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RF Test Report:

Airspan Networks Finland Oy

ASN900

FCC ID: URK-ASN900

IC: 4548D-ASN900

SC_TR051_B

Prepared for: Airspan Communications Ltd

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1 Revision History

Revision	Originator	Date	Comment
A	Sulis Consultants	12 Mar 2012	Issued as 1st release
B	Sulis Consultants	13 Mar 2012	Updated sections 7 and 12.

2 Purpose

This report details testing performed on ASN900 against FCC and Industry Canada requirements.

3 Reference Documents

[1]	Title 47 CFR15	Federal Communications Commission Title 47 Code of Federal Regulations Part 15
[2]	ANSI C63.10-2009	IEEE American National Standard for Testing Unlicensed Wireless Devices Committee 63 standard 63-10 10th September 2009.
[3]	558074 D01 DTS Meas Guidance v01	Federal Communications Commission Office of Engineering and Technology Laboratory Division Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
[4]	RSS-GEN Issue 3	Industry Canada: General Requirements and Information for the Certification of Radio Apparatus (December 2010)
[5]	RSS-210 Issue 8	Industry Canada: Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment (December 2010)
[6]	ICES-003 Issue 4	Industry Canada Spectrum Management and Telecommunications Policy; Interference-Causing Equipment Standard; Digital Apparatus (February 2004)
[7]	SC_TR051_Plots_B	Sulis Consultants Ltd: RF Test Report: Airspan Networks Finland Oy ASN900 Measurement plots

4 Test Information

4.1 Client

Airspan Networks Finland Oy
Valkjärventie 7 C
FIN-02130
ESPOO
Finland

4.2 Test Location and test personnel

Conducted Emissions

Testing was performed by Charlie Blackham of Sulis Consultants at:

Sulis Consultants Ltd, Mead House, Longwater Road, Eversley, RG27 0NW, UK
Hursley EMC Services Ltd, Unit 16, Brickfield Lane, Chandlers Ford, Hampshire

Radiated Emissions

Testing was performed by Rob St John James of Hursley EMC Services Ltd at:

Company Offices: Hursley EMC Services Ltd, Unit 16, Brickfield Lane, Chandlers Ford, Hampshire

EMI Measurement Site: Hursley EMC Services Ltd, Hursley Park, Winchester;

FCC Registered UK Designation number: UK0006

IC Assigned Code: 7104A

4.3 Test sample

The results herein only refer to sample detailed in section 6

5 Product Description

The ASN900 contains two identical RF modules:

- RF1 can be configured to operate in one of two ways:
  - *Either* connected to integrated 23dBi antenna for operation in the 5725-5850 MHz band via cable connected to AUX port.
  - *Or* to N-type external connector RF1-1 via cable connected to Main port
- RF2 can be configured only to operate via N-type external connector RF1-1 via cable connected to Main port

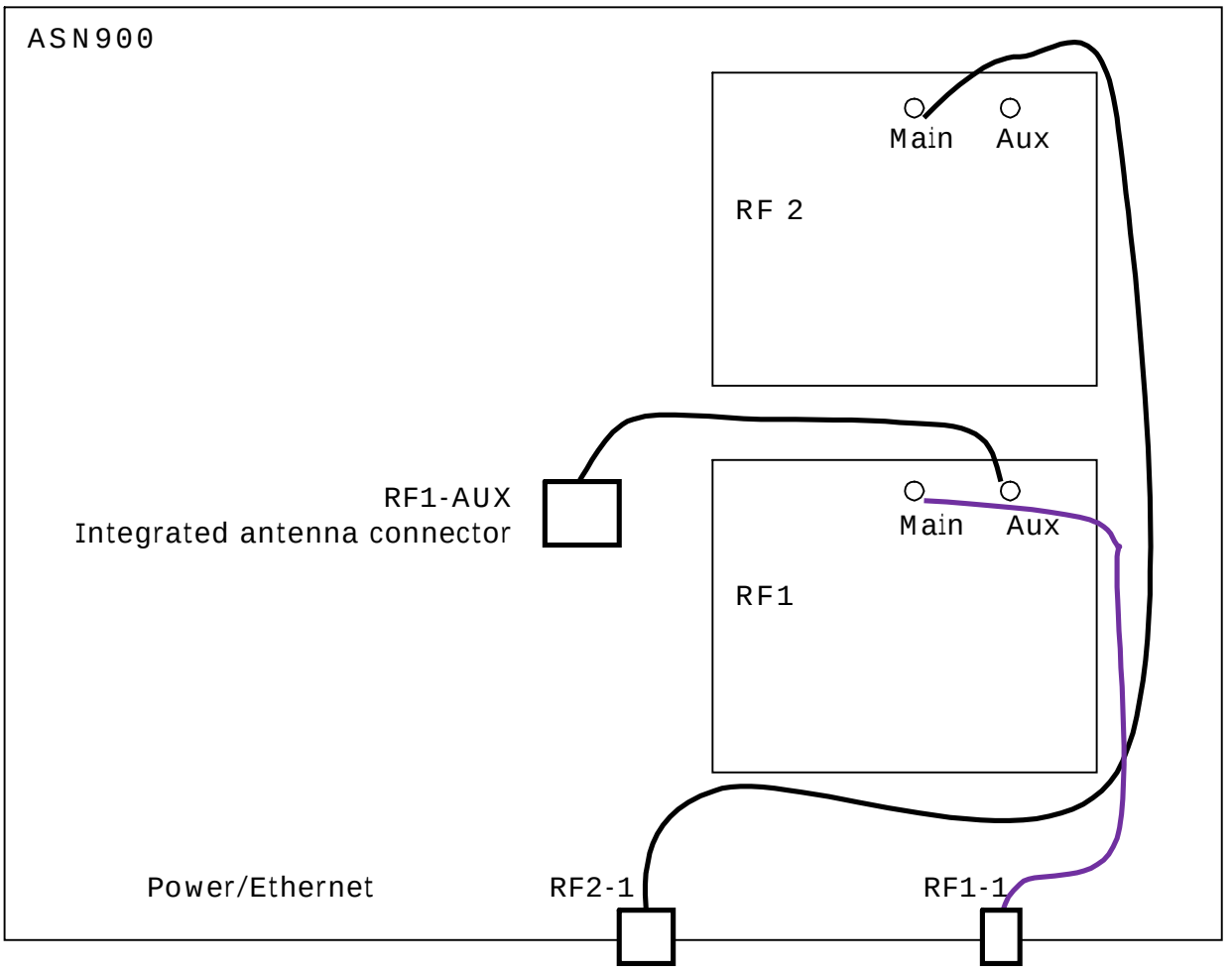


Figure 1: EUT configuration

6 Test Configuration

6.1 Test sample and Operating mode

The equipment under test (EUT) was:

Manufacturer	Model Number	Serial Number
Airspan Communications Finland OY	ASN900	FF900-100509K304603SA05B

Table 1: Equipment under test

6.2 Support equipment

The support equipment was:

Description	Manufacturer	Name	Serial Number
PC	Acer	Aspire	97KU87ZUFM649041BD2703

