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

Nº 51/LE147

Test report No:
NIE: 59830RRF.007A1

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	TCAM1NA0
Other identification of the product	HW version: E4.2 SW version: PI007.1 FCC ID: KR5TCAM1NA0 IC: 7812D-TCAM1NA0
(*) 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) (10-1-19 Edition): Measurement standard. USA FCC Part 22 (10-1-19 Edition): Public Mobile Services. USA FCC Part 24 (10-1-19 Edition): Personal Communications Services. USA FCC Part 27 (10-1-19 Edition): Miscellaneous Wireless Communications Services. USA FCC Part 15.209 (10-1-19 Edition): Radiated emission limits; general requirements. USA FCC Part 15.247 (10-1-19 Edition): Operation within the bands 902 - 928 MHz, 2400 -2483.5 MHz, and 5725 - 5850 MHz. USA FCC Part 15.407 (10-1-19 Edition): General technical requirements. CANADA RSS-130 Issue 1, Oct. 2013. CANADA RSS-132 Issue 3, Jan. 2013. CANADA RSS-133 Issue 6 Amendment 1, Jan. 2018. CANADA RSS-139 Issue 3, Jul. 2015. 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. Guidance for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices 789033 D02 General U-NII Test Procedures New Rules v02r01 dated Dec 14, 2017. ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices. ANSI C63.26-2015. ANSI/TIA-603-E: 2016.
Approved by (name / position & signature)	Jose Carlos Luque RF Lab. Supervisor 74841983Y JOSE CARLOS LUQUE (C:A29507456) Firmado digitalmente por 74841983Y JOSE CARLOS LUQUE (C:A29507456) Fecha: 2020.07.21 13:59:09 +02'00'
Date of issue	2020-07-21
Report template No	FDT08_22 (*) "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:

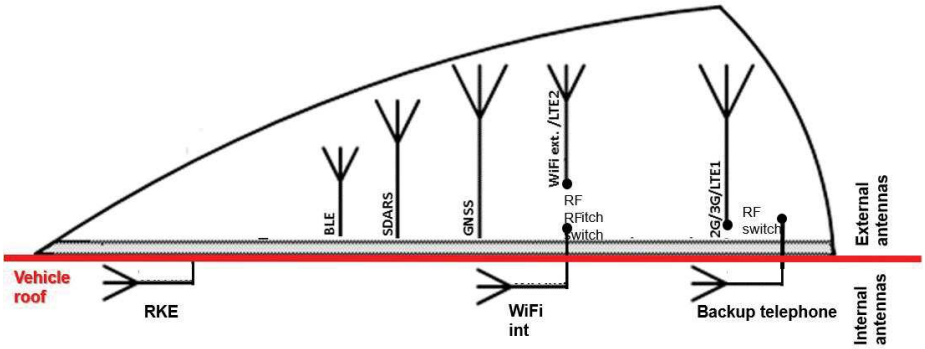
1. Information relating to the description of the sample ("Identification of the item tested", "Trademark", "Model and/or type reference tested").
2. The sample of the Telematics and Connectivity Antenna Module (TCAM) model Continental TCAM1NA0 is a vehicle antenna module for telematic and connectivity purposes.

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

The TCAM1NA0 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
59830B/052	Telematics and Connectivity Antenna Module	Continental TCAM1NA0	SNRD004262	2020/01/31
59830B/029	CAN-Box	Kredig CAN-STIM3	--	2019/11/11
59830B/034	Harness	--	--	2019/11/11

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

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:	☐	☐	☐	☐	☐
	☐	AC:	☐	☐	☐	☐	☐
	☒	DC: 12V					
	☐	DC:					
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: -40°C to 85°C Supply Voltage Range: 8 V to 16 V DC						
Software version .....:	PI007.1						
Hardware version .....:	E4.2						
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-001	Continental Automotive Systems
	ISM/RKE 434 MHz RF receiver module	Model: A2C38291300	Continental Automotive GmbH
Accessories (not part of the test item) .....:	Description	Type	Manufacturer
	bracket		
	1x harness w/o USB		
	3x harness w USB		
	Inlay disc		
	Design cap		
Documents as provided by the applicant.....:	Description	File name	Issue date
	TCAM_Testhouse_Manual_ 29Oct2019_V1		

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)	2020-02-13
Date (finish)	2020-03-24

Document history

Report number	Date	Description
59830RRF.007	2020-04-16	First release.
59830RRF.007A1	2020-07-21	Second release. A sentence in "**Appendix C"** section "**Radiated Emission - Test Method"** is modified to clarify that the equipment comply the licensed and unlicensed limits. The FCC §15.209(a) limit is added to results in CELLULAR LTE Band 7 and Cellular LTE Band 12 with Bluetooth Low Energy / GFSK, WLAN 2.4GHz in 802.11b and WLAN 5 GHz (U-NII-1 and 3) in 802.11 a20 / 6 Mbps. The Cellular LTE band 12 measurement tables with Bluetooth Low Energy / GFSK and 802.11b and the Cellular LTE band 12 with Bluetooth Low Energy / GFSK and WLAN 5 GHz (U-NII-1 and 3) in 802.11 a20 / 6 Mbps are modified. This modification test report cancels and replaces the test report 59830RRF.007

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 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar

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 %
Air pressure	Min. = 860 mbar Max. = 1060 mbar

Remarks and comments

The tests have been performed by the technical personnel: José Manuel Jiménez, Miguel Manuel López, Miguel Ángel Torres, Pablo Redondo, Nicolás Salguero, José Carlos Moreno, Alfonso Gutiérrez.

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 7 GHz ROHDE AND SCHWARZ ESR7	2018/10	2020/10
4.	Biconical/Log Antenna 30MHz - 6GHz ETS LINDGREN 3142E	2017/09	2020/09
5.	Signal and Spectrum Analyzer ROHDE AND SCHWARZ FSV40	2018/02	2020/02
6.	RF Pre-amplifier G>30dB, 1-18GHz BONN ELEKTRONIK BLMA 0118-3A	2019/04	2020/04
7.	Horn antenna 1-18 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9120 D	2018/01	2021/01
8.	Broadband Horn Antenna 18 - 40 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9170	2018/07	2021/07
9.	Signal and Spectrum Analyzer ROHDE AND SCHWARZ FSV40	2019/10	2021/10
10.	RF Pre-amplifier 40 dB, 10 MHz - 6 GHz BONN ELEKTRONIK BLNA 0160-01N	2019/02	2020/08
11.	EMI Test Receiver 7 GHz ROHDE AND SCHWARZ ESR7	2019/10	2021/10
12.	Biconical/Log Antenna 30 MHz - 6 GHz ETS LINDGREN 3142E	2017/04	2020/04
13.	DC Power Supply 30V/5A KEYSIGHT TECHNOLOGIES, U8002A	N.A.	N.A.
14.	Digital Multimeter, FLUKE 175	2019/10	2020/10
15.	Signal and Spectrum Analyzer ROHDE AND SCHWARZ FSV40	2019/09	2021/09
16.	RF Pre-amplifier, 40 dB ,1-18 GHz BONN ELEKTRONIK BLMA 0118-1M	2019/04	2020/04
17.	Horn Antenna 1-18 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9120 D	2019/11	2022/11
18.	RF Pre-amplifier G>30 dB, 18 GHz - 40 GHz BONN ELEKTRONIK BLMA 1840-1M	2019/02	2021/02

Testing verdicts

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

Summary

FCC PART 15 / FCC PART 22 / FCC PART 24 / FCC PART 27 / RSS-247 / RSS-130 / RSS-132 / RSS-133 / RSS-139 / 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 22.917 / RSS-132 5.5 FCC 24.238 / RSS-133 6.5 FCC 27.53 / RSS-139 6.6 / RSS-130 4.6 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 22 / RSS-132

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: +1.7 dBi

Maximum Declared Gain for WLAN 2.4 GHz: +5.9 dBi

Maximum Declared Gain for WLAN 5 GHz U-NII-1: +3.6 dBi

Maximum Declared Gain for WLAN 5 GHz U-NII-3: +5.2 dBi

Maximum Declared Gain for CELLULAR:

LOW Bands	GAIN	ANTENNA TYPE
2G Band 850 MHz WCDMA FDD V LTE FDD 5	+4 dBi	Internal (3D)

TEST FREQUENCIES:

Based on preliminary testing that identified those corresponding to the worst cases (with the highest E.I.R.P.):

	CELLULAR 2G (worst case of antenna)	
Band:	GSM-850	
Frequency Range:	824 – 849 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Middle: 190	836.6 MHz

	WLAN (IEEE 802.11 anac) / U-NII (worst case of antenna)	
Mode:	802.11 a20: MCS0	
Frequency Range:	5150 MHz to 5250 MHz (U-NII-1)	
Channel Spacing:	20 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Low: 36	5180
Frequency Range:	5725 MHz to 5850 MHz (U-NII-3)	
Channel Spacing:	20 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Highest: 165	5825

	WLAN (IEEE 802.11 bgn2040) / Digital Transmission System (DTS) (worst case of antenna)	
Mode:	802.11 b: 1, 2, 5.5 & 11 Mbps (SISO)	
Channel Spacing:	20 MHz	
Frequency Range:	2412 MHz to 2472 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	1	2412
	11	2462

	Bluetooth LE	
Mode:	GFSK	
Channel Spacing:	1 MHz	
Frequency Range:	2400 MHz to 2483.5 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	39	2480
	37	2402

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 and FCC Unlicensed National Information Infrastructure (U-NII) Devices 789033 D02 General U-NII Test Procedures New Rules v02r01 dated Dec 14, 2017.

.

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.

Transmission modes selected with each radio (based on preliminary testing that identified those corresponding to the worst cases)**:**

* CELLULAR 2G: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in GSM-850 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 b / 1Mbps 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) mode configuration as this 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 GSM-850, WLAN 2.4GHz in 802.11 b / 1 Mbps, 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 GSM-850, WLAN 5GHz (U-NII-1) in 802.11 a20 / 6 Mbps, Bluetooth Low Energy / GFSK.

3. CELLULAR 2G, WLAN 5 GHz, BLUETOOTH Co-Location, with the EUT configured to simultaneously transmit three signals at maximum output power, CELLULAR 2G in GSM-850, 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.

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

1. 2G Band GSM-850. FCC §2.1053 & §22.917 / RSS-132 Clause 5.5.

FCC §22.917:

> (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-132 Clause 5.5:

> i. In the first 1.0 MHz band immediately outside and adjacent to each of the sub-bands specified in Section 5.1, the power of emissions per any 1% of the occupied 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 immediately outside and adjacent to each of the sub-bands, the power of emissions in any 100 kHz bandwidth shall be attenuated (in dB) below the transmitter output power P (dBW) by at least 43 + 10 log10 p (watts). If the measurement is performed using 1% of the occupied bandwidth, power integration over 100 kHz 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 40 GHz.

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

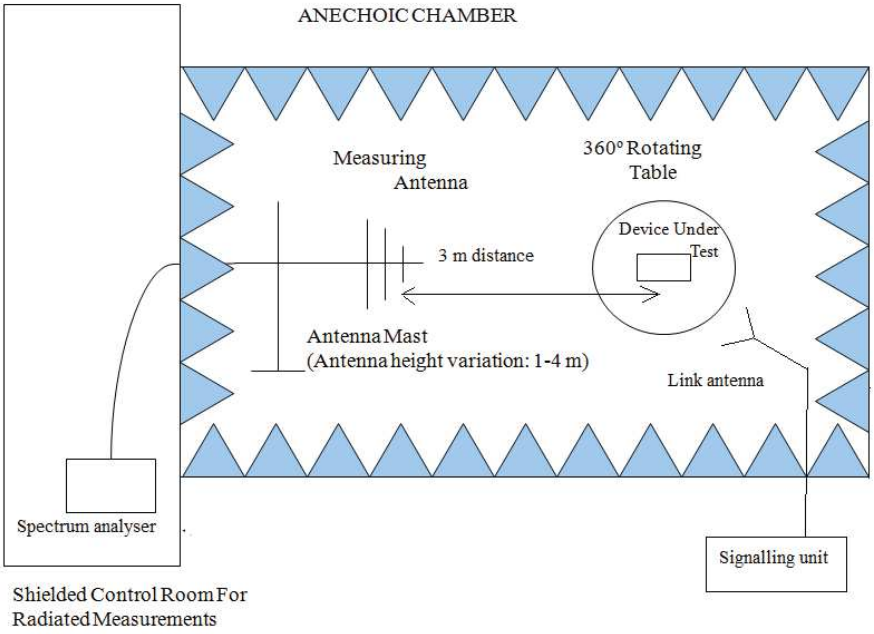
Detected emissions were maximized at each frequency by rotating the EUT and adjusting the measuring antenna height and polarization. The maximum meter reading was recorded.

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.

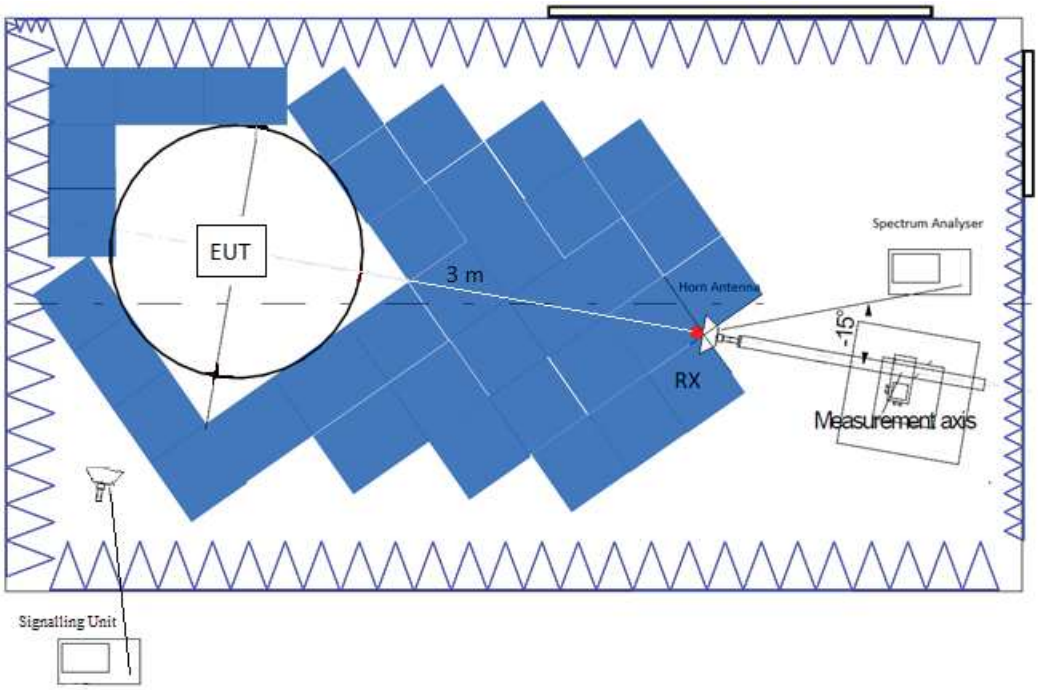
These measurements have been performed in order to check the impact of the Co-Location of all radio interfaces (that can be transmitting simultaneously).

TEST SETUP:

Radiated measurements below 1 GHz.



Radiated measurements above 1 GHz.



RESULTS:

- **Mode 2G Band GSM-850 , 802.11 b, Bluetooth Low Energy:**

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

2G Band GSM-850:	Middle Channel (836.6 MHz).
802.11 b:	High Channel (2462 MHz).
Bluetooth Low Energy:	Low Channel (2402 MHz).

