



RADIO TEST REPORT –REP009236

Type of assessment:

Final product testing

Applicant:

Texa Spa

Via I Maggio, 9

31050 Monastier di Treviso (TV) – Italy

Product:

Vehicle diagnostic system with Bluetooth connectivity

Model:

DP2.2-488

FCC ID:

T8RDP22

IC Registration number:

23618-DP22

Specifications:

- ◆ FCC 47 CFR Part 15 Subpart C, §15.247
- ◆ RSS-247, Issue 2, Feb 2017, Section 5
- ◆ RSS-Gen, Issue 5, April 2018 - Amendment 1 (March 2019) - Amendment 2 (February 2021)

Date of issue: April 21, 2023

D. Guarnone

Tested by

Signature

P. Barbieri

Reviewed by

Signature

This test report shall not be partially reproduced without the prior written consent of Nemko S.p.A. The phase of sampling of equipment under test is carried out by the customer. Results indicated in this test report refer exclusively to the tested samples and apply to the sample as received. This Test Report, when bearing the Nemko name and logo is only valid when issued by a Nemko laboratory, or by a laboratory having special agreement with Nemko.

Lab locations

Company name	Nemko Spa
Address	Via del Carroccio, 4
City	Biassono
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 contained in this report are within Nemko Spa ISO/IEC 17025 accreditation.

Copyright notification

Nemko Spa authorizes the applicant to reproduce this report provided it is reproduced in its entirety and for use by the company's employees only. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Nemko Spa accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Table of Contents

Table of Contents	3
Section 1 Report summary	4
1.1 Test specifications	4
1.2 Test methods	4
1.3 Exclusions	4
1.4 Statement of compliance.....	4
1.5 Test report revision history.....	4
Section 2 Engineering considerations	5
2.1 Modifications incorporated in the EUT for compliance	5
2.2 Technical judgment	5
2.3 Deviations from laboratory tests procedures	5
Section 3 Test conditions	6
3.1 Atmospheric conditions.....	6
3.2 Power supply range	6
Section 4 Measurement uncertainty	7
4.1 Uncertainty of measurement	7
Section 5 Information provided by the applicant	8
5.1 Disclaimer	8
5.2 Applicant/Manufacture	8
5.3 EUT information	8
5.4 Radio technical information.....	8
5.5 EUT setup details	9
Section 6 Summary of test results	13
6.1 Testing location	13
6.2 Testing period.....	13
6.3 Sample information	13
6.4 ISSED RSS-Gen, Issue 5, test results	13
6.5 ISSED RSS-247, Issue 2, test results for frequency hopping spread spectrum systems (FHSS)	14
6.6 ISSED RSS-247, Issue 2, test results for digital transmission systems (DTS)	14
6.7 FCC Part 15 Subpart C, intentional radiators test results	15
Section 7 Test equipment.....	16
7.1 Test equipment list	16
Section 8 Testing data	17
8.1 Number of frequencies	17
8.2 Antenna requirement	19
8.3 Frequency Hopping Systems requirements, 2 GHz operation	20
8.4 Transmitter output power and e.i.r.p. requirements for FHSS 2 GHz	48
8.5 Spurious (out-of-band) unwanted emissions.....	59
Section 9 EUT photos	133
9.1 Set-up photos	133
9.2 External photos.....	134

Section 1 Report summary

1.1 Test specifications

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
RSS-Gen, Issue 5, April 2018 – Amendment 1 (March 2019) – Amendment 2 (February 2021)	General Requirements for Compliance of Radio Apparatus
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-102, Issue 5, March 19, 2015 - Amendment 1 (February 2, 2021)	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)

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
REP009236	April 21, 2023	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	2022-04	2023-04
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 $\pm 5\%$, 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	Same as applicant
Manufacture address	Same as applicant

5.3 EUT information

Product	Device to gain useful information for the driver and mechanical
Model	DP2.2-488
Serial number	TONPY000056
Power supply requirements	12 V DC, 80 mA max
Product description and theory of operation	The EUT is a compact device that, during normal vehicle operation, can acquire information useful both to the driver and the mechanic. The data acquired is useful to detect problems connected to the vehicle's management and its maintenance status. The device must be connected to a specific diagnostic socket called OBD socket. The device communicates with the vehicle's control unit through the OBD socket and acquires the required data. The device is able to acquire the required data from the vehicle and to transmit it in real time via Bluetooth to the smartphone selected as a display unit. For this to occur, a specific app must be installed in the display unit.

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 MHz
Frequency Max (MHz)	2480 MHz
Channel numbers	0–79
RF power Max (W), Conducted	0.24 mW (-6.18 dBm)
Field strength, dBμV/m @ 3 m	90.68 dBμV/m
Measured BW (kHz), 99% OBW	1332 kHz
Type of modulation	GFSK π/4-DQPSK 8-DPSK
Emission classification	F1D
Transmitter spurious, dBμV/m @ 3 m	42.67 dBμV/m @ 4959 MHz (Peak)
Antenna information	PCB antenna Part No. M310221 ETHERTRONICS with gain of 1.7 dBi

5.5 EUT setup details

5.5.1 Radio exercise details

Operating conditions

The EUT has been tested with the Bluetooth_test_V2 software provided by the applicant, as following:

Parameter	Value
Local_Device_B...	000000000000
Hopping_Mode	79 channel
Frequency	2402 MHz
Modulation_Type	PRBS9 Pattern
Logical_Channel	ACL Basic
BB_Packet_Type	DH5 / 3-DH5
BB_Packet_Len...	0xFFFF
Tx_Power_Level	0 dBm
Transmit_Power...	0
Transmit_Power...	0x7

Command Name	Value
tx_test0	Expand all Collapse all
Command Name	Parameter
	Value
	Local_Device_B...
	Hopping_Mode
	Frequency
	Modulation_Type
	Logical_Channel
	BB_Packet_Type
	BB_Packet_Len...
	Tx_Power_Level
	Transmit_Power...
	Transmit_Power...

Operating conditions (continued)

BB Packet type used: DM1, 2-DH5, 3-DH5

Transmitter state

TX Power used: 0 dBm

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
--	--	--

Table 5.5-2: EUT interface ports

Description	Qty.
ODB connector	1

Table 5.5-3: Support equipment

Description	Brand name	Model, Part number, Serial number, Revision level
Test Bench	Texa Spa	BT certification bench
Notebook	Dell	Latitude 7480

Table 5.5-4: Inter-connection cables

Cable description	From	To	Length (m)
ODB cable	EUT	Test Bench	1.4
USB cable	Test Bench	PC	1.8
DC cable	Test Bench	Power supply	2.3

EUT setup configuration, continued

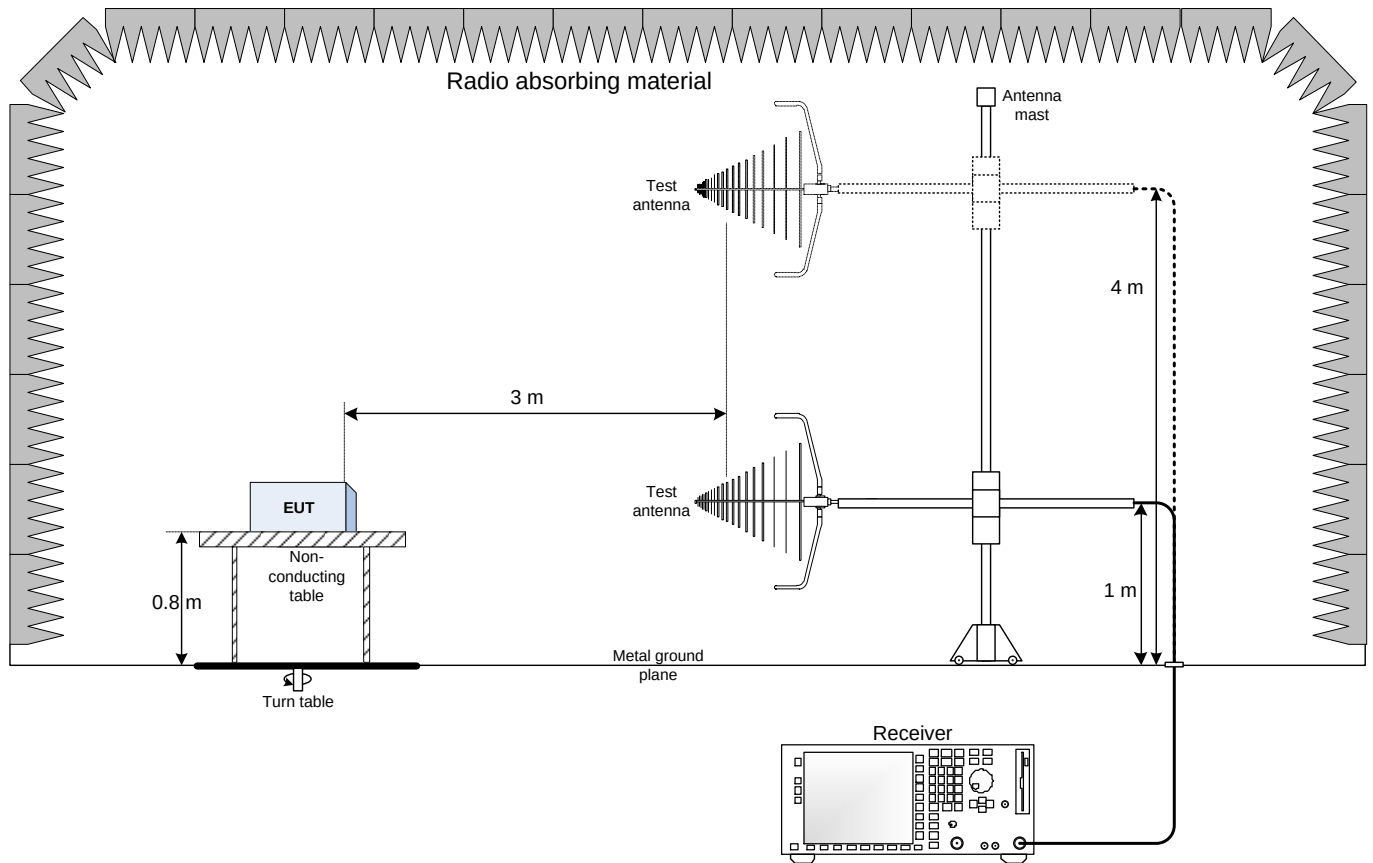


Figure 5.5-1: Radiated testing block diagram (below 1 GHz)

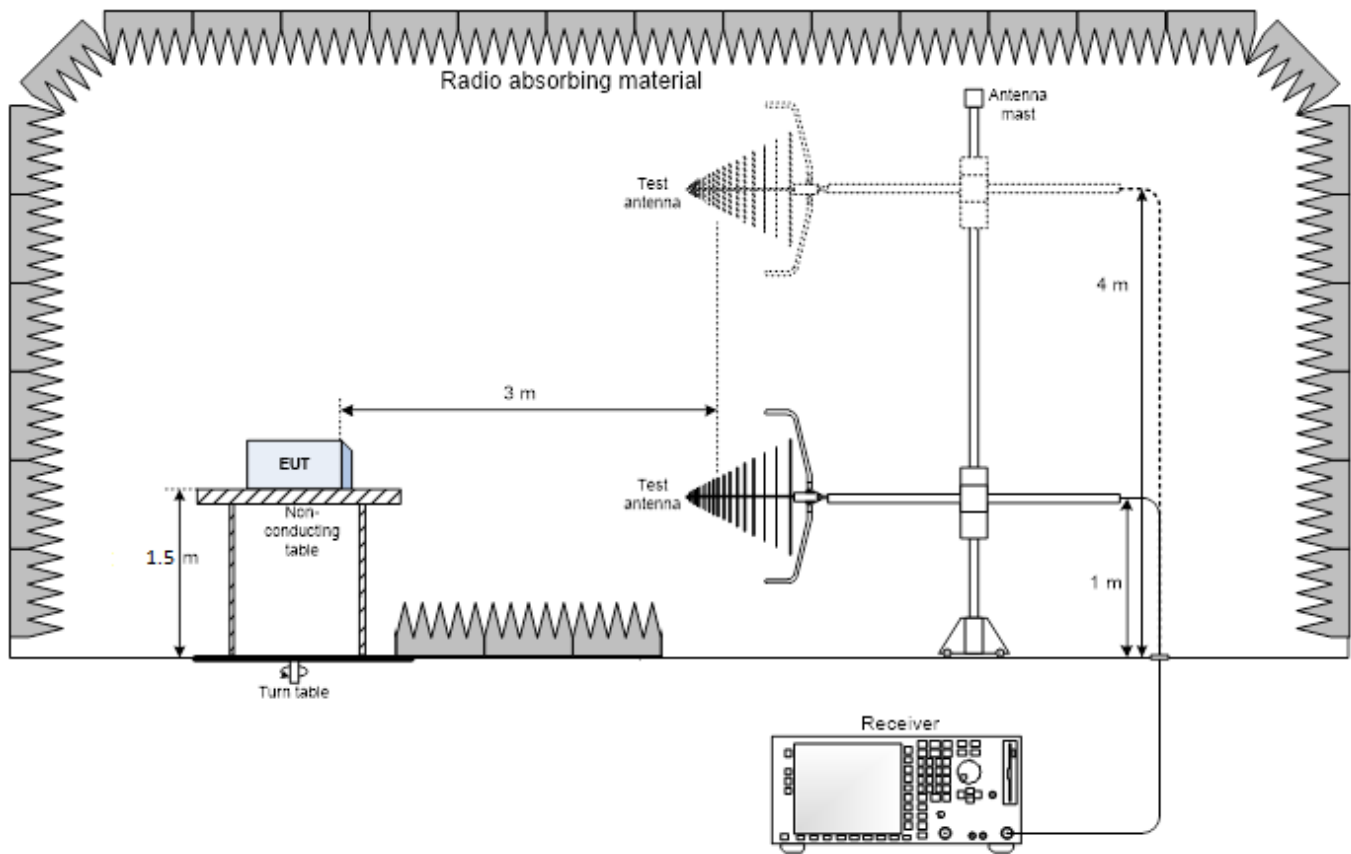


Figure 5.5-2: Radiated testing block diagram (above 1 GHz)

