SPRscan Overview System Description

1. Introduction

This document provides an overview of the operation of the ERA Technology Ltd Surface Penetrating Radar - SPRscan. Pulse generator circuit diagrams and module internal photographs are contained in three separate documents: SPRscan 500 MHz antenna circuit diagrams and internal photographs, SPRscan 250 MHz Antenna Circuit Diagrams and internal photographs, SPRscan 1 GHz antenna circuit diagrams and internal photographs.

2. Over-View

SPRscan is an ultra-wide band radar intended for geophysical surveying and non destructive testing. In use, the system performs time domain reflectometry by radiating a radio frequency impulse with a repetition frequency of 1 MHz from a transmitting dipole (TX dipole). Transitions between materials exhibiting different wave impedances through which the electromagnetic wave travels cause the wave to be reflected. These reflections are received by the receiving dipole (RX dipole) and sampled by the instrument. Results may be displayed in real time on the system screen and recorded on an internal hard disk drive for later analysis. In the field, the system is usually powered from a rechargeable battery.

The system may either be carried with the antenna being dragged along the ground by a simple pull handle or it may be mounted on a trolley incorporating a distance encoder; the trolley providing mechanical support and accurate data registration.

When used for data capture, SPRscan comprises the following items as a minimum:

Controller	A ruggedised PC based upon an AMD 5x86-133 MHz processor with hard disk drive, floppy disk drive, TFT LCD display, custom internal keyboard and custom interface card housed in a custom metal enclosure.
Head Electronics	The radar control and data acquisition subsystem.
Antenna	Comprises a pair of shielded resistively loaded dipoles, a pulse generator, a preamplifier and a surface proximity sensor.
Function Handle	A hand grip incorporating control buttons and dead man's switch.

For different applications antennas are available with the following centre frequencies: 250 MHz, 500 MHz and 1 GHz. When used with the 250 MHz and 500 MHz antennas, the head electronics are mounted within the antenna housing. When used with the 1 GHz antenna the head electronics is mounted within a separate housing.

In addition to it's use as the radar system controller, SPRscan's controller may be used as a stand alone PC for analysis of previously recorded data. In this mode SPRscan is usually powered from a mains adaptor.

Further items which may be fitted include standard commercial PC peripherals including the following: keyboard, mouse, parallel port device and external monitor.

SPRscan has two active methods of reducing radio interference; these involve the incorporation of a dead man's switch to automatically inhibit impulse transmission when the system is idle and a surface proximity sensor to automatically inhibit impulse transmission when an antenna is not in contact with a suitable surface.

The product has been tested and self certified to meet the requirements of the European low voltage and EMC directives.

The following items comprise the SPRscan system:

Head Electronics	Standard	
Controller	Standard	
500 MHz antenna	Standard	
Radar interface cable (2 m)	Standard	
Mains power adaptor	Standard	
1m power cable	Standard	
Battery pack and charger	Standard	
Standard pull handle	Standard	
Function handle	Standard	
Keyboard	Standard	
Mouse	Standard	
Training	Standard	
250 MHz antenna	Optional	
1 GHz antenna	Optional	
Trolley	Optional	Incorporating distance encoder
Fast charger	Optional	
Automotive power inverter	Optional	
Radar interface cable (25 m)	Optional	Lengths up to 25 m available to order

The mains power adaptor is a commercial off the shelf item with the following specifications:

Type of equipment:	Switching power adaptor PUP55-13-ZZ-S
Manufacturer:	Protek Electronics Corp.
Power:	100 to 240 V 50-60 Hz input
	13-17 V 3.6 A
Approvals:	CSA, UL

3. Operating Modes

Figures 1 – 4 show some of the various configurations in which the SPRscan system may be operated. Section 5 provides photographs of the individual modules and the equipment in typical configurations. The SPRscan hardware manual provides further information.

