# Low duty factor analysis report for SAR test exclusion

The Thin Point transmitter (BLE) is used as a portable device operating in 2402 – 2478 MHz band. It is equipped with an internal printed antenna. The smallest distance from antenna to outer surface of the device is 2 mm.

Maximum measured transmitter power derived from section 7.2, Table 7.2.2 of the PIXRAD_FCC.28663_BLE measurement test report:

| Pout conducted | | Maximum antenna gain, dBi | Pout EIRP | |
|---|---|---|---|---|
| dBm | mW | | dBm | mW |
| 8.9 | 7.8 | 0 | 8.9 | 7.8 |

SAR test exclusion threshold for 2.48 GHz at test separation distances is as follows:

[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] x

[√f(GHz)] ≤ 3.0

According to the manufacturer's declaration the worst case condition is: transmission of 0.5 msec every 100 msec. Within a 6 min period the total transmission time will be 1.8 sec.

The max transmitter duty cycle is 1.8 s/ 360 s = 0.005=0.5%.

The equivalent averaged conducted power and EIRP is 0.039 mW

7.8 mW x duty cycle = 7.8 mW x 0.005=0.039 mW

[0.039 mW/2.0 mm] x √2.48 = 0.02 x 1.575 = 0.032 ≤ 3.0,

where 2 mm is the smallest distance from antenna to outer surface of the device.

According to KDB 447498 D01 v05r02 the device is excluded from SAR evaluation.

# *P1100 – Thin Point System Specifications*

# 1 Table of Contents

## 2 Table of Figures



## 3 Table of Tables

# 4 Document Scope

This document describes the Pixie system specification covering on H/W specifications such as electrical, mechanical, manufacturing support and environmental as well as system aspect.

# 5 Terms and Abbreviations

The following table describes terms and abbreviations used in the document.

| | |
|---|---|
| **App or Phone App** | Refers to the application running on iPhone |
| **FW** | Refers to the application running on the Pixie Point. |
| **PN** | Pixie Network. |
| **PNC** | Pixie Network Coordinator. The tag nominated to control and sync a pixie network. |
| **PNM** | Pixie Network Member. A member tag of a pixie network. |
| **UWB** | Ultra Wide Band used for ranging (3-7GHz). |
| **ISM** | Industrial, Scientific and Medical radio bands |
| **BLE** | Bluetooth Low Energy |
| **PixePoint** | Small form factor element act as a remote location sensor that can accurately measure its distance from other Points and share that information with any BLE enabled device or with another PixiePoint.<br>Note: The usage of the name PixePoint in this document refers to both PixePoint and ThinPoint. |
| **ThinPoint** | Change in form factor, same as functionality as the **PixePoint** |

*Table 1: Terms and Abbreviations*

# 6 General System Description

## 6.1 System Description

The Pixie Platform enables consumer apps to connect physical items to the digital world and it adds the unique functionality of location Pixie Platform is a consumer aimed system solution containing Hardware - **Pixie Points**, (the Pixie Point tags will be attached as miniature stickers to the objects) Firmware and Software running on mobile phones, which digitizes the physical location of items tagged by a Pixie Point and creates an accurate map of those tagged items in an indoor environment. The range of the system is up to 15m indoors.


*Figure 1: Pixie Platform Layers*

The consumers will use Pixie platform in order to locate items relative to the user (phone), locate the user him/herself(phone) relative to items when the location of the items is known, or use the knowledge of relative location of items (for example determine whether an item is inside or outside of a certain volume). There's no need in a fixed location Pixie Point in order to use the product, it requires no installation and no infrastructure for the location.
The Pixie platform will empower many apps, assuming each app will involve as few as 3 and upwards of Pixie Points

## 6.2 The Thin Point

The Pixie/Thin Point is a smart tag that has the ability to connect to other Pixie Points and create a Pixie Network using proprietary Pixie-protocol (running over a 2.4GHz ISM Physical Layer -PHY), connect to a phone using Standard Bluetooth Low Energy (BLE) and measure the distance to other Pixie Points using an 802.15.4a Ultra Wide Band (UWB) two-way Time of Flight (TOF) measurement.


*Figure 2: Pixie Points*

Each Pixie Point includes a 2.4GHz ISM controller, an 802.15.4a radio, Power management unit, a power source ($LiMnO_2$) primary battery and a wide band antennas. It is controlled by embedded software (Tag Firmware) that manages the Pixie Point operation. The electrical circuits battery and antenna are packaged in a thin plastic case creating a sticker.

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# 7 Thin Point Simplified Block diagram

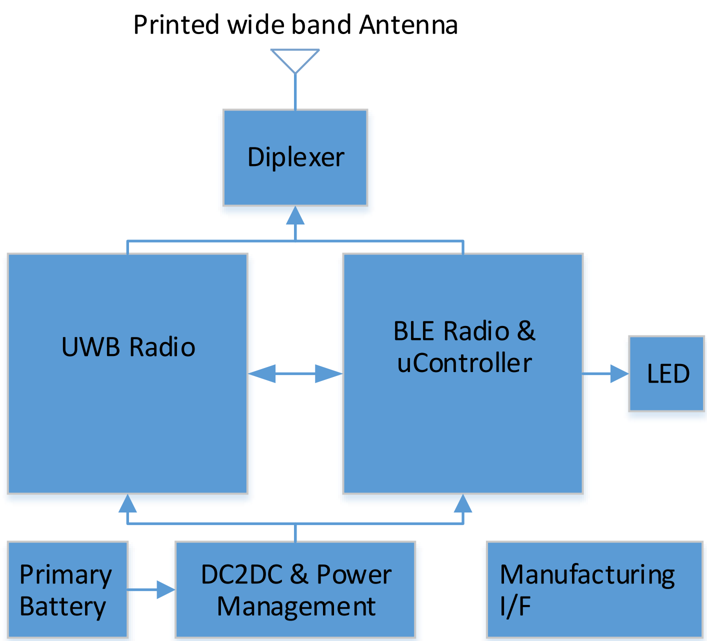



*Figure 3: Pixie Points Simplified Block Diagram*

**UWB Radio** (Ranging Module): The Ranging module is based on a UWB Time based pulse radio with the ability to very precisely measure the time of flight of the radio signal. The module is implementing a Two Way Ranging method (Tx, Rx, Tx). The measurements are controlled by the Tag Firmware driver implemented in a micro controller.

**BLE Radio and uController**: The module contains ultra-low power 2.4 GHz wireless transceiver, a 32 bit ARM Cortex M0 CPU, flash memory, and analog and digital peripherals. The Radio implementing Bluetooth low energy (BLE) and the proprietary 2.4 GHz protocols running the Pixie Network

**Printed wide band antenna and Diplexer**: The pixie point is using wide band antenna covering both BLE (2.4Ghz) and UWB (4GHz) spectrum. The antenna is integral part of the mechanical structure mechanically and electrically in this design we consider the use of two concept dual antenna or single wide band antenna with a Diplexer.
Battery: The Primary battery is based on Lithium-manganese dioxide chemistry using a standard process and shapes.

**Power Management unit**: The power management unit is an H/W and S/W module (driven by the Tag Firmware) according to the several power states of the system. The H/W unit responsible for efficient voltage conversion, power shutdown and most important is to avoid high pulses directly from battery using controlled current limiters and capacitor bank.

# 8 Pixie Point Communication Protocols HL descriptions

## 8.1 BLE

Bluetooth 4.1 low energy (BLE) radio using the s132 stack implementing a soft radio over nRF52832 device.

BLE radio is used as the main and only link between a phone app and a Pixie tag or a PN. The primary use of BLE is to serve as a command/response channel to issue PN, ranging and device commands.

A phone runs a central BLE radio stack, which means the phone can initiate and manage several connection in master role. The nRF52832 device runs a soft peripheral BLE stack (s132) which support a single connection in slave role.

BLE supports only master to slave connections and does not support broadcast or multicast, thus the usage for it in a Pixie system is limited.

Power/current profile for BLE is very low, with packets usually shorter than 1ms (and often as short as 150us).

## 8.2 Pixie Network over BLE – Pixie Protocol

Pixie Network over BLE (BLE+) radio, a proprietary Pixie ISM band radio using the nRF52832 radio hardware (time sharing with s110 BLE stack also running on the same hardware). The primary use of BLE+ radio is PN timing synchronization and network/ranging control.

