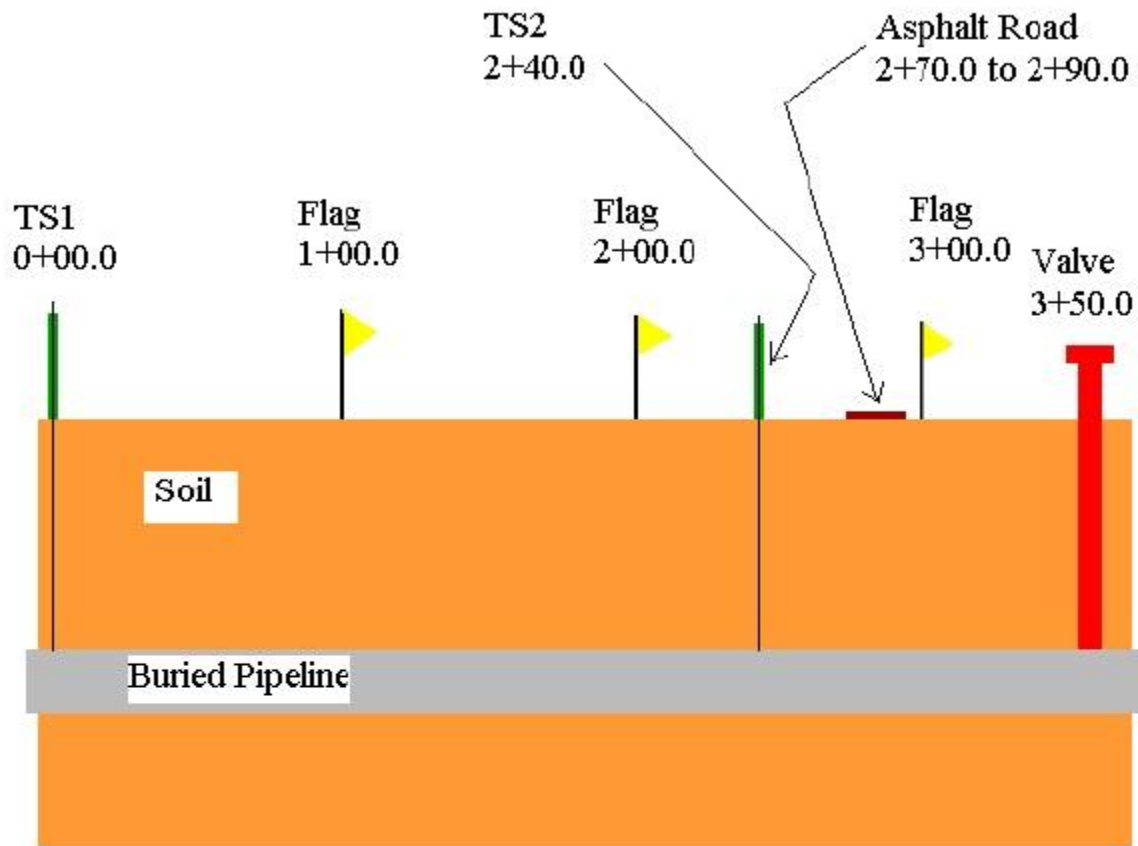
Figure 6: Fictitious Section of Pipeline

The important features on this section of pipe are as follows:

TS1: Test Station 1. Coincides with station 0+00.0 (reference zero station)
Flags: Located at 1+00.0 (100 feet from reference zero station), 2+00.0
       (200 feet from reference zero station) and 3+00.0 (300 feet from
   reference zero station).
TS2: Test Station 2 located at 2+40.0 (240 feet from reference zero station)
Asphalt Road: A 20 feet wide asphalt road located b/w 2+70.0 and 2+90.0
          (270 feet from reference zero to 290 feet from reference zero)
Valve: Located at 3+50.0 (350 feet from reference zero station)

Since, in our example, we have set up the right-hand cane to be the "read" cane, voltages will be recorded each time you "trigger" the right-hand cane's push button (by pressing down on the button) as you walk down the length of the pipeline. Triggering a recording using the right-hand cane button, in this case, would have the same effect as tapping on the "Read" button on the above screen.

Since you recorded voltages at the starting test station (TS1 in Figure 6), you have already established a "Device" location and, as shown below, this device is identified in the graph on the survey screen by the letter "D". In fact, all "Devices" encountered as you go down the length of the survey section will be marked on the graph in this fashion. Please note, however, that this first "D" marker will disappear from the graph as soon as the first survey measurement is recorded. All subsequent "Device" locations, however, will be indicated permanently with a "D" marker on the graph in the survey screen.
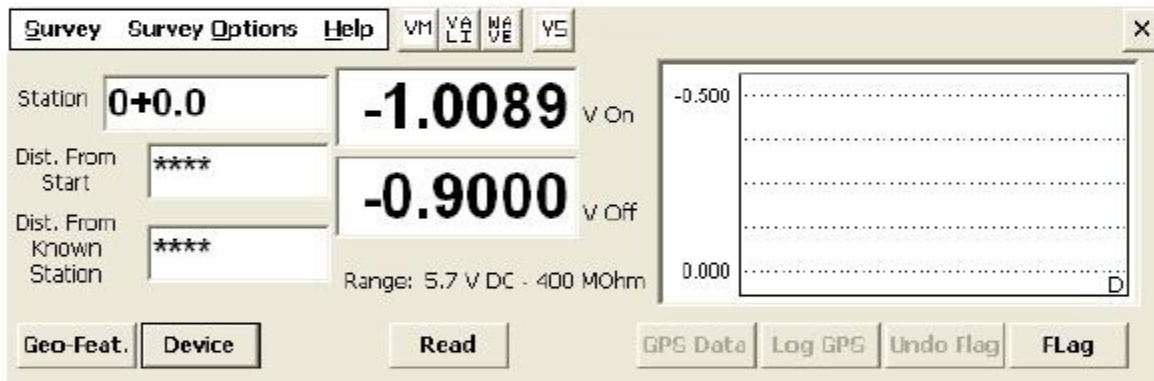
Since we indicated during the DA Meter's setup process that we expected to record voltages every 2.5 feet, each time you "trigger" readings using the right-hand cane's push button, the data logger will assume that you have traveled an additional 2.5 feet down the line section. Consequently, you should try to place the electrodes over the pipe at 2.5 feet intervals.

For instance, the screen will appear as shown below after the second triggering event (it is assumed that your first reading (first triggering event will be at the starting location).
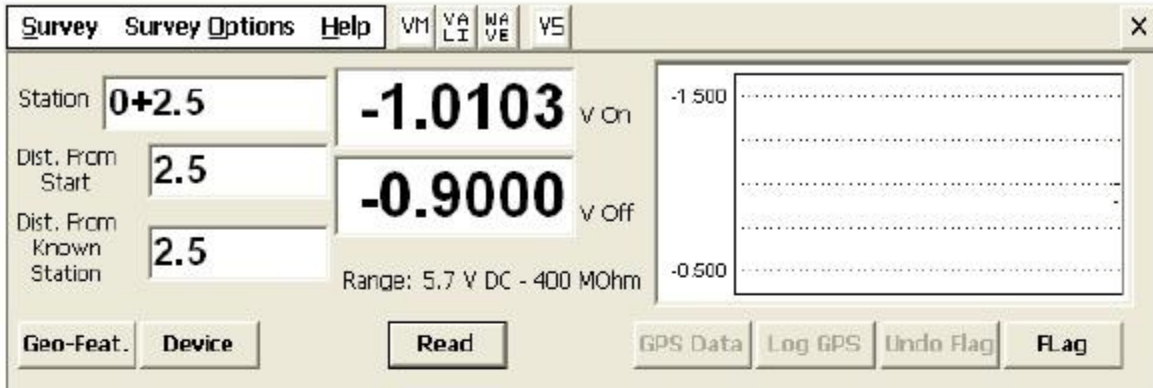
As can be seen from the above screen, the DA Meter assumes that you are now at a distance of 2.5 feet from where you started, which was at starting station 0+0.0 (or, 0+00.0).

The DA Meter's software program will add 2.5 feet to the assumed distance from the starting station every time the right-hand cane button is triggered. If you recall, we also set things up so that when the left-hand cane's push button is pressed (triggered), we would record the location of survey flags, which are typically placed at 100 feet intervals down the length of the pipe. In this case, triggering the left-hand cane would have the same effect as tapping once on the "Flag" button on the survey screen. Consequently, when you encounter your first survey flag and trigger the left-hand cane, the DA Meter's software will assume that you have traveled a distance of 100 feet from the starting test station. (A flag is considered a "Known Station")

At this point, the screen will appear as shown below.
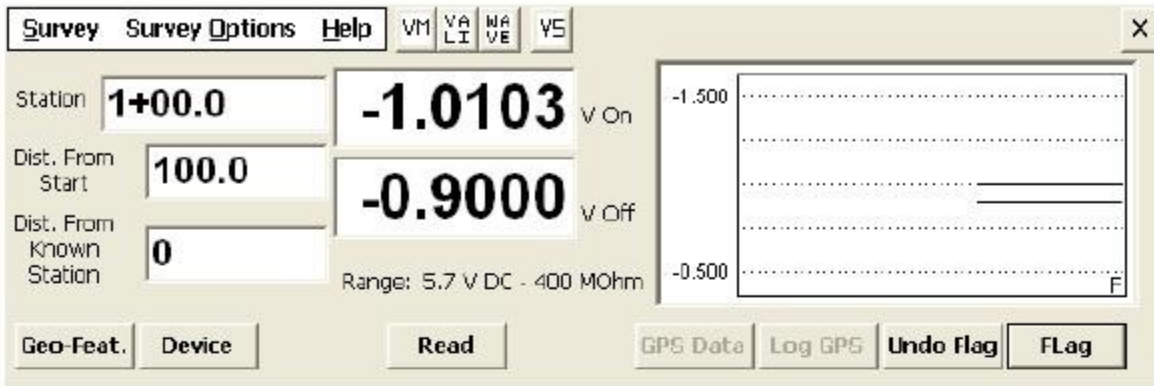
Notice that the station number is now 1+00.0 The" 1" represents 100 feet, so the DA Meter assumes that you are now 100 feet from your reference zero location. Notice also the "F" marker on the graph (for Flag).

