


pulseEKKO PRO

USER'S GUIDE

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s u b s u r f a c e i m a g i n g s o l u t i o n s

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1 Overview

This manual describes how to set up and run a pulseEKKO PRO LF (low frequency) Ground Penetrating Radar (GPR) system connected to a Digital Video Logger (DVL) for data display and storage.

System Assembly & Startup:	Section 2 System Assembly and Startup on page 2 details the step by step procedure for assembling the pulseEKKO PRO system. It also describes how to start up the DVL and navigate around the menus.
Setting Data Collection Parameters:	<p>Section 3 System Setup Parameters on page 31 covers the procedure for selecting appropriate data collection parameters. Although every effort has been made to make the software as transparent and user friendly as possible, this section explains in greater detail each of the options and menu items in the data collection program.</p> <p>To get up and running quickly see Section 3.1 System Parameters for a Quick Start to Data Collection on page 32.</p>
Scope Mode:	Section 4 Running in Scope Mode on page 65 describes how to set timezero to ensure the system is ready for data collection.
Data Collection:	Section 5 Data Collection Mode on page 69 describes running the radar system and collecting data.
Surveying Techniques:	Section 6 Surveying Techniques on page 82 describes system configurations and offers hints for properly collecting data in field conditions.
Troubleshooting:	Section 7 Troubleshooting on page 95 presents some simple steps the user should go through when things do not work as they should.
File Management:	Section 8 File Management on page 104 describes how to transfer data from the DVL to a PC and how to delete files and directories from the DVL.
Care and Maintenance:	Section 9 Care and Maintenance on page 111 discusses procedures for the care and maintenance of your pulseEKKO PRO system.
Helpful Hints:	Section 10 Helpful Hints on page 117 lists some helpful hints, based on years of experience, to help make data collection and field operations run as smooth as possible.

2 System Assembly and Startup

2.1 System Configurations

The modular design of the pulseEKKO PRO GPR makes the system very flexible and readily field-portable in a number of configurations. This section details the steps for assembling the Low Frequency Hand Held (Figure 2-1) and High Frequency Hand Towed (Figure 2-2) configurations.

2.1.1 Low Frequency Hand Held

There are four essential components to the low frequency radar system: the Digital Video Logger (DVL), the control module, the transmitter assembly and the receiver assembly. The control module is attached to the back of the DVL. The transmitter and receiver assemblies are connected to the control module via appropriate fibre optics cables (Figure 2-1).

Complete system configurations for data acquisition are shown later (Section 6.1: P82).

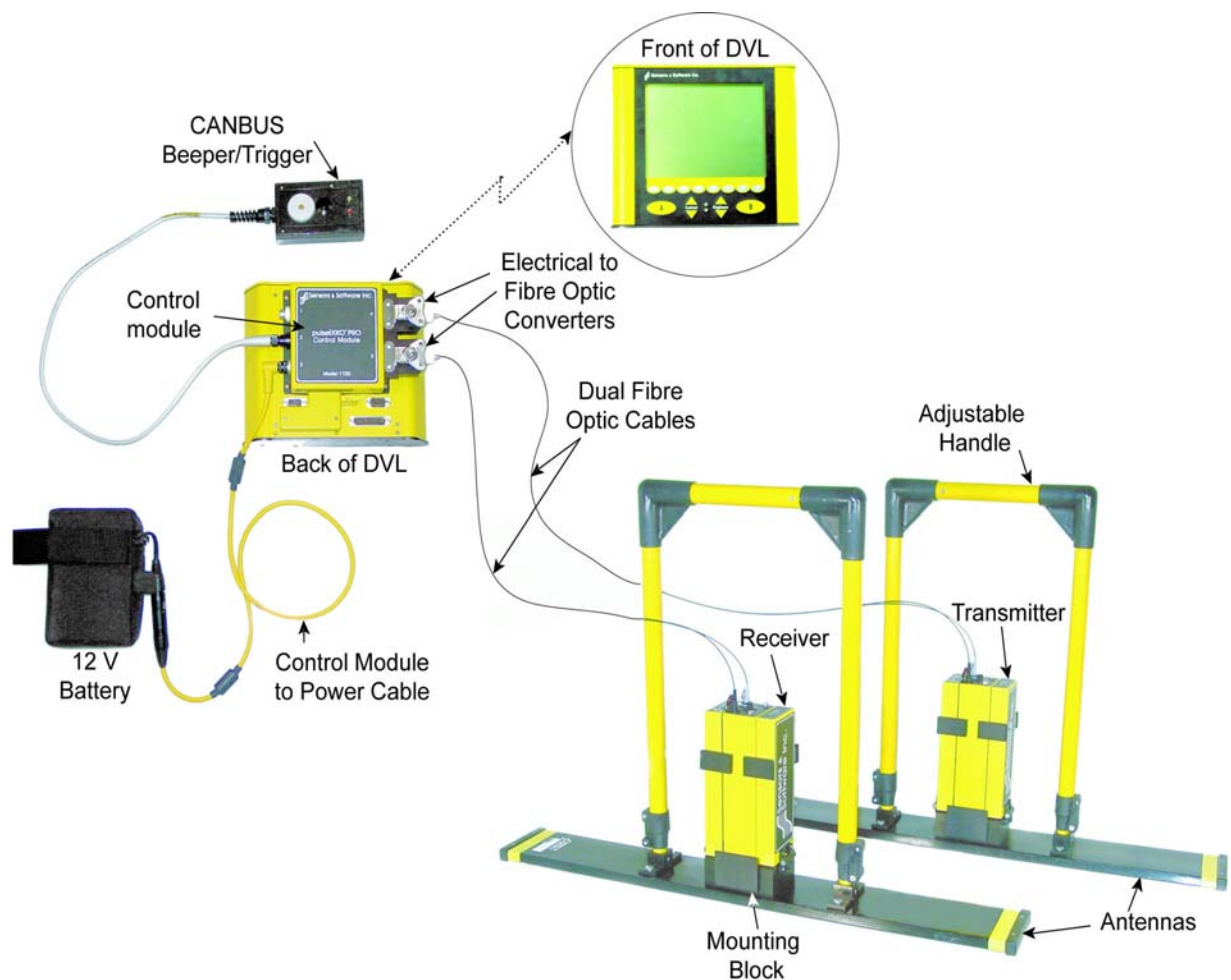


Figure 2-1: The complete low frequency pulseEKKO PRO hand held Assembly

2.1.2 High Frequency Hand Towed

There are four essential components to the high frequency radar system: the Digital Video Logger (DVL), the control module, the transmitting transducer and the receiving transducer. The control module is attached to the back of the DVL. The transducers are connected to the control module via the transducer cables (Figure 2-2).

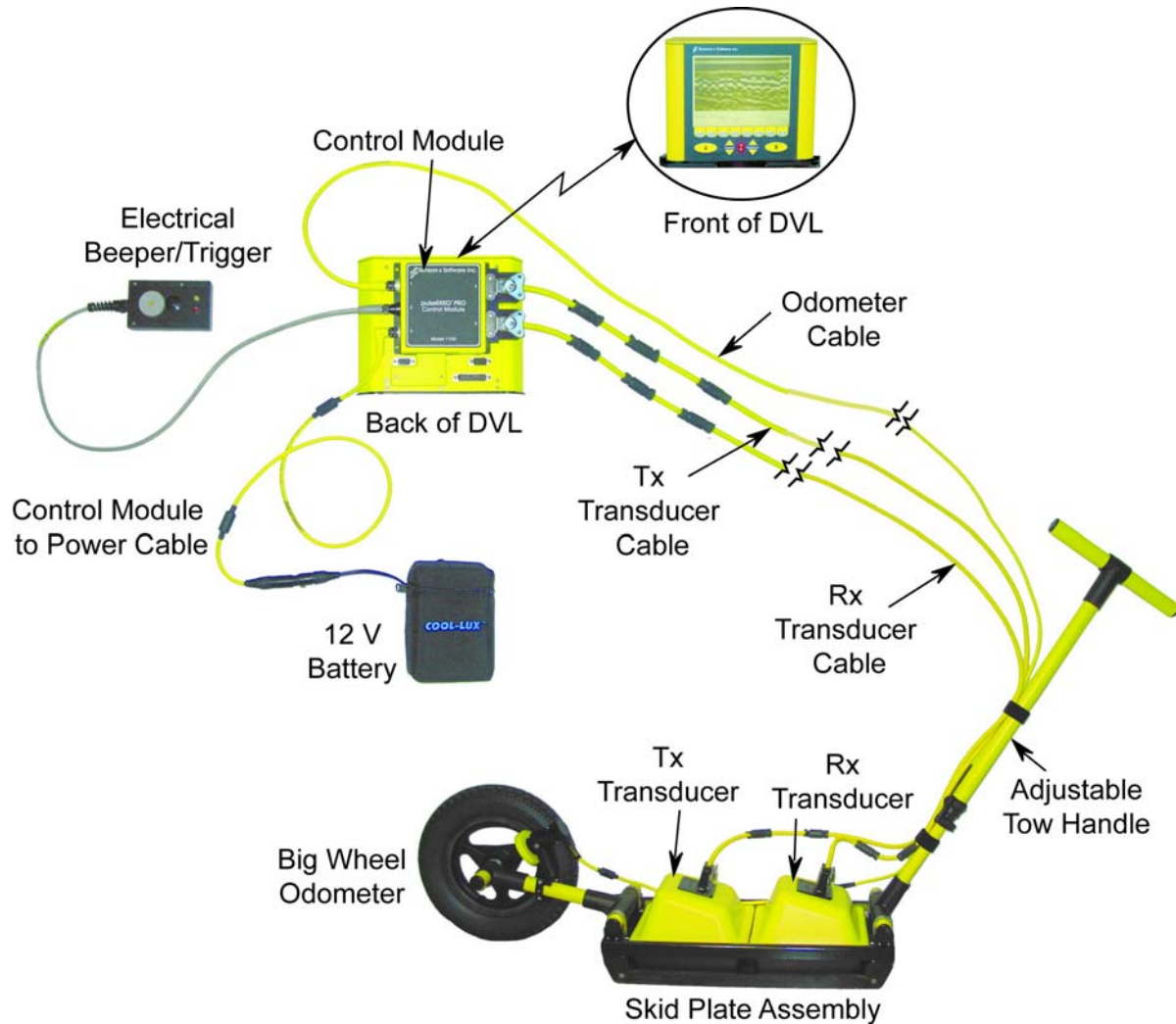


Figure 2-2: The complete high frequency pulseEKKO PRO tow mode assembly.

2.2 DVL and Control Module

The DVL and Control Module are common to all configurations.

2.2.1 Attaching the Control Module to the DVL

The control module unit must be attached to the back of the DVL (Figure 2-3). This may already have been done at the factory. Proceed to the next section, if this is the case.



Figure 2-3: The DVL with the control module attached to the back.

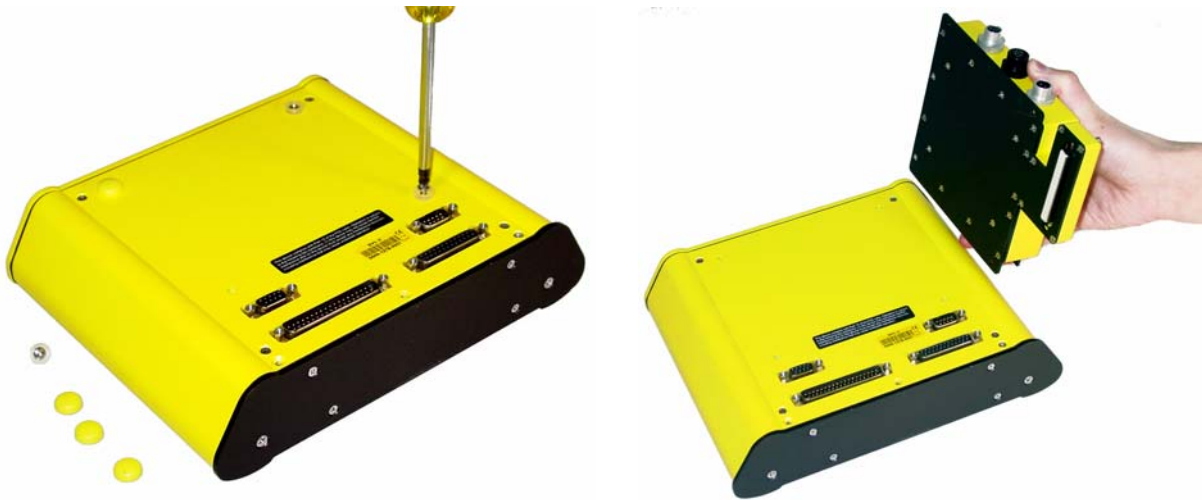


Figure 2-4: Remove the 4 yellow caps and the 4 screws from the back of the DVL (left) and place the control module on the back of the DVL (right). Make sure that the 37 pin connector is aligned properly with the 37 socket connector on the control module.



Figure 2-5: Attach the control module to the DVL using the 4 screws supplied (left) and a Phillips screwdriver (not supplied). Tighten the 37 pin connectors into place (right) with a small slotted screwdriver (not supplied).

2.2.2 Attaching the Fibre Optic Converters for Low frequency Antennas

Low frequency, unshielded antennas in the frequency range from 12.5 to 200 MHz require fibre optic cables to connect the transmitter and receiver to the control module. Higher frequency, shielded antennas use electrical cables to connect the transmitter and receiver to the control module. The control module is designed to accept both types of cables.

For low frequency antennas, the Electronic to Fibre Optic Converters must be attached to the control module and secured using the latches (Figure 2-6).



Figure 2-6: Low frequency antennas (12.5 to 200 MHz) require the electrical to fibre optic converters to be attached to the control module and secured using the latches.

2.3 Low Frequency Transmitter, Receiver and Antenna Assembly

2.3.1 Low Frequency Antennas

The pulseEKKO PRO can be used with many different antennas. There are 5 low frequency, unshielded, bistatic antennas available: 12.5, 25, 50, 100 and 200 MHz (Figure 2-7). The best frequency of antenna to use on a survey depends on the survey objectives (Section 3.2.1: P34).

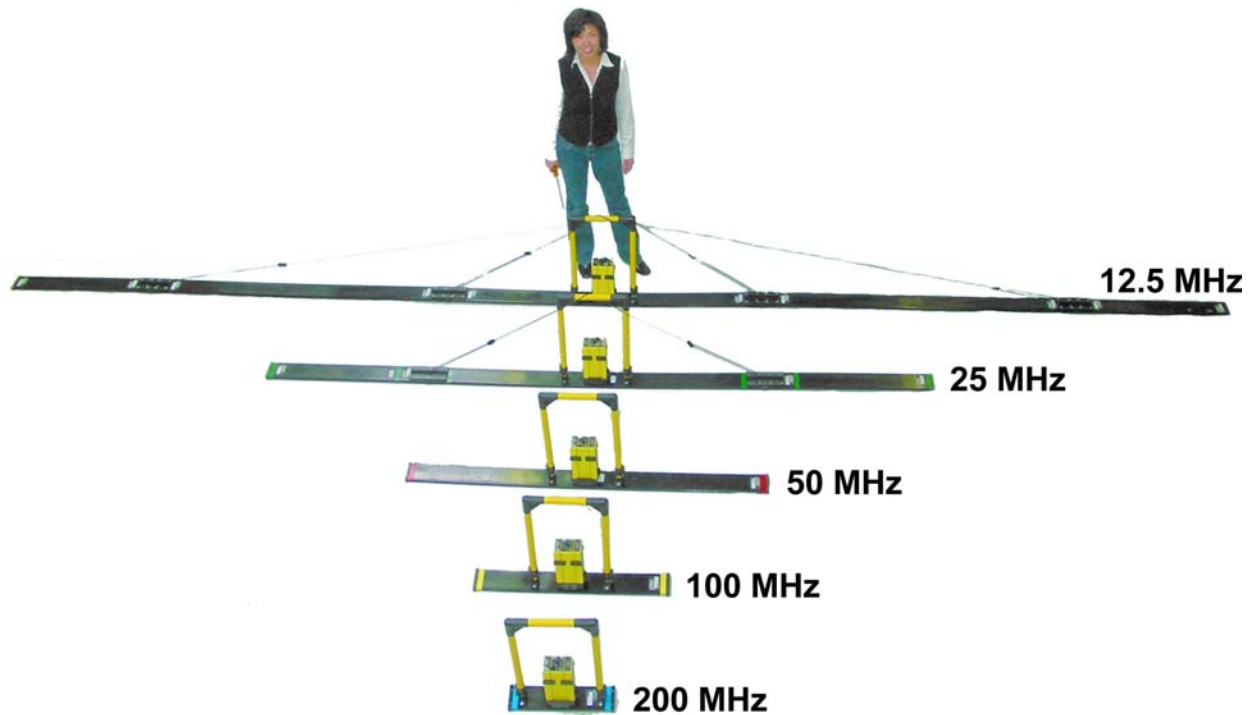


Figure 2-7: Low frequency, unshielded, bistatic antennas available for the pulseEKKO PRO. The antennas come in pairs; one transmitting antenna and one receiving antenna. The shortest antennas, the 200 MHz, are 0.5 metres long while the longest, the 12.5 MHz are 8 metres long.

The procedure for attaching the transmitter and receiver to any low frequency antenna is outlined below.

2.3.2 Attaching the Sockets to the Transmitter and Receiver

Insert and tighten the two female brass antenna sockets into the bottom of the transmitter and receiver electronic boxes (Figure 2-8). Tighten the sockets finger-tight. **DO NOT APPLY UNDUE FORCE!**

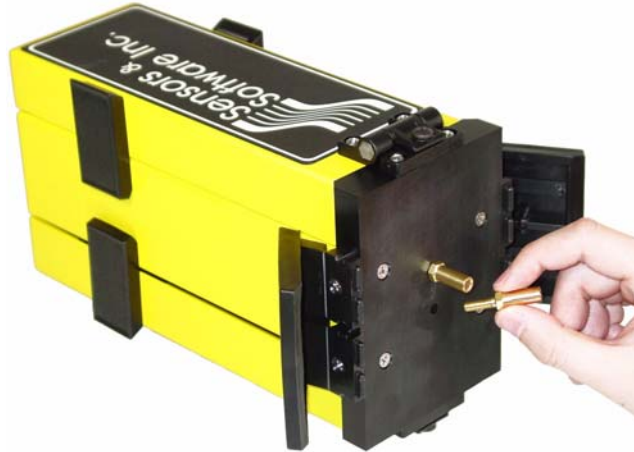


Figure 2-8: Hand tighten the brass sockets into the bottom of the transmitter and receiver.

2.3.3 Inserting Pins into the Antennas

Insert the two male brass antenna pins into the two threaded holes in the center of the antennas. Tighten the pins finger-tight (Figure 2-9). **DO NOT APPLY UNDUE FORCE!**



Figure 2-9: Insert the male brass antenna pins into the holes on the top of the antenna and finger-tighten.

