

Test Report No:  
 NIE: 68001RRF.015

## Partial Test Report

Reference Standard:  
 USA FCC Part 27

(*) Identification of item tested	Telematic control unit with wireless technologies, used in automotive industry
(*) Trademark	BMW
(*) Model and /or type reference	WAVE-11-HAF-R2
(*) Derived model not tested	WAVE-11-HIGH-R2
Other identification of the product	Type: B424 HW version: D5 SW version: 21411A.004_045_017 IMEI TAC: 35011736 (OEM modem), 35894272 (CUS modem) Contains FCC ID: T8GSAN9000 Contains FCC ID: T8GSAN9001 Contains IC: 6434A-SAN9000 Contains IC: 6434A-SAN9001
(*) Features	GSM, UMTS, LTE, 5G, GNSS
Applicant	HARMAN BECKER AUTOMOTIVE SYSTEMS GMBH BECKER-GOERING-STR. 16; 76307 KARLSBAD, GERMANY
Test method requested, standard	USA FCC Part 27 (10-1-20 Edition). ANSI C63.26-2015. KDB 971168 D01 Power Meas License Digital Systems v03r01, April. 2018.
Approved by (name / position & signature)	Rafael López Martín EMC Consumer & RF Lab. Manager
Date of issue	2022-03-09
Report template No.	FDT08_23 (*) "Data provided by the client"

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## Competences and guarantees

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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 covers the performed tests in this 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.

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## General conditions

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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

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

## Data provided by the client

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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 model WAVE-11-HAF-R2 is a Telematics control unit with wireless technologies, used in automotive, equipped with 2 modems, OEM and customer. The project name WAVE has the meaning "Wireless Access in Vehicular Environment" and thus describes the key features of this device as Communication and Data Interface. This unit was designed for automotive usage and contains the following features: GSM, UMTS, LTE, 5G, and GNSS.

3. Derived model not tested. These models have been declared by the supplier of the sample as being the same as the model under test.

**HARMAN AUTOMOTIVE DIVISION**  
HARMAN BECKER AUTOMOTIVE SYSTEMS GMBH  
BECKER-GÖRING-STRASSE 16  
76307 KARLSBAD, GERMANY



### Declaration of similarity

To whom it may concern,

We, **Harman Becker Automotive Systems GmbH**, located in  
**Becker-Goering-Str. 16; 76307 Karlsbad, Germany**

Hereby declare that the following units: **WAVE-11-HIGH-R2** and **WAVE-11-HAF-R2** have integrated the same NAD modules, are using same schematic and same PCB layout.

The only difference between the two models is that **WAVE-11-HIGH-R2** is equipped with chipset U-Blox UBX-F9940, where **WAVE-11-HAF-R2** is equipped with chipset ST-Micro STA9100MGA & STA5635S.

Where only one of the aforementioned variants has been used as DUT, shall remain valid and applicable for these two models described.

This declaration is intended to be included in the test reports where applies

Regards



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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
68001/009	Telematic control unit with wireless technologies, used in automotive industry (Type B424)	WAVE-11-HAF-R2	B4250\$0M4907002	2021/08/10
68000C/083	Antenna (DA WAVE HIGH US 5G ROW)	DA05DI20	--	2021/08/27
62486/024	Antenna Box	AB01-I20-01	--	2020/09/22
62486/027	Antenna Box	AB01-I20-01	--	2020/09/22
68000C/067	Spoiler Antenna ZB G05/G07	--	0014	2021/07/29
62486/025	Antenna Box	AB01-I20-01	--	2020/09/22
62486/061	RF Harness	--	--	2020/09/22
68000C/009	Battery	607492	--	2021/07/29

Auxiliary elements used with the Sample S/01:

Control No.	Description	Model	Serial No.	Date of reception
62486/048	RF Cable for 4-Fakra	--	--	2020/09/22
62486/055	OABR Cable	--	--	2020/09/22
62486/047	RF Cable for 4-Fakra	--	--	2020/09/22
62486/063	OABR 1000 BaseT Converter	--	--	2020/09/22
62486/070	OABR Cable Adapter	--	--	2020/09/22
62486/156	OABR Cable Adapter	--	--	2020/09/28
68000C/032	SOS Button (E-Call)	9385	11221	2020/09/28
62486/042	Antenna ground planes for roof	--	--	2020/09/22
62486/044	Antenna ground planes for roof	--	--	2020/09/22

Sample S/01 has undergone the following test(s):

The Radiated tests indicated in the Appendix A (5G NR SA Band n77A + LTE Band 42).

## Test sample description

Ports.....:	Port name and description	Cable			
		Specified max length [m]	Attached during test	Shielded	Coupled to patient <sup>(3)</sup>
	RF connector –code D violet trunk/roof)	Port not used for SOP2021 (it has V2X interfaces and gateway for SDARS signal towards another ECU)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	RF connector – code C blue (trunk/roof)	>5m	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
	NanoMQS 20pol	>5m	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	NanoMQS 10pol	>8m	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	HDBT MATENet 2-Pol (Roof/Trunk)	>5m	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	Antenna Connector grey (Roof)	<0.5m	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Supplementary information to the ports.....:	--				
Rated power supply .....	Voltage and Frequency				
	<input checked="" type="checkbox"/>	DC: 12V car battery / attenuator (4,5 V ≤ UB ≤ 18 V; UB typical: 12 V)			
Rated Power..... :	12V DC				
Clock frequencies..... :	25MHz; 26MHz; 32, 768kHz; 49.58MHz;				
Other parameters .....	See Technical description				
Software version..... :	21411A.004_045_017				
Hardware version .....	D5				
Dimensions in cm (W x H x D) ... :	160x18x112 mm				
Mounting position .....	<input type="checkbox"/>	Table top equipment			
	<input type="checkbox"/>	Wall/Ceiling mounted equipment			
	<input type="checkbox"/>	Floor standing equipment			
	<input type="checkbox"/>	Hand-held equipment			
	<input checked="" type="checkbox"/>	Other: automotive telematics control unit			
Modules/parts..... :	Module/parts of test item		Type	Manufacturer	
	--				
Accessories (not part of the test item) .....	Description		Type	Manufacturer	
	Cable Harness		-		
	2G/3G/4G/5G Antenna		-	Hirschmann/ Molex	
	E-CALL button/LED		-		
	SOS Loudspeaker		-		

	Wake-up unit Box	-	
Documents as provided by the applicant..... :	Description	File name	Issue date
	Technical Description		

<sup>(3)</sup> Only for Medical Equipment

## Identification of the client

HARMAN BECKER AUTOMOTIVE SYSTEMS GMBH  
 BECKER-GOERING-STR. 16, 76307 KARLSBAD, GERMANY

## Testing period and place

<b>Test Location</b>	DEKRA Testing and Certification S.A.U.
<b>Date (start)</b>	2022-03-02
<b>Date (finish)</b>	2022-03-04

## Document history

Report number	Date	Description
68001RRF.015	2022-03-09	First release.