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 8.49 GHz	PK	43 + 10 log (P) dB = -13 dBm -> 82.23 dBµV/m
8.49 to 26 GHz	PK	74 dBµV/m
8.49 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

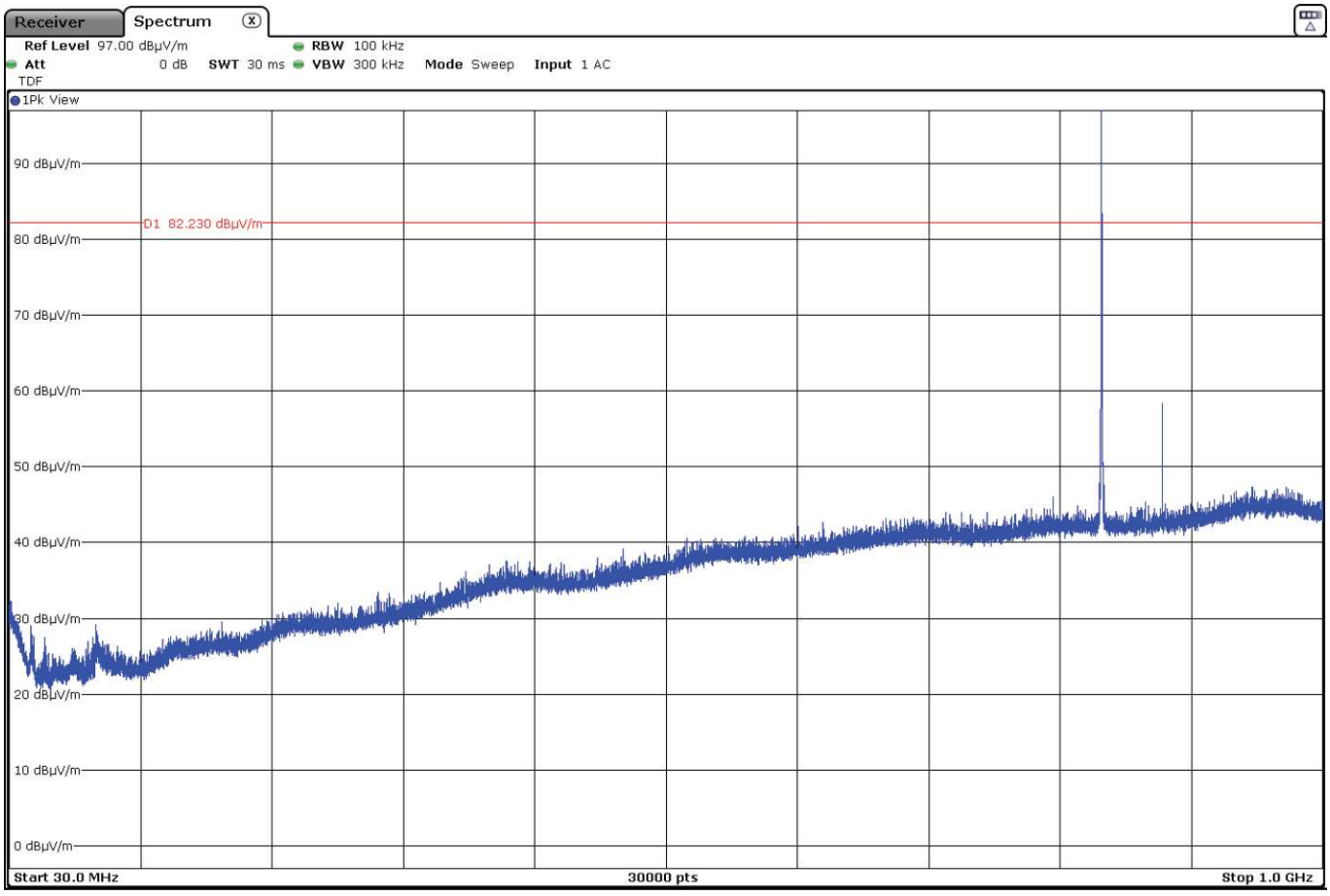
Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (GHz)	Detector	E (dBµV/m)	Polarization
7.32577	Peak	63.5	H
7.38597	Peak	64.56	H
9.8481	Peak	56.6	V

Measurement uncertainty (dB)	<±3.88 for f < 1GHz <±3.70 for f ≥ 1 GHz up to 18 GHz <±3.33 for f ≥ 18 GHz up to 26 GHz

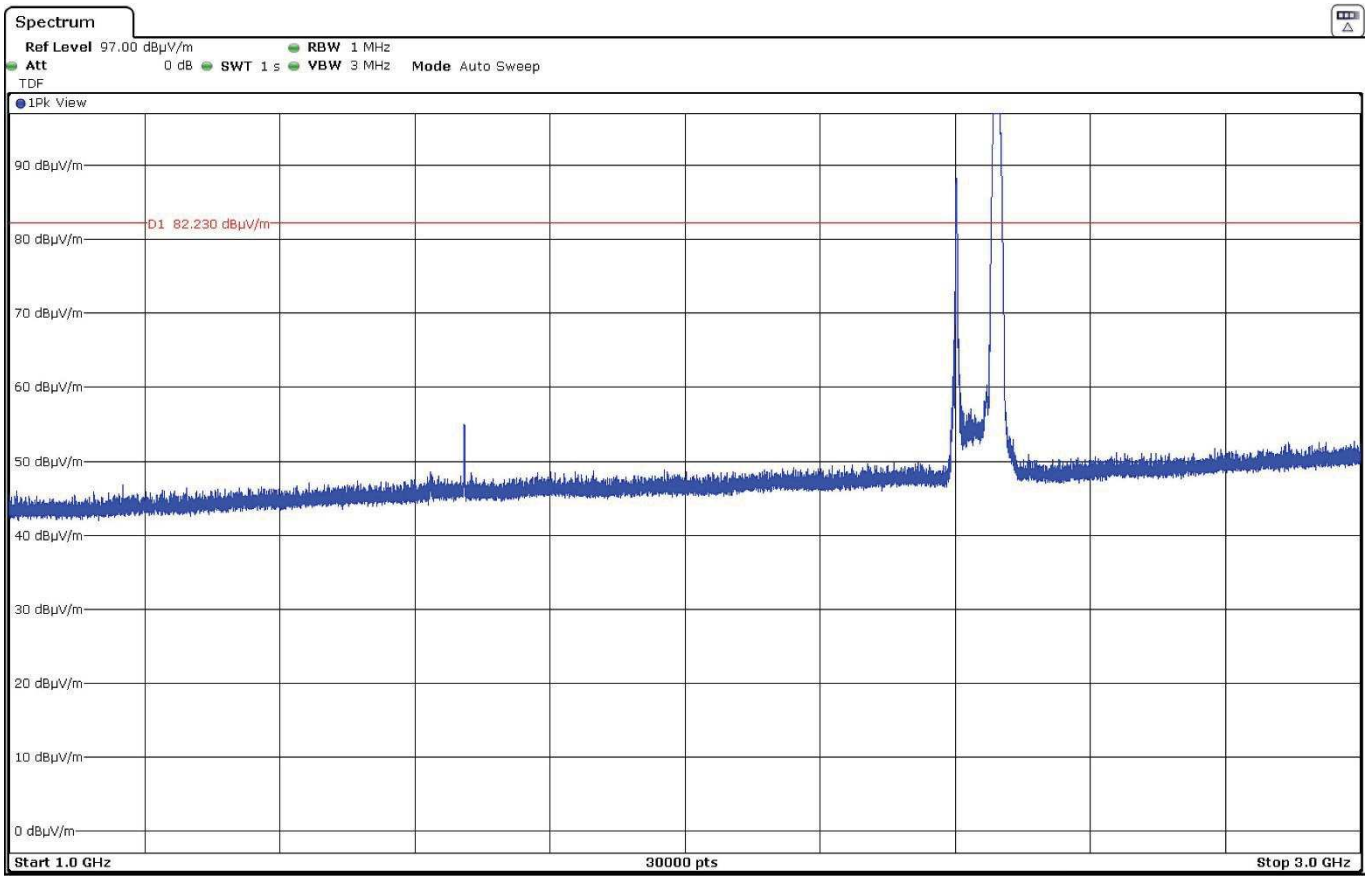
Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz



The peak above the limit is the Carrier frequency 2G Band GSM-850 (836.6 MHz). The other peak at 881.6 MHz corresponds to the downlink signal 2G Band GSM-850.

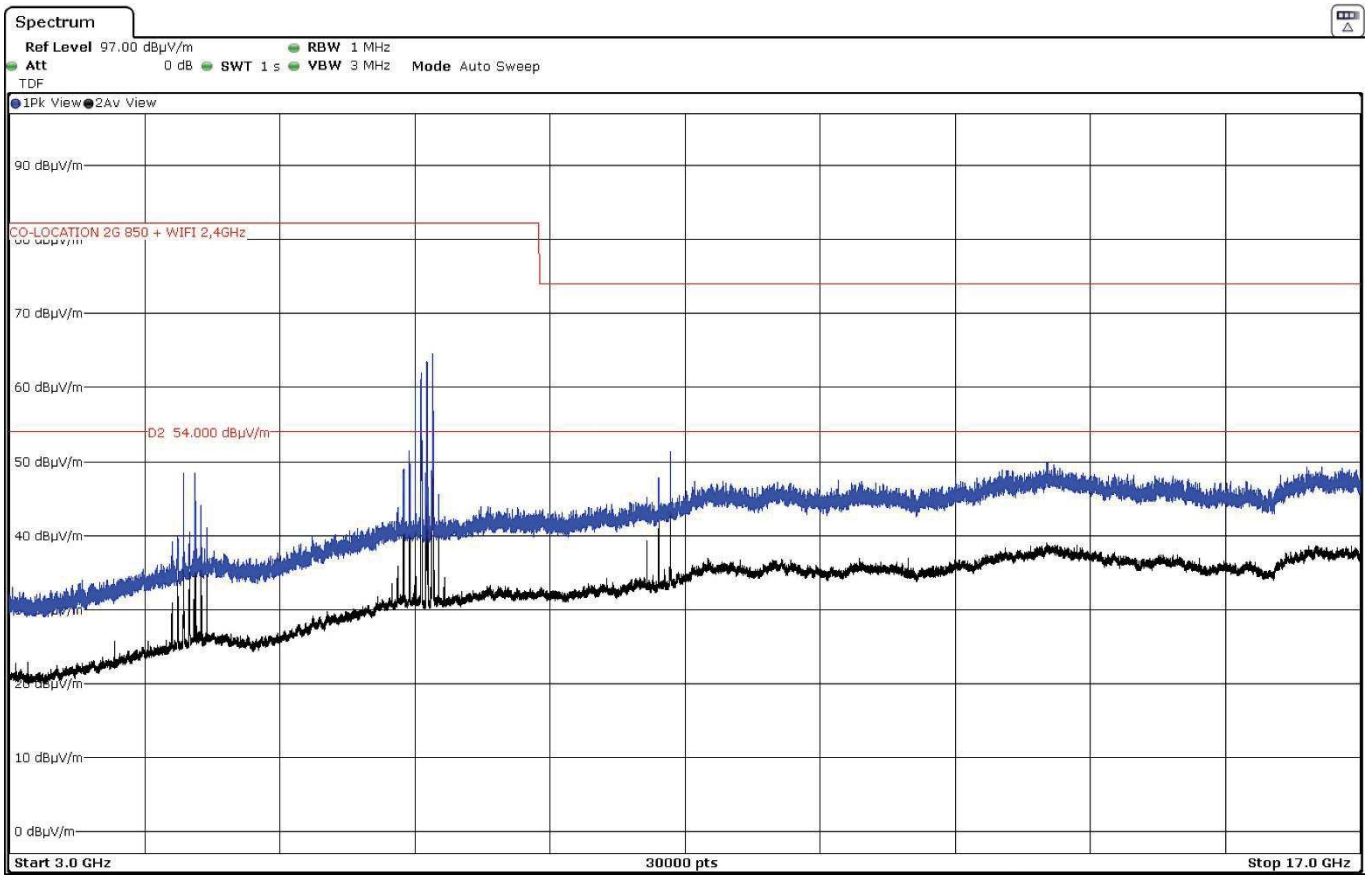
FREQUENCY RANGE 1 - 3 GHz



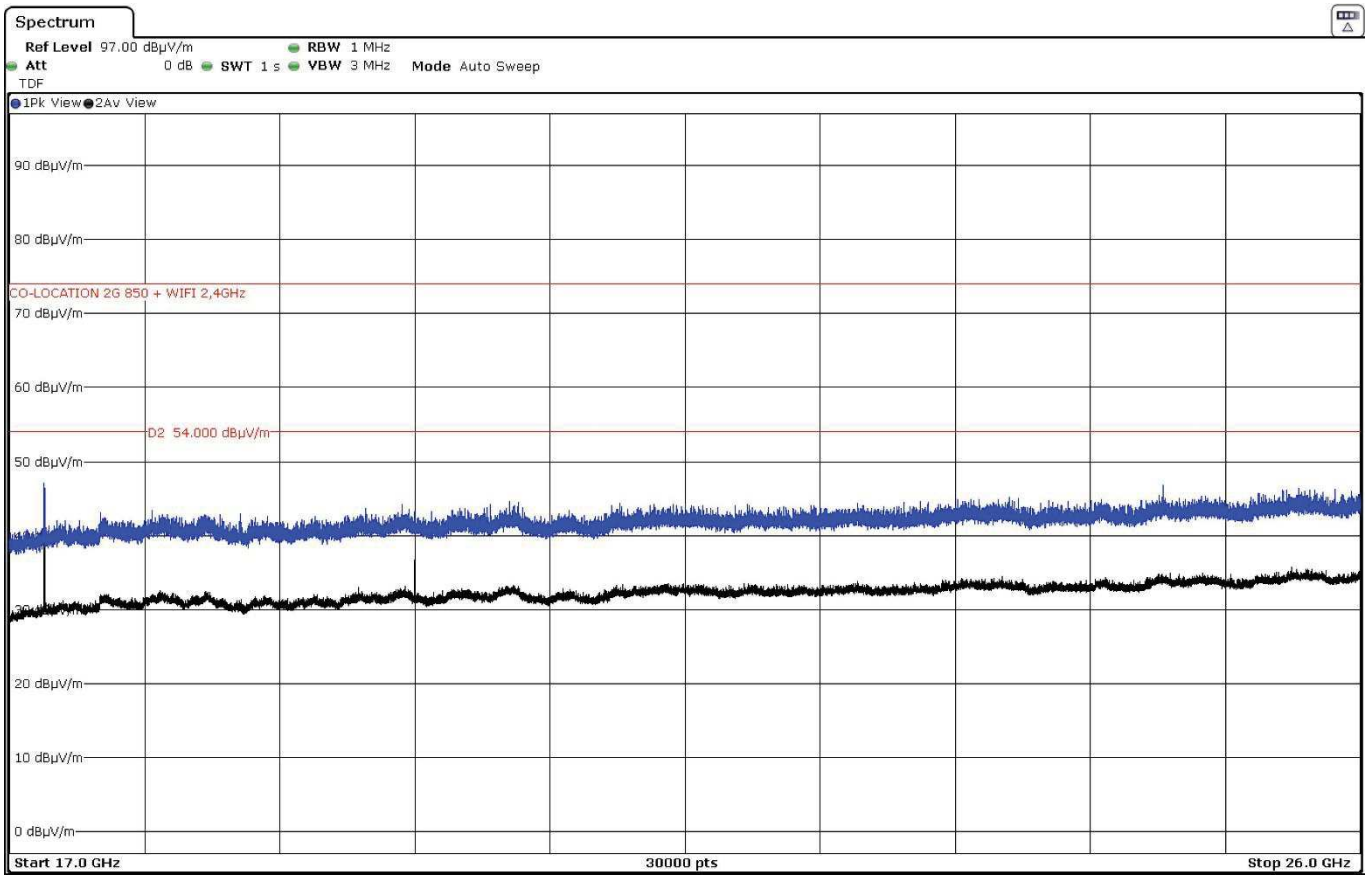
The peak above the limit on the left is the Carrier frequency Bluetooth Low Energy (2402 MHz).

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

FREQUENCY RANGE 3 – 17 GHz



FREQUENCY RANGE 17 - 26 GHz



- **Mode 2G Band GSM-850, 802.11 a20 U-NII-1, Bluetooth Low Energy:**

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

2G Band GSM-850:	Middle Channel (836.6 MHz).
802.11 a U-NII-1:	BW=20 MHz, Low Channel (5180 MHz).
Bluetooth Low Energy:	High Channel (2480 MHz).

