REP016207

Test Report

Product	Telematics unit for mounting on forklifts
Name and address of the applicant	Toyota Material Handling, Inc. 5559 Inwood Drive, Columbus IN 47201, USA
Name and address of the manufacturer	Toyota Material Handling, Inc. 5559 Inwood Drive, Columbus IN 47201, USA
Model	DHUnx
Rating	External DC supply (12-48 V_{DC})
Trademark	TOYOTA
Additional information	WiFi, BT Classic, BLE, WCDMA, LTE
Tested according to	**Parts of FCC Part 15.247** Digital Transmission Systems **Parts of ISED Canada RSS-247, Issue 3** Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
Order number	PRJ0033045
Tested in period	2023-08-23 to 2023-08-29
Issue date	2023-11-20
Name and address of the testing laboratory	Nemko Scandinavia AS Instituttveien 6 2007 Kjeller, Norway www.nemko.com CAB Number: FCC: NO0001 ISED: NO0470 ISED No: 2040D-1 **An accredited technical test executed under the Norwegian accreditation scheme**

Prepared by [Frode Sveinsen]	Approved by [Jan G Eriksen]

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Template version: C

Revision history

Revision	Date	Comment	Sign
A	2023-11-20	First edition	FS

GENERAL REMARKS

This report applies only to the sample(s) tested. It is the manufacturer's responsibility to ensure the additional production units of this product are manufactured with identical electrical and mechanical components. The manufacturer is solely responsible for any modifications to the product that could result in non-compliance with the relevant regulations.

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Opinions expressed within this report regarding general assessments and qualifications for PASS or FAIL to the standards limits and requirements, are not part of the current accreditation. Neither are opinions expressed regarding model variants covered by the testing of this report.

CALIBRATION

All instruments used in the tests given in this test report are calibrated and traceable to national or international standards. Between calibrations all test set-ups are controlled and verified on a regular basis by periodic checks to ensure, with 95% confidence, that the instruments remain within the calibrated levels.

MEASUREMENT UNCERTAINTY

Measurement uncertainties are calculated or considered for all instruments and instrument set-ups used during these tests. Uncertainty figures are found in a separate clause in this report.

CONTENTS

1 INFORMATION

1.1 Test Item

Name	**Toyota**
Model/version	**DHUnx**
FCC ID	**2A226-TELETMH02**
ISED ID	**27732-TELETMH02**
Serial number	**202308REVC161150**
Hardware identity and/or version	**Rev. C**
Software identity and/or version	**1.3.0-Engdrop3-Gerrit7902_3-b253bde**
Frequency Range	**2402–2480 MHz**
Number of Channels	**40**
Operating Modes	**Bluetooth Low Energy (1Mb Mode only)**
Type of Modulation	**GFSK, Bitrate 1Mb**
Conducted Output Power	**2.1 mW (Peak)**
Antenna Connector	**Quad MiniFakra**
Antenna Type	**Molex Antenna, P/N: 2144500750** **(P/N is for version with 750mm cable length, longer cables may also be used)** **Antenna element LTE1: Rx/Tx** **Antenna element LTE2: Rx Only** **Antenna element WiFi/BT: Rx/Tx 2.4GHz WiFi/BT/BLE and 5GHz WiFi** **Antenna element GNSS: Rx Only GNSS/GPS**
Antenna Diversity Supported	**Not for Bluetooth Low Energy**
Smart Antennas Supported	**No**
Power Source	**External DC Supply (12-48V_{DC}, supplied through MX23 connector)**
Interfaces	**MX23 Connector** **HSD Connector (100TX Ethernet)**

Description of Test Item

The EUT is a telematics unit with radio modules for BT/BLE/WiFi and Mobile (WCDMA and LTE). Both radio modules are certified radio modules. The EUT also contains a GPS receiver.

This test report covers only additional radiated tests for the new antennas.