If you continue on down the pipe triggering voltage recordings using the right-hand cane's push button until you encounter the next survey flag and you then press the left-hand cane's push button to register this second survey flag, the screen will appear as shown below.
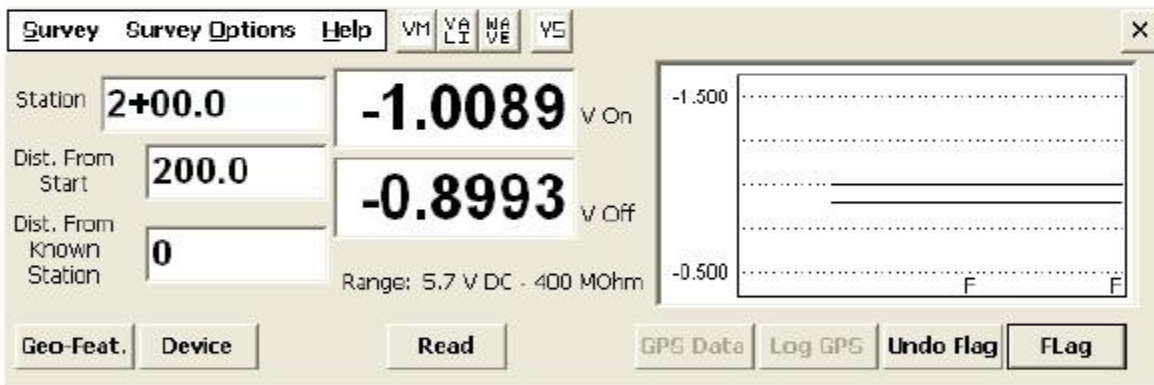
In this case, the station number is now 2+00.0 The "2" represents an assumed 200 feet from the reference zero location. A second Flag marker also appears on the graph.

Let's now assume that you encounter a second test station (TS2 in Figure 6) at a distance of 40 feet from the second survey flag location and you need to do a "reconnect" of the trail wire at this location.

In this case, when you encounter the test station, you would tap once on the "Device" button on the survey screen and then highlight "reconnect". The Device Readings screen at this point will appear as shown below.
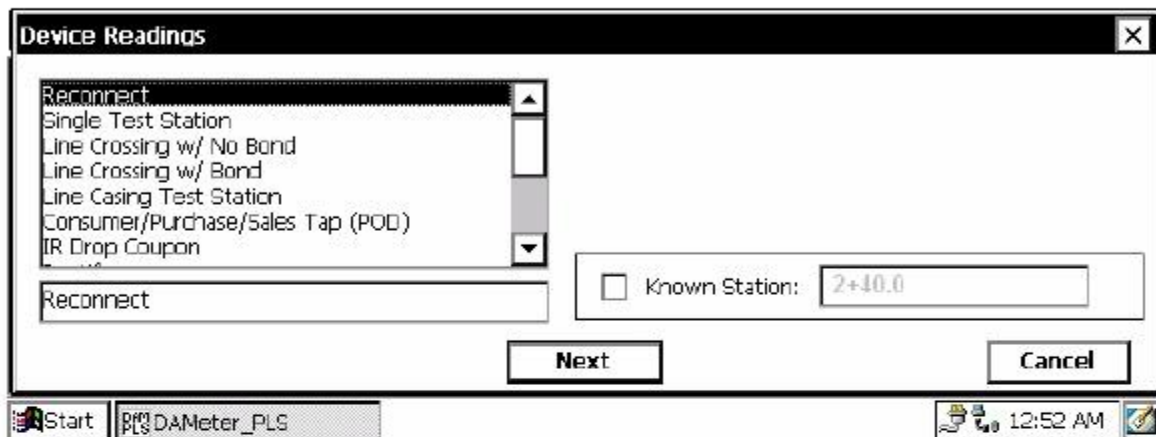
By tapping once on the "Next" button, the screen shown below will appear.
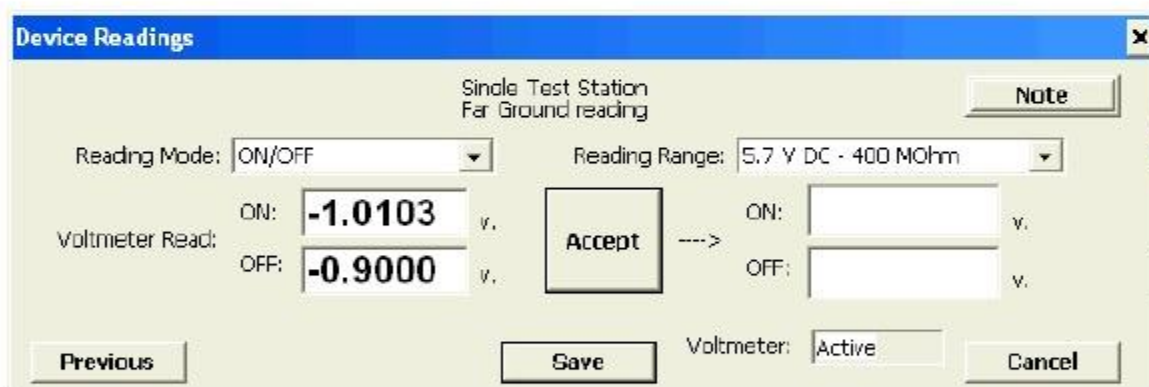
You are being prompted here to accept and save the "Far Ground" voltages prior to breaking the trail wire connection (see Section III. 2, Step 11 for an explanation of Far- and Near-Ground readings). By doing so, the screen shown below will appear.
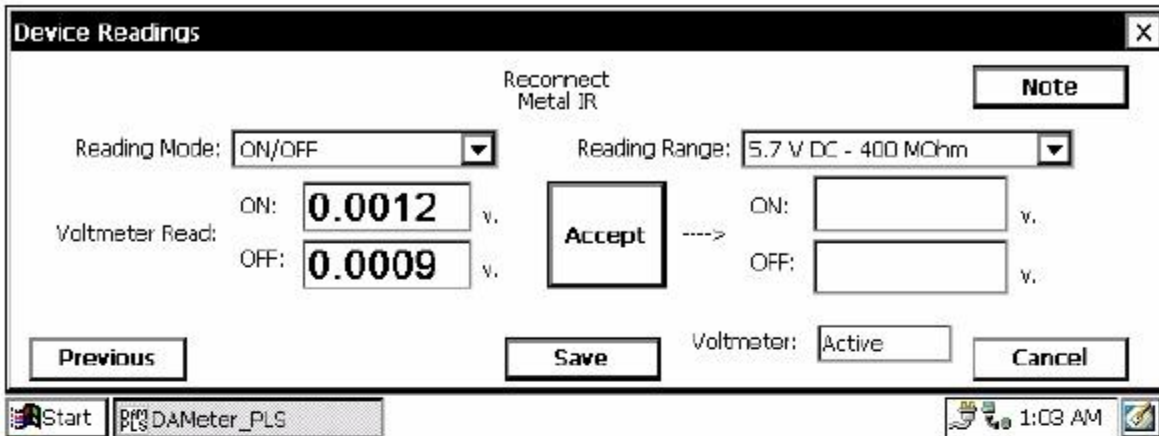
At this point you are being prompted to take "Metal IR" readings at the test station. To do so, you would connect a test lead from the black banana plug terminal on the DA Meter to the test station and disconnect the reference electrode data-probes (you could place the ceramic plug ends of the probes on top of your shoes to provide an open circuit). At this point, the DA Meter will be reading the potential difference between the two test stations (the far-ground station and the near-ground station). If you'd like to record the Metal IR data, you would save the readings by tapping on "accept" and then "save" after setting up to take the readings.

The next screen to appear is as shown below.
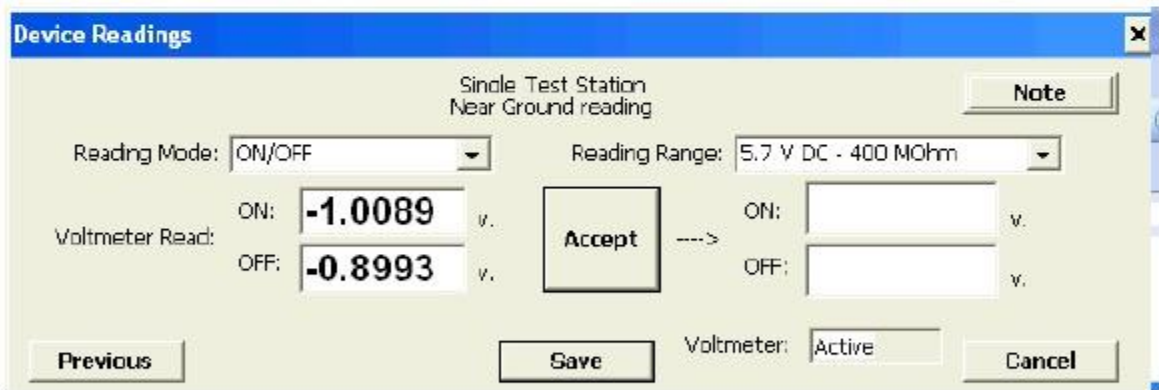
In this case, you are being prompted to accept and save the "Near Ground" voltages after connecting the trail wire to the second test station (TS2). If you recorded the Metal IR data, you would first disconnect the test lead from the DA Meter and then reconnect the data-probes.

