DEKRA Testing and Certification, S.A.U.
Parque Tecnológico de Andalucía,
c/ Severo Ochoa nº 2 · 29590 Campanillas · Málaga · España
C.I.F. A29 507 456

Test report No:
NIE: 69323RRF.004

Partial Test report

USA FCC Part 15.31(h), Part 22, Part 24, Part 27, Part 15.209, Part 15.247, Part 15.407
CANADA RSS-130, RSS-132, RSS-133, RSS-139, RSS-247, RSS-Gen

(*) Identification of item tested	TCAM: Telematics and Connectivity Antenna Module
(*) Trademark	Continental
(*) Model and /or type reference	TCAM1NA2
Other identification of the product	HW version: E4.4 SW version: 11.16.11 FCC ID: KR5TCAM1NA2 IC: 7812D-TCAM1NA2
(*) Features	2G, 3G, LTE, GNSS, WLAN, BLE, ISM Receiver
Applicant	Continental Automotive GmbH Siemensstrasse 12 93055 Regensburg, Germany
Test method requested, standard	USA FCC Part 15.31(h) (10-1-20 Edition): Measurement standard. USA FCC Part 24 (10-1-20 Edition): Personal Communications Services. USA FCC Part 27 (10-1-20 Edition): Miscellaneous Wireless Communications Services. USA FCC Part 15.209 (10-1-20 Edition): Radiated emission limits; general requirements. USA FCC Part 15.247 (10-1-20 Edition): Operation within the bands 902 - 928 MHz, 2400 -2483.5 MHz, and 5725 - 5850 MHz. USA FCC Part 15.407 (10-1-20 Edition): General technical requirements. CANADA RSS-130 Issue 2, Feb. 2019. CANADA RSS-133 Issue 6 Amendment 1, Jan. 2018. CANADA RSS-199 Issue 3, December 2016. CANADA RSS-Gen Issue 5 (April 2018). CANADA RSS-247 Issue 2 (February 2017). -Transmitter out of band radiated emissions with simultaneous transmissions. Guidance for Performing Compliance Measurements on Digital Transmission System, Frequency Hopping

	Spread Spectrum System, and Hybrid Systems Devices Operating Under Section 15.247 of the FCC Rules. 558074 D01 Meas Guidance v05r02 dated April 2, 2019. KDB 971168 D01 Power Meas License Digital Systems v03r01, April. 2018. ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices. ANSI C63.26-2015.
Approved by (name / position & signature)	Rafael López EMC Consumer & RF Lab. Manager  2021.11.04 13:42:46 +01'00'
Date of issue	2021-11-04
Report template No	FDT08_23 (*) "Data provided by the client"

Index

Competences and guarantees

DEKRA Testing and Certification S.A.U. is a testing laboratory accredited by the National Accreditation Body (ENAC -Entidad Nacional de Acreditación), to perform the tests indicated in the Certificate No. 51/LE 147.

DEKRA Testing and Certification is a FCC-recognized accredited testing laboratory with appropriate scope of accreditation that include testing performed in this test report.

DEKRA Testing and Certification is an ISED-recognized accredited testing laboratory with appropriate scope of accreditation that include testing performed in this test report.

In order to assure the traceability to other national and international laboratories, DEKRA Testing and Certification S.A.U. has a calibration and maintenance program for its measurement equipment.

DEKRA Testing and Certification S.A.U. guarantees the reliability of the data presented in this report, which is the result of the measurements and the tests performed to the item under test on the date and under the conditions stated on the report and, it is based on the knowledge and technical facilities available at DEKRA Testing and Certification S.A.U. at the time of performance of the test.

DEKRA Testing and Certification S.A.U. is liable to the client for the maintenance of the confidentiality of all information related to the item under test and the results of the test.

The results presented in this Test Report apply only to the particular item under test established in this document.

General conditions

1. This report is only referred to the item that has undergone the test.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
3. This document is only valid if complete; no partial reproduction can be made without previous written permission of DEKRA Testing and Certification S.A.U.
4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of DEKRA Testing and Certification S.A.U. and the Accreditation Bodies.

Uncertainty

Uncertainty (factor k=2) was calculated according to the DEKRA Testing and Certification S.A.U. internal document PODT000.

Data provided by the client

The following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item tested", "Trademark", "Model and/or type reference tested").
2. The sample of the TCAM model TCAM1NA2 is a vehicle antenna module for telematic and connectivity purposes.

   It consists of a fin antenna with integrated telematics transceivers for different wireless services as well as several interfaces to the vehicle.

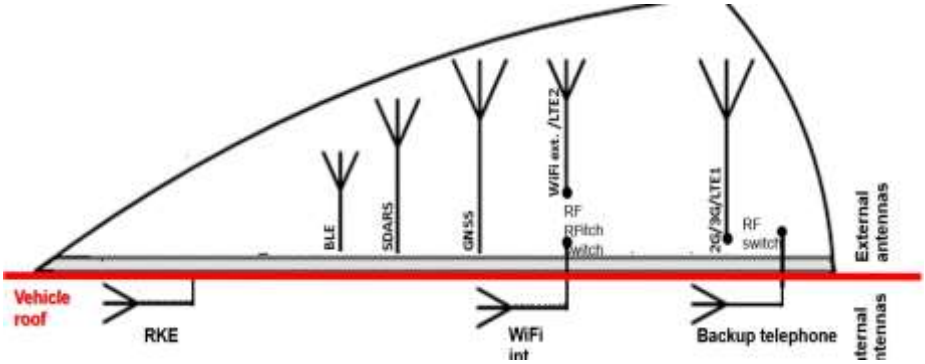
The TCAM1NA2 main parts are:

Antennas for cellular, WLAN, BLE, ISM receiver (RKE), SDARS with LNA
GNSS with LNA for Navigation: Beidou, Galileo, GPS, Glonass
Antenna selection via RF switches
TCAM internal antennas (all are TCAM internal, no extern antenna connections):
Tel1 ant: 2G, 3G, 4G/LTE1 (vehicle outside)
Tel2 ant: LTE2 (Rx only) (vehicle outside)
MIMO with LTE1- and LTE2-antenna. LTE2 is Rx only
Backup telephone antenna: 2G, 3G, 4G/LTE (vehicle inside)
Wi-Fi internal antenna (vehicle inside)
Wi-Fi external antenna (vehicle outside)
BLE antenna (vehicle outside)
Stacked patch antenna featuring GNSS
ISM receiver antenna
SDARS antenna

CAT4 NAD with 2G/3G/4G/LTE and GNSS, FCC certified
VoLTE
ISM receiver module (434MHz) for: RKE (Remote Keyless Entry), PASE (Passive Start and Entry, TPMS (Tire Pressure Monitoring System), FCC tested
Wi-Fi chip
BLE chip
1st internal embedded Sim-IC
Service calls

External interfaces:

Main power supply
External backup battery
External SIM card slot (2nd private customer SIM, optional)
External microphone in the OHC (Overhead Compartment)
A2B
External backup speaker
BroadR-Reach
CEM connection (K-Line)
Infotainment CAN
Airbag input
Debug interfaces (USB, UART)



DEKRA Testing and Certification S.A.U. declines any responsibility with respect to the information provided by the client and that may affect the validity of results.

Usage of samples

Samples undergoing test have been selected by: The client.

- Sample S/01 is composed of the following elements:

Control Nº	Description	Model	Serial Nº	Date of reception
69323/013	Telematics and Connectivity Antenna Module	TCAM1NA2	00076329	2021/07/14
59830B/140	Harness	--	--	2021/02/04

Sample S/01 has undergone the following test(s): All radiated tests indicated in Appendix A and B.

Test sample description

Ports…… :	Port name and description	Cable					
		Specified max length [m]	Attached during test	Shielded	Coupled to patient(3)		
	USB diagnostic	~3m	☐	☐	☐		
	UART diagnostic	~3m	☐	☐	☐		
	BRR diagnostic	~3m	☐	☐	☐		
	---		☐	☐	☐		
Supplementary information to the ports…… :	---						
Rated power supply .....:	Voltage and Frequency		Reference poles				
			L1	L2	L3	N	PE
	☐	AC:	☐	☐	☐	☐	☐
	☒	DC: 12V					
Rated Power .....:	4.2 W dc (cellular, Wi-Fi, BLE, GNSS active)						
Clock frequencies.....:	32.768kHz, 16MHz, 19.2MHz, 24MHz, 25MHz, 27.6MHz, 48MHz						
Other parameters .....:	Operating temperature Range: -10°C to 55°C Supply Voltage Range: 8 V to 16 V DC						
Software version .....:	11.16.11						
Hardware version .....:	E4.4						
Dimensions in cm (W x H x D) ....:	10.5cm x 15.5cm x 9cm						
Mounting position .....:	☐	Table top equipment					
	☐	Wall/Ceiling mounted equipment					
	☐	Floor standing equipment					
	☐	Hand-held equipment					
	☒	Other: Vehicular environment equipment					
Modules/parts.....:	Module/parts of test item		Type		Manufacturer		
	Network Access Device (NAD), (cellular, GNSS)		Model: BL28NA		Continental Automotive Systems		
	ISM/RKE 434 MHz RF receiver module		Model: A2C382		Continental Automotive Systems		
	--						

Accessories (not part of the test item) .....:	Description	Type	Manufacturer
	1-2 x test harnesses with USB 1 x test harness without USB (if necessary)		Continental
	Laptop (if necessary)	Elite Book	HP
	BLE eval board (if necessary)		TI
	Load boxes (if necessary)	Multiple	Multiple
	--		
Documents as provided by the applicant .....:	Description	File name	Issue date
	RF guide	21cw12_TCAM_Country_RF_Manual	
	Functional Guide	User Guide for Functional Testing on Component Level 2	
	Additional Guides (if necessary)	multiple	
	--		

Identification of the client

Continental Automotive GmbH

Siemensstrasse 12, 93055 Regensburg, Germany

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2021-09-07
Date (finish)	2021-09-09

Document history

Report number	Date	Description
69323RRF.004	2021-11-04	First release.

Environmental conditions

In the control chamber, the following limits were not exceeded during the test:

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %

In the semianechoic chamber, the following limits were not exceeded during the test.

Temperature	Min. = 15 ºC Max. = 35 ºC
Relative humidity	Min. = 20 % Max. = 75 %

Remarks and comments

The tests have been performed by the technical personnel: Nicolás Salguero and Miguel Manuel López.

Used instrumentation:

Radiated Measurements

		Last Calibration	Due Calibration
1.	Semianechoic Absorber Lined Chamber ETS LINDGREN FACT 3 200 STP	N.A.	N.A.
2.	Shielded Room ETS LINDGREN S101	N.A.	N.A.
3.	EMI Test Receiver, 9kHz - 7 GHz, ROHDE AND SCHWARZ ESR7	2020/12	2022/12
4.	Biconical/Log Antenna 30MHz - 6GHz ETS LINDGREN 3142E	2020/04	2023/04
5.	Signal and Spectrum Analyzer, 2Hz-50GHz, ROHDE AND SCHWARZ FSW50	2020/07	2022/07
6.	RF Pre-amplifier G>40dB, 10MHz-6GHz BONN ELEKTRONIK BLNA 0160-01N	2021/03	2022/03
7.	RF Pre-amplifier G>40dB, 1-18GHz BONN ELEKTRONIK BLMA 0118-1M	2021/06	2022/06
8.	RF Pre-amplifier G>30dB, 18 - 40 GHz BONN ELEKTRONIK BLMA 1840-3G	2019/11	2021/11
9.	Horn antenna 1-18 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9120 D	2019/11	2022/11
10.	Broadband Horn Antenna 18 - 40 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9170	2020/05	2023/05
11.	DC Power Supply 30V/5A KEYSIGHT TECHNOLOGIES U8002A	N/A	N/A
12.	Digital Multimeter FLUKE 175	2020/11	2021/11

Testing verdicts

Not applicable:	N/A
Pass:	P
Fail:	F
Not measured :	N/M

Summary

FCC PART 15 / FCC PART 24 / FCC PART 27 / RSS-247 / RSS-130 / RSS-133 / RSS-199 / RSS-Gen PARAGRAPH		
Requirement – Test case	**Verdict**	**Remark**
FCC 15.31(h), FCC 15.209 (a), FCC 15.247 (d), FCC 15.407 / RSS-Gen 8.9, RSS-247 5.5. FCC 24.238 / RSS-133 6.5 FCC 27.53 / RSS-199 4.5 / RSS-130 4.7 Emission limitations radiated (Transmitter)	P	(1)
Supplementary information and remarks: (1) Only Co-location radiated spurious emission test was requested.		

Appendix A: Test results FCC Part 24 / RSS-133

INDEX

TEST CONDITIONS

POWER SUPPLY (V):

V nonimal: 12 Vdc

Type of Power Supply: External power supply (Car Battery).

ANTENNA:

Type of Antennas: Internal.

Maximum Declared Gain for Bluetooth LE: +2.1 dBi

Maximum Declared Gain for WLAN 2.4 GHz: +0.3 dBi (WI-FI external Antenna)

Maximum Declared Gain for WLAN 5 GHz U-NII-3: -1.9 dBi (WI-FI internal Antenna)

Maximum Declared Gain for CELLULAR:

LOW Bands	GAIN	ANTENNA TYPE
2G Band 1900 MHz	+2.7 dBi	Internal (3D)

TEST FREQUENCIES:

	CELLULAR 2G	
Band:	PCS-1900	
Frequency Range:	1850 – 1910 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Mid: 661	1880

	WLAN (IEEE 802.11 n/ac) / U-NII	
Mode:	802.11 a20: MCS0	
Frequency Range:	5725 MHz to 5850 MHz (U-NII-3)	
Channel Spacing:	20 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Highest: 149	5745

	WLAN (IEEE 802.11 bgn2040) / Digital Transmission System (DTS)	
Mode:	802.11 n20: MCS0- MCS7 (SISO)	
Channel Spacing:	20 MHz	
Frequency Range:	2412 MHz to 2472 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	11	2462

	Bluetooth LE
Mode:	GFSK
Channel Spacing:	1 MHz
Frequency Range:	2400 MHz to 2483.5 MHz
Transmit Channel:	Advertising mode

The test set-up was made in accordance to the general provisions of FCC DTS Measurement 558074 D01 DTS Meas Guidance v05r02 dated April 2, 2019.

The EUT was tested in the following operating mode:

- Continuous transmission with a modulated carrier at maximum power in all required channels selecting the supported data rates/modulations types.

During transmitter test the EUT was being controlled by the SW tool to operate in a continuous transmit mode on the test channel as required and in each of the different modulation modes.

The following configurations were selected based on preliminary testing that identified those corresponding to the worst cases:

Transmission modes selected with each radio:

* CELLULAR 2G: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in PCS-1900 band configuration as this channel was found to transmit higher EIRP than all the other 2G channels.

* WLAN 5 GHz: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in 802.11 a20 / 6Mbps mode configuration as this mode was found to transmit higher EIRP than all the other 5 GHz WLAN modes.

* WLAN 2.4 GHz: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in 802.11 n20 / MCS0 mode configuration as this mode was found to transmit higher EIRP than all the other 2.4 GHz WLAN modes.

* BLUETOOTH: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in Bluetooth Low Energy (GFSK) advertising mode.

Simultaneous transmission modes selected:

1. CELLULAR 2G, WLAN 2.4 GHz, BLUETOOTH Co-Location, with the EUT configured to simultaneously transmit three signals at maximum output power, CELLULAR 2G in PCS-1900, WLAN 2.4GHz in 802.11 n20 / MCS0, Bluetooth Low Energy / GFSK.

