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

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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. 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.

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

Figure 1: Pixie Platform Layers

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.

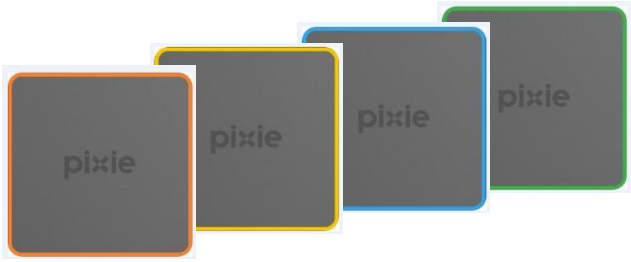


Figure 2: Pixie Points

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.

7 Thin Point Simplified Block diagram

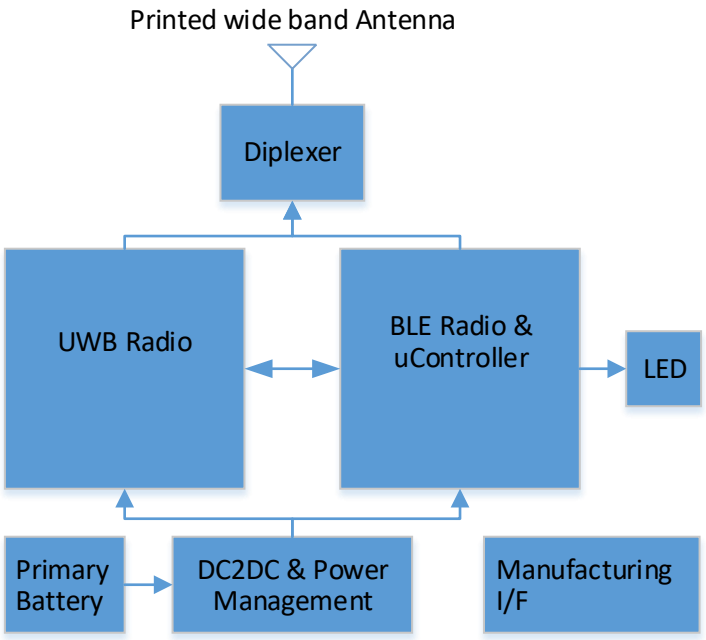


Figure 3: Pixie Points Simplified Block Diagram

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

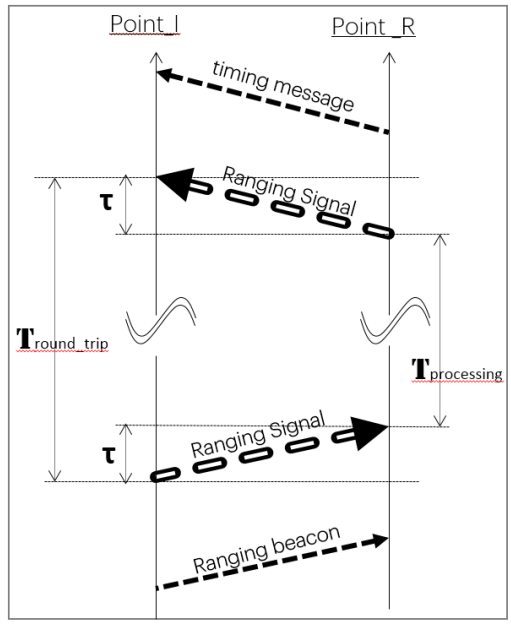


Figure 4 - ToF Measurement

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

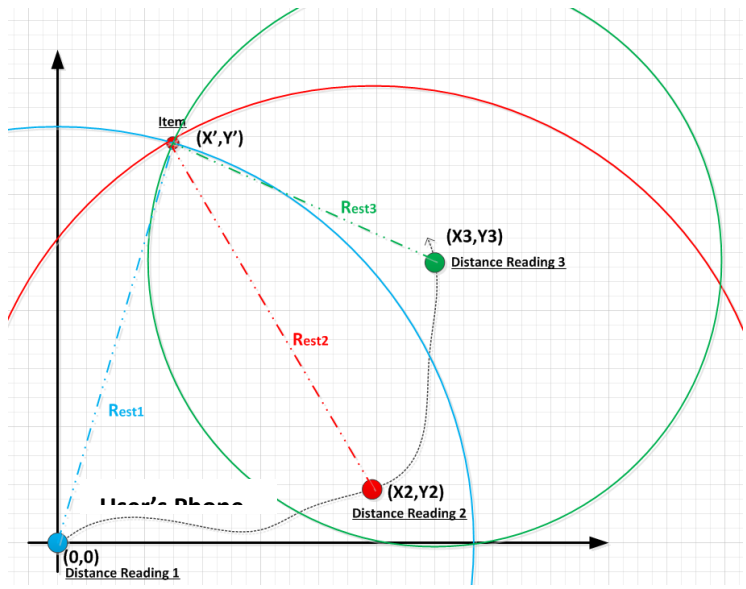


Figure 5 - Triangulation with a single Point

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℃.
