pulseEKKO PRO TLF-A Transmitter

USER'S GUIDE

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This warranty gives you specific rights. You may have other rights which vary from province to province, territory to territory and certain limitations contained in this limited warranty may not apply to you.

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In the event of any conflict between any provision in this licence agreement and limited warranty and any applicable provincial legislation, the applicable provincial legislation takes precedence over the contravening provision. This agreement shall be governed and construed in accordance with the laws of the Province of Ontario, Canada.

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Failure of either party to enforce any of its rights in this agreement or take action against any other party in the event of a breach of this agreement shall not be considered a waiver of the right to subsequent enforcement of its rights or actions in the event of subsequent breaches by the other party.

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You acknowledge that you have read this agreement, understand it and agree to be bound by its terms and conditions. You further agree that this agreement is the complete and exclusive statement of agreement between the parties and supersedes all proposals or prior agreements oral or written between the parties relating to the subject matter of this agreement.

Should you have any questions concerning this agreement, please contact in writing:

Table of Contents

1   Overview

This manual describes how to use the pulseEKKO PRO Ground Penetrating Radar (GPR) system transmitter.

System Assembly   Section 2 on page 3 discusses in detail the step by step procedure for
& Startup: assembling the pulseEKKO PRO system and connecting the transmit-
                           ter to it.

Troubleshooting: Section 3 on page 9 presents some simple steps the user should go
                           through when the transmitter is not working as it should.

Care and Maintenance: Section 4 on page 11 discusses procedures for the care and mainte-
                           nance of your pulseEKKO transmitter.

Helpful Hints: Based on years of experience, Section 5 lists some helpful hints to
                           help make data collection and field operations run as smooth as possi-
                           ble.

Users should read Sensors & Software's statement on issues regarding health and safety in Appendix A - Health & Safety Certification.

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2   System Assembly and Startup

The modular design of the pulseEKKO Pro GPR makes the system very flexible and readily field-portable. There are four essential components to the radar system: the control or console unit, the transmitter assembly, the receiver assembly and the Digital Video Logger (DVL). The transmitter and receiver assemblies are connected to the console unit via appropriate fiber optics cables and the console is connected to the DVL via a RS232 cable (Figure 2-1). This section discusses the detailed steps to follow to assemble the whole pulseEKKO Pro system.
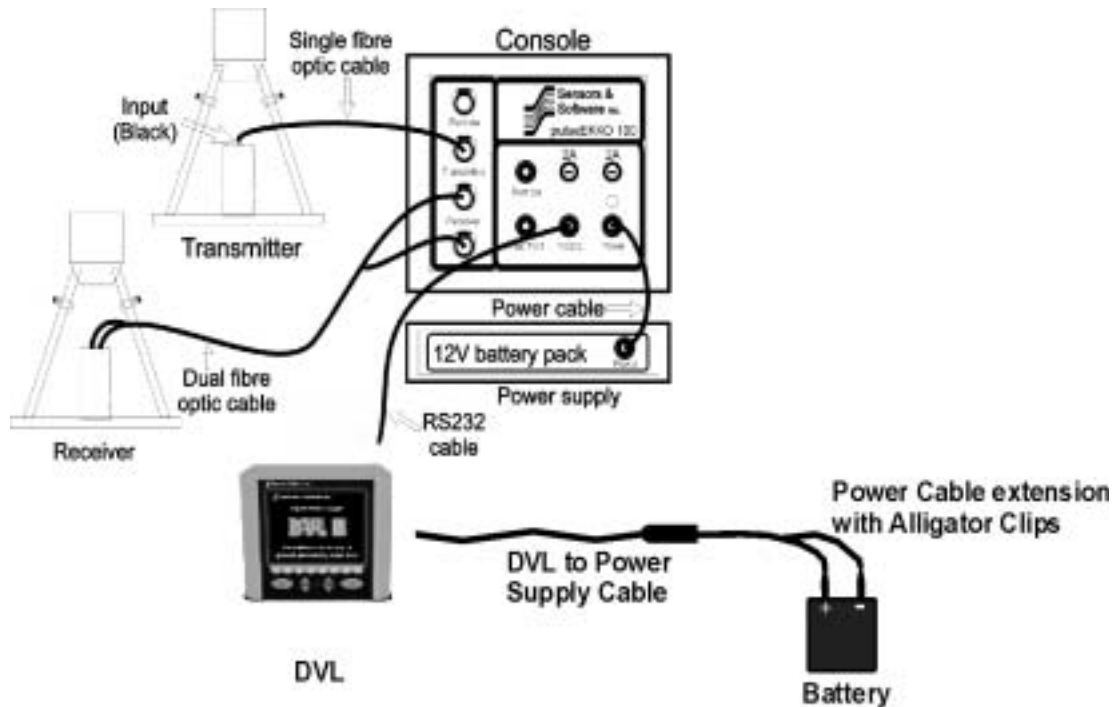

Figure: 2-1

2.1   Antenna Assembly

The procedures for assembling the transmitter and receiver antennas are identical. A detailed diagram of this assembly can be found in Figure 2-2. The assembly steps are as follows:

a) Check the two male brass antenna connector pins for damage; replace if necessary. Insert the pins into the two threaded holes in the center of the antennas. Tighten the pins finger-tight. DO NOT APPLY UNDUE FORCE !

