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Wireless test report – 376028-2R1TRFWL

Applicant:

6harmonics Inc.

Product type:

Television Band Device (TVBD)

Model:	Model variant:
GWS-5000 Series	GWS-5002E

FCC ID:	IC Registration Number:
2AASTGWS-5002E	20750-GWS-5002E

Specifications:

- FCC 47 CFR Part 15 Subpart H – RF testing only

Television Band Devices

- RSS-222 February 5, 2015; Issue 1 – RF testing only

White Space Devices (WSDs)

Date of issue: November 7, 2019

Andrey Adelberg, Senior Wireless/EMC Specialist	
Test engineer(s)	Signature
Kevin Rose, Wireless/EMC Specialist	
Reviewed by	Signature

Test location

Company name	Nemko Canada Inc.		
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City	Ottawa		
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Telephone	+1 613 737 9680		
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Toll free	+1 800 563 6336		
Website	www.nemko.com		
Site number	FCC: CA2040; (3 m semi anechoic chamber)		

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.

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Table of contents

Table of contents **3**

Section 1. Report summary **4**

1.1 Applicant and manufacturer 4

1.2 Test specifications 4

1.3 Test procedures 4

1.4 Statement of compliance 4

1.5 Exclusions 4

1.6 Test report revision history 4

Section 2. Summary of test results **5**

2.1 FCC Part 15, general requirements test results 5

2.2 FCC Part 15 Subpart H, test results 5

2.3 IC RSS-GEN, Issue 4, test results 5

2.4 RSS-222, test results 5

Section 3. Equipment under test (EUT) details **6**

3.1 Sample information 6

3.2 EUT information 6

3.3 Technical information 6

3.4 Product description and theory of operation 7

3.5 EUT exercise details 7

3.6 EUT setup diagram 7

Section 4. Engineering considerations **8**

4.1 Modifications incorporated in the EUT 8

4.2 Technical judgment 8

4.3 Deviations from laboratory tests procedures 8

Section 5. Test conditions **9**

5.1 Atmospheric conditions 9

5.2 Power supply range 9

Section 6. Measurement uncertainty **10**

6.1 Uncertainty of measurement 10

Section 7. Test equipment **11**

7.1 Test equipment list 11

Section 8. Testing data **12**

8.1 FCC 15.31(e) Variation of power source 12

8.2 FCC 15.31(m) and RSS-Gen 6.9 Number of frequencies 13

8.3 FCC 15.203 and RSS-Gen, section 6.8 Antenna requirement 14

8.4 FCC 15.207(a) and RSS-Gen 8.8 AC power line conducted emissions limits 15

8.5 RSS-Gen 6.7 Occupied (Emission) bandwidth 18

8.6 FCC 15.709(b)(ii) and RSS-222 6.2.1.2 Maximum conducted output power for fixed TVBDs 19

8.7 FCC 15.709(b)(ii) and RSS-222 6.2.1.2 The power spectral density from the TVBD 21

8.8 FCC 15.709(d) and RSS-222 6.3 Transmitter band edge and adjacent channel power for fixed TVBDs 23

8.9 FCC 15.709(d)(2) and RSS-222 6.3.3 Radiated spurious emissions beyond the television channels 28

8.10 RSS-222 6.4 Field Strength Emissions in the band 602–620 MHz 34

Section 9. Block diagrams and photos of test set-ups **37**

9.1 Radiated emissions set-up for frequencies below 1 GHz 37

9.2 Radiated emissions set-up for frequencies above 1 GHz 38

9.3 Conducted emissions set-up 38

Section 1. Report summary

1.1 Applicant and manufacturer

Company name	6harmonics Inc.
Address	Suite 10 - 21 Concourse Gate
City	Ottawa
Province/State	ON
Postal/Zip code	K2E 7S4
Country	Canada

1.2 Test specifications

FCC 47 CFR Part 15, Subpart H	Television Band Devices
RSS-222 February 5, 2015; Issue 1	White Space Devices (WSDs)

1.3 Test procedures

416721 D01 White Space Test Procedures v02	Certification Test Procedures for TV Band (White Space) Devices Authorized Under Subpart H of the Part 15 Rules
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
367619 (June 2019) KDB Submission	KDB Submission to FCC for GWS5002 TVWS Device: 6harmonics Inc.

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard except as noted in section 1.5 below. 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 #	Date of issue	Details of changes made to test report
TRF	September 30, 2019	Original report issued
R1TRF	November 7, 2019	Updated antenna port results (removed 2nd antenna port results)

Section 2. Summary of test results

2.1 FCC Part 15, general requirements test results

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
§15.31(e)	Variation of power source	Pass
§15.31(m)	Number of tested frequencies	Pass
§15.203	Antenna requirement	Pass

Notes: EUT is an AC powered device.

2.2 FCC Part 15 Subpart H, test results

Part	Test description	Verdict
§15.709(b)(ii)	Maximum conducted output power for fixed TVBDs	Pass
§15.709(b)(ii)	Power spectral density for fixed TVBDs	Pass
§15.709(d)	Adjacent channel power for fixed TVBDs	Pass
§15.709(d)	Radiated spurious emissions outside TV bands	Pass
§15.709(c)(4)	Emissions in the band 602–620 MHz	Pass
§15.709(c)(5)	AC power line conducted limits	Pass

Note: none

2.3 IC RSS-GEN, Issue 4, test results

Part	Test description	Verdict
7.1.2	Receiver radiated emission limits	Not applicable
7.1.3	Receiver conducted emission limits	Not applicable
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Pass

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

2.4 RSS-222, test results

Section	Test description	Verdict
6.2.1.2	Transmitter output power for Fixed WSDs	Pass
6.2.1.2	Transmitter power spectral density (PSD) for Fixed WSDs	Pass
6.3.2	Transmitter band edge and adjacent channel power limits	Pass
6.3.3	Spurious emissions measurements and limits	Pass
6.4	Field strength emissions in the band 602–620 MHz	Pass

Note: none

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	June 24, 2019
Nemko sample ID number	1

3.2 EUT information

Product name	Television Band Device (TVBD)
Model	GWS-5000 Series
Model variants	GWS-5002E (CPE)
Serial number	520000047 (CPE)

3.3 Technical information

Operating band	470–698 MHz (channels 14–51)
Operating frequency*	USA: 473–695 MHz Canada: 473–599 MHz and 623–695 MHz
Modulation type	BPSK, QPSK, 16-QAM, and 64-QAM
Channel bandwidth	6, 12, 18, 24 MHz
Emission designator	W7D
Power requirements	120 V_{AC} 60 Hz from PoE (see below)

*Note: * see section 8.2 for detailed channel frequencies.*

Table 3.3-1: *Antenna information*

Antenna information
9 dBi Dual Polarized LPDA KP Antennas PN: KP-TWDPLP9
9 dBi Dual Polarized LPDA Wireless Instruments PN: WiLPDA M0406-65-9X
9 dBi Dual Polarized LPDA Wireless Instruments PN: WiLPDA M0608-65-9X
8 dBi Single Polarized LPDA 6Harmonics PN: GWS-SL14174A
12 dBi Panel Dual Polarized Wireless Instruments SA MO4706-65-12 (Non-congested areas only)
12 dBi Panel Dual Polarized KP Antennas PN: KP-TWDP65S-12 (Non-congested areas only)
12 dBi Panel Single Polarized KP Antennas PN: P-TWVP65S-12 (Non-congested areas only)
12 dBi Panel Single Polarized 6Harmonics PN: GWS-SL12948B (Non-congested areas only)
11 dBi Panel Dual Polarized MTI PN: MT006D11VH (Non-congested areas only)
8 dBi Panel Dual Polarized Wireless Instruments PN: WiBOX PA M0407-8X
9 dBi Panel Dual Polarized KP Antennas PN: KP-TWDPFP9
8 dBi Panel Dual Polarized Lanbowan PN: ANT0407D8Z-DP
7.5 dBi Panel Dual Polarized MTI PN:MT006D07VH
7 dBi Panel Single Polarized 6Harmonics PN: GWS-SL12948A
6 dBi Omni Vertical Polarization 6Harmonics PN: GWS-SL13304A
2 dBi Omni Vertical Polarization 6Harmonics PN: GWS-SL13319A

Table 3.3-2: *Power supplies*

Antenna information
Microsemi 9501 PoE
Ubiquiti PoE -54-80W
Netonix PoE switch configured to 48V 1.5A
Ubiquiti PoE -50-60W

3.4 Product description and theory of operation

TV Whitespace wireless solution with industry leading throughput and range to meet the most demanding of deployment challenges. The GWS-5000 series is the most advanced TV whitespace solution available and is the 5th generation of TV Whitespace radio developed by 6Harmonics. Throughput with a 24 MHz and a single spatial stream Tx can achieve 72 Mbps UDP and 50 Mbps TCP/IP. Conducted transmit power up to 27.7 dBm/24 MHz per spatial stream is available in the USA. Radio receive sensitivity is −103 dBm/6 MHz. The radios can operate in a point-to-point or point-to-multi-point mode. With integrated GPS geolocation and the FCC approved Nominet TV Whitespace database, the radios are fully compliant for use in the USA.
Based upon the globally accepted robust Wi-Fi protocol, the GWS-5000 series radios are able to maintain NLOS data links in the most challenging of TVWS deployments when faced with in-band noise & interference, multipath fade, trees or other obstructions.
The radio is available in two different form factors, each having a different enclosure;

- The base station version contains the radio with two transmit chains i.e. MIMO transmit & receive.
- The client station version contains the radio with a single transmit chain and diversity receive i.e. SISO transmit and MIMO receive.

3.5 EUT exercise details

The EUT was powered from a PoE. During the tests a laptop was used to connect to the EUT and configure the device to transmit continuously with the desired modulation and power.
All conducted measurements were with the MIMO TX version as the worst case. EUT was tested with the appropriate antennas for spurious and conducted emissions to ensure the enclosure variation did not have impact.

3.6 EUT setup diagram

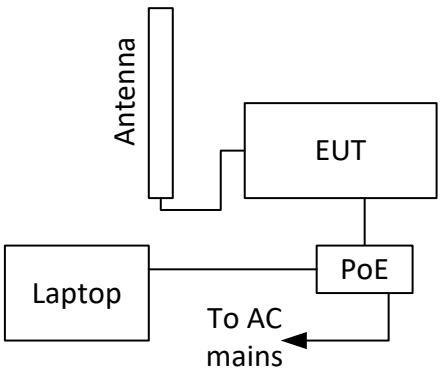


Figure 3.6-1: *Setup diagram*

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

The GWS-5002 radio (BTS) has two transmit chains.
The CPE model variant GWS-5002E has one of the transmit chains removed, specifically the power amplifier module. In that sense the GWS-5002E is “less than” the GWS-5002. In addition, the GWS-5002E has a different enclosure. All antenna port measurements were performed on GWS-5002 model as a worst-case representative.
For the additional RSS-222 Section 6.4 *Field Strength Emissions in the band 602–620 MHz* requirement, – Channel-37 filter was used to achieve compliance.

