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Wireless test report – 350995-4TRFWL

Applicant:

Eurotech SpA

Product name:

ReliaGATE 10-12

DynaGATE 10-12

Model:

REGATE-10-12-GS02

Model variant:

DYGATE-10-12-GS02

FCC ID:

UKMMRG1012

IC Registration number:

21442-MRG1012

Specifications:

- FCC 47 CFR Part 15 Subpart E, §15.407

  Unlicensed National Information Infrastructure Devises

- RSS-247, Issue 2, Section 6, Feb 2017

  Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

Test location

Company name	Nemko Canada Inc.
Address	292 Labrosse Avenue
City	Pointe-Claire
Province	QC
Postal code	H9R 5L8
Country	Canada
Telephone	+1 514 694 2684
Facsimile	+1 514 694 3528
Toll free	+1 800 563 6336
Website	www.nemko.com
Site number	FCC: CA2041; IC: 2040G-5 (3 m semi anechoic chamber)

Tested by	Yong Huang Wireless/EMC Specialist
Reviewed by	Kevin Rose, Wireless/EMC Specialist
Review date	September 14, 2018
Reviewer signature	

Limits of responsibility

Note that 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.
This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contain in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

Copyright notification

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Eurotech SpA
Address	Via Fratelli Solari 3/a 33020 Amaro, UD, Italy

1.2 Test specifications

FCC 47 CFR Part 15, Subpart E, Clause 15.407 RSS-247, Issue 2, February 2017	Unlicensed National Information Infrastructure Devises Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.3 Test methods

789033 D02 General UNII Test Procedures New Rules v02r01 (Dec 14, 2017)	Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices Part 15, Subpart E
FCC 16-24 (March 2, 2016)	Memorandum opinion and order for U-NII-3 (5.725–5.85 GHz) band
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was completed against all relevant requirements of the test standard. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See “Summary of test results” for full details.

1.5 Exclusions

None

1.6 Test report revision history

Revision #	Details of changes made to test report
TRF	Original report issued

Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

Part	Test description	Verdict
§15.31(e)	Variation of power source	Pass[1]
§15.203	Antenna requirement	Pass[2]

Notes: [1] Measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, was performed with the supply voltage varied between 85 % and 115 % of the nominal rated supply voltage. No noticeable output power variation was observed

[2]The Antennas uses a unique coupling to the intentional radiator.

2.2 FCC Part 15 Subpart E, test results

Part	Test description	Verdict
§15.403(i)	Emission bandwidth	Pass
§15.407(a)(1)	Power and density limits within 5.15–5.25 GHz band	Not applicable
§15.407(a)(2)	Power and density limits within 5.25–5.35 GHz and 5.47–5.725 GHz bands	Not applicable
§15.407(a)(3)	Power and density limits within 5.725–5.85 GHz band	Pass
§15.407(b)(1)	Undesirable emission limits for 5.15–5.25 GHz band	Not applicable
§15.407(b)(2)	Undesirable emission limits for 5.25–5.35 GHz band	Not applicable
§15.407(b)(3)	Undesirable emission limits for 5.47–5.725 GHz bands	Not applicable
§15.407(b)(4)	Undesirable emission limits for 5.725–5.85 GHz band	Pass
§15.407(b)(6)	Conducted limits for U-NII devices using an AC power line	Pass
§15.407(e)	Minimum 6 dB bandwidth of U-NII devices within the 5.725–5.85 GHz band	Pass
§15.407(g)	Frequency stability	Pass
§15.407(h)(1)[1]	Transmit power control (TPC)	Not applicable
§15.407(h)(2)[1]	Dynamic Frequency Selection (DFS)	Not applicable

Notes: [1] DFS and TPC requirements are only applicable to 5.25–5.35 GHz and 5.47–5.725 GHz bands

2.3 RSS-Gen, Issue 4, test results

Part	Test description	Verdict
6.6	Occupied Bandwidth	Pass
7.1.2[1]	Receiver radiated emission limits	Not applicable
7.1.3[1]	Receiver conducted emission limits	Not applicable
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Pass
8.11[2]	Frequency stability	Pass

Notes: [1] According to sections 5.2 and 5.3 of RSS-Gen, Issue 4: if EUT does not have a stand-alone receiver neither scanner receiver, then it exempt from receiver requirements.

[2] According to section 8.11 of RSS-Gen, Issue 4: if the frequency stability of the licence-exempt radio apparatus is not specified in the applicable standard (RSS), measurement of the frequency stability is not required

2.4 ISED RSS-247, Issue 2, test results

Section	Test description	Verdict
6.1 (1)[1]	Types of Modulation	Pass
6.2.1 (1)	Power limits for 5150–5250 MHz band	Not applicable
6.2.2 (1)	Power limits for 5250–5350 MHz band	Not applicable
6.2.3 (1)	Power limits for 5470–5600 MHz and 5650–5725 MHz bands	Not applicable
6.2.4 (1)	Power limits for 5725–5850 MHz band	Pass
6.2.4 (1)	Minimum 6 dB bandwidth	Pass
6.2.1 (2)	Unwanted emission limits for 5150–5250 MHz band	Not applicable
6.2.2 (2)	Unwanted emission limits for 5250–5350 MHz band	Not applicable
6.2.2 (2)	TPC requirements for devices with a maximum e.i.r.p. greater than 500 mW	Not applicable
6.2.2 (3)	E.i.r.p. at different elevations restrictions for 5250–5350 MHz band	Not applicable
6.2.3 (2)	Unwanted emission limits for 5470–5600 MHz and 5650–5725 MHz bands	Not applicable
6.2.4 (2)	Unwanted emission limits for 5725–5850 MHz band	Pass
6.3	Dynamic Frequency Selection (DFS) for devices operating in the bands 5250–5350 MHz, 5470–5600 MHz and 5650–5725 MHz	Not applicable

Notes: [1] The EUT employs digital modulations: 802.11a/n

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	July 17, 2018
Nemko sample ID number	Item #2

3.2 EUT information

Product name	ReliaGATE 10-12 DynaGATE 10-12
Model	REGATE-10-12-GS02
Model variant	DYGATE-10-12-GS02
Serial number	Y117LQA0010

3.3 Technical information

Applicant IC company number	21442
IC UPN number	MRG1012
All used IC test site(s) Reg. number	2040G-5
RSS number and Issue number	RSS-247 Issue 2, Section 6, February 2017
Frequency band	5725–5850 MHz
Frequency Min (MHz)	5745 (20 MHz channel), 5755 (40 MHz channel)
Frequency Max (MHz)	5825 (20 MHz channel), 5795 (40 MHz channel))
RF power Max (W), Conducted	0.0151 (11.8 dBm for 20 MHz channel), 0.0105(10.2 dBm for 40 MHz channel)
Measured BW (kHz) (26 dB)	23480 (20 MHz channel), 41400 (40 MHz channel)
Measured BW (kHz) (6 dB)	16000 (20 MHz channel), 35120 (40 MHz channel)
Type of modulation	802.11a/n
Emission classification (F1D, G1D, D1D)	W7D
aTransmitter spurious, Units @ distance	50.46 dBµV/m at 3m average at 3.883 GHz
Power requirements	24 $V_{DC,}$ via 120 V_{AC} adapter or battery
Antenna information	The EUT uses a unique antenna coupling. EUT has 2 antenna configurations. The max antenna peak gain is 5.47 dBi at 2.4 GHz band and 7.07 dBi at 5 GHz WIFI bands. Linx Technologies ANT-DB1-RAF-RPS (2.5 dBi for 2.4 GHz, 4.6 dBi antenna for 5 GHz) Taoglas MA.950.W.A.LBICG.005 (5.47 dBi for 2.4GHz, 7.07 for 5GHz)

3.4 Product description and theory of operation

The ReliaGATE and DynaGATE 10-12 are loT Edge Gateways that have been designed to deliver LTE connectivity (with 3G fallback) to industrial and lightly rugged applications. Based on the TI AM335x Cortex-A8 (Sitara) processor family, with 1 GB of RAM, 4 GB of eMMC and user-accessible MicroSD and dual Micro-SIM slots, the ReliaGATE and DynaGATE 10-12 are low power gateways suitable for demanding use cases. They support a 6 to 36 V power supply with transient protection and ignition sense, two protected RS-232/RS-485 serial ports, two CAN bus interfaces, three noise and surge protected USB ports, and four isolated digital interfaces

3.5 EUT exercise details

EUT was set to continuously transmit mode during tests, by test software provided by client.
The EUT runs a Linux operating system which allows for the testing to be performed using engineering test tools and scripts. Communication with the EUT is via a serial console or Ethernet connection which provides a Linux command line interface for execution of the test tools/scripts. These tools/scripts configure the radio modules to enable continuous transmission with the ability to adjust modulation, frequency and output power as required.

WiFi/BT – using a engineering test tool provided by the silicon vendor allowing for full radio control.
Cellular – using Linux scripts running AT command sequences provided by the cellular radio module vendor allowing for full radio control.

3.6 EUT setup diagram

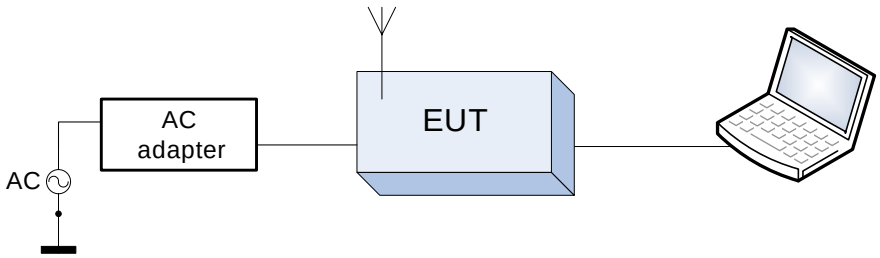


Figure 3.6-1: *Setup diagram*

3.7 EUT sub assemblies

Table 3.7-1: *EUT sub assemblies*

Description	Brand name	Model/Part number	Serial number
REGATE-10-12	Eurotech	REGATE-10-12-GS02	Y117LQA0010
AC adapter	Sunny	SYS15412424	None

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT

There were no modifications performed to the EUT during this assessment.

4.2 Technical judgment

Differences between the variants are as below. REGATE-10-12 was chosen as representative worst-case.

Model	**ReliaGATE 10-12**					**DynaGATE 10-12**				
Variant (Base Hardware) REGATE-10-12-xx	**REGATE-10-12-GS02 (EMC Sample Unit)**	**REGATE-10-12-01**	**REGATE-10-12-02**	**REGATE-10-12-03**	**REGATE-10-12-05**	**DYGATE-10-12-GS02 (EMC Sample Unit)**	**DYGATE-10-12-01**	**DYGATE-10-12-02**	**DYGATE-10-12-03**	**DYGATE-10-12-05**
OS SW Versions Refer Note 1.	-	**REGATE-10-12-21 REGATE-10-12-31**	**REGATE-10-12-22 REGATE-10-12-32**	**REGATE-10-12-23 REGATE-10-12-33**	**REGATE-10-12-25 REGATE-10-12-35**	-	**DYGATE-10-12-21 DYGATE-10-12-31**	**DYGATE-10-12-22 DYGATE-10-12-32**	**DYGATE-10-12-23 DYGATE-10-12-33**	**DYGATE-10-12-25 DYGATE-10-12-35**
GENERAL										
Processor	TI Sitara AM3352 1GHz									
DRAM	1GB DDR3									
STORAGE	4GB eMMC, micro SD slot accessible under service panel opening, 256kbit EEPROM									
PCB Design	Both models share the same PCB design with population differences as described below (8-layers PCB)									
Ethernet	2x 10-100Mbps on shielded RJ45									
Serial	Two identical 2-lines channels(RX/TX, RA+/RB-) available on 3.5mm terminal									
Debug	RS232 3.3V TTL debug port available under service panel opening									
CAN	Two identical Can bus ports available on 3.5mm terminal header with external power delivery 5V@100mA									
Digital I/O	2x Digital Input 36V, 1kV Opto-isolated, 2x Digital Output (40VDC), 500mA fuse protected, 1KHz Max Switching(optorelay)									
USB	3x Host 2.0 (Noise and Surge Protected) - Type A – Electrically identical to DynaGATE 10-12 Variants					3x Host 2.0 (Noise and Surge Protected) - High Retention Type A - Electrically identical to ReliaGATE 10-12 Variants				
Expansion	Yes, for Side Expansion Modules (24way 2mm/2row female header)									
WIRELESS										
LTE	TELIT LE910-NA1 LTE	None	None	TELIT LE910-NA1 LTE		TELIT LE910-NA1 LTE	None	None	TELIT LE910-NA1 LTE	
WiFi	Jorjin WG7833-B0	None	Jorjin WG7833-B0	None	Jorjin WG7833-B0	Jorjin WG7833-B0	None	Jorjin WG7833-B0	None	Jorjin WG7833-B0
GPS	U-Blox NEO M8 GPS	Optional U-Blox NEO-M8x GPS Receiver				Integrated U-Blox NEO-M8x GPS Receiver				
OTHER										
RTC	Yes (Lithium BR1225 battery backup)					Yes (Supercap backup)				
Sensors	Temperature, Accelerometer									
Buttons	1x RESET, 1x user programmable available under the service panel									
LEDs	1x Power, 1x Cellular, 4x Programmable									
TPM	Factory Option									
SIM slot	2x microSIM (User Accessible under the service panel)									
Power	6-36VDC, with Transient Protection, Vehicle Ignition Sense (2W typ.)									
ENVIRONMENT										
Operating temp. range	- 20 to +70°C					- 40 to +85°C				
Storage temp. range	- 40 to +85°C									
MECHANICAL										
Enclosure	ABS Plastic					Aluminium Sheetmetal				
Ingress	IP40									
Dimensions	138.9x115.0x46.2mm (LxWxH) - with mounting bracket and SMA connectors					138.9x118.2x51.6mm (LxWxH) - with mounting bracket and SMA connectors				

Note 1: Radio module firmware and operating system based radio firmware loaded during OS boot are identical across all REGATE-10-12-xx and DYGATE-10-12-xx variants.

