TRaC RADIO TEST REPORT

FOR

Sub10 Systems Limited

ON

Liberator-V1000

DOCUMENT NO. TRA-015579-W-US-1b

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TRaC Wireless Test Report : TRA-015579-W-US-1b

Applicant : Sub10 Systems Limited

Apparatus : Liberator-V1000

Specification(s) : CFR47 Part15 C 15.255: October 2012

Purpose of Test : Certification

Authorised by : 

: Radio Product Manager

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Section 1: Introduction

1.1 General

This report contains an assessment of an apparatus against Radio Standards based upon tests carried out on samples submitted to the Laboratory.

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1.4 Apparatus Assessed

The following apparatus was assessed between 27/01/14 and 15/07/14

Liberator-V1000

The apparatus is a point to point full duplex wireless data link operating in the 57 GHz to 64 GHz band. The EUT is fitted with an Integral Antenna which has a gain of 38dBi.

The equipment will operate in a 100 MB/s mode with a 100 MHz channel bandwidth referred to as V100 mode in this report and in a 1GB/s mode with a 500 MHz channel bandwidth referred to as V1000 mode in this report.

1.5 Test Result Summary

Full details of test results are contained within Appendix A. The following table summarises the results of the assessment.

The statements relating to compliance with the standards below apply ONLY as qualified in the notes and deviations stated in sections 1.6 to 1.7 of this test report.

Full details of test results are contained within Appendix A. The following table summarises the results of the assessment.

Test Type	Regulation	Measurement standard	Result
Frequency Stability	Title 47 of the CFR: Part 15 Subpart C; 15.255 (f)	TIA-603C	Pass
Harmonics and Spurious Emissions	Title 47 of the CFR: Part 15 Subpart C; 15.255 (c)	TIA-603C	Pass
Transmitter Power Limitation	Title 47 of the CFR: Part 15 Subpart C; 15.255 (b) (1)	TIA-603C (Note)	Pass
Transmitter Peak Power (conducted)	Title 47 of the CFR: Part 101 Subpart C; 15.255 (e)	TIA-603C (Note)	Pass
Power Line Conducted emissions	Title 47 of the CFR: Part 15 Subpart b; 15.107	ANSI C63.4	Pass
Spurious emissions from digital circuitry	Title 47 of the CFR: Part 15 Subpart b; 15.109	ANSI C63.4	Pass
RF Exposure	Title 47 of the CFR: Part 2 ; 2.1093	-	Pass

Note:

The fundamental power for the EUT was measured according to the FCC Rule Section 15.255 using the measurement procedure in KDB200443

1.6 Notes Relating To The Assessment

With regard to this assessment, the following points should be noted:

The results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

The apparatus was set up and exercised using the configurations, modes of operation and arrangements defined in this report only.

Particular operating modes, apparatus monitoring methods and performance criteria required by the standards tested to have been performed except where identified in Section 1.7 of this test report (Deviations from Test Standards).

For emissions testing, throughout this test report, “Pass” indicates that the results for the sample as tested were below the specified limit (refer also to Section 2, Measurement Uncertainty).

Where relevant, the apparatus was only assessed using the monitoring methods and susceptibility criteria defined in this report.

All testing with the exception of testing at the Open Area Test Site was performed under the following environmental conditions:

Temperature	: 17 to 23 °C
Humidity	: 45 to 75 %
Barometric Pressure	: 86 to 106 kPa

All dates used in this report are in the format dd/mm/yy.

This assessment has been performed in accordance with the requirements of ISO/IEC 17025.

1.7 Deviations from Test Standards

There were no deviations from the standards tested to.

Section 2: Measurement Uncertainty

2.1 Measurement Uncertainty Values

For test data recorded, the following measurement uncertainty was calculated:

Radiated Electric Field Emissions

Quantity Range	Quantity	Expanded Uncertainty
9kHz to 150 kHz	Amplitude dB(µV/m)	±1.6dB
150 kHz to 30 MHz	Amplitude dB(µV/m)	±2.1dB
30MHz to 300MHz Horizontal	Amplitude dB(µV/m)	±5.1dB
30MHz to 300MHz Vertical	Amplitude dB(µV/m)	±5.2dB
300MHz to 1GHz Horizontal	Amplitude dB(µV/m)	±5.4dB
300MHz to 1GHz Vertical	Amplitude dB(µV/m)	±5.2dB
1GHz to 18GHz Horizontal	Amplitude dB(µV/m)	±4.4dB
1GHz to 18GHz Vertical	Amplitude dB(µV/m)	±4.4dB
18GHz to 26.5GHz Horizontal	Amplitude dB(µV/m)	±4.2dB
18GHz to 26.5GHz Vertical	Amplitude dB(µV/m)	±4.2dB
26.5GHz to 40GHz Horizontal	Amplitude dB(µV/m)	±4.3dB
26.5GHz to 40GHz Vertical	Amplitude dB(µV/m)	±4.3dB

Section 3: Modifications

3.1 Modifications Performed During Assessment

No modifications were performed during the assessment

Appendix A: Formal Emission Test Results

Abbreviations used in the tables in this appendix:

Spec	: Specification
Mod	: Modification
EUT	: Equipment Under Test
SE	: Support Equipment
L	: Live Power Line
N	: Neutral Power Line
E	: Earth Power Line
Pk	: Peak Detector
QP	: Quasi-Peak Detector
Av	: Average Detector
CDN	: Coupling & decoupling network

ALSR	: Absorber Lined Screened Room
OATS	: Open Area Test Site
ATS	: Alternative Test Site
Ref	: Reference
Freq	: Frequency
MD	: Measurement Distance
SD	: Spec Distance
Pol	: Polarisation
H	: Horizontal Polarisation
V	: Vertical Polarisation

A1 Frequency Stability

Frequency stability testing was performed using a spectrum analyser and V band mixer. The EUT was connected directly to the waveguide flange of the mixer and was set to transmit a CW carrier. The analyser was set to the centre frequency of the carrier with a frequency span of 10 MHz. The carrier frequency was measured using the marker counter function of the analyser.

Test Details: A end – V100 Mode	
Test Requirement	Title 47 of the CFR: Part 15 Subpart C Clause 15.255(f)
Measurement standard	ANSI C63.10
EUT sample number	S01 and S02
Modification state	0
SE in test environment	None
SE isolated from EUT	Laptop
EUT set up	Refer to Appendix C

Temperature °C	Measured Frequency Bottom Channel (GHz)	Measured Frequency Top Channel (GHz)
-20	58.4999293	59.499928
-10	58.4999433	59.4999423
0	58.4998876	59.4998838
10	58.4997425	59.4997477
20	58.4995872	59.4995941
30	58.4994763	59.4994672
40	58.4993901	59.4993795
50	58.4993990	59.4993895
55	58.4995680	59.4995664

Voltage (V)	Measured Frequency Bottom Channel (GHz)	Measured Frequency Top Channel (GHz)
98	58.4995872	59.4995941
132	58.4995872	59.4995941

Test Details: A end – V1000 Mode	
Test Requirement	Title 47 of the CFR: Part 15 Subpart C Clause 15.255(f)
Measurement standard	ANSI C63.10
EUT sample number	S01 and S02
Modification state	0
SE in test environment	None
SE isolated from EUT	Laptop
EUT set up	Refer to Appendix C

Temperature °C	Measured Frequency Bottom Channel (GHz)	Measured Frequency Top Channel (GHz)
-20	58.4993372	59.4993379
-10	58.4993303	59.4993196
0	58.4993276	59.4993144
10	58.4993227	59.4993083
20	58.4993189	59.4992992
30	58.4993154	59.499291
40	58.4993066	59.4992874
50	58.4992902	59.4992925
55	58.4993195	59.4993254

Voltage (V)	Measured Frequency Bottom Channel (GHz)	Measured Frequency Top Channel (GHz)
98	58.4993189	59.4992992
132	58.4993189	59.4992992

Test Details: B end – V100 Mode	
Test Requirement	Title 47 of the CFR: Part 15 Subpart C Clause 15.255(f)
Measurement standard	ANSI C63.10
EUT sample number	S03 and S02
Modification state	0
SE in test environment	None
SE isolated from EUT	Laptop
EUT set up	Refer to Appendix C

Temperature °C	Measured Frequency Bottom Channel (GHz)	Measured Frequency Top Channel (GHz)
-20	61.4999288	62.4999266
-10	61.4999442	62.4999411
0	61.4998812	62.4998828
10	61.4997401	62.4997465
20	61.4995843	62.4995933
30	61.4994734	62.4994654
40	61.4993888	62.4993781
50	61.4993976	62.4993877
55	61.4995678	62.4995639

Voltage (V)	Measured Frequency Bottom Channel (GHz)	Measured Frequency Top Channel (GHz)
98	61.4995843	62.4995933
132	61.4995843	62.4995933

Test Details: B end – V1000 Mode	
Test Requirement	Title 47 of the CFR: Part 15 Subpart C Clause 15.255(f)
Measurement standard	ANSI C63.10
EUT sample number	S03 and S02
Modification state	0
SE in test environment	None
SE isolated from EUT	Laptop
EUT set up	Refer to Appendix C

Temperature °C	Measured Frequency Bottom Channel (GHz)	Measured Frequency Top Channel (GHz)
-20	61.4993356	62.4993360
-10	61.4993293	62.4993181
0	61.4993254	62.4993119
10	61.4993202	62.4993063
20	61.4993164	62.4992982
30	58.4993140	62.4992898
40	61.4993038	62.4992844
50	61.4992888	62.4992910
55	61.4993175	62.4993238

Voltage (V)	Measured Frequency Bottom Channel (GHz)	Measured Frequency Top Channel (GHz)
98	61.4993164	62.4992982
132	61.4993164	62.4992982

Limit Clause 15.255

(f) Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the temperature range -20 to +50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

A2 Transmitter Power Limitation

Conducted carrier power was verified using the measurement procedure in FCC KDB200443; with the EUT transmitting on its lowest, centre and highest carrier frequency in turn.

The EUT was connected to a V band diode detector which was in turn connected directly to the input of a 500 MHz bandwidth DSO. The oscilloscope was set to a 50Ω input impedance dc coupled with full (500MHz) bandwidth selected. The EUT was set to transmit at full power with normal modulation. The DSO was adjusted to give as large a voltage display possible on the screen and the output voltage of the detector was determined using the RMS voltage measurement function of the DSO. This voltage was then used to determine the power level from the EUT.

Test Details: A end	
Regulation	Title 47 of the CFR: Part15 Subpart C 15.255 (b) (1)
Measurement standard	ANSI C63.10
EUT sample number	S07 and S09
Modification state	0
SE in test environment	None
SE isolated from EUT	Laptop
EUT set up	Refer to Appendix C

V100 Mode

Frequency (GHz)	Measured conducted power (dBm)	Antenna Gain dBi	EIRP (dBm)	EIRP limit (dBm)
58.5	10.6	38.0	48.6	56.0
59.0	10.6	38.0	48.6	56.0
59.5	10.8	38.0	48.8	56.0

V1000 Mode

Frequency (GHz)	Measured conducted power (dBm)	Antenna Gain dBi	EIRP (dBm)	EIRP limit (dBm)
58.5	10.5	38.0	48.5	56.0
59.0	10.5	38.0	48.5	56.0
59.5	10.7	38.0	48.7	56.0

Test Details: B end	
Regulation	Title 47 of the CFR: Part15 Subpart C 15.255 (b) (1)
Measurement standard	ANSI C63.10
EUT sample number	S08 and S09
Modification state	0
SE in test environment	None
SE isolated from EUT	Laptop
EUT set up	Refer to Appendix C

V100 Mode

Frequency (GHz)	Measured conducted power (dBm)	Antenna Gain dBi	EIRP (dBm)	EIRP limit (dBm)
61.5	11.8	38.0	49.8	56.0
62.0	12.3	38.0	50.3	56.0
62.5	11.9	38.0	49.9	56.0

V1000 Mode

Frequency (GHz)	Measured conducted power (dBm)	Antenna Gain dBi	EIRP (dBm)	EIRP limit (dBm)
61.5	11.9	38.0	49.9	56.0
62.0	12.2	38.0	50.2	56.0
62.5	12.0	38.0	50.0	56.0

Limit 15.255

(b) Within the 57-64 GHz band, emission levels shall not exceed the following equivalent isotropically radiated power (EIRP):

(1) Products other than fixed field disturbance sensors shall comply with one of the following emission limits, as measured during the transmit interval:

(i) Except as indicated in paragraph (b)(1)(ii) of this section, the average power of any emission shall not exceed 40 dBm and the peak power of any emission shall not exceed 43 dBm.

(ii) For transmitters located outdoors, the average power of any emission shall not exceed 82 dBm minus 2 dB for every dB that the antenna gain is less than 51 dBi. The peak power of any emission shall not exceed 85 dBm minus 2 dB for every dB that the antenna gain is less than 51 dBi.

A3 Transmitter Peak Power (Conducted)

Conducted carrier power was verified using the measurement procedure in FCC KDB200443; with the EUT transmitting on its lowest, centre and highest carrier frequency in turn.

The EUT was connected to a V band diode detector which was in turn connected directly to the input of a 500 MHz bandwidth DSO. The oscilloscope was set to a 50Ω input impedance dc coupled with full (500MHz) bandwidth selected. The EUT was set to transmit at full power with normal modulation. The DSO was adjusted to give as large a voltage display possible on the screen and the output voltage of the detector was determined using the RMS voltage measurement function of the DSO. This voltage was then used to determine the power level from the EUT.

Test Details: A end	
Test Requirement	Title 47 of the CFR: Part 15 Subpart C Clause 15.255(e)
Measurement standard	ANSI C63.10
EUT sample number	S07 and S09
Modification state	0
SE in test environment	None
SE isolated from EUT	Laptop
EUT set up	Refer to Appendix C

V100 Mode

Test Conditions Temperature / Voltage	Frequency GHz	Conducted Power (dBm)	Limit (dBm)
20°C / 115 V (Note1)	58.5	10.6	27
20°C / 115 V (Note1)	59.0	10.6	27
20°C / 115 V (Note1)	59.5	10.8	27

V1000 Mode

Test Conditions Temperature / Voltage	Frequency GHz	Conducted Power (dBm)	Limit (dBm)
20°C / 115 V (Note1)	58.5	10.5	27
20°C / 115 V (Note1)	59.0	10.5	27
20°C / 115 V (Note1)	59.5	10.7	27

Test Details: B end	
Test Requirement	Title 47 of the CFR: Part 15 Subpart C Clause 15.255(e)
Measurement standard	ANSI C63.10
EUT sample number	S08 and S09
Modification state	0
SE in test environment	None
SE isolated from EUT	Laptop
EUT set up	Refer to Appendix C

V100 Mode

Test Conditions Temperature / Voltage	Frequency GHz	Conducted Power (dBm)	Limit (dBm)
20°C / 115 V (Note1)	61.5	11.8	27
20°C / 115 V (Note1)	62.0	12.3	27
20°C / 115 V (Note1)	62.5	11.9	27

V1000 Mode

Test Conditions Temperature / Voltage	Frequency GHz	Conducted Power (dBm)	Limit (dBm)
20°C / 115 V (Note1)	61.5	11.9	27
20°C / 115 V (Note1)	62.0	12.2	27
20°C / 115 V (Note1)	62.5	12.0	27

Note:

1 No variation in power was observed whilst varying the supply voltage between 85% and 115% of the nominal value.

47CFR 15.255 Emission limits.

(e) Except as specified elsewhere in this paragraph (e), the total peak transmitter output power shall not exceed 500 mW (27 dBm).

A4 Transmit Radiated Electric Field Emissions

The effect of the EUT set-up on the measurements is summarised in note (c) below. Preliminary scans were performed using a spectrum analyser with a peak detector and with the RBW equal to 100 kHz below 1 GHz and 1MHz above 1 GHz. Formal emissions identified in the preliminary scans were measured using a test receiver. The maximum permitted field strength is listed in Section 15.255(c). The EUT was set to transmit mode on its lowest, centre and highest carrier frequency in turn.

The following test site was used for final measurements as specified by the standard tested to :

3m open area test site : ☐ 3m alternative test site : ☒

The EUT was placed on a 0.8m high table and was rotated to maximise the emissions found during the preliminary scans. The antenna was then raised and lowered between 1m and 4m and the maximised emissions recorded.

Test Details: Transmit Mode A end	
Regulation	Title 47 of the CFR: Part 15 Subpart C Clause 15.255 (c)
Measurement standard	ANSI C63.4
Frequency range	30MHz to 200 GHz
EUT sample number	S01 and S02
Modification state	0
SE in test environment	None
SE isolated from EUT	Laptop
EUT set up	Refer to Appendix C

30 MHz to 40 GHz

Ref No.	FREQ. (MHz)	DET	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	FIELD ST'GH (dBµV/m)	EXTRAP FACT (dB)	FIELD ST'GH (dBµV/m)	LIMIT (dBµV/m)
1	81.503	Pk	30.3	1.2	7.1	0	38.6	0	38.6	60.0
2	81.503	Qp	28.9	1.2	7.1	0	37.2	0	37.2	40.0
3	214.200	Pk	29.5	1.4	10.3	0	41.2	0	41.2	60.0
4	214.200	Qp	25.9	1.4	10.3	0	37.6	0	37.6	40.0

All other emissions were a minimum of 20 dB below the test limit

40 GHz to 200 GHz

Ref No.	FREQ. (GHz)	DET	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	MIXER CONVERSION LOSS (dB)	EXTRAP FACT (dB)	FIELD ST'GH (dBµV/m)	Power Flux Density (pW/cm^2)	LIMIT (pW/cm^2)
All emissions were a minimum of 20 dB below the test limit										90.0

Test Details: Transmit Mode B end	
Regulation	Title 47 of the CFR: Part 15 Subpart C Clause 15.255(c)
Measurement standard	ANSI C63.4
Frequency range	30MHz to 200 GHz
EUT sample number	S03 and S02
Modification state	0
SE in test environment	None
SE isolated from EUT	Laptop
EUT set up	Refer to Appendix C

30 MHz to 40 GHz

Ref No.	FREQ. (MHz)	DET	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	PRE AMP (dB)	FIELD ST'GH (dBµV/m)	EXTRAP FACT (dB)	FIELD ST'GH (dBµV/m)	LIMIT (dBµV/m)
1	79.100	Pk	33.6	1.1	7.1	0	41.8	0	41.8	60.0
2	79.100	Qp	29.1	1.1	7.1	0	37.3	0	37.3	40.0
3	214.179	Pk	31.1	1.4	10.3	0	42.8	0	42.8	60.0
4	214.179	Qp	26.8	1.4	10.3	0	38.5	0	38.5	40.0

All other emissions were a minimum of 20 dB below the test limit

40 GHz to 200 GHz

Ref No.	FREQ. (GHz)	DET	MEAS Rx (dBµV)	CABLE LOSS (dB)	ANT FACT. (dB/m)	MIXER CONVERSION LOSS (dB)	EXTRAP FACT (dB)	FIELD ST'GH (dBµV/m)	Power Flux Density (pW/cm^2)	LIMIT (pW/cm^2)
All emissions were a minimum of 20 dB below the test limit										90.0

Limits

47CFR 15.255(c) Emission limits.

(1) The power density of any emissions outside the 57–64 GHz band shall consist solely of spurious emissions.
(2) Radiated emissions below 40 GHz shall not exceed the general limits in Section 15.209.
(3) Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm2 at a distance of 3 meters.
(4) The levels of the spurious emissions shall not exceed the level of the fundamental emission.

Notes:

(a) For Frequencies below 1 GHz, RBW= 100 kHz, testing was performed with CISPR16 compliant test receiver with QP detector. Above 1 GHz tests were performed using a spectrum analyser using the following settings:

i. Peak RBW=VBW= 1MHz
ii. Average RBW= 1 MHz, VBW = 10 Hz or using an average detector.

These settings as per ANSI C63.10

(b) Where results have been measured at one distance, and a signal level displayed at another, the results have been extrapolated using the following formula:

(c) $$\text{Extrapolation}\,(\text{dB}) = 20\log_{10}\left(\frac{\text{measurement distance}}{\text{specification distance}}\right)$$

(d) The results displayed take into account applicable antenna factors and cable losses.

(e) The levels may have been rounded for display purposes.

(f) The following table summarises the effect of the EUT operating mode, internal configuration and arrangement of cables / samples on the measured emission levels :

	See (i)	See (ii)	See (iii)	See (iv)
Effect of EUT operating mode on emission levels		✓		
Effect of EUT internal configuration on emission levels		✓		
Effect of Position of EUT cables & samples on emission levels		✓		

(i) Parameter defined by standard and / or single possible, refer to Appendix D
(ii) Parameter defined by client and / or single possible, refer to Appendix D
(iii) Parameter had a negligible effect on emission levels, refer to Appendix D
(iv) Worst case determined by initial measurement, refer to Appendix D

A6 ac Power Line Conducted Emissions (15.207)

The EUT was placed on a 0.8m high table 0.4m away from a reference ground plane and a minimum of 0.8m from other metallic surfaces. The EUT was powered by a 115V 60 Hz supply via a Line Impedance Stabilising Network (LISN) placed 0.8m from the EUT. The EUT power cord was 1m long. The RF port of the LISN was connected to a spectrum analyser via a pulse limiter for preliminary scans. The EUT was set to transmit using normal modulation on each frequency in turn and with the EUT powered but not transmitting. Preliminary scans were made on both the Line and Neutral lines in turn using a spectrum analyser with a peak detector. Frequencies identified during the preliminary scans were then formally measured using a test receiver.

Test Details: Transmit Mode A/B end	
Regulation	Title 47 of the CFR: Part 15 Subpart C Clause 15.255 (c)
Measurement standard	ANSI C63.4
Frequency range	30MHz to 231 GHz
EUT sample number	S01, S02 and S03
Modification state	0
SE in test environment	None
SE isolated from EUT	Laptop
EUT set up	Refer to Appendix C

The worst case ac power line port conducted emission measurements are listed below:

Results measured using the average detector compared to the average limit

Ref No.	Freq (MHz)	Conductor	Result (dBuV)	Spec Limit (dBuV)	Margin (dB)	Result Summary
1	0.199	Live	46.0	53.7	-7.7	Pass
2	0.265	Live	40.3	51.3	-11.0	Pass
3	0.331	Live	40.6	49.4	-8.8	Pass
4	0.397	Live	40.4	47.9	-7.5	Pass
5	0.463	Live	39.0	46.6	-7.6	Pass
6	0.530	Live	41.8	46.0	-4.2	Pass
7	4.300	Live	43.0	46.0	-3.0	Pass
8	4.830	Live	43.9	46.0	-2.1	Pass
9	4.970	Live	40.9	46.0	-5.1	Pass
10	5.630	Live	47.4	50.0	-2.6	Pass
11	0.199	Neutral	39.6	53.7	-14.1	Pass
12	0.265	Neutral	32.2	51.3	-19.1	Pass
13	0.331	Neutral	30.2	49.4	-19.2	Pass
14	0.397	Neutral	31.6	47.9	-16.3	Pass
15	0.463	Neutral	31.4	46.6	-15.2	Pass
16	0.530	Neutral	33.6	46.0	-12.4	Pass
17	4.300	Neutral	42.3	46.0	-3.7	Pass
18	4.830	Neutral	44.2	46.0	-1.8	Pass
19	4.970	Neutral	41.8	46.0	-4.2	Pass
20	5.630	Neutral	48.1	50.0	-1.9	Pass

Results measured using the quasi-peak detector compared to the quasi–peak limit

Ref No.	Freq (MHz)	Conductor	Result (dBuV)	Spec Limit (dBuV)	Margin (dB)	Result Summary
1	0.199	Live	52.8	63.7	-10.9	Pass
2	0.265	Live	45.5	61.3	-15.8	Pass
3	0.331	Live	47.0	59.4	-12.4	Pass
4	0.397	Live	48.8	57.9	-9.1	Pass
5	0.463	Live	49.8	56.6	-6.8	Pass
6	0.530	Live	49.5	56.0	-6.5	Pass
7	4.300	Live	43.8	56.0	-12.2	Pass
8	4.830	Live	45.5	56.0	-10.5	Pass
9	4.970	Live	42.9	56.0	-13.1	Pass
10	5.630	Live	48.1	60.0	-11.9	Pass
11	0.199	Neutral	51.5	63.7	-12.2	Pass
12	0.265	Neutral	43.4	61.3	-17.9	Pass
13	0.331	Neutral	41.9	59.4	-17.5	Pass
14	0.397	Neutral	38.1	57.9	-19.8	Pass
15	0.463	Neutral	36.8	56.6	-19.8	Pass
16	0.530	Neutral	40.0	56.0	-16.0	Pass
17	4.300	Neutral	43.2	56.0	-12.8	Pass
18	4.830	Neutral	45.7	56.0	-10.3	Pass
19	4.970	Neutral	43.4	56.0	-12.6	Pass
20	5.630	Neutral	48.7	60.0	-11.3	Pass

A7 Unintentional Radiated Electric Field Emissions - 15.109 (Receiver/Digital circuitry)

The EUT is a full duplex system and as such does not have a receive mode in normal operation. In addition emissions testing for transmitter spurious below 40 GHz is performed to 15.209 limits, which is equivalent to the 15.109 Class B limits.

Appendix B: Supporting Graphical Data

This appendix contains graphical data obtained during testing.

Notes:

(a) The radiated electric field emissions and conducted emissions graphical data in this appendix is preview data. For details of formal results, refer to Appendix A and Appendix B.

(b) All plots in this appendix were performed using a spectrum analyser with a peak detector and no pre-selection below 1 GHz. Formal test results were performed using a CISPR 16 compliant test receiver with the appropriate detector function. Taking this into consideration, preview plots are indicative only, and should not be taken to determine compliance with the test standard

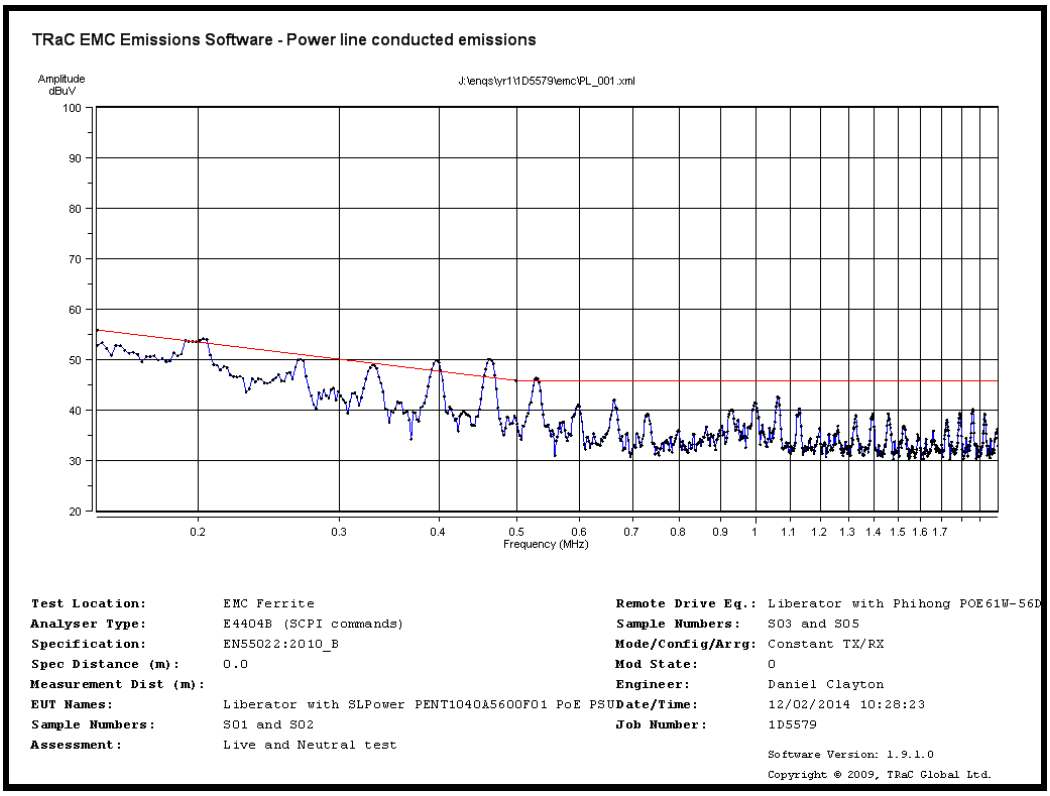
(c) The time and date on the plots do not necessarily equate to the time of the test.

(d) Where relevant, on power line conducted emission plots, the limit displayed is the average limit, which is stricter than the quasi peak limit.

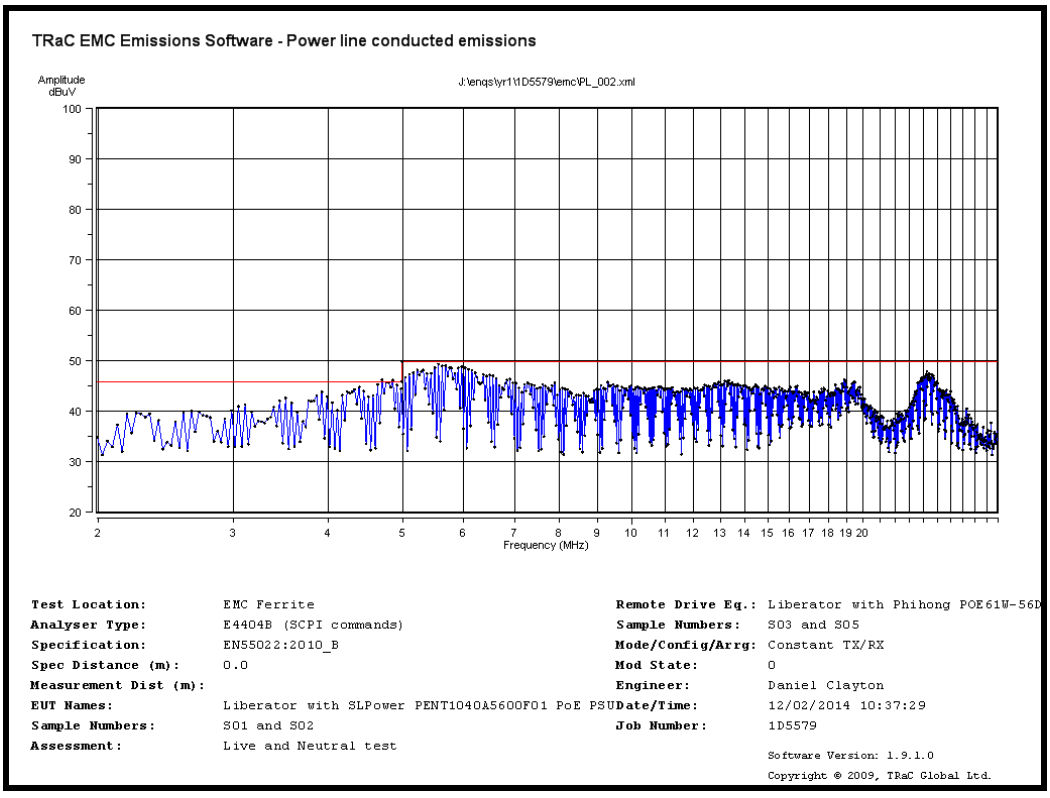
(e) Appendix C details the numbering system used to identify the sample and its modification state.

(f) The plots presented in this appendix may not be a complete record of the measurements performed, but are a representative sample, relative to the final assessment.