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.
3 m EMI test chamber	TDK	SAC-3	FA002047	1 year	January 24, 2020
Flush mount turntable	Sunol	FM2022	FA002082	—	NCR
Controller	Sunol	SC104V	FA002060	—	NCR
Antenna mast	Sunol	TLT2	FA002061	—	NCR
61505 AC source	Chroma	61509	FA003036	—	VOU
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	May 8, 2020
Spectrum analyzer	Rohde & Schwarz	FSU	FA001877	1 year	October 26, 2019
Horn (1–18 GHz)	ETS Lindgren	3117	FA002840	1 year	January 16, 2020
Preamp (1–18 GHz)	ETS Lindgren	124334	FA002873	1 year	November 4, 2019
Horn antenna (1–18 GHz)	EMCO	3115	FA000825	1 year	October 8, 2019
LISN	Rohde & Schwarz	ENV216	FA002023	1 year	August 13, 2019

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

Section 8. Testing data

8.1 FCC 15.31(e) Variation of power source

8.1.1 Definitions and limits

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

8.1.2 Test date

Start date	June 24, 2019

8.1.3 Observations, settings and special notes

EUT input is 48 V_{DC} from the PoE power supply.

8.1.4 Test data

EUT Power requirements:	☒ AC	☐ DC	☐ Battery
If EUT is an AC or a DC powered, was the noticeable output power variation observed?	☐ YES	☒ NO	☐ N/A
If EUT is battery operated, was the testing performed using fresh batteries?	☐ YES	☐ NO	☒ N/A
If EUT is rechargeable battery operated, was the testing performed using fully charged batteries?	☐ YES	☐ NO	☒ N/A

8.2 FCC 15.31(m) and RSS-Gen 6.9 Number of frequencies

8.2.1 Definitions and limits

FCC:
Measurements on intentional radiators or receivers shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table.

ISED:
Except where otherwise specified, measurements shall be performed for each frequency band of operation for which the radio apparatus is to be certified, with the device operating at the frequencies in each band of operation shown in table below. The frequencies selected for measurements shall be reported in the test report.

Table 8.2-1: *Frequency Range of Operation*

Frequency range over which the device operates (in each band)	Number of test frequencies required	Location of measurement frequency inside the operating frequency range
1 MHz or less	1	Center (middle of the band)
1–10 MHz	2	1 near high end, 1 near low end
Greater than 10 MHz	3	1 near high end, 1 near center and 1 near low end

Note: “near” means as close as possible to or at the centre / low end / high end of the frequency range over which the device operates.

8.2.2 Test date

Start date	June 24, 2019

8.2.3 Observations, settings and special notes

None

8.2.4 Test data

Table 8.2-2: *Test channels frequencies selection*

Start of Frequency range, MHz	End of Frequency range, MHz	Frequency range bandwidth, MHz	Channel size, MHz	Low channel, MHz	Mid channel, MHz	High channel, MHz
470	698	228	6	473	587	695
			12	476	584	692
			18	479	587	689
			24	482	584	686

8.3 FCC 15.203 and RSS-Gen, section 6.8 Antenna requirement

8.3.1 Definitions and limits

FCC:
An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

ISED:
The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report.

8.3.2 Test date

Start date	June 24, 2019

8.3.3 Observations, settings and special notes

None

8.3.4 Test data

Must the EUT be professionally installed?	☒ YES	☐ NO	
Does the EUT have detachable antenna(s)?	☒ YES	☐ NO	
If detachable, is the antenna connector(s) non-standard?	☐ YES	☒ NO	☐ N/A

8.4 FCC 15.207(a) and RSS-Gen 8.8 AC power line conducted emissions limits

8.4.1 Definitions and limits

FCC 15.709(c)(4):
White space devices connected to the AC power line are required to comply 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 8.4-1: *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.

8.4.2 Test date

Start date	June 28, 2019

8.4.3 Observations, settings and special notes

The EUT was set up as tabletop configuration.

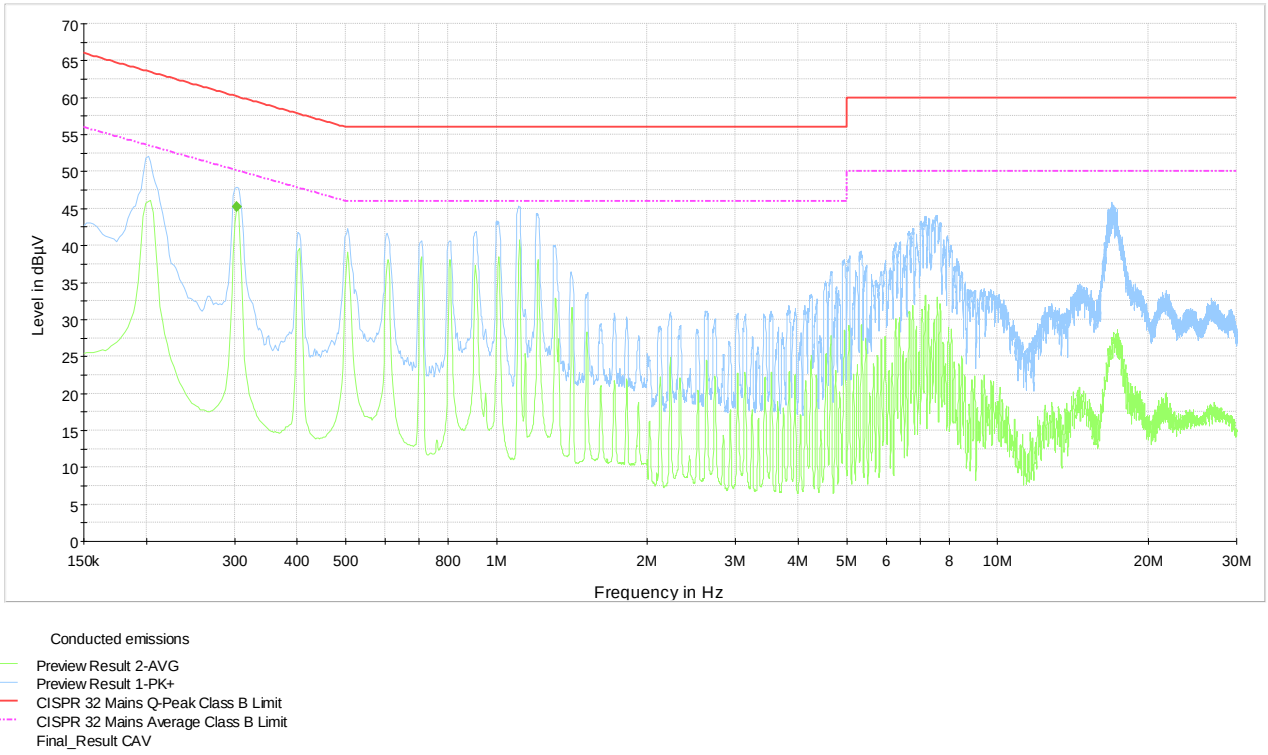
The spectral scan has been corrected with transducer factors (i.e. cable loss, LISN factors, and attenuators) for determination of compliance.

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:

	Preview measurements	Final measurements
Resolution bandwidth	9 kHz	9 kHz
Video bandwidth	30 kHz	30 kHz
Detector mode	Peak and Average	Quasi-Peak and Average
Trace mode	Max Hold	Max Hold
Measurement time	1000 ms	1000 ms

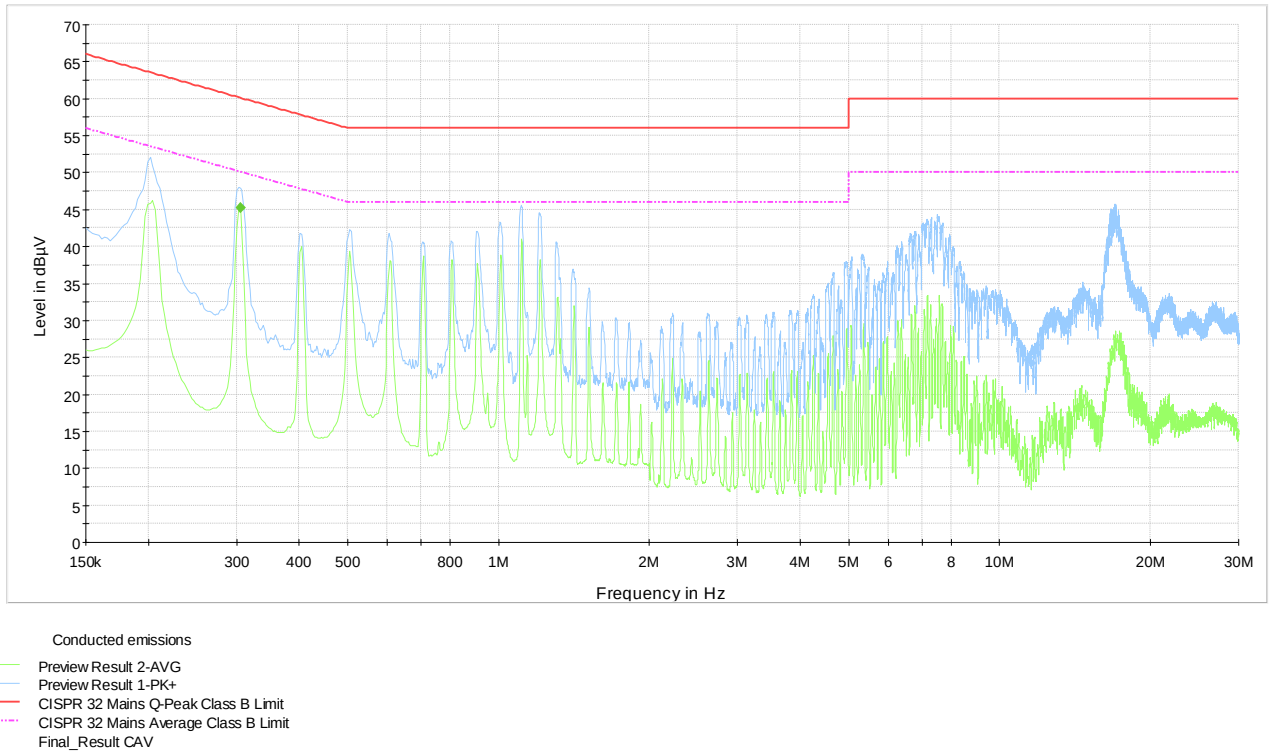
8.4.4 Test data



Plot 8.4-1: *Conducted emissions on phase line*

Table 8.4-2: *Average conducted emissions results on phase line*

Frequency, MHz	Average result, dBµV	Correction, dB	Margin, dB	Limit, dBµV
0.303000	45.24	9.7	4.92	50.16



Plot 8.4-2: *Conducted emissions on neutral line*

Table 8.4-3: *Average conducted emissions results on phase line*

Frequency, MHz	Average result, dBµV	Correction, dB	Margin, dB	Limit, dBµV
0.305250	45.24	9.7	4.90	50.10

8.5 RSS-Gen 6.7 Occupied (Emission) bandwidth

8.5.1 Definitions and limits

The occupied bandwidth or the "99% emission bandwidth" is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

8.5.2 Test date

Start date	June 24, 2019

8.5.3 Observations, settings and special notes

Spectrum analyzer settings:

Detector mode	Peak
Resolution bandwidth	100 kHz
Video bandwidth	RBW × 3
Trace mode	Max Hold

8.5.4 Test data

Table 8.5-1: *99% occupied bandwidth verification results*

Channel bandwidth, MHz	99% occupied bandwidth, MHz
6	3.596
12	8.582
18	12.372
24	15.096

Note: there is no 99% occupied bandwidth limit in the standard's requirements, the measurement results provided for information purposes only.