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

c) Attach the antenna mounting block to the antenna 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. Quarter-turn fasteners work by aligning the screw in the socket and the pressing downward and tightening a

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quarter of a turn. DO NOT APPLY UNDUE FORCE. It is usually best to have all the screws properly aligned in their socket before tightening each one.

d) Carefully place the electronic boxes down onto the mounting block such that both brass pins fully connect. Then use the 2 plastic draw latch connectors to hold the electronics boxes on the mounting block.

e) With the transmitter and receiver power switched OFF, unlatch the 2 battery covers on the sides of the electronics and open. Place one 12-volt battery on each side on the electronics boxes making sure the positive (+) terminal faces inward toward the electronics (the battery only fits properly in this orientation). Close and latch the battery covers. Note that the system will run with only one 12 volt battery but using two batteries is recommended.

f) Attach the adjustable handle to the antenna using the flat head screwdriver to tighten the 4 quarter-turn fasteners as with the mounting block. This handle can then be adjusted for height by loosening the 2 knurled knobs by hand, moving the handle to the desired height and retightening the knobs (Figure 2-2).
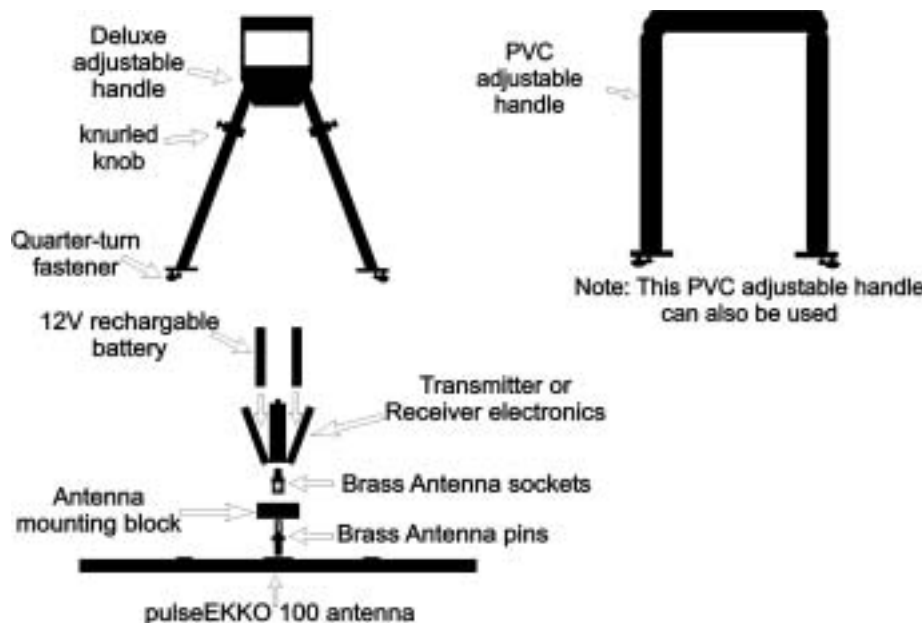
Figure: 2-2

2.2   Connecting up the Radar

Once the antennas are assembled, the next step is to connect the antennas to the console and the console to the DVL. Refer to Figure 2-1.

a) Check the fiber optic cables for damage by holding one end towards a light source and looking into the other end. If light is not transmitted through the cable or appears dim, then replace or repair the cable. Inspect the cable for any kinks or signs of damage and, again, repair if necessary.

b) Plug the black end of the single fiber optics cable (or dual fiber optics cable if you are using a remote trigger or odometer; see below) into the INPUT (black) connector in the transmitter and the other end into the single red receptacle labelled "Transmitter" on the console.

c) Plug the dual fiber optics cable into the receiver, black to black and grey to grey, and the other ends likewise into the double yellow receptacles labelled "Receiver" on the radar console.

d) Using the RS232 cable, connect the console unit (white receptacle) to the serial port on the DVL (the cable will only fit in one of the receptacles on the back of the DVL). It is suggested that these connections be secured with proper screws to prevent accidental disconnection during operation.

e) Connect the DVL to Power Supply Cable to the 9-socket connector on the back of the DVL. Then connect the Power Cable Extension with Alligator Clips to the end of the DVL to Power Supply Cable. 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.

f) Turn the transmitter and receiver ON by pressing the button on the top of each unit. The red Power light should come on to indicate that power is being received. If not, check that the batteries inside the Transmitter and Receiver are fully charged and have been inserted the right way.

g) Turn the DVL ON by pressing any button on the front. As the DVL boots up, the lower red light will come on and it will beep until it has fully booted up.

h) Connect the console power supply to the white POWER receptacle and turn power supply ON, if necessary. If a battery cable is being used make sure that the black clip is attached to the negative (-) and the red clip is attached to the positive (+) battery terminals.

i) Before actually storing data, allow the console to run to reach ambient operating temperature. This time varies depending on outside temperature; however, 5 to 10 minutes is generally sufficient.

