pulseEKKO® PRO

Technical Description

PEMD 109

subsurface imaging solutions

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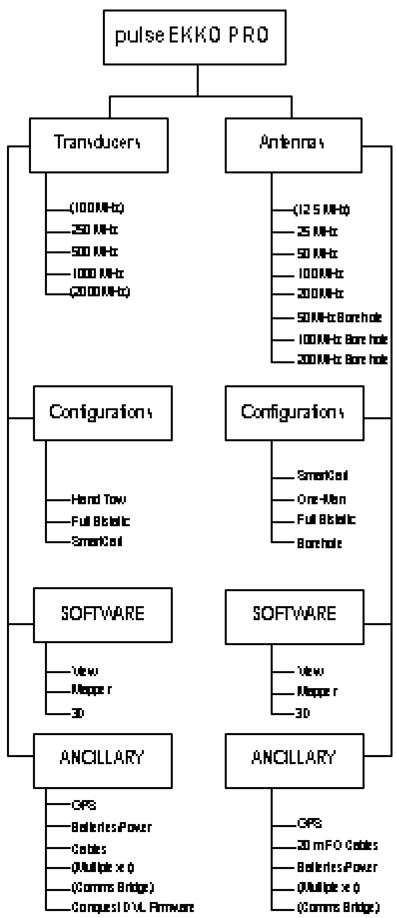
1. General

The pulseEKKO PRO is a lightweight, portable, and digital ground penetrating radar (GPR) system. The pulseEKKO family has traditionally featured modular design, high performance, flexible deployment and simple user operation. Built to exacting standards and performance specifications, the pulseEKKO PRO is the system of choice for GPR professionals.

Depending on jurisdiction, the pulseEKKO PRO has antennas which span frequencies from 10 to 2000 MHz. With the highest GPR performance available, the depth of exploration in difficult GPR terrains achieved with the pulseEKKO PRO is unsurpassed. Presentation of data in high quality report-ready annotated format reflects the need to meet the demands of engineering and geotechnical project managers and to provide completely documented history for future project demands.

2. System Configurations

The pulseEKKO PRO family is modular, giving the user maximum flexibility. The family is shown in Figure 1 with several deployment configurations shown in Figure 2. A system block diagram is presented in Figure 3.



(a) (b) (c)

(d) (e) (f)

Figure 2*: A few of the pulseEKKO PRO configurations; (a) SmartCart (b) SmartCart (c) Hand Tow (d) One-Man (e) Full Bi-Static (f) Borehole.*