2.3.4 Attaching the Mounting Blocks to the Antennas

Attach the antenna mounting blocks to the antennas by using the flathead screwdriver to tighten the 4 (four) quarter-turn fasteners, ensuring that the male brass antenna pins protrude up the center holes of the mounting blocks (Figure 2-10). Quarter-turn fasteners work by aligning the screw in the socket and then pressing downward and tightening a quarter of a turn. **DO NOT APPLY UNDUE FORCE.** It is usually best to have all four of the quarter-turn fasteners properly aligned in their sockets before tightening them. To do this, put slight pressure on the quarter-turn fastener and rotate it until you feel it drop into the socket. Then align the other three quarter-turn fasteners in the same manner. Once complete, go back and tighten all of them.

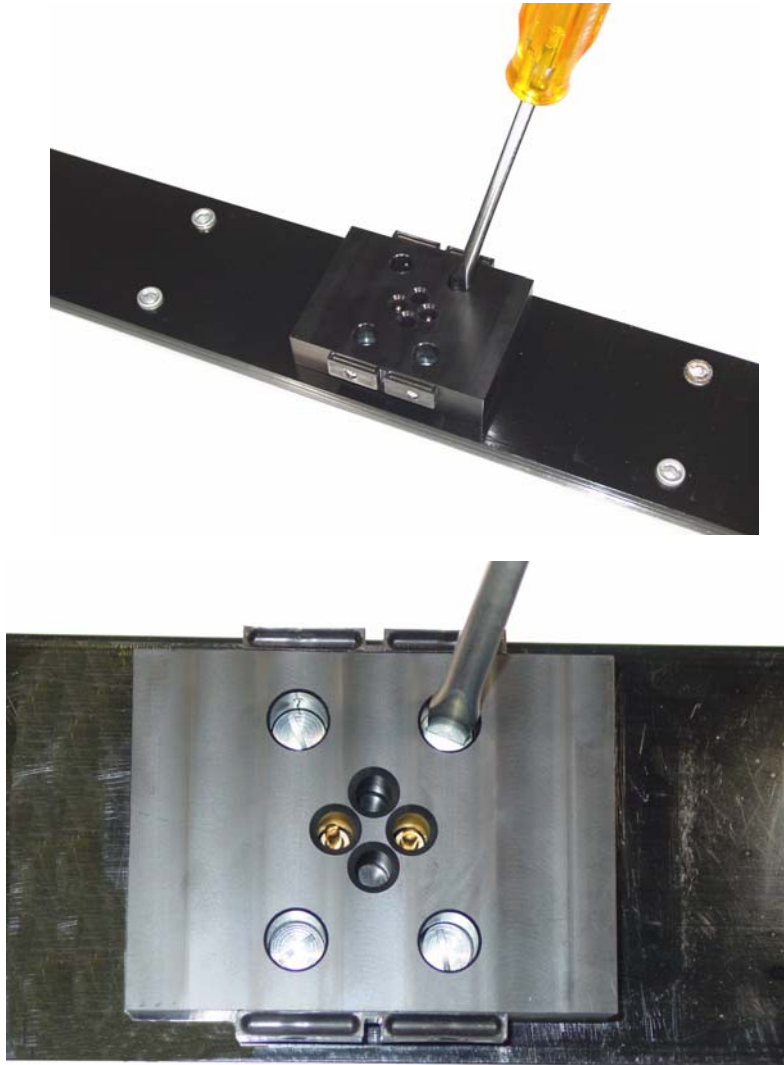


Figure 2-10: Attach the mounting blocks to the top of the antenna using the 4 quarter-turn fasteners. Before doing so, make sure that the 2 male brass antenna pins have been screwed into the top of the antenna first.

2.3.5 Latching the Transmitter and Receiver to the Mounting Blocks

Carefully place the transmitter and receiver electronic boxes down onto the mounting blocks such that both brass pins fully connect (Figure 2-11 Left). Then use the 2 plastic draw latch connectors to hold the electronics boxes onto the mounting block (Figure 2-11 Right).

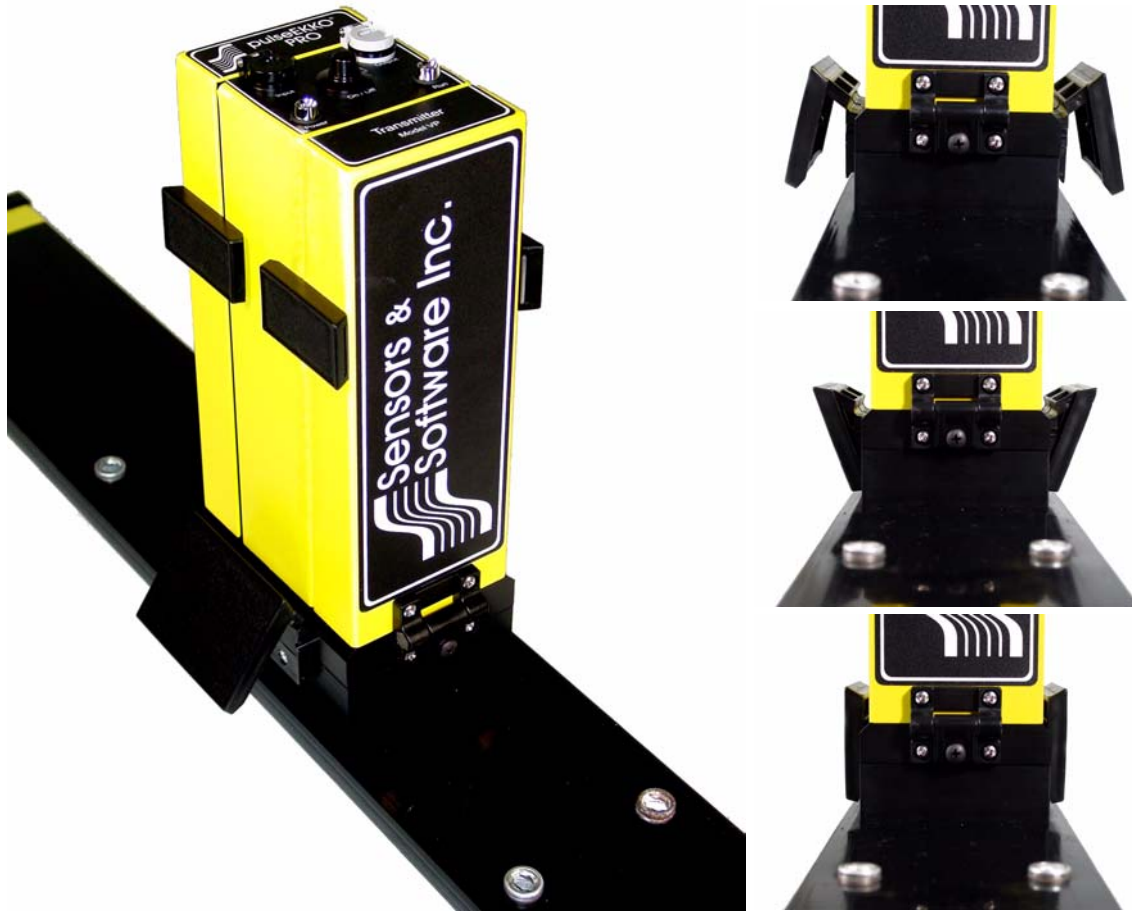


Figure 2-11: Attaching the Transmitter and Receiver to the antennas.

2.3.6 Inserting Batteries into the Transmitter and Receiver

With the transmitter and receiver power switched OFF, unlatch the 2 battery covers on the sides of the electronics and open (Figure 2-12). Place one 12-volt battery on each side on the electronics boxes making sure the positive (+) terminal faces inward toward the electronics (Figure 2-13). The battery is “keyed” with a notch in one side so it only fits properly in this orientation. Close and latch the battery covers.



Figure 2-12: Opening the battery compartment doors.



Figure 2-13: Insert the 12 Volt battery into the battery compartment making sure that battery polarity is correct. The positive (+) terminal faces inward. The battery is “keyed” so it will only seat properly in the compartment if it is in the correct orientation.

2.3.7 Attaching Handles

2.3.7.1 Attaching the Adjustable Handles

Attach the adjustable handle to the antenna using the flat head screwdriver to tighten the 4 quarter-turn fasteners as with the mounting block (Figure 2-14).

This handle can then be adjusted for height by loosening the 2 levers by hand, moving the handle to the desired height and retightening the levers (Figure 2-15).



Figure 2-14: Attach the adjustable handles to the antennas by tightening the 4 quarter-turn fasteners. Adjust the height of the handle by loosening the levers at the base of the handles (right) and pulling the handles up to the correct height.



Figure 2-15: Once the handles have been adjusted to the correct height, lock them into place by tightening the levers as shown on the right.

2.3.8 Connecting the Fibre Optic Cables

The next step is to connect the transmitter and receiver to the control module.

- a) The pulseEKKO PRO low frequency system uses 2 dual fibre optic cables like the one shown in Figure 2-16. These cables should be tested periodically (Section 7.2: P99) and inspected for kinks or signs of damage and repaired if necessary (Section 9.6: P113).



Figure 2-16: Dual fibre optic cable used with the transmitter and receiver. The black and grey strain reliefs on the end of the cable (left) plug into the same coloured fibre optic receptacles on the top of the transmitter and receiver (see Figure 2-17). The connection on the other end of the cable (right) connects to either fibre optic receptacle on the control module (see Figure 2-18).

- b) To connect the pulseEKKO PRO in the standard configuration shown in Figure 2-1, plug the dual fibre optics cable into the transmitter making sure the colour on the strain relief jacket matches the colour of the receptacle door, black to black and grey to grey (Figure 2-17). Confirm that the fibre optic connection is seated properly by pushing down gently until the connection “clicks” into place.
- c) The pulseEKKO PRO system can be used with a pulseEKKO 100 transmitter (Section 3.2.8: P41). If the transmitter is a pulseEKKO 100 transmitter, the fibre optic **Output** connection on the transmitter should **NOT** be connected.



Figure 2-17: Attaching the fibre optic cables to the transmitter and receiver. Make sure to match the connector colour to the door colour (grey to grey and black to black). Push the fibre optic cable down until you can feel it “click” into place.

- d) After attaching the dual fibre optic cables to the transmitter and receiver, the other end of the fibre optic cables are attached to the fibre optic converters on the control module (Figure 2-18). The fibre optic cable from the transmitter connects to the fibre optic converter labelled 4. The fibre optic cable from the receiver connects to the fibre optic converter labelled 5. Note that the fibre optic connection at the control module is keyed and will only attach properly in one orientation.



Figure 2-18: The dual fibre optic cable from the transmitter and receiver attaches to the electrical to fibre optic converters on the control module. The fibre optic cable from the transmitter connects to the control module receptacle labelled 4 while the fibre optic cable from the receiver connects to the control module receptacle labelled 5. This connection is keyed so it will only attach when the fibre optic cable is in the orientation shown.

2.4 High Frequency Transducer Assembly

2.4.1 High Frequency Transducers

The pulseEKKO PRO can be used with many different antennas.

Low frequency antennas in the range from 12.5 to 200 MHz were shown earlier (see Figure 2-7).

There are also 3 high frequency, shielded, bistatic antennas available: 250, 500 and 1000 MHz (Figure 2-19). Each antenna box is really a “transducer” because it consists of both an antenna and the electronics. The transmitting transducer is indicated with a “T” on the label, e.g. T500, while the receiving transducer is indicated with an “R” on the label, e.g. R500.

The best frequency of antenna to use on a survey depends on the survey objectives (see Antenna Frequency, Section 3.2.1: P34)

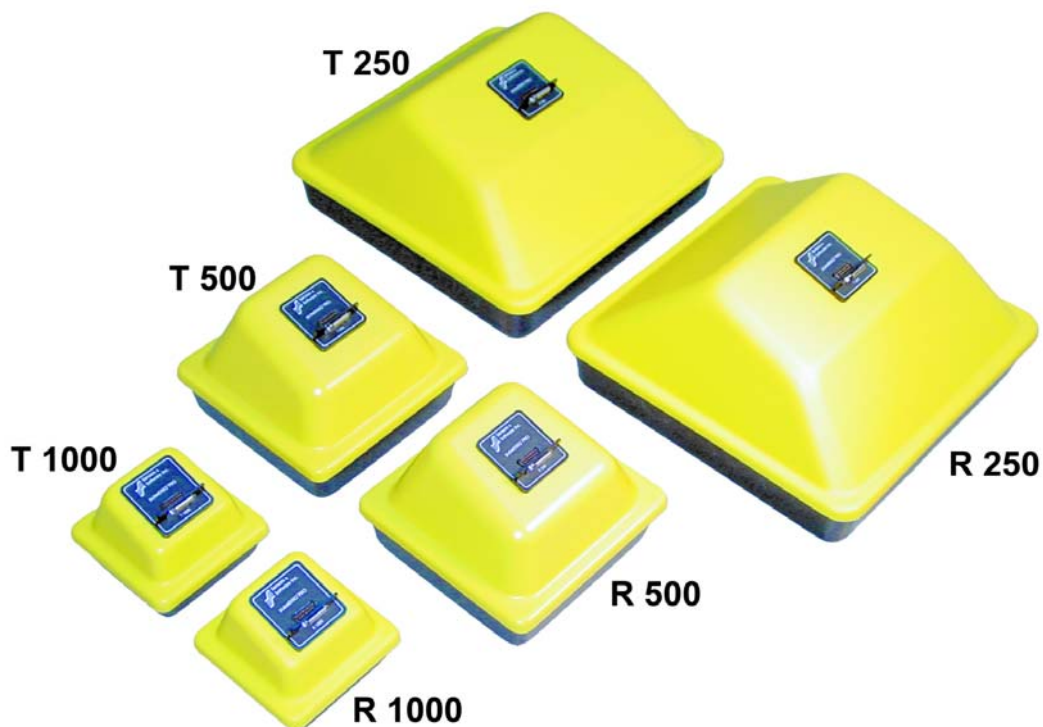


Figure 2-19: High frequency, shielded, bistatic antennas available for the pulseEKKO PRO. The antennas come in pairs, one transmitting transducer and one receiving transducer. These are indicated by an “T” and “R” on the labels. The 1000 MHz transducers are 14.5 cm (6 in) across, the 500 MHz transducers are 22.5 cm (9 in) across and the 250 MHz transducers are 38 cm (15 in) across and all are square.

The procedure for attaching the transducers to the skid plate and attaching to the adjustable tow handle is described below.

2.4.2 Mounting Transducers to the Skid Plate

Skid plates are sized to fit a pair of transducers positioned side by side.

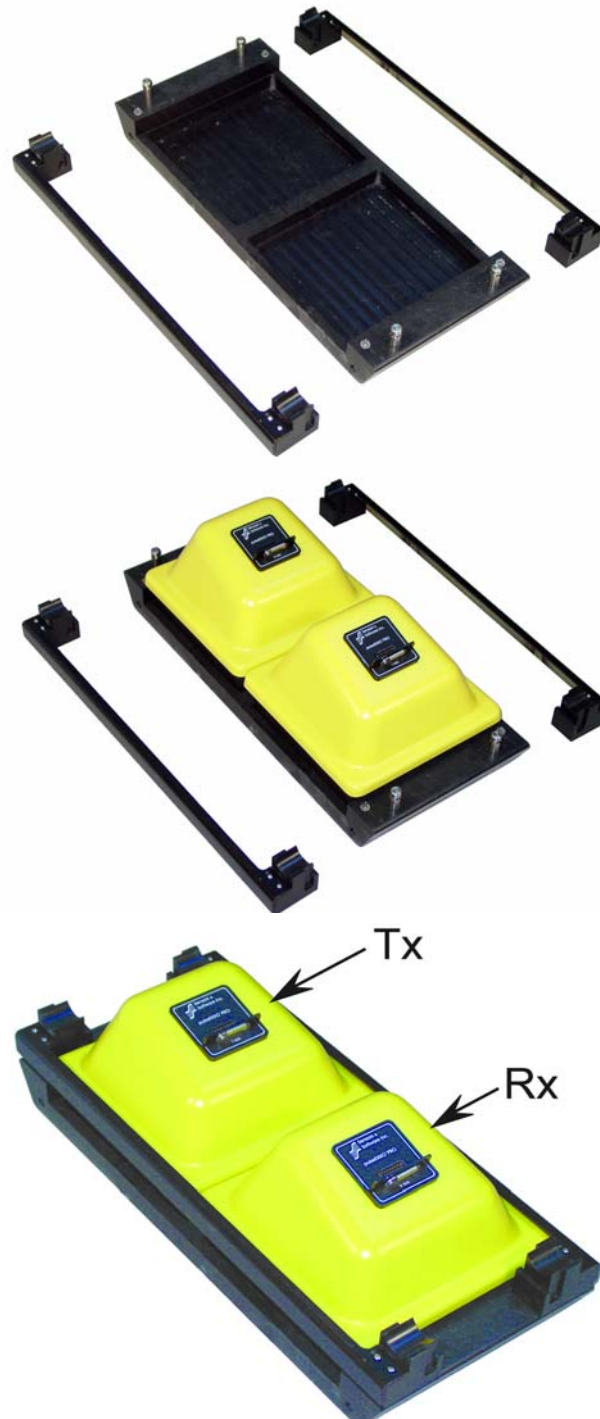


Figure 2-20: Mounting the transducers onto the skid plate. The skid plate assembly consists of the bottom piece and two side flanges (top). The transducers are placed onto the bottom skid plate with the labels facing the same direction (middle) with the receiving transducer (R500) in front of the transmitting transducer (T500). The transducers are held onto the skid plate by placing the two flanges over the mounting posts. The above images show the assembly of the 500 MHz transducers onto the 500 MHz skid plate. The procedure for the 250 and 1000 MHz transducers onto their skid plates is exactly the same.

2.4.3 High Frequency Hand-Towed System

One method of deploying the high frequency antennas is the Hand-towed configuration that includes the adjustable tow handle and an odometer. This section details the assembly of this configuration.

2.4.3.1 Attaching the Adjustable Tow Handle



Figure 2-21: To attach the adjustable tow handle to the skid plate assembly, place the T end of the handle into the trough on the end of the skid plate assembly where the receiving transducer label is facing. The T end of the handle is attached to the skid plate assembly by placing the U-bracket over the top and into the vertical slots. The handle is secured into place by inserting the metal pins into the holes at the bottom of the U bracket.

2.4.3.2 Attaching the Big Wheel Odometer



Figure 2-22: The big wheel odometer. Ensure that the small yellow odometer is tightly pressed against the rim of the wheel so that it spins when the big wheel is rotated.



Figure 2-23: The big wheel odometer attaches to the skid plate assembly exactly the same way as the adjustable tow handle is attached. Place the T end of the odometer into the trough on the end of the skid plate assembly. The labels on the transmitting transducer should be facing away from this end. The T end of the odometer is attached to the skid plate assembly by placing the U-bracket over the top and into the vertical slots. The odometer is secured into place by inserting the metal pins into the holes at the bottom of the U bracket.

2.4.3.3 Connecting the Odometer Cable to the Control Module

The Big Wheel Odometer comes with a long cable that extension to allow it to connect to receptacle 1 on the control module (Figure 2-24). The Big Wheel Odometer and odometer cable can be seen in the complete system configuration (See Figure 2-2 on page 3).