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 17, 2023	Test end date	April 14, 2023
-----------------	----------------	---------------	----------------

6.3 Sample information

Receipt date	March 17, 2023	Nemko sample ID number(s)	4710790001
--------------	----------------	---------------------------	------------

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 2, 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	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: --

6.6 ISED RSS-247, Issue 2, 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	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: --

6.7 FCC Part 15 Subpart C, intentional radiators test results for frequency hopping spread spectrum systems (FHSS)

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	Pass
§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	Pass
§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

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	2023-01	2024-01
EMI Receiver	Rohde & Schwarz	ESW44	101620	2022-08	2023-08
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	2020-04	2023-04
Broadband Amplifier	Schwarzbeck Mess-Elektronik	BBV9718C	00121	2023-03	2024-03
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	2021-09	2023-09

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	D. Guarnone	Test date	March 23, 2023

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:

- 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.
- 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.
- 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:

- 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).
- 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).
- 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	2402	2441	2480

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	D. Guarnone	Test date	March 23, 2023

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
PCB	ETHERTRONICS	M310221	1.7 dBi	--

8.3 Frequency Hopping Systems requirements, 2 GHz operation

8.3.1 References, definitions and limits

FCC:

- (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.
- d) ay be avoided or suppressed provided that at least 15 hopping channels are used.

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.

8.3.2 Test summary

Verdict	Pass		
Tested by	D. Guarnone	Test date	March 23, 2023

8.3.3 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

Observations, settings and special notes, continued

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

Resolution bandwidth	shall be $\leq$ channel spacing and where possible RBW should be set $\gg 1/T$, where T is the expected dwell time per channel.
Video bandwidth	$\geq$ 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	$\geq 1-5\%$ of the 20 dB bandwidth
Video bandwidth	$\geq$ RBW
Frequency span	approximately 2 to 5 times the 20 dB bandwidth, centered on a hopping channel
Detector mode	Peak
Trace mode	Max Hold

8.3.4 Test equipment used

Equipment	Manufacturer	Model no.	Asset no.
EMI Receiver	Rohde & Schwarz	ESW44	101620
Spectrum Analyzer	Rohde & Schwarz	FSW43	101767
Antenna 1 - 18 GHz	Schwarzbeck Mess-Elektronik	STLP9148	STLP 9148-152
Controller	Maturo	FCU3.0	10041
Tilt antenna mast	Maturo	TAM4.0-E	10042
Turntable	Maturo	TT4.0-ST	2.527
Semi-anechoic chamber	Nemko S.p.a.	10m semi-anechoic chamber	530

8.3.5 Test data

Table 8.3-1: 20 dB bandwidth results

Frequency, MHz	Modulation	20 dB bandwidth, MHz
2402	GFSK	1.024
2441	GFSK	1.019
2480	GFSK	0.725
2402	$\pi/4$ -DQPSK	1.29
2441	$\pi/4$ -DQPSK	1.24
2480	$\pi/4$ -DQPSK	1.24
2402	8-DPSK	1.28
2441	8-DPSK	1.26
2480	8-DPSK	1.27

Test data, continued

Table 8.3-2: 99% occupied bandwidth results

Frequency, MHz	Modulation	99% occupied bandwidth, kHz
2402	GFSK	937.5
2441	GFSK	932.7
2480	GFSK	961.5
2402	$\pi/4$ -DQPSK	1255
2441	$\pi/4$ -DQPSK	1221
2480	$\pi/4$ -DQPSK	1284
2402	8-DPSK	1269
2441	8-DPSK	1207
2480	8-DPSK	1332

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

Table 8.3-3: Carrier frequency separation results

Carrier frequency separation, kHz	Minimum limit, kHz	Margin, kHz
1000	833 kHz	-167

Notes: The limit is two thirds of the 20 dB bandwidth = $2/3$ of 1.25 MHz = 833 kHz

Table 8.3-4: Number of hopping frequencies results

Number of hopping frequencies	Minimum limit	Margin
79	15	-64

Table 8.3-5: Average time of occupancy results for DM1 BB packet type

Dwell time of each pulse, ms	Number of pulses within period	Total dwell time within period, ms	Limit, ms	Margin, ms
0.308	500	154	400	-246

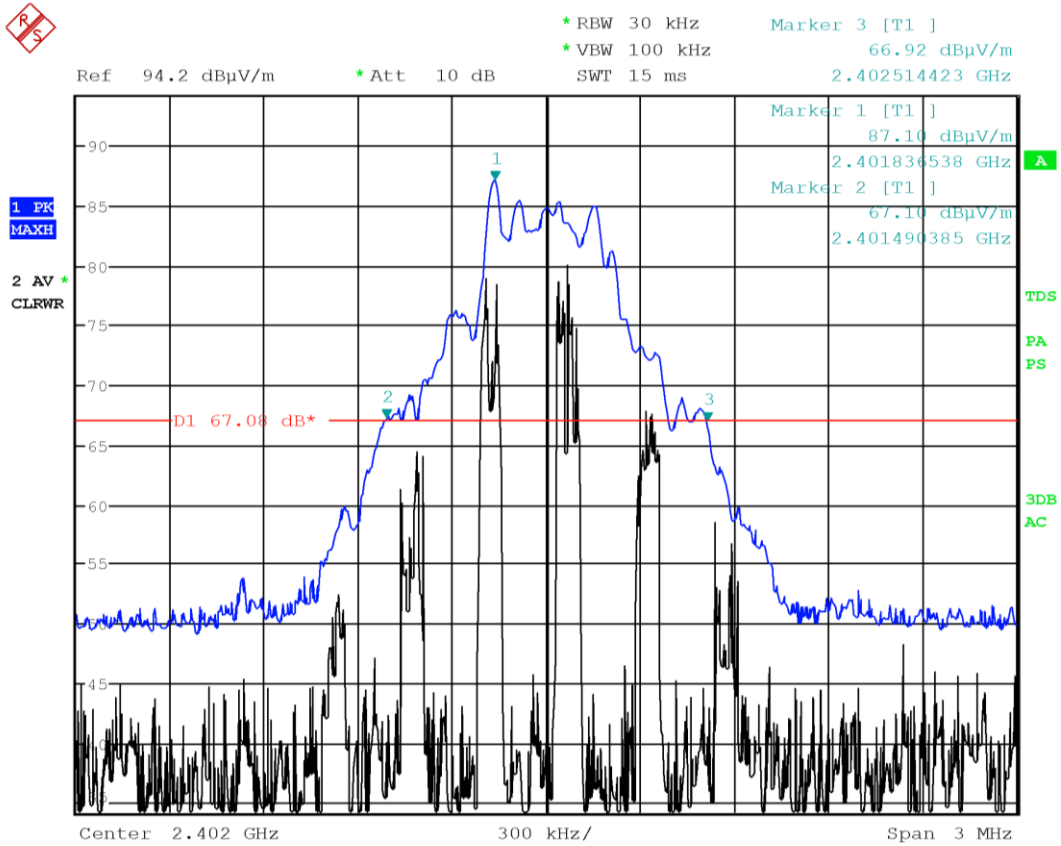
Notes: Measurement Period is 31.6 s

Table 8.3-6: Average time of occupancy results for 3-DH5 BB packet type

Dwell time of each pulse, ms	Number of pulses within period	Total dwell time within period, ms	Limit, ms	Margin, ms
3.028	112	339	400	-61