If the Far- and Near-Ground voltages are within the maximum allowable % difference range that you established during your setup procedure (see Section III. 2 step 11), you will be returned to the Survey screen as shown below. If, on the other hand, the Far- and Near-Ground voltages differ by more than the allowable range, a window will appear showing all four readings and asking you whether or not you will accept the readings as is, or if you would like to re-take the near-ground readings.
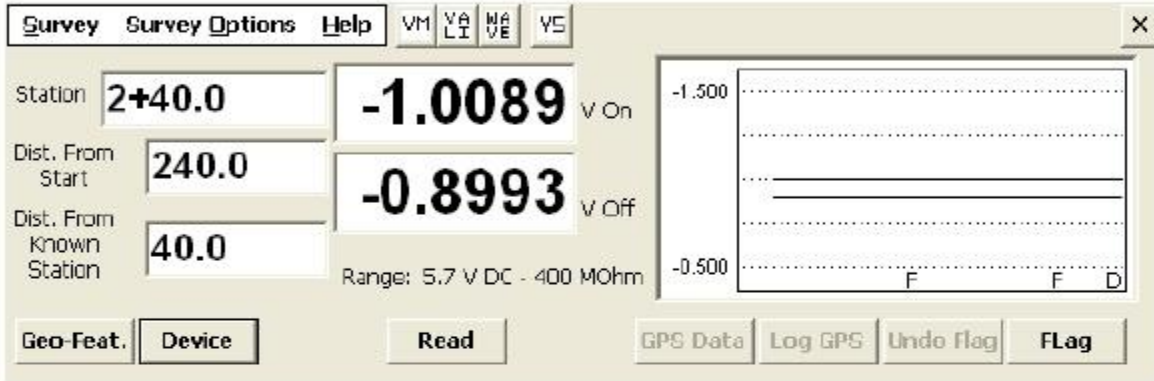
Now, let's assume that at an additional 30 feet down the pipe from the "reconnect" location, you encounter a "Geo-Feature", ie, a geographical feature of some type. In this case, when you reach this location, you would tap once on the "Geo-Feat." button on the survey screen. At this point, the screen would be as shown below.
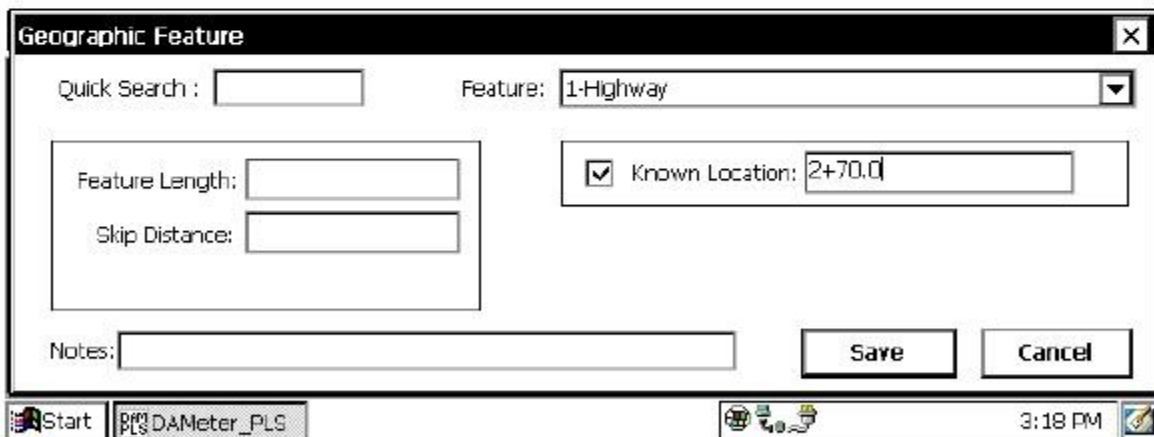
You can select the type of geo-feature that you have encountered by tapping once on the pull-down-list arrow button in the "Feature" field.

Alternatively, you could perform a quick search for the feature by typing in the "Quick Search" field the number associated with the feature or the first few letters of the name of the feature.

If, for example, the geo-feature is an "Asphalt Road", and the width of the road that you have to cross is 20 feet, you can enter a "Feature Length" of 20 feet (see Figure 6). You could restart voltage recordings immediately on the other side of the road. However, if there is a survey flag an additional 10 feet beyond the other side of the road, you might want to restart making voltage recordings at the flag location. If this were the case, the survey screen would appear as shown below.
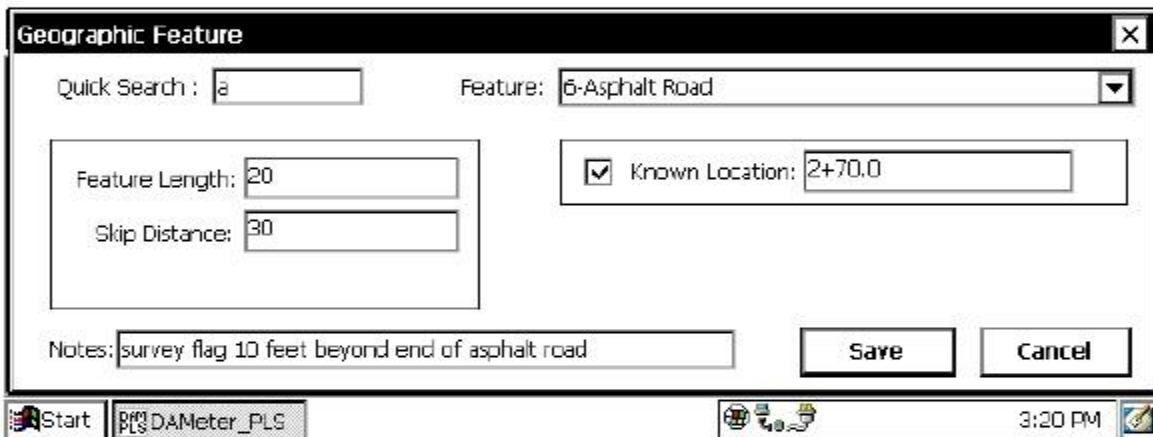
By tapping once on the "Save" button, the survey screen shown below will appear.
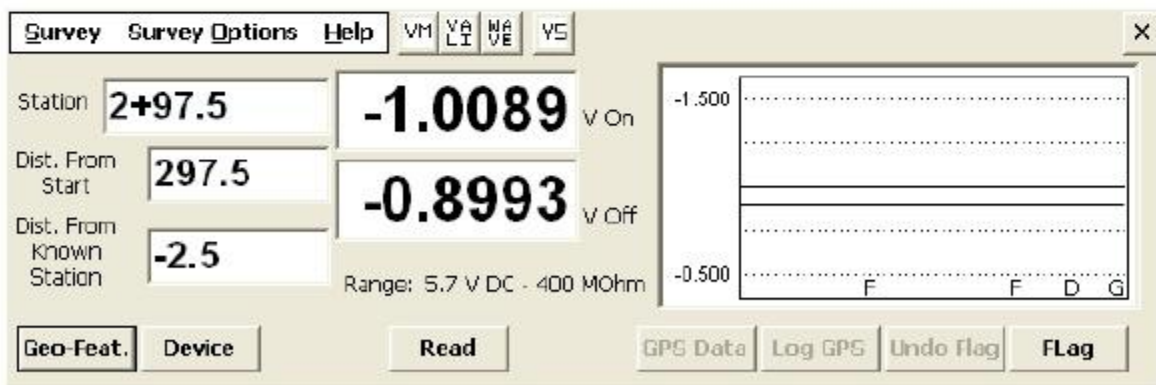
As can be seen from the above screen, the DA Meter's software assumes that you are 2.5 feet short of the survey flag on the other side of the asphalt road and that your next voltages will be recorded when you trigger the "read" cane when you are actually at the survey flag location. Notice that a "G" marker has been added to the graph (for Geo-Feature).

By triggering the "read" cane (your right-hand reference electrode cane), the survey screen shown below will appear. You can also trigger the "flag" cane (your left-hand reference electrode cane) at this time, to register the survey flag.
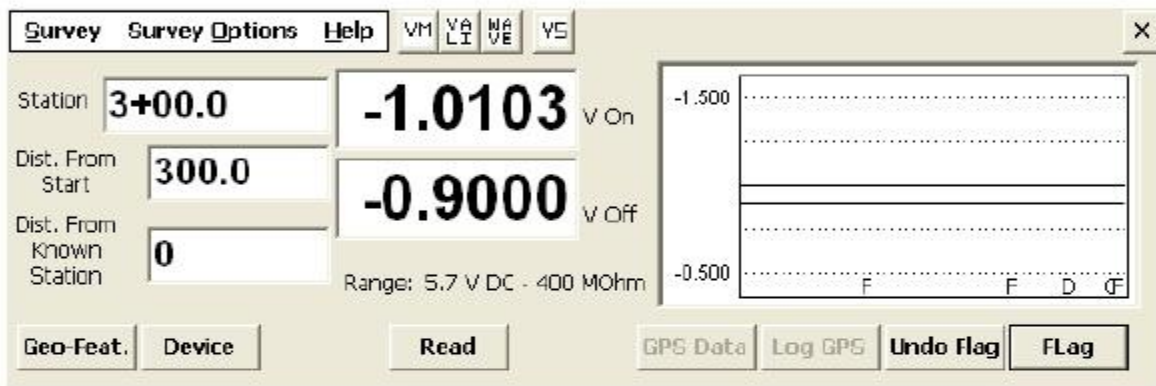
Now let's assume that you encounter a "Valve" at an additional 50 feet down the pipe from this survey flag (see Figure 6). Since, a valve is considered a "Device", you would stop and tap once on the "Device" button on the survey screen and then tap on "Valve". The screen shown below would appear.
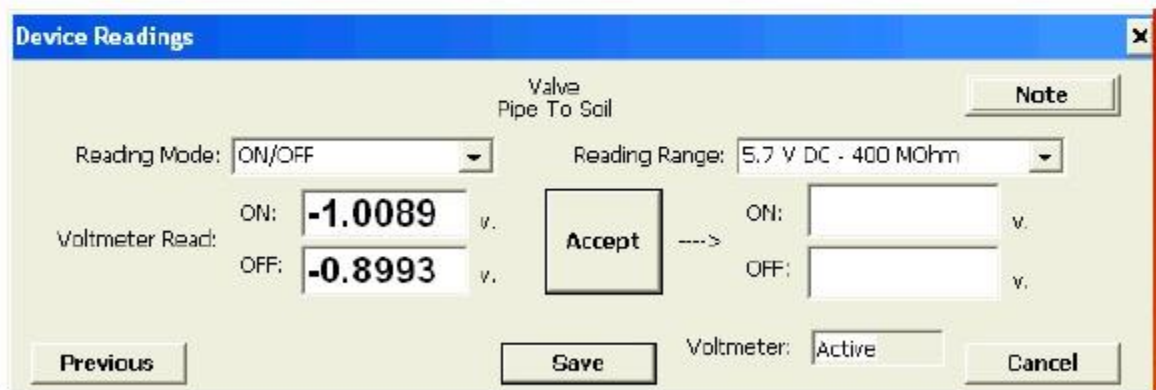
In this case, you would record the pipe-to-soil voltages at the valve location by triggering the right-hand cane (or by tapping once on the "Accept" button and then once on the "save" button on the survey screen).