1.2 Normal test conditions

Temperature:	**20 - 24 °C**
Relative humidity:	**20 - 50 %**
Normal test voltage:	**24V DC (2x 12V lead acid batteries, Fiamm FG20451)**

The EUT was powered from two fully charged batteries during all tests.
The values are the limit registered during the test period.

1.3 Test Engineer

Frode Sveinsen

1.4 Antenna Requirement

Does the EUT have detachable antenna(s)?	**☒ YES**	**☐ NO**
If detachable, is the antenna connector(s) non-standard?	**☒ YES**	**☐ NO**
Antenna Connector: Quad MiniFakra		

Requirement: FCC 15.203, 15.204

1.5 EUT Operating Modes

Description of operating modes	**Continuous TX**
Additional information	**The following settings were used for all tests:** **Power Setting: Default** **Bit Pattern: PSRB** **Frame Type: Default** **Bit rate: 1 Mbit**

1.6 Radio Modules

Data for radio modules				
Manufacturer	**Model No**	**Identification**	**Original Test Report**	**Technology**
Quectel	**AF20**	**FCC ID: XMR202303AF20** **IC: 10224A-202306AF20**	**TA R2212A1318-R2V1**	**BT Classic**
			TA R2212A1318-R1V1	**BT Low Energy**
			TA R2212A1318-R1V1	**WLAN**
			TA R2212A1318-R3V1	**UNII 2TX**
			TA R2212A1318-R4V1	**DFS**
Quectel	**AG35-NA**	**FCC ID: XMR201905AG35NA** **IC: 10224A-2019AG35NA**	**Sporton FG912203A** **Sporton FG180602A**	**WCDMA**
			Sporton FG912203B **Sporton FG180602B**	**LTE**

GSM850/GSM1900 (2G) is disabled in this product.

1.7 Comments

The EUT uses the Bluetooth Low Energy protocol.

All ports were populated during spurious emission measurements.

This test report covers only selected tests for new antennas, all other tests are covered by the original Test Report.

2 TEST REPORT SUMMARY

2.1 General

All measurements are tracable to national standards.

The tests were conducted for demonstrating compliance with FCC CFR 47 Part 15, paragraph 15.247 and ISED Canada RSS-247 Issue 3 and RSS-GEN Issue 5.

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

Radiated tests were made in a semi-anechoic chamber at measuring distance 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
DTS	Equipment Code	☐ Family Listing

2.2 Test Summary

Name of test	FCC Part 15 reference	RSS-247 Issue 3, RSS-GEN Issue 5 reference	ANSI C63.10-2013 Reference	Result
Supply Voltage Variations	15.31(e)	6.11 (RSS-GEN)	5.13	Complies
Antenna Requirement	15.203	6.8 (RSS-GEN)	5.8	Complies
Power Line Conducted Emission	15.107(a) 15.207(a)	7.2 / 8.8 (RSS-GEN)	6.2	N/A
Occupied Bandwidth (99% BW)	N/A	6.7 (RSS-GEN)	6.9.3	N/T
DTS Bandwidth	15.247(a)(2)	5.2 (1) (RSS-247)	11.8 Option 2	N/T
Peak Power Output	15.247(b)	5.4 (RSS-247)	11.9.1.1	Complies
Power Spectral Density	15.247(d)	5.2 (2) (RSS-247)	11.10.2 PKPSD (DTS)	N/T
Spurious Emissions (Antenna Conducted)	15.247(c)	5.5 (RSS-247)	6.7 11.11 (DTS)	N/T
Spurious Emissions (Radiated)	15.247(c) 15.109(a) 15.209(a)	3.3 (RSS-247) 7.3 (RSS-GEN) 8.9 (RSS-GEN)	6.3, 6.5, 6.6, 6.10 11.12, 11.13 (DTS)	Complies

3 TEST RESULTS

3.1 Peak Power Output

FCC Part 15.247 (b)

ISED Canada RSS-247 Issue 3, Clause 5.4

Measurement procedure: ANSI C63.10-2013 Clause 11.9.1.2

Test Results: Complies

Measurement Data:

Carrier Freq.	Bit rate	Field Strength (dBµV/m)	EIRP (dBm)	EIRP (mW)
2402 MHz	1Mb	91.2	-4.0	0.40
2440 MHz	1Mb	90.2	-5.0	0.31
2480 MHz	1Mb	89.2	-6.0	0.25

Field Strength was measured at 3m.