Max. Discharge Current	45mA	At 23±2℃ Continues discharge current of 45mA Capacity should be >50% (Till Cut-off voltage)
Max. Discharge Current	75mA	At 23±2℃ Continues discharge cycle of: 3Sec – ON (75mA), 27Sec – OFF (0mA) Capacity should be >50%. (Till Cut-off voltage)
Discharge Cut-off Voltage	2.0V	At Nominal Capacity
Operating Temperature	-20℃~ +60℃	Nominal Capacity varies in temperature
Cell Weight	Approx:2.0g	
Self-Discharge Rate	2%/Year	
Mechanical Dimensions	Length：32.2 mm Max Width：25.0 mm Max Thickness：1.4mm Max	Measured at 23℃ ± 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 Copper: 1oz
Impedance	50Ω	
Supported Frequency Bands	BLE: 2400-2483MHz UWB Ch.2: 3774-4243.2MHz UWB Ch.3: 4243.2-4742.4MHz	

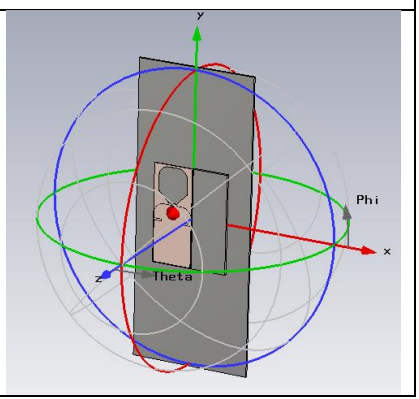
	UWB Ch.5: 6240-6739.2MHz		
Tested Radiation patterns	Antenna Cut Orientations: Cut XZ (Green) Cut XY (Blue) Cut YZ (Red)		