Figure 2-24: The Big Wheel Odometer uses a long extension cable (not shown) to attach to receptacle 1 on the control module.

To acquire data with an odometer, the Trigger Method must be set to Odometer (Section 3.3.1.2: P43).

2.4.3.4 Connecting the Transducer Cables

The next step is to connect the transducers to the control module.



Figure 2-25: Connecting the transducer cables to the transducers. The connections are secured with latches.



Figure 2-26: Connecting the transducer cables to the Control Module. The transducer cable from the transmitting transducer connects to the control module receptacle labelled 4 while the transducer cable from the receiving transducer connects to the control module receptacle labelled 5. The cable attachments are secured with latches.

2.5 Adding Accessories

There are several accessories that can be connected to the pulseEKKO PRO system. These include two types of beeper/triggers, odometers, GPS and the DVL Carrier. These are described below.

2.5.1 Electrical Beeper/Trigger Unit

The Electrical Beeper/Trigger comes as a standard accessory with the pulseEKKO PRO system.

To connect the electrical beeper/trigger unit, attach it to receptacle 2 on the control module (Figure 2-27). This connector will only attach to the number 2 receptacle on the control so there is no chance of error.

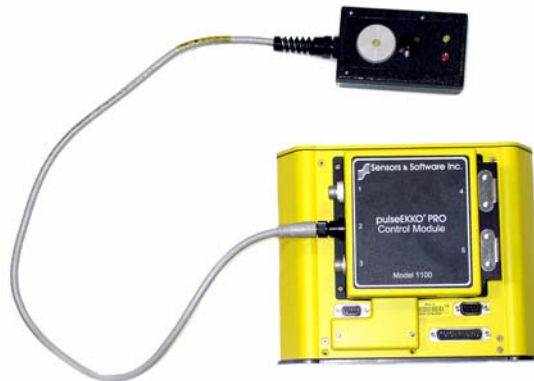


Figure 2-27: Attach the electrical Remote Beeper/ Trigger unit to the control module receptacle labelled 2.

When the radar system is run with the Trigger Method set to CANBUS (Section 3.3.1.1: P43), data acquisition can be controlled using the button on the electrical beeper/trigger unit.

As well, during data acquisition, the beeper will emit a sound as data are being collected, as long as the Beeper Activated option (Section 3.3.2: P43) is set to CANBUS.

Another method of triggering the system is to set the Trigger Method to DVL button (Section 3.3.1.1: P43) and the Beeper Activated option to CANBUS (Section 3.3.2: P43). Pressing the B button the DVL will trigger the system to acquire a data trace and an audible beep from the electrical beeper/trigger unit will indicate when data are being collected.

If the DVL carrier is included as part of the system (see Section 2.5.3 DVL Carrier on page 23), the user may find it convenient to attach the electrical Beeper/Trigger to the frame of the DVL carrier.

2.5.2 Fibre Optic Beeper/Trigger Unit

The Fibre Optic Beeper/Trigger unit is an optional component for triggering the low frequency system to collect data. It serves the same function as the standard Electrical Beeper and Trigger (Figure 2-27) unit but can attach to the handle of the transmitting antenna so that the antenna operator can control the data collection.

To attach the Fibre Optic unit to the pulseEKKO PRO handles, insert the end of the hand screw through the hole in the adjustable handle attached to the transmitting antenna and tighten it into the unit (Figure 2-28).



Figure 2-28: Attaching the Fibre Optic Remote Beeper/Trigger unit to the transmitter handle.

To connect the fibre optic remote beeper/trigger unit you should have the dual fibre optic cable for the control module to transmitter connection plus a short single fibre optic cable (Figure 2-29). One of the two cables on the dual fibre optic cable should already be connected to the **Input** (black) receptacle on the transmitter.

Figure 2-29 illustrates the proper connection of the Fibre Optic Remote Beeper/Trigger unit. Ensure that:

- 1) The second fibre optic cable of the dual cable connects to the **Output** (grey) fibre optic connector on the remote trigger and beeper unit. This connection enables the trigger part of the remote beeper/trigger unit to work.
- 2) The short single fibre optic cable connects from the **Input** (black) fibre optic connector on the remote trigger and beeper unit to the **Output** (grey) receptacle on the transmitter. This connection enables the beeper part of the remote beeper/trigger unit to work.

Note that if you have a pulseEKKO 100 transmitter (Section 3.2.8: P41) you cannot use the pulseEKKO PRO fibre optic beeper/trigger.

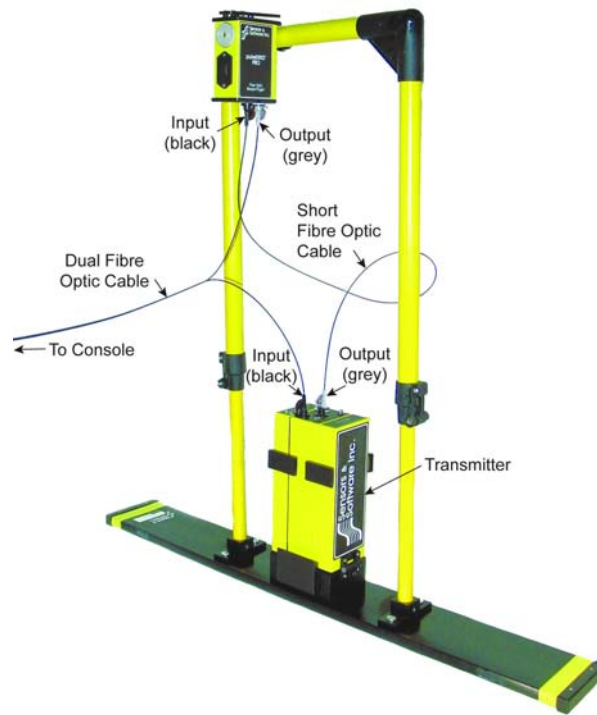


Figure 2-29: Fibre optic cabling details for the Fibre Optic Remote Beeper/Trigger unit.

The Fibre Optic Remote Beeper/Trigger unit is powered by one 9 Volt battery that slides into the battery compartment (Figure 2-30). Please note the proper polarity of the battery. An alkaline 9V battery will normally power the unit for 3-5 hours of heavy use so it is a good idea to have spare 9 Volt batteries available. Lithium 9V batteries are also available that will power the unit for approximately 20 hours. When the voltage from the battery is gets too low, the red light on the top of the Fibre Optic Remote (not visible in the figures) will start to flash. This indicates that the battery should be replaced within approximately 30 minutes.



Figure 2-30: The Fibre Optic Remote Beeper/Trigger unit operates with a 9 Volt battery that can be accessed by opening the battery compartment on the side of the unit.

To turn the Fibre Optic Remote Beeper/Trigger unit on, depress the thumb lever on the top of the unit and hold it down for 3 seconds. The red light will come on and start to flash. After 3 seconds the unit will beep 3 times and the red light will stop flashing and stay on. This indicates that the unit is ready for data collection.

To turn the Fibre Optic Remote Beeper and Trigger unit off, depress the thumb lever and hold it down for 3 seconds. After 3 seconds the unit will beep once and the red light will go out.

The fibre optic beeper/trigger will automatically turn off after 7 minutes of non-use.

When the radar system is run with the Trigger Method set to Fibre Optic (Section 3.3.1.1: P43), data acquisition can be controlled using the thumb lever on the remote beeper/trigger unit.

During data acquisition, the beeper will emit a beep as data are being collected, as long as the Beeper Activated (Section 3.3.2: P43) is set to Fibre Optic.

2.5.3 DVL Carrier

For convenience during data acquisition, the DVL and control module can be carried using the optional DVL Carrier shown in Figure 2-31.



Figure 2-31: The DVL and control module can be attached to the optional DVL Carrier for hands-free operation. The DVL can be adjusted to optimize the view angle.

2.5.4 Odometers

The pulseEKKO PRO system can accept an odometer input to trigger the system to acquire data at equal distance intervals (Step Sizes). An odometer eliminates the necessity of using a tape measure or survey makers.

The pulseEKKO PRO is designed to work with a number of different odometers. This includes the Big Wheel Odometer (See Figure 2-23 on page 17), the SmartCart odometer (Figure 2-32 below) as well as vehicle odometers available from Sensors & Software.

The odometer has an electrical connection to receptacle 1 on the control module (Figure 2-32).



Figure 2-32: The pulseEKKO PRO accepts input from various odometers including the wheel odometer shown in the figure, which is typically used with the SmartCart. Odometers attach to receptacle 1 on the control module.

When the radar system is run with the Trigger Method set to Odometer (Section 3.3.1.2: P43), data acquisition is controlled by the odometer.

2.5.5 GPS

The DVL has a serial port on the back for attaching a GPS receiver. This port will accommodate any GPS receiver that has a standard NMEA string output through the serial port.

The DVL settings will need to be changed to accommodate the input of GPS data (Section 3.3.4: P44).



Figure 2-33: Attaching a GPS to the serial port on the back of the DVL.

2.6 Starting the pulseEKKO PRO System

2.6.1 Powering the DVL and Control Module

Connect the Control Module to Power Supply Cable to the receptacle labelled 3 on the control module (Figure 2-34) This cable will only fit on the number 3 receptacle. Note that the other end of this cable has an XLR connector. Power can be supplied to the DVL by using a battery (normally supplied by Sensors & Software) with the mating XLR connector.

If powering the DVL with a user-supplied standard 12 Volt battery, connect the optional Power Cable Extension with Alligator Clips to the end of the Control Module to Power Supply Cable (Figure 2-34). The alligator clips can then be connected to a 12 Volt battery. Make sure that the black clip is attached to the negative (-) and the red clip is attached to the positive (+) battery terminals. If the alligator clips are connected to the wrong terminals of the battery, the DVL will not be powered. When the DVL is receiving power the upper red light on the front of the DVL will be illuminated.

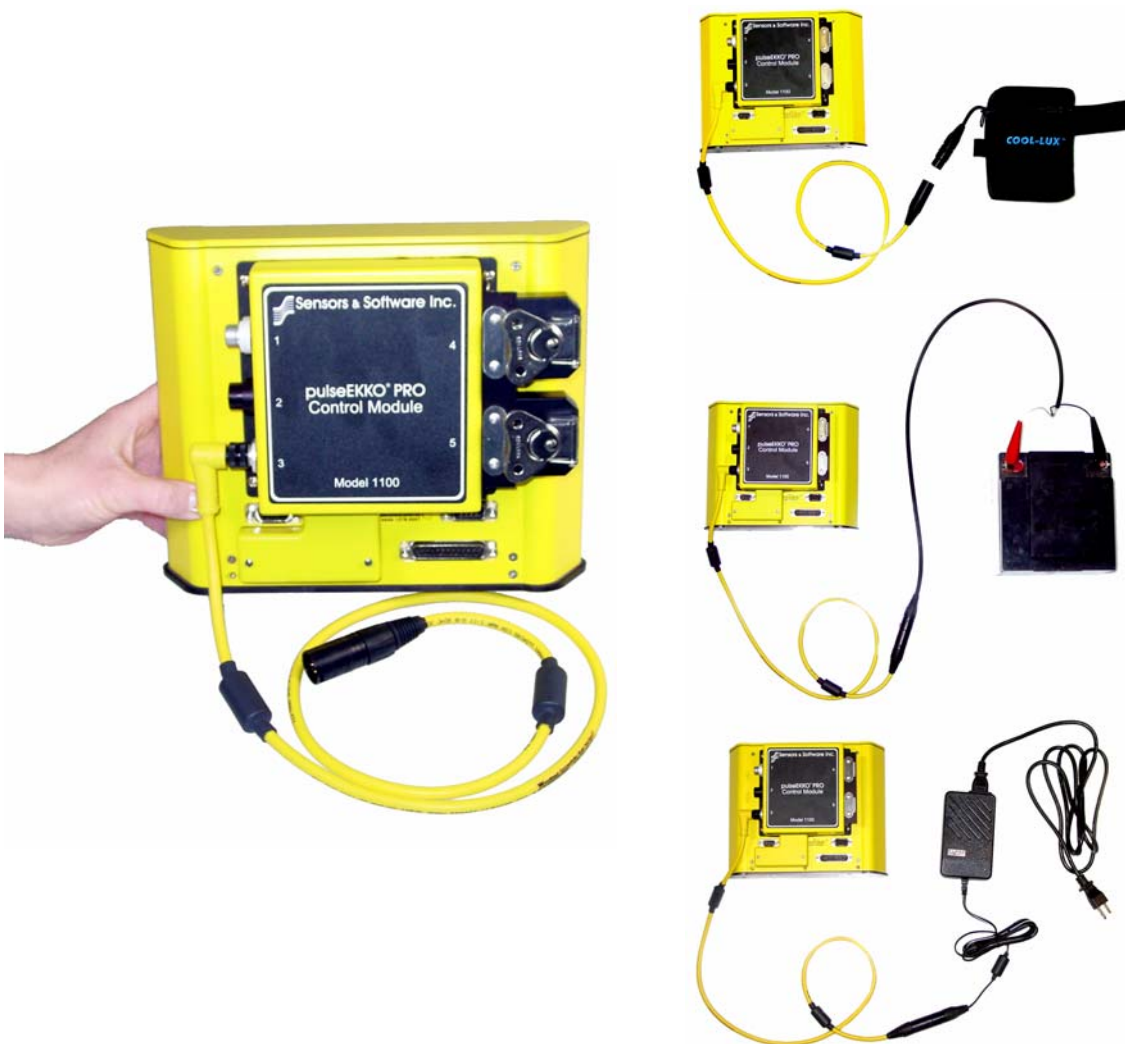


Figure 2-34: Attach the Control Module to Power Supply Cable to receptacle 3 on the control module (left). The DVL and control module can then be powered using the battery with the XLR connector supplied by Sensors & Software (top right). This battery may be a belt battery (shown) or a larger SmartCart battery. Using the optional alligator clip cable, the DVL and control module can also be powered using any standard 12 Volt battery (middle right). The DVL and control module can also be powered using the supplied AC mains (bottom right). This last option is used when powering the DVL in the office to download data.

2.6.2 Powering the Low Frequency Transmitter and Receiver

Turn the transmitter and receiver ON by pressing the button on the top of each unit. The red Power LED on the top of the unit will flash 5 times and then stay on to indicate the unit is ready for operation. If not, check that the batteries inside the Transmitter and Receiver are fully charged and have been inserted the right way.

When not collecting data, the transmitter and receiver should be turned OFF to increase the life of the batteries.

2.6.3 Digital Video Logger

Once all the cable connections are made between the control module, transmitter, receiver, the Digital Video Logger (DVL) and the battery, the upper red LED light on the DVL panel should be lit. If the battery voltage is too low, the LED light will flash for about 30 seconds and go out. If the light flashes or does not appear, check the connections and make sure the battery is fully charged.

The low voltage indicator can be helpful for identifying when the battery needs to be recharged. If the battery voltage drops too low the DVL will cease to operate.

The front of the DVL is shown in Figure 2-35. To start the system, press any button on the front panel. The DVL will begin to beep indicating it is booting up. The lower red LED on the front panel should illuminate.

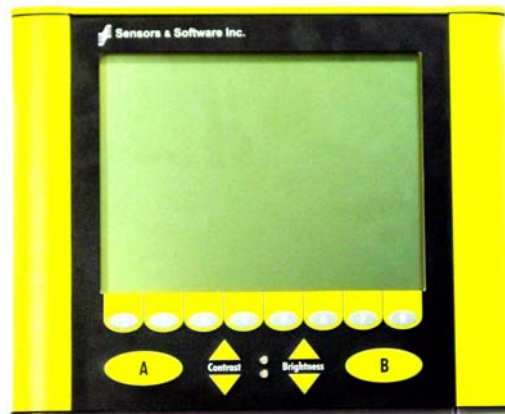


Figure 2-35: Digital Video Logger (DVL) face

The water-resistant membrane keypad has a number of buttons that can be pressed to perform various tasks.

Menu Buttons: The buttons labelled 1 to 8 correspond to menu choices that appear listed on the screen or along the bottom of the screen when the Digital Video Logger is turned on.

In addition, there are two general-purpose buttons labelled A and B. All buttons are DVL software application dependent and roles change. The operation will be self-explanatory from the display screen.

Screen: The DVL screen is a grey scale LCD selected for its wide temperature range and visibility in sunlight. Visibility can be a major problem with viewing GPR data displays outdoors and considerable effort has been expended on getting a readily visible outdoor display.

Brightness: The yellow Brightness control arrows are used to increase and decrease the screen brightness. Increasing the Brightness setting may improve the visibility of the screen in dark conditions.

Contrast: The yellow Contrast control arrows are used to increase and decrease the screen contrast. Increasing the Contrast setting may improve the visibility of the screen on a bright, sunny day.

Temperature sensors within the DVL automatically compensate the screen setting so that manual adjustments of Brightness and Contrast should seldom be needed after initial setup.

2.6.4 Main Menu

Once all components are properly connected, the radar is ready to operate under DVL control. Turn the DVL on by pressing any button on the front. After the DVL boots up the main menu is displayed (Figure 2-36). There is also a flow chart of the complete menu system on the DVL shown in Figure 2-37.

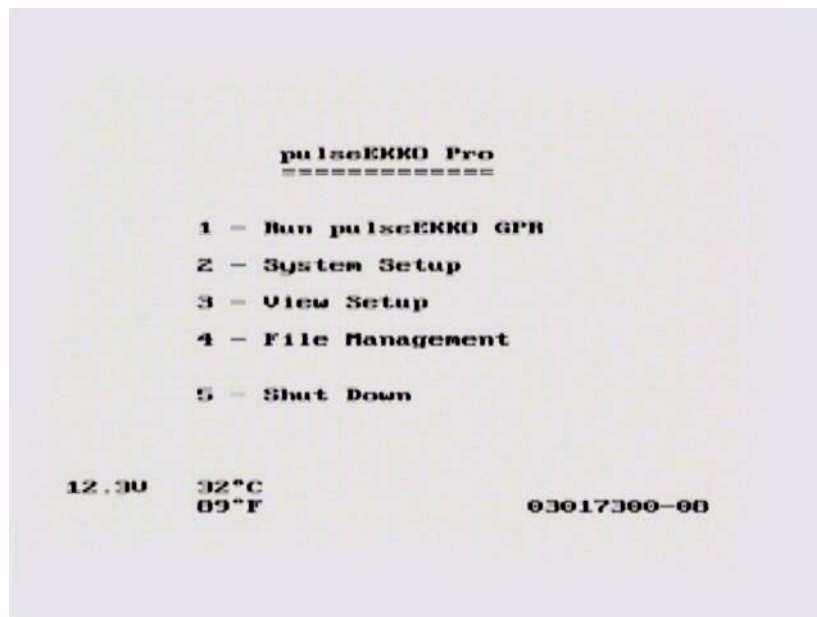


Figure 2-36: pulseEKKO PRO main menu screen on the DVL.

To begin acquiring data, press button number 1 for **Run pulseEKKO GPR**. Details about data collection are given in Section 4 on page 65.