Output Power reported is Maximum Peak Power.

Radiated Power was calculated from measured Field Strength using the method described in FCC KDB 412172 D01.

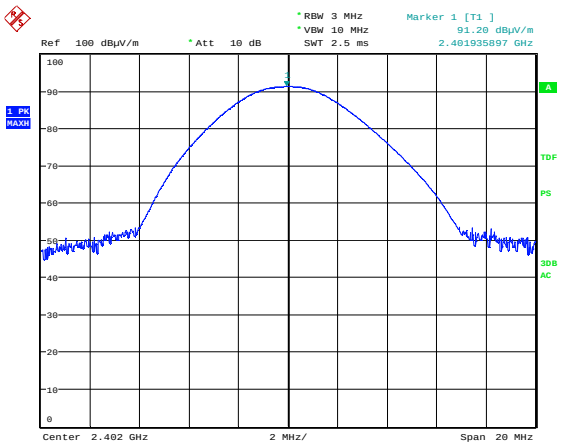
See attached plots.

Requirements:

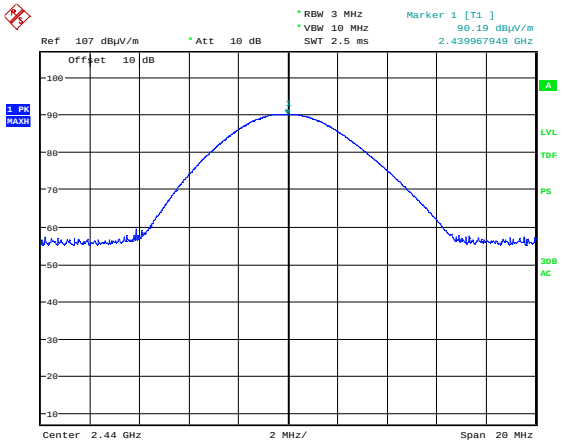
The maximum peak output power shall not exceed the following limits:

For Digital Transmission Systems in the 2400 - 2483.5 MHz band: 1 Watt

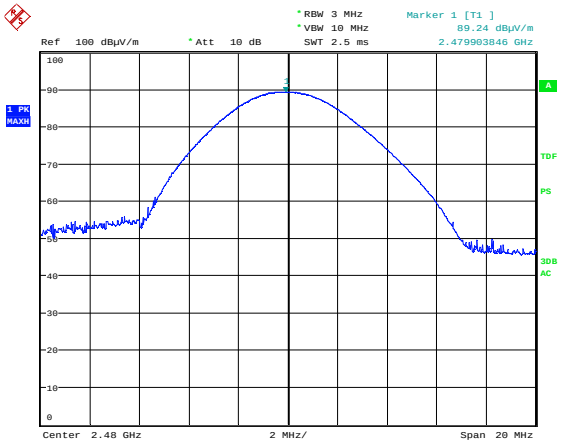
If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power from the intentional radiator shall be reduced below the stated value above by the amount in dB that the directional gain of the antenna exceeds 6 dBi.



