

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 Parts of FCC Parts 22 / 24 / 27 / 90 Parts of ISED Canada RSS-247, Issue 2 Parts of ISED Canada RSS-130 / RSS-132 / RSS-133 / RSS-139 / RSS-199
Order number	PRJ0033045
Tested in period	2023-08-24 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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Revision history

Revision	Date	Comment	Sign
00	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.

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
Number of antennas	1 for BT/BLE/WiFi 2 for WCDMA/LTE (only 1 is used for TX, both are used for RX) 1 for GPS (RX only)
Supported Radio Technologies	Bluetooth Classic Bluetooth Low energy WiFi 2.4 GHz / 5 GHz WCDMA 850 / 1900 / 2100 LTE (FDD/TDD)
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	Yes, but only for RX on LTE
Smart Antenna System	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. Both radio modules are certified radio modules. The EUT also contains a GPS receiver.

This test report only covers only interoperability tests for simultaneous operation of the two radio modules.

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 EUT Operating Modes

All tests were performed with WiFi / BT / BLE programmed from the Qualcomm Radio Control Software.

Power values for these technologies are noted in the individual test reports.

The mobile transmitter was programmed from the CMW500 for WCDMA and LTE. The mobile signal was programmed to the maximum output power supported for each technology.

1.5 Radio Modules

Data for radio modules				
Manufacturer	Model No	Identification	Original Test Report	Technology
Quectel	AF20	FCC ID: XMR202303AF20 IC: 10224A-202303AF20	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-201905AG35NA	Sporton FG912203A Sporton FG180602A	WCDMA
			Sporton FG912203B Sporton FG180602B	LTE

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

1.6 Mobile Frequency Bands and Standards

Band	FCC	ISED Canada	Uplink Freq	Downlink Freq	Technology	Common Name
B02	Part 24E	RSS-133 Issue 6 A1	1850-1910 MHz	1930-1990 MHz	WCDMA, LTE	1900 PCS
B04	Part 27C	RSS-139 Issue 3	1710-1755 MHz	2110-2155 MHz	WCDMA, LTE	AWS-1
B05	Part 22H	RSS-132 Issue 3	824-849 MHz	869-894 MHz	WCDMA, LTE	850
B07	Part 27C	RSS-199 Issue 3	2500-2570 MHz	2620-2690 MHz	LTE	2600
B12	Part 27C	RSS-130 Issue 2	699-716 MHz	729-746 MHz	LTE	700 a
B13	Part 27C	RSS-130 Issue 2	777-787 MHz	746-756 MHz	LTE	700 c
B17	Part 27C	RSS-130 Issue 2	704-716 MHz	734-746 MHz	LTE	700 b
B41	Part 27C	RSS-199 Issue 3	2496-2690 (TDD)		LTE	TD 2600+

1.7 Comments

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.

All results are tested to limits for FCC 15.209 since these are the strictest limits.

2 TEST REPORT SUMMARY

2.1 General

All measurements are traceable 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 performed in a semi-anechoic chamber at measuring distances of 3m.

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

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

Test Summary

Name of test	FCC Part 15 reference	RSS-247 Issue 3, RSS-GEN Issue 5 reference	ANSI C63.10-2013 Reference	Result
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 Radiated Emissions, Interoperability

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 Detector for Pre-scan (Measurements with Quasi-Peak Detector below 1 GHz)

Measuring distance: 3m (1 – 18 GHz)

A 2.4 GHz Band Reject Filter was used for measurements from 1 GHz to 18 GHz

The limit for Part 15.209 was used for all tests since this is the strictest limit.

The limit for most of the tested licensed bands are -13 dBm average, which is equivalent to 82 dB μ V/m @3m.

Antenna factor, PreAmp Gain and Cable Loss are included in spectrum analyzer "Transducer factor".

Results are shown below. No other emissions related to intermodulation were detected.

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	
	All Limits below 1GHz are with Quasi Peak Detector	
30 – 88 MHz	100 μ V/m	40.0 dB μ V/m
88 – 216 MHz	150 μ V/m	43.5 dB μ V/m
216 – 960 MHz	200 μ V/m	46.0 dB μ V/m
960 – 1000 MHz	500 μ V/m	54.0 dB μ V/m
	Average Detector	Peak Detector
1 – 26 GHz	54.0 dB μ V/m	74.0 dB μ V/m

WCDMA1900 + WiFi								
WiFi ch06/ch116 + WCDMA ch9400								
Measured Frequency (MHz)	Carrier Freq WiFi (MHz)	Carrier Freq LTE (MHz)	Measured Emissions (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
			Peak	Average	Peak	Average	Peak	Average
Any	2437	1880	/	/	74	54	/	/
Any	5580	1880	/	/	74	54	/	/

WCDMA2100 + WiFi								
WiFi ch06/ch116 + WCDMA ch1312/ch1400								
Measured Frequency (MHz)	Carrier Freq WiFi (MHz)	Carrier Freq WCDMA (MHz)	Measured Emissions (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
			Peak	Average	Peak	Average	Peak	Average
Any	2437	1712.4	/	/	74	54	/	/
Any	5580	1730	/	/	74	54	/	/

WCDMA850 + WiFi								
WiFi ch06/Ch116 + WCDMA ch4132								
Measured Frequency (MHz)	Carrier Freq WiFi (MHz)	Carrier Freq WCDMA (MHz)	Measured Emissions (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
			Peak	Average	Peak	Average	Peak	Average
Any	2437	826.4	/	/	74	54	/	/
Any	5580	826.4	/	/	74	54	/	/

LTE Band 02 + WiFi								
WiFi ch06 + LTE ch18925/ch18900								
Measured Frequency (MHz)	Carrier Freq WiFi (MHz)	Carrier Freq LTE (MHz)	Measured Emissions (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
			Peak	Average	Peak	Average	Peak	Average
Any	2437	1882.5	/	/	74	54	/	/
Any	5580	1880	/	/	74	54	/	/

LTE Band 04 + WiFi								
WiFi ch06/ch116 + LTE ch20175								
Measured Frequency (MHz)	Carrier Freq WiFi (MHz)	Carrier Freq LTE (MHz)	Measured Emissions (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
			Peak	Average	Peak	Average	Peak	Average
Any	2437	1732.5	/	/	74	54	/	/
Any	5580	1732.5	/	/	74	54	/	/

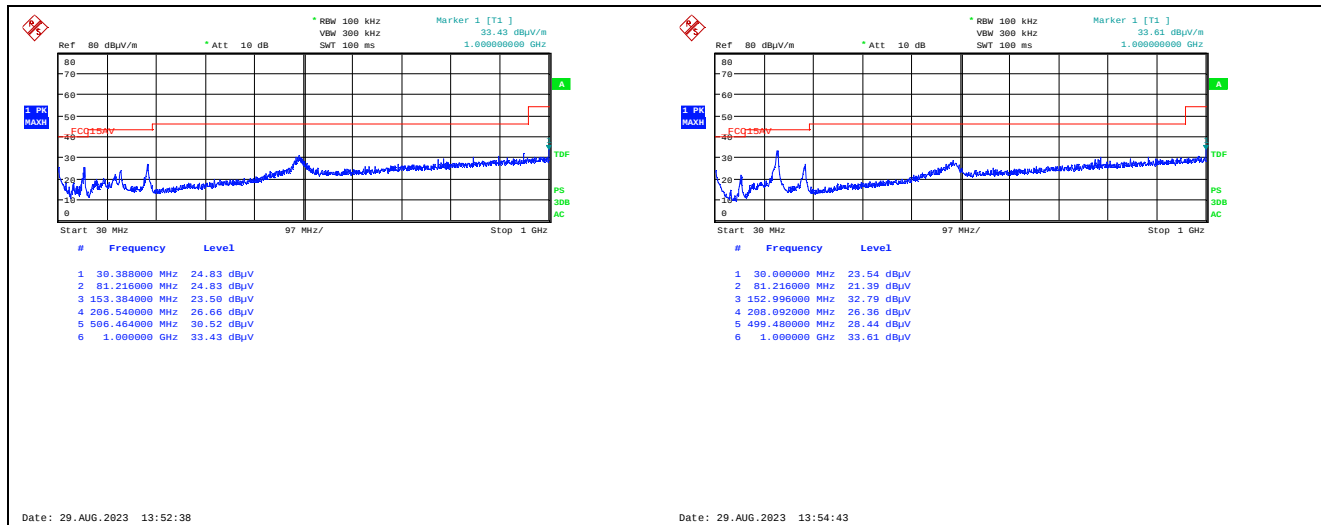
LTE Band 05 + WiFi								
WiFi ch06/ch116 + LTE ch20525								
Measured Frequency (MHz)	Carrier Freq WiFi (MHz)	Carrier Freq LTE (MHz)	Measured Emissions (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
			Peak	Average	Peak	Average	Peak	Average
Any	2437	836.5	/	/	74	54	/	/
Any	5580	836.5	/	/	74	54	/	/