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5. Test conditions

5.1 Atmospheric conditions

Temperature	15–30 °C
Relative humidity	20–75 %
Air pressure	860–1060 mbar

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

5.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages ±5 %, for which the equipment was designed.

Section 6. Measurement uncertainty

6.1 Uncertainty of measurement

Measurement uncertainty budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of K = 2 with 95% certainty.

Test name	Measurement uncertainty, dB
All antenna port measurements	0.55
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78
AC power line conducted emissions	3.55

Section 7. Test equipment

7.1 Test equipment list

Table 7.1-1: *Equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
Flush mount turntable	Sunol	FM2022	FA002550	—	NCR
Controller	Sunol	SC104V	FA002551	—	NCR
Antenna mast	Sunol	TLT2	FA002552	—	NCR
Spectrum analyzer	Rohde & Schwarz	FSV 40	FA002731	1 year	Oct 10/18
50 Ω coax cable	C.C.A.	None	FA002603	—	VOU
50 Ω coax cable	C.C.A.	None	FA002605	—	VOU
50 Ω coax cable	C.C.A.	None	FA002607	—	VOU
Bilog antenna (20–2000 MHz)	Sunol	JB1	FA002517	1 year	Dec. 6/18
Horn antenna (1–18 GHz)	EMCO	3115	FA001452	1 year	Nov. 20/18
Horn antenna (18–40 GHz)	EMCO	3116	FA002487	2 year	Aug. 16/18
Pre-amplifier (0.5–18 GHz)	COM-POWER	PAM-118A	FA002561	1 year	Sept. 21/18
Pre-amplifier (18–40 GHz)	COM-POWER	PAM-840	FA002508	1 year	May 8/19
5725-5850 MHz Notch Filter	Microwave Circuits	N0257881	FA002692	—	VOU
50 Ω coax cable	HUBER+SUHNER	SUCOFLEX 100	FA002564	—	VOU
Three phase power system	TESEQ	ProfLine 2115-400	FA002516	1 year	Aug. 21/18
Power sensor	Rohde & Schwarz	NRP18S	FA002730	1 year	Oct 21/18
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 40	FA002071	1 year	Sept. 18/18
Environmental Chamber	ESPEC	EPX-4H	FA002736	1 year	June 6/19
True RMS Multimeter	Fluke	175	FA002642	1 year	Nov. 2/18
LISN	Rohde & Schwarz	ENV216	FA002514	1 year	Dec. 15/18

Note: NCR - no calibration required, VOU - verify on use

Section 8. Testing data

8.1 FCC 15.403(i) Emission bandwidth, 15.407(e) 6 dB bandwidth

8.1.1 Definitions and limits

FCC:
15.403(i) For purposes of this subpart the emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolution bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement.
15.407(e) Within the 5.725–5.85 GHz band, the minimum 6 dB bandwidth of U-NII devices shall be at least 500 kHz.

8.1.2 Test summary

Test start date	July 26, 2018
Test engineer	Yong Huang

8.1.3 Observations, settings and special notes

Spectrum analyzer settings:

Resolution bandwidth	approximately 1% of EBW (for 26 dB BW), 100 kHz (for 6 dB BW)
Video bandwidth	> RBW
Detector mode	Peak
Trace mode	Max Hold

8.1.4 Test data

Table 8.1-1: *26 dB bandwidth results*

Modulation	Frequency, MHz	26 dB bandwidth, MHz
802.11a	5745	23.00
	5785	22.22
	5825	23.48
802.11n HT20	5745	23.08
	5785	22.94
	5825	23.02
802.11n HT40	5755	40.56
	5795	41.40

Table 8.1-2: *6 dB bandwidth results*

Modulation	Frequency, MHz	6 dB bandwidth, MHz	Minimum limit, MHz	Minimum margin, MHz
802.11a	5745	15.48	0.5	14.98
	5785	15.14	0.5	14.64
	5825	15.14	0.5	14.64
802.11n HT20	5745	16.00	0.5	15.50
	5785	15.12	0.5	14.62
	5825	15.12	0.5	14.62
802.11n HT40	5755	35.00	0.5	34.50
	5795	35.12	0.5	34.62

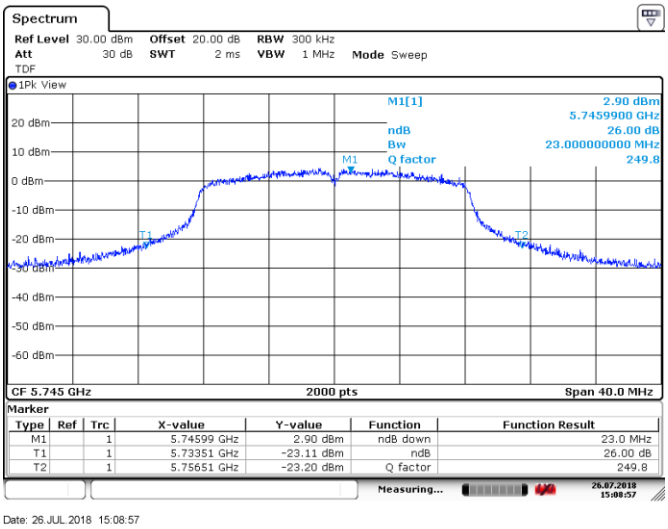


Figure 8.1-1: *26 dB bandwidth on 802.11a, sample plot*

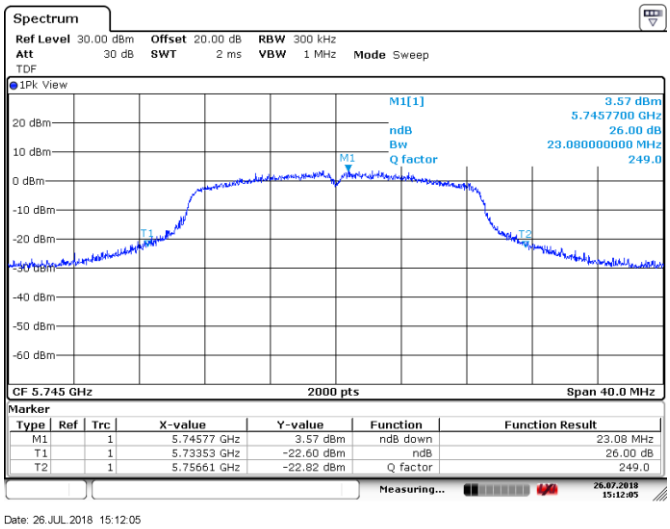


Figure 8.1-2: *26 dB bandwidth on 802.11n HT20, sample plot*

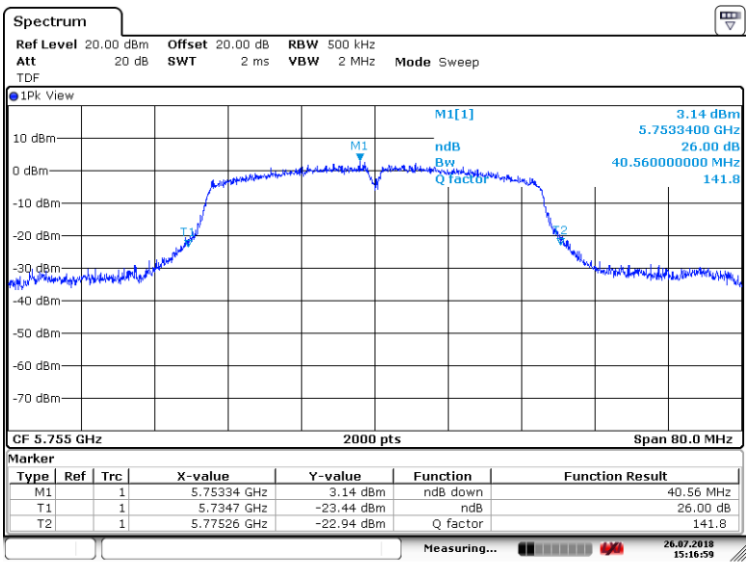


Figure 8.1-3: *26 dB bandwidth on 802.11n HT40, sample plot*

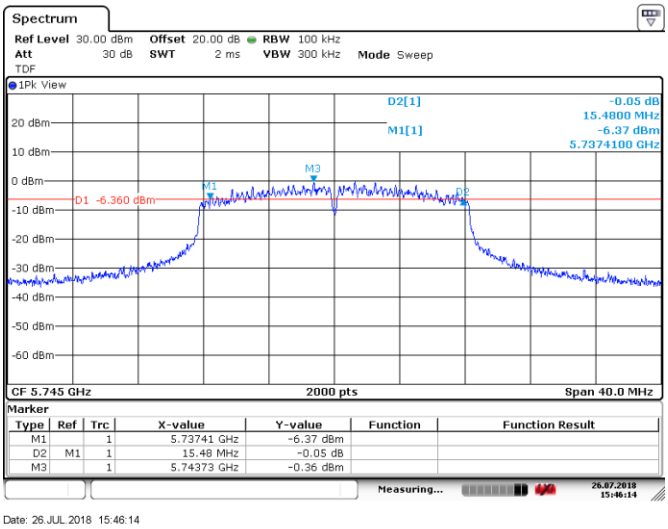


Figure 8.1-4: *6 dB bandwidth on 802.11a, sample plot*

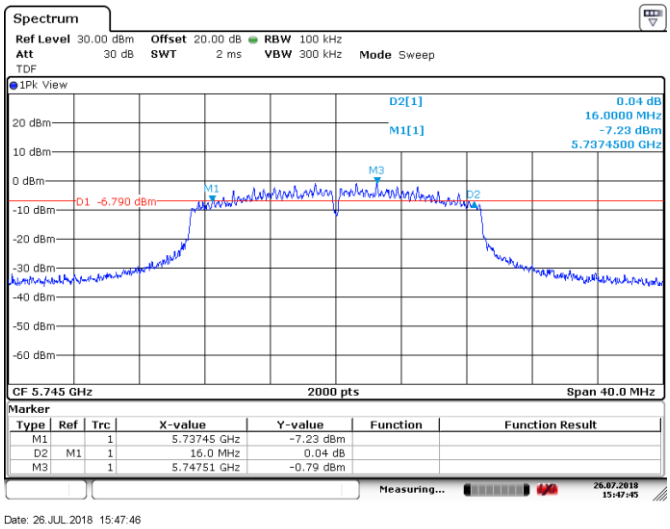


Figure 8.1-5: *6 dB bandwidth on 802.11n HT20, sample plot*

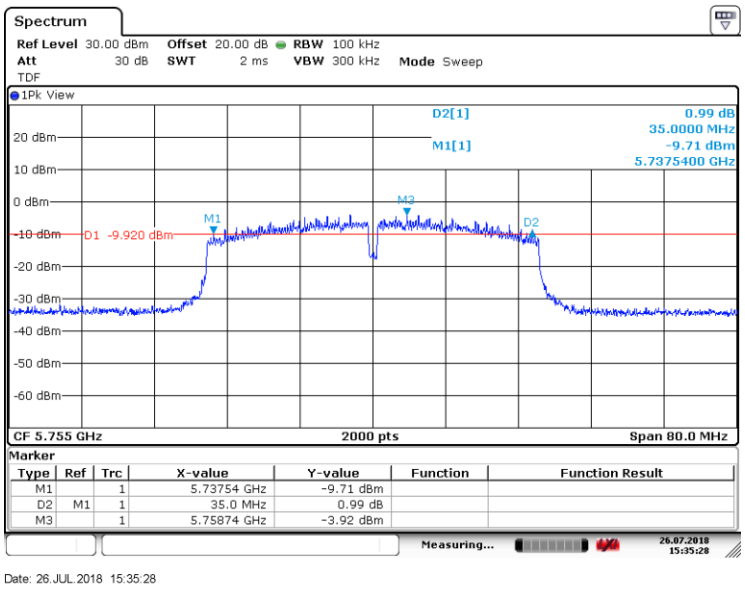


Figure 8.1-6: *6 dB bandwidth on 802.11n HT40, sample plot*

8.2 RSS-Gen 6.6 Occupied bandwidth

8.2.1 Definitions and limits

The emission bandwidth (×dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated × dB below the maximum in-band spectral density of the modulated signal. Spectral density (power per unit bandwidth) is to be measured with a detector of resolution bandwidth in the range of 1% to 5% of the anticipated emission bandwidth, and a video bandwidth at least 3× the resolution bandwidth.

