Report No. 433049-08-R00

Test Report

Product	Telematics unit for mounting on forklifts
Name and address of the applicant	Toyota Material Handling Manufacturing Sweden AB Svarvargatan 8 SE-59581 Mjölby, Sweden
Name and address of the manufacturer	Toyota Material Handling Manufacturing Sweden AB Svarvargatan 8 SE-59581 Mjölby, Sweden
Model	DHU4
Rating	External DC supply (12-48 V_{DC})
Trademark	TOYOTA
Serial number	2117000000251
Additional information	WiFi, BT Classic, BLE
Tested according to	**Parts of FCC Part 15.247** Digital Transmission Systems **Parts of ISED Canada RSS-247, Issue 2** Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
Order number	433049
Tested in period	2021-09-15 to 2021-10-25
Issue date	2022-02-24
Name and address of the testing laboratory	Instituttveien 6 Kjeller, Norway www.nemko.com CAB Number: FCC: NO0001 ISED: NO0470 **An accredited technical test executed under the Norwegian accreditation scheme**

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

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Revision history

Revision	Date	Comment	Sign
00	2022-02-24	First edition	FS

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”.

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1 INFORMATION

1.1 Test Item

Name	**Toyota**
Model/version	**DHU4**
FCC ID	**2A24D-DHU4**
ISED ID	**27803-DHU4**
Serial number	**2117000000251**
Hardware identity and/or version	**Rev. B**
Software identity and/or version	**dv_b1_2021-05-05**
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	**1.37 mW (Peak)**
Antenna Connector	**Quad MiniFakra**
Antenna Type	**Smarteq SmartDisc Combi (4-in-1 antenna, 2xLTE, GNSS, WIFi/BT/BLE)** **P/N: 550237 (tested with 200mm cable, 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	**FC20**	**FCC ID: XMR201703FC20** **IC: 10224A-201703FC20** **P/N: FC20-Q73**	**Siemic 16050028-FCC-R3** **TA R2105A0465-R2**	**BT Classic**
			Siemic 16050028-FCC-R4 **TA R2105A0465-R1**	**BT Low Energy**
			Siemic 16050028-FCC-R1 **TA R2105A0465-R1**	**WLAN**
			Siemic 16050028-FCC-R2 **TA R2105A0465-R3**	**UNII 2TX**
			TA R2105A0465-R4V1	**DFS**
Quectel	**EG25**	**FCC ID: XMR201903EG25G** **IC: 10224A-201903EG25G** **P/N: EG25GGB-256-SGNS**	**SGS HR/2019/1001601** **SGS HR/2019/1001603**	**GSM/WCDMA/LTE**

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 Industry Canada RSS-247 Issue 2 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 distances of 1m, 3m and 10m.

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 2, 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)**	**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**

3 TEST RESULTS

3.1 Peak Power Output

FCC Part 15.247 (b)

ISED Canada RSS-247 Issue 2, Clause 5.4

Measurement procedure: ANSI C63.10-2013 Clause 11.9.1.2

Test Results: Complies

Measurement Data:

Smartec Antenna				
Carrier Freq.	**Bit rate**	**Field Strength (dBµV/m)**	**EIRP (dBm)**	**EIRP (mW)**
2402 MHz	**1Mb**	**94.6**	**-0.7**	**0.86**
2480 MHz	**1Mb**	**96.4**	**1.1**	**1.29**

Output Power reported is Maximum Peak Power.

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

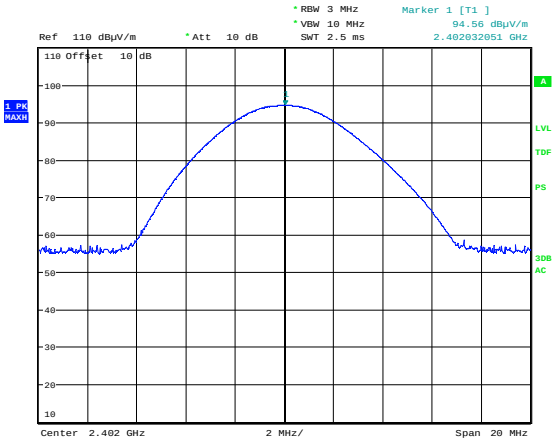
See attached plots.