Notes: Measurement Period is 31.6 s

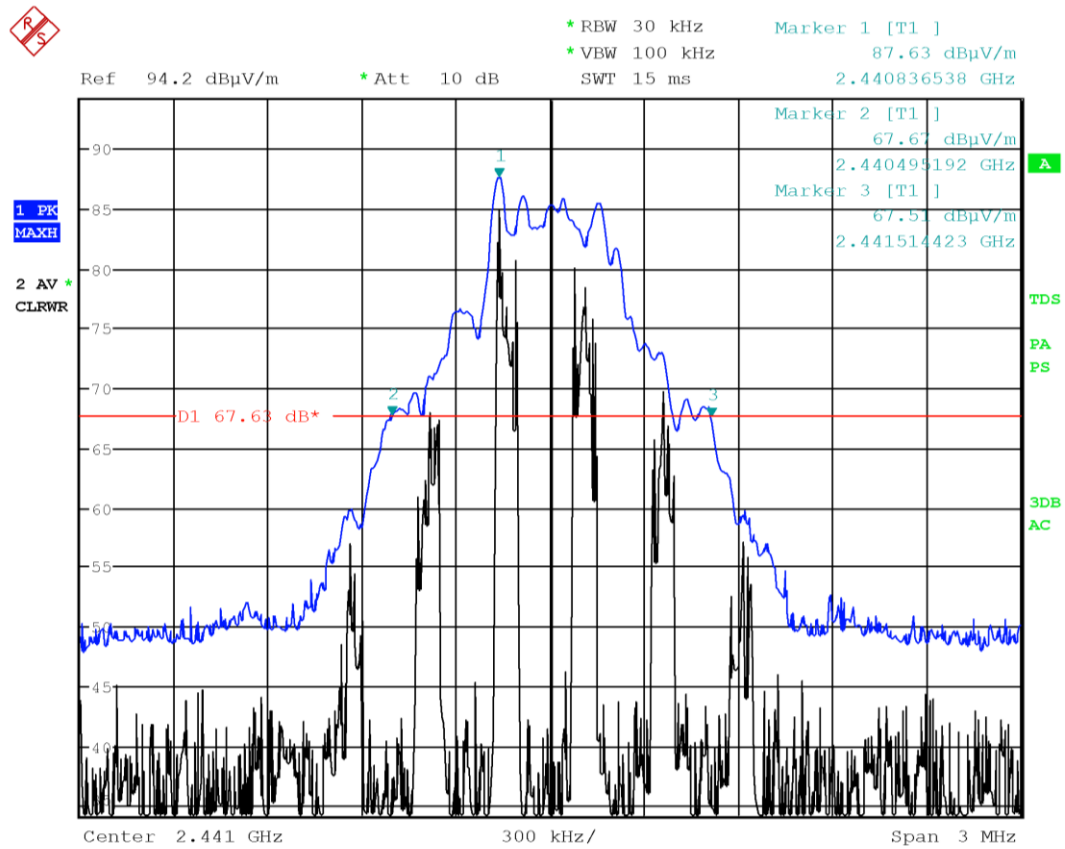
Test data, continued



Date: 23.MAR.2023 17:40:48

Figure 8.3-1: 20 dB bandwidth on low channel with GFSK modulation

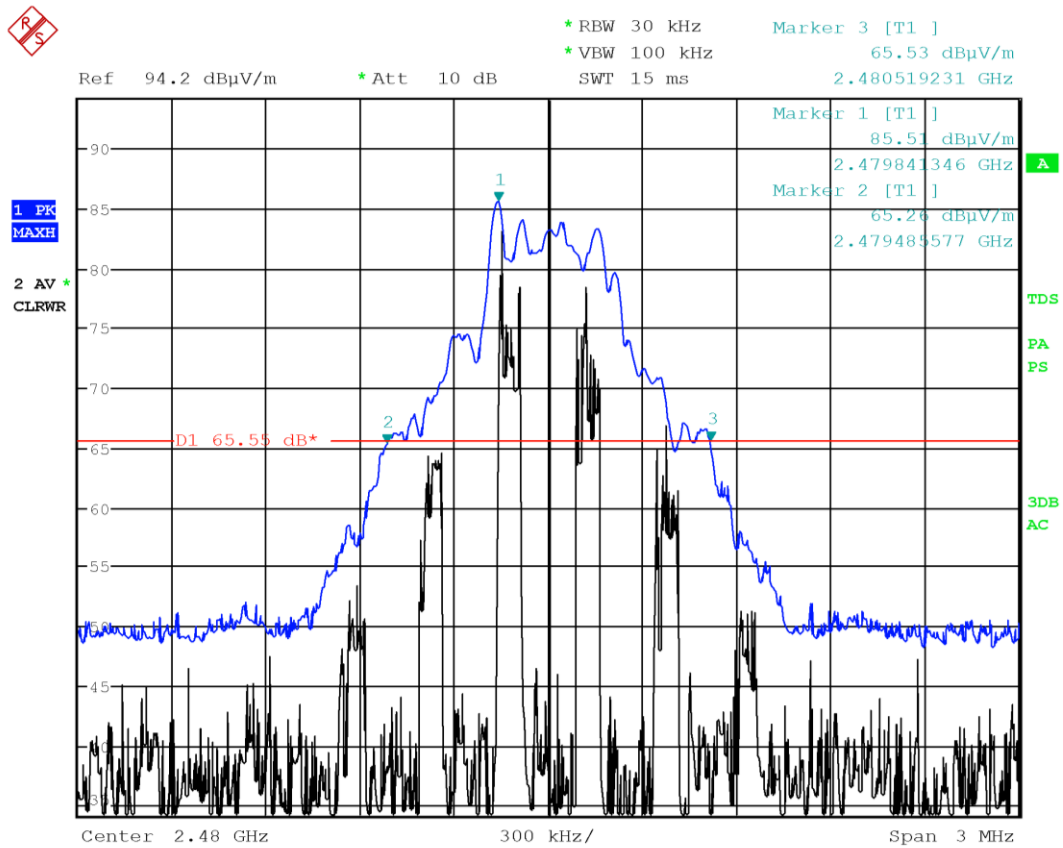
Test data, continued



Date: 23.MAR.2023 17:28:36

Figure 8.3-2: 20 dB bandwidth on mid channel with GFSK modulation

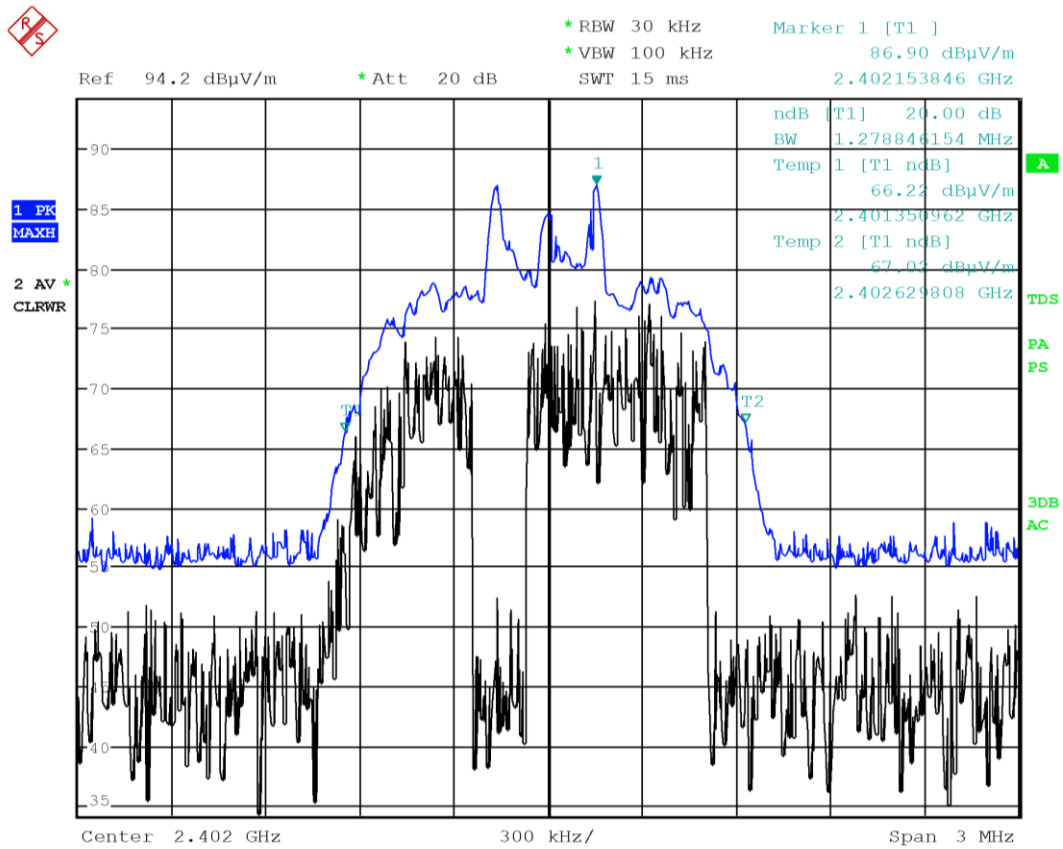
Test data, continued



Date: 23.MAR.2023 17:25:15

Figure 8.3-3: 20 dB bandwidth on high channel with GFSK modulation

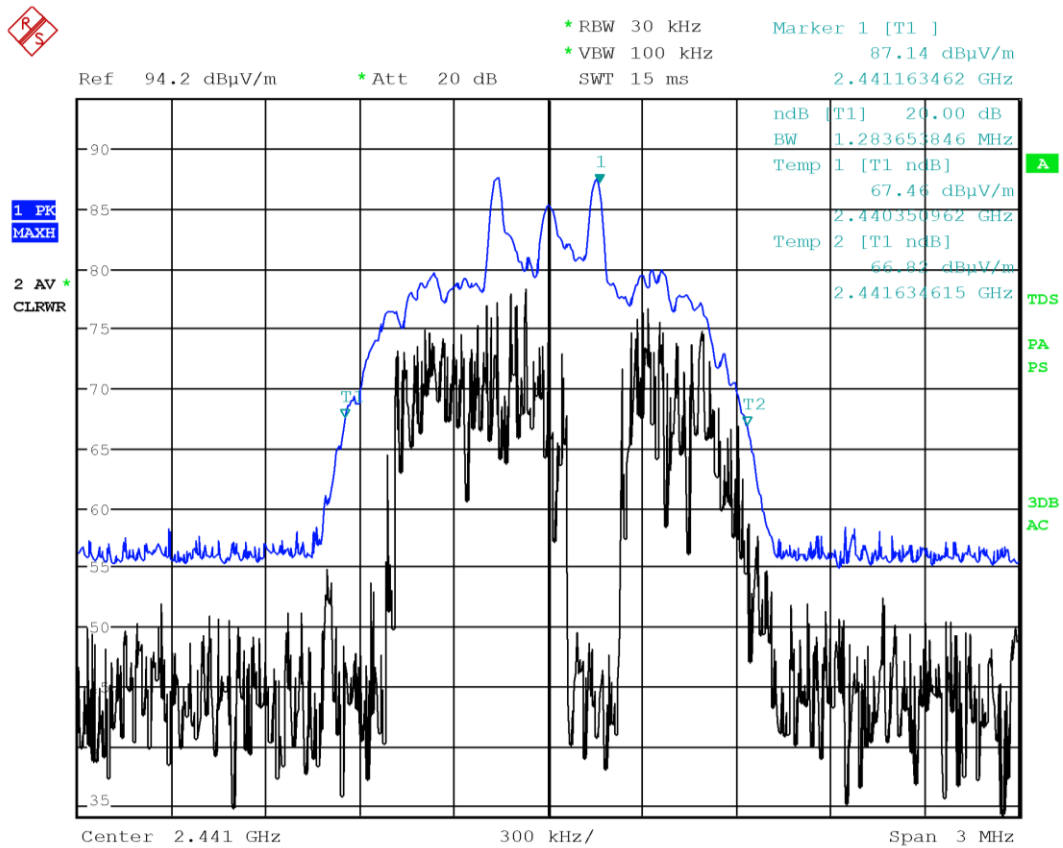
Test data, continued



Date: 23.MAR.2023 16:38:59

Figure 8.3-4: 20 dB bandwidth on low channel with 8-DPSK modulation

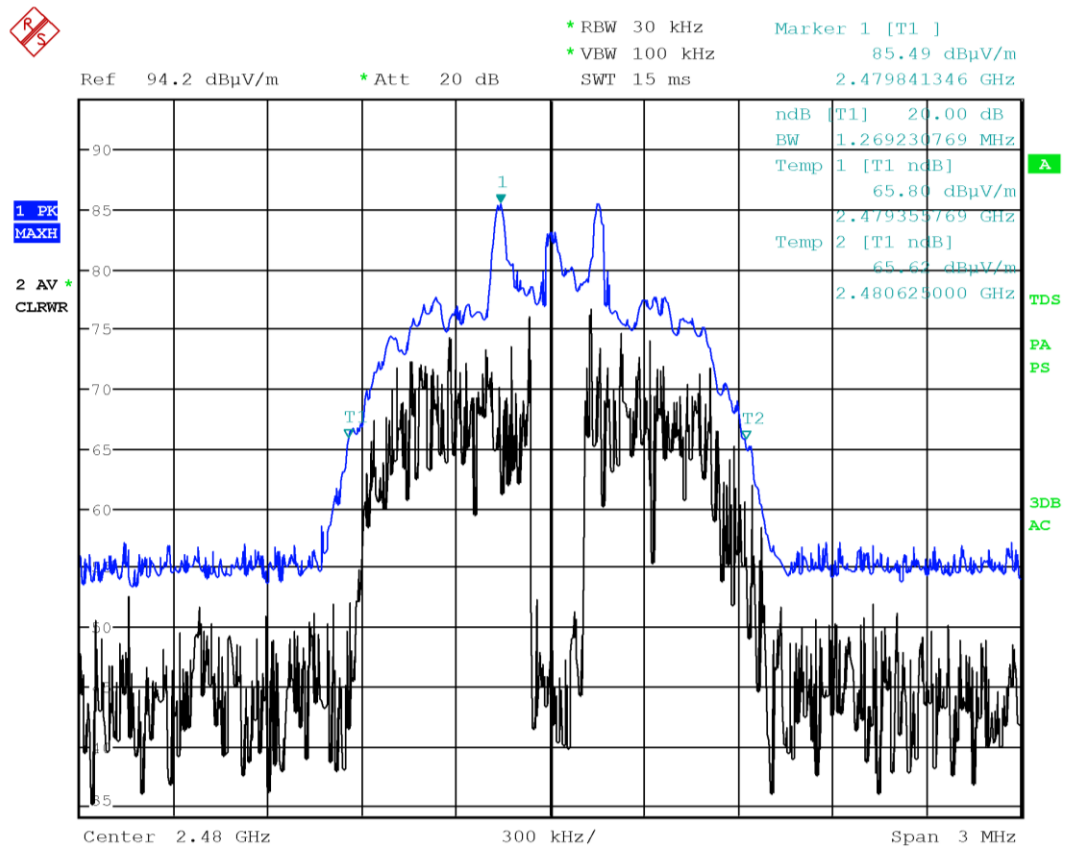
Test data, continued