Being a proprietary protocol BLE+ benefits from the low power profile of the nRF52832 device (same as BLE) while allowing implementation of a protocol most suited to carry out Pixie system operations, utilizing broadcast and TDMA schemes to minimize air time.

The BLE stack support allocation of time slots of the radio to the application layer, and in a BLE friendly manner, meaning that radio can be allocated to the application taking priority over BLE link. This considerably simplifies the system design for BLE+ as radio and CPU activity can be scheduled for BLE+ usage in a fully deterministic manner.

Pixie Protocol enables the use of accurate distance measurements in the IoT world, from a power consumption and size perspective. Lowering power consumption during idle mode is critical to enable small footprint suitable for IoT. In addition, Pixie Protocol leads to significantly lower power consumption during measurement mode using
fully-synchronous operation of the ranging modules – critical for battery life

The fact that Pixie system uses Pixie Protocol for communication rather than using UWB for that purpose increases range measurement by focusing UWB regulatory power budget on ranging only. This is critical for achieving range sufficiency in residential /office environment

From the smart – device perspective, the Pixie network is a single BLE entity. This simplifies things and saves power for the phone as well as for the Pixie points. Pixie SDK (part of the application) is in charge of managing the network. In addition, the network automatically reacts to changes – if for example, if you are leaving home, taking few several of a network members with you and to go to the office, the network will automatically split to two networks.

Pixie network is self-maintained thus enables LoT to run on background, when a smart-device is not in range, while the sensor distance data is stored in the network

Each Pixie network has a unique ID that could be shared with is set by the smart device during set up of the specific network. The access to the network can be done only by devices which hold a secret key, so the system is private and can be operated either by the device that set up the network or by an authorized device which got the secret key

Pixie Network Stack Basic features:

- Star connection around a Pixie network coordinator (which may change over time)
- Add points
- Merge or split networks
- Auto split of networks
- Frequency hopping
- Shared BLE advertising
- Supporting BLE + Pixie Protocol + ranging stack concurrently

## 8.3 UWB and distance Measurements

IEEE802.15.4-2011 UWB radio using the DW1000 device. Each transition / reception is according to LDC, operating in zero payload mode (preamble, SFD and optional PHY header)

UWB radio is used as a “ruler” in the system and is used to perform ranging measurements between tags. Ranging is done using a symmetrical two way ranging algorithm using DW provided software stack which is 802.15.4 compliant (excluding nonstandard SFD in some channel configurations).

Pixie is measuring Time of Flight (ToF). With ToF, two Pixie points measure the time it takes to RF signals to travel between them. Measuring ToF leads to accurate and robust distance estimation, relying on the constant RF propagation speed (the speed of light). Unlike signal strength, ToF is only mildly affected by obstacles. Time-of-Flight is also the method used by the GPS system, in a larger scale

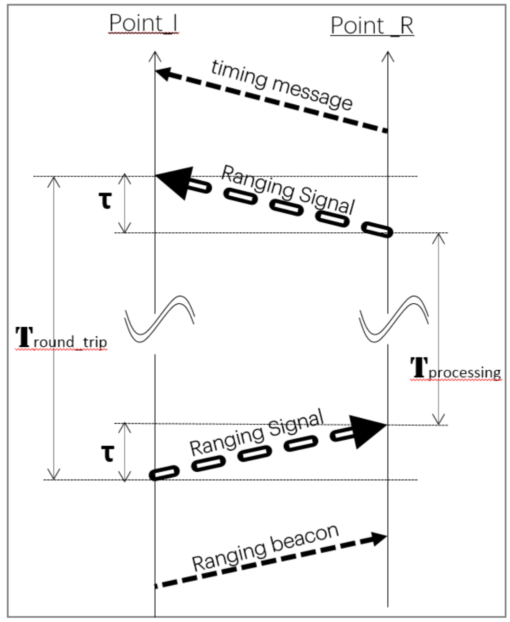



*Figure 4 - ToF Measurement*

The specific method LoT uses is two way ToF measurement. The two way method eliminates the need for fine (<1nsec level) clock synchronization between the pixie points. This method is sensitive however, to clock frequency difference (drift) between the points which results in an error, especially when the processing time is long. A simplified timing flow is shown in Figure 4.

One point (Point_I in the diagram) sends the ranging beacon (message) followed by the ranging signal. After sending the ranging signal Point_I triggers a timer to measure the overall procedure time. This time is marked T_round_trip. The propagation time of the ranging signal between the points, marked Ƭ is what the procedure aims to estimate. Multiplying Ƭ with the propagation speed (The speed of light c ) will result in the distance estimation.

After receiving the ranging signal the responding point (Point_R) starts measuring its processing time. The processing time is the time from the reception of the correlation sequence of the ranging signal till the point completes to send its ranging signal response to Point_I. This time is marked with T_processing.

Point_R sends back a ranging signal. Since Processing time is very short, the locations of the points as well as the environment are not changing significantly within the time of the measurement, so the propagation time of the signal on the way back is also Ƭ. After receiving the Point_R ranging signal response, Point_I stops its time measurement. It now has an estimation for T_round_trip. Point_R also sends a timing message containing its estimation for T_processing.

As T_round_trip= 2* Ƭ +T_processing, Point_I has now all the information to extract Ƭ.

## 8.4 Pixie's Location Engine

The location processes the distances measurement data transmitted from the Pixie-network (these arrives in the form of distance matrixes). It builds true maps of the points in the Pixie network using various triangulation and trilateration techniques, depended on the structure of the network

If there are enough points in range, the location engine will build the map by connecting triangles, where each triangle is determined by the 3 distances between 3 Pixie Points defining the vertices of the triangle.

In addition to data processing, the Location Engine contains a module that manages Pixie networks – their structure and activity profile, in order to optimize the power consumption of the Pixie Network while maintaining LoT functionality and performance

The Location Engine is also capable of solving the orientation of certain nodes relative to the map of points, based on movements of these points. This is required in cases when there is a need to show the map on a smart device screen, and the Location Engine matches the orientation of the map to the orientation of the screen

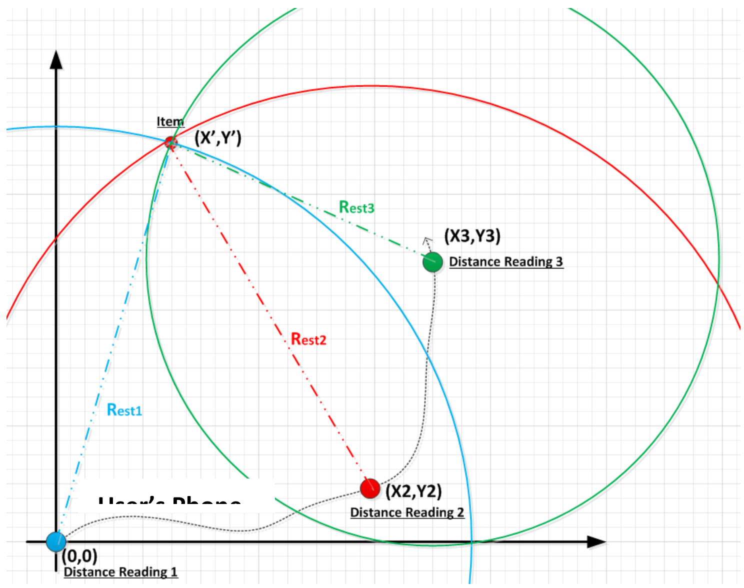



*Figure 5 - Triangulation with a single Point*

Solving orientation is supported for any number of point, even if there is only 1 point in range and a Pixiefied Phone. In that case, described in the diagram, the system performs trilateration over time, while tracking the user movements using the phone's inertial measurement unit (IMU).