LTE Band 07 + WiFi								
WiFi ch06/ch116 + LTE 2600 ch21100/ch21300								
Measured Frequency (MHz)	Carrier Freq WiFi (MHz)	Carrier Freq LTE (MHz)	Measured Emissions (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
			Peak	Average	Peak	Average	Peak	Average
Any	2437	2555	/	/	74	54	/	/
Any	2437	2535	/	/	74	54	/	/
Any	5580	2535	/	/	74	54	/	/

LTE Band 12 + WiFi								
WiFi ch06/ch116 + LTE ch23090/23095								
Measured Frequency (MHz)	Carrier Freq WiFi (MHz)	Carrier Freq LTE (MHz)	Measured Emissions (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
			Peak	Average	Peak	Average	Peak	Average
Any	2437	707.5	/	/	74	54	/	/
Any	2437	707	/	/	74	54	/	/
Any	5580	707	/	/	74	54	/	/

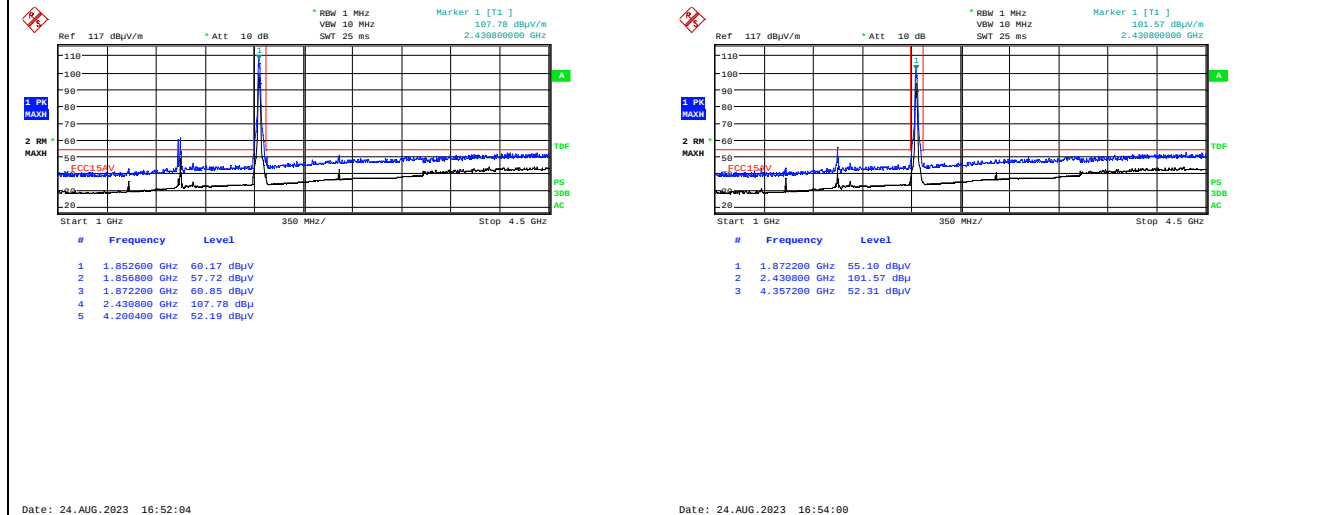
LTE Band 13 + WiFi								
WiFi ch06 + LTE ch23210/ch23230								
Measured Frequency (MHz)	Carrier Freq WiFi (MHz)	Carrier Freq LTE (MHz)	Measured Emissions (dBµV/m)		Limit (dBµV/m)		Margin (dB)	
			Peak	Average	Peak	Average	Peak	Average
Any	2437	780	/	/	74	54	/	/
Any	2437	782	/	/	74	54	/	/

WCDMA1900 (Band 02)



30-1000MHz, WiFi ch116 11n MCS0 + WCDMA ch9400 VP

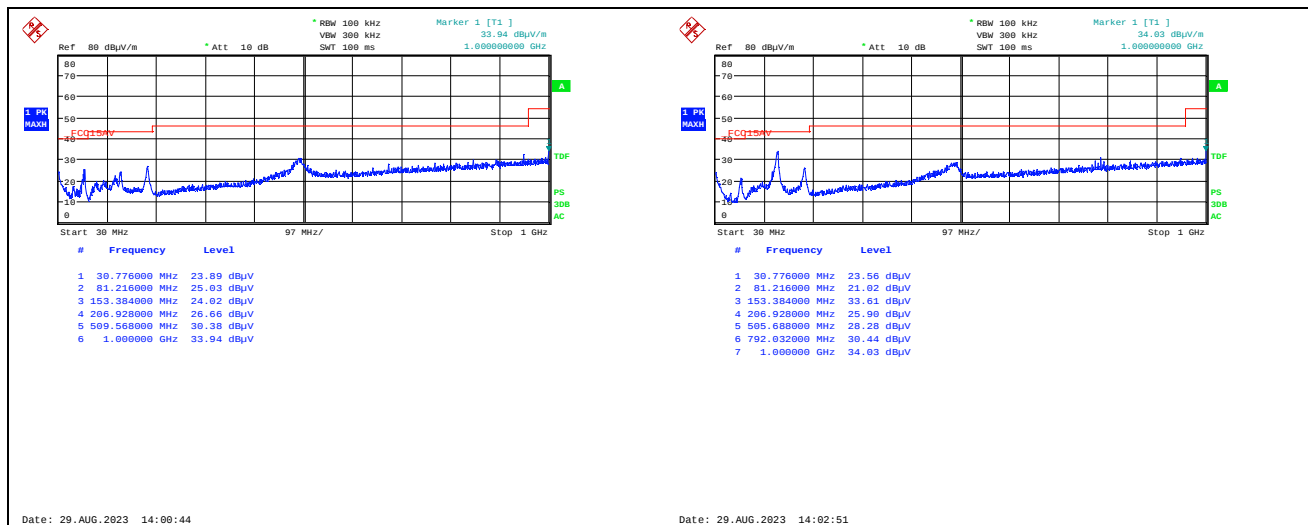
HP



1000-4500MHz, WiFi ch06 11g 54M + WCDMA ch9400 VP

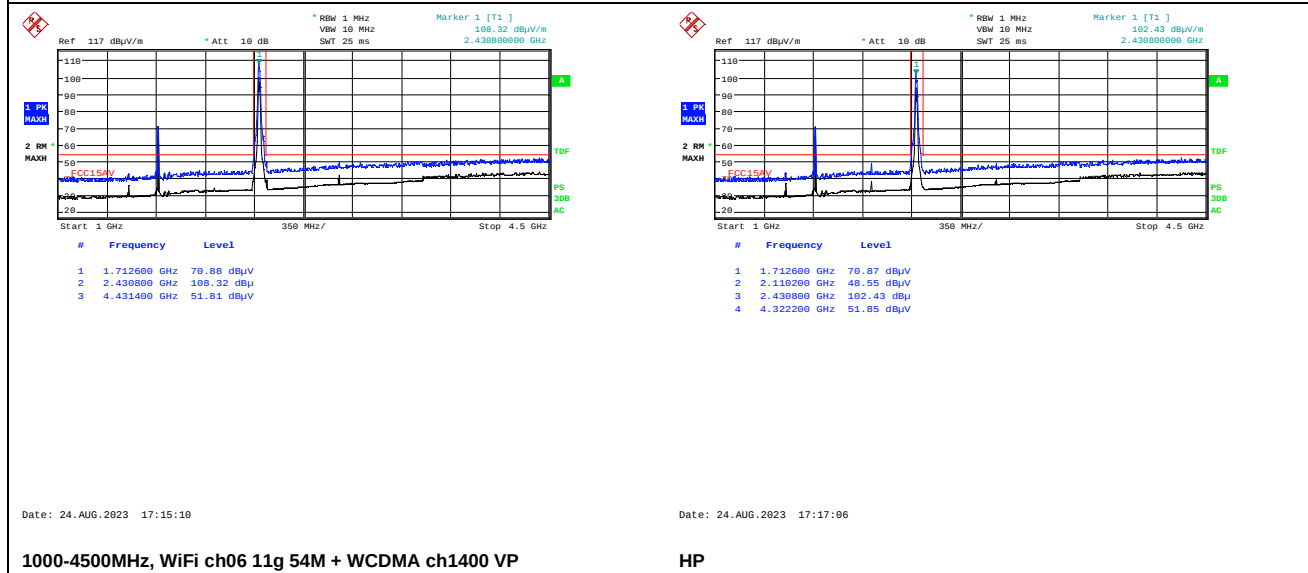
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WCDMA2100 (Band 04)



