Report No. 461063-04-R00

Test Report

Product	InSite Construction Data Acquisition System
Name and address of the applicant	Vemaventuri AB Johan på Gårdas Gata 5A 412 50 Gothenburg, Sweden
Name and address of the manufacturer	Vemaventuri AB Johan på Gårdas Gata 5A 412 50 Gothenburg, Sweden
Model	HUB-0
Rating	18.5VDC
Trademark	ISC Hub
Serial number	See page 3
Additional information	This product contains following FCC/ISED certified radio modules: - Wi-fi, ESP32-WROOM-32U - LTE/GNSS, SARA-R510M8S-01B
Tested according to	FCC KDB 996369 D04 Module Integration Guide V01, section 2e Modular transmitter integration guide-quidance for host product manufactures composite system operation (Co-Location)
Order number	461063
Tested in period	2022-05-09 – 2022-11-01
Issue date	2022-11-21
Name and address of the testing laboratory	Nemko Scandinavia AS Instituttveien 6, 2007 Kjeller, Norway CAB Number: FCC: NO0001 ISED: NO0470

An accredited technical test executed under the Norwegian accreditation scheme

Prepared by [G.Suhanthakumar]	Approved by [Frode Sveinsen]

CONTENTS

1 INFORMATION

1.1 Test Item

Radio Technology	**w-fi**	**LTE M1/NB2 IoT/GNSS**
Model/version	**HUB-0**	**HUB-0**
FCC ID	**2A6OFPICHBM01**	**2A6OFPICHBM01**
ISED ID	**28483-PICHBM01**	**28483-PICHBM01**
Serial number	**Marked as "Nemko 461063 00001"**	**Marked as "Nemko 461063 00001"**
Hardware identity and/or version	**HV01MK08**	**HV01MK08**
Software identity and/or version	**V0.0.1**	**V0.0.1**
Frequency Range	**2412 – 2472 MHz**	**CAT M1 bands: 2, 4, 5, 8, 12, 13, 25, 26, 66, 71 CAT NB2 Bands: 2, 4, 5, 8, 12, 13, 66, 71**
Number of Channels	**13**	**/**
Operating Modes	**802.11 b/g/n HT20 802.11 n HT40**	**Tx and Rx GNSS : RX**
Type of Modulation	**DSSS and OFDM**	**LTE : TDD/FDD, MIMO-OFDM GNSS : BPSK**
Conducted Output Power		
Antenna Connector	**UFL**	**UFL**
Number of Antennas	**1 for wi-fi (2dBi gain)**	**1 for LTE (2dBi gain) and 1 for GNSS**
Diversity or Smart Antennas	**NO**	**NO**
Power Supply	**18.5VDC (System has 5x3.69 lithium-ion batteries)**	**18.5VDC (System has 5x3.6.9 lithium-ion batteries)**
Desktop Charger	**100 - 240VAC AC/DC**	**100 - 240VAC AC/DC**

Description of Test Item

The EUT is a Data Acquisition System.

The EUT supports IEEE 802.11 b/g/n modes and HT20 and HT40 modes (only for 11n). The antenna used for wi-fi and LTE are recommended by the module manufacturers.

The EUT does not have smart antenna system. The LTE and wi-fi can transmit simulataneoulsy.

It contains certified LTE/GNSS module from U-blox SARA-R412M-02B (FCC ID: XPYUBX19KM01, ISED ID:8595A-UBX19KM01) and 2.4GHz wi-fi module from Espressif Systems for ESP32-WROOM-32U (FCC ID:2AC7Z-ESP32WROOM32U, ISED ID:21098- ESP32WROOM32U).

1.2 Normal test condition

Temperature:	20 - 24 °C
Relative humidity:	20 - 50 %
Normal test voltage:	18.5V DC

The values are the limit registered during the test period.

1.3 Test Engineer(s)

G.Suhanthakumar

1.4 Antenna Requirement

Does the EUT have detachable antenna(s)?	**☐ YES**	**☒ NO**
If detachable, is the antenna connector(s) non-standard?	**☐ YES**	**☐ NO**
The tested equipment has only integral antennas. Conducted tests were performed with a temporary antenna connector.		

Requirement: FCC 15.203, 15.204

1.5 EUT Operating Modes

Description of operating modes	Continuous TX modulation
Additional information	2.4GHz wifi simulatenious with LTE-M1/NB2 IoT bands.

Worst case conditions:

LTE Band	DL Frequency (MHz)	UL Frequency (MHz)	Max power(dBm)	IEEE 802.11b, 1Mbps	Ch2412/2472MHz
B2	1960.0	1880.0	23	☑	☑
B4	2132.5	1732.5	23	☑	☑
B8	942.5	897.5	23	☑	☑

1.6 Comments

All measurements were done with the EUT powered by a fully charged battery.