# 9 Pixie Point H/W Specifications

## 9.1 Electrical

### 9.1.1 Battery

| Parameter | Value | Notes |
|---|---|---|
| Model | CP143225 | Topology: 1S1P |
| Type/Chemistry | Primary Non-rechargeable $Li-MnO_2$ | |
| Nominal Voltage | 3.0V | Open load voltage 3.10V - 3.20V. |
| Nominal Capacity | 150mAh@1mA Discharge | Nominal Capacity refer to the capacity of 1mA discharge to 2.0V cut-off voltage at 23°C. |
| Max. Discharge Current | 45mA | At 23±2°C<br>Continues discharge current of 45mA<br>Capacity should be >50%<br>(Till Cut-off voltage) |
| Max. Discharge Current | 75mA | At 23±2°C<br>Continues discharge cycle of:<br>3Sec – ON (75mA), 27Sec – OFF (0mA)<br>Capacity should be >50%.<br>(Till Cut-off voltage) |
| Discharge Cut-off Voltage | 2.0V | At Nominal Capacity |
| Operating Temperature | -20°C~ +60°C | Nominal Capacity varies in temperature |
| Cell Weight | Approx:2.0g | |
| Self-Discharge Rate | 2%/Year | |
| Mechanical Dimensions | Length : 32.2 mm Max<br>Width : 25.0 mm Max<br>Thickness : 1.4mm Max | Measured at 23°C ± 2 |
| Swelling | 1.5mm Max. | @ end of life (2.0V) |

*Table 2: Battery Specifications*

### 9.1.2 Integrated Printed Antenna

| Parameter | Value | Notes |
|---|---|---|
| Type | Wide band single port printed antenna | Material FR4<br>Copper: 1oz |
| Impedance | 50Ω | |
| Supported Frequency Bands | BLE: 2400-2483MHz<br>UWB Ch.2: 3774-4243.2MHz<br>UWB Ch.3: 4243.2-4742.4MHz | |

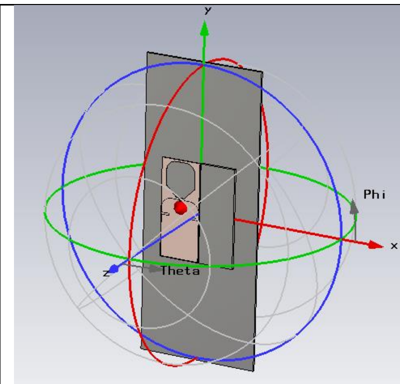
| | | | |
|---|---|---|---|
| | UWB Ch.5: 6240-6739.2MHz | | |
| Tested Radiation patterns | Antenna Cut Orientations:<br>Cut XZ (Green)<br>Cut XY (Blue)<br>Cut YZ (Red) |  |  |

*Table 3: Integrated Printed Antenna Specifications*

### 9.1.2.1 Radiation Patterns – Gain

- BLE (Center=2450MHz, BW=80MHz)
- UWB Ch2 (Center=4000MHz, BW=500MHz)
- UWB Ch3 (Center=4500MHz, BW=500MHz)
- UWB Ch5 (Center=6500MHz, BW=500MHz)

Total Gain (V+H) [dBi] in XZ, cuts, Simulation

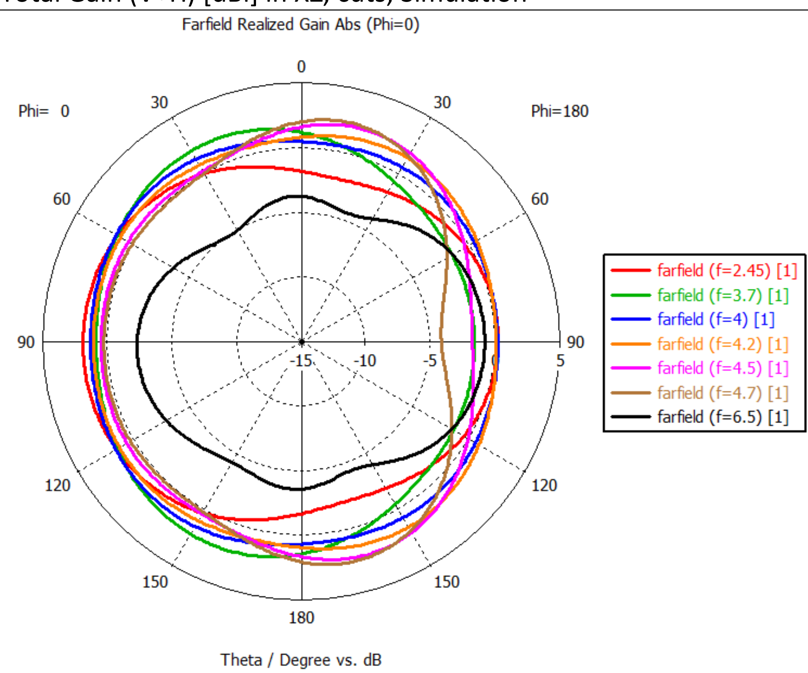



*Figure 6: Antenna Gain – XZ*

Total Gain (V+H) [dBi] in XY, cuts, Simulation

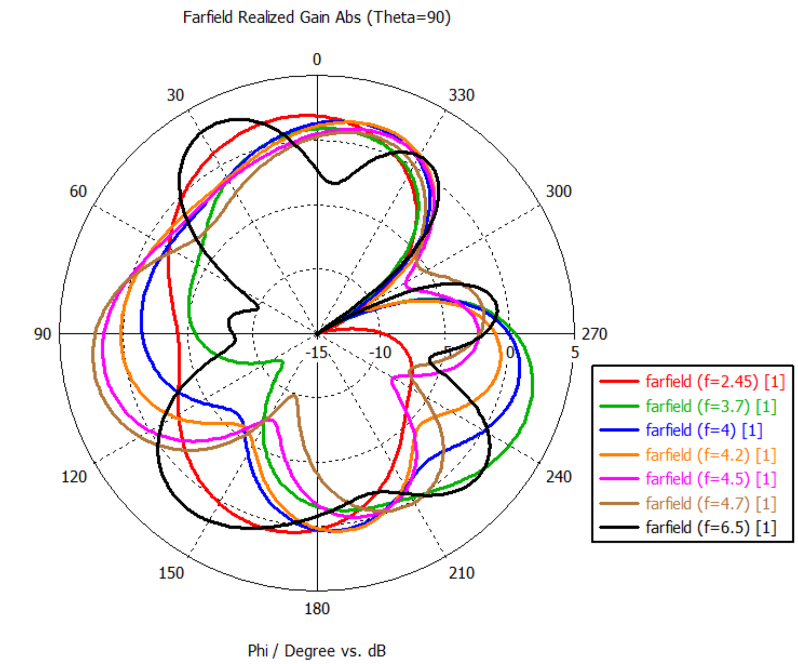



*Figure 7: Antenna Gain - XY*

Total Gain (V+H) [dBi] in YZ cuts, Simulation

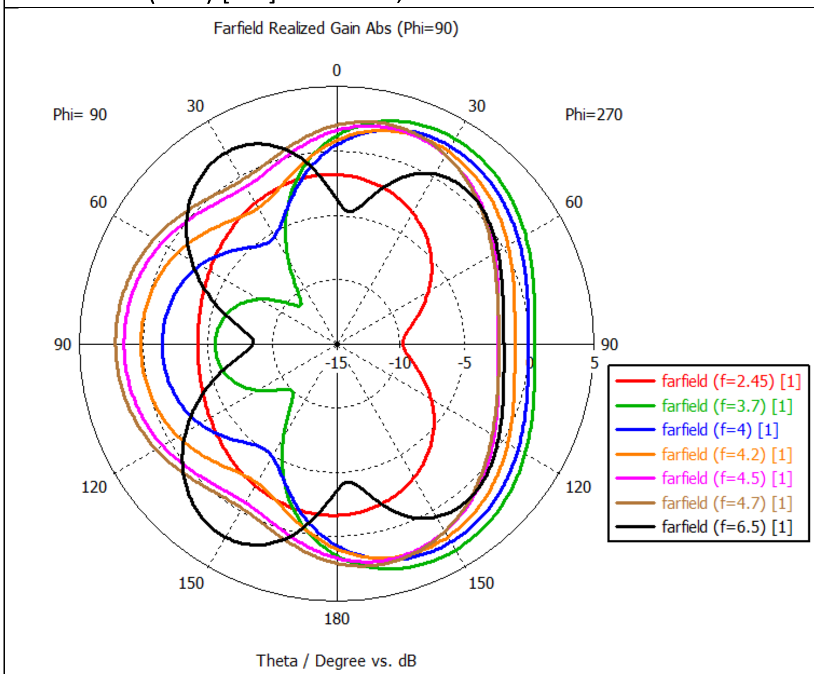



*Figure 8: Antenna Gain - YZ*

### 9.1.3 UWB Radio

| Parameter | Value | Notes |
|---|---|---|
| Max Tx Power | -14.3dBm±0.25 | Calibrated at ATE |
| Typical Rx Sensitivity | -97dBm | At 1% PER |
| Supported Frequency Channels | Ch.2: 3774-4243.2MHz<br>Ch.3: 4243.2-4742.4MHz<br>Ch.5: 6240-6739.2MHz | |
| Channel Bandwidth | 500MHz | |