Date: 23.MAR.2023 16:33:15

Figure 8.3-5: 20 dB bandwidth on mid channel with 8-DPSK modulation

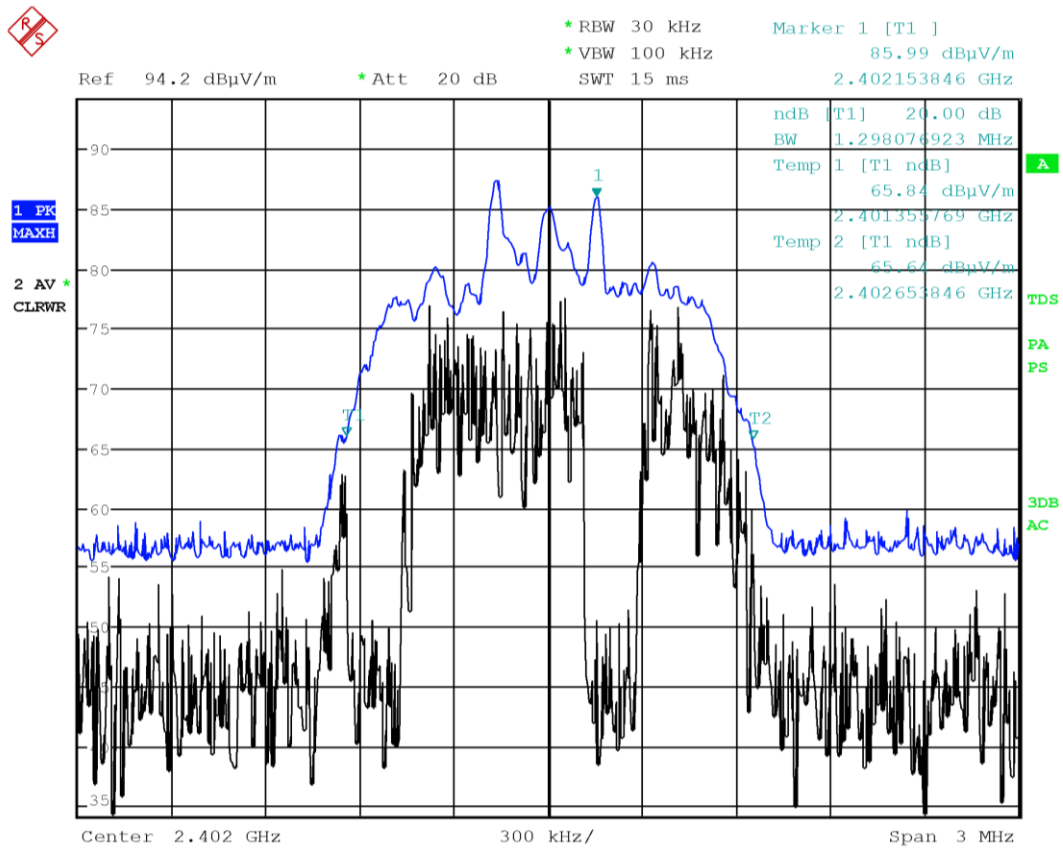
Test data, continued



Date: 23.MAR.2023 16:29:26

Figure 8.3-6: 20 dB bandwidth on high channel with 8-DPSK modulation

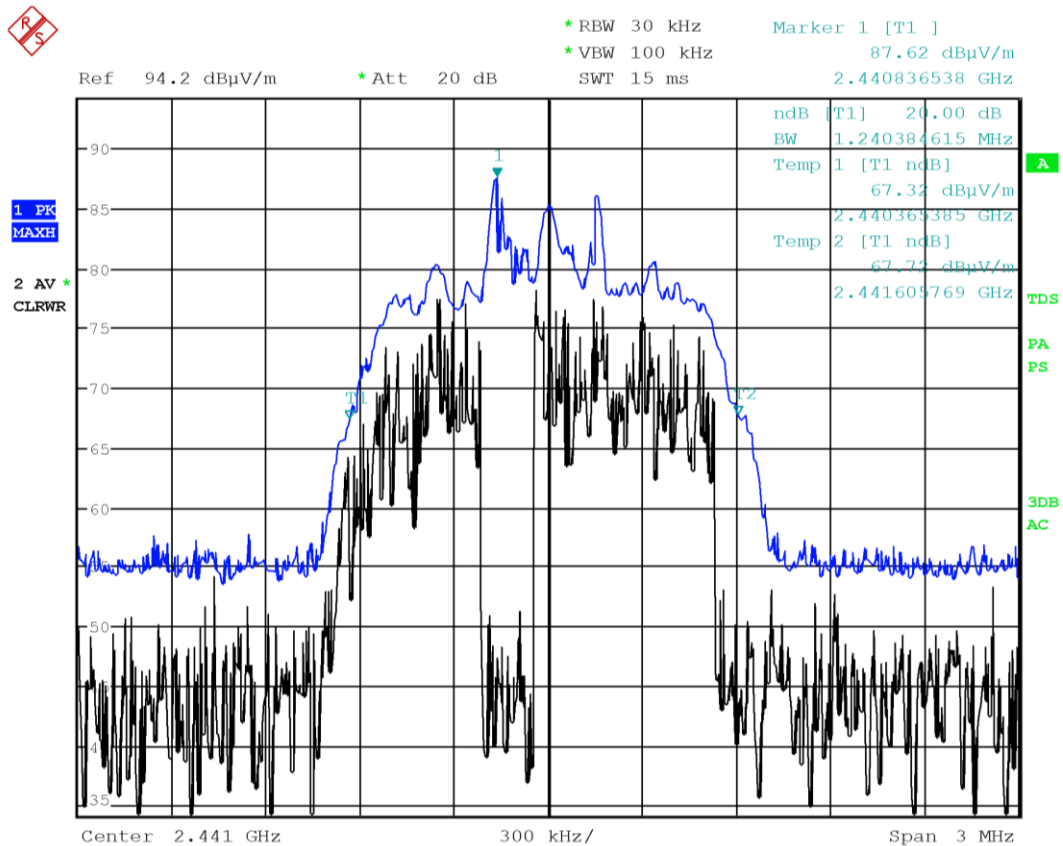
Test data, continued



Date: 23.MAR.2023 17:03:20

Figure 8.3-7: 20 dB bandwidth on low channel with $\pi/4$ -DQPSK modulation

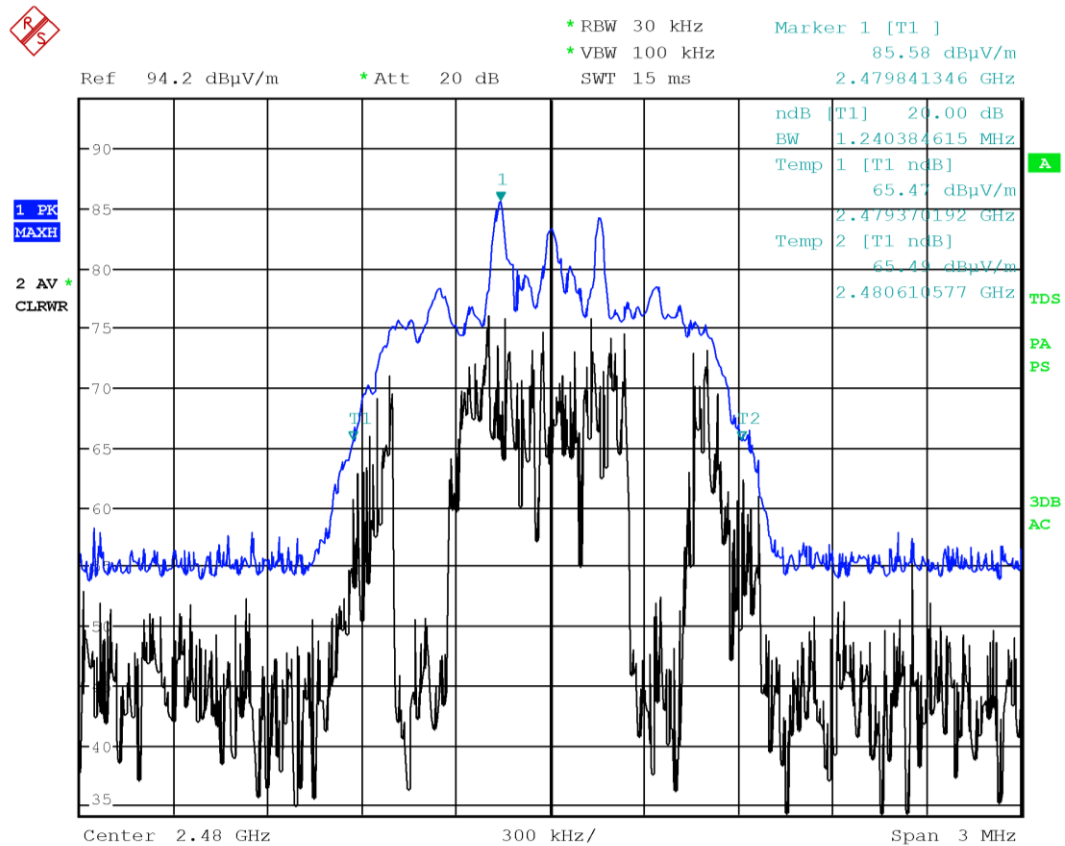
Test data, continued



Date: 23.MAR.2023 17:10:51

Figure 8.3-8: 20 dB bandwidth on mid channel with $\pi/4$ -DQPSK modulation

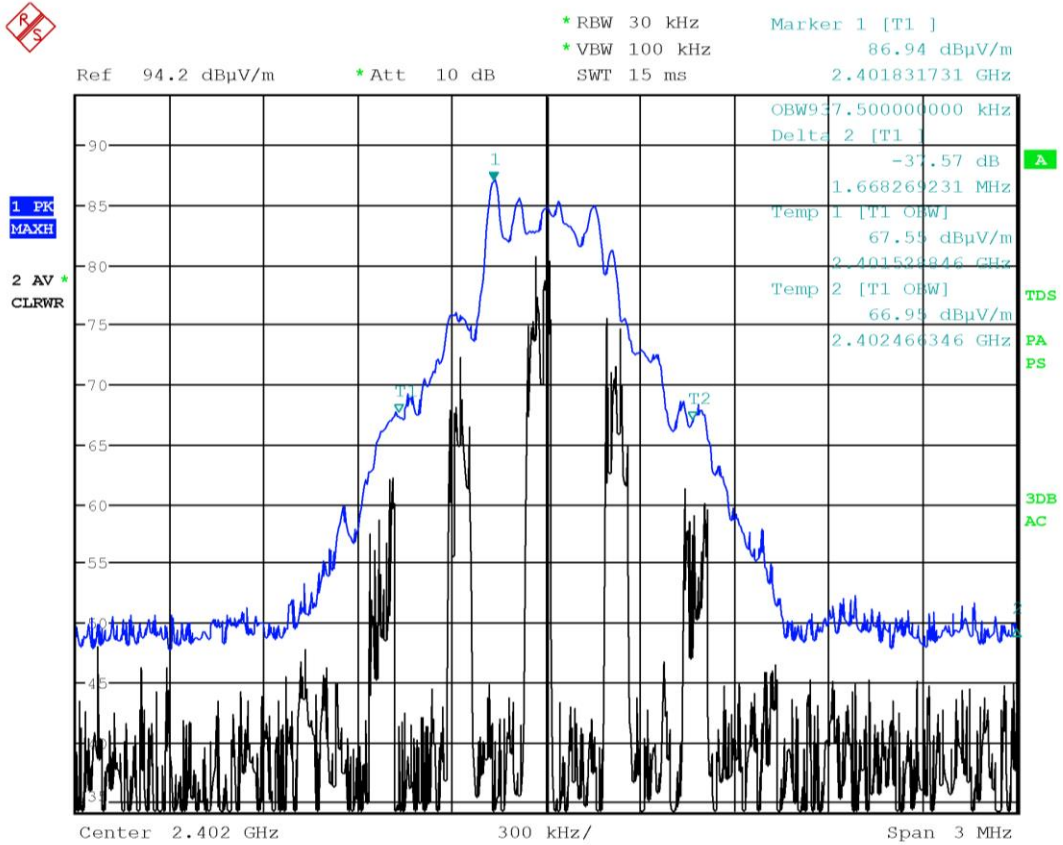
Test data, continued



Date: 23.MAR.2023 17:13:12