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 8.49 GHz	PK	43 + 10 log (P) dB = -13 dBm -> 82.23 dBµV/m
8.49 to 26 GHz	PK	74 dBµV/m
26 to 40 GHz	PK	68.23 dBµV/m (**) OR 74 dBµV/m (*)
8.49 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

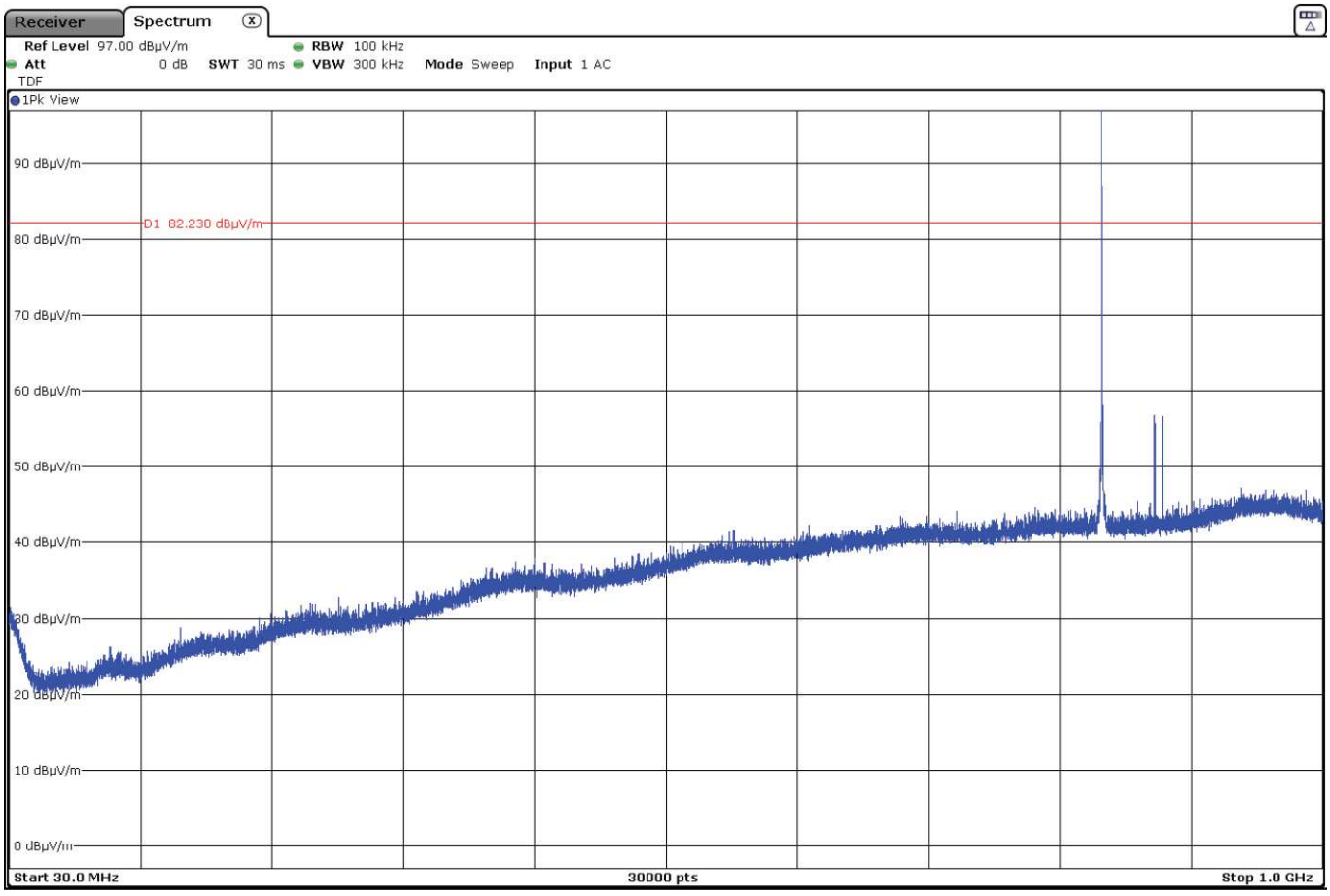
Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (GHz)	Detector	E (dBµV/m)	Polarization
39.5667	Peak	56.07	V
	Average	44.57	

Measurement uncertainty (dB)	<±3.81 for f < 1GHz <±4.72 for f ≥ 1 GHz up to 18 GHz <±3.34 for f ≥ 18 GHz up to 40 GHz

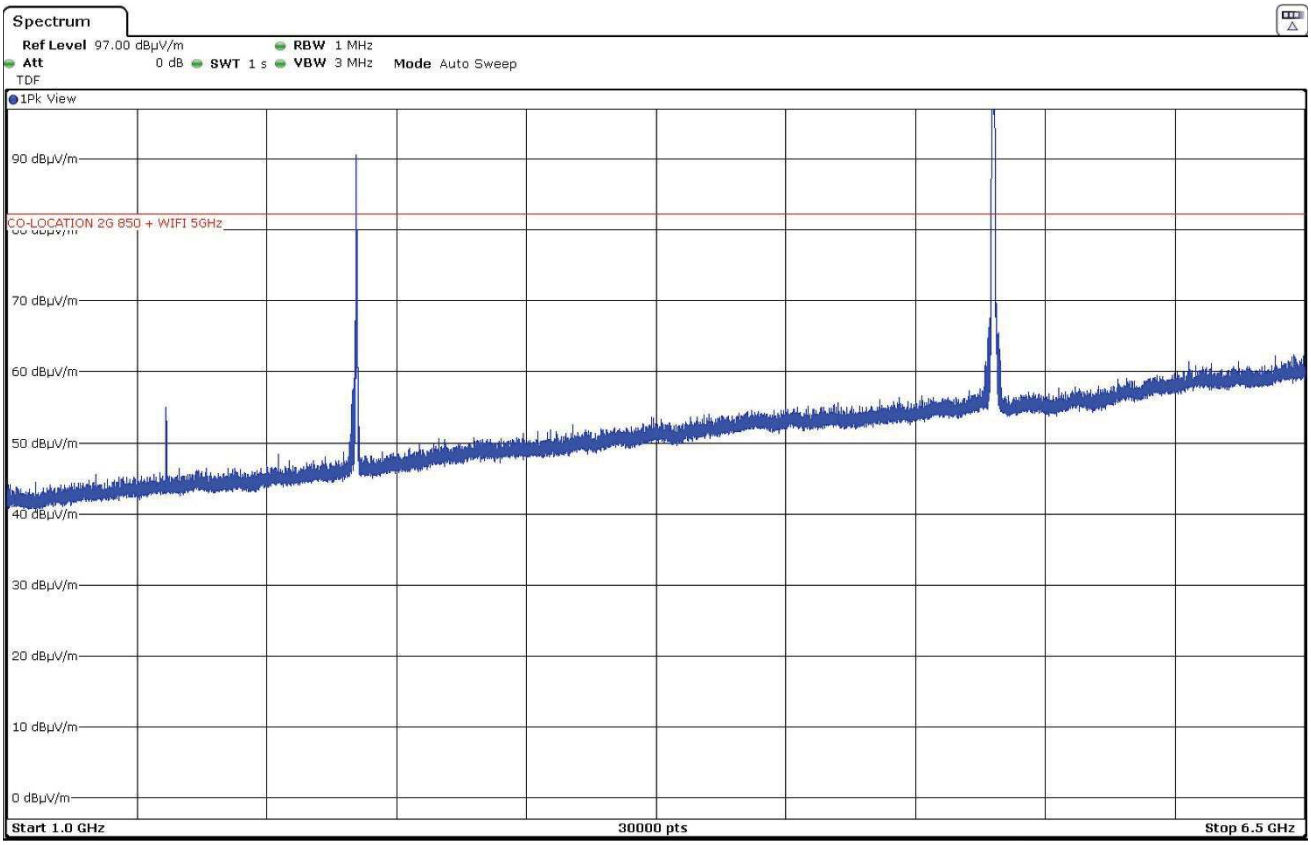
Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz



The peak above the limit is the Carrier frequency 2G Band GSM-850 (836.6 MHz). The peak at 881.6 MHz corresponds to the downlink signal 2G Band GSM-850.

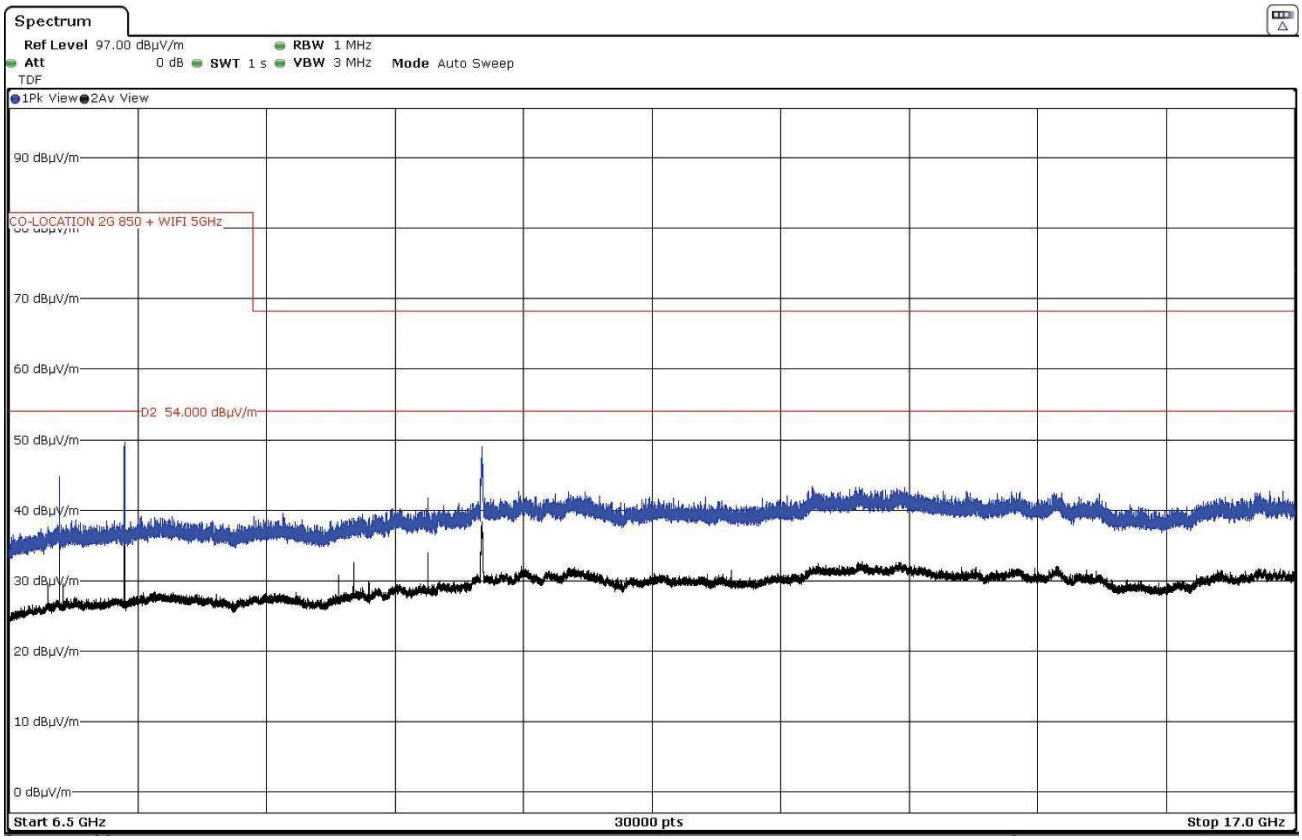
FREQUENCY RANGE 1 – 6.5 GHz



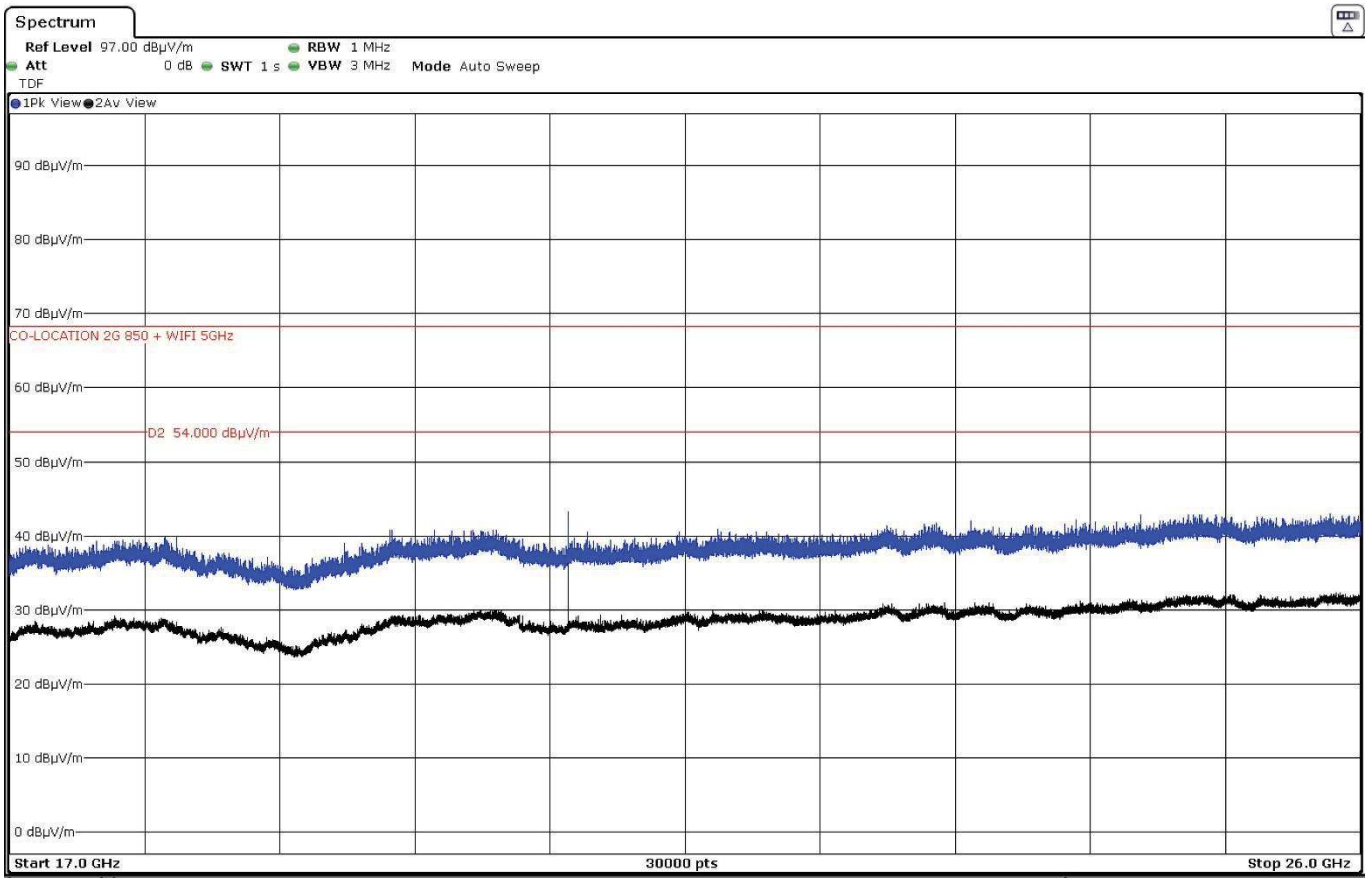
The peak above the limit on the left is the Carrier frequency Bluetooth Low Energy (2480 MHz).

The peak above the limit on the right is the Carrier frequency 802.11 a20 (5180 MHz).