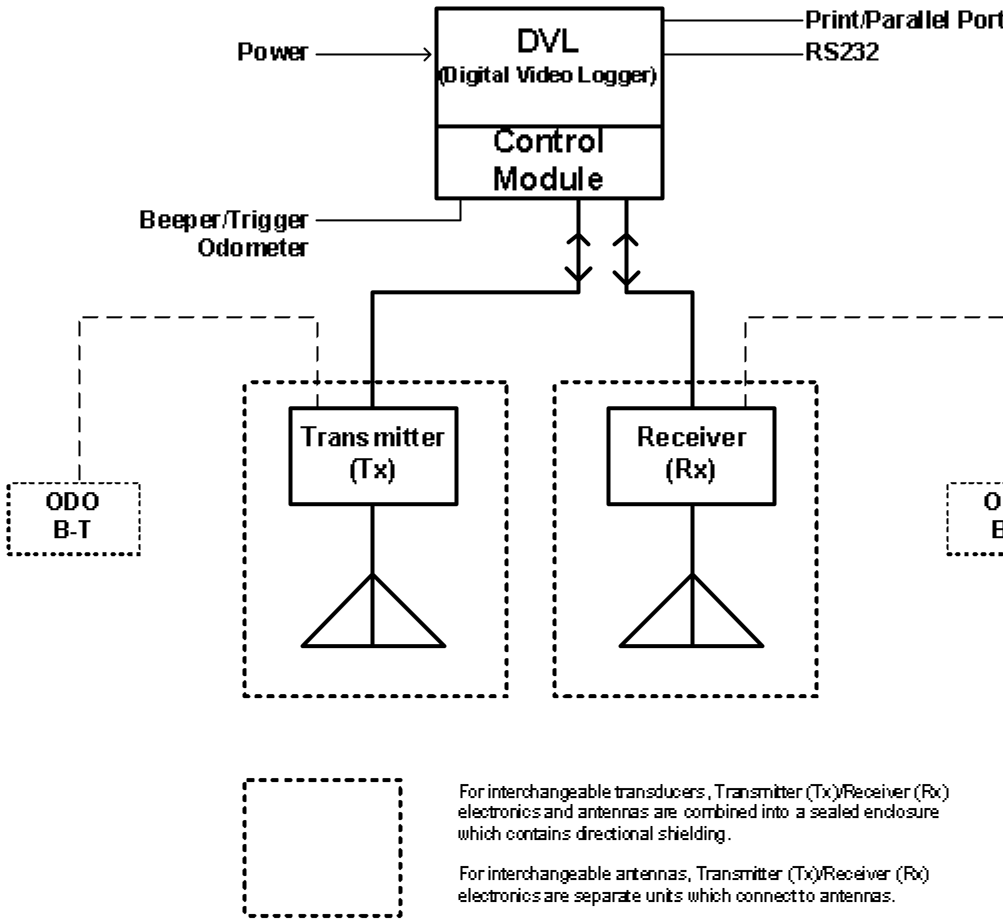


Figure 3 *pulseEKKO PRO system block diagram.*

The system is fully bistatic meaning that there are separately deployable antennas for transmitting and receiving. The bistatic design provides the flexibility needed for addressing the wide variety of GPR applications. The two antennas can be maintained in a fixed arrangement for reflection profiling or moved independently for CMP/WARR soundings or transillumination measurements necessary for tomographic imaging as depicted in Figure 4.

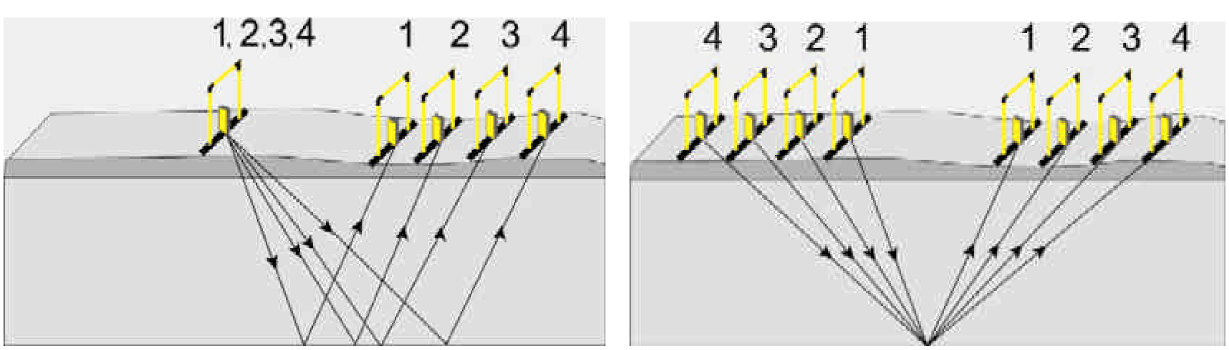


Figure 4 *Antennas can be maintained in a fixed arrangement for reflection profiling or moved independently for CMP/WARR soundings or transillumination measurements necessary for tomographic imaging*

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A pulseEKKO system consists of 6 basic components, namely, a transmitting and a receiving antenna, a transmitter electronics unit, a receiver electronics unit, a control module and a computer. With the pulseEKKO PRO, the DVL (digital video logger) computer is an integral part of the system and provides user control, data display and data storage. The user interface and control software allow the system to be operated easily. Default standards minimize time to start operation.

The operating frequency band is determined by the antennas and associated radio frequency. The pulseEKKO PRO uses interchangeable dipole antennas at low frequencies (10 to 200 MHz) and interchangeable shielded transducers at high frequencies (200 to 2000 MHz).

At low frequencies, independent transmitter and receiver electronics units plug into a range of dipole antennas. At high frequencies, integrated antenna, electronics, and shielding are packaged into transducers which are interchangeable. All electronics modules are intelligent with bi-directional communications to prove data and status.

The basic control module provides two control ports supporting a transmitting electronics unit and a receiving electronics unit. The advanced multichannel control module provides eight ports which can control any combination of transmitting and receiving systems. The channel assignment is fully programmable to allow a huge range of system configurations.

All data storage is on removable flash (solid state) memory which is located in the DVL. The removable flash can be read from any PC and data copied onto other storage media as needed. The flash memory also uploads new DVL control firmware. In addition, the DVL can access any of the intelligent transmitter and receiver electronics and upgrade control firmware and calibration tables.