When the occupied bandwidth limit is not stated in the applicable RSS or reference measurement method, the transmitted signal bandwidth shall be reported as the 99% emission bandwidth, as calculated or measured.

8.2.2 Test summary

Test start date	July 26, 2018
Test engineer	Yong Huang

8.2.3 Observations, settings and special notes

Spectrum analyzer settings:

Resolution bandwidth:	1 % to 5 % of OBW
Video bandwidth:	≥3 × RBW
Detector mode:	Peak
Trace mode:	Max Hold

8.2.4 Test data

Table 8.2-1: *99 % bandwidth results*

Modulation	Frequency, MHz	99 % bandwidth, MHz
802.11a	5745	16.72
	5785	16.72
	5825	16.70
802.11n HT20	5745	17.78
	5785	17.86
	5825	17.80
802.11n HT40	5755	36.04
	5795	36.20

8.2.4 Test data, continued

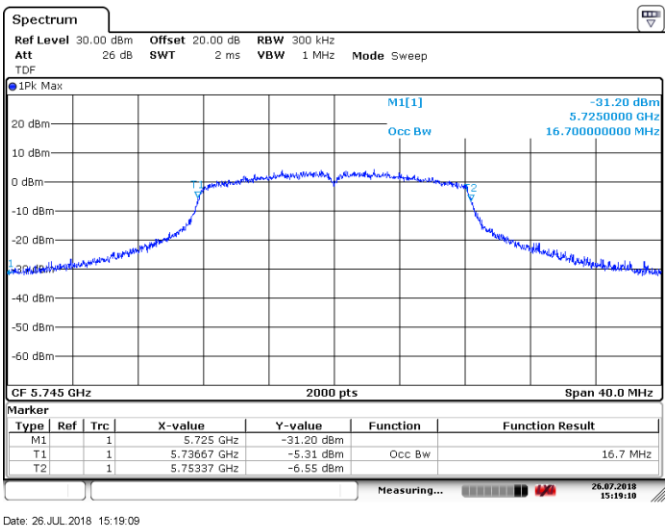


Figure 8.2-1: *99 % bandwidth on 802.11a, sample plot*

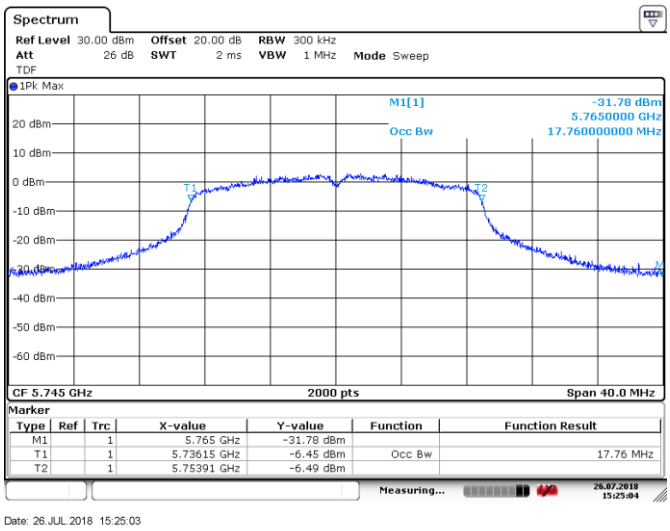


Figure 8.2-2: *99 % bandwidth on 802.11n HT20, sample plot*

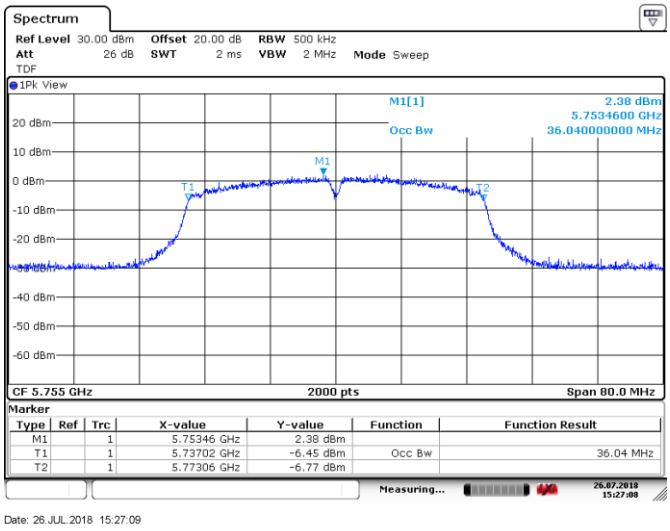


Figure 8.2-3: *99 % bandwidth 802.11n HT40, sample plot*

8.3 FCC 15.407(a)(3) and RSS-247 6.2.4.1 5.725–5.85 GHz band output power and spectral density limits

8.3.1 Definitions and limits

FCC:
For the band 5.725–5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. In addition, the maximum power spectral density shall not exceed 30 dBm in any 500-kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. However, fixed point-to-point U-NII devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

ISED:
The maximum conducted output power shall not exceed 1 W. The power spectral density shall not exceed 30 dBm in any 500 kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. However, fixed point-to-point devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications and multiple collocated transmitters transmitting the same information.

8.3.2 Test summary

Test start date:	July 26, 2018
Test engineer:	Yong Huang

8.3.3 Observations, settings and special notes

As per manufacturer declaration, EUT is for indoor use only. EUT was configured to continuous transmit mode during tests.
Output power was tested using RMS power meter.
The highest and lowest data rate setting have been investigated, only the worst-cases were presented.

Spectrum analyzer settings for PSD measurement:

Resolution bandwidth	500 kHz
Video bandwidth	2 MHz
Frequency span	> EBW
Detector mode	RMS
Trace mode	Power Averaging over 100 sweeps

EIRP was calculated as follows: $EIRP = P_{combined} + antenna\ directional\ gain$

Total antenna gain was calculated as follows: $Directional\ gain = 10\log[(\ 10^{\frac{G1}{20}} + 10^{\frac{G2}{20}})^2 / N_{ANT})$

Output power/EIRP/PSD limit adjustment(in case antenna gain is more than 6 dBi): Output power/EIRP/PSD limit – (Total antenna gain – 6 dBi).

8.3.4 Test data

Table 8.3-1: *Output power measurements results , Taoglas Antenna configuration*

Modulation	Frequency, MHz	Output power, dBm	Power limit, dBm	Margin, dB
802.11a	5745	11.8	28.9	17.1
	5785	11.8	28.9	17.1
	5825	11.6	28.9	17.3
802.11n HT20	5745	11.0	28.9	17.9
	5785	11.1	28.9	17.8
	5825	10.8	28.9	18.1
802.11n HT40	5755	10.2	28.9	18.7
	5795	10.2	28.9	18.7

Table 8.3-2: *PSD measurements results , Taoglas Antenna configuration*

Modulation	Frequency, MHz	PSD, dBm/500 kHz	Limit, dBm/500 kHz	Margin, dB
802.11a	5745	-2.1	28.9	31.0
	5785	-2.0	28.9	31.0
	5825	-2.3	28.9	31.2
802.11n HT20	5745	-1.5	28.9	30.4
	5785	-1.8	28.9	30.7
	5825	-2.0	28.9	31.0
802.11n HT40	5755	-7.0	28.9	35.9
	5795	-7.0	28.9	35.9

Table 8.3-3: *Output power measurements results , Linx Technology Antenna configuration*

Modulation	Frequency, MHz	Output power, dBm	Power limit, dBm	Margin, dB
802.11a	5745	11.8	30.0	18.2
	5785	11.8	30.0	18.2
	5825	11.6	30.0	18.4
802.11n HT20	5745	11.0	30.0	19.0
	5785	11.1	30.0	18.9
	5825	10.8	30.0	19.2
802.11n HT40	5755	10.2	30.0	19.8
	5795	10.2	30.0	19.8

Table 8.3-4: *PSD measurements results , Linx Technology Antenna configuration*

Modulation	Frequency, MHz	PSD, dBm/500 kHz	Limit, dBm/500 kHz	Margin, dB
802.11a	5745	-2.1	30.0	32.1
	5785	-2.0	30.0	32.0
	5825	-2.3	30.0	32.3
802.11n HT20	5745	-1.5	30.0	31.5
	5785	-1.8	30.0	31.8
	5825	-2.0	30.0	32.0
802.11n HT40	5755	-7.0	30.0	37.0
	5795	-7.0	30.0	37.0

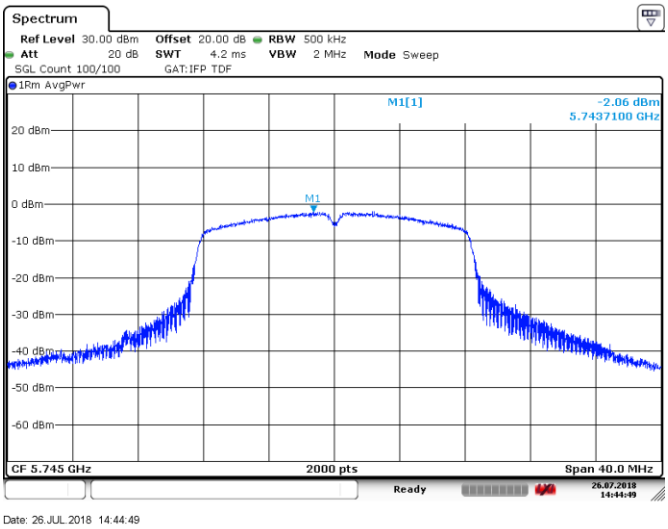


Figure 8.3-1: *PSD on 802.11a Sample plot*

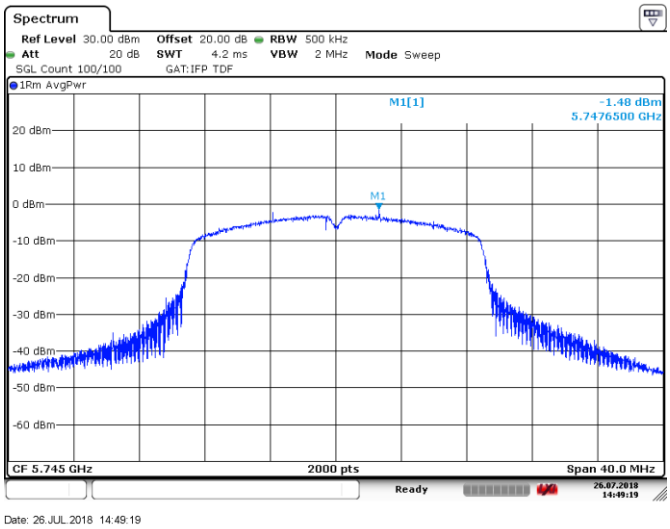


Figure 8.3-2: *PSD on 802.11n HT20, Sample plot*

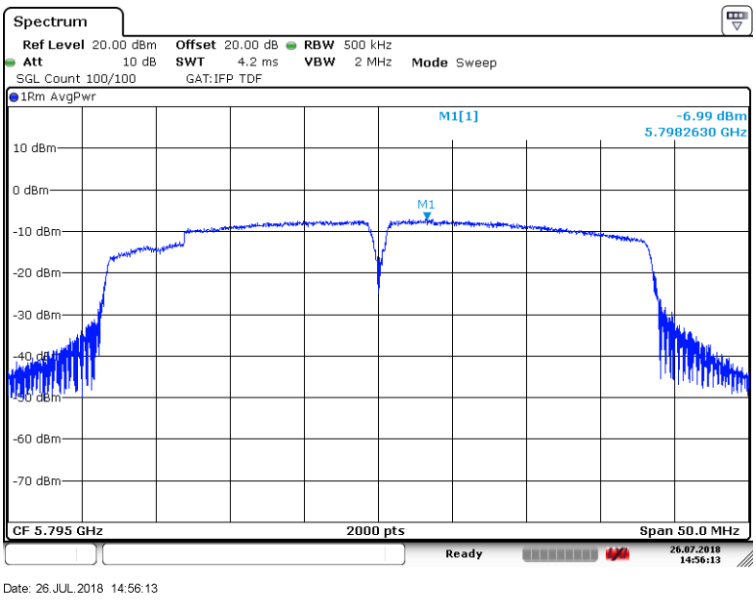


Figure 8.3-3: *PSD on 802.11n HT40, Sample plot*

8.4 FCC 15.407(b) and RSS-247 6.2.4.2 Spurious (out-of-band) emissions

8.4.1 Definitions and limits

FCC:

(i) All emissions shall be limited to a level of −27 dBm/MHz at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.
(ii) Devices certified before March 2, 2017 with antenna gain greater than 10 dBi may demonstrate compliance with the emission limits in § 15.247(d), but manufacturing, marketing and importing of devices certified under this alternative must cease by March 2, 2018. Devices certified before March 2, 2018 with antenna gain of 10 dBi or less may demonstrate compliance with the emission limits in § 15.247(d), but manufacturing, marketing and importing of devices certified under this alternative must cease before March 2, 2020.