2. CELLULAR 2G, WLAN 5 GHz, BLUETOOTH Co-Location, with the EUT configured to simultaneously transmit three signals at maximum output power, CELLULAR 2G in PCS-1900, WLAN 5GHz (U-NII-3) in 802.11 a20 / 6 Mbps, Bluetooth Low Energy / GFSK.

Radiated emissions

SPECIFICATION:

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c) / RSS-Gen):

Frequency Range (MHz)	Field strength (µV/m)	Field strength (dBµV/m)	Measurement distance (m)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	30
1.705 - 30.0	30	-	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
960 - 25000	500	54	3

The emission limits shown in the above table are based on measurements employing CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

For average radiated emission measurements above 1000 MHz, there is also a limit corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

1. 2G PCS-1900. FCC §2.1053 & §24.238 / RSS-133 Clause 6.5.

FCC §24.238:

> (a) Out of band emissions. The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10 log(P) dB.

RSS-133 Clause 6.5:

> i. In the 1.0 MHz bands immediately outside and adjacent to the equipment's operating frequency block, the emission power per any 1% of the emission bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 log10p(watts).
>
> ii. After the first 1.0 MHz, the emission power in any 1 MHz bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 log10p(watts). If the measurement is performed using 1% of the emission bandwidth, power integration over 1.0 MHz is required.

METHOD:

The measurement was performed with the EUT inside an anechoic chamber.

The spectrum was scanned from 9 kHz to at least the 10th harmonic of the highest frequency of the co-located radios till 26 GHz.

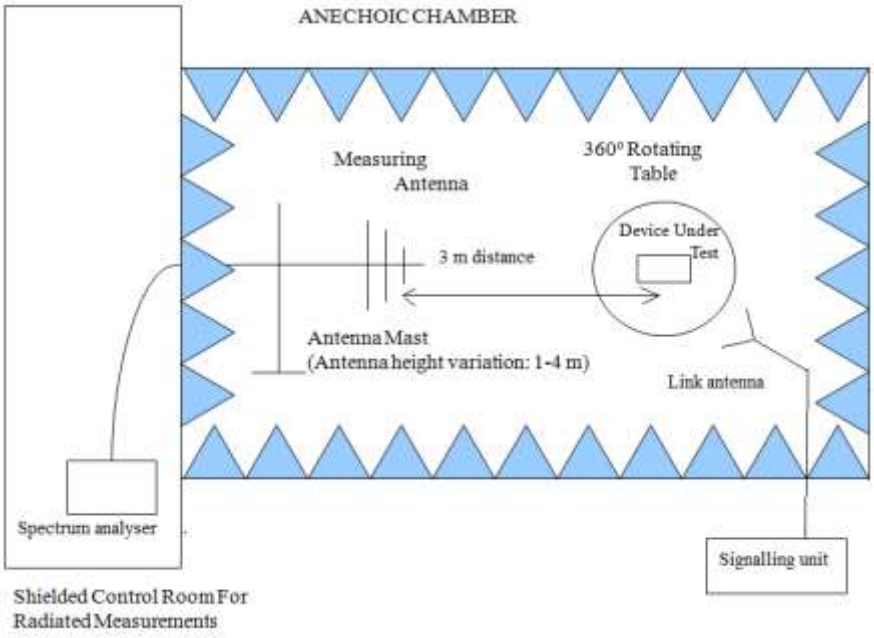
The EUT was placed on a non-conductive stand at a 3 meter distance from the measuring antenna.
Detected emissions were maximized at each frequency by rotating the EUT and adjusting the measuring antenna height and polarization. The maximum meter reading was recorded.

The field strength is calculated by adding correction factor to the measured level from the spectrum analyzer. This correction factor includes antenna factor, cable loss and pre-amplifiers gain.

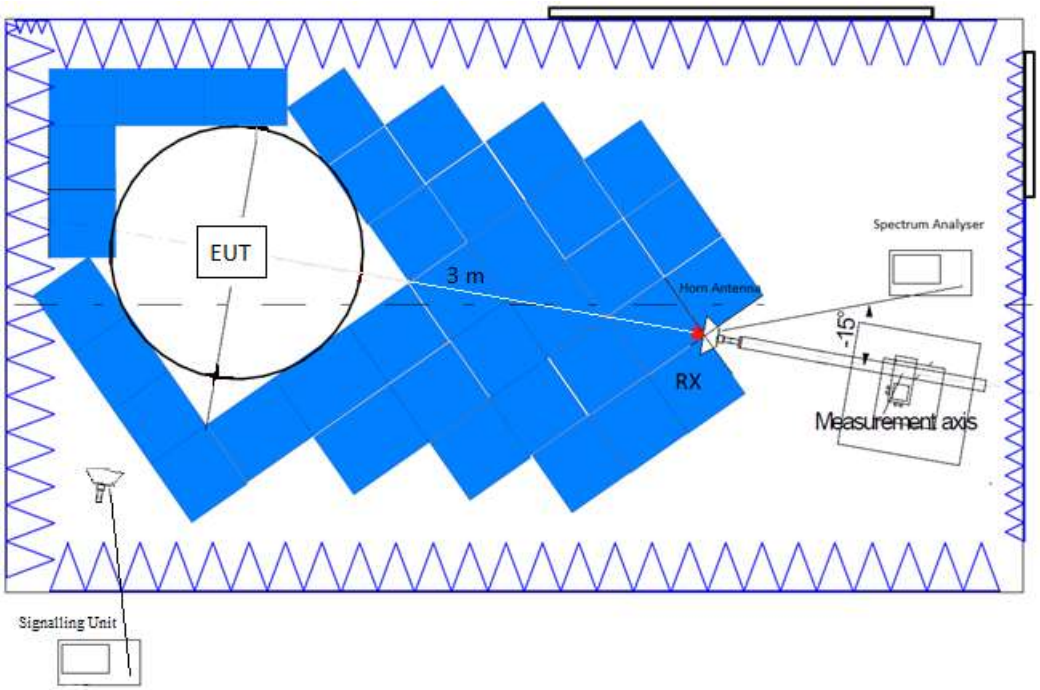
These measurements have been performed in order to check the impact of the Co-Location of all radio interfaces (that can be transmitting simultaneously).

TEST SETUP:

Radiated measurements below 1 GHz.



Radiated measurements above 1 GHz.



RESULTS:

- **Mode 2G Band PCS-1900 , 802.11 n, Bluetooth Low Energy:**

GPRS & EDGE:
A preliminary scan determined the GPRS modulation as the worst case.

2G Band PCS-1900:	Middle Channel (1880 MHz).
802.11 n20:	High Channel (2462 MHz).
Bluetooth Low Energy:	Advertising mode.

LIMIT: The spurious frequencies were measured at 3 meter. The limit of the test is determined by:

Frequency Range	Detector	Limit at 3m (dBµV/m)
30 MHz to 19.1 GHz	PK	43 + 10 log (P) dB = -13 dBm -> 82.23 dBµV/m
19.1 to 26 GHz	PK	74 dBµV/m
19.1 to 26 GHz	AVG	54 dBµV/m (*)

(*) Radiated emissions which fall in the restricted bands, as defined in §15.205(a).

(**) Radiated emissions which fall in the non-restricted bands.

Frequency range 30 MHz - 1 GHz

No spurious frequencies at less than 20 dB below the limit.

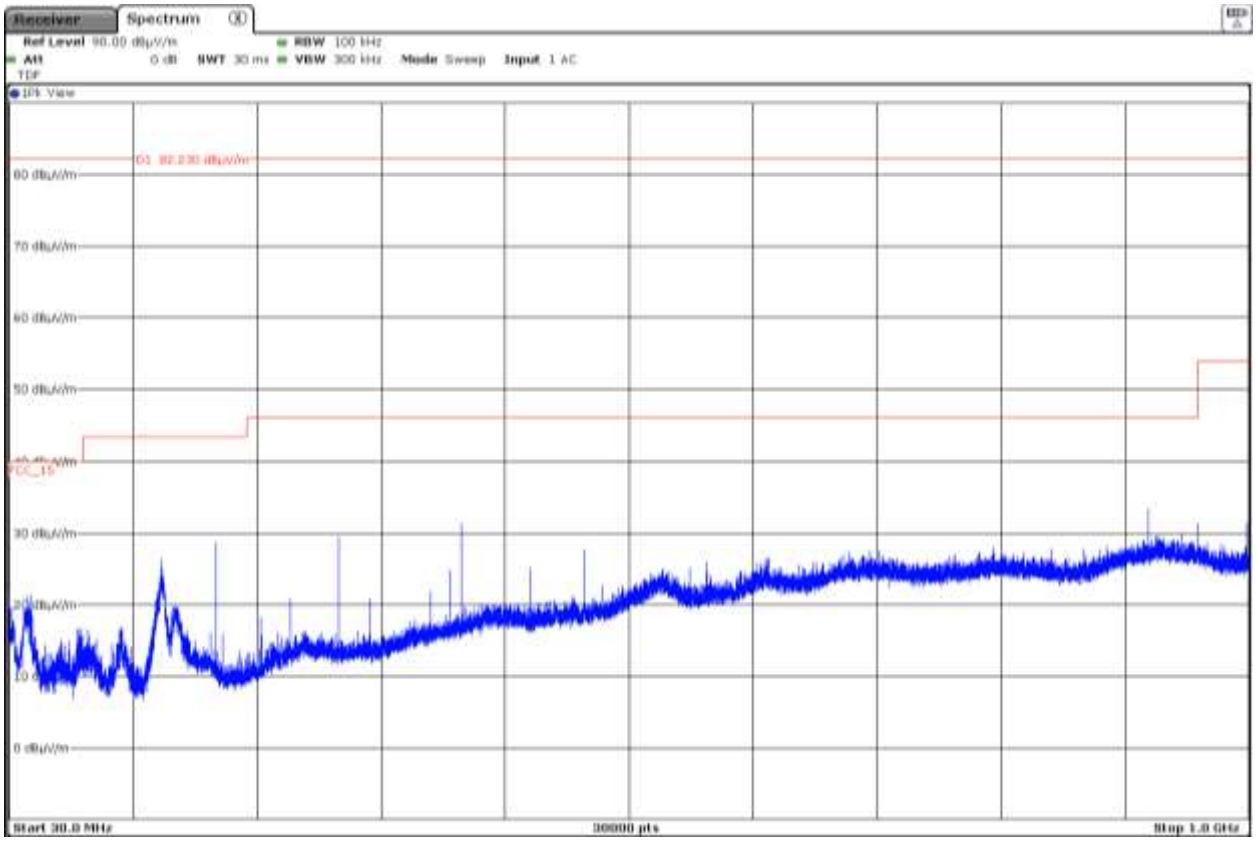
Frequency range 1 – 26 GHz

Spurious frequency (GHz)	Detector	E (dBµV/m)	Polarization
4.3766	Peak	64.49	H

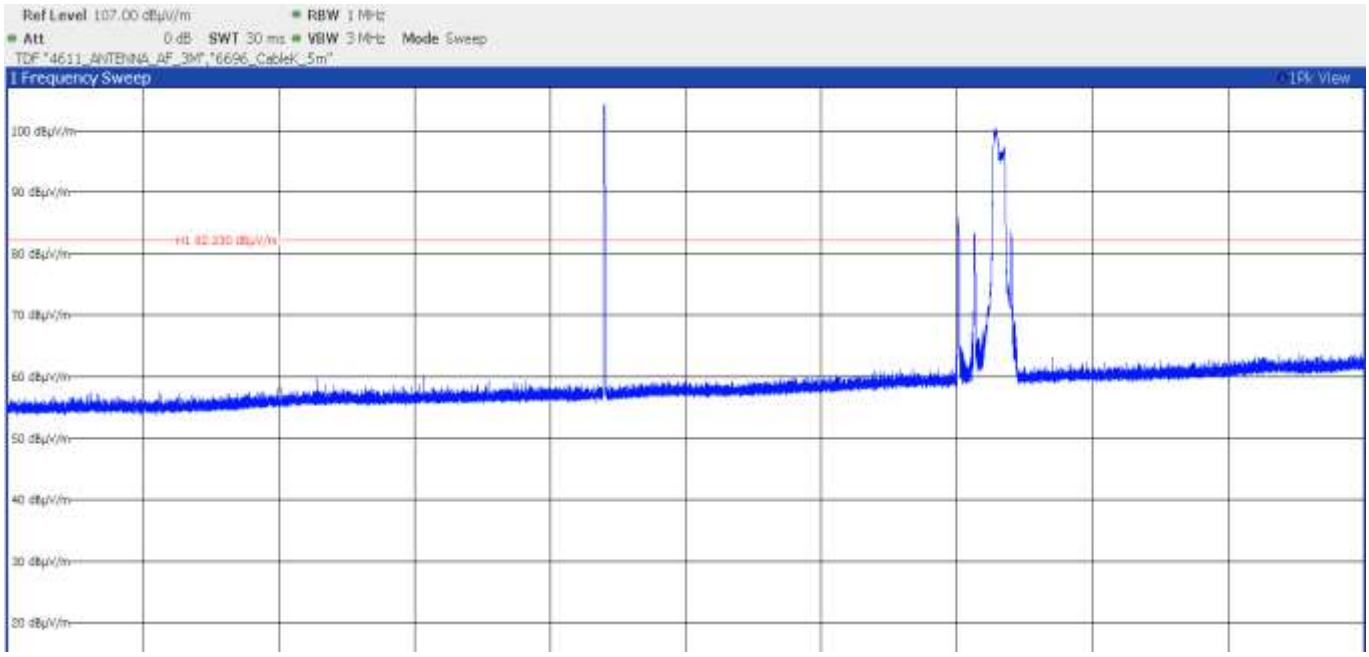
Measurement uncertainty (dB)	<±4.99 for f < 1GHz <±4.98 for f ≥ 1 GHz up to 3 GHz <±4.98 for f ≥ 3 GHz up to 17 GHz <±5.08 for f ≥ 17 GHz up to 26 GHz

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz



FREQUENCY RANGE 1 – 3 GHz

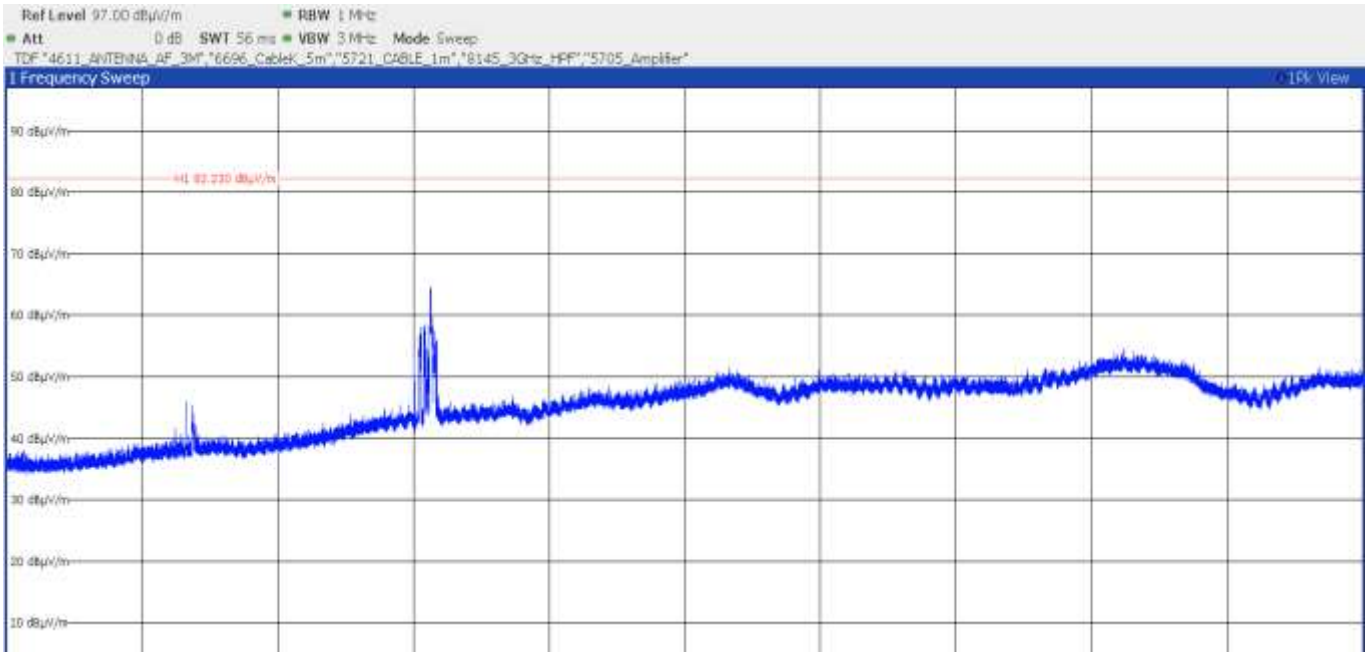


The peak above the limit on the left is the Carrier frequency 2G Band PCS-1900 (1880 MHz).