8.6 FCC 15.709(b)(ii) and RSS-222 6.2.1.2 Maximum conducted output power for fixed TVBDs

8.6.1 Definitions and limits

FCC:
For fixed TVBDs, the maximum power delivered to the transmitting antenna shall not exceed one watt per 6 megahertz of bandwidth on which the device operates. The power delivered to the transmitting antenna is the maximum conducted output power reduced by the signal loss experienced in the cable used to connect the transmitter to the transmit antenna. The maximum gain of the transmitting antenna used with a Fixed WSD must be declared by the manufacturer in the certification application. If the transmitting antenna gain exceeds 6 dBi for fixed white space device operating at up to 36 dBm EIRP, the conducted output power limit shall all be reduced by the amount in dB by which the gain exceeds 6 dBi.
ISED:
Fixed WSD conducted power level per 6 MHz of bandwidth on which the devices operate shall not exceed the level of 30 dBm (1 W) during any time of continuous transmission.
The maximum gain of the transmitting antenna used with a fixed WSD must be declared by the manufacturer in the certification application. If the transmitting antenna gain exceeds 6 dBi, the conducted output power limits shall all be reduced by the amount in decibels by which the gain exceeds 6 dBi.

8.6.2 Test date

Start date	June 24, 2019

8.6.3 Observations, settings and special notes

The power integration was performed over 12 MHz, 18 MHz and 24 MHz channel bandwidth for information purposes only.
Spectrum analyser settings for output power:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	RMS
Sweep time:	5 s
Trace mode:	Power Averaging over 10 traces
Integration bandwidth:	6 MHz

8.6.4 Test data

Table 8.6-1: *Conducted output power and EIRP measurements for 8 dBi antenna configuration*

(BW) Channel	Frequency, MHz	Power, dBm/6 MHz	Power limit*, dBm/6 MHz	Margin, dB	Antenna gain*, dBi	EIRP, dBm	EIRP limit, dBm	Margin, dB
(6 MHz) Low	473	19.57	28.00	8.43	8.00	27.57	36.00	8.43
(6 MHz) Mid	587	19.54	28.00	8.46	8.00	27.54	36.00	8.46
(6 MHz) High	695	19.19	28.00	8.81	8.00	27.19	36.00	8.81
(12 MHz) Low	476	23.03	28.00	4.97	8.00	31.03	36.00	4.97
(12 MHz) Mid	584	21.75	28.00	6.25	8.00	29.75	36.00	6.25
(12 MHz) High	692	22.34	28.00	5.66	8.00	30.34	36.00	5.66
(18 MHz) Low	479	24.05	28.00	3.95	8.00	32.05	36.00	3.95
(18 MHz) Mid	587	22.38	28.00	5.62	8.00	30.38	36.00	5.62
(18 MHz) High	689	24.19	28.00	3.81	8.00	32.19	36.00	3.81
(24 MHz) Low	482	24.38	28.00	3.62	8.00	32.38	36.00	3.62
(24 MHz) Mid	584	24.94	28.00	3.06	8.00	32.94	36.00	3.06
(24 MHz) High	686	25.12	28.00	2.88	8.00	33.12	36.00	2.88

Note: * Antenna gain is 9 dBi with 1 dB cable loss, the net gain is 8 dBi, therefore 2 dB reduction in output power limit was required.

Table 8.6-2: *Conducted output power and EIRP measurements for 11 dBi antenna configuration (for less congested areas)*

(BW) Channel	Frequency, MHz	Power, dBm/6 MHz	Power limit, dBm/6 MHz	Margin, dB	Antenna gain*, dBi	EIRP, dBm	EIRP limit, dBm	Margin, dB
(6 MHz) Low	473	19.57	29.00	9.43	11.00	30.57	40.00	9.43
(6 MHz) Mid	587	19.54	29.00	9.46	11.00	30.54	40.00	9.46
(6 MHz) High	695	19.19	29.00	9.81	11.00	30.19	40.00	9.81
(12 MHz) Low	476	23.03	29.00	5.97	11.00	34.03	40.00	5.97
(12 MHz) Mid	584	21.75	29.00	7.25	11.00	32.75	40.00	7.25
(12 MHz) High	692	22.34	29.00	6.66	11.00	33.34	40.00	6.66
(18 MHz) Low	479	24.05	29.00	4.95	11.00	35.05	40.00	4.95
(18 MHz) Mid	587	22.38	29.00	6.62	11.00	33.38	40.00	6.62
(18 MHz) High	689	24.19	29.00	4.81	11.00	35.19	40.00	4.81
(24 MHz) Low	482	24.38	29.00	4.62	11.00	35.38	40.00	4.62
(24 MHz) Mid	584	24.94	29.00	4.06	11.00	35.94	40.00	4.06
(24 MHz) High	686	25.12	29.00	3.88	11.00	36.12	40.00	3.88

Note: Antenna gain is 12 dBi with 1 dB cable loss, therefore net gain is 11 dBi, reduction of 1 dB is required for output power limit within less congested areas.

Table 8.6-3: *Conducted total transmit output power*

(BW) Channel	Frequency, MHz	Total Transmit Output Power, dBm
(6 MHz) Low	473	19.57
(6 MHz) Mid	587	19.54
(6 MHz) High	695	19.19
(12 MHz) Low	476	**23.86**
(12 MHz) Mid	584	22.61
(12 MHz) High	692	23.10
(18 MHz) Low	479	**26.44**
(18 MHz) Mid	587	25.61
(18 MHz) High	689	26.29
(24 MHz) Low	482	26.53
(24 MHz) Mid	584	27.44
(24 MHz) High	686	26.80

8.7 FCC 15.709(b)(ii) and RSS-222 6.2.1.2 The power spectral density from the TVBD

8.7.1 Definitions and limits

FCC:
The power spectral density from the TVBD shall not be greater than the following values when measured in any 100 kHz band during any time interval of continuous transmission:
Fixed devices with 36 dBm EIRP: 12.6 dBm/100 kHz conducted power density.
The PSD limits for fixed white space devices operating at up to 36 dBm (4000 milliwatts) are based on a maximum transmitting antenna gain of 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.
ISED:
Fixed WSD conducted PSD per 100 kHz band within a 6 MHz wide channel shall not exceed the 12.6 dBm/100 kHz level during any time of continuous transmission.
The maximum gain of the transmitting antenna used with a fixed WSD must be declared by the manufacturer in the certification application. If the transmitting antenna gain exceeds 6 dBi, the power spectral density (PSD) limits shall all be reduced by the amount in decibels by which the gain exceeds 6 dBi.

8.7.2 Test date

Start date	June 24, 2019

8.7.3 Observations, settings and special notes

Spectrum analyser settings for PSD:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	RMS
Sweep time:	5 s
Trace mode:	Power Averaging over 10 traces

8.7.4 Test data

Table 8.7-1: *Conducted PSD and EIRPSD measurements for 8 dBi antenna configuration*

(BW) Channel	Frequency, MHz	PSD, dBm/100 kHz	PSD limit, dBm/100 kHz	Margin, dB	Antenna gain*, dBi	EIRP PSD, dBm/100 kHz	EIRPSD limit, dBm/100 kHz	Margin, dB
(6 MHz) Low	473	5.30	10.60	5.30	8.00	13.30	18.60	5.30
(6 MHz) Mid	587	5.19	10.60	5.41	8.00	13.19	18.60	5.41
(6 MHz) High	695	4.83	10.60	5.77	8.00	12.83	18.60	5.77
(12 MHz) Low	476	7.09	10.60	3.51	8.00	15.09	18.60	3.51
(12 MHz) Mid	584	5.30	10.60	5.30	8.00	13.30	18.60	5.30
(12 MHz) High	692	6.73	10.60	3.87	8.00	14.73	18.60	3.87
(18 MHz) Low	479	7.96	10.60	2.64	8.00	15.96	18.60	2.64
(18 MHz) Mid	587	6.31	10.60	4.29	8.00	14.31	18.60	4.29
(18 MHz) High	689	8.39	10.60	2.21	8.00	16.39	18.60	2.21
(24 MHz) Low	482	8.54	10.60	2.06	8.00	16.54	18.60	2.06
(24 MHz) Mid	584	9.05	10.60	1.55	8.00	17.05	18.60	1.55
(24 MHz) High	686	9.27	10.60	1.33	8.00	17.27	18.60	1.33

Note: * Antenna gain is 9 dBi with 1 dB cable loss, the net gain is 8 dBi, therefore 2 dB reduction in PSD limit was required.

Table 8.7-2: *Conducted PSD and EIRPSD measurements for 11 dBi antenna configuration (for less congested areas)*

(BW) Channel	Frequency, MHz	PSD, dBm/100 kHz	PSD limit, dBm/100 kHz	Margin, dB	Antenna gain*, dBi	EIRP PSD, dBm/100 kHz	EIRPSD limit, dBm/100 kHz	Margin, dB
(6 MHz) Low	473	5.30	11.60	6.30	11.00	16.30	22.60	6.30
(6 MHz) Mid	587	5.19	11.60	6.41	11.00	16.19	22.60	6.41
(6 MHz) High	695	4.83	11.60	6.77	11.00	15.83	22.60	6.77
(12 MHz) Low	476	7.09	11.60	4.51	11.00	18.09	22.60	4.51
(12 MHz) Mid	584	5.30	11.60	6.30	11.00	16.30	22.60	6.30
(12 MHz) High	692	6.73	11.60	4.87	11.00	17.73	22.60	4.87
(18 MHz) Low	479	7.96	11.60	3.64	11.00	18.96	22.60	3.64
(18 MHz) Mid	587	6.31	11.60	5.29	11.00	17.31	22.60	5.29
(18 MHz) High	689	8.39	11.60	3.21	11.00	19.39	22.60	3.21
(24 MHz) Low	482	8.54	11.60	3.06	11.00	19.54	22.60	3.06
(24 MHz) Mid	584	9.05	11.60	2.55	11.00	20.05	22.60	2.55
(24 MHz) High	686	9.27	11.60	2.33	11.00	20.27	22.60	2.33

Note: Antenna gain is 12 dBi with 1 dB cable loss, therefore net gain is 11 dBi, reduction of 1 dB is required for power density limit within less congested areas.