The output power level during simulatenious transmissions was set to maximum.

2 TEST REPORT SUMMARY

2.1 General

All measurements are tracable to national standards.

Tests were performed in accordance with ANSI C63.4-2014, ANSI C63.10-2013 and ANSI C63.26-2015.

Radiated tests were made in a semi-anechoic chamber at measuring distances of 3m.

A description of the test facility is on file with FCC and ISED.

☒ New Submission	☒ Production Unit
☐ Class II Permissive Change	☐ Pre-production Unit
PCB Equipment Code	☐ Family Listing

THIS TEST REPORT APPLIES ONLY TO THE ITEM(S) AND CONFIGURATIONS TESTED.

Deviations from, additions to, or exclusions from the test specifications are described in “Summary of Test Data”.

2.2 Test Summary

Name of test	FCC Part 15 reference	RSS-247 Issue 2, RSS-GEN Issue 5 reference	ANSI C63.10-2013 Reference	Result
Spurious Emissions (Radiated)	15.247(c) 15.109(a) 15.209(a)	5.5 (RSS-247) 7.3 (RSS-GEN) 8.9 (RSS-GEN)	6.3, 6.5, 6.6, 6.10 11.12, 11.13 (DTS)	Complies

[1] The tested equipment only operates with battery

[2] Integral antenna.

Revision history

Revision	Date	Comment	Sign
00	2022-11-21	First edition	gns

3 TEST RESULTS

3.1 Restricted Bands of operation

Restricted Bands of operation for FCC and ISED are defined in FCC Part 15.205 and ISED RSS-GEN, Issue 5 clause 8.10.

Generally, no fundamentals are allowed in the restricted bands and all emissions must comply with the limits in FCC 15.209 or RSS-GEN, Issue 5, clause 8.9.

FCC (MHz)	ISED Canada (MHz)	FCC (GHz)	ISED Canada (GHz)
0.090-0.110		**0.96-1.24** **1.3-1.427**	**0.96-1.427**
0.495-0.505		1.435-1.6265	
2.1735-2.1905		1.6455-1.6465	
	3.020-3.026	1.660-1.710	
4.125-4.128		1.7188-1.7222	
4.17725-4.17775		2.2-2.3	
4.20725-4.20775		2.31-2.39	
	5.677-5.683	2.4835-2.5	
6.215-6.218		**2.69-2.9**	**2.655-2.9**
6.26775-6.26825		3.26-3.267	
6.31175-6.31225		3.332-3.339	
8.291-8.294		3.3458-3.358	
8.362-8.366		**3.6-4.4**	**3.5-4.4**
8.37625-8.38675		4.5-5.15	
8.41425-8.41475		5.35-5.46	
12.29-12.293		7.25-7.75	
12.51975-12.52025		8.025-8.5	
12.57675-12.57725		9.0-9.2	
13.36-13.41		9.3-9.5	
16.42-16.423		10.6-12.7	
16.69475-16.69525		13.25-13.4	
16.80425-16.80475		14.47-14.5	
25.5-25.67		15.35-16.2	
37.5-38.25		17.7-21.4	
73-74.6		22.01-23.12	
74.8-75.2		23.6-24.0	
108-121.94 **123-138**	**108-138**	31.2-31.8	
149.9-150.05		36.43-36.5	
156.52475-156.52525		Above 38.6	
156.7-156.9			
162.0125-167.17			
167.72-173.2			
240-285			
322-335.4			
399.9-410			
608-614			

Frequencies in **Bold** text are specific for FCC or ISED, all other frequencies are common.

3.3 Radiated Emission, 30 – 1000 MHz.

FCC Part 15.209 (a)

ISED Canada RSS-GEN Issue 5, Clause 7.3/8.9

Measurement procedure: ANSI C63.10-2013 Clause 11.12

Test Results: Complies

Measurement Data:

Detector: Peak (found frequencies were measured with Quasi-Peak Detector)

Measuring distance 3 m

Tested in active mode.

