

Test report No:
NIE: 62486RRF.005

Partial Test Report

USA FCC 15.31(h), 22, 24

CANADA RSS-132, RSS-133

(*) Identification of item tested	Telematic control unit with wireless technologies, used in automotive industry
(*) Trademark	BMW
(*) Model and /or type reference	WAVE-11-HIGH-R1
Other identification of the product	HW version: D3 SW version: 20512H.001_047_009 FCC ID: T8GWAVE11HIGH-R1 IC: 6434A-WAVE11HIGH-R1
(*) 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 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. CANADA RSS-132 Issue 3, Jan. 2013. CANADA RSS-133 Issue 6, Jan. 2018. -Transmitter out of band radiated emissions with simultaneous transmissions. KDB 971168 D01 Power Meas License Digital Systems v03r01, April 2018. ANSI C63.26-2015.
Approved by (name / position & signature)	José Carlos Luque RF Lab. Supervisor 
Date of issue	2021-02-02
Report template No	FDT08_23 (*) "Data provided by the client"

Firmado digitalmente por
74841983Y JOSE
CARLOS LUQUE
(C:A29507456)
Fecha: 2021.02.02
13:17:57 +01'00'

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Competences and guarantees

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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-HIGH-R1 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.

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 N°	Description	Model	Serial N°	Date of reception
62486E/105	Telematic Control Unit	WAVE-11-HIGH-R1	B392120L4900533	2020/09/28
62486E/012	Antenna	DA05DI20	--	2020/09/22
62486E/036	Antenna Box	AB01-I20-01	--	2020/09/22
62486E/037	Antenna Box	AB01-I20-01	--	2020/09/22
62486E/038	Antenna Box	AB01-I20-01	--	2020/09/22
62486E/039	Antenna Box	AB01-I20-01	--	2020/09/22
62486E/060	Harness 20 pol	--	--	2020/09/22
62486E/061	Harness 20 pol	--	--	2020/09/22

Auxiliary elements used with the Sample S/01:

Control N°	Description	Model	Serial N°	Date of reception
62486E/110	Battery Li-ion	11FR1580-2	--	2020/09/28
62486E/042	Antenna ground planes for roof	--	--	2020/09/22
62486E/045	RF Cable for 4-Fakra	--	--	2020/09/22
62486E/056	OABR Cable	--	--	2020/09/22
62486E/064	OABR 1000 BaseT Converter	--	--	2020/09/22
62486E/067	I-Box OABR Adapter	--	--	2020/09/22
62486E/071	Ethernet Cable	--	--	2020/09/22
62486E/090	Speaker	FR7	--	2020/09/28
62486E/097	SOS Pulser (E-Call)	9385	11224	2020/09/28

Sample S/01 has undergone the following test(s): The Radiated tests indicated in the Appendixes A, B.

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		Reference poles				
			L1	L2	L3	N	PE
	☐	AC:	☐	☐	☐	☐	☐
	☐	AC:	☐	☐	☐	☐	☐
	☒	DC: 12V car battery / attenuator (4,5 V ≤ UB ≤ 18 V; UB typical: 12 V)					
☐	DC:						
Rated Power	12V DC						
Clock frequencies.....	25MHz;26MHz;32,768kHz;49,58MHz;						
Other parameters	See Technical description						
Software version	D3						
Hardware version	20512H.001_047_009						

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)	2020-11-18
Date (finish)	2020-12-14

Document history

Report number	Date	Description
62486RRF.005	2021-02-02	First release.

Environmental conditions

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

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

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

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

Remarks and comments

The tests have been performed by the technical personnel: Verónica García, Pablo Redondo, José Manuel Jiménez, Miguel Manuel López, Nicolás Salguero.

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	2019/11	2022/11
4. RF Preamplifier, 40 dB ,1-18 GHz BONN ELEKTRONIK BLMA 0118-1M	2020/05	2021/05
5. EMI Test Receiver 7 GHz ROHDE AND SCHWARZ ESR7	2019/10	2021/10
6. Spectrum Analyzer ROHDE AND SCHWARZ FSW50	2020/07	2022/07
7. Wideband Radio Communication Tester ROHDE AND SCHWARZ CMW500	2020/07	2021/07
8. Log Periodic Antenna, SCHWARZBECK MESS-ELEKTRONIK USLP 9142	N.A.	N.A.
9. Horn Antenna 1-18 GHz, SCHWARZBECK BBHA 9120 D	2018/01	2021/01
10. DC Power Supply 30V/5A KEYSIGHT TECHNOLOGIES U8002A	---	---
11. Digital Multimeter FLUKE 179	2020/06	2021/06
12. Low Noise Amplifier G>30dB, 18 - 40 GHz BONN ELEKTRONIK BLMA 1840-1M	2019/02	2021/02
13. Wideband Radio Communication Tester ROHDE AND SCHWARZ CMW500	2020/04	2021/04
14. Biconical/Log Antenna 30MHz - 6GHz ETS LINDGREN 3142E	2020/10	2023/10
15. Horn Antenna 1-18 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9120 D	2018/01	2021/01
16. RF Preamplifier G>30dB, 1-18GHz BONN ELEKTRONIK BLMA 0118-3A	2020/10	2021/10
17. Signal and Spectrum Analyzer 10 Hz - 40 GHz ROHDE AND SCHWARZ FSV40	2019/10	2021/10
18. DC Power Supply, 30V/5A KEYSIGHT TECHNOLOGIES U8002A	---	---
19. Digital Multimeter, FLUKE 175	2020/11	2021/11
20. Horn Antenna 18 - 40 GHz SCHWARZBECK MESS-ELEKTRONIK BBHA 9170	2018/07	2021/07

Testing verdicts

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

Summary

FCC Parts 15, 22, 24 / RSS-132, RSS-133 PARAGRAPH		
Requirement – Test case	Verdict	Remark
FCC 15.31(h), FCC 22.917 / RSS-132 5.5., FCC 24.238 / RSS-133 6.5. Emission limitations radiated (Transmitter)	P	(1) (2)
<u>Supplementary information and remarks:</u> (1) Only Co-Location radiated spurious emission test was requested. (2) The report 62486RRF.001 contains the results of the pre-testing to determine the worst case of the setting of the antennas: · Conf #1: MIMO1 Port -> Int BuA Antenna / MIMO2 Port -> MIMO2 Antenna / Antennenbox for NAD#2. · Conf #2: MIMO1 Port -> Int BuA Antenna / MIMO2 Port -> MIMO2 Antenna / FSA antenna for NAD#2. · Conf #3: MIMO1 Port -> MIMO1 Antenna / MIMO2 Port -> MIMO2 Antenna / Antennenbox for NAD#2. · Conf #4: MIMO1 Port -> MIMO2 Antenna / MIMO2 Port -> MIMO2 Antenna / FSA antenna for NAD#2.		

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

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TEST CONDITIONS

POWER SUPPLY (V):

V nominal: 12 Vdc

Type of Power Supply: DC external (car battery).

TEST FREQUENCIES:

Based on preliminary testing that identified the worst cases, in terms of the highest E.I.R.P.

	CELLULAR 2G + 3G		
Band:	2G Band GSM-850		
Frequency Range:	824 – 849 MHz		
Transmit Channel:	Module	Channel	Channel Frequency (MHz)
	NAD1	Middle: 190	836.6
	NAD2	Adjacent channel to Middle: 192	837
Band:	3G Band V		
Frequency Range:	824 – 849 MHz		
Transmit Channel:	Module	Channel	Channel Frequency (MHz)
	NAD2	Adjacent channel to Middle: 4207	841.4
	NAD1	Middle: 4182	836.4

	CELLULAR 2G + LTE		
Band:	2G Band GSM-850		
Frequency Range:	824 – 849 MHz		
Transmit Channel:	Module	Channel	Channel Frequency (MHz)
	NAD1	Middle: 190	836.6
	NAD2	Adjacent channel to Middle: 192	837
Band:	LTE Band 5		
Frequency Range:	824 – 849 MHz		
Transmit Channel:	Module	Channel	Channel Frequency (MHz)
	NAD2	Adjacent channel to Middle: 20575	841.5
	NAD1	Adjacent channel to High: 20625	846.5

	CELLULAR 3G + LTE		
Band:	3G Band V		
Frequency Range:	824 – 849 MHz		
Transmit Channel:	Module	Channel	Channel Frequency (MHz)
	NAD1	Middle: 4182	836.4
	NAD2	Adjacent channel to Middle: 4175	835
Band:	LTE Band 5		
Frequency Range:	824 – 849 MHz		
Transmit Channel:	Module	Channel	Channel Frequency (MHz)
	NAD2	Adjacent channel to Middle: 20575	841.5
	NAD1	Adjacent channel to High: 20625	846.5

The test set-up was made in accordance to the general provisions of the KDB 971168 D01 Power Meas License Digital Systems v03r01, April 2018.

Selected Transmission Modes for each Radio:

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

- **Module NAD1:**

- * Cellular 2G Band GSM-850: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in:

- Cellular 2G Band GSM-850 / Middle Channel in GPRS mode configuration.

- * Cellular 3G Band V: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in: Cellular 3G Band V / Middle Channel in WCDMA mode configuration.

- * Cellular LTE: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in: Cellular LTE Band 5 / Adjacent channel to High Channel in QPSK mode configuration.

- **Module NAD2:**

- * Cellular 2G Band GSM-850: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in:

- Cellular 2G Band GSM-850 / Adjacent channel to Middle Channel in GPRS mode configuration.

- * Cellular 3G Band V: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in: Cellular 3G Band V / Adjacent channel to Middle Channel in WCDMA mode configuration.

- * Cellular LTE: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in: Cellular LTE Band 5 / Adjacent channel to Middle Channel in QPSK mode configuration.

TESTED SIMULTANEOUS TRANSMISSION MODES:

*** Co-Location mode 2G Band GSM-850, 3G Band V**, with the EUT configured to simultaneously transmit two signals at maximum output power:

CO-LOCATION	2G Band GSM-850		3G Band V	
	Module	Channel	Module	Channel
MULTI-TRANSMITTER MODE 1	NAD1	Middle	NAD2	Adjacent channel to Middle
MULTI-TRANSMITTER MODE 2	NAD2	Adjacent channel to Middle	NAD1	Middle

*** Co-Location mode 2G Band GSM-850, LTE Band 5**, with the EUT configured to simultaneously transmit two signals at maximum output power:

CO-LOCATION	2G Band GSM-850		LTE Band 5	
	Module	Channel	Module	Channel
MULTI-TRANSMITTER MODE 1	NAD1	Middle	NAD2	Adjacent channel to Middle
MULTI-TRANSMITTER MODE 2	NAD2	Adjacent channel to Middle	NAD1	Adjacent channel to High

*** Co-Location mode 3G Band V, LTE Band 5**, with the EUT configured to simultaneously transmit two signals at maximum output power:

CO-LOCATION	3G Band V		LTE Band 5	
	Module	Channel	Module	Channel
MULTI-TRANSMITTER MODE 1	NAD1	Middle	NAD2	Adjacent channel to Middle
MULTI-TRANSMITTER MODE 2	NAD2	Adjacent channel to Middle	NAD1	Adjacent channel to High

Radiated emissions

SPECIFICATION:

1. 2G Band GSM-850, 3G Band V, LTE Band 5. FCC §2.1053 & §22.917 / RSS-132 Issue 3 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 $43 + 10 \log_{10} P$ (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 $43 + 10 \log_{10} P$ (watts). If the measurement is performed using 1% of the occupied bandwidth, power integration over 100 kHz is required.

Measurement Limit:

According to the 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 P_o transmitting power the specified minimum attenuation becomes $43 + 10 \log(P_o)$ and the level in dBm relative P_o becomes:

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

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 highest frequency of the co-located radios.

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 maximum field strength (dBμV/m) is measured and 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.