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

Note that it is possible for the pulseEKKO Pro console and the DVL to share a common 12 Volt power source like a battery. Simply connect the alligator clips on the Console Power Supply cable and the Power Cable Extension with Alligator Clips to the proper terminals of the battery.

2.3   Adding Optional Items

2.3.1   Fiber Optic Remote Trigger and Beeper Unit

To attach the Fiber Optic Remote unit to the pulseEKKO Pro deluxe handles, remove the screw near the top of one of the handles. Then attach the two pieces of the handle attachment assembly (Figure 2-3) and replace the screw as shown. Now press the Fiber Optic Remote onto the handle and twist it a quarter-turn into place.
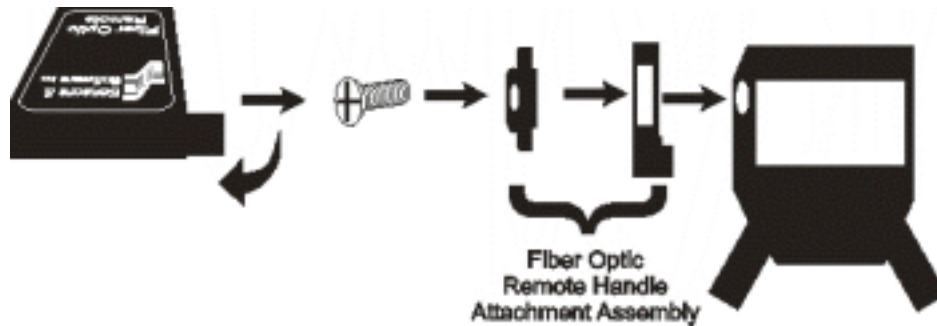
Figure: 2-3

For PVC handles, attach the Fiber Optic Remote to the handle as shown in Figure 2-4.

Figure: 2-4

To connect up the fiber optic remote trigger and beeper unit you should have a dual fiber optic cable for the console to transmitter connection plus a short single fiber optic cable (Figure 2-5). One of the two cables on the dual fiber optic cable will, if the above directions were followed, already be connected from the red transmitter receptacle on the console to the black (INPUT) receptacle on the transmitter.

Figure: 2-5

The steps necessary to complete the connection of the remote trigger and beeper unit are:
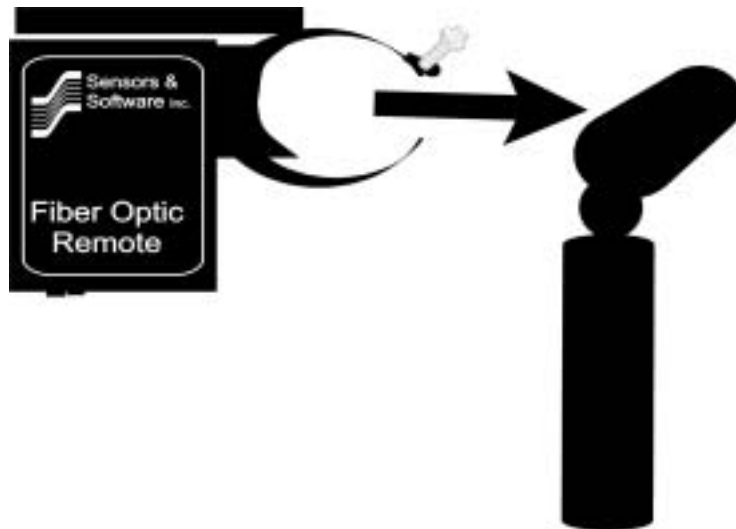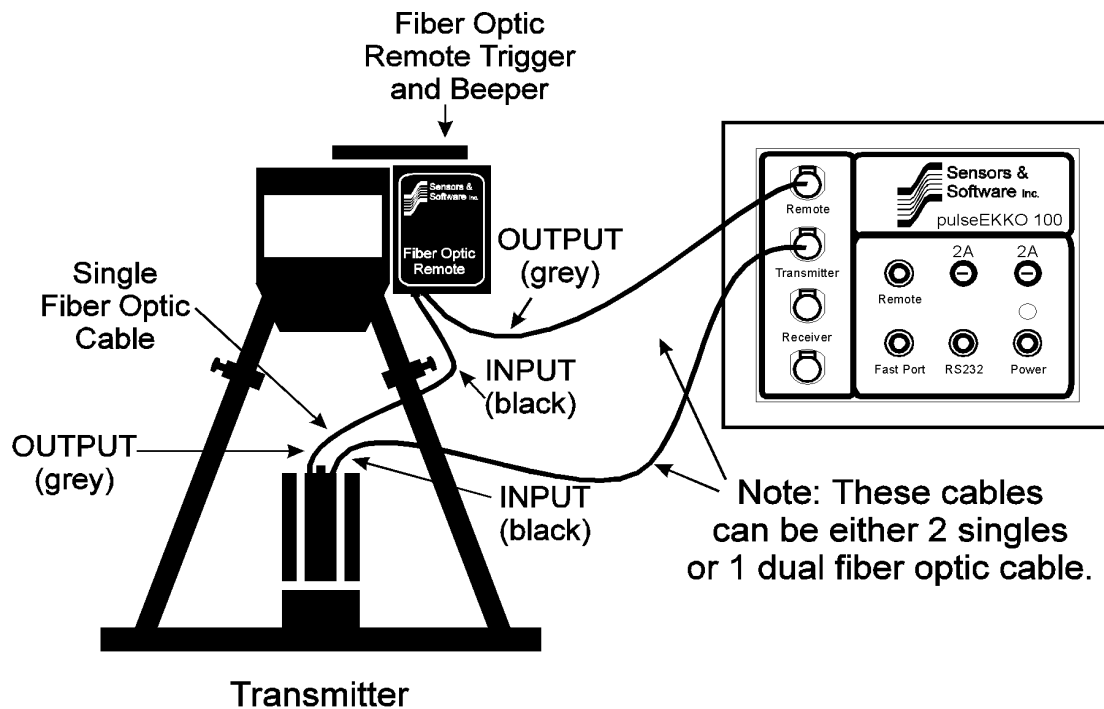
1) The black fiber optic cable of the dual cable connects from the red REMOTE receptacle on the console to the OUTPUT (grey) fiber optic connector on the remote trigger and beeper unit. This connection is necessary for the trigger part of the remote trigger and beeper unit to work.