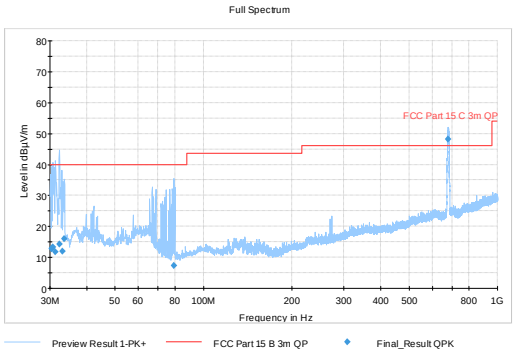
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.387523	12.90	40.00	27.10	1000.0	120.000	154.0	V	162.0	-16.1
30.459100	12.74	40.00	27.26	1000.0	120.000	171.0	V	260.0	-16.0
30.750500	13.26	40.00	26.74	1000.0	120.000	183.0	V	271.0	-16.0
31.250650	11.76	40.00	28.24	1000.0	120.000	223.0	V	303.0	-15.8
32.307500	14.29	40.00	25.71	1000.0	120.000	249.0	V	313.0	-15.5
33.060550	11.94	40.00	28.06	1000.0	120.000	277.0	V	303.0	-15.3
33.499750	16.09	40.00	23.91	1000.0	120.000	106.0	V	45.0	-15.2
79.057700	7.26	40.00	32.74	1000.0	120.000	207.0	V	1.0	-18.7
677.712750	48.13	46.00	Note 1	1000.0	120.000	342.0	H	0.0	-3.3

Note 1: Non-restricted band

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
31.529150	13.97	40.00	26.03	1000.0	120.000	234.0	V	10.0	-15.7
32.067500	15.22	40.00	24.78	1000.0	120.000	242.0	V	25.0	-15.6
32.084450	14.90	40.00	25.10	1000.0	120.000	274.0	V	54.0	-15.6
32.419500	13.22	40.00	26.78	1000.0	120.000	276.0	V	37.0	-15.5
34.249350	11.71	40.00	28.29	1000.0	120.000	156.0	V	87.0	-15.0
738.158800	48.49	46.00	Note 1	1000.0	120.000	123.0	H	33.0	-2.5

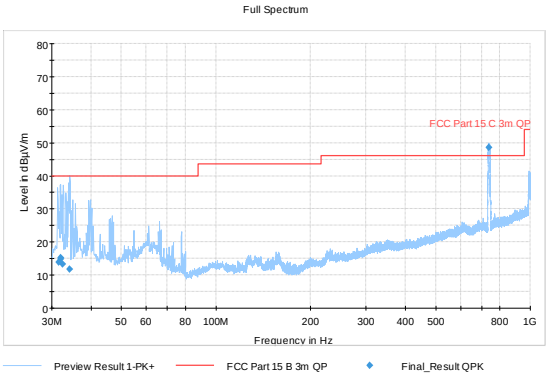
Note 1: Non-restricted band

B4 LTE-NB2IoT/Ch2412MHz,11b 1Mbps



Radiated Emissions 30 - 1000 MHz, B4 LTE-NB2IoT/Ch2412MHz,11b 1Mbps

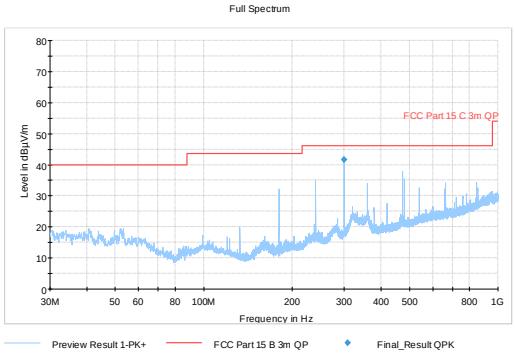
B4 LTE-NB2IoT/Ch2472MHz,11b 1Mbps



Radiated Emissions 30 - 1000 MHz, B4 LTE-NB2IoT/Ch2472MHz,11b 1Mbps

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
300.019150	41.68	46.00	4.32	1000.0	120.000	100.0	H	35.0	-10.8	15:39:02 - 04.07.2022

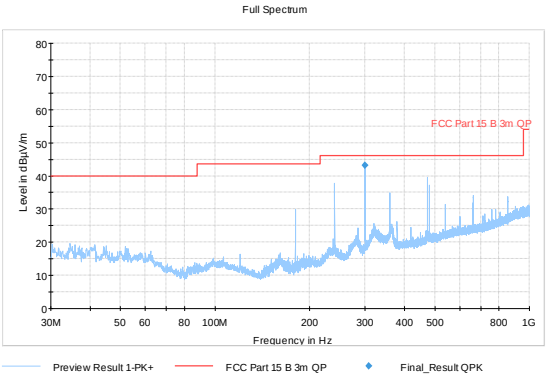
B4 LTE-M1/Ch2412MHz,11b 1Mbps



Radiated Emissions 30 - 1000 MHz, B4 LTE-M1/Ch2412MHz,11b 1Mbps

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
300.018950	43.15	46.00	2.85	1000.0	120.000	104.0	H	185.0	-10.8

B4 LTE-M1/Ch2472MHz,11b 1Mbps



Radiated Emissions 30 - 1000 MHz, B4 LTE-M1/Ch2472MHz,11b 1Mbps

Observed emissions are in non-restricted band.