30-1000MHz, WiFi ch116 11n MCS0 + WCDMA ch1312 VP

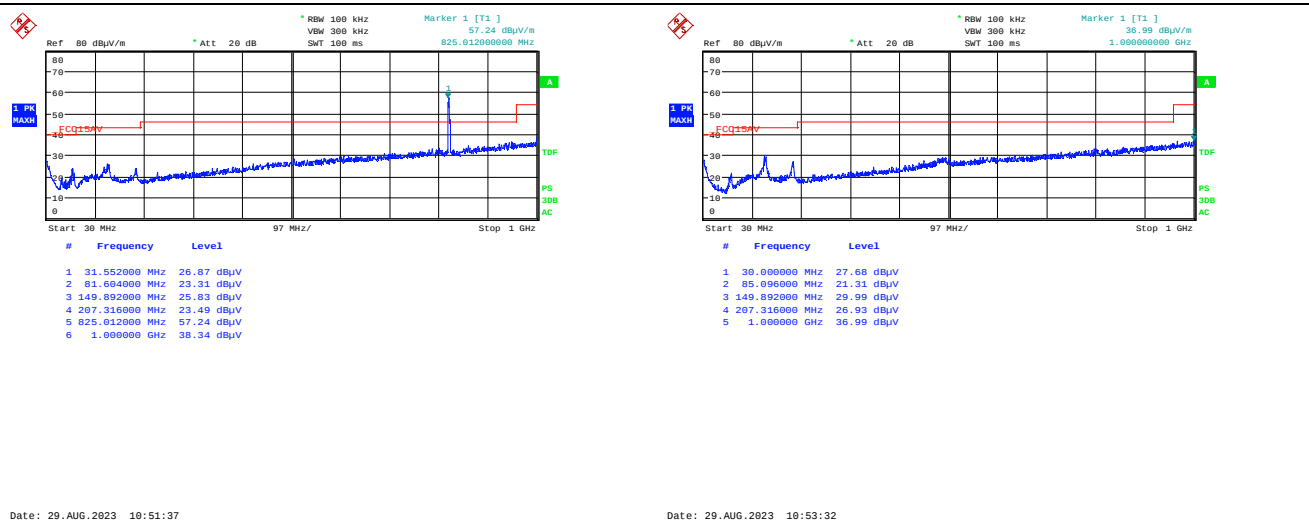
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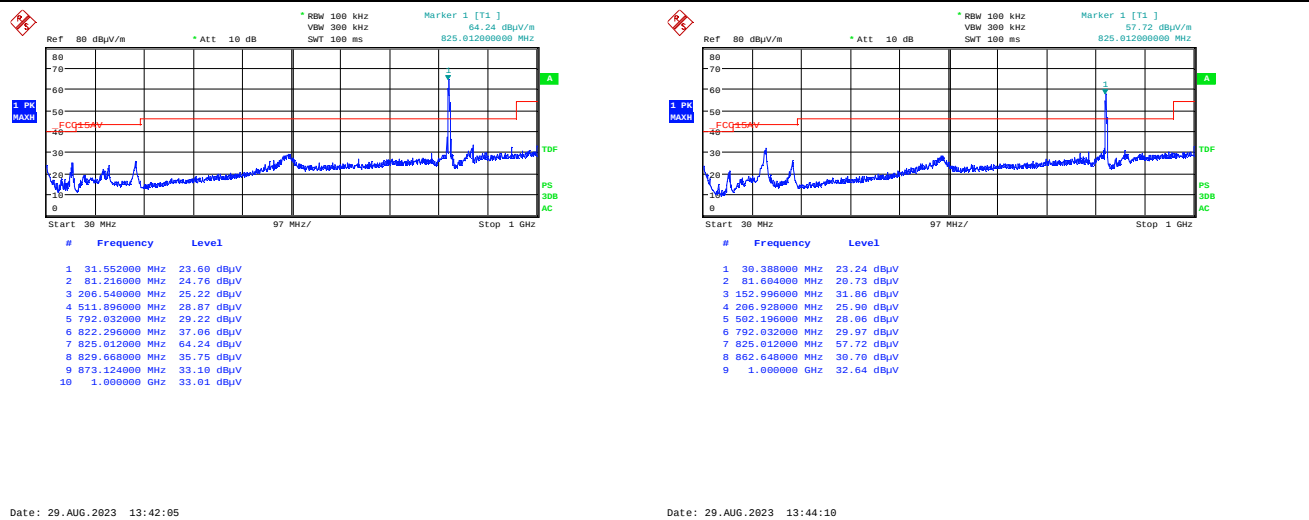
1000-4500MHz, WiFi ch06 11g 54M + WCDMA ch1400 VP

HP

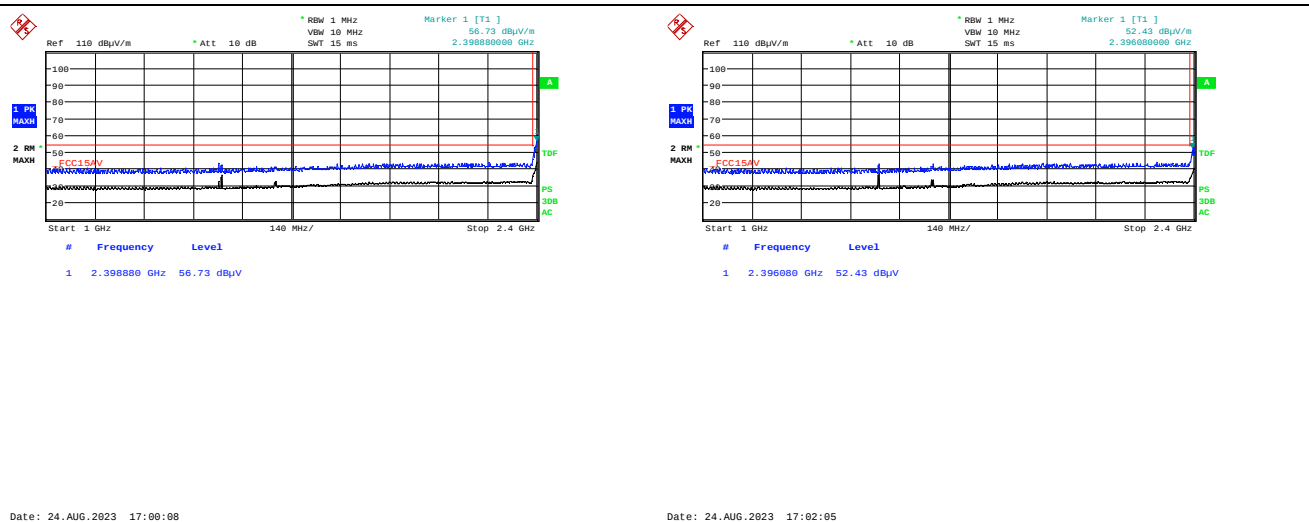
WCDMA850 (Band 05)



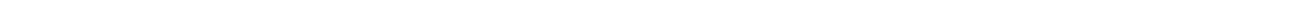
30-1000MHz, WiFi ch06 11g 54M + WCDMA ch4132 VP

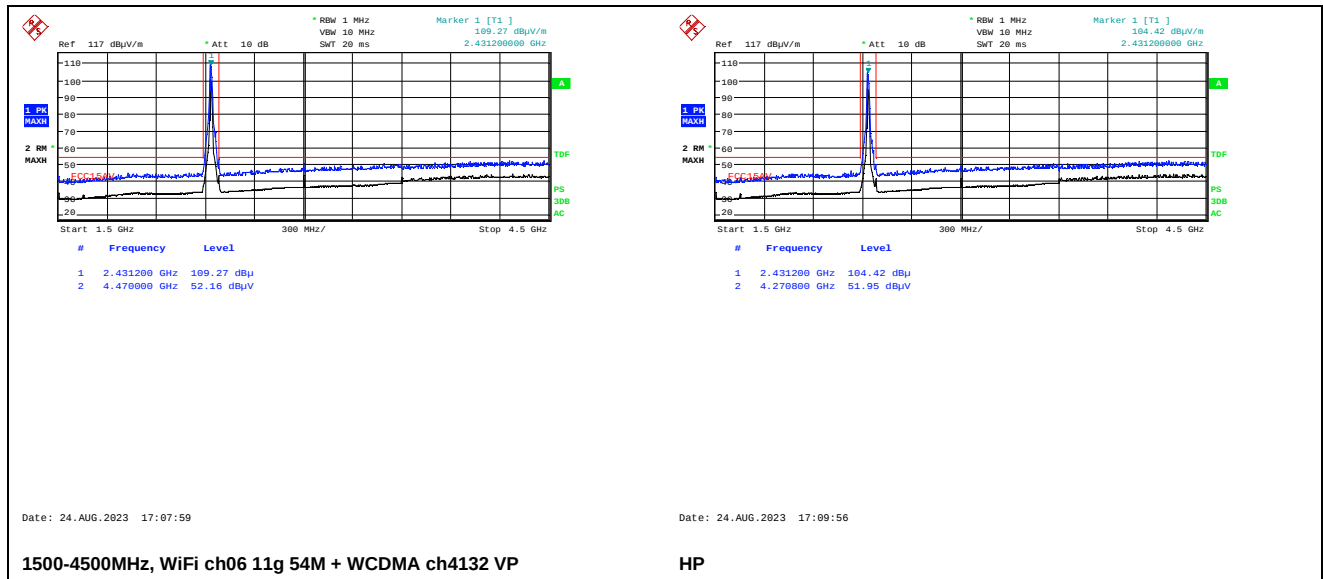


30-1000MHz, WiFi ch116 11n MCS0 + WCDMA ch4132 VP

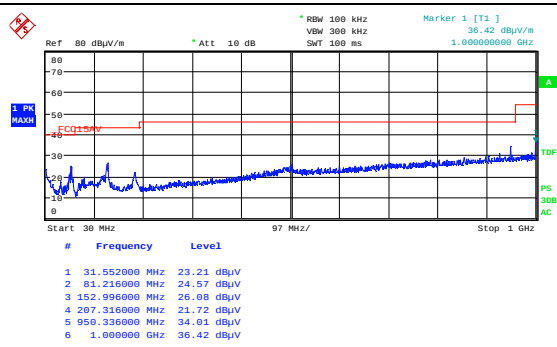


1000-2400MHz, WiFi ch06 11g 54M + WCDMA ch4132 VP

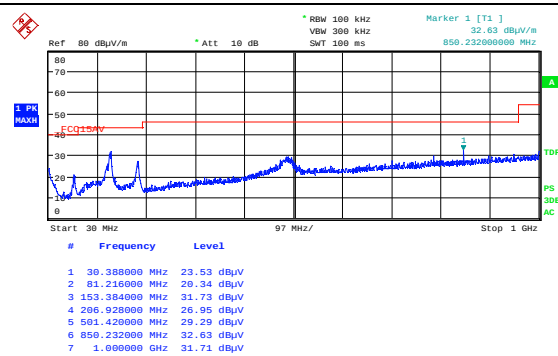




LTE Band 02

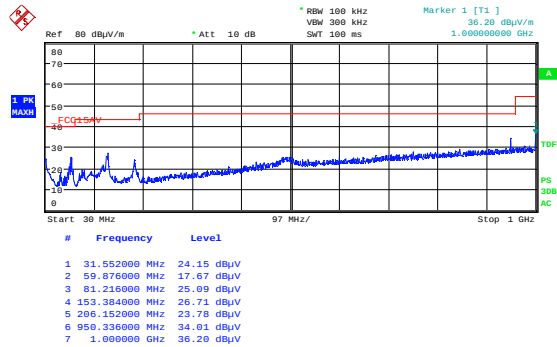


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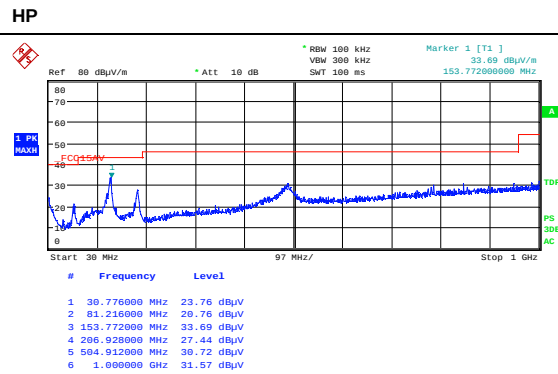


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30-1000MHz, WiFi ch06 11g 54M + LTE ch18900 VP

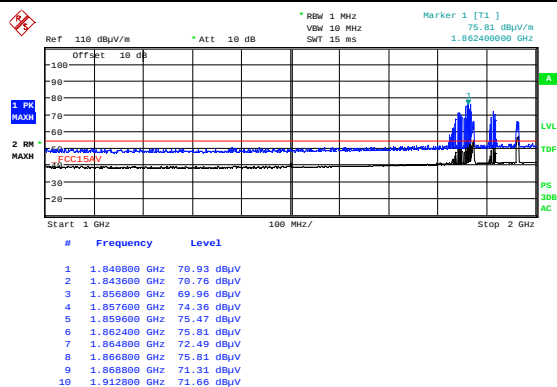


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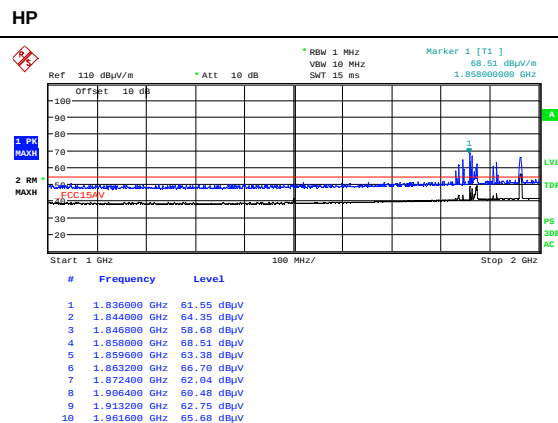


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30-1000MHz, WiFi ch116 11n MCS0 + LTE ch18900 VP



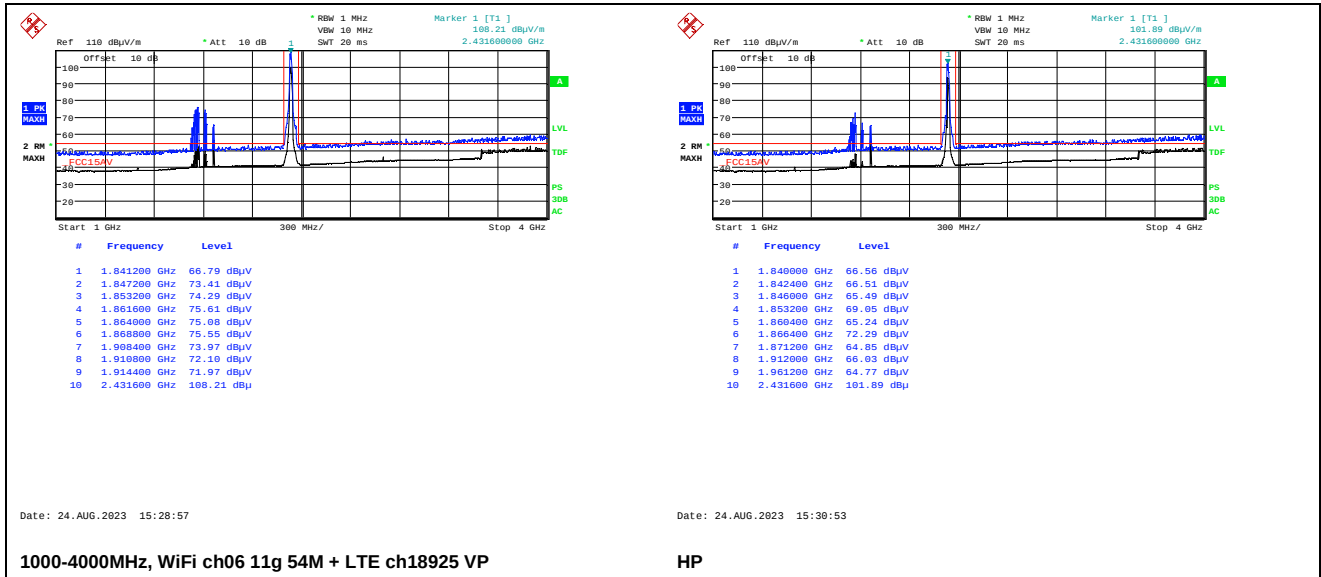
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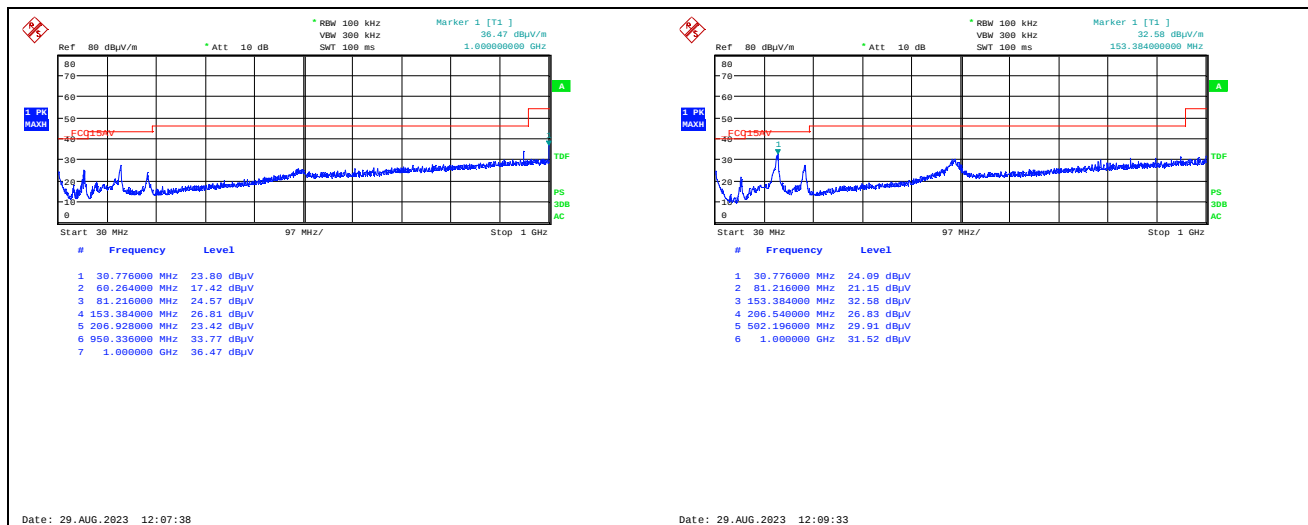
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1000-2000MHz, WiFi ch06 11g 54M + LTE ch18925 VP

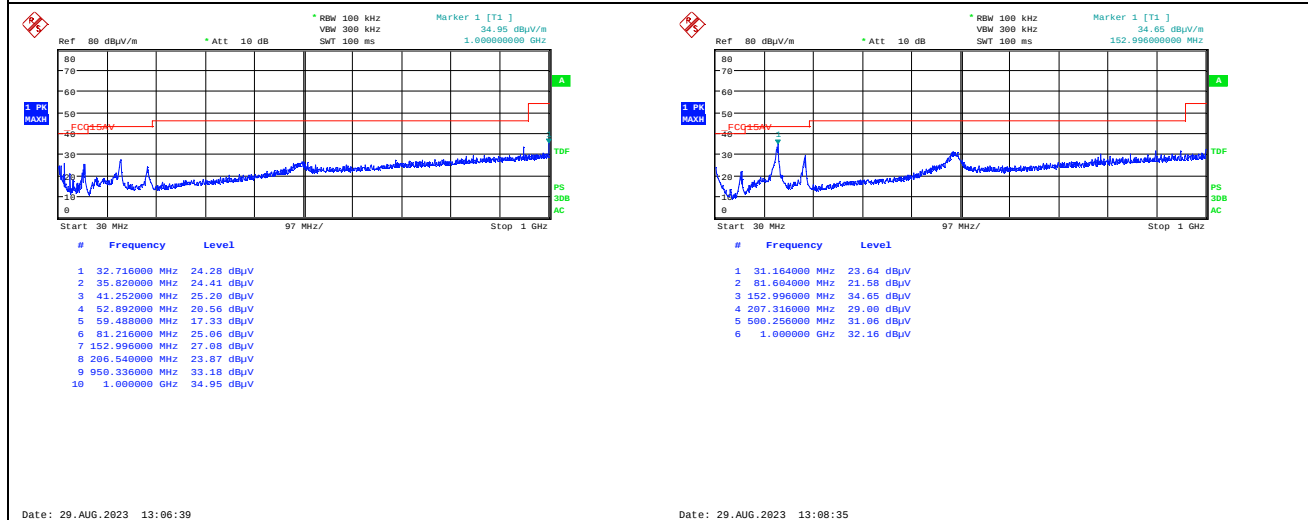
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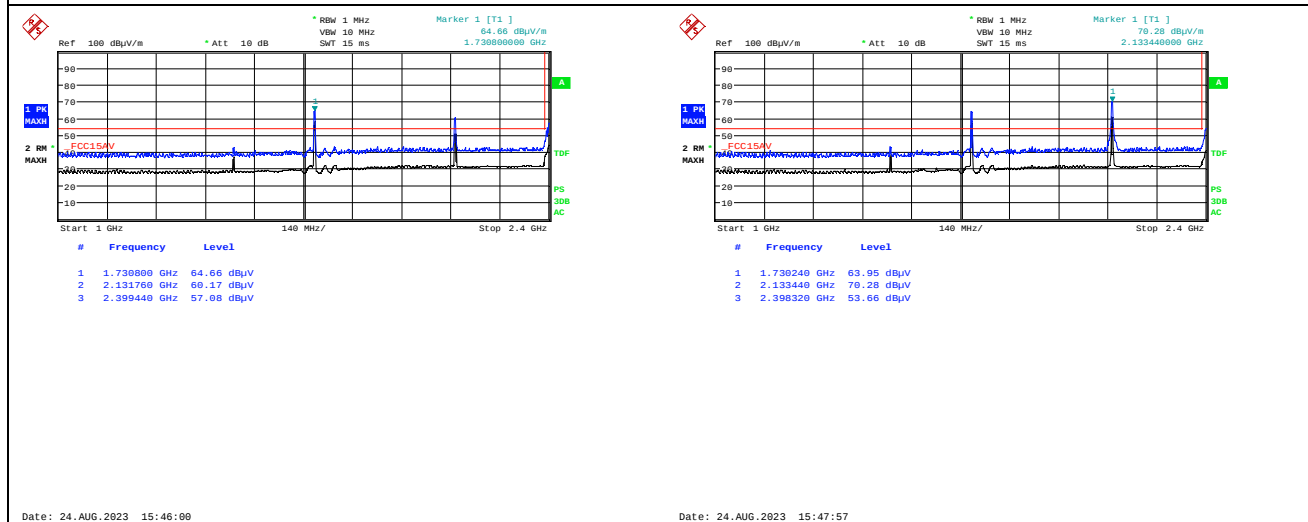
LTE Band 04



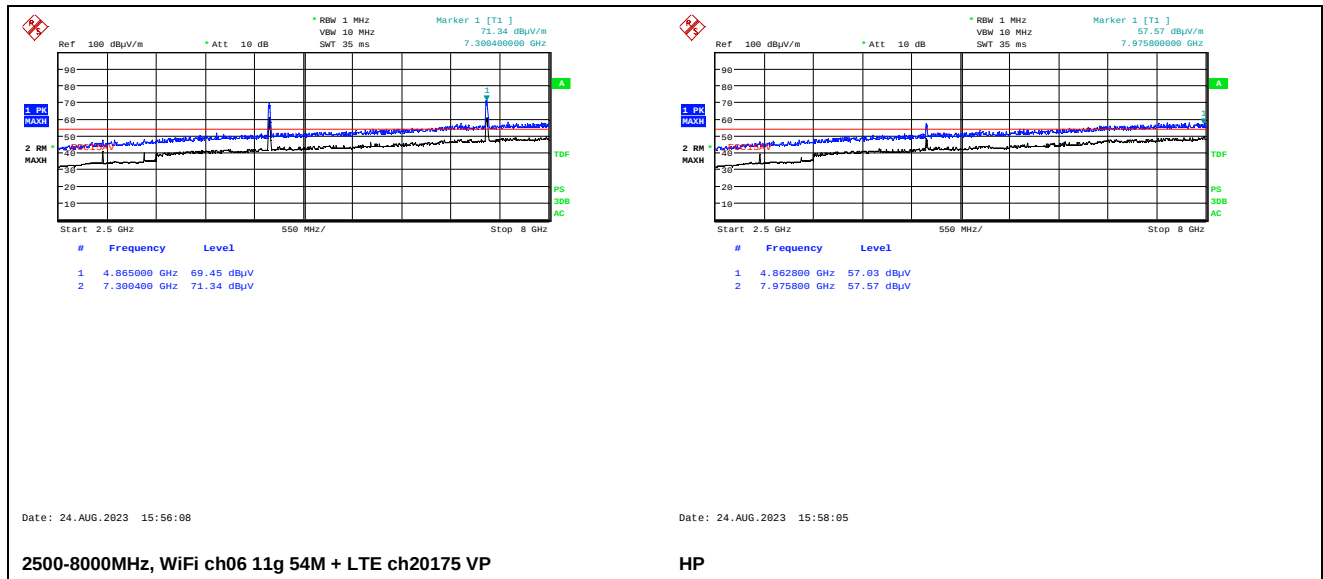
30-1000MHz, WiFi ch06 11g 54M + LTE ch20175 VP



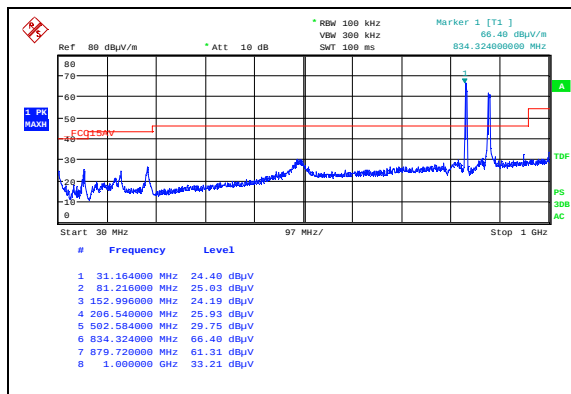
30-1000MHz, WiFi ch116 11n MCS0 + LTE ch20175 VP



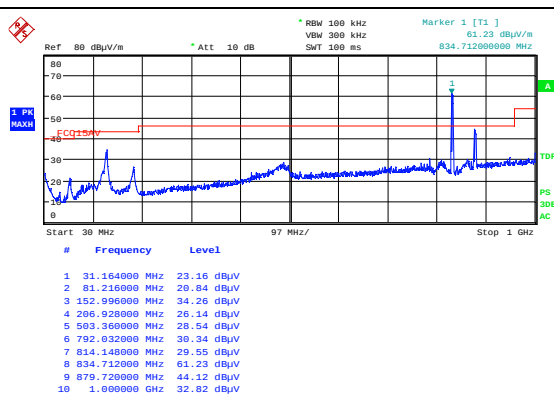
1000-2400MHz, WiFi ch06 11g 54M + LTE ch20175 VP



LTE Band 05

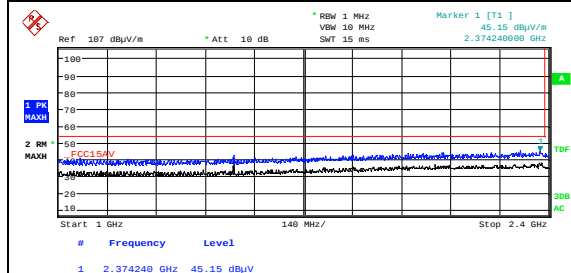


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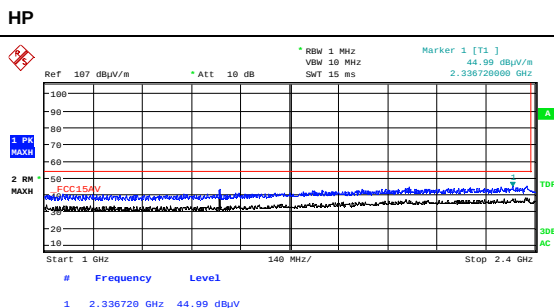


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30-1000MHz, WiFi ch116 11n MCS0 + LTE ch20525 VP

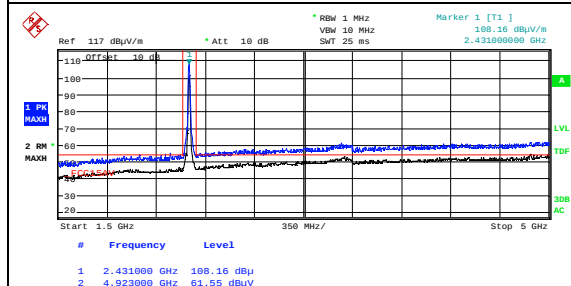


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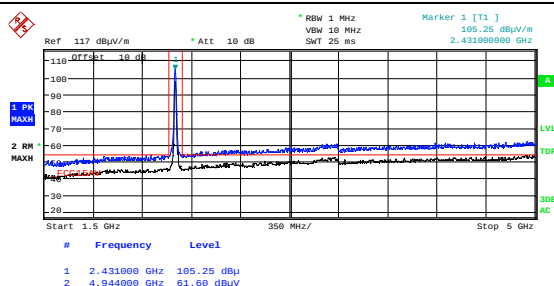


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1000-2400MHz, WiFi ch06 11g 54M + LTE ch20525 VP



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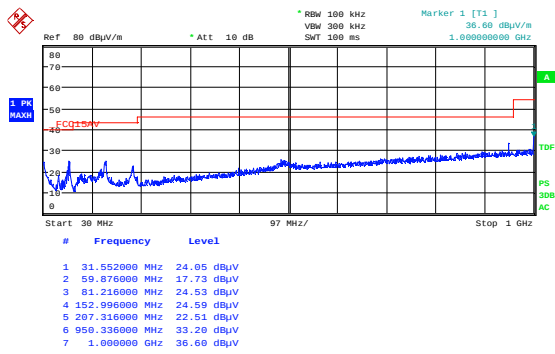


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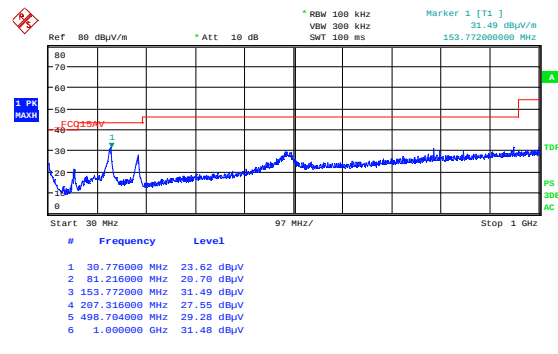
1500-5000MHz, WiFi ch06 11g 54M + LTE ch20525 VP

HP

LTE Band 07

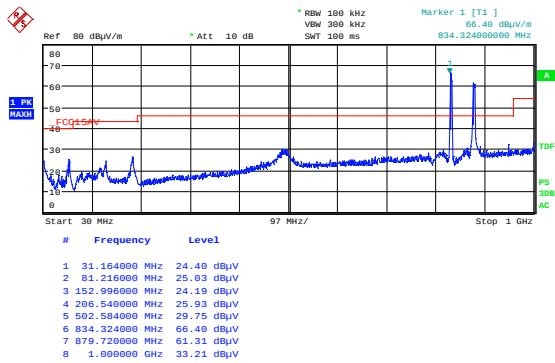


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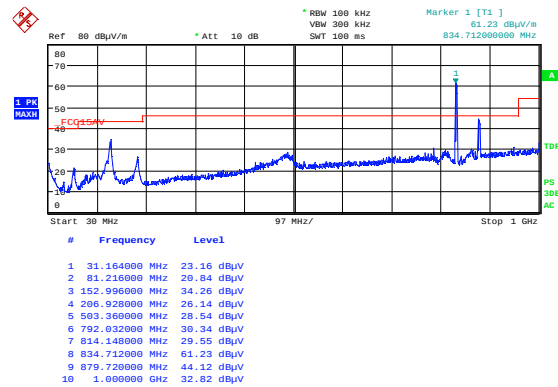
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30-1000MHz, WiFi ch06 11g 54M + LTE ch21100 VP



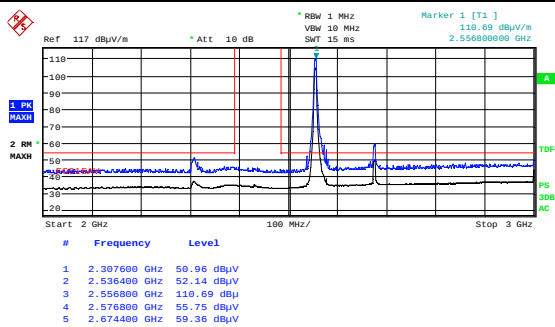
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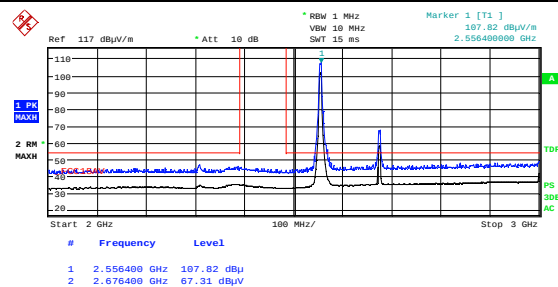
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30-1000MHz, WiFi ch116 11n MCS0 + LTE ch21100 VP



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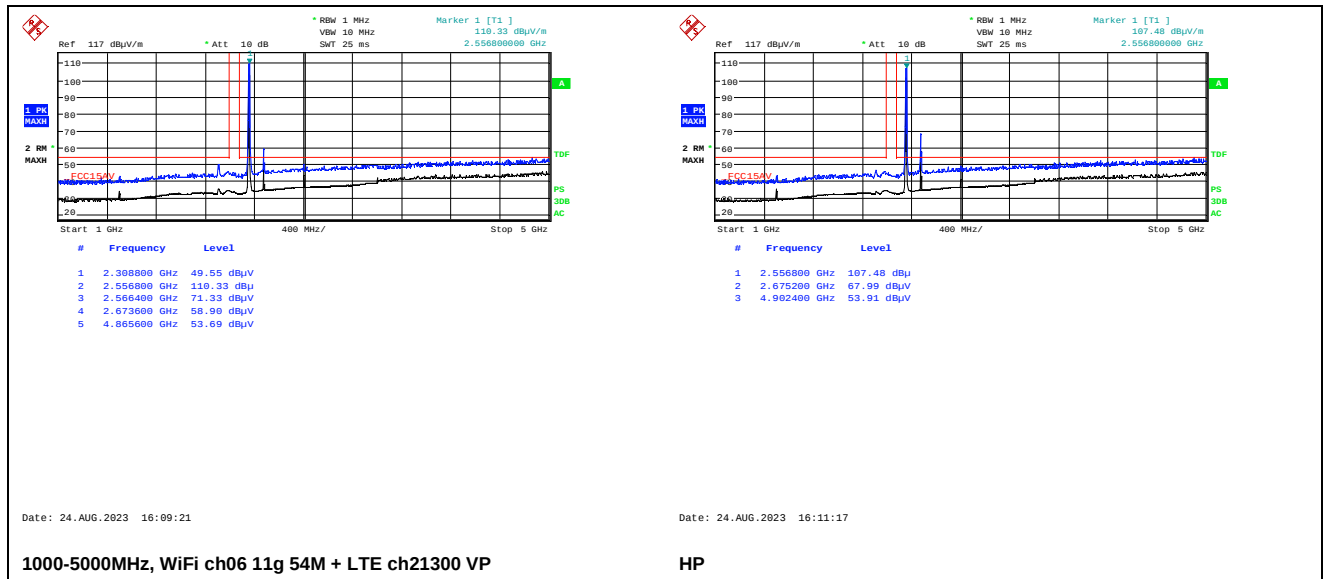
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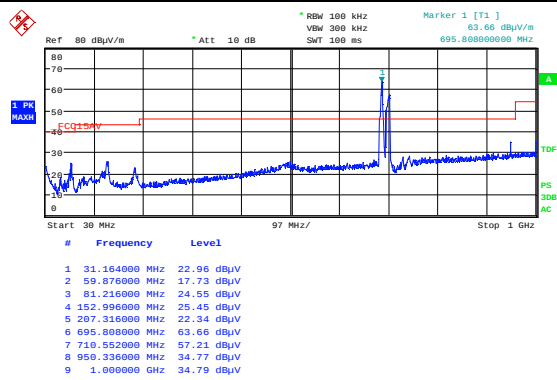
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2000-3000MHz, WiFi ch06 11g 54M + LTE ch21300 VP

HP

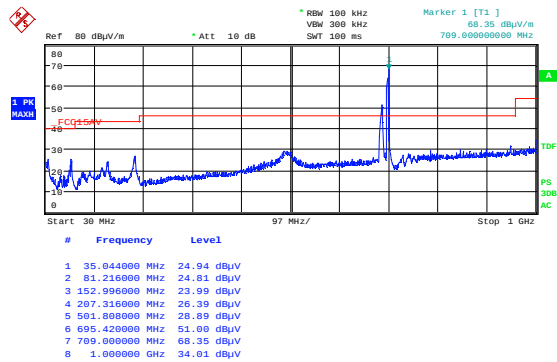


LTE Band 12



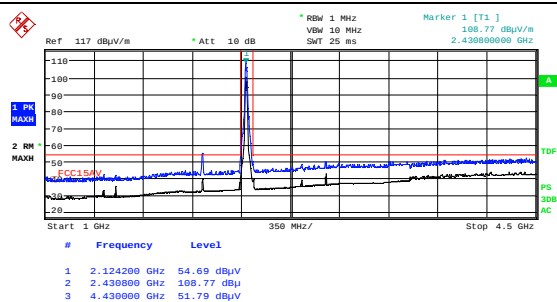
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30-1000MHz, WiFi ch06 11g 54M + LTE ch23090 VP



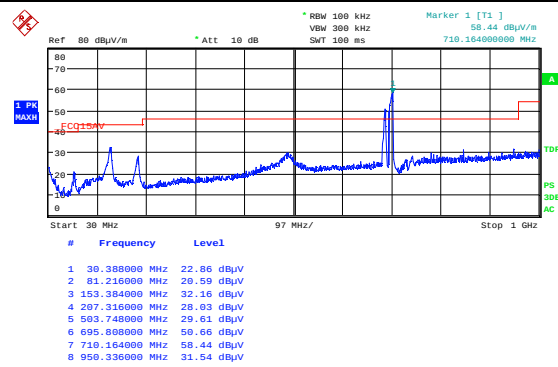
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30-1000MHz, WiFi ch116 11n MCS0 + LTE ch23090 VP



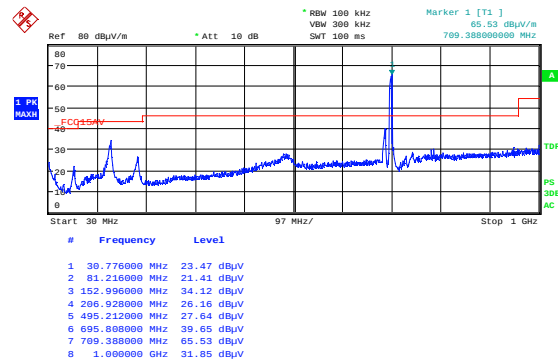
Date: 24.AUG.2023 16:39:58

1000-4500MHz, WiFi ch06 11g 54M + LTE ch23095 VP



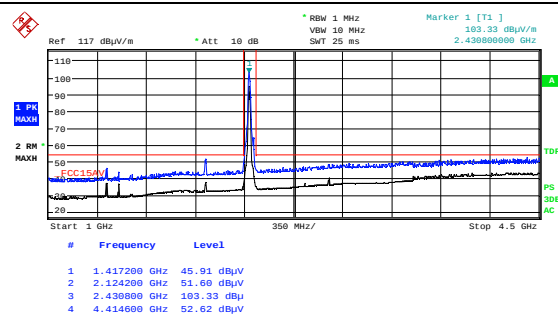
Date: 29.AUG.2023 12:36:09

HP



Date: 29.AUG.2023 13:22:20

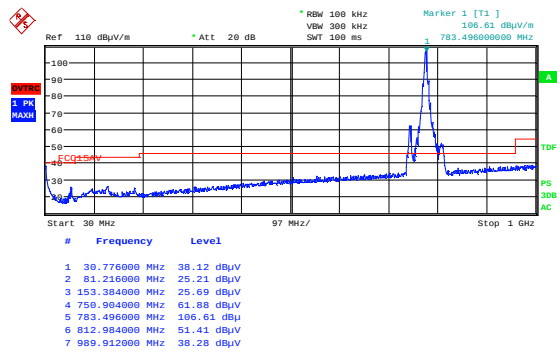
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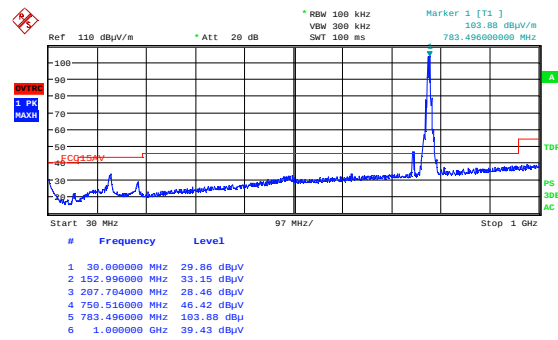
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HP

LTE Band 13

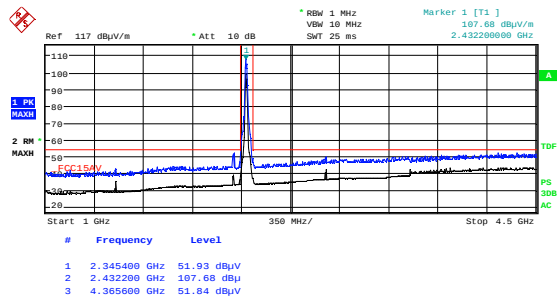


Date: 29.AUG.2023 12:49:24



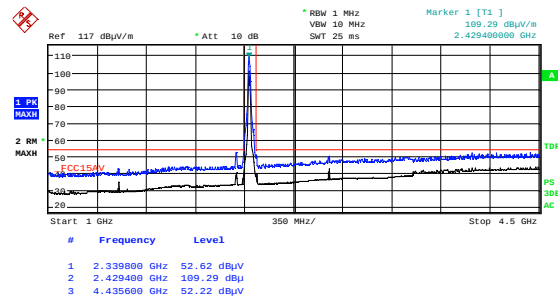
Date: 29.AUG.2023 12:51:20

30-1000MHz, WiFi ch06 11g 54M + LTE ch23230 VP



Date: 24.AUG.2023 16:31:57

HP



Date: 24.AUG.2023 16:27:58

1000-4500MHz, WiFi ch06 11g 54M + LTE ch23210 VP

HP

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	6810-17B	Attenuator	Suhner	LR 1669	2023-05	2024-05
3	N0324415	BandStop Filter (2.4GHz)	Microwave Circuits	LR 1760	COU	
4	WLK5-1100-1485-7000-40SS	Low Pass Filter (1GHz)	Wainwright Inst.	LR 1761	COU	
5	310	Preamplifier	Sonoma Inst.	LR 1686	2023-08	2024-08
6	8449A	Pre-amplifier	Hewlett Packard	LR 1322	2023-08	2024-08
7	3115	Horn Antenna	EMCO	LR 1330	2022-12	2027-12

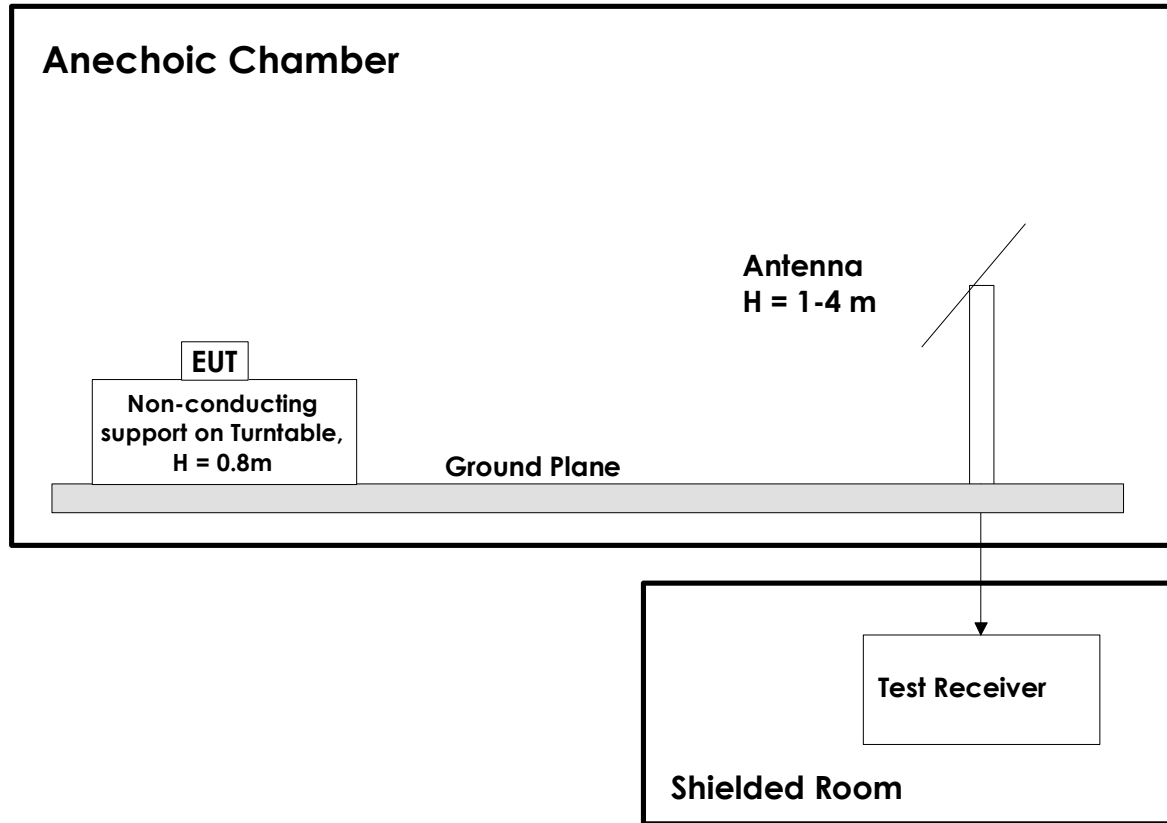
Note: COU – calibrate on use; N/A – Not Applicable

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.