Japan Test Report

Equipment	:	**Bluetooth 4.2 module (BLE only)**
Model No.	:	**BL652-SC**
Brand Name	:	**Laird**
Applicant	:	**Laird Technologies**
Address	:	**W66N220 Commerce Court, Cedarburg, Wisconsin 53012, USA**
Standard	:	**Article 2 Paragraph 1 Item 19**
Received Date	:	**May 14, 2018**
Tested Date	:	**Jul. 19, 2016 (For original test) Jun. 04 ~ Jun. 06, 2018 (For new test)**

Measurement was conducted by the following test method:
the test method of Ordinance Concerning Technical Regulations Conformity Certification etc. of Specified Radio Equipment in Annex 1, the Ministry of Internal Affairs and Communication notification in Annex "43" of Article 88, Paragraph 1 and ARIB STD-T66.

We, International Certification Corp., would like to declare that the tested sample has been evaluated and in compliance with the requirement of the above standards. The test results contained in this report refer exclusively to the product. It may be duplicated completely for legal use with the approval of the applicant. It shall not be reproduced except in full without the written approval of our laboratory.

Reviewed by: **Approved by:**

James Fan / Assistant Manager **Gary Chang / Manager**

Testing Laboratory 2732

Table of Contents

Release Record

Report No.	Version	Description	Issued Date
JR662202-07AE	Rev. 01	Initial issue	Jul. 27, 2018

Summary of Test Results

Ref. Std. Clause	Description	Result
3.2(2)(3)	Antenna Power	Pass
3.2(4)	Frequency Tolerance	Pass
3.2(6)	Transmitter Spurious Emission	Pass
3.2(7)	Occupied Bandwidth	Pass
3.3(1)	Receiver Emission	Pass
3.4.1	Interference prevention function	Pass

1 General Description

1.1 Information

This report is issued as a supplementary report to original ICC report no. JR662202-04AE. The modification is concerned with adding 2 antenna and 2 Mbps data rate by software setting.

All test items are evaluated for 2 Mbps data rate and test results of 1 Mbps data rate were kept the same as recorded in original report.

1.1.1 Specification of the Equipment under Test (EUT)

Power Type	3.3Vdc from host
Type(s) of Modulation / Technology	GFSK / 1 Mbps GFSK / 2 Mbps
Frequency Range (MHz)	2402 ~ 2480 MHz
Total Channel Number	40
HW Version	A1
SW Version	28.7.3.0

1.1.2 Accessories

N/A

1.1.3 Antenna Details(New antenna was marked in boldface.)

Ant. No.	Brand	Model	Type	Connector	Gain (dBi)
1	LSR	FlexPIFA 001-0022	FlexPIFA	MHF4	2
2	LSR	FlexNotch 001-0023	Flexible Notch	MHF4	2
3	MAG. LAYERS	EDA-8709-2G4C1-B27	Dipole	MHF4	2
4	Walsin	RFDPA870910EMAB302	Dipole	MHF4	2
5	Walsin	RFDPA870900SBAB8G1	Dipole	MHF4	2
6	YAMAMOTO METAL	YAN-02-C-MHF4P-050	Chip	MHF4	-1.76
7	**Laird**	**PCA-4606-2G4C1-A33-CY Laird # 0600-00056**	**PCB Dipole**	**IPEX**	**2.21**
8	**Laird**	**EFA2400A3S-10MH4L**	**mFlexPIFA**	**MHF4**	**2**

Note: Please refer to Appendix G for more details about antenna pattern and other information.

1.1.4 Antenna Power

Operating Mode	Rated Power (mW)	Measured Conducted Power (mW)	Radiated Power (mW)
BT-LE(1Mbps)	3.5	3.090	4.90
BT-LE(2Mbps)	2.5	2.679	4.457

1.1.5 Channel List

Frequency band (MHz)				2400~2483.5			
Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
37	2402	9	2422	18	2442	28	2462
0	2404	10	2424	19	2444	29	2464
1	2406	38	2426	20	2446	30	2466
2	2408	11	2428	21	2448	31	2468
3	2410	12	2430	22	2450	32	2470
4	2412	13	2432	23	2452	33	2472
5	2414	14	2434	24	2454	34	2474
6	2416	15	2436	25	2456	35	2476
7	2418	16	2438	26	2458	36	2478
8	2420	17	2440	27	2460	39	2480

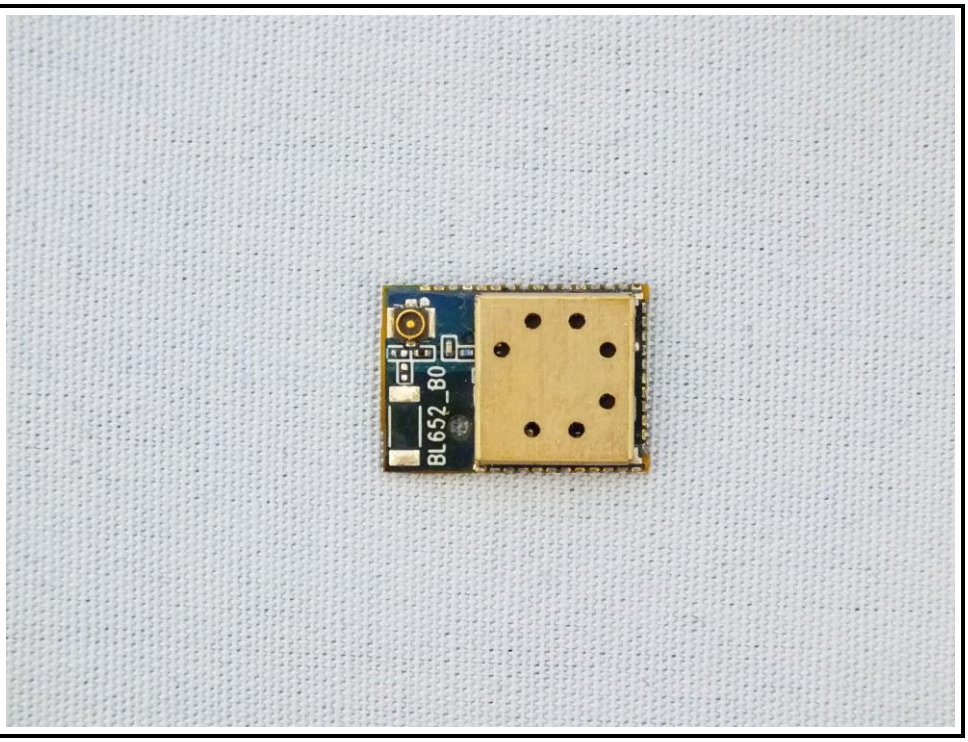
1.1.6 Test Tool and Power Setting

Mode	Test Tool
BT-LE(1Mbps)	nRFgo Studio v. 1.16.1.3119
BT-LE(2Mbps)	UwTerminal v7.94

Modulation Mode	Test Frequency (MHz)		
	2402	2440	2480
BT-LE(1Mbps)	Default	Default	Default
BT-LE(2Mbps)	Default	Default	Default

1.1.7 Protection Method for High Frequency and Modulation Section

Protected Method	Description
Shielding Case	RF and Modulation components are covered with shielding case and this shielding case is soldered

Photo	

1.2 Test Equipment and Calibration Data

Test Item	RF Conducted				
Test Site	(TH01-WS)				
Test date	Jul. 19, 2016				
Instrument	**Manufacturer**	**Model No.**	**Serial No.**	**Calibration Date**	**Calibration Until**
Spectrum Analyzer	R&S	FSV40	101063	Feb. 17, 2016	Feb. 16, 2017
Power Meter	Anritsu	ML2495A	1241002	Sep. 21, 2015	Sep. 20, 2016
Power Sensor	Anritsu	MA2411B	1207366	Sep. 21, 2015	Sep. 20, 2016
DC POWER SOURCE	GW INSTEK	GPC-3060D	EM884797	Oct. 20, 2015	Oct. 19, 2016
Measurement Software	Sporton	Sporton_1	1.3.30	NA	NA
Note 1: Calibration Interval of instruments listed above is one year. Note 2: Above instruments are calibrated by Electronics Testing Center					

Test Item	RF Conducted				
Test Site	(TH01-WS)				
Test date	Jun. 04 ~ Jun. 06, 2018				
Instrument	**Manufacturer**	**Model No.**	**Serial No.**	**Calibration Date**	**Calibration Until**
Spectrum Analyzer	R&S	FSV40	101063	Apr. 16, 2018	Apr. 15, 2019
Power Meter	Anritsu	ML2495A	1241002	Oct. 16, 2017	Oct. 15, 2018
Power Sensor	Anritsu	MA2411B	1207366	Oct. 16, 2017	Oct. 15, 2018
DC POWER SOURCE	GW INSTEK	GPC-6030D	EM892433	Oct. 26, 2017	Oct. 25, 2018
Measurement Software	Sporton	Sporton_1	1.3.30	NA	NA
Note 1: Calibration Interval of instruments listed above is one year. Note 2: Above instruments are calibrated by Electronics Testing Center					

1.3 Testing Applied Standards

According to the specifications of the manufacturer, the EUT must comply with the requirements of the following standards:

Article 2 Paragraph 1 Item 19

1.4 Measurement Uncertainty

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level (based on a coverage factor (k=2)

Measurement Uncertainty	
Parameters	**Uncertainty**
Frequency error	±33.988 Hz
Bandwidth	±33.988 Hz
Conducted power	±0.537 dB
TX Conducted emission	±2.308 dB
RX Conducted emission	±2.525 dB

2 Test Configuration

2.1 Testing Location and Conditions

Test Site	Site Category	Ambient Condition	Tested By
TH01-WS	OVEN Room	25℃ / 65%	Chris Zeng

2.2 The Worst Test Modes and Channel Details

Test item	Mode	Test Frequency (MHz)
Antenna Power Frequency Tolerance Transmitter Spurious Emission Occupied Bandwidth Spreading Bandwidth Collateral Emission of Receiver Spreading Factor Interference prevention function	BT LE	2402 / 2440 / 2480

3 Transmitter Test Results

3.1 Antenna Power

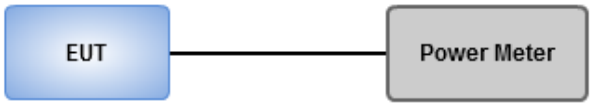
3.1.1 Limit of Antenna Power

Mode	Limit	Tolerance
1) FH, FH+DS, FH+OFDM	3 mW / MHz	+20 % , -80 %
2) OFDM(Narrow- bandwidht), DS	10 mW / MHz	
3) Other than 1) & 2)	10mW	
4) OFDM (Wide-band)	5 mW / MHz	

3.1.2 Test Procedures

Measure the total power by Power Meter

3.1.3 Test Setup



3.1.4 Test Result of Maximum Transmit Power

Reference Documents	Test Mode
Appendix A1, A2	BT-LE

3.2 Frequency Tolerance

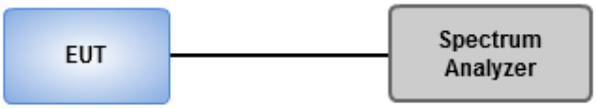
3.2.1 Limit of Frequency Tolerance

Frequency tolerance shall be +/- 50ppm.

3.2.2 Test Procedures

1. Set Span = 150kHz, RBW = 1kHz, VBW = 30kHz, Sweep time = Auto, detector = Peak.
2. Use Peak search function to find the max peak value and record this value (RF).
3. Calculate frequency tolerance by below formula
   FT(ppm) = { (RF) – (MF) / (MF) } × 1000000
   (FT: Frequency Tolerance, RF: Reading Frequency, MF: Measurement Frequency.)

3.2.3 Test Setup



3.2.4 Test Result of Frequency Tolerance

Reference Documents	Test Mode
Appendix B	BT-LE

3.3 Occupied Bandwidth

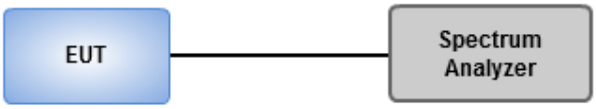
3.3.1 Limit of Occupied Bandwidth

Mode	Limit (MHz)
FH	83.5
FH+DS	83.5
FH+OFDM	83.5
OFDM(Narrow- bandwidht), DS	26
Others	26
OFDM (Wide-band)	38

3.3.2 Test Procedures

1. Set Span = 40MHz, RBW = VBW = 300kHz, detector = Peak, Sweep time = Auto.
2. Enable OBW function of spectrum analyzer to measure OBW and capture test plot.

3.3.3 Test Setup



3.3.4 Test Result of Occupied Bandwidth

Reference Documents	Test Mode
Appendix C	BT-LE

3.4 Transmitter Spurious Emissions

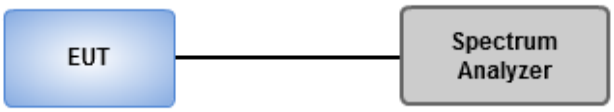
3.4.1 Limit of Transmitter Spurious Emissions

Item	Limits
Tx Spurious Emission	≤ 2.5 μW (2387MHz > f ; 2496.5MHz < f).
	≤ 25 μW. (2387MHz ≤ f < 2400MHz) and (2483.5MHz < f ≤ 2496.5MHz).

3.4.2 Test Procedures

1. Set EUT to transmit at rated power and channel to perform test.
2. Set RBW = VBW = 1MHz, Detector type = Peak, Sweep time = Auto.
3. Following above setting of spectrum analyzer to measure spurious emission of 30~12500 MHz.

3.4.3 Test Setup



3.4.4 Test Result of Transmitter Spurious Emissions

Reference Documents	Test Mode
Appendix D	BT-LE

3.5 Interference Prevention Function

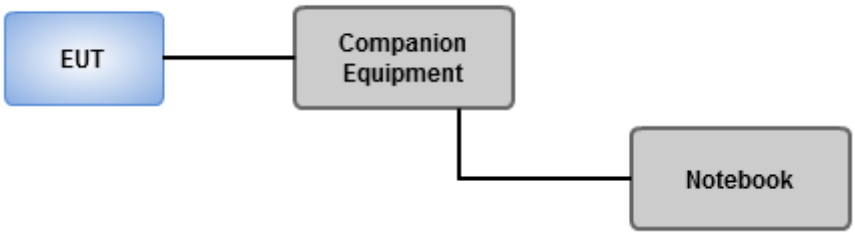
3.5.1 Limit of Interference Prevention Function

Limits
The identification code shall be 48 bits long

3.5.2 Test Procedures

1. Set EUT under operating mode and link up with companion equipment
2. Check communication status between EUT and companion equipment is normal
3. Confirm the MAC address of EUT

3.5.3 Test Setup



3.5.4 Test Result of Interference Prevention Function

Reference Documents	Test Mode
Appendix E	BT-LE

4 Receiver Test Results

4.1 Receiver Spurious Emissions

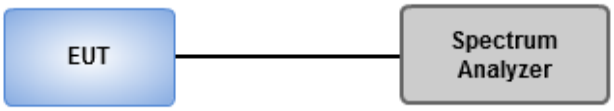
4.1.1 Limit of Receiver Spurious Emissions

Item	Limits
Rx Spurious Emission	≤ 4nW (f < 1GHz).
	≤ 20nW (1GHz ≤ f).

4.1.2 Test Procedures

1. Set EUT under receiving condition to perform test
2. Set RBW = VBW = 100kHz, detector = Peak, Sweep time = Auto for emission measurement below 1GHz.
3. Set RBW = VBW=1MHz, detector = Peak, Sweep time = Auto for emission measurement above 1GHz.

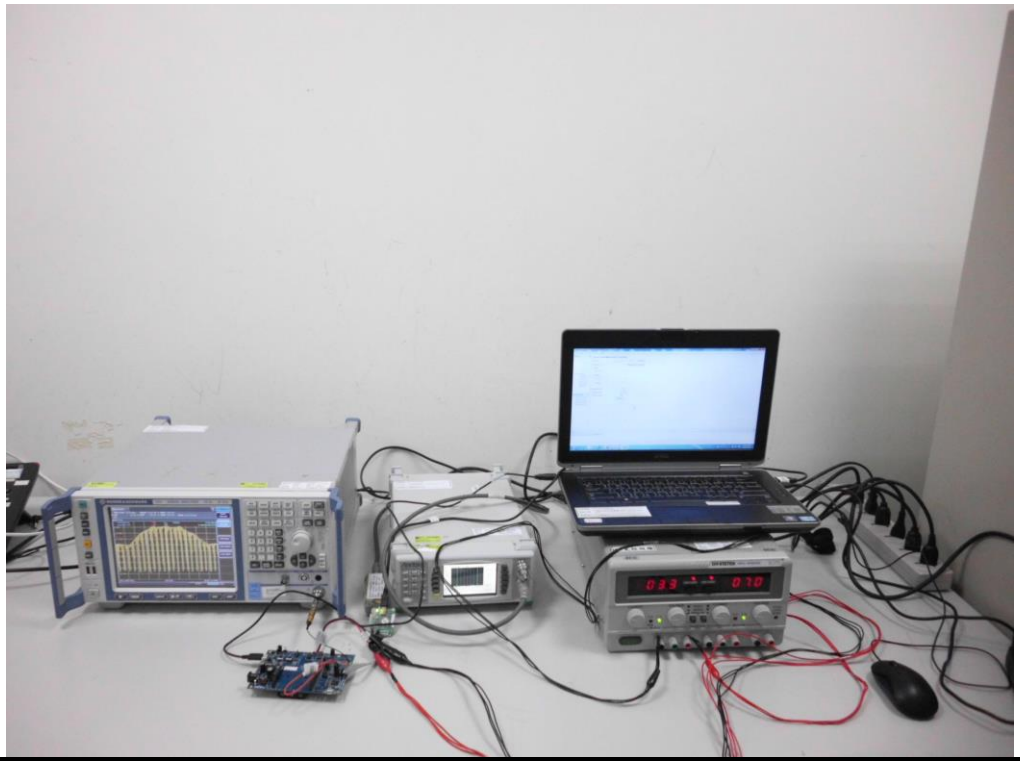
4.1.3 Test Setup



4.1.4 Test Result of Receiver Spurious Emissions

Reference Documents	Test Mode
Appendix F	BT-LE

5 Photographs of the Test Configuration



6 Test laboratory information

Established in 2012, ICC provides foremost EMC & RF Testing and advisory consultation services by our skilled engineers and technicians. Our services employ a wide variety of advanced edge test equipment and one of the widest certification extents in the business.

International Certification Corp (EMC and Wireless Communication Laboratory), it is our definitive objective is to institute long term, trust-based associations with our clients. The expectation we set up with our clients is based on outstanding service, practical expertise and devotion to a certified value structure. Our passion is to grant our clients with best EMC / RF services by oriented knowledgeable and accommodating staff.

Our Test sites are located at Linkou District and Kwei Shan District. Location map can be found on our website http://www.icertifi.com.tw.

Linkou	**Kwei Shan**	**Kwei Shan Site II**
Tel: 886-2-2601-1640	Tel: 886-3-271-8666	Tel: 886-3-271-8640
No. 30-2, Ding Fwu Tsuen, Lin Kou District, New Taipei City, Taiwan, R.O.C.	No. 3-1, Lane 6, Wen San 3rd St., Kwei Shan District, Tao Yuan City 333, Taiwan, R.O.C.	No. 14-1, Lane 19, Wen San 3rd St., Kwei Shan District, Tao Yuan City 333, Taiwan, R.O.C.

If you have any suggestion, please feel free to contact us as below information

Tel: 886-3-271-8666
Fax: 886-3-318-0155
Email: ICC_Service@icertifi.com.tw

==END==

Test results of 1 Mbps data rate

Appendix A 19-LE

1. Test Results

	Test Voltage		V	Normal Voltage (3.3V)			High Voltage (3.6V)			Low Voltage (1.7V)			Remarks
Testing for Electrical Specification	Test Frequency		MHz	2402	2440	2480	2402	2440	2480	2402	2440	2480	Low/Mid/High of test frequency range
	Measured Frequency		MHz	2401.9731	2439.9726	2479.9721	2401.9732	2439.9727	2479.9726	2401.9734	2439.9727	2479.9725	
	Frequency Error		ppm	-11.20	-11.23	-11.25	-11.16	-11.19	-11.05	-11.07	-11.19	-11.09	Limit ≦ 50 ppm
	Occupied Bandwidth		MHz	1.34	1.29	1.29	1.32	1.28	1.29	1.33	1.29	1.29	Limit ≦ 26 MHz (RB/VB : 300kHz)
	Spread-spectrum Bandwidth		MHz	0.88	0.86	0.86	0.88	0.86	0.85	0.88	0.86	0.85	Spread Factor Limit ≧ 5 (DSSS and FHSS)
	Unwanted Emission Intensity (Power emission within 1MHz bandwidth)	※ 1	μW	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	Limit ≦ 0.25 μW (-36 dBm)
		※ 2	μW	0.0090	0.0072	0.0090	0.0082	0.0083	0.0102	0.0086	0.0102	0.0076	Limit ≦ 2.5 μW (-26 dBm)
		※ 3	μW	1.8450	0.0108	0.0106	1.8450	0.0086	0.0098	1.8197	0.0095	0.0100	Limit ≦ 25 μW (-16 dBm)
		※ 4	μW	0.0089	0.0089	0.2291	0.0095	0.0089	0.2208	0.0078	0.0083	0.2234	Limit ≦ 25 μW (-16 dBm)
		※ 5	μW	0.0029	0.0019	0.0011	0.0027	0.0020	0.0013	0.0023	0.0018	0.0013	Limit ≦ 2.5 μW (-26 dBm)
	Antenna Power (Measured Power)		mW	3.083	3.076	3.048	3.090	3.083	3.055	3.076	3.069	3.041	Limit ≦ 10 mW (10 dBm)
	Antenna Power (Rated Power)		mW	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	Limit ≦ 10 mW (10 dBm)
	Antenna Power Error		mW	-0.42	-0.42	-0.45	-0.41	-0.42	-0.45	-0.42	-0.43	-0.46	
			%	-11.91	-12.11	-12.92	-11.71	-11.91	-12.72	-12.11	-12.31	-13.12	Limit + 20% ~ - 80%
	Limitation of Collateral Emission of Receiver	※ 6	nW	0.0012	0.0009	0.0013	0.0016	0.0012	0.0011	0.0011	0.0013	0.0015	Limit ≦ 4 nW (-54 dBm)
		※ 7	nW	0.0942	0.0933	0.0652	0.0811	0.0887	0.0587	0.1026	0.0935	0.0621	Limit ≦ 20 nW (-47 dBm)
	Radio Interference Prevention Function		ID Code	Good, MAC Address :E6:F4:EA:4D:0C:0E									
			Carrier Sense	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR: Not Require

※ 1: Frequency Band 1 (30 MHz ≦ f ≦ 2387 MHz)
※ 2: Frequency Band 2 (2387 MHz < f ≦ 2400 MHz)
※ 3: Frequency Band 3 (2483.5 MHz ≦ f < 2496.5 MHz)
※ 4: Frequency Band 4 (2496.5 MHz ≦ f < 12.5 GHz)
※ 5: Frequency Band 5 (30 MHz ≦ f < 1000 MHz)
※ 6: Frequency Band 6 (1000 MHz ≦ f < 12.5 GHz)

2. Antenna Power (Conducted Power)

	Test Voltage	V	Normal Voltage (3.3V)			High Voltage (3.6V)			Low Voltage (1.7V)			Remarks
Testing for Electrical Specification	Test Frequency	MHz	2402	2440	2480	2402	2440	2480	2402	2440	2480	
	Power Meter Raw from EUT	dBm	1.61	1.60	1.56	1.62	1.61	1.57	1.60	1.59	1.55	
	Cable Loss	dB	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	Refer to Calibration Result
	Duty Cycle Factor	dB	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	Duty Factor = 10 × $10Log_{10}$(1/Duty Cycle)
	Antenna Power (Conducted)	dBm	4.89	4.88	4.84	4.90	4.89	4.85	4.88	4.87	4.83	Limit ≦ 10 mW (10 dBm)
	Antenna Power (Conducted)	mW	3.083	3.076	3.048	3.090	3.083	3.055	3.076	3.069	3.041	
	Antenna Power Error	mW	-0.42	-0.42	-0.45	-0.41	-0.42	-0.45	-0.42	-0.43	-0.46	
		%	-11.91	-12.11	-12.92	-11.71	-11.91	-12.72	-12.11	-12.31	-13.12	Limit + 20% ~ - 80%
	Tranmsitter ON_{Time}	msec	0.4130									RBW : 1 MHz ; VBW : 1 MHz ; SP : 0Hz
	Tranmsitter $(ON+OFF)_{Time}$	msec	0.6231									
	Tranmsitter Duty Cycle	%	66.29%									

3. Transmission Radiation Angle Width (This test item will not be applied to the EIRP power is lower than 12.14dBm)

No.	Antenna Power	Antenna				Cable			Tatal Gain D=B-C	EIRP F=A+D	Permited Angle	Judgement	Remarks (Antenna Model)
	A (dBm)	Type	Gain B (dBi)	3dB Beam-width Horizontal (Degree)	3dB Beam-width Vertical (Degree)	Model	Length (m)	Loss C (dB)	(dBi)	(dBm)	(Degree)		
1	4.90	FlexPIFA	2.00			-	-		2.00	6.90	305.70	Good	Model: FlexPIFA 001-0022
2	4.90	Flexible North	2.00			-	-		2.00	6.90	305.70	Good	Model: FlexNotch 001-0023
3	4.90	Dipole	2.00			-	-		2.00	6.90	305.70	Good	Model: EDA-8709-2G4C1-B27 Model: RFDPA870910EMAB302 Model: RFDA870900SBAB8G1
4	4.90	Chip	-1.76						-1.76	3.14	360.00	Good	Model: A24-HASM-450
5													
6													
7													
8													
9													
10													
11													
12													

4. Unwanted Emission Intensity

	Test Voltage		V	Normal Voltage (3.3V)			High Voltage (3.6V)			Low Voltage (1.7V)			Remarks
Unwanted Emission Intensity	Test Frequency		MHz	2402	2440	2480	2402	2440	2480	2402	2440	2480	
	Unwanted Emission Frequency	※ 1	MHz	776.10	930.50	967.00	790.10	784.50	990.90	982.50	842.10	825.20	RBW : 100 kHz ; VBW : 100k Hz
		※ 2	MHz	2273.60	2307.70	2351.90	2273.60	2311.70	2351.90	2273.60	2311.70	2351.90	RBW : 1 MHz ; VBW : 1 MHz
		※ 3	MHz	2399.99	2391.86	2391.95	2399.97	2391.71	2391.80	2399.97	2392.22	2391.71	
		※ 4	MHz	2489.78	2487.93	2485.43	2490.17	2488.25	2485.32	2490.09	2488.22	2485.38	
		※ 5	MHz	4805.50	4877.50	4964.50	4805.50	4877.50	4964.50	4805.50	4877.50	4964.50	
	Cable Loss	※ 1	dB	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	
		※ 2	dB	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	
		※ 3	dB	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	
		※ 4	dB	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	1.49	
		※ 5	dB	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	
	Spectrum Raw	※ 1	dBm	-71.62	-71.89	-72.11	-71.69	-71.50	-72.36	-71.78	-71.65	-71.71	
		※ 2	dBm	-51.94	-52.92	-51.93	-52.36	-52.31	-51.40	-52.17	-51.42	-52.68	
		※ 3	dBm	-28.83	-51.17	-51.23	-28.83	-52.15	-51.56	-28.89	-51.71	-51.51	
		※ 4	dBm	-52.00	-52.00	-37.89	-51.71	-52.01	-38.05	-52.58	-52.31	-38.00	
		※ 5	dBm	-57.13	-59.08	-61.26	-57.40	-58.85	-60.56	-58.23	-59.15	-60.60	
	Unwanted Emission Intensity	※ 1	dBm	-70.74	-71.01	-71.23	-70.81	-70.62	-71.48	-70.90	-70.77	-70.83	Limit ≦ 2.5 μW (-26 dBm)
		※ 2	dBm	-50.45	-51.43	-50.44	-50.87	-50.82	-49.91	-50.68	-49.93	-51.19	
		※ 3	dBm	-27.34	-49.68	-49.74	-27.34	-50.66	-50.07	-27.40	-50.22	-50.02	Limit ≦ 25 μW (-16 dBm)
		※ 4	dBm	-50.51	-50.51	-36.40	-50.22	-50.52	-36.56	-51.09	-50.82	-36.51	Limit ≦ 25 μW (-16 dBm)
		※ 5	dBm	-55.37	-57.32	-59.50	-55.64	-57.09	-58.80	-56.47	-57.39	-58.84	Limit ≦ 2.5 μW (-26 dBm)
	Unwanted Emission Intensity	※ 1	μW	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	Limit ≦ 2.5 μW (-26 dBm)
		※ 2	μW	0.0090	0.0072	0.0090	0.0082	0.0083	0.0102	0.0086	0.0102	0.0076	
		※ 3	μW	1.8450	0.0108	0.0106	1.8450	0.0086	0.0098	1.8197	0.0095	0.0100	Limit ≦ 25 μW (-16 dBm)
		※ 4	μW	0.0089	0.0089	0.2291	0.0095	0.0089	0.2208	0.0078	0.0083	0.2234	Limit ≦ 25 μW (-16 dBm)
		※ 5	μW	0.0029	0.0019	0.0011	0.0027	0.0020	0.0013	0.0023	0.0018	0.0013	Limit ≦ 2.5 μW (-26 dBm)

※ 1: Frequency Band 1 (30 MHz ≦ f ≦ 1000 MHz)
※ 2: Frequency Band 2 (1000 MHz < f ≦ 2387 MHz)
※ 3: Frequency Band 3 (2387 MHz < f ≦ 2400 MHz)
※ 4: Frequency Band 4 (2483.5 MHz ≦ f < 2496.5 MHz)
※ 5: Frequency Band 5 (2496.5 MHz ≦ f < 12.5 GHz)
※ 6: Frequency Band 6 (30 MHz ≦ f < 1000 MHz)
※ 7: Frequency Band 7 (1000 MHz ≦ f < 12.5 GHz)

5. Limitation of Collateral Emission of Receiver

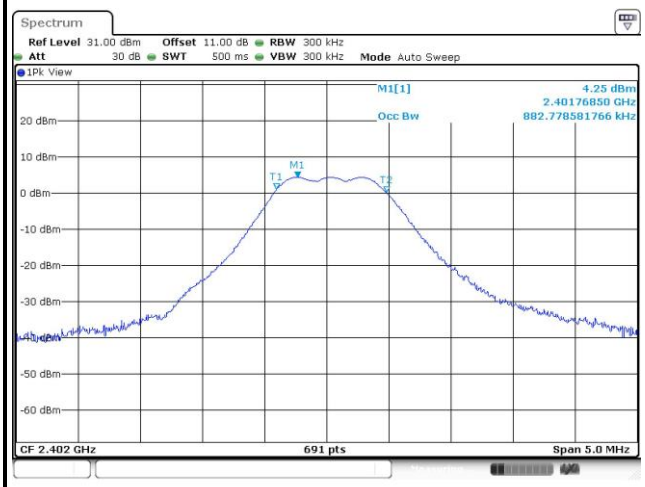
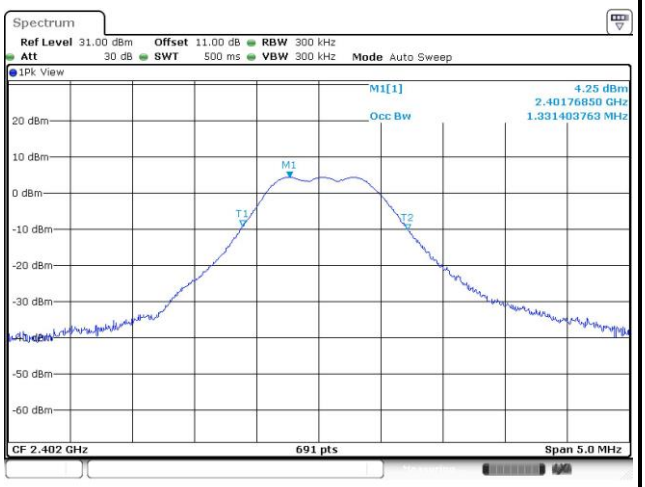
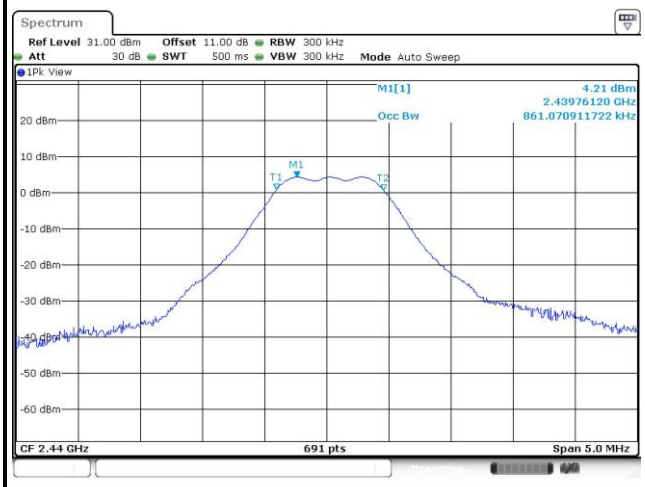
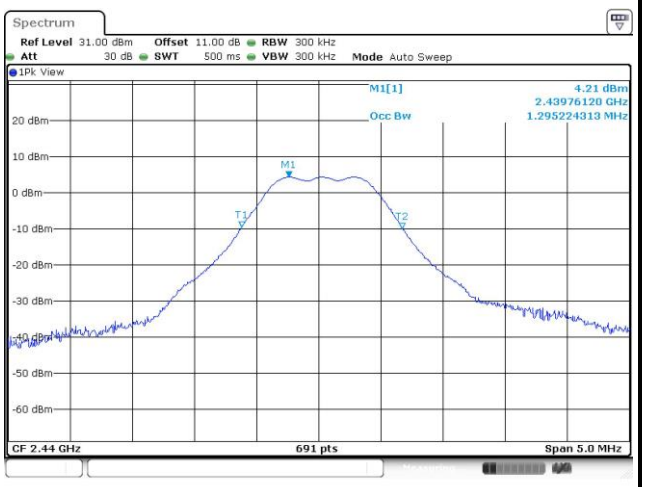
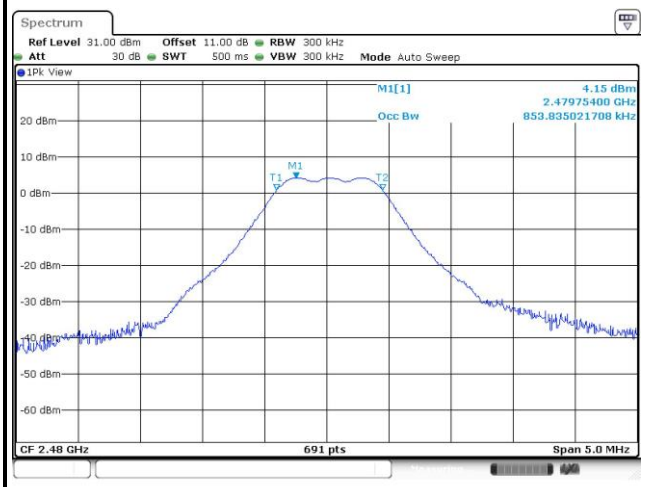
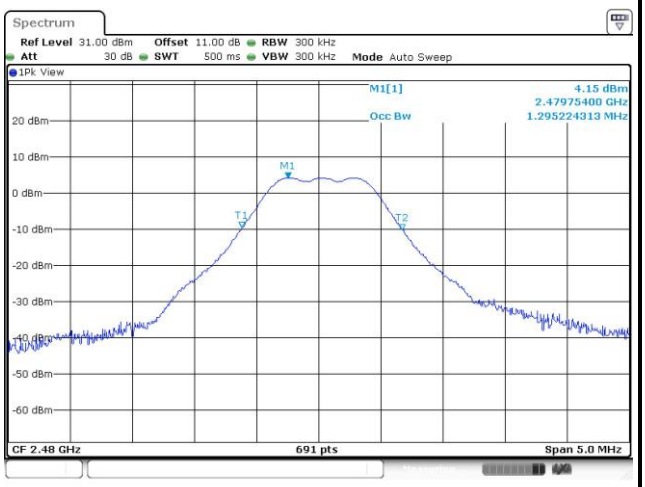
	Test Voltage		V	Normal Voltage (3.3V)			High Voltage (3.6V)			Low Voltage (1.7V)			Remarks
Limitation of Collateral Emission	Test Frequency		MHz	2402	2440	2480	2402	2440	2480	2402	2440	2480	
	Spurious Emission Frequency	※ 6	MHz	624.50	88.30	624.50	624.50	624.50	624.50	32.10	64.40	64.40	1st 30MHz～1000MHz:: Maximum emission and all emissions beyond 1/10 of the limitation must be indicated.
		※ 6	MHz	-	-	-	-	-	-	-	-	-	2nd
		※ 6	MHz	-	-	-	-	-	-	-	-	-	3rd
		※ 7	MHz	4803.00	4886.00	4953.00	4803.00	4886.00	4953.00	4803.00	4886.00	4953.00	1st 1000MHz～12.5GHz:: Maximum emission and all emissions beyond 1/10 of the limitation must be indicated.
		※ 7	MHz	-	-	-	-	-	-	-	-	-	2nd
		※ 7	MHz	-	-	-	-	-	-	-	-	-	3rd
	Cable Loss	※ 6	dB	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	1st
		※ 6	dB	-	-	-	-	-	-	-	-	-	2nd
		※ 6	dB	-	-	-	-	-	-	-	-	-	3rd
		※ 7	dB	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1st
		※ 7	dB	-	-	-	-	-	-	-	-	-	2nd
		※ 7	dB	-	-	-	-	-	-	-	-	-	3rd
	Spectrum Raw	※ 6	dBm	-90.21	-91.28	-89.66	-88.97	-89.95	-90.31	-90.61	-89.63	-89.01	1st
		※ 6	dBm	-	-	-	-	-	-	-	-	-	2nd
		※ 6	dBm	-	-	-	-	-	-	-	-	-	3rd
		※ 7	dBm	-72.02	-72.06	-73.62	-72.67	-72.28	-74.07	-71.65	-72.05	-73.83	1st
		※ 7	dBm	-	-	-	-	-	-	-	-	-	2nd
		※ 7	dBm	-	-	-	-	-	-	-	-	-	3rd
	Spurious Emission Intensity	※ 6	dBm	-89.33	-90.40	-88.78	-88.09	-89.07	-89.43	-89.73	-88.75	-88.13	1st
		※ 6	dBm	-	-	-	-	-	-	-	-	-	2nd Limit ≦ 4 nW (-54 dBm) RBW : 100 kHz ; VBW : 100 kHz
		※ 6	dBm	-	-	-	-	-	-	-	-	-	3rd
		※ 7	dBm	-70.26	-70.30	-71.86	-70.91	-70.52	-72.31	-69.89	-70.29	-72.07	1st
		※ 7	dBm	-	-	-	-	-	-	-	-	-	2nd Limit ≦ 20 nW (-47 dBm) RBW : 1 MHz ; VBW : 1 MHz
		※ 7	dBm	-	-	-	-	-	-	-	-	-	3rd
	Spurious Emission Intensity	※ 6	nW	0.0012	0.0009	0.0013	0.0016	0.0012	0.0011	0.0011	0.0013	0.0015	Total Emission Power
		※ 6	nW	0.0012	0.0009	0.0013	0.0016	0.0012	0.0011	0.0011	0.0013	0.0015	1st
		※ 6	nW	-	-	-	-	-	-	-	-	-	2nd Limit ≦ 4 nW (-54 dBm) RBW : 100 kHz ; VBW : 100 kHz
		※ 6	nW	-	-	-	-	-	-	-	-	-	3rd
		※ 7	nW	0.0942	0.0933	0.0652	0.0811	0.0887	0.0587	0.1026	0.0935	0.0621	Total Emission Power
		※ 7	nW	0.0942	0.0933	0.0652	0.0811	0.0887	0.0587	0.1026	0.0935	0.0621	1st
		※ 7	nW	-	-	-	-	-	-	-	-	-	2nd Limit ≦ 20 nW (-47 dBm) RBW : 1 MHz ; VBW : 1 MHz
		※ 7	nW	-	-	-	-	-	-	-	-	-	3rd

※ 1: Frequency Band 1 (30 MHz ≦ f ≦ 1000 MHz)
※ 2: Frequency Band 2 (1000 MHz < f ≦ 2387 MHz)
※ 3: Frequency Band 3 (2387 MHz < f ≦ 2400 MHz)
※ 4: Frequency Band 4 (2483.5 MHz ≦ f < 2496.5 MHz)
※ 5: Frequency Band 5 (2496.5 MHz ≦ f < 12.5 GHz)
※ 6: Frequency Band 6 (30 MHz ≦ f < 1000 MHz)
※ 7: Frequency Band 7 (1000 MHz ≦ f < 12.5 GHz)

Test plots of 1 Mbps data rates

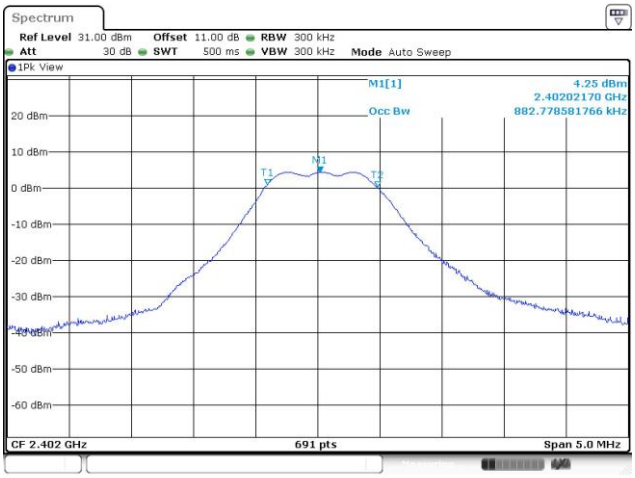
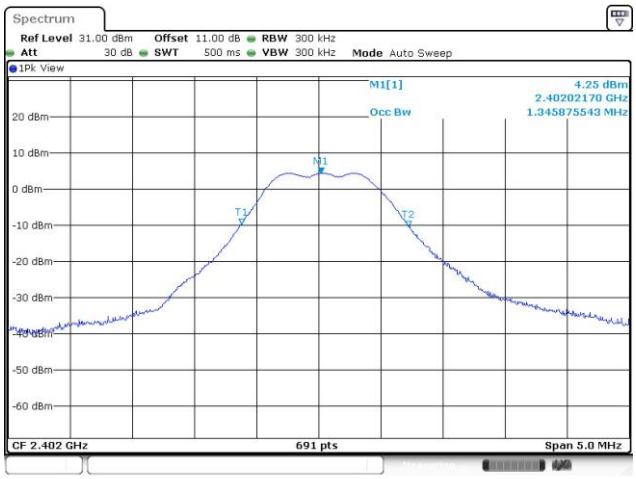
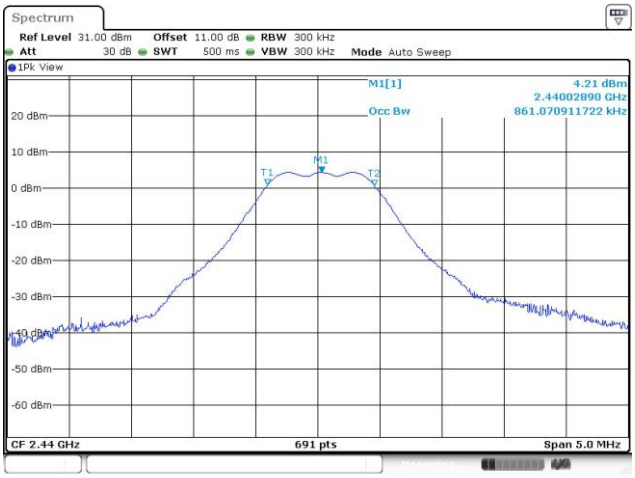
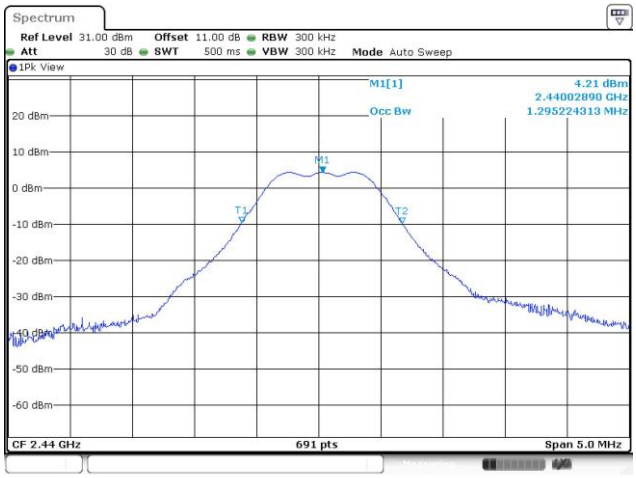
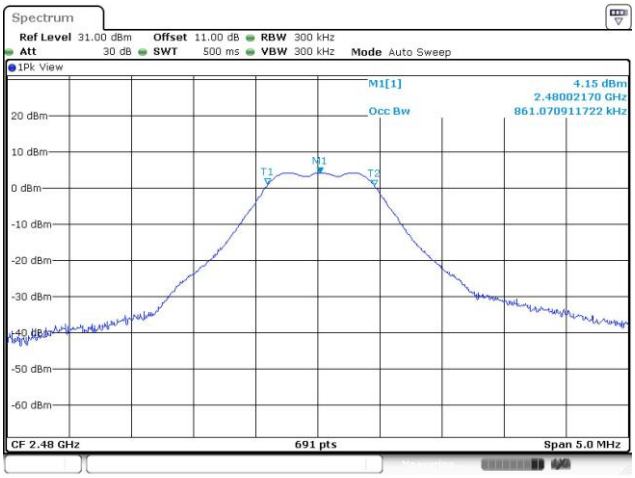
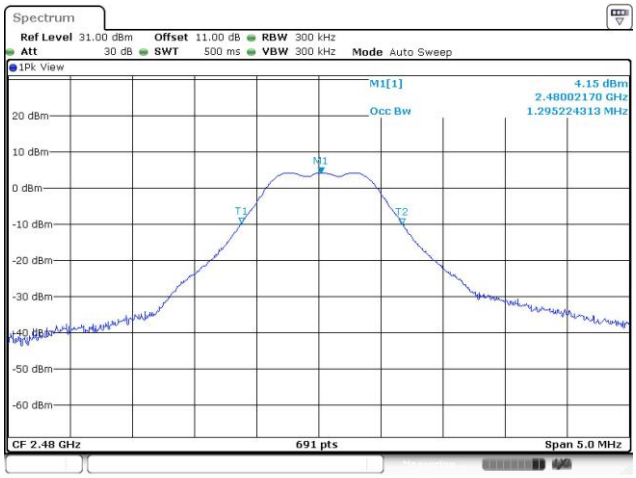
Occupied and Spread Bandwidth

1.7 Vdc

Spread bandwidth	Occupied Bandwidth
	
	
	

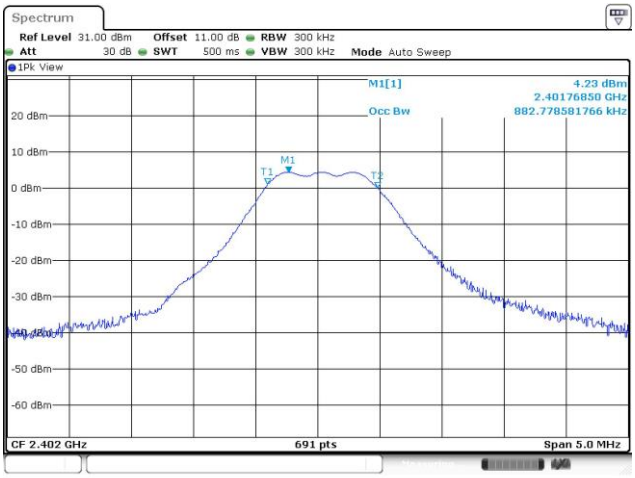
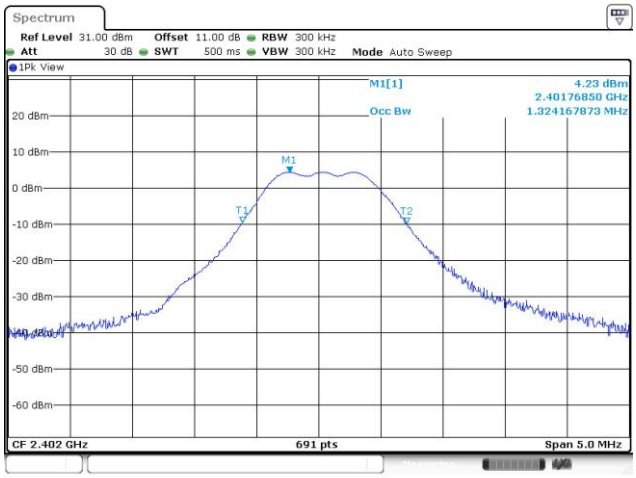
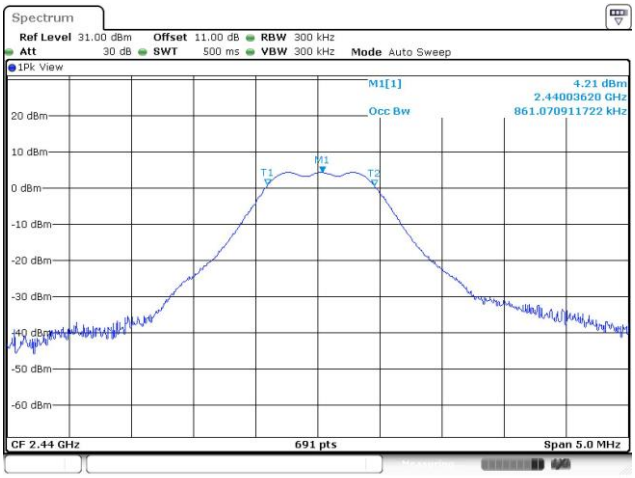
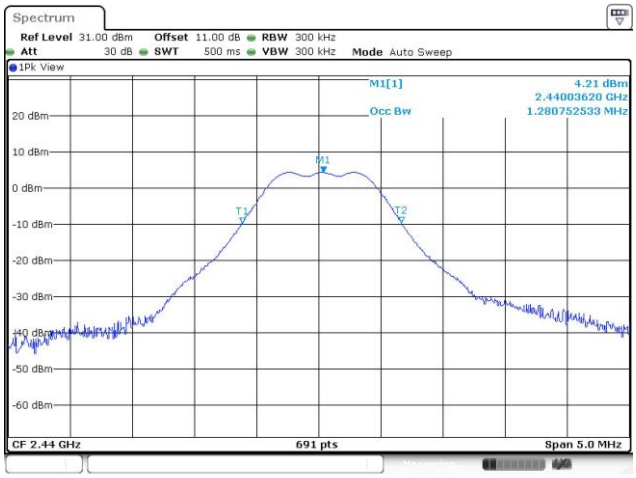
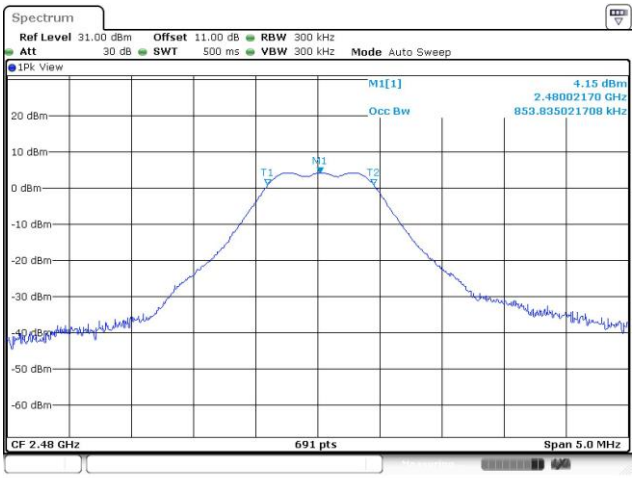
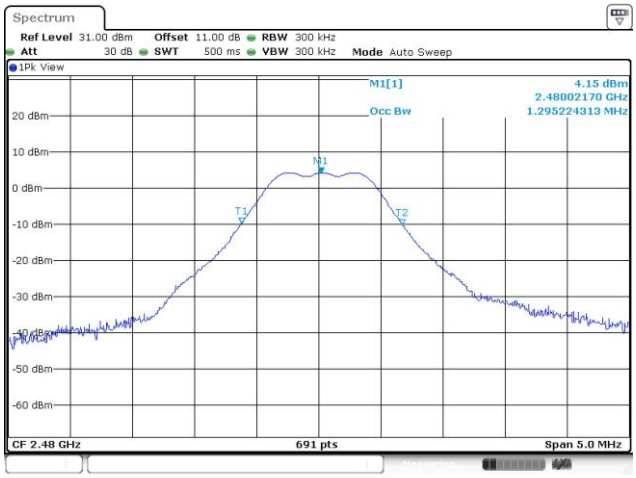
Test plots of 1 Mbps data rates

3.3 Vdc

Spread bandwidth	Occupied Bandwidth
	
	
	

Test plots of 1 Mbps data rates

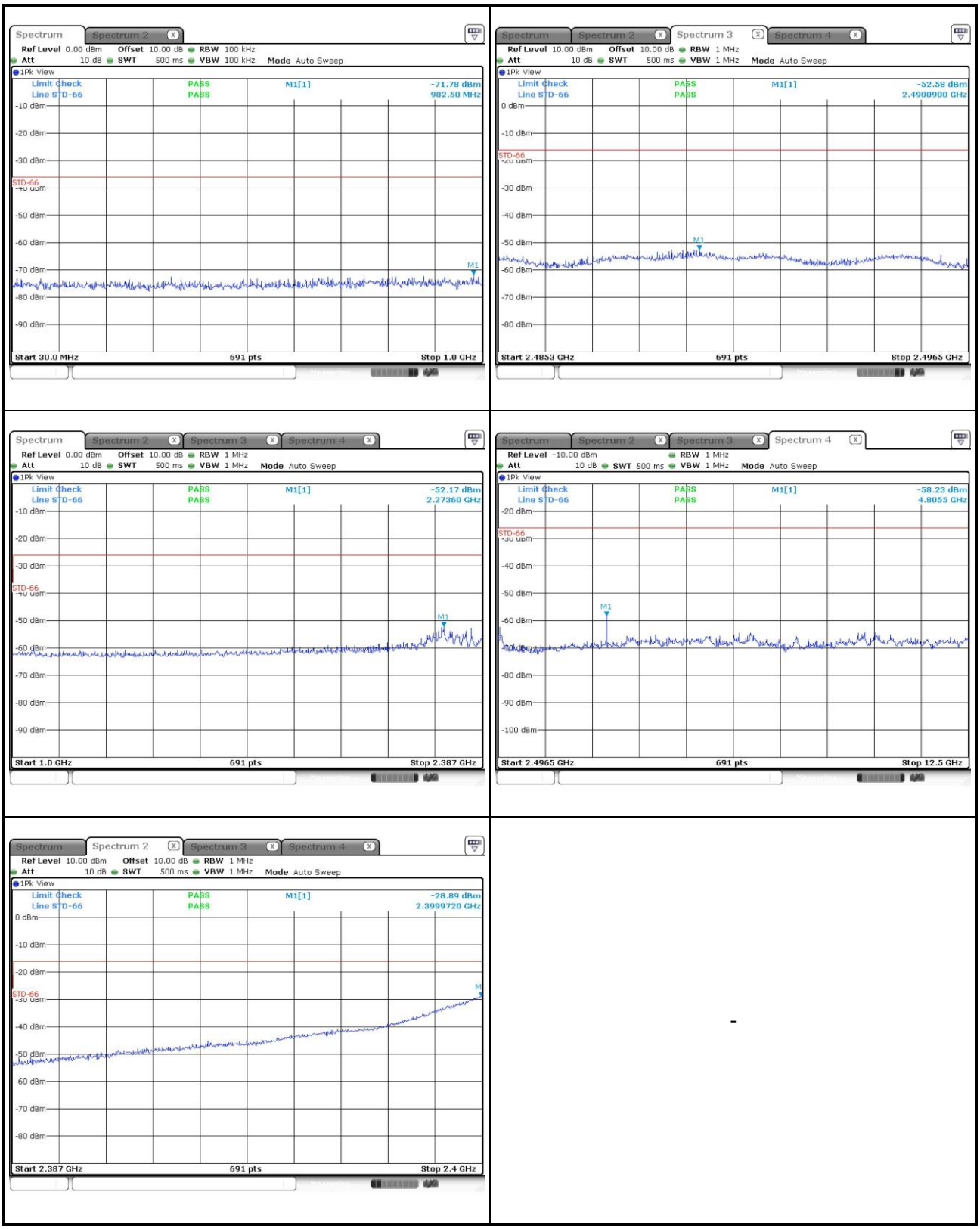
3.6 Vdc

Spread bandwidth	Occupied Bandwidth
	
	
	

Test plots of 1 Mbps data rates

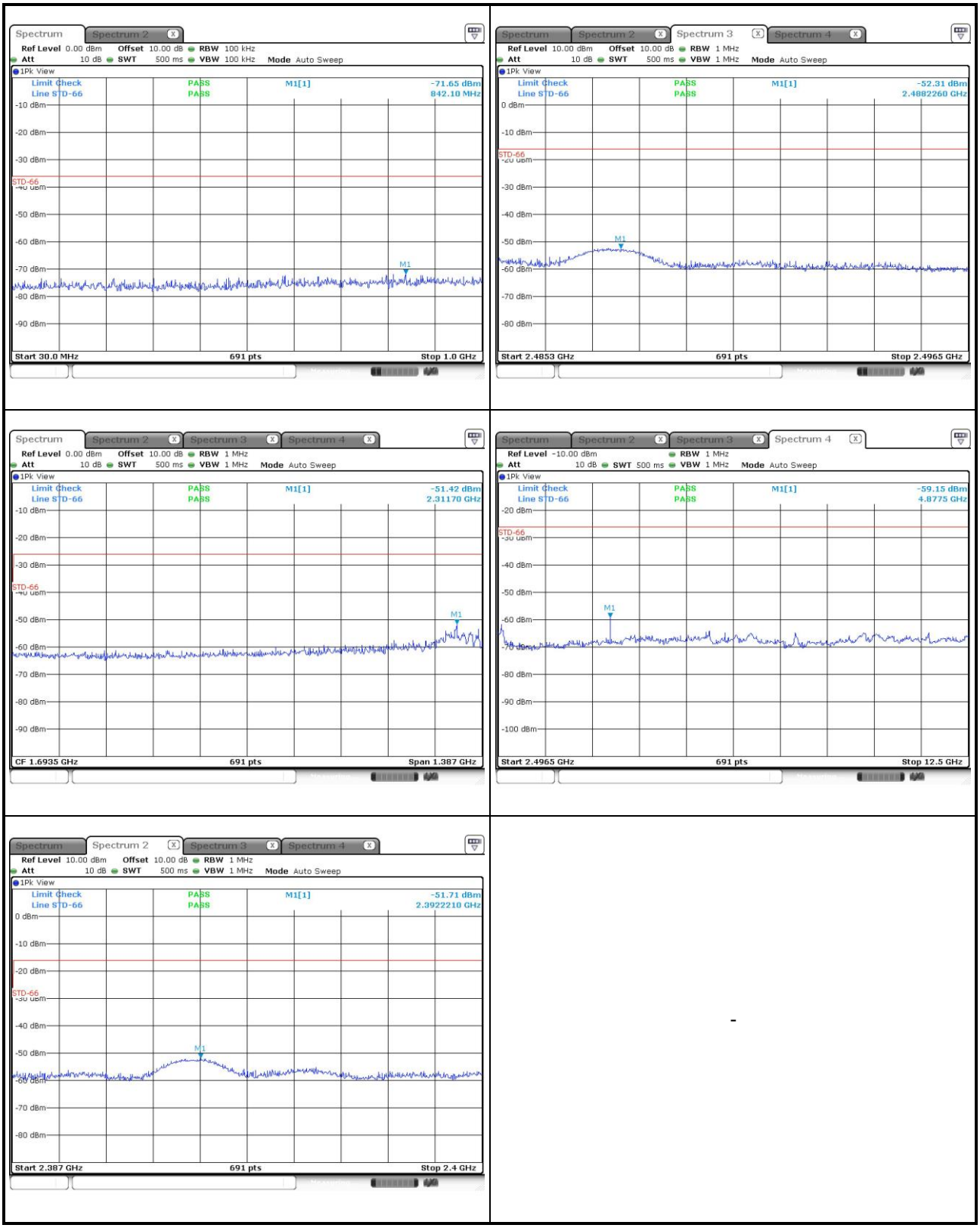
TX spurious Emission

1.7 Vdc / 2402 MHz



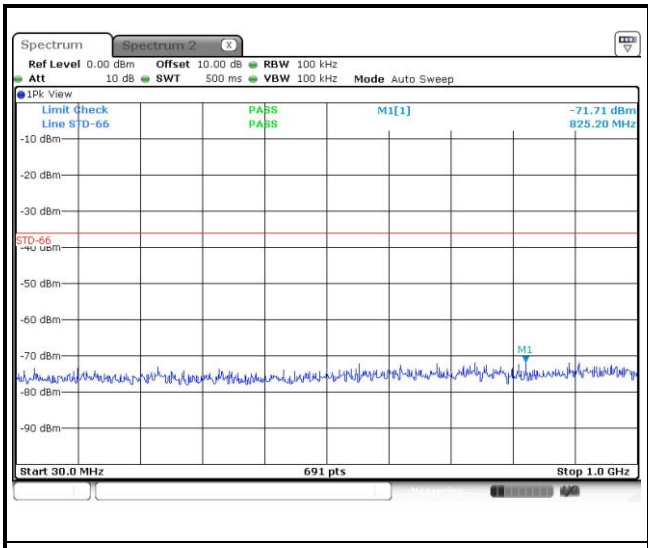
Test plots of 1 Mbps data rates

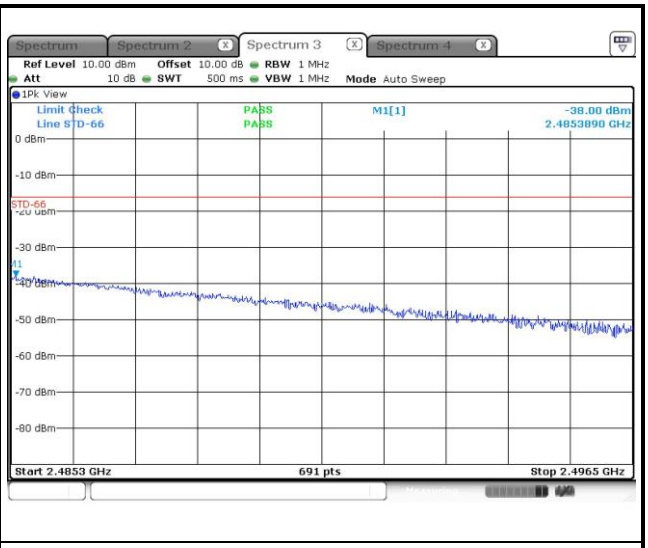
1.7 Vdc / 2440 MHz

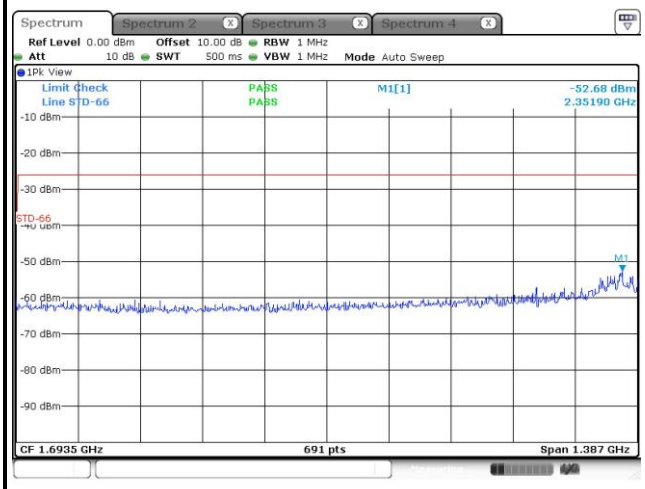


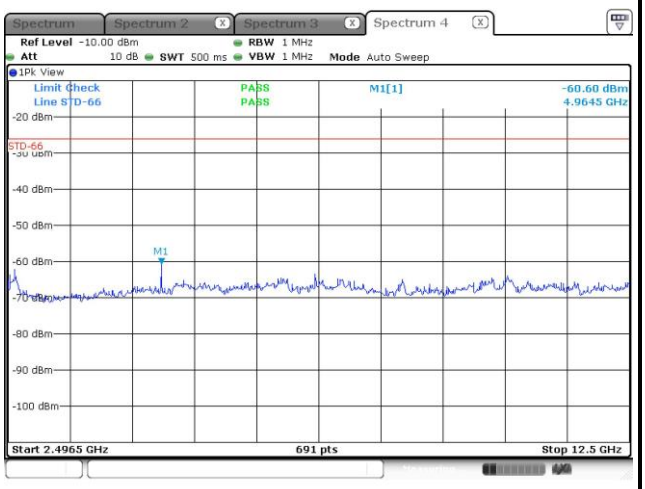
Test plots of 1 Mbps data rates

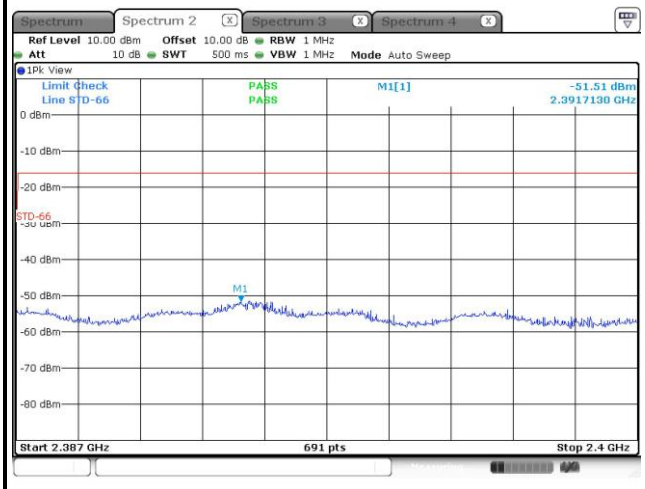
1.7 Vdc / 2480 MHz











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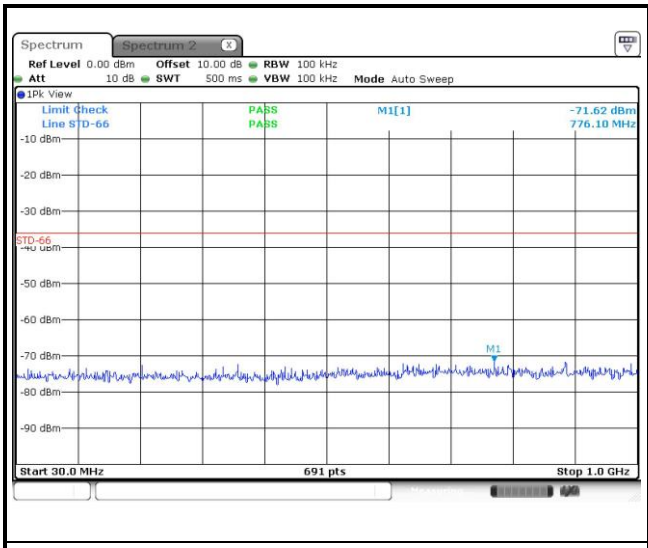
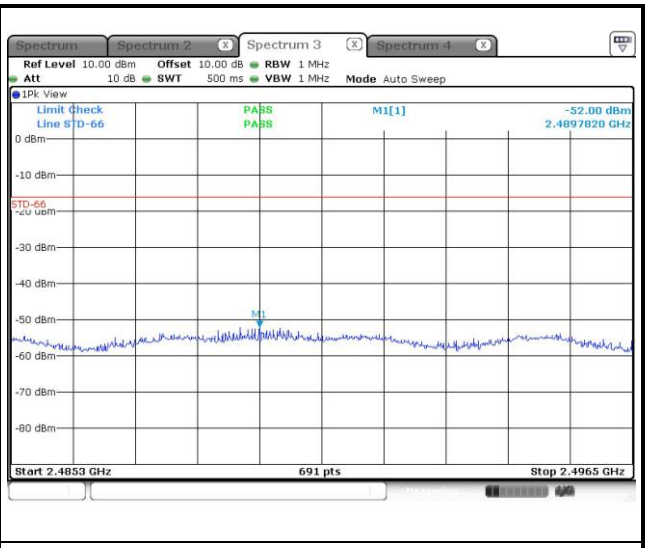
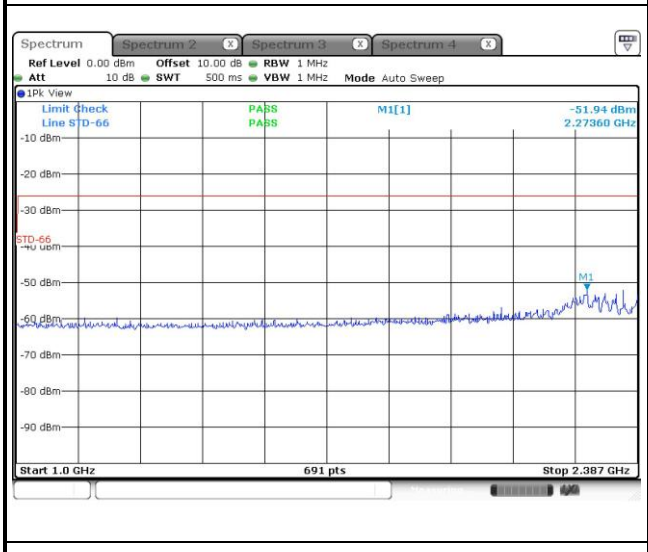
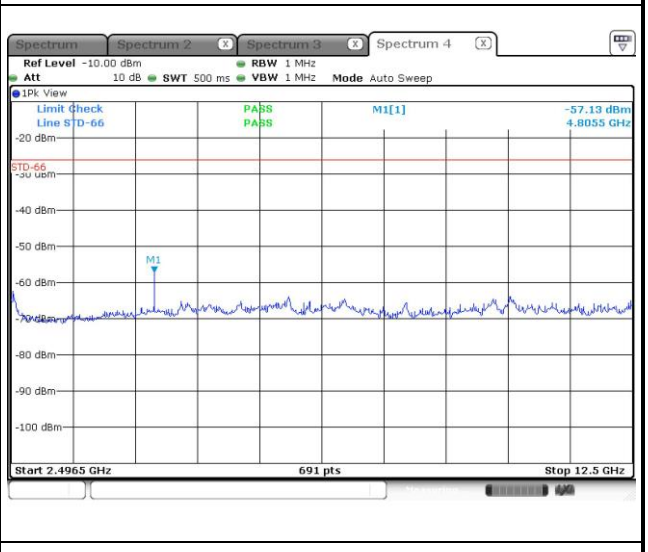
Test plots of 1 Mbps data rates

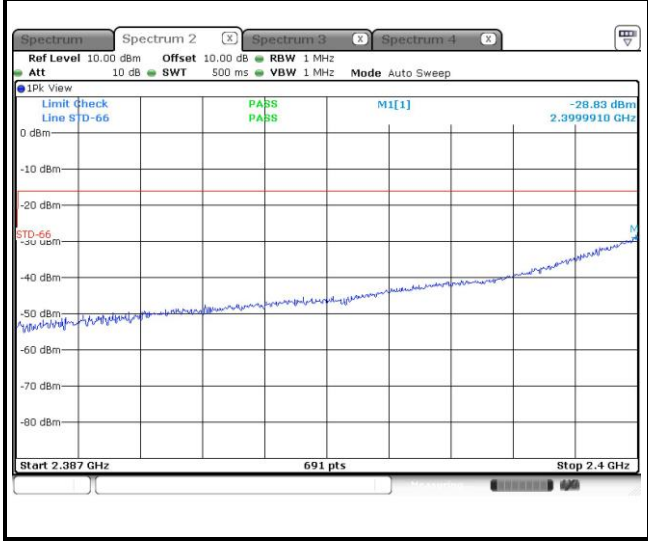
3.3 Vdc / 2402 MHz











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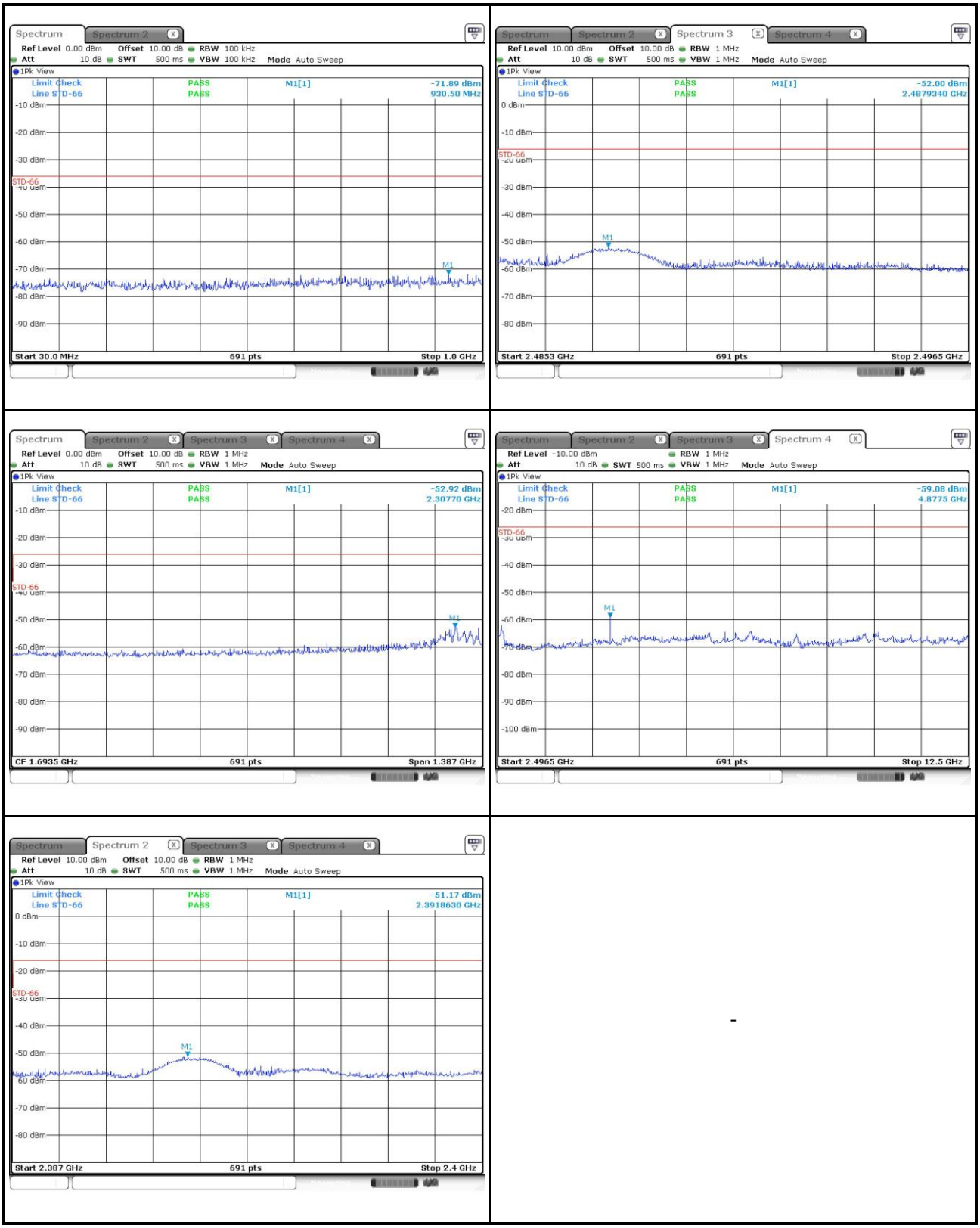
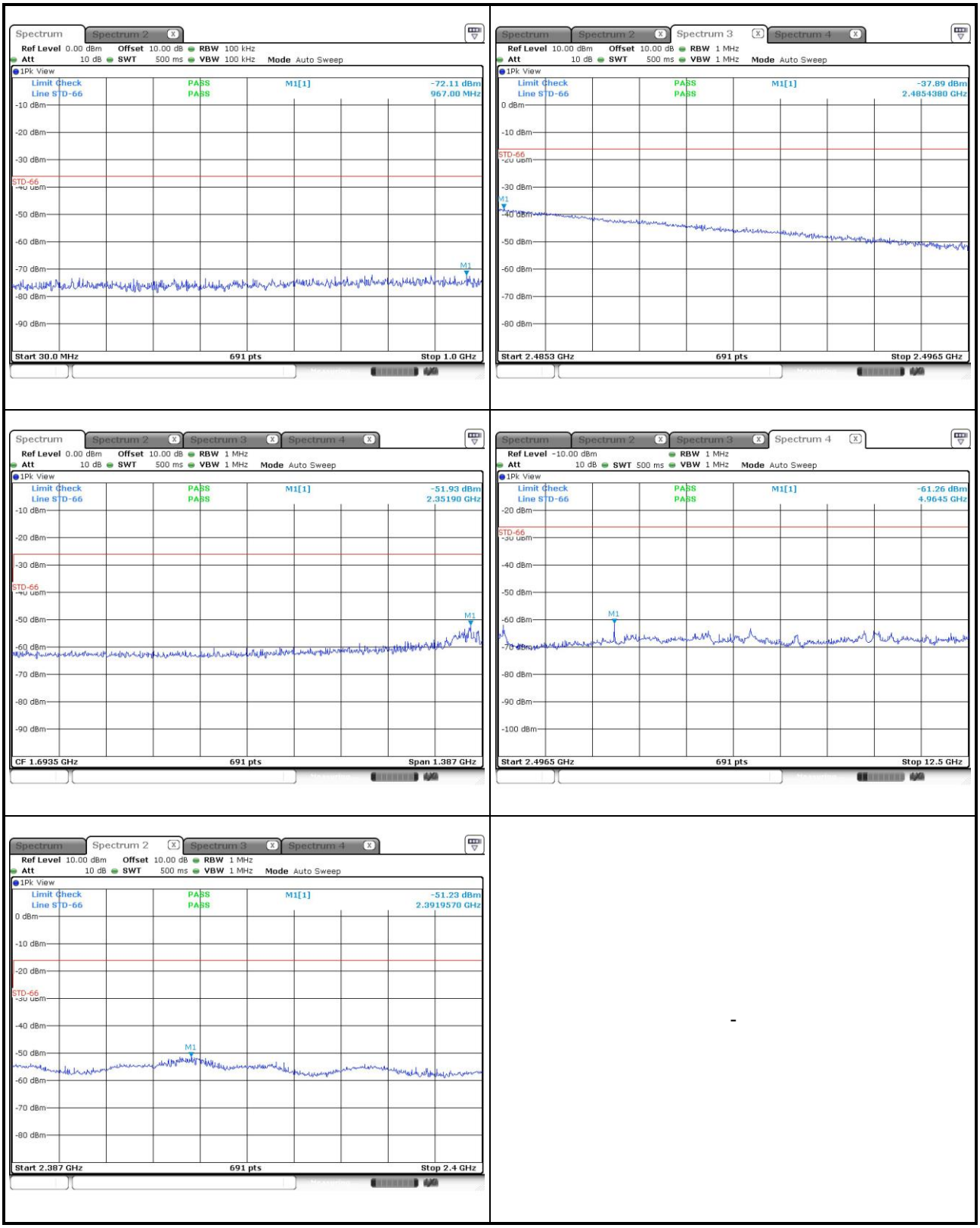
Test plots of 1 Mbps data rates

3.3 Vdc / 2440 MHz



Test plots of 1 Mbps data rates

3.3 Vdc / 2480 MHz



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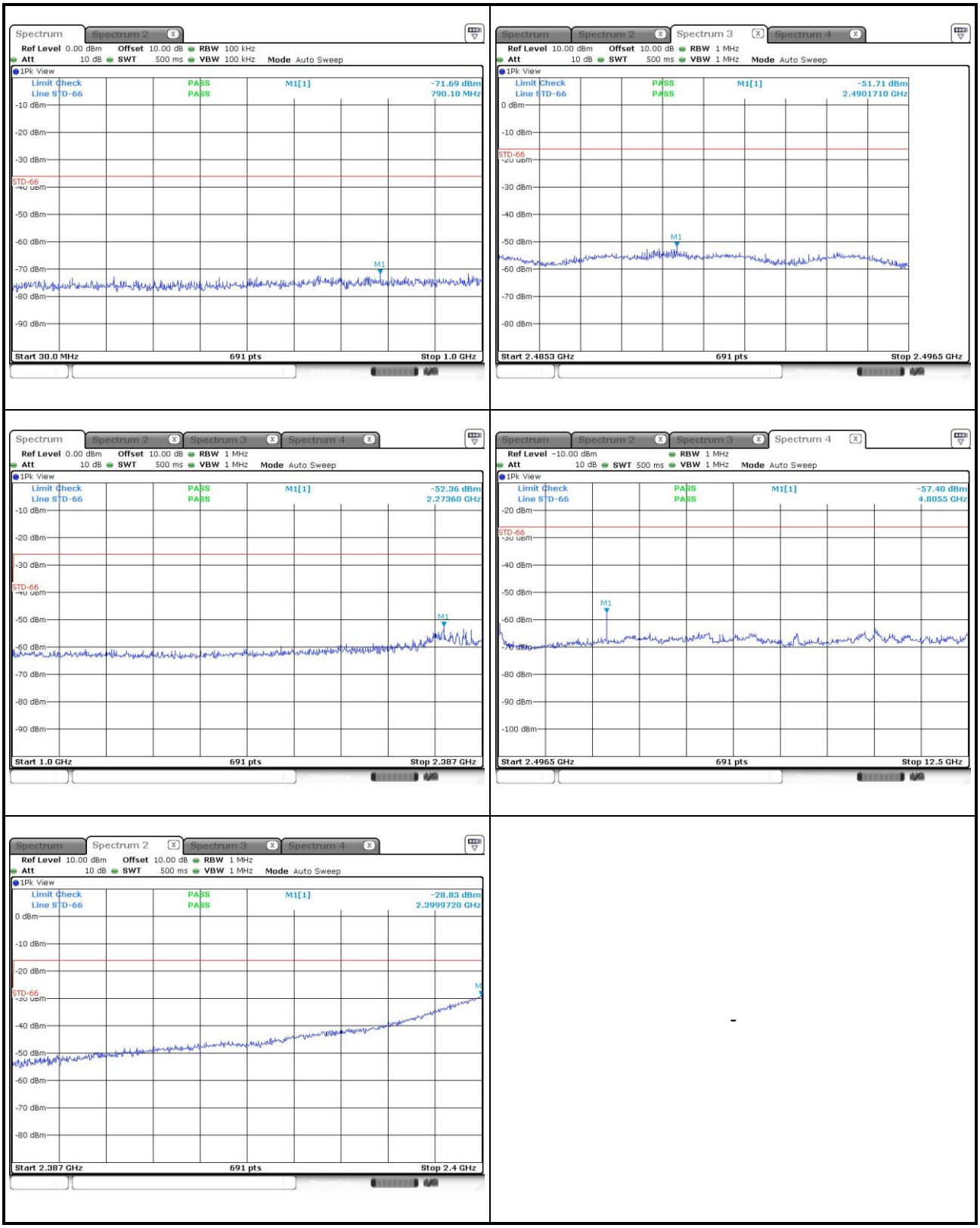
Test plots of 1 Mbps data rates

3.6 Vdc / 2402 MHz



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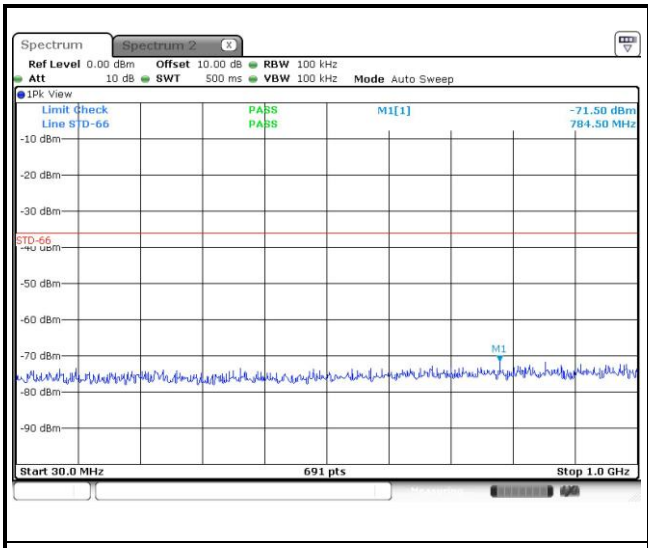
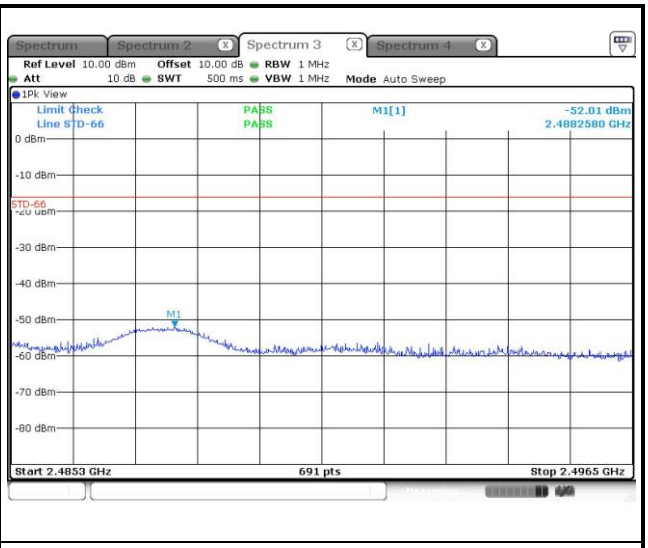
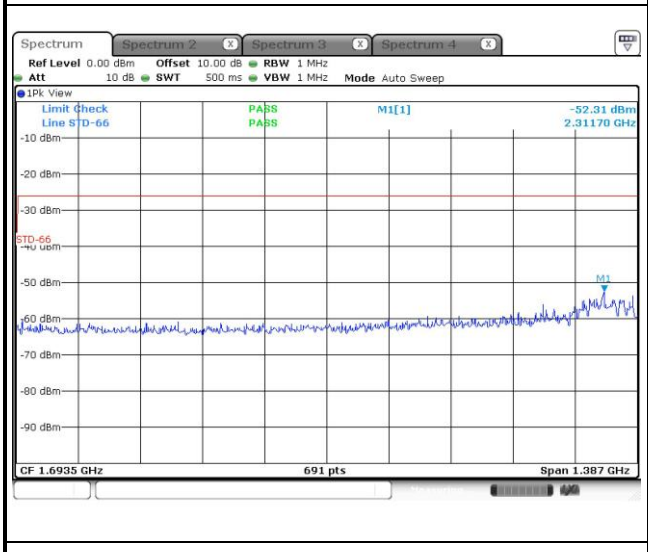
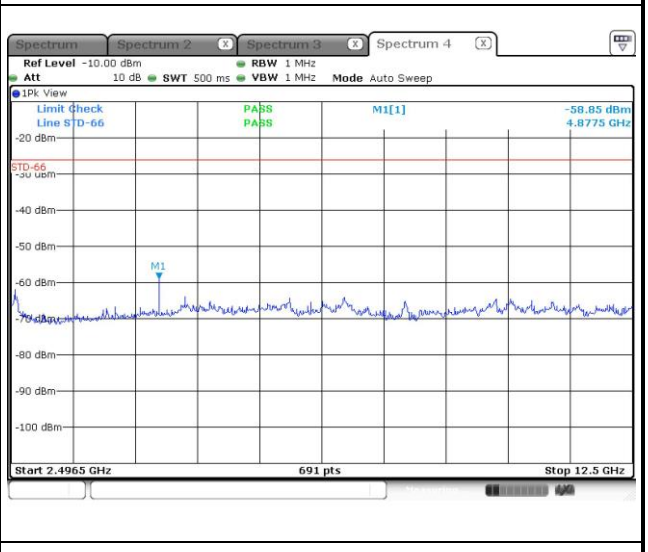
Test plots of 1 Mbps data rates

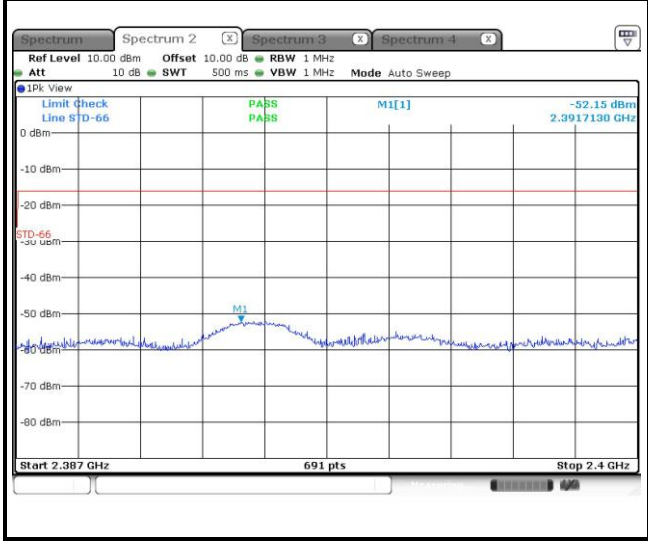
3.6 Vdc / 2440 MHz











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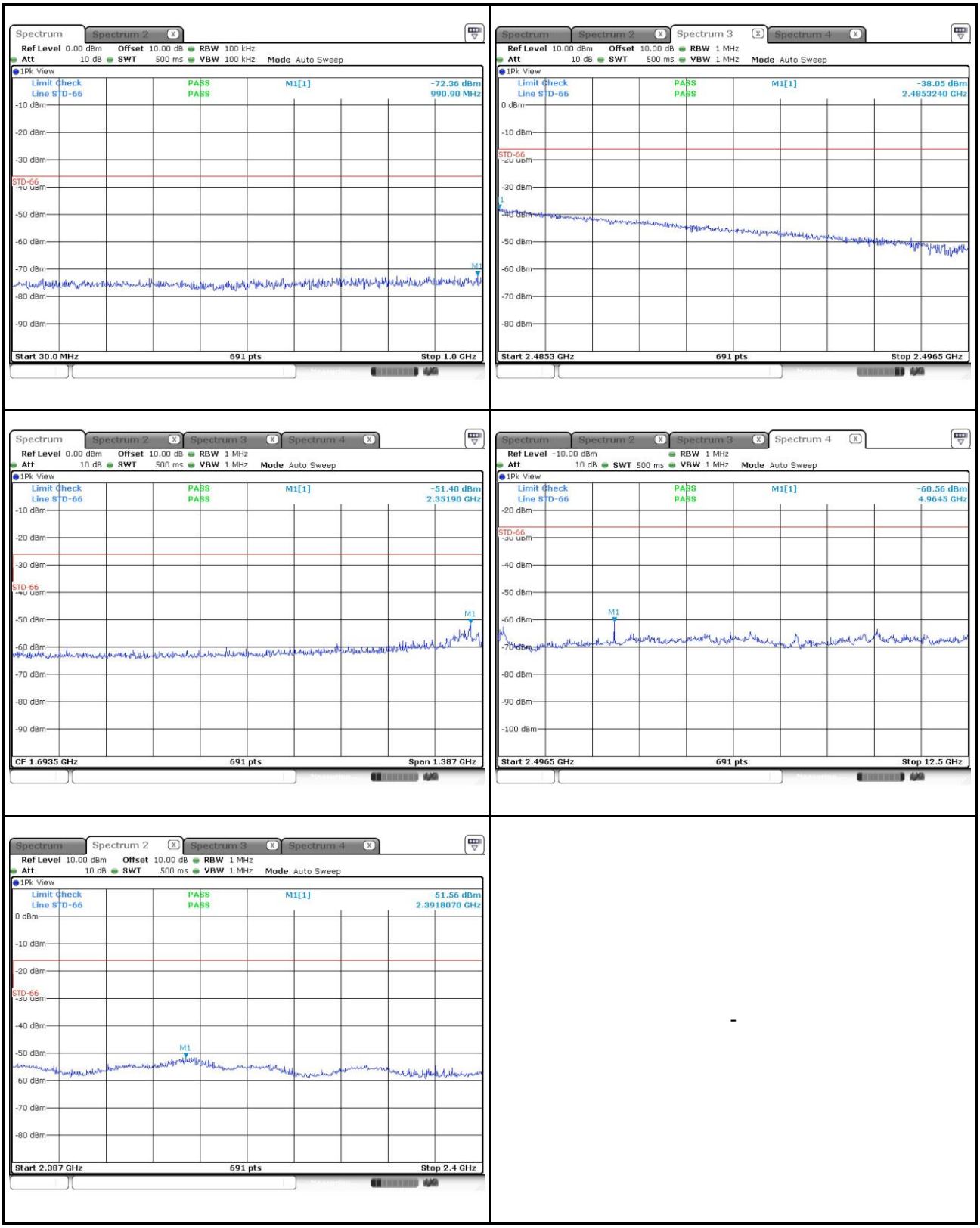
Test plots of 1 Mbps data rates

3.6 Vdc / 2480 MHz

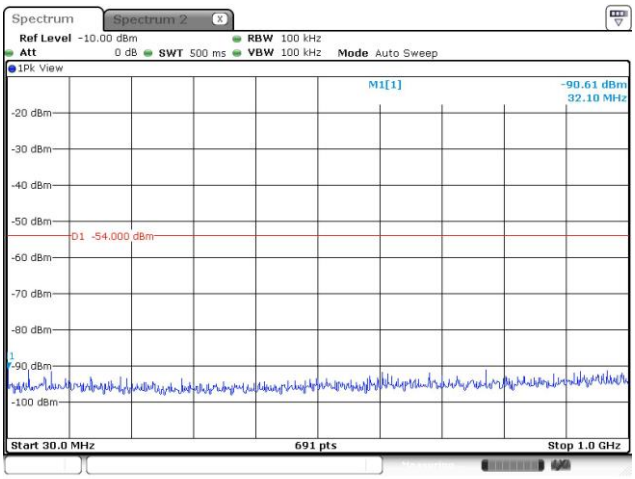


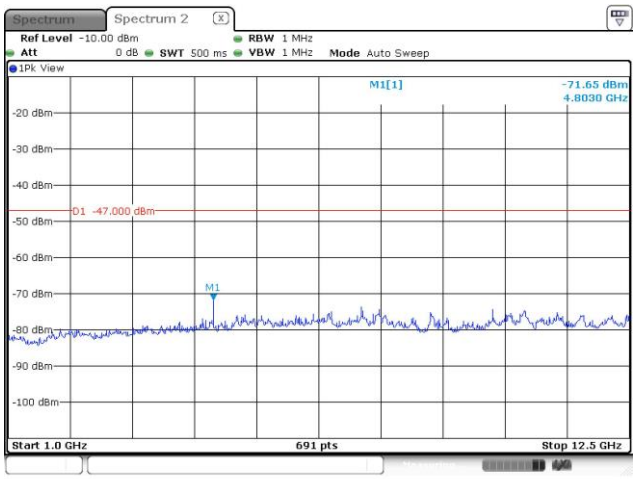
Test plots of 1 Mbps data rates

Receiver Emission

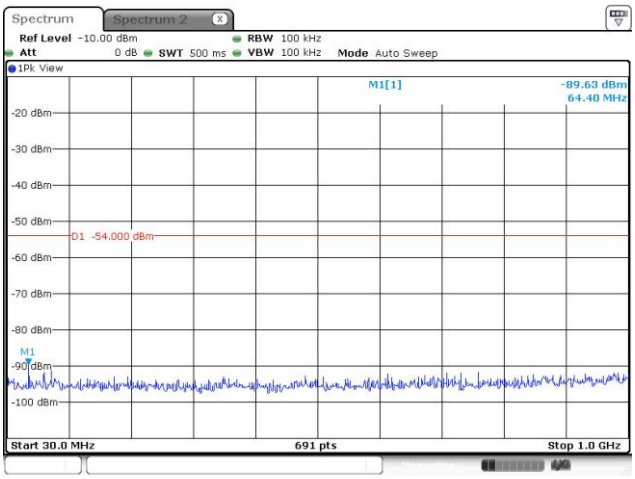
1.7 Vdc

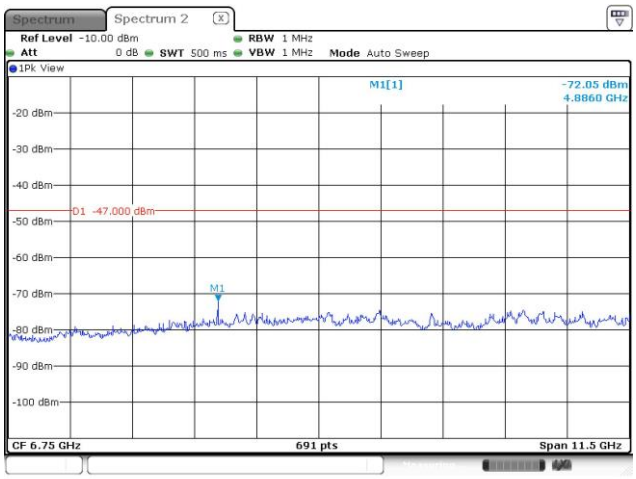
2402 MHz



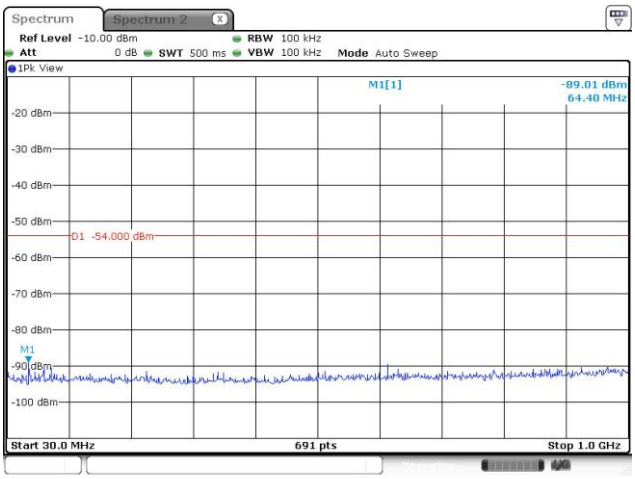


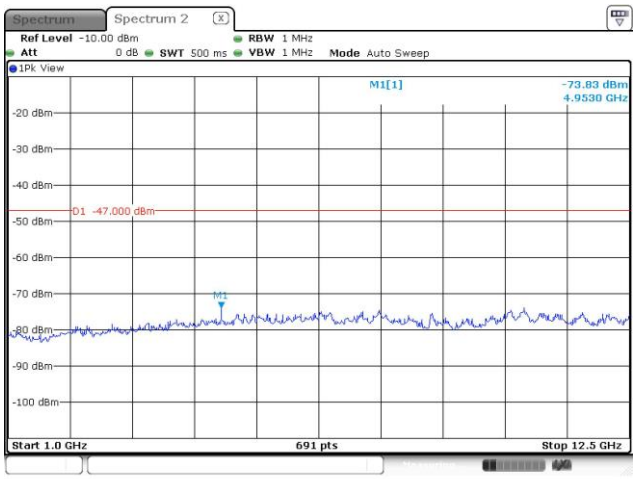
2440 MHz





2480 MHz

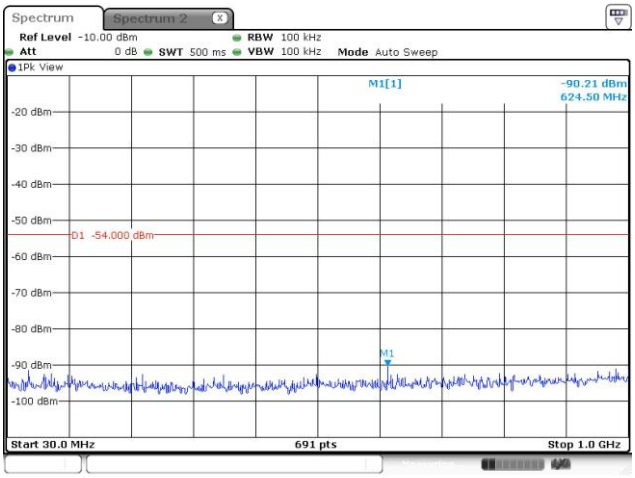


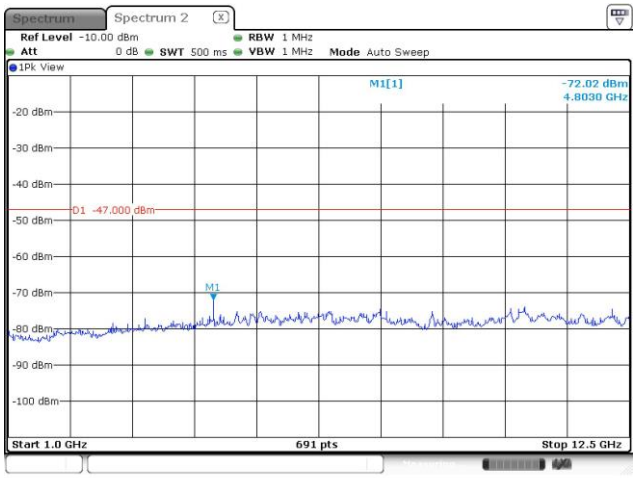


Test plots of 1 Mbps data rates

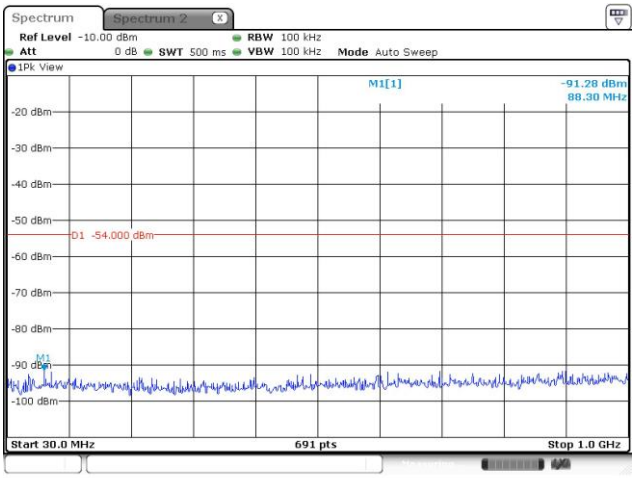
3.3 Vdc

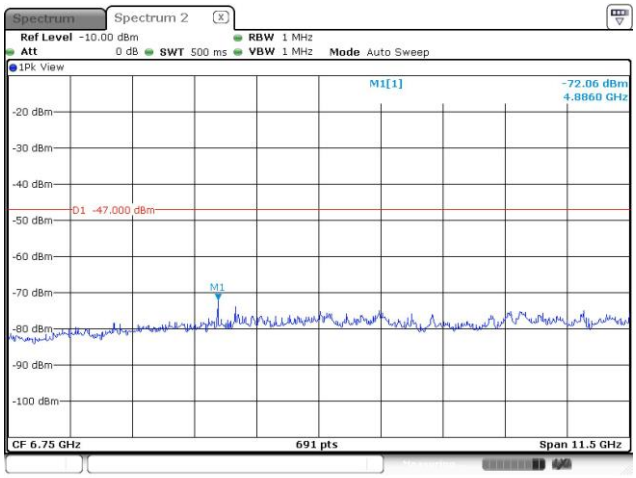
2402 MHz



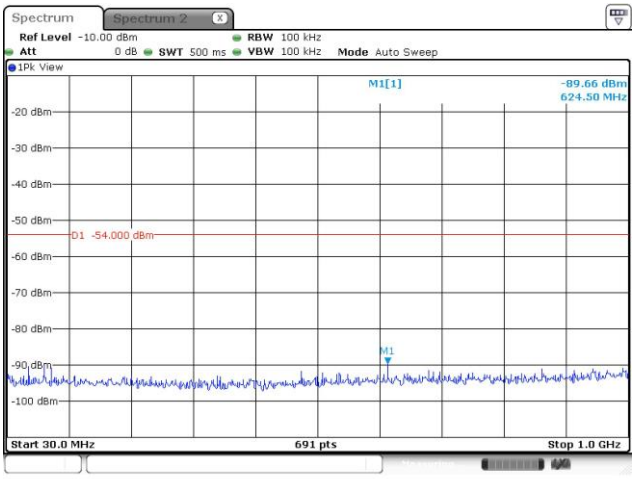


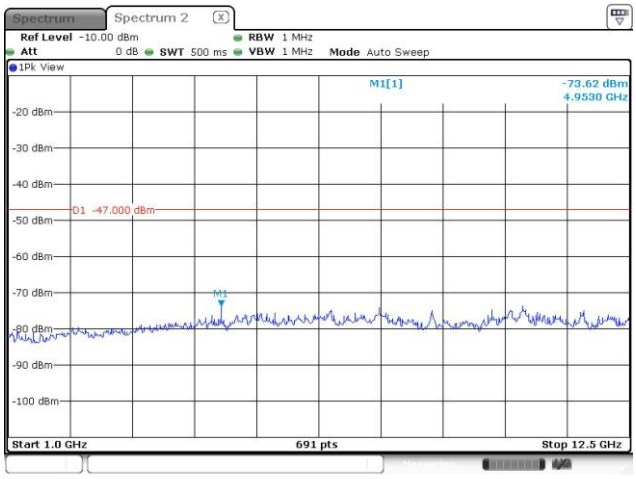
2440 MHz





2480 MHz

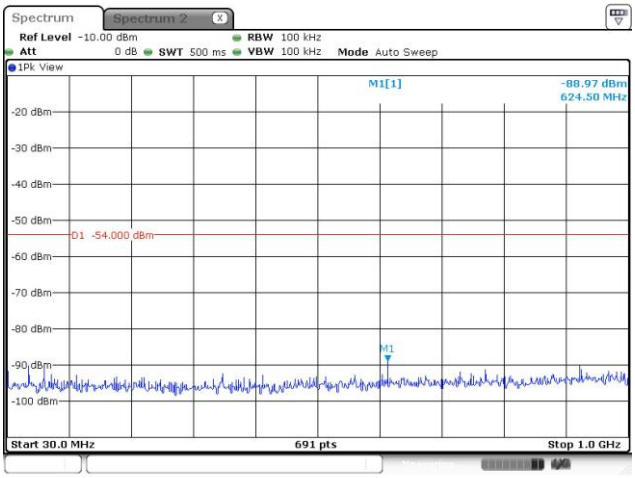


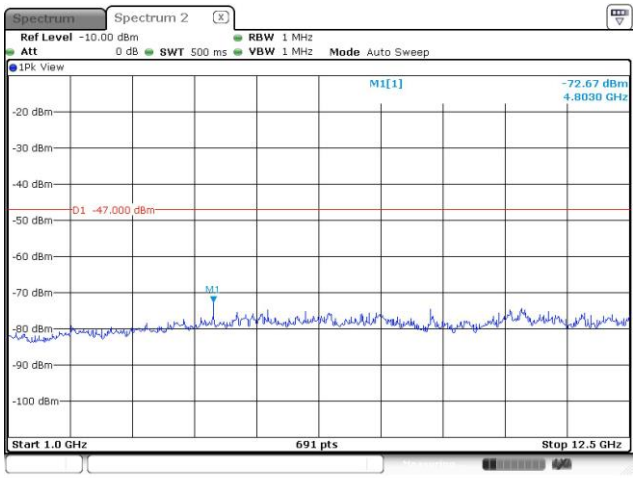


Test plots of 1 Mbps data rates

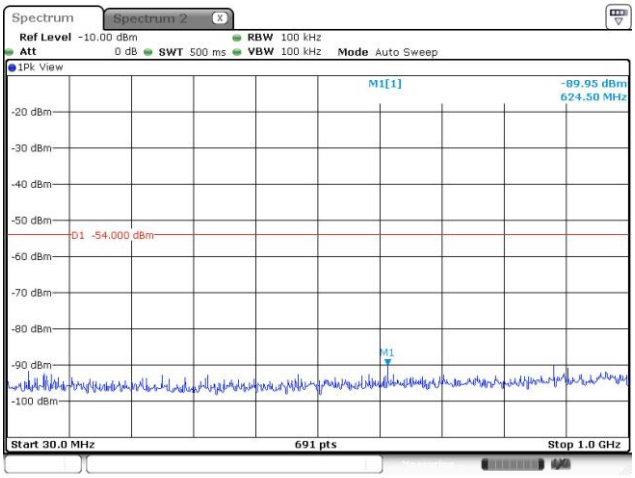
3.6 Vdc

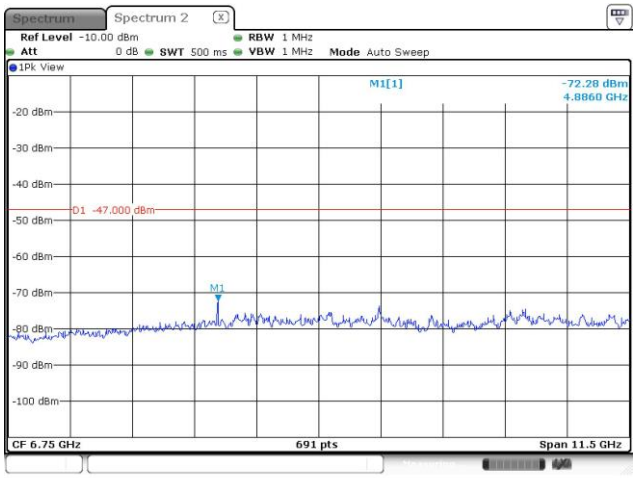
2402 MHz



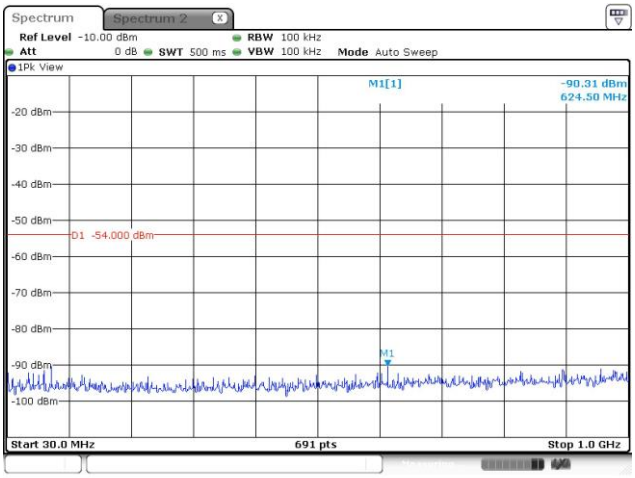


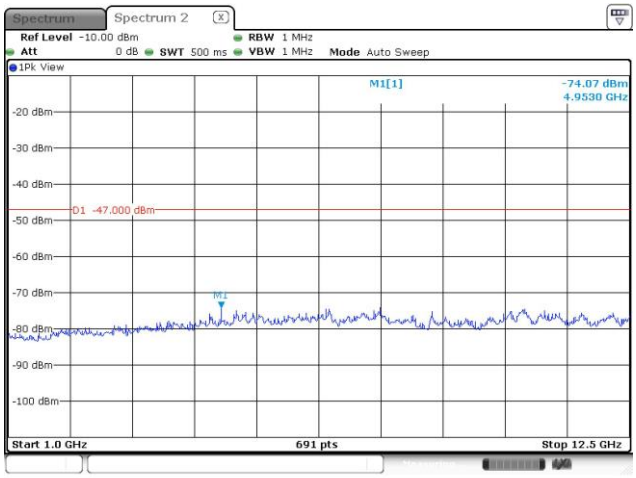
2440 MHz





2480 MHz





Test results of 2 Mbps data rate

Power Tolerance-DTS Result

Appendix A.1

Summary

Mode	Result	Power (dBm)	Power (mW)	Declare (mW)	Tolerance (%)	Limit+ (%)	Limit- (%)
2.4-2.4835GHz	-	-	-	-	-	-	-
BT-LE(2Mbps)	Pass	4.28	2.679	2.5	7.17	20	-80

Result

Mode	Result	Power (dBm)	Power (mW)	Declare (mW)	Tolerance (%)	Limit+ (%)	Limit- (%)
BT-LE(2Mbps)	-	-	-	-	-	-	-
2402MHz_TnomVnom	Pass	4.24	2.655	2.50	6.18	20	-80
2402MHz_TnomVmin	Pass	4.27	2.673	2.50	6.92	20	-80
2402MHz_TnomVmax	Pass	4.28	2.679	2.50	7.17	20	-80
2440MHz_TnomVnom	Pass	4.19	2.624	2.50	4.97	20	-80
2440MHz_TnomVmin	Pass	4.16	2.606	2.50	4.25	20	-80
2440MHz_TnomVmax	Pass	4.20	2.630	2.50	5.21	20	-80
2480MHz_TnomVnom	Pass	4.17	2.612	2.50	4.49	20	-80
2480MHz_TnomVmin	Pass	4.08	2.559	2.50	2.34	20	-80
2480MHz_TnomVmax	Pass	4.11	2.576	2.50	3.05	20	-80

Total Power-DTS Result

Appendix A.2

Summary

Mode	Power (dBm)	Power (mW)	EIRP (dBm)	EIRP (mW)
2.4-2.4835GHz	-	-	-	-
BT-LE(2Mbps)	4.28	2.679	6.49	4.457

P1 = Port 1 output power; **Power** = Total power sum by **P1**;

Result

Mode	Result	Gain (dBi)	Power (dBm)	Power (mW)	Power Lim. (mW)	EIRP (dBm)	EIRP (mW)	EIRP Lim. (mW)
BT-LE(2Mbps)	-	-	-	-	-	-	-	-
2402MHz_TnomVnom	Pass	2.21	4.24	2.655	10	6.45	4.416	16.368
2402MHz_TnomVmin	Pass	2.21	4.27	2.673	10	6.48	4.446	16.368
2402MHz_TnomVmax	Pass	2.21	4.28	2.679	10	6.49	4.457	16.368
2440MHz_TnomVnom	Pass	2.21	4.19	2.624	10	6.40	4.365	16.368
2440MHz_TnomVmin	Pass	2.21	4.16	2.606	10	6.37	4.335	16.368
2440MHz_TnomVmax	Pass	2.21	4.20	2.630	10	6.41	4.375	16.368
2480MHz_TnomVnom	Pass	2.21	4.17	2.612	10	6.38	4.345	16.368
2480MHz_TnomVmin	Pass	2.21	4.08	2.559	10	6.29	4.256	16.368
2480MHz_TnomVmax	Pass	2.21	4.11	2.576	10	6.32	4.285	16.368

P1 = Port 1 output power; **Power** = Total power sum by **P1**;

Summary

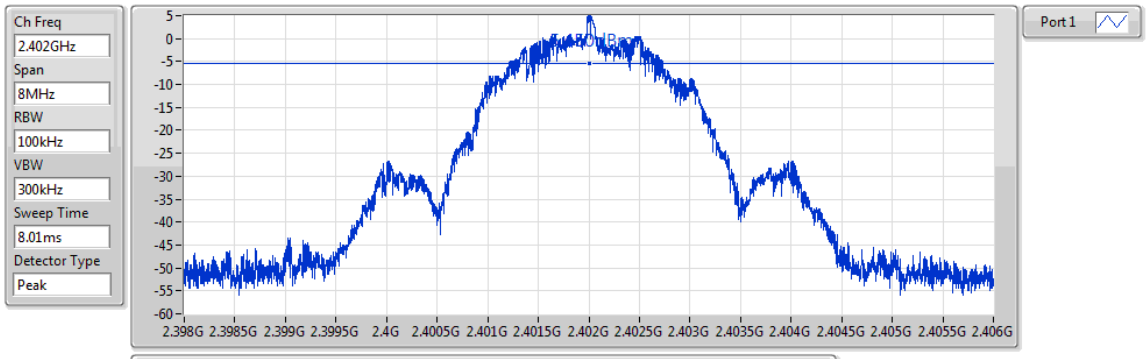
Mode	Result	Ch (Hz)	Center (Hz)	ppm	Limit (ppm)	Port	Remark
2.4-2.4835GHz	-	-	-	-	-	-	-
BT-LE(2Mbps)	Pass	2.48G	2.479967G	-13.306	±50	1	-

Result

Mode	Result	Ch (Hz)	Center (Hz)	ppm	Limit (ppm)	Port	Remark
BT-LE(2Mbps)	-	-	-	-	-	-	-
2402MHz_TnomVnom	Pass	2.402G	2.401971G	-12.281	±50	1	-
2402MHz_TnomVmin	Pass	2.402G	2.401981G	-8.118	±50	1	-
2402MHz_TnomVmax	Pass	2.402G	2.401981G	-8.014	±50	1	-
2440MHz_TnomVnom	Pass	2.44G	2.439983G	-7.172	±50	1	-
2440MHz_TnomVmin	Pass	2.44G	2.439981G	-7.787	±50	1	-
2440MHz_TnomVmax	Pass	2.44G	2.439983G	-6.967	±50	1	-
2480MHz_TnomVnom	Pass	2.48G	2.479968G	-13.004	±50	1	-
2480MHz_TnomVmin	Pass	2.48G	2.479967G	-13.306	±50	1	-
2480MHz_TnomVmax	Pass	2.48G	2.479969G	-12.5	±50	1	-

BT-LE(2Mbps) **Freq. Stability**

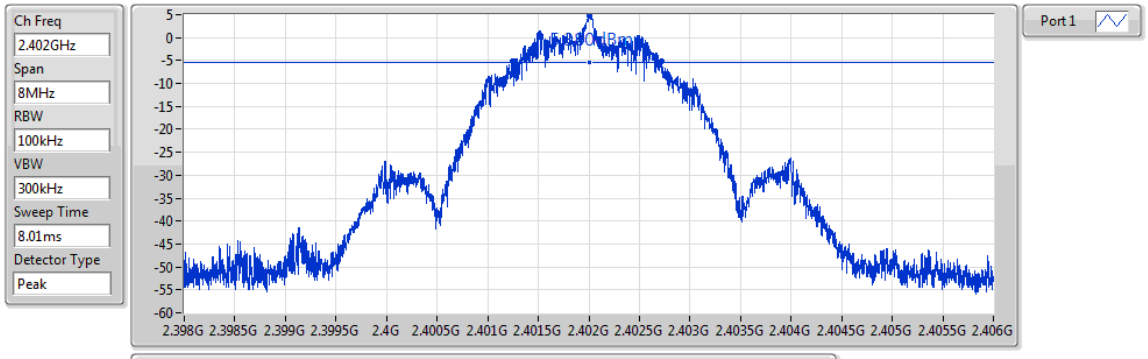
2402MHz_TnomVnom



Ch(Hz)	Center(Hz)	Fl(Hz)	Fh(Hz)	ppm	Limit(ppm)	Port	Remark
2.402G	2.401971G	2.401238G	2.402703G	-12.281	±50	1	-

BT-LE(2Mbps) **Freq. Stability**

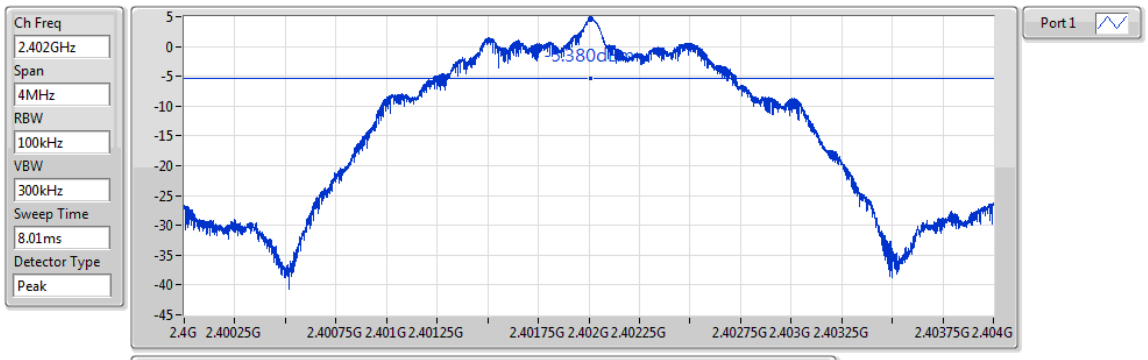
2402MHz_TnomVmin



Ch(Hz)	Center(Hz)	Fl(Hz)	Fh(Hz)	ppm	Limit(ppm)	Port	Remark
2.402G	2.401981G	2.401244G	2.402717G	-8.118	±50	1	-

BT-LE(2Mbps) **Freq. Stability**

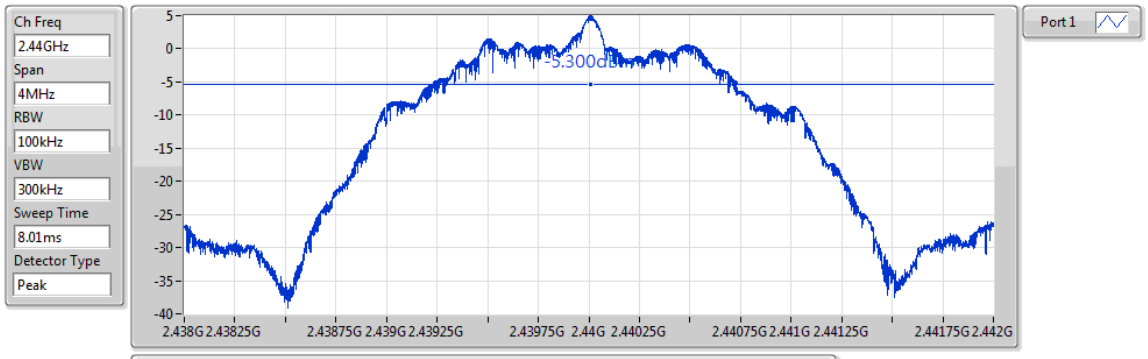
2402MHz_TnomVmax



Ch(Hz)	Center(Hz)	Fl(Hz)	Fh(Hz)	ppm	Limit(ppm)	Port	Remark
2.402G	2.401981G	2.401243G	2.402719G	-8.014	±50	1	-

BT-LE(2Mbps) **Freq. Stability**

2440MHz_TnomVnom



Ch(Hz)	Center(Hz)	Fl(Hz)	Fh(Hz)	ppm	Limit(ppm)	Port	Remark
2.44G	2.439983G	2.439241G	2.440724G	-7.172	±50	1	-

BT-LE(2Mbps) **Freq. Stability**

2440MHz_TnomVmin

Ch(Hz)	Center(Hz)	Fl(Hz)	Fh(Hz)	ppm	Limit(ppm)	Port	Remark
2.44G	2.439981G	2.439241G	2.440722G	-7.787	±50	1	-

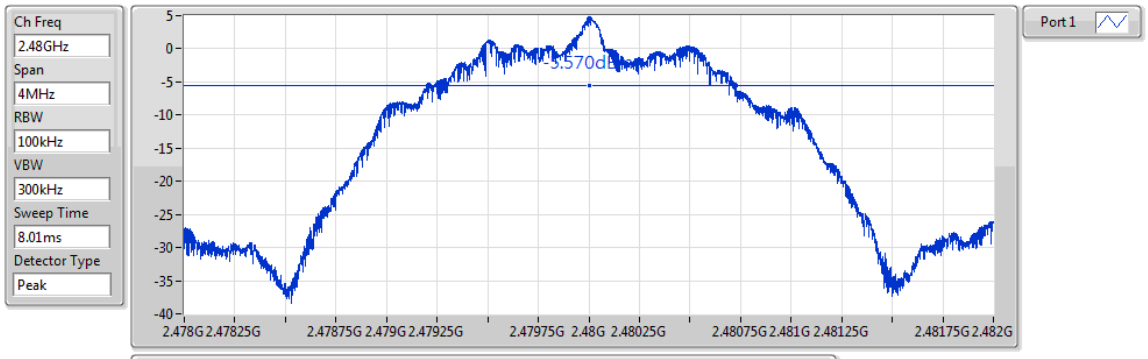
BT-LE(2Mbps) **Freq. Stability**

2440MHz_TnomVmax

Ch(Hz)	Center(Hz)	Fl(Hz)	Fh(Hz)	ppm	Limit(ppm)	Port	Remark
2.44G	2.439983G	2.439238G	2.440728G	-6.967	±50	1	-

BT-LE(2Mbps) **Freq. Stability**

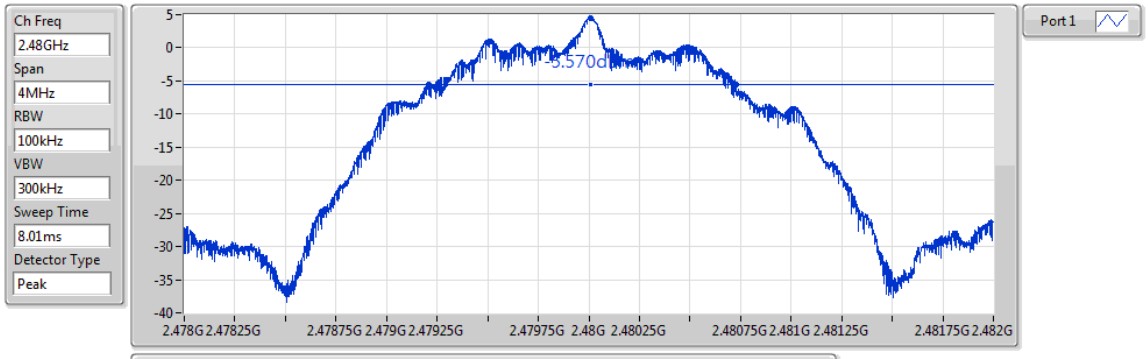
2480MHz_TnomVnom



Ch(Hz)	Center(Hz)	Fl(Hz)	Fh(Hz)	ppm	Limit(ppm)	Port	Remark
2.48G	2.479968G	2.479211G	2.480725G	-13.004	±50	1	-

BT-LE(2Mbps) **Freq. Stability**

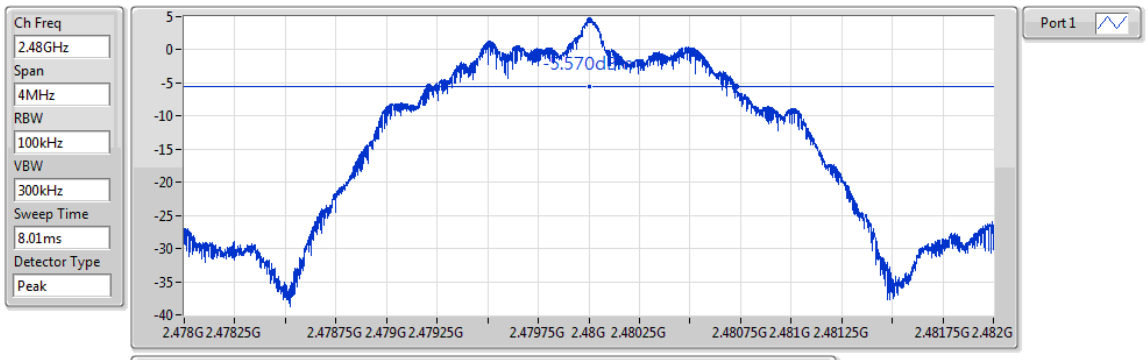
2480MHz_TnomVmin



Ch(Hz)	Center(Hz)	Fl(Hz)	Fh(Hz)	ppm	Limit(ppm)	Port	Remark
2.48G	2.479967G	2.479206G	2.480728G	-13.306	±50	1	-

BT-LE(2Mbps) **Freq. Stability**

2480MHz_TnomVmax



Ch(Hz)	Center(Hz)	Fl(Hz)	Fh(Hz)	ppm	Limit(ppm)	Port	Remark
2.48G	2.479969G	2.479211G	2.480728G	-12.5	±50	1	-

Summary

Mode	Max-OBW (MHz)	ITU-Code	Min-OBW (MHz)
2.4-2.4835GHz	-	-	-
BT-LE(2Mbps)	2.199	2M20F1D	2.191

Max-OBW = Maximum 99% occupied bandwidth; **Min-OBW** = Minimum 99% occupied bandwidth;

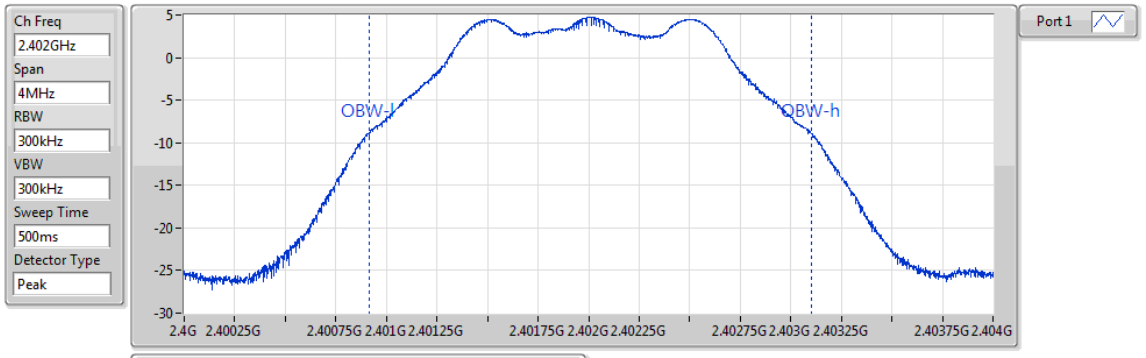
Result

Mode	Result	Limit (MHz)	P1-OBW (MHz)
BT-LE(2Mbps)	-	-	-
2402MHz_TnomVnom	Pass	26	2.191
2402MHz_TnomVmin	Pass	26	2.191
2402MHz_TnomVmax	Pass	26	2.191
2440MHz_TnomVnom	Pass	26	2.195
2440MHz_TnomVmin	Pass	26	2.195
2440MHz_TnomVmax	Pass	26	2.195
2480MHz_TnomVnom	Pass	26	2.199
2480MHz_TnomVmin	Pass	26	2.199
2480MHz_TnomVmax	Pass	26	2.197

P1-OBW = Port 1 99% occupied bandwidth;

BT-LE(2Mbps) **OBW**

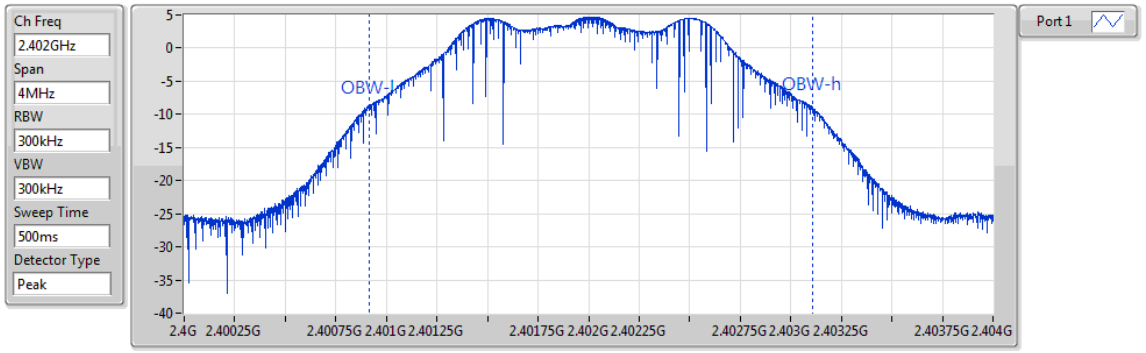
2402MHz_TnomVnom



OBW(MHz)	Fl-OBW(Hz)	Fh-OBW(Hz)	Limit(MHz)	Port
2.191	2.400913G	2.403103G	26	1

BT-LE(2Mbps) **OBW**

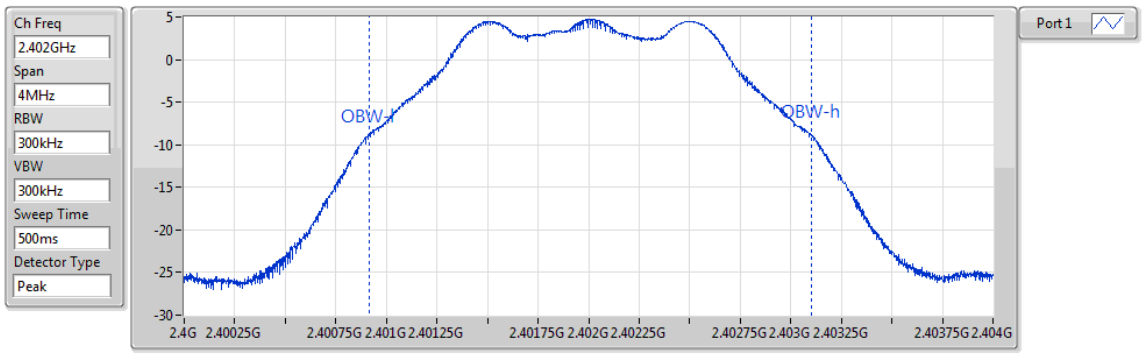
2402MHz_TnomVmin



OBW(MHz)	Fl-OBW(Hz)	Fh-OBW(Hz)	Limit(MHz)	Port
2.191	2.400915G	2.403105G	26	1

BT-LE(2Mbps) **OBW**

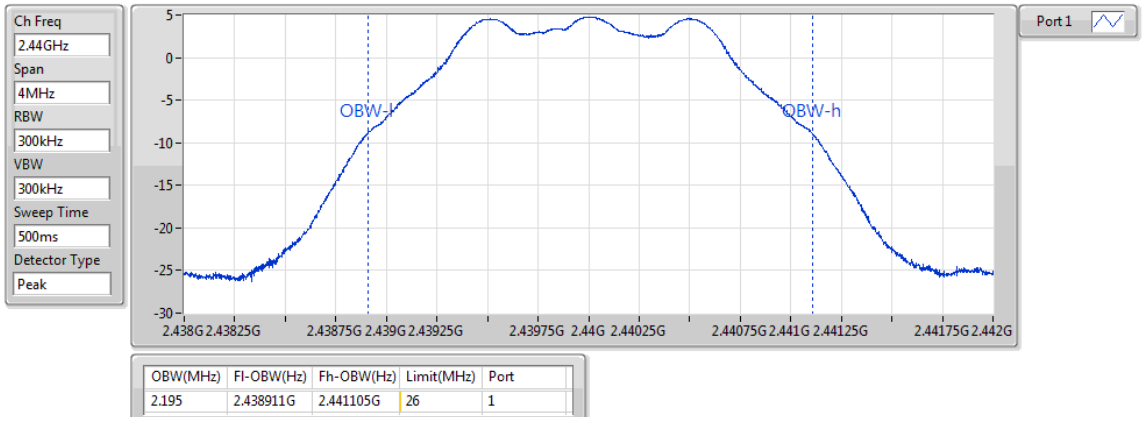
2402MHz_TnomVmax



OBW(MHz)	Fl-OBW(Hz)	Fh-OBW(Hz)	Limit(MHz)	Port
2.191	2.400913G	2.403103G	26	1

BT-LE(2Mbps) **OBW**

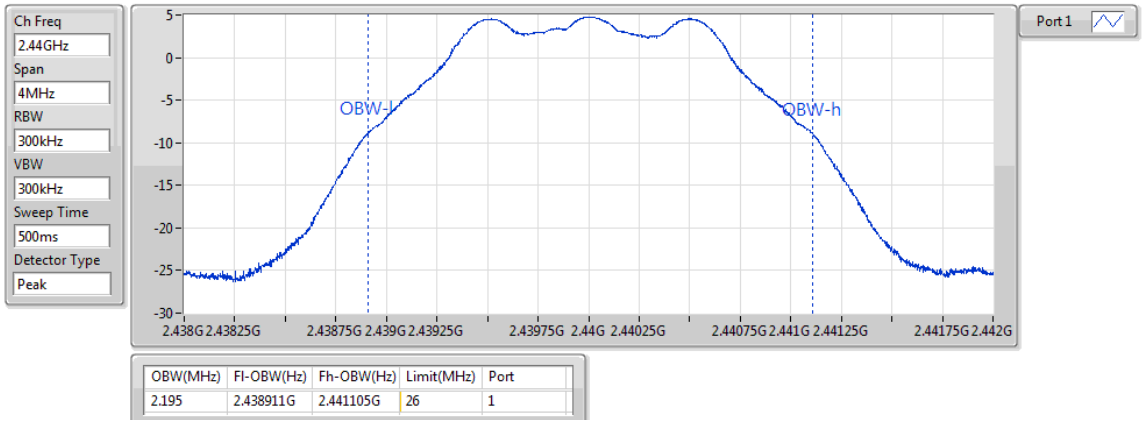
2440MHz_TnomVnom



OBW(MHz)	Fl-OBW(Hz)	Fh-OBW(Hz)	Limit(MHz)	Port
2.195	2.438911G	2.441105G	26	1

BT-LE(2Mbps) **OBW**

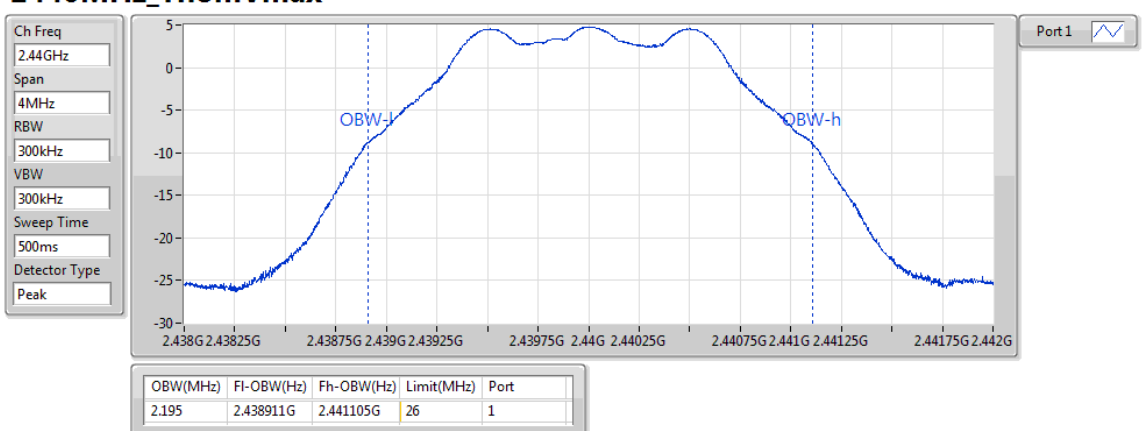
2440MHz_TnomVmin



OBW(MHz)	Fl-OBW(Hz)	Fh-OBW(Hz)	Limit(MHz)	Port
2.195	2.438911G	2.441105G	26	1

BT-LE(2Mbps) **OBW**

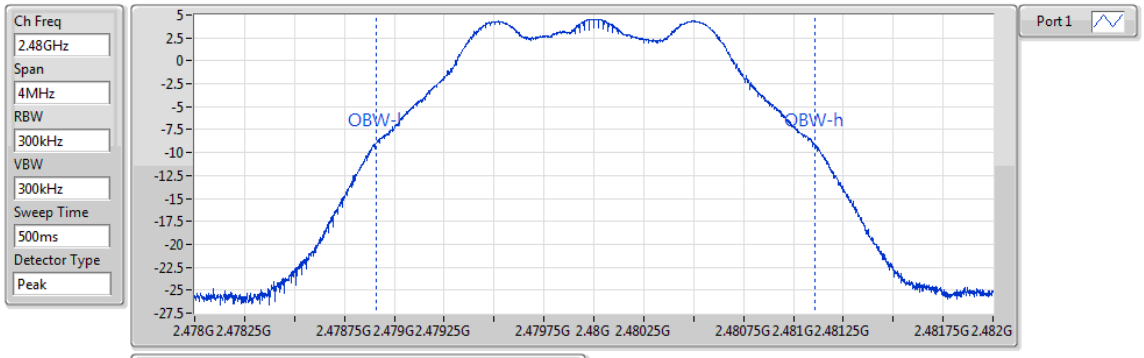
2440MHz_TnomVmax



OBW(MHz)	Fl-OBW(Hz)	Fh-OBW(Hz)	Limit(MHz)	Port
2.195	2.438911G	2.441105G	26	1

BT-LE(2Mbps) **OBW**

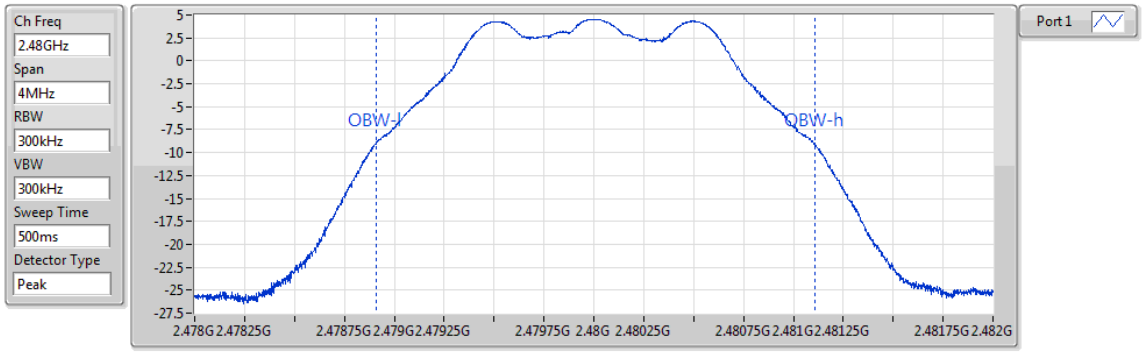
2480MHz_TnomVnom



OBW(MHz)	Fl-OBW(Hz)	Fh-OBW(Hz)	Limit(MHz)	Port
2.199	2.478909G	2.481107G	26	1

BT-LE(2Mbps) **OBW**

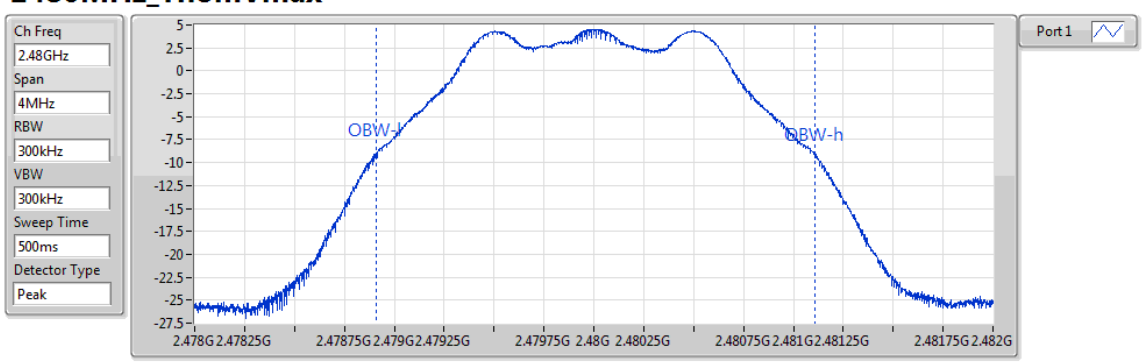
2480MHz_TnomVmin



OBW(MHz)	Fl-OBW(Hz)	Fh-OBW(Hz)	Limit(MHz)	Port
2.199	2.478909G	2.481107G	26	1

BT-LE(2Mbps) **OBW**

2480MHz_TnomVmax



OBW(MHz)	Fl-OBW(Hz)	Fh-OBW(Hz)	Limit(MHz)	Port
2.197	2.478911G	2.481107G	26	1

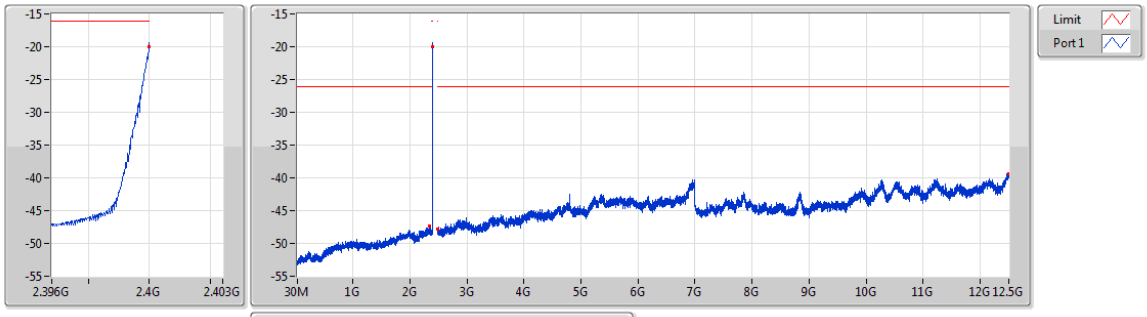
Summary

Mode	Result	F-Start (Hz)	F-Stop (Hz)	RBW (Hz)	Freq (MHz)	Psum (dBm)	Psum (uW/MHz)	Limit (dBm)	Limit (uW/MHz)	Margin (dB)
2.4-2.4835GHz	-	-	-	-	-	-	-	-	-	-
BT-LE(2Mbps)	Pass	2.387G	2.4G	1M	2399.974	-19.97	10.06932	-16.02	25	-3.95

Result

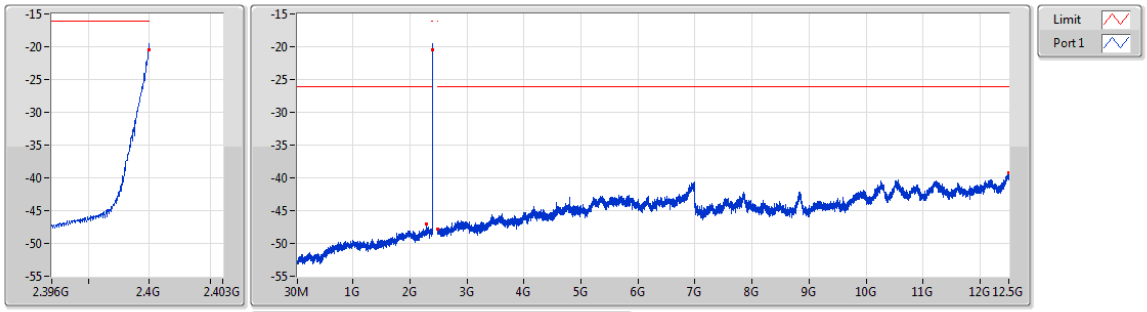
Mode	Result	F-Start (Hz)	F-Stop (Hz)	RBW (Hz)	Freq (MHz)	Psum (dBm)	Psum (uW/MHz)	Limit (dBm)	Limit (uW/MHz)	Margin (dB)
BT-LE(2Mbps)	-	-	-	-	-	-	-	-	-	-
2402MHz_TnomVnom	Pass	30M	2.387G	1M	2338.682	-47.37	0.01832	-26.02	2.5	-21.35
2402MHz_TnomVnom	Pass	2.387G	2.4G	1M	2399.974	-19.97	10.06932	-16.02	25	-3.95
2402MHz_TnomVnom	Pass	2.4835G	2.4965G	1M	2489.974	-47.89	0.01626	-16.02	25	-31.87
2402MHz_TnomVnom	Pass	2.4965G	12.5G	1M	12494.998	-39.31	0.11722	-26.02	2.5	-13.29
2402MHz_TnomVmin	Pass	30M	2.387G	1M	2298.613	-46.96	0.02014	-26.02	2.5	-20.94
2402MHz_TnomVmin	Pass	2.387G	2.4G	1M	2399.974	-20.51	8.89201	-16.02	25	-4.49
2402MHz_TnomVmin	Pass	2.4835G	2.4965G	1M	2490.104	-47.88	0.01629	-16.02	25	-31.86
2402MHz_TnomVmin	Pass	2.4965G	12.5G	1M	12500	-39.21	0.11995	-26.02	2.5	-13.19
2402MHz_TnomVmax	Pass	30M	2.387G	1M	2341.039	-47.56	0.01754	-26.02	2.5	-21.54
2402MHz_TnomVmax	Pass	2.387G	2.4G	1M	2399.974	-20.05	9.88553	-16.02	25	-4.03
2402MHz_TnomVmax	Pass	2.4835G	2.4965G	1M	2489.766	-47.84	0.01644	-16.02	25	-31.82
2402MHz_TnomVmax	Pass	2.4965G	12.5G	1M	12491.247	-38.72	0.13428	-26.02	2.5	-12.70
2440MHz_TnomVnom	Pass	30M	2.387G	1M	2351.645	-47.52	0.0177	-26.02	2.5	-21.50
2440MHz_TnomVnom	Pass	2.387G	2.4G	1M	2391.914	-48.13	0.01538	-16.02	25	-32.11
2440MHz_TnomVnom	Pass	2.4835G	2.4965G	1M	2488.05	-47.73	0.01687	-16.02	25	-31.71
2440MHz_TnomVnom	Pass	2.4965G	12.5G	1M	12482.494	-39.10	0.12303	-26.02	2.5	-13.08
2440MHz_TnomVmin	Pass	30M	2.387G	1M	2341.039	-47.49	0.01782	-26.02	2.5	-21.47
2440MHz_TnomVmin	Pass	2.387G	2.4G	1M	2391.758	-48.04	0.0157	-16.02	25	-32.02
2440MHz_TnomVmin	Pass	2.4835G	2.4965G	1M	2487.946	-47.78	0.01667	-16.02	25	-31.76
2440MHz_TnomVmin	Pass	2.4965G	12.5G	1M	12476.242	-38.69	0.13521	-26.02	2.5	-12.67
2440MHz_TnomVmax	Pass	30M	2.387G	1M	2376.394	-47.54	0.01762	-26.02	2.5	-21.52
2440MHz_TnomVmax	Pass	2.387G	2.4G	1M	2392.226	-48.11	0.01545	-16.02	25	-32.09
2440MHz_TnomVmax	Pass	2.4835G	2.4965G	1M	2488.154	-47.79	0.01663	-16.02	25	-31.77
2440MHz_TnomVmax	Pass	2.4965G	12.5G	1M	12492.497	-39.10	0.12303	-26.02	2.5	-13.08
2480MHz_TnomVnom	Pass	30M	2.387G	1M	2336.325	-47.61	0.01734	-26.02	2.5	-21.59
2480MHz_TnomVnom	Pass	2.387G	2.4G	1M	2392.33	-48.08	0.01556	-16.02	25	-32.06
2480MHz_TnomVnom	Pass	2.4835G	2.4965G	1M	2483.526	-43.67	0.04295	-16.02	25	-27.65
2480MHz_TnomVnom	Pass	2.4965G	12.5G	1M	12494.998	-39.23	0.1194	-26.02	2.5	-13.21
2480MHz_TnomVmin	Pass	30M	2.387G	1M	2330.432	-47.69	0.01702	-26.02	2.5	-21.67
2480MHz_TnomVmin	Pass	2.387G	2.4G	1M	2391.784	-48.11	0.01545	-16.02	25	-32.09
2480MHz_TnomVmin	Pass	2.4835G	2.4965G	1M	2483.526	-43.70	0.04266	-16.02	25	-27.68
2480MHz_TnomVmin	Pass	2.4965G	12.5G	1M	12498.75	-38.67	0.13583	-26.02	2.5	-12.65
2480MHz_TnomVmax	Pass	30M	2.387G	1M	2316.29	-47.59	0.01742	-26.02	2.5	-21.57
2480MHz_TnomVmax	Pass	2.387G	2.4G	1M	2392.07	-48.16	0.01528	-16.02	25	-32.14
2480MHz_TnomVmax	Pass	2.4835G	2.4965G	1M	2483.578	-43.90	0.04074	-16.02	25	-27.88
2480MHz_TnomVmax	Pass	2.4965G	12.5G	1M	12492.497	-39.08	0.12359	-26.02	2.5	-13.06

BT-LE(2Mbps) CSE-TX-2402MHz_TnomVnom



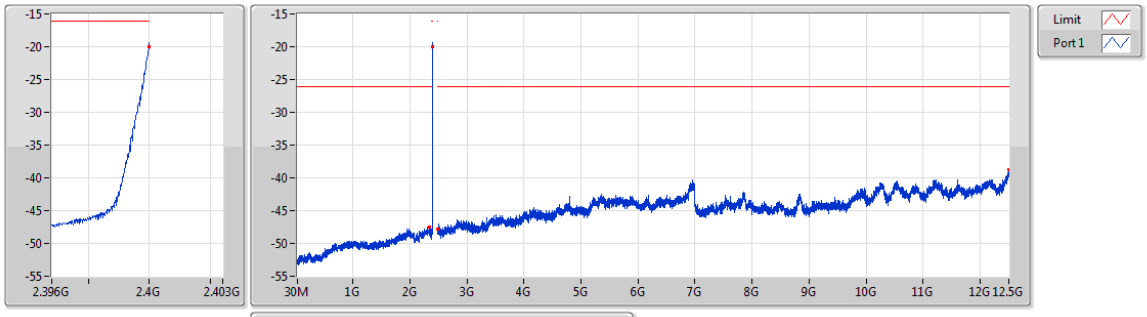
Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
2338.682	-47.37	-26.02	-21.35	-47.37
2399.974	-19.97	-16.02	-3.95	-19.97
2489.974	-47.89	-16.02	-31.87	-47.89
12494.998	-39.31	-26.02	-13.29	-39.31

BT-LE(2Mbps) CSE-TX-2402MHz_TnomVmin



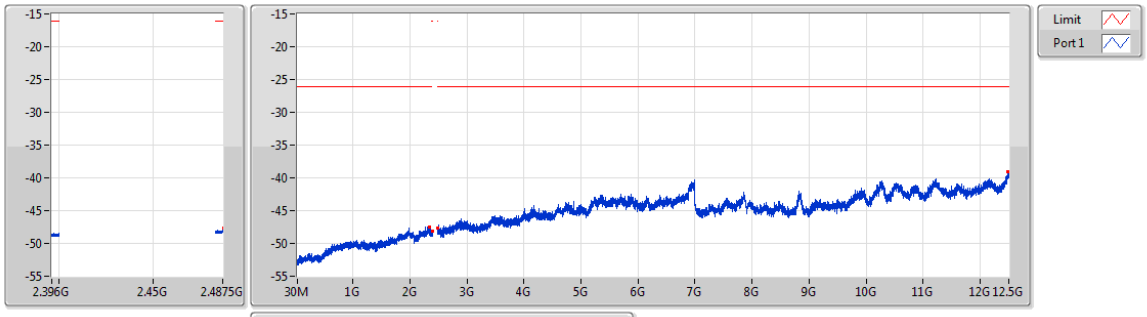
Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
2298.613	-46.96	-26.02	-20.94	-46.96
2399.974	-20.51	-16.02	-4.49	-20.51
2490.104	-47.88	-16.02	-31.86	-47.88
12500	-39.21	-26.02	-13.19	-39.21

BT-LE(2Mbps) CSE-TX-2402MHz_TnomVmax



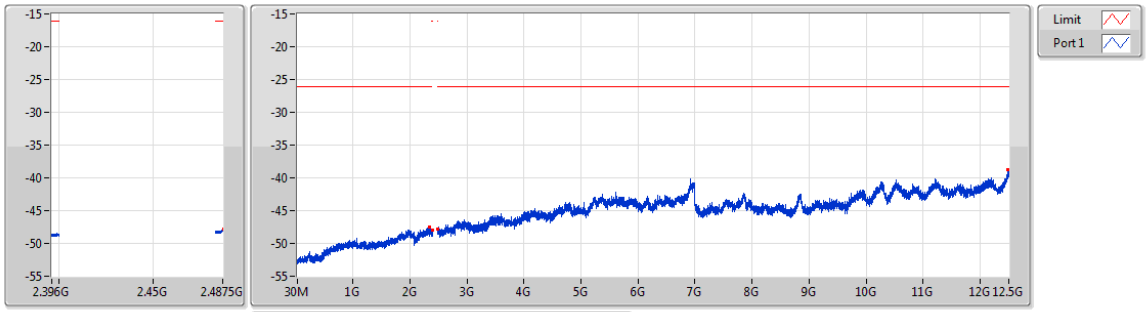
Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
2341.039	-47.56	-26.02	-21.54	-47.56
2399.974	-20.05	-16.02	-4.03	-20.05
2489.766	-47.84	-16.02	-31.82	-47.84
12491.247	-38.72	-26.02	-12.70	-38.72

BT-LE(2Mbps) CSE-TX-2440MHz_TnomVnom



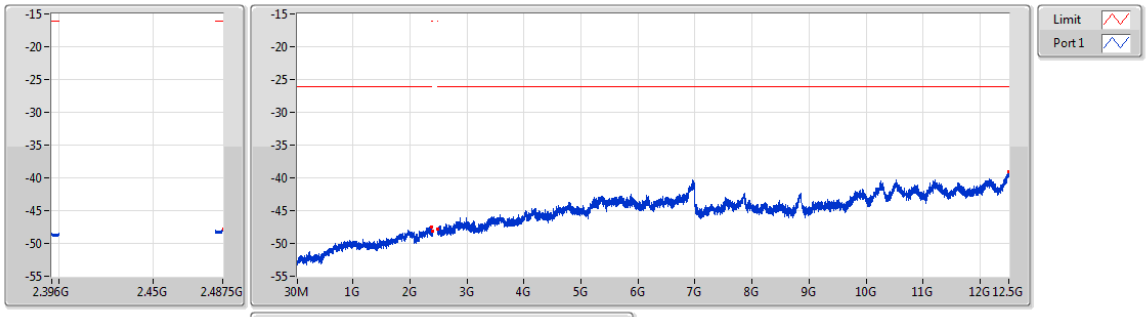
Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
2351.645	-47.52	-26.02	-21.50	-47.52
2391.914	-48.13	-16.02	-32.11	-48.13
2488.05	-47.73	-16.02	-31.71	-47.73
12482.494	-39.10	-26.02	-13.08	-39.10

BT-LE(2Mbps) CSE-TX-2440MHz_TnomVmin



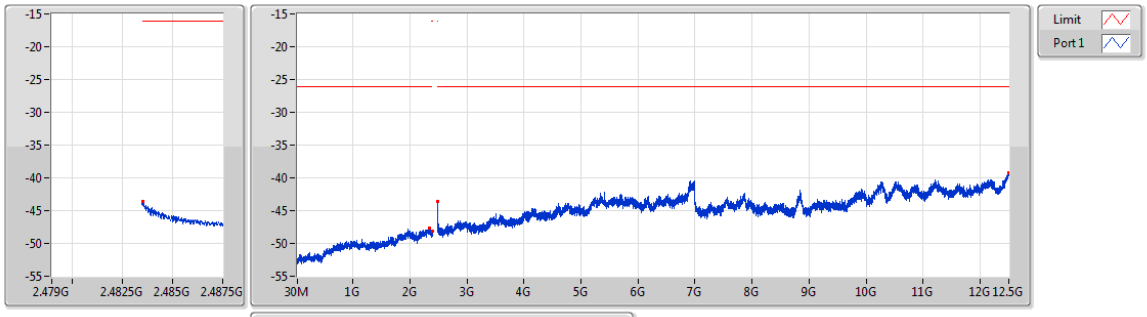
Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
2341.039	-47.49	-26.02	-21.47	-47.49
2391.758	-48.04	-16.02	-32.02	-48.04
2487.946	-47.78	-16.02	-31.76	-47.78
12476.242	-38.69	-26.02	-12.67	-38.69

BT-LE(2Mbps) CSE-TX-2440MHz_TnomVmax



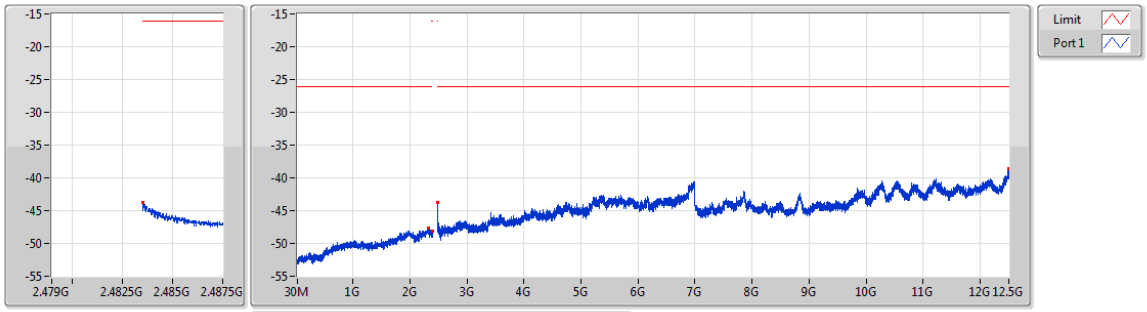
Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
2376.394	-47.54	-26.02	-21.52	-47.54
2392.226	-48.11	-16.02	-32.09	-48.11
2488.154	-47.79	-16.02	-31.77	-47.79
12492.497	-39.10	-26.02	-13.08	-39.10

BT-LE(2Mbps) CSE-TX-2480MHz_TnomVnom



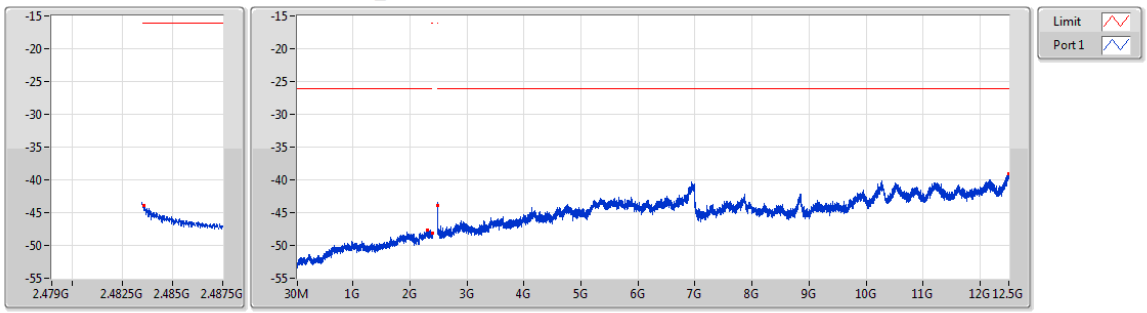
Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
2336.325	-47.61	-26.02	-21.59	-47.61
2392.33	-48.08	-16.02	-32.06	-48.08
2483.526	-43.67	-16.02	-27.65	-43.67
12494.998	-39.23	-26.02	-13.21	-39.23

BT-LE(2Mbps) CSE-TX-2480MHz_TnomVmin



Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
2330.432	-47.69	-26.02	-21.67	-47.69
2391.784	-48.11	-16.02	-32.09	-48.11
2483.526	-43.70	-16.02	-27.68	-43.70
12498.75	-38.67	-26.02	-12.65	-38.67

BT-LE(2Mbps) CSE-TX-2480MHz_TnomVmax



Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
2316.29	-47.59	-26.02	-21.57	-47.59
2392.07	-48.16	-16.02	-32.14	-48.16
2483.578	-43.90	-16.02	-27.88	-43.90
12492.497	-39.08	-26.02	-13.06	-39.08

Summary

Mode	Result	ID Length	ID Limit	Function
2.4-2.4835GHz	-	-	-	-
BT-LE(2Mbps)	Pass	E6:F4:EA:4D:0C:0E	48 bits	Good

Result

Mode	Result	ID Length	ID Limit	Function
BT-LE(2Mbps)	-	-	-	-
2402MHz_TnomVnom	Pass	E6:F4:EA:4D:0C:0E	48 bits	Good
2402MHz_TnomVmin	Pass	E6:F4:EA:4D:0C:0E	48 bits	Good
2402MHz_TnomVmax	Pass	E6:F4:EA:4D:0C:0E	48 bits	Good
2440MHz_TnomVnom	Pass	E6:F4:EA:4D:0C:0E	48 bits	Good
2440MHz_TnomVmin	Pass	E6:F4:EA:4D:0C:0E	48 bits	Good
2440MHz_TnomVmax	Pass	E6:F4:EA:4D:0C:0E	48 bits	Good
2480MHz_TnomVnom	Pass	E6:F4:EA:4D:0C:0E	48 bits	Good
2480MHz_TnomVmin	Pass	E6:F4:EA:4D:0C:0E	48 bits	Good
2480MHz_TnomVmax	Pass	E6:F4:EA:4D:0C:0E	48 bits	Good

Summary

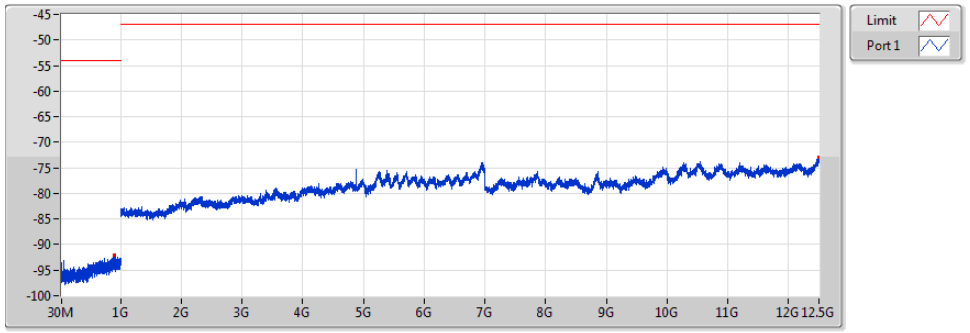
Mode	Result	F-Start (Hz)	F-Stop (Hz)	RBW (Hz)	Freq (MHz)	Psum (dBm)	Psum (nW/MHz)	Limit (dBm)	Limit (nW/MHz)	Margin (dB)
2.4-2.4835GHz	-	-	-	-	-	-	-	-	-	-
BT-LE(2Mbps)	Pass	1G	12.5G	1M	12489.937	-72.64	0.05445	-46.99	20	-25.65

Result

Mode	Result	F-Start (Hz)	F-Stop (Hz)	RBW (Hz)	Freq (MHz)	Psum (dBm)	Psum (nW/MHz)	Limit (dBm)	Limit (nW/MHz)	Margin (dB)
BT-LE(2Mbps)	-	-	-	-	-	-	-	-	-	-
2402MHz_TnomVnom	Pass	30M	1G	100k	901.545	-91.95	0.00064	-53.98	4	-37.97
2402MHz_TnomVnom	Pass	1G	12.5G	1M	12494.25	-73.02	0.04989	-46.99	20	-26.03
2402MHz_TnomVmin	Pass	30M	1G	100k	965.08	-92.03	0.00063	-53.98	4	-38.05
2402MHz_TnomVmin	Pass	1G	12.5G	1M	12498.562	-73.10	0.04898	-46.99	20	-26.11
2402MHz_TnomVmax	Pass	30M	1G	100k	945.195	-92.30	0.00059	-53.98	4	-38.32
2402MHz_TnomVmax	Pass	1G	12.5G	1M	12498.562	-73.19	0.04797	-46.99	20	-26.20
2440MHz_TnomVnom	Pass	30M	1G	100k	967.505	-92.21	0.0006	-53.98	4	-38.23
2440MHz_TnomVnom	Pass	1G	12.5G	1M	12497.125	-73.04	0.04966	-46.99	20	-26.05
2440MHz_TnomVmin	Pass	30M	1G	100k	656.135	-92.28	0.00059	-53.98	4	-38.30
2440MHz_TnomVmin	Pass	1G	12.5G	1M	12497.125	-73.10	0.04898	-46.99	20	-26.11
2440MHz_TnomVmax	Pass	30M	1G	100k	931.615	-92.36	0.00058	-53.98	4	-38.38
2440MHz_TnomVmax	Pass	1G	12.5G	1M	12469.812	-73.06	0.04943	-46.99	20	-26.07
2480MHz_TnomVnom	Pass	30M	1G	100k	962.17	-92.20	0.0006	-53.98	4	-38.22
2480MHz_TnomVnom	Pass	1G	12.5G	1M	12489.937	-72.64	0.05445	-46.99	20	-25.65
2480MHz_TnomVmin	Pass	30M	1G	100k	943.74	-92.18	0.00061	-53.98	4	-38.20
2480MHz_TnomVmin	Pass	1G	12.5G	1M	12494.25	-73.13	0.04864	-46.99	20	-26.14
2480MHz_TnomVmax	Pass	30M	1G	100k	656.135	-91.86	0.00065	-53.98	4	-37.88
2480MHz_TnomVmax	Pass	1G	12.5G	1M	12491.375	-72.79	0.0526	-46.99	20	-25.80

BT-LE(2Mbps) **CSE-RX-**

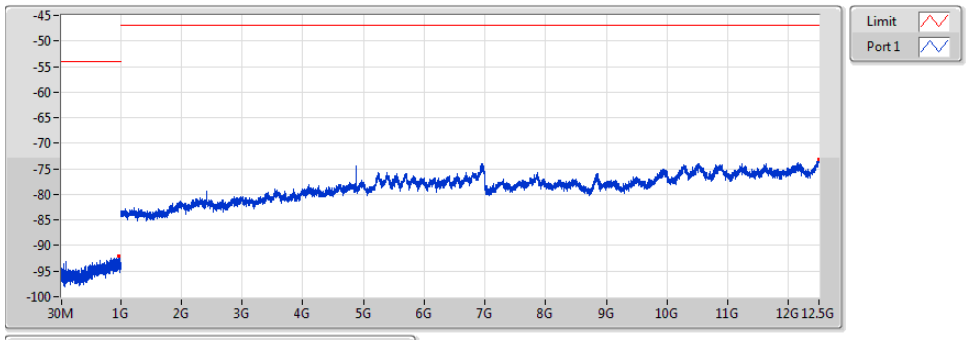
2402MHz_TnomVnom



Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
901.545	-91.95	-53.98	-37.97	-91.95
12494.25	-73.02	-46.99	-26.03	-73.02

BT-LE(2Mbps) **CSE-RX-**

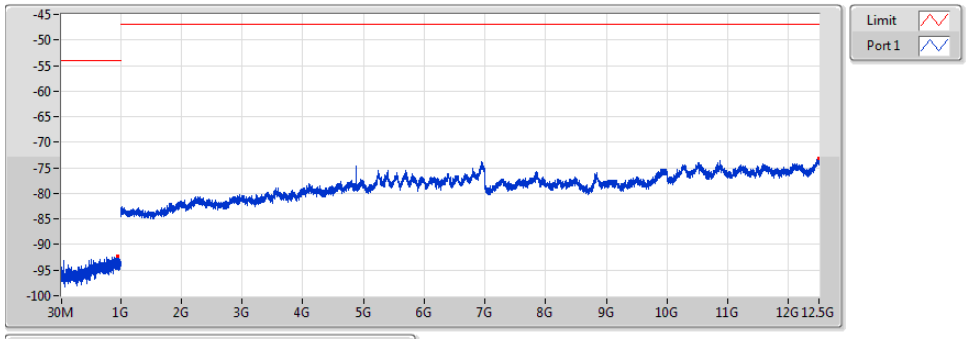
2402MHz_TnomVmin



Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
965.08	-92.03	-53.98	-38.05	-92.03
12498.562	-73.10	-46.99	-26.11	-73.10

BT-LE(2Mbps) **CSE-RX-**

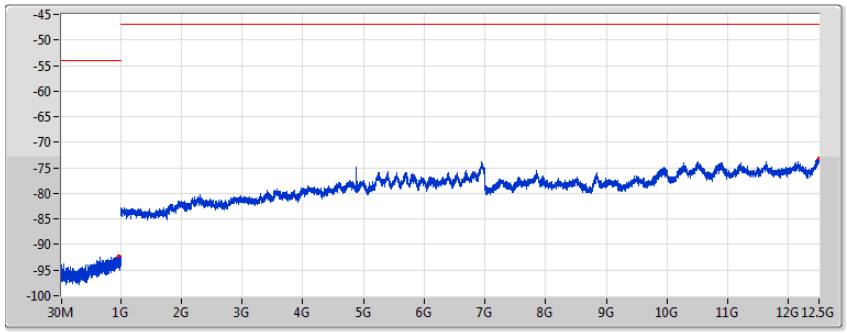
2402MHz_TnomVmax



Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
945.195	-92.30	-53.98	-38.32	-92.30
12498.562	-73.19	-46.99	-26.20	-73.19

BT-LE(2Mbps) **CSE-RX-**

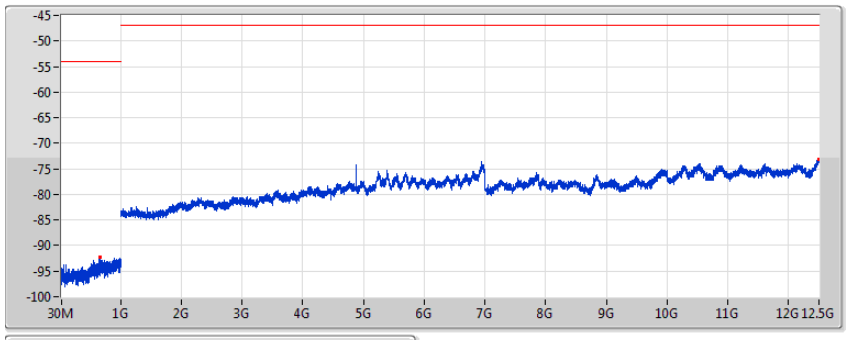
2440MHz_TnomVnom



Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
967.505	-92.21	-53.98	-38.23	-92.21
12497.125	-73.04	-46.99	-26.05	-73.04

BT-LE(2Mbps) **CSE-RX-**

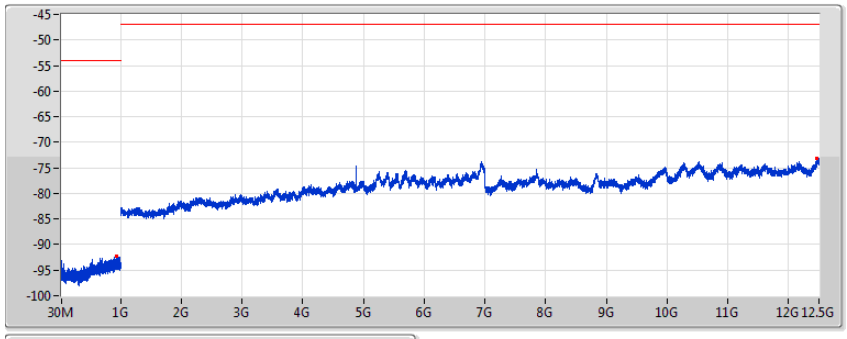
2440MHz_TnomVmin



Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
656.135	-92.28	-53.98	-38.30	-92.28
12497.125	-73.10	-46.99	-26.11	-73.10

BT-LE(2Mbps) **CSE-RX-**

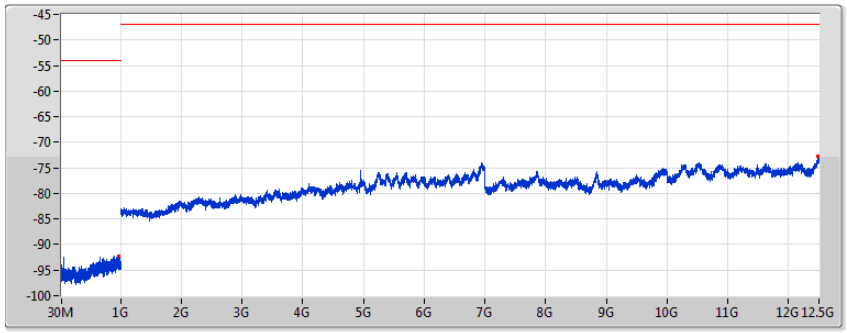
2440MHz_TnomVmax



Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
931.615	-92.36	-53.98	-38.38	-92.36
12469.812	-73.06	-46.99	-26.07	-73.06

BT-LE(2Mbps) **CSE-RX-**

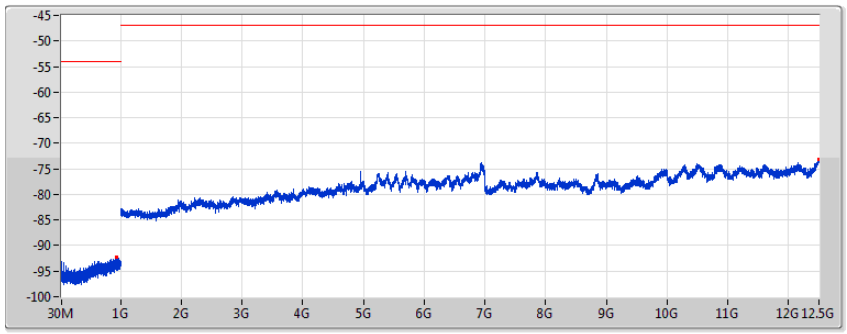
2480MHz_TnomVnom



Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
962.17	-92.20	-53.98	-38.22	-92.20
12489.937	-72.64	-46.99	-25.65	-72.64

BT-LE(2Mbps) **CSE-RX-**

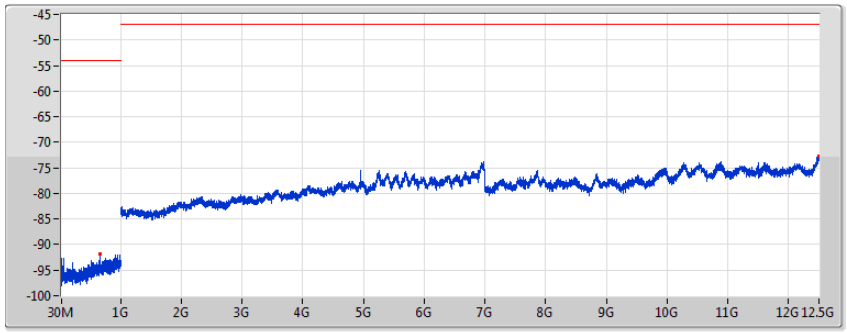
2480MHz_TnomVmin



Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
943.74	-92.18	-53.98	-38.20	-92.18
12494.25	-73.13	-46.99	-26.14	-73.13

BT-LE(2Mbps) **CSE-RX-**

2480MHz_TnomVmax



Freq(MHz)	Psum(dBm)	Limit(dBm)	Margin(dB)	P1(dBm)
656.135	-91.86	-53.98	-37.88	-91.86
12491.375	-72.79	-46.99	-25.80	-72.79

Appendix G. Antenna Information

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	2.4 GHz FlexPIFA Antenna w/MHF4L Cable, 100mm

Table 1 Orderable Part Numbers

KEY FEATURES

- Can be installed on different non-conductive surfaces and thicknesses.
- Can be installed near metals or the human body.
- Can be installed on flat or curved surfaces.
- Quick and easy Installation
- Adhesive holds to surface during humidity exposure and hot/cold cycles.
- RoHS Compliant

SPECIFICATIONS

Specification	Value
Peak Gain	+2 dBi
Average Gain	>-1.5 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
Connector Height	U.FL: 2.5mm Max
	MHF4L: 1.4mm Max

Table 2 Specifications

PHYSICAL DIMENSIONS (MM)

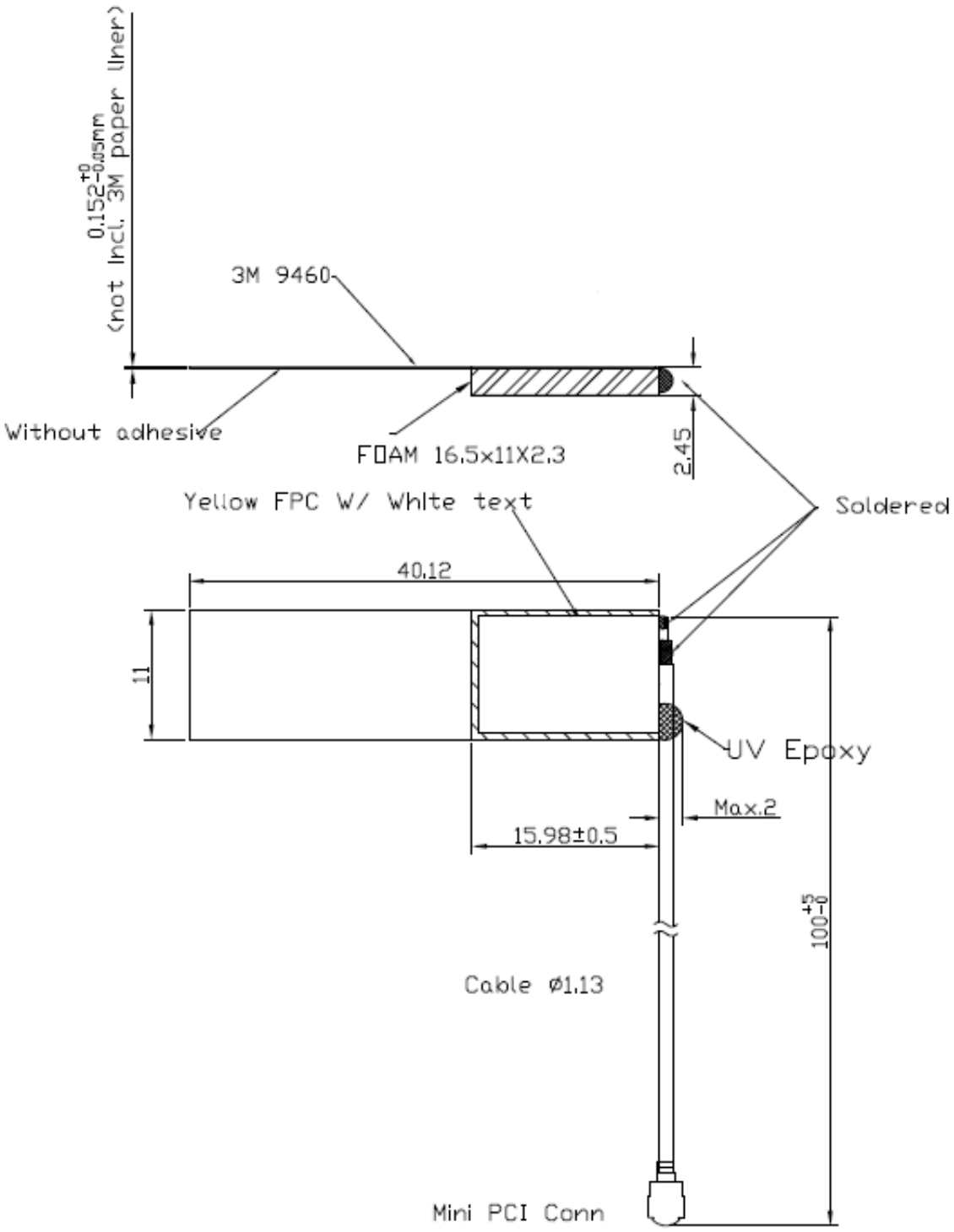


Figure 1 Physical Dimensions

TEST SETUP

Antenna measurements such as VSWR were measured with an Agilent E5071C Vector Network Analyzer. Radiation patterns were measured with a CMT Planar 804/1 Vector Network Analyzer in a Howland Company 3100 Chamber equivalent. Phase Center is 9 inches above the Phi positioner.

Flat surface measurements were done with the antenna centered on a 1.5 mm thick plate of Polycarbonate. Curved surface measurements were taken by placing the antenna on the inside and outside of different diameter PVC tubing.

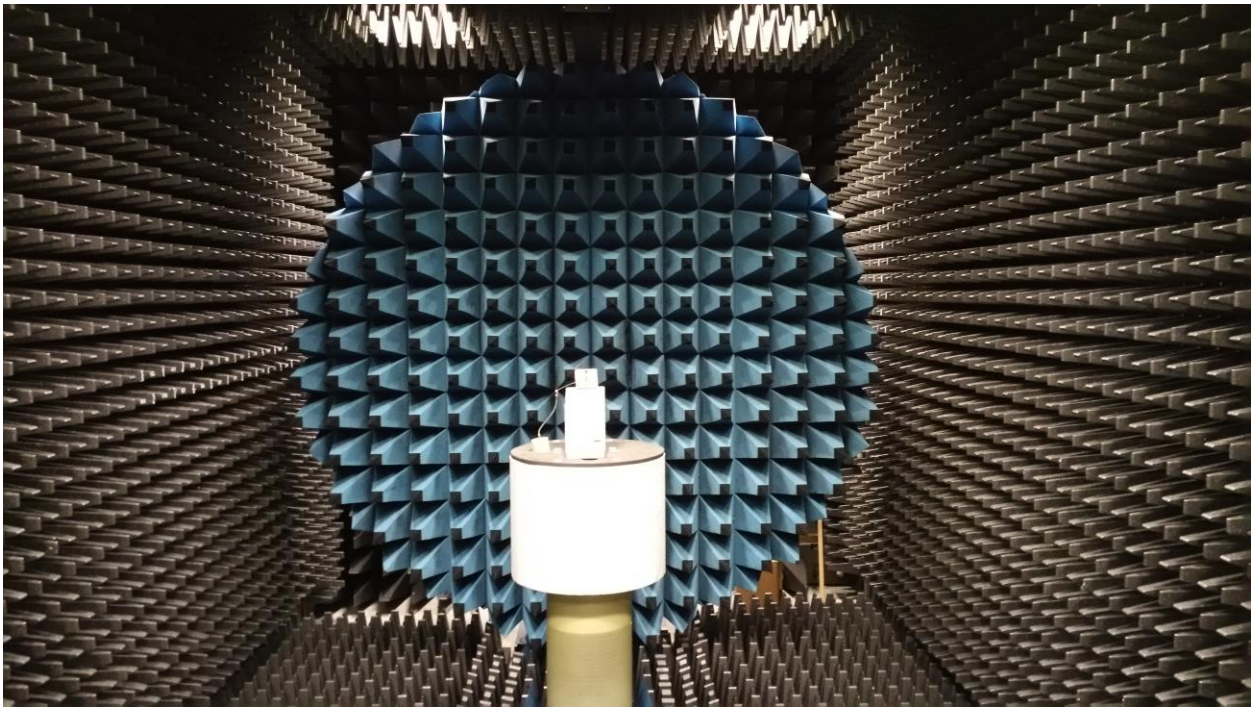


Figure 2 Antenna Chamber

FLAT SURFACE ANTENNA MEASUREMENTS

VSWR

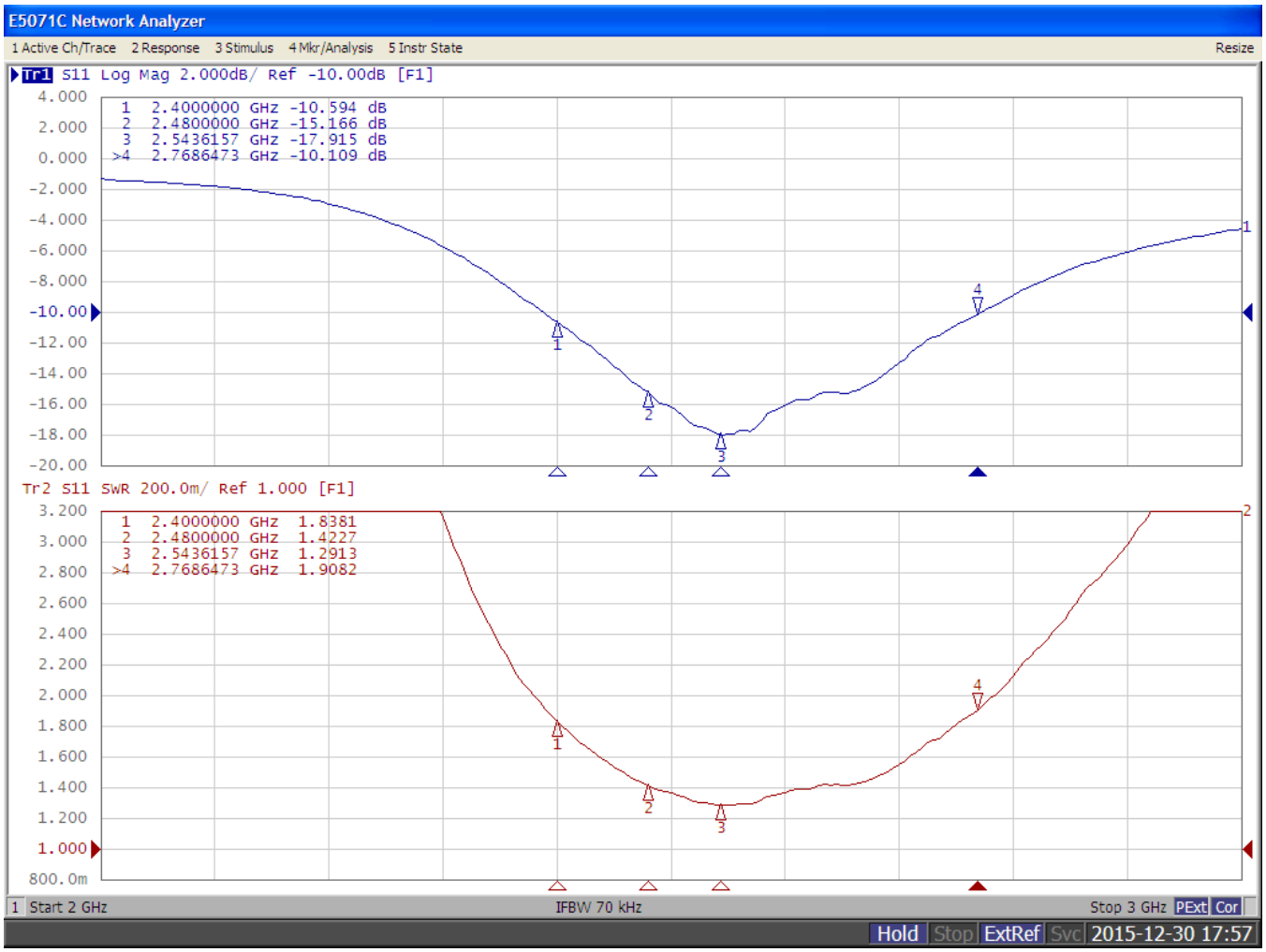


Figure 3 Antenna VSWR measured on a 1.5 mm thick plate of Polycarbonate

FLAT SURFACE ANTENNA RADIATION PERFORMANCE

FlexPIFA centered on a 1.5 mm thick plate of Polycarbonate

Antenna Measurement Set-Up:

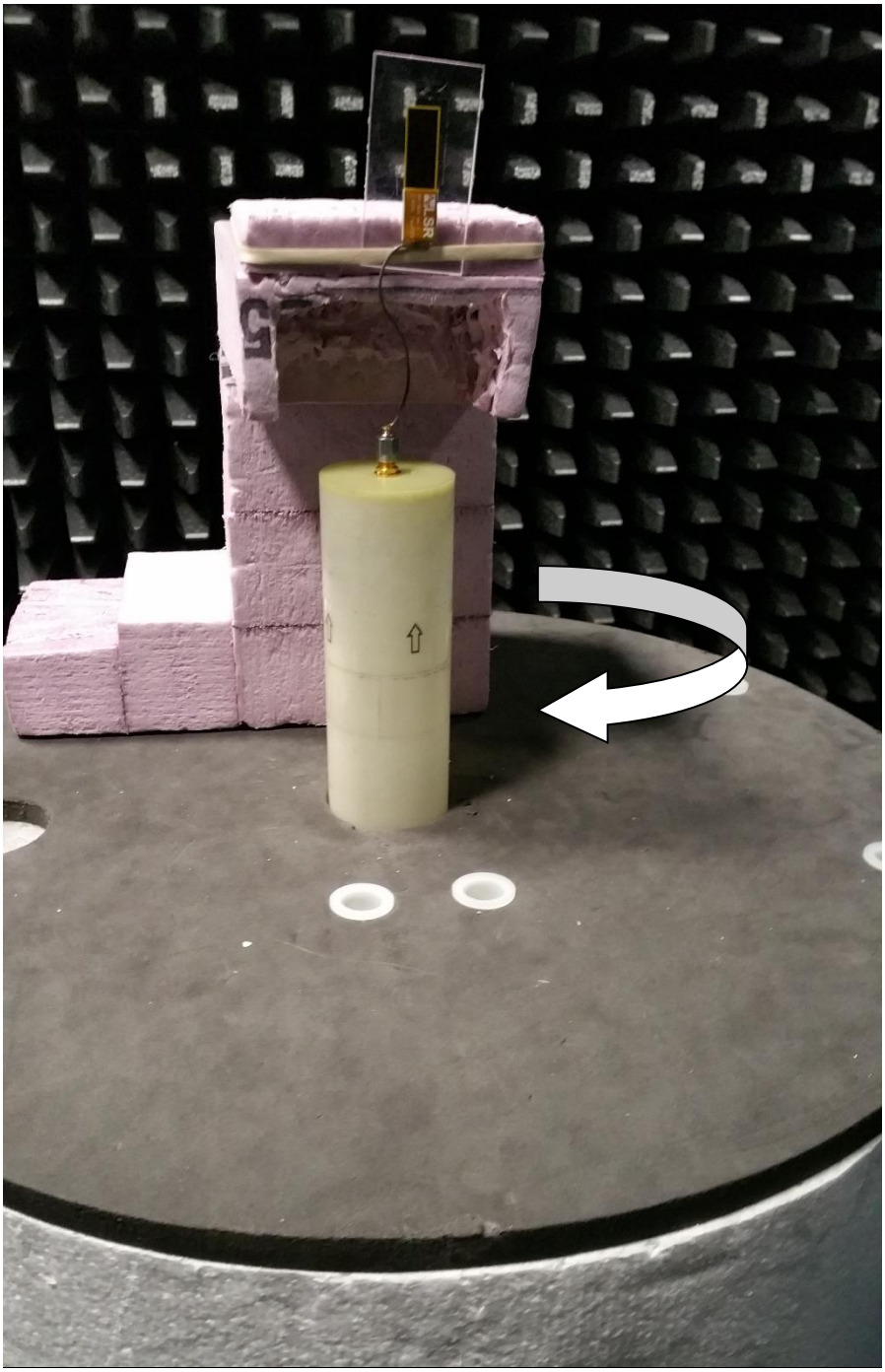


Figure 4 Flat Surface Set-Up

Azimuthal Conical Cuts at 2400 MHz:

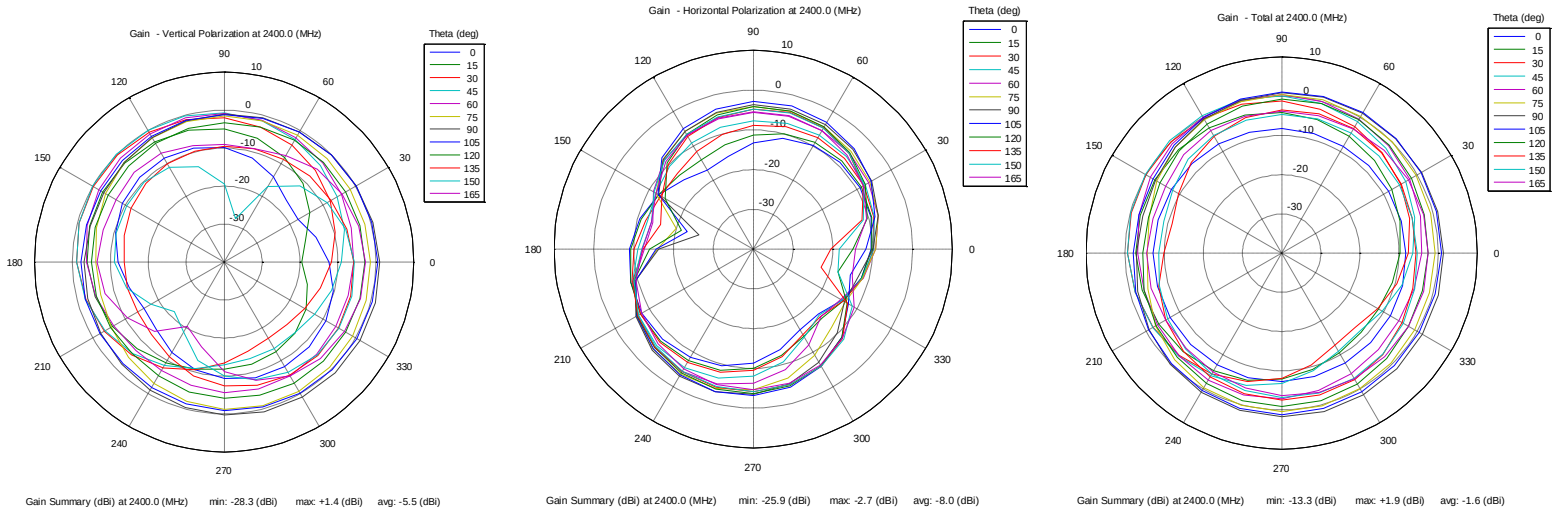


Figure 5 Vertical, Horizontal, and Total Gain Patterns

3D Plots at 2400 MHz:

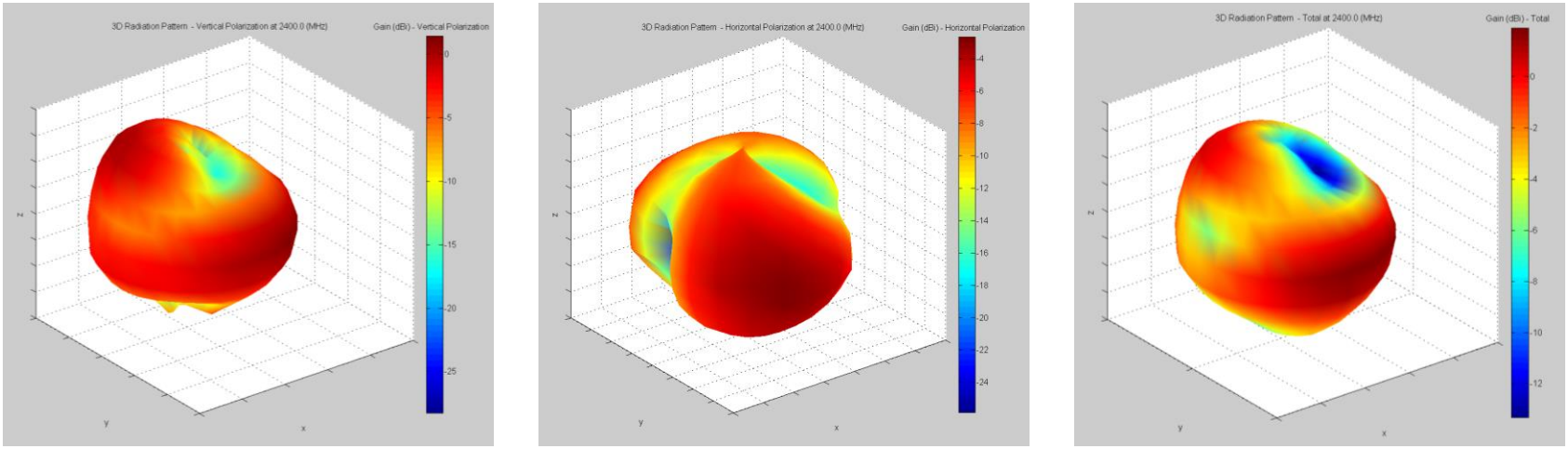


Figure 6 Vertical, Horizontal, and Total Gain Plots

Azimuthal Conical Cuts at 2440 MHz:

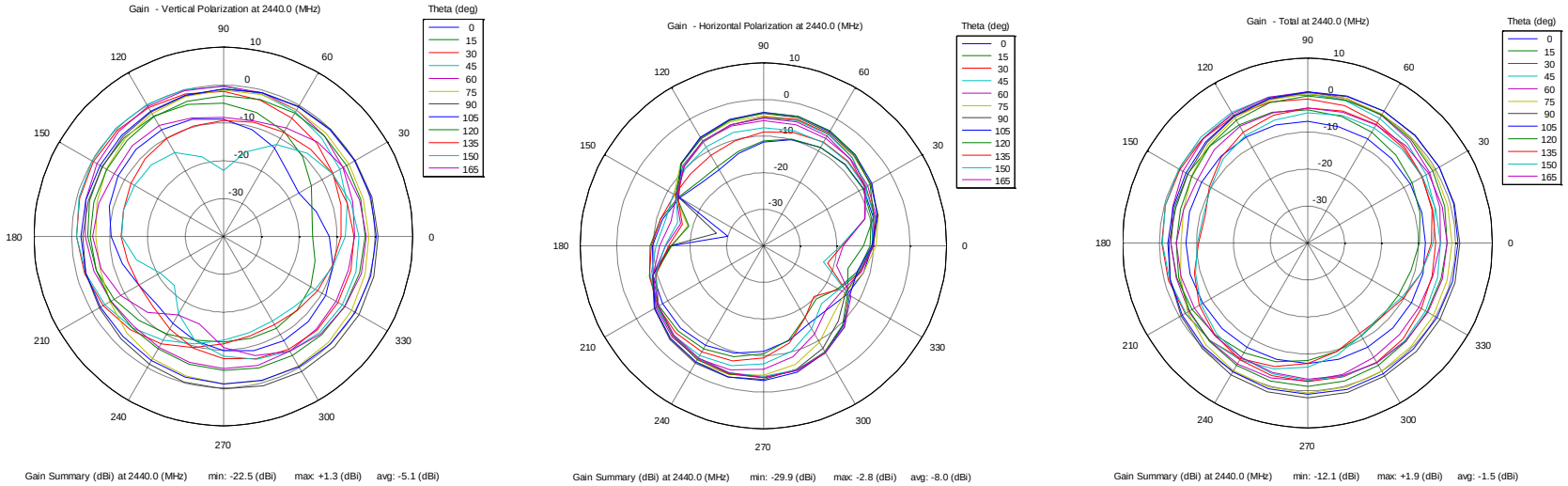


Figure 7 Vertical, Horizontal, and Total Gain Patterns

3D Plots at 2440 MHz:

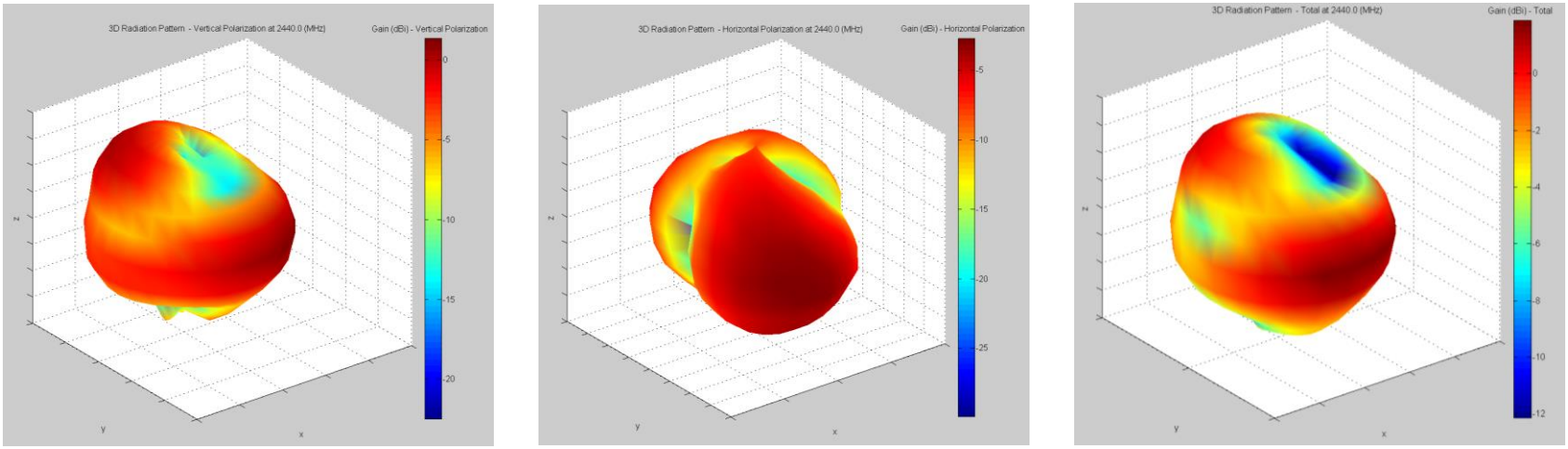


Figure 8 Vertical, Horizontal, and Total Gain Plots

Azimuthal Conical Cuts at 2480 MHz:

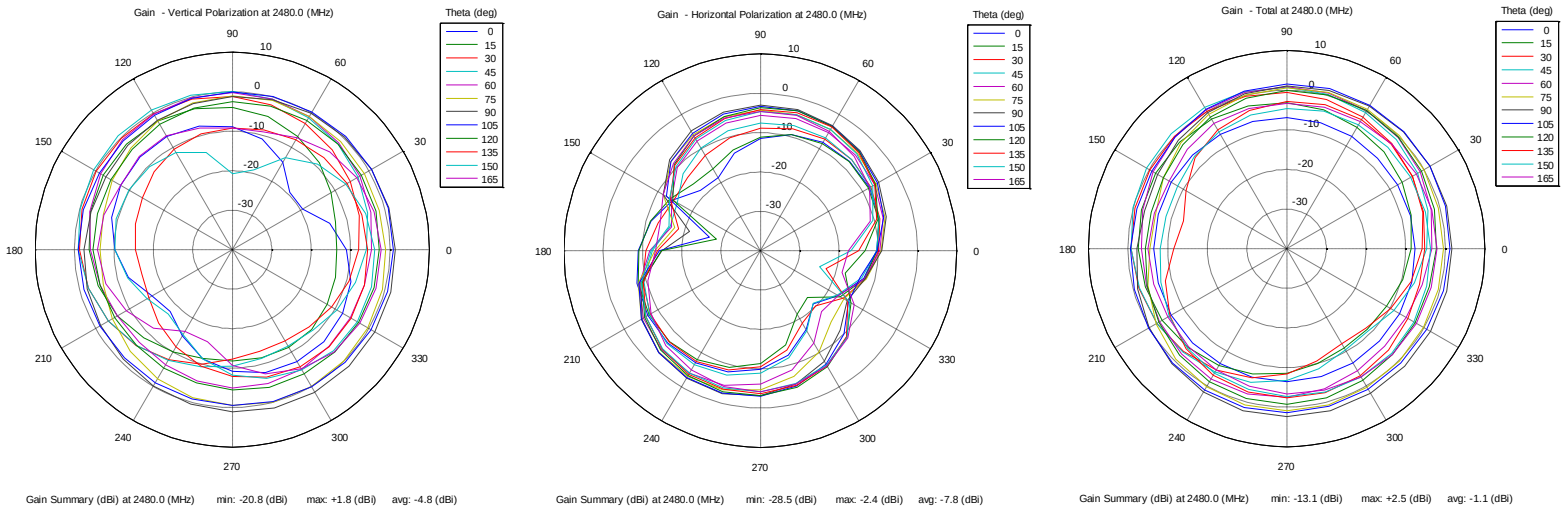


Figure 9 Vertical, Horizontal, and Total Gain Patterns

3D Plots at 2480 MHz:

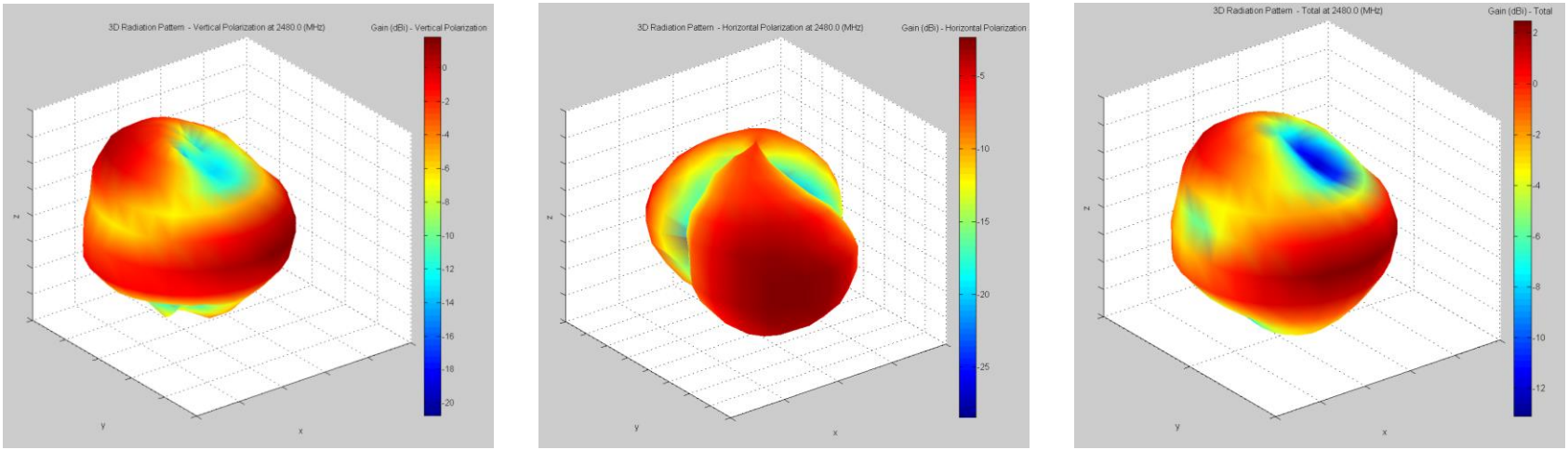


Figure 10 Vertical, Horizontal, and Total Gain Plots

CURVED SURFACE ANTENNA RADIATION PERFORMANCE

Flex PIFA inside 51 mm Inner Diameter PVC tube.

Antenna Measurement Set-Up:

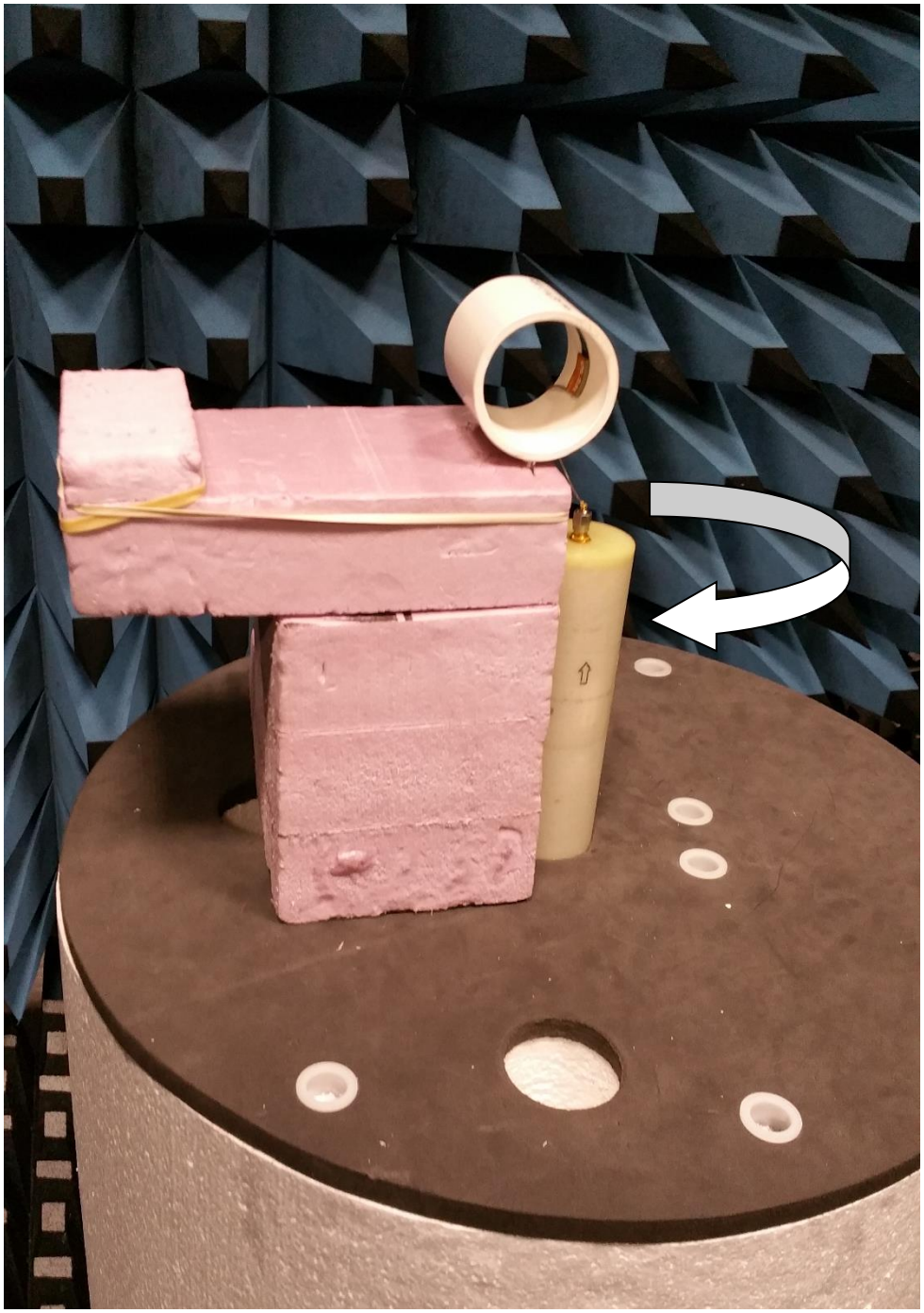


Figure 11 Concave Curve Set-Up

Azimuthal Conical Cuts at 2440 MHz:

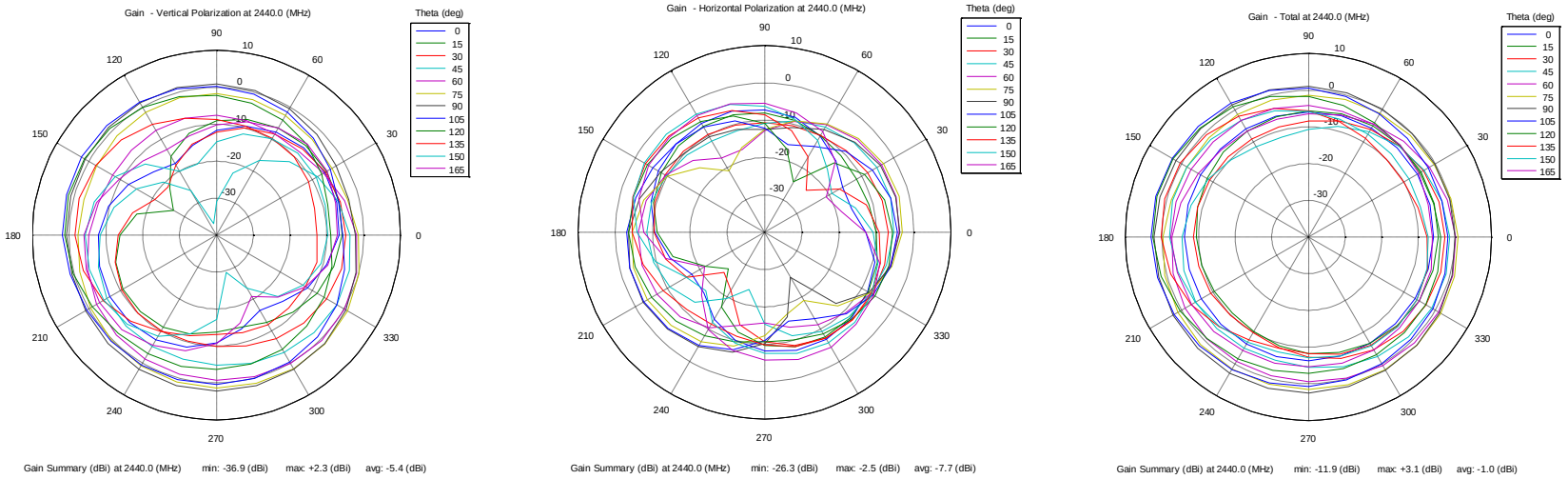


Figure 12 Vertical, Horizontal, and Total Gain Patterns

3D Plots at 2440 MHz:

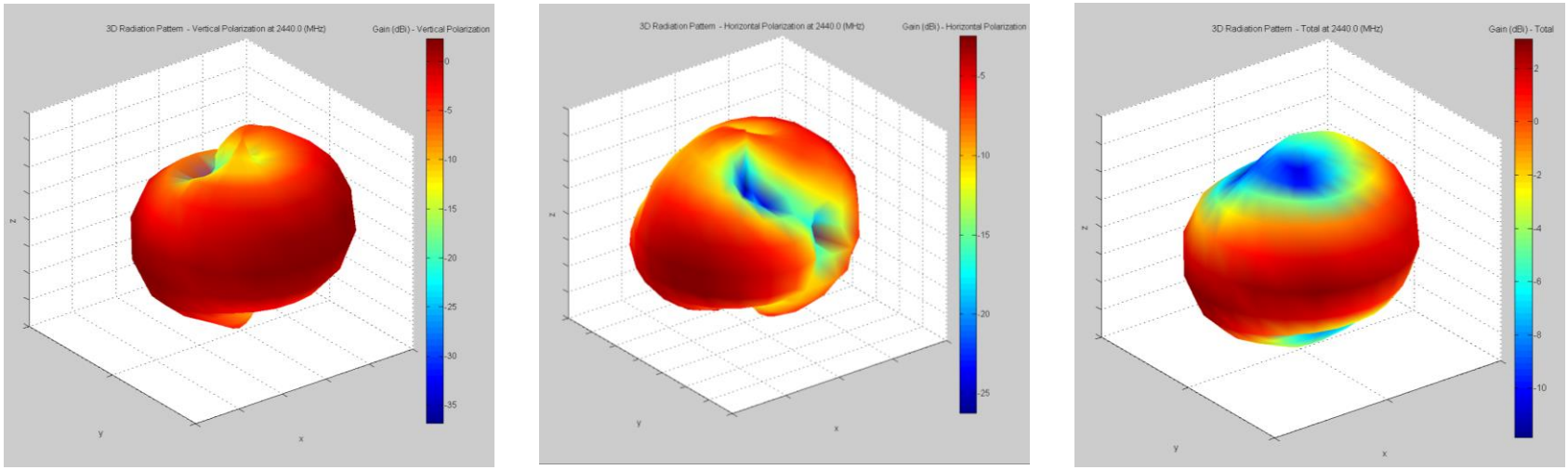


Figure 13 Vertical, Horizontal, and Total Gain Plots

Flex PIFA outside 60 mm Outer Diameter PVC tube.

Antenna Measurement Set-Up:

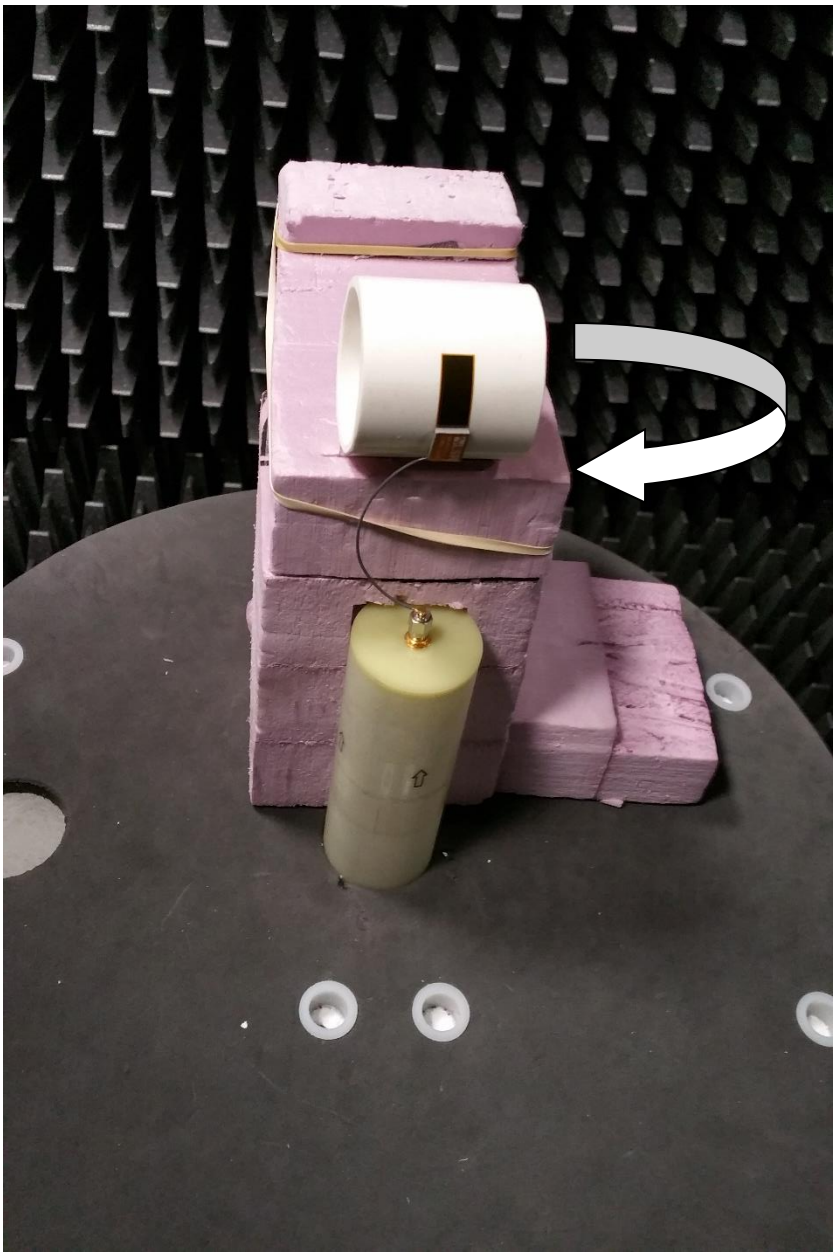


Figure 14 Convex Curve Set-Up

Azimuthal Conical Cuts at 2440 MHz:

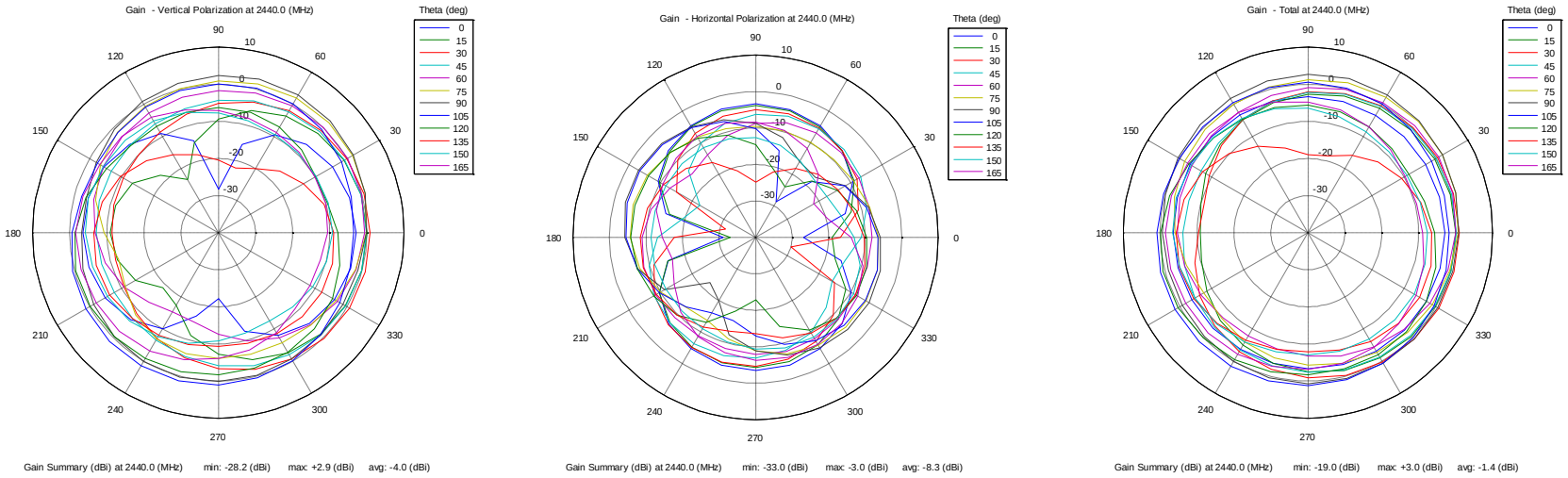


Figure 15 Vertical, Horizontal, and Total Gain Patterns

3D Plots at 2440 MHz:

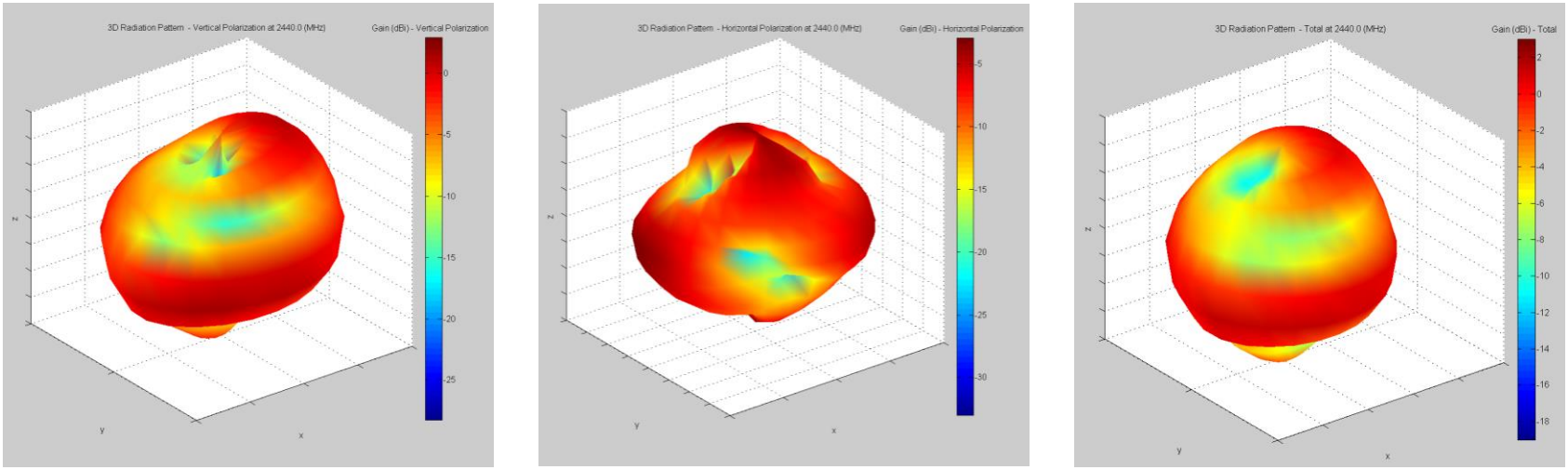


Figure 16 Vertical, Horizontal, and Total Gain Plots

OPTIMAL INSTALLATION GUIDE

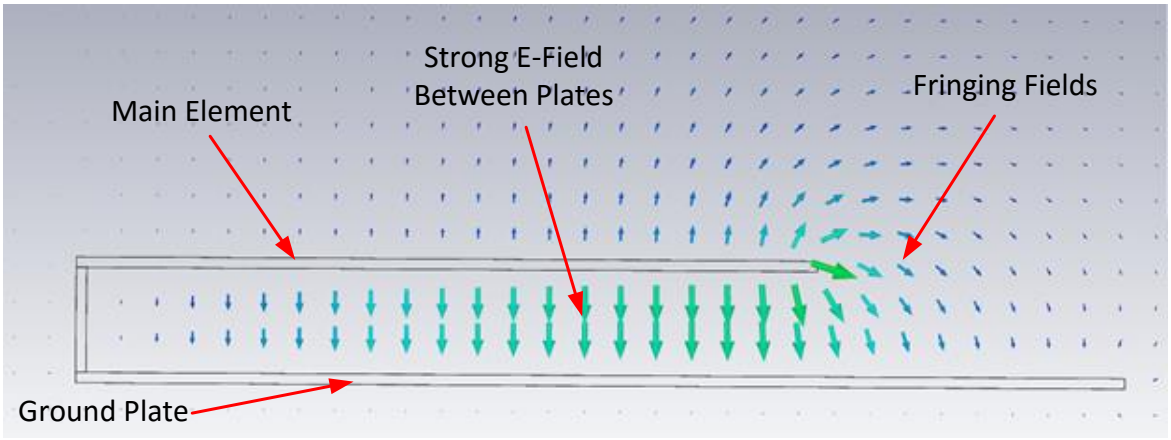


Figure 17 E-Field Radiation from FlexPIFA, Taken from CST Simulation

The main element should be kept clear of any non-metal objects (such as plastics) on top of it by at least 3 mm (see **Figure 18**). Similarly, the two long sides of the FlexPIFA should be kept clear of any non-metal object by at least 2 mm (See **Figure 19**). A 1 mm clearance should be observed from the ground wall to any non-metal object. Mounting the FlexPIFA in a situation that does not allow for these clearance recommendations may change the gain characteristics stated in the datasheet, which could impact overall range of the wireless system.

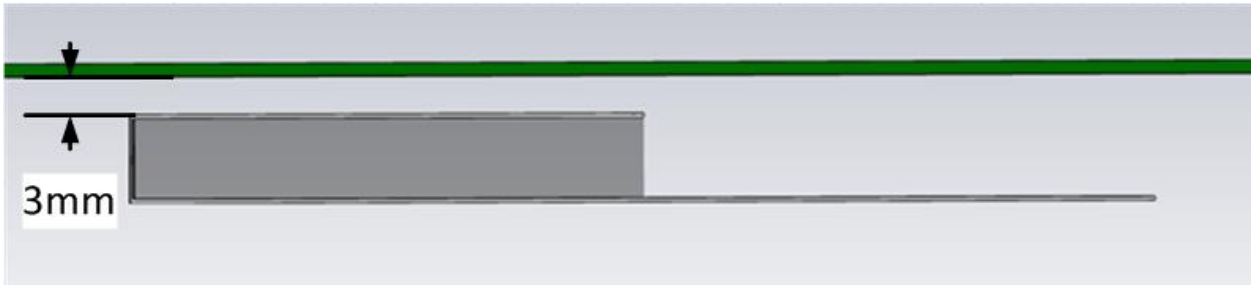
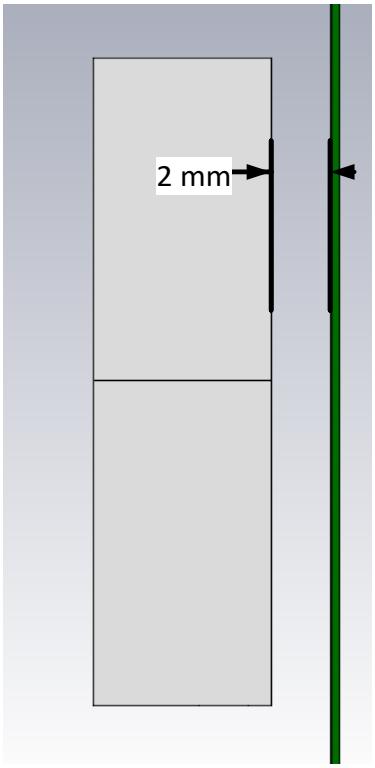
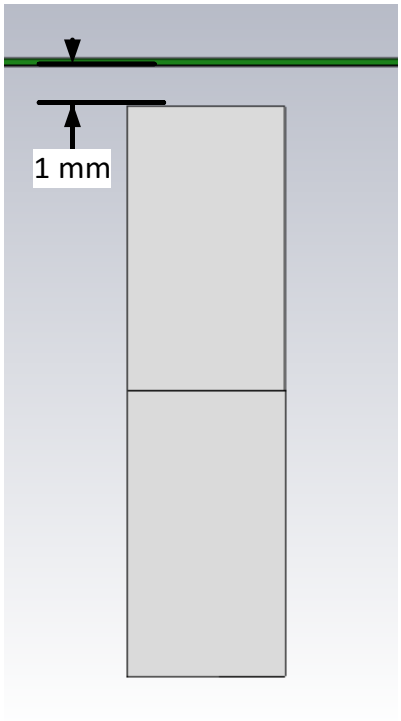


Figure 18 Top Clearance



Side Clearance



Ground Wall Clearance

Figure 19 Side and Ground Wall Clearance

The ideal material for the FlexPIFA to be mounted on is 1.5 mm thick polycarbonate for maximum performance. However, as previously mentioned, the FlexPIFA can tolerate other non-metallic surfaces and thicknesses and still radiate effectively. Depending on the type of material, the FlexPIFA may be detuned.

The coaxial cable feeding the FlexPIFA should be routed away from the antenna. Do not run the coaxial cable over the top of the FlexPIFA or near the tip of the main element. The cable should be routed as shown in **Figure 20**.

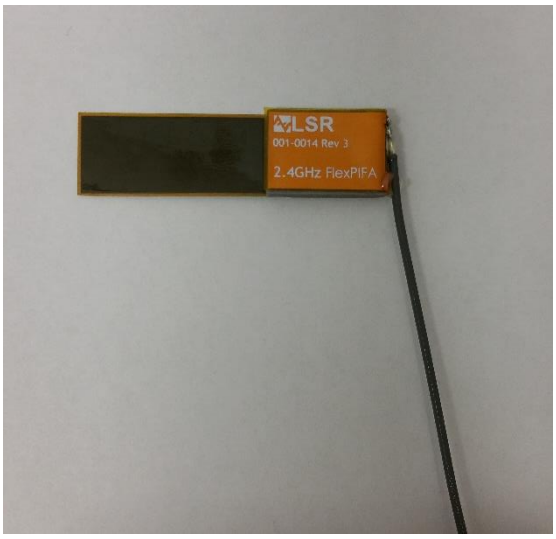


Figure 20 Recommended Cable Routing

As with any antenna, care should be taken not to place conductive materials or objects near the antenna (except as described in the next section). The radiated fields from the antenna will induce currents on the surface of the metal; as a result those currents then produce their own radiation. These re-radiating fields from the metal will interfere with the fields radiating from the FlexPIFA (this is true for any antenna). Other objects, such as an LCD display, placed in close proximity to the antenna may not affect its tuning but it can distort the radiation pattern. Materials that absorb electromagnetic fields should be kept away from the antenna to maximize performance. Common things to keep in mind when placing the antenna:

Wire Routing

Speakers – these generate magnetic fields

Metal Chassis and Frames

Battery Location

Proximity to Human Body

Display Screen – these will absorb radiation

Paint – do not use metallic coating or flakes

Flex Limits of the FlexPIFA

One of the unique features of the FlexPIFA is its ability to flex. However, due to the adhesive there are limits as to how much the antenna can be flexed and remain secured to the device. The FlexPIFA should not be flexed in a convex position with a radius less than 16mm. Going smaller than this may result in the antenna peeling off the surface over time. Should a tighter radius of curvature be required, it is recommended you contact LSR for assistance.

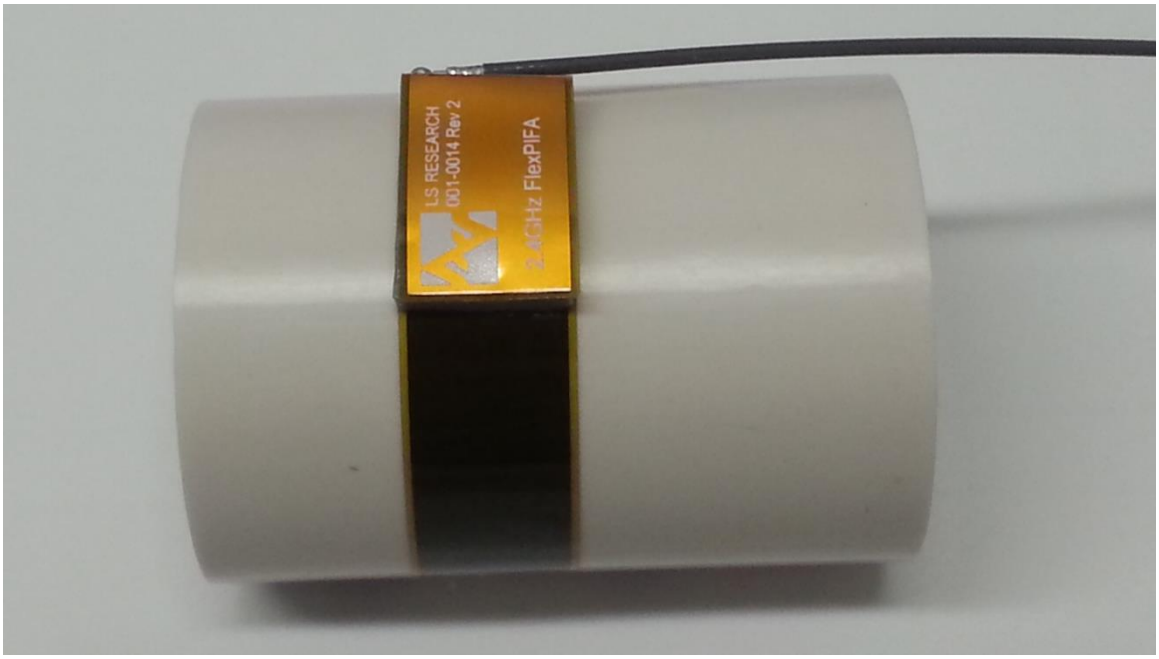


Figure 21 Convex Mounted

The FlexPIFA should not be flexed in a concave position with a radius less than 25mm. In this scenario, the limiting factor is performance. The ground plate of the antenna is pressed closer to the main element. As previously discussed in the introduction of this application note, the fringing fields developing off the end of the element are responsible for most of the radiation. In a concave position with a radius of curvature less than 25mm, the fringing fields are adversely affected and gain suffers. If a tighter radius of curvature is required, it is recommended you contact LSR for assistance.

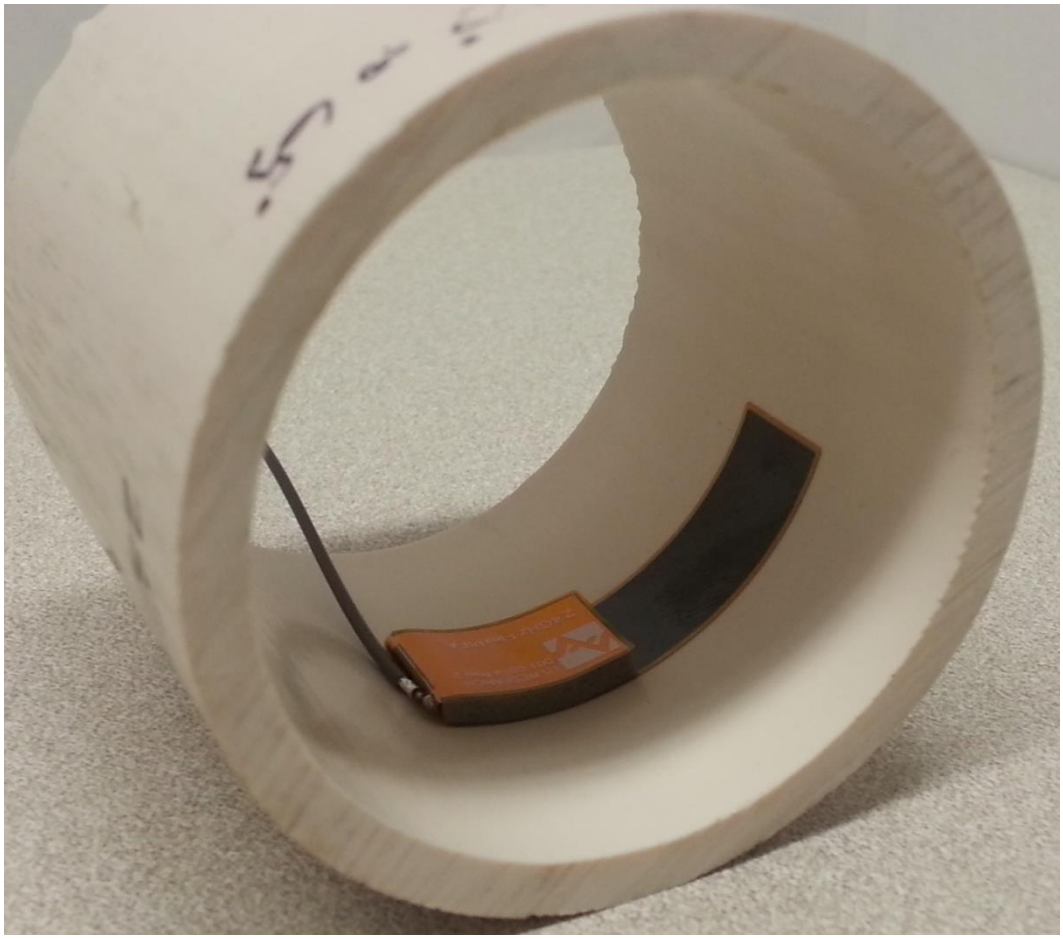


Figure 22 Concave Mounted

The FlexPIFA is not designed to be twisted or crumpled. The adhesive back should lay flush with the surface it is mounted on.

Mounting on Metal and Body Loaded Applications

The FlexPIFA can tolerate being mounted on conductive surfaces. There will be some detuning of the antenna, which translates into some gain reduction. Even though the FlexPIFA is optimized to work on non-metallic surfaces, it still radiates efficiently due to the fringing fields (Shown in **Figure 17**). The ground plate of the FlexPIFA carries the adhesive backing; placing the antenna onto a metal surface simply enlarges the size of the ground beneath the main element. Previously the fringing fields only interacted with the small ground of the FlexPIFA - however they are now interacting with the much larger ground. The fringing fields still develop and radiate, but the antenna will no longer tune as well to the 2.4 GHz frequency band. Consequently the VSWR increases and there is some loss in radiated power. If the FlexPIFA cannot meet your range requirements after being implemented on a metal surface, contact LSR Design Services for a custom antenna build to help meet your application needs.

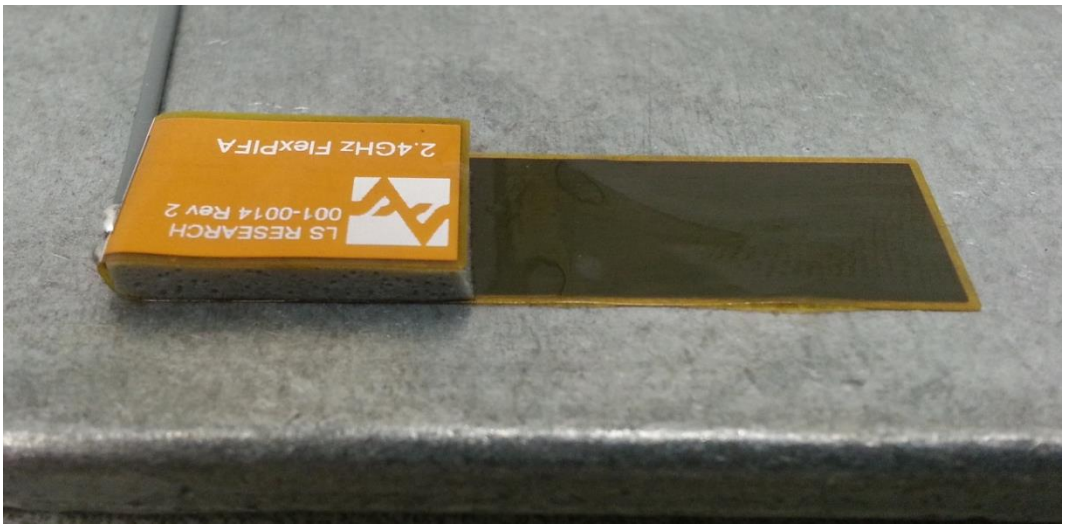


Figure 23 FlexPIFA Mounted on Metal

Do not mount the FlexPIFA where metal is within 10 mm above the main element (see **Figure 25**). Not only will this severely limit the radiation pattern (mainly due to the re-radiation problem previously described) it will detune the antenna inside of this range. Similarly, the two long sides of the FlexPIFA should be kept clear of any metal object by at least 5 mm. These keep out requirements pertain to **conductive** materials only, and are different from those listed in the previous sections which apply to **non-conductive** materials. In general, it is good practice to always keep metals as far away from the antenna as possible.

For the best performance, a spacer should be placed between the FlexPIFA and the conductive surface (see **Figure 24**). The spacer should be 1.5 mm thick polycarbonate. This will significantly improve performance and tuning of the FlexPIFA on a metal surface. Other non-conductive materials such as ABS plastic can be used; however polycarbonate will provide the best results.

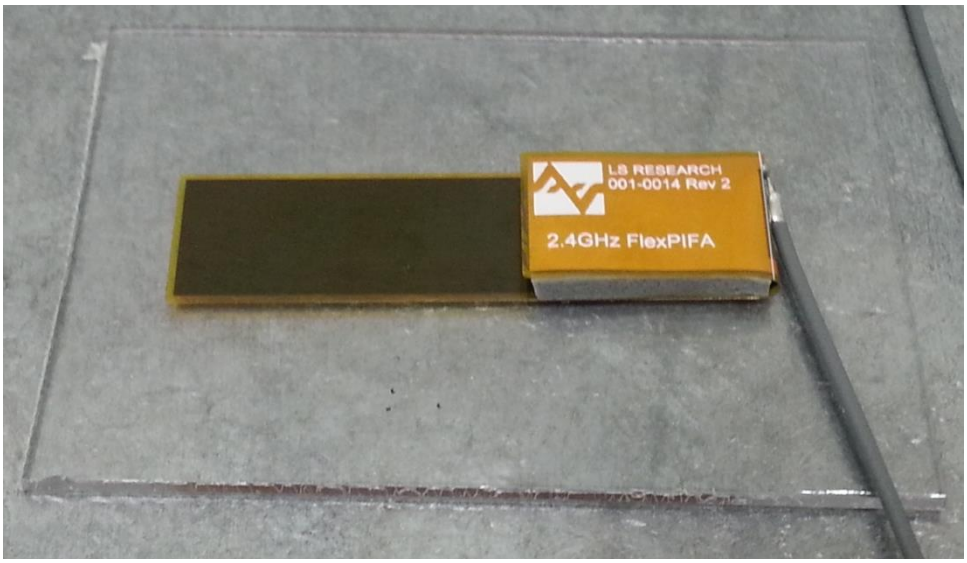


Figure 24 FlexPIFA Mounted on Metal Surface with 1.5mm Thick Polycarbonate Spacer

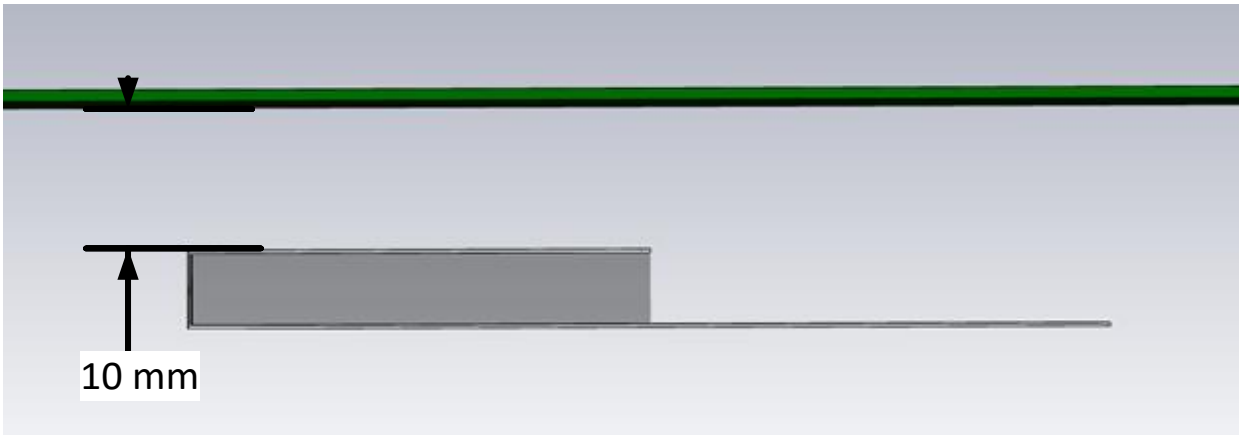


Figure 25 Metal near Main Element

For body worn applications, the FlexPIFA can tolerate the presence of the human body. It is not recommended that the antenna be mounted directly on body tissue, this will detune the FlexPIFA. Additionally the human body is an excellent absorber of 2.4GHz RF signals. As a result of this, expect a reduction in range due to the presence of a body. In a body worn application, the ground plate of the FlexPIFA should be closest to the body tissue. The main element should be pointed away from the body. Additionally, for handheld devices the FlexPIFA should be mounted in a location where it will not be covered by the hand. If the antenna is mounted in a location where the main element will be covered or near a human body, ensure that there is at least a 10mm separation distance between the main element and the body as shown in **Figure 25**. Additionally, when the FlexPIFA is mounted very close to body tissue, use a spacer to create separation distance between the body tissue and ground plate. This will ensure maximum performance and prevent the antenna from detuning. As previously mentioned, the ideal spacer material is 1.5 mm thick polycarbonate.

Quite often this separation distance between the body tissue and the FlexPIFA is already provided by the enclosure. **Figure 26** below is an example of a bracelet with the FlexPIFA integrated inside it. The enclosure provides enough spacing between the antenna and body tissue to prevent any major detuning. The enclosure is made of polycarbonate.

Figure 26 FlexPIFA Integrated into Bracelet

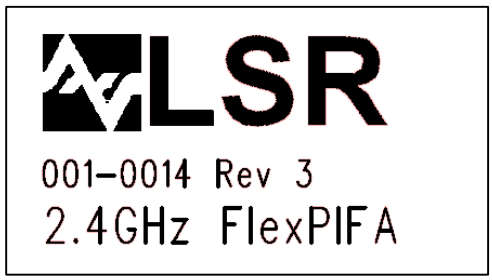
PRODUCT REVISION HISTORY

001-0014 (U.FL Connector)

Rev 1: Pre-Production Release

Rev 2: Initial Release

Rev 3: Changed Exposed Area of Solder Pads (Improve Soldering), Applying UV Glue (Strengthen Cable Joint) and increased top length from 15.2mm to 16.6mm – Silkscreen Side of FPC (Improve Tuning)



001-0022 (MHF4L Connector)

Rev 1: Initial Release

CONTACTING LSR

Headquarters	LS Research, LLC W66 N220 Commerce Court Cedarburg, WI 53012-2636 USA Tel: 1(262) 375-4400 Fax: 1(262) 375-4248
Website	www.lsr.com
Technical Support	forum.lsr.com
Sales Contact	sales@lsr.com

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

KEY FEATURES

- Can be installed on flat or curved surfaces.
- Simple custom options with trimming length.
- Quick and easy Installation
- Flexible, ultra-low profile
- RoHS Compliant
- Adhesive holds to surface during humidity exposure and hot/cold cycles

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

PHYSICAL DIMENSIONS (MM)

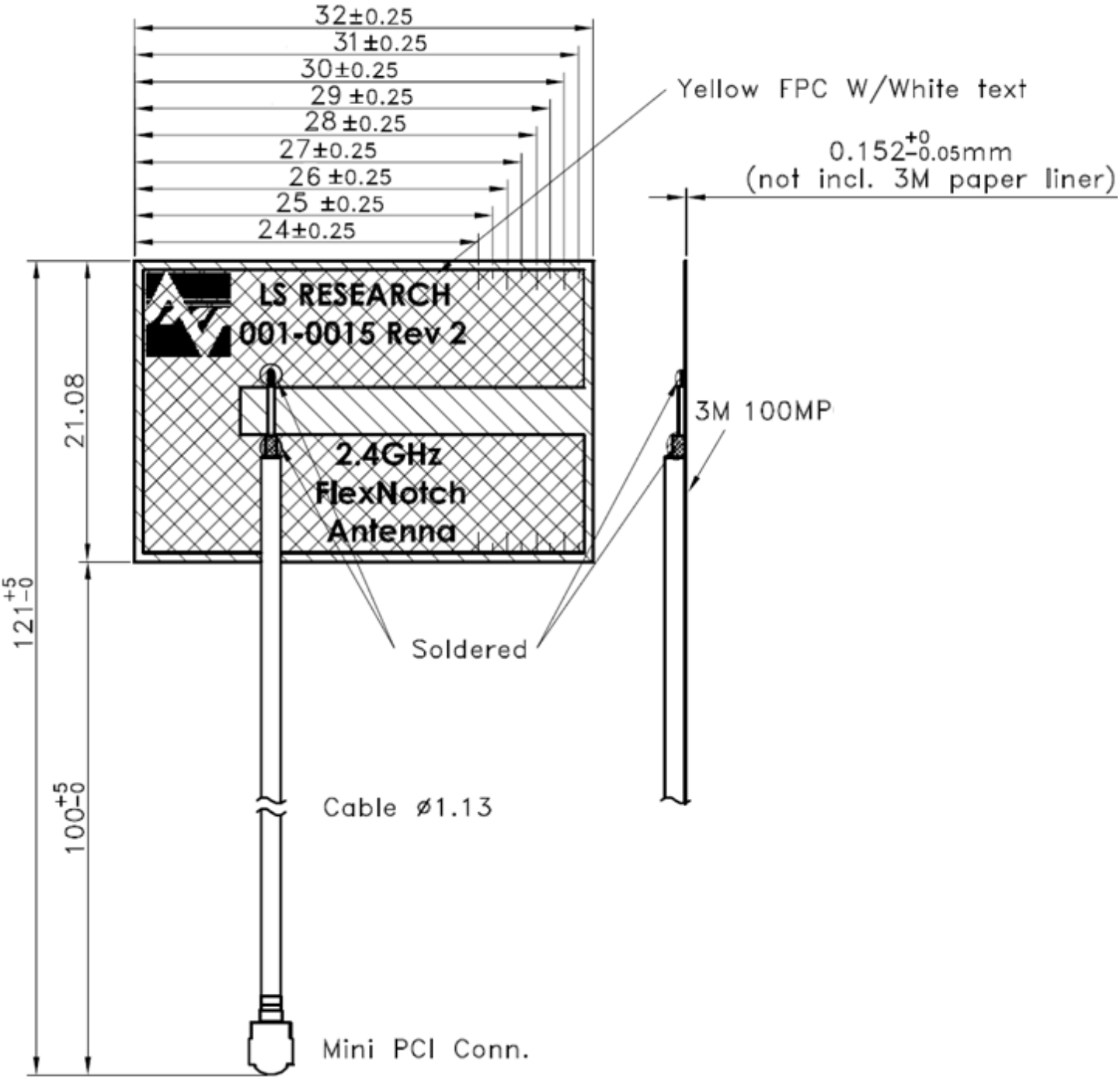


Figure 1 Physical Dimensions

TEST SETUP

Antenna measurements such as VSWR were measured with an Agilent E5071C Vector Network Analyzer. Radiation patterns were measured with an Agilent 5181A Signal Generator and Agilent E4445A Spectrum Analyzer in a 3 meter Anechoic Chamber.

Flat surface measurements were done with the antenna centered on a 1.5 mm thick plate of Polycarbonate.

FLAT SURFACE ANTENNA MEASUREMENTS

VSWR

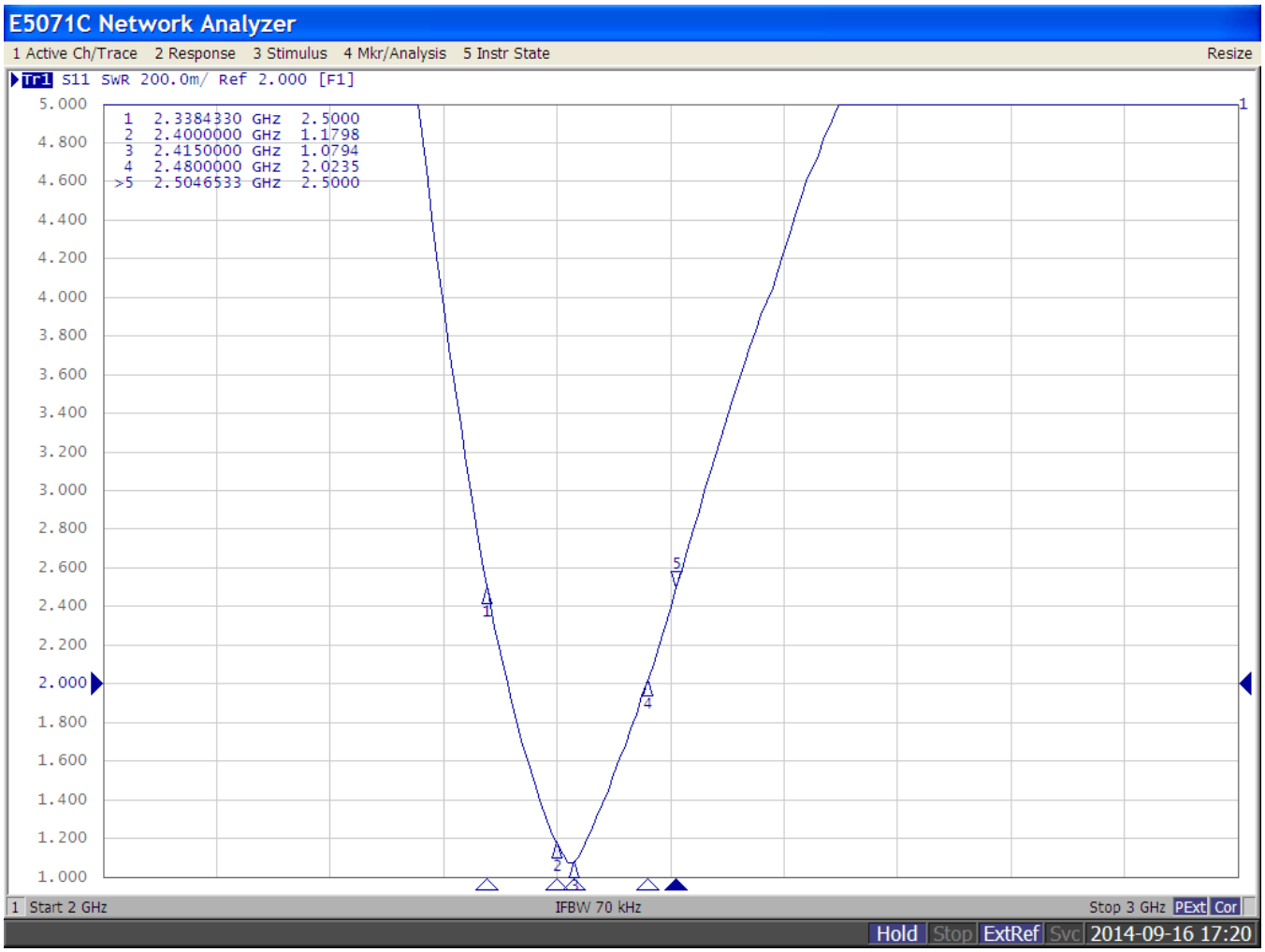


Figure 2 Antenna VSWR measured on a 1.5 mm thick plate of Polycarbonate

FLAT SURFACE ANTENNA RADIATION PERFORMANCE

FlexNotch centered on a 1.5 mm thick plate of Polycarbonate

Antenna Measurement Set-Up

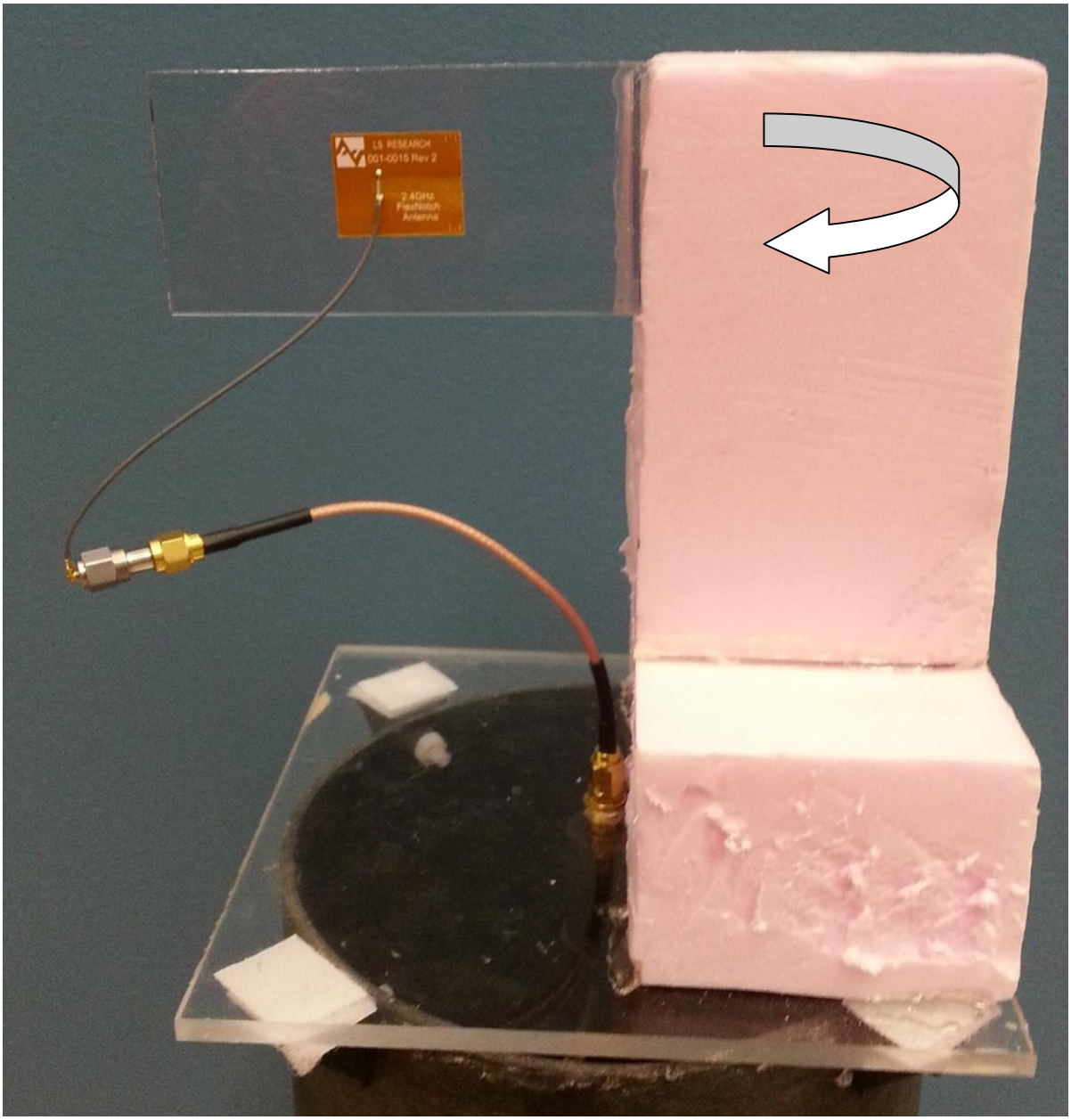


Figure 3 Horizontal Orientation Measurement

Horizontal Orientation at 2440 MHz:

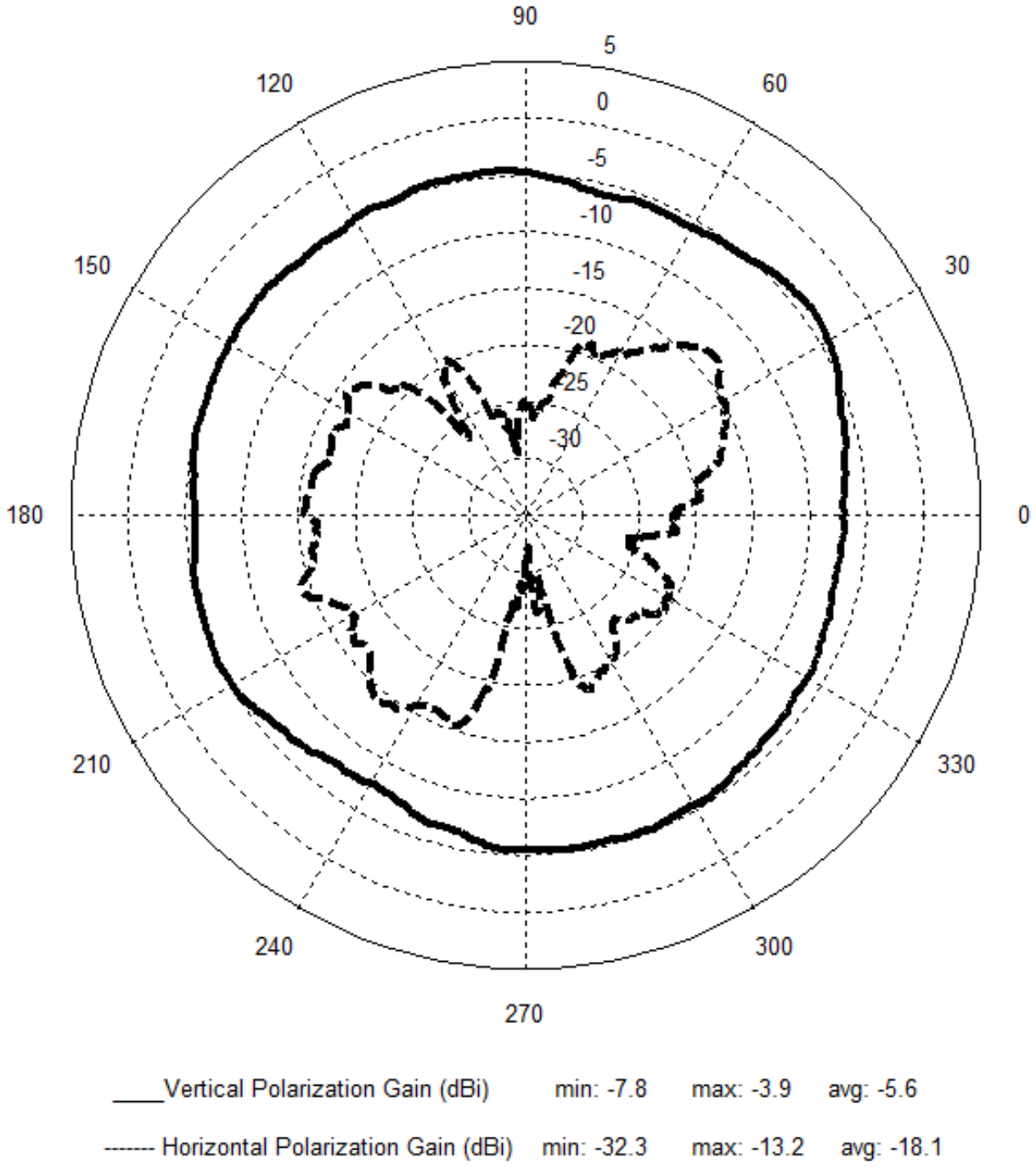


Figure 4 Horizontal Orientation Pattern

Antenna Measurement Set-Up

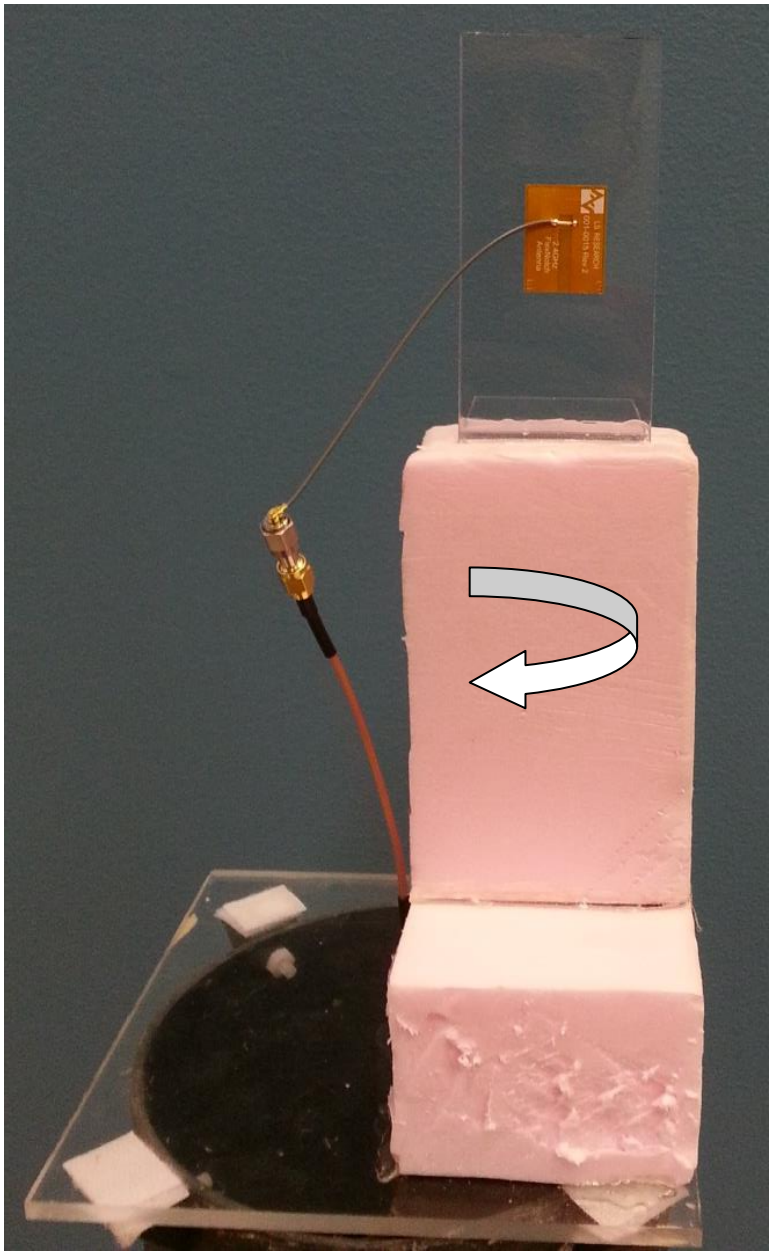


Figure 5 Vertical Orientation Measurement

Vertical Orientation at 2440 MHz:

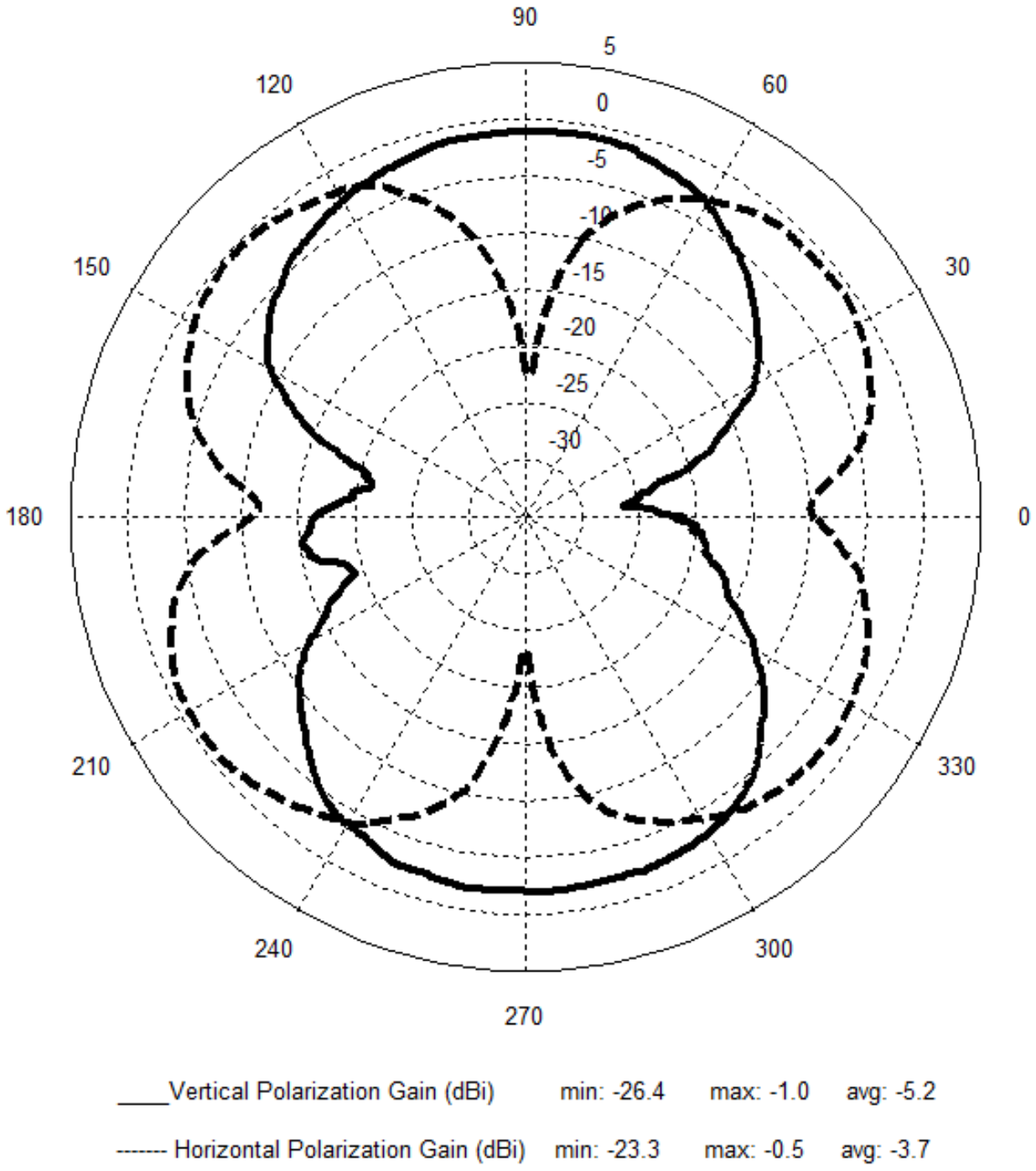


Figure 6 Vertical Orientation Pattern

Antenna Measurement Set-Up

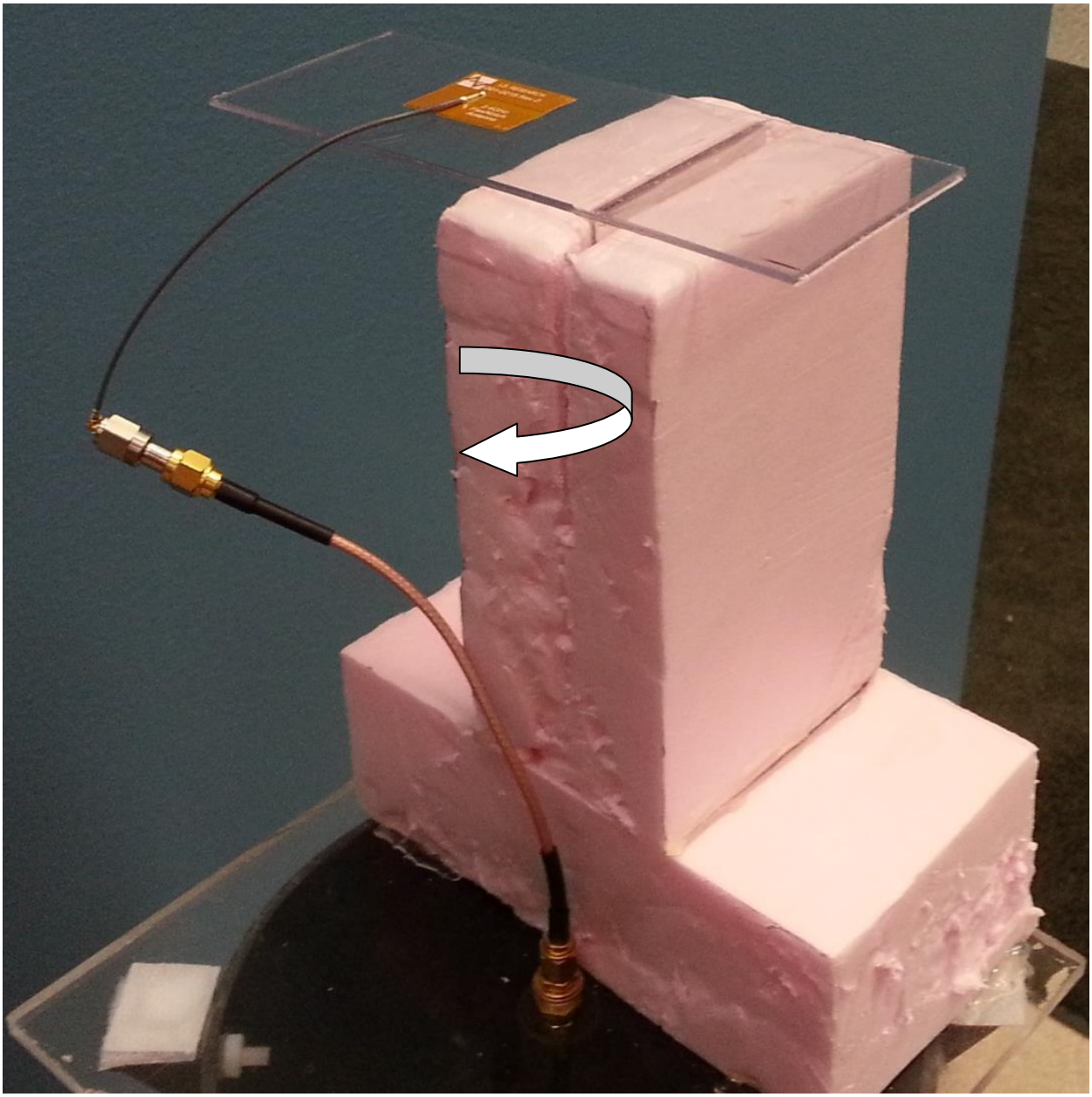


Figure 7 Flat Orientation Measurement

Flat Orientation at 2440 MHz:

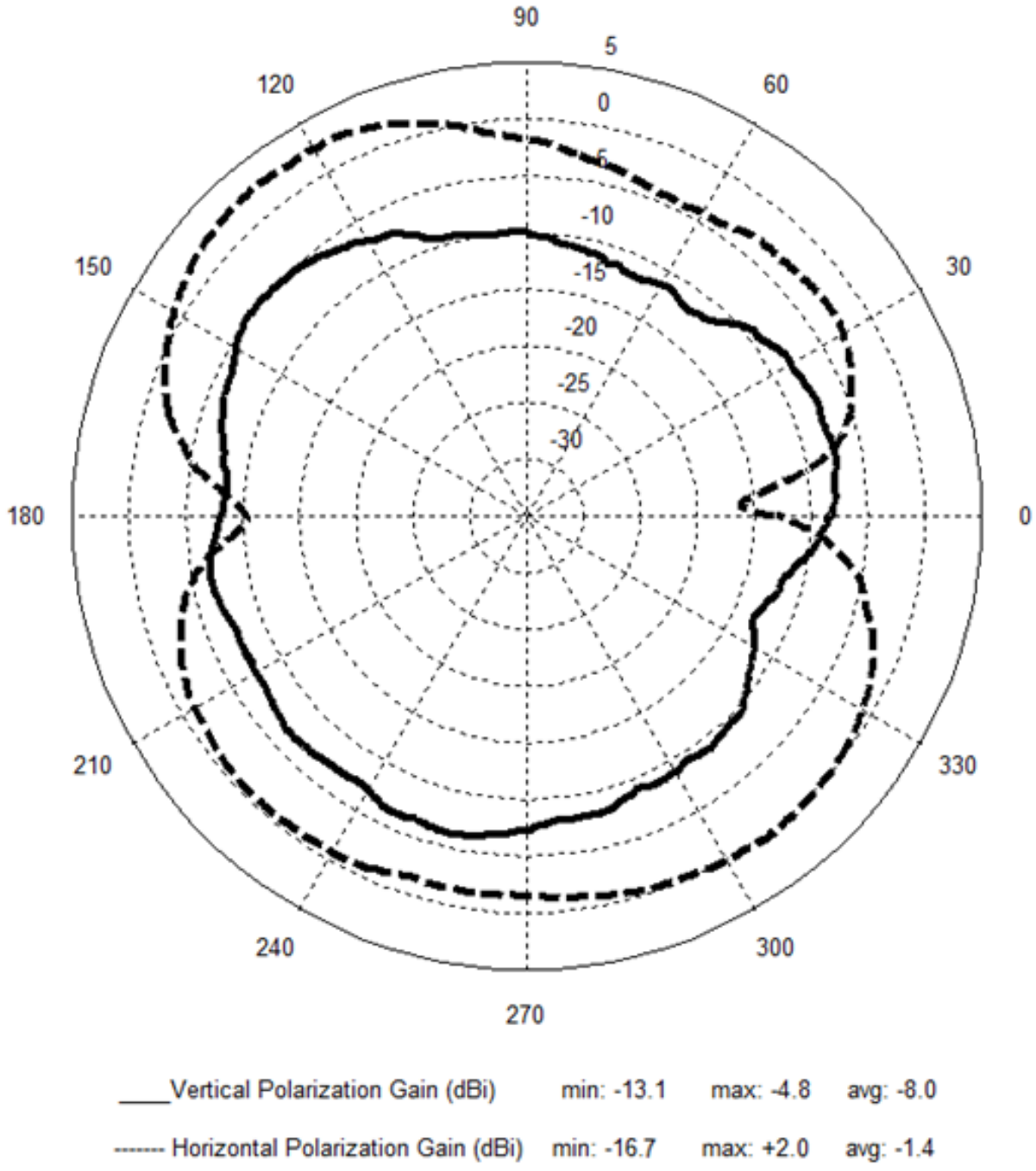


Figure 8 Flat Orientation Pattern

OPTIMAL INSTALLATION GUIDE

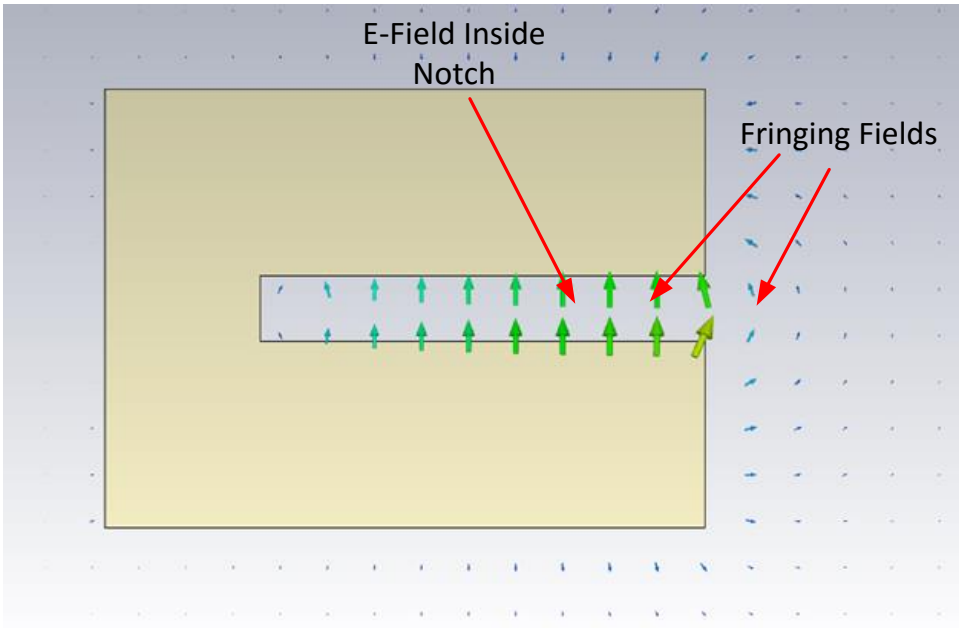


Figure 9 E-Field Radiation from FlexNotch, Taken from CST Simulation

The FlexNotch should be kept clear of any non-metal objects (such as plastics) on top of it by at least 5 mm (see **Figure 10**). Similarly, all four sides of the FlexNotch should be kept clear of any non-metal object by at least 1 mm (See **Figure 11** and **Figure 12**). Mounting the FlexNotch in a situation that does not allow for these clearance recommendations may change the gain characteristics stated in the datasheet, which could impact overall range of the wireless system.

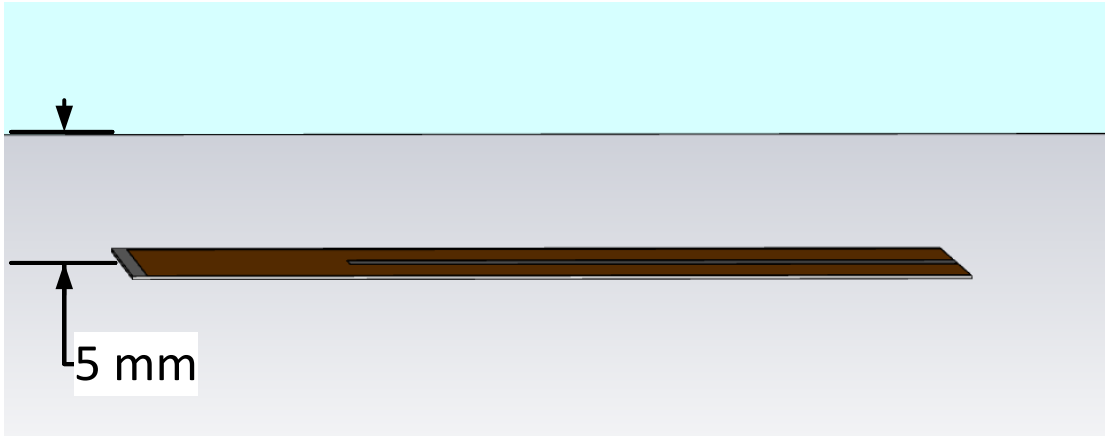
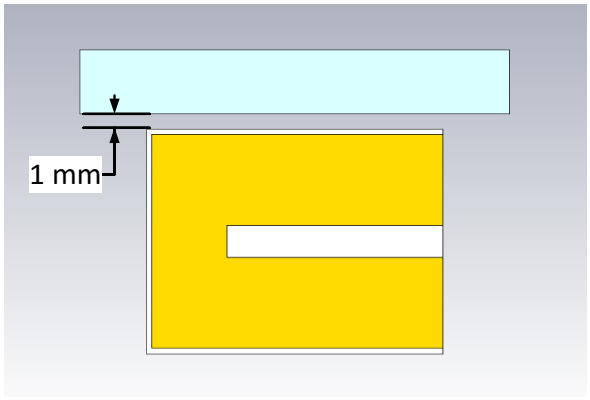
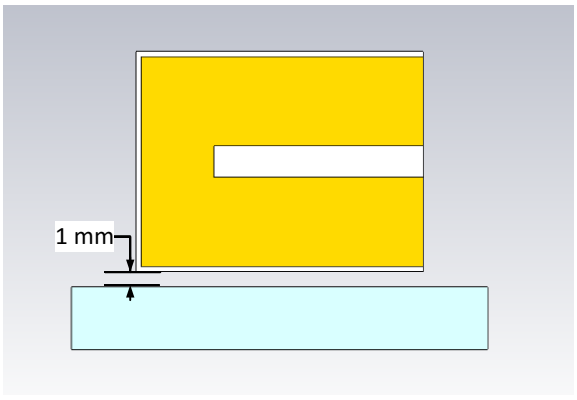


Figure 10 Above FlexNotch Clearance

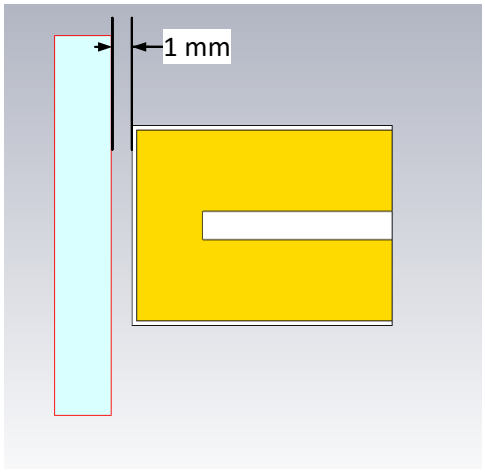


Top Clearance

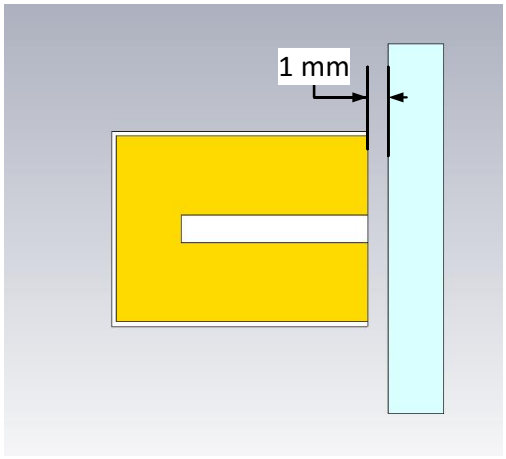


Bottom Clearance

Figure 11 Top and Bottom Clearance



Left 'Cold' Side Clearance

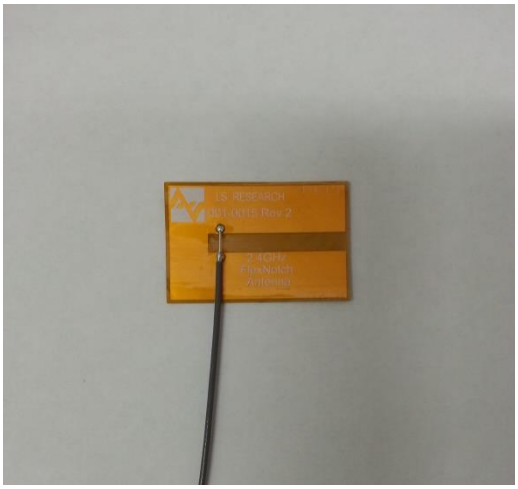


Open Side Clearance

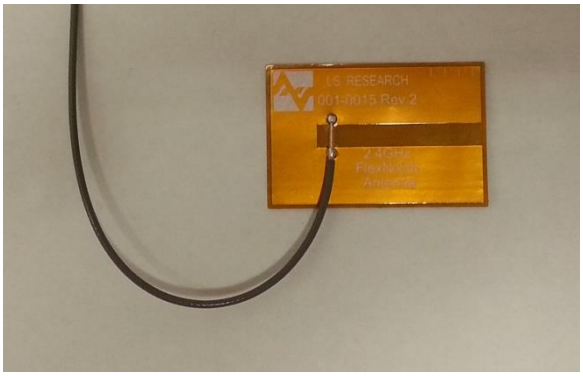
Figure 12 Open Side Clearance

The ideal material for the FlexNotch to be mounted on is 1.5 mm thick polycarbonate; this will result in maximum performance. If the FlexNotch is mounted on a different material, the tuning will change. This can cause a decrease in performance. LSR can retune the FlexNotch for specific implementations and different materials on request.

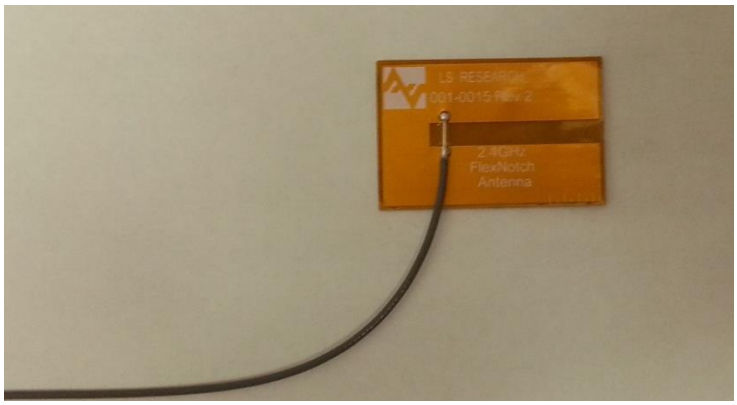
The coaxial cable feeding the FlexNotch should be routed away from the antenna. Do not run the coaxial cable above the FlexNotch or near the open end of the notch. The cable should be routed perpendicular to the side of the FlexNotch (this is the way the cable comes assembled), around the cold side, or away from the ground wall. All three of these options are shown in **Figure 13**.



Perpendicular to the side



Around the ‘Cold’ Side



Away from the Notch wall

Figure 13 Recommended Cable Routing

As with any antenna, care should be taken not to place conductive materials or objects near the antenna. The radiated fields from the antenna will induce currents on the conductive surface; as a result those currents then produce their own radiation. These re-radiating fields from the metal will interfere with the fields radiating from the FlexNotch (this is true for any antenna). Other objects, such as an LCD display, placed in close proximity to the antenna may not affect its tuning but it can distort the radiation pattern. Materials that absorb electromagnetic fields should be kept away from the antenna to maximize performance. Common things to keep in mind when placing the antenna:

Wire Routing

Speakers – these generate magnetic fields

Metal Chassis and Frames

Battery Location

Proximity to Human Body

Display Screen – these will absorb radiation

Paint – do not use metallic coating or flakes

Flex Limits of the FlexNotch

One of the unique features of the FlexNotch is its ability to flex. However, due to the adhesive there are limits as to how much the antenna can be flexed and remain secured to the device. The FlexNotch should not be flexed in a convex position with a radius less than 16 mm. Going smaller than this may result in the antenna peeling off the surface over time. Should a tighter radius of curvature be required, it is recommended you contact LSR Design Services for assistance.

Figure 14 Convex Mounted

The FlexNotch should not be flexed in a concave position with a radius less than 16 mm. Similar to the restrictions on the convex position, potential exists for the adhesive to peel off over time if the FlexNotch is bent beyond a 16 mm radius. If a tighter radius of curvature is required, it is recommended you contact LSR for assistance. The FlexNotch is not designed to be twisted or crumpled. The adhesive back should lay flush with the surface it is mounted on.

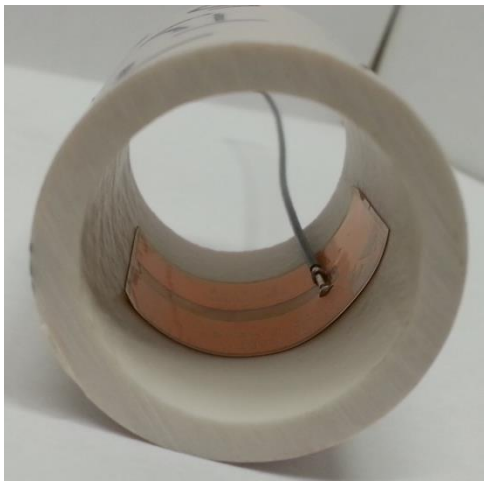


Figure 15 Concave Mounted

Mounting on Metal and Body Loaded Applications

The FlexNotch can tolerate being near conductive surfaces. A 1 mm clearance should be observed between the top, bottom, and cold sides of the FlexNotch from any metal (see **Figure 11**). Metal should be kept away from the open end of the FlexNotch by at least 10 mm. However, any metal in close proximity to the open end will disrupt the radiation pattern and could cause a decrease in antenna gain.

Keep any metal above the FlexNotch away by at least 10 mm; this will prevent the antenna from detuning. However this will still cause some distortion of the radiation pattern. **Do NOT mount the FlexNotch on a metal surface**.

These same guidelines also apply to body worn applications.

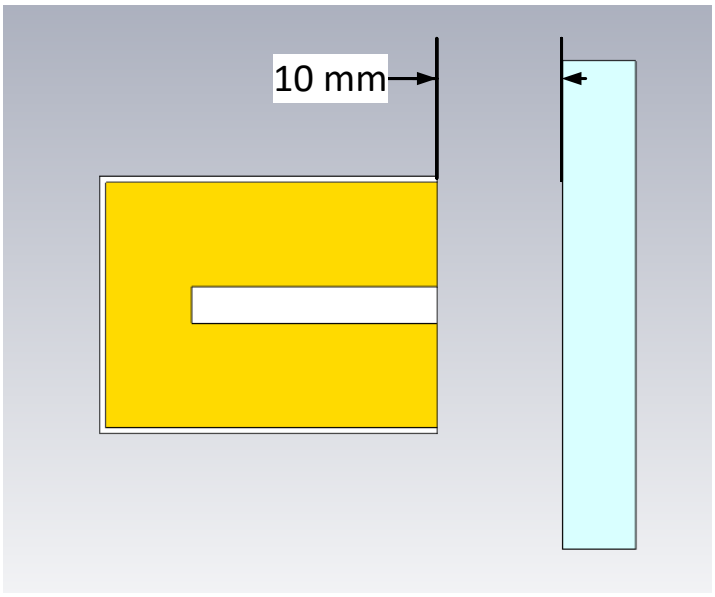


Figure 16 Open Side Metal Clearance

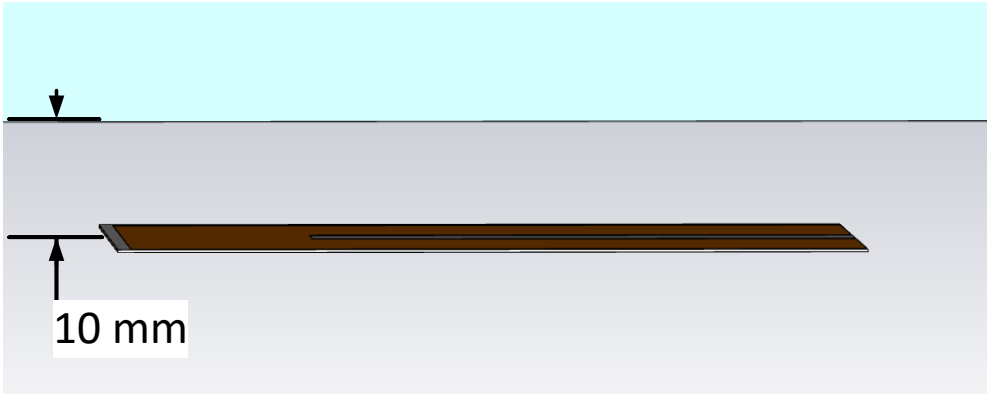


Figure 17 Above Notch Metal Clearance

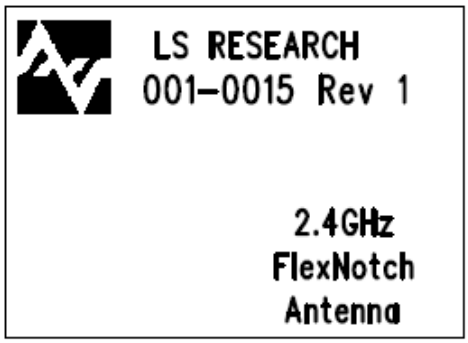
CUSTOMER SPECIFIC TUNING

LSR will assist with custom tuning of the antenna for your specific end product. Simply send LSR a sample of your enclosure or platform, and LSR will tune an antenna for you. LSR will send the results back indicating which trim mark the antenna should be cut to, to optimize performance. You then trim the antennas at time of assembly to the indicated hash mark, and stick to your product.

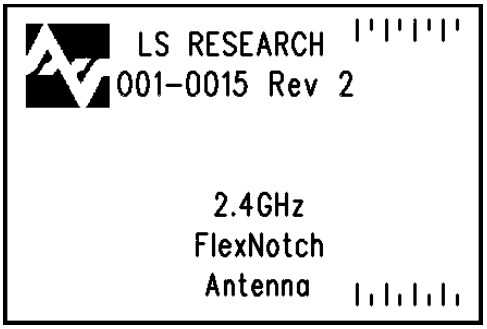
PRODUCT REVISION HISTORY

001-0015 (U.FL Connector)

Rev 1: Initial Production Release



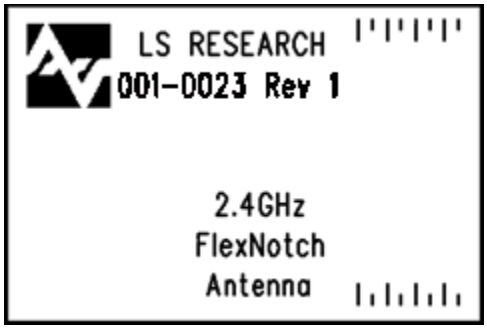
Rev 2:



- Added Cut Hash Marks in intervals of 1 mm (Small Mark) and 2 mm (Large Mark)

001-0023 (MHF4L Connector)

Rev 1: Initial Production Release



CONTACTING LSR

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Cedarburg, WI 53012-2636
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Tel: 1(262) 375-4400
Fax: 1(262) 375-4248

Website www.lsr.com

Technical Support forum.lsr.com

Sales Contact sales@lsr.com

APPROVAL SHEET
(RoHS)

CUSTOMER	:	**Laird**
CUSTOMER'S PART NO.	:	
DESCRIPTION	:	**RF ANTENNA ASSEMBLY**
PART NO.	:	**EDA-8709-2G4C1-B27-CY**
DATE	:	
AUTHORIZED BY	:	*Marco Hsu*

	FULLY APPROVED	PARTIALLY APPROVED	REJECTED
SIGN			
SUGGESTION			

美磊科技股份有限公司

MAG. LAYERS SCIENTIFIC-TECHNICS CO., LTD

HEAD OFFICE / HSINCHU PLANT

No 18, Tz-Chiang Road, Hsin-Chu Industrial Park, Hsin-Chu, Taiwan

TEL: +886-3-5972488 FAX: +886-3-5972477

http://www.maglayers.com.tw

E-mail：info@maglayers.com.tw

Contents

RF Antenna Assembly Specification

ELECTRICAL PROPERTIES

1.1	Frequency Range……	2.4GHz ~2.5GHz
1.2	Impedance……	50 Ohm Nominal
1.3	VSWR……	2 (Max)
1.4	Return Loss……	-10dB (Max)
1.5	Radiation……	Omni-directional (Only Antenna)
1.6	Gain(peak)……	2.0dBi (Only Antenna)
1.7	Cable Loss……	0.7dB
1.8	Polarization……	Linear Vertical
1.9	Admitted Power……	1W

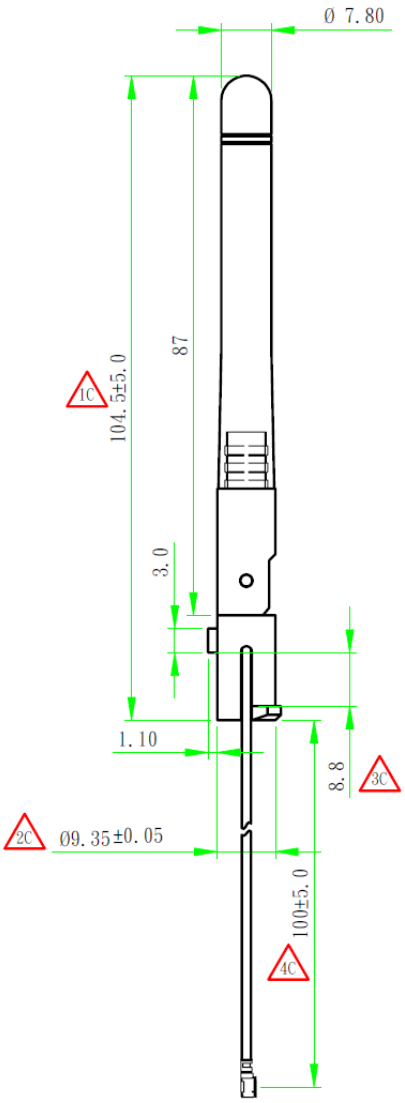
PHYSICAL PROPERTIES

2.1	Cable……	§ 1.13 Black
2.2	Antenna Cover……	TPEE
2.3	Antenna Base……	PC/PBT
2.4	Operating Temp……	-25℃ ~ +75℃
2.5	Storage Temp……	-30℃ ~ +75℃
2.6	Color……	Black
2.7	Connector……	IPEX Compatible(MHF4)

Mechanical Specification

LTR	DESCRIPTION	DATE	REQ. BY
A	NEW Release	12/05/12'	HWCHAN

RoHS COMPLIANT



MECHANICAL
Antenna Cover : TPEE
Antenna Base : PC/PBT
Color: Black

ELECTRICAL
Frequency : 2.4GHz
Cable : Coaxial Cable 1.13(Black)
Connector : IPEX Compatible(MHF4)

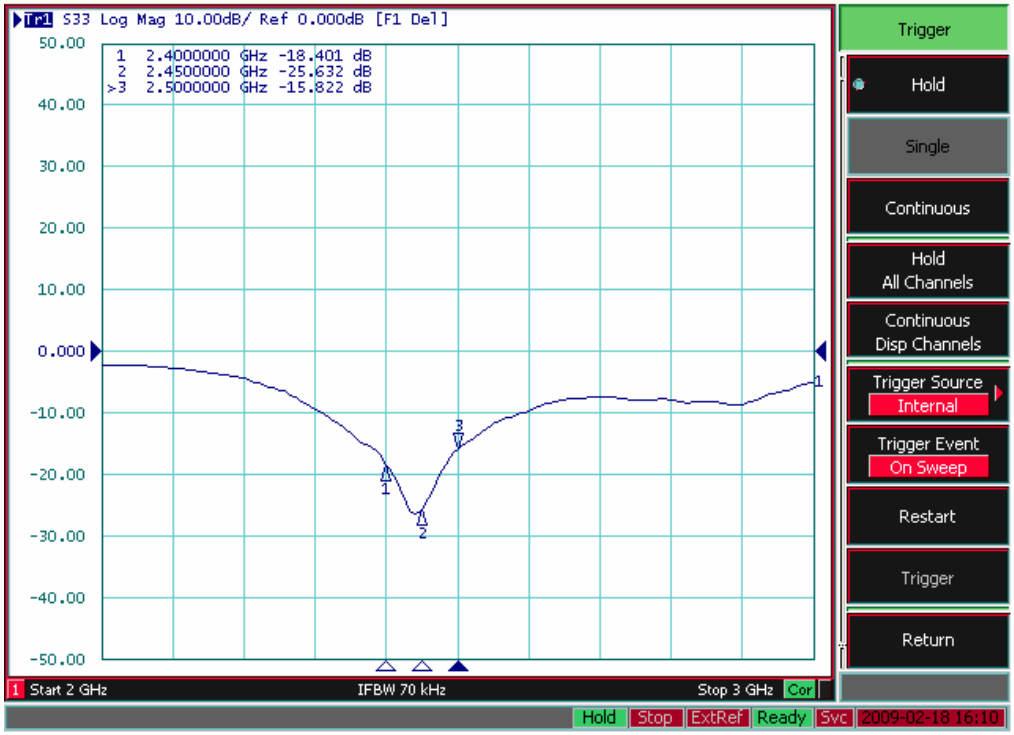
※凡標記△C記號者，為品管檢驗之尺寸

設計 DR. HWCHAN 2012/12/05	核准 APPD. Marco 2012/12/05	容許公差 TOLERANCE .XXX ±0.20 .XX ±0.35 .X ±0.50 X ±1.00 ANG ±5	品名 ARTICLE EDA-8709-2G4C1-B27
版本說明 REVISION NOTE			
MAGLAYERS			單位 UNIT: mm / 比例 SCALE: **** / 張數 SHEET: 1 / 版本 REV.: A

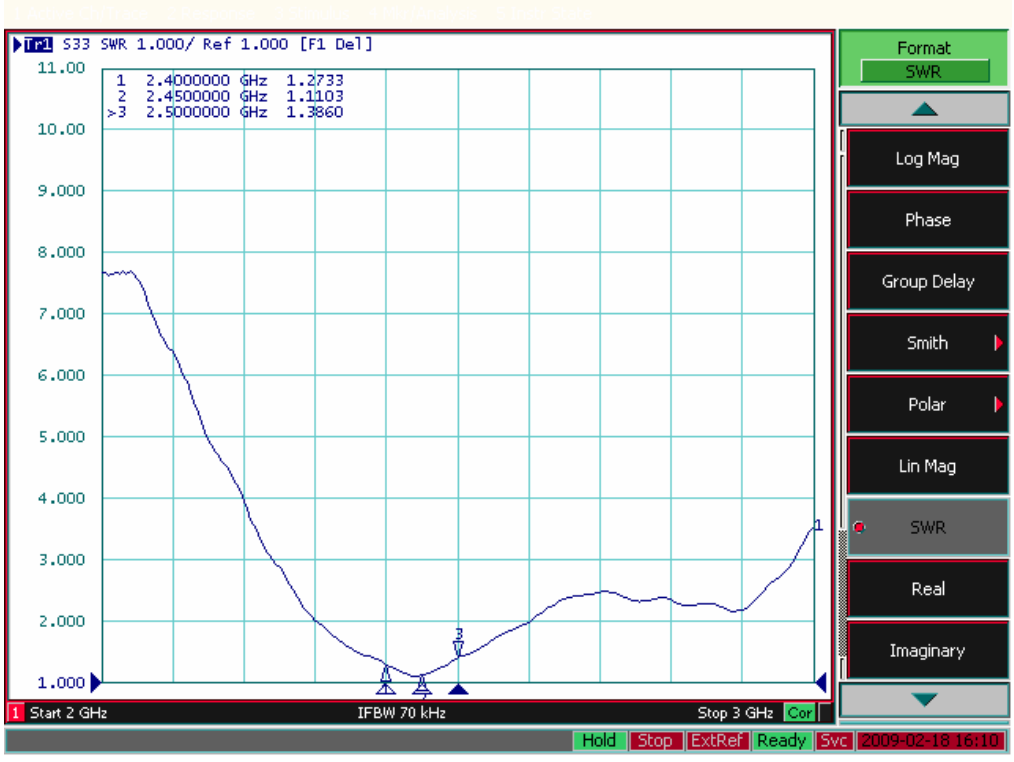
ELECTRICAL CHARACTERISTICS

P/NO: EDA-8709-2G4C1-B27
Spec: 2.4 GHz ~2.5GHz

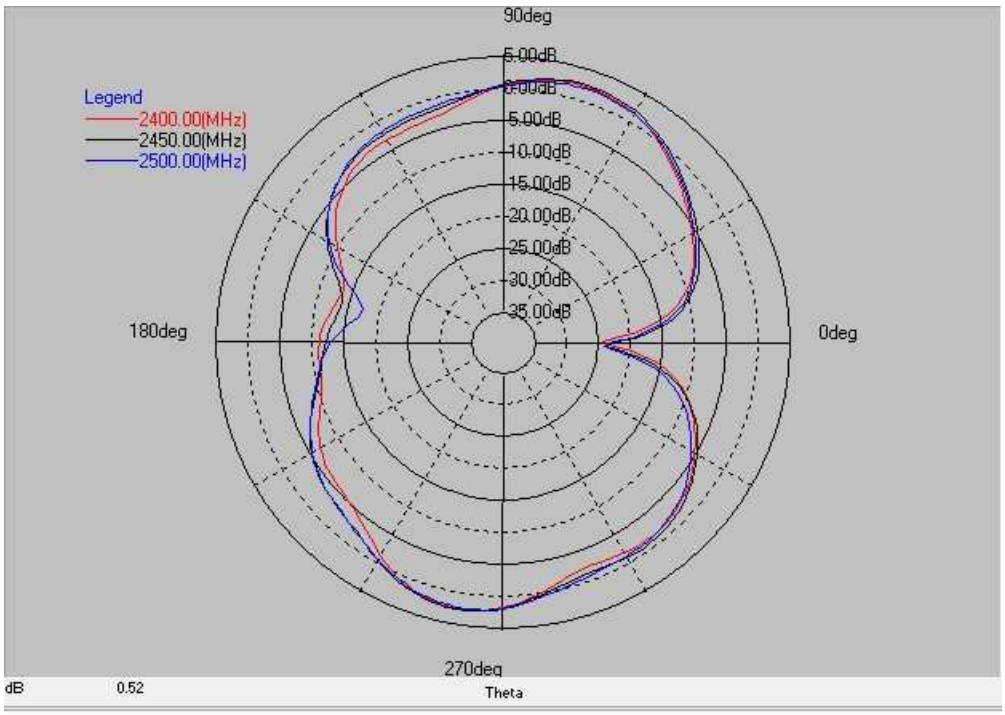
S11



VSWR

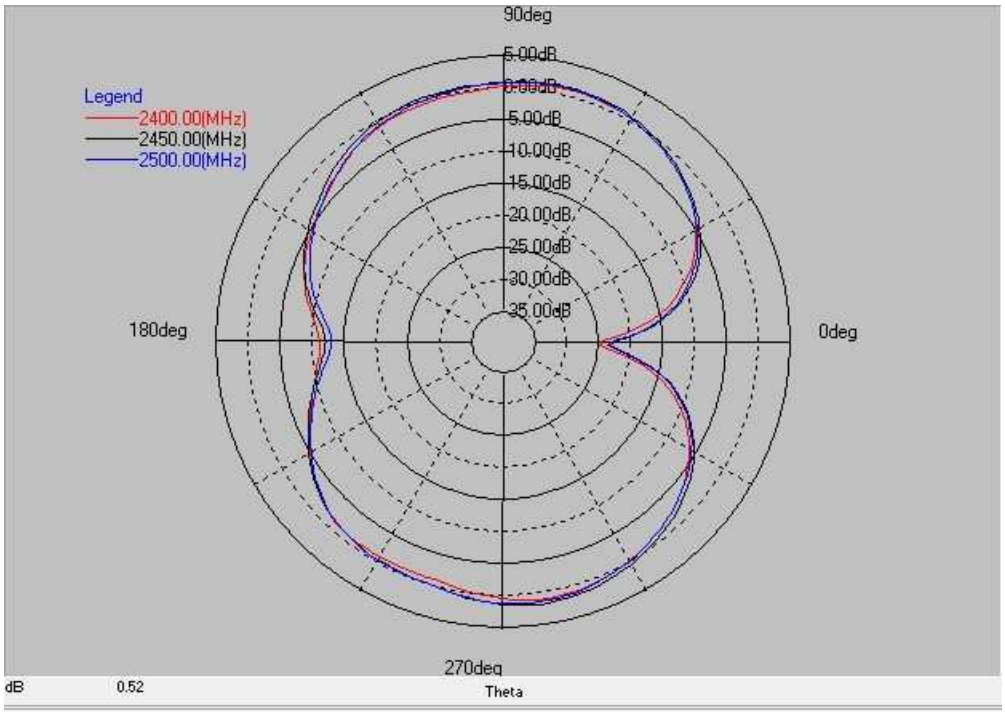


Frequency(MHz)：**2400~2500.**　　Pattern Field：**X-Z plane**



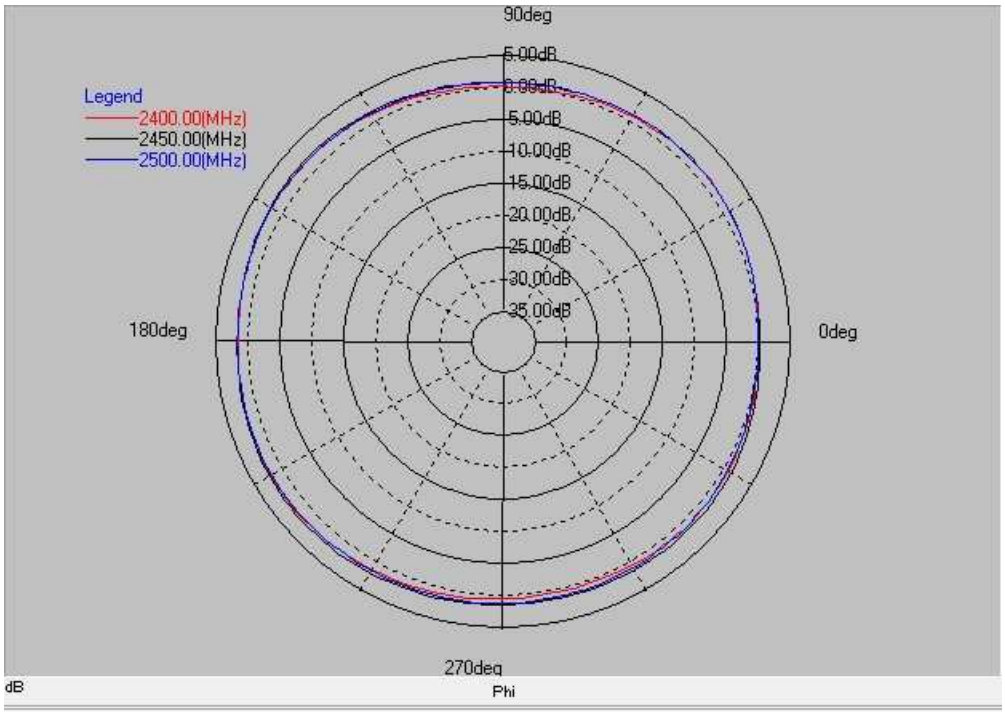
Layer	Max value	Min value	Average
2400(MHz)	2.05 dB	-24.34 dB	-2.61 dB
2450(MHz)	2.25 dB	-23.80 dB	-2.07 dB
2500(MHz)	2.16 dB	-24.13 dB	-2.29 dB

Frequency(MHz)：**2400~2500.**　Pattern Field：**Y-Z plane**



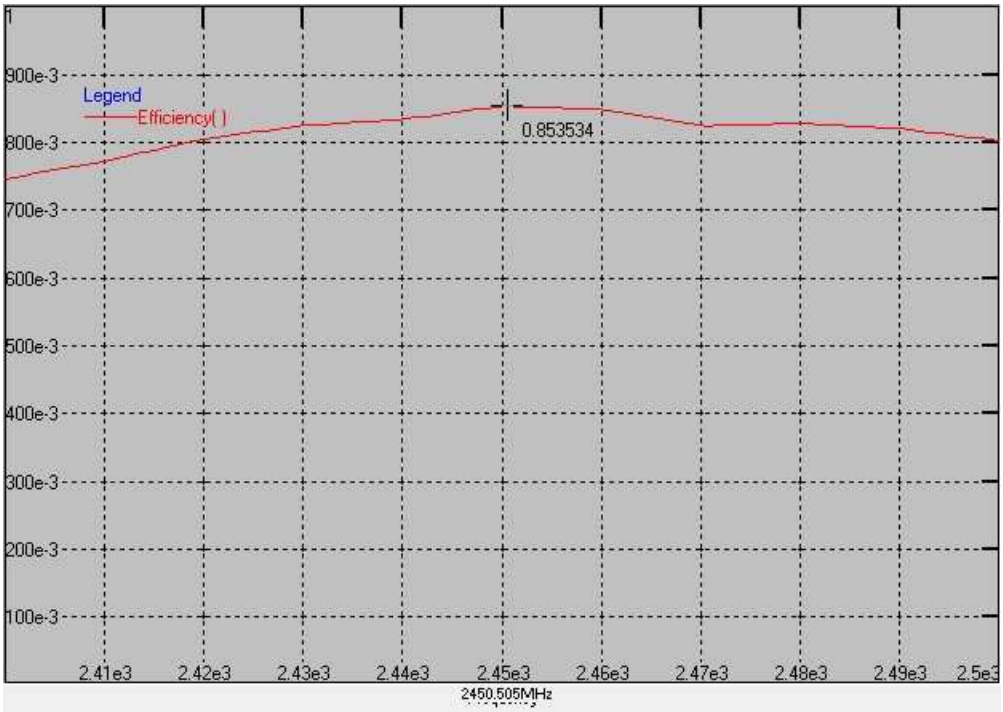
Layer	Max value	Min value	Average
2400(MHz)	0.89 dB	-24.94 dB	-2.45 dB
2450(MHz)	1.59 dB	-23.09 dB	-1.85 dB
2500(MHz)	1.30 dB	-23.44 dB	-2.16 dB

Frequency(MHz)：**2400~2500.**　Pattern Field：**X-Y plane**



Layer	Max value	Min value	Average
2400(MHz)	2.12 dB	-0.06 dB	1.02 dB
2450(MHz)	2.32 dB	0.34 dB	1.40 dB
2500(MHz)	1.91 dB	0.16 dB	1.15 dB

Antenna Efficiency



Maximum Efficiency At 2.4~2.5GHz: 85.35%

Dipole Antenn

– RFDPA870910EMAB302 for Single Band 2.4 GHz Application

ELECTRICAL CHARACTERISTICS

Item	Specification
Working Frequency Range	2.4 ~ 2.5 GHz (Note-1)
Gain	2 dBi
Return Loss	-10dB(Max)
VSWR	2 max.
Polarization	Linear Vertical
Radiation Pattern	Omni-directional
Impedance	50Ω

*Note 1. Central Frequency should be defined after customers' application approval.

MATERIAL TABLE

Items	Description
Cable	Coaxial Cable ϕ1.13(Black)
Antenna Cover	TPEE
Antenna UP Base	PC
Antenna Down Base	PC/PBT
Connector	四代IPEX
Brass Tube	Brass
Rivet	POM
Color	Black

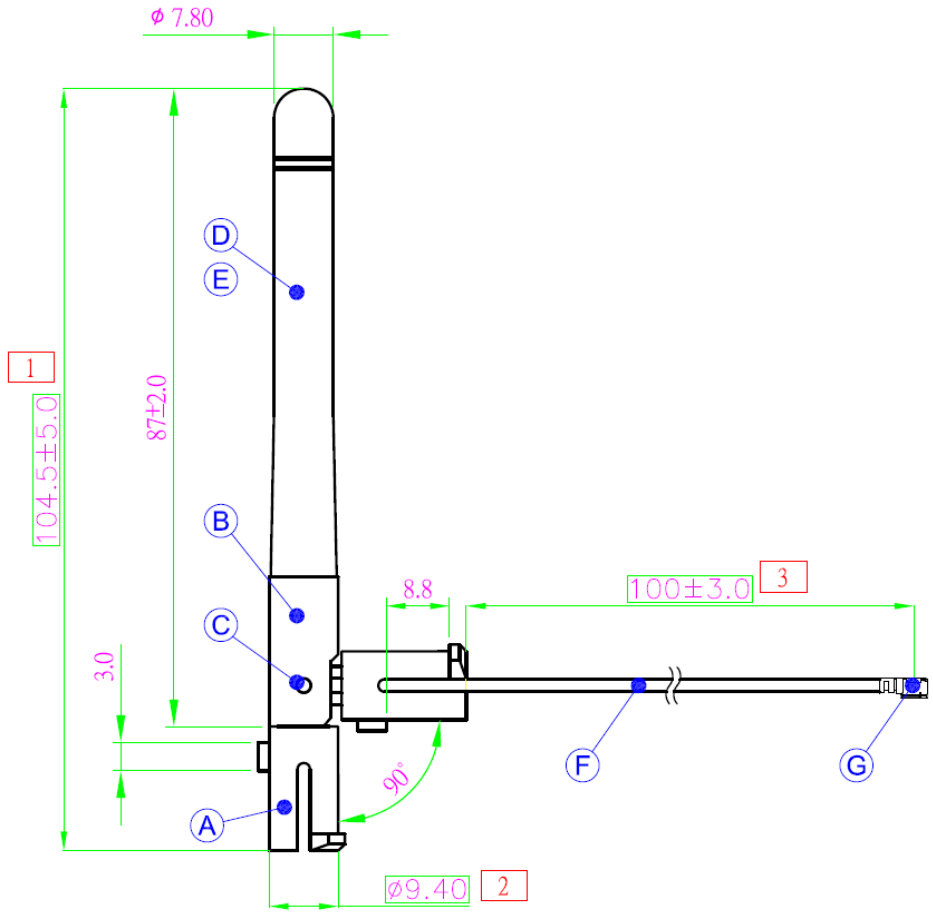
ORDERING RULE

RF	DPA	8709	10	E	M	A	B	3	02
Type Code	**Product Code**	**Dipole Dimension (Unit: mm)**	**Cable Length (unit: cm)**	**Connector Brand**	**Type of Connector**	**Application**	**Project status**	**Wire Diameter**	**Project**
Walsin RF Device	DPA: Dipole Antenna	Per 2 digits of length, width e.g.: 8709 Length 87mm, Width 9.4mm	2 digits for cable length e.g.: 30 Cable Length:30cm	A: N C:MCX D:IPEX III E: IPEX IV F: IPEX A13 H: Hirose I: IPEX K:F M: MMCX S: SMA T: TNC U:MURATA N: None	A: Reverse Female B: Reverse Male F: Female M: Male N: None	0: 0GHz 1:1GHz 3: 3GHz 5: 5 GHz 6: 6GHz A: 2.4GHz ISM band B: GSM 900/1800 dual band G: GPS band L: 2.4/5.2/5.8 GHz tri-band N: NFC T:LTE band U:UHF W: WCDMA band P:WPC D:DECT	B: MP T:During Test X: Pile Run	0:None 1:⌀0.81 2:⌀ 1.32 3:⌀1.13 4:Low Loss ⌀1.13 5:⌀0.50 6:RG316 7:⌀1.37 8:RG178 9: Low Loss ⌀1.37 A:RG174 B:RG178單芯線 C:WPC用 0.3mm D:DECT用 E：RG405	01~99 series number

DIMENSIONS

ELECTRICAL
Frequency:2.4GHz
Gain:2dBi

No.	DESCRIPTION	MAT'L	Color	Q'TY
A	Antenna Down Base	PC+PBT	Black	1
B	Antenna Up Base	PC	Black	1
C	Rivet	POM	Black	2
D	Antenna Cover	TPEE	Black	1
E	Brass Tube	Brass	--	1
F	Coaxial Cable 1.13	--	Black	1
G	四代IPEX	--	Glod	1



※標記□記號者，為重點檢驗尺寸

LTR	DESCRIPTION	DATE	REQ. BY

華新科技股份有限公司
Walsin Technology Corporation

設計 DR. SHLEE 2016.02.03
核准 APPD. Marco

容許公差 TOLERANCE
6以下.....±0.2
6以上~30.....±0.5
30以上~120.....±0.8
120以上~315.....±1.2
315以上~1000.....±2.0
1000以上~2000.....±3.0

品名 ARTICLE: RFDPA870910EMAB302

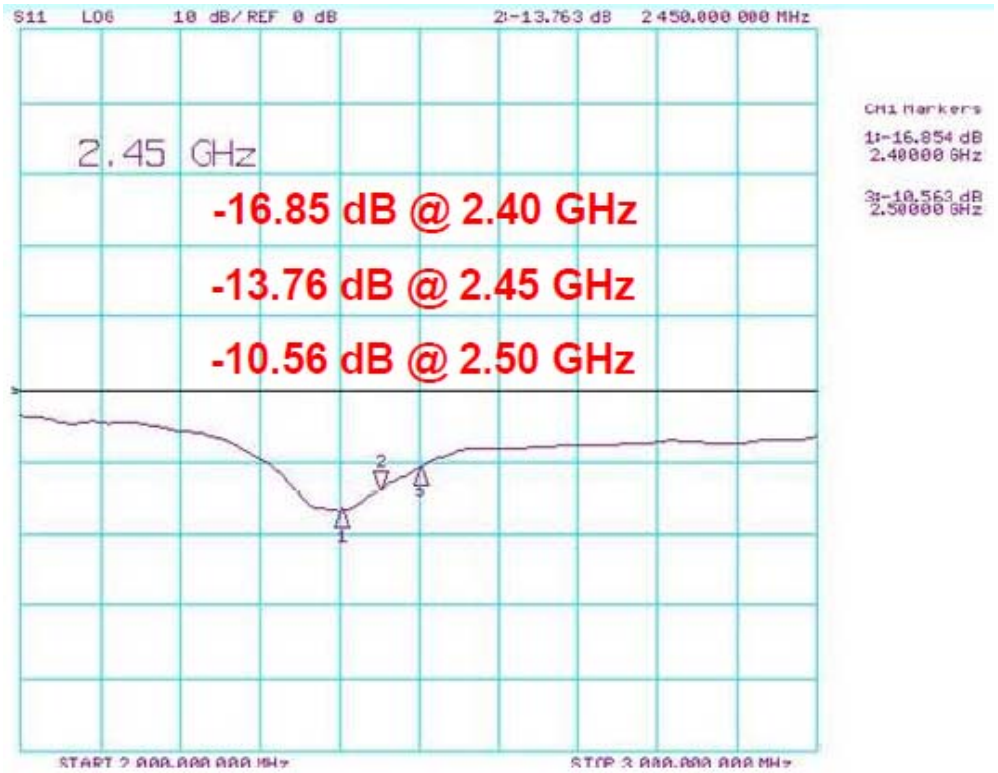
版本 REV.: A

單位 UNIT: mm
比例 SCALE: ****
張數 SHEET: 1

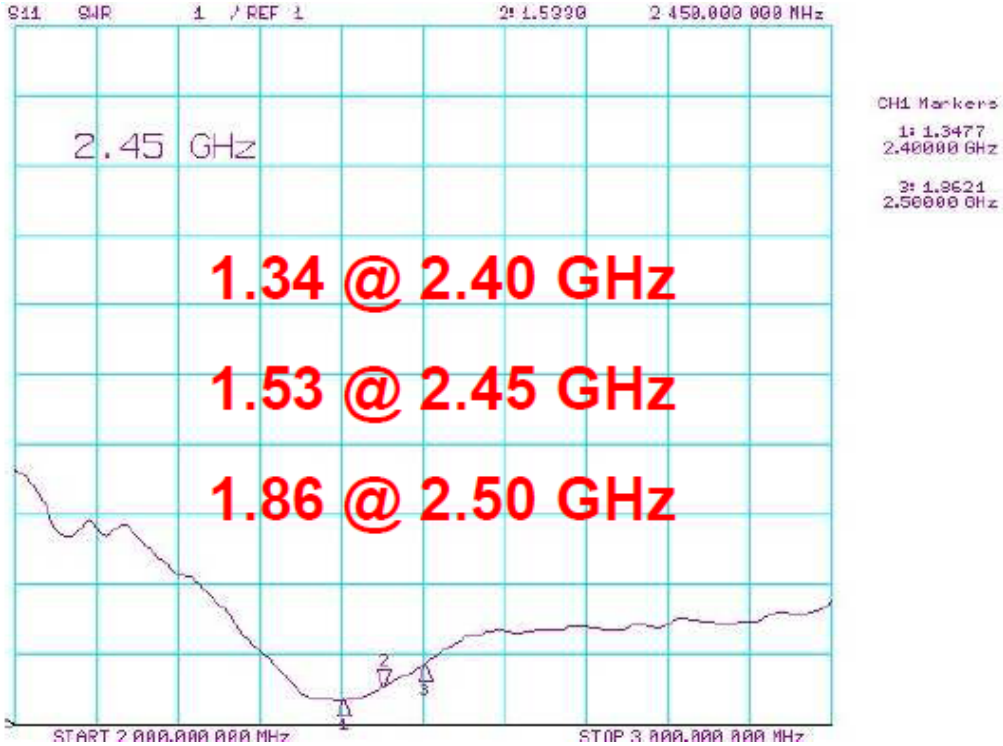
Test Report

■ELECTRICAL CHARACTERISTICS

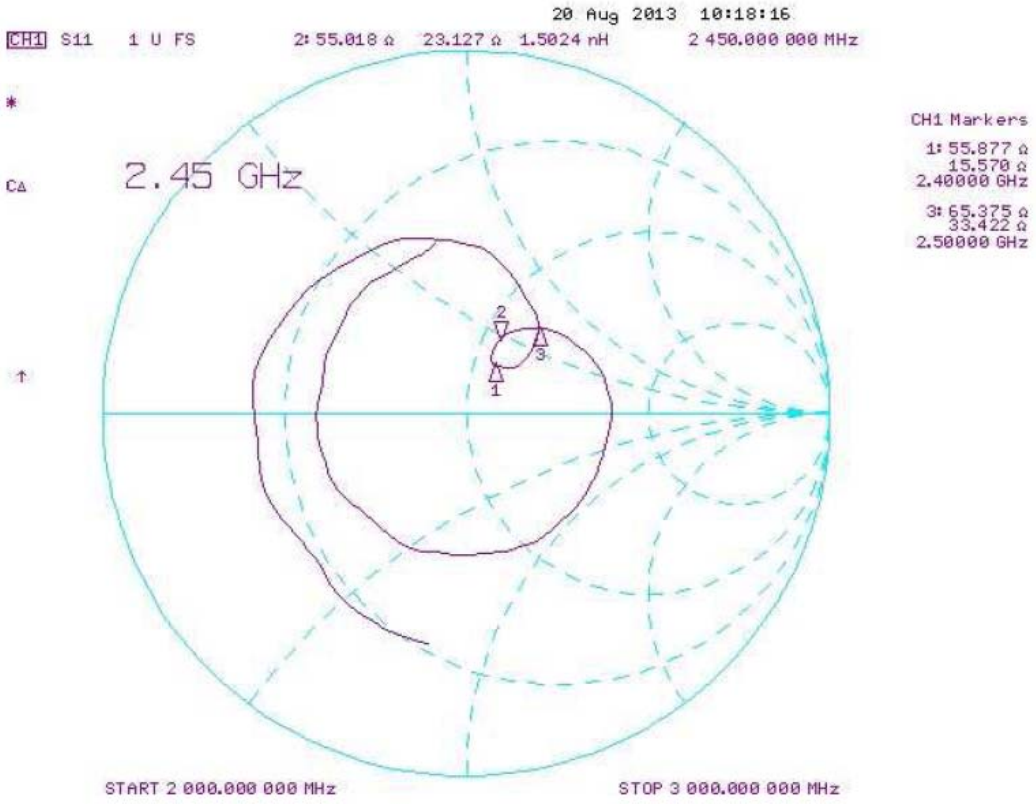
Return Loss



VSWR



Smith Chart


20 Aug 2013 10:18:16
CH1 S11 1 U FS
2: 55.018 Ω 23.127 Ω 1.5024 nH
2 450.000 000 MHz
2.45 GHz
CH1 Markers
1: 55.877 Ω
15.570 Ω
2.40000 GHz
3: 65.375 Ω
33.422 Ω
2.50000 GHz
START 2 000.000 000 MHz
STOP 3 000.000 000 MHz

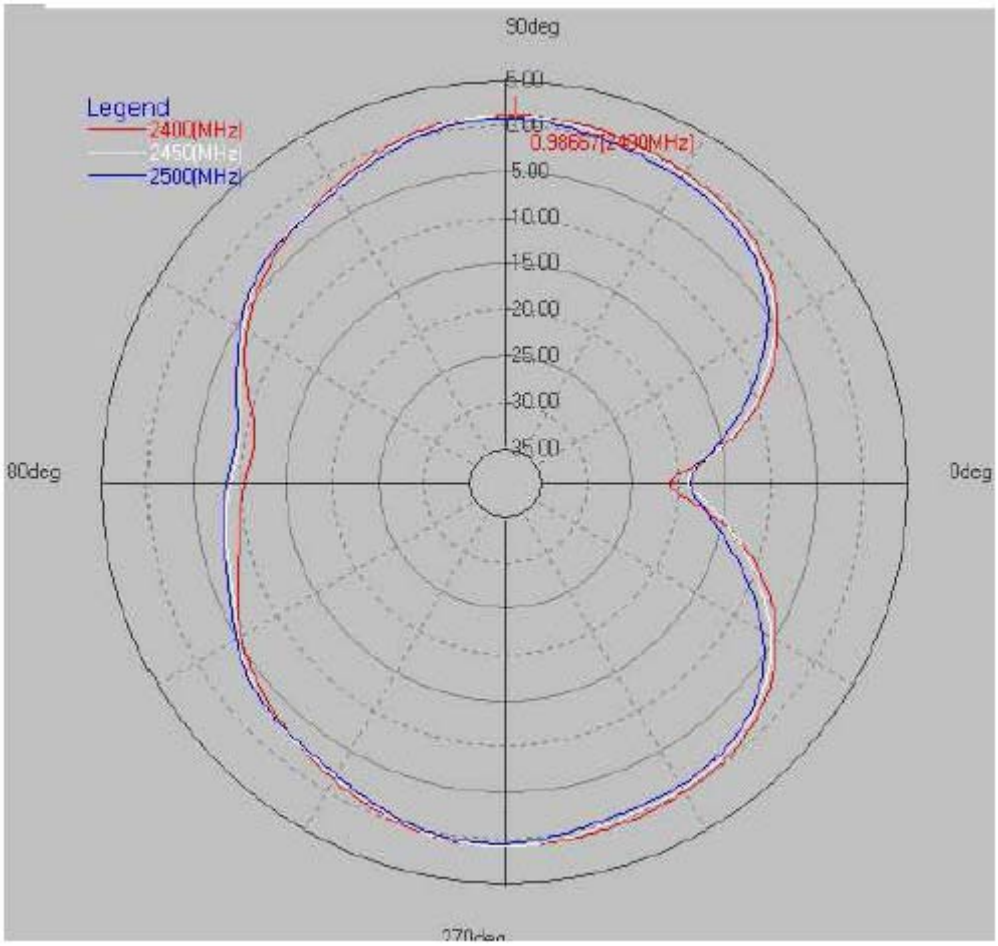
RADIATION PATTERN

2400~2500 MHz

X-Z Plane

Phi=0.00deg

Gain . dB



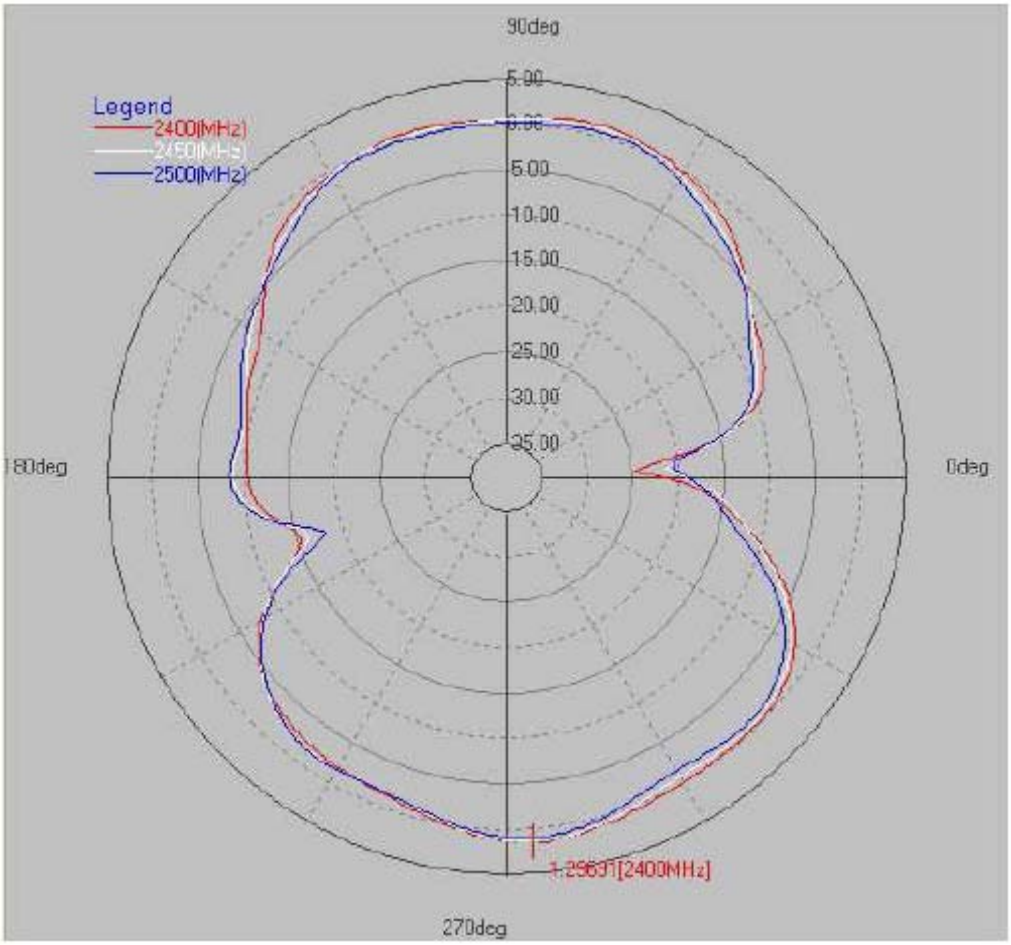
Frequency(GHz)	Peak (dB)		Average (dB)
	Max.	Min.	
2.40	1.89	-21.17	-2.25
2.45	1.92	-19.12	-2.41
2.50	1.81	-18.81	-2.74

2400~2500 MHz

Y-Z Plane

Phi=90.00deg

Gain . dB



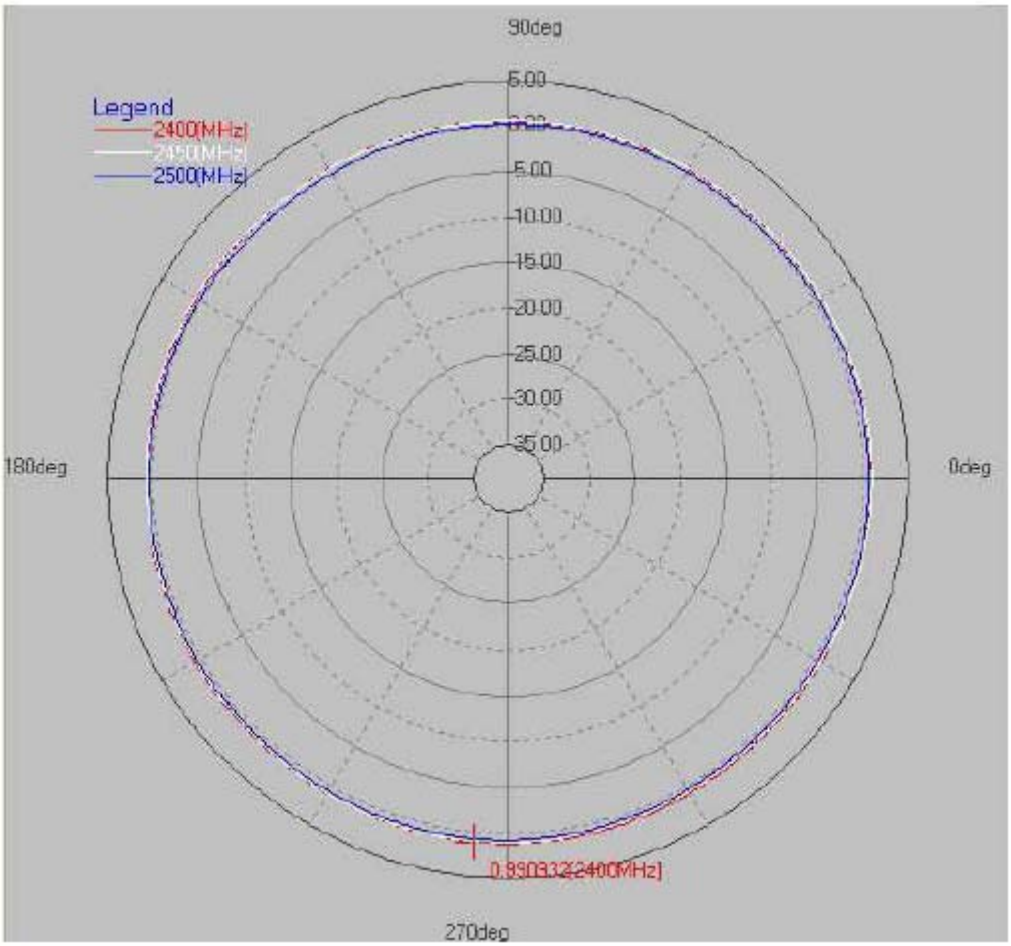
Frequency(GHz)	Peak (dB)		Average (dB)
	Max.	Min.	
2.40	2.04	-24.68	-2.25
2.45	2.00	-21.44	-2.47
2.50	1.81	-20.59	-2.84

2400~2500 MHz

X-Y Plane

Theta=90.00deg

Gain . dB



Frequency(GHz)	Peak (dB)		Average (dB)
	Max.	Min.	
2.40	1.89	0.35	0.70
2.45	1.90	0.36	0.68
2.50	1.80	-0.16	0.33

APPROVAL SHEET

Dipole ANTENNA
2.4 GHz Single Band Working Frequency
Halogens Free Product
P/N: RFDPA870900SBAB8G1

Customer：_____

Customer ‘s Part No.：_____

Approval No.：_____

Issue Date：_____

*Contents in this sheet are subject to change without prior notice.

Version	Date	Description	Author
V01	2015 Sep.	New Release	PIPI

ELECTRICAL CHARACTERISTICS

Item	Specification
Working Frequency Range	2.4 ~ 2.5 GHz (Note-1)
Gain	2 dBi
Return Loss	-10dB(Max)
VSWR	2 max.
Polarization	Linear
Radiation Pattern	Omni-directional
Impedance	50Ω

*Note 1. Central Frequency should be defined after customers' application approval.

MATERIAL TABLE

Items	Description
Cable	RG178(Brown)
Antenna Cover	TPEE
Antenna Base	PC/PBT
Connector	Reverse SMA Plug
Color	Black
Brass Tube	Brass

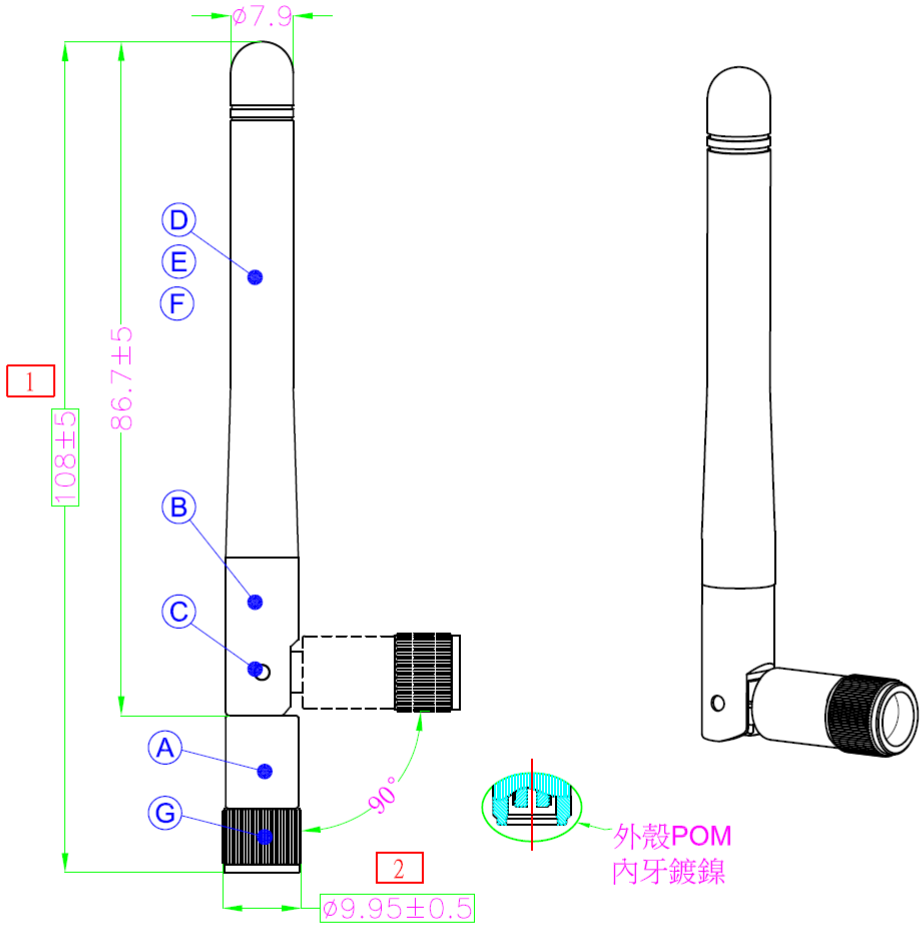
ORDERING RULE

RF	DPA	8709	00	S	B	A	B	8	G1
Type Code	**Product Code**	**Dipole Dimension (Unit: mm)**	**Cable Length (unit: cm)**	**Connector Brand**	**Type of Connector**	**Application**	**Project status**	**Wire Diameter**	**Project**
Walsin RF Device	DPA: Dipole Antenna	Per 2 digits of length, width e.g.: 8709 Length 86.7mm, Width 9.95mm	2 digits for cable length e.g.: 00 None Cable	A: N C:MCX D:IPEX III E: IPEX IV F: IPEX A13 H: Hirose I: IPEX M: MMCX S: SMA T: TNC U:MURATA N: None	A: Reverse Female B: Reverse Male F: Female M: Male N: None	0: 0GHz 3: 3GHz 5: 5 GHz 6: 6GHz A: 2.4GHz ISM band B: GSM 900/1800 dual band G: GPS band L: 2.4/5.2/5.8 GHz tri-band N: NFC T:LTE band W: WCDMA band	B: MP T:During Test X: Pile Run	0:None 1:∅0.81 3:∅1.13 6:RG316 7:∅1.37 8:RG178	01~99 series number

DIMENSIONS

ELECTRICAL
Frequency:2.4GHZ
Gain:2dBi

No.	MAT	MAT'L	Color	Q'TY
A	Antenna Down Base	PC+PBT	Black	1
B	Antenna Up Base	PC	Black	1
C	Rivet	POM	Black	2
D	Antenna Cover	TPEE	Black	1
E	Brass Tube	Brass	--	1
F	RG178 CABLE	--	Brown	1
G	Reverse SMA Plug	--	Black	1



※標記□記號者，為重點檢驗尺寸

LTR	DESCRIPTION	DATE	REQ. BY

設計 DR. HWCHAN 2013.08.29
核准 APPD.

容許公差 TOLERANCE
.XXX ±0.20
.XX ±0.35
.X ±0.50
X ±1.00
ANG ±5

品名 ARTICLE: RFDPA870900SBAB8G1

版本 REV. A

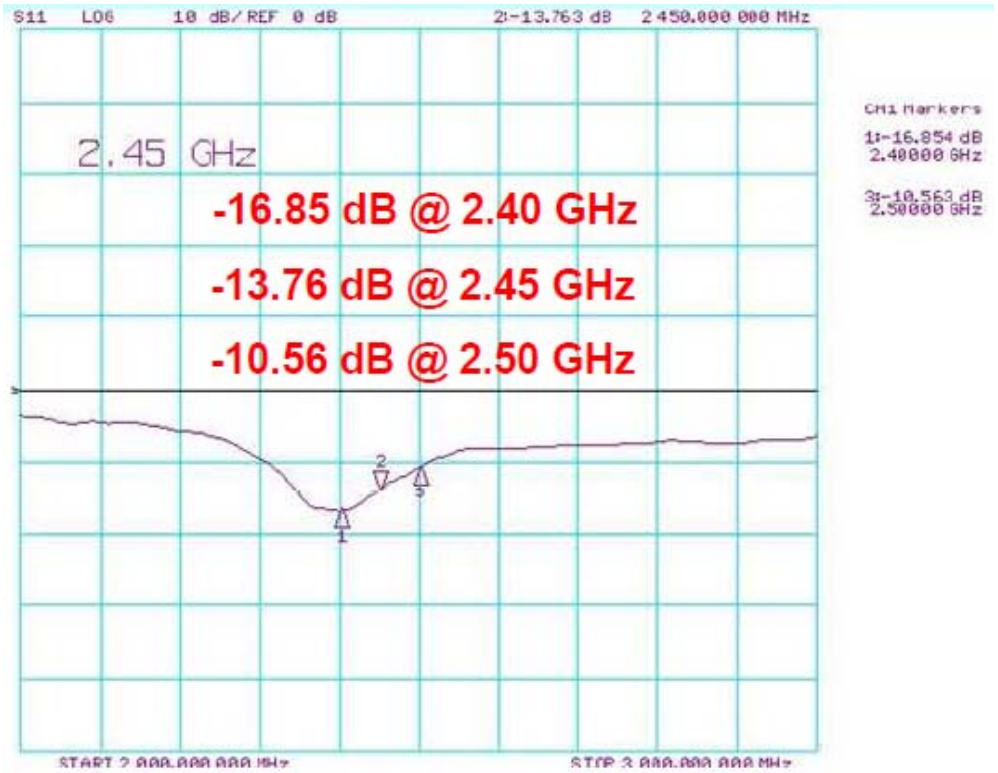
單位 UNIT: mm
比例 SCALE: ****
張數 SHEET: 1

華新科技股份有限公司
Walsin Technology Corporation

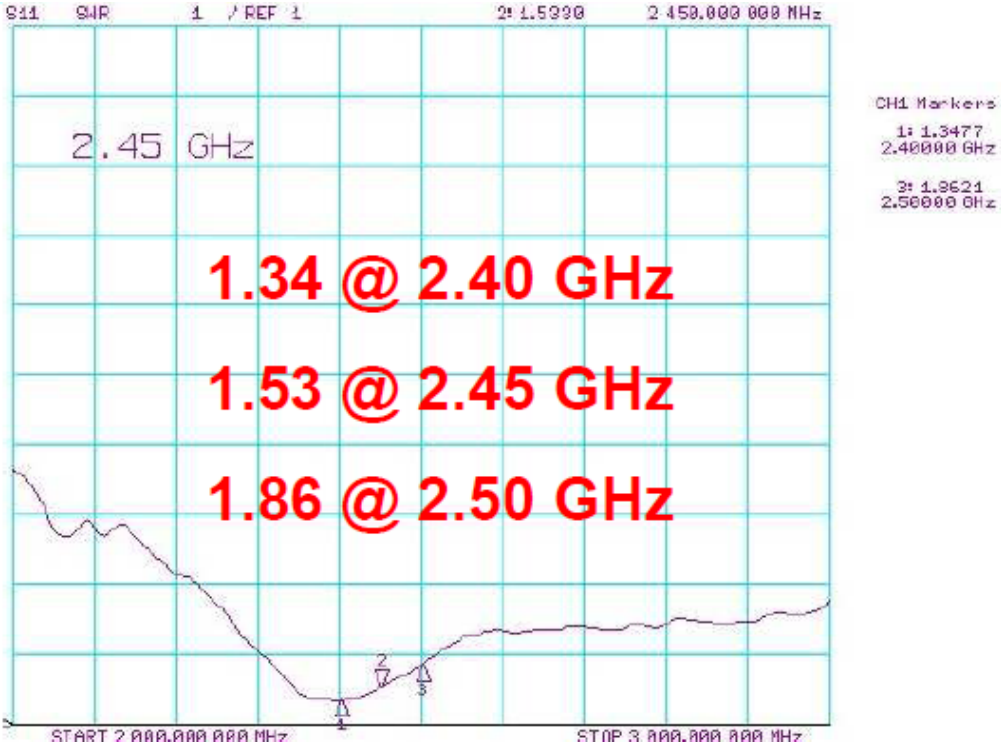
Test Report

■ELECTRICAL CHARACTERISTICS

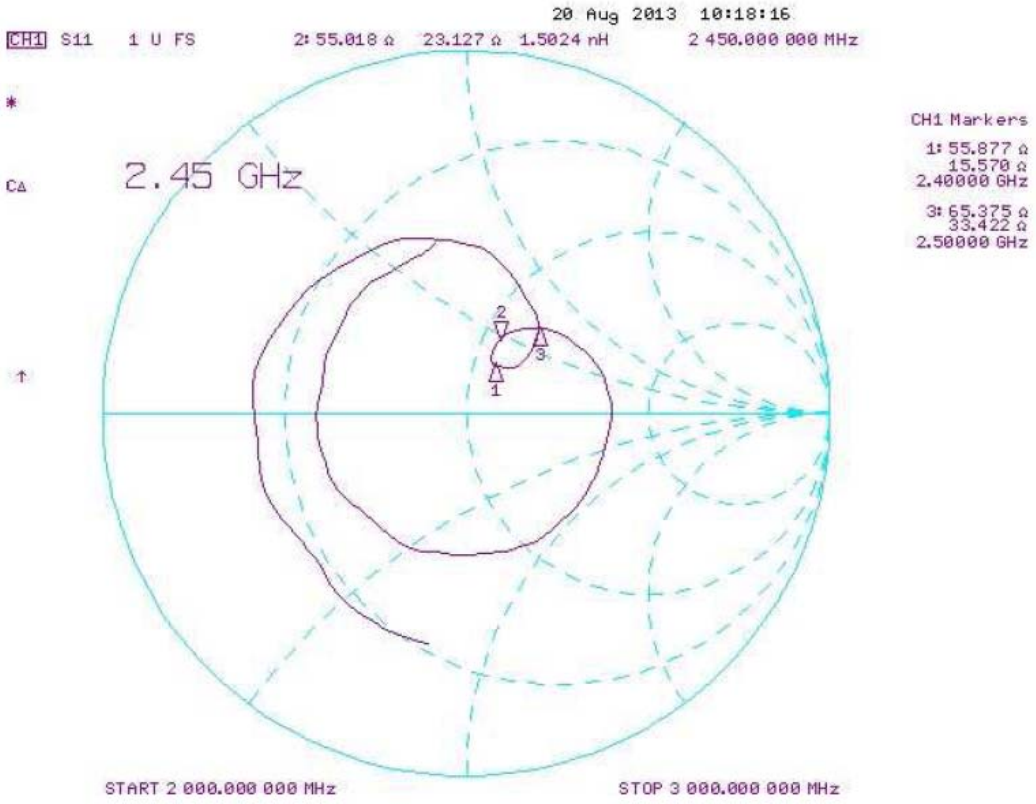
Return Loss



VSWR



Smith Chart


20 Aug 2013 10:18:16
CH1 S11 1 U FS
2: 55.018 Ω 23.127 Ω 1.5024 nH
2 450.000 000 MHz
2.45 GHz
CH1 Markers
1: 55.877 Ω
15.570 Ω
2.40000 GHz
3: 65.375 Ω
33.422 Ω
2.50000 GHz
START 2 000.000 000 MHz
STOP 3 000.000 000 MHz

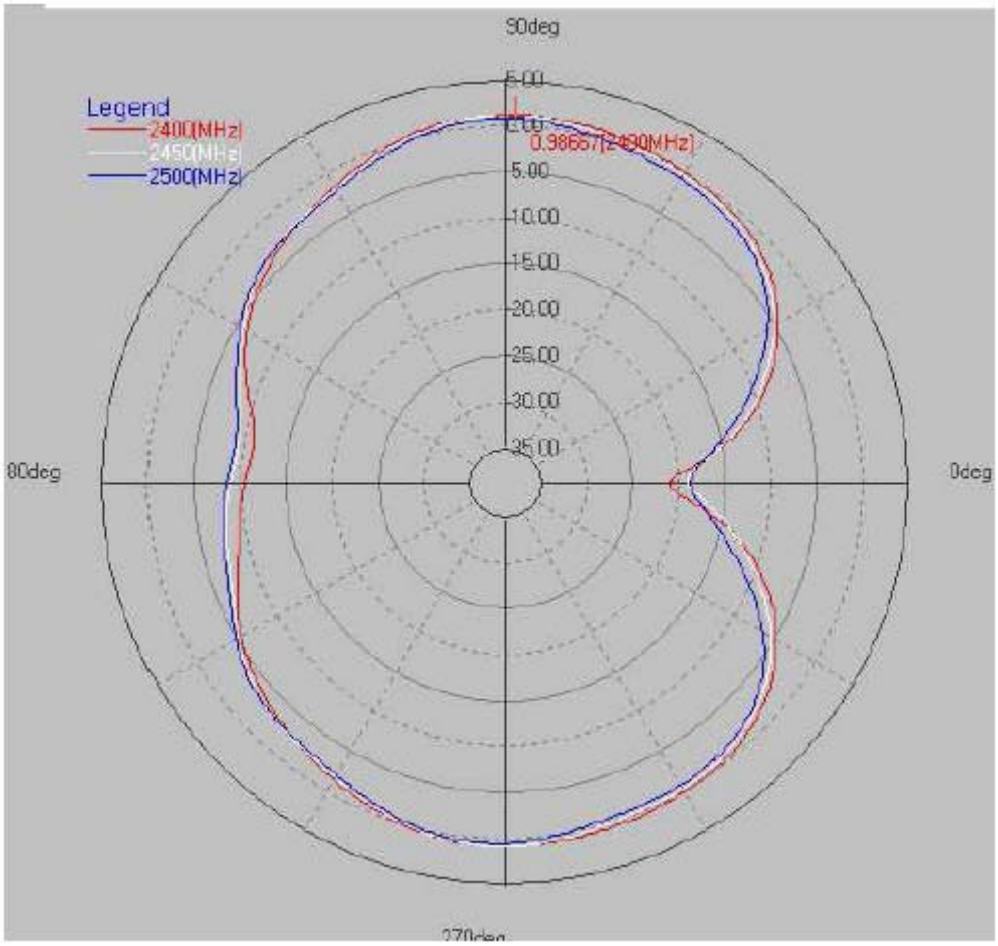
RADIATION PATTERN

2400~2500 MHz

X-Z Plane

Phi=0.00deg

Gain . dB



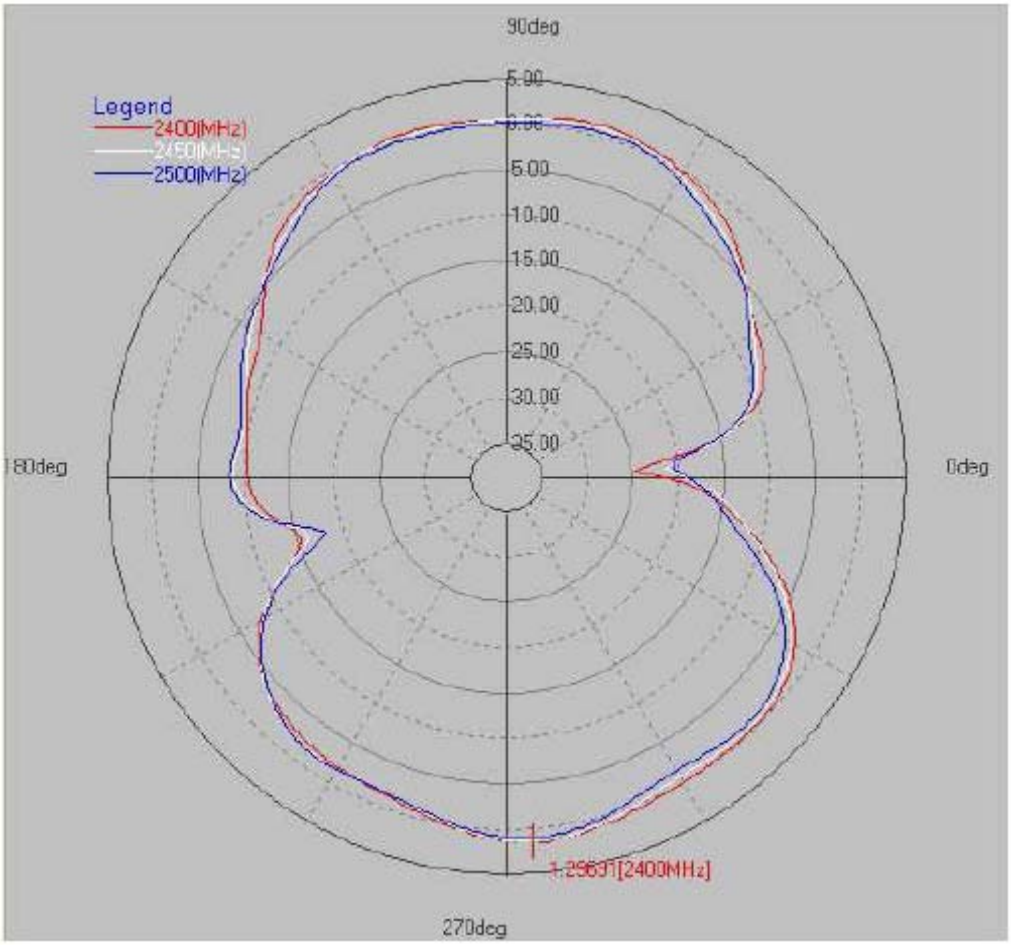
Frequency(GHz)	Peak (dB)		Average (dB)
	Max.	Min.	
2.40	1.89	-21.17	-2.25
2.45	1.92	-19.12	-2.41
2.50	1.81	-18.81	-2.74

2400~2500 MHz

Y-Z Plane

Phi=90.00deg

Gain . dB



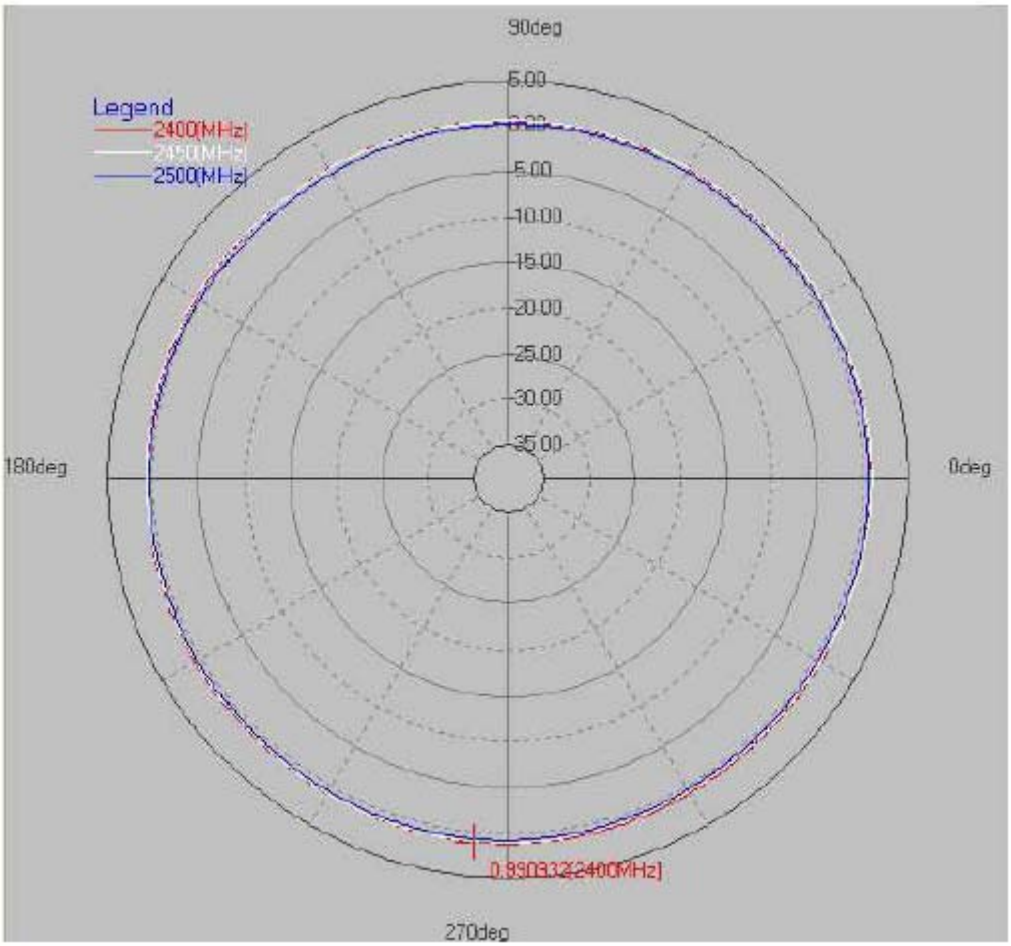
Frequency(GHz)	Peak (dB)		Average (dB)
	Max.	Min.	
2.40	2.04	-24.68	-2.25
2.45	2.00	-21.44	-2.47
2.50	1.81	-20.59	-2.84

2400~2500 MHz

X-Y Plane

Theta=90.00deg

Gain . dB



Frequency(GHz)	Peak (dB)		Average (dB)
	Max.	Min.	
2.40	1.89	0.35	0.70
2.45	1.90	0.36	0.68
2.50	1.80	-0.16	0.33

Package

蘇州華科電子有限公司

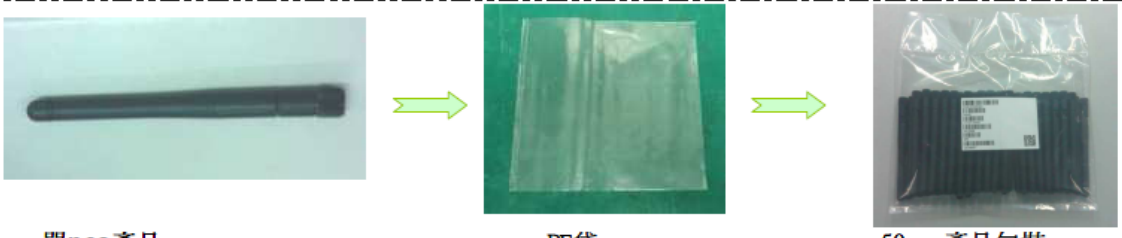
制品規格書

版別：1.0.0

客戶		品名	RFDPA870900SAXB8G1(2dBi)	發行編號		頁次	1/1

產品包裝圖示:

圖示一

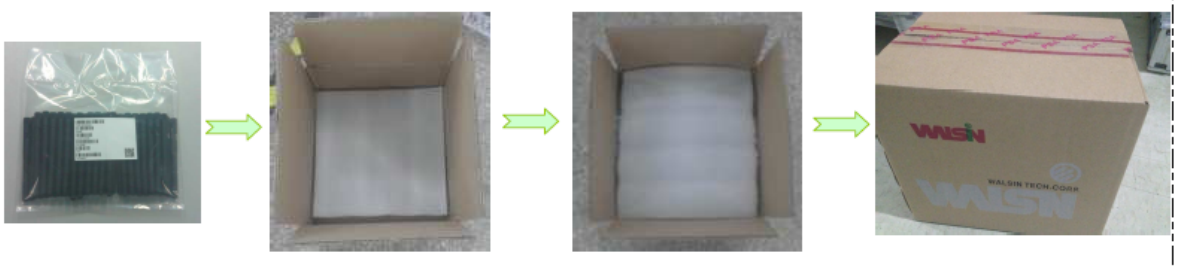


單pcs產品　　PE袋　　50pcs產品包裝

圖示二

珍珠棉　　外箱　　珍珠棉放進外箱中

圖示三



產品包裝說明：

1.將單PCS產品裝入PE袋中，每PE袋裝50PCS.(如圖示一)

2.將珍珠棉放入外箱中(如圖示二)

3.將裝好的成品(如圖示三)放入外箱中，每箱放1000pcs產品，上下各放1片珍珠棉。

4. 包裝材料規格

5.規格:長 210*寬230*厚度0.07mm

6.規格:長330*寬330*高8mm

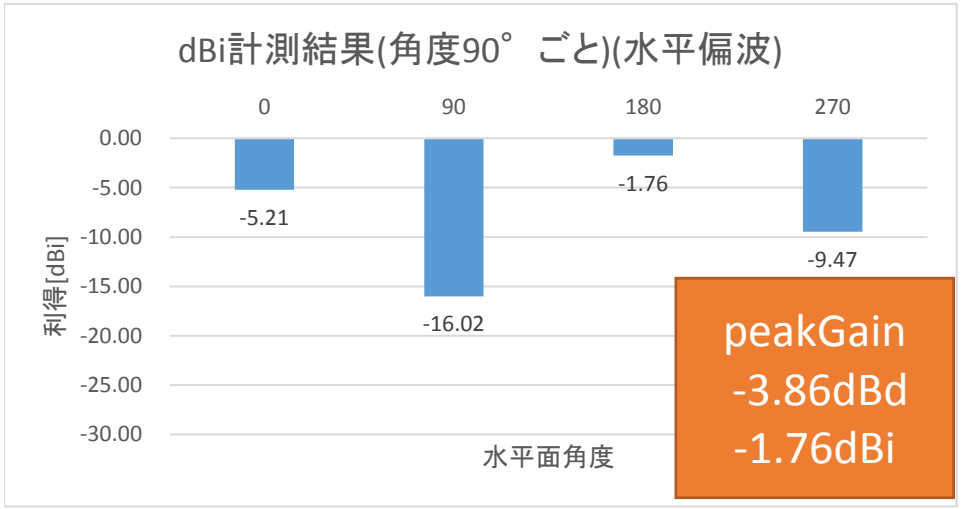
7.規格:長350*寬350*高190mm

8.產品標簽需貼到最小包裝（參照出貨標籤粘貼SOP)

FORM NO:

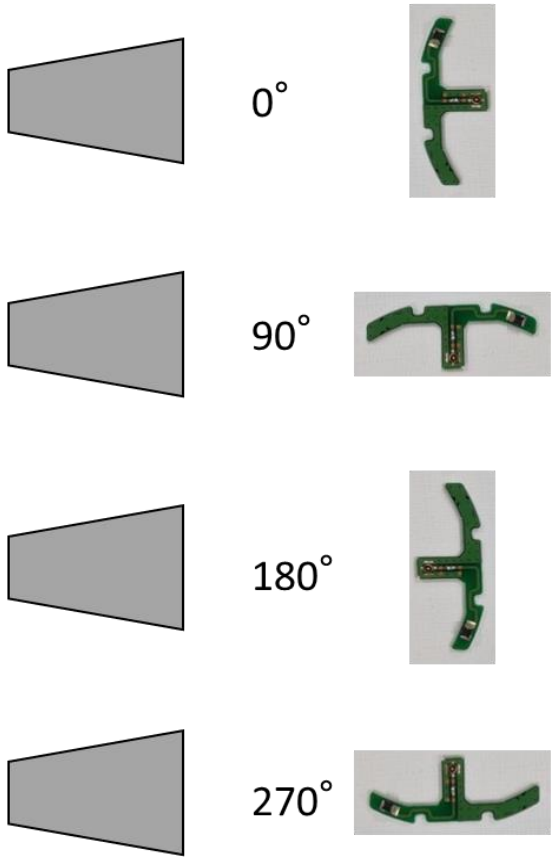
基準アンテナ
型番　　YAN-02-C-MHF4P-050
メーカー　YAMAMOTO METAL
技術　　1/2波長ダイポールアンテナ

送信出力　　120　dBμV
送受信アンテナ間距離 約　　2.5 m



送信アンテナ角度

受信アンテナ　　送信アンテナ



株式会社　山本金属製作所

APPROVAL SHEET
(RoHS)

CUSTOMER	:	**Laird**
CUSTOMER'S PART NO.	:	
DESCRIPTION	:	**PCB DIPOLE ANTENNA ASSEMBLY**
PART NO.	:	**PCA-4606-2G4C1-A33-CY**
DATE	:	
AUTHORIZED BY	:	*Marco Hsu*

	FULLY APPROVED	PARTIALLY APPROVED	REJECTED
SIGN			
SUGGESTION			

美磊科技股份有限公司

MAG. LAYERS SCIENTIFIC-TECHNICS CO., LTD
HEAD OFFICE / HSINCHU PLANT

No 18, Tz-Chiang Road, Hsin-Chu Industrial Park, Hsin-Chu, Taiwan

TEL: +886-3-5972488 FAX: +886-3-5972477

http://www.maglayers.com.tw

E-mail：info@maglayers.com.tw

Contents

Antenna Specification

ELECTRICAL PROPERTIES

1.1 Frequency Range……..……..2.4GHz ~2.5GHz

1.2 Impedance……..……..50 Ohm Nominal

1.3 VSWR……..……..2 (Max)

1.4 Return Loss…….. ……..-10dB (Max)

1.5 Radiation…….. ……..Omni-directional

1.6 Gain(peak)……..……..2.21dBi

1.7 Polarization……..……..Linear Vertical

1.8 Admitted Power…….. ……..1W

PHYSICAL PROPERTIES

2.1 Cable……..……..Coaxial Cable § 1.13 Black

2.2 Antenna Material……..FR4(黑漆噴錫板)

23 Operating Temp…….. ……..-25℃ ~ +75℃

2.4 Storage Temp…….. ……..-30℃ ~ +75℃

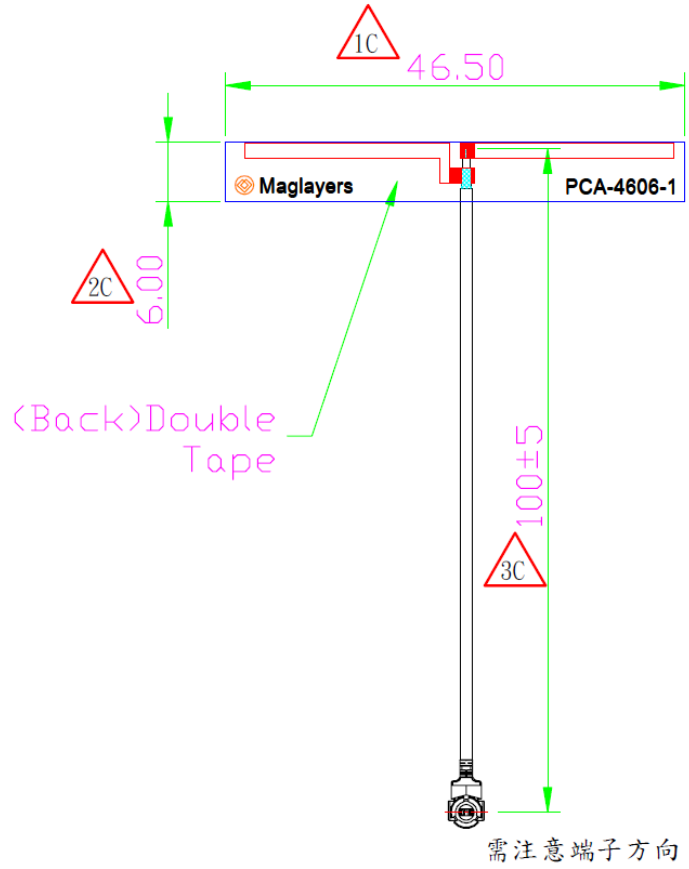
2.5 Connector……..……..IPEX 4 Compatible

Mechanical Specification

RoHS COMPLIANT

MECHANICAL
Body :FR4(黑色噴錫板)
Double Tape:3M 467

ELECTRICAL
Frequency : 2.4GHz
Cable : Coaxial Cable ϕ1.13(Black)
Connector:IPEX 4 Compatible



LTR	DESCRIPTION	DATE	REQ. BY
A	New Release	03/11/13'	HWCHAN

※凡標記 C 記號者,為品管檢驗之尺寸

設計 DR.	核准 APPD.
HWCHAN 2013/03/11	Marco 2013/03/11

版本說明 REVISION NOTE

容許公差	TOLERANCE
.XXX	±0.20
.XX	±0.35
.X	±0.50
X	±1.00
ANG	±5

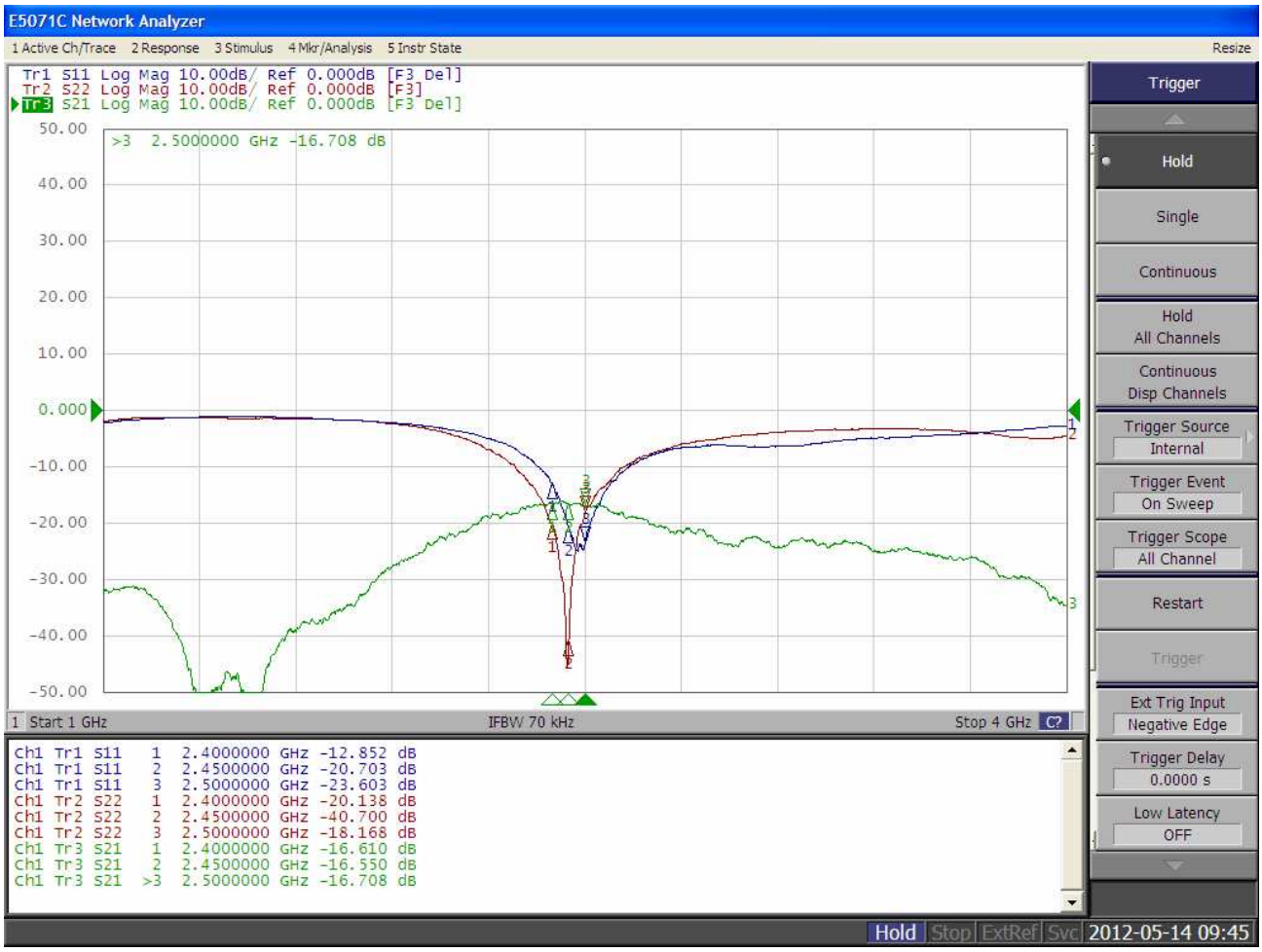
品名 ARTICLE
PCA-4606-2G4C1-A33

MAGLAYERS

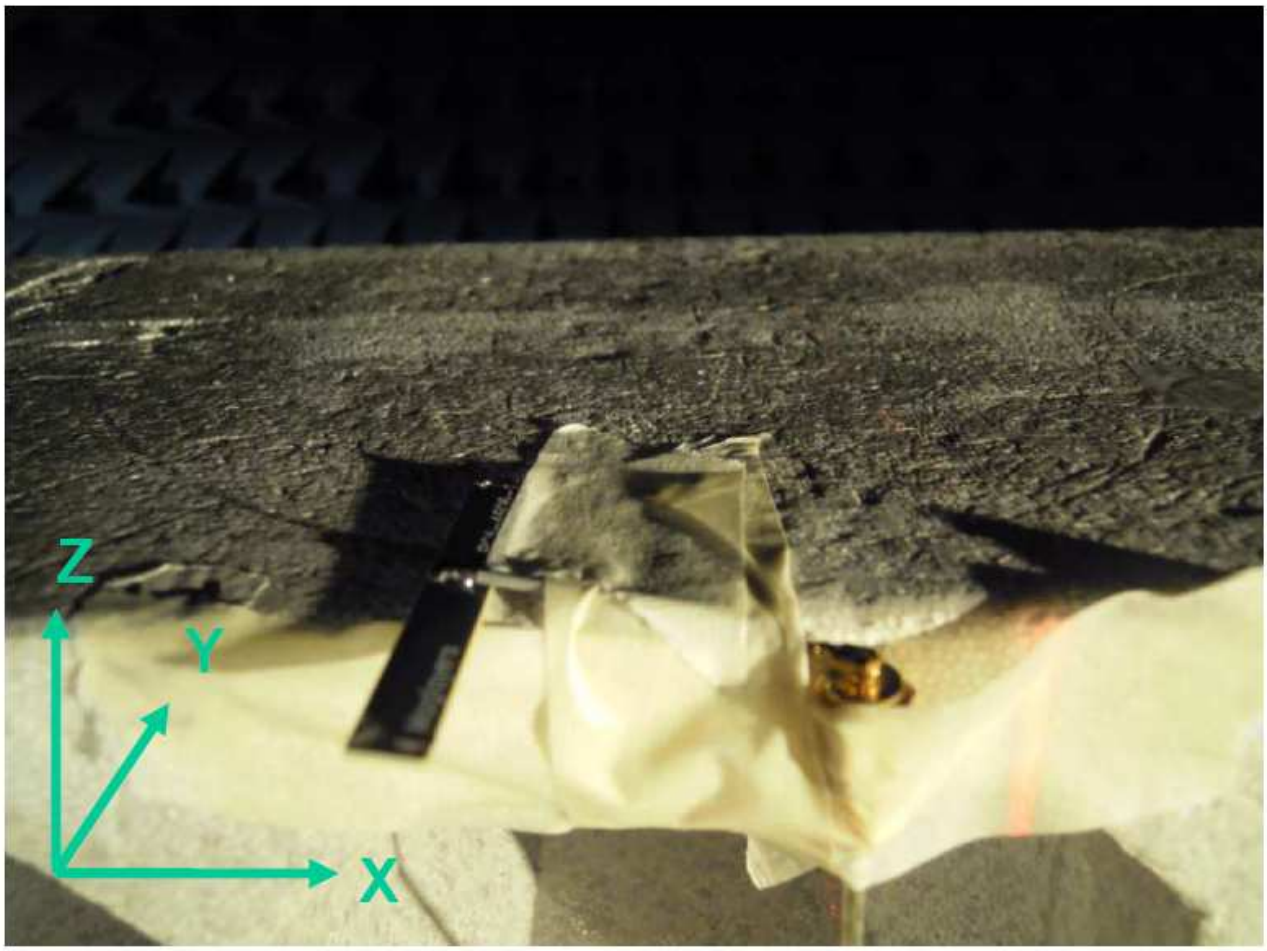
單位 UNIT	比例 SCALE	張數 SHEET	版本 REV.
mm	****	1	A

ELECTRICAL CHARACTERISTICS

P/NO: PCA-4606-2G4C1-A33
Spec: 2.4GHz ~ 2.5GHz
S11

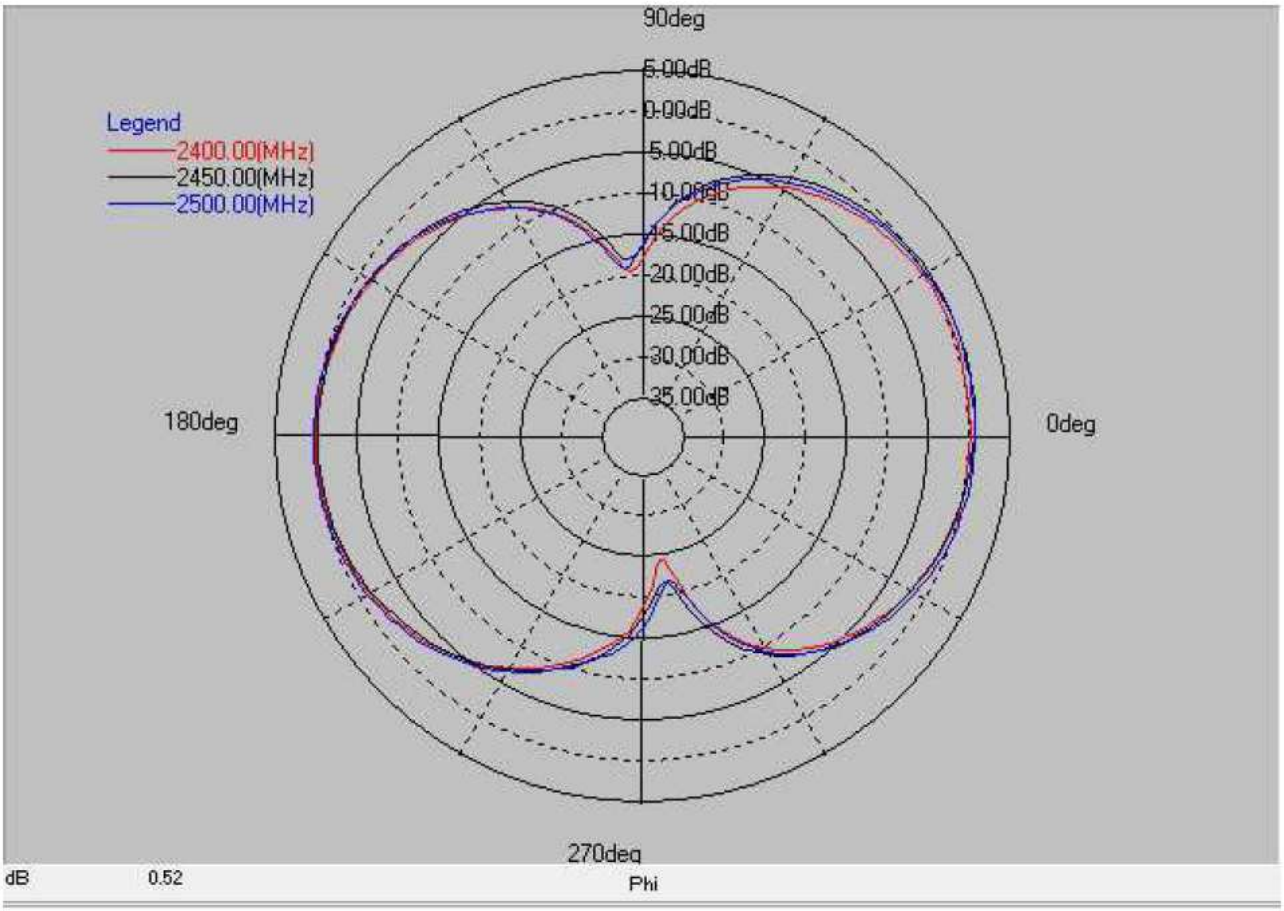


Experimental Setup



Frequency(MHz)：**2400~2500.** Pattern Field：**X-Z plane**

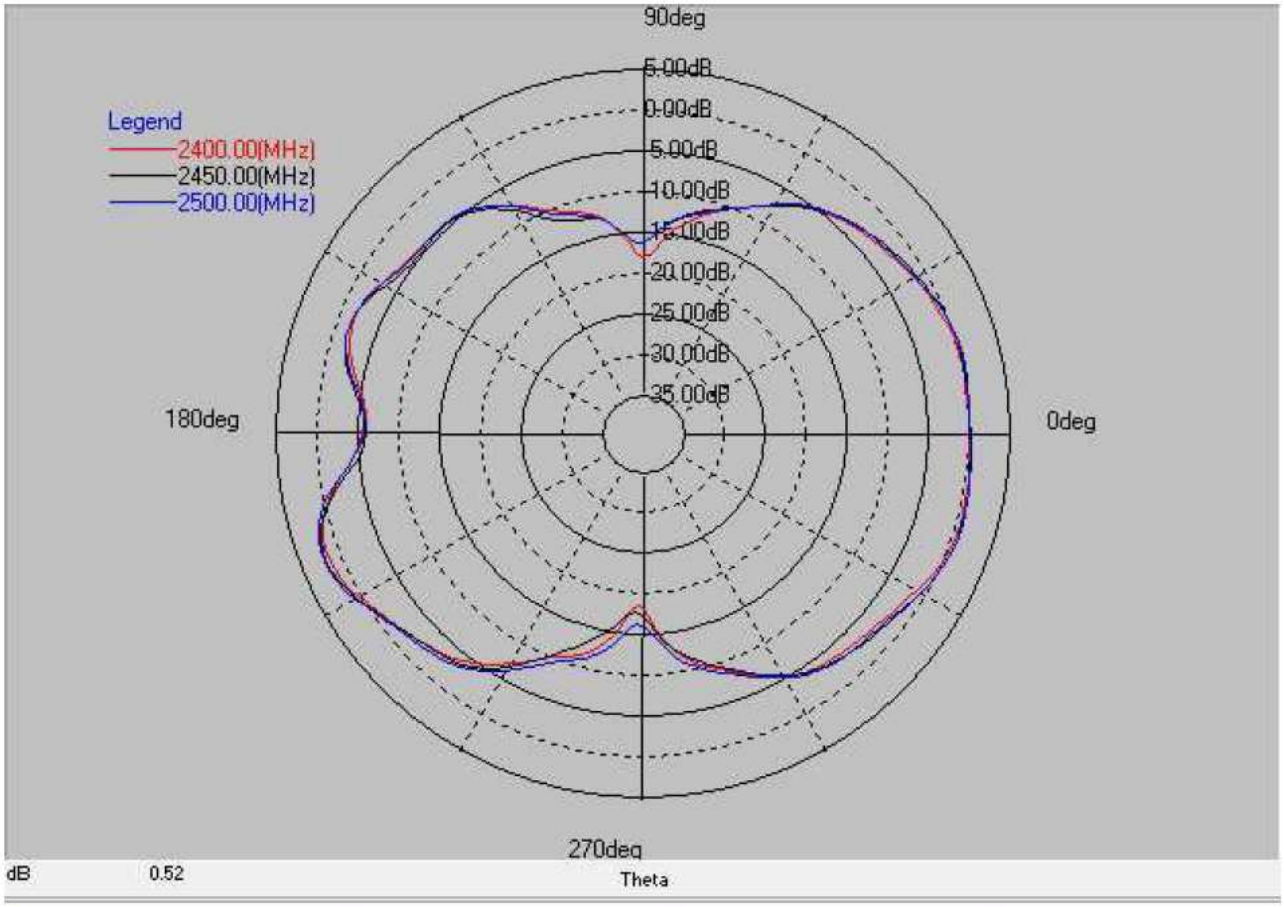
Gain . dB



Layer	Max value	Min value	Average
2400(MHz)	0.26 dB	-24.63 dB	-3.13 dB
2450(MHz)	0.97 dB	-21.94 dB	-2.80 dB
2500(MHz)	0.81 dB	-22.13 dB	-2.68 dB

Frequency(MHz)：**2400~2500.** Pattern Field：**Y-Z plane**

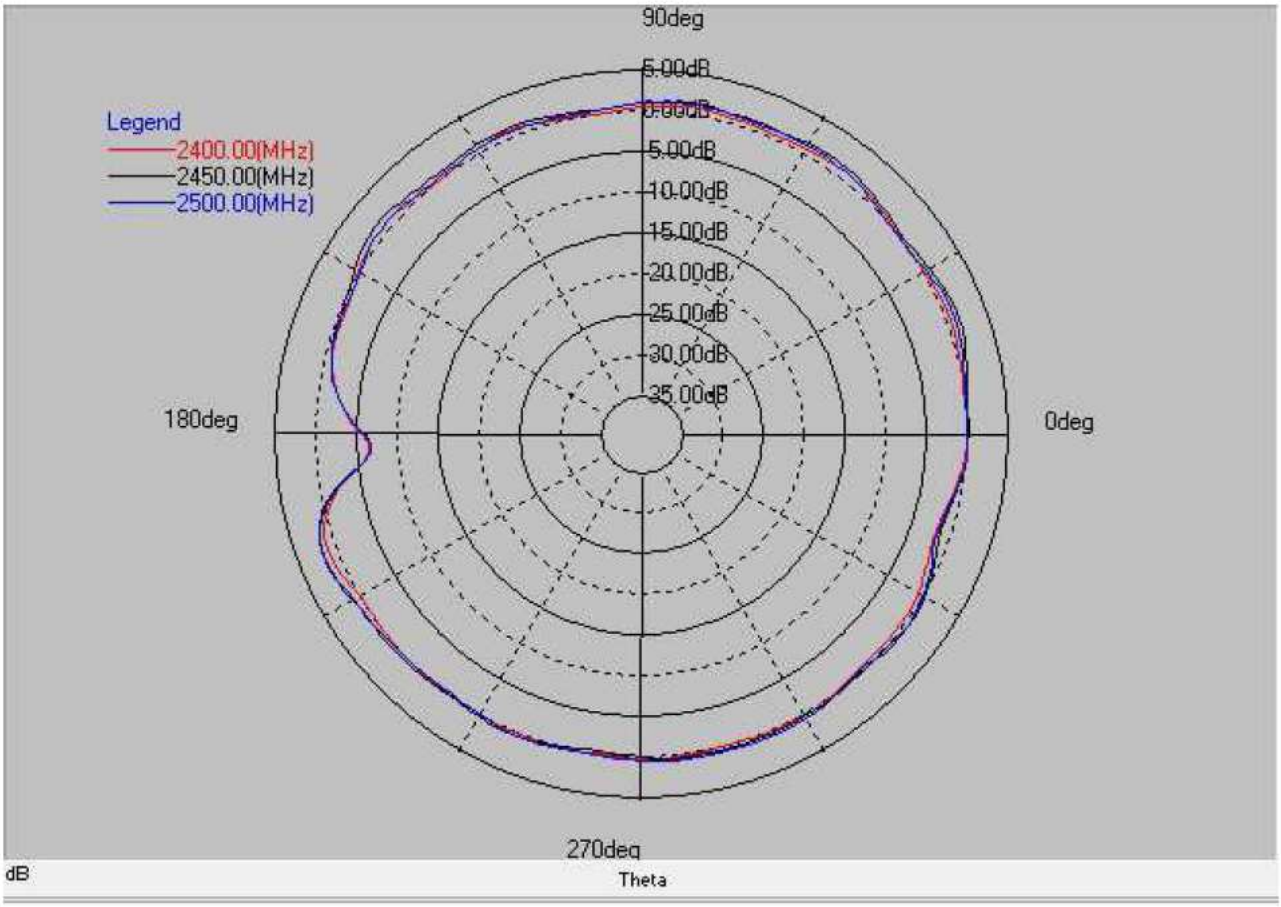
Gain . dB



Layer	Max value	Min value	Average
2400(MHz)	1.48 dB	-18.90 dB	-3.41 dB
2450(MHz)	1.99 dB	-18.04 dB	-3.20 dB
2500(MHz)	2.21 dB	-16.54 dB	-3.06 dB

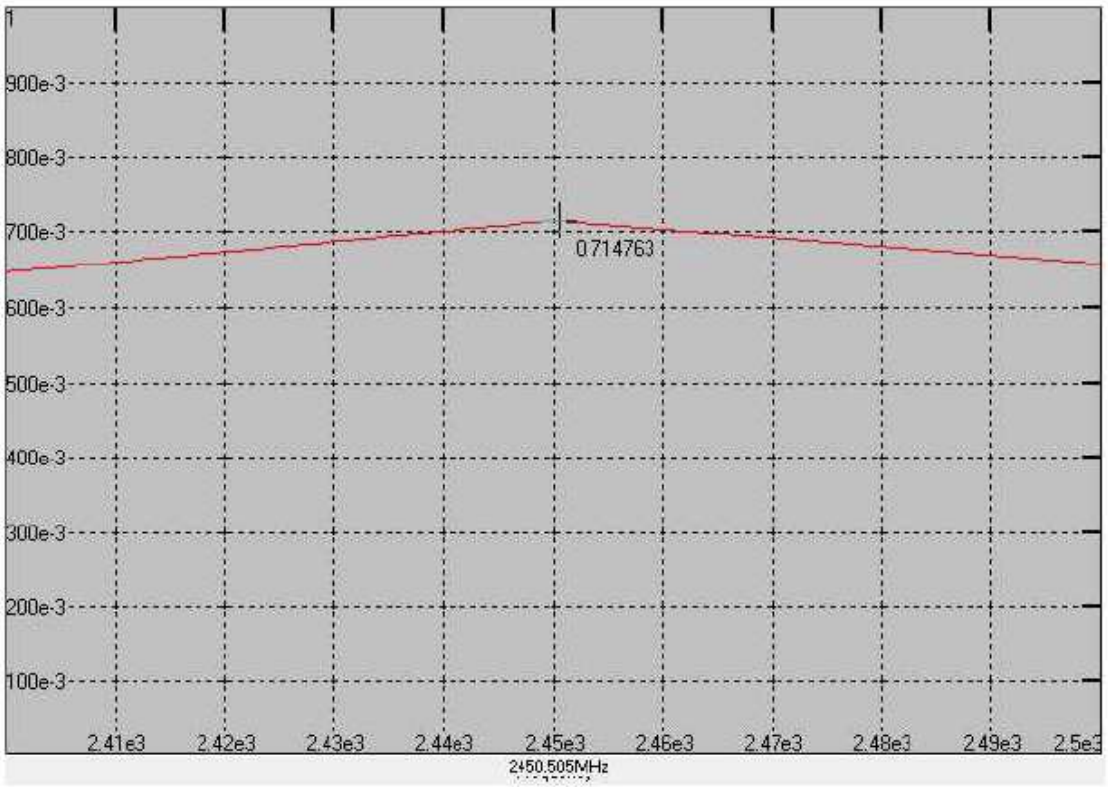
Frequency(MHz)：**2400~2500.** Pattern Field：**X-Y plane**

Gain . dB



Layer	Max value	Min value	Average
2400(MHz)	1.12 dB	-6.49 dB	-0.15 dB
2450(MHz)	1.93 dB	-6.78 dB	0.32 dB
2500(MHz)	1.84 dB	-6.65 dB	0.14 dB

Antenna efficiency



Maximum Efficiency At 2.4-2.5 GHz : 71.47%

Datasheet

mFlexPIFA

2.4 – 2.5 GHz mFlexPIFA +2 dBi Antenna, 100 mm cable length with U.FL or MHF4 connector

Version 2.1

REVISION HISTORY

Version	Date	Notes	Contributors	Approver
2.0	15 Aug 2017	Initial Release on website		Sue White
2.1	20 Mar 2018	Added new antenna connector information; transitioned to new template; updated contact information		Jay White

Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852 2923 0610

CONTENTS

Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852 2923 0610

1 Ordering Information

Table 1: Ordering information

Order Number	Description
001-0030	mFlexPIFA – 2.4 GHz embedded metal FlexPIFA antenna, 100 mm cable length w/U.FL connector
EFA2400A3S-10MH4L	mFlexPIFA – 2.4 GHz embedded metal FlexPIFA antenna, 100 mm cable length w/MHF4 connector

2 Key Features

- Designed to be installed directly on metal
- Can be installed on different conductive surfaces and thicknesses
- Can be installed on flat or curved surfaces
- Quick and easy Installation
- Adhesive holds to surface during humidity exposure and hot/cold cycles
- RoHS compliant

3 Specifications

Table 2: mFlexPIFA specifications

Specification	Value
Peak Gain	+2 dBi
Average Gain	>-4.2 dBi
Impedance	50 ohms
Type	Flexible Planar Inverted F Antenna (FlexPIFA)
Polarization	Linear
VSWR	≤ 3.0:1, 2400 - 2480 MHz
Frequency	2400 - 2480 MHz
Weight	1.8 g
Size	25.4 mm × 23.4 mm × 2.5 mm
Antenna Color	Clear Yellow
Adhesive	3M 100MP
Operating Temp	-40°C to +85°C
Connector Height	U.FL: 2.5 mm maximum

Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852 2923 0610

4 Physical Dimensions

Note: All measurements are in millimetres (mm).

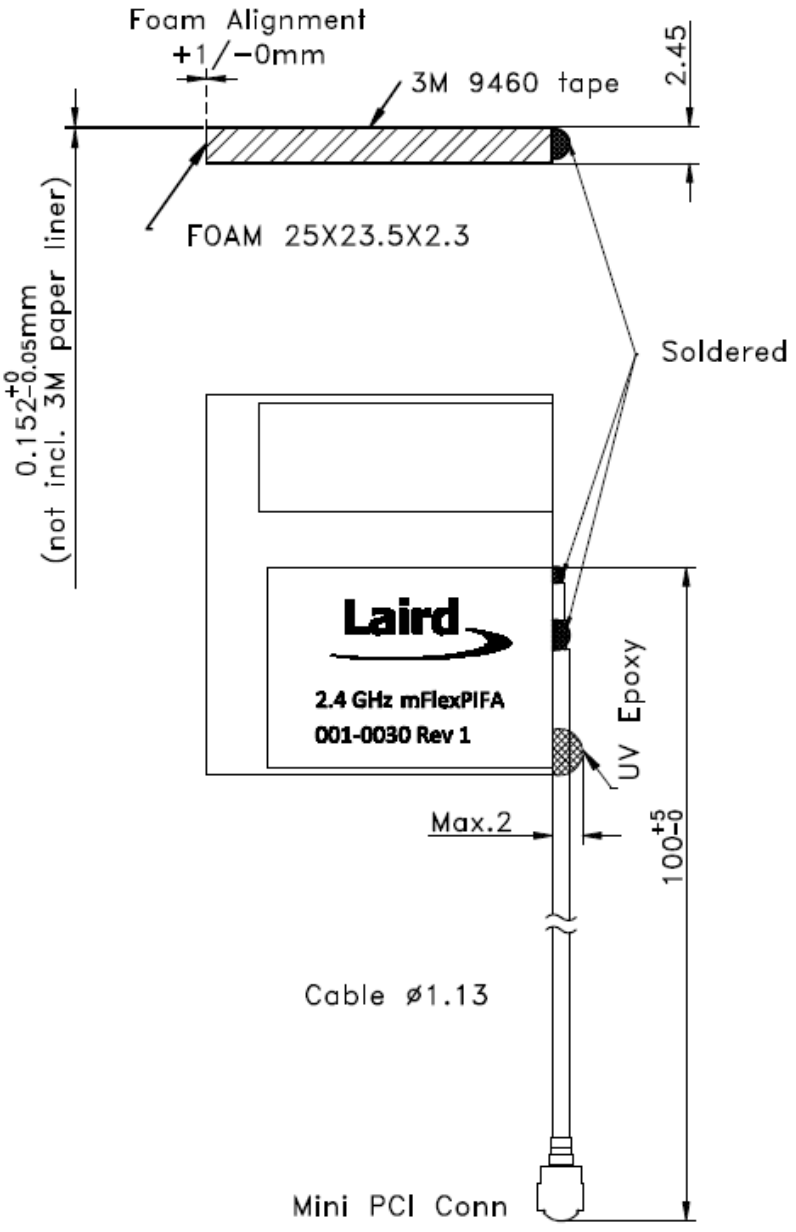


Figure 1: Physical dimensions

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Europe: +44-1628-858-940
Hong Kong: +852 2923 0610

5 Test Setup

Antenna measurements such as VSWR are measured with an Agilent E5071C Vector Network Analyzer. Radiation patterns are measured with a CMT Planar 804/1 Vector Network Analyzer in a Howland Company 3100 Chamber equivalent. Phase Center is 9 inches above the Phi positioner.

Flat surface measurements are done with the antenna centered on a 100 x 100 mm, 0.35 mm thick brass plate. Curved surface measurements are taken by placing the antenna on a curved surface made of 0.35 mm thick brass.

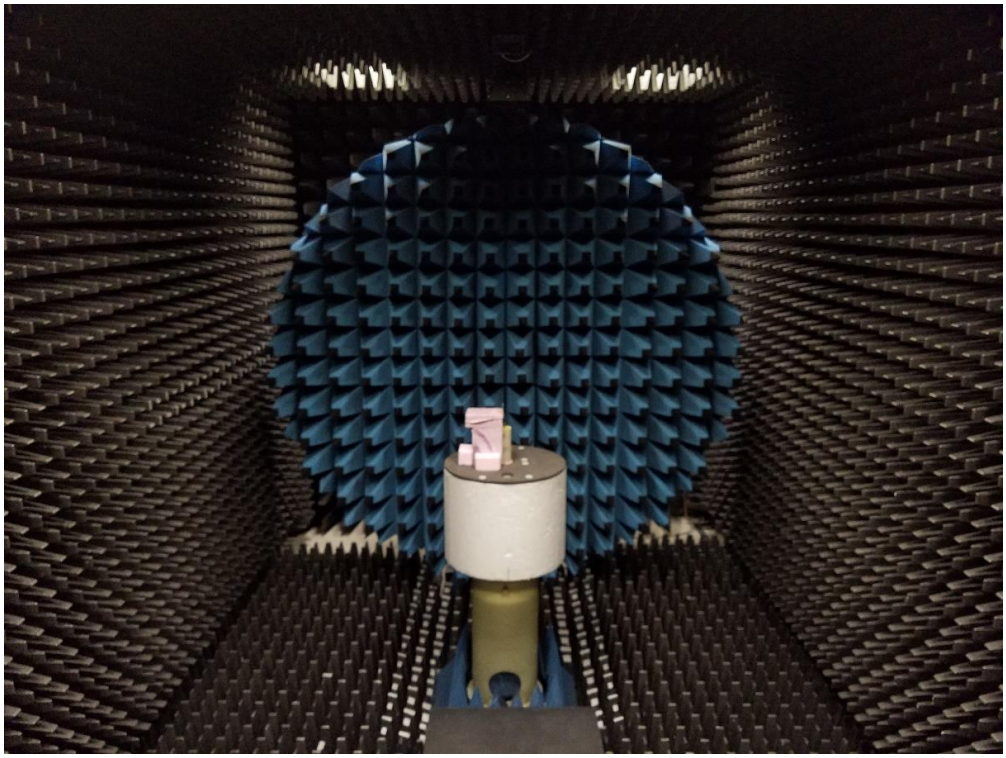

Figure 2 Antenna Chamber

Americas: +1-800-492-2320
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6 Flat Surface Antenna Measurements

Return Loss

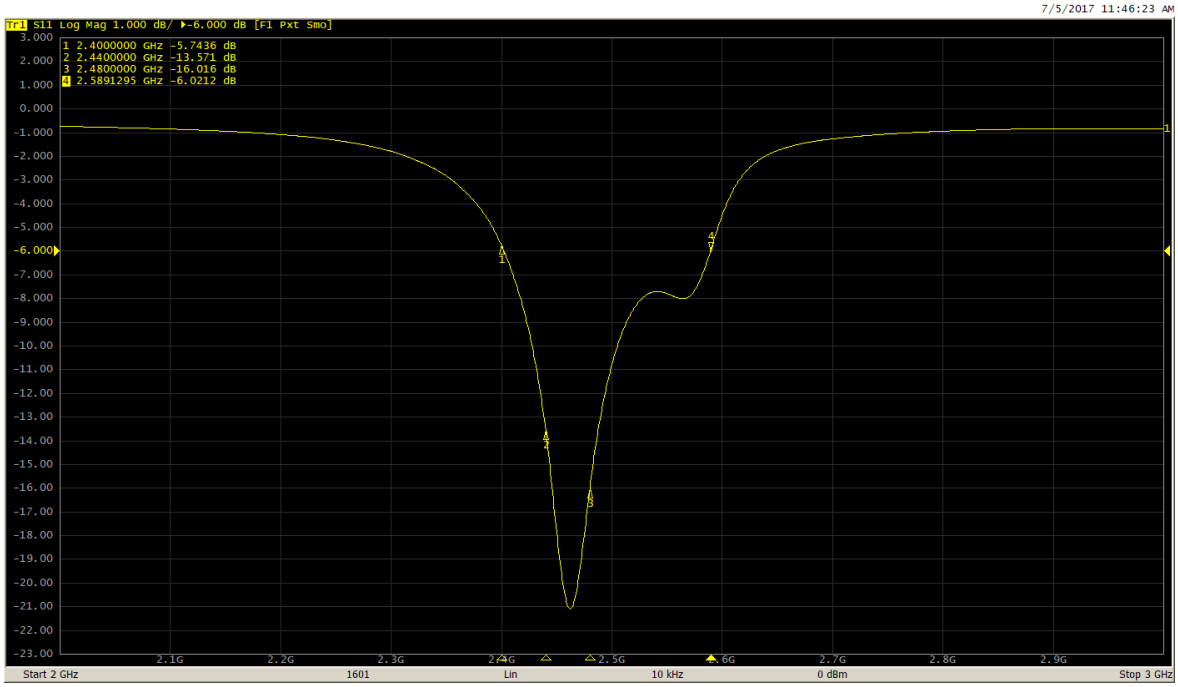

Figure 3: Return loss measured on a 0.35 mm thick, 100 x 100 mm brass plate

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Europe: +44-1628-858-940
Hong Kong: +852 2923 0610

7 Flat Surface Antenna Radiation Performance

7.1 Antenna Setup

The mFlexPIFA is centered on a 100 x 100 mm brass plate.

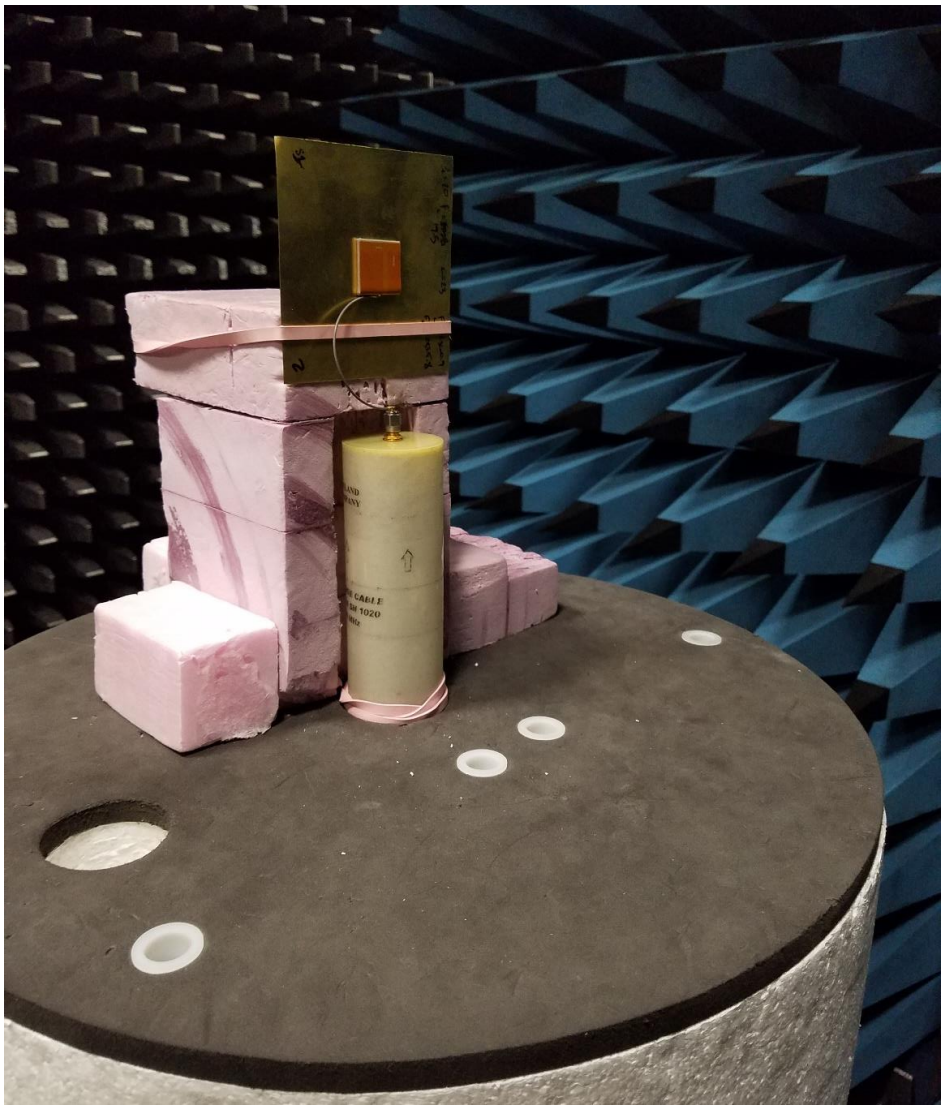

Figure 4: Flat surface setup

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Europe: +44-1628-858-940
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7.2 Results – Flat Surface

2400 MHz

Azimuthal Conical Cuts at 2400 MHz

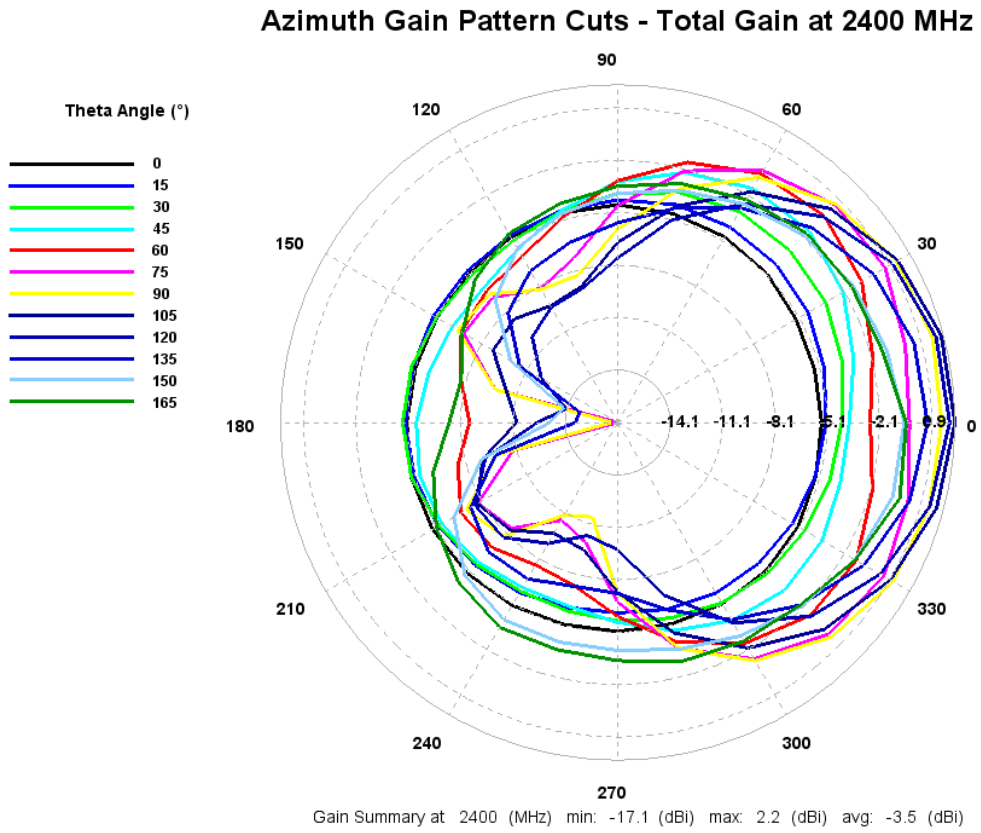

Figure 5: Total gain pattern – 2400 MHz

Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852 2923 0610

3D Plots at 2400 MHz

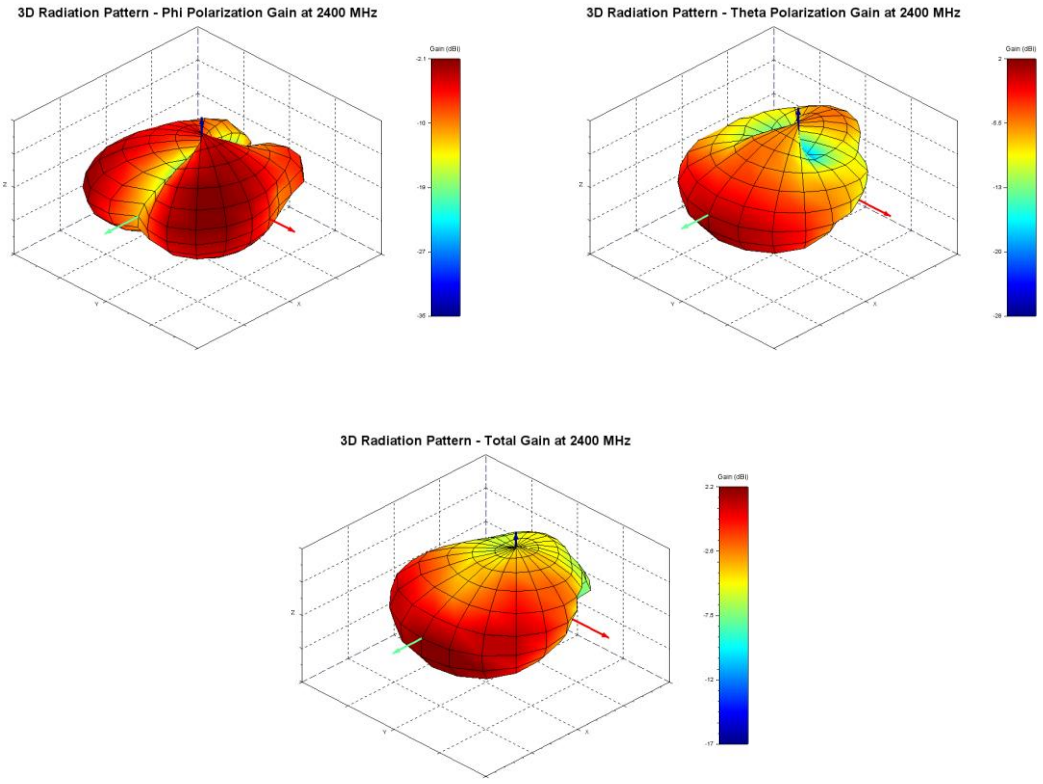

Figure 6: Phi, theta, and total gain plots – 2400 MHz

Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852 2923 0610

2440 MHz

Azimuthal Conical Cuts at 2440 MHz

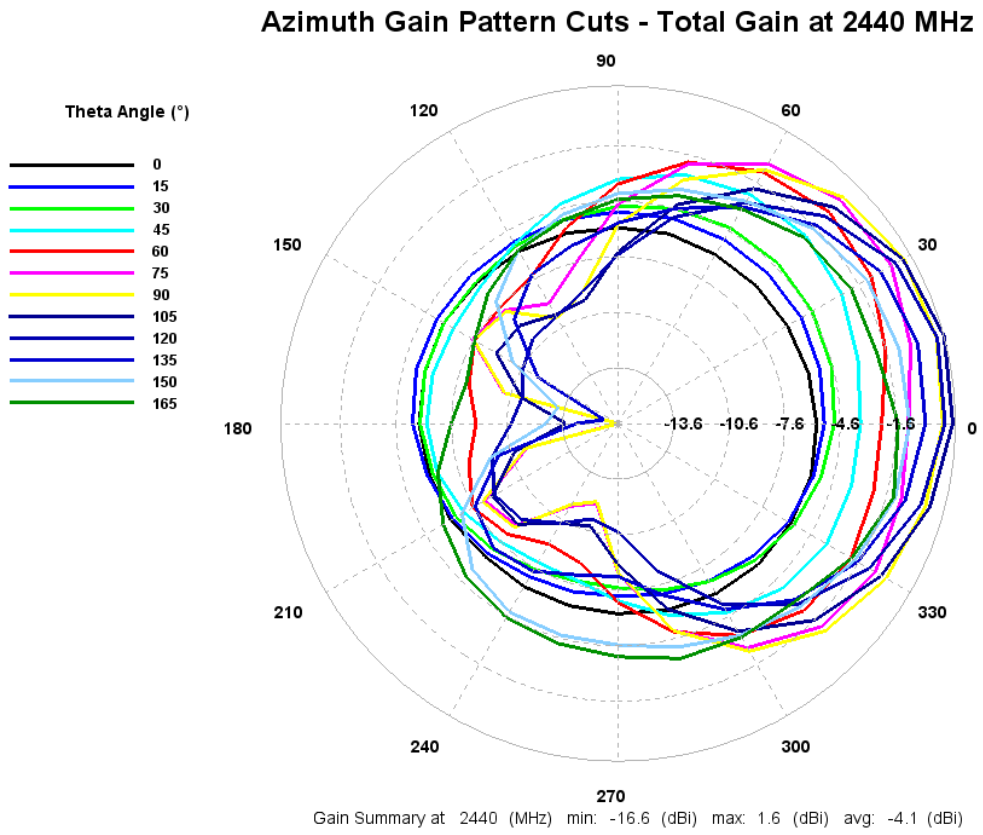

Figure 7: Total gain pattern – 2440 MHz

Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852 2923 0610

3D Plots at 2440 MHz

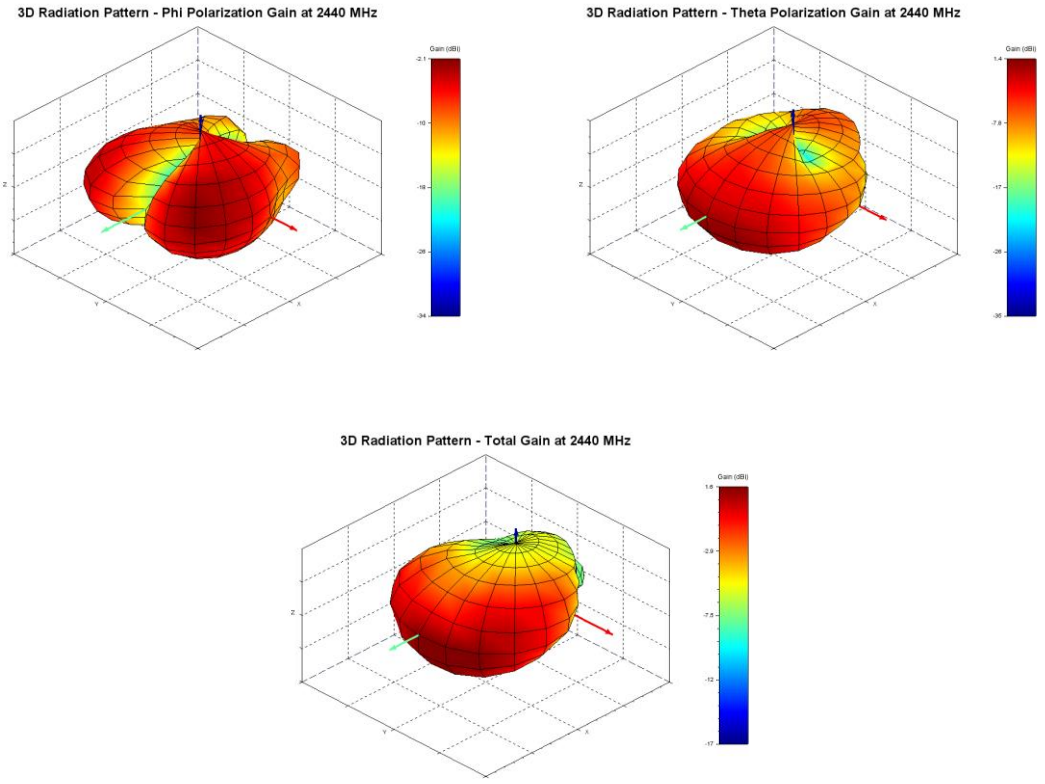

Figure 8: Phi, theta, and total gain plots – 2440 MHz

Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852 2923 0610

2480 MHz

Azimuthal Conical Cuts at 2480 MHz

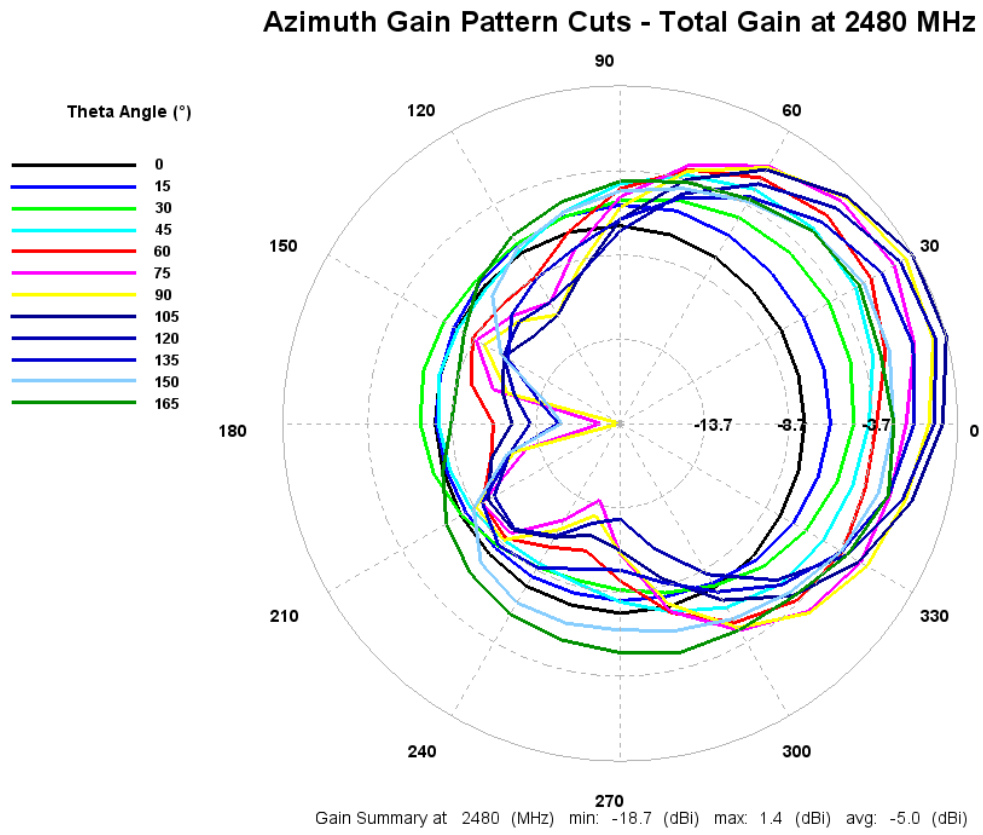

Figure 9: Total gain pattern – 2480 MHz

Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852 2923 0610

3D Plots at 2480 MHz

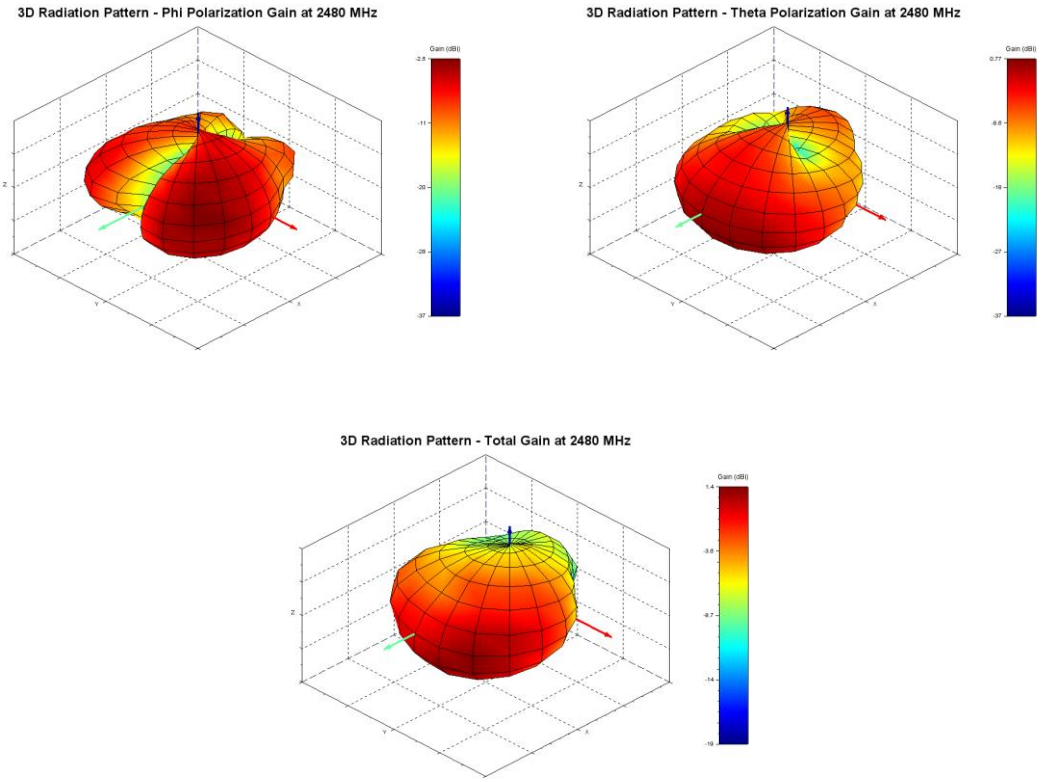

Figure 10: Phi, theta, and total gain plots – 2480 MHz

Americas: +1-800-492-2320
Europe: +44-1628-858-940
Hong Kong: +852 2923 0610

8 Curved Surface Antenna Radiation Performance

8.1 Antenna Setup

The mFlexPIFA is placed on the outside of a 60-mm outer diameter metal tube.

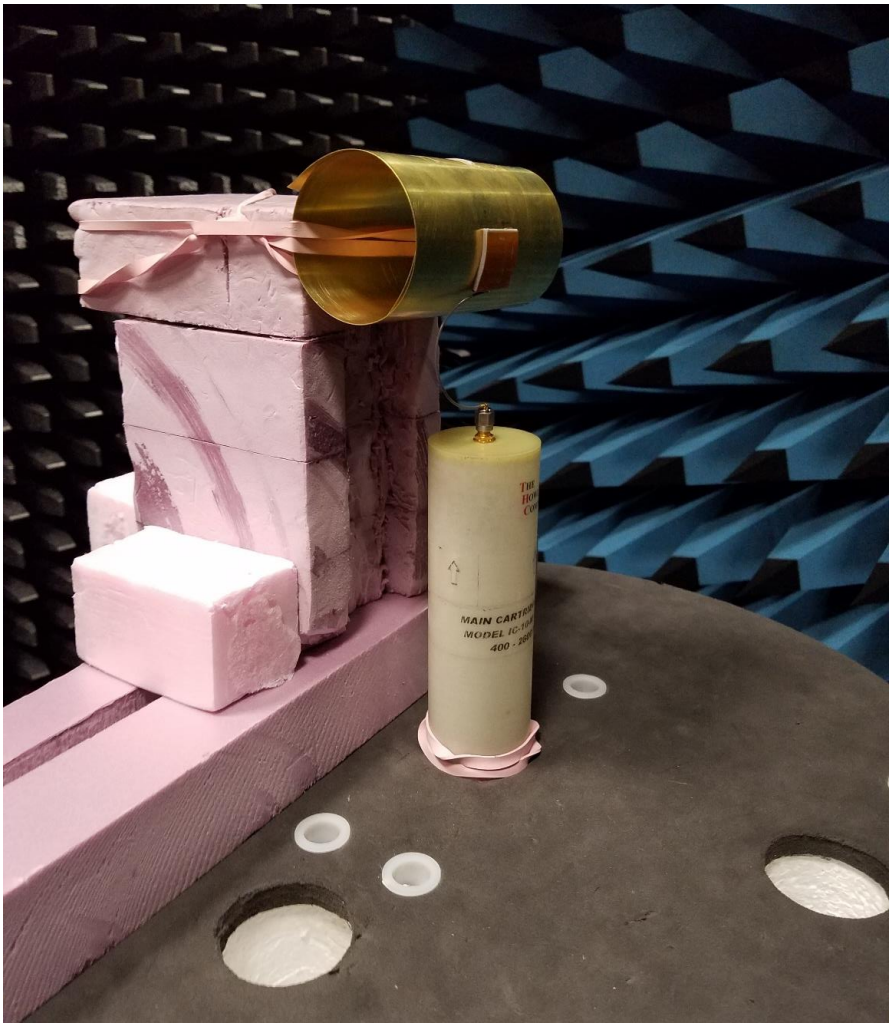

Figure 11: Convex curve setup

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8.2 Results – Curved Surface

2440 MHz

Azimuthal Conical Cuts at 2440 MHz

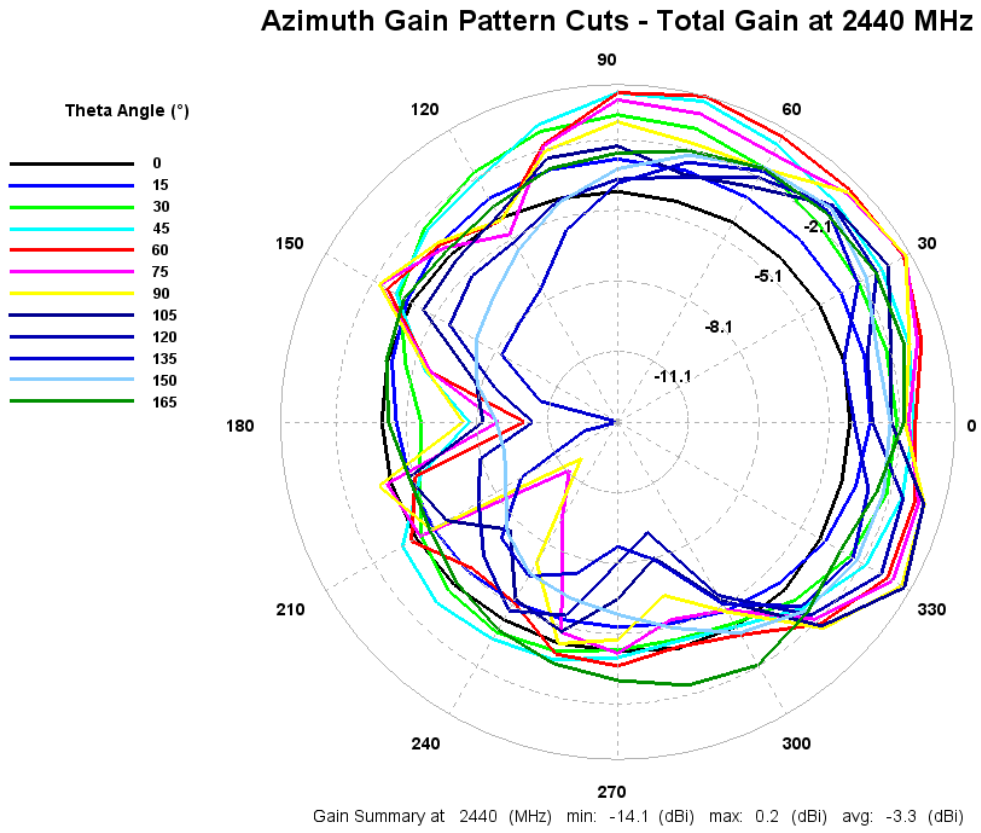

Figure 12: Total gain pattern – 2440 MHz

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3D Plots at 2440 MHz

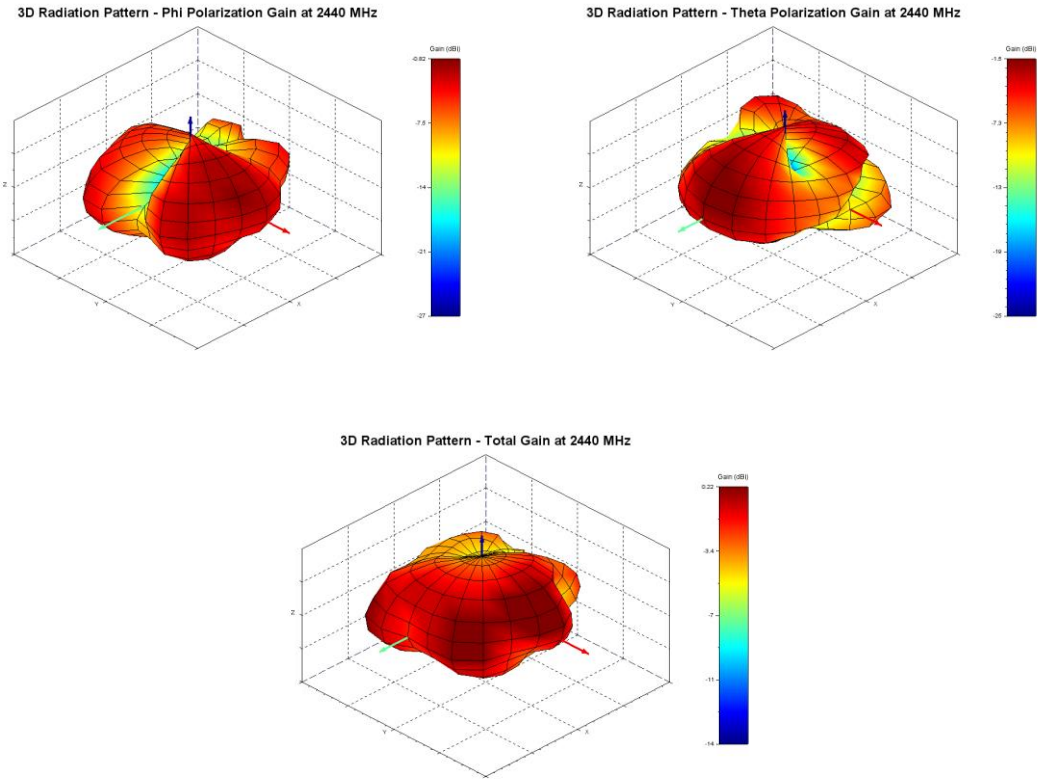

Figure 13: Phi, theta, and total gain plots – 2440 MHz

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9 Optimal Installation Guide

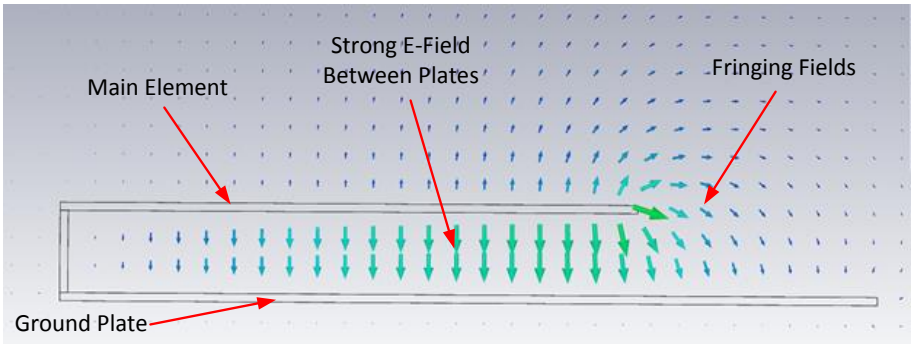

Figure 14: E-field radiation from the FlexPIFA. Taken from CST simulation

Keep the main element clear of any non-metal objects (such as plastics) on top of it by at least three millimeters (see Figure 15).

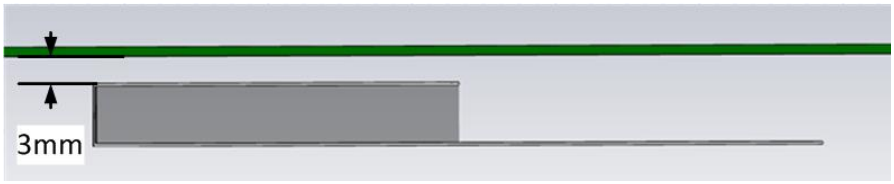

Figure 15: Top clearance

Similarly, keep the two long sides of the mFlexPIFA clear of any non-metal objects by at least two millimeters (see Figure 16). For metal objects, the top side of the mFlex should be kept clear by at least two millimeters and the bottom side of the mFlex at least 12 millimeters (see Figure 17).

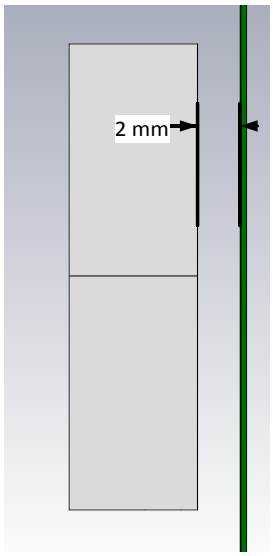

Figure 16: Non-metal side clearance

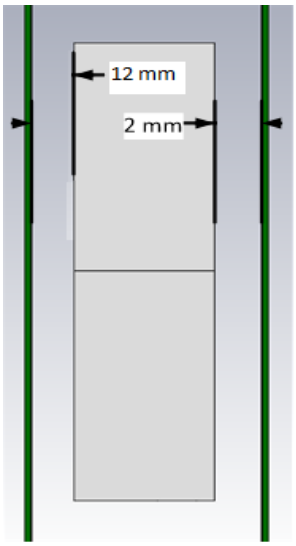

Figure 17: Metal side clearance

A one-millimeter clearance should be observed from the ground wall to any non-metal object (Figure 18). A 15-millimeter clearance should be observed for metal objects (Figure 19).

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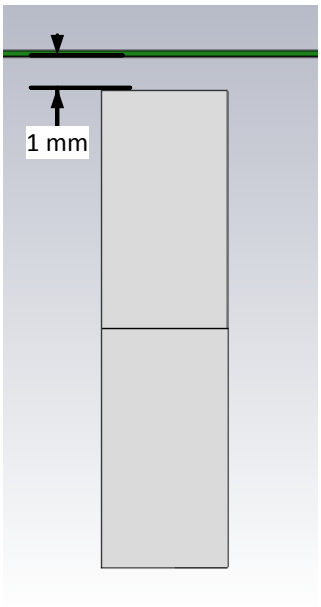

Figure 18: Non-metal ground wall clearance

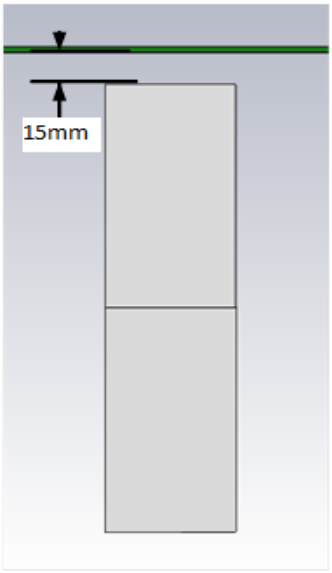

Figure 19: Metal ground wall clearance

Important! Mounting the mFlexPIFA in a situation that does not allow for these clearance recommendations may change the gain characteristics stated in the datasheet, which could impact overall range of the wireless system.

The ideal material for the mFlexPIFA to be mounted on (for maximum performance) is brass. However, as previously mentioned, the mFlexPIFA can tolerate other metallic surfaces and thicknesses and still radiate effectively. Depending on the type of material, the mFlexPIFA may be detuned.

The coaxial cable feeding the mFlexPIFA should be routed away from the antenna. Do not run the coaxial cable over the top of the mFlexPIFA or near the tip of the main element. The cable should be routed perpendicular to the side of the mFlexPIFA (this is the way the cable comes assembled) or away from the ground wall. These options are shown in Figure 20.

Perpendicular to the Side

Away from the Ground Wall

Figure 20: Recommended cable routing

As with any antenna, do not place objects near the antenna (except as described in the next section). Other objects, such as an LCD display, placed near the antenna may not affect its tuning but can distort the radiation pattern. Materials that absorb electromagnetic fields should be kept away from the antenna to maximize performance.

The following are some common things to keep in mind when placing the antenna:

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- Wire routing
- Speakers – These generate magnetic fields
- Battery location
- Proximity to human body
- Display screen – These absorb radiation

9.1 Flex Limits of the mFlexPIFA

One of the unique features of the mFlexPIFA is its ability to flex. However, due to the adhesive, there are limits to how much the antenna can be flexed and still remain secured to the device. The mFlexPIFA should not be flexed in a convex position with a radius less than 60 millimeters. Going smaller than this may result in the antenna peeling off the surface over time. Should a tighter radius of curvature be required, we recommend that you contact Laird/LSR Design Services for assistance.

Figure 21: Convex mounted

We do not recommend mounting the mFlexPIFA in a metal-enclosed concave position. In this scenario, the limiting factor is performance. The ground plate of the antenna is pressed closer to the main element. The fringing fields developing off the end of the element are responsible for most of the radiation. In a concave position, the fringing fields are adversely affected and gain suffers. This can also potentially create a Faraday's cage and cancel most of the RF radiation from the antenna.

If a concave position is required, we recommend that you contact Laird/LSR Design Services for assistance.

Note:	The mFlexPIFA is not designed to be twisted or crumpled. The adhesive back should lay flush with the surface on which it is mounted.

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10 Product Revision History

Rev 1: Initial Production Release

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