2) The short single fiber optic cable connects from the INPUT (black) fiber optic connector on the remote trigger and beeper unit to the OUTPUT (grey) receptacle on the transmitter. This connection is necessary for the beeper part of the remote trigger and beeper unit to work.

During data acquisition, the beeper will emit a beep as data are being collected.

As well, when the radar system is run in Step mode, data acquisition can be controlled using the button on the remote trigger and beeper unit.

2.3.2 Odometer

The pulseEKKO Pro odometer is useful for collecting data at a user defined stepsize (1 cm to 10 m) without the necessity of a tape measure or survey makers.

The odometer has 2 settings: string and wheel. The wheel odometer setting can be used in situations where a wheel or cart can easily be pulled across the surface. The string odometer setting is useful when conditions are too rugged for the use of a wheel.

The odometer has both a fiber optic connection and an electrical connection (Figure 2-6). Either connection can be used to connect the odometer to the console.
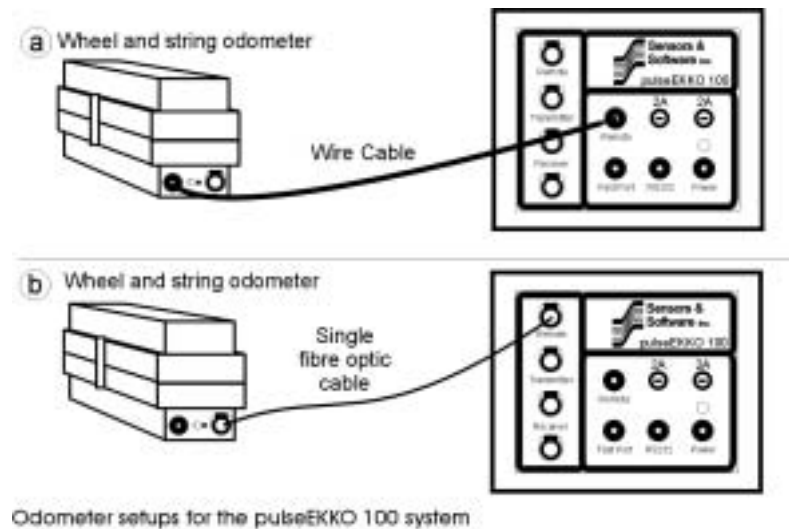

Figure: 2-6

1) **Electrical Connection:** To connect up the odometer using the electrical connection you should have the proper cable for the console to odometer connection. Connect the cable from the red electrical REMOTE receptacle on the console to the electrical receptacle on the odometer. (Figure 2-6a)

2) **Fiber Optic Connection:** To connect up the odometer using the fiber optic connection you should have a dual fiber optic cable for the console to transmitter connection. One of the two cables on the dual fiber optic cable will, if the above directions were followed, already be connected from the red transmitter receptacle on the console to the INPUT (black) receptacle on the transmitter. (Figure 2-6b)

To complete the connection of the odometer the black fiber optic cable of the dual cable connects from the red REMOTE receptacle on the console to the grey fiber optic connector on the odometer.