Requirements:

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

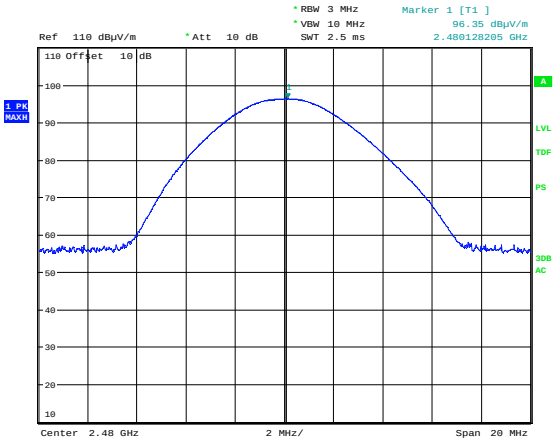
For Digital Transmission Systems in the 2400 - 2483.5 MHz band: 1 Watt

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.



Date: 15.SEP.2021 15:37:31

Maximum Field Strength, 2402 MHz, GFSK, 1M



Date: 15.SEP.2021 15:51:15

Maximum Field Strength, 2480 MHz, GFSK, 1Mb

3.2 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 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**

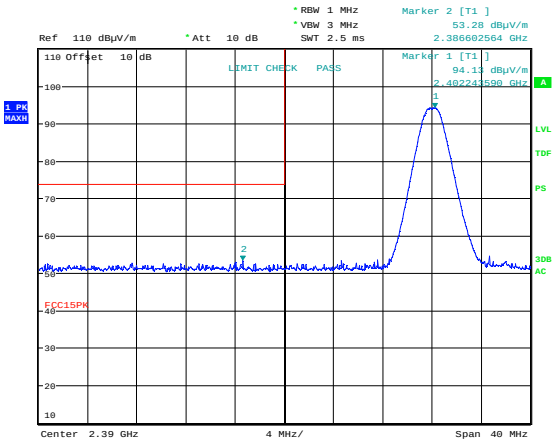
Test Results: Complies

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	53.3	40.6	74	54	20.7	13.4
2480 MHz 1Mb	2483.5 MHz	56.7	48.8			17.3	5.2

See attached plots.

Smartec Antenna



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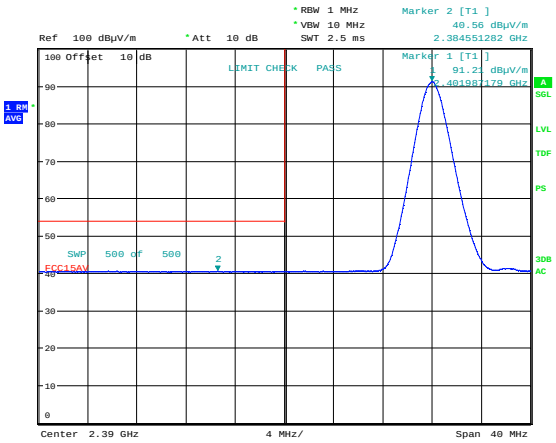
Lower Band Edge 2402 MHz, 1Mb, Pk



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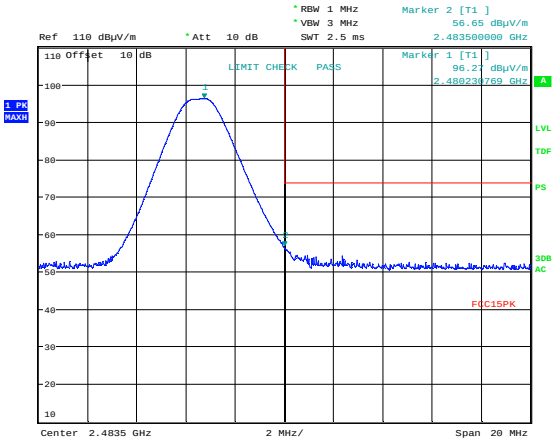
Lower Band Edge 2402 MHz, 1Mb, Av