To setup data collection parameters, press button number 2 for **System Setup**. Details about setting data collection parameters are given in Section 3 System Setup Parameters on page 31.

The current system setup parameters can be viewed by pressing button number 3 for **View Setup**.

Data files collected can be transferred to an external PC and deleted from the DVL using the **File Management** menu item. File Management can be selected by pressing button 4 from the main menu. Details about using File Management are given in Section 8 on page 104.

The DVL can be shut down by pressing button number 5. Exit also serves an important function. Before exiting, the program saves all the current parameters. This process enables the system to start up with the same settings as before it was last powered off. Therefore, the user should NOT shut off the DVL by only removing the power.

The two numbers displayed in the lower left corner of the main menu are the internal temperature of the DVL in Celsius and Fahrenheit and the voltage of the power supply running the DVL. When the DVL voltage drops to 10.2 Volts or less, the DVL will shut down. If this occurs in the middle of a data file, that file will be lost.

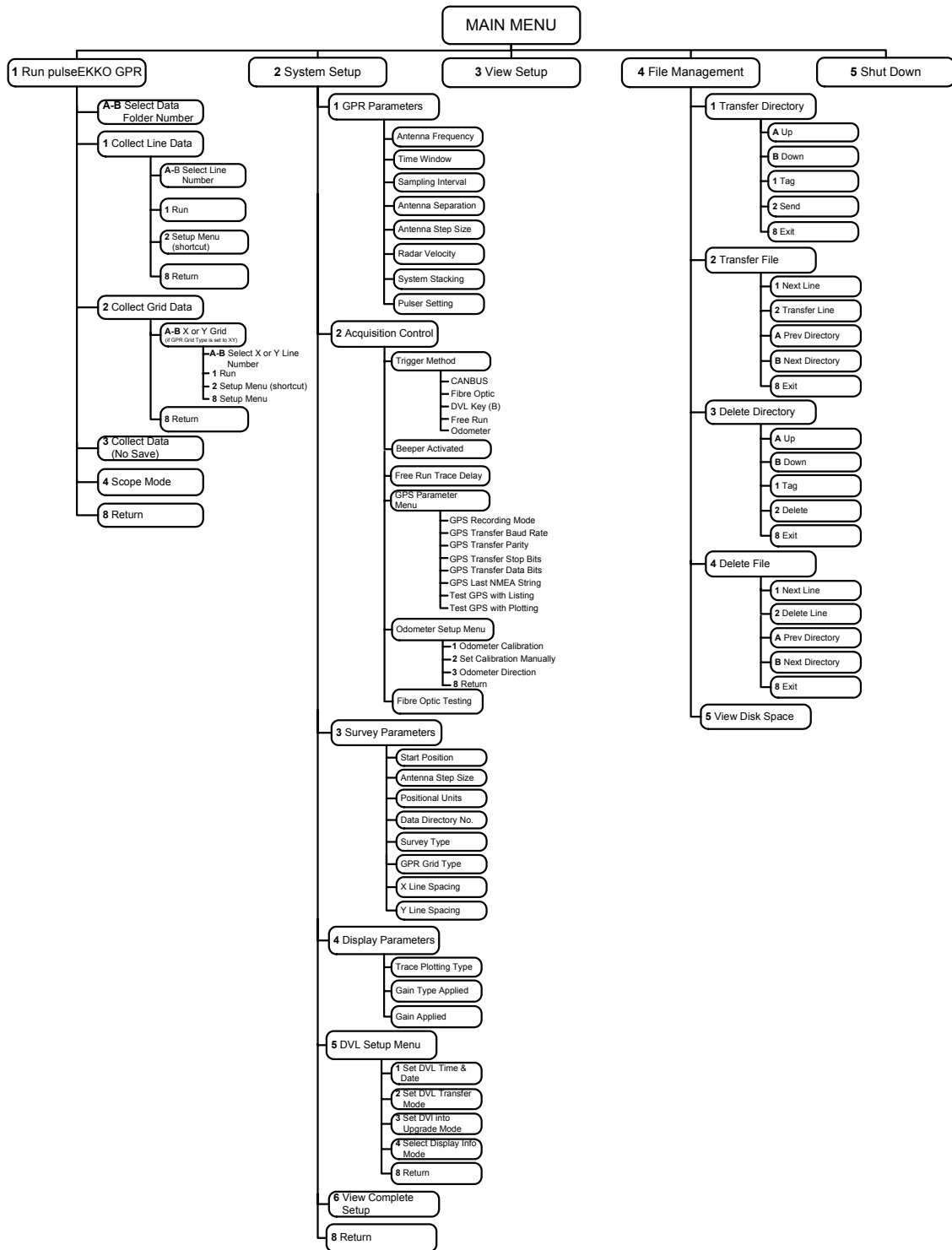


Figure 2-37: Flow chart of the complete pulseEKKO PRO DVL menu system.

2.6.5 Using the Software Menus

Menu items can be selected in one of two ways:

- 1) If the menu item has a number listed beside it, that item can be selected by pressing the corresponding button number on the DVL. For example, in the above menu (See Figure 2-36 on page 27), pressing the number 1 will select the option for running a pulseEKKO GPR system.
- 2) On a menu with items that are not numbered, one of the menu items will be flashing to indicate that it is currently selected. Pressing the button immediately below the word “Up” or “Down” to choose another option. Once the menu item is flashing, it can be changed to preset values by pressing the A or B buttons. Pressing the button under Return will take the user up to the previous menu level.

The above explanation may sound complicated but having used it a few times, the whole procedure will become intuitive after a few usages.

3 System Setup Parameters

The **System Setup** option from the main menu (See Figure 2-36 on page 27) is used to set up the data collection parameters.



Figure 3-1: The System Setup main menu is used to access and change any parameter used for data collection. Related parameters are grouped under different menu headings, for example, GPR Parameters list the variables specific to the GPR system. Select View Complete Setup from this menu to quickly locate the desired parameter and the heading it is listed under.

Selecting **View Complete Setup** from this menu or **View Setup** from the main menu (See Figure 2-36 on page 27) displays all the current parameter settings for the pulseEKKO PRO system. A screen display similar to the one in Figure 3-2 will be seen:

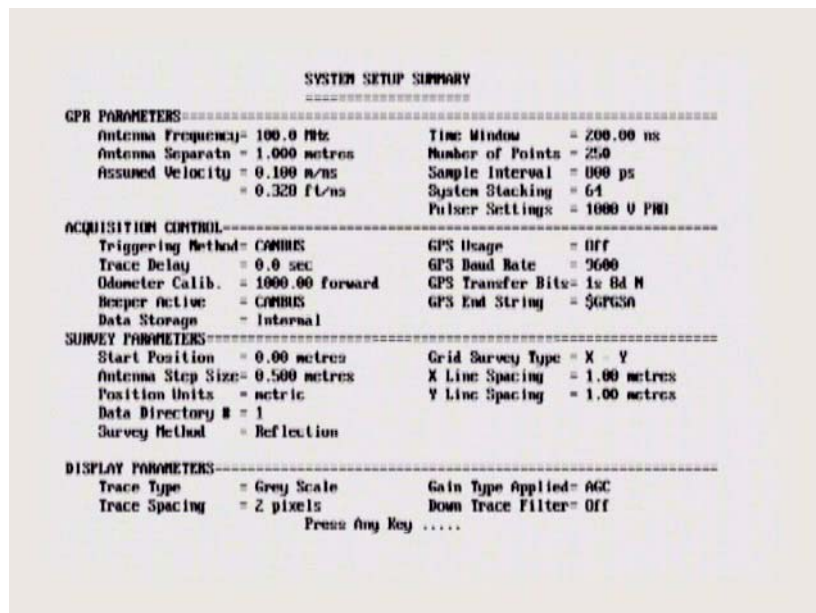


Figure 3-2: The **View Setup** option displays all the current settings and indicates which System Setup headings to select to change individual parameters. For example, select Acquisition Control to change the Triggering Method.

Figure 3-2 illustrates how many parameters must be set before data collection can start. While intimidating, many of the parameters can use the default values while many others are rarely changed at all.

3.1 System Parameters for a Quick Start to Data Collection

All the system parameters are detailed in this section but for a quick start to data collection, the most important parameters to consider before proceeding to the next section, Running in Scope Mode, and starting data collection are:

- 1) Frequency (Section 3.2.1: P34)
- 2) Time Window (Section 3.2.2: P35)
- 3) Sampling Interval (Section 3.2.3: P36)
- 4) Antenna Separation (Section 3.2.4: P37)
- 5) Antenna Step Size (Section 3.2.5: P38)
- 6) System Stacking (Section 3.2.7: P40)
- 7) Trigger Method (Section 3.3.1: P42)

3.2 GPR Parameters

Selecting the GPR Parameters menu option will display a screen similar to Figure 3-3. This section describes, in detail, each parameter listed in this menu.

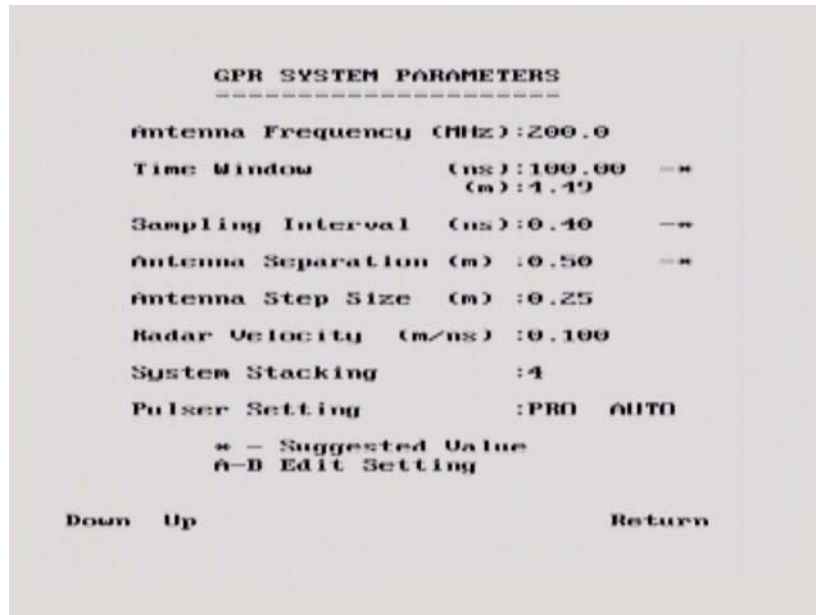


Figure 3-3: The GPR System Parameters menu. Use the Up and Down buttons to move to the desired parameter and edit the value by pressing the A and B buttons. Several of the parameters have suggested values, indicated by an asterisk (*), but these values can still be changed by the user.

3.2.1 Antenna Frequency

Deciding which antenna frequency to use for a survey depends on the objectives of the survey. As frequency decreases the depth of investigation generally increases but spatial resolution decreases. Therefore, the ideal survey will be one that uses the highest frequency that adequately penetrates to the target depth. This is not always easy to determine and often field experimentation with several different frequencies is necessary.

This parameter is set under System Setup - GPR Parameters - Antenna Frequency.

The following table offers a guide to frequency selection. It is based on the assumption that spatial resolution of the target is about 25% of the target depth. The values are based on practical experience and should be used as a quick guide only.

Depth (m)	Center Frequency (MHz)
0.5	1000
1.0	500
2.0	200
5.0	100
10	50
30	25
50	10

Note that the hardware cannot determine which antenna is attached. The user must correctly enter this parameter.

It is important that the correct frequency be entered since this value is used in many computations including pulse width, used in the DEWOW correction (Appendix B: GPR Signal Processing Artifacts), and for several default settings such as sampling interval (Section 3.2.3: P36).

3.2.2 Time Window

The Time Window setting determines how long (and therefore how deep) the radar system will probe the subsurface. It is important that it is set to a value appropriate for the depth of the survey target. An entire survey could fail if the window is not sufficiently long enough to sample to the depth of the target. Conversely, too long a time window increases the data volume and decreases productivity.

This parameter is set under System Setup - GPR Parameters - Time Window.

The Time Window value will be set to a default value based on the antenna frequency selected (Section 3.2.1: P34) as shown in the table below.

Frequency (MHz)	Default Time Window (ns)	Approximate Depth (m) with V=0.1m/ns	Approximate Depth (ft) with V=0.328ft/ns
12.5	1600	80	262
25	800	40	131
50	400	20	66
100	200	10	33
200	100	5	16
250	100	5	16
500	50	2.5	8
1000	25	1.25	4

Note: The default Time Window value may not be appropriate for the survey at hand. If not, the value can be changed by the user.

Since the radar system really measures time, and survey targets are at a specific depth, an estimate of velocity can be used to relate depth to time to obtain a good time window value. The DVL automatically calculates and displays a depth value based on the Time Window value and the current Radar Velocity value (Section 3.2.6: P39).

3.2.2.1 How Depth is Determined

Ground penetrating radar systems record the time for a radio wave to travel to a target and back. The depth to that target is calculated based on the velocity at which the wave travels to the target. In ideal reflection operation, depth is calculated as:

$$D = V \times T/2$$

Where D is Depth (m)

V is Velocity (m/ns)

T is Two-way travel time (ns)

The wave velocity depends on the properties of the material. The Noggin software allows the user to input different velocities, which changes the total depth range displayed on the screen. A value of 0.1 m/ns (or 0.33 ft/ns) is a good average value for geologic materials; a table of the velocities of common geologic materials is listed below (Section 3.2.6: P39).

3.2.3 Temporal Sampling Interval

The pulseEKKO PRO system samples the GPR signals returning to the receiver. The resulting GPR data is a series of numbers that represent signal amplitude at equally spaced time intervals. The time interval between points on the trace is called the Temporal Sampling Interval.

The sampling interval is dependent on the frequency of the antennas being used. Higher frequencies need to be sampled at a finer time sampling interval than lower frequencies.

This parameter is set under System Setup - GPR Parameters - Sampling Interval.

The Sampling Interval value will be set to a default value based on the antenna frequency selected (Section 3.2.1: P34) as shown in the table below. It can, however, be changed. **In general, the default Sampling Interval should NOT be changed by the user.**

The recommended temporal sampling interval versus antenna frequency is reproduced below:

Center Frequency (MHz)	Recommended Sampling Interval (ns)
12.5	6.4
25	3.2
50	1.6
100	0.8
200	0.4
250	0.4
500	0.2
1000	0.1

It is important not to choose a sampling interval that is too large for a particular frequency otherwise the data may be aliased (undersampled and thus not very representative of the real signal). Choosing a sampling interval too small will increase the data volume unnecessarily and may slow down the data collection process.

3.2.3.1 Determining the Number of Points per Trace

The number of points per trace is displayed in the View Setup screen (See Figure 3-2 on page 31). Points are calculated based on the time window length and the sampling interval. For example, using a time window of 300 ns and a sampling interval of 0.8 ns, the number of points is calculated as follows:

$$\begin{aligned}
 \text{points} &= \text{time window} / \text{sampling interval} \\
 &= 300 \text{ ns} / 0.8 \text{ ns} \\
 &= 375
 \end{aligned}$$

3.2.4 Antenna Separation

As the transmitting and receiving antennas are moved along a survey line, it is important that a separation be maintained between them. When the antennas are mounted on a cart the antenna separation is fixed, but when the antennas are not fixed in position, it is common to use a rope or measuring tape to maintain the proper separation (See Figure 6-4 on page 84).

This parameter is set under System Setup - GPR Parameters - Antenna Separation.

The Antenna Separation value will be set to a default value based on the antenna frequency selected (Section 3.2.1: P34) as shown in the table below.

Frequency (MHz)	Minimum Antenna Separation (metres)	Minimum Antenna Separation (feet)
12.5	8	26
25	4	13
50	2	6
100	1	3
110	1	3
200	0.5	1.5
250	0.38	1.25 (15 in)
500	0.225	0.75 (9 in)
1000	0.15	0.5 (6 in)

The rule of thumb is that the minimum antenna separation should equal the antenna length. For example, 100 MHz antennas are 1 metre long and should be kept about 1 metre apart during a survey. If the antenna spacing is too small, receiver electronics may be overloaded by the transmit signal resulting in data clipping (see Appendix B: GPR Signal Processing Artifacts for a discussion of this problem).

Note that this parameter has no meaning for any mode of operation where the antenna separation changes such as when collecting a CMP/WARR profile.

3.2.5 Antenna Step Size

This specifies the distance the antenna pair will be moved each time to collect a new trace during a Reflection mode survey (Section 3.4.5: P51).

To properly resolve subsurface targets spatially, it is important that a proper Antenna Step Size be selected. Too coarse a Step Size may result in missed subsurface targets while too fine a Step Size will result in large data volumes and slow survey productivity.

This parameter is set under System Setup - GPR Parameters - Antenna Step Size.

The Antenna Step Size value will be set to a default value based on the antenna frequency selected (Section 3.2.1: P34) as shown in the table below.

Frequency (MHz)	Recommended Antenna Step Size (metres)	Recommended Antenna Step Size (feet)
12.5	2	6
25	1	3
50	0.5	1.5
100	0.25	1
200	0.1	0.33 (4 in)
250	0.05	0.166 (2 in)
500	0.025	0.0833 (1 in)
1000	0.01	0.042 (0.5 in)

Note that the default values can be overridden by changing the Step Size value directly.

When using an odometer to collect data, make sure that odometer has been properly calibrated (Section 3.3.5.1: P48), otherwise positional information will be incorrect.

In CMP mode (Section 6.11: P91), the step size is interpreted to be the total increment in separation between each trace. Therefore, if each antenna is moved 0.25 metres then the Step Size is 0.5 metres.

3.2.6 Radar Velocity

If an accurate depth axis on the real-time display is desired, or the user wishes to see the approximate depth of penetration while setting the time window value (Section 3.2.2: P35), the user should supply the program with the average radar wave propagation velocity (in m/ns or ft/ns).

The best way to determine the radar velocity of the survey area is to extract the velocity using the Hyperbola Curve Fitting routine (Section 5.5.4.1: P75) or a Common Mid Point (CMP) survey (Section 6.11: P91).

Note that having an incorrect radar velocity value does NOT affect the quality of the GPR data collected. It will only affect the depth scale on the display. This can be changed later.

If it is not possible to determine the radar velocity directly, refer to the chart below which lists the radar velocities of various materials.

Material	Velocity (m/ns)	Velocity (ft/ns)
Air	0.30	0.98
Ice	0.16-0.17	0.52
Dry Soil	0.15	0.49
Dry Sand	0.15	0.49
Granite	0.13	0.43
Dry Salt	0.13	0.43
Dry Rock	0.12	0.39
Limestone	0.12	0.39
Wet Rock	0.10	0.33
Concrete	0.08-0.12	0.26-0.39
Pavement	0.10	0.33
Shales	0.09	0.30
Silts	0.07	0.23
Wet Soil	0.06	0.20
Wet Sand	0.06	0.20
Clays	0.06	0.20
Fresh Water	0.033	0.11
Sea Water	0.033	0.11

A velocity of 0.1 m/s or 0.33 ft/ns is a good value to use when uncertain about the velocity of the material being surveyed.

