FLEXTRONICS

EMC Test Report
for
ARUS 32 B4

Radio Access Technology (RAT): LTE

Tested to:	**CFR 47 FCC Part 15 B** **CFR 47 FCC Part 27** **ICES-003** **RSS-139**
Document number:	**K0002479-TR-RAD-01-01**
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Prepared for:	**Ericsson Canada** **349 Terry Fox Drive,** **Ottawa, Ontario,** **Canada, K2K 2V6**

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About this document

The release control record, document approvals, and laboratory Accreditations are as follows.

Release control record

Release no.	Reason for change	Date released
01	Initial release	Aug 29, 2014

Approvals

Function	Name	Job title	Record of Approval
Document Release Approval	Steve Tippet	Lab Operations Manager	Damien Warin on behalf of Steve Tippet
Technical reviewer	Kasi Sivaratnam	EMC Discipline Specialist	
Author	Dave Pampararo	Product Compliance Specialist	

Accreditations

The Design Validation Centre (DVC) test facilities are accredited by the Standards Council of Canada (SCC) to ISO/IEC 17025 in accordance with the scope of accreditation outlined at the web site http://palcan.scc.ca/Specs/PDF/95_e.pdf [16]. The SCC is a signatory of the APLAC [4] and ILAC [14] Mutual Recognition Arrangements. The SCC's Laboratory Accreditation Program has been evaluated and has demonstrated its competence to operate according to the requirements of ISO/IEC 17011.

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1. Introduction

This document is written and distributed by Flextronics Canada Design Services Inc. Whenever Flextronics is mentioned in this document it shall be taken as referring to Flextronics Canada Design Services Inc.

1.1 Purpose and scope

This document reports the results and findings of the Electromagnetic Compatibility (EMC) test activities performed by the Design Validation Centre (DVC) on the product KRC 118 050/1 ARUS 32 B4 for Ericsson Canada. The objective of the test activities was to evaluate compliance of the product in multiple radio modes of operation against:

- Radiated Emissions and Conducted Emissions of FCC Part 15 Subpart B [12] and ICES-003 [13].
- Spurious Emissions of FCC Part 27 [12] and RSS-139 [10]

1.2 Executive summary

The ARUS 32 B4 radio, tested in LTE modes of operation, is verified to comply with the following standards:

- Radiated Emissions and Conducted Emissions of FCC Part 15 Subpart B [12] and ICES-003 [13].
- Spurious Emissions of FCC Part 27 [12] and RSS-139 [10]

The test results in this report apply only to the tested units.

The configuration, operation, support equipment and setup of the ARUS 32 B4 / AIR 32 B4A B2P are described in Section 3.

The assessment activities and detailed test results for the ARUS 32 B4 / AIR 32 B4A B2P are presented in the Section 5 of this document.

1.3 Test lab information

Lab Name	Flextronics Design Validation Centre
Mailing / Shipping Address	1280 Teron Rd., Kanata, Ontario, K2K 2C1, Canada
Primary Technical Contact	Steve Tippet
Title	Manager of Regulatory Design & Compliance
Phone	613-895-2050, extension 2820

1.4 Customer information

Company Name	Ericsson Canada
Mailing Address	349 Terry Fox Drive, Ottawa, On, K2K 2V6, Canada
Primary Contact	David Bolzon
Title	Hardware Developer, Object Leader, Regulatory / Product Integrity
Phone	1.613.219.5892
E-mail	david.bolzon@ericsson.com

2. Test results summary

Table 1 summarizes the regulatory test case results for selected worst case modes of operation of the ARUS 32 B4. The ARUS 32 was tested in an AIR 32 B4A B2P host test platform. The EUT is DC powered therefore AC power test cases are not applicable.

Table 1: Summary of test results

Test case description	Test result	Radio Mode of Operation
Radiated Emissions (RE) from 30MHz to 22 GHz FCC Part 15 Subpart B – Class B ICES 003 – Class B	Pass	LTE Bottom Channel 1.4MHz BW QPSK 1 Carrier
AC Power Conducted Emissions FCC Part 15 Subpart B – Class B ICES 003 – Class B	Not Applicable	
Spurious Emissions , traffic mode RSS-139, RSS-GEN, FCC Part 27	Pass	
Radiated Emissions (RE) from 30MHz to 22 GHz FCC Part 15 Subpart B – Class B ICES 003 – Class B	Pass	LTE Middle Channel 1.4MHz BW QPSK 1 Carrier
AC Power Conducted Emissions FCC Part 15 Subpart B – Class B ICES 003 – Class B	Not Applicable	
Spurious Emissions , traffic mode RSS-139, RSS-GEN, FCC Part 27	Pass	
Radiated Emissions (RE) from 30MHz to 22 GHz FCC Part 15 Subpart B – Class B ICES 003 – Class B	Pass	LTE Top Channel 1.4MHz BW QPSK 1 Carrier
AC Power Conducted Emissions FCC Part 15 Subpart B – Class B ICES 003 – Class B	Not Applicable	
Spurious Emissions , traffic mode RSS-139, RSS-GEN, FCC Part 27	Pass	
Radiated Emissions (RE) from 30MHz to 22 GHz FCC Part 15 Subpart B – Class B ICES 003 – Class B	Pass	LTE 1.4MHz BW QPSK 2 Carrier
AC Power Conducted Emissions FCC Part 15 Subpart B – Class B ICES 003 – Class B	Not Applicable	
Spurious Emissions , traffic mode RSS-139, RSS-GEN, FCC Part 27	Pass	

3. Equipment under test

3.1 Assessed hardware

Table 2 indicates the hardware that was assessed. The unit was operating in LTE mode.

Table 2: Assessed hardware

Hardware component	Part number	Release number
ARUS 32 B4	KRC 118 050/1	R1A

3.2 Product overview

The ARUS 32 B4 is a multi-standard Antenna Radio Unit (ARUS) forming part of Ericsson's Radio Base Station (RBS) equipment. The ARUS product provides the radio access for mobile and fixed devices and is intended for the outdoor environment.

The ARUS 32 B4 is designed to be co-located and directly mated with a compatible antenna, specified for transceiver path optimization. A fibre optic interface provides the ARUS / RBS control and digital communications between the Radio and RBS. The location of the ARUS with respect to the RBS is only limited to a distance dictated by the limitations of the fibre link.

The ARUS 32 B4 supports four (4) Transmit / Receive ports operating in the E-UTRA Band 4 (AWS) at a Downlink (transmit) frequency from 2110 MHz to 2155 MHz and an Uplink (receive) frequency from 1710 MHz to 1755 MHz. The radio operates in FDD (Frequency Division Duplex) with a duplex spacing of 400 MHz and supports operation on multi Radio Access Transmission Standards (RATS) at transmit bandwidths up to 20 MHz. The ARUS 32 B4 radio operates over the 4 transmit ports in Single, Multi-Carrier, Mixed Mode, and MIMO transmission with a maximum rated RF output power of 30W per port over an operational temperature of -40° C to +55° C.

The ARUS is mounted directly behind a specified antenna along with a Fan Tray and Solar Shield cover, which provides Forced Air Cooling and ducting for directional air flow and thermal optimization. The Fan Tray has an internal controller which will vary the fan speed based on temperature and cooling requirements monitored by sensors in the ARUS and Fan Tray. Power for the Fan Tray is provided from the ARUS (28V ±6% @ 1.25A).

The ARUS product also has an active RET (Remote Electronic Tilt) function provided for antenna directional optimization. Power for this option is provided via the ARUS RET interface (30V @ < 2A).

Figure 1: AIR 32 B4A B2P Test Platform for ARUS 32 B4 EMC testing and compliance assessment

Figure 2: ARUS 32 B4

Table 3: Product Technical Details

Model:	**ARUS B4**	**AIR 32 B4A B2P**
Part No.	KRC 118 050/1	KRD 901 044/1
Antenna Ports:	4 TX/RX Ports (Coaxial Kenya)	4 TX/RX Ports (Coaxial Nairobi)
IBW:	45MHz	
FDD:	400MHz	
Frequency:	TX (DL): 2110 - 2155MHz	
	RX (UL): 1710 - 1755MHz	
Nominal O/P per Antenna Port:	Single Carrier: 1 x 30W (44.77dBm)	
Up to 20MHz Carrier BW	Multi-Carrier: 2 x 15W (41.76dBm)	
Up to 15MHz Carrier BW	Multi-Carrier: 3 x 10W (40.00dBm)	
Up to 10MHz Carrier BW	Multi-Carrier: 4 x 7.5W (38.75dBm)	
Accuracy (Nominal):	>5MHz from BE: ±0.3dB (25°C), ±0.6dB (45-55°C)	
Nominal Voltage:	-48 VDC @ 20A	
RAT:	LTE: SC, MC	
Modulation:	QPSK, 16QAM, 64QAM	
Channel Bandwidth:	1.4, 3, 5, 10, 15, 20 MHz	
Maximum Combined OBW per Port:	45MHz	
Digital Interface:	CPRI: 2.5Gbps / 5Gbps /10Gbps (Data 1, Data 2)	
Channel Raster:	100kHz	
Regulatory Requirements:	FCC: CFR 47 Part 2, 27	
	EMC: CFR 47 Part 15	
	IC: RSS-GEN, RSS-139	
	EMC: ICES-003	
SR and MC:	MIMO 4 x 4, TX Diversity	
Regulatory ID:	FCC: TA8AKRC118050-1	
	IC: 287AB-AS1180501	
	IC Model: AS1180501	
Operating Temperature:	-40°C to +55°C	
Total Power based on IBW:	45MHz IBW: 4 x 30W	With KRD Forced Air Cooling
LTE Supported Carrier Configurations:	BW=1.4, 3, 5, 10 (1-4); BW=15 (1-3); BW=20 (1-2)	
Dimensions	460 x 310 x 120 mm [H x W x D]	

Table 4: Channel Frequencies

Number of Carriers	Bandwidth	Carrier Frequency Configuration (MHz)		
		Bottom	Middle	Top
1	1.4 MHz	2110.7	2132.5	2154.3
1	3 MHz	2111.5	2132.5	2153.5
1	5 MHz	2112.5	2132.5	2152.5
1	10 MHz	2115.0	2132.5	2150.0
1	15 MHz	2117.5	2132.5	2147.5
1	20 MHz	2120.0	2132.5	2145.0
2	1.4 MHz	-	2110.7 + 2154.3	-
2	3 MHz	-	2111.5 + 2153.5	-
2	5 MHz	-	2112.5 + 2152.5	-
2	10 MHz	-	2115.0 + 2150.0	-
2	15 MHz	-	2117.5 + 2147.5	-
2	20 MHz	-	2120.0 + 2145.0	-
4	1.4 MHz	-	2110.7 + 2112.1 + 2152.9 + 2154.3	-
4	3 MHz	-	2111.5 + 2114.5 + 2150.5 + 2153.5	-
4	5 MHz	-	2112.5 + 2117.5 + 2147.5 + 2152.5	-
4	10 MHz	-	2115 + 2125 + 2140 + 2150	-

3.3 System modifications

There were no modifications made to the system or its sub-assemblies under test.

3.4 Power and grounding requirements

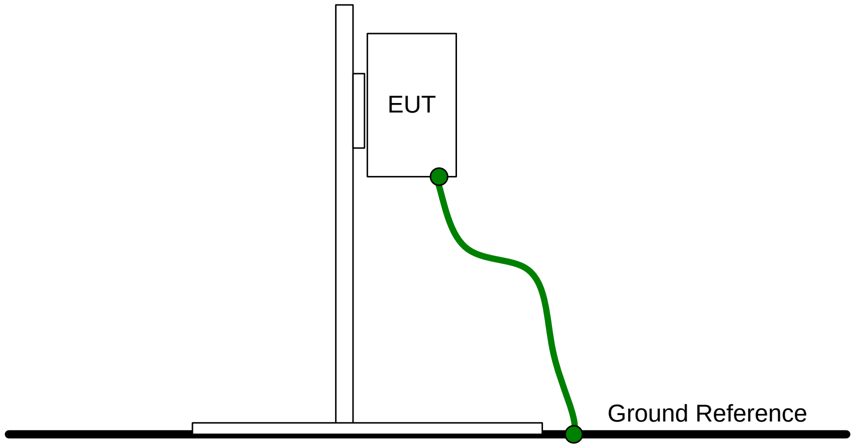
The power requirements for the ARUS 32 B4 are as follows.

Table 5: DC power requirements

Voltage	Rated Current
-48 V DC	Rated Current: 20 Amp at 4 x 30W RF output

For EMC testing, the system was grounded in the same manner as its typical installation as shown in Figure 3.

Figure 3: System grounding



3.5 Clocks, oscillators, or switching frequencies for power supplies

- OOK: 2.176 MHz
- FSK: 9.69/11.07 MHz
- BFN, BCLK: 10.00 MHz
- AIB: 14.40 MHz
- XP: 19.44 MHz
- Eth: 25.000 MHz
- BFN, BBCLK: 30.72 MHz
- ADC, Surveyor: 61.44 MHz
- DAC, TOR: 122.88 MHz
- DAC data: 245.76 MHz
- DAC clk: 491.52 MHz
- ADC: 983.04 MHz
- CPRI E.6: 614.4 (Mb/s)
- CPRI E.24: 2457.6 (Mb/s)
- CIPRI E.48: 4915.2 (Mb/s)
- CIPRI E.96: 9.8304 (Gb/s)
- RXIFLO: 439.04 MHz
- RXRFLO: 2090.90 MHz
- TXRFLO: 2112.50, 2132.50, 2152.50 MHz
- TOR_LO : 2266.10,2286.101306.10 MHz

3.6 Product port definition and EUT cable information

Table 6 identifies all the cables and ports on the system tested.

Table 6: AIR32 B4A B2P port definition

Port or cable designation	Interface description	Port location	Permanent connection	Shielded cable	Max cable length (m)	Max quantity	Environ-ment
DC Power	48V, 3 Wire	DC PWR In	Yes	Yes	>10	1/system	Outdoor
Ground	Main Unit Ground cable	GND Point, bottom, centre	Yes	No	3	1/system	Outdoor
Data 1	CPRI Fiber Cable	Bottom, inner most	Yes	No	15 KM	1/system	Outdoor
Data 2	CPRI Fiber Cable	Bottom, outer most	Optional	No	15 KM	1/system	Outdoor
RF A, B, C, D	Transmit and Receive Cable	Test Unit Modified for access to these ports.	No	Yes	>10	1/port	Outdoor

Table 7 identifies the cables present during testing.

Table 7: Cable description

Cable ref #	Port or cable designation	Qty	Cable length (m)	Termination during testing
1	DC Power	1	3	Lab Power Source, -48 VDC
2	Ground Cable	1	2	Lab Ground Location
3	Data 1	1	10	STS-2
4	Data 2	1	10	STS-2
5	RF A, B, C, D	1 per port	7.5	STS-2
ARUS 32 B4 Accessory Cables				
6	Fan Power & Signal Cable	1	292 mm	Terminated into Fan Tray (power and signal)
7	RET: Cable (SMA coax)	1	20 mm	Terminated into the antenna RET port. (30V @ < 2A)
8	MMI: Optical LED Indicator interface	1	965mm	No Termination (indicator only)

3.7 Software and operations of the EUT

The software load used to operate the system was representative of the latest production software.

The software version number was R59AE.