With either of these connections made, when the radar system is run in Step mode, data acquisition is controlled by the odometer.

3   Troubleshooting

In this section, a thorough discussion of the error conditions will be presented together with a systematic step-by-step procedure for tracking down the source of the problem.

3.1   Transmitter Problem: No Signal on Screen

a) In Graph mode try the Automatic timezero search. Keep the antennas about one antenna length apart.

b) If the error comes up "No Signal Found" then try using the Full Search option in Graph mode timezero search to look for the pulse.

If the pulse still cannot be found do the following checks:

Make sure the transmitter battery is properly charged and connected.

Check the condition of the single fiber optic cable to the transmitter, looking for any signs of stress or damage. Replace or repair if needed.

Check that the brass antenna sockets in the bottom of the transmitter and the brass antenna pins in the top of the antenna are properly tightened. Also check that there is a good contact between them.

Set the system up with a time window of 1500 ns, stacks at 1024 and sampling interval at 800ps. Unplug the grey transmitter fiber optics at the console.

With the system running, look for a red light coming from the grey hole in the console (single hole). Plug this cable back in and unplug the INPUT (black) cable at the transmitter. Check for a red light coming from the cable.

If the above process fails while checking the light in the cable then replace the cable.

If the above process fails while checking the light in the console, carefully remove the back from the console unit and check the short fiber optic cables inside the unit. As a test, these short sections of cable may be bypassed by plugging the long transmitter fiber optic cable directly into the electronics. Replace or polish the short cable if needed.

c) If the signal is still not found, set the system up with the maximum time window (2048 ns on older systems, 32000 ns on newer systems) and stacks at one. Run in Graph mode and use the Full Search option to look for signal. If the pulse is visible on the trace, adjust it to the shaded region. Now you should be able to change the time window back to the desired length and have timezero visible.

d) If the signal is still not found, contact Sensors & Software Inc.

4   Care and Maintenance

4.1   General

To operate the pulseEKKO Pro equipment in a geophysical field environment, the user should exercise the normal care afforded other field instrumentation. Items that require specific maintenance procedures are listed below together with detailed descriptions of the procedures.

All the equipment is 'shower proof' but will not tolerate total immersion. If the equipment is immersed in water, open up the affected box, and dry it out before operating. If the equipment is operated in very humid conditions, open up the boxes occasionally and allow the components to dry out. Condensation inside the console may occur in cold, wet climates. If condensation is seen, open up the console and dry out before applying power.

The interior of the console can become very hot very quickly if exposed to strong, direct sunlight. High temperatures can affect system electronics and may lead to failures. Try to keep the console well insulated against extreme temperatures. If a suspected heat failure does occur, stop the system and allow it to cool down before retrying.

The equipment is housed in heavy duty boxes and can withstand a reasonable amount of physical abuse. Items that are particularly sensitive to damage are the following.

4.2   Radar Unit

If operated in dusty conditions the console receptacles and fiber optic sockets may become dusty inside. In such conditions open the unit up on a regular basis and blow out or vacuum all the dust. It is best to place the plastic connector plugs into the receptacles when not in use.

4.3   Battery Power Requirements

The pulseEKKO Pro console is designed to operate from a 12 volts DC, 3 to 4 amp source such as batteries or power supply. The input voltage tolerance is 10.2 volts to 15 volts. The console draws 1 amp.

The transmitter employs one or two 12-volt batteries and draw less than 1 amp. They will, under normal conditions, run for 4 hours or more on a pair of 2.3 AH batteries. Sets of rechargeable lead-acid batteries are provided with the system for the transmitter.

4.4   Transmitter and Receiver Battery Maintenance

The pulseEKKO Pro transmitter both use one or two 12-volt sealed lead acid batteries. If they are maintained in a charged condition they will give long life and reliable service. Improper use and maintenance will greatly reduce their life.

Sealed lead acid batteries should NEVER be left in a discharged condition for any period of time. Charge the batteries as soon as possible after use.

Charge batteries at room temperature whenever possible.

The receiver and transmitter contain a voltage monitoring circuit that will turn off the unit when the input voltage drops below 10.2 volts. If the voltage of the discharged batteries is measured some time after they have been changed it will be higher than 10.2 volts (this is normal). Do not mix charged and discharged batteries and DO NOT attempt to use discharged batteries a second time.

If a battery has been deeply discharged or left in a discharged condition for some period of time it may not accept charge immediately when it is connected to the charger (The fast charge LED will not light).   If the fast charge light does not come on within 6 hours the battery should be considered damaged and discarded.