*Table 4: BLE Radio Specifications*

### 9.1.4 BLE Radio

| Parameter | Value | Notes |
|---|---|---|
| Max Tx Power | +4dBm | At antenna port |
| Typ Tx Power | +2.5dBm | At antenna port |
| Typical Rx Sensitivity | -96dBm | At 1Mbps, 0.1% BER |
| Supported Frequency band | 2400-2483MHz | |
| Channel Bandwidth | 1MHz | |

*Table 5: UWB Radio Specifications*

### 9.1.5 Power Consumption Main Profiles

#### *9.1.5.1 Sleep current*

| Parameter | Value | Notes |
|---|---|---|
| Sleep current | Min 2.4µA<br>Max 4.0µA | Sleep only , No transmissions or receptions occurs |

*Table 6: Min / Max sleep current*

#### *9.1.5.2 Average Standby current*

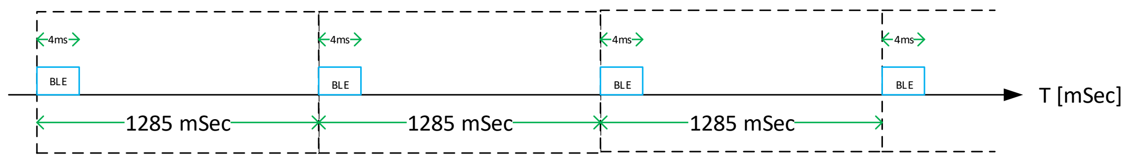



*Figure 9: Average standby current*

| Parameter | Value | Notes |
|---|---|---|
| Average Standby current | 13µA | Sleep mode and BLE slow advertise |

*Table 7: Average standby current*

#### *9.1.5.3 Average Operational current*

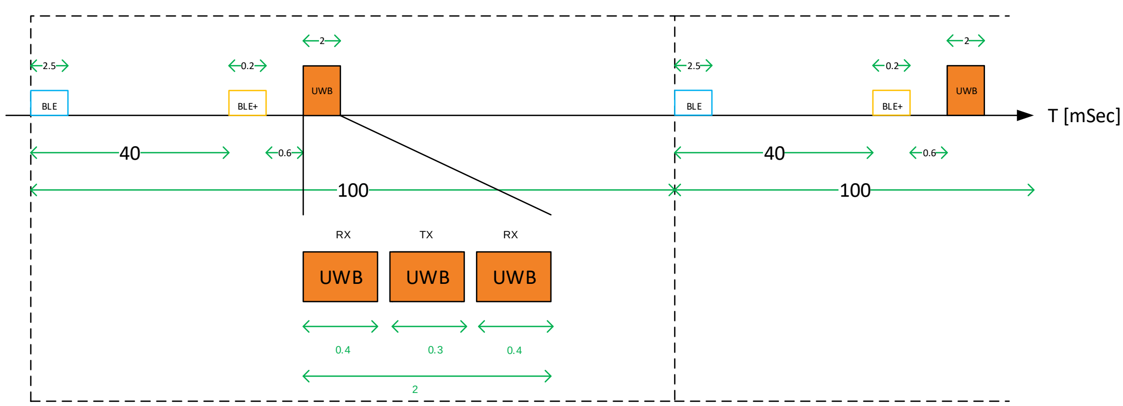



*Figure 10: Average operational current*

| Parameter | Value | Notes |
|---|---|---|
| Average Operational current | 1.4mA | BLE connection, Pixie Network and UWB transaction every 100ms |

*Table 8: Average operational current*

## 9.2 Manufacturing

### 9.2.1 ICT Electrical Interface

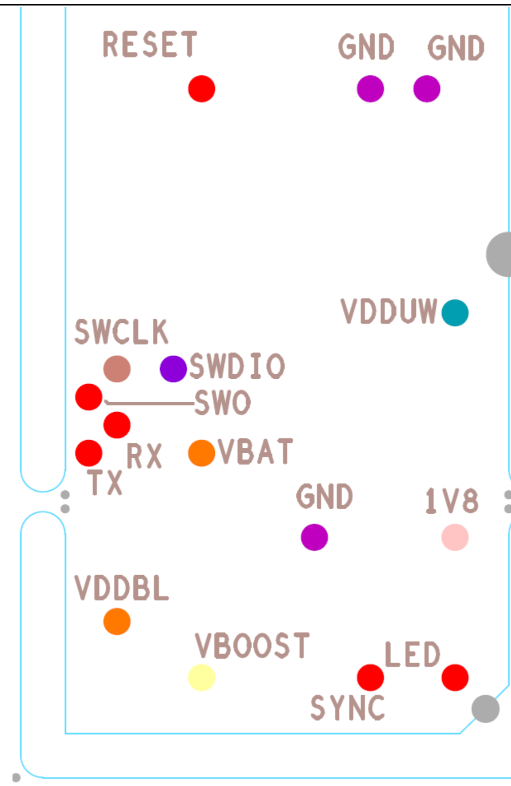
| Pin # | Pin Name | Signal Description | Tag Bottom view (ICT side) |
|---|---|---|---|
| 1 | VDDBL | uP VDDBL output voltage from the Tag. Used for voltage sensing by the J-LINK |  |
| 2 | UTX | J-LINK UART TX output line | |
| 3 | URX | J-LINK UART RX input line | |
| 4 | SWDIO | J-LINK SWDIO output line | |
| 5 | SWDCK | J-LINK SWDCK output line | |
| 6 | LED | TAG LED to measure the LED voltage | |
| 7 | SYNC | TAG output I/O which use to drive the LED/Sync between TAG and the golden unit (big Boy) | |
| 8 | VBOOST | VBOOST – used to bypass UWB radio Bank Capacitor and drive 3.0V voltage directly to the VBOOST. | |
| 9 | 1V8 | 1.8V output voltage from the Tag | |
| 10 | VDDUW | 3.0V output voltage from the Tag (BOOST Output) | |
| 11 | VBAT | The TAG Battery Voltage Input | |
| 12 | GND | GROUND #1 | |
| 13 | GND | GROUND #2 | |
| 14 | RESET | Tag Reset Input line | |



*Table 9: ICT Electrical interface Specifications*

### 9.2.2 Testing and Calibration Parameters

| No | Test | Typical results | Units | DUT min | DUT max | Golden Min | Golden Max | Max deviation of successive Measurements (X10) |
|---|---|---|---|---|---|---|---|---|
| 1 | Sleep current test | 3.1 | uA | 2.4 | 4 | 2.8 | 3.4 | 0.1 |
| 2 | Led Test | 2.65 | V | 2.5 | 2.8 | 2.6 | 2.7 | 0.1 |
| 3 | Battery test | 3 | V | 2.95 | 3.05 | 2.95 | 3.05 | 0.05 |
| 4 | BLE - High Freq 16Mhz | ±5 | PPM | -25 | 25 | -3 | 3 | 1 |
| 5 | BLE- Low Freq 32.768Khz | ±20 | PPM | -30 | 30 | -10 | 10 | 2 |
| 6 | BLE - Output level | 2.5 | dBm | 1 | 4 | 2.8 | 3.4 | 0.5 |
| 7 | BLE TX - sensitivity | <0.1 | BER | 0 | 0.1 | 0 | 0.05 | 0.05 |
| 8 | BLE RX - sensitivity | <0.1 | BER | 0 | 0.1 | 0 | 0.05 | 0.05 |
| 9 | UWB carrier frequency | ±1.5 | PPM | -1.5 | 1.5 | -0.75 | 0.75 | 0.5 |
| 9A | UWB Calib offset - Decimal setting | 13 | | 0 | 31 | 8 | 18 | 2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10 | UWB power - Ch2 | -14.3 | dBm | -14.05 | -14.55 | -14.05 | -14.55 | 0.25 |
| 10A | Gain Ch 2 | 21 | dB | 18 | 24 | 20 | 22 | 1 |
| 11 | UWB power - Ch3 | -14.3 | dBm | 14.05 | -14.55 | -14.05 | -14.55 | 0.25 |
| 11A | Gain Ch 3 | 20 | dB | 18 | 24 | 20 | 22 | 1 |
| 12 | UWB power - Ch5 | -14.3 | dBm | 14.05 | -14.55 | -14.05 | -14.55 | 0.25 |
| 12A | Gain Ch 5 | 15 | dB | 10.5 | 18.5 | 18 | 22 | 1 |
| 13 | UWB TX - Ch2 Per | 1 | % PER | 0/100 | 1/100 | 0/100 | 1/100 | 1/100 |
| 14 | UWB RX- Ch2 | 1 | % PER | 0/100 | 1/100 | 0/100 | 1/100 | 1/100 |
| 15 | Ant Dly - Ch2 - 16 MHz PRF | 514.71 | nSec | 512 | 517 | 513.5 | 516 | 0.1 |
| 16 | Ant Dly - Ch2 - 64 MHz PRF | 514.86 | nSec | 512 | 517 | 513.5 | 516 | 0.1 |
| 17 | Ant Dly - Ch3 - 16 MHz PRF | 514.63 | nSec | 512 | 517 | 513.5 | 516 | 0.1 |
| 18 | Ant Dly - Ch3 - 16 MHz PRF | 514.58 | nSec | 512 | 517 | 513.5 | 516 | 0.1 |
| 19 | Ant Dly - Ch5 - 16 MHz PRF | 515.47 | nSec | 512 | 517 | 513.5 | 516 | 0.1 |
| 20 | Ant Dly - Ch5 - 16 MHz PRF | 515.11 | nSec | 512 | 517 | 513.5 | 516 | 0.1 |