B.1 Conducted Plots



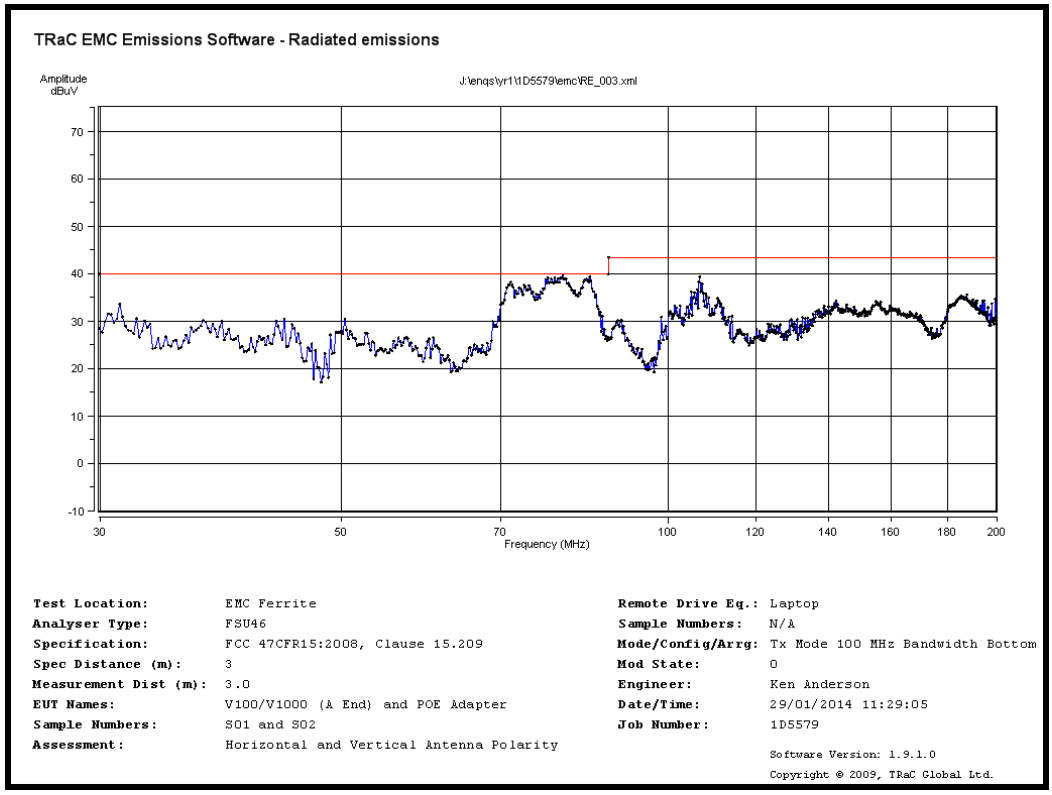
Power Line emissions 150 kHz to 2 MHz



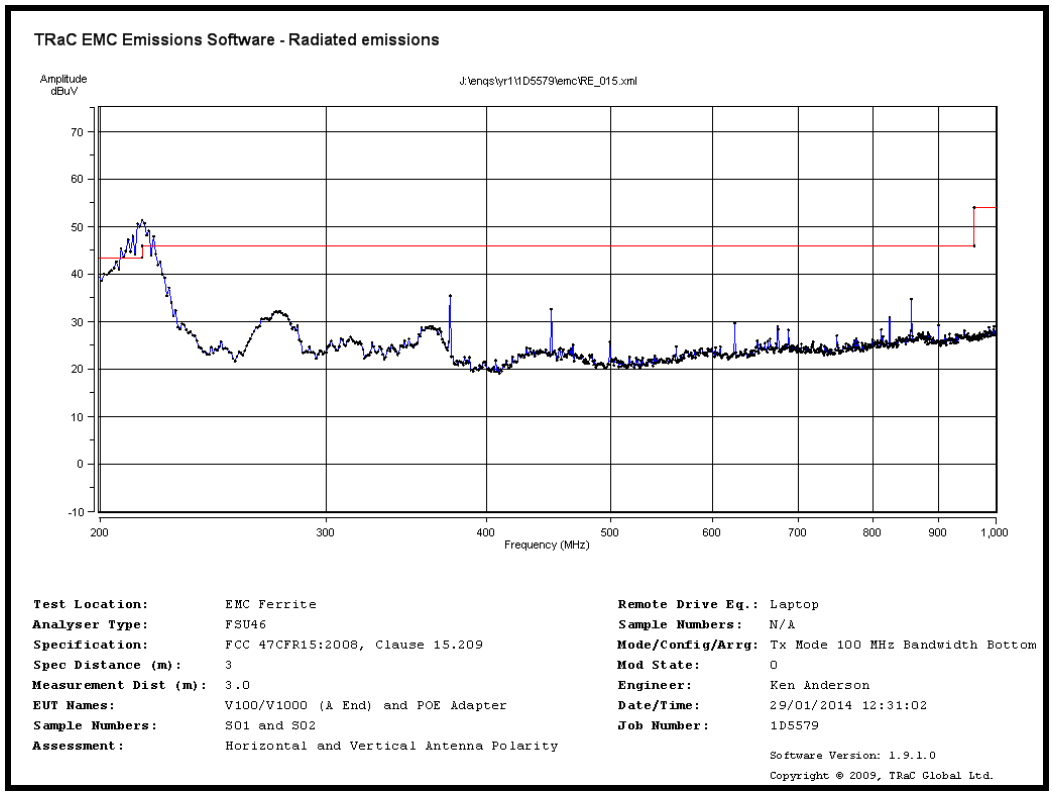
Power Line emissions 2 MHz to 30 MHz

B.2 Radiated spurious emissions plots

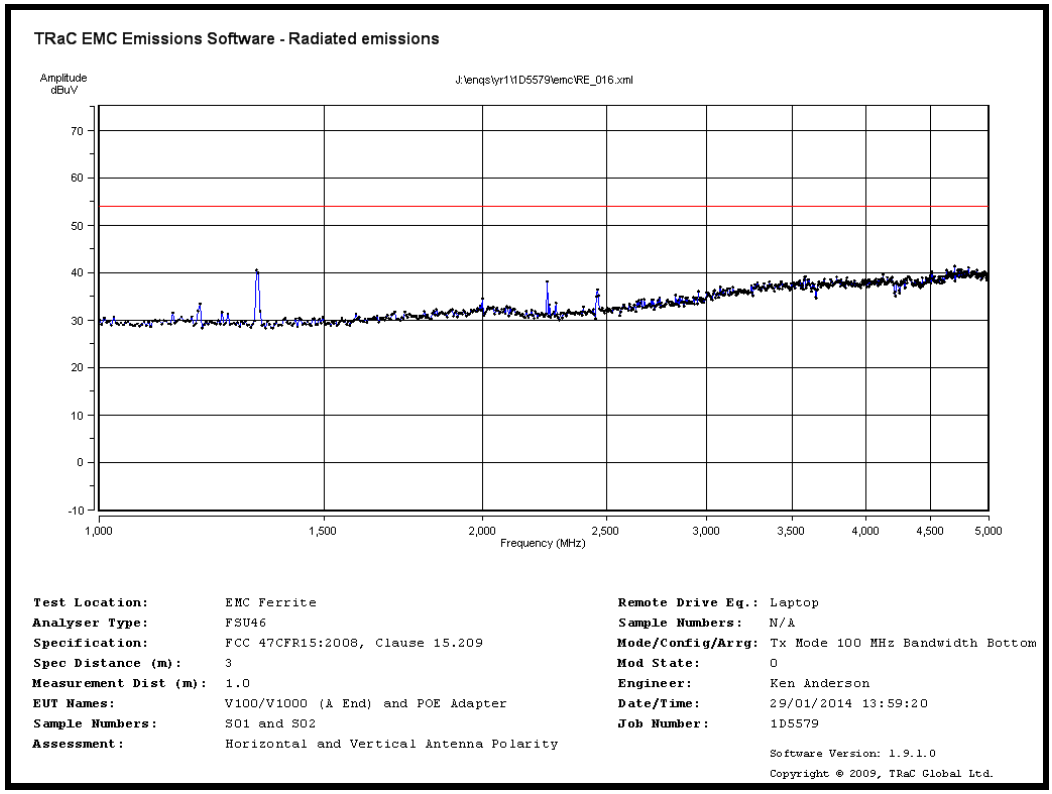
B.2.1 V100 Mode



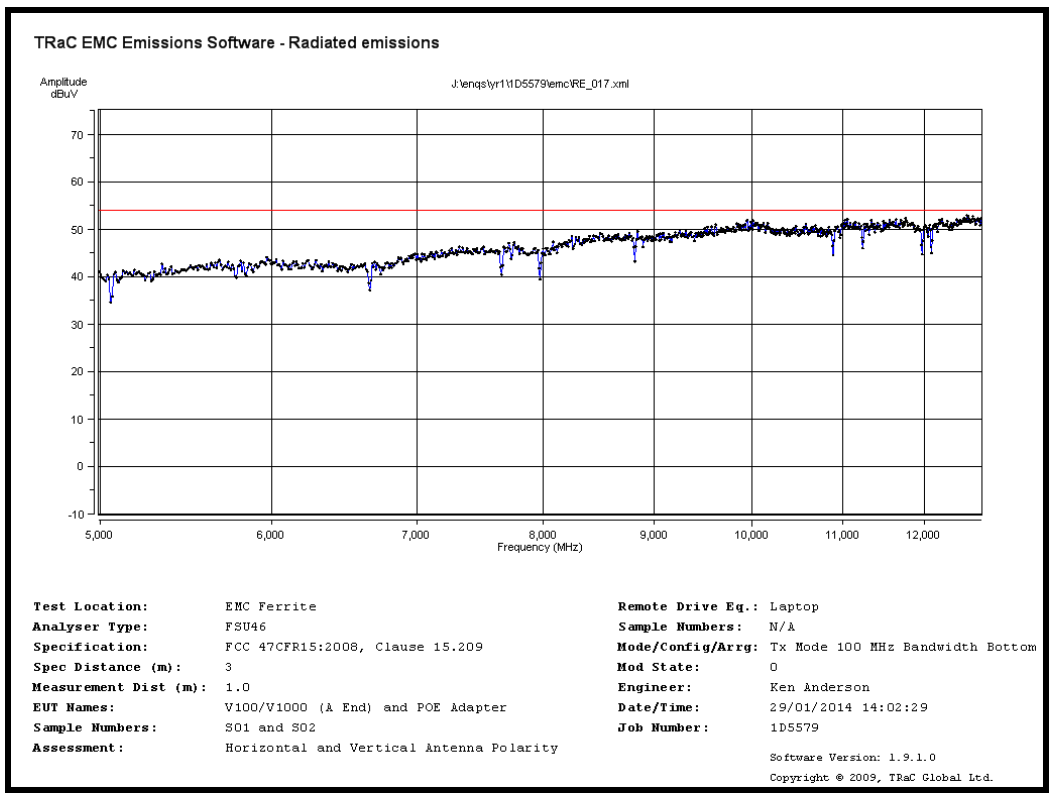
A end 30 MHz to 200 MHz – Bottom Channel



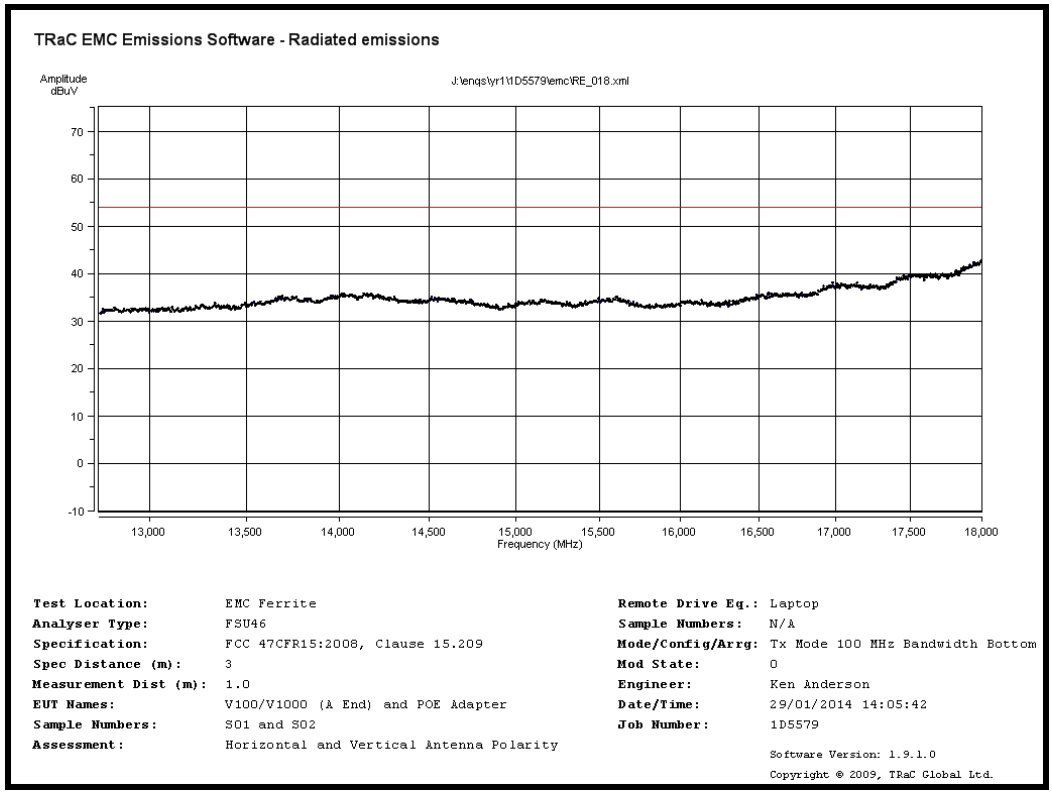
A end 200 MHz to 1GHz– Bottom Channel



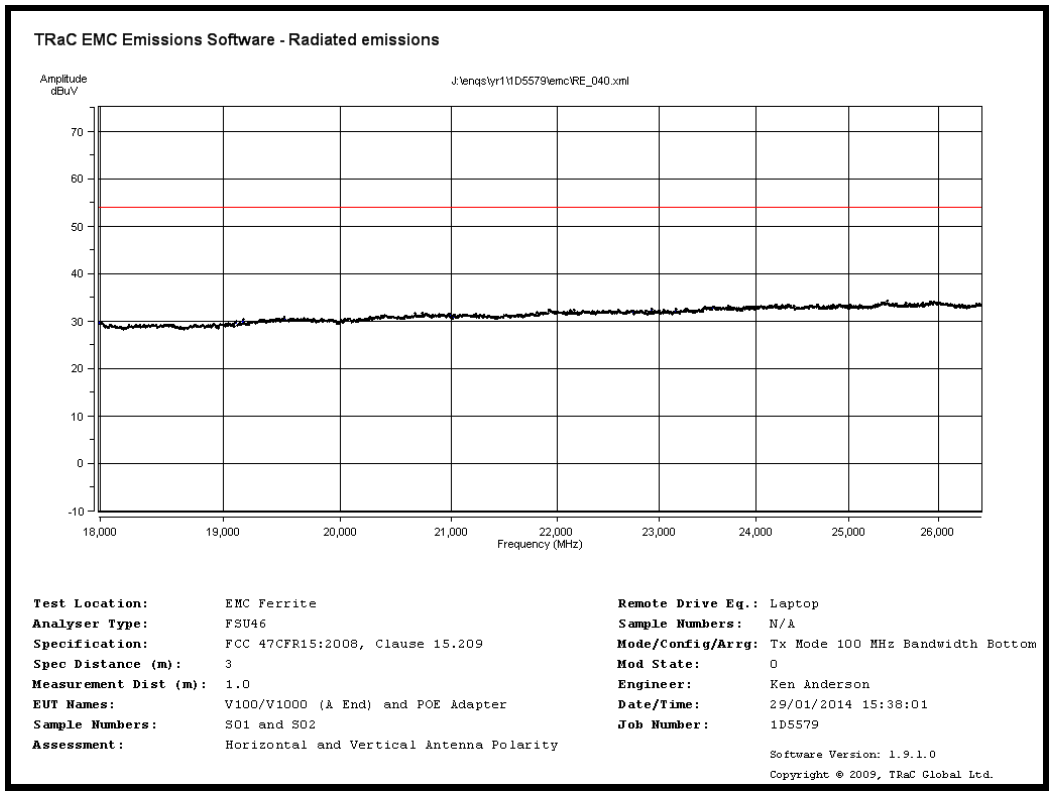
A end 1 GHz to 5 GHz– Bottom Channel



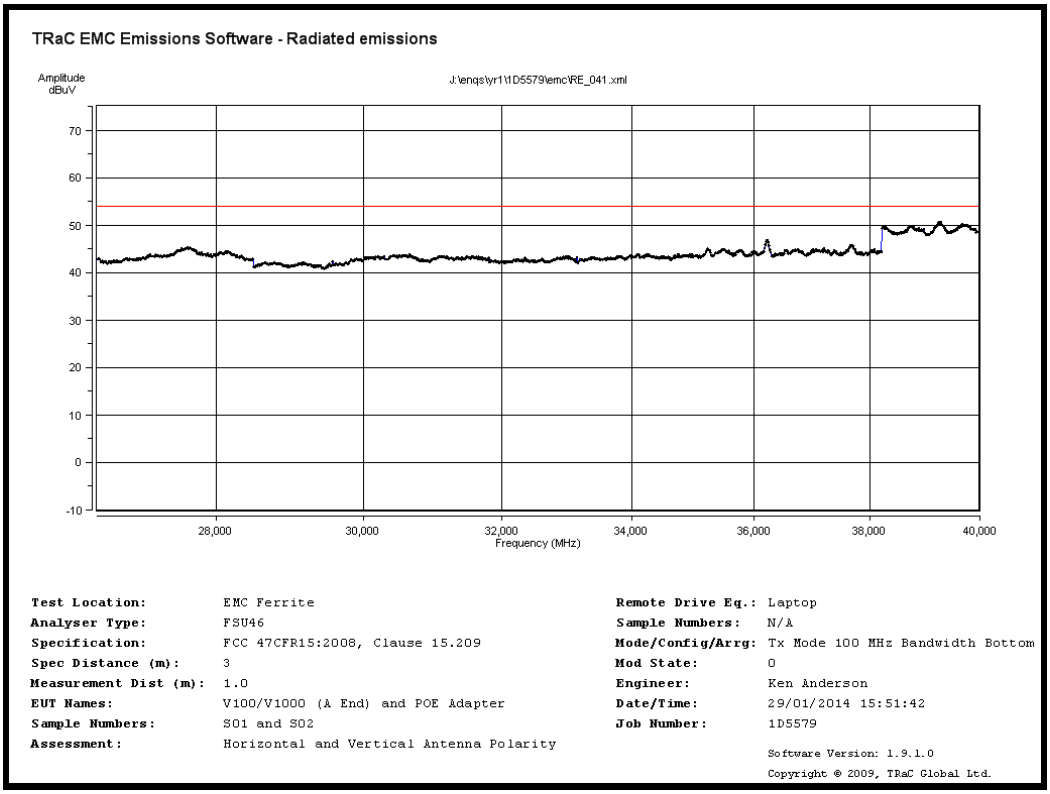
A end 5 GHz to 12.75 GHz– Bottom Channel



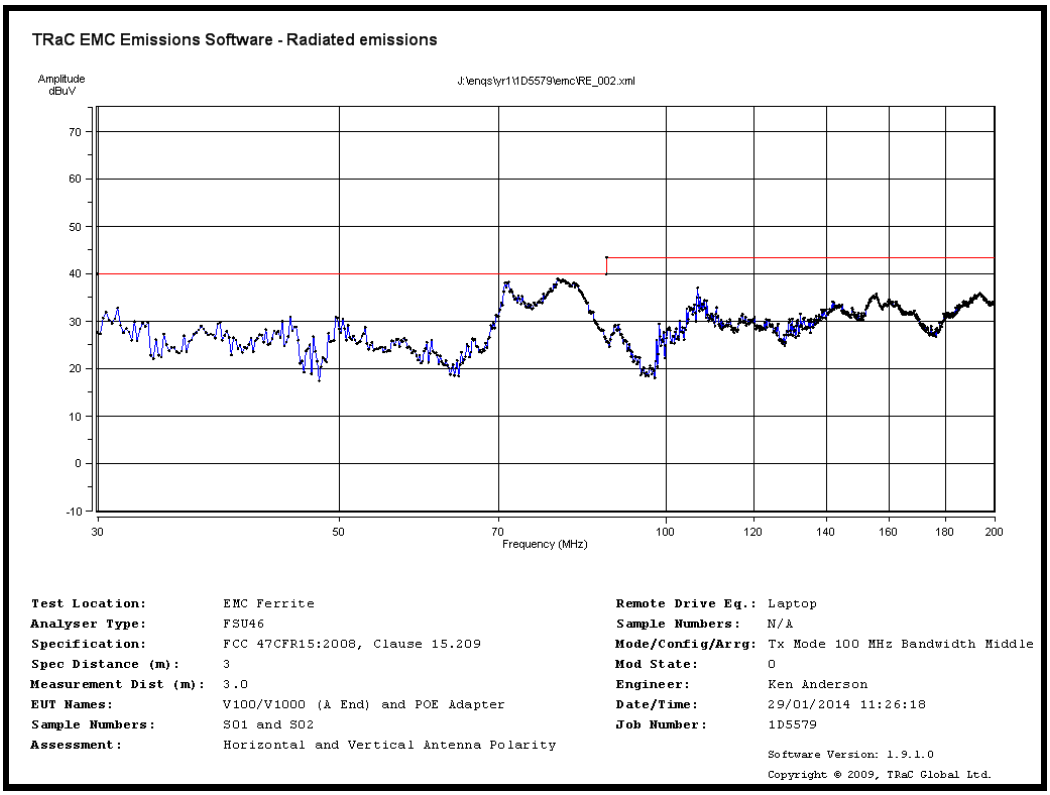
A end 12.75 GHz to 18 GHz– Bottom Channel



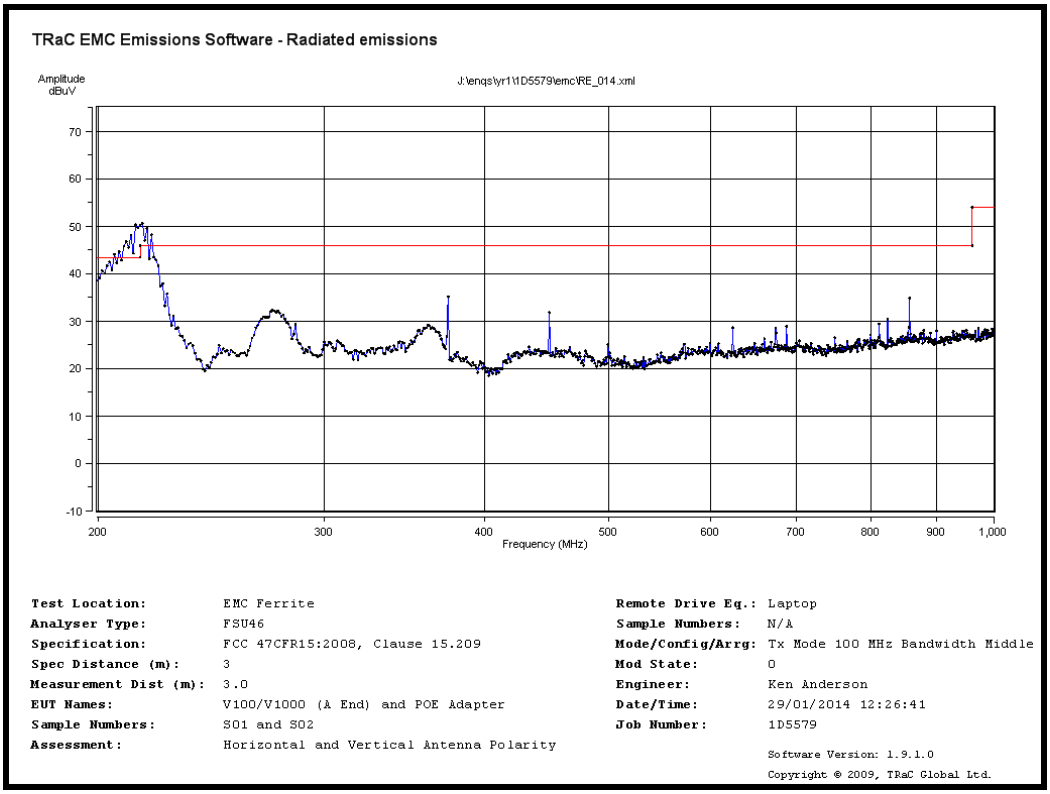
A end 18 GHz to 26.5 GHz– Bottom Channel



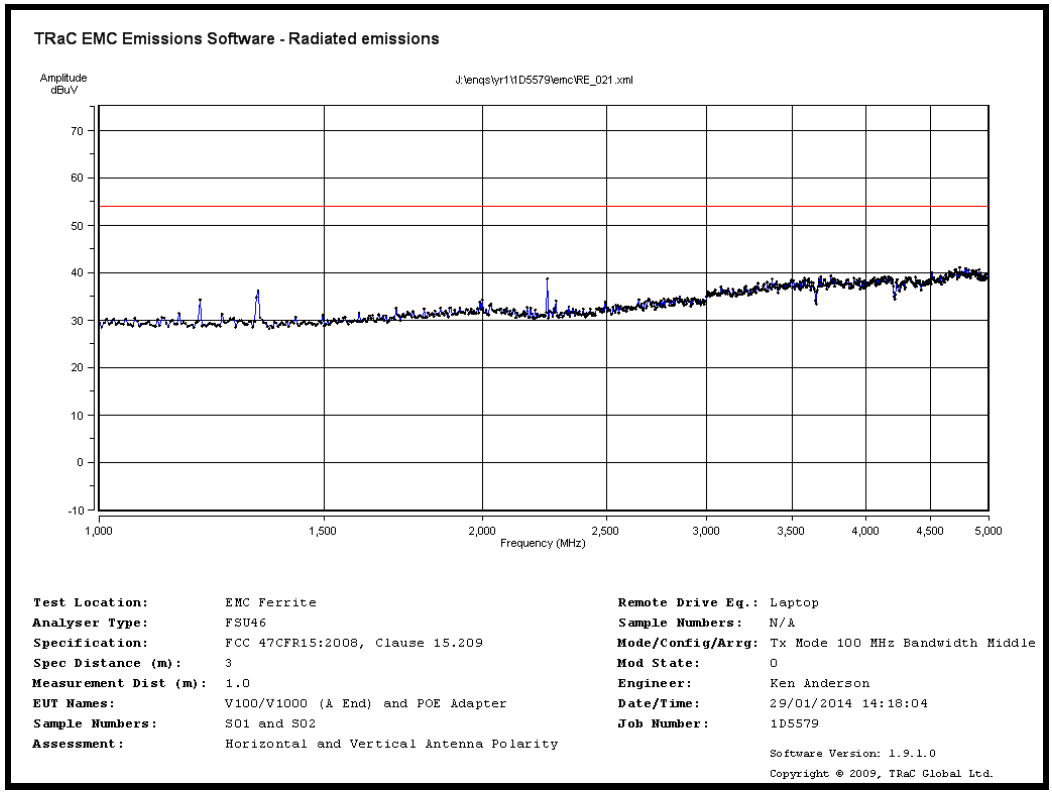
A end 26.5 GHz to 40 GHz– Bottom Channel



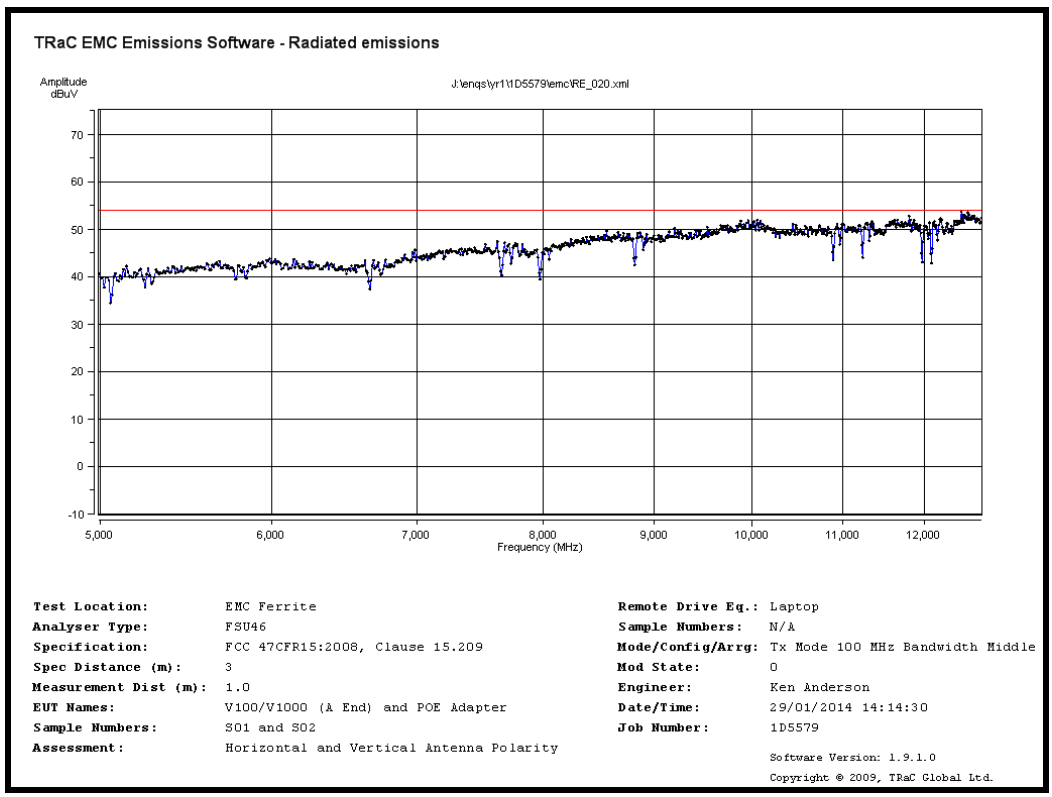
A end 30 MHz to 200 MHz – Middle Channel



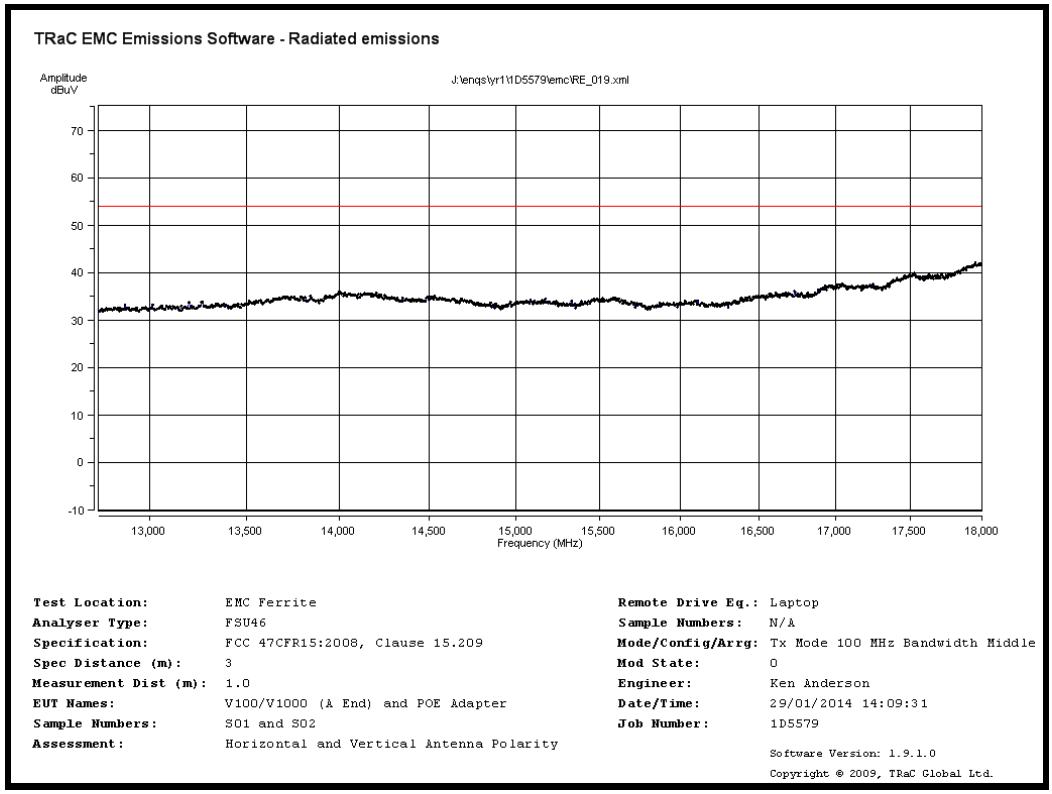
A end 200 MHz to 1GHz– Middle Channel



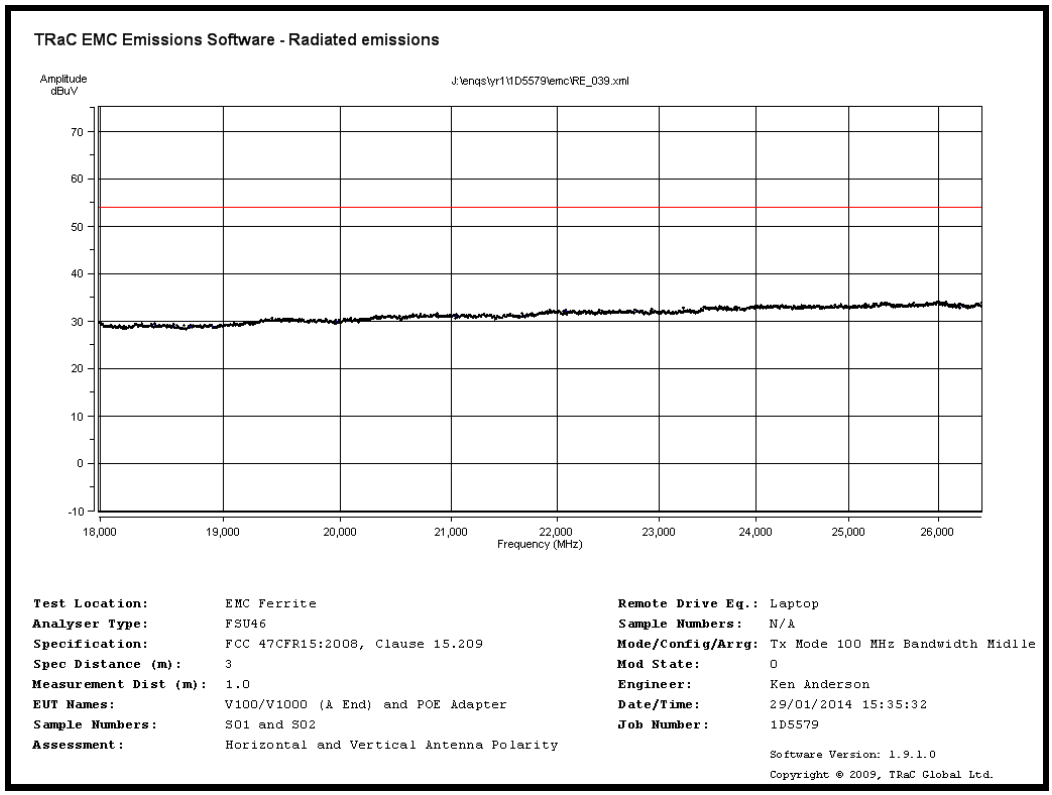
A end 1 GHz to 5 GHz– Middle Channel



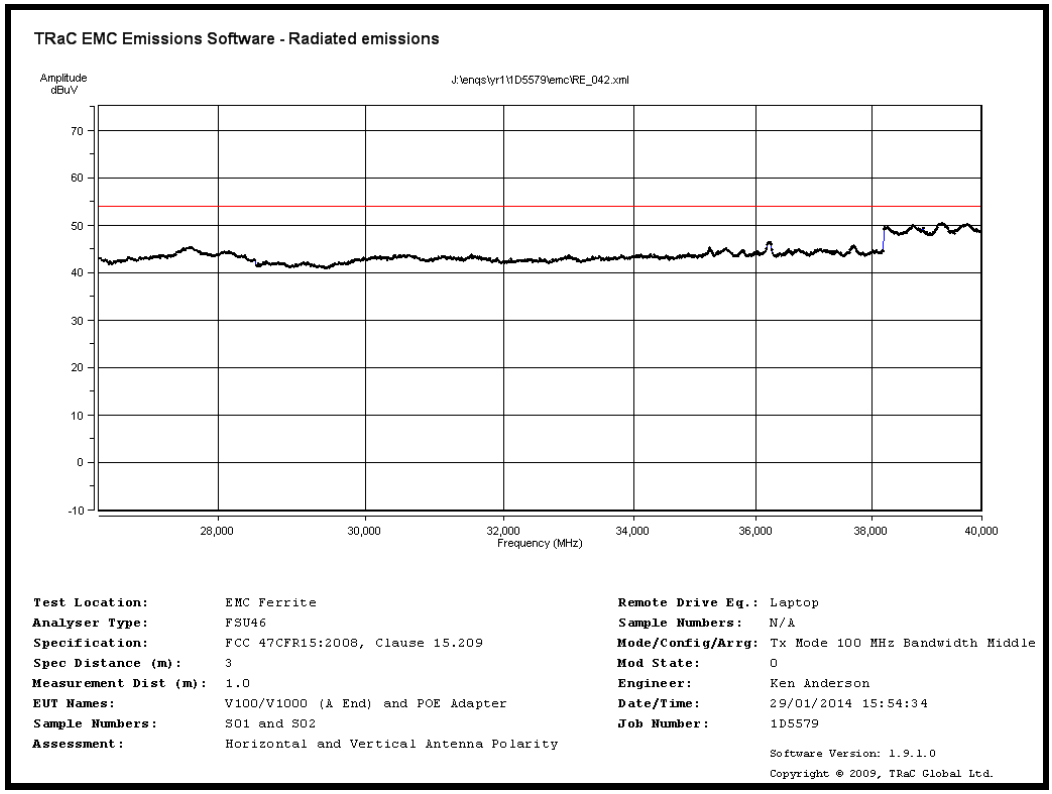
A end 5 GHz to 12.75 GHz– Middle Channel