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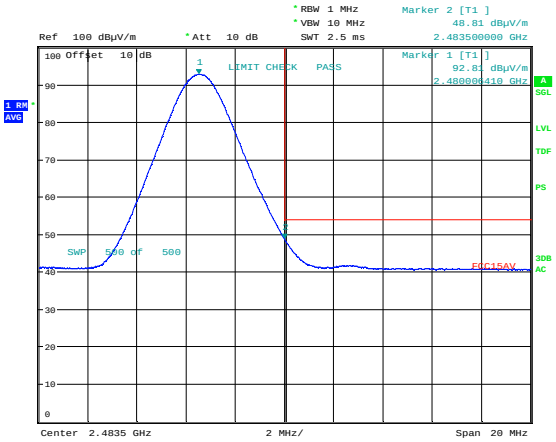
Upper Band Edge 2480 MHz, 1Mb, Pk



Date: 15.SEP.2021 15:53:35

Upper Band Edge 2480 MHz, 1Mb, Av

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

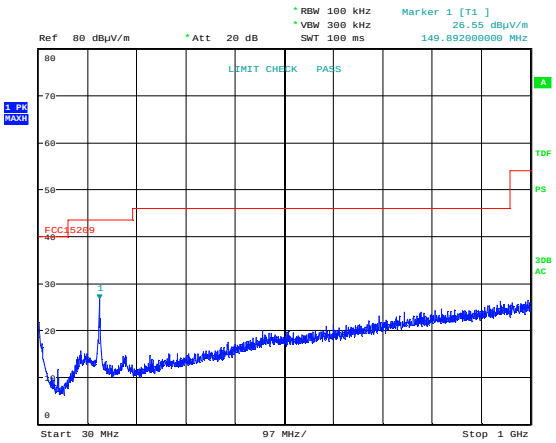
Tested in with BLE Active in Burst Mode

Measured Frequency (MHz)	Carrier Frequency (MHz)	Bit rate	Measured Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)
30 – 88	2440	Any	< 20	40.0	> 20
88 – 216	2440	Any	< 20	43.5	> 23.5
216 – 960	2440	Any	< 26	46.0	> 20
960 – 1000	2440	Any	< 30	54.0	> 24
150	Any	Any	22.8	43.5	20.7

See attached plots

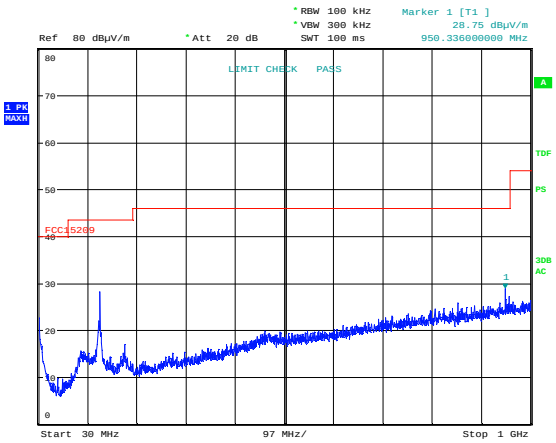
Requirements/Limit

FCC	Part 15.209 @ frequencies defined in §15.205	
ISED	RSS-GEN Issue 5, Clause 8.9 @ frequencies defined in clause 8.10	
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	



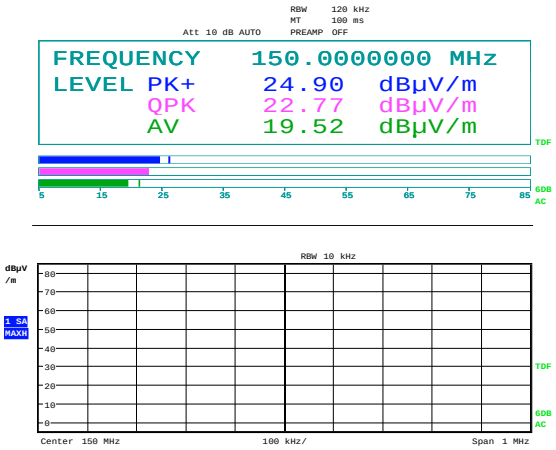
Date: 17.SEP.2021 15:04:37

Radiated Emissions 30 - 1000 MHz, 1Mb, VP



Date: 17.SEP.2021 15:06:35

Radiated Emissions 30 - 1000 MHz, 1Mb, HP



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Radiated Emissions 150 MHz (Max: HP)