## Environmental conditions

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

<b>Temperature</b>	Min. = 15 °C Max. = 35 °C
<b>Relative humidity</b>	Min. = 20 % Max. = 75 %

In the semi-anechoic chamber, the following limits were not exceeded during the test:

<b>Temperature</b>	Min. = 15 °C Max. = 35 °C
<b>Relative humidity</b>	Min. = 20 % Max. = 75 %

## Remarks and comments

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

Used instrumentation:

### Radiated Measurements:

Equipment	Model	Manufacturer	Next Calibration
SEMIANECHOIC ABSORBER LINED CHAMBER IV	FACT 3 200 STP	ETS LINDGREN	N.A.
SHIELDED ROOM	S101	ETS LINDGREN	N.A.
HYBRID BILOG ANTENNA 30MHz-6GHz	3142E	ETS LINDGREN	2023-10-29
HORN ANTENNA 1-18GHz	BBHA 9120 D	SCHWARZBECK	2023-08-24
HORN ANTENNA 17-40GHz	BBHA 9170	SCHWARZBECK	2023-05-05
PRE-AMPLIFIER G>30dB 1GHz-18GHz	BLMA 0118-3A	BONN ELEKTRONIK	2022-12-01
PRE-AMPLIFIER G>30dB 17-40GHz	BLMA 1840-4A	BONN ELEKTRONIK	2022-09-08
EMI TEST RECEIVER 9kHz-7GHz	ESR7	ROHDE AND SCHWARZ	2023-11-08
SIGNAL AND SPECTRUM ANALYZER 10Hz-40GHz	FSV40	ROHDE AND SCHWARZ	2022-03-12
WIDEBAND RADIO COMMUNICATION TESTER	CMW500	ROHDE AND SCHWARZ	2023-08-10
UXM 5G RF Test Platform	E7515B	KEYSIGHT TECHNOLOGIES	2023-02-22
DC POWER SUPPLY 30V/5A	U8002A	KEYSIGHT TECHNOLOGIES	N.A.
DIGITAL MULTIMETER	175	FLUKE	2022-11-04



## Testing verdicts

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

## Summary

FCC PART 27			
Requirement – Test case		Verdict	Remark
FCC 27.50:	RF output power	N/M	(1)
FCC 2.1047:	Modulation characteristics	N/M	(1)
FCC 27.54:	Frequency stability	N/M	(1)
FCC 2.1049:	Occupied Bandwidth	N/M	(1)
FCC 27.53:	Spurious emissions at antenna terminals	N/M	(1)
FCC 27.53:	Radiated emissions	P	--
<u>Supplementary information and remarks:</u>			
(1) Test not requested.			

## Appendix A: Test results for FCC Part 27

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## TEST CONDITIONS

The module with the highest antenna gain was tested using the worst-case obtained for conducted output power for 5G NR SA. The other module was tested using an LTE channel adjacent to 5G NR; a setting allowing communication in the same band with both modules simultaneously was used.

(\*): Data provided by the Applicant.

### POWER SUPPLY (\*):

Vnominal: 12 Vdc  
 Type of Power Supply: External DC (vehicle battery).

### TEST FREQUENCIES (\*):

5G NR SA & LTE (MIMO 2x2):

#### 5G NR SA Band n77 + LTE Band 42:

Table 4.3.1.1.1.77-2: Test frequencies for NR operating band n77 and SCS 30 kHz

Band width [MHz]	carrier Bandwidth [PRBs]	Range	Carrier centre [MHz]	Carrier centre [ARFCN]	point A [MHz]	absolute Frequency Point A [ARFCN]	offsetTo Carrier [Carrier PRBs]	SS block SCS [kHz]	GSCN	absolute Frequency SSB [ARFCN]	$k_{SSB}$	CORE SET#0 Offset [RBs] Note 1	CORE SET#0 Index Note 1	offsetTo PointA (SIB1) [PRBs] Note 1	
10	24	Downlink & Uplink	Low	3305.01	620334	3300.69	620046	0	30	7711	620352	18	2	2	4
			Mid	3750	650000	3708.96	647264	102		8020	650016	16	2	2	208
			High	4194.99	679666	4009.23	667282	504		8329	679680	14	2	2	1012
15	38	Downlink & Uplink	Low	3307.5	620500	3300.66	620044	0	30	7711	620352	20	2	2	4
			Mid	3750	650000	3706.44	647096	102		8018	649824	16	1	1	206
			High	4192.5	679500	4004.22	666948	504		8325	679296	12	0	0	1008
20	51	Downlink & Uplink	Low	3310.02	620668	3300.84	620056	0	30	7711	620352	8	2	2	4
			Mid	3750	650000	3704.1	646940	102		8016	649632	4	0	0	204
			High	4189.98	679332	3999.36	666624	504		8322	679008	0	2	2	1012
40	106	Downlink & Uplink	Low	3320.01	621334	3300.93	620062	0	30	7711	620352	2	2	2	4
			Mid	3750	650000	3694.2	646280	102		8010	649056	16	3	3	210
			High	4179.99	678666	3979.47	665298	504		8308	677664	6	1	1	1010
50	133	Downlink & Uplink	Low	3325.02	621668	3301.08	620072	0	30	7711	620352	16	1	1	2
			Mid	3750	650000	3689.34	645956	102		8006	648672	4	1	1	206
			High	4174.98	678332	3969.6	664640	504		8301	676992	16	0	0	1008
60	162	Downlink & Uplink	Low	3330	622000	3300.84	620056	0	30	7711	620352	8	2	2	4
			Mid	3750	650000	3684.12	645608	102		8003	648384	16	3	3	210
			High	4170	678000	3959.4	663960	504		8294	676320	0	1	1	1010
80	217	Downlink & Uplink	Low	3340.02	622668	3300.96	620064	0	30	7711	620352	0	2	2	4
			Mid	3750	650000	3674.22	644948	102		7996	647712	4	3	3	210
			High	4159.98	677332	3939.48	662632	504		8280	674976	8	0	0	1008
90	245	Downlink & Uplink	Low	3345	623000	3300.9	620060	0	30	7711	620352	4	2	2	4
			Mid	3750	650000	3669.18	644612	102		7992	647328	4	1	1	206
			High	4155	677000	3929.46	661964	504		8273	674304	4	0	0	1008
100	273	Downlink & Uplink	Low	3350.01	623334	3300.87	620058	0	30	7711	620352	6	2	2	4
			Mid	3750	650000	3664.14	644276	102		7989	647040	4	3	3	210
			High	4149.99	676666	3919.41	661294	504		8266	673632	2	0	0	1008

Note 1: The CORESET#0 Index and the associated CORESET#0 Offset refers to Table 13-4 in TS 38.213 [22]. The value of CORESET#0 Index is signalled in the four most significant bits of the IE pdcc-ConfigSIB1 in the MIB. The offsetToPointA IE is expressed in units of resource blocks assuming 15 kHz subcarrier spacing for FR1 and 60 kHz subcarrier spacing for FR2.

Module NAD2					Module NAD1			
Channel	Test frequencies for 5G Carrier in Band n77A				LTE Band 42			
	SCS (kHz)	BW (MHz)	Freq. (MHz)	NR-ARFCN	Channel	BW (MHz)	Freq. (MHz)	EARFCN
Low	30	40	3720.0	648000	Adjacent channel to Low	20	3580.0	43390
Middle	30	40	3840.0	656000	Adjacent channel to Middle	20	3580.0	43390
High	30	40	3960.0	664000	Adjacent channel to High	20	3580.0	43390

Note: Tested channels due to the characteristics of the simultaneous transmission of both modules.

## Radiated Emissions

### SPECIFICATION

#### **1. 5G NR SA Band n77A + LTE Band 42. FCC §2.1053 & §27.53 (I).**

FCC §27.53 (I):

(2) For mobile operations in the 3700-3980 MHz band, the conducted power of any emission outside the licensee's authorized bandwidth shall not exceed  $-13$  dBm/MHz. Compliance with this paragraph is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater. However, in the 1 megahertz bands immediately outside and adjacent to the licensee's frequency block, the minimum resolution bandwidth for the measurement shall be either one percent of the emission bandwidth of the fundamental emission of the transmitter or 350 kHz. In the bands between 1 and 5 MHz removed from the licensee's frequency block, the minimum resolution bandwidth for the measurement shall be 500 kHz.

### METHOD

The measurement was performed with the EUT inside a semi-anechoic chamber.

The spectrum was scanned from 30 MHz to at least the 10th harmonic of the highest frequency generated within the equipment.

The EUT was placed on a non-conductive stand at a 3 meter distance from the measuring antenna for measurements below 18 GHz and at 1 m distance for measurements above 18 GHz.