ISED:
Devices operating in the band 5725-5850 MHz with antenna gain greater than 10 dBi can have unwanted emissions that comply with either the limits in this section or in section 5.5 until six (6) months after the publication date of this standard for certification. Certified devices that do not comply with emission limits in this section shall not be manufactured, imported, distributed, leased, offered for sale or sold after April 1, 2018.

Devices operating in the band 5725-5850 MHz with antenna gain of 10 dBi or less can have unwanted emissions that comply with either the limits in this section or in section 5.5 until April 1, 2018 for certification. Certified devices that do not comply with emission limits in this section shall not be manufactured, imported, distributed, leased, offered for sale or sold after April 1, 2020.

Devices operating in the band 5725-5850 MHz shall have e.i.r.p. of unwanted emissions comply with the following:

a. 27 dBm/MHz at frequencies from the band edges decreasing linearly to 15.6 dBm/MHz at 5 MHz above or below the band edges;
b. 15.6 dBm/MHz at 5 MHz above or below the band edges decreasing linearly to 10 dBm/MHz at 25 MHz above or below the band edges;
c. 10 dBm/MHz at 25 MHz above or below the band edges decreasing linearly to −27 dBm/MHz at 75 MHz above or below the band edges; and
d.−27 dBm/MHz at frequencies more than 75 MHz above or below the band edges.

Table 8.4-1: *FCC §15.209 and RSS-Gen – Radiated emission limits*

Frequency, MHz	Field strength of emissions µV/m	Field strength of emissions dBµV/m	Measurement distance, m
0.009–0.490	2400/F *(F in kHz)*	$67.6 - 20 \times \log_{10}$(F) *(F in kHz)*	300
0.490–1.705	24000/F *(F in kHz)*	$87.6 - 20 \times \log_{10}$(F) *(F in kHz)*	30
1.705–30.0	30	29.5	30
30–88	100	40.0	3
88–216	150	43.5	3
216–960	200	46.0	3
above 960	500	54.0	3

Notes: In the emission table above, the tighter limit applies at the band edges.
For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test

Table 8.4-2: *ISED restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	12.51975–12.52025	399.9–410	5.35–5.46
2.1735–2.1905	12.57675–12.57725	608–614	7.25–7.75
3.020–3.026	13.36–13.41	960–1427	8.025–8.5
4.125–4.128	16.42–16.423	1435–1626.5	9.0–9.2
4.17725–4.17775	16.69475–16.69525	1645.5–1646.5	9.3–9.5
4.20725–4.20775	16.80425–16.80475	1660–1710	10.6–12.7
5.677-5.683	25.5–25.67	1718.8–1722.2	13.25–13.4
6.215–6.218	37.5–38.25	2200–2300	14.47–14.5
6.26775–6.26825	73–74.6	2310–2390	15.35–16.2
6.31175–6.31225	74.8–75.2	2655–2900	17.7–21.4
8.291–8.294	108–138	3260–3267	22.01–23.12
8.362–8.366	156.52475–156.52525	3332–3339	23.6–24.0
8.37625–8.38675	156.7–156.9	3345.8–3358	31.2–31.8
8.41425–8.41475	240–285	3500–4400	36.43–36.5
12.29–12.293	322–335.4	4500–5150	Above 38.6

Note: Certain frequency bands listed in Table 8.4-2 and above 38.6 GHz are designated for low-power license-exempt applications. These frequency bands and the requirements that apply to the devices are set out in this Standard

Table 8.4-3: *FCC restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	Above 38.6
13.36–13.41			

8.4.2 Test summary

Test start date:	July 26, 2018
Test engineer:	Yong Huang

8.4.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to 40 GHz while the EUT was continuously transmitting.
Conducted measurements were performed on the antenna ports, with the highest and the lowest data rate, the worst case is presented.
In the conducted plots below, the reference level offset was adjusted to include antenna directional gains, the max peak gain of two antenna configurations has been applied to show as representative worst case.
Radiated measurements below 18 GHz were performed at a distance of 3 m. Radiated measurements above 18 GHz were performed at a distance of 1 m.
Cabinet radiation were performed while the antenna connector was terminated with 50 Ω load. Below 1 GHz and above 18 GHz, no emissions related to RF transmitter were detected within 6 dB below the limit.

Spectrum analyser for peak conducted measurements within restricted bands below 1 GHz:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser for peak conducted measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser for average conducted measurements within restricted bands above 1 GHz for frequencies where peak results were above the average limit:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	RMS
Trace mode:	Power average
Number of averaging traces:	100

Spectrum analyser for peak conducted measurements outside restricted bands:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyzer settings for radiated measurements within restricted bands below 1 GHz:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyzer settings for peak radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

8.4.4 Test data

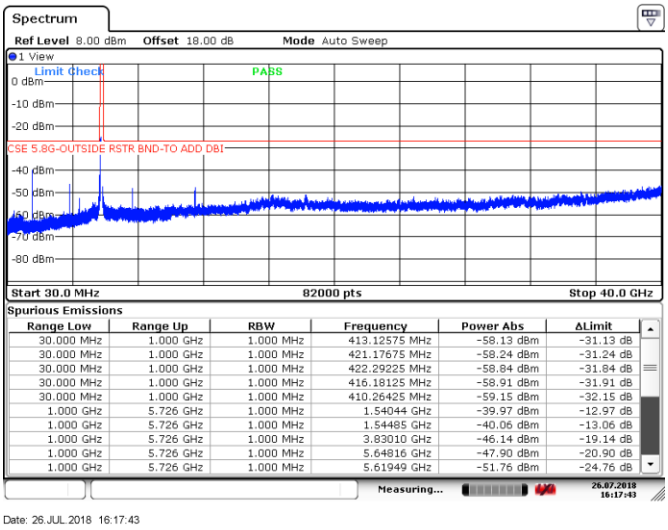


Figure 8.4-1: *Spurious emissions outside restricted bands, Tx on ch 149, 802.11a*

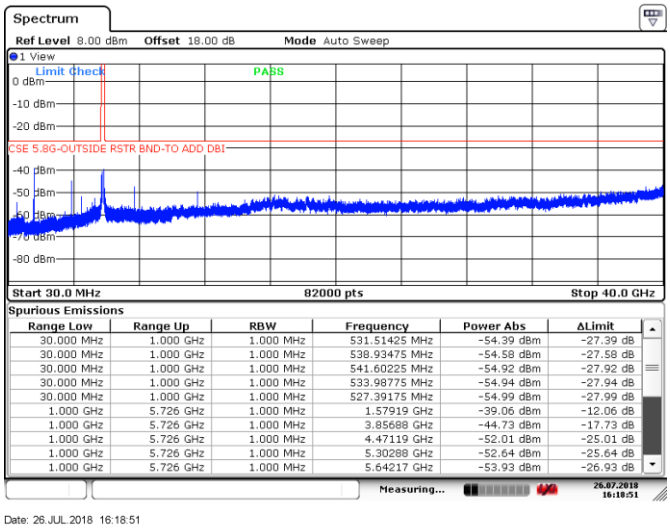


Figure 8.4-2: *Spurious emissions outside restricted bands, Tx on ch 157, 802.11a*

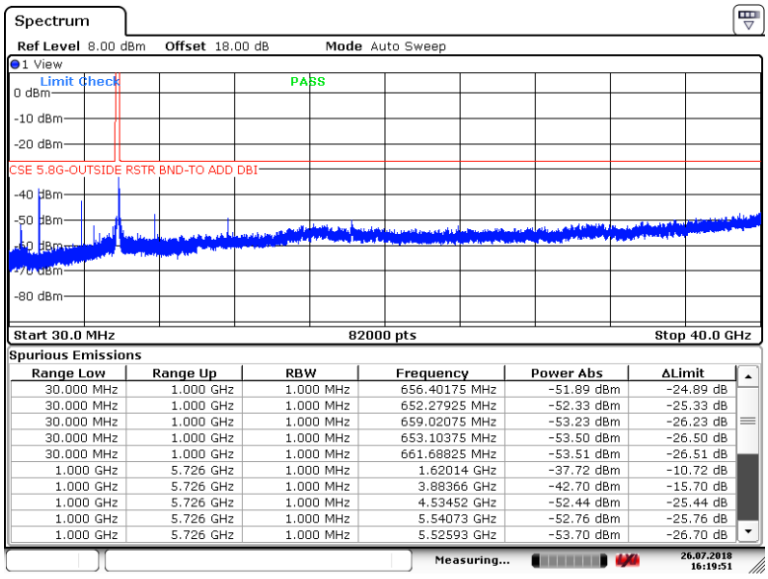


Figure 8.4-3: *Spurious emissions outside restricted bands, Tx on ch 165, 802.11a*

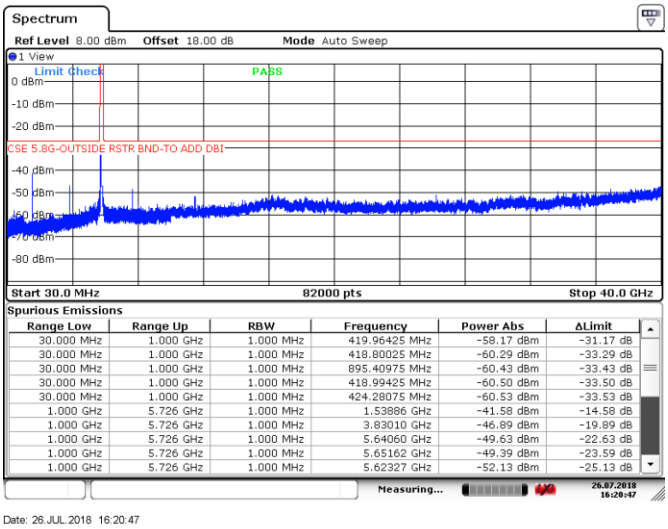


Figure 8.4-4: *Spurious emissions outside restricted bands, Tx on ch 149, 802.11n HT20*

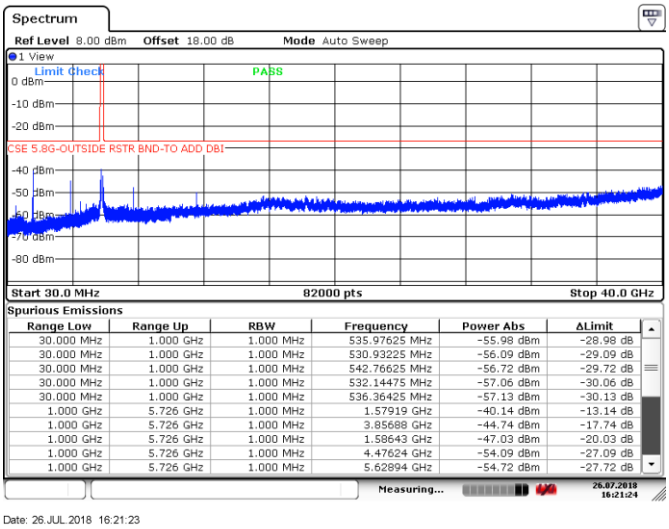


Figure 8.4-5: *Spurious emissions outside restricted bands, Tx on ch 157, 802.11n HT20*