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

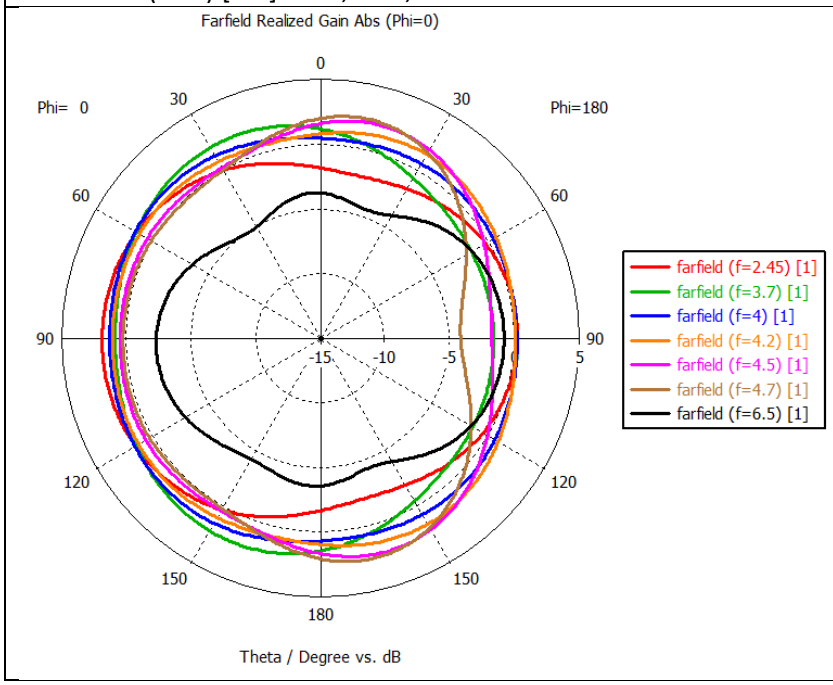


Figure 6: Antenna Gain – XZ

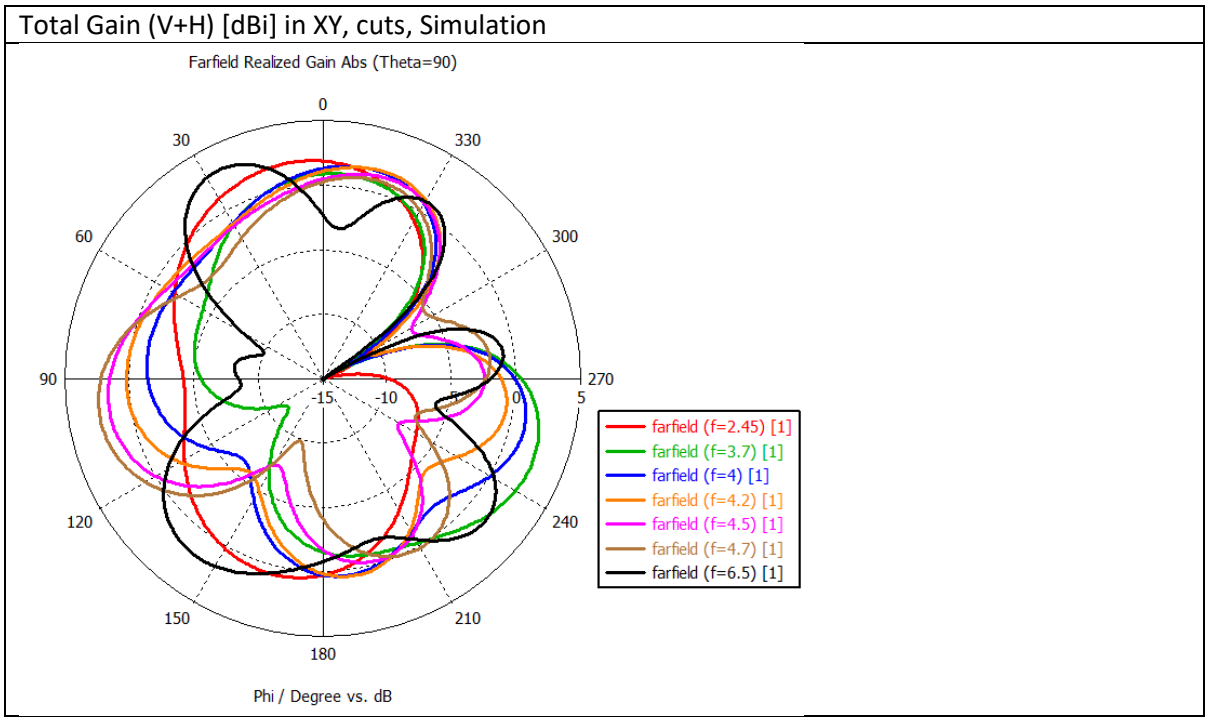


Figure 7: Antenna Gain - XY

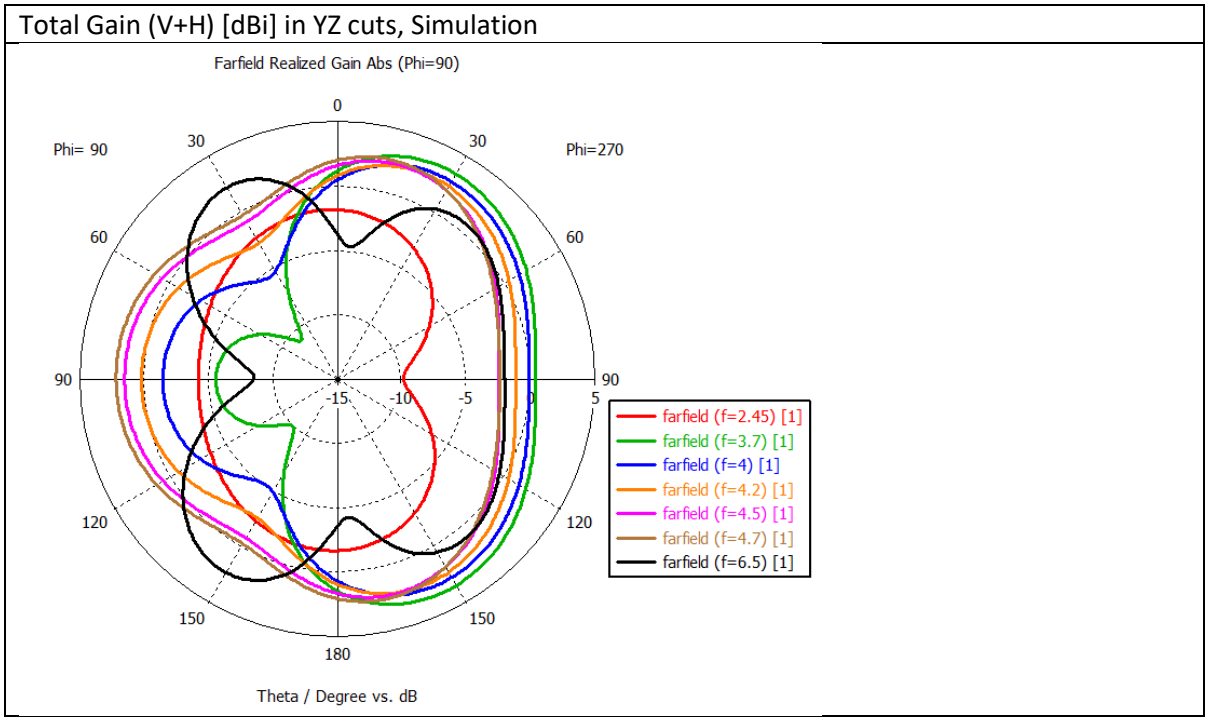


Figure 8: Antenna Gain - YZ

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 Ch.3: 4243.2-4742.4MHz 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 Max 4.0µA	Sleep only , No transmissions or receptions occurs