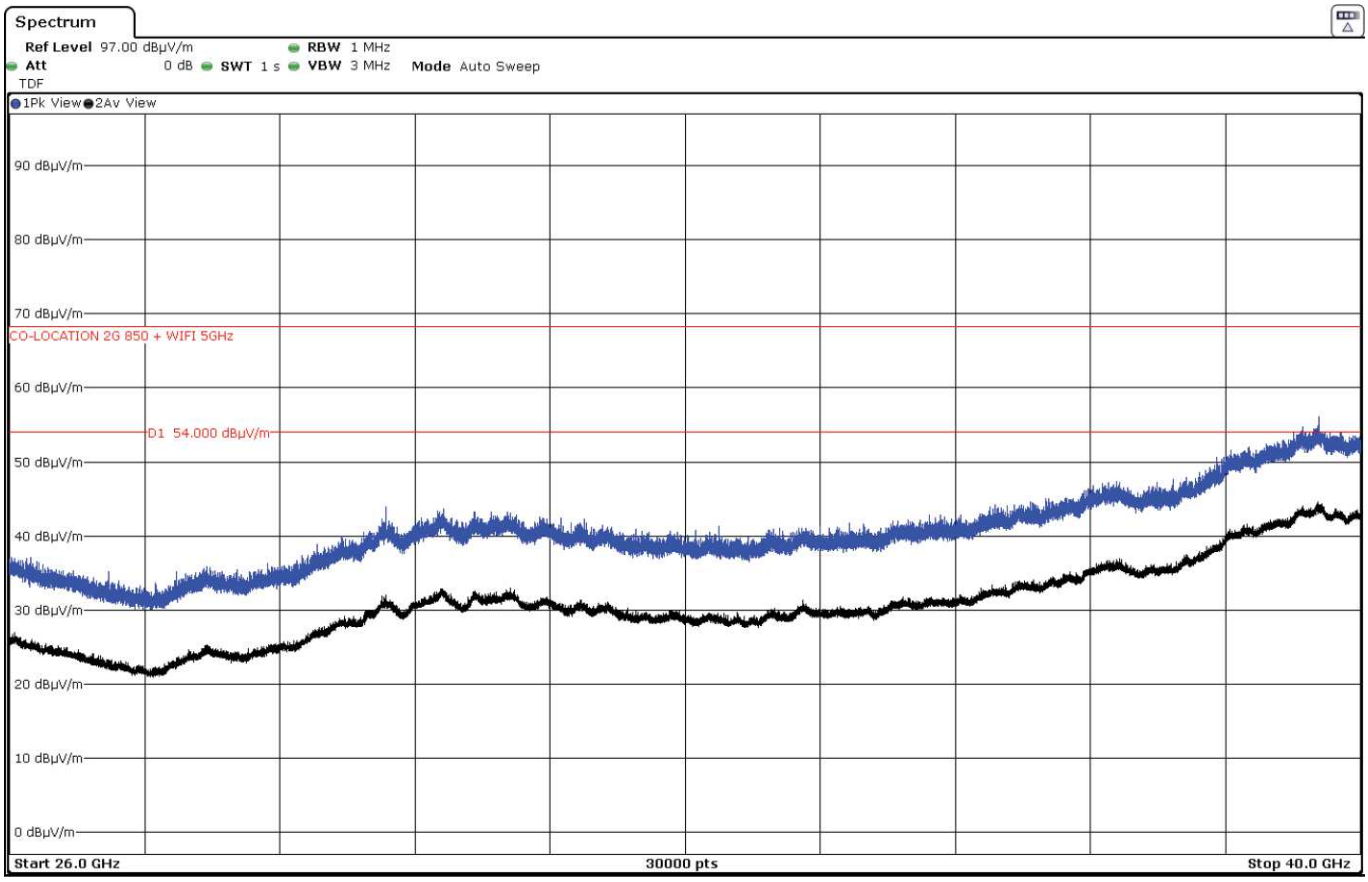
FREQUENCY RANGE 6.5 – 17 GHz



FREQUENCY RANGE 17 - 26 GHz



FREQUENCY RANGE 26 - 40 GHz



- **Mode 2G Band GSM-850, 802.11 a20 U-NII-3, Bluetooth Low Energy:**

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

2G Band GSM-850:	Middle Channel (836.6 MHz).
802.11 a U-NII-3:	BW=20 MHz, High Channel (5825 MHz).
Bluetooth Low Energy:	Low Channel (2402 MHz).

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 8.49 GHz	PK	43 + 10 log (P) dB = -13 dBm -> 82.23 dBµV/m
8.49 to 26 GHz	PK	74 dBµV/m
26 to 40 GHz	PK	68.23 dBµV/m (**) OR 74 dBµV/m (*)
8.49 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

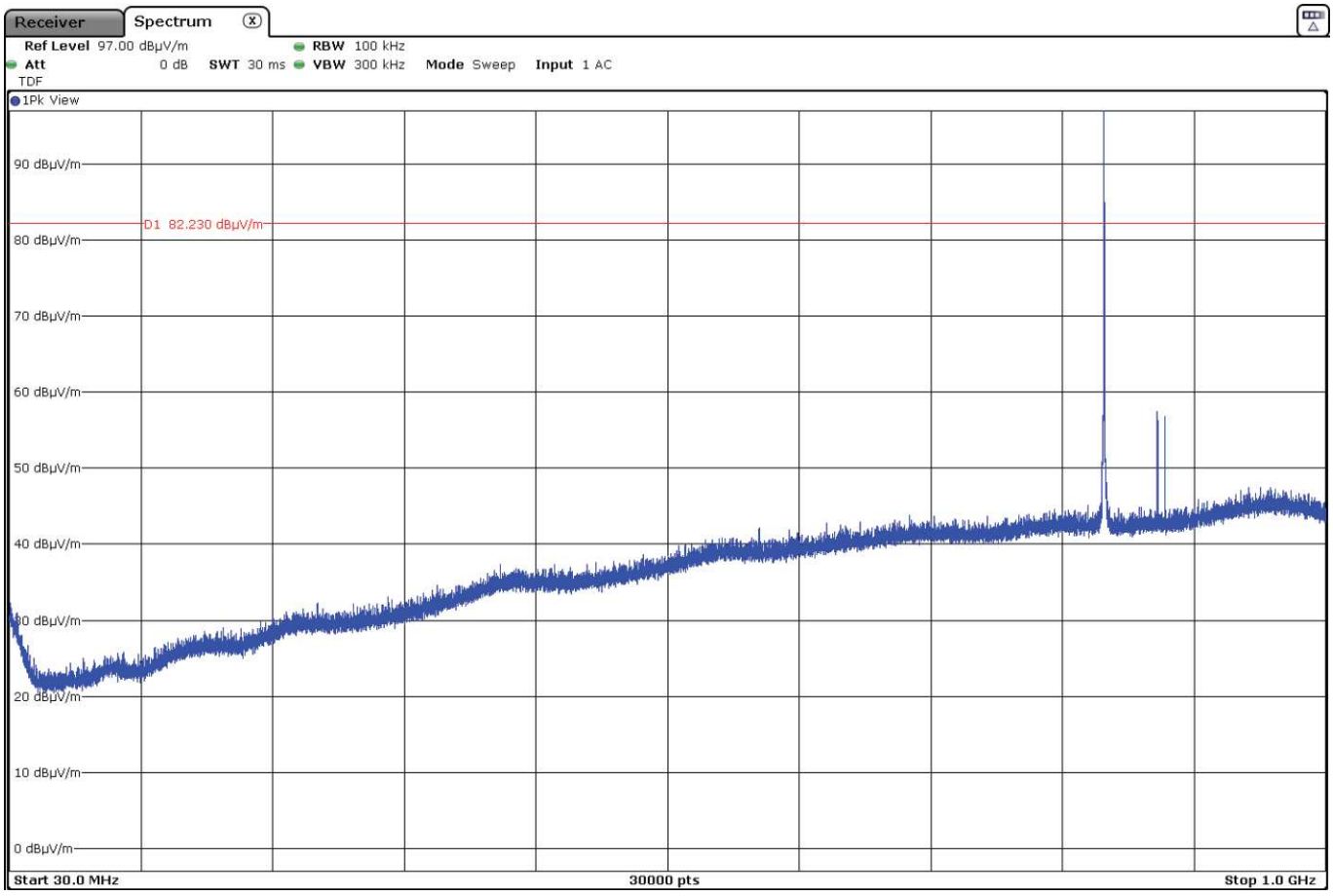
Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (GHz)	Detector	E (dBµV/m)	Polarization
39.6143	Peak	55.05	V
	Average	43.16	

Measurement uncertainty (dB)	<±3.81 for f < 1GHz <±4.72 for f ≥ 1 GHz up to 18 GHz <±3.34 for f ≥ 18 GHz up to 40 GHz

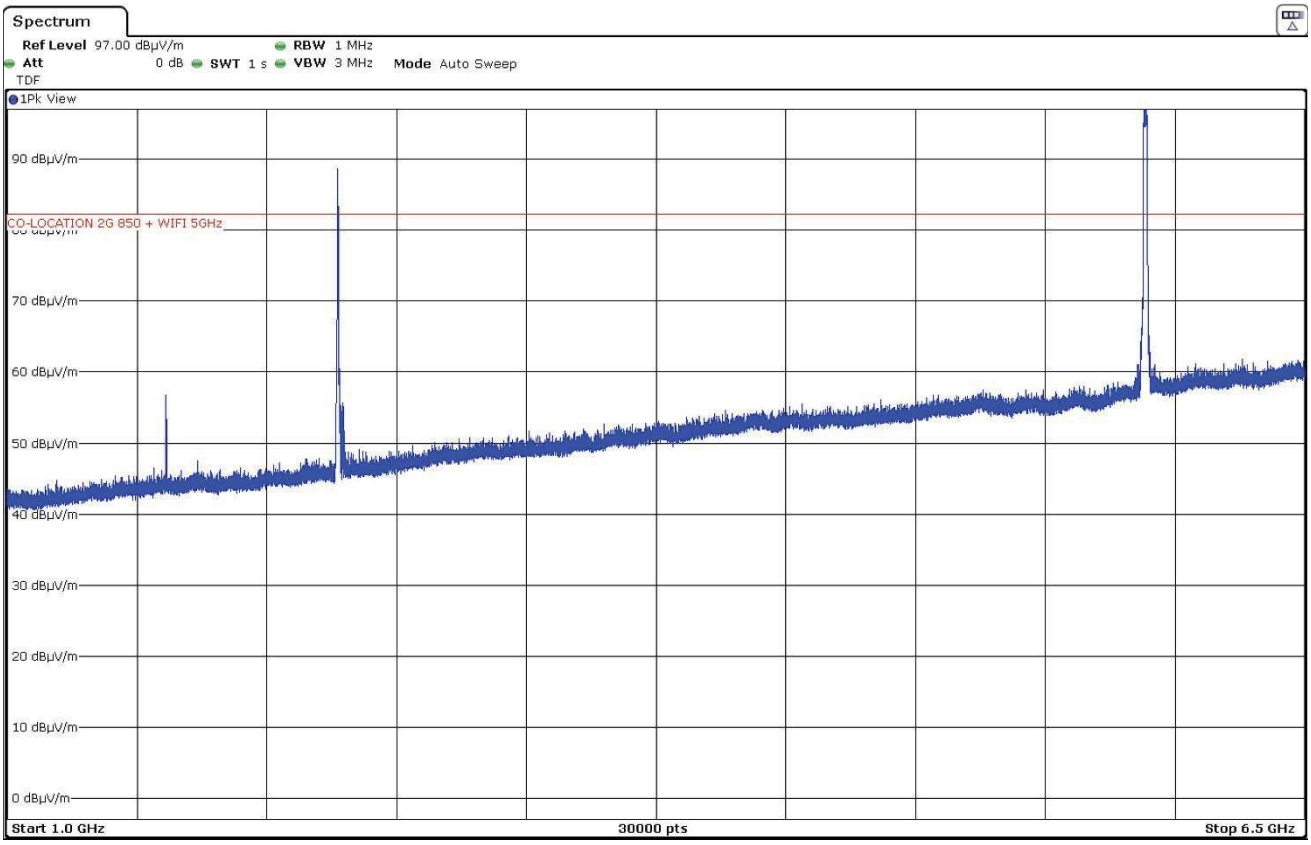
Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz



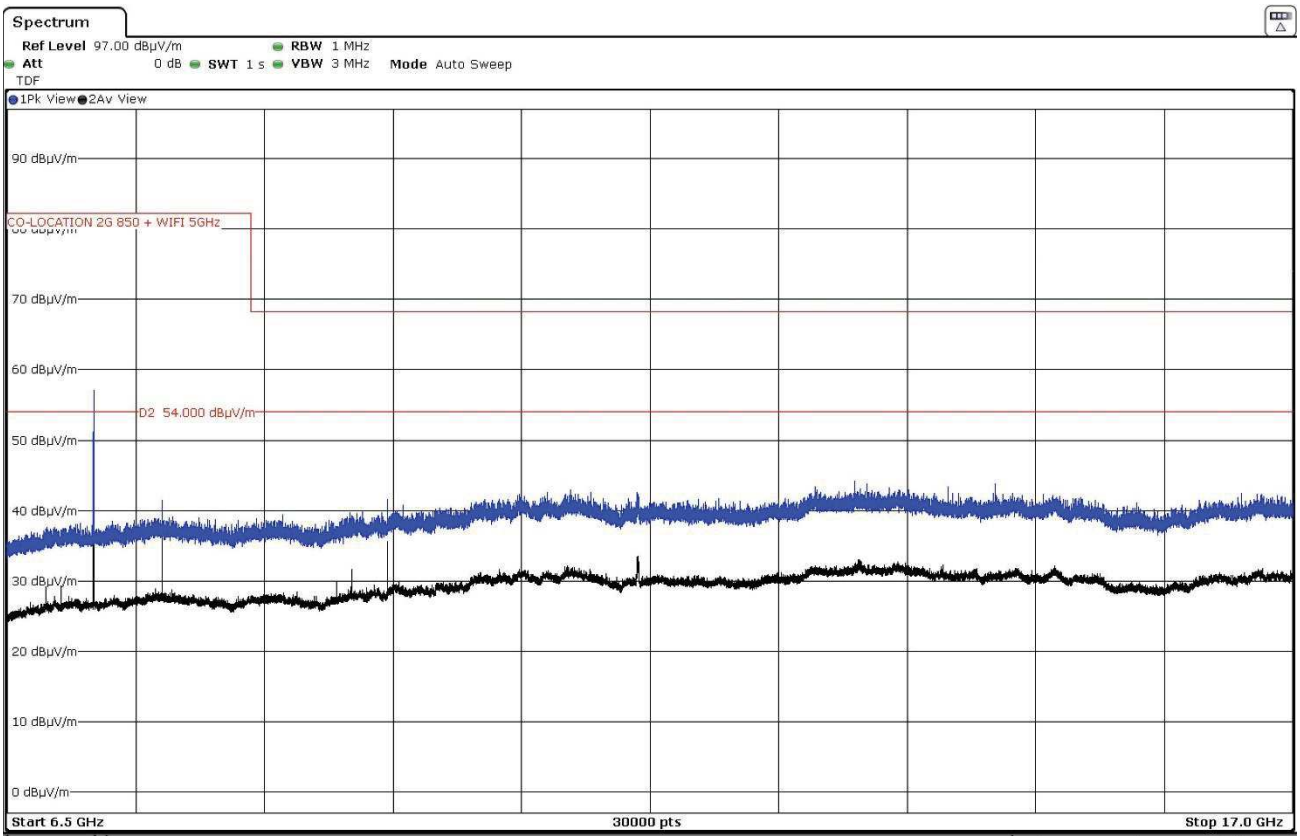
The peak above the limit is the Carrier frequency 2G Band GSM-850 (836.6 MHz). The peak at 881.6 MHz corresponds to the downlink signal 2G Band GSM-850.