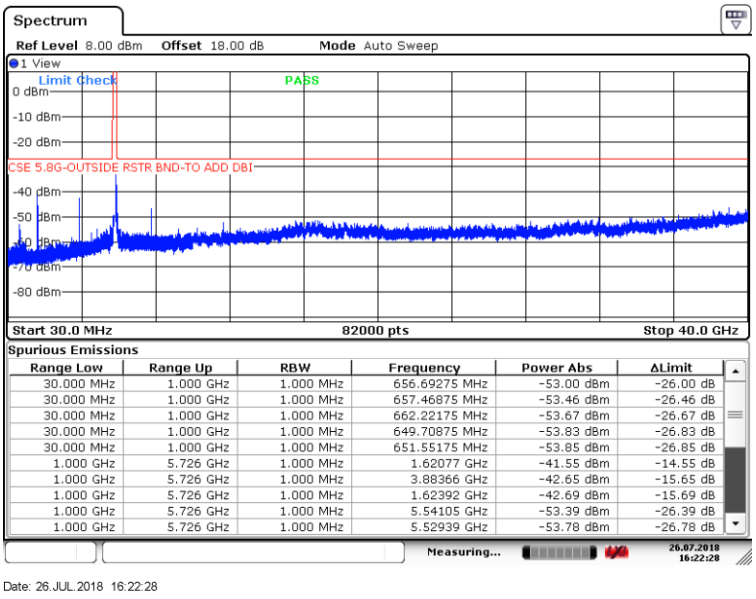


Figure 8.4-6: *Spurious emissions outside restricted bands, Tx on ch 165, 802.11n HT20*

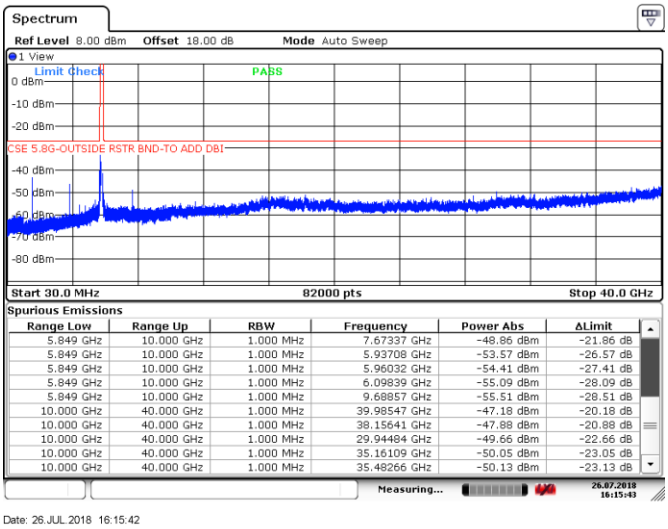


Figure 8.4-7: *Spurious emissions outside restricted bands, Tx on ch 151, 802.11n HT40*

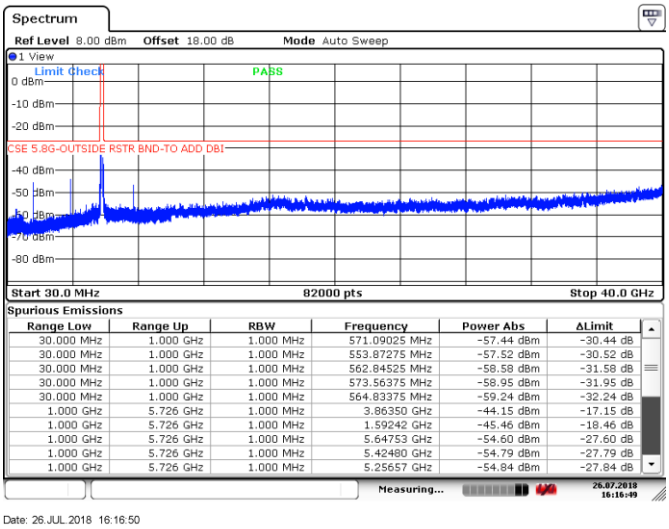
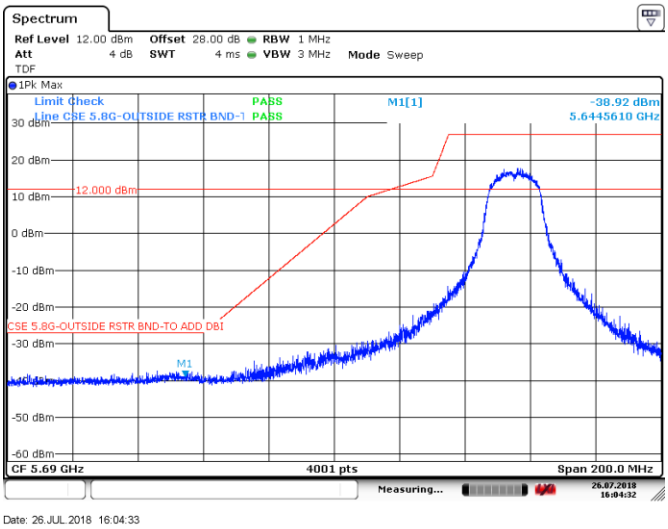
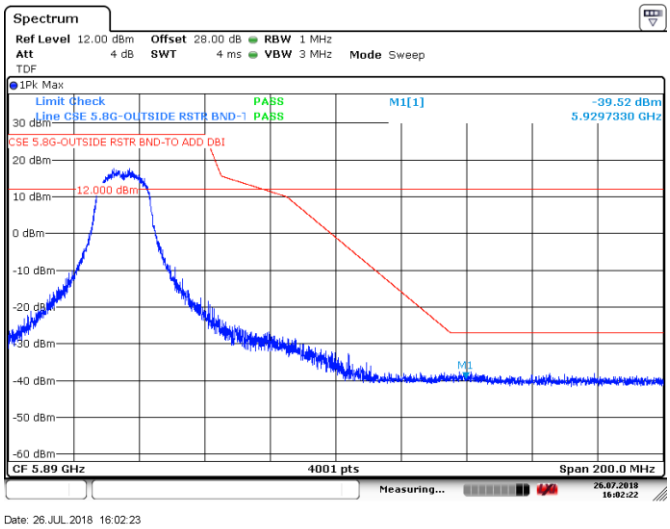


Figure 8.4-8: *Spurious emissions outside restricted bands, Tx on ch 159, 802.11n HT40*



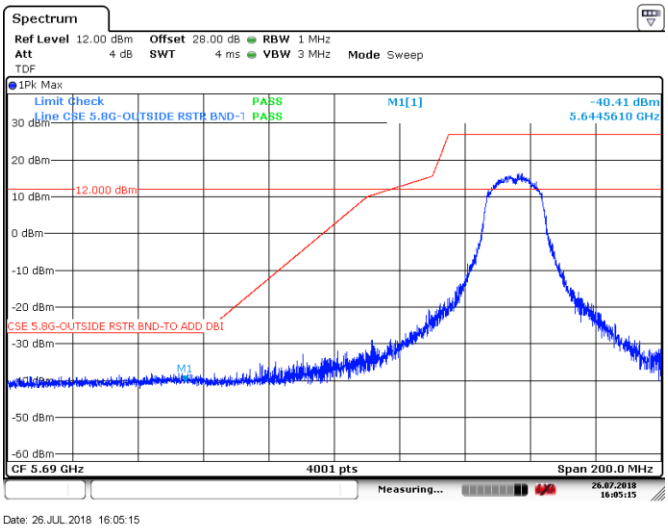
Date: 26.JUL.2018 16:04:33

Figure 8.4-9: *Lower band edge, Tx on ch 149, 802.11a*



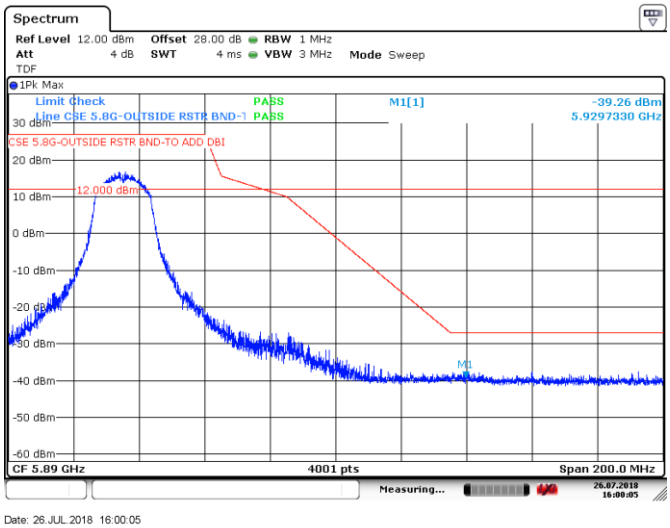
Date: 26.JUL.2018 16:02:23

Figure 8.4-10: *Upper band edge, Tx on ch 165, 802.11a*



Date: 26.JUL.2018 16:05:15

Figure 8.4-11: *Lower band edge, Tx on ch 149, 802.11n HT20*



Date: 26.JUL.2018 16:00:05

Figure 8.4-12: *Upper band edge, Tx on ch 165, 802.11n HT20*

Note: Peak limit EIRP equivalent: 74 dBµV/m – 95.23 dB = −21.23 dBm
Average limit EIRP equivalent: 54 dBµV/m – 95.23 dB = −41.23 dBm

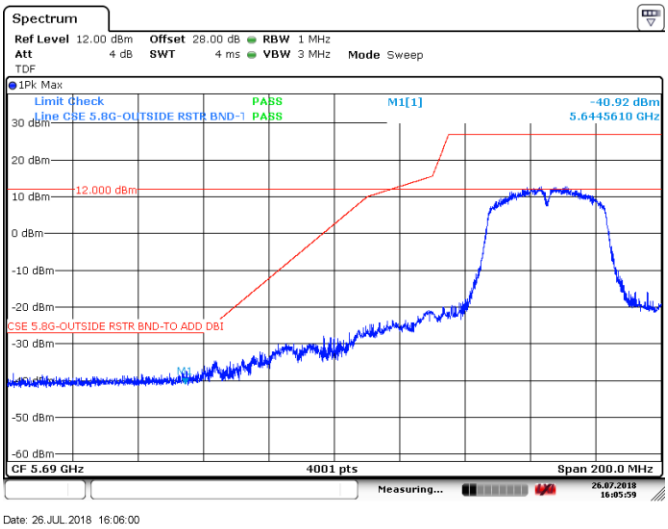


Figure 8.4-13: *Lower band edge, Tx on ch 151, 802.11n HT40*

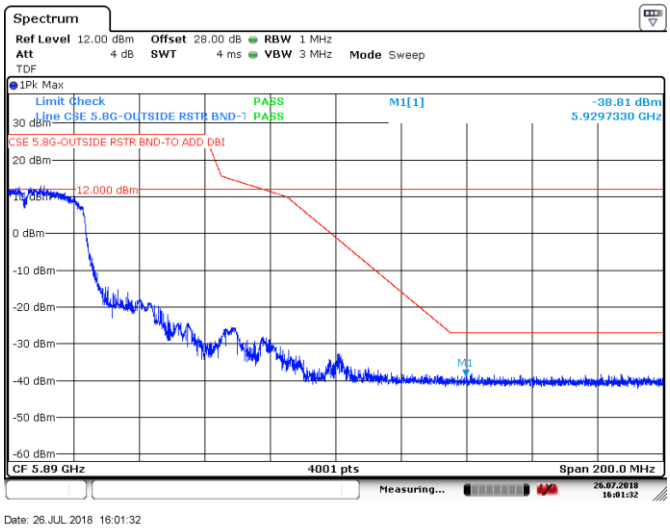
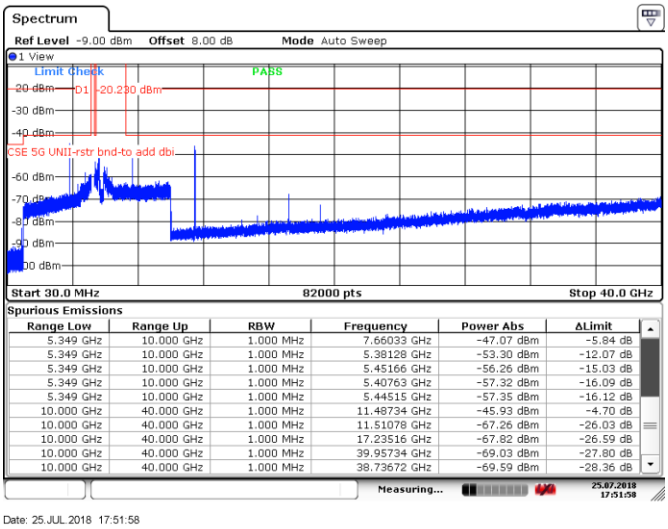


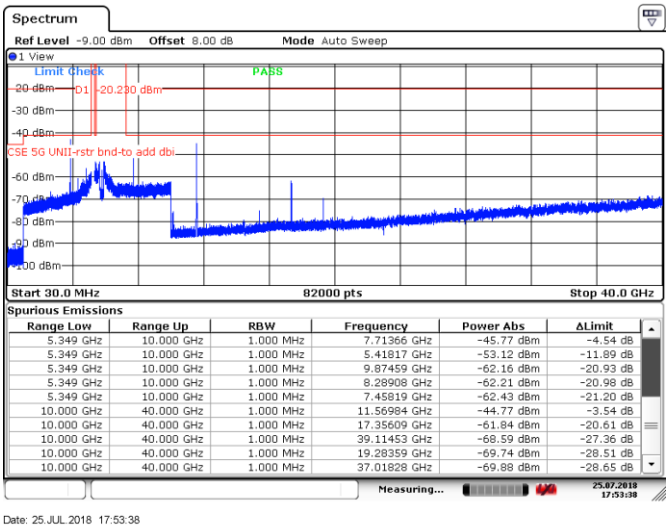
Figure 8.4-14: *Upper band edge, Tx on ch 159, 802.11n HT40*

Note: Peak limit EIRP equivalent: 74 dBµV/m – 95.23 dB = −21.23 dBm
Average limit EIRP equivalent: 54 dBµV/m – 95.23 dB = −41.23 dBm



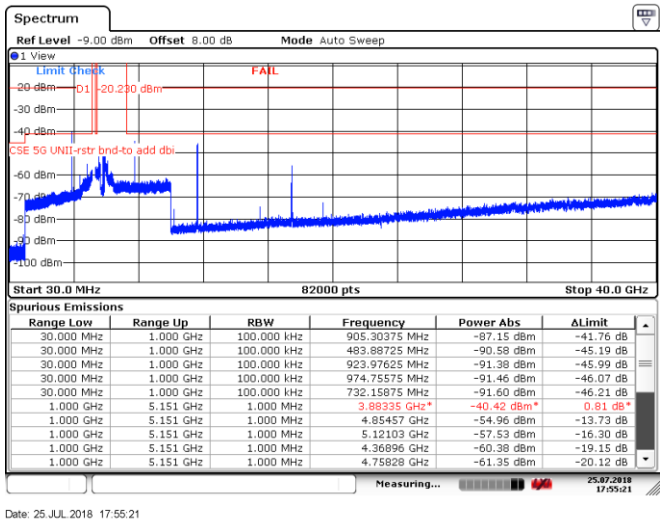
Date: 25.JUL.2018 17:51:58

Figure 8.4-15: *Spurious emissions within restricted bands, Tx on ch 149, 802.11a*



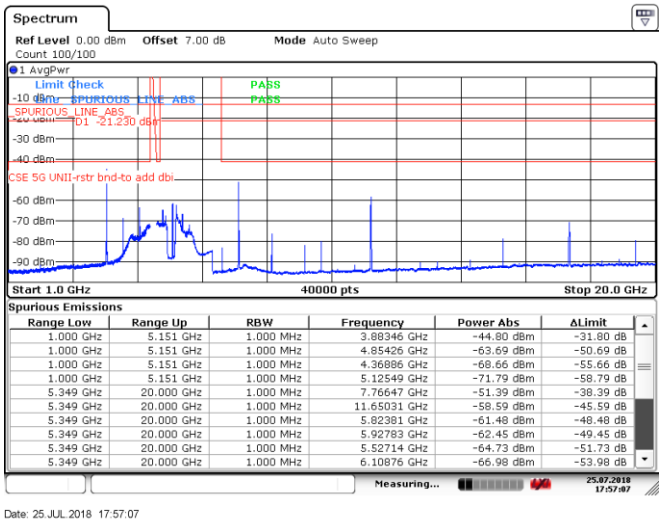
Date: 25.JUL.2018 17:53:38

Figure 8.4-16: *Spurious emissions within restricted bands, Tx on ch 157, 802.11a*



Date: 25.JUL.2018 17:55:21

Figure 8.4-17: *Spurious emissions within restricted bands, Tx on ch 165, 802.11a, Peak measurement*



Date: 25.JUL.2018 17:57:07

Figure 8.4-18: *Spurious emissions within restricted bands, Tx on ch 165, 802.11a, Average measurement*

Note: Peak limit EIRP equivalent: 74 dBµV/m – 95.23 dB = −21.23 dBm
Average limit EIRP equivalent: 54 dBµV/m – 95.23 dB = −41.23 dBm
EUT's antenna max gain and ground reflection factors below 1 GHz have been included in the factors of the plots above.
Where Peak measurement is over the limit, Average measurement is performed.
Transmitter spurious emission calculation as below:

E = EIRP – 20log D + 104.8 =-44.8 – 20Log 3 + 104.8 = 50.46 dBµV/m at 3m
margin of compliance = 54 – 50.46 = 3.54 dB
where:
E = electric field strength in dBµV/m,
EIRP = equivalent isotropic radiated power in dBm = -44.80 dBm
D = specified measurement distance in meters = 3 m
Average field strength limit = 54 dBµV/m at 3m

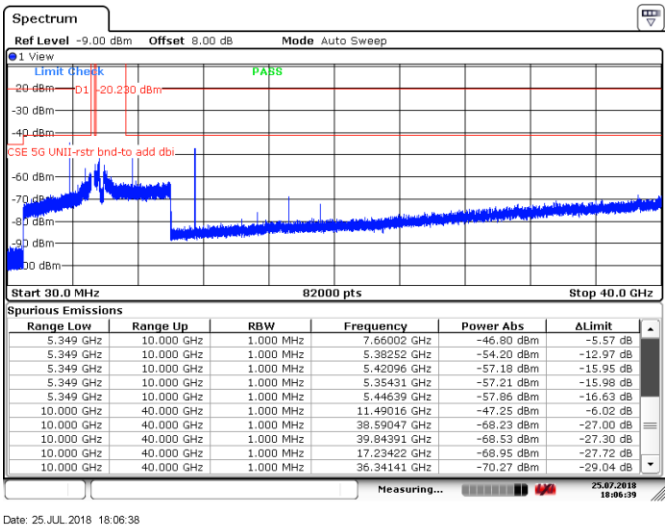


Figure 8.4-19: *Spurious emissions within restricted bands, Tx on ch 149, 802.11n HT20*

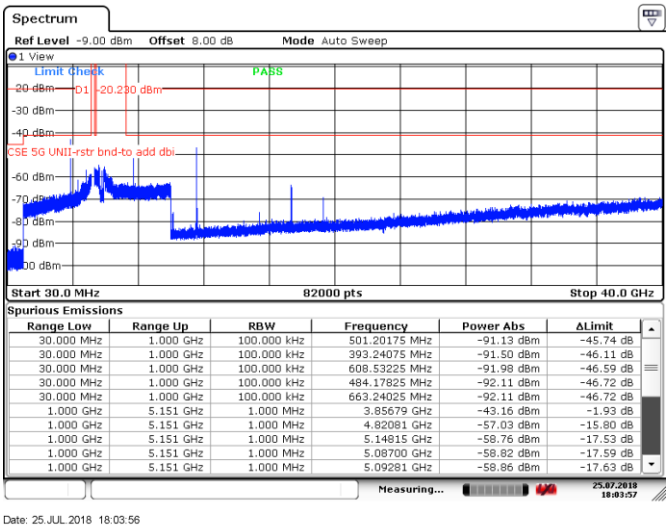


Figure 8.4-20: *Spurious emissions within restricted bands, Tx on ch 157, 802.11n HT20*

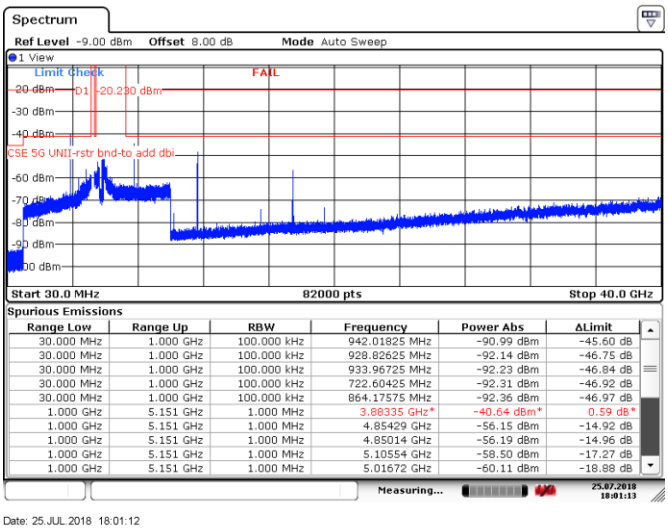


Figure 8.4-21: *Spurious emissions within restricted bands, Tx on ch 165, 802.11n HT20, Peak measurement*

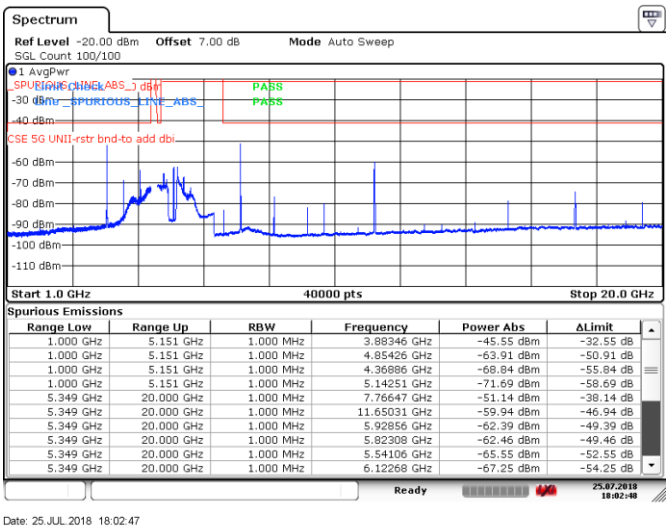


Figure 8.4-22: *Spurious emissions within restricted bands, Tx on ch 165, 802.11n HT20, Average measurement*

Note: Peak limit EIRP equivalent: 74 dBµV/m – 95.23 dB = −21.23 dBm
Average limit EIRP equivalent: 54 dBµV/m – 95.23 dB = −41.23 dBm
EUT's antenna max gain and ground reflection factors below 1 GHz have been included in the factors of the plots above.
Where Peak measurement is over the limit, Average measurement is performed.

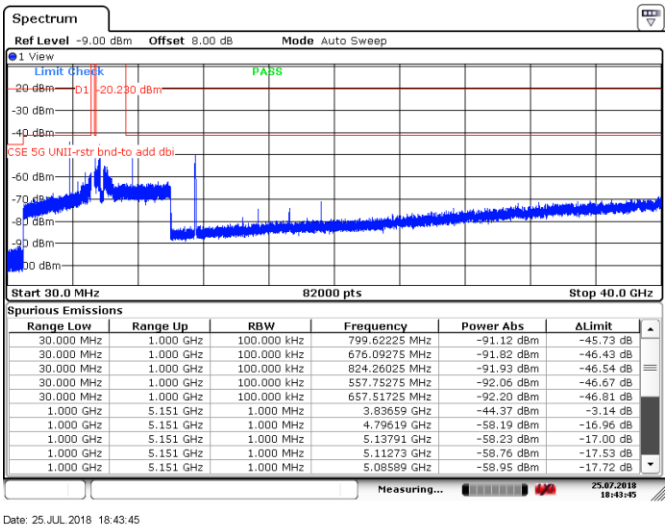


Figure 8.4-23: *Spurious emissions within restricted bands, Tx on ch 151, 802.11n HT40, Peak detector*

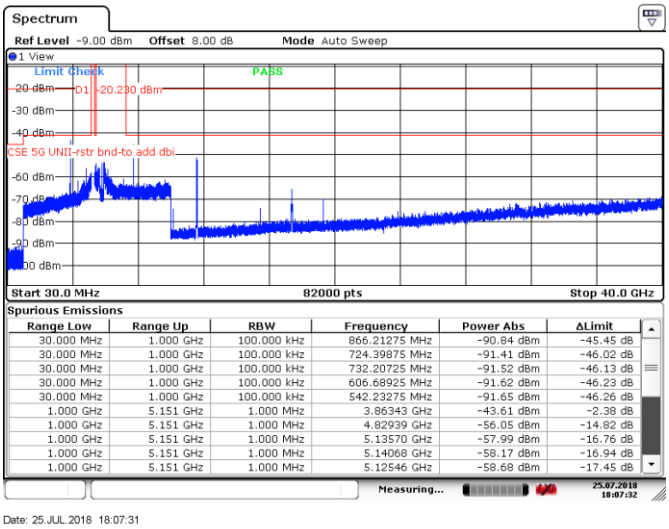


Figure 8.4-24: *Peak Spurious emissions within restricted bands, Tx on ch 159, 802.11n HT40, Peak detector*

Note: Peak limit EIRP equivalent: 74 dBµV/m – 95.23 dB = −21.23 dBm
Average limit EIRP equivalent: 54 dBµV/m – 95.23 dB = −41.23 dBm
EUT's antenna max gain and ground reflection factors below 1 GHz have been included in the factors of the plots above.

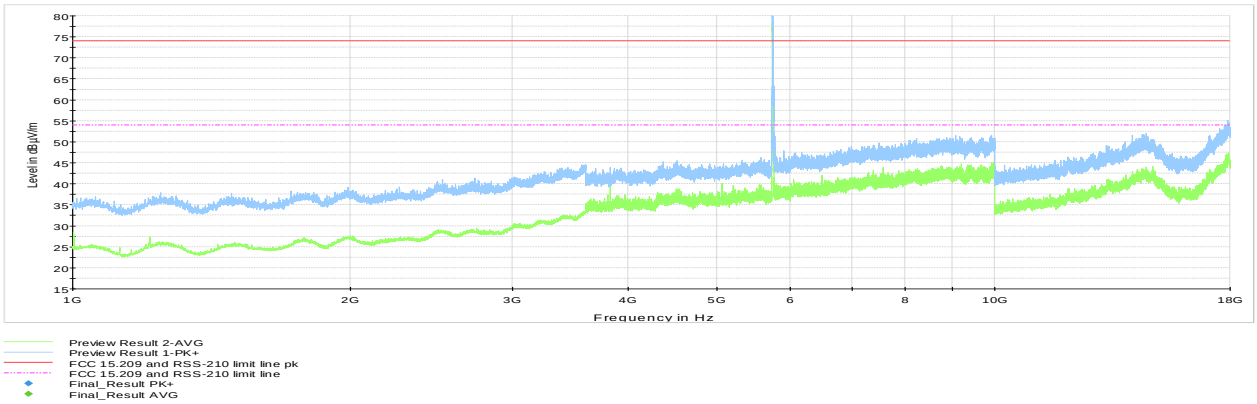


Figure 8.4-25: *Cabinet Radiated spurious emission 1 to 18 GHz Tx on low channel*

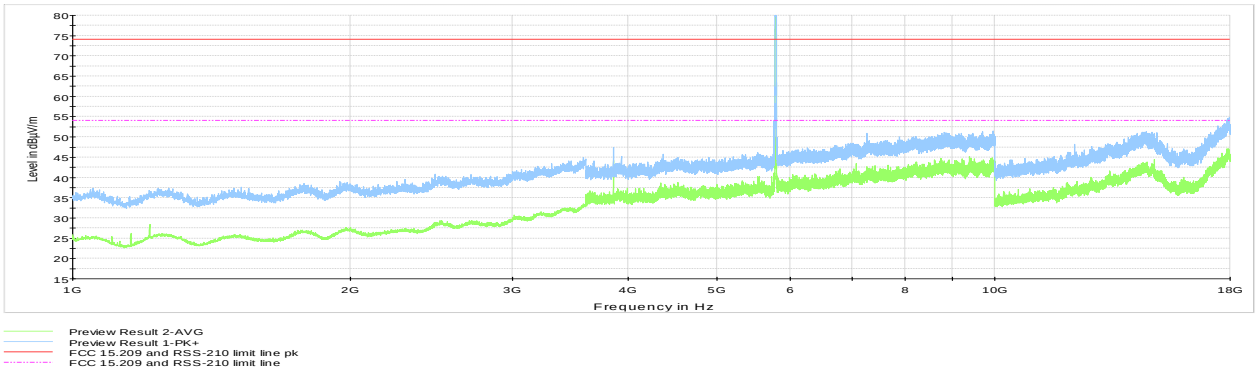


Figure 8.4-26: *Cabinet Radiated spurious emission 1 to 18 GHz, Tx on mid channel*

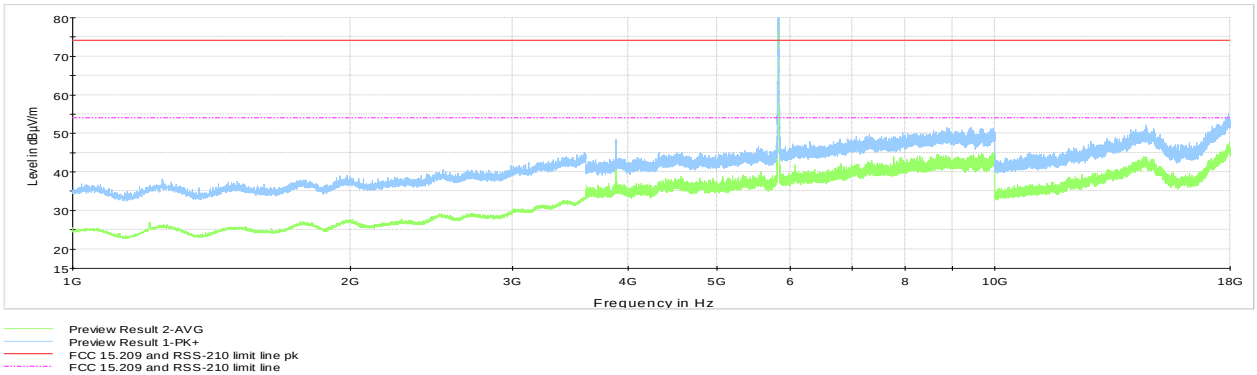


Figure 8.4-27: *Cabinet Radiated spurious emission 1 to 18 GHz, Tx on high channle*

Note: Spectrum was searched from 30 MHz to 25 GHz. Below 1 GHz and above 18 GHz, no emissions related to RF transmitter were detected within 6 dB below the limit. The emissions above limit on plots above are from intentional transmission.

8.5 FCC 15.207(a) AC power line conducted emissions limits

8.5.1 Definitions and limits

FCC §15.407(6)(b):

Any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in §15.207

FCC §15.207(a):
Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

ISED:
A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz, shall not exceed the limits in table below.

Unless the requirements applicable to a given device state otherwise, for any radio apparatus equipped to operate from the public utility AC power supply either directly or indirectly (such as with a battery charger), the radio frequency voltage of emissions conducted back onto the AC power lines in the frequency range of 0.15 MHz to 30 MHz shall not exceed the limits shown in table below. The more stringent limit applies at the frequency range boundaries.

Table 8.5-1: *Conducted emissions limit*

Frequency of emission (MHz)	Conducted limit (dBµV)	
	Quasi-peak	Average**
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

Note: * - The level decreases linearly with the logarithm of the frequency.
** - A linear average detector is required.

8.5.2 Test summary

Test start date:	August 17, 2018
Test engineer:	Yong Huang

8.5.3 Observations, settings and special notes

The EUT was set up as tabletop configuration.

The spectral scan has been corrected with transducer factors (i.e. cable loss, LISN factors, and attenuators) for determination of compliance.

A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

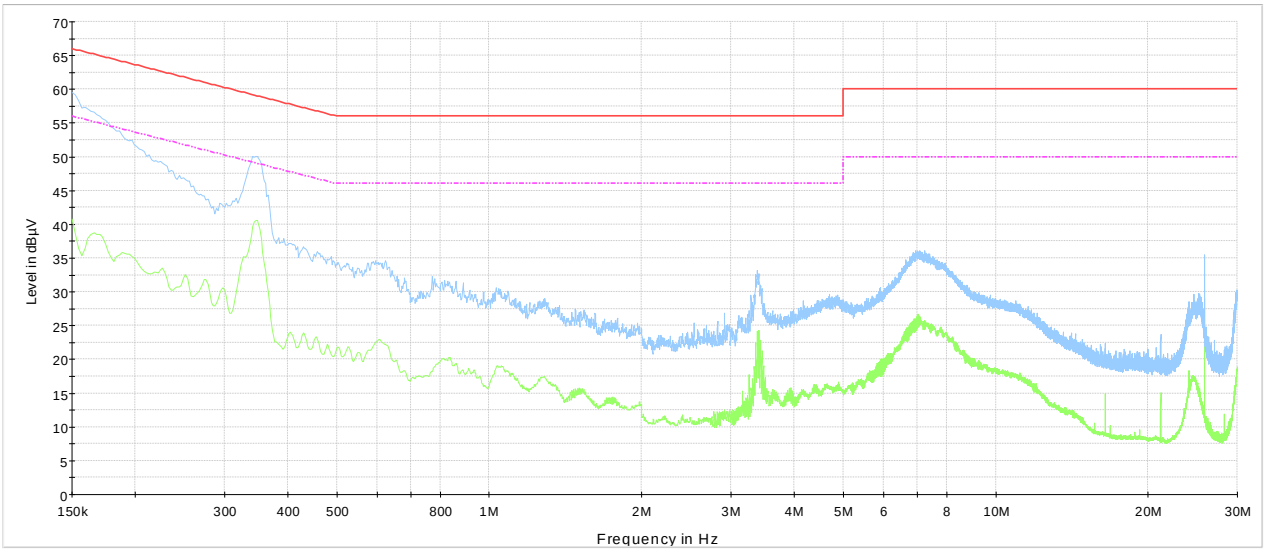
Receiver settings for preview measurements:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average
Trace mode	Max Hold
Measurement time	100 ms

Receiver settings for final measurements:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Quasi-Peak and Average
Trace mode	Max Hold
Measurement time	100 ms

8.5.4 Test data



Plot 8.5-1: *Conducted emissions on phase line*

Table 8.5-2: *Quasi-Peak conducted emissions results on phase line*

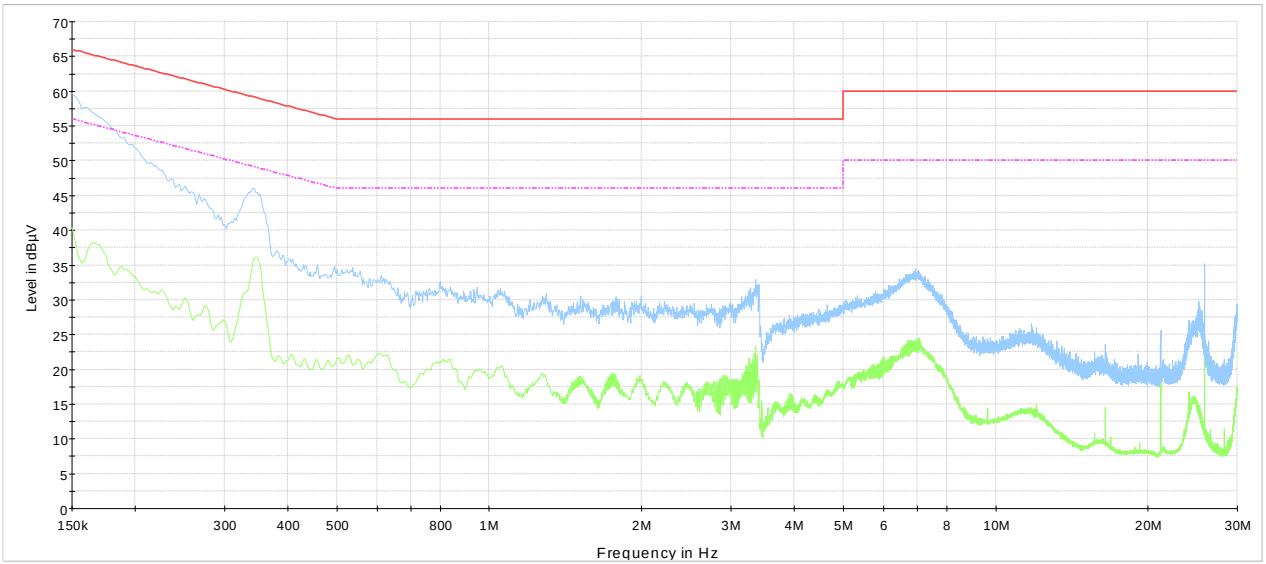
Frequency, MHz	Q-Peak result, dBµV	Correction, dB	Margin, dB	Limit, dBµV
0.150	57.5	9.4	8.5	66.0
0.348	47.0	9.4	12.0	59.0

Table 8.5-3: *Average conducted emissions results on phase line*

Frequency, MHz	Average result, dBµV	Correction, dB	Margin, dB	Limit, dBµV
0.346	40.5	9.4	8.6	49.1

Notes: [1] Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB)
[3] Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions have been recorded.

Sample calculation: 37.1 dBµV (result) = 26.6 dBµV (receiver reading) + 9.5 dB (Correction factor)



Plot 8.5-2: *Conducted emissions on neutral line*

Table 8.5-4: *Quasi-Peak conducted emissions results on neutral line*

Frequency, MHz	Q-Peak result, dBµV	Correction, dB	Margin, dB	Limit, dBµV
0.150	57.5	9.4	8.5	66.0

Notes: [1] Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB)
[3] Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions have been recorded.

Sample calculation: 37.1 dBµV (result) = 26.6 dBµV (receiver reading) + 9.5 dB (Correction factor)

8.6 FCC 15.407(g) and RSS-Gen 8.11 Frequency stability

8.6.1 Definitions and limits

Manufacturers of U-NII (IC: LE-LAN) devices are responsible for ensuring frequency stability such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the user's manual.

8.6.2 Test summary

Test start date:	August 20, 2018
Test engineer:	Yong Huang

8.6.1 Observations, settings and special notes

As per EUT's document provided by client, EUT's Operating Temperature is -40 °C to +70 °C(REGATE-10-12) and -40 °C to +85 °C (DYGATE-10-12), Nominal AC input voltage is 120 V.

Spectrum analyzer settings:

Resolution bandwidth:	10 Hz
Video bandwidth:	10 Hz
Detector mode:	Peak
Trace mode:	Max Hold

8.6.2 Test data

Table 8.6-1: *Frequency drift measurement*

Test conditions Temperature, Voltage	Nominal frequency, GHz	Frequency, GHz	Drift, Hz
+85 °C, Nominal	5.785	5.7851036850	106218
+70 °C, Nominal	5.785	5.7850130120	15545
+23 °C, +15 %	5.785	5.7849974670	0
+23 °C, Nominal	5.785	5.7849974670	reference
+23 °C, −15 %	5.785	5.7849974670	0
-40 °C, Nominal	5.785	5.7849965990	-868

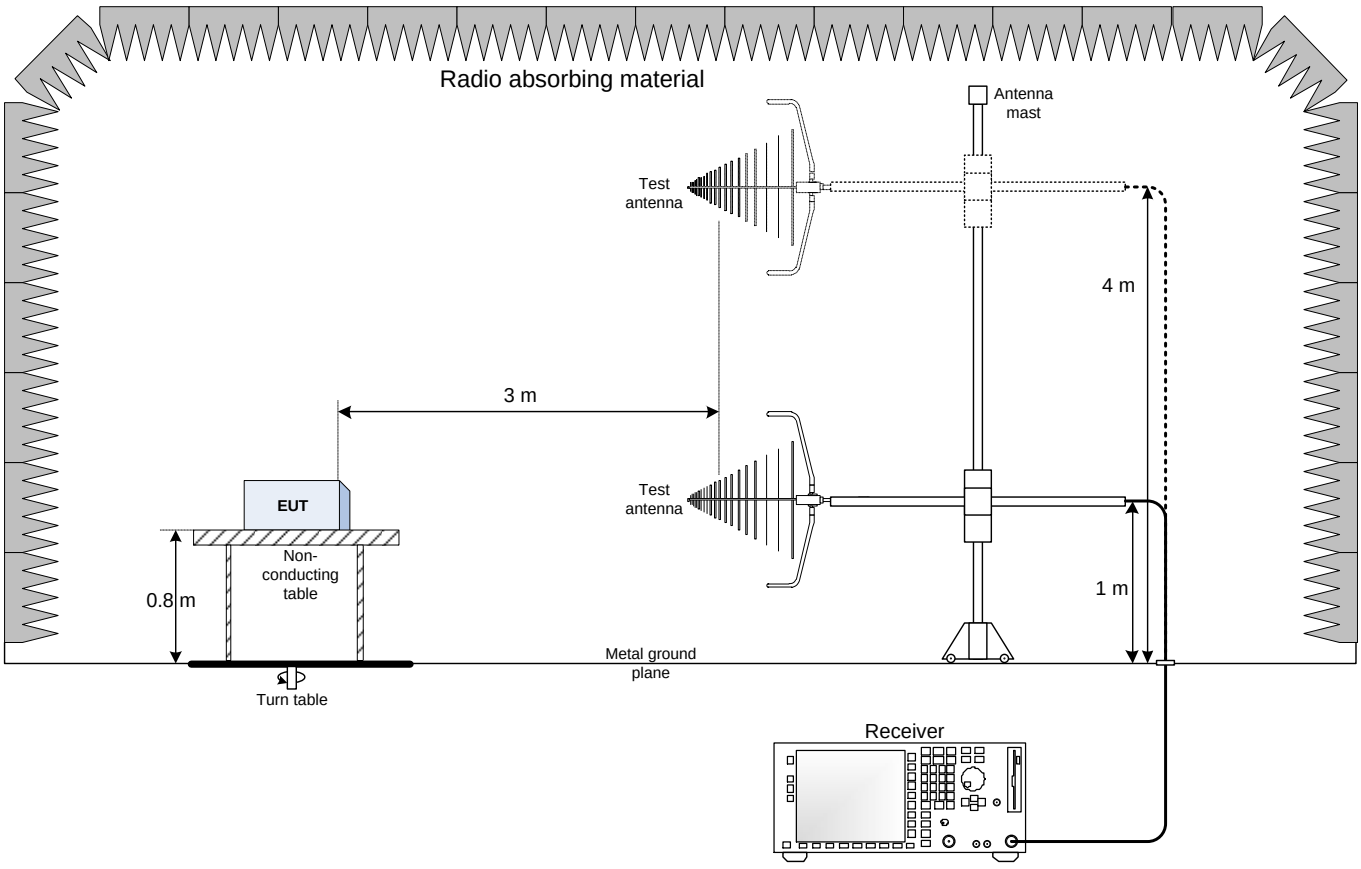
Minimum lower band edge margin is more than 1 kHz

Minimum upper band edge margin is more than 107 kHz

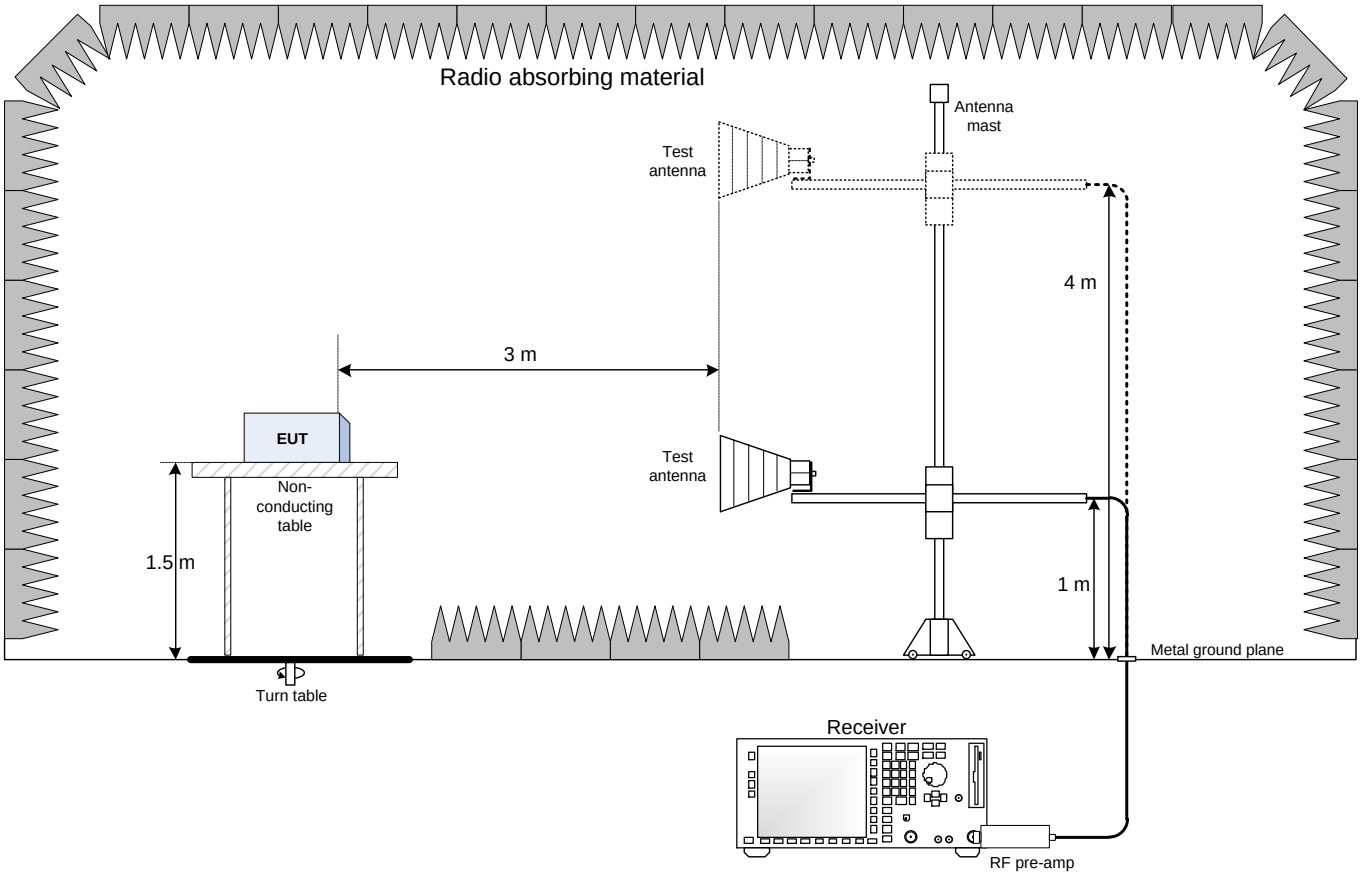
The frequency drifts in above table are within these minimum margins, the emissions are deemed to maintain within the band of operation.

Section 9. Block diagrams of test set-ups

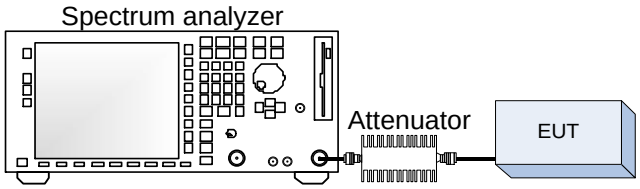
9.1 Radiated emissions set-up for frequencies below 1 GHz



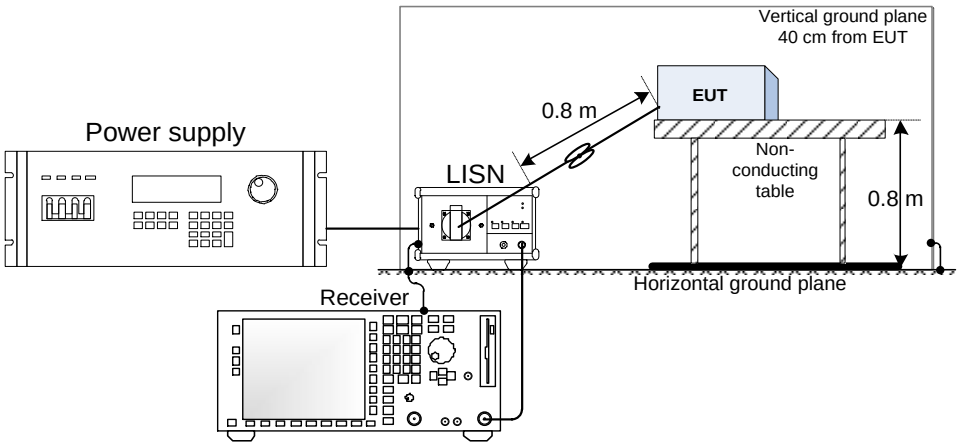
9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 Antenna port conducted measurements set-up



9.4 Conducted emissions on AC line set-up



(End of report)