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:

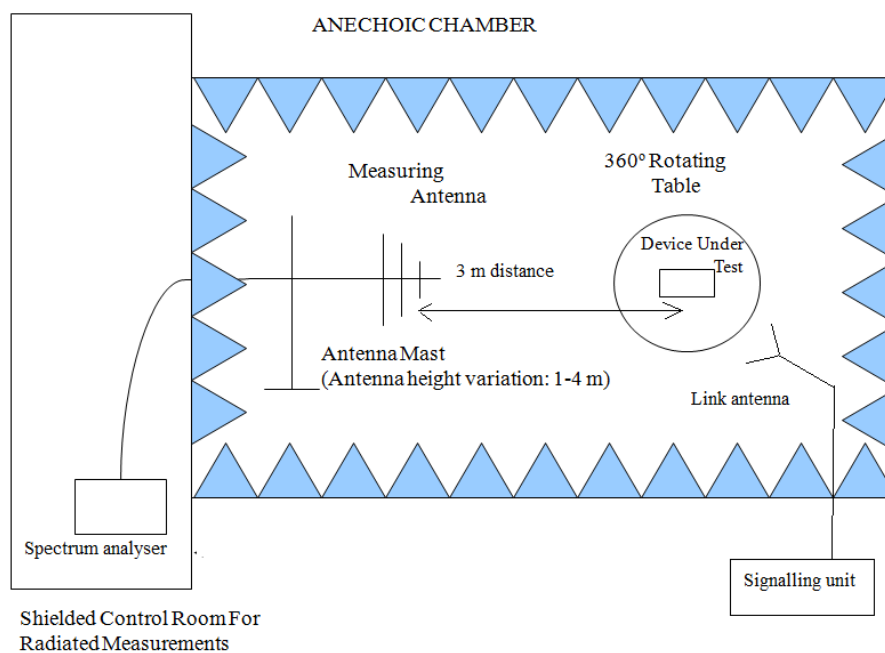
$$\text{EIRP (dBm)} = E \text{ (dBμV/m)} + 20 \log(D) - 104.8; \text{ where } D \text{ is the measurement distance (in the far field region) in m.}$$
$$D = 3 \text{ m}$$

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

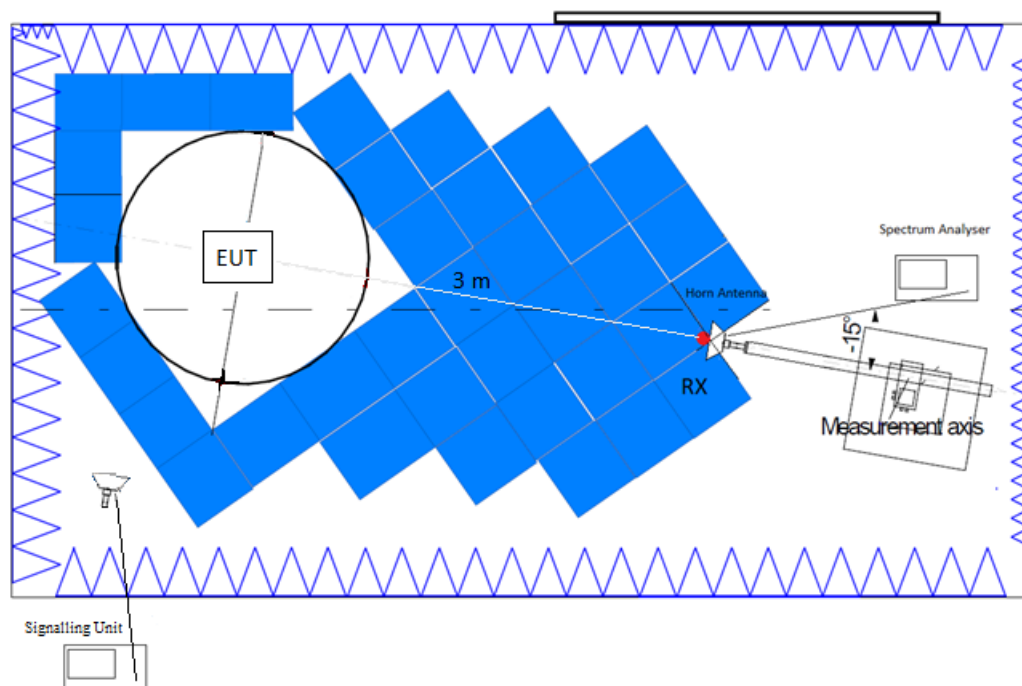
A resolution bandwidth / video bandwidth of 100 kHz / 300 kHz or higher were used for frequencies below 1 GHz and 1 MHz / 3 MHz for frequencies above 1 GHz.

TEST SETUP:

Radiated measurements below 1 GHz:



Radiated measurements above 1 GHz up to 8.5 GHz:



RESULTS:

• Co-Location mode 2G Band GSM-850, 3G Band V:

MULTI-TRANSMITTER MODE 1: A preliminary scan determined the module NAD1, 2G Band GSM-850, Middle Channel, GPRS modulation and the module NAD2, 3G Band V, Middle Channel, WCDMA modulation as the worst case. The following results are the ones of the worst case.

2G Band GSM-850: Module NAD1. Middle Channel (836.6 MHz). GPRS.
3G Band V: Module NAD2. Adjacent channel to Middle Channel (841.4 MHz). WCDMA.

MULTI-TRANSMITTER MODE 2: A preliminary scan determined the module NAD2, 2G Band GSM-850, Middle Channel, GPRS modulation and the module NAD1, 3G Band V, Middle Channel, WCDMA modulation as the worst case. The following results are the ones of the worst case.

2G Band GSM-850: Module NAD2. Adjacent channel to Middle Channel (837 MHz).GPRS.
3G Band V: Module NAD1. Middle Channel (836.4 MHz). WCDMA.

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

Frequency Range	Detector	Limit at 3m (dBm)
30 MHz to 8.5 GHz	PK	$43 + 10 \log (P) \text{ dB} = -13 \text{ dBm}$

MULTI-TRANSMITTER MODE 1:

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.

MULTI-TRANSMITTER MODE 2:

Frequency range 30 MHz - 1 GHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	E.I.R.P. (dBm)	Polarization	Detector	Measurement Uncertainty (dB)
280.648	-32.3	H	Peak	$\leq \pm 4.99$

Frequency range 1 - 8.5 GHz:

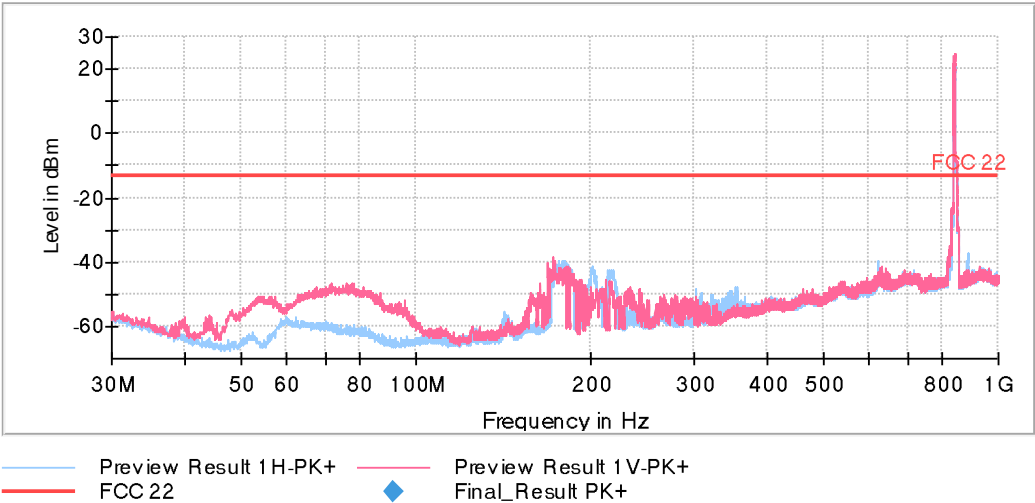
No spurious frequencies at less than 20 dB below the limit.

Measurement Uncertainty (dB)	$\leq \pm 4.99$ for $f < 1 \text{ GHz}$ $\leq \pm 4.98$ for $f \geq 1 \text{ GHz}$ up to 8.5 GHz
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Verdict: PASS

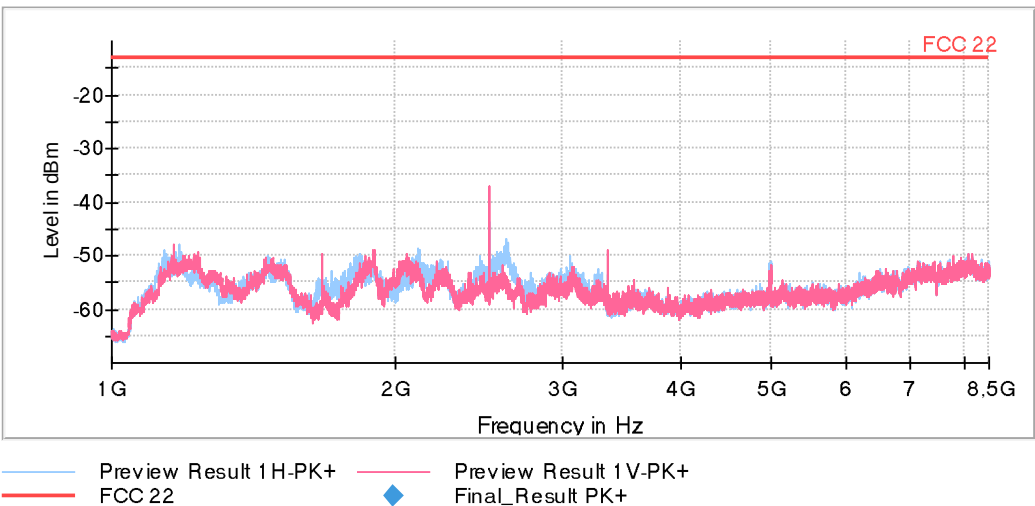
MULTI-TRANSMITTER MODE 1:

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



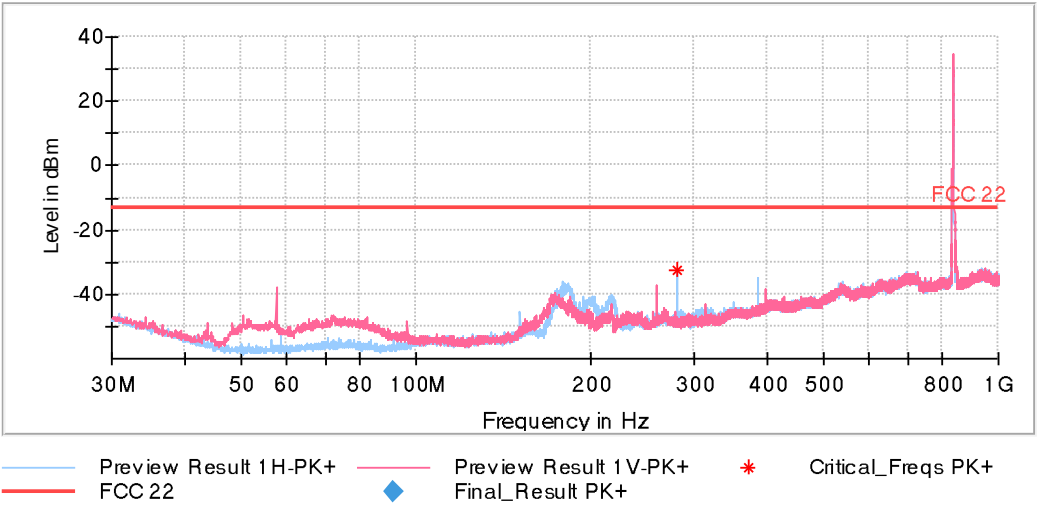
The peaks above the limit are the carriers frequencies of the 2G Band GSM-850 and the 3G Band V.

FREQUENCY RANGE 1 - 8.5 GHz (worst case):



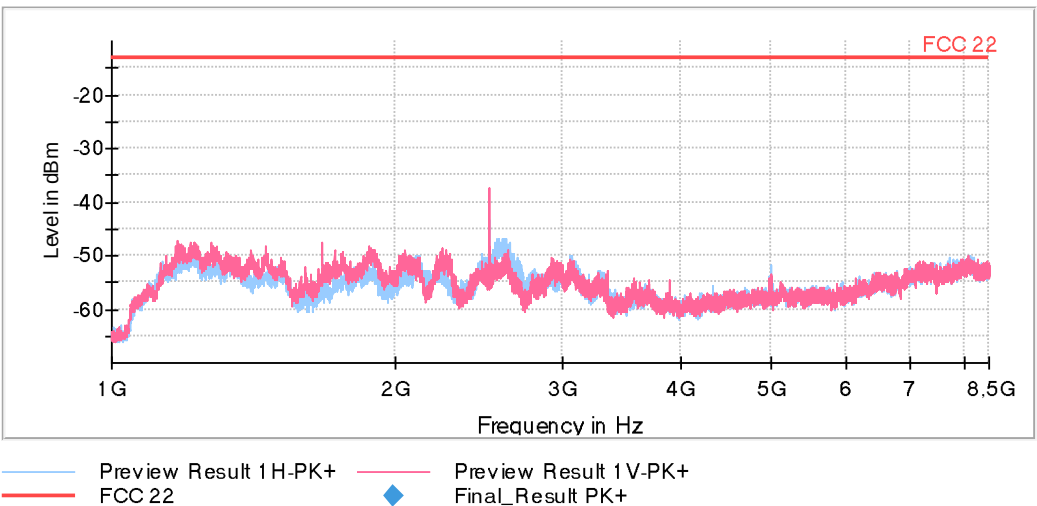
MULTI-TRANSMITTER MODE 2:

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



The peaks above the limit are the Carriers frequencies of the 2G Band GSM-850 and the 3G Band V.

FREQUENCY RANGE 1 - 8.5 GHz (worst case):



• **Co-Location mode 2G Band GSM-850, LTE Band 5:**

MULTI-TRANSMITTER MODE 1: A preliminary scan determined the module NAD1, 2G Band GSM-850, Middle Channel, GPRS modulation and the module NAD2, LTE Band 5, Middle Channel, QPSK modulation as the worst case. The following results are the ones of the worst case.

2G Band GSM-850: Module NAD1. Middle Channel (836.6 MHz). GPRS.
LTE Band 5: Module NAD2. Adjacent channel to Middle Channel (841.5 MHz). QPSK. BW=5 MHz.
RB Size=1. RB Offset=0.

MULTI-TRANSMITTER MODE 2: A preliminary scan determined the module NAD2, 2G Band GSM-850, Middle Channel, GPRS modulation and the module NAD1, LTE Band 5, Middle Channel, QPSK modulation as the worst case. The following results are the ones of the worst case.

