MICROTRACK TEST REPORT

Applicable Standards

Part 15 of Title 47 of the code of Federal Regulations
Paragraphs 15.31, 15.35, 15.205, 15.209
Part 2 of Title 47 Paragraphs 2.948

List of Measuring Equipment

ARA model ALA-130/RS Calibrated Loop Antenna
Agilent Technologies model E7402A Spectrum Analyzer

Calibration

Certificates of calibration are included in the Test Setup Photo file.

TEST SITE

The test site with the cable locations are shown in Fig 1.

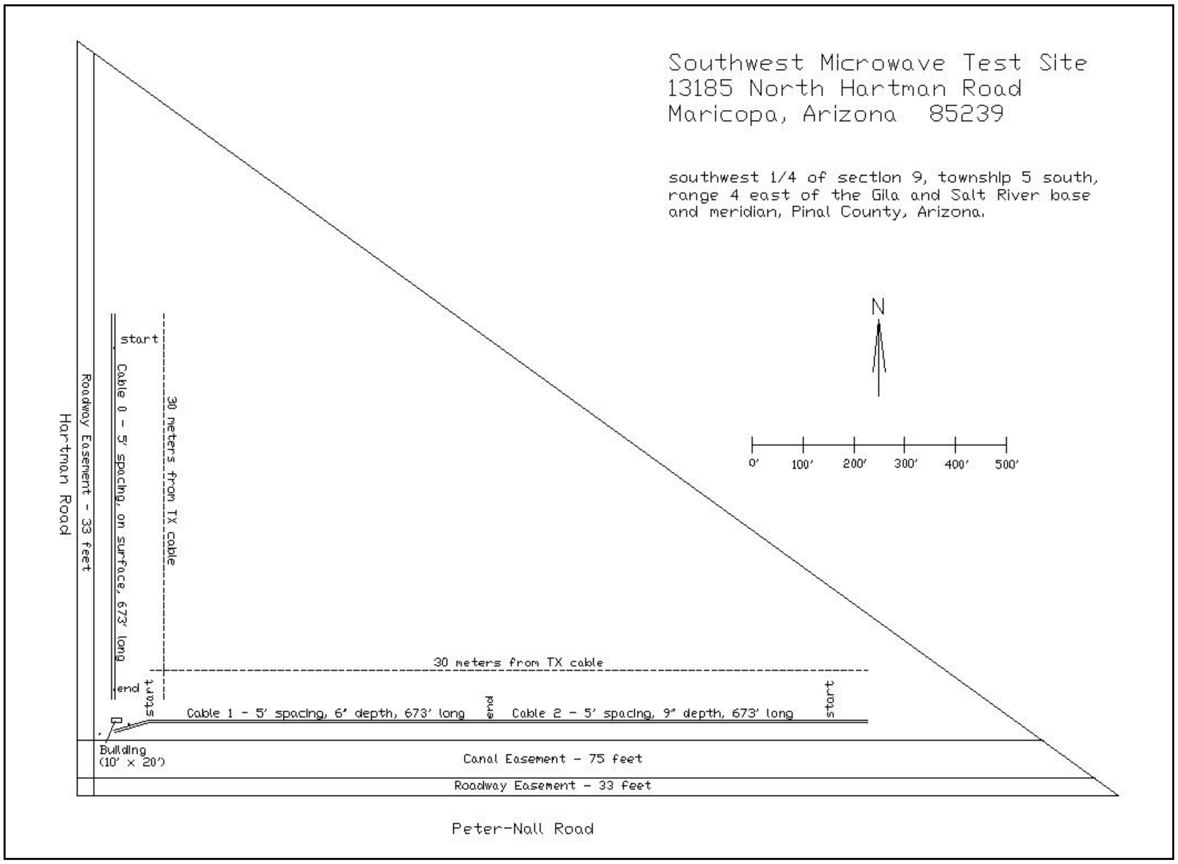

Fig 1

MEASUREMENT PROCEDURE

Microtrack is a low power intrusion detection system. It requires two pairs of 200 meters of radiating cable buried 6 to 9 inches below the surface of the ground. Testing at the typical contract test facility that conforms to Title 47 Part 2 paragraph 2.948 is not feasible due to space limitations.
Southwest Microwave, Inc. purchased 31.7 acres of vacant flat desert land in Pinal County, Arizona (Fig 1) for the purpose of engineering and compliance testing of Microtrack and other intrusion detection products. Radiation measurements are made on both buried and unburied cable to determine the maximum field strength possible. Although the Microtrack Sensor is designed and specified only as buried cable system, it is important to know if the system is still in compliance if it is not buried but on the surface of the ground.

Measurements of the field strength are made with a calibrated shielded loop antenna (ARA Model ALA-130/RS) and a spectrum analyzer (Agilent Technologies Model E7402A). The Model E7402A was specifically designed by Agilent for FCC and ETSI compliance testing. The loop antenna is mounted on a plastic PVC frame to maintain a constant height above the ground. Measurements are taken at 2.5 and 10 meter intervals along a line parallel and 3 meters from the cable. The data, in the form of a spectrum analyzer screens are recorded on a floppy disk and transferred to a CD for a permanent record. This series of measurements reveals the maximum field strength where data on a line perpendicular to the cable is recorded at one meter intervals out to a distance of 30 meters. Height data is also recorded up to 4 meters high at positions where the field strength is at a maximum.
A standard test setup is stored on the Spectrum Analyzer "C" directory for which the peak detector is set for 9 KHz bandwidth and the correction factors for the calibrated loop antenna and the cable losses are included. Field strength in dbμV/m is then read directly from the spectrum analyzer screen. Peak detection was used since quasi-peak measurements are much slower to record. Approximately 400 spectrum analyzer screens (one for each data point) were recorded to arrive at the electro-magnetic field profile for each of the three leaky cables.

Transmitted power is limited to 63 mw by fixing the peak to peak voltage at 5 volts on the power amplifier feeding the leaky cable. Each 200 meters of cable receives power 50% of the time. The leaky cables are designed for a coupling loss of 63 db as measured from the transmitter input to the cable and the power received by a standard calibrated antenna located 3 meters from the cable.

Transmitter power = 63 mw = 10*log (63) = 18 dbm

This value is confirmed by measurement shown in Fig 3 for a 5 volt cw source at 25 MHz. Peak values of the MICROTRACK transmitter with the four frequency phase modulated software are measured at 10.68 dbm (Fig 2). The maximum field strength measured at 3 meters from the buried cable is 55 dbμV. The relationship of dbμV and dbm is:

dbμV=107+Pdbm
Transmitter Voltage =117 dbμV
Received Voltage = 55 dbμv
Coupling loss (db) = Transmitter voltage (dbμv) –Receive voltage (dbμv) at 3 meters from the cable.
Coupling loss = 62.68db (voltage)

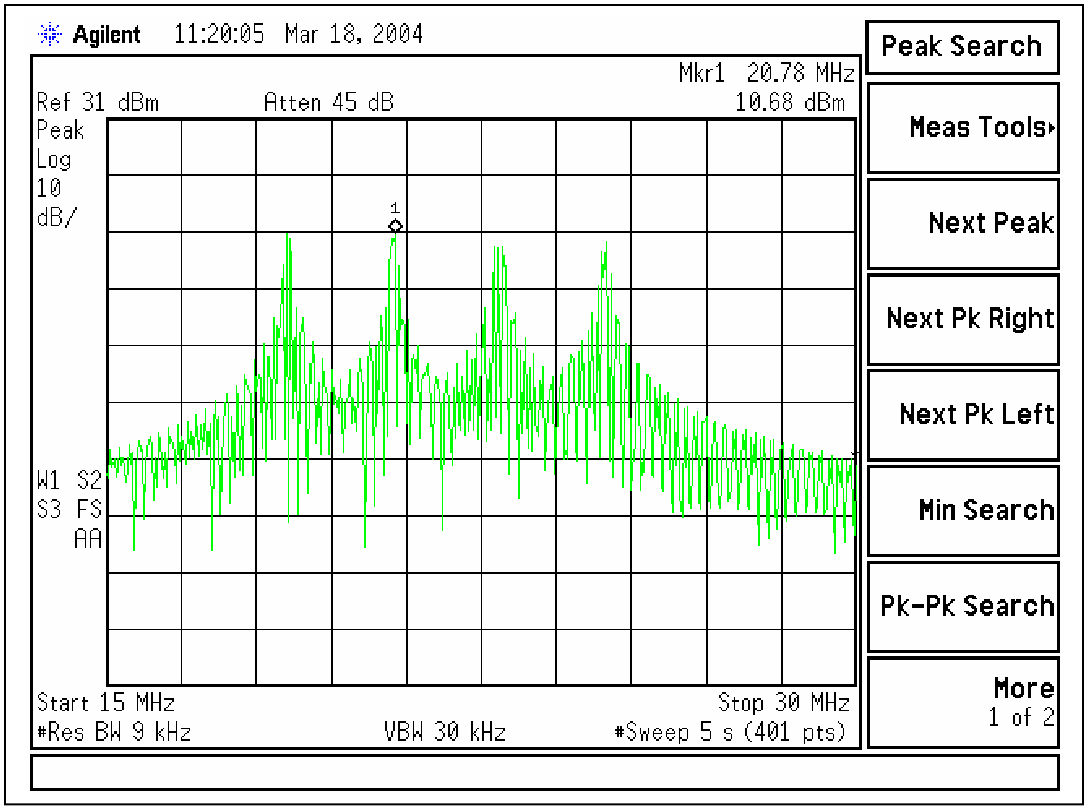
Agilent 11:20:05 Mar 18, 2004
Mkr1 20.78 MHz
Ref 31 dBm Atten 45 dB 10.68 dBm
Peak
Log
10
dB/
W1 S2
S3 FS
AA
Start 15 MHz Stop 30 MHz
#Res BW 9 kHz VBW 30 kHz #Sweep 5 s (401 pts)
Peak Search
Meas Tools
Next Peak
Next Pk Right
Next Pk Left
Min Search
Pk-Pk Search
More
1 of 2

