DEKRA Testing and Certification, S.A.U.
Parque Tecnológico de Andalucía,
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C.I.F. A29507456

ISED CABid: ES1909

Test report No:
NIE: 68001RRF.010

Partial Test Report

Reference Standard:
USA FCC Part 22
CANADA RSS-132

(*) 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 22 (10-1-19 Edition). CANADA RSS-132 Issue 3, January 2013. - Radiated emissions. 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  2022.01.11 16:44:50 +01'00'
Date of issue	2022-01-11
Report template No	FDT08_23 (*) "Data provided by the client"

Index

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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 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-GOERING-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

i. V. Alexandru Neacsu

By: Alexandru Costin Neacsu
Title: Regulatory Product Compliance Expert
Company: Harman Becker
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i. V.

By: Victor Negrea
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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.

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	B4250S0M4907002	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/065	Spoiler Antenna (FSA-WAVE-5G Links)	FS01DI20	--	2021/10/28
62486/026	Antenna Box	AB01-I20-01	--	2020/09/22
62486/062	RF Harness	--	--	2020/09/22

Auxiliary elements used with the Sample S/01:

Control Nº	Description	Model	Serial Nº	Date of reception
68000C/009	Battery	607492	--	2021/07/29
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
62486/162	OABR 1000 BaseT Converter	--	--	2020/09/28
62486/070	I-Box OABR Adapter	--	--	2020/09/22
62486/101	SOS Button (E-Call)	9385	11221	2020/09/28
62486/042	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.

Test sample description

Ports……:	Port name and description	Cable			
		Specified max length [m]	Attached during test	Shielded	Coupled to patient(3)
	RF connector –code D violet trunk/roof)	Port not used for SOP2021 (it has V2X interfaces and gateway for SDARS signal towards another ECU)	☐	☒	☐
	RF connector – code C blue (trunk/roof)	>5m	☒	☒	☐
	NanoMQS 20pol	>5m	☒	☐	☐
	NanoMQS 10pol	>8m	☒	☐	☐
	HDBT MATEnet 2-Pol (Roof/Trunk)	>5m	☒	☐	☐
	Antenna Connector grey (Roof)	<0.5m	☒	☒	☐
Supplementary information to the ports……:	-				
Rated power supply ..... :	Voltage and Frequency				
	☒	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 ..... :	☐	Table top equipment			
	☐	Wall/Ceiling mounted equipment			
	☐	Floor standing equipment			
	☐	Hand-held equipment			
	☒	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/3G4G/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		

(3) Only for Medical Equipment

Identification of the client

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

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2021-10-21
Date (finish)	2021-10-21

Document history

Report number	Date	Description
68001RRF.010	2022-01-11	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: Alfonso Gutierrez 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.	Horn Antenna 1-18 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9120 D	2020/08	2023/08
4.	Biconical/Log Antenna 30MHz - 6 GHz ETS LINDGREN 3142E	2020/10	2023/10
5.	RF Preamplifier G>30dB, 1-18GHz BONN ELEKTRONIK BLMA 0118-3A	2020/10	2021/10
6.	Signal and Spectrum Analyzer 10 Hz - 40 GHz ROHDE AND SCHWARZ FSV40	2021/10	2023/10
7.	EMI Test Receiver 7 GHz ROHDE AND SCHWARZ ESR7	2019/10	2021/10
8.	Wideband Radio Communication Tester ROHDE AND SCHWARZ CMW500	N/A	N/A
10.	EMI Test Receiver 7 GHz ROHDE AND SCHWARZ ESR7	2020/12	2022/12
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 22 / RSS-132 PARAGRAPH		
Requirement – Test case	**Verdict**	**Remark**
FCC 22.913 / RSS-132 5.4: RF output power	N/M	(1)
FCC 2.1047 / RSS-132 5.2: Modulation characteristics	N/M	(1)
FCC 22.355 / RSS-132 5.3: Frequency stability	N/M	(1)
FCC 2.1049: Occupied Bandwidth	N/M	(1)
FCC 22.917 / RSS-132 5.5: Spurious emissions at antenna terminals	N/M	(1)
FCC 22.917 / RSS-132 5.5: Radiated emissions	P	
Supplementary information and remarks: (1) Test not requested. Radiated emissions test only requested.		