Maximum Field Strength, 2402 MHz, GFSK, 1Mb, Max: VP



Maximum Field Strength, 2440 MHz, GFSK, 1Mb, Max: VP



Maximum Field Strength, 2480 MHz, GFSK, 1Mb, Max: VP

3.2 Restricted Bands of operation

Restricted Bands of operation for FCC and ISED are defined in FCC Part 15.205 and ISED Canada 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 Emissions, Band Edge

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**

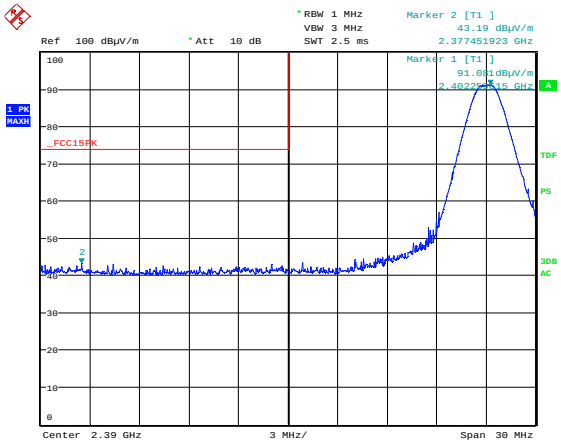
Test Results: Complies

Measurement Data:

Carrier Frequency and Data Rate	Band Edge Frequency	Measured Field Strength (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
		Peak Detector	Average Detector	Peak Det	Average Det	Peak Det	Average Det
2402 MHz 1Mb	2390 MHz	43.2	/	74	54	30.8	/
2480 MHz 1Mb	2483.5 MHz	47.9	/			26.1	/

Peak Values are below the Average Limit.

See attached plots.



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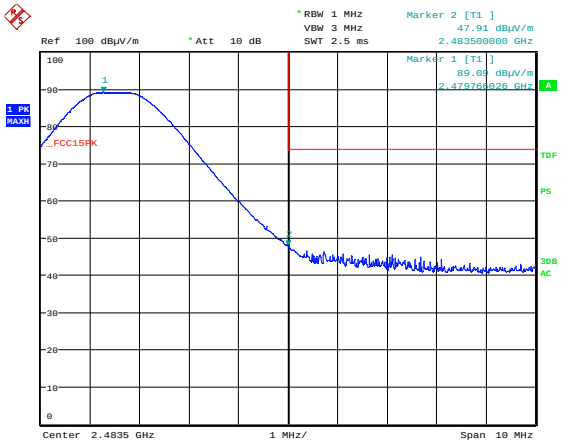
Lower Band Edge 2402 MHz, 1Mb, Pk



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Upper Band Edge 2480 MHz, 1Mb, Pk

3.4 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 (spurious frequencies were measured with Quasi-Peak Detector)

Measuring distance 3m

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
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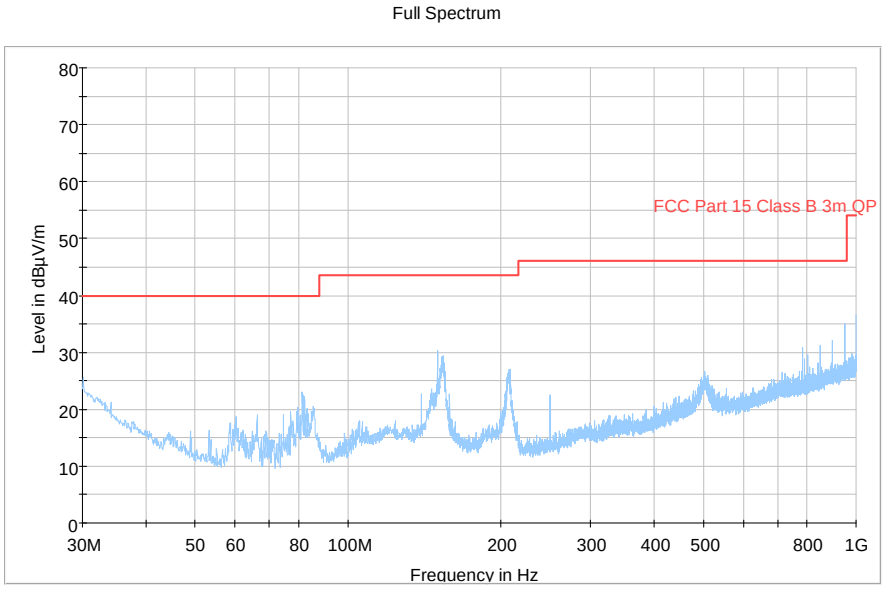
See attached plot.