Requirements/Limit

FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 5, Clause 8.9 @ frequencies defined in clause 8.10	
Frequency	Radiated emission limit @3 meters	
30 – 88 MHz	100 µV/m	40.0 dBµV/m
88 – 216 MHz	150 µV/m	43.5 dBµV/m
216 – 960 MHz	200 µV/m	46.0 dBµV/m
960 – 1000 MHz	500 µV/m	54.0 dBµV/m
	Limits above are with Quasi Peak Detector	

3.4 Radiated Emissions, 1-13 GHz

FCC Part 15.209 (a)

ISED Canada RSS-GEN Issue 5, Clause 7.3/8.9

Measurement procedure: **ANSI C63.10-2013 Clause 11.12**

Test Results: Complies

Measurement Data:

Measuring distance: 3m (1 – 13 GHz)

A pre-scan was performed above 13 GHz and no spurious emissions were detected.

Peak Detector and Average, RBW=1 MHz

Configuration	Measured Frequency Range (GHz)	Intermodulation
B4 LTE-NB2IoT/Ch2412MHz,11b 1Mbps	1 - 13	No Intermodulation detected
B4 LTE-NB2IoT/Ch2472MHz,11b 1Mbps	1 - 13	No Intermodulation detected
B4 LTE-M1Ch2412MHz,11b 1Mbps	1 - 13	No Intermodulation detected
B4 LTE-M1/Ch2472MHz,11b 1Mbps	1 - 13	No Intermodulation detected

A Band Reject Filter was used for measurements.

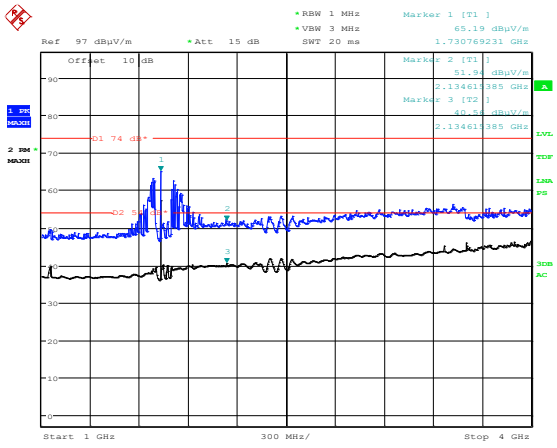
Antenna factor, amplifier gain and cable loss are included in spectrum analyzer “Transducer factor”

See plots

Requirements/Limit

FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 5, clause 8.9 @ frequencies defined in clause 8.10	
	Radiated emission limit @3 meters	
Frequency	Average Detector	Peak Detector
1 – 26 GHz	54.0 dBµV/m	74.0 dBµV/m

LTE NB2 IoT:



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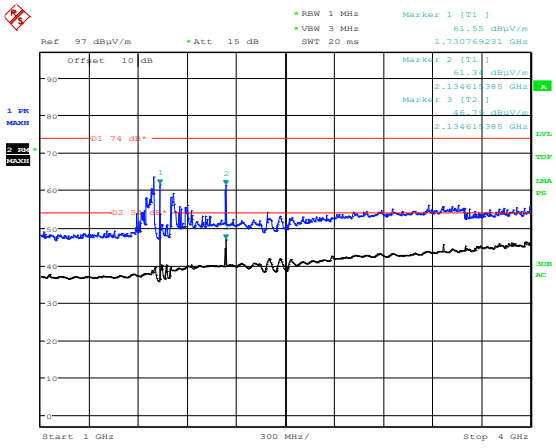
Radiated Emissions 1 - 4GHz, B4 LTE-NB2 IoT/Ch2412MHz,11b 1Mbps, HP ,pk scan



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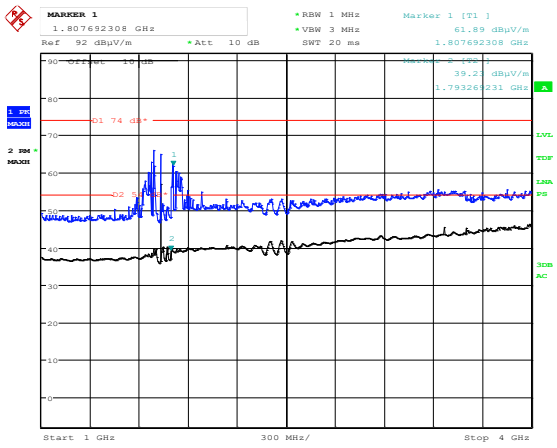
Radiated Emissions 1 - 4GHz, B4 LTE-NB2 IoT/Ch2412MHz,11b 1Mbps, VP ,pk scan