3.8 Customer support equipment

During emissions testing the system was configured with a STS-2.

Table 8: Test support equipment

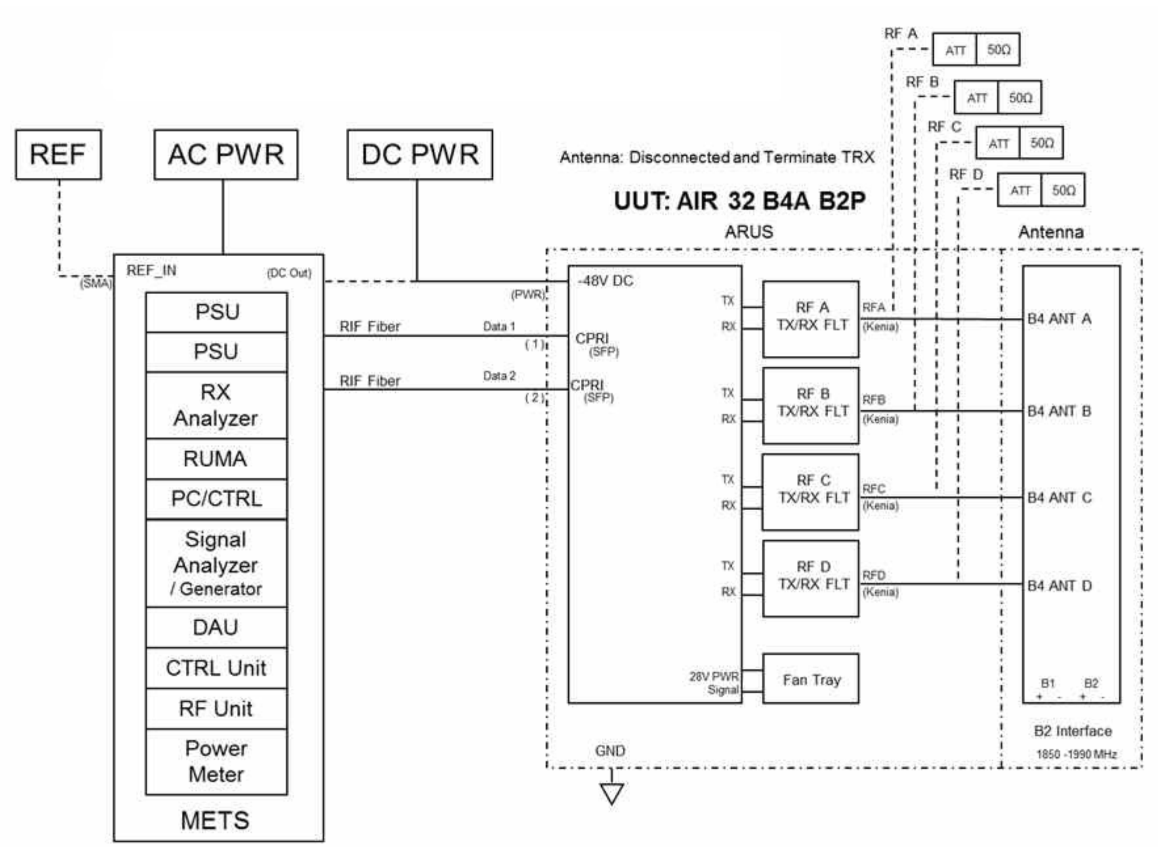
Make	Model
Ericsson	STS-2 / CT-10 Software load to R17B08

3.9 Hardware Configuration of the EUT

Traffic mode, channel, and operational mode were set to achieve required test coverage. Figure 4 shows the test setup of the radio and support equipment with cabling for the Emissions testing.

Section 5.1.5 describes the rationale for test coverage of multiple radio mode settings.

Figure 4: Setup for Emission Testing



Photographs of all the test configurations used throughout this test report are in Appendix A: Test setup photographs.

3.10 Inventory of the EUT

The following table identifies the ARUS 32 B4's units that were tested.

Table 9: Inventory

Component	Part number	Release number	Serial number
ARUS 32 B4	KRC 118 050/1	R1A	C828074984

4. General test conditions

4.1 Description of test facilities

Radiated Emissions testing was performed in a 10-meter Ambient Free Chamber (AFC). The AFC consists of a shielded room lined with ferrite tiles and anechoic material.

The temperature and humidity in these test facilities are controlled and maintained between 15 ºC and 35 ºC with a relative humidity between 30 % and 60 %. Levels are recorded and any exceptions are included in the detailed test results sections of this report.

The above facilities are located at 1280 Teron Road, Kanata, Ontario, Canada.

Facility accreditation information is located in the Accreditations section of this test report.

4.2 Measurement Instrumentation

The measurement instrumentation conforms to ANSI C63.2 [1] and CISPR 16 [5]. Calibration of the measurement instrumentation is maintained in accordance with the supplier's recommendations, or as necessary to ensure its accuracy.

5. Detailed Emissions Test Results

Emissions from telecommunication systems manifest themselves in two forms: Conducted Emissions on cables and Radiated Emissions from the entire system (that is, electronic modules, hardware, and cables). Emissions standards restrict these different forms of emissions generated by the system. For information on test facilities and measurement instrumentation, see Section 4.

5.1 Radiated Emissions, E-field (FCC & ICES)

This test verifies that the EUT does not produce excess amounts of E-field Radiated Emissions (RE) that could interfere with licensed radiators.

5.1.1 Test specification and limits

The testing requirements are as follows.

Table 10: Radiated emissions requirements

Requirement	Method	Country
FCC Part 15.109, Subpart B	ANSI C63.4	USA
ICES-003		Canada

The limits of the E-field RE tests are as follows:

Table 11: E-field RE test limits at 10 m for Class B of FCC & ICES-003

Frequency range (MHz)	**FCC Part 15 ICES-003** (dBμV/m)
30 to 88	29.5
88 to 216	33.0
216 to 960	35.5
960 to 40000	43.5

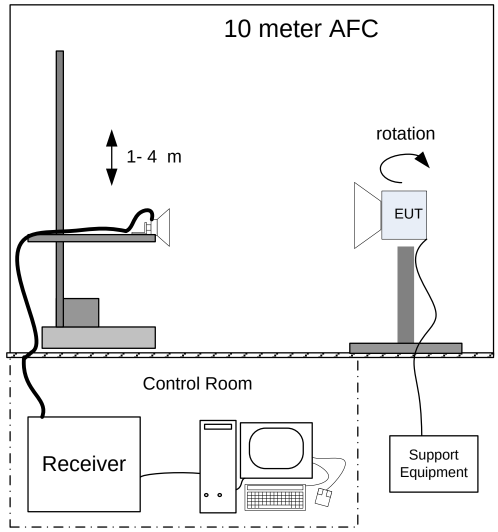
5.1.2 Test procedure

Verifications of the test equipment and AFC were performed before the installation of the EUT in accordance with the quality assurance procedures documented in the EMC test procedures document [9]. The test was performed using the procedures described in ANSI C63.4 [2] and FCC Part 15 [10].

- The EUT was placed on the turntable inside the AFC (configured as in normal operation) as shown in Figure 5. The system and its cables were separated from the ground plane by an insulating support 10 mm in height. The system was grounded in accordance with its installation specifications. No additional grounding connections were connected.

- For tests between **30 MHz and 1 GHz** the receive bi-log antenna was placed at 3 m away from the EUT. An initial scan was performed to find emissions (frequencies) requiring detailed measurement. The pre-scan was performed by rotating the system 360 degrees while recording all emissions (frequency and amplitude). This procedure was repeated for antenna heights of 1 to 4 m, and for horizontal and vertical polarizations of the receiving antenna. The detector mode was quasi-peak (QP) unless otherwise noted.
- For tests between **1 GHz and 10 GHz** the receive horn antenna was placed at 3 m away from the EUT. An initial scan was performed to find emissions (frequencies) requiring detailed measurement. The pre-scan was performed by rotating the system 360 degrees while recording all emissions (frequency and amplitude). This procedure was repeated for antenna heights of 1 to 4 m, and for horizontal and vertical polarizations of the receiving antenna. The detector mode was average (AVG) unless otherwise noted. The peak level can be no more than 20 dB above this limit.
- For tests between **10 GHz to 18 GHz** the receive horn antenna was placed at a 3 m distance from the EUT. An initial scan was performed to find emissions (frequencies) requiring detail measurement. The pre-scan was performed by rotating the system 360 degrees while recording all emissions (frequency and amplitude). This procedure was repeated for antenna heights of 1 to 4 m, and for horizontal and vertical polarizations of the receiving antenna. These measurements were made with an average detector mode (AVG) unless otherwise noted.
- For tests between **18 GHz to 26.5 GHz** the receive horn antenna was placed at a 1 m distance from the EUT. An initial scan was performed to find emissions (frequencies) requiring detail measurement. The pre-scan was performed manually in close proximity to the EUT to find any system emissions in this frequency band. This search was performed on four sides of the EUT, along the entire height of the EUT, using both polarization of the receive antenna. Final measurements were made with an average detector mode (AVG) unless otherwise noted.
- For **all the above frequency ranges** optimization was performed based on the pre-scan data. For each identified frequency, the EUT was rotated in azimuth over 360 degrees and the direction of maximum emission was noted. Antenna height was then varied from 1 to 4 m at this azimuth to obtain maximum emissions. The procedure was repeated for both horizontal and vertical polarizations (where applicable) of the search antenna. The maximum level measured was recorded.

Figure 5: Test setup for Emissions Measurements



5.1.3 Calculation of the compliance margin

The following parameters and coefficients are used to calculate and derive compliance levels and margins with respect to measurement results and test parameters. The example below illustrates the manner in which the emissions levels are calculated.

The rows in these tables are defined as follows.

Meter Reading (dBµV) =	Voltage measured using the spectrum analyzer with the proper detector
Gain/Loss Factor (dB) =	Cumulative gain or loss of pre-amplifier and cables used in the measurement path (a negative value indicates gain)
Correction (dB) =	Gain/Loss Factor (dB) + Antenna factor (dB)
Level (dBµV/m) =	Corrected value or field strength, that is, the parameter of interest that is compared to the limit
Margin (dB) =	Level with respect to the appropriate limit (a positive Margin indicates that the Level is below the limit and that the measurement is a PASS)

The values in the Level row are calculated as follows:

Level = Meter Reading + Correction (dB)

The values in the Margin row are calculated as follows:

Margin = Limit – Level

5.1.4 Measurement uncertainties

Uncertainty evaluation has been calculated according to the method described in CISPR 16 [5]. The expanded measurement instrumentation uncertainty (with a 95 % level of confidence) on E-field RE is:

- ± 3.8 dB between 30 MHz and 1 GHz
- ± 4.7 dB between 1 GHz and 10 GHz
- ± 4.8 dB between 10 GHz and 18 GHz
- ± 4.6 dB between 18 GHz and 26.5 GHz

5.1.5 Strategy for selection of multiple radio modes to be tested

In order to determine the worst case emissions for all operating configurations, the ARUS 32 B4 was operated at full power and scanned for emissions during a pre-compliance assessment. The purpose for this exercise was to ensure that the selected configurations represented the absolute worst case configurations / scenarios with respect to emissions. This prescan assessment determined that the following configurations required full compliance testing.

For this determination, the EUT was configured for LTE RAT, QPSK, 1.4MHz BW with:

a) LTE RAT, QPSK, 1.4MHz BW Top channel, single carrier
b) LTE RAT, QPSK, 1.4MHz BW Middle channel, single carrier
c) LTE RAT, QPSK, 1.4MHz BW Bottom channel, single carrier
d) LTE RAT, QPSK, 1.4MHz BW 2 carrier

5.1.6 Test results for RAT: BOT Channel, 1.4MHz QPSK, 1 Carrier, LTE

Test location: DVC 10-meter AFC
Date tested: Aug 7, 2014
Tested by: Martin Lee / Kasi Sivaratnam
Test setup: See Appendix A: Test setup photographs.

Figure 6: Plot of RE from 10 KHz to 30 MHz (Bottom 1.4QPSK 1C LTE)

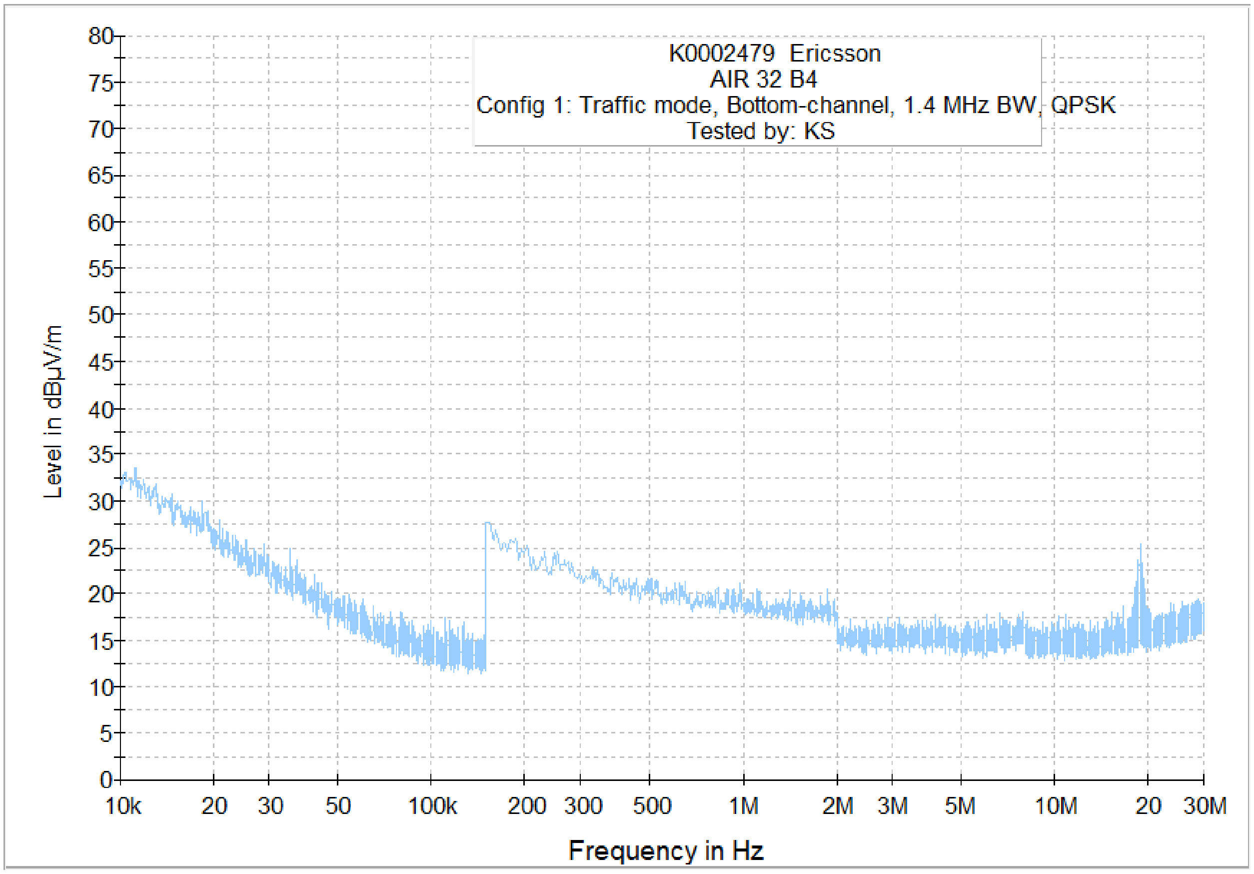


Figure 7: Plot of RE from 30 MHz to 1 GHz (Bottom 1.4QPSK 1C LTE)