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	< 58	< 44	74	54	> 16	> 10

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

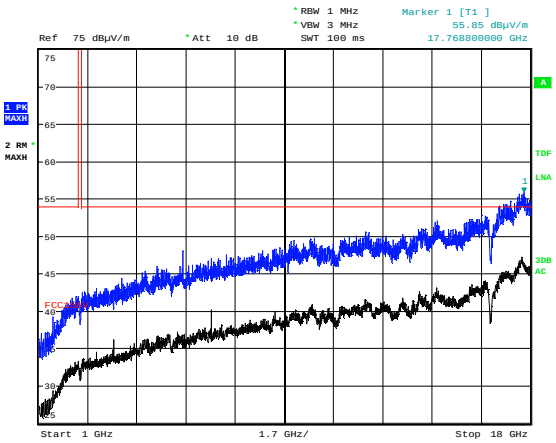
A Band Reject Filter was used for measurements from 1 GHz to 18 GHz.

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



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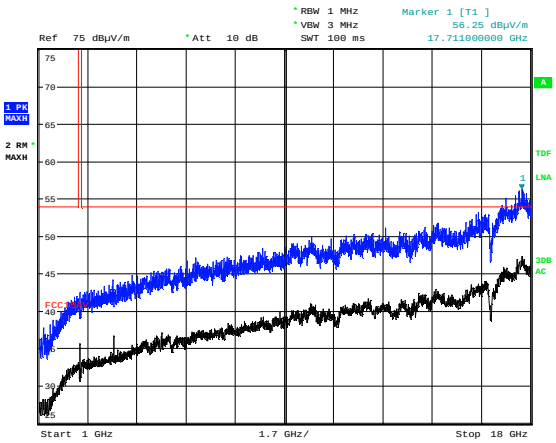
Radiated Emissions 1 - 18 GHz, 2440 MHz, 1Mb, VP



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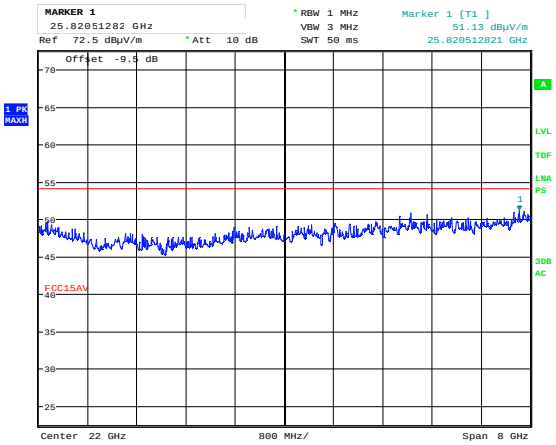
Radiated Emissions 1 - 18 GHz, 2440 MHz, 1Mb, HP



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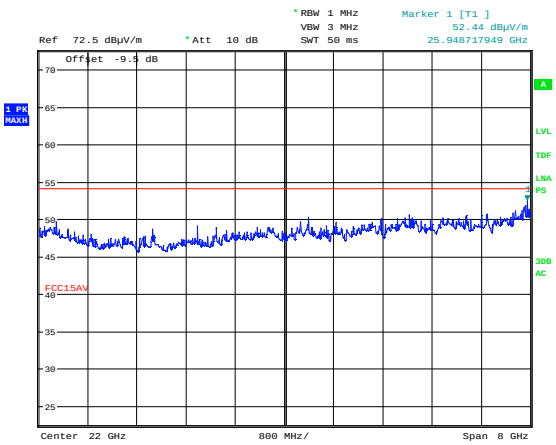
Prescan 18 - 26 GHz, 2440 MHz, VP, @1m, Smartec