Fig 2

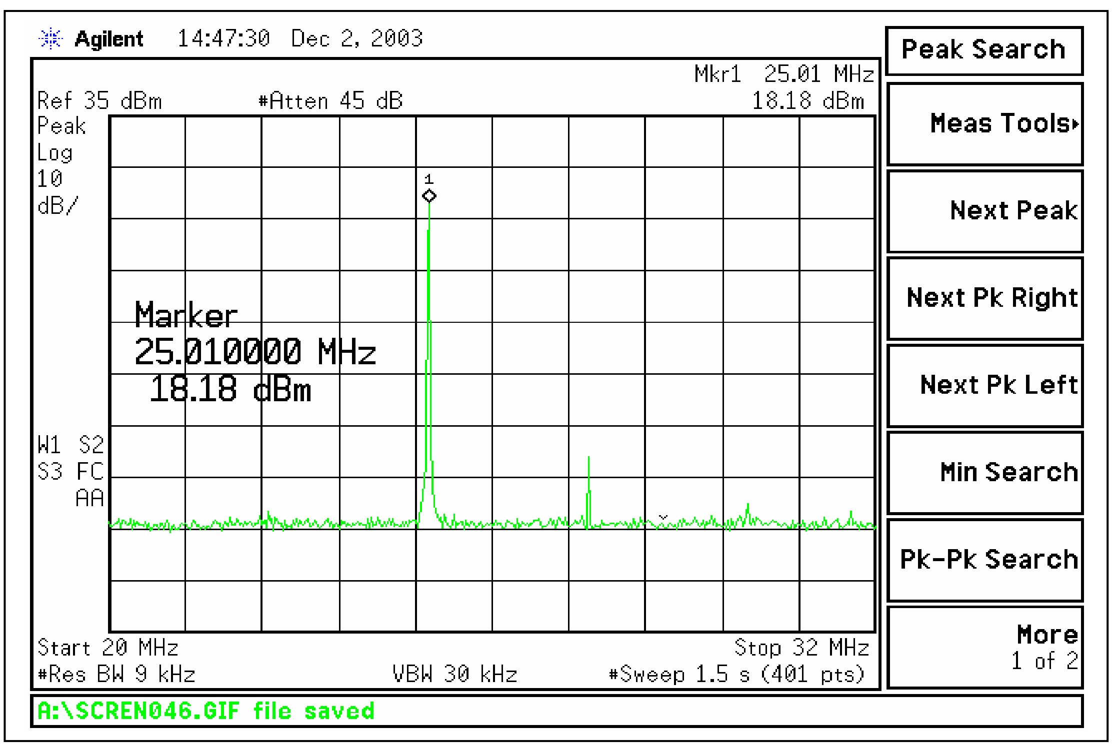
Agilent 14:47:30 Dec 2, 2003
Mkr1 25.01 MHz
Ref 35 dBm #Atten 45 dB 18.18 dBm
Peak
Log
10
dB/
Marker
25.010000 MHz
18.18 dBm
W1 S2
S3 FC
AA
Start 20 MHz Stop 32 MHz
#Res BW 9 kHz VBW 30 kHz #Sweep 1.5 s (401 pts)
A:\SCREN046.GIF file saved
Peak Search
Meas Tools
Next Peak
Next Pk Right
Next Pk Left
Min Search
Pk-Pk Search
More
1 of 2

Fig 3

RADIATED EMISSION TESTS

Field strength data were taken as described in the PROCEDURES section. Three pairs of leaky cables were measured., one pair buried 6 inches (15.24 cm) below the surface, one pair buried 9 inches (22.86 cm) below the surface, and one pair on the surface of the ground.

A diagram of the test setup is shown in Fig 4. The primary application for intrusion detection will require burial beneath the surface, which will attenuate the field strength due to the conductivity of the soil. The recorded data show the buried cable has significantly lower field strength compared to cable on the surface. The maximum field strength of the surface cable however is below the limit of 30µVolts/meter at 30 meters specified in Part 15 Paragraph 209. Vertical and horizontal polarization is recorded for each data position. The loop antenna is the orthogonal dual of a dipole and the vertical E field is measured with the plane of the loop parallel to the ground and the horizontal polarization with plane of loop perpendicular to the ground.

The tests were conducted with modified sweep as described in the 'OERATIONAL DESCRIPTION". The linear sweep function has been turned off and replaced with four discrete frequencies. The phase code modulation is still in place. The spectrum is shown in Fig 3. Measurements were made with a peak value in a 9 KHz detection bandwidth. Although Quasi-peak reading is allowed and would yield lower values, peak reading is much faster. This is a major issue with nearly 400 data points for each cable.

Soil Conductivity at the test site has been measured at .3 to .5 mS/meter with low moisture content. When the soil is dry, the conductivity was below the .01 mS/m sensitivity level of the test instrument (PET 2000, Dual Purpose EC Meter). Conductivity and dielectric constant of the soil increases with moisture and cause greater attenuation of the surface wave. The tests conducted in dry sandy soil may then be considered as worst case maximum with respect to radiation from the buried cable

BURIED CABLE

These tests were conducted with a pair of 205 meter leaky cables spliced to 20 meters of shielded lead-in cable buried 6 inches below the surface of the ground. The lead-in cables are used to connect both the transmitter and the receiver to their respective leaky cables. The receiver cable is also buried 6 inches below the ground surface parallel to the transmitter cable with 1.5 meters separation.

PARALLEL TO THE CABLE

The first measurements are made close to the cable on a parallel line 3 meters distance from the cable. Data is recorded on the spectrum analyzer at 2.5 meter intervals for the first 50 meters and then 10 meter intervals the remaining length of cable including lead out cable used to terminate the surface wave. This data is plotted in Fig 5. It shows the profile of the field strength as a function of distance from the transmitter input. This gives a clear indication of where the maximums are along the cable. 30, 100 and 200 meters were chosen for additional perpendicular data points. These tests were recorded 03/23/2004 through 03/29/2004.