Table 2: Support Equipment

6.3 Test equipment

Hursley EMC tests

#ID	CP	Manufacturer	Type	Serial No.	Description	Calibration due date
010	1	HP	8568B	2601A02322	Spectrum analyser	23/03/2012
239	1	Rohde Schwarz	ENV216	100016	AMN - single phase	19/05/2012
004	1	Rohde Schwarz	ESH-3	893607/002	Test receiver (9kHz-30MHz)	22/09/2012
288	1	Rohde Schwarz	ESVP	894276/008	Receiver	17/03/2012
092	2	Schwarzbeck	VULB 9163	232 (grey)	Trilog antenna (30-3000MHz)	30/09/2013
021	1	Rohde Schwarz	ESIB	100192	Test receiver (40GHz)	12/04/1012
073	3	Schwarzbeck	BBHA9120B	237	Horn antenna (1-10GHz)	17/06/2013
127	3	Schwarzbeck	BBHA9120B	391	Horn antenna (1-10GHz)	15/12/2012
071	3	Q-par Angus	WBH218HN	2895	Horn antenna (2-18GHz)	03/11/2012
053	1	HP	8449B	3008A01394	Pre-amplifier (1.0-26.5GHz)	04/04/2012
070	1	HP+short cable	8449B	3008A00481	Pre-amplifier (1.0-26.5GHz) + 0.5m cable	17/11/2012
033	1	HP	8593EM	3726U00203	Spectrum analyser (9kHz-26.5GHz)	28/03/2012
040	1	HP	8593EM	3536A00137	Spectrum analyser (9kHz-26.5GHz)	17/06/2012
215	1	Sucoflex	106		Cable SMA (18GHz)	27/07/2012
271	1	Sucoflex	106		Cable SMA (18GHz)	19/01/2013
091	1	ATM	E4888/911	CF210K	K' 10.5m cable assy (26.5GHz)	10/03/2013
011	3	Q-par Angus	QSH20S20S	4350	Horn antenna (18-26.5GHz)	18/06/2012
086	3	Q-par Angus	QSH22F20	5462	Antenna+preamp+cable (26.5-40GHz)	25/06/2012
357	1	Micro-Tronics	BRM50702	25	Notch Filter	21/06/2012

Table 3: Test Equipment for measurements performed at Hursley EMC

Sulis Consultants Conducted Tests

Description	Manufacturer	Name	Serial Number	Calibration certificate
Receiver	R&S	ESIB40	100109	ETC Cert. C24515A Issued 09 Nov 2011
RF Cable	Rosenberger	FA147A	BUAOOE 2281	EMC Hire Cal Due 26 Aug 2012

Table 4: Test Equipment for measurements performed at Sulis Consultants

6.4 Equipment set-up

Equipment was configured as per figure 1:

- The PC was connected via Ethernet with a web-browser and Putty session running to allow ASN900 to be configured and operated in a suitable test mode

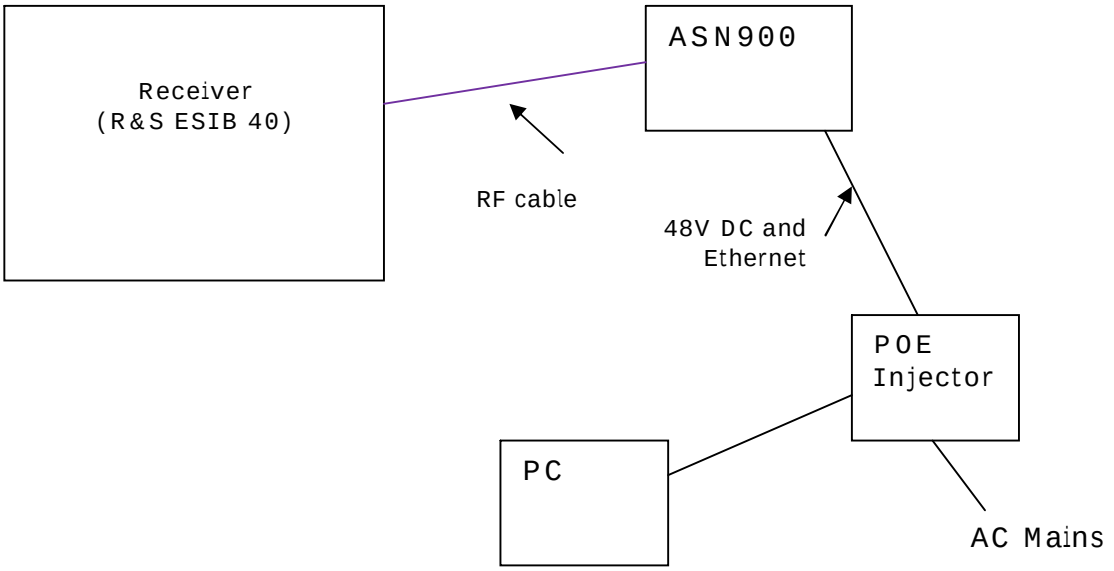


Figure 2: Test Configuration

6.5 Supported Antennas

The EUT supports operation with the following antennas:

Modes	Frequency Range (MHz)	Antenna type	Type	Gain
802.11a	5745.0 5785.0 5825.0	Integral	Flat Panel	23 dBi
		External	Flat Panel	22 dBi
			Omni-directional	9 dBi
802.11b 802.11g	2412.0 to 2462.0	External	Omni-directional	6dBi

Table 5: EUT Antenna configurations

6.6 EUT operating modes

The EUT supports operation at the following modes, frequencies, data rates and modulation rates.
All conducted measurements and all radiated measurements above 1 GHz were performed with one radio port operating as described in the relevant part of the test results sections 8 to 13.

Modes	Frequency (MHz) Top Middle Bottom	Channel Bandwidth (MHz)	Data Rate (MBit/s)	Modulation
802.11a	5745.0 5785.0 5825.0	10 20	6 / 9	BPSK
			12 /18	QPSK
			24 / 36	QAM 16
			48 / 54	QAM 64
802.11b	2412.0 2437.0 2462.0	20	1	BPSK
			2	QPSK
			5.5	QPSK
			11	QPSK
802.11g	2412.0 2437.0 2462.0	20	6 / 9	BPSK
			12 /18	QPSK
			24 / 36	QAM 16
			48 / 54	QAM 64

Table 6: ASN900 operating modes

Radiated Emissions testing for emissions in restricted bands was performed over the frequency range 30-1000 MHz in one of two modes that combined operation of the both radios during the same measurement. Data rates were determined by worst case conducted results.

Mode	Port	Antenna	Gain	Mode	Bandwidth	Data rate	Channels
1	RF1	Integral	23	802.11a	10	Auto	5745 5785 5825
	RF2	External	6	802.11b	20	11 MBit/s	2412 2437 2462
2	RF1	External	22	802.11a	20	9 Mbit/s	5745 5785 5825
	RF2	External	6	802.11g	20	54 MBit/s	2412 2437 2462

Table 7: ASN900 Operating Modes for radiated emissions < 1GHz

7 Summary of tests performed

Test	Clause	Limit / Requirement	Result
Occupied bandwidth	FCC 15.247(a)(2)	> 500 kHz	Pass – section 8.0
	IC RSS-210 A8.2(a)		Pass – section 8.0
Max peak conducted TX power	FCC 15.247(b)(3)	1 W	Pass – section 9.0
	IC RSS-210 A8.4(4)		Pass – section 9.0
Power Spectral Density	FCC 15.247(e)	8dBm / 3 kHz	Pass – section 10.0
	IC RSS-210 A8.2(b)		Pass – section 10.0
Out of Band Emissions Non-restricted bands	FCC 15.247(d)	>20dB below peak carrier /100 kHz BW	Pass – section 11.0
	IC RSS-210 A8.5		Pass – section 11.0
Out of Band Emissions Restricted-band	FCC 15.247(d) / 15.205(a) and 15.209(a)	15.209(a) table	Pass – section 12.0
	RSS GEN 7.2.5	RSS Gen table 3	Pass – section 12.0
Max antenna gain	FCC 15.247(b)(4)	< 6dBi without TX power reduction	Pass – section 9.0
AC conducted emissions	FCC 15.207	FCC 15.207	Pass – section 13.0
	RSS Gen 7.2.4	RSS Gen Table 4	Pass – section 13.0

Table 8: Summary of tests performed and results

Unless stated otherwise, all tests were performed with device set to transmit at maximum possible power:

- 20dBm for 802.11a
- 18dBm for 802.11b and 802.11g

Further to Restricted Band testing in section 12, it has been found necessary to reduce TX powers as follows:

Modes	Frequency Range (MHz)	Antenna type	Type	Gain	Maximum set TX power
802.11a	5745.0 5785.0 5825.0	Integral	Flat Panel	23 dBi	10 dBm
		External	Flat Panel	22 dBi	10 dBm
			Omni-directional	9 dBi	18dBm
802.11b	2412.0 to 2462.0	External	Omni-directional	6dBi	18dBm (unchanged)
802.11g	2412 to 2457	External	Omni-directional	6dBi	17 dBm
	2462	External	Omni-directional	6dBi	13 dBm

Table 9a: Revised maximum transmit powers

8 Occupied Bandwidth test

All tests performed by Charlie Blackham of Sulis Consultants ltd at Sulis Consultants premises.