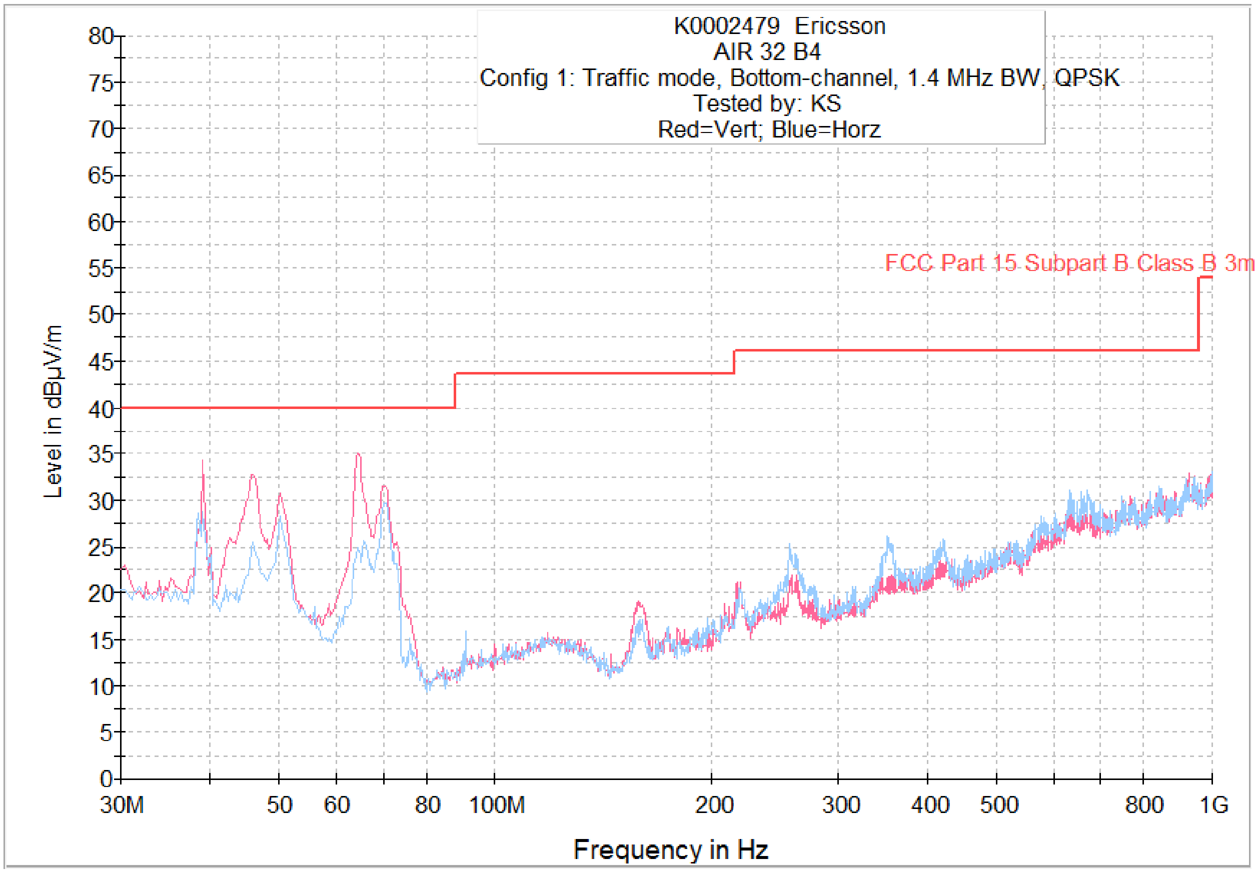
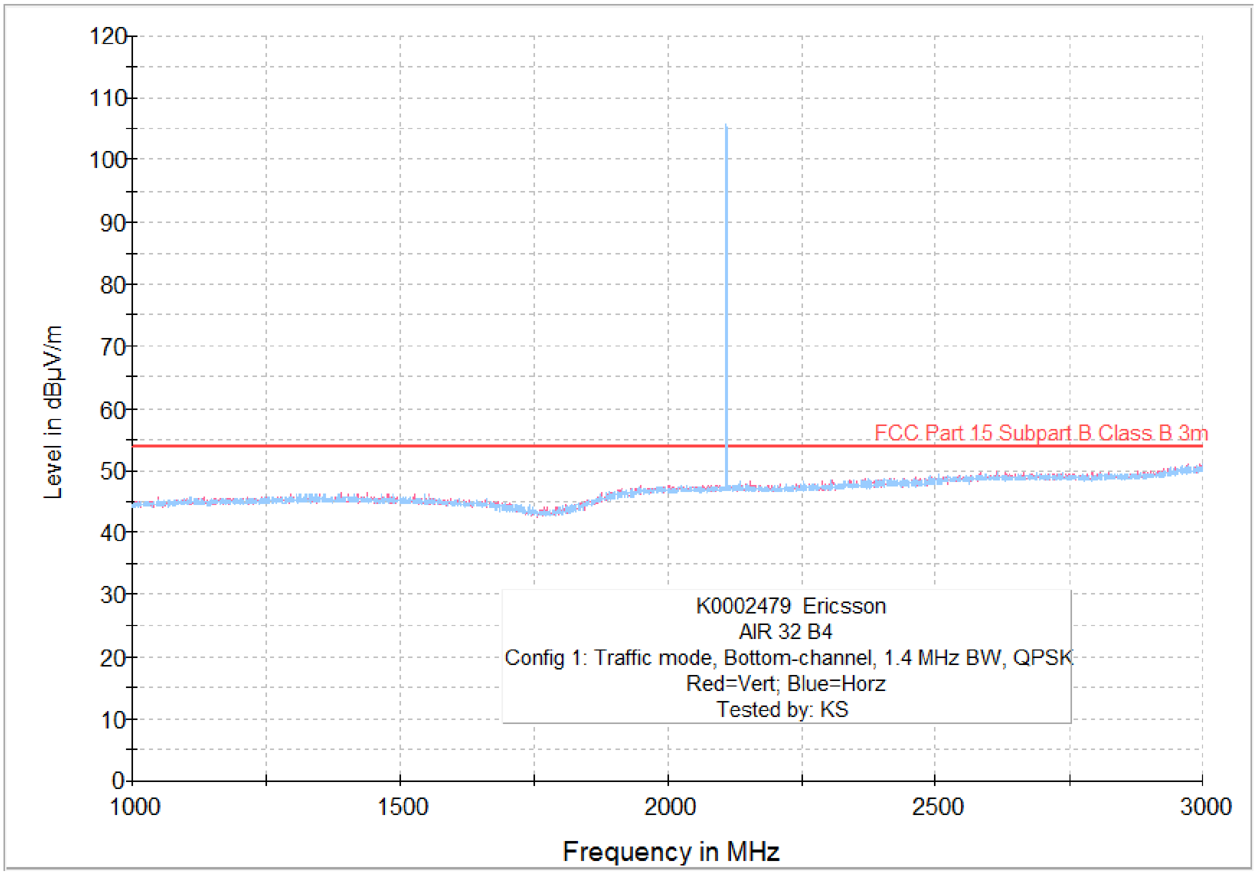


Table 12: E-field RE test results at 3 m for FCC part 15 from 30 to 1000 MHz (Bottom 1.4QPSK 1C LTE)

Frequency (MHz)	Level (dBµV/m)	Detector	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin to FCC Limit (dB)	Note
39.345750	17.9	QP	102	V	171	17.2	22.0	
45.819750	32.1	QP	102	V	98	16.3	7.9	
50.199750	29.2	QP	102	V	101	15.4	10.8	
64.671750	33.1	QP	203	V	283	10.0	6.8	
69.998250	30.6	QP	323	V	2	8.4	9.3	

Figure 8: Plot of RE from 1 to 3 GHz (Bottom 1.4QPSK 1C LTE)



Note 1: The emission shown above the limit is the radio transmit frequency.

Table 13: E-field RE test results at 3 m for FCC part 15 from 1 to 3 GHz (Bottom 1.4QPSK 1C LTE)

Frequency (MHz)	Level (dBµV/m)	Detector	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin to FCC Limit (dB)	Note
2996.408000	47.7	AVG	401.0	H	1	25	6.3	Noise Floor

Figure 9: Plot of RE from 3 to 10 GHz (Bottom 1.4QPSK 1C LTE)

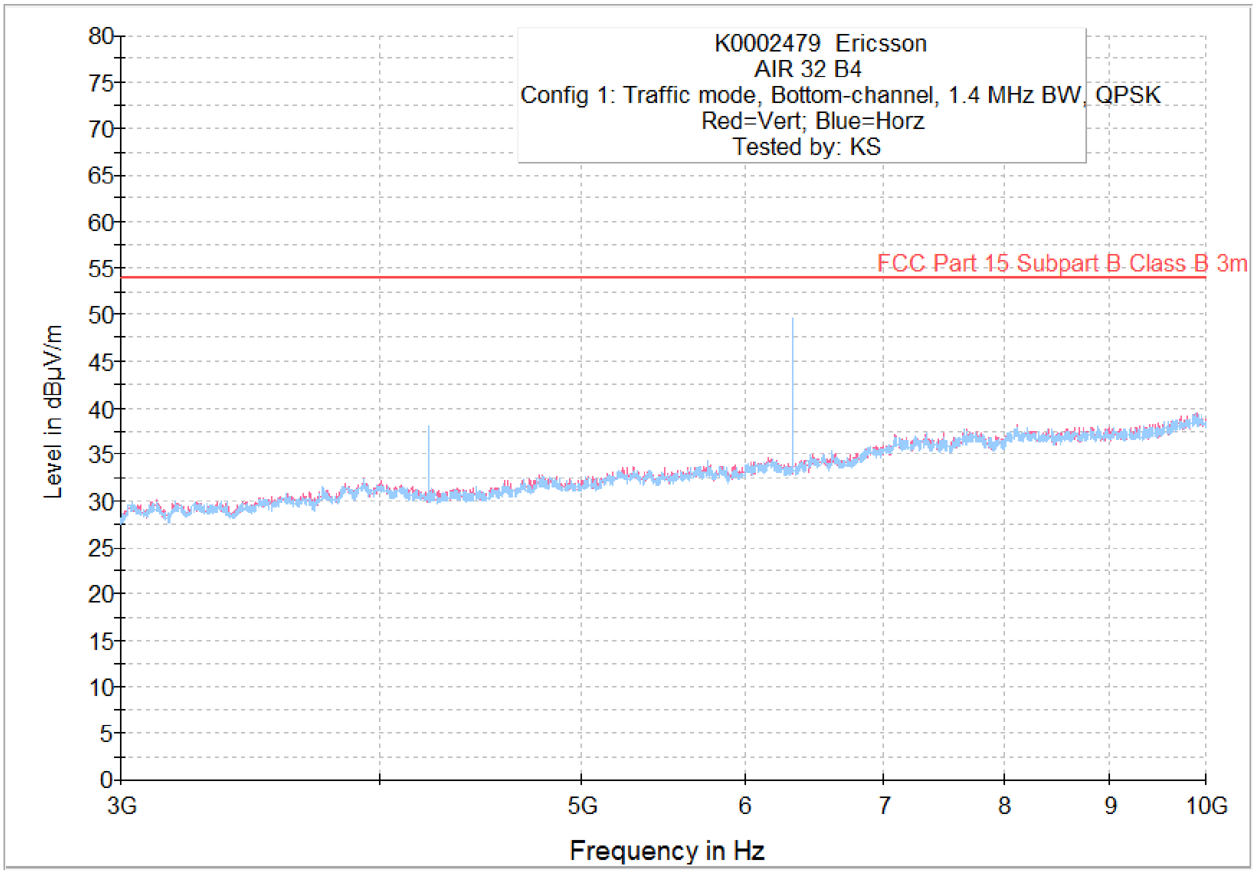
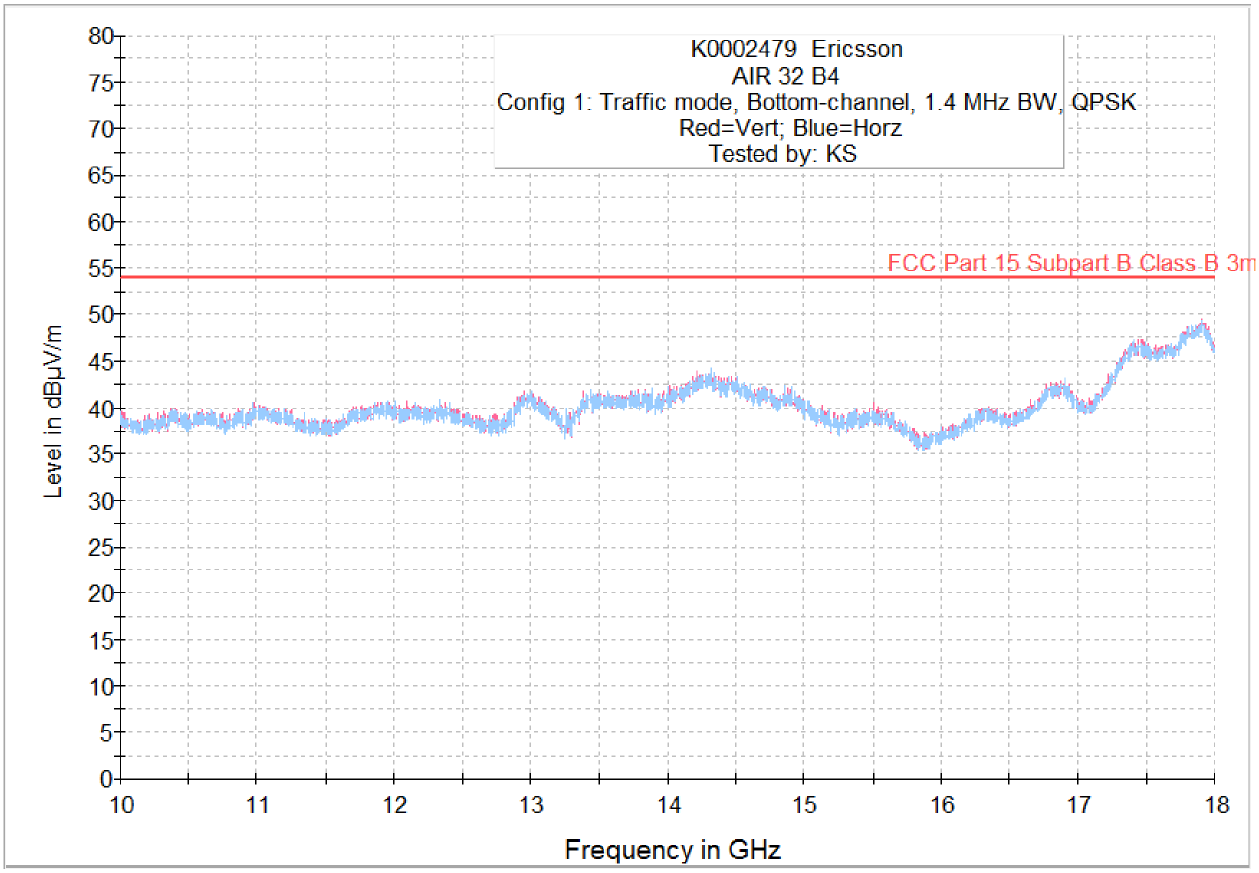