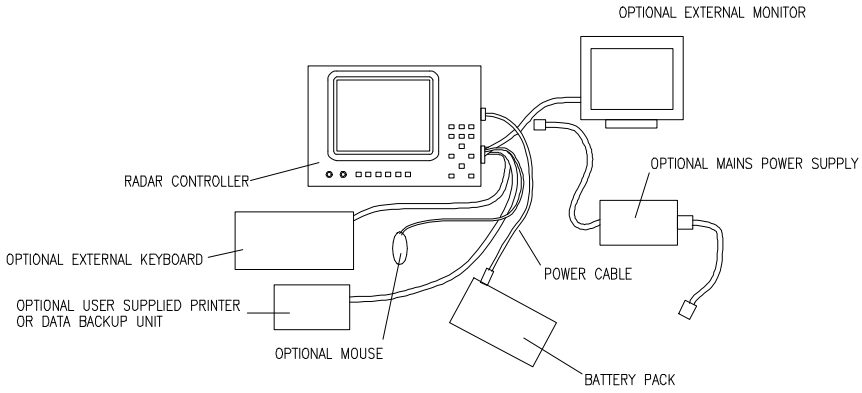

Fig. 1: Controller in office mode

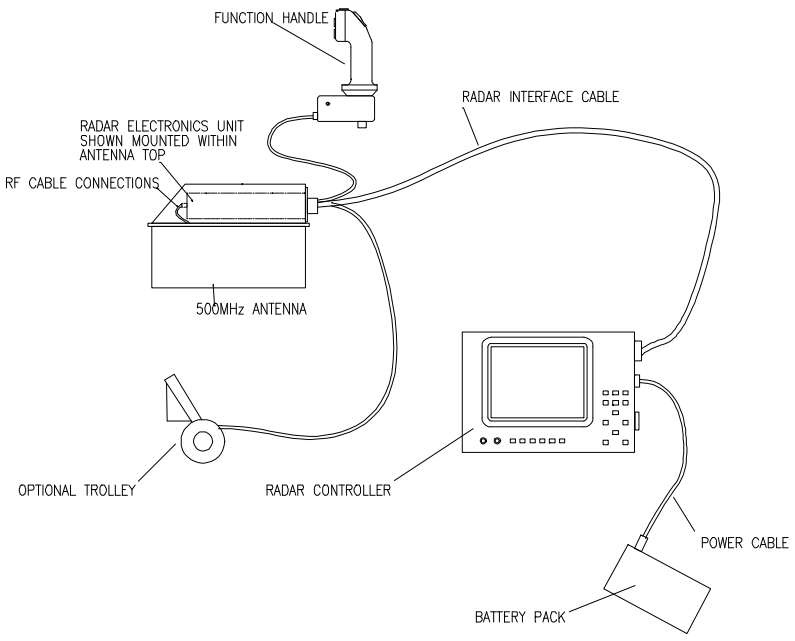

Fig. 2: SPRscan with 500 MHz antenna

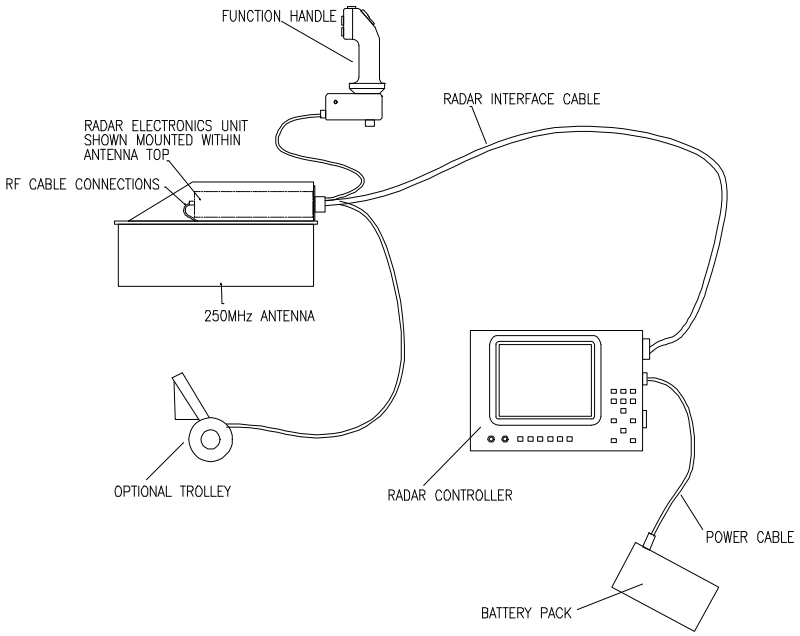

Fig. 3: SPRscan with 250 MHz antenna

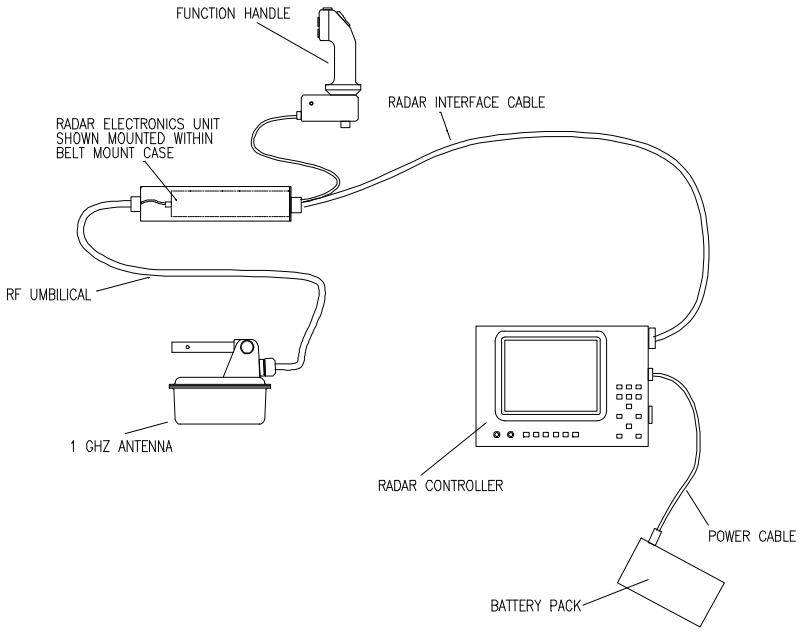

Fig. 4: SPRscan with 1 GHz antenna

4.Overview Technical Description of Main SPRscan Modules

4.1 General

The SPRscan surface penetrating radar comprises three main components: a control unit, a radar head and an antenna. To these are added peripherals and supporting mechanical parts such as pull handles, distance encoders and a function control handle. Fig. 5 shows an outline block diagram. All peripheral cables are screened to minimise the emission of radio frequency interference. Brief details of the interfaces are also provided in this diagram.