3.2.7 System Stacking

In noisy environments, one way of improving signal to noise is to collect more than one trace at each survey position, averaging them and recording the averaged trace. This is known as “trace stacking” or “stacking”. Data quality improves because the noise, which is usually a random addition to the trace, tends to zero when averaged while the GPR signal is constant, thus increasing the “signal-to-noise ratio”.

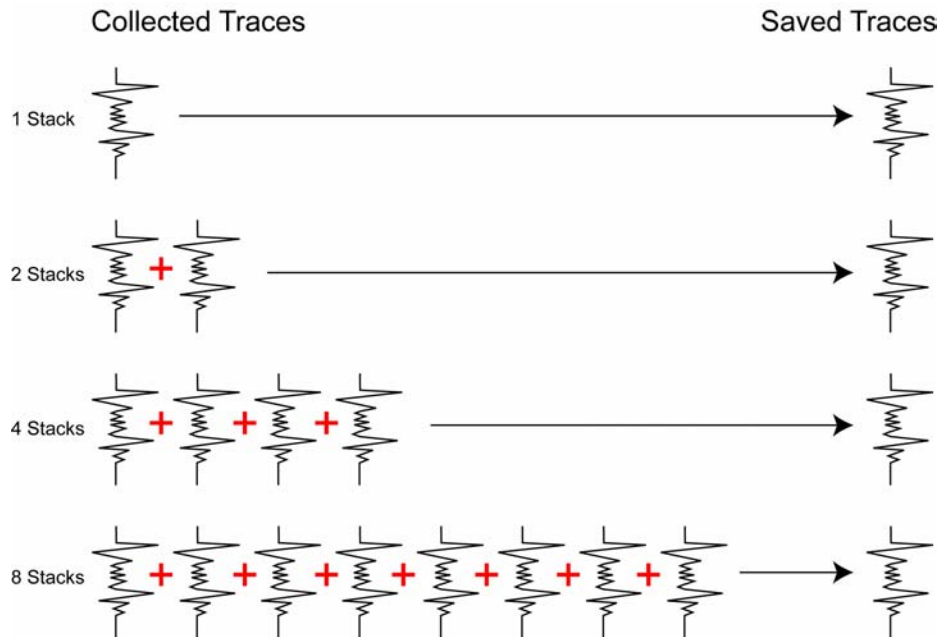


Figure 3-4: The concept of “stacking” data. At each data collection point, the trace is collected multiple times. These traces are averaged together to calculate the data trace that is actually saved. Stacking improves the data quality by improving the signal-to-noise ratio.

While stacking improves data quality, it may slow down survey production. The more stacks, the longer it takes to collect data at each survey position. Therefore, it is important to find the optimum number of stacks that still reveal the target adequately.

This parameter is set under System Setup - GPR Parameters - System Stacking.

While stacks can be set from 1 to 32767, for most surveys, stacking 4 to 64 times is suitable.

Stacking is normally reduced when: 1) the survey objective is looking for very strong responses or 2) production speed is vital, such as measurements made from a rapidly moving vehicle.

When the system is run in Free Run mode (Section 3.3.1.3: P43), the user can control the speed the system collects data by increasing or decreasing the number of stacks. Increasing the number of Stacks has the effect of slowing down the data collection speed of the Noggin system. Decreasing the number of Stacks has the effect of speeding up the data collection speed of the Noggin system.

3.2.8 Pulser Setting

This setting allows the user to specify which transmitter (or pulser) is being used for data collection. Several different transmitters can be used with a pulseEKKO PRO system.

In general, if you have a pulseEKKO PRO transmitter, set Pulser Setting to **PRO Auto**. This will automatically set the transmitter to the highest voltage available for that transmitter. For example, a 400 Volt transmitter will be set to 400 Volts and a 1000 Volt transmitter will be set to 1000 Volts.

The only time that PRO Auto is not the correct setting for a pulseEKKO PRO transmitter is if you have a 400 to 1000 variable voltage transmitter and you want to set the pulser voltage to a value lower than 1000 Volts. As mentioned above, using the PRO Auto setting for this transmitter will result in the voltage being set to the highest value, in this case 1000 volts. To set the transmitter to a different value, say 500 volts, it is necessary to edit the Pulser Setting until PRO 500V is displayed.

Note that if you have a 400 volt or 1000 volt transmitter and you try to set it to a voltage other than the correct one, an error will occur when you try to collect data.

The 1000 volt pulser is recommended when using 12.5 to 100 MHz antennas, while the 400 volt pulser is recommended for 50 to 200 MHz antennas. Both pulsers can, however, be used for all antennas.

The pulseEKKO PRO can also be run using pulseEKKO 100 transmitters. The three options are PE100 400 for the 400 volt transmitter, PE100 1K for the 1000 volt transmitter and PE100 5K for the 5000 volt transmitter.

3.3 Acquisition Control

Selecting the Acquisition Control parameters menu option from the System Setup main menu (See Figure 3-1 on page 31), will display a screen similar to Figure 3-5. This section details each parameter listed in this menu.

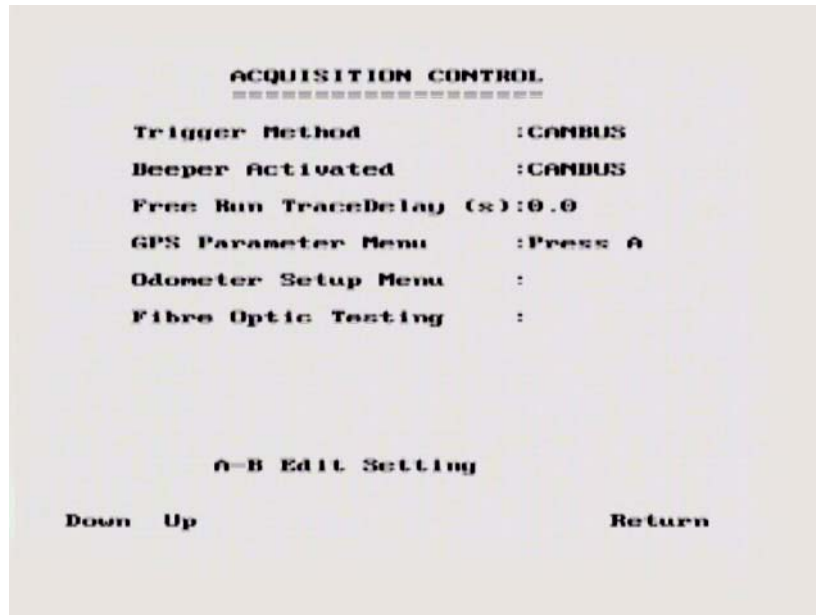


Figure 3-5: The Acquisition Control menu. Use the Up and Down buttons to move to the desired parameter and edit the value by pressing the A and B buttons. Selecting any of the last three options opens sub-menus to edit these parameters.

3.3.1 Trigger Method

The Trigger Method determines what device is going to trigger the transmitter to fire and collect a data trace.

This parameter is set under System Setup - Acquisition Control - Trigger Method.

There are 5 ways to trigger the transmitter to fire:

- 1) DVL B Button
- 2) Electrical Trigger
- 3) Fibre Optic Trigger
- 4) Odometer
- 5) Free Run

The Trigger Method to use is best determined by the user after examination of the site to assess the ease with which the radar can be moved from position to position.

3.3.1.1 Triggers

Triggering the system with an electrical, Fibre Optic or DVL B Button trigger (options 1 -3) is best for surveying in difficult terrain where antennas cannot be moved easily or at regular time intervals. For the position of each measurement point, the system assumes the operator has moved the antennas one step size along the survey line. This is also the mode to select when an odometer is used to trigger the system at specific distance intervals.

In Trigger mode, the user presses the B button on the DVL screen or an external trigger button to collect the next trace. The user is prompted with "READY" or "HIT TRIGGER" on the DVL screen to indicate the system is ready to collect the next trace.

Note that when data are collected with the electrical or the fibre optic trigger, the device may emit a beeping sound after the button is pressed, indicating data collection is taking place. The beeping sound will only occur if the corresponding Beeper Activated option is selected (Section 3.3.2: P43).

3.3.1.2 Odometer

Selecting this option means that the system will be triggered to collect data using the input from the odometer (Section 2.5.4: P23). See Section 6.6 Odometer Data Acquisition on page 88 for more details about data acquisition with an odometer.

3.3.1.3 Free Run

Selecting this option means that the system is not triggered by a particular device but runs continuously in time.

The system automatically collects data at regular, user-determined time intervals. This is called "Free Run" mode and is best for surveys in flat, unobstructed terrain where antennas can be moved easily. For the position of each measurement point, the system assumes the operator has moved the antennas one step size along the survey line. True position can also be controlled by the user adding markers at known positions along the survey line and Rubberbanding the data in post-processing.

When Free Run operation is used, it is necessary to slow the data collection down by increasing the number of stacks (Section 3.2.7: P40) and the time delay between data traces (Section 3.3.3: P44). These options allow the user to control the speed of the data acquisition.

The number of stacks and time delay should be set to values that, when combined with speed the system is moving at, provide an appropriate Step Size interval. This may take a little experimenting to determine the optimal values for stacks, time delay and the actual speed that the system is moving.

3.3.2 Beeper Activated

The Electrical and Fibre Optic Beeper/Trigger units are designed to emit a beeping sound as a trace of GPR data is being collected. However, they will only beep if they have been activated to do so with this menu.

The available settings in this menu are: CANBUS, Fibre Optic, Both or None.

Selecting None means that even if a Beeper/Trigger is present and is the Trigger Method being used (Section 3.3.1: P42), it will not beep.

3.3.3 Free Run Trace Delay

When the system is run in Free-Run mode (Section 3.3.1.3: P43), this option allows the user can specify a time delay (in seconds) between traces. This delay allows time for the user to set up the antennas at the new position. The computer automatically collects the next trace after the elapsed time has passed.

The Trace Delay is input in tenths of seconds, between each data collection point. To run the system as quickly as possible, set this value to 0.0 seconds. For a longer time delay, use the buttons to set the value.

Factors as the radar site, operator experience, weather, etc. will determine how long the delay time should be. Trial and error will decide the appropriate setting.

3.3.4 GPS Parameter Menu

The Global Positioning System (GPS) uses special satellites around the Earth to determine the position of a GPS receiver located anywhere on the surface of the Earth. GPS receivers can be purchased from a number of manufacturers.

The DVL has a serial port on the back for attaching a GPS receiver (Section 2.5.5: P24). This port will accommodate any GPS receiver that has a standard NMEA string output through the serial port.

The GPS receiver can be set up to send one or more types of data strings. These strings are called NMEA-0183 strings and each contains positional or other information in specific formats. Each type of string is specified by a 5-character prefix. *Note that Sensors & Software GPR data can only be integrated with GPS data if at least one of the NMEA strings output by the GPS are GPGGA, GPRMC or GPGLL.* These are the only strings that have the positional information required.

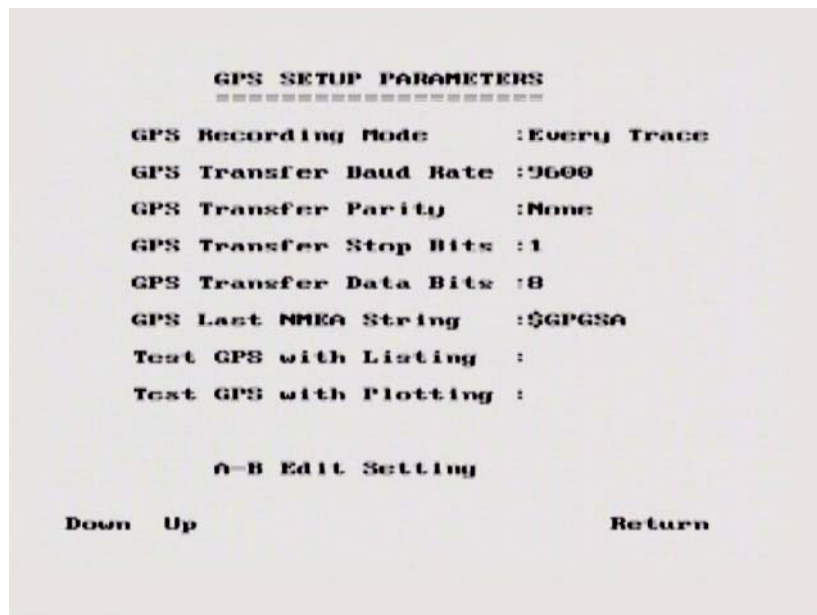


Figure 3-6: The GPS Setup Parameter screen.

This feature allows GPS information to be recorded while collecting GPR data. The GPS information may be useful for mapping where GPR surveys have been performed (see Reading Every X Traces below) or determining where a specific target of interest is located in GPS co-ordinates (see Tagging mode below).

The DVL can be set up to read and log GPS information collected during data acquisition with the GPR system. GPS information can be logged in two different ways:

- 1) For every trace collected by the GPR system, or
- 2) Every time the user adds a fiducial to the data by pressing the Fiducial button or the A button (Section 5.4: P72).

This feature provides a means of capturing GPS information to an independent file. *Note that the GPS information is NOT automatically integrated with the GPR data.* After data acquisition is complete, the data can be downloaded to a PC and the EKKO_View Deluxe software can be used to integrate the GPS data with the GPR data.

In order for the DVL to read the GPS data string, the GPS settings for the specific GPS receiver must be input into this menu. There are 4 important items that must be input correctly for the DVL to display the GPS strings: Baud Rate, Stop Bits, Data Bits and Parity. These are discussed in more detail below. The default values listed below are the values that are typically used. Read the GPS Receiver User's Guide or experiment with the settings to find the correct ones.

Once these 4 items are set correctly you should be able to run Test GPS with Listing and have GPS information written to the screen.

When the logging of GPS information is enabled, during data acquisition, a message will appear in the bottom left-hand corner of the DVL screen indicating whether GPS data is successfully being received.

3.3.4.1 GPS Recording Mode

There are three GPS Recording Modes available:

Off mode means that a GPS receiver is not connected to the DVL so no GPS information is being logged. This should be the setting if you do not have a GPS receiver.

Reading every x traces mode means that every time the GPR collects 1, 5, 10, 20 or 50 traces of GPR data, a data string of GPS information will be added to a file. This file has the same name as the data file i.e. LINE6, but with a GPS extension. This file can be accessed after transferring the GPR data files to an external PC (Section 8.3: P106).

For example, if the number of traces is set to 1, the LINE6.GPS may look like this:

```
Trace #1
$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-35.09,M,5.0,0118*79
$GPVTG,34.0,T,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,4.2,2.1,3.6*36
Trace #2
$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-35.09,M,5.0,0118*79
$GPVTG,34.0,T,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,4.2,2.1,3.6*36
Trace #3
$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-35.09,M,5.0,0118*79
$GPVTG,34.0,T,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,4.2,2.1,3.6*36
Trace #4
$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-35.09,M,5.0,0118*79
$GPVTG,34.0,T,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,4.2,2.1,3.6*36
```

Note that when the Reading per Trace option is on, it is still possible to add fiducial markers to the GPS file. These will appear as F1, F2 etc. between the trace numbers. For example, a portion of LINE6.GPS may look like this:

```
Trace #85
$GPGGA,134850.00,4338.204868,N,07938.429003,W,2,06,2.1,152.60,M,-35.09,M,4.2,0118*74
$GPVTG,152.6,T,,002.3,N,004.3,K,D*43
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,4.2,2.1,3.7*37
F1
$GPGGA,134850.00,4338.204868,N,07938.429003,W,2,06,2.1,152.60,M,-35.09,M,4.2,0118*74
$GPVTG,152.6,T,,002.3,N,004.3,K,D*43
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,4.2,2.1,3.7*37
Trace #86
$GPGGA,134851.00,4338.204362,N,07938.428362,W,2,06,2.1,152.40,M,-35.09,M,5.2,0118*72
$GPVTG,136.9,T,,002.8,N,005.2,K,D*45
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,4.2,2.1,3.7*37
```

On a Tag mode means that whenever a fiducial marker (F1, F2 etc.) is added to the data by pressing the Fiducial button or the A button on the DVL (Section 5.4: P72), a data string of GPS information will be added to a file. This file has the same name as the data file i.e. LINE6, but with a GPS extension. This file can be accessed after transferring the GPR data files to an external PC.

For example, LINE6.GPS may look like this:

```
F1
$GPGGA,134218.00,4338.190204,N,07938.438411,W,2,05,2.6,154.60,M,-35.09,M,4.0,0118*7B
$GPVTG,356.8,T,,000.2,N,000.4,K,D*4B
$GPGSA,A,3,30,10,13,24,06,,,,,,,,4.3,2.6,3.4*36
F2
$GPGGA,134219.00,4338.190294,N,07938.438409,W,2,05,2.6,154.45,M,-35.09,M,5.0,0118*7C
$GPVTG,1.3,T,,000.4,N,000.7,K,D*44
$GPGSA,A,3,30,10,13,24,06,,,,,,,,4.3,2.6,3.4*36
F3
$GPGGA,134221.00,4338.190261,N,07938.438285,W,2,05,2.6,154.05,M,-35.09,M,5.2,0118*79
$GPVTG,10.0,T,,000.2,N,000.4,K,D*72
$GPGSA,A,3,30,10,13,24,06,,,,,,,,4.3,2.6,3.4*36
F4
$GPGGA,134222.00,4338.190397,N,07938.438255,W,2,05,2.6,153.95,M,-35.09,M,5.0,0118*73
$GPVTG,9.8,T,,000.3,N,000.5,K,D*42
$GPGSA,A,3,30,10,13,24,06,,,,,,,,4.3,2.6,3.4*36
```

If the GPS mode is set to Reading per Trace or Fiducial Tagging AND the GPR is Run Without Saving Data (Section 5.8: P81), it is still possible to log GPS data strings. Every time a fiducial marker is added to the data by pressing the Fiducial button or the A button on the DVL (Section 5.4: P72), a data string of GPS information is added to a file. This file is called TAGGED.GPS and can be exported using the File Management option (Section 8: P104).