FREQUENCY RANGE 1 – 6.5 GHz

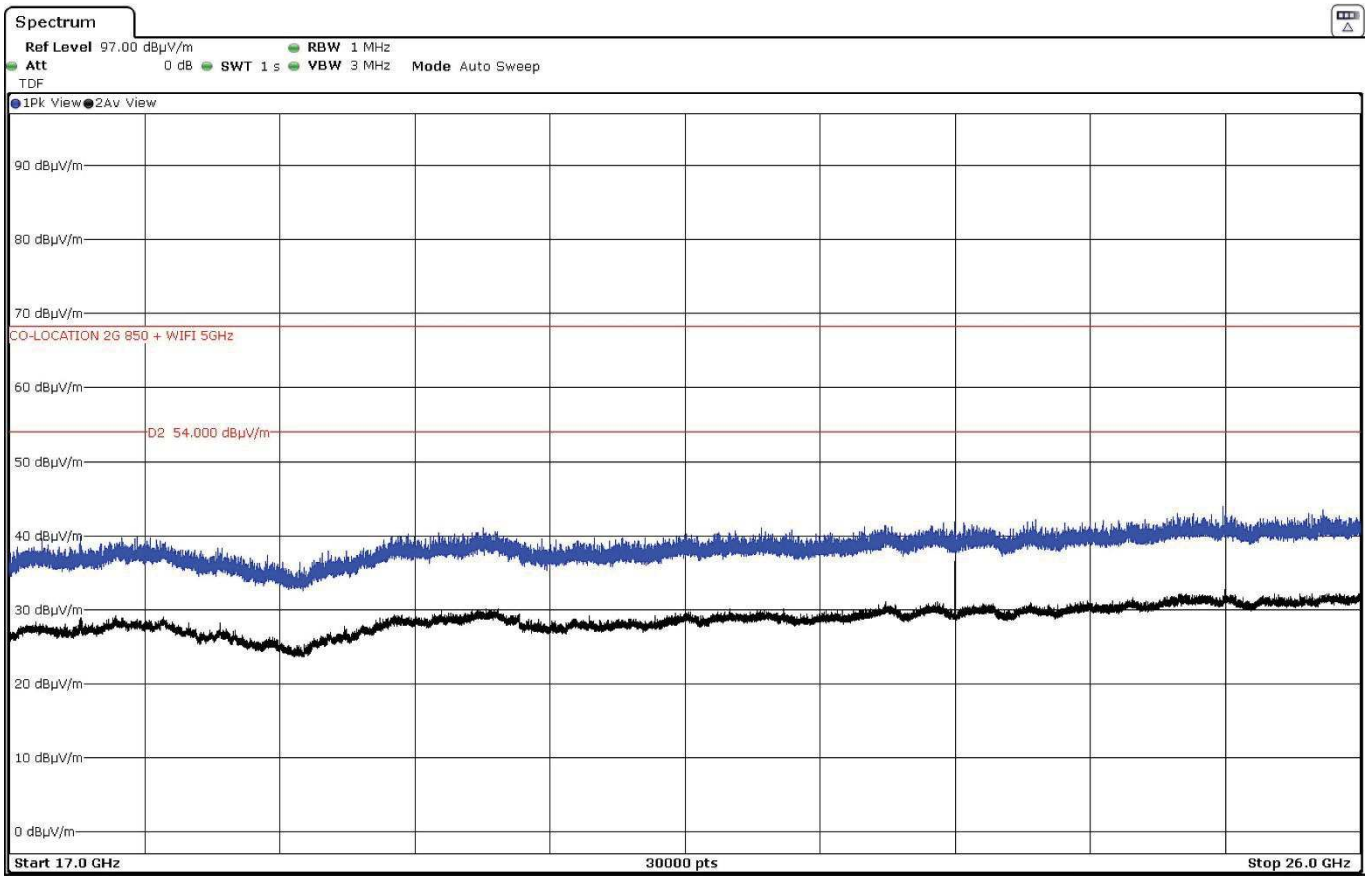


The peak above the limit on the left is the Carrier frequency Bluetooth Low Energy (2402 MHz)
The peak above the limit on the right is the Carrier frequency 802.11 a20 U-NII-3 (5825 MHz).

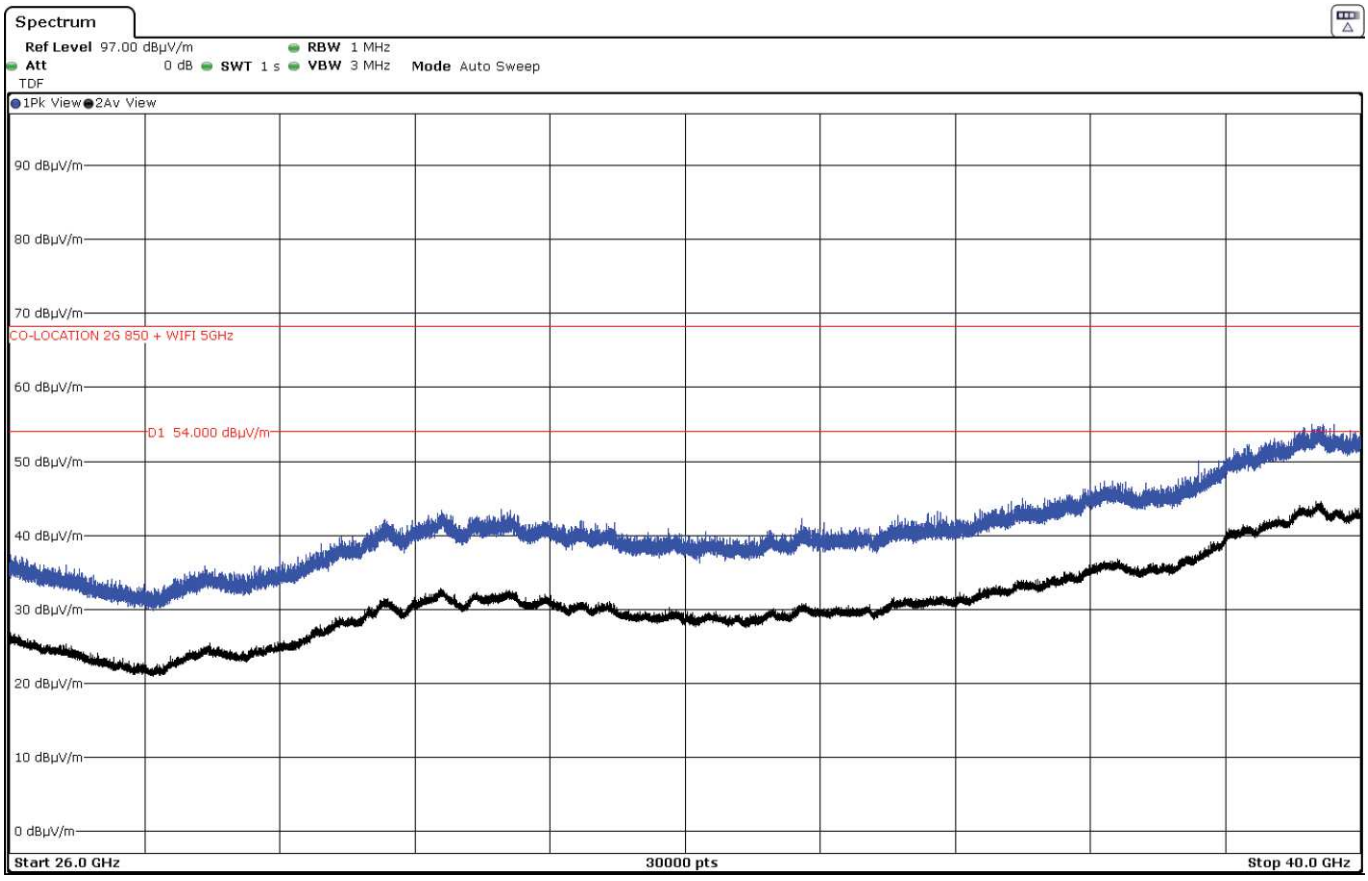
FREQUENCY RANGE 6.5 – 17 GHz



FREQUENCY RANGE 17 - 26 GHz



FREQUENCY RANGE 26 - 40 GHz



Appendix B: 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: +1.7 dBi

Maximum Declared Gain for WLAN 2.4 GHz: +5.9 dBi

Maximum Declared Gain for WLAN 5 GHz U-NII-1: +3.6 dBi

Maximum Declared Gain for WLAN 5 GHz U-NII-3: +5.2 dBi

Maximum Declared Gain for CELLULAR:

MIDDLE Bands	GAIN	ANTENNA TYPE
2G Band 1900 MHz WCDMA FDD II LTE FDD 2	+4 dBi	Internal (3D)

TEST FREQUENCIES:

	CELLULAR 2G (worst case of antenna)	
Band:	PCS-1900	
Frequency Range:	1850 – 1910 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	High: 810	1909.8

	WLAN (IEEE 802.11 n/ac) / U-NII (worst case of antenna)	
Mode:	802.11 a20: MCS0	
Frequency Range:	5150 MHz to 5250 MHz (U-NII-1)	
Channel Spacing:	20 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Low: 36	5180
Frequency Range:	5725 MHz to 5850 MHz (U-NII-3)	
Channel Spacing:	20 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	Highest: 165	5825

	WLAN (IEEE 802.11 bgn2040) / Digital Transmission System (DTS) (worst case of antenna)	
Mode:	802.11 b: 1, 2, 5.5 & 11 Mbps (SISO)	
Channel Spacing:	20 MHz	
Frequency Range:	2412 MHz to 2472 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	1	2412
	11	2462

	Bluetooth LE	
Mode:	GFSK	
Channel Spacing:	1 MHz	
Frequency Range:	2400 MHz to 2483.5 MHz	
Transmit Channel:	Channel	Channel Frequency (MHz)
	39	2480
	37	2402

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 and FCC Unlicensed National Information Infrastructure (U-NII) Devices 789033 D02 General U-NII Test Procedures New Rules v02r01 dated Dec 14, 2017.

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 b / 1Mbps 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) mode configuration as this 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 b / 1 Mbps, 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-1) in 802.11 a20 / 6 Mbps, Bluetooth Low Energy / GFSK.

3. 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 40 GHz.

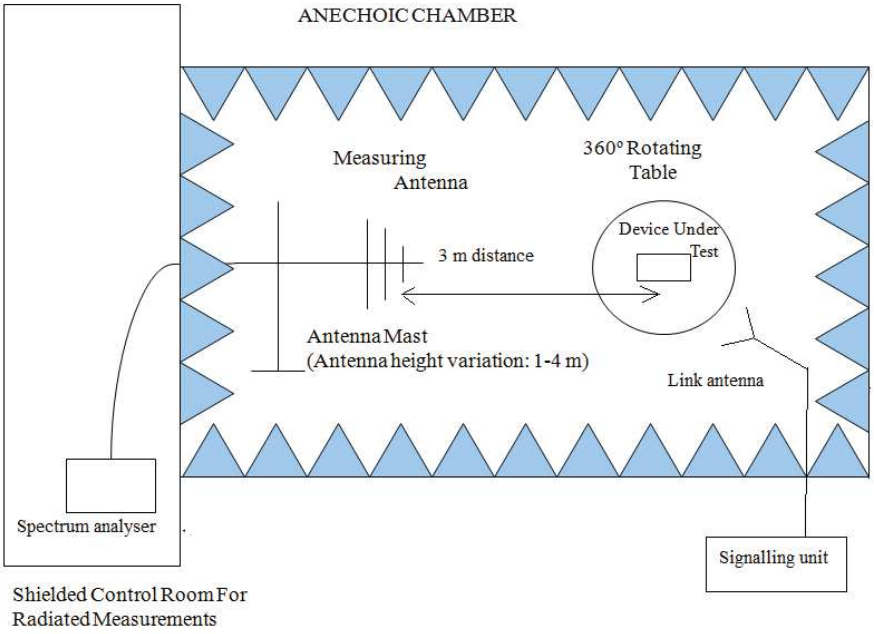
The EUT was placed on a non-conductive stand at a 3 meter distance from the measuring antenna.
Detected emissions were maximized at each frequency by rotating the EUT and adjusting the measuring antenna height and polarization. The maximum meter reading was recorded.

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.

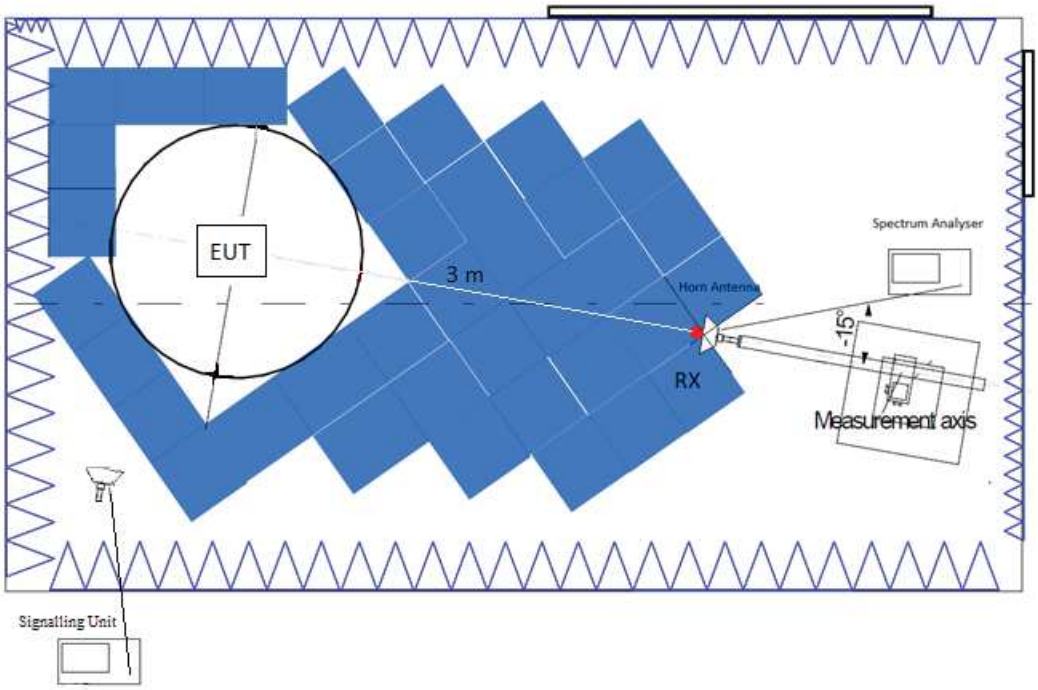
These measurements have been performed in order to check the impact of the Co-Location of all radio interfaces (that can be transmitting simultaneously).

TEST SETUP:

Radiated measurements below 1 GHz.



Radiated measurements above 1 GHz.



RESULTS:

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

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

2G Band PCS-1900:	High Channel (1909.8 MHz).
802.11 b:	High Channel (2462 MHz).
Bluetooth Low Energy:	Low Channel (2402 MHz).

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.