*Table 10: Testing and calibration parameters*

## 9.3 Mechanical

### 9.3.1 Dimensions and Weight

| Parameter | Value | Notes |
|---|---|---|
| External Dimensions | 53mm x 52mm x 2mm | Thickness including double adhesive |
| Total Weight | ≤ 10g | Fully assembled Tag including double adhesive |

*Table 11: Dimensions and weight specifications*

### 9.3.2 Enclosure parts and printings

#### *9.3.2.1 Top Shell Printing*

| Parameter | Value | Illustration |
|---|---|---|
| Product Graphic Layer - Top | Material- Digital Print.<br>Note: Graphic design (Artwork) may varies |   |

*Table 12: Top Shell Printing specifications*

#### *9.3.2.2 Bottom Shell label Printings*

| Parameter | Value | | Illustration |
|---|---|---|---|
| Product Graphic Layer – Bottom<br>Regulation Text | Material - Digital Print.<br><br>CE Marking<br>WEEE Marking<br>Model Number:<br>FCC ID:<br>Industrial Canada ID: | <br><br><br><br>P1100<br>2ADBO-P1100<br>TBD |  |

*Table 13: Bottom Shell printing specifications*

#### *9.3.2.3 Materials & Lamination*

| Parameter | Value | Notes | |
|---|---|---|---|
| Lamination material | BOYUAN Digital Press Sheet B5110T |   |  |
| Inner filler Glue | Polytek Poly-Optic® 1411 Liquid Plastics<br>Shore Hardness – D80 | | |

*Table 14: Materials and Lamination*

## 9.4 Environmental

| Parameter | Value | Notes |
|---|---|---|
| Operation temperature range | 0℃ – +45℃ | |
| Storage temperature range | -10℃ - +55℃ | |
| IP Protection Class | IP67 | 30 min , 1 meter depth |
| Drop test | 1 meter on hard floor. Tag is attached to 100g phone like device | |
| Temperature cycle test Cold | ETSI EN 300 019-2-3 T3.2 (IEC 60068-2-1, Ab/Ad: Cold), Temp -10/) test time 16 hours. | |
| Temperature cycle test Hot | Hot: ETSI EN 300 019-2-3 T3.2 (IEC 60068-2-2 Bb/Bd: Dry heat), Temperature: 50C Test time: 16h | |
| Humidity | ETSI EN 300 019-2-3 T3.2 (IEC 60068-2-56 Cb: Damp heat), Temperature: 30C RH: 95% Test time: 4 days (96h) | |
| Vibration test – Random and Shook | ETSI EN 300 019-2-3 T3.2 (IEC 60068-2-64) ETSI EN 300 019-2-3 T3.2 (IEC 60068-2-27) | |

*Table 15: Environmental*

## 9.5 Certification (Regulation / Compliance)

Notes:

FCC: The system is for indoor UWB systems (§ 15.517)

EN 302 065: Without DAA, it works in LDC (Low Duty Cycle).

### 9.5.1 Radio

| No. | Geography | Standard | Notes |
|---|---|---|---|
| 1 | Europe | EN 302 065-1 V1.3.1 | Ch.2, Ch.3, Ch.5 - 3774-4243.2MHz, 4243.2-4742.4MHz,6240-6739.2MHz |
| 2 | Europe | EN 300 328 V1.8.1:12 | BLE |
| 3 | USA/Canada | 47 CFR part 15 Sub F; RSS-220 | Ch.2, Ch.3, Ch.5 - 3774-4243.2MHz, 4243.2-4742.4MHz,6240-6739.2MHz |
| 4 | USA/ Canada | 47 CFR part 15 Sub C Sec 15.247;<br>RSS-210:10 Issue 8 | BLE |

*Table 16: Regulation / Compliance - Radio*

### 9.5.2 EMC

| No. | Geography | Standard | Notes |
|---|---|---|---|
| 1 | Europe | EN 301 489-1 V1.9.2:11; EN 301 489-17 V2.2.1:12; EN 301 489-33 V1.1.1 | |
| 2 | USA/ Canada | 47 CFR part 15 Sub B; ICES-003:04 | |

*Table 17: Regulation / Compliance - EMC*

### 9.5.3 Safety

| No. | Geography | Standard | Notes |
|---|---|---|---|
| 1 | Europe | EN 60950-1:06+A11:09 +A1:10+A12:11+A2:13 | |

*Table 18: Regulation / Compliance - safety*

## 9.6 Qualification

### 9.6.1 Bluetooth Qualification P1100

| Item | Description |
|---|---|
| nRF52832 QFN48 Bluetooth low energy Qualified Design ID (QD ID) | TBD |
| Declaration of Compliance (DoC) / Product listing | TBD |

*Table 19: Bluetooth Qualification*

Hermon Laboratories Ltd.
Harakevet Industrial Zone, Binyamina 30500, Israel
Tel. +972-4-6288001
Fax. +972-4-6288277
E-mail: mail@hermonlabs.com

HERMON LABORATORIES

ELECTRICAL TESTING
0839.01

# TEST REPORT

**ACCORDING TO: FCC 47CFR part 15 subpart C § 15.247(DTS) and subpart B; RSS-247 issue 1, RSS-Gen issue 4 section 7**

**FOR:**

## Pixie Technology Ltd.
## Thin Point
## Model:P1100
## FCC ID:2ADBO-P1100

HERMON LABORATORIES

# Table of contents

# 1 Applicant information

| | |
|---|---|
| **Client name:** | Pixie Technology Ltd. |
| **Address:** | 8 Hamada street,Bld. B, 3rd floor, Herzliya 46733, Israel |
| **Telephone:** | +972 77 921 5815 |
| **Fax:** | +972 77 921 5833 |
| **E-mail:** | tsachs@getpixie.com |
| **Contact name:** | Mr. Tsach Shwartz |

# 2 Equipment under test attributes

| | |
|---|---|
| **Product name:** | Thin Point |
| **Product type:** | Transceiver |
| **Model(s):** | P1100 |
| **Serial number:** | Prototype |
| **Hardware version:** | 1 |
| **Software release:** | 001 |
| **Receipt date** | 31-Jul-16 |

# 3 Manufacturer information

| | |
|---|---|
| **Manufacturer name:** | Pixie Technology Ltd. |
| **Address:** | 8 Hamada street,Bld. B, 3rd floor, Herzliya 46733, Israel |
| **Telephone:** | +972 77 921 5815 |
| **Fax:** | +972 77 921 5833 |
| **E-Mail:** | tsachs@getpixie.com |
| **Contact name:** | Mr. Tsach Shwartz |

# 4 Test details

| | |
|---|---|
| **Project ID:** | 28663 |
| **Location:** | Hermon Laboratories Ltd. Harakevet Industrial Zone, Binyamina 30500, Israel |
| **Test started:** | 31-Jul-16 |
| **Test completed:** | 28-Aug-16 |
| **Test specification(s):** | FCC Part 15 subpart C §15.247 (DTS), subpart B §15.109;<br>RSS-247 issue 1, RSS-Gen issue 4 section 7, ICES-003 issue 6:2016 |