An example of a TAGGED.GPS file is shown below.

```
New File 09-18-2000 13:53:38
F1
$GPGGA,134227.00,4338.190520,N,07938.438280,W,2,05,2.6,153.98,M,-35.09,M,4.6,0118*7E
$GPVTG,347.7,T,,000.3,N,000.5,K,D*44
$GPGSA,A,3,30,10,13,24,06,,,,,,,,4.3,2.6,3.4*36
F2
$GPGGA,134228.00,4338.190238,N,07938.438286,W,2,05,2.6,153.87,M,-35.09,M,4.4,0118*75
$GPVTG,5.4,T,,000.2,N,000.4,K,D*42
$GPGSA,A,3,30,10,13,24,06,,,,,,,,4.3,2.6,3.4*36
F3
$GPGGA,134229.00,4338.190277,N,07938.438273,W,2,05,2.6,153.76,M,-35.09,M,5.4,0118*7A
$GPVTG,23.4,T,,000.1,N,000.2,K,D*73
$GPGSA,A,3,30,10,13,24,06,,,,,,,,4.3,2.6,3.4*36
F4
$GPGGA,134231.00,4338.190127,N,07938.438362,W,2,05,2.6,154.59,M,-35.09,M,5.0,0118*7A
$GPVTG,20.2,T,,000.2,N,000.3,K,D*74
$GPGSA,A,3,30,10,13,24,06,,,,,,,,4.3,2.6,3.4*36
*****
New File 09-18-2000 13:55:36
F1
$GPGGA,134259.00,4338.192453,N,07938.449096,W,2,06,2.4,153.14,M,-35.09,M,5.4,0118*75
$GPVTG,310.9,T,,000.5,N,001.0,K,D*4A
```



```

$GPGSA,A,3,04,30,10,13,24,06,,,,,,,,,3.2,2.4,2.1*32
F2
$GPGGA,134301.00,4338.192559,N,07938.449176,W,2,06,2.4,153.17,M,-35.09,M,5.0,0118*7A
$GPVTG,314.4,T,,,000.6,N,001.1,K,D*41
$GPGSA,A,3,04,30,10,13,24,06,,,,,,,,,3.2,2.4,2.1*32
F3

```

3.3.4.2 Baud Rate

The baud rate is the speed that data is sent from the GPS receiver to the serial port of the DVL. The available options are: 2400, 4800, 9600 (default) or 19200. Often, the baud rate for GPS units is 4800. If you are having a problem getting the GPS to work with the DVL, the Baud Rate is the most likely problem.

3.3.4.3 Stop Bits

The available settings for Stop Bits are: 1 (default) or 2.

3.3.4.4 Data Bits

The available settings for Data Bits are: 7 or 8 (default).

3.3.4.5 Parity

The available settings for Parity are: none (default), odd or even.

3.3.4.6 Last NMEA String

The GPS receiver can be set up to send one or more types of data strings. These strings are called NMEA-0183 strings and each contains positional or other information in specific formats. Each type of string is specified by a 5-character prefix. There are numerous NMEA strings but examples of three different NMEA strings (GPGGA, GPVTG and GPGSA) are shown below.

```

$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-35.09,M,5.0,0118*79
$GPVTG,34.0,T,,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,,4.2,2.1,3.6*36
$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-35.09,M,5.0,0118*79
$GPVTG,34.0,T,,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,,4.2,2.1,3.6*36
$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-35.09,M,5.0,0118*79
$GPVTG,34.0,T,,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,,4.2,2.1,3.6*36
$GPGGA,134713.00,4338.221086,N,07938.421365,W,2,06,2.1,152.51,M,-35.09,M,5.0,0118*79
$GPVTG,34.0,T,,,001.4,N,002.5,K,D*70
$GPGSA,A,3,30,26,10,13,24,06,,,,,,,,,4.2,2.1,3.6*36

```

Before using the GPS with the GPR, the DVL software needs to know the prefix of the LAST string being sent in each group. In the example above, three strings are being sent each time (GPGGA, GPVTG and GPGSA). Since GPGSA is the last one being sent in each group, the End String needs to be specified as GPGSA.

To see what the End String is for your particular GPS, run Test GPS with Listing and note the first 5 characters on the last line after each series of strings is written to the screen. These are the 5 characters that need to be filled in under Last NMEA String.

The Last NMEA String option allows the user to fill in the necessary 5 character GPS prefix. Use the numbered buttons to change the letters forward in the alphabet. Use the Change Direction button make the letters go backward in the alphabet.

See the GPS Receiver User's Guide for details on how to set up the receiver to output specific NMEA strings or groups of NMEA strings.

3.3.4.7 Test GPS with Listing

After all the settings above have been input and the GPS receiver is attached to the serial port on the DVL, the test option allows the user to check that the DVL is receiving the GPS output.

If the NMEA strings are successfully being read by the DVL they will appear on the DVL screen. This is a good time to note the prefix of the last NMEA string in the list and input it in the End String setting above.

If the NMEA strings do not appear, check that the port settings are correct. It is also possible that a crossover cable is required between the output cable of the GPS receiver and the serial port on the DVL.

3.3.4.8 Test GPS with Plotting

Once the GPS system is running successfully, selecting Test GPS with Plotting can be used to graphically display the GPS data. This screen displays the GPS Time, Latitude, Longitude and Altitude as well as other values indicating the accuracy of the GPS reading. The GPS position is also displayed in a square that can be Zoomed from 2 metres square to 16384 metres square.

3.3.5 Odometer Setup Menu

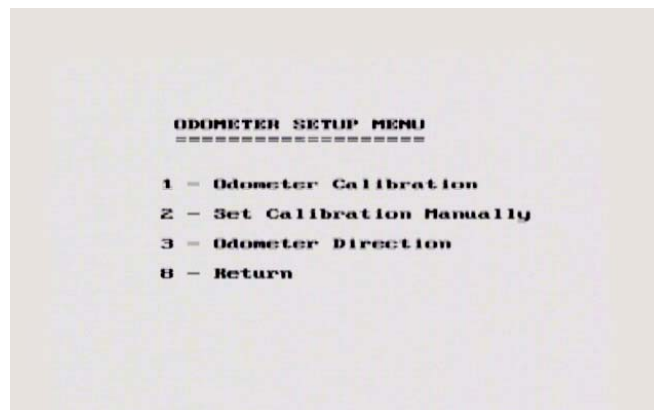


Figure 3-7: Odometer Setup Menu.

3.3.5.1 Odometer Calibration

The odometer should be calibrated periodically to ensure accuracy.

When Odometer Calibration is selected, the user is prompted to select the length of the line to calibrate on. There are 8 different choices in metres and 8 choices in feet. To toggle the units between metres and feet, press the B button. Pressing the A button on this screen gives the additional option to select a user defined value. The user-defined value can range from 0.01 to 5000 metres or 0.01 to 26400 feet.

When the calibration distance has been selected follow the directions on the screen:

Set the system at zero and press A

Move the system the selected distance and press B

Press A to exit.

Odometer calibration values for the SmartCart odometer should be around 1080.

3.3.5.2 Set Odometer Manually

When Odometer Calibration is selected, the user is prompted to manually enter the odometer calibration factor. In general, this method of odometer calibration is not recommended because it will not be as accurate as calibrating the odometer over a known distance.

3.3.5.3 Odometer Direction

This setting determines whether data are collected as the system is rolled forward or reverse. The back up arrow (Section 6.6.2: P89) will work in the direction opposite to this setting. The available options are: Forward and Reverse.

3.3.6 Fibre Optic Testing

As part of troubleshooting a problem with the system, the fibre optic cables can be tested for damage (Section 7.2: P99).

3.4 Survey Parameters

Selecting the Survey Parameters menu option from the System Setup main menu (See Figure 3-1 on page 31), will display a screen similar to Figure 3-8. This section details each parameter listed in this menu.

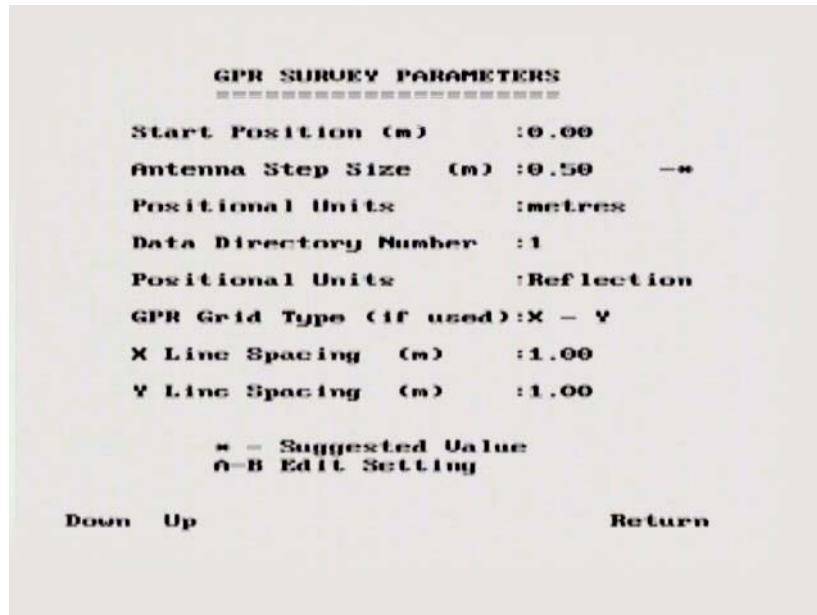


Figure 3-8: The GPR Survey Parameters menu. Use the Up and Down buttons to move to the desired parameter and edit the value by pressing the A and B buttons.

3.4.1 Start Position

This is the starting position for the first trace. Normally, most lines start at position zero (0.0) and the position of each trace increments by the Antenna Step Size (Section 3.2.5: P38). The Start Position value can be changed to a non-zero and even a negative value if necessary.

It is assumed that the units for all position and distance quantities are the units specified under Positional Units (Section 3.4.3: P50).

For a CMP/WARR measurement, the start position is the initial antenna separation.

3.4.2 Antenna Step Size

The Antenna Step Size can be changed in this menu as well as the menu under System Setup - GPR Parameters (Section 3.2.5: P38).

3.4.3 Positional Units

Two distance units are available: metres or feet. This information is stored in the header file and is used in plotting scales. All distance parameters in the other menus will be interpreted based on the setting of this item.

3.4.4 Data Directory Number

This option is used to determine the directory that the data files will be saved to. The idea is that related data files are saved in the same directory.

The Data Directory Number can be changed in this menu or under the Run pulseEKKO menu (Section 5.1: P69).

The user has access to 20 different directories for data storage.

3.4.5 Survey Type

Ground penetrating radar has been used in many different survey modes to gather information. Three of the more common modes are:

- a) Reflection mode, which is by far the most common mode used to map underlying stratigraphy, (See Figure 6-1 on page 82).
- b) CMP (Common Mid Point) or WARR (Wide Angle Reflection and Refraction), useful in deducing information on wave propagation velocity versus depth (Section 6.11: P91) and
- c) Transillumination where the transmitting and receiving antennas are situated at opposite sides of a partition to study the transmission properties of the dividing material (Section 6.12: P93). The options available here are Trans., Trans - ZOP, Trans - MOG and Trans - VRP. Calibration files are also related to Transillumination surveys.

3.4.6 GPR Grid Type

The grid parameter settings in the Survey Parameters menu allow the user to modify settings specific to collecting data in organized grids. This includes the grid type and line spacing.

Data are normally collected on a grid if the user is interested in displaying the data as a 3D volume (using the EKKO_3D software) or as a plan map (using the EKKO Mapper software). Producing accurate 3D volumes or plan maps is easier if the field survey is properly designed and data are collected correctly.

Positional accuracy of each line is vital if the user wants to be able to relocate targets of interest after the data have been processed.

For linear targets like pipes and utilities, the best GPR response occurs when the GPR survey line crosses the target at right angles. If possible, it is always best to run GPR survey lines perpendicular to the direction of linear targets.

Sensors & Software's EasyGrid makes laying out an accurate, square grid simple. Contact Sensors & Software for more details.

The Grid Type determines the way that the area of the grid is to be covered by the survey lines. Survey lines can be either a set of parallel lines in the X axis direction (Figure 3-9), a set of parallel lines in the Y axis direction (Figure 3-10), or, for complete coverage, parallel lines in both the X and Y direction (Figure 3-11).

X Lines Only

Set up a first-quadrant XY grid. Data lines run in the X direction, distance increasing from the Y axis baseline. Line numbers increase in the positive Y direction (see Figure 3-9). Lines must be equally spaced. It is not critical that all the lines are the same length. However, it does make processing easier if all the lines start at the same baseline position (usually defined as zero (0.0)).

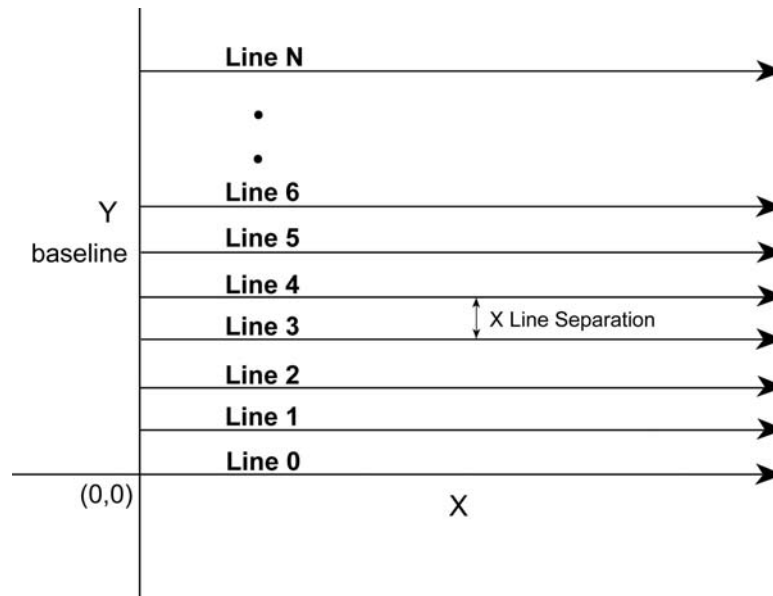


Figure 3-9: The line configuration for lines collected in X Lines Only mode. The convention is that X lines are parallel to the X axis. For seamless integration into data processing software like EKKO Mapper, note that the lines are assumed to be collected with X positions increasing as the line moves away from the Y baseline. Line numbers start at line 0 and increment as the lines move away from the X axis. The Line Spacing distance needs to be specified in the grid settings and lines should be equally spaced.

Y Lines Only

Set up a first-quadrant XY grid. Data lines run in the Y direction, distance increasing from the X axis baseline. Line numbers increase in the positive X direction (see Figure 3-10). Lines must be equally spaced. It is not critical that all the lines are the same length. However, it does make processing easier if all the lines start at the same baseline position (usually defined as zero (0.0)).

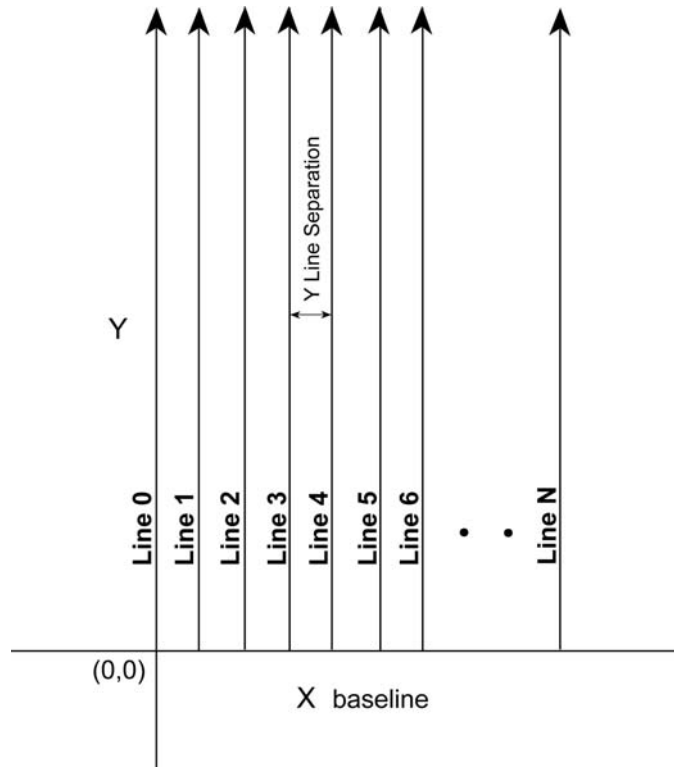


Figure 3-10: The line configuration for lines collected in Y Lines Only mode. The convention is that Y lines are parallel to the Y axis. For seamless integration into data processing software like EKKO Mapper, note that the lines are assumed to be collected with Y positions increasing as the line moves away from the X baseline. Line numbers start at line 0 and increment as the lines move away from the Y axis. The Line Spacing distance needs to be specified in the grid settings and lines should be equally spaced.

X and Y Lines

Set up a first-quadrant XY grid. X data lines run in the X direction, distance increasing from the Y axis baseline. Line numbers increase in the positive Y direction (see Figure 3-11). Lines must be equally spaced. Y data lines run in the Y direction, distance increasing from the X axis baseline. Line numbers increase in the positive X direction. Lines should be equally spaced. The line spacing of the X lines and Y lines can be different.

It is not critical that all the lines are the same lengths. However, it does make processing easier if all the lines start at the same baseline position (usually defined as zero (0.0)).

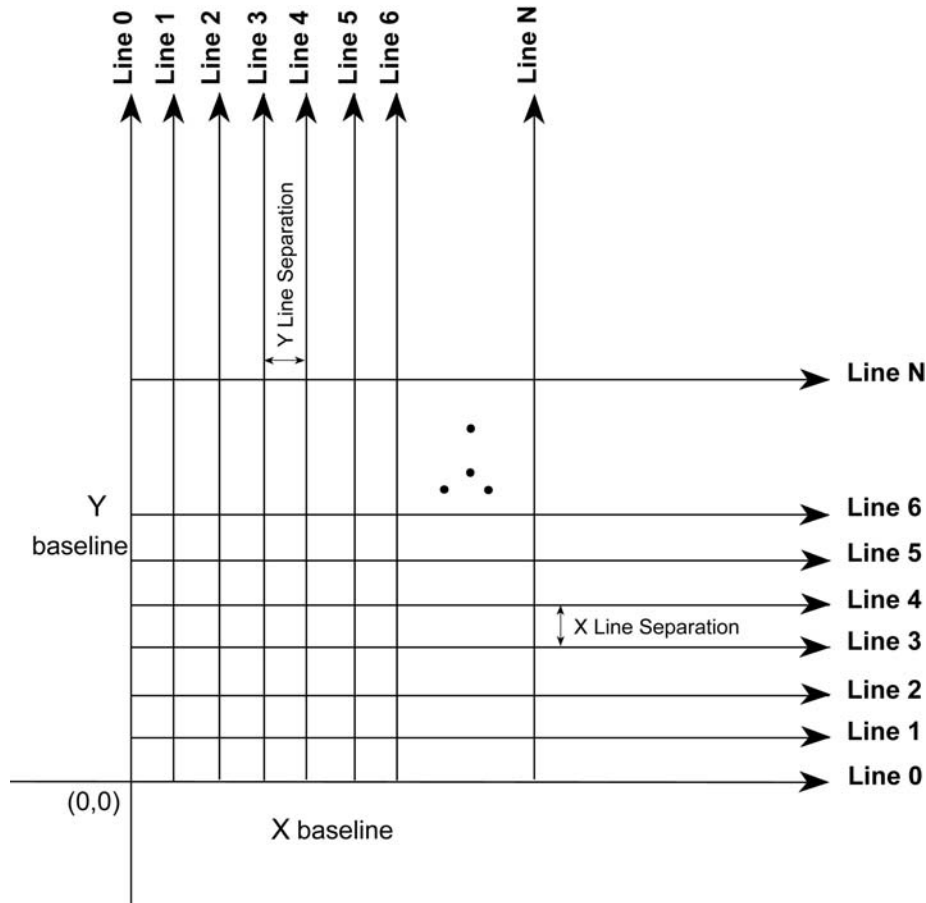


Figure 3-11: The line configuration for lines collected in XY Lines mode. The convention is that X lines are parallel to the X axis and Y lines are parallel to the Y axis. For seamless integration into data processing software like EKKO Mapper, note that the lines are assumed to be collected with X positions increasing away from the Y baseline and the Y positions increasing away from the X baseline. Line numbers start at line 0 and increment as the lines move away from the axes. The Line Spacing distances needs to be specified in the grid settings and lines should be equally space, although the X line spacing and Y line spacing can be different.

