Application Report
SWRA496A–March 2016–Revised October 2017

CC-Antenna-DK2 and Antenna Measurements Summary

Richard Wallace

ABSTRACT

The purpose of the antenna development kit (CC-Antenna-DK2) is to ease the decision of which type of low-cost antenna can be implemented as well as give an estimation of the performance that can be achieved.

Contents

1 Introduction 13
2 CC-Antenna-DK2 13
3 Conclusion 51
4 References 52
Appendix A CTIA Measurement Reports 53

List of Figures

1 CC-Antenna-DK2 Panel 14
2 CC-Antenna-DK2 Board Showing Metal Layers, Solder Paste, Silkscreen and v-Cut 14
3 Top Metal Layer and Contour 15
4 Bottom Metal Layer and Contour 15
5 JSC-JS Cable (MXJA01JA1200) Provided With the CC-Antenna-DK2 15
6 JSC-SMA Low-Cost Cable Provided With the CC-Antenna-DK2 16
7 Insertion Loss of MXFR01JA3000 Low-Cost Cable 16
8 CC-Antenna-DK2 Board #9 Connected to a CC1350 SensorTag Rev 1.3.x 16
9 Connecting to a Launchpad 16
10 Board #1 – CR2032 Dual-Band 868 MHz and 2.4 GHz PCB Antenna 17
11 Impedance Measurement With No Matching Components 18
12 SWR Measurements of Board #1 - Single-Band Configuration 2.4 GHz 19
13 SWR Measurements of Board #1 - Dual-Band Configuration 868 MHz and 2.4 GHz 20
14 Board #2 – Compact 2.4 GHz PCB Antenna 21
15 Impedance and SWR Measurement With No Matching Components 21
16 Board #3 - Fractus Dual-Band 868 MHz and 2.4 GHz Chip Antenna 22
17 SWR Measurements of Board #3 23
18 Board #4: 433-510 MHz PCB Antenna 24
19 Impedance Measurement With No Matching Components 24
20 SWR Measurements of Board #4 - Single-Band Configuration 433 MHz 25
21 SWR Measurements of Board #4 - Single-Band Configuration 470-510 MHz 26
22 Board #5: 2.4 GHz Antenna Diversity 27
23 Impedance Measurement With No Matching Components 27
24 5A - SWR Measurements 27
25 Impedance Measurement With No Matching Components 28
26 5B - SWR Measurements 28
27 Board #6: Compact PCB Antenna 29

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2.1.2 Board #2: Compact 2.4 GHz PCB Antenna

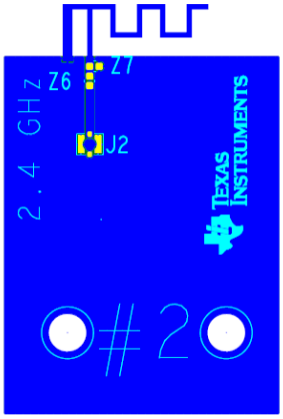

Figure 14. Board #2 – Compact 2.4 GHz PCB Antenna

Table 6. PCB Size and BOM for Board #2

Size	Width (mm)	Height (mm)
PCB Board	35	44
GND	26	34
Reference Designator	**Part Number**	**Value**
Z6	RK73Z1ETTP	0 Ω
Z7	DNM	—

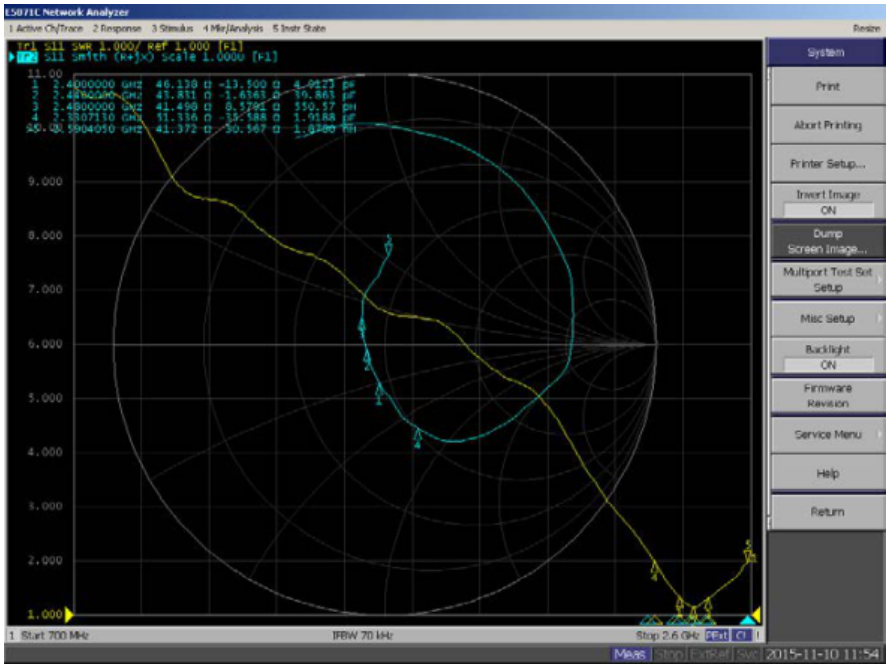

Figure 15. Impedance and SWR Measurement With No Matching Components

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A.2 Board #2: Compact 2.4 GHz PCB Antenna

A.2.1 2.40 GHz

Table 64. Board #2: OTA Evaluation Results (2.40 GHz)

Test Description	Test Result
Total Radiated Power	–1.96 dBm
Peak EIRP	2.67 dBm
Directivity	4.63 dBi
Efficiency	-1.96 dB
Efficiency	63.62 %
Peak Gain	2.67 dBi
NHPRP 45°	-3.81 dBm
NHPRP 45°/TRP	-1.85 dB
NHPRP 45°/TRP	65.30%
NHPRP 30°	-5.64 dBm
NHPRP 30°/TRP	-3.68 dB
NHPRP 30°/TRP	42.89%
NHPRP 22.5°	-6.91 dBm
NHPRP 22.5°/TRP	-4.95 dB
NHPRP 22.5°/TRP	32.00%
UHRP	-5.36 dBm
UHRP/TRP	-3.40 dB
UHRP/TRP	45.75%
LHRP	-4.62 dBm
LHRP/TRP	-2.66 dB
LHRP /TRP	54.25%
PGRP (0-120°)	-3.63 dBm
PGRP/TRP	-1.67 dB
PGRP/TRP	68.15%
Front/Back Ratio	4.81
PhiBW	91.1°
PhiBW Up	40.6°
PhiBW Down	50.6°
ThetaBW	30.3°
ThetaBW Up	13.8°
ThetaBW Down	16.5°
Boresight Phi	105°
Boresight Theta	150°
Maximum Power	2.67 dBm
Minimum Power	-12.21 dBm
Average Power	-1.78 dBm
Max/Min Ratio	14.88 dB
Max/Avg Ratio	4.44 dB
Min/Avg Ratio	-10.43 dB
Worst Single Value	-21.64 dBm
Worst Position	Azi = 255°; Elev = 105°; Pol = Horizontal
Best Single Value	2.23 dBm
Best Position	Azi = 0°; Elev = 135°; Pol = Vertical

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Table 65. Board #2: RP_2400.000_tot

Azimuth (°)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	-2.5	-0.68	-0.38	1.07	-0.99	-0.34	-0.22	-0.4	0.48	2.56	-1.49	-3.14	-1.66
15	-2.55	-0.78	0.25	0.38	-0.84	-2.53	-0.75	0.26	1.51	0.27	-1.64	-4	-2.28
30	-2.19	-0.99	0.08	-2.92	-1.64	-2	-2.55	-1	0.85	-2.25	-0.41	-4.67	-2.79
45	-1.89	-1.32	-2.06	-5.25	-5.92	-1.14	-0.15	-2.27	-4.67	1.22	-0.87	-3.81	-3.05
60	-1.99	-1.95	-4.15	-4.6	-4.77	-3.27	-1.14	-0.9	-2.2	1.6	-0.02	-2.48	-2.25
75	-2.05	-2.26	-4.2	-3.84	-1.9	-2.25	-4.79	-3.83	-0.83	0.28	1.55	-0.89	-1.7
90	-1.59	-2.37	-3.1	-3.37	-1.13	-1.98	-6.72	-10.4	-3.47	0.09	2.34	-0.29	-1.9
105	-1.57	-2.75	-2.13	-2.23	-1.44	-3.71	-7.59	-6.77	-5.35	0.21	2.67	-0.59	-1.78
120	-1.84	-3.35	-1.85	-1.68	-2.06	-4.25	-4.72	-3.15	-3.19	-0.19	2.36	-0.92	-1.16
135	-1.85	-3.23	-1.37	-1.32	-2.55	-3.47	-1.25	-0.55	-1.73	-1.11	1.04	-1.54	-1.1
150	-1.65	-2.82	-0.76	-0.81	-3.24	-3.58	-0.05	1.12	-1.4	-0.86	-0.91	-2.73	-1.27
165	-1.3	-2.12	-0.25	-0.4	-2.42	-5.47	-1.98	0.92	-3.48	0.41	-0.69	-4.1	-1.56
180	-1.36	-1.84	0.05	0.03	-0.21	-4.32	-4.97	-3.04	-4.11	-1.23	0.29	-4.61	-1.64
195	-1.98	-2.41	-0.7	-0.02	0.13	-2.6	-1.62	-3.47	-7.52	-8.79	-1.98	-4.17	-1.81
210	-2.29	-3.57	-2.15	-1.8	-1.31	-1.94	-1.2	-2.95	-7.6	-5.16	-7.24	-3.48	-2.37
225	-2.28	-4.34	-3.46	-6.77	-3.45	-4.22	-6.28	-6.83	-4.15	-2.95	-4.24	-3.82	-2.76
240	-2.35	-3.72	-3.81	-10.56	-5.55	-9.93	-8.66	-9.89	-6.3	-3.67	-1.41	-4.81	-2.22
255	-2.47	-3.06	-3.62	-9.29	-10.87	-7.9	-6.08	-8.95	-7.68	-4.53	-0.57	-5.35	-1.2
270	-2.89	-3.12	-3.26	-7.16	-12.21	-7.97	-8.29	-4.86	-2.51	-3.63	-0.64	-6.39	-0.71
285	-2.9	-2.97	-2.15	-4.74	-6.66	-9.42	-10.24	-4.57	-0.13	-1.36	-0.29	-6.3	-0.35
300	-2.26	-2.23	-0.83	-3.02	-3.19	-5.64	-6.22	-4.43	0.51	-0.15	0.54	-5.69	-0.28
315	-2.64	-1.47	0.26	-1.24	-0.66	-2.24	-2	-4.15	0.54	0.4	1.49	-5.31	-0.53
330	-2.59	-0.67	0.46	-0.82	1.08	-1.63	-0.4	-3.03	0.23	0.16	1.92	-4.43	-1.02
345	-2.64	-0.59	-0.17	-0.66	1.52	-1	-0.87	-1.99	0.67	0.87	1.18	-4.25	-1.39
360	-2.5	-0.68	-0.38	1.07	-0.99	-0.34	-0.22	-0.4	0.48	2.56	-1.49	-3.14	-1.66

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Table 66. Board #2: RP_2400.000_hor

Azimuth (°)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	-11.9	-12.18	-11.87	-14.98	-11.88	-15.6	-9.79	-9.21	-9.63	-8.75	-12.13	-15.08	-12.39
15	-7.9	-7.5	-10.68	-12.87	-14.55	-20.21	-14.17	-10.14	-7.36	-12.59	-9.27	-17.29	-8.81
30	-4.97	-5.24	-9.21	-14.34	-21.06	-14.65	-17.64	-15.47	-8.91	-10.17	-8.3	-8.5	-6.13
45	-3.2	-4.03	-7.4	-13.26	-13.73	-10.45	-10.76	-15.34	-12.3	-7.82	-4.39	-4.44	-3.93
60	-2.41	-3.63	-5.99	-8.23	-7.72	-9.42	-6.68	-13.49	-7.76	-4.51	-0.51	-2.57	-2.52
75	-2.18	-3.03	-4.47	-4.94	-3.42	-7.28	-11.15	-18.53	-6.27	-1.3	1.49	-1.38	-2.06
90	-2.19	-2.84	-3.41	-3.96	-2.37	-5.99	-13.97	-15.35	-6.82	0.01	1.88	-1.65	-2.6
105	-3.24	-3.7	-3.71	-4	-3.22	-6.95	-13.28	-17.4	-8.33	-0.43	1.25	-3.54	-3.73
120	-5.71	-5.68	-4.8	-5.23	-5.08	-9.64	-11.82	-14.26	-12.47	-2.37	-0.35	-6.35	-5.07
135	-8.92	-9.87	-6.3	-6.82	-8.25	-15.24	-9.39	-13.65	-20.01	-7.31	-3.74	-11.38	-7.14
150	-12.48	-17.16	-8.64	-8.25	-10.35	-14.99	-9.27	-13.78	-9.8	-13.87	-9.05	-17.63	-10.04
165	-19.23	-14.18	-13.95	-11.89	-9.85	-11.23	-11.51	-12.85	-9.45	-12.97	-10.7	-13.56	-13.8
180	-13.53	-8.92	-10.99	-9.61	-12.85	-10.05	-9.79	-13.04	-11.45	-17.7	-8.6	-10.28	-11.13
195	-9.01	-6.46	-5.2	-5.57	-10.58	-10.63	-11.9	-8.75	-13.39	-13.06	-9.48	-8.66	-6.93
210	-6.23	-6.02	-3.39	-5.29	-4.42	-8.11	-17.14	-9.7	-13.08	-7.64	-11.71	-7.69	-4.85
225	-4.19	-5.9	-3.9	-7.61	-3.76	-8.11	-13.2	-12.62	-7.71	-6.59	-6.81	-7.35	-3.7
240	-3.15	-4.96	-5.46	-11.92	-7.12	-11.08	-10.36	-13.93	-7.34	-5.82	-2.87	-7.05	-2.87
255	-2.67	-3.91	-5.66	-12.86	-16.41	-12.98	-10.6	-21.64	-14.7	-5.34	-0.97	-6.59	-2.26
270	-3.37	-3.66	-4.31	-9.71	-16.49	-14.9	-12.05	-12.98	-15.71	-5.75	-0.73	-7.09	-2.51
285	-4.41	-3.6	-3.24	-8.39	-13.16	-15.51	-12.65	-10.25	-10.06	-7.81	-1.51	-6.79	-3.31
300	-5.02	-3.68	-3.1	-9.44	-13.7	-16.45	-11.39	-9.26	-7.7	-11.05	-3.15	-6.69	-4.38
315	-7.33	-5.54	-5.09	-13.94	-14.88	-15.46	-10.78	-9.86	-6.87	-15.35	-5.35	-7.07	-6.76
330	-10.94	-9.08	-8.58	-20.15	-16.44	-11.66	-9.53	-10.4	-6.86	-14.51	-8.64	-6.37	-10.67
345	-18.91	-13.78	-14.44	-19.62	-16.03	-11.53	-6.68	-10.26	-7.98	-10.79	-17.66	-7.33	-16.81
360	-11.9	-12.18	-11.87	-14.98	-11.88	-15.6	-9.79	-9.21	-9.63	-8.75	-12.13	-15.08	-12.39

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Table 67. Board #2: RP_2400.000_ver

Azimuth (deg)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	-3.03	-1	-0.7	0.96	-1.36	-0.47	-0.73	-1.02	0.04	2.23	-1.88	-3.43	-2.04
15	-4.05	-1.82	-0.11	0.17	-1.03	-2.6	-0.96	-0.16	0.91	0.03	-2.46	-4.2	-3.37
30	-5.44	-3.03	-0.46	-3.24	-1.69	-2.24	-2.69	-1.16	0.36	-3.02	-1.19	-6.99	-5.5
45	-7.76	-4.65	-3.56	-6	-6.7	-1.68	-0.55	-2.49	-5.49	0.65	-3.43	-12.48	-10.4
60	-12.34	-6.88	-8.76	-7.07	-7.83	-4.48	-2.56	-1.14	-3.61	0.38	-9.71	-19.31	-14.45
75	-17.44	-10.14	-16.4	-10.32	-7.21	-3.89	-5.94	-3.98	-2.29	-4.89	-17.19	-10.63	-12.68
90	-10.47	-12.34	-14.75	-12.33	-7.21	-4.18	-7.63	-12.07	-6.16	-17.23	-7.67	-5.97	-10.13
105	-6.53	-9.81	-7.27	-6.96	-6.17	-6.5	-8.95	-7.16	-8.4	-8.4	-2.88	-3.65	-6.19
120	-4.13	-7.16	-4.92	-4.21	-5.06	-5.73	-5.67	-3.5	-3.74	-4.22	-0.96	-2.39	-3.42
135	-2.8	-4.29	-3.06	-2.75	-3.92	-3.76	-1.97	-0.77	-1.79	-2.3	-0.72	-2.01	-2.34
150	-2.02	-2.98	-1.53	-1.67	-4.18	-3.9	-0.61	0.98	-2.07	-1.08	-1.64	-2.88	-1.89
165	-1.37	-2.4	-0.44	-0.72	-3.29	-6.81	-2.49	0.74	-4.75	0.2	-1.14	-4.62	-1.83
180	-1.63	-2.79	-0.3	-0.47	-0.45	-5.67	-6.7	-3.5	-5	-1.33	-0.31	-5.98	-2.16
195	-2.94	-4.59	-2.61	-1.44	-0.25	-3.34	-2.05	-5	-8.82	-10.82	-2.83	-6.07	-3.41
210	-4.53	-7.23	-8.2	-4.37	-4.22	-3.13	-1.31	-3.99	-9.04	-8.78	-9.16	-5.56	-5.98
225	-6.77	-9.54	-13.55	-14.33	-15.07	-6.51	-7.27	-8.16	-6.68	-5.41	-7.74	-6.37	-9.85
240	-10.12	-9.78	-8.82	-16.27	-10.73	-16.26	-13.57	-12.07	-13.01	-7.75	-6.87	-8.76	-10.83
255	-15.86	-10.56	-7.89	-11.81	-12.29	-9.51	-7.98	-9.19	-8.64	-12.22	-11.2	-11.39	-7.86
270	-12.65	-12.4	-9.96	-10.69	-14.24	-8.96	-10.66	-5.59	-2.73	-7.76	-17.34	-14.63	-5.42
285	-8.22	-11.69	-8.68	-7.19	-7.77	-10.64	-13.95	-5.93	-0.6	-2.48	-6.42	-15.99	-3.4
300	-5.54	-7.72	-4.75	-4.14	-3.59	-6.02	-7.79	-6.16	-0.2	-0.51	-1.88	-12.54	-2.41
315	-4.45	-3.63	-1.24	-1.48	-0.83	-2.46	-2.61	-5.51	-0.33	0.28	0.48	-10.09	-1.72
330	-3.27	-1.35	-0.12	-0.87	1	-2.08	-0.96	-3.9	-0.72	0.01	1.53	-8.87	-1.52
345	-2.75	-0.8	-0.34	-0.72	1.44	-1.4	-2.19	-2.69	0.04	0.56	1.12	-7.19	-1.52
360	-3.03	-1	-0.7	0.96	-1.36	-0.47	-0.73	-1.02	0.04	2.23	-1.88	-3.43	-2.04

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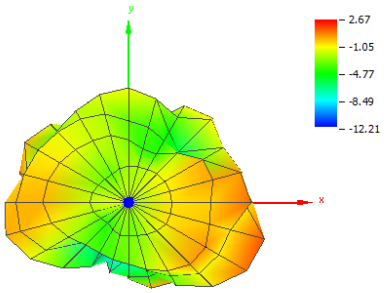

Figure 100. Board #2 (2.40 GHz): Theta = 0, Phi = 0

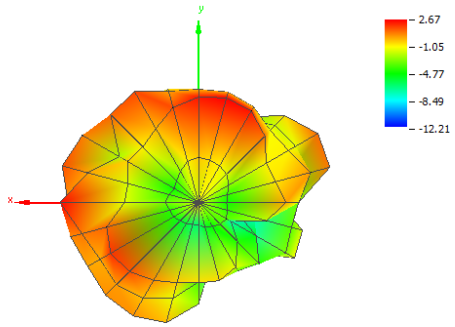

Figure 101. Board #2 (2.40 GHz): Theta = 180, Phi = 0

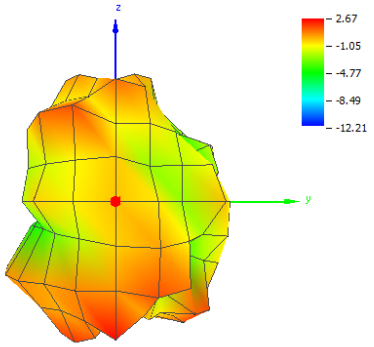

Figure 102. Board #2 (2.40 GHz): Theta = 90, Phi = 0

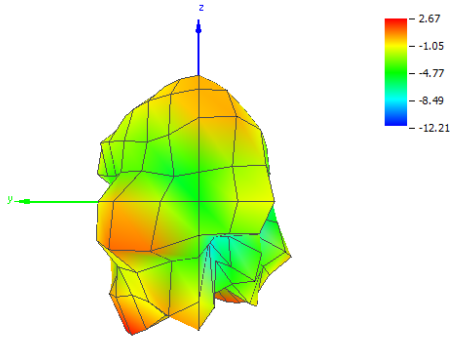

Figure 103. Board #2 (2.40 GHz): Theta = 90, Phi = 180

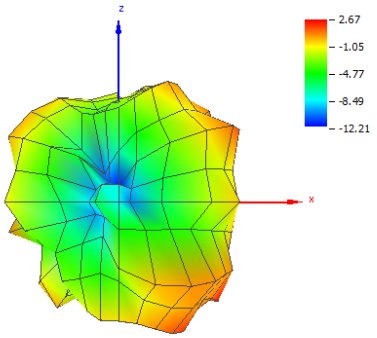

Figure 104. Board #2 (2.40 GHz): Theta = 90, Phi = 270

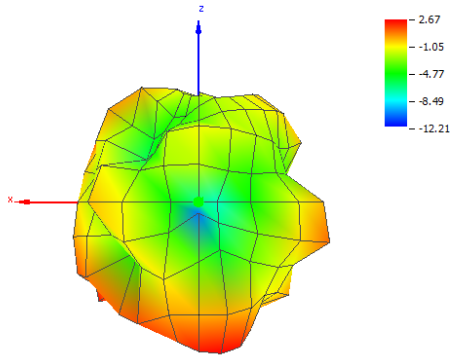

Figure 105. Board #2 (2.40 GHz): Theta = 90, Phi = 90

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A.2.2 2.44 GHz

Table 68. Board #2: OTA Evaluation Results (2.44 GHz)

Test Description	Test Result
Total Radiated Power	-2.06 dBm
Peak EIRP	2.78 dBm
Directivity	4.84 dBi
Efficiency	-2.06 dB
Efficiency	62.30 %
Peak Gain	2.78 dBi
NHPRP 45°	-4.02 dBm
NHPRP 45° / TRP	-1.96 dB
NHPRP 45° / TRP	63.68 %
NHPRP 30°	-5.85 dBm
NHPRP 30° / TRP	-3.80 dB
NHPRP 30° / TRP	41.71 %
NHPRP 22.5°	-7.15 dBm
NHPRP 22.5° / TRP	-5.09 dB
NHPRP 22.5° / TRP	30.97 %
UHRP	-5.52 dBm
UHRP / TRP	-3.47 dB
UHRP / TRP	45.03 %
LHRP	-4.65 dBm
LHRP / TRP	-2.60 dB
LHRP / TRP	54.97 %
PGRP (0-120°)	-3.80 dBm
PGRP / TRP	-1.74 dB
PGRP / TRP	66.93 %
Front/Back Ratio	7.63
PhiBW	121.5°
PhiBW Up	44.7°
PhiBW Down	76.8°
ThetaBW	43.3°
ThetaBW Up	29.8°
ThetaBW Down	13.6°
Boresight Phi	105°
Boresight Theta	150°
Maximum Power	2.78 dBm
Minimum Power	-14.52 dBm
Average Power	-1.66 dBm
Max/Min Ratio	17.30 dB
Max/Avg Ratio	4.44 dB
Min/Avg Ratio	-12.86 dB
Worst Single Value	-21.71 dBm
Worst Position	Azi = 270°; Elev = 60°; Pol = Horizontal
Best Single Value	2.13 dBm
Best Position	Azi = 90°; Elev = 150°; Pol = Horizontal

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Table 69. Board #2: RP_2440.000_tot

Azimuth (°)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	-1.86	-0.49	0.34	-0.59	-1.22	-0.73	-1.31	-2.79	-0.13	0.74	-1.68	-3.42	-1.74
15	-1.1	-0.49	-0.36	-0.85	-2.32	-3.69	-1.83	-1.46	-0.26	-1.59	-2.78	-2.69	-0.86
30	-0.57	-1.11	-0.43	-2.28	-1.8	-5.6	-4.21	-2.28	0.86	-5.91	0.14	-1.54	0
45	-0.61	-2.06	-0.64	-3.95	-2.39	-1.79	0.47	-2.79	-3.02	-0.5	1.35	-0.95	0.33
60	-1.16	-2.58	-1.52	-3.96	-3.36	-4	-1.47	0.66	-2.76	1.93	1.18	-0.79	0.69
75	-1.36	-3.04	-2.75	-3.19	-1.89	-3.6	-5.66	-1.29	-1.1	1.36	1.65	-0.58	0.13
90	-1.32	-3.67	-3.04	-2.24	-0.82	-3.28	-6.19	-7.42	-3.86	0.29	2.46	0	-0.51
105	-1.32	-4.1	-2.19	-1.72	-0.3	-3.89	-6.39	-10.85	-7.06	-0.54	2.78	0.26	-0.23
120	-0.74	-2.74	-1.22	-1.37	-0.21	-3.87	-4.48	-6.48	-5.73	-1.59	2.17	-0.21	-0.12
135	0.14	-1.68	-0.48	-0.48	-1.38	-3.37	-2.1	-1.5	-2.08	-1.78	0.78	-1.34	-0.45
150	0.35	-1.49	0.17	0.01	-2.34	-4.5	-1.8	0.63	-1.14	0.26	-0.24	-2.3	-0.66
165	-0.14	-1.37	0.01	0.65	-0.56	-5.51	-4.88	0.31	-2.82	1.04	0.41	-2.63	-0.29
180	-1.1	-1.9	-1.21	0.95	0.78	-3.34	-7	-5.56	-3.74	-2.36	0.02	-2.79	0.27
195	-2.02	-3.3	-2.92	-0.31	-0.65	-1.78	-1.37	-3.92	-8.37	-12.15	-3.74	-2.74	-0.36
210	-2.39	-3.95	-4.67	-3.64	-4.49	-3.12	-2.49	-2.26	-5.1	-4.04	-6.3	-2.98	-1.41
225	-2.79	-3.59	-5.41	-8.52	-5.87	-6.14	-9.92	-6.2	-2.75	-4.43	-1.99	-4.23	-1.38
240	-2.8	-3.28	-5.83	-6.47	-8.17	-5.48	-9.58	-11.13	-7.22	-4.5	0.04	-4.85	-1.07
255	-2.45	-2.79	-6.18	-5.83	-13.59	-6.61	-7.86	-10.24	-4.63	-2.7	0.39	-5.58	-0.67
270	-2.16	-2.05	-5.75	-6.76	-14.52	-7.6	-8.54	-4	-0.82	-1.89	0.51	-6.38	-0.46
285	-2.17	-2.07	-4.85	-5.59	-7.4	-8.09	-7.41	-2.32	0.49	-1.35	0.71	-7.15	-0.31
300	-2.55	-1.82	-2.58	-2.59	-4.68	-4.05	-4.34	-2.6	0.59	-0.94	1.22	-6.03	-0.01
315	-2.19	-1.18	-0.87	-1.49	-3.16	-0.83	-1.53	-2.52	0.28	-0.86	1.9	-4.55	0.02
330	-2.33	-1.03	0.18	-1.47	-1.43	-0.23	0.38	-2.78	0.19	-0.29	2.5	-3.58	-0.1
345	-2.66	-0.6	0.49	-1.71	0.01	-1.4	0.07	-1.85	0.8	0.15	2.21	-3.62	-0.73
360	-1.86	-0.49	0.34	-0.59	-1.22	-0.73	-1.31	-2.79	-0.13	0.74	-1.68	-3.42	-1.74

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Table 70. Board #2: RP_2440.000_hor

Azimuth (°)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	-10.99	-10.89	-10.33	-13.56	-10.94	-21.57	-10.78	-10.06	-10.04	-9.92	-13.64	-15.08	-12.31
15	-6.62	-6.88	-8.61	-11.39	-11.02	-18.3	-14.62	-9.8	-9.11	-13.17	-11.27	-16.67	-8.14
30	-3.57	-5.36	-8.03	-9.43	-17.2	-16.17	-15.26	-11.56	-9.72	-10.99	-8.84	-7.65	-3.92
45	-2.36	-4.86	-7	-9.41	-12.06	-13.79	-9.06	-9.56	-13.61	-7.56	-4.24	-3.48	-1.43
60	-1.88	-4.22	-5.07	-6.74	-6.75	-11.77	-10.06	-12.64	-8.77	-4.2	-0.29	-1.48	-0.35
75	-1.46	-3.73	-3.59	-3.8	-3.41	-8.41	-11.43	-17.22	-6.23	-1.06	1.59	-0.67	-0.5
90	-1.66	-4.2	-3.25	-2.91	-2.14	-7.16	-10.67	-12.26	-6.53	0.08	2.13	-0.93	-0.97
105	-2.7	-5.81	-3.32	-3.56	-2.44	-8.69	-12.83	-12.23	-8.35	-0.75	1.65	-2.07	-1.14
120	-4.2	-7.69	-3.97	-5.6	-4.41	-13.64	-16.13	-13.57	-14.02	-3.08	0.1	-4.14	-2.02
135	-6.36	-11.14	-5.92	-7	-9.57	-17.43	-13.96	-14.12	-14.09	-9.02	-3.21	-7.52	-3.82
150	-10.17	-19.52	-9.21	-8.51	-11.43	-12.17	-9.71	-12.97	-7.6	-20.12	-8.57	-14.51	-6.82
165	-15.82	-14.63	-11.12	-9.24	-9.27	-10.96	-10.09	-11.25	-7.16	-13.55	-11.97	-16.95	-10.38
180	-15.56	-9.46	-8.4	-6.73	-9.55	-11.08	-13.77	-12.29	-12.58	-16.59	-9.06	-10.7	-10.47
195	-11.32	-7.81	-5.66	-4.4	-7.78	-9.71	-10.95	-8.42	-15.01	-13.45	-9.2	-7.92	-7.96
210	-7.88	-6.96	-5.47	-4.99	-6.03	-7.75	-11.51	-10.02	-13.3	-7.88	-9.24	-6.97	-5.36
225	-5.39	-5.87	-7.85	-9.16	-6.21	-7.4	-17.22	-13.53	-8.45	-7.45	-4.94	-7.34	-3.14
240	-3.68	-4.57	-9.97	-15.24	-10.09	-9.52	-10.81	-16.23	-8.52	-5.83	-1.63	-7.71	-2
255	-2.64	-3.21	-7.99	-11.35	-17.36	-11.97	-8.98	-19.49	-12.12	-4.18	0.03	-7.49	-1.35
270	-2.45	-2.2	-6.06	-8.9	-21.71	-10.27	-9.21	-10.54	-12.47	-4.27	0.27	-6.87	-1.33
285	-3.15	-2.77	-6.09	-8.94	-20.44	-10.27	-8.42	-6.57	-8.93	-6.09	-0.37	-7.61	-2.38
300	-5.31	-4.2	-6.81	-9.86	-19.35	-9.41	-7.55	-5.4	-6.54	-9.23	-1.28	-7.48	-4.09
315	-7.15	-5.78	-7.79	-12.39	-19.96	-9.11	-6.69	-5.29	-6.09	-13.25	-3.31	-8	-6.61
330	-10.58	-10.47	-13.88	-17.17	-20.62	-9.59	-6.13	-7.66	-7.02	-15.15	-6.67	-8.45	-9.25
345	-17.38	-18.14	-19.73	-17.48	-17.95	-11.28	-6.3	-9.28	-8.29	-11.52	-14.78	-8.63	-12.73
360	-10.99	-10.89	-10.33	-13.56	-10.94	-21.57	-10.78	-10.06	-10.04	-9.92	-13.64	-15.08	-12.31

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Table 71. Board #2: RP_2440.000_ver

Azimuth (°)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	-2.43	-0.9	-0.04	-0.81	-1.71	-0.76	-1.83	-3.69	-0.59	0.35	-1.97	-3.72	-2.14
15	-2.53	-1.62	-1.06	-1.25	-2.95	-3.84	-2.07	-2.15	-0.87	-1.9	-3.44	-2.87	-1.77
30	-3.6	-3.15	-1.26	-3.21	-1.92	-5.99	-4.56	-2.82	0.46	-7.52	-0.45	-2.76	-2.25
45	-5.41	-5.28	-1.78	-5.41	-2.88	-2.08	-0.05	-3.82	-3.42	-1.45	-0.06	-4.51	-4.43
60	-9.31	-7.6	-4.04	-7.21	-6.01	-4.79	-2.11	0.45	-4.01	0.71	-4.22	-9.16	-6.02
75	-17.76	-11.36	-10.34	-12.02	-7.21	-5.35	-7	-1.4	-2.69	-2.34	-16.77	-17.63	-8.54
90	-12.6	-13.12	-16.32	-10.74	-6.63	-5.56	-8.1	-9.16	-7.24	-12.91	-8.89	-7.12	-10.53
105	-6.99	-8.98	-8.6	-6.34	-4.4	-5.64	-7.51	-16.49	-12.95	-13.87	-3.62	-3.56	-7.43
120	-3.34	-4.41	-4.5	-3.43	-2.29	-4.35	-4.79	-7.42	-6.42	-6.96	-2.03	-2.45	-4.61
135	-0.96	-2.2	-1.95	-1.57	-2.09	-3.54	-2.39	-1.74	-2.36	-2.68	-1.42	-2.54	-3.14
150	-0.06	-1.56	-0.37	-0.65	-2.92	-5.32	-2.57	0.44	-2.25	0.22	-0.93	-2.57	-1.87
165	-0.26	-1.58	-0.34	0.18	-1.19	-6.96	-6.43	-0.01	-4.81	0.89	0.15	-2.8	-0.73
180	-1.26	-2.74	-2.13	0.14	0.35	-4.14	-8.03	-6.6	-4.35	-2.52	-0.55	-3.56	-0.12
195	-2.57	-5.2	-6.23	-2.45	-1.59	-2.55	-1.88	-5.82	-9.44	-18.05	-5.19	-4.3	-1.19
210	-3.83	-6.95	-12.44	-9.36	-9.76	-4.96	-3.07	-3.06	-5.81	-6.36	-9.38	-5.19	-3.64
225	-6.26	-7.5	-9.08	-17.16	-17.11	-12.13	-10.82	-7.09	-4.11	-7.43	-5.07	-7.14	-6.17
240	-10.13	-9.19	-7.95	-7.09	-12.64	-7.65	-15.64	-12.74	-13.09	-10.3	-4.92	-8.01	-8.22
255	-16.09	-13.15	-10.86	-7.27	-15.96	-8.1	-14.28	-10.78	-5.48	-8.09	-10.57	-10.07	-9.04
270	-14.02	-16.99	-17.25	-10.85	-15.44	-10.97	-16.98	-5.08	-1.13	-5.64	-12.04	-16.06	-7.89
285	-9.11	-10.31	-10.89	-8.28	-7.62	-12.14	-14.24	-4.36	-0.04	-3.13	-5.86	-17.17	-4.53
300	-5.83	-5.56	-4.64	-3.49	-4.83	-5.54	-7.16	-5.83	-0.34	-1.64	-2.38	-11.5	-2.16
315	-3.87	-3.03	-1.86	-1.86	-3.25	-1.53	-3.11	-5.79	-0.86	-1.12	0.34	-7.16	-1.04
330	-3.03	-1.55	0	-1.59	-1.48	-0.77	-0.72	-4.49	-0.73	-0.43	1.94	-5.3	-0.67
345	-2.81	-0.67	0.45	-1.83	-0.06	-1.87	-1.07	-2.71	0.23	-0.16	2.12	-5.26	-1.01
360	-2.43	-0.9	-0.04	-0.81	-1.71	-0.76	-1.83	-3.69	-0.59	0.35	-1.97	-3.72	-2.14

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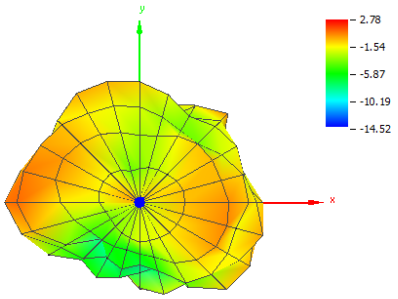

Figure 106. Board #2 (2.44 GHz): Theta = 0, Phi = 0

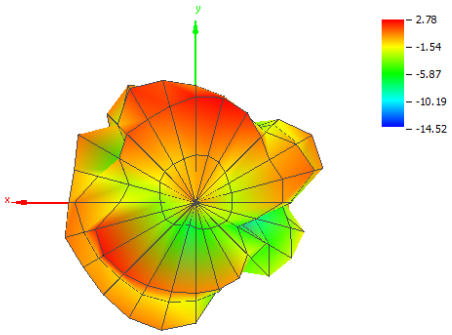

Figure 107. Board #2 (2.44 GHz): Theta = 180, Phi = 0

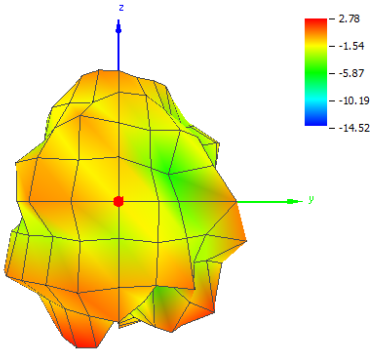

Figure 108. Board #2 (2.44 GHz): Theta = 90, Phi = 0

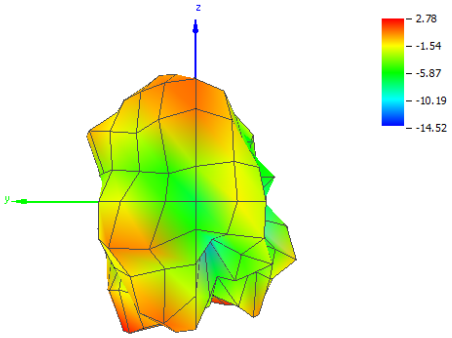

Figure 109. Board #2 (2.44 GHz): Theta = 90, Phi = 180

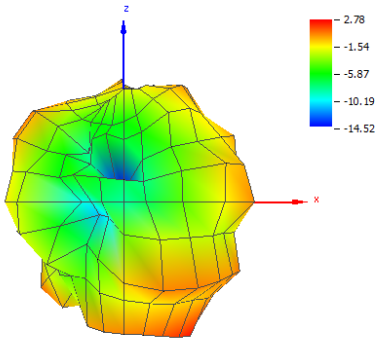

Figure 110. Board #2 (2.44 GHz): Theta = 90, Phi = 270

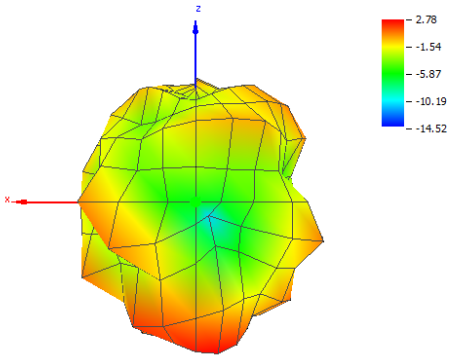

Figure 111. Board #2 (2.44 GHz): Theta = 90, Phi = 90

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A.2.3 2.48 GHz

Table 72. Board #2: OTA Evaluation Results (2.48 GHz)

Test Description	Test Result
Total Radiated Power	-1.46 dBm
Peak EIRP	3.14 dBm
Directivity	4.61 dBi
Efficiency	-1.46 dB
Efficiency	71.40 %
Peak Gain	3.14 dBi
NHPRP 45°	-3.25 dBm
NHPRP 45° / TRP	-1.79 dB
NHPRP 45° / TRP	66.24 %
NHPRP 30°	-4.94 dBm
NHPRP 30° / TRP	-3.48 dB
NHPRP 30° / TRP	44.88 %
NHPRP 22.5°	-6.14 dBm
NHPRP 22.5° / TRP	-4.68 dB
NHPRP 22.5° / TRP	34.06 %
UHRP	-4.17 dBm
UHRP / TRP	-2.71 dB
UHRP / TRP	53.56 %
LHRP	-4.79 dBm
LHRP / TRP	-3.33 dB
LHRP / TRP	46.44 %
PGRP (0-120°)	-2.75 dBm
PGRP / TRP	-1.29 dB
PGRP / TRP	74.30 %
Front/Back Ratio	3.40
PhiBW	80.0°
PhiBW Up	38.5°
PhiBW Down	41.4°
ThetaBW	90.4°
ThetaBW Up	60.4°
ThetaBW Down	30.0°
Boresight Phi	345°
Boresight Theta	30°
Maximum Power	3.14 dBm
Minimum Power	-13.65 dBm
Average Power	-1.21 dBm
Max/Min Ratio	16.79 dB
Max/Avg Ratio	4.35 dB
Min/Avg Ratio	-12.44 dB
Worst Single Value	-21.69 dBm
Worst Position	Azi = 345°; Elev = 60°; Pol = Horizontal
Best Single Value	3.12 dBm
Best Position	Azi = 345°; Elev = 30°; Pol = Vertical

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Table 73. Board #2: RP_2480.000_tot

Azimuth (°)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	0.94	0.87	1.77	0.5	1.3	0.72	-2.49	-6.52	-2.66	0.16	-1.39	-2.06	-0.56
15	0.31	0.5	0.41	1.89	-0.44	0.93	0.3	-3.91	-2.35	0.43	-2.71	-1.17	-0.37
30	-0.53	-0.58	-0.06	2.31	1.06	-3.39	-1.6	0.83	1.16	-3.61	0.09	-1.18	-0.45
45	-1.44	-1.57	-0.58	-0.16	-0.75	-1.22	0.47	-0.3	-1.64	-0.6	1.07	-2.26	-0.19
60	-2.08	-2.57	-2.75	-2.29	-4.46	-2.92	-0.11	1.62	-4.16	2.12	0.1	-2.52	-0.65
75	-1.82	-3.5	-3.77	-3.1	-3.16	-3.64	-1.91	0.66	-0.85	1.33	0.19	-2.07	-1.64
90	-2.03	-4.06	-3.66	-3.38	-0.97	-1.43	-2.57	-2.63	-1.59	0.05	1.32	-1.19	-1.06
105	-2.02	-3.37	-3.12	-2.65	0.21	-1.12	-2.12	-3.92	-3.45	-0.89	1.94	-1.03	-0.66
120	-0.79	-3.06	-1.24	-0.66	0.24	-1.43	-0.57	-0.97	-3.03	-1.03	1.52	-1.41	-0.45
135	0.42	-2.6	0.01	0.27	-0.67	-1.76	0.41	0.98	-1.47	-0.66	0.2	-2.03	-0.08
150	0.65	-1.13	0.54	1.15	-1.68	-1.99	0.33	1.08	-2.22	0.29	-0.84	-2.83	0.76
165	0.02	-0.83	0.76	2.07	0.09	-1.9	-1.72	-1.66	-3.79	-0.16	-0.26	-3.29	1.27
180	-0.36	-1.55	0.09	2.56	1.65	-1	-2.73	-8.12	-4.47	-7.38	-0.47	-4.54	0.69
195	-0.44	-2.15	-1.84	1.86	0.56	0.44	0.49	-2.69	-10.46	-8.05	-4.02	-4.7	-0.23
210	-1.19	-2.57	-3.12	-1.34	-2.7	-0.39	-2.68	-4.85	-3.47	-2.95	-6.22	-4.88	-0.88
225	-1.65	-2.93	-3.19	-5.76	-5.85	-5.56	-10.96	-8.92	-3.32	-4.7	-1.65	-5.23	-1.31
240	-1.83	-3.03	-3.42	-4.74	-10.8	-4.79	-6.28	-13.26	-7.18	-4.19	-0.18	-6.04	-1.26
255	-1.84	-3.43	-3.77	-3.14	-13.65	-4.87	-9.47	-9.24	-3.99	-2.43	-0.53	-7.23	-1.37
270	-1.79	-3.44	-2.82	-3.68	-9.11	-8.95	-10.88	-5.89	-0.97	-2.11	-0.39	-7.28	-0.8
285	-1.15	-2.59	-1.54	-3.24	-5.42	-7.49	-6.36	-4.62	-0.11	-2.74	0.27	-6.41	-0.5
300	-0.43	-2.2	-0.18	-1.61	-3.97	-3.29	-3.96	-4.74	-0.25	-2.71	1.03	-5.68	-0.26
315	0.03	-0.97	1.2	0.08	-2.72	-0.73	-2.53	-4.95	-0.54	-2.54	1.49	-5.29	-0.4
330	0.93	0.34	2.66	1.4	-1.36	1.33	-0.25	-6.21	-1.65	-2.79	1.68	-4.74	-1.02
345	1.35	1.18	3.14	1.09	0.33	1.02	0.35	-6.65	-2.42	-2.86	1.31	-3.77	-1.13
360	0.94	0.87	1.77	0.5	1.3	0.72	-2.49	-6.52	-2.66	0.16	-1.39	-2.06	-0.56

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Table 74. Board #2: RP_2480.000_hor

Azimuth (°)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	-10.89	-12.83	-10.51	-13.66	-9.52	-13.86	-10.31	-10.16	-12.09	-6.57	-12.85	-11.29	-17.12
15	-8.29	-8.35	-8.05	-11	-8.49	-14.74	-13.75	-7.35	-9.65	-7.11	-9.99	-19.9	-10.72
30	-6.26	-5.83	-6.11	-8.58	-13.28	-20.37	-15.62	-8.47	-6.45	-7.01	-9.9	-11.26	-5.78
45	-4.55	-4.28	-5.36	-8.28	-10.27	-12.66	-12.69	-9.59	-8.83	-6.36	-7.13	-6.29	-3.64
60	-2.88	-3.42	-4.73	-6.34	-7.22	-7.22	-9.69	-16.47	-8.34	-5.11	-2.62	-3.34	-2.7
75	-2	-3.69	-4.13	-4.39	-4.5	-5.67	-7.05	-15.62	-6.69	-2.61	-0.12	-2.21	-2.5
90	-2.47	-4.77	-3.99	-3.64	-2.09	-4.27	-8.43	-10.7	-7.15	-1.1	1.12	-2.16	-1.76
105	-3.73	-5.9	-4.93	-4.85	-2.15	-4.83	-10.33	-11.4	-8.13	-1.41	1.05	-2.91	-1.38
120	-4.23	-8.58	-6.22	-5.88	-4.84	-8.08	-13.09	-15.62	-13.62	-4.19	-0.93	-4.56	-2.06
135	-5.12	-13.96	-7.62	-7.34	-8.11	-18.45	-15.73	-16.49	-14.51	-10.31	-5.25	-7.24	-3.88
150	-8.44	-21.41	-10.59	-11.08	-10.55	-11.47	-12.78	-13.08	-8.6	-18.04	-12.29	-11.46	-7.06
165	-15.31	-12.71	-12.28	-9.63	-11.46	-8.76	-10.03	-8.87	-8.66	-14.21	-13.27	-14.62	-10.93
180	-19.91	-8.65	-6.87	-4.65	-10.54	-14.75	-14.09	-11.7	-13.08	-21.08	-10.1	-12.4	-15.77
195	-11.54	-7.27	-4.49	-2.67	-5.34	-7.68	-19.06	-11.96	-17.25	-12.61	-10.73	-9.61	-11.24
210	-6.82	-6.39	-4.62	-3.28	-3.8	-5.35	-11.17	-9.47	-11.55	-8.92	-11.1	-8.17	-6.33
225	-4.14	-5.41	-6.21	-6.53	-6.78	-6.26	-12.33	-11.64	-8.06	-7.87	-5.79	-7.72	-3.67
240	-2.66	-4.26	-6.39	-8.81	-16.08	-10.58	-16.05	-14.86	-10.88	-5.61	-2.29	-8.26	-1.97
255	-2.01	-3.88	-4.79	-5.79	-16.65	-17.76	-15.71	-20.65	-14.51	-4.56	-1.07	-9.17	-1.56
270	-2.03	-3.58	-3.24	-3.98	-11.99	-10.94	-14.78	-12.48	-12.7	-4.71	-0.94	-8.18	-1.2
285	-2.21	-3.25	-2.42	-4.12	-10.02	-8.83	-11.56	-7.19	-9.24	-5.74	-1.69	-7.02	-1.76
300	-3.16	-4.84	-3.71	-5.5	-11.34	-8.88	-9.6	-5.61	-6.65	-8.43	-2.7	-7.78	-3.25
315	-5.47	-6.76	-5.82	-8.94	-13.69	-10.26	-8.98	-6.13	-5.98	-11.79	-4.2	-8.32	-5.28
330	-9.09	-10.37	-9.47	-16.66	-18.1	-12.57	-7.56	-8.9	-7.71	-13.33	-7.34	-9.78	-9.26
345	-15.06	-16.35	-20.36	-20.65	-21.69	-12.06	-8.03	-12.82	-10.16	-10.77	-14.4	-9.29	-13.91
360	-10.89	-12.83	-10.51	-13.66	-9.52	-13.86	-10.31	-10.16	-12.09	-6.57	-12.85	-11.29	-17.12

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Table 75. Board #2: RP_2480.000_ver

Azimuth (°)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	0.65	0.68	1.51	0.33	0.93	0.57	-3.28	-8.99	-3.19	-0.88	-1.72	-2.61	-0.65
15	-0.34	-0.11	-0.26	1.66	-1.18	0.81	0.13	-6.53	-3.25	-0.41	-3.61	-1.23	-0.79
30	-1.89	-2.12	-1.3	1.94	0.9	-3.48	-1.78	0.28	0.33	-6.26	-0.37	-1.63	-1.96
45	-4.34	-4.9	-2.34	-0.88	-1.26	-1.54	0.26	-0.84	-2.56	-1.94	0.36	-4.44	-2.8
60	-9.84	-10.08	-7.09	-4.46	-7.73	-4.94	-0.62	1.55	-6.26	1.21	-3.21	-10.14	-4.9
75	-15.69	-17.31	-14.83	-9	-8.93	-7.92	-3.49	0.56	-2.16	-0.92	-11.44	-17.05	-9.12
90	-12.21	-12.28	-14.93	-15.78	-7.41	-4.63	-3.87	-3.36	-3.01	-6.3	-12.26	-8.16	-9.36
105	-6.9	-6.91	-7.8	-6.65	-3.57	-3.53	-2.83	-4.77	-5.26	-10.34	-5.4	-5.57	-8.81
120	-3.41	-4.49	-2.9	-2.22	-1.37	-2.49	-0.82	-1.12	-3.43	-3.89	-2.13	-4.29	-5.53
135	-1	-2.93	-0.82	-0.56	-1.54	-1.85	0.31	0.9	-1.69	-1.15	-1.26	-3.58	-2.42
150	0.08	-1.17	0.19	0.88	-2.29	-2.51	0.12	0.91	-3.35	0.23	-1.16	-3.47	-0.02
165	-0.11	-1.12	0.54	1.76	-0.23	-2.9	-2.42	-2.58	-5.5	-0.34	-0.48	-3.63	1
180	-0.4	-2.49	-0.88	1.65	1.37	-1.18	-3.06	-10.64	-5.11	-7.57	-0.97	-5.32	0.59
195	-0.79	-3.74	-5.24	-0.02	-0.73	-0.29	0.44	-3.24	-11.49	-9.93	-5.07	-6.38	-0.59
210	-2.58	-4.9	-8.45	-5.76	-9.21	-2.07	-3.34	-6.69	-4.21	-4.22	-7.93	-7.63	-2.34
225	-5.25	-6.55	-6.2	-13.63	-13.01	-13.85	-16.62	-12.25	-5.1	-7.55	-3.76	-8.84	-5.08
240	-9.42	-9.11	-6.47	-6.9	-12.33	-6.12	-6.76	-18.36	-9.6	-9.75	-4.32	-10.02	-9.47
255	-16.02	-13.55	-10.57	-6.54	-16.67	-5.1	-10.65	-9.56	-4.39	-6.55	-9.86	-11.65	-15.01
270	-14.41	-18.41	-13.19	-15.41	-12.25	-13.31	-13.15	-6.96	-1.27	-5.56	-9.67	-14.57	-11.42
285	-7.78	-11.12	-8.91	-10.59	-7.27	-13.24	-7.92	-8.11	-0.67	-5.75	-4.14	-15.19	-6.48
300	-3.73	-5.62	-2.73	-3.9	-4.84	-4.7	-5.34	-12.18	-1.37	-4.06	-1.36	-9.84	-3.3
315	-1.41	-2.3	0.24	-0.5	-3.08	-1.24	-3.64	-11.18	-2.01	-3.09	0.12	-8.28	-2.1
330	0.47	-0.05	2.38	1.33	-1.45	1.15	-1.15	-9.57	-2.89	-3.19	1.1	-6.37	-1.72
345	1.25	1.1	3.12	1.06	0.3	0.8	-0.33	-7.85	-3.22	-3.62	1.2	-5.2	-1.36
360	0.65	0.68	1.51	0.33	0.93	0.57	-3.28	-8.99	-3.19	-0.88	-1.72	-2.61	-0.65

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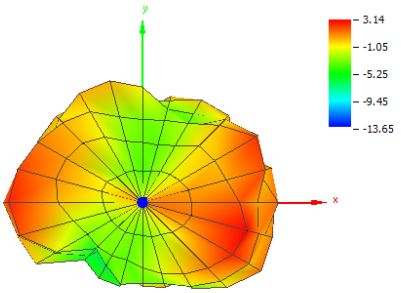

Figure 112. Board #2 (2.48 GHz): Theta = 0, Phi = 0

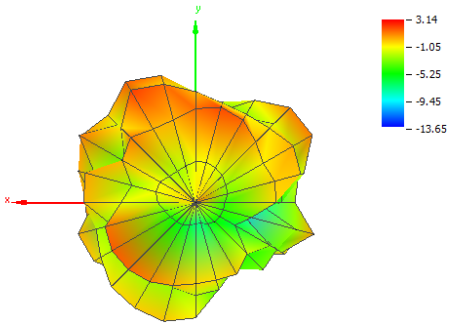

Figure 113. Board #2 (2.48 GHz): Theta = 180, Phi = 0

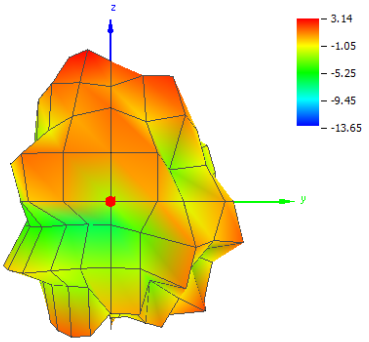

Figure 114. Board #2 (2.48 GHz): Theta = 90, Phi = 0

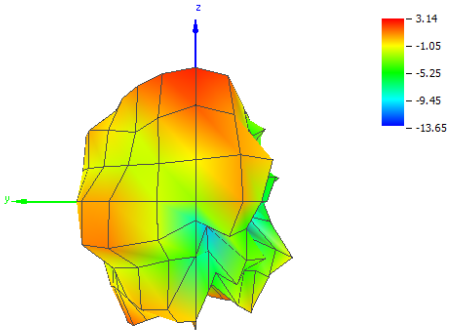

Figure 115. Board #2 (2.48 GHz): Theta = 90, Phi = 180

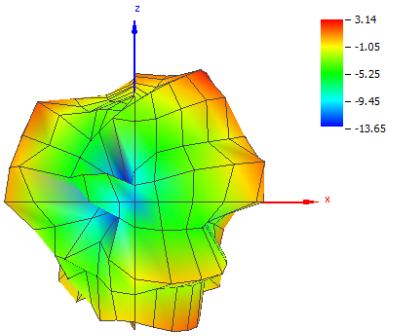

Figure 116. Board #2 (2.48 GHz): Theta = 90, Phi = 270

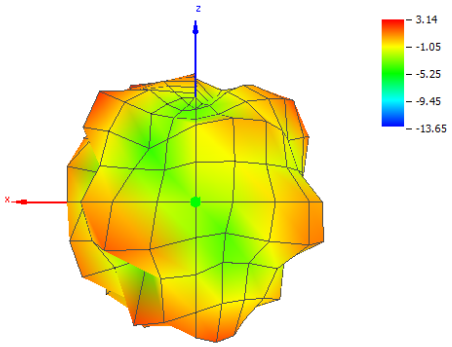

Figure 117. Board #2 (2.48 GHz): Theta = 90, Phi = 90

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