Measurement method
Test was conducted as per [Ref 3] section 5.1.2 using the automatic bandwidth measurement capability of the receiver, whilst using the following settings:

- Set resolution bandwidth (RBW) to be within the 1-5 % of the emission bandwidth (EBW):
  - 100 kHz was used for 10 MHz channels
  - 300 kHz was used for 20 MHz channels
- Set the video bandwidth to ≥ 3 x RBW
- Detector = Peak.
- Trace mode = max hold.
- Sweep = auto couple.
- Allow the trace to stabilize.
- Record measured Occupied Bandwidth

8.1 Port RF1-1: 5725-5875 MHz band

The EUT set to transmit at maximum power of 20 dBm on the required channel.

Frequency (MHz)	Channel Bandwidth (MHz)	Data Rate (MBit/s)	Occupied Bandwidth (MHz)	Requirement	Result	Plot name
5825.0	20	6	17.154	>500 kHz	Pass	Not taken
		9	17.154		Pass	Not taken
		12	17.154		Pass	Not taken
		18	17.154		Pass	Not taken
		24	17.154		Pass	Not taken
		36	17.154		Pass	Not taken
		48	17.154		Pass	Not taken
		54	17.154		Pass	Occ-5825-20M
5785.0	20	54	17.154		Pass	Occ-5785-20M
5745.0	20	54	17.154		Pass	Occ-5745-20M
5745.0	10	26	8.457		Pass	Occ-5745-10M
5785.0	10	26	8.457		Pass	Occ-5785-10M
5825.0	10	26	8.457		Pass	Occ-5825-10M

Table 10: Occupied Bandwidth test; port RF1-1; 5725-5875 MHz band

8.2 Port RF2-1: 5725-5875 MHz band

This port was tested using highest data rate as this was found to be worst case for port RF1-1.

The EUT set to transmit at maximum power of 20 dBm on the required channel.

Frequency (MHz)	Channel Bandwidth (MHz)	Data Rate (MBit/s)	Occupied Bandwidth (MHz)	Requirement	Result	Plot name
5745.0	20	54	17.475	>500 kHz	Pass	Occ-5745-20M -2 (see note)
5785.0	20	54	17.876		Pass	Occ-5785-20M-2
5825.0	20	54	17.956		Pass	None recorded
5745.0	10	26	8.578		Pass	Occ-5745-10M -2
5785.0	10	26	9.259		Pass	Occ-5785-10M-2
5825.0	10	26	8.938		Pass	Occ-5825-10M-2

Table 11: Occupied Bandwidth test; port RF2-1; 5725-5875 MHz band

It was noted that the shape of the spectral mask was slightly lower
When measuring using -6dB points (Occ-5745-20M -2 - 6dB), the EBW was 16.754.

8.3 Port RF1-1: 2400-2483.5 MHz band; 20 MHz channel

The EUT was set to transmit at maximum power of 18 dBm on the required channel.

Frequency (MHz)	Mode	Data Rate (MBit/s)	Occupied Bandwidth (MHz)	Requirement	Result	Plot name
2437	802.11b	1	15.3111	>500 kHz	Pass	Occ-2437-b-1-1
		2	15.3111		Pass	Occ-2437-b-2-1
		5.5	15.3911		Pass	Occ-2437-b-5.5-1
		11	15.3111		Pass	Occ-2437-b-11-1
2412		11	15.3111		Pass	Occ-2412-b-11-1
2462		11	15.3911		Pass	Occ-2462-b-11-1
2412	802.11g	1	16.5131		Pass	Occ-2412-g-1-1
		54	16.5131		Pass	Occ-2412-g-54-1
2437		54	16.5131		Pass	Occ-2437-g-54-1
2462		54	16.5131		Pass	Occ-2462-g-54-1
2462	802.11b	11	15.4712		Pass	Occ#2-2462-b-11-1
2462	802.11g	54	17.0742		Pass	Occ#2-2462-g-54-1

Table 12: Occupied Bandwidth test; port RF1-1; 2400-2483 MHz band

[1] Measured by mistake with RBW = 100 kHz / VBW = 300 kHz which is slightly below prescribed 1-5%.
[2] These two frequencies remeasured with correct RBW = 300 kHz / VBW = 1 MHz

8.4 Port RF2-1: 2400-2483.5 MHz band; 20 MHz channel

The EUT was set to transmit at maximum power of 18 dBm on the required channel.

Frequency (MHz)	Mode	Data Rate (MBit/s)	Occupied Bandwidth (MHz)	Requirement	Result	Plot name
2412	802.11b	11	15.471	>500 kHz	Pass	Occ-2412-b-11-2
2437		11	15.471		Pass	Occ-2437-b-11-2
2462		11	15.471		Pass	Occ-2462-b-11-2
2412	802.11g	54	17.074		Pass	Occ-2412-g-11-2
2437		54	17.074		Pass	Occ-2437-g-11-2
2462		54	16.994		Pass	Occ-2462-g-11-2

Table 13: Occupied Bandwidth test; port RF1-1; 2400-2483 MHz band

8.5 Port RF1-AUX:

A few additional measurements were done on the RF1-AUX port which is the alternative antenna port on module RF1 and connects to the integral antenna.

EUT set to transmit at maximum power of 20 dBm on the correct channel.

Frequency (MHz)	Channel Bandwidth (MHz)	Mode	Data Rate (MBit/s)	Occupied Bandwidth (MHz)	Requirement	Result	Plot name
5785	10	802.11a	26	8.457	>500 kHz	Pass	Occ-5785-10-Int
5785	20	802.11a	54	17.234		Pass	Occ-5785-20-Int

Table 14: Occupied Bandwidth test; port RF1-Int; 5725-5850 MHz band

9 Maximum Peak Conducted Power

All tests performed by Charlie Blackham of Sulis Consultants ltd at Sulis Consultants premises.

Measurement method

Test was conducted as per [Ref 3] section 5.2.1.2 using the Channel Power measurement capability of the receiver, whilst using the following settings:

- Set the RBW = 1 MHz.
- Set the VBW = 3 MHz.
- Set the span to a value that is 5-30 % greater than the EBW.
- Detector = peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Use the spectrum analyzer's integrated band power measurement function with band limits set equal to the EBW band edges
- Check that detector is still set to peak.
- Allow trace to fully stabilize.
- Record channel power.

9.1 Port RF1-1: 5725-5875 MHz band

The EUT may operate in this band using one of the following antennas:

- Integral 23dBi antenna for point-to-point operation
- External 22 dBi antenna for point-to-point operation
- External 9dBi antenna for point-to-multipoint operation.

15.247(b) permits use of antennas with gain greater than 6dBi for point-to-point operation without reduction in maximum permitted transmit power.

15,247(b) requires maximum permitted transmit power to be reduced by 1dB for every dB that omni-directional antenna gain exceeds 6dBi. The omni-directional antenna in this band has a gain of 9dBi so maximum permitted transmit power is 27dBm when used with omni-directional antenna.

Since EUT cannot transmit above 20dBm, the 27dBm limit will be applied for all operation configurations in 5725-5875 MHz band.

EUT set to transmit at maximum power of 20 dBm on the required channel.