Do not assume that a battery that is still charging after 8 hours is nearing the end of its charge cycle. Typical charging time for an empty battery is 12 hours from start of fast charge. When charging a depleted battery it is normal for the charge light to go out after 6-8 hours. The charger has gone into trickle mode only and the battery must remain in the charger for the minimum 12 hours required.

Ensure that the batteries are fully charged before storing. If practical, store the batteries in a cool place, 10◦C (a refrigerator is ideal), but make sure the temperature is not likely to drop below -30◦C or the electrolyte may freeze and possibly split the case.

4.5   Testing Batteries

If you are experiencing reduced operation time with either your pulseEKKO Pro Transmitter the problem will be the result of a damaged 12 V Battery or a poor battery connection in one of the battery compartments. The pulseEKKO Pro Transmitter is designed to operate while using a 12V battery in one battery compartment or both battery compartments. This feature can be used to load test the batteries, as outlined below:

a) Label all batteries so that they can be distinguished from one another.

b) Insert fully charged suspect battery into the battery compartment of either the Transmitter or Receiver unit.

c) Open the empty top battery compartment and measure the D.C. voltage at the two contact points on the battery holder plate. A suspect battery will show a substantial drop in voltage when the battery is loaded down (POWER ON) and will slowly drop to less than 10 V after 2 hours of monitoring voltage. A good battery will remain at 12 V or higher after 2 hours of monitoring voltage.

All battery compartments should be checked periodically for proper operation. Take a known good battery and install into the four battery compartments. Ensure the power light activates with no intermittent operation. If the power light will not activate look in the battery compartment and check the battery contact for signs of excessive stress. Also check the condition of the 2A fuse wiring. If the problem persists, remove the six screws holding the battery plate in place and lift upwards. On the bottom of the battery plate you will see a small circuit board that extends the battery input to the power switch. Check the connections to and from this board. Please contact Sensors & Software Inc. should all the above fail to resolve the problem.

4.6   Fiber Optics Cables

These cables can stand a great deal of abrasive wear but the user should avoid sharp bends in the cable, pulling the cable at right angles close to the fiber optics connectors, or allowing the unprotected ends to get dirty or scratched. Erratic timezero jumps usually indicate a cracked cable. If problems are encountered with the fiber optics cables, repair is very straightforward and is outlined in detail below. The best policy is to carry spares. Short fiber optic cables are located inside each of the units. These short cables may need cleaning and polishing from time to time.

5   Helpful Hints

5.1   Handling Fiber Optic Cables

The fiber optic cables are the most fragile component in the system. They can be easily damaged by misuse.

When handling the fiber optic cables always roll and unroll them as if they were on a spool. DO NOT roll them around your arm like a rope or extension cord. Also, these cables do not twist, therefore laying the roll on the ground and pulling the cable off will cause the cables to tangle.

5.2   Connecting the Fiber Optics

Always push in and remove the cable by holding the strain relief jacket or the plastic end connector. Pulling on the cable will loosen the crimp and damage the cable. After connecting the fiber optic cables to the antenna electronic boxes, loosely loop the cable and tape off some slack onto the handles. Most breaks occur right at the cable ends when they are accidentally pulled.

5.3   Batteries

Replace batteries before they go dead. Nothing is more annoying than losing data in the middle of a traverse. Only operate continuously for about 3 hours before replacing unless you have new, well charged batteries. Carry plenty of spares.

Appendix A Health & Safety Certification

Radio frequency electromagnetic fields may pose a health hazard when the fields are intense. Normal fields have been studied extensively over the past 30 years with no conclusive epidemiology relating electromagnetic fields to health problems. Detailed discussions on the subject are contained in the references and the web sites listed below.