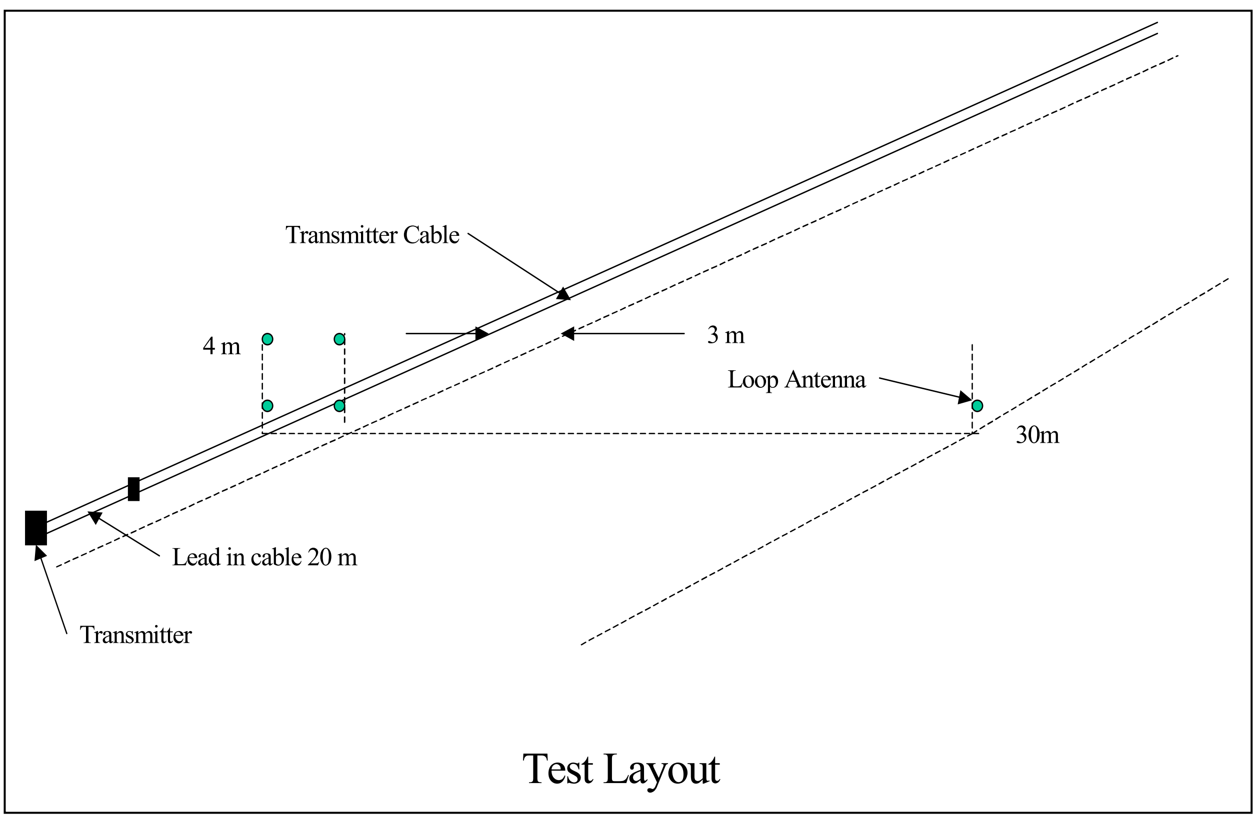

Fig 4

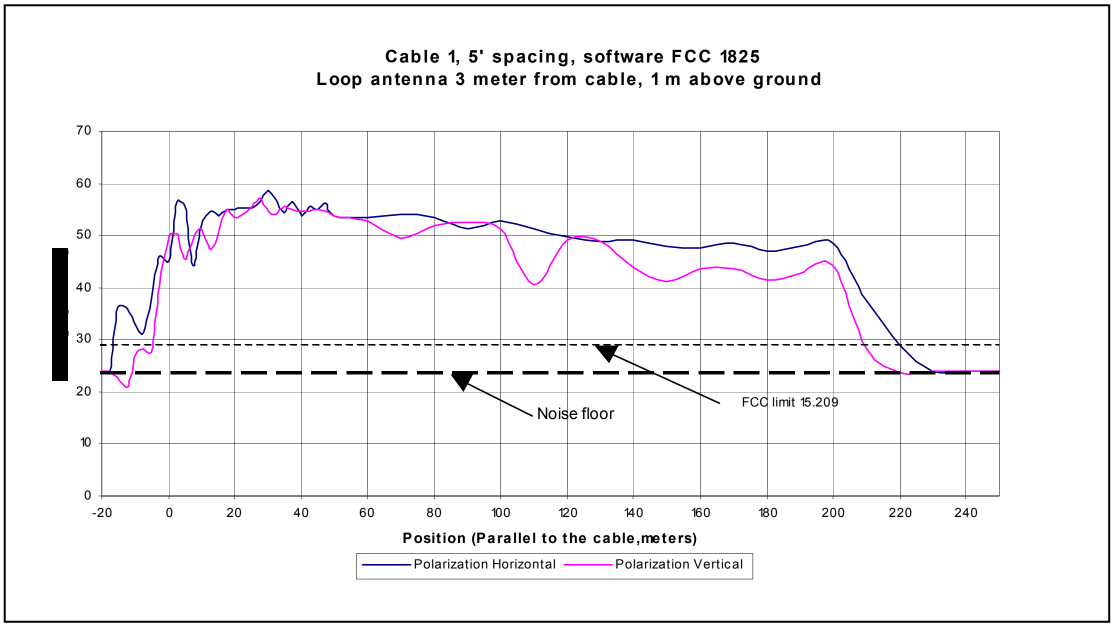

Fig 5

PERPENDICULAR TO THE CABLE

Fig 6 shows the shape of the field perpendicular to the cable at the three maximums. This data was recorded at 1 meter intervals out to a distance where the field strength fell below the noise level of the spectrum analyzer and then every 5 meters out to 30 meters. The 9 KHz detection bandwidth has a noise floor of 24dbµV/m. The vertical polarized field strength falls rapidly with distance, approximately 10db/m and the horizontal polarization decays more slowly at 5db/m. The data recorded for Fig 6 at 35 meters from the start of the leaky cable shows the maximum field strength, which drops below the 15.209 limit at 21 meters from the cable. This represents the maximum of the surface wave field strength. Cable and radiation losses attenuates the field as distances increase from the transmitter input

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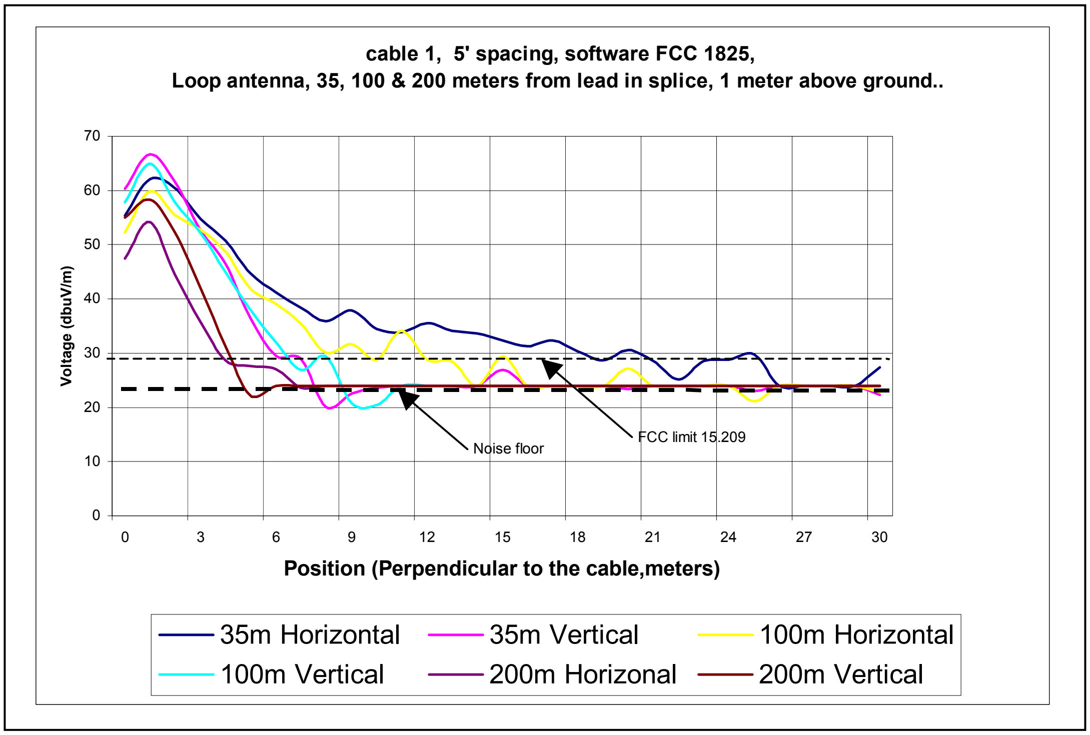

Fig 6

VERTICAL FROM THE GROUND

A PVC fixture for measuring field strength a various heights above the ground is shown the Test Setup Photo Section. The loop antenna can be moved in .5 meter increments up to a maximum of four meters. Data was recorded for 9 positions where the parallel and perpendicular measurements indicated a possible maximum field strength. The 3 graphs of height data, show decreasing field strength with increased height. It has been determined that horizontal polarized energy 1 meter above the ground is typical of the maximum field strength for distances beyond 10 meters from the cable.

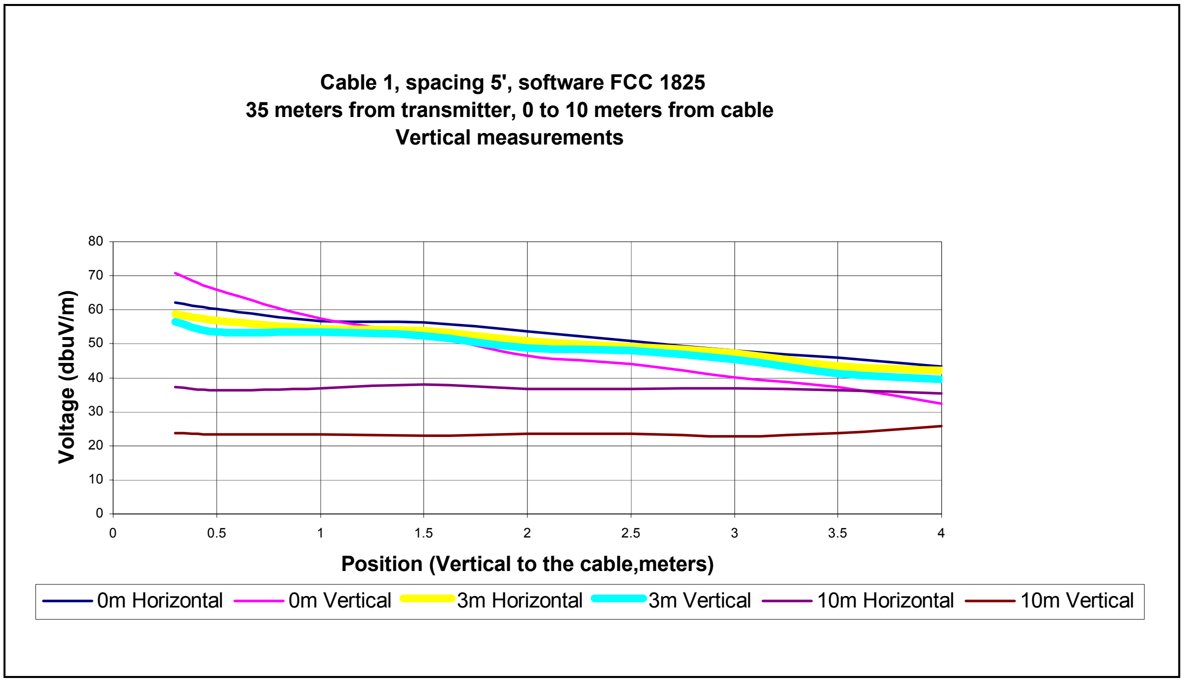
Cable 1, spacing 5', software FCC 1825
35 meters from transmitter, 0 to 10 meters from cable
Vertical measurements
Voltage (dbuV/m)
Position (Vertical to the cable,meters)
0m Horizontal
0m Vertical
3m Horizontal
3m Vertical
10m Horizontal
10m Vertical