Frequency (MHz)	Channel Bandwidth (MHz)	Data Rate (MBit/s)	Channel Power (dBm)	Limit (dBm)	Result	Plot name
5825.0	20 (17.154)	9	20.07	27.0	Pass	CP-5825-20M-9
		18	20.02	27.0	Pass	CP-5825-20M-18
		36	20.09	27.0	Pass	CP-5825-20M-36
		54	19.98	27.0	Pass	CP-5825-20M-54
5785.0		36	19.89	27.0	Pass	CP-5785-20M-36
5745.0		36	20.03	27.0	Pass	CP-5745-20M-36
5745.0	10 (8.457)	36	20.06	27.0	Pass	CP-5745-10M-36
5785.0		36	20.06	27.0	Pass	CP-5785-10M-36
5825.0		36	20.34	27.0	Pass	CP-5825-10M-36

Table 15: Channel Power test; port RF1-1; 5725-5875 MHz band

9.2 Port RF2-1: 5725-5875 MHz band

This port was tested using the worst case data rate for port RF1-1.

EUT set to transmit at maximum power of 20 dBm on the required channel.

Frequency (MHz)	Channel Bandwidth (MHz)	Data Rate (MBit/s)	Channel Power (dBm)	Limit (dBm)	Result	Plot name
5745.0	20	36	19.51	27.0	Pass	CP-5745-20M-36-2
5785.0	20	36	19.33	27.0	Pass	CP-5785-20M-36-2
5825.0	20	36	19.23	27.0	Pass	CP-5825-20M-36-2
5745.0	10	36	19.05	27.0	Pass	CP-5745-10M-36-2
5785.0	10	36	19.36	27.0	Pass	CP-5785-10M-36-2
5825.0	10	36	19.34	27.0	Pass	CP-5825-10M-36-2

Table 16: Channel Power test; port RF2-1; 5725-5875 MHz band

9.3 Port RF1-1: 2400-2483.5 MHz band; 20 MHz channel

Operation in this band is done using an external omni-directional antenna with gain of 6dBi. As per 15.247(b) omni-directional antennas with gain of up to 6dBi may be used without reduction in maximum permitted transmit power.

EUT set to transmit at maximum power of 18 dBm on the correct channel.

The actual Emission Bandwidths were found to be:

15.471 MHz for 802.11b

17.074 MHz for 802.11g

Frequency (MHz)	Mode	Data Rate (MBit/s)	Channel Power (dBm)	Limit (dBm)	Result	Plot name
2437	802.11b	1	18.39	30.0	Pass	CP-2437-b-1-1
		2	18.22	30.0	Pass	CP-2437-b-2-1
		5.5	18.08	30.0	Pass	CP-2437-b-5.5-1
		11	18.43	30.0	Pass	CP-2437-b-11-1
2412		11	18.59	30.0	Pass	CP-2412-b-11-1
2462		11	18.20	30.0	Pass	No plot recorded
2412	802.11g	1	21.35	30.0	Pass	CP-2412-g-1-1
		54	21.37	30.0	Pass	CP-2412-g-54-1
2437		54	21.01	30.0	Pass	CP-2437-g-54-1
2462		54	20.73	30.0	Pass	CP-2462-g-54-1

Table 17: Channel Power test; port RF1-1; 2400-2483 MHz band

9.4 Port RF2-1: 2400-2483.5 MHz band; 20 MHz channel

EUT set to transmit at maximum power of 18 dBm on the correct channel

The actual Emission Bandwidths were found to be:

15.471 MHz for 802.11b

17.074 MHz for 802.11g

Frequency (MHz)	Mode	Data Rate (MBit/s)	Channel Power (dBm)	Limit (dBm)	Result	Plot name
2412	802.11b	11	18.60	30.0	Pass	CP-2412-b-11-2
2437		11	17.83	30.0	Pass	CP-2437-b-11-2
2462		11	17.68	30.0	Pass	CP-2462-b-11-2
2412	802.11g	54	20.82	30.0	Pass	CP-2412-g-11-2
2437		54	20.47	30.0	Pass	CP-2437-g-11-2
2462		54	20.27	30.0	Pass	CP-2462-g-11-2

Table 18: Channel Power test; port RF1-1; 2400-2483 MHz band

9.5 Port RF1-AUX:

A few additional measurements were done on the RF1-AUX port which is the alternative antenna port on module RF1 and connects to the integral antenna.

EUT set to transmit at maximum power of 20 dBm on the correct channel.

The actual Emission Bandwidths were found to be:

8.457 MHz for 10 MHz channel

17.234 MHz for 20 MHz channel

Frequency (MHz)	Channel Bandwidth (MHz)	Data Rate (MBit/s)	Channel Power (dBm	Limit (dBm)	Result	Plot name
5745.0	10	36	19.16	27.0	Pass	CP-5745-10-Int
5785.0		36	19.12	27.0	Pass	CP-5785-10-Int
5825.0		36	19.06	27.0	Pass	CP-5825-10-Int
5745.0	20	36	18.87	27.0	Pass	CP-5745-20-Int
5785.0		36	18.82	27.0	Pass	CP-5785-20-Int
5825.0		36	18.70	27.0	Pass	CP-5825-20-Int

Table 19: Channel Power test; port RF1-Int; 5725-5825 MHz band

10 Maximum Power Spectral Density

All tests performed by Charlie Blackham of Sulis Consultants ltd at Sulis Consultants premises.

Measurement method
Maximum Peak Conducted Power was performed using Peak Detector, so Peak Detector will be used for this test.

- Set the RBW = 100 kHz.
- Set the VBW ≥ 300 kHz.
- Set the span to 5-30 % greater than the EBW.
- Detector = peak.
- Sweep time = auto couple.
- Trace mode = max hold.
- Allow trace to fully stabilize.
- Use the peak marker function to determine the maximum power level in any 100 kHz band segment within the fundamental EBW.
- Scale the observed power level to an equivalent value in 3 kHz by adjusting (reducing) the measured power by a bandwidth correction factor (BWCF) where BWCF = 10log (3 kHz/100 kHz = -15.2 dB).
- Compare resultant PSD value with maximum permitted value of 8dBm/3kHz.

10.1 Port RF1-1: 5725-5875 MHz band

EUT set to transmit at maximum power of 20 dBm on the required channel.

Frequency (MHz)	Channel Bandwidth (MHz)	Data Rate (MBit/s)	Peak Marker reading	PSD (dBm/3kHz)	Result	Plot name
5825.0	20	9	2.52	-12.68	Pass	PSD-5825-20M-9
		18	2.35	-12.85	Pass	PSD-5825-20M-18
		36	2.06	-13.14	Pass	PSD-5825-20M-36
		54	2.08	-13.12	Pass	PSD-5825-20M-54
5785.0		9	2.04	-13.16	Pass	PSD-5785-20M-9
5745.0		9	2.49	-12.71	Pass	PSD-5745-20M-9
5745.0	10	auto	4.78	-10.42	Pass	PSD-5745-10M
5785.0		Auto	4.97	-10.23	Pass	PSD-5785-10M
5825.0		auto	4.57	-10.63	Pass	PSD-5825-10M

Table 20: Spectral Density test; port RF1-1; 5725-5875 MHz band

10.2 Port RF2-1: 5725-5875 MHz band

This port was tested on 10 MHz channels as this was worst case for port RF1-1.

EUT set to transmit at 20 dBm on the correct channel.

Frequency (MHz)	Channel Bandwidth (MHz)	Data Rate (MBit/s)	Peak Marker reading	PSD (dBm/3kHz	Result	Plot name
5745.0	10	auto	4.26	-10.94	Pass	PSD-5745-10M-9-2
5785.0	10	Auto	3.90	-11.30	Pass	PSD-5785-10M-9-2
5825.0	10	auto	4.49	-10.71	Pass	PSD-5825-10M-9-2

Table 21: Spectral Density test; port RF2-1; 5725-5875 MHz band

10.3 Port RF1-1: 2400-2483.5 MHz band; 20 MHz channel

EUT set to transmit at maximum power of 18 dBm on the correct channel.