Appendix A: Test results for FCC Part 22 / RSS-132

INDEX

TEST CONDITIONS

POWER SUPPLY (V):

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

The module with the highest antenna gain has been tested using the worst case obtained for conducted output power for New Radio 5G. And the other module has been tested using an adjacent channel to the 5G with LTE band with a setting that would allow communication in the same band to both modules simultaneously.

TEST FREQUENCIES:

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

n5A + LTE Band 5:

Table 4.3.1.1.1.5-1: Test frequencies for NR operating band n5 and SCS 15 kHz

CBW [MHz]	*carrier Bandwidth* [PRBs]	Range		Carrier centre [MHz]	Carrier centre [ARFCN]	point A [MHz]	*absolute FrequencyPoint A* [ARFCN]	*offsetToCarrier* [Carrier PRBs]	SS block SCS [kHz]	GSCN	*absolute FrequencySSB* [ARFCN]	k_{SSB}	Offset Carrier CORESET#0 [RBs] Note 2	CORESET#0 Index (Offset [RBs]) Note 1	offsetToPointA (SIB1) [PRBs] Note 1
5	25	Downlink	Low	871.5	174300	869.25	173850	0	15	2178	174270	8	1	0 (0)	1
			Mid	881.5	176300	860.89	172178	102		2203	176210	0	0	0 (0)	102
			High	891.5	178300	798.53	159706	504		2228	178330	4	1	1 (2)	507
		Uplink	Low	826.5	165300	824.25	164850	0	-	-	-	-	-	-	-
			Mid	836.5	167300	743.53	148706	504		-	-	-	-	-	-
			High	846.5	169300	843.17	168634	6		-	-	-	-	-	-
10	52	Downlink	Low	874	174800	869.32	173864	0	15	2179	174290	10	1	0 (0)	1
			Mid	881.5	176300	858.46	171692	102		2197	175730	2	0	0 (0)	102
			High	889	177800	793.6	158720	504		2218	177410	2	1	2 (4)	509
		Uplink	Low	829	165800	824.32	164864	0	-	-	-	-	-	-	-
			Mid	836.5	167300	741.1	148220	504		-	-	-	-	-	-
			High	844	168800	838.24	167648	6		-	-	-	-	-	-
15	79	Downlink	Low	876.5	175300	869.39	173878	0	15	2177	174250	4	0	0 (0)	0
			Mid	881.5	176300	856.03	171206	102		2191	175250	4	0	0 (0)	102
			High	886.5	177300	788.67	157734	504		2205	176430	4	1	2 (4)	509
		Uplink	Low	831.5	166300	824.39	164878	0	-	-	-	-	-	-	-
			Mid	836.5	167300	738.67	147734	504		-	-	-	-	-	-
			High	841.5	168300	833.31	166662	6		-	-	-	-	-	-
20	106	Downlink	Low	879	175800	869.46	173892	0	15	2178	174270	6	0	0 (0)	0
			Mid	881.5	176300	853.6	170720	102		2185	174770	6	0	0 (0)	102
			High	884	176800	783.74	156748	504		2192	175450	6	1	2 (4)	509
		Uplink	Low	834	166800	824.46	164892	0	-	-	-	-	-	-	-
			Mid	836.5	167300	736.24	147248	504		-	-	-	-	-	-
			High	839	167800	828.38	165676	6		-	-	-	-	-	-

Note 1: The CORESET#0 Index and the associated CORESET#0 Offset refers to Table 13-1 in TS 38.213 [22]. The value of CORESET#0 Index is signalled in controlResourceSetZero (pdcch-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.
Note 2: The parameter Offset Carrier CORESET#0 specifies the offset from the lowest subcarrier of the carrier and the lowest subcarrier of CORESET#0. It corresponds to the parameter $\Delta F_{OffsetCORESET\text{-}0\text{-}Carrier}$ in Annex C expressed in number of common RBs.