Fig 7

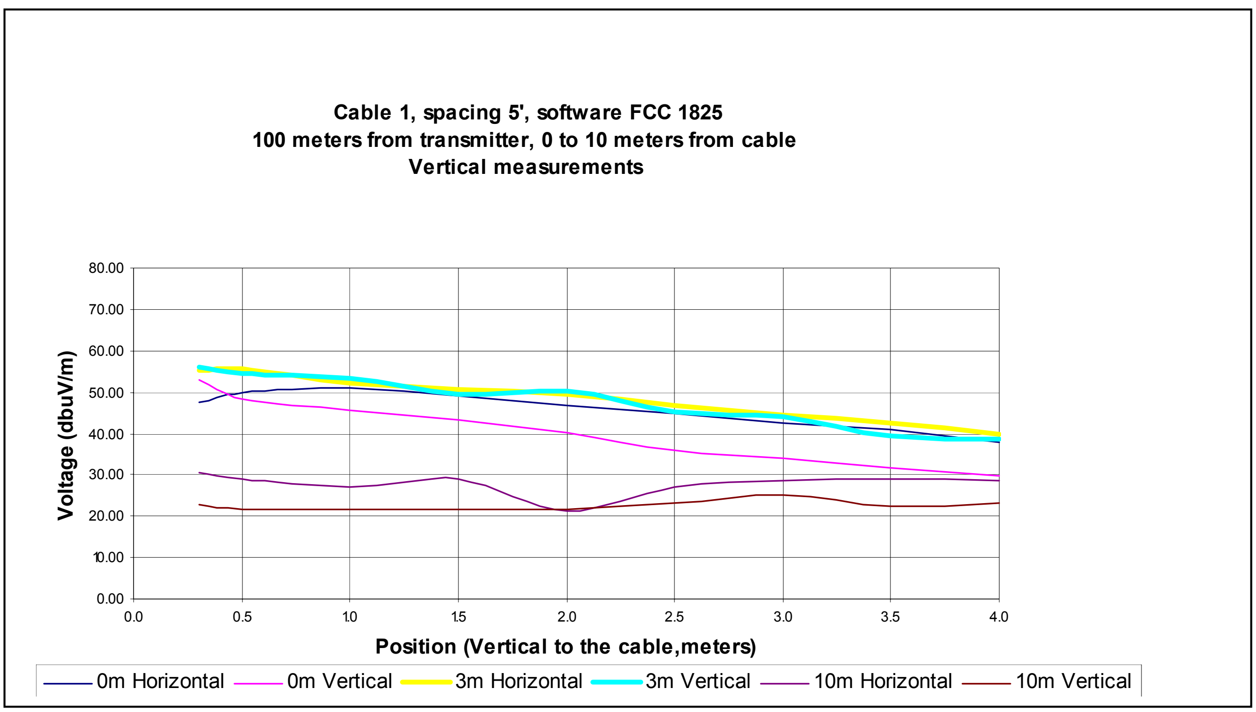
Cable 1, spacing 5', software FCC 1825
100 meters from transmitter, 0 to 10 meters from cable
Vertical measurements
Voltage (dbuV/m)
Position (Vertical to the cable,meters)
0m Horizontal
0m Vertical
3m Horizontal
3m Vertical
10m Horizontal
10m Vertical

Fig 8

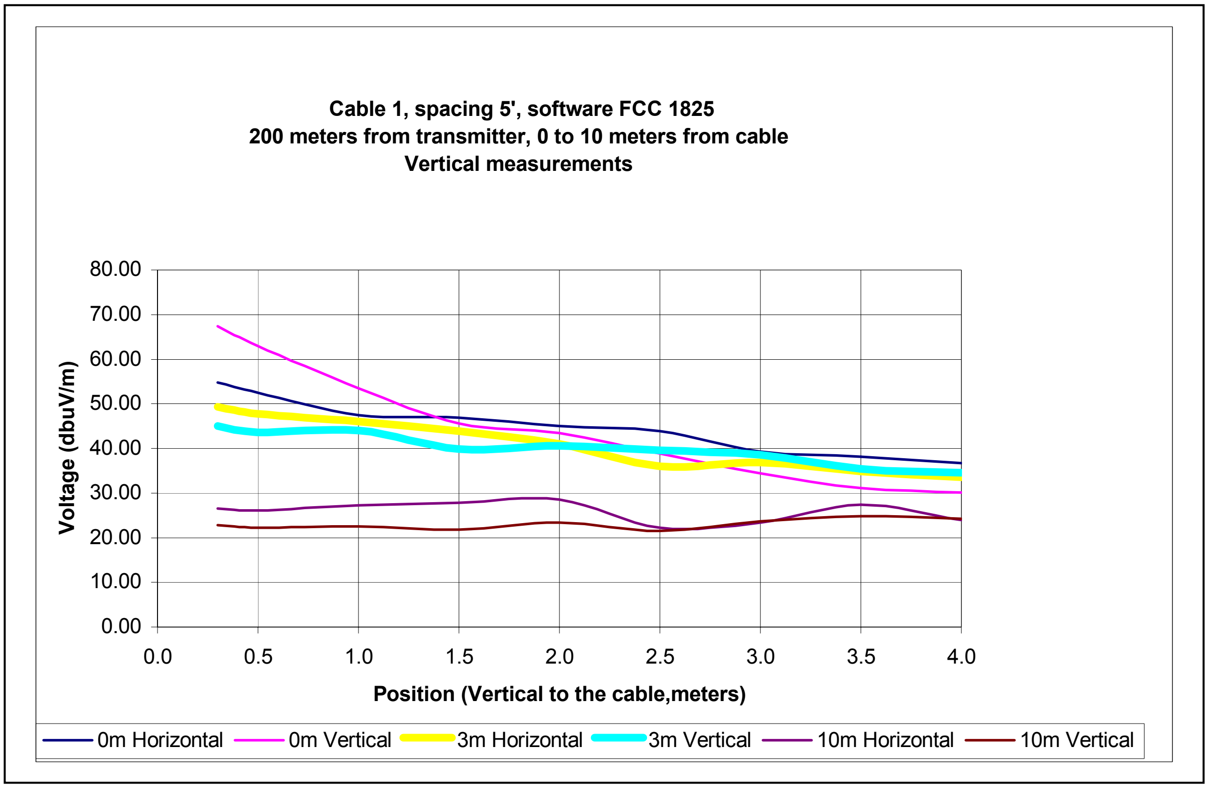

Fig 9

BURIED CABLE 2

Cable 2 is buried at depth of 9 inches extending in line with Cable 1. Data was recorded in same manner as for Cable 1. Field strength averages lower (2 to 3 db) over most of the length with the maximum at 5 meters. Fig 10 shows the field strength at a parallel line 3 meters from the cable

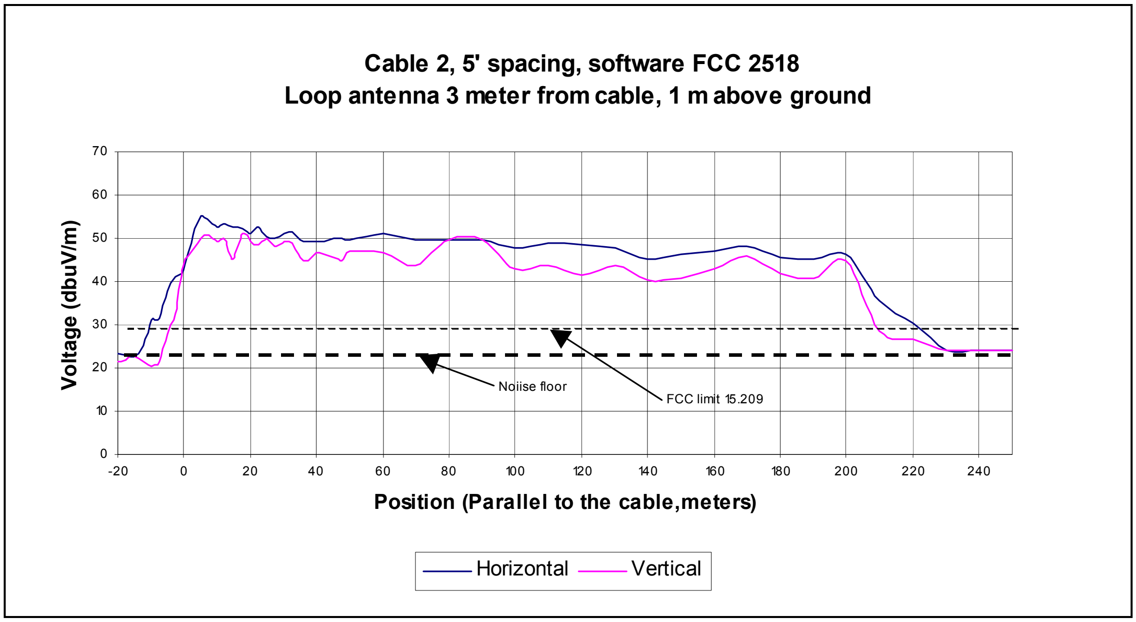

Fig 10

Perpendicular Measurements

Field strength falls below the 15.209 limit at 13 meters.