Figure 8.3-9: 20 dB bandwidth on high channel with $\pi/4$ -DQPSK modulation

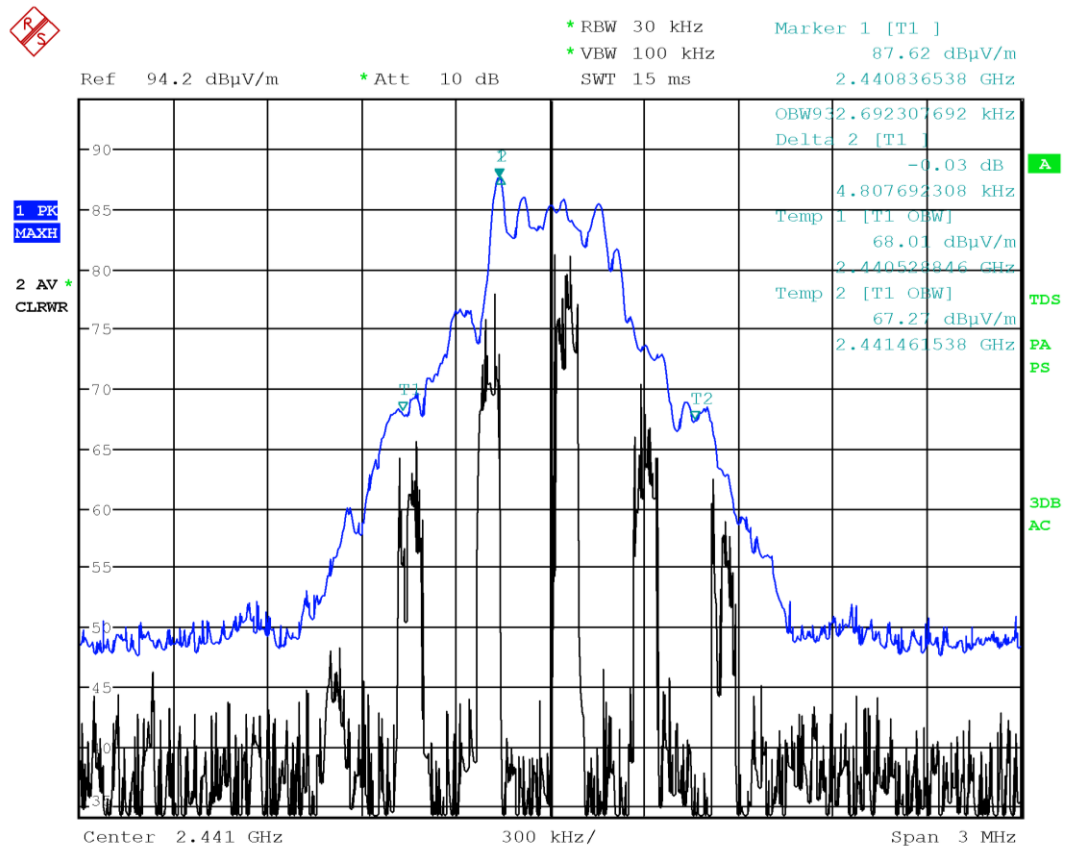
Test data, continued



Date: 23.MAR.2023 17:37:50

Figure 8.3-10: 99% bandwidth on low channel with GFSK modulation

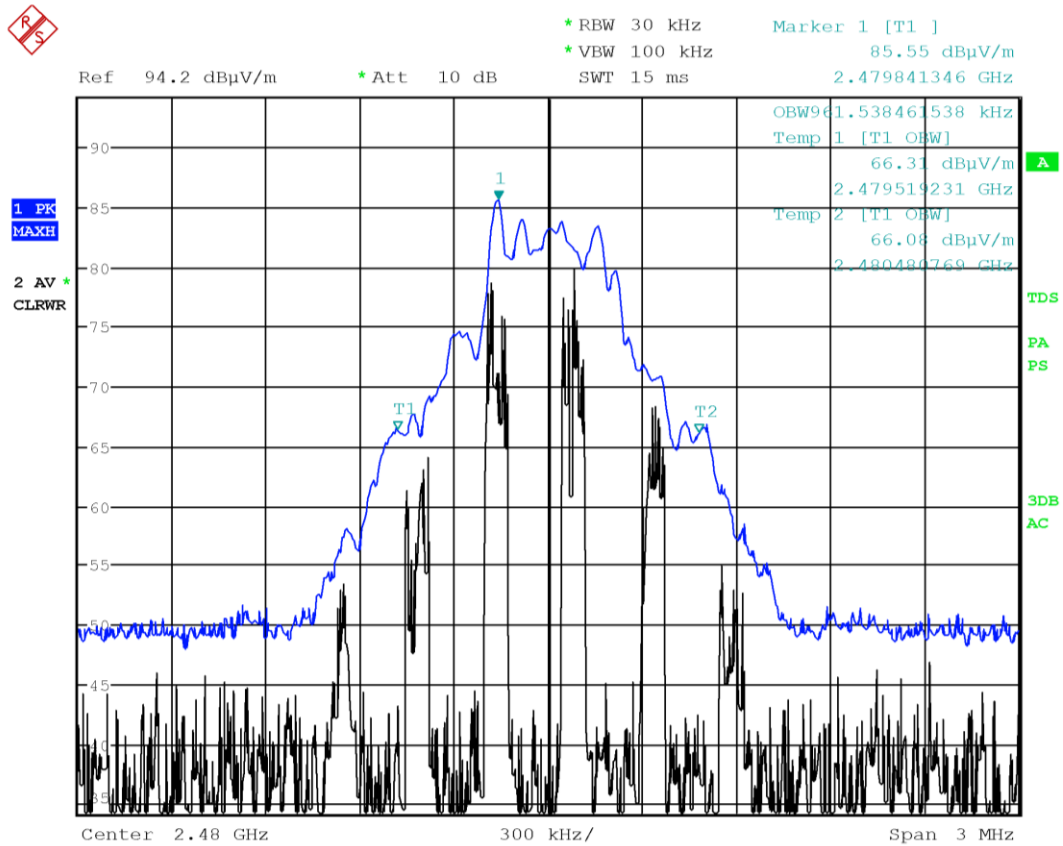
Test data, continued



Date: 23.MAR.2023 17:32:10

Figure 8.3-11: 99% bandwidth on mid channel with GFSK modulation

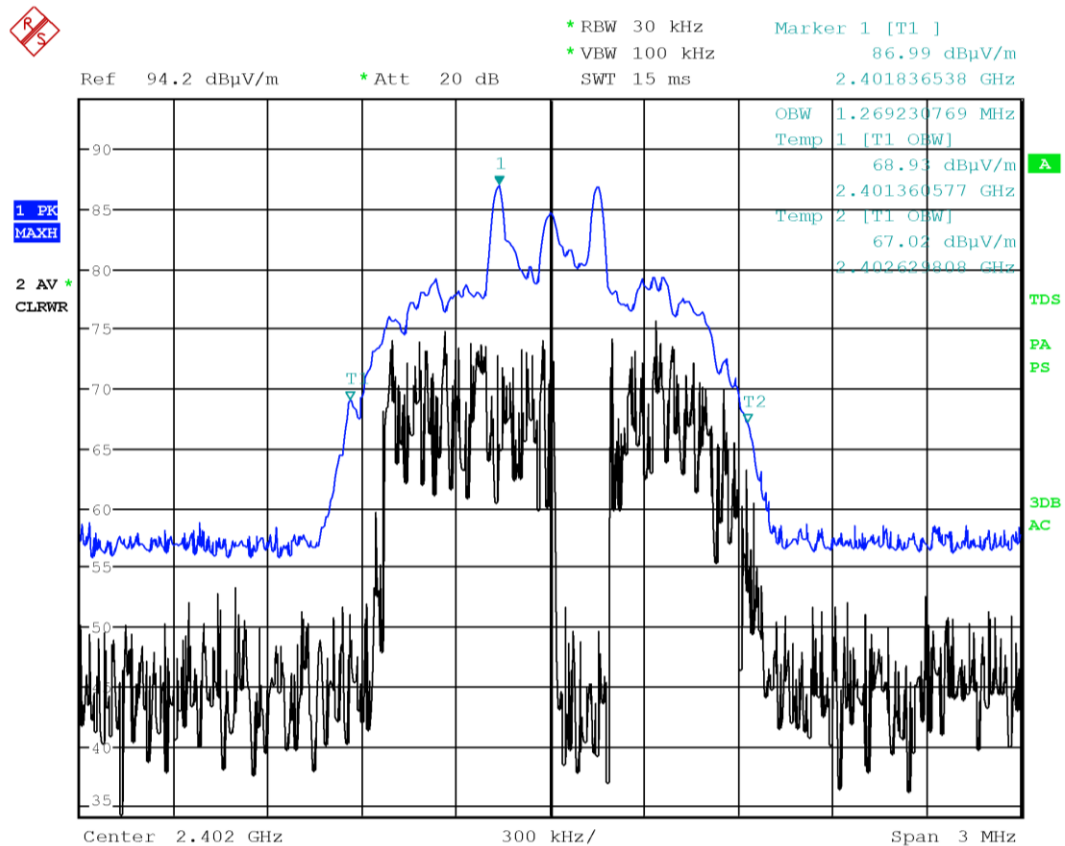
Test data, continued



Date: 23.MAR.2023 17:18:27

Figure 8.3-12: 99% bandwidth on high channel with GFSK modulation

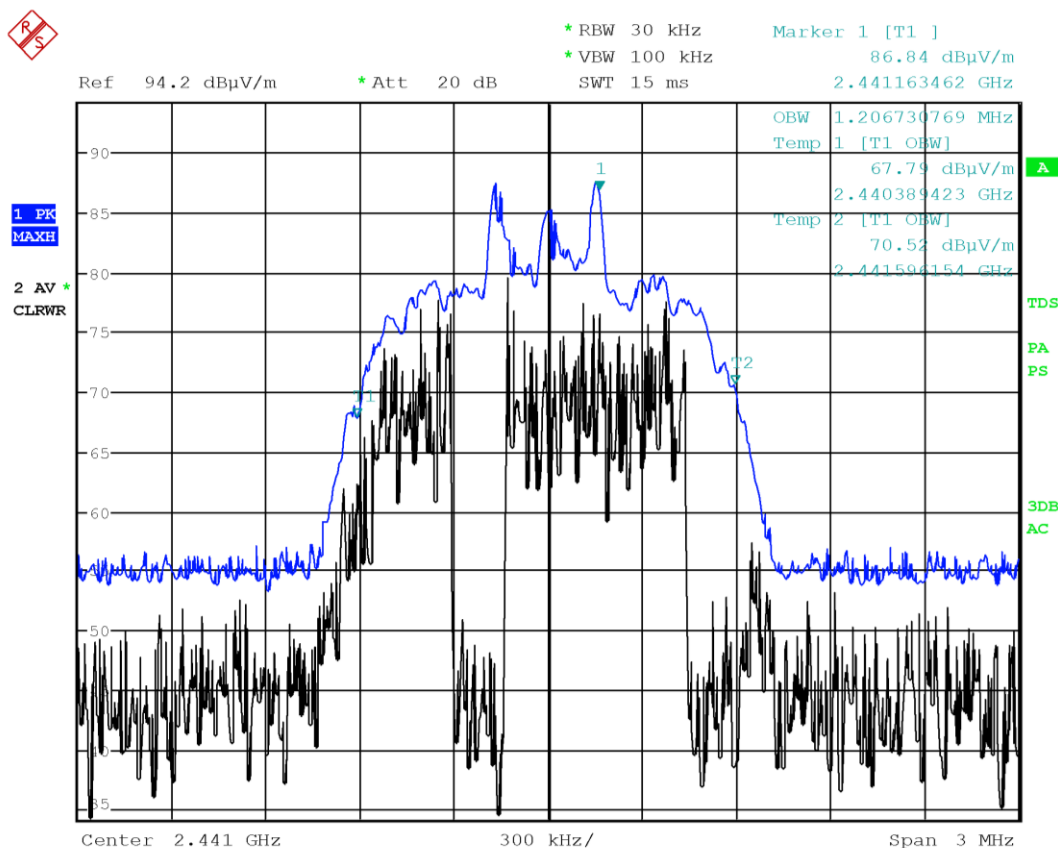
Test data, continued



Date: 23.MAR.2023 16:37:57

Figure 8.3-13: 99% bandwidth on low channel with 8-DPSK modulation

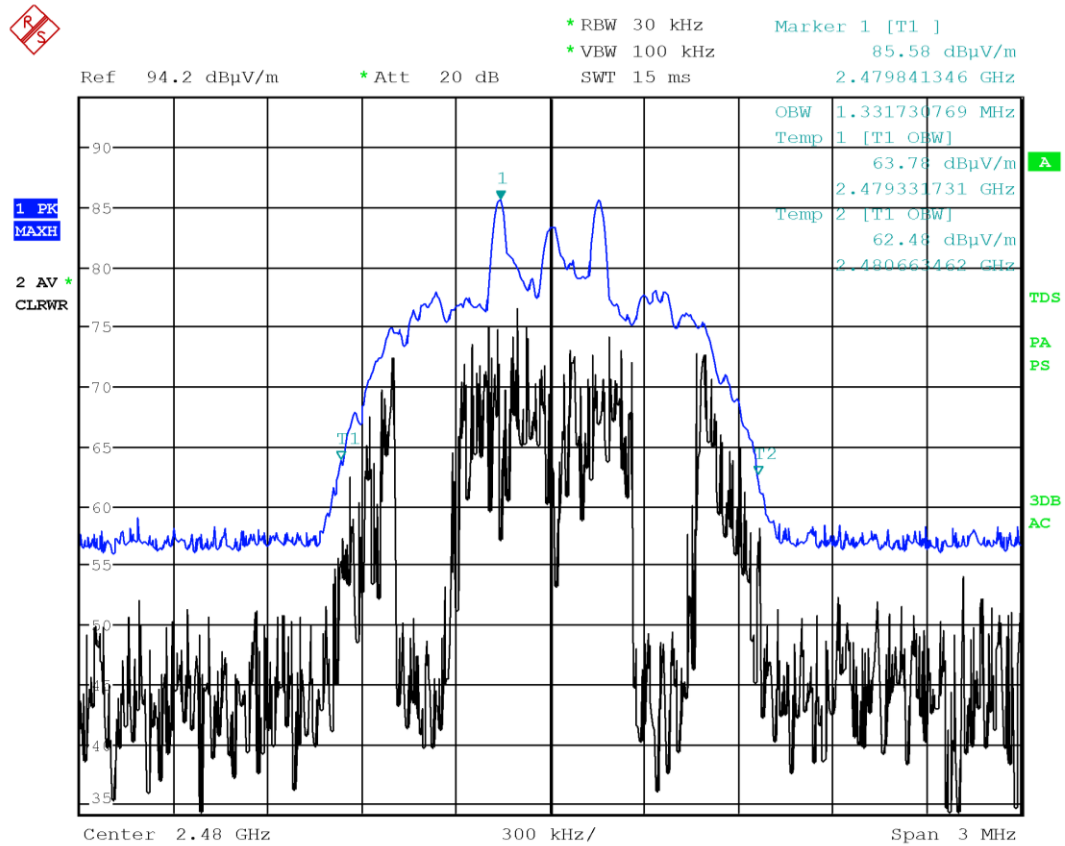
Test data, continued