8.8 FCC 15.709(d) and RSS-222 6.3 Transmitter band edge and adjacent channel power for fixed TVBDs

8.8.1 Definitions and limits

FCC:
(1) The adjacent channel emission limits apply in the six-megahertz channel immediately adjacent to each white space channel or group of contiguous white space channels in which the white space device is operating.
Fixed devices with 36 dBm EIRP: −42.8 dBm/100 kHz conducted power.
(2) At frequencies beyond the six-megahertz channel immediately adjacent to each white space channel or group of contiguous white space channels in which the white space device is operating the white space device shall meet the requirements of §15.209.
(3) Emission measurements in the adjacent bands shall be performed using a minimum resolution bandwidth of 100 kHz with an average detector. A narrower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 100 kHz.

ISED:
6.3.1.1 Band Edge Measurement

The band edge measurement must be performed relative to both the low (fL) and upper (fU) channel edge frequencies. The PSD is to be measured within a 100 kHz band segment relative to the channel edge (i.e. fL –100 kHz). The following steps provide the settings and procedures to follow to perform the band edge measurements.

6.3.1.2 Adjacent Channel Measurement

The adjacent channel emission limit applies in any 100 kHz band segment within either the lower or upper 6 MHz frequency band relative to the operating channel (N±1, where N represents the channel of operation).

6.3.2 Limits

Band edge and adjacent channel power level for Fixed WS shall not exceed the conducted levels of −42.8 dBm/100 kHz

8.8.2 Test date

Start date	June 24, 2019

8.8.3 Observations, settings and special notes

Adjacent channel is located 100 kHz away from the Band edge frequency and they both have the same limit, therefore 'Based edge level' reported in the tables below is the highest measured value between the two.
Based on the KDB submission guidance for testing of a multiple contiguous channel TV Whitespace device for 6Harmonics Inc., no reduction of adjacent channel power and band edge power for antennas greater than 6 dBi is required.
Spectrum analyser settings for adjacent channel power and band edge power:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	RMS
Sweep time:	5 s
Trace mode:	Power Averaging over 10 traces