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 maximum field strength (dB $\mu$ V/m) of each detected emission at less than 20 dB respect to the limit is converted to an equivalent EIRP level (dBm) according to ANSI C63.26 with the formula:

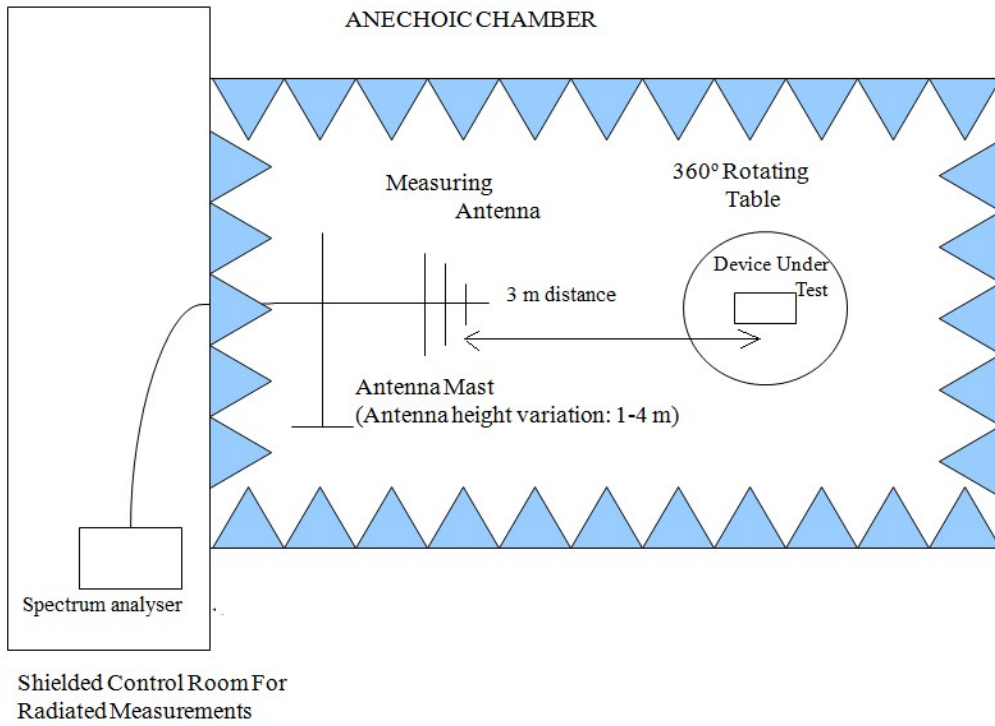
$$\text{EIRP (dBm)} = E \text{ (dB}\mu\text{V/m)} + 20 \log(D) - 104.8;$$

where D is the measurement distance (in the far field region) in m (D = 3 m).

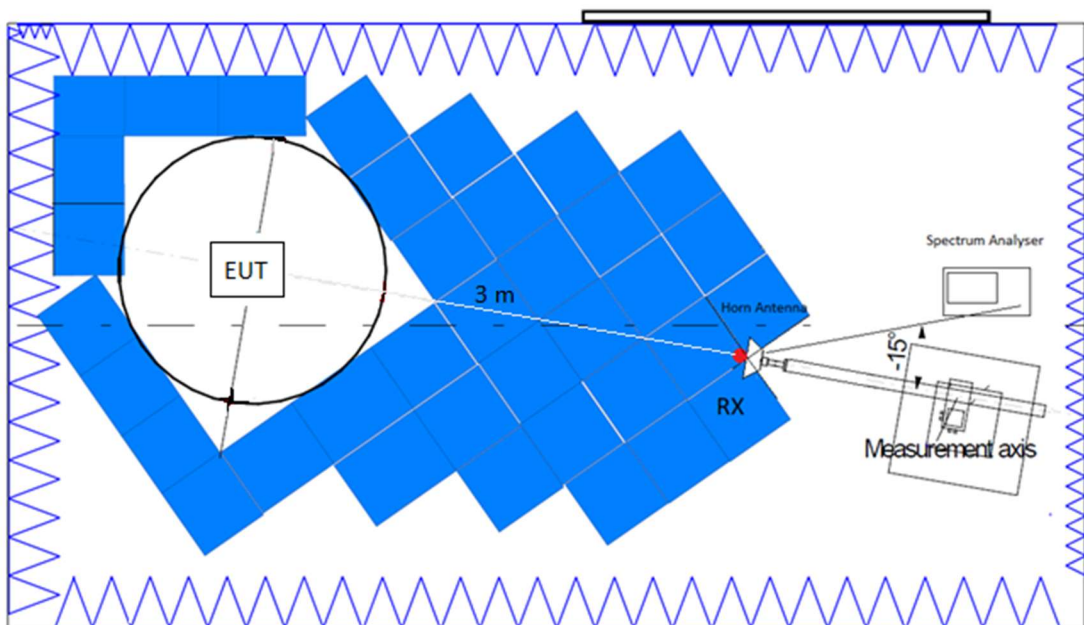
A resolution bandwidth / video bandwidth of 1 MHz / 3 MHz was used.

### TEST SETUP

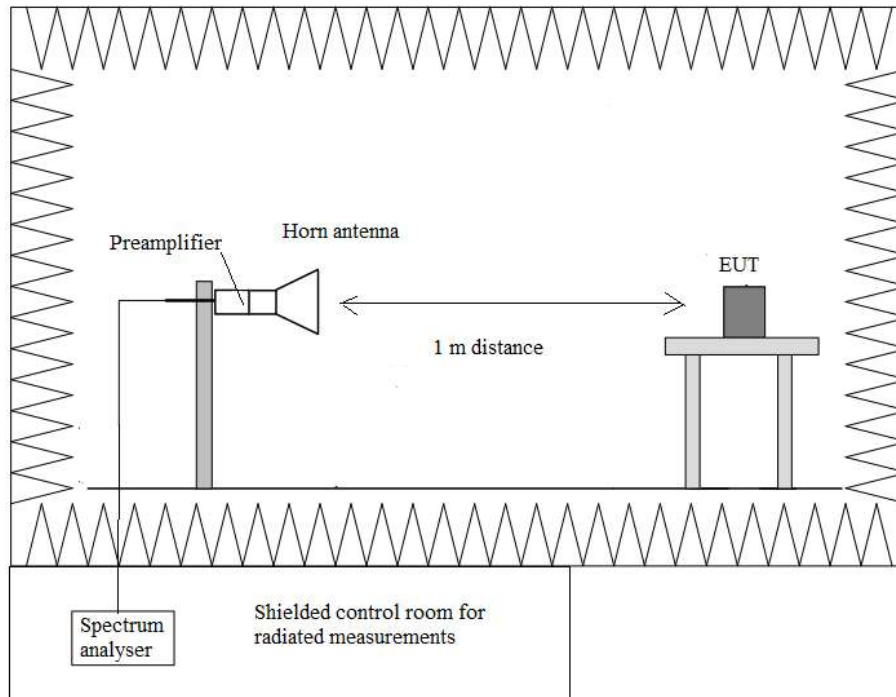
Radiated measurements setup from 30 MHz to 1 GHz:



Radiated measurements setup from 1 GHz to 18 GHz:



Radiated measurements setup above 18 GHz:



## RESULTS

- **5G NR SA Band n77A + LTE Band 42:**

A preliminary scan determined the worst-case:

- 1) 5G NR SA Band n77A (Module NAD2):  
Pi/2 BPSK, BW = 40 MHz, SCS=30 kHz, RB=1, Offset=0.
- 2) LTE Band 42 (Module NAD1):  
QPSK, BW = 20 MHz, RB=1, Offset=50.

The following results are for this worst-case configuration.