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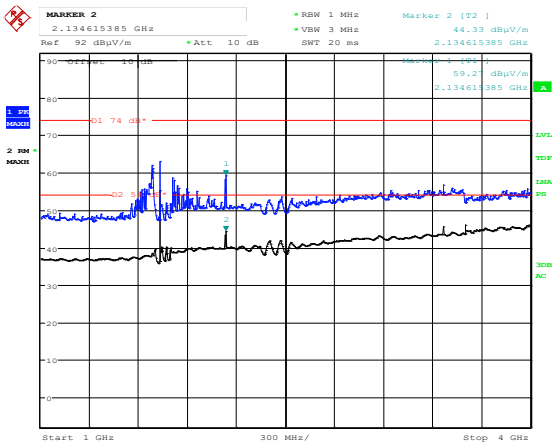

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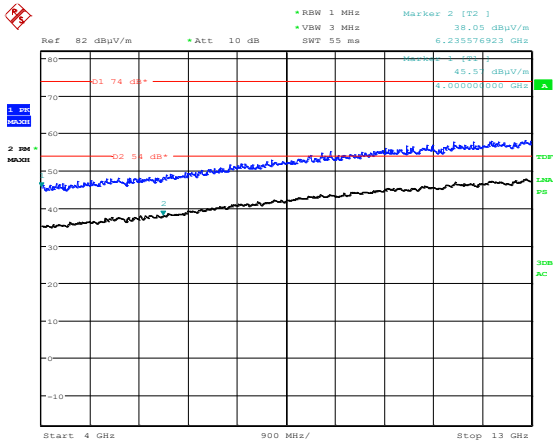

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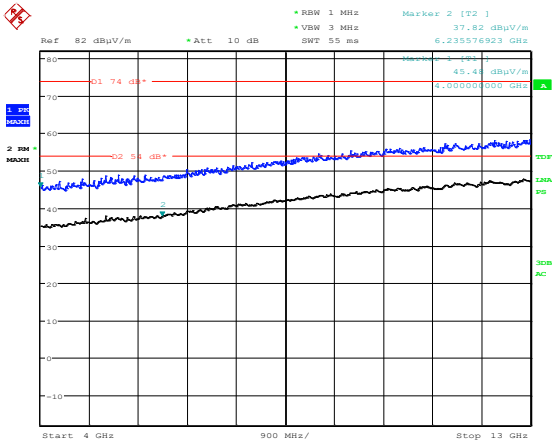
Radiated Emissions 4 - 13GHz, B4 LTE-NB2 IoT/Ch2412MHz,11b 1Mbps, HP ,pk scan



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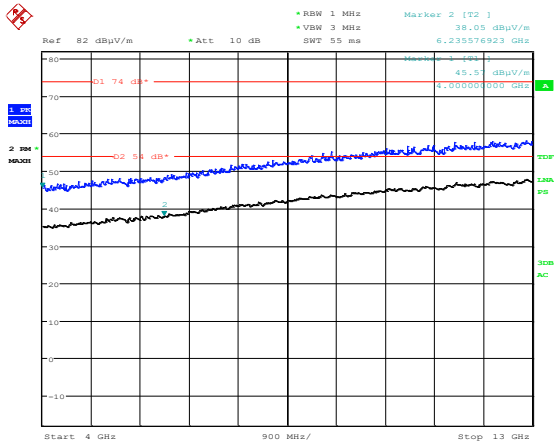
Radiated Emissions 4 - 13GHz, B4 LTE-NB2 IoT/Ch2412MHz,11b 1Mbps, VP ,pk scan



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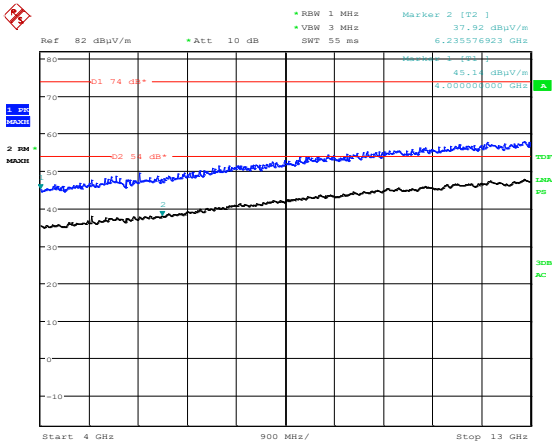
Radiated Emissions 4 - 13GHz, B4 LTE-NB2 IoT/Ch2472MHz,11b 1Mbps, HP ,pk scan



