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RADIO TEST REPORT

REPORT NUMBER: M2005002-4

TEST STANDARD: FCC PART 15 SUBPART C SECTION 15.247
ISED RSS-247 SECTION 5.0

CLIENT: DEFINIUM TECHNOLOGIES PTY LTD

DEVICE: COOLER GUARDIAN

MODEL: DT1104-0100

FCC ID: 2AW4U-DT1104-0100

IC: 26329-DT11040100

DATE OF ISSUE: 19 NOVEMBER 2020

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REVISION TABLE

Version	Sec/Para Changed	Change Made	Date
1		Initial issue of document	19/11/2020

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RADIO TEST REPORT

CERTIFICATE OF COMPLIANCE

Device:	Cooler Guardian
Model:	DT1104-0100
Manufacturer:	Definium Technologies Pty Ltd
Radio Module:	Semtech SX1262 LoRa Transceiver (DTS)
FCC ID:	2AW4U-DT1104-0100
IC:	26329-DT11040100
Tested for:	Definium Technologies Pty Ltd
Address:	Unit 6, 16-18 Goodman Court, Invermay Tasmania, 7248
Phone Number:	+61 03 6334 1048
Contact:	Tony Oetterli
Email:	toetterli@definium.net
Standard:	FCC Part 15, Subpart C, Section 15.247 Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz ISED RSS-247, Issue 2, Section 5 Standard specifications for frequency hopping systems and digital transmission systems operating in the bands 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz
Result:	The Cooler Guardian complied with the applicable requirements above standards. Refer to Report M2005002-4 for full details.
Test Date(s):	22 May, 6 & 7 July, 2020
Issue Date:	19 November 2020
Test Engineer(s):	Wilson Xiao
Attestation:	*I hereby certify that the device(s) described herein were tested as described in this report and that the data included is that which was obtained during such testing.*
Authorised Signatory:	Shabbir Ahmed Lead Engineer – RF & Wireless

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RADIO REPORT FOR CERTIFICATION

1 TEST SUMMARY

Section	Description	FCC	ISED	Result(s)
6.1	Antenna Requirement	§15.203	§RSS-Gen 6.8	Complied
6.2	Restricted Bands of Operation	§15.205	§RSS-Gen 8.10	Complied
6.3	Conducted Limits	§15.207	§RSS-Gen 8.8	Not Applicable
6.4	Radiated emission limits; general requirements	§15.209	§RSS-Gen 8.9	Complied
6.5	6 dB Bandwidth	§15.247(a)(2)	§RSS-247 5.2(a)	Complied
6.6	Peak Output Power	§15.247(b)(3)	§RSS-247 5.4(d)	Complied
6.7	Out-of-Band/Spurious Emissions	§15.247(d)	§RSS-247 5.5	Complied
6.8	Band-Edge Emission Measurements	§15.247(d)	§RSS-247 5.5	Complied
6.9	Power spectral density	§15.247(e)	§RSS-247 5.2(b)	Complied
6.10	Maximum Permissible Exposure	§15.247(i)	§RSS-102	Complied
6.11	Occupied Bandwidth – 99% power	§15.215	§RSS-Gen 6.7	Complied

2 TEST FACILITY

2.1 General

EMC Technologies Pty Ltd is accredited by the FCC as a test laboratory able to perform compliance testing for the public. EMC Technologies Pty Ltd has also been designated as a Conformity Assessment Body (CAB) by Australian Communications and Media Authority (ACMA) under the APECTEL MRA and is designated to perform compliance testing on equipment subject to Declaration of Conformity (DoC) and Certification under Parts 15 and 18 of the FCC Commission's rules – **Registration Number 494713 & Designation number AU0001**.

EMC Technologies Pty Ltd is also an ISED Canada recognized testing laboratory – **ISED company number: 3569B** and **CAB identifier number: AU0001.**

2.2 Test Laboratory/Accreditations

NATA is the Australian National laboratory accreditation body and has accredited EMC Technologies to operate to the IEC/ISO17025 requirements. A major requirement for accreditation is the assessment of the company and its personnel as being technically competent in testing to the standards. This requires fully documented test procedures, continued calibration of all equipment to the National Standard at the National Measurements Institute (NMI) and an internal quality system similar to ISO 9002. NATA has mutual recognition agreements with the National Voluntary Laboratory Accreditation Program (NVLAP) and the American Association for Laboratory Accreditation (A^2LA).

All testing in this report has been conducted in accordance with EMC Technologies' scope of NATA accreditation to ISO 17025 for both testing and calibration and ISO 17020 for Inspection – **Accreditation Number 5292**.

The current full scope of accreditation can be found on the NATA website: www.nata.com.au

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3 TEST EQUIPMENT CALIBRATION

Measurement instrumentation and transducers were calibrated in accordance with the applicable standards by an independent NATA registered laboratory such as Keysight Technologies (Australia) Pty Ltd or the National Measurement Institute (NMI) or in-house. All equipment calibration is traceable to Australian national standards at the National Measurements Institute.

Equipment Type	Make/Model/Serial Number	Last Cal. dd/mm/yyyy	Due Date dd/mm/yyyy	Cal. Interval
Chamber	Frankonia SAC-3-2 (R-144)	17/07/2017	17/07/2020	3 Year*1
EMI Receiver	R&S ESR7 Sn: 101804 (R-142)	06/08/2019	06/08/2020	1 Year*2
	R&S ESW26 Sn: 101306 (R-143)	05/06/2020	05/06/2021	1 Year*2
Antennas	EMCO 6502 Active Loop Antenna Sn: 9311-2801 (A-231)	16/11/2018	16/11/2020	2 Year*2
	SUNOL JB1 Sn. A061917 (A-425)	04/09/2019	04/09/2021	2 Year*2
	EMCO 3115 Horn Antenna Sn: 8908-3282 (A-004)	16/01/2019	16/01/2022	3 Year*1
Cables*3	Huber & Suhner Sucoflex 104A Sn: 503061 (C-463)	03/01/2020	03/01/2021	1 Year*1
	Huber & Suhner Sucoflex 104A Sn: 507099 (C-479)	03/01/2020	03/01/2021	1 Year*1
	Huber & Suhner Sucoflex 104A Sn: 503055 (C-457)	04/06/2020	04/06/2021	1 Year*1
	Huber & Suhner Sucoflex 104A Sn: 800448 (C-520)	04/06/2020	04/06/2021	1 Year*1

Note *1. Internal NATA calibration.
Note *2. External NATA / A2LA calibration.
Note *3. Cables are verified before measurements are taken.

4 MEASUREMENT UNCERTAINTY

EMC Technologies has evaluated the equipment and the methods used to perform the emissions testing. The estimated measurement uncertainties for emissions tests shown within this report are as follows:

Radiated Emissions:	9 kHz to 30 MHz	±4.1 dB
	30 MHz to 300 MHz	±5.1 dB
	300 MHz to 1000 MHz	±4.7 dB
	1 GHz to 18 GHz	±4.6 dB
	18 GHz to 40 GHz	±4.6 dB
Peak Output Power:		±1.5 dB

The above expanded uncertainties are based on standard uncertainties multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95%.

Application of measurement uncertainty for this report:

The referenced uncertainty standard specifies that determination of compliance shall be based on measurements without taking into account measurement instrumentation uncertainty. However, the measurement uncertainty shall appear in the test report.

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5 Device Details

(Information supplied by the Client)

The device is Lora IoT temperature and humidity sensor.

5.1 EUT (Transmitter) Details

Radio:	Semtech SX1262 LoRa Transceiver
Manufacturer:	Semtech Corporation
Number of Channels:	8
Operating Frequency:	903 MHz – 914.2 MHz Low Channel: 903 MHz Mid Channel: 907.8 MHz High Channel: 914.2 MHz
Nominal Bandwidth:	500 kHz (*declared by client*)
Modulation:	LoRa* (DTS)
Data rate:	12500 bits per second
Antenna:	PulseLarsen W3113 PCB Helical Trace
Antenna Peak Gain:	0.8 dBi

*Note: LoRa is Semtech's proprietary spread-spectrum modulation technique derived from existing Chirp Spread Spectrum (CSS) technology.

5.2 EUT (Host) Details

Test Sample:	Cooler Guardian
Model:	DT1104-0100
Serial Number:	000025
Firmware Version:	1.1.0
Supply Rating:	3.6 V DC, 1.0A
Manufacturer:	Definium Technologies Pty Ltd

5.3 Test Configuration

Testing was performed with the transceiver set to transmit continuously at Low channel (903MHz), Mid Channel (907.8 MHz) and High Channel (914.2 MHz).

The following commands were used to set up the transceiver via a serial connection software (**Tera Term, Version 4.105**):

"lora 2 8 1"

"mod 903000000 9 0" / "mod 907800000 9 0" / "mod 914200000 9 0"

5.4 Modifications

No modifications were required to achieve compliance.

5.5 Deviations from the Standard

Note any deviations to the standard

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6 RESULTS

6.1 §15.203/ RSS-Gen 6.8 – Antenna Requirement

The transceiver incorporates an integral PCB antenna that cannot be replaced by another type.

Antenna Type: PCB Helical Trace
Antenna gain: 0.8 dBi
Connector: Not Applicable

6.2 §15.205/ RSS-Gen 8.10/ RSS-247 3.3 – Restricted Bands of Operation

The provisions of the §15.205/ RSS-Gen 8.10/ RSS-247 3.3 restricted bands of operation and §15.209 radiated emissions limits have been met, refer to section 6.7

6.3 §15.207/ RSS-Gen 8.8 – Conducted Limits

The device is battery DC powered and does not connect directly or indirectly to the AC mains network. Test was not applicable.

6.4 §15.209/ RSS-Gen 8.9 – Radiated emission limits; general requirements

The provisions of the §15.205/ RSS-Gen 8.10/ RSS-247 3.3 restricted bands of operation and §15.209/ RSS-Gen 8.9 radiated emissions limits have been met, refer to section 6.7

6.5 §15.247(a)(2)/ RSS-247 5.2(a) – 6 dB bandwidth

6.5.1 Test Procedure

The tests were performed in accordance with ANSI C63.10: 2013 Clause 11.8 DTS bandwidth.

The 6 dB bandwidth was measured while the device was transmitting with typical modulation applied. The resolution bandwidth of 100 kHz and the video bandwidth of 300 kHz were utilised when measuring the bandwidth.

