

Test report No:
NIE: 72976RAN.001

Test report

Peak Gain and Efficiency Antenna Measurements

(*) Identification of 1tem tested	Connected Instrumentation Cluster for Motorcycles
(*) Trademark	Bosch
(*) Model and /or type reference tested	ICC65V2
(*) Other identification of the product	HW version: HW20.04 SW version: N/A FCC ID: 2AUXS-ICC6P5IN2? IC: 25847-ICC6P5IN2?
(*) Features	Bluetooth, Wi-Fi
(*) Manufacturer	Robert Bosch GmbH Robert-Bosch-Platz 1, 70839 Gerlingen, Germany
Test methodology according to	[1] 3GPP TS 34.114: "User Equipment (UE) / Mobile Station (MS) Over The Air (OTA) antenna performance; Conformance testing", V 12.2.0, (2016-10-05).
Approved by (name / position & signature)	Miguel Lacave Antennas Lab Manager
Date of issue	2022-09-19
Report template No	FAN41_01 (*) "Data provided by the client"

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Uncertainty

Uncertainty (factor $k=2$) was calculated according to the following documents:

1. CTIA Test Plan for Wireless Device Over-the-Air Performance: Method of Measurement for Radiated RF Power and Receiver Performance, Version 3.9.4, February 2022.
2. FAN06 - OTA SISO CTIA - AMS-8700 Uncertainty report

Data provided by the client

The following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item tested", "Trademark", "Model and/or type reference tested", "Other identification of the product", "Features", "Manufacturer" and "Test sample description").

DEKRA Testing and Certification, S.A.U. declines any responsibility with respect to the information provided by the client and that may affect the validity of results.

Usage of samples

Samples undergoing test have been selected by the client.

Sample M/01 is composed of the following elements:

Control N°	Description	Model	S/N	Date of reception
72976B/004	Display	ICC65V2	--	2022-08-18
72976B/035	Device Control Box	--	--	2022-08-18

1. Sample M/01 has undergone the test(s) specified in subclause "Test method requested".

Test sample description

The device under test consist of a connected instrumentation cluster for motorcycles.

Identification of the client

Company name: Robert Bosch GmbH

Postal address: Robert-Bosch-Platz 1, 70839 Gerlingen, Germany

Contact person: Karin Silberhorn

Telephone / e-mail: +49 5121 49-7662 / Karin.Silberhorn@de.bosch.com

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2022-08-25
Date (finish)	2022-08-25

Document history

Report number	Date	Description
72976RAN.001	2022-09-19	First release

Remarks and comments

The instrumentation utilized to perform the tests covered in this test report is listed in the following table.

	Equipment	Serial Number	Control N°
1.	Anechoic chamber ETS LINDGREN AMS-8700	N.A.	5281
2.	Positioning system controller and RF switch ETS LINDGREN EMCENTER 7000-001	00151214	5237
3.	OTA measurement software ETS LINDGREN EMQuest v1.14	1460	5286
4.	Vector Network Analyzer Keysight Technologies E5071C	MY46104904	3267
5.	Temperature and Humidity probe, model HWg-STE	600380	5780

Testing has been performed by Francisco José Alcaide.

Appendix A: Test results

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1. TEST CONDITIONS

1.1 Test frequencies and output power

Antenna gain and efficiency 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.

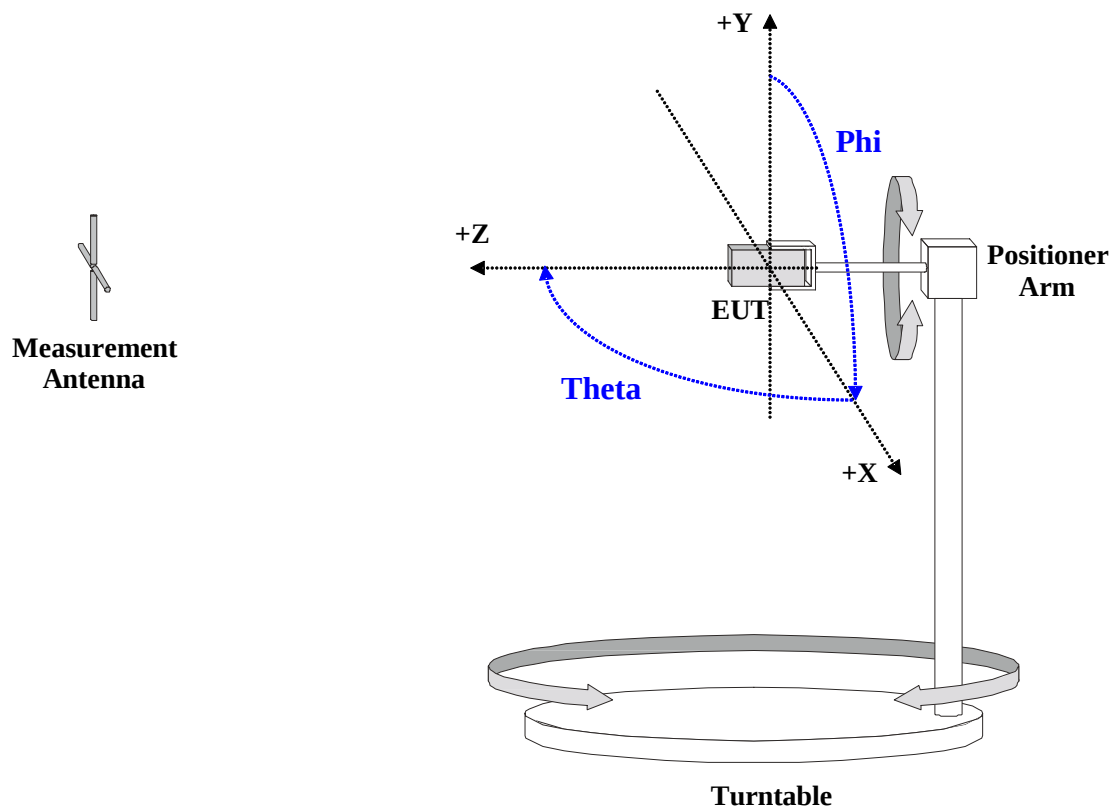


Fig. 1. Coordinate system.

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 and efficiency

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

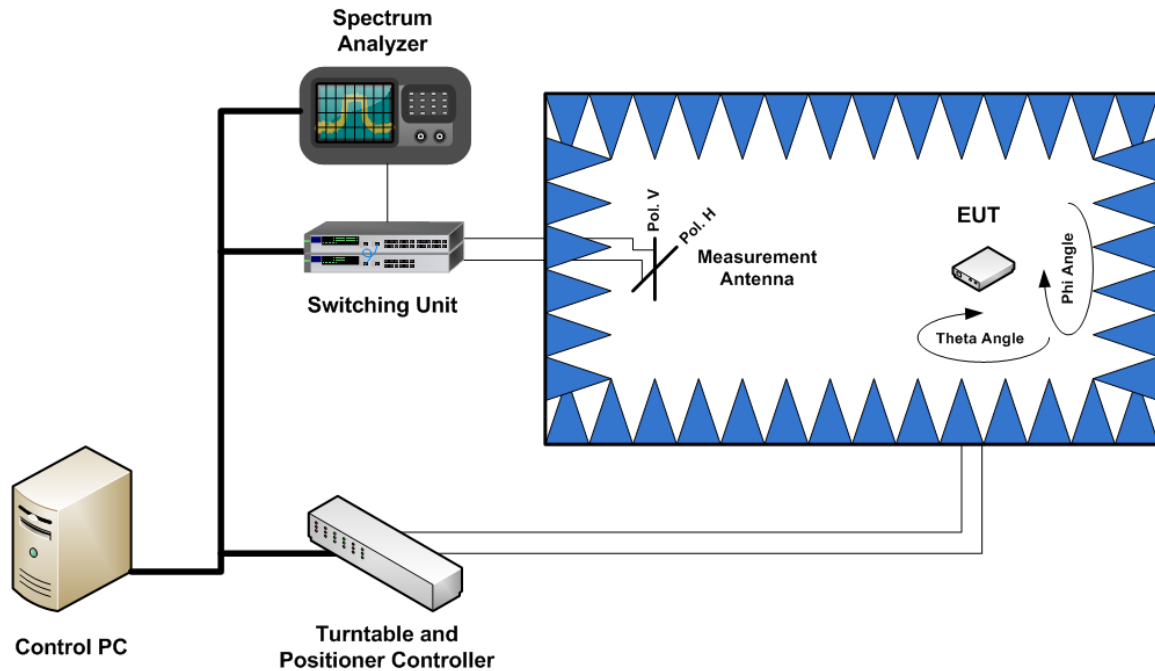


Fig. 2. Equipment and connections for antenna peak gain and efficiency measurements.

The EUT was placed inside a fully anechoic test system and hold on a multi-axis positioning system (see Figure 18). The EUT was never switched on, all signal excitations were generated by a Vector Network Analyzer (VNA) 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 for antenna BT 0 values are presented below:

Frequency (MHz)	Gain (dBi)	Efficiency (%)
2400	0.92	49.38
2401	0.88	49.02
2402	0.86	48.28
2403	0.89	48.39
2404	0.90	48.02
2405	0.91	48.33
2406	0.88	48.27
2407	0.89	48.30
2408	0.84	48.02
2409	0.78	47.67
2410	0.74	47.28
2411	0.65	46.56
2412	0.63	46.26
2413	0.56	45.61
2414	0.58	45.42
2415	0.63	45.70
2416	0.63	46.07
2417	0.62	46.03
2418	0.60	46.24
2419	0.64	46.52
2420	0.57	45.69
2421	0.56	45.55
2422	0.50	44.90
2423	0.48	45.09
2424	0.52	45.46
2425	0.46	45.03
2426	0.52	45.64
2427	0.53	45.87
2428	0.58	46.24
2429	0.63	46.74
2430	0.64	46.89
2431	0.62	46.85
2432	0.56	46.31
2433	0.53	46.22
2434	0.49	46.00
2435	0.55	46.65
2436	0.59	46.99
2437	0.70	47.71
2438	0.74	48.00
2439	0.88	48.70
2440	0.93	48.85
2441	0.90	48.52
2442	0.99	48.90
2443	0.98	48.53
2444	0.98	48.64
2445	1.03	48.72
2446	0.99	48.56
2447	1.06	49.16
2448	1.10	49.43
2449	1.16	50.03
2450	1.19	49.89
2451	1.23	50.42
2452	1.24	50.20
2453	1.18	49.74
2454	1.16	49.79
2455	1.15	49.64
2456	1.16	49.86
2457	1.18	50.04
2458	1.17	50.17
2459	1.15	50.08
2460	1.13	49.97
2461	1.15	50.56
2462	1.18	50.55
2463	1.18	50.35
2464	1.13	49.89
2465	1.14	50.09
2466	1.12	49.94
2467	1.15	50.42
2468	1.22	50.80
2469	1.24	50.98
2470	1.28	51.23
2471	1.39	51.72
2472	1.35	51.21
2473	1.40	51.45
2474	1.40	51.66
2475	1.38	51.38
2476	1.34	51.17
2477	1.34	51.28
2478	1.43	52.13
2479	1.41	51.81
2480	1.47	52.20
2481	1.51	52.62
2482	1.59	53.05
2483	1.59	52.90
2484	1.57	52.58
2485	1.55	52.58

Frequency (MHz)	Gain (dBi)	Efficiency (%)
2486	1.58	52.56
2487	1.62	53.04
2488	1.65	53.33
2489	1.71	54.02
2490	1.75	54.15
2491	1.78	54.52
2492	1.80	54.69
2493	1.86	54.89
2494	1.88	55.09
2495	1.87	54.85
2496	1.87	54.78
2497	1.84	54.60
2498	1.82	54.70
2499	1.88	55.04
2500	1.91	55.51

Antenna peak gain and efficiency for antenna BT 1 values are presented below:

Frequency (MHz)	Gain (dBi)	Efficiency (%)
2400	0.79	52.78
2401	0.79	52.45
2402	0.70	51.65
2403	0.72	51.89
2404	0.66	51.58
2405	0.66	51.96
2406	0.70	51.91
2407	0.68	51.97
2408	0.67	51.66
2409	0.64	51.43
2410	0.61	51.19
2411	0.56	50.63
2412	0.54	50.54
2413	0.46	50.00
2414	0.41	49.94
2415	0.41	50.33
2416	0.51	50.86
2417	0.49	50.83
2418	0.54	51.17
2419	0.60	51.58
2420	0.55	50.76
2421	0.55	50.75
2422	0.52	50.22
2423	0.55	50.59
2424	0.61	51.27
2425	0.53	50.89
2426	0.61	51.71
2427	0.63	51.96
2428	0.69	52.48
2429	0.78	53.11
2430	0.83	53.40
2431	0.85	53.47
2432	0.80	52.93
2433	0.75	52.98
2434	0.73	52.82
2435	0.79	53.70
2436	0.81	54.15
2437	0.87	54.96
2438	0.87	55.36
2439	0.99	56.26
2440	0.97	56.42
2441	0.93	56.05
2442	0.97	56.44
2443	0.90	55.95
2444	0.96	56.05
2445	1.00	56.03
2446	1.02	55.76
2447	1.12	56.38
2448	1.20	56.64
2449	1.28	57.30
2450	1.34	57.11
2451	1.37	57.62
2452	1.38	57.26
2453	1.36	56.55
2454	1.40	56.44
2455	1.41	56.09
2456	1.45	56.18
2457	1.49	56.25
2458	1.50	56.27
2459	1.50	56.10
2460	1.49	55.83
2461	1.57	56.35

Frequency (MHz)	Gain (dBi)	Efficiency (%)
2462	1.57	56.17
2463	1.54	55.75
2464	1.51	55.14
2465	1.51	55.19
2466	1.48	54.78
2467	1.51	55.06
2468	1.52	55.24
2469	1.52	55.21
2470	1.53	55.34
2471	1.56	55.63
2472	1.53	54.99
2473	1.51	55.07
2474	1.52	55.16
2475	1.47	54.60
2476	1.43	54.18
2477	1.42	54.12
2478	1.47	54.87
2479	1.44	54.47
2480	1.44	54.68
2481	1.43	54.91
2482	1.47	55.11
2483	1.42	54.80
2484	1.40	54.32
2485	1.38	54.25
2486	1.37	54.16
2487	1.38	54.54
2488	1.38	54.72
2489	1.42	55.28
2490	1.41	55.23
2491	1.42	55.47
2492	1.43	55.53
2493	1.41	55.62
2494	1.44	55.66
2495	1.39	55.21
2496	1.36	55.00
2497	1.33	54.73
2498	1.33	54.80
2499	1.36	55.04
2500	1.37	55.44

Antenna peak gain and efficiency for antenna WLAN 0 values are presented below:

Frequency (MHz)	Gain (dBi)	Efficiency (%)
2400	1.55	46.54
2401	1.53	46.34
2402	1.41	45.70
2403	1.43	45.89
2404	1.37	45.63
2405	1.39	46.00
2406	1.35	46.01
2407	1.35	46.14
2408	1.32	45.91
2409	1.27	45.69
2410	1.23	45.44
2411	1.14	44.80
2412	1.10	44.58
2413	1.05	44.02
2414	0.98	43.89
2415	1.01	44.22
2416	1.03	44.56
2417	1.00	44.53
2418	0.99	44.69
2419	1.00	45.00
2420	0.93	44.26
2421	0.90	44.19
2422	0.88	43.67
2423	0.88	43.88
2424	0.90	44.31
2425	0.85	43.87
2426	0.91	44.44
2427	0.93	44.59
2428	0.94	44.97
2429	0.99	45.39
2430	1.01	45.54
2431	1.02	45.51
2432	0.93	44.98
2433	0.94	44.89
2434	0.92	44.68
2435	0.98	45.28
2436	1.00	45.60
2437	1.06	46.14

Frequency (MHz)	Gain (dBi)	Efficiency (%)
2438	1.07	46.37
2439	1.13	46.94
2440	1.11	46.98
2441	1.06	46.57
2442	1.09	46.74
2443	1.01	46.23
2444	0.99	46.16
2445	0.95	46.10
2446	0.92	45.78
2447	0.95	46.22
2448	0.99	46.35
2449	1.03	46.75
2450	1.00	46.38
2451	1.04	46.65
2452	1.00	46.10
2453	0.89	45.42
2454	0.89	45.29
2455	0.86	44.88
2456	0.84	44.83
2457	0.83	44.78
2458	0.80	44.64
2459	0.76	44.35
2460	0.71	43.94
2461	0.74	44.25
2462	0.69	43.83
2463	0.62	43.33
2464	0.53	42.55
2465	0.51	42.43
2466	0.43	41.93
2467	0.49	42.07
2468	0.50	42.08
2469	0.52	41.96
2470	0.52	41.95
2471	0.49	41.97
2472	0.41	41.24
2473	0.43	41.17
2474	0.43	41.04
2475	0.40	40.52
2476	0.44	40.19
2477	0.45	40.07
2478	0.50	40.52
2479	0.51	40.11
2480	0.49	40.19
2481	0.50	40.26
2482	0.45	40.29
2483	0.41	40.00
2484	0.33	39.50
2485	0.38	39.39
2486	0.35	39.18
2487	0.38	39.30
2488	0.40	39.31
2489	0.45	39.58
2490	0.41	39.35
2491	0.39	39.30
2492	0.35	39.15
2493	0.33	38.98
2494	0.31	38.85
2495	0.24	38.41
2496	0.20	38.10
2497	0.19	37.75
2498	0.21	37.67
2499	0.20	37.58
2500	0.22	37.65

3. Graphs

3.1 Antenna Peak Gain & Efficiency for Antenna BT_0

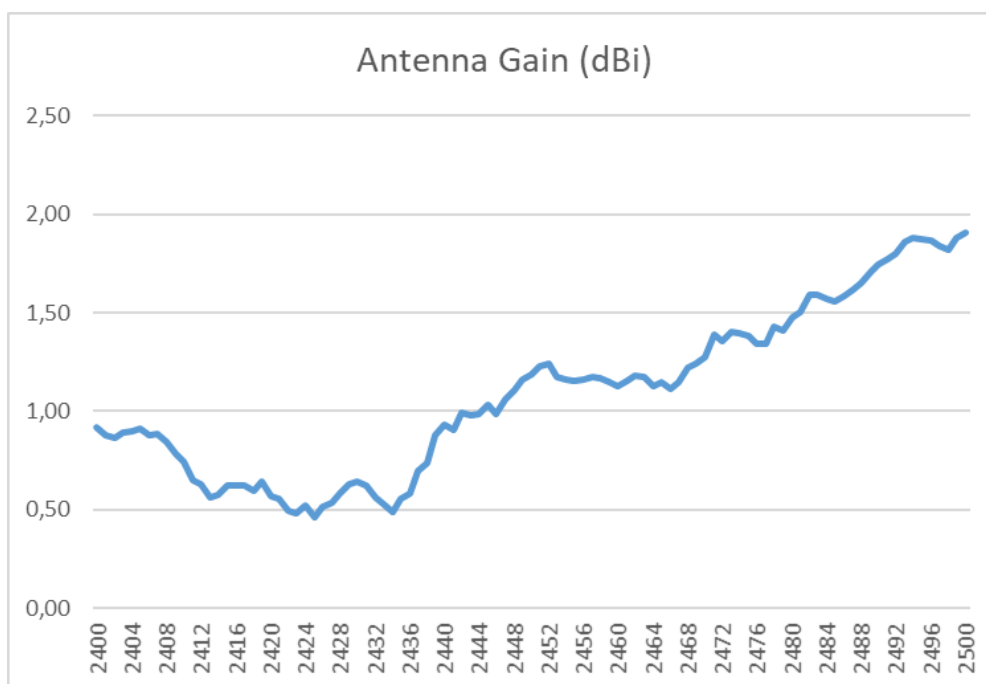


Fig. 3. Antenna Peak Gain, frequency range 2400 MHz – 2500 MHz.

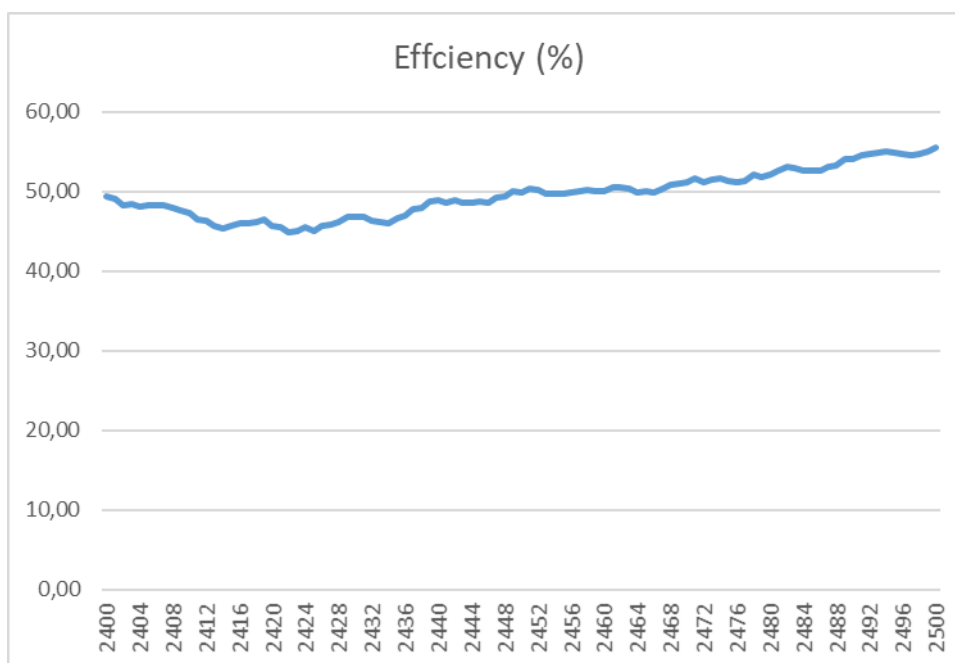


Fig. 4. Antenna Efficiency, frequency range 2400 MHz – 2500 MHz.

3.2 Antenna Peak Gain & Efficiency for Antenna BT_1

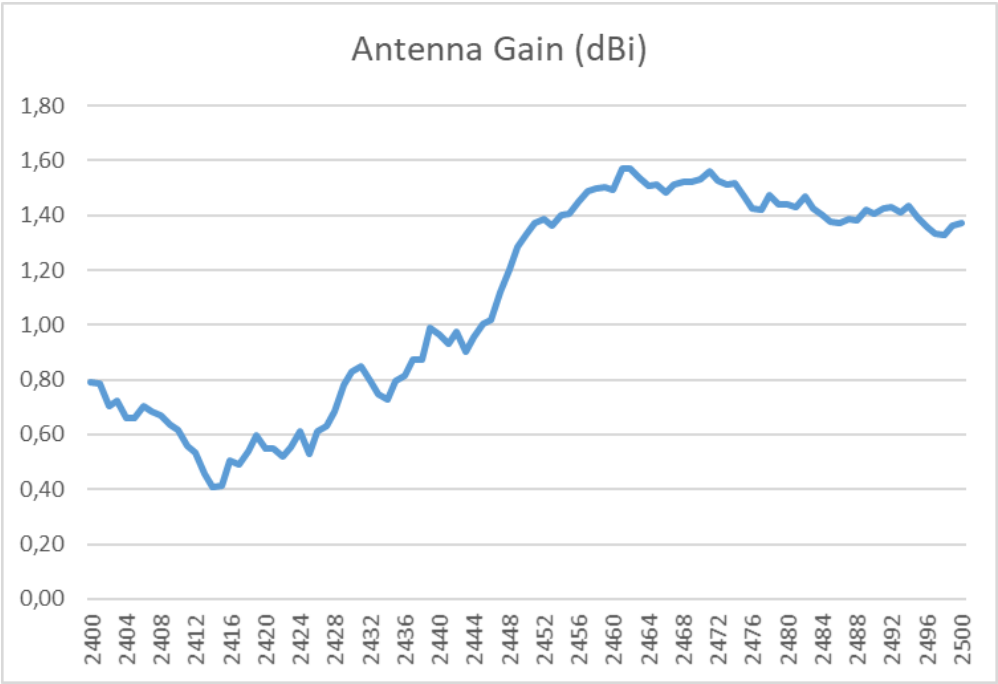


Fig. 5. Antenna Peak Gain, frequency range 2400 MHz – 2500 MHz.

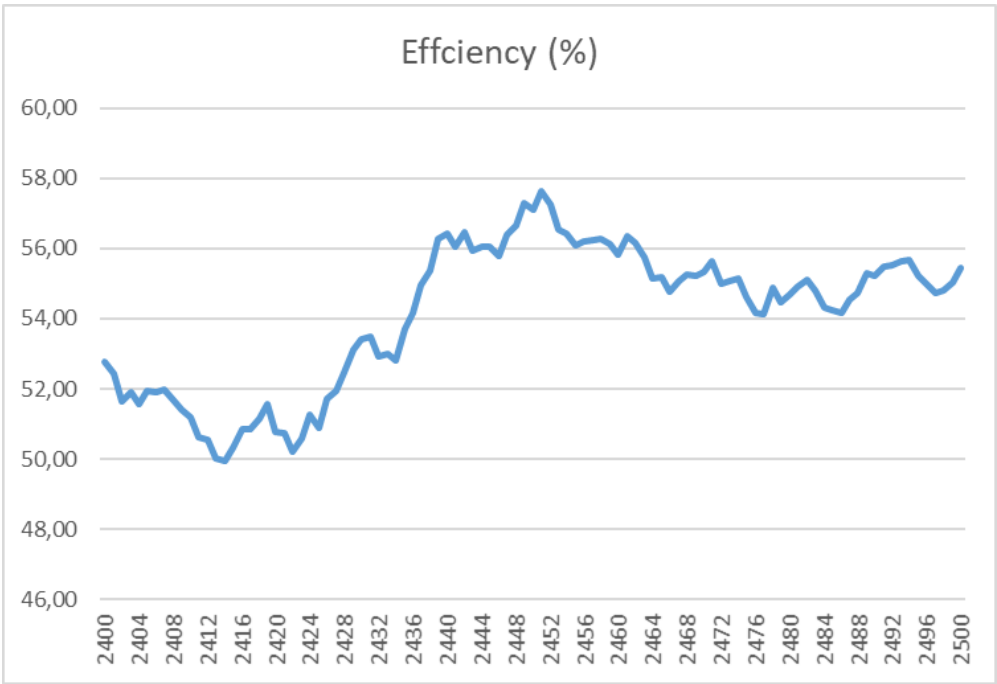


Fig. 6. Antenna Efficiency, frequency range 2400 MHz – 2500 MHz.

3.3 Antenna Peak Gain & Efficiency for Antenna WLAN_0

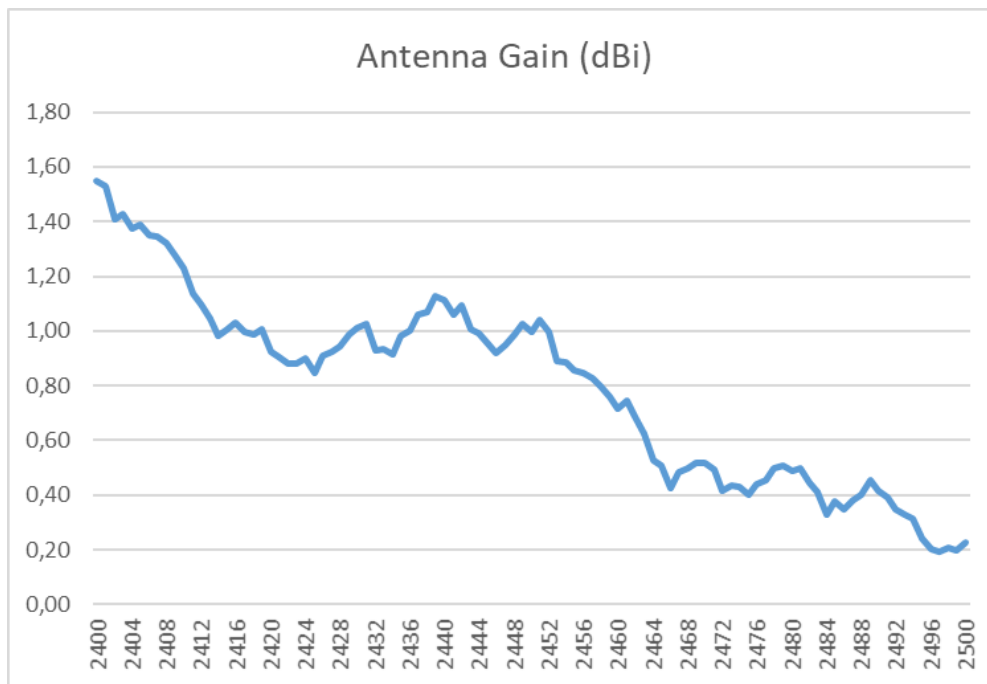


Fig. 7. Antenna Peak Gain, frequency range 2400 MHz – 2500 MHz.

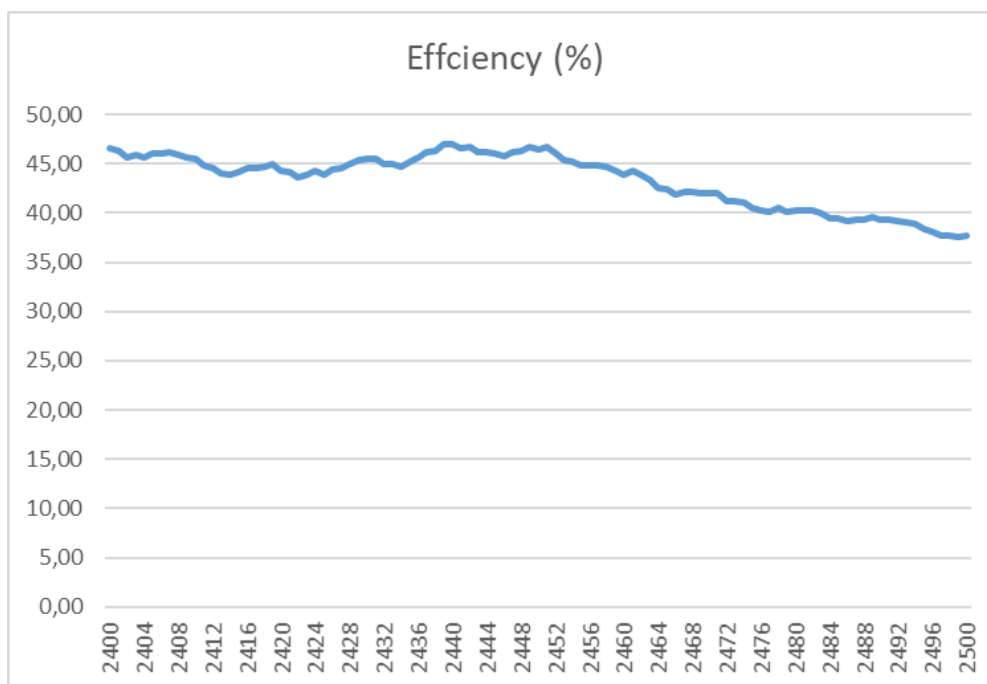


Fig. 8. Antenna Efficiency, frequency range 2400 MHz – 2500 MHz.

4. 3D – Antenna Gain Pattern

4.1 3D – BT_0 Antenna Gain Pattern – 2402 MHz – Free Space

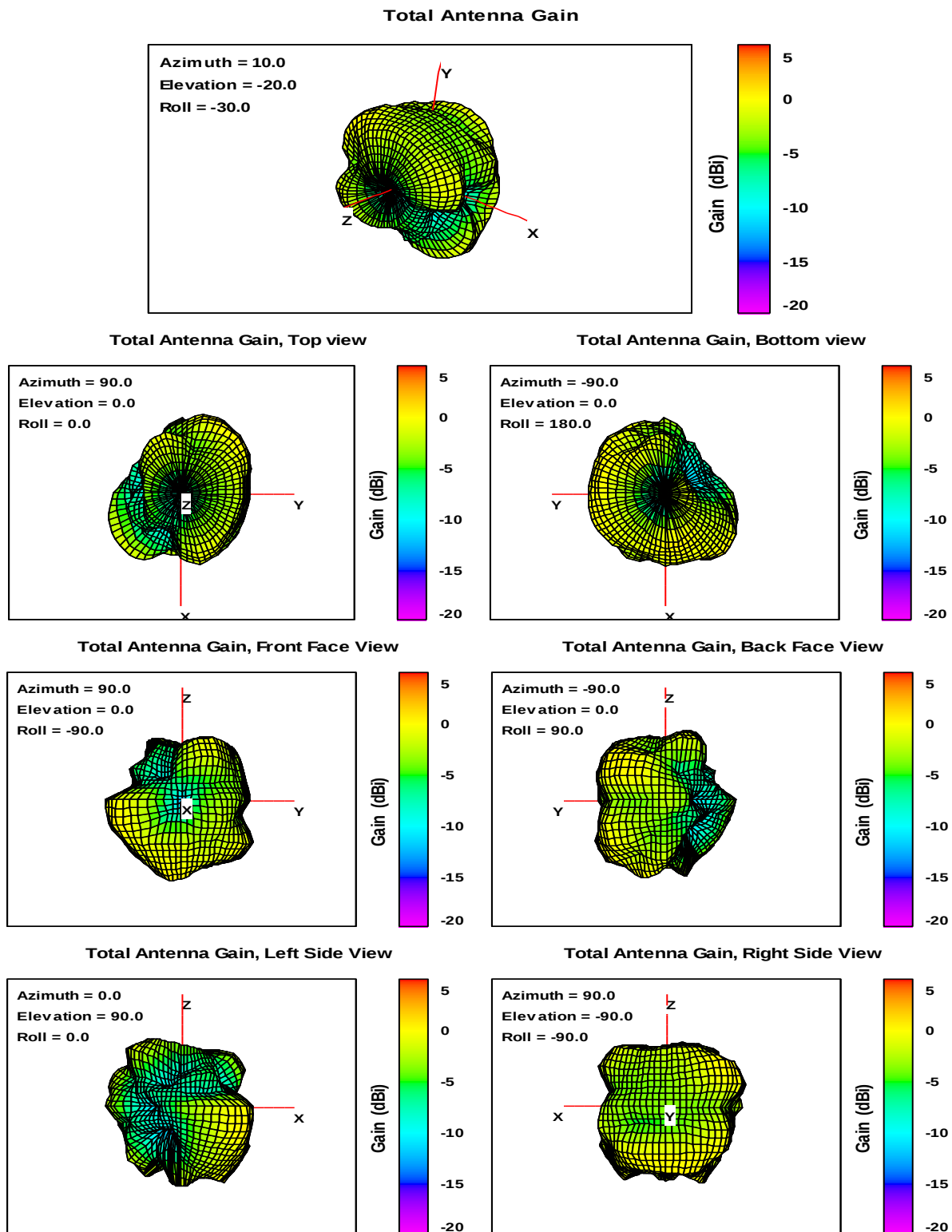


Fig. 9. BT_0 Antenna Gain, BTLE Low Channel, 2402 MHz.

4.2 3D – BT_0 Antenna Gain Pattern – 2440 MHz – Free Space

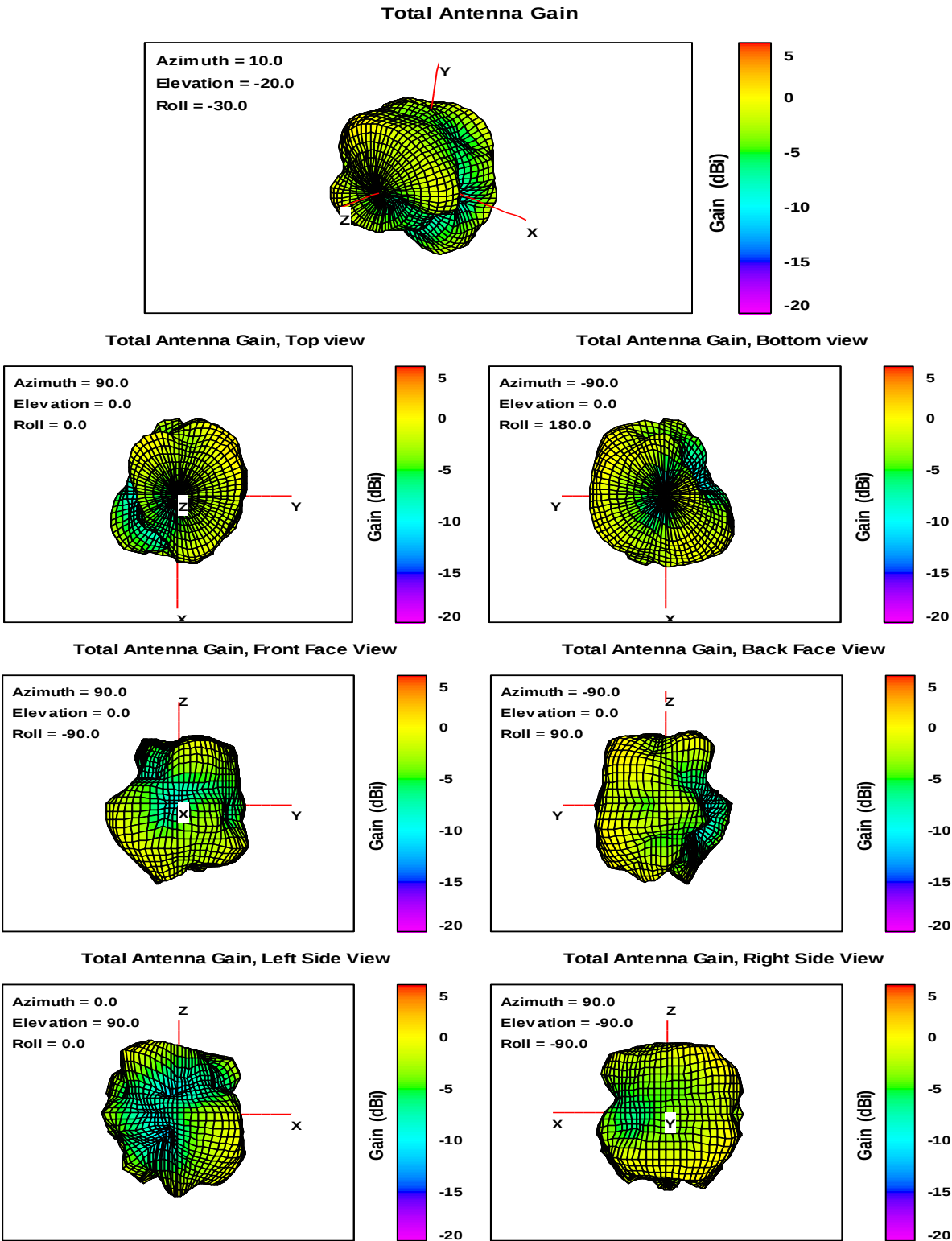


Fig. 10. BT_0 Antenna Gain, BTLE Mid Channel, 2440 MHz.

4.3 3D – BT_0 Antenna Gain Pattern – 2480 MHz – Free Space

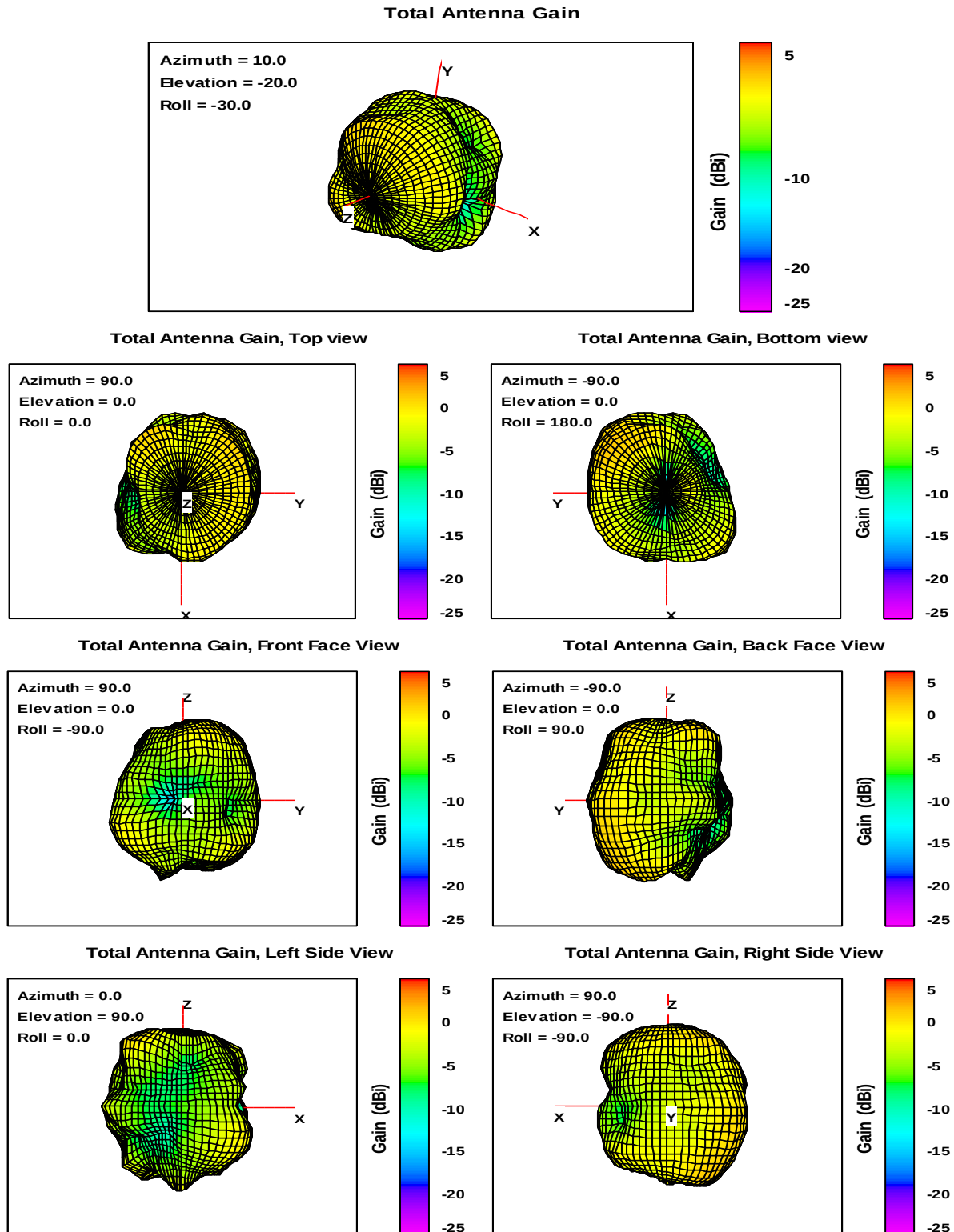


Fig. 11. BT_0 Antenna Gain, BTLE High Channel, 2480 MHz.

4.4 3D – BT_1 Antenna Gain Pattern – 2402 MHz – Free Space

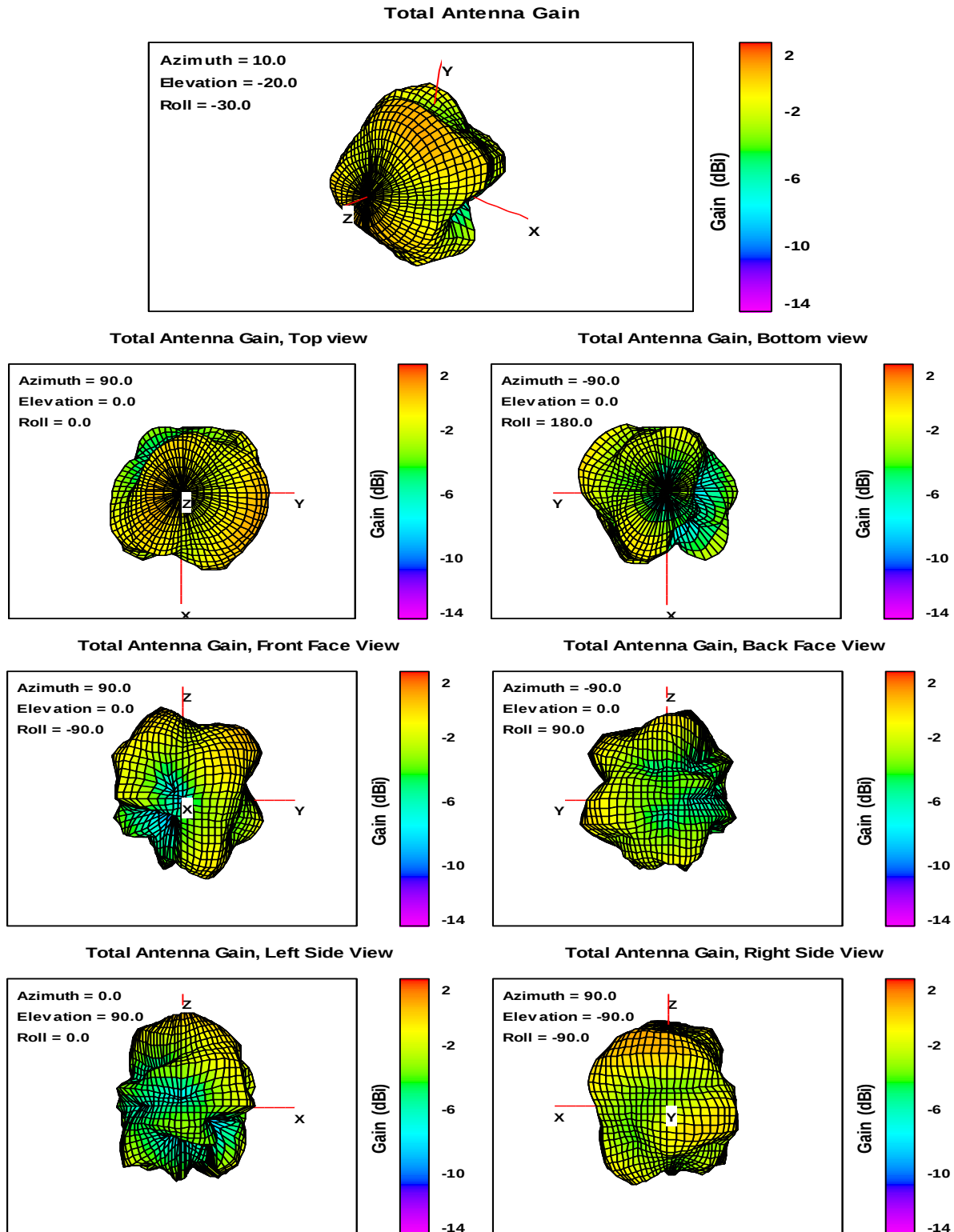


Fig. 12. BT_1 Antenna Gain, BTLE Low Channel, 2402 MHz.

4.5 3D – BT_1 Antenna Gain Pattern – 2440 MHz – Free Space

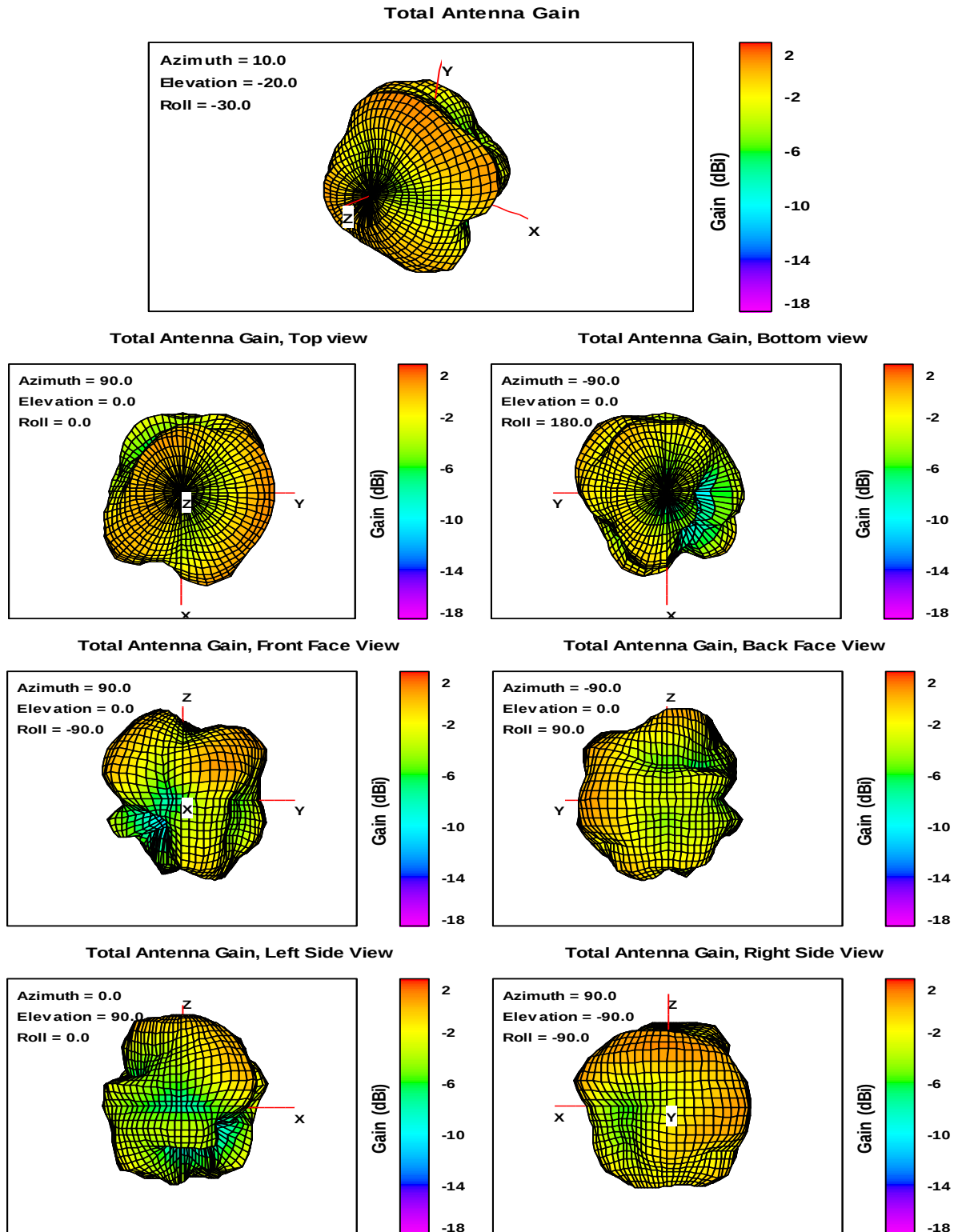


Fig. 13. BT_1 Antenna Gain, BTLE Mid Channel, 2440 MHz.

4.6 3D – BT_1 Antenna Gain Pattern – 2480 MHz – Free Space

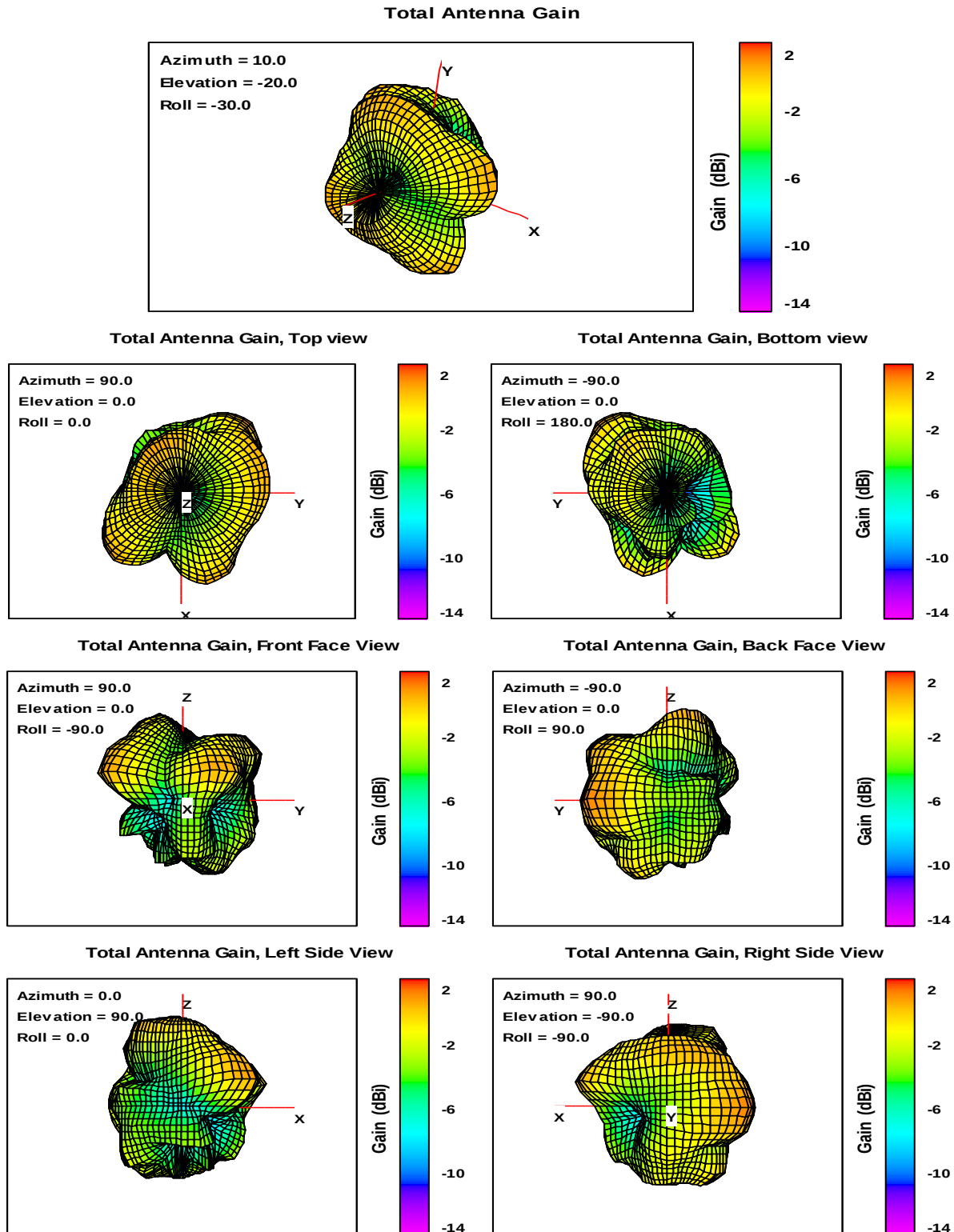


Fig. 14. BT_1 Antenna Gain, BTLE High Channel, 2480 MHz.

4.7 3D – WLAN_0 Antenna Gain Pattern – 2412 MHz – Free Space

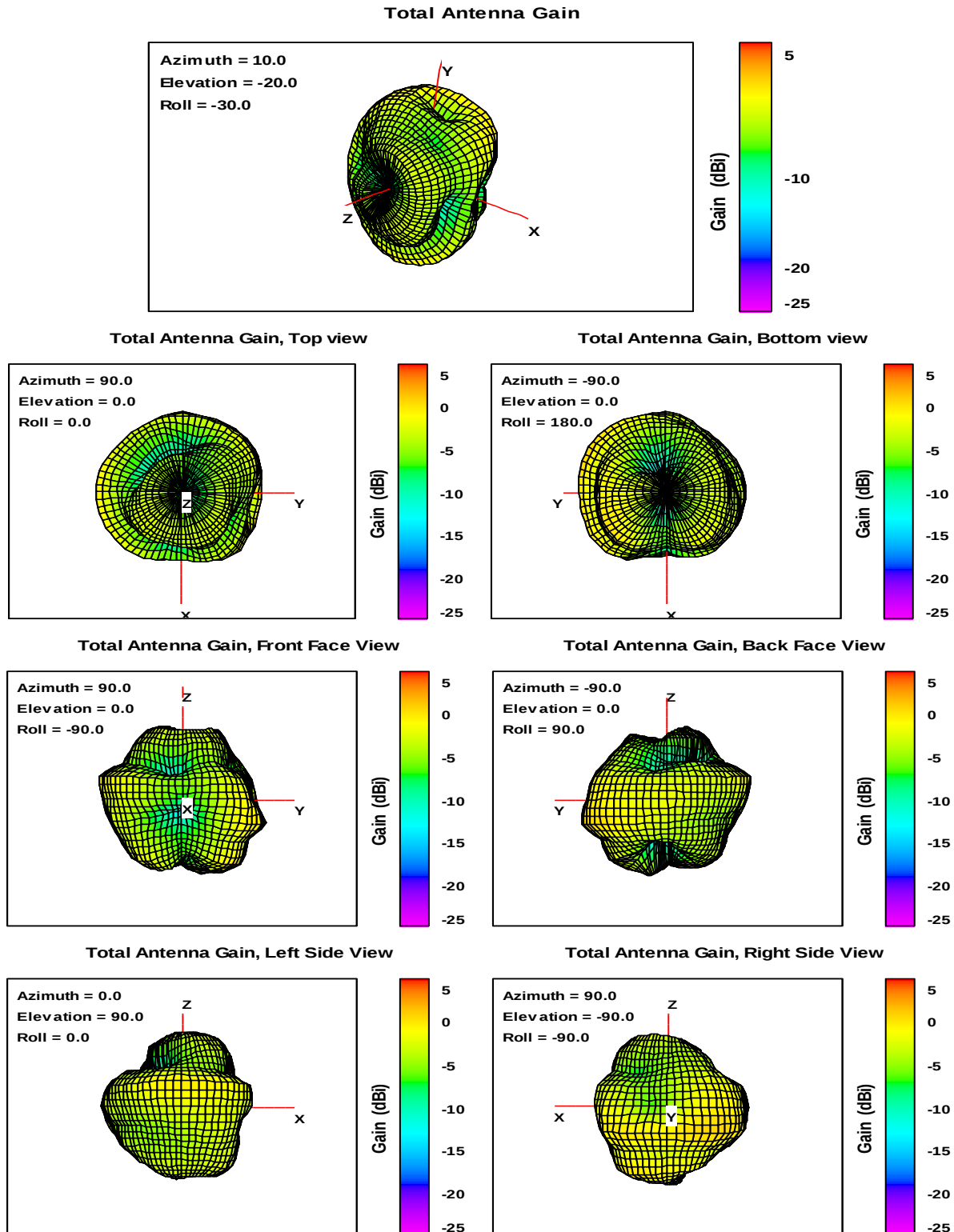


Fig. 15. WLAN_0 Antenna Gain, WLAN Channel 1, 2412 MHz.

4.8 3D – WLAN_0 Antenna Gain Pattern – 2437 MHz – Free Space

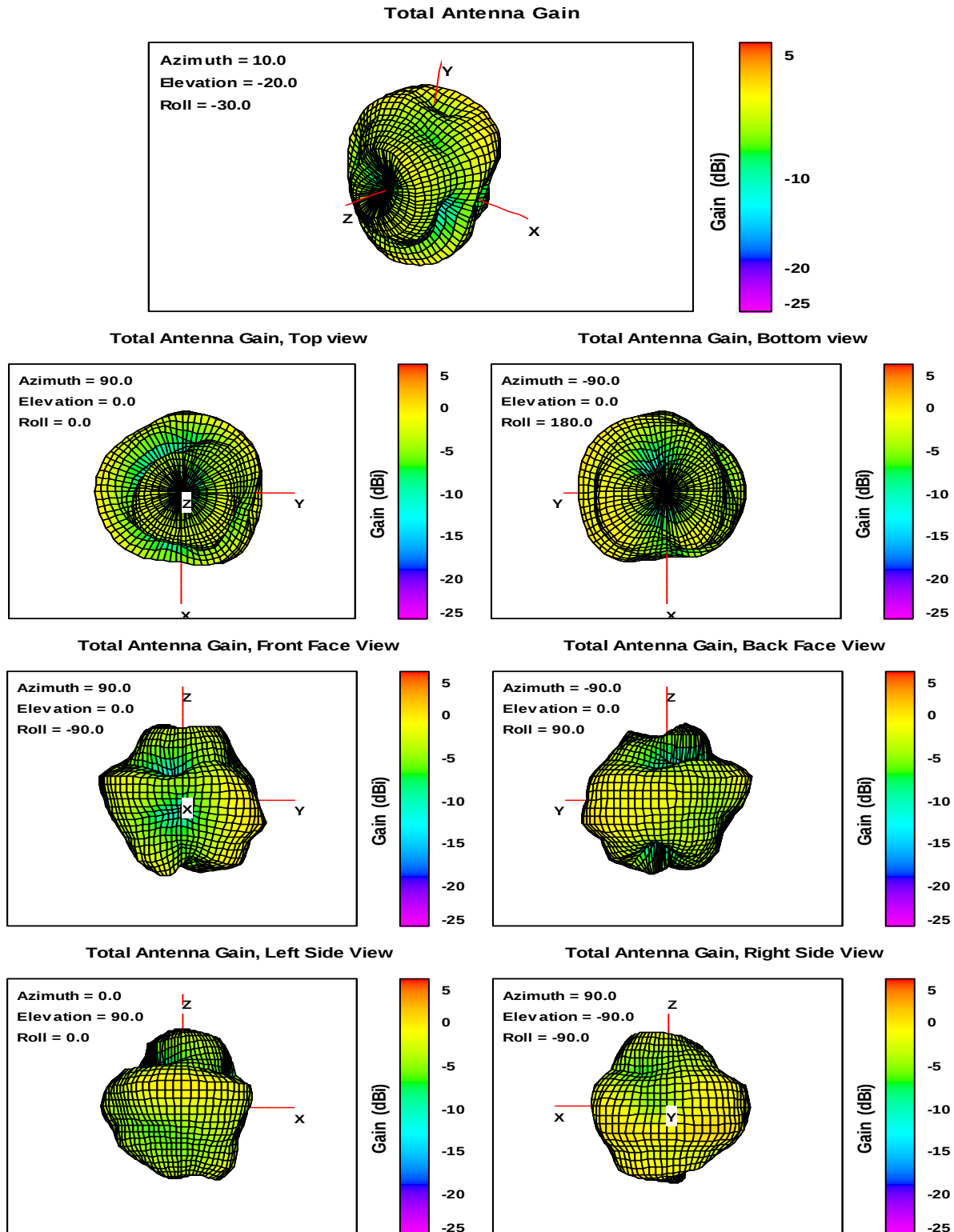


Fig. 16. WLAN_0 Antenna Gain, WLAN Channel 6, 2437 MHz.

4.9 3D – WLAN_0 Antenna Gain Pattern – 2472 MHz – Free Space

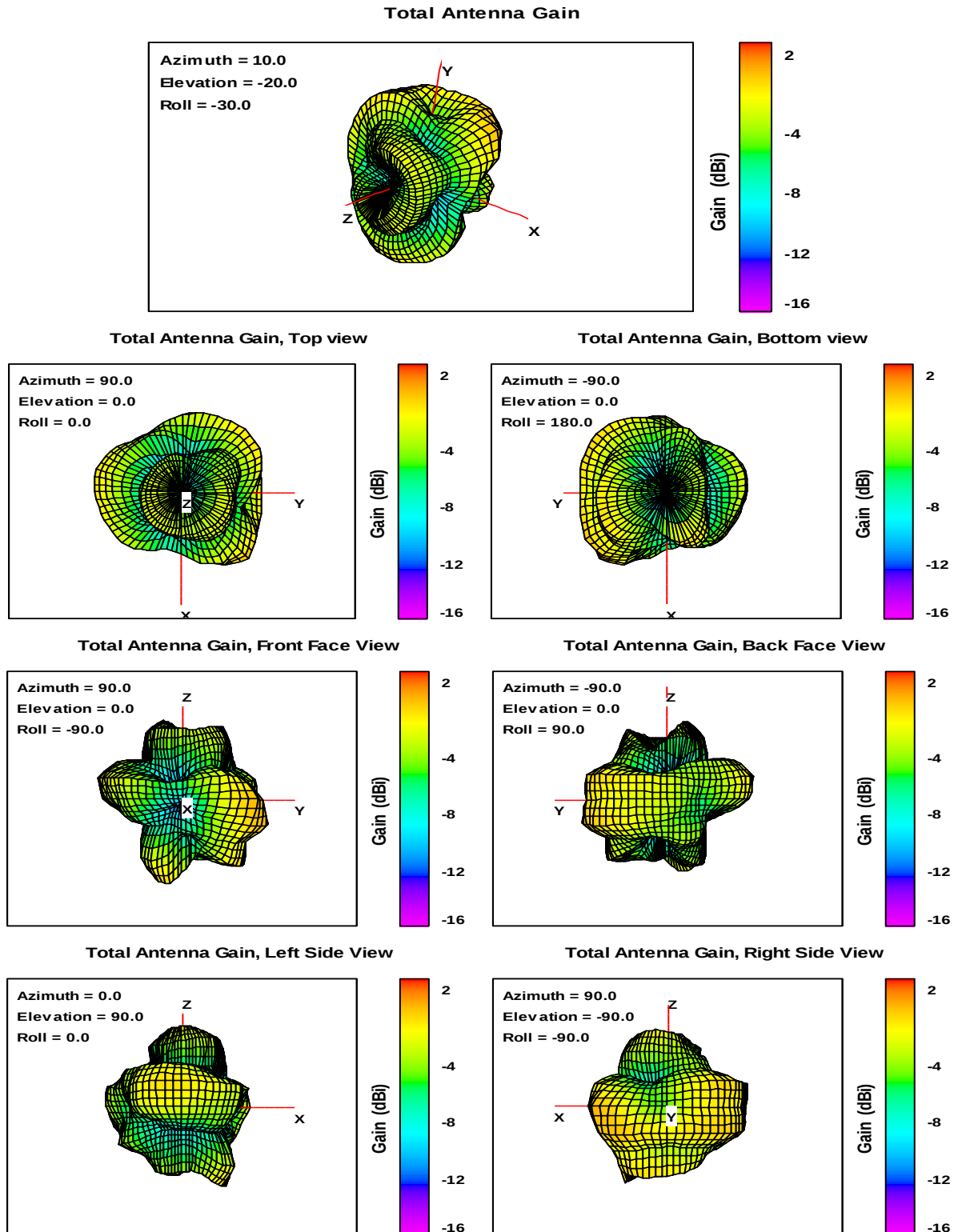


Fig. 17. WLAN_0 Antenna Gain, WLAN Channel 13, 2472 MHz.

Appendix B: Photographs

Test set:

- Test set-up: Initial position: $\Theta = 0^\circ$, $\Phi = 0^\circ$

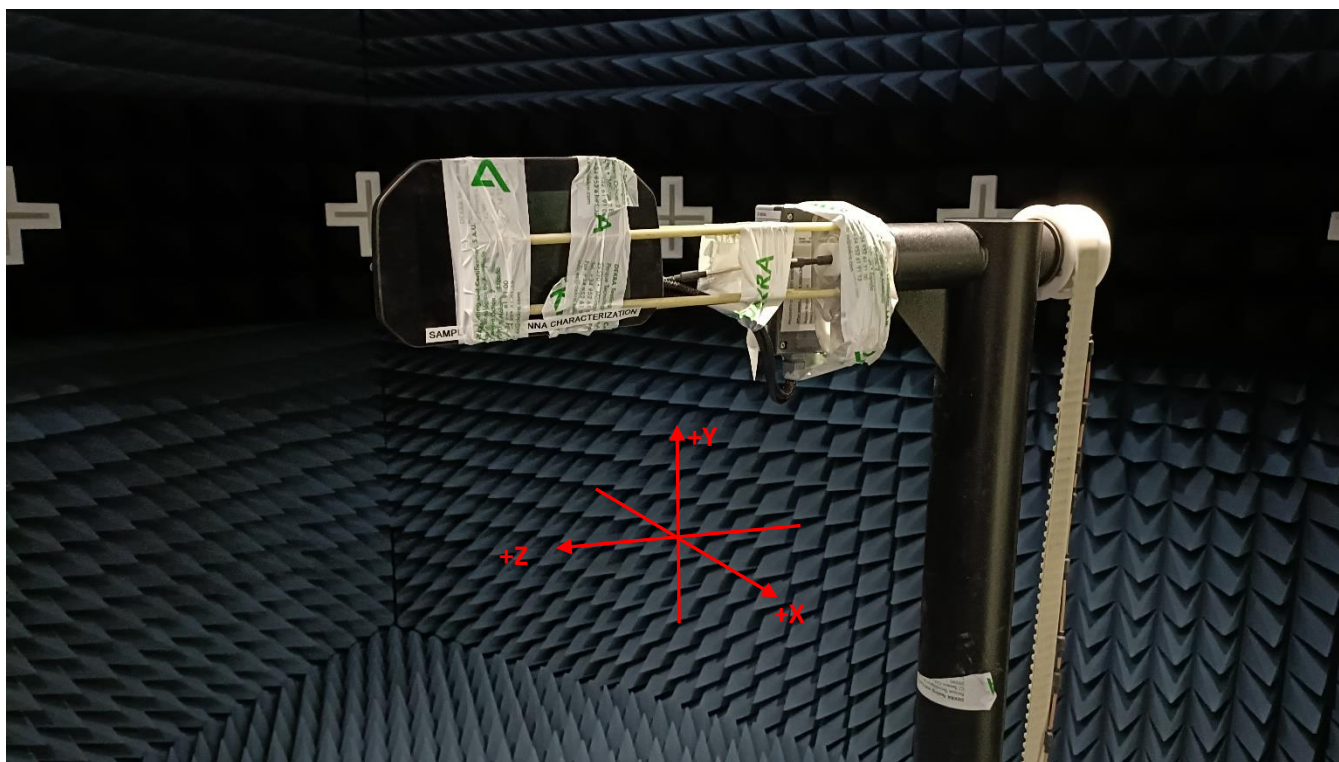
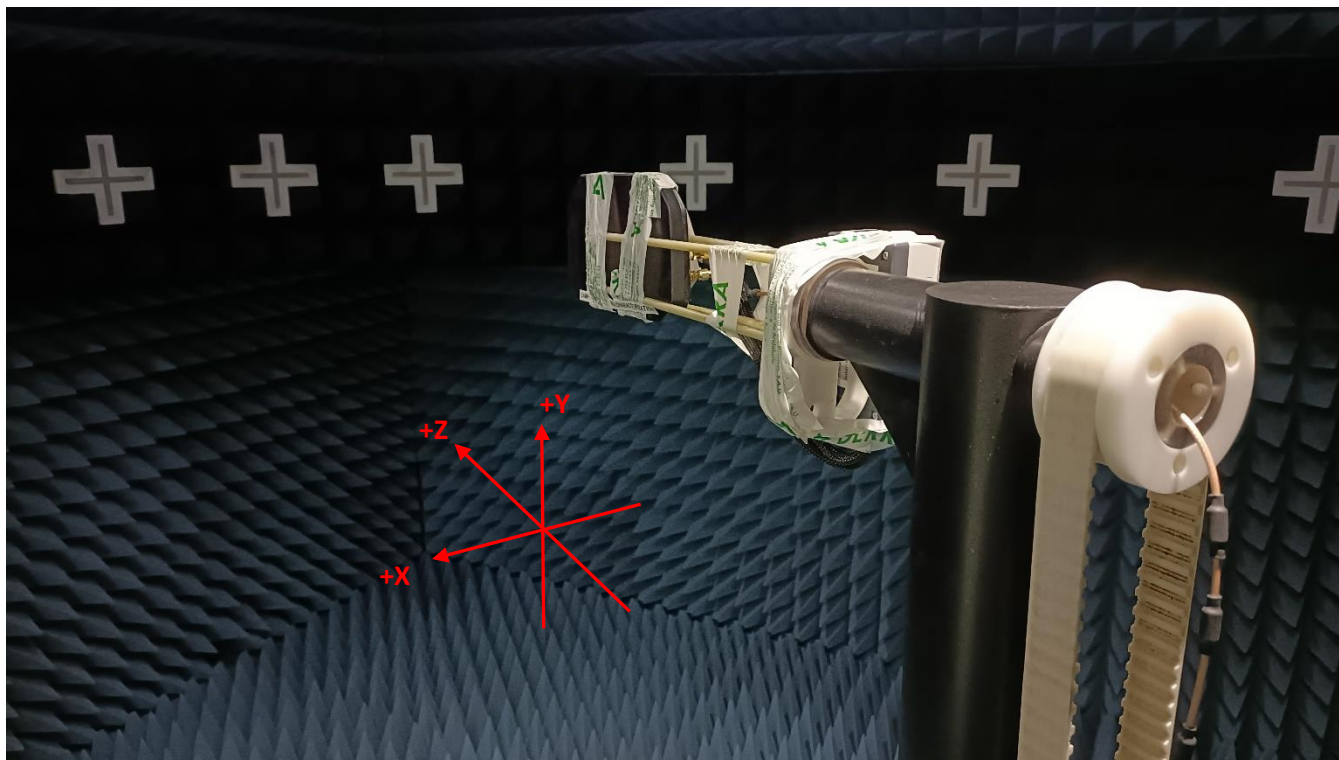


Fig 18. Test set-up view.