Date: 23.MAR.2023 16:34:15

Figure 8.3-14: 99% bandwidth on mid channel with 8-DPSK modulation

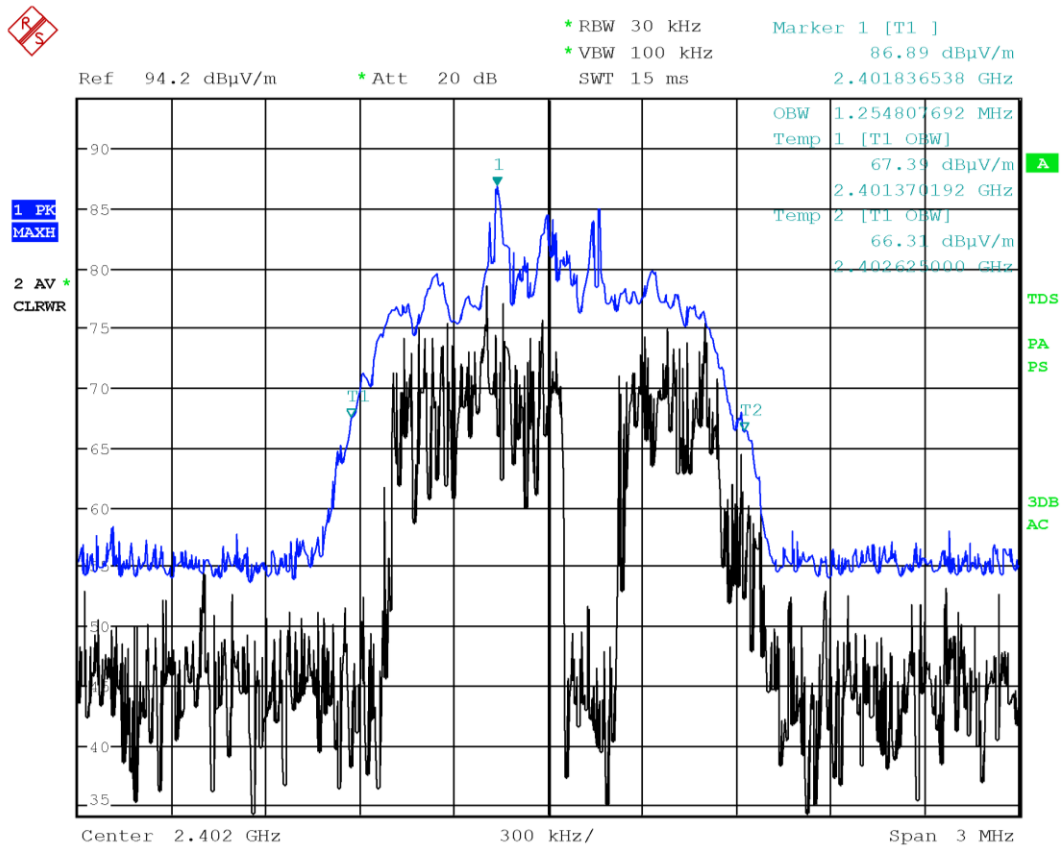
Test data, continued



Date: 23.MAR.2023 16:21:42

Figure 8.3-15: 99% bandwidth on high channel with 8-DPSK modulation

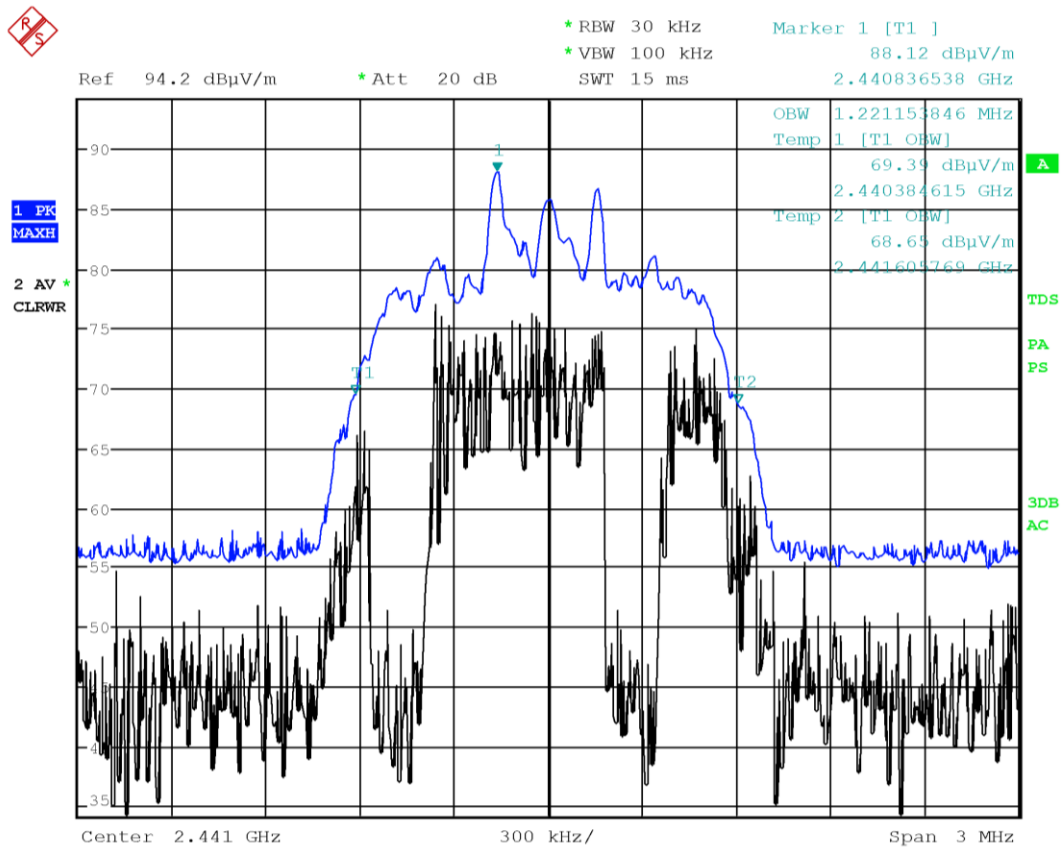
Test data, continued



Date: 23.MAR.2023 17:04:44

Figure 8.3-16: 99% bandwidth on low channel with $\pi/4$ -DQPSK modulation

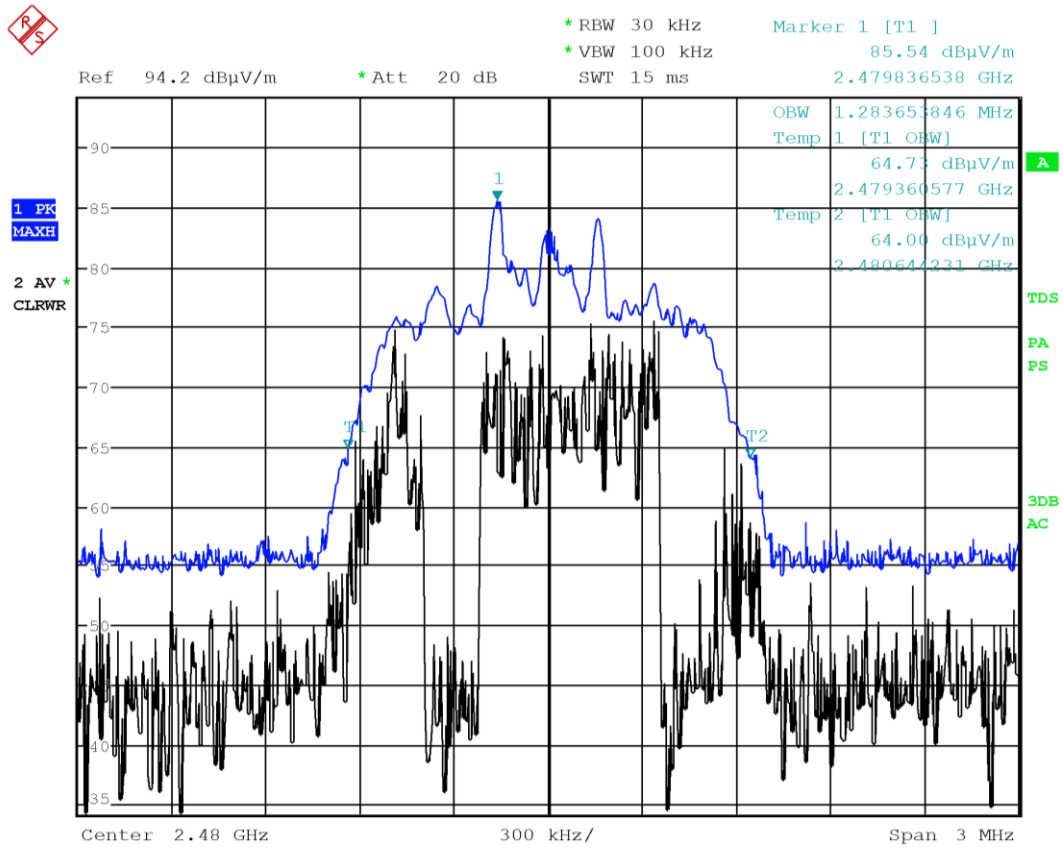
Test data, continued



Date: 23.MAR.2023 17:09:56

Figure 8.3-17: 99% bandwidth on mid channel with $\pi/4$ -DQPSK modulation

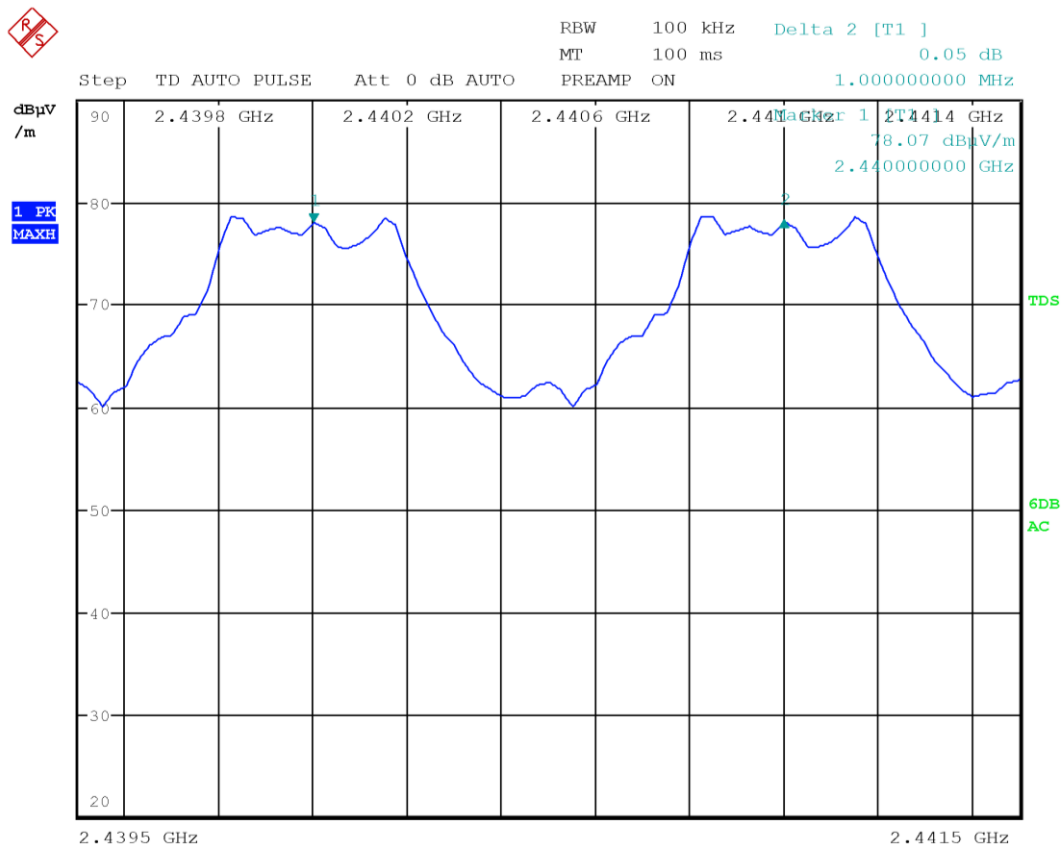
Test data, continued



Date: 23.MAR.2023 17:14:35

Figure 8.3-18: 99% bandwidth on high channel with $\pi/4$ -DQPSK modulation