3. Operational Principles

A GPR system is designed to emit a radio frequency electromagnetic field and acquire the response created by the area around the system. The pulseEKKO PRO digitizes the detected response as a function of a time delay after emitting the signals. In a bistatic system, such as the pulseEKKO PRO, this requires synchronizing time at the transmitter and receiver which may not be located at the same physical position.

Given that radiowaves travel at or near the speed of light, careful management of time delays and highly stable linear time bases are critical. pulseEKKO PRO systems employ digital equivalent time sampling (DETS) which enables fully digital sampling of signal amplitude as well as with precise calibrated digital timing. Further, systems can be started and stopped and data acquired over any arbitrary defined time window. These features make the pulseEKKO PRO much more acceptable in the increasingly restrictive radio emissions regulatory world.

The pulseEKKO PRO can be operated in a wide range of manners but all result in the acquisition of a digitally sampled waveform (i.e. radar trace) representing the voltage at the receiver antenna input as a function of time. Data acquisition follows these basic steps.

(a) The operator indicates the antenna or transducer frequency to the control unit. This step will establish default settings for parameters such as the time interval between digital waveform samples to ensure signals are properly sampled and not aliased.

(b) Prior to operation, the operator sets the length of the time window. The use can accept or change the default time or interval between samples. (This defines the number of points in the digitally sampled, namely, time window/time interval.)

(c) The pulseEKKO PRO data acquisition can be triggered from a variety of sources. Data traces can be acquired at programmed time intervals, at a button push, or by an odometer wheel or similar device. The user normally selects the desired triggering source or accepts a default.

(d) The user selects whether to save data, and if so, what file to save the data in. (The pulseEKKO PRO uses the standard Sensors & Software Inc. file format common to all its products and has been in use for more than 20 years.)

(e) At this point, the user tells the system to acquire data. The system then enters an endless loop of acquisition of data.

(f) On each trigger (time interval, push button, odometer, tick) the system will fire the transmitter and record a digital waveform. In a multiple transmitter/receiver configuration, the next pre-programmed configuration will be selected.

(g) The digital waveform is passed to the DVL for display and/or recording to flash memory.

(h) The system goes quiescent until the next trigger at which point the sequence (f), (g), and (h) are repeated.

(i) When the user tells the system to stop, data acquisition is stopped. The user can select to resume or terminate. If terminate is selected, the recorded data file is permanently closed. Normally, termination represents the end of recording for a survey transect.

(j) If another transect is to be surveyed, the user returns to step (d). The data recording file is automatically incremented (if this feature is enabled).

In addition to this big picture operation, the pulseEKKO PRO has distributed intelligence. On a continuing basis, the digital time base is constantly self-adjusting to maintain long and short term stability. The microprocessors in the control module, the transmitter, and the receiver constantly monitor supply voltage and ambient temperature to dynamically compensate for any amplitude and timing variations that these effects introduce. Precision measurement is a defining characteristic of all pulseEKKO systems.

4. Component Specifications

4.1 DVL & Control Module

1. Provides the user interface and standard default configurations.
2. Provides for raw data storage and replay on solid state memory (see Figure 6).
3. The GPR control module contains a stabilized digital clock and precise interval timer essential for DETS.
4. Two standard transmitter/receiver bidirectional communications parts.
5. Bidirectional Canbus interface to support beeper trigger and other peripherals.

6. An optical encoder odometer port for bidirectional position measurements.
7. Fibre optic conversion modules for Transmitter-Receiver fibre optics cabling.
8. All components satisfy FCC, EC, and other regulatory jurisdiction rules.

Specifications	
Weight:	2.1 kg
Size:	172 x 146 x 37 mm
Power:	200 mA @ 12V
Environmental:	IP66
Software Stacks:	Unlimited
Hardware Stacks:	1 – 32,000
PRF:	Variable to 100 kHz
Display:	640 x 480 – All light
Operating Temperature:	-40°C to +50°C
Electronics Display Operating Temperature	-10°C to +50°C
Time Window:	1 to 200,000 ns
Points/Trace	1 to 32,000
Active Temperature Compensation	-50 °C to +50°C

(a) *(b)*

Figure 5: (a) DVL front and (b) back.

Figure 6: Removable flash.

4.2 Transmitter Specifications (12.5, 25, 50, 100, 200 MHz)

1. Fibre optic linked transmitter for interchangeable antennas 12.5, 25, 50, 100, 200 MHz.
2. Transmitters certified for USA, EC, and other jurisdictions. (Some frequency limits apply in specific regions).
3. Variable power transmitters are available for use in some countries.
4. Bidirectional communications – time/commands in, status data out.
5. Powered by widely available standard gel cell batteries.
6. Power consumption Tx voltage and rep rate dependent. Quiescence.
7. Lower cost industry standard F.O. connections.
8. LED light indicator for data acquisition.
9. Power indicator on and low power LED indicators.
10. Automated temperature/ supply voltage compensation to assure timing and amplitude stability.