2G Band GSM-850: Module NAD2. Adjacent channel to Middle Channel (837 MHz). GPRS.
LTE Band 5: Module NAD1. Adjacent channel to High Channel (846.5 MHz). QPSK. BW=5 MHz.
RB Size=1. RB Offset=0.

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

Frequency Range	Detector	Limit at 3m (dBm)
30 MHz to 8.5 GHz	PK	$43 + 10 \log (P) \text{ dB} = -13 \text{ dBm}$

MULTI-TRANSMITTER MODE 1:

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.

MULTI-TRANSMITTER MODE 2:

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:

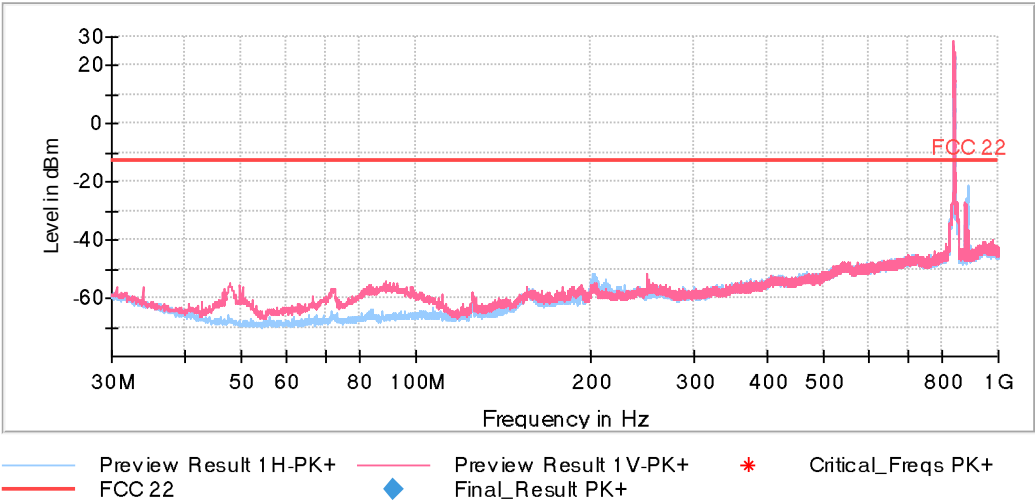
Spurious frequency (GHz)	E.I.R.P. (dBm)	Polarization	Detector	Measurement Uncertainty (dB)
1.688125000	-25.88	V	Peak	<±5.13
2.510781250	-23.82	V	Peak	<±5.13

Measurement Uncertainty (dB)	<±5.08 for $f < 1 \text{ GHz}$ <±5.13 for $f \geq 1 \text{ GHz}$ up to 8.5 GHz
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Verdict: PASS

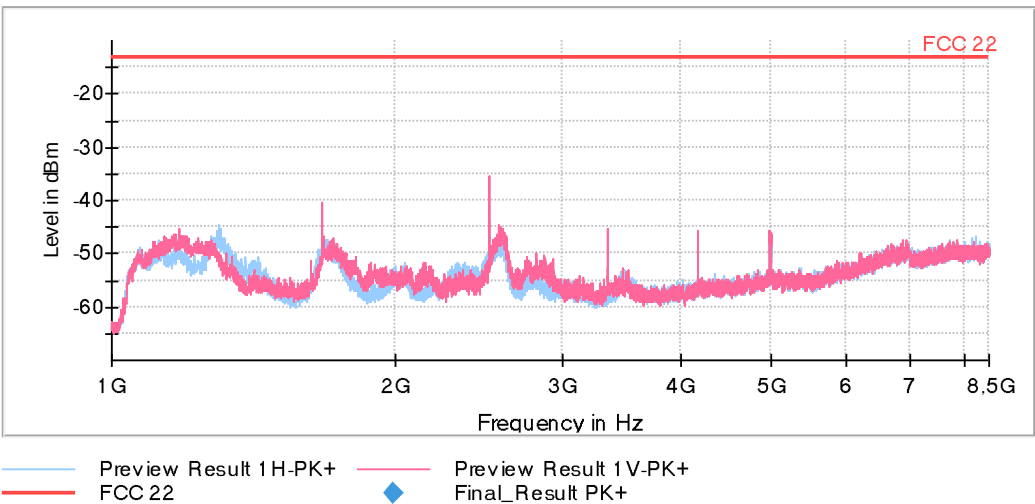
MULTI-TRANSMITTER MODE 1:

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



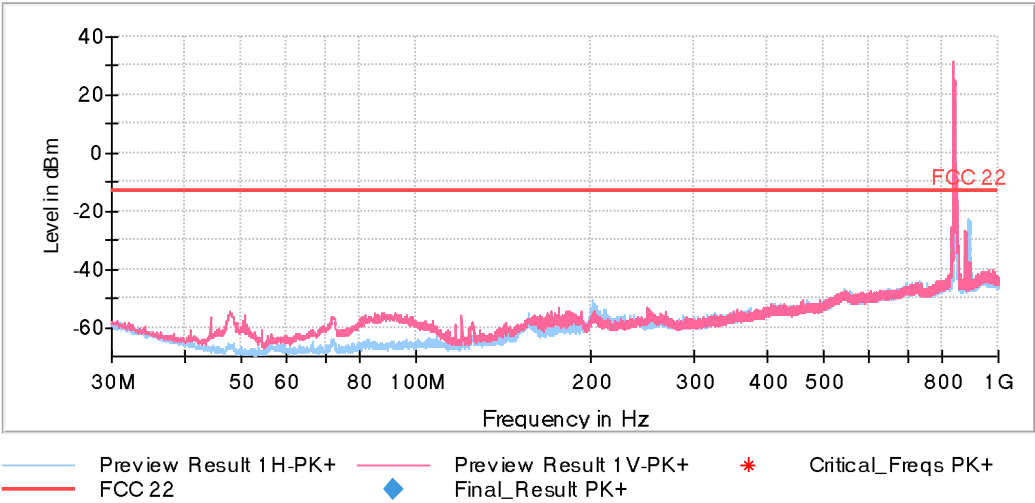
The peaks above the limit are the Carriers frequencies of the 2G Band GSM-850 and the LTE Band 5.

FREQUENCY RANGE 1 - 8.5 GHz (worst case):



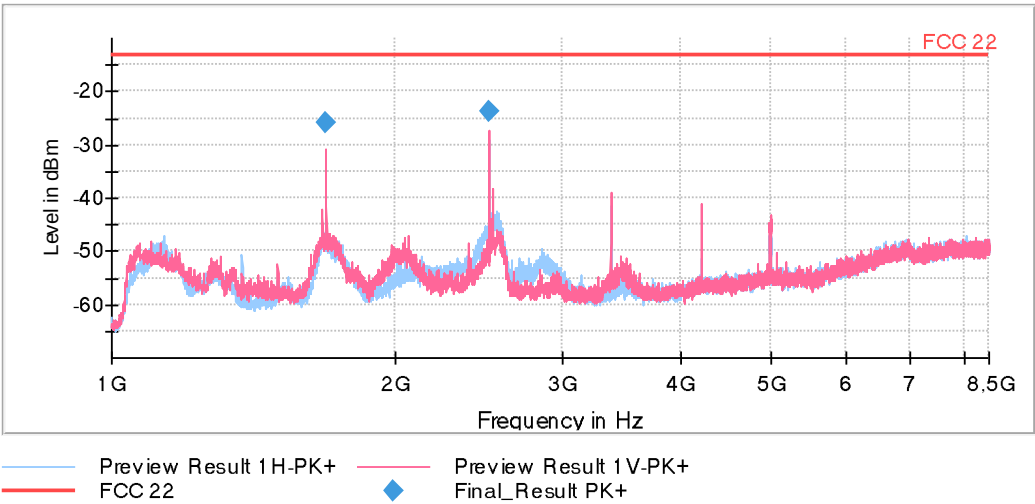
MULTI-TRANSMITTER MODE 2:

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



The peaks above the limit are the Carriers frequencies of the 2G Band GSM-850 and the LTE Band 5.

FREQUENCY RANGE 1 - 8.5 GHz (worst case):



- **Co-Location mode 3G Band V, LTE Band 5:**

MULTI-TRANSMITTER MODE 1: A preliminary scan determined the module NAD1, 3G Band V, Middle Channel, WCDMA modulation and the module NAD2, LTE Band 5, Middle Channel, QPSK modulation as the worst case. The following results are the ones of the worst case.

3G Band V: Module NAD1. Middle Channel (836.4 MHz). WCDMA.
LTE Band 5: Module NAD2. Adjacent channel to Middle Channel (841.5 MHz). QPSK. BW=5 MHz.
RB Size=1. RB Offset=0.

MULTI-TRANSMITTER MODE 2: A preliminary scan determined the module NAD2, 3G Band V, Middle Channel, WCDMA modulation and the module NAD1, LTE Band 5, High Channel, QPSK modulation as the worst case. The following results are the ones of the worst case.

3G Band V: Module NAD2. Adjacent channel to Middle Channel (835 MHz). WCDMA.
LTE Band 5: Module NAD1. Adjacent channel to High Channel (846.5 MHz). QPSK. BW=5 MHz.
RB Size=1. RB Offset=0.

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

Frequency Range	Detector	Limit at 3m (dBm)
30 MHz to 8.5 GHz	PK	$43 + 10 \log (P) \text{ dB} = -13 \text{ dBm}$

MULTI-TRANSMITTER MODE 1:

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.

MULTI-TRANSMITTER MODE 2:

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:

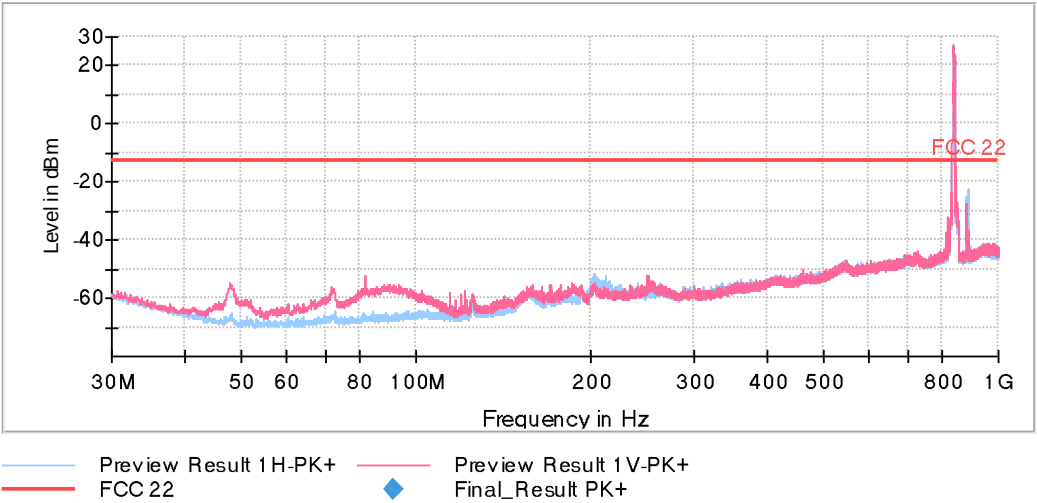
Spurious frequency (GHz)	E.I.R.P. (dBm)	Polarization	Detector	Measurement Uncertainty (dB)
1.68859375	-21.35	V	Peak	± 5.13

Measurement Uncertainty (dB)	± 5.08 for $f < 1 \text{ GHz}$ ± 5.13 for $f \geq 1 \text{ GHz}$ up to 8.5 GHz
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Verdict: PASS

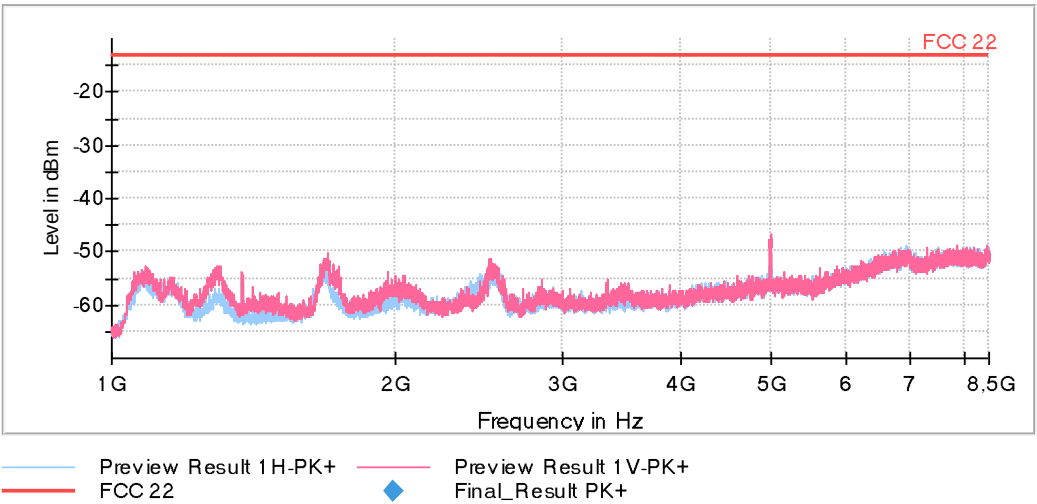
MULTI-TRANSMITTER MODE 1:

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



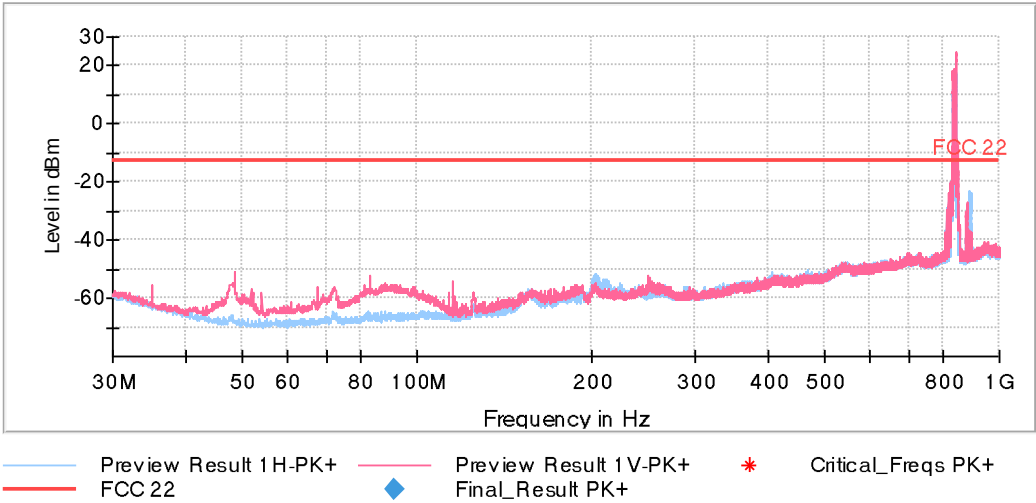
The peaks above the limit are the Carriers frequencies of the 3G Band V and LTE Band 5.