8.8.4 Test data

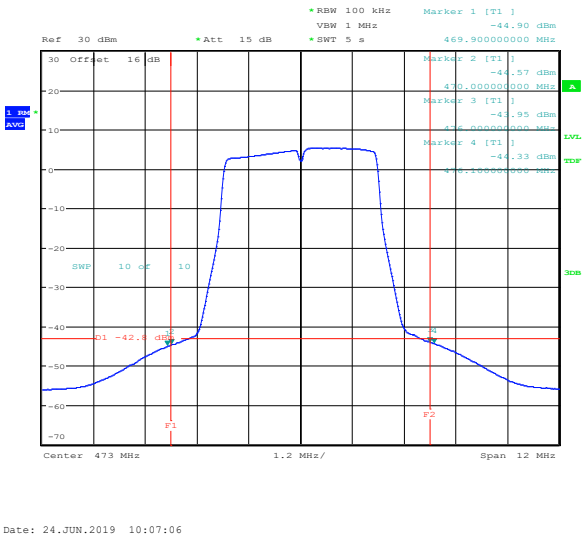


Figure 8.8-1: *Conducted band edge and adjacent channel emissions*

Bandwidth: *6 MHz*
Channel: *Low*
Frequency: *473 MHz*

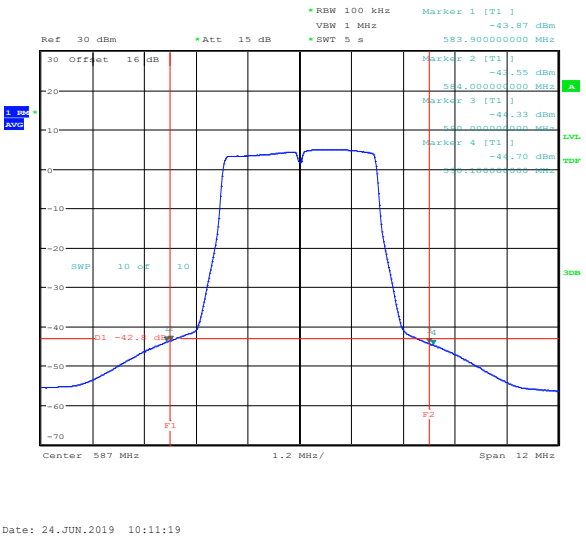


Figure 8.8-2: *Conducted band edge and adjacent channel emissions*

Bandwidth: *6 MHz*
Channel: *Mid*
Frequency: *587 MHz*

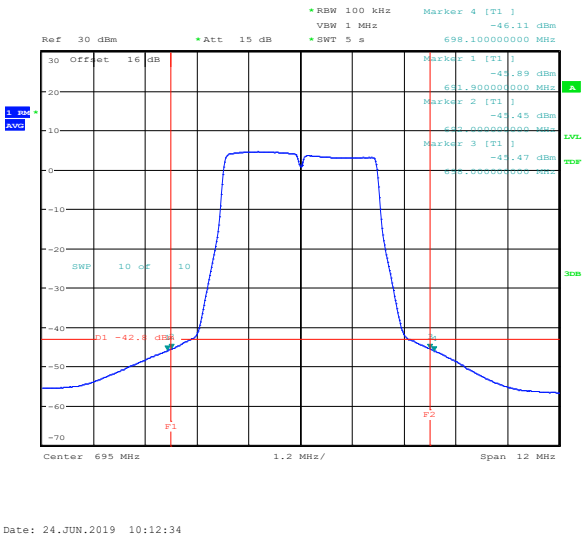


Figure 8.8-3: *Conducted band edge and adjacent channel emissions*

Bandwidth: *6 MHz*
Channel: *High*
Frequency: *695 MHz*

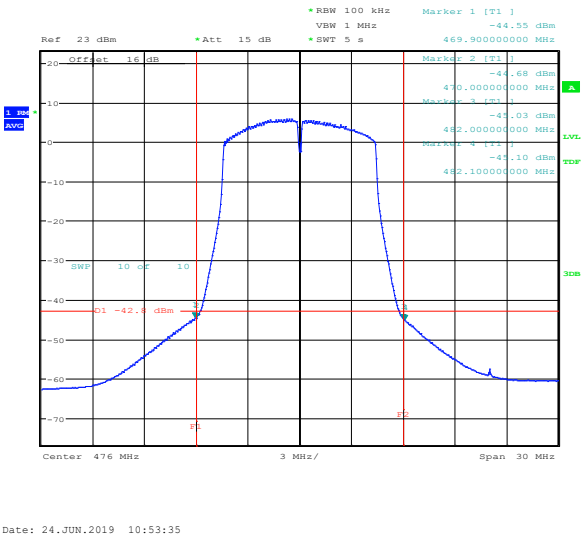


Figure 8.8-4: *Conducted band edge and adjacent channel emissions*

Bandwidth: *12 MHz*
Channel: *Low*
Frequency: *476 MHz*

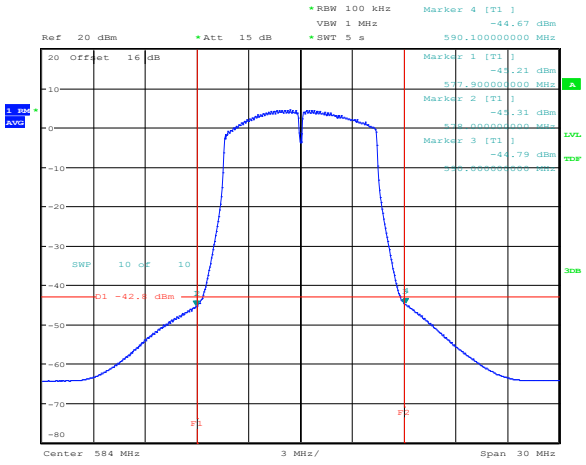


Figure 8.8-5: *Conducted band edge and adjacent channel emissions*

Bandwidth: 12 MHz
Channel: Mid
Frequency: 584 MHz

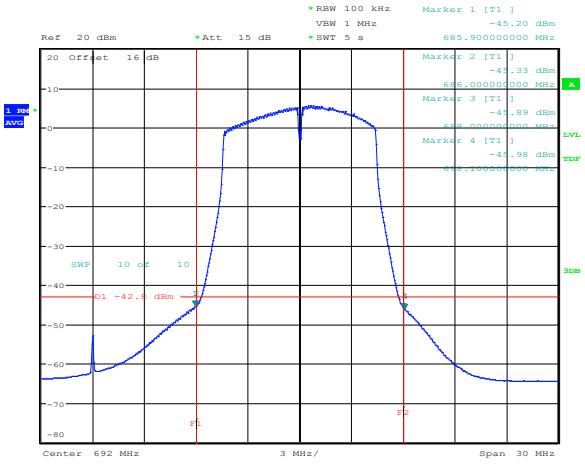


Figure 8.8-6: *Conducted band edge and adjacent channel emissions*

Bandwidth: 12 MHz
Channel: High
Frequency: 692 MHz

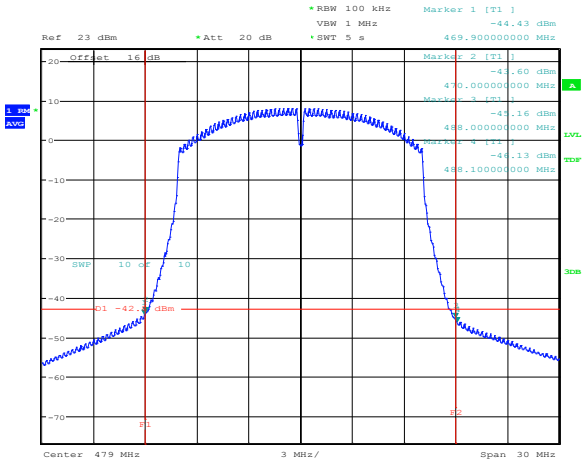


Figure 8.8-7: *Conducted band edge and adjacent channel emissions*

Bandwidth: 18 MHz
Channel: Low
Frequency: 479 MHz

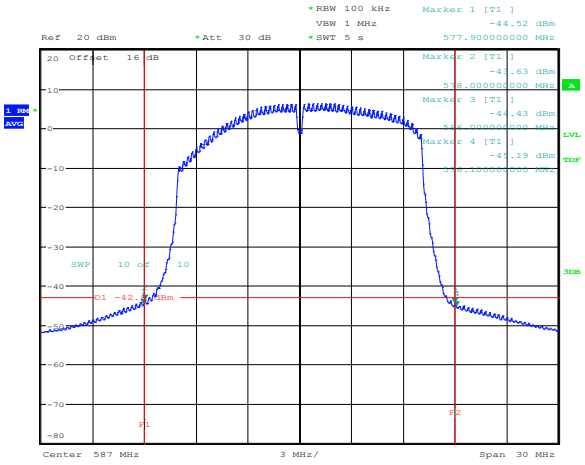


Figure 8.8-8: *Conducted band edge and adjacent channel emissions*

Bandwidth: 18 MHz
Channel: Mid
Frequency: 587 MHz

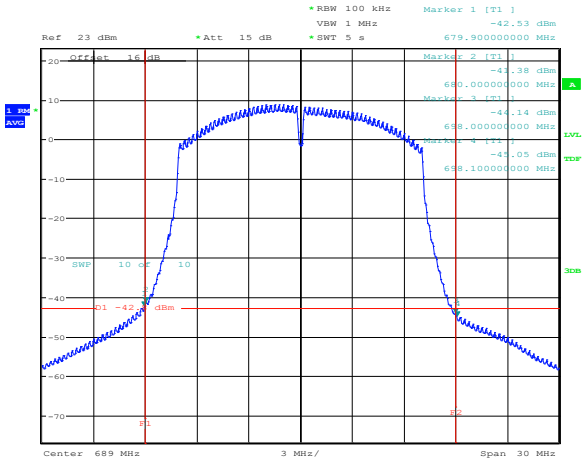


Figure 8.8-9: *Conducted band edge and adjacent channel emissions*

Bandwidth: *18 MHz*
Channel: *High*
Frequency: *689 MHz*

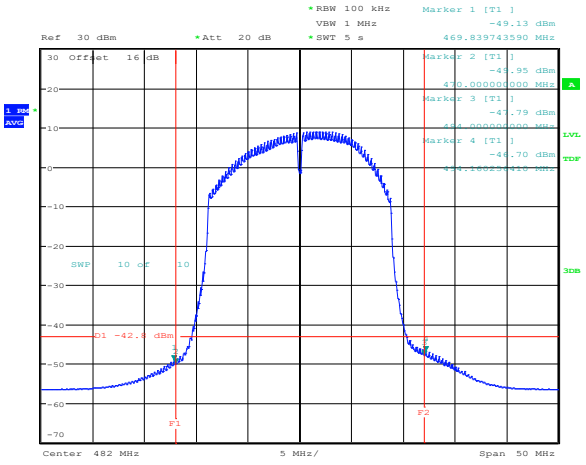


Figure 8.8-10: *Conducted band edge and adjacent channel emissions*

Bandwidth: *24 MHz*
Channel: *Low*
Frequency: *482 MHz*

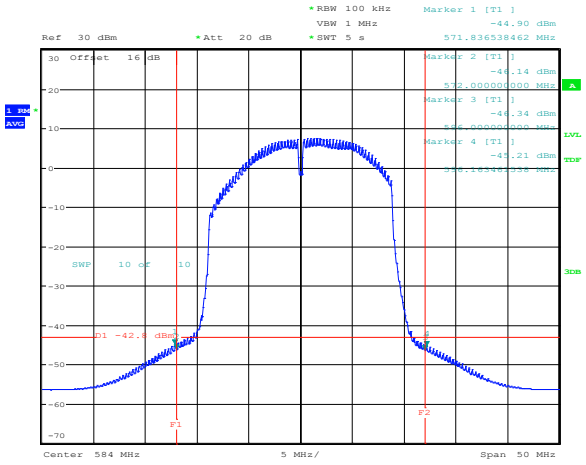


Figure 8.8-11: *Conducted band edge and adjacent channel emissions*

Bandwidth: *24 MHz*
Channel: *Mid*
Frequency: *584 MHz*

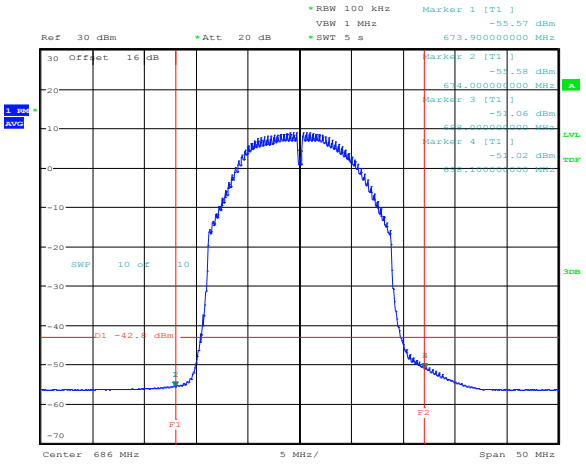


Figure 8.8-12: *Conducted band edge and adjacent channel emissions*

Bandwidth: *24 MHz*
Channel: *High*
Frequency: *686 MHz*

Table 8.8-1: *Band edge measurements for 6 MHz channel*

Channel	Frequency, MHz	Band edge level, dBm/100 kHz	Band edge limit, dBm/100 kHz	Margin, dB
Low	470.0	-44.57	-42.80	1.77
Low	476.0	-43.95	-42.80	1.15
Mid	584.0	-43.55	-42.80	0.75
Mid	590.0	-44.33	-42.80	1.53
High	692.0	-45.45	-42.80	2.65
High	698.0	-45.47	-42.80	2.67

Table 8.8-2: *Band edge measurements for 12 MHz channel*

Channel	Frequency, MHz	Band edge level, dBm/100 kHz	Band edge limit, dBm/100 kHz	Margin, dB
Low	469.9	-44.55	-42.80	1.75
Low	482.0	-45.03	-42.80	2.23
Mid	577.9	-45.21	-42.80	2.41
Mid	590.1	-44.67	-42.80	1.87
High	685.9	-45.20	-42.80	2.40
High	698.0	-48.89	-42.80	6.09

Table 8.8-3: *Band edge measurements for 18 MHz channel*

Channel	Frequency, MHz	Band edge level, dBm/100 kHz	Band edge limit, dBm/100 kHz	Margin, dB
Low	470.0	-43.60	-42.80	0.80
Low	488.0	-45.16	-42.80	2.36
Mid	578.0	-43.63	-42.80	0.83
Mid	596.0	-44.43	-42.80	1.63
High	680.0	-43.59	-42.80	0.79
High	698.0	-44.14	-42.80	1.34

Table 8.8-4: *Band edge measurements for 24 MHz channel*

Channel	Frequency, MHz	Band edge level, dBm/100 kHz	Band edge limit, dBm/100 kHz	Margin, dB
Low	469.9	-49.13	-42.80	6.33
Low	494.1	-46.70	-42.80	3.90
Mid	571.9	-44.90	-42.80	2.10
Mid	596.1	-45.21	-42.80	2.41
High	673.9	-55.57	-42.80	12.77
High	698.1	-51.02	-42.80	8.22

8.9 FCC 15.709(d)(2) and RSS-222 6.3.3 Radiated spurious emissions beyond the television channels

8.9.1 Definitions and limits

FCC:
At frequencies beyond the television channels immediately adjacent to the channel in which the TVBD is operating, the radiated emissions from TVBDs shall meet the requirements of § 15.209.
ISED:
Beyond the adjacent channel emissions, the emission limits of RSS-Gen apply. See RSS-Gen for guidance on performing those measurements

Table 8.9-1: *FCC §15.209 and RSS-Gen Radiated emission limits*

Frequency, MHz	Field strength of emissions		Measurement distance
	µV/m	dBµV/m	m
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

8.9.2 Test date

Start date	July 5, 2019

8.9.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 7 GHz.
Radiated measurements were performed at a distance of 3 m.

Spectrum analyser settings for radiated measurements below 1 GHz:

Resolution bandwidth:	120 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak or Quasi-peak
Trace mode:	Max Hold

Spectrum analyser settings for peak radiated measurements above 1 GHz:

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

Spectrum analyser settings for average radiated measurements above 1 GHz:

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

8.9.4 Test data

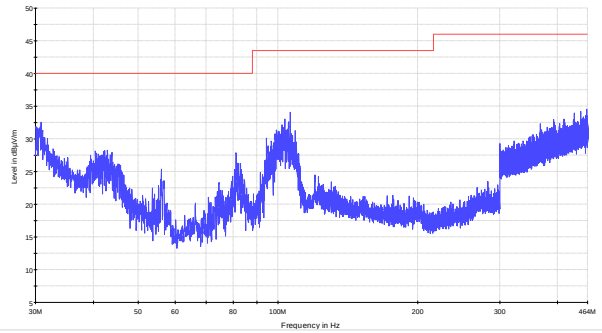


Figure 8.9-1: *Radiated spurious emissions within 30–464 MHz for low channel for LPDA antenna*

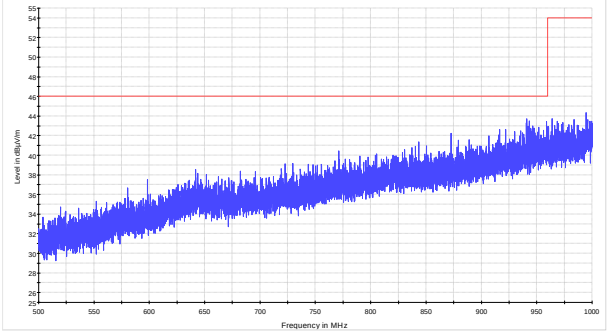


Figure 8.9-2: *Radiated spurious emissions within 500–1000 MHz for low channel for LPDA antenna*

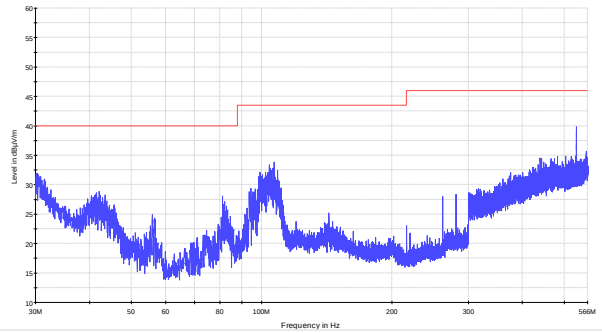


Figure 8.9-3: *Radiated spurious emissions within 30–566 MHz for mid channel for LPDA antenna*

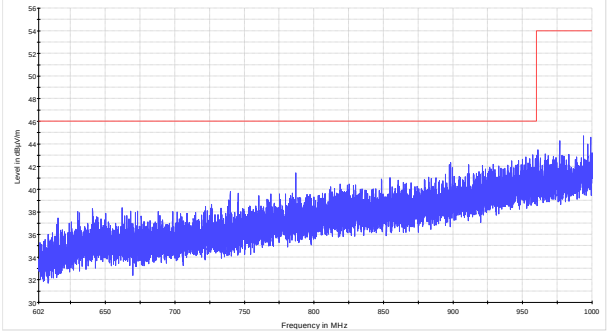


Figure 8.9-4: *Radiated spurious emissions within 602–1000 MHz for mid channel for LPDA antenna*

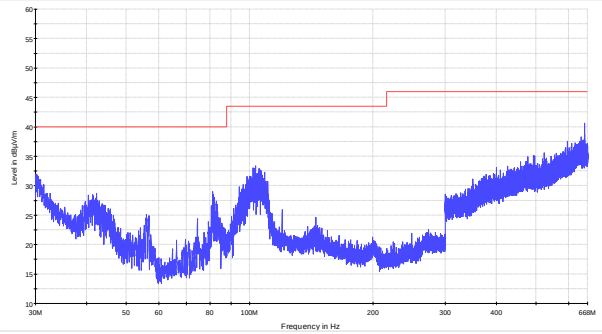


Figure 8.9-5: *Radiated spurious emissions within 30–668 MHz for high channel for LPDA antenna*