# 5 Tests summary

| Test | Status |
|---|---|
| **Transmitter characteristics** | |
| FCC Section 15.247(a)2 / RSS-247 section 5.2(1), 6 dB bandwidth | Pass |
| FCC Section 15.247(b)3/ RSS-247 section 5.4(4), Peak output power | Pass |
| FCC section 15.247(i) / RSS-102 section 2.5.1, RF exposure | Pass, the exhibit to the application of certification is provided |
| FCC Section 15.247(d) / RSS-247 section 5.5, Radiated spurious emissions | Pass |
| FCC Section 15.247(d)/ RSS-247 section 5.5, Emissions at band edges | Pass |
| FCC Section 15.247(e) / RSS-247 section 5.2(2), Peak power density | Pass |
| FCC section 15.203 / RSS-Gen section 8.3, Antenna requirement | Pass |
| FCC section 15.207(a) / RSS-Gen section 8.8, Conducted emission | Not required |
| **Unintentional emissions** | |
| FCC section 15.107/ RSS-Gen section 8.8, Conducted emission at AC power port | Not required |
| FCC section 15.109, RSS-Gen section 7, Radiated emission | Pass |

Testing was completed against all relevant requirements of the test standard. The results obtained indicate that the product under test complies in full with the requirements tested.
The test results relate only to the items tested. Pass/ fail decision was based on nominal values.

| | Name and Title | Date | Signature |
|---|---|---|---|
| **Tested by:** | Mrs. E. Pitt, test engineer | August 28, 2016 | |
| **Reviewed by:** | Mrs. M. Cherniavsky, certification engineer | September 1, 2016 | |
| **Approved by:** | Mr. M. Nikishin, EMC and Radio group manager | March 12, 2017 | |

# 6 EUT description

## 6.1 General information

The EUT, ThinPoint tag, is a very low power wireless device utilizing 2 wireless technologies:

BLE (Bluetooth) to communicate with smartphones and UWB to measure distance between the tags.

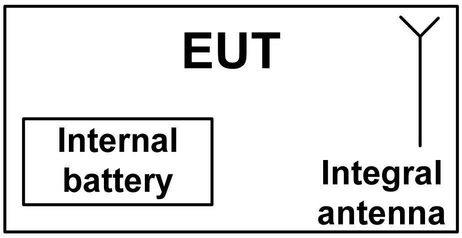
The tag is working in very low duty cycle. Most of the time the tag is advertising (sends BLE standard "existing" message). Advertise is done every 2 sec for 3 msec. The UWB radio is set to deep sleep.

Once the smartphone responses the tag can communicate with the smartphone and via smartphone can communicate with other similar tags and measure Tag to Tag range using the UWB radio.

The UWB radio is active for minimal time that is needed for range measurement – about 2 -3 msec.

After the measurement sequence, the UWB is set to deep sleep again. The BLE (Bluetooth) and UWB radio do not work at the same time. There is one built-in antenna for UWB and BLE.

## 6.2 Test configuration




## 6.3 Changes made in EUT

No changes were performed in the EUT during testing.

## 6.4 Transmitter characteristics

| **Type of equipment** | |
|---|---|
| V | Stand-alone (Equipment with or without its own control provisions) |
| | Combined equipment (Equipment where the radio part is fully integrated within another type of equipment) |
| | Plug-in card (Equipment intended for a variety of host systems) |

| | |
|---|---|
| **Assigned frequency range** | 2400 -2483.5 MHz |
| **Operating frequencies** | 2402-2478 MHz |
| **Maximum rated output power** | Peak output power 8.9 dBm |

| | | | | | |
|---|---|---|---|---|---|
| **Is transmitter output power variable?** | V | No | | | |
| | | Yes | | continuous variable | |
| | | | | stepped variable with stepsize | dB |
| | | | minimum RF power | | dBm |
| | | | maximum RF power | | dBm |

| **Antenna connection** | | | | | |
|---|---|---|---|---|---|
| unique coupling | standard connector | V | Integral | | with temporary RF connector |
| | | | | V | without temporary RF connector |

| **Antenna/s technical characteristics** | | | |
|---|---|---|---|
| Type | Manufacturer | Model number | Gain |
| Internal Printed Omni | Pixie | P1100 | 0 dBi |

| | |
|---|---|
| **Transmitter aggregate data rate/s** | 1 Mbps |
| **Type of modulation** | GFSK |
| **Modulating test signal (baseband)** | PRBS |

| **Transmitter power source** | | | | | |
|---|---|---|---|---|---|
| V | Battery | **Nominal rated voltage** | 3.0 V | Battery type | Lithium Manganese Dioxide |
| | DC | **Nominal rated voltage** | | | |
| | AC mains | **Nominal rated voltage** | | Frequency | Hz |

| | | | |
|---|---|---|---|
| **Test specification:** | **Section 15.247(a)2 / RSS-247 section 5.2(1), 6 dB bandwidth** | | |
| **Test procedure:** | ANSI C63.10 section 11.8.1 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 31-Jul-16 - 14-Aug-16 | | |
| **Temperature:** 23 ºC | **Relative Humidity:** 55 % | **Air Pressure:** 1005 hPa | **Power:** Battery |
| **Remarks:** | | | |

# 7 Transmitter tests according to 47CFR part 15 subpart C and RSS-247 requirements

## 7.1 Minimum 6 dB bandwidth

### 7.1.1 General

This test was performed to measure 6 dB bandwidth of the EUT carrier frequency. Specification test limits are given in Table 7.1.1.

**Table 7.1.1 The 6 dB bandwidth limits**

| Assigned frequency, MHz | Modulation envelope reference points*, dBc | Minimum bandwidth, kHz |
|---|---|---|
| 2400.0 – 2483.5 | 6.0 | 500.0 |

* - Modulation envelope reference points provided in terms of attenuation below the peak of modulated carrier.

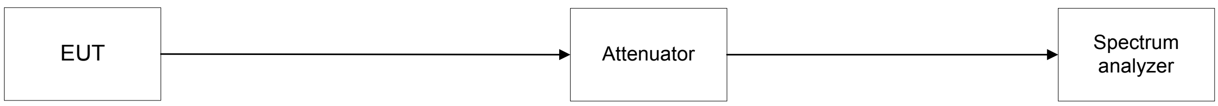
### 7.1.2 Test procedure

**7.1.2.1** The EUT was set up as shown in Figure 7.1.1, energized and its proper operation was checked.

**7.1.2.2** The EUT was set to transmit modulated carrier.

**7.1.2.3** The transmitter minimum 6 dB bandwidth was measured with spectrum analyzer as frequency delta between reference points on modulation envelope and provided in Table 7.1.2 and associated plot.

**Figure 7.1.1 The 6 dB bandwidth test setup**



| Test specification: | Section 15.247(b)3 / RSS-247 section 5.4(4), Maximum output power | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10 sections 11.9.2.2.4 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 31-Jul-16 - 14-Aug-16 | | |
| Temperature: 23 ºC | Relative Humidity: 55 % | Air Pressure: 1005 hPa | Power: Battery |
| Remarks: | | | |

## 7.2 Peak output power

### 7.2.1 General

This test was performed to measure the maximum peak output power radiated by transmitter. Specification test limits are given in Table 7.2.1.

**Table 7.2.1 Peak output power limits**

| Assigned frequency range, MHz | Maximum antenna gain, dBi | Peak output power* | | Equivalent field strength limit @ 3m, dB(μV/m)** |
|---|---|---|---|---|
| | | W | dBm | |
| 2400.0 – 2483.5 | 6.0 | 1.0 | 30.0 | 131.2 |

*- The limit is provided in terms of conducted RF power at the antenna connector. If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power limit shall be reduced below the stated value as follows:

by 1 dB for every 3 dB that the directional gain of antenna exceeds 6 dBi for fixed point-to-point transmitters operate in 2400-2483.5 MHz band;
without any corresponding reduction for fixed point-to-point transmitters operate in 5725-5850 MHz band;
by the amount in dB that the directional gain of antenna exceeds 6 dBi for the rest of transmitters.

**- Equivalent field strength limit was calculated from the peak output power as follows: E=sqrt(30×P×G)/r, where P is peak output power in Watts, r is antenna to EUT distance in meters and G is transmitter antenna gain in dBi.

### 7.2.2 Test procedure

**7.2.2.1** The EUT was set up as shown in Figure 7.2.1, energized and its proper operation was checked.

**7.2.2.2** The EUT was adjusted to produce maximum available to end user RF output power.

**7.2.2.3** The resolution bandwidth of spectrum analyzer was set wider than 6 dB bandwidth of the EUT and the field strength of the EUT carrier frequency was measured with antenna connected to spectrum analyzer/ EMI receiver. To find maximum radiation the turntable was rotated $360^0$ and the measuring antenna height was swept in both vertical and horizontal polarizations.