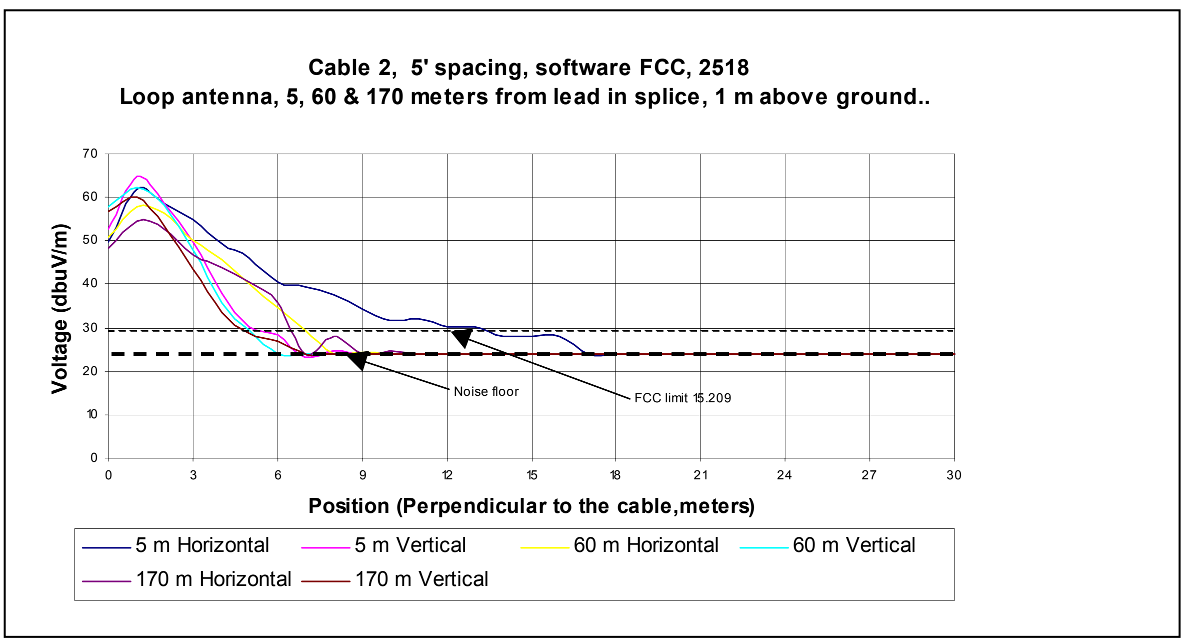

Fig 11

Vertical Measurements

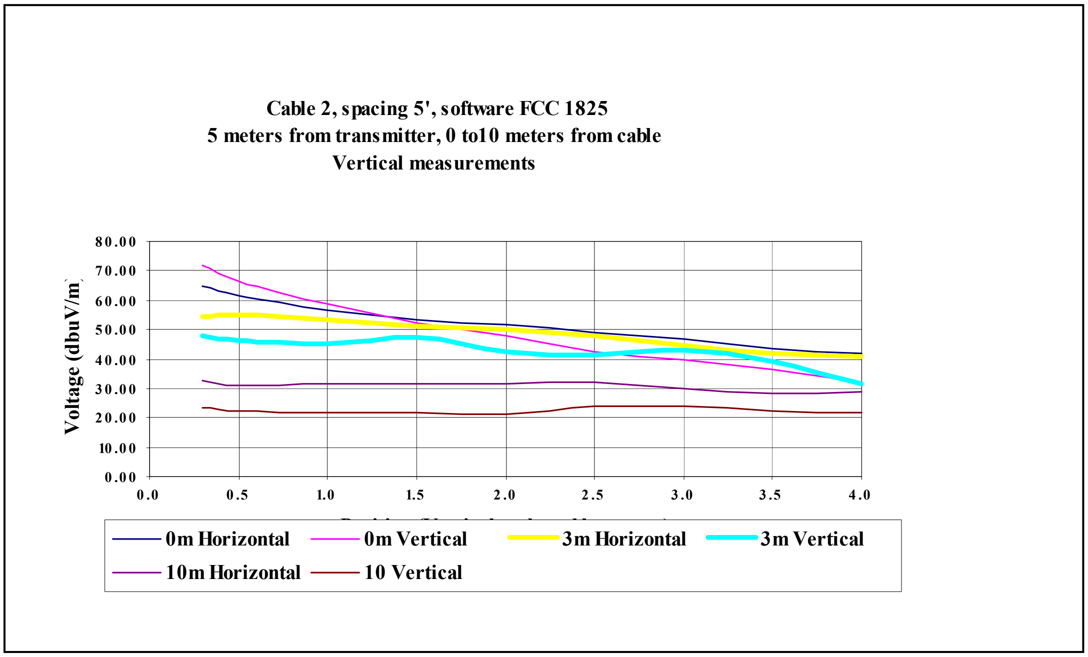

Fig 12

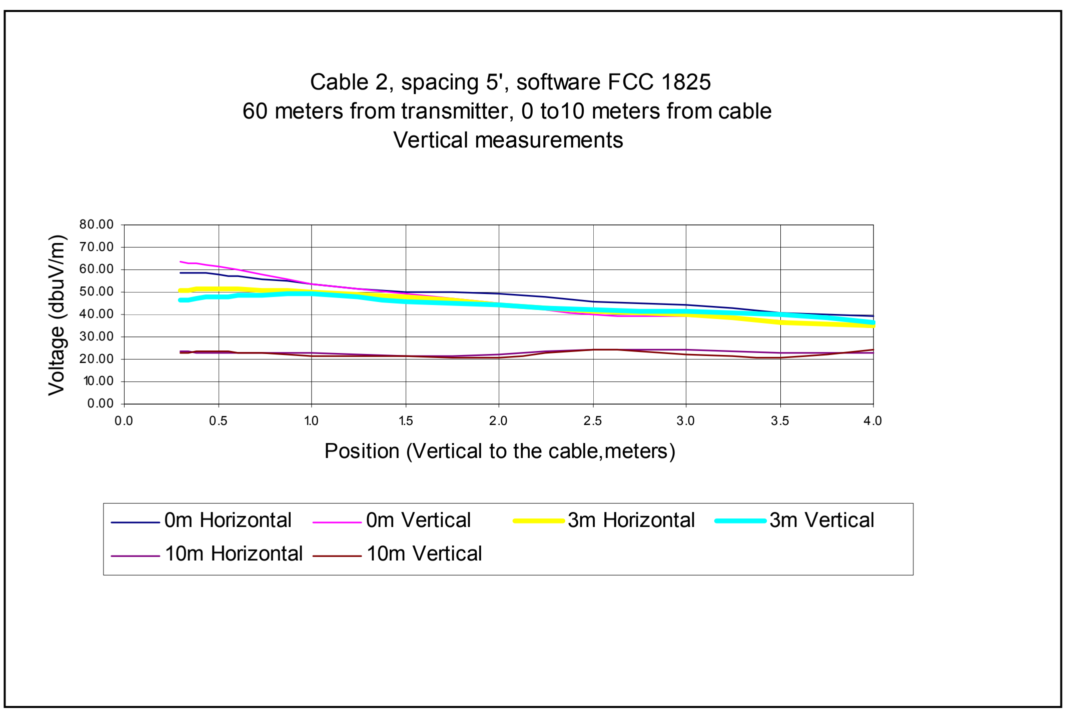

Fig 13

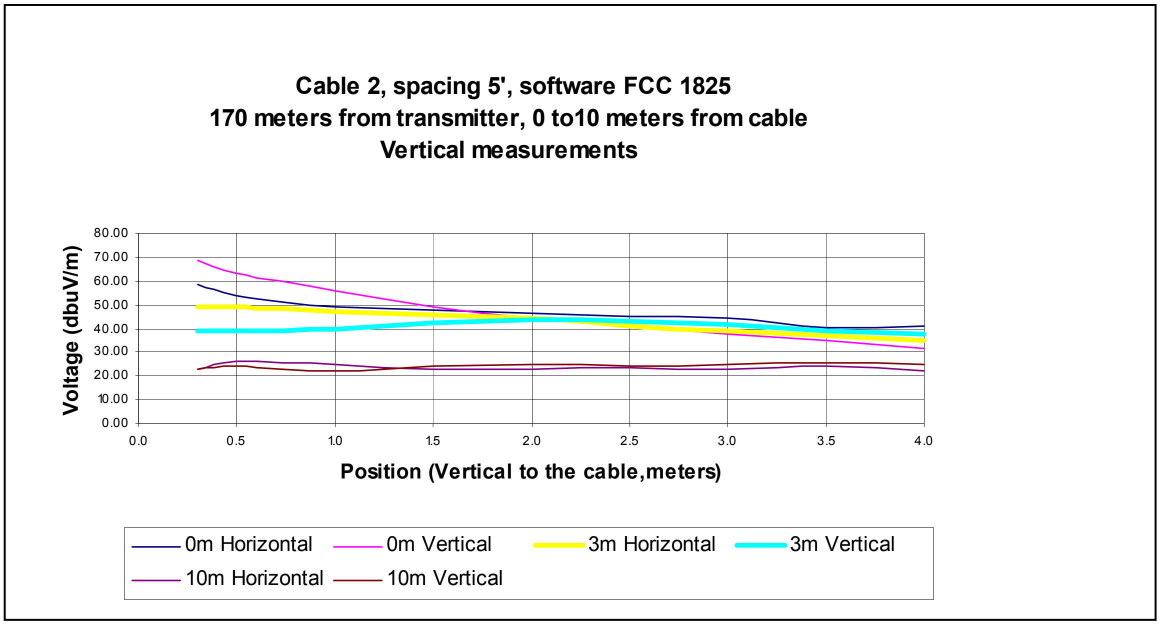

Fig 14

UNBURIED CABLE 3

Cable 3 is on the surface of the ground and should have higher field strength because the soil attenuation is less. Although Southwest Microwave will not install the Microtrack cable on the surface of the ground due to nuisance alarms, it will be useful to measure the field strength to provide an upper bound for 15.209 compliance.

This data was recorded 12/17/03 with the same Microtrack Processor but with a different set of frequencies.

21.209 MHz
23.210 MHz
27.879 MHz
29.880 MHz

The change to a lower band of frequencies was the result of certain interference issues relating to the CB band and the restricted band at 25.5-25.67 MHz. The data recorded with higher band provides creditable evidence the unburied cable would also be in compliance.

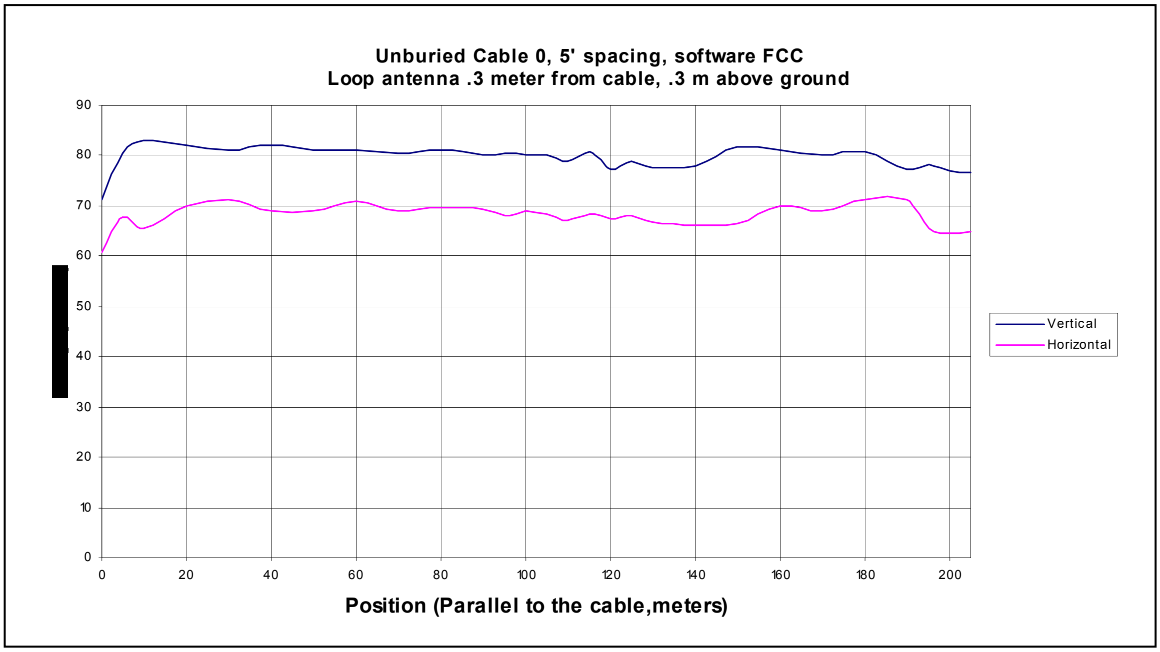

Fig 15

PERPENDICULAR TO THE CABLE

