1 Compact 2.4 GHz PCB Antenna

1.1 Layout and Implementation

Small changes of the antenna dimensions may have large impact on the performance. Therefore it is strongly recommended to make an exact copy of the reference design to achieve optimum performance. The easiest way to implement the antenna is to import the gerber or DXF file showing the antenna layout. These files are named IFA_USB.spl and IFA_USB.dxf respectively and are included in the CC2511 USB dongle reference design available from http://www.ti.com\lpw. The imported file can be used as a template when drawing the antenna. By using this procedure it should be possible to make an exact copy. If the PCB CAD tool being used does not support import of DXF or gerber files, Figure 3 and Table 1 should be used to ensure correct implementation. It is recommended to generate a gerber file for comparison with IFA_USB.spl when making a manual implementation. Most gerber viewers have the possibility to import several gerber files at the same time. Thus by placing the gerber file, showing the manually implemented antenna, on top of IFA_USB.spl it is easy to verify that the antenna is correctly implemented. It is also recommended to use the same thickness and type of PCB material as used in the reference design. Information about the PCB can be found in a separate readme file included in the reference design. To compensate for a thicker/thinner PCB the antenna could be made slightly shorter/longer.

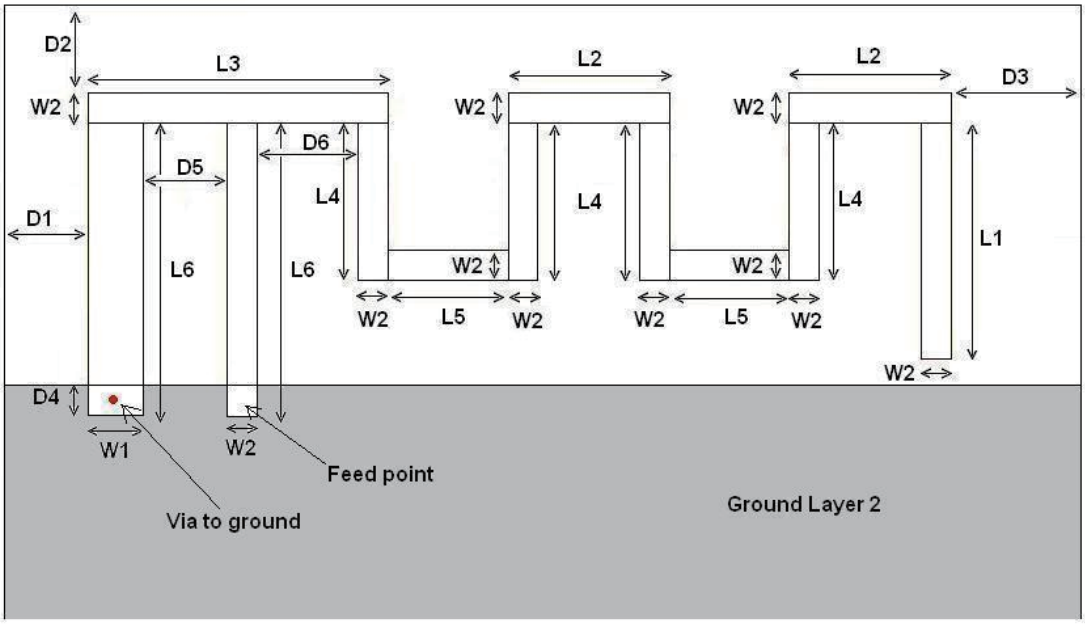

Figure 3: Antenna Dimensions

L1	3.94 mm
L2	2.70 mm
L3	5.00 mm
L4	2.64 mm
L5	2.00 mm
L6	4.90 mm
W1	0.90 mm
W2	0.50 mm
D1	0.50 mm
D2	0.30 mm
D3	0.30 mm
D4	0.50 mm
D5	1.40mm
D6	1.70 mm

Table 1: Antenna Dimensions

2 Compact 2.4 GHz PCB Antenna

2.1 2.40 GHz

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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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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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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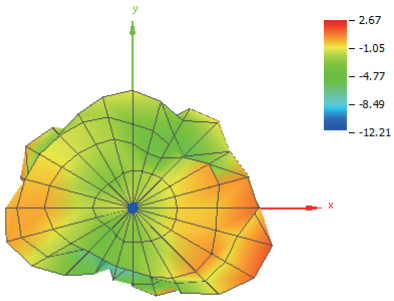
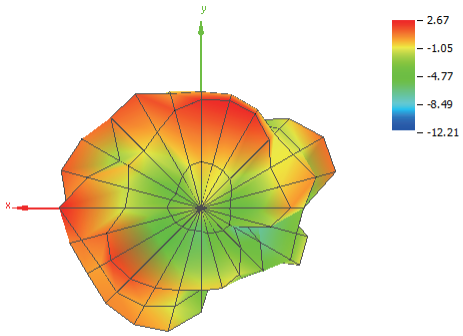
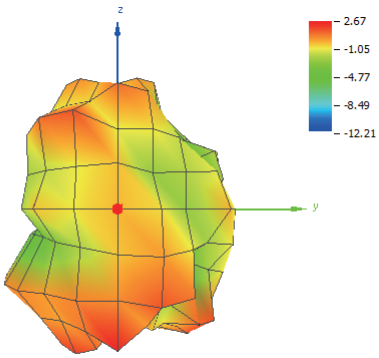
Azimuth (deg)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	-3.03	-1	-0.7	0.96	-1.36	-0.47	-0.73	-1.02	0.04	2.23	-1.88	-3.43	-2.04
15	-4.05	-1.82	-0.11	0.17	-1.03	-2.6	-0.96	-0.16	0.91	0.03	-2.46	-4.2	-3.37
30	-5.44	-3.03	-0.46	-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



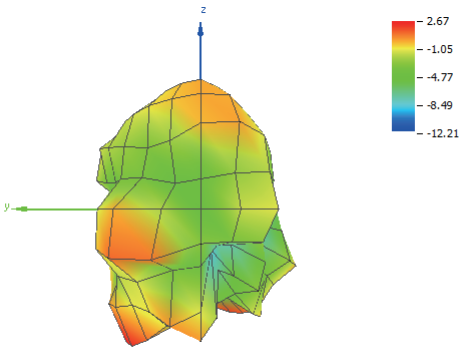
(2.40 GHz): Theta = 0, Phi = 0



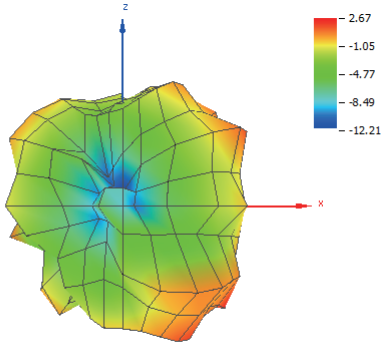
(2.40 GHz): Theta = 180, Phi = 0



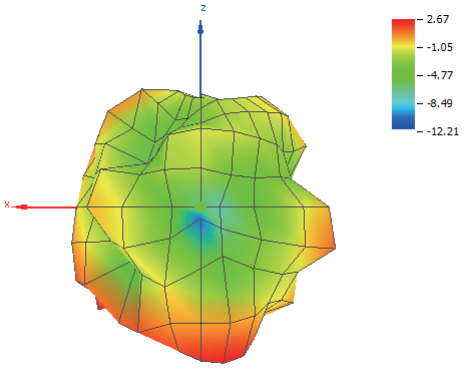
(2.40 GHz): Theta = 90, Phi = 0



(2.40 GHz): Theta = 90, Phi = 180



(2.40 GHz): Theta = 90, Phi = 270



(2.40 GHz): Theta = 90, Phi = 90

2.2 2.44 GHz

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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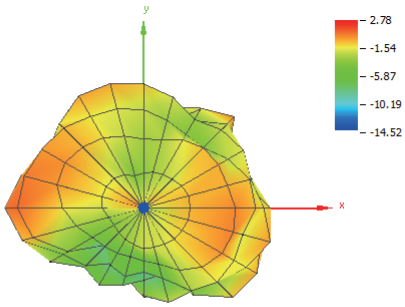
Azimuth (°)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	-1.86	-0.49	0.34	-0.59	-1.22	-0.73	-1.31	-2.79	-0.13	0.74	-1.68	-3.42	-1.74
15	-1.1	-0.49	-0.36	-0.85	-2.32	-3.69	-1.83	-1.46	-0.26	-1.59	-2.78	-2.69	-0.86
30	-0.57	-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

RP_2440.000_hor

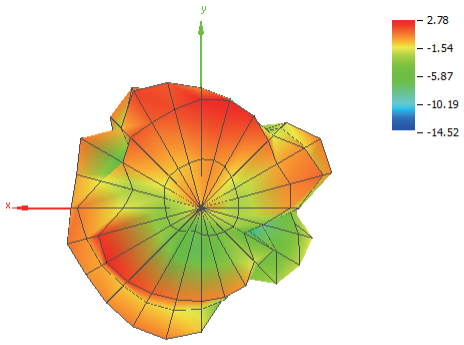
Azimuth (°)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	-10.99	-10.89	-10.33	-13.56	-10.94	-21.57	-10.78	-10.06	-10.04	-9.92	-13.64	-15.08	-12.31
15	-6.62	-6.88	-8.61	-11.39	-11.02	-18.3	-14.62	-9.8	-9.11	-13.17	-11.27	-16.67	-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

RP_2440.000_ver

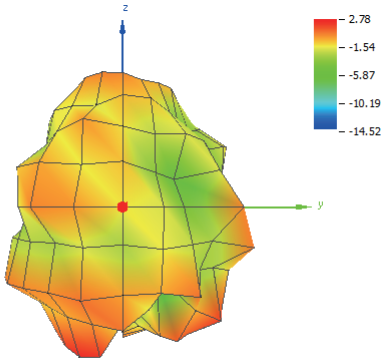
Azimuth (°)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	-2.43	-0.9	-0.04	-0.81	-1.71	-0.76	-1.83	-3.69	-0.59	0.35	-1.97	-3.72	-2.14
15	-2.53	-1.62	-1.06	-1.25	-2.95	-3.84	-2.07	-2.15	-0.87	-1.9	-3.44	-2.87	-1.77
30	-3.6	-3.15	-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



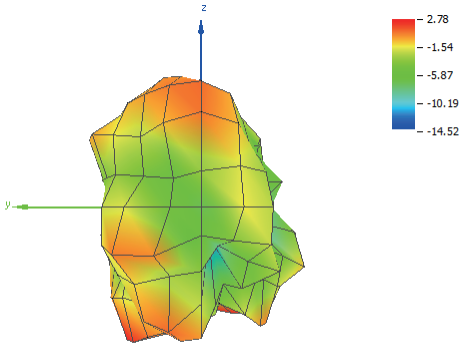
(2.44 GHz): Theta = 0, Phi = 0



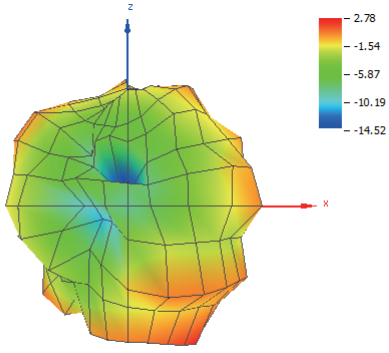
(2.44 GHz): Theta = 180, Phi = 0



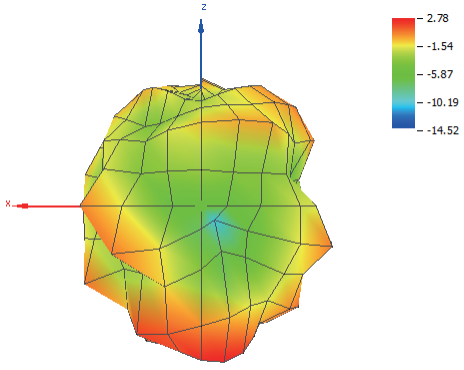
(2.44 GHz): Theta = 90, Phi = 0



(2.44 GHz): Theta = 90, Phi = 180



(2.44 GHz): Theta = 90, Phi = 270



(2.44 GHz): Theta = 90, Phi = 90

2.3 2.48 GHz

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

RP_2480.000_tot

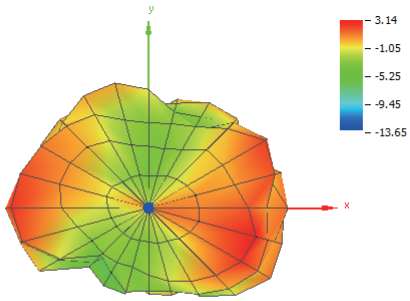
Azimuth (°)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	0.94	0.87	1.77	0.5	1.3	0.72	-2.49	-6.52	-2.66	0.16	-1.39	-2.06	-0.56
15	0.31	0.5	0.41	1.89	-0.44	0.93	0.3	-3.91	-2.35	0.43	-2.71	-1.17	-0.37
30	-0.53	-0.58	-0.06	2.31	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

RP_2480.000_hor

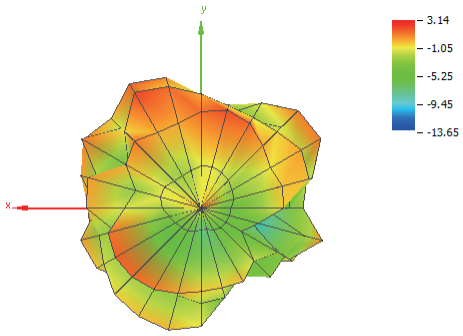
Azimuth (°)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	-10.89	-12.83	-10.51	-13.66	-9.52	-13.86	-10.31	-10.16	-12.09	-6.57	-12.85	-11.29	-17.12
15	-8.29	-8.35	-8.05	-11	-8.49	-14.74	-13.75	-7.35	-9.65	-7.11	-9.99	-19.9	-10.72
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

RP_2480.000_ver

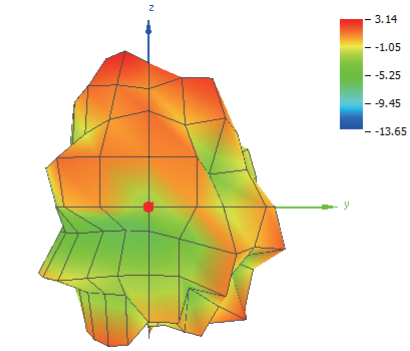
Azimuth (°)	0° (dB)	15° (dB)	30° (dB)	45° (dB)	60° (dB)	75° (dB)	90° (dB)	105° (dB)	120° (dB)	135° (dB)	150° (dB)	165° (dB)	180° (dB)
0	0.65	0.68	1.51	0.33	0.93	0.57	-3.28	-8.99	-3.19	-0.88	-1.72	-2.61	-0.65
15	-0.34	-0.11	-0.26	1.66	-1.18	0.81	0.13	-6.53	-3.25	-0.41	-3.61	-1.23	-0.79
30	-1.89	-2.12	-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



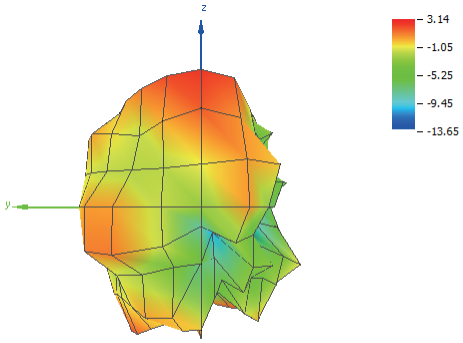
(2.48 GHz): Theta = 0, Phi = 0



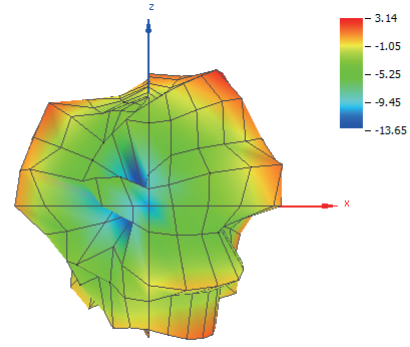
(2.48 GHz): Theta = 180, Phi = 0



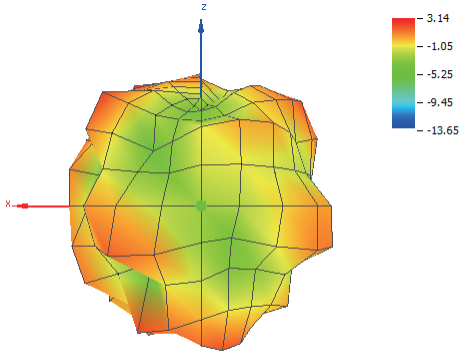
(2.48 GHz): Theta = 90, Phi = 0



(2.48 GHz): Theta = 90, Phi = 180



(2.48 GHz): Theta = 90, Phi = 270



(2.48 GHz): Theta = 90, Phi = 90

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