Having done so, the screen shown below will appear.

This screen allows you to note the condition of the valve and to make any relevant comments about the valve.

After tapping once on the "Save" button, the Survey screen shown below will appear.
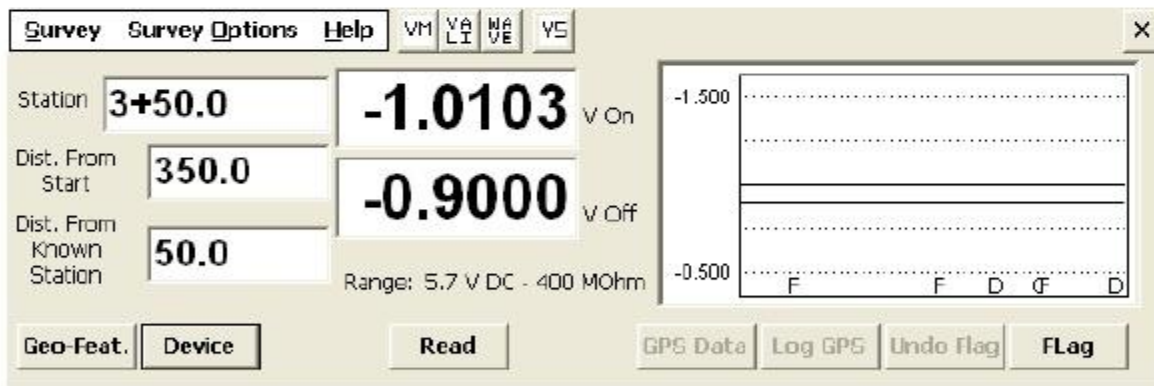
Since, in our fictitious section of pipe, the valve represents the end of the section, you would terminate the survey by tapping once on "Survey" in the menu bar and selecting "Finish Survey".

At this point you have completed the CIS on this section of the pipeline and the survey data have been stored (saved) in the DA Meter's memory in the file that you named at the outset of the CIS. You are now ready to "upload" the survey data to MCM's Database Management System (see Section VI).

V. 5 How to Use the GPS Buttons, if "Active", on the Survey Screen

If you selected a GPS receiver type during your setup process (Section III. 2, step 13), the two GPS button will be "active" on the Survey screen as shown below.
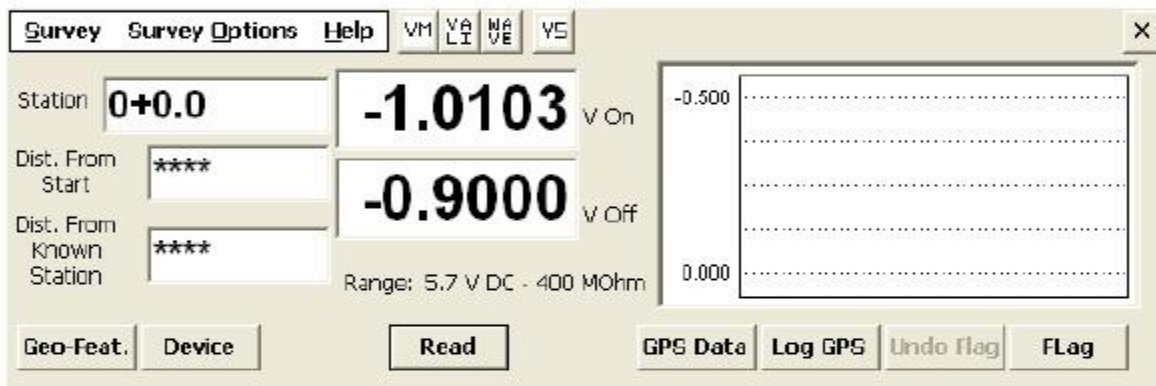
If you have a GPS receiver attached to your DA Meter (via the COM 1 Port), and the receiver has been properly-configured to output NMEA data strings (in the GGA format – see your DA Meter User's Manual, Appendix 1, if you are using a Trimble GPS Pathfinder receiver), you will be able to conveniently examine position data in real-time at any given location on your survey using these GPS buttons.

By tapping once on the "GPS Data" button, you can view a summary of the GPS data associated with your current location. You can also see how many satellites (Sat. In Use) were used in the determination of the position data for your present location. Ideally, a minimum of 5 satellites should be involved for good position accuracy.
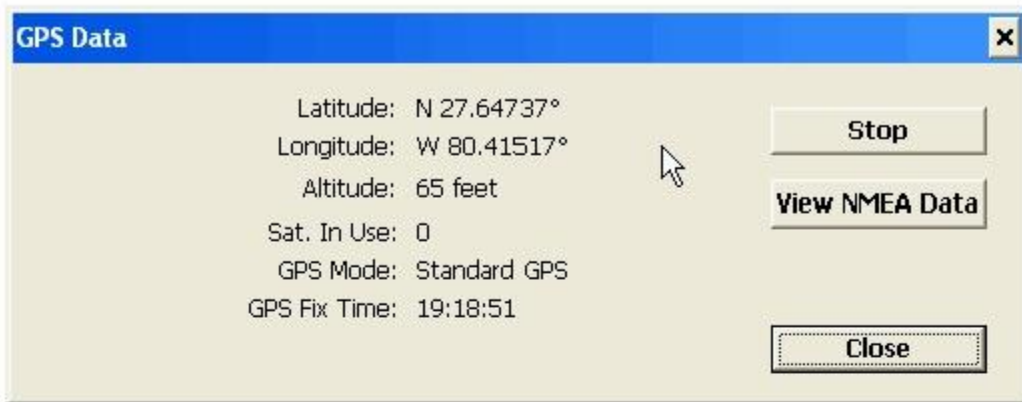
You can also view the NMEA data output by the GPS receiver by tapping once on the "View NMEA Data" button on the above window. New NMEA data will stream into the DA Meter every second. You can freeze this data by tapping once on the "Stop" button, which will allow you to examine the NMEA data strings.

You can also log (record) GPS data at any location on your survey, by tapping once on the "Log GPS" button. Alternatively, as discussed in Section III. 2, Step 14, you can pre-program the DA Meter to automatically log (record) GPS data at items such as Flags, Devices and Geo-Features.

With reference to Section III. 2, Step 14 (setting-up the DA Meter with GPS choices):

If you placed a tick in the box labeled "Log GPS at Flags", GPS data will be "logged" automatically at survey flags when either you tap on the "Flag" button on the survey screen or when you trigger the "flag" designated cane.
If you placed a tick in the box labeled "Log GPS at DCP/Feature", GPS data will be logged automatically at "Devices" or "Geo-Features" when you tap the "Device" button or when you tap the "Geo-Feat." button.

Obviously, with automatic logging of GPS data, you do not have to remember at each critical location to go through the GPS logging step.

SECTION VI: HOW TO COPY SURVEY FILES FROM THE DA METER TO YOUR PC

VI. 1 Introduction

Survey data are stored in independent files (one file for each survey) on the CompactFlash memory card on the DA Meter and you can copy survey files to your PC using one of two approaches; manually or via the driver in the ProActive software program.

The ProActive software program represents MCM's pipeline integrity database management system and this program allows integration of pipeline survey data in a database system and offers extensive reporting (both textual and graphical) capabilities on the survey data.

If you have the ProActive software program installed on your PC, or you can bring your DA Meter to a PC that has ProActive installed on it, you can use the ProActive program to automatically access survey files on the DA Meter. If either of these situations applies, you would proceed to Section VI. 3.

Note: The ProActive software program is required to actually view and analyze the survey data.

If you do not have the ProActive software program installed on your PC and you cannot bring your DA Meter to a PC that has ProActive installed on it, you can copy survey files manually from your DA Meter to your PC and you can subsequently send the copied files to a recipient that has ProActive installed on their PC. If this situation applies, you would proceed to Section VI. 2.

Note: In order to copy survey files from your DA Meter to your PC, either manually or via ProActive, you will need to have the Microsoft ActiveSync software program installed on your PC.

VI. 2 The Manual Approach

Step 1:
Connect a serial data communications cable between the DA Meter's

9-pin communication terminal (see Section IV. 2, Figure 5) and the serial data communications port on your PC and switch on your DA Meter. With Microsoft's ActiveSync program installed on your PC, the ActiveSync window will appear on your desktop and the program will confirm that two-way communication has been established.

Step 2:
Follow the procedures detailed below:

- Double-click on "My Computer" on your PC
- Double-click on "Mobile Device"
- Double-click on "My Handheld PC"
- Double-click on "CompactFlash"
- Double-click on "dameter_data
- Click on the survey file you wish to copy (highlight the file)
- Copy the file to a local folder

You would now be in a position to send the survey file to a recipient who has access to the ProActive software program.

Note: Do not rename the survey file prior to sending the file to the recipient, as the survey file must have the same name as the survey itself.

VI. 3 Using the Driver in the ProActive Software Program

Step 1:
Create a folder on your PC's hard-drive that will be used to "permanently" save files copied from your data-logger. You might choose to name this folder something like, "Surveys". If you are only interested in viewing survey data in the form of excel spreadsheets, you should also create a folder within the "Surveys" folder that can be used for this purpose and name this folder something like "Exported Surveys". More on this later.

Step 2:
Connect a serial data communications cable between the DA Meter's 9-pin communication terminal (see Section IV. 2, Figure 5) and the serial data communications port on your PC and switch on your DA Meter. With Microsoft's ActiveSync installed, the ActiveSync

window will appear on your desktop and the program will confirm that two-way communication has been established.

