Pacific P4.00 BLE RF Performance Measurements

Project: Pacific

Number: eLB1806-015

Revision: 1.0

Revision history

Rev	Author	Change Details	Approver's role
1.0	Jake Makaling	Initial release	David Boehm

1 Aim

The aim of this analysis is to ascertain RF performance characteristics of the BLE circuit on Pacific P4.00. The results in this eLB can help to identify the best-case orientation and worst-case orientation.

This report covers the above work applicable to the ResMed Pacific product/project.

2 References

[Ref 1] eLB1385-220 Pacific P4.00 ublox MainFG PCBA Build Standard (Obj Id: A5247047)

[Ref 2] eLB1792-013 Pacific P3.10 BLE RF Performance Measurements (Obj Id: A5245242)

[Ref 3] eLB1397-005 Using Pacific Cellular & BLE Blast Mode (Obj Id: A4624838)

[Ref 4] BLE_TRP_0dBm (Obj Id: A5268869)

3 Definitions

Table 1: Definitions

Item	Definition
BLE	Bluetooth Low Energy
DUT	Device Under Test
EIRP	Effective Isotropic Radiated Power
FG	Flow Generator
OTA	Over-the-air
RF	Radio Frequency
SoC	System on Chip
TRP	Total Radiated Power
TX	Transmit

Refer to QMDEF for definitions not provided.

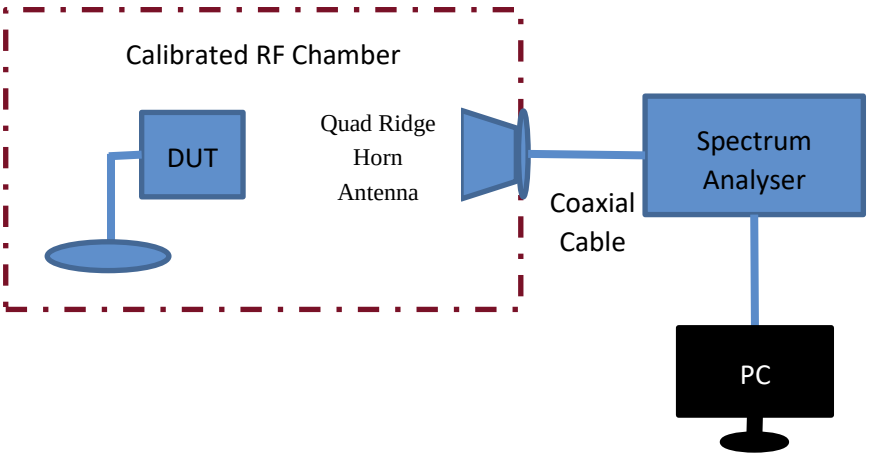
4 Background

The RF performance measurements have been completed on Pacific P3.10 (see [Ref 1]) but must be completed again as the BLE TX Power was changed to 0 dBm (previously was 3 dBm).

5 Method

5.1 Hardware Setup

The following hardware setup will be used for OTA measurements.



Item	Details	Traceability
DUT	P4.00 WW-M1 TT	(90)R390-7667(91)1S0.7(21)2228Q00118

5.2 Software Setup

The following software will be used for this test.

Table 2: FG Software

Item	Version
Software	FG22.3 Blast Mode "ConfigurationIdentifier": "CF04600.08.98.00.fa37285b5", "ApplicationIdentifier": "SW04600.08.6.1.0.fa37285b5", "BootloaderIdentifier": "SW04601.00.1.1.0.736edbdfd", "DataModelVersionIdentifier": "2.3.0.707528f6c"

Table 3: BLE Software

Item	Version
BLE Application	Bluetooth_Application_ST318.2.13.10.423.5_c47c8e1787f.s37

5.3 Procedure

1. Load the software in section 5.2 to the FG and BLE chip.
2. Set the BLE blast mode with following parameters (see [Ref 3] for how to set up BLE blast parameters):
   - BluetoothBlastTxPowerLevel = 0 (New power set for BG22)
   - BluetoothBlastChannels = 0-0/19-19/39-39 (Channels 0/19/39 – one channel per test)

- BluetoothBlastDwellTime = 10000000 (10000 seconds)
- BluetoothBlastPacketType = TestPktPrbs9 (pseudo-random data)
- BluetoothBlastPacketLength = 255 (255 bytes)
- BluetoothBlast PhysicalLayer = TestPhy1m (1Mb/s)

3. Measure the radiated power using the RF chamber at various polar positions with a 15-degree interval, over both rotational axes with antenna input power set to 0 dBm.
4. Obtain a 3D polar plot illustrating the device's radiated system performance in all directions.
5. Obtain the **total radiated power (TRP) figure, maximum and minimum Effective Isotropic Radiated Power (EIRP) and direction**, and derive the **antenna efficiency**, **directivity, and gain** for each channel**.**

5.4 Pass/fail criteria

N/A. Results for reference only.