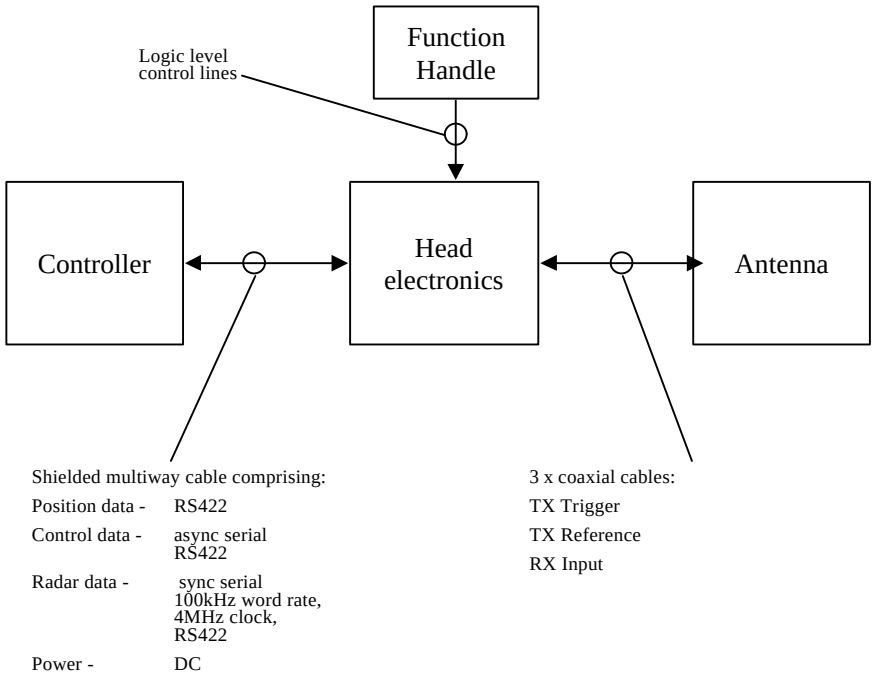

Fig. 5: SPRscan general block diagram

4.2 Controller Overview

The SPRscan controller is a battery powered custom designed PC. It is designed to be rugged and waterproof. Fig. 6 shows a block diagram. It uses a 133 MHz AMD 5x86 processor with a 33 MHz external bus. The processor card supported with a standard 3.5" floppy drive, a shock mounted 2.5" hard disk, a power supply, backplane, keyboard and a TFT LCD display. The interface to the radar head electronics unit is via a custom ISA bus interface card, which converts the serial data stream from the radar head into a parallel data stream suitable for processing and display.