Frequency (MHz)	Mode	Data Rate (MBit/s)	Peak Marker reading	PSD (dBm/3kHz	Result	Plot name
2437	802.11b	1	4.71	-10.49	Pass	PSD-2437-b-1-1
		2	5.25	-9.95	Pass	PSD-2437-b-2-1
		5.5	4.61	-10.59	Pass	PSD-2437-b-5.5-1
		11	6.28	-8.92	Pass	PSD-2437-b-11-1
2412		11	5.96	-9.24	Pass	PSD-2412-b-11-1
2462		11	5.85	-9.35	Pass	PSD-2462-b-11-1
2412	802.11g	1	4.04	-11.16	Pass	PSD-2412-g-1-1
		54	4.18	-11.02	Pass	PSD-2412-g-54-1
2437		54	4.15	-11.05	Pass	PSD-2437-g-54-1
2462		54	2.95	-12.25	Pass	PSD-2462-g-54-1

Table 22: Spectral Density test; port RF1-1; 2400-2483 MHz band

10.4 Port RF2-1: 2400-2483.5 MHz band; 20 MHz channel

EUT set to transmit at maximum power of 18 dBm on the correct channel

Frequency (MHz)	Mode	Data Rate (MBit/s)	Peak Marker reading	PSD (dBm/3kHz	Result	Plot name
2412	802.11b	11	6.54	-8.66	Pass	PSD-2412-b-11-2
2437		11	5.47	-9.73	Pass	PSD-2437-b-11-2
2462		11	5.25	-9.95	Pass	PSD-2462-b-11-2
2412	802.11g	54	3.70	-11.50	Pass	PSD-2412-g-11-2
2437		54	2.82	-12.38	Pass	PSD-2437-g-11-2
2462		54	2.92	-12.28	Pass	PSD-2462-g-11-2

Table 23: Spectral Density test; port RF1-1; 2400-2483 MHz band

10.5 Port RF1-AUX:

A few additional measurements were done on the RF1-AUX port which is the alternative antenna port on module RF1 and connects to the integral antenna.

EUT set to transmit at maximum power of 20 dBm on the correct channel.

The actual Emission Bandwidths were found to be:

8.457 MHz for 10 MHz channel

17.234 MHz for 20 MHz channel

Frequency (MHz)	Channel Bandwidth (MHz)	Data Rate (MBit/s)	Peak Marker reading	PSD (dBm/3kHz	Result	Plot name
5745.0	10	auto	2.75	-12.45	Pass	PSD-5745-10-Int
5785.0		Auto	3.01	-12.19	Pass	PSD-5785-10-Int
5825.0		auto	2.69	-12.51	Pass	PSD-5825-10-Int
5745.0	20	9	1.39	-13.61	Pass	PSD-5745-20-Int
5785.0		9	1.07	-13.93	Pass	PSD-5785-20-Int
5825.0		9	1.04	-13.96	Pass	PSD-5825-20-Int

Table 24: Spectral Density test; port RF1-Int; 5725-5825 MHz band

11 Maximum Unwanted Emissions Levels

All tests performed by Charlie Blackham of Sulis Consultants ltd at Sulis Consultants premises.

Measurement method
Since peak power measurements were made using a peak detector, the same detector will be used for unwanted emissions. The unwanted emissions shall be at least 20dB lower than the wanted emission.
Testing in the bands immediately adjacent to the wanted band may be done with lower than stated RBW provided the power is integrated over the required bandwidth.

First, establish a reference level by using the following procedure for measuring the peak power level in any 100 kHz bandwidth within the fundamental emission:

The measurement procedure for determining the reference level laid down in section 5.4.1.1 of KDB558074 is identical to measurement method employed in section 10, so maximum values "Peak Marker Values" obtained in section 10.0 shall be used.

Next, determine the power in 100 kHz band segments outside of the authorized frequency band using the following measurement:

Measurement Procedure - Unwanted Emissions

- Set RBW = 100 kHz.
- Set VBW = 300 kHz.
- Set span to encompass the spectrum to be examined.
- Detector = peak.
- Trace Mode = max hold.
- Sweep = auto couple.
- Allow the trace to stabilize (this may take some time, depending on the extent of the span).

11.1 Port RF1-1: 5725-5875 MHz band

The Maximum out of Band Emissions values are determined by subtracting 20dB from the values obtained in section 10.1 and detailed in table 19 which gives the resultant maximum out-of-band emissions levels detailed in table 24:

Frequency (MHz)	Channel Bandwidth (MHz)	Data Rate (MBit/s)	Peak Marker reading	Maximum out of band emission (dBm)	Plot name
5825.0	20	9	2.52	-17.48	PSD-5825-20M-9
5785.0		9	2.04	-17.96	PSD-5785-20M-9
5745.0		9	2.49	-17.51	PSD-5745-20M-9
5745.0	10	auto	4.78	-15.22	PSD-5745-10M
5785.0		Auto	4.97	-15.03	PSD-5785-10M
5825.0		auto	4.57	-15.43	PSD-5825-10M

Table 25: Out of band emissions limits; 5725-5875 MHz band

For ease of testing the following limit lines shall be applied:

-18.0 dBm for 20 MHz channels
-15.5 dBm for 10 MHz channels

20 MHz Channels

Emissions measurements made against an out-of-band emissions limit of -18dBm. Plots were recorded on the ESIB analyser with 3 traces on each plot:

Trace 1: 5745.0 MHz transmit frequency
Trace 2: 5785.0 MHz transmit frequency
Trace 3: 5825.0 MHz transmit frequency

Test Frequency range (MHz)	Operating Frequency (MHz)			Result
30-5000	Plot: 802-11a_20M_30-5000 No emissions within 20 dB of limit			Pass
5000-6000	Plot: 802-11a_20M_5000-6000			Pass
	Trace 1 -32.45 dBm at 5725.0 MHz	Trace 2 No emissions within 20 dB of limit	Trace 3 -36.38 dBm at 5850.0 MHz	
6000-10000	Plot: 802-11a_20M_6000-10000 No emissions within 20 dB of limit			Pass

Table 26: Out of band emissions; port RF1-1; 20 MHz; 5725-5875 MHz band

Emissions measurements above 10 GHz were done in 10MHz channel mode as this mode had the higher power density.

10 MHz Channels

Emissions measurements made against an out-of-band emissions limit of -15.5dBm.
Plots were recorded on the ESIB analyser with 3 traces on each plot:

Trace 1: 5745.0 MHz transmit frequency
Trace 2: 5785.0 MHz transmit frequency
Trace 3: 5825.0 MHz transmit frequency

Test Frequency range (MHz)	Measurement plot and significant emissions			Result
30-5000	Plot: 802-11a_10M_1000-5000 No emissions within 30 dB of limit			Pass
5000-6000	Plot: 802-11a_10M_5000-6000			Pass
	Trace 1 -43.43 dBm at 5725.0 MHz	Trace 2 No emissions within 30 dB of limit	Trace 3 -48.02 dBm at 5850.0 MHz	
6000-10000	Plot: 802-11a_10M_6000-10000 No emissions within 30 dB of limit			Pass
10000-15000	Plot: 802-11a_10M_10000-15000 No emissions within 30 dB of limit			Pass
15000-20000	Plot: 802-11a_10M_15000-20000 No emissions within 30 dB of limit			Pass
20000-25000	Plot: 802-11a_10M_20000-25000 No emissions within 30 dB of limit			Pass
25000-30000	Plot: 802-11a_10M_25000-30000 No emissions within 30 dB of limit			Pass
30000-35000	Plot: 802-11a_10M_30000-35000 No emissions within 30 dB of limit			Pass
35000-40000	Plot: 802-11a_10M_35000-40000 No emissions within 30 dB of limit			Pass

Table 27: Out of band emissions; port RF1-1; 20 MHz; 5725-5875 MHz band

11.2 Port RF2-1: 5725-5875 MHz band

This port was not tested.
Port RF2-1 is connected to an identical module to port RF2-1 via a slightly longer cable – this explains the slightly lower TX power level.

11.3 Port RF1-1: 2400-2483.5 MHz band; 20 MHz channel

The Maximum Out of Band Emissions values are determined by subtracting 20dB from the values obtained in section 10.3 and detailed in table 21 which gives the resultant maximum out-of-band emissions levels detailed in table 27.