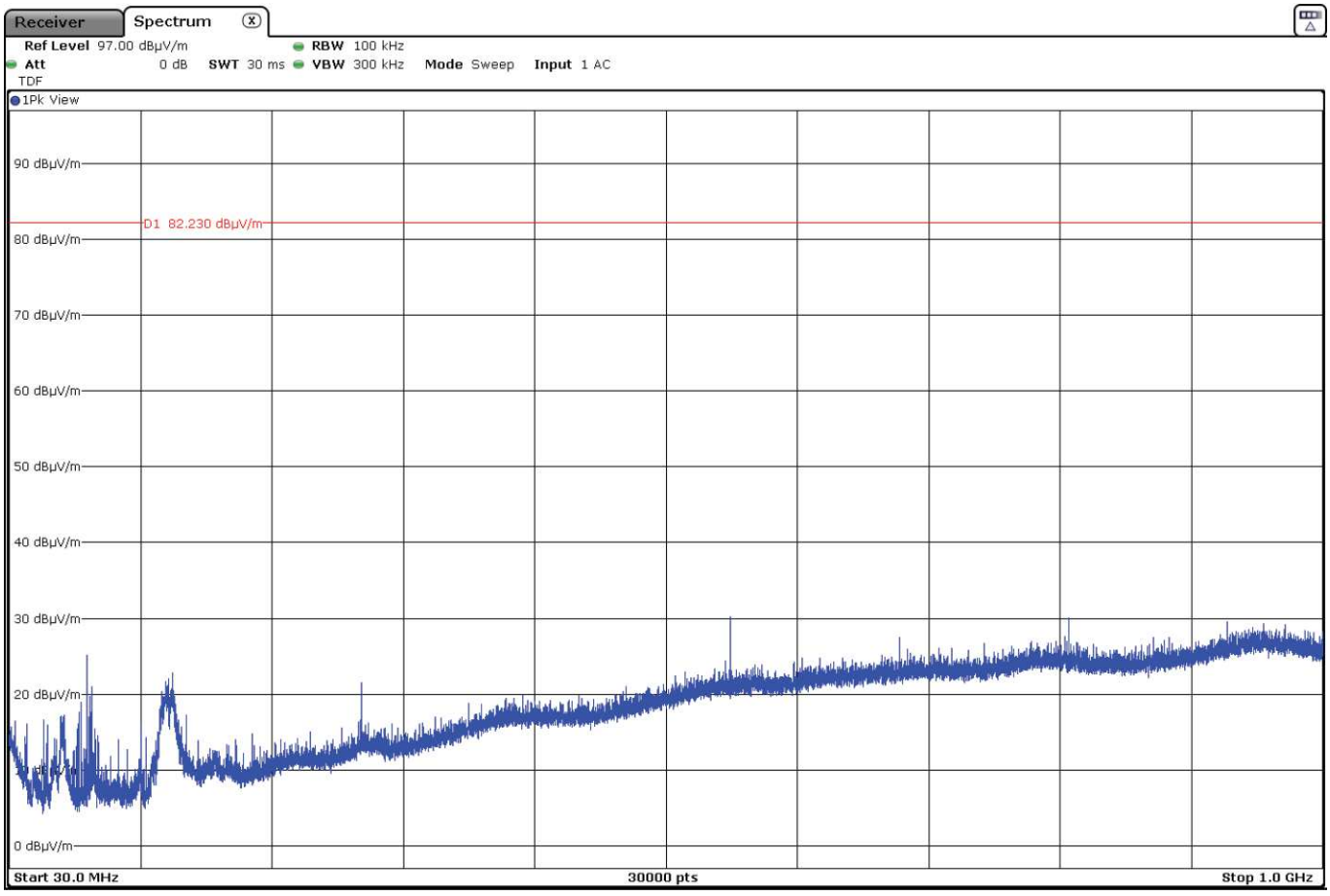
Frequency range 1 – 26 GHz

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

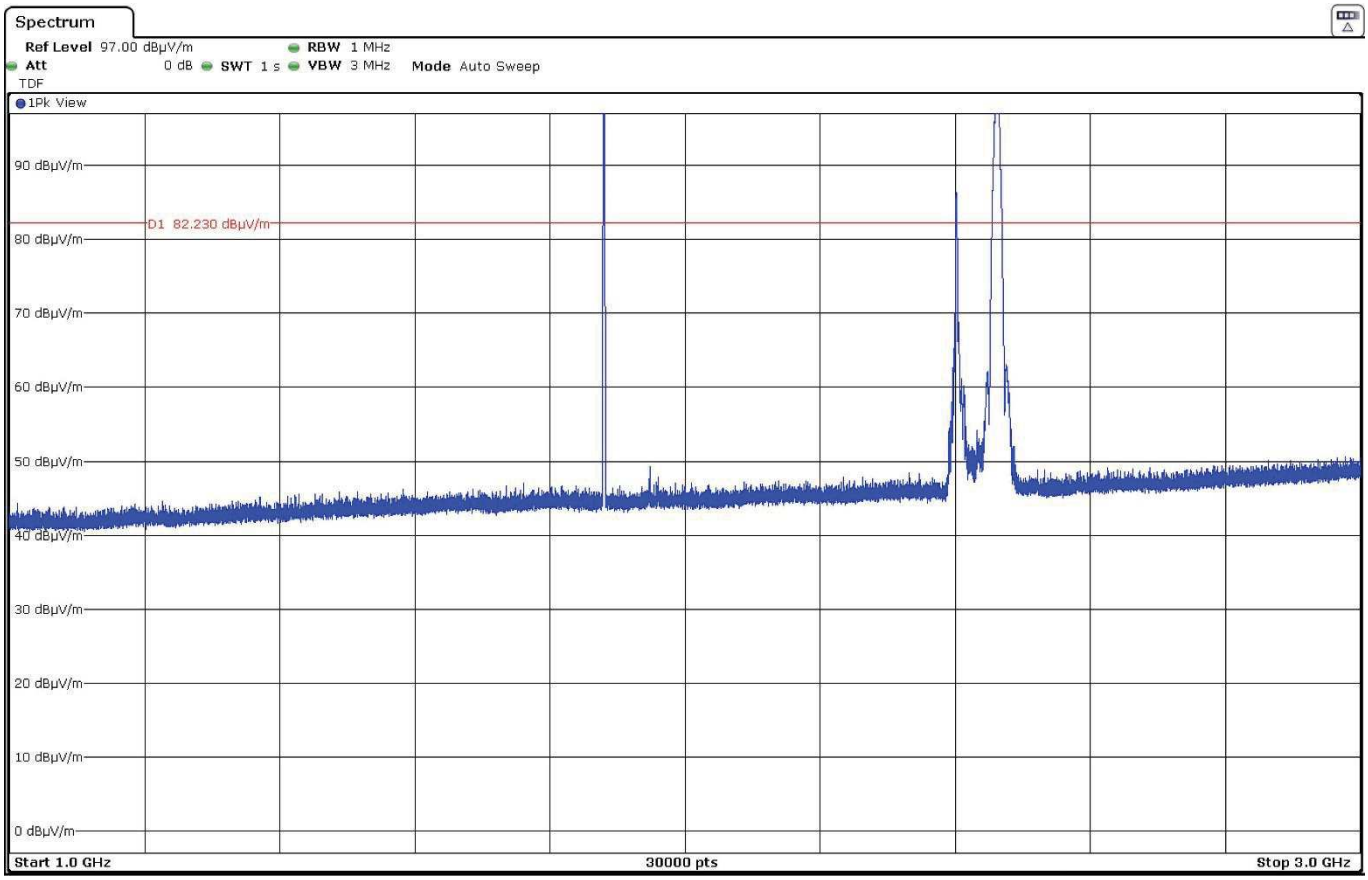
Measurement uncertainty (dB)	<±3.81 for f < 1GHz <±3.70 for f ≥ 1 GHz up to 18 GHz <±3.34 for f ≥ 18 GHz up to 26 GHz

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz



FREQUENCY RANGE 1 – 3 GHz

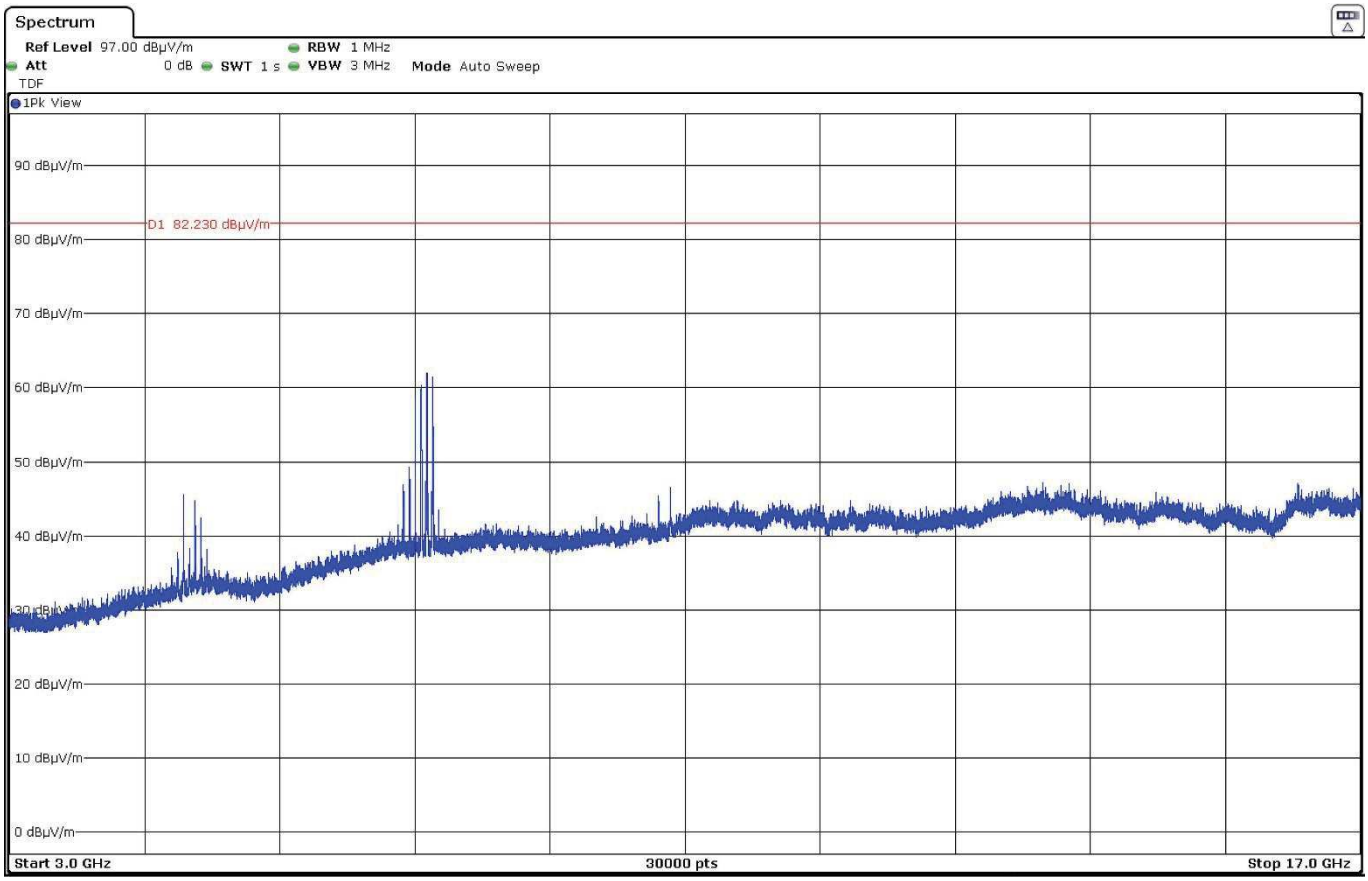


The peak above the limit on the left is the Carrier frequency 2G Band PCS-1900 (1909.8 MHz).

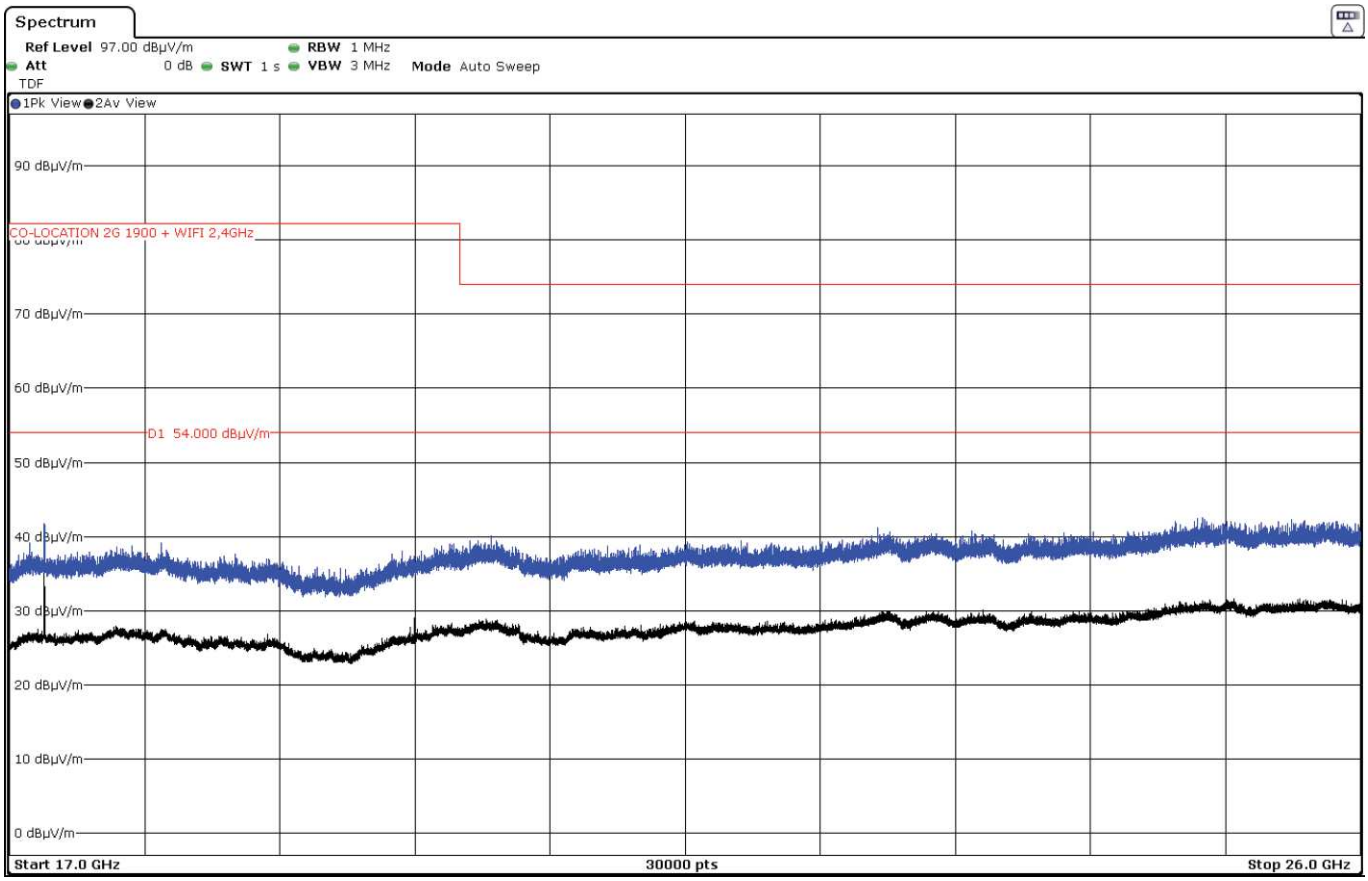
The peak above the limit in the middle is the Carrier frequency Bluetooth Low Energy (2402 MHz).

The peak above the limit on the right is the Carrier frequency 802.11 b (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:	High Channel (1909.8 MHz).
802.11 a U-NII-1:	BW=20 MHz, Low Channel (5180 MHz).
Bluetooth Low Energy:	High Channel (2480 MHz).

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

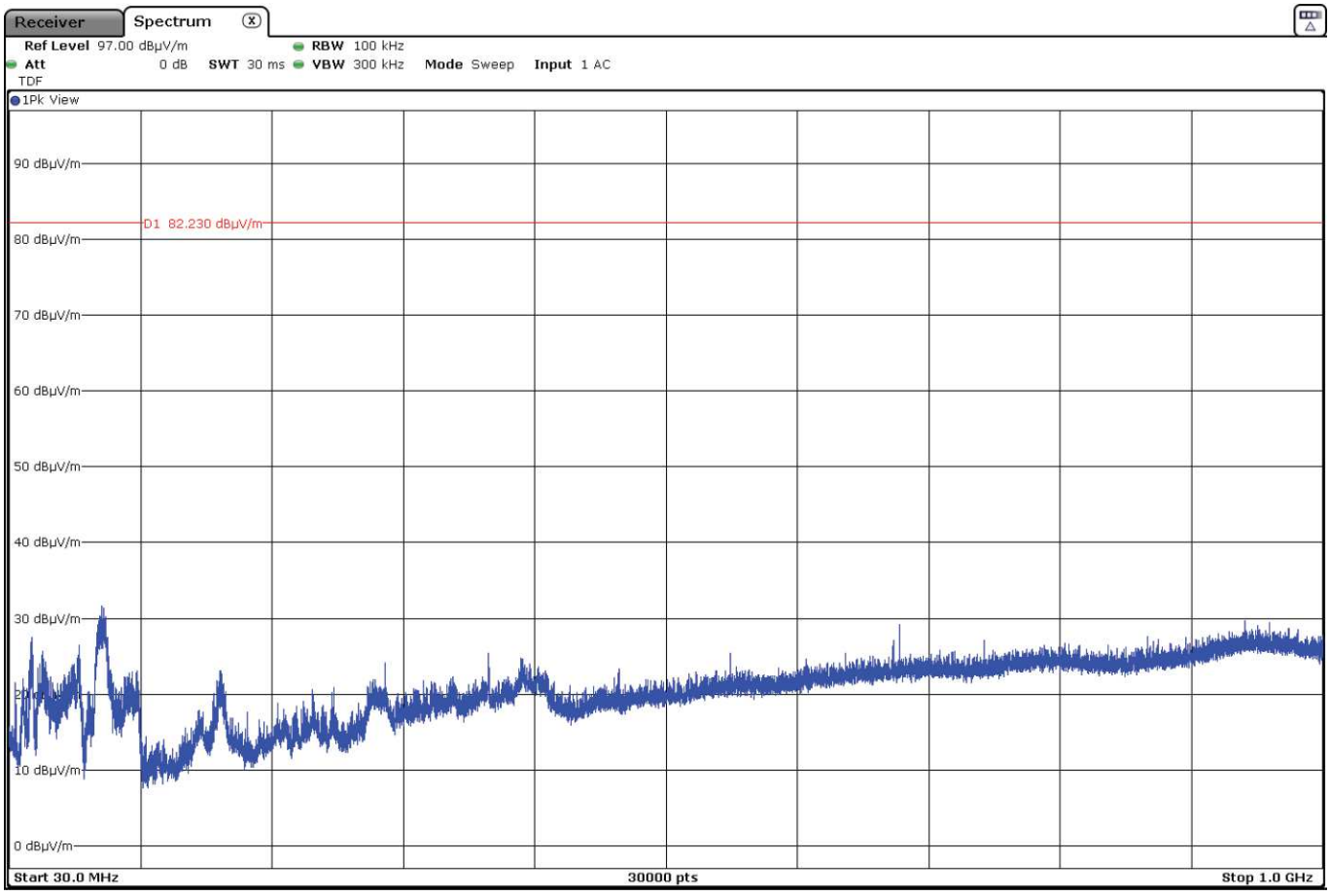
Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (GHz)	Detector	E (dBµV/m)	Polarization
20.71955	Peak	42.52	V
39.49997	Peak	55.17	V
	Average	44.43	
39.55037	Peak	54.99	H
	Average	44.61	