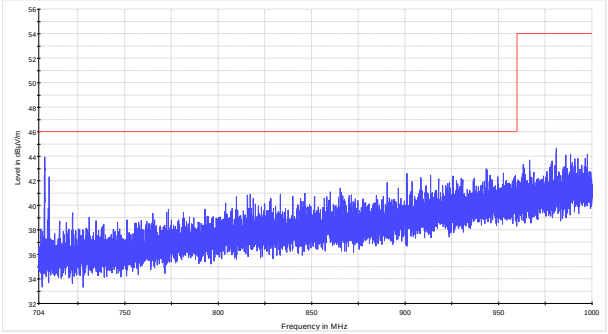


Figure 8.9-6: *Radiated spurious emissions within 704–1000 MHz for high channel for LPDA antenna*

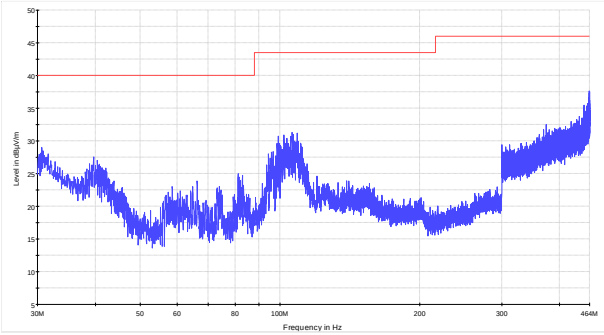


Figure 8.9-7: *Radiated spurious emissions within 30–464 MHz for low channel for Panel antenna*

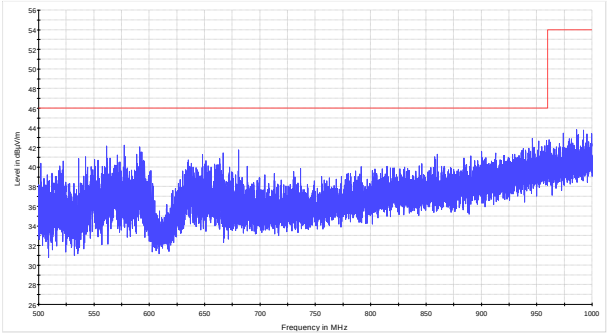


Figure 8.9-8: *Radiated spurious emissions within 500–1000 MHz for low channel for Panel antenna*

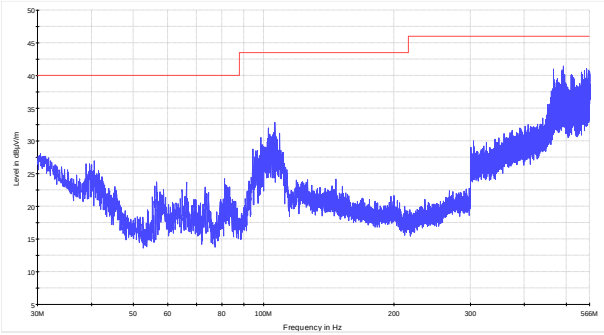


Figure 8.9-9: *Radiated spurious emissions within 30–566 MHz for mid channel for Panel antenna*

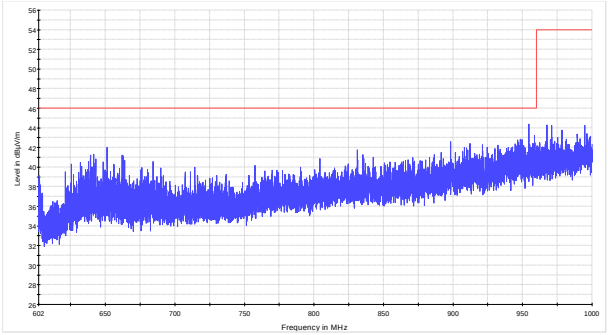


Figure 8.9-10: *Radiated spurious emissions within 602–1000 MHz for mid channel for Panel antenna*

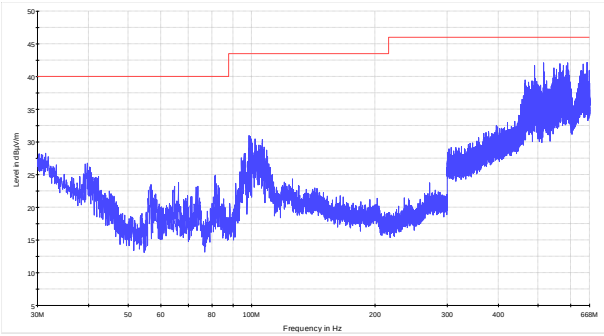


Figure 8.9-11: *Radiated spurious emissions within 30–668 MHz for high channel for Panel antenna*

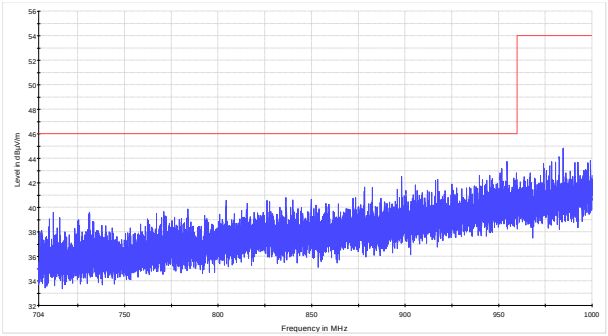


Figure 8.9-12: *Radiated spurious emissions within 704–1000 MHz for high channel for Panel antenna*

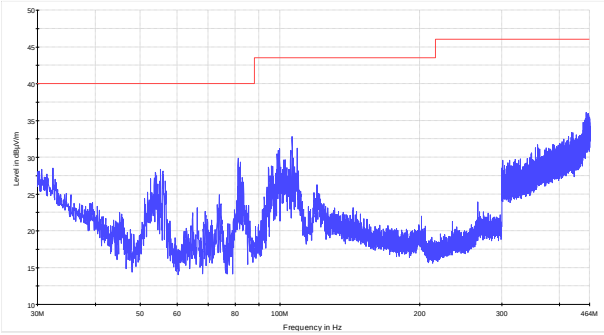


Figure 8.9-13: *Radiated spurious emissions within 30–464 MHz for low channel for Omnidirectional antenna*

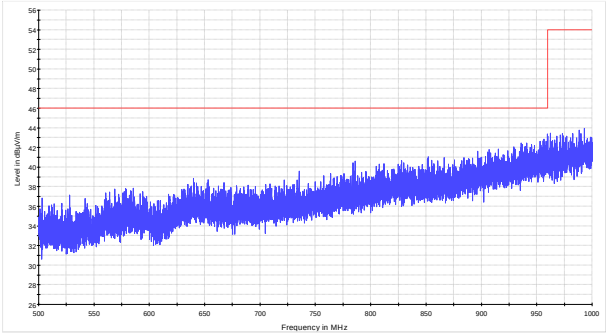


Figure 8.9-14: *Radiated spurious emissions within 500–1000 MHz for low channel for Omnidirectional antenna*

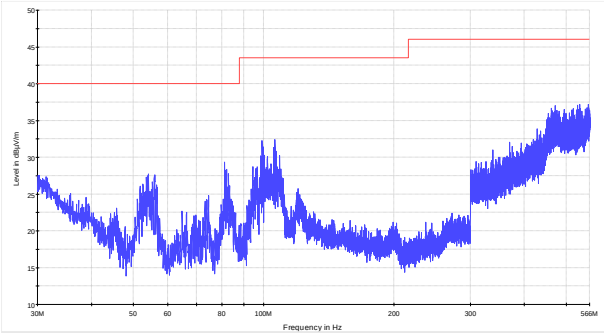


Figure 8.9-15: *Radiated spurious emissions within 30–566 MHz for mid channel for Omnidirectional antenna*

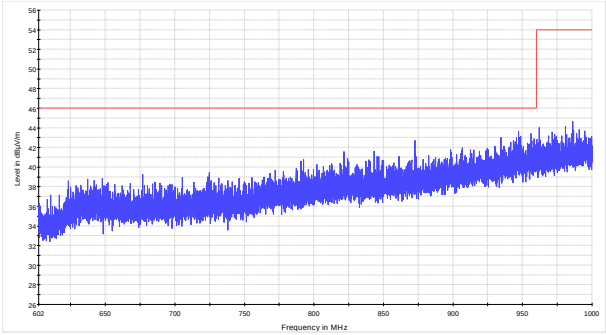


Figure 8.9-16: *Radiated spurious emissions within 602–1000 MHz for mid channel for Omnidirectional antenna*

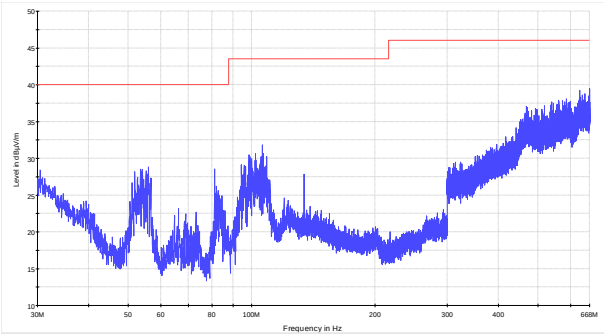


Figure 8.9-17: *Radiated spurious emissions within 30–668 MHz for high channel for Omnidirectional antenna*

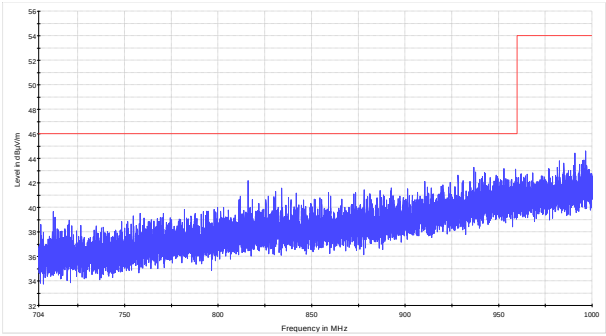


Figure 8.9-18: *Radiated spurious emissions within 704–1000 MHz for high channel for Omnidirectional antenna*

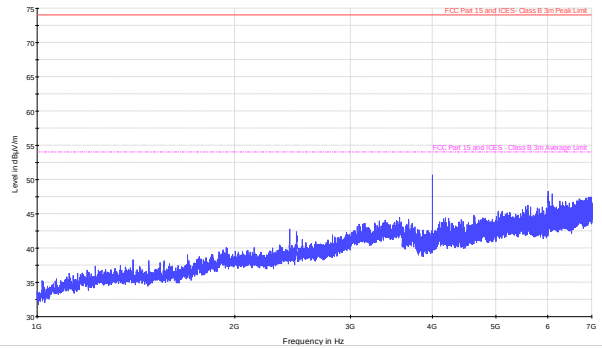


Figure 8.9-19: *Radiated spurious emissions within 1–7 GHz for low channel for LPDA antenna*

