

Small Size 2.4 GHz PCB antenna

1,INTRODUCTION

The PCB antenna used on easyiot.tech CC2530, TLSR8258, EFR32, ESP8266, ESP32 chip, the reference design is described in this application note. It can be used in all 2.4 GHz designs, especially where small space is required for the antenna. This application note describes the antenna dimensions, the RF performance. The reflection at the feed point of the antenna determines how much of the applied power is delivered to the antenna. A reflection of less than -10 dB across the 2.4 GHz ISM band, when connected to a 50 ohm source, was a design goal. Reflection of less than -10 dB, or VSWR less than 2, ensures that more than 90% of the available power is delivered to the antenna. Bandwidth is in this document defined as the frequency band where more than 90% of the available power is delivered to the antenna.

Electrical Specifications	
Frequency Range (MHz)	2400-2500
Input Impedence (Ω)	50
V.S.W.R	≤ 1.5
Gain (dBi)	1
Polarization Type	Horizontal
Power Capacity (w)	2
Mechanical Specifications	
Antenna Length (mm)	mm
Radiator	Cuprum
Connect Type	NC
Working Temp(°C)	-10~40
Storage Temperature(°C)	-20~55
antenna size	10.3mm*4.4mm*0.035mm

Table 1 : antenna Specifications

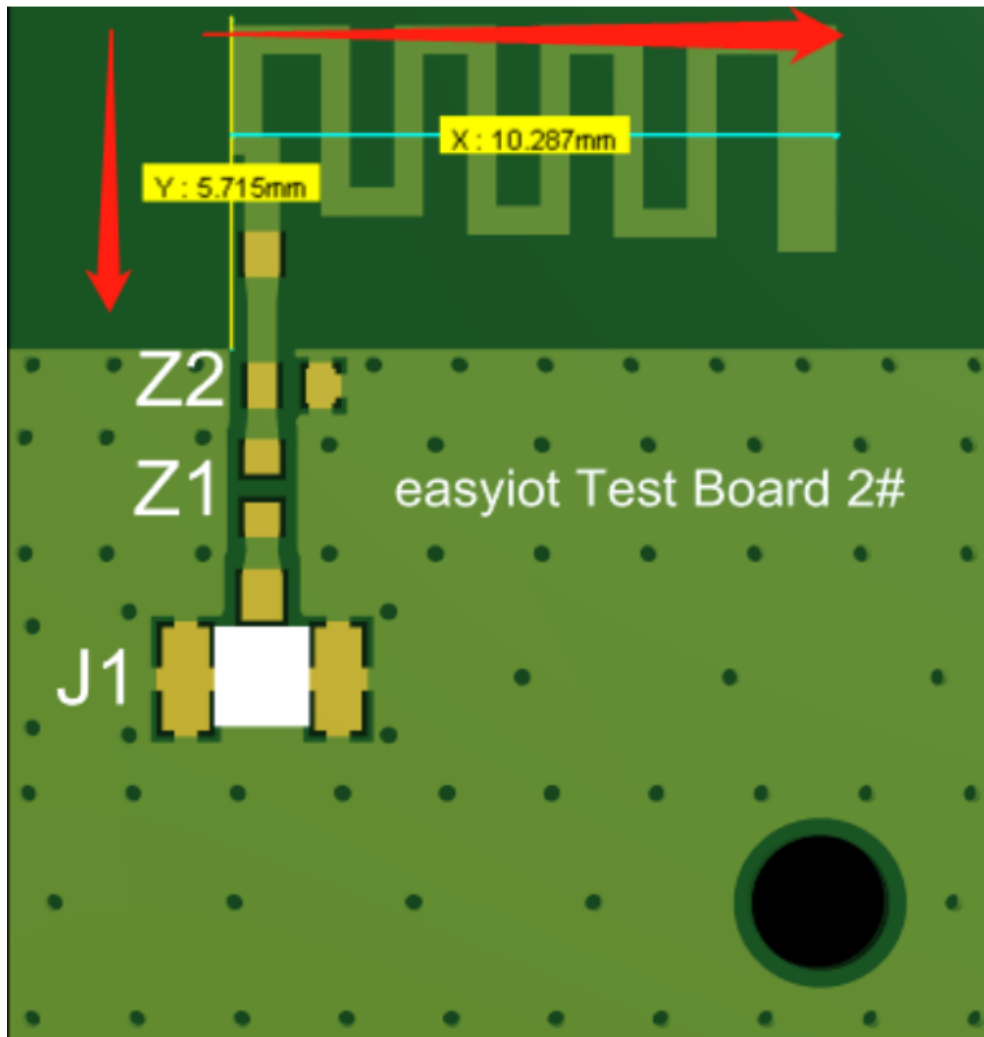


Figure 1: 2.4 GHz antenna

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	-8.01	-9.07	-16.92	-17.43	-20.31	-13.56	-15.16	-16.27	-13.82	-8.22	-6.63	-16.15	-7.12
15	-8.25	-10.42	-15.83	-15.03	-14.02	-10.85	-13.44	-15.02	-15.02	-9.14	-10.06	-13.45	-4.42
30	-7.59	-10.28	-11.38	-11.66	-13.35	-13.53	-17.77	-17.88	-9.77	-10.27	-12.37	-9.17	-2.03
45	-6.2	-7.84	-7.01	-7.77	-17.57	-20.3	-20.34	-11.52	-5.24	-5.91	-4.74	-6.12	-0.42
60	-5.2	-5.47	-4.1	-4.46	-10.25	-9.73	-19.25	-5.83	-2.71	-2.56	-1.48	-4.36	0.53
75	-5.27	-4.01	-2.12	-2.5	-4.07	-6.66	-15.95	-3.9	-1.2	-1.04	0.18	-2.44	1.27
90	-6.03	-3.08	-0.62	-2.06	-2.34	-6.94	-12.56	-3.72	-0.15	-0.46	1.06	-0.89	1.38
105	-6.4	-1.99	0.03	-1.82	-2.89	-8.32	-10.57	-4.15	-1.3	-1.23	1.47	-0.15	0.86
120	-6.15	-1.66	-0.2	-1.7	-4	-7.44	-9.43	-5.76	-4.72	-3.32	0.92	-0.55	-0.16
135	-7.19	-2.66	-1.01	-1.31	-3.18	-3.94	-9.43	-9.4	-9.54	-7.22	-1.35	-2.09	-2.07
150	-8.64	-5	-2.86	-3.07	-2.64	-3.88	-10.39	-17.43	-11.38	-10.77	-5.12	-4.29	-4.1
165	-10.72	-9.36	-7.78	-9.67	-6.53	-9.59	-16.35	-13.26	-12.15	-13.07	-10.42	-7.65	-5.55
180	-12.44	-14.43	-13.21	-10.11	-8.72	-10.74	-14.98	-11.65	-14.85	-16.18	-9.49	-9.13	-5.41
195	-13.53	-14.29	-9.76	-9.11	-8.47	-15.98	-11.31	-12.03	-15.63	-12.66	-7.99	-6.5	-4.04
210	-11.41	-11.54	-9.24	-12.46	-13.73	-17.01	-10.27	-15.89	-12.24	-12.27	-7.87	-4.26	-2.5
225	-8.43	-10.43	-10.69	-19.03	-18.76	-15.88	-12.39	-19.17	-14.13	-15.68	-7.86	-3.44	-0.64
240	-7.19	-11.55	-11.52	-20.73	-20.23	-15.06	-15.17	-17.74	-22.58	-14.1	-8.64	-3.24	0.73
255	-6.7	-13.78	-11.32	-18.61	-18.76	-15.86	-21.14	-19.13	-11.91	-9.37	-13.88	-2.85	1.57
270	-6.05	-15.45	-11.41	-16.54	-18.82	-22.19	-21.87	-15.68	-8.53	-7.07	-22.82	-2.67	1.77
285	-5.61	-14.69	-11.07	-14.61	-16.26	-17.9	-22.5	-14.59	-7.01	-5.75	-16.15	-3.01	1.71
300	-5.83	-11.86	-10.85	-15.02	-14.56	-16.27	-18.22	-11.87	-5.94	-5.37	-16.04	-3.96	1.28
315	-5.76	-9.15	-11.49	-15.77	-14.64	-14.66	-13.21	-9.2	-5.71	-5.35	-16.03	-5.26	-0.11
330	-6.03	-8.54	-13.01	-15.83	-17.1	-15.34	-13.45	-9.76	-6.14	-6.48	-11.07	-7.07	-2.26
345	-6.92	-7.88	-14.44	-15.88	-21.21	-18.27	-19.45	-12.13	-7.49	-8.34	-7.05	-10.04	-5.64
360	-8.01	-9.07	-16.92	-17.43	-20.31	-13.56	-15.16	-16.27	-13.82	-8.22	-6.63	-16.15	-7.12

Figure 4: 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	-3.67	-5.51	-2.91	-5.21	-1.69	-2.42	-0.79	-4.75	-1.99	1.9	0.28	0.69	1.95
15	-3.21	-3.5	-2	-2.19	0.52	-1.1	0.87	-2.01	-0.65	1.04	1.31	0.59	1.71
30	-3.33	-1.7	-0.89	0.68	1.58	1.68	2.02	1.46	0.21	-0.36	2.5	0.77	0.76
45	-4.17	-0.68	-0.36	1.76	1.16	3.01	2.77	2.29	1.05	-1.7	3.11	0.21	-1.33
60	-4.78	-0.93	-1.62	0.11	-1.49	1.29	0.82	0.16	0.36	-1.58	2.47	-0.39	-3.87
75	-5.85	-2.22	-3.94	-4.21	-4.77	-2.94	-2.95	-4.29	-3.81	-3.36	0.16	-1.45	-6.19
90	-6.33	-4.43	-6.26	-9.66	-8.28	-9.46	-10.14	-8.3	-13.25	-7.01	-4.58	-3.8	-6.44
105	-6.74	-8.18	-13.37	-16.79	-19.57	-13.43	-13.51	-15.82	-18.67	-10.97	-14.26	-8.12	-4.49
120	-7.1	-10.94	-16.88	-9.81	-10.37	-7.69	-7.6	-12.85	-12.36	-18.55	-8.79	-10.02	-2
135	-6	-7.88	-6.19	-5.29	-5.04	-6.75	-4.07	-10.06	-5.31	-10.43	-2.26	-5.56	0.07
150	-4.61	-4.76	-2.34	-1.17	0.15	-0.99	1.18	-4.04	-1.18	-3.31	0.13	-2.91	1.32
165	-3.56	-3.63	-1.12	0.65	1.56	2.99	2.36	1.5	-0.75	-0.31	0.3	-1.74	1.95
180	-3.04	-4.15	-1.94	-0.6	-0.67	2.22	0.01	1.22	-2.25	-0.81	-1.38	-1.79	2.04
195	-3.07	-6.49	-4.59	-3.48	-6.25	-2.54	-6.04	-6	-6.37	-3.5	-4.5	-3.13	1.59
210	-4.06	-10.76	-6.38	-5.59	-9.7	-6	-8.9	-12.28	-6.92	-6.04	-6.53	-5.28	0.83
225	-6.12	-12.9	-5.61	-6.96	-6.04	-5.64	-7.86	-6.36	-6.59	-6.39	-7.43	-7.68	-0.57
240	-7.88	-9.55	-4.18	-6.72	-3.5	-5.5	-4.24	-4.93	-4.64	-6.37	-11.46	-8.14	-2.71
255	-8.28	-8.28	-3.47	-4.78	-3.95	-2.73	-4.18	-3.34	-4.55	-9.7	-20.16	-5.76	-6.68
270	-8.94	-8.9	-2.93	-3.3	-3.88	-2.36	-3.78	-1.95	-6.57	-14.72	-14.52	-4.06	-6.95
285	-9.35	-9.66	-3.07	-3.23	-2.86	-4.39	-3.22	-2.8	-7.21	-17.55	-13.19	-3.35	-3.19
300	-8.86	-10.3	-3.49	-3.06	-2.46	-6.15	-3.5	-4.29	-7.22	-16.37	-11.53	-3.02	-0.71
315	-8.03	-11.17	-4.35	-3.43	-3.62	-6.96	-4.07	-5.54	-11.89	-11.06	-6.67	-2.5	0.64
330	-6.88	-11.13	-4.56	-4.34	-5.84	-7.1	-4.56	-6.26	-18.24	-6.46	-2.73	-1.94	1.21
345	-5.78	-9.23	-3.6	-5.11	-6.39	-4.42	-5.49	-7.33	-6.53	-2.07	-1.83	-0.93	1.63
360	-3.67	-5.51	-2.91	-5.21	-1.69	-2.42	-0.79	-4.75	-1.99	1.9	0.28	0.69	1.95

Figure 5: RP_2400.000_ver

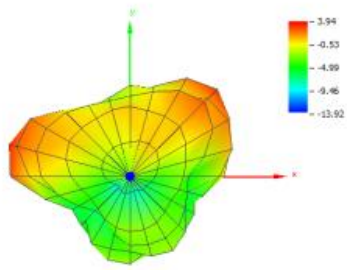


Figure 6 Board #2 (2.40 GHz): Theta = 0, Phi = 0

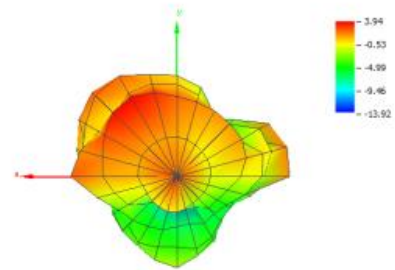


Figure 7 Board #2 (2.40 GHz): Theta = 180, Phi = 0

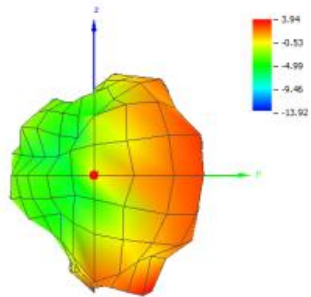


Figure 8 Board #2 (2.40 GHz): Theta = 90, Phi = 0

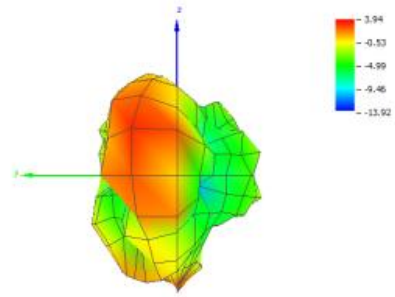


Figure 9 Board #2 (2.40 GHz): Theta = 90, Phi = 180

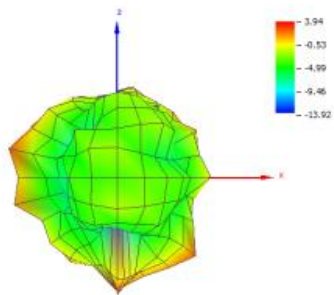


Figure 10 Board #2 (2.40 GHz): Theta = 90, Phi = 270

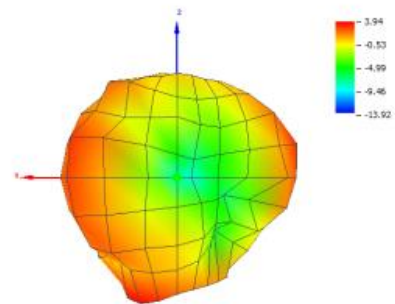


Figure 11 Board #2 (2.40 GHz): Theta = 90, Phi = 90

3, 2.48GHz

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	-2.36	-3.11	-4.97	-0.87	-4.91	-0.47	-2.39	-3.53	-5.23	-2.81	0.23	-0.14	2.87
15	-3.72	-3.48	-2.73	-0.57	-1.6	-0.11	0.78	-2.97	-1.26	0.61	1.05	0.15	2.15
30	-4.6	-2.8	-1.02	0.21	0.84	0.08	2.24	1.88	0.62	1.82	2.91	0.48	1.42
45	-5.07	-2.38	-0.21	1.75	1.43	2.11	3.24	4.09	2.41	1.85	4.29	0.97	1.32
60	-5.94	-2.74	-0.33	2.42	0.88	2.73	2.42	4.22	3.39	3.02	4.76	2	1.82
75	-6.77	-3.19	-1.36	1.32	-1.11	0.29	-1.46	2.82	2.09	3.61	4.08	2.39	2.3
90	-4.18	-2.81	-2.5	-1.6	-2.64	-4.63	-6.85	-1.06	0.09	2.54	3.2	1.53	2.38
105	-2.65	-2.4	-1.41	-2.53	-1.75	-5.62	-6.55	-4.02	-1.41	0.04	2.54	0.95	2.73
120	-2.18	-2.12	-0.25	-1.97	-1.74	-2.83	-5.55	-5.28	-3.19	-3.23	2.06	0.47	3.21
135	-2.07	-3.2	0.06	-1.11	0.27	-0.57	-1.71	-8.45	-1.91	-2.77	1.51	-0.05	3.07
150	-2.23	-3.71	0.15	-0.26	2.54	1.89	2.35	-0.97	1.5	1.43	1.7	-0.22	3.13
165	-2.02	-3.28	-0.17	0.91	2.55	3.95	2.69	3.71	1.47	2.65	1.59	0.18	3.2
180	-1.88	-2.45	-1.58	0.13	-0.51	1.49	0.23	2.58	-0.44	0.34	-0.61	0.24	3.54
195	-1.95	-2.41	-4.52	-4.42	-5.93	-4.51	-3.03	-4.23	-4.46	-3.25	-4.9	0.3	3.87
210	-2.15	-3.45	-8.17	-13.6	-8.72	-4.55	-5.23	-7.35	-3.12	-7.06	-7.06	0	3.82
225	-2.5	-4.16	-9.69	-11.54	-6.17	-3.12	-3.61	-4.13	-4.22	-4.39	-6.93	-0.81	3.34
240	-3.25	-4.18	-9.21	-10.08	-5.01	-3.45	-2.21	-3.79	-2.72	-3.59	-6.79	-1.27	2.71
255	-3.69	-3.91	-8.25	-6.85	-3.98	-1.48	-2.83	-1.29	-3.13	-7.53	-8.72	-1.84	2.55
270	-3.49	-2.59	-6.91	-5.53	-4.42	-3.33	-2.12	-1.51	-4.46	-6.84	-13.72	-2.37	2.66
285	-3.05	-1.94	-6.06	-5.52	-7.31	-6.34	-2.73	-5.06	-3.75	-5.38	-10.93	-2.62	2.51
300	-2.38	-1.62	-5.67	-5.09	-9.84	-7.61	-4.39	-7.86	-3.21	-5.93	-9.54	-2.75	3.04
315	-1.37	-1.14	-5.42	-3.97	-9.94	-7.21	-6.48	-6.95	-4.79	-4.38	-8.43	-2.32	3.87
330	-0.57	-0.99	-5.92	-2.79	-7.42	-6.61	-6.18	-6.51	-8.54	-3.49	-4.03	-2.11	4.16
345	-0.52	-1.76	-6.37	-1.9	-5.94	-5.43	-5.13	-6.03	-11.37	-4.61	-1.35	-1.69	3.84
360	-2.36	-3.11	-4.97	-0.87	-4.91	-0.47	-2.39	-3.53	-5.23	-2.81	0.23	-0.14	2.87

Figure 12: 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	-13.74	-15.95	-21.04	-15.88	-17.19	-12.06	-13.03	-16.63	-8.94	-5.67	-7.56	-19.15	-7.41
15	-11.75	-15.35	-19.36	-13.24	-12	-8.96	-12.88	-14	-9.41	-6.27	-9.98	-15.17	-5.43
30	-8.79	-10.64	-11.98	-9.59	-8.47	-15.74	-12.66	-12.06	-10.37	-16.86	-16.66	-11.29	-2.53
45	-7.2	-6.78	-7.68	-5.89	-7.94	-13.6	-19.63	-10.04	-7.84	-8.62	-6.32	-6.62	-0.51
60	-7.05	-5.37	-4.46	-3.05	-5.57	-7.47	-18.3	-6.17	-2.91	-1.79	-1.56	-2.41	0.98
75	-7.8	-4.93	-3.22	-1.79	-3.66	-5.34	-15.88	-4.03	-0.75	0.92	0.91	-0.64	1.68
90	-4.82	-3.44	-2.78	-2.36	-2.83	-5.52	-11.56	-4.51	-0.62	1.04	2.15	-0.25	1.39
105	-3.45	-2.52	-1.56	-3.11	-2.91	-7.85	-10.97	-5.27	-1.7	-0.88	2.24	0.2	0.79
120	-3.66	-2.37	-0.59	-2.66	-3.38	-6.03	-9.73	-7.29	-4.65	-4.51	1.3	-0.02	-0.21
135	-4.29	-4.12	-1.29	-2.39	-1.67	-2.49	-8.89	-13.28	-10.36	-12.41	-1.34	-1.36	-2.09
150	-6.01	-7.06	-3.7	-5.09	-2.44	-4.33	-10.77	-13.98	-8.76	-13.51	-6.54	-4.06	-4.76
165	-7.79	-9.94	-7.72	-8.74	-7.01	-8.37	-12.01	-7.94	-12.09	-17.74	-14.72	-6.82	-8.24
180	-9.26	-10.57	-9.38	-9.03	-8.34	-11.97	-9.2	-12.87	-20.95	-13.78	-9.91	-8.05	-8.07
195	-9.33	-8.75	-8.81	-10.78	-8.39	-16.05	-8.23	-11.54	-18.34	-9.14	-9.03	-6.88	-4.56
210	-8.35	-7.42	-9.66	-15.36	-13.65	-17.99	-10.75	-15.43	-9.6	-12.18	-10.37	-5.34	-1.85
225	-7.13	-6.92	-11.19	-17.19	-18.87	-9.21	-10.17	-16.75	-10.38	-20.3	-10.2	-4.53	-0.36
240	-5.88	-6.62	-12.79	-13.69	-16.63	-9.59	-18.81	-18.1	-19.16	-11.77	-10.58	-4.05	0.72
255	-5.08	-7.01	-13.52	-16.68	-14.27	-16.33	-18.25	-16.66	-12.74	-10.74	-13.59	-3.98	1.52
270	-5.32	-8.49	-15.52	-17.74	-16.51	-13.86	-17.34	-19.27	-10.28	-9.82	-17.58	-4.31	1.95
285	-6.23	-10.1	-16.83	-15.47	-15.85	-13.17	-16.97	-17.56	-10.87	-7.6	-13.5	-5.2	1.35
300	-8.41	-12.52	-17.34	-16.24	-13.37	-13.89	-14.83	-12.44	-9.53	-6.71	-12.13	-6.71	0.47
315	-12.63	-12.09	-15.08	-16.38	-15.82	-19.37	-15.51	-11.17	-10.4	-7	-12.98	-9.06	-0.5
330	-13.73	-10.72	-13.52	-17.62	-21.84	-20.44	-17.46	-13.01	-12.7	-9.2	-11.52	-12.79	-2.37
345	-13.57	-11.47	-14.26	-17.04	-18.98	-22	-18.8	-19.6	-13.83	-10.65	-8.84	-16.49	-5.02
360	-13.74	-15.95	-21.04	-15.88	-17.19	-12.06	-13.03	-16.63	-8.94	-5.67	-7.56	-19.15	-7.41

Figure 13: 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	-2.68	-3.34	-5.08	-1.01	-5.17	-0.78	-2.79	-3.75	-7.64	-5.98	-0.56	-0.2	2.44
15	-4.47	-3.77	-2.82	-0.81	-2.01	-0.71	0.59	-3.32	-1.99	-0.39	0.69	0.02	1.32
30	-6.69	-3.58	-1.39	-0.27	0.3	-0.03	2.1	1.7	0.26	1.76	2.86	0.18	-0.82
45	-9.2	-4.34	-1.06	0.93	0.89	1.99	3.22	3.92	1.98	1.44	3.9	0.13	-3.32
60	-12.42	-6.17	-2.45	0.97	-0.23	2.29	2.38	3.81	2.23	1.28	3.61	0.05	-5.7
75	-13.54	-8.01	-5.94	-1.6	-4.64	-1.1	-1.62	1.81	-1.09	0.25	1.22	-0.6	-6.45
90	-12.79	-11.5	-14.62	-9.52	-16.5	-11.95	-8.65	-3.67	-8.14	-2.79	-3.5	-3.19	-4.56
105	-10.39	-17.96	-16.08	-11.5	-8.05	-9.59	-8.5	-10.02	-13.36	-7.14	-9.29	-7.04	-1.71
120	-7.59	-14.62	-11.43	-10.31	-6.78	-5.65	-7.64	-9.6	-8.62	-9.16	-5.9	-9.24	0.56
135	-6.04	-10.42	-5.68	-7.02	-4.16	-5.03	-2.64	-10.18	-2.58	-3.27	-1.68	-5.9	1.49
150	-4.59	-6.4	-2.15	-1.99	0.89	0.71	2.14	-1.19	1.07	1.28	1	-2.53	2.36
165	-3.35	-4.34	-1.01	0.41	2.04	3.69	2.54	3.4	1.27	2.61	1.49	-0.79	2.87
180	-2.75	-3.18	-2.37	-0.43	-1.3	1.29	-0.3	2.46	-0.48	0.17	-1.15	-0.45	3.23
195	-2.83	-3.56	-6.54	-5.56	-9.57	-4.82	-4.59	-5.12	-4.64	-4.54	-7.02	-0.62	3.2
210	-3.34	-5.68	-13.53	-18.39	-10.4	-4.75	-6.66	-8.09	-4.23	-8.66	-9.78	-1.5	2.44
225	-4.33	-7.43	-15.04	-12.92	-6.41	-4.34	-4.69	-4.38	-5.42	-4.5	-9.69	-3.21	0.92
240	-6.67	-7.86	-11.72	-12.56	-5.32	-4.66	-2.31	-3.96	-2.82	-4.3	-9.14	-4.53	-1.65
255	-9.32	-6.83	-9.77	-7.33	-4.41	-1.63	-2.96	-1.42	-3.63	-10.34	-10.43	-5.92	-4.22
270	-8.14	-3.89	-7.56	-5.8	-4.7	-3.73	-2.26	-1.58	-5.77	-9.87	-16.02	-6.8	-5.53
285	-5.9	-2.66	-6.44	-5.98	-7.96	-7.36	-2.9	-5.31	-4.69	-9.35	-14.43	-6.11	-3.77
300	-3.62	-1.99	-5.98	-5.44	-12.39	-8.77	-4.8	-9.72	-4.36	-13.79	-13	-4.98	-0.47
315	-1.71	-1.5	-5.92	-4.23	-11.24	-7.48	-7.06	-9.02	-6.19	-7.82	-10.3	-3.36	1.9
330	-0.79	-1.48	-6.74	-2.94	-7.58	-6.79	-6.52	-7.62	-10.64	-4.85	-4.89	-2.5	3.07
345	-0.74	-2.25	-7.14	-2.03	-6.16	-5.52	-5.32	-6.22	-15	-5.86	-2.2	-1.84	3.24
360	-2.68	-3.34	-5.08	-1.01	-5.17	-0.78	-2.79	-3.75	-7.64	-5.98	-0.56	-0.2	2.44

Figure 14: RP_2480.000_ver

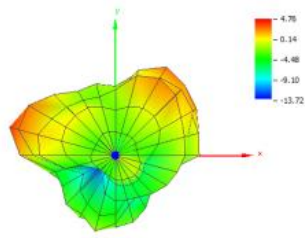


Figure 15 Board #2 (2.48 GHz): Theta = 0, Phi = 0

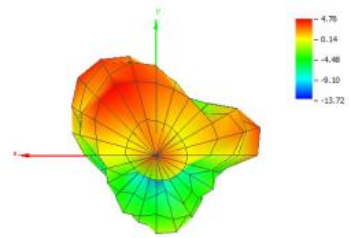


Figure 16 Board #2 (2.48 GHz): Theta = 180, Phi = 0

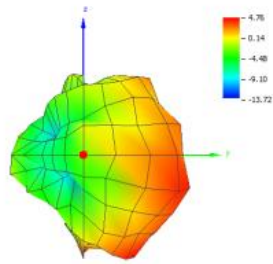


Figure 17 Board #2 (2.48 GHz): Theta = 90, Phi = 0

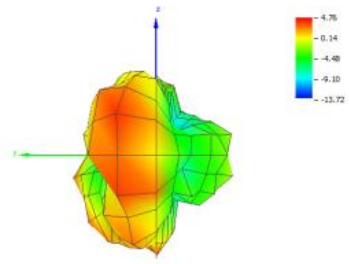


Figure 18 Board #2 (2.48 GHz): Theta = 90, Phi = 180

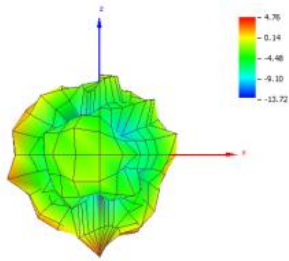


Figure 19 Board #2 (2.48 GHz): Theta = 90, Phi = 270

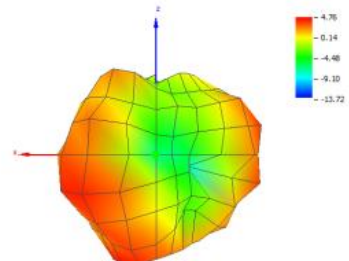


Figure 20 Board #2 (2.48 GHz): Theta = 90, Phi = 90