Table 14: E-field RE test results at 3 m for FCC part 15 from 1 to 3 GHz (Bottom 1.4QPSK 1C LTE)

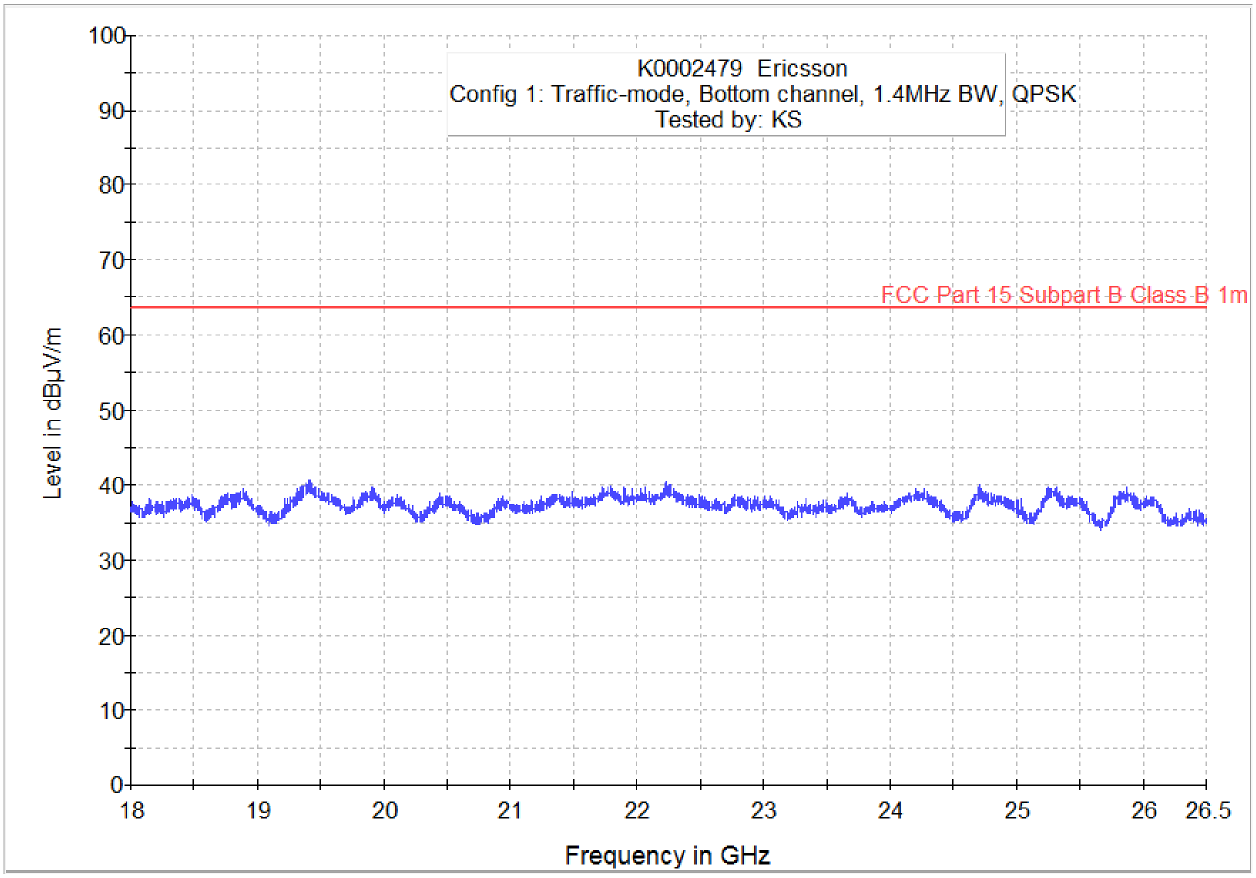
Frequency (MHz)	Level (dBµV/m)	Detector	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin to FCC Limit (dB)	Note
4221.285000	37.6	AVG	112	H	65	0.0	16.4	
6332.280000	47.4	AVG	203	H	173	5.3	6.6	

Figure 10: Plot of RE from 10 to 18 GHz (Bottom 1.4QPSK 1C LTE)



Note 1: All frequencies measured had greater than 6dB of passing margin. The noise floor in the upper frequency band was verified.

Figure 11: Plot of RE from 18 to 26.5 GHz (Bottom 1.4QPSK 1C LTE)



Note 1: There were no emissions within 6 dB of the limit to report.

5.1.7 Test results for RAT: Middle Channel, 1.4MHz QPSK, 1 Carrier, LTE

Test location:	DVC 10-meter AFC
Date tested:	Aug 7, 2014
Tested by:	Martin Lee / Kasi Sivaratnam
Test setup:	See Appendix A: Test setup photographs.

Figure 12: Plot of RE from 10 KHz to 30 MHz (Middle 1.4QPSK 1C LTE)

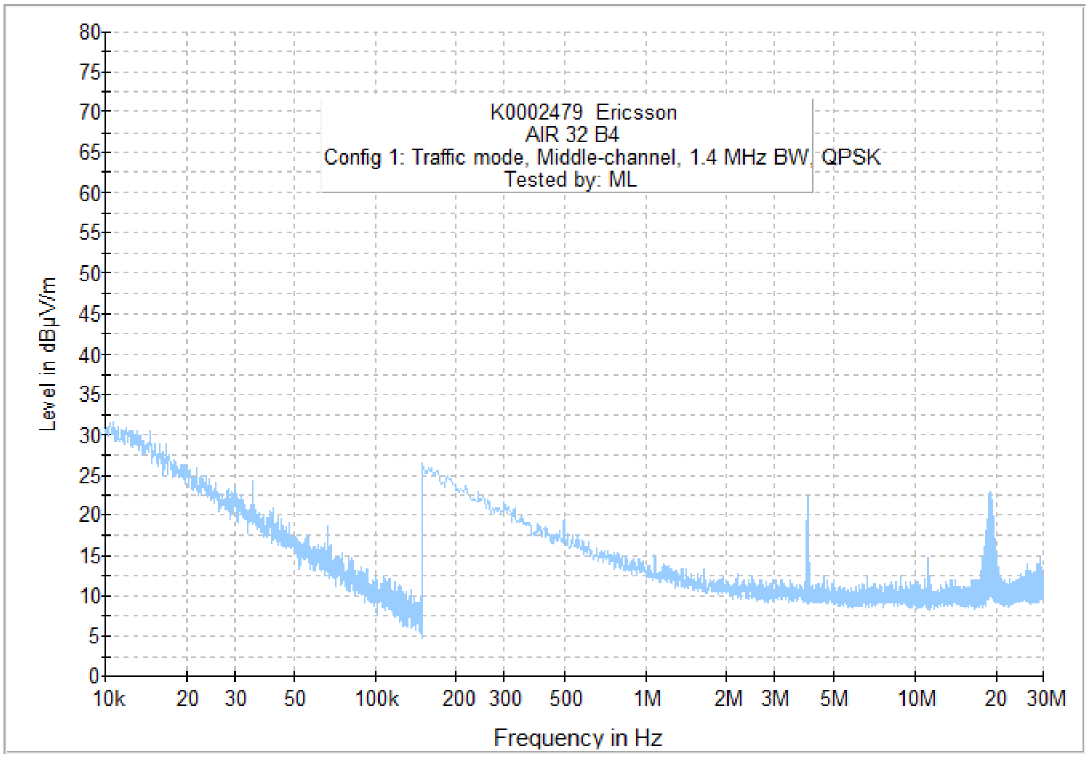


Figure 13: Plot of RE from 30 MHz to 1 GHz (Middle 1.4QPSK 1C LTE)

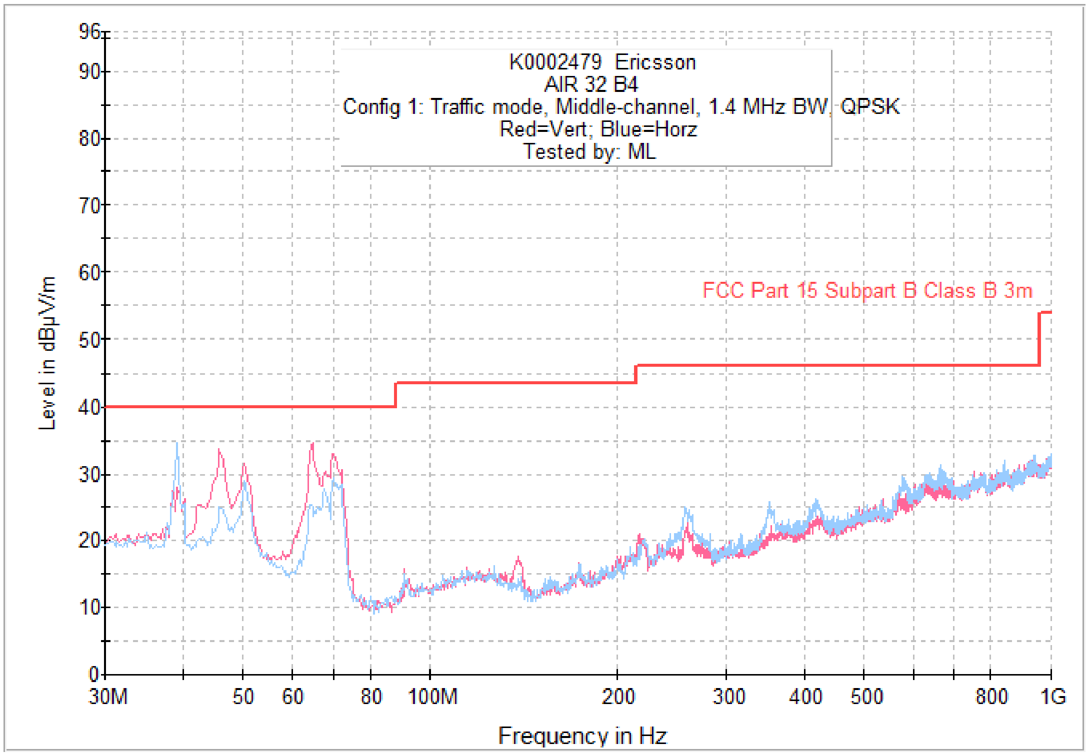
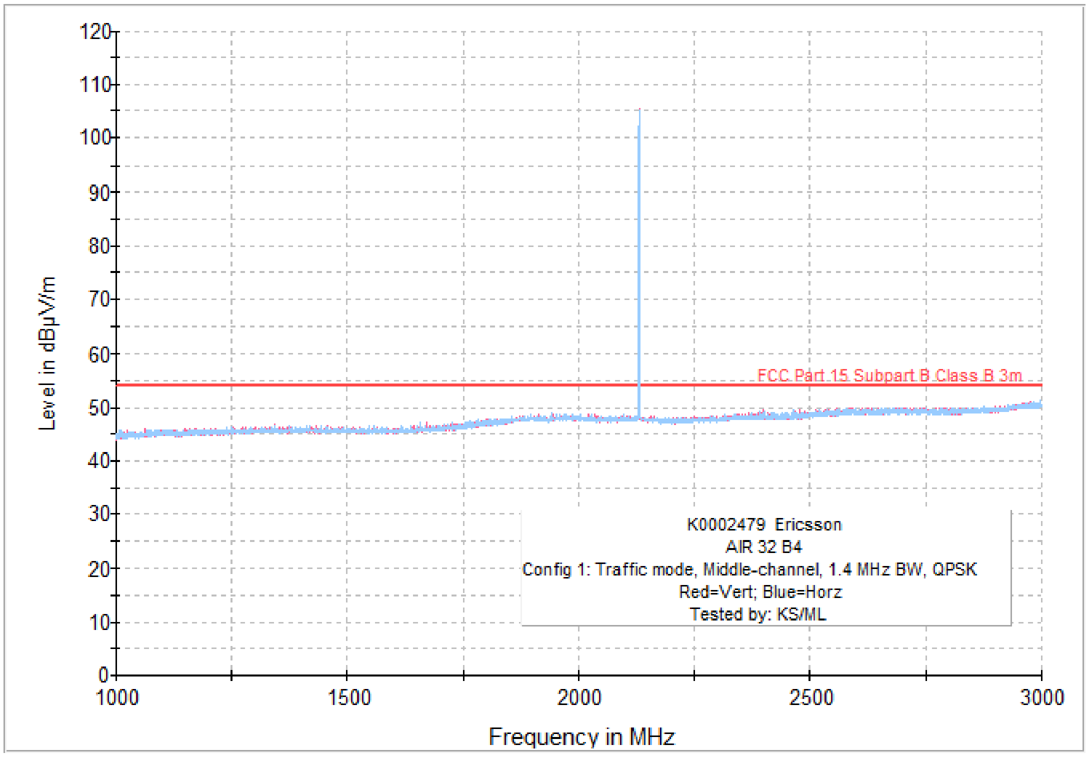


Table 15: E-field RE test results at 3 m for FCC part 15 from 30 to 1000 MHz (Middle 1.4QPSK 1C LTE)

Frequency (MHz)	Level (dBµV/m)	Detector	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin to FCC Limit (dB)	Note
39.224250	15.2	QP	102	H	2	17.2	24.8	
45.833750	34.6	QP	102	V	100	16.3	5.3	
50.183750	32.9	QP	102	V	106	15.4	7.0	
64.539250	35.1	QP	203	V	277	10.1	4.9	
70.018750	33.4	QP	203	V	325	8.4	6.5	

Figure 14: Plot of RE from 1 to 3 GHz (Middle 1.4QPSK 1C LTE)



Note 1: The emission shown above the limit is the radio transmit frequency.