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	



Radiated Emissions 30 - 1000 MHz, 1Mb

3.5 Radiated Emissions, 1-26 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 – 18 GHz)
1m (18 – 26 GHz)

RBW/VBW = 1MHz/3MHz

Carrier freq. (MHz)	Measured Frequency (GHz)	Measured Emissions (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
		Peak Det.	Average Det.	Peak	Average	Peak	Average
Any	1 - 26	< 56	< 48	74	54	> 18	> 6

Average Detector values are calculated from Peak values by Duty Cycle Correction Factor.

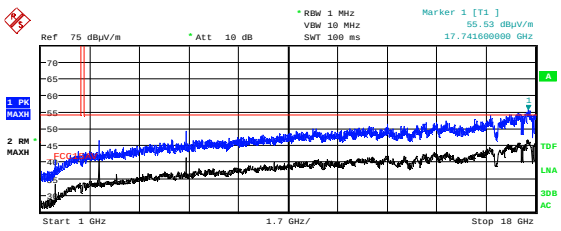
A Band Reject Filter was used for measurements from 1 GHz to 18 GHz.

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



#	Frequency	Level
1	5.998000 GHz	48.95 dBµV
2	16.425800 GHz	53.69 dBµV
3	17.381200 GHz	54.47 dBµV
4	17.741600 GHz	55.53 dBµV
5	17.959200 GHz	53.97 dBµV

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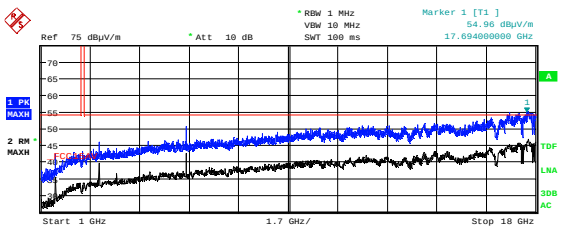
Radiated Emissions 1 - 18 GHz, 2402 MHz, 1Mb, VP



#	Frequency	Level
1	1.499800 GHz	42.14 dBµV
2	5.998000 GHz	50.36 dBµV
3	16.463200 GHz	52.96 dBµV
4	17.078600 GHz	54.69 dBµV
5	17.694000 GHz	54.96 dBµV
6	17.911600 GHz	54.14 dBµV

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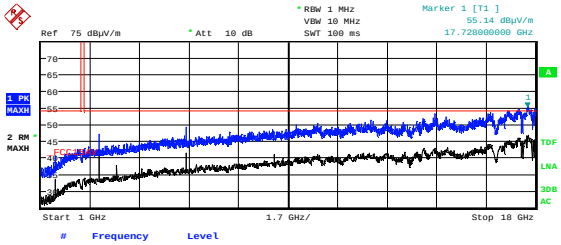

#	Frequency	Level
1	2.999200 GHz	47.04 dBµV
2	5.998000 GHz	49.02 dBµV
3	16.442800 GHz	53.51 dBµV
4	17.415200 GHz	54.58 dBµV
5	17.728000 GHz	55.14 dBµV
6	18.000000 GHz	54.67 dBµV

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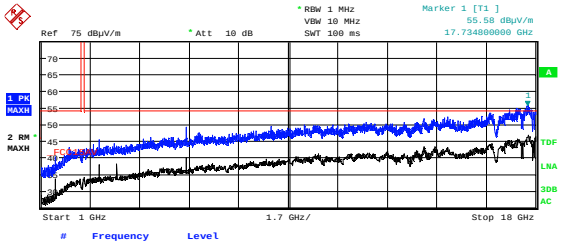
Radiated Emissions 1 - 18 GHz, 2440 MHz, 1Mb, VP