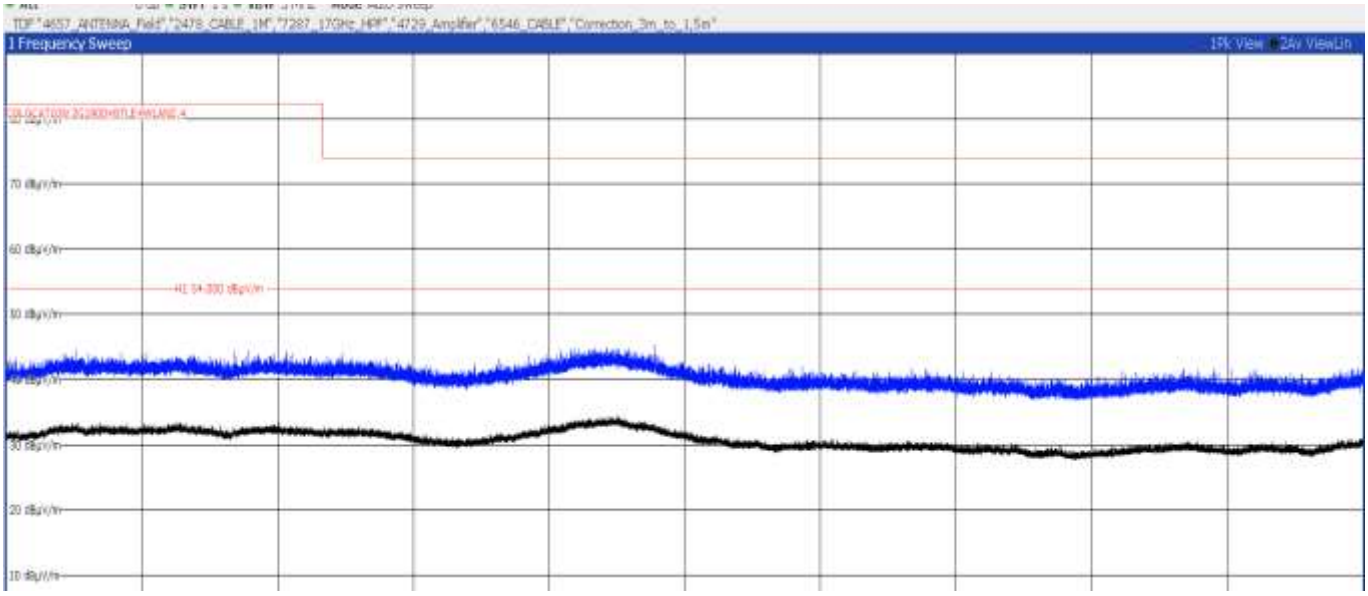
The peak above the limit in the middle is the Carrier frequency Bluetooth Low Energy (advertising mode).

The peak above the limit on the right is the Carrier frequency 802.11 n20 (2462 MHz).

FREQUENCY RANGE 3 – 17 GHz



FREQUENCY RANGE 17 - 26 GHz



- **Mode 2G PCS-1900, 802.11 a20 U-NII-1, Bluetooth Low Energy:**

GPRS & EDGE:
A preliminary scan determined the GPRS modulation as the worst case.

2G Band PCS-1900:	Middle Channel (1880 MHz).
802.11 a U-NII-3:	BW=20 MHz, Low Channel (5745 MHz).
Bluetooth Low Energy:	Advertising mode.

LIMIT: The spurious frequencies were measured at 3 meter. The limit of the test is determined by:

Frequency Range	Detector	Limit at 3m (dBµV/m)
30 MHz to 19.1 GHz	PK	43 + 10 log (P) dB = -13 dBm -> 82.23 dBµV/m
19.1 to 26 GHz	PK	-21.23 dBm -> 74 dBµV/m
26 to 40 GHz	PK	68.23 (**) OR 74 dBµV/m (*)
19.1 to 40 GHz	AVG	54 dBµV/m (*)

(*) Radiated emissions which fall in the restricted bands, as defined in §15.205(a).
(**) Radiated emissions which fall in the non-restricted bands.

Frequency range 30 MHz - 1 GHz

No spurious frequencies at less than 20 dB below the limit.

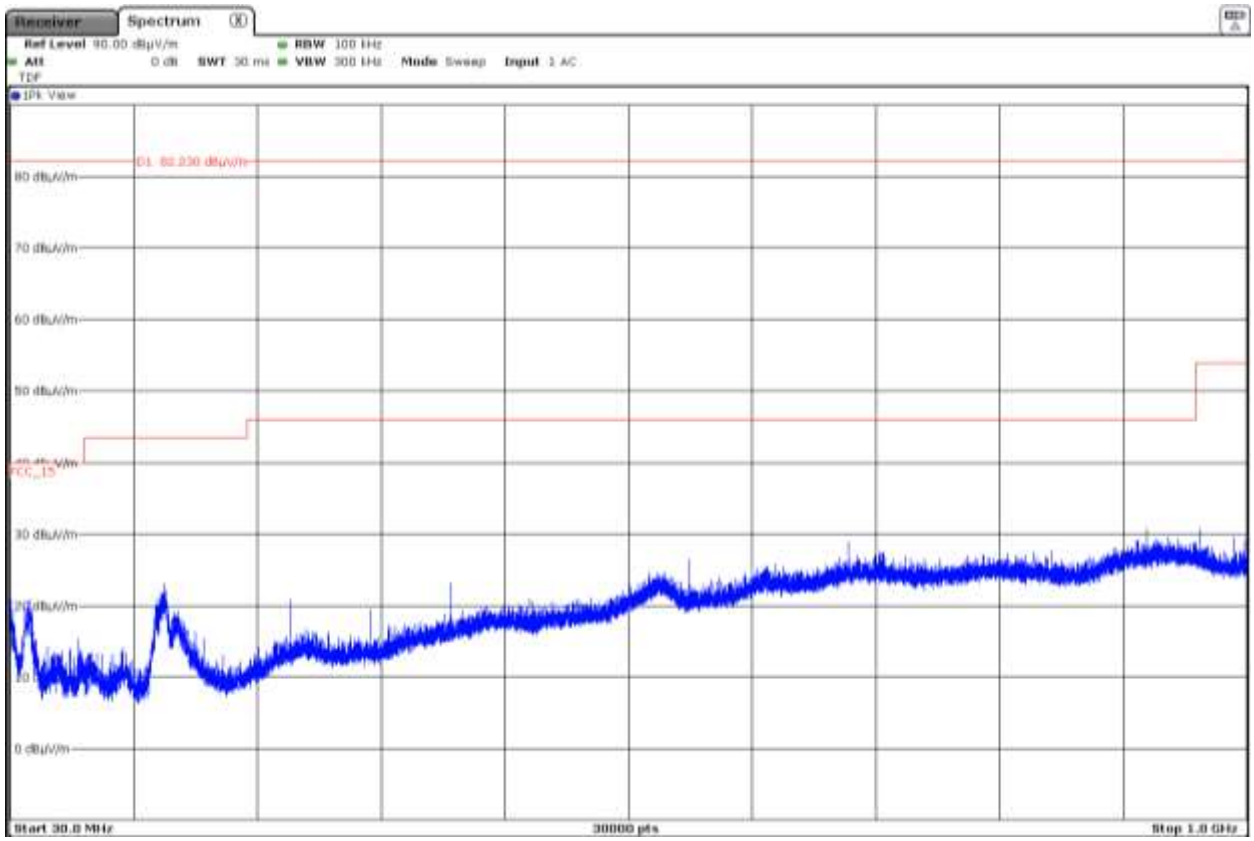
Frequency range 1 - 40 GHz

No spurious frequencies at less than 20 dB below the limit.

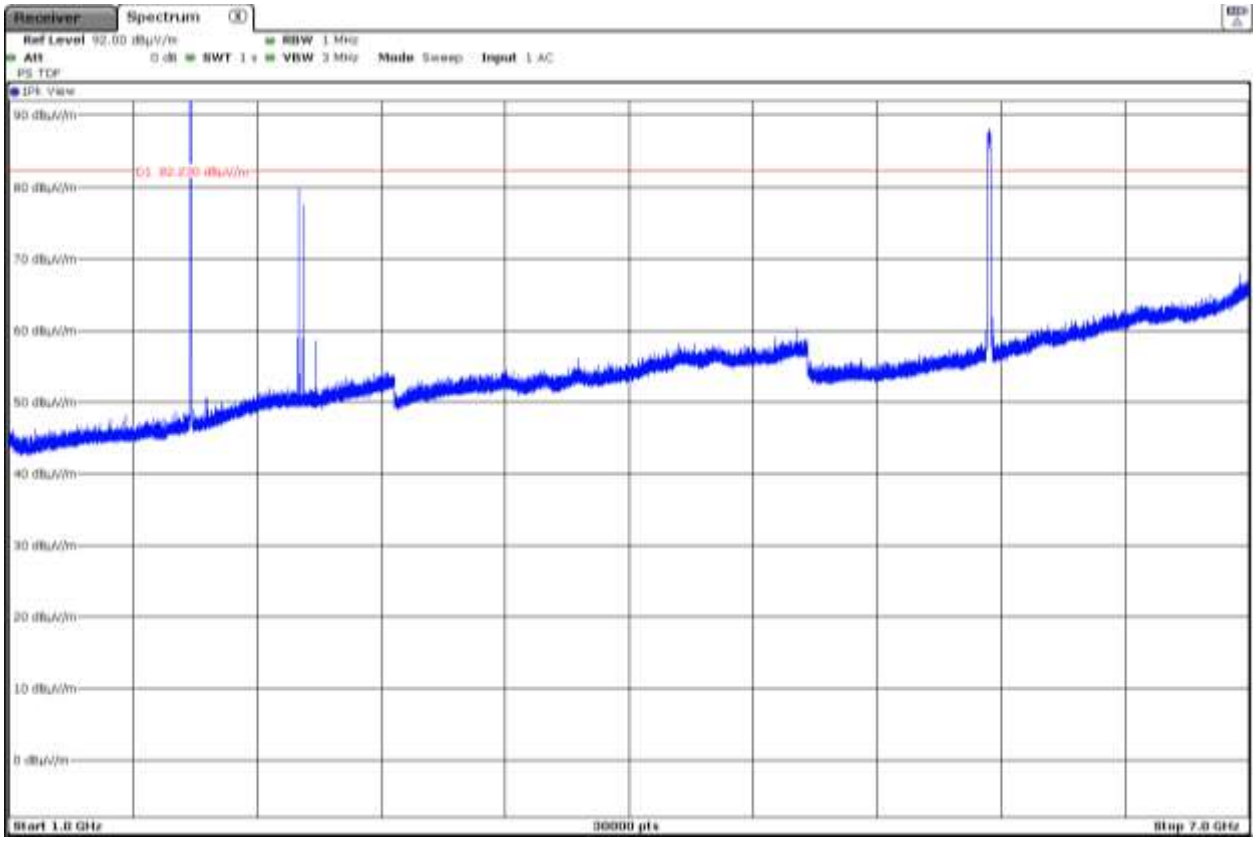
Measurement uncertainty (dB)	<±4.99 for f < 1GHz <±4.98 for f ≥ 1 GHz up to 7 GHz <±4.98 for f ≥ 7 GHz up to 17 GHz <±5.08 for f ≥ 17 GHz up to 26.5 GHz <±5.33 for f ≥ 26.5 GHz up to 40 GHz