Fig 16, 17, and 18 show the shape of the field perpendicular to the cable at the three maximums. This data was recorded at 1 meter intervals out to a distance where the field strength fell below the noise level of the spectrum analyzer. The 9 KHz detection bandwidth has a noise floor of 18µV/m or 24dbµV/m. The vertical polarized field strength falls rapidly with distance, approximately 10db/m and the horizontal polarization decays more slowly at 5db/m. The data recorded for Fig 16 at 8 meters from the start of the leaky cable shows the maximum field strength that drops below the noise floor at 20 meters from the cable. Recorded data on two separate buried cables show consistently lower field strength approximately (10 db).

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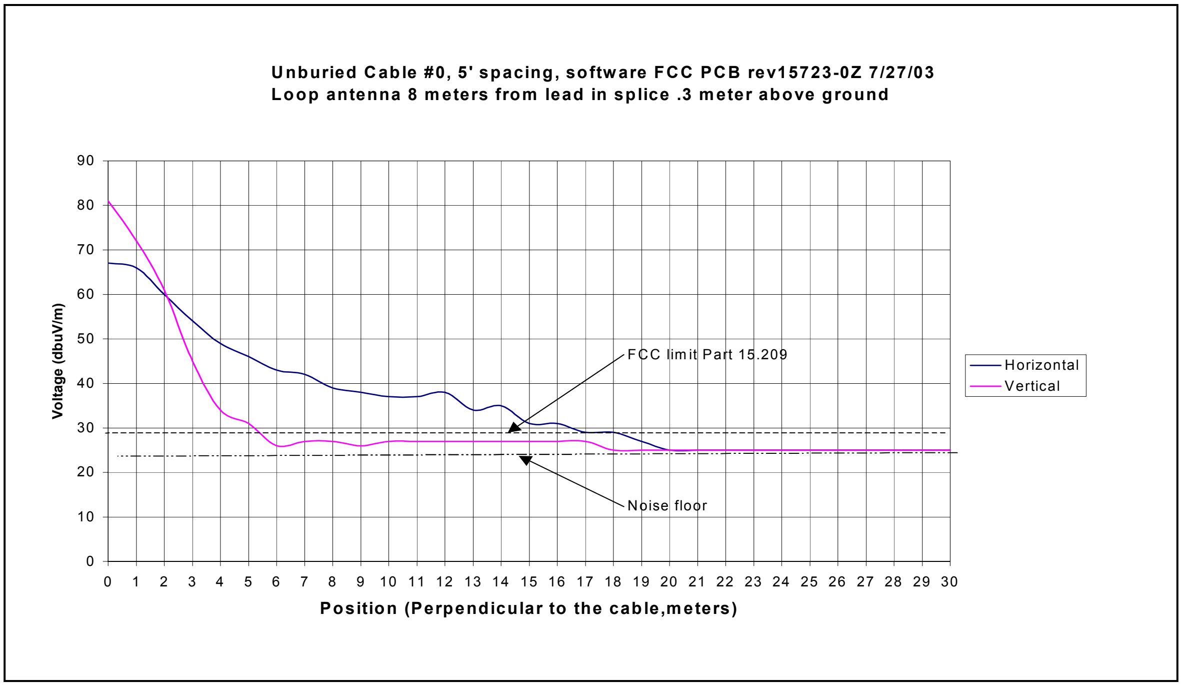
Unburied Cable #0, 5' spacing, software FCC PCB rev15723-0Z 7/27/03
Loop antenna 8 meters from lead in splice .3 meter above ground
Voltage (dbuV/m)
Position (Perpendicular to the cable,meters)
FCC limit Part 15.209
Noise floor
Horizontal
Vertical