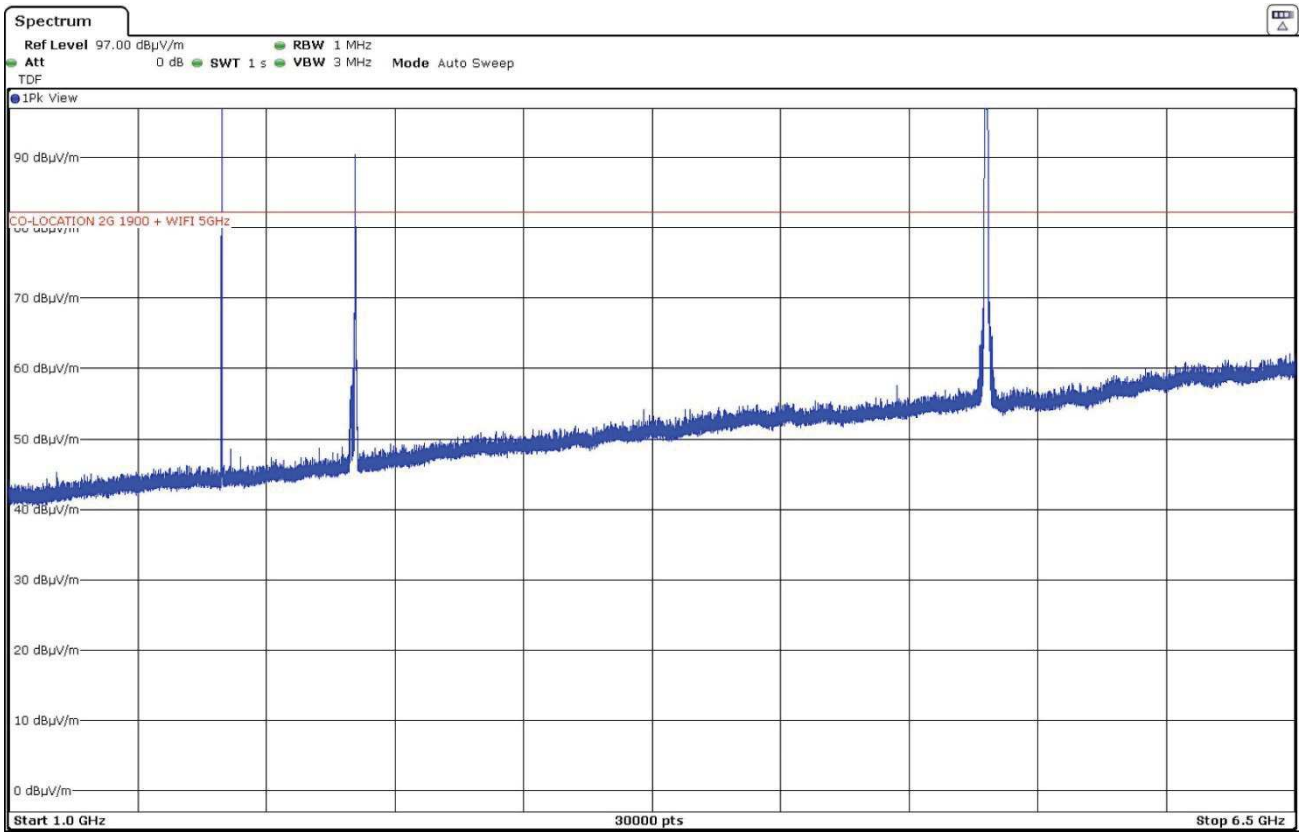
Measurement uncertainty (dB)	<±3.81 for f < 1GHz <±4.72 for f ≥ 1 GHz up to 18 GHz <±3.34 for f ≥ 18 GHz up to 40 GHz

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz

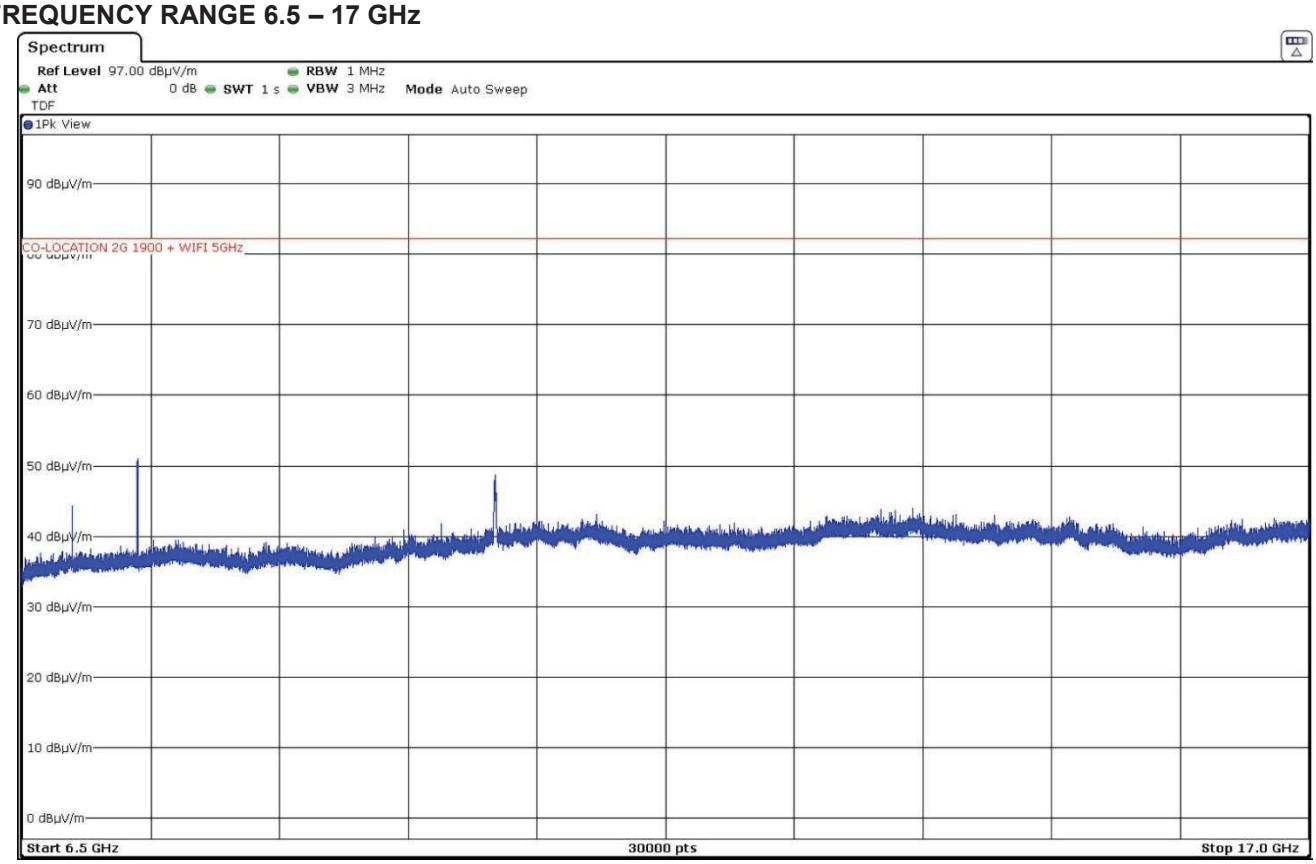


FREQUENCY RANGE 1 – 6.5 GHz

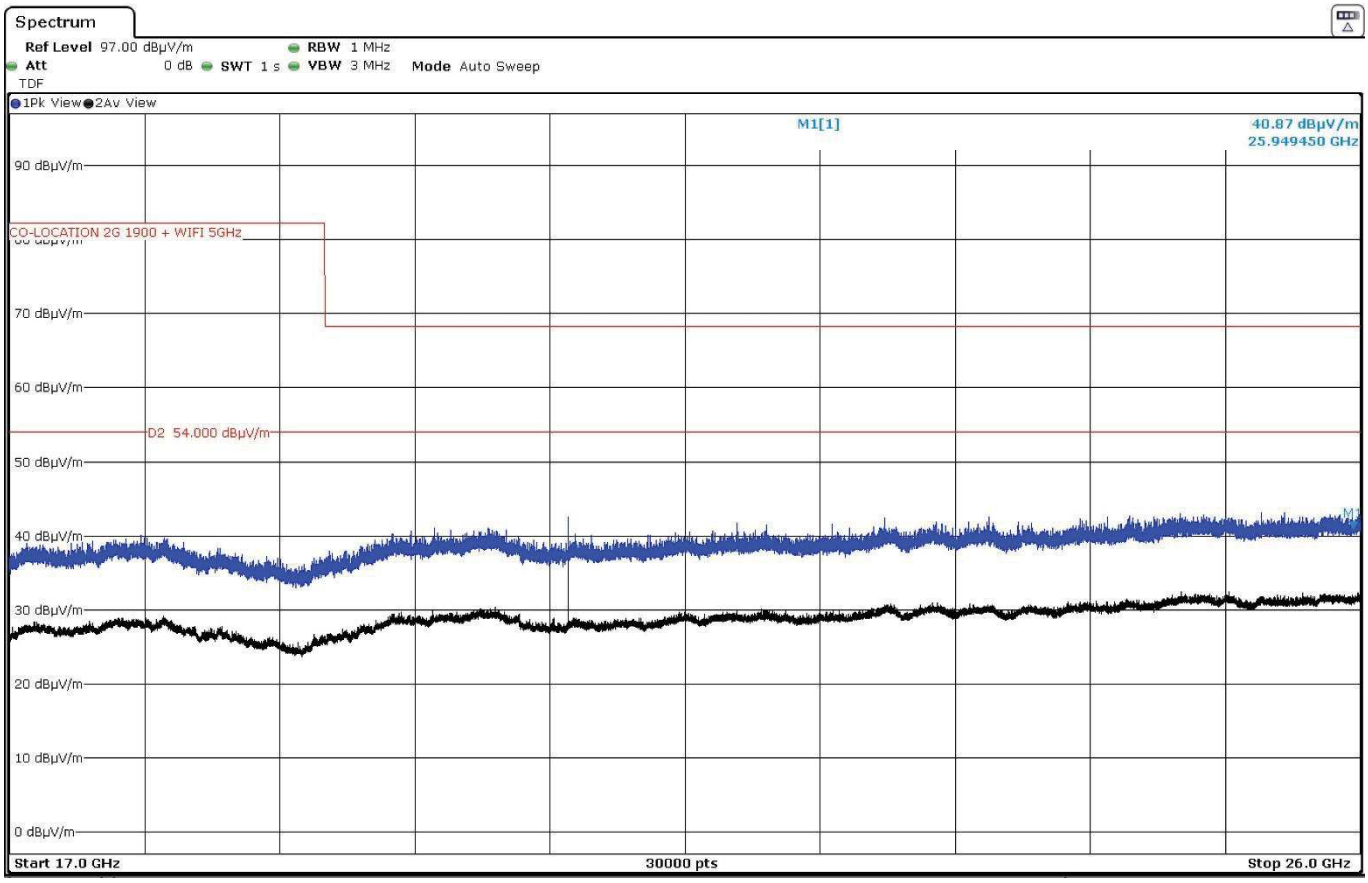


The peak above the limit on the left is the Carrier frequency 2G PCS-1900 (1909.8 MHz).
The peak above the limit in the middle is the Carrier frequency Bluetooth Low Energy (2480 MHz).
The peak above the limit on the right is the Carrier frequency 802.11 a20 (5180 MHz).

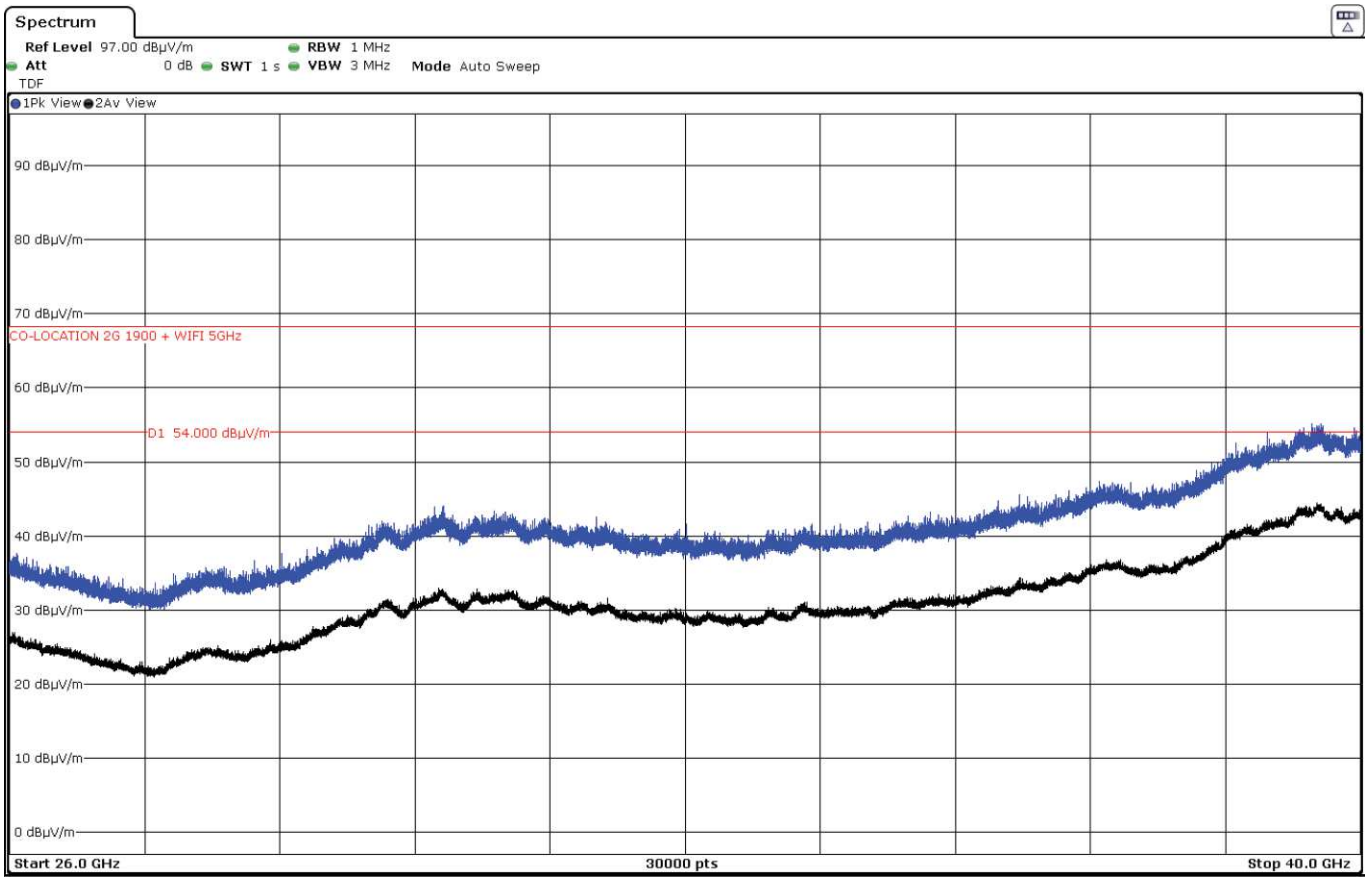
FREQUENCY RANGE 6.5 – 17 GHz



FREQUENCY RANGE 17 - 26 GHz



FREQUENCY RANGE 26 - 40 GHz



- **Mode 2G PCS-1900, 802.11 a20 U-NII-3, Bluetooth Low Energy:**

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

2G Band PCS-1900:	Middle Channel (1909.8 MHz).
802.11 a U-NII-3:	BW=20 MHz, High Channel (5825 MHz).
Bluetooth Low Energy:	Low Channel (2402 MHz).