- **Low Channel:**

**Frequency range 30 MHz – 1 GHz:**

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

**Frequency range 1 GHz – 40 GHz:**

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

- **Middle Channel:**

**Frequency range 30 MHz – 1 GHz:**

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

**Frequency range 1 GHz – 40 GHz:**

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

- **High Channel:**

**Frequency range 30 MHz – 1 GHz:**

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

**Frequency range 1 GHz – 40 GHz:**

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



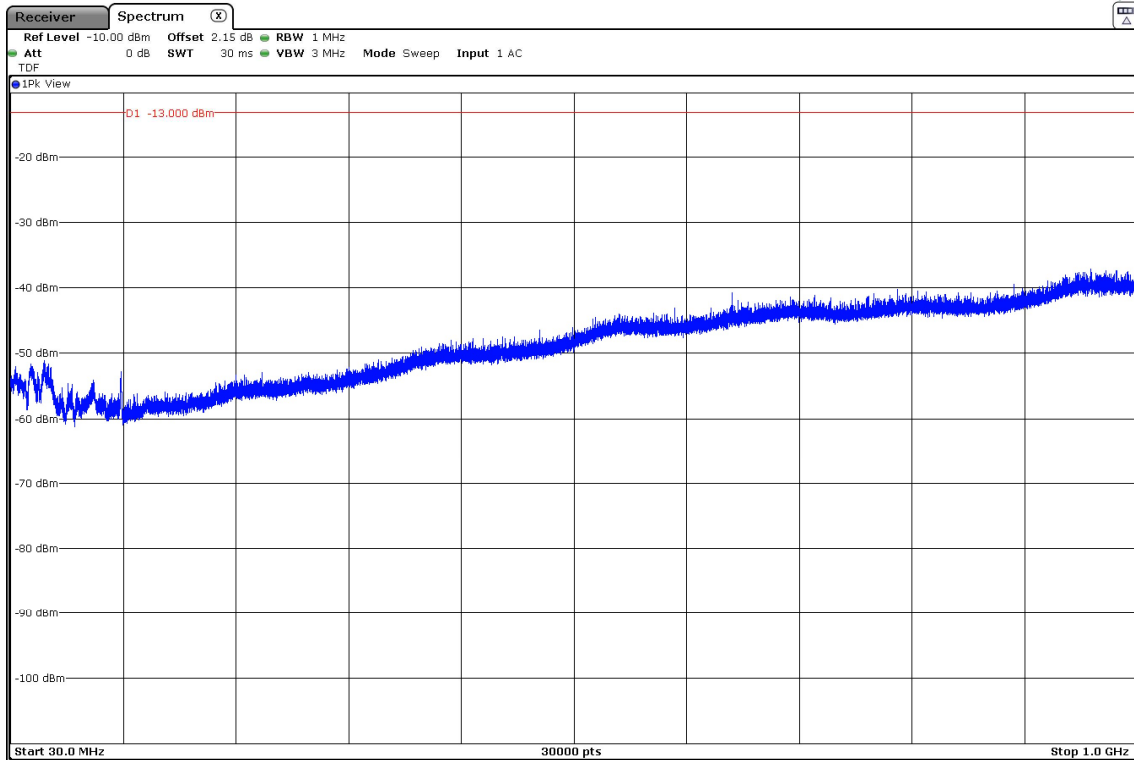
Measurement Uncertainty (dB):	< ±4.90 for $f < 1$ GHz
	< ±4.11 for $f \geq 1$ GHz up to 7 GHz
	< ±4.32 for $f \geq 7$ GHz up to 18 GHz
	< ±4.75 for $f \geq 18$ GHz up to 40 GHz

Verdict: PASS

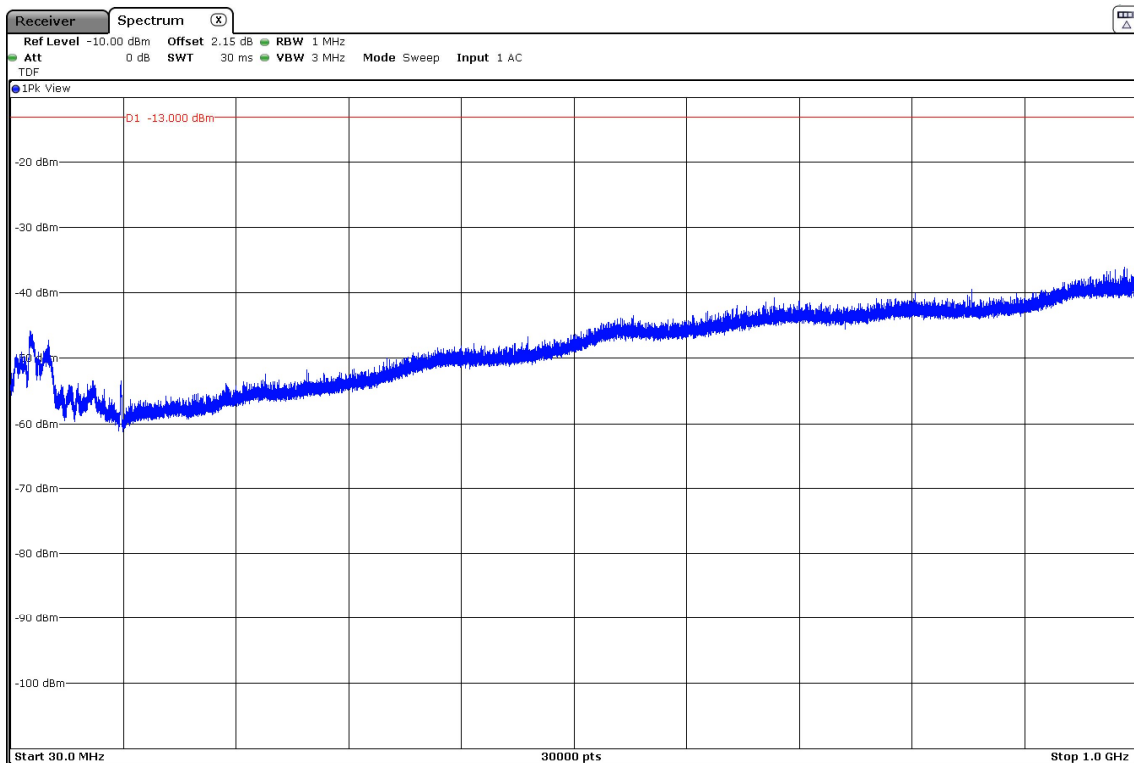
ATTACHMENTS

**FREQUENCY RANGE 30 MHz – 1 GHz (worst-case):**

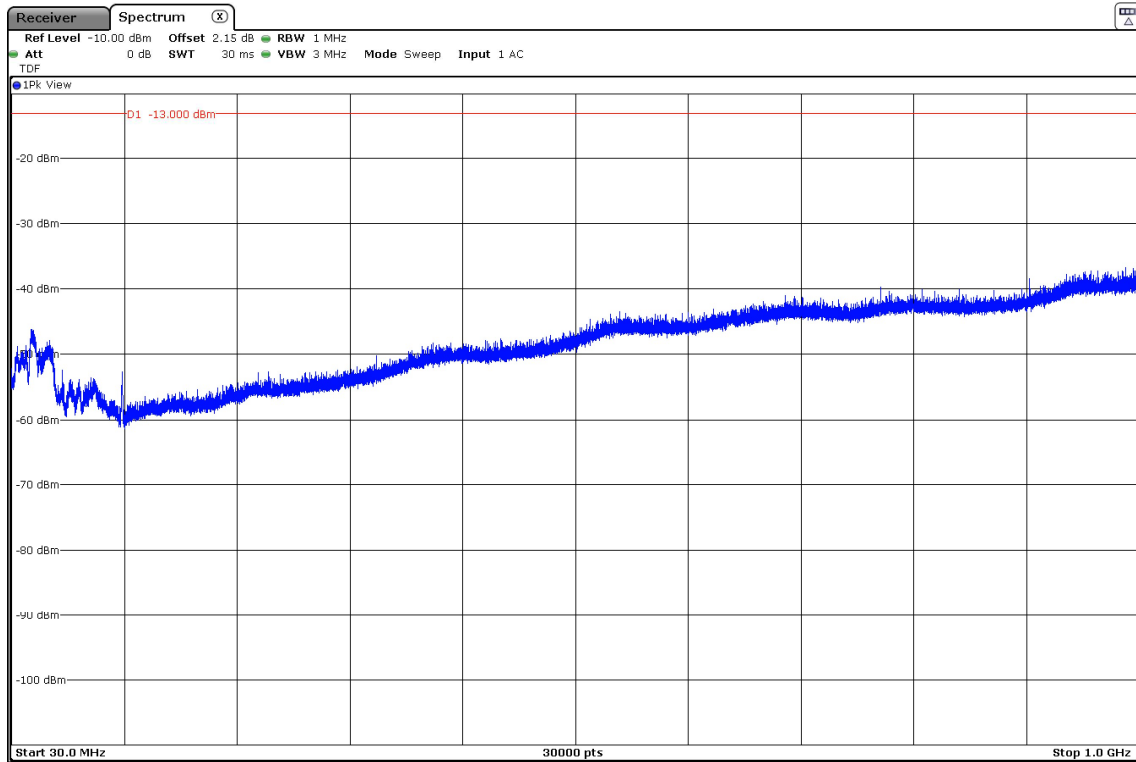
- Low Channel:



- Middle Channel:

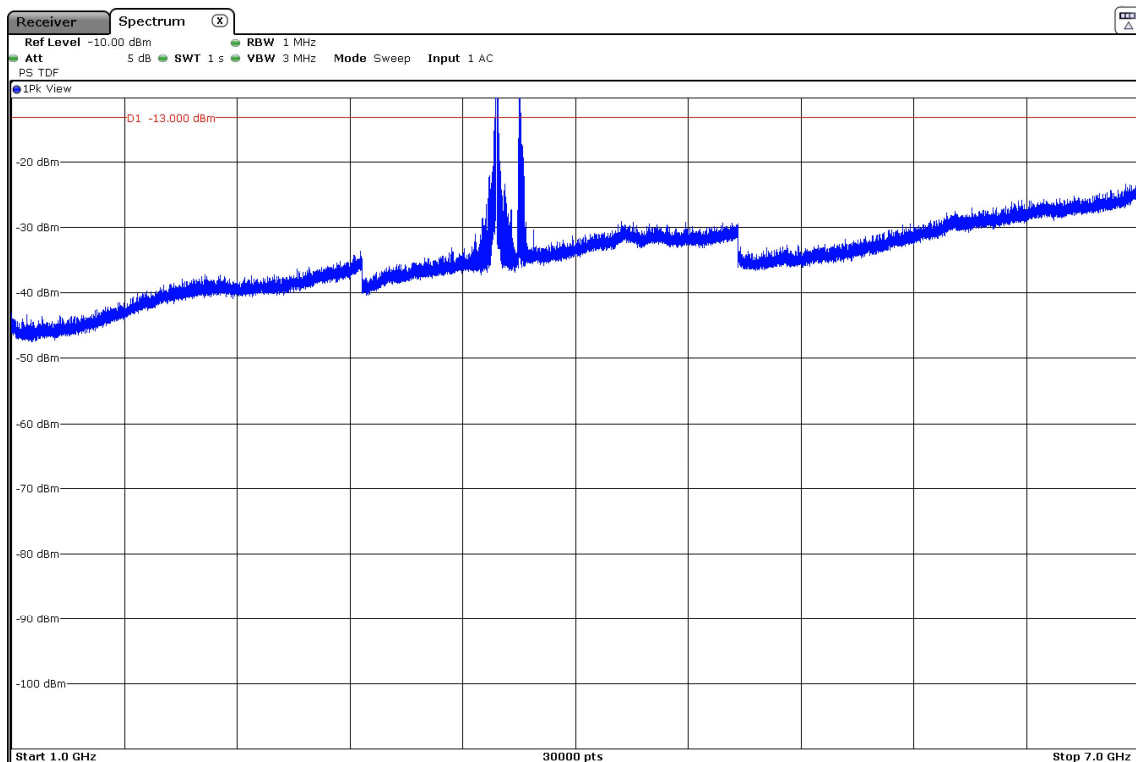


- High Channel:



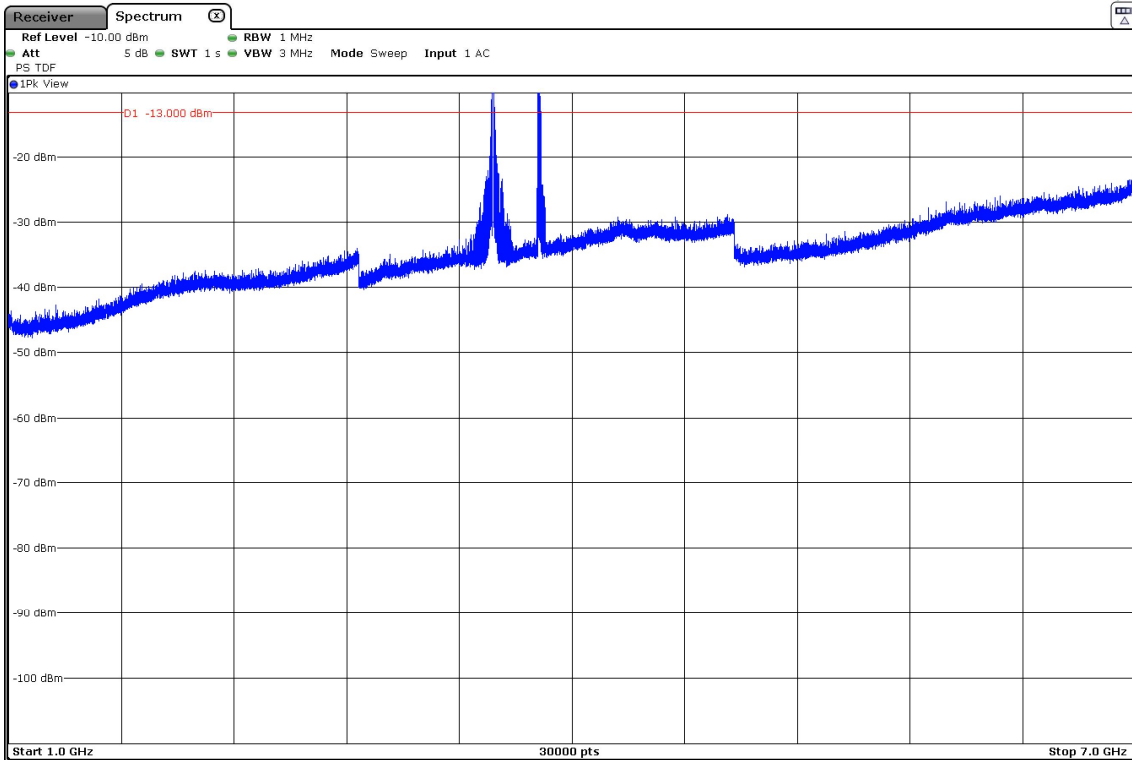
FREQUENCY RANGE 1 GHz – 7 GHz (worst-case):

- Low Channel:



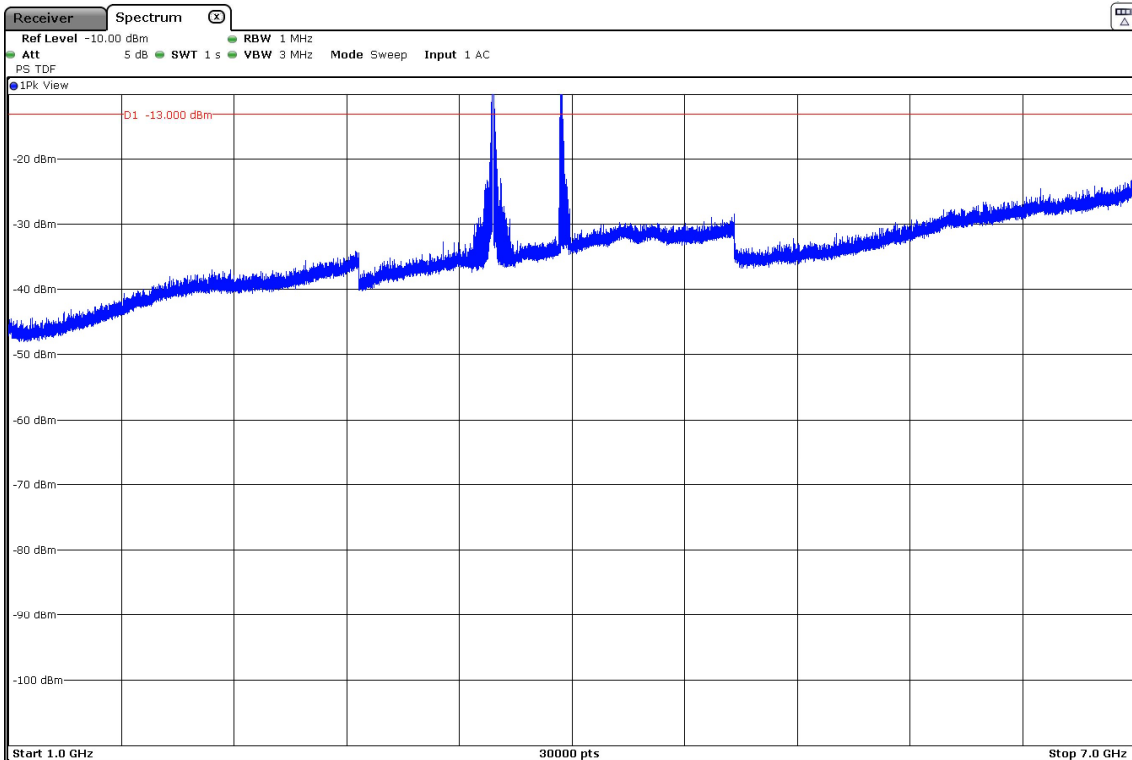
The peaks above the limit are the carriers.

- Middle Channel:



The peaks above the limit are the carriers.

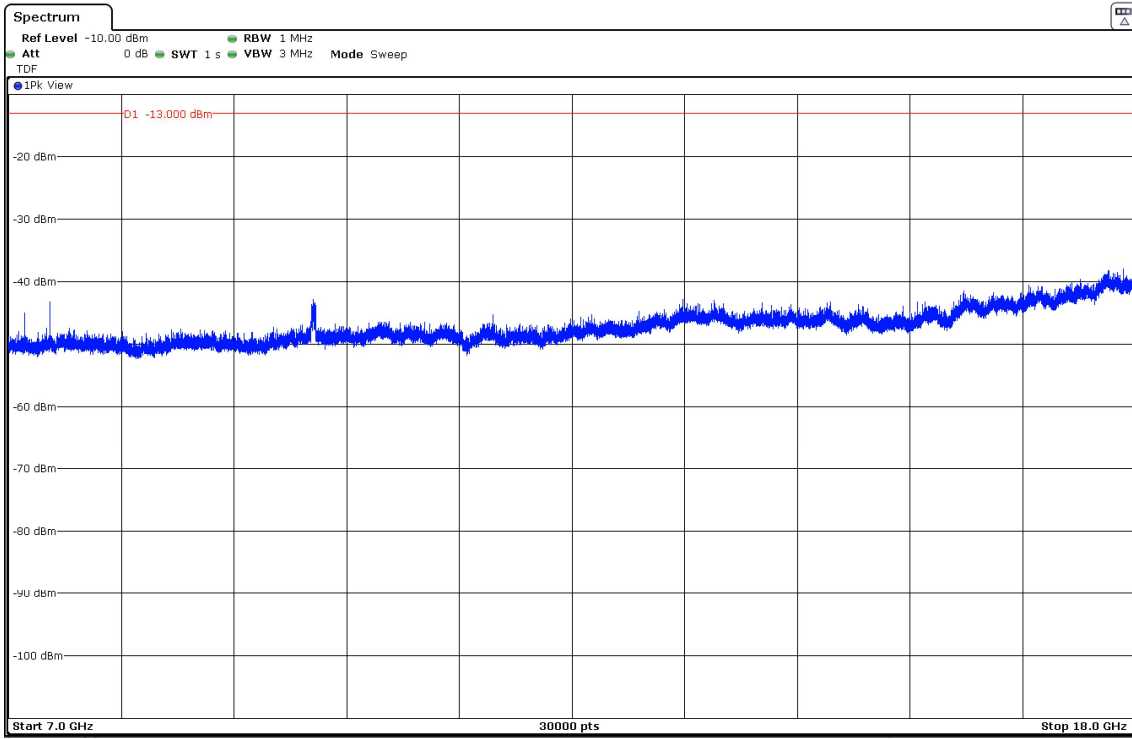
- High Channel:



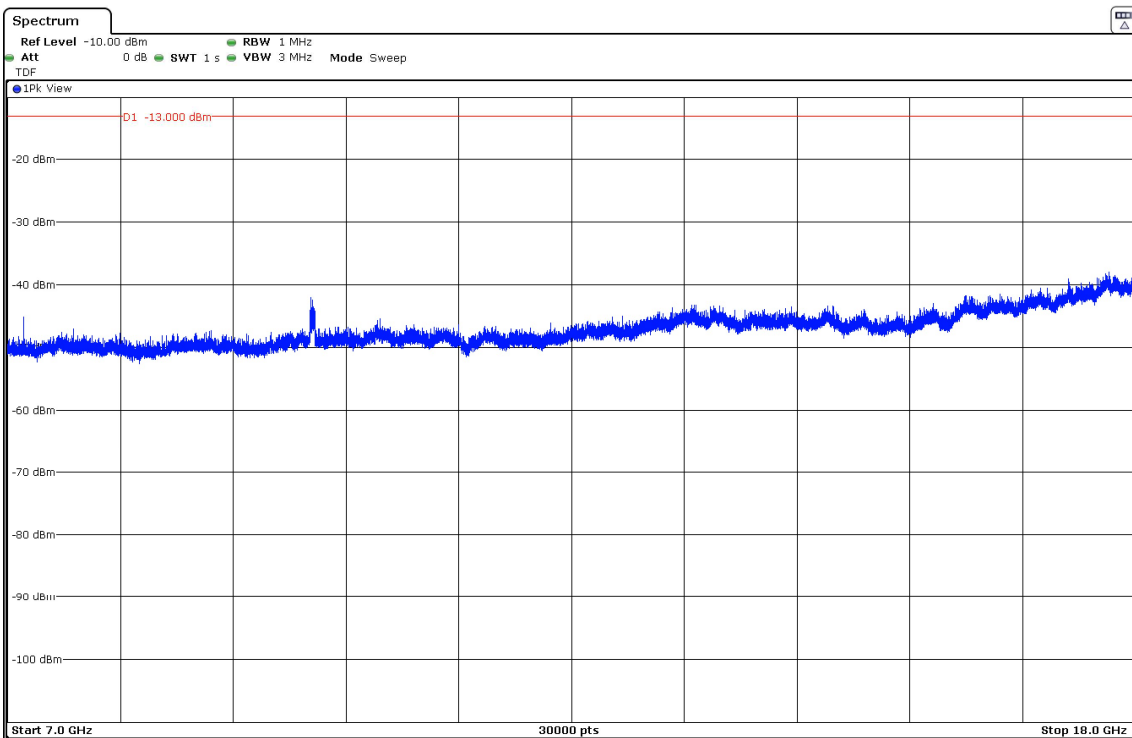
The peaks above the limit are the carriers.