#	Frequency	Level
1	16.429200 GHz	53.27 dBµV
2	17.333600 GHz	54.69 dBµV
3	17.734800 GHz	55.58 dBµV

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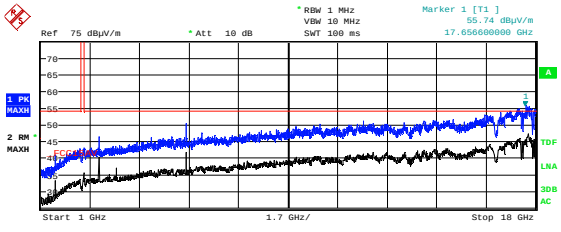

#	Frequency	Level
1	5.998000 GHz	50.25 dBµV
2	16.249000 GHz	52.79 dBµV
3	17.415200 GHz	54.71 dBµV
4	17.656600 GHz	55.74 dBµV
5	17.952400 GHz	54.39 dBµV

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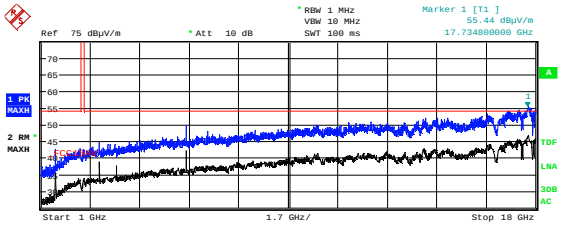
Radiated Emissions 1 - 18 GHz, 2480 MHz, 1Mb, VP



#	Frequency	Level
1	1.499800 GHz	42.48 dBµV
2	5.998000 GHz	49.57 dBµV
3	16.334000 GHz	53.03 dBµV
4	17.734800 GHz	55.44 dBµV
5	17.996600 GHz	54.59 dBµV

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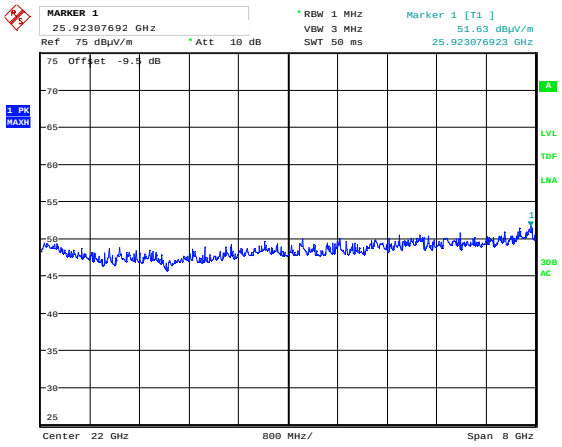

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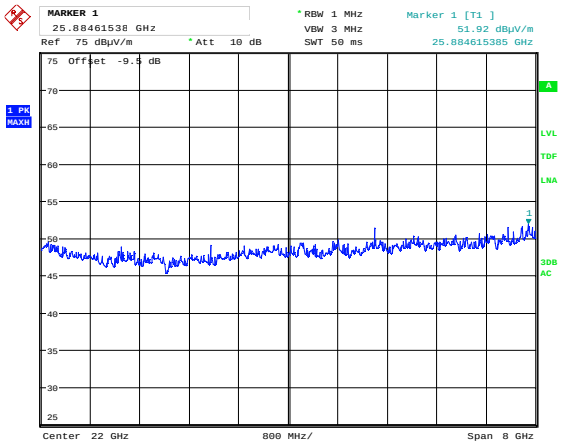
Prescan 18 - 26 GHz, 2402 MHz, VP, @1m