**7.2.2.4** The maximum field strength of the EUT carrier frequency was measured as provided in Table 7.2.2 and associated plots.

**7.2.2.5** The maximum peak output power was calculated from the field strength of carrier as follows:

$$P = (E \times d)^2 / (30 \times G),$$

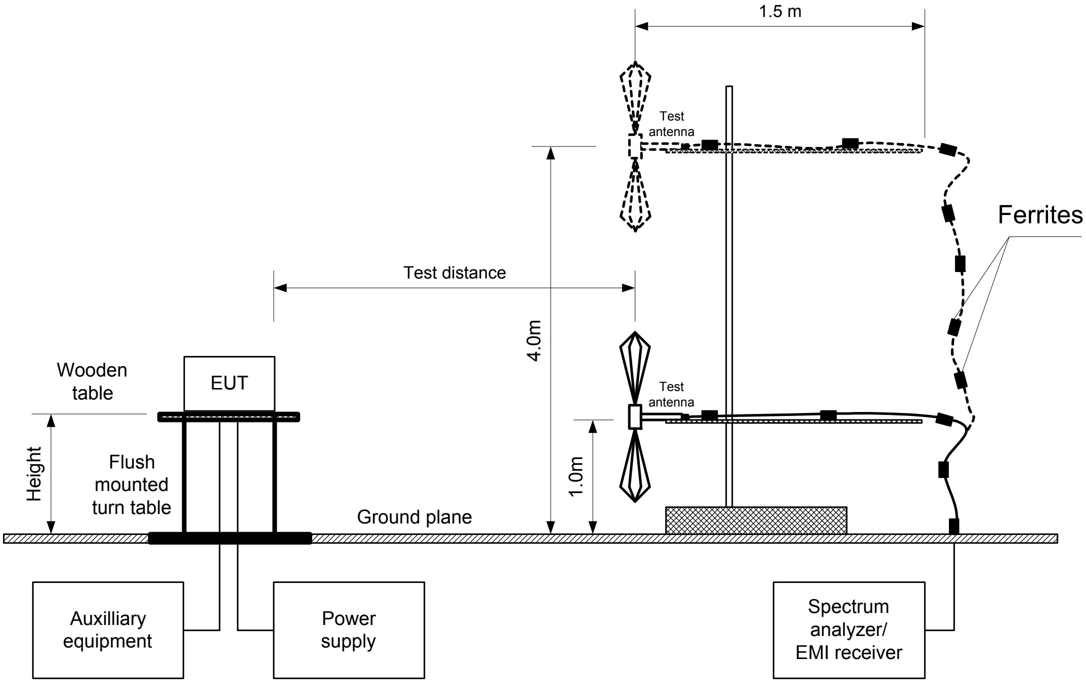
where P is the peak output power in W, E is the field strength in V/m, d is the test distance and G is the transmitter numeric antenna gain over an isotropic radiator.
The above equation was converted in logarithmic units for 3 m test distance:

Peak output power in dBm = Field strength in dB(μV/m) - Transmitter antenna gain in dBi – 95.2 dB

**7.2.2.6** The worst test results (the lowest margins) were recorded in Table 7.2.2.

| | | | |
|---|---|---|---|
| **Test specification:** | **Section 15.247(b)3 / RSS-247 section 5.4(4), Maximum output power** | | |
| **Test procedure:** | ANSI C63.10 sections 11.9.2.2.4 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 31-Jul-16 - 14-Aug-16 | | |
| **Temperature:** 23 ºC | **Relative Humidity:** 55 % | **Air Pressure:** 1005 hPa | **Power:** Battery |
| **Remarks:** | | | |

**Figure 7.2.1 Setup for carrier field strength measurements**



| **Test specification:** | **Section 15.247(b)3 / RSS-247 section 5.4(4), Maximum output power** | | |
|---|---|---|---|
| **Test procedure:** | ANSI C63.10 sections 11.9.2.2.4 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 31-Jul-16 - 14-Aug-16 | | |
| **Temperature:** 23 ºC | **Relative Humidity:** 55 % | **Air Pressure:** 1005 hPa | **Power:** Battery |
| **Remarks:** | | | |

**Table 7.2.2 Peak output power test results**

| | |
|---|---|
| ASSIGNED FREQUENCY: | 2400-2483.5 MHz |
| TEST DISTANCE: | 3 m |
| TEST SITE: | OATS |
| EUT HEIGHT: | 1.5 m |
| DETECTOR USED: | Peak |
| TEST ANTENNA TYPE: | Double ridged guide |
| MODULATION: | GFSK |
| BIT RATE: | 1 Mbps |
| DETECTOR USED: | Peak |
| EUT 6 dB BANDWIDTH: | 714.8 kHz |
| RESOLUTION BANDWIDTH: | 1 MHz |
| VIDEO BANDWIDTH: | 3 MHz |

| Frequency, MHz | Field strength, dB(μV/m) | Antenna polarization | Antenna height, m | Azimuth, degrees* | EUT antenna gain, dBi | Peak output power, dBm** | Limit, dBm | Margin, dB*** | Verdict |
|---|---|---|---|---|---|---|---|---|---|
| 2402 | 102.90 | Horizontal | 1.7 | 30 | 0 | 7.70 | 30.00 | -22.30 | Pass |
| 2440 | 103.21 | Horizontal | 1.9 | 60 | 0 | 8.01 | 30.00 | -21.99 | Pass |
| 2478 | 104.08 | Horizontal | 1.8 | 60 | 0 | 8.88 | 30.00 | -21.12 | Pass |

*****- EUT front panel refer to 0 degrees position of turntable.
******- Peak output power was calculated from the field strength of carrier as follows: $P = (E \times d)^2 / (30 \times G)$,
where P is the peak output power in W, E is the field strength in V/m, d is the test distance in meters and G is the transmitter numeric antenna gain over an isotropic radiator. The above equation was converted in logarithmic units for 3 m test distance: *Peak output power in dBm = Field strength in dB(μV/m) - Transmitter antenna gain in dBi – 95.2 dB*
***- Margin = Peak output power – specification limit.

**Reference numbers of test equipment used**

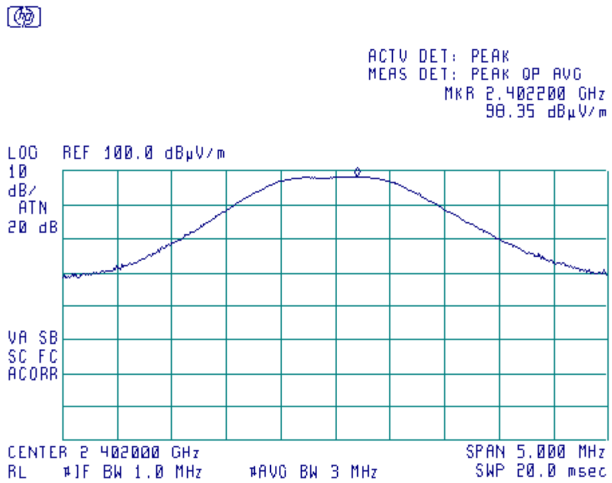
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| HL 0521 | HL 1984 | HL 4278 | HL 4353 | | | | |

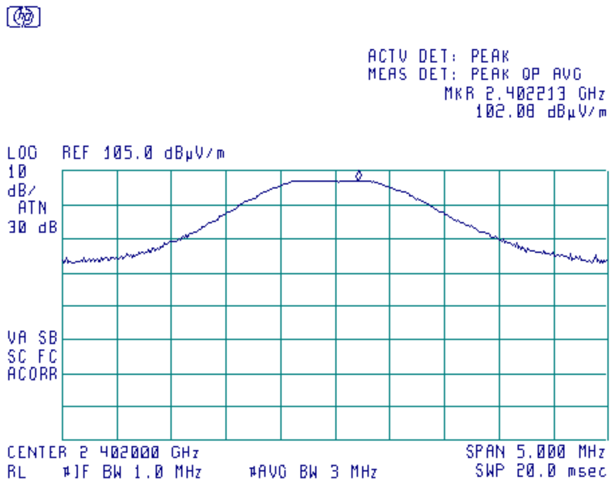
Full description is given in Appendix A.