Table 6: Min / Max sleep current

9.1.5.2 Average Standby current

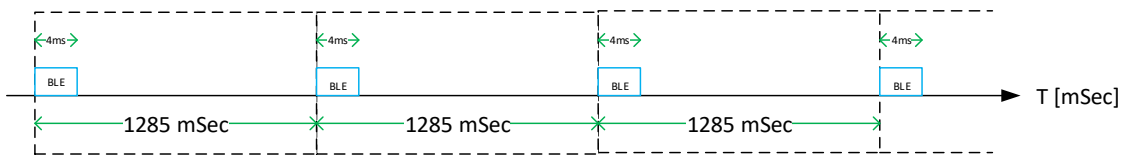


Figure 9: Average standby current

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

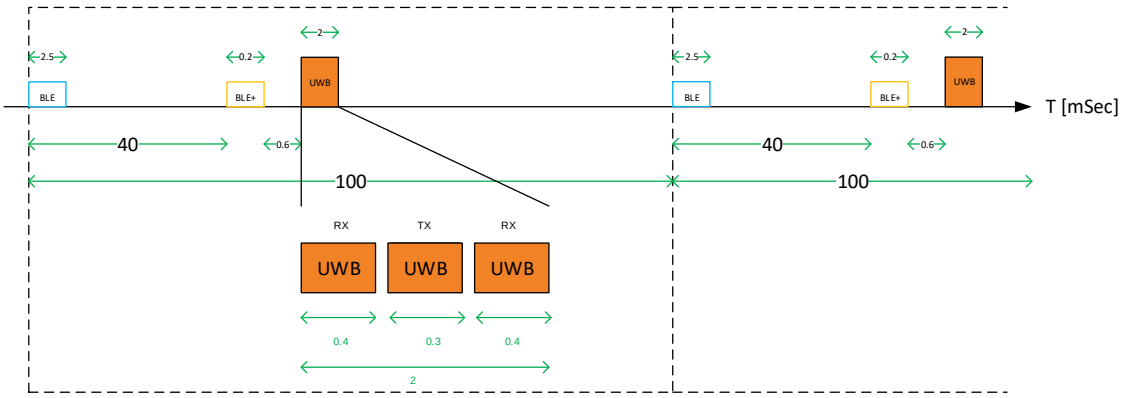


Figure 10: Average operational current

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

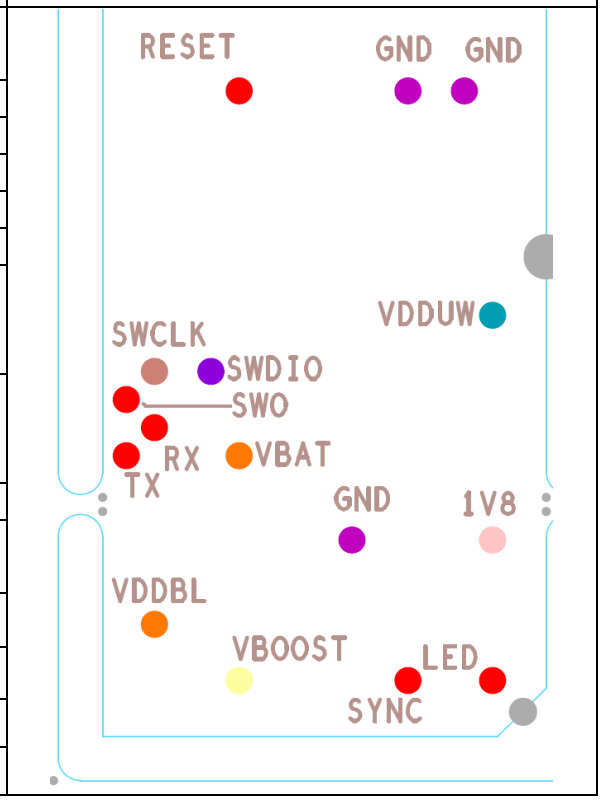
Pin #	Pin Name	Signal Description	Tag Bottom view (ICT side)
1	VDDBL	uP VDDBL output voltage from the Tag. Used for voltage sensing by the J-LINK	
2	UTX	J-LINK UART TX output line	
3	URX	J-LINK UART RX input line	
4	SWDIO	J-LINK SWDIO output line	
5	SWDCK	J-LINK SWDCK output line	
6	LED	TAG LED to measure 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. 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 Regulation Text	Material - Digital Print. CE Marking WEEE Marking Model Number: P1100 FCC ID: 2ADBO-P1100 Industrial Canada ID: 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 Shore Hardness – D80		

Table 14: Materials and Lamination

9.4 Environmental

Parameter	Value	Notes
Operation temperature range	0°C – +45°C	
Storage temperature range	-10°C - +55°C	
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; 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

ELECTRICAL TESTING
0839.01

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

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

This report is in conformity with ISO/ IEC 17025. The "A2LA Accredited" symbol endorsement applies only to the tests and calibrations that are listed in the scope of Hermon Laboratories accreditation. The test results relate only to the items tested. This test report shall not be reproduced in any form except in full with the written approval of Hermon Laboratories Ltd.

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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; 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.

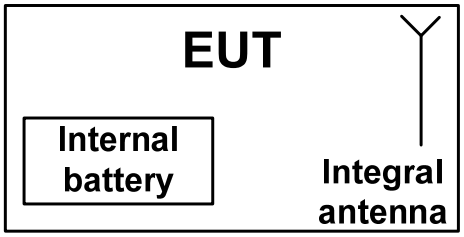
The tag is working in very low duty cycle. Most of the time the tag is advertising (sends BLE standard "existing" message). Advertise is done every 2 sec for 3 msec. The UWB radio is set to deep sleep.

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.

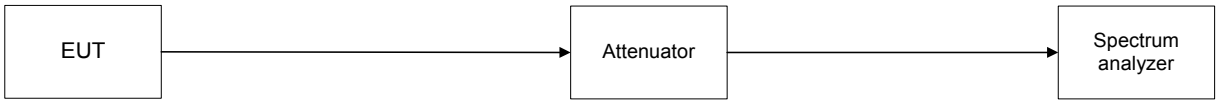
7.1.2 Test procedure

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:

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

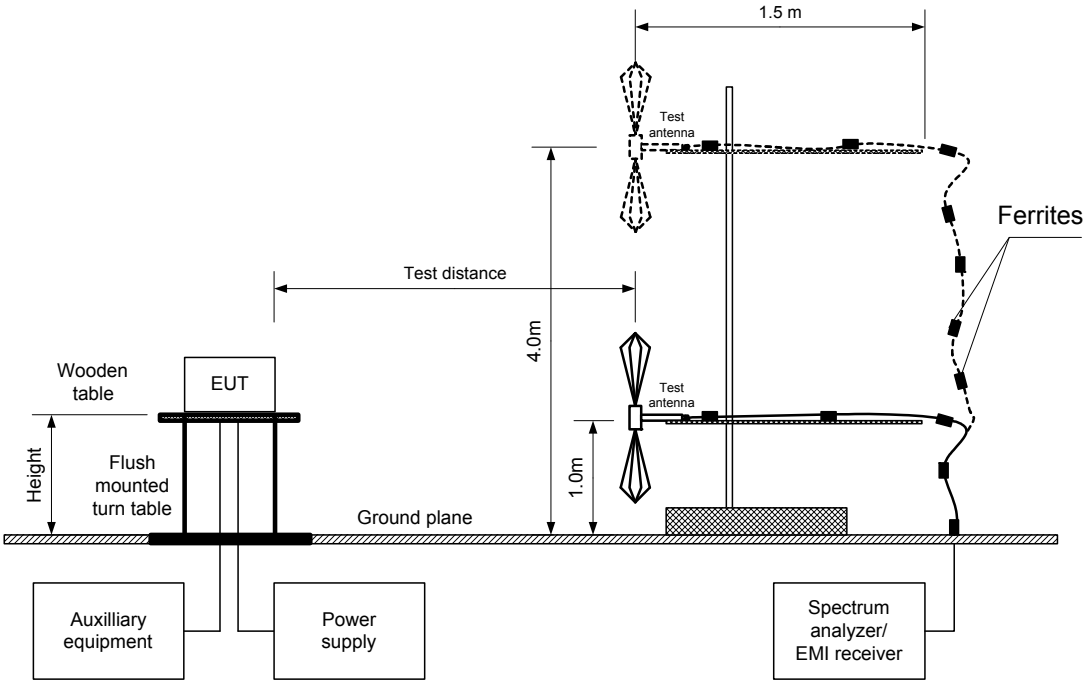
where P is the peak output power in W, E is the field strength in V/m, d is the test distance and G is the transmitter numeric antenna gain over an isotropic radiator.
The above equation was converted in logarithmic units for 3 m test distance:

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

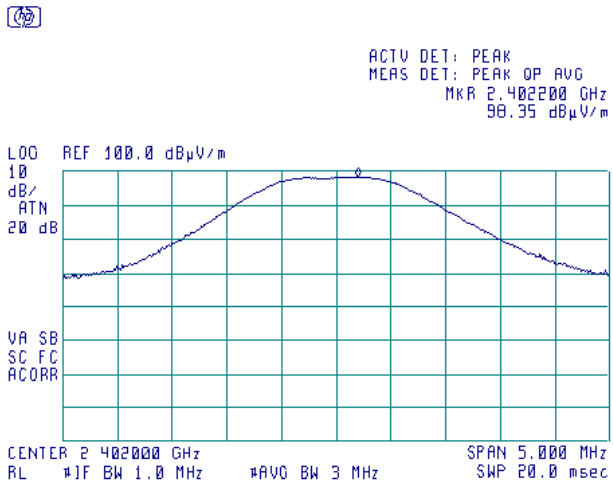
HL 0521	HL 1984	HL 4278	HL 4353				

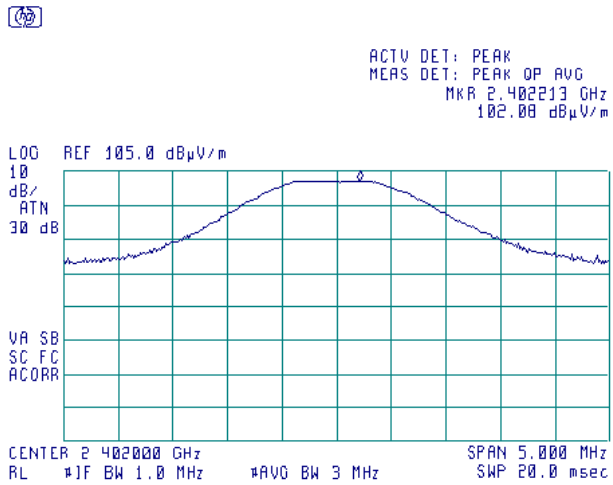
Full description is given in Appendix A.