Fig 16

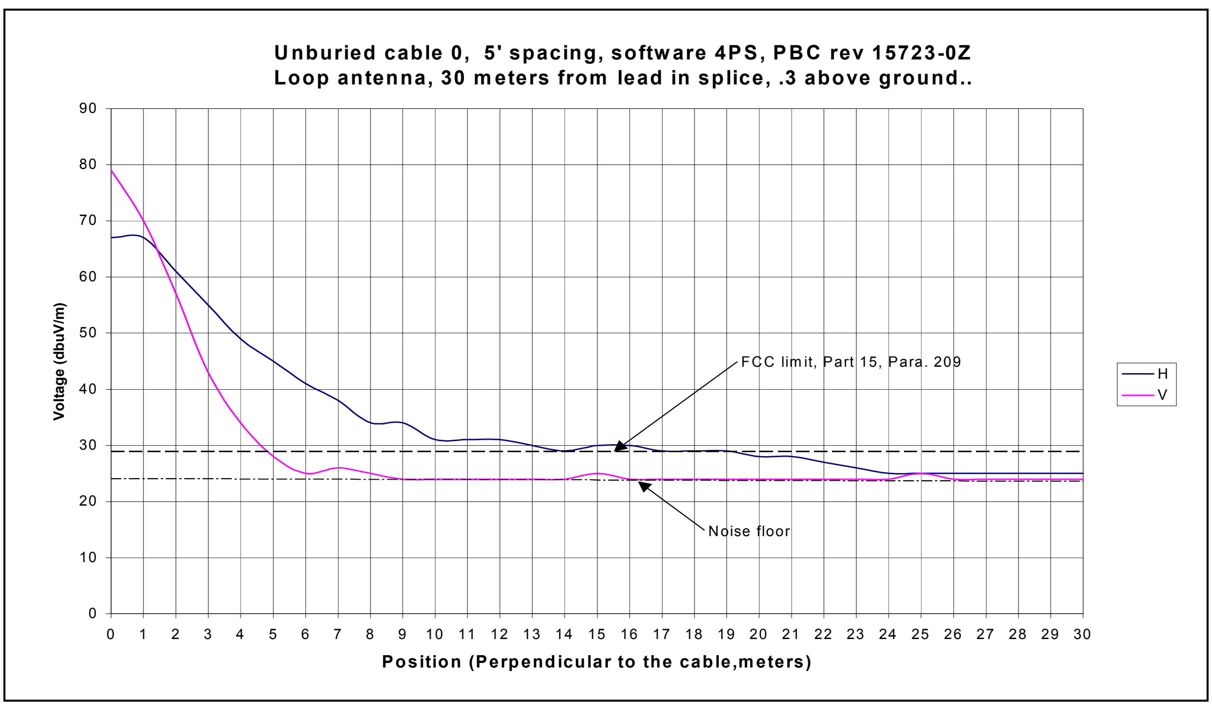
Unburied cable 0, 5' spacing, software 4PS, PBC rev 15723-0Z
Loop antenna, 30 meters from lead in splice, .3 above ground..
Voltage (dbuV/m)
Position (Perpendicular to the cable,meters)
FCC limit, Part 15, Para. 209
Noise floor
H
V

Fig 17

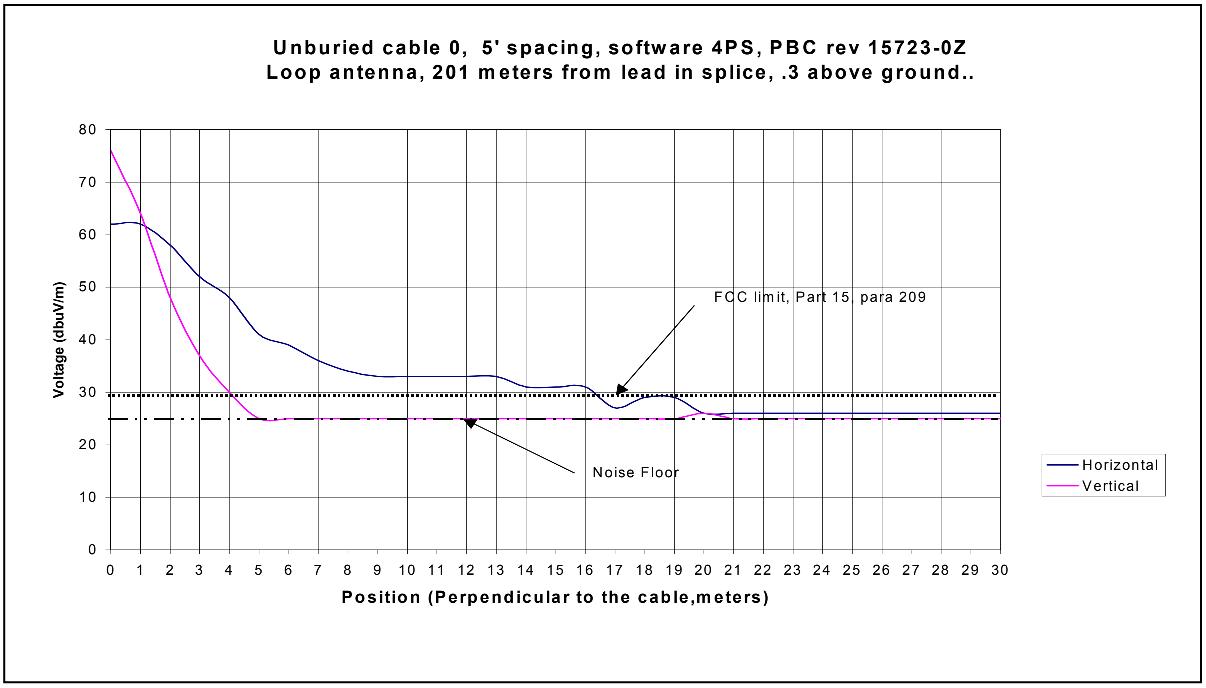

Fig 18

VERTICAL FROM THE GROUND

A PVC fixture for measuring field strength a various heights above the ground is shown in the Test Setup File. The loop antenna can be moved in .5 meter increments up to a maximum of four meters. Data was recorded for ten positions where the parallel and perpendicular measurements indicated a possible maximum field strength. The ten graphs of height data, show decreasing field strength with increased height for the horizontal polarization. The vertical polarization has a small increase in field strength at 2 meters height and at 5 meters perpendicular to the cable. This increase is not significant as the vertical polarization drops off below the noise level at or before 10 meters from the cable. It has been determined that horizontal polarized energy near the ground is typical of the maximum field strength for distances beyond 10 meters from the cable.

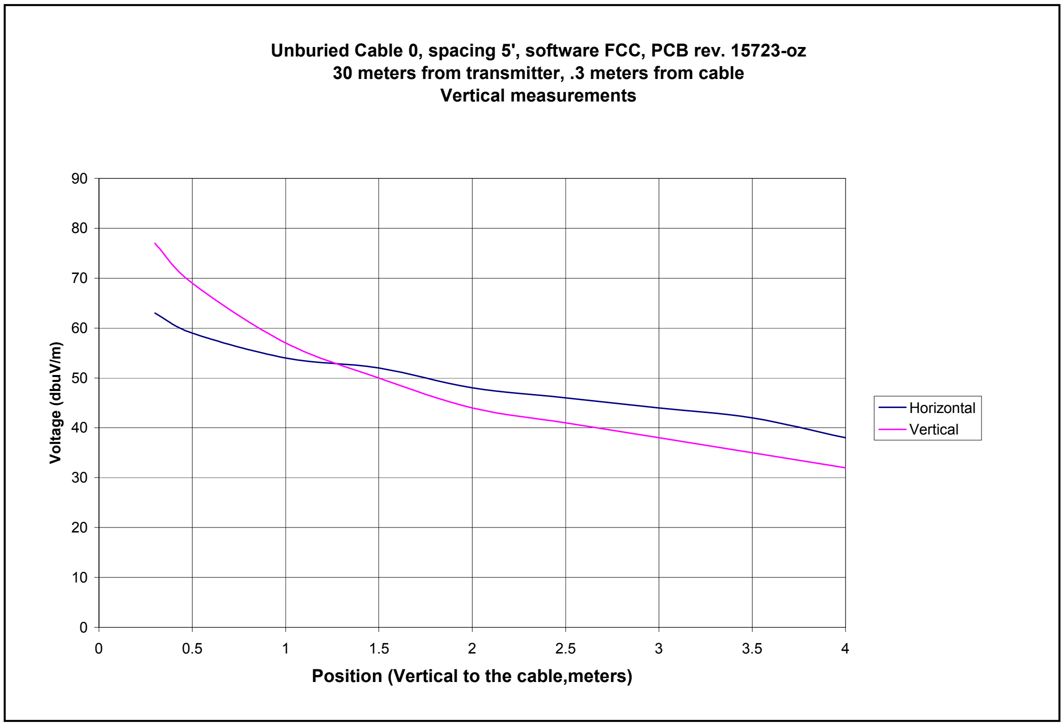
Unburied Cable 0, spacing 5', software FCC, PCB rev. 15723-oz
30 meters from transmitter, .3 meters from cable
Vertical measurements
Voltage (dbuV/m)
0
10
20
30
40
50
60
70
80
90
0
0.5
1
1.5
2
2.5
3
3.5
4
Position (Vertical to the cable,meters)
Horizontal
Vertical

Fig 19

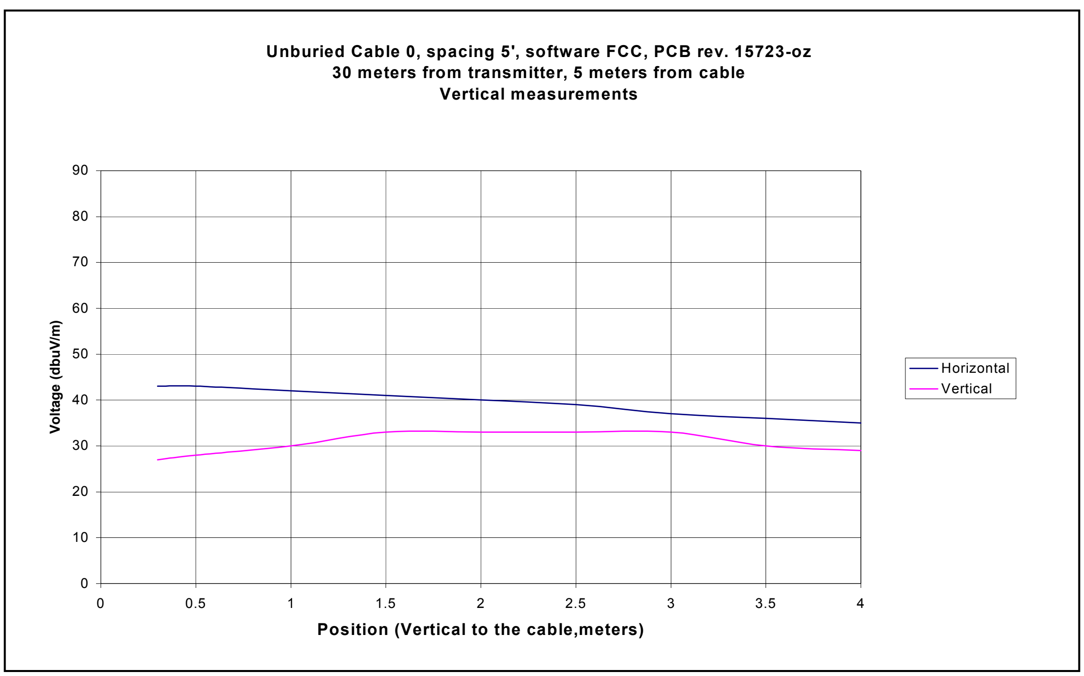
Unburied Cable 0, spacing 5', software FCC, PCB rev. 15723-oz
30 meters from transmitter, 5 meters from cable
Vertical measurements
Voltage (dbuV/m)
0
10
20
30
40
50
60
70
80
90
0
0.5
1
1.5
2
2.5
3
3.5
4
Position (Vertical to the cable,meters)
Horizontal
Vertical

Fig 20

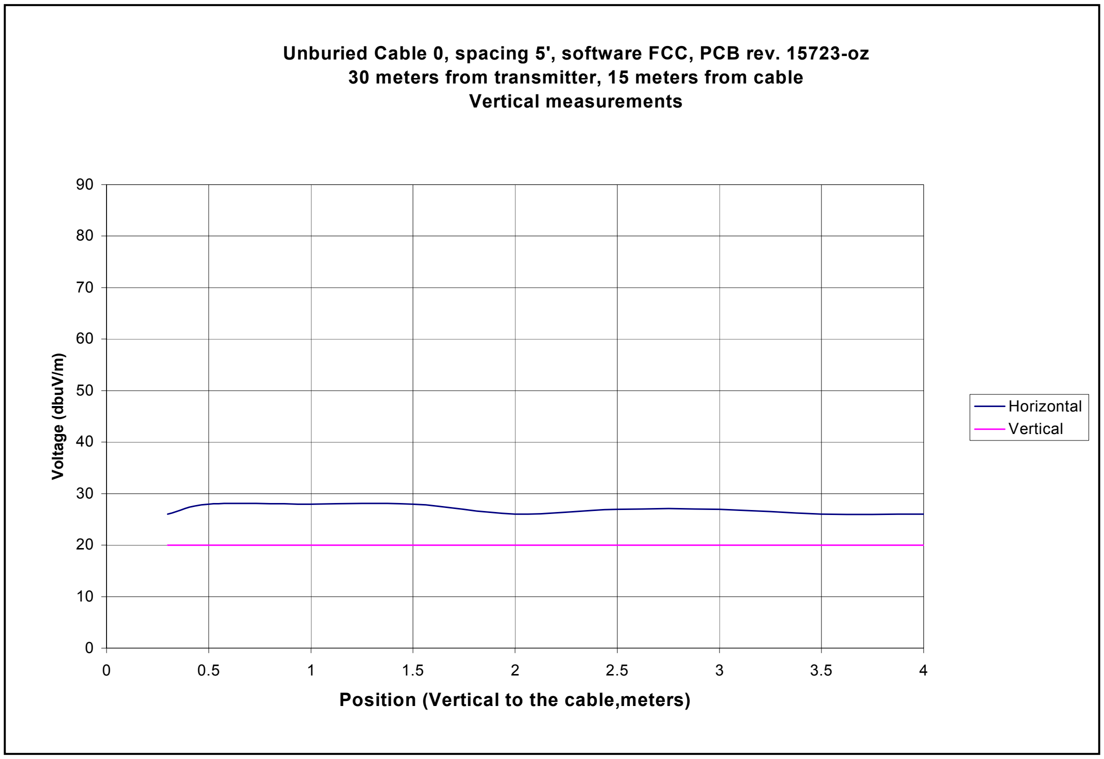
Unburied Cable 0, spacing 5', software FCC, PCB rev. 15723-oz
30 meters from transmitter, 15 meters from cable
Vertical measurements
Voltage (dbuV/m)
Position (Vertical to the cable,meters)
Horizontal
Vertical

Fig 21

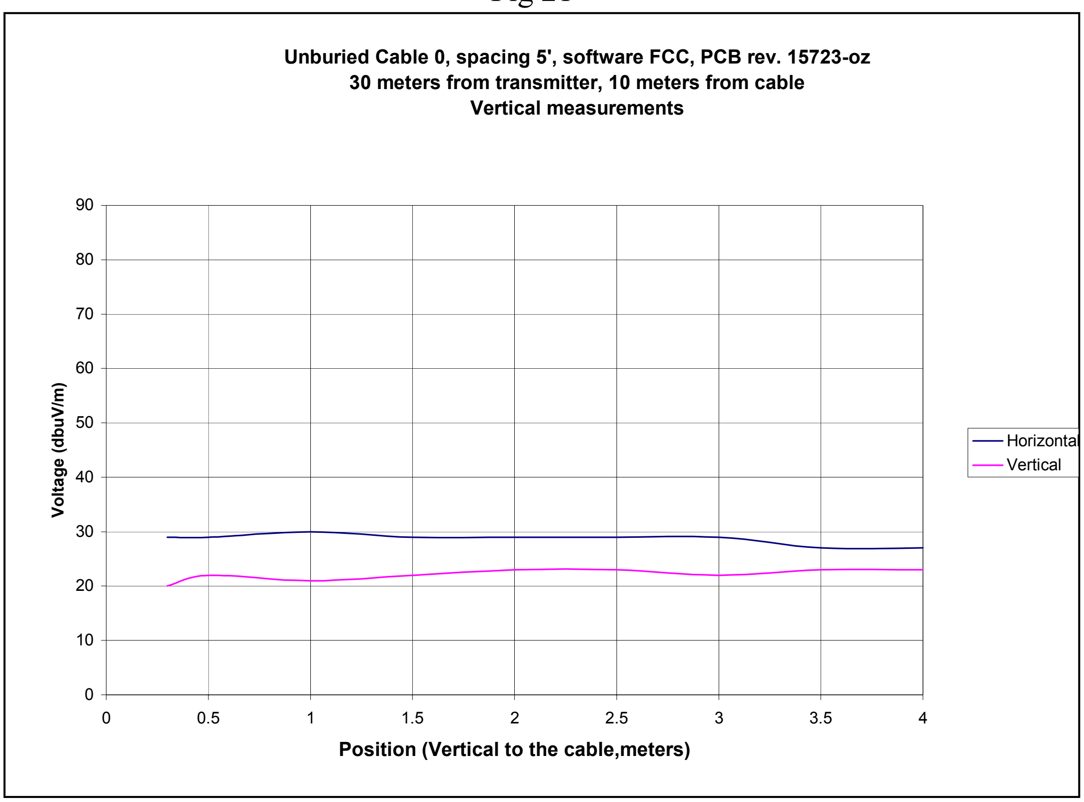
Unburied Cable 0, spacing 5', software FCC, PCB rev. 15723-oz
30 meters from transmitter, 10 meters from cable
Vertical measurements
Voltage (dbuV/m)
Position (Vertical to the cable,meters)
Horizontal
Vertical

Fig 22