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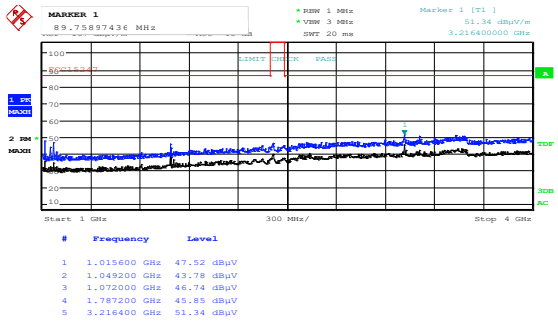
LTE M1



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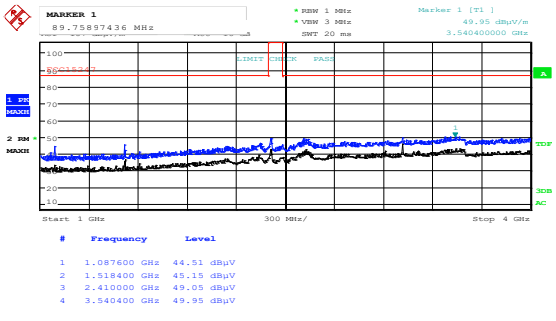
Radiated Emissions 1 - 4GHz, B8 LTE M1/Ch2412MHz,11b 1Mbps, HP ,pk scan



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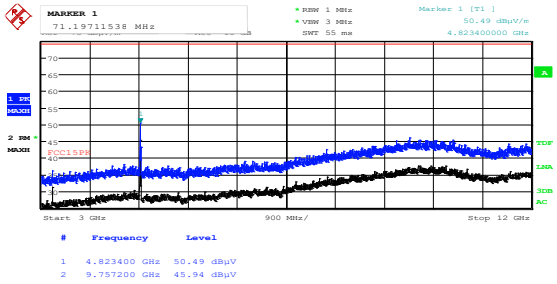
Radiated Emissions 1 - 4GHz, B8 LTE M1/Ch2412MHz,11b 1Mbps, VP ,pk scan



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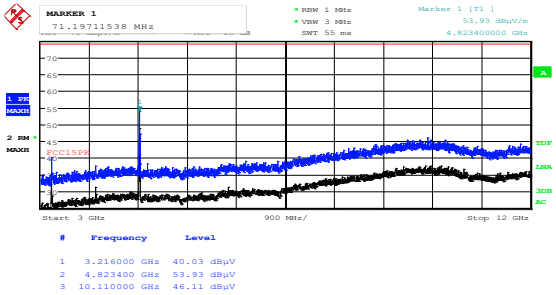
Radiated Emissions 3 - 12GHz, B8 LTE M1/Ch2412MHz,11b 1Mbps, HP ,pk scan



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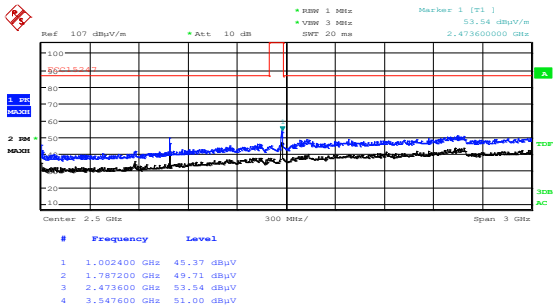
Radiated Emissions 3 - 12GHz, B8 LTE M1/Ch2412MHz,11b 1Mbps, VP ,pk scan



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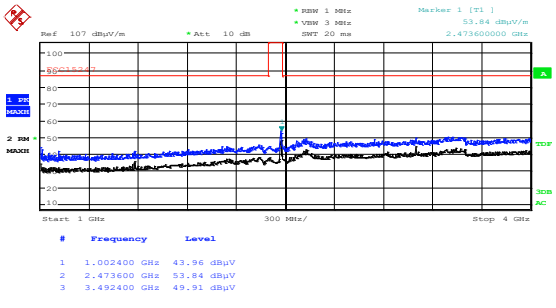
Radiated Emissions 1 - 4GHz, B8 LTE M1/Ch2472MHz,11b 1Mbps, HP ,pk scan