Test data, continued



Date: 24.MAR.2023 16:31:13

Figure 8.3-19: Carrier frequency separation

Test data, continued

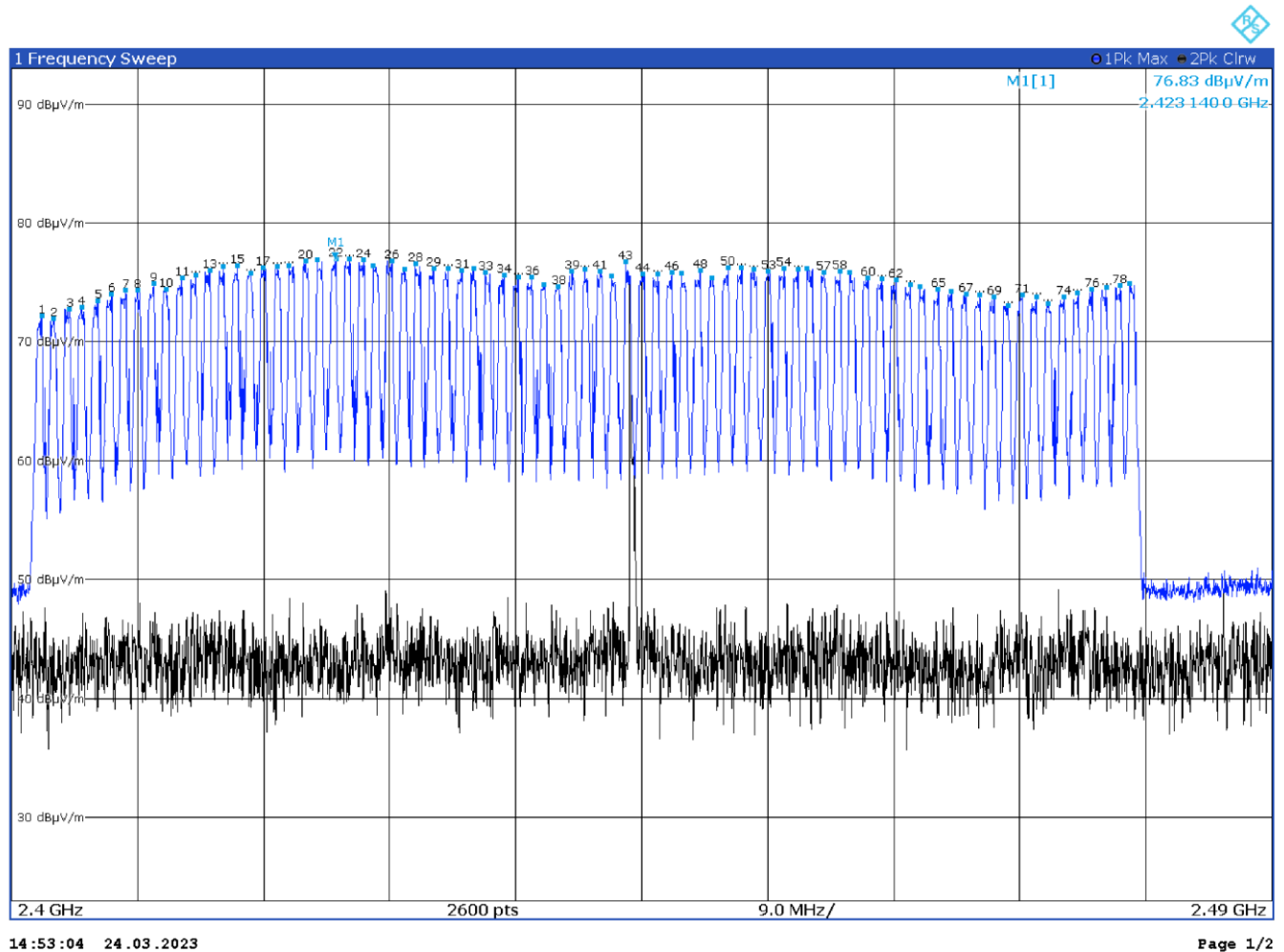
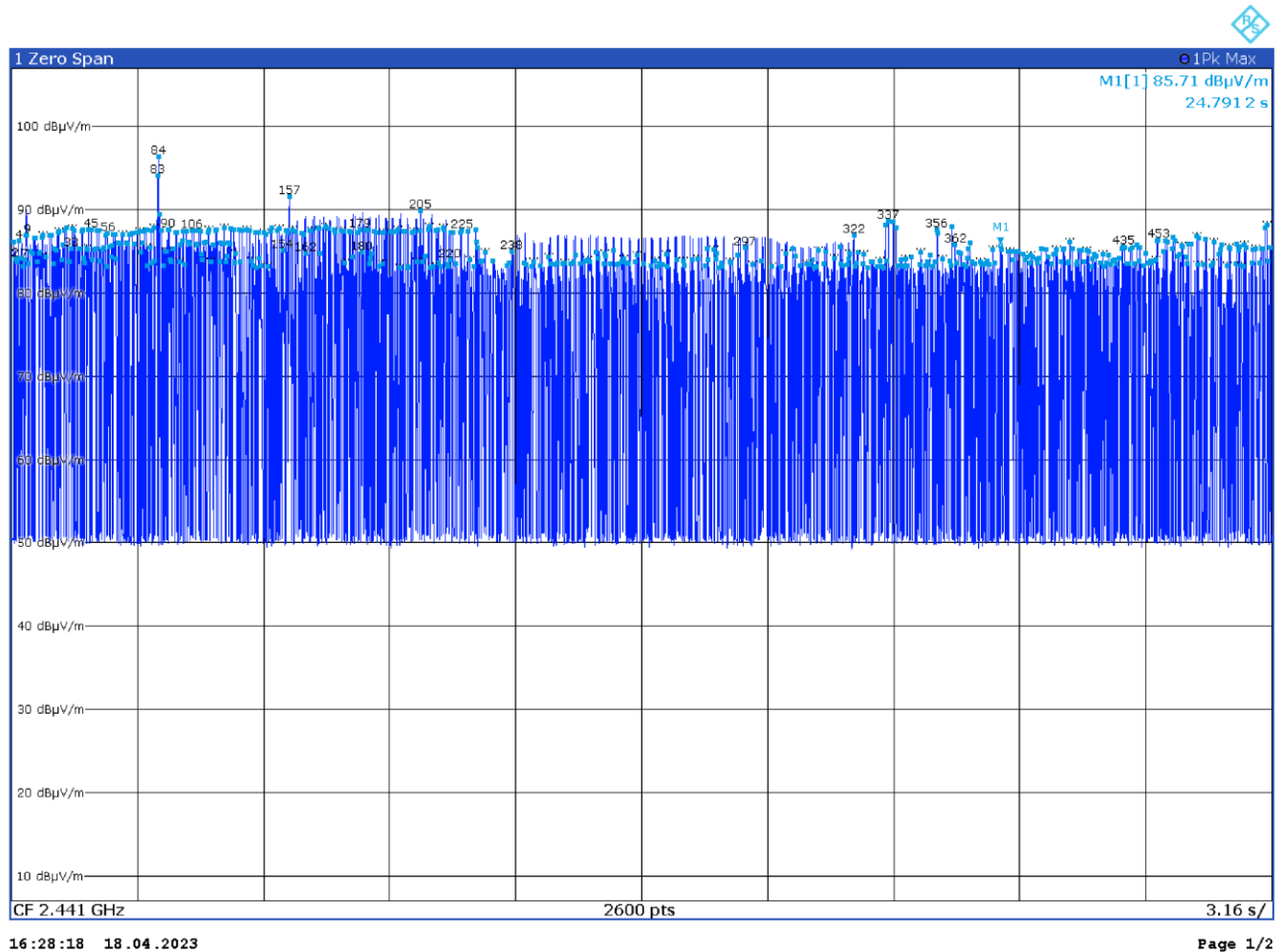


Figure 8.3-20: Number of hopping channels

Test data, continued



244	13.471 643 s	84.309 dBµV/m	494	31.332 513 s	85.348 dBµV/m
245	13.508 119 s	83.522 dBµV/m	495	31.381 147 s	85.347 dBµV/m
246	13.641 862 s	83.409 dBµV/m	496	31.429 781 s	87.904 dBµV/m
247	13.678 338 s	83.687 dBµV/m	497	31.478 415 s	88.237 dBµV/m
248	13.824 240 s	83.530 dBµV/m	498	31.514 890 s	83.894 dBµV/m
249	13.872 874 s	83.665 dBµV/m	499	31.551 366 s	85.431 dBµV/m
250	14.018 776 s	83.554 dBµV/m	500	31.575 683 s	85.458 dBµV/m