The USA Federal Communication Commission (FCC) and Occupational Safety and Health Administration (OSHA) both specify acceptable levels for electromagnetic fields. Similar power levels are mandated by corresponding agencies in other countries. Maximum permissible exposures and time duration specified by the FCC and OSHA vary with excitation frequency. The lowest threshold plane wave equivalent power cited is 0.2 mW/cm^2 for general population over the 30 to 300 MHz frequency band. All other applications and frequencies have higher tolerances as shown in graphically in Figure A-1.
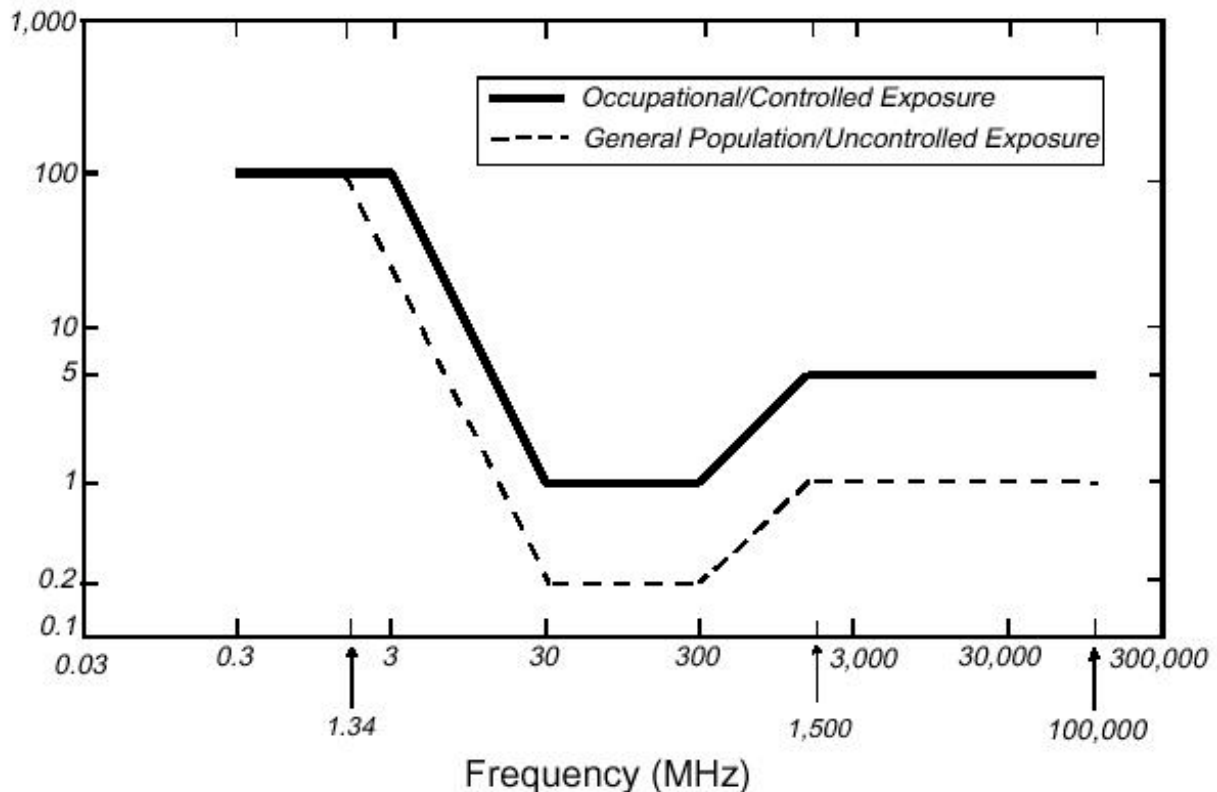

Figure A-1: FCC limits for maximum permissible exposure (MPE) plane-wave equivalent power density mW/cm^2.

All Sensors & Software Inc. pulseEKKO, Noggin and Conquest products are normally operated at least 1 m from the user and as such are classified as "mobile" devices according to the FCC. Typical power density levels at a distance of 1 m or greater from any Sensors & Software Inc. product are less than 10^{-3} mW/cm^2 which are 200 to 10,000 times lower than mandated limits. As such, Sensors & Software Inc. products pose no health and safety risk when operated in the normal manner of intended use.

References

1. Questions and answers about biological effects and potential hazards of radio-frequency electromagnetic field

   USA Federal Communications Commission, Office of Engineering & Technology

   OET Bulletin 56
   (Contains many references and web sites)

2. Evaluation Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields.

   USA Federal Communications Commission, Office of Engineering & Technology

   OET Bulletin 56
   (Contains many references and web sites)

3. USA Occupational Safety and Health Administration regulations paragraph 1910.67 and 1910.263.

Web Sites

www.fcc.gov/Bureau/EngineeringTechnlogy/Documents/bulletin

www.osha-slc.gov/SLTC (see radio frequency)

Appendix B   FCC Regulations

This device complies with Part 15 of the USA Federal Communications Commission (FCC) Rules. Operation in the USA is subject to the following two conditions:

(1) this device may not cause harmful interference and
(2) this device must accept any interference received, including interference that may cause undesired operation.

Part 15 – User Information

This equipment has been tested and found to comply with the limits for a Class A digital device, where applicable, and for an ultrawide bandwidth (UWB) device where applicable, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

WARNING

Changes or Modifications not expressly approved by Sensors & Software Inc. could void the user's authority to operate the equipment.

Certification of this equipment has been carried out using approved cables and peripheral devices. The use of non-approved or modified cables and peripheral devices constitutes a Change or Modification outlined in the warning above.

Operating Restrictions

Operation of this device is limited to purposes associated with law enforcement, fire fighting, emergency rescue, scientific research, commercial mining, or construction. Parties operating this equipment must be eligible for licensing under the provisions of Part 90 of this chapter.