6.5.2 Limits

In the band 902 – 928 MHz, the minimum 6 dB bandwidth is to be at least 500 kHz.

6.5.3 Results

Table 6-1: 6dB Bandwidth

Freq. [MHz]	6 dB Bandwidth [kHz]	Limit [kHz]
903	633.40	>= 500
907.8	633.40	>= 500
914.2	635.40	>= 500

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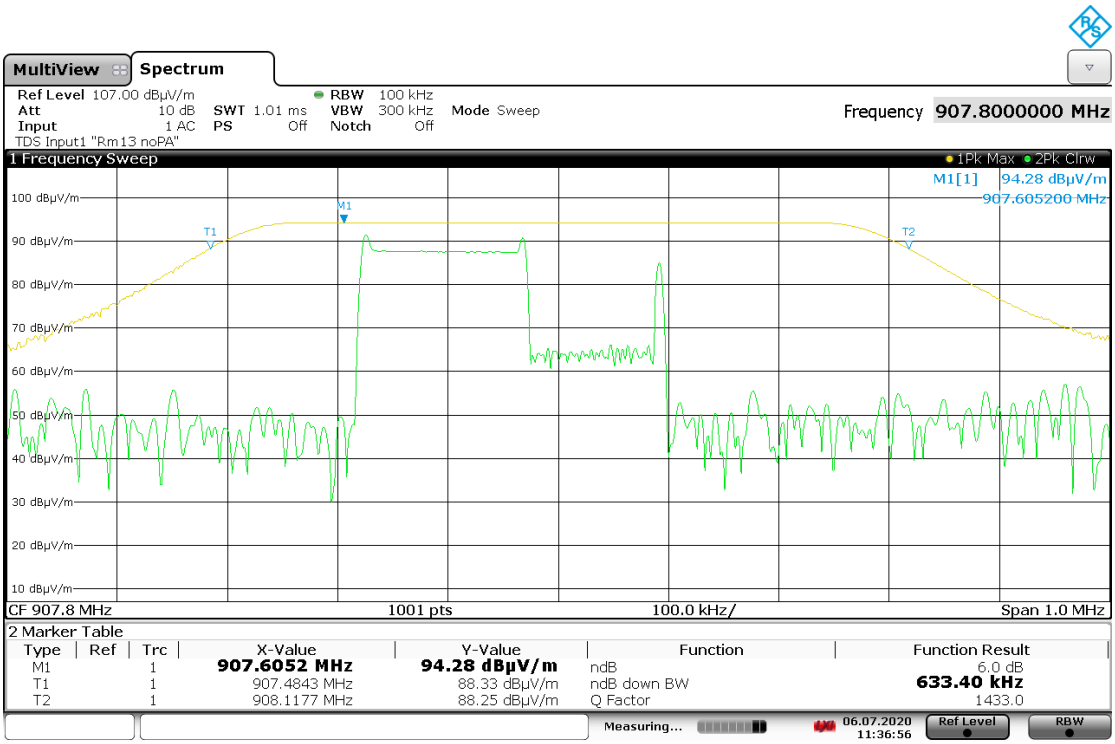
Graph 6-1: 6 dB bandwidth, 903 MHz



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Graph 6-2: 6 dB bandwidth, 907.8 MHz

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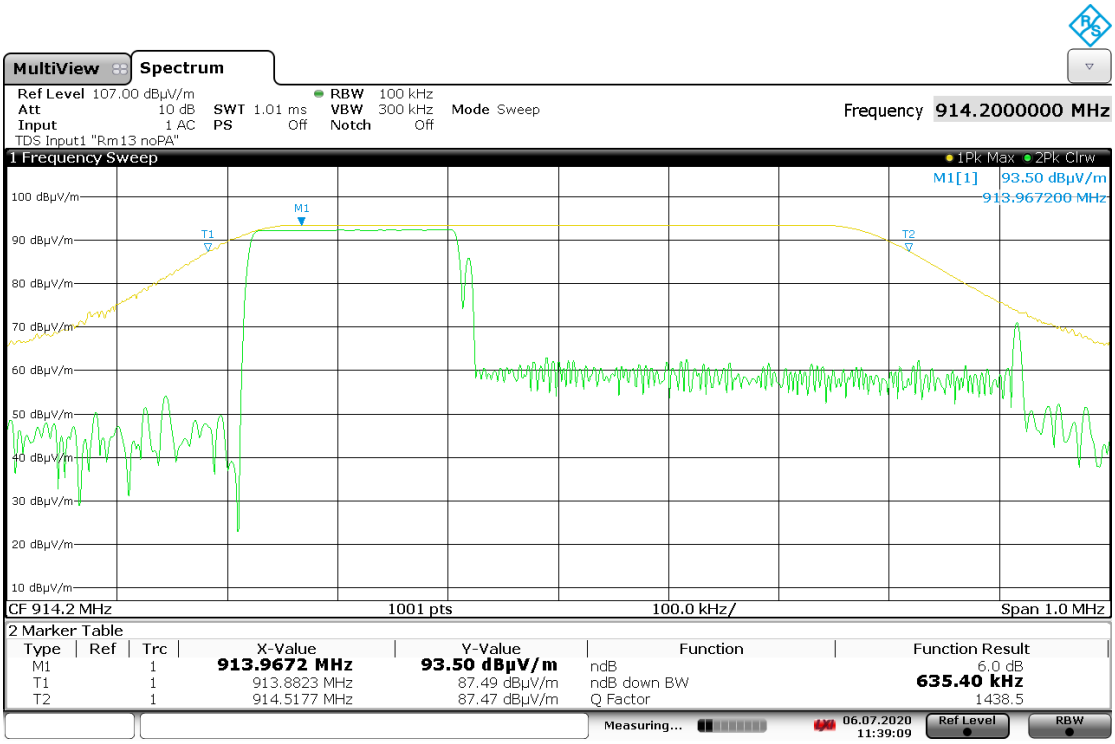

Graph 6-3: 6 dB bandwidth, 914.2 MHz

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6.6 §15.247(b)(3)/ RSS-247 5.4(d) – Peak Output Power

6.6.1 Test Procedure

The field strength of the fundamental transmitted frequency was measured inside a semi-anechoic chamber compliant with ANSI C63.4: 2014 in accordance to ANSI C63.10: 2013 clause 11.9.1.1.

The EUT was positioned on a test turn-table and rotated through 360° to determine the highest emissions. The measurement antenna was also varied between 1 and 4 metres height. Different orientations of the EUT (x, y and z-axis) and measurement antenna polarisations (vertical and horizontal) were investigated to produce the highest emission EIRP.

All measurements were made at a distance of 3 metres.

6.6.2 Limits

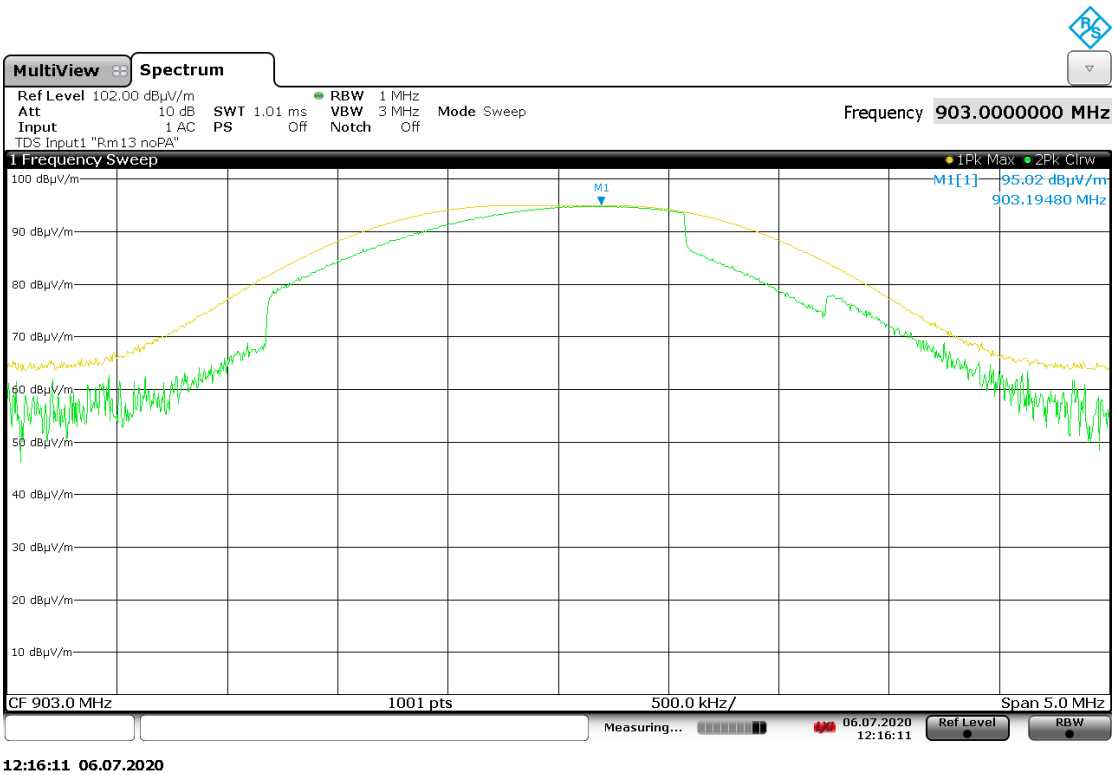
The maximum conducted output power at 902 -928 MHz is 1 Watts or 30 dBm.

6.6.3 Results

Table 6-2: Maximum EIRP

Freq. [MHz]	E-Field@ 3 m dBuV/m	EIRP (dBm)	Antenna Gain (dBi)	Equivalent Conducted Output Power (dBm)	Limit (dBm)	Results
903	95.02	-0.21	0.8	-1.01	30	Complied
907.8	91.75	-3.48	0.8	-4.28	30	Complied
914.2	93.00	-2.23	0.8	-3.03	30	Complied

The measured radiated field strength is converted to equivalent conducted output power for checking compliance (KDB 558074 D01 Section 3).



Graph 6-4: Max EIRP, 903 MHz

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Graph 6-5: Max EIRP, 907.8 MHz

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Graph 6-6: Max EIRP, 914.2 MHz

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6.7 §15.247(d)/ RSS-247 5.5 – Out-of-Band/Spurious Emissions

6.7.1 Test procedure

Radiated out-of-band/spurious emissions measurements were performed in a semi-anechoic chamber compliant with ANSI C63.4: 2014.