3.4.7 X Line Spacing

For X Only or XY grid data acquisition, the distance between the X survey lines needs to be specified in this menu (Figure 3-9 and Figure 3-11). The distance units are assumed to be the same as those specified in Positional Units (Section 3.4.3: P50)

If an XY grid is being collected, note that the line spacing of the X lines and Y lines can be different.

3.4.8 Y Line Spacing

For Y Only or XY grid data acquisition, the distance between the Y survey lines needs to be specified in this menu (Figure 3-10 and Figure 3-11). The distance units are assumed to be the same as those specified in Positional Units (Section 3.4.3: P50)

If an XY grid is being collected, note that the line spacing of the X lines and Y lines can be different.

3.5 Display Parameters

Selecting the Display Parameters menu option from the System Setup main menu (See Figure 3-1 on page 31), will display a screen similar to Figure 3-12. This section details each parameter listed in this menu.

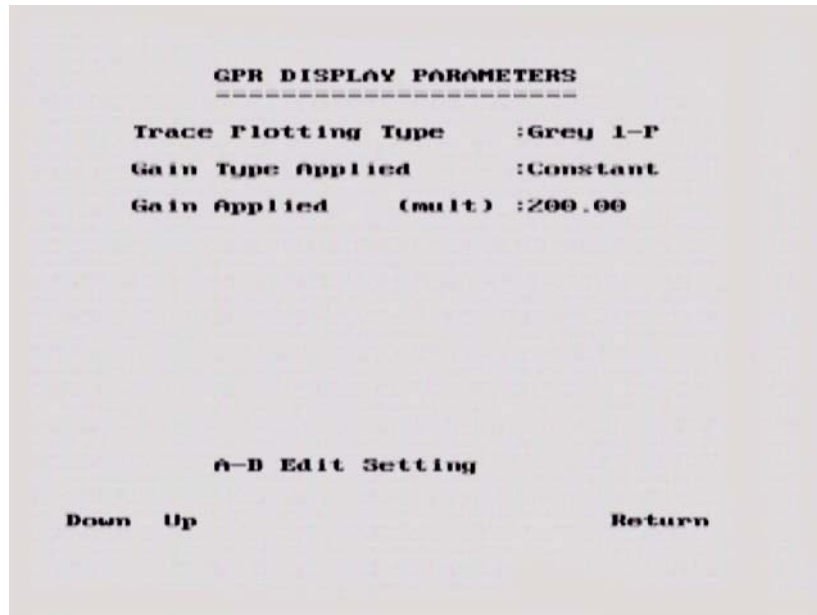


Figure 3-12: The Display Parameters menu. Use the Up and Down buttons to move to the desired parameter and edit the value by pressing the A and B buttons.

3.5.1 Trace Plotting Type

The data traces can be plotted in two ways: Grey scale or Wiggle.

Grey means each data point is plotted as a grey strip based on its amplitude (Figure 3-13).

If traces are plotted in grey scale, the trace width, in pixels, can also be specified. The choices are 1, 2, 4 or 8 pixels with 2 or 1 pixels being the usual setting. For example, the VGA screen on the DVL with a resolution width of 640 pixels can display:

80 traces 8 pixels wide

160 traces 4 pixels wide

320 traces 2 pixels wide

640 traces 1 pixel wide

The narrower the trace width, the more data that can be displayed on one screen.

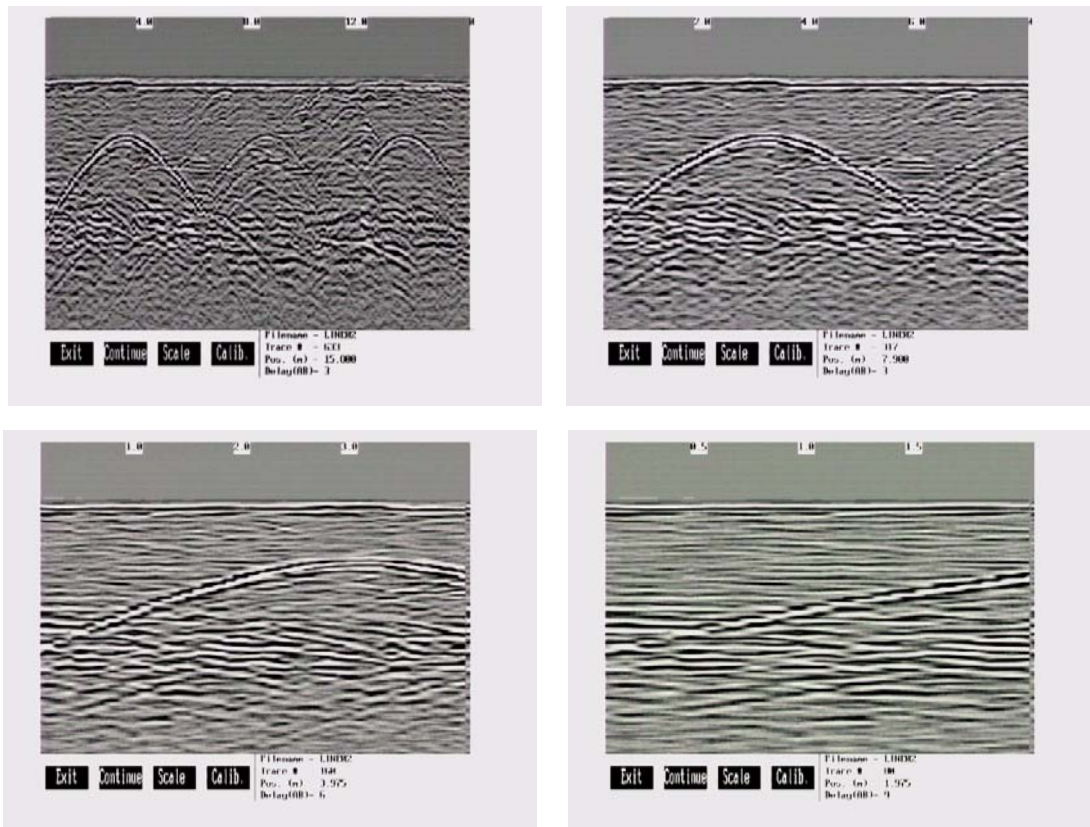


Figure 3-13: Grey scale traces depict the signal amplitude as shades of grey from white to black. Data traces can be plotted to the screen with a width of 1 pixel (top left), 2 pixels (top right), 4 pixels (bottom left) or 8 pixels (bottom right). The narrower the trace width, the more data that can be plotted on one screen. In this example, plotting the data 1 pixel wide results in 16 metres of data displayed on one screen while 2 pixels results in 8 metres of data, 4 pixels results in 4 metres of data and 8 pixels results in 2 metres of data.

Wiggle means the traces will be plotted as a curved line with the amplitude determining the size of the curve (Figure 3-14). The wiggle traces can be plotted with shading on the Left side or negative amplitude side of the trace (Wiggle - L), the Right side or positive amplitude side of the trace (Wiggle - R) or with no shading (Wiggle - N). The normal default is to shade on the right (positive amplitude) side.

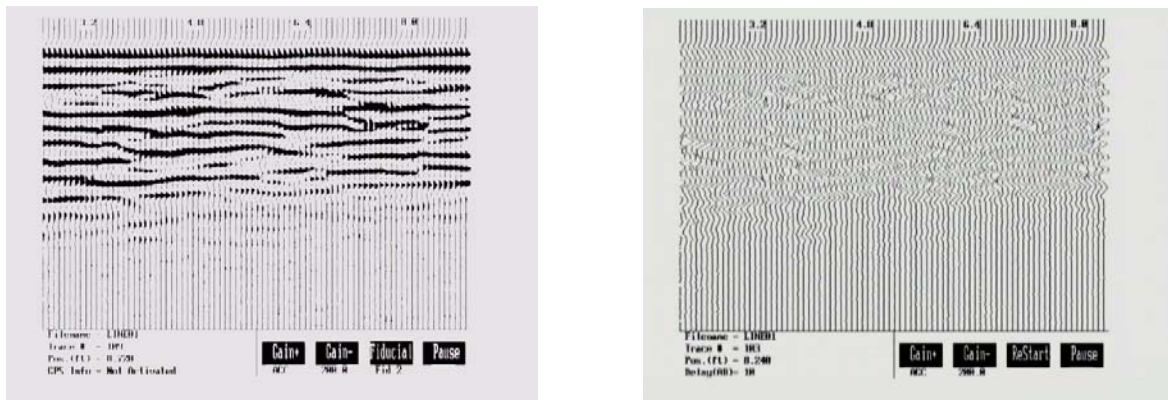


Figure 3-14: Wiggle trace plots show signal strength with a curved line. The left (or negative) side of the curve or the right (or positive) side of the curve can be shaded (left image). The right image shows the wiggle traces with no shading.

3.5.2 Gain Type Applied and Gain Applied

Since the radar signal strength normally decreases with increasing time, it is usually necessary to apply some sort of gain function to boost the weaker signals at later times.

The raw, ungained data shows little signal except for the strong near-surface reflectors (Figure 3-15). No gain may be useful in areas where the radar signal is very strong or in areas where the targets are very shallow.

Four gains are available: AGC, SEC, Constant, and None. These are each described below.

No matter which gain function has been selected, the data are ALWAYS stored WITHOUT any gain applied. Gain is only applied for real-time display purposes.

For data collection in the field, AGC and constant gains are often the most practical to show that the system is working properly and to show a range of reflectors in the material. Other more sophisticated gains, like SEC functions, can be applied later when plotting the data in the office.

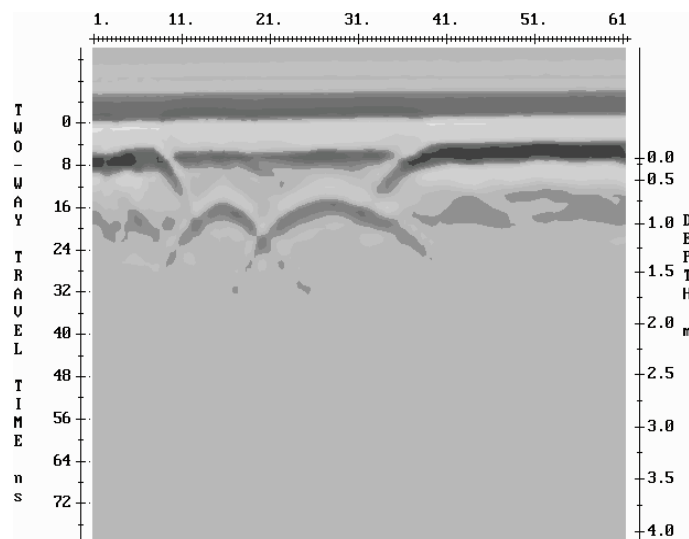


Figure 3-15: Display of a data section over buried tanks. No gain was applied before plotting.

Note that none of the gain functions are permitted to boost a data point value to greater than 32767 or less than -32767. Values where this occurs are trapped and forced to 32767 or -32767.

3.5.2.1 AGC Gain

The AGC (Automatic Gain Control) gain attempts to equalize all signals by applying a gain which is inversely proportional to the signal strength (Figure 3-16). This type of gain is most useful for defining continuity of reflecting events. The user should realize that AGC does not preserve relative amplitude information. Hence once the data have been AGC'ed, the user can no longer make reliable deductions concerning the strength of any particular reflector relative to other reflectors (Figure 3-17).

Since the AGC gain is inversely proportional to the signal strength, very small signals can produce very large gains. Therefore some type of gain limiting scheme must be applied. The user enters the maximum gain which can be applied to the data. This maximum gain is then fixed for the whole data set.

Note that if a data point multiplied by the gain exceeds 32767, the absolute value of the new data point value becomes 32767 or -32767.

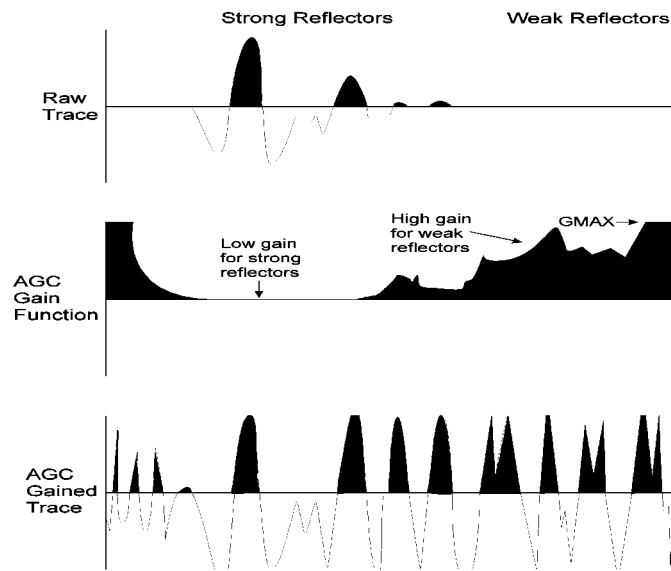


Figure 3-16: Shows how the AGC function (middle) is inversely related to reflector strength of the raw trace (top). The AGC gained trace (bottom) is a result of multiplying each point in the raw trace with the equivalent point in the AGC function.

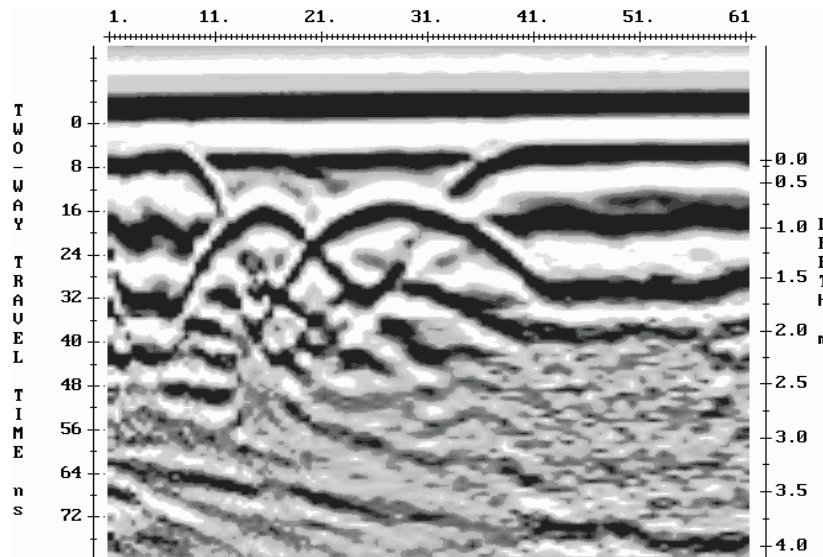


Figure 3-17: Display of a data section over buried tanks. An AGC gain was applied before plotting.

The only user variable for the AGC gain is the **Max Gain Applied** value. This is a number between 1 and 32767 which determines the maximum gain that can be applied to any data point. This maximum gain is fixed for the whole data set. A typical value would be 50 - 2000 depending on the noise and average signal levels.

3.5.2.2 SEC Gain

The SEC (Spreading & Exponential Compensation) gain is a composite of a linear time gain and an exponential time gain. This gain compensates for the spherical spreading losses and the exponential dissipation of energy in the data being collected. Since radar data is attenuated exponentially and the SEC is an exponential function (Figure 3-18), it tends to be the gain closest to physical reality. Therefore, unlike the AGC gain (Figure 3-18), reflections can be compared for relative signal strength (Figure 3-19 and Figure 3-20).

This gain is essentially an exponential function. This exponential function could, in fact, go to infinity. Therefore, as with the AGC gain some gain limiting factor must be applied. This gain limiting factor is identical to the one used in the AGC gain (see AGC above).

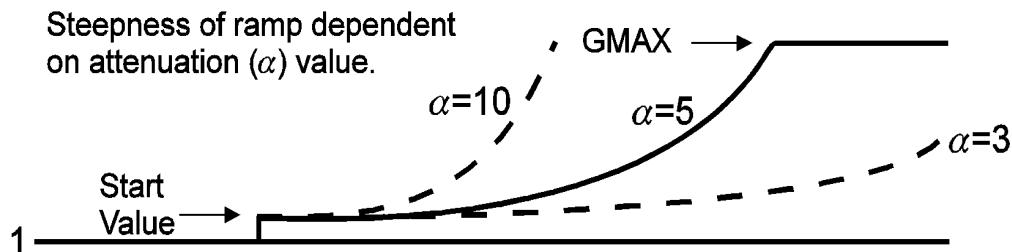


Figure 3-18: The SEC function has one parameter that must be specified. GMAX is a limiting value on the function. The Attenuation (α) value determines the steepness of the ramp. When data are collected in areas with high attenuation, a higher Attenuation (α) value may be necessary to reveal weaker signals.

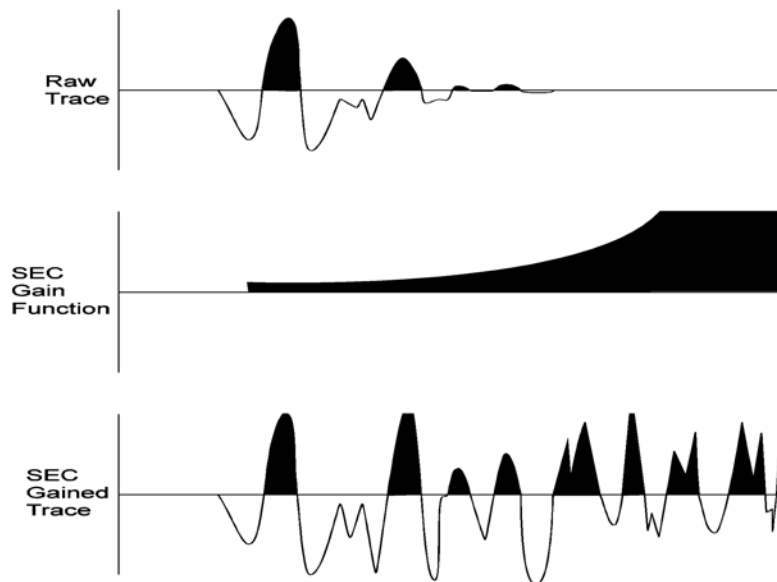


Figure 3-19: Shows the exponential nature of the SEC function (middle). The SEC gained trace (bottom) is a result of multiplying each point in the raw trace (top) with the equivalent point in the SEC function.