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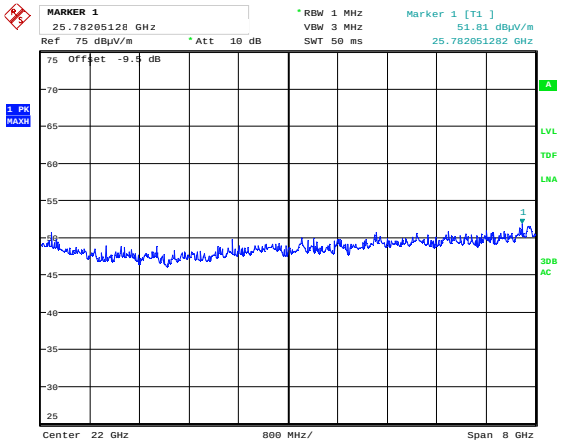

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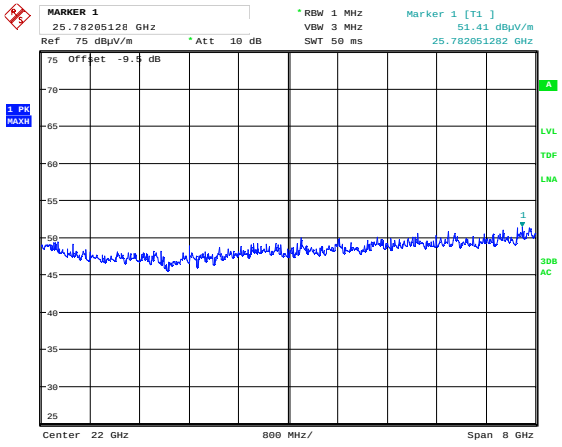
Prescan 18 - 26 GHz, 2440 MHz, VP, @1m



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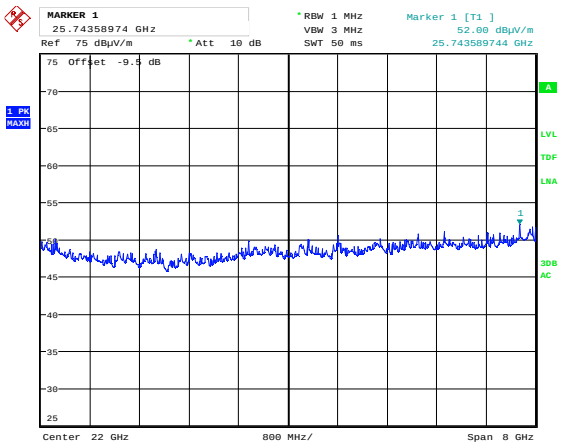

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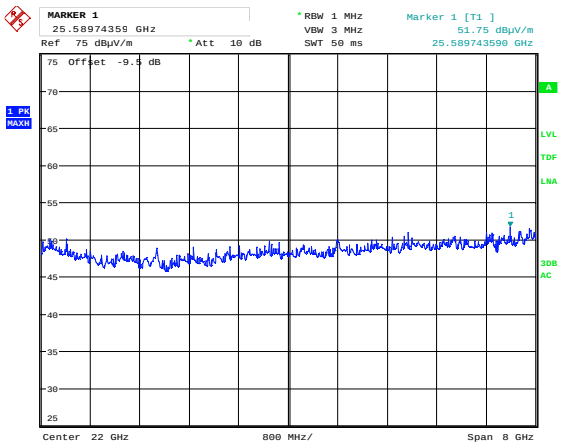
Prescan 18 - 26 GHz, 2480 MHz, VP, @1m



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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	ESU40	Measuring Receiver	Rohde & Schwarz	LR 1639	2023-01	2024-01
2	N0324415	BandStop Filter (2.4GHz)	Microwave Circuits	LR 1760	COU	
3	WLK5-1100-1485-7000-40SS	Low Pass Filter (1.0 GHz)	Wainwright Inst.	LR 1761	COU	
4	310	Preamplifier	Sonoma Inst.	LR 1686	2023-08	2024-08
5	8449A	Pre-amplifier	Hewlett Packard	LR 1322	2023-08	2024-08
6	3115	Horn Antenna	EMCO	LR 1330	2022-12	2027-12
7	3117-PA	Horn Antenna +PreAmp	EMCO	LR 1717	2023-08	2024-08
8	JB3	BiLog Antenna	Sunol	N-4525	2023-04	2026-04
9	Model 638	Antenna Horn	Narda	LR 1480	N/A	