Table 16: E-field RE test results at 3 m for FCC part 15 from 1 to 3 GHz (Middle 1.4QPSK 1C LTE)

Frequency (MHz)	Level (dBµV/m)	Detector	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin to FCC Limit (dB)	Note
2996.964000	47.6	AVG	277.0	H	0	25.3	6.4	Noise Floor

Figure 15: Plot of RE from 3 to 10 GHz (Middle 1.4QPSK 1C LTE)

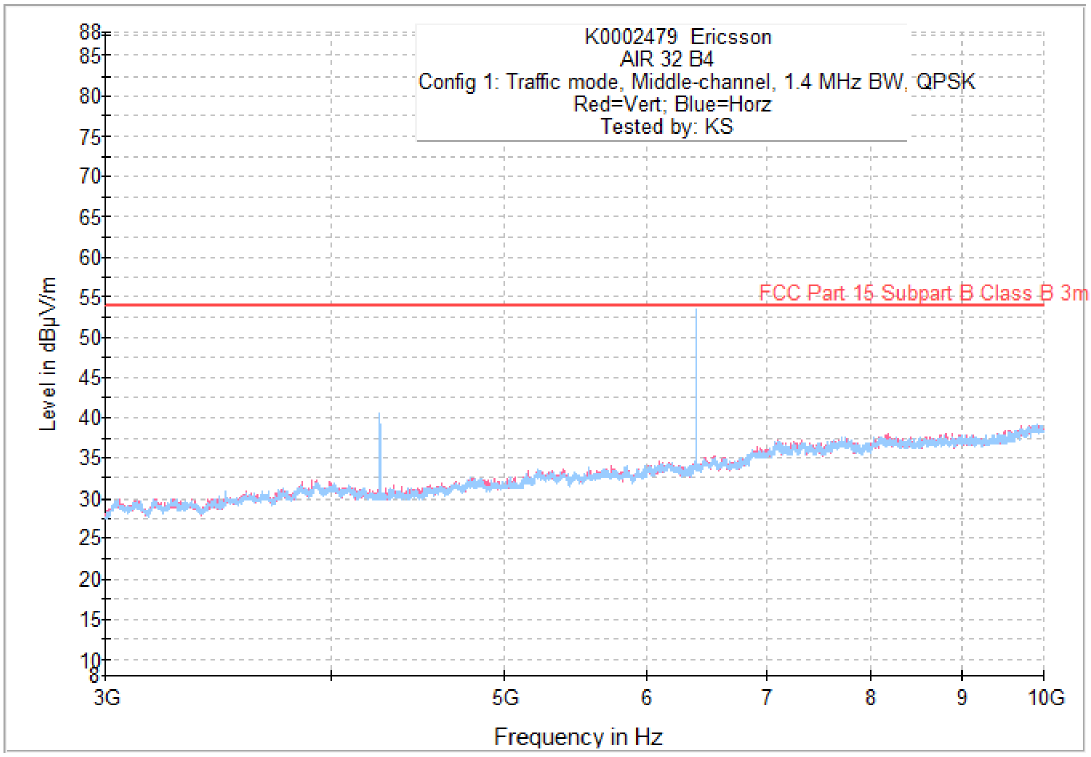
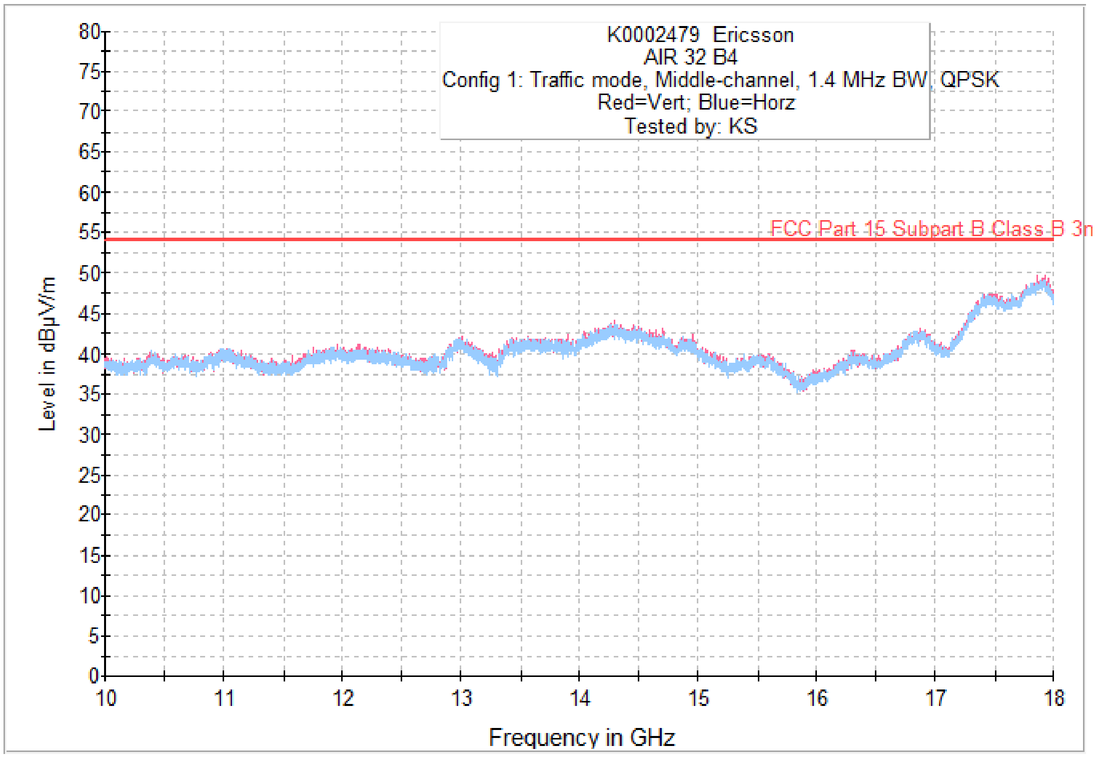


Table 17: E-field RE test results at 3 m for FCC part 15 from 3 to 10 GHz (Middle 1.4QPSK 1C LTE)

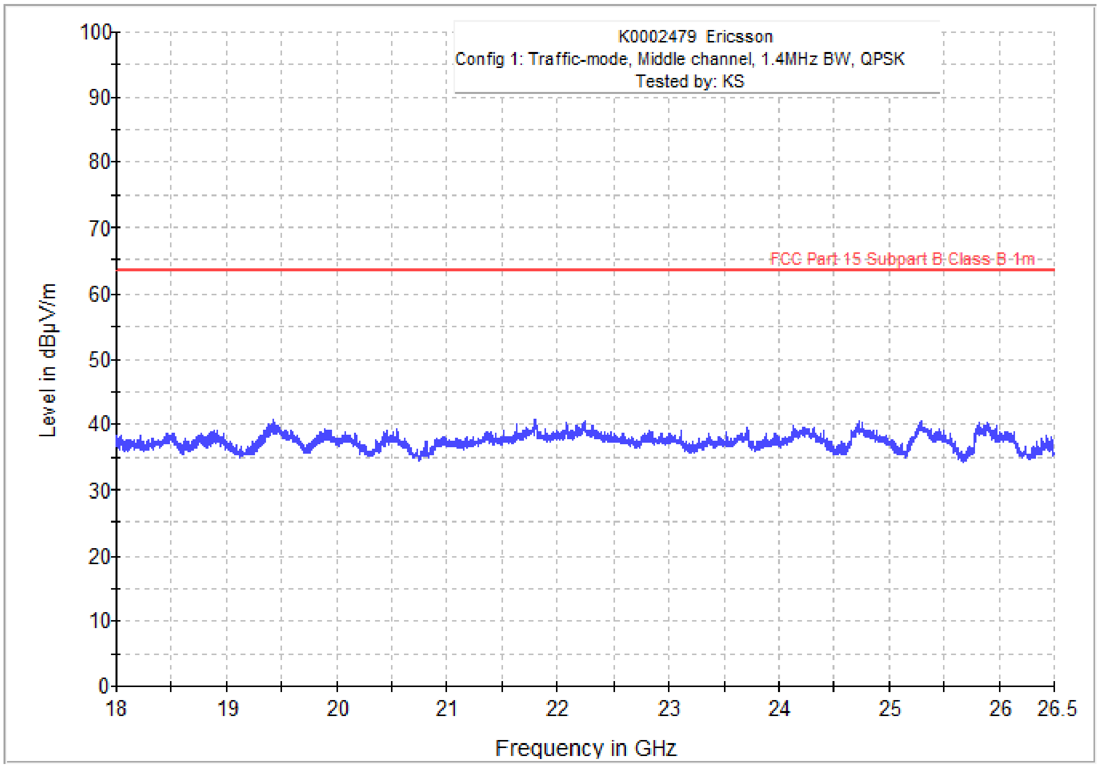
Frequency (MHz)	Level (dBµV/m)	Detector	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin to FCC Limit (dB)	Note
4265.051000	37.6	AVG	102	H	62	0.0	16.4	
6397.529000	51.4	AVG	154	H	104	5.8	2.6	

Figure 16: Plot of RE from 10 to 18 GHz (Middle 1.4QPSK 1C LTE)



Note 1: All frequencies measured had greater than 6dB of passing margin. The noise floor in the upper frequency band was verified.

Figure 17: Plot of RE from 18 to 26.5 GHz (Middle 1.4QPSK 1C LTE)



Note 1: There were no emissions within 6 dB of the limit to report.

5.1.8 Test results for RAT: Top Channel, 1.4MHz QPSK, 1 Carrier, LTE

Test location: DVC 10-meter AFC

Date tested: Aug 6 &7, 2014

Tested by: Martin Lee / Kasi Sivaratnam

Test setup: See Appendix A: Test setup photographs.

Figure 18: Plot of RE from 10 KHz to 30 MHz (Top 1.4QPSK 1C LTE)

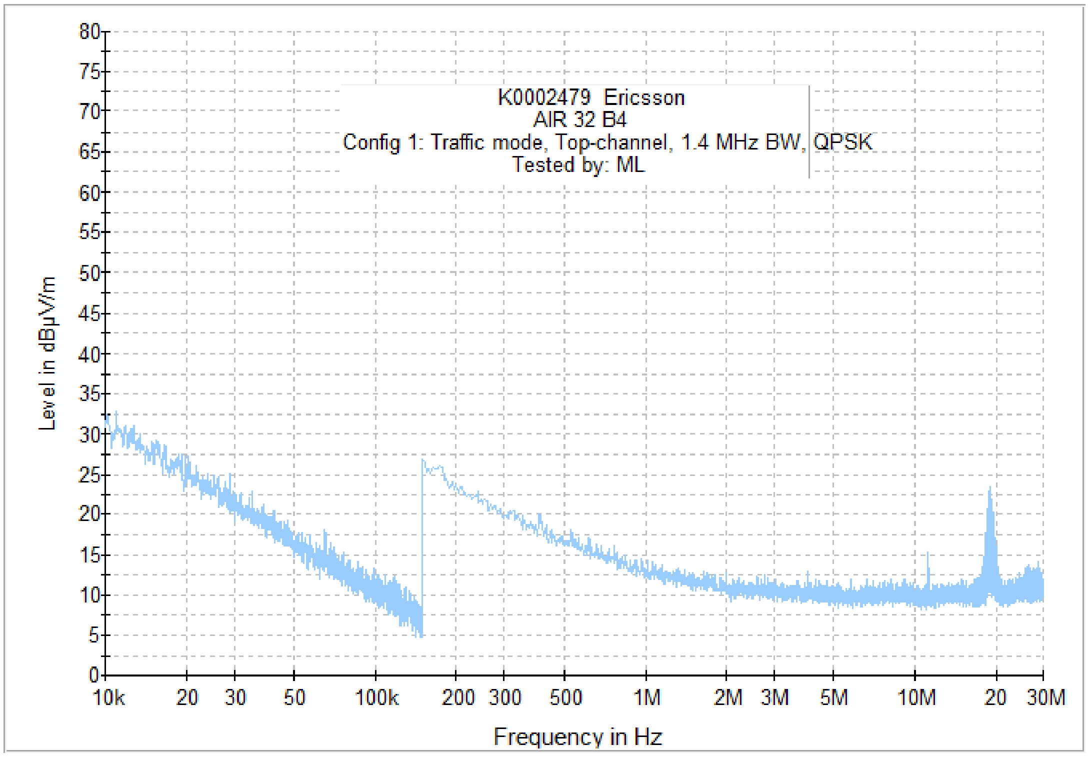


Figure 19: Plot of RE from 30 MHz to 1 GHz (Top 1.4QPSK 1C LTE)

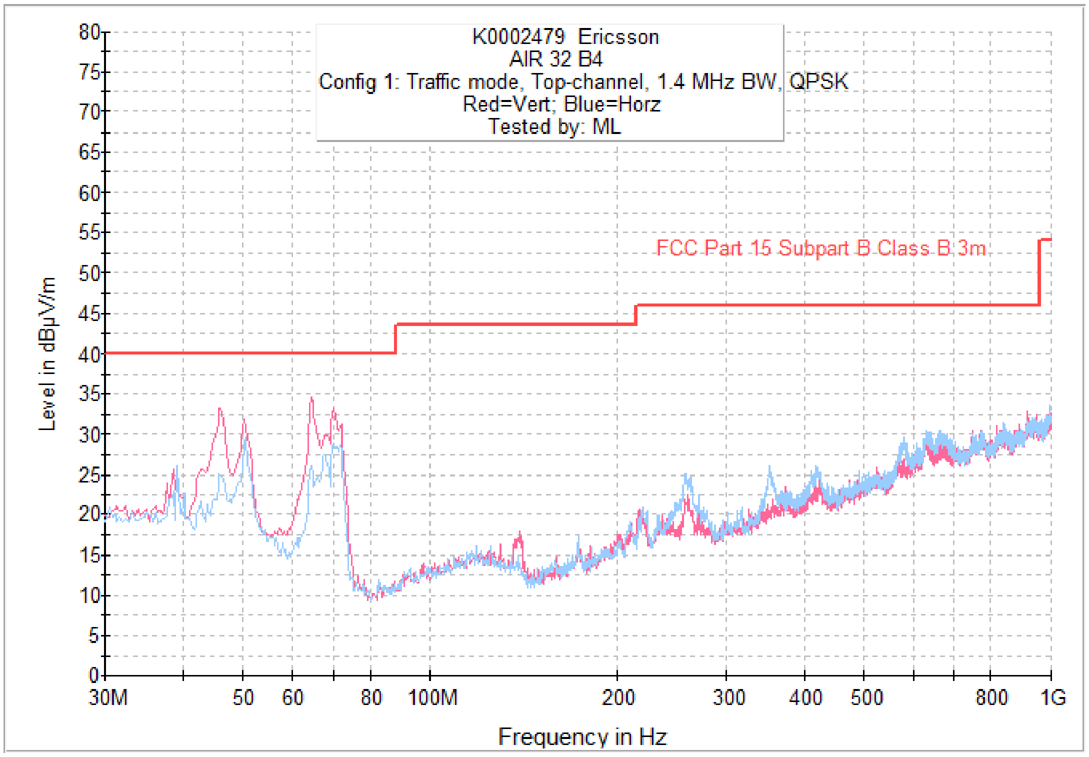
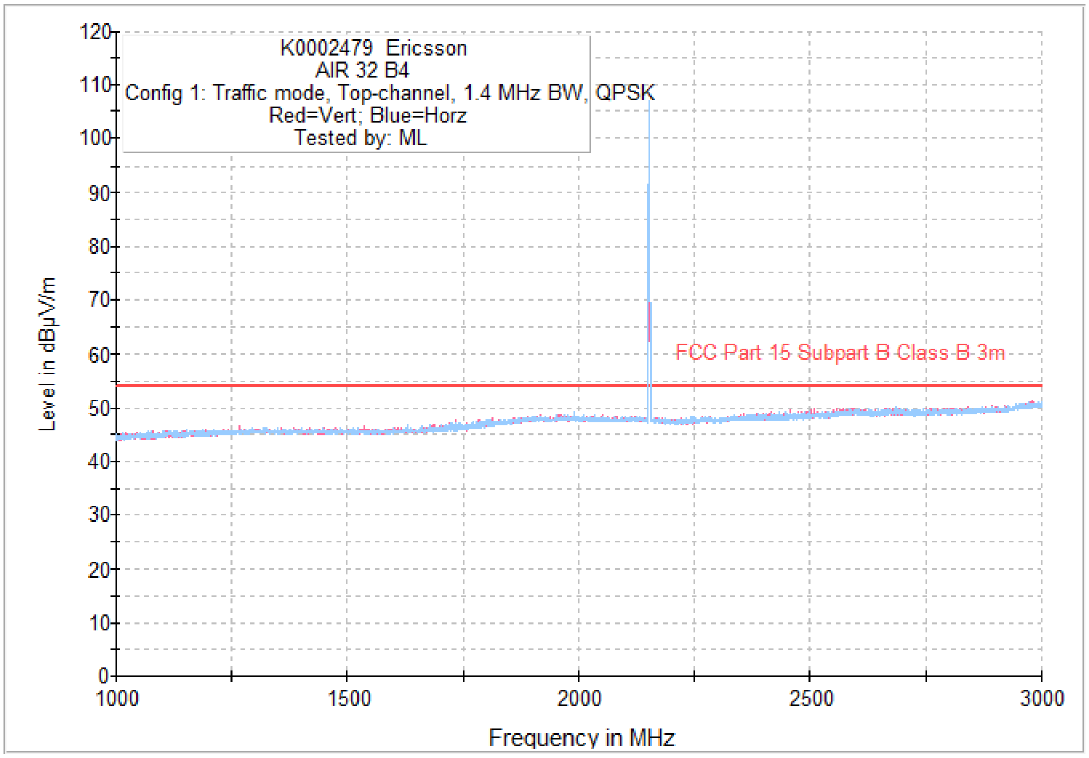


Table 18: E-field RE test results at 3 m for FCC part 15 from 30 to 1000 MHz (Top 1.4QPSK 1C LTE)

Frequency (MHz)	Level (dBµV/m)	Detector	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin to FCC Limit (dB)	Note
45.913750	34.7	QP	102	V	98	16.3	5.3	
50.178750	32.7	QP	102	V	104	15.4	7.2	
64.503250	34.8	QP	203	V	278	10.1	5.1	
70.014750	33.6	QP	203	V	325	8.4	6.4	

Figure 20: Plot of RE from 1 to 3 GHz (Top 1.4QPSK 1C LTE)



Note 1: The emission shown above the limit is the radio transmit frequency.