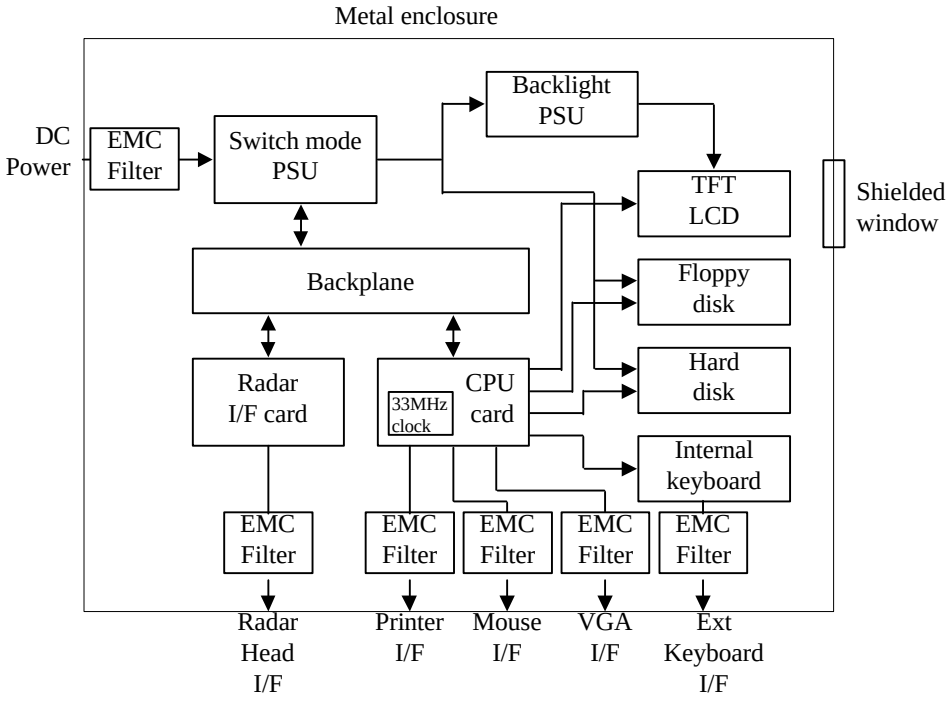

Fig. 6: SPRscan controller block diagram

Extensive EMC filtering and shielding is provided to ensure compliance with office and domestic EMC radiated limits. As can be seen from the block diagram all ports are EMC protected. The LCD screen is provided with a shielded window to minimise emissions.

To permit operation of the controller from the mains supply an external universal input power supply is provided.

4.3 Radar Head Overview

The radar head unit is the heart of the SPRscan system and is used with all of the SPRscan antennas. A block diagram is given in Fig 7. This unit comprises four main blocks: the power supply which takes raw DC from the Controller and generates the necessary circuit supplies of +5 and +/- 15 V, the control interface which takes instructions from the controller and sets up the radar circuitry, the central timing circuit which produces the required control signals to operate the antenna pulse generators and the radar receiver, and the radar receiver chain which takes the incoming RF signal, processes it and produces a 16 bit digitised output.

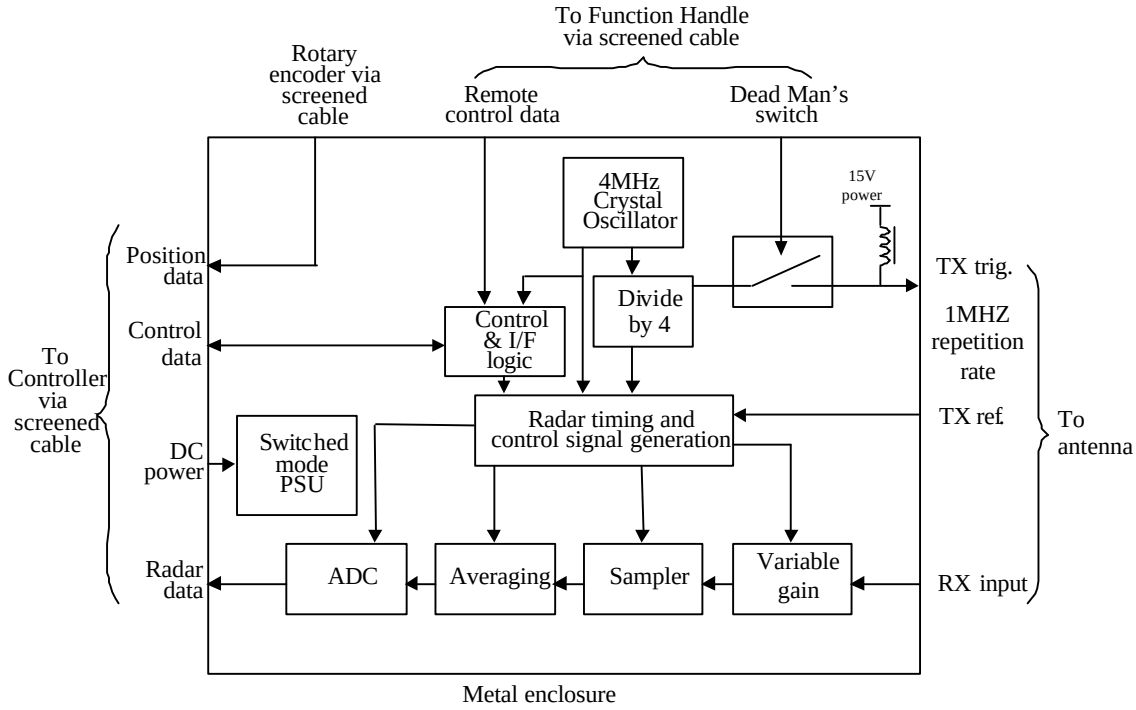

Fig. 7: SPRscan head electronics block diagram

The antenna interface comprises three signals: TX trigger, TX reference and RX. TX trigger is the main antenna control signal. It consists of a 1 V peak to peak pulse, 120 ns long with a repetition rate of 1 MHz superimposed on a regulated 15 V DC level. The latter is used as a power supply for the antenna circuits. The TX reference signal is a reference pulse from the antenna pulse generators. This is used to start the radar receiver timing for each repetition cycle.

The RX signal is the amplified wideband return signal picked up by the antenna.

The 1 MHz pulse repetition rate is derived by dividing a 4 MHz crystal oscillator by 4. This oscillator also provides the timing for the whole of the radar receiver. It has an absolute accuracy of 100 ppm.

To prevent the radar transmitting when it is not actively being used a "dead man's switch" is fitted in the function handle. If this switch is not pressed by the user the radar head will not send trigger pulses to operate the pulse generator. The power supply is enabled to power the antenna surface proximity sensor. These two circuits minimise the risk of interference to other users of the radio spectrum.

4.4 Antenna Over-View

All of the antennas: 250 MHz, 500 MHz and 1 GHz, have built-in pulse generators mounted on the radiating TX blades. The 1 MHz trigger signal must be present for the generator to operate. They all follow a basic design using a step recovery diode driven by a fast switching transistor to produce sharp impulses. This pulse is then fed to a 1:4 unbalanced to balanced transformer which drives the series and shunt resistance loaded radiating dipole elements. As the antennas cannot radiate a direct current, the impulse is differentiated to produce a wavelet as the radiated waveshape. This has a bandwidth of typically three octaves. The bandwidth is limited by the radiating elements which act as bandpass filters. A block diagram is shown in Fig. 8.