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz

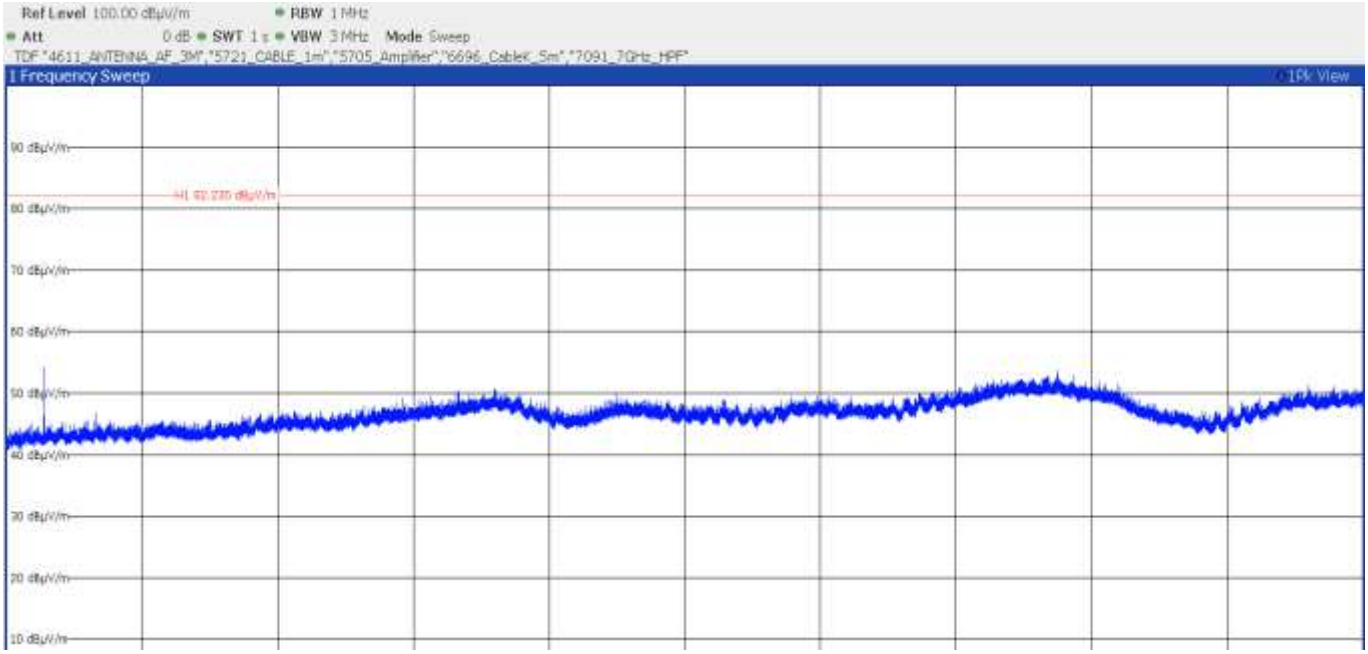


FREQUENCY RANGE 1 – 7 GHz

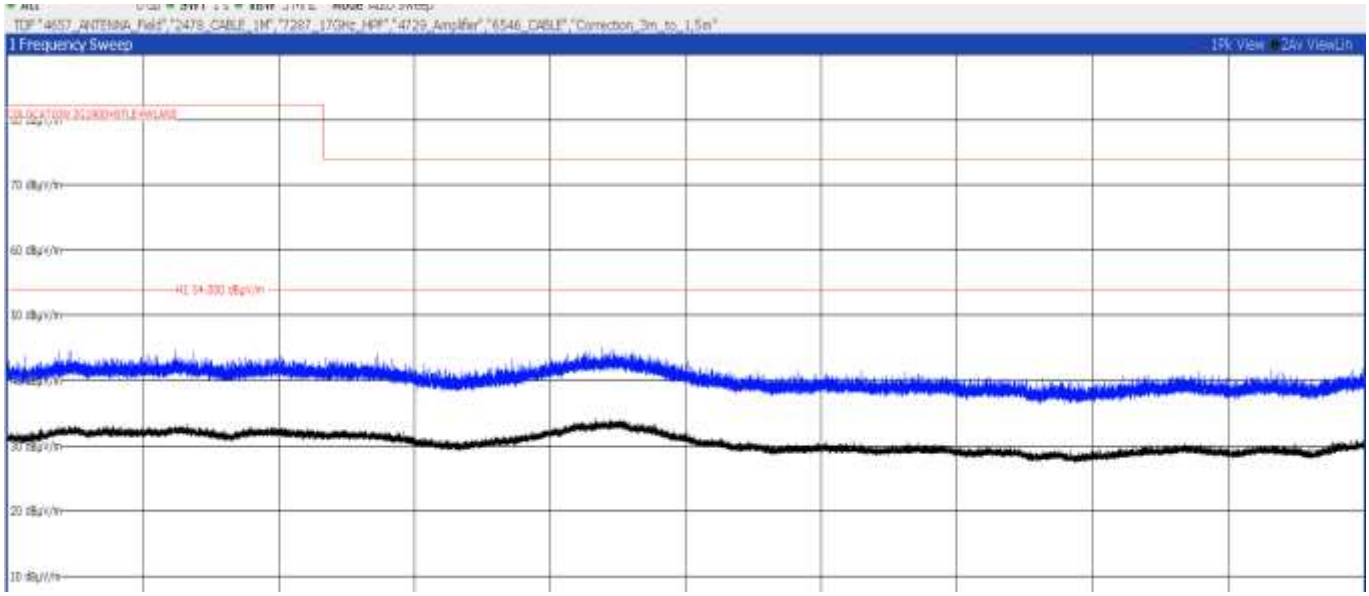


The peak above the limit on the left is the Carrier frequency 2G PCS-1900 (1880 MHz).
The peak above the limit in the middle is the Carrier frequency Bluetooth Low Energy (advertising mode).
The peak above the limit on the right is the Carrier frequency 802.11 a20 (5745 MHz).

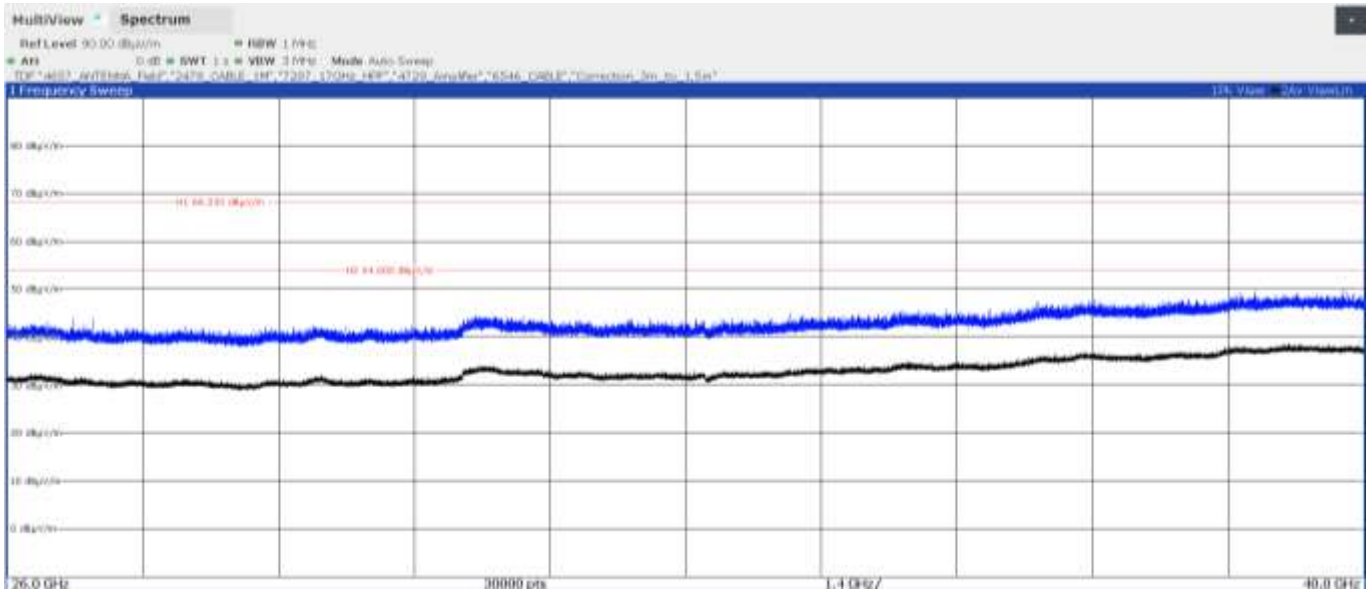
FREQUENCY RANGE 7 – 17 GHz



FREQUENCY RANGE 17 - 26 GHz



FREQUENCY RANGE 26 - 40 GHz



Appendix B: Test results FCC Part 27 / RSS-199, RSS-130

INDEX

TEST CONDITIONS

POWER SUPPLY (V):

V nonimal: 12 Vdc

Type of Power Supply: External power supply (Car Battery).

ANTENNA:

Type of Antennas: Internal.

Maximum Declared Gain for Bluetooth LE: +2.1 dBi

Maximum Declared Gain for WLAN 2.4 GHz: +0.3 dBi (WI-FI external Antenna)

Maximum Declared Gain for WLAN 5 GHz U-NII-3: -1.9 dBi (WI-FI internal Antenna)

Maximum Declared Gain for CELLULAR:

HIGH Band	GAIN	ANTENNA TYPE
LTE Band 7 (2600 MHz)	+5.5 dBi	Internal (3D)

LOW Band	GAIN	ANTENNA TYPE
LTE Band 12 (700 MHz)	+2.0 dBi	Internal (3D)

TEST FREQUENCIES:

	CELLULAR LTE (Bands 7, 12)	
Band:	LTE 7	
Frequency Range:	2500 – 2570 MHz	
Channel Spacing:	200 kHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	High: 21100	2535
Band:	LTE 12	
Frequency Range:	699 – 716 MHz	
Channel Spacing:	200 kHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Low: 23173	715.3

	WLAN (IEEE 802.11 anac) / U-NII	
Mode:	802.11 a20: MCS0	
Frequency Range:	5725 MHz to 5850 MHz (U-NII-3)	
Channel Spacing:	20 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Highest: 149	5745

	WLAN (IEEE 802.11 bgn2040) / Digital Transmission System (DTS)	
Mode:	802.11 n20: MCS0- MCS7 (SISO)	
Channel Spacing:	20 MHz	
Frequency Range:	2412 MHz to 2472 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	11	2462

	Bluetooth LE
Mode:	GFSK
Channel Spacing:	1 MHz
Frequency Range:	2400 MHz to 2483.5 MHz
Transmit Channel:	Advertising mode

The test set-up was made in accordance to the general provisions of FCC DTS Measurement 558074 D01 DTS Meas Guidance v05r02 dated April 2, 2019.

The EUT was tested in the following operating mode:

- Continuous transmission with a modulated carrier at maximum power in all required channels selecting the supported data rates/modulations types.

During transmitter test the EUT was being controlled by the SW tool to operate in a continuous transmit mode on the test channel as required and in each of the different modulation modes.

The following configurations were selected based on preliminary testing that identified those corresponding to the worst cases:

Transmission modes selected with each radio:

* CELLULAR: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in LTE bands 7, 12 configuration as these channels were found to transmit higher EIRP than all the other LTE bands.

* 5 GHz WLAN: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in 802.11 a20 / 6Mbps mode configuration as this mode was found to transmit higher EIRP than all the other 5 GHz WLAN modes.

* 2.4 GHz WLAN: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in 802.11 n20 / MCS0 mode configuration as this mode was found to transmit higher EIRP than all the other 2.4 GHz WLAN modes.

* BLUETOOTH: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in Bluetooth Low Energy (GFSK) advertising mode.

Simultaneous transmission modes selected:

1. CELLULAR LTE, WLAN 2.4 GHz, BLUETOOTH Co-Location, with the EUT configured to simultaneously transmit three signals at maximum output power, CELLULAR LTE Band 7, WLAN 2.4 GHz in 802.11 n20 / MCS0, Bluetooth Low Energy / GFSK.

2. CELLULAR LTE, WLAN 5 GHz, BLUETOOTH Co-Location, with the EUT configured to simultaneously transmit three signals at maximum output power, CELLULAR LTE Band 7, WLAN 5 GHz (U-NII-3) in 802.11 a20 / 6 Mbps, Bluetooth Low Energy / GFSK.

3. CELLULAR LTE, WLAN 2.4 GHz Co-Location, with the EUT configured to simultaneously transmit three signals at maximum output power, CELLULAR LTE Band 12, WLAN 2.4 GHz in 802.11 n20 / MCS0, Bluetooth Low Energy / GFSK.

4. CELLULAR LTE, WLAN 5 GHz Co-Location, with the EUT configured to simultaneously transmit three signals at maximum output power, CELLULAR LTE Band 12, WLAN 5 GHz (U-NII-3) in 802.11 a20 / 6 Mbps, Bluetooth Low Energy / GFSK.

Radiated emissions

SPECIFICATION:

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c) / RSS-Gen):

Frequency Range (MHz)	Field strength (µV/m)	Field strength (dBµV/m)	Measurement distance (m)
0.009-0.490	2400/F(kHz)	-	300
0.490-1.705	24000/F(kHz)	-	30
1.705 - 30.0	30	-	30
30 - 88	100	40	3
88 - 216	150	43.5	3
216 - 960	200	46	3
960 - 25000	500	54	3

The emission limits shown in the above table are based on measurements employing CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

For average radiated emission measurements above 1000 MHz, there is also a limit corresponding to 20 dB above the indicated values in the table is specified when measuring with peak detector function.

RSS-247. Attenuation below the general field strength limits specified in RSS-Gen is not required.

1. LTE Band 7. FCC §2.1053 & §27.53 (m) (4) / RSS-199 Clause 4.5.

FCC §27.53 (m) (4)

> (m) For BRS and EBS stations, the power of any emissions outside the licensee's frequency bands of operation shall be attenuated below the transmitter power (P) measured in watts in accordance with the standards below. If a licensee has multiple contiguous channels, out-of-band emissions shall be measured from the upper and lower edges of the contiguous channels.
>
> > (4) For mobile digital stations, the attenuation factor shall be not less than 40 + 10 log (P) dB on all frequencies between the channel edge and 5 megahertz from the channel edge, 43 + 10 log (P) dB on all frequencies between 5 megahertz and X megahertz from the channel edge, and 55 + 10 log (P) dB on all frequencies more than X megahertz from the channel edge, where X is the greater of 6 megahertz or the actual emission bandwidth as defined in paragraph (m)(6) of this section. In addition, the attenuation factor shall not be less that 43 + 10 log (P) dB on all frequencies between 2490.5 MHz and 2496 MHz and 55 + 10 log (P) dB at or below 2490.5 MHz. Mobile Satellite Service licensees operating on frequencies below 2495 MHz may also submit a documented interference complaint against BRS licensees operating on channel BRS Channel 1 on the same terms and conditions as adjacent channel BRS or EBS licensees.

RSS-199 Clause 4.5.

> 4.5. In the 1 MHz band immediately outside and adjacent to the channel edge, the unwanted emission power shall be measured with a resolution bandwidth of at least 1% of the occupied bandwidth for base station and fixed subscriber equipment, and 2% for mobile subscriber equipment. Beyond the 1 MHz band, a resolution bandwidth of 1 MHz shall be used. A narrower resolution bandwidth can be used, provided that the measured power is integrated over the full required measurement bandwidth of 1 MHz, or 1% or 2% of the occupied bandwidth, as applicable.

Equipment shall comply with the following unwanted emission limits:

(b) for mobile subscriber equipment, the power of any unwanted emissions measured as above shall be attenuated (in dB) below the transmitter power, P (dBW), by at least:

40 + 10 log10 p from the channel edges to 5 MHz away

43 + 10 log10 p between 5 MHz and X MHz from the channel edges, and

55 + 10 log10 p at X MHz and beyond from the channel edges

In addition, the attenuation shall not be less than 43 + 10 log10 p on all frequencies between 2490.5 MHz and 2496 MHz, and 55 + 10 log10 p at or below 2490.5 MHz.

In (b), p is the transmitter power measured in watts and X is 6 MHz or the equipment occupied bandwidth, whichever is greater.

2. LTE Band 12. FCC §2.1053 & §27.53 (g) / RSS-130 Clause 4.6.

FCC §27.53 (g):

(g) For operations in the 600 MHz band and the 698-746 MHz band, the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, by at least 43 + 10 log (P) dB. Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kilohertz or greater. However, in the 100 kilohertz bands immediately outside and adjacent to a licensee's frequency block, a resolution bandwidth of at least 30 kHz may be employed.

RSS-130 Issue 1 Clause 4.6.:

The power of any unwanted emissions in any 100 kHz bandwidth on any frequency outside the frequency range(s) within which the equipment is designed to operate shall be attenuated below the transmitter power, P (dBW), by at least 43 + 10 log10 p (watts), dB. However, in the 100 kHz band immediately outside the equipment’s operating frequency range, a resolution bandwidth of 30 kHz may be employed.

METHOD:

The measurement was performed with the EUT inside an anechoic chamber.

The spectrum was scanned from 9 kHz to at least the 10th harmonic of the highest frequency of the co-located radios till 26 GHz.

The EUT was placed on a non-conductive stand at a 3 meter distance from the measuring antenna.

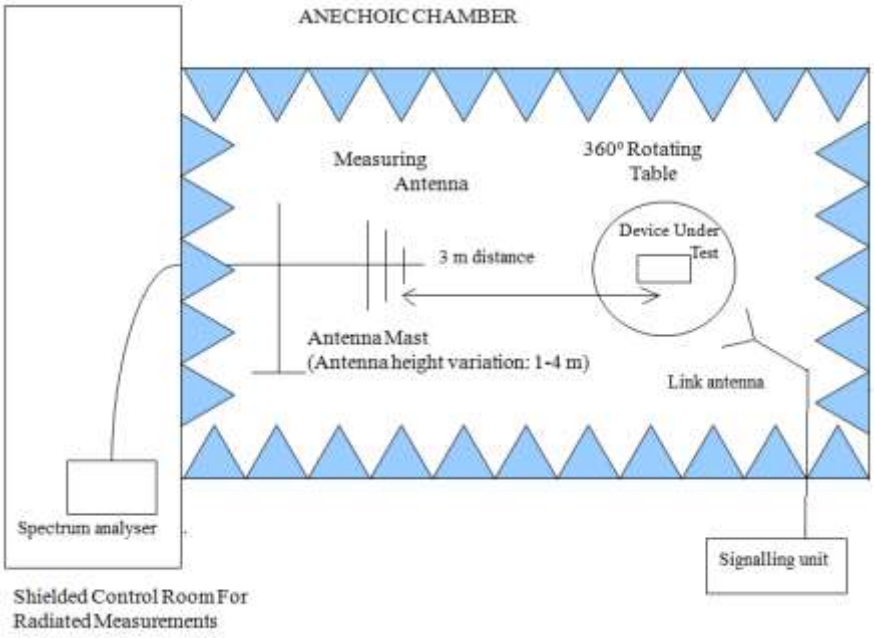
Detected emissions were maximized at each frequency by rotating the EUT and adjusting the measuring antenna height and polarization. The maximum meter reading was recorded.