Table 19: E-field RE test results at 3 m for FCC part 15 from 1 to 3 GHz (Top 1.4QPSK 1C LTE)

Frequency (MHz)	Level (dBµV/m)	Detector	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin to FCC Limit (dB)	Note
2998.572000	61.8	AVG	398	V	202	25.3	-7.8	Noise Floor

Figure 21: Plot of RE from 3 to 10 GHz (Top 1.4QPSK 1C LTE)

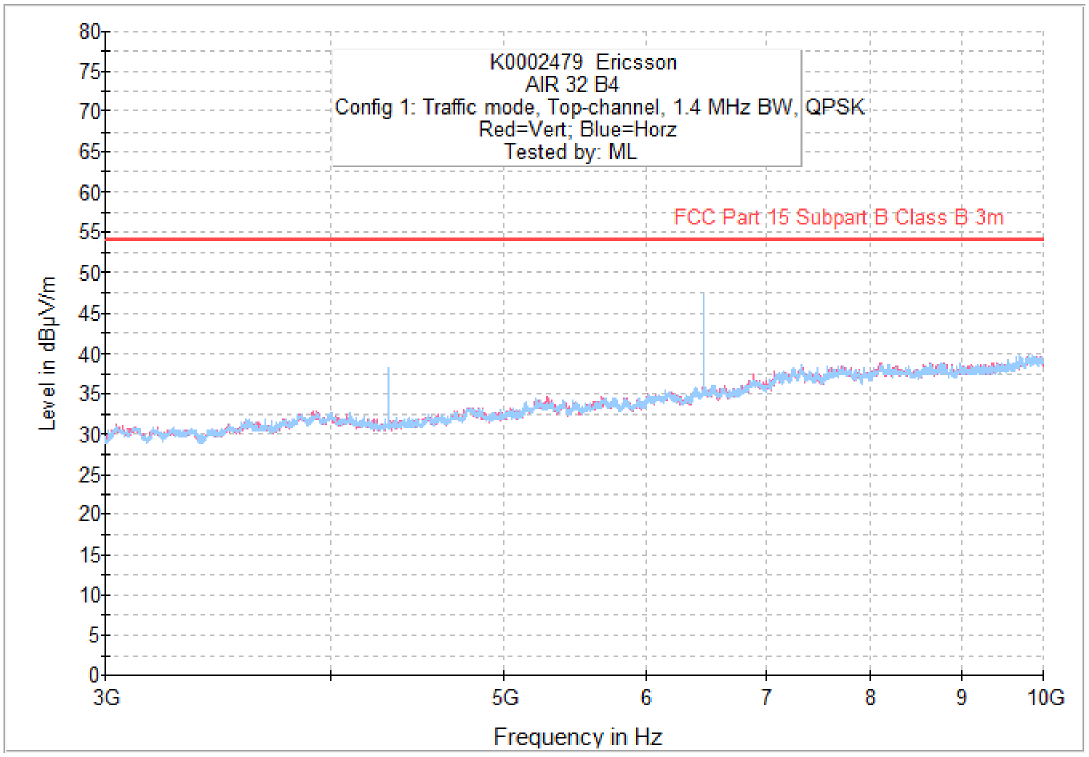
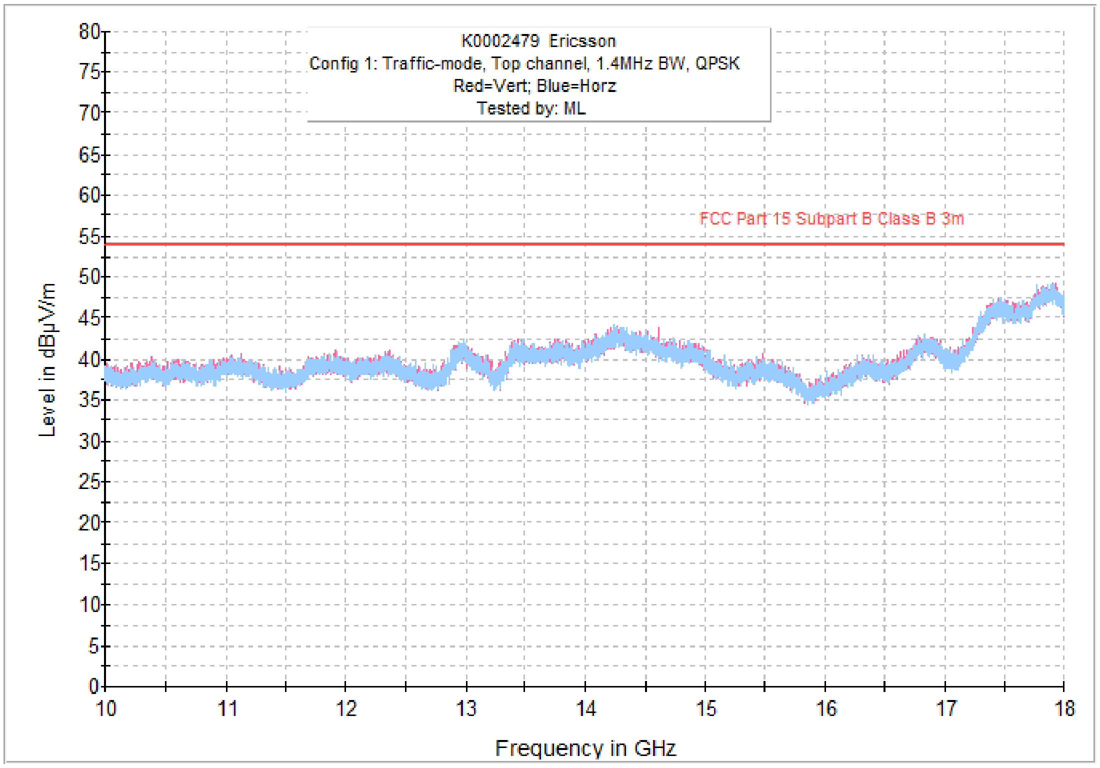


Table 20: E-field RE test results at 3 m for FCC part 15 from 3 to 10 GHz (Top 1.4QPSK 1C LTE)

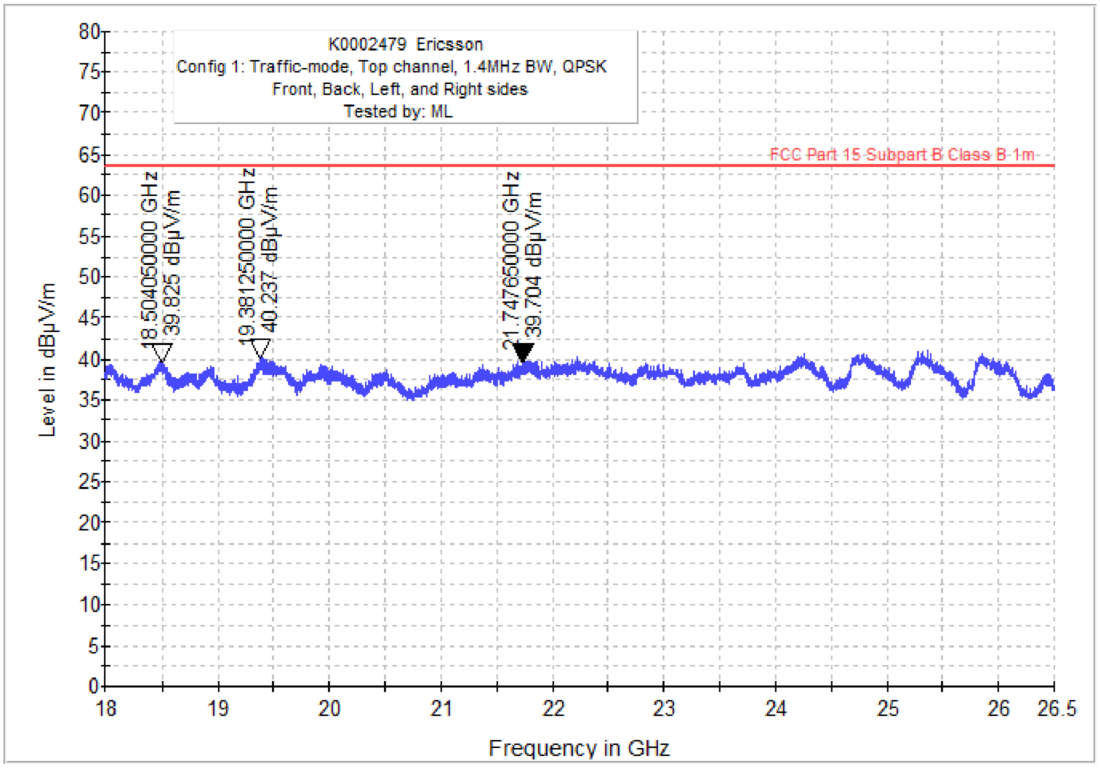
Frequency (MHz)	Level (dBµV/m)	Detector	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin to FCC Limit (dB)	Note
4308.516000	36.8	AVG	101	H	114	0.6	17.1	
6463.079000	46.4	AVG	179	V	196	7.0	7.5	

Figure 22: Plot of RE from 10 to 18 GHz (Top 1.4QPSK 1C LTE)



Note 1: All frequencies measured had greater than 6dB of passing margin. The noise floor in the upper frequency band was verified.

Figure 23: Plot of RE from 18 to 26.5 GHz (Top 1.4QPSK 1C LTE)



Note 1: There were no emissions within 6 dB of the limit to report.

5.1.9 Test results for RAT: 1.4MHz QPSK, 2 Carrier, LTE

Test location: DVC 10-meter AFC

Date tested: Aug 12, 2014

Tested by: Martin Lee / Kasi Sivaratnam

Test setup: See Appendix A: Test setup photographs.

Figure 24: Plot of RE from 10 KHz to 30 MHz (1.4QPSK 2 Carrier LTE)