| | | | |
|---|---|---|---|
| **Test specification:** | **Section 15.247(b)3 / RSS-247 section 5.4(4), Maximum output power** | | |
| **Test procedure:** | ANSI C63.10 sections 11.9.2.2.4 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 31-Jul-16 - 14-Aug-16 | | |
| **Temperature:** 23 °C | **Relative Humidity:** 55 % | **Air Pressure:** 1005 hPa | **Power:** Battery |
| **Remarks:** | | | |

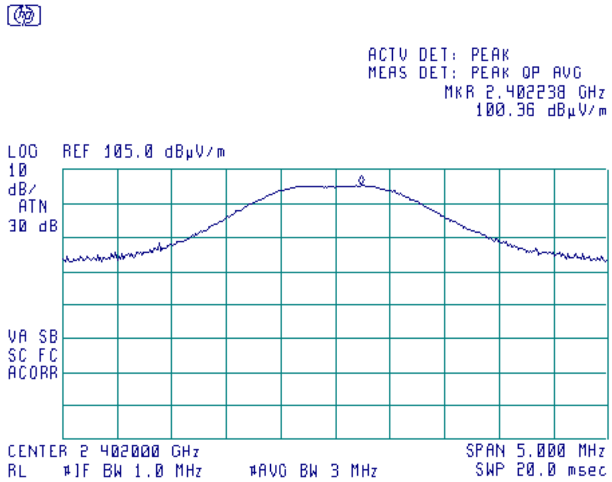
**Plot 7.2.1 Field strength of carrier at low frequency**

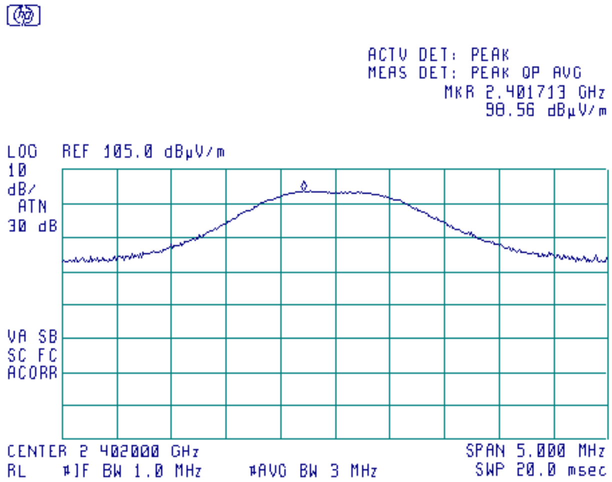
TEST SITE: OATS
TEST DISTANCE: 3 m
ANTENNA POLARIZATION: Vertical / Horizontal
EUT PLANE X-axis




EUT PLANE Y-axis



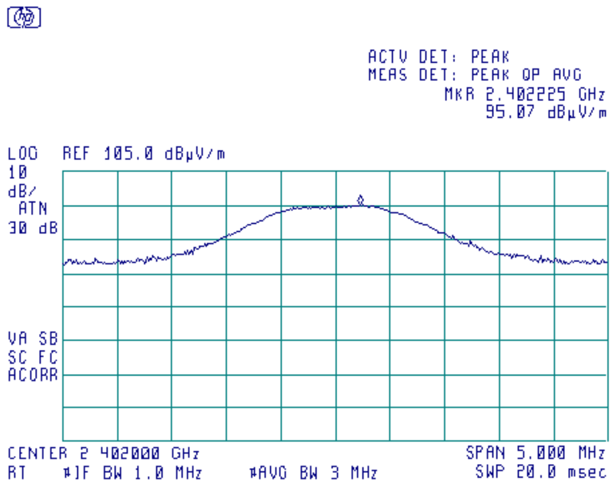



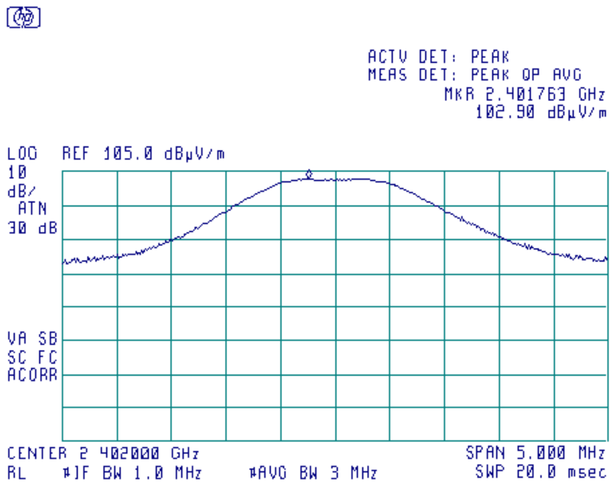
| **Test specification:** | **Section 15.247(b)3 / RSS-247 section 5.4(4), Maximum output power** | | |
|---|---|---|---|
| **Test procedure:** | ANSI C63.10 sections 11.9.2.2.4 | | |
| **Test mode:** | Compliance | **Verdict:** | PASS |
| **Date(s):** | 31-Jul-16 - 14-Aug-16 | | |
| **Temperature:** 23 ºC | **Relative Humidity:** 55 % | **Air Pressure:** 1005 hPa | **Power:** Battery |
| **Remarks:** | | | |

**Plot 7.2.2 Field strength of carrier at low frequency**

TEST SITE: OATS
TEST DISTANCE: 3 m
ANTENNA POLARIZATION:
Vertical Horizontal

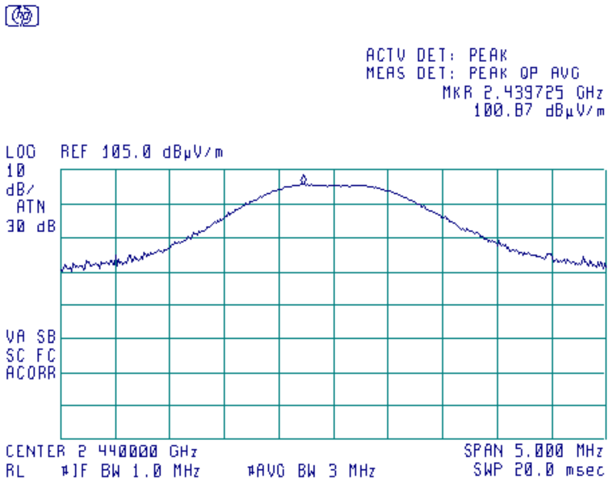
EUT PLANE Z-axis

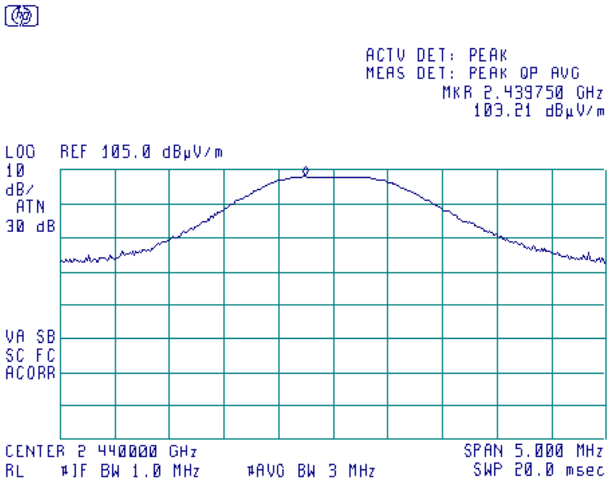



**Plot 7.2.3 Field strength of carrier at mid frequency**

TEST SITE: OATS
TEST DISTANCE: 3 m
EUT PLANE X,Y,Z-axes
ANTENNA POLARIZATION:
Vertical Horizontal



| Test specification: | Section 15.247(b)3 / RSS-247 section 5.4(4), Maximum output power | | |
|---|---|---|---|
| Test procedure: | ANSI C63.10 sections 11.9.2.2.4 | | |
| Test mode: | Compliance | Verdict: | PASS |
| Date(s): | 31-Jul-16 - 14-Aug-16 | | |
| Temperature: 23 °C | Relative Humidity: 55 % | Air Pressure: 1005 hPa | Power: Battery |
| Remarks: | | | |

**Plot 7.2.4 Field strength of carrier at high frequency**

| | |
|---|---|
| TEST SITE: | OATS |
| TEST DISTANCE: | 3 m |
| EUT PLANE | X,Y,Z-axes |
| ANTENNA POLARIZATION: | |
| Vertical | Horizontal |