Summary of FCC Part 90 and Part 15 Authorisation Tests for the Slope Stability Radar

Issue 1 24 September 2004 – D. Noon.
Issue 2 20 October 2004 – R. Hodgson.
Issue 3 3 March 2005 – P. Bellett
(preliminary test results and block diagrams added)

Background:

The Slope Stability Radar (SSR) is used by open-pit mines as a safety device to measure the movements of mine walls prior to collapse. Refer to http://www.groundprobe.com for more information. It is currently the only technology that can provide continuous monitoring of wall movements over broad areas and with sub-millimetre precision. SSR units are low volume devices (~100's systems in total) and are typically operated in remote mine areas.

The SSR system comprises a radar module, camera module and scanning antenna mounted on a tripod, and a computer module, display module and power module mounted on a trailer. The radar module is connected to the computer module, but can operate under normal pulsed radar operation without any other module connected. The power module is a bank of 12 V batteries that are intermittently charged by a diesel generator, and has a Part 15 FCC compliant AC backup charger. The computer module and a standard PC are connected via an FCC Part 15.247 approved telemetry link. A watchdog module is connected to the standard PC. A RAPS (remote area power supply) battery management module is used to charge the batteries via the diesel generator.

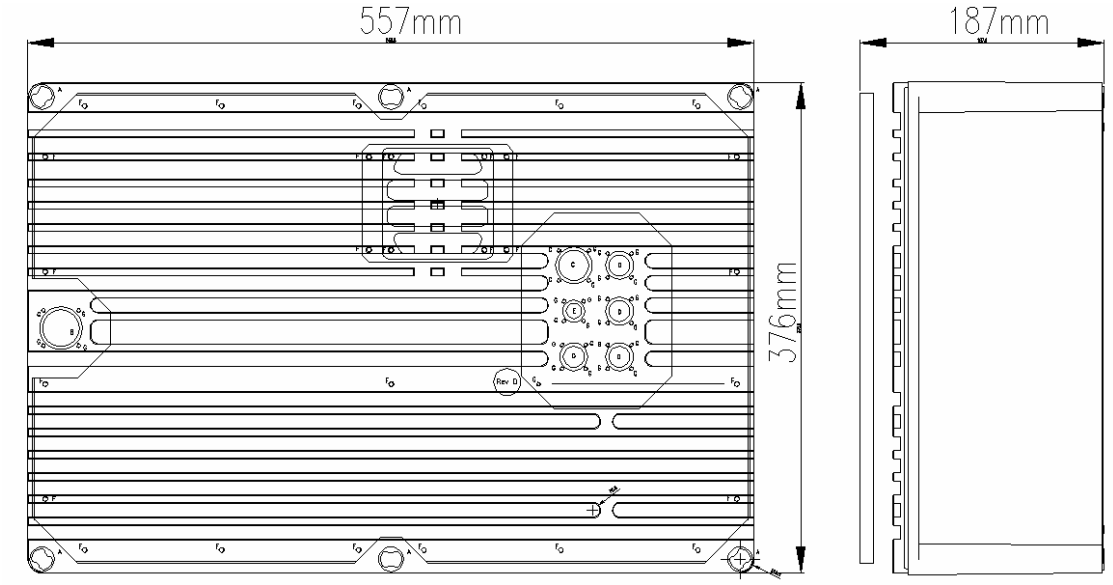
Certification under FCC Part 90 is being sought for the radar module, and FCC Part 15 Class A Verification shall apply for the remaining digital devices.

FCC Part 90 Certification Requirements on the Radar

CCS has suggested the following tests for the radar; permissible values have been determined by a discussion with Steve Dayhoff of the FCC OET on September 20, 2004:

SSR Radar Electronics Module Specifications:

Emission Designation:	P0N
Centre Frequency:	9552.5 MHz
99% Bandwidth:	105 MHz
Mean Transmitter Power:	30 mW
Peak Transmitter Power:	60 mW
Pulse Width:	4.522 microseconds
Pulse Repetition Frequency:	107.107 kHz
Antenna Gain:	38 dBi
Maximum EIRP:	25.8 dBW
Lowest generated RF:	107.107 kHz
Power Supply:	12V DC batteries charged intermittently by diesel generator. Universal AC input battery charger for backup.
Temperature:	-26 degrees to 55 degrees Centigrade



1. Power Output 2.1046

Section 2.1046(a) For transmitters other than single sideband, independent sideband and controlled carrier radiotelephone, power output shall be measured at the RF output terminals when the transmitter is adjusted in accordance with the tune-up procedure to give the values of current and voltage on the circuit elements specified in Sec. 2.1033(c)(8). The electrical characteristics of the radio frequency load attached to the output terminals when this test is made shall be stated.

(b) [Does not apply]

(c) For measurements conducted pursuant to paragraphs (a) and (b) of this section, all calculations and methods used by the applicant for determining carrier power or peak envelope power, as appropriate, on the basis of measured power in the radio frequency load attached to the transmitter output terminals shall be shown. Under the test conditions specified, no components of the emission spectrum shall exceed the limits specified in the applicable rule parts as necessary for meeting occupied bandwidth or emission limitations.

Reporting Requirement Only: The mean conducted RF power output of the radar module (under normal pulse radar operation) will be measured using a power meter.

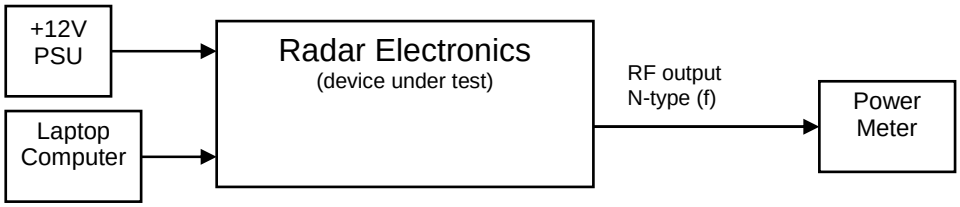


Figure 1 Proposed Test Configuration – Power Output Test

Preliminary Test Result:
Syndetic reports this difficult to measure, as the power meter was jumping around a bit. Probably due to beating between the power meter and the TR/RX switching of the radar. The power meter would jump between -5 and +5dBm.

2. Modulation 2.1047

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Section 2.1047 (a) to (c) [Does not apply]

d) Other types of equipment. A curve or equivalent data which shows
that the equipment will meet the modulation requirements of the
rules under which the equipment is to be licensed.
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Reporting Requirement Only: The pulse shape will be measured and the duty cycle will be calculated.

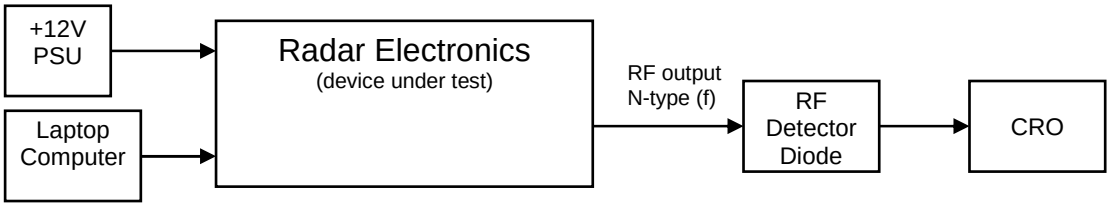

Figure 2 Proposed Test Configuration - Modulation Test

3. Bandwidth 2.1049

Section 2.1049 The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured under the following conditions as applicable:

(a) to (h) [Does not apply]

(i) Transmitters designed for other types of modulation--when modulated by an appropriate signal of sufficient amplitude to be representative of the type of service in which used. A description of the input signal should be supplied.

Reporting Requirement Only: The 99% bandwidth (EBW) of the radar module only (under normal pulse radar operation) is measured using a spectrum analyser with 99% bandwidth function (RBW between 1% and 3% of the EBW).