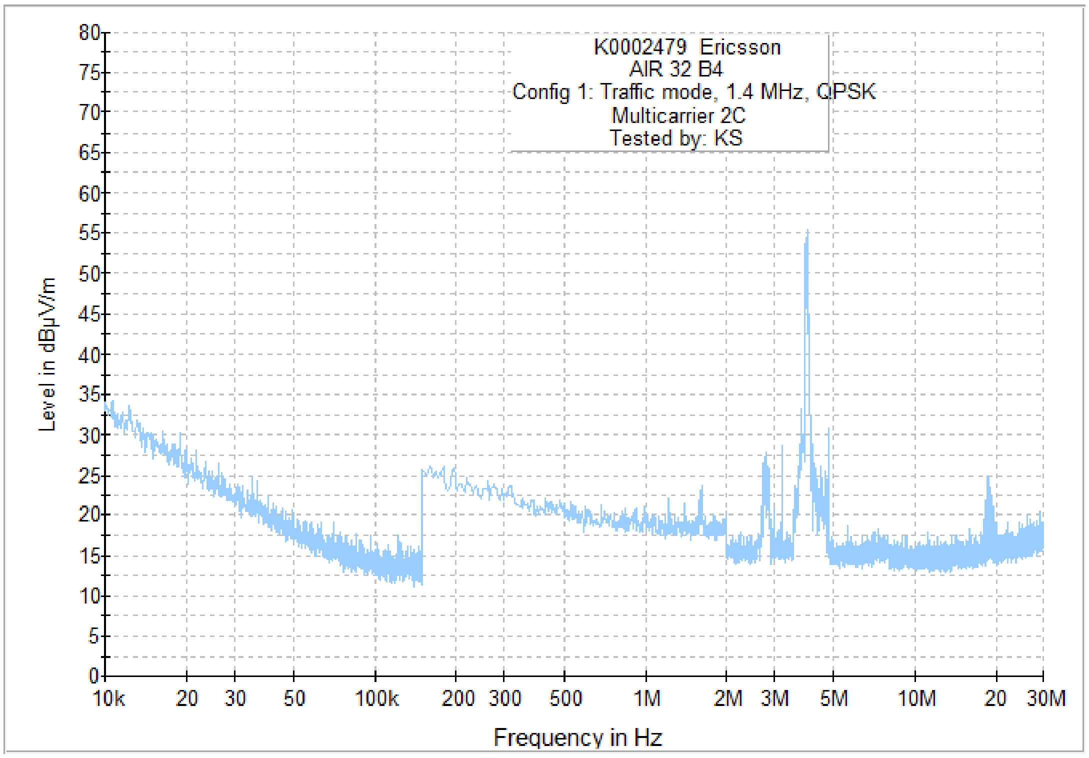
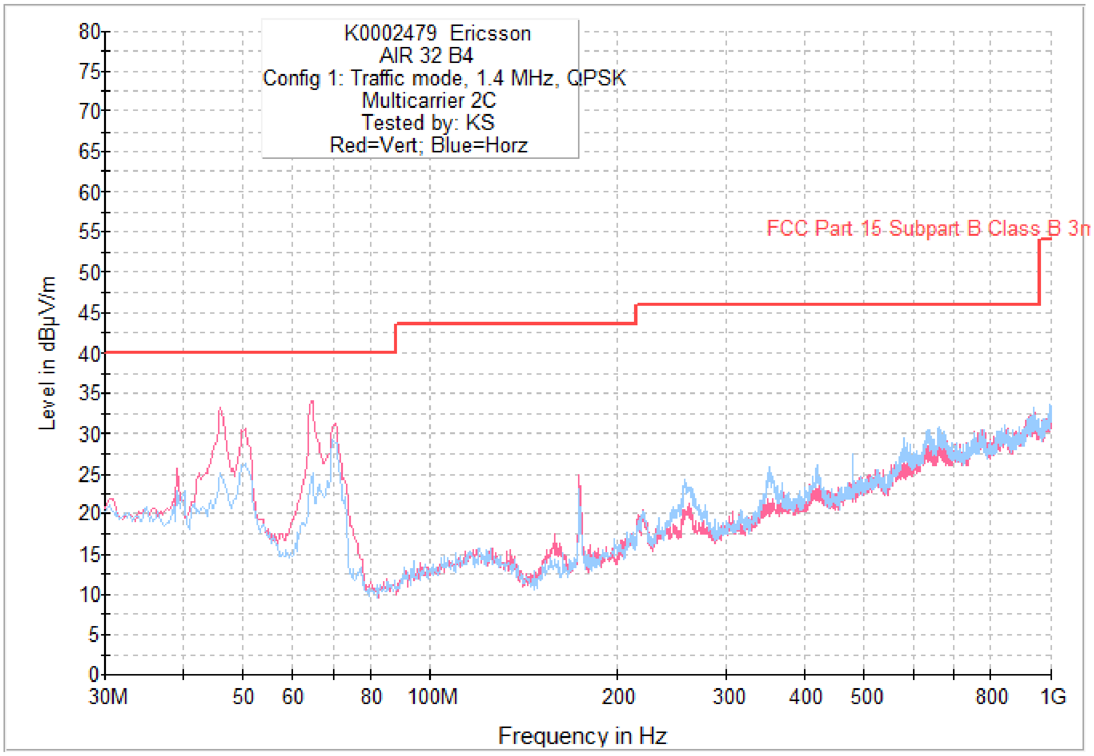
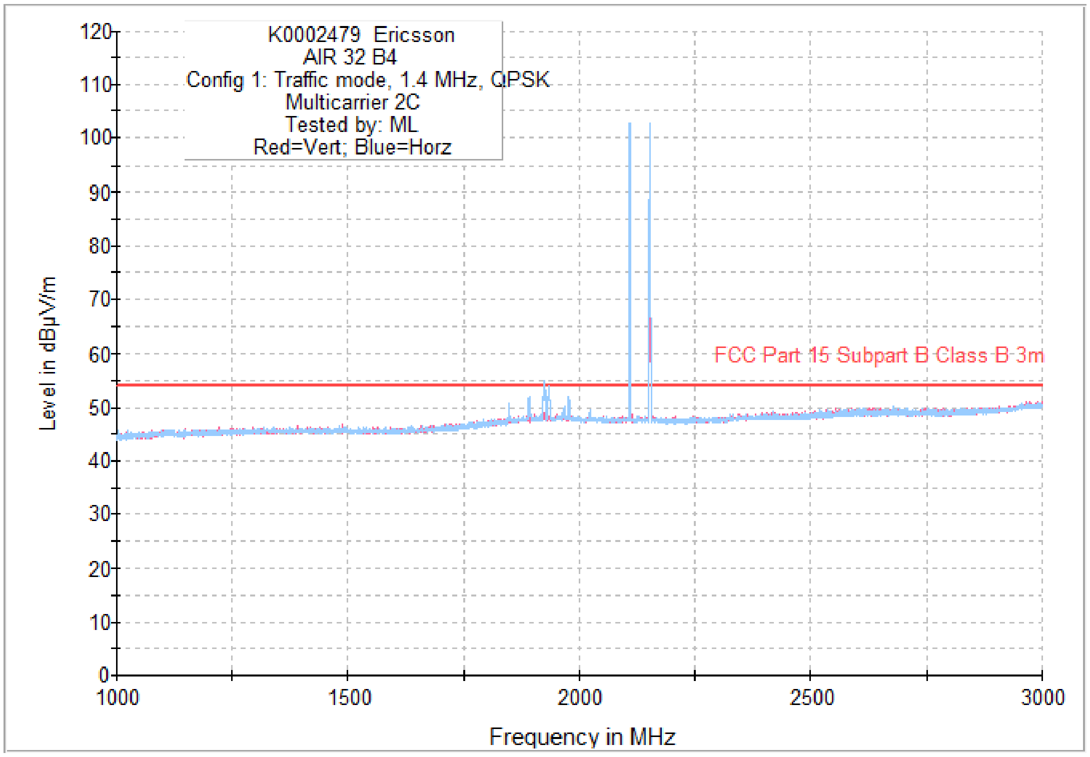


Figure 25: Plot of RE from 30 MHz to 1 GHz (1.4QPSK 2 Carrier LTE)



Note 1: All measurements had greater than 6 dB of margin to the limit.

Figure 26: Plot of RE from 1 to 3 GHz (1.4QPSK 2 Carrier LTE)



Note 1: The emissions shown above the limit are the radio transmit frequencies.

Table 21: E-field RE test results at 3 m for FCC part 15 from 1 to 3 GHz (1.4QPSK 2 Carrier LTE)

Frequency (MHz)	Level (dBµV/m)	Detector	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin to FCC Limit (dB)	Note
1848.910000	45.9	AVG	146	H	175	21.1	8.1	
1892.474000	49.3	AVG	183	H	187	21.5	4.7	
1936.154000	50.6	AVG	147	H	268	21.7	3.3	
1979.912000	49.7	AVG	124	H	188	21.9	4.3	
2023.562000	47.2	AVG	112	H	175	22.0	6.7	

Figure 27: Plot of RE from 3 to 10 GHz (1.4QPSK 2 Carrier LTE)

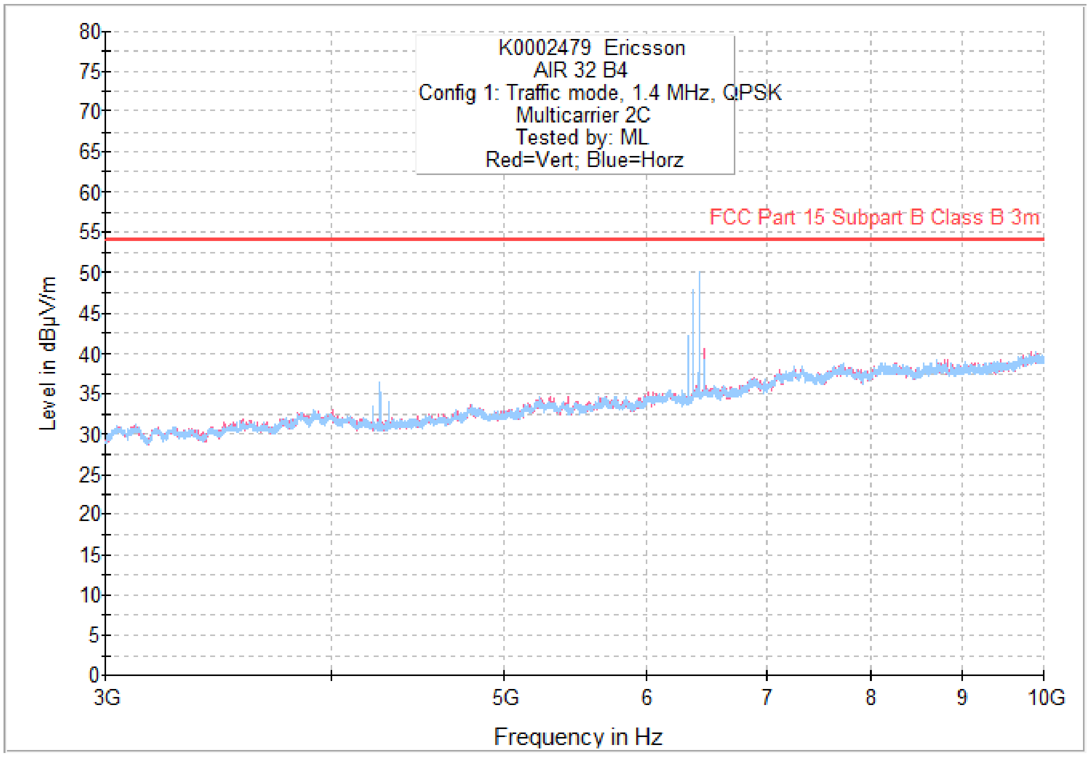
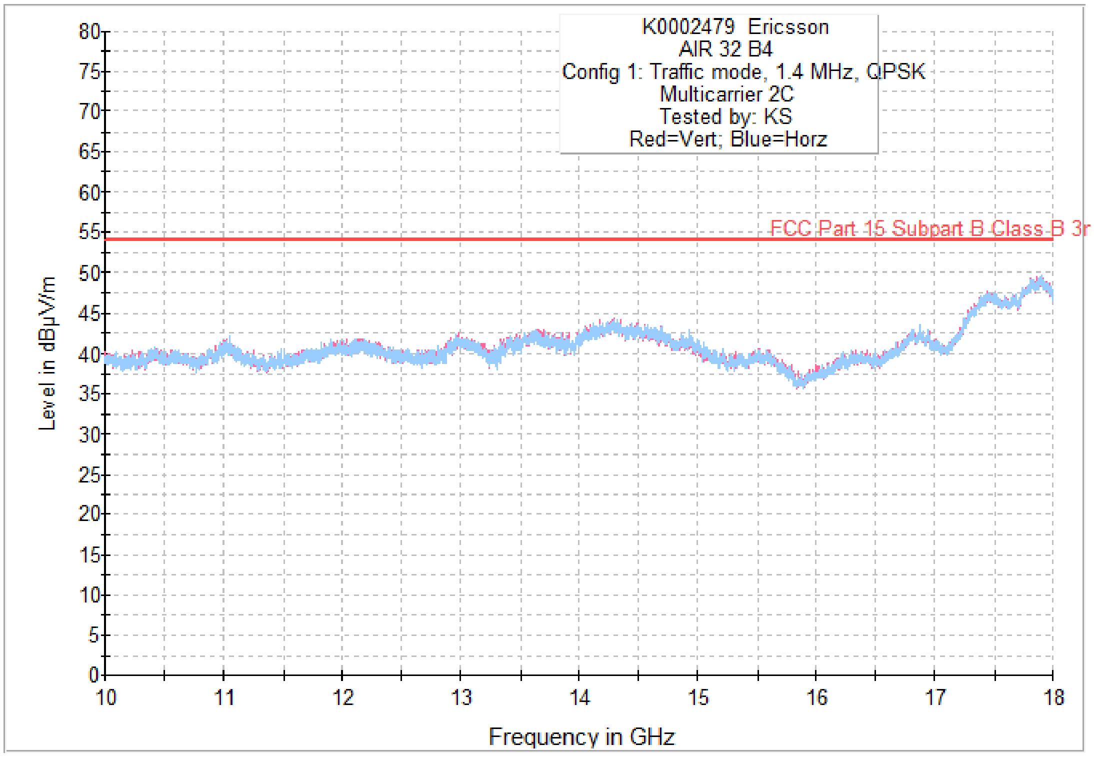


Table 22: E-field RE test results at 3 m for FCC part 15 from 3 to 10 GHz (1.4QPSK 2 Carrier LTE)

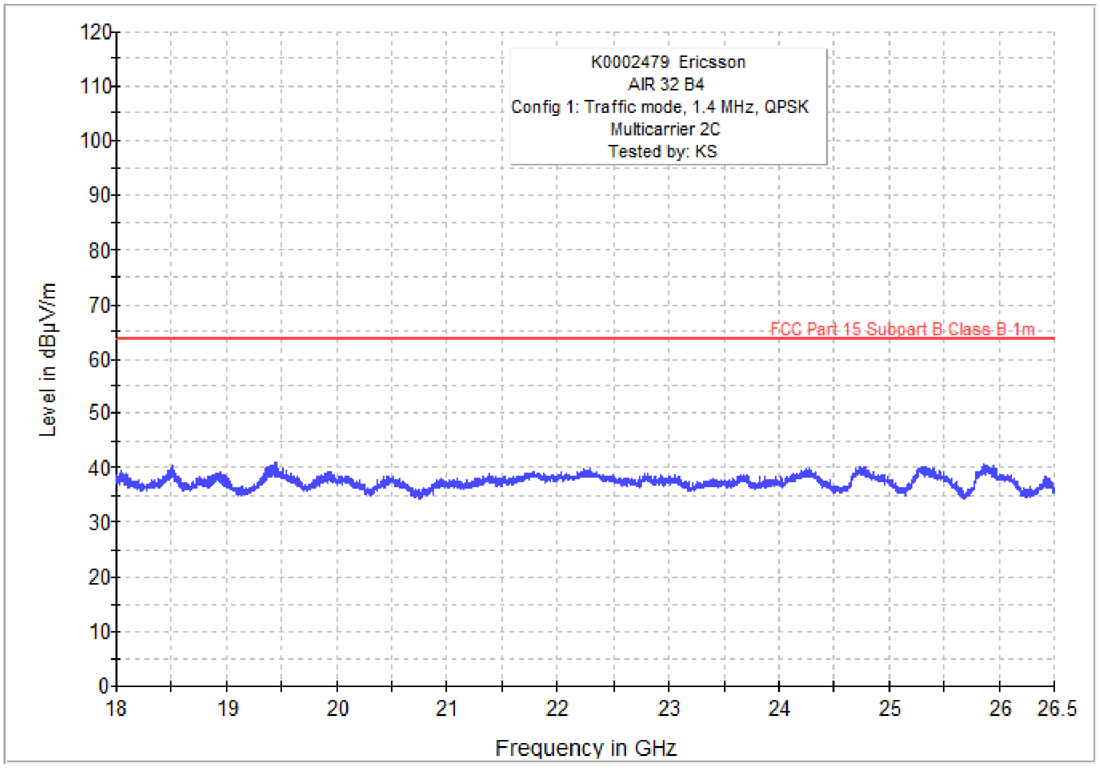
Frequency (MHz)	Level (dBµV/m)	Detector	Height (cm)	Polarization	Azimuth (deg)	Corr. (dB)	Margin to FCC Limit (dB)	Note
6419.305000	48.0	AVG	177	H	183	6.9	6.0	

Figure 28: Plot of RE from 10 to 18 GHz (1.4QPSK 2 Carrier LTE)



Note 1: All frequencies measured had greater than 6dB of passing margin. The noise floor in the upper frequency band was verified.

Figure 29: Plot of RE from 18 to 26.5 GHz (1.4QPSK 2 Carrier LTE)



Note 1: There were no emissions within 6 dB of the limit to report.

5.1.10 Test equipment

The test equipment used for all configurations was as follows.

Table 23: E-field RE test equipment

Description	Make	Model number	Asset ID	Calibr. date	Calibr. due
High Pass Filter	Microwave Circuits inc.	H3G02G1	SSG012728	1/9/2014	1/9/2015
Low Pass RF Filter	Hewlett Packard	360 B	SSG013707	6/4/2014	6/4/2015
Double Ridged Horn	Emco	3115	SSG012508	12/20/2013	12/20/2014
Bilog Antenna	Antenna Research Associates	LPB 2520A	SSG012772	12/20/2013	12/20/2014
Coaxial Cable # 26	Huber & Suhner	ST18/Nm/Nm/36, Sucotest	SSG012785	1/9/2014	1/9/2015
Coaxial Cable # 27	Huber & Suhner	ST18/Nm/Nm/36, Sucotest	SSG012786	1/8/2014	1/8/2015
Coaxial Cable # 6	Huber & Suhner	106A, Sucoflex	SSG012456	1/15/2014	1/15/2015
Pre-Amplifier	BNR	LNA	SSG012360	4/4/2014	4/4/2015
EMI / EMC Test Software	Rohde & Schwarz	EMC32, Ver. 8.52	n/a	n/a	n/a
EMI Receiver	Rohde & Schwarz	ESU40	SSG013672	11/4/2013	11/4/2014
EMI Receiver	Rohde & Schwarz	ESU26	SSG013729	1/22/2014	1/22/2015
Coaxial Cable # 14	Huber & Suhner	104PEA, Sucoflex	SSG012041	1/8/2014	1/8/2015
Low Pass RF Filter	Hewlett Packard	360 B	SSG013707	6/4/2014	6/4/2015
Coaxial Cable	Huber & Suhner	101 PEA, Sucoflex	SSG012290	8/11/2014	8/11/2015
Horn Antenna (18 - 26.5 GHz)	Emco	3160-09	SSG012292	12/27/2013	12/27/2014
Active Monopole Antenna	Emco	3301B	SSG012683	2/17/2014	2/17/2015
10-18 GHz, Coaxial Cable H3	Micro-Coax	UFA 210B-1-1500-504504, Utiflex	SSG012376	1/9/2014	1/9/2015
Attenuator	Weinschel	6070-20	SSG013016	5/20/2014	5/20/2015
Attenuator	Narda	766-3	SSG012759	4/4/2014	4/4/2015
6 dB Attenuator	Narda	774-6	SSG013706	5/8/2014	5/8/2015
Additional Substitution Measurement Test Equipment					
EMC Automation Software	Rohde & Schwarz	EMC32 V.8.52	SSG013731	not required	not required
Bilog Antenna	Antenna Research Associates	LPB 2520A	SSG012772	12/20/13	12/20/14
Double Ridged Horn	Emco	3115	SSG012508	12/20/13	12/20/14
Signal Generator	Anritsu	69369A	SSG012077	4/9/14	4/9/15
Coaxial Cable # 26	Huber & Suhner	ST18/Nm/Nm/36, Sucotest	SSG012785	1/09/14	1/09/15
Pre-Amplifier	BNR	LNA	SSG012360	4/04/14	4/04/15
Coaxial Cable # 14	Huber & Suhner	104PEA, Sucoflex	SSG012041	1/08/14	1/08/15
Coaxial Cable # 27	Huber & Suhner	ST18/Nm/Nm/36, Sucotest	SSG012786	1/08/14	1/08/15
EMI Receiver	Rohde & Schwarz	ESU26	SSG013729	1/22/14	1/22/15
Coaxial Cable # 6	Huber & Suhner	106A, Sucoflex	SSG012456	1/15/14	1/15/15

5.1.11 Test conclusion

The ARUS 32 B4 has passed the E-field Radiated Emission tests with respect to the Class B limit of FCC Part 15 Subpart B and ICES-003 for LTE modes of operation tested.

5.2 Radiated Spurious Emissions

5.2.1 Test specification and limits

The testing requirements are as follows.

Table 24: Spurious emissions requirements

Test Method	Level
RSS-139 / RSS-GEN	"The power of any emission outside a licensee's frequency block shall be attenuated below the transmitter power (P) in watts by at least 43 + 10 log10 (P) dB"
FCC part 2.1053, 2.1057	ANSI C63.4 [2], TIA-603-C [3]
FCC Part 27.53	ANSI C63.4 [2], TIA-603-C [3]

5.2.1.1 FCC Part 2.1053 Measurements required: Field strength of spurious radiation.

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 FCC 2.1049, as appropriate.

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 half wave dipole antennas.

5.2.1.2 FCC Part 2.1057 Frequency spectrum to be investigated.

The spectrum should be investigated from the lowest radio frequency signal generated in the equipment, without going below 9 kHz, up to at least the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower. Particular attention should be paid to harmonics and sub harmonics 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. The amplitude of spurious emissions, which are attenuated more than 20 dB below the permissible value, need not be reported.

5.2.2 Test procedure

Verifications of the test equipment and AFC were completed before the installation of the EUT in accordance with the quality assurance procedures documented in the EMC test procedures document [9].

- The EUT was placed on a turntable inside the AFC (configured as in normal operation). The system and its cables were separated from the ground plane by an insulating support 10 mm in height. The system was grounded in accordance with its installation specifications. No additional grounding connections were connected.
- For tests between **30 MHz and 1 GHz** the receive antenna (bi-log) was placed at 3 m away from the EUT. An initial scan was performed to find emissions (frequencies) requiring detailed measurement. The pre-scan was performed by rotating the system 360 degrees while recording all emissions (frequency and amplitude). This procedure was repeated for antenna heights of 1 to 4 m, and for horizontal and vertical polarizations of the receiving antenna. The detector mode was RMS with a 120 kHz bandwidth unless otherwise noted.
- For tests between **1 GHz and 10 GHz** the receive antenna (horn) was placed at 3 m away from the EUT. An initial scan was performed to find emissions (frequencies) requiring detailed measurement. The pre-scan was performed by rotating the system 360 degrees while recording all emissions (frequency and amplitude). This procedure was repeated for antenna heights of 1 to 4 m, and for horizontal and vertical polarizations of the receiving antenna. The detector mode was RMS with a 1 MHz bandwidth unless otherwise noted.
- For FCC Part 15 or ICES tests between **10 GHz to 18 GHz** the receive horn antenna was placed at a 3 m distance from the EUT. An initial scan was performed to find emissions (frequencies) requiring detail measurement. The pre-scan was performed by rotating the system 360 degrees while recording all emissions (frequency and amplitude). This procedure was repeated for antenna heights of 1 to 4 m, and for horizontal and vertical polarizations of the receiving antenna. These measurements were made with an average detector mode (AVG) with 1 MHz bandwidth unless otherwise noted.
- For FCC Part 15 or ICES tests between **18 GHz to 26.5 GHz** the receive horn antenna was placed at a 1 m distance from the EUT. An initial scan was performed to find emissions (frequencies) requiring detail measurement. The pre-scan was performed manually in close proximity to the EUT to find any system emissions in this frequency band. This search was performed on four sides of the EUT, along the entire height of the EUT, using both polarization of the receive antenna. Final measurements were made with an average detector mode (AVG) with 1 MHz bandwidth unless otherwise noted.
- For **all the above frequency ranges** optimization was performed based on the pre-scan data. For each identified frequency, the EUT was rotated in azimuth over 360 degrees and the direction of maximum emission was noted. Antenna height was then varied from 1 to 4 m at this azimuth to obtain maximum emissions. The procedure was repeated for both horizontal and vertical polarizations (where applicable) of the search antenna. The maximum level measured was recorded. The spectrum analyzer was verified to make sure it was not saturating in the presence of the radio signal.
- The highest emissions were re-evaluated using the substitution method. This is accomplished by replacing the EUT by a calibrated antenna, cable and signal generator. This equipment is used to transmit a signal that will generate a RF meter reading level identical to the one recorded when the EUT was present for the optimization.

5.2.3 Calculation of the compliance margin

The following parameters and coefficients are used to calculate and derive compliance levels and margins with respect to measurement results and test parameters. The example below illustrates the manner in which the emissions levels are calculated.

The rows in these tables are defined as follows.

Meter Reading (dBμV) =	Voltage measured using the spectrum analyzer with quasi-peak adapter
Gain/Loss Factor (dB) =	Cumulative gain or loss of pre-amplifier and cables used in the measurement path (a negative value indicates gain)
Correction (dB)	Gain/Loss Factor (dB) + Antenna factor (dB)
Level (dBμV/m) =	Corrected value or field strength, that is, the parameter of interest that is compared to the limit
Margin (dB) =	Level with respect to the appropriate limit (a positive Margin indicates that the Level is below the limit and that the measurement is a PASS)

The values in the Level row are calculated as follows:

Level = Meter Reading + Correction (dB)

The values in the Margin row are calculated as follows:

The following example shows the manner in which the compliance margin is calculated for ERP:

ERP = **Effective Radiated Power or Equivalent Radiated Power**

ERP (dBm) = Signal generator level (dBm) – Cable losses (dB) + Antenna gain (dBi) – half wave dipole gain (2.15 dB)

Margin = Limit – ERP

dBi to dBd conversion factor is 2.15

5.2.4 Measurement uncertainties

Uncertainty evaluation has been calculated according to the method described in CISPR 16 [5]. The expanded measurement instrumentation uncertainty (with a 95 % level of confidence) on E-field RE is:± 3.5 dB between 10 kHz and 30 MHz, ± 4.8 dB between 30 MHz and 1 GHz, ± 4.6 dB between 1 GHz and 10 GHz.

5.2.5 Test results for Spurious Emissions

Test location: DVC 10-meter AFC

Date tested: August 22, 2014

Tested by: Nick Viktorov

Table 25: Spurious Emissions ERP Results (AIR32 B4A B2P LTE)

Mode	Frequency (MHz)	Meter reading dB(μV/m)	Signal Generator level (dBm)	Cable Loss (dB)	Polarization	Antenna Gain (dBi)	ERP (dBm)	Margin to FCC Part 27 & RSS 139 (dB)
Top Channel 1.4MHz QPSK	45.91375	34.7	-57.9	0.76	V	-7.9	-68.7	55.7
Top Channel 1.4MHz QPSK	50.17875	32.7	-59.9	0.84	V	-4.5	-67.4	54.4
Top Channel 1.4MHz QPSK	64.50325	34.8	-57.8	0.93	V	0.4	-60.5	47.5
Top Channel 1.4MHz QPSK	70.01475	33.6	-59.0	1.00	V	0.7	-61.5	48.5
2 Carrier 1.4MHz QPSK	1925.764744	72.2	-28.0	5.25	H	8.454	-26.9	13.9
2 Carrier 1.4MHz QPSK	1966.449359	67.9	-34.5	5.25	H	8.454	-33.4	20.4
Bottom Channel 1.4MHz QPSK	4221.285	53.3	-47.0	8.09	H	10.452	-46.8	33.8
Middle Channel 1.4MHz QPSK	4265.051	52.7	-47.5	8.09	H	10.452	-47.3	34.3
Top Channel 1.4MHz QPSK	4308.516	51.0	-49.7	8.17	H	10.726	-49.3	36.3

5.2.6 Test equipment

Refer to the test equipment list presented in Section 5.1.10 on page 46.

5.2.7 Test conclusion

The ARUS 32 B4 has passed the spurious radiated emission test cases with respect to the limits of RSS-139 and FCC Part 27 for all radio modes of operation tested.

6. References

The documents, regulations, and standards that are referenced throughout this test report are listed alphabetically as follows.

1. ANSI C63.2-2009, American National Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz – Specifications.
2. ANSI C63.4-2003, Methods of Measurement of Radio-Noise Emission from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
3. ANSI/TIA-603-C-2004, Land Mobile FM or PM Communications Equipment Measurement and Performance Standards.
4. APLAC, Asia Pacific Laboratory Accreditation Cooperation, Website (http://www.aplac.org).
5. CISPR 16 Publications (all parts and sections), Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods - Part 1: Radio Disturbance and Immunity Measuring Apparatus.
6. CISPR 22 (2008), Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement.
7. DVC Lab Operations Manual KG000347-QD-LAB-01
8. DVC Quality Manual, K0000608-QD-QM-01
9. EMC General Lab Test Procedure, KP000270-LP-EMC-01-15, June 28, 2012.
10. RSS-139 — RSS-139 - Advanced Wireless Services Equipment Operating in the Bands 1710–1755 MHz and 2110–2155 MHz, Issue 2, February 2009.
11. RSS Gen — General Requirements and Information for the Certification of Radio Apparatus, Issue 3, December 2010.
12. FCC Rules for Radio Frequency Devices, Title 47 of the Code of Federal Regulations, U.S. Federal Communications Commission.
13. ICES-003 Issue 5 (2012), “Spectrum Management: Interference-causing equipment standard (Digital Apparatus)”.
14. ILAC, International Laboratory Accreditation Cooperation, Website (http://www.ilac.org/)
15. Lab34 Edition 1, “The Expression of Uncertainty in EMC Testing”, UKAS, August 2002.
16. Standards Council of Canada, Scope of Accreditation for the Design Validation Centre of Flextronics Canada Design Services Inc. outlined at the following web site http://palcan.scc.ca/Specs/PDF/95_e.pdf

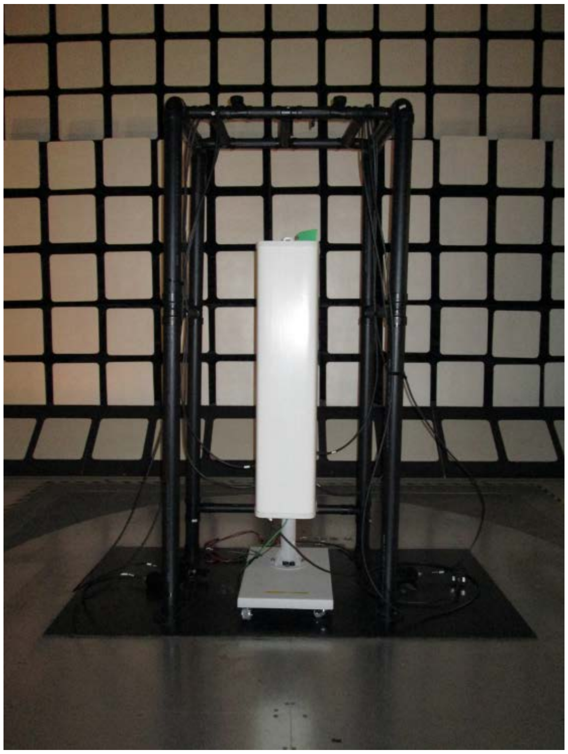
7. Appendices

The Appendices contain information that supports other sections in this document. A section refers to an Appendix as appropriate.

7.1 Appendix A: Test setup photographs

Photographs of the EMC test setups are as follows.

Figure 30: Setup for Emissions tests



7.2 Appendix B: Abbreviations

The abbreviations of terms used in this document are as follows.

Term	Definition
A	6 dB Coaxial Attenuator (conducted immunity)
AE	Auxiliary Equipment
AFC	Ambient Free Chamber
ANSI	American National Standards Institute
AVG	Average detector
CE	Conducted Emissions
CISPR	Comité International Spécial Perturbation Radioélectrique (International Special Committee on Radio Interference)
CSA	Canadian Standards Association
dB	Decibel
DVC	Design Validation Centre (Flextronics)
EMC	Electromagnetic Compatibility
EN	European Normative
EUT	Equipment Under Test
FCC	Federal Communications Commission, USA
GND	Ground
IC	Industry Canada
ICES	Canadian Specification: ICES-003, Issue 3, “Spectrum Management: Interference-causing equipment standard (Digital Apparatus)
IEC	International Electro technical Association
NA, na	not applicable
PK	Peak Detector
QP	Quasi-peak Detector
QPA	Quasi-peak Adapter (for the Spectrum Analyzer)
RBW	Resolution Bandwidth
RE	Radiated Emissions
RF	Radio-Frequency
SA	Spectrum Analyzer, the CISPR 16, ANSI C63.2 Compliant EMI meter
SCC	Standards Council of Canada
UKAS	United Kingdom Accreditation Service
VBW	Video Bandwidth

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Flextronics Canada Design Services Inc.

EMC Test Report

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