5.5 Sample Size

Sample size = 1 (type test).

5.6 Build Standard

Table 4 - Traceability

Item	Details	Traceability
FG/PCBA	P4.00 WW-M1 TT [Ref 1]	FG SN: 22222172425 PCBA SN: (90)R390-7667(91)1S0.7(21)2228Q00118

5.7 Equipment

Table 5 - Equipment

Equipment	Equipment ID	Calibration due
Rhode & Schwarz CMW 500 Wideband Radio Communication Tester	031530	24-Nov-2023
Keysight N9010B Signal Analyzer	023495	04-Nov-2023

6 Results

6.1 Result data

Table 6 – Test Date

Test Date	Testing Completed By
08-Nov-2022	Jake Makaling

The assembled unit was placed into the RF Chamber as shown in Figure 1**.** See Figure 2 for axis reference (z-axis of all measurement points from below to above the P4.00 Pacific unit, y-axis points from the right to the left of the unit, and x-axis points from the front to the back of the unit).

Figure 1. Placement of DUT

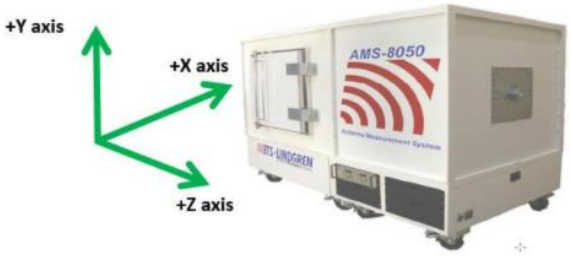


Figure 2. Orientation Reference

Below is the radiation pattern of the Bluetooth Antenna inside the DUT.

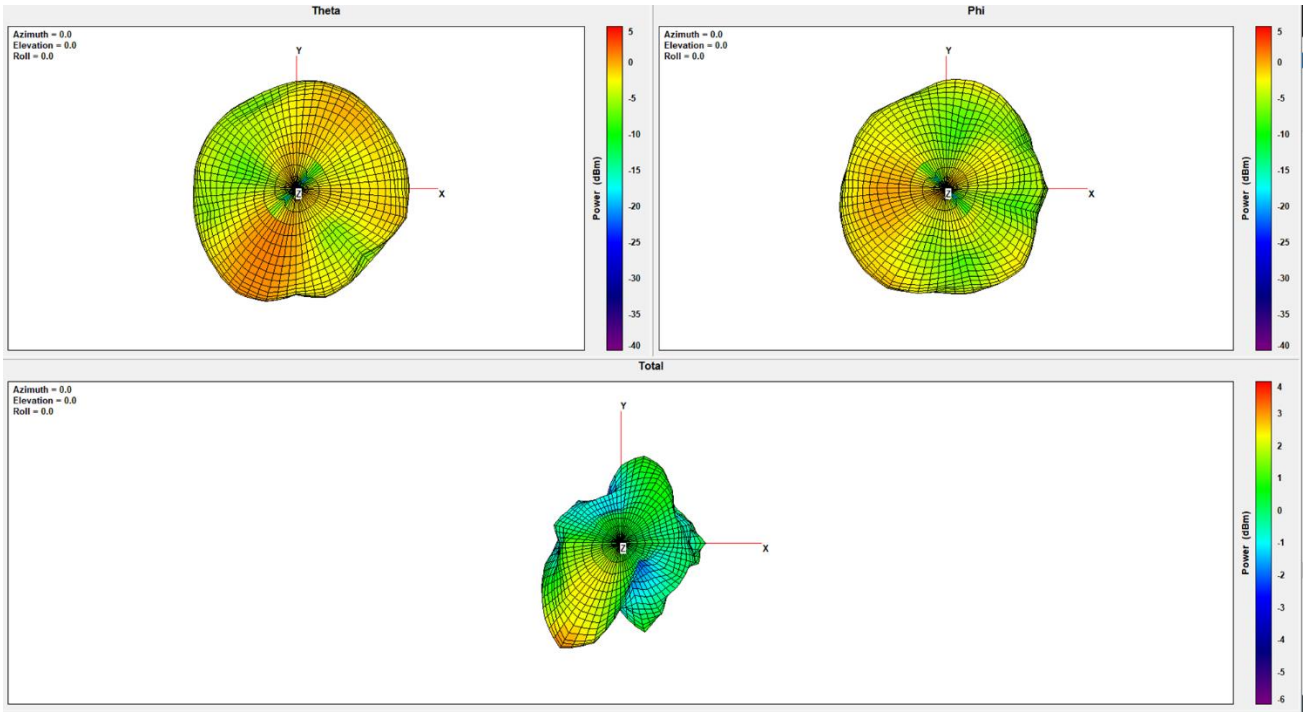


Figure 3 Radiation Pattern

The maximum radiation is located towards the front, right-hand side of the device, where the tub is located (see Figure 4).