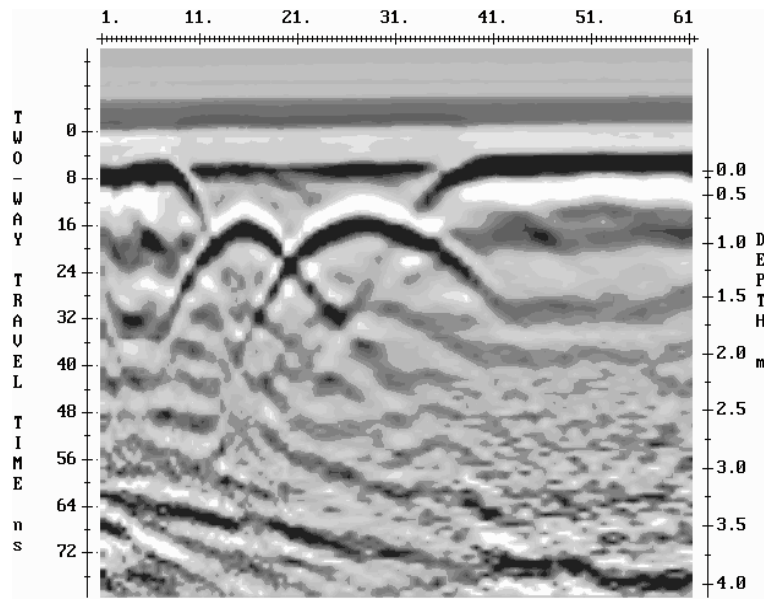


Figure 3-20: Display of a data section over buried tanks. An SEC gain was applied before plotting.

The only user variable for the SEC gain is the **Alpha Gain Applied** value. This quantity represents the radar wave attenuation given in decibels/metre. A typical value is 0.5 to 5.

3.5.2.3 Constant Gain

This routine will apply a constant gain factor to the input data set. The only parameter required is the constant factor to multiply all data points by. Thus if the user enters the number 10, all data points will be multiplied by a factor of 10. This will gain strong signals and weak signals equally and result in the clipping of strong signals.

The advantage of a constant gain is that it is easy to understand how the amplification works. The disadvantage of a constant gain is that it tends to over-gain the strong signals at the beginning of the trace Figure 3-21.

The parameter needed for the Constant gain function is the **Constant Multiplier**. Typical values for the Constant gain are in the range from 5 to 1000.

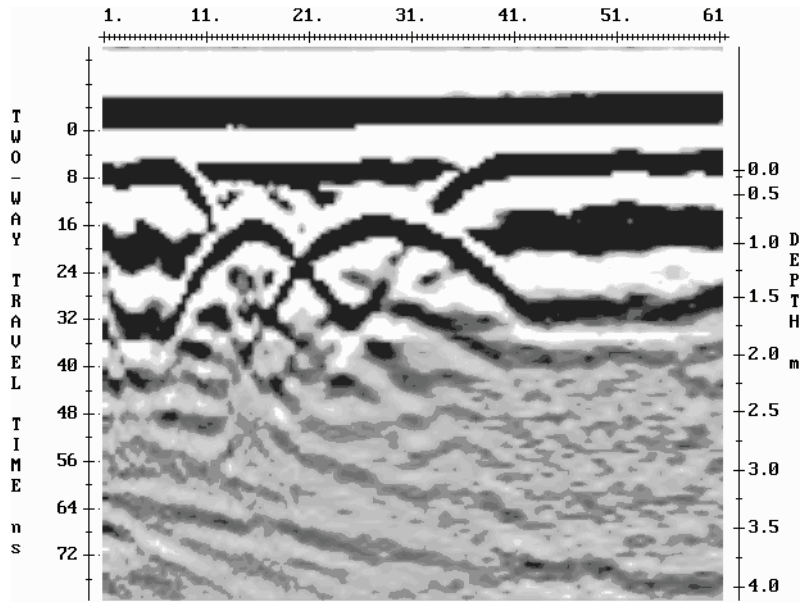


Figure 3-21: Display of a data section over buried tanks. A Constant gain was applied before plotting.

3.6 DVL Setup Menu

3.6.1 Set DVL Time and Date

The date and time are saved with the data files. The DVL date and time setting can be changed by moving to one or more of the appropriate fields and editing the current setting. The LEFT and RIGHT arrows are used to move between fields. To change any of the numbers or months, use the UP and DOWN arrows to increase or decrease the value. When the desired date and time are set, press ENTER to save the changes.

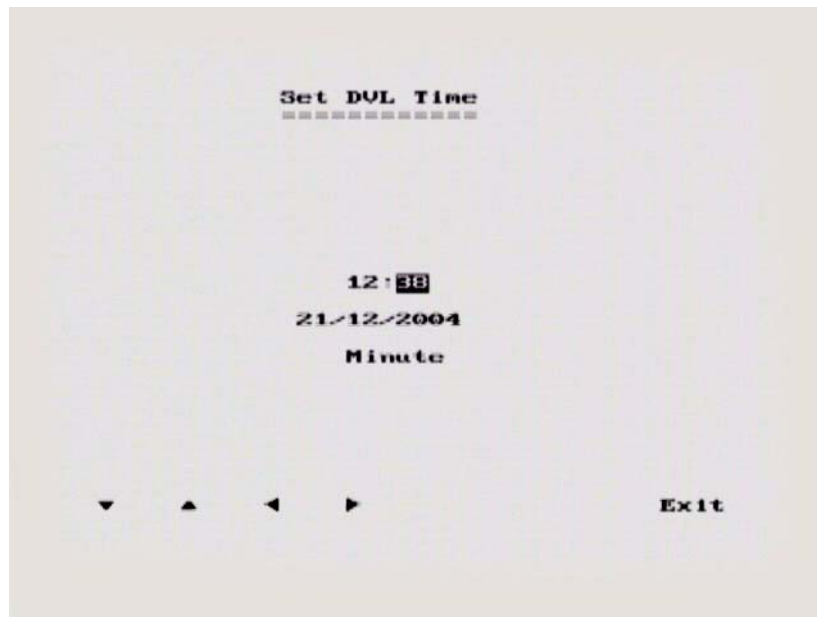


Figure 3-22: DVL set time and date screen.

3.6.2 Set DVL Transfer Mode

When transferring data from the DVL to a PC (Section 8.1: P105), two different types of PXFER cable are available, Normal and Turbo. For the data transfer to be successful, the DVL Transfer Mode specified in this menu must be set to the correct cable. Normal PXFER cables have black bands near the ends while the Turbo PXFER cables have pink bands near the ends.

3.6.3 Set DVL into Upgrade Mode

This option is used to upgrade the software on the DVL. DO NOT press this button until told to do so in the instructions accompanying the software upgrade. If you do accidentally enter this menu item, the only way to exit is to disconnect the power to the DVL.

3.6.4 Select Display Info Mode

The Display Info Mode refers to the messages written to the screen at the start of data collection. When the user presses the Start button to acquire a line of data, the system must set up communications between the various system components and initialize them. During this process, messages are written to the screen. The Display Info mode determines the level of message detail.

There are two options available under Display Info Mode: Normal and Display Info.

In normal mode, a minimal number of messages are written. In Display Info mode, detailed messages about every system interaction are written to the screen.

In general, it is best to use Normal mode unless you are trying to troubleshoot a system problem (Section 7: P95).

3.7 View Complete Setup

The View Complete Setup option displays a listing of the current setup parameters for the pulseEKKO PRO (See Figure 3-2 on page 31).

3.8 Return

Selecting Return will exit the System Setup menus and return the user to the pulseEKKO PRO main menu screen (see Section 2.6.4 on page 27). Exit also serves an important function. Before exiting, the program saves all the current data collection parameters. This process enables the user to continue with the same settings when the system is restarted.

4 Running in Scope Mode

Once the System Setup parameters have been set, data collection can begin by selecting **1 - Run pulseEKKO GPR** from the main menu. The screen shown in Figure 4-1 will be visible.

Turn on the transmitter and receiver and ensure that they are fully powered and initialized by checking that the Power LED on the top of the unit has stopped flashing.

Scope Mode (described in this section) is used to check that the system is running correctly before starting to collect and save survey data in **Collect Line Data** or **Collect Grid Data** mode (Section 5: P69).

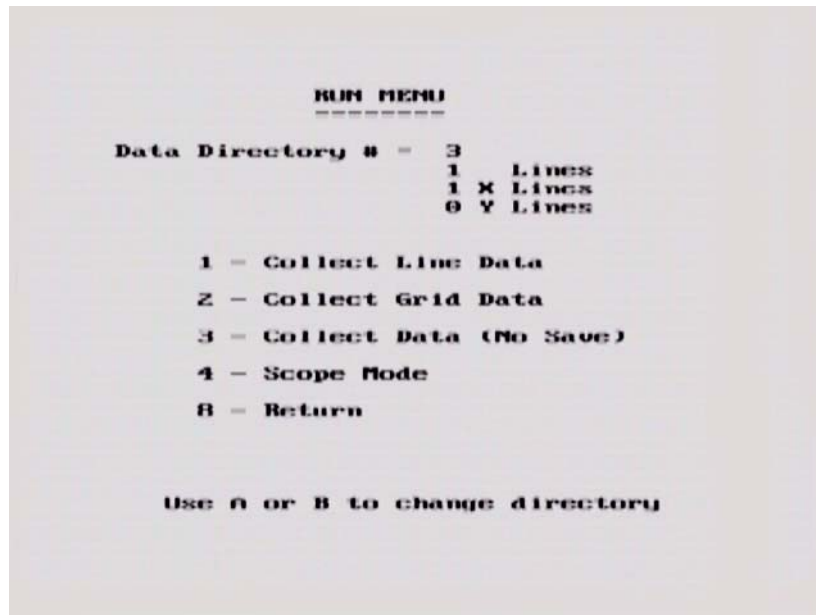


Figure 4-1: The Run menu allows the operator to find the pulse and set up timezero in Scope mode, collect Line data, grid data or collect data without saving. If data are to be saved, the data directory number is selected using the A and B buttons.

Scope mode is used to make sure that connections are correct, all parameters are properly set and valid data are being collected. Scope mode displays the radar trace in the traditional oscilloscope scan format (see Figure 4-2). Scope mode should normally be run first, prior to data collection and storage. Data cannot be saved in Scope mode. Once the user is satisfied that everything is working, they can switch to Collect mode to begin data collection.

Scope mode serves two main functions:

- a) to ensure that valid data are being collected properly, and
- b) to set the location of the transmit pulse (which is the reference timezero or the first break).

Selecting **Scope Mode** from the main menu displays a screen with **EXIT**, **SCALE** and **START**.

START begins data collection. **EXIT** returns the user to the Run menu shown in Figure 4-1. **SCALE** allows the user to modify the maximum amplitude displayed on the graph scale. This parameter may take on any value between 1 and 50 millivolts. The default value of 50 is rarely changed.

4.1 Scope Screen

A sample of a screen data plot while in Scope mode is shown in Figure 4-2. The radar amplitude (in millivolts) is plotted in the vertical axis while the time axis is plotted in the horizontal axis. The length of the time axis depends on the Time Window value. Each division in the time axis is 10% of the length of the Time Window. In the case shown in Figure 4-2, the Time Window is 100 ns so each division is 10 ns wide.

Below the plot, the vertical amplitude scale, trace number, time window, sampling interval (DeltaT), timezero offset, number of points, stacks and frequency are listed. It also indicates that the data trace is being filtered with a 25 point DEWOW filter (see Appendix B: GPR Signal Processing Artifacts).

Pressing the **START** button begins data collection. The **STOP** pauses acquisition and displays a menu with further options.

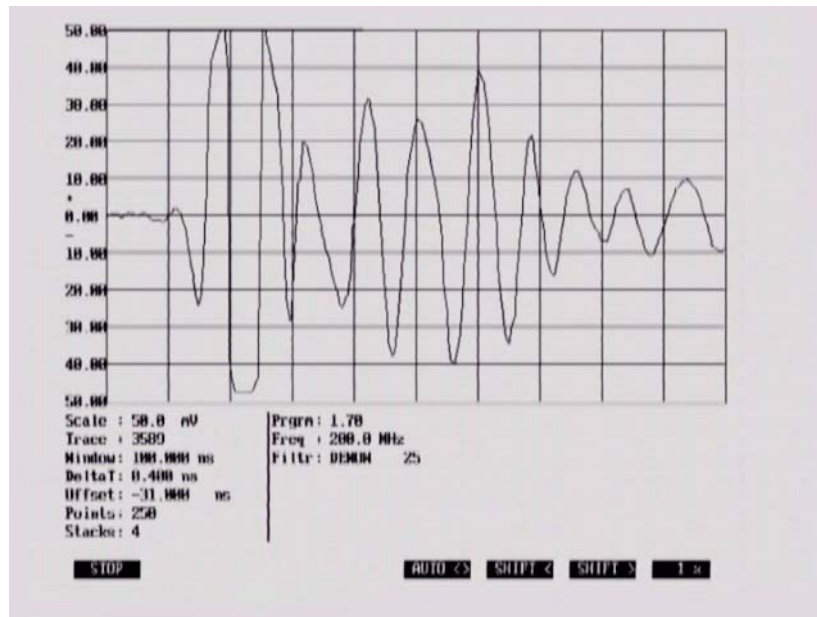


Figure 4-2: A sample of a screen data plot while using Scope mode. The parameters below the graph, the trace number, time window, sampling interval (DeltaT), points, stacks and frequency are listed (Section 3: P31). The Offset parameter listed is explained below.

The **Offset** is the value used to adjust the first break to the ideal region. The value has no importance to the radar data; it is only used for the adjustment of the initial radar pulse to the desired position within the time window. It compensates for changes in cables and differences in electronic components.

4.1.1 Adjusting Timezero (Offset)

Assuming that data are coming in, the first step is to ensure 'timezero' is in the correct location. Timezero, for our purposes, is defined as the first arrival of the radar wave; it is used as a convenient reference starting point for the trace, hence the name: timezero.

Timezero should be located near the beginning of the second vertical division on the screen (Figure 4-2). Locating timezero to the right (further in time) of the second division has no ill effect on the data, it just means possible reflectors may be lost off the bottom of your recording window. Locating timezero to the left of the second division should be avoided.

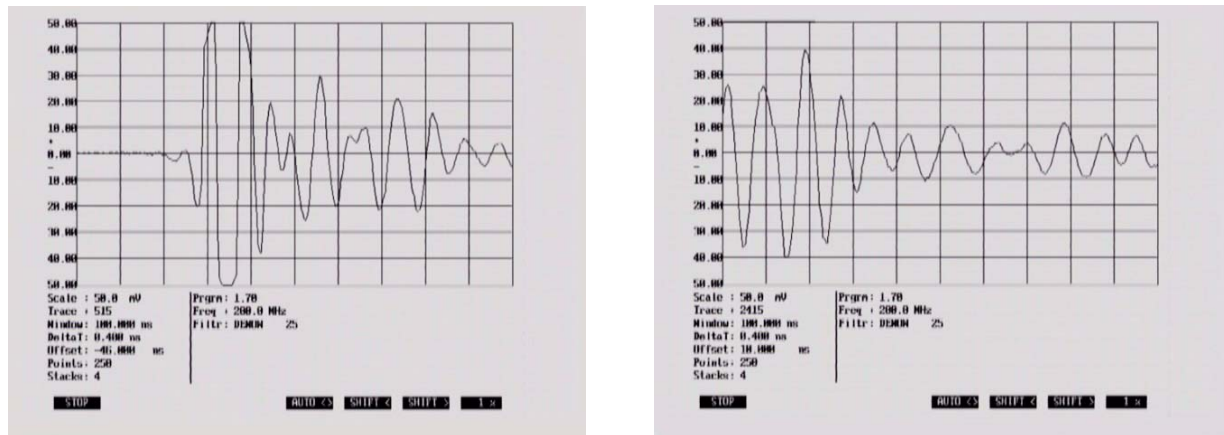


Figure 4-3: Timezero or the first break is the first large deflection in the trace. Ideally, timezero needs to be shifted to the start of the second vertical division as shown in Figure 4-2. Use the **Auto <>** button to try and automatically locate timezero and set it to the correct position. The **Shift >** and **Shift <** buttons can be used to move timezero to the right and left respectively. When a **Shift** button has been pressed, it changes to reverse video and timezero will keep moving in that direction until **Shift** is turned off by pressing it again. The percentage button indicates the percentage of the shift in each step, a larger percentage indicating a larger shift. Locating timezero further to the right reduces the amount of data collected from the subsurface (left). Locating timezero further left affects the data collected and should be avoided.

The location of timezero is affected by a number of factors. These include: various system hardware components, length of fibre optic cables, separation of transmitter and receiver antennas, and the total time window.

To set 'timezero', the transmit and receive antennas should be set to the antenna separation being used for the survey (Section 3.2.4: P37). This assures a large first arrival with minimal propagation delay. The start of the second division represents the 'ideal' location for timezero (see Figure 4-2). The purpose is to adjust the 'timezero' location so that it falls near the start of the second division. There are 4 menu options along the bottom of the screen to assist with adjusting timezero: **Auto <>**, **Shift <**, **Shift >** and a percentage.

Pressing **Auto <>** initiates an automatic search and adjust to bring the timezero location within the ideal region. The automatic search and adjust, while not perfect, should work get timezero close to the ideal region most of the time. It is based on the assumption that the first break (first signal to arrive) is strong compared to the surrounding background noise. If antennas are at a large separation, or there is a large amount of external noise then this automatic adjustment may not function correctly.

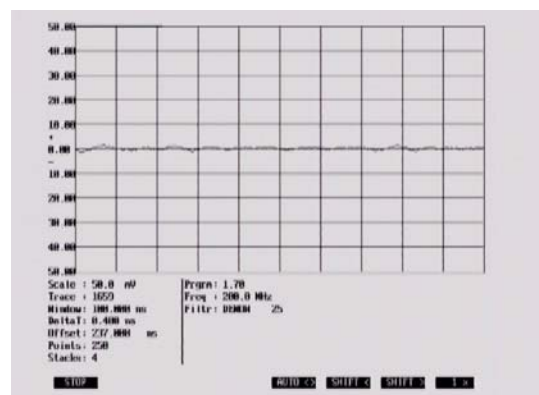


Figure 4-4: If the transmit pulse is not visible on the Scope screen, use **Auto <>** to shift the pulse closer to the ideal region shown in Figure 4-2.

Shift > and **Shift <** are used if the transmit pulse is visible on the screen but needs to be moved into the ideal region (Figure 4-3). The Shift button will change to reverse video when selected and the pulse will step across the screen in the direction indicated. Pressing the Shift button again will deactivate the shift and stop the pulse. The percentage value (1%, 5%, 10% and 25%) determine the amount that the pulse is shifted in each step. Generally, 1% or 5% work well. The higher values tend to shift the pulse in large steps and it is easy for the pulse to shift a long way very quickly.

In general, timezero should be found near an Offset value (listed on the scope screen) of around zero ns.

If no transmit pulse is found then there is a problem with the transmitter (Section 7.5: P101).

Once the user is happy that everything is working properly and all parameters are correctly set, pressing the **STOP** and **EXIT** button exits Scope mode and returns the user to the main Run menu. At this point, the user can select Collect to begin data collection.