The test frequency range was sub-divided into smaller bands with the defined resolution bandwidths to permit reliable display and identification of emissions.

Frequency range [MHz]	Measurement Bandwidth [kHz]	Measurement Distance [m]	Antenna
0.009 to 0.150	0.2	3	0.6 metre loop antenna
0.150 to 30	9	3	
30 to 1000	120	3	Biconilog hybrid
1000 to 18 000	1000	3	Standard gain or broadband horn
18 000 to 40 000	1000	1	

EUT was set at a height of 0.8 m for measurements below 1000 MHz and set at a height of 1.5 m for measurements above 1000 MHz.

The sample was slowly rotated with the spectrum analyser set to Max-Hold. This was performed for at least two antenna heights. When an emission was located, it was positively identified and its maximum level found by rotating the automated turntable and by varying the antenna height. For below 1000 MHz the emissions were measured with a Quasi-Peak detector, and for above 1000 MHz the emissions were measured with Peak and Average detectors.

EUT was investigated on all three axes (x, y, and z) with antenna. Measurements on the worst axis are presented below.

The measurement data for each frequency range was corrected for cable losses, antenna factors and preamplifier gain. This process was performed for both horizontal and vertical polarisations of the measurement antenna.

6.7.2 Evaluation of field strength

Field strengths were calculated automatically by the software using pre-stored calibration data. The method of calculation is shown below:

$$\boldsymbol{E = V + AF - G + L}$$

Where: E = Radiated Field Strength in dBµV/m.
V = EMI Receiver Voltage in dBµV/m.
AF = Antenna Factor in dB (stored as a data array).
G = Preamplifier Gain in dB (stored as a data array).
L = Cable loss in dB (stored as a data array of Insertion Loss versus frequency).

6.7.3 Limits

The limit applied is in accordance with the out-of-band/spurious emissions limit defined in §15.247(d).

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.

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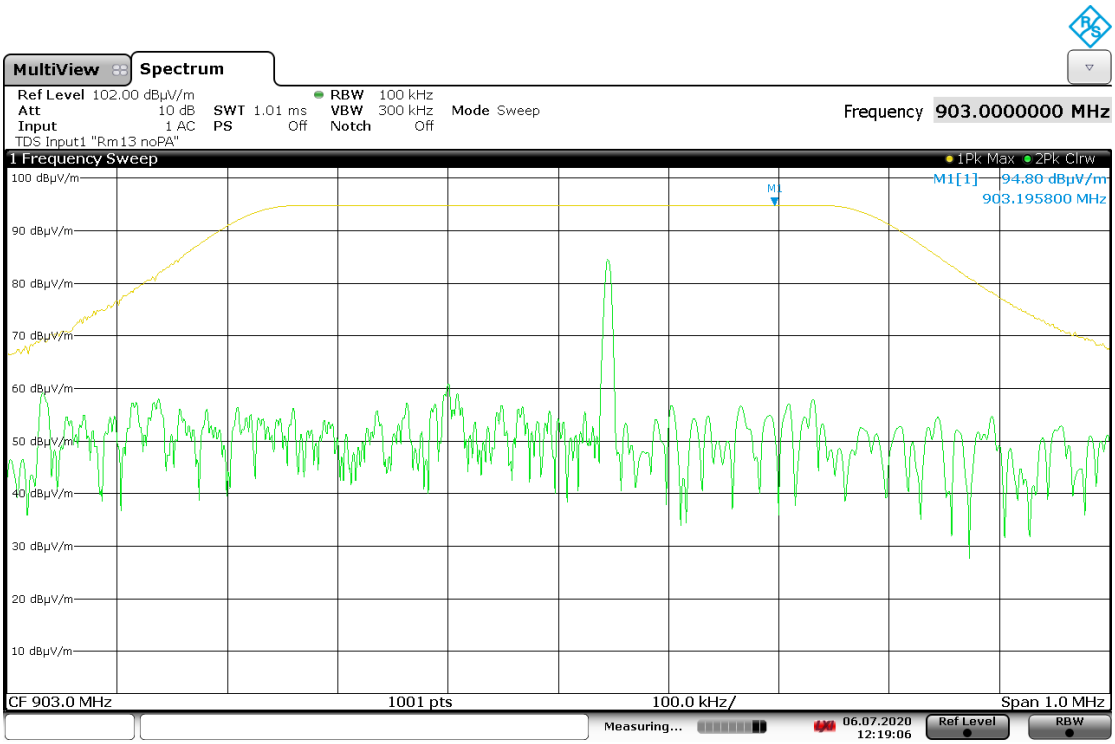
The in-band peak PSD in 100 kHz bandwidth were measured on all channels according to ANSI C63.10-2013 clause 11.11.2. The maximum PSD level was used to establish the limit for nonrestricted frequency bands. However, the general limits of §15.209 apply for the restricted bands of operation defined in §15.205.

Table 6-3: 100 kHz reference level measurement

Freq. (MHz)	Peak at 3 m (dBµV/m)	Established Limit at 3m (dBµV/m)
903	94.80	74.80



Graph 6-7: 100 kHz bandwidth reference level

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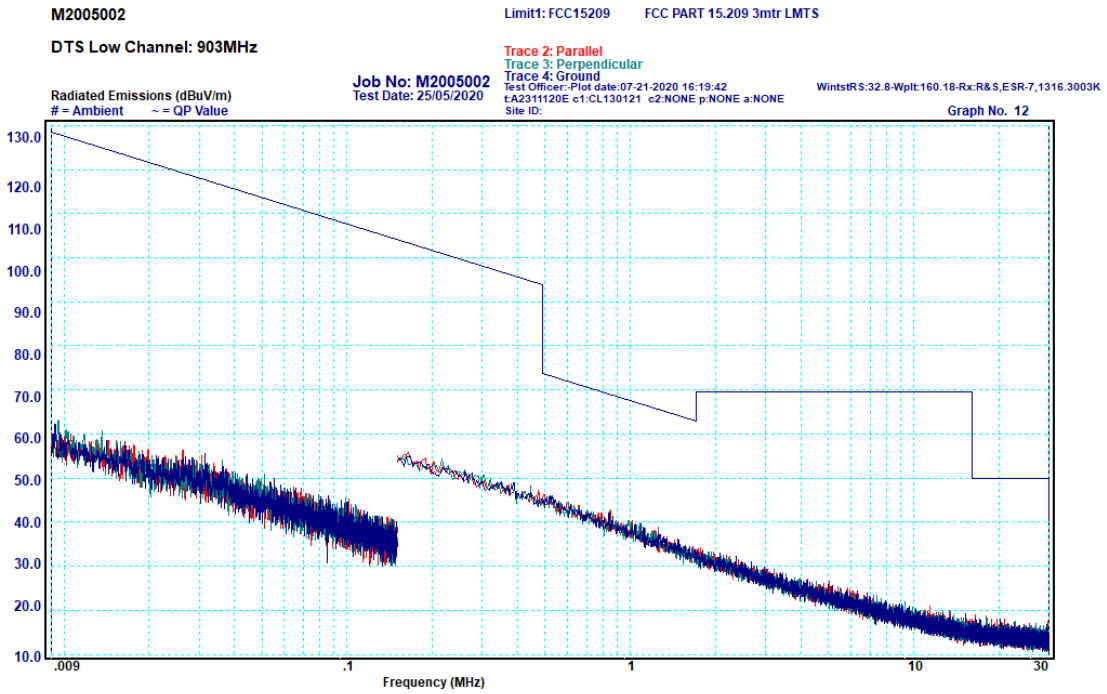
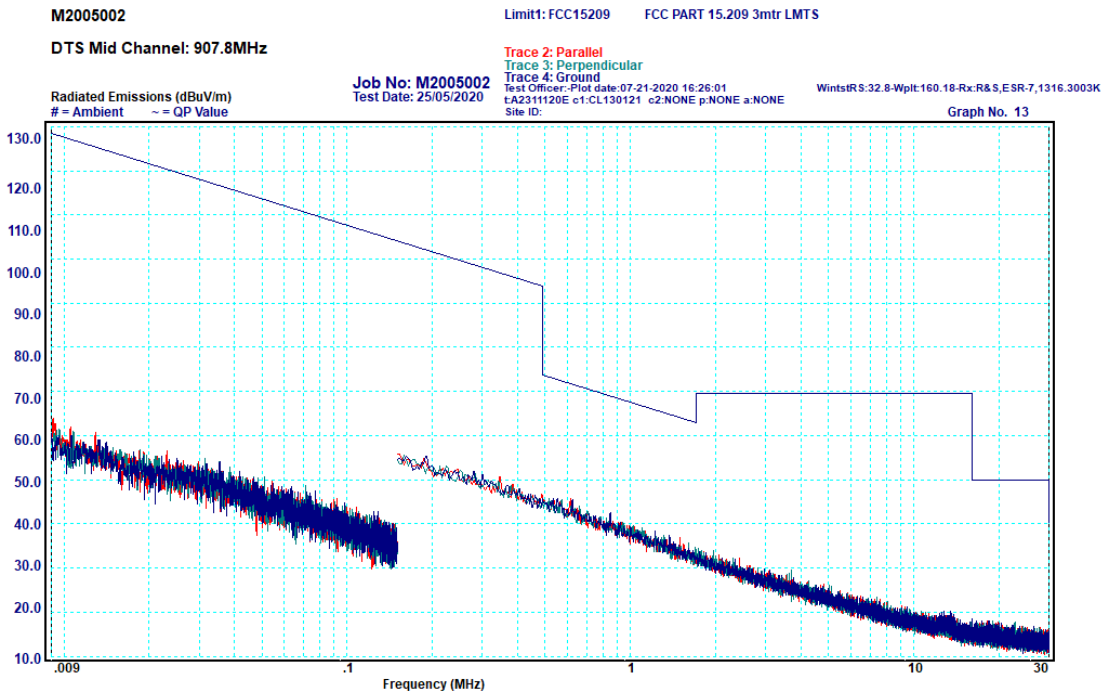
6.7.4 Transmitter Spurious Emissions: 9 kHz to 30 MHz

All emissions measured in the frequency band 9kHz - 30MHz complied with the requirements of the standard.



Graph 6-8: Transmitter Spurious Emissions, 9kHz – 30 MHz, 903 MHz

No peaks were measured within 10 dB of the limit.