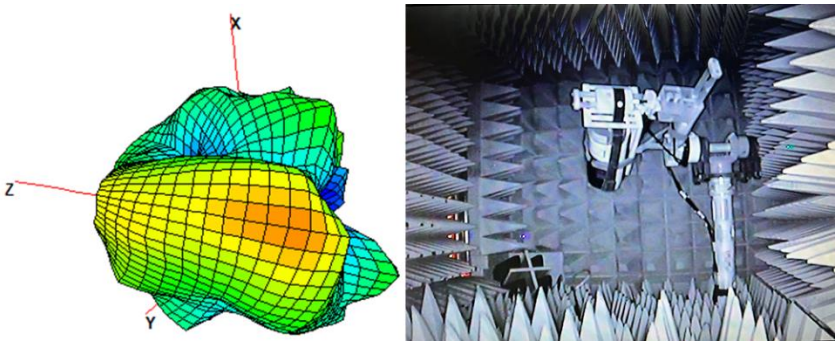


Figure 4 Maximum Radiation

The minimum radiation is located underneath the tub, in between the heater plate and motor (see Figure 5).

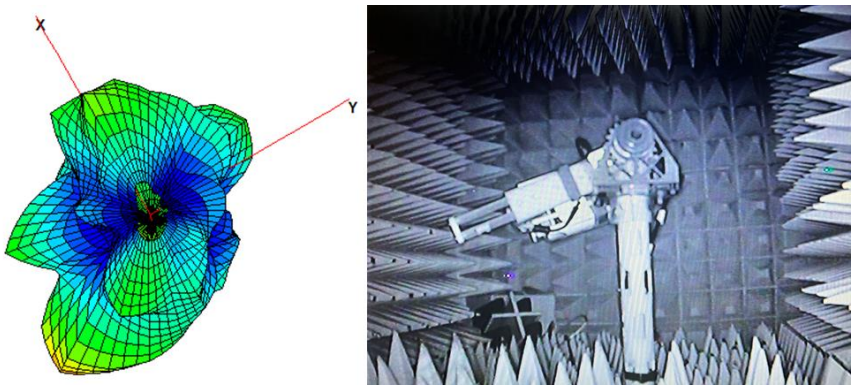


Figure 5 Minimum Radiation

The TRP measurement parameters for the DUT are summarized in the table below. Raw data can be found in [Ref 4].

Table 7 – Results Summary

Channel	*0*	*19*	*39*
Total Radiated Power	-0.58 dBm	-1.02 dBm	-0.62 dBm
Peak EIRP	1.76 dBm	2.55 dBm	3.31 dBm
Peak EIRP Location	$(\theta, \phi) = (60^{\circ}, 240^{\circ})$	$(\theta, \phi) = (75^{\circ}, 240^{\circ})$	$(\theta, \phi) = (75^{\circ}, 240^{\circ})$
Minimum EIRP	-5.24 dBm	-5.54 dBm	-5.90 dBm
Minimum EIRP Location	$(\theta, \phi) = (165^{\circ}, 285^{\circ})$	$(\theta, \phi) = (165^{\circ}, 285^{\circ})$	$(\theta, \phi) = (165^{\circ}, 285^{\circ})$
Efficiency	70.96%	79.07 %	86.64%
Directivity	3.25 dBi	3.57 dBi	3.94 dBi
Gain	1.76 dBi	2.55 dBi	3.31 dBi

Note that the chamber measurements have an approximate tolerance of ±1.5 dBm (the chamber is not certified).

7 Discussion

Analysis from raw data in [Ref 4] shows the overall best-case and worst-case EIRP locations are around the same area across all 3 channels. The best-case orientation is at (θ, Φ) = (75°, 240°) and worst-case orientation is at (θ, Φ) = (135°, 90°), both at Channel 39. These results on P4.00 are similar in terms of location and orientation to P3.10 [Ref 1] (difference being that BLE TX Power was set to 0 dBm for P4.00 and previously set to 3.2 dBm for P3.10 at the time of testing).

The difference in EIRP performance between best and worst-case is recorded to be 9.21 dBm.

8 Conclusion

The BLE RF Performance characteristics for Pacific P4.00 (BLE TX Power set to 0 dBm) have been measured and documented successfully via OTA chamber testing. The overall best-case orientation is at (θ, Φ) = (75°, 240°), and overall worst-case orientation is at (θ, Φ) = (165°, 285°).