Specifications	
Operating Temperature	-40°C to +50°C
Weight:	28 kg
Size:	230 x 150 x 150 (mm)
Quiescent Power:	100 mA @ 12V
Maximum Active Power:	100 mA @ 12V
Cable Interface:	Fibre Optics
Power Stabilization:	uP control to 10.5 V
Active Temperature Compensation	-50 °C to +50°C

Figure 7: 12.5,25, 50, 100, 200 MHz antennas.

Figure 8: Close up of inter-changeable dipole antennas with full bistatic handle and electronics module attached. The fibre optics cables and beeper trigger are also shown.

4.3 Receiver Specifications (12.5, 25, 50, 100, 200 MHz)

1. Fibre optic communications receiver electronics for inter-changeable antennas 12.5, 25, 50, 100, 200 MHz.
2. Electronics certified for USA, EC, and other jurisdictions. (Some frequency limits may apply.)
3. Bidirectional communications – time/commands in, status and data out.
4. Powered by widely available standard gel cell batteries.

5. Low power consumption.
6. Lower cost industry standard F.O. connections.
7. LED light indicator for data acquisition.
8. Power indicator on and low power LED indicators.
9. Automated temperature/supply voltage compensation to assure timing and amplitude stability.

Specifications	
Operating Temperature	-40^{o}C to +50^{o}C
Weight:	2.8 kg
Size:	230 x 160 x 150 (mm)
Power:	100 mA @ 12V
LSB Voltage:	1.5 µV
A/D Range:	16 bit
Control Connection:	Fibre Optics
Power Stabilization:	uP controlled to 10.5 V
Active Temperature Compensation	-50 ^{o}C to +50^{o}C

Figure 9: 12.5, 25, 50, 100, 200 MHz antennas.

Figure 10: Attached to inter-changeable dipole antennas and handles.

5. Antennas

5.1 Dipole Antennas (12.5, 25, 50, 100, 200 MHz)

All dipole antennas are short linear, resistively loaded and center fed. The antennas are designed to maximize close ground coupling which maximizes energy transfer into the ground and minimizes energy leakage into the air.

Figure 11: 12.5, 25, 50, 100, 200 MHz Antennas.

The antennas and electronics design are matched to create the best impulsive dipole antennas response with minimal impact from ground loading.

5.2 Borehole Antennas (50, 100, 200 MHz)

The borehole antennas are very similar to the dipole antennas (see section 5.1). The same linear dipole design is embedded into a sealed waterproof tube used for insertion into a borehole in the ground. The transmitter and receiver electronics are placed inside the shielded container to eliminate spurious emissions. GPR signals are connected to the antennas by the customer design stealth borehole cable.

Figure 14: Borehole antenna.

6. Data Processing & Imaging Software

6.1 EKKO_View

Win_EKKO is a complete Windows-based software package for working with Sensors & Software digital GPR data. Using a spreadsheet approach to display all the GPR data in a project, files can be quickly edited, processed, converted to other formats and plotted. Editing and processing can be done on individual files or to any or all the files in a project. Favorite processing streams can be saved as "recipes" to use on other data sets.

6.2 EKKO_Mapper

EKKO_Mapper is designed to create plan-view maps of Sensors & Software digital GPR data collected in an area. Survey lines can be collected in either parallel lines or a grid. Multiple maps of different depth ranges can be produced or the user can specify exactly what depth range to map. To emphasize the feature of interest, the GPR data can be processed using temporal and spatial filters, gain, migration, enveloping and topographic corrections. Depth of penetration and noise maps can also be produced.

6.3 EKKO_Pointer

The EKKO_Pointer software package can be used with Sensors & Software digital GPR data to automatically identify areas where subsurface objects are likely to exist. EKKO_Pointer searches the GPR data and locates hyperbolas; responses that are indicative of localized targets. When these target responses are displayed in plan, side and end views, the location and orientation of targets of interest can be determined.

6.4 EKKO_3D

EKKO_3D allows the Sensors & Software digital GPR user to combine parallel survey lines to form a data volume (or cube) that is exported to the 3D-visualization program T3D. The data can then be stretched, squeezed, rotated, sliced and colored to produce images that assist in data interpretation and data presentation. T3D also provides the ability to produce variable opacity images and animations.