Graph 6-9: Transmitter Spurious Emissions, 9kHz – 30 MHz, 907.8 MHz

No peaks were measured within 10 dB of the limit.

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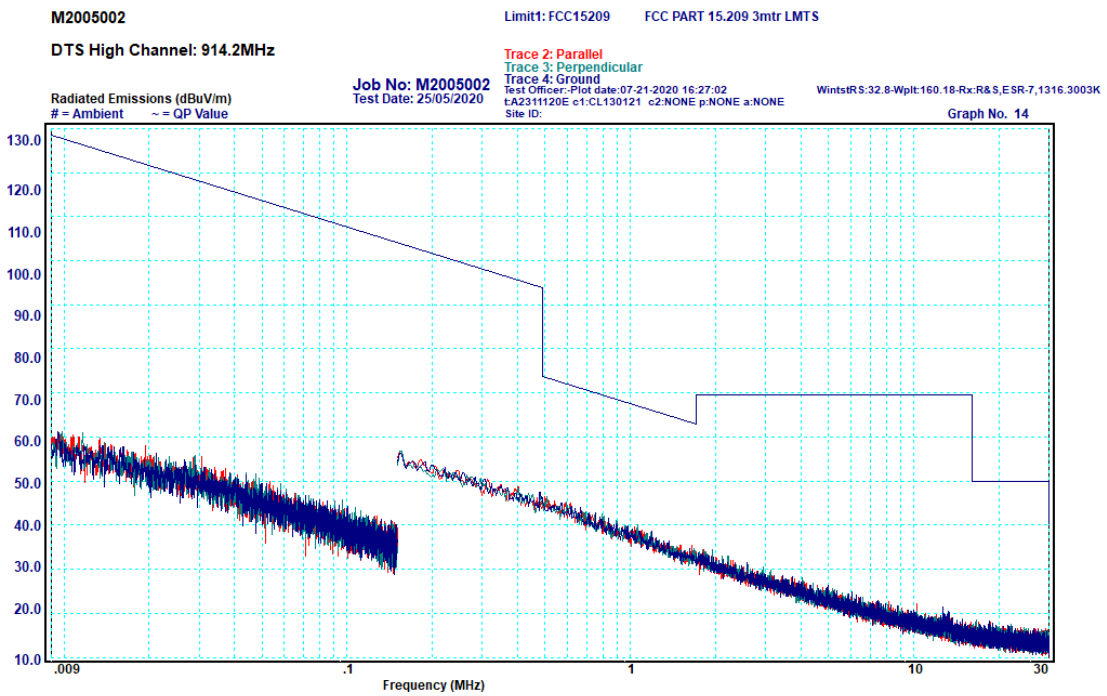

Graph 6-10: Transmitter Spurious Emissions, 9kHz – 30 MHz, 914.2 MHz

No peaks were measured within 10 dB of the limit.

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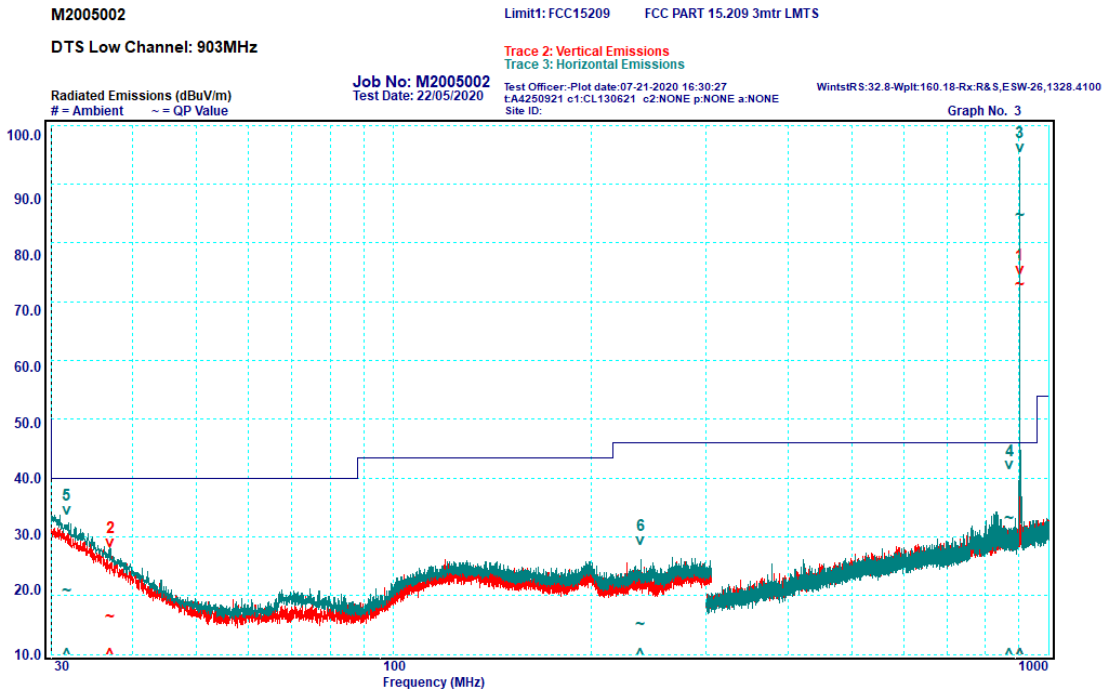
6.7.5 Transmitter Spurious Emissions: 30 - 1000 MHz

All emissions measured in the frequency band 30 – 1000 MHz complied with the requirements of the standard.



Graph 6-11: Transmitter Spurious Emissions, 30 – 1000 MHz, 903 MHz

Table 6-4: Transmitter Spurious Emissions, 30 – 1000 MHz, 903 MHz

Peak	Frequency [MHz]	Polarisation	Quasi Peak		
			Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]
1*	902.99	Vertical	N/A	N/A	N/A
2	37.02	Vertical	16.3	40	-23.7
3*	903	Horizontal	N/A	N/A	N/A
4	870.87	Horizontal	33.2	46	-12.8
5	31.71	Horizontal	20.8	40	-19.2
6	238.33	Horizontal	15.1	46	-30.9

*Peaks 1 and 3 are the fundamental transmissions and are not subject to the spurious emissions limit of the standard

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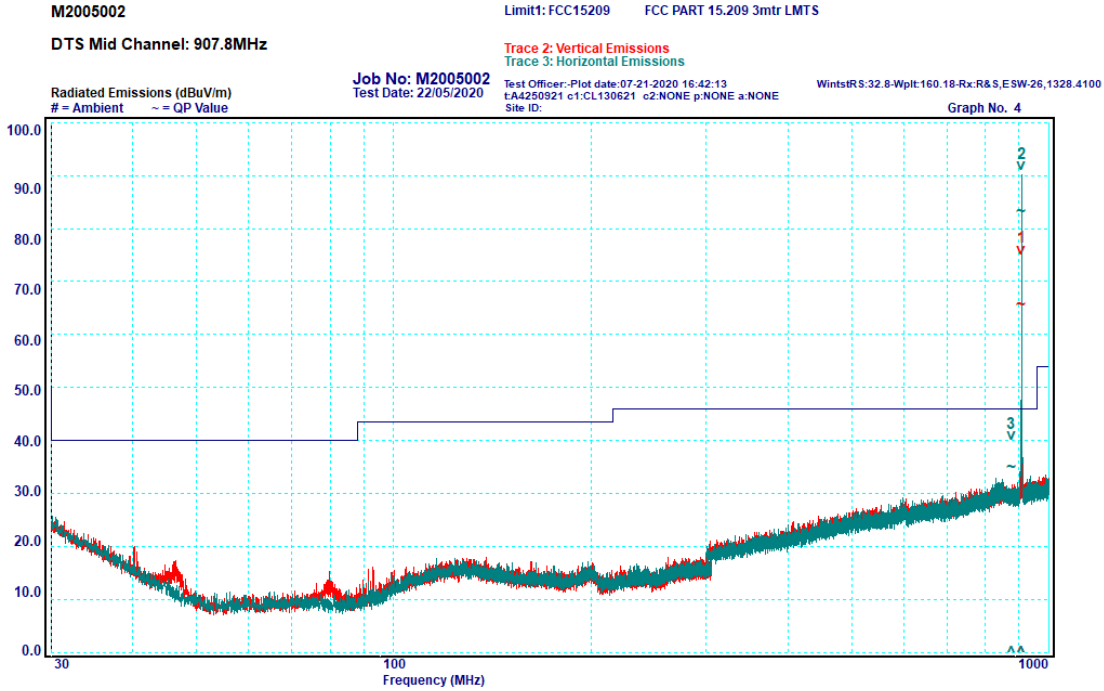

Graph 6-12: Transmitter Spurious Emissions, 30 – 1000 MHz, 907.8 MHz

Table 6-5: Transmitter Spurious Emissions, 30 – 1000 MHz, 907.8 MHz

Peak	Frequency [MHz]	Polarisation	Quasi Peak		
			Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]
1*	907.8	Vertical	N/A	N/A	N/A
2*	907.91	Horizontal	N/A	N/A	N/A
3	875.63	Horizontal	34.9	46	-11.1

*Peaks 1 and 2 are the fundamental transmissions and are not subject to the spurious emissions limit of the standard

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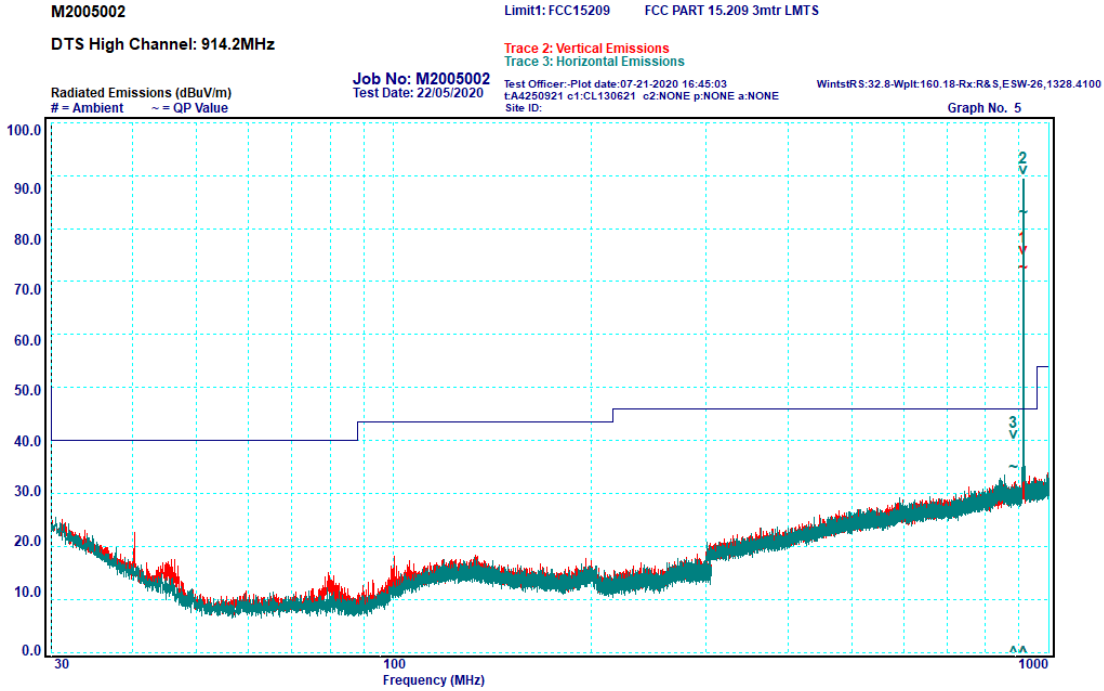

Graph 6-13: Transmitter Spurious Emissions, 30 – 1000 MHz, 914.2 MHz

Table 6-6: Transmitter Spurious Emissions, 30 – 1000 MHz, 914.2 MHz

Peak	Frequency [MHz]	Polarisation	Quasi Peak		
			Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]
1*	914.2	Vertical	N/A	N/A	N/A
2*	914.01	Horizontal	N/A	N/A	N/A
3	882.03	Horizontal	35	46	-11

*Peaks 1 and 2 are the fundamental transmissions and are not subject to the spurious emissions limit of the standard

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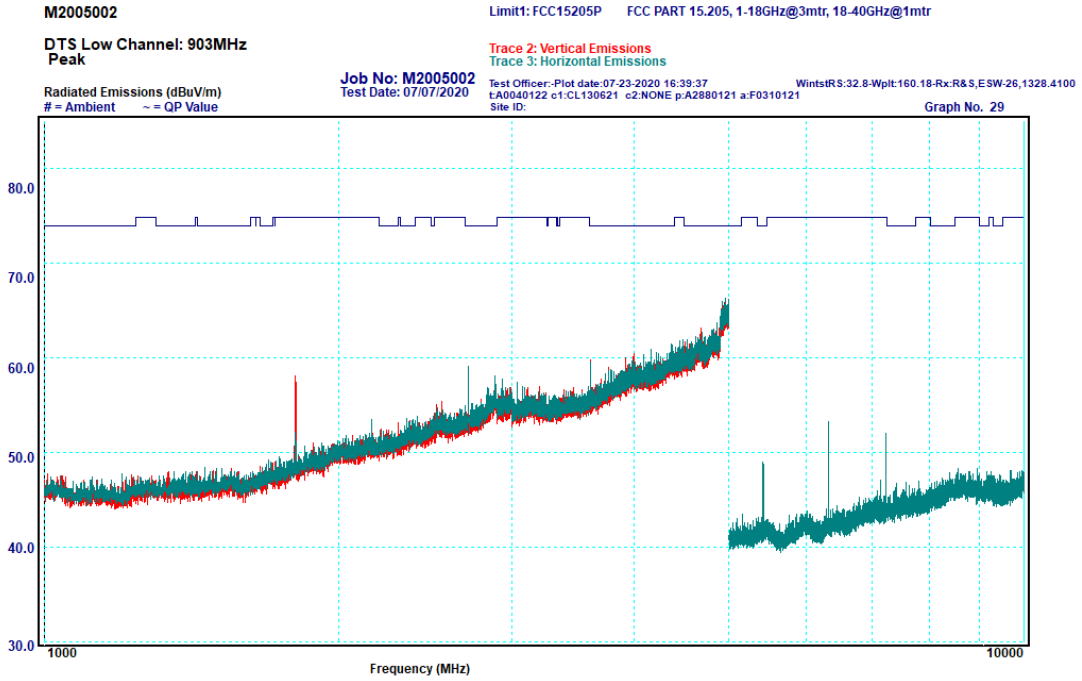
6.7.6 Transmitter Spurious Emissions: 1 - 10 GHz

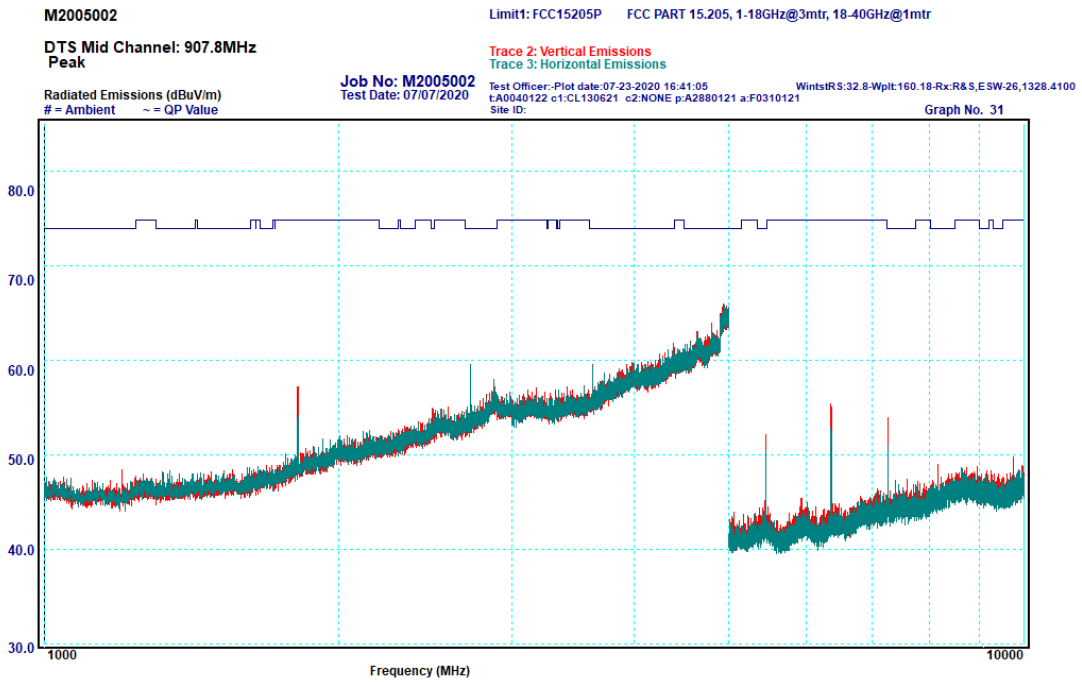
All emissions measured in the frequency band 1 – 10 GHz complied with the requirements of the standard.

Peak Measurements:



Graph 6-14: Transmitter Spurious Emissions, 1 – 10 GHz, 903 MHz, Peak

No peaks were measured within 10 dB of the limit.



Graph 6-15: Transmitter Spurious Emissions, 1 – 10 GHz, 907.8 MHz, Peak

No peaks were measured within 10 dB of the limit.

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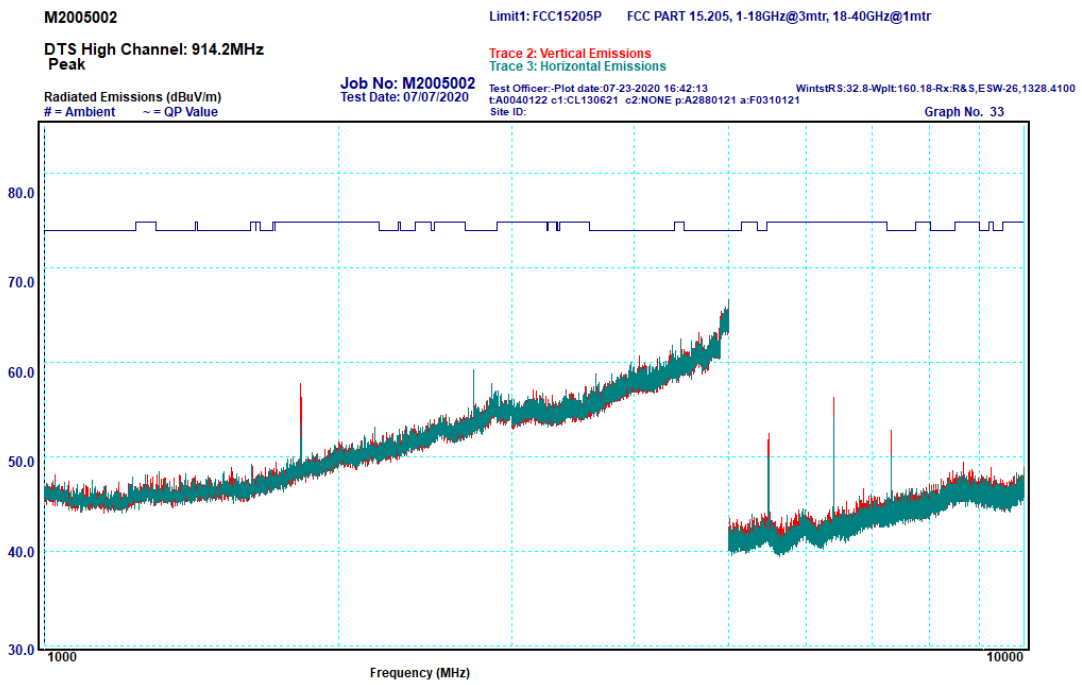

Graph 6-16: Transmitter Spurious Emissions, 1 – 10 GHz, 914.2 MHz, Peak

No peaks were measured within 10 dB of the limit.

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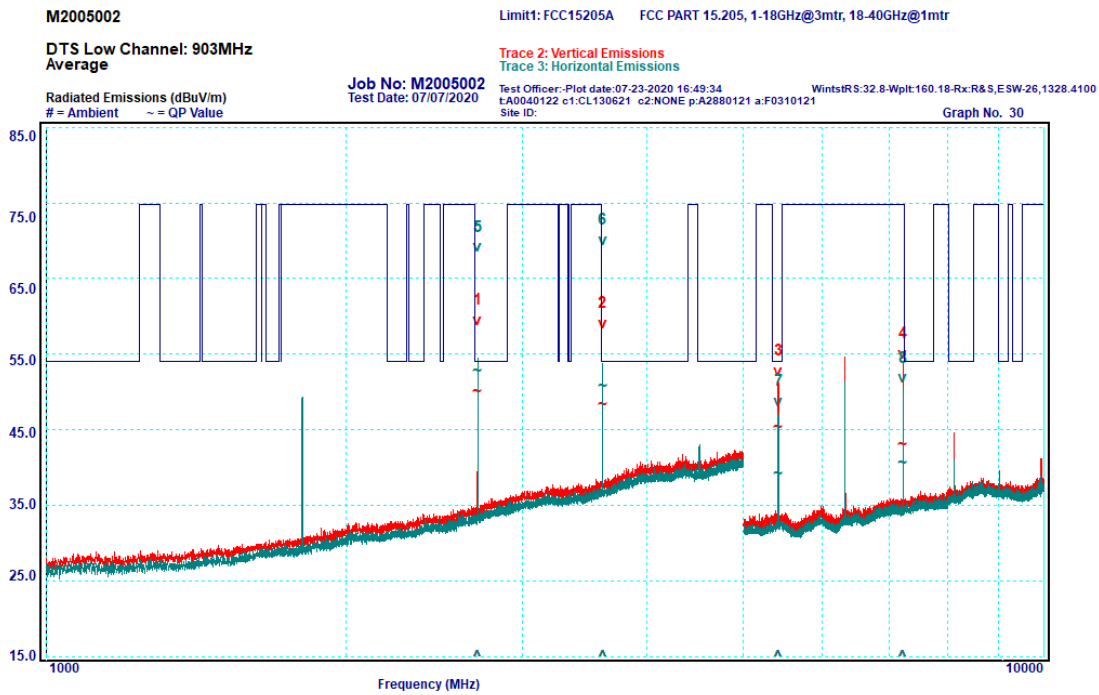
Average Measurements:



Graph 6-17: Transmitter Spurious Emissions, 1 – 10 GHz, 903 MHz, Average

Table 6-7: Transmitter Spurious Emissions, 1 – 10 GHz, 903 MHz, Average

Peak	Frequency [MHz]	Polarisation	Avg		
			Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]
1	2709.06	Vertical	50	54	-4
2	3612	Vertical	48.3	54	-5.7
3	5418	Vertical	45.3	54	-8.7
4	7223.74	Vertical	43	74.8	-31.8
5	2709.06	Horizontal	52.7	54	-1.3
6	3612.14	Horizontal	50.7	54	-3.3
7	5417.99	Horizontal	39.1	54	-14.9
8	7224.57	Horizontal	40.5	74.8	-34.3

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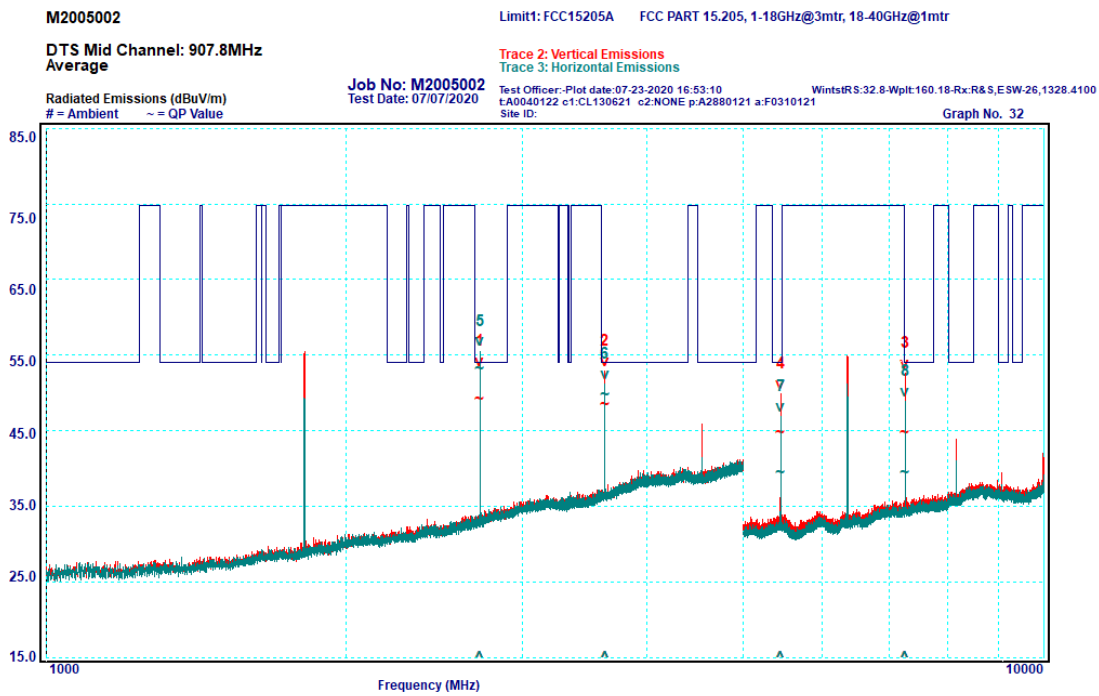

Graph 6-18: Transmitter Spurious Emissions, 1 – 10 GHz, 907.8 MHz, Average

Table 6-8: Transmitter Spurious Emissions, 1 – 10 GHz, 907.8 MHz, Average

Peak	Frequency [MHz]	Polarisation	Avg		
			Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]
1	2723.45	Vertical	49.2	54	-4.8
2	3631.1	Vertical	48.4	54	-5.6
3	7262.18	Vertical	44.7	54	-9.3
4	5446.82	Vertical	44.7	54	-9.3
5	2723.48	Horizontal	53.1	54	-0.9
6	3631.15	Horizontal	49.8	54	-4.2
7	5446.6	Horizontal	39.5	54	-14.5
8	7262.4	Horizontal	39.5	54	-14.5

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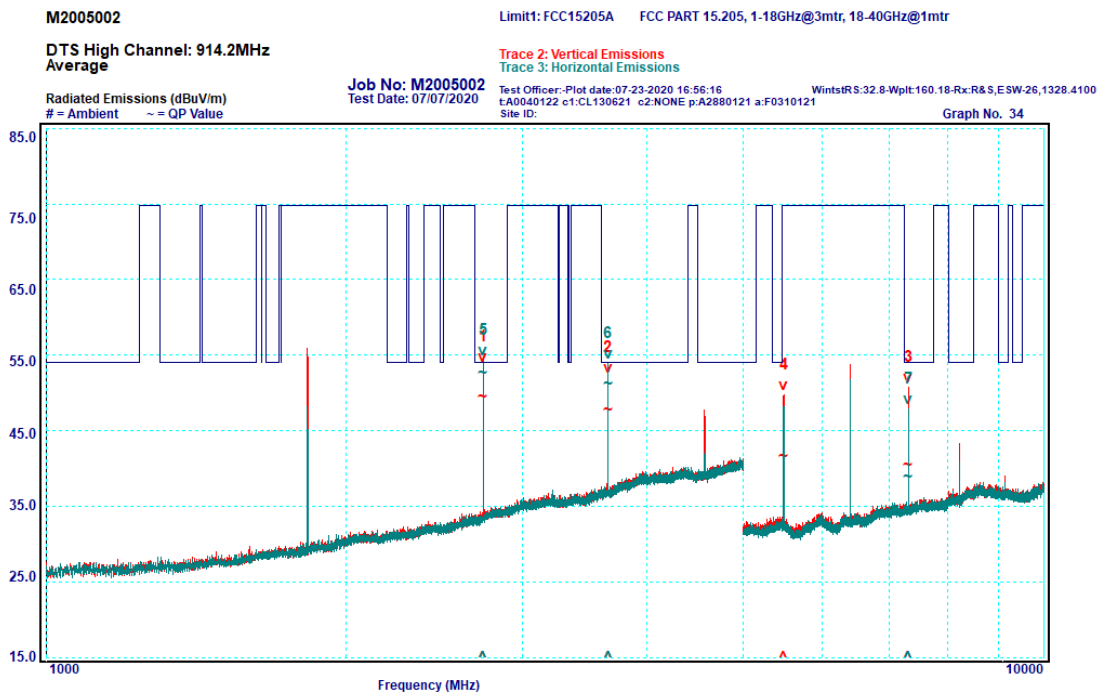

Graph 6-19: Transmitter Spurious Emissions, 1 – 10 GHz, 914.2 MHz, Average

Table 6-9: Transmitter Spurious Emissions, 1 – 10 GHz, 914.2 MHz, Average

Peak	Frequency [MHz]	Polarisation	Avg		
			Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]
1	2742.63	Vertical	49.5	54	-4.5
2	3656.88	Vertical	47.7	54	-6.3
3	7313.6	Vertical	40.5	54	-13.5
4	5485.3	Vertical	41.6	74.8	-33.2
5	2742.17	Horizontal	52.6	54	-1.4
6	3656.88	Horizontal	51.2	54	-2.8
7	7313.66	Horizontal	38.8	54	-15.2

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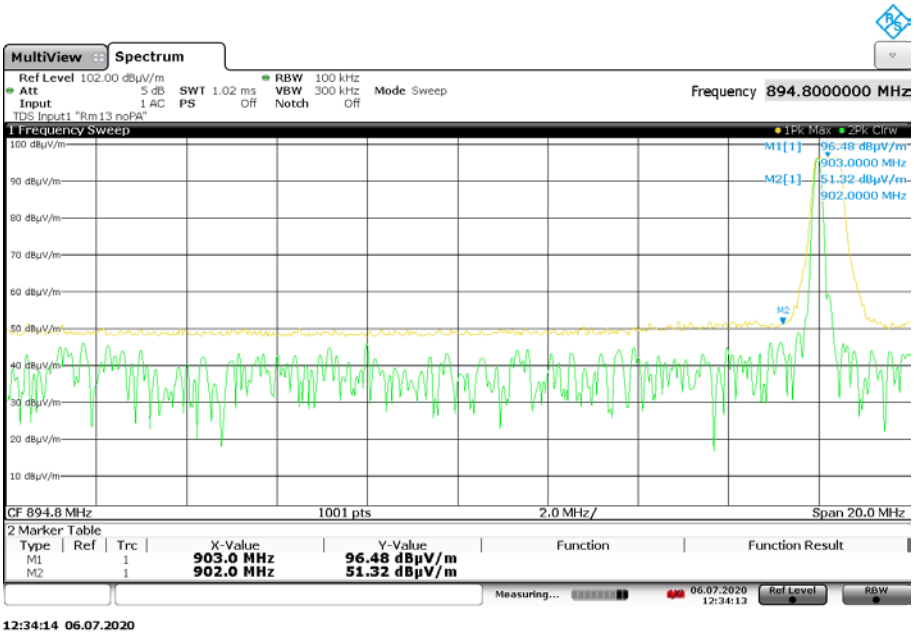
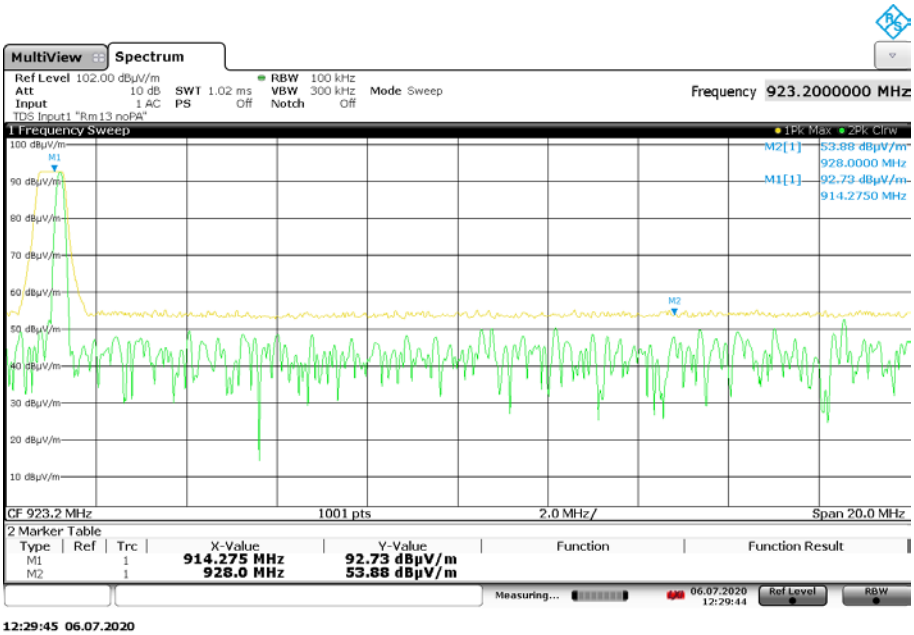
6.8 §15.247(d)/ §RSS-247 5.5 – Band Edge Emission Measurements

Band-edge measurements were done using radiated in accordance to ANSI C63.10 clause 11.13.1. All emissions measured near the lower and higher band edge complied with the requirements of §15.247/ RSS-247 5.0. There were no restricted Band-edges.



Graph 6-20: Lower Band edge (Authorised-band), 903 MHz, Peak



Graph 6-21: Upper Band edge (Authorised-band), 914.2 MHz, Peak

Table 6-10: Band edge Measurement

Measurement Type	Freq [MHz]	Measurement [dBuV/m]	Limit [dBuV/m]	Result
Peak	902	51.32	74.80	Complied
Peak	928	53.88	74.80	Complied

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6.9 §15.247(e)/ RSS-247 5.2(b) – Power Spectral Density

6.9.1 Test procedure

The tests were performed in accordance with ANSI C63.10: 2013 Clause 11.10 Maximum power spectral density level in the fundamental emissions.

Power spectral density measurements were made at 3 metres. The measurement resolution bandwidth was 3 kHz. The orientation of the EUT and the measurement antenna height and polarisation that produced the highest EIRP was used.

Power spectral density measurements were done at radiated method. The measurement resolution bandwidth was 3 kHz.

6.9.2 Limits

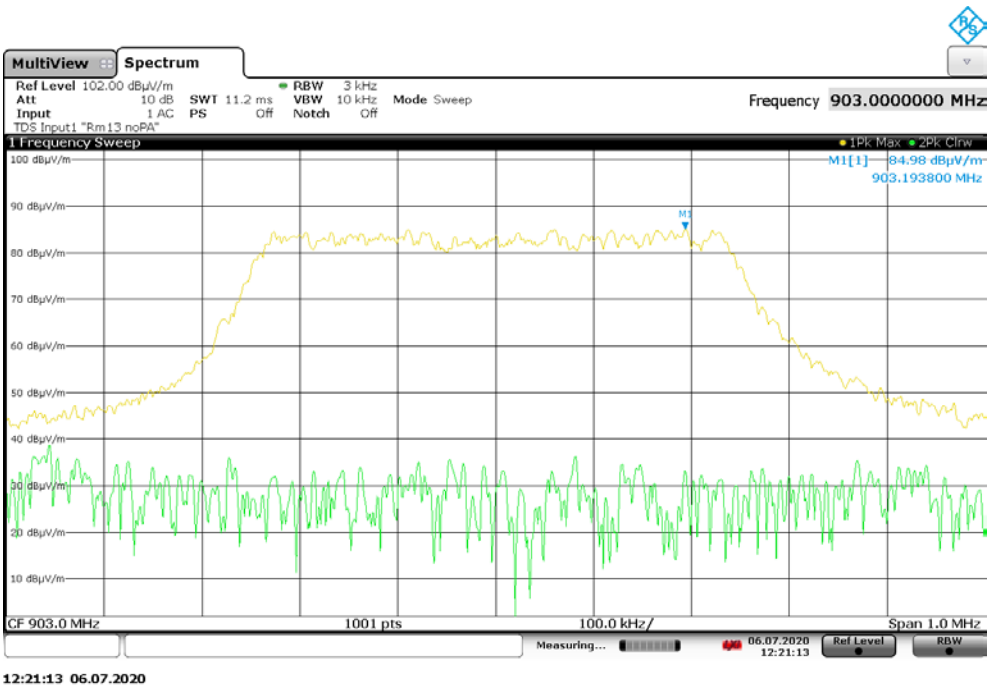
The maximum conducted power spectral density (PSD) is 8 dBm per 3 kHz.

6.9.3 Results

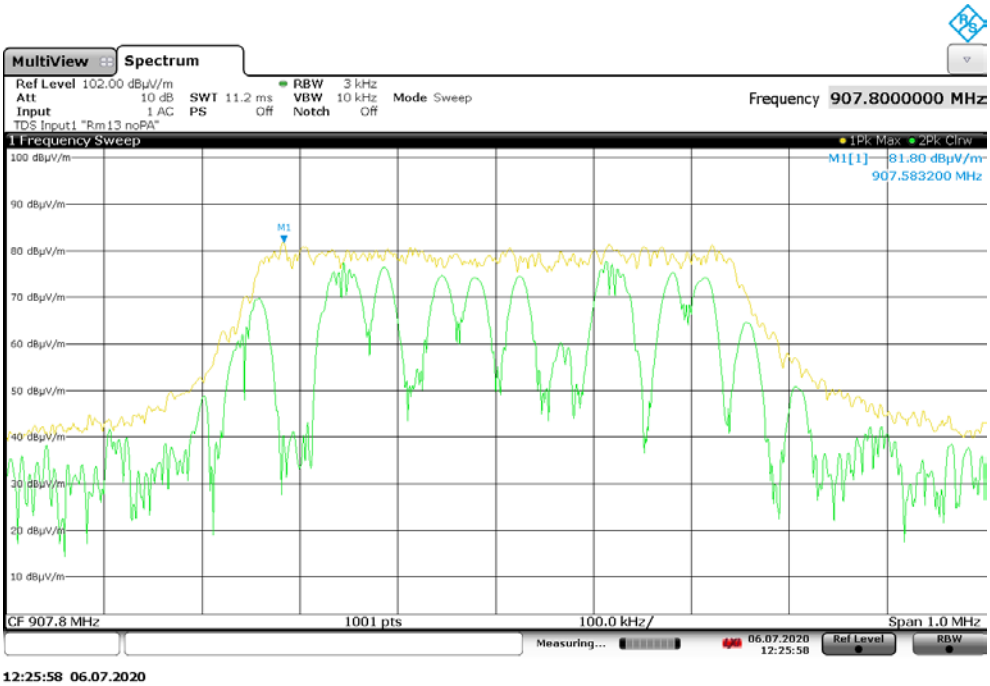
The measured radiated field strength is converted to equivalent conducted output power spectral density for checking compliance (KDB 558074 D01 Section 3).

Table 6-11: Power spectral density

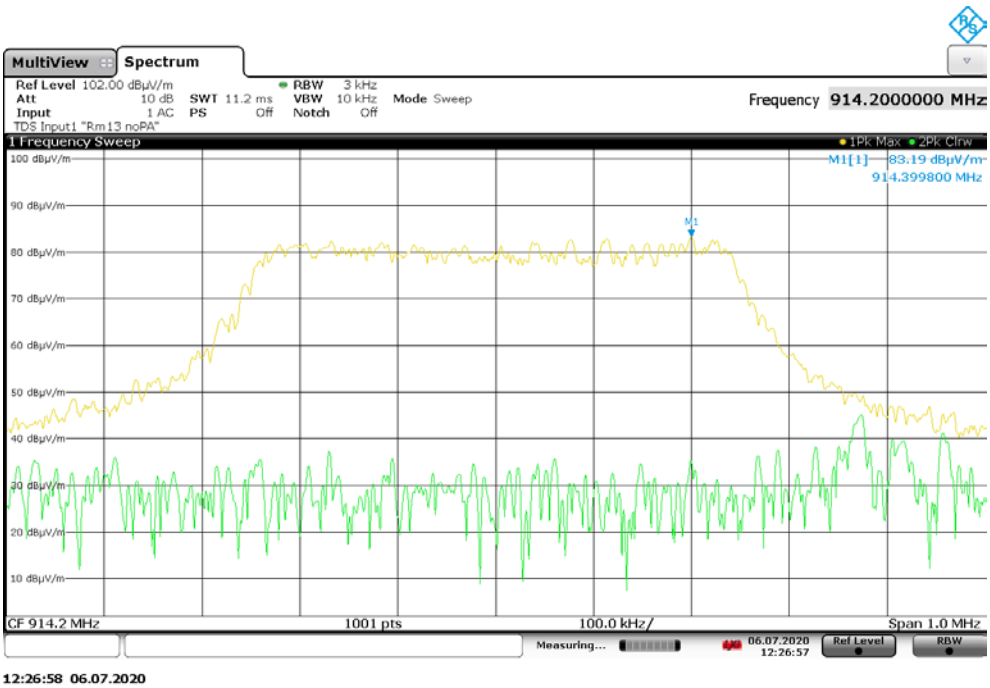
Freq. [MHz]	E-Field@ 3 m		Antenna Gain (dBi)	Equivalent Conducted Output PSD (dBm)	Limit (dBm)	Results
	dBuV/m	dBm				
903	84.98	-10.25	0.8	-11.05	8	Complied
907.8	81.80	-13.43	0.8	-14.23	8	Complied
914.2	83.19	-12.04	0.8	-12.84	8	Complied



Graph 6-22: Radiated Power Spectral Density, 903 MHz



Graph 6-23: Radiated Power Spectral Density, 907.8 MHz



Graph 6-24: Radiated Power Spectral Density, 914.2 MHz

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6.10 §15.247(i)/ §RSS-Gen 3.4/§RSS-102 – Maximum Permissible Exposure

The EUT complied with the applicable maximum permissible exposure levels. Refer to EMC Technologies report M2005002-8 (RSS-102 report) and M2005002-9 (FCC 2.1091 report).