Based on maximum Spectral Density levels found, testing will be performed as follows:

Frequency (MHz)	Mode	Data Rate (MBit/s)	Peak Marker reading	PSD (dBm)	Plot name
2437	802.11b	11	6.28	-13.72	PSD-2437-b-11-1
2412		11	5.96	-14.04	PSD-2412-b-11-1
2462		11	5.85	-14.15	PSD-2462-b-11-1
2412	802.11g	54	4.18	-15.82	PSD-2412-g-54-1
2437		54	4.15	-15.85	PSD-2437-g-54-1
2462		54	2.95	-17.05	PSD-2462-g-54-1

Table 28: Spectral Density test; port RF1-1; 2400-2483 MHz band

For ease of testing the following limits shall be applied:

-14.5 dBm for 802.11b
-17.5 dBm for 802.11g

EUT set to transmit at maximum power of 18 dBm on the correct channel.

802.11b operation Channels

Emissions measurements made against an out-of-band emissions limit of -14.5dBm. Plots were recorded on the ESIB analyser with 3 traces on each plot:

Trace 1: 2412.0 MHz transmit frequency
Trace 2: 2437.0 MHz transmit frequency
Trace 3: 2462.0 MHz transmit frequency

Test Frequency range (MHz)	Operating Frequency (MHz)			Result
30-1000	Plot: RB_802-11b_30-1000 No emissions within 30 dB of limit			Pass
1000-2200	Plot: 802-11b_1000-2200 No emissions within 30 dB of limit			Pass
2200-2600	Plot: 802-11b_2200-2600			Pass
	Trace 1 For information: -40.44 dBm at 2400 MHz	Trace 2 No emissions within 20 dB of limit	Trace 3 For information: -51.35 dBm at 2483.5 MHz	
2600-5000	Plot: 802-11b_2600_5000 No emissions within 30 dB of limit			Pass
5000-10000	Plot: 802-11b_5000-10000 No emissions within 30 dB of limit			Pass
10000-15000	Plot: 802-11b_10000-15000 No emissions within 30 dB of limit			Pass
15000-20000	Plot: 802-11b_15000-20000 No emissions within 30 dB of limit			Pass
20000-25000	Plot: 802-11b_20000-25000 No emissions within 30 dB of limit			Pass

Table 29: Out of band emissions; port RF1-1; 802.11b

802.11g operation Channels

Emissions measurements made against an out-of-band emissions limit of -17.5 dBm.
Emissions measurements made against an out-of-band emissions limit of -14.5dBm.
Plots were recorded on the ESIB analyser with 3 traces on each plot:

Trace 1: 2412.0 MHz transmit frequency
Trace 2: 2437.0 MHz transmit frequency
Trace 3: 2462.0 MHz transmit frequency

Test Frequency range (MHz)	Operating Frequency (MHz)			Result
30-1000	Plot: RB_802-11g_30-1000			Pass
1000-2200	RB_802-11g_1000-2200_PK No emissions within 30 dB of limit			Pass
2200-2600	Plot: 802-11g_2200-2600			Pass
	-23.38 dBm at 2400 MHz		-42.21 dBm at 2483.5 MHz	
2380-2425	Plot: 802-11g_2380-2425			Pass
	Trace 1 -24.75 dBm at 2400 MHz	Not measured	Not measured	
2600-5000	Plot: 802-11g_2600-5000 No emissions within 30 dB of limit			Pass
5000-10000	Plot: 802-11g_5000-10000 No emissions within 30 dB of limit			Pass
10000-15000	Plot: 802-11g_10000-15000 No emissions within 30 dB of limit			Pass
15000-20000	Plot: 802-11g_15000-20000 No emissions within 30 dB of limit			Pass
20000-25000	Plot: 802-11g_20000-25000 No emissions within 30 dB of limit			Pass

Table 30: Out of band emissions; port RF1-1; 802.11g

11.4 Port RF2-1: 2400-2483.5 MHz band; 20 MHz channel

This port was not tested as Port RF2-1 is connected to an identical module to port RF2-1 via a slightly longer cable.

11.5 Port RF1-AUX:

A few additional measurements were done on the RF1-AUX port which is the alternative antenna port on module RF1 and connects to the integral antenna.

EUT set to transmit at maximum power of 20 dBm on the correct channel.

Testing was done for band edge compliance using 20 MHz channels as these use same centre frequencies as 10 MHz channels but have emissions nearer to the band edge.

The Power Spectral Density reading for this port was done with 10 MHz channels so these will be re-measured for 20 MHz channels

Frequency (MHz)	Channel Bandwidth (MHz)	Data Rate (MBit/s)	Peak Marker reading	Spectral Density (dBm	Plot name
5745.0	20	9	1.39	-18.61	PSD-5745-20-Int
5785.0		9	1.07	-18.93	PSD-5785-20-Int
5825.0		9	1.04	-18.96	PSD-5825-20-Int

Table 31: Spectral Density test; port RF1-Int; 5725-5825 MHz band

For ease of testing the following limit lines shall be applied:
-19.0 dBm for 20 MHz channels

20 MHz Channels

Emissions measurements made against an out-of-band emissions limit of -19dBm.

Test Frequency range (MHz)	Operating Frequency (MHz)			Result
30-1000	Plot: 802-11a_20M_INT_5000-6000			Pass
	Trace 1 -32.96 dBm at 5725.0 MHz	Trace 2 No emissions within 20 dB of limit	Trace 3 -38.57 dBm at 5850.0 MHz	

Table 32: Out of band emissions; port RF1-INT; 20 MHz; 5725-5875 MHz band

12 Maximum Emissions – Restricted Band

The majority of measurements for this requirement was covered using radiated emissions. Tests at certain frequencies, notably near to transmit frequencies were measured using conducted methods.

Measurement method – conducted measurements (final)
The radiated emissions field strength limit specified in 15.209(a) is converted to a conducted power at the antenna port as per section 5.4.2 of KDB 558074-d01.

Frequency (MHz)	Field strength (µV/m)	Measurement distance (m)	Field Strength (dBµV/m)	EIRP (dBm)	6	9	22	23
30–88	100	3	40.0	-55.3	-61.3	-64.3	-77.3	-78.3
88–216	150	3	43.5	-51.7	-57.7	-60.7	-73.7	-74.7
216–960	200	3	46.0	-49.2	-55.2	-58.2	-71.2	-72.2
Above 960	500	3	54.0	-41.3	-47.3	-50.3	-63.3	-64.3

Measurements were only made above 1 GHz, so the following test method was used as per section 5.4.2.2.2.1 of the KDB:

- Set the analyzer span to encompass the entire unwanted emission bandwidth.
- Set the required limit line as per above table.
- Set the RBW = 1 MHz.
- Set the VBW = 3 MHz.
- Detector = power average (RMS).
- Ensure that the number of measurement points in the sweep to ≥ 2 x (span/RBW).
- Manually set the sweep time to: ≥ 10 x (number of measurement points in sweep) x (transmission symbol period).
- Perform the measurement over a single sweep.
- Use the peak marker function to determine the maximum average power level in any 1 MHz of the unwanted emission.

Where a measurement was performed as a "conducted pre-scan" this was done with max-hold prior to final measurements being made radiated.

Measurement method – radiated measurements

Procedure: In accordance with ANSI C63.10:2009.

A search was made of the frequency spectrum from 30 MHz to 26 GHz or 40 GHz depending on the operating mode of the EUT and the measurements reported are the highest emissions relative to the 'FCC CFR 47 Section 15.209 and 15.249 Limits' at a measuring distance of three metres.

- Initial measurements were made is a semi-anechoic chamber using a peak detector: Emissions below 1 GHz that fell in Restricted Bands were then measured on the Open Area Test Site.
- Emissions above 1 GHz that fell in the Restricted Band and were within 12dB of the average limit were measured using an average detector. Where this average emission was within 12 dB of the limit the emission was measured on the Open Area Test Site.