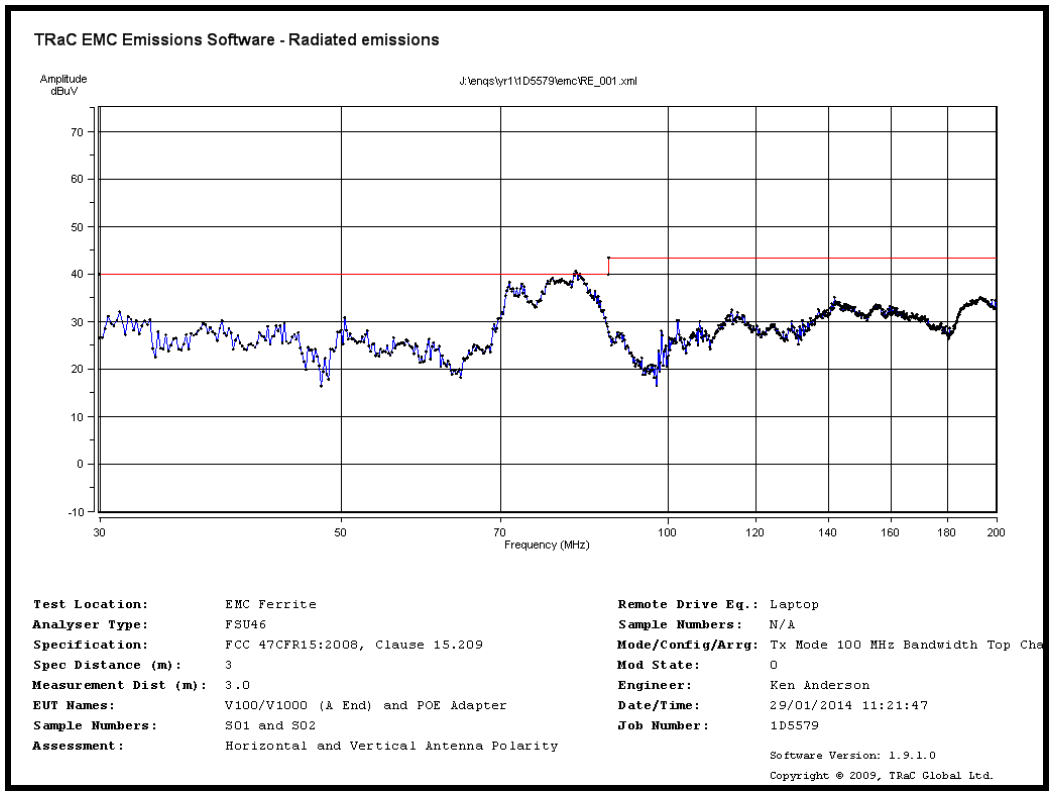
A end 12.75 GHz to 18 GHz– Middle Channel



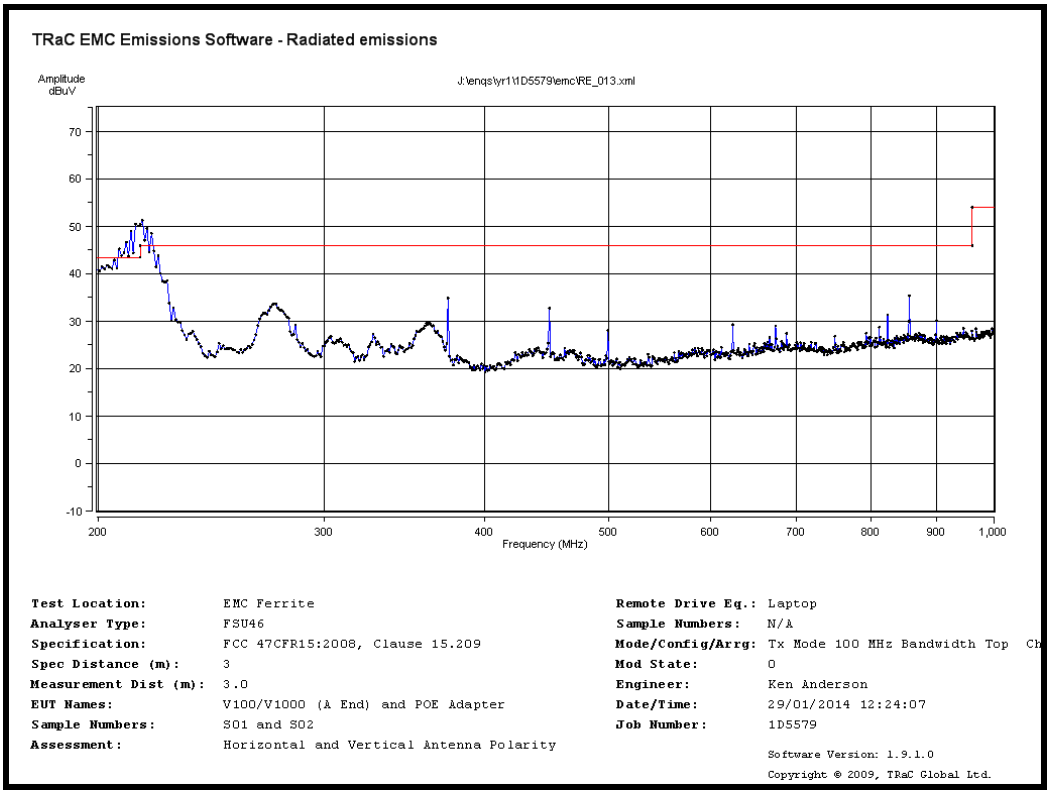
A end 18 GHz to 26.5 GHz– Middle Channel



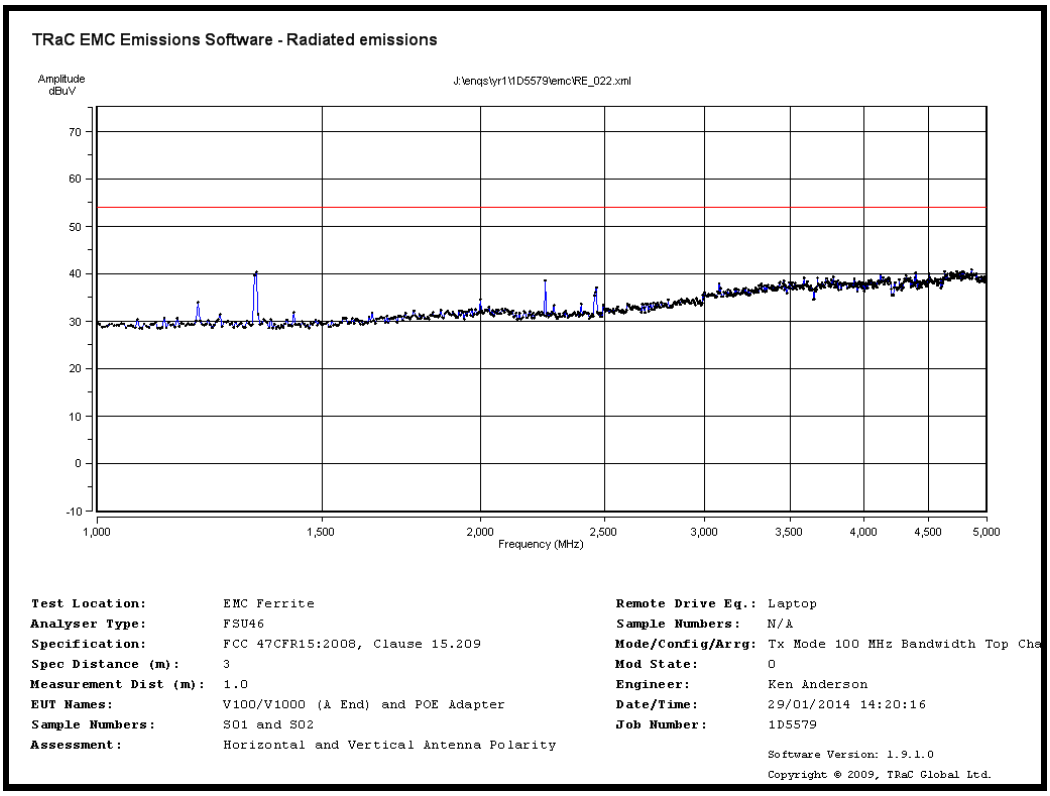
A end 26.5 GHz to 40 GHz– Middle Channel



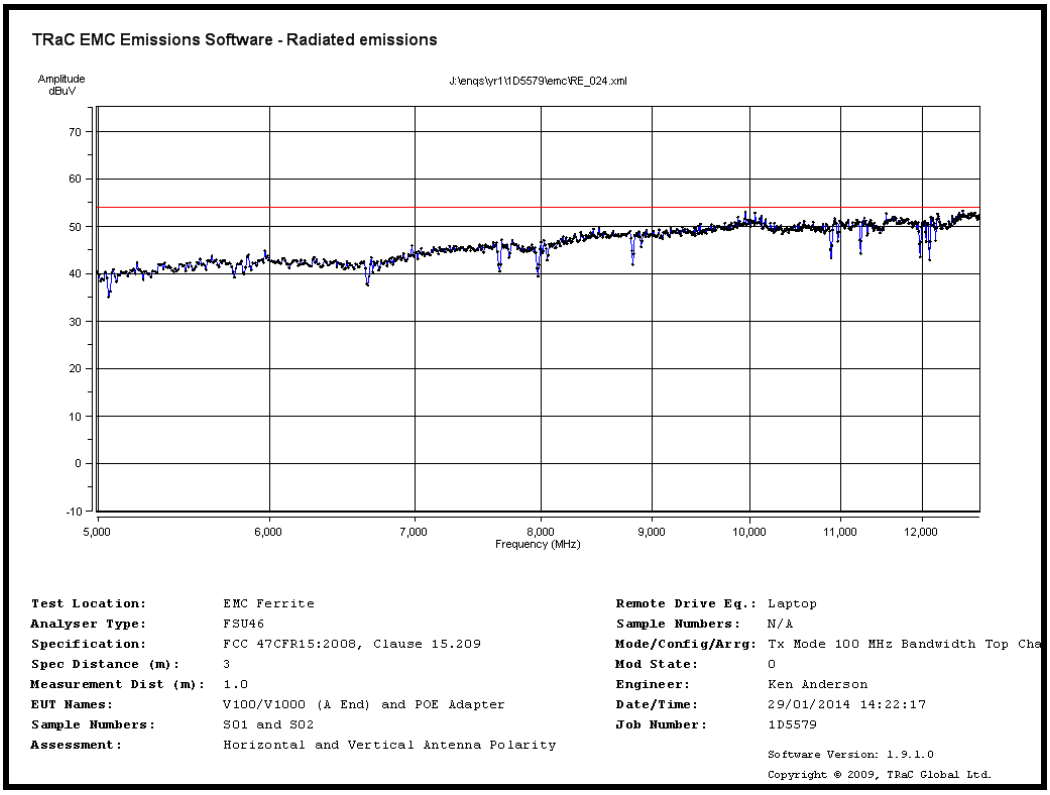
A end 30 MHz to 200 MHz – Top Channel



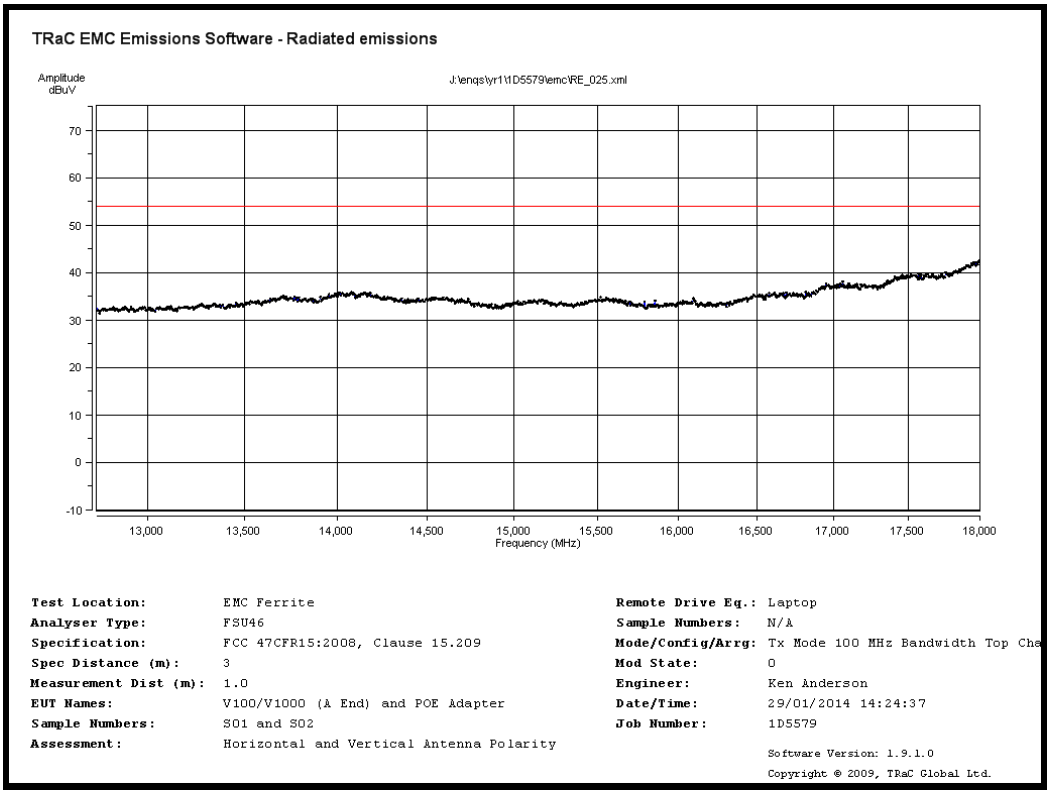
A end 200 MHz to 1GHz– Top Channel



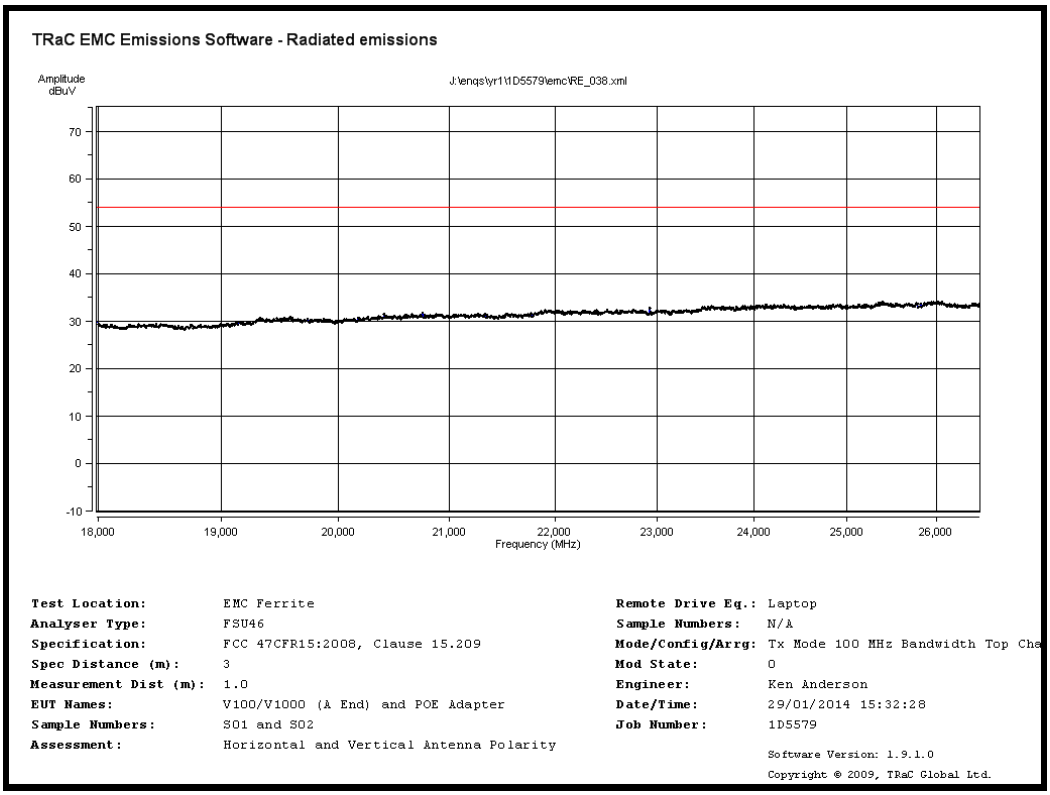
A end 1 GHz to 5 GHz– Top Channel



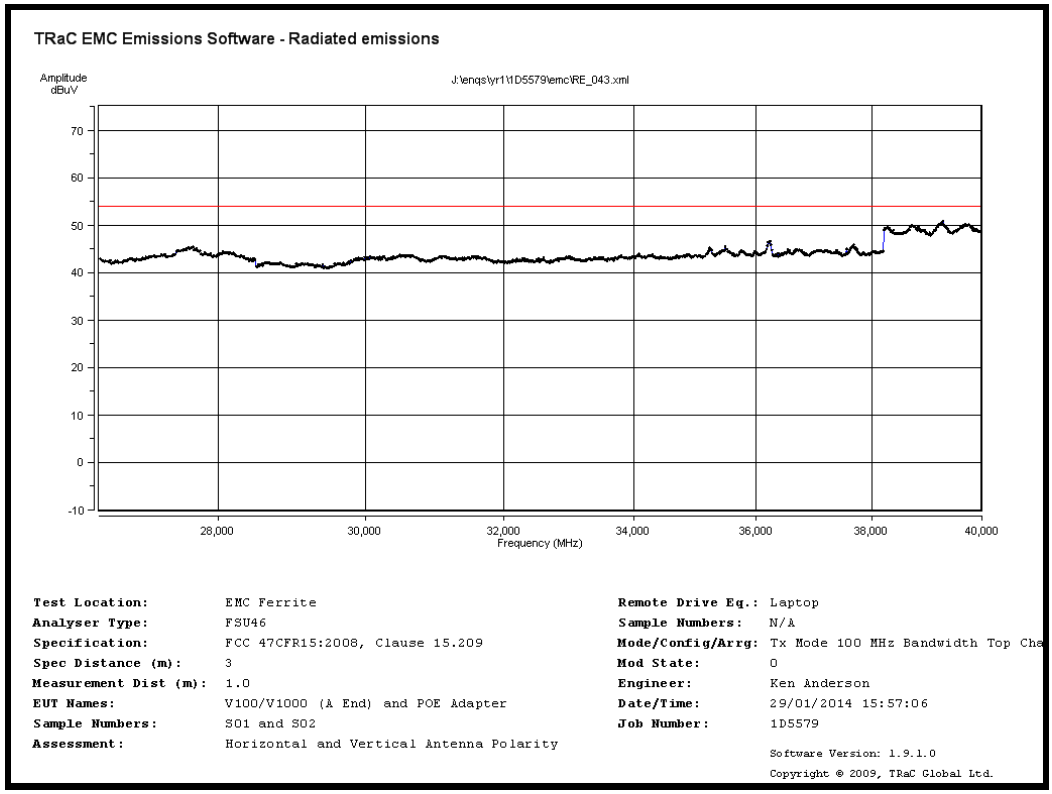
A end 5 GHz to 12.75 GHz– Top Channel



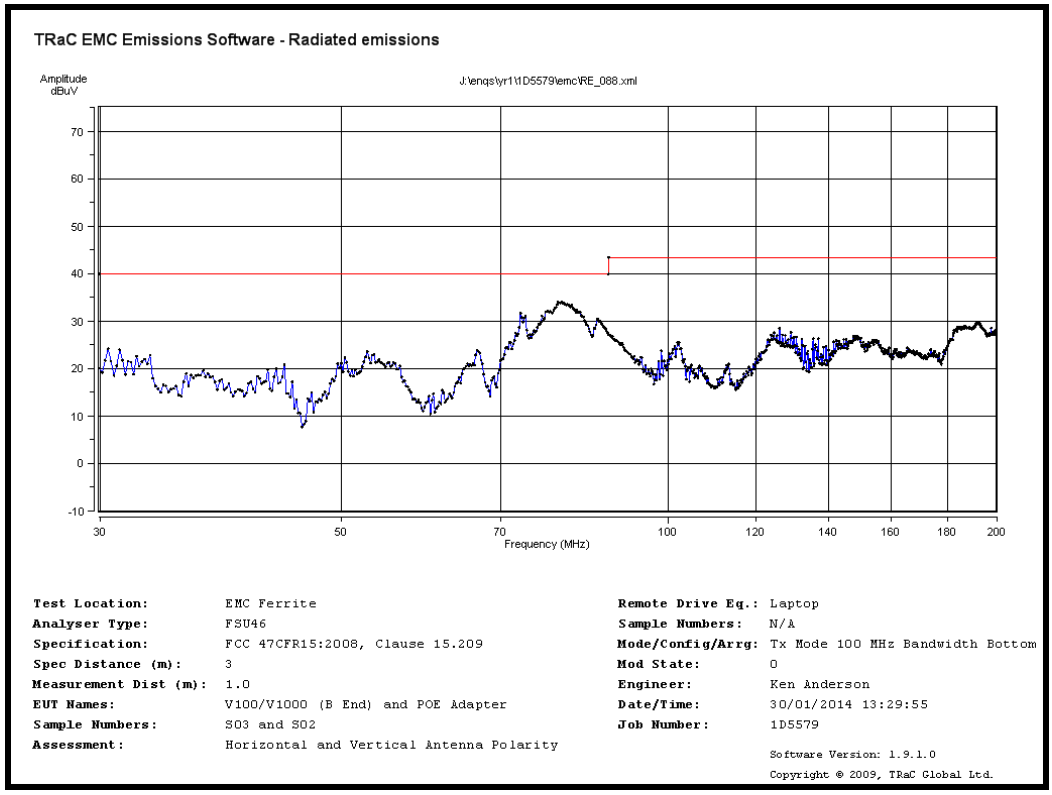
A end 12.75 GHz to 18 GHz– Top Channel



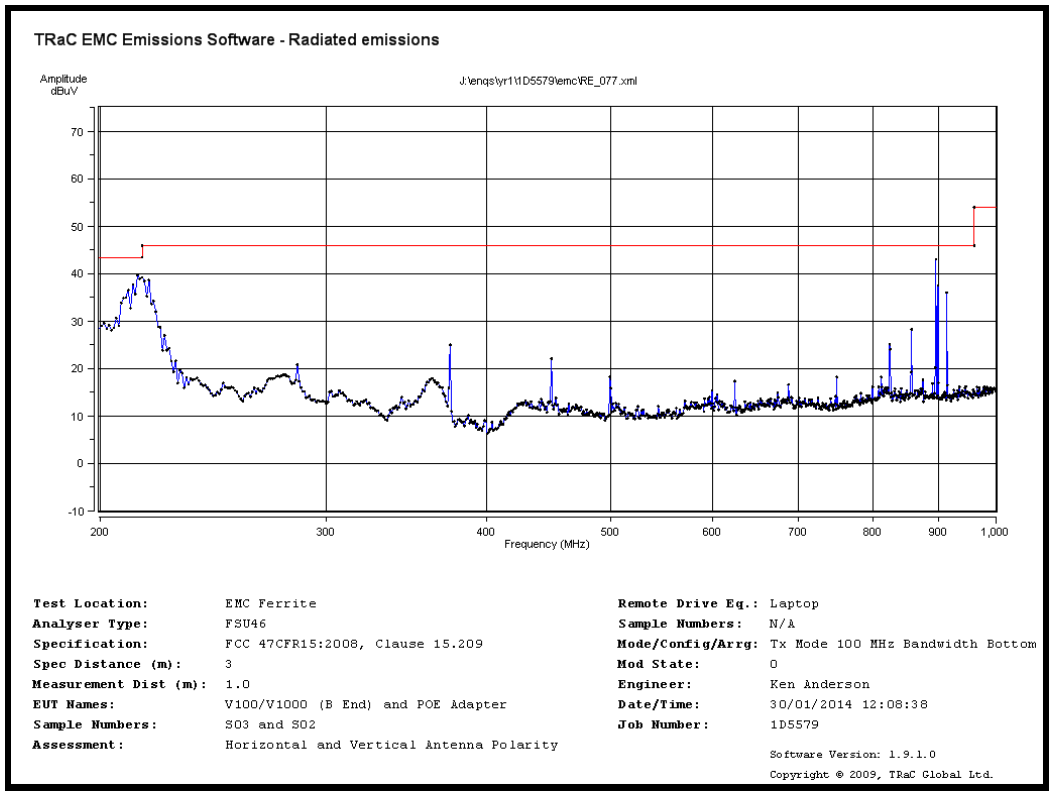
A end 18 GHz to 26.5 GHz– Top Channel



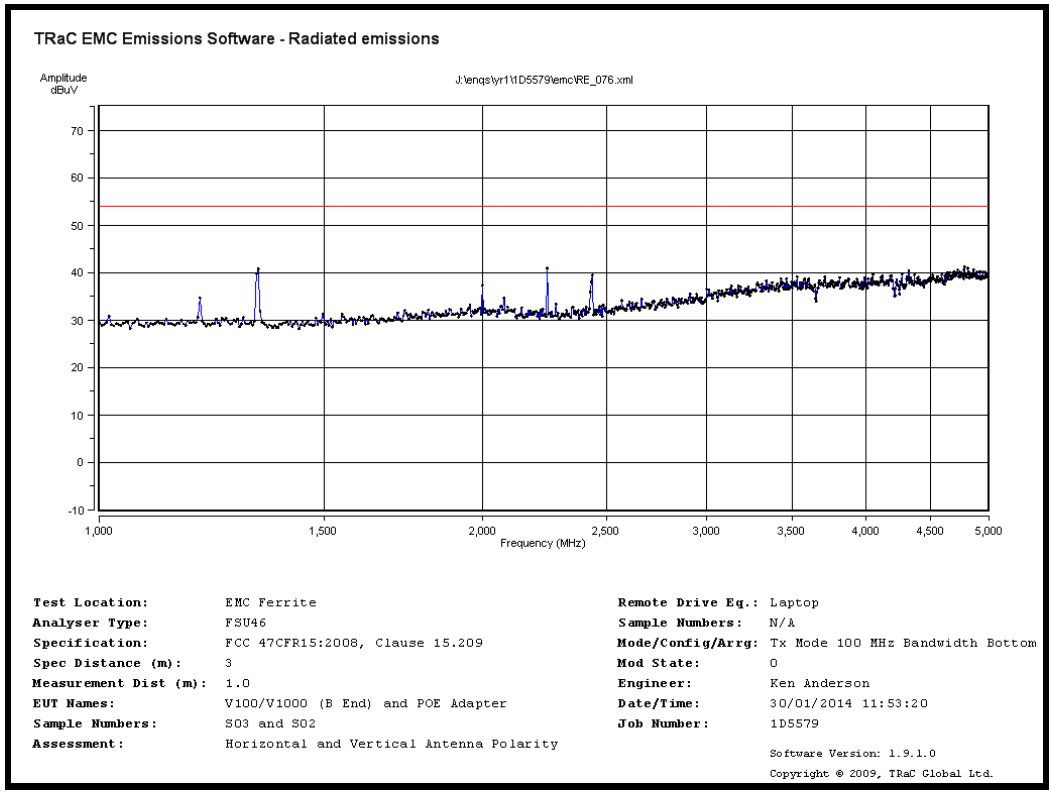
A end 26.5 GHz to 40 GHz– Top Channel



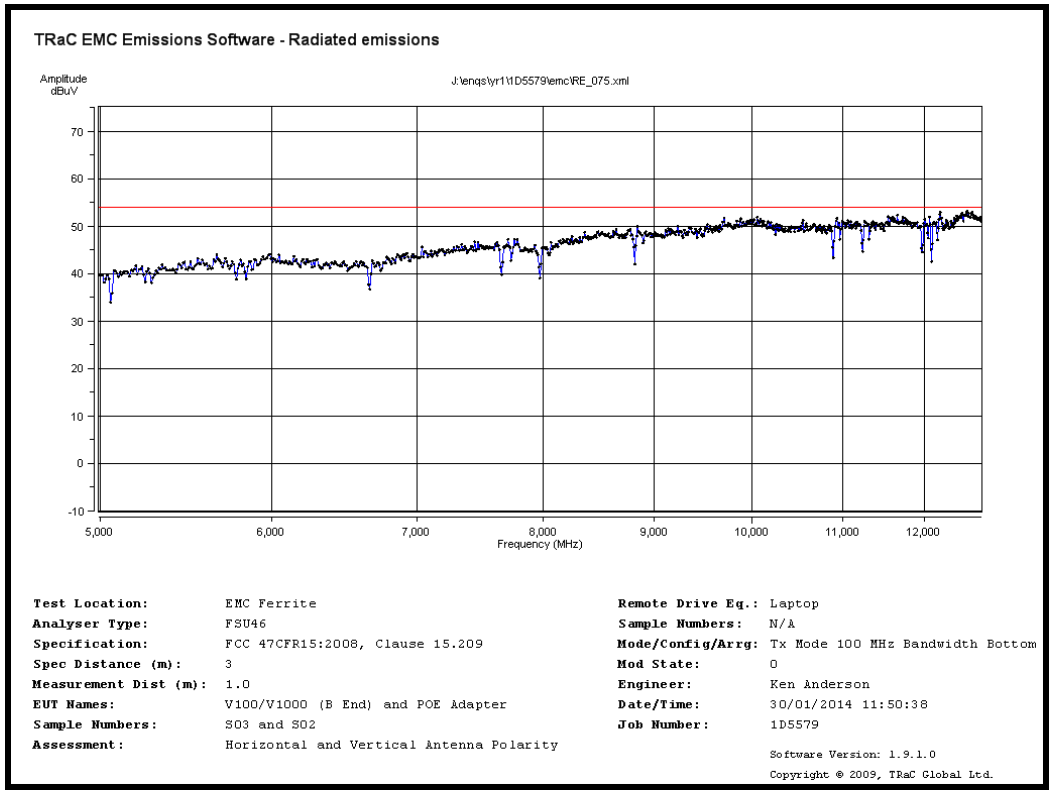
B end 30 MHz to 200 MHz – Bottom Channel



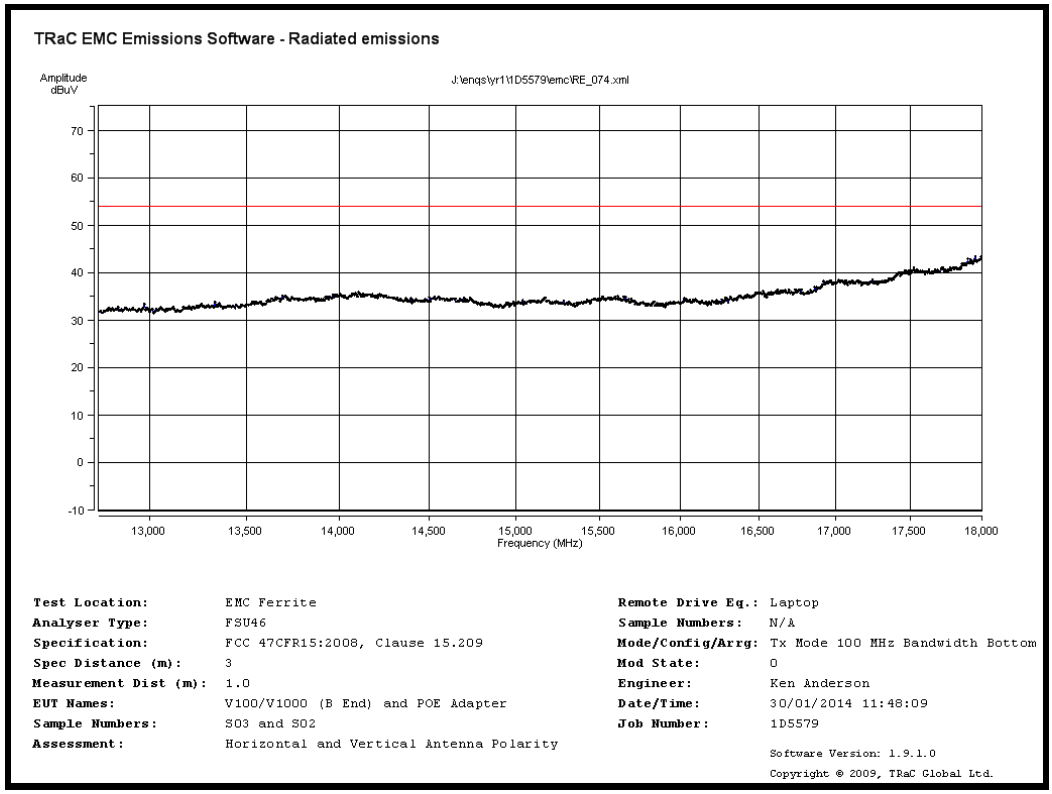
B end 200 MHz to 1GHz– Bottom Channel



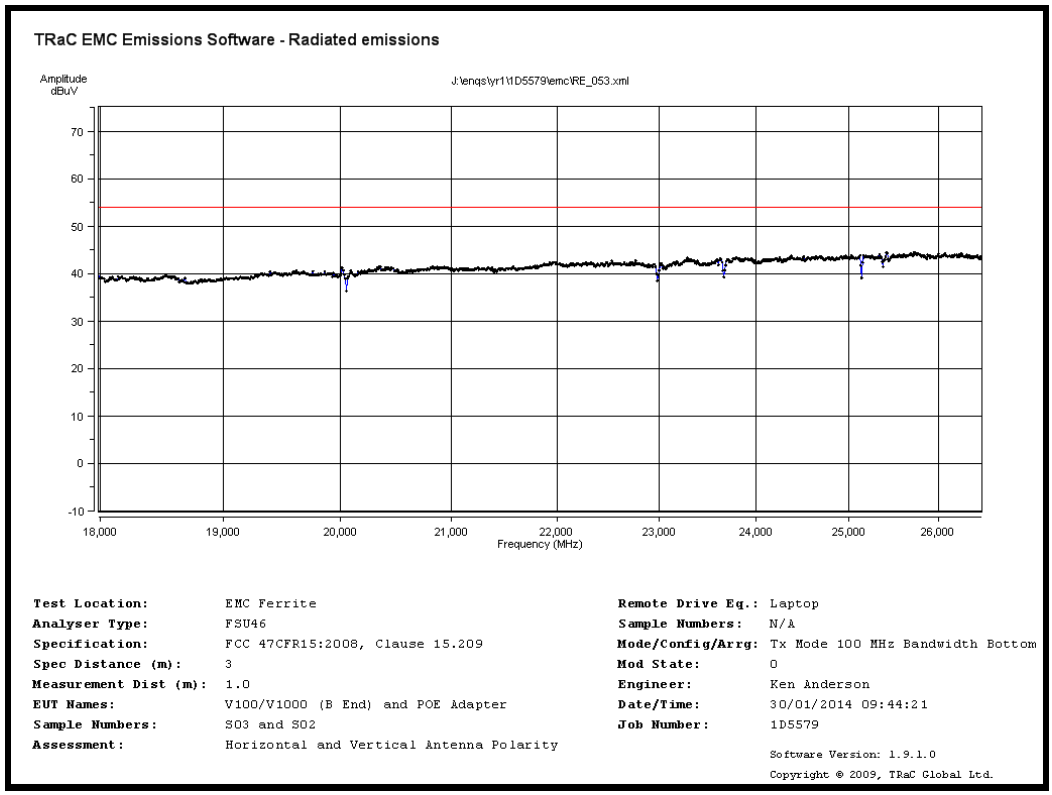
B end 1 GHz to 5 GHz– Bottom Channel



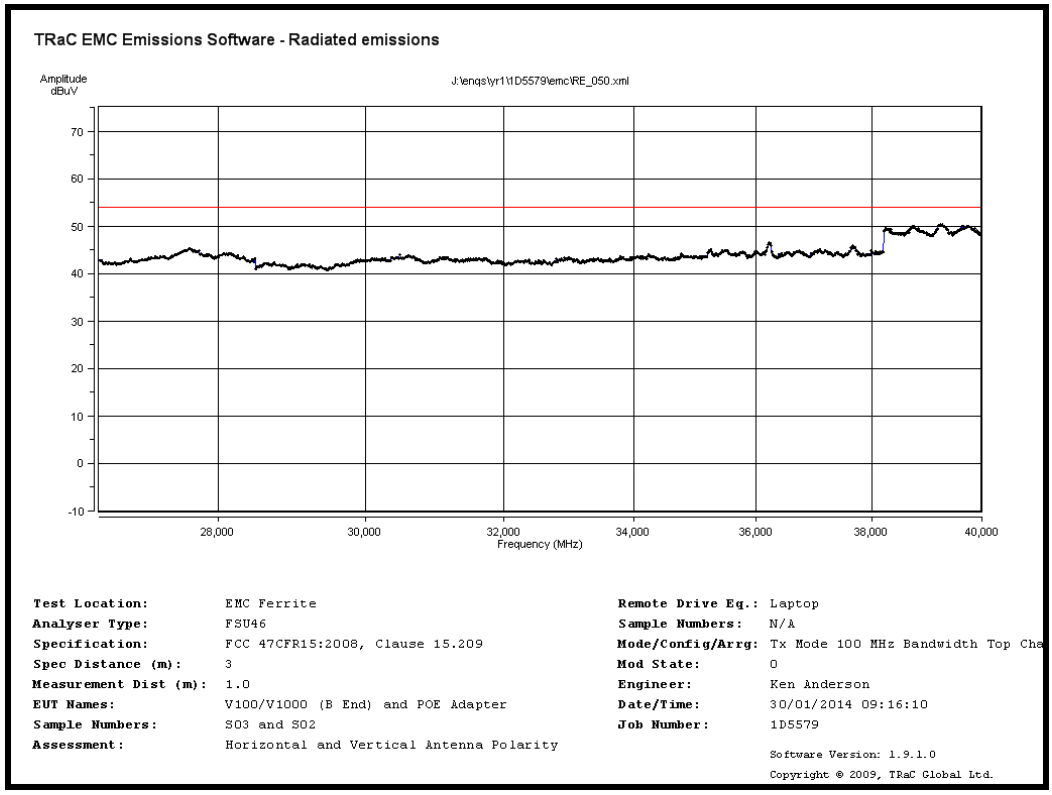
B end 5 GHz to 12.75 GHz– Bottom Channel



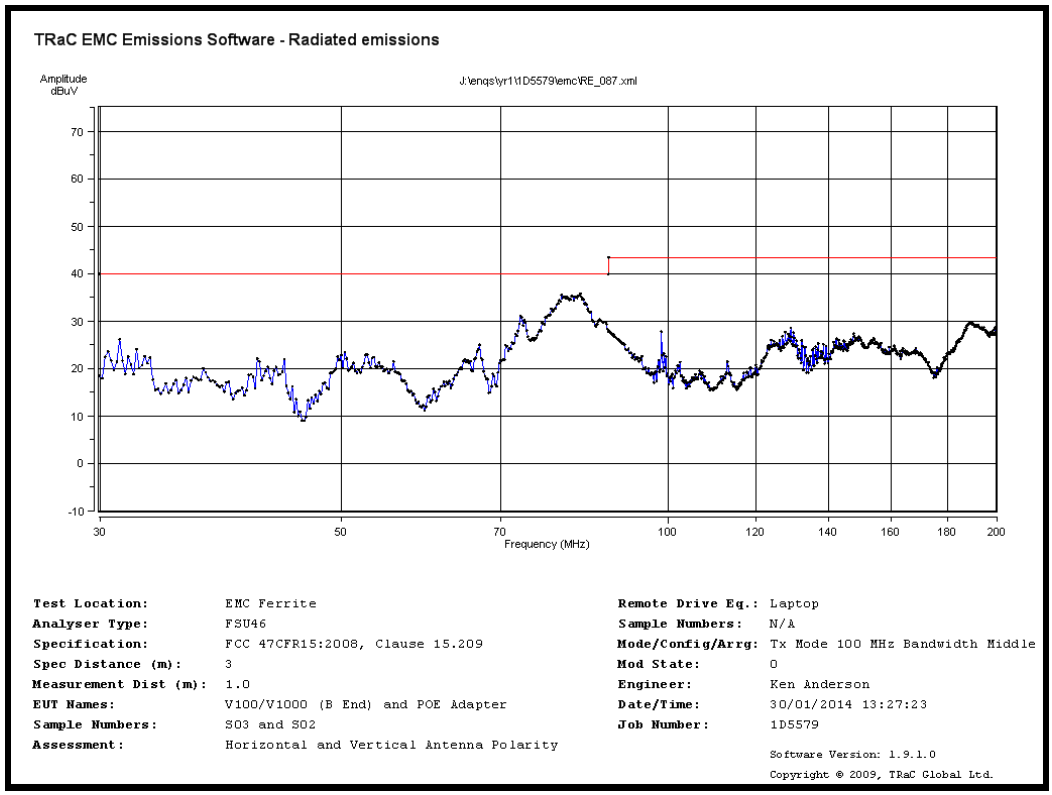
B end 12.75 GHz to 18 GHz– Bottom Channel



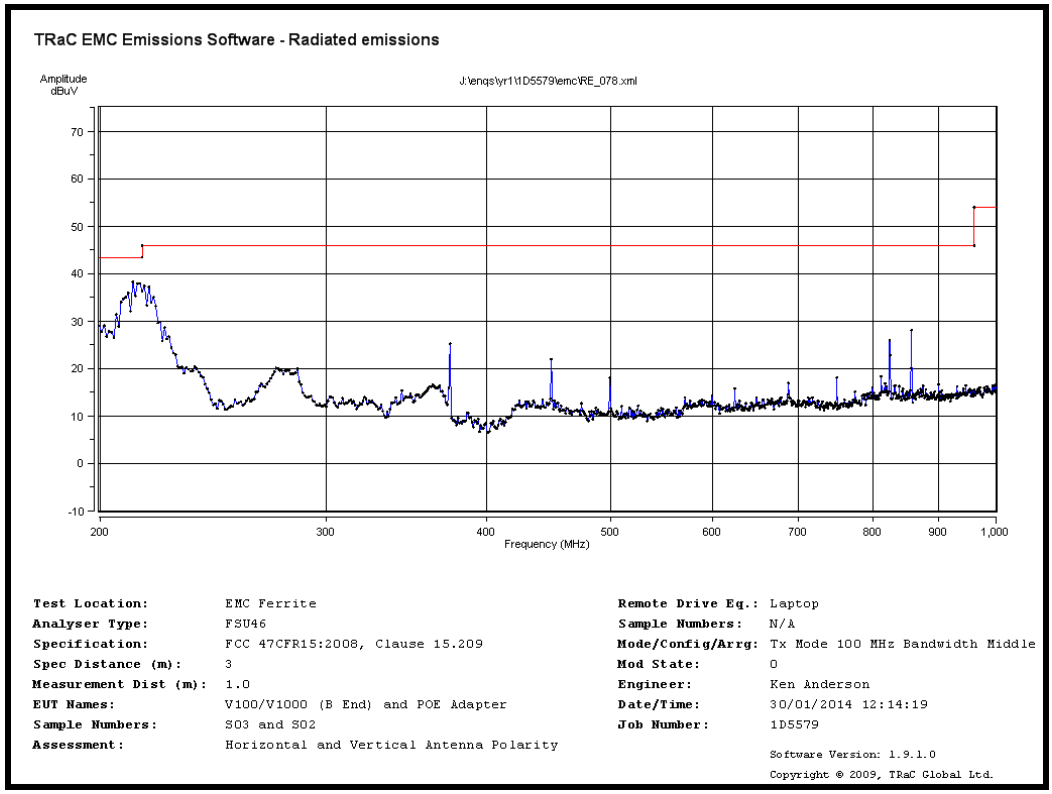
B end 18 GHz to 26.5 GHz– Bottom Channel



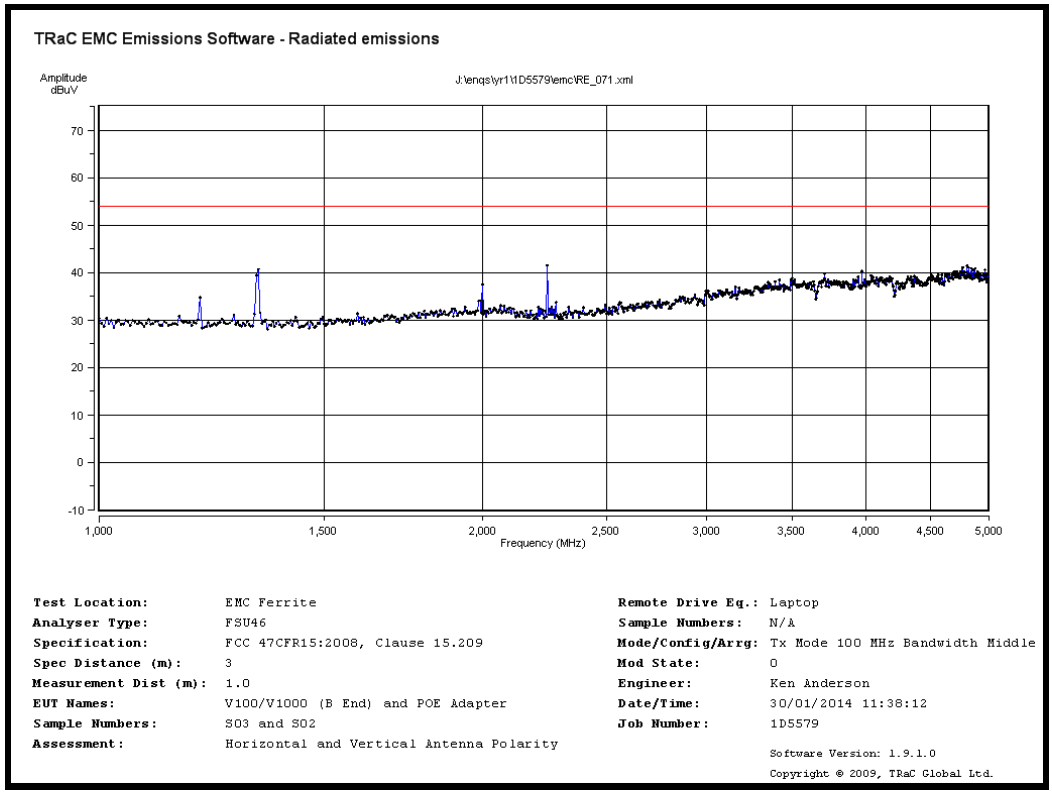
B end 26.5 GHz to 40 GHz– Bottom Channel



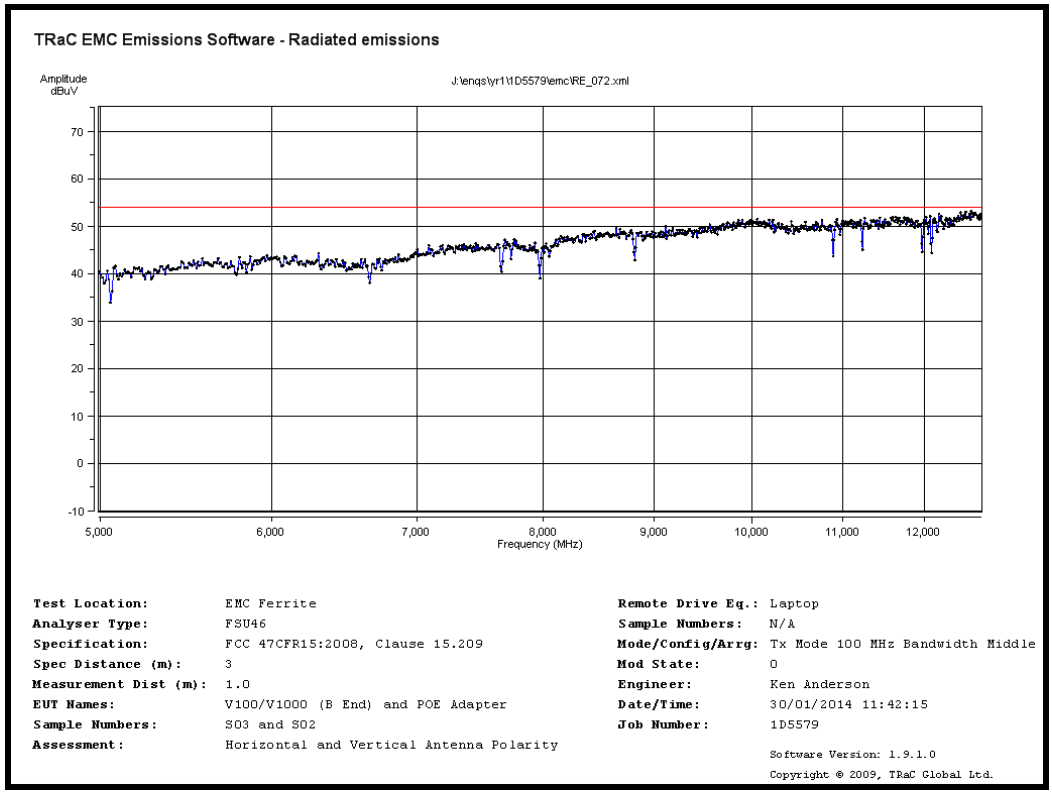
B end 30 MHz to 200 MHz – Middle Channel



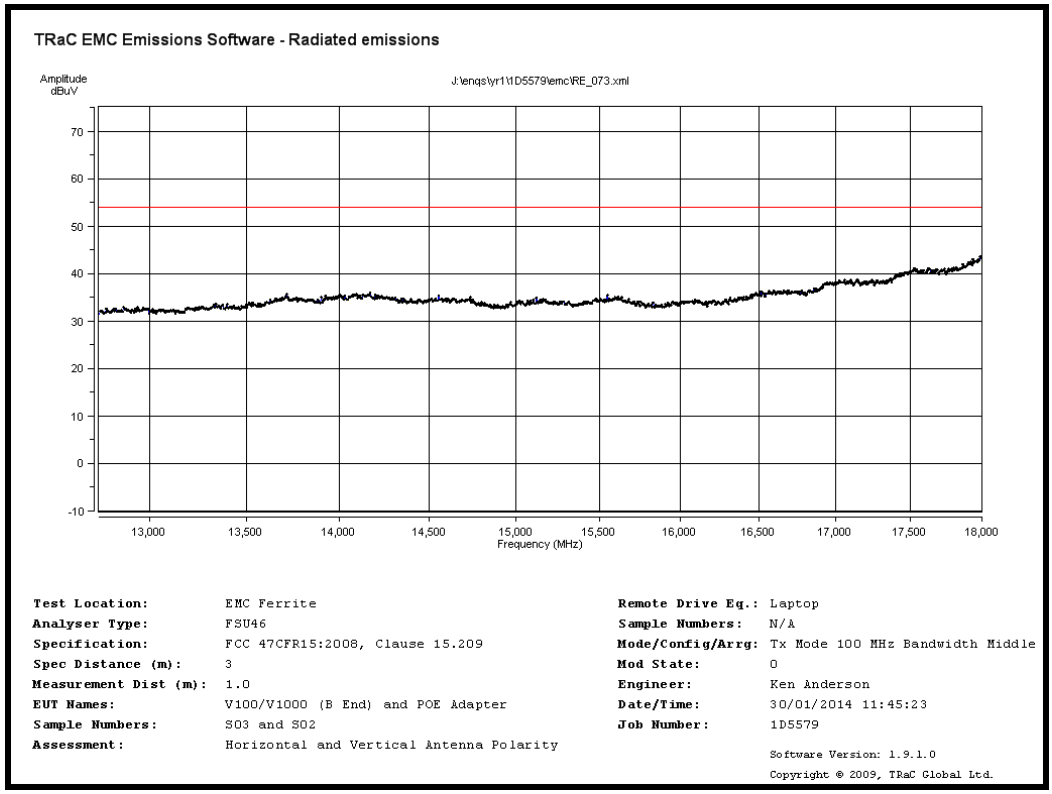
B end 200 MHz to 1GHz– Middle Channel



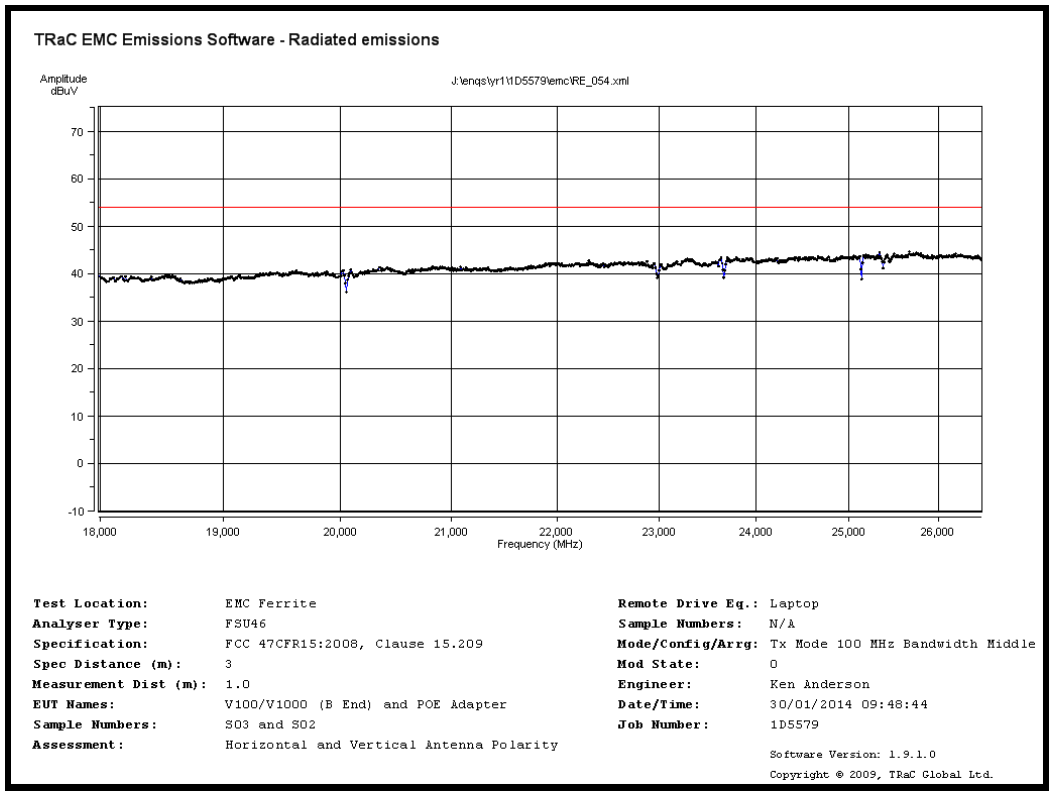
B end 1 GHz to 5 GHz– Middle Channel



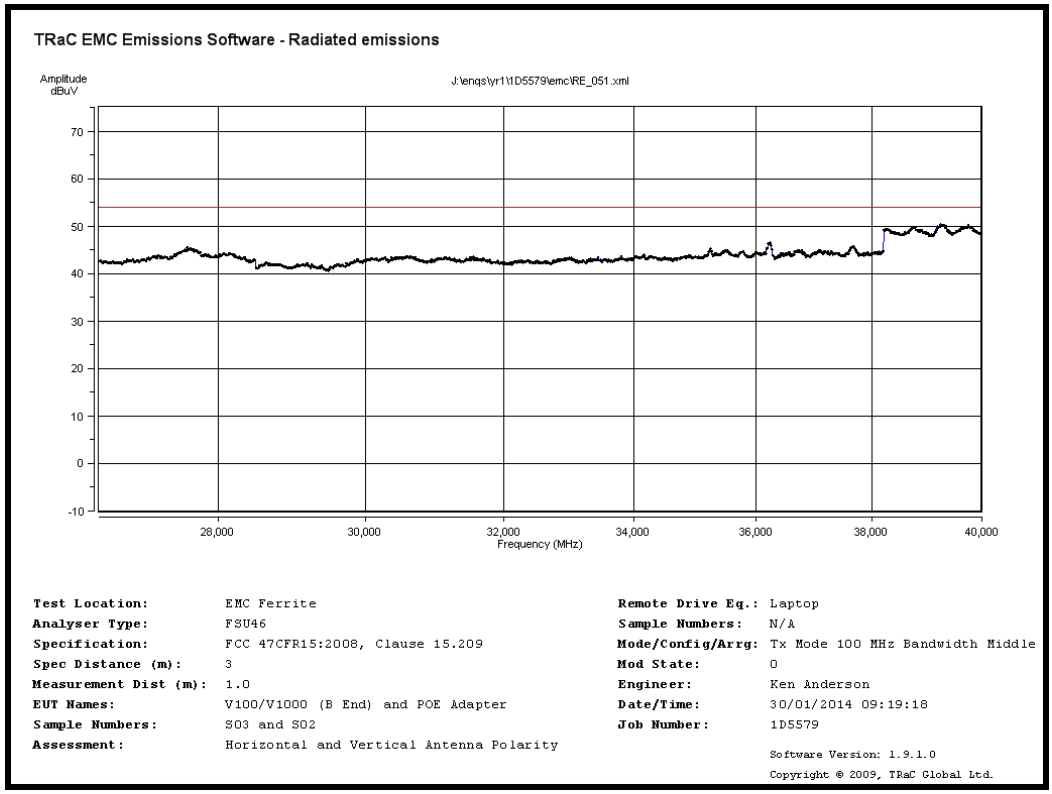
B end 5 GHz to 12.75 GHz– Middle Channel



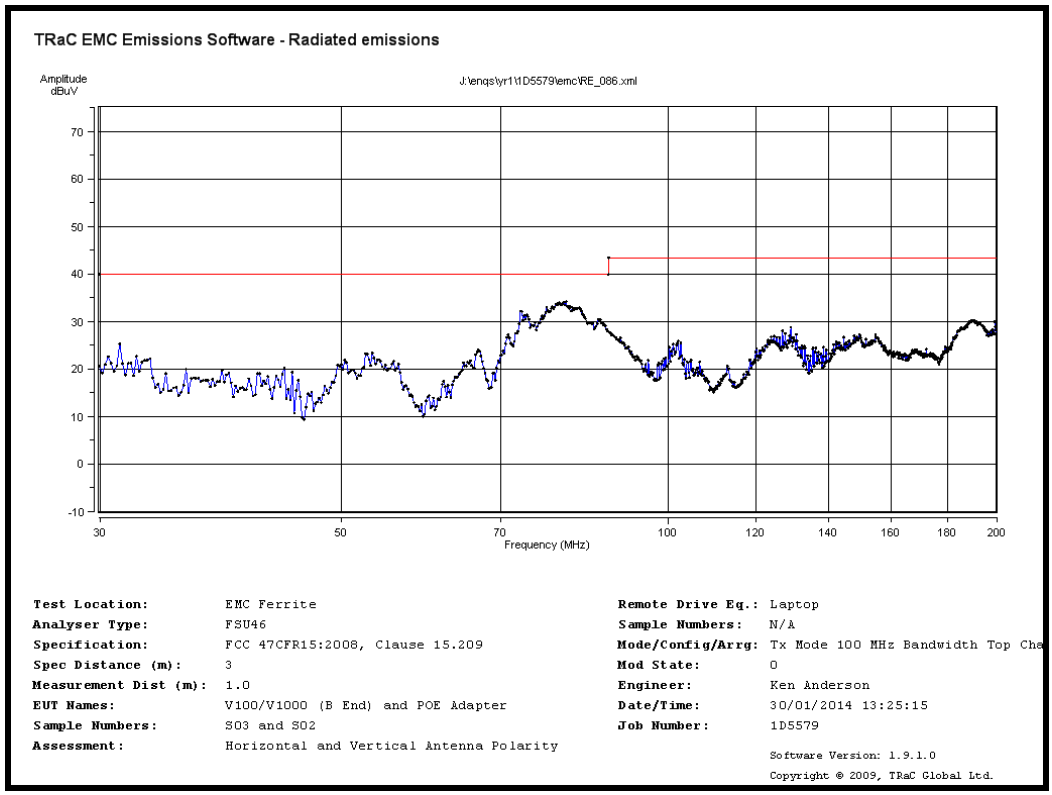
B end 12.75 GHz to 18 GHz– Middle Channel



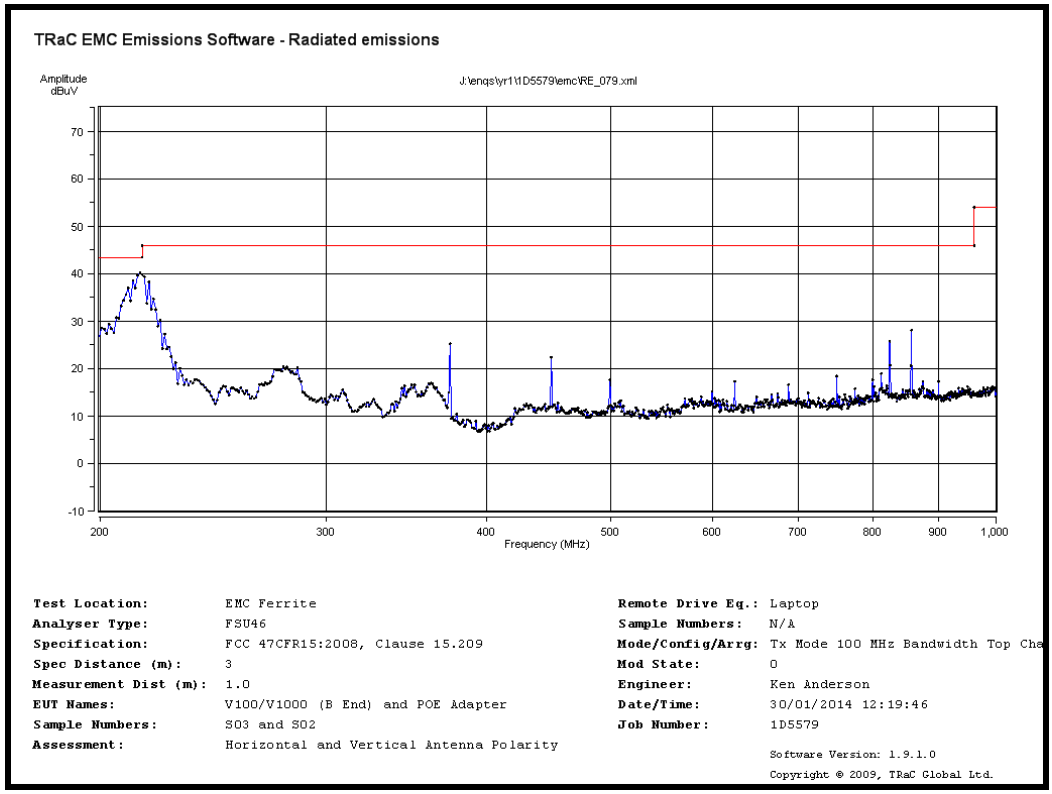
B end 18 GHz to 26.5 GHz– Middle Channel



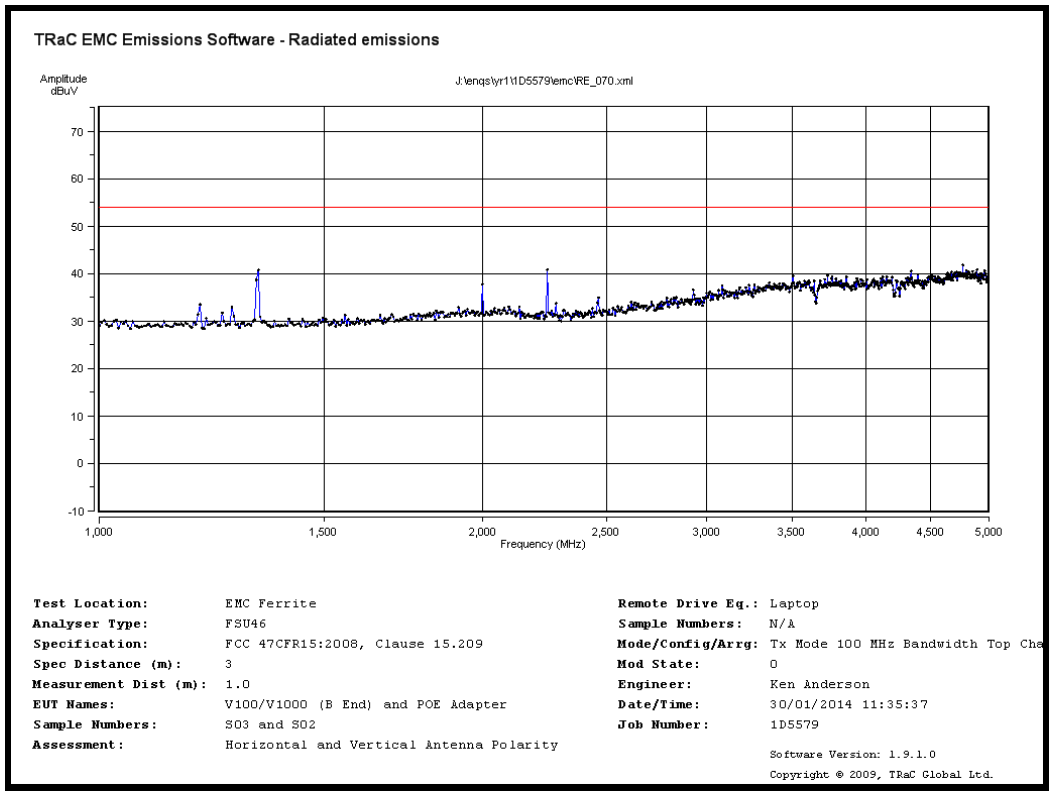
B end 26.5 GHz to 40 GHz– Middle Channel



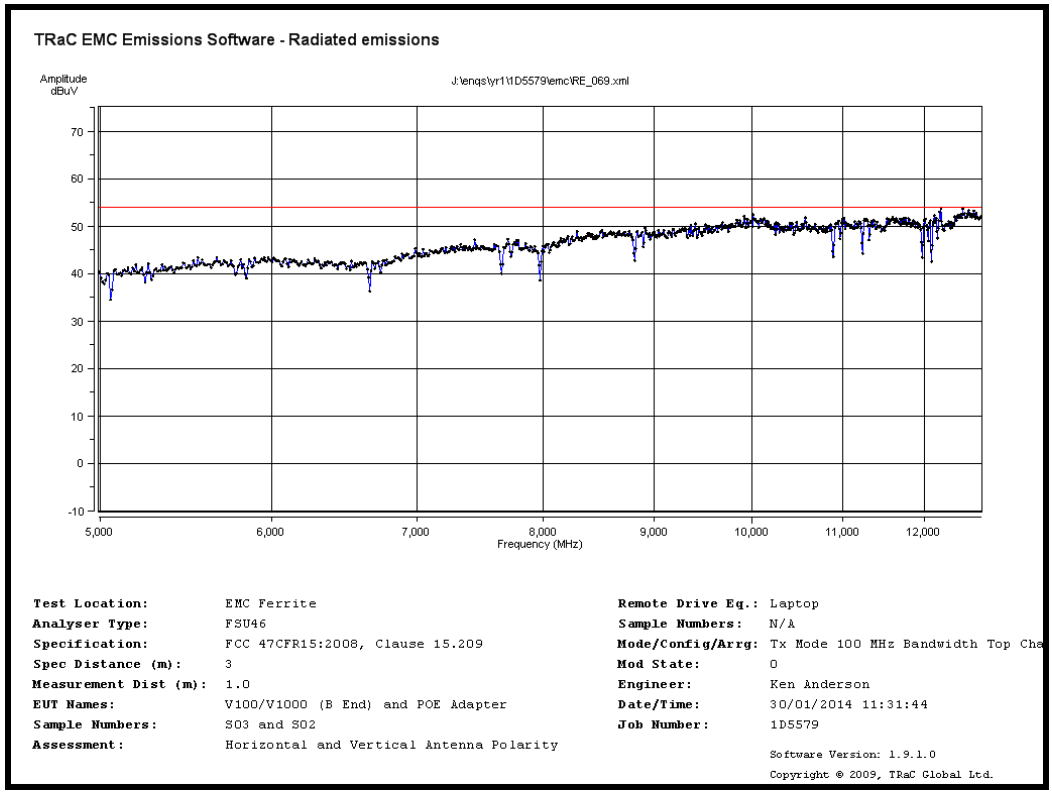
B end 30 MHz to 200 MHz – Top Channel



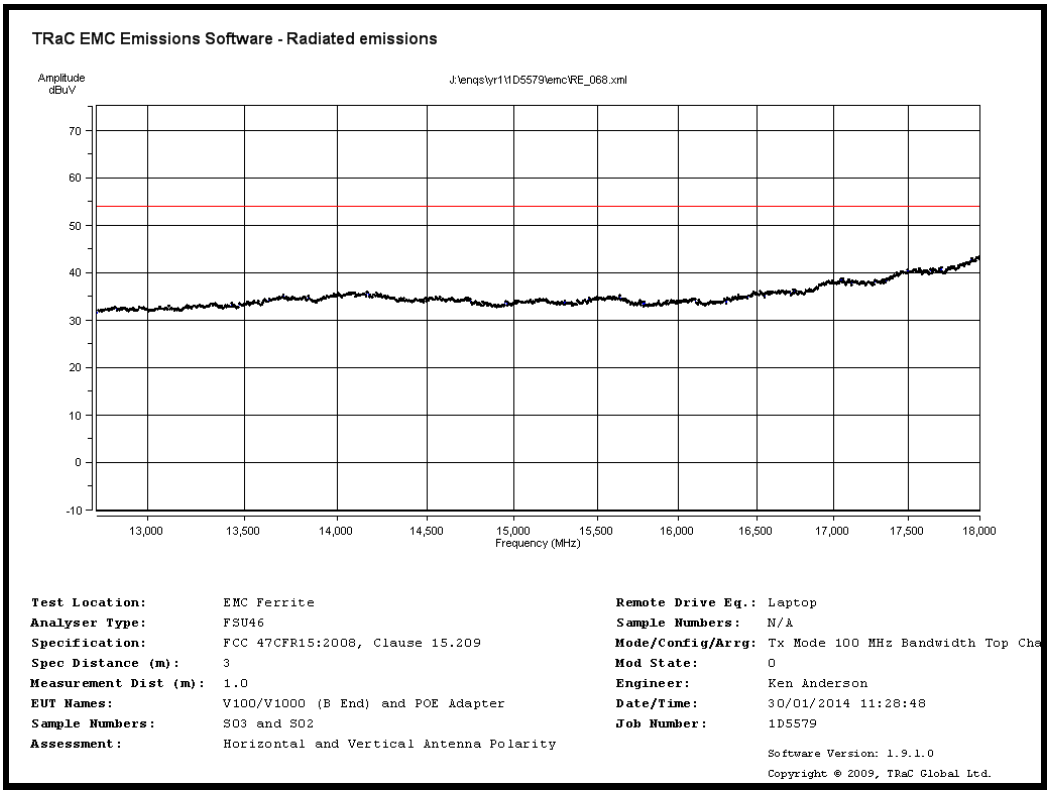
B end 200 MHz to 1GHz– Top Channel



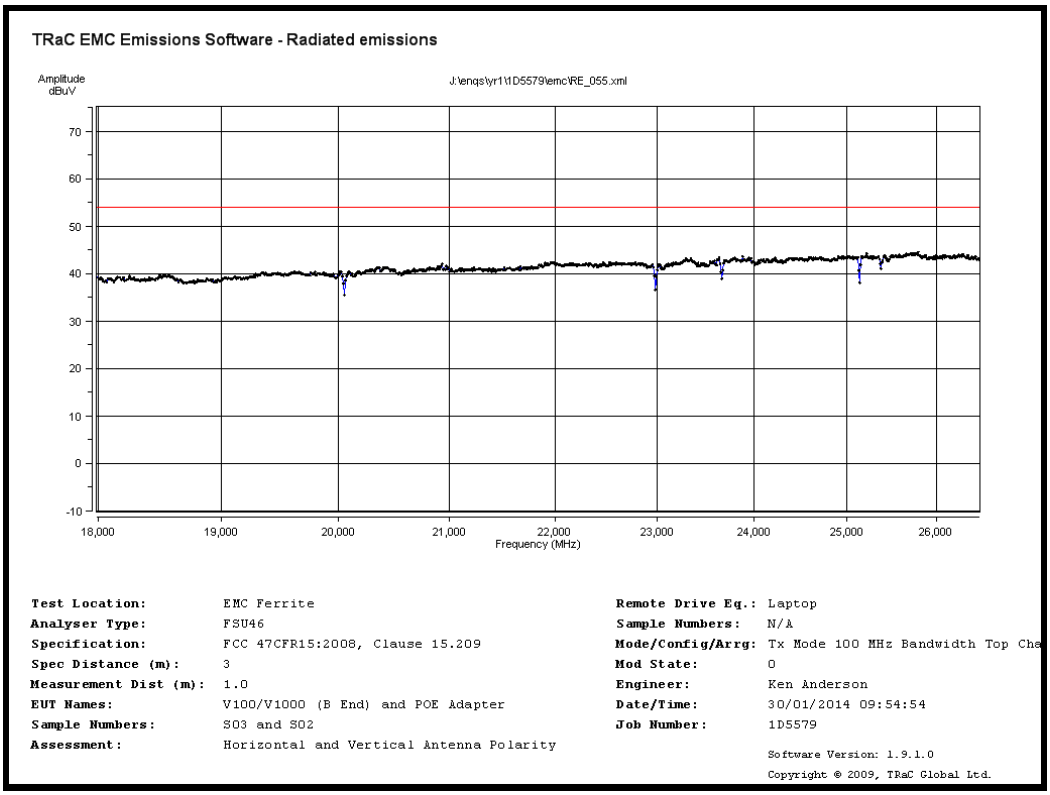
B end 1 GHz to 5 GHz– Top Channel



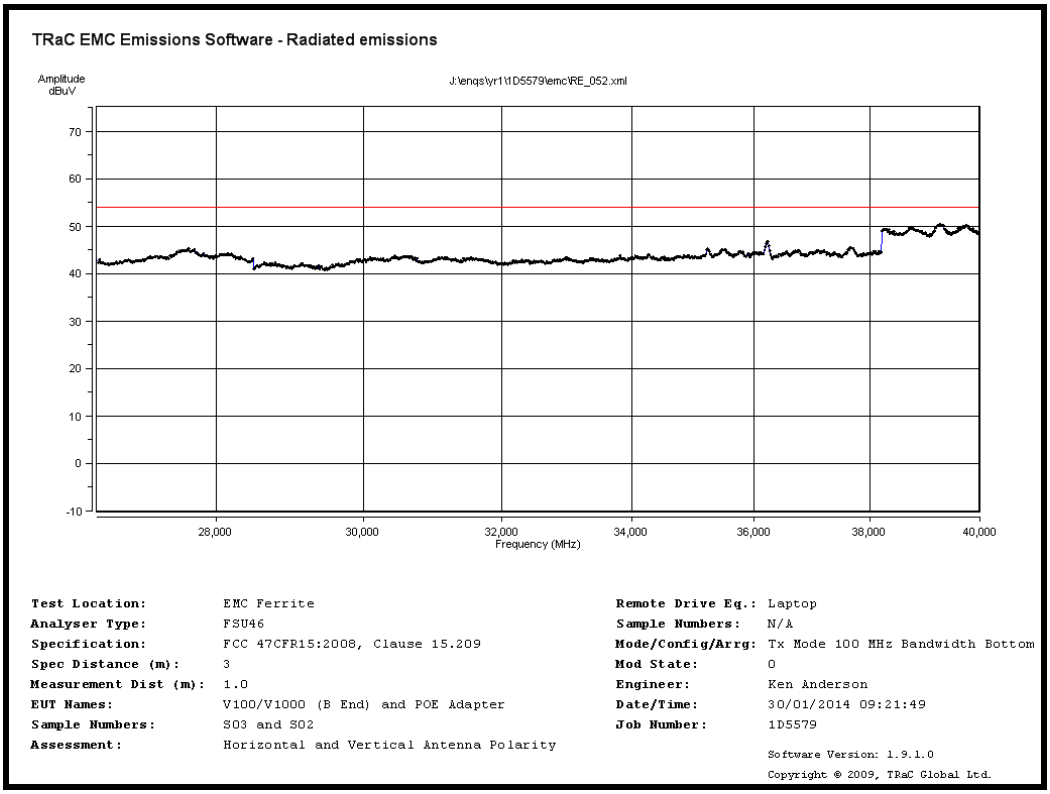
B end 5 GHz to 12.75 GHz– Top Channel



B end 12.75 GHz to 18 GHz– Top Channel

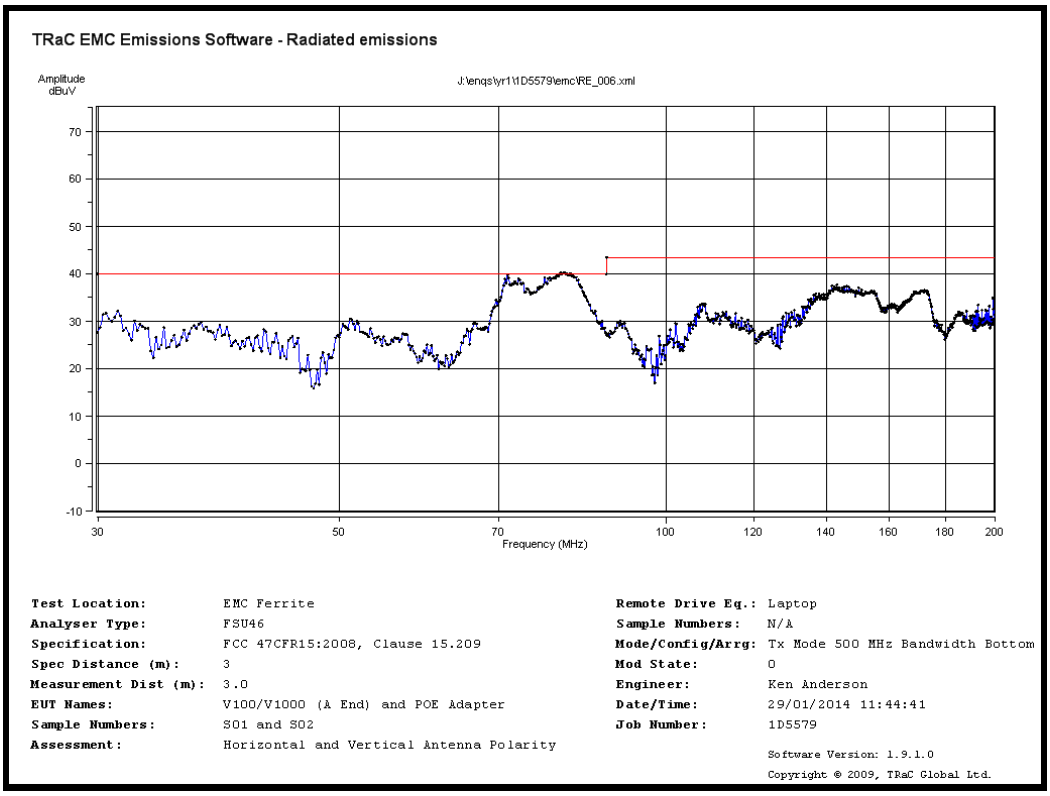


B end 18 GHz to 26.5 GHz– Top Channel

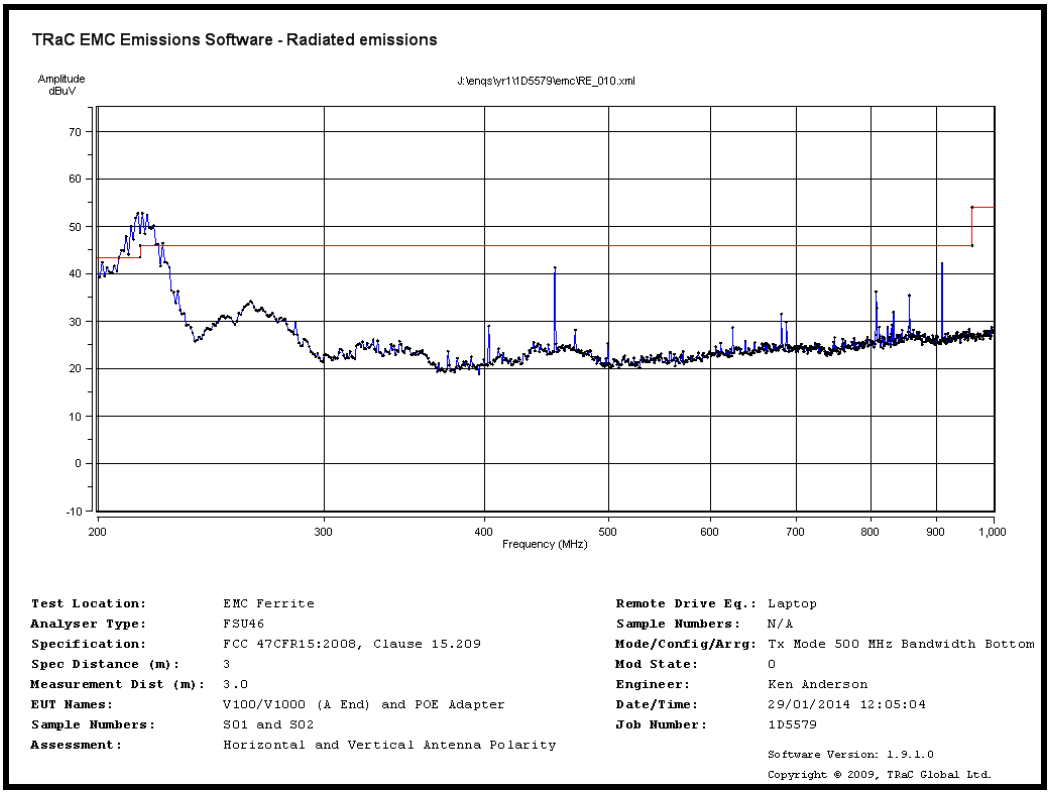


B end 26.5 GHz to 40 GHz– Top Channel

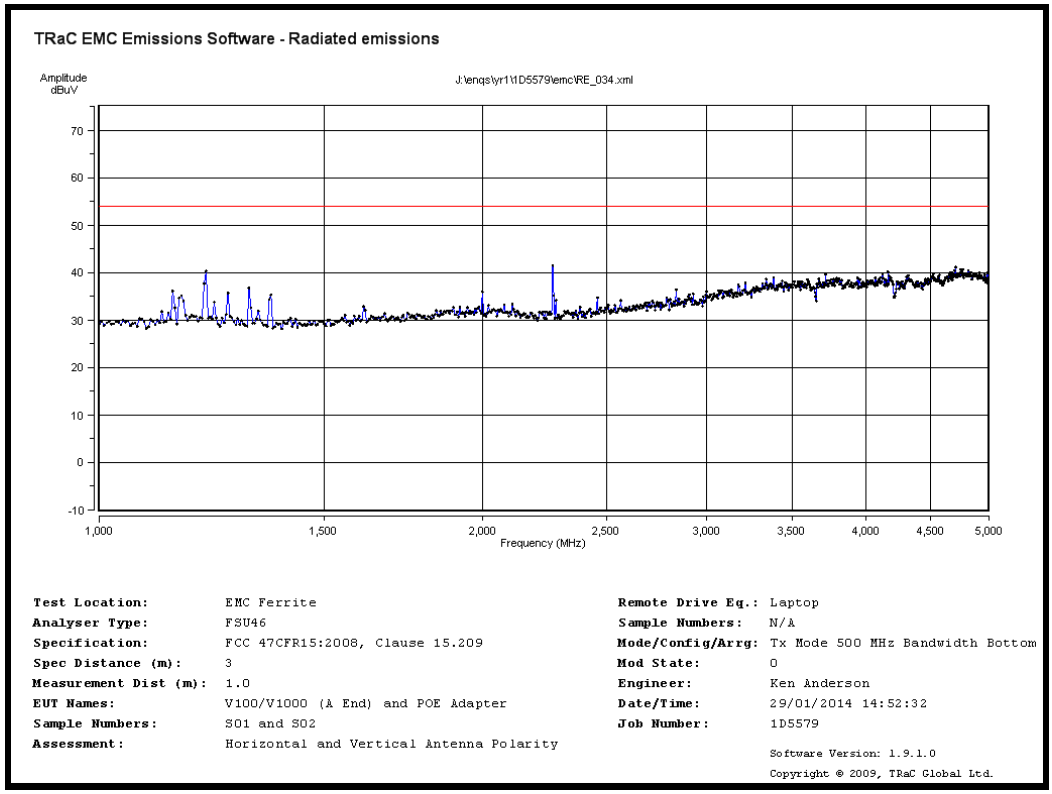
B2.2 V1000 Mode



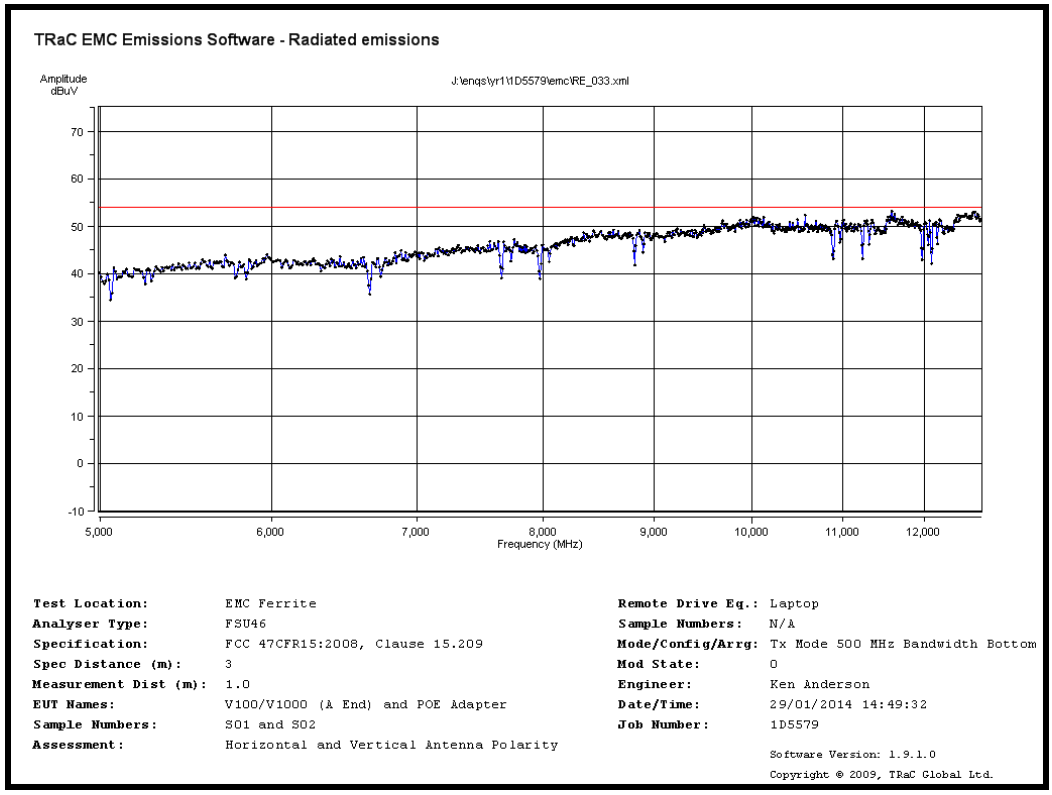
A end 30 MHz to 200 MHz – Bottom Channel



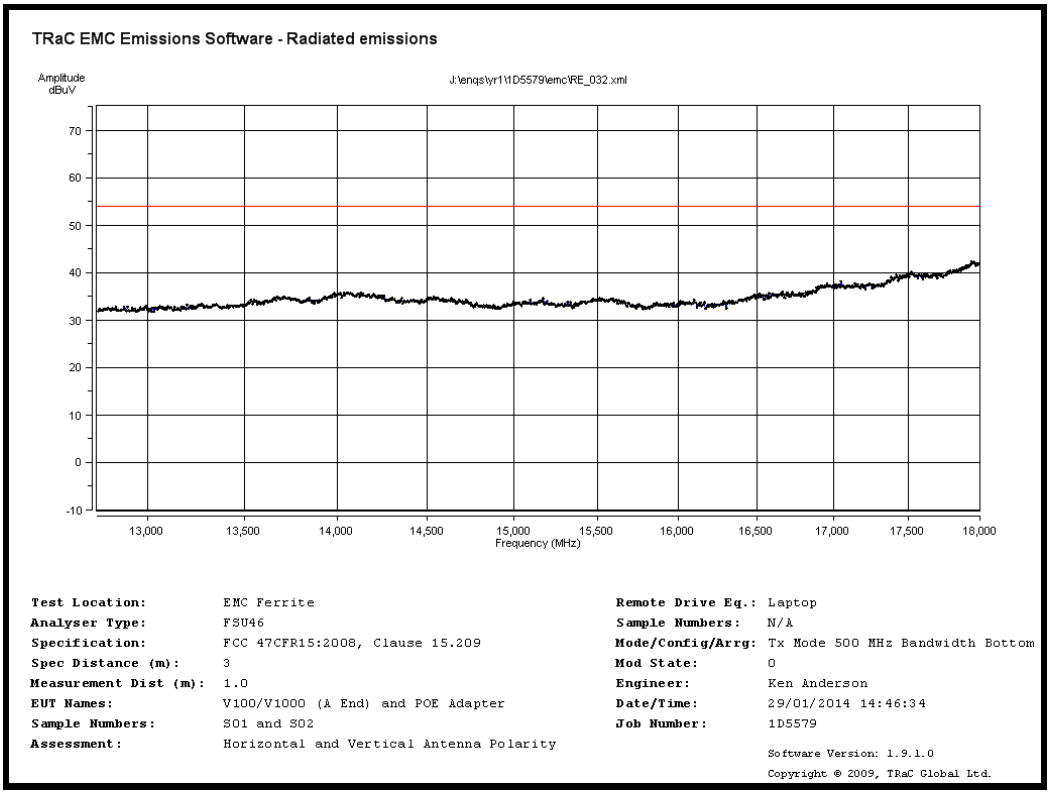
A end 200 MHz to 1GHz– Bottom Channel



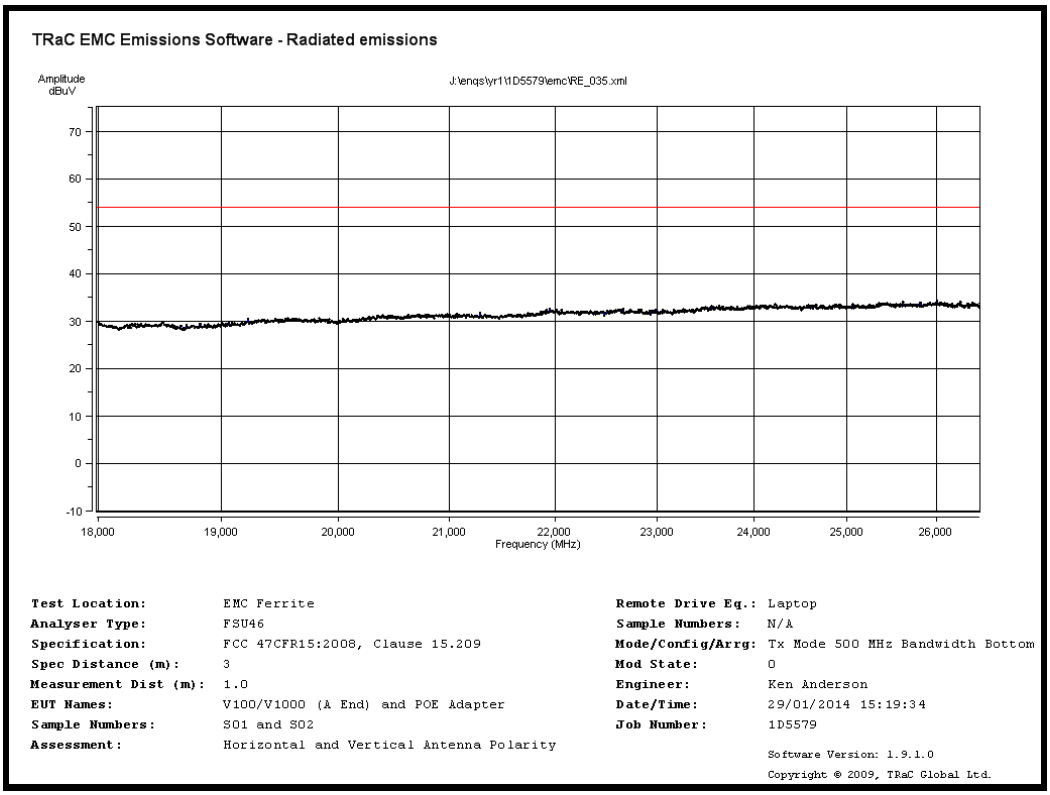
A end 1 GHz to 5 GHz– Bottom Channel



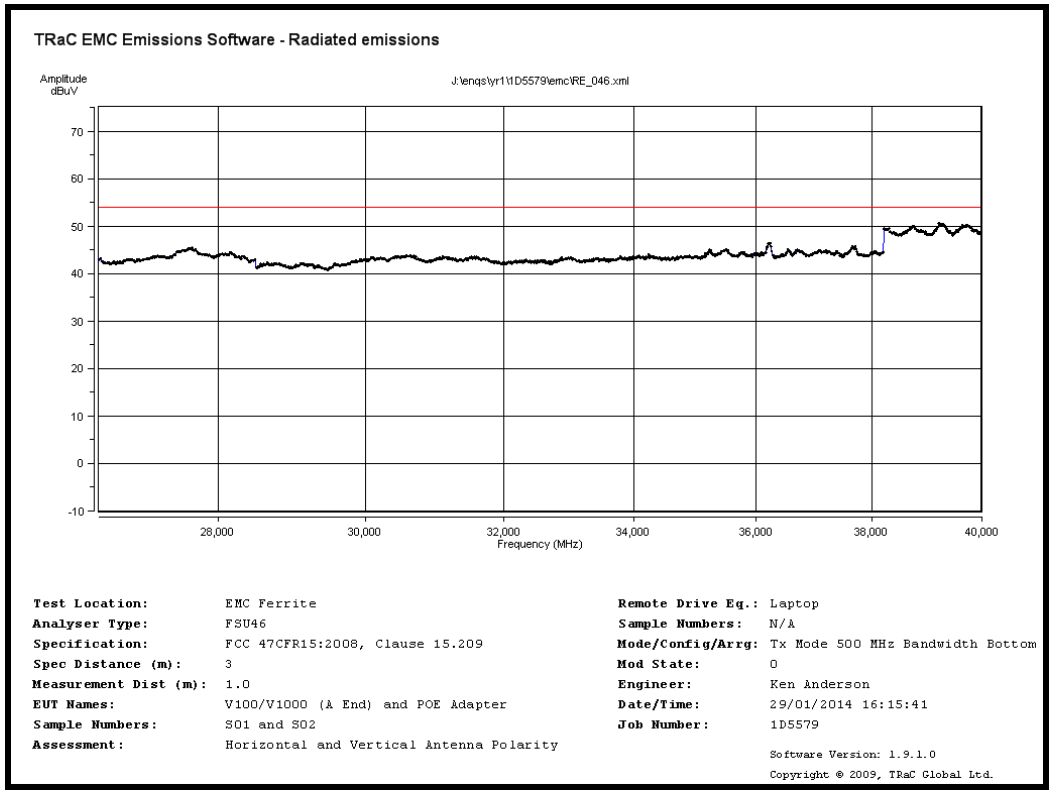
A end 5 GHz to 12.75 GHz– Bottom Channel



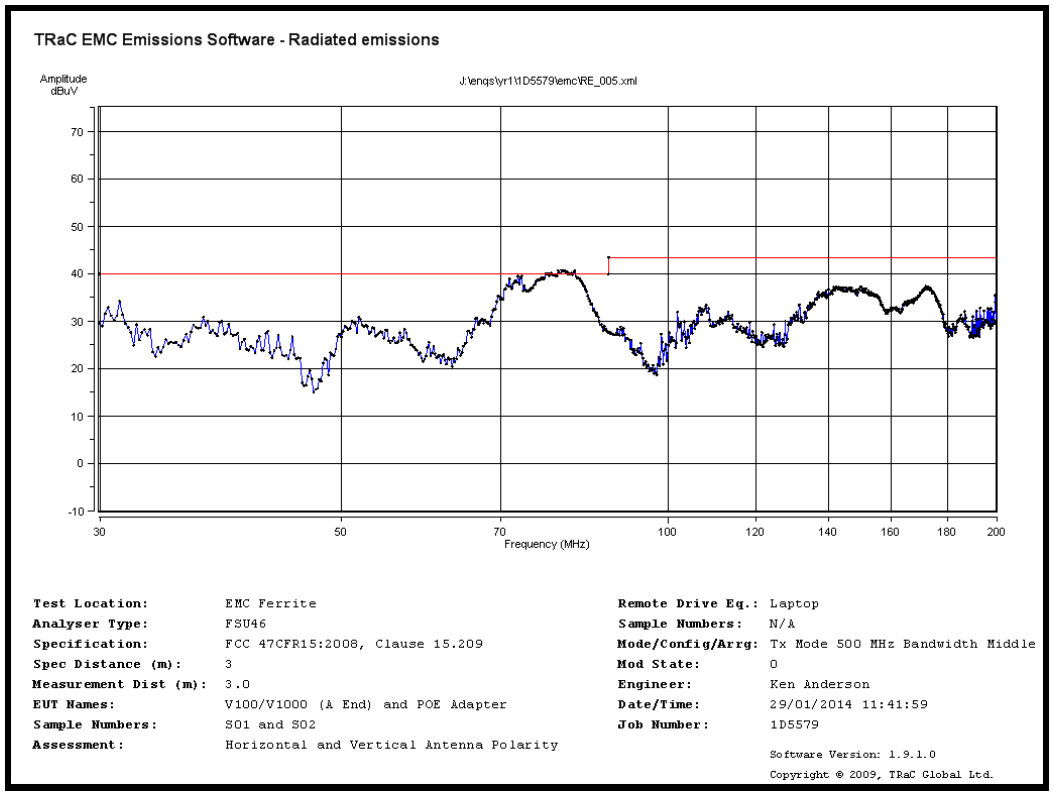
A end 12.75 GHz to 18 GHz– Bottom Channel



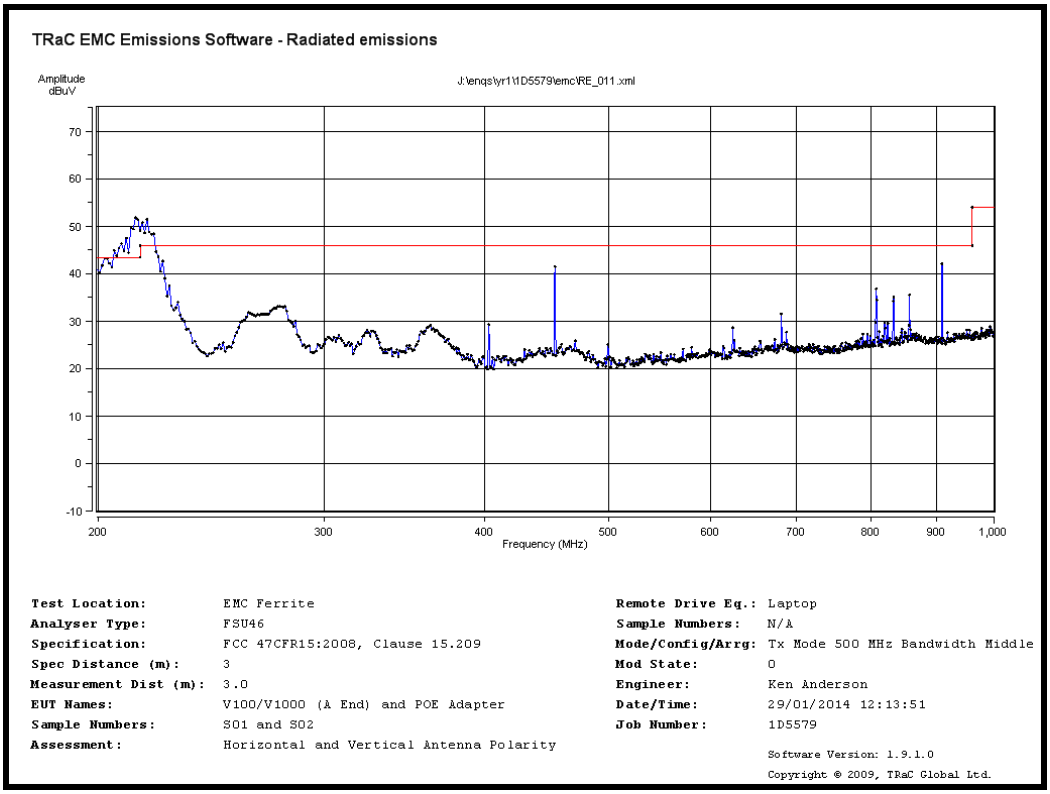
A end 18 GHz to 26.5 GHz– Bottom Channel



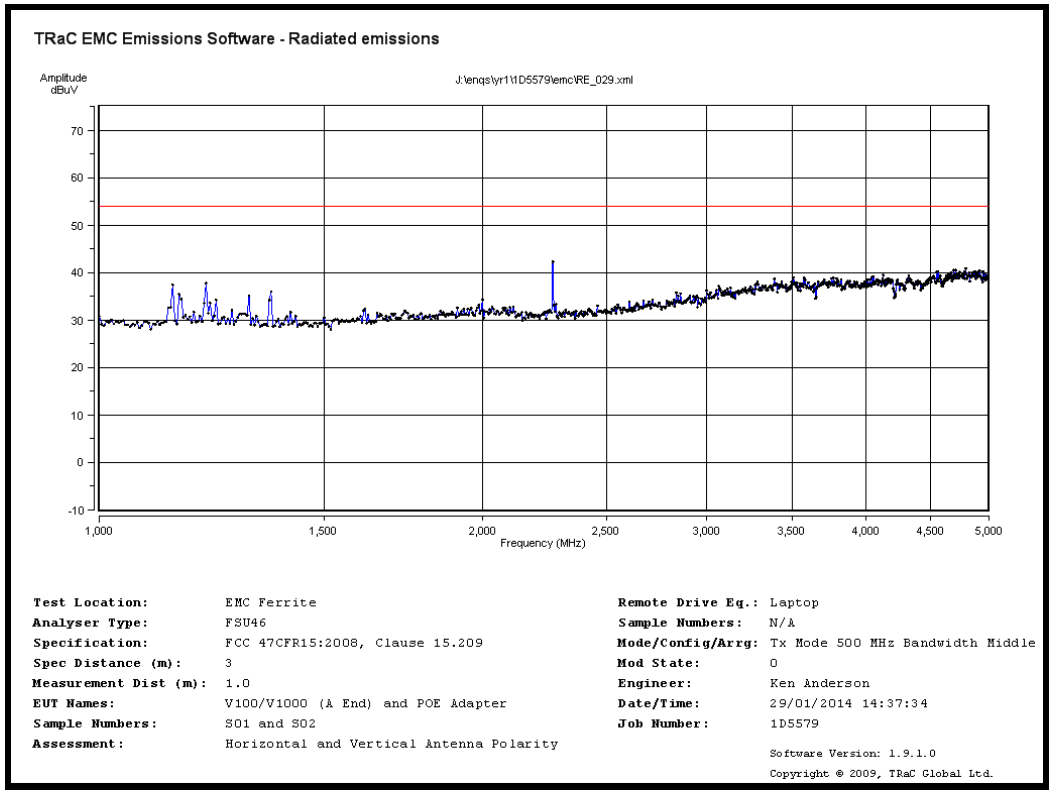
A end 26.5 GHz to 40 GHz– Bottom Channel



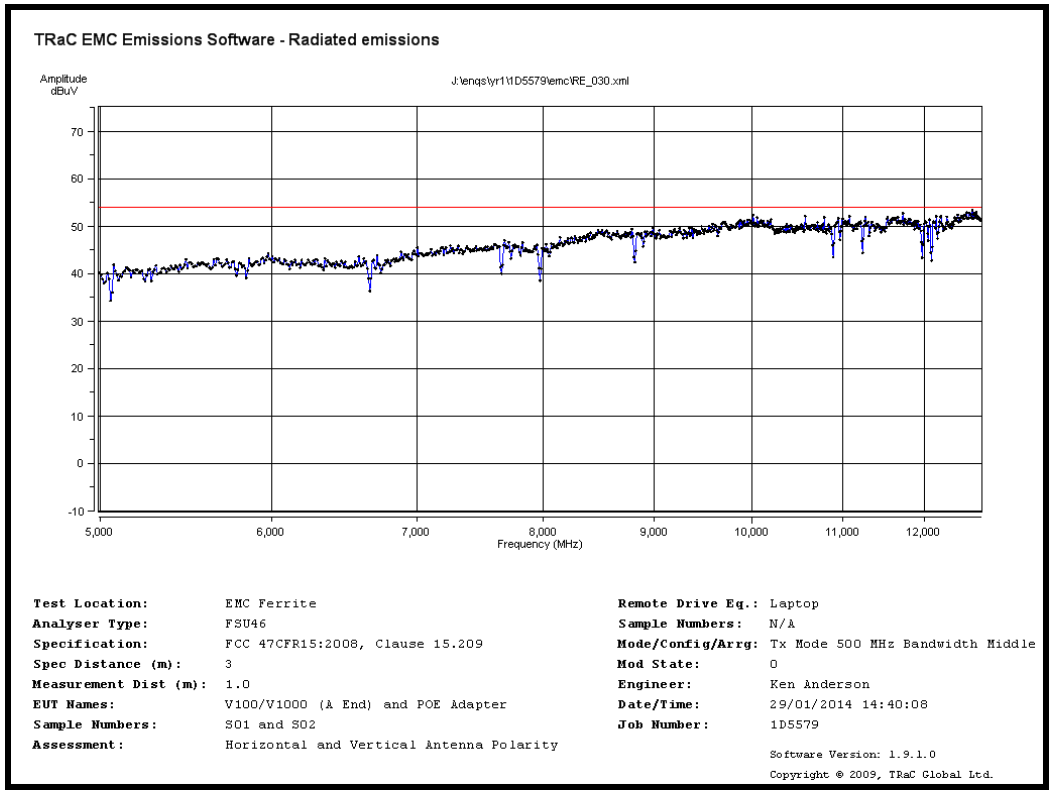
A end 30 MHz to 200 MHz – Middle Channel



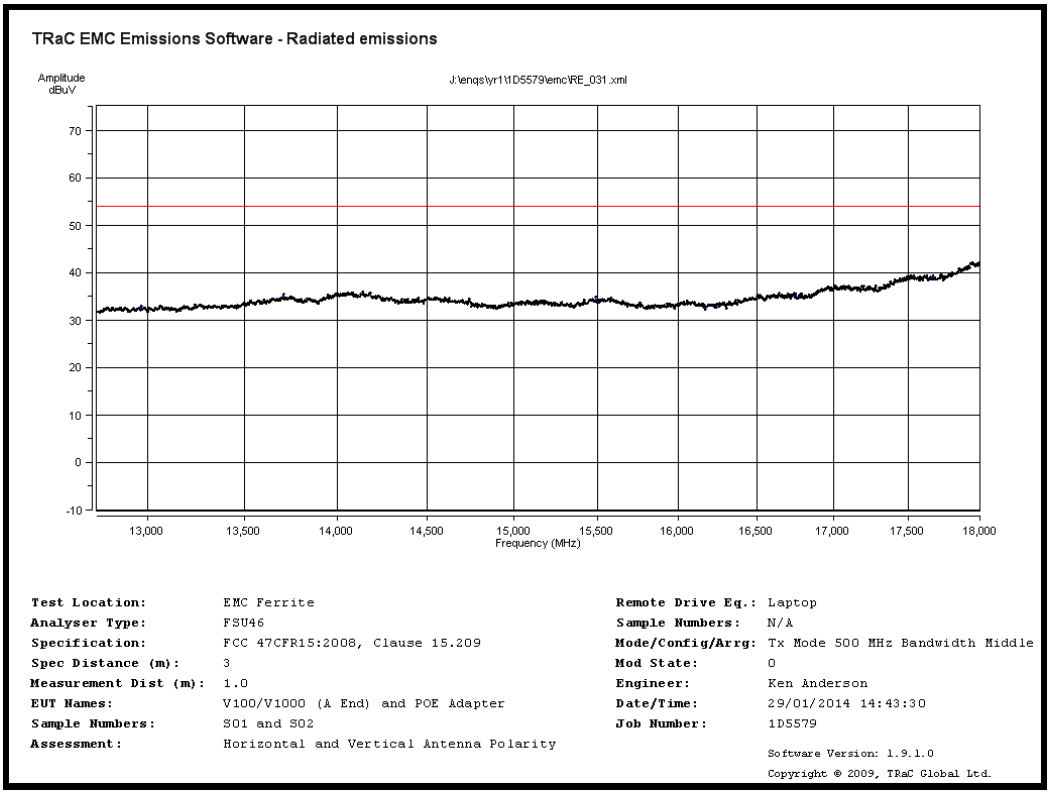
A end 200 MHz to 1GHz– Middle Channel



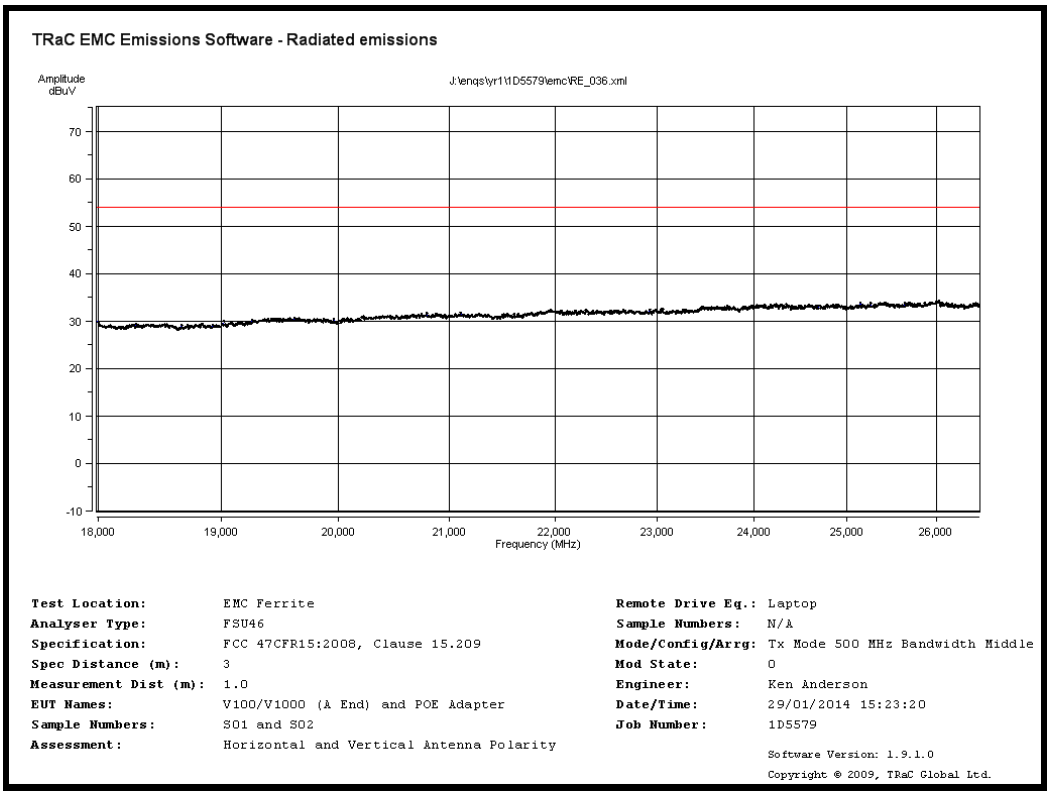
A end 1 GHz to 5 GHz– Middle Channel



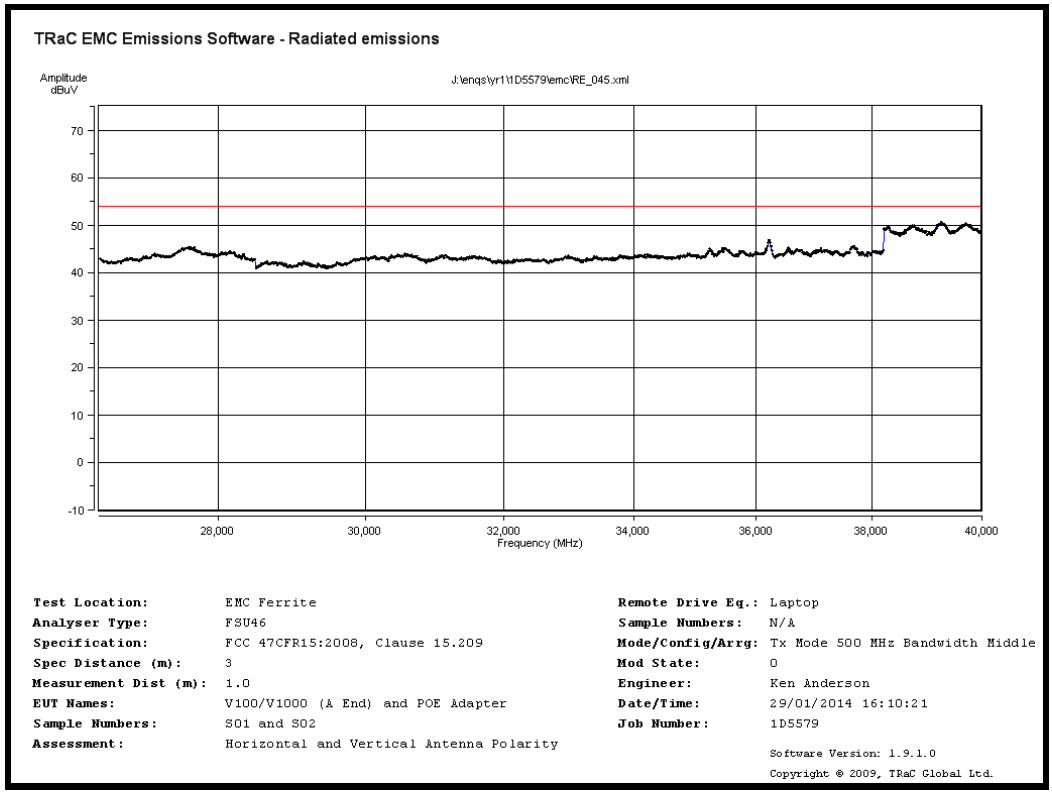
A end 5 GHz to 12.75 GHz– Middle Channel



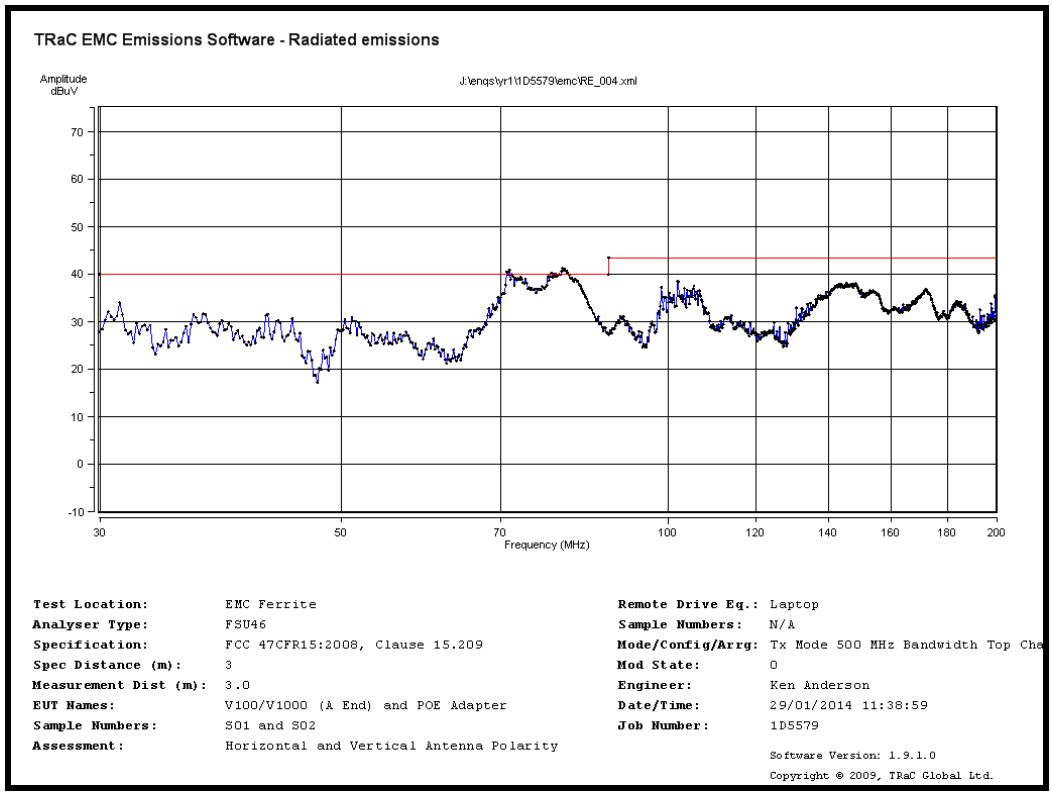
A end 12.75 GHz to 18 GHz– Middle Channel



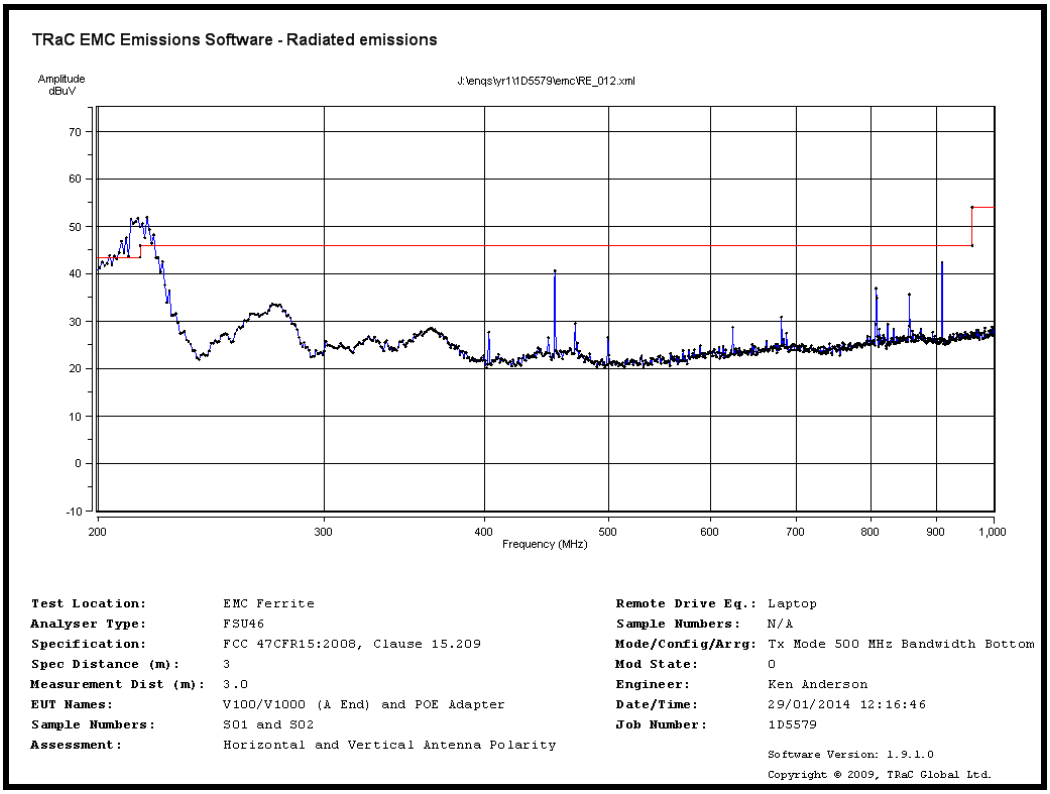
A end 18 GHz to 26.5 GHz– Middle Channel



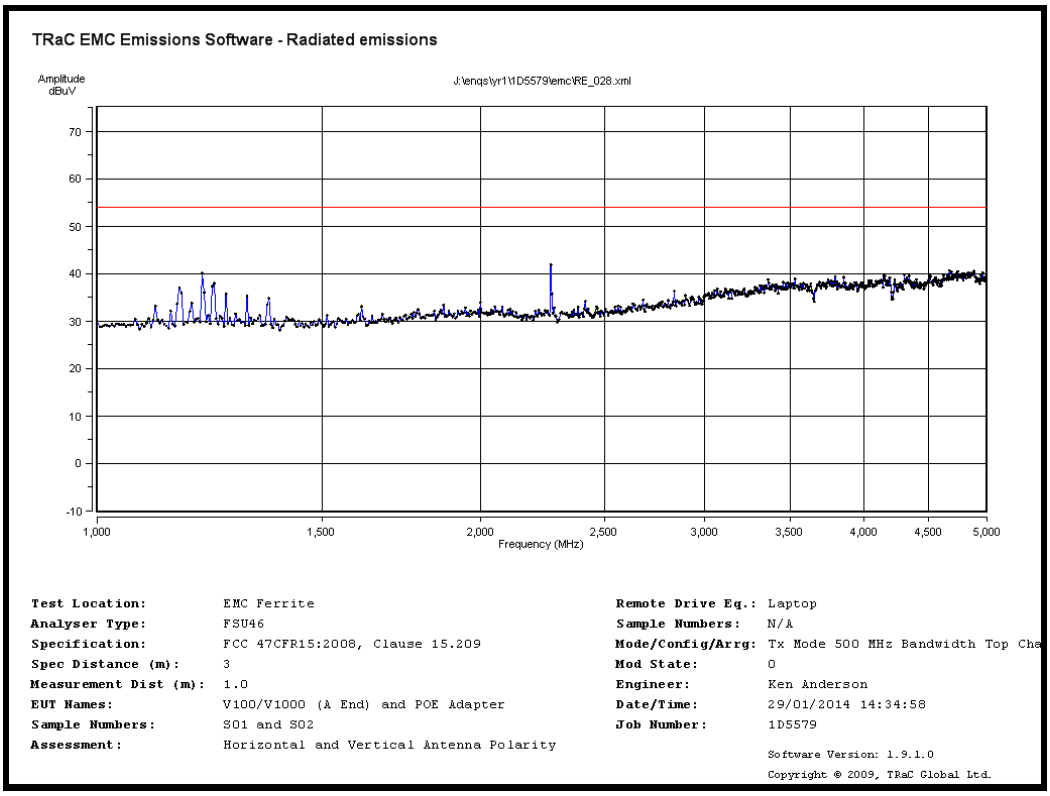
A end 26.5 GHz to 40 GHz– Middle Channel



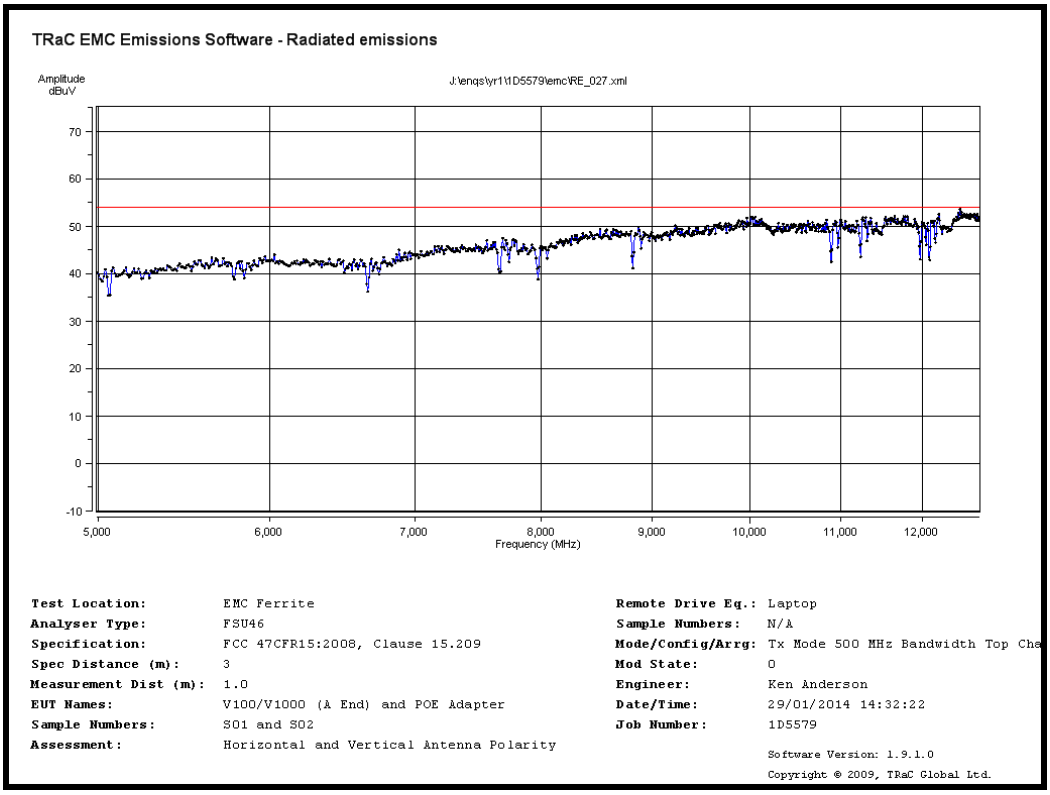
A end 30 MHz to 200 MHz – Top Channel



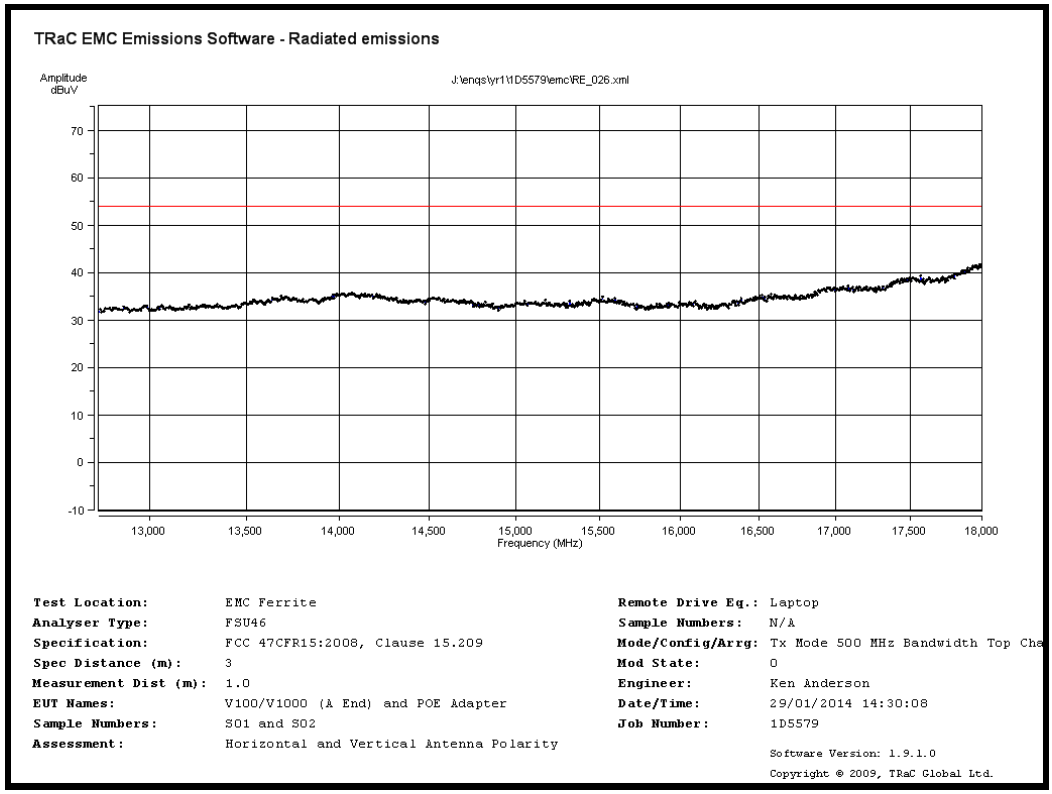
A end 200 MHz to 1GHz– Top Channel



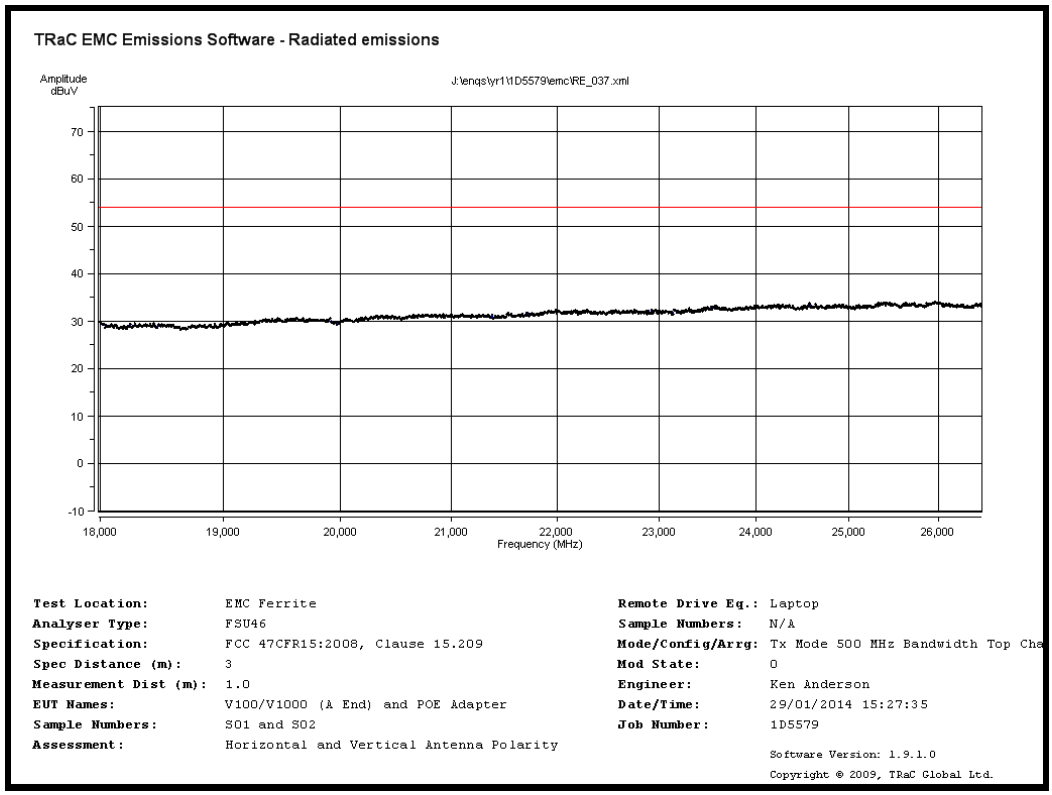
A end 1 GHz to 5 GHz– Top Channel



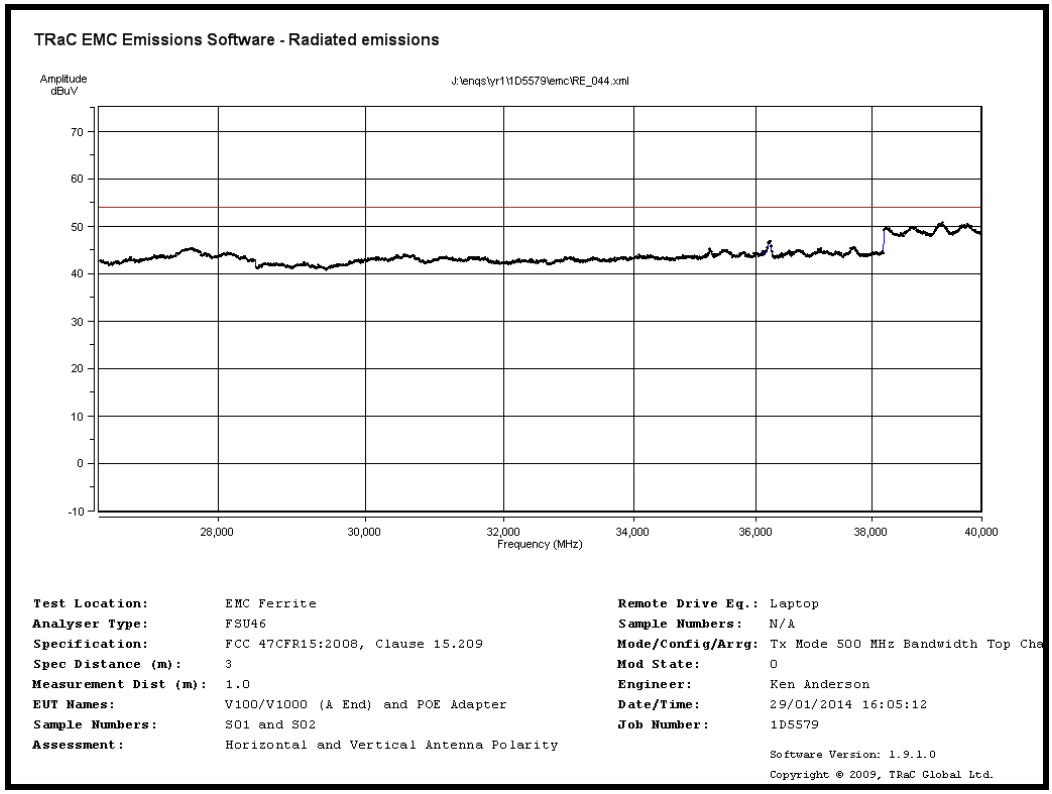
A end 5 GHz to 12.75 GHz– Top Channel



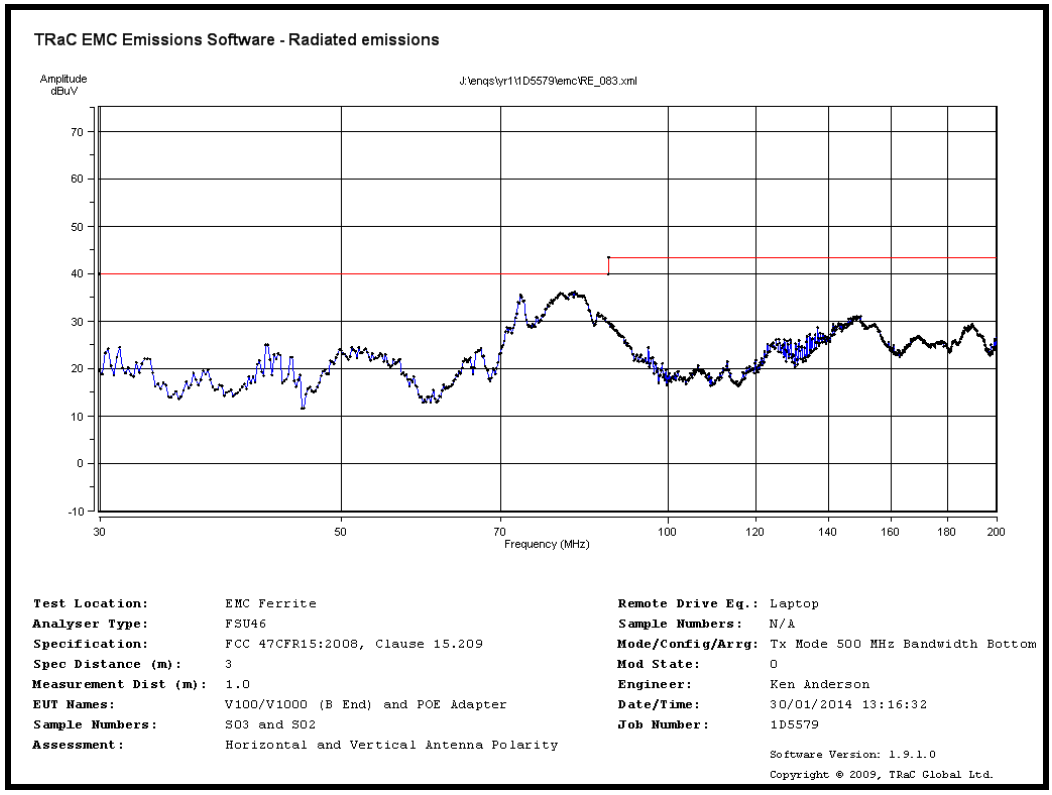
A end 12.75 GHz to 18 GHz– Top Channel



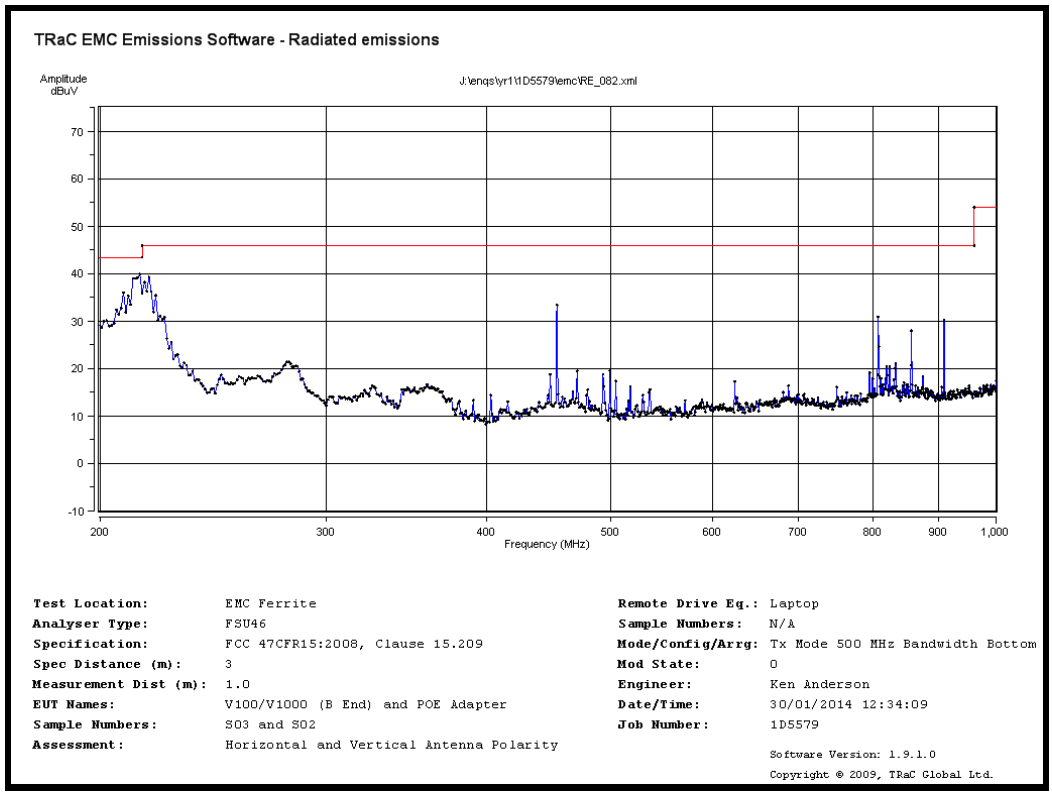
A end 18 GHz to 26.5 GHz– Top Channel



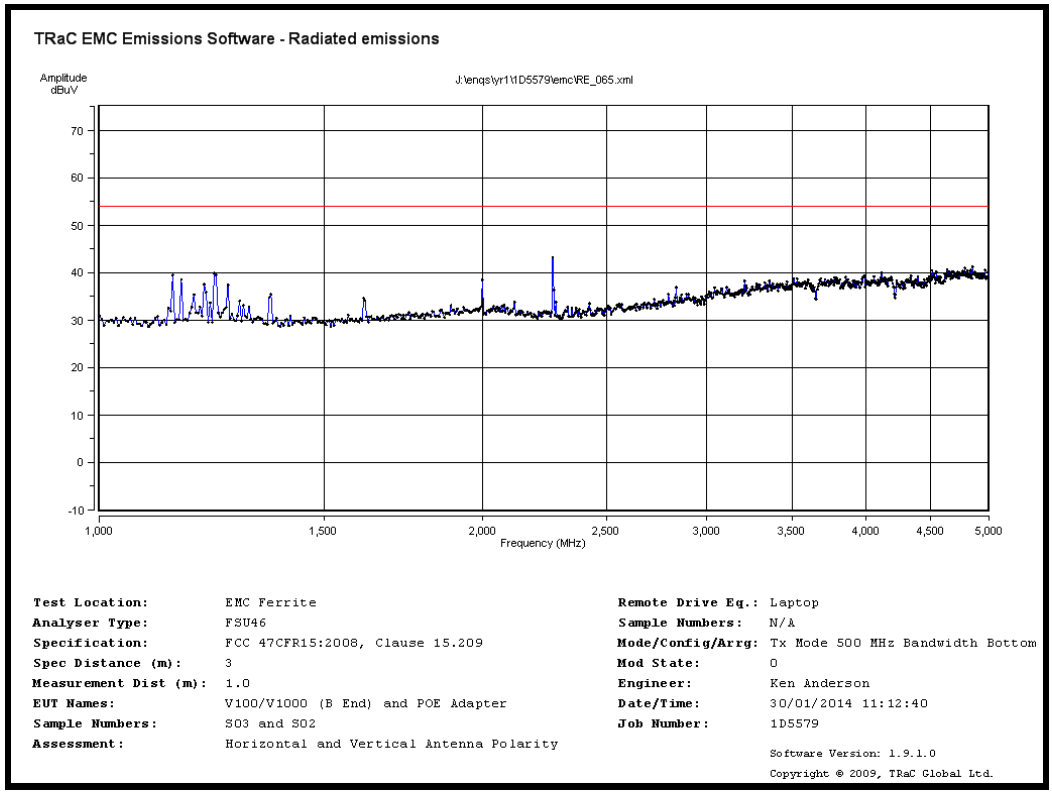
A end 26.5 GHz to 40 GHz– Top Channel



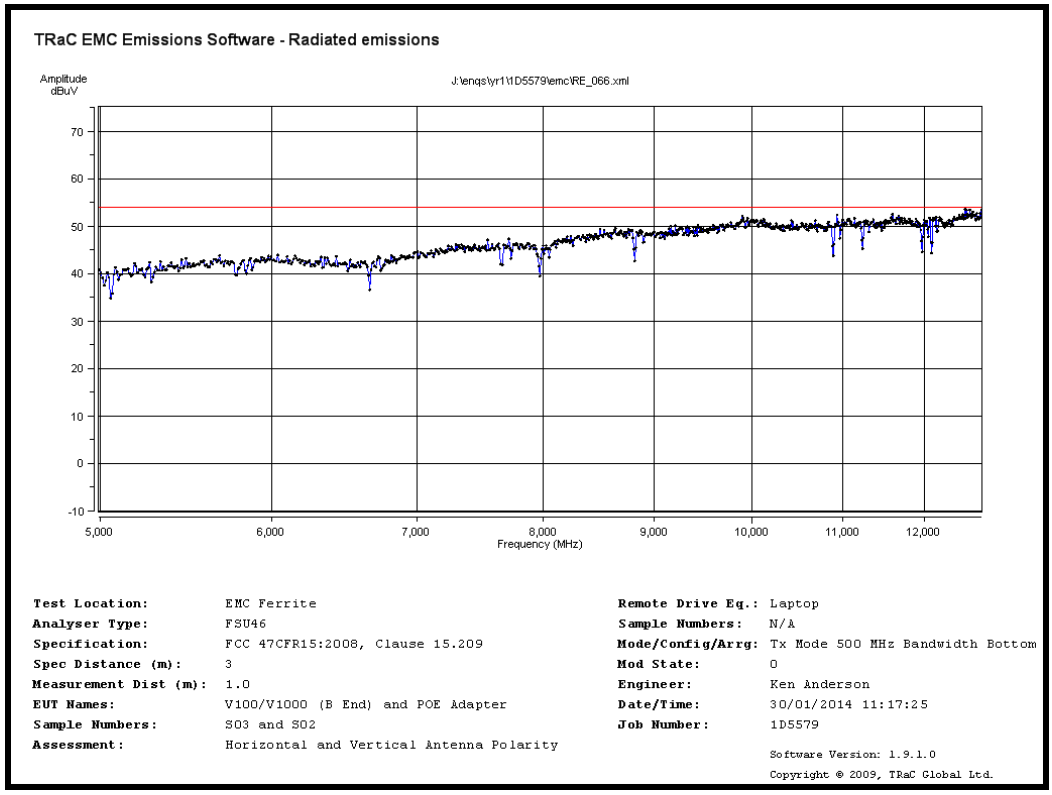
B end 30 MHz to 200 MHz – Bottom Channel



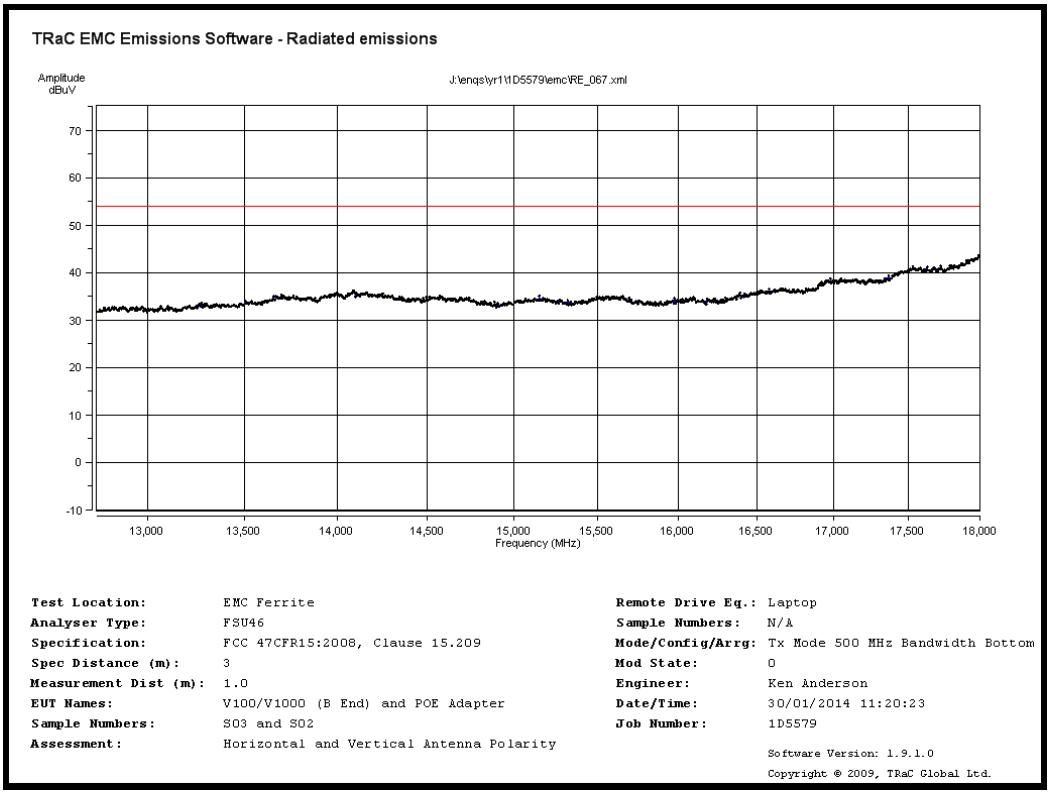
B end 200 MHz to 1GHz– Bottom Channel



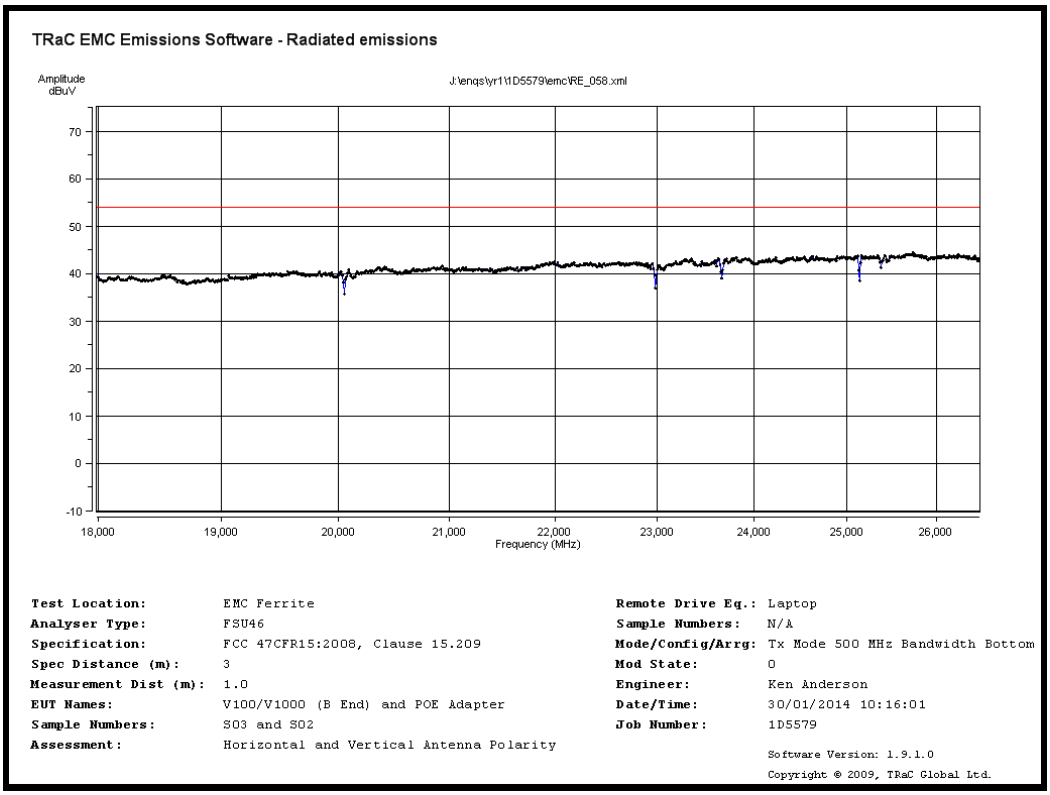
B end 1 GHz to 5 GHz– Bottom Channel



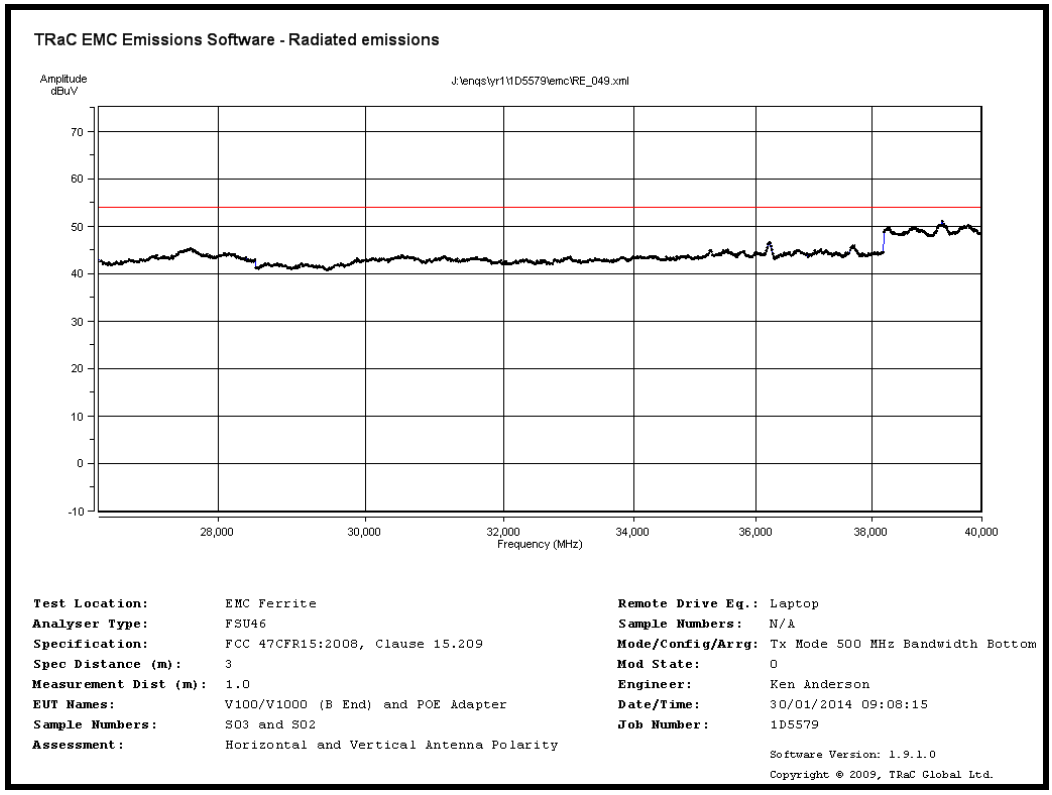
B end 5 GHz to 12.75 GHz– Bottom Channel



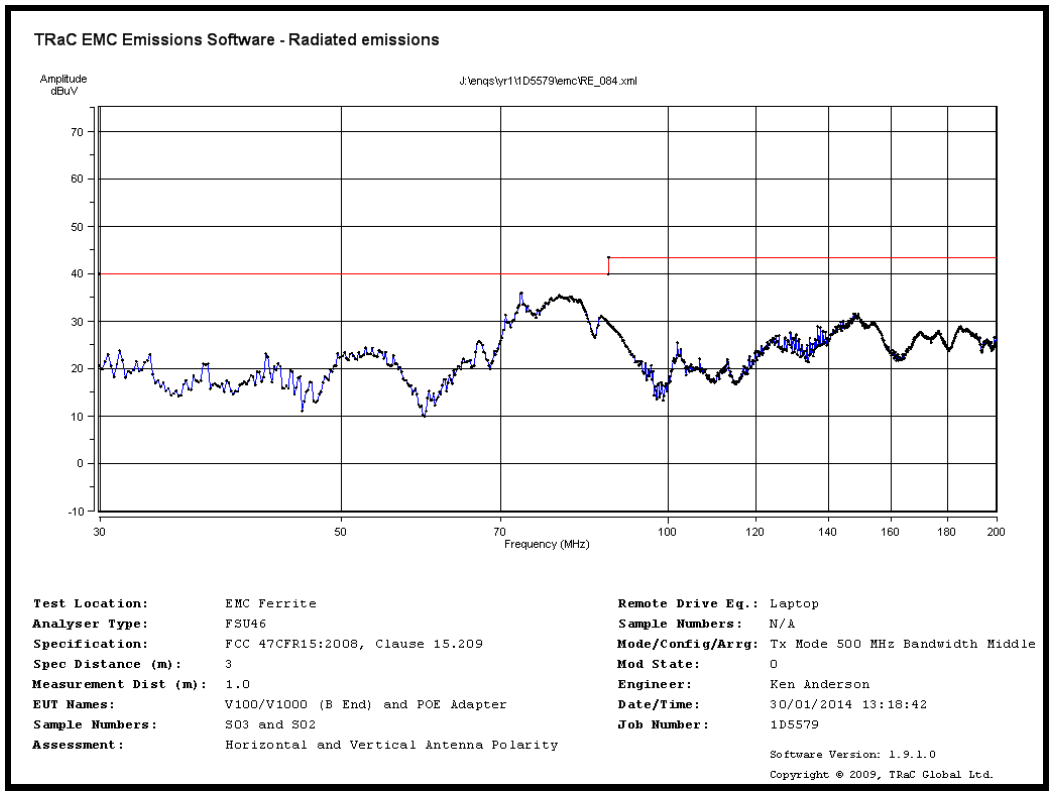
B end 12.75 GHz to 18 GHz– Bottom Channel



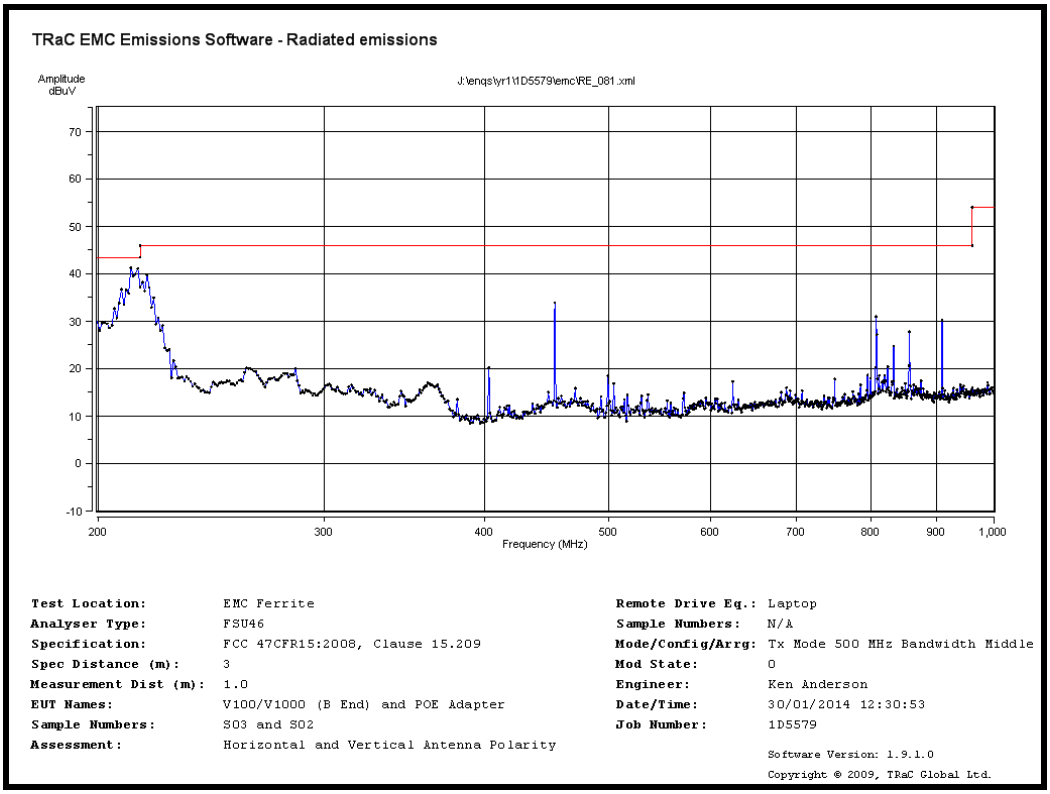
B end 18 GHz to 26.5 GHz– Bottom Channel



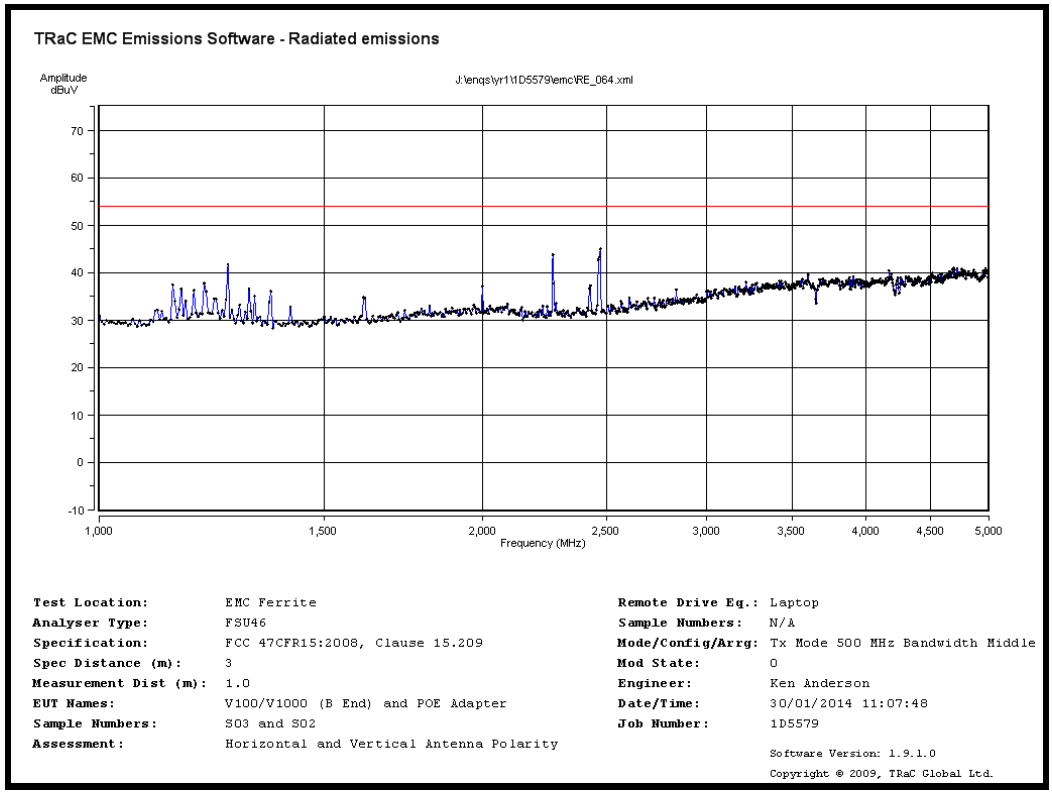
B end 26.5 GHz to 40 GHz– Bottom Channel



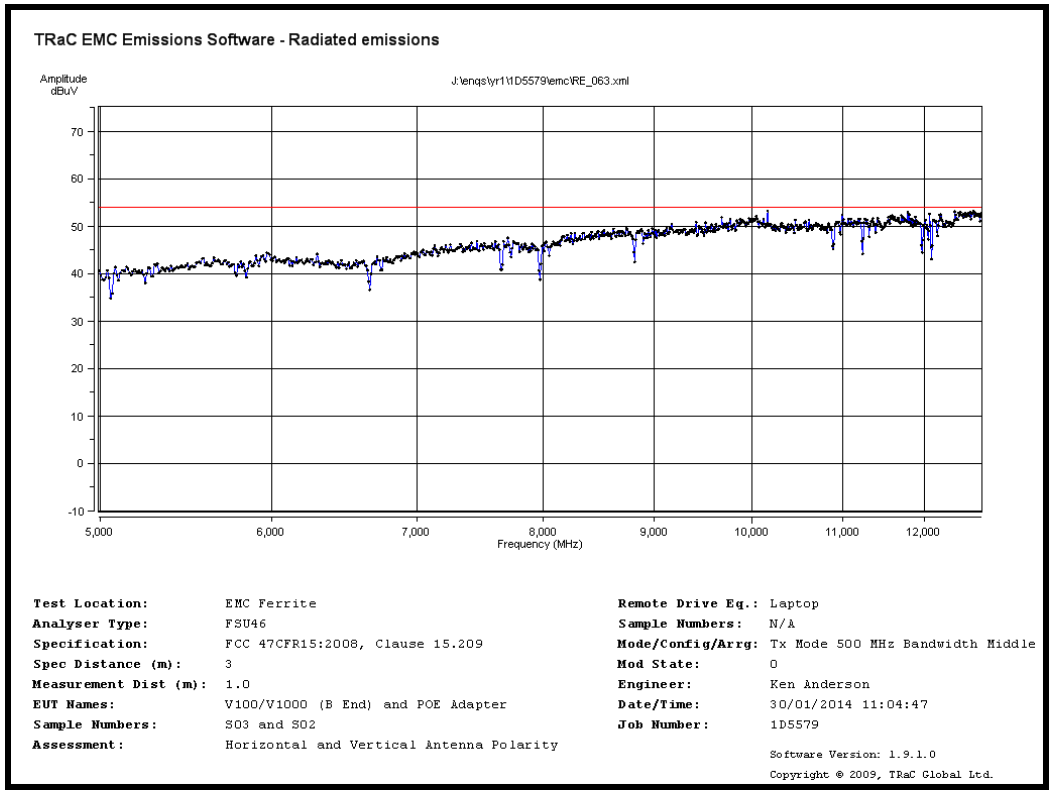
B end 30 MHz to 200 MHz – Middle Channel



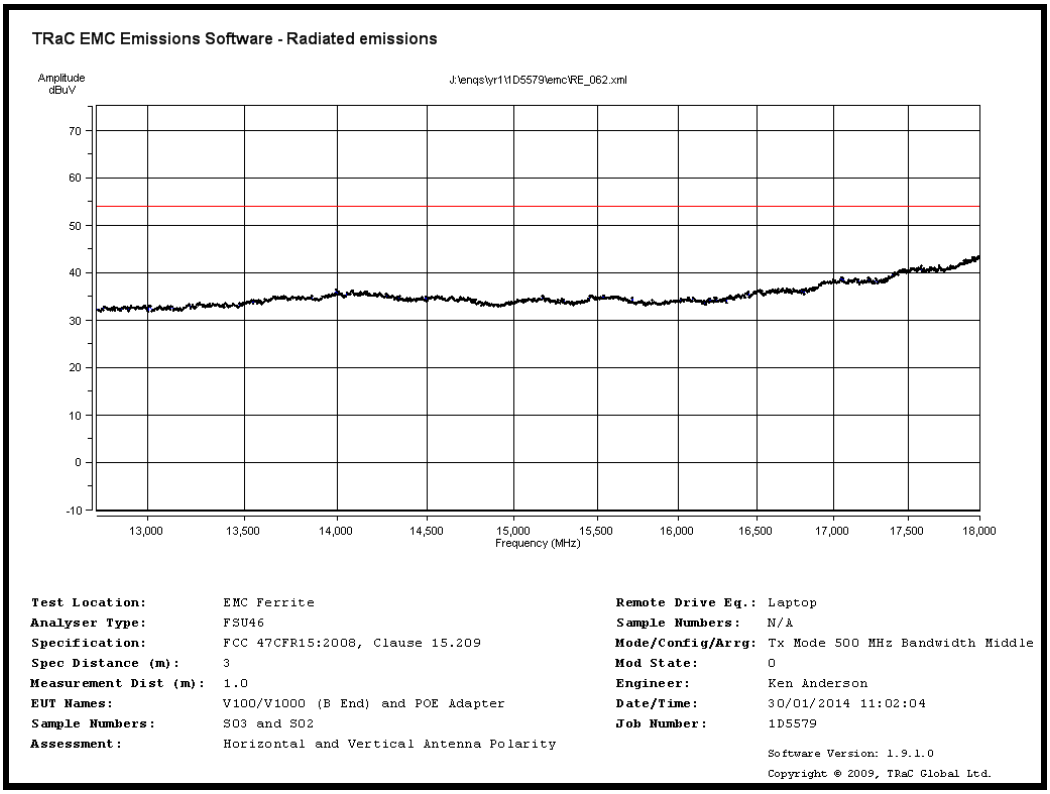
B end 200 MHz to 1GHz– Middle Channel



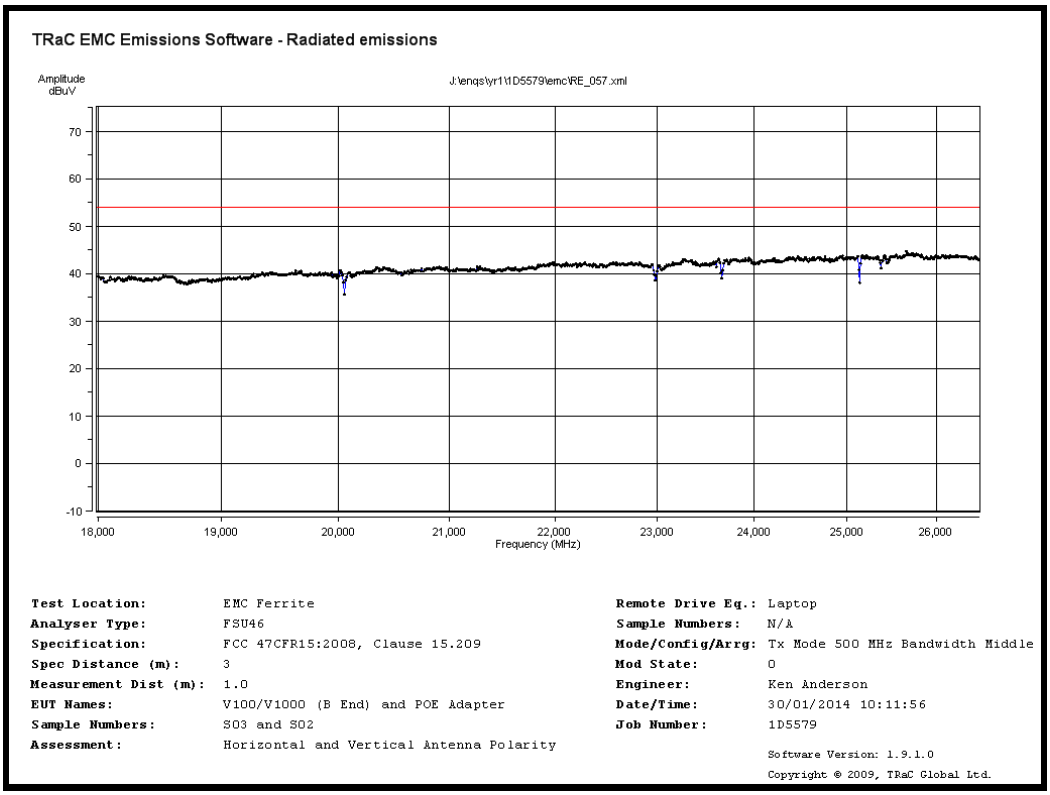
B end 1 GHz to 5 GHz– Middle Channel



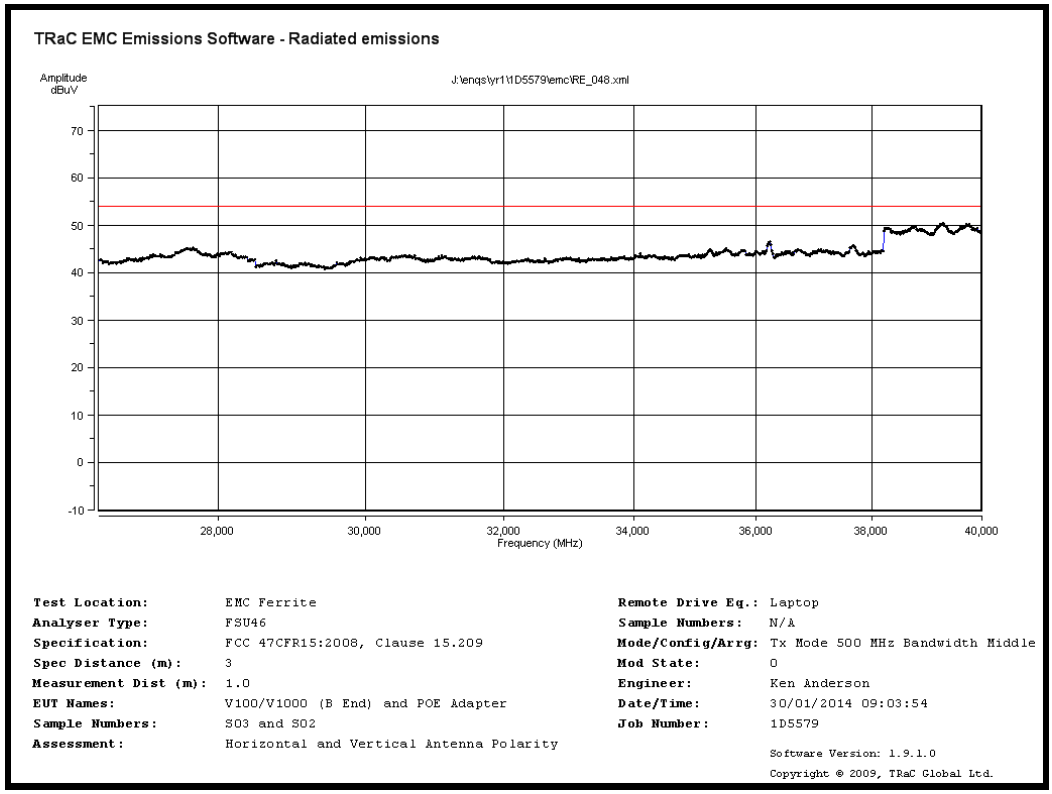
B end 5 GHz to 12.75 GHz– Middle Channel