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 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1005 hPa	**Power:** Battery
Remarks:			

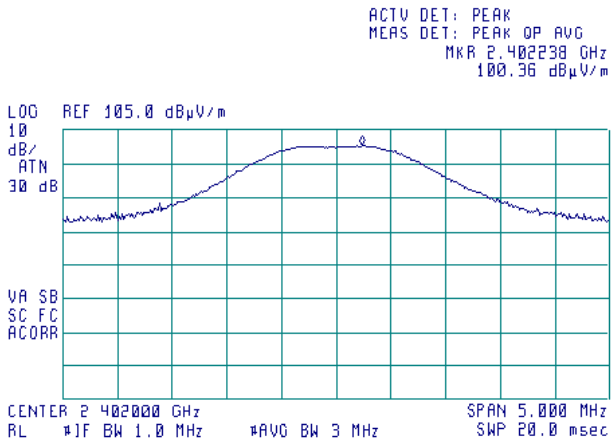
Plot 7.2.1 Field strength of carrier at low frequency

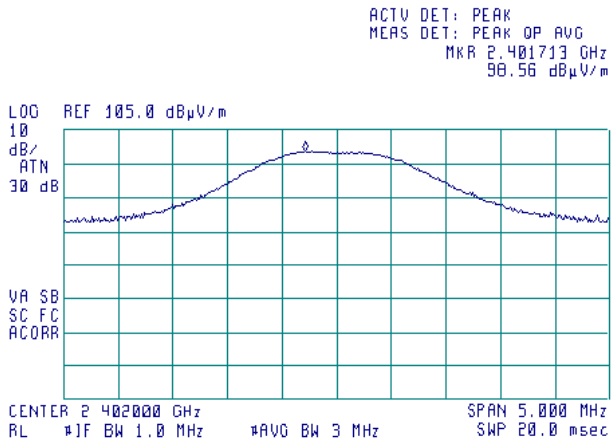
TEST SITE: OATS
TEST DISTANCE: 3 m
ANTENNA POLARIZATION:
Vertical Horizontal
EUT PLANE X-axis





EUT PLANE Y-axis



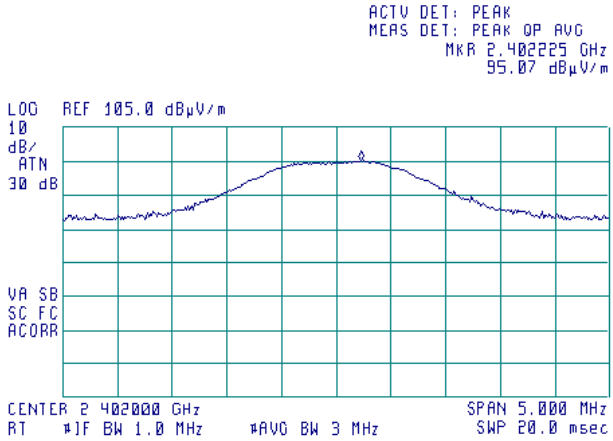


Test specification:	**Section 15.247(b)3 / RSS-247 section 5.4(4), Maximum output power**		
Test procedure:	ANSI C63.10 sections 11.9.2.2.4		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	31-Jul-16 - 14-Aug-16		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1005 hPa	**Power:** Battery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

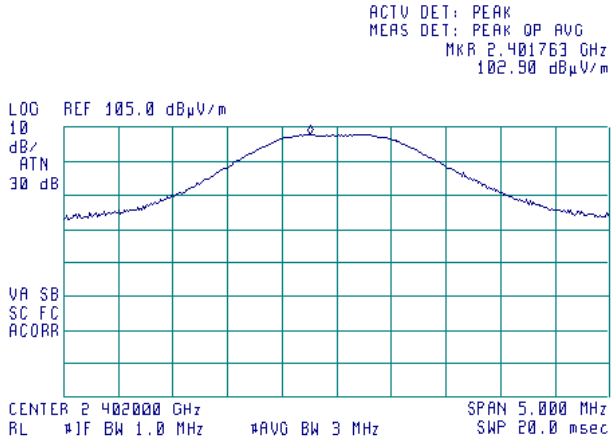
Plot 7.2.2 Field strength of carrier at low frequency