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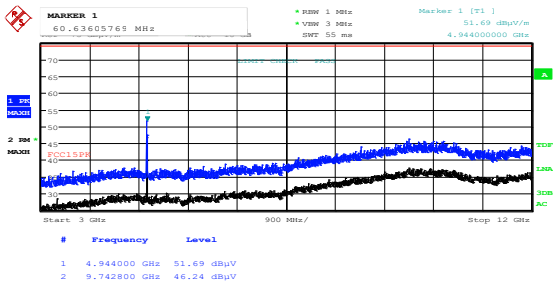
Radiated Emissions 1 - 4GHz, B8 LTE M1/Ch2472MHz,11b 1Mbps, VP ,pk scan



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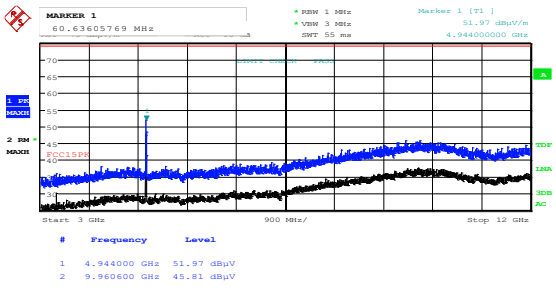
Radiated Emissions 3 - 12GHz, B8 LTE M1/Ch2472MHz,11b 1Mbps, HP ,pk scan



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Radiated Emissions 3 - 12GHz, B8 LTE M1/Ch2472MHz,11b 1Mbps, VP ,pk scan

4 Measurement Uncertainty

Measurement Uncertainty Values		
Test Item		**Uncertainty**
Output Power		±0.5 dB
Power Spectral Density		±0.5 dB
Out of Band Emissions, Conducted	**< 3.6 GHz**	±0.6 dB
	> 3.6 GHz	±0.9 dB
Spurious Emissions, Radiated	**< 1 GHz**	±2.5 dB
	> 1 GHz	±2.2 dB
Emission Bandwidth		±4 %
Power Line Conducted Emissions		+2.9 / -4.1 dB
Spectrum Mask Measurements	**Frequency**	±5 %
	Amplitude	±1.0 dB
Frequency Error		±0.6 ppm
Temperature Uncertainty		±1 °C

All uncertainty values are expanded standard uncertainty to give a confidence level of 95%, based on coverage factor k=2

5 LIST OF TEST EQUIPMENT

To facilitate inclusion on each page of the test equipment used for related tests, each item of test equipment and ancillaries are identified (numbered) by the Test Laboratory.

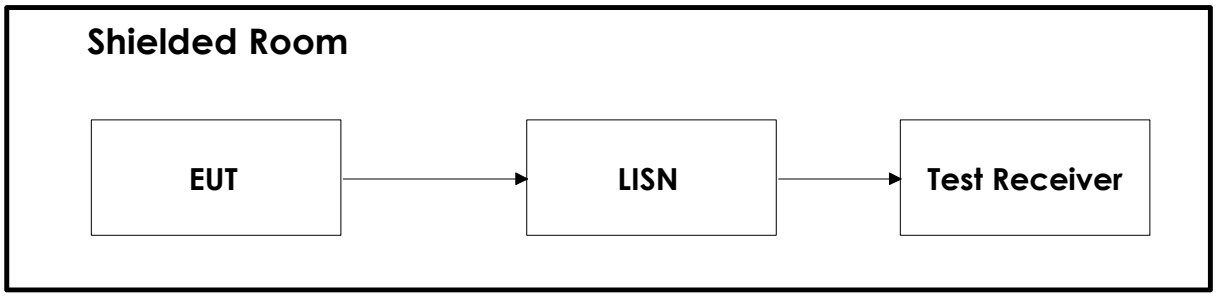
No.	Model number	Description	Manufacturer	Ref. no.	Cal. date	Cal. Due
1.	FSU26	Spectrum Analyzer	Rohde & Schwarz	LR 1504	2020-01	2022-01
2.	6810.17B	Attenuator	Suhner	LR 1668	COU	
3.	NO324415	Band Reject Filter	Microwave Circuits	LR 1760	COU	
4.	6HC3000/18000	High pass filter	Trilithic	LR 1614	COU	
5.	NO408981	Band Reject Filter	Microwave Circuits	LR 1766	COU	
6.	NO417483	Band Reject Filter	Microwave Circuits	LR 1767	COU	
7.		Band Reject Filter	Microwave Circuits	LR 1795	COU	
8.	6HC2000/18000	High Pass filter	Trilithic	LR 1613	COU	
9.	VULB	BiLog Antenna	Schwarzbeck	LR 1616	2021-05	2023-05
10.	316	Preamplifier	Sonoma Inst.	LR 1686	2021-08	2023-08
11.	3117-PA	Horn Antenna +PreAmp	EMCO	LR 1717	2022-08	2023-08
12.	8449A	Pre-amplifier	Hewlett Packard	LR 1322	2022-08	2023-08
13.	638	Antenna Horn	Narda	LR 1480	N/A	
14.	4768-10	Attenuator	Narda	LR 1670	COU	
15.	Model 87V	Multimeter	Fluke	LR 1599	2021-01	2023-01
16.	ST18/SMA/N/36	RF Cable	Suhner	LR 1627	COU	

The software listed below has been used for one or more tests.