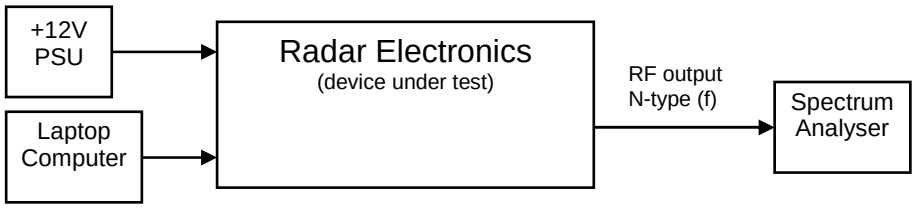

Figure 3 Proposed Test Configuration - Bandwidth Test

Preliminary Test Results – Bandwidth

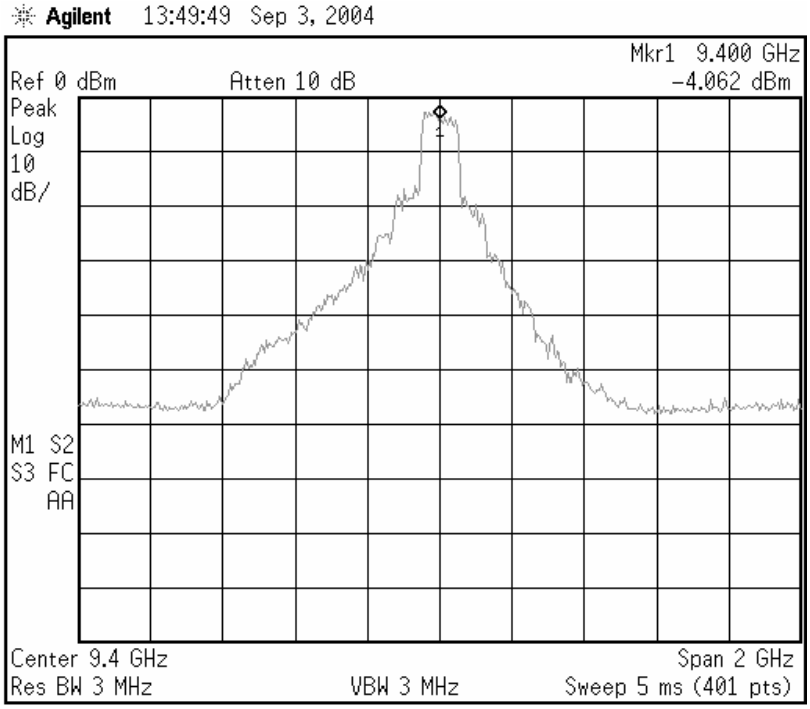

Figure 4 Test 2.1049 99% Bandwidth. Plot 194 REB012

Preliminary Test Results – Bandwidth (cont.)

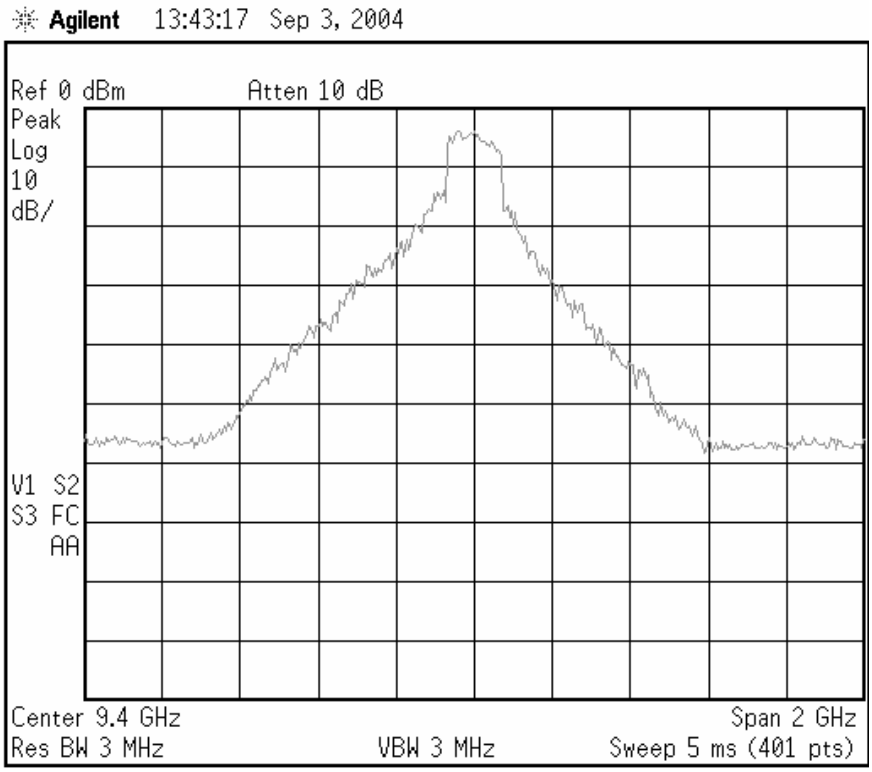

Figure 5 Test 2.1049 99% Bandwidth Plot 193 REB012

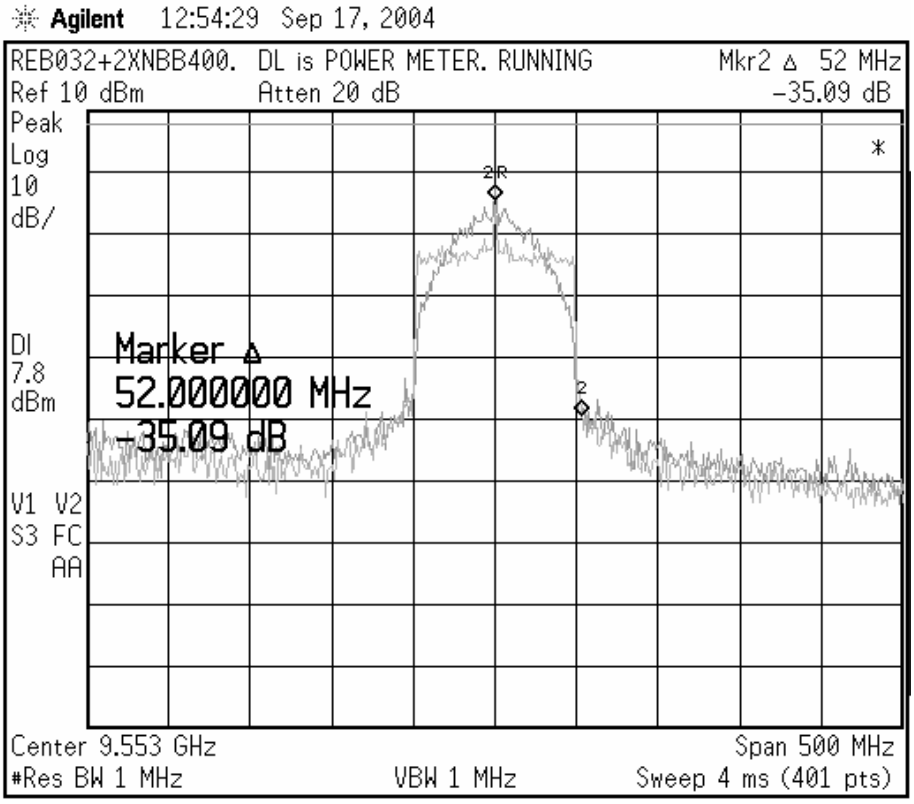

Figure 6. Tests on REB032 with 8dB of attenuation on DAC. Modified upconverter used (2xNBB-400). SSR Control 1.61 Apex 5.81 flat Apex 5.83 rounded.

Preliminary Test Results – Bandwidth (cont.)

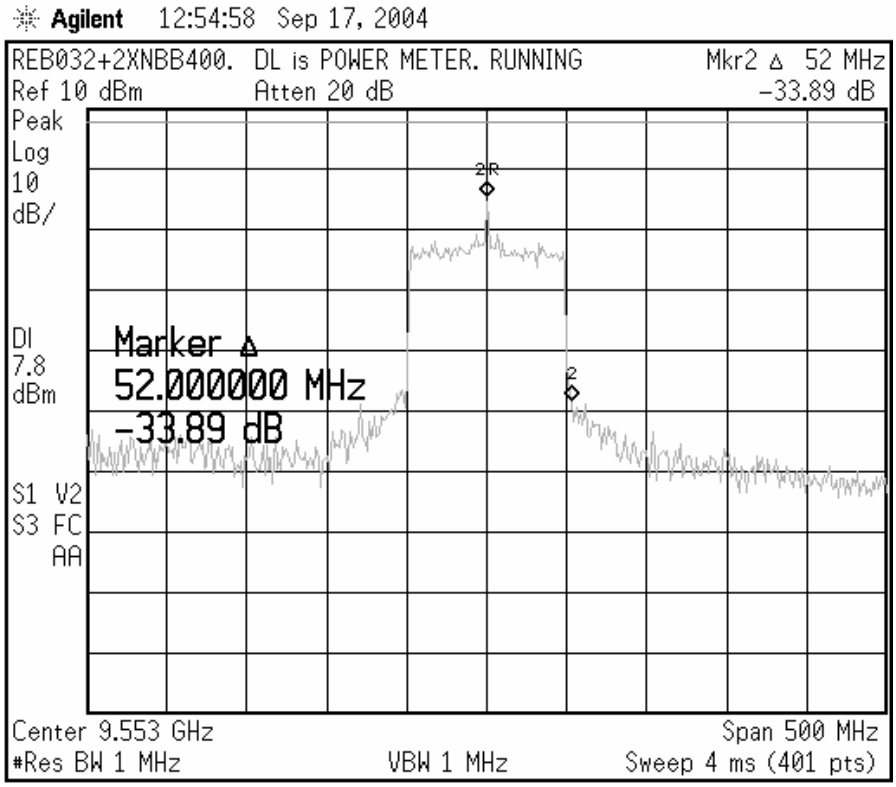

Figure 7. Tests on REB032 **Output switched to be on all the time. The UPCONV has been modified by changing the ERA-2s to NBB400s and there is 8dB of attenuation applied externally to the IF input.**

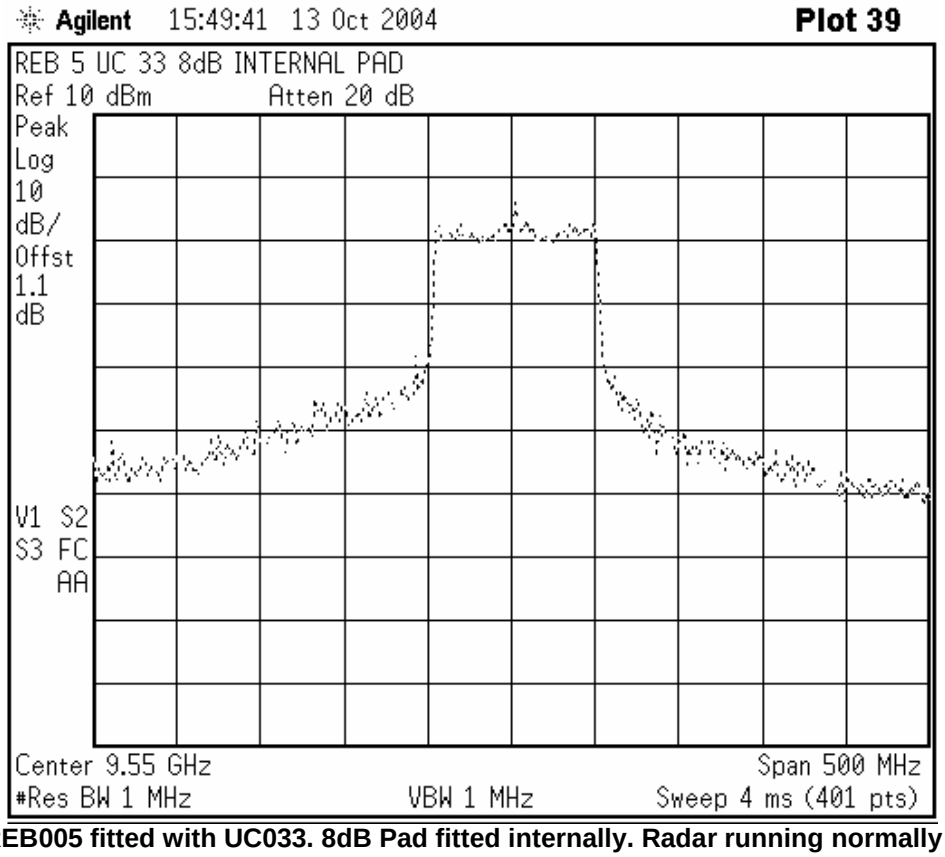

Figure 8 REB005 fitted with UC033. 8dB Pad fitted internally. Radar running normally (not CW).

Preliminary Test Results – Bandwidth (cont.)

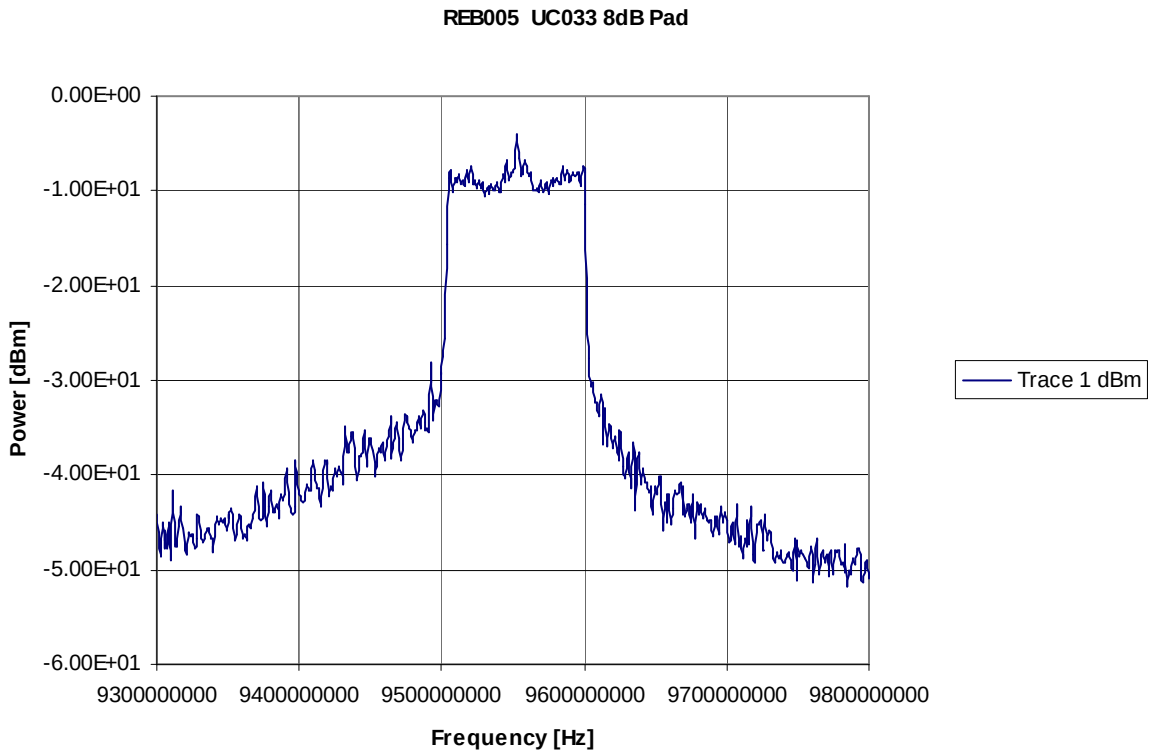

Figure 9 REB005 fitted with UC033. 8dB Pad fitted internally. Radar running normally (not CW). (Same as Figure 8)

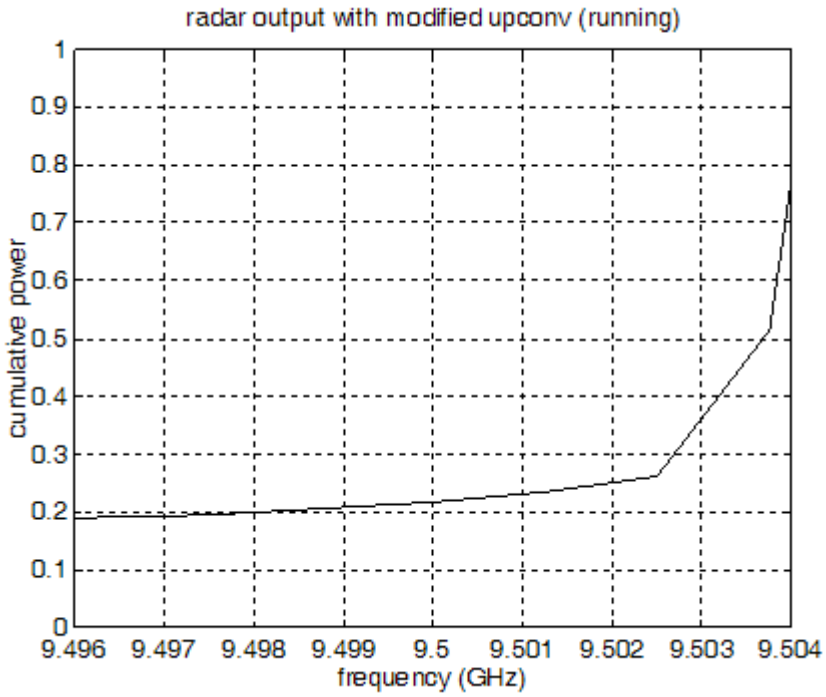

Figure 10 REB005 fitted with UC033. 8dB Pad fitted internally.
Radar running normally (not CW).
(Data from Figure 9 processed to show that the 0.5% percent point is above 9.5GHz)

Preliminary Test Results – Bandwidth (cont.)

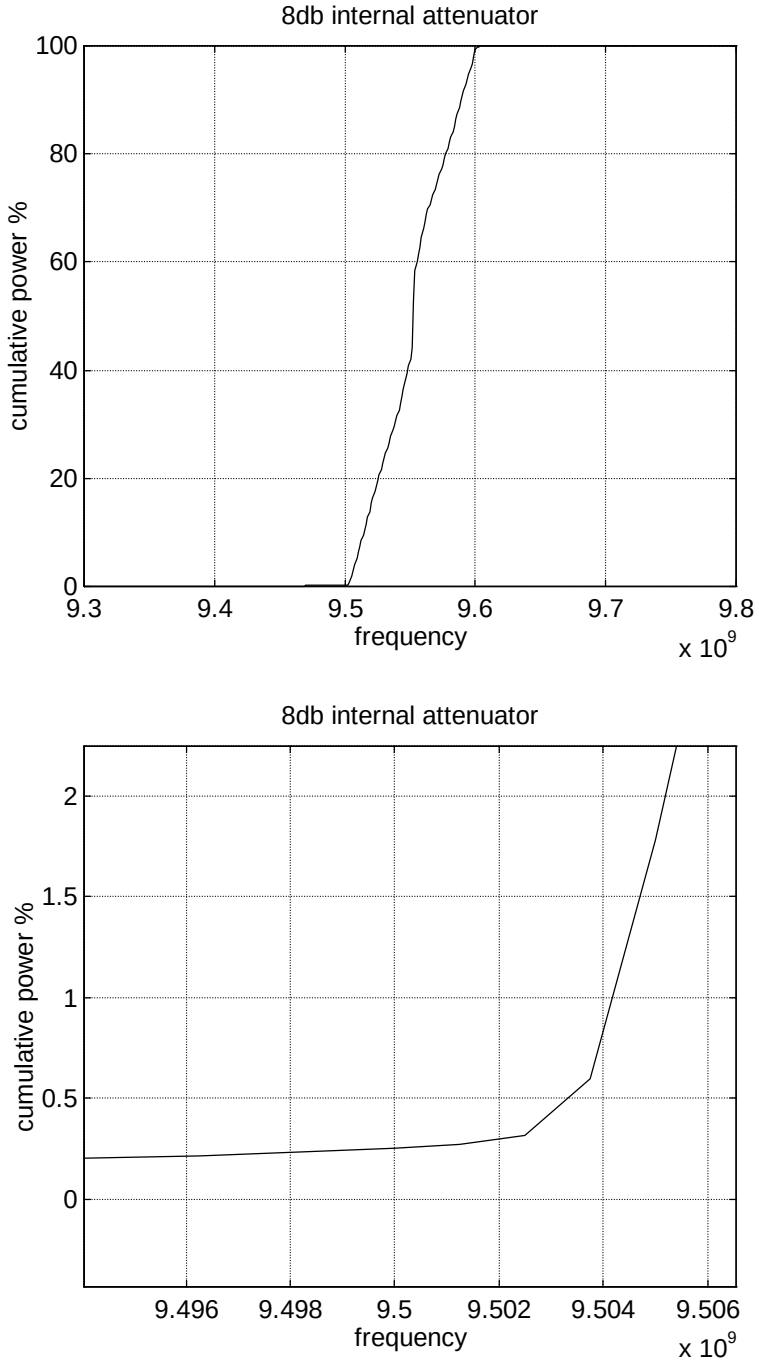

Figure 11 REB005 fitted with UC033. 8dB Pad fitted internally. (Shows that the REB easily meets the 99% BW constraints.)

4. Conducted Spurious 2.1051

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Section 2.1051 The radio frequency voltage or powers generated
within the equipment and appearing on a spurious frequency shall be
checked at the equipment output terminals when properly loaded with
a suitable artificial antenna. Curves or equivalent data shall show
the magnitude of each harmonic and other spurious emission that can
be detected when the equipment is operated under the conditions
specified in Sec. 2.1049 as appropriate. The magnitude of spurious
emissions which are attenuated more than 20 dB below the
permissible value need not be specified.
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The conducted spurious emissions (under normal pulse radar operation) are measured using a spectrum analyser connected to the antenna port of the radar. The RBW settings on the spectrum analyser should be set for:

9-150 kHz:	300 Hz RBW	(or 200 Hz CISPR BW)
150kHz-30 MHz:	10 kHz RBW	(or 9 kHz CISPR BW)
30-1000 MHz:	100 kHz RBW	(or 120 kHz CISPR BW)
> 1000 MHz	1 MHz RBW	

The permissible spurious levels are:

For frequencies outside the authorized band of 9500 to 10,000 MHz, the attenuation must be at least 43 + 10 log(Pm) dB. Pm is defined as the mean power of the radar in Watts. This equation will result in a -13 dBm limit line, regardless of the value of Pm: Pm (dBW) - attenuation = Pm (dBW) - (43 + 10 log(Pm)) = -43 dBW = -13 dBm.

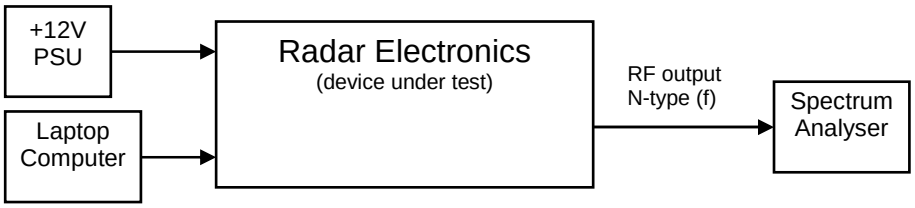

Figure 12 Proposed Test Configuration – Conducted Spurious Test

Preliminary Test Results – Conducted Spurious:

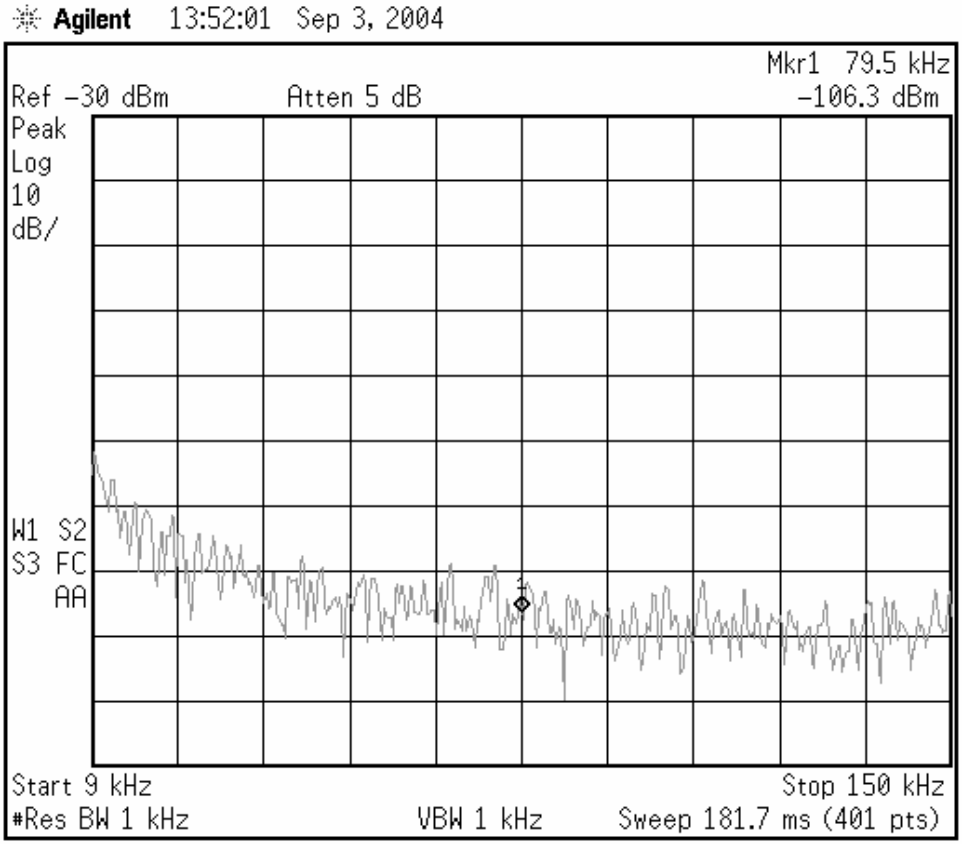

Figure 14. 9kHz - 150kHz 300Hz BW. note 1kHz RBW Plot 195 REB012

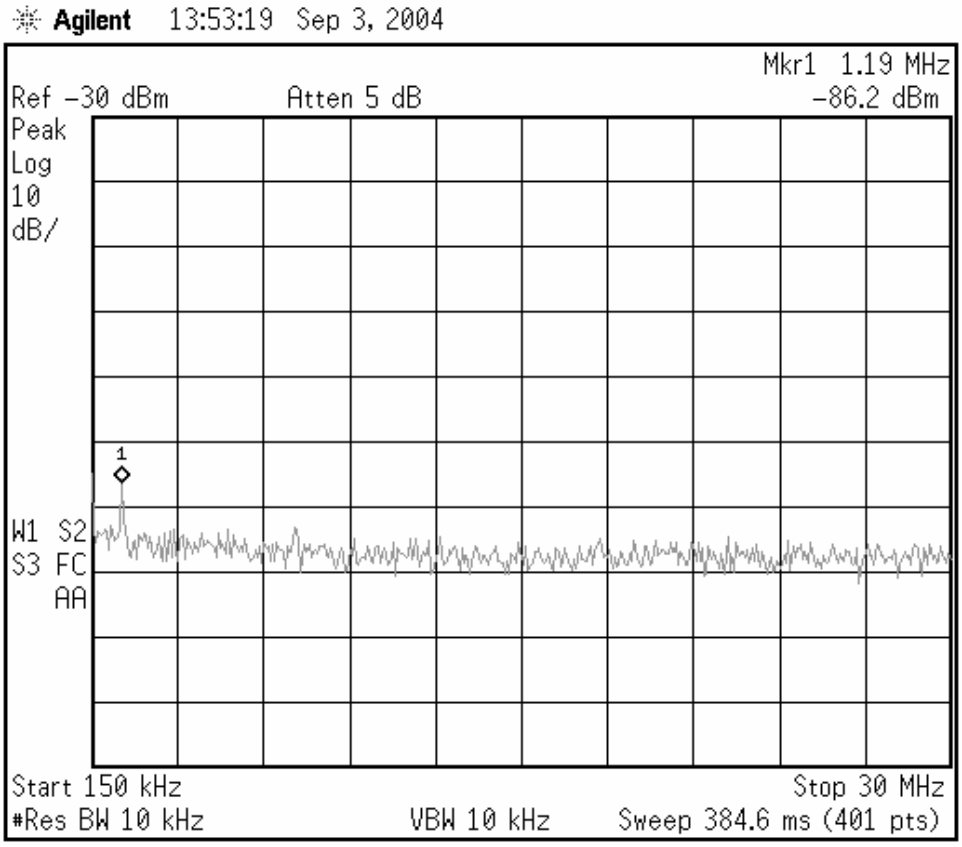

Figure 15. 150kHz - 30MHz 10kHz RBW Plot 196. REB012

Preliminary Test Results – Conducted Spurious (cont.):

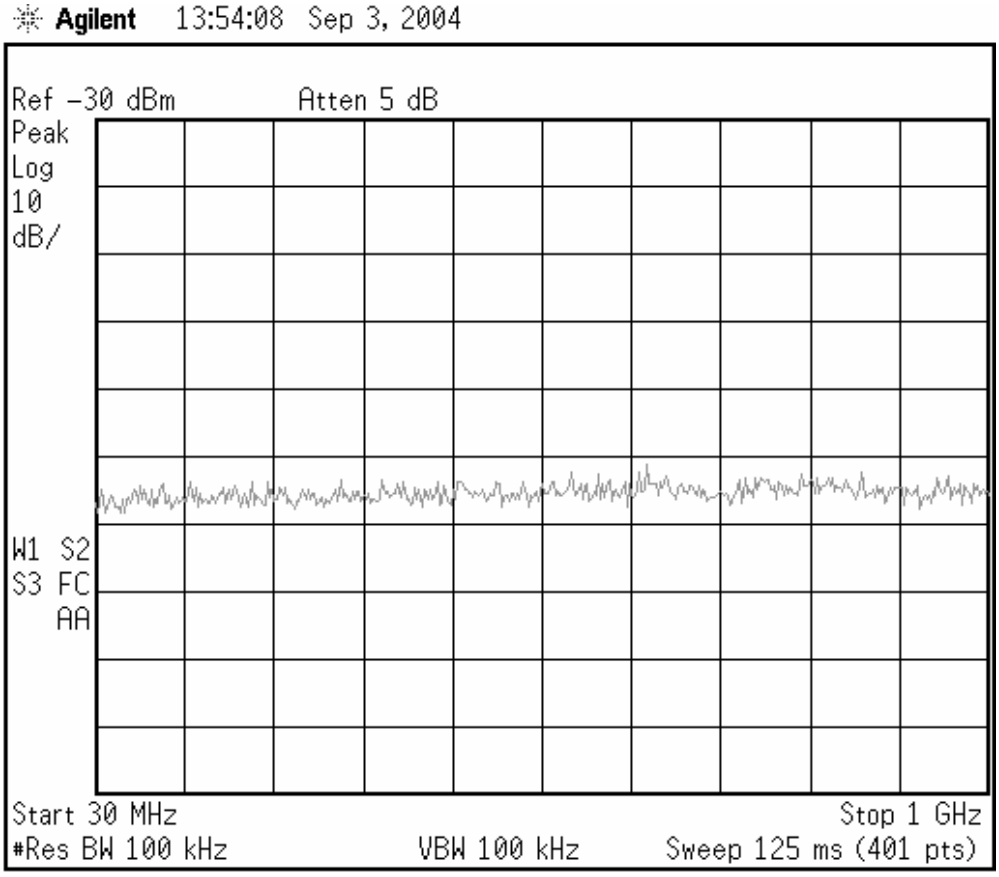

Figure 16. 30MHz - 1GHz 100kHz RBW Plot 197. REB012

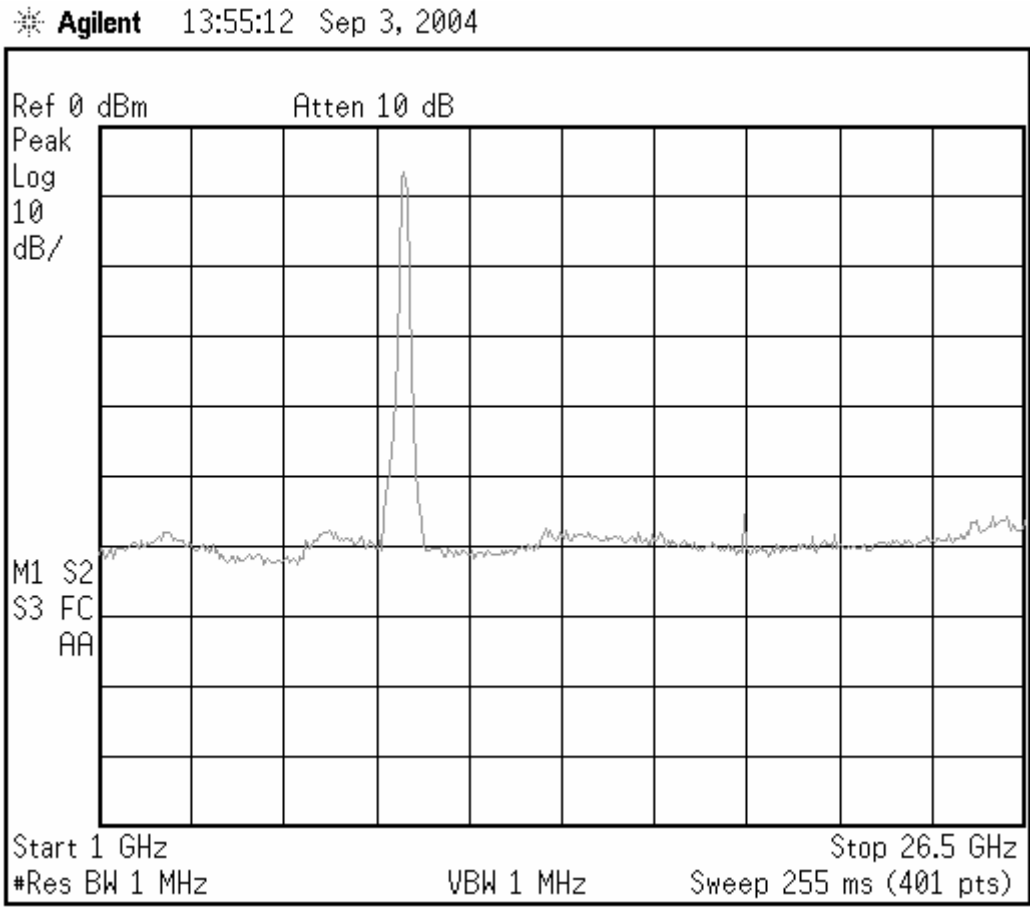

Figure 17. 1GHz - 26.5GHz Plot 198. REB012

5. Radiated Spurious 2.1053

Section 2.1053(a) Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data shall be supplied showing the magnitude of each harmonic and other spurious emission. For this test, single sideband, independent sideband, and controlled carrier transmitters shall be modulated under the conditions specified in paragraph (c) of Sec. 2.1049, as appropriate. For equipment operating on frequencies below 890 MHz, an open field test is normally required, with the measuring instrument antenna located in the far-field at all test frequencies. In the event it is either impractical or impossible to make open field measurements (e.g. a broadcast transmitter installed in a building) measurements will be accepted of the equipment as installed. Such measurements must be accompanied by a description of the site where the measurements were made showing the location of any possible source of reflections which might distort the field strength measurements. Information submitted shall include the relative radiated power of each spurious emission with reference to the rated power output of the transmitter, assuming all emissions are radiated from halfwave dipole antennas.

(b) The measurements specified in paragraph (a) of this section shall be made for the following equipment:
(1) [Does not apply]
(2) All equipment operating on frequencies higher than 25 MHz.
(3) All equipment where the antenna is an integral part of, and attached directly to the transmitter.
(4) Other types of equipment as required, when deemed necessary by the Commission.

The radiated field strength of spurious emissions (under normal pulse radar operation) is measured using a spectrum analyser connected to a calibrated antenna. The radar module, transmitter cable and antenna shall be set up on an Open Area Test Site or Alternate Test Site in accordance with ANSI C63.4-2003. The field strength of these spurious emissions will be converted to EIRP. The RBW settings on the spectrum analyser should be set for:

9-150 kHz:	300 Hz RBW	(or 200 Hz CISPR BW)
150kHz-30 MHz:	10 kHz RBW	(or 9 kHz CISPR BW)
30-1000 MHz:	100 kHz RBW	(or 120 kHz CISPR BW)
> 1000 MHz	1 MHz RBW	

The permissible spurious levels are:

For frequencies outside the authorized band of 9500 to 10,000 MHz, the attenuation must be at least 43 + 10 log(Pm) dB. Pm is defined as the mean EIRP of the radar in Watts. This equation will result in a -13 dBm EIRP limit line, regardless of the value of Pm: Pm (dBW) - attenuation = Pm (dBW) - (43 + 10 log(Pm)) = -43 dBW = -13 dBm EIRP.

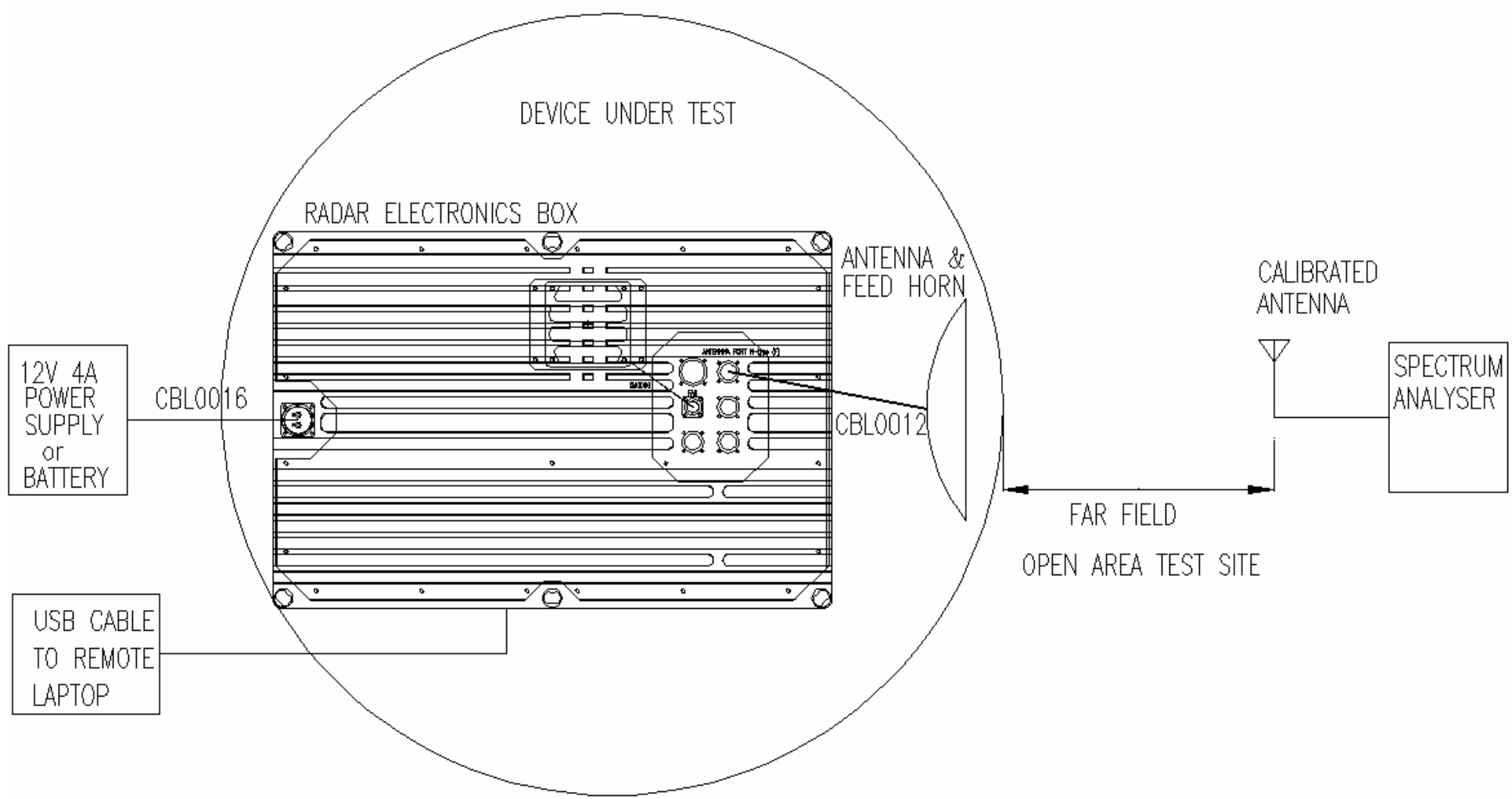

Figure 18 Proposed test configuration - Radiated Spurious Test

6. Stability 2.1055

(a) The frequency stability shall be measured with variation of ambient temperature as follows:
(1) From -30[deg] to +50[deg] centigrade for all equipment except that specified in paragraphs (a) (2) and (3) of this section.
(2)–(3) [Does not apply]

(b) Frequency measurements shall be made at the extremes of the specified temperature range and at intervals of not more than 10[deg] centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. The short term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stabilizing circuitry need be subjected to the temperature variation test.

(c) [Does not apply]

(d) The frequency stability shall be measured with variation of primary supply voltage as follows:
(1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.
(2) [Does not apply]
(3) The supply voltage shall be measured at the input to the cable normally provided with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.

(e) [Does not apply]

Reporting Requirement Only: A spectrum analyser (Span and RBW as required to yield adequate marker frequency counter resolution) is used to measure the frequency stability of the carrier frequency, over temperature and supply voltage. Alternatively, a spectrum analyser is used to measure the frequency at which maximum emission occurs, over temperature and supply voltage.

The temperature range is –26 deg C to +55 deg C. The primary voltage range is 85 % to 115% of nominal. This means that the input DC power supply is to be varied from 11.0V to 14.8V (12.9VDC nominal).

Note: The frequency stability must be adequate to ensure that emissions remain within the Authorized Band (9,500-10,000 MHz) over the specified temperature and voltage variations.

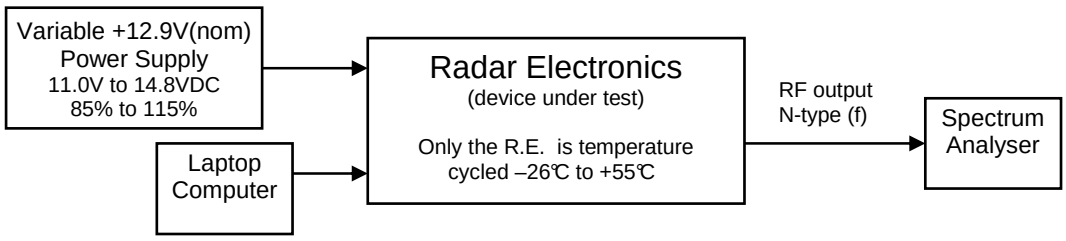

Figure 19 Proposed Test Configuration – Stability Test

7. Frequency Range 2.1057

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Section 2.1057(a) In all of the measurements set forth in Secs.
2.1051 and 2.1053, the spectrum shall be investigated from the
lowest radio frequency signal generated in the equipment, without
going below 9 kHz, up to at least the frequency shown below:
    (1) If the equipment operates below 10 GHz: to the tenth
harmonic of the highest fundamental frequency or to 40 GHz,
whichever is lower.
    (2)-(3) [Does not apply]

    (b) Particular attention should be paid to harmonics and
subharmonics of the carrier frequency as well as to those
frequencies removed from the carrier by multiples of the oscillator
frequency. Radiation at the frequencies of multiplier stages should
also be checked.
    (c) The amplitude of spurious emissions which are attenuated
more than 20 dB below the permissible value need not be reported.
    (d) [Does not apply]
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The lowest oscillator in the radar circuit is 107.107 kHz and the highest frequency generated is less than 10 GHz, so measurements for Sections 2.1051 and 2.1053 will be taken from 100 kHz to 40 GHz.

Part 90 Special requirements for protection from RF radiation

Section 1.1310 requires an RF exposure calculation (MER) to determine the minimum separation distance between the EUT and any personnel, and documentation of this distance in the user manual.

Reporting Requirement Only: Limits for Occupational/Controlled Exposure and for General Population/Uncontrolled Exposure will be calculated and documented in the user manual.

Part 90 Certification by TCB

A test house can conduct the Part 90 tests and submit the test results to a TCB. The TCB reviews and grants the equipment authorisation on behalf of the FCC.

CCS (Compliance Certification Services, USA) is an approved TCB.

The Australian test house needs to be on file with the FCC for CCS to accept test results for certification.

EMC Technologies laboratories in Brisbane, Sydney and Melbourne are on file with the FCC. There is no requirement for the Australian test lab to be NATA approved for Part 90 tests.

Part 90 Licensing requirements:

Authorized band is 9,500 to 10,000 MHz under Part 90.103 Radiolocation Service.
There are no spectrum mask requirements since this is neither a channelized device nor a channelized rule part.
Spurious emissions limit (for both conducted power at the antenna port, and radiated EIRP) is: For frequencies outside the authorized band of 9500 to 10,000 MHz, the attenuation must be at least 43 + 10 log(Pm) dB. This formula yields a limit of –13 dBm conducted, and –13 dBm EIRP radiated. The spurious emissions limit shall apply from 100 kHz to 40 GHz, excluding the authorized band (9,500 to 10,000 MHz).
The emission designator is P0N and the 99% EBW shall be specified in the prefix characters to this designator. For example, 105MP0N = 105 MHz EBW and P0N emission type.

The maximum mean power the licensee is authorized to use is specified on the license.

Testing Notes

The Part 90 tests may be performed without mounting the radar module and dish on the trailer and tripod.
The dish and modified feedhorn is mounted on a rotating frame and attached to the radar module for the spurious tests.
The Victron power supply connected to 115V 60Hz AC is required to power the radar module during the Part 90 tests.
A notebook computer can be connected to the radar module to allow normal pulsed radar operation. The spurious from the notebook should easily pass the part 90 spurious (ensure that Bluetooth and wireless is deactivated). Alternatively the notebook can be moved far away from the site and connected to the radar module via a long cable

FCC Part 15 Class A – Test requirements for the remaining modules

The following digital modules are to be connected and tested under FCC Part 15 Class A:

- Computer Module – Note that the computer module contains an Elpro 905U-D radio modem (unmodified) that has FCC Part 15.247 modular approval. The Elpro 905U-D radio modem must be powered off while the computer module is tested under Part 15 Class A. The motor control modules are powered up, but no motors are connected to the Computer Module

- Display Module – Connected to the Computer Module via an external cable

- Dual Pro Charger – Pro series 2 Bank charger connects to 110V 60Hz AC utility supply and supplies 12V DC via the 12V battery bank to the computer module via a power cable.

- Radar Module – Note that only the following devices should be powered during Part 15 Class A testing of the radar module: Power supply board, APEX board and clock input, USB Hub, Interpolators, Camera power supply unit. All digital and non-digital devices that are part of the radar circuit should be powered off. The radar module is to be connected to the computer module via an umbilical cable and power cable. (the 220MHz Clock Oscillator Board and the ADC Board must also be powered up).

- Camera Module – Connected to the Radar Module via an external cable.

- Watchdog Module – Stand-alone device. Connected to 115V AC 60 Hz utility supply.

- RAPS battery management module -- Comprises a Battery Monitor and Smart Alternator Regulator for monitoring the batteries voltage, current and temperature. The module is packaged as a pre-assembled kit and is mounted on the battery cover of the existing RAPS. Refer to the block diagram, Figure 20, for connections to the batteries, charger and computer module.

Both conducted and radiated emission tests are required for these digital devices from 30 MHz to 5 GHz - 15.33(b).

Part 15.109B specifies the radiation emission field strength limits at 10m from DUT for Part 15 Class A devices:

30-88 MHz	90 uV/m
88-216 MHz	150 uV/m
216-960 MHz	210 uV/m
> 960 MHz	300 uV/m

Part 15.109g gives alternative CISPR Class A limits for frequencies less than 960 MHz.

Labelling requirements

For Part 90 Equipment Authorization: Follow 2.925 for equipment labelling, and 2.1091 for user manual annotations.

For Part 15 Equipment Authorization: Follow 15.19, 15.21 and 15.105. In addition, a label shall be placed on the computer module stating “Contains Part 15 device FCC ID: O9PELPSS0D” for the Elpro 905U-D modem.