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

EUT PLANE

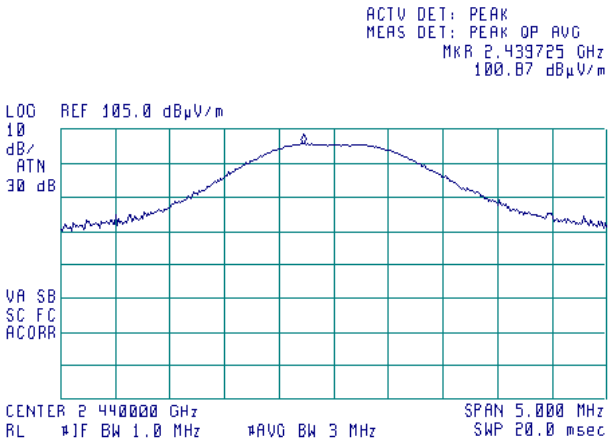


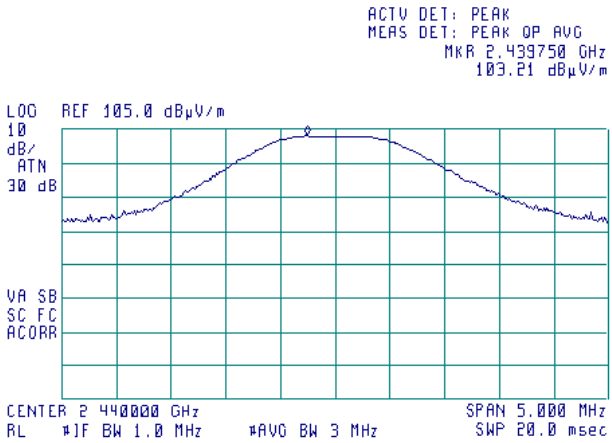
Z-axis



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



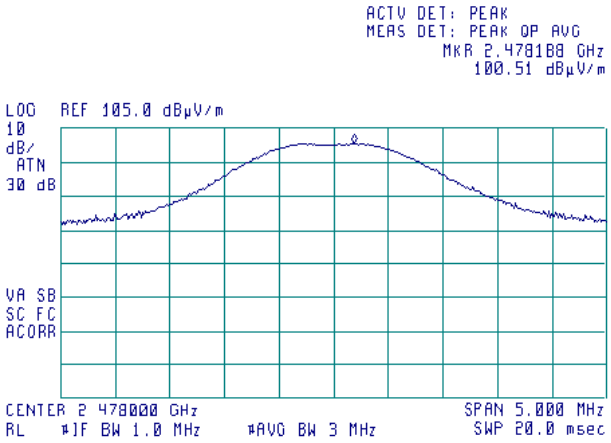
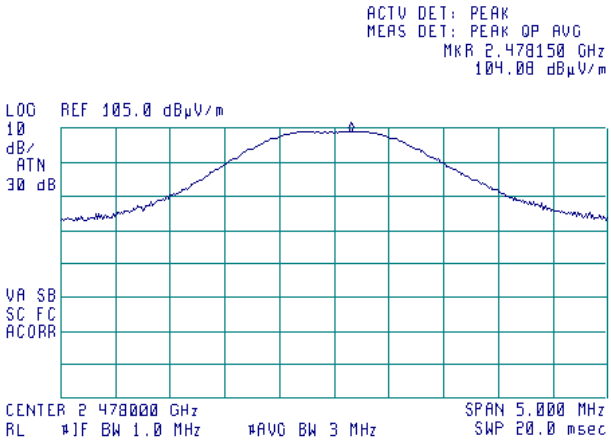


Test specification:	**Section 15.247(b)3 / RSS-247 section 5.4(4), Maximum output power**		
Test procedure:	ANSI C63.10 sections 11.9.2.2.4		
Test mode:	Compliance	**Verdict:**	PASS
Date(s):	31-Jul-16 - 14-Aug-16		
Temperature: 23 ºC	**Relative Humidity:** 55 %	**Air Pressure:** 1005 hPa	**Power:** Battery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