6.11 §15.215/ §RSS-Gen 6.7 Occupied Bandwidth – 99% power

6.11.1Test procedure

The bandwidth containing 99% power of the transmitted signal was measured using the procedure from ANSI C63.10 section 6.9.

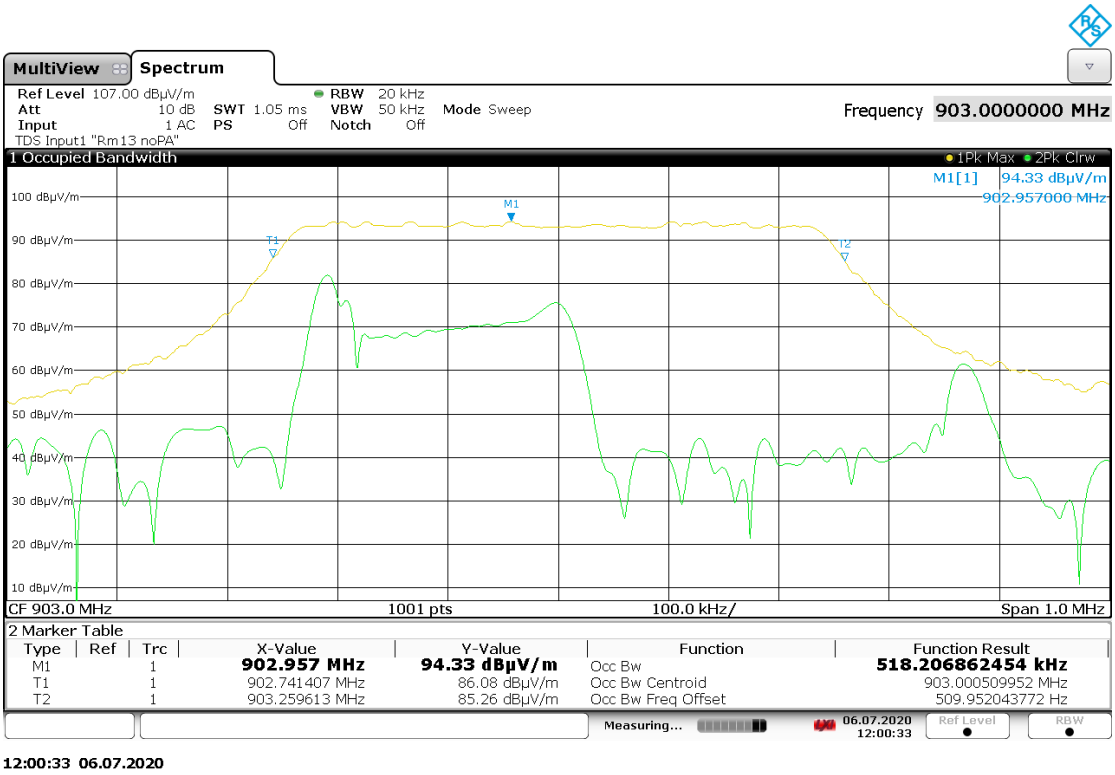
6.11.2 Limits

The 99% power should be contained within the frequency band 902 - 928 MHz.

6.11.3 Results

Table 6-12: Occupied Bandwidth

Freq. [MHz]	99% Bandwidth [kHz]	Low Frequency [MHz]	High Frequency [MHz]	Result
903	518.2	902.74	903.25	Complied
907.8	518.6	907.54	908.05	Complied
914.2	518.8	913.94	914.45	Complied



Graph 6-25: Occupied bandwidth, 903 MHz

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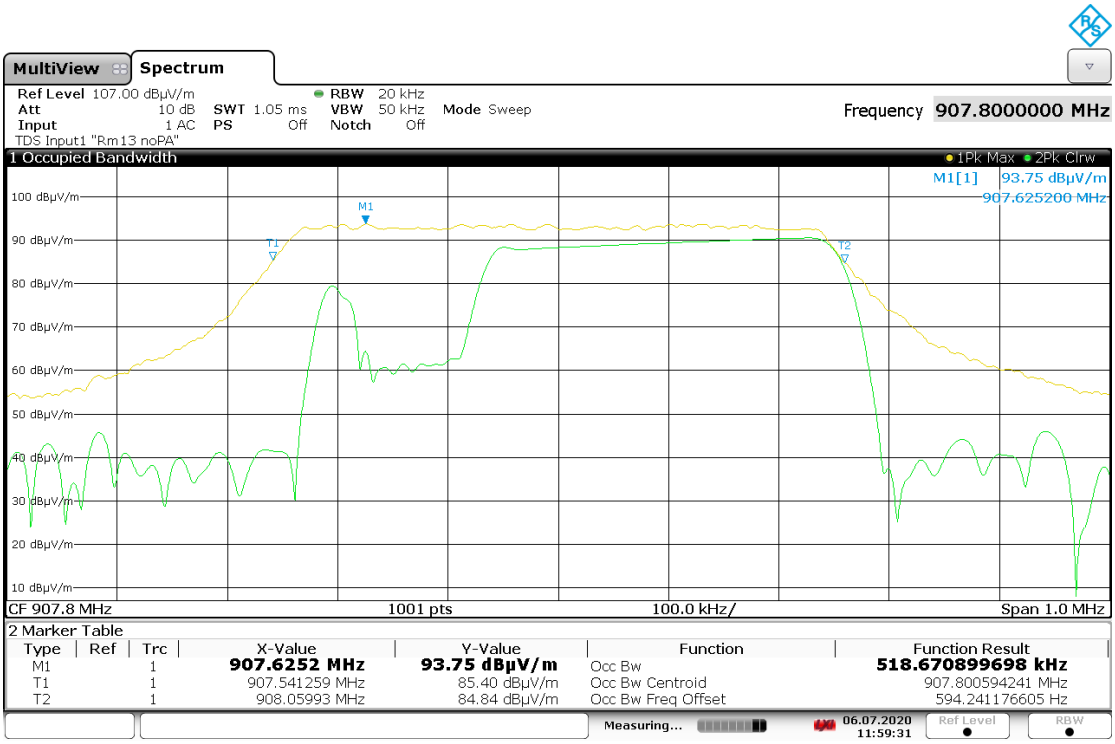
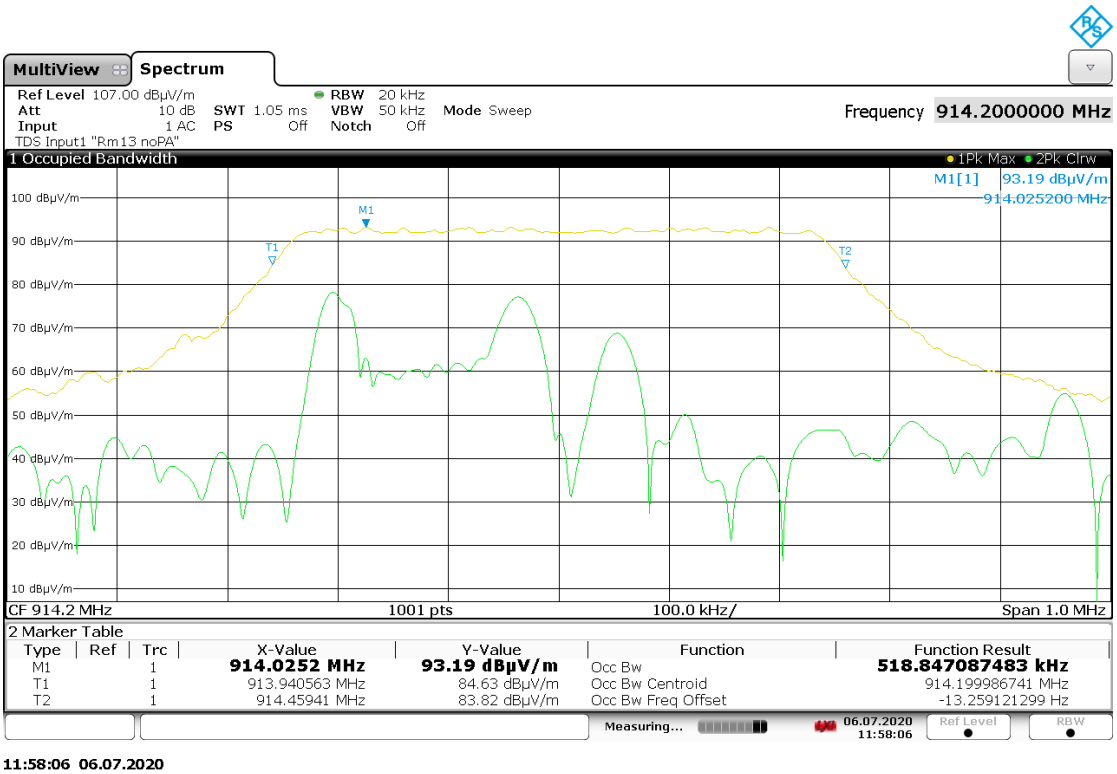


Graph 6-26: Occupied bandwidth, 907.8 MHz



Graph 6-27: Occupied bandwidth, 914.2 MHz

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