FREQUENCY RANGE 1 - 8.5 GHz (worst case):



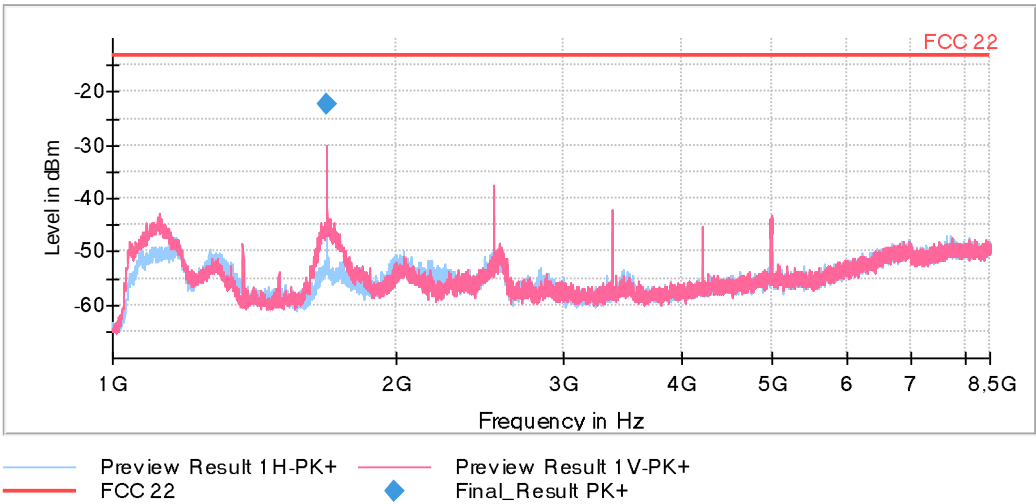
MULTI-TRANSMITTER MODE 2:

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



The peaks above the limit are the Carriers frequencies of the 3G Band V and LTE Band 5.

FREQUENCY RANGE 1 - 8.5 GHz (worst case):



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

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TEST CONDITIONS

POWER SUPPLY (V):

V nominal: 12 Vdc

Type of Power Supply: DC external (car battery).

TEST FREQUENCIES:

Based on preliminary testing that identified the worst cases, in terms of the highest E.I.R.P.

	CELLULAR 2G + 3G		
Band:	2G Band GSM-1900		
Frequency Range:	1850 – 1910 MHz		
Transmit Channel:	Module	Channel	Channel Frequency (MHz)
	NAD1	Middle: 662	1880.2
	NAD2	Adjacent channel to Middle: 664	1880.6
Band:	3G Band II		
Frequency Range:	1850 – 1910 MHz		
Transmit Channel:	Module	Channel	Channel Frequency (MHz)
	NAD2	Adjacent channel to Middle: 9425	1885
	NAD1	Middle: 9400	1880

	CELLULAR 2G + LTE		
Band:	2G Band GSM-1900		
Frequency Range:	1850 – 1910 MHz		
Transmit Channel:	Module	Channel	Channel Frequency (MHz)
	NAD1	Middle: 662	1880.2
	NAD2	Adjacent channel to Middle: 664	1880.6
Band:	LTE Band 25		
Frequency Range:	1850 – 1915 MHz		
Transmit Channel:	Module	Channel	Channel Frequency (MHz)
	NAD2	Adjacent channel to Middle: 26515	1897.5
	NAD1	Middle: 26365	1882.5

	CELLULAR 3G + LTE		
Band:	3G Band II		
Frequency Range:	1850 – 1910 MHz		
Transmit Channel:	Module	Channel	Channel Frequency (MHz)
	NAD1	Middle: 9400	1880
	NAD2	Adjacent channel to Middle: 9425	1885
Band:	LTE Band 25		
Frequency Range:	1850 – 1915 MHz		
Transmit Channel:	Module	Channel	Channel Frequency (MHz)
	NAD2	Adjacent channel to Middle: 26515	1897.5
	NAD1	Adjacent channel to Low: 26115	1857.5

The test set-up was made in accordance to the general provisions of the KDB 971168 D01 Power Meas License Digital Systems v03r01, April 2018.

Selected Transmission Modes for each Radio:

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

- **Module NAD1:**

- * Cellular 2G Band PCS-1900: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in:
Cellular 2G Band PCS-1900 / Middle Channel in EDGE mode configuration.

- * Cellular 3G Band II: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in:
Cellular 3G Band II / Middle Channel in HSUPA mode configuration.

- * Cellular LTE: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in:
Cellular LTE Band 25 / Middle Channel in QPSK mode configuration.
Cellular LTE Band 25 / Adjacent channel to Low Channel in QPSK mode configuration.

- **Module NAD2:**

- * Cellular 2G Band PCS-1900: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in:
Cellular 2G Band PCS-1900 / Adjacent channel to Middle Channel in EDGE mode configuration.

- * Cellular 3G Band II: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in:
Cellular 3G Band II / Adjacent channel to Middle Channel in HSUPA mode configuration.

- * Cellular LTE: Transmitter radiated spurious emissions tests were performed with the EUT transmitting in:
Cellular LTE Band 25 / Adjacent channel to Middle Channel in QPSK mode configuration.

TESTED SIMULTANEOUS TRANSMISSION MODES:

*** Co-Location mode 2G Band PCS-1900, 3G Band II**, with the EUT configured to simultaneously transmit two signals at maximum output power:

CO-LOCATION	2G Band PCS-1900		3G Band II	
	Module	Channel	Module	Channel
MULTI-TRANSMITTER MODE 1	NAD1	Middle	NAD2	Adjacent channel to Middle
MULTI-TRANSMITTER MODE 2	NAD2	Adjacent channel to Middle	NAD1	Middle

*** Co-Location mode 2G Band PCS-1900, LTE Band 25**, with the EUT configured to simultaneously transmit two signals at maximum output power:

CO-LOCATION	2G Band PCS-1900		LTE Band 25	
	Module	Channel	Module	Channel
MULTI-TRANSMITTER MODE 1	NAD1	Middle	NAD2	Adjacent channel to Middle
MULTI-TRANSMITTER MODE 2	NAD2	Adjacent channel to Middle	NAD1	Middle

*** Co-Location mode 3G Band II, LTE Band 25**, with the EUT configured to simultaneously transmit two signals at maximum output power:

CO-LOCATION	3G Band II		LTE Band 25	
	Module	Channel	Module	Channel
MULTI-TRANSMITTER MODE 1	NAD1	Middle	NAD2	Adjacent channel to Middle
MULTI-TRANSMITTER MODE 2	NAD2	Adjacent channel to Middle	NAD1	Adjacent channel to Low

Radiated emissions

SPECIFICATION:

1. 2G PCS-1900, 3G Band II, LTE Band 25. FCC §2.1053 & §24.238 / RSS-133 Issue 6 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 Issue 6 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 $43 + 10 \log_{10} P$ (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 $43 + 10 \log_{10} P$ (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 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 17 GHz and at 1 m distance for measurements above 17 GHz.

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 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.

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:

$$\text{EIRP (dBm)} = E (\text{dB}\mu\text{V/m}) + 20 \log(D) - 104.8; \text{ where } D \text{ is the measurement distance (in the far field region) in m.}$$
$$D = 3 \text{ m}$$

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 P_o transmitting power, the specified minimum attenuation becomes $43+10\log(P_o)$, and the level in dBm relative P_o becomes:

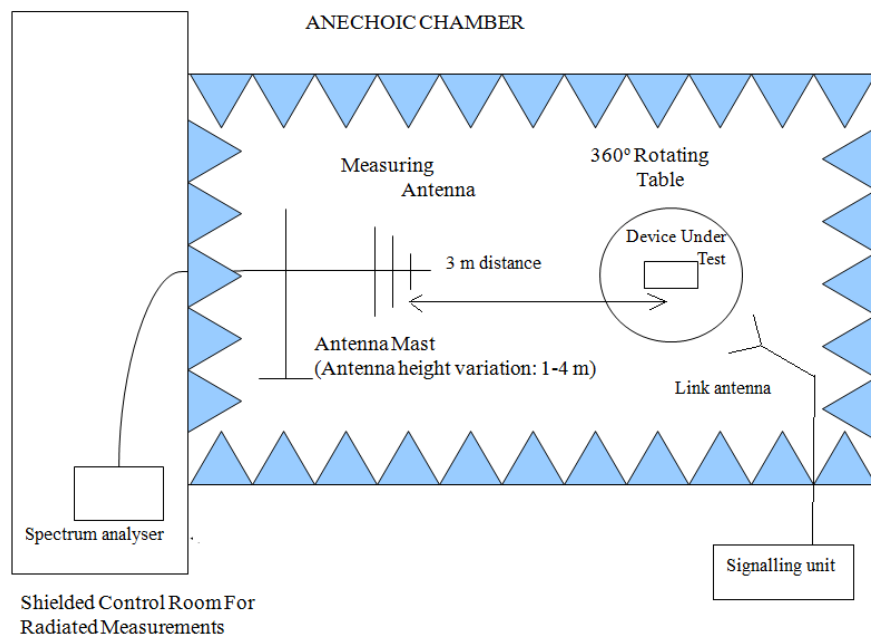
$$P_o (\text{dBm}) - [43 + 10 \log(P_o \text{ in mwatts}) - 30] = -13 \text{ dBm}$$

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

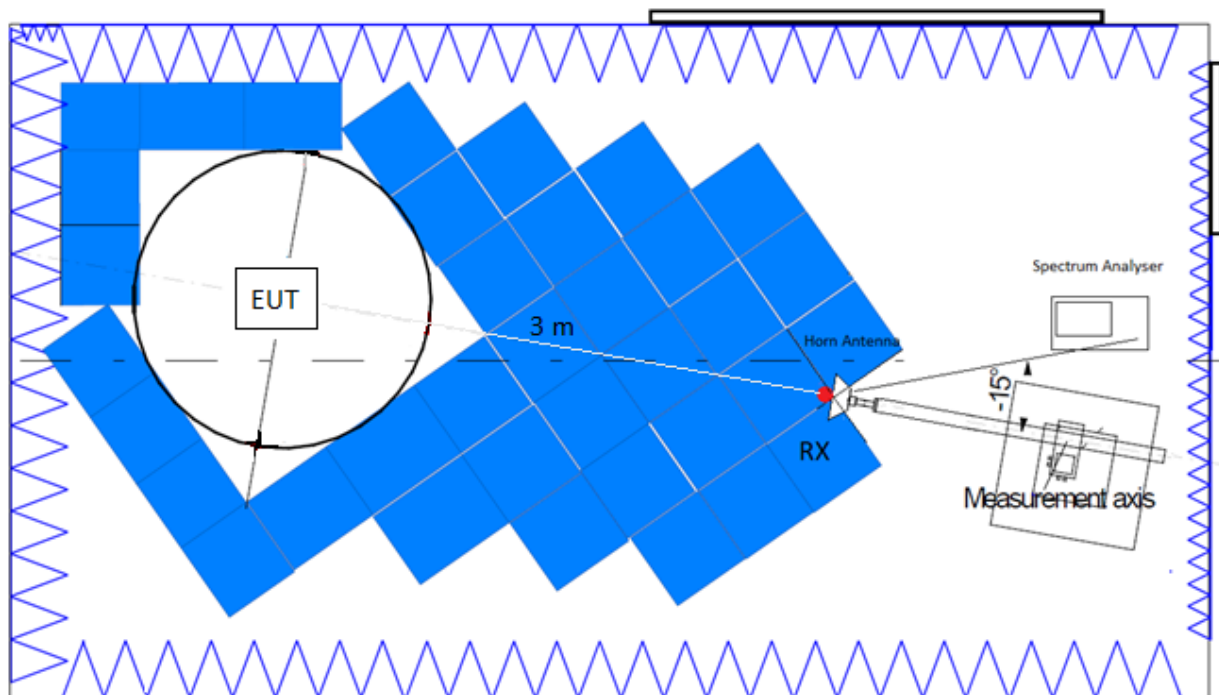
A resolution bandwidth / video bandwidth of 100 kHz / 300 kHz or higher were used for frequencies below 1 GHz and 1 MHz / 3 MHz for frequencies above 1 GHz.