Step 3:
Double-click on the "ProActive" icon on your PC's desktop screen.

This will open up ProActive's main menu window. A window labeled "Entire Database" will also be seen here. The suggested organization of **your "Entire Database" is discussed in the ProActive Training Manual.**

Step 4:
Click once on the "Surveys" button on the main menu bar at the top of the screen.

This will open a window labeled "Data Logger: Get Pipeline Survey".

By clicking on the pull-down-list arrow button in the "Data Logger" field, you can select the data-logger from which you are copying the survey file. As shown in the drop-down-list, the various data-loggers currently supported by ProActive are offered as choices.

Step 5:
Select DA Meter Option.

Highlight "DA Meter" in the drop-down-list and click on the "Go" button. This will open up a window labeled, "Driver (Pipeline Survey)".

Note: It may take a few seconds for the "Driver" Window to appear.

Step 6:
Select the Survey File to be Copied.

Select "Pipeline Survey" in the field labeled "Data Type".

The "Surveys" field in the "DA Meter Driver" window will list all of the survey files currently stored on your DA Meter's CompactFlash memory card. Highlight the survey file that you would like to be copied to your PC. Also, place a tick in the box labeled "Copy to Local Folder" and identify the folder's location on your hard-drive in the field underneath.

This is the folder that you set up previously in which to save all of your survey files copied from your DA Meter. If you named the folder "Surveys", the folder's location would be:
C:\Surveys
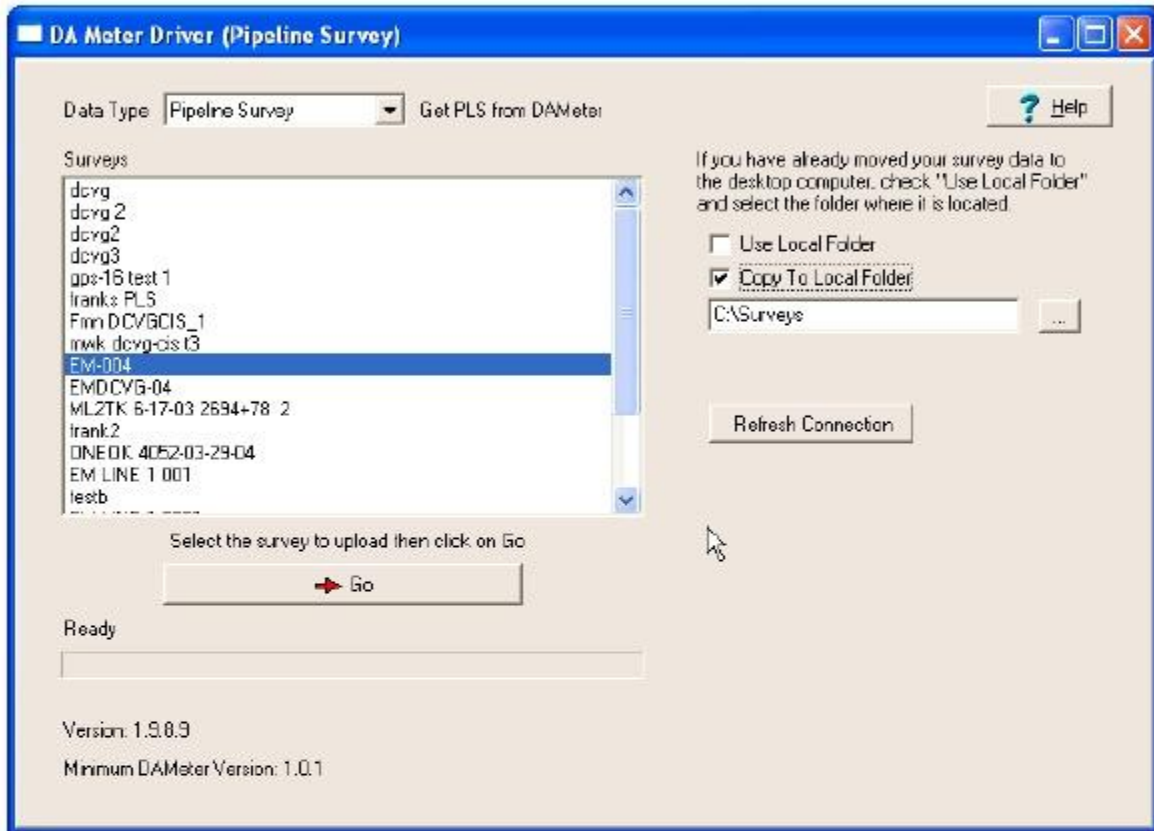
As an example, the "Driver" window would appear as shown above if the file named "EM-004" was selected for copying to your PC and if the folder to which the survey file was to be copied was named, "Surveys" on your hard-drive. Of course, the actual survey file names appearing in this field will depend on the filenames of the surveys that have been performed using your own DA Meter.

In our example, the "Driver" will have located survey file, EM-004, in our DA Meter's memory and when the "Go" button on the Driver Window is clicked, the survey file named, EM-004, will be saved on our PC's hard-drive, at which time the survey data could be brought into the database management section of ProActive.

Click on the "Go" button.

Step 7:
Examine the Survey Data Prior to Bringing the Data into the Database Management Section of ProActive.

You will have actually completed the process of copying a survey file to a local folder on your PC by this point, using the Driver in ProActive.

However, before exiting the Driver, it is recommended that you examine your survey data prior to bringing the data into the Database Management Section of ProActive. The process of bringing survey data into the database **management section of ProActive is detailed in the ProActive Training Manual.**

To do so, click on the "cancel" button on the window that is currently showing ("Data Logger: Get Pipeline Survey Window"). The "DA Meter Driver" window will again be shown but, this time, there will be a selection of tabs on the window, labeled as follows:

Survey Settings
Readings
Device Readings
Graph

By clicking on these tabs, you can view information on the Survey conditions or you can view actual survey data.

Example:
The EM-004 survey mentioned above is an actual survey that was performed on a buried pipeline. It was a continuous-mode CIS performed under High/Low rectifier-current interrupted conditions. By clicking on the various tabs on the "Driver" window for this uploaded survey, we can view either the survey conditions that were setup on the DA Meter prior to the survey (see Section III. 2), or we can view actual readings and graphical representations of the CIS readings for this example.

By clicking on the "Survey Settings" tab the window shown below is displayed.

DAMeter Driver (Pipeline Survey)	
Survey Type	Continuous CIS
Rectifier Mode	Cycle ON/OFF
Cane Button Allowed To – DCP	Accept -> Save
Cane Button Allowed To - Survey	Pause Flag
Survey Walking Direction	Decreasing
Use Metric	N
Max. acceptable Far and Near Ground Reading Difference %	15
AC System	60 Hz
Maximum Acceptable Low Voltage	-0.850
GPS Type	MCM External
Use GPS Altitude	Y
Auto Log GPS at Flags	Y
Auto Log GPS at DCP/Feature	Y
Auto Log GPS at Sidedrain/Anomaly	Y
DCVG Defect Max mV = 1st read of Tot mV	Y
Differential GPS Required	Y
CIS Flag Read Count %	20
Dist per reading	4.0
Dist between Flags	100
Name of P/L	EXXON MOBIL 12 inch
Current Station	0+32.0000
Valve Segment	1
Time To Walk Between Flags In Secs.	45
Enable Auto Learn	N

As can be seen, the settings data indicate a Continuous CIS, with rectifier in the current ON/OFF mode . Additional settings information, including the voltmeter settings would be seen by scrolling down. Again, these survey settings were established during the DA Meter survey setup procedures (see Section III. 2).

By clicking on the "Readings" tab, the window shown below is displayed.

DA Meter Driver (Pipeline Survey)

Data No	Dist From Sta	Station No	On Voltage	Off Voltage	Comments	DCP/Feature	Latitude	Longitude	Altitude
1	4.000	00017+22	-1.0501	-0.8588		Line Marker	26.96132	-98.06273	75.393
2	8.000	00017+18	-1.0482	-0.8317					
3	12.000	00017+14	-1.0456	-0.8577					
4	16.000	00017+10	-1.0454	-0.8541					
5	20.000	00017+06	-0.8492	-0.8492					
6	24.000	00017+02	-1.0390	-0.6666					
7	28.000	00016+98	-1.0468	-0.8558					
8	32.000	00016+94	0.9571	-0.1642					
9	36.000	00016+90	-1.0628	-0.8729					
10	40.000	00016+86	-1.0496	-0.8607					
11	44.000	00016+82	-1.0477	-1.0084					
12	48.000	00016+78	-1.0515	-0.8616					
13	52.000	00016+74	-1.0501	-0.8595					
14	56.000	00016+70	-1.0207	-0.6426					
15	60.000	00016+66	-1.0188	-0.8285					
16	64.000	00016+62	-1.0181	-0.8282					
17	68.000	00016+58	-1.0009	-0.8120					
18	72.000	00016+54	-0.5916	-0.7701					
19	76.000	00016+50	-0.9693	-0.7777					
20	80.000	00016+46	-0.9715	-0.7803					
21	84.000	00016+42	-0.9719	-0.7817					
22	88.000	00016+38	-0.9776	-0.7831					

As can be seen from the above window, the actual readings recorded during the CIS are presented here. It can be seen that readings in this case were taken at 4 feet intervals. And, the High and the Low voltage readings are presented at each of the measurement locations.

It can also be seen from the above window that DCP (Device) and/or Geo-Feature locations are identified (for example, a "line marker" is indicated at the first measurement location).

By clicking on the "Device Readings" tab, the window shown below is displayed.

DA Meter Driver (Pipeline Survey)

Download | Survey Info | Readings | Device Readings | PLS Graph

Station No	DCP/Feature	Value1	Value2	Value3	Reading Tex	Comment	Latitude	Longitude	Altitude
00017+22	Line Marker	0.0000	0.0000	0.0000			26.96132	-98.06273	75.360!
00017+22	Test Station	0.0000	0.0000	0.0000			26.96132	-98.06273	75.360!
00017+22	Casing Vent	0.0000	0.0000	0.0000			26.96132	-98.06273	75.360!
00012+22	Custom 1	0.0000	0.0000	0.0000		4FT 0IN	26.96247	-98.06362	70.209'
00007+18	Custom 1	0.0000	0.0000	0.0000		4FT 7IN	26.96360	-98.06450	69.028!
00003+46	Power Line Cr	0.0000	0.0000	0.0000		IRON GIANT	26.96444	-98.06516	70.144:
00002+98	Line Marker	0.0000	0.0000	0.0000			26.96457	-98.06526	71.587!
00002+98	Bend in Pipe	0.0000	0.0000	0.0000		LEFT	26.96457	-98.06526	71.587!
00002+82	Custom 2	0.0000	0.0000	0.0000		AGM 12	26.96457	-98.06525	71.522:
00002+50	Line Crossing	0.0000	0.0000	0.0000		DUKE ENER	26.96458	-98.06539	72.375:
00002+50	Line Crossing	-1.2505	-0.8473	0.0000		NO TEST ST	26.96458	-98.06539	72.375:
00002+50	Line Crossing	-0.0696	-0.0221	0.0000		TOP LUG ON	26.96458	-98.06539	72.375:
00002+50	Line Crossing	-1.2505	-0.8470	0.0000		FAR GROUN	26.96458	-98.06539	72.375:
00002+50	Line Crossing	-1.4747	-1.2450	0.0000		BOTTOM LU	26.96458	-98.06539	72.375:
00002+22	Custom 1	0.0000	0.0000	0.0000		3FT 11IN	26.96459	-98.06548	71.128!
00001+30	Fence	0.0000	0.0000	0.0000			26.96460	-98.06575	75.492'
00001+30	Line Marker	0.0000	0.0000	0.0000			26.96460	-98.06575	75.492'
00001+30	Custom 3	0.0000	0.0000	0.0000		ENTER VAL'	26.96460	-98.06575	75.492'
00001+30	Rocky	0.0000	0.0000	0.0000			26.96460	-98.06575	75.492'
00000+82	Pig Trap	0.0000	0.0000	0.0000			26.96461	-98.06586	77.165:
00000+82	Reconnect: F	-1.1602	-0.8278	0.0000		THIS IS WHI	26.96461	-98.06586	77.165:
00000+82	Valve: Structu	-1.1345	-0.7939	0.0000			26.96461	-98.06586	77.165:

Any "Devices" or "Geo-Features" that were registered on the survey will be listed in this window as well as any associated comments that were entered on the DA Meter and GPS position data, if recorded at these locations. Any voltage readings recorded at "Devices" will also be presented here.

Finally, by clicking on the "Graph" tab, the window shown below is displayed.
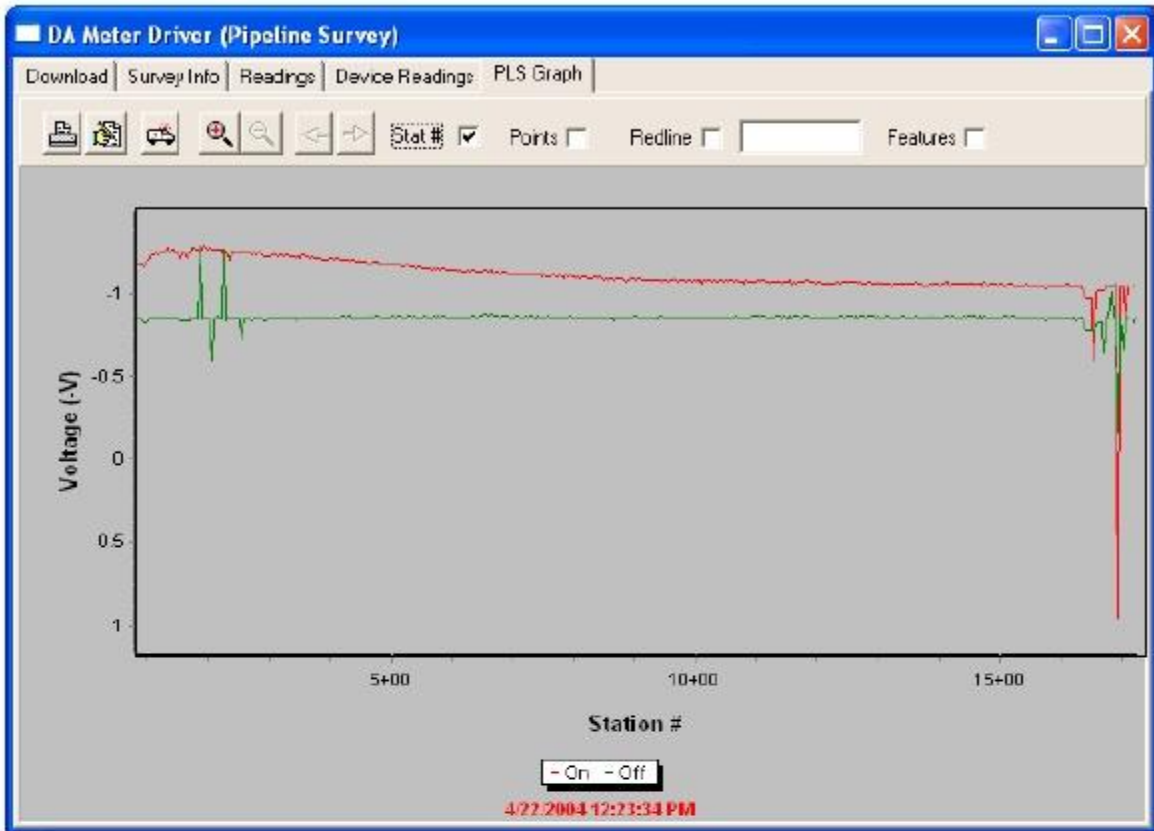
The above window shows a graphical representation of the survey data for this example survey. As can be seen, both the high voltage and the low voltage readings are shown together in graphical form (the red line represents the high voltage readings and the green line represents the low voltage readings in the above case.

As can be seen from the above window, a graphical representation of the survey data is extremely useful with regard to immediately identifying potential problem areas.

Excel Spreadsheet Option:
Another option exists at this point, particularly if you do not plan to bring the survey data into the Database Management Section of ProActive, and that is to export the survey back out of the Driver in the form of spreadsheets. This can be done by clicking on the "Export to Excel" button **on the "DA Meter Driver" window and selecting the "Exported Surveys"** folder in the "Save-As" window.

Remember that you previously setup an "Exported Surveys" folder on your hard-drive.

By accessing your "Exported Surveys" folder, you can view the survey information, survey readings and DCP/Features data in spreadsheet form.

At this point in the process, having examined your survey data, you can decide whether or not to bring the data into the Database Management Section of ProActive, where the survey can be integrated with any other surveys you might have in your ProActive Database.

After importation, you can manage the data associated with all of your surveys in a whole host of ways inside ProActive. The data management functions available within ProActive are beyond the scope of this particular **manual, however, you are referred to our ProActive Training Manual for** specific information.

Appendix 1

How to Connect the Chainer and Counter Unit for
Close Interval Survey Applications

The following section describes how you would make appropriate connections in order to incorporate the MCM chainer (wire measure) and counter unit for CIS applications.

When properly configured, the counter emits a short audible signal (beep) each time 2.5 feet (or 1 meter for the metric version) of trail wire is fed through the chainer. A longer beep is emitted each time 100 feet (or 100 meters for the metric version) of trail wire is fed through the chainer. An operator can then trigger readings (or designate survey flag locations) in response to the audible signals using the push-button switches on the MCM data-probes. This represents the "manual triggering" option.

An alternative approach is possible, which is known as the "automatic triggering" option. In this case, readings are triggered automatically each time 2.5 feet (or 1 meter for the metric version) of trail wire is fed through the chainer.

There are two possible mounting scenarios for the counter/display unit and, in each case it is possible to use manual triggering or automatic triggering. Consequently, there are four possible cabling configurations and each of these configurations is described below.

Counter/Display Unit Mounted Separately on Data-Logger Tray:

Option 1:   Manual Triggering
Figure 1 illustrates the cabling configuration for this option. As can be seen from the figure, a 3-wire cable (coiled black cable with 3-pin plugs on either end) connects the hip pack (or the back pack) with the counter unit. Two of the wires carry the wire measure signal and the third wire connects to the structure (pipe) via the trail wire.

The structure can be connected to either the positive or the negative side of the data-logger's voltmeter by connecting a banana plug cable from the

counter unit to either the red or the black banana plug terminal on the data-logger. By connecting this cable to the red banana plug terminal (positive side of the voltmeter) and using two black-band cables to connect the data-probes to the data-logger via the dual-probe adapter (effectively connecting the data-probes to the negative side of the voltmeter), you would read negative pipe-to-soil voltages. This situation is illustrated in Figure 1. If you wanted to read positive pipe-to-soil voltages, you would connect the banana plug cable from the counter unit to the black banana plug terminal on the data-logger and you would use two red-band data-probe cables.

Option 2:   Automatic Triggering
Figure 2 illustrates the cabling configuration for this option. A "trigger cable" is connected from the counter unit to the 5-pin terminal on the data-logger as shown in the figure. The red and the black wires of the trigger cable are connected to the "External Beeper" connection terminals on the underside of the counter unit. The red and the black wires connect to the terminals labeled, positive and negative, respectively.

Again, as in Option 1, the structure (pipe) can be connected to either the positive or the negative side of the voltmeter by connecting a banana plug cable from the counter unit to either the red or the black banana plug terminal on the data-logger. By connecting this cable to the red banana plug terminal of the data-logger (positive side of the voltmeter), as shown in the figure, the data-probes would be connected to the negative side of the voltmeter, via the black banana plug terminal on the data-logger. In this case, you would read negative pipe-to-soil voltages. If you wanted to read positive pipe-to-soil voltages, you would connect the banana plug cable from the counter unit to the black banana plug terminal on the data-logger and you would connect the data-probes to the red banana plug terminal on the data-logger.