The field strength is calculated by adding correction factor to the measured level from the spectrum analyzer. This correction factor includes antenna factor, cable loss and pre-amplifiers gain.

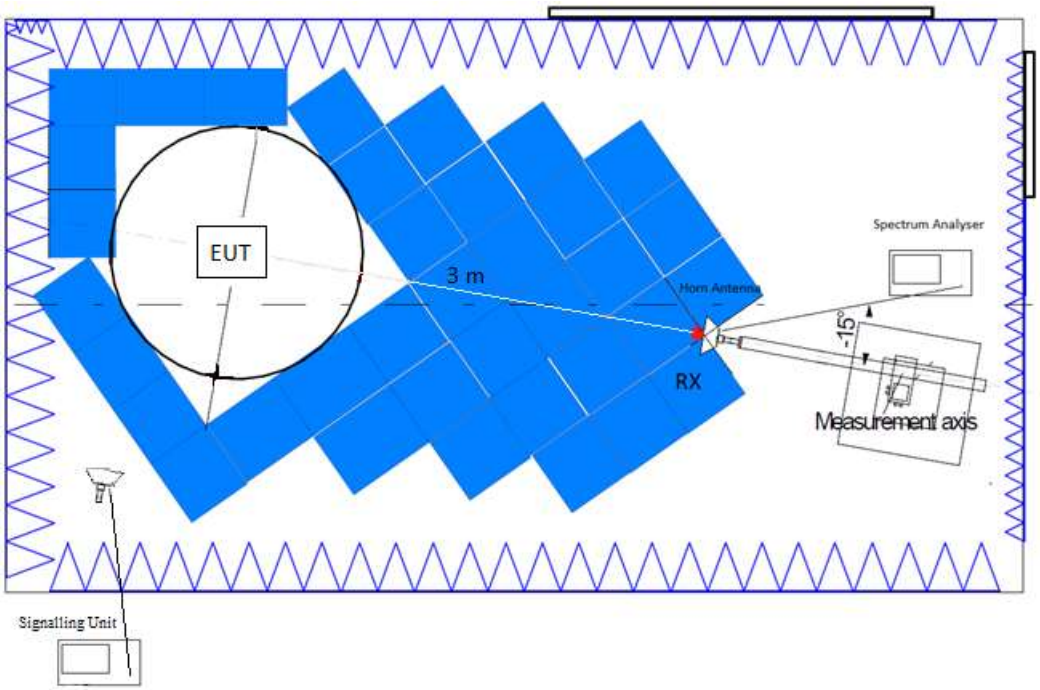
These measurements have been performed in order to check the impact of the Co-Location of all radio interfaces (that can be transmitting simultaneously).

TEST SETUP:

Radiated measurements below 1 GHz.



Radiated measurements above 1 GHz.



RESULTS:

- **Mode LTE Band 7, 802.11 n20, Bluetooth Low Energy.**

QPSK & 16QAM:
A preliminary scan determined the QPSK modulation as the worst case.

LTE Band 7:	Middle Channel (2535 MHz). RB=1.
WLAN 802.11 n20:	High Channel (2462 MHz).
Bluetooth Low Energy:	Advertising mode

LIMIT: The spurious frequencies were measured at 3 meter. The limit of the test is determined by:

Frequency Range	Detector	Limit at 3m (dBµV/m)
30 MHz to 26 GHz	PK	55 + 10 log (P) dB = -25 dBm -> 70.23 dBµV/m (**) OR -21.23 dBm -> 74 dBµV/m (*)

(*) Radiated emissions which fall in the restricted bands, as defined in §15.205(a).

(**) Radiated emissions which fall in the non-restricted bands.

Frequency range 30 MHz - 1 GHz

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 26 GHz

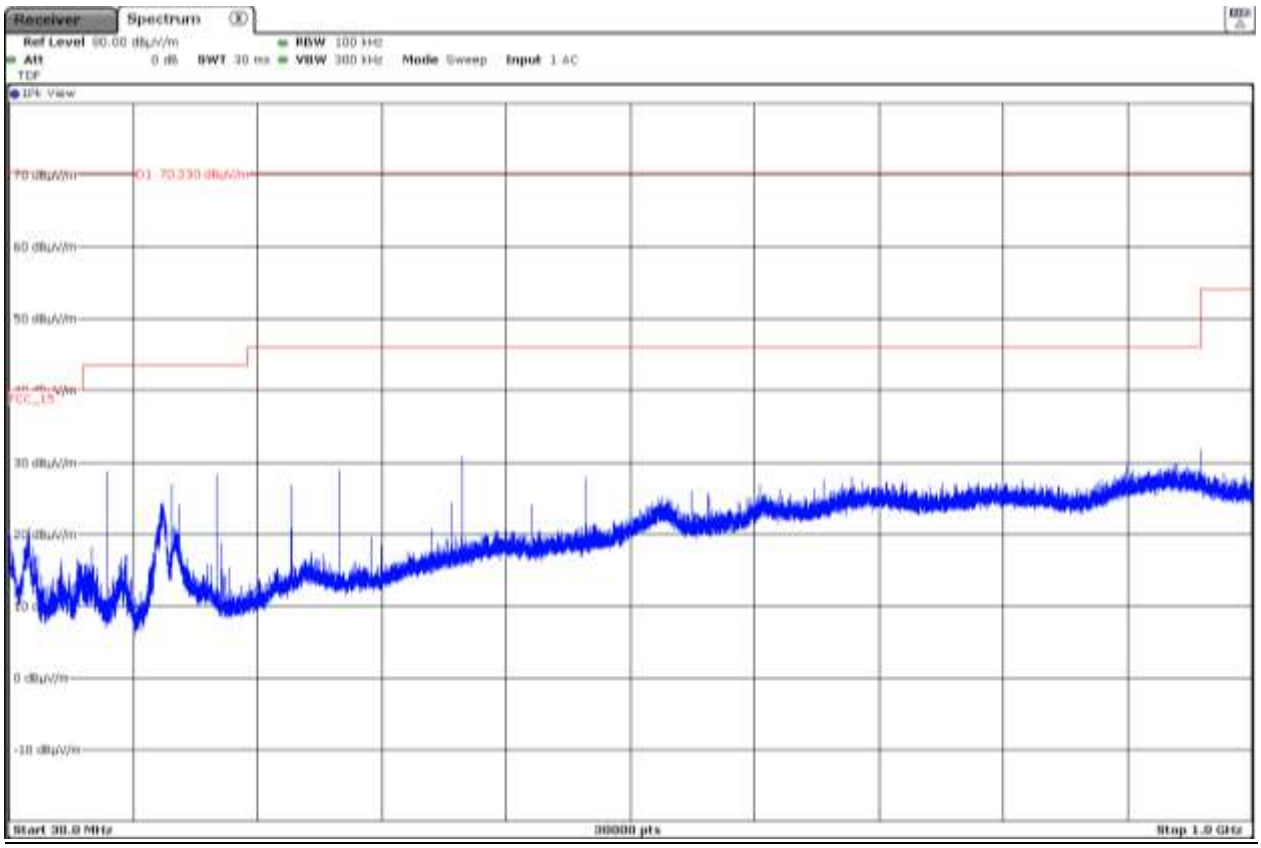
Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (GHz)	Detector	E (dBµV/m)	Polarization
2.5084	Peak	64.69	V
7.3720	Peak	64.62	H

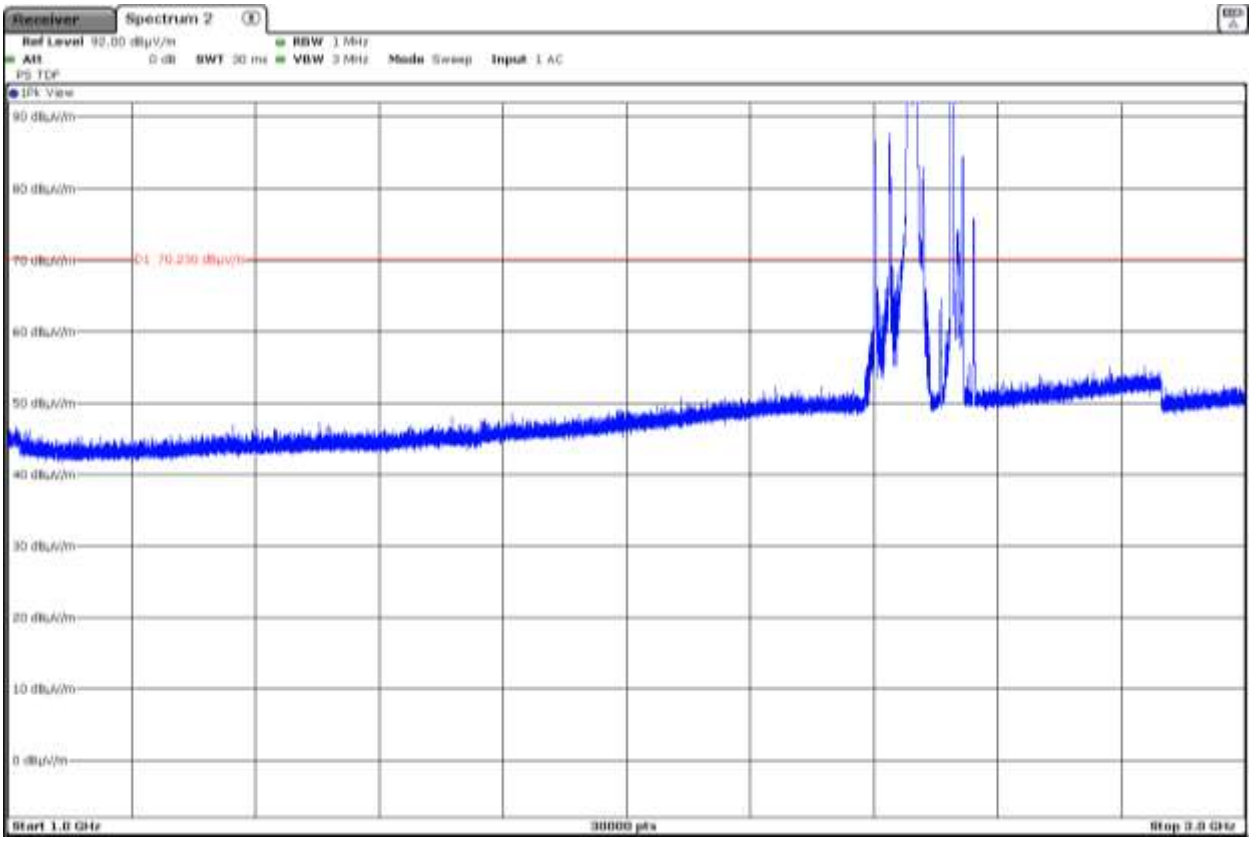
Measurement uncertainty (dB)	<±4.99 for f < 1GHz <±4.98 for f ≥ 1 GHz up to 3 GHz <±4.98 for f ≥ 3 GHz up to 17 GHz <±5.08 for f ≥ 17 GHz up to 26 GHz

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz

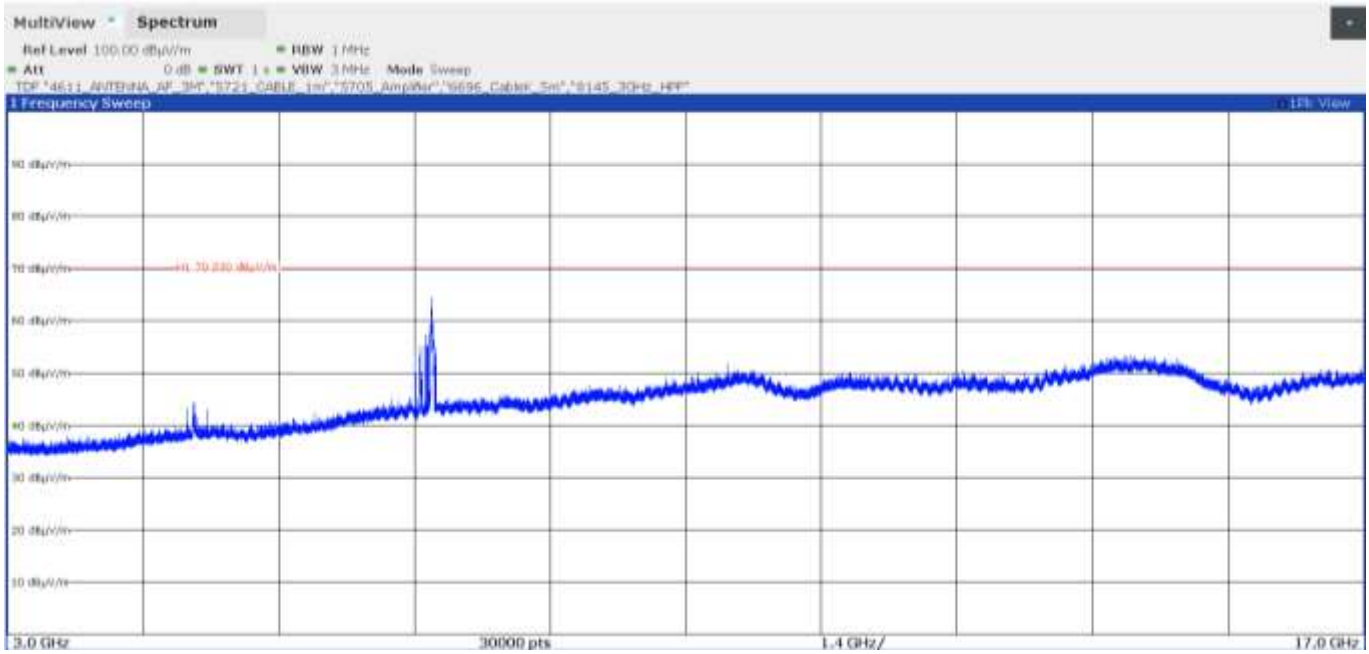


FREQUENCY RANGE 1 – 3 GHz

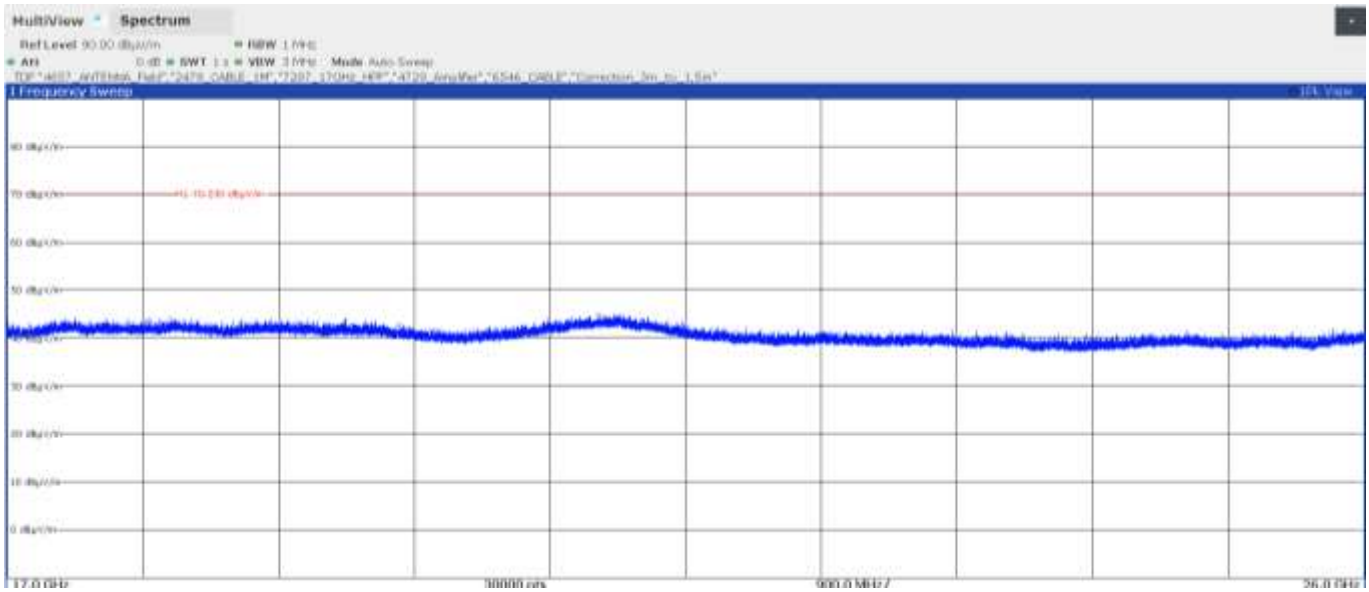


The peak above the limit on the left is the Carrier frequency Bluetooth Low Energy (advertising mode).
The peak above the limit in the middle is the Carrier frequency 802.11 n20 (2462 MHz).
The peak above the limit on the left is the Carrier frequency LTE Band 7 (2535 MHz).

FREQUENCY RANGE 3 – 17 GHz



FREQUENCY RANGE 17 - 26 GHz



- **Mode LTE Band 7, 802.11 a20 U-NII-3, Bluetooth Low Energy.**

QPSK & 16QAM
A preliminary scan determined the QPSK modulation as the worst case.

LTE Band 7:	Middle Channel (2535 MHz), RB=1.
802.11 a U-NII-3:	BW=20 MHz, Low Channel (5745 MHz).
Bluetooth Low Energy:	Advertising mode.

LIMIT: The spurious frequencies were measured at 3 meter. The limit of the test is determined by:

Frequency Range	Detector	Limit at 3m (dBµV/m)
30 MHz to 1 GHz	PK	55 + 10 log (P) dB = -25 dBm -> 70.23 dBµV/m
1 to 26 GHz	PK	74 dBµV/m
26 to 40 GHz	PK	68.23 (**) OR 74 dBµV/m (*)
26 to 40 GHz	AVG	54 dBµV/m (*)

(*) Radiated emissions which fall in the restricted bands, as defined in §15.205(a).
(**) Radiated emissions which fall in the non-restricted bands.

Frequency range 30 MHz - 1 GHz

No spurious frequencies at less than 20 dB below the limit.

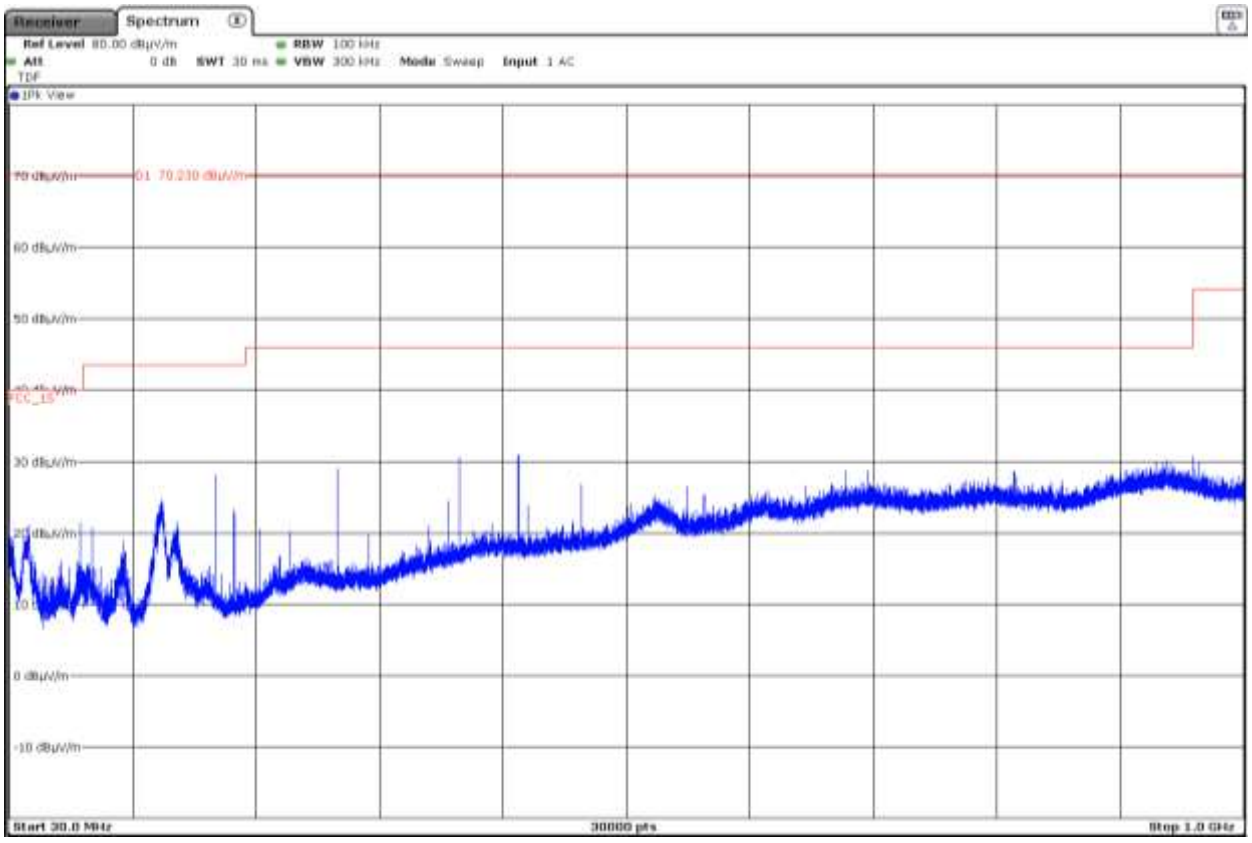
Frequency range 1 - 40 GHz

No spurious frequencies at less than 20 dB below the limit.

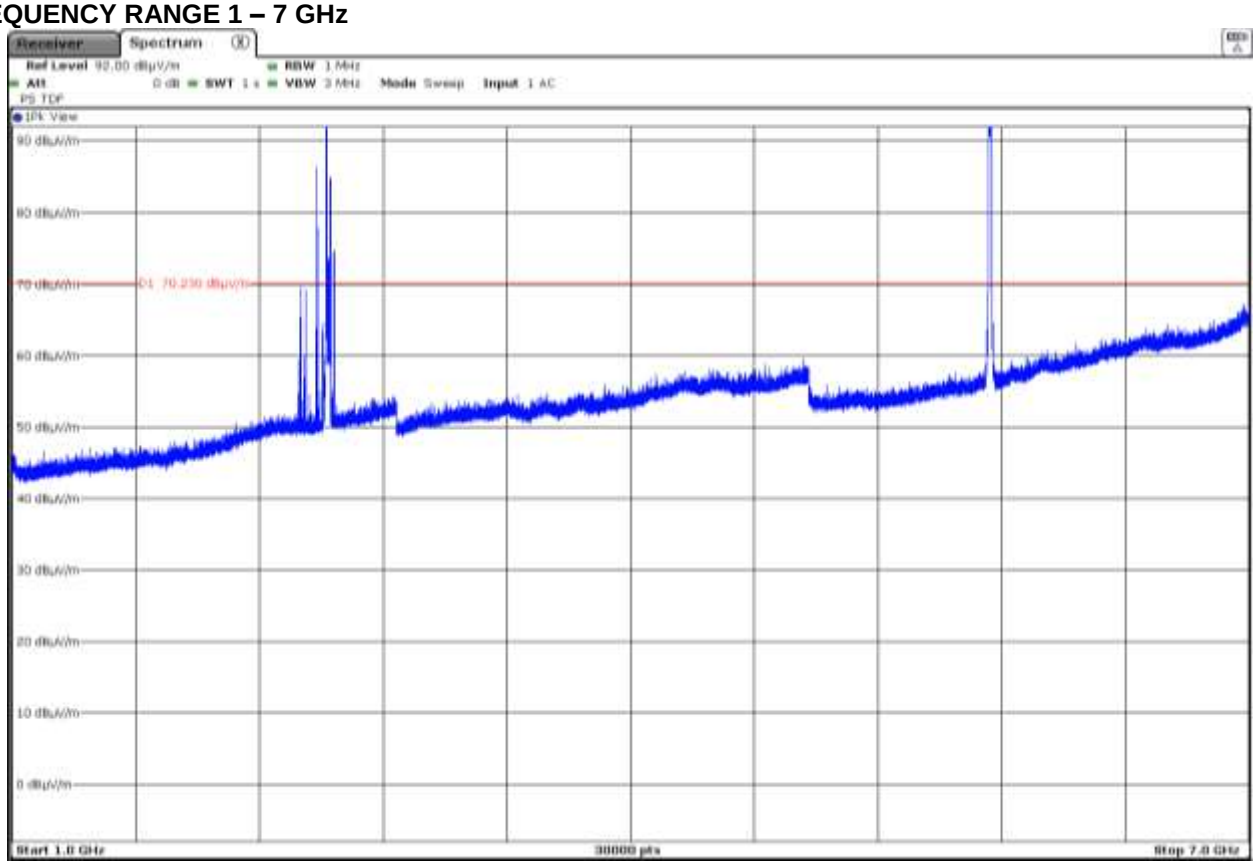
Measurement uncertainty (dB)	<±4.99 for f < 1GHz <±4.98 for f ≥ 1 GHz up to 7 GHz <±4.98 for f ≥ 7 GHz up to 17 GHz <±5.08 for f ≥ 17 GHz up to 26.5 GHz <±5.33 for f ≥ 26.5 GHz up to 40 GHz

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz



FREQUENCY RANGE 1 – 7 GHz

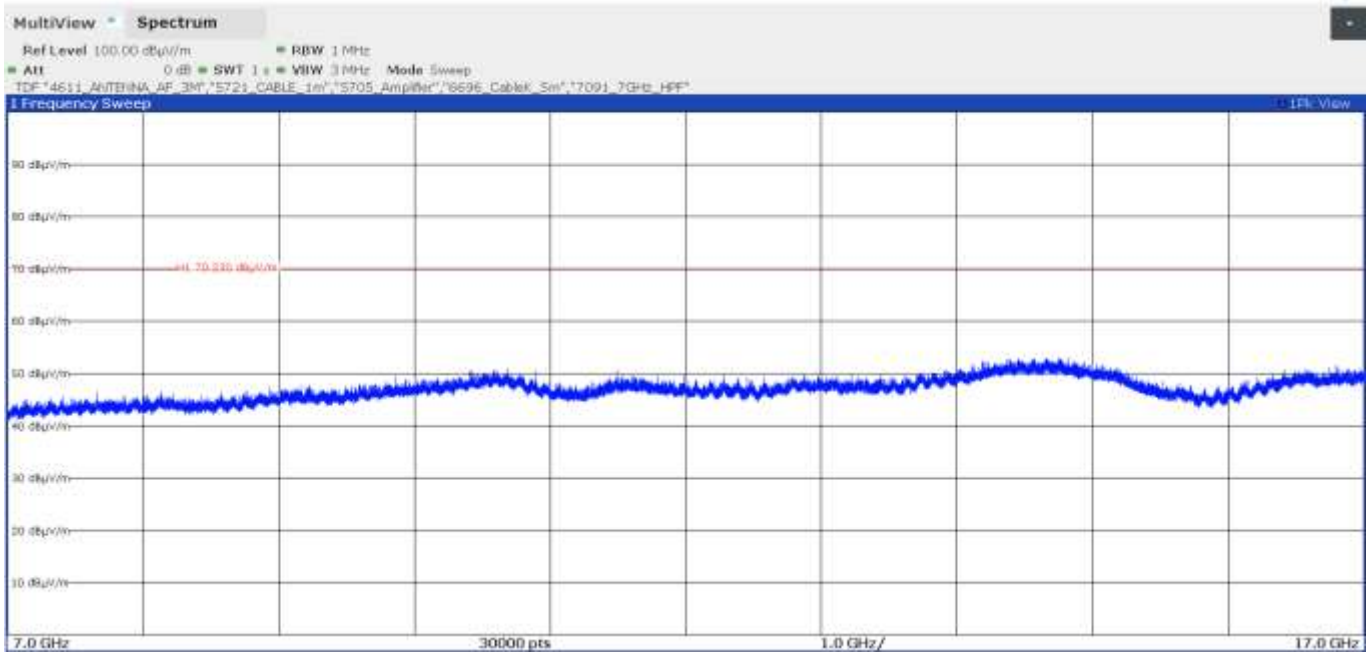


The peak above the limit on the left is the Carrier frequency Bluetooth Low Energy (Advertising mode).

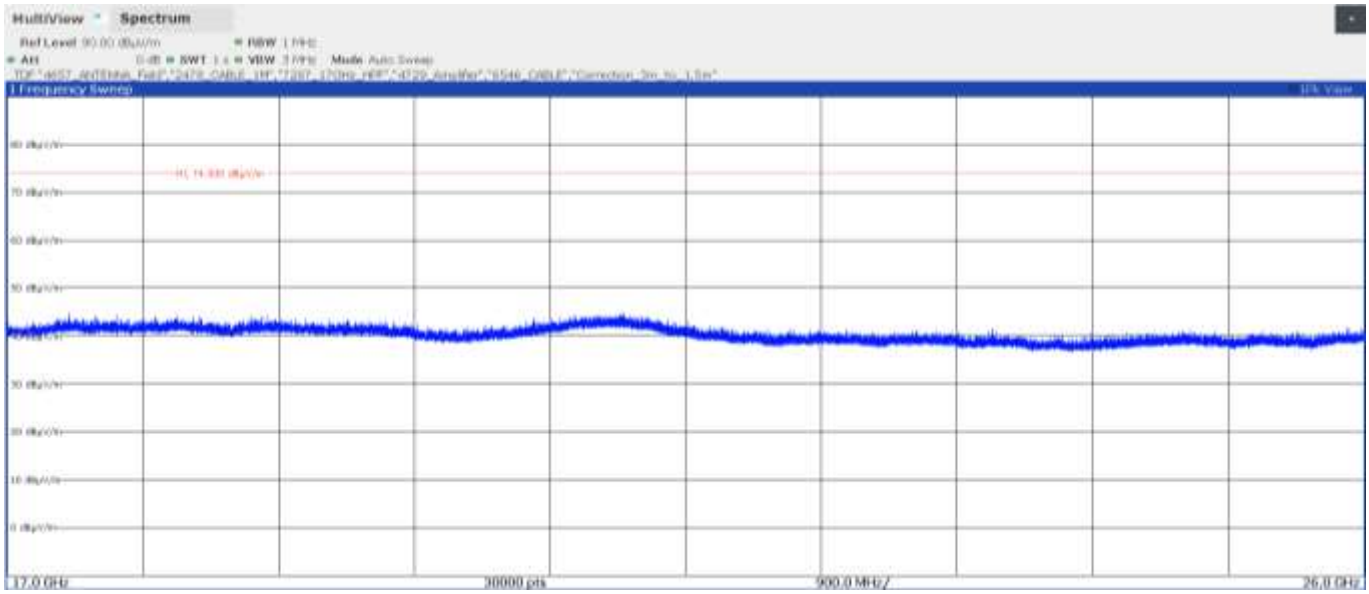
The peak above the limit in the middle is the Carrier frequency LTE Band 7 (2535 MHz)

The peak above the limit on the right is the Carrier frequency 802.11 a20 (5745 MHz).

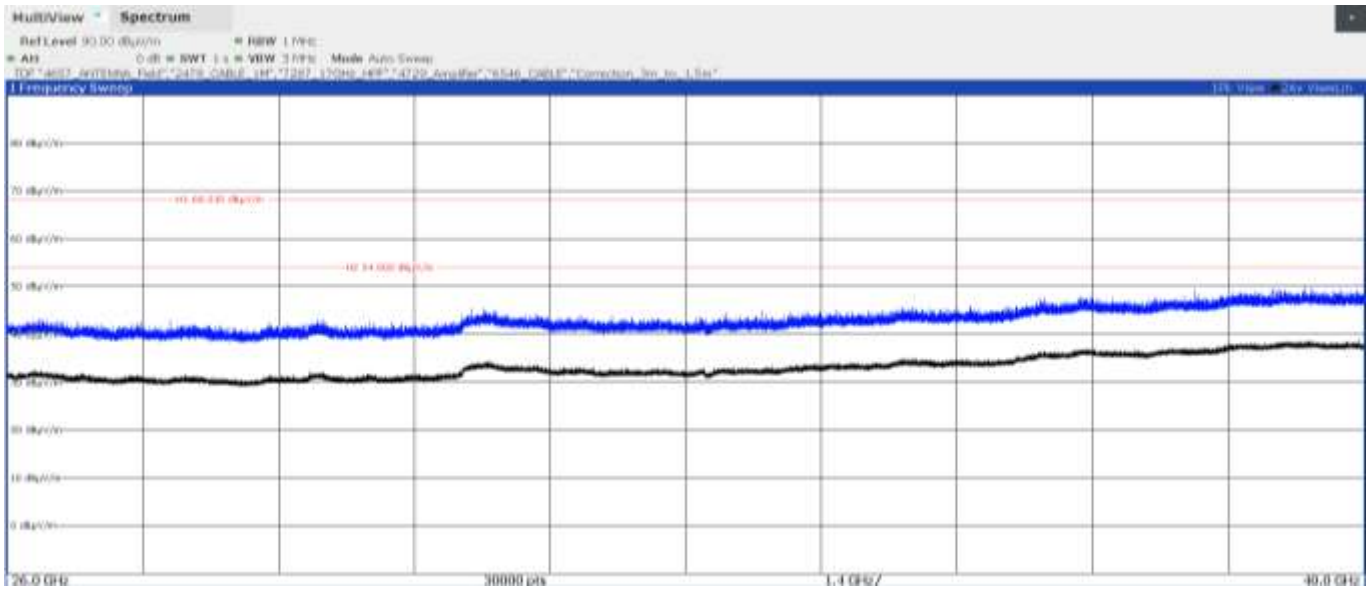
FREQUENCY RANGE 7 – 17 GHz



FREQUENCY RANGE 17 - 26 GHz



FREQUENCY RANGE 26 - 40 GHz



- **Mode LTE Band 12, 802.11 b, Bluetooth Low Energy.**

QPSK & 16QAM
A preliminary scan determined the 16QAM modulation as the worst case.

LTE Band 12:	High Channel (715.3 MHz), RB=1.
WLAN 802.11 b:	High Channel (2462 MHz).
Bluetooth Low Energy:	Advertising mode.

LIMIT: The spurious frequencies were measured at 3 meter. The limit of the test is determined by:

Frequency Range	Detector	Limit at 3m (dBµV/m)
30 MHz to 7.16 GHz	PK	43 + 10 log (P) dB = -13 dBm -> 82.23 dBµV/m
7.16 to 26 GHz	PK	74 dBµV/m
7.16 to 26 GHz	AVG	54 dBµV/m (*)

(*) Radiated emissions which fall in the restricted bands, as defined in §15.205(a).

Frequency range 30 MHz - 1 GHz

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 26 GHz

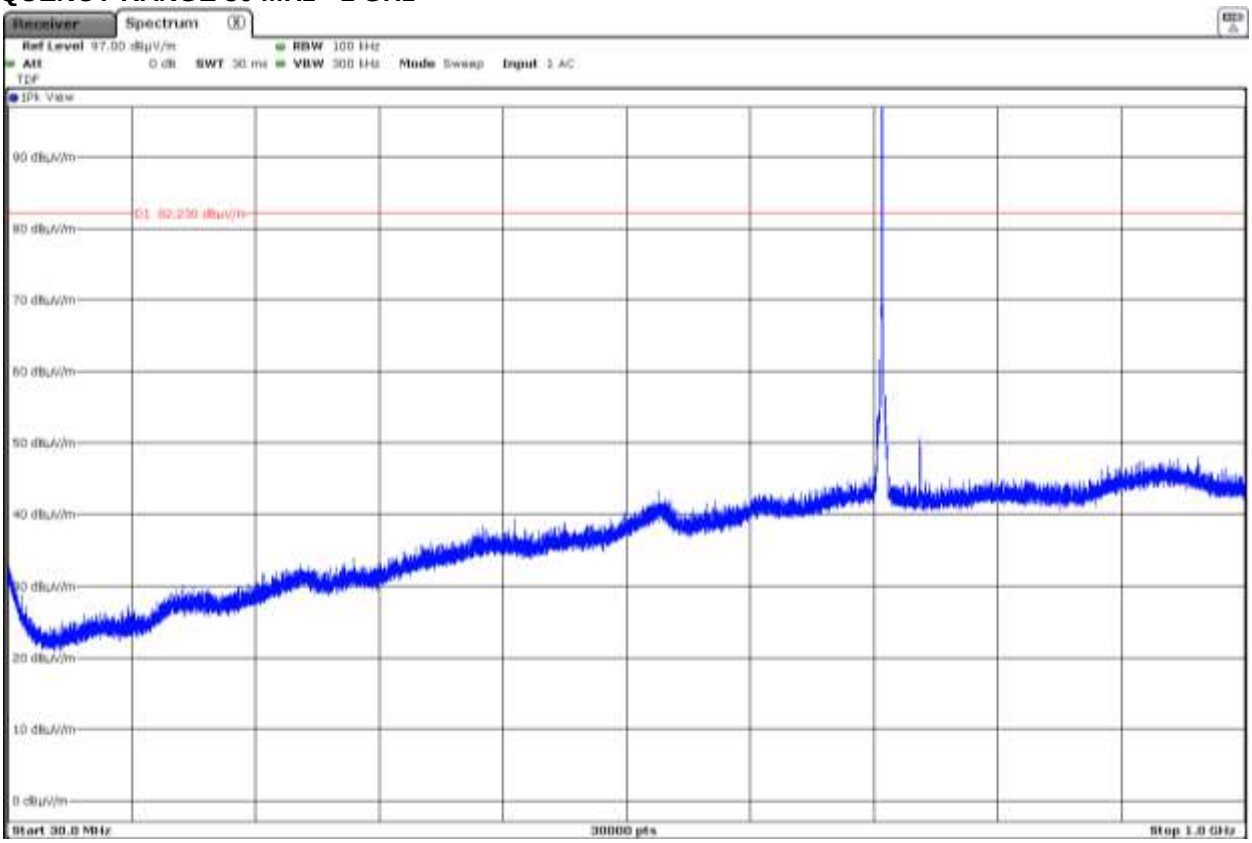
Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (GHz)	Detector	E (dBµV/m)	Polarization
7.3724	Peak	62.22	H
	Average	47.24	
9.7042	Peak	50.57	V
9.8479	50.57	50.04	V

Measurement uncertainty (dB)	<±4.99 for f < 1GHz <±4.98 for f ≥ 1 GHz up to 3 GHz <±4.98 for f ≥ 3 GHz up to 17 GHz <±5.08 for f ≥ 17 GHz up to 26 GHz

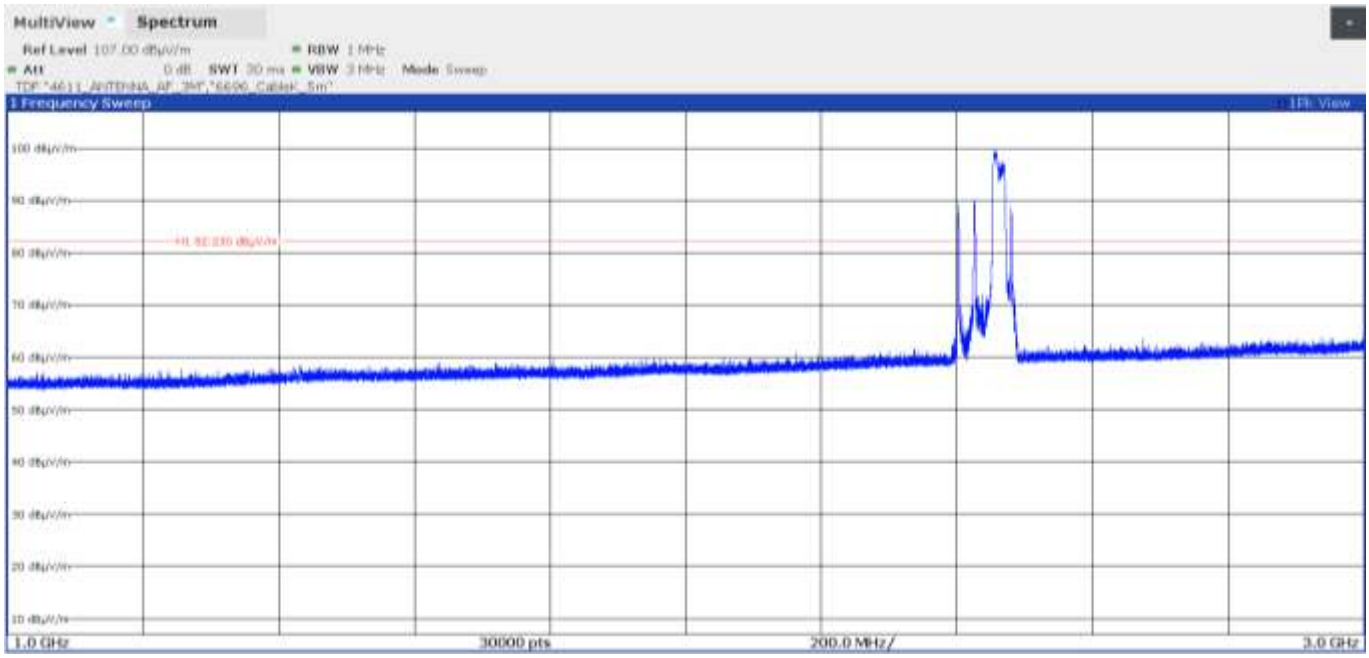
Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz



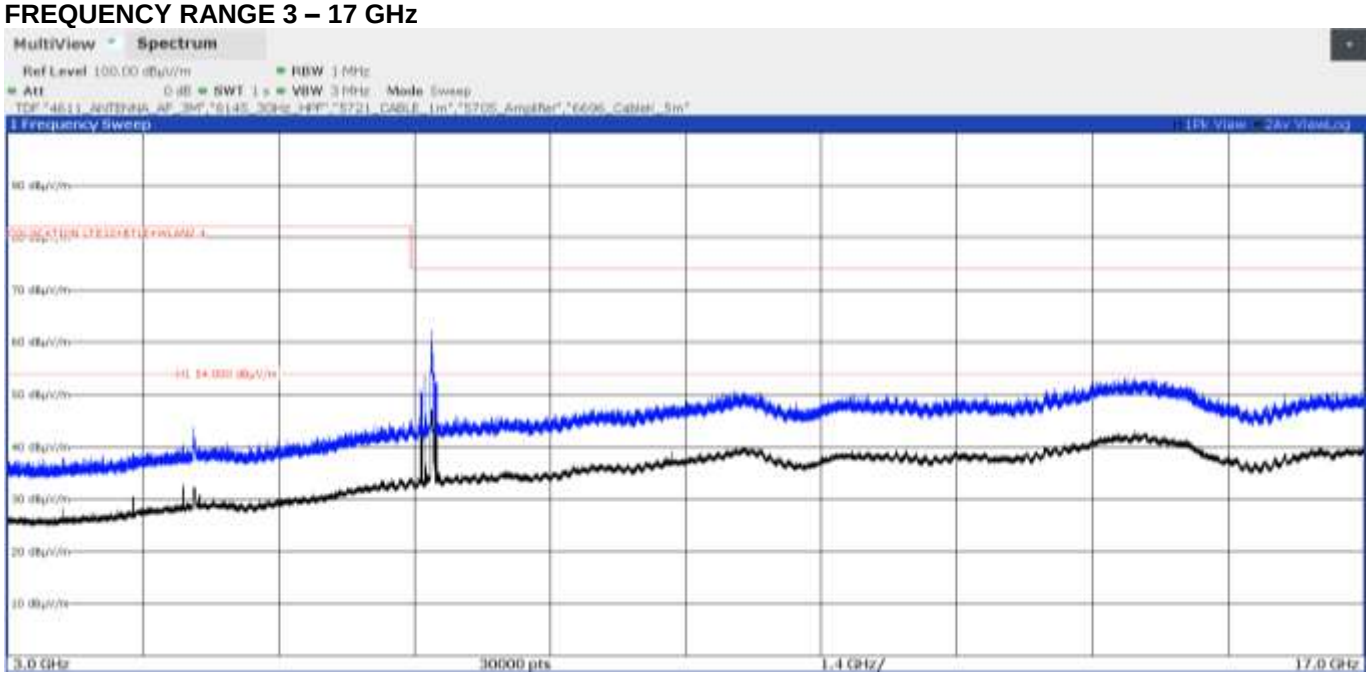
The peak above the limit is the Carrier frequency LTE Band 12 (715.3 MHz)

FREQUENCY RANGE 1 – 3 GHz

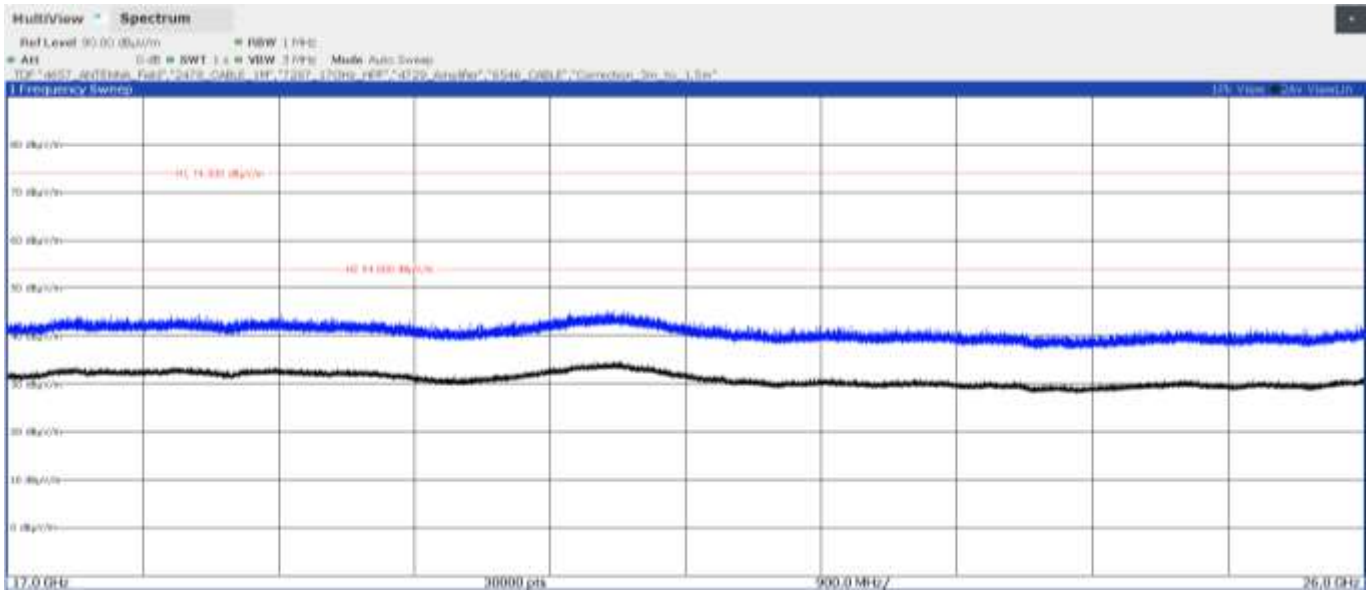


The peak above the limit on the left is the Carrier frequency Bluetooth Low Energy (Advertising mode).
The peak above the limit on the right is the Carrier frequency 802.11 n20 (2462 MHz).

FREQUENCY RANGE 3 – 17 GHz



FREQUENCY RANGE 17 - 26 GHz



- **Mode LTE Band 12, 802.11 a20 U-NII-3, Bluetooth Low Energy.**

QPSK & 16QAM
A preliminary scan determined the 16QAM modulation as the worst case.

LTE Band 12:	Low Channel (715.3 MHz), RB=1.
802.11 a U-NII-3:	BW=20 MHz, Low Channel (5745 MHz).
Bluetooth Low Energy:	Low Channel (Advertising mode).

LIMIT: The spurious frequencies were measured at 3 meter. The limit of the test is determined by:

Frequency Range	Detector	Limit at 3m (dBµV/m)
30 MHz to 7.16 GHz	PK	43 + 10 log (P) dB = -13 dBm -> 82.23 dBµV/m
7.16 to 26 GHz	PK	74 dBµV/m
26 to 40 GHz	PK	68.23 dBµV/m (**) OR 74 dBµV/m (*)
7.16 to 40 GHz	AVG	54 dBµV/m (*)

(*) Radiated emissions which fall in the restricted bands, as defined in §15.205(a).
(**) Radiated emissions which fall in the non-restricted bands.

Frequency range 30 MHz - 1 GHz

No spurious frequencies at less than 20 dB below the limit.

Frequency range 1 - 40 GHz

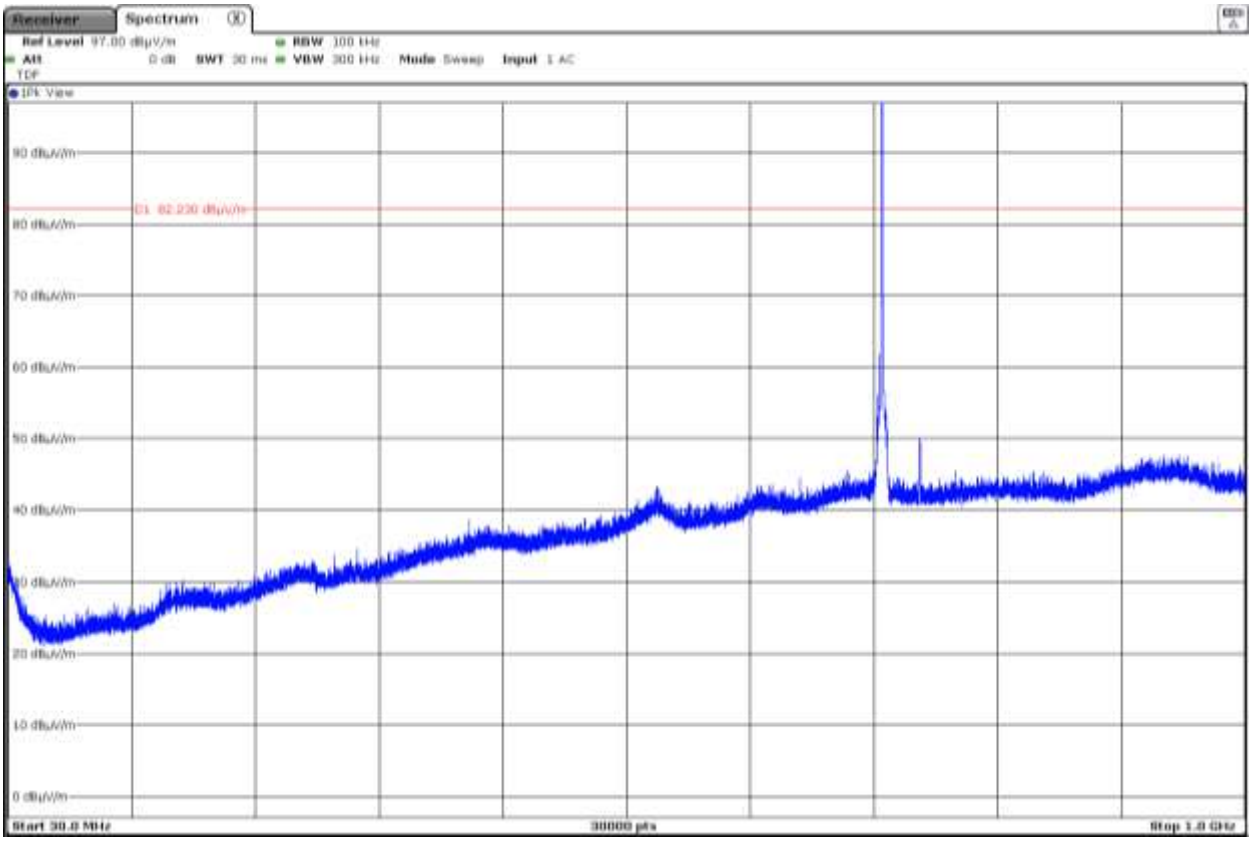
Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (GHz)	Detector	E (dBµV/m)	Polarization
7.2782	Peak	48.56	H
7.4395	Peak	53.69	H
7.6595	Peak	46.27	H

Measurement uncertainty (dB)	<±4.99 for f < 1GHz <±4.98 for f ≥ 1 GHz up to 7 GHz <±4.98 for f ≥ 7 GHz up to 17 GHz <±5.08 for f ≥ 17 GHz up to 26.5 GHz <±5.33 for f ≥ 26.5 GHz up to 40 GHz

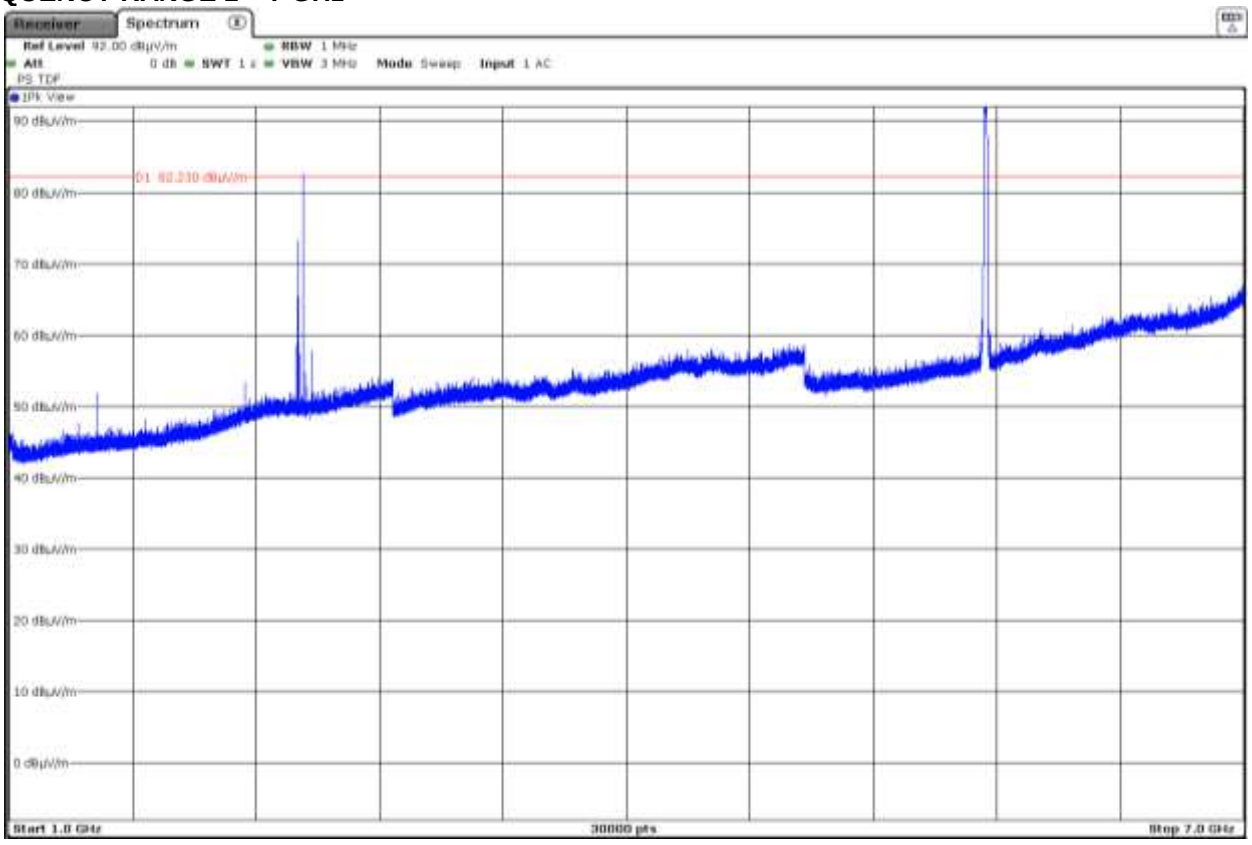
Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz



The peak above the limit is the Carrier frequency LTE Band 12 (715.3 MHz)

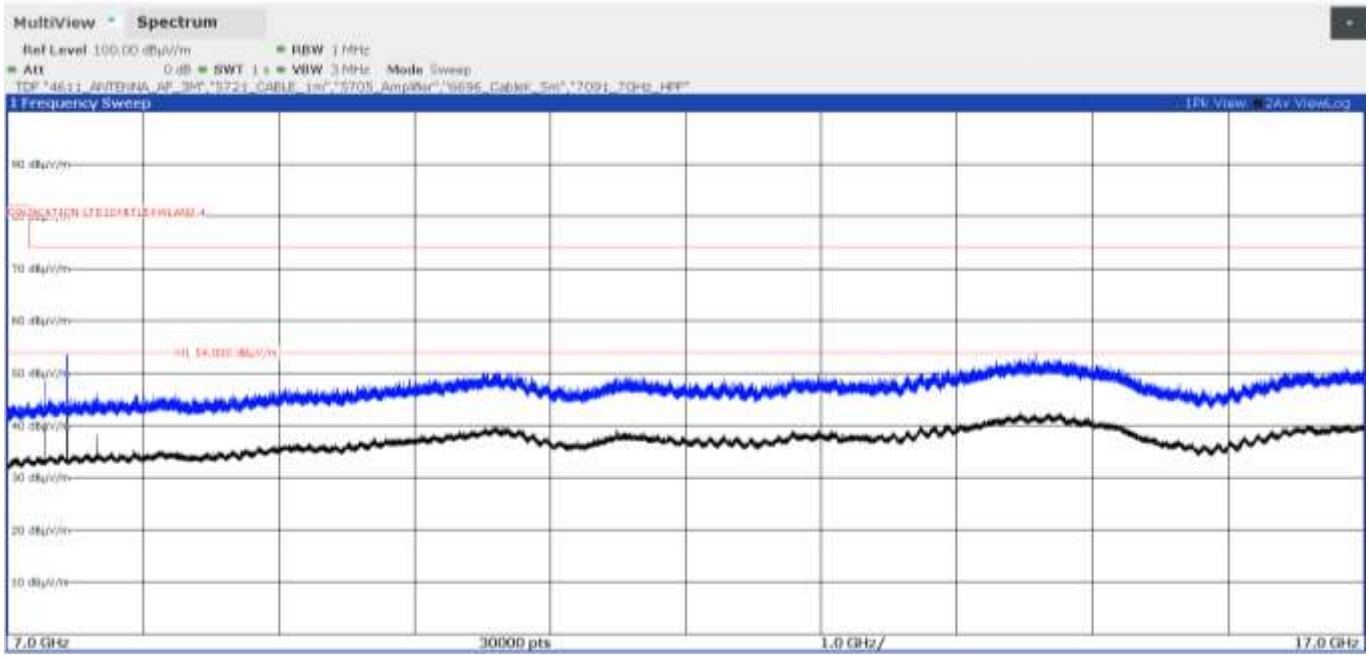
FREQUENCY RANGE 1 – 7 GHz



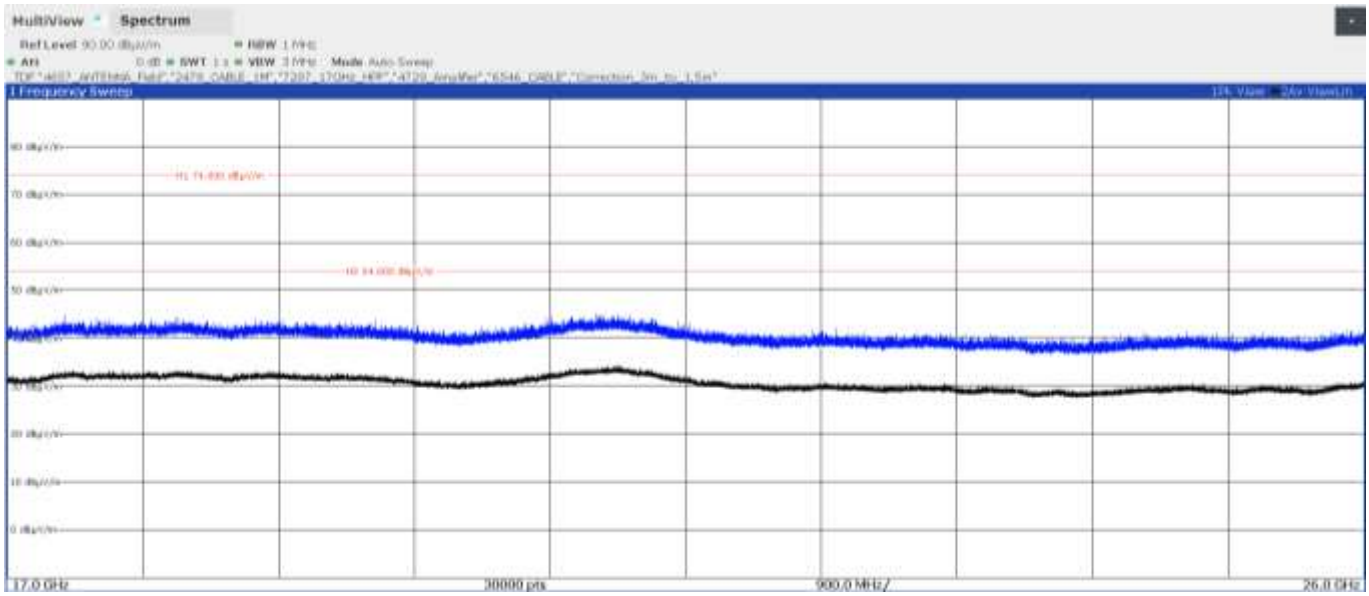
The peak close to the limit on the left is the Carrier frequency Bluetooth Low Energy (Advertising mode).

The peak above the limit on the right is the Carrier frequency 802.11 a20 (5745 MHz).

FREQUENCY RANGE 7 – 17 GHz



FREQUENCY RANGE 17 - 26 GHz



FREQUENCY RANGE 26 - 40 GHz