TEST SETUP:

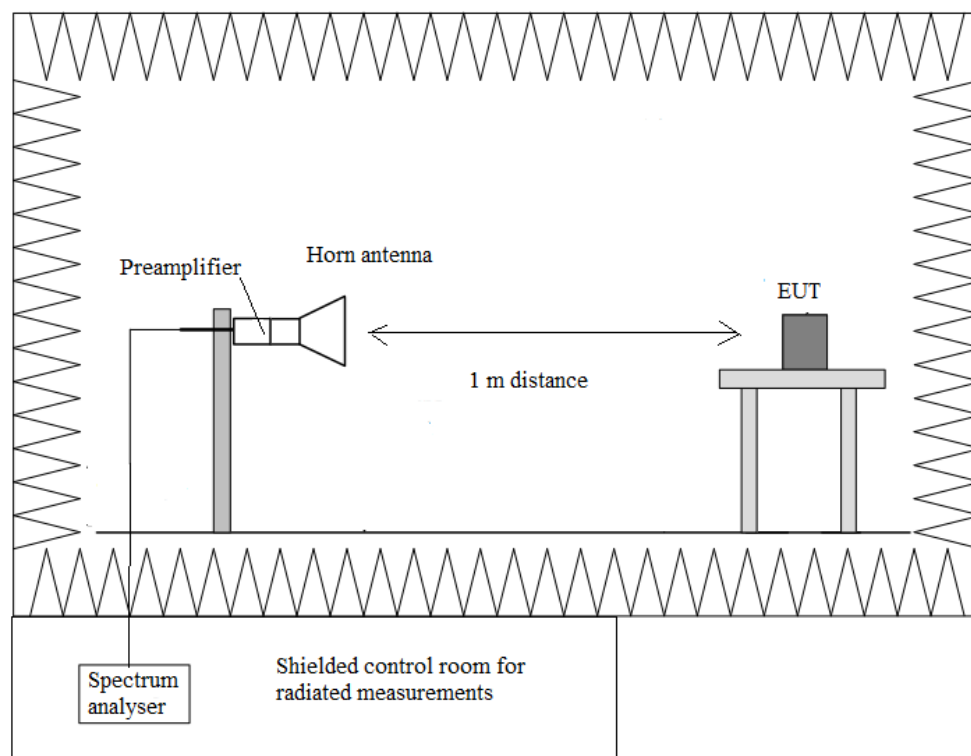
Radiated measurements below 1 GHz:



Radiated measurements setup from 1 GHz to 17 GHz:



Radiated measurements setup $f > 17$ GHz:



RESULTS:

• Co-Location mode 2G PCS-1900, 3G Band II:

MULTI-TRANSMITTER MODE 1: A preliminary scan determined the module NAD1, 2G Band PCS-1900, Middle Channel, EDGE modulation and the module NAD2, 3G Band II, Middle Channel, HSUPA modulation as the worst case. The following results are the ones of the worst case.

2G Band PCS-1900: Module NAD1. Middle Channel (1880.2 MHz). EDGE.

3G Band II: Module NAD2. Adjacent channel to Middle Channel (1885 MHz). HSUPA.

MULTI-TRANSMITTER MODE 2: A preliminary scan determined the module NAD2, 2G Band PCS-1900, Middle Channel, EDGE modulation and the module NAD1, 3G Band II, Middle Channel, HSUPA modulation as the worst case. The following results are the ones of the worst case.

2G Band PCS-1900: Module NAD2. Adjacent channel to Middle Channel (1880.6 MHz). EDGE.

3G Band II: Module NAD1. Middle Channel (1880 MHz). HSUPA.

LIMIT: The limit of the test is determined by:

Frequency Range	Detector	Limit at 3m (dBm)
30 MHz to 20 GHz	PK	$43 + 10 \log (P) \text{ dB} = -13 \text{ dBm}$

MULTI-TRANSMITTER MODE 1:

Frequency range 30 MHz - 1 GHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	E.I.R.P. (dBm)	Polarization	Detector	Measurement Uncertainty (dB)
210.953500	-30.18	V	Peak	<±4.99
470.913500	-29.16	V	Peak	<±4.99
492.011000	-28.34	V	Peak	<±4.99
515.194000	-29.06	V	Peak	<±4.99
540.074500	-31.15	V	Peak	<±4.99
565.585500	-25.34	V	Peak	<±4.99
668.357000	-31.44	V	Peak	<±4.99
699.639500	-31.03	V	Peak	<±4.99
722.628500	-32.31	V	Peak	<±4.99

Frequency range 1 - 20 GHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (GHz)	E.I.R.P. (dBm)	Polarization	Detector	Measurement Uncertainty (dB)
3.7605	-26.84	V	Peak	<±4.98

MULTI-TRANSMITTER MODE 2:

Frequency range 30 MHz - 1 GHz:

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

Frequency range 1 - 20 GHz:

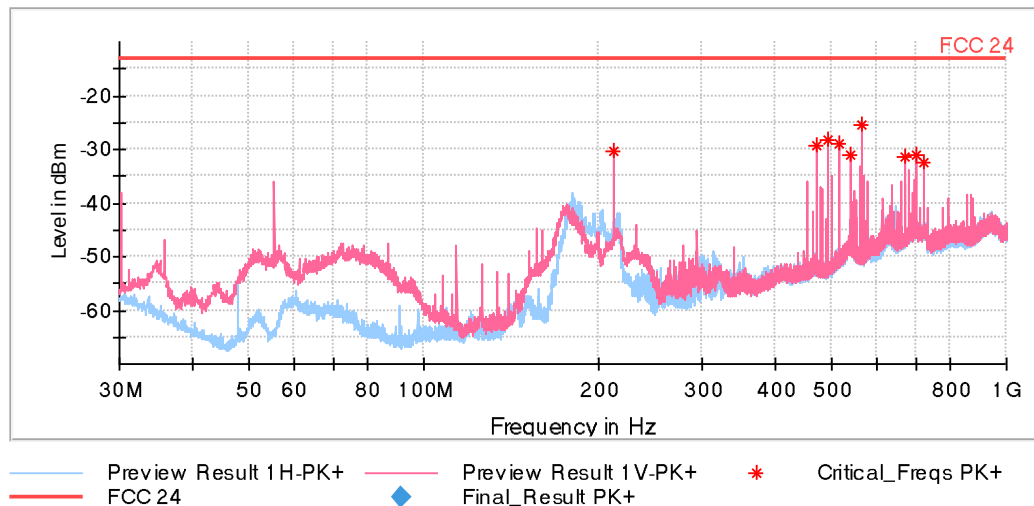
No spurious frequencies at less than 20 dB below the limit.

Measurement Uncertainty (dB)	<±4.99 for $f < 1$ GHz
	<±4.98 for $f \geq 1$ GHz up to 17 GHz
	<±5.08 for $f \geq 17$ GHz up to 20 GHz

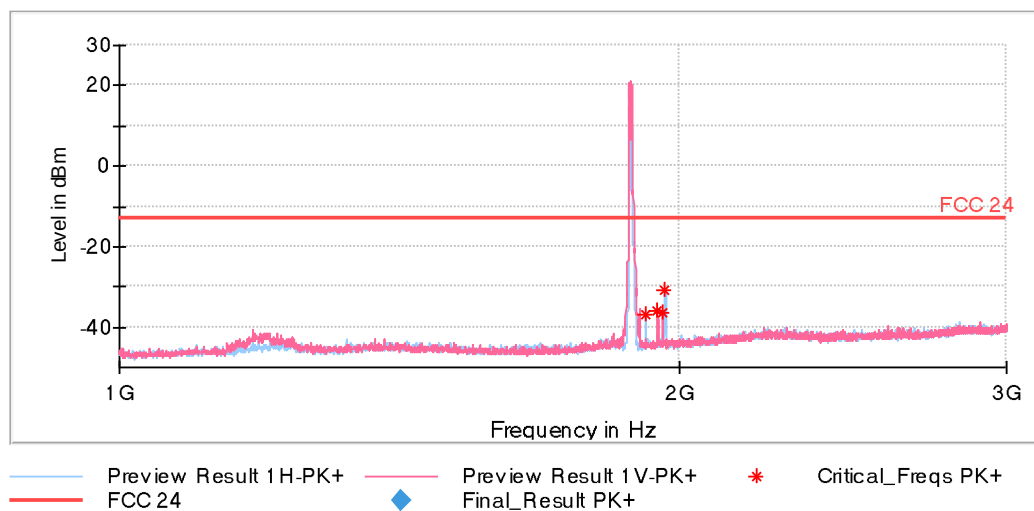
Verdict: PASS

MULTI-TRANSMITTER MODE 1:

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

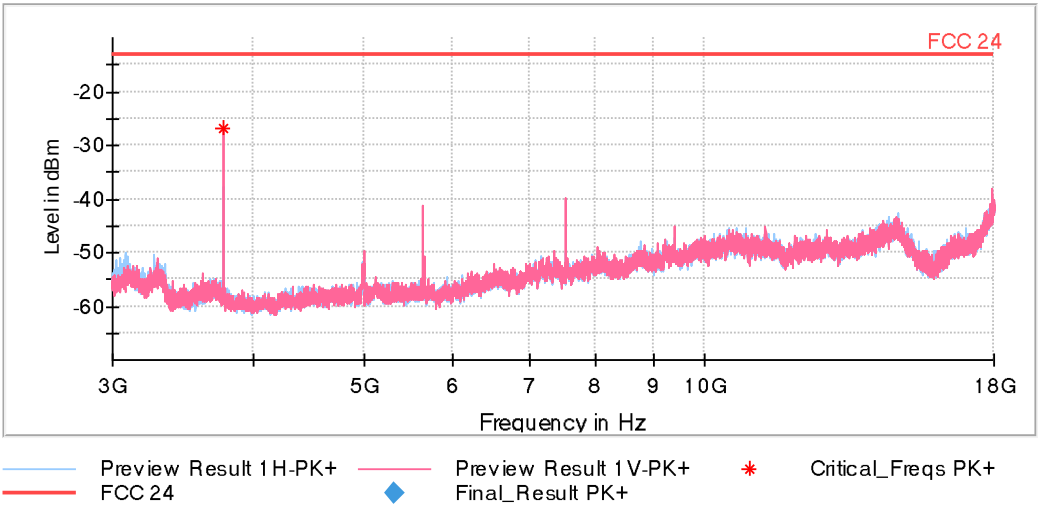


FREQUENCY RANGE 1 - 3 GHz (worst case):

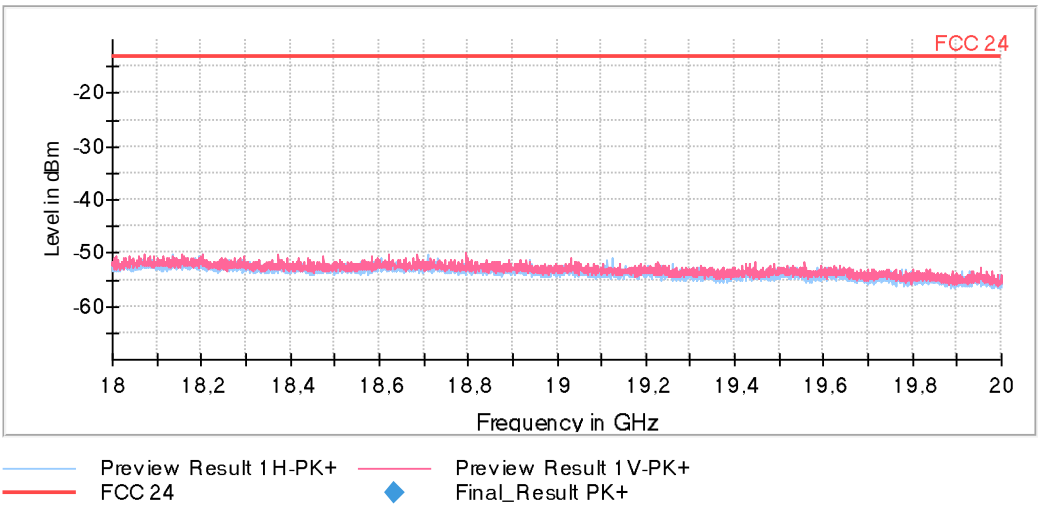


The peaks above the limit are the Carriers frequencies of the 2G Band PCS-1900 and the 3G Band II.