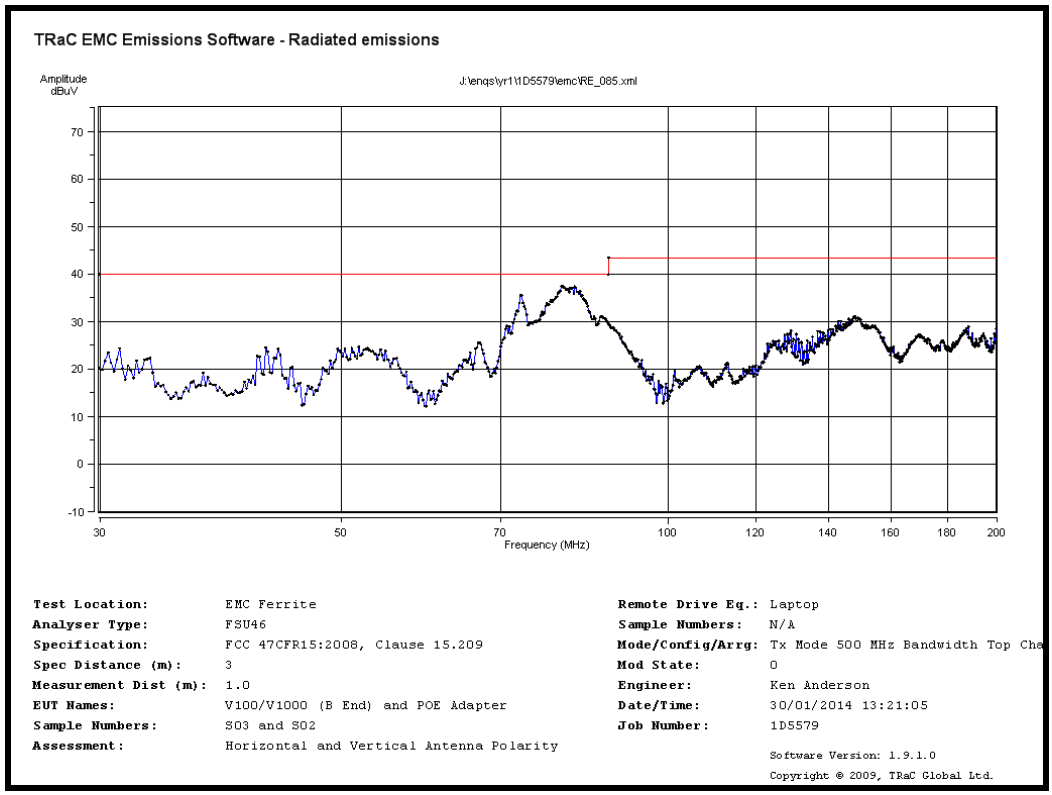
B end 12.75 GHz to 18 GHz– Middle Channel



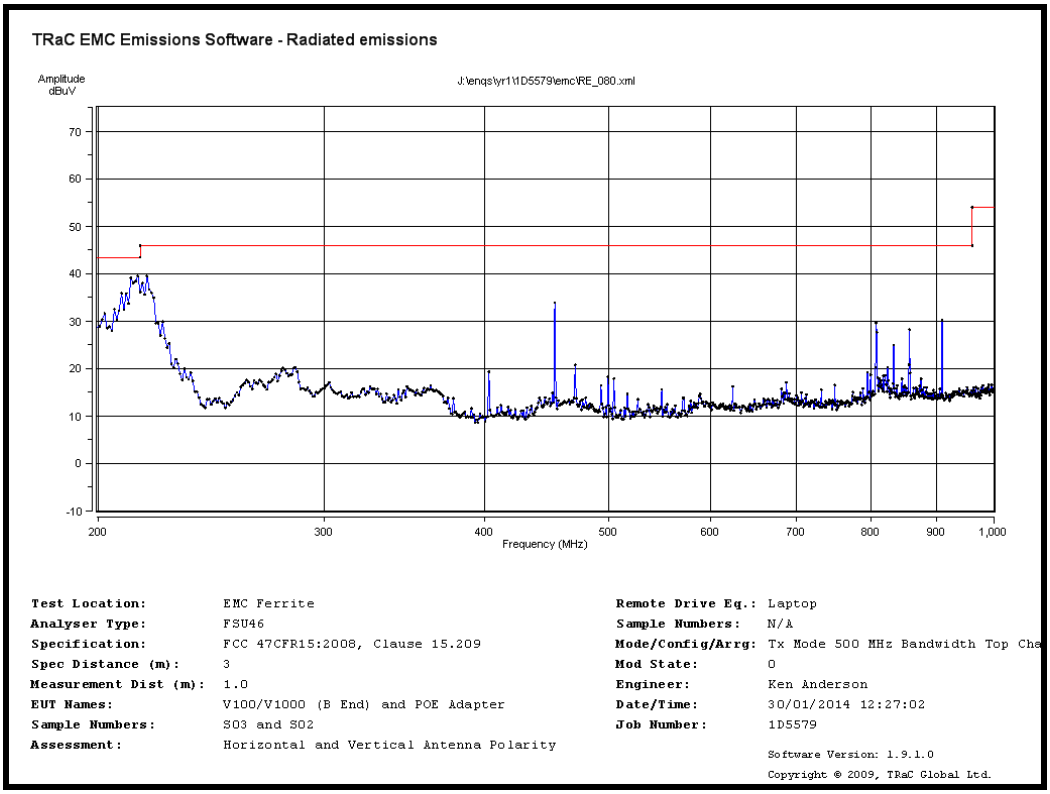
B end 18 GHz to 26.5 GHz– Middle Channel



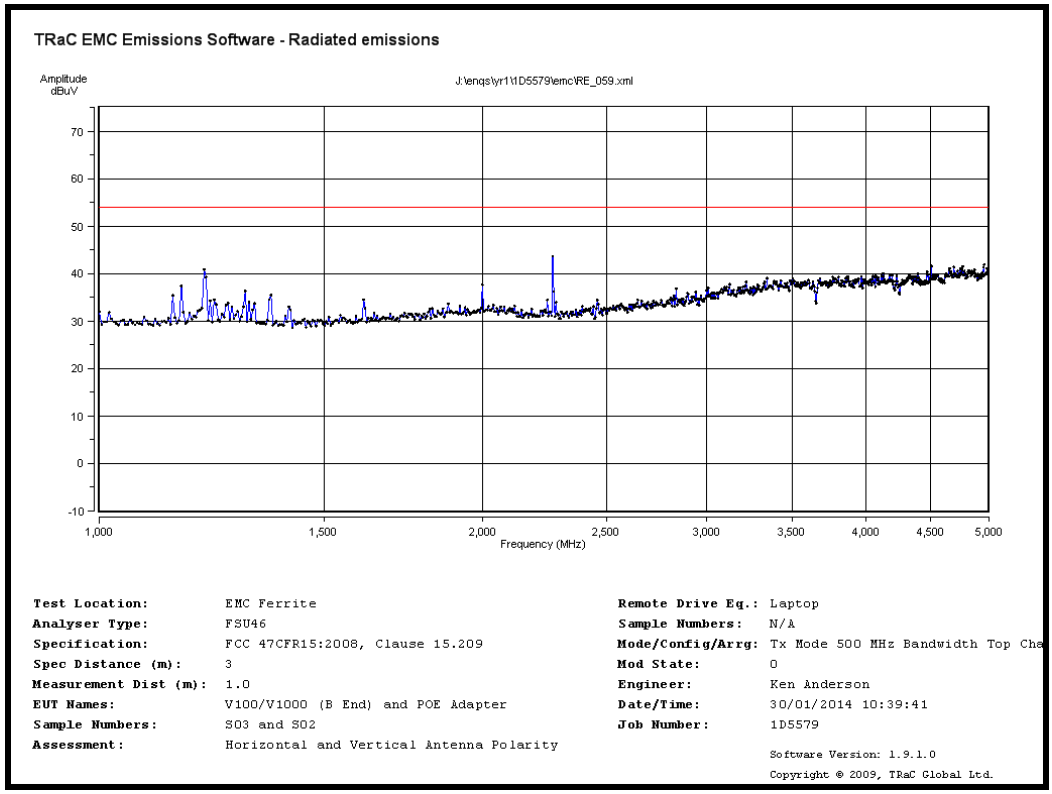
B end 26.5 GHz to 40 GHz– Middle Channel



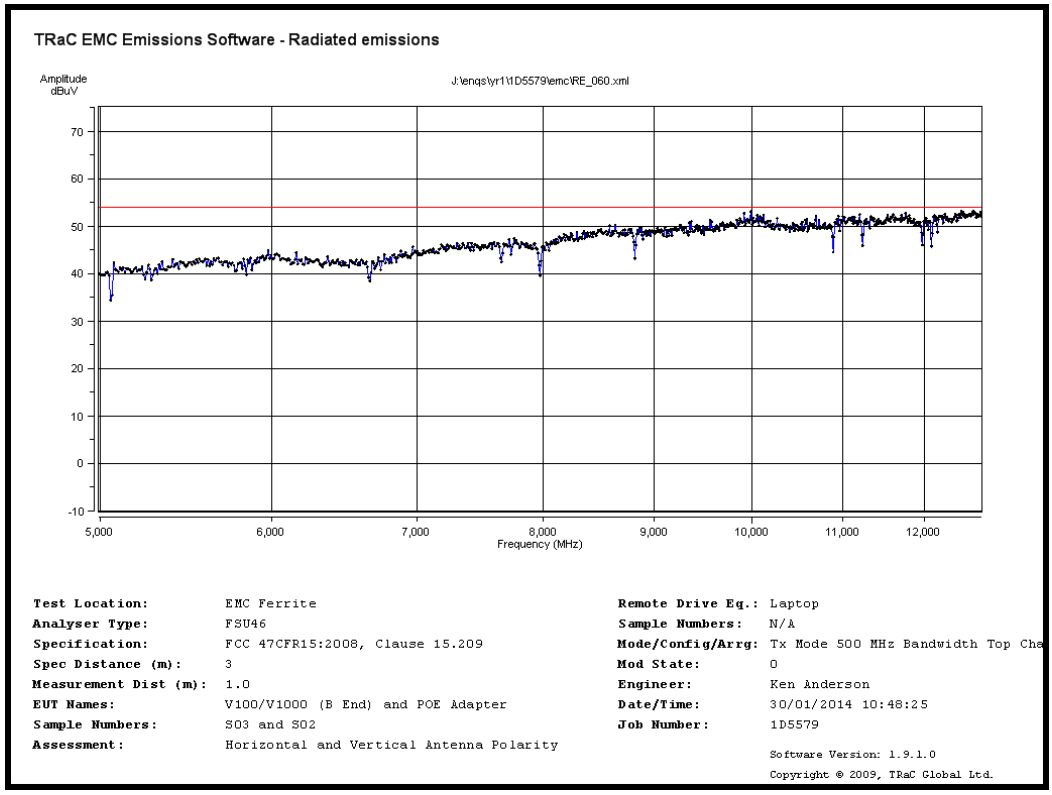
B end 30 MHz to 200 MHz – Top Channel



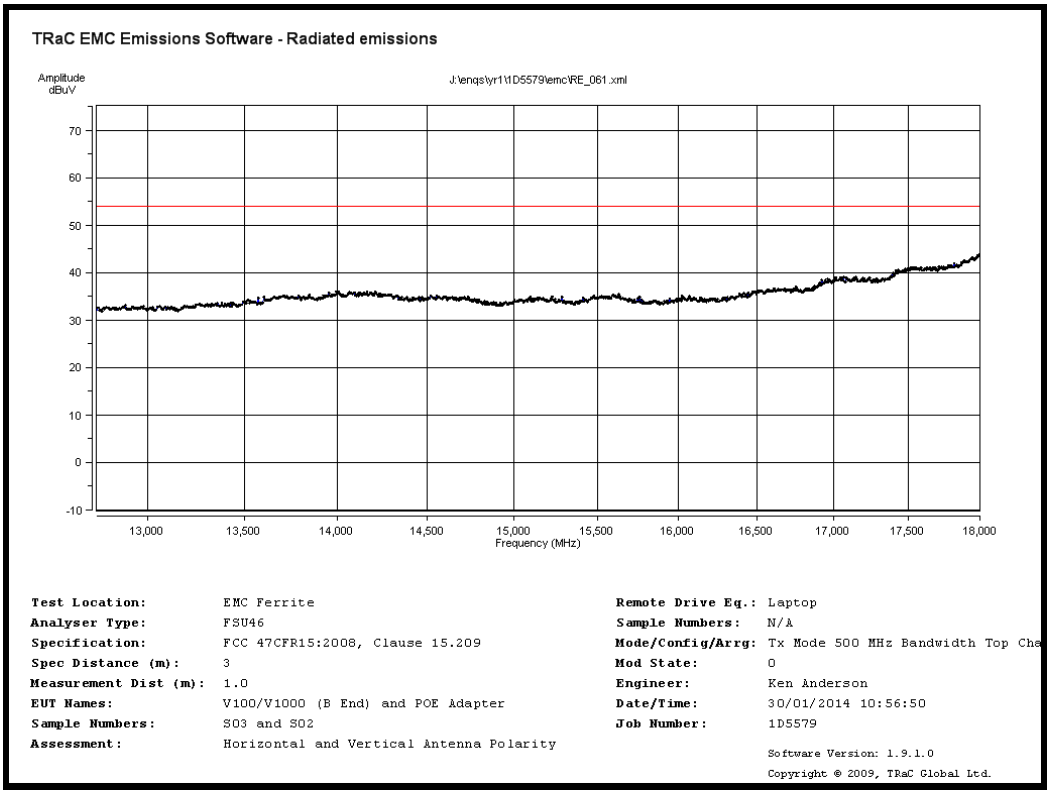
B end 200 MHz to 1GHz– Top Channel



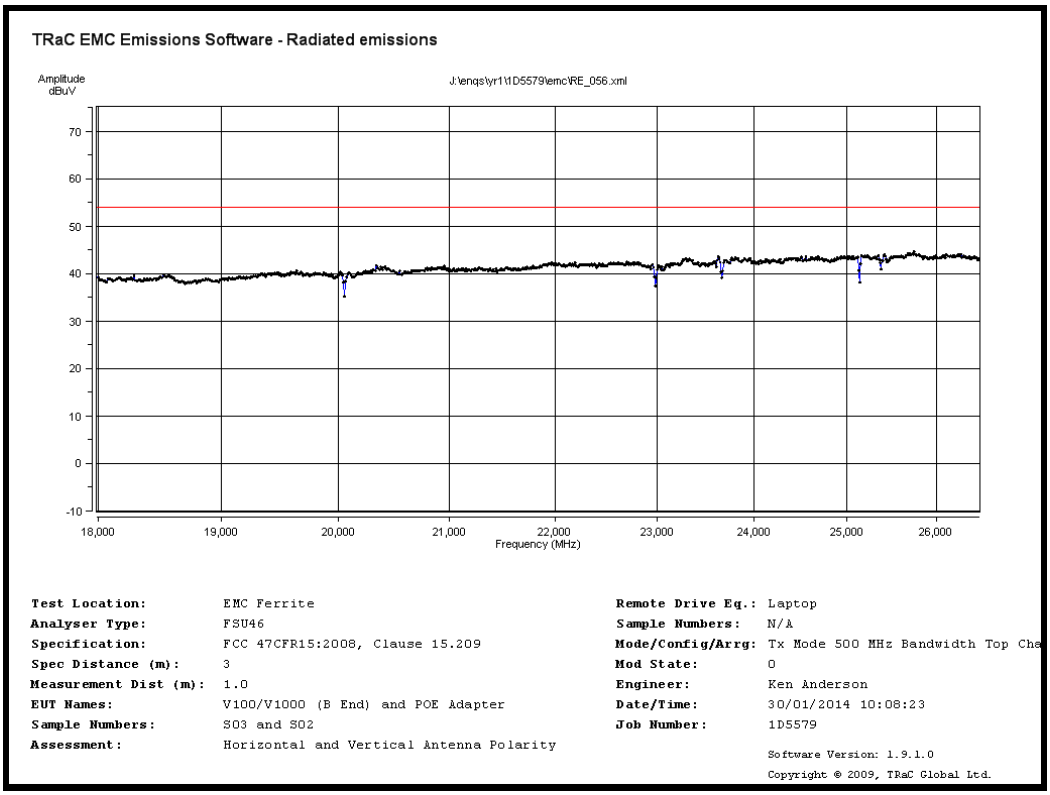
B end 1 GHz to 5 GHz– Top Channel



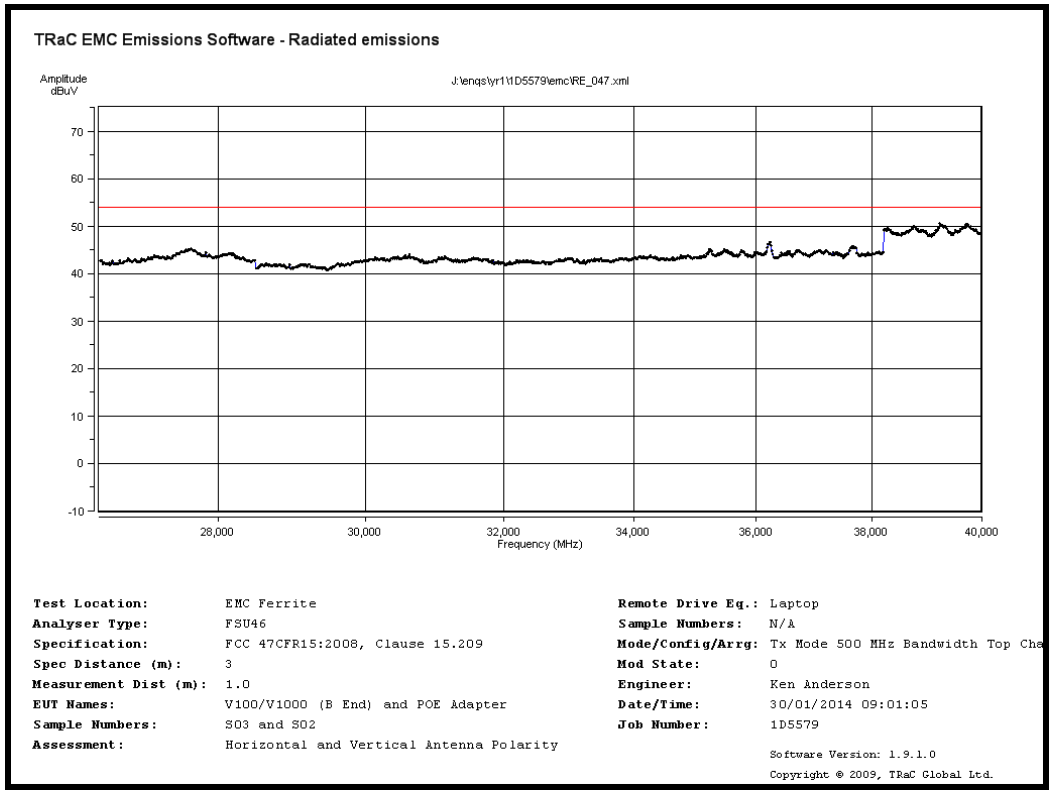
B end 5 GHz to 12.75 GHz– Top Channel



B end 12.75 GHz to 18 GHz– Top Channel



B end 18 GHz to 26.5 GHz– Top Channel



B end 26.5 GHz to 40 GHz– Top Channel

Appendix C: Additional Test and Sample Details

This appendix contains details of:

1. The samples submitted for testing.
2. Details of EUT operating mode(s)
3. Details of EUT configuration(s) (see below).
4. EUT arrangement (see below).

Throughout testing, the following numbering system is used to identify the sample and it's modification state:

Sample No: Sxx Mod w

where:

xx = sample number eg. S01
w = modification number eg. Mod 2

The following terminology is used throughout the test report:

Support Equipment (SE) is any additional equipment required to exercise the EUT in the applicable operating mode. Where relevant SE is divided into two categories:

SE in test environment: The SE is positioned in the test environment and is not isolated from the EUT (e.g. on the table top during REFE testing).

SE isolated from the EUT: The SE is isolated via filtering from the EUT. (e.g. equipment placed externally to the ALSR during REFE testing).

EUT configuration refers to the internal set-up of the EUT. It may include for example:

Positioning of cards in a chassis.
Setting of any internal switches.
Circuit board jumper settings.
Alternative internal power supplies.

Where no change in EUT configuration is **possible**, the configuration is described as “single possible configuration”.

EUT arrangement refers to the termination of EUT ports / connection of support equipment, and where relevant, the relative positioning of samples (EUT and SE) in the test environment.

For further details of the test procedures and general test set ups used during testing please refer to the related document "EMC Test Methods - An Overview", which can be supplied by TRaC Telecoms & Radio upon request.

C1) Test samples

The following samples of the apparatus were submitted by the client for testing :

Sample No.	Description	Identification
S01	V100/V1000 (A end)	S1000390B999990000
S02	POE Adapter	1
S03	V100/V1000 (B end)	S1000391B999990000
S07	V100/V1000 (A end)	S1000390B171402977
S08	V100/V1000 (B end)	S1000391B171403983
S09	POE Adapter	1

The following samples of apparatus were supplied by TRaC as support or drive equipment (auxiliary equipment):

TRaC Identification	Description
IT-0070	Test Laptop HP Compaq nx6125

C2) EUT Operating Mode During Testing.

Test	Description of Operating Mode: TX
All tests detailed in this report excluding: Receiver Spurious Emissions	EUT continuously transmitting using BPSK and 8-PSK modulation on 58.5, 59.0 and 59.5 GHz (A end) and 51.5, 62 and 62.5 GHz (B end)

C3) EUT Configuration Information.

Sample	Internal Configuration Details
S01/S03	Single possible internal configuration
S07/S08	Single possible internal configuration

C4) List of EUT Ports

The table below describes the termination of EUT ports:

Sample : S01/03
Tests : all

Port	Description of Cable Attached	Cable length	Equipment Connected
Power/Ethernet	Cat 5screened	0.9m	S02

Sample : S07/08
Tests : all

Port	Description of Cable Attached	Cable length	Equipment Connected
Power/Ethernet	Cat 5screened	0.9m	S09

C5 Details of Equipment Used

For Radiated Electric Field Emissions 30MHz to 1GHz:

RFG No	Type	Description	Manufacturer	Date Calibrated.
REF886	Lab 16	Large Anechoic Chamber	TRaC	10/05/13
RFG095	96002	Bicon Antenna (30-200MHz)	Eaton	09/05/13
RFG191	3146	Log Periodic Antenna (200-1000MHz)	EMCO	09/05/13
REF927	310	Pre-Amp (9kHz-1GHz)	Sonoma	15/09/11
REF910	FSU46	Spectrum Analyser	R&S	21/03/13
RFG452	-	HF RF coaxial cable	UTIFLEX	03/07/13
REF881	-	HF RF coaxial cable	Teledyne Reynolds	06/06/13
REF882	-	HF RF coaxial cable	Teledyne Reynolds	06/06/13
REF884	-	HF RF coaxial cable	Teledyne Reynolds	06/06/13
REF885	-	HF RF coaxial cable	Teledyne Reynolds	06/06/13
REF859	9117	Bicon Antenna	VUBA	08/07/13
REF832	219-8004-2000 0608	Type K Male to Type K Male Cable 2.0m	Teledyne Reynolds	04/07/13
REF919	219-8004-4000 0311	Type K Male to Type K Male Cable 4.0m	Teledyne Reynolds	04/07/13
REF883	-	HF RF coaxial cable 3.0m	Teledyne Reynolds	06/06/13

For Radiated Electric Field Emissions 1GHz to 40GHz:

RFG No	Type	Description	Manufacturer	Date Calibrated
REF886	Lab 16	Large Anechoic Chamber	TRaC	10/05/13
REF910	FSU46	Spectrum analyser	R & S	21/03/13
129	3115	Horn Antennas	EMCO	14/09/11
913	HP8449B	Microwave Pre-Amp (1-26.5GHz)	HP	31/01/13
RFG452	-	HF RF coaxial cable	UTIFLEX	03/07/13
REF881	-	HF RF coaxial cable	Teledyne Reynolds	06/06/13
REF882	-	HF RF coaxial cable	Teledyne Reynolds	06/06/13
REF884	-	HF RF coaxial cable	Teledyne Reynolds	06/06/13
REF885	-	HF RF coaxial cable	Teledyne Reynolds	06/06/13
REF832	219-8004-2000 0608	Type K Male to Type K Male Cable 2.0m	Teledyne Reynolds	04/07/13
REF919	219-8004-4000 0311	Type K Male to Type K Male Cable 4.0m	Teledyne Reynolds	04/07/13
REF883	-	HF RF coaxial cable 3.0m	Teledyne Reynolds	06/06/13
360	SMP22	Signal Generator	R & S	08/04/13

For Conducted Carrier power

RFG No	Type	Description	Manufacturer	Date Calibrated
REF2127	SFD-503753-15SF-N1	V Band Diode Detector	Sage Millineter Inc	07/07/14
482	TDS744A	Oscilloscope	Tektronix	10/06/14

Appendix D: Additional Information

Product Data

SUB10 systems.com

Liberator-V1000

Applications

Gigabit Small Cell Backhaul

Campus Connectivity

Fiber Extension

Highlights

1 Gigabit Full-Duplex in 60 GHz band

All-Outdoor invisible footprint

Smallest Form Factor

Optimized for street level deployment

Robust Aluminium Housing

SyncE & 1588 Compliant

Optional 256 bit AES encryption

About 60 GHz

The 60GHz band is license-free or license-exempt in most countries. Due to Oxygen Absorption it is possible to operate without interference issues, even when deploying links in close proximity to each other. Large networks can be deployed and operate at extremely high densities with tens of links deployed on a single roof top or street. Sub10's combination of narrow beam width and high quality construction, gives the Liberator series outstanding performance and excellent frequency reuse.

Liberator-V1000

The future of wireless backhaul

Gigabit Full-Duplex & All-Outdoor Wireless Backhaul for dense network deployments

The Liberator V1000 is an extremely versatile and cost-effective all-outdoor wireless ethernet link operating in the 60 GHz Band delivering a Full-Duplex data rate of 1000 Mbps for distances up to 800 metres. Optimized for invisible street level deployments, the V1000 provides an ideal solution for challenging high-density applications with exceptionally high throughput requirements such as Small Cell Backhaul, Fiber Extensions, Campus Connectivity, Wireless Video Surveillance and Data Center Backhaul.

The combination of a high gain antenna with particularly low sidelobes and the option to use multiple channels ensures excellent interference immunity and allows multiple co-located units on a single pole to overcome pole sway, twist and/or tilt. The patent-pending "Snapback" SyncE allows rapid synchronization in just a few seconds, and the future-proof programmable platform allows new features to be added as Carrier & Enterprise requirements change in the future. The Liberator V1000 is an easy-to-deploy and flexible wireless backhaul solution designed to meet the highest throughput and reliability requirements.

For more information please contact us!

www.sub10systems.com

Technical specifications for Liberator-V1000

Frequency Bands	57 - 64 GHz Band
Modulation	8-PSK / QPSK / BPSK
Range	up to 800 metres
Ethernet throughput	1Gbps (full-duplex 8-PSK)
Max Tx Power	+6 dBm
Max EIRP	44 dBm
RX Sensitivity	-60 dBm
Channel width	250 / 500 MHz
Antenna gain	38 dBi
Link adaptation	Adaptive coding & modulation, ATPC
Interference immunity	Channel switch capability
Availability	Up to 99.999% (use Sub10 Link Availability Calculator)
MTBF	25 years
Wind load	160 km/h (operating) and 200 km/h (survival)
Ethernet frame size	64 bytes up to 9,600 bytes
Latency	< 200 microseconds
Synchronisation	SyncE, IEEE 1588v2, patent pending snapback technology
VLAN for management	IEEE 802.1Q
QoS	Flow control, 802.1p, DiffServ, 8 queues
Network management	SNMP v1, v2c, v3
GUI	HTTP web-browser
Encryption	AES 256 bit as an option available
Connector	RJ-45 (outdoor gigabit Ethernet seal kit included)
Voltage alignment port	Waterproofed QMA socket
ODU Terminal size	182 x 182 x 68mm
Weight	2,5 kg
Power supply	Power Over Ethernet ("Ultra-PoE" / PoE++), consumption 30W
Operating temperature	-40°C to +55°C

Contact Information:

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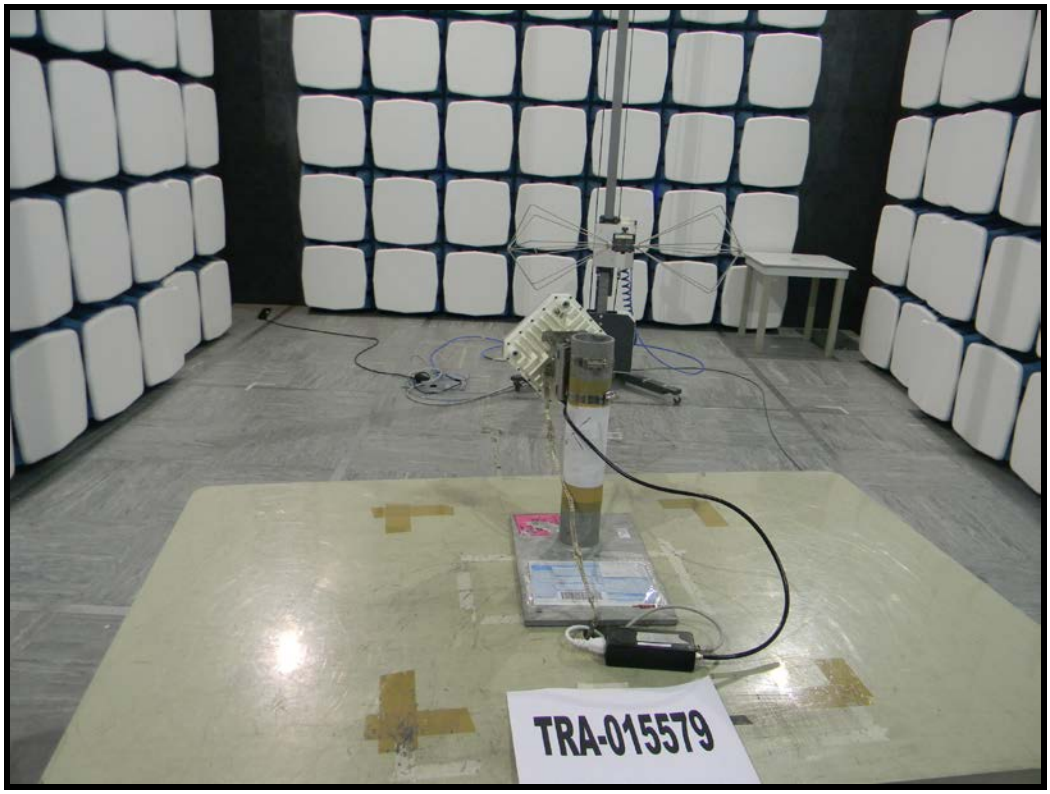
Devon, TQ12 3RZ, United Kingdom

Telephone: +44 (0) 16 26 - 81 85 20
E-Mail: info@sub10systems.com
Web: www.sub10systems.com

Appendix E: Photographs and Figures

Photograph 1 Radiated Spurious Emissions - Front View
Photograph 2 Radiated Spurious Emissions - Rear View

Photograph 1



Photograph 2