Module NAD2					Module NAD1			
Test frequencies for n5A					Test frequencies for LTE Band 5			
5G Carrier in Band n5								
Channel	n5A				LTE Band 5			
	SCS (kHz)	BW (MHz)	Freq. (MHz)	NR-ARFCN	Channel	BW (MHz)	Freq. (MHz)	EARFCN
Low	15	20	834	166800	Adjacent channel to Low	5	846.5	20625
Middle	15	20	836.5	167300	Adjacent channel to Middle	1.4	847.2	20632
High	15	20	839	167800	Adjacent channel to High	5	826.5	26815

Radiated emissions

SPECIFICATION:

FCC §22.917 and RSS-132 Issue 3 Clause 5.5:

The power of emissions shall be attenuated below the transmitter power (P) by a factor of at least 43 + 10 log (P) dB. P in watts.

METHOD:

The measurement was performed with the EUT inside an anechoic chamber. The spectrum was scanned from 30 MHz to at least the 10th harmonic of the High frequency generated within the equipment.

The EUT was placed on a 1 meter high 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 field strength (dBµV/m) is measured and recorded.

The maximum field strength (dBµV/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:

EIRP (dBm) = E (dBµV/m) + 20 log(D) - 104.8; where D is the measurement distance (in the far field region) in m. D = 3 m

Measurement Limit:

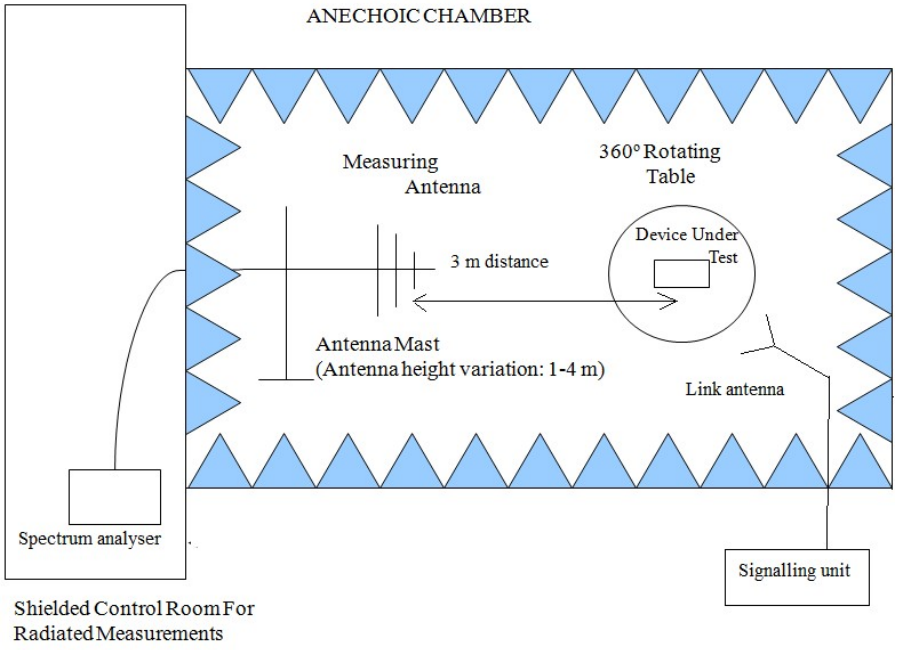
According to specification. the power of emissions shall be attenuated below the transmitter power (P) by a factor of at least 43 + 10 log (P) dB. P in Watts.
At Po transmitting power. the specified minimum attenuation becomes 43+10log (Po). and the level in dBm relative Po becomes:

$$Po\ (dBm) – [43 + 10 \log (Po \text{ in mWatts}) - 30] = -13\ dBm$$

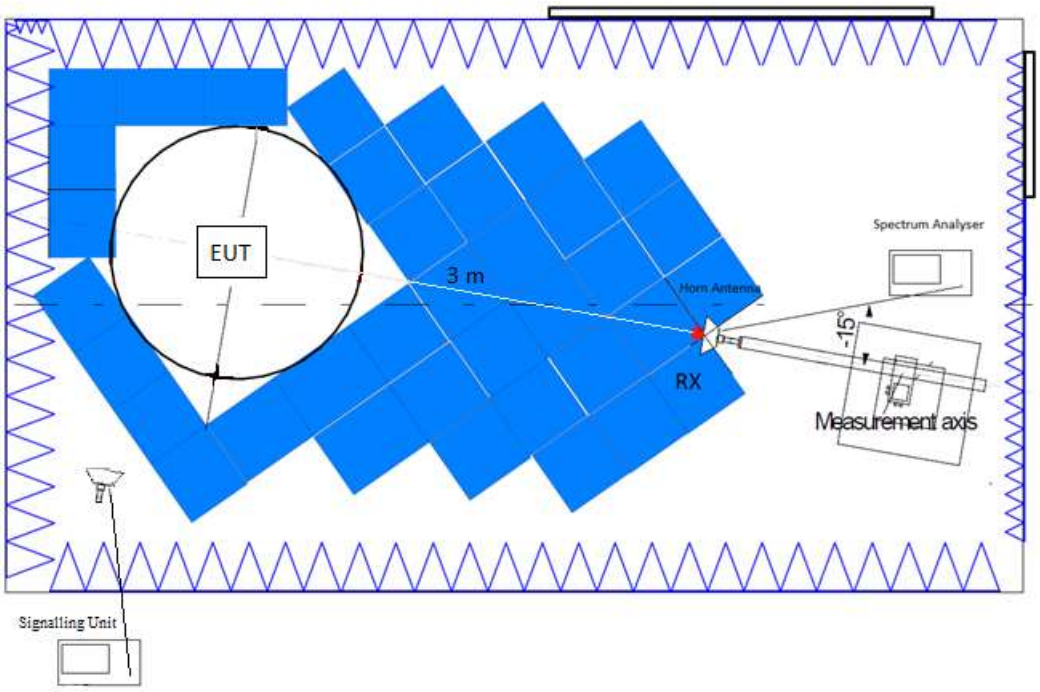
A resolution bandwidth / video bandwidth of 100 kHz / 300 kHz was used for frequencies below 1 GHz and 1 MHz / 3 MHz for frequencies above 1 GHz.

TEST SETUP:

Radiated measurements below 1 GHz:



Radiated measurements above 1 GHz up to 8.5 GHz:



RESULTS:

- **n5A + LTE Band 5:**

A preliminary scan determined the worst case:

1) n5A (Module NAD2):

   n5A: Pi/2 BPSK, BW=20 MHz, SCS=15 kHz, RB=1, Offset=0.

2) LTE Band 5 (Module NAD1):

   5: QPSK, BW=5 MHz (for Low and High Channels), BW=1.4 MHz (for Middle Channel), RB=1, Offset=0.

The following results are the ones of the worst case.

- LOW CHANNEL:

Frequency range 30 MHz - 1 GHz:

Spurious frequency (MHz)	E.I.R.P (dBm)	Polarization	Detector	Measurement Uncertainty (dB)
817.9795	-25.21	V	Peak	<± 5.08
850.9110	-21.16	V	Peak	<± 5.08

Frequency range 1 - 8.5 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 - 8.5 GHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (GHz)	E.I.R.P (dBm)	Polarization	Detector	Measurement Uncertainty (dB)
2.53984	-32.72	V	Peak	<± 5.13

- HIGH CHANNEL:

Frequency range 30 MHz - 1 GHz:

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

Frequency range 1 - 8.5 GHz:

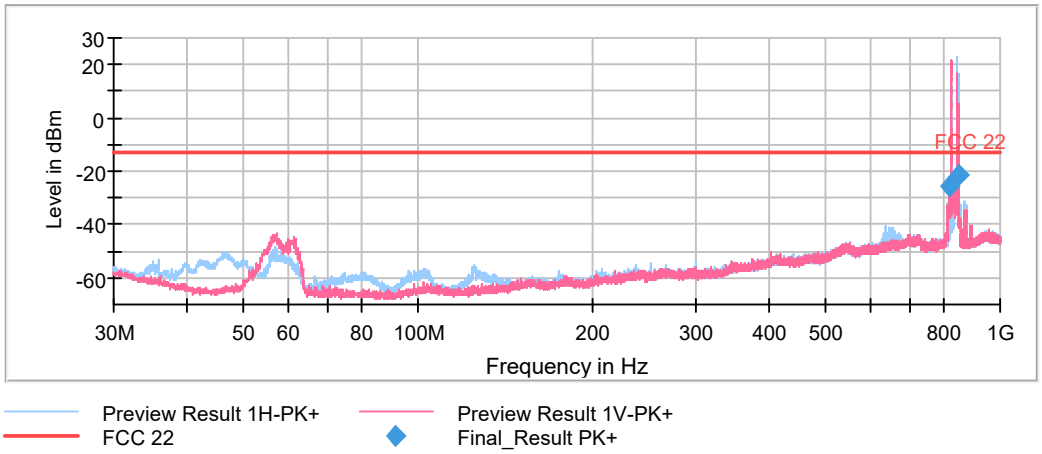
No spurious frequencies at less than 20 dB below the limit.

Measurement Uncertainty (dB): <± 5.08 for f ≥ 30 MHz up to 1 GHz
<± 5.13 for f ≥ 1 GHz up to 8.5 GHz

Verdict: PASS

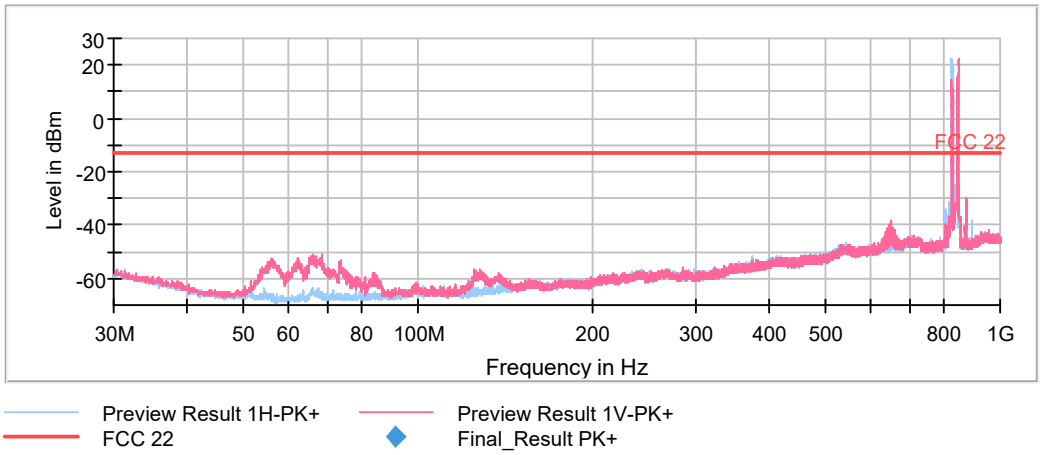
FREQUENCY RANGE 30 MHz - 1 GHz (worst case):

- Low Channel:



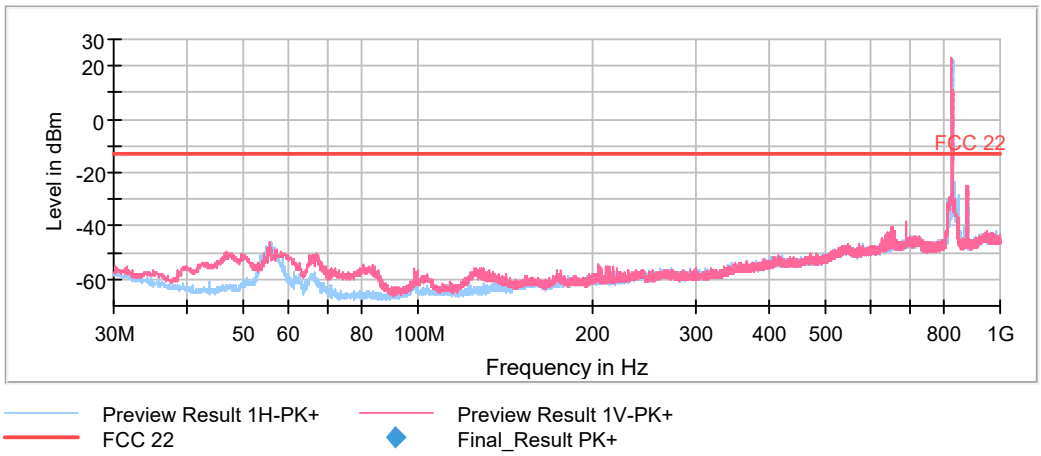
The peaks above the limit are the carrier frequencies. The peaks at 879MHz and 891.5MHz correspond to the downlink signals.