FCC Interpretation of Operation Restrictions issued July 12, 2002
(FCC Order DA02-1658, paragraph 9)

The regulations contain restrictions on the parties that are eligible to operate imaging systems. [1] Under the new regulations, GPRs and wall imaging systems may be used only by law enforcement, fire and emergency rescue organizations, by scientific research institutes, by commercial mining companies, and by construction companies. Since the adoption of the *Order*, we have received several inquiries from the operators of GPRs and wall imaging systems noting that these devices often are not operated by the users listed in the regulations but are operated under contract by personnel specifically trained in the operation of these devices. We do not believe that the recent adoption of the UWB rules should disrupt the critical safety services that can be

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1.   See 47 C.F.R. §§15.509(b), 15.511(b), and 15.513(b)

performed effectively only through the use of GPRs and wall imaging systems. We viewed these operating restrictions in the broadest of terms. For example, we believe that the limitation on the use of GPRs and wall imaging systems by construction companies encompasses the inspection of buildings, roadways, bridges and runways even if the inspection finds no damage to the structure and construction does not actually result from the inspection; the intended purpose of the operation of the UWB device is to determine if construction is required. We also believe that the GPRs and wall imaging systems may be operated for one of the purposes described in the regulations but need not be operated directly by one of the described parties. For example, a GPR may be operated by a private company investigating forensic evidence for a local police department.

FCC Permitted Mode of Usage

The GPR antenna must be kept on the surface to be in compliance with FCC regulations. Use of the antenna is not permitted if it is lifted off the surface. Use as a through-the-wall imaging device is prohibited.

GPR Use Coordination

FCC regulation 15.525(c) requires users of GPR equipment to coordinate the use of their GPR equipment as described below:

a) UWB imaging systems require coordination through the FCC before the equipment may be used. The operator shall comply with any constraints on equipment usage resulting from this coordination.

b) The users of UWB imaging devices shall supply operational areas to the FCC Office of Engineering and Technology, which shall coordinate this information with the Federal Government through the National Telecommunications and Information Administration. The information provided by the UWB operator shall include the name, address, and other pertinent contact information of the user, the desired geographical area(s) of operation, and the FCC ID number and other nomenclature of the UWB device. If the imaging device is intended to be used for mobile applications, the geographical area(s) of operation may be the state(s) or county(ies) in which the equipment will be operated. The operator of an imaging system used for fixed operation shall supply a specific geographical location or the address at which the equipment will be operated. This material shall be submitted to the following address:

Frequency Coordination Branch., OET
Federal Communications Commission
445 12th Street, SW
Washington, D.C. 20554

ATTN: UWB Coordination

The form given on the following page is a suggested format for performing the coordination.

FCC GROUND PENETRATING RADAR COORDINATION NOTICE

NAME:

ADDRESS:

CONTACT INFORMATION [CONTACT NAME AND PHONE NUMBER]:

AREA OF OPERATION [COUNTIES, STATES OR LARGER AREAS]:

FCC ID: [E.G. QJQ-PE-PRO-TLF-A)]

EQUIPMENT NOMENCLATURE: [E.G. PULSEEKKO PRO TLF-A]

Send the information to:

Frequency Coordination Branch., OET
Federal Communications Commission
445 12th Street, SW
Washington, D.C. 20554
ATTN: UWB Coordination
Fax: 202-418-1944

INFORMATION PROVIDED IS DEEMED CONFIDENTIAL

Appendix C   Instrument Interference

Immunity regulations place the onus on instrument/apparatus/device manufacturers to assure that extraneous interference will not unduly cause an instrument/apparatus/device to stop functioning or to function in a faulty manner.

Based on independent testing house measurements, Sensors & Software Inc. systems comply with such regulations in Canada, USA, European Community and most other jurisdictions. GPR devices can sense electromagnetic fields. External sources of electromagnetic fields such as TV stations, radio stations and cell phones, can cause signals detectable by a GPR which may degrade the quality of the data that a GPR device records and displays.

Such interference is unavoidable but sensible survey practice and operation by an experienced GPR practitioner can minimize such problems. In some geographic areas emissions from external sources may be so large as to preclude useful measurements. Such conditions are readily recognized and accepted by the professional geophysical community as a fundamental limitation of geophysical survey practice. Such interference being present in the GPR recordings is not considered as an equipment fault or as a failure to comply with immunity regulations.

Appendix D   Safety Around Explosive Devices

Concerns are expressed from time to time on the hazard of GPR products being used near blasting caps and unexploded ordnance (UXO). Experience with blasting caps indicates that the power of Sensors & Software Inc.'s GPR products are not sufficient to trigger blasting caps. Based on a conservative independent testing house analysis, we recommend keeping the GPR transmitters at least 5 feet (2m) from blasting cap leads as a precaution. Some customers do experimental trials with their particular blasting devices to confirm with safety. We strongly recommend that GPR users routinely working with explosive devices develop a systematic safety methodology in their work areas.

The UXO issue is more complex and standards on fuses do not exist for obvious reasons. To date, no problems have been reported with any geophysical instrument used for UXO. Since proximity and vibration are also critical for UXO, the best advice is to be cautious and understand the risks.