LSR
a Laird Business
W66 N220 Commerce Court ● Cedarburg, WI 53012
Phone: 262.375.4400 ● Fax: 262.375.4248
www.lsr.com

TEST REPORT # 316053 B
LSR Job #: C-2395

Compliance Testing of:
Sterling LWB

Test Date(s):
July 11th to 13th 2016

Prepared For:
Attention: Josh Bablitch
LSR
W66N220 Commerce Ct.
Cedarburg, WI 53012

This Test Report is issued under the Authority of:
Khairul Aidi Zainal, Engineering Manager-Test Services.

Signature:  Date: 7/19/16

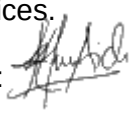
Test Report Reviewed by:	Project Engineer:
Michael Hintzke, EMC Engineer III	Khairul Aidi Zainal, Engineering Manager-Test Services.
Signature:  Date: 7/18/16	Signature:  Date: 7/16/16

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EXHIBIT 1. INTRODUCTION

1.1 - Scope

Normative References:	Article 2 Paragraph 1 of the Certification Ordinance ARIB STD-T66 V2.1 "Second Generation Low Power data Communication System/Wireless LAN System" ARIB STD-T33 1 "Low Power data Communication System/Wireless LAN System" Ordinance Regulating radio Equipment
Purpose of Test:	To test for compliance against the requirements of the Japanese Radio Law for products operating under category WW and Article 2 item (19)
Test procedures:	Radio Law (Law No. 131) Ministerial Ordinance No. 37 (Rules Concerning Technical Regulations Conformity Certification of Specified Radio Equipment) Ordinance Regulating Radio Equipment MIC notice 88 (test methods and appendix to Post of the Ministerial Ordinance N0.37)

1.2 - LS Research, LLC Test Facility

LS Research, LLC is accredited by A2LA (American Association for Laboratory Accreditation) as conforming to ISO/IEC 17025, 2005 “General Requirements for the Competence of Calibration and Testing Laboratories”.

As an EMC Testing Laboratory, our Accreditation and Assessments are recognized through the following:

TESTING CERT #1255.01

A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025: 2005 with Electrical (EMC) Scope of Accreditation
A2LA Certificate Number: 1255.01

Federal Communications Commission (FCC) – USA

Listing of 3 Meter Semi-Anechoic Chamber based on Title 47 CFR – Part 2.948
FCC Registration Number: 90756

Industrie Canada Industry Canada

Canada

Industry Canada

On file, 3 Meter Semi-Anechoic Chamber based on RSS-GEN – Issue 4
File Number: IC 3088A-2
On file, 3 Meter Semi-Anechoic Chamber based on RSS-GEN – Issue 4
File Number: IC 3088A-3

1.3 – Location of Testing

All testing was performed at the following location utilizing the facilities listed below, unless otherwise noted.

LS Research, LLC
W66 N220 Commerce Court
Cedarburg, Wisconsin, 53012 USA,

List of Facilities Located at LS Research, LLC:

Semi-Anechoic Chamber

1.4 – Test Equipment Utilized

A complete list of equipment utilized in testing is provided in Appendix A of this test report. Calibration dates are indicated in Appendix A. All test equipment is calibrated by a calibration laboratory accredited to the requirements of ISO/IEC 17025, and traceable to SI standards.

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1 – Client Information

Manufacturer Name:	LSR
Address:	W66N220 Commerce Ct. Cedarburg. WI 53012
Contact Name:	Josh Bablitch
E-mail address:	Josh.bablitch@lairdtech.com

2.2 - Equipment Under Test (EUT) Information

The following information has been supplied by the applicant.

Product Name:	Sterling-LWB
Model Number:	STERLING-LWB
Serial Number:	33

2.3 - EUT'S Technical Specifications

EUT Frequency Range (in MHz)	2402 MHz to 2480MHz
Antenna Power	☒ Conducted Measurement ☐ Radiated Measurement
Minimum channels (mW/MHz) based on estimation of spreading bandwidth from 20 hopping channels:	GFSK = 0.5152 EDR2 = 0.1659 EDR3 = 0.1665
Maximum channels (mW/MHz):	GFSK = 0.1286 EDR2 = 0.0415 EDR3 = 0.0416
Occupied Bandwidth and Spreading Bandwidth (99% and 90%)	90% (MHz): Maximum channels: GFSK =71.9 EDR2 = 72.4 EDR3 = 72.4 99% (MHz): Maximum channels: GFSK =79.4 EDR2 = 79.4 EDR3 = 79.4
Type of Modulation	GFSK (basic rate), π/4-DQPSK (EDR2), 8DPSK (EDR3)
Frequency Tolerance %, Hz, ppm	Better than 50 ppm
Antenna Information	
Detachable/non-detachable	Non-detachable and detachable
Type	Chip, Dipole, FlexNotch, FlexPIFA
Gain and Pattern	Peak Gain (dBi): Chip = 1.5 Dipole = 2.0 FlexNotch = 2.0 FlexPIFA = 2.0 Pattern : Omni-directional

2.4 - Product Description

The Sterling-LWB is a multi-standard module with support for WLAN (802.11 b/g/n), and Bluetooth V2.1 and Bluetooth 4.0 & 4.1 with multiple antenna options.

This device has been designed to operate with the antenna listed below, and having a maximum gain of 2.0 dBi. The required antenna impedance is 50 ohms.

Chip Antenna: Johanson Part # 2450AT18D0100 Peak Gain 1.5 dBi

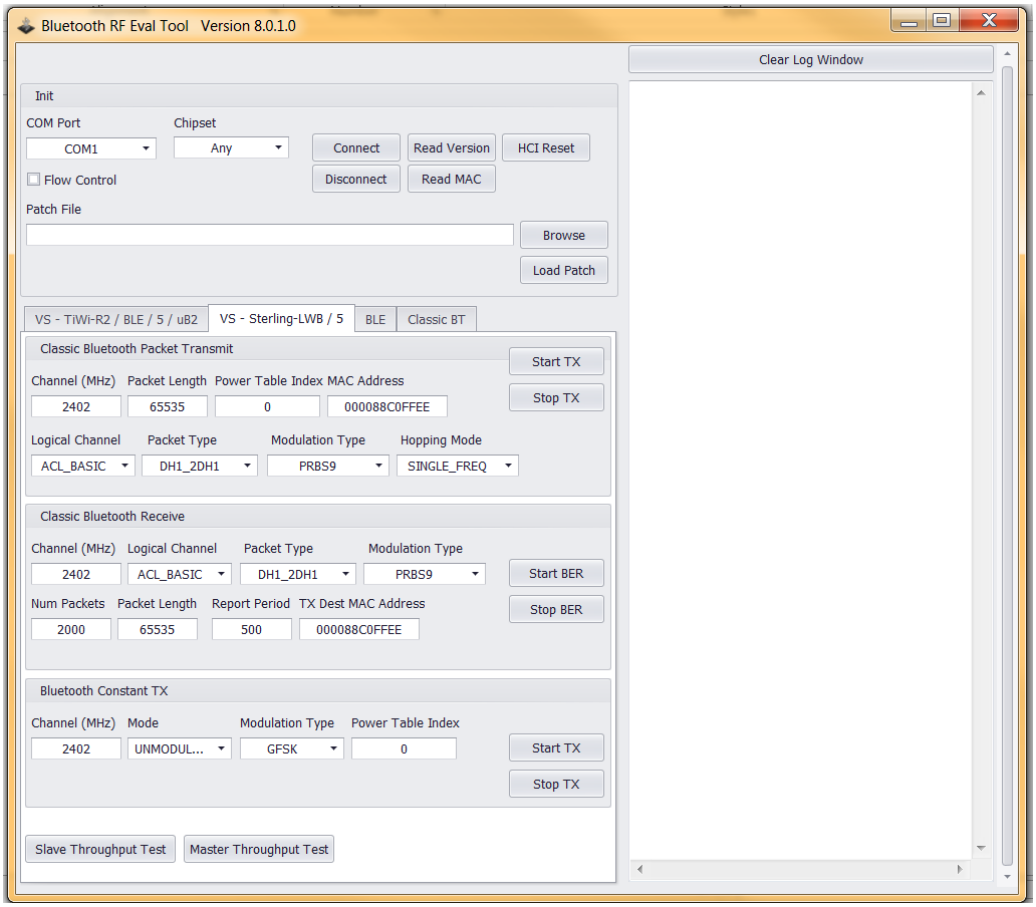
U.FL Antenna port utilizes the following antenna options:

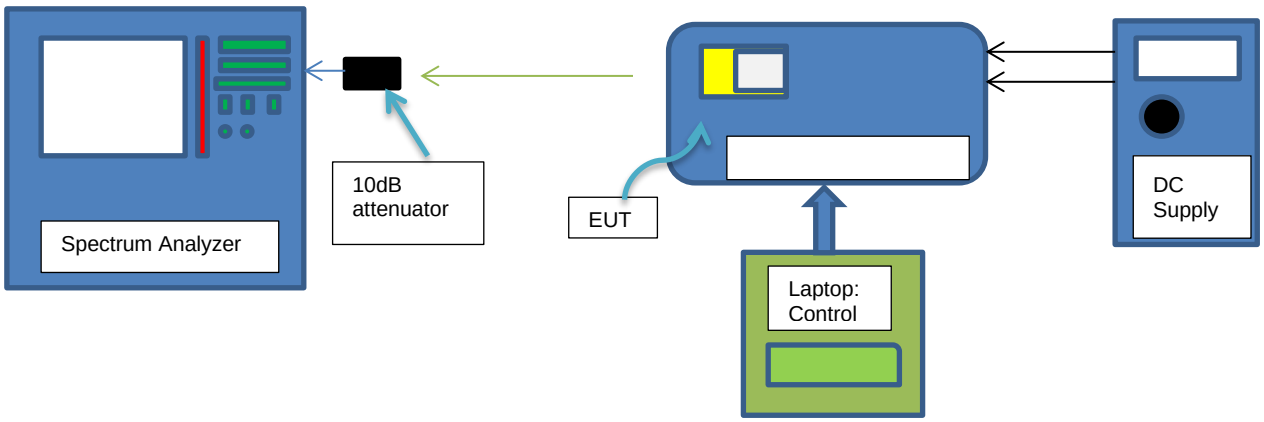
LSR 2.4 GHz Dipole Antenna 2dBi
LSR 2.4 GHz FlexPIFA 2dBi
LSR 2.4 GHz FlexNotch 2dBi

2.5 – Test Configuration

The EUT was powered using a switching mode power supply. The power supply was set to the nominal (+3.3 VDC) voltage and ±10% of the nominal voltage for testing (+3.6 VDC and + 3.0 VDC).

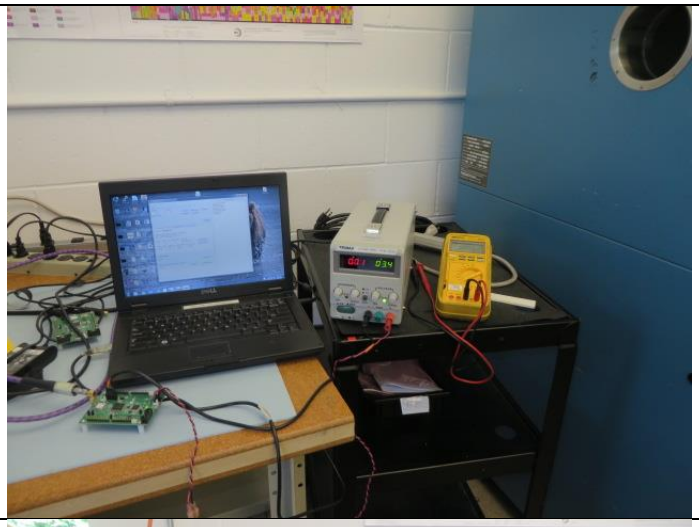
The EUT was connected to a laptop running the Bluetooth RF Eval Tool, Version 8.0.1.0 proprietary software. The EUT was connected to this laptop via a USB A to USB mini cable. The image below is a screen shot of the main control screen:





Test Setup photos:

Conducted Measurement Setup



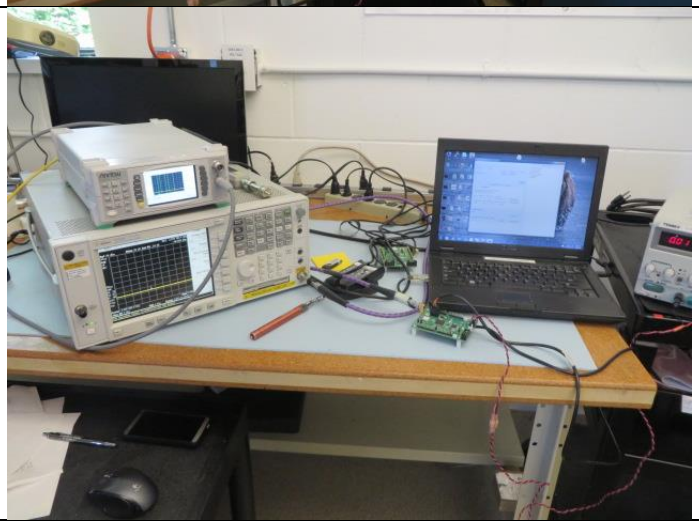


EXHIBIT 3. EUT OPERATING CONDITIONS & CONFIGURATIONS DURING TESTS

3.1 - Climate Test Conditions

Temperature:	70-71° F
Humidity:	32-35%
Pressure:	729-742mmHg

3.2 - Summary Of Test Results

Ordinance Number	Description	Compliance (Yes/No)
Article 49.20	Frequency Allocation	Yes
Article 5, Annex 1	Frequency Tolerance	Yes
Article 49.20	Antenna Power	Yes
Article 14	Output Power Tolerance	Yes
Article 49.20	Spreading Bandwidth	Yes
Article 6, Annex 2 30	Occupied Bandwidth	Yes
Article 49.20	E.I.R.P	Yes
Article 49.20	Antenna Absolute gain	Yes
Article 49.20	Spreading Factor	Yes
Article 7, Annex 3	Transmitter Spurious emissions	Yes
Article 24	Secondary/receiver emissions	Yes
Article 49.20	Dwell Time	Yes
Article 49.20	Housing Requirement	Yes
Article 9.4.9	Interference Prevention function	Yes
Article 15.1	Voltage fluctuation	Yes
Article 49.20	OFDM Sub-carriers	N/A

3.3 - Modifications Incorporated In The EUT For Compliance Purposes

☒ None ☐ Yes (explain below)

3.4 - Deviations & Exclusions From Test Specifications

☒ None ☐ Yes (explain below)

EXHIBIT 4. DECLARATION OF CONFORMITY

The EUT was found to MEET the requirements for a Direct Sequence Spread Spectrum and OFDM Transmitter device under Article 2 Paragraph 1 of the Certification Ordinance.

LSR certifies that the data contained herein was taken under conditions that meet or exceed the requirements of the test specifications. The results in this Test Report apply only to the item(s) tested on the above-specified dates. Any modifications made to the EUT subsequent to the indicated test date(s) will invalidate the data herein, and void this certification.

EXHIBIT 5: Frequency Allocation.

Test Engineer:	Khairul Aidi Zainal
Test Date:	11

Requirement:

The requirement per Article 49.20 of the Ordinance Regulating Radio equipment authorizes equipment within the range 2400 MHz to 2483.5MHz

Result:
The EUT was found to operate between:

1. 2402 MHz to 2480 MHz for Bluetooth mode.

The EUT Complies with the requirements of the Ordinance regulating Radio Equipment.

EXHIBIT 6: Frequency Tolerance.

Test Engineer:	Aidi Zainal
Test Date:	7/11/2016

Requirement:

Article 5, Annex 1 tables 7-8 of the Ordinance regulating Radio Equipment has a limit of ±50ppm.

Test note:

1. EUT was set to single channel transmission (low, medium and high).
2. EUT was set to continuously transmitting un-modulated.
3. Frequency counter function of the Spectrum analyzer was used to measure the frequency.
4. Measurement performed at nominal, +10% nominal and -10% nominal supply voltage.

Result:

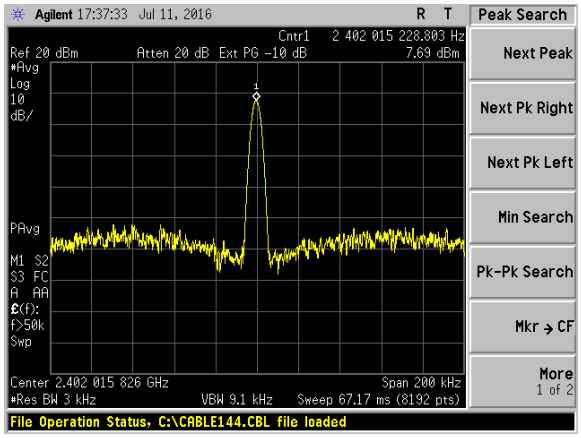
The EUT had a maximum deviation of 221Hz which is better than 50ppm. The EUT complies with the requirement of the Ordinance regulating Radio Equipment.

Data:

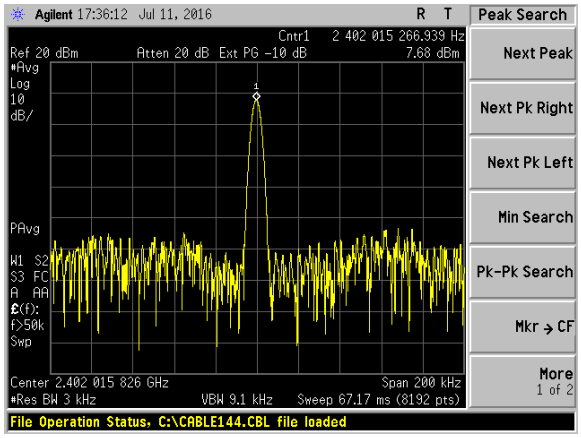
	Channel Frequency (Hz)			
Channel	Nominal	+10%	-10%	Max Deviation (Hz)
Low	2402015228	2402015266	2402015244	38
Middle	2440019822	2440019691	2440019912	221
High	2480024549	2480024517	2480024538	32

Screen Captures (Only low channel presented):

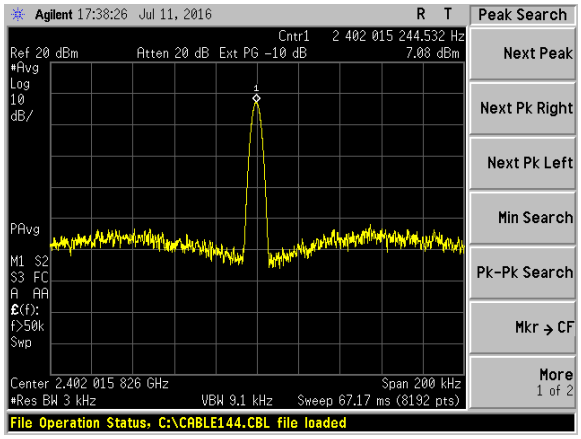
2402 MHz:



Nominal Supply Voltage (3.3 VDC)



+10% Nominal Supply Voltage (3.6 VDC)



-10% Nominal Supply Voltage (3.0 VDC)

EXHIBIT 7. Antenna Power and EIRP Power Density

Test Engineer:	Khairul Aidi Zainal
Test Date:	7/11/16 – 7/12/16

Requirement:

Article 49.20 of the Ordinance regulating Radio Equipment allows an absolute maximum (including +20% tolerance) antenna power of 3mW/MHz for an FHSS system that occupies the frequency range 2400 to 2483.5 MHz. The maximum EIRP power density allowed is 12.14 dBm/MHz for non-directional antennas and 22.14 dBm/MHz for directional antennas.

Test note:

1. For classic Bluetooth measurement, the EUT was set to hopping mode (79 channels).
2. Measurement performed at nominal, +10% nominal and -10% nominal supply voltage.
3. Hopping settings:
    a. GFSK
    b. EDR2
    c. EDR3
4. Measurement procedure: Wide band power sensor attached to power meter.
    a. Measured power is then divided by the spreading bandwidth (in MHz)
5. An estimation of the spreading bandwidth was used to determine antenna power for the minimum channel mode of AFH. The minimum channel used in AFH mode is 20:
    a. Spreading bandwidth (minimum) = [Spreading bandwidth (maximum)/maximum number of channels(80)] * minimum number of channels (20)
    b. GFSK Example:
    Spreading bandwidth (minimum) = [71.8MHz/80]*20
    = 18.0 MHz.
    Antenna power (minimum channel) = 9.247/18.0 = 0.5152 mW/MHz

Result:

The EUT is compliant to the requirement of the Ordinance regulating Radio Equipment.

Data:

A. Maximum channels

	GFSK											
EUT supply voltage (V)	RMS power (dBm)	RMS power (mW)	Spreading BW (MHz)	RMS power (mW/MHz)	RMS power (dBm/MHz)	RMS power limit (dBm/MHz)	RMS power margin (dB)	Antenna Gain (dBi)	EIRP (dBm/MHz)	EIRP (mW/MHz)	EIRP limit (dBm/MHz)	EIRP margin (dB)
3.3VDC (Nominal)	9.1	8.128	71.8	0.1132	-9.5	4.0	13.5	2.0	-7.5	0.179	6.1	13.6
2.97VDC (-10%)	8.5	7.129	71.8	0.0992	-10.0	4.0	14.0	2.0	-8.0	0.157	6.1	14.1
3.6VDC (Max declared)	9.7	9.247	71.9	0.1286	-8.9	4.0	12.9	2.0	-6.9	0.204	6.1	13.0

	EDR2											
EUT supply voltage (V)	RMS power (dBm)	RMS power (mW)	Spreading BW (MHz)	RMS power (mW/MHz)	RMS power (dBm/MHz)	RMS power limit (dBm/MHz)	RMS power margin (dB)	Antenna Gain (dBi)	EIRP (dBm/MHz)	EIRP (mW/MHz)	EIRP limit (dBm/MHz)	EIRP margin (dB)
3.3VDC (Nominal)	4.7	2.917	72.4	0.0403	-13.9	4.0	17.9	2.0	-11.9	0.064	6.1	18.0
2.97VDC (-10%)	4.4	2.729	72.3	0.0378	-14.2	4.0	18.2	2.0	-12.2	0.060	6.1	18.3
3.6VDC (Max declared)	4.8	2.999	72.3	0.0415	-13.8	4.0	17.8	2.0	-11.8	0.066	6.1	17.9

	EDR3											
EUT supply voltage (V)	RMS power (dBm)	RMS power (mW)	Spreading BW (MHz)	RMS power (mW/MHz)	RMS power (dBm/MHz)	RMS power limit (dBm/MHz)	RMS power margin (dB)	Antenna Gain (dBi)	EIRP (dBm/MHz)	EIRP (mW/MHz)	EIRP limit (dBm/MHz)	EIRP margin (dB)
3.3VDC (Nominal)	4.5	2.838	72.4	0.0392	-14.1	4.0	18.1	2.0	-12.1	0.062	6.1	18.2
2.97VDC (-10%)	4.2	2.624	72.4	0.0363	-14.4	4.0	18.4	2.0	-12.4	0.057	6.1	18.5
3.6VDC (Max declared)	4.8	3.013	72.4	0.0416	-13.8	4.0	17.8	2.0	-11.8	0.066	6.1	17.9

Note:

1. The limits listed in the tables take into account the upper end of the output power tolerance (+20%) hence is shown to be lower than the 3mW/MHz

B. Minimum Channels

	GFSK											
EUT supply voltage (V)	RMS power (dBm)	RMS power (mW)	Spreading BW (MHz)	RMS power (mW/MHz)	RMS power (dBm/MHz)	RMS power limit (dBm/MHz)	RMS power margin (dB)	Antenna Gain (dBi)	EIRP (dBm/MHz)	EIRP (mW/MHz)	EIRP limit (dBm/MHz)	EIRP margin (dB)
15.0VDC (Nominal)	9.1	8.128	18.0	0.4528	-3.4	4.0	7.4	1.5	-1.9	0.640	6.1	8.0
13.5 VDC (-10%)	8.5	7.129	18.0	0.3971	-4.0	4.0	8.0	1.5	-2.5	0.561	6.1	8.6
16.5 VDC (+10%)	9.7	9.247	18.0	0.5152	-2.9	4.0	6.9	1.5	-1.4	0.728	6.1	7.5

	EDR2											
EUT supply voltage (V)	RMS power (dBm)	RMS power (mW)	Spreading BW (MHz)	RMS power (mW/MHz)	RMS power (dBm/MHz)	RMS power limit (dBm/MHz)	RMS power margin (dB)	Antenna Gain (dBi)	EIRP (dBm/MHz)	EIRP (mW/MHz)	EIRP limit (dBm/MHz)	EIRP margin (dB)
15.0VDC (Nominal)	4.7	2.917	18.1	0.1612	-7.9	4.0	11.9	1.5	-6.4	0.228	6.1	12.5
13.5 VDC (-10%)	4.4	2.729	18.1	0.1510	-8.2	4.0	12.2	1.5	-6.7	0.213	6.1	12.8
16.5 VDC (+10%)	4.8	2.999	18.1	0.1659	-7.8	4.0	11.8	1.5	-6.3	0.234	6.1	12.4

	EDR3											
EUT supply voltage (V)	RMS power (dBm)	RMS power (mW)	Spreading BW (MHz)	RMS power (mW/MHz)	RMS power (dBm/MHz)	RMS power limit (dBm/MHz)	RMS power margin (dB)	Antenna Gain (dBi)	EIRP (dBm/MHz)	EIRP (mW/MHz)	EIRP limit (dBm/MHz)	EIRP margin (dB)
15.0VDC (Nominal)	4.5	2.838	18.1	0.1569	-8.0	4.0	12.0	1.5	-6.5	0.222	6.1	12.6
13.5 VDC (-10%)	4.2	2.624	18.1	0.1451	-8.4	4.0	12.4	1.5	-6.9	0.205	6.1	13.0
16.5 VDC (+10%)	4.8	3.013	18.1	0.1665	-7.8	4.0	11.8	1.5	-6.3	0.235	6.1	12.4

Note:

1. The limits listed in the tables take into account the upper end of the output power tolerance (+20%) hence is shown to be lower than the 3mW/MHz

EXHIBIT 8. Absolute Antenna Gain

Test Engineer:	N/A
Test Date:	N/A

Requirement:

The absolute maximum antenna gain allowed by Article 49.20 of the Ordinance regulating Radio Equipment is 12.14 dBi.

Result:

This device has been designed to operate with the antenna listed below, and having a maximum gain of 2.0 dBi. The required antenna impedance is 50 ohms.

Chip Antenna: Johanson Part # 2450AT18D0100 Peak Gain 1.5 dBi

U.FL Antenna port utilizes the following antenna options:

LSR 2.4 GHz Dipole Antenna 2dBi
LSR 2.4 GHz FlexPIFA 2dBi
LSR 2.4 GHz FlexNotch 2dBi

The peak gain value is below the stated limit and is therefore compliant to the requirement of the Ordinance regulating Radio Equipment.

Data:

The information provided was taken from the antenna manufacturer's data sheet.

Chip Antenna:

"High Frequency Ceramic Solutions"

2.45 GHz SMD Antenna, EIA 1210, Detuning resilient, Edge Mount Design — P/N 2450AT18D0100

Detail Specification: 9/17/2015 — Page 1 of 6

This antenna is optimal for edge middle mounting; rectangular and circular PCB shape applications, go to pages 2-4 for more info.

General Specifications			
Part Number	2450AT18D0100	Input/Output Power	2W max. (CW)
Frequency (MHz)	2400 - 2500	Impedance	50 Ω
Peak Gain	1.5 dBi typ. (XZ-total)	Reel Quantity	3,000
Average Gain	-1.0 dBi typ. (XZ-total)	Storage Temp	-40 to +85°C
Return Loss	10.0 dB min.	Total Radiation Efficiency[1]	72%
Operating Temperature	-40 to +125°C		

[1]Efficiency measured on 2450AT18D0100-EB1GMA 40x20mm EVB on page 2

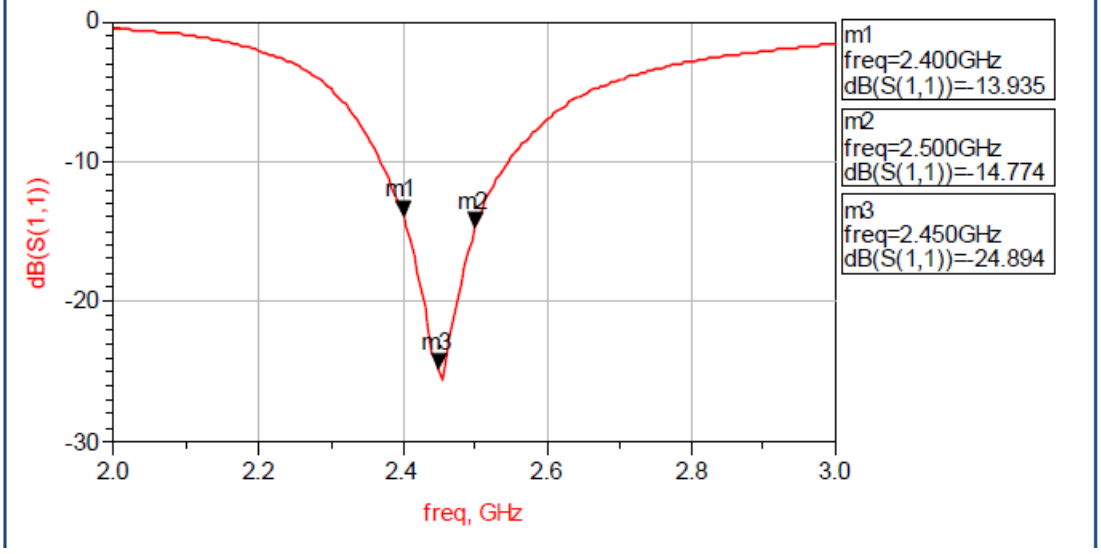
"High Frequency Ceramic Solutions"

2.45 GHz SMD Antenna, EIA 1210, Detuning resilient, Edge Mount Design — P/N 2450AT18D0100

Detail Specification: 04/04/12 — Page 3 of 5

This antenna is optimal for edge middle mounting; rectangular and circular PCB shape applications, go to pages 2-4 for more info.

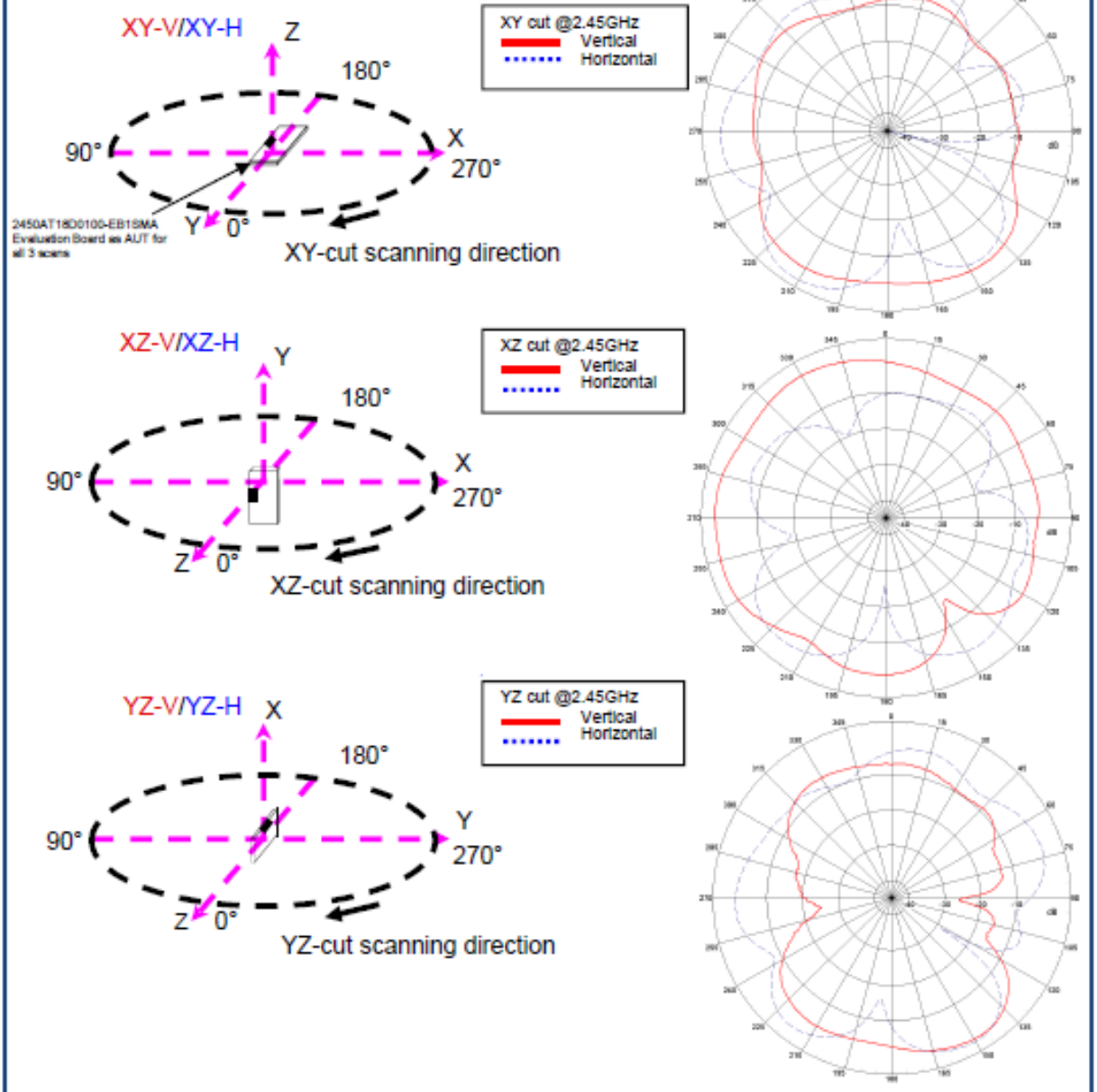
Typical Return Loss (S11) Electrical Performance (T=25°C)



This antenna is optimal for edge middle mounting; rectangular and circular PCB shape applications, go to pages 2-4 for more info.

Typical EM Radiation Performance (T=25°C)

Typical Radiation Patterns



Dipole Antenna:

2.4 GHz – 2.5 GHz Dipole 2dBi Antenna for Reverse Polarity SMA

ORDERING INFORMATION

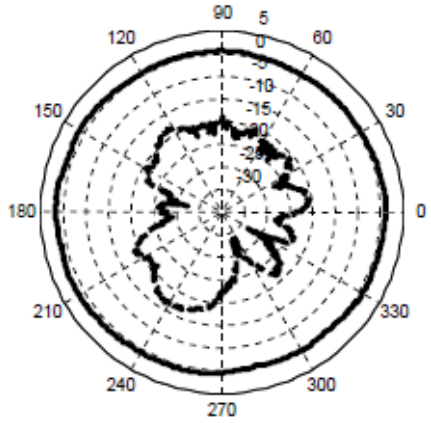
Order Number	Description
001-0001	2.4 GHz dipole antenna for reverse polarity SMA connector.

SPECIFICATIONS

Specification	Value
Gain	+2 dBi
Impedance	50 ohms, Nominal
Type	Dipole
Polarization	Linear Vertical
VSWR	≤2.5 : 1, Maximum
Frequency	2400-2500MHz
Weight	13g
Size	105×10 mm
Antenna Color	Black

TYPICAL ANTENNA RADIATION PERFORMANCE

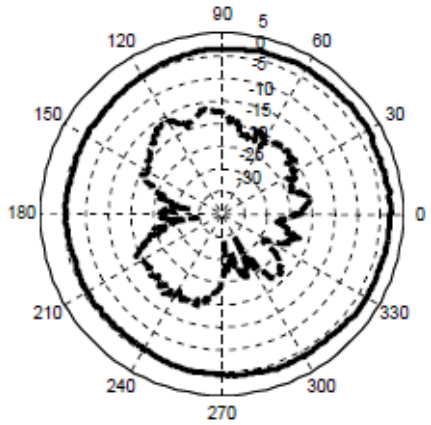
LSR ANTENNA STRAIGHT 2405 MHz



____Vertical Polarization Gain (dBi)

------ Horizontal Polarization Gain (dBi)

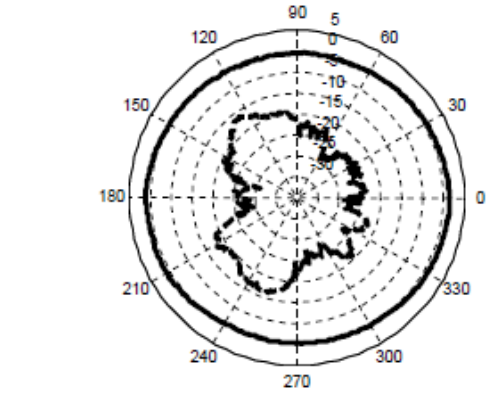
LSR ANTENNA STRAIGHT 2440 MHz



____Vertical Polarization Gain (dBi)

------ Horizontal Polarization Gain (dBi)

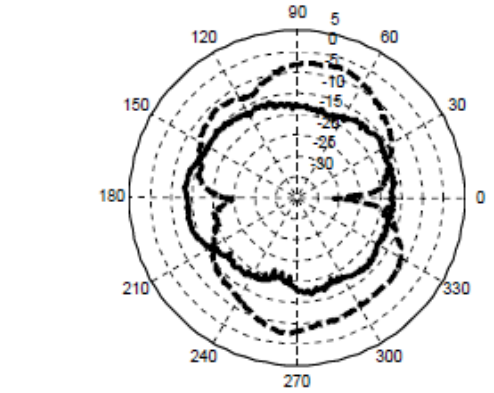
LSR ANTENNA STRAIGHT 2480 MHz



____Vertical Polarization Gain (dBi)

----- Horizontal Polarization Gain (dBi)

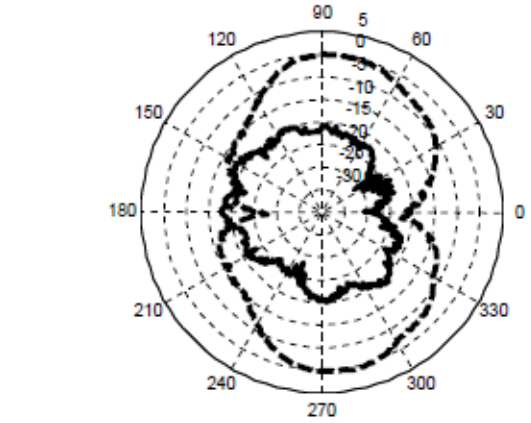
LSR ANTENNA BENT 2405 MHz



____Vertical Polarization Gain (dBi)

----- Horizontal Polarization Gain (dBi)

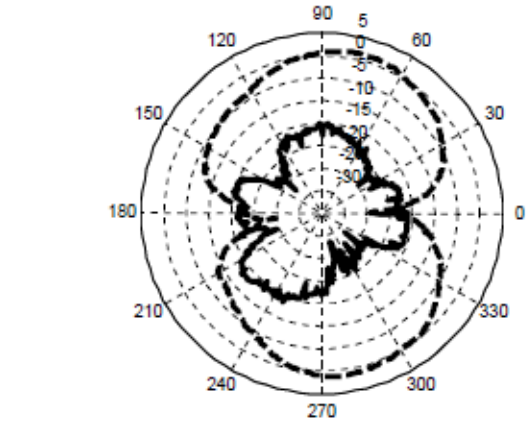
LSR ANTENNA BENT 2440 MHz



____Vertical Polarization Gain (dBi)

------ Horizontal Polarization Gain (dBi)

LSR ANTENNA BENT 2480 MHz



____Vertical Polarization Gain (dBi)

------ Horizontal Polarization Gain (dBi)

FlexNotch Antenna:

2.4 GHz – 2.5 GHz FlexNotch 2 dBi Antenna w/U.FL Cable, 100mm

ORDERING INFORMATION

Order Number	Description
001-0015	2.4 GHz FlexNotch Antenna w/U.FL Cable, 100mm
001-0023	2.4GHz FlexNotch Antenna w/ MHF4L Cable, 100mm

Table 1 Orderable Part Numbers

SPECIFICATIONS

Specification	Value
Peak Gain	+2 dBi
Average Gain	>-1.6 dBi
Impedance	50 ohms
Type	Flexible Notch
Polarization	Linear
VSWR	< 2.5:1, 2400 - 2480 MHz
Frequency	2400 – 2480 MHz
Weight	0.85g
Size	32.0mm × 21.08mm
Antenna Color	Clear Yellow
Adhesive	3M 100MP
Operating Temp	-40°C to +85°C

Table 2 Specifications

Horizontal Orientation at 2440 MHz:

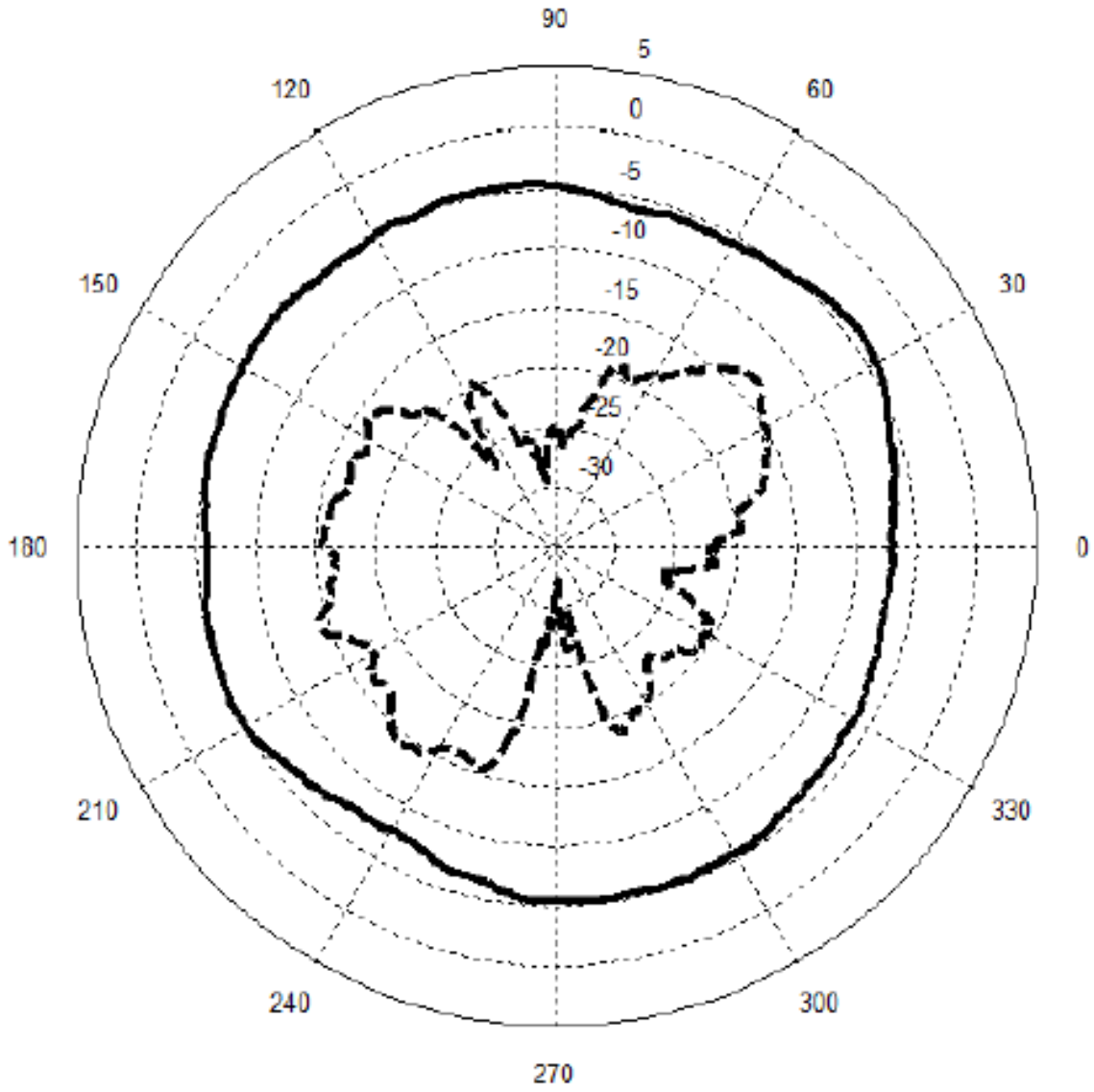


Figure 4 Horizontal Orientation Pattern

Vertical Orientation at 2440 MHz:

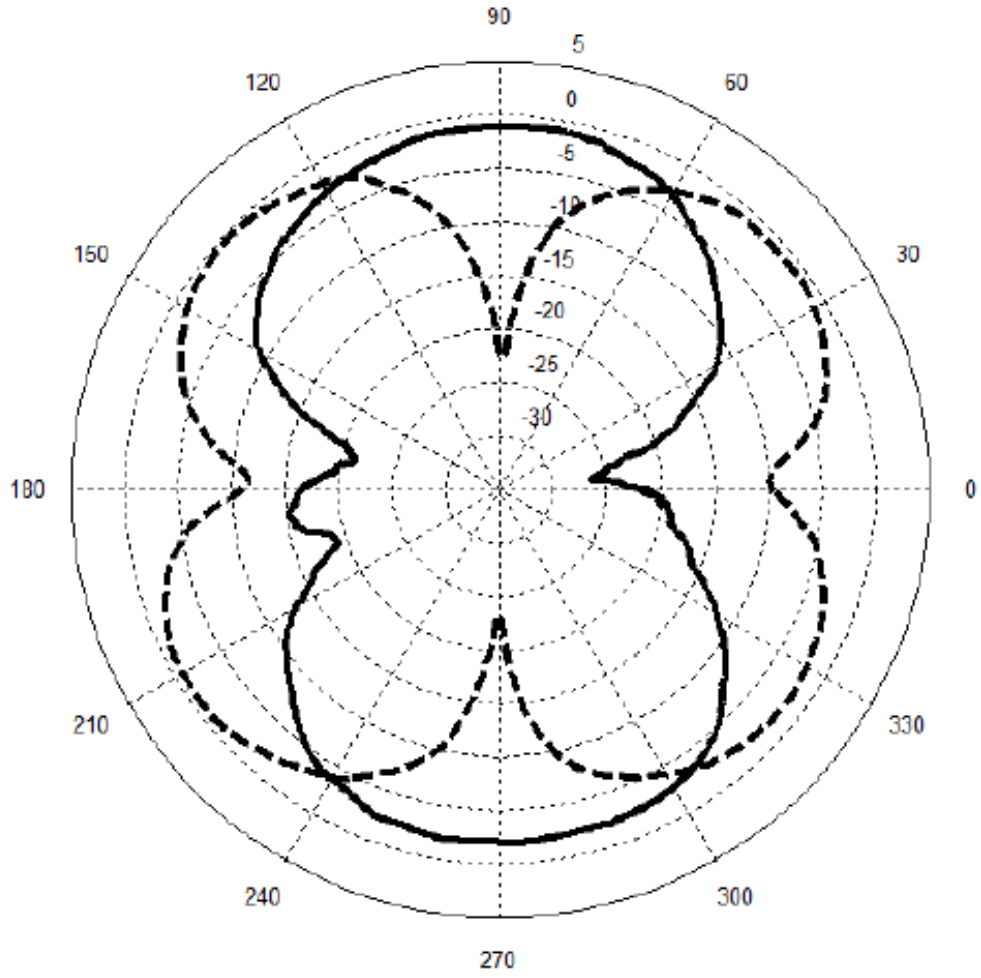


Figure 6 Vertical Orientation Pattern

Flat Orientation at 2440 MHz:

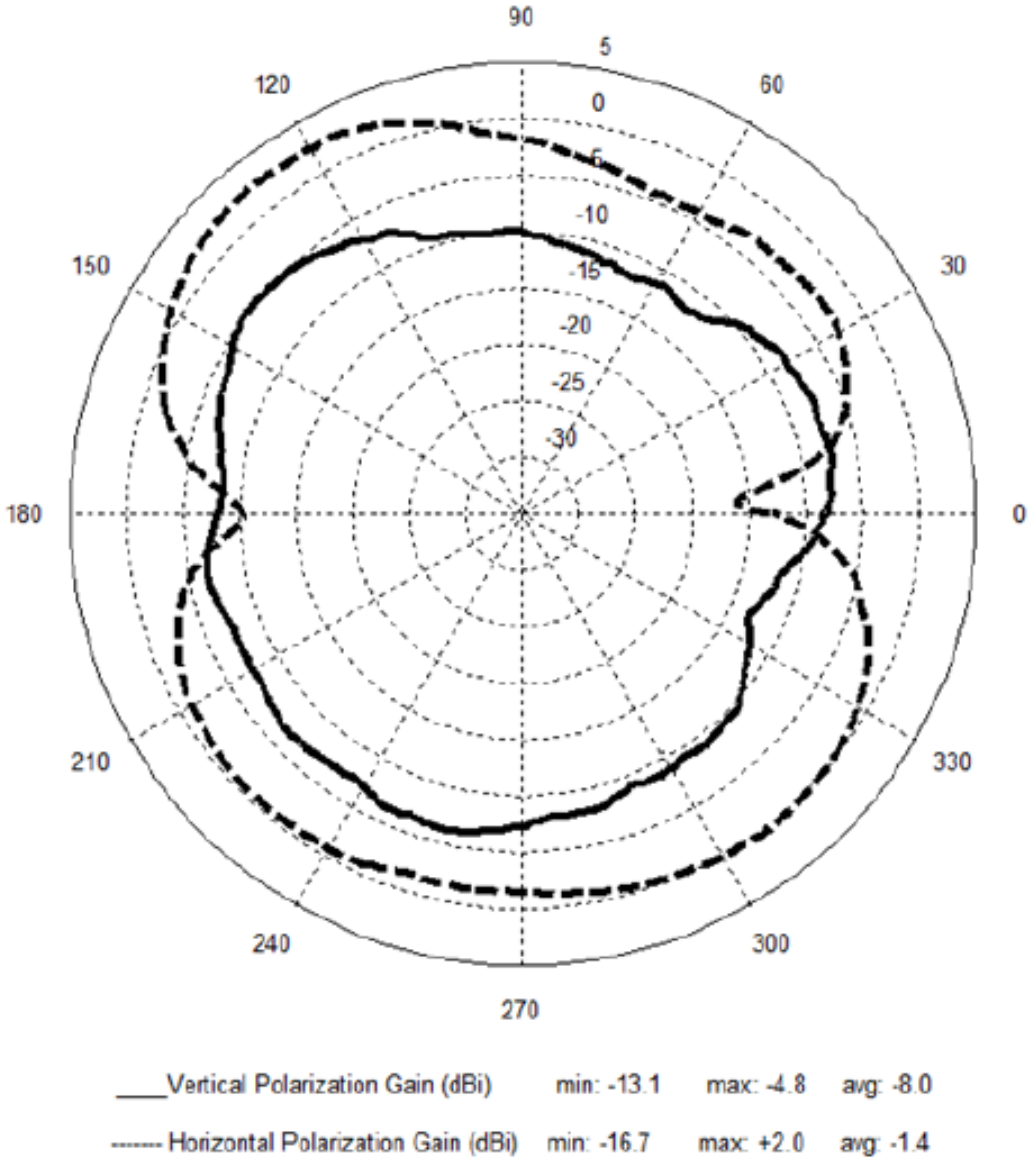


Figure 8 Flat Orientation Pattern

FlexPIFA antenna:

LSR
Design. Create. Certify. Connect.

2.4 GHz FlexPIFA Antenna, 100mm
Datasheet

2.4 GHz – 2.5 GHz FlexPIFA 2 dBi Antenna w/U.FL Cable, 100mm

ORDERING INFORMATION

Order Number	Description
001-0014	2.4 GHz FlexPIFA Antenna w/U.FL Cable, 100mm
001-0022	2.4GHz FlexPIFA Antenna w/MHF4L Cable, 100mm

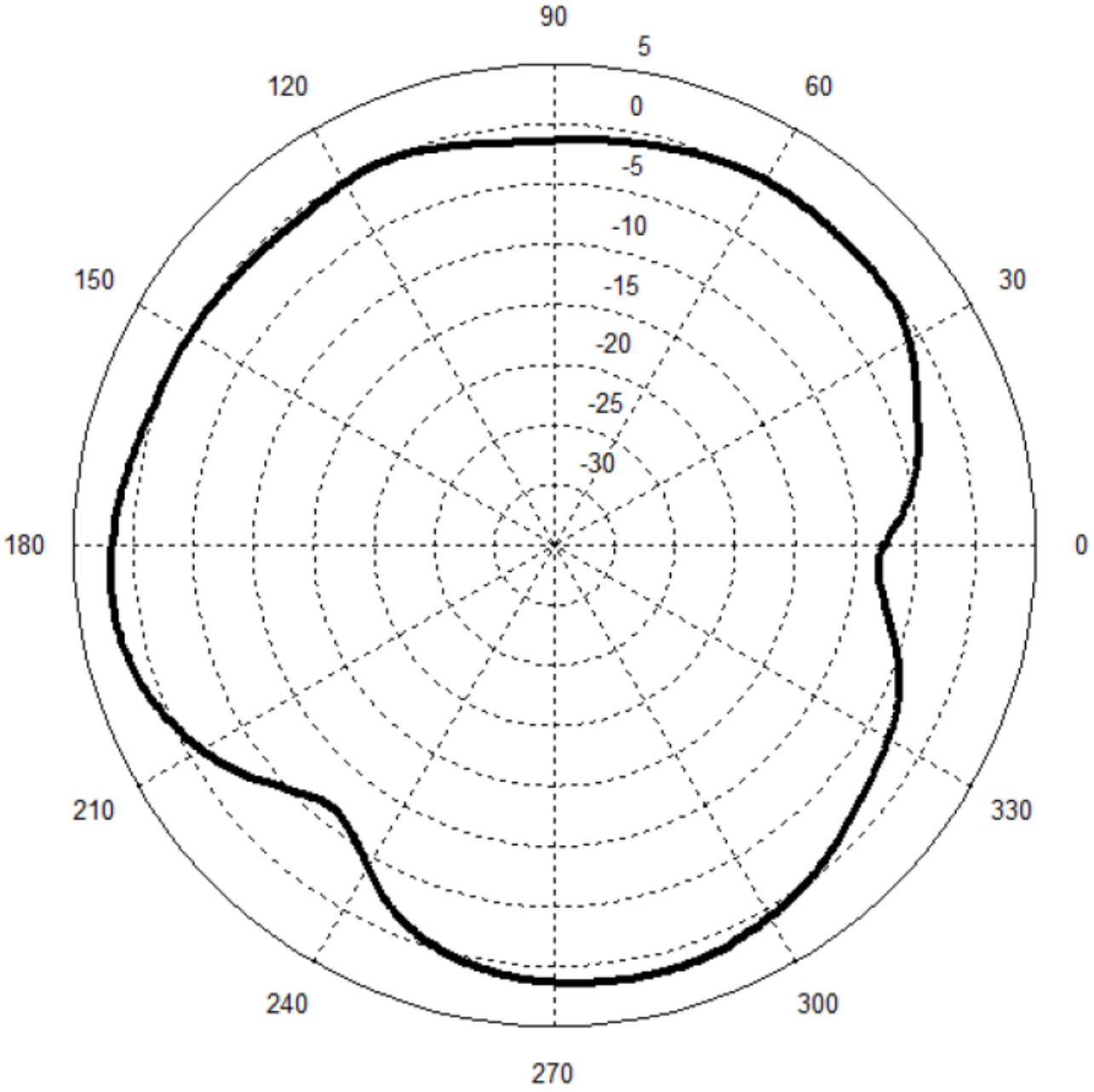
Table 1 Orderable Part Numbers

SPECIFICATIONS

Specification	Value
Peak Gain	+2 dBi
Average Gain	>-2.3 dBi
Impedance	50 ohms
Type	Flexible Planar Inverted F Antenna (FlexPIFA)
Polarization	Linear
VSWR	< 2.0:1, 2400 - 2480 MHz
Frequency	2400 – 2480 MHz
Weight	1.13g
Size	40.1mm × 11mm × 2.5mm
Antenna Color	Clear Yellow
Adhesive	3M 100MP
Operating Temp	-40°C to +85°C

Table 2 Specifications

Vertical Orientation at 2440 MHz:



Horizontal Orientation at 2440 MHz:

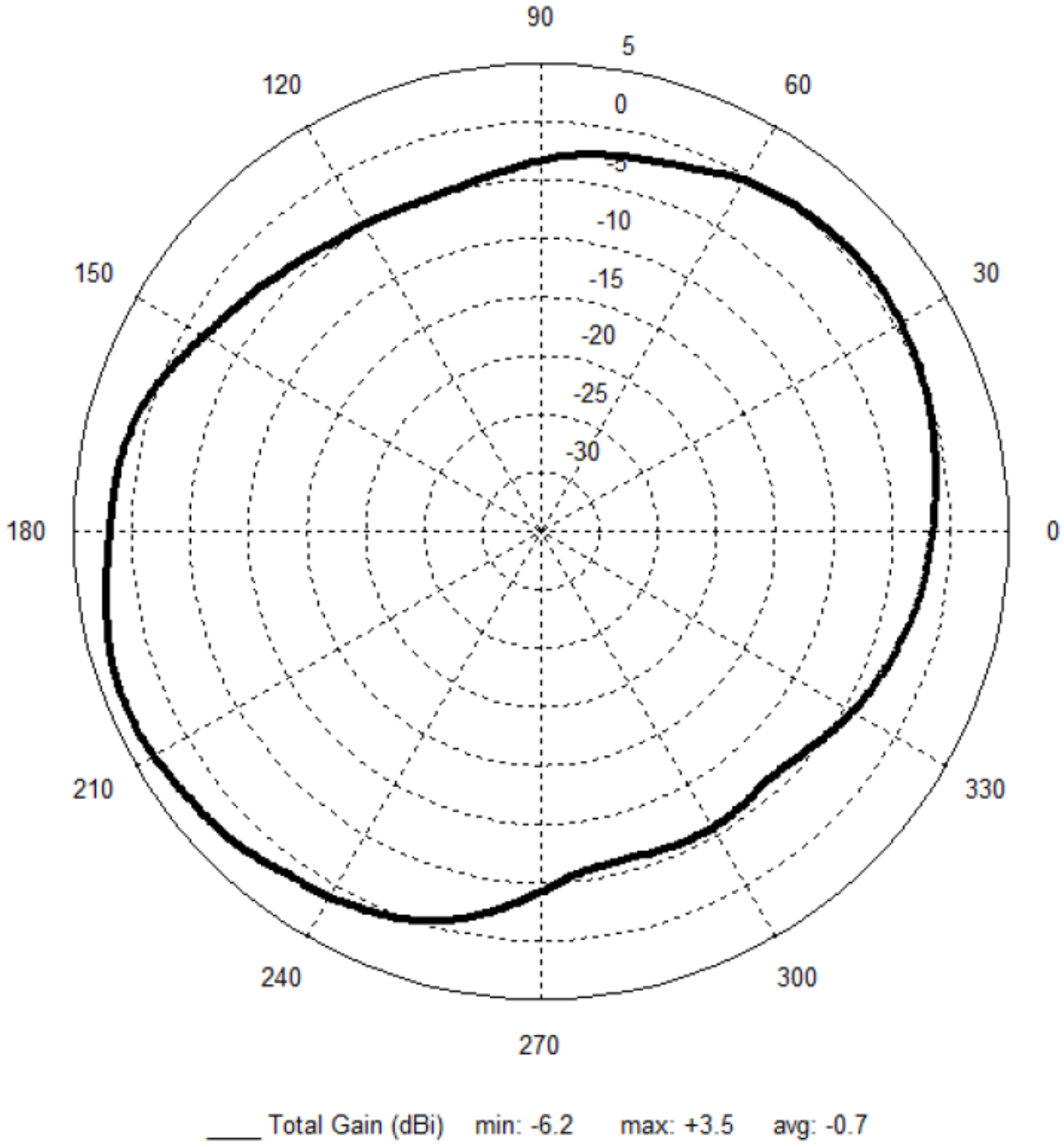


Figure 6 Horizontal Orientation Pattern

Flat Orientation at 2440 MHz:

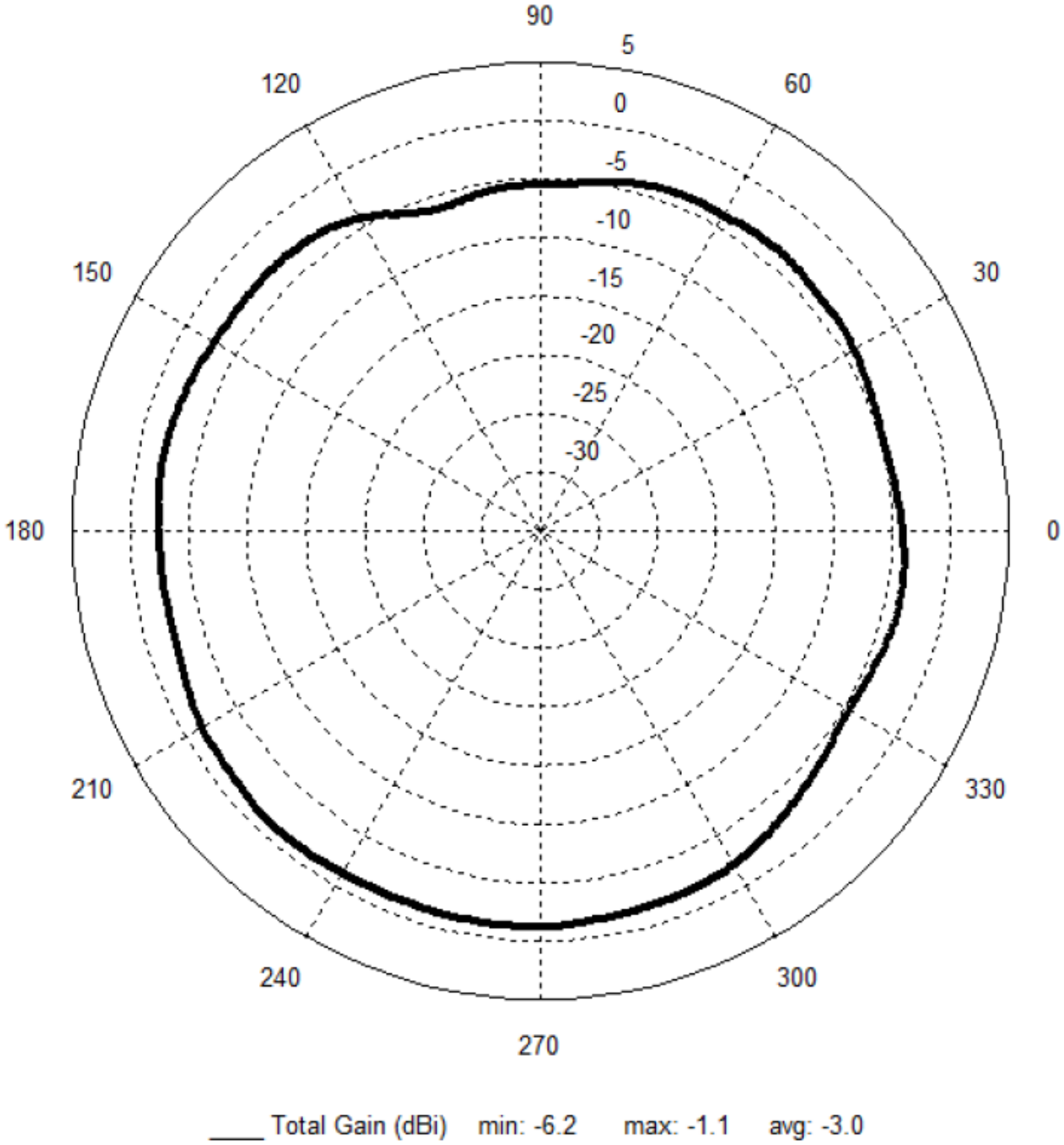


EXHIBIT 9. Occupied Bandwidth and Spreading Bandwidth

Test Engineer:	Khairul Aidi Zainal
Test Date:	7/11/2016

Requirement:

Article 49.20 of the Ordinance regulating Radio Equipment requires that the minimum spreading bandwidth, which is the 90% bandwidth, be a minimum of 500 kHz.

Article 6, Annex 2 of the Ordinance regulating Radio Equipment requires that the occupied bandwidth, which is defined as the 99% bandwidth, be:

1. 26 MHz for DSSS systems
2. 83.5 MHz for FHSS systems

Test note:

1. For Bluetooth measurement, the EUT was set to hopping mode for all modulations.
2. Measurement performed at nominal, +10% nominal and -10% nominal supply voltage.
3. The Occupied Bandwidth measurement function of the Spectrum analyzer was used to perform the measurements.

Result:

The EUT is compliant to the requirement of the Ordinance regulating Radio Equipment.

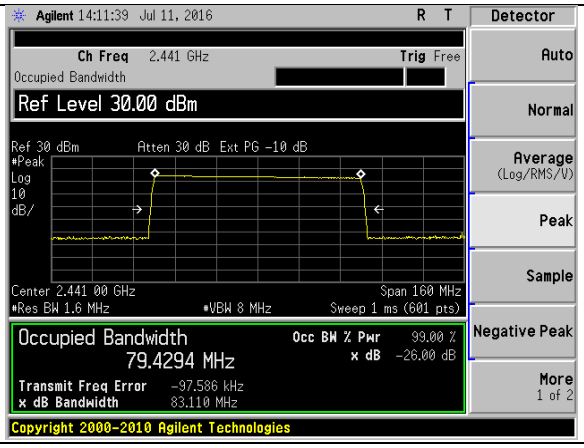
Data:

Maximum Channels:

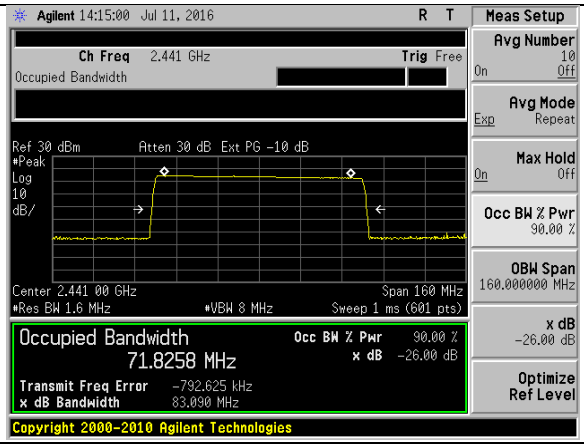
	GFSK				EDR2				EDR3			
EUT supply voltage (V)	Occupied Bandwidth / 99% BW (MHz)	Limit (MHz)	Margin (MHz)	Spreading Bandwidth/ 90% BW (MHz)	Occupied Bandwidth / 99% BW (MHz)	Limit (MHz)	Margin (MHz)	Spreading Bandwidth/ 90% BW (MHz)	Occupied Bandwidth / 99% BW (MHz)	Limit (MHz)	Margin (MHz)	Spreading Bandwidth/ 90% BW (MHz)
3.3VDC (Nominal)	79.4	83.5	4.1	71.8	79.4	83.5	4.1	72.4	79.4	83.5	4.1	72.4
2.97VDC (-10%)	79.4	83.5	4.1	71.8	79.4	83.5	4.1	72.3	79.4	83.5	4.1	72.4
3.6VDC (Max declared)	79.4	83.5	4.1	71.9	79.5	83.5	4.0	72.3	79.4	83.5	4.1	72.4

Captures:
The plots provided are those at nominal supply voltage only.

GFSK

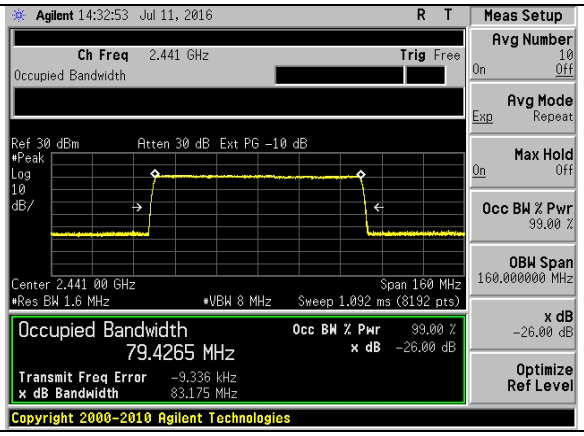


Occupied Bandwidth (99%)

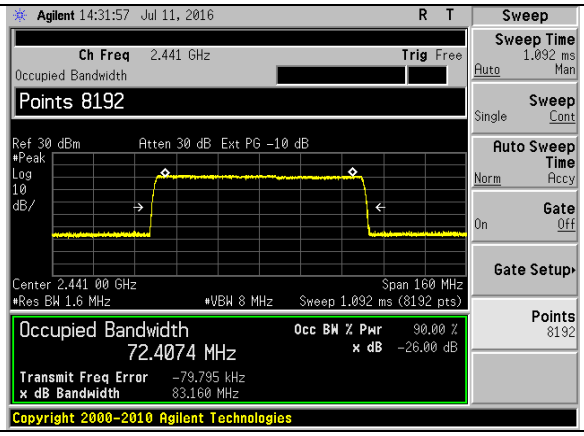


Spreading Bandwidth (90%)

EDR2

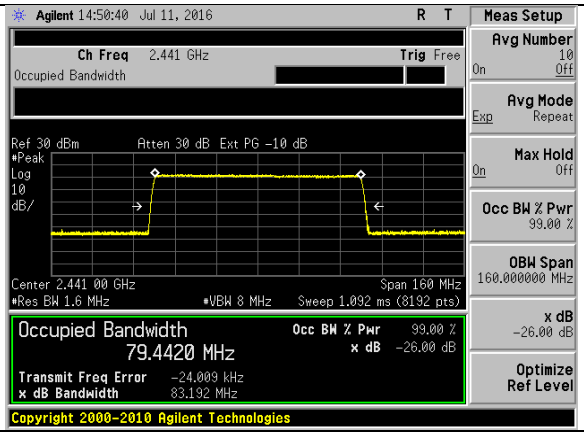


Occupied Bandwidth (99%)

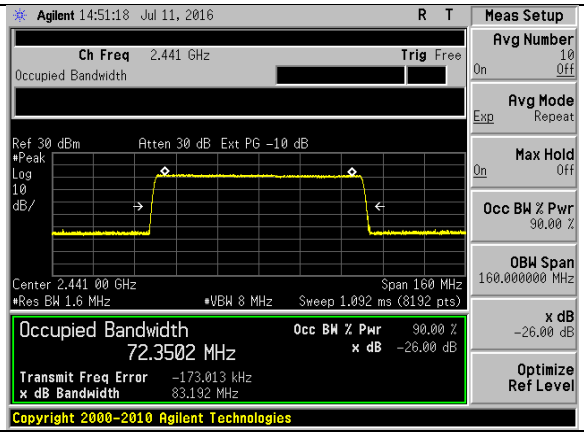


Spreading Bandwidth (90%)

EDR3



Occupied Bandwidth (99%)



Spreading Bandwidth (90%)

EXHIBIT 10. Transmitter Spurious Emissions

Test Engineer:	Khairul Aidi Zainal
Test Date:	7/11/16 – 7/13/16

Requirement:
Article 7 of the Ordinance Regulating Radio Equipment, table 3, sets forth the requirements for Transmitter spurious emissions.

The limits for category WW:

Frequency band	Permissible average power at 1MHz band -width of spurious emission
Lower than 2,387 MHz and higher than 2,496.5MHz	Lower than 2.5 μW
Higher than 2,387 MHz, lower than 2400MHz, and higher than 2,483.5 and lower than 2,496.5 MHz.	Lower than 25 μW

Exclusion bands:
In case of the frequency hopping systems and a combination of hopping and other modulation method(s), the range from 2,374 MHz to 2,509.5 MHz is excluded. For other modulation methods, the range from 2,400 MHz to 2,483.5 MHz is excluded.

Test note:

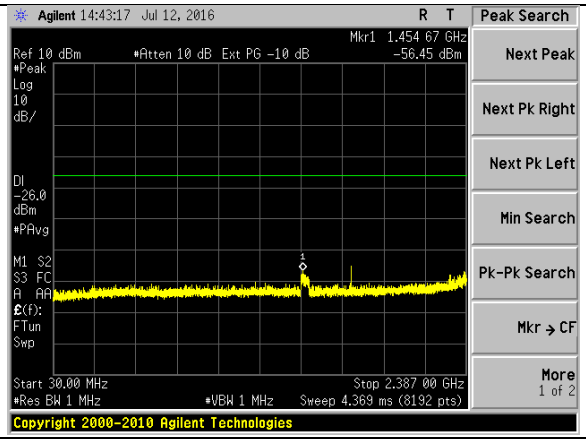
1. EUT was tested at the lowest, middle and high channels.
2. Measurement performed at nominal, +10% nominal and -10% nominal supply voltage.
3. Testing performed across all modulations/modes (GFSK, EDR2, EDR3)

Result:

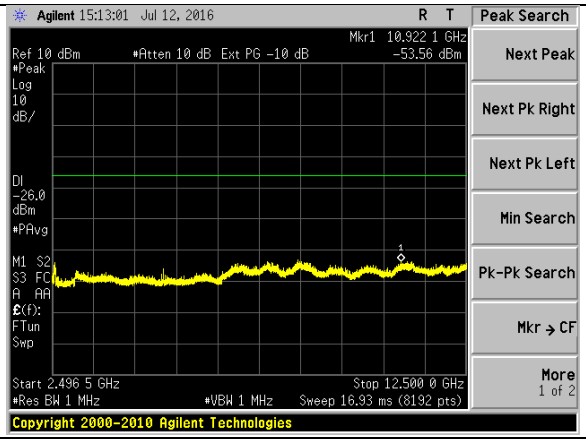
The transmitter spurious emissions of the EUT were more than 6dB below the limit. The EUT is found to be compliant to the requirement of the Ordinance regulating Radio Equipment.

Screen Captures:

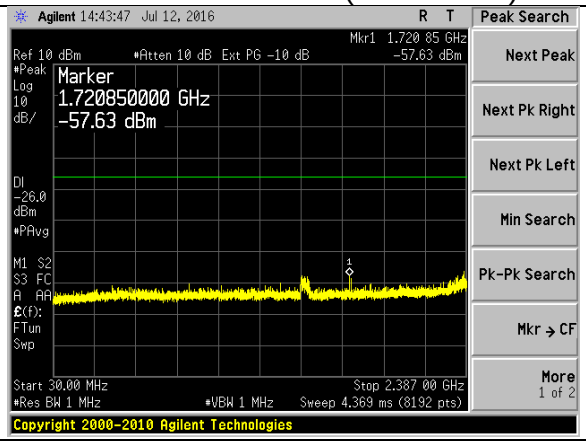
30MHz to 2387MHz & 2496.5MHz to 12500MHz



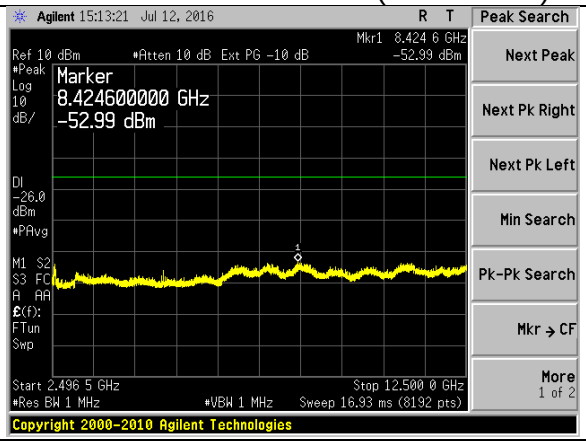
30MHz to 2387 MHz (low channel)



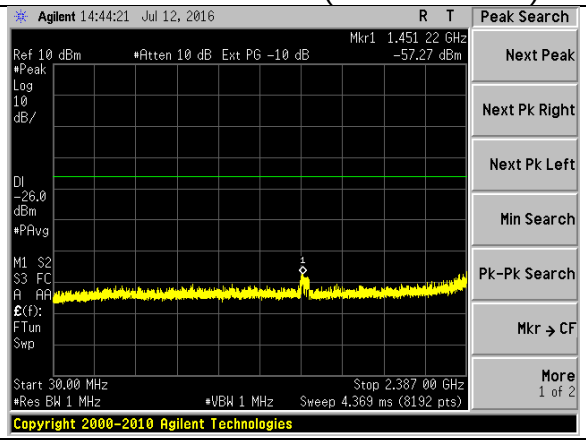
2496.5MHz to 12500MHz (low channel)



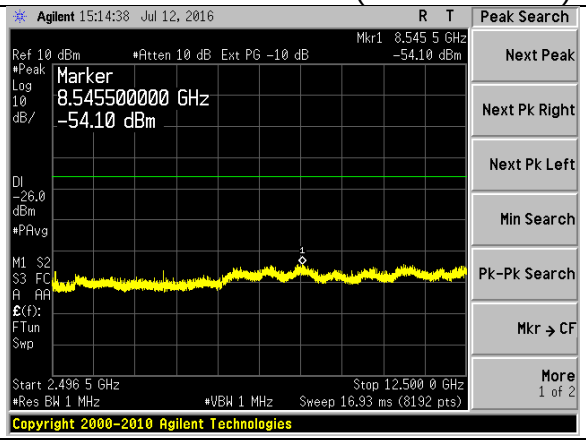
30MHz to 2387 MHz (middle channel)



2496.5MHz to 12500MHz (middle channel)



30MHz to 2387 MHz (high channel)



2496.5MHz to 12500MHz (high channel)

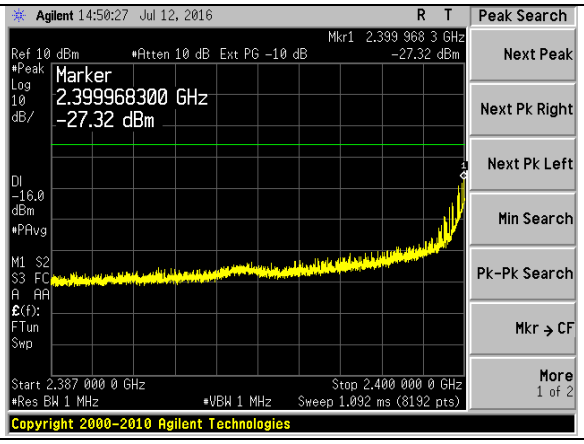
Note:

1. The plots above were obtained at nominal supply voltage. Emissions were unchanged at different supply voltages

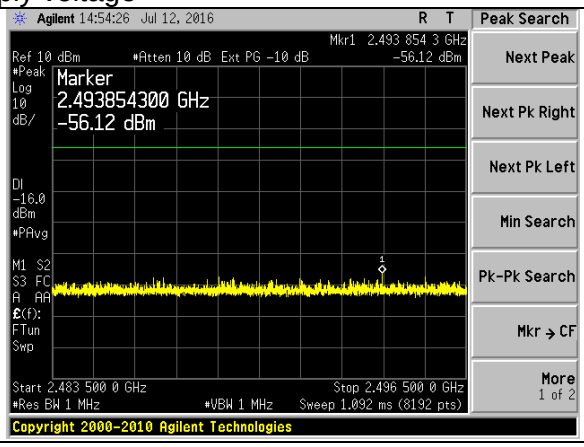
2387MHz to 2400MHz & 2483.5MHz to 2496.5MHz

GFSK:

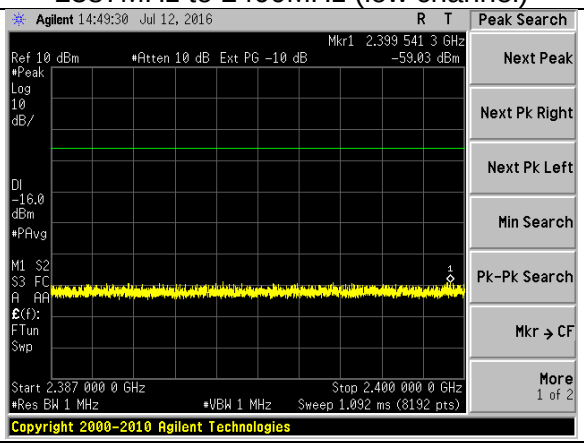
Nominal supply voltage



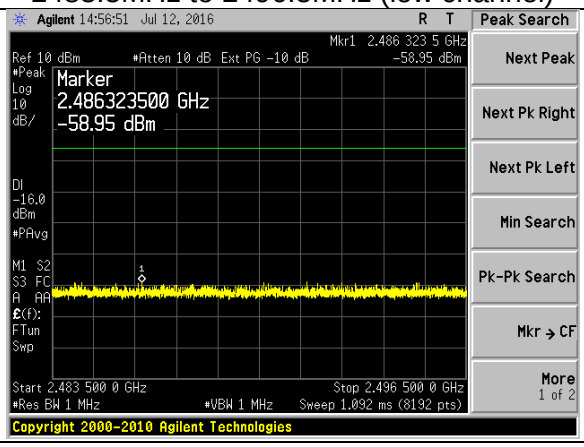
2387MHz to 2400MHz (low channel)



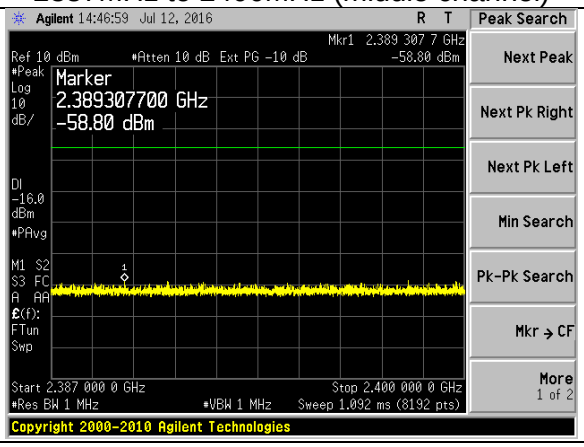
2483.5MHz to 2496.5MHz (low channel)



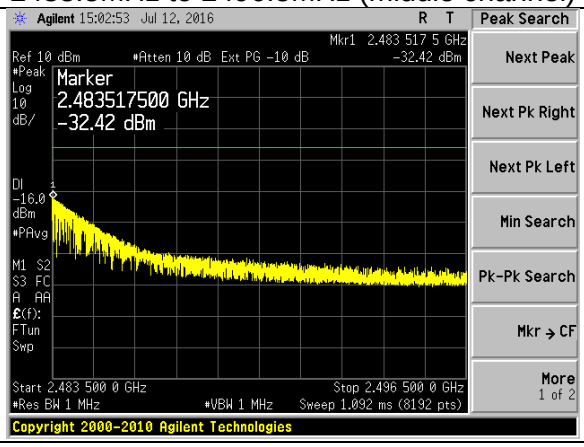
2387MHz to 2400MHz (middle channel)



2483.5MHz to 2496.5MHz (middle channel)

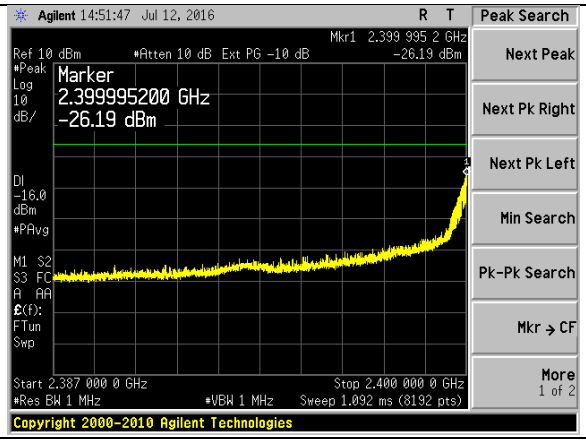


2387MHz to 2400MHz (high channel)

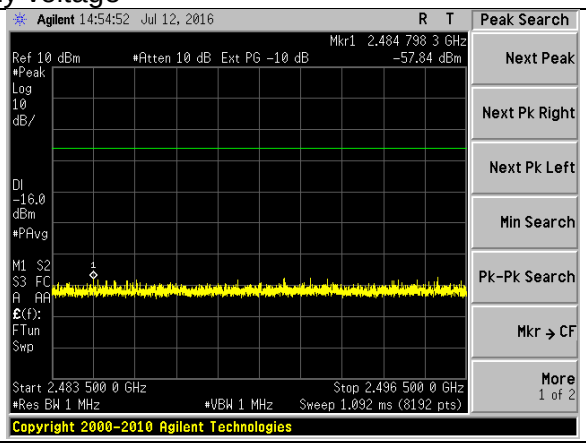


2483.5MHz to 2496.5MHz (high channel)

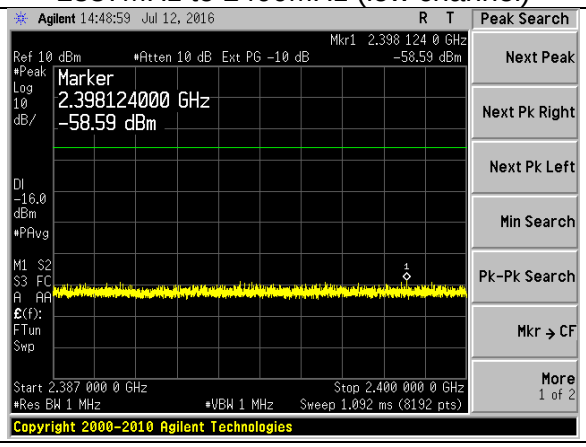
+10% supply voltage



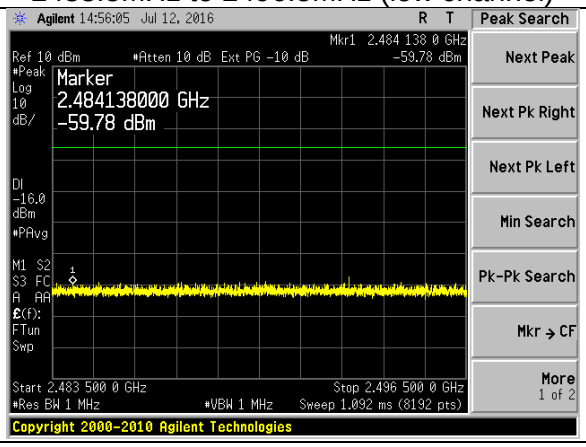
2387MHz to 2400MHz (low channel)



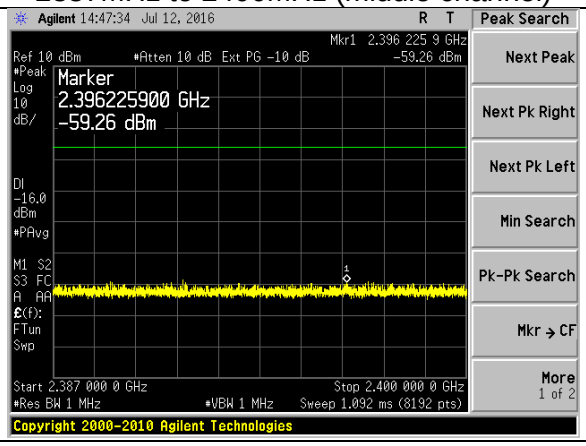
2483.5MHz to 2496.5MHz (low channel)



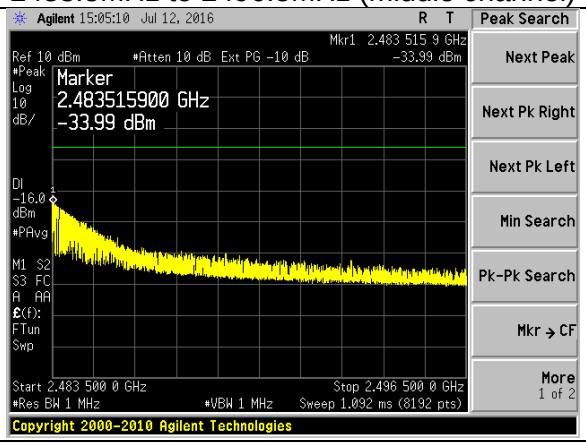
2387MHz to 2400MHz (middle channel)



2483.5MHz to 2496.5MHz (middle channel)

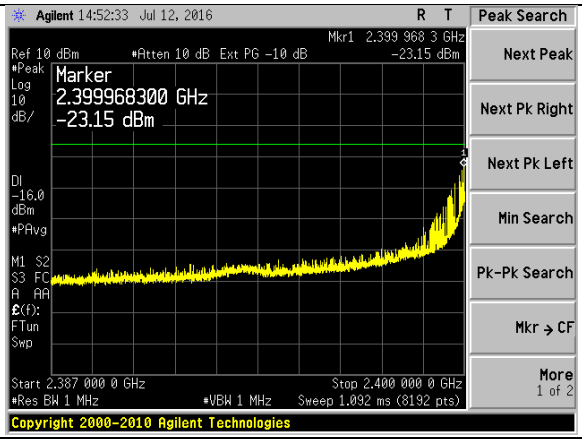


2387MHz to 2400MHz (high channel)

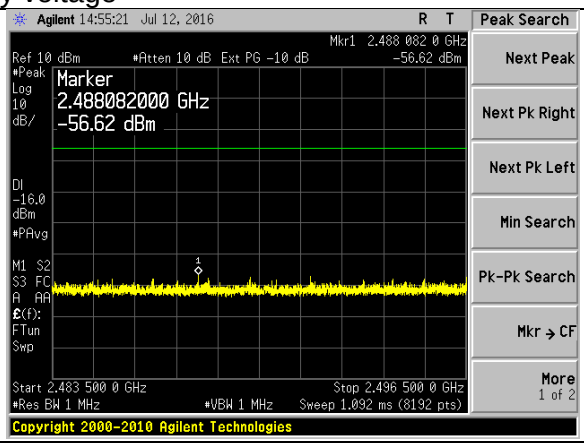


2483.5MHz to 2496.5MHz (high channel)

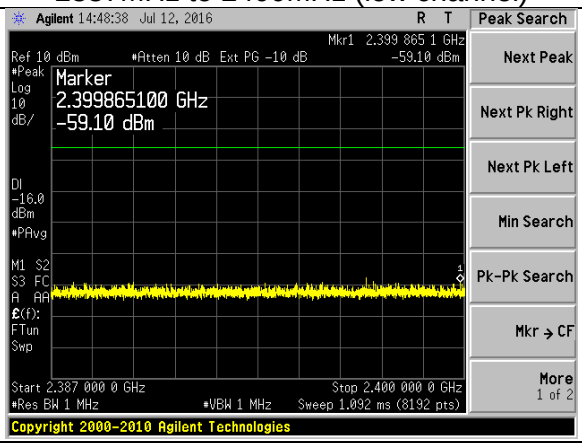
-10% supply voltage



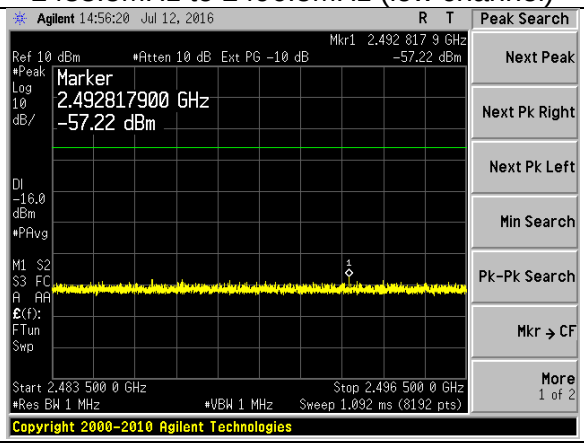
2387MHz to 2400MHz (low channel)



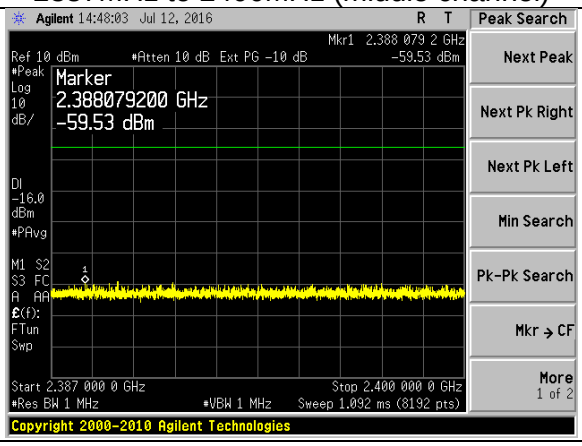
2483.5MHz to 2496.5MHz (low channel)



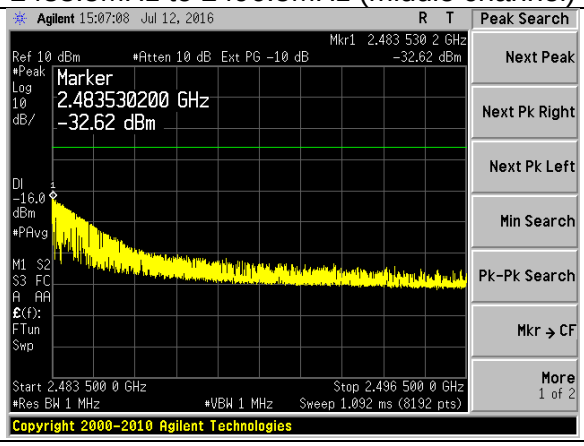
2387MHz to 2400MHz (middle channel)



2483.5MHz to 2496.5MHz (middle channel)



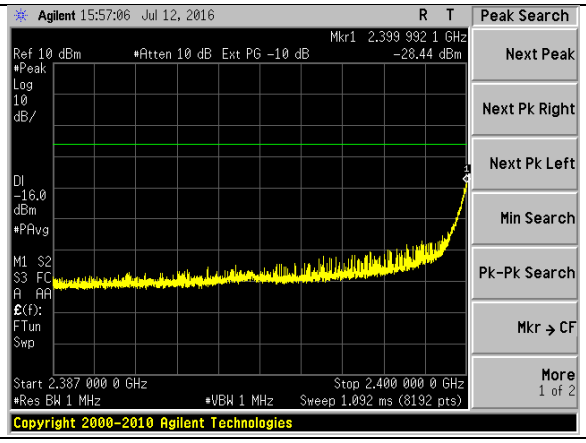
2387MHz to 2400MHz (high channel)



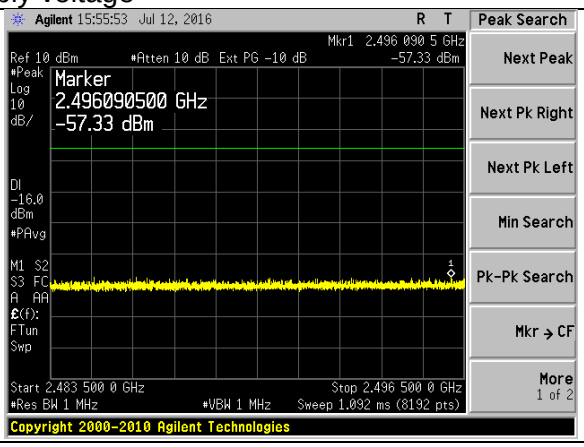
2483.5MHz to 2496.5MHz (high channel)

EDR2:

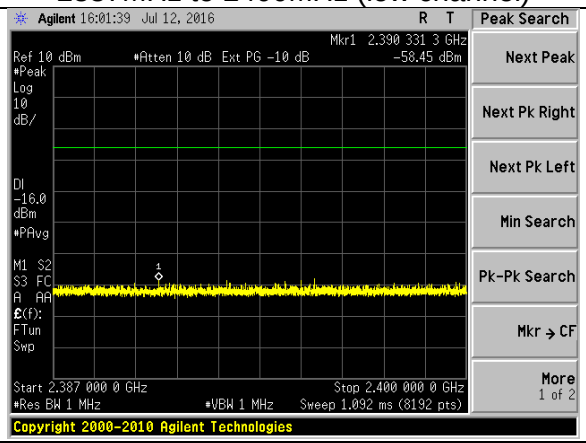
Nominal supply voltage



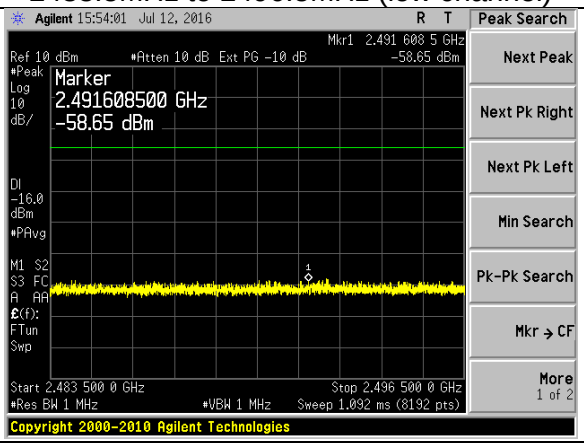
2387MHz to 2400MHz (low channel)



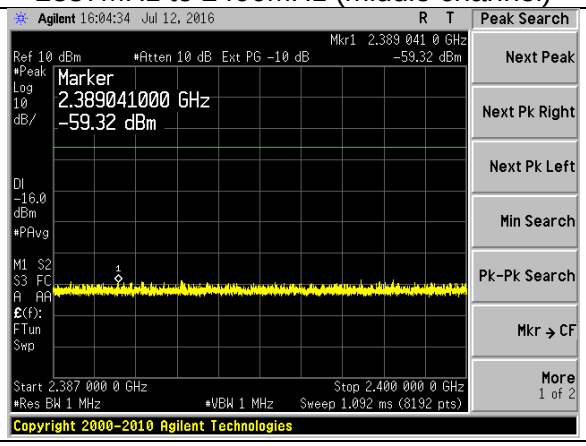
2483.5MHz to 2496.5MHz (low channel)



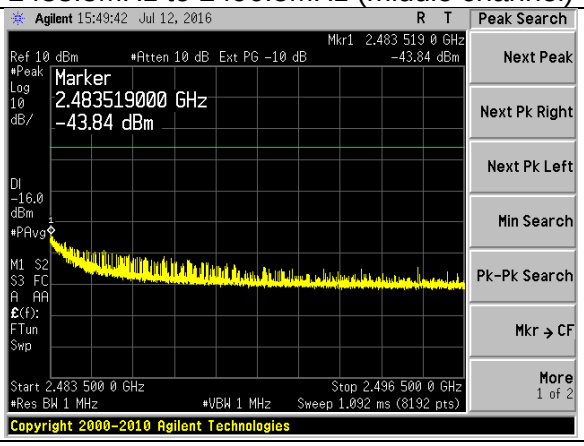
2387MHz to 2400MHz (middle channel)



2483.5MHz to 2496.5MHz (middle channel)

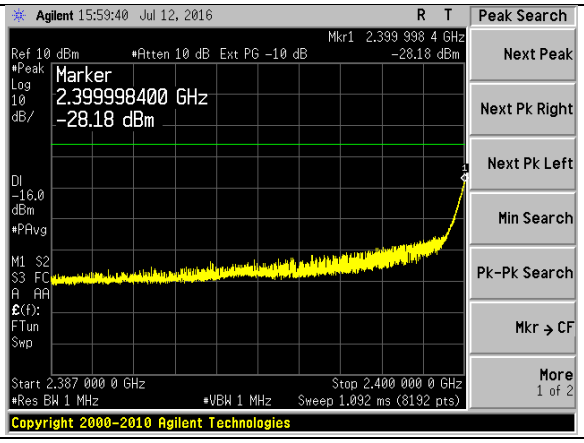


2387MHz to 2400MHz (high channel)

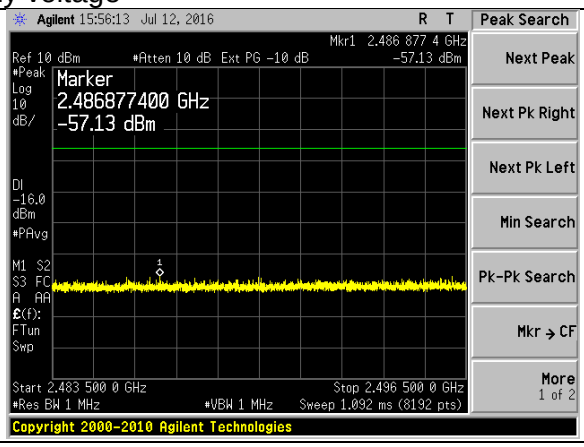


2483.5MHz to 2496.5MHz (high channel)

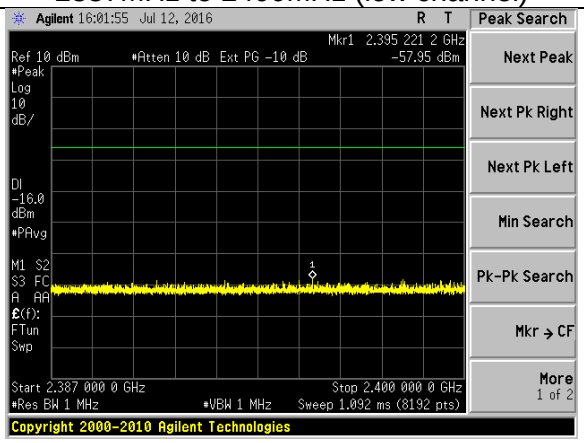
+10% supply voltage



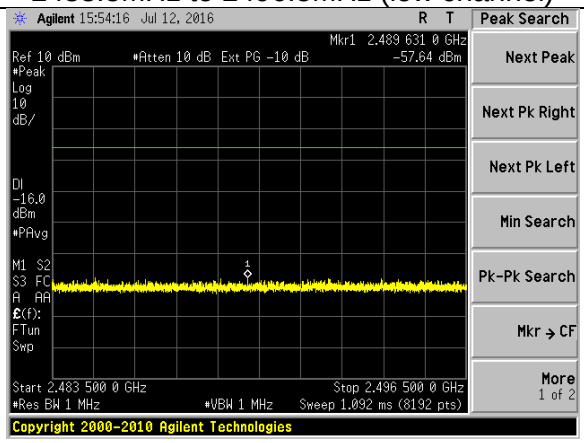
2387MHz to 2400MHz (low channel)



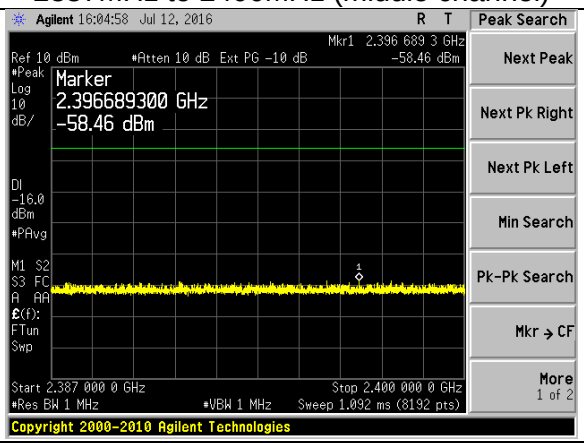
2483.5MHz to 2496.5MHz (low channel)



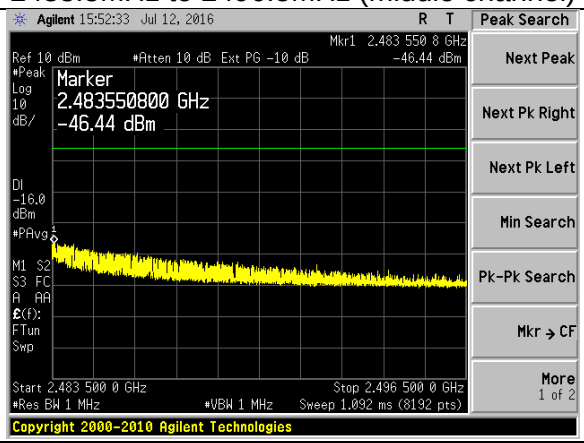
2387MHz to 2400MHz (middle channel)



2483.5MHz to 2496.5MHz (middle channel)

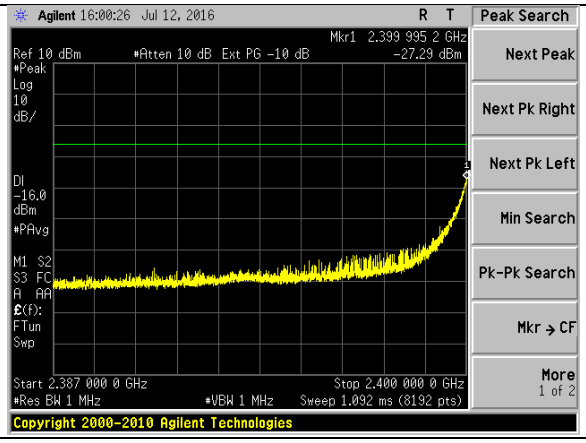


2387MHz to 2400MHz (high channel)

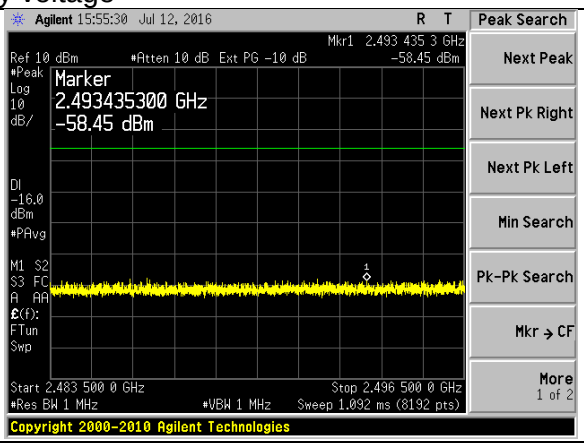


2483.5MHz to 2496.5MHz (high channel)

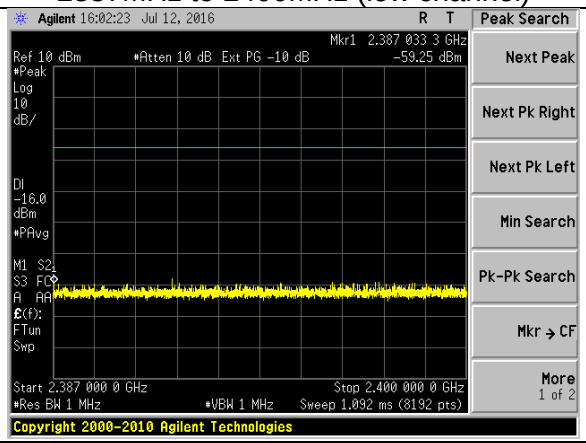
-10% supply voltage



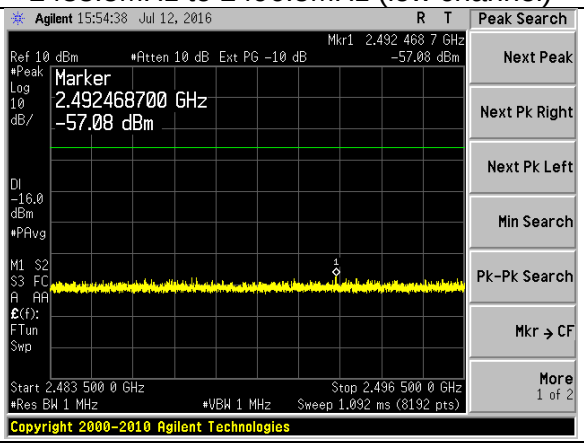
2387MHz to 2400MHz (low channel)



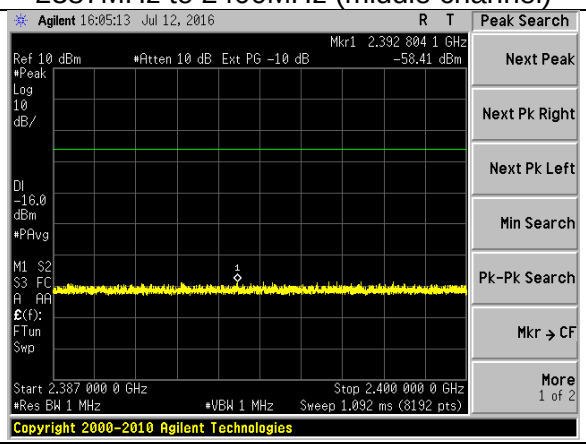
2483.5MHz to 2496.5MHz (low channel)



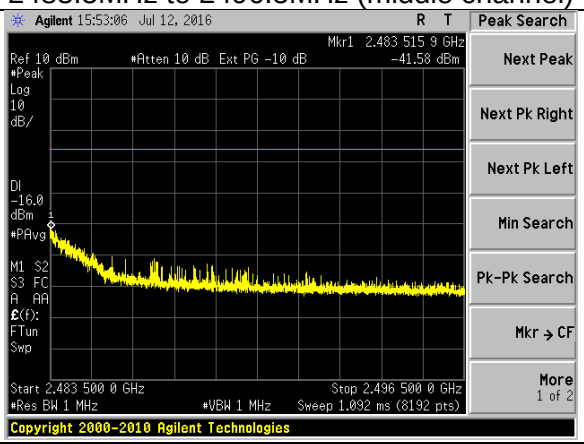
2387MHz to 2400MHz (middle channel)



2483.5MHz to 2496.5MHz (middle channel)



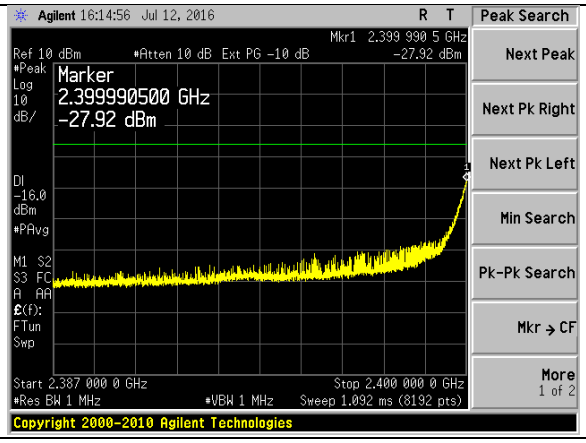
2387MHz to 2400MHz (high channel)



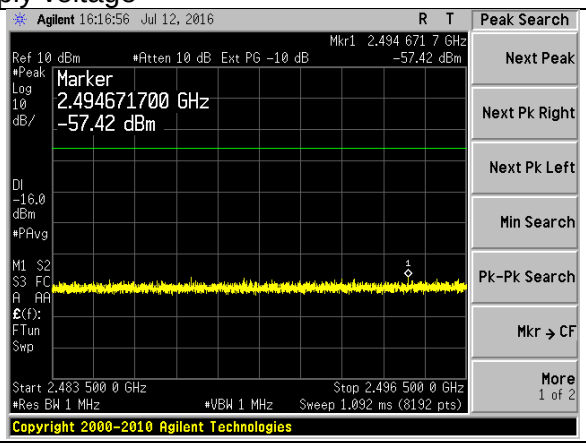
2483.5MHz to 2496.5MHz (high channel)

EDR3:

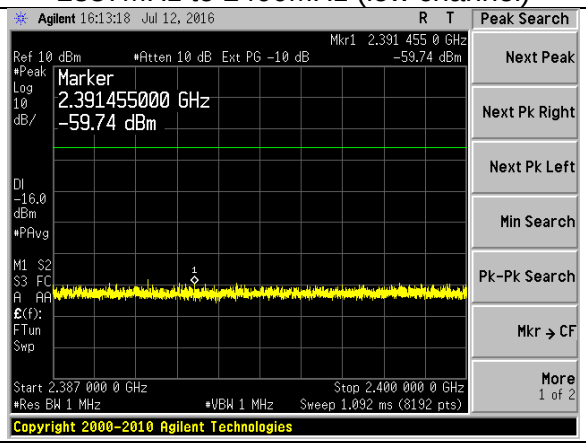
Nominal supply voltage



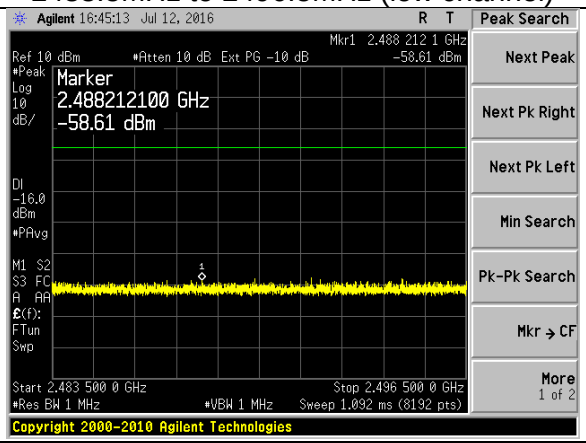
2387MHz to 2400MHz (low channel)



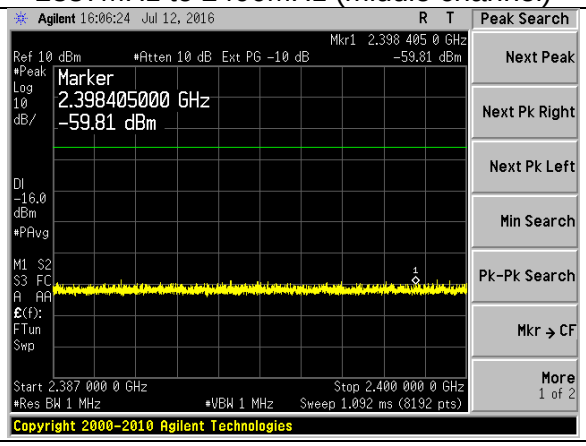
2483.5MHz to 2496.5MHz (low channel)



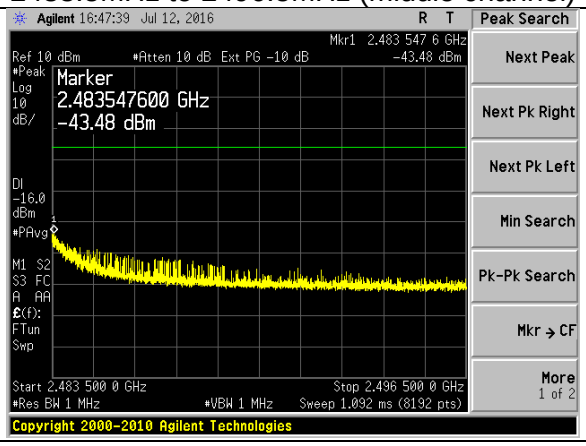
2387MHz to 2400MHz (middle channel)



2483.5MHz to 2496.5MHz (middle channel)

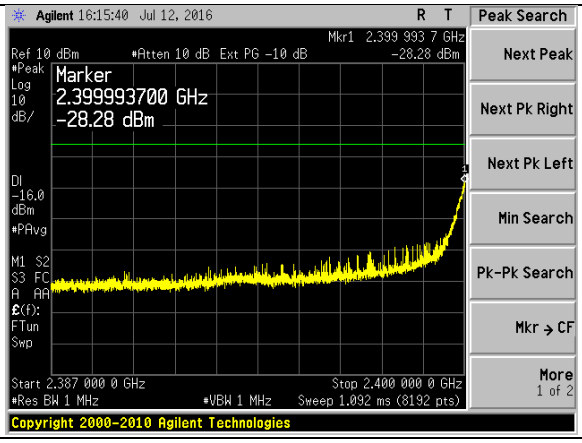


2387MHz to 2400MHz (high channel)

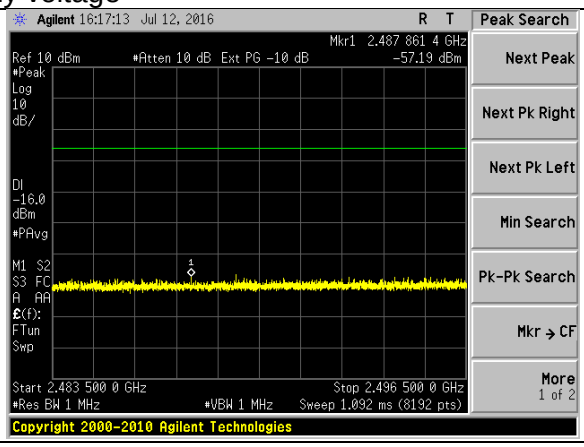


2483.5MHz to 2496.5MHz (high channel)

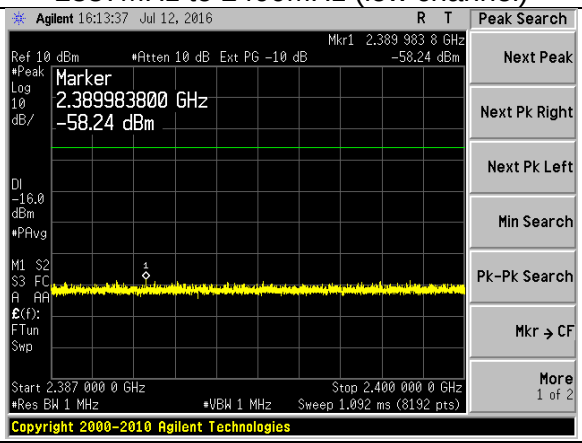
+10% supply voltage



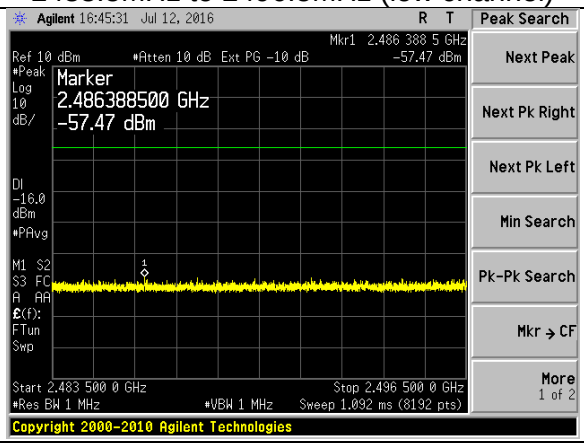
2387MHz to 2400MHz (low channel)



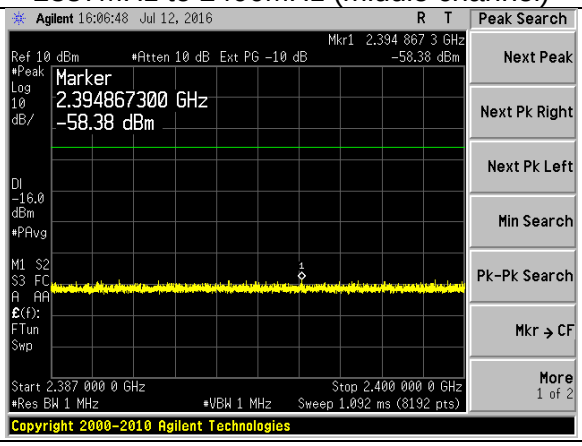
2483.5MHz to 2496.5MHz (low channel)



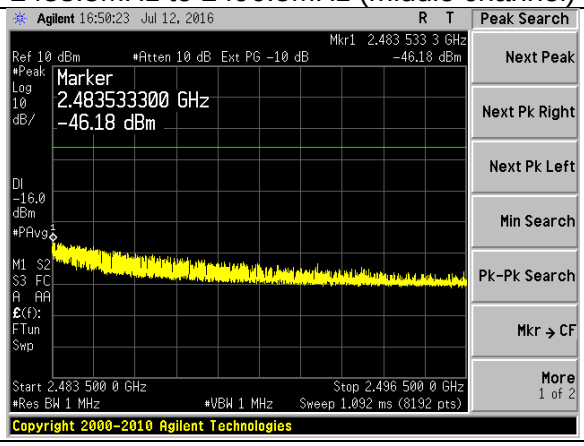
2387MHz to 2400MHz (middle channel)



2483.5MHz to 2496.5MHz (middle channel)

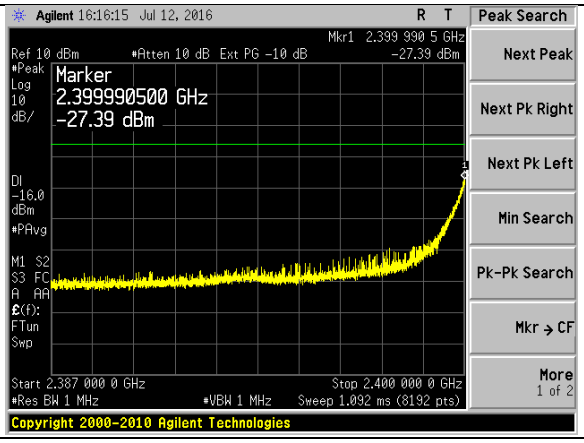


2387MHz to 2400MHz (high channel)

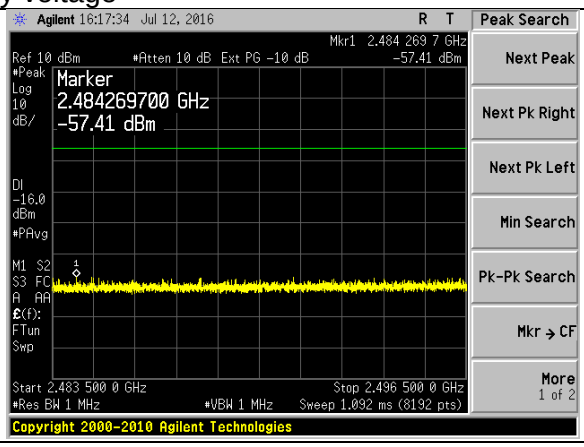


2483.5MHz to 2496.5MHz (high channel)

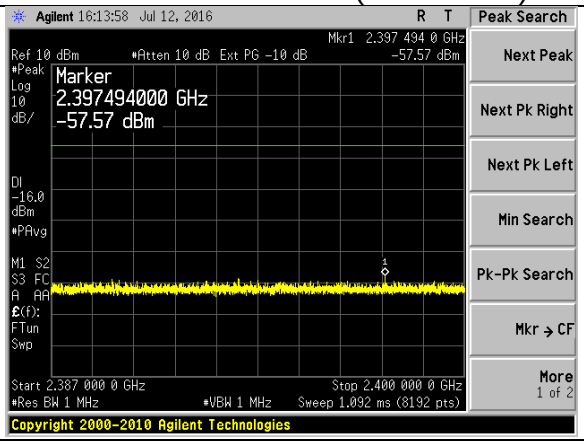
-10% supply voltage



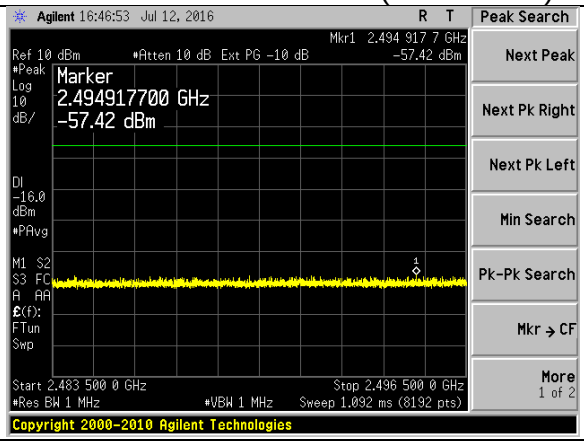
2387MHz to 2400MHz (low channel)



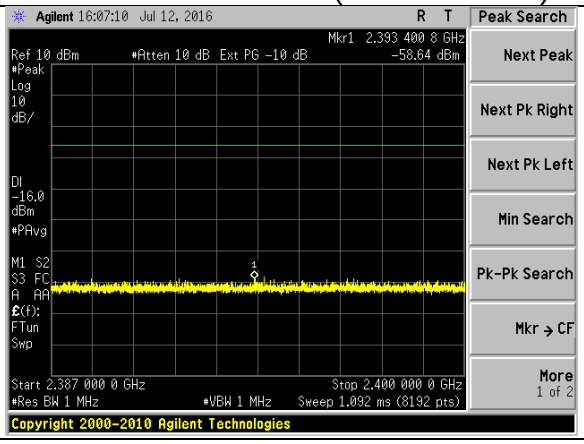
2483.5MHz to 2496.5MHz (low channel)



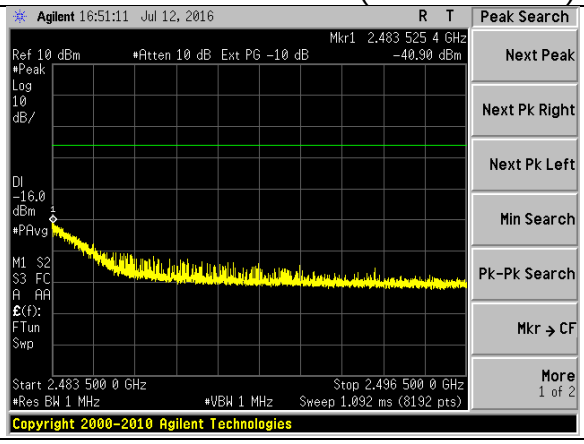
2387MHz to 2400MHz (middle channel)



2483.5MHz to 2496.5MHz (middle channel)



2387MHz to 2400MHz (high channel)



2483.5MHz to 2496.5MHz (high channel)

EXHIBIT 11. Secondary Emissions

Test Engineer:	Khairul Aidi Zainal
Test Date:	7/12/16

Requirement:
Article 24 of the Ordinance Regulating Radio Equipment sets forth the requirements for secondary/receiver emissions.

The limits:

30 MHz to 1000 MHz	Lower than 4.0 nW
1000 MHz to 12500 MHz	Lower than 20.0 nW

Test note:

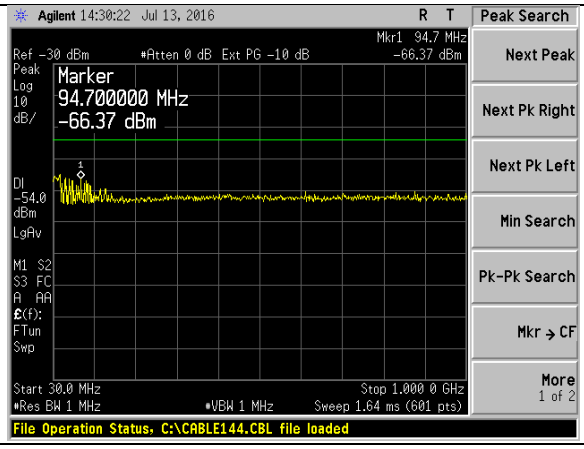
1. EUT was tested at the lowest, middle and high channels.
2. Measurement performed at nominal, +10% nominal and -10% nominal supply voltage.

Result:

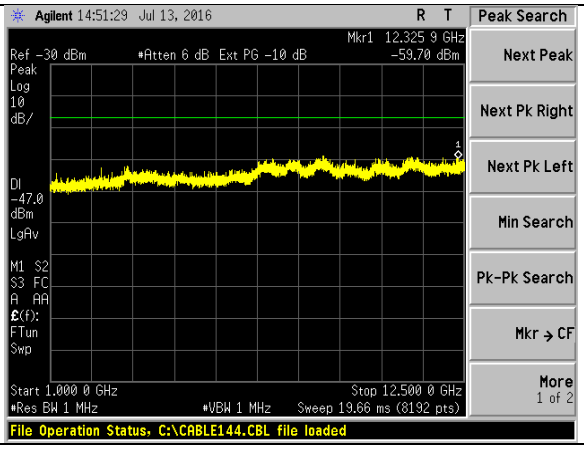
The secondary emissions of the EUT were more than 6dB below the limit. The EUT is found to be compliant to the requirement of the Ordinance regulating Radio Equipment.

Screen Captures:

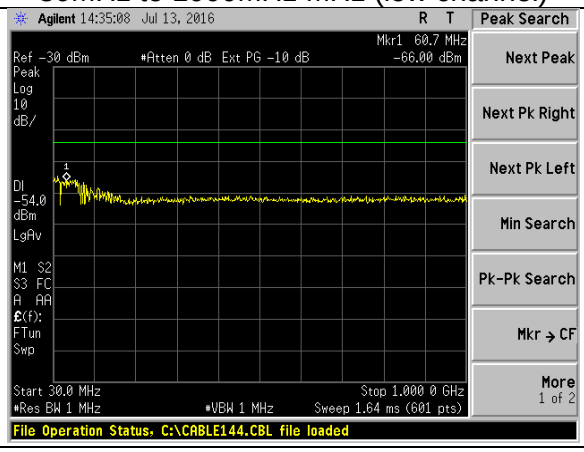
30MHz to 1000MHz & 1000MHz to 12500MHz



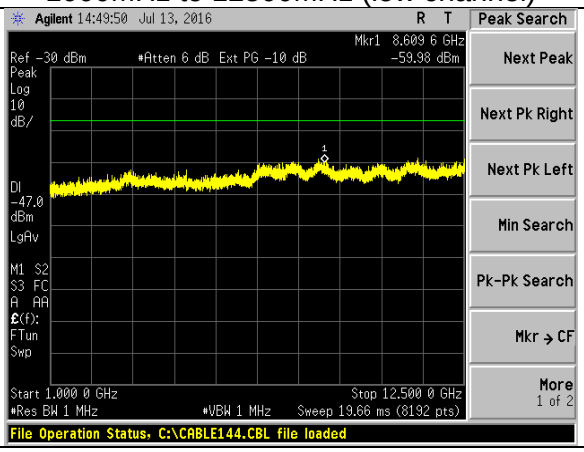
30MHz to 1000MHz MHz (low channel)



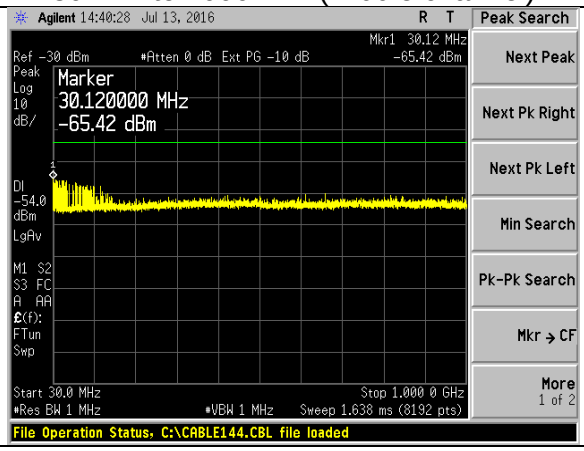
1000MHz to 12500MHz (low channel)



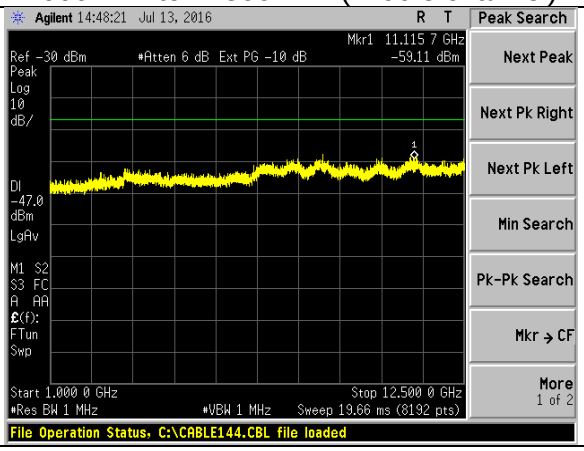
30MHz to 1000MHz (middle channel)



1000MHz to 12500MHz (middle channel)



30MHz to 1000MHz (high channel)



1000MHz to 12500MHz (high channel)

Note:

1. The plots above were obtained at nominal supply voltage. Emissions were unchanged at different supply voltages.
2. The limit line is presented on the plots.

EXHIBIT 12. Dwell Time

Test Engineer:	Khairul Aidi Zainal
Test Date:	7/12/16

Requirement:
Article 49.20 and article 2 of the Ordinance Regulating Radio Equipment sets forth the requirements for dwell time/retention time. This requirement only applies to FHSS systems with direct modulation.

The dwell time of an FHSS system is limited to 0.4 seconds or less.

Test note:

1. Dwell time measured at the lowest, middle and highest channel while the EUT was hopping.
2. Hopping settings (worst case):
    a. GFSK
    b. EDR2
    c. EDR3
3. Observation time is ((Spreading BW in MHz/Symbol rate in MSymps) X 0.4s):
    a. GFSK = 28.8
    b. EDR2 = 29.0
    c. EDR3 = 29.0
4. Measure time of single burst then measure number of burst in 5 seconds window. Extrapolate data to the appropriate observation time

Result:

The longest dwell time measured for the EUT was **0.349 seconds** hence the EUT is found to be compliant to the requirement of the Ordinance regulating Radio Equipment.

Data:

	3.3 VDC (Nominal)														
	GFSK					EDR2					EDR3				
Channels	Single burst (mS)	number of burst in 5s	Retention time within 28.8s (s)	Limit (s)	Margin(s)	Single burst (ms)	number of burst in 5s	Retention time within 29.0s (s)	Limit (s)	Margin(s)	Single burst (ms)	number of burst in 5s	Retention time within 29.0s (s)	Limit (s)	Margin(s)
Low (2402 MHz)	2.887	21.0	0.349	0.400	0.051	2.746	20.0	0.319	0.400	0.081	2.748	20.0	0.319	0.400	0.081
Midle (2440 MHz)	2.887	21.0	0.349	0.400	0.051	2.746	20.0	0.319	0.400	0.081	2.748	20.0	0.319	0.400	0.081
High (2480 MHz)	2.887	21.0	0.349	0.400	0.051	2.746	20.0	0.319	0.400	0.081	2.748	20.0	0.319	0.400	0.081

	+10%														
	GFSK					EDR2					EDR3				
Channels	Single burst (mS)	number of burst in 5s	Retention time within 28.8s (s)	Limit (s)	Margin(s)	Single burst (ms)	number of burst in 5s	Retention time within 29.0s (s)	Limit (s)	Margin(s)	Single burst (ms)	number of burst in 5s	Retention time within 29.0s (s)	Limit (s)	Margin(s)
Low (2402 MHz)	2.887	21.0	0.349	0.400	0.051	2.746	20.0	0.319	0.400	0.081	2.748	20.0	0.319	0.400	0.081
Midle (2440 MHz)	2.887	21.0	0.349	0.400	0.051	2.746	20.0	0.319	0.400	0.081	2.748	20.0	0.319	0.400	0.081
High (2480 MHz)	2.887	21.0	0.349	0.400	0.051	2.746	20.0	0.319	0.400	0.081	2.748	20.0	0.319	0.400	0.081

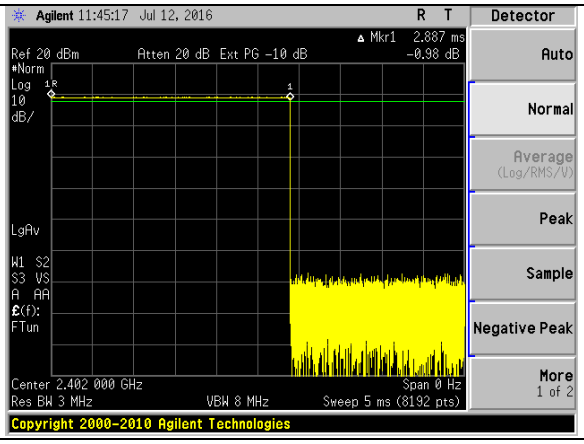
	-10%														
	GFSK					EDR2					EDR3				
Channels	Single burst (mS)	number of burst in 5s	Retention time within 28.8s (s)	Limit (s)	Margin(s)	Single burst (ms)	number of burst in 5s	Retention time within 29.0s (s)	Limit (s)	Margin(s)	Single burst (ms)	number of burst in 5s	Retention time within 29.0s (s)	Limit (s)	Margin(s)
Low (2402 MHz)	2.887	21.0	0.349	0.400	0.051	2.746	20.0	0.319	0.400	0.081	2.748	20.0	0.317	0.400	0.083
Midle (2440 MHz)	2.887	21.0	0.349	0.400	0.051	2.746	20.0	0.319	0.400	0.081	2.748	20.0	0.317	0.400	0.083
High (2480 MHz)	2.887	21.0	0.349	0.400	0.051	2.746	20.0	0.319	0.400	0.081	2.748	20.0	0.317	0.400	0.083

Captures:

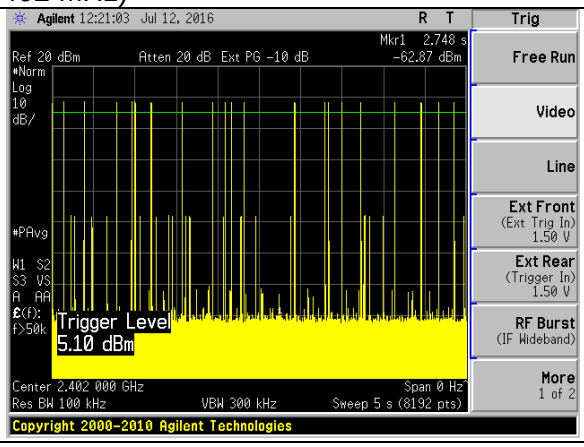
The plots provided are those at nominal supply voltage only.

A. GFSK

Low Channel (2402 MHz)

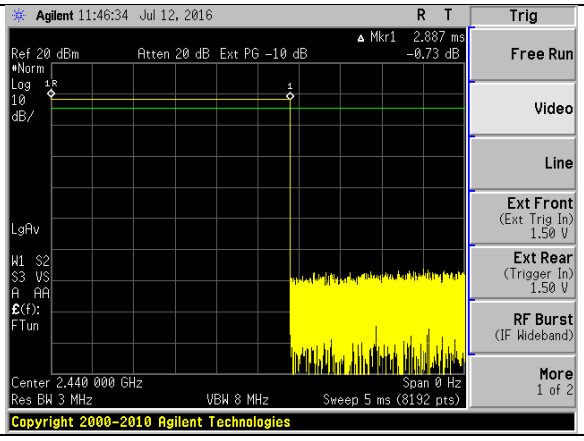


Single Burst

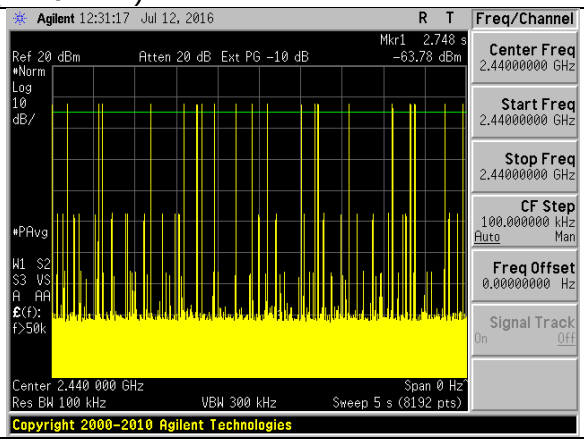


5 second window

Middle Channel (2440 MHz)

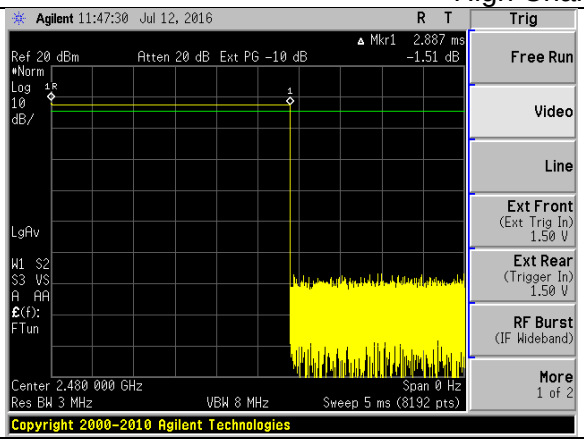


Single Burst

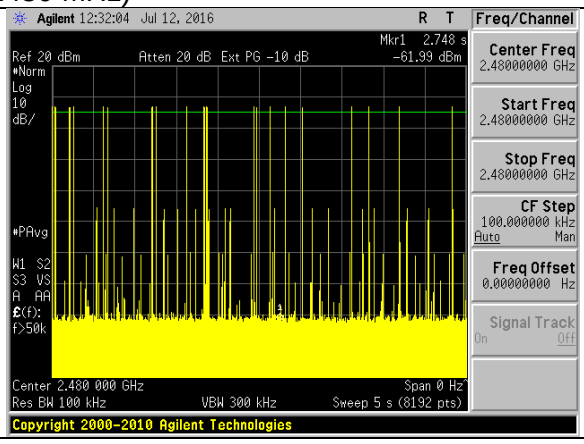


5 second window

High Channel (2480 MHz)



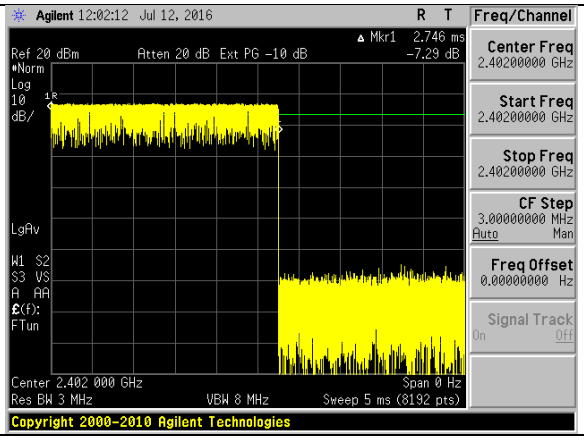
Single Burst



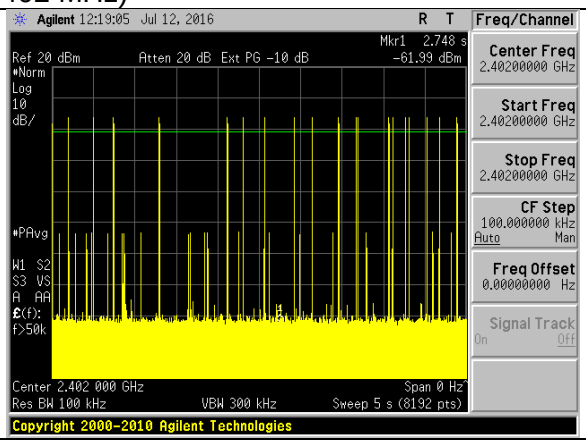
5 second window

B. EDR2

Low Channel (2402 MHz)

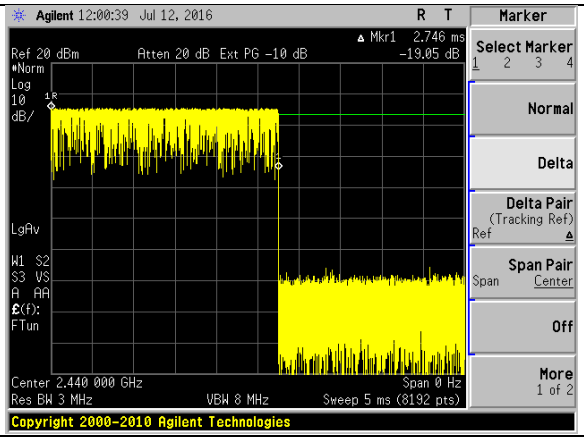


Single Burst

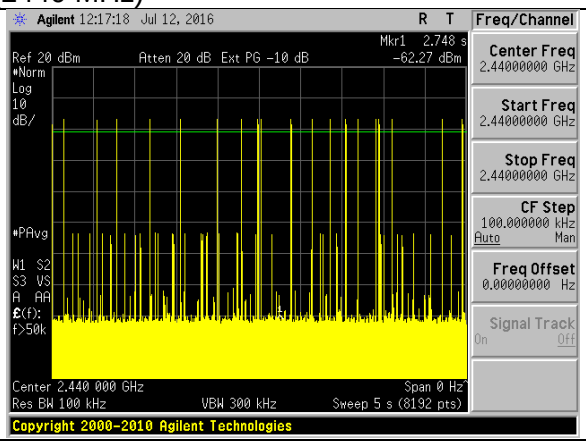


5 second window

Middle Channel (2440 MHz)

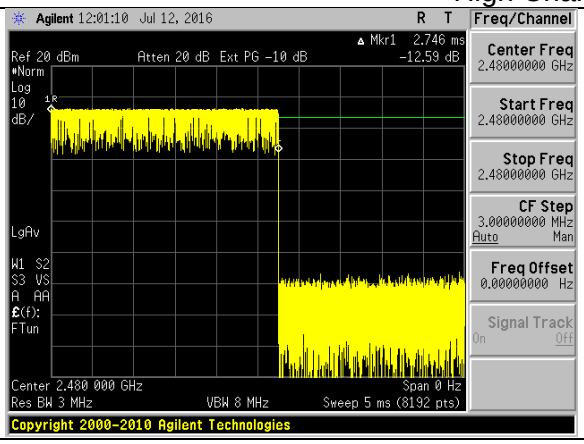


Single Burst

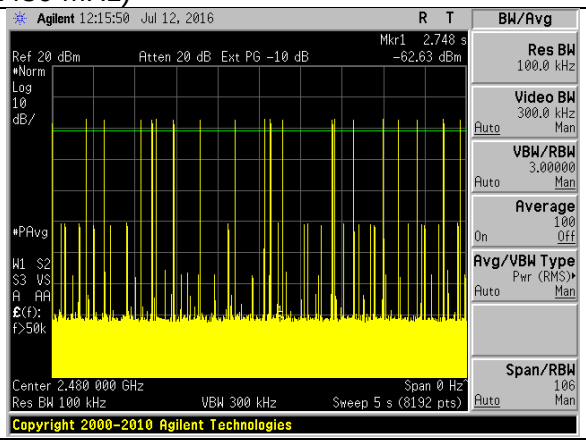


5 second window

High Channel (2480 MHz)



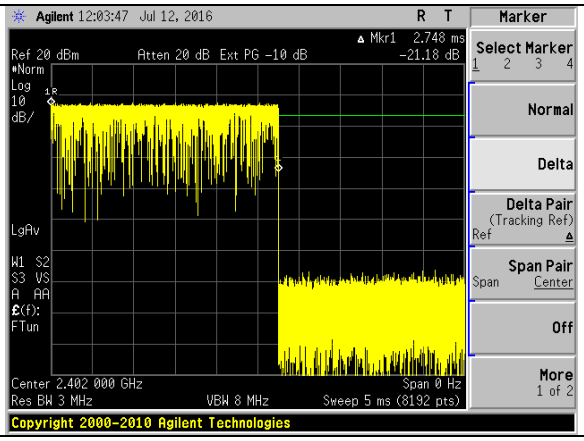
Single Burst



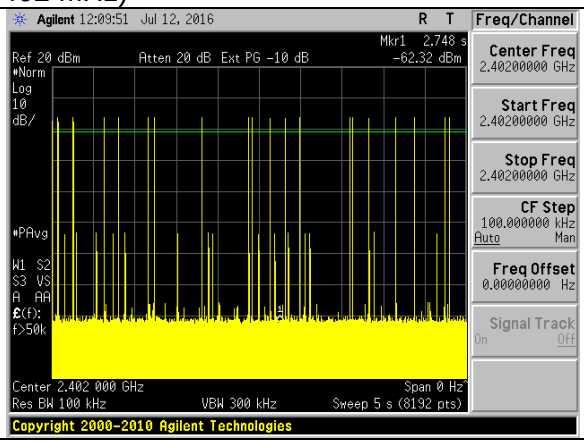
5 second window

C. EDR3

Low Channel (2402 MHz)

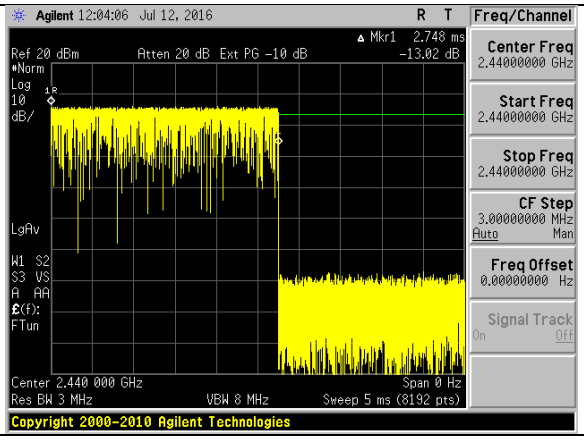


Single Burst

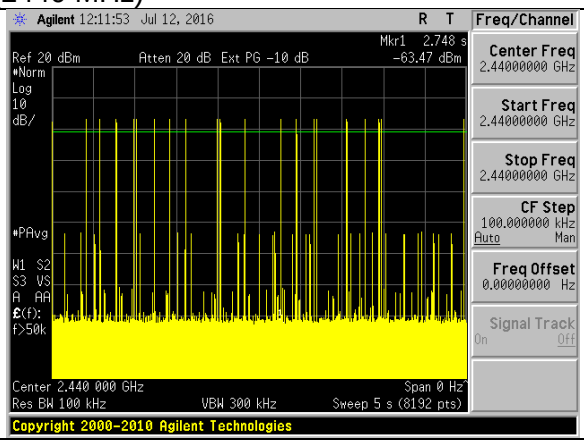


5 second window

Middle Channel (2440 MHz)

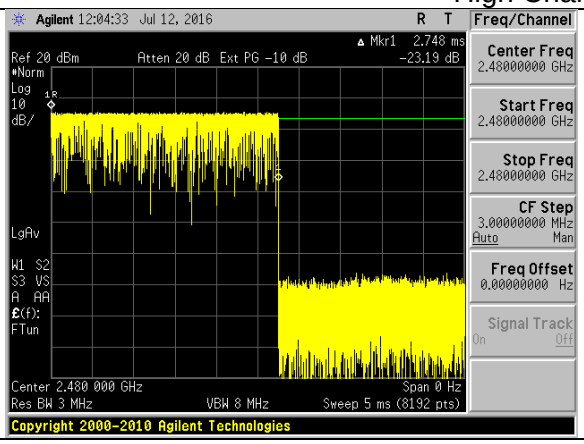


Single Burst

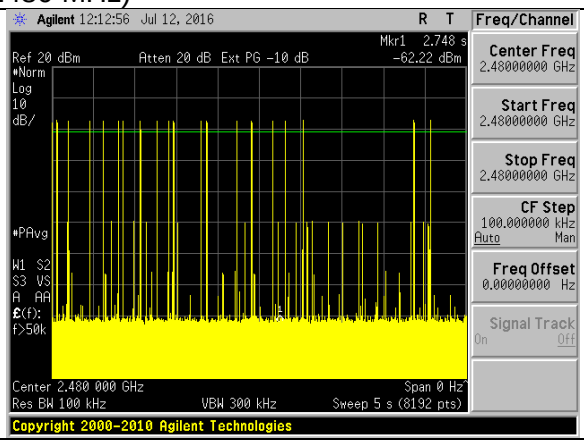


5 second window

High Channel (2480 MHz)



Single Burst



5 second window

EXHIBIT 13. Spreading Factor

Test Engineer:	Khairul Aidi Zainal
Test Date:	7/11/2016

Requirement:
Article 49.20 of the Ordinance Regulating Radio Equipment sets forth the requirements for spreading factor.

The spreading factor for category WW is greater than 5.

Result:

The worst case spreading factor was calculated to be 17.4. The EUT is found to be compliant to the requirement of the Ordinance regulating Radio Equipment.

Data:

A. Maximum channels:

	GFSK (1DH5)				EDR2 (2DH5)				EDR3 (3DH5)			
EUT supply voltage (V)	Spreading Bandwidth/ 90% BW (MHz)	Transmission rate (Msymbol/s)	Spreading factor	Limit	Spreading Bandwidth/ 90% BW (MHz)	Transmission rate (Msymbol/s)	Spreading factor	Limit	Spreading Bandwidth/ 90% BW (MHz)	Transmission rate (Msymbol/s)	Spreading factor	Limit
3.3VDC (Nominal)	71.8	1.0	71.8	> 5	72.4	1.0	72.4	> 5	72.4	1.0	72.4	> 5
2.97VDC (-10%)	71.8	1.0	71.8	> 5	72.3	1.0	72.3	> 5	72.4	1.0	72.4	> 5
3.6VDC (Max declared)	71.9	1.0	71.9	> 5	72.3	1.0	72.3	> 5	72.4	1.0	72.4	> 5

B. Minimum Channels:

	GFSK (1DH5)				EDR2 (2DH5)				EDR3 (3DH5)			
EUT supply voltage (V)	Spreading Bandwidth/ 90% BW (MHz)	Transmission rate (Msymbol/s)	Spreading factor	Limit	Spreading Bandwidth/ 90% BW (MHz)	Transmission rate (Msymbol/s)	Spreading factor	Limit	Spreading Bandwidth/ 90% BW (MHz)	Transmission rate (Msymbol/s)	Spreading factor	
15.0VDC (Nominal)	18.0	1.0	18.0	> 5	18.1	1.0	18.1	> 5	18.1	1.0	18.1	> 5
13.5 VDC (-10%)	18.0	1.0	18.0	> 5	18.1	1.0	18.1	> 5	18.1	1.0	18.1	> 5
16.5 VDC (+10%)	18.0	1.0	18.0	> 5	18.1	1.0	18.1	> 5	18.1	1.0	18.1	> 5

Note:

1. Spreading bandwidth was estimated using the equation below:
*Spreading bandwidth (minimum) = [Spreading bandwidth (maximum)/maximum number of channels (80)] * minimum number of channels (20)*

EXHIBIT 14. Antenna Power Tolerance

Test Engineer:	Khairul Aidi Zainal
Test Date:	7/11/2016

Requirement:
Article 14 of the Ordinance Regulating Radio Equipment sets forth the requirements for antenna power tolerance. The antenna power of a device shall be within -80% and +20% of the rated or declared antenna power.

Result:

The measured antenna power for the EUT was within the prescribed range. The EUT is found to be compliant to the requirement of the Ordinance regulating Radio Equipment.

Data:

	GFSK (1DH5)					EDR2 (2DH5)					EDR3 (3DH5)				
EUT supply voltage (V)	RMS power (dBm/MHz)	RMS power,P (mW/MHz)	Rated RMS power (mW/MHz)	Tolerance	Pass/Fail	RMS power (dBm/MHz)	RMS power (mW/MHz)	Rated RMS power (mW/MHz)	Tolerance	Pass/Fail	RMS power (dBm/MHz)	RMS power (mW/MHz)	Rated RMS power (mW/MHz)	Tolerance	Pass/Fail
3.3VDC (Nominal)	9.1	8.128	8.300	6.640mW< P < 10.000mW	Pass	4.7	2.917	2.700	2.160mW< P < 3.240mW	Pass	4.5	2.838	2.700	2.160mW< P < 3.240mW	Pass
2.97VDC (-10%)	8.5	7.129	8.300	6.640mW< P < 10.000mW	Pass	4.4	2.729	2.700	2.160mW< P < 3.240mW	Pass	4.2	2.624	2.700	2.160mW< P < 3.240mW	Pass
3.6VDC (Max declared)	9.7	9.247	8.300	6.640mW< P < 10.000mW	Pass	4.8	2.999	2.700	2.160mW< P < 3.240mW	Pass	4.8	3.013	2.700	2.160mW< P < 3.240mW	Pass

EXHIBIT 15. Amount of carrier in 1 MHz

Requirement:

Article 2, Item (19) 49.20 1) g / 49.20 3) h Notice 88 Appendix 43, 44, 45 requires that if OFDM is applied, the amount of carriers within 1 MHz shall be 1 or more.

Result:

For systems classified as FHSS, there are no requirements.

EXHIBIT 16. "Not Easily To Open"

Requirement:
Article 2 of the Ordinance Regulating Radio Equipment states that the EUT shall be constructed in such a way that the RF parts cannot be reached easily by the user

Result:

The radio module, except for the antenna port, is located under a shield.

The EUT is found to be compliant to the requirement of the Ordinance regulating Radio Equipment.

EXHIBIT 17. Voltage fluctuation

Requirement:
Article 15-1 of the Ordinance Regulating Radio Equipment states that all measurements shall be carried out with three different supply voltages: The rated nominal value, -10% and +10%. However if the EUT uses an internal voltage regulator, supplying power to all critical parts of the radio circuitry, it is acceptable to restrict the measurements to the nominal supply voltage value under the condition that the regulator is capable to reduce the voltage variation to a value smaller than 1% of input (if the input is varied by 10%).

Result:

All testing were performed with supply voltage varied at ±10% of the nominal voltage.

EXHIBIT 18. Interference Prevention Function

Requirement:
Article 2 of the Ordinance Regulating Radio Equipment states that the EUT shall have the capability to transmit or to receive the MAC identification automatically, so that sender and receiver shall exclude other equipment.

Result:

Statement from manufacturer:

"The device has a radio module that implements the IEEE 802.11 b/g/n (HT20) protocols, as well as, Bluetooth 2.1 + EDR & 4.0 (BLE) protocols. The module's 48 bit MAC address is transmitted during the connection phase to a master or peer."

APPENDIX A – Test Equipment List

Date : 6-May-2016 Type Test : Conducted measurements Job # : C-2395

Prepared By: Aidi Customer : LSR Quote #: 316053

No.	Asset #	Description	Manufacturer	Model #	Serial #	Cal Date	Cal Due Date	Equipment Status
1	EE 960090	Power Meter	Anritsu	ML2495A	1335006	3/25/2015	3/25/2016	Active Calibration
2	EE 960073	Spectrum Analyzer	Agilent	E4446A	US45300564	10/25/2015	10/25/2016	Active Calibration
3	AA 960144	Phaseflex	Gore	EKD01D010720	5800373	Verification	Verification	System
4	EE 960054	Multimeter	HP	971A	JP40011152	3/16/2015	3/16/2016	Active Calibration

Project Engineer: Quality Assurance: Coty Hammerer

APPENDIX B - Uncertainty Statement

Table of Expanded Uncertainty Values, (K=2) for Specified Measurements

Measurement Type	*Particular Configuration*	*Uncertainty Values*
Radiated Emissions	*3 – Meter chamber, Biconical Antenna*	*4.82 dB*
Radiated Emissions	*3-Meter Chamber, Log Periodic Antenna*	*4.88 dB*
Radiated Emissions	*3-Meter Chamber, Horn Antenna*	*4.85 dB*
Radiated Emissions	*10-Meter OATS, Biconical Antenna*	*4.32 dB*
Radiated Emissions	*10-Meter OATS, Log Periodic Antenna*	*3.63 dB*
Absolute Conducted Emissions	*Agilent PSA/ESA Series*	*1.38 dB*
AC Line Conducted Emissions	*Shielded Room/EMCO LISN*	*3.20 dB*
Radiated Immunity	*3 Volts/Meter in 3-Meter Chamber*	*2.05 Volts/Meter*
Conducted Immunity	*3 Volts level*	*2.33 V*
EFT Burst, Surge, VDI	*230 VAC*	*54.4 V*
ESD Immunity	*Discharge at 15kV*	*3200 V*
Temperature/Humidity	*Thermo-hygrometer*	*0.64° / 2.88 %RH*