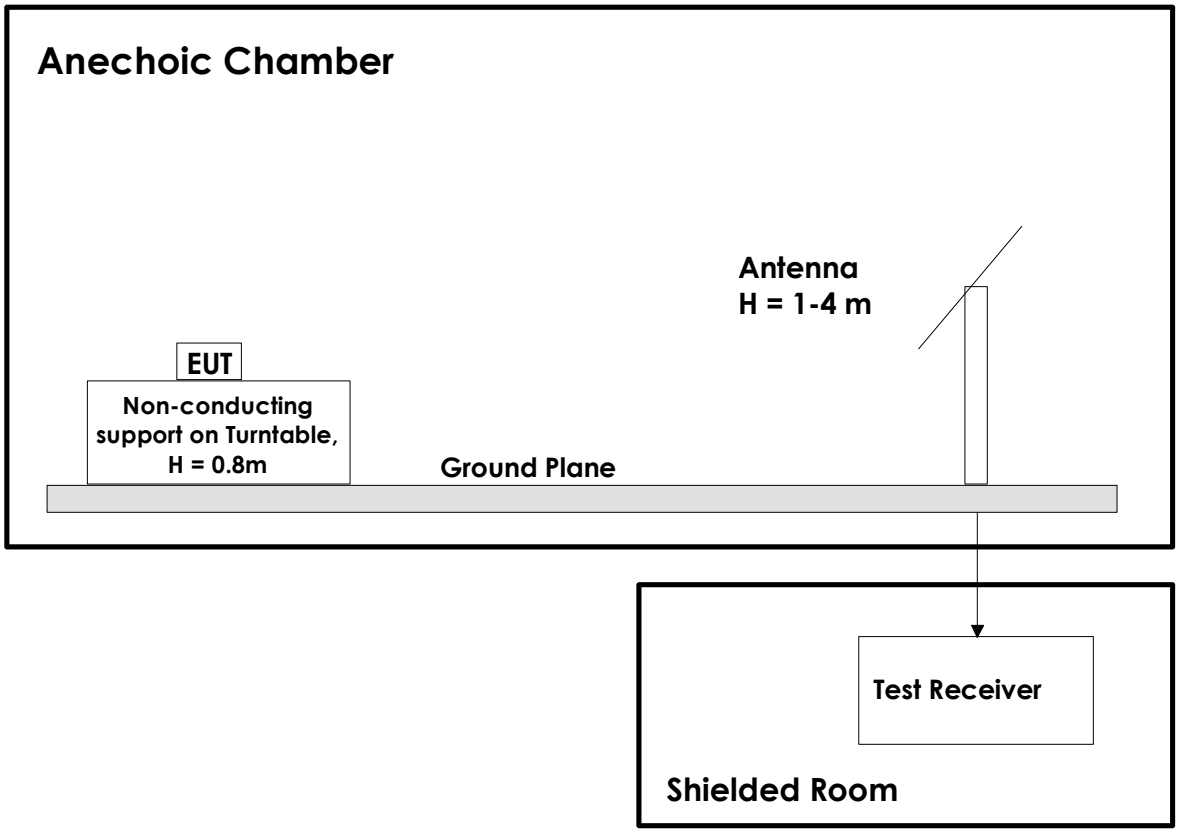
No.	Manufacturer	Name	Version	Comment
1	Rohde & Schwarz	EMC32	10.30.10	Power Line Conducted test software
2	Rohde & Schwarz	EMC32	10.30.10	Radiated Emission test software
3	Nemko AS	RSPlot	1.0.8.0	Screen capture from R&S Spectrum Analyzers

6 BLOCK DIAGRAM

6.1 Power Line Conducted Emission



6.2 Test Site Radiated Emission



This test setup is used for all radiated emissions tests. For frequencies below 30 MHz the measuring distance is 10m, for all other frequencies it is 3m or 1m. Emissions above 1 GHz are measured with a Spectrum Analyzer and Horn Antenna. For measurements above 18 GHz the test receiver is moved inside the anechoic chamber and located next to the antenna to minimize the cable loss. All measurements at 1GHz and above were performed with turntable height 1.5m and with the ground plane covered by absorbers. A pre-amplifier is used for all measurements above 30 MHz, and High-Pass or Band-Pass filter is used for all harmonics.