

5inColorD

Peak Gain and Efficiency Antenna Measurements

(*) Identification of 1tem tested	An instrument cluster with Bluetooth® for operation in a vehicle
(*) Trademark	BOSCH
(*) Model and /or type reference tested	5inColorD
(*) Other identification of the product	HW version: C3.2 SW version: BRP5-0.0.SWP25.1.28 FCC ID: 2AUXS-5INCOLORD IC: 25847-5INCOLORD
(*) Features	Bluetooth LE
(*) Manufacturer	Robert Bosch GmbH Robert-Bosch-Platz 1,70839 Gerlingen, Germany
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Document history

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Appendix A: Test results

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1. TEST CONDITIONS

1.1 Test frequencies and output power

Antenna gain, efficiency and S_{11} measurements were performed at the range from 2400 MHz to 2500 MHz for the EUT.

Test frequencies were selected accordingly with the EUT operating frequency range.

1.2 Antenna orientation and setup requirements

For the 3D radiation pattern measurements the EUT is rotated along two different spherical axes: theta (θ) and phi (ϕ). The relationship between the 3D Cartesian coordinate system (X, Y, Z) and the theta and phi axes is illustrated in the following figure. This coordinate system should be used as reference in all 3D radiation pattern graphs in section 4 as well as test setup photographs in Appendix B.

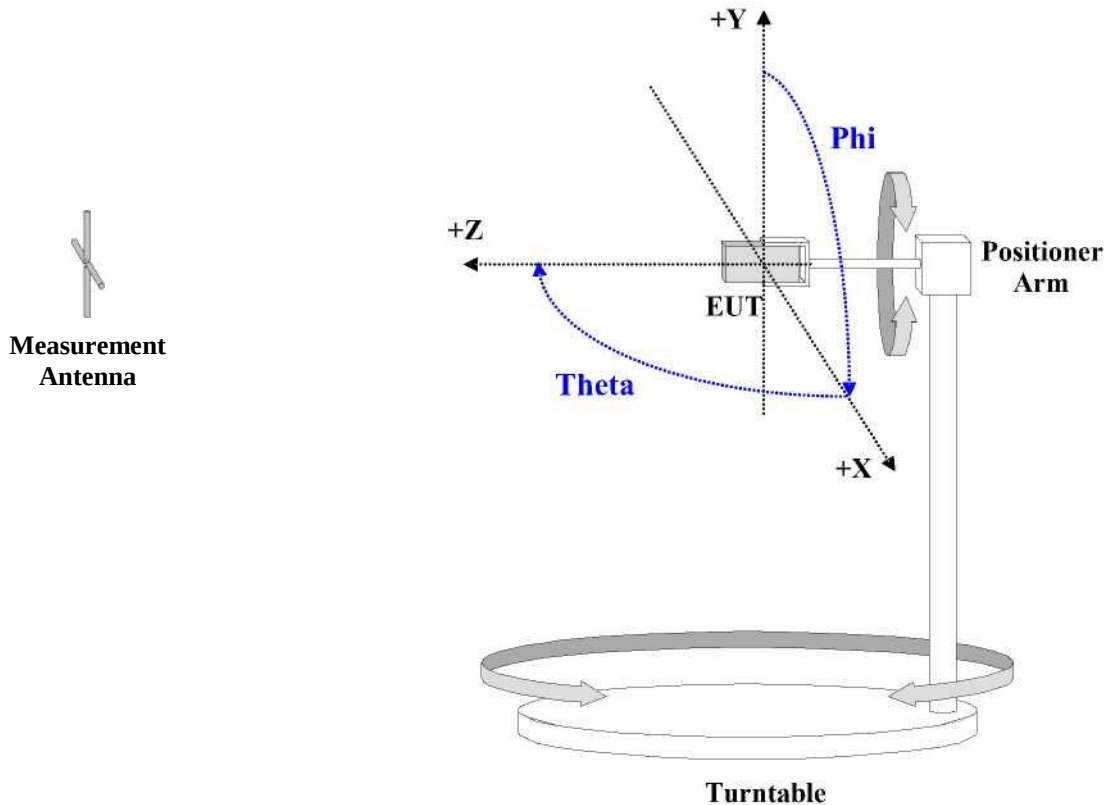


Fig. 1. Coordinate system.

Theta is the spherical axis that rotates along the Cartesian Y axis while Phi is the spherical axis that rotates along the Cartesian Z axis. The initial measurement position (Theta = 0° and Phi = 0°) is illustrated in each of the test setup photographs in Appendix B. The EUT has only one mechanical configuration each and they were tested in the "Free-space" configuration, whereby EUT has been placed directly on a support placed 2 meters away from the measurement antenna.

2. TEST RESULTS

2.1 Antenna peak gain, efficiency and S_{11}

The test setup used to derive test results in this clause is illustrated below.

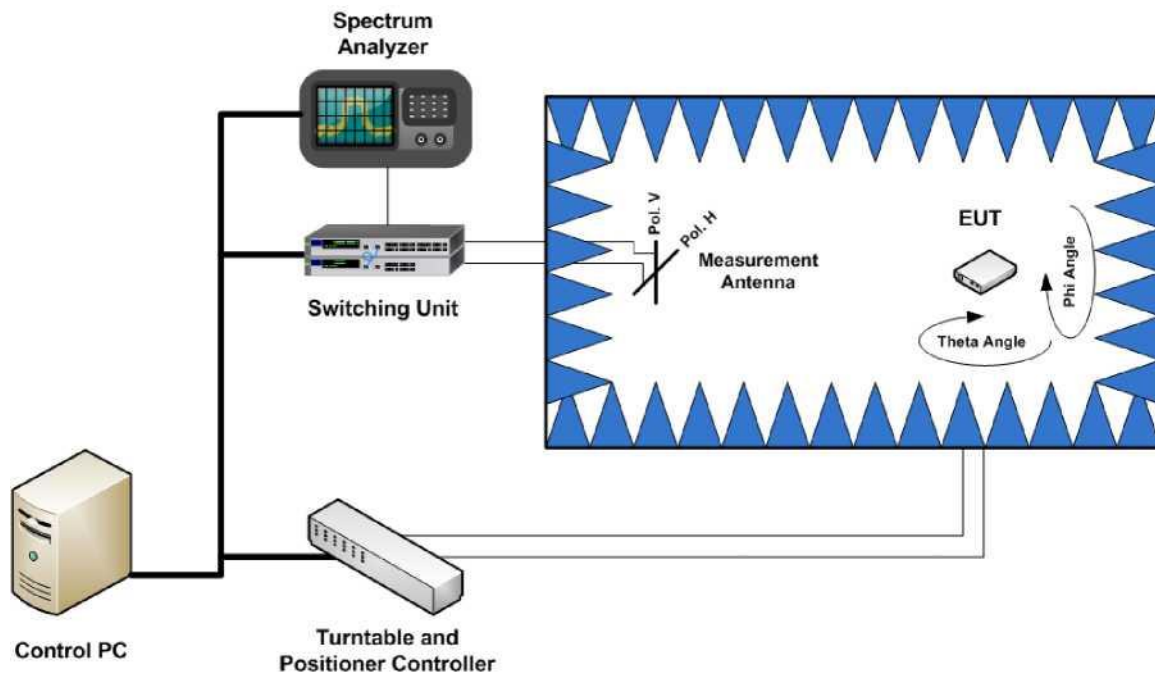


Fig. 2. Equipment and connections for antenna peak gain and efficiency measurements.

The EUT was placed inside a fully anechoic test system and hold on a multi-axis positioning system (see Figure 9). The EUT was never switched on, all signal excitations were generated by a Vector Network Analyzer (ZVA40) set to operate on the different test frequencies.

The measurements were performed at intervals of 15 degrees along the theta and phi axes and at both horizontal and vertical polarizations.

Antenna peak gain and efficiency values are presented below:

Frequency (MHz)	Gain (dBi)	Efficiency (%)	Efficiency (dB)
2400	2.62	57.59	-2.40
2401	2.59	57.34	-2.42
2402	2.63	57.92	-2.37
2403	2.65	58.15	-2.35
2404	2.67	58.33	-2.34
2405	2.69	58.28	-2.35
2406	2.65	57.79	-2.38
2407	2.64	57.36	-2.41
2408	2.63	57.12	-2.43
2409	2.57	56.56	-2.47
2410	2.59	56.87	-2.45
2411	2.58	56.74	-2.46
2412	2.61	57.30	-2.42
2413	2.64	57.64	-2.39
2414	2.63	57.47	-2.41
2415	2.61	57.46	-2.41
2416	2.61	57.35	-2.41
2417	2.57	57.08	-2.44
2418	2.56	56.95	-2.45
2419	2.57	56.60	-2.47
2420	2.55	56.40	-2.49
2421	2.55	56.25	-2.50
2422	2.59	56.45	-2.48
2423	2.62	56.94	-2.45
2424	2.66	57.59	-2.40
2425	2.71	57.97	-2.37
2426	2.68	57.75	-2.38
2427	2.64	57.07	-2.44
2428	2.62	56.68	-2.47
2429	2.61	56.12	-2.51
2430	2.58	55.74	-2.54
2431	2.58	55.47	-2.56
2432	2.59	55.43	-2.56
2433	2.60	55.46	-2.56
2434	2.60	55.47	-2.56
2435	2.61	55.56	-2.55
2436	2.61	55.52	-2.56
2437	2.61	55.38	-2.57
2438	2.62	55.54	-2.55
2439	2.60	54.99	-2.60
2440	2.56	54.57	-2.63
2441	2.55	54.46	-2.64
2442	2.54	54.58	-2.63
2443	2.54	54.73	-2.62
2444	2.57	55.09	-2.59
2445	2.56	55.08	-2.59
2446	2.56	55.13	-2.59
2447	2.54	54.97	-2.60
2448	2.54	55.25	-2.58
2449	2.53	55.14	-2.59
2450	2.55	55.45	-2.56
2451	2.57	55.60	-2.55
2452	2.56	55.72	-2.54
2453	2.61	56.28	-2.50
2454	2.59	56.48	-2.48
2455	2.60	56.93	-2.45
2456	2.62	57.24	-2.42
2457	2.64	57.70	-2.39
2458	2.68	57.98	-2.37
2459	2.70	58.19	-2.35
2460	2.76	58.97	-2.29
2461	2.79	59.39	-2.26
2462	2.81	60.03	-2.22
2463	2.85	60.51	-2.18
2464	2.84	60.58	-2.18
2465	2.85	60.87	-2.16
2466	2.86	60.84	-2.16
2467	2.83	60.49	-2.18
2468	2.85	60.62	-2.17
2469	2.87	60.99	-2.15
2470	2.90	61.44	-2.12
2471	2.92	61.69	-2.10
2472	2.97	62.22	-2.06
2473	3.02	62.74	-2.02
2474	3.04	62.97	-2.01
2475	3.04	62.86	-2.02
2476	3.02	62.51	-2.04
2477	3.01	62.36	-2.05
2478	3.02	62.35	-2.05
2479	3.00	61.97	-2.08
2480	3.02	62.18	-2.06
2481	3.04	62.46	-2.04
2482	3.06	62.72	-2.03
2483	3.05	62.55	-2.04
2484	3.07	62.79	-2.02
2485	3.06	62.58	-2.04

Frequency (MHz)	Gain (dBi)	Efficiency (%)	Efficiency (dB)
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2486	3.07	62.69	-2.03
2487	3.03	62.09	-2.07
2488	3.04	62.06	-2.07
2489	3.07	62.07	-2.07
2490	3.08	62.05	-2.07
2491	3.12	62.64	-2.03
2492	3.17	63.29	-1.99
2493	3.19	63.87	-1.95
2494	3.21	64.16	-1.93
2495	3.23	64.42	-1.91
2496	3.22	64.22	-1.92
2497	3.21	64.14	-1.93
2498	3.23	64.23	-1.92
2499	3.22	64.18	-1.93
2500	3.25	64.68	-1.89

S11 values are presented below:

Frequency (MHz)	S11 (dB)
2400	-6.96
2401	-6.98
2402	-7.00
2403	-7.02
2404	-7.04
2405	-7.05
2406	-7.06
2407	-7.07
2408	-7.07
2409	-7.07
2410	-7.07
2411	-7.07
2412	-7.09
2413	-7.10
2414	-7.13
2415	-7.15
2416	-7.16
2417	-7.19
2418	-7.21
2419	-7.23
2420	-7.26
2421	-7.28
2422	-7.30
2423	-7.32
2424	-7.35
2425	-7.38
2426	-7.40
2427	-7.41
2428	-7.42
2429	-7.43
2430	-7.44
2431	-7.45
2432	-7.46
2433	-7.47
2434	-7.47
2435	-7.49
2436	-7.51
2437	-7.53
2438	-7.55
2439	-7.57
2440	-7.60
2441	-7.63
2442	-7.66
2443	-7.69
2444	-7.71
2445	-7.75
2446	-7.77
2447	-7.79
2448	-7.81
2449	-7.83
2450	-7.84
2451	-7.86
2452	-7.90
2453	-7.93
2454	-7.97
2455	-8.02
2456	-8.05
2457	-8.08
2458	-8.10
2459	-8.13
2460	-8.17
2461	-8.21
2462	-8.25

Frequency (MHz)	S11 (dB)
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2463	-8,30
2464	-8,36
2465	-8,41
2466	-8,48
2467	-8,54
2468	-8,60
2469	-8,66
2470	-8,71
2471	-8,76
2472	-8,80
2473	-8,83
2474	-8,85
2475	-8,87
2476	-8,90
2477	-8,92
2478	-8,94
2479	-8,98
2480	-9,00
2481	-9,05
2482	-9,12
2483	-9,05
2484	-9,10
2485	-9,15
2486	-9,24
2487	-9,31
2488	-9,37
2489	-9,42
2490	-9,48
2491	-9,55
2492	-9,59
2493	-9,64
2494	-9,69
2495	-9,76
2496	-9,83
2497	-9,89
2498	-9,97
2499	-10,06
2500	-10,15

3. TEST RESULTS

3.1 Antenna peak gain, efficiency and S₁₁

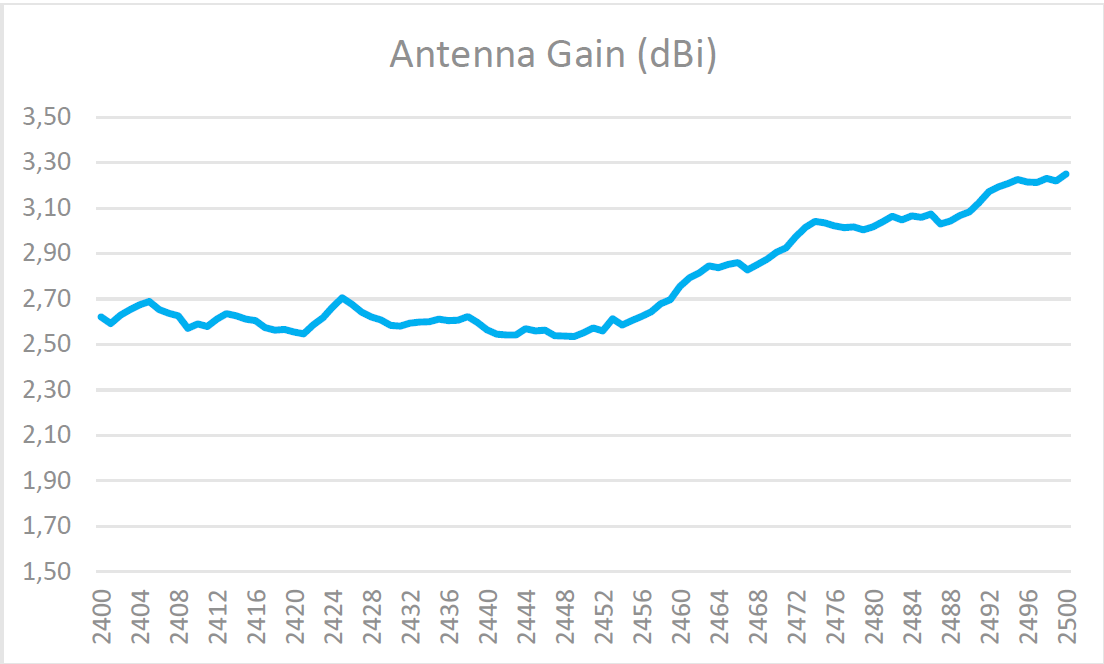


Fig. 3. Antenna Peak Gain, frequency range 2400 MHz – 2500 MHz.

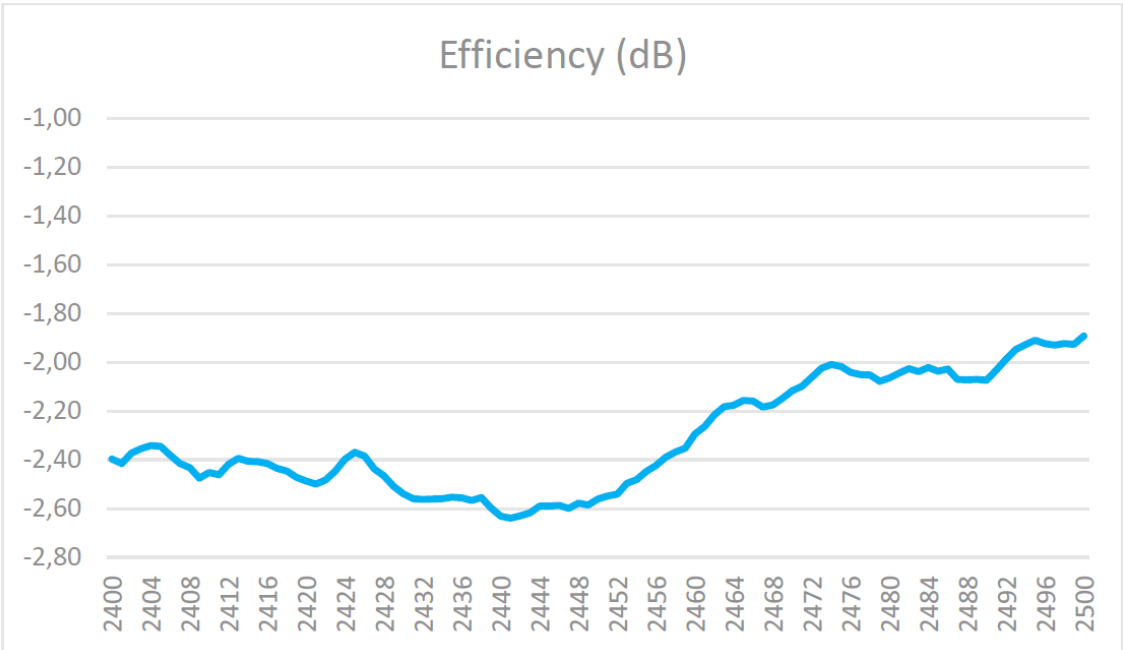


Fig. 4. Antenna Efficiency, frequency range 2400 MHz – 2500 MHz.

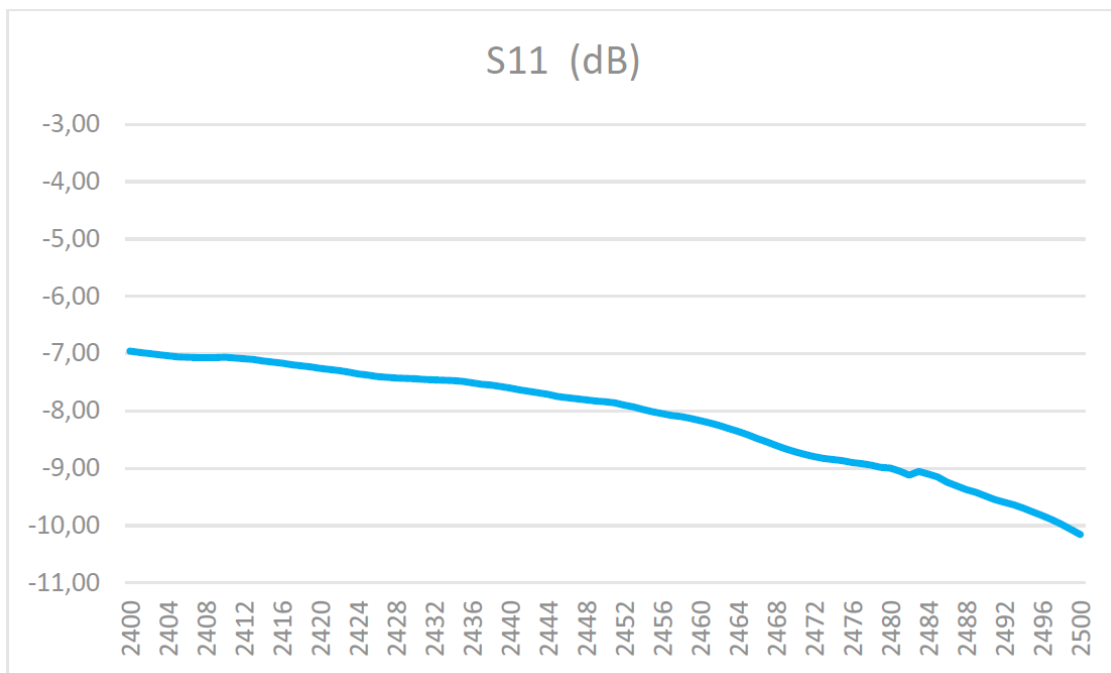


Fig. 5. S_{11} , frequency range 2400 MHz – 2500 MHz.

4.

3D Antenna Gain Pattern

4.1

3D Antenna Gain Pattern - 2402 MHz - Free Space

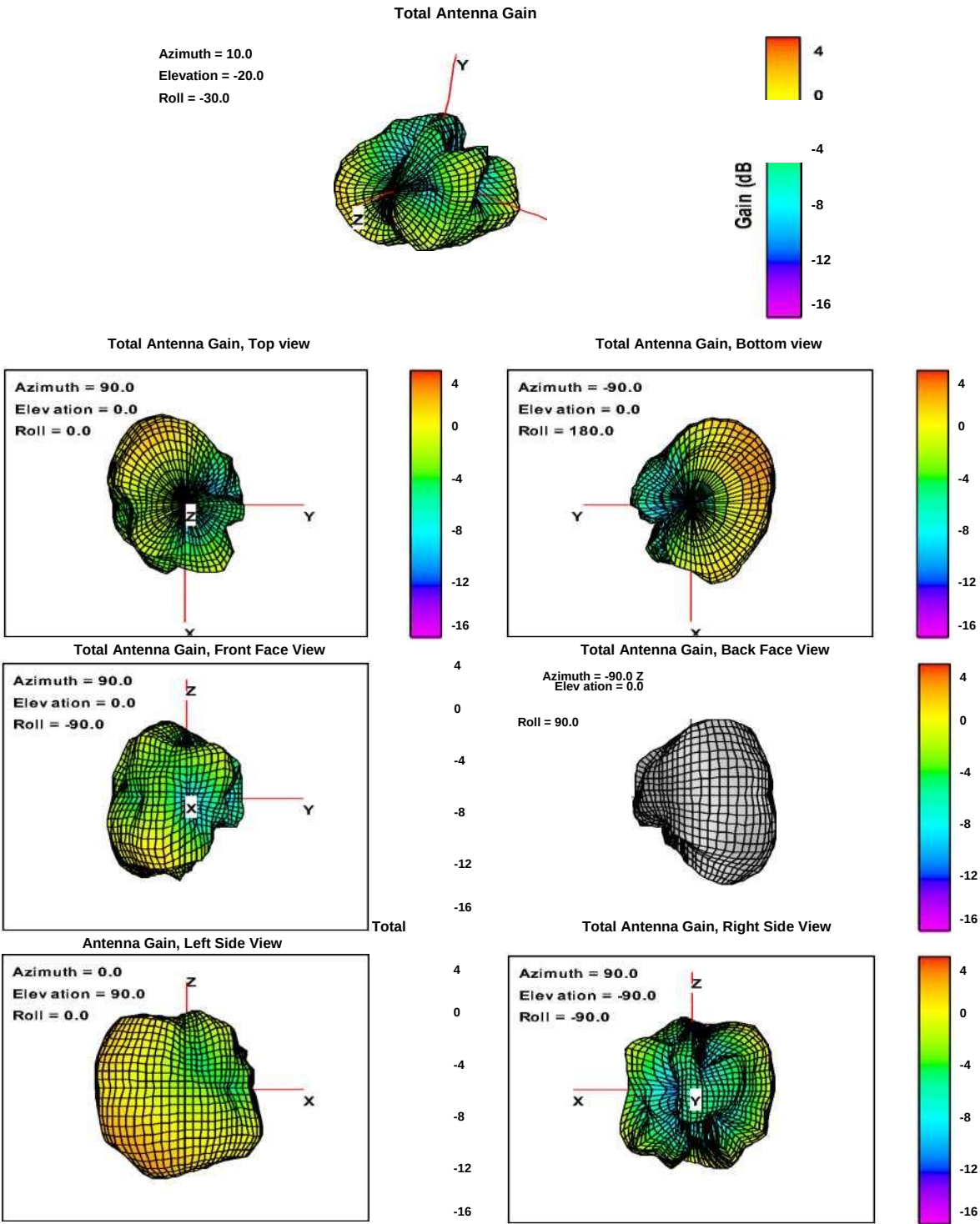


Fig. 6. Antenna Gain, BTLE Low Channel, 2402 MHz.

4.2 3D Antenna Gain Pattern - 2440 MHz - Free Space

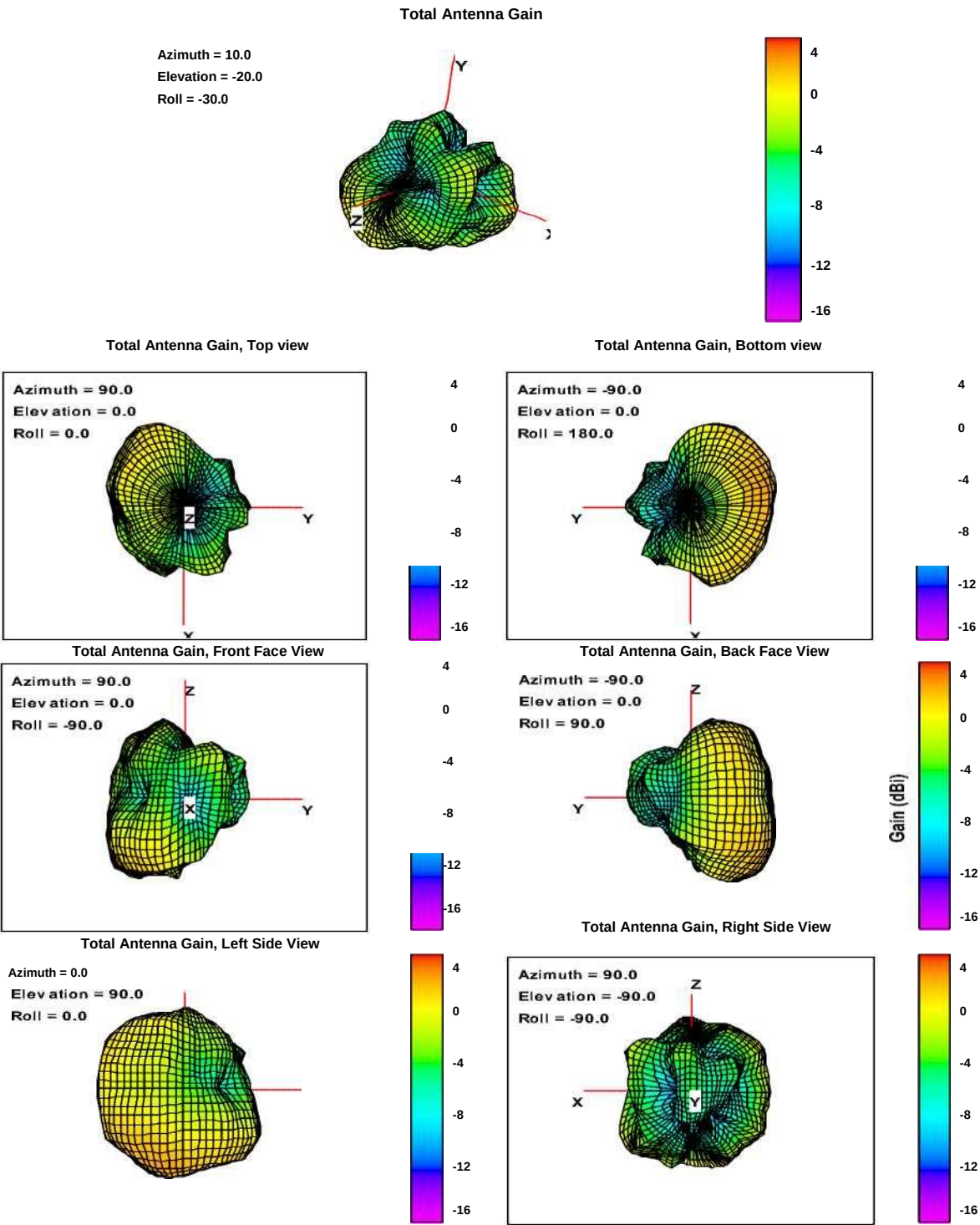


Fig. 7. Antenna Gain, BTLE Mid Channel, 2440 MHz.

4.3 3D Antenna Gain Pattern - 2480 MHz - Free Space

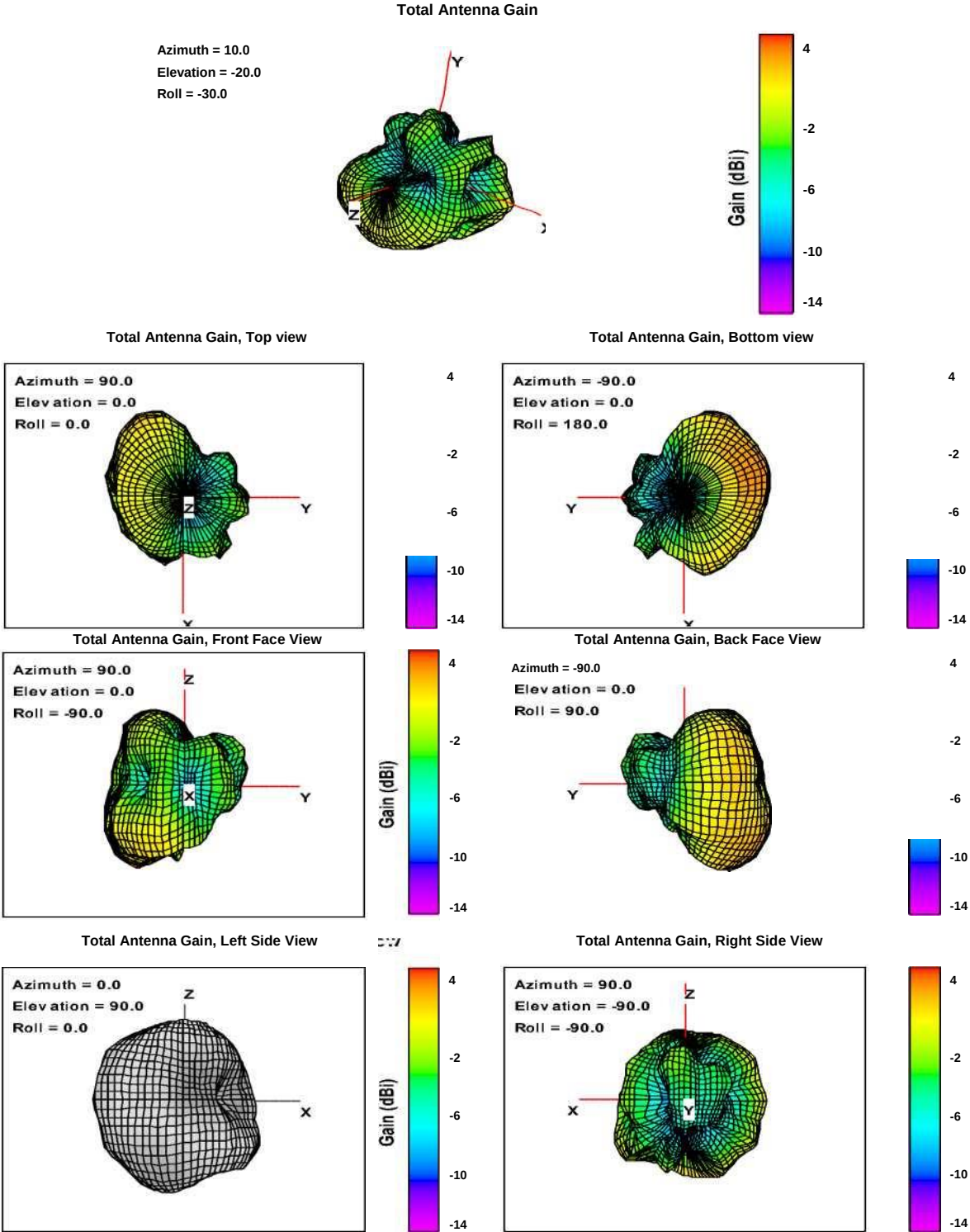


Fig. 8. Antenna Gain, BTLE High Channel, 2480 MHz.