Date: 12.OCT.2021 13:09:22

Prescan 18 - 26 GHz, 2440 MHz, HP, @1m, Smartec

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	2021-02	2022-02
2	6810-17B	Attenuator	Suhner	LR 1669	2021-08	2022-08
3	N0324415	BandStop Filter	Microwave Circuits	LR 1760	COU	
4	WLK5-1100-1485-7000-40SS	Low Pass Filter	Wainwright Inst.	LR 1761	COU	
5	317	Preamplifier	Sonoma Inst.	LR 1687	2021-08	2022-08
6	8449A	Pre-amplifier	Hewlett Packard	LR 1322	2021-08	2022-08
7	3115	Horn Antenna	EMCO	LR 1330	N/A	
8	3117-PA	Horn Antenna +PreAmp	EMCO	LR 1717	2021-08	2022-08
9	Model 638	Antenna Horn	Narda	LR 1480	N/A	
10	ST18/SMA/N/36	RF Cable	Suhner	LR 1627	COU	

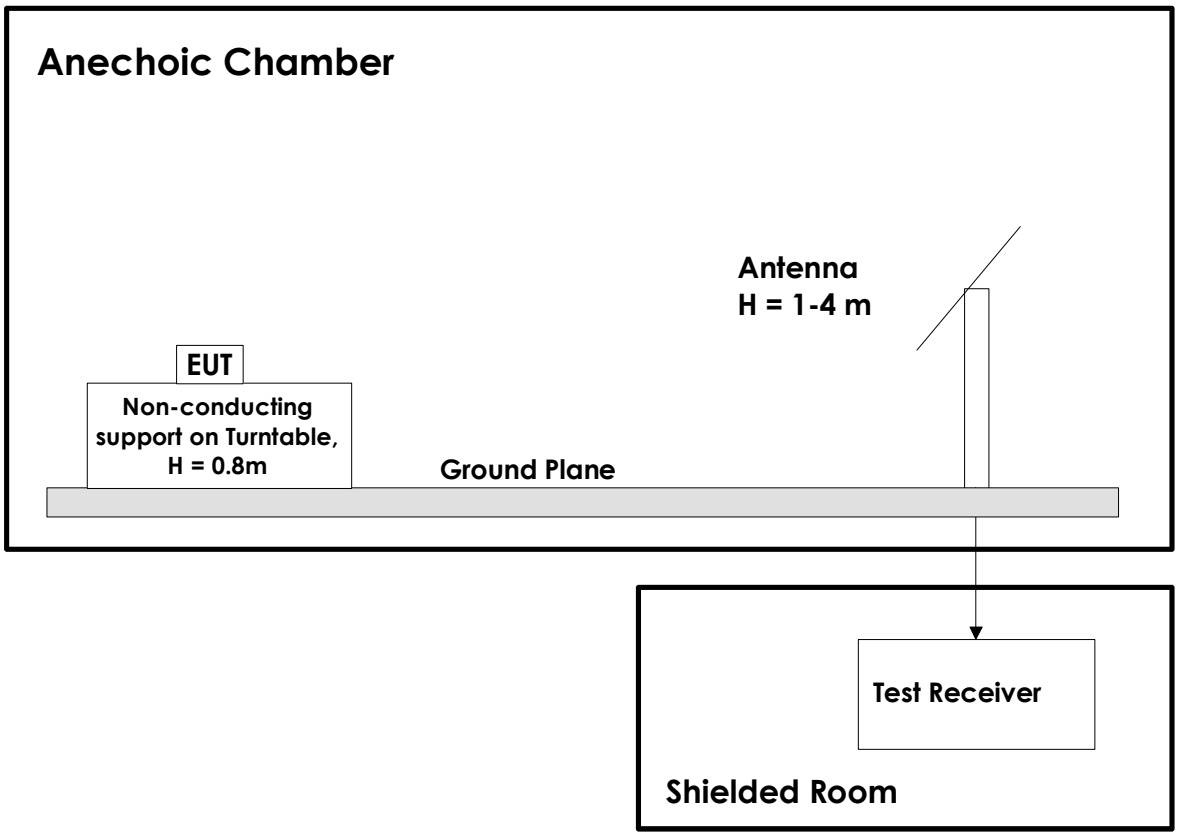
Note: COU – calibrate on use; N/A – Not Applicable

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.