### FREQUENCY RANGE 7 GHz – 18 GHz (worst-case):

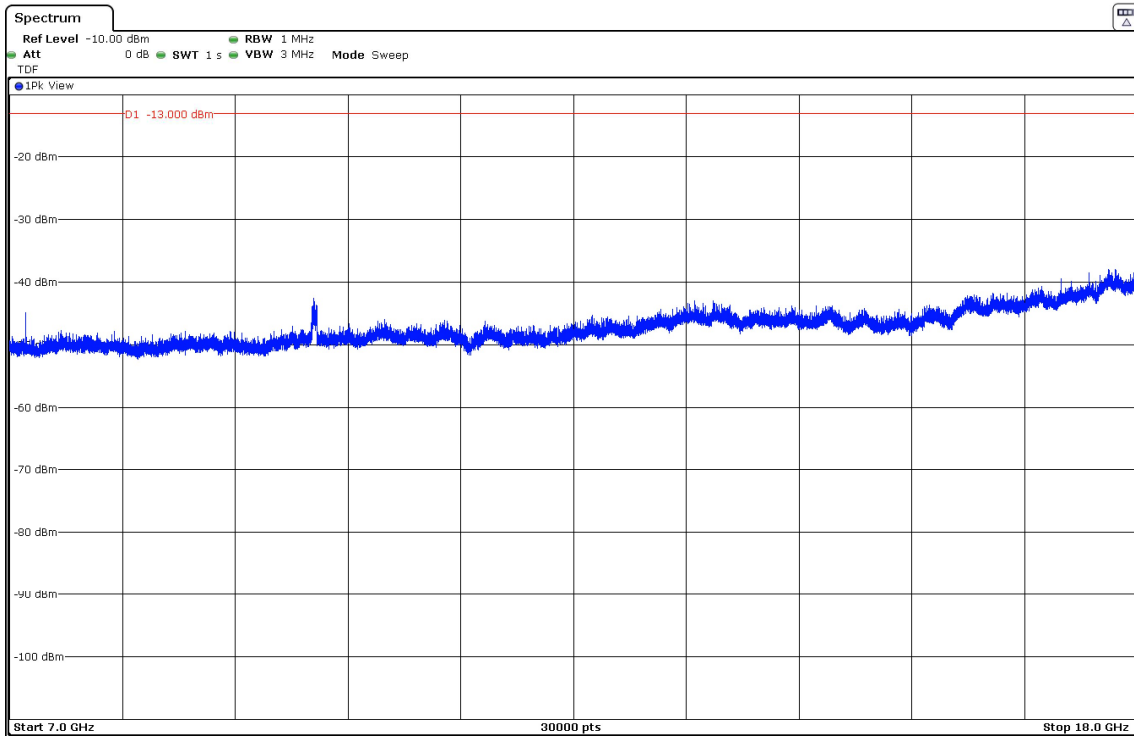
- Low Channel:



- Middle Channel:

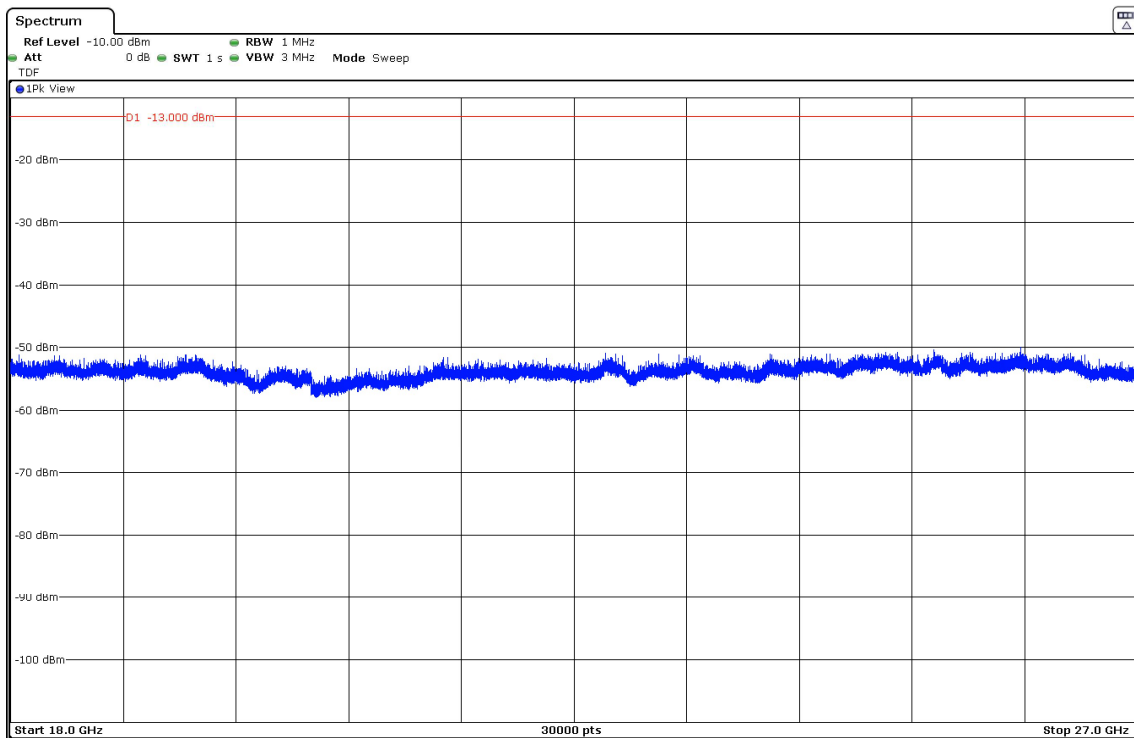


- High Channel:

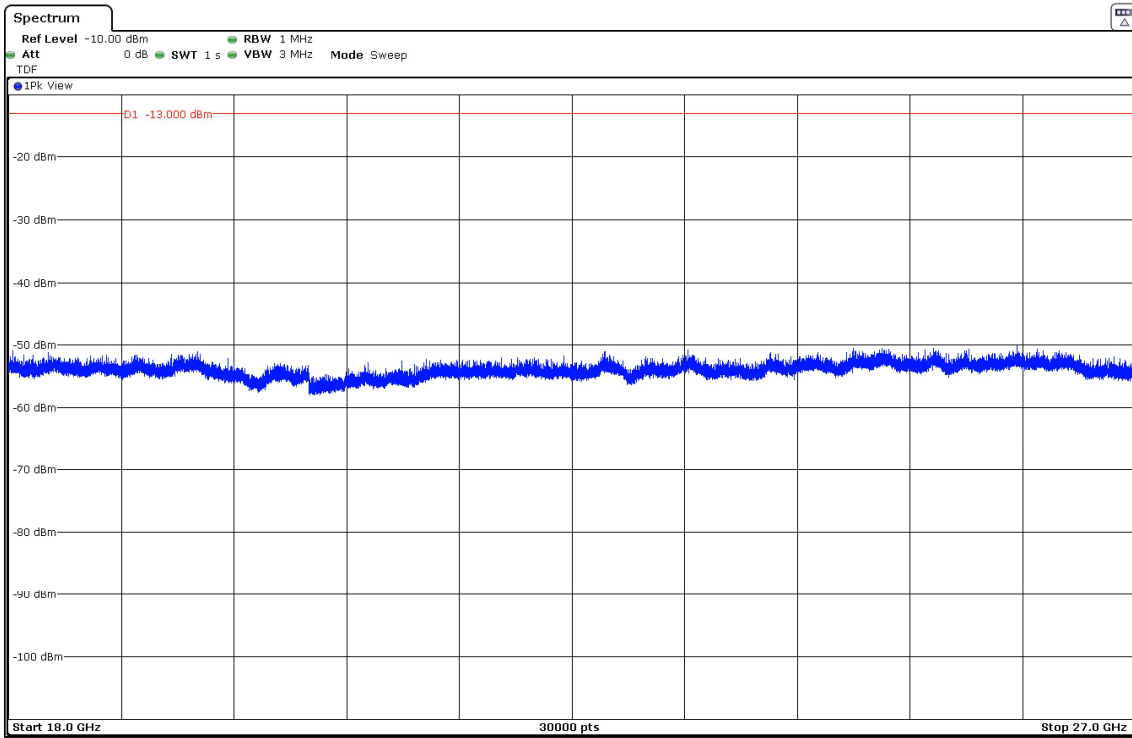


**FREQUENCY RANGE 18 GHz – 27 GHz (worst-case):**

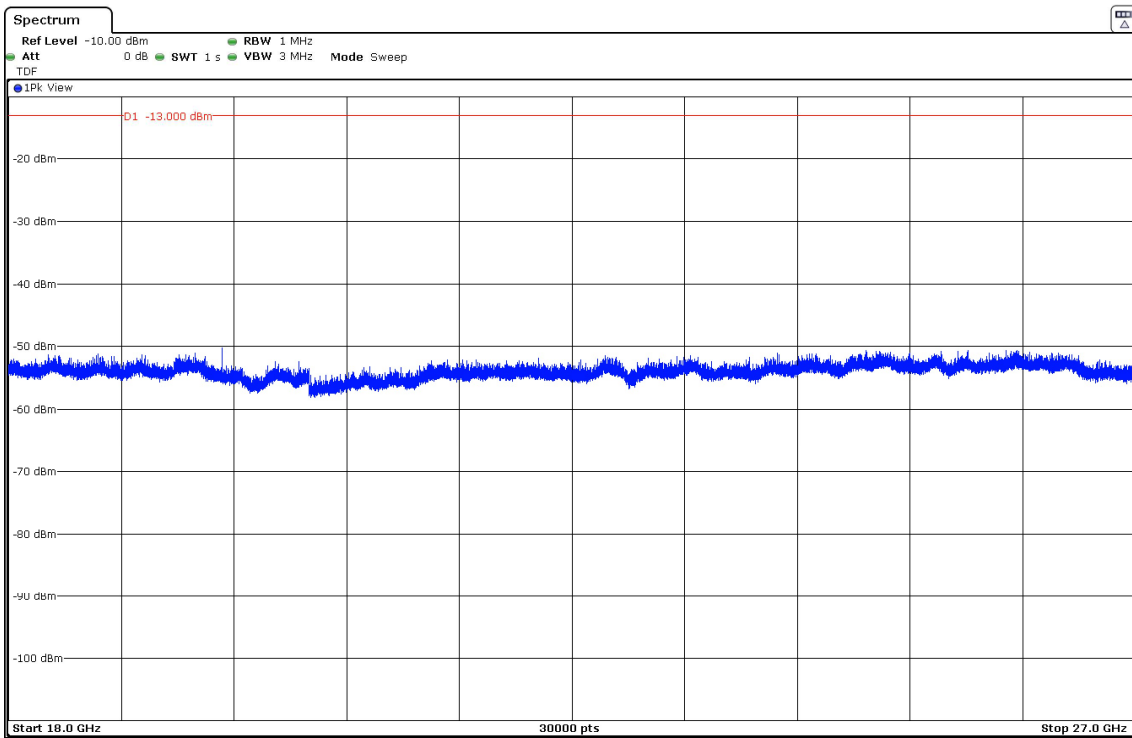
- Low Channel:



- Middle Channel:

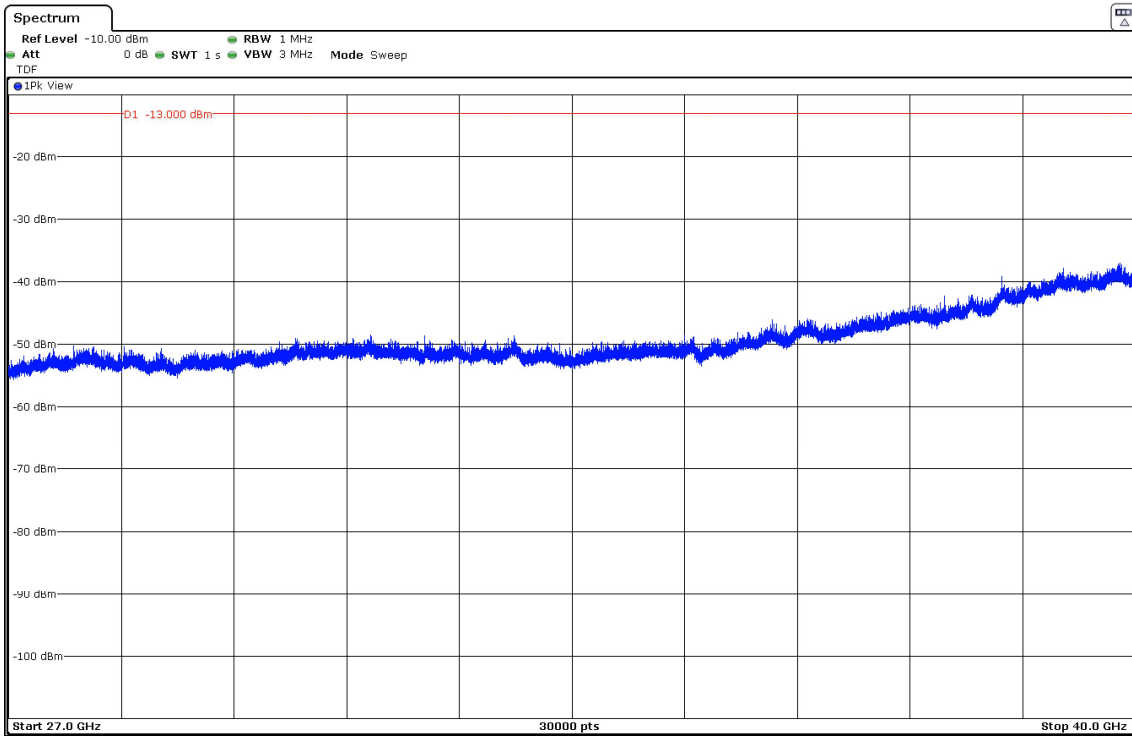


- High Channel:

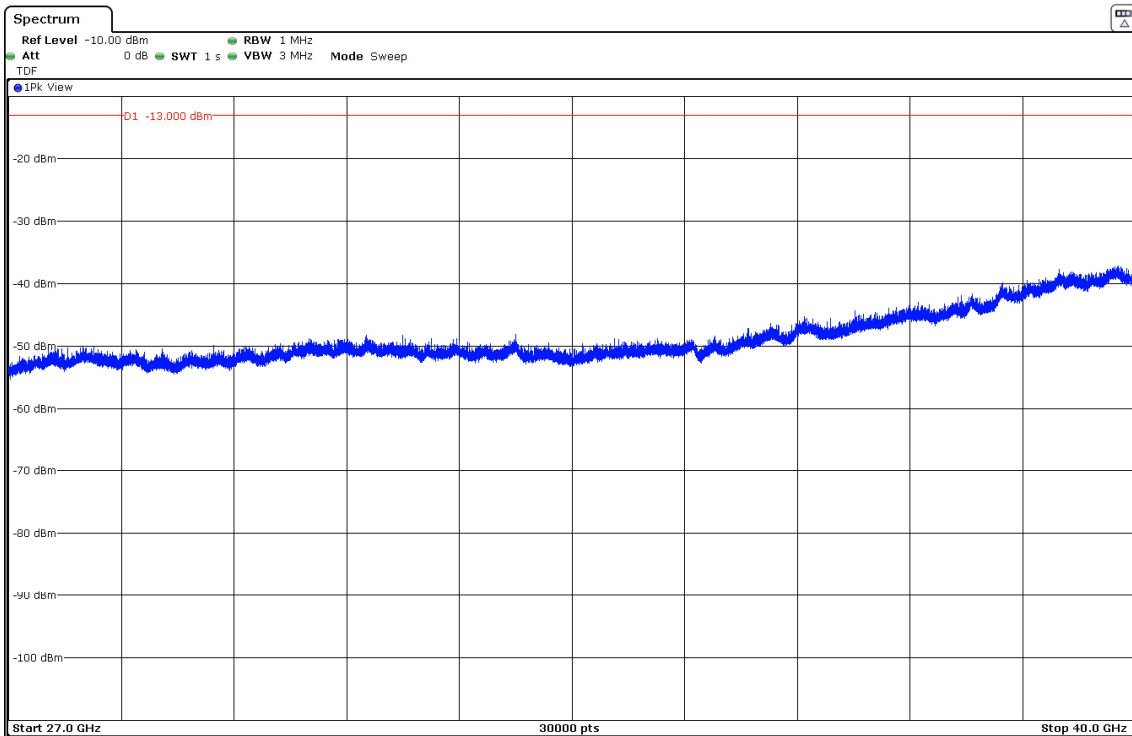


**FREQUENCY RANGE 27 GHz – 40 GHz (worst-case):**

- Low Channel:



- Middle Channel:





- High Channel:

