Bluetooth Antenna Pattern Measurement
Test Report for
DT FPDM

Report Reference: MDE_HARMAN_2321_OTA_02
Date: 23.10.2023

Test Laboratory:
7layers GmbH
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40880 Ratingen
Germany

Deutsche Akkreditierungsstelle
D-PL-12140-01-01
D-PL-12140-01-02
D-PL-12140-01-03

Content:

1 Project and Result Summary

DUT	DT FPDM	DUT Code	Conducted Sample: DE1009073bb01 Radiated Sample: DE1009073ba01
Test lab	7layers GmbH Borsigstr. 11 40880 Ratingen Germany	Set up	free space
		Test start	11.10.2023
Customer	Harman Internationa 30001 Cabor Drive NOVI, MI 48377 United States	Report date	23.10.2023
		Report by	Dieter Sütthoff

Bluetooth, DH1			
RMS Detector	**2402 MHz**	**2441 MHz**	**2480 MHz**
Antenna Port Input Power	**6.9**	**8.4**	**8.8**
Tot. Rad. Pwr. (dBm)	-9.0	-6.6	-4.3
Peak EIRP (dBm)	**-3.9**	**-0.9**	**1.1**
Directivity (dBi)	5.0	5.7	5.4
Efficiency (dB)	-15.9	-15.0	-13.1
Efficiency (%)	2.6	3.1	4.9
Gain (dBi)	**-10.8**	**-9.3**	**-7.7**

Tab. 1: Test result summary

Fig. 1: Photo of DUT.

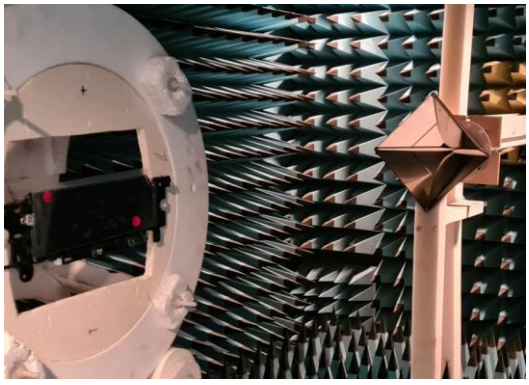

Fig. 2: Photo of DUT test set up.

Test Lab Declaration

All test results stated relate only to the device tested.

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- **in the resulting document it's status (being an excerpt) is clearly stated and**
- **in minimum chapter 1 is completely included.**
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2 Revision History

Report version control			
Version	**Release date**	**Change Description**	**Version validity**
MDE_HARMAN_2321_OTA_02	11.10.2023	initial	valid

1 Signatures

Responsible for Accreditation Scope: Robert Machulec

Responsible for Test Report: Dieter Sülthoff

2 Brief Description of Settings and Test Method

2.1 Test Procedure TRP

The method of measurement for radiated RF power and receiver performance are based on the principals of the test standard CTIA: "Test Plan for Wireless Device Over the Air Performance" **[1]**.

In general, the following approach is applied for TRP measurements:

- For TRP measurement put OUT in DH1 (local Tx) mode where it is transmitting periodical RF energy.
- Rotate the OUT.
- Gather power data for both, vertical and horizontal polarization.
- Calculate total radiated power by integrating over the whole sphere as outlined in **[1]**.

The test setup was placed at the turning device inside a fully anechoic chamber. The OUT is Set to transmit with maximum output power.

Therefore, Following Teraterm Commans was send to the EUT:

```
root@fpdm-c112:~# systemctl stop wicome
Warning: wicome.service changed on disk. Run 'systemctl daemon-reload' to reload units.
root@fpdm-c112:~#
root@fpdm-c112:~# BTPORT="/dev/ttyS1"
root@fpdm-c112:~# ## send reset command
root@fpdm-c112:~# printf "\x01\x03\x0C\x00" >> $BTPORT
root@fpdm-c112:~# ## read BT ID
root@fpdm-c112:~# printf "\x01\x09\x10\x00" >> $BTPORT
root@fpdm-c112:~#
root@fpdm-c112:~# #### slave mode, DUT mode:
root@fpdm-c112:~# printf "\x01\x05\x0C\x03\x02\x00\x02" >> $BTPORT
root@fpdm-c112:~# printf "\x01\x1A\x0C\x01\x03" >> $BTPORT
root@fpdm-c112:~# printf "\x01\x03\x18\x00" >> $BTPORT
```

DH1 for Basic Data Rate:

printf "\x01\x00\xFC\x13\xC2\x02\x00\x09\x00\x20\x00\x04\x50\x00\x00\x17\x00\x04\x00\x1B\x00\x00\x00" >> $BTPORT

Channel Freq: 2402MHz

printf "\x01\x00\xFC\x13\xC2\x02\x00\x09\x00\x09\x00\x04\x50\x00\x00\x04\x00\x62\x09\x32\xFF\x00\x00" >> $BTPORT

Channel Freq: 2441MHz

printf "\x01\x00\xFC\x13\xC2\x02\x00\x09\x00\x24\x00\x04\x50\x00\x00\x04\x00\x89\x09\x32\xFF\x00\x00" >> $BTPORT

Channel Freq: 2480MHz

printf "\x01\x00\xFC\x13\xC2\x02\x00\x09\x00\x09\x00\x04\x50\x00\x00\x04\x00\xB0\x09\x32\xFF\x00\x00" >> $BTPORT

The total radiated power (TRP) of the test setup was measured with Spectrum analyzer in all angle direction (3D) using a step width of <= 15° and using two measurement antenna polarizations (vertical and horizontal).

The spectrum analyzer was set to RBW=VBW=10MHz, RMS detector for measurement.

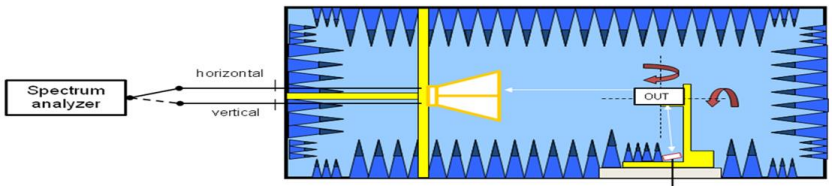


Fig. 1: Block diagram for TRP measurement

2.2 Definitions:

3GPP	3rd Generation Partnership Project
BER	Bit error rate or bit error ratio
CTIA	Cellular Telecommunications & Internet Association
DUT	Device under test
FS	Free space
TP	Talk position (phone is situated at SAM = human head phantom)
TRP	Total Radiated Power
EIRP	Effective Isotropic Radiated Power
TRS	Total Radiated Sensitivity (same as TIS in CTIA), loss of link level
EIRS	Effective Isotropic Radiated Sensitivity

3 References and Standards Used

[1] CTIA: "CTIA-01.20-Test-Methodology-SISO-Anechoic-Chamber", Revision 4.0.0, 02/2022

[2] 7 layers document: "OTA Measurement Uncertainties", Version 06/2023.

3.1 Equipment List

For TRP measurements:

Antenna:	Dual polarized horn ETS3164-03 by ETS	SN 00052619
Receiver1:	FSP3 spectrum analyzer by R&S last cal: 02.2023 next cal: 02/2025	SN 838164/004
Receiver2:	FSP3 spectrum analyzer by R&S last cal: 05.2021 next cal: 05/2025	SN 836722/011

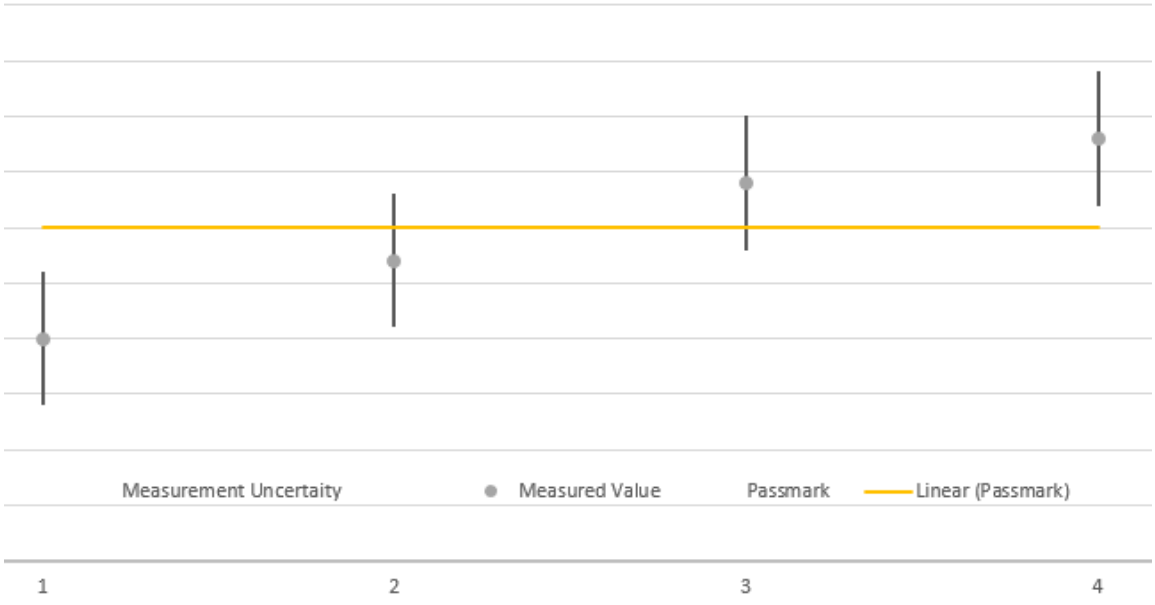
4 Measurement Uncertainty

The uncertainty analysis provided has been carried out according to CTIA [1]. Details can be found in a separate document. In summary the expanded uncertainties at 95% do meet the appropriate CTIA requirements [1].

	MU 7L DE
TRP	1.7

Standard specific table with the measurement uncertainties of the used parameters

The measurement uncertainties for all parameters are calculated with an expansion factor (coverage factor) k = 1.96. This means, that the true value is in the corresponding interval with a probability of 95 %.



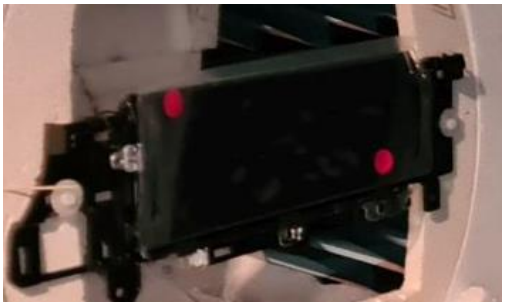
The verdicts in this test report are given according the above diagram:

Case	Measured Value	Uncertainty Range	Verdict
1	below pass mark	below pass mark	Passed
2	below pass mark	within pass mark	Passed
3	above pass mark	within pass mark	Failed
4	above pass mark	above pass mark	Failed

That means, the laboratory applies, as decision rule (see ISO/IEC 17025:2017), the so-called shared risk principle.

5 Detailed Radiated Test Results and Pattern

For orientation of the EUT in the result pictures below the following photos illustrate the used orientation



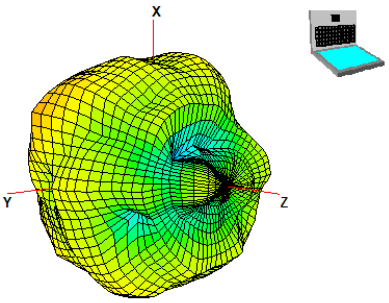
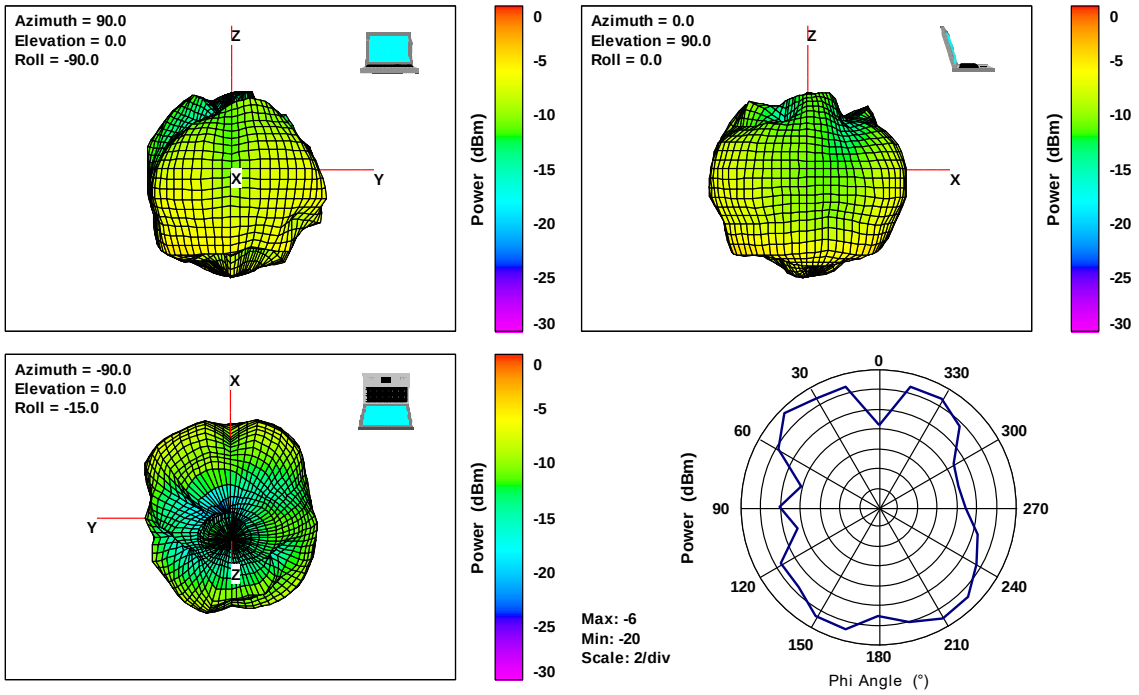


Fig. 3: Photo orientation of DUT.

5.1 Radiation Pattern, TRP (2402 MHz)

Pattern at 2402 MHz:

Ant. Port Input Pwr. (dBm)	Tot. Rad. Pwr. (dBm)	Peak EIRP (dBm)	Efficiency (dB)	Gain (dBi)
6.9	-9.0	-3.9	-15.9	-10.8