Note: With this option (Option 2), you do not use the MCM data-probe cables. Instead, you would connect banana plug cables (not supplied with the package) to the banana plug terminals on the data-probes and, via a common connection, you would connect both banana plug cables to either the black or the red banana plug terminal on the data-logger, depending on whether you wanted to read negative or positive pipe-to-soil voltages (see above).

Counter/Display Unit Mounted Directly on Data-Logger:

Option 3:   Manual Triggering
Figure 3 illustrates the cabling configuration for this option. This option is similar to Option 1 accept that, in this case, the counter unit is mounted directly on the data-logger via the banana plug prongs on the counter unit.

In this case, an external banana plug cable is not required between the counter unit and the data-logger to make connection to the structure (pipe). Instead, this connection is made via the internal wiring in the counter unit.

The structure (pipe) lead inside the counter unit can be wired to the positive or to the negative side of the voltmeter. In the illustration shown in Figure 3, the structure lead is wired to the positive side of the voltmeter, which means that you would read negative pipe-to-soil voltages when using the black-band data-probe cables connected to the data-probes. If you wanted to read positive pipe-to-soil voltages, you would connect the structure (pipe) lead (inside the counter unit) to the negative side of the voltmeter and you would use two red band data-probe cables to connect to the data-probes.

Note: The counter unit comes with the structure (pipe) lead pre-wired to the negative side of the voltmeter, however, by opening up the unit, you can change the connection to re-wire the structure to the positive side of the voltmeter (for negative pipe-to-soil readings).

Option 4:   Automatic Triggering
Figure 4 illustrates the cabling configuration for this option. This option is similar to Option 2 accept that, in this case, the counter unit is mounted directly on the data-logger via the banana plug prongs on the counter unit. The "trigger cable" is used in this option and is connected as described in Option 2.

Again, an external banana plug cable is not required between the counter unit and the data-logger to make connection to the structure (pipe) with this option. Instead, this connection is made via the internal wiring in the counter unit.

In the illustration shown in Figure 4, the structure lead is wired to the positive side of the voltmeter, which means that you would read negative pipe-to-soil voltages with the data-probes connected to the negative side of

the voltmeter, as shown. As with Option 3, the structure (pipe) lead inside the counter unit can be wired to the positive or to the negative side of the voltmeter. If you wanted to read positive pipe-to-soil voltages, you would connect the structure (pipe) lead (inside the counter unit) to the negative side of the voltmeter and you would connect the data-probes, via banana plug cables, to the positive side of the voltmeter.