12.1 Port RF1-1:802.11a; integral 23dBi antenna

All radiated emissions testing performed by Rob St John James of Hursley EMC.

EUT set to transmit on maximum power of 20dBm with channel bandwidth of 10 MHz.

Test Frequency range (MHz)	Measurement method	Operating Frequency (MHz)		
		5745	5785	5825
30-1000 MHz	Radiated	See section 12.2 and section 12.3		
1000-10000	Conducted pre-scan			
		5_8_LOW	5_8_MID	5_8_Hi
	Radiated @1m: limit 63.5 dBµV/m	Note: TX power reduced to 10dBm Worst case emission: 5.354 GHz: 72.0 dBµV/m Peak 60.0 dBµV/m Average		
100000-18000	Conducted pre-scan	RB_802-11a_10000-18000		
		Trace 1	Trace 2	Trace 3
	Radiated @1m: limit 63.5 dBµV/m	2nd Harmonic 11490 MHz 53.6 dBµV/m	2nd Harmonic 11570 MHz 53.5 dBµV/m	2nd Harmonic 11650 MHz 53.3dBµV/m
18000-26000	Radiated	No significant emissions		
		Plot: 26Glow	Plot: 26Gmid	Plot: 26Ghigh
26000-40000	Radiated	No significant emissions		
		Plot: 40Glow	Plot: 40Gmid	Plot: 40Ghigh

Table 33: Out of band emissions limits; 5725-5875 MHz band

Testing was initially performed from 18000 to 40000 MHz and no significant emissions were found.
Radiated emissions below 18000 MHz could not achieve sufficient noise floor due to coupling of the intentional emission into the analyser so measurements were made conducted:

- Initial scans were made using conducted test method with the ESIB in analyser mode.
- Final measurements of frequencies in restricted bands were made radiated at 1m due to noise floor being too near the limit line. This was because external amplifier could not be used as it was being overloaded by fundamental

100000-18000 MHz
The 2nd harmonics that "failed" the conducted limit line derived from worst case in-band antenna gain did not appear out of the noise floor when measured radiated.

1000-100000 MHz
Final measurements were perform radiated.
The EUT failed the limit line with TX power of 20dBm
Transmit power was reduced to 10dBm and worst case emission passed.

As 802.11a mode can also be used with 9dBi antenna, the worst case Restricted Band portion was checked conducted against limit of -50.3dBm when transmitting at 20dBm with 10 MHz channel bandwidth for maximum power density.

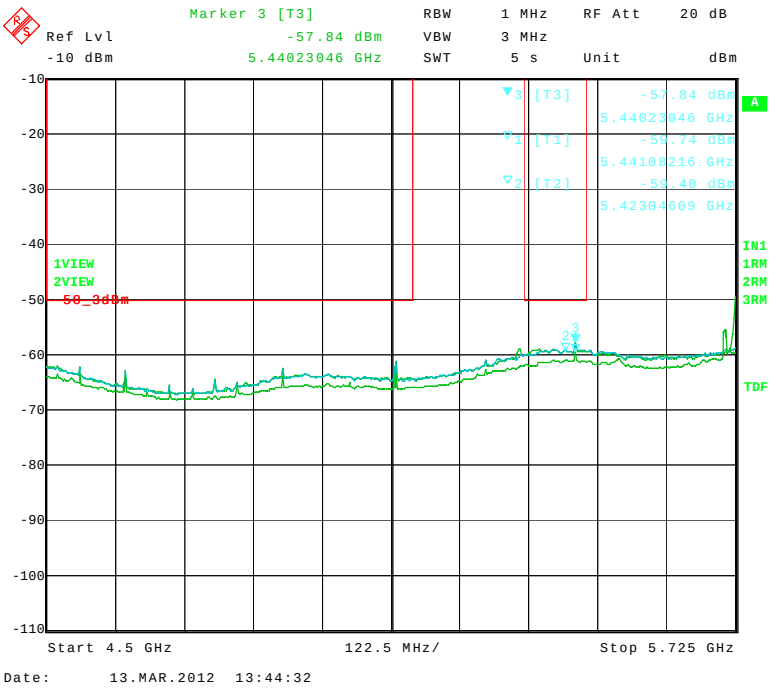


Figure 3: 802.11a Rest Band 20dBm with 9dBi antenna

12.2 Port RF1-2:802.11b; external 6dBi antenna

All radiated testing performed by Rob St John James of Hursley EMC.
All conducted testing performed by Charlie Blackham of Sulis Consultants Ltd.

For frequencies above 1000 MHz, testing was performed in worst case mode of 11 MBit/s at maximum power of 18dBm.
For testing at frequencies below 1000 MHz, EUT was operating with both 2.4 and 5.8 GHz radios as per table 7, Mode 1.

Test Frequency range (MHz)	Measurement method	Operating Frequency (MHz)		
		2412	**2437**	**2462**
30-1000	Radiated	Worst case emissions in table 35 in section 12.3		
		12CE0103_22	12CE0103_23	12CE0103_24
1000-10000	Radiated	Worst case emissions in table 35 in section 12.3		
		12CE0103_18	12CE0103_19	12CE0103_20
2483.5 – 2500.0	Conducted (final)	801B0118	801B0618	801B_TOP 801B1118
10000-18000	Radiated	No significant peaks found		
		12CE0103_05	12CE0103_06	12CE0103_07
18000-26000	Radiated	No significant peaks found Plot: 26G_b		
		Trace 1	Trace 2	Trace 3

Table 34: Restricted band emissions; port RF1-1; 802.11b and mode 1

Worst case radiated emissions in bands 30-1000 and 1000-18000 were found to be when radio was operating in mode 2 and results are shown in section 12.3

12.3 Port RF1-2:802.11g; Restricted Band

All radiated testing performed by Rob St John James of Hursley EMC.
All conducted testing performed by Charlie Blackham of Sulis Consultants Ltd.
Testing was performed in worst case mode of 11 MBit/s at maximum power of 18dBm.
For frequencies above 1000 MHz, testing was performed in worst case mode of 11 MBit/s at maximum power of 18dBm.
For testing at frequencies below 1000 MHz, EUT was operating with both 2.4 and 5.8 GHz radios as per table 7, Mode 2.

Test Frequency range (MHz)	Measurement method		Operating Frequency (MHz)		
		2412	2437	2457	2462
30-1000	Radiated	See table			
		12CE0103_25	12CE0103_26	N/A	12CE0103_27
1000-10000	Radiated	See table			
		12CE0103_15	12CE0103_16	N/A	12CE0103_17
2483.5 – 2500.0	Conducted (final)	801G0117 (17dBm TX)	801G0617 (17dBm TX)	801G1017 (17dBm TX)	801G_TP2 (Fail) 801GTP13 (13dBm TX)
10000-18000	Radiated	No significant peaks found			
		12CE0103_08	12CE0103_09	N/A	12CE0103_10
18000-26000	Radiated	No significant peaks found Plot: 26G_g			
		Trace 1	Trace 2	N/A	Trace 3

Table 35: Restricted band emissions; port RF1-1; 802.11g and Mode 2

Significant emissions:
Worst case emissions in bands 30-1000 and 1000-18000 were found to be when radio was operating in mode 2:

Frequency (MHz)	QP Detector emission	Average Detector emission	Limit	Result
34.6125	21.10 dBµV/m	-	40.00 dBµV/m	Pass
199.999	30.52 dBµV/m	-	43.50 dBµV/m	Pass
399.993	25.80 dBµV/m	-	46.00 dBµV/m	Pass
499.989	40.30 dBµV/m	-	46.00 dBµV/m	Pass
699.985	43.15 dBµV/m	-	46.00 dBµV/m	Pass
1200.000	-	48.54 dBµV/m	54.00 dBµV/m	Pass
1892.4500	-	24.90 dBµV/m	54.00 dBµV/m	Pass
2487.67	-	-49.29 dBm	-47.30 dBm	Pass
4874.100	-	27.31 dBµV/m	54.00 dBµV/m	Pass
4822.900	-	38.79 dBµV/m	54.00 dBµV/m	Pass

Table 36: Radiated Spurious Emissions - restricted bands

13 Mains Conducted Emissions

Testing was performed by Rob St John James at Hursley EMC Services test laboratory at Hursley, Winchester.