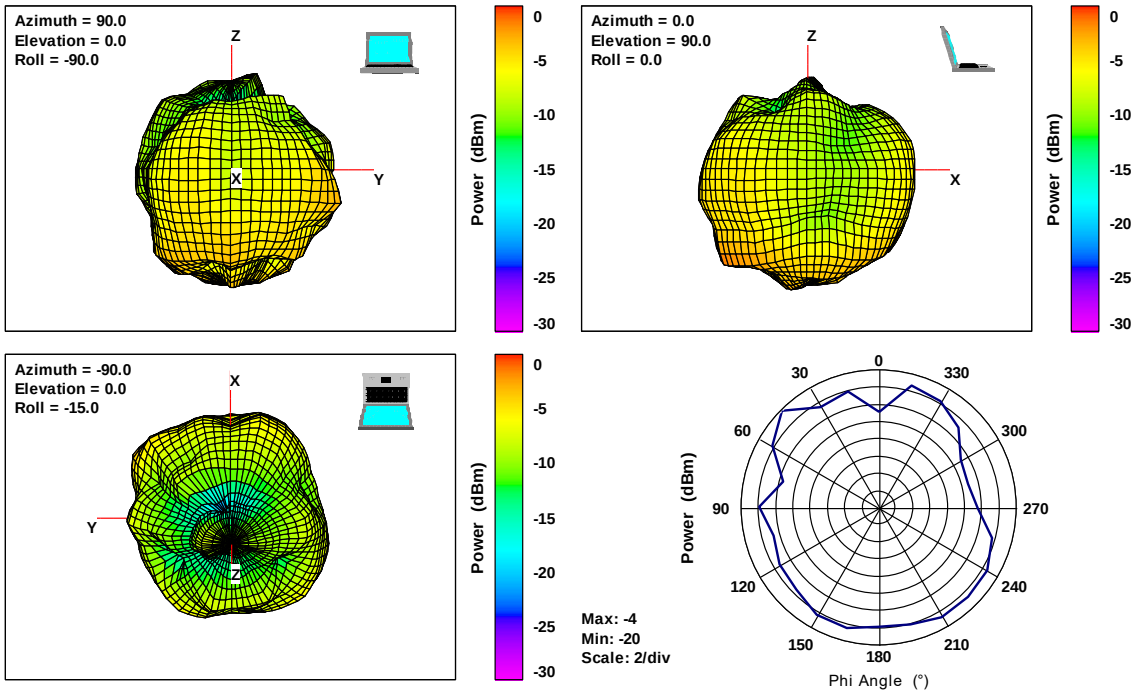


Theta = 90°

5.2 Radiation Pattern, TRP (2441 MHz)

Pattern at 2441 MHz:

Ant. Port Input Pwr. (dBm)	Tot. Rad. Pwr. (dBm)	Peak EIRP (dBm)	Efficiency (dB)	Gain (dBi)
8.4	-6.6	-0.9	-15.0	-9.3

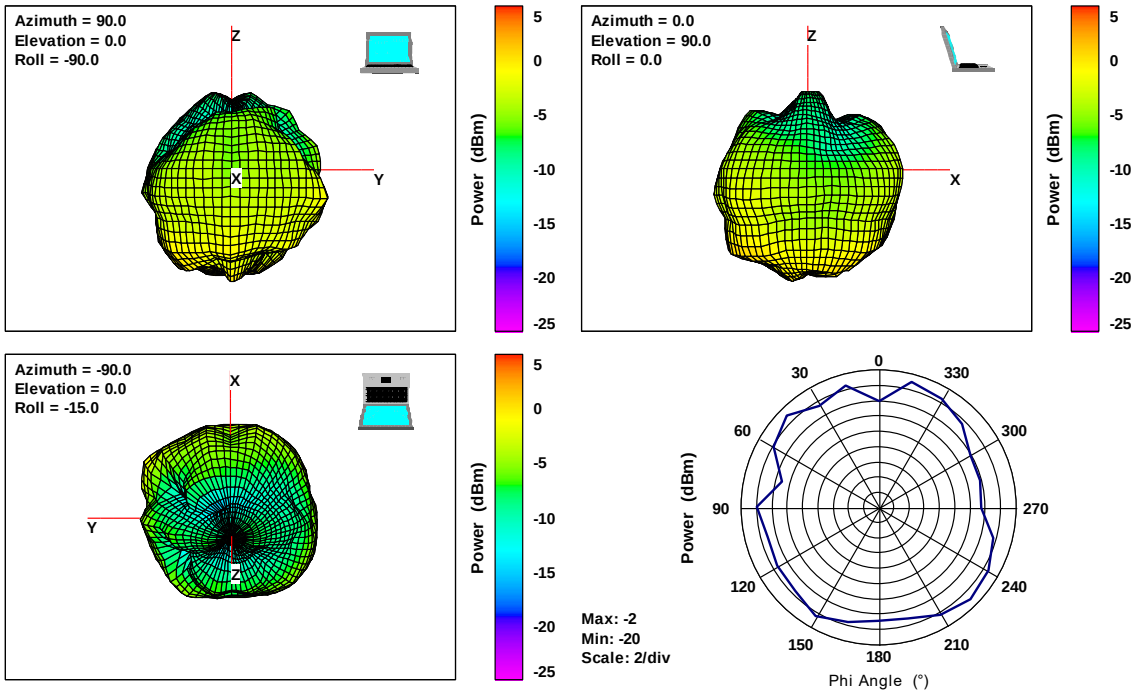


Theta = 90°

5.3 Radiation Pattern, TRP (2480 MHz)

Pattern at 2480 MHz:

Ant. Port Input Pwr. (dBm)	Tot. Rad. Pwr. (dBm)	Peak EIRP (dBm)	Efficiency (dB)	Gain (dBi)
8.8	-4.3	1.1	-13.1	-7.7



Theta = 90°