Testing Notes

The Part 15 tests may be performed without mounting the digital devices on the trailer and tripod. The antenna, motors and encoders are not connected during the Part 15 Tests

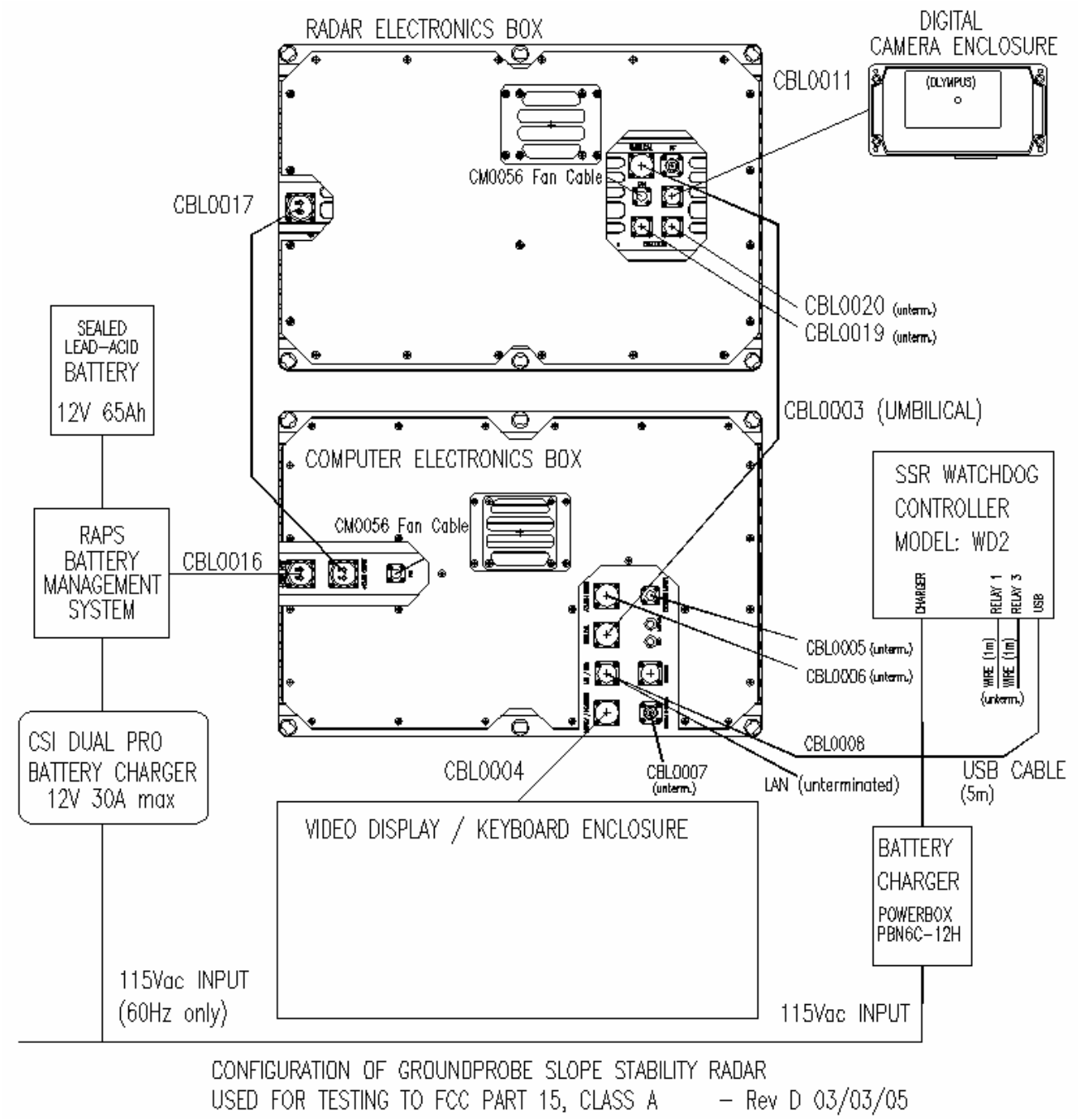

Figure 20 Proposed Test Configuration – For FCC Part 15 Tests

Description of SSR external cables used for FCC Part 15 testing

Cable Number	Current drawing revision	Cable Description	Notes in addition to cable drawing
CBL0003	B	Cable, 12P MIL-C-26482 14-12P Umbilical (Computer Electronics to Radar Electronics)	Aluminium foil screened cable. One Fair-Rite ferrite fitted at Radar Electronics End of cable. (p/n 0443167251 snap-on ferrites for 10mm cable) Cable passes through ferrite once.
CBL0004	A	Cable, 19P MIL-C-26482 14-19P Display (Computer Electronics to Display)	This cable was fitted with a copper cable braid over the cable bundle.
CBL0005	B	Cable, 3P 62GB 8-33P (Computer Electronics to Elevation Actuator)	No modifications. Screened cable. Cable unterminated during test (normally connects to motor)
CBL0006	B	Cable, 12P MIL-C-26482 14-12S (Computer Electronics to Azimuth Motor)	No modifications. Al. foil screened cable. Cable unterminated during test (normally connects to motor)
CBL0007		Cable, Coax. RG58 N(m)-N(m) (Computer Electronics to Modem Antenna)	No modifications. Cable unterminated during test (normally connects to modem antenna)
CBL0008	C	Cable, 8P MIL-C-26482 12-08P (Computer Electronics to LAN/USB)	No modifications. This cable is connected occasionally to backup the computer data, and is not normally connected during Radar operation. LAN cable unterminated during test USB cable connected to USB port on SSR Watchdog Controller during the test.
CBL0011	C	Cable, 7P MIL-C-26482 10-7P (Radar Electronics to Camera Enclosure)	Aluminium foil screened cable. Cable screen is bonded to connector backshell. At camera end, the cable screen is connected to the metal camera enclosure using a wire and ring terminal. One Fair-Rite ferrite is fitted at Radar Electronics end of cable. (p/n 0443164251 snap-on ferrites for 6mm cable) Cable passes through ferrite once.
CBL0013	A	Cable, 6P MIL-C-26482 10-6P (Radar Electronics to Azimuth Encoder)	Aluminium foil screened cable. Cable screen is bonded to connector backshells at both ends. Cable unterminated during test (normally connects to antenna position encoder) One Fair-Rite ferrite is fitted at Radar Electronics end of cable. (p/n 0443164151 snap-on ferrites for 13mm cable) Cable passes through ferrite twice.
CBL0014	A	Cable, 6P MIL-C-26482 10-6S (Radar Electronics to Elevation Encoder)	Aluminium foil screened cable. Cable screen is bonded to connector backshells at both ends. Cable unterminated during test (normally connects to antenna position encoder) One Fair-Rite ferrite is fitted at Radar Electronics end of cable. (p/n 0443164151 snap-on ferrites for 13mm cable) Cable passes through ferrite twice.

Description of SSR external cables used for FCC Part 15 testing

(cont.)

Cable Number	Current drawing revision	Cable Description	Notes in addition to cable drawing
CBL0016	B	Cable, 2 Pole Pwr to 18-02S, DC Power (RAPS to Computer Electronics)	Unscreened DC power cable. No modifications. This is the DC input cable for the EUT, and connects power from the battery via the battery monitor hardware.
CBL0017	B	Cable, 2 18-02P to 18-02S, DC Power (Computer Electronics to Radar Electronics)	Unscreened DC power cable. No modifications.
CBL0019	A	Cable, 6P MIL-C-26482 10-6P to 10-6S (Radar Electronics to Azimuth Encoder)	Aluminium foil screened cable. Cable screen is bonded to connector backshells at both ends. Cable unterminated during test (normally connects to antenna position encoder)
CBL0020	A	Cable, 6P MIL-C-26482 10-6S (Radar Electronics to Elevation Encoder)	Aluminium foil screened cable. Cable screen is bonded to connector backshells at both ends. Cable unterminated during test (normally connects to antenna position encoder)
CM0056	B	External Fan Connector	Braid screened microphone cable. Cable screen is bonded to connector backshell.

Unused or Unterminated connectors on Computer Electronics Box:

Environmental sensors connector – not connected during normal Radar operation
Alarm output – 4mm banana connectors. Not used.

Unused or Unterminated connectors on Radar Electronics Box:

RF output port – unterminated during FCC Part 15 tests.

SSR Watchdog Controller cables:

a) A commercial screened USB cable connects to USB port (5m).
b) Unscreened wires are connected to relay outputs – Relay 1 and Relay 3
c) The battery charger is connected to charger input – unscreened cable.

DC Power Supply Cables

Cables between the battery, the battery charger and the battery monitor system are all unscreened DC power cables less than 1m long.

Reference:

Block Diagram – Configuration of GroundProbe Slope Stability Radar Used for Testing to FCC Part 15 Class A (Rev C 22/2/05)