FREQUENCY RANGE 3 - 18 GHz (worst case):

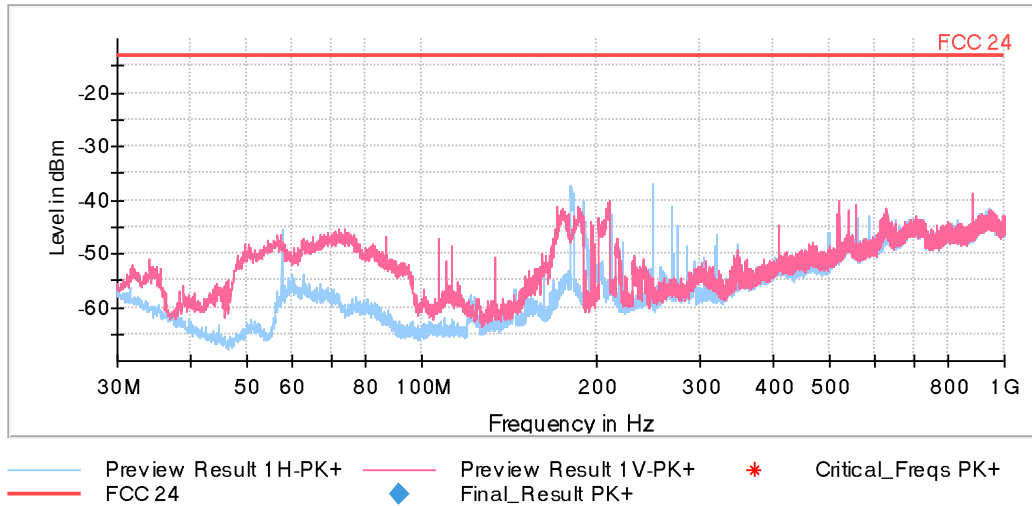


FREQUENCY RANGE 18 - 20 GHz (worst case):

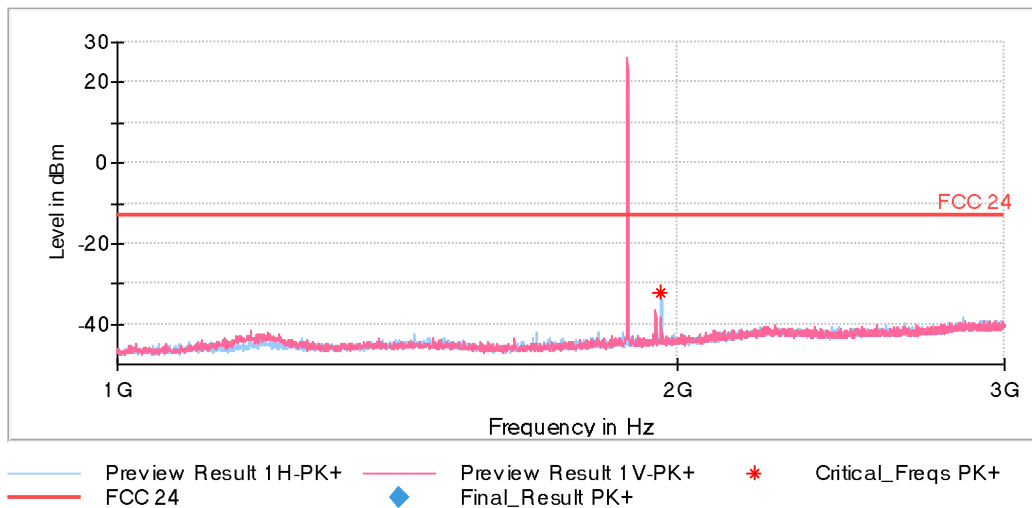


MULTI-TRANSMITTER MODE 2:

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

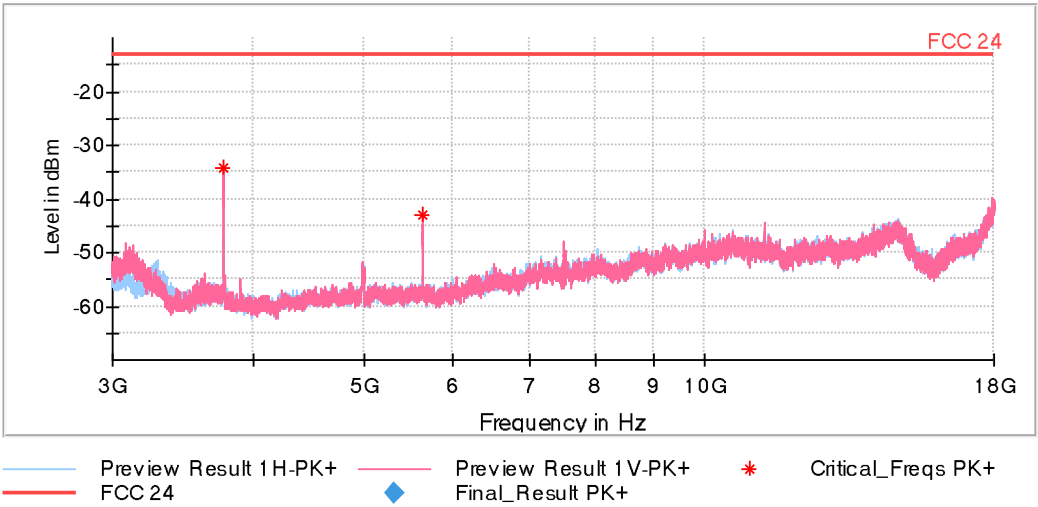


FREQUENCY RANGE 1 - 3 GHz (worst case):

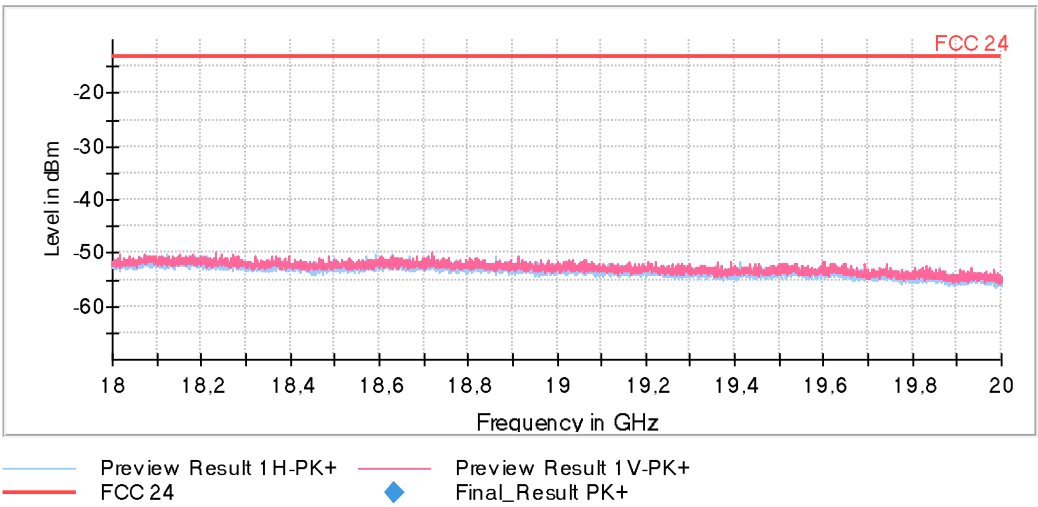


The peaks above the limit are the Carriers frequencies of the 2G Band PCS-1900 and the 3G Band II.

FREQUENCY RANGE 3 - 18 GHz (worst case):



FREQUENCY RANGE 18 - 20 GHz (worst case):



- **Co-Location mode 2G PCS-1900, LTE Band 25:**

MULTI-TRANSMITTER MODE 1: A preliminary scan determined the module NAD1, 2G Band PCS-1900, Middle Channel, EDGE modulation and the module NAD2, LTE Band 25, Middle Channel, QPSK modulation as the worst case. The following results are the ones of the worst case.

2G Band PCS-1900: Module NAD1. Middle Channel (1880.2 MHz). EDGE.
LTE Band 25: Module NAD2. Adjacent channel to Middle Channel (1897.5 MHz). BW=15 MHz. QPSK. RB Size=1. RB Offset=0.

MULTI-TRANSMITTER MODE 2: A preliminary scan determined the module NAD2, 2G Band PCS-1900, Middle Channel, EDGE modulation and the module NAD1, LTE Band 25, Middle Channel, QPSK modulation as the worst case. The following results are the ones of the worst case.

2G Band PCS-1900: Module NAD2. Adjacent channel to Middle Channel (1880.6 MHz). EDGE.
LTE Band 25: Module NAD1. Middle Channel (1882.5 MHz). BW=15 MHz. QPSK. RB Size=1. RB Offset=0.

LIMIT: The limit of the test is determined by:

Frequency Range	Detector	Limit at 3m (dBm)
30 MHz to 20 GHz	PK	$43 + 10 \log (P) \text{ dB} = -13 \text{ dBm}$

MULTI-TRANSMITTER MODE 1:

Frequency range 30 MHz - 1 GHz:

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

Frequency range 1 - 20 GHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (GHz)	E.I.R.P. (dBm)	Polarization	Detector	Measurement Uncertainty (dB)
3.760	-22.34	V	Peak	$<\pm 4.98$

MULTI-TRANSMITTER MODE 2:

Frequency range 30 MHz - 1 GHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	E.I.R.P. (dBm)	Polarization	Detector	Measurement Uncertainty (dB)
53.765	-29.29	V	Peak	$<\pm 4.99$
55.705	-32.06	V	Peak	$<\pm 4.99$
320.515	-32.97	H	Peak	$<\pm 4.99$

Frequency range 1 - 20 GHz:

Spurious frequencies at less than 20 dB below the limit:

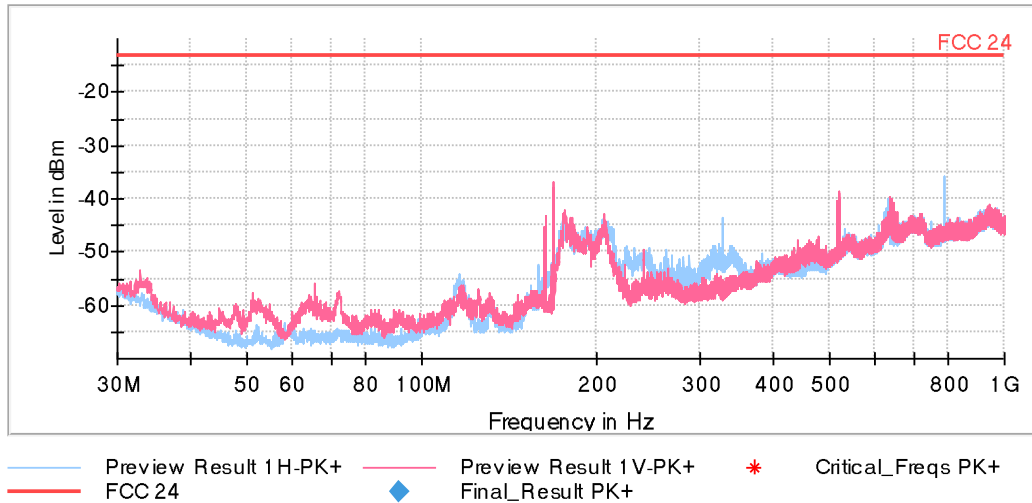
Spurious frequency (GHz)	E.I.R.P. (dBm)	Polarization	Detector	Measurement Uncertainty (dB)
3.752	-24.74	V	Peak	<±4.98

Measurement Uncertainty (dB)	<±4.99 for f < 1 GHz <±4.98 for f ≥ 1 GHz up to 17 GHz <±5.08 for f ≥ 17 GHz up to 20 GHz
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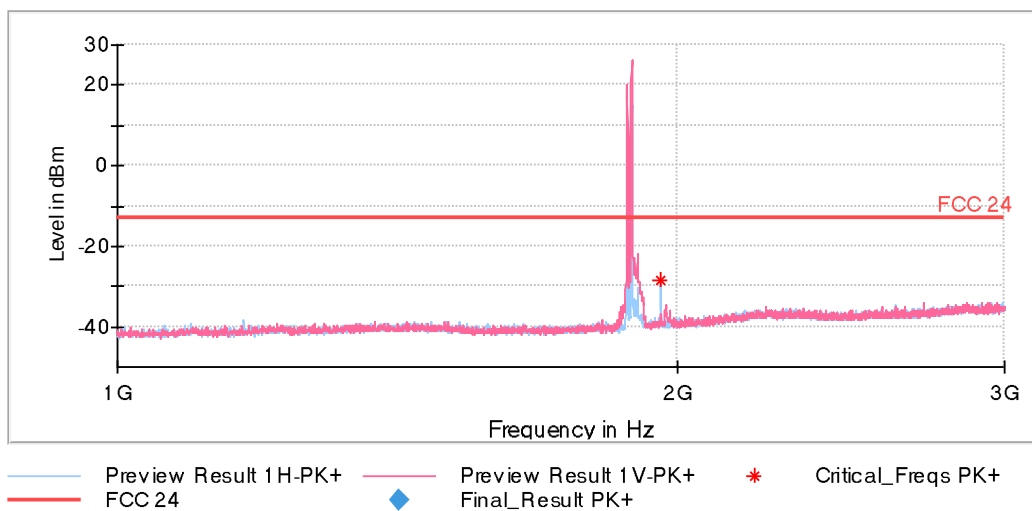
Verdict: PASS

MULTI-TRANSMITTER MODE 1:

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

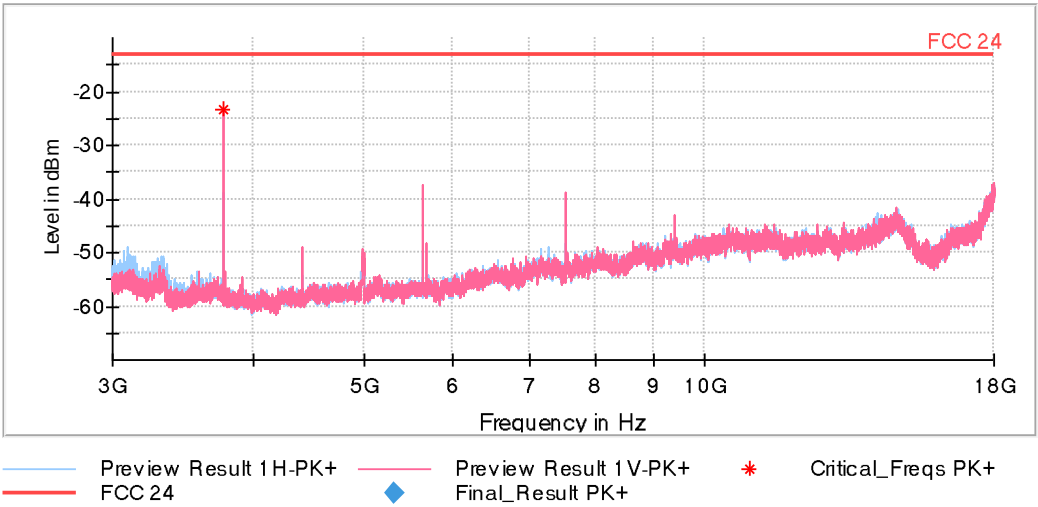


FREQUENCY RANGE 1 - 3 GHz (worst case):

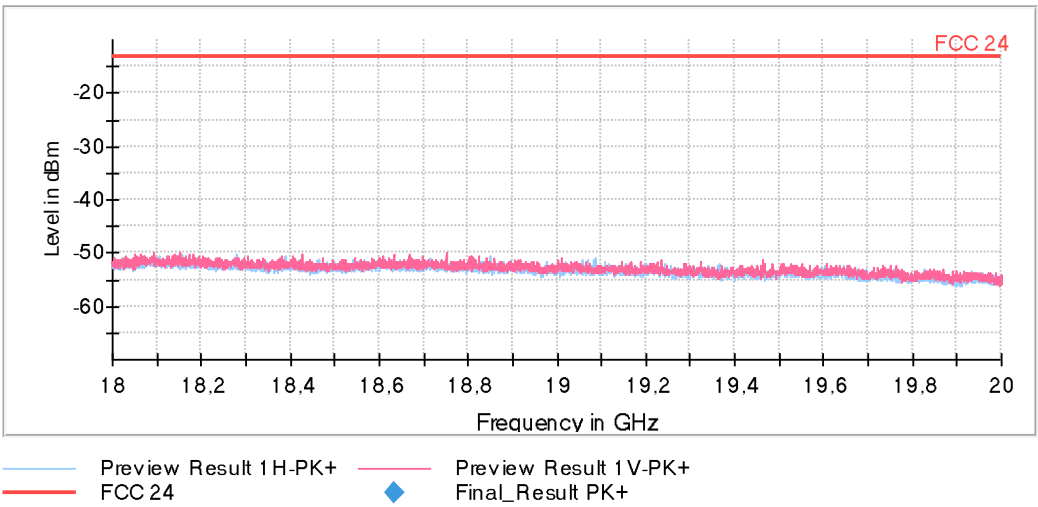


The peaks above the limit are the Carriers frequencies of the 2G Band PCS-1900 and LTE Band 25.

FREQUENCY RANGE 3 - 18 GHz (worst case):

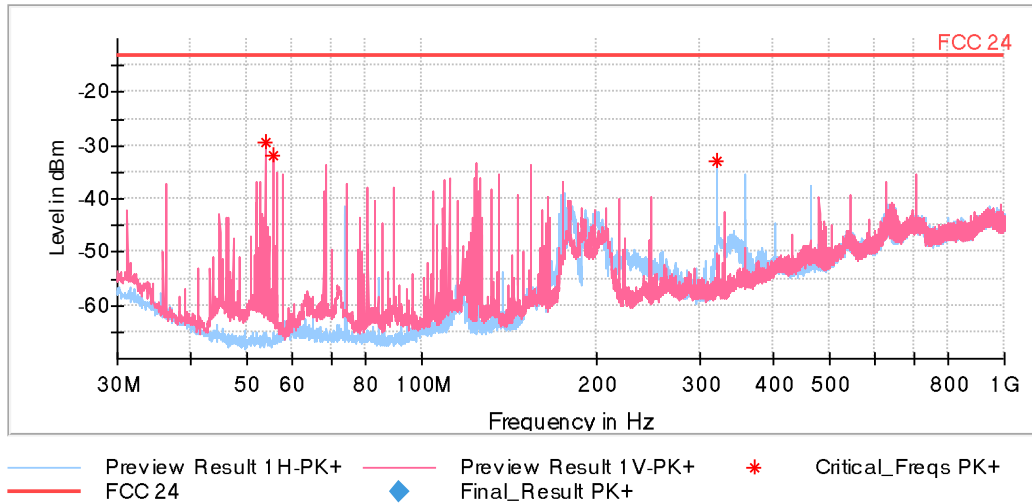


FREQUENCY RANGE 18 - 20 GHz (worst case):

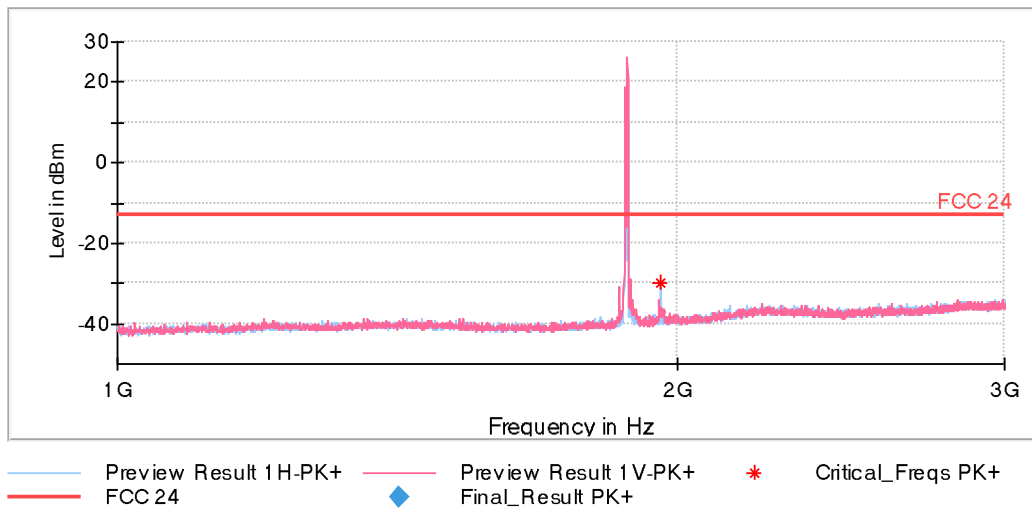


MULTI-TRANSMITTER MODE 2:

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

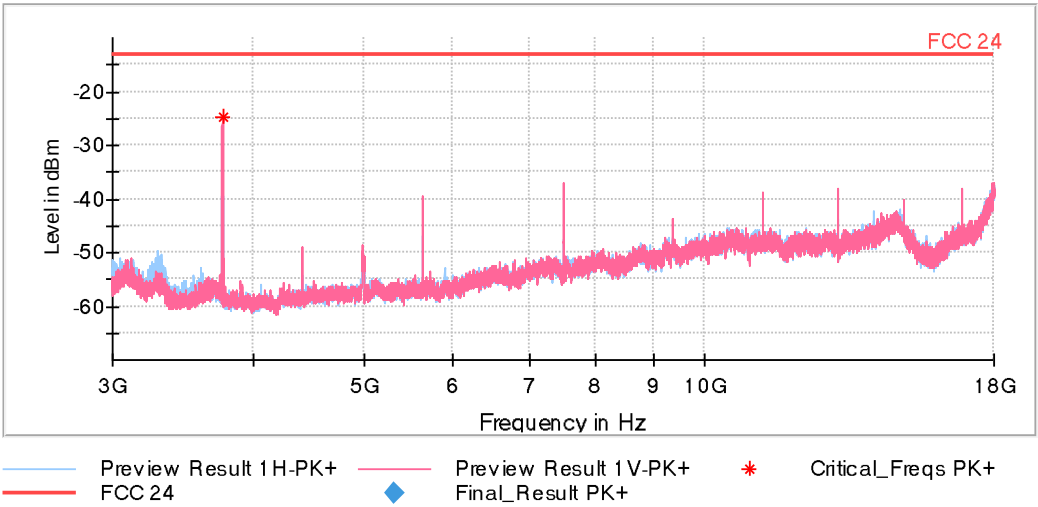


FREQUENCY RANGE 1 - 3 GHz (worst case):

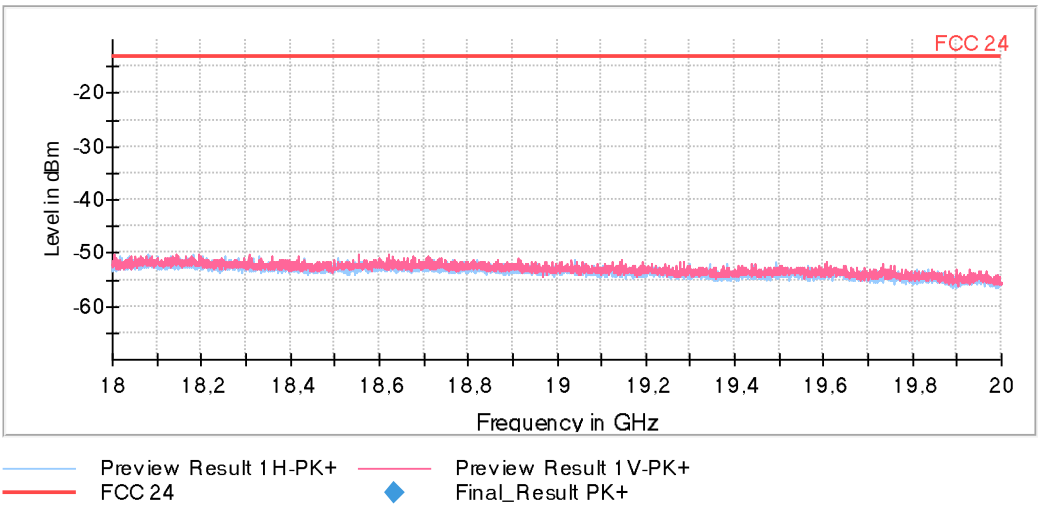


The peaks above the limit are the Carriers frequencies of the 2G Band PCS-1900 and LTE Band 25.

FREQUENCY RANGE 3 - 18 GHz (worst case):



FREQUENCY RANGE 18 - 20 GHz (worst case):



- **Co-Location mode 3G Band II, LTE Band 25:**

MULTI-TRANSMITTER MODE 1: A preliminary scan determined the module NAD1, 3G Band II, Middle Channel, HSUPA modulation and the module NAD2, LTE Band 25, Middle Channel, QPSK modulation as the worst case. The following results are the ones of the worst case.

3G Band II: Module NAD1. Middle Channel (1880 MHz). HSUPA.

LTE Band 25: Module NAD2. Adjacent channel to Middle Channel (1897.5 MHz). QPSK. BW=15 MHz.
RB Size=1. RB Offset=0.

MULTI-TRANSMITTER MODE 2: A preliminary scan determined the module NAD2, 3G Band II, Middle Channel, HSUPA modulation and the module NAD1, LTE Band 25, Low Channel, QPSK modulation as the worst case. The following results are the ones of the worst case.

3G Band II: Module NAD2. Adjacent channel to Middle Channel (1885 MHz). HSUPA.

LTE Band 25: Module NAD1. Adjacent channel to Low Channel (1857.5 MHz). QPSK. BW=15 MHz.
RB Size=1. RB Offset=0.