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
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

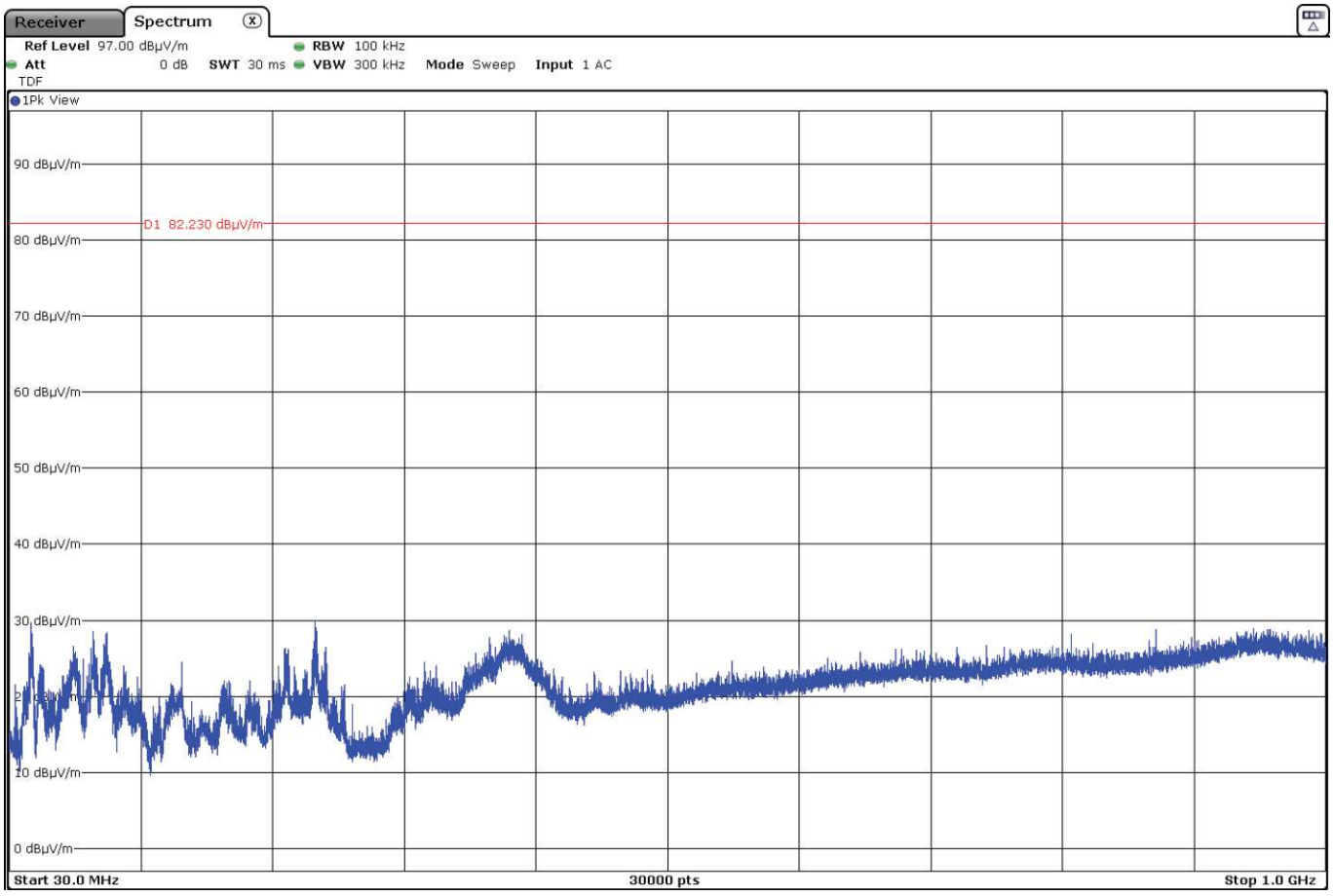
Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (GHz)	Detector	E (dBµV/m)	Polarization	Limit (dBµV/m)
39.56017	Peak	55.99	V	74
	Average	44.53		54
39.4197	Peak	54.72	H	74
	Average	43.09		54

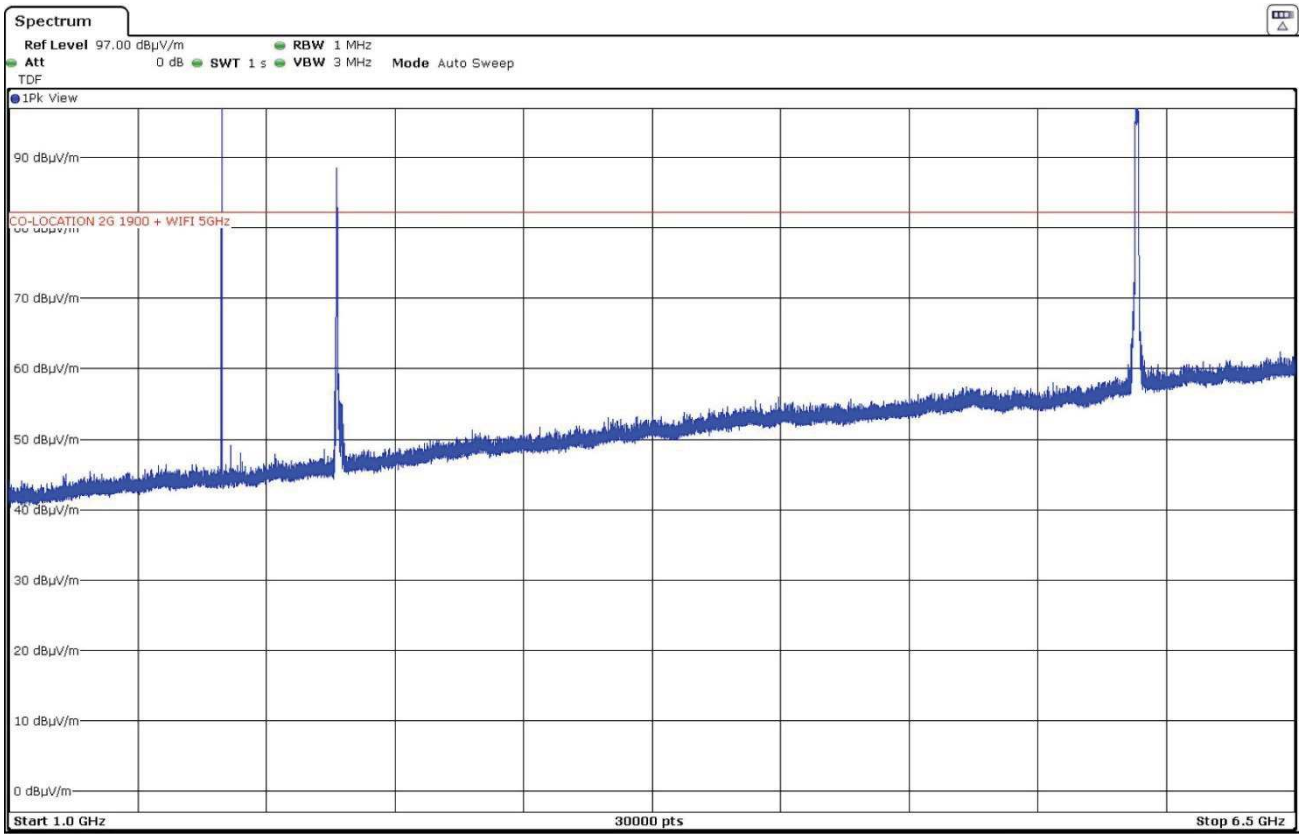
Measurement uncertainty (dB)	<±3.81 for f < 1GHz <±4.72 for f ≥ 1 GHz up to 18 GHz <±3.34 for f ≥ 18 GHz up to 40 GHz

Verdict: PASS

FREQUENCY RANGE 30 MHz - 1 GHz

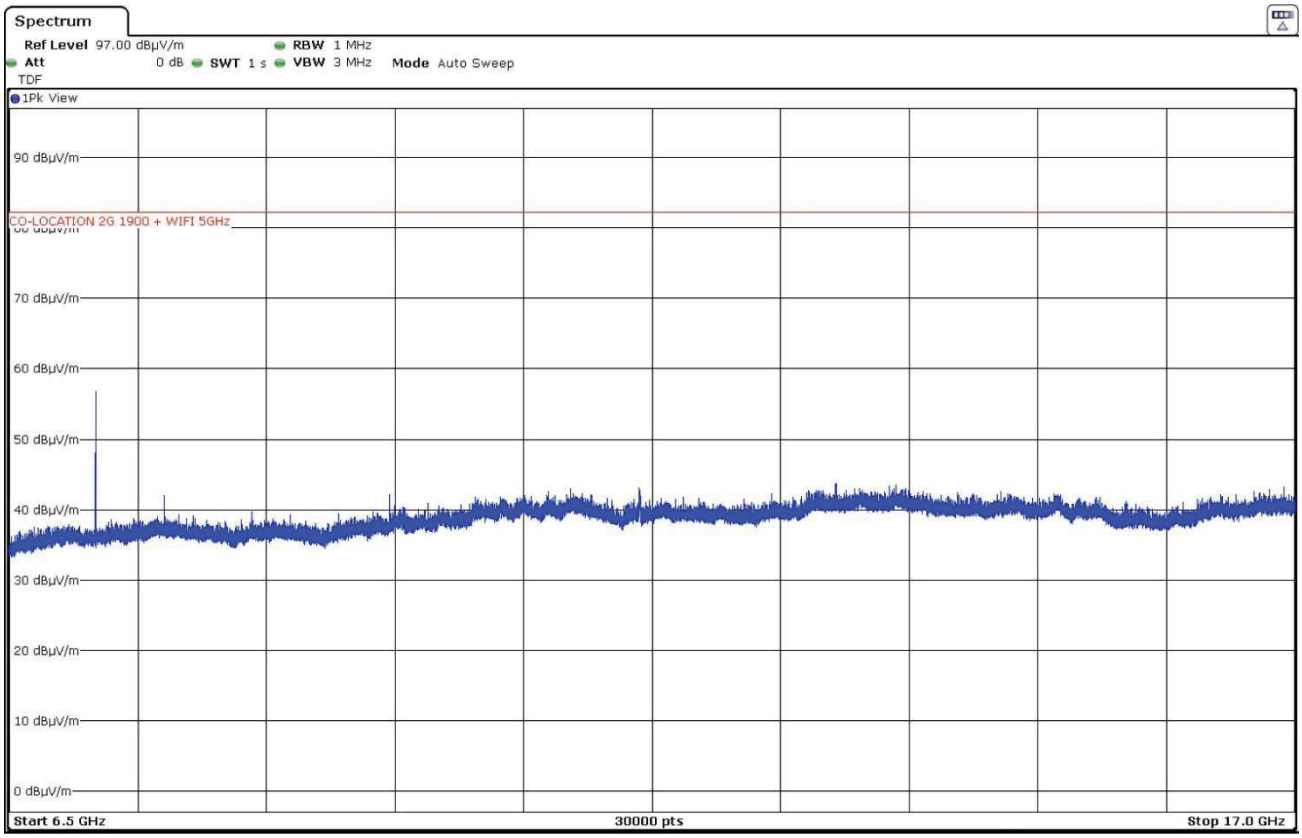


FREQUENCY RANGE 1 – 6.5 GHz

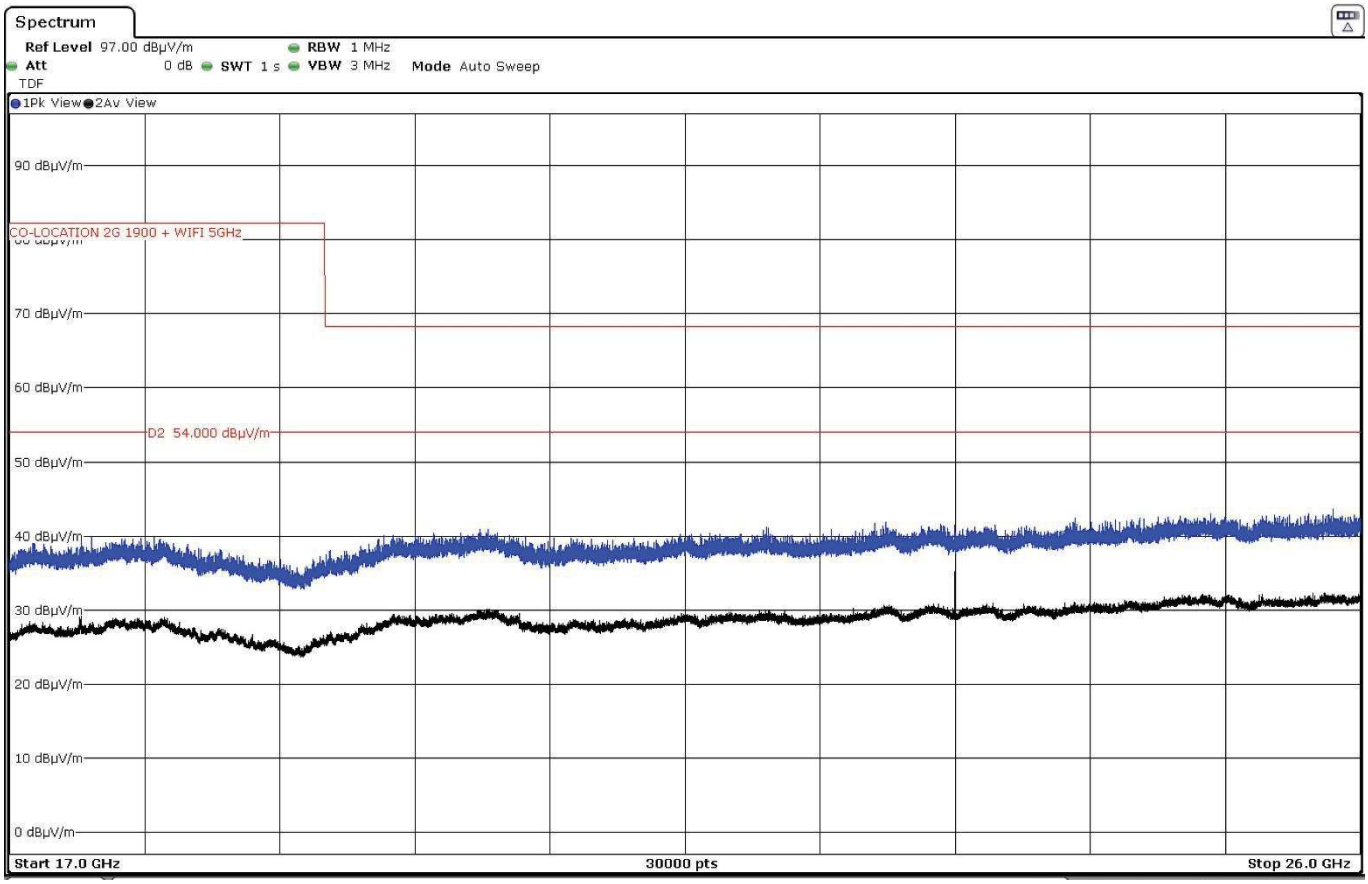


The peak above the limit on the left is the Carrier frequency 2G PCS-1900 (1909.8 MHz).
The peak above the limit in the middle is the Carrier frequency Bluetooth Low Energy (2402 MHz)
The peak above the limit on the right is the Carrier frequency 802.11 a20 (5825 MHz).

FREQUENCY RANGE 6.5 – 17 GHz



FREQUENCY RANGE 17 - 26 GHz



FREQUENCY RANGE 26 - 40 GHz