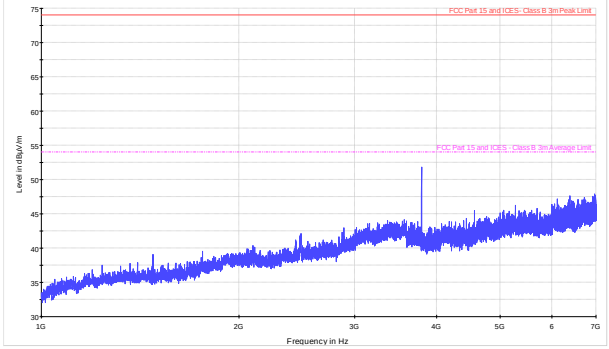


Figure 8.9-20: *Radiated spurious emissions within 1–7 GHz for mid channel for LPDA antenna*

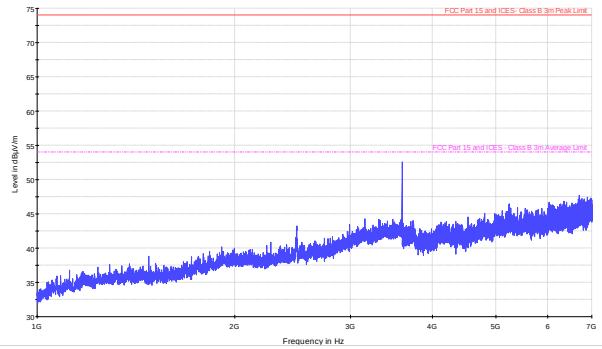


Figure 8.9-21: *Radiated spurious emissions within 1–7 GHz for high channel for LPDA antenna*

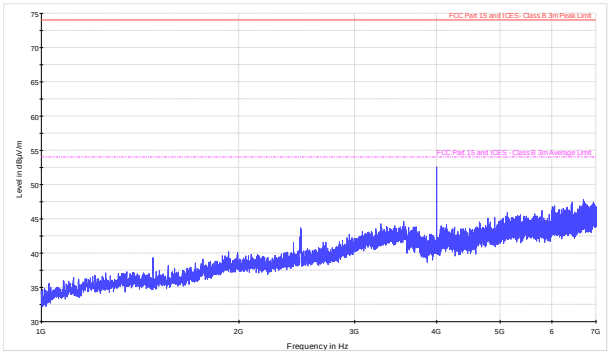


Figure 8.9-22: *Radiated spurious emissions within 1–7 GHz for low channel for Panel antenna*

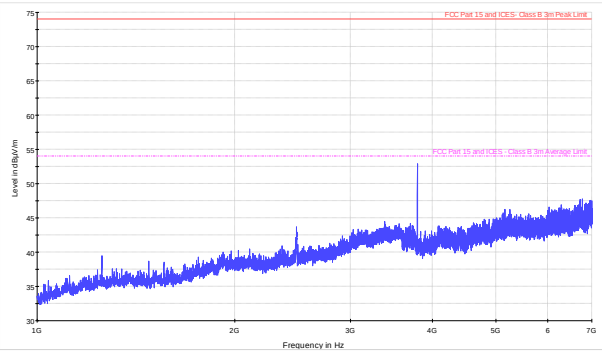


Figure 8.9-23: *Radiated spurious emissions within 1–7 GHz for mid channel for Panel antenna*

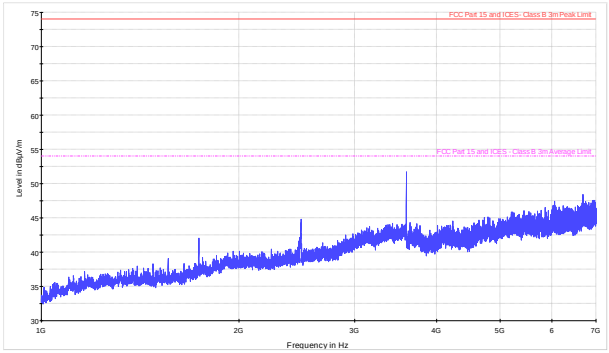


Figure 8.9-24: *Radiated spurious emissions within 1–7 GHz for high channel for Panel antenna*

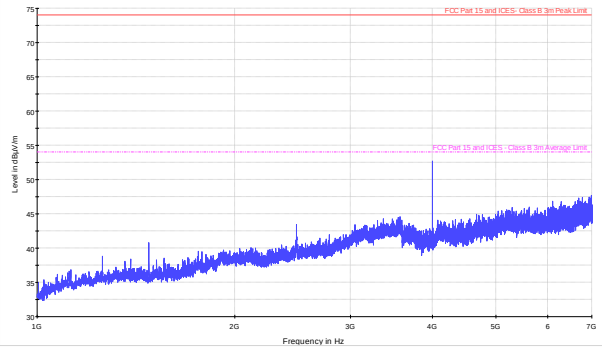


Figure 8.9-25: *Radiated spurious emissions within 1–7 GHz for low channel for Omnidirectional antenna*

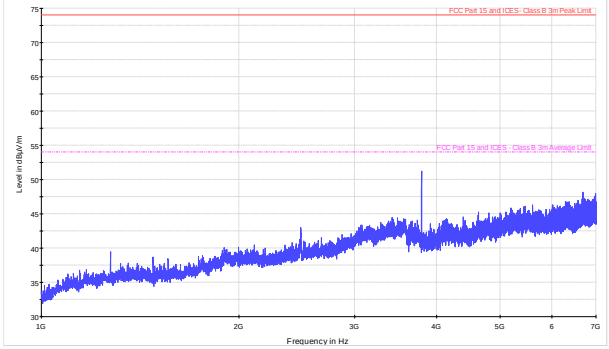


Figure 8.9-26: *Radiated spurious emissions within 1–7 GHz for mid channel for Omnidirectional antenna*

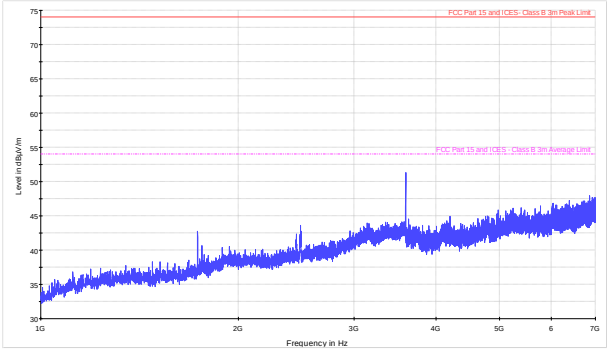


Figure 8.9-27: *Radiated spurious emissions within 1–7 GHz for high channel for Omnidirectional antenna*

8.10 RSS-222 6.4 Field Strength Emissions in the band 602–620 MHz

8.10.1 Definitions and limits

Transmitter field strength emissions must comply with the following field strength limits at a distance of one metre.

Table 8.10-1: *602–620 MHz band field strength limits*

Frequency, MHz	Field strength, dBµV/m/120 kHz at 1 m distance
602–607	120 – 5 × (F – 602)
607–608	95
608–614	30
614–615	95
615–620	120 – 5 × (620 – F)

Notes: F is frequency in MHz

8.10.2 Test date

Start date	July 10, 2019

8.10.3 Observations, settings and special notes

The spectrum was searched from 602 MHz to the 620 MHz.
Radiated measurements were performed at a distance of 1 m.

Spectrum analyser settings:

Resolution bandwidth:	120 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

8.10.4 Test data

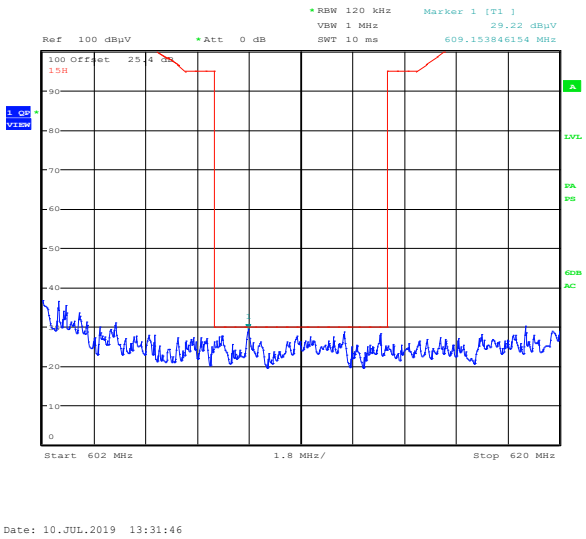


Figure 8.10-1: *Radiated spurious emissions within 602–620 MHz for lower adjacent channel to the restricted band, LPDA antenna*

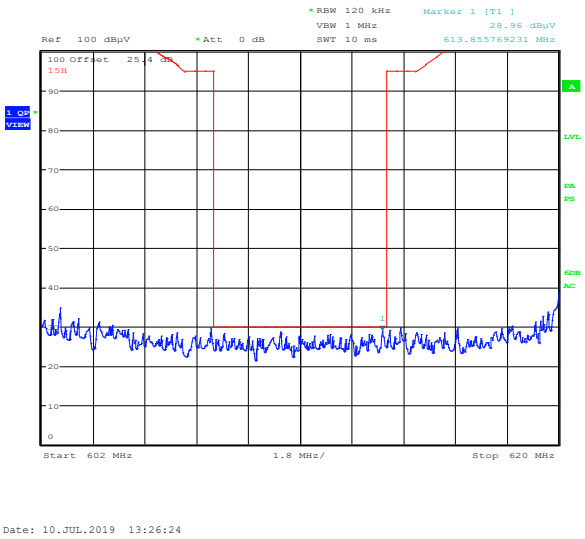


Figure 8.10-2: *Radiated spurious emissions within 602–620 MHz for upper adjacent channel to the restricted band, LPDA antenna*

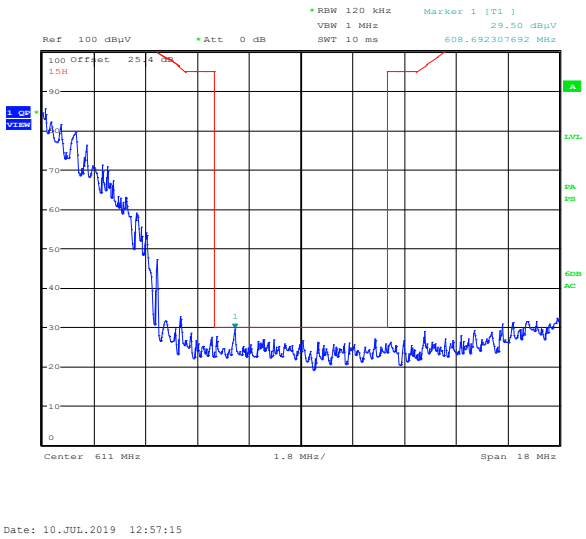


Figure 8.10-3: *Radiated spurious emissions within 602–620 MHz for lower adjacent channel to the restricted band, Panel antenna*

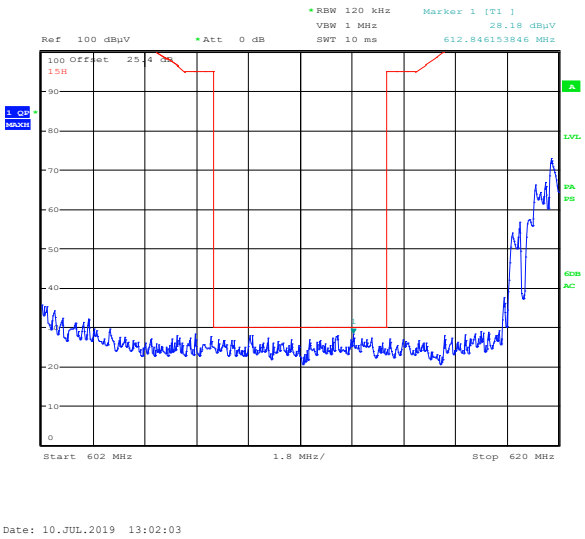


Figure 8.10-4: *Radiated spurious emissions within 602–620 MHz for upper adjacent channel to the restricted band, Panel antenna*

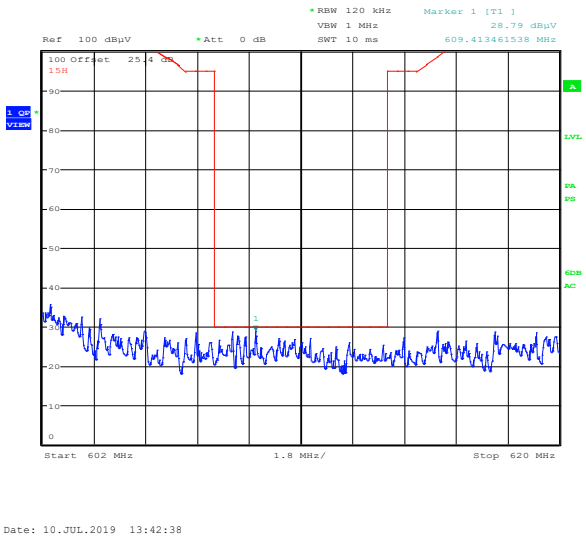


Figure 8.10-5: *Radiated spurious emissions within 602–620 MHz for lower adjacent channel to the restricted band, Omnidirectional antenna*

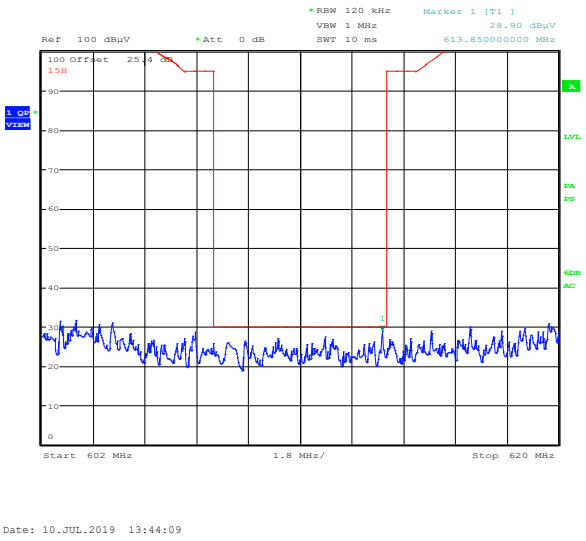
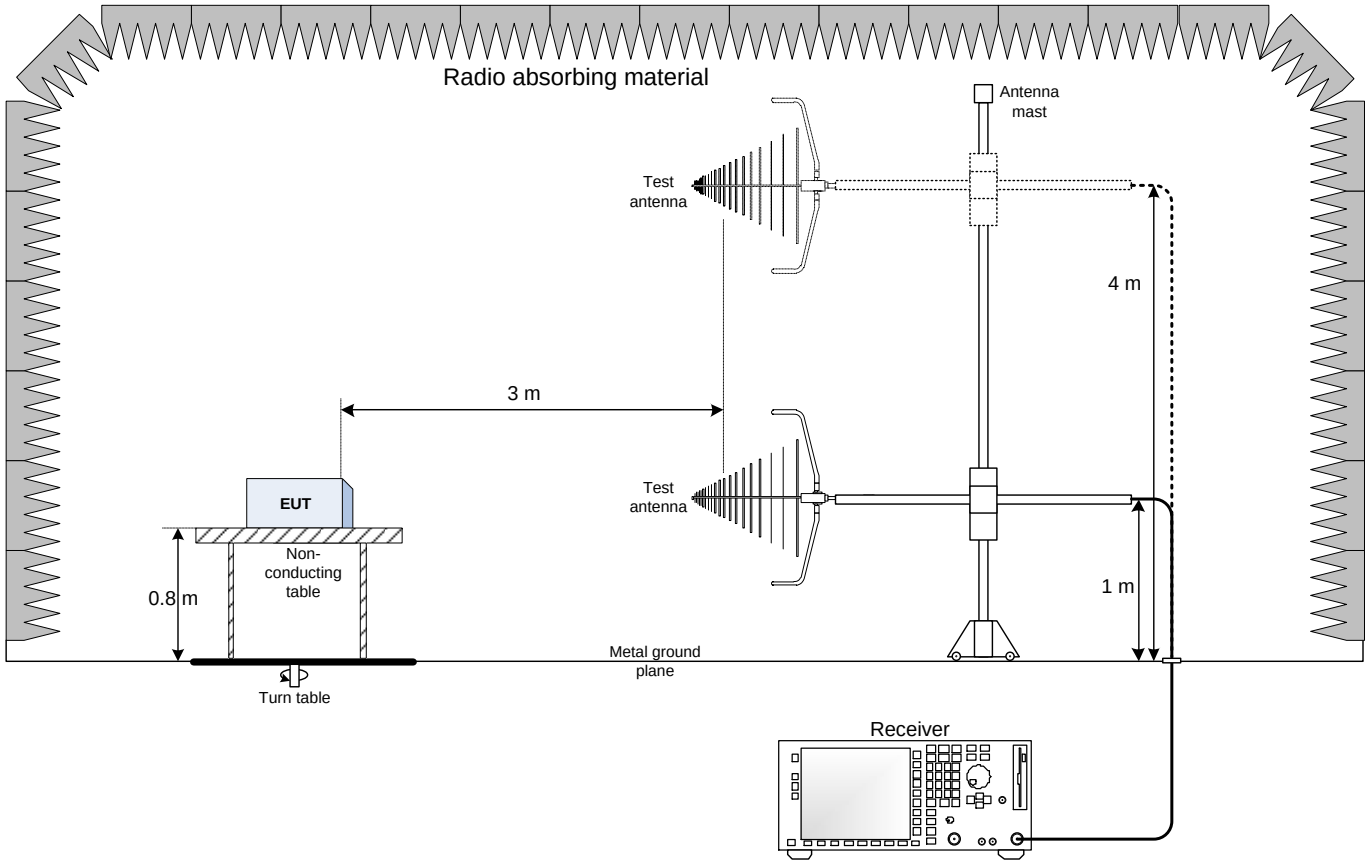


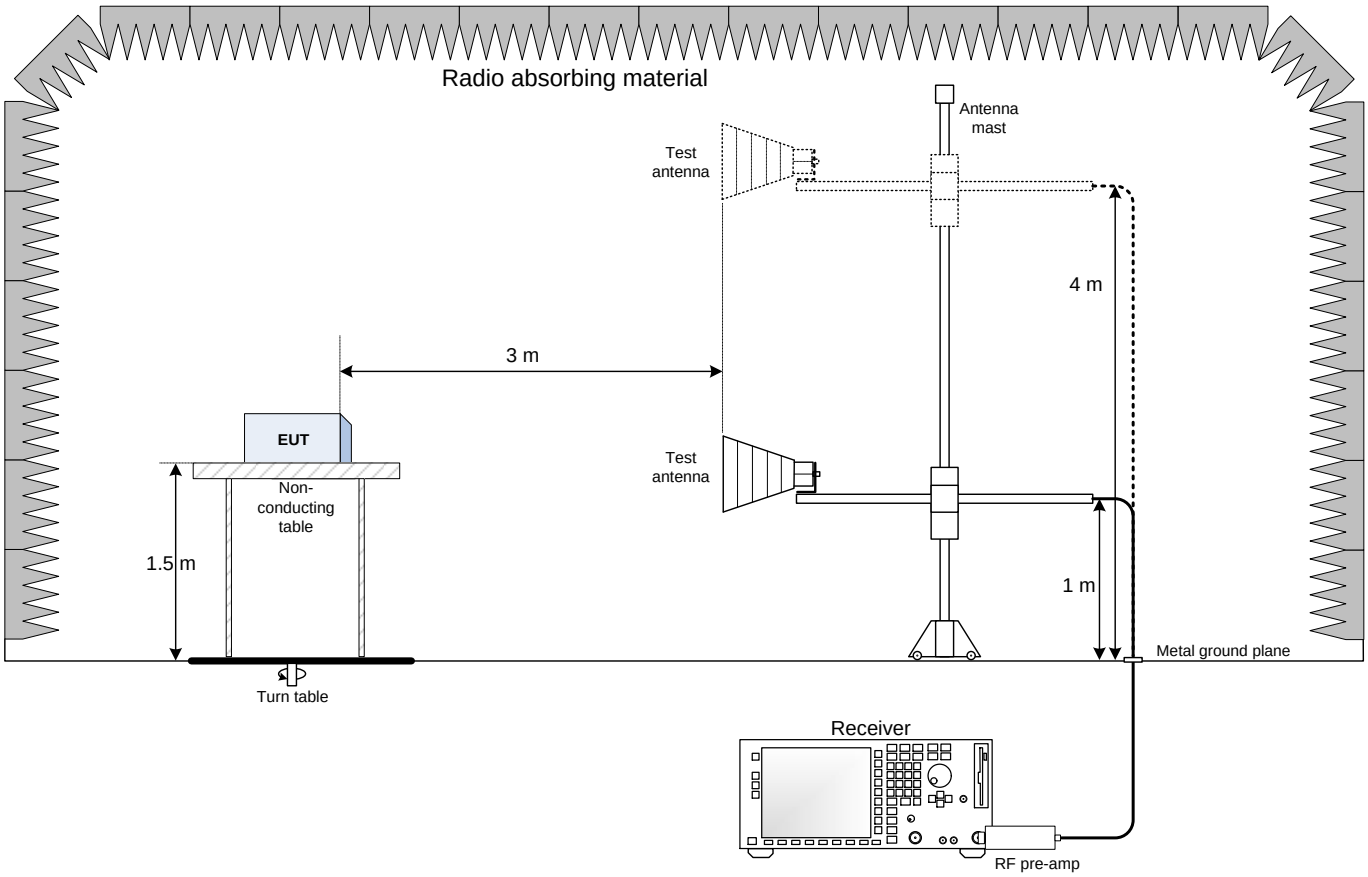
Figure 8.10-6: *Radiated spurious emissions within 602–620 MHz for upper adjacent channel to the restricted band, Omnidirectional antenna*

Section 9. Block diagrams and photos 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 Conducted emissions set-up