LIMIT: The limit of the test is determined by:

Frequency Range	Detector	Limit at 3m (dBm)
30 MHz to 20 GHz	PK	$43 + 10 \log (P) \text{ dB} = -13 \text{ dBm}$

MULTI-TRANSMITTER MODE 1:

Frequency range 30 MHz - 1 GHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	E.I.R.P. (dBm)	Polarization	Detector	Measurement Uncertainty (dB)
70.9825	-23.07	V	Peak	$<\pm 4.99$

Frequency range 1 - 20 GHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (GHz)	E.I.R.P. (dBm)	Polarization	Detector	Measurement Uncertainty (dB)
1.904	-21.15	V	Peak	$<\pm 4.98$

MULTI-TRANSMITTER MODE 2:

Frequency range 30 MHz - 1 GHz:

Spurious frequencies at less than 20 dB below the limit:

Spurious frequency (MHz)	E.I.R.P. (dBm)	Polarization	Detector	Measurement Uncertainty (dB)
59.003	-31.32	V	Peak	<±4.99
423.5775	-32.55	V	Peak	<±4.99
430.707	-27.90	V	Peak	<±4.99
613.0185	-28.95	V	Peak	<±4.99
695.3715	-27.62	V	Peak	<±4.99
881.563	-31.6	V	Peak	<±4.99
989.4755	-32.55	V	Peak	<±4.99

Frequency range 1 - 20 GHz:

Spurious frequencies at less than 20 dB below the limit:

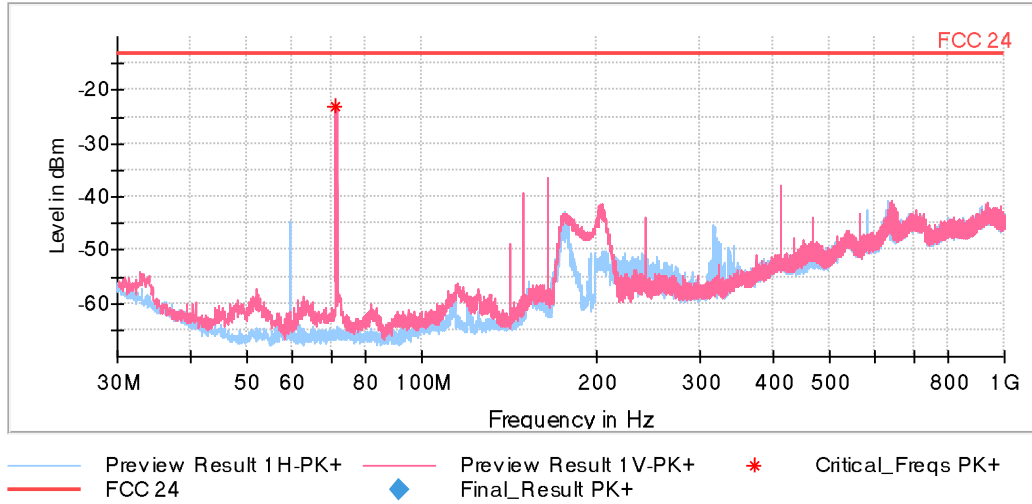
Spurious frequency (GHz)	E.I.R.P. (dBm)	Polarization	Detector	Measurement Uncertainty (dB)
3.7015	-23.09	V	Peak	<±4.98

Measurement Uncertainty (dB)	<±4.99 for $f < 1$ GHz <±4.98 for $f \geq 1$ GHz up to 17 GHz <±5.08 for $f \geq 17$ GHz up to 20 GHz
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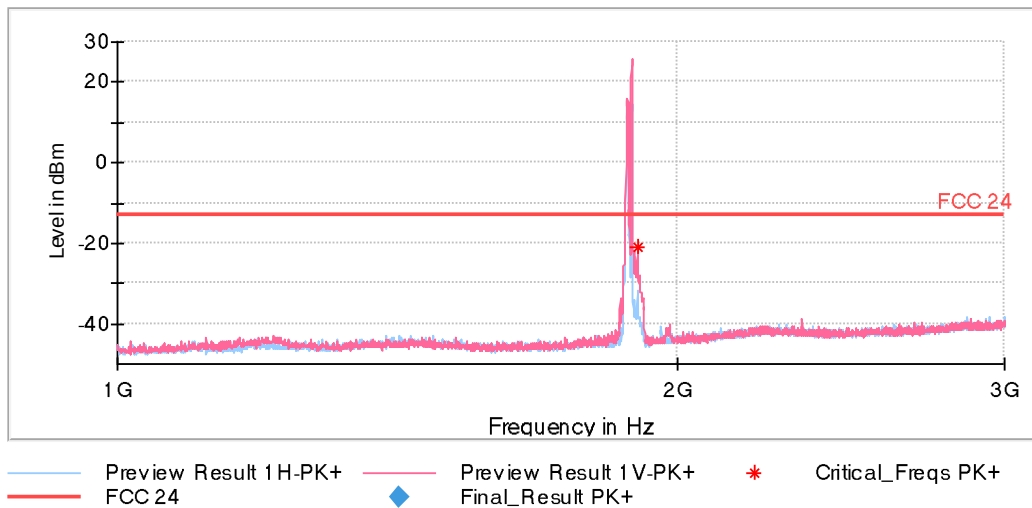
Verdict: PASS

MULTI-TRANSMITTER MODE 1:

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

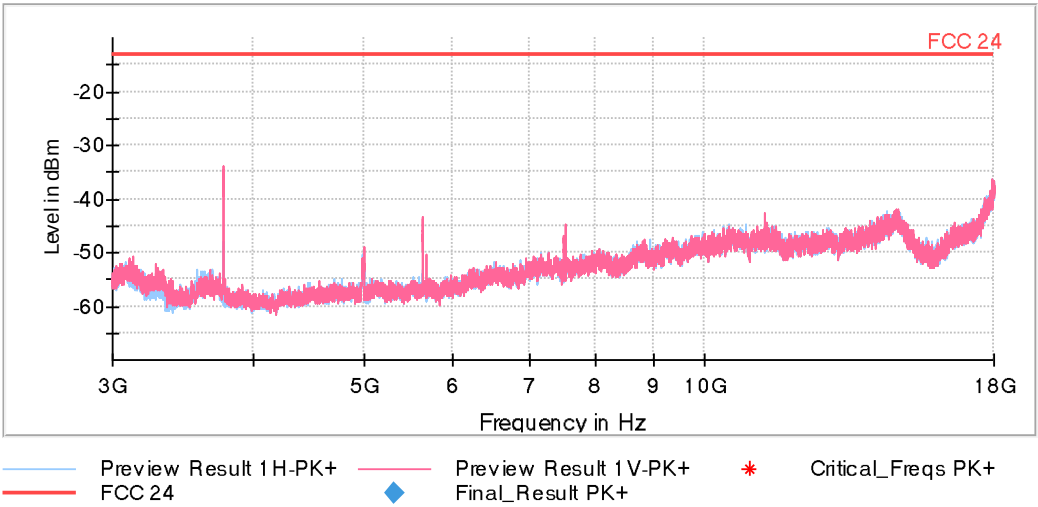


FREQUENCY RANGE 1 - 3 GHz (worst case):

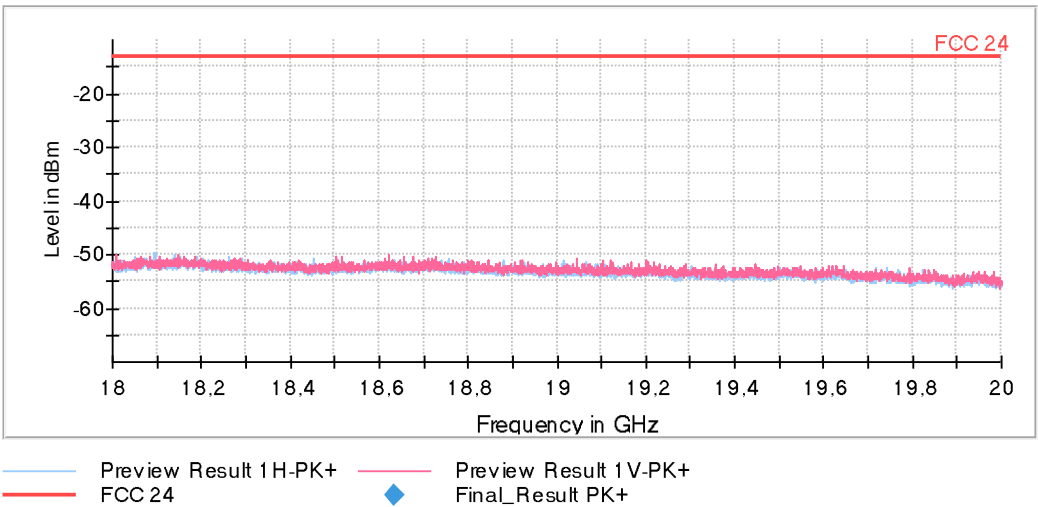


The peaks above the limit are the Carriers frequencies of the 3G Band II and LTE Band 25.

FREQUENCY RANGE 3 - 18 GHz (worst case):

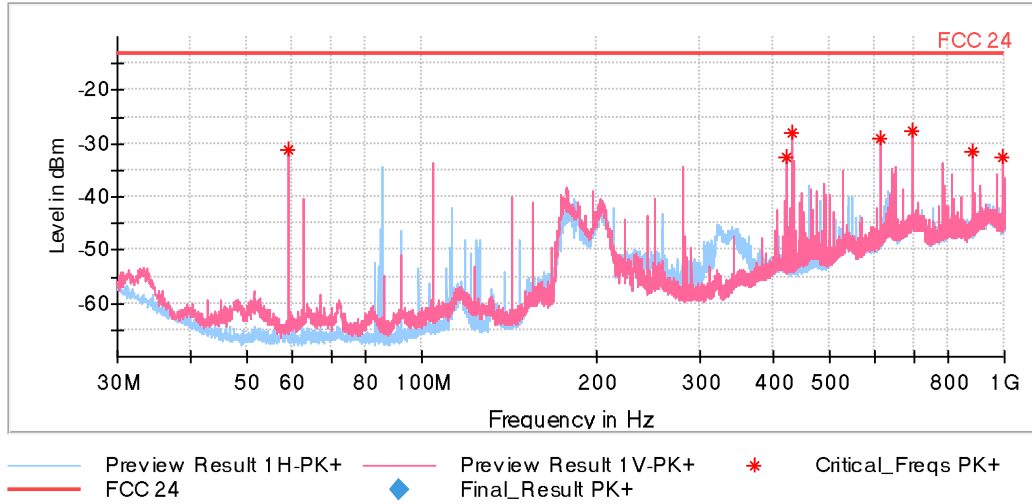


FREQUENCY RANGE 18 - 20 GHz (worst case):

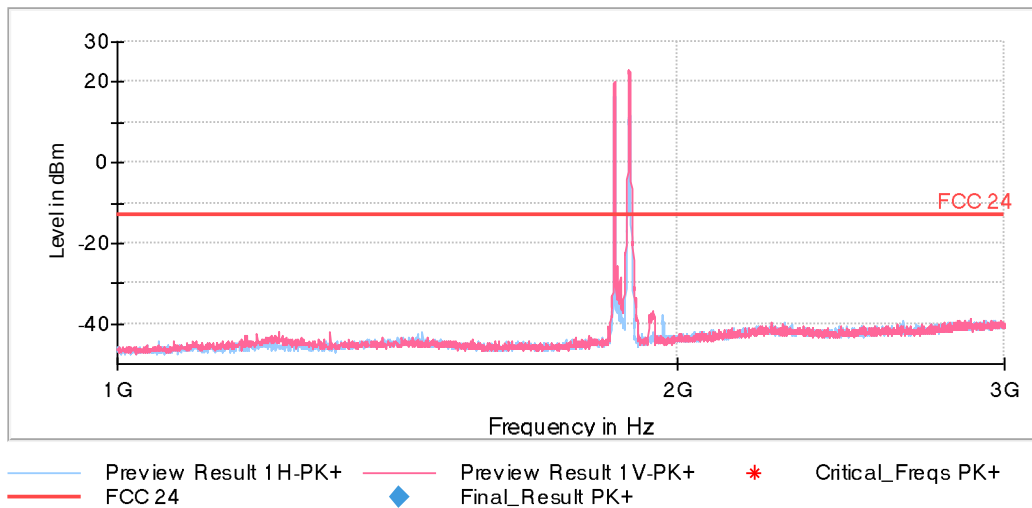


MULTI-TRANSMITTER MODE 2:

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

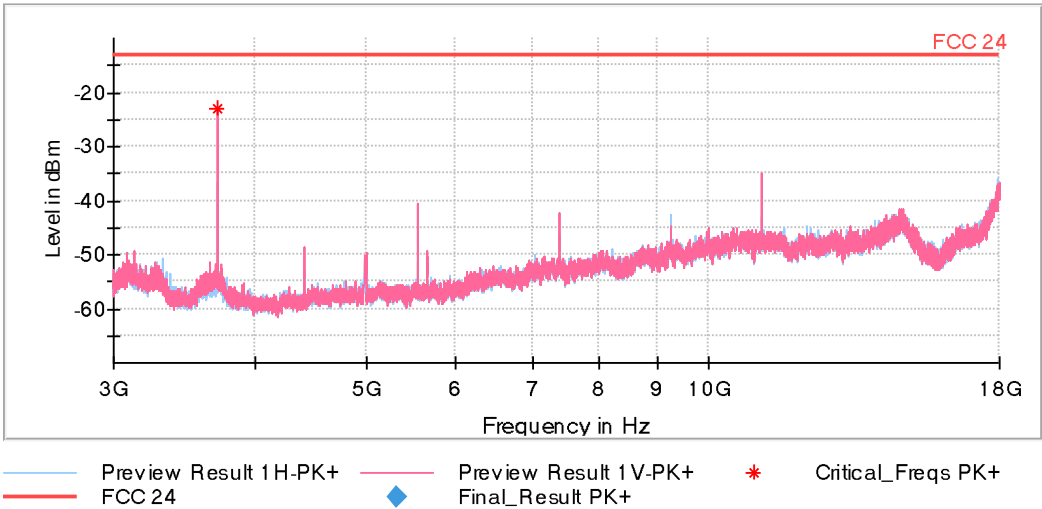


FREQUENCY RANGE 1 - 3 GHz (worst case):



The peaks above the limit are the Carriers frequencies of the 3G Band II and LTE Band 25.

FREQUENCY RANGE 3 - 18 GHz (worst case):



FREQUENCY RANGE 18 - 20 GHz (worst case):