Note: With this option (Option 4), you do not use the MCM data-probe cables. Instead, you would connect banana plug cables (not supplied with the package) to the banana plug terminal on the data-probes and, via a common connection, you would connect both banana plug cables to either the black or the red banana plug terminals on the data-logger, depending on whether you wanted to read negative or positive pipe-to-soil voltages (see above).
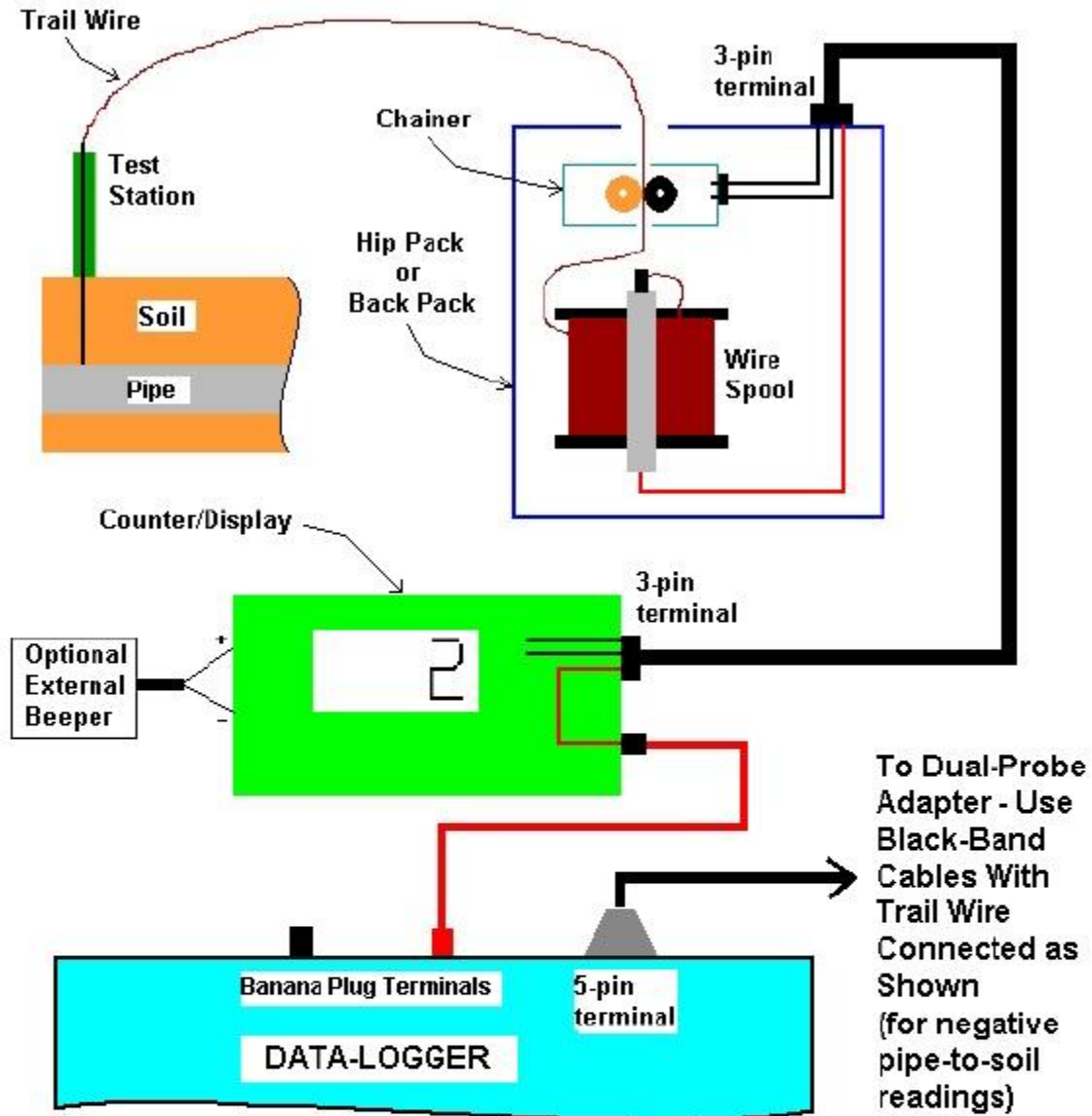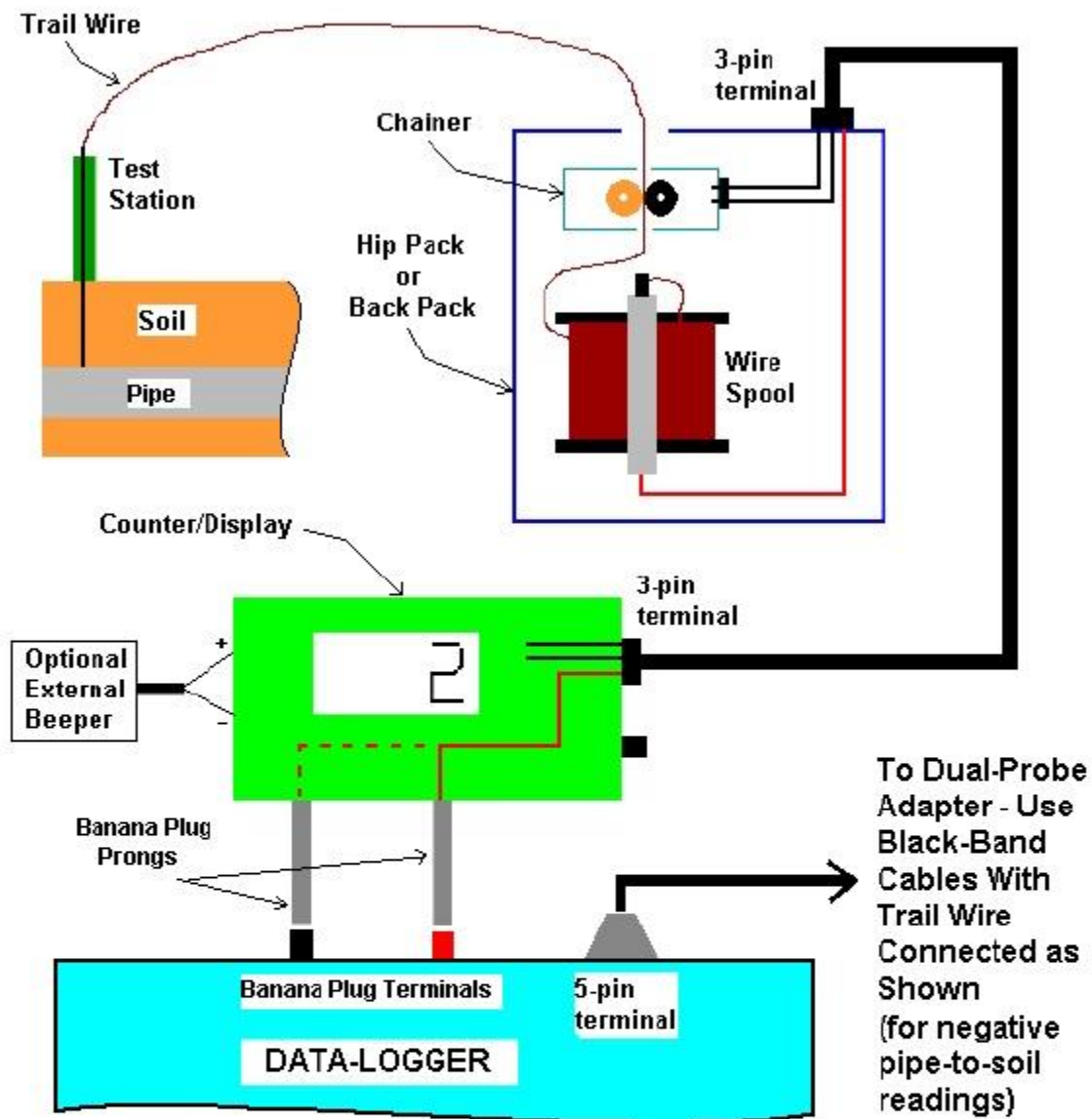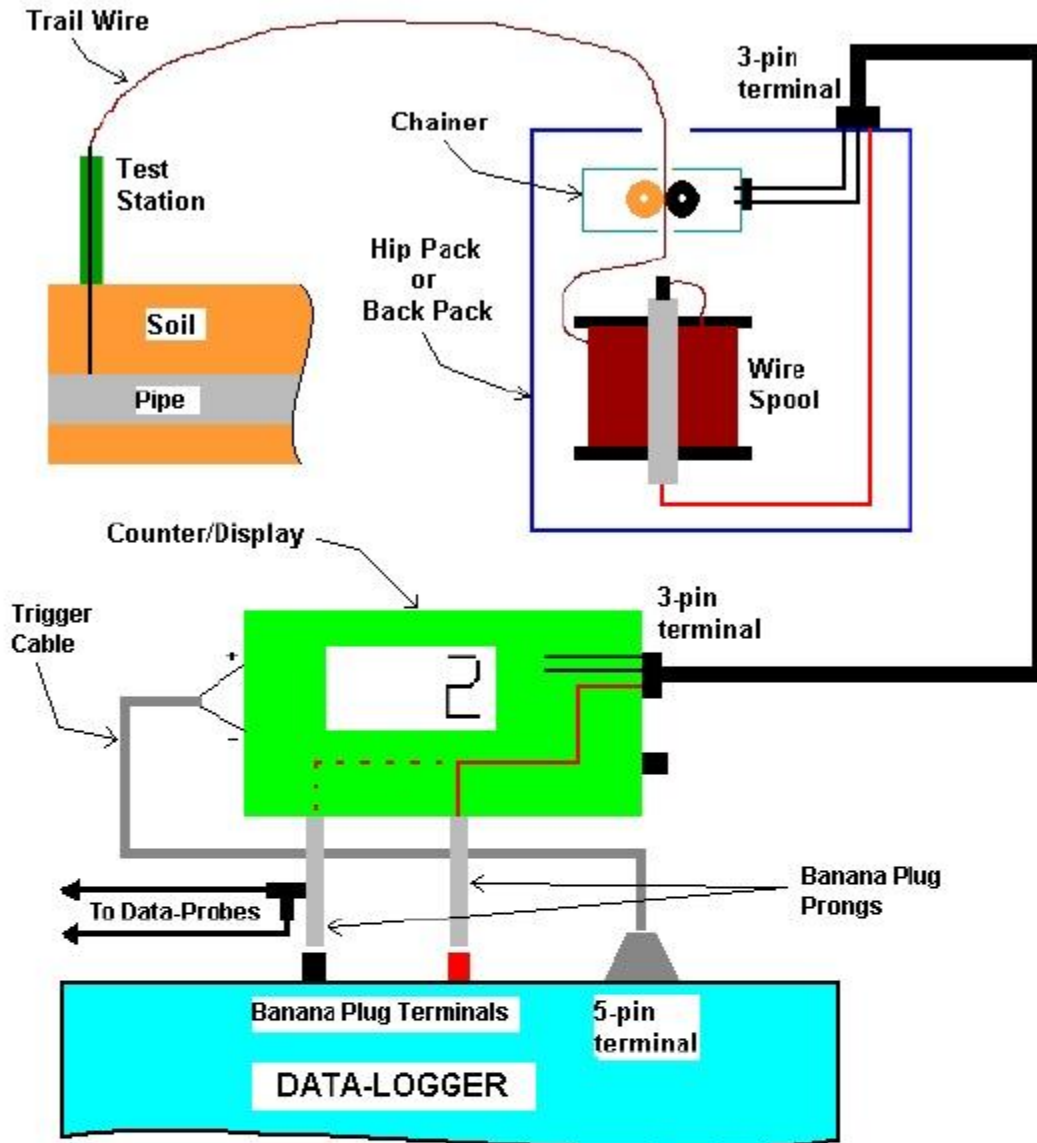
Figure 1: **Counter/Display Unit Mounted on Tray – Connections for Manual Triggering of Readings Using Data-Probe Push-Buttons**
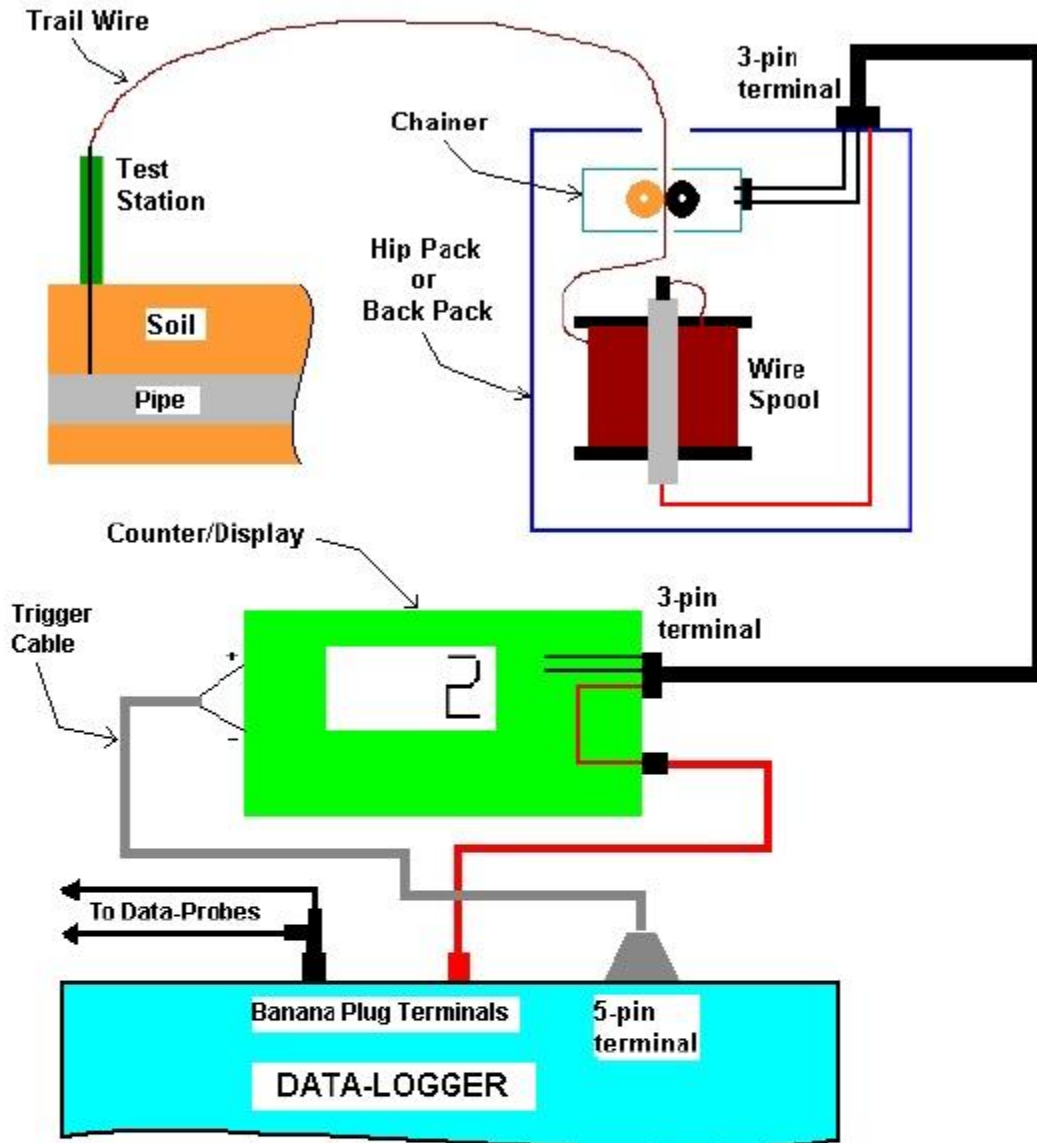
Figure 2: **Counter/Display Unit Mounted on Tray – Connections for Automatic Triggering of Readings**
[banana plug cables (not included with package) are connected to the data-probes – MCM data-probe cables are not used]

Figure 3: **Counter/Display Unit Mounted Directly on Data-Logger - Connections for Manual Triggering of Readings Using Data-Probe Push-Buttons**
[Structure lead shown as wired to POSITIVE for negative pipe-to-soil readings using black-band data-probe cables]

Figure 4: Counter/Display Unit Mounted Directly on Data-Logger - Connections for Automatic Triggering of Readings
[Banana plug cables (not included with package) are connected to the data-probes – MCM data-probe cables are not used. Also, structure lead shown as wired to POSITIVE for negative pipe-to-soil readings]

APPENDIX 2: How to Delete Survey Files from the DA Meter

Once you have copied your survey files to your PC (see Section VI), you can (if you wish) delete the files from your DA Meter's CompactFlash memory card if you need, for example, to create space in the data-logger's file storage memory to make room for future survey files.

Your survey files are stored in the DA Meter on a "non-volatile" CompactFlash card. Since this memory is "non-volatile", your survey data will be safe, even if all power is lost to your DA Meter. Please note, however, that the DA Meter's program files (the files that actually run the DA Meter) are stored in a volatile memory, and so, if all power was lost (ie, the battery-pack and back-up battery were fully discharged), you would need to re-install the DA Meter's software application package – see the DA Meter User's Manual.

Since your survey files are stored on the CompactFlash card, you will have to access this memory in order to delete selected survey files. The procedure would be as follows:

   • Double-tap on the "My Handheld PC" icon
   • Double-tap on "Compact Flash"
   • Double-tap on "dameter_data"
   • Tap once on the Survey File you wish to delete
   • Tap once on the Delete button (χ symbol on menu bar)