Test Configuration

A filtered 115V/60Hz supply was fed to the system under test, via a 50Ω/50µH Line Impedance Stabilisation Network (LISN). The LISN was directly bonded to a conductive ground plane.

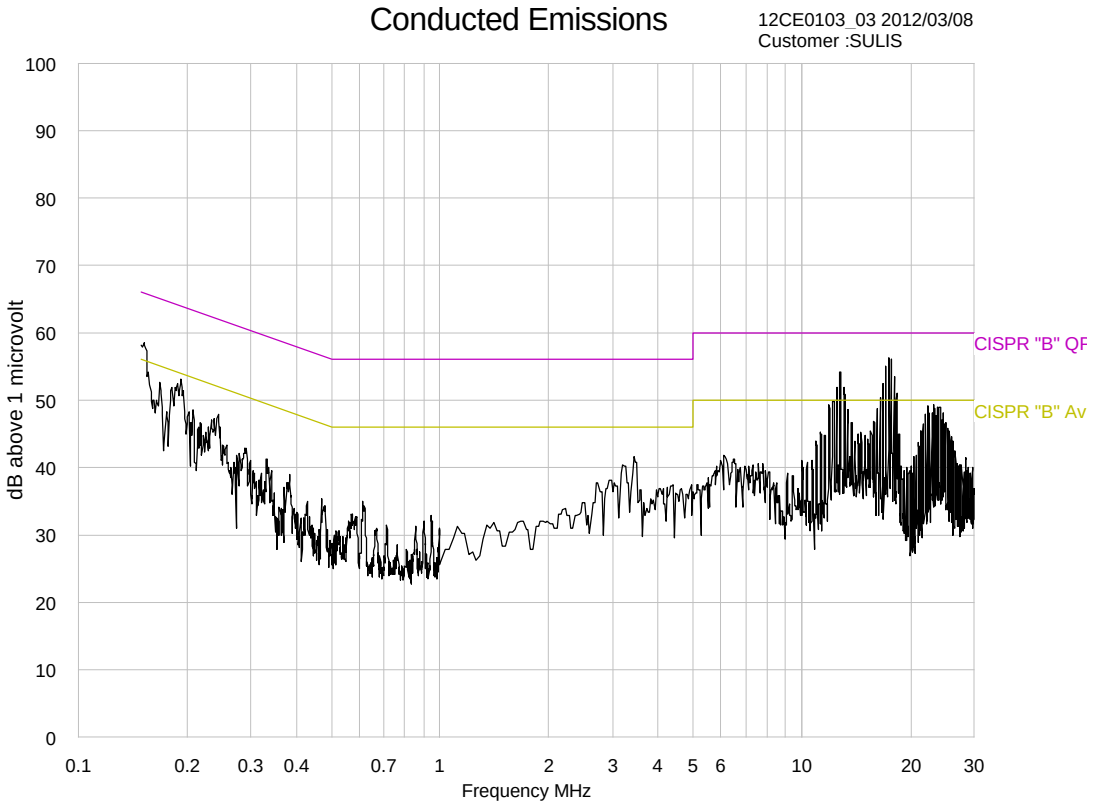
Test Measurement

The worst-case emissions were identified on both the neutral and phase(s) with a spectrum analyser set to scan from 0.15 MHz to 30 MHz.
The worst-case peaks were then identified and measured using an RF receiver using a quasi-peak detector and compared to the frequency range and limits of CISPR 22 as specified by ANSI C63.4- 2003.
Quasi-peak values that exceeded the average limit were then re-measured using the average signal detector.
Emissions that meet the average limit on a quasi-peak measurement are deemed to meet both the average and quasi-peak specification.

The worst-case results are presented in this report.

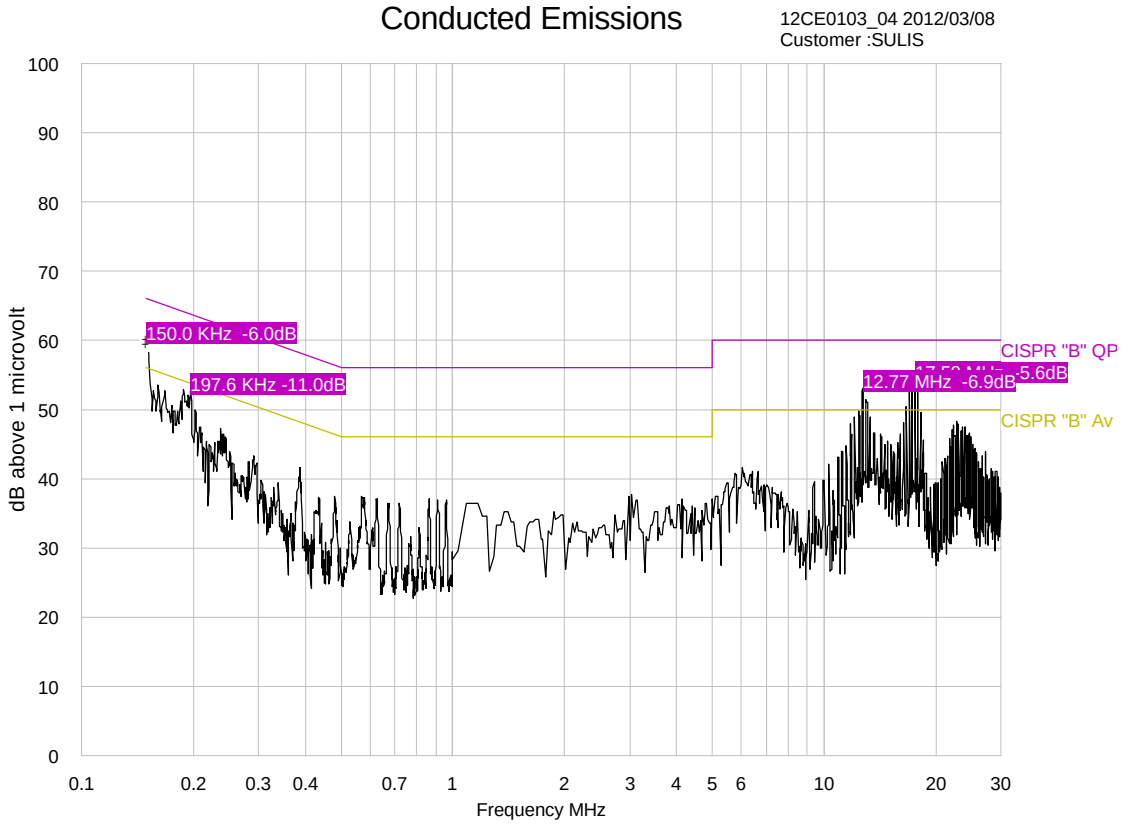
Measurements made according to the FCC rules and Hursley EMC Services test procedure CON-02.

13.1 Neutral line (plot 12CE0103_03)



Frequency (MHz)	QP emission (dBµV)	QP limit (dBµV)	Ave emission (dBµV)	Ave limit (dBµV)	Result
0.15036	47.7	66.0	11.8	56.0	Pass
0.18801	49.4	64.1	23.7	54.1	Pass
12.755	31.8	60.0	32.7	50.0	Pass
17.307	34.2	60.0	34.1	50.0	Pass
23.075	33.1	60.0	28.6	50.0	Pass

13.2 Live line (plot 12CE0103_04)



Frequency (MHz)	QP emission (dBµV)	QP limit (dBµV)	Ave emission (dBµV)	Ave limit (dBµV)	Result
0.151624	46.9	65.9	11.4	55.9	Pass
0.189391	48.9	64.1	33.3	54.1	Pass
12.6637	43.9	60.0	30.3	50.0	Pass
17.1847	48.1	60.0	31.6	50.0	Pass