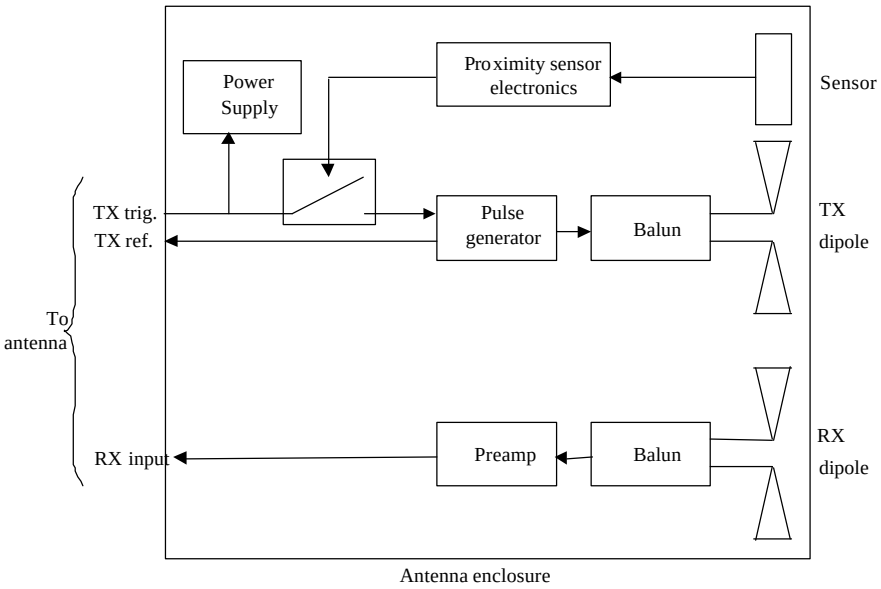

Fig. 8: SPRscan generic antenna block diagram

Though each pulse generator follows a basic design, there are implementation differences to achieve optimum performance for each frequency range. For example, a different step recovery diode is needed for the 1 GHz antennas due to the shorter pulse length and the design has to be split over two printed circuits due to mechanical space constraints.

The receiver uses a similar series and shunt resistance loaded antenna and 4:1 balun combined with a 20 dB low noise pre-amplifier to improve the noise figure of the radar head.

All of the antennas are of similar mechanical design. They comprise an aluminium construct partitioned into two areas for transmit and receive functions. This provides shielding and mechanical mounting. The blades are mounted on the bottom of the construct on an insulating support. Further shielding and damping is provided by radar absorbing material mounted around each antenna element. To provide mechanical and environmental protection the antenna is mounted in a set of ABS plastic mouldings which are glued together to prevent user access.

Due to the space available the radar head is mounted in the top of the 500 MHz and 250 MHz antennas. With the 1 GHz the radar head is mounted in a belt or backpack mounted case connected to the antenna via a 3 m cable.

To prevent inadvertent transmission of the radiated energy into free space, a surface proximity sensor is fitted to turn off the pulse generator if the antenna is not in contact with an absorbing surface.

5 External Photographs of SPRscan Components

Fig. 9: SPRscan system disassembled with 500 MHz antenna

Fig. 10: SPRscan controller in office mode

Fig. 11: SPRscan with 500 MHz antenna in use

Fig. 12: SPRscan trolley incorporating encoder

Fig. 13: SPRscan head electronics

Fig. 14: SPRscan function handle

Fig. 15: 250 MHz antenna

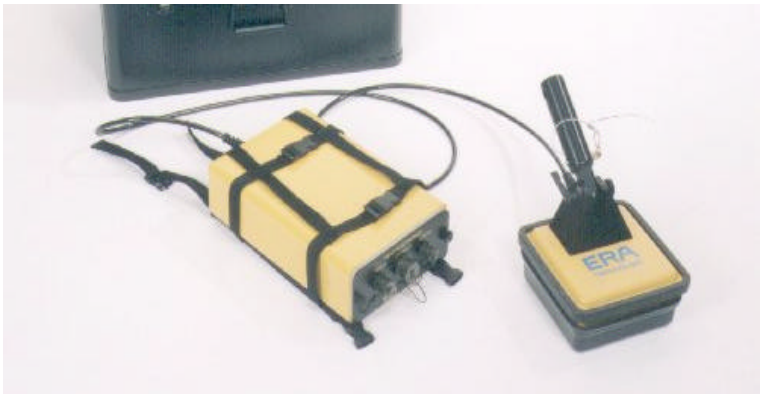

Fig. 16: 1 GHz antenna