- Middle Channel:



The peaks above the limit are the carrier frequencies. The peaks at 881.5MHz and 892.3MHz correspond to the downlink signals.

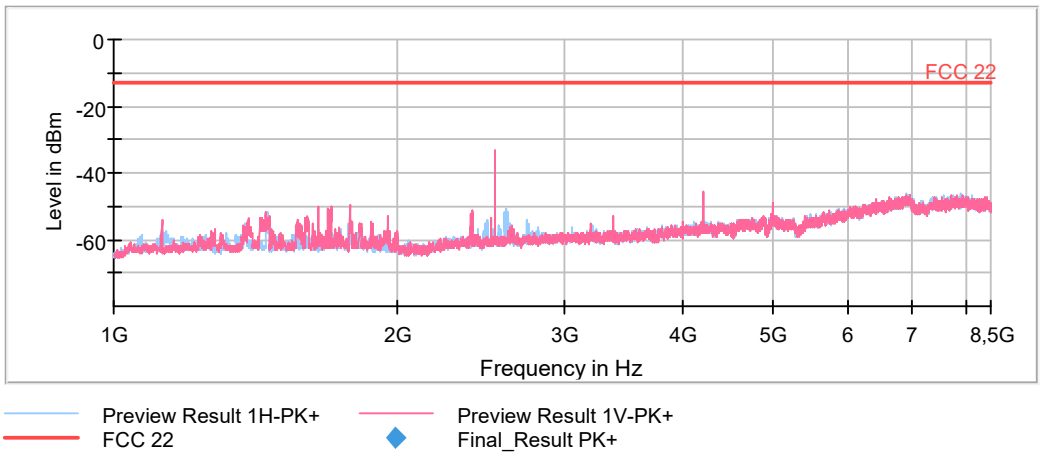
- High Channel:



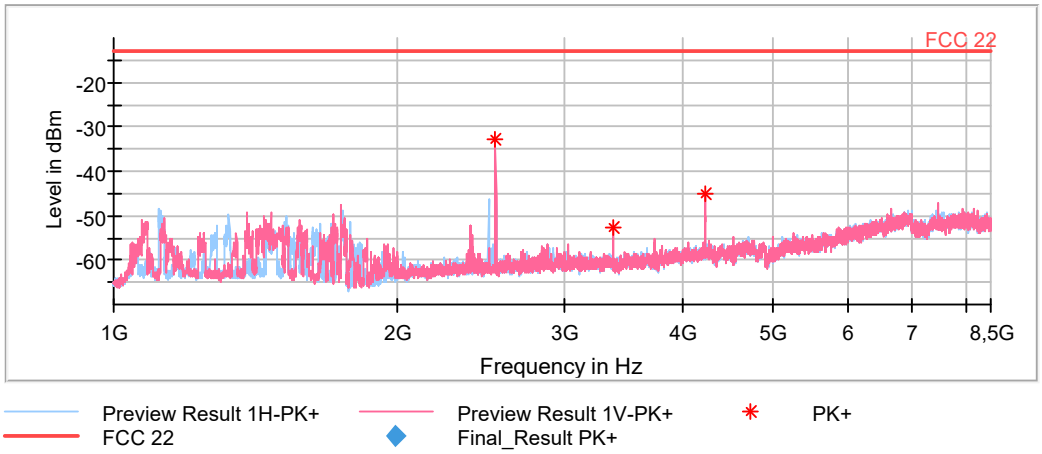
The peaks above the limit are the carrier frequencies. The peaks at 884MHz corresponds to the downlink signal.

FREQUENCY RANGE 1 - 8.5 GHz (worst case):

- Low Channel:



- Middle Channel:



- High Channel: