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RADIO TEST REPORT – 431857-2TRFWL

Type of assessment:

Final product testing

Applicant:

Texa Spa

Via I Maggio, 9

31050 Monastier di Treviso (TV)

Italy

Product:

Diagnosis black box

Model:

TMD MK5

Model variant(s):

--

FCC ID:

T8R-TMDFPT

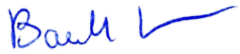
IC Registration number:

23618-TMDFP

Specifications:

- FCC 47 CFR Part 15 Subpart C, §15.247
- RSS-247, Issue 2, Feb 2017, Section 5

Date of issue: March 24, 2021

P. Barbieri	
Tested by	Signature
D. Guarnone	
Reviewed by	Signature

Lab locations

Company name	Nemko S.p.A
Address	Via del Carroccio, 4
City	Biassono
Province	MB
Postal code	20053
Country	Italy
Telephone	+1 514 694 2684
Facsimile	+1 514 694 3528
Toll free	+1 800 563 6336
Website	www.nemko.com
Site 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 S.p.A.. ISO/IEC 17025 accreditation.

Copyright notification

Table of Contents

Section 1 Report summary

1.1 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–585 MHz
RSS-247, Issue 2, Feb 2017, Section 5	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.2 Test methods

558074 D01 15.247 Meas Guidance v05r02 (April 2, 2019)	Guidance for compliance measurements on digital transmission system, frequency hopping spread spectrum system, and hybrid system devices operating under section 15.247 of the FCC rules.
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

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
431857-2TRFWL	March 24, 2021	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

In the laboratory, the following ambient conditions are respected for each test reported below:

Temperature	18 – 33 °C
Relative humidity	25 – 70 %
Air pressure	860 – 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	12/2020	12/2022
Thermo-hygrometer data loggers	Testo	175-H2	38203337/703	12/2020	12/2022
Barometer	Castle	GPB 3300	072015	03/2020	03/2021

3.1 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	Texa Spa
Applicant address	Via I Maggio, 9 – 31050 Monastier di Treviso (TV) – Italy
Manufacture name	Texa Spa
Manufacture address	Via I Maggio, 9 – 31050 Monastier di Treviso (TV) – Italy

5.3 EUT information

Product	Diagnosis black box
Model	TMD MK5
Serial number	4318570001 and 4318750002 (Number assignad by Nemko Spa)
Power supply requirements	Vehicle battery (12 or 24 V DC)
Product description and theory of operation	The EUT is a locator for vehicular application, supplied by the vehicle battery. It's provided with a Bluetooth radio module for data exchange with another device and a LTE radio module model Quectel BG96 for the communication with a remote server.

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 MHz
Frequency Min (MHz)	2402
Frequency Max (MHz)	2480
Channel numbers	78
RF power Max (W), Conducted	2.2 mW (3.5 dBm)
Field strength, dBµV/m @ 3 m	N/A
Measured BW (kHz), 20 dB OBW	1380 kHz
Measured BW (kHz), 99% OBW	1221 kHz
Type of modulation	BT (QPSK, 8PSK)
Emission classification	F1D
Equipment Class	DSS
Transmitter spurious, dBµV/m @ 3 m	48.1 dBµV/m @ 4880 MHz (Peak)
Antenna information	Pulse CW3043 SMD ceramic chip Antenna, gain 4 dBi

5.5 EUT setup details

5.5.1 Radio exercise details

Operating conditions	The EUT use an embedded linux operating system version 4.14.79.AUTOINC+. To put the EUT is continuous transmission the Cypress mbt software (002-14799 Rev. C) has been used with the following commands, provided by the applicant: BR DH5 mode: CH 0 mbt radio_tx_test DEADBEEF0198 2402 4 1 15 65535 +3 CH 39 mbt radio_tx_test DEADBEEF0198 2441 4 1 15 65535 +3 CH 78 mbt radio_tx_test DEADBEEF0198 2480 4 1 15 65535 +3 EDR 2DH5 mode: CH 0 mbt radio_tx_test DEADBEEF0198 2402 4 0 14 65535 +3 CH 39 mbt radio_tx_test DEADBEEF0198 2441 4 0 14 65535 +3 CH 78 mbt radio_tx_test DEADBEEF0198 2480 4 0 14 65535 +3 EDR 3DH5 mode: CH 0 mbt radio_tx_test DEADBEEF0198 2402 4 0 15 65535 +3 CH 39 mbt radio_tx_test DEADBEEF0198 2441 4 0 15 65535 +3 CH 78 mbt radio_tx_test DEADBEEF0198 2480 4 0 15 65535 +3 BR hopping mode: DH1 mbt radio_tx_test DEADBEEF0198 0 4 1 4 65535 +3 DH3 mbt radio_tx_test DEADBEEF0198 0 4 1 11 65535 +3 DH5 mbt radio_tx_test DEADBEEF0198 0 4 1 15 65535 +3
Transmitter state	Transmitter set into continuous mode.

5.5.2 EUT setup configuration

Table 5.5-1: *EUT interface ports*

Description	Qty.
DC power port with four wires cable connected to an external DC power source	1
USB port with standard cable (used only for programming the EUT) connected to a PC	1

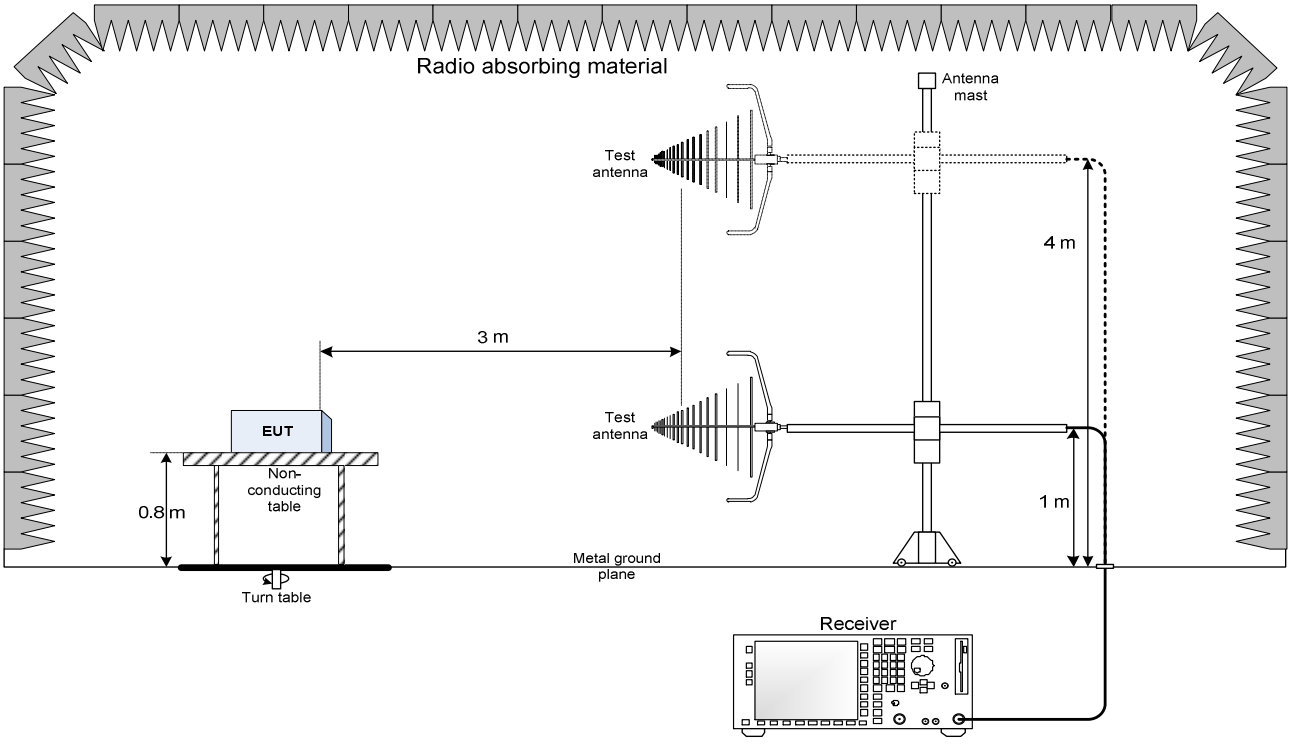


Figure 5.5-1: *Radiated testing block diagram below 1 GHz with sample 4318570001*

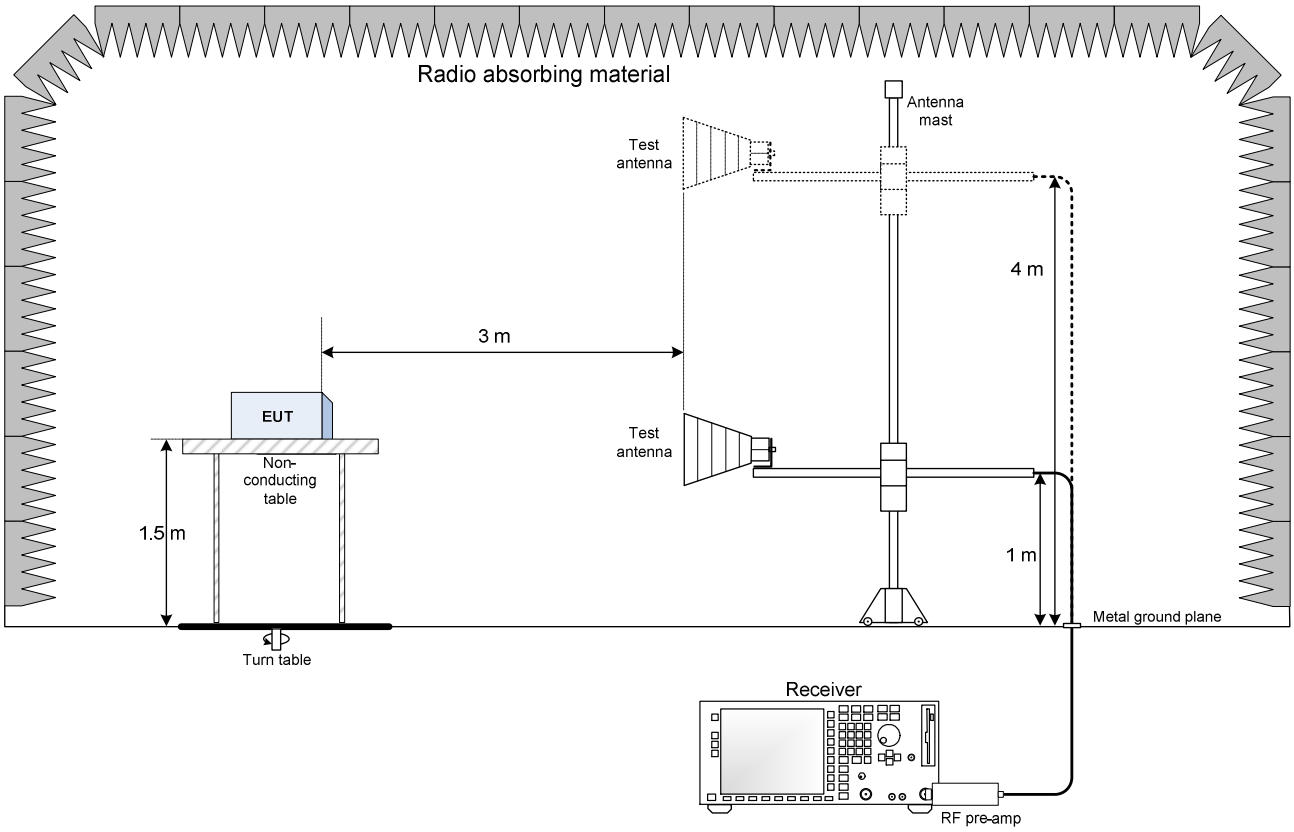


Figure 5.5-2: *Radiated testing block diagram below 1 GHz with sample 4318570001*

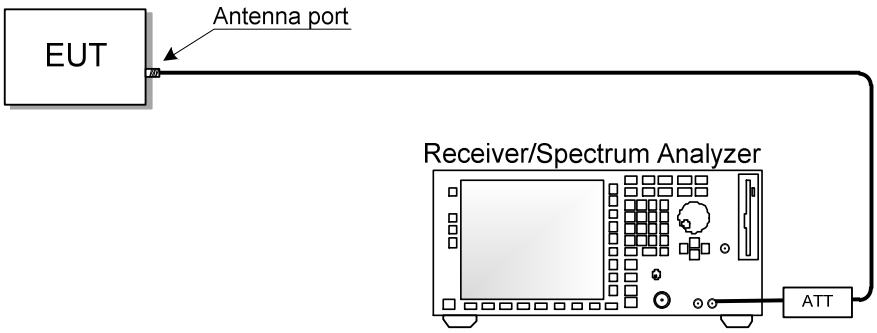


Figure 5.5-3: *Antenna port testing block diagram with sample 4318570002 (temporary antenna connector provided by the manufacturer)*

Section 6 Summary of test results

6.1 Testing location

Test location (s)	Nemko Spa Via del Carroccio, 4 – 20053 Biassono (MB) - Italy

6.2 Testing period

Test start date	March 17, 2021	Test end date	March 24, 2021

6.3 Sample information

Receipt date	March 17, 2021	Nemko sample ID number(s)	431857

6.4 FCC Part 15 Subpart A and C, general requirements test results

Table 6.4-1: *FCC general requirements results*

Part	Test description	Verdict
§15.207(a)	Conducted limits	Not applicable
§15.31I	Variation of power source	Pass
§15.31(m)	Number of tested frequencies	Pass
§15.203	Antenna requirement	Pass

Notes: The EUT is supplied by a vehicle battery

6.5 FCC Part §15.247 test results for frequency hopping spread spectrum systems (FHSS)

Table 6.5-1: *FCC FHSS requirements results*

Part	Test description	Verdict
§15.247(a)(1)(i)	Requirements for operation in the 902–928 MHz band	Not applicable
§15.247(a)(1)(ii)	Requirements for operation in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Requirements for operation in the 2400–2483.5 MHz band	Pass
§15.247(b)(1)	Maximum peak output power in the 2400–2483.5 MHz band and 5725–5850 MHz band	Pass
§15.247(b)(2)	Maximum peak output power in the 902–928 MHz band	Not applicable
§15.247I(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247I(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(f)	Time of occupancy for hybrid systems	Not applicable

Notes: --

6.6 FCC Part §15.247 test results for digital transmission systems (DTS)

Table 6.6-1: *FCC DTS requirements results*

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

Notes: --

6.7 ISED RSS-Gen, Issue 5, test results

Table 6.7-1: *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 supplied by a vehicle battery

6.8 ISED RSS-247, Issue 2, test results for frequency hopping spread spectrum systems (FHSS)

Table 6.8-1: *ISED FHSS requirements results*

Part	Test description	Verdict
5.1 (a)	Bandwidth of a frequency hopping channel	Pass
5.1 (b)	Minimum channel spacing	Pass
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	Pass
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	Pass
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	Pass

Notes: --

6.9 ISED RSS-247, Issue 2, test results for digital transmission systems (DTS)

Table 6.9-1: *ISED DTS requirements results*

Part	Test description	Verdict
5.2 (a)	Minimum 6 dB bandwidth	Not applicable
5.2 (b)	Maximum power spectral density	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 (d)	Systems employing digital modulation techniques	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: --

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.
EMI receiver (20 Hz ÷ 8 GHz)	Rohde & Schwarz	ESU8	100202	08/2020	08/2021
EMI receiver (2 Hz ÷ 44 GHz)	Rohde & Schwarz	ESW44	101620	09/2020	09/2021
Spectrum Analyzer (2 Hz ÷ 43 GHz)	Rohde & Schwarz	FSW43	101767	01/2021	01/2022
Trilog Antenna (30 MHz ÷ 7 GHz)	Schwarzbeck	VULB 9162	9162-025	07/2018	07/2021
Bilog antenna (1 ÷ 18 GHz)	Schwarzbeck	STLP 9148	9148-123	07/2018	07/2021
Horn Antenna (4 ÷ 40 GHz)	RFSpin	DRH40	061106A40	04/2020	04/2023
Preamplifier (1 ÷ 18 GHz)	Schwarzbeck	BBV 9718C	00121	01/2021	01/2022
Preamplifier (18 ÷ 40 GHz)	Sage	STB-1834034030-KFKF-L1	18490-01	03/2020	03/2021
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	10m semi-anechoic chamber	530	09/2019	09/2021
Shielded room	Siemens	10m control room	1947	NCR	NCR

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

Section 8 Testing data

8.1 Variation of power source

8.1.1 References, definitions and limits

FCC §15.31 (e):

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

8.1.2 Test summary

Verdict	Pass				
Tested by	P. Barbieri	Test date	March 17, 2021	Sample tested	4318570001

8.1.3 Observations, settings and special notes

The testing was performed as per ANSI C63.10 Section 5.13.

a) Where the device is intended to be powered from an external power adapter, the voltage variations shall be applied to the input of the adapter provided with the device at the time of sale. If the device is not marketed or sold with a specific adapter, then a typical power adapter shall be used.
b) For devices, where operating at a supply voltage deviating ±15% from the nominal rated value may cause damages or loss of intended function, test to minimum and maximum allowable voltage per manufacturer's specification and document in the report.
c) For devices with wide range of rated supply voltage, test at 15% below the lowest and 15% above the highest declared nominal rated supply voltage.
d) For devices obtaining power from an input/output (I/O) port (USB, firewire, etc.), a test jig is necessary to apply voltage variation to the device from a support power supply, while maintaining the functionalities of the device.

For battery-operated equipment, the equipment tests shall be performed using a variable power supply.

8.1.4 Test data

EUT Power requirements:	☐ AC	☒ DC	☒ Battery
If EUT is an AC or a DC powered, was the noticeable output power variation observed?	☐ YES	☒ NO	☐ N/A
If EUT is battery operated, was the testing performed using fresh batteries?	☐ YES	☐ NO	☒ N/A
If EUT is rechargeable battery operated, was the testing performed using fully charged batteries?	☒ YES	☐ NO	☐ N/A

8.2 Number of frequencies

8.2.1 References, definitions and limits

FCC §15.31:

(m) Measurements on intentional radiators or receivers shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table.

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 8.2-1: *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.

8.2.2 Test summary

Verdict	Pass				
Tested by	P. Barbieri	Test date	March 17, 2021	Sample tested	4318570001

8.2.3 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.

8.2.4 Test data

Table 8.2-2: *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	2402	2441	2480

8.3 Antenna requirement

8.3.1 References, definitions and limits

FCC §15.203:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

FCC §15.247:

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

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.

8.3.2 Test summary

Verdict	Pass				
Tested by	P. Barbieri	Test date	March 17, 2021	Sample tested	4318570001

8.3.3 Observations, settings and special notes

None

8.3.4 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 8.3-1: *Antenna information*

Antenna type	Manufacturer	Model number	Maximum gain	Connector type
Ceramic Chip Antenna	Pulse Electronics	CW3043	4 dBi	None

8.4 Frequency Hopping Systems requirements, 2 GHz operation

8.4.1 References, definitions and limits

FCC §15.247:

(a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(iii) Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

(f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

Table 8.4-1: *Summary of the basic requirements*

$P_{max\text{-}pk} \leq 1$ W	$P_{max\text{-}pk} \leq 0.125$ W
$N_{ch} \geq 75$	$N_{ch} \geq 15$
$\Delta f \geq$ MAX { 25 kHz, $BW_{20\ dB}$ }	$\Delta f \geq$ MAX [MAX { 25 kHz, 0.67×$BW_{20\ dB}$ } OR MAX{25 kHz, $BW_{20\ dB}$}]
max. $BW_{20\ dB}$ not specified	max. $BW_{20\ dB}$ not specified
$t_{ch} \leq 0.4$ s for T = 0.4×Nch	$t_{ch} \leq 0.4$ s for T = 0.4×Nch

Note: t_{ch} = average time of occupancy; T = period; N_{ch} = # hopping frequencies; BW = bandwidth; Δf = hopping channel carrier frequency separation

RSS-247, Clause 5.1:

a. The bandwidth of a frequency hopping channel is the 20 dB emission bandwidth, measured with the hopping stopped. The system's radio frequency (RF) bandwidth is equal to the channel bandwidth multiplied by the number of channels in the hopset. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

b. FHSs shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2400–2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W.

d. FHSs operating in the band 2400–2483.5 MHz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

RSS-247, Clause 5.3:

Hybrid systems employ a combination of both frequency hopping and digital transmission techniques and shall comply with the following:

a. With the digital transmission operation of the hybrid system turned off, the frequency hopping operation shall have an average time of occupancy on any frequency not exceeding 0.4 seconds within a duration in seconds equal to the number of hopping frequencies multiplied by 0.4.

8.4.2 Test summary

Verdict	Pass				
Tested by	P. Barbieri	Test date	March 22, 2021	Sample tested	4318570002

8.4.3 Observations, settings and special notes

Carrier frequency separation was tested per ANSI C63.10 subclause 7.8.2. Spectrum analyser settings:

Resolution bandwidth	Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
Video bandwidth	≥ RBW
Frequency span	Wide enough to capture the peaks of two adjacent channels
Detector mode	Peak
Trace mode	Max Hold

Number of hopping frequencies was tested per ANSI C63.10 subclause 7.8.3. Spectrum analyser settings:

Resolution bandwidth	To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
Video bandwidth	≥ RBW
Frequency span	The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
Detector mode	Peak
Trace mode	Max Hold

Time of occupancy (dwell time) was tested per ANSI C63.10 subclause 7.8.4. Spectrum analyser settings:

Resolution bandwidth	shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
Video bandwidth	≥ RBW
Frequency span	Zero span, centered on a hopping channel.
Detector mode	Peak
Trace mode	Max Hold

20 dB bandwidth was tested per ANSI C63.10 subclause 6.9.2. Spectrum analyser settings:

Resolution bandwidth	≥ 1–5% of the 20 dB bandwidth
Video bandwidth	≥ RBW
Frequency span	approximately 2 to 5 times the 20 dB bandwidth, centered on a hopping channel
Detector mode	Peak
Trace mode	Max Hold

8.4.4 Test equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
Spectrum Analyzer (2 Hz ÷ 43 GHz)	Rohde & Schwarz	FSW43	101767	01/2021	01/2022
Shielded room	Siemens	10m control room	1947	NCR	NCR

8.4.5 Test data

Table 8.4-2: *20 dB bandwidth results*

Modulation	Frequency, MHz	20 dB bandwidth, MHz
BT BR DH5	2402	1.05
BT BR DH5	2441	1.04
BT BR DH5	2480	1.04
BT EDR 2DH5	2402	1.38
BT EDR 2DH5	2441	1.38
BT EDR 2DH5	2480	1.37
BT EDR 3DH5	2402	1.37
BT EDR 3DH5	2441	1.36
BT EDR 3DH5	2480	1.37

Table 8.4-3: *99% occupied bandwidth results*

Modulation	Frequency, MHz	99% occupied bandwidth, kHz
BT BR DH5	2402	947.0
BT BR DH5	2441	948.5
BT BR DH5	2480	956.9
BT EDR 2DH5	2402	1210.3
BT EDR 2DH5	2441	1211.8
BT EDR 2DH5	2480	1215.2
BT EDR 3DH5	2402	1214.3
BT EDR 3DH5	2441	1219.1
BT EDR 3DH5	2480	1220.7

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

Table 8.4-4: *Carrier frequency separation results*

Carrier frequency separation, kHz	Minimum limit, kHz	Margin, kHz
1009	918	91

Table 8.4-5: *Number of hopping frequencies results*

Number of hopping frequencies	Minimum limit	Margin
79	15	64

Table 8.4-6: *Average time of occupancy results*

Modulation	Dwell time of each pulse, ms	Number of pulses within period	Total dwell time within period, ms	Limit, ms	Margin, ms
DH1	0.410	197	80.8	400	-319.2
DH3	1.650	130	214.5	400	-185.5
DH5	2.890	79	228.3	400	-171.7

Notes: Measurement Period is 31.6 s

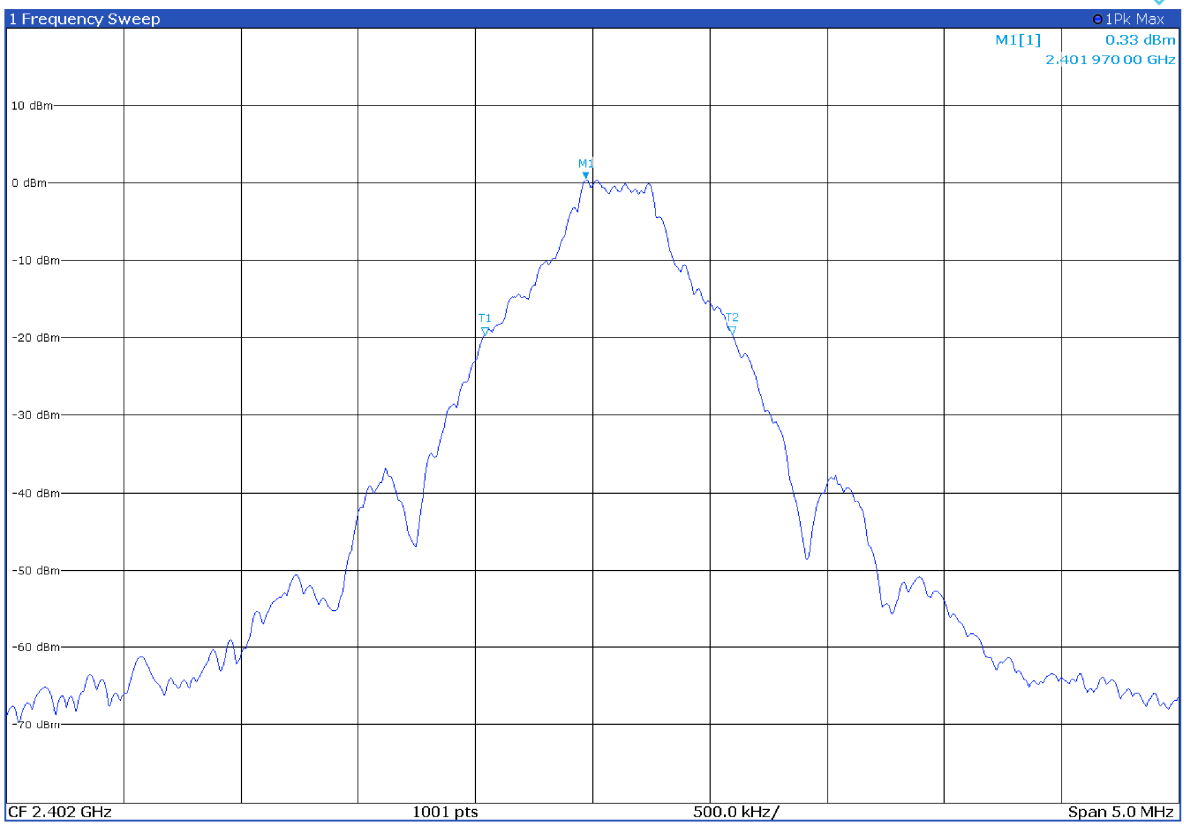


Figure 8.4-1: 20 dB bandwidth on low channel – modulation BR DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.401 97 GHz**	**0.33 dBm**	ndB	20.0 dB
T1		1	2.401 540 5 GHz	-19.72 dBm	ndB down BW	**1.05 MHz**
T2		1	2.402 594 4 GHz	-19.61 dBm	Q Factor	2 279.0

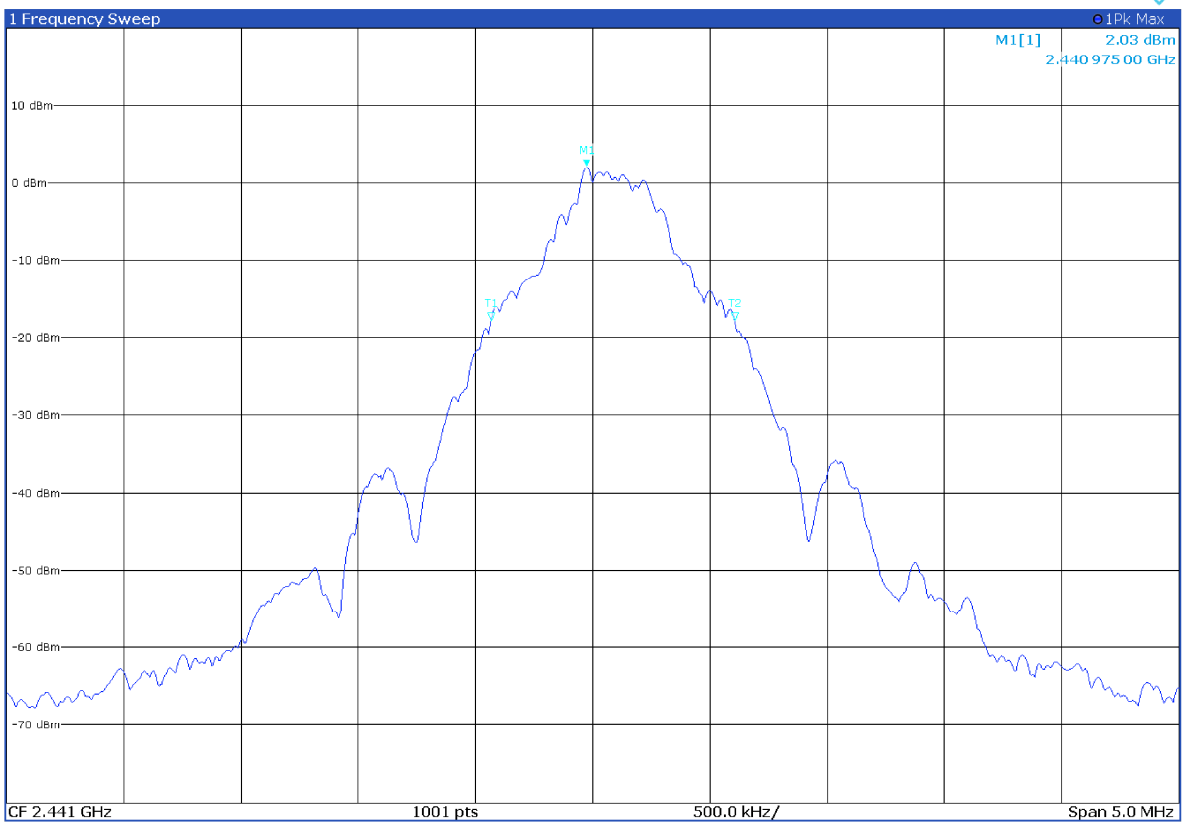


Figure 8.4-2: 20 dB bandwidth on mid channel – modulation BR DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.440 975 GHz**	**2.03 dBm**	ndB	20.0 dB
T1		1	2.440 565 4 GHz	-17.80 dBm	ndB down BW	**1.04 MHz**
T2		1	2.441 604 4 GHz	-17.79 dBm	Q Factor	2 349.4

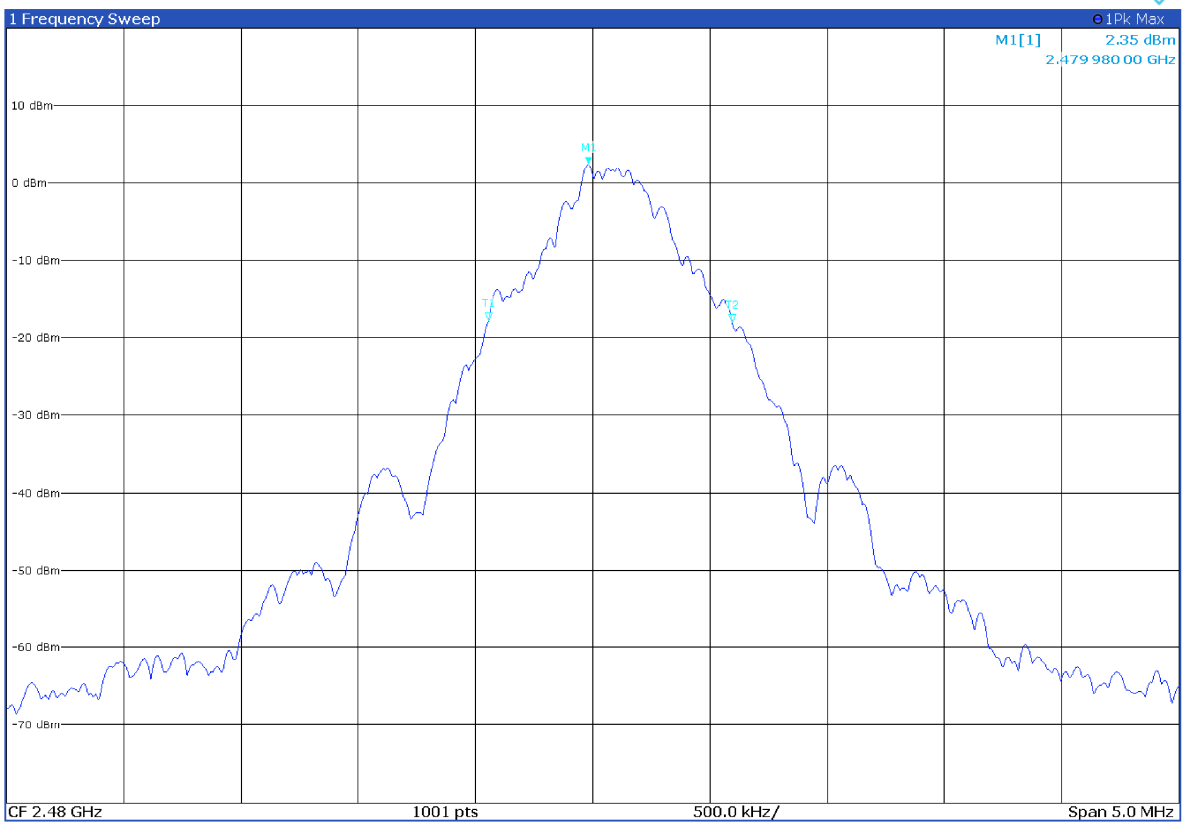


Figure 8.4-3: 20 dB bandwidth on high channel – modulation BR DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.479 98 GHz**	**2.35 dBm**	ndB	20.0 dB
T1		1	2.479 555 4 GHz	-17.85 dBm	ndB down BW	**1.04 MHz**
T2		1	2.480 594 4 GHz	-17.99 dBm	Q Factor	2387.0

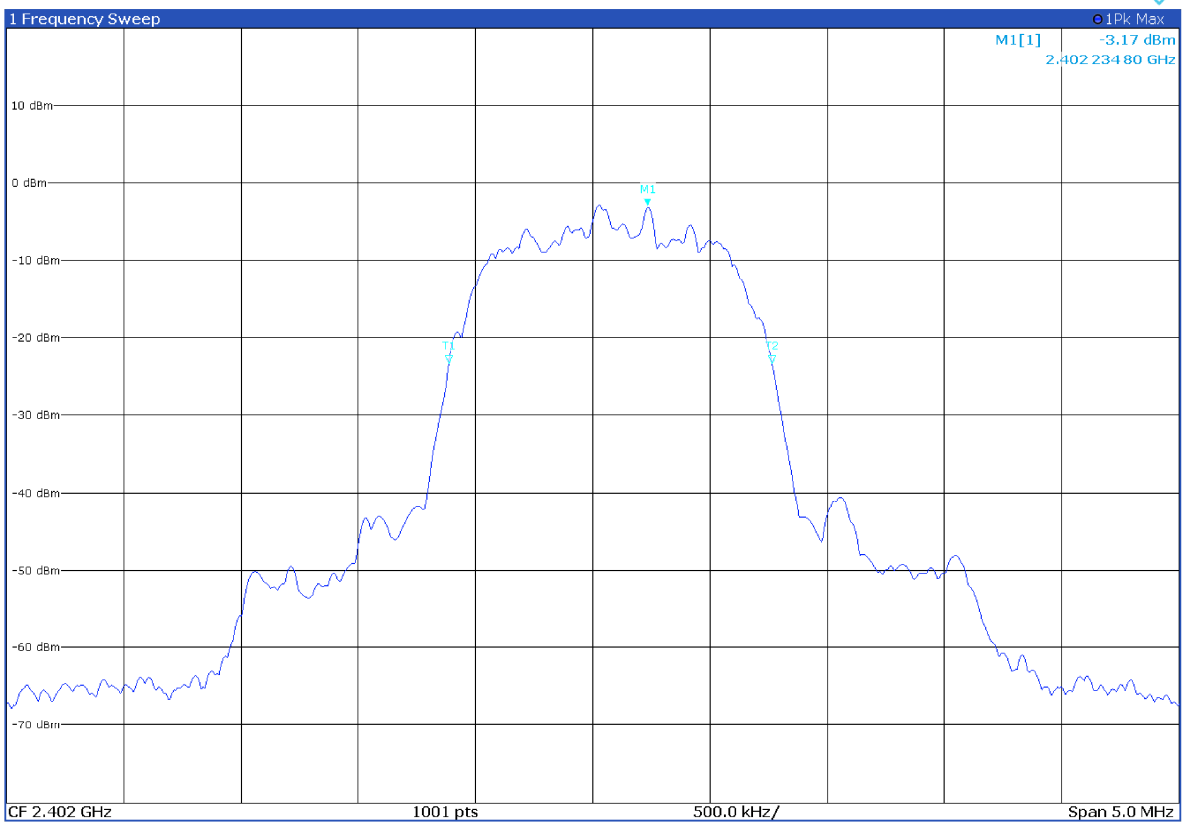


Figure 8.4-4: 20 dB bandwidth on low channel – modulation EDR 2DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.402 234 8 GHz**	**-3.17 dBm**	ndB	20.0 dB
T1		1	2.401 385 6 GHz	-23.32 dBm	ndB down BW	**1.38 MHz**
T2		1	2.402 764 2 GHz	-23.32 dBm	Q Factor	1 742.5

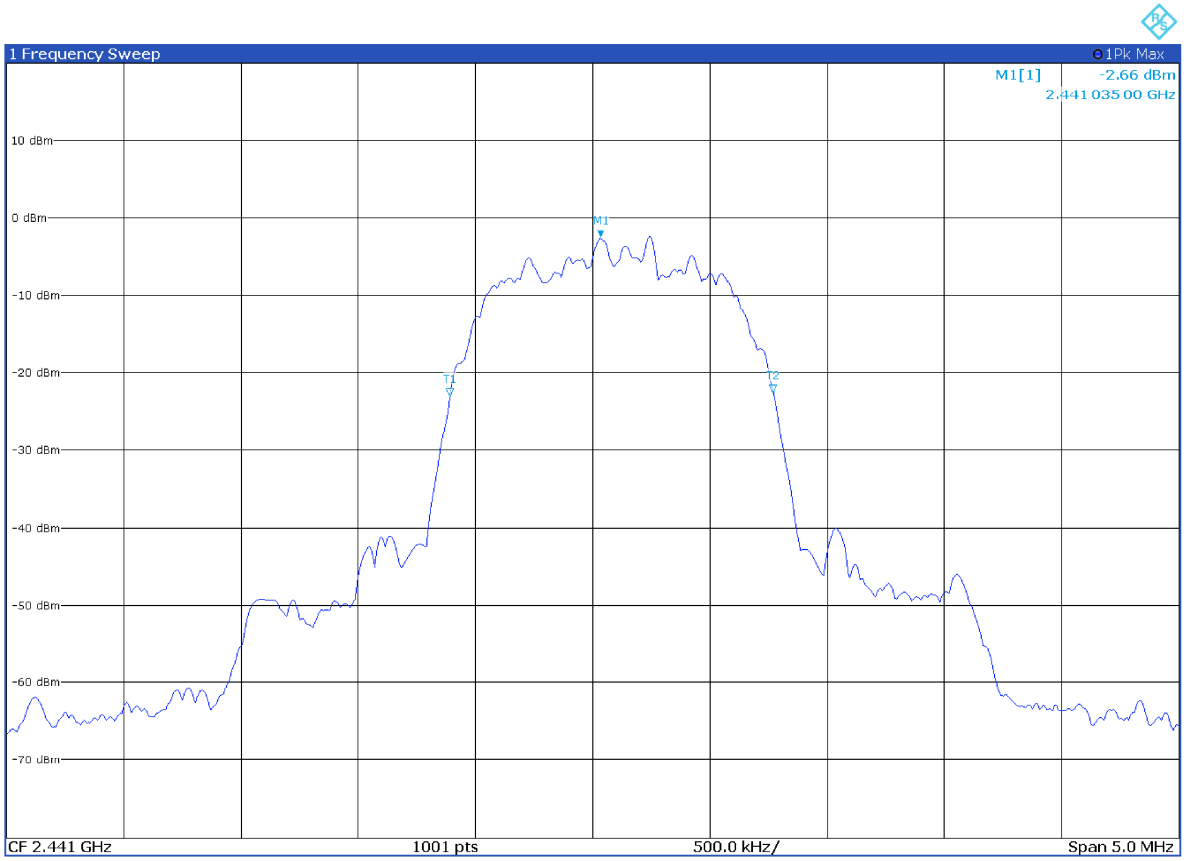


Figure 8.4-5: 20 dB bandwidth on mid channel – modulation EDR 2DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.441 035 GHz**	**-2.66 dBm**	ndB	20.0 dB
T1		1	2.440 390 6 GHz	-23.07 dBm	ndB down BW	**1.38 MHz**
T2		1	2.441 769 2 GHz	-22.55 dBm	Q Factor	1 770.6

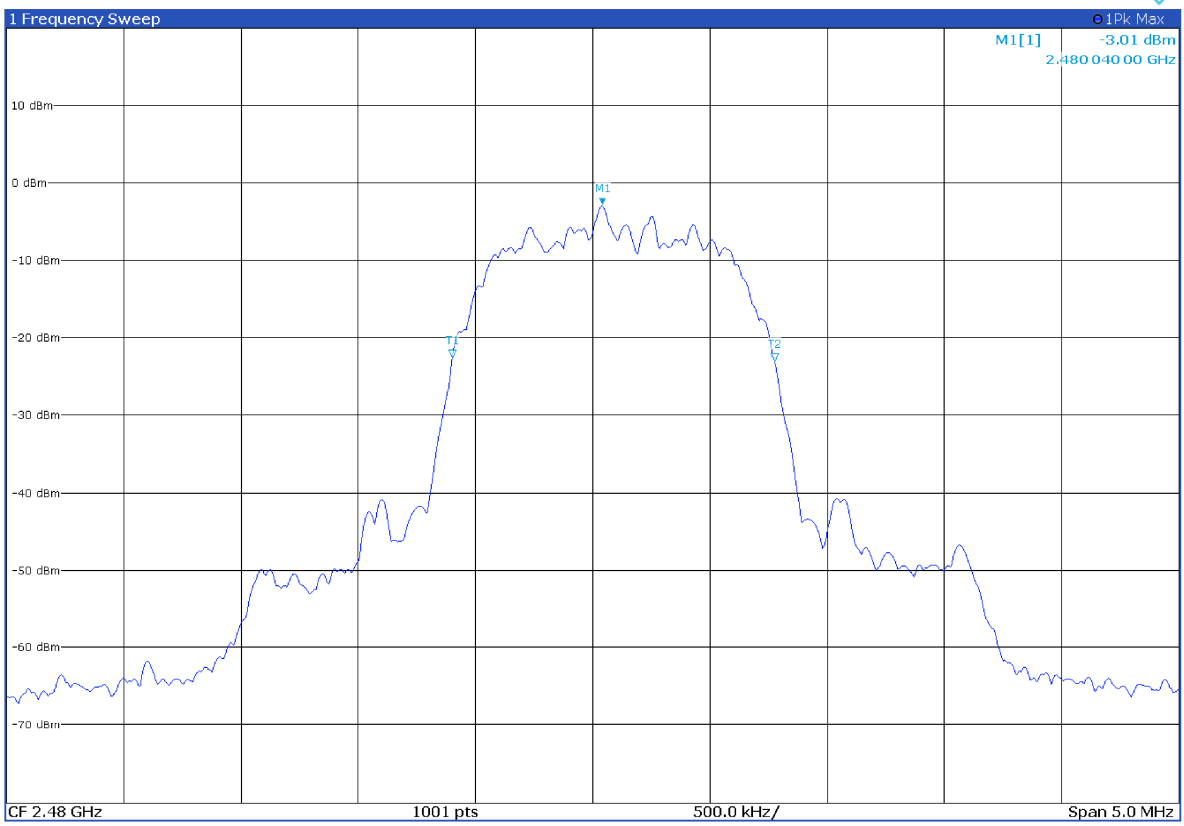


Figure 8.4-6: 20 dB bandwidth on high channel – modulation EDR 2DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.480 04 GHz**	**-3.01 dBm**	ndB	20.0 dB
T1		1	2.479 400 6 GHz	-22.59 dBm	ndB down BW	**1.37 MHz**
T2		1	2.480 774 2 GHz	-23.06 dBm	Q Factor	1 805.5

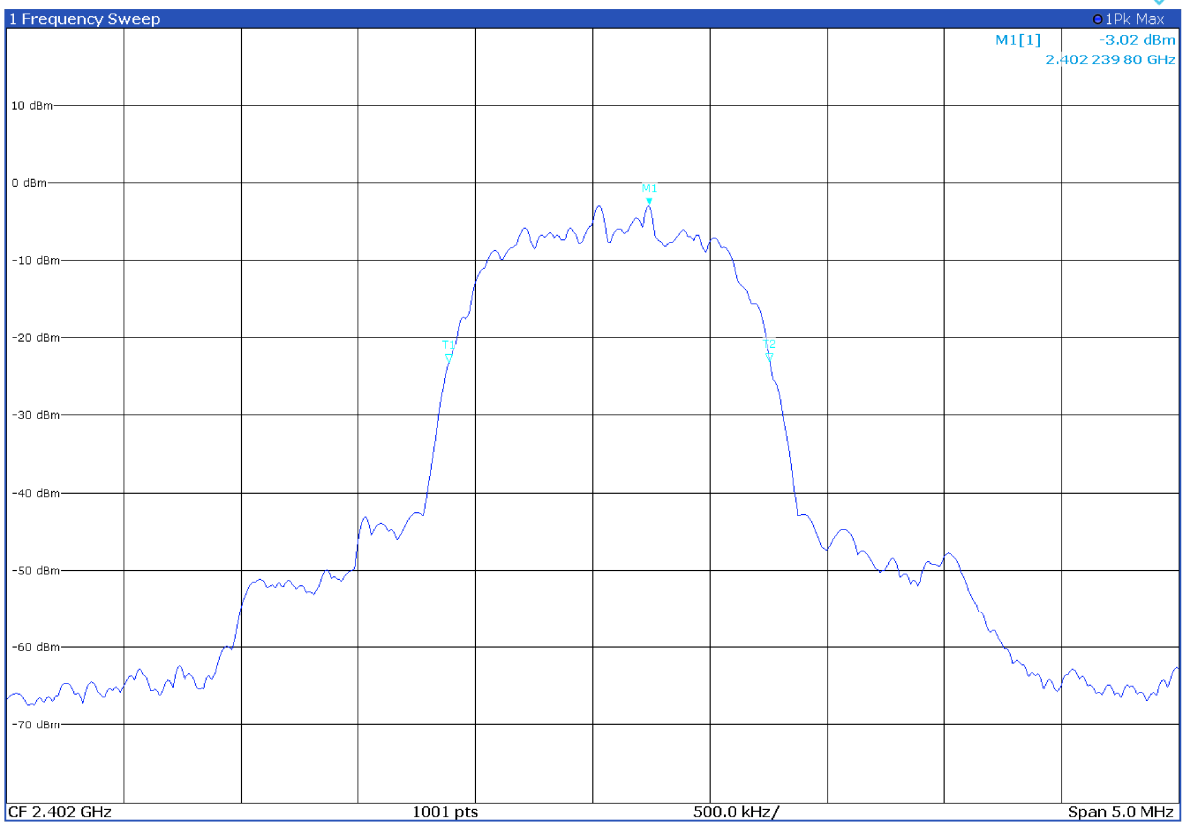


Figure 8.4-7: 20 dB bandwidth on low channel – modulation EDR 3DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.402 239 8 GHz**	**-3.02 dBm**	ndB	20.0 dB
T1		1	2.401 385 6 GHz	-23.20 dBm	ndB down BW	**1.37 MHz**
T2		1	2.402 754 2 GHz	-23.01 dBm	Q Factor	1 755.2

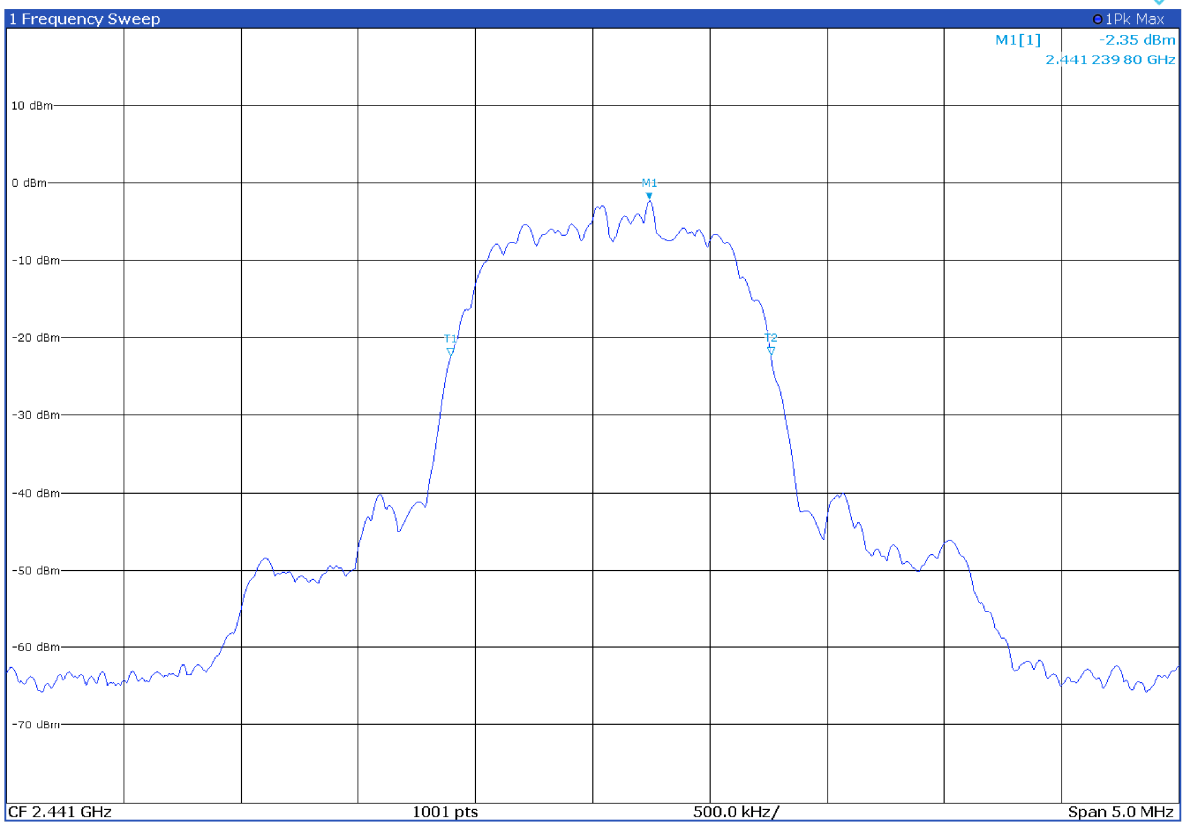


Figure 8.4-8: 20 dB bandwidth on mid channel – modulation EDR 3DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.441 239 8 GHz**	**-2.35 dBm**	ndB	20.0 dB
T1		1	2.440 395 6 GHz	-22.36 dBm	ndB down BW	**1.36 MHz**
T2		1	2.441 759 2 GHz	-22.27 dBm	Q Factor	1 790.2

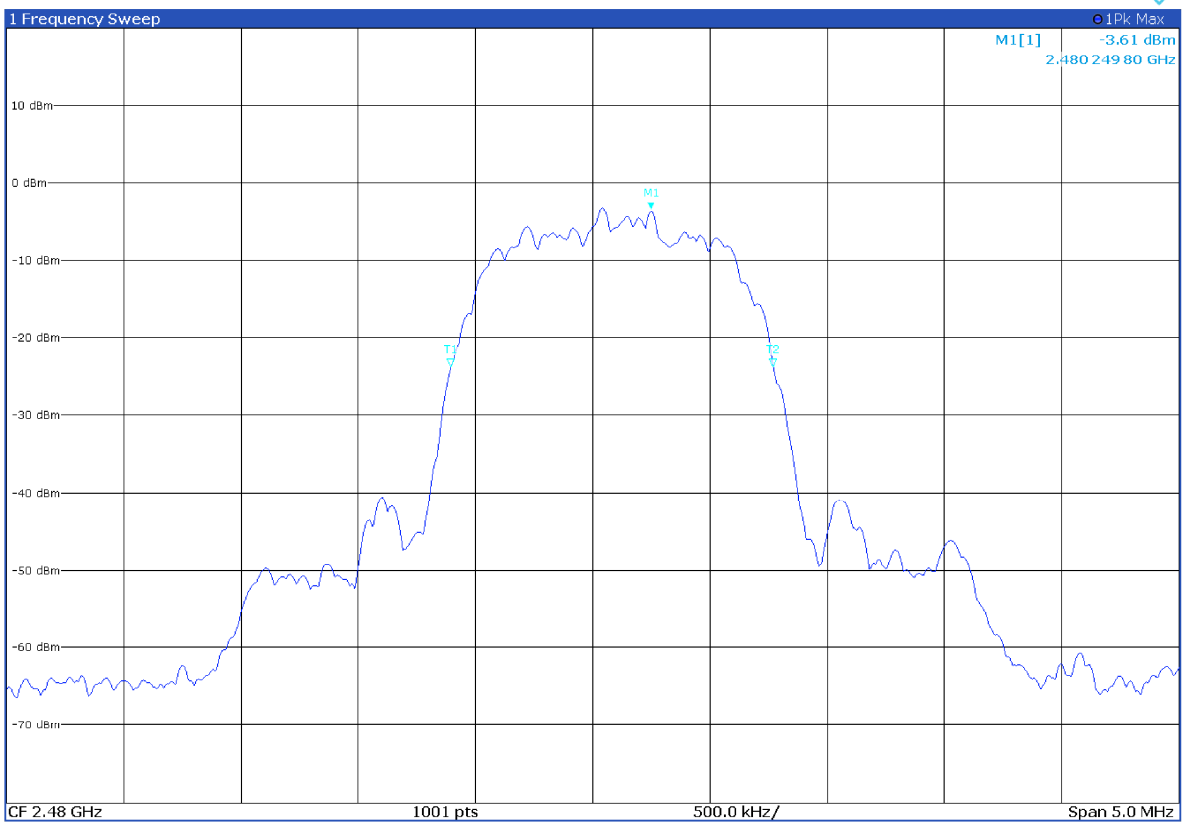


Figure 8.4-9: 20 dB bandwidth on high channel – modulation EDR 3DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.480 249 8 GHz**	**-3.61 dBm**	ndB	20.0 dB
T1		1	2.479 395 6 GHz	-23.68 dBm	ndB down BW	**1.37 MHz**
T2		1	2.480 769 2 GHz	-23.74 dBm	Q Factor	1 805.6

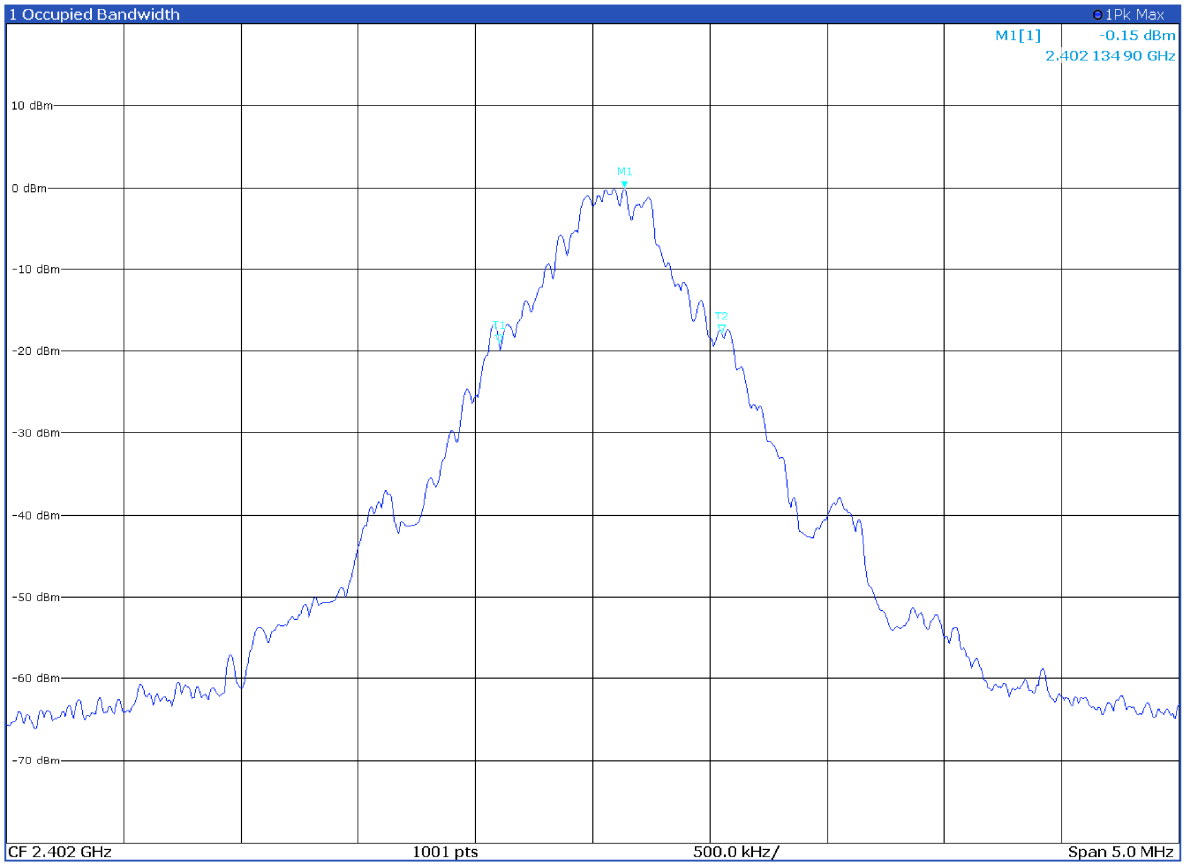


Figure 8.4-10: 99% bandwidth on low channel – modulation BR DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.402 134 9 GHz**	**-0.15 dBm**	Occ Bw	**946.972 840 21 kHz**
T1		1	2.401 601 17 GHz	-18.99 dBm	Occ Bw Centroid	2.402 074 652 GHz
T2		1	2.402 548 14 GHz	-17.82 dBm	Occ Bw Freq Offset	74.652 373 559 kHz

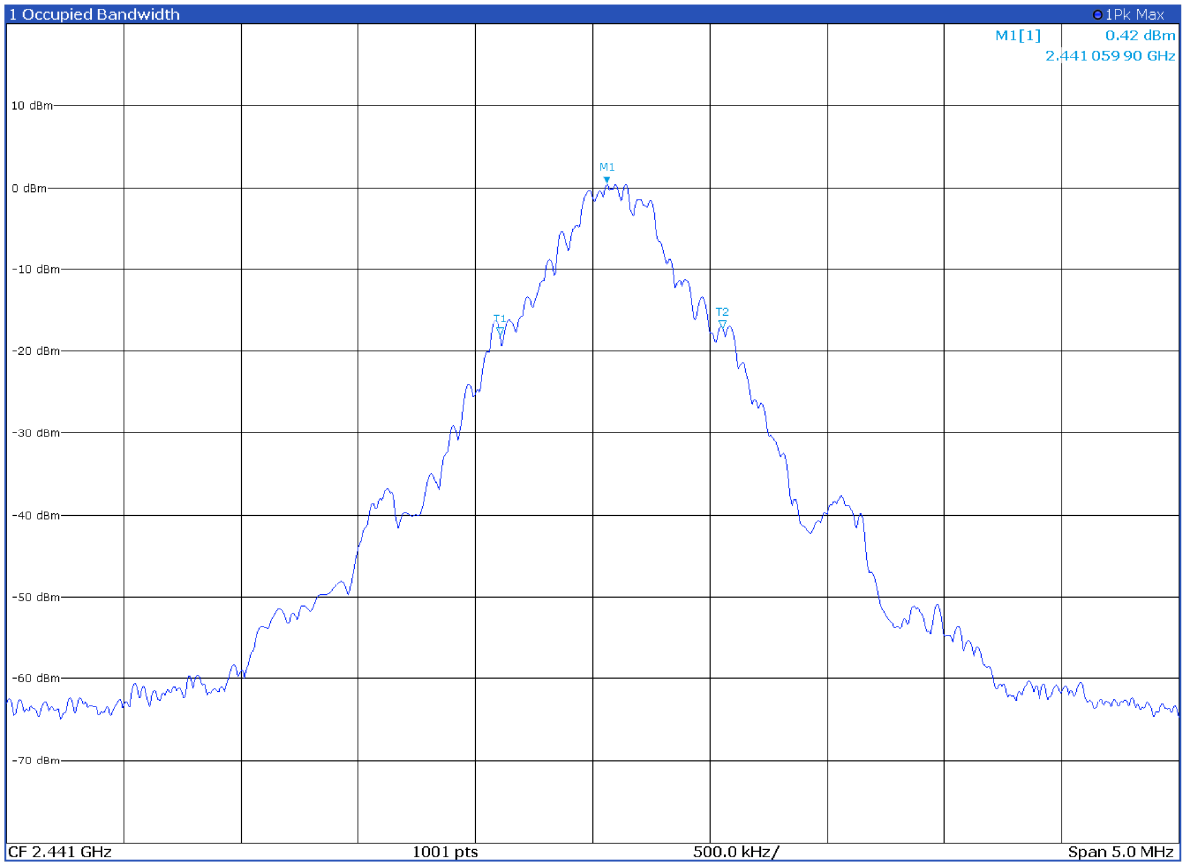


Figure 8.4-11: 99% bandwidth on mid channel – modulation BR DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.441 059 9 GHz**	**0.42 dBm**	Occ Bw	**948.525 605 254 kHz**
T1		1	2.440 606 14 GHz	-18.16 dBm	Occ Bw Centroid	2.441 080 402 GHz
T2		1	2.441 55467 GHz	-17.25 dBm	Occ Bw Freq Offset	80.402 397 404 kHz

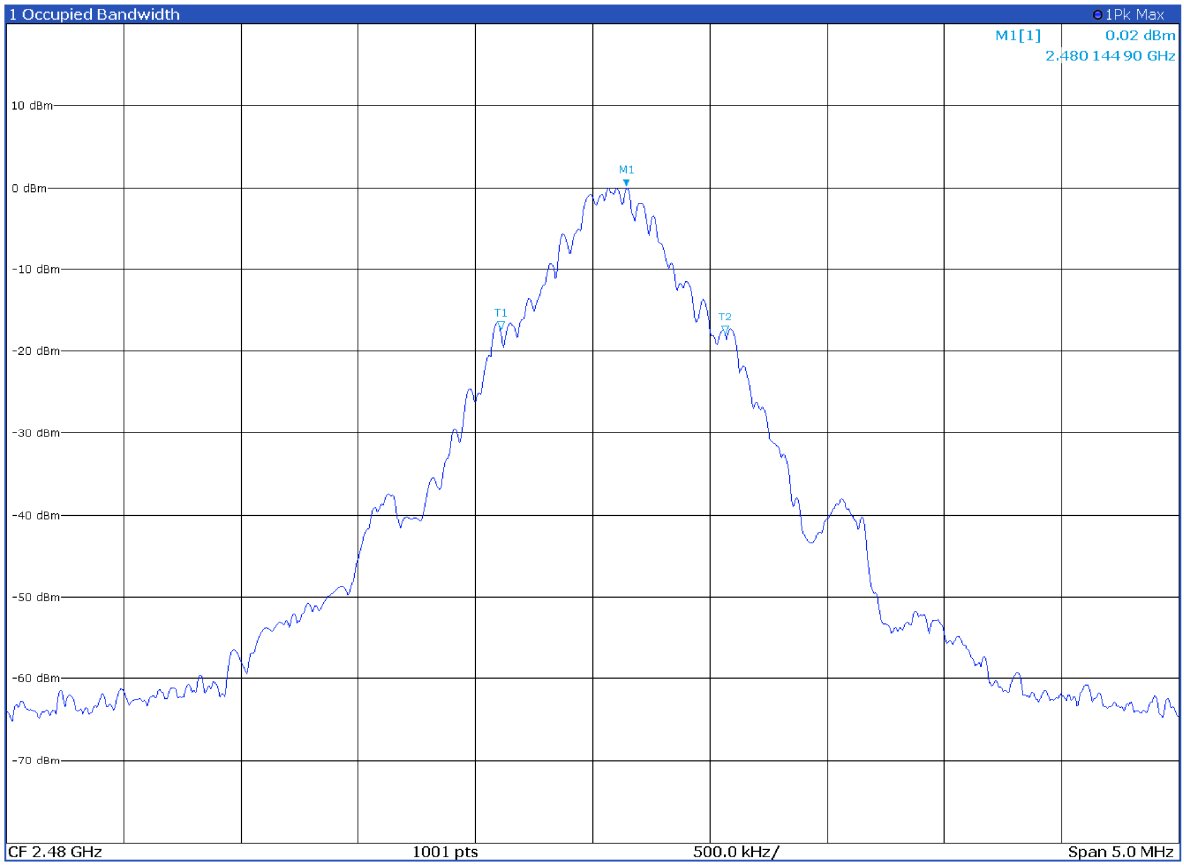


Figure 8.4-12: 99% bandwidth on high channel – modulation BR DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.480 144 9 GHz**	**0.02 dBm**	Occ Bw	**956.905 519 494 kHz**
T1		1	2.479 607 48 GHz	-17.35 dBm	Occ Bw Centroid	2.480 085 929 GHz
T2		1	2.480 564 38 GHz	-17.97 dBm	Occ Bw Freq Offset	85.929 346 157 kHz

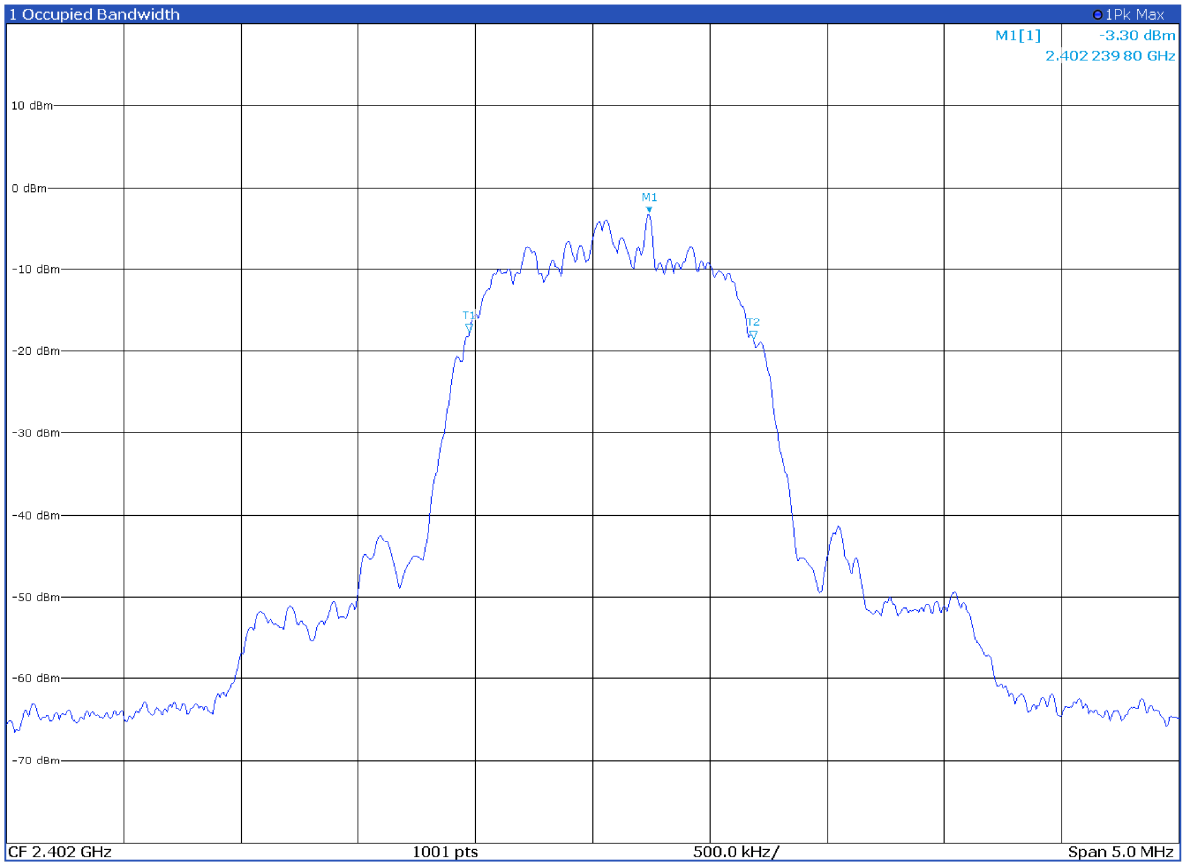


Figure 8.4-13: 99% bandwidth on low channel – modulation EDR 2DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.402 239 8 GHz**	**-3.30 dBm**	Occ Bw	**1.210 304 763 MHz**
T1		1	2.401 473 75 GHz	-17.73 dBm	Occ Bw Centroid	2.402 078 906 GHz
T2		1	2.402 684 06 GHz	-18.60 dBm	Occ Bw Freq Offset	78.906 119 242 kHz

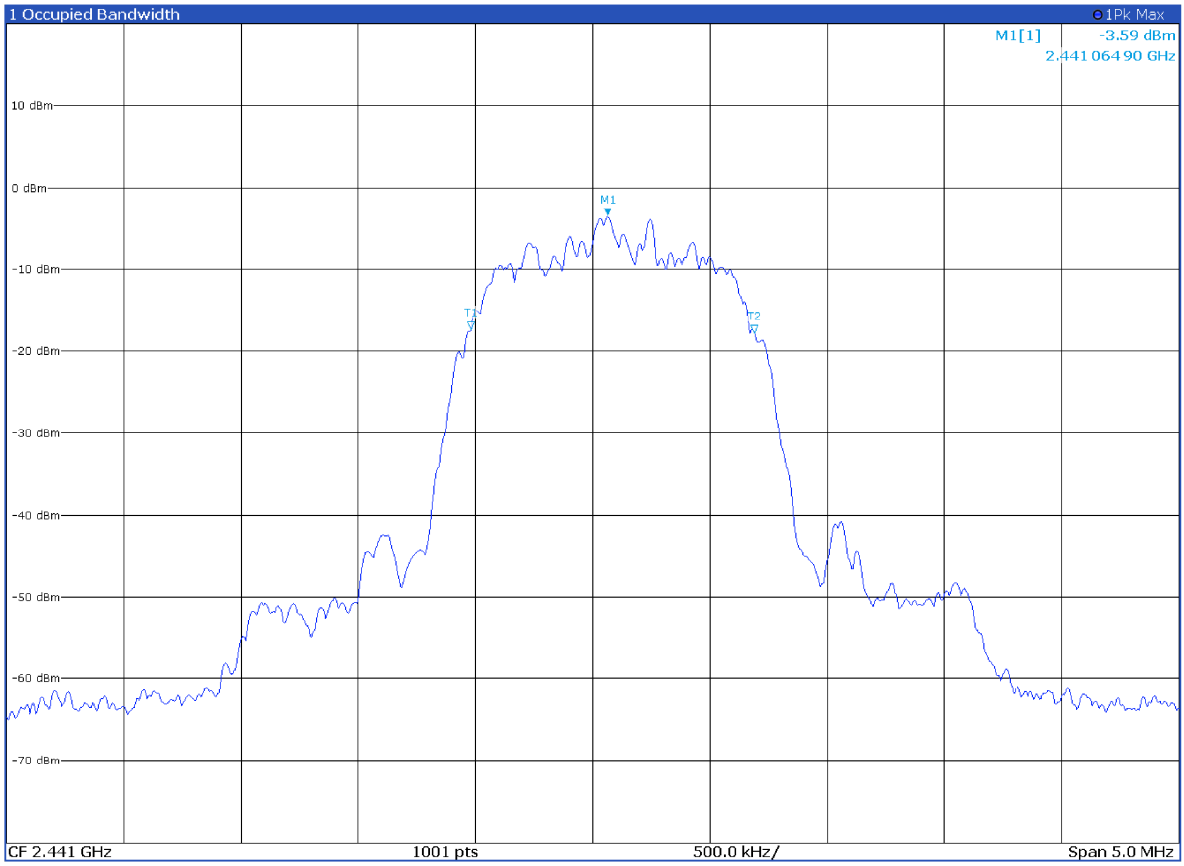


Figure 8.4-14: 99% bandwidth on mid channel – modulation EDR 2DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.441 064 9 GHz**	**-3.59 dBm**	Occ Bw	**1.211 837 736 MHz**
T1		1	2.440 478 6 GHz	-17.45 dBm	Occ Bw Centroid	2.441 084 514 GHz
T2		1	2.441 690 43 GHz	-17.83 dBm	Occ Bw Freq Offset	84.513 930 438 kHz

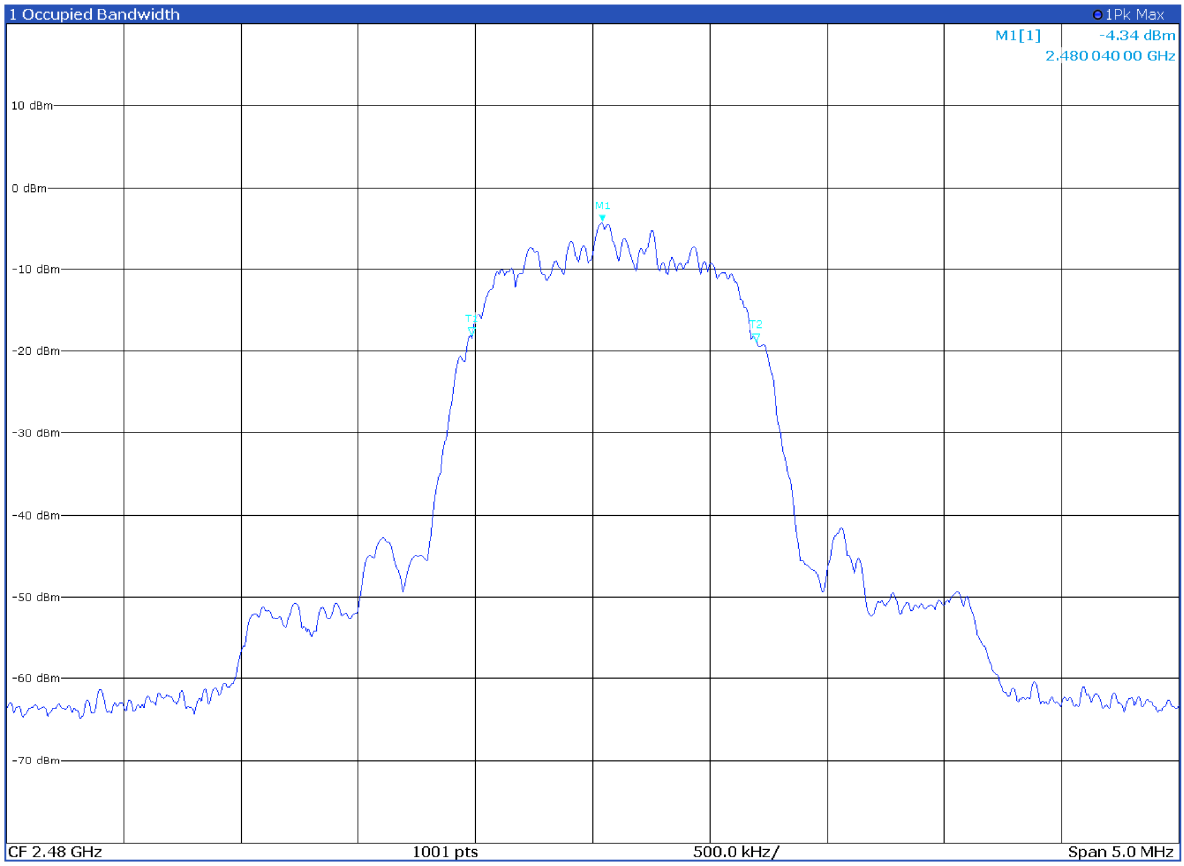


Figure 8.4-15: 99% bandwidth on high channel – modulation EDR 2DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.480 04 GHz**	**-4.34 dBm**	Occ Bw	**1.215 238 839 MHz**
T1		1	2.479 482 55 GHz	-18.12 dBm	Occ Bw Centroid	2.480 090 168 GHz
T2		1	2.480 697 79 GHz	-18.95 dBm	Occ Bw Freq Offset	90.168 313 296 kHz

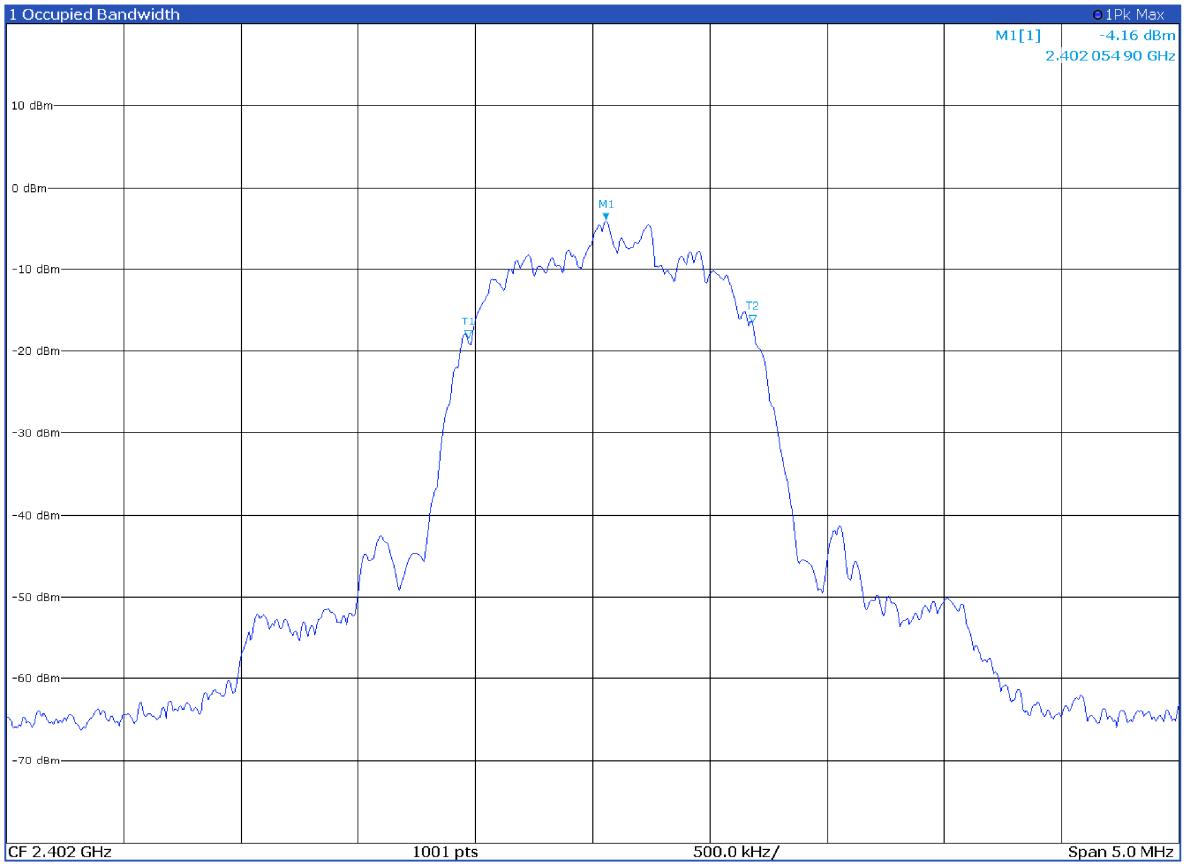


Figure 8.4-16: 99% bandwidth on low channel – modulation EDR 3DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.402 054 9 GHz**	**-4.16 dBm**	Occ Bw	**1.214 264 158 MHz**
T1		1	2.401 467 25 GHz	-18.47 dBm	Occ Bw Centroid	2.402 074 387 GHz
T2		1	2.402 681 52 GHz	-16.56 dBm	Occ Bw Freq Offset	74.387 030 283 kHz

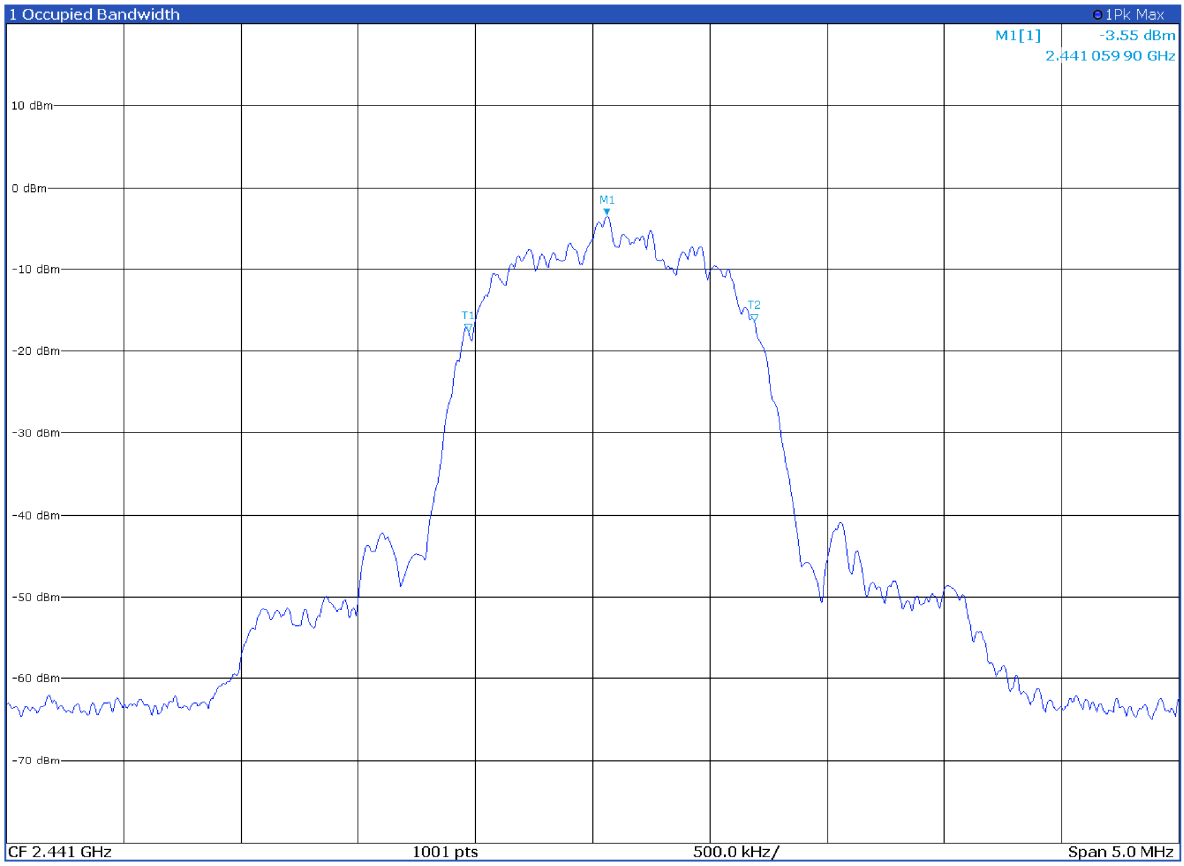


Figure 8.4-17: 99% bandwidth on mid channel – modulation EDR 3DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.441 059 9 GHz**	**-3.55 dBm**	Occ Bw	**1.219 094 019 MHz**
T1		1	2.440 470 81 GHz	-17.69 dBm	Occ Bw Centroid	2.441 080 358 GHz
T2		1	2.441 689 9 GHz	-16.40 dBm	Occ Bw Freq Offset	80.357 561 054 kHz

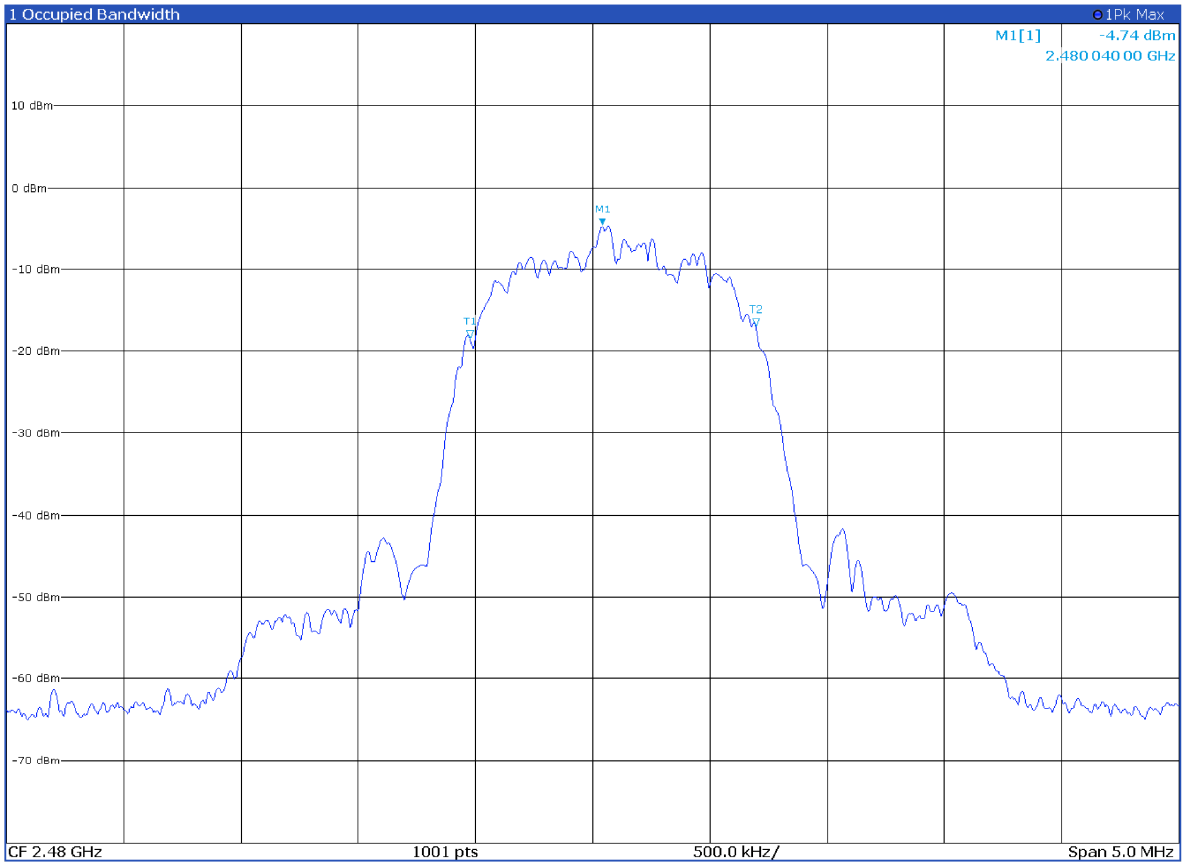


Figure 8.4-18: 99% bandwidth on high channel – modulation EDR 3DH5

2 Marker Table

Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**2.480 04 GHz**	**-4.74 dBm**	Occ Bw	**1.220 755 863 MHz**
T1		1	2.479 475 78 GHz	-18.43 dBm	Occ Bw Centroid	2.480 086 156 GHz
T2		1	2.480 696 53 GHz	-17.01 dBm	Occ Bw Freq Offset	86.155 850 475 kHz

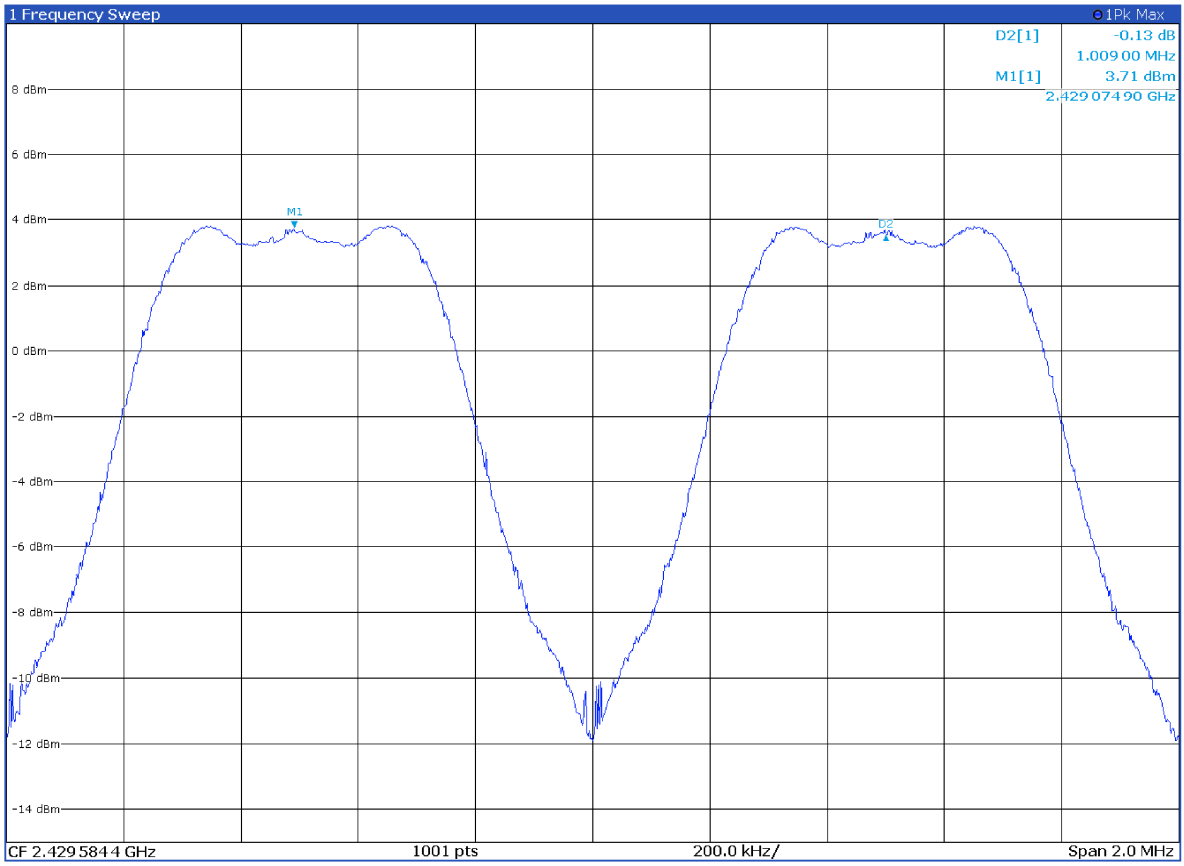


Figure 8.4-19: Carrier frequency separation

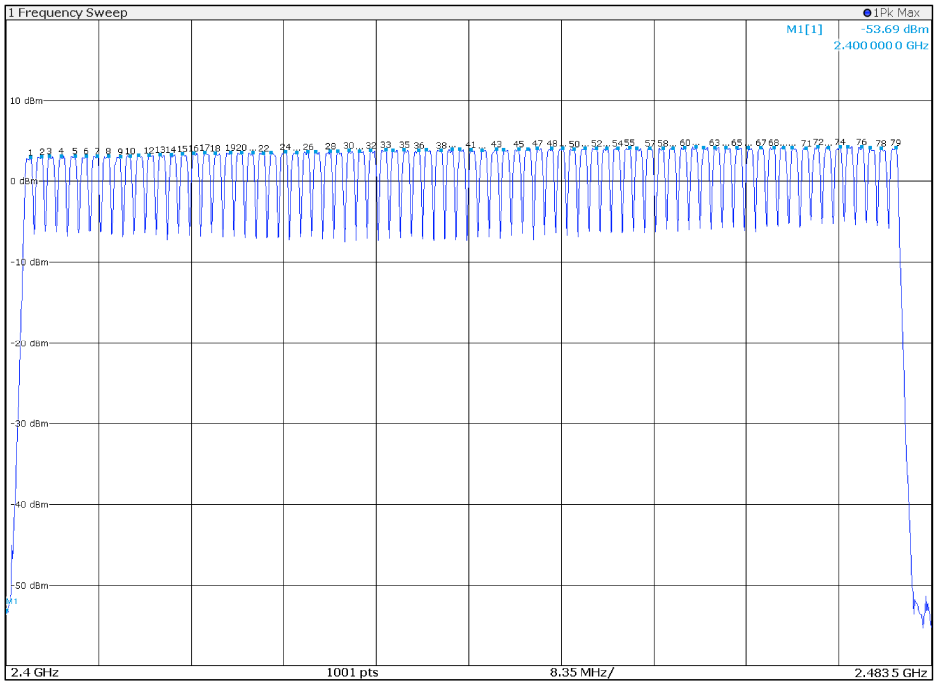


Figure 8.4-20: Number of hopping channels

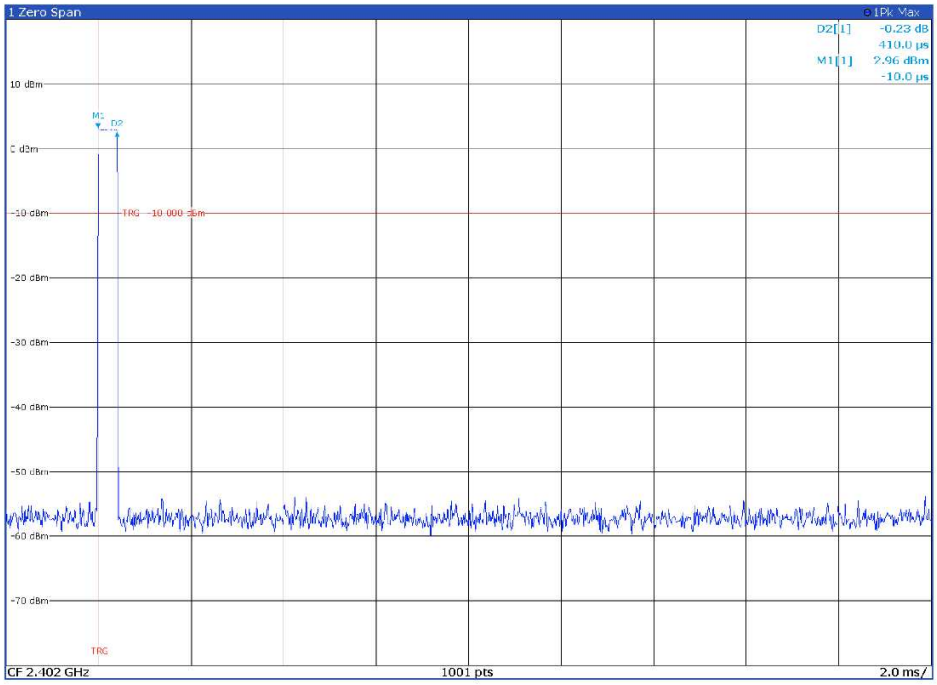


Figure 8.4-21: Dwell time for modulation DH1

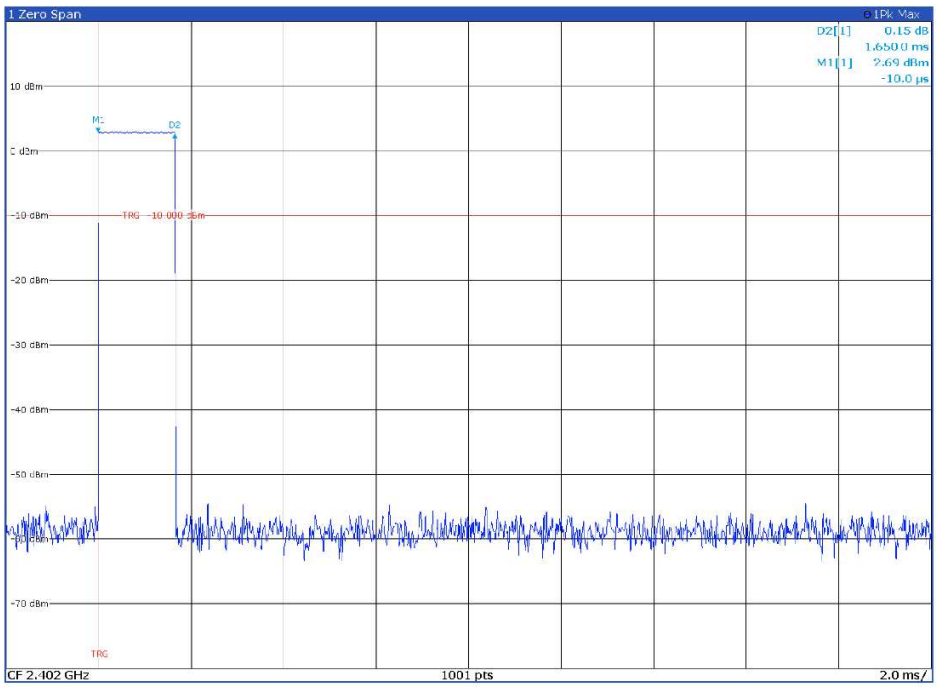


Figure 8.4-22: Dwell time for modulation DH3

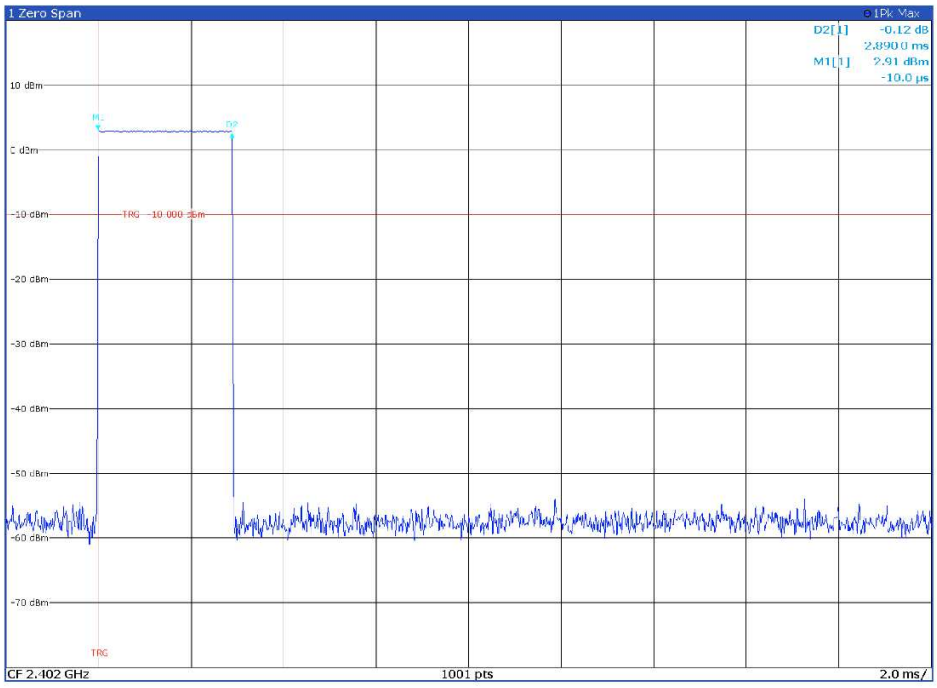


Figure 8.4-23: Dwell time for modulation DH5

8.5 Transmitter output power and e.i.r.p. requirements for FHSS 2 GHz

8.5.1 References, definitions and limits

FCC §15.247:

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(1) For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 watt (30 dBm). For all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts (21 dBm).

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

RSS-247, Clause 5.4:

Devices shall comply with the following requirements, where applicable:

b. For FHSs operating in the band 2400–2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W (30 dBm) if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W (21 dBm) if the hopset uses less than 75 hopping channels. The e.i.r.p. shall not exceed 4 W (36 dBm), except as provided in section 5.4(e).

e. Fixed point-to-point systems in the bands 2400–2483.5 MHz and 5725–5850 MHz 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.

8.5.2 Test summary

Verdict	Pass				
Tested by	P. Barbieri	Test date	March 22, 2021	Sample tested	4318570002

8.5.3 Observations, settings and special notes

Conducted output power was tested per ANSI C63.10 subclause 7.8.5. The hopping shall be disabled for this test. Spectrum analyser settings:

Resolution bandwidth	> 20 dB bandwidth of the emission being measured
Video bandwidth	≥ RBW
Frequency span	approximately 5 times the 20 dB bandwidth, centered on a hopping channel
Detector mode	Peak
Trace mode	Max Hold

8.5.4 Test equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
Spectrum Analyzer (2 Hz ÷ 43 GHz)	Rohde & Schwarz	FSW43	101767	01/2021	01/2022
Shielded room	Siemens	10m control room	1947	NCR	NCR

8.5.5 Test data

Table 8.5-1: *Output power and EIRP results for BR DH5 modulation*

Frequency, MHz	Output power, dBm	Output power limit, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
2402	2.9	30.00	-27.1	4	6.9	36.00	-29.1
2441	3.5	30.00	-26.5	4	7.5	36.00	-28.5
2480	3.0	30.00	-27.0	4	7.0	36.00	-29.0

Notes: EIRP = Output power + Antenna gain

Table 8.5-2: *Output power and EIRP results for EDR 2DH5 modulation*

Frequency, MHz	Output power, dBm	Output power limit, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
2402	1.8	30.00	-28.2	4	5.8	36.00	-30.2
2441	2.4	30.00	-27.6	4	6.4	36.00	-29.6
2480	1.8	30.00	-28.2	4	5.8	36.00	-30.2

Notes: EIRP = Output power + Antenna gain

Table 8.5-3: *Output power and EIRP results for EDR 3DH5 modulation*

Frequency, MHz	Output power, dBm	Output power limit, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
2402	2.3	30.00	-27.7	4	6.3	36.00	-29.7
2441	2.8	30.00	-27.2	4	6.8	36.00	-29.2
2480	2.2	30.00	-27.8	4	6.2	36.00	-29.8

Notes: EIRP = Output power + Antenna gain

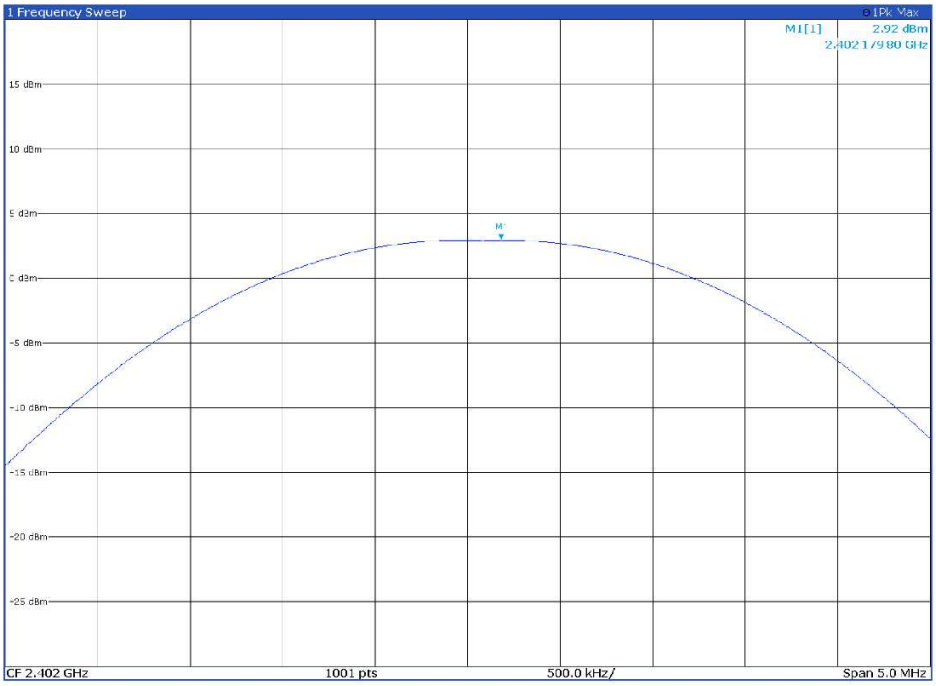


Figure 8.5-1: Output power on low channel – modulation BR DH5

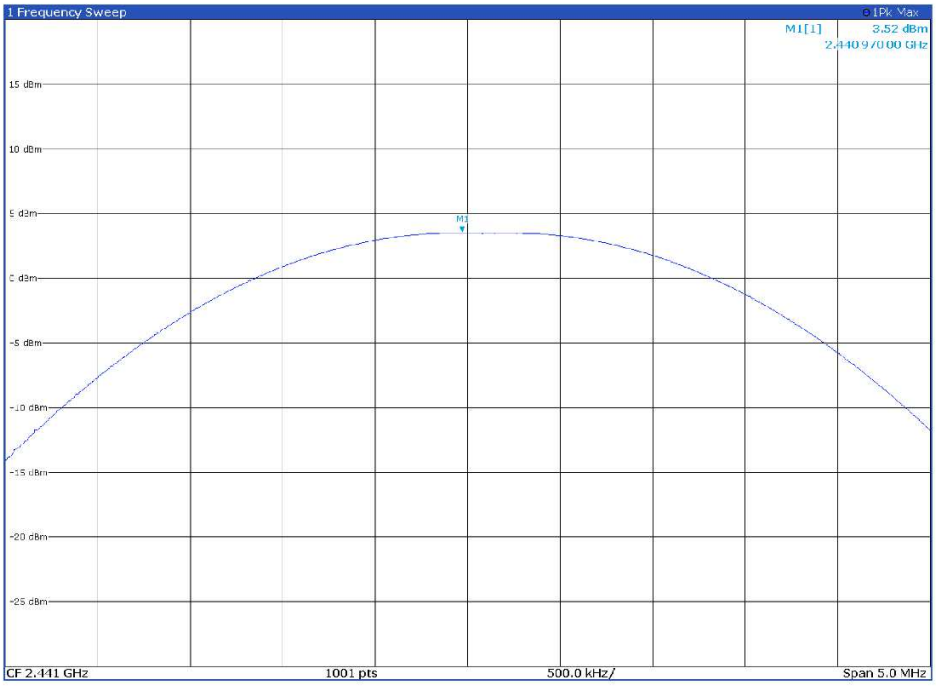


Figure 8.5-2: Output power on mid channel – modulation BR DH5

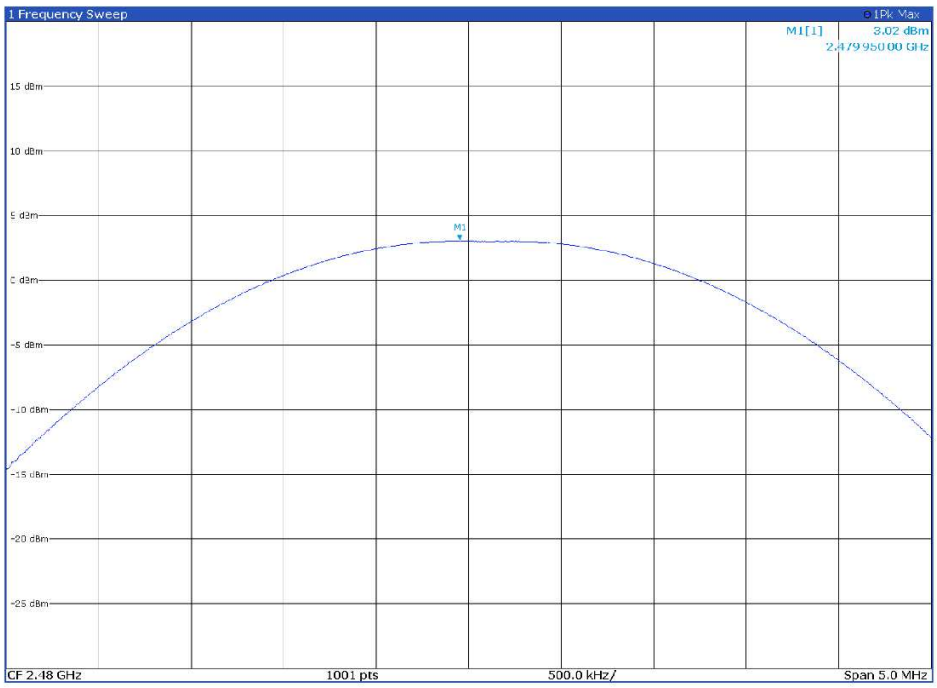


Figure 8.5-3: Output power on high channel – modulation BR DH5

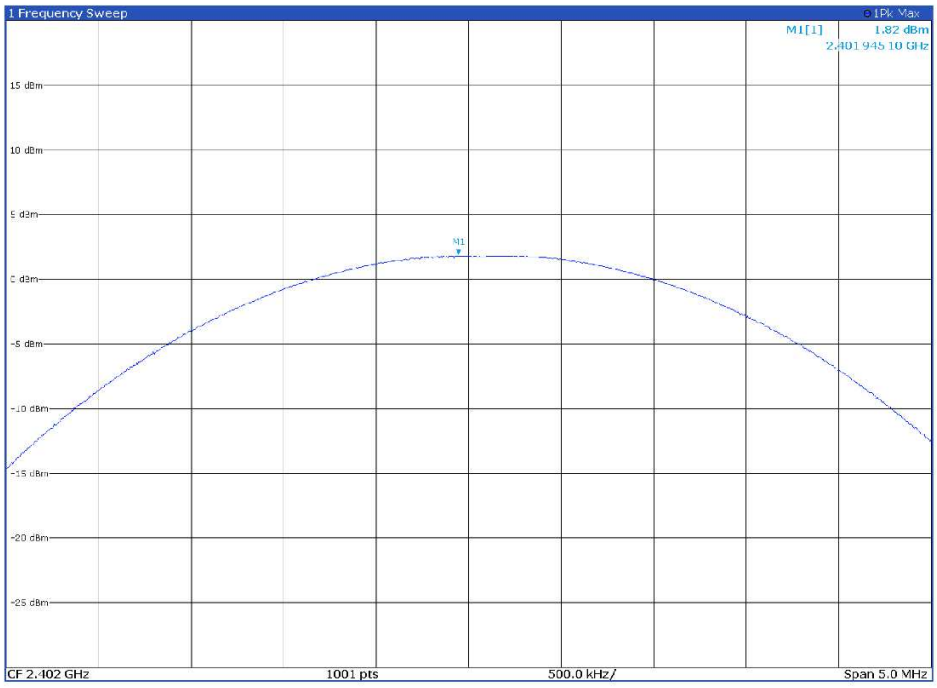


Figure 8.5-4: Output power on low channel – modulation EDR 2DH5

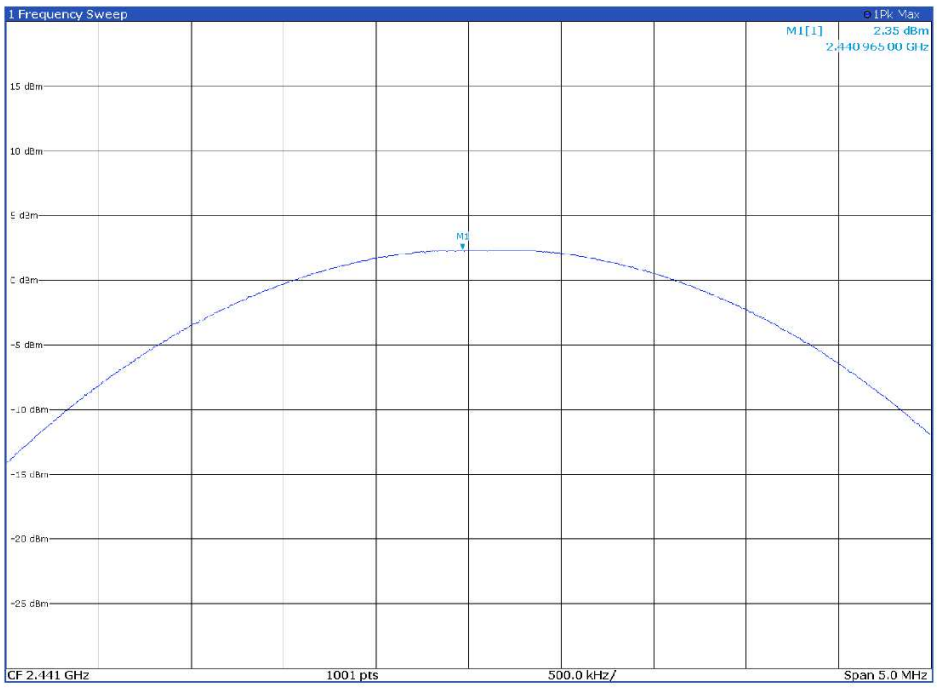


Figure 8.5-5: Output power on mid channel – modulation EDR 2DH5

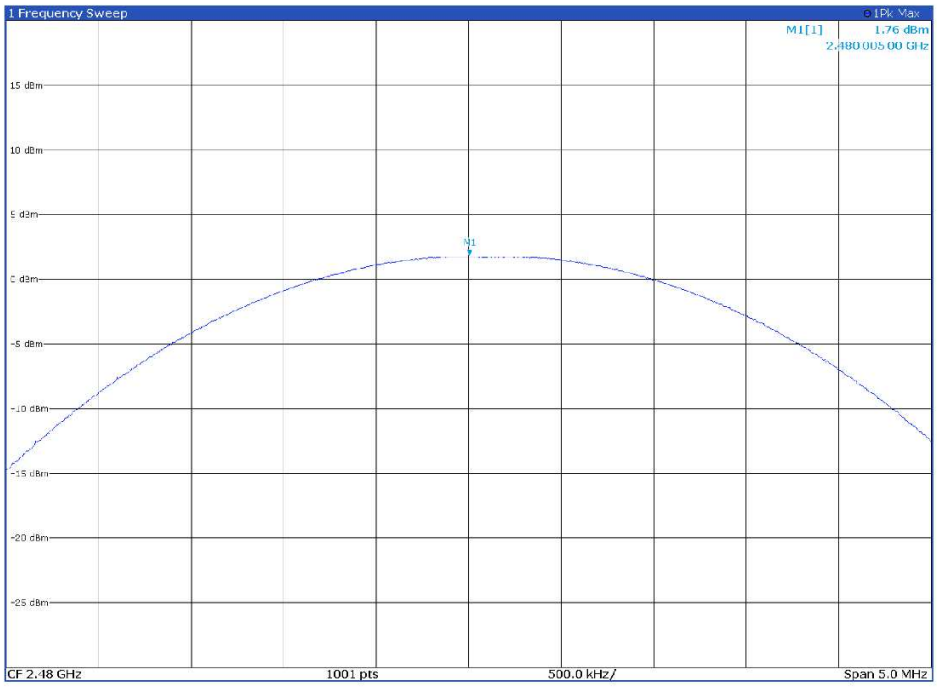


Figure 8.5-6: Output power on high channel – modulation EDR 2DH5

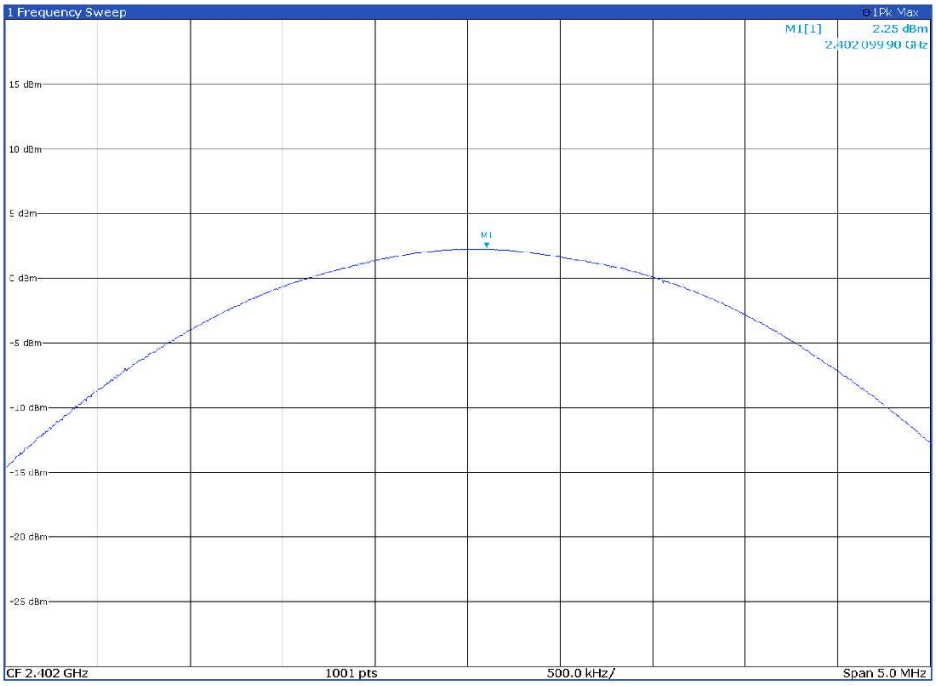


Figure 8.5-7: Output power on low channel – modulation EDR 3DH5

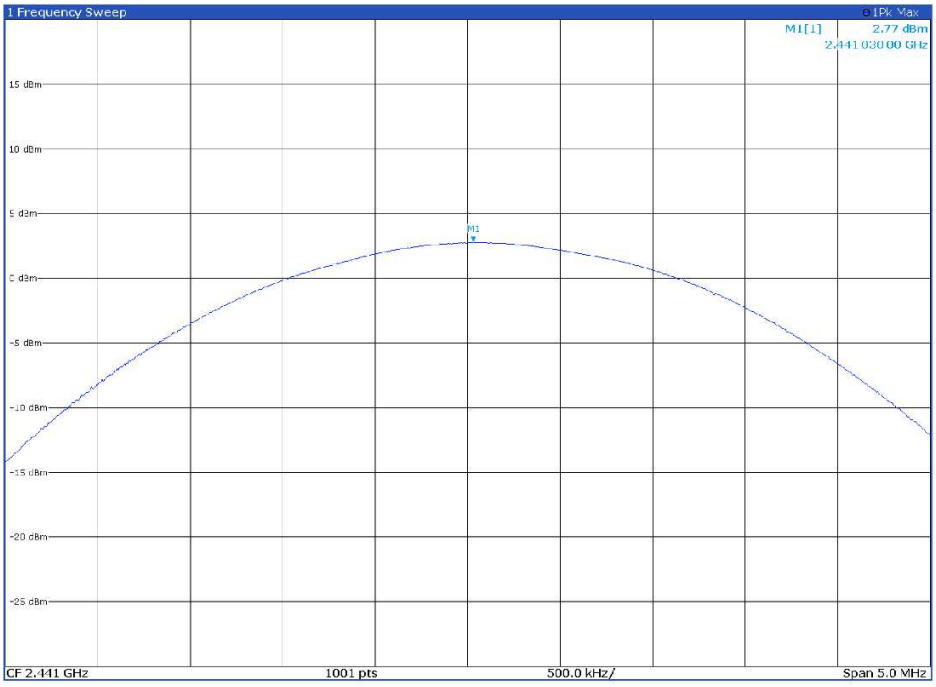


Figure 8.5-8: Output power on mid channel – modulation EDR 3DH5

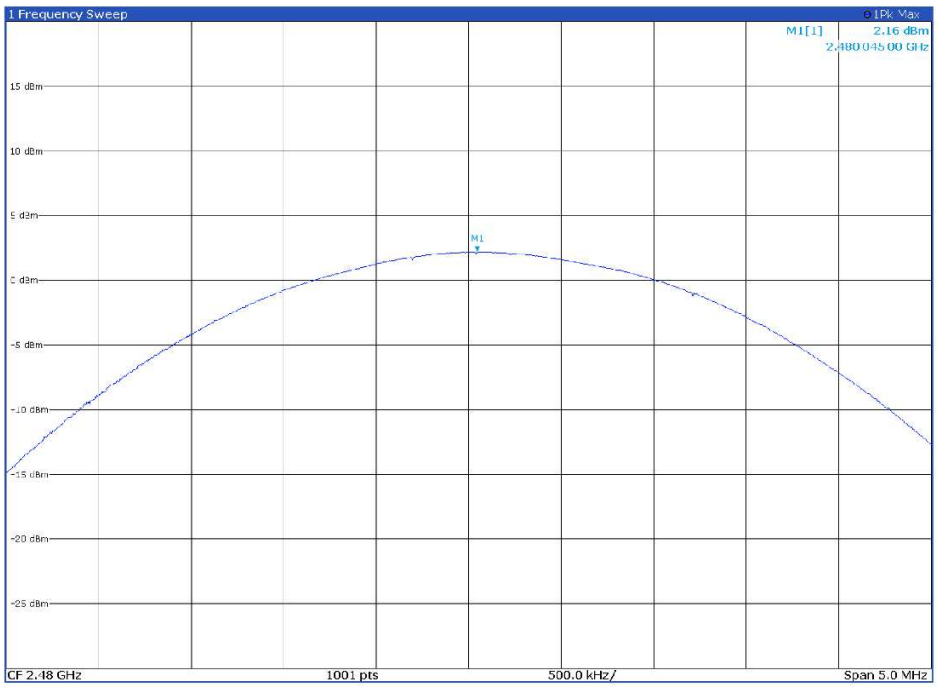


Figure 8.5-9: Output power on high channel – modulation EDR 3DH5

8.6 Spurious (out-of-band) unwanted emissions

8.6.1 References, definitions and limits

FCC §15.247:

(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

RSS-247, Clause 5.5:

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Table 8.6-1: *FCC §15.209 and RSS-Gen – Radiated emission limits*

	Field strength of emissions		
Frequency, MHz	**µV/m**	**dBµV/m**	**Measurement distance, m**
0.009–0.490	2400/F	$67.6 - 20 \times \log_{10}(F)$	300
0.490–1.705	24000/F	$87.6 - 20 \times \log_{10}(F)$	30
1.705–30.0	30	29.5	30
30–88	100	40.0	3
88–216	150	43.5	3
216–960	200	46.0	3
above 960	500	54.0	3

Notes: In the emission table above, the tighter limit applies at the band edges.
For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test.

References, definitions and limits, continued

Table 8.6-2: *ISED restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	12.57675–12.57725	399.9–410	7.25–7.75
0.495–0.505	13.36–13.41	608–614	8.025–8.5
2.1735–2.1905	16.42–16.423	960–1427	9.0–9.2
3.020–3.026	16.69475–16.69525	1435–1626.5	9.3–9.5
4.125–4.128	16.80425–16.80475	1645.5–1646.5	10.6–12.7
4.17725–4.17775	25.5–25.67	1660–1710	13.25–13.4
4.20725–4.20775	37.5–38.25	1718.8–1722.2	14.47–14.5
5.677–5.683	73–74.6	2200–2300	15.35–16.2
6.215–6.218	74.8–75.2	2310–2390	17.7–21.4
6.26775–6.26825	108–138	2483.5–2500	22.01–23.12
6.31175–6.31225	149.9–150.05	2655–2900	23.6–24.0
8.291–8.294	156.52475–156.52525	3260–3267	31.2–31.8
8.362–8.366	156.7–156.9	3332–3339	36.43–36.5
8.37625–8.38675	162.0125–167.17	3345.8–3358	
8.41425–8.41475	167.72–173.2	3500–4400	Above 38.6
12.29–12.293	240–285	4500–5150	
12.51975–12.52025	322–335.4	5350–5460	

Note: Certain frequency bands listed in Table 8.6-2 and above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to related devices are set out in the 200 and 300 series of RSSs.

Table 8.6-3: *FCC restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	Above 38.6
13.36–13.41			

8.6.2 Test summary

Verdict	Pass		
Tested by	P. Barbieri	Test date	March 17, 2021
Sample tested	4318570002 for band-edge test in non-restricted frequency bands and 4318570001 for the others		

8.6.3 Observations, settings and special notes

- As part of the current assessment, the test range of 9 kHz to 10th harmonic has been fully considered and compared to the actual frequencies utilized within the EUT. Since the EUT contains a transmitter in the GHz range, the EUT has been deemed compliant without formal testing in the 9 kHz to 30 MHz test range, therefore formal test results (tabular data and/or plots) are not provided within this test report.
- Radiated measurements were performed at a distance of 3 m.
- DTS emissions in non-restricted frequency bands test was performed as per KDB 558074, section 8.5 with reference to ANSI C63.10 subclause 11.11.
- Since fundamental power was tested using the maximum peak conducted output power procedure to demonstrate compliance, the spurious emissions limit is −20 dBc/100 kHz.
- DTS emissions in restricted frequency bands test was performed as per KDB 558074, section 8.6 with reference to ANSI C63.10 subclause 11.12.
- DTS band-edge emission measurements test was performed as per KDB 558074, section 8.7 with reference to ANSI C63.10 subclause 11.13.

Spectrum analyser settings for radiated measurements within restricted bands below 1 GHz:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for peak radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for average radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	10 Hz
Detector mode:	Peak
Trace mode:	Max Hold

8.6.4 Test equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
EMI receiver (20 Hz ÷ 8 GHz)	Rohde & Schwarz	ESU8	100202	08/2020	08/2021
EMI receiver (2 Hz ÷ 44 GHz)	Rohde & Schwarz	ESW44	101620	09/2020	09/2021
Spectrum Analyzer (2 Hz ÷ 43 GHz)	Rohde & Schwarz	FSW43	101767	01/2021	01/2022
Trilog Antenna (30 MHz ÷ 7 GHz)	Schwarzbeck	VULB 9162	9162-025	07/2018	07/2021
Bilog antenna (1 ÷ 18 GHz)	Schwarzbeck	STLP 9148	9148-123	07/2018	07/2021
Horn Antenna (4 ÷ 40 GHz)	RFSpin	DRH40	061106A40	04/2020	04/2023
Preamplifier (1 ÷ 18 GHz)	Schwarzbeck	BBV 9718C	00121	01/2021	01/2022
Preamplifier (18 ÷ 40 GHz)	Sage	STB-1834034030-KFKF-L1	18490-01	03/2020	03/2021
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	10m semi-anechoic chamber	530	09/2019	09/2021
Shielded room	Siemens	10m control room	1947	NCR	NCR

8.6.5 Test data for BR DH5 modulation

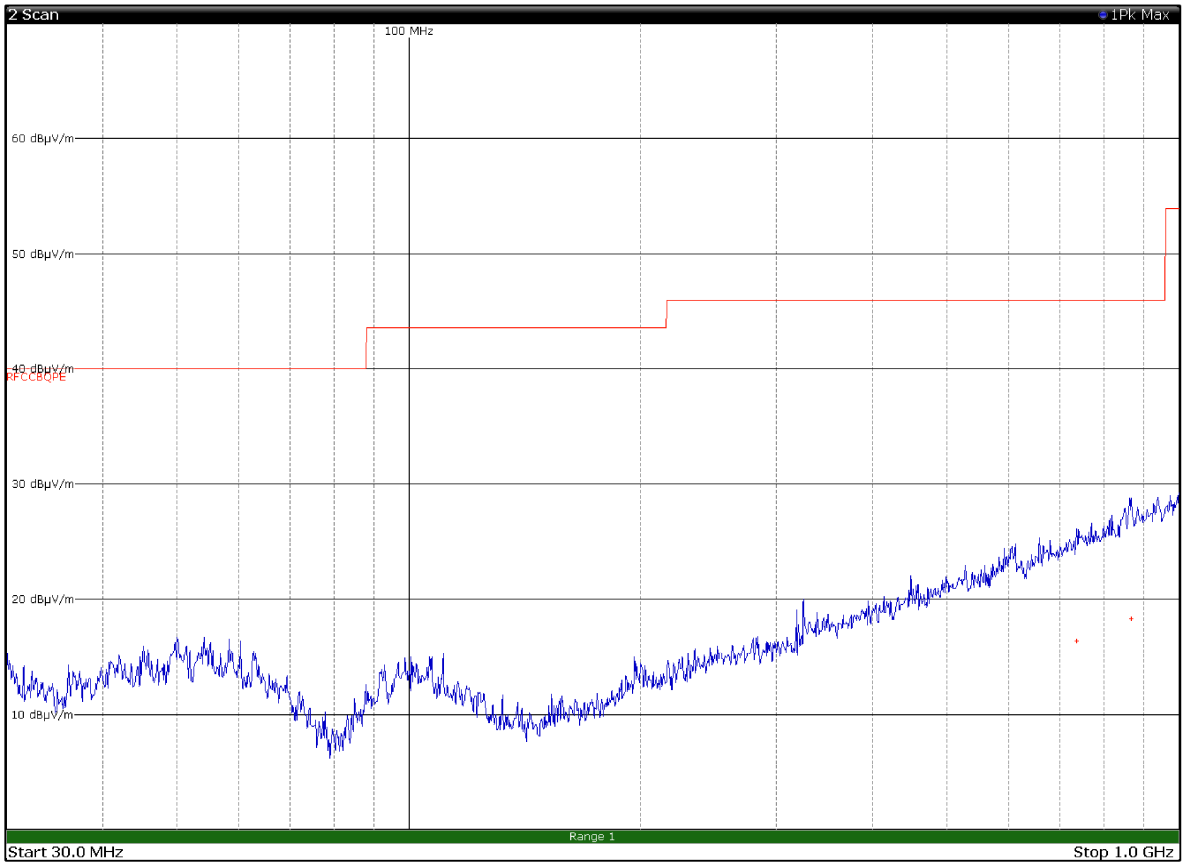


Figure 8.6-1: Radiated spurious emissions on low channel with antenna in horizontal polarization – EUT in horizontal position

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
736.0200	16.5	46.0	-29.5	QP
866.4600	18.4	46.0	-27.6	QP
Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.				

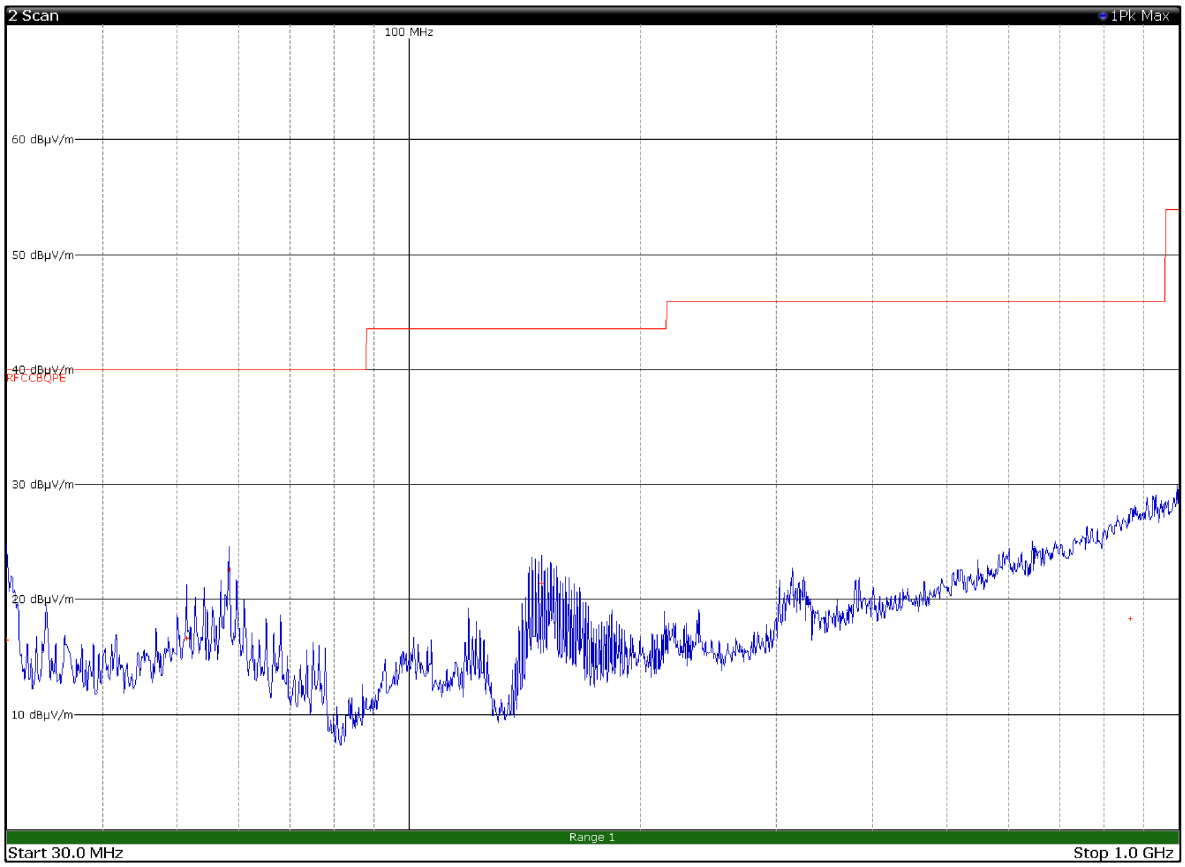
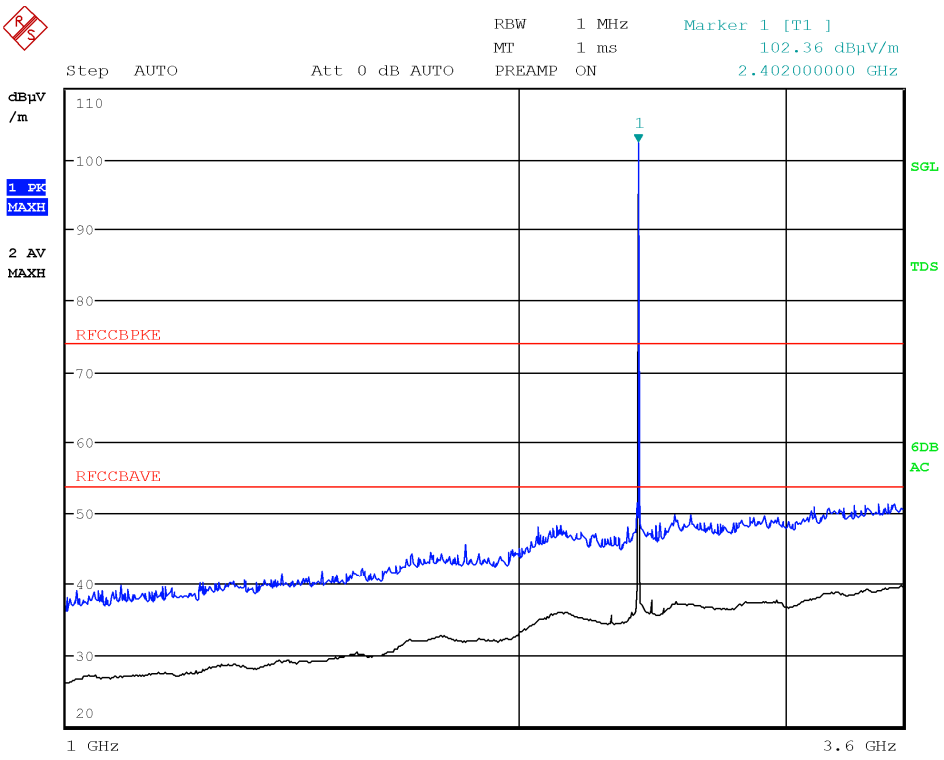


Figure 8.6-2: Radiated spurious emissions on low channel with antenna in vertical polarization – EUT in horizontal position

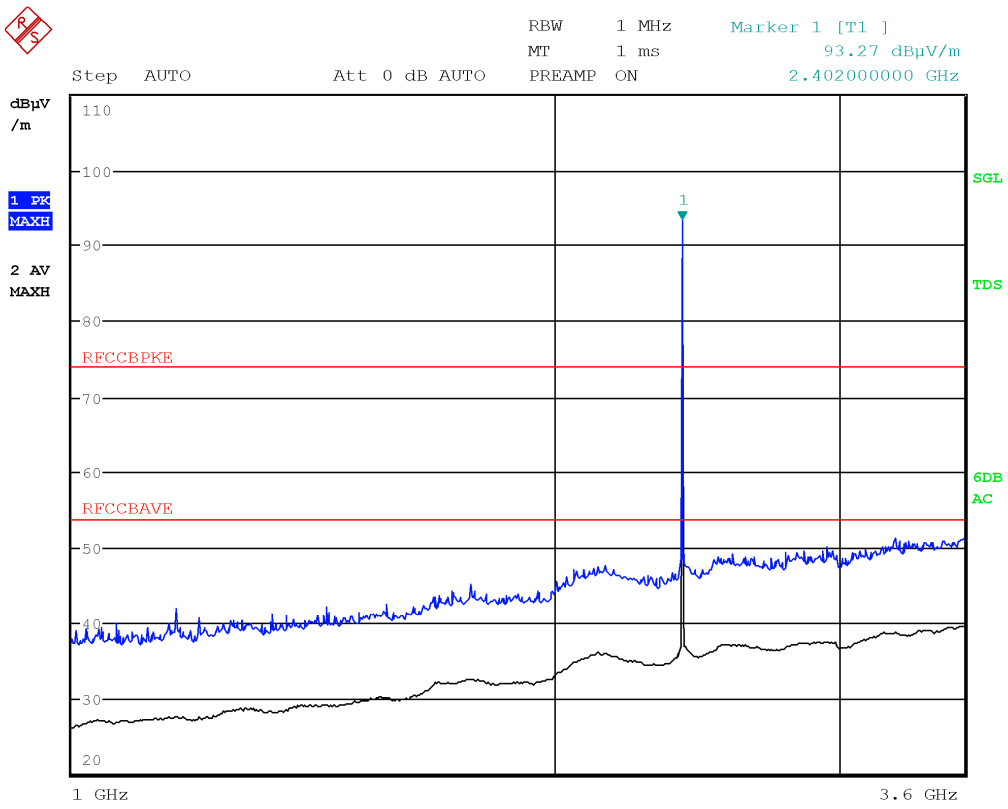
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
30.0000	16.6	40.0	-23.4	QP
51.3900	16.7	40.0	-23.3	QP
58.3500	22.6	40.0	-17.4	QP
148.6200	21.4	43.5	-22.1	QP
865.2000	18.4	46.0	-27.6	QP
Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.				



Peak level under the average limit – no additional measures need

Limit exceeded by the carrier

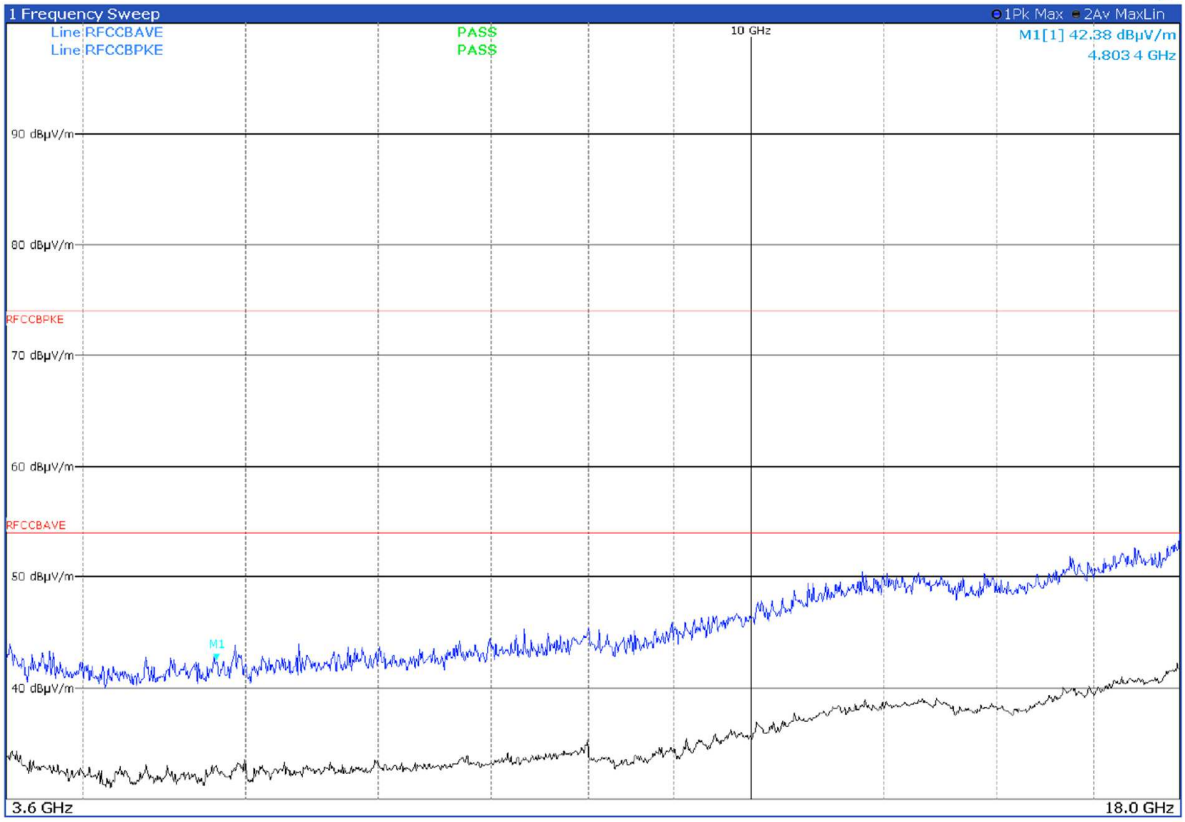
Figure 8.6-3: Radiated spurious emissions on low channel with antenna in horizontal polarization – EUT in horizontal position



Peak level under the average limit – no additional measures need

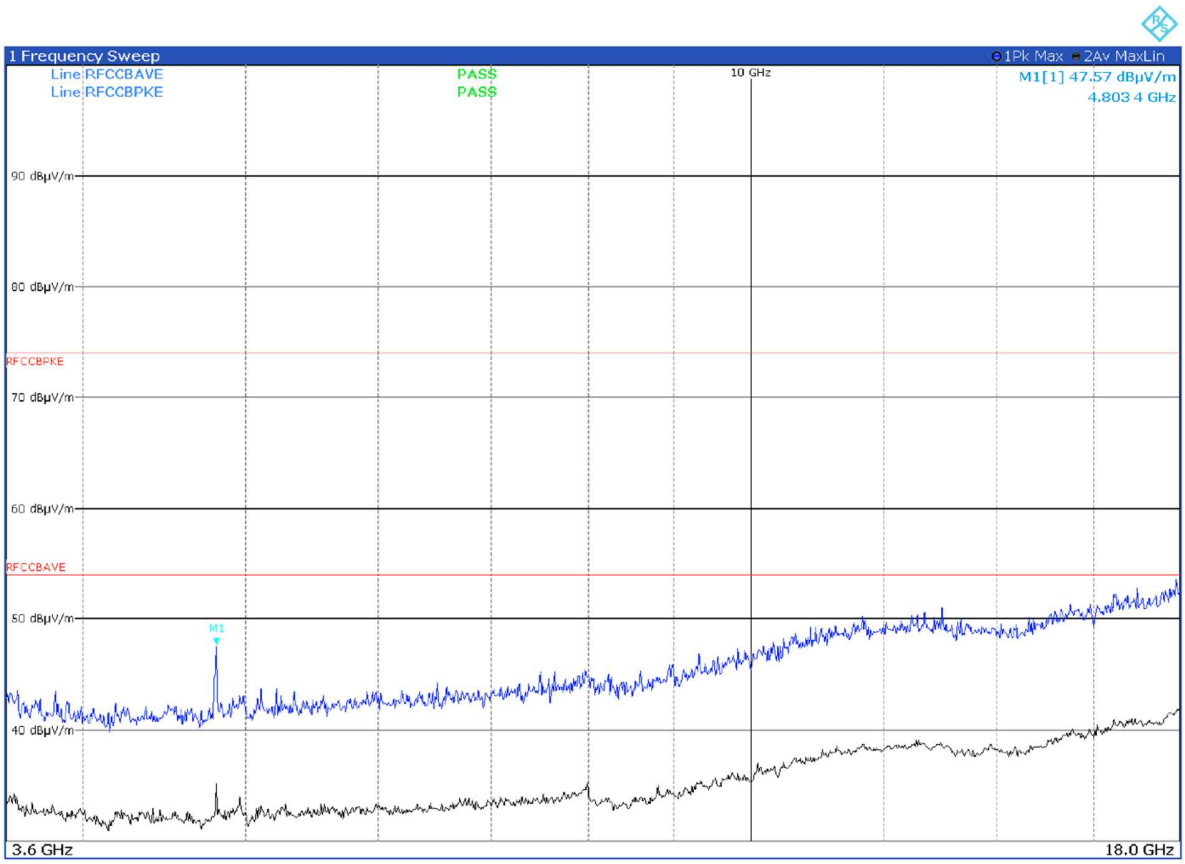
Limit exceeded by the carrier

Figure 8.6-4: Radiated spurious emissions on low channel with antenna in vertical polarization – EUT in horizontal position



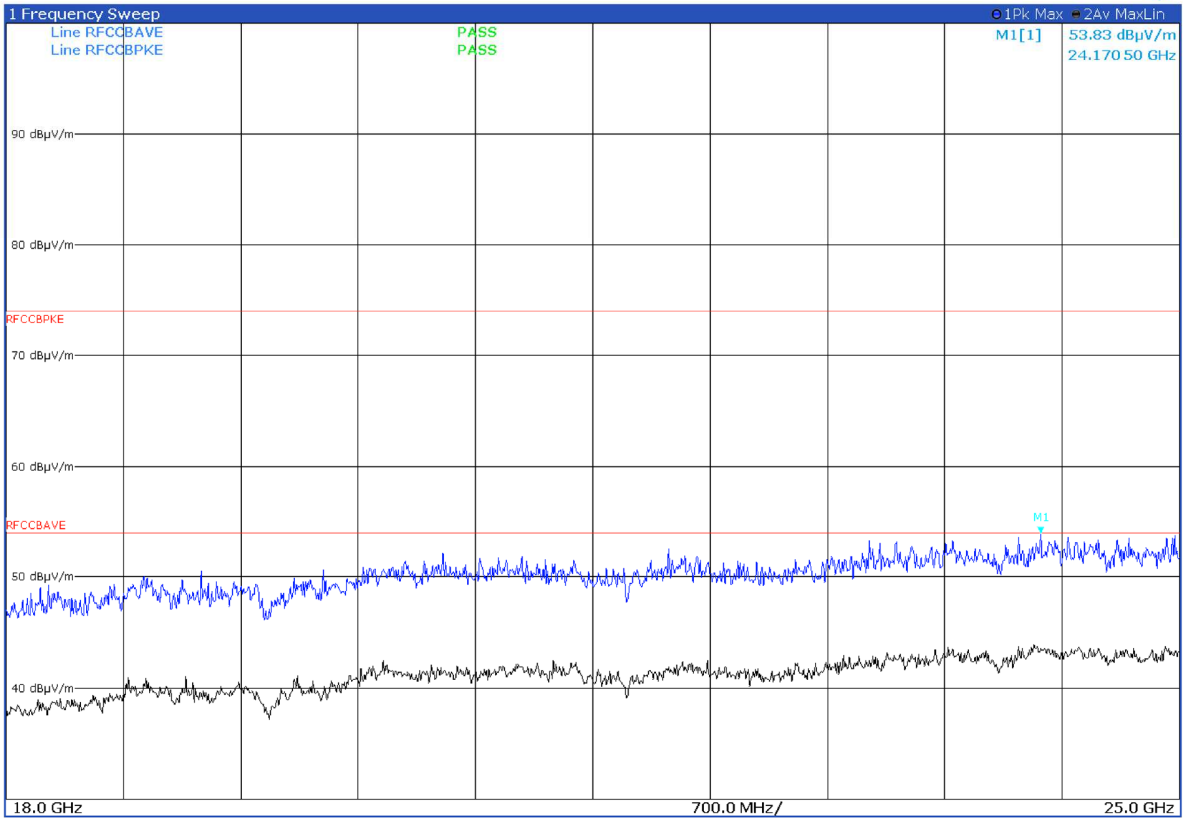
Peak level under the average limit – no additional measures need

Figure 8.6-5: Radiated spurious emissions on low channel with antenna in horizontal polarization – EUT in horizontal position



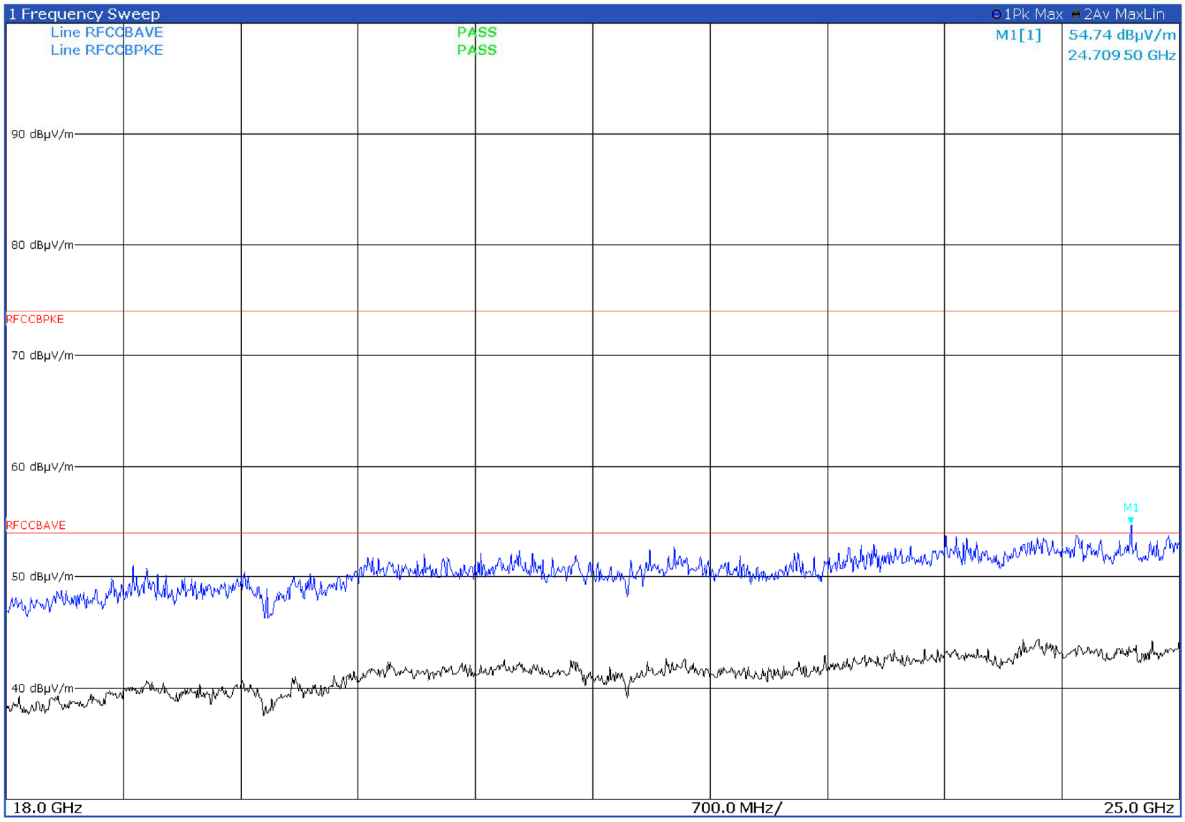
Peak level under the average limit – no additional measures need

Figure 8.6-6: Radiated spurious emissions on low channel with antenna in vertical polarization – EUT in horizontal position



Peak level under the average limit – no additional measures need

Figure 8.6-7: Radiated spurious emissions on low channel with antenna in horizontal polarization – EUT in horizontal position



Peak level under the average limit – no additional measures need

Figure 8.6-8: Radiated spurious emissions on low channel with antenna in vertical polarization – EUT in horizontal position

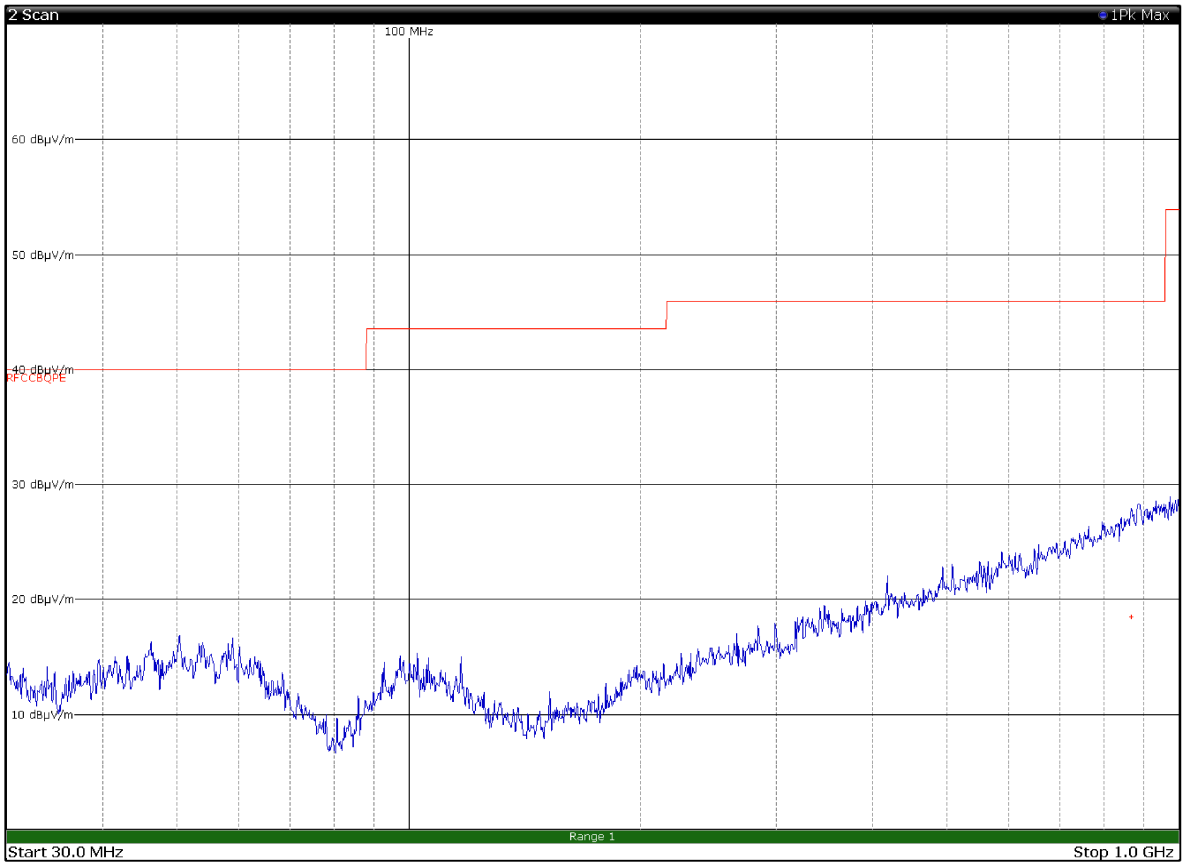


Figure 8.6-9: Radiated spurious emissions on mid channel with antenna in horizontal polarization – EUT in horizontal position

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
867.9900	18.5	46.0	-27.5	QP
Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.				

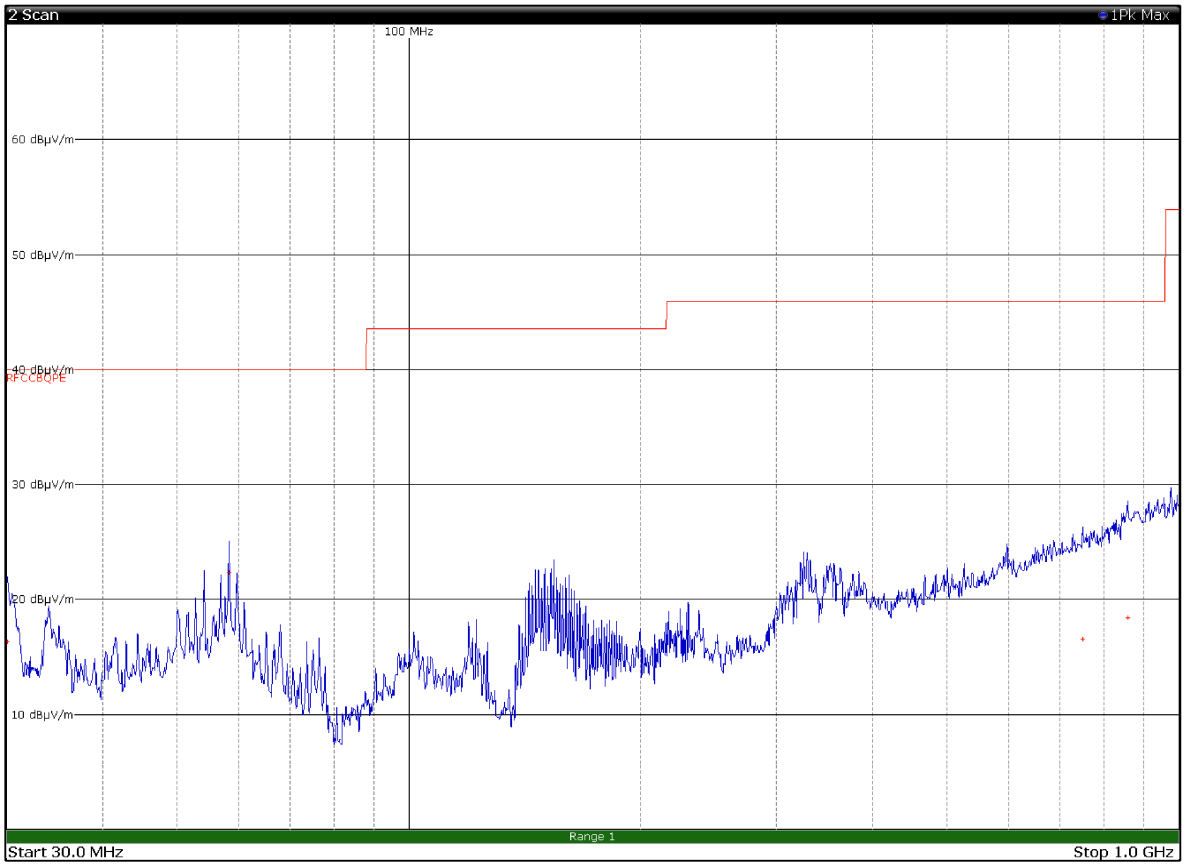
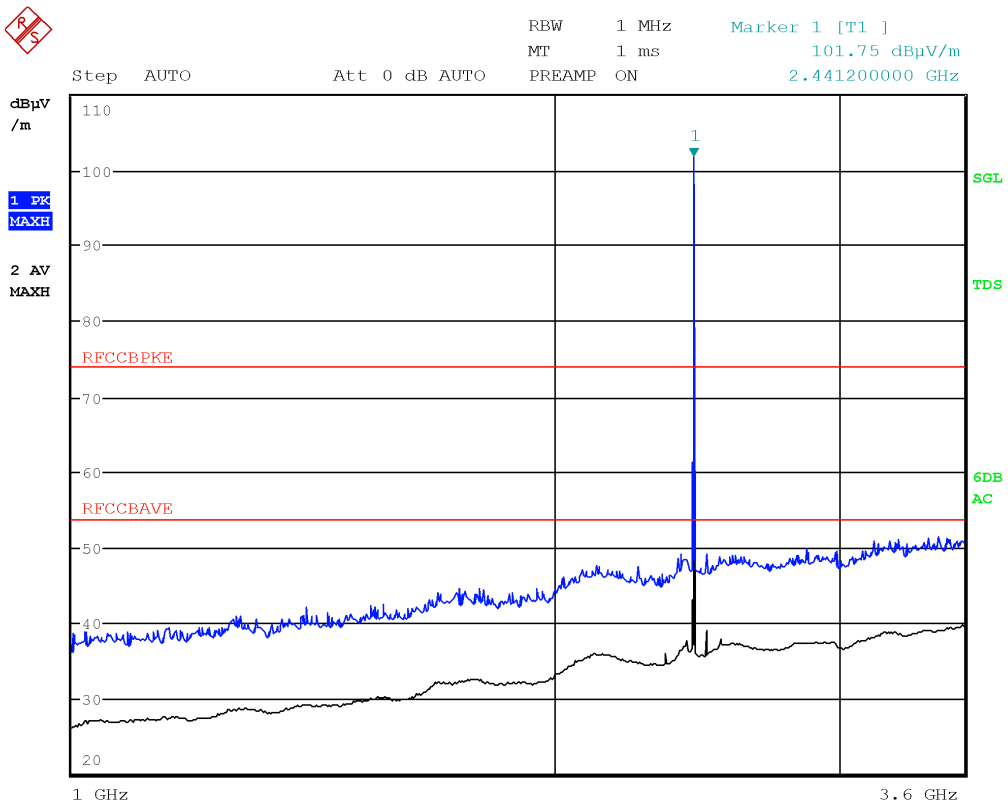


Figure 8.6-10: Radiated spurious emissions on mid channel with antenna in vertical polarization – EUT in horizontal position

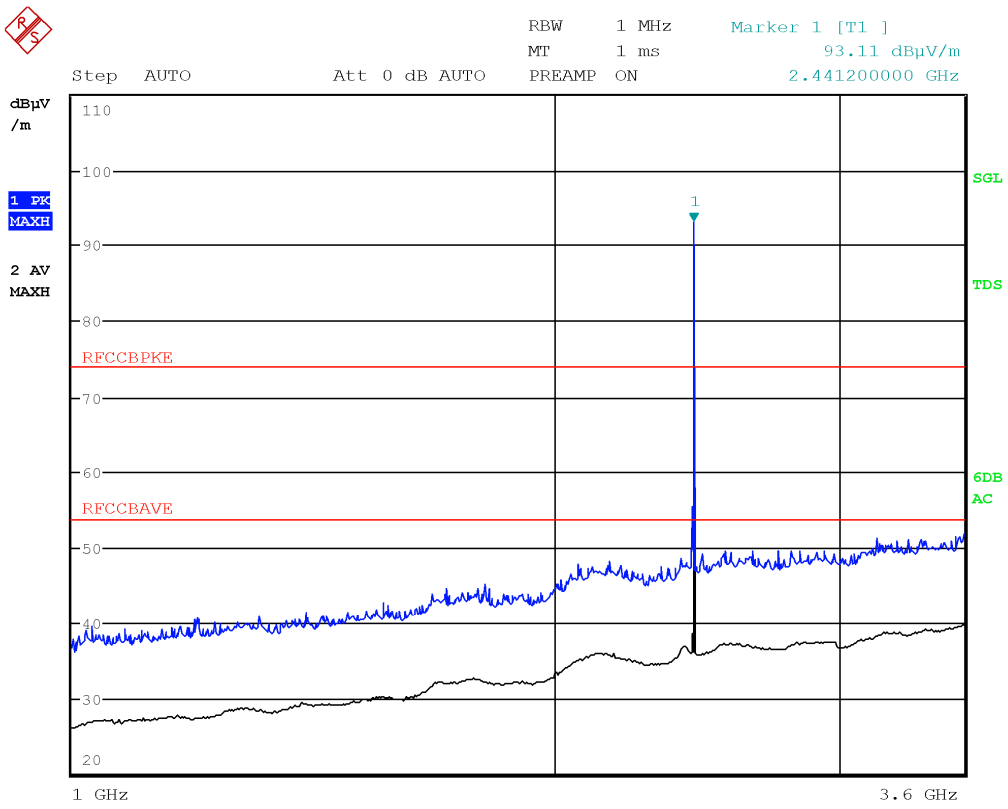
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
30.0900	16.4	40.0	-23.6	QP
58.3500	22.4	40.0	-17.6	QP
749.3700	16.6	46.0	-29.4	QP
857.9100	18.4	46.0	-27.6	QP
Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.				



Peak level under the average limit – no additional measures need

Limit exceeded by the carrier

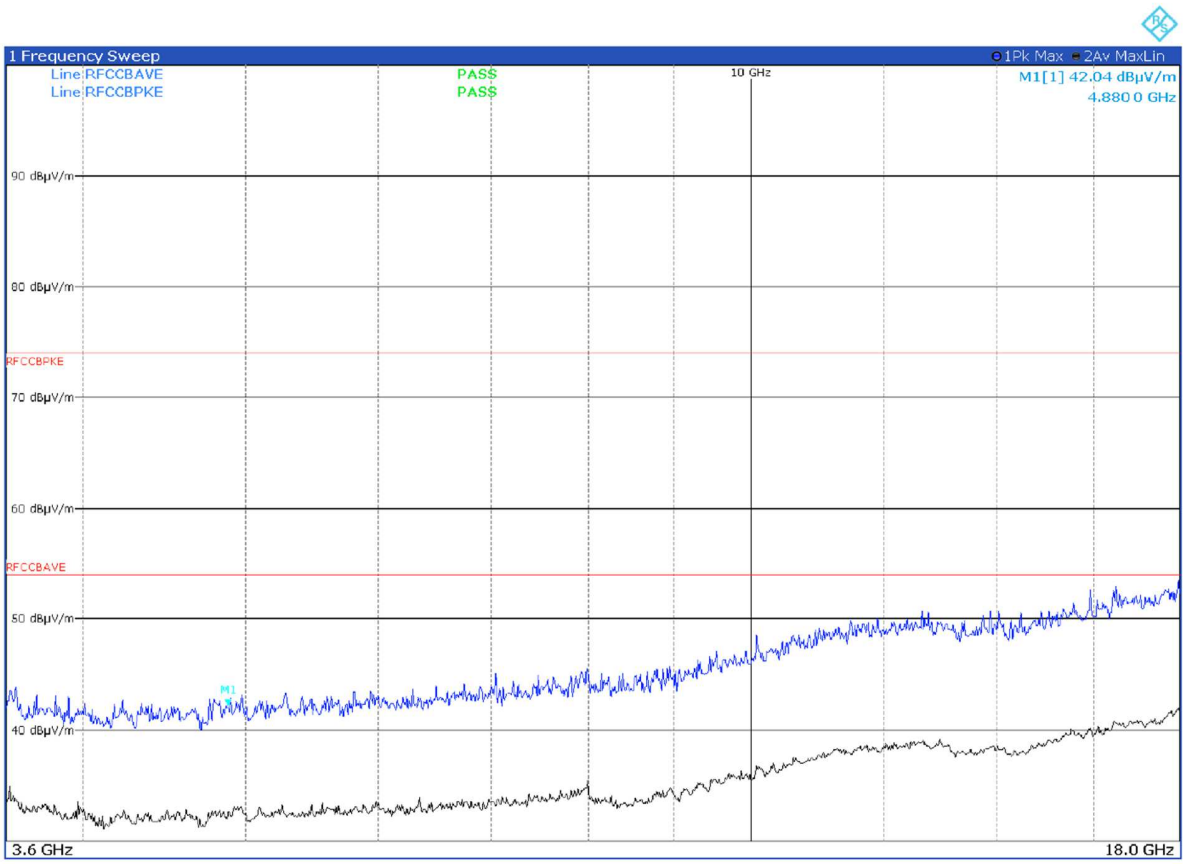
Figure 8.6-11: Radiated spurious emissions on mid channel with antenna in horizontal polarization – EUT in horizontal position



Peak level under the average limit – no additional measures need

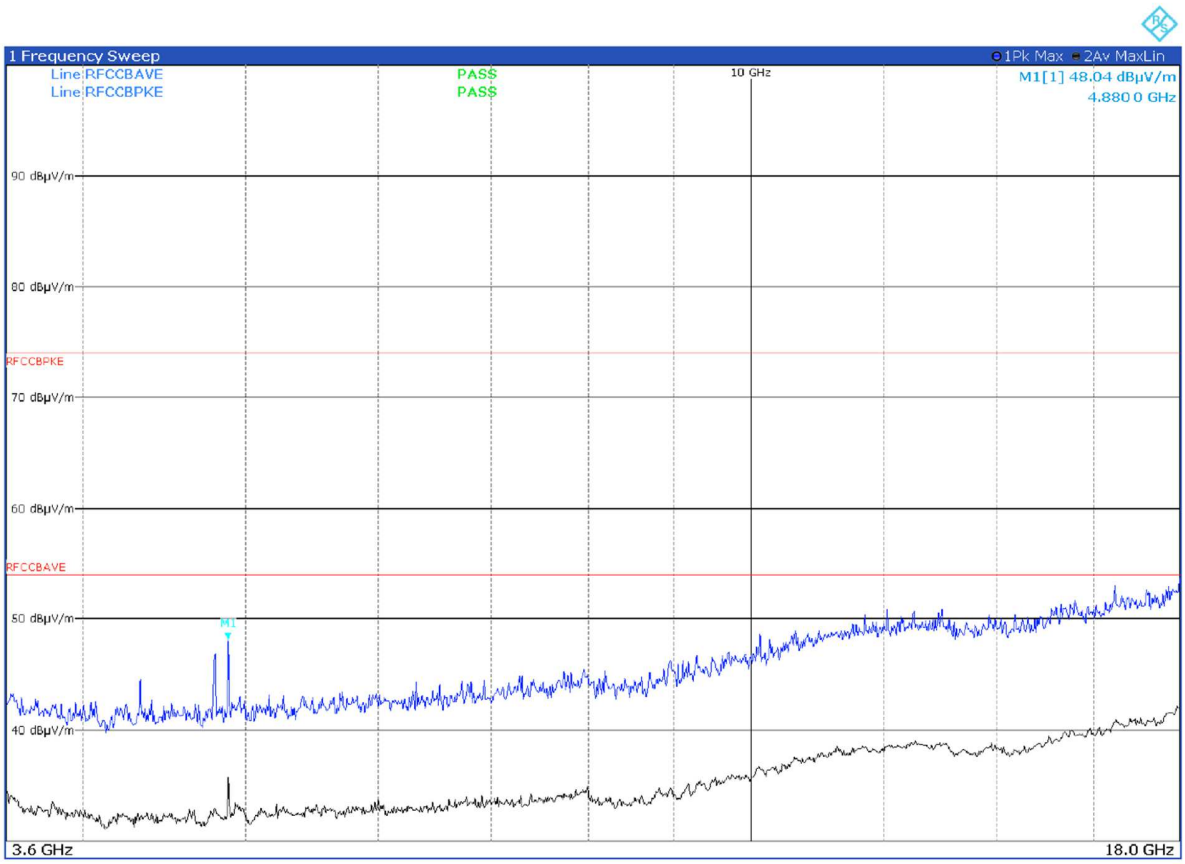
Limit exceeded by the carrier

Figure 8.6-12: Radiated spurious emissions on mid channel with antenna in vertical polarization – EUT in horizontal position



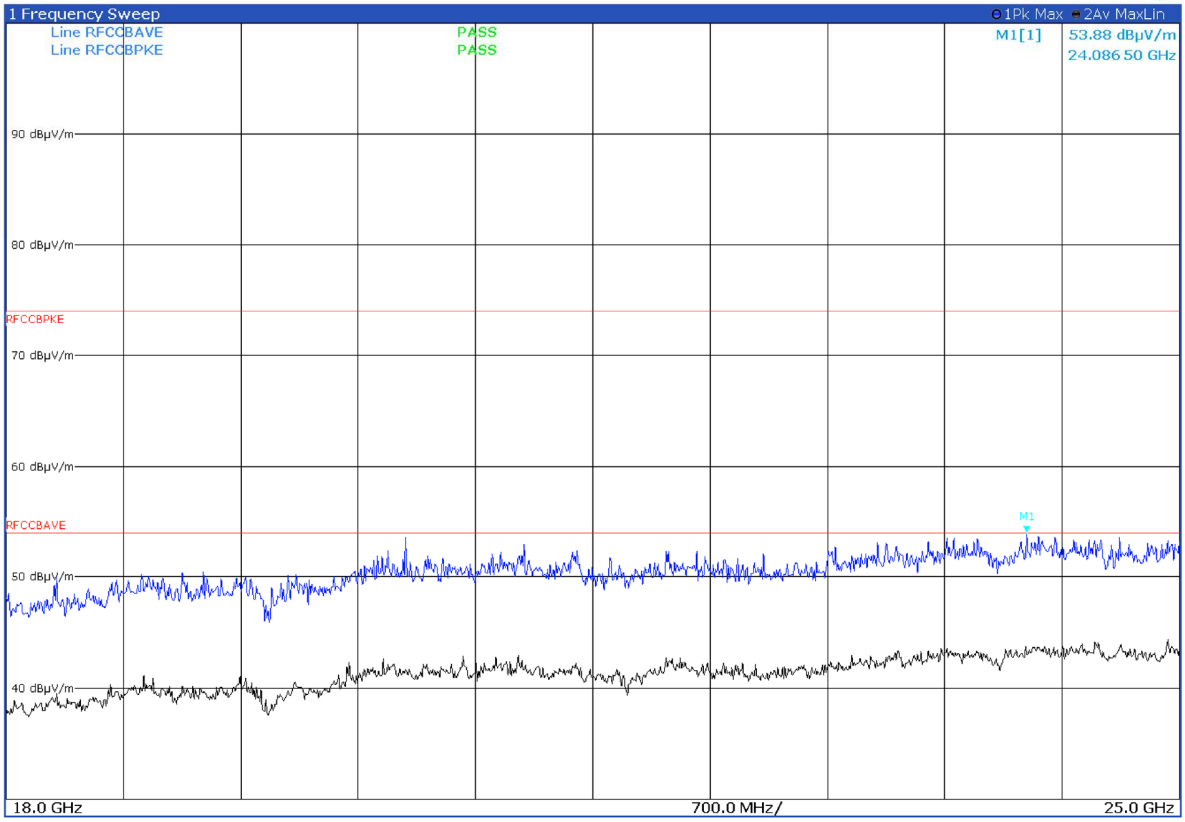
Peak level under the average limit – no additional measures need

Figure 8.6-13: Radiated spurious emissions on mid channel with antenna in horizontal polarization – EUT in horizontal position



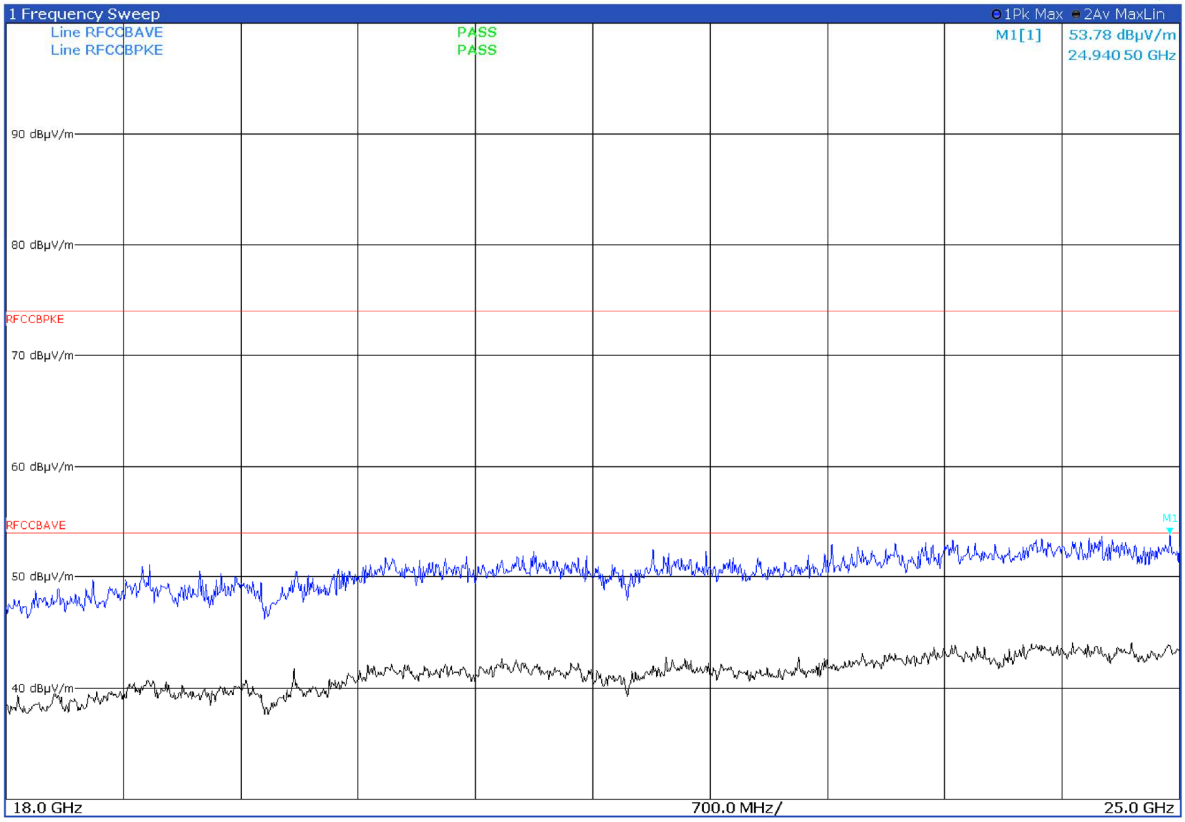
Peak level under the average limit – no additional measures need

Figure 8.6-14: Radiated spurious emissions on mid channel with antenna in vertical polarization – EUT in horizontal position



Peak level under the average limit – no additional measures need

Figure 8.6-15: Radiated spurious emissions on mid channel with antenna in horizontal polarization – EUT in horizontal position



Peak level under the average limit – no additional measures need

Figure 8.6-16: Radiated spurious emissions on mid channel with antenna in vertical polarization – EUT in horizontal position

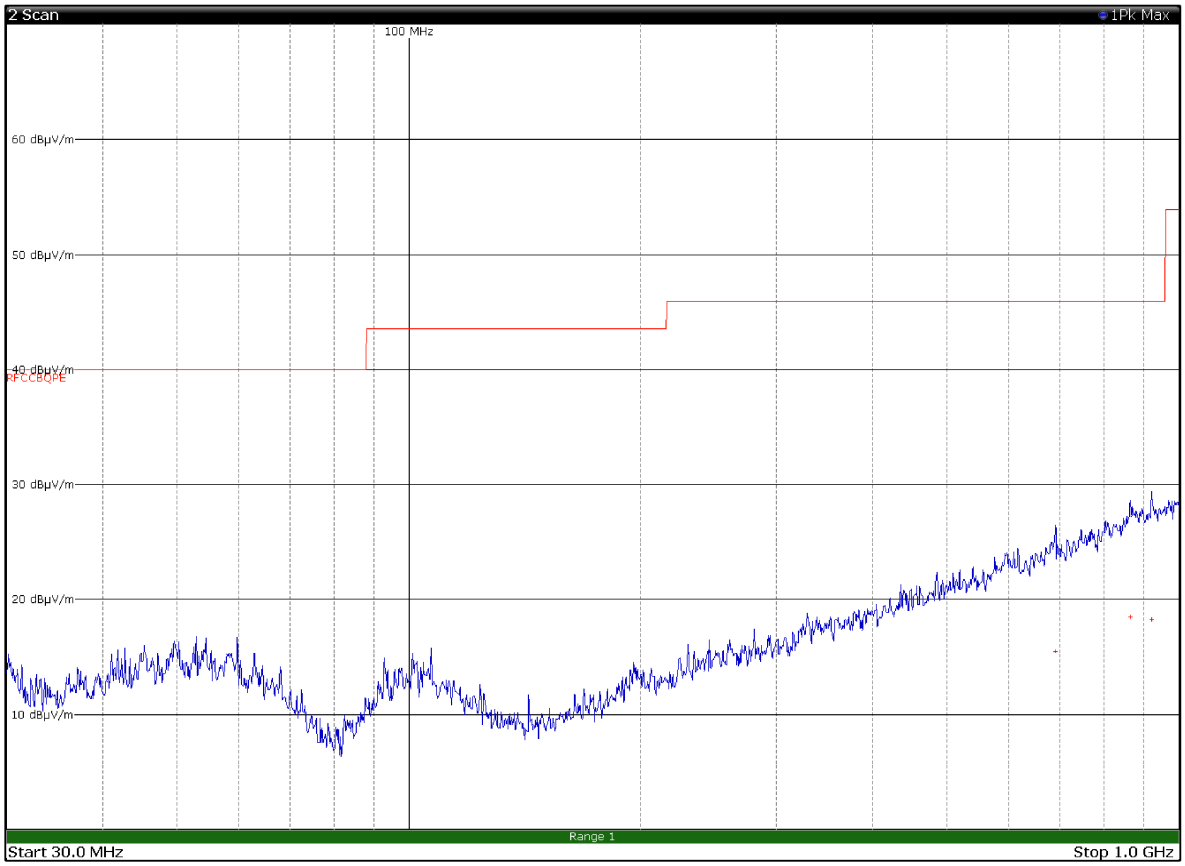


Figure 8.6-17: Radiated spurious emissions on high channel with antenna in horizontal polarization – EUT in horizontal position

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
691.7700	15.5	46.0	-30.5	QP
863.8500	18.5	46.0	-27.5	QP
920.8200	18.3	46.0	-27.7	QP
Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.				

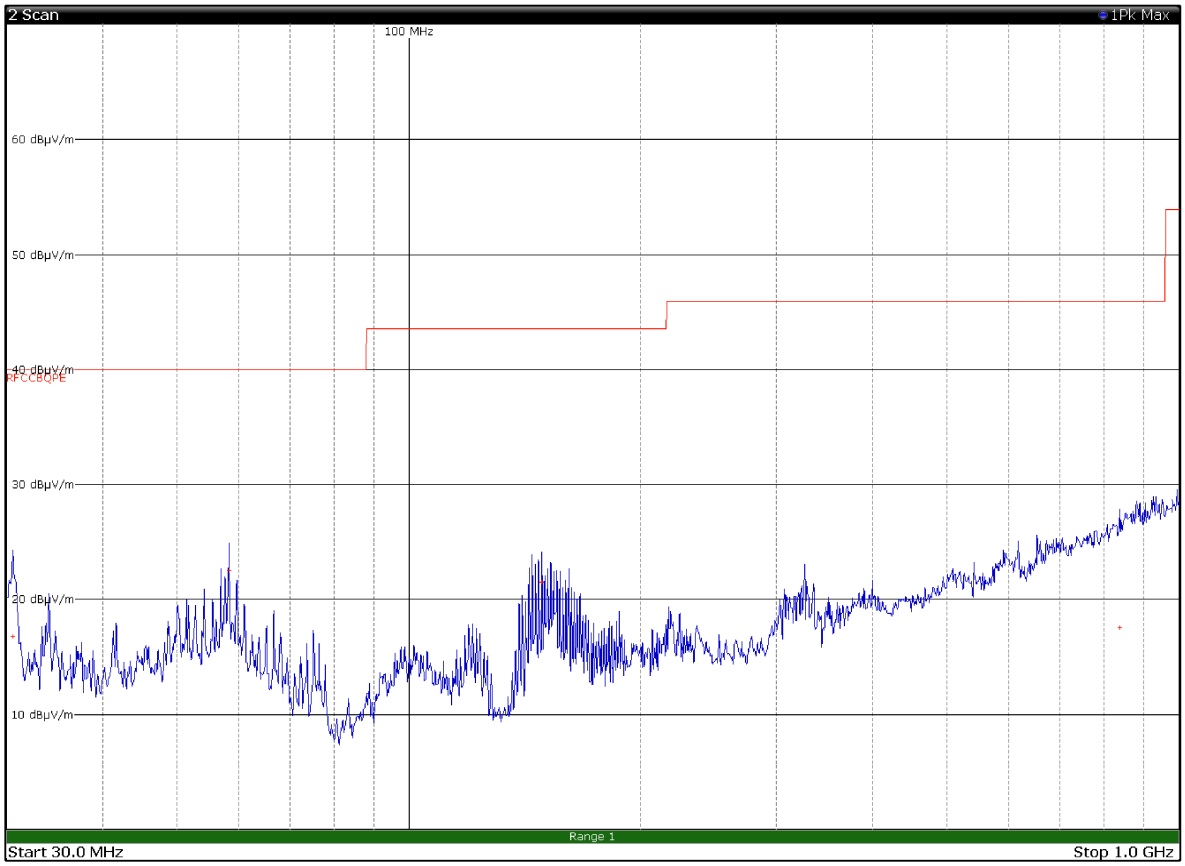
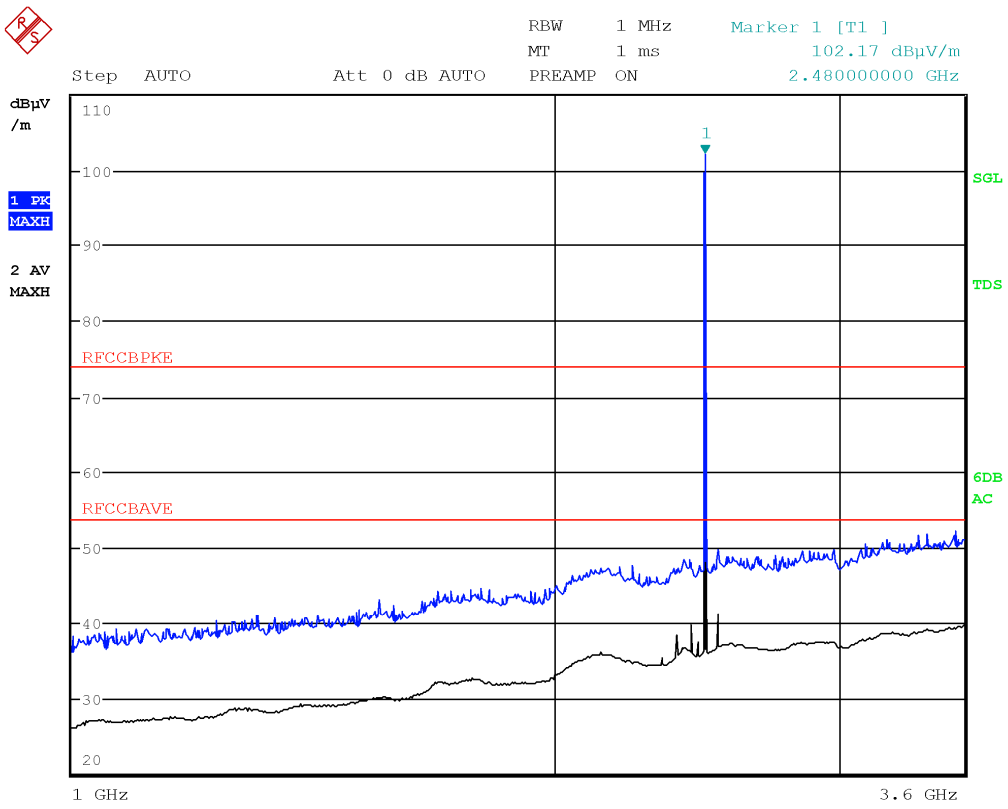


Figure 8.6-18: Radiated spurious emissions on high channel with antenna in vertical polarization – EUT in horizontal position

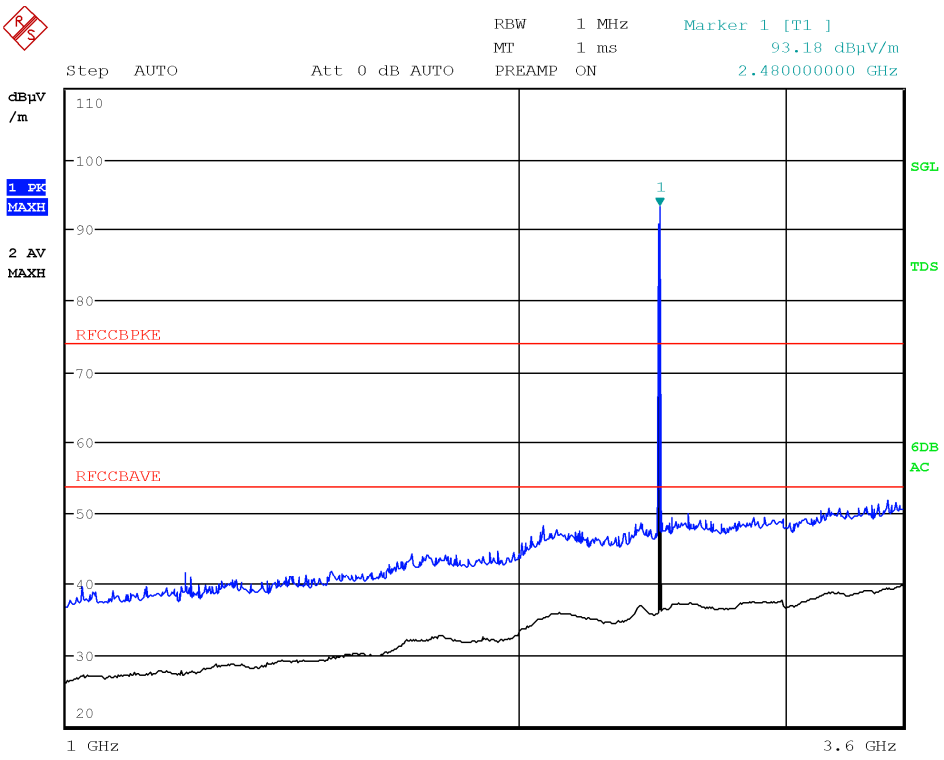
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
30.5700	16.9	40.0	-23.1	QP
58.3500	22.5	40.0	-17.5	QP
148.6200	21.6	43.5	-21.9	QP
837.7200	17.6	46.0	-28.4	QP
Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.				



Peak level under the average limit – no additional measures need

Limit exceeded by the carrier

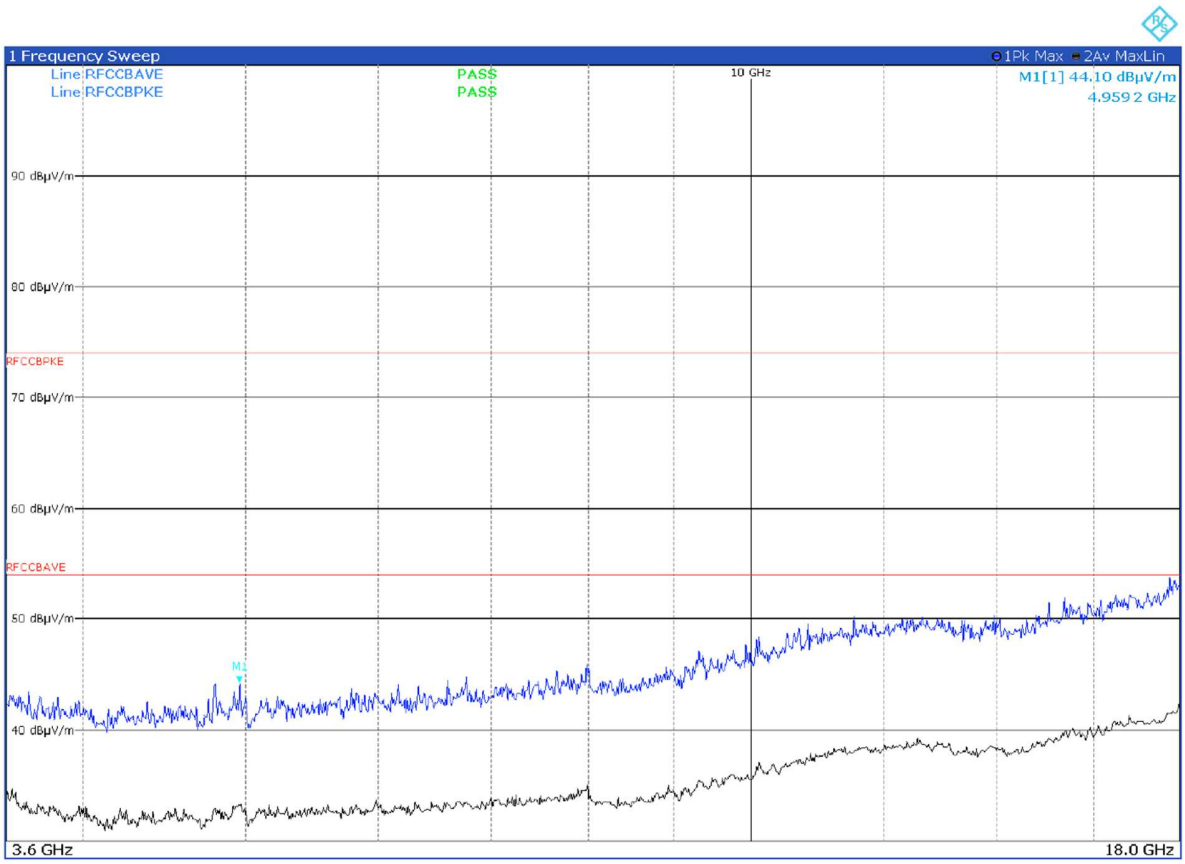
Figure 8.6-19: Radiated spurious emissions on high channel with antenna in horizontal polarization – EUT in horizontal position



Peak level under the average limit – no additional measures need

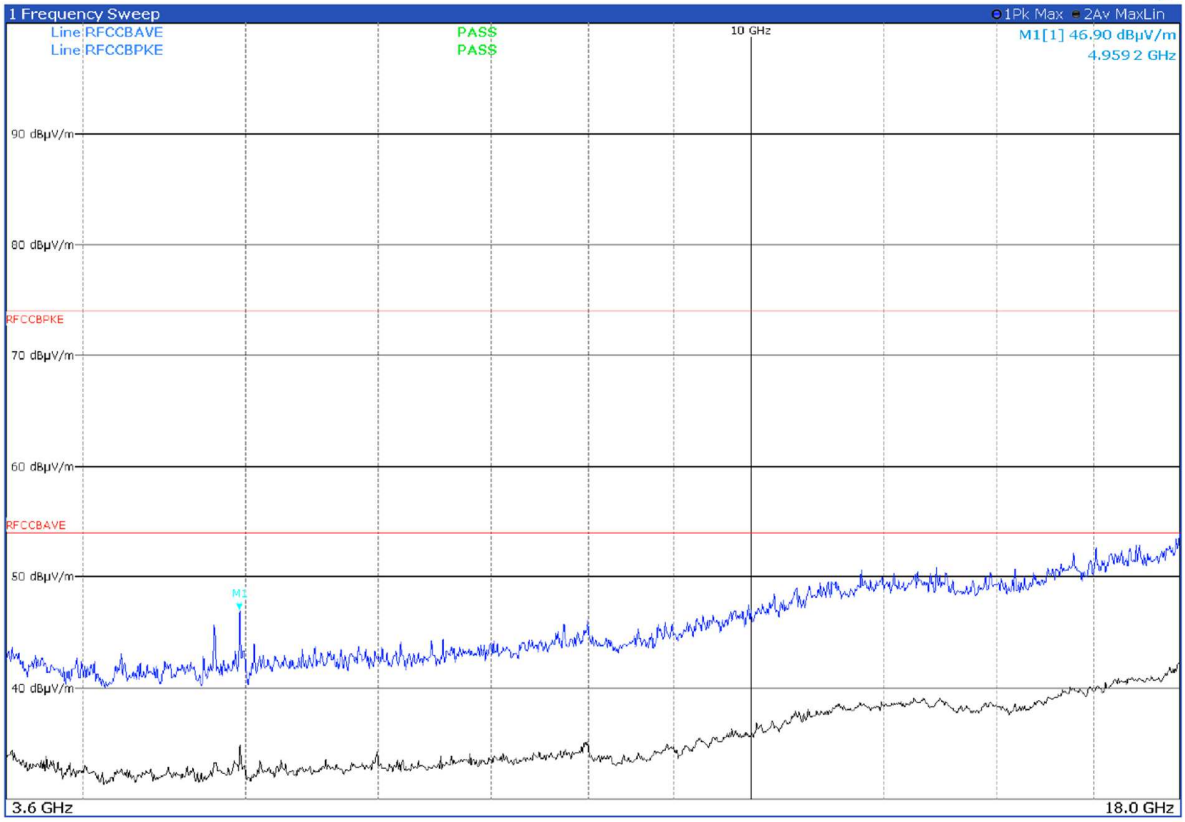
Limit exceeded by the carrier

Figure 8.6-20: Radiated spurious emissions on high channel with antenna in vertical polarization – EUT in horizontal position



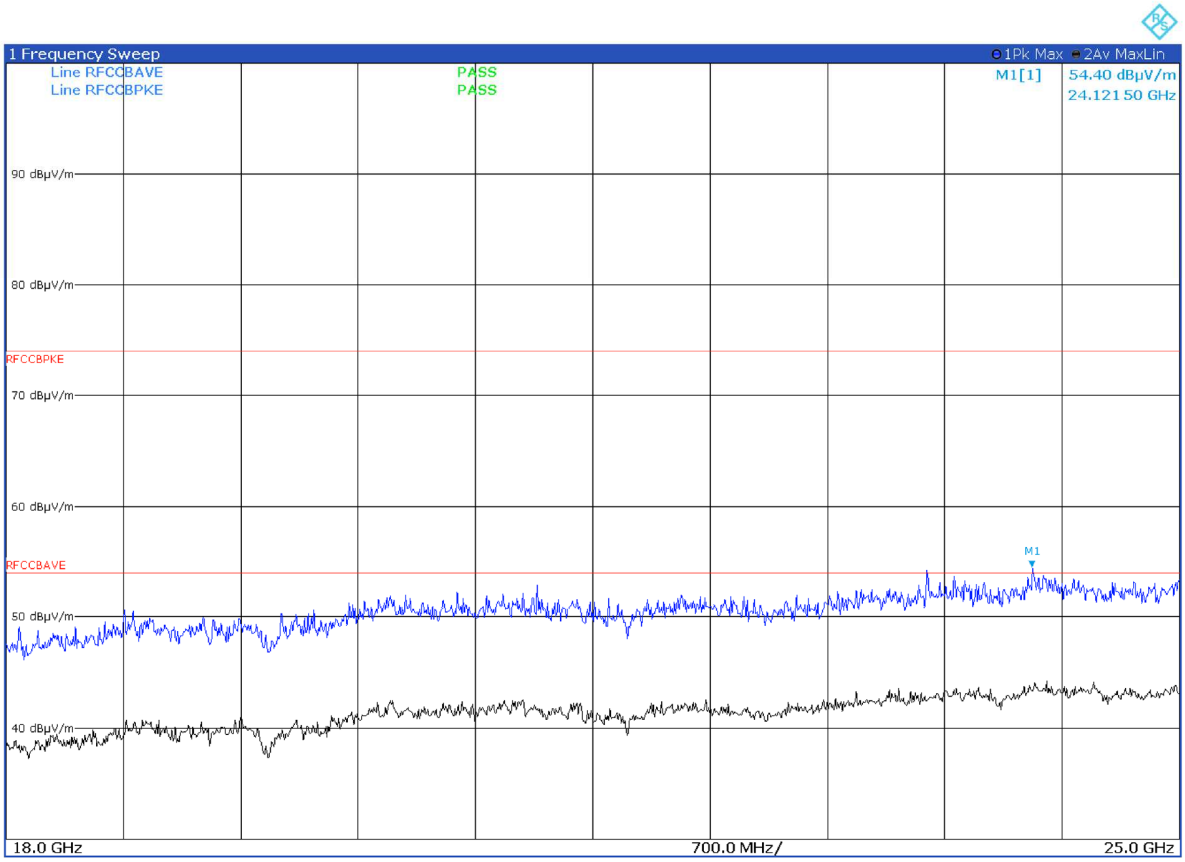
Peak level under the average limit – no additional measures need

Figure 8.6-21: Radiated spurious emissions on high channel with antenna in horizontal polarization – EUT in horizontal position



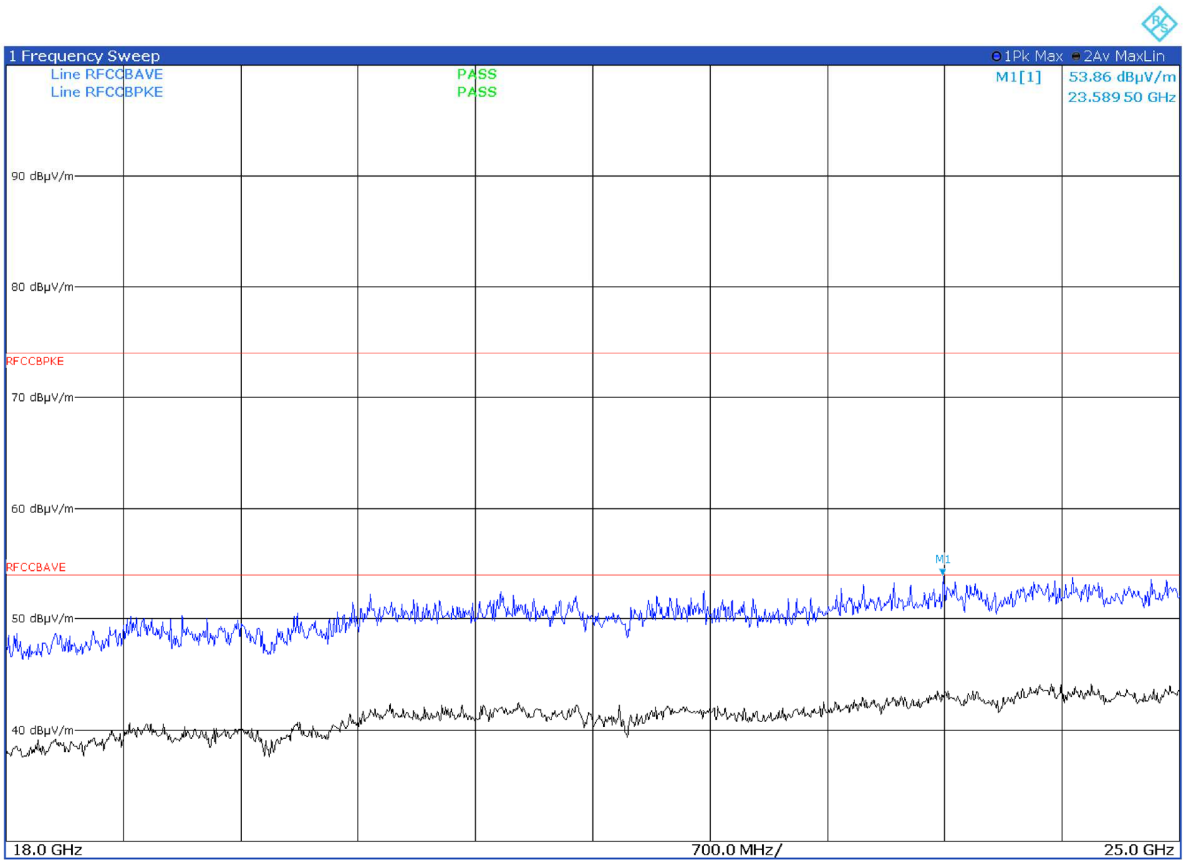
Peak level under the average limit – no additional measures need

Figure 8.6-22: Radiated spurious emissions on high channel with antenna in vertical polarization – EUT in horizontal position



Peak level under the average limit – no additional measures need

Figure 8.6-23: Radiated spurious emissions on high channel with antenna in horizontal polarization – EUT in horizontal position



Peak level under the average limit – no additional measures need

Figure 8.6-24: Radiated spurious emissions on high channel with antenna in vertical polarization – EUT in horizontal position

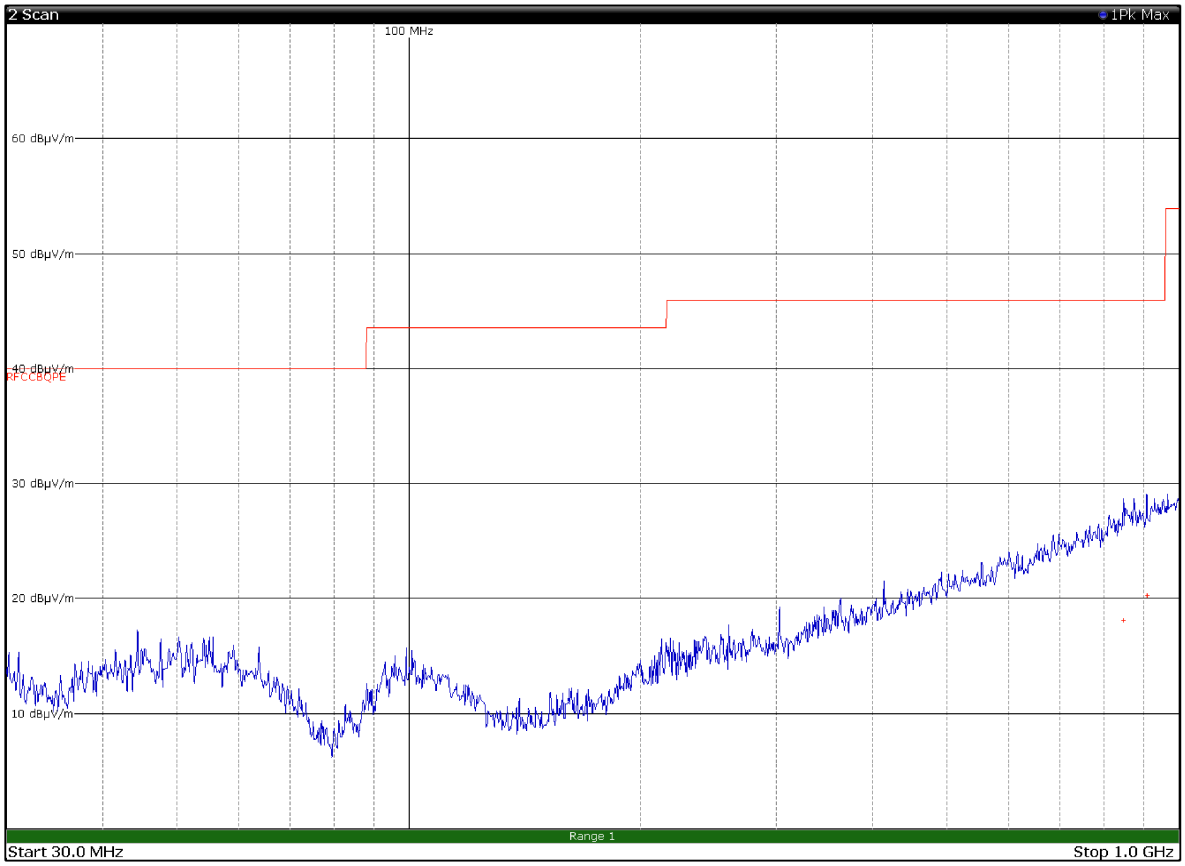


Figure 8.6-25: Radiated spurious emissions on low channel with antenna in horizontal polarization – EUT in vertical position

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
847.6500	18.2	46.0	-27.8	QP
908.1300	20.3	46.0	-25.7	QP
Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.				

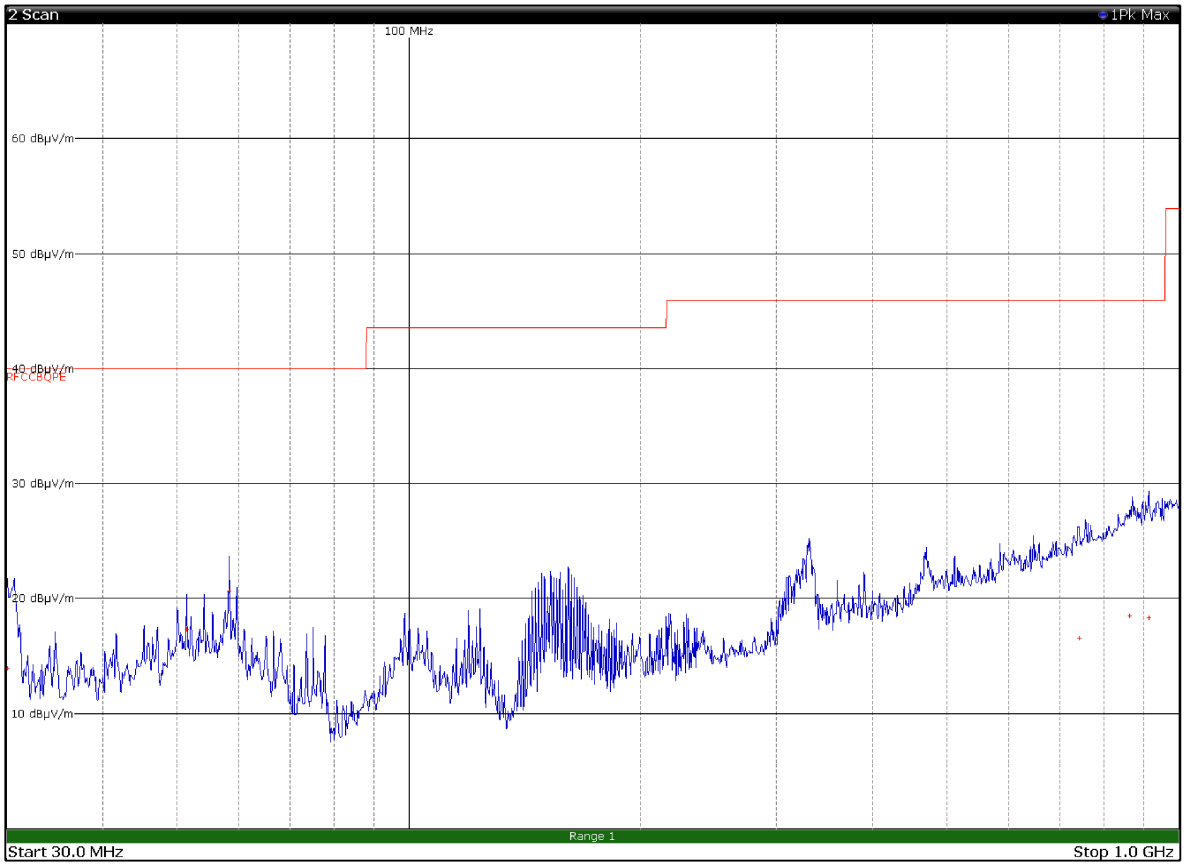
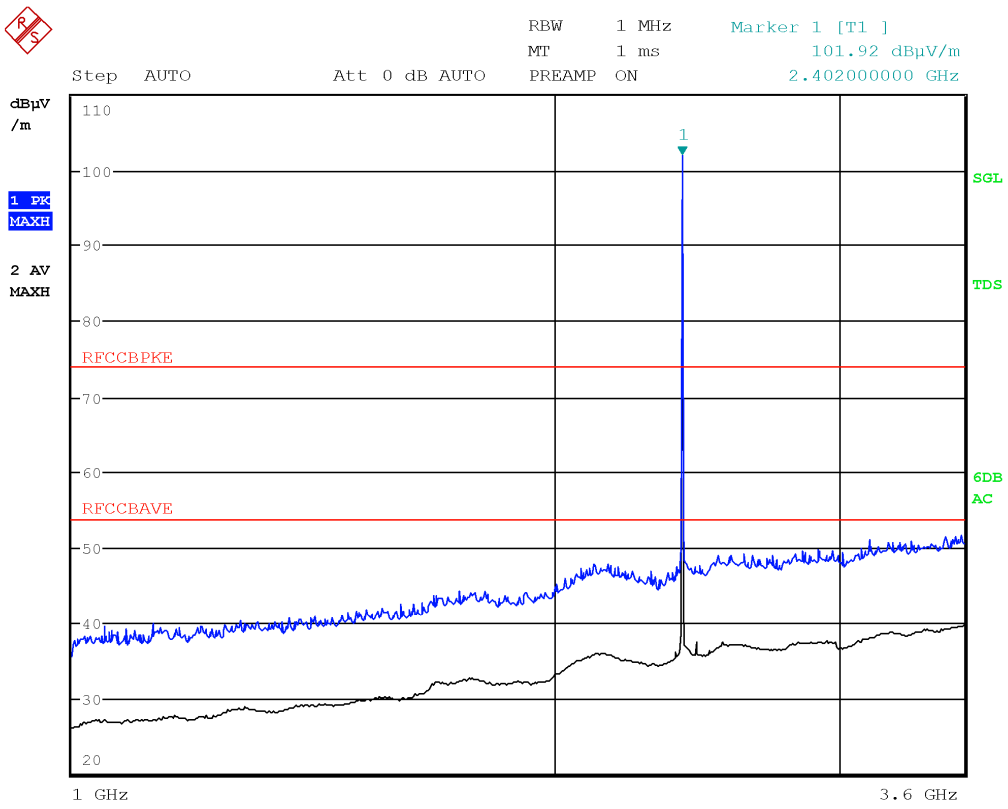


Figure 8.6-26: Radiated spurious emissions on low channel with antenna in vertical polarization – EUT in vertical position

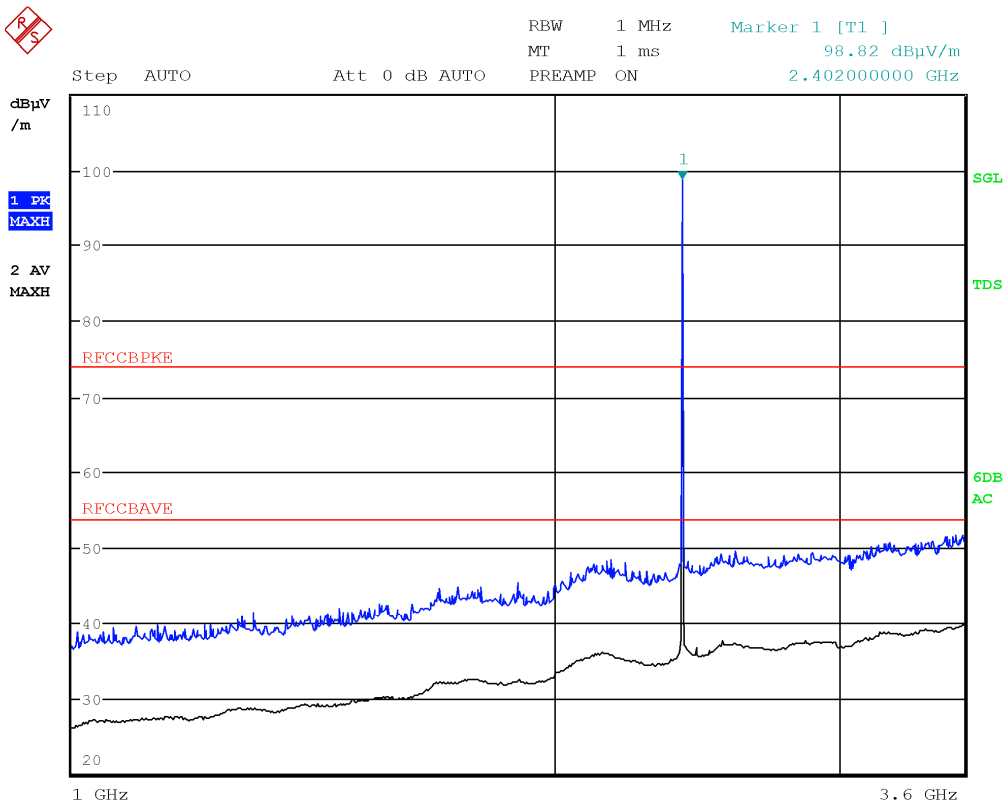
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Detector
30.0900	13.9	40.0	-26.1	QP
51.3900	17.4	40.0	-22.6	QP
58.3500	20.7	40.0	-19.3	QP
742.0200	16.6	46.0	-29.4	QP
863.6400	18.5	46.0	-27.5	QP
913.6800	18.4	46.0	-27.6	QP
Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.				



Peak level under the average limit – no additional measures need

Limit exceeded by the carrier

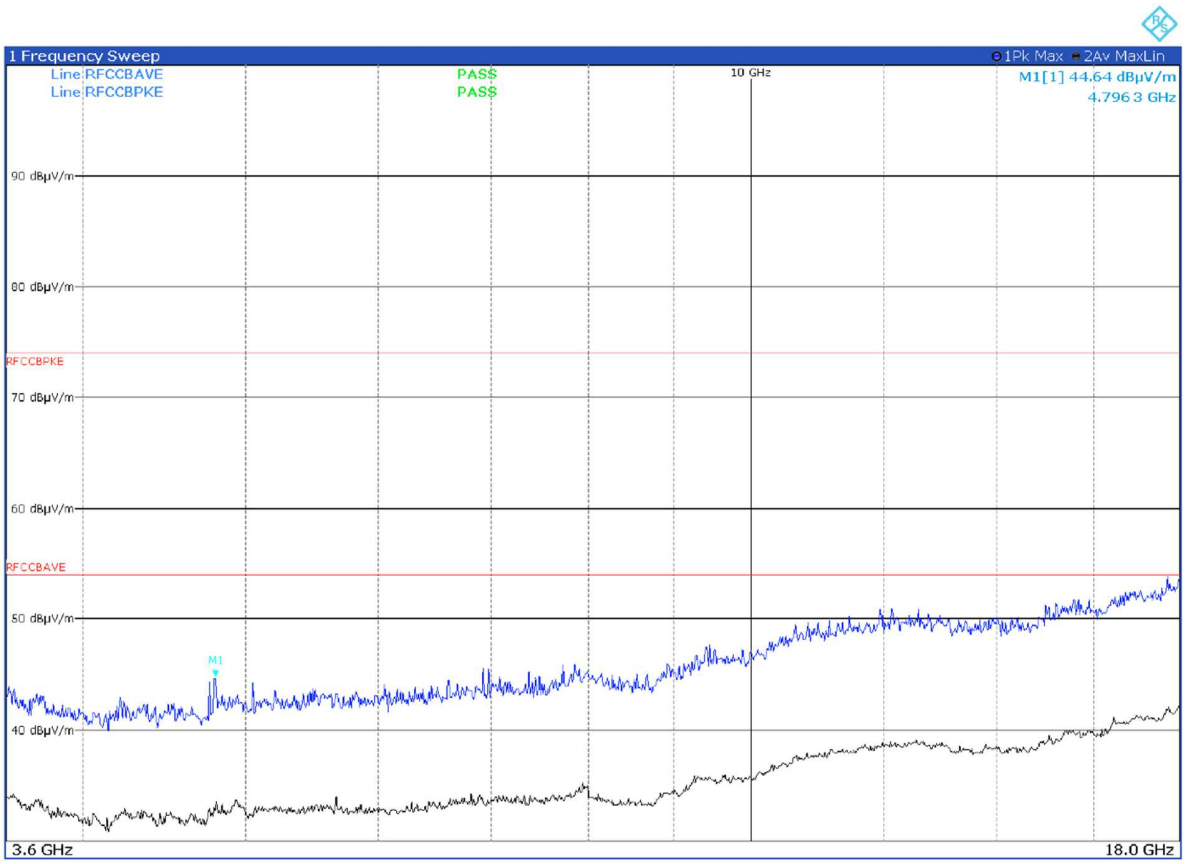
Figure 8.6-27: Radiated spurious emissions on low channel with antenna in horizontal polarization – EUT in vertical position



Peak level under the average limit – no additional measures need

Limit exceeded by the carrier

Figure 8.6-28: Radiated spurious emissions on low channel with antenna in vertical polarization – EUT in vertical position



Peak level under the average limit – no additional measures need

Figure 8.6-29: Radiated spurious emissions on low channel with antenna in horizontal polarization – EUT in vertical position