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RADIO TEST REPORT – REP025674

Type of assessment:

Final product testing

Applicant:

Pirelli Tire LLC

10 East 40th Street 25th Floor, New Yoork, 10016, NY, USA

Product:

Pirelli Control Module

Model:

PCM-3C-E

FCC ID:

2ANX7CPCM1

IC Registration number:

24121-CPCM1

Specifications:

- FCC 47 CFR Part 15 Subpart C, §15.247
- RSS-247, Issue 3, August 2023 , Section 5

Date of issue: March 29, 2024

Oscar Frau
Tested by

Firmato digitalmente da Frau Oscar
Signature

Roberto Giampaglia
Reviewed by

Digitally signed by Giampaglia Roberto
Signature

Lab locations

Company name	Nemko Spa
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Province	MB
Postal code	20853
Country	Italy
Telephone	+39 039 220 12 01
Facsimile	+39 039 220 12 21
Website	www.nemko.com
ISED number	FCC: 682159; IC: 9109A (10 m semi anechoic chamber)

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report. This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contain in this report are within Nemko Spa ISO/IEC 17025 accreditation.

Copyright notification

Table of Contents

Section 1 Report summary

1.1 Test specifications

RSS-247, Issue 3, August 2023, Section 5	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
FCC 47 CFR Part 15 Subpart C, §15.247	Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

1.2 Test methods

DA 00-705, Released March 30, 2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-Gen, Issue 5, April 2018 Amendment 1 (March 2019) Amendment 2 (February 2021)	General Requirements for Compliance of Radio Apparatus

1.3 Exclusions

None

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard except as noted in section 1.3 above. Results obtained indicate that the product under test complies In full with the requirements tested. The test results relate only to the items tested.

See "Summary of test results" for full details.

1.5 Test report revision history

***Table 1.5-1**: Test report revision history*

Revision #	Date of issue	Details of changes made to test report
REP025674	March 29, 2024	Original report issued

Section 2 Engineering considerations

2.1 Modifications incorporated in the EUT for compliance

There were no modifications performed to the EUT during this assessment.

2.2 Technical judgment

None

2.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 3 Test conditions

3.1 Atmospheric conditions

Temperature	15 °C – 35 °C
Relative humidity	20 % – 75 %
Air pressure	86 kPa (860 mbar) – 106 kPa (1060 mbar)

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

The following instruments are used to monitor the environmental conditions:

Equipment	Manufacturer	Model no.	Asset no.	Cal date	Next cal.
Thermo-hygrometer data loggers	Testo	175-H2	20012380/305	2023-04	2024-04
Thermo-hygrometer data loggers	Testo	175-H2	38203337/703	2022-12	2024-12
Barometer	Castle	GPB 3300	072015	2022-12	2024-12

3.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages ±5 %, for which the equipment was designed.

Section 4 Measurement uncertainty

4.1 Uncertainty of measurement

The measurement uncertainty was calculated for each test and quantity listed in this test report, according to CISPR 16-4-2 and other specific test standard and is documented in Nemko Spa working manual WML1002.
The assessment of conformity for each test performed on the equipment is performed not taking into account the measurement uncertainty. The two following possible verdicts are stated in the report:
P (Pass) - The measured values of the equipment respect the specification limit at the points tested. The specific risk of false accept is up to 50% when the measured result is close to the limit.
F (Fail) - One or more measured values of the equipment do not respect the specification limit at the points tested. The specific risk of false reject is up to 50% when the measured result is close to the limit.
Hereafter Nemko's measurement uncertainties are reported:

EUT	Type	Test	Range	Measurement Uncertainty	Notes
Transmitter	Conducted	Frequency error	0.001 MHz ÷ 40 GHz	0.08 ppm	(1)
		Carrier power RF Output Power	0.009 MHz ÷ 30 MHz	1.1 dB	(1)
			30 MHz ÷ 18 GHz	1.5 dB	(1)
			18 MHz ÷ 40 GHz	3.0 dB	(1)
			40 MHz ÷ 140 GHz	5.0 dB	(1)
		Adjacent channel power	1 MHz ÷ 18 GHz	1.4 dB	(1)
		Conducted spurious emissions	0.009 MHz ÷ 18 GHz	3.0 dB	(1)
			18 GHz ÷ 40 GHz	4.2 dB	(1)
			40 GHz ÷ 220 GHz	6.0 dB	(1)
		Intermodulation attenuation	1 MHz ÷ 18 GHz	2.2 dB	(1)
		Attack time – frequency behaviour	1 MHz ÷ 18 GHz	2.0 ms	(1)
		Attack time – power behaviour	1 MHz ÷ 18 GHz	2.5 ms	(1)
		Release time – frequency behaviour	1 MHz ÷ 18 GHz	2.0 ms	(1)
		Release time – power behaviour	1 MHz ÷ 18 GHz	2.5 ms	(1)
		Transient behaviour of the transmitter– Transient frequency behaviour	1 MHz ÷ 18 GHz	0.2 kHz	(1)
		Transient behaviour of the transmitter – Power level slope	1 MHz ÷ 18 GHz	9%	(1)
		Frequency deviation - Maximum permissible frequency deviation	0.001 MHz ÷ 18 GHz	1.3%	(1)
		Frequency deviation - Response of the transmitter to modulation frequencies above 3 kHz	0.001 MHz ÷ 18 GHz	0.5 dB	(1)
		Dwell time	-	3%	(1)
		Hopping Frequency Separation	0.01 MHz ÷ 18 GHz	1%	(1)
		Occupied Channel Bandwidth	0.01 MHz ÷ 18 GHz	2%	(1)
		Modulation Bandwidth	0.01 MHz ÷ 18 GHz	2%	(1)
	Radiated	Radiated spurious emissions	0.009 MHz ÷ 26.5 GHz	6.0 dB	(1)
			26.5 GHz ÷ 66 GHz	8.0 dB	(1)
			66 GHz ÷ 220 GHz	10 dB	(1)
		Effective radiated power transmitter	10 kHz ÷ 26.5 GHz	6.0 dB	(1)
			26.5 GHz ÷ 66 GHz	8.0 dB	(1)
			66 GHz ÷ 220 GHz	10 dB	(1)

NOTES:
(1) The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k = 2, which for a normal distribution corresponds to a coverage probability of approximately 95 %

Section 5 Information provided by the applicant

5.1 Disclaimer

This section contains information provided by the applicant and has been utilized to support the test plan. Inaccurate information provided by the applicant can affect the validity of the results contained within this test report. Nemko accepts no responsibility for the information contained within this section and the impact it may have on the test plan and resulting measurements.

5.2 Applicant/Manufacture

Applicant name	Pirelli Tire LLC.
Applicant address	10 East 40th Street 25th Floor, New York, 10016, NY, USA
Manufacture name	Same as applicant
Manufacture address	Same as applicant

5.3 EUT information

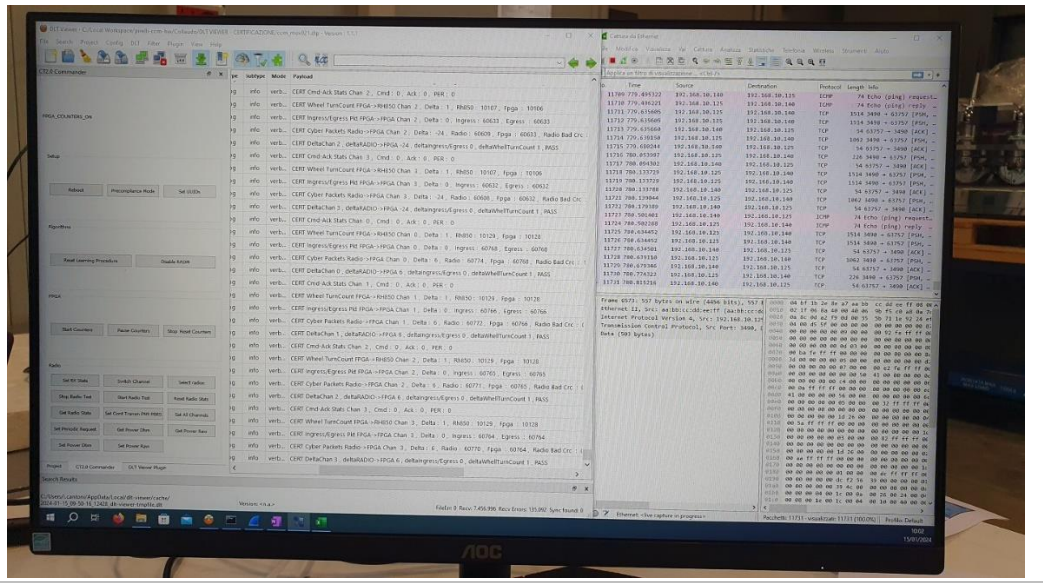
Product	Pirelli Control Module
Model	PCM-3C-E
Serial number	PRJ0046976001 (assigned by Nemko S.p.A.)
Power supply requirements	12 V DC, 500 mA max
Product description and theory of operation	The EUT is a Pirelli Cyber Control Module (2.4GHz RF Electronic Control Unit (ECU) and Vehicle Radio Receiver).

5.4 Radio technical information

Category of Wideband Data Transmission equipment	☐ Frequency Hopping Spread Spectrum (FHSS) equipment ☒ Other types of Wideband Data Transmission equipment (e.g. DSSS, OFDM, etc.).
Frequency band	2400–2483.5
Frequency Min (MHz)	2407
Frequency Max (MHz)	2477
Channel numbers	0–31
RF power Max (W), Conducted	Port 1: 3.83 mW (5.84 dBm) Port 2: 3.82 mW (5.83 dBm) Port 3: 3.65 mW (5.62 dBm) Port 4: 3.58 mW (5.54 dBm)
Field strength, dBµV/m @ 3 m	106.39
Measured BW (kHz), 6 dB OBW	1015
Measured BW (kHz), 99% OBW	1571
Type of modulation	GFSK
Emission classification	1M57F1D
Transmitter spurious, dBµV/m @ 3 m	52.1 (@12206.25 MHz)
Antenna information	Dedicated, 4 x Taoglass WSA.2400.A.101151; max peak gain 4.67 dBi

5.5 EUT setup details

5.5.1 Radio exercise details

Operating conditions	The EUT has been tested with DLT Viewer software provided by the applicant, as following: 
Transmitter state	Transmitter set into continuous mode.

5.5.2 EUT setup configuration

***Table 5.5-1**: EUT sub assemblies*

Description	Brand name	Model, Part number, Serial number, Revision level
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***Table 5.5-2**: EUT interface ports*

Description	Qty.
DC	1
Antenna port 1	1
Antenna port 2	1
Antenna port 3	1
Antenna port 4	1
Antenna port 5	1
Automotive Ethernet	1
CAN	1

***Table 5.5-3**: Support equipment*

Description	Brand name	Model, Part number, Serial number, Revision level
Laptop	Dell	Latitude
Optical AETH converter	MK	OptoLAN 100Base-T1
ETH media converter	NXP	RDDRONE-T1ADAPT
RF generator	R&S	SMBV100B
3 x CAN converter	--	--

***Table 5.5-4**: Inter-connection cables*

Cable description	From	To	Length (m)
Optical fiber	Optical AETH converter (master)	Optical AETH converter (slave)	10.0
CAN Bus	PC	EUT	5.0
Power line	Power supply	EUT	1.5

EUT setup configuration, continued

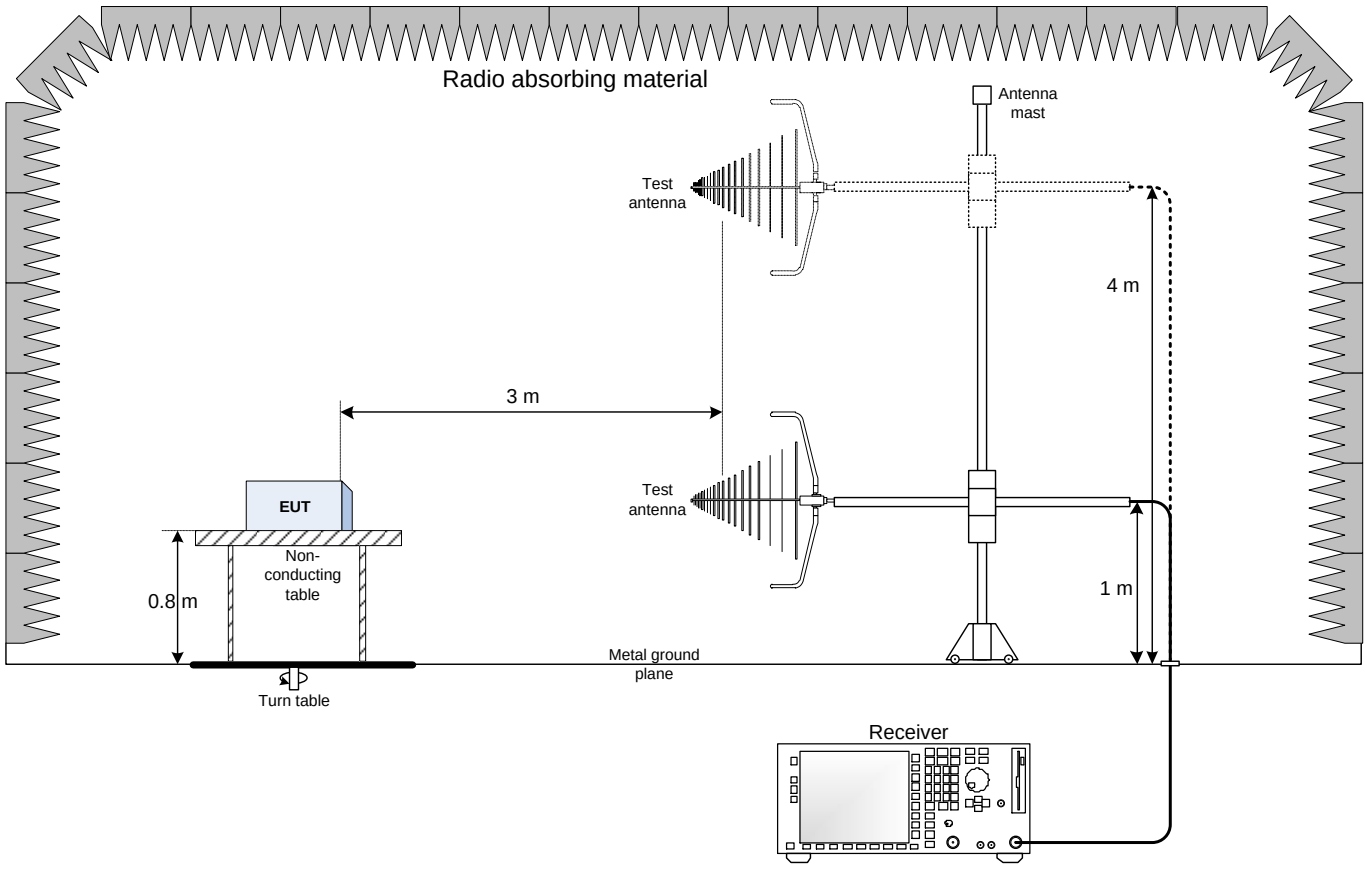


Figure 5.5-1*: Radiated testing block diagram (below 1 GHz)*

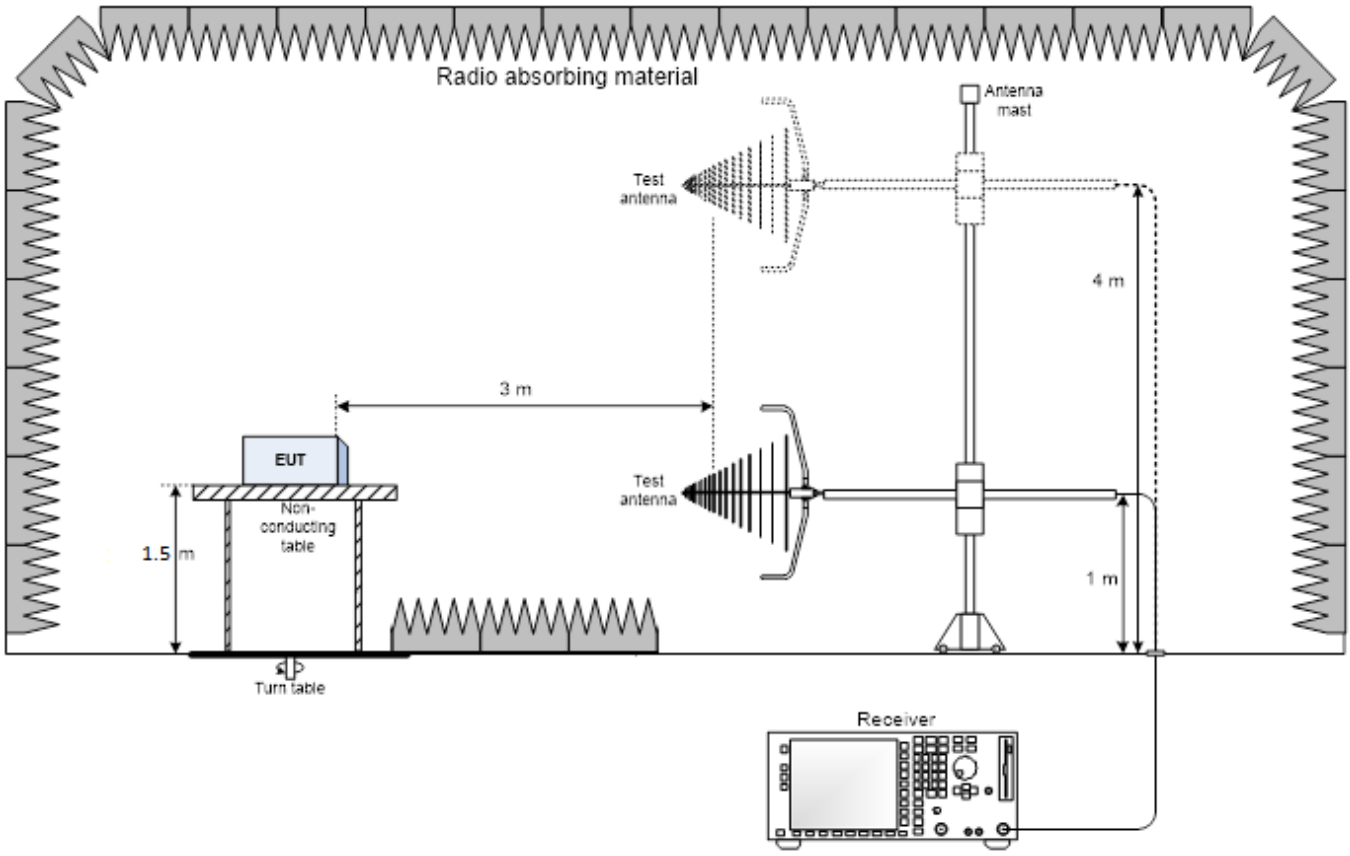


Figure 5.5-2*: Radiated testing block diagram (above 1 GHz)*

Section 6 Summary of test results

6.1 Testing location

Test location (s)	Nemko S.p.A. Via Del Carroccio, 4 20853 Biassono (MB) Italy

6.2 Testing period

Test start date	March 21, 2024	Test end date	March 29, 2024

6.3 Sample information

Receipt date	January 15, 2024	Nemko sample ID number(s)	PRJ0046976001

6.4 ISED RSS-Gen, Issue 5, test results

***Table 6.4-1**: RSS-Gen requirements results*

Part	Test description	Verdict
7.3	Receiver radiated emission limits	Not applicable
7.4	Receiver conducted emission limits	Not applicable
6.9	Operating bands and selection of test frequencies	Pass
8.8	AC power-line conducted emissions limits	Not applicable

Notes: [1]According to sections 5.2 and 5.3 of RSS-Gen, Issue 5 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.
The EUT is a DC powered device supply by the vehicle battery

6.5 ISED RSS-247, Issue 3, test results for frequency hopping spread spectrum systems (FHSS)

***Table 6.5-1**: ISED FHSS requirements results*

Part	Test description	Verdict
5.1 (a)	Bandwidth of a frequency hopping channel	Not applicable
5.1 (b)	Minimum channel spacing	Not applicable
5.1 (c)	Systems operating in the 902–928 MHz band	Not applicable
5.1 (d)	Systems operating in the 2400–2483.5 MHz band	Not applicable
5.1 (e)	Systems operating in the 5725–5850 MHz band	Not applicable
5.3	Hybrid Systems	
5.3 (a)	Digital modulation turned off	Not applicable
5.3 (b)	Frequency hopping turned off	Not applicable
5.4	Transmitter output power and e.i.r.p. requirements	
5.4 (a)	Systems operating in the 902–928 MHz band	Not applicable
5.4 (b)	Systems operating in the 2400–2483.5 MHz band	Not applicable
5.4 (c)	Systems operating in the 5725–5850 MHz	Not applicable
5.4 (e)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
5.4 (f)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
5.5	Unwanted emissions	Not applicable

Notes: --

6.6 ISED RSS-247, Issue 3, test results for digital transmission systems (DTS)

***Table 6.6-1**: ISED DTS requirements results*

Part	Test description	Verdict
5.2 (a)	Minimum 6 dB bandwidth	Pass
5.2 (b)	Maximum power spectral density	Pass
5.3	Hybrid Systems	
5.3 (a)	Digital modulation turned off	Not applicable
5.3 (b)	Frequency hopping turned off	Not applicable
5.4	Transmitter output power and e.i.r.p. requirements	
5.4 (d)	Systems employing digital modulation techniques	Pass
5.4 (e)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
5.4 (f)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
5.5	Unwanted emissions	Pass

Notes: --

6.7 FCC Part 15 Subpart C, general requirements test results

Part	Test description	Verdict
§15.207(a)	Conducted limits	Not applicable
§15.31(e)	Variation of power source	Pass[1]
§15.203	Antenna requirement	Pass

Notes: [1] Measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, was performed with the supply voltage varied between 85 % and 115 % of the nominal rated supply voltage. No noticeable output power variation was observed.

[2] The Antennas are located within the enclosure of EUT and not user accessible.

6.8 FCC Part 15 Subpart C, intentional radiators test results

Part	Test description	Verdict
§15.247(a)(1)(i)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(a)(1)(ii)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
§15.247(a)(2)	Minimum 6 dB bandwidth for systems using digital modulation techniques	Pass
§15.247(b)(1)	Maximum peak output power of frequency hopping systems operating in the 2400–2483.5 MHz band and 5725–5850 MHz band	Not applicable
§15.247(b)(2)	Maximum peak output power of Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(b)(3)	Maximum peak output power of systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands	Pass
§15.247(c)(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247(c)(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Not applicable
§15.247(d)	Spurious emissions	Pass
§15.247(e)	Power spectral density for digitally modulated devices	Pass
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

6.9 ISED RSS-GEN, Issue 5, test results

Part	Test description	Verdict
7.1.2	Receiver radiated emission limits	Not applicable
7.1.3	Receiver conducted emission limits	Not applicable
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Not applicable

Notes:

[1] According to sections 5.2 and 5.3 of RSS-Gen, Issue 5 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.

Section 7 Test equipment

7.1 Test equipment list

***Table 7.1-1**: Equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
Spectrum Analyzer	Rohde & Schwarz	FSW43	101767	2024-01	2025-01
EMI Receiver	Rohde & Schwarz	ESW44	101620	2023-08	2024-08
Antenna Trilog 25MHz - 8GHz	Schwarzbeck Mess-Elektronik	VULB9162	9162-025	2021-07	2024-07
Antenna 1 - 18 GHz	Schwarzbeck Mess-Elektronik	STLP9148	STLP 9148-152	2021-09	2024-09
Double Ridge Horn Antenna	RFSpin	DRH40	061106A40	2023-04	2026-04
Broadband Amplifier	Schwarzbeck Mess-Elektronik	BBV9718C	00121	2024-03	2025-03
Controller	Maturo	FCU3.0	10041	NCR	NCR
Tilt antenna mast	Maturo	TAM4.0-E	10042	NCR	NCR
Turntable	Maturo	TT4.0-5T	2.527	NCR	NCR
Semi-anechoic chamber	Nemko S.p.a.	10m semi-anechoic chamber	530	2023-09	2025-09
3m Semi anechoic chamber	Comtest	SAC-3	1711-150	2022-09	2024-09
Software turntable and mast	Maturo	mcApp	8.1.0.5410	NCR	NCR
Cable set	Rosenberger and Huber + Suhner	RE01+RE02	1.654+1.655	2023-11	2024-11

Notes: NCR - no calibration required, VOU - verify on use

Section 8 Testing data

8.1 Number of frequencies

8.1.1 References, definitions and limits

RSS-Gen, Clause 6.9:

Except where otherwise specified, measurements shall be performed for each frequency band of operation for which the radio apparatus is to be certified, with the device operating at the frequencies in each band of operation shown in table below. The frequencies selected for measurements shall be reported in the test report.

Table 8.1-1: *Frequency Range of Operation*

Frequency range over which the device operates (in each band)	Number of test frequencies required	Location of measurement frequency inside the operating frequency range
1 MHz or less	1	Center (middle of the band)
1–10 MHz	2	1 near high end, 1 near low end
Greater than 10 MHz	3	1 near high end, 1 near center and 1 near low end

Notes: "near" means as close as possible to or at the centre / low end / high end of the frequency range over which the device operates.

8.1.2 Test summary

Verdict	Pass		
Tested by	O. Frau	Test date	March 21, 2024

8.1.3 Observations, settings and special notes

ANSI C63.10, Clause 5.6.2.1:

The number of channels tested can be reduced by measuring the center channel bandwidth first and then applying the following relaxations as appropriate:

a) For each operating mode, if the measured channel bandwidth on the middle channel is at least 150% of the minimum permitted bandwidth, then it is not necessary to measure the bandwidth on the high and low channels.

b) For multiple-input multiple-output (MIMO) systems, if the measured channel bandwidth on testing the middle channel exceeds the minimum permitted bandwidth by more than 50% on one transmit chain, then it is not necessary to repeat testing on the other chains.

c) If the measured channel bandwidth on the middle channel is less than 50% of the maximum permitted bandwidth, then it is not necessary to measure the bandwidth on the high and low channels.

ANSI C63.10, Clause 5.6.2.2:

For devices with multiple operating modes, measurements on the middle channel can be used to determine the worst-case mode(s). The worst-case modes are as follows:

a) Band edge requirements—Measurements on the mode with the widest bandwidth can be used to cover the same channel (center frequency) on modes with narrower bandwidth that have the same or lower output power for each modulation family (e.g., OFDM and direct sequence spread spectrum).

b) Spurious emissions—Measure the mode with the highest output power and the mode with the highest output power spectral density for each modulation family (e.g., OFDM and direct sequence spread spectrum).

c) In-band PSD—Measurements on the mode with the narrowest bandwidth can be used to cover all modes within the same modulation family of an equal or lower output power provided the result is less than 50% of the limit.

8.1.4 Test data

Table 8.1-2: *Test channels selection*

Start of Frequency range, MHz	End of Frequency range, MHz	Frequency range bandwidth, MHz	Low channel, MHz	Mid channel, MHz	High channel, MHz
2400	2483.5	83.5	2407	2440	2477

8.2 Antenna requirement

8.2.1 References, definitions and limits

RSS-Gen, Clause 6.8:

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report.

8.2.2 Test summary

Verdict	Pass		
Tested by	O. Frau	Test date	March 21, 2024

8.2.3 Observations, settings and special notes

None

8.2.4 Test data

Must the EUT be professionally installed?	☒ YES	☐ NO	
Does the EUT have detachable antenna(s)?	☒ YES	☐ NO	
If detachable, is the antenna connector(s) non-standard?	☒ YES	☐ NO	☐ N/A

Table 8.2-1: Antenna information

Antenna type	Manufacturer	Model number	Maximum gain	Connector type
Dedicated	Taoglass	WSA.2400.A.101151	4.67 dBi	SMA

8.3 Minimum 6 dB bandwidth for DTS systems

8.3.1 References, definitions and limits

RSS-247, Clause 5.2:

DTSs include systems that employ digital modulation techniques resulting in spectral characteristics similar to direct sequence systems. The following applies to the bands 902-928 MHz and 2400-2483.5 MHz:

a. The minimum 6 dB bandwidth shall be 500 kHz.

RSS-Gen, Clause 6.7:

6 dB bandwidth is defined as the frequency range between two points, one at the lowest frequency below and one at the highest frequency above the carrier frequency, at which the maximum power level of the transmitted emission is attenuated 6 dB below the maximum in-band power level of the modulated signal, where the two points are on the outskirts of the in-band emission.

For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).

8.3.2 Test summary

Verdict	Pass		
Tested by	O. Frau	Test date	March 22, 2024

8.3.3 Observations, settings and special notes

The test was performed as per KDB 558074, section 8.2 with reference to ANSI C63.10 subclause 11.8.
Spectrum analyser settings:

Resolution bandwidth	6 dB BW: 100 kHz; 99% OBW: 1–5% of OBW
Video bandwidth	≥3 × RBW
Frequency span	≥2 × OBW
Detector mode	Peak
Trace mode	Max Hold

8.3.4 Test equipment used

Equipment	Manufacturer	Model no.	Asset no.
EMI Receiver	Rohde & Schwarz	ESW44	101620
Spectrum Analyzer	Rohde & Schwarz	FSW43	101767

8.3.5 Test data

Table 8.3-1: *99% occupied bandwidth results – Antenna port 1*

Modulation	Frequency, MHz	99% occupied bandwidth, MHz
GFSK	2407	1.571
GFSK	2440	1.563
GFSK	2477	1.556

Notes: There is no 99% occupied bandwidth limit in the standard's requirements, the measurement results provided for information purposes only.

Table 8.3-2: *6 dB bandwidth results – Antenna port 1*

Modulation	Frequency, MHz	6 dB bandwidth, MHz	Minimum limit, MHz	Margin, MHz
GFSK	2407	1.015	0.5	0.515
	2440	0.991	0.5	0.491
	2477	0.987	0.5	0.487

Table 8.3-3: *99% occupied bandwidth results – Antenna port 2*

Modulation	Frequency, MHz	99% occupied bandwidth, MHz
GFSK	2407	1.555
GFSK	2440	1.550
GFSK	2477	1.547

Notes: There is no 99% occupied bandwidth limit in the standard's requirements, the measurement results provided for information purposes only.

Table 8.3-4: *6 dB bandwidth results – Antenna port 2*

Modulation	Frequency, MHz	6 dB bandwidth, MHz	Minimum limit, MHz	Margin, MHz
GFSK	2407	0.991	0.5	0.491
	2440	0.995	0.5	0.495
	2477	0.995	0.5	0.495

Table 8.3-5: *99% occupied bandwidth results – Antenna port 3*

Modulation	Frequency, MHz	99% occupied bandwidth, MHz
GFSK	2407	1.551
GFSK	2440	1.550
GFSK	2477	1.553

Notes: There is no 99% occupied bandwidth limit in the standard's requirements, the measurement results provided for information purposes only.

Table 8.3-6: *6 dB bandwidth results – Antenna port 3*

Modulation	Frequency, MHz	6 dB bandwidth, MHz	Minimum limit, MHz	Margin, MHz
GFSK	2407	0.995	0.5	0.495
	2440	0.991	0.5	0.491
	2477	0.991	0.5	0.491

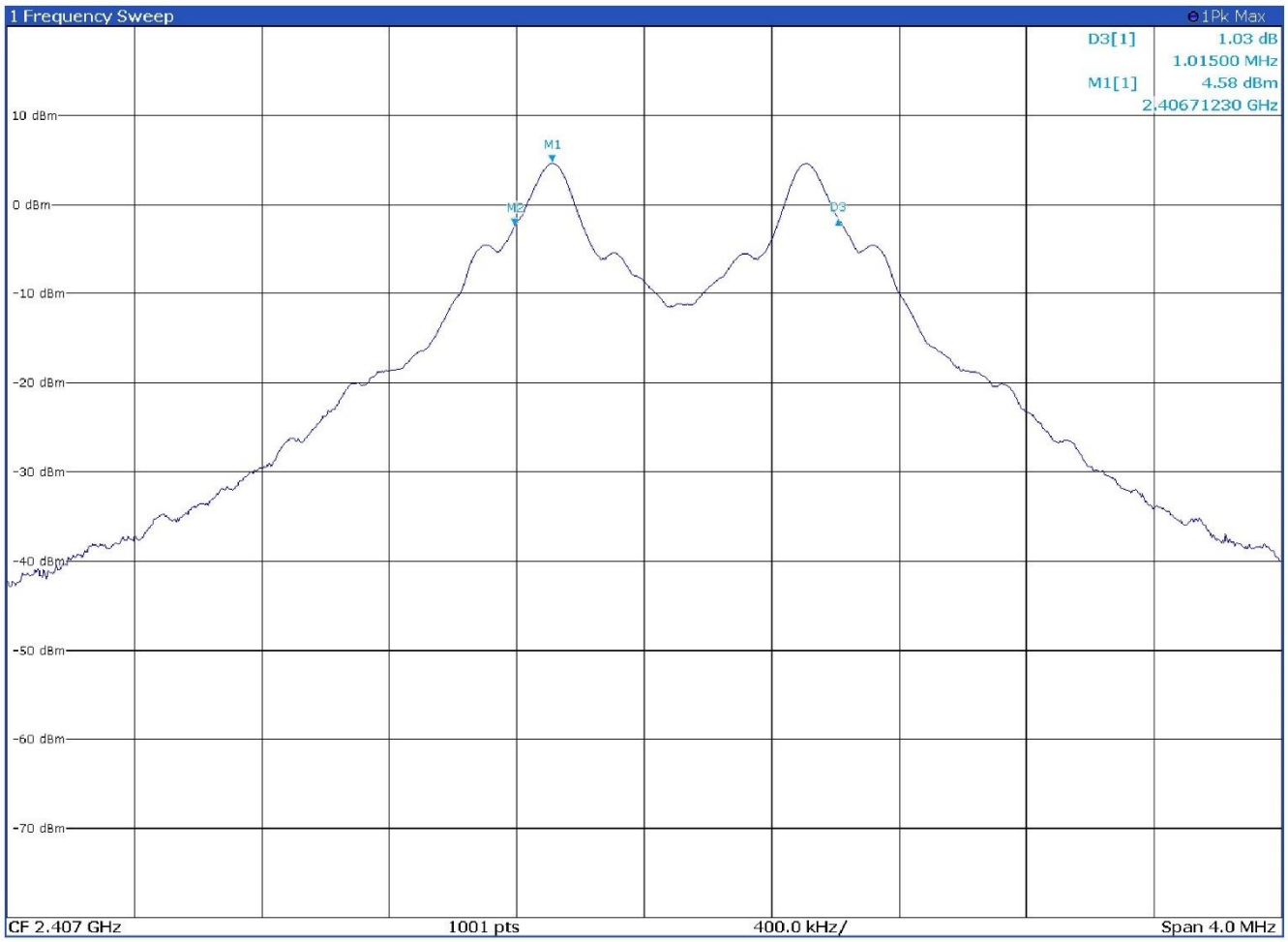
Table 8.3-7: *99% occupied bandwidth results – Antenna port 4*

Modulation	Frequency, MHz	99% occupied bandwidth, MHz
GFSK	2407	1.560
GFSK	2440	1.552
GFSK	2477	1.562

Notes: There is no 99% occupied bandwidth limit in the standard's requirements, the measurement results provided for information purposes only.

Table 8.3-8: *6 dB bandwidth results – Antenna port 4*

Modulation	Frequency, MHz	6 dB bandwidth, MHz	Minimum limit, MHz	Margin, MHz
GFSK	2407	0.995	0.5	0.495
	2440	0.995	0.5	0.495
	2477	0.991	0.5	0.491

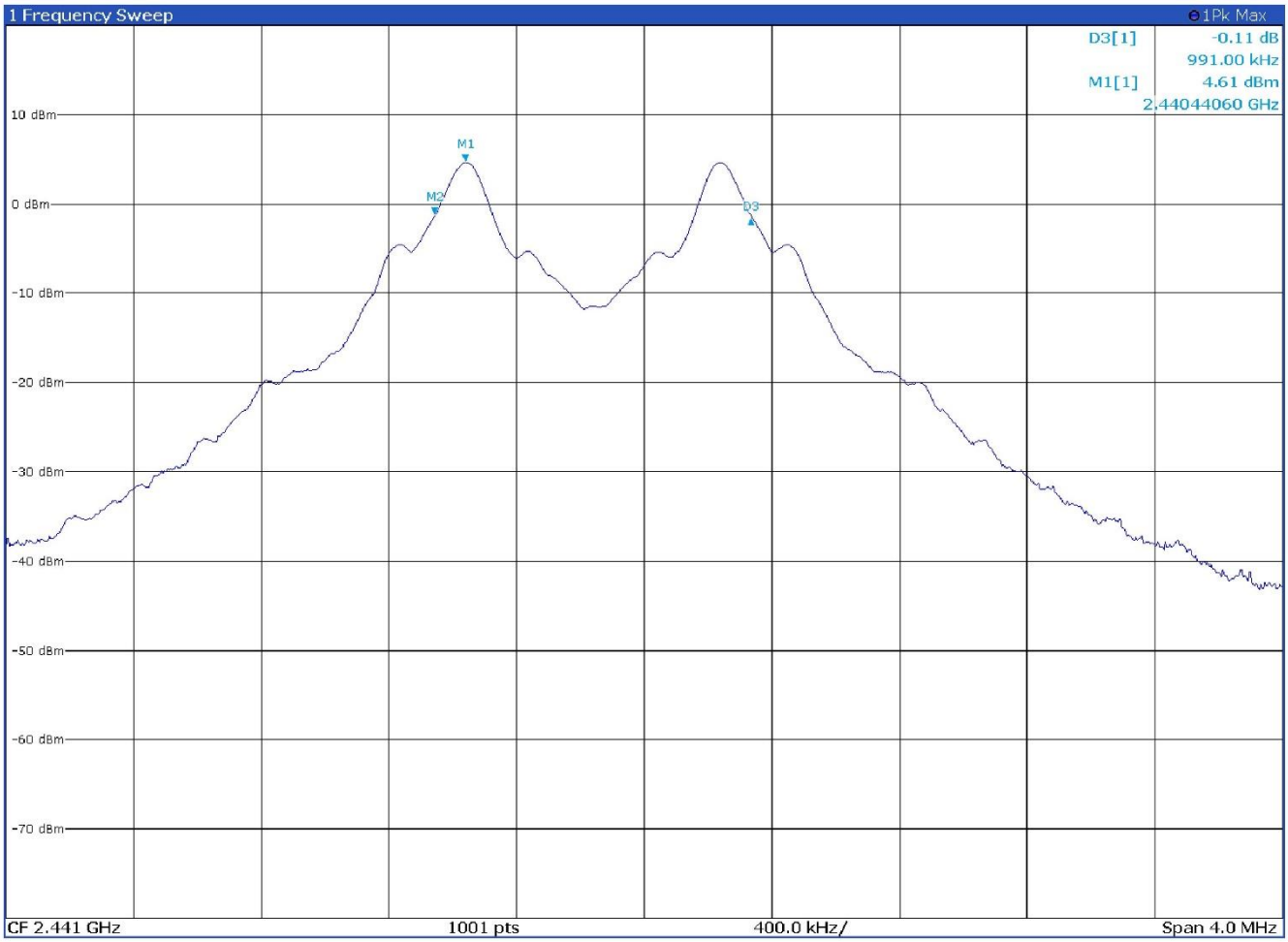


2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4067123 GHz**	**4.58 dBm**		
M2		1	**2.4065924 GHz**	**-2.53 dBm**		
D3	M2	1	**1.015 MHz**	**1.03 dB**		

Figure 8.3-1*: 6 dB bandwidth on low channel – Antenna port 1*

Test data, continued

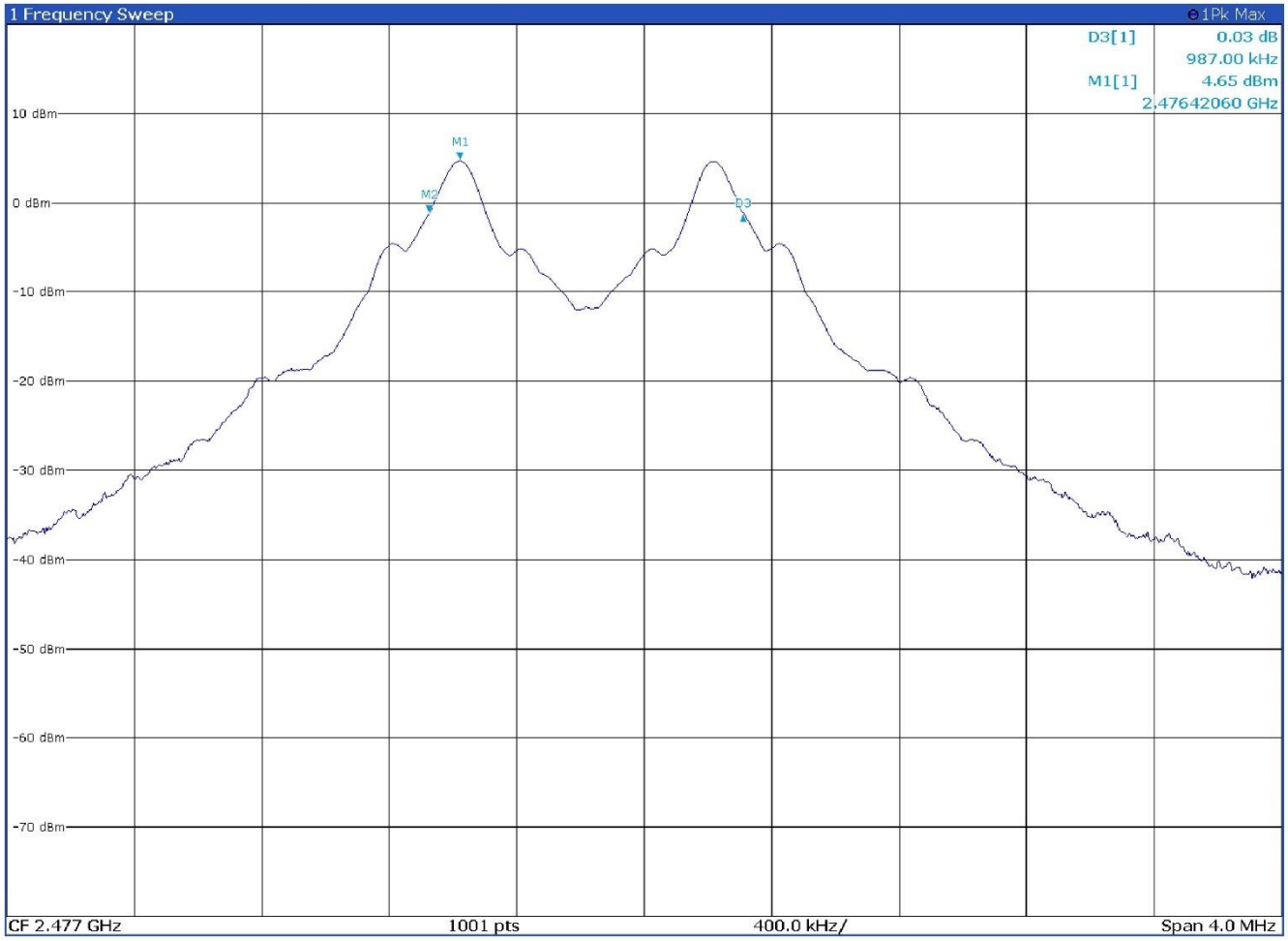


2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4404406 GHz**	**4.61 dBm**		
M2		1	**2.4403447 GHz**	**-1.30 dBm**		
D3	M2	1	**991.0 kHz**	**-0.11 dB**		

Figure 8.3-2*: 6 dB bandwidth on mid channel – Antenna port 1*

Test data, continued

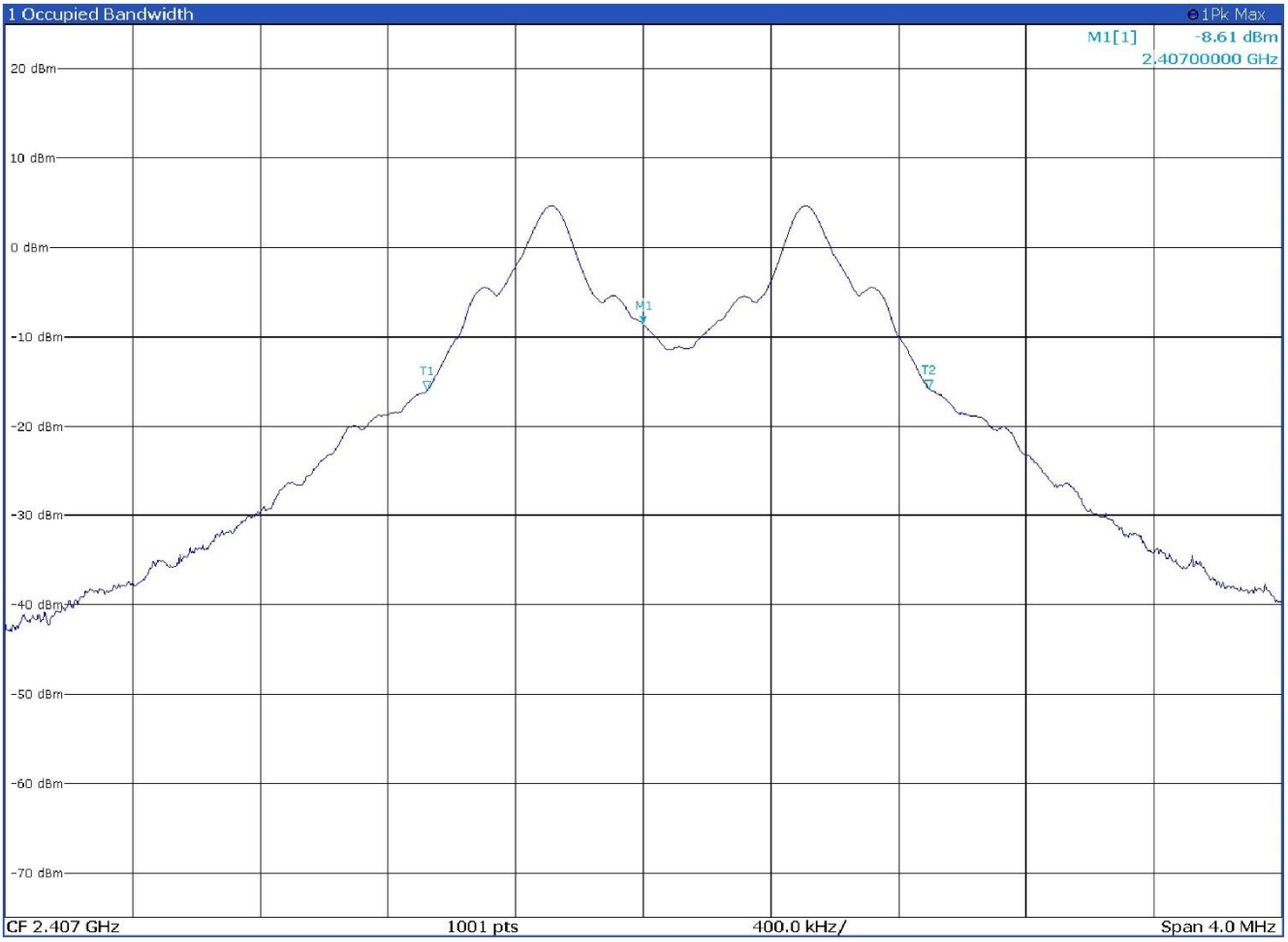


2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4764206 GHz**	**4.65 dBm**		
M2		1	**2.4763247 GHz**	**-1.25 dBm**		
D3	M2	1	**987.0 kHz**	**0.03 dB**		

Figure 8.3-3*: 6 dB bandwidth on high channel – Antenna port 1*

Test data, continued

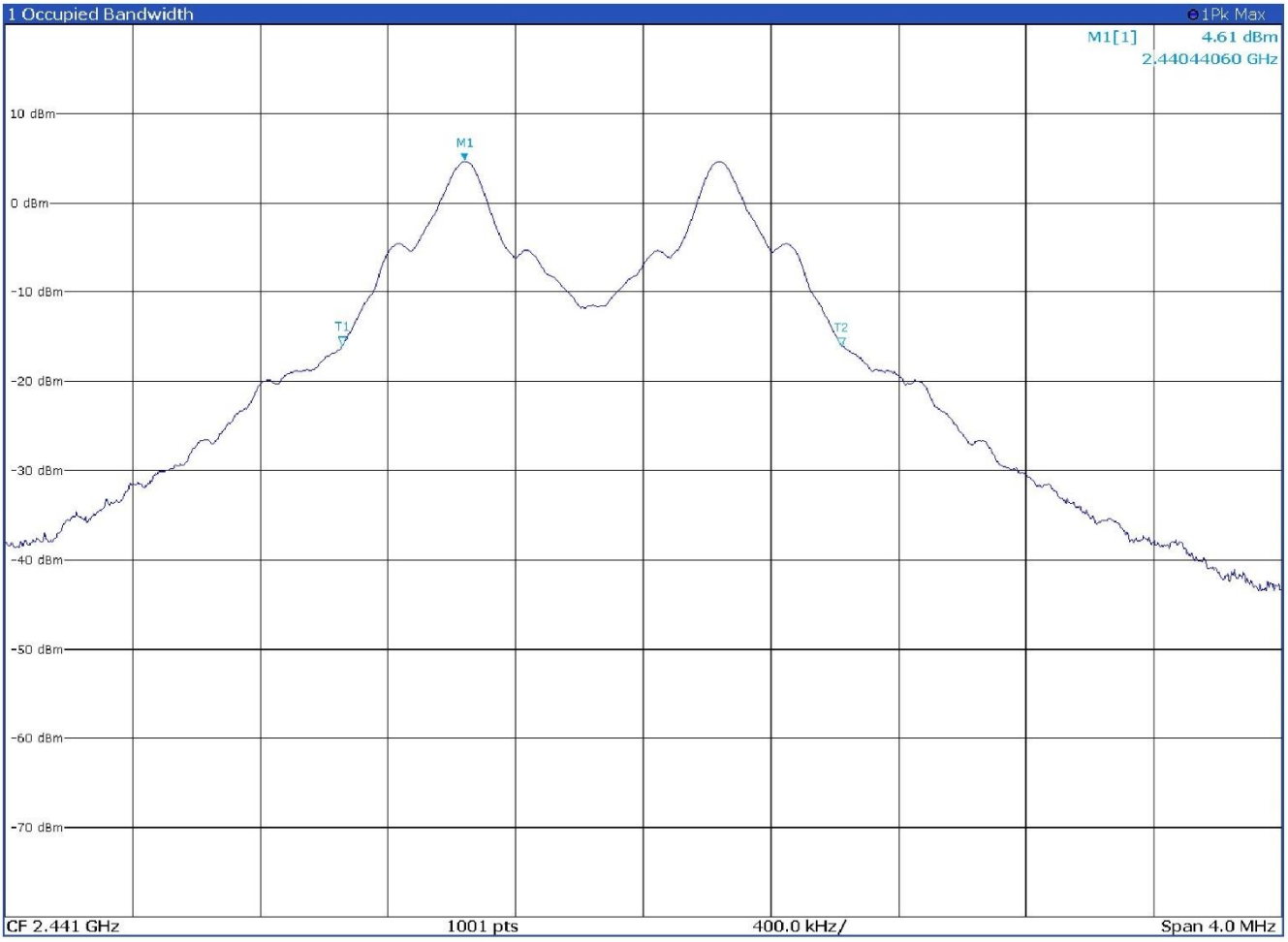


2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.407 GHz**	**-8.61 dBm**	Occ Bw	**1.570690785 MHz**
T1		1	2.40632294 GHz	-15.89 dBm	Occ Bw Centroid	2.407108286 GHz
T2		1	2.40789363 GHz	-15.86 dBm	Occ Bw Freq Offset	108.286133577 kHz

Figure 8.3-4: *99% bandwidth on low channel – Antenna port 1*

Test data, continued

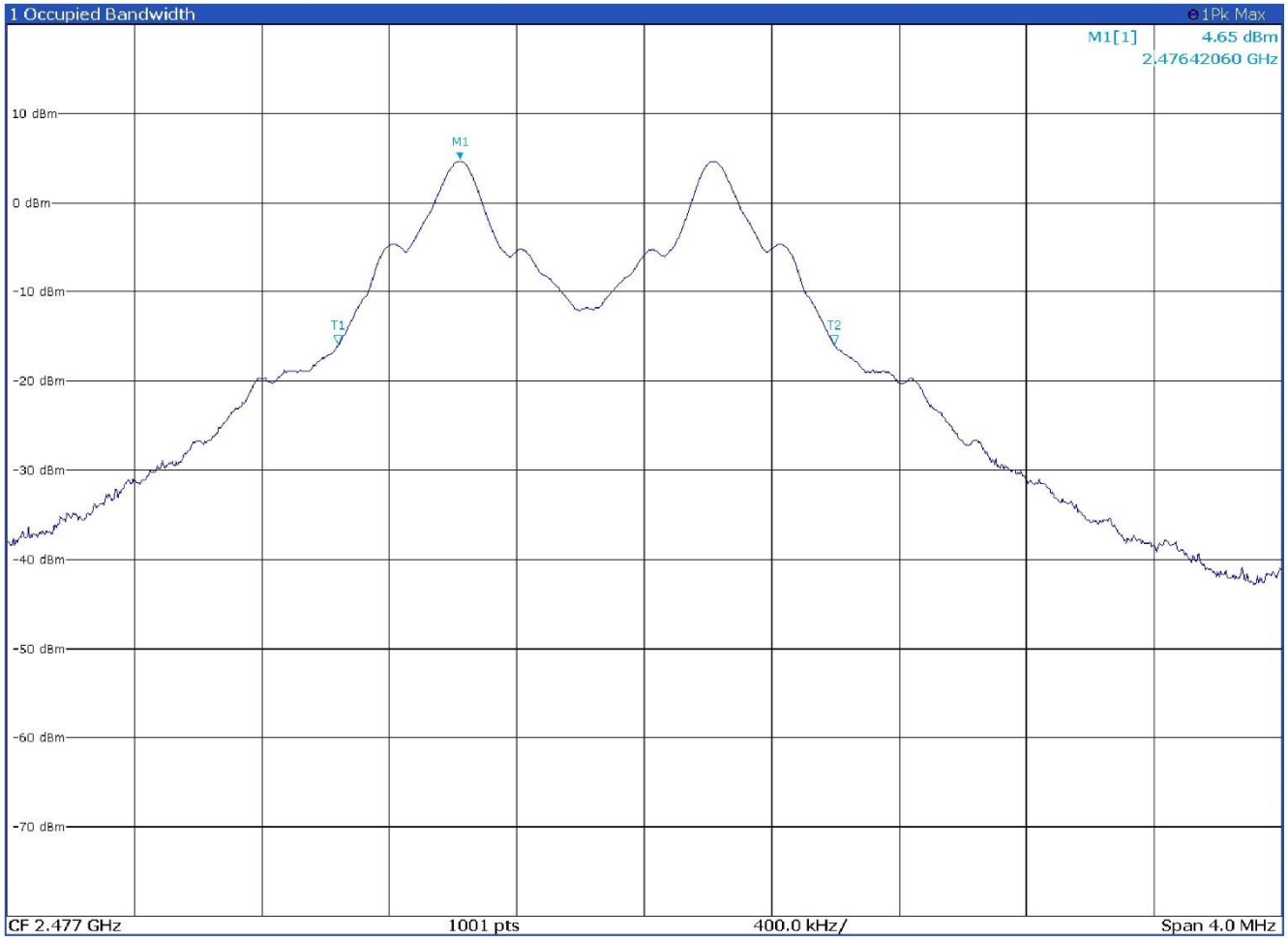


2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4404406 GHz**	**4.61 dBm**	Occ Bw	**1.563161638 MHz**
T1		1	2.44005846 GHz	-15.99 dBm	Occ Bw Centroid	2.440840041 GHz
T2		1	2.44162162 GHz	-16.10 dBm	Occ Bw Freq Offset	-159.958901879 kHz

Figure 8.3-5*: 99% bandwidth on mid channel – Antenna port 1*

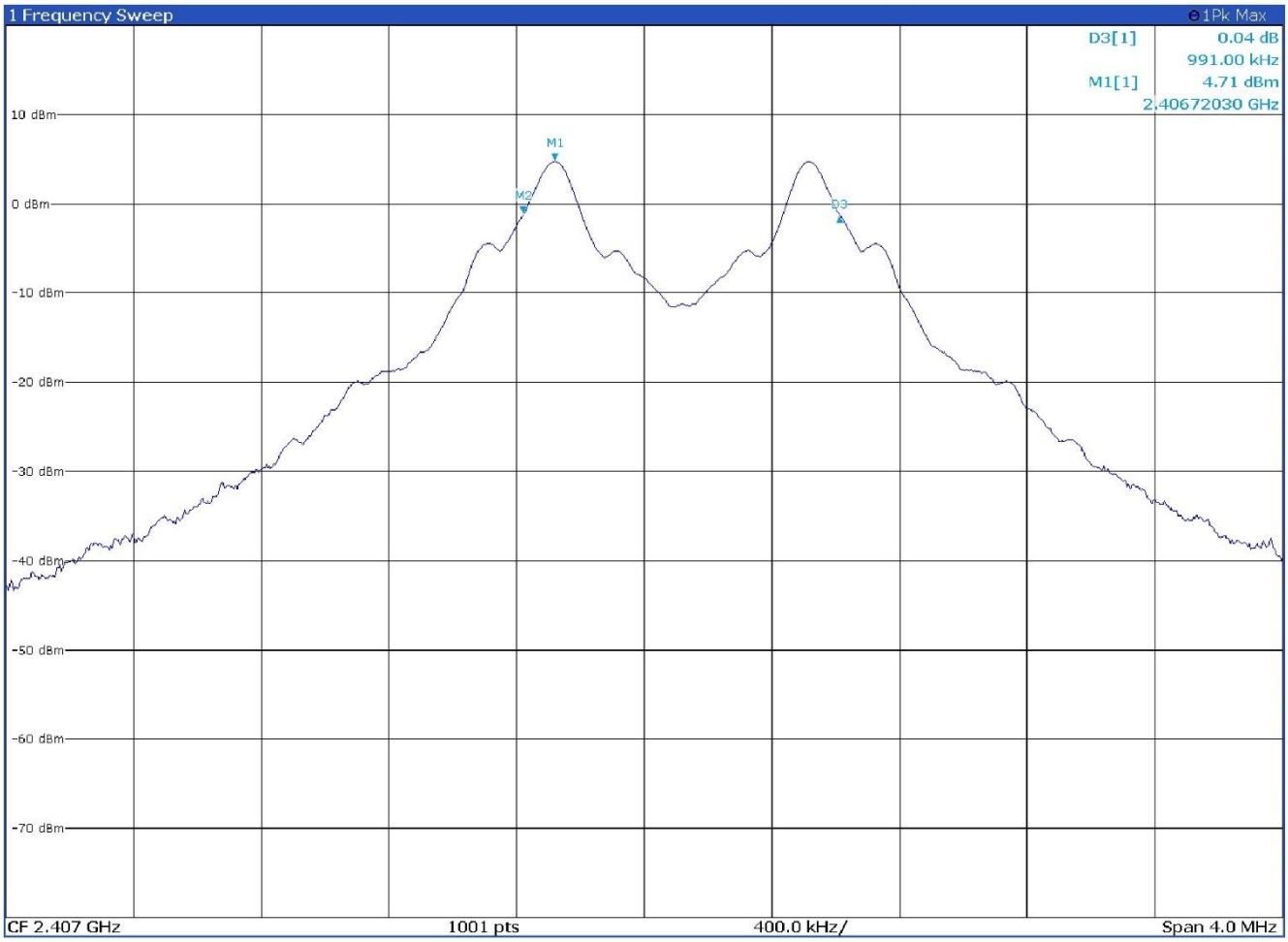
Test data, continued



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4764206 GHz**	**4.65 dBm**	Occ Bw	**1.555906771 MHz**
T1		1	2.47604065 GHz	-15.91 dBm	Occ Bw Centroid	2.476818607 GHz
T2		1	2.47759656 GHz	-15.92 dBm	Occ Bw Freq Offset	-181.392958202 kHz

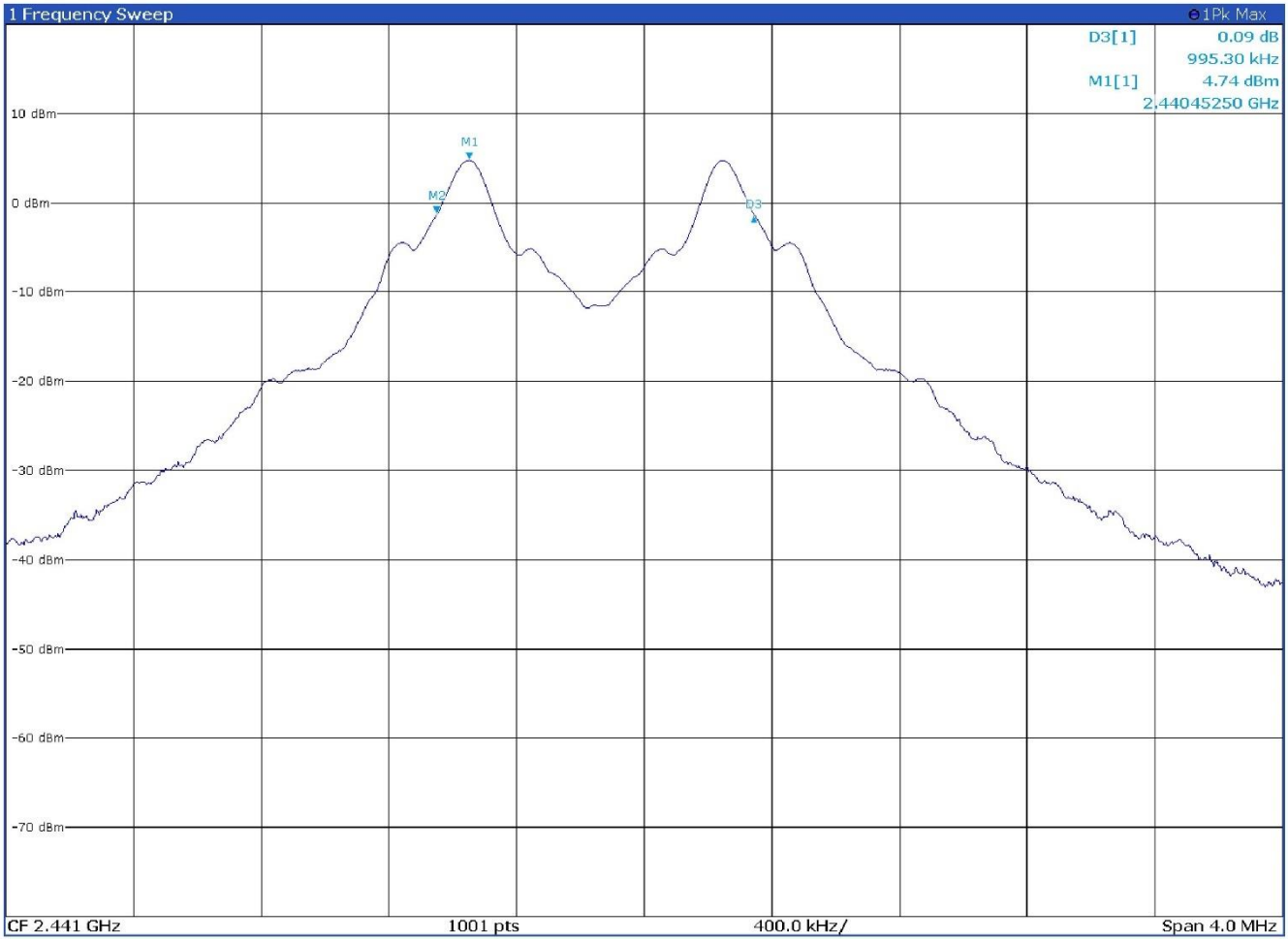
Figure 8.3-6*: 99% bandwidth on high channel – Antenna port 1*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4067203 GHz**	**4.71 dBm**		
M2		1	**2.4066204 GHz**	**-1.25 dBm**		
D3	M2	1	**991.0 kHz**	**0.04 dB**		

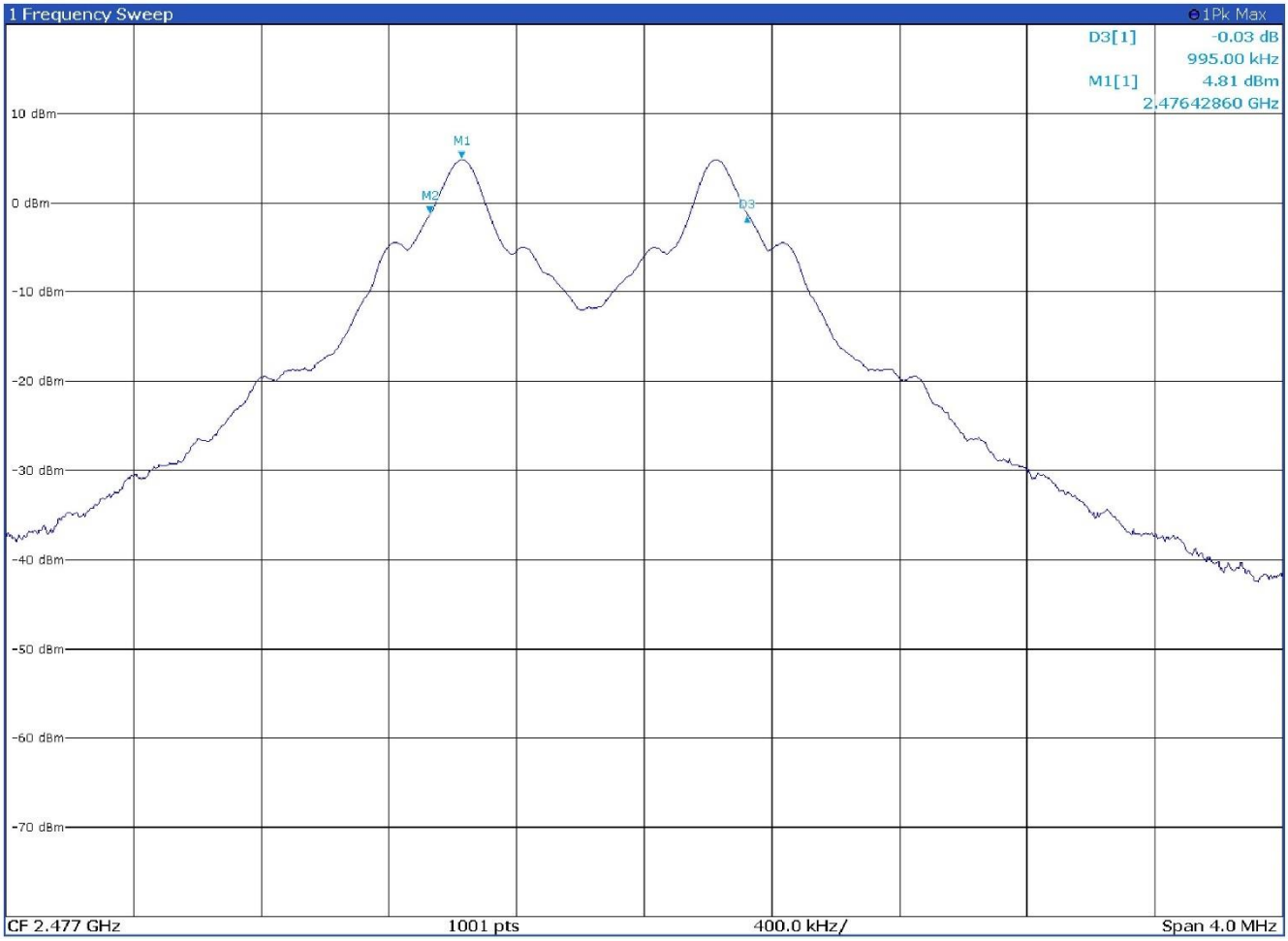
Figure 8.3-7: *6 dB bandwidth on low channel – Antenna port 2*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4404525 GHz**	**4.74 dBm**		
M2		1	**2.4403483 GHz**	**-1.38 dBm**		
D3	M2	1	**995.3 kHz**	**0.09 dB**		

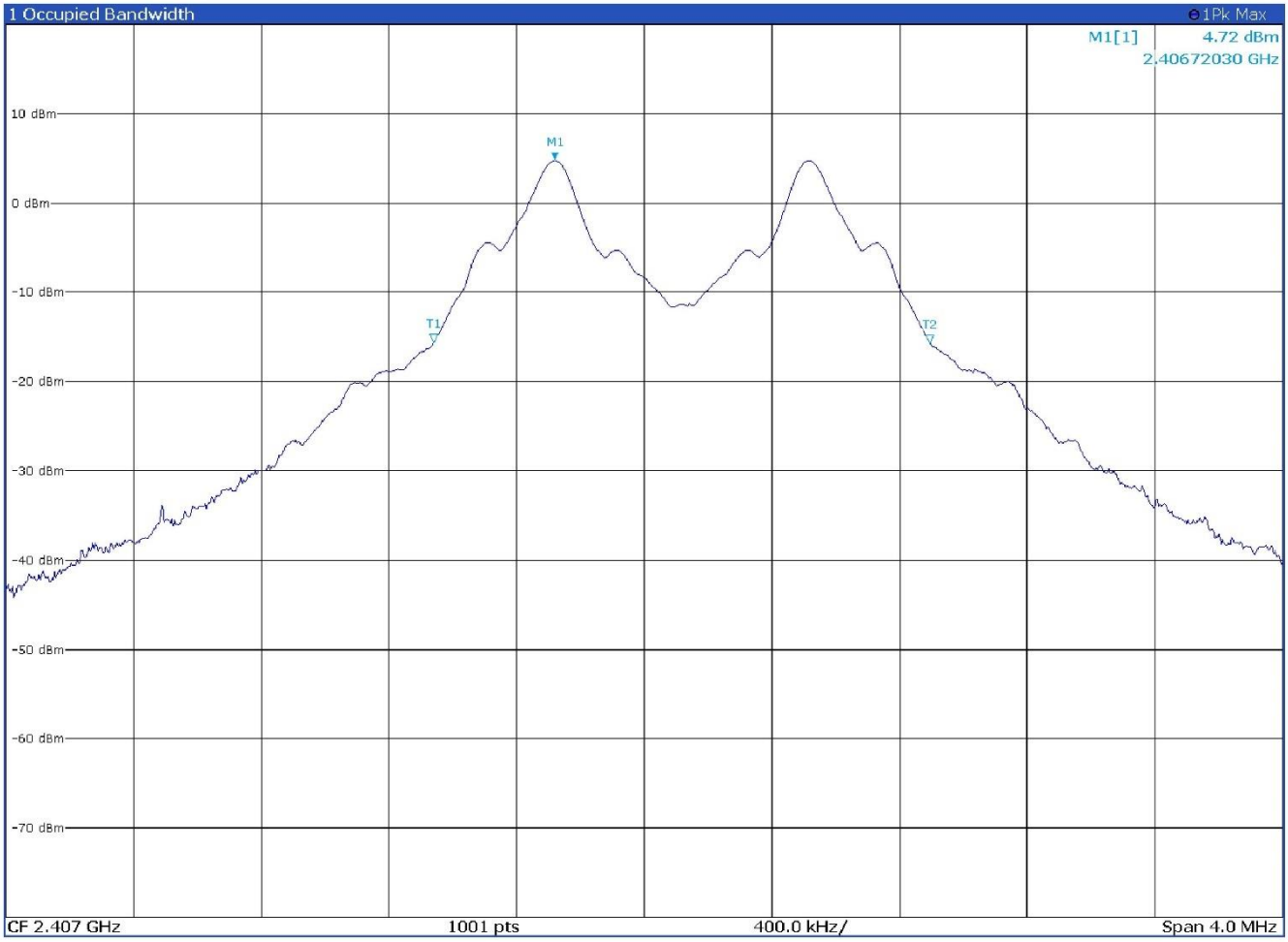
Figure 8.3-8: *6 dB bandwidth on mid channel – Antenna port 2*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4764286 GHz**	**4.81 dBm**		
M2		1	**2.4763287 GHz**	**-1.29 dBm**		
D3	M2	1	**995.0 kHz**	**-0.03 dB**		

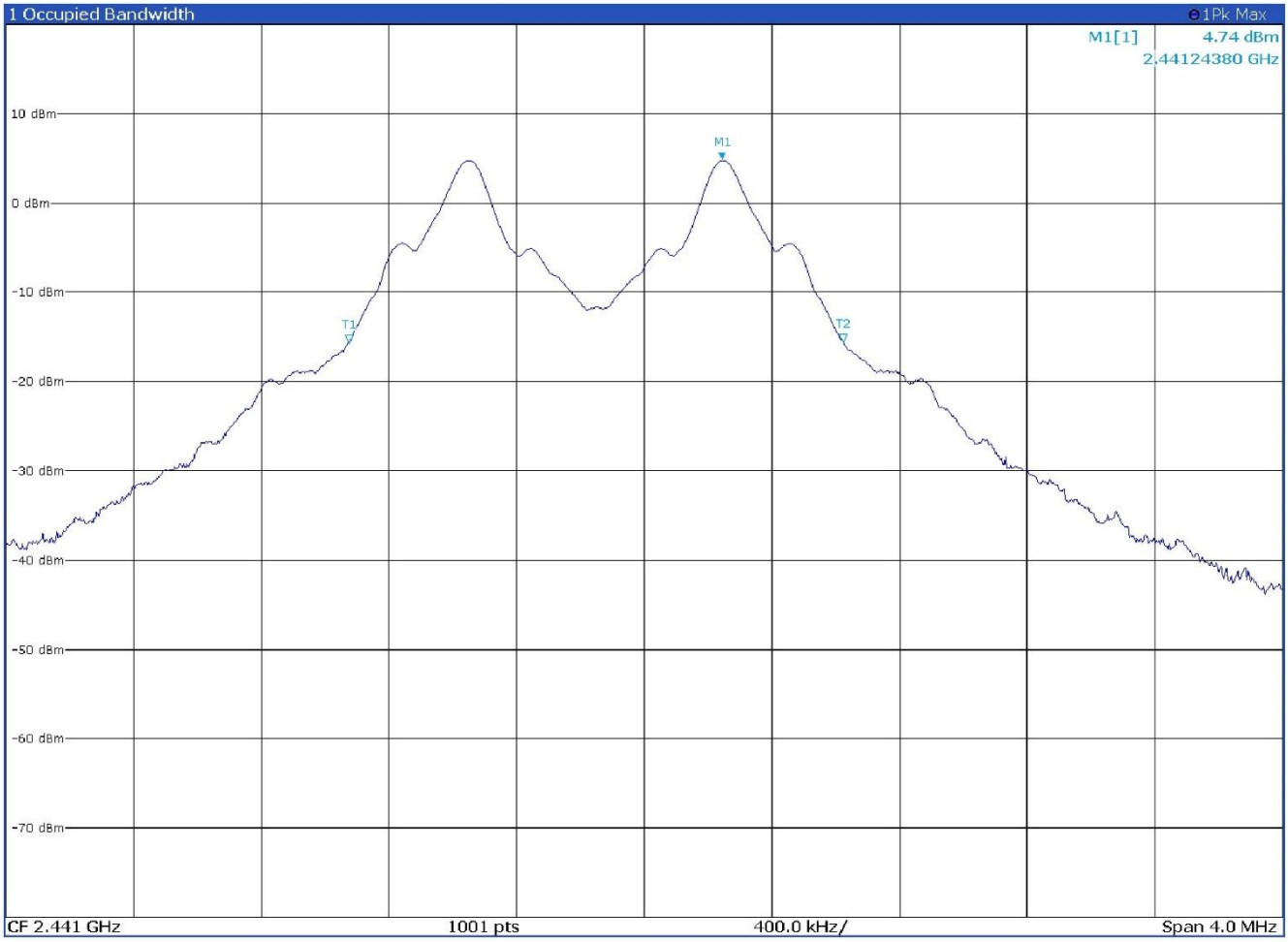
Figure 8.3-9: *6 dB bandwidth on high channel – Antenna port 2*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4067203 GHz**	**4.72 dBm**	Occ Bw	**1.555253546 MHz**
T1		1	2.40634015 GHz	-15.62 dBm	Occ Bw Centroid	2.40711778 GHz
T2		1	2.40789541 GHz	-15.72 dBm	Occ Bw Freq Offset	117.78043511 kHz

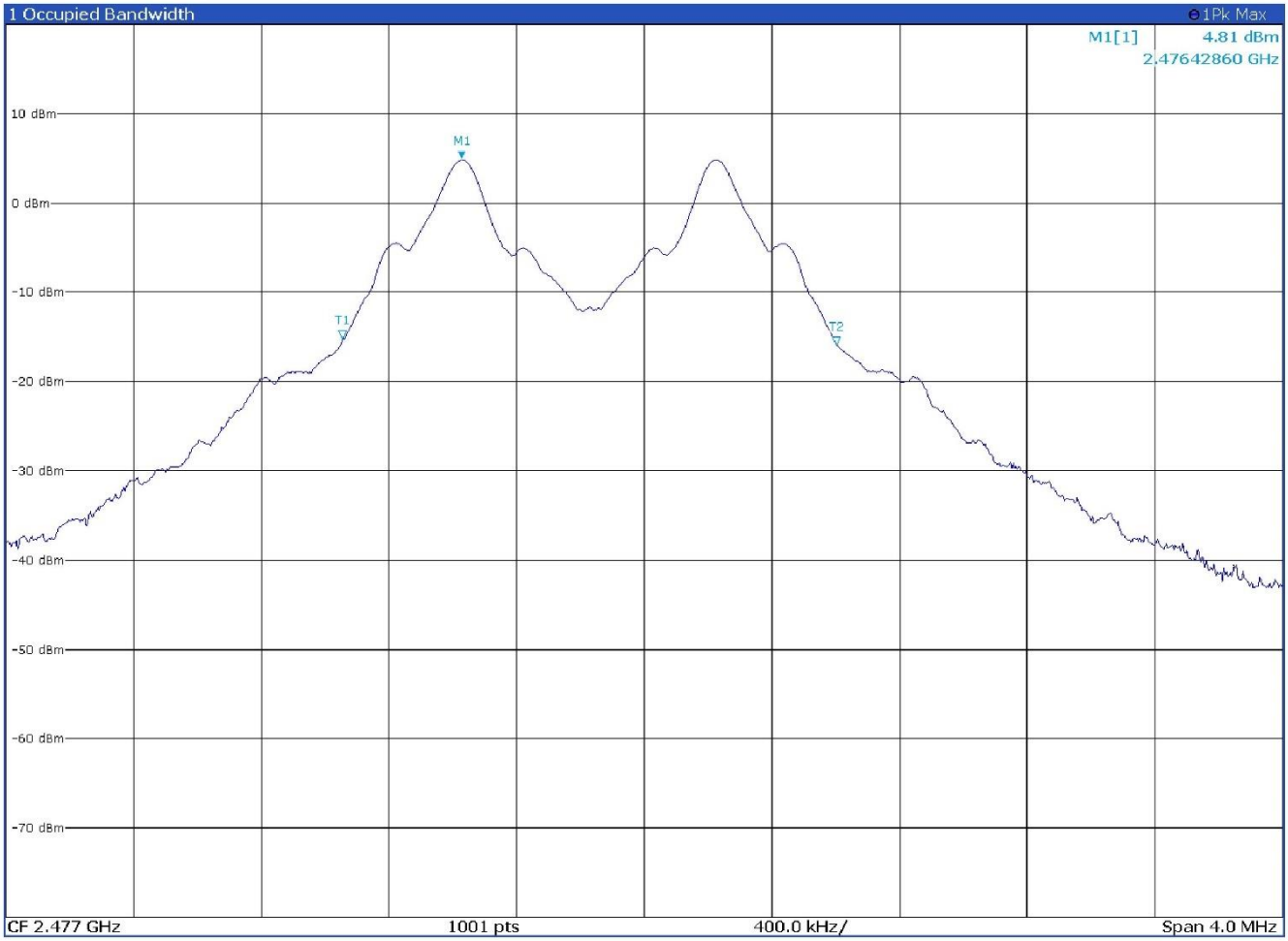
Figure 8.3-10: *99% bandwidth on low channel – Antenna port 2*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4412438 GHz**	**4.74 dBm**	Occ Bw	**1.5502637 MHz**
T1		1	2.44007411 GHz	-15.75 dBm	Occ Bw Centroid	2.440849241 GHz
T2		1	2.44162437 GHz	-15.65 dBm	Occ Bw Freq Offset	-150.759166053 kHz

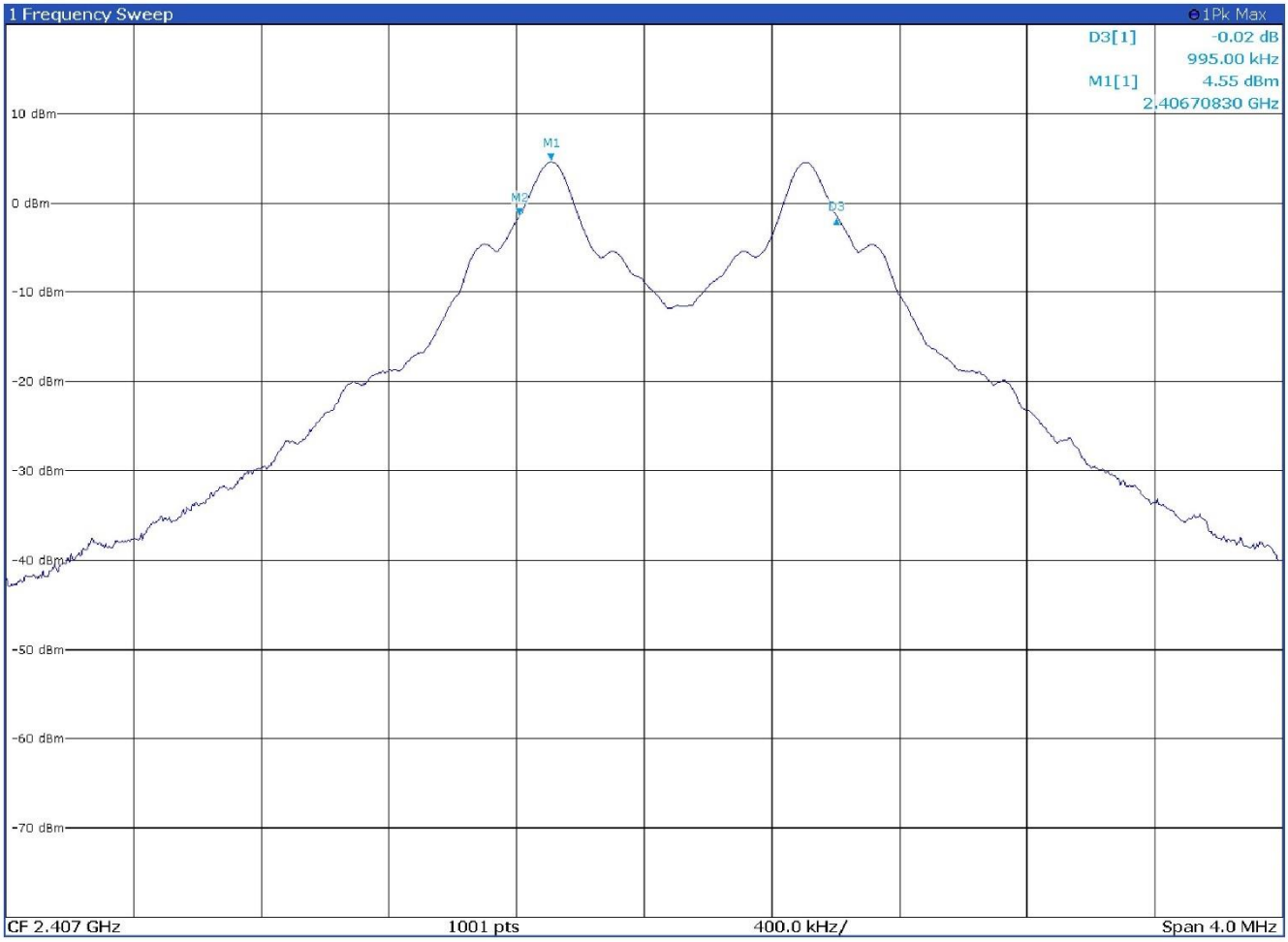
Figure 8.3-11: *99% bandwidth on mid channel – Antenna port 2*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4764286 GHz**	**4.81 dBm**	Occ Bw	**1.546857163 MHz**
T1		1	2.47605505 GHz	-15.22 dBm	Occ Bw Centroid	2.476828476 GHz
T2		1	2.47760191 GHz	-15.96 dBm	Occ Bw Freq Offset	-171.523513477 kHz

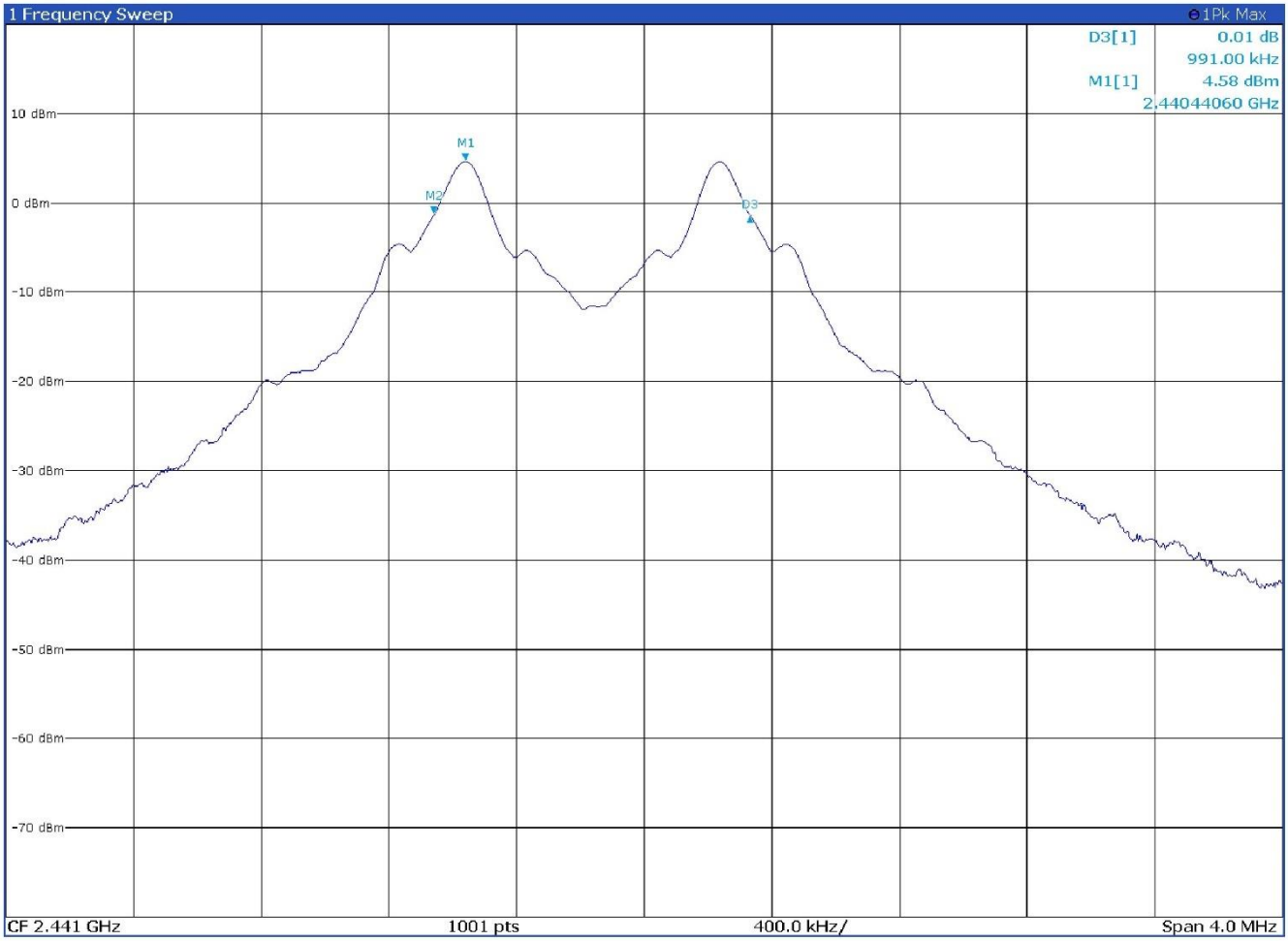
Figure 8.3-12: *99% bandwidth on high channel – Antenna port 2*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4067083 GHz**	**4.55 dBm**		
M2		1	**2.4066084 GHz**	**-1.50 dBm**		
D3	M2	1	**995.0 kHz**	**-0.02 dB**		

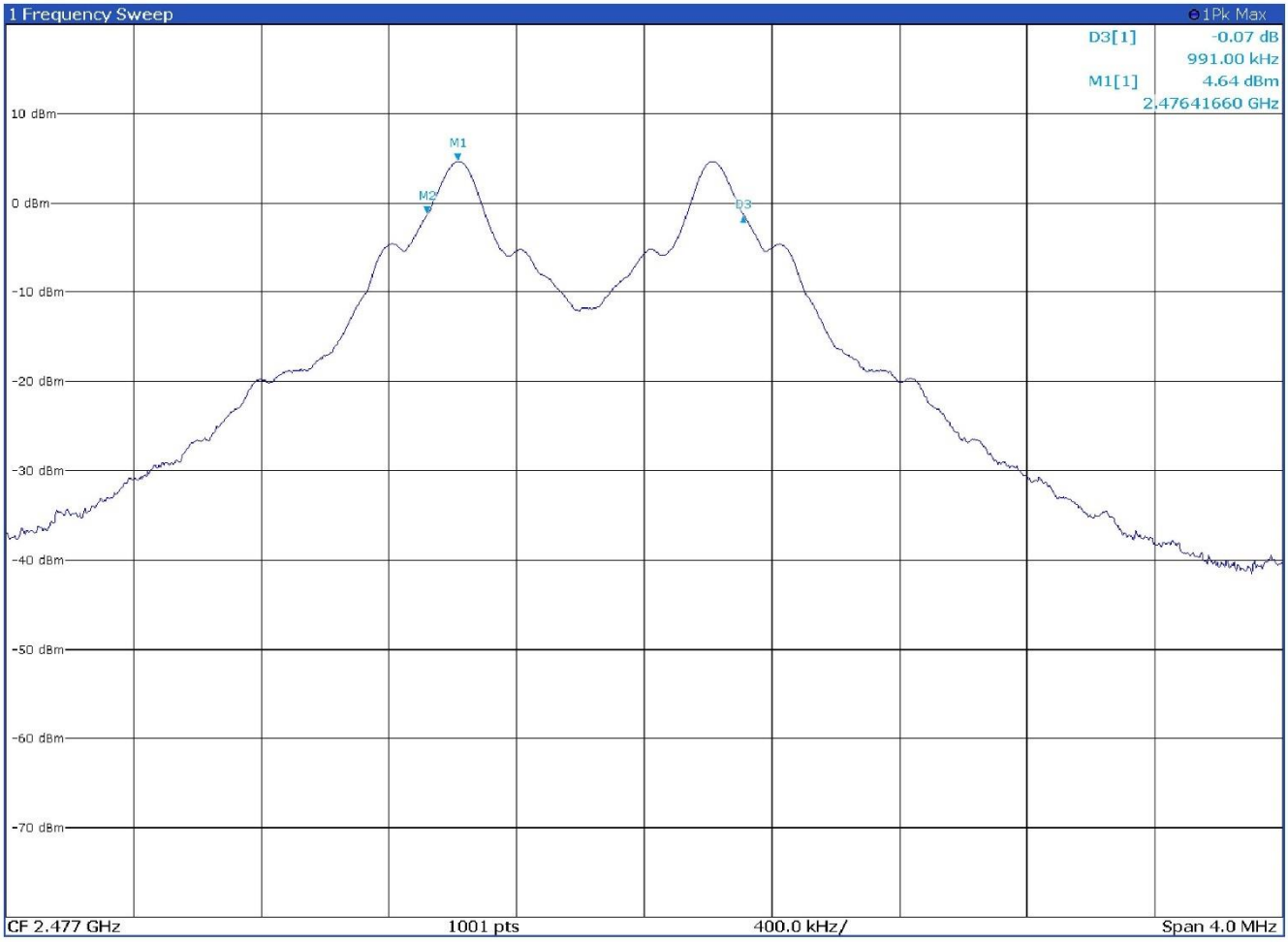
Figure 8.3-13: *6 dB bandwidth on low channel – Antenna port 3*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4404406 GHz**	**4.58 dBm**		
M2		1	**2.4403407 GHz**	**-1.39 dBm**		
D3	M2	1	**991.0 kHz**	**0.01 dB**		

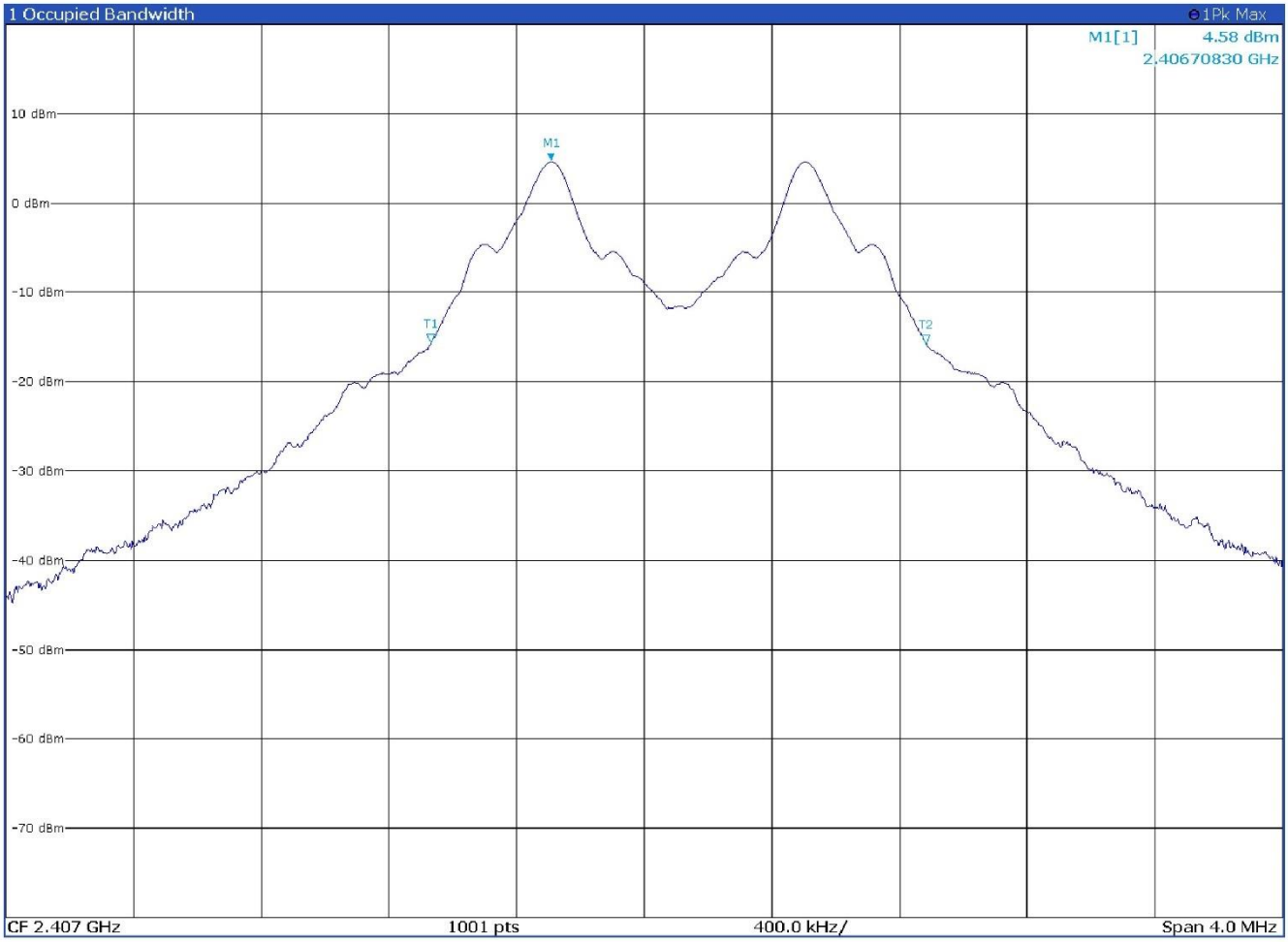
Figure 8.3-14: *6 dB bandwidth on mid channel – Antenna port 3*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4764166 GHz**	**4.64 dBm**		
M2		1	**2.4763207 GHz**	**-1.30 dBm**		
D3	M2	1	**991.0 kHz**	**-0.07 dB**		

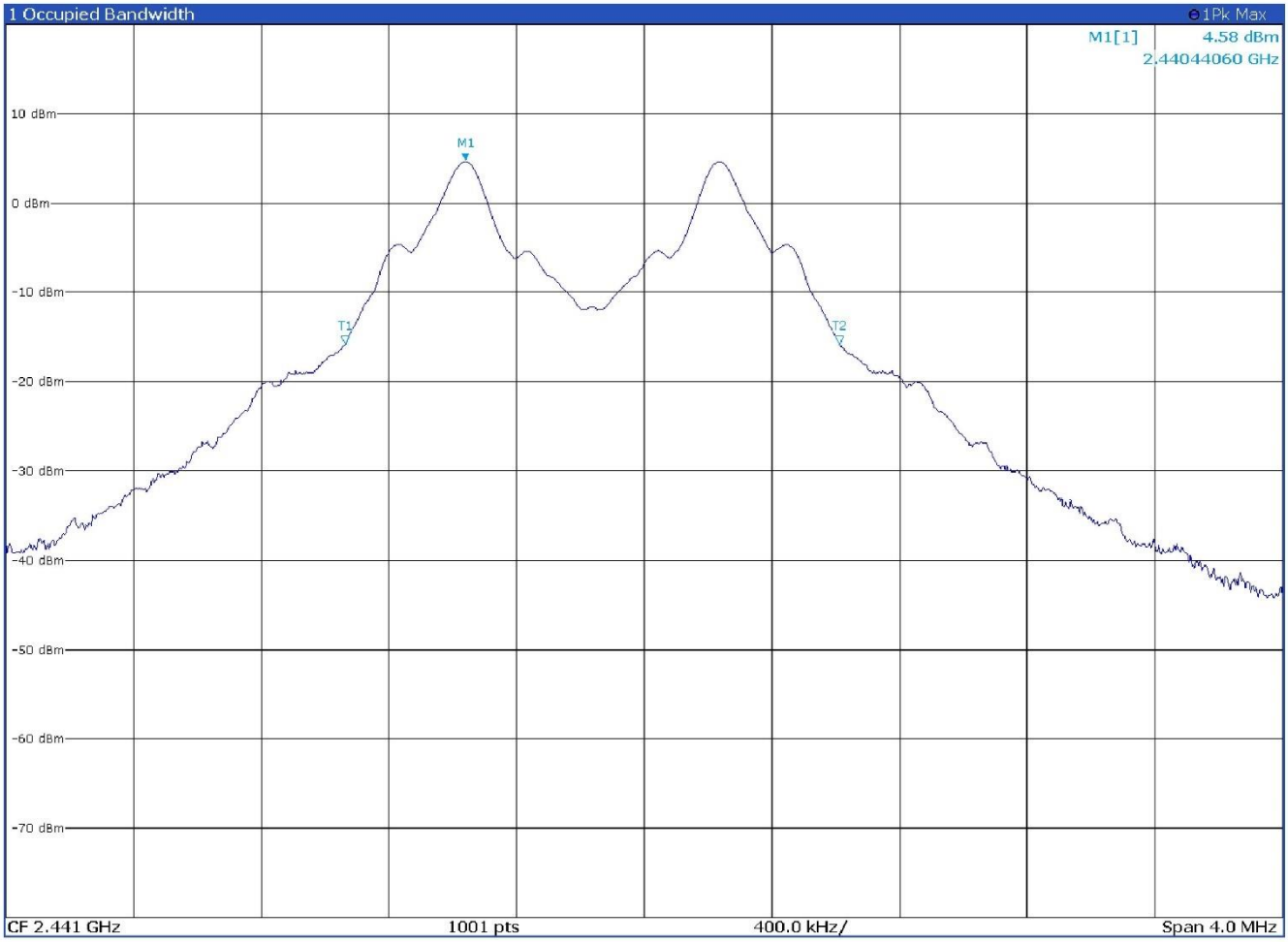
Figure 8.3-15: *6 dB bandwidth on high channel – Antenna port 3*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4067083 GHz**	**4.58 dBm**	Occ Bw	**1.550623708 MHz**
T1		1	2.4063325 GHz	-15.62 dBm	Occ Bw Centroid	2.407107808 GHz
T2		1	2.40788312 GHz	-15.74 dBm	Occ Bw Freq Offset	107.80827795 kHz

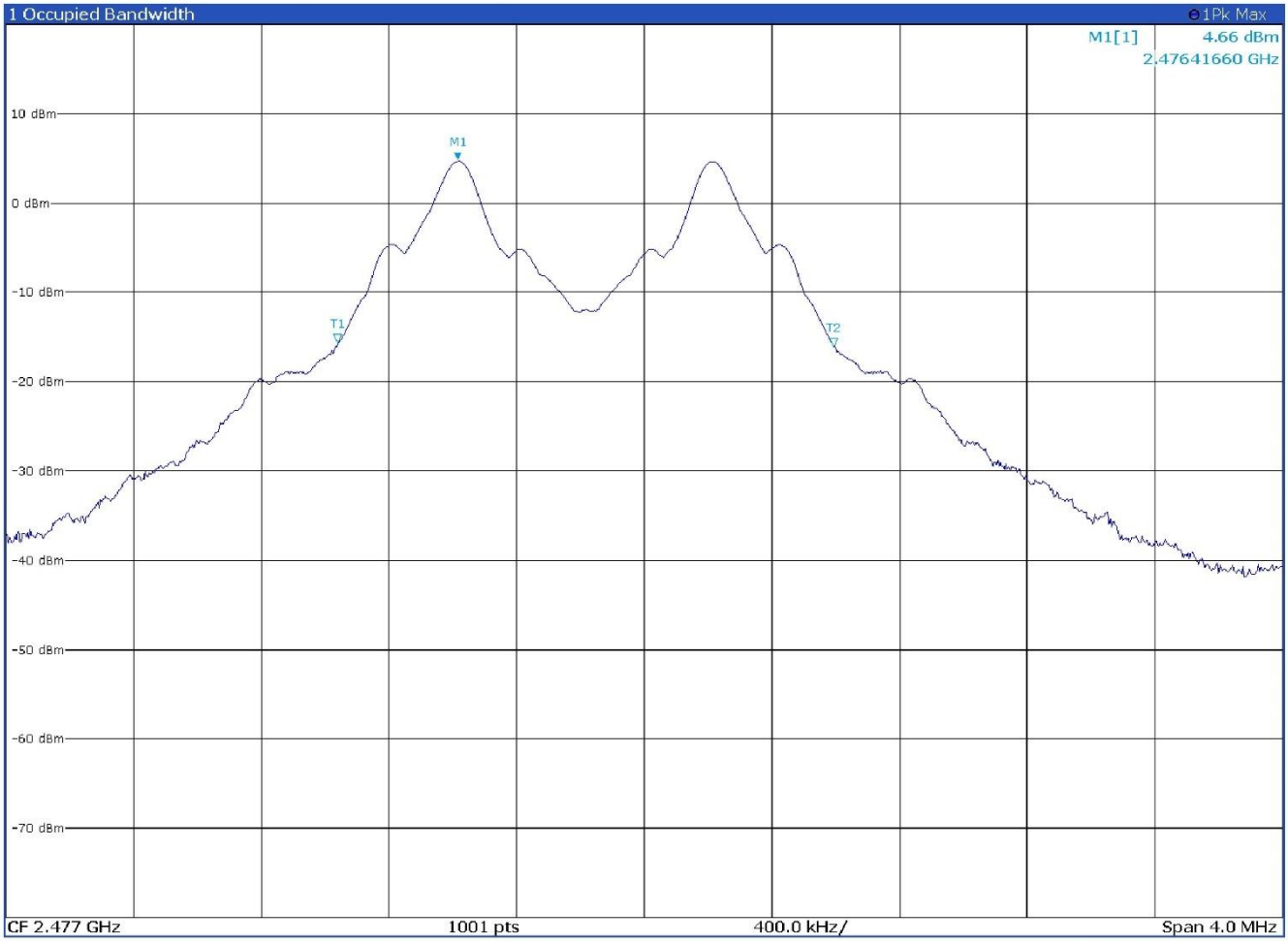
Figure 8.3-16: *99% bandwidth on low channel – Antenna port 3*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4404406 GHz**	**4.58 dBm**	Occ Bw	**1.550148862 MHz**
T1		1	2.44006279 GHz	-15.85 dBm	Occ Bw Centroid	2.440837863 GHz
T2		1	2.44161294 GHz	-15.89 dBm	Occ Bw Freq Offset	-162.13669526 kHz

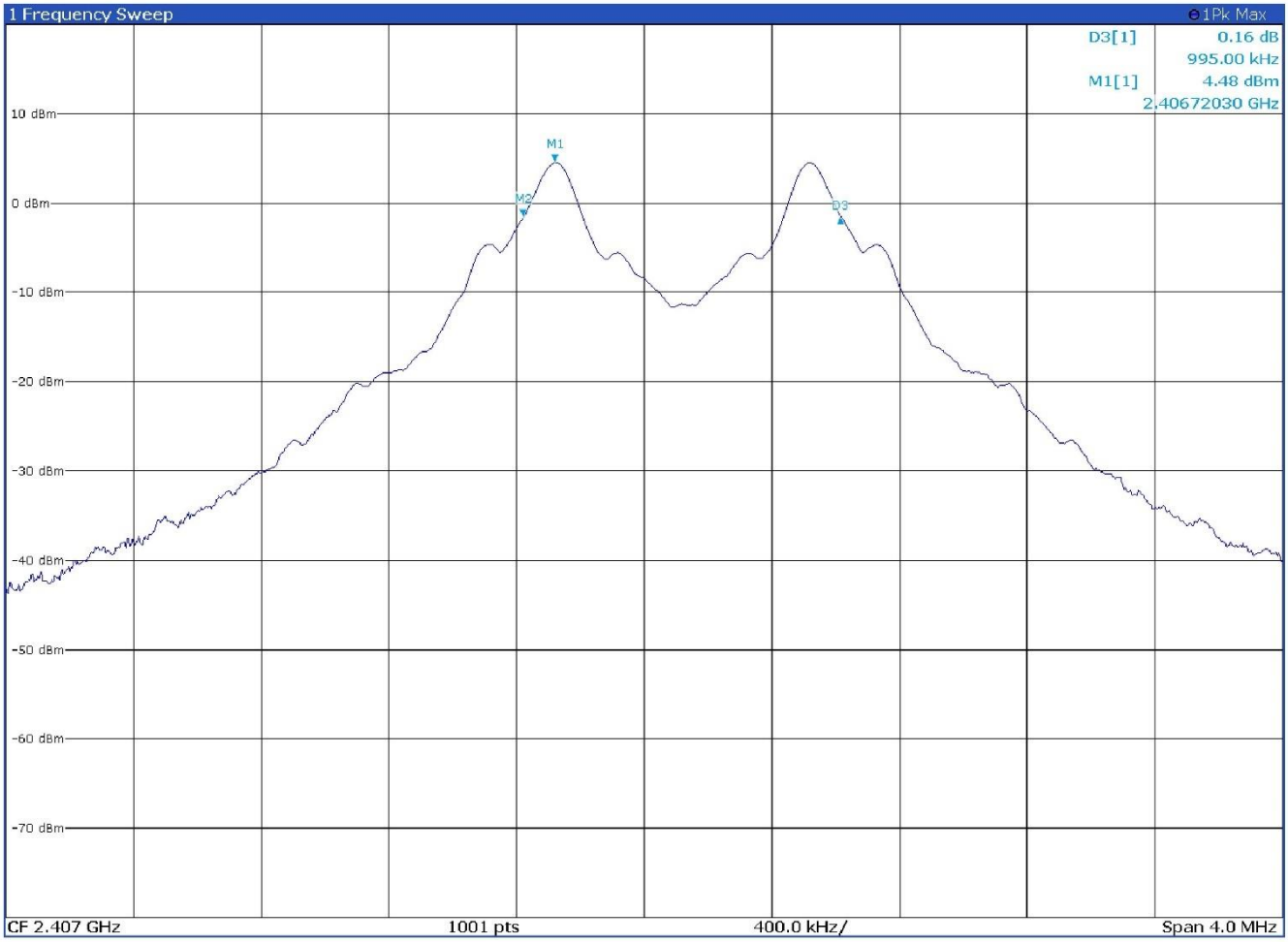
Figure 8.3-17: *99% bandwidth on mid channel – Antenna port 3*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4764166 GHz**	**4.66 dBm**	Occ Bw	**1.552871925 MHz**
T1		1	2.47604061 GHz	-15.69 dBm	Occ Bw Centroid	2.476817048 GHz
T2		1	2.47759348 GHz	-16.05 dBm	Occ Bw Freq Offset	-182.95185072 kHz

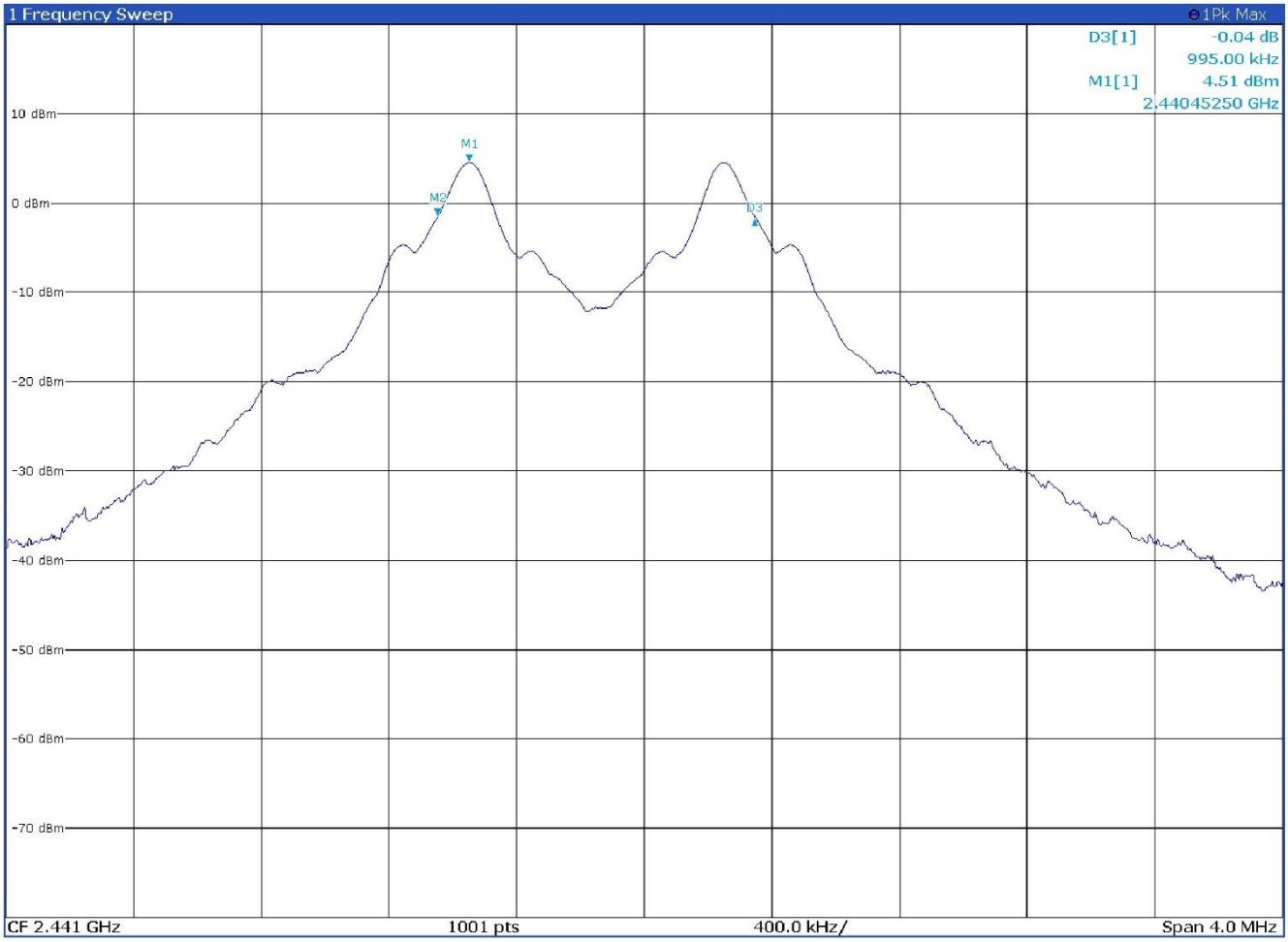
Figure 8.3-18: *99% bandwidth on high channel – Antenna port 3*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4067203 GHz**	**4.48 dBm**		
M2		1	**2.4066204 GHz**	**-1.62 dBm**		
D3	M2	1	**995.0 kHz**	**0.16 dB**		

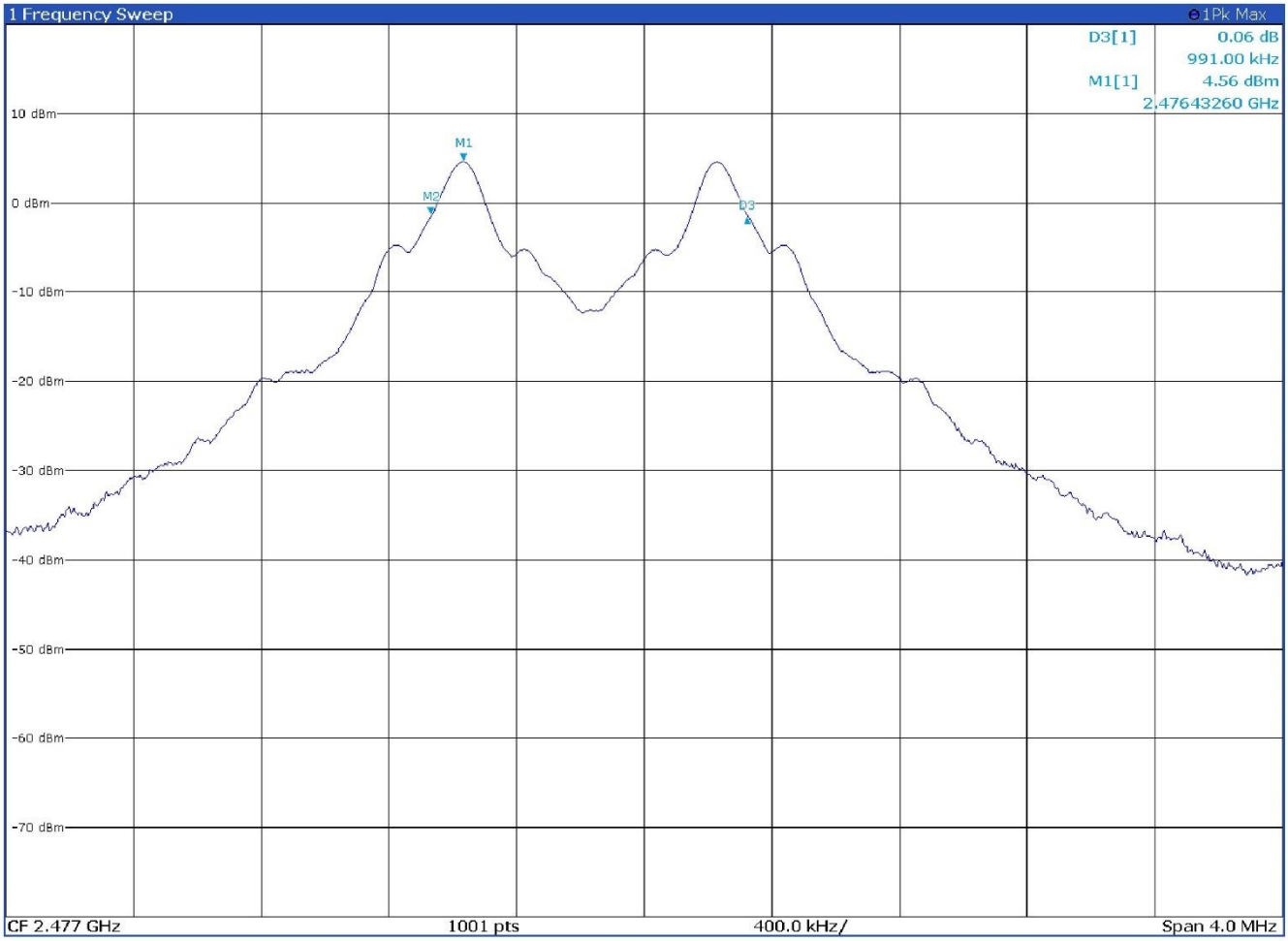
Figure 8.3-19: *6 dB bandwidth on low channel – Antenna port 4*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4404525 GHz**	**4.51 dBm**		
M2		1	**2.4403526 GHz**	**-1.56 dBm**		
D3	M2	1	**995.0 kHz**	**-0.04 dB**		

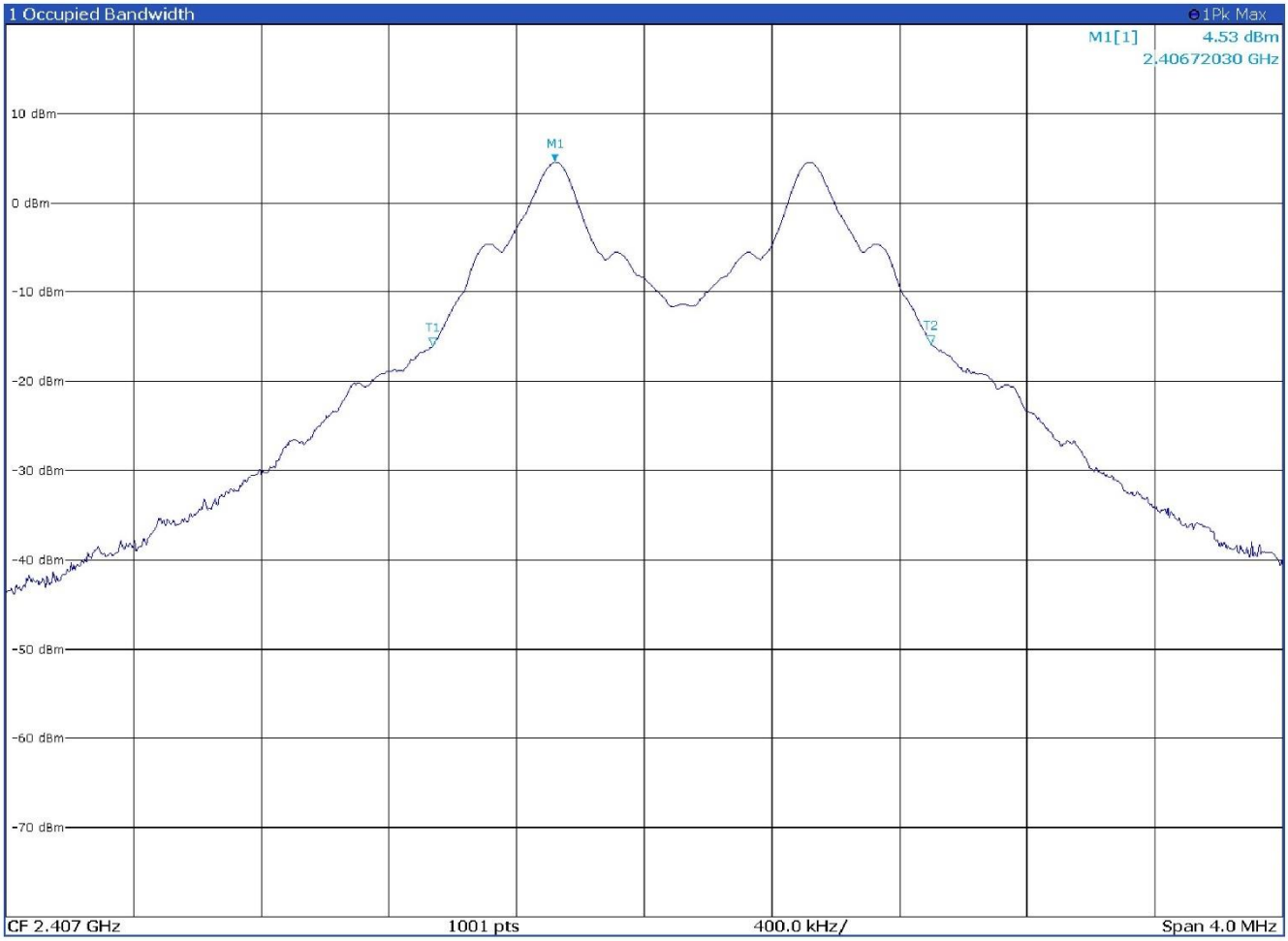
Figure 8.3-20: *6 dB bandwidth on mid channel – Antenna port 4*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4764326 GHz**	**4.56 dBm**		
M2		1	**2.4763327 GHz**	**-1.49 dBm**		
D3	M2	1	**991.0 kHz**	**0.06 dB**		

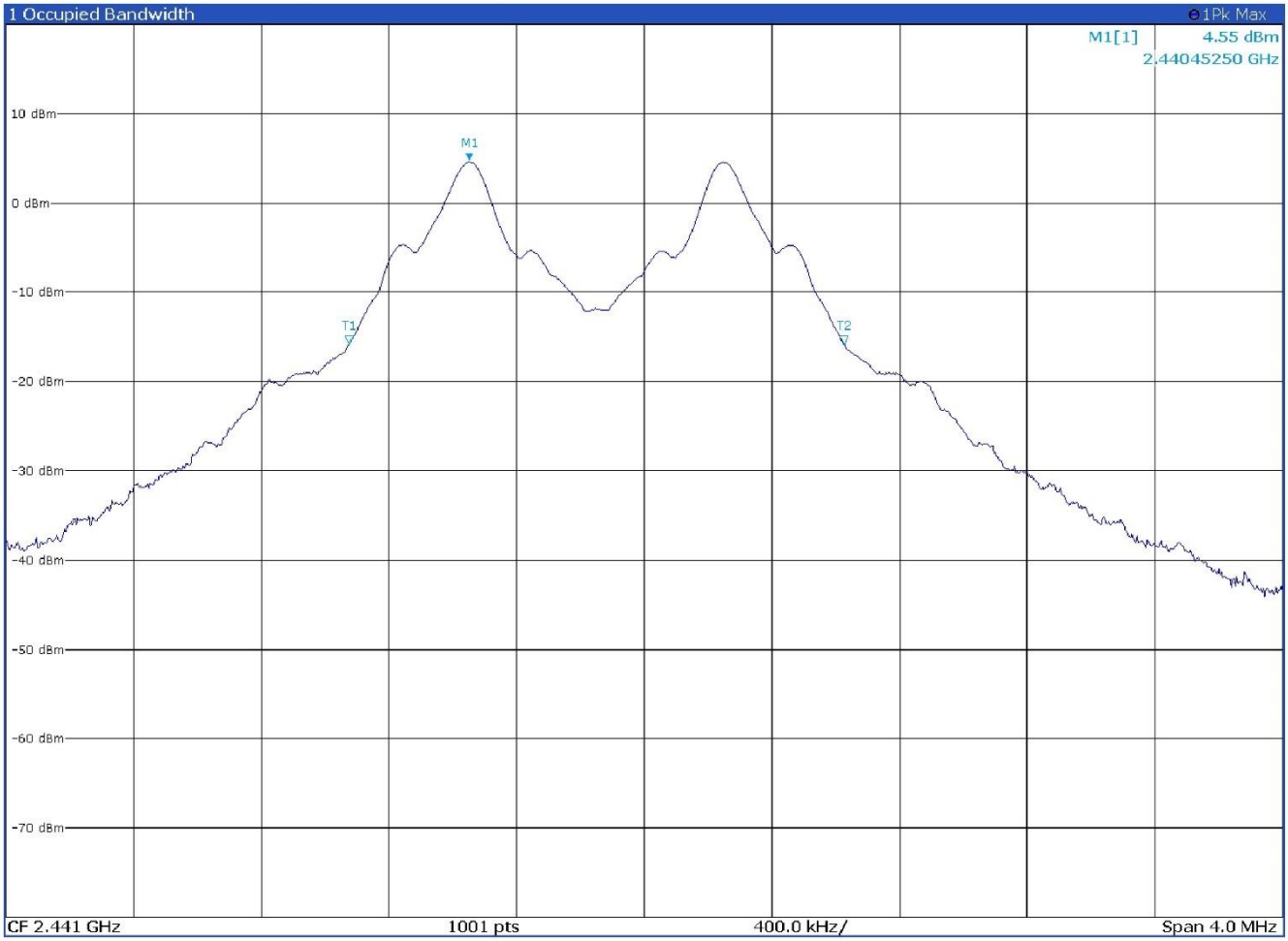
Figure 8.3-21: *6 dB bandwidth on high channel – Antenna port 4*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4067203 GHz**	**4.53 dBm**	Occ Bw	**1.559819627 MHz**
T1		1	2.40633797 GHz	-16.08 dBm	Occ Bw Centroid	2.40711788 GHz
T2		1	2.40789779 GHz	-15.84 dBm	Occ Bw Freq Offset	117.879874462 kHz

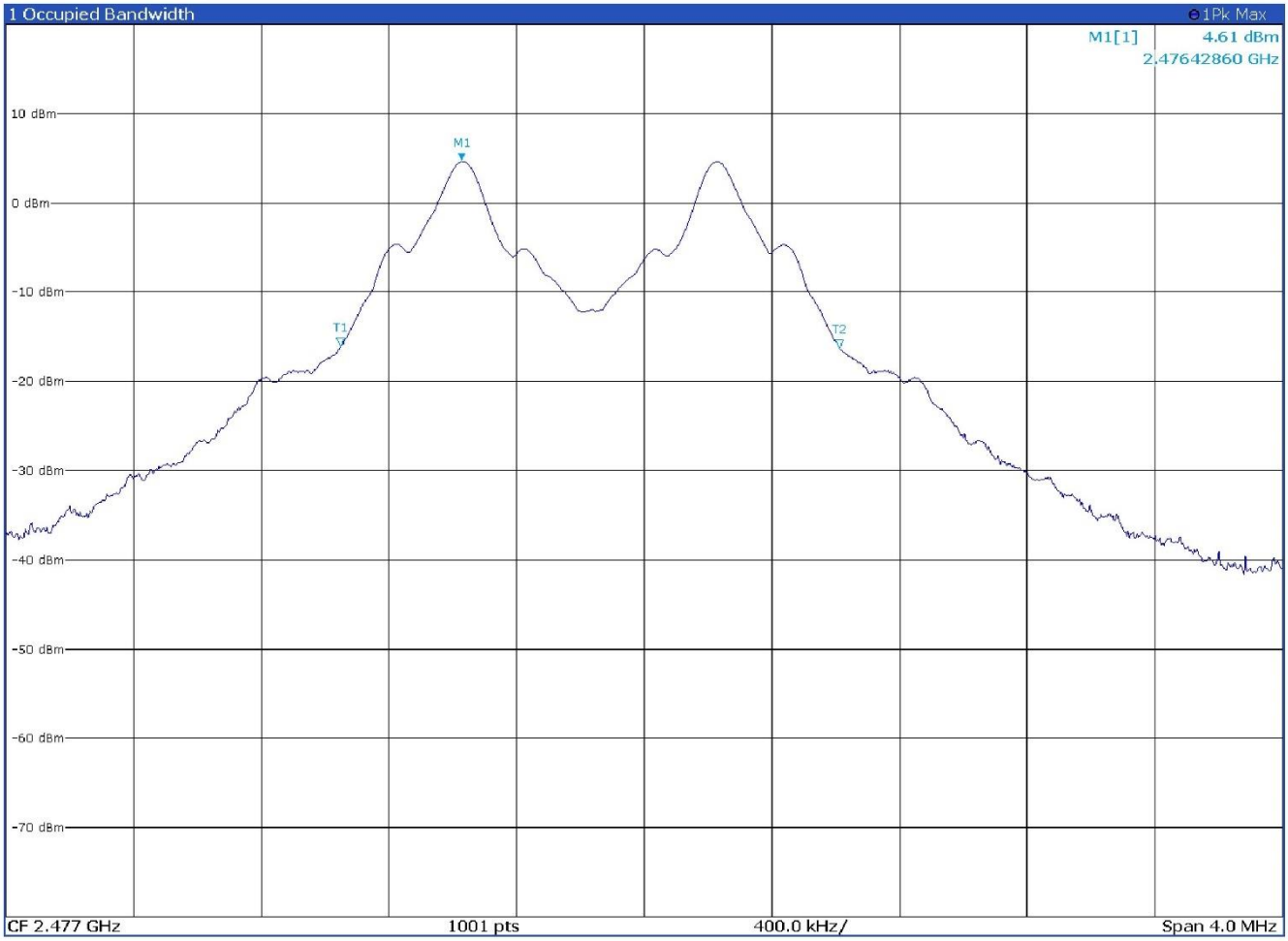
Figure 8.3-22: *99% bandwidth on low channel – Antenna port 4*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4404525 GHz**	**4.55 dBm**	Occ Bw	**1.552056396 MHz**
T1		1	2.44007463 GHz	-15.90 dBm	Occ Bw Centroid	2.440850656 GHz
T2		1	2.44162668 GHz	-15.87 dBm	Occ Bw Freq Offset	-149.344471814 kHz

Figure 8.3-23: *99% bandwidth on mid channel – Antenna port 4*



2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.4764286 GHz**	**4.61 dBm**	Occ Bw	**1.562240391 MHz**
T1		1	2.47604919 GHz	-16.08 dBm	Occ Bw Centroid	2.476830315 GHz
T2		1	2.47761143 GHz	-16.27 dBm	Occ Bw Freq Offset	-169.685413225 kHz

Figure 8.3-24: *99% bandwidth on high channel – Antenna port 4*

8.4 Transmitter output power and e.i.r.p. requirements for DTS in 2.4 GHz

8.4.1 References, definitions and limits

RSS-247, Clause 5.4:

Devices shall comply with the following requirements, where applicable:

d. For DTSs employing digital modulation techniques operating in the 2400–2483.5 MHz band,, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power. The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements, averaged across all symbols in the signalling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or transmitting at a reduced power level. If multiple modes of operation are implemented, the maximum conducted output power is the highest total transmit power occurring in any mode.

e. Fixed point-to-point systems in the 2400–2483.5 MHz band are permitted to have an e.i.r.p. higher than 4 W provided that the higher e.i.r.p. is achieved by employing higher gain directional antennas and not higher transmitter output powers. Point-to-multipoint systems, omnidirectional applications and multiple co-located transmitters transmitting the same information are prohibited from exceeding an e.i.r.p. of 4 W.

f. Transmitters operating in the band 2400–2483.5 MHz, may employ antenna systems that emit multiple directional beams simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers, provided that the emissions comply with the following:

i. Different information must be transmitted to each receiver.

ii. If the transmitter employs an antenna system that emits multiple directional beams, but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device (i.e. the sum of the power supplied to all antennas, antenna elements, staves, etc., and summed across all carriers or frequency channels) shall not exceed the applicable output power limit specified in sections 5.4(b) and 5.4(d). However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

iii. If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the applicable power limit specified in sections 5.4(b) and 5.4(d). If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the applicable limit specified in sections 5.4(b) and 5.4(d). In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the applicable limit specified in sections 5.4(b) and 5.4(d) by more than 8 dB.

iv. Transmitters that transmit a single directional beam shall operate under the provisions of sections 5.4(b), 5.4(d) and 5.4(e).

8.4.2 Test summary

Verdict	Pass		
Tested by	O. Frau	Test date	March 25, 2024

8.4.3 Observations, settings and special notes

The test was performed as per KDB 558074, section 8.3 with reference to ANSI C63.10 subclause 11.9.1 (peak power) using method PKPM1 (Peak power meter method)
Spectrum analyser settings:

Resolution bandwidth	> OBW
Video bandwidth	≥3 × RBW
Frequency span	approximately 5 times the OBW
Detector mode	Peak
Trace mode	Max Hold

8.4.4 Test equipment used

Equipment	Manufacturer	Model no.	Asset no.
EMI Receiver	Rohde & Schwarz	ESW44	101620
Spectrum Analyzer	Rohde & Schwarz	FSW43	101767

8.4.5 Test data

All the measured Output power below has been carried out with loss of the cable = 0.65 dBm

Table 8.4-1: *Output power and EIRP results (conducted measurement) – Antenna port 1*

Frequency, MHz	Field strength, dBµV/m	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB	Antenna gain, dBi	Output power, dBm	Output power limit, dBm	Output power margin, dB
2407	106.39	11.16	36	-24.84	4.67	5.84	30	-24.16
2440	106.32	11.09	36	-24.91	4.67	5.77	30	-24.23
2477	106.26	11.03	36	-24.97	4.67	5.71	30	-24.29

Note: EIRP [dBm] = Output power [dBm] + Antenna gain [dBi] + Cable Loss [dBm]
Field Strength [dBµV/m] = EIRP [dBm] + 95.23 [dB];

Table 8.4-2: *Output power and EIRP results (conducted measurement) – Antenna port 2*

Frequency, MHz	Field strength, dBµV/m	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB	Antenna gain, dBi	Output power, dBm	Output power limit, dBm	Output power margin, dB
2407	106.38	11.15	36	-24.85	4.67	5.83	30	-24.17
2440	106.38	11.15	36	-24.85	4.67	5.83	30	-24.17
2477	106.34	11.11	36	-24.89	4.67	5.79	30	-24.21

Note: EIRP [dBm] = Output power [dBm] + Antenna gain [dBi] + Cable Loss [dBm]
Field Strength [dBµV/m] = EIRP [dBm] + 95.23 [dB];

Table 8.4-3: *Output power and EIRP results (conducted measurement) – Antenna port 3*

Frequency, MHz	Field strength, dBµV/m	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB	Antenna gain, dBi	Output power, dBm	Output power limit, dBm	Output power margin, dB
2407	106.15	10.92	36	-25.08	4.67	5.60	30	-24.40
2440	106.17	10.94	36	-25.06	4.67	5.62	30	-24.38
2477	106.14	10.91	36	-25.09	4.67	5.59	30	-24.41

Note: EIRP [dBm] = Output power [dBm] + Antenna gain [dBi] + Cable Loss [dBm]
Field Strength [dBµV/m] = EIRP [dBm] + 95.23 [dB];

Table 8.4-4: *Output power and EIRP results (conducted measurement) – Antenna port 4*

Frequency, MHz	Field strength, dBµV/m	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB	Antenna gain, dBi	Output power, dBm	Output power limit, dBm	Output power margin, dB
2407	106.08	10.85	36	-25.15	4.67	5.53	30	-24.47
2440	106.09	10.86	36	-25.14	4.67	5.54	30	-24.46
2477	106.06	10.83	36	-25.17	4.67	5.51	30	-24.49

Note: EIRP [dBm] = Output power [dBm] + Antenna gain [dBi] + Cable Loss [dBm]
Field Strength [dBµV/m] = EIRP [dBm] + 95.23 [dB];

Table 8.4-5*: Output power and EIRP results (conducted measurement) – Simultaneous transmission*

Frequency, MHz	Max EIRP, dBm	Max EIRP, mW	Sum EIRP, mW	Sum EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
Ant. 1	11.16	13.06	50.70	17.05	36	-18.95
Ant. 2	11.15	13.03				
Ant. 3	10.94	12.42				
Ant. 4	10.86	12.19				

Test data, continued

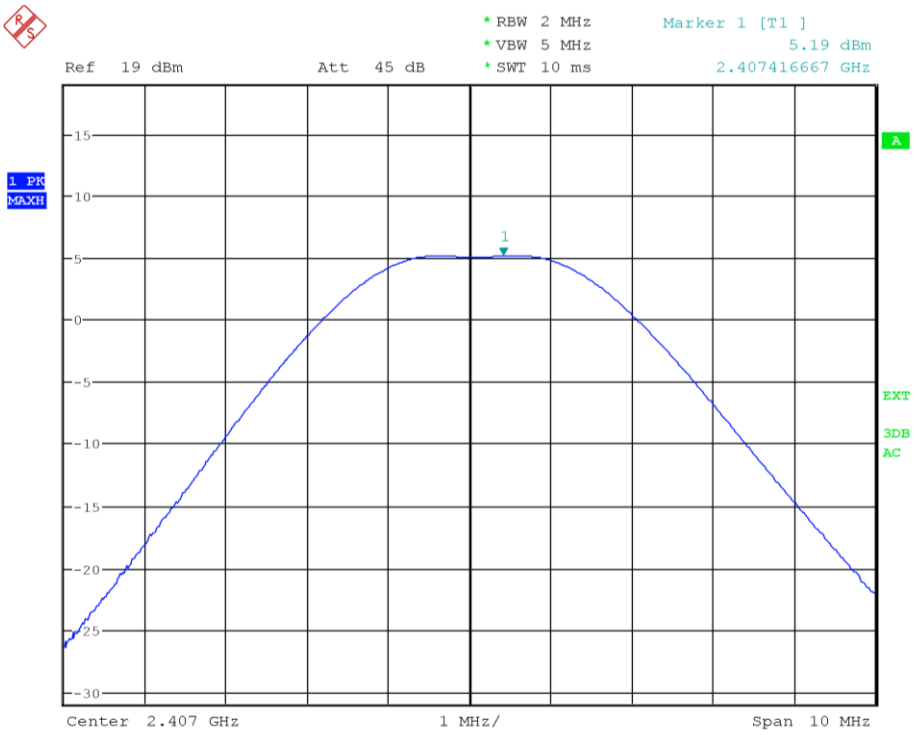


Figure 8.4-1*: Output power on low channel – Antenna port 1*

Test data, continued

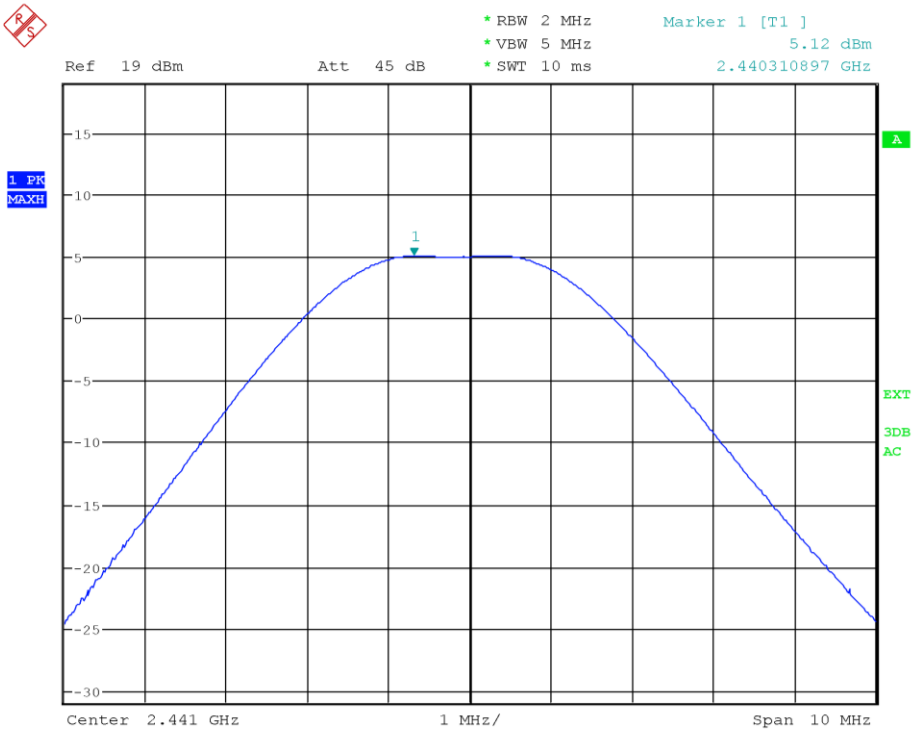


Figure 8.4-2*: Output power on mid channel – Antenna port 1*

Test data, continued

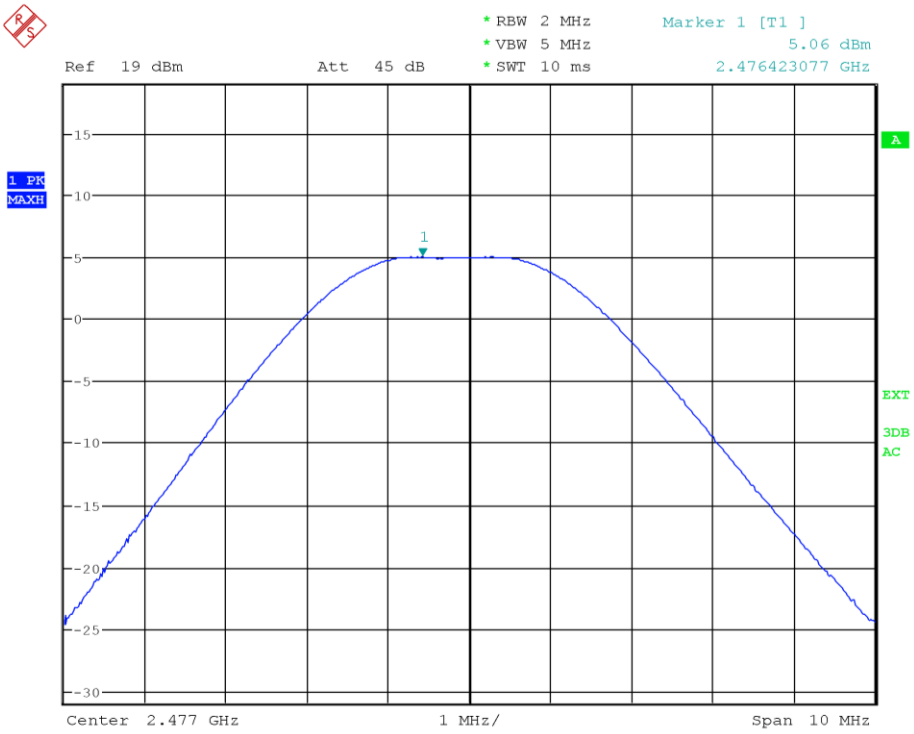


Figure 8.4-3*: Output power on high channel – Antenna port 1*

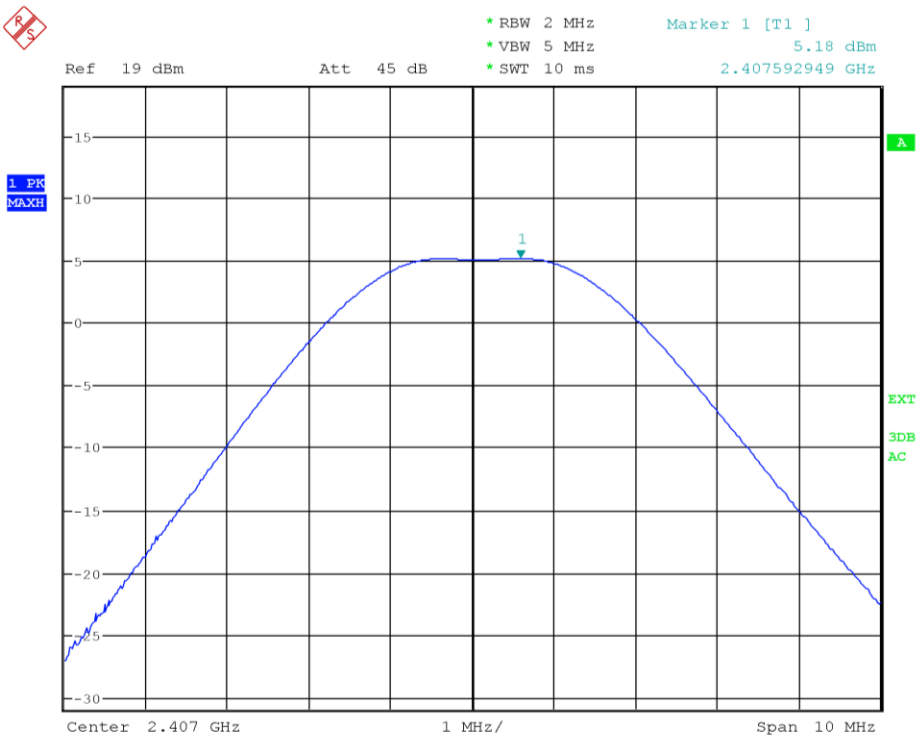


Figure 8.4-4: *Output power on low channel – Antenna port 2*

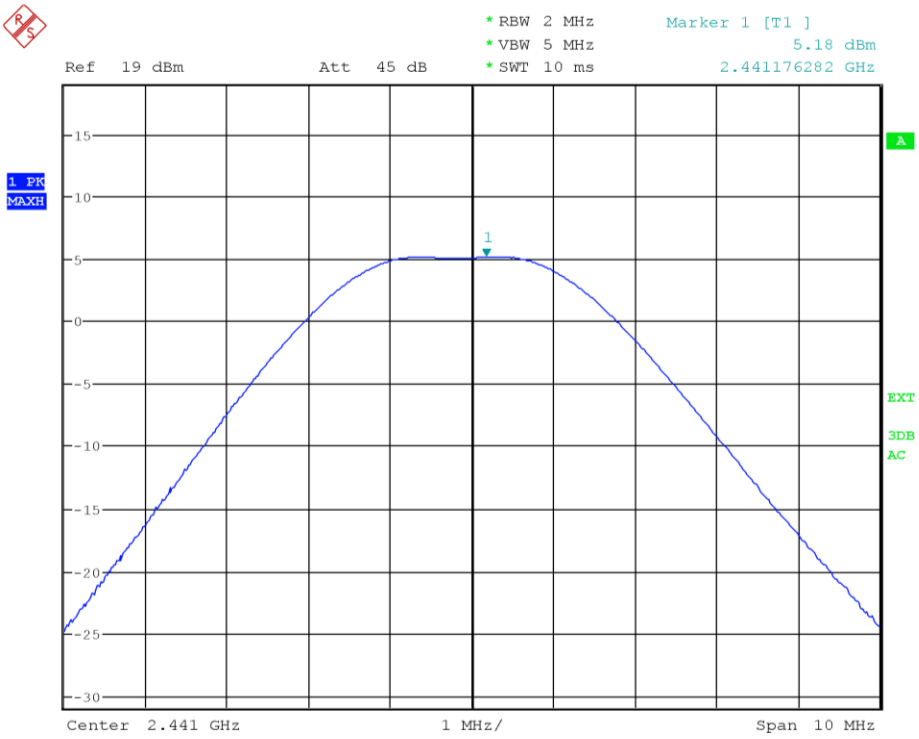


Figure 8.4-5: *Output power on mid channel – Antenna port 2*

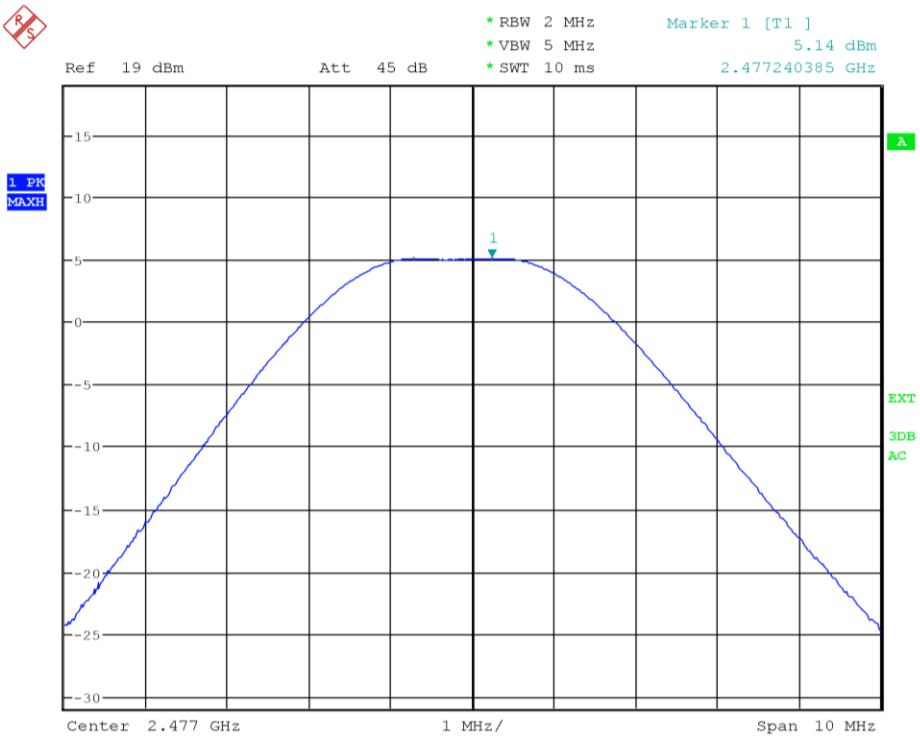


Figure 8.4-6: *Output power on high channel – Antenna port 2*

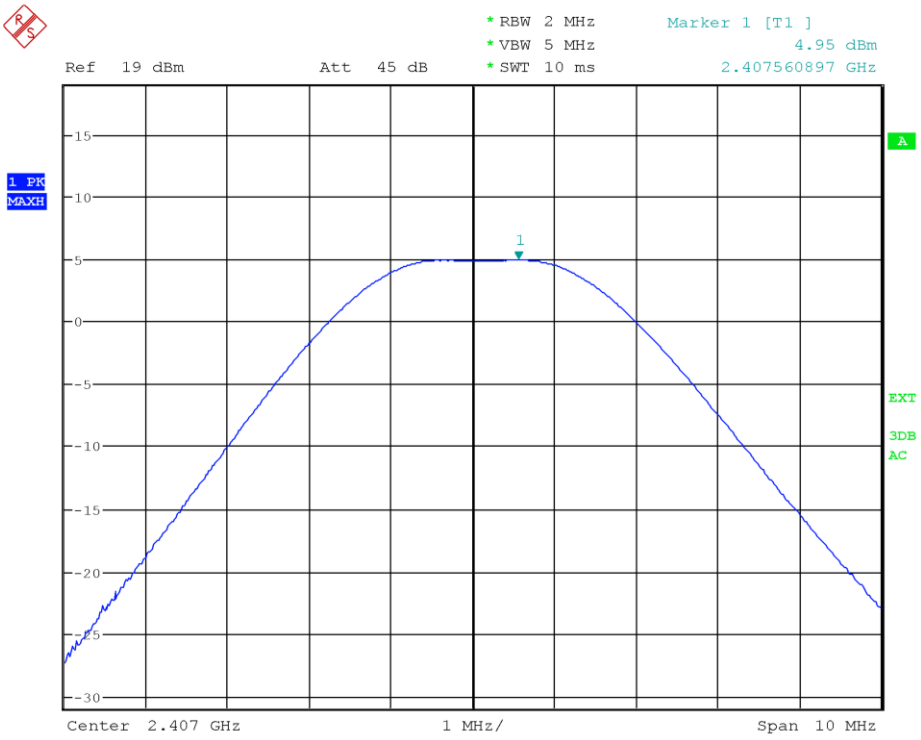


Figure 8.4-7: *Output power on low channel – Antenna port 3*

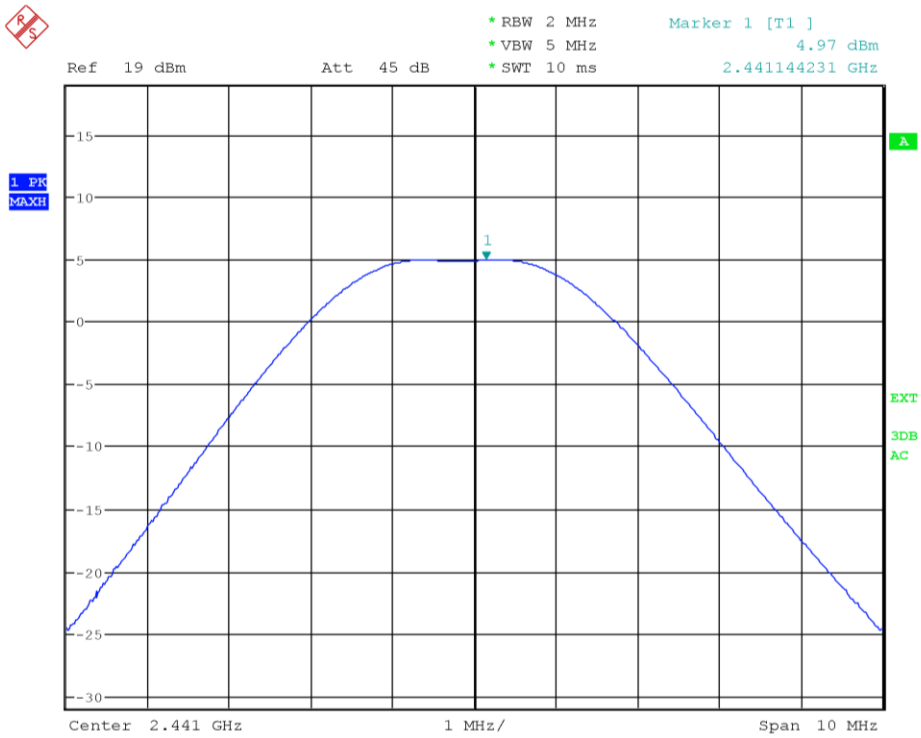


Figure 8.4-8: *Output power on mid channel – Antenna port 3*

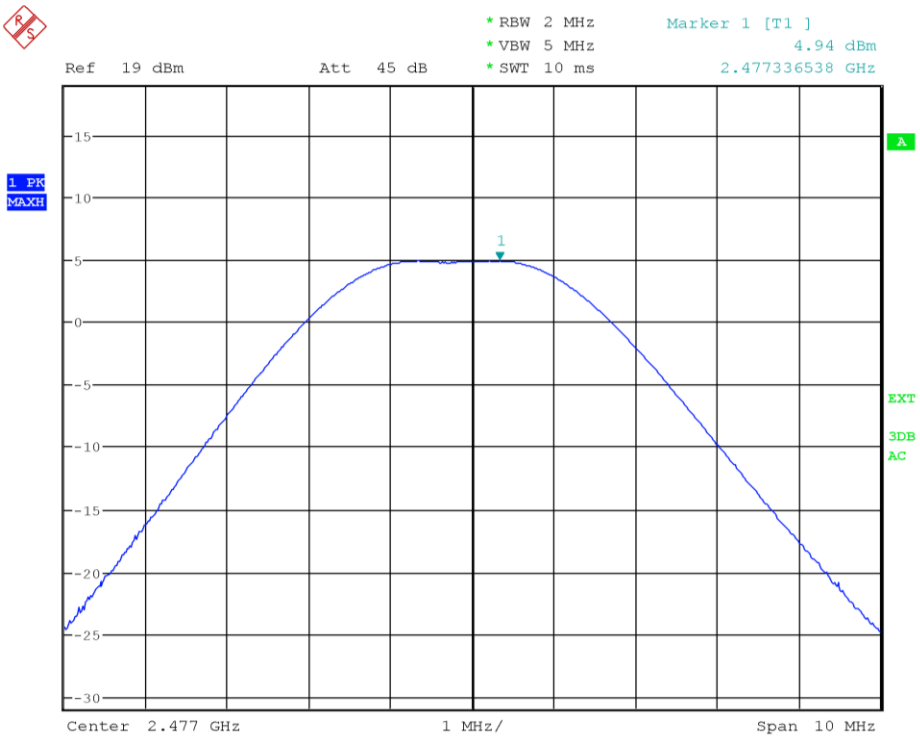


Figure 8.4-9: *Output power on high channel – Antenna port 3*

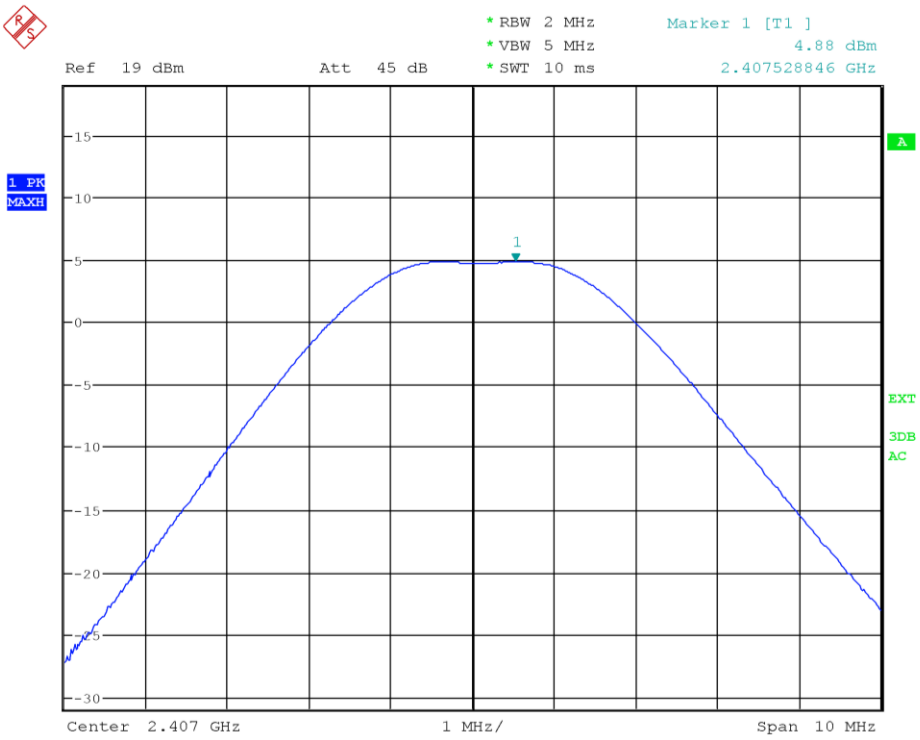


Figure 8.4-10: *Output power on low channel – Antenna port 4*