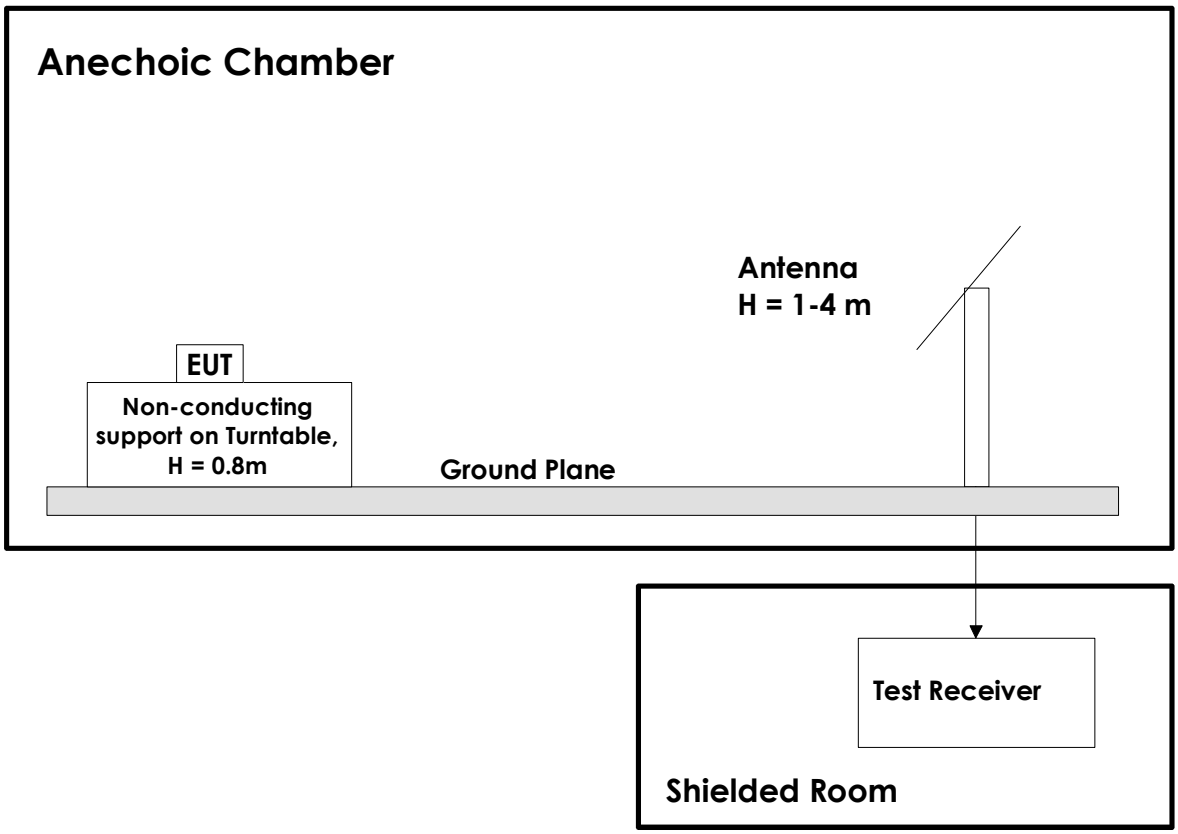
Note: COU – calibrate on use; N/A – Not Applicable

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

No.	Manufacturer	Name	Version	Comment
1	Rohde & Schwarz	EMC32	10.50.10	EMC test software
2	Nemko AS	RSPlot	1.0.8.0	Screenshots from R&S Spectrum Analyzers

6 BLOCK DIAGRAM

6.1 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.