16:28:18 18.04.2023

Page 2/2

Figure 8.3-21: Number of pulses within period for DM1 BB Packet type

Test data, continued

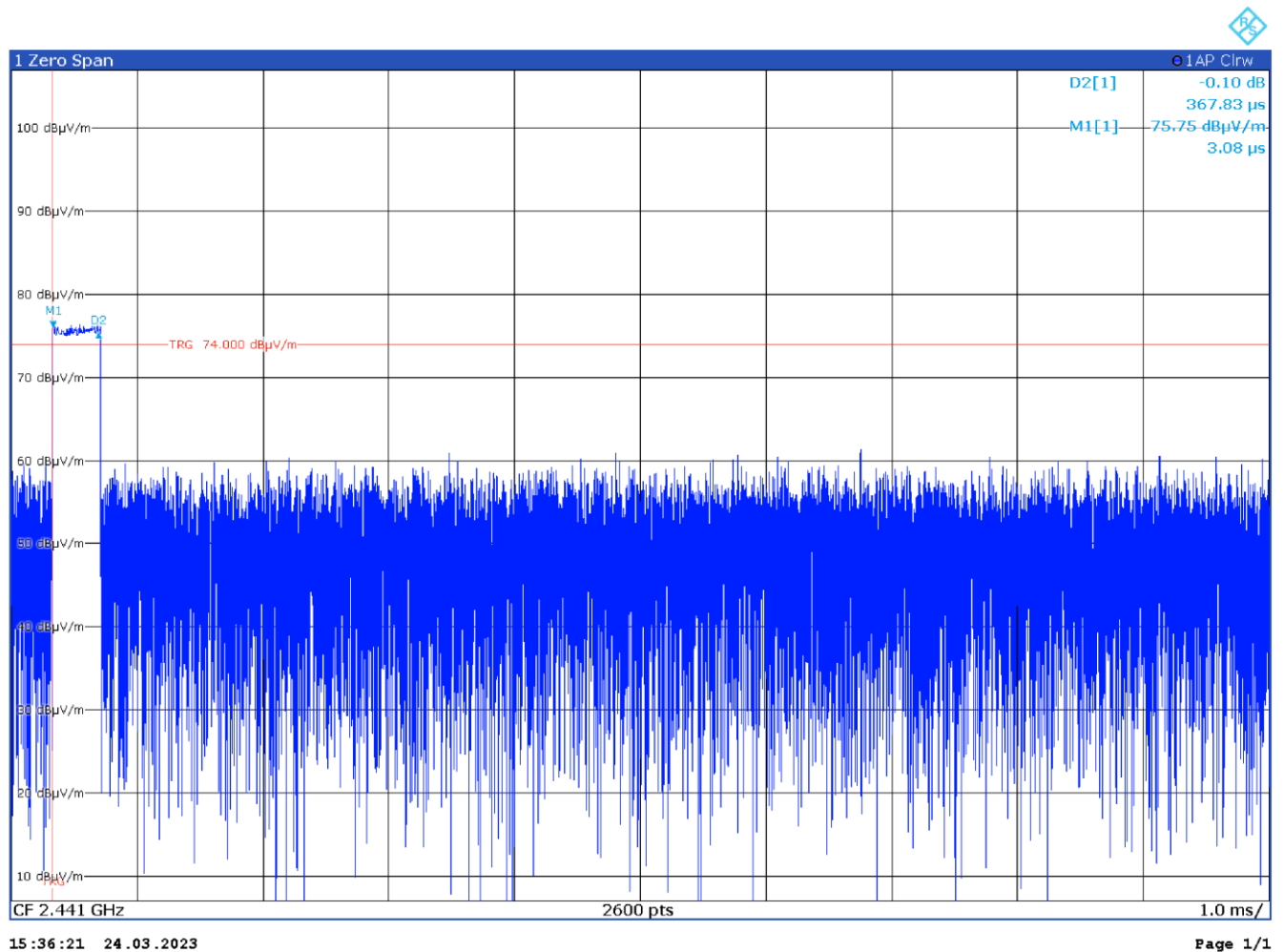
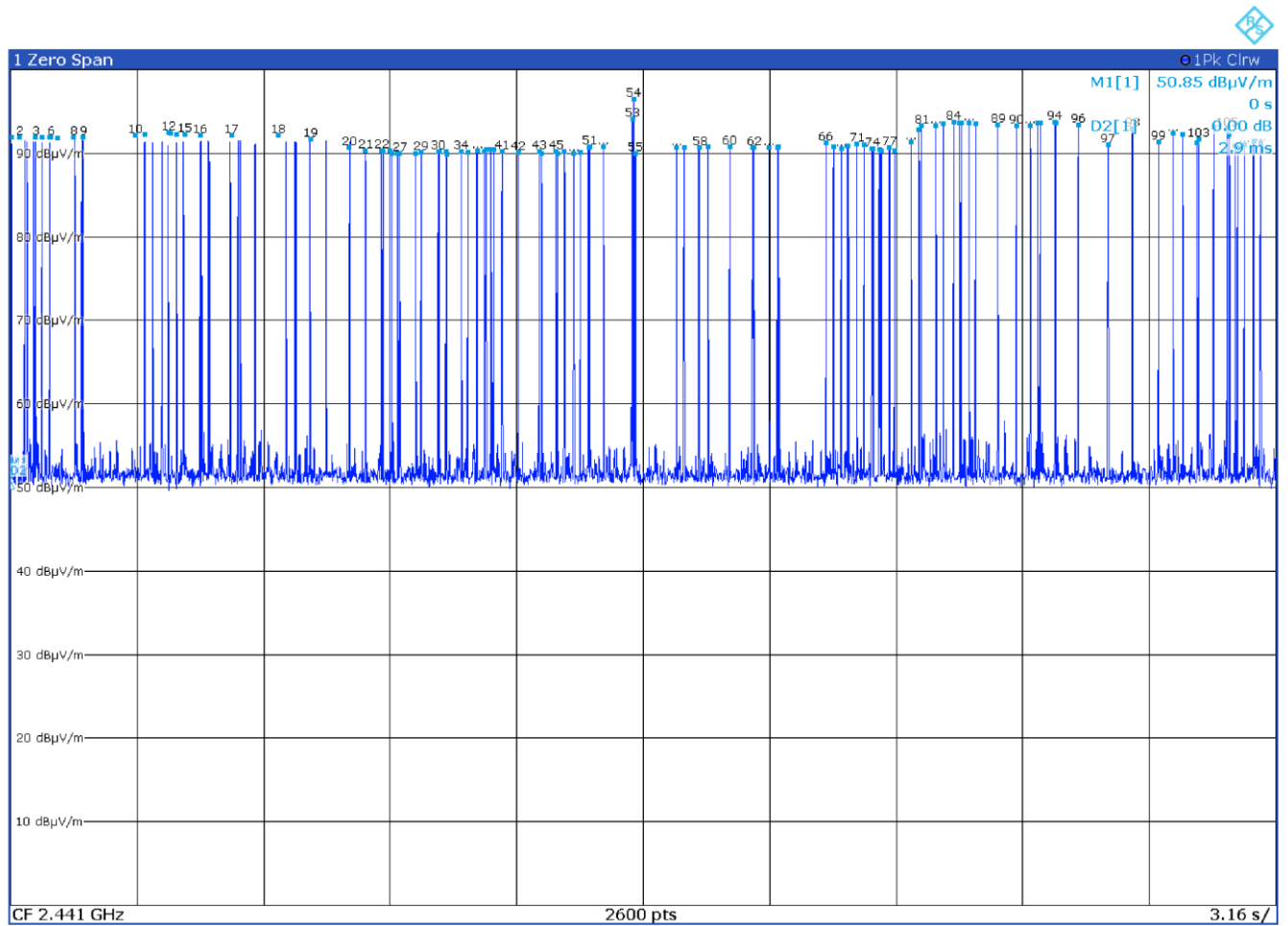


Figure 8.3-22: Dwell time for DM1 BB Packet type

Test data, continued



14:56:47 18.04.2023

Page 1/2

34	5.218000 s	92.200 dBμV/m	134	19.137314 s	91.225 dBμV/m
35	5.252482 s	91.440 dBμV/m	135	19.502270 s	90.759 dBμV/m
36	5.872566 s	91.182 dBμV/m	136	19.550904 s	91.097 dBμV/m
37	5.909042 s	91.535 dBμV/m	137	19.684648 s	90.846 dBμV/m
38	6.456175 s	92.376 dBμV/m	138	19.757599 s	91.102 dBμV/m
39	6.589919 s	92.530 dBμV/m	139	19.891343 s	90.719 dBμV/m
40	6.784456 s	92.391 dBμV/m	140	19.927818 s	90.981 dBμV/m
41	6.833090 s	92.466 dBμV/m	141	20.280416 s	90.654 dBμV/m
42	6.881724 s	91.518 dBμV/m	142	20.924817 s	91.048 dBμV/m
43	7.112736 s	91.442 dBμV/m	143	21.034244 s	90.618 dBμV/m
44	7.222162 s	92.487 dBμV/m	144	21.180146 s	90.721 dBμV/m
45	7.611235 s	92.524 dBμV/m	145	21.265256 s	90.635 dBμV/m
46	8.146210 s	92.570 dBμV/m	146	21.678646 s	91.509 dBμV/m
47	8.243478 s	91.613 dBμV/m	147	21.848865 s	90.682 dBμV/m
48	8.608234 s	91.720 dBμV/m	148	21.909658 s	91.476 dBμV/m
49	8.669027 s	91.769 dBμV/m	149	22.055560 s	91.479 dBμV/m

14:50:34 18.04.2023

Page 2/2

Figure 8.3-23: Number of pulses within period for DH5 BB Packet type

Test data, continued

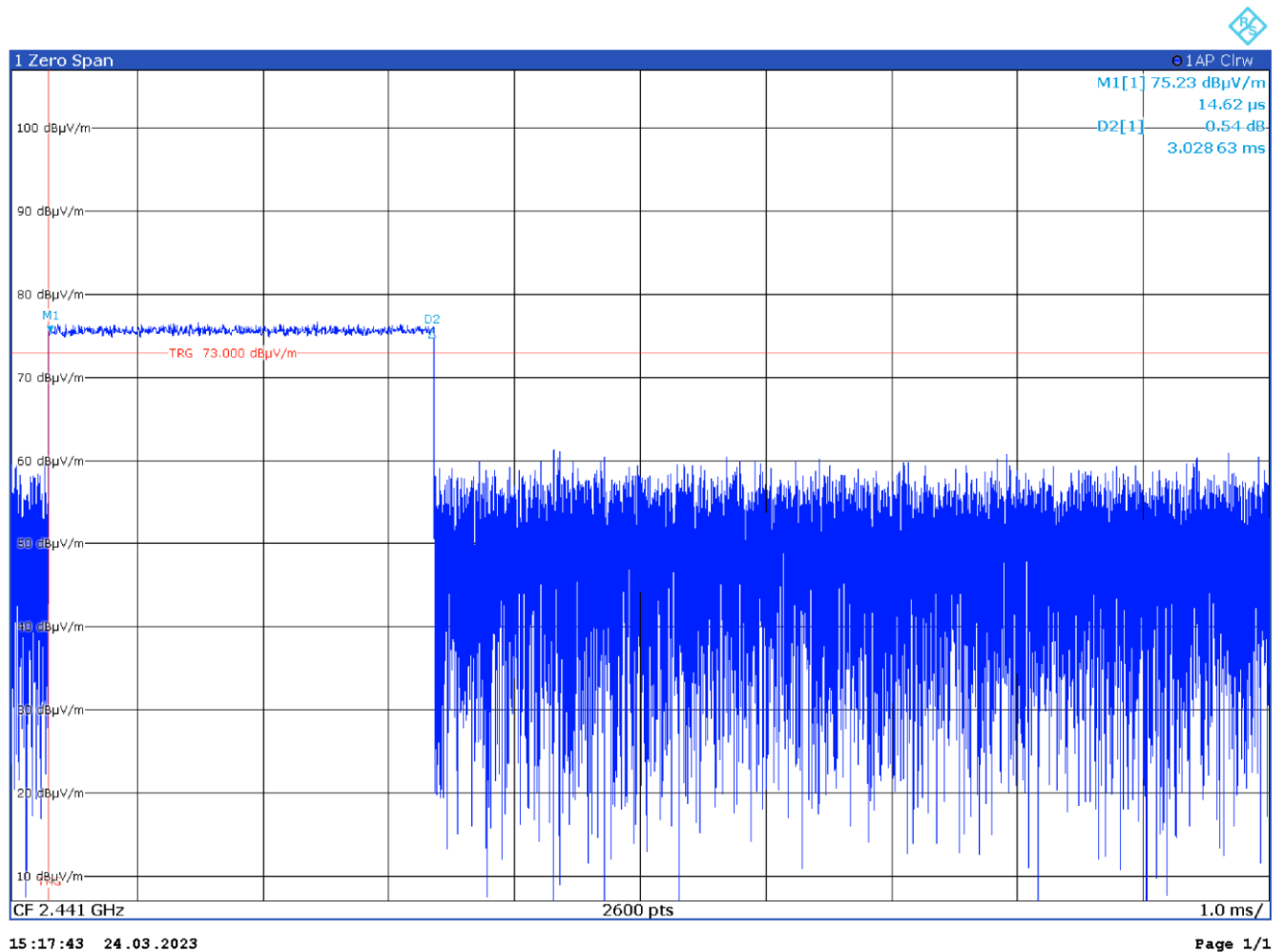


Figure 8.3-24: Dwell time for DH5 BB Packet type

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

8.4.1 References, definitions and limits

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.

8.4.2 Test summary

Verdict	Pass		
Tested by	D. Guarnone	Test date	March 23, 2023

8.4.3 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

8.4.4 Test equipment used

Equipment	Manufacturer	Model no.	Asset no.
EMI Receiver	Rohde & Schwarz	ESW44	101620
Spectrum Analyzer	Rohde & Schwarz	FSW43	101767
Antenna 1 - 18 GHz	Schwarzbeck Mess-Elektronik	STLP9148	STLP 9148-152
Controller	Maturo	FCU3.0	10041
Tilt antenna mast	Maturo	TAM4.0-E	10042
Turntable	Maturo	TT4.0-5T	2.527
Semi-anechoic chamber	Nemko S.p.a.	10m semi-anechoic chamber	530

8.4.5 Test data

Table 8.4-1: Output power and EIRP results for GFSK (radiated measurement)

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
2402	88.93	-6.23	36	-42.23	1.7	-7.93	30	-37.93
2440	90.62	-4.54	36	-40.54	1.7	-6.24	30	-36.24
2480	89.06	-6.10	36	-42.10	1.7	-7.80	30	-37.80

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

Table 8.4-2: Output power and EIRP results for π/4-DQPSK (radiated measurement)

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
2402	90.07	-5.09	36	-41.09	1.7	-6.79	30	-36.79
2440	90.54	-4.62	36	-40.62	1.7	-6.32	30	-36.32
2480	88.79	-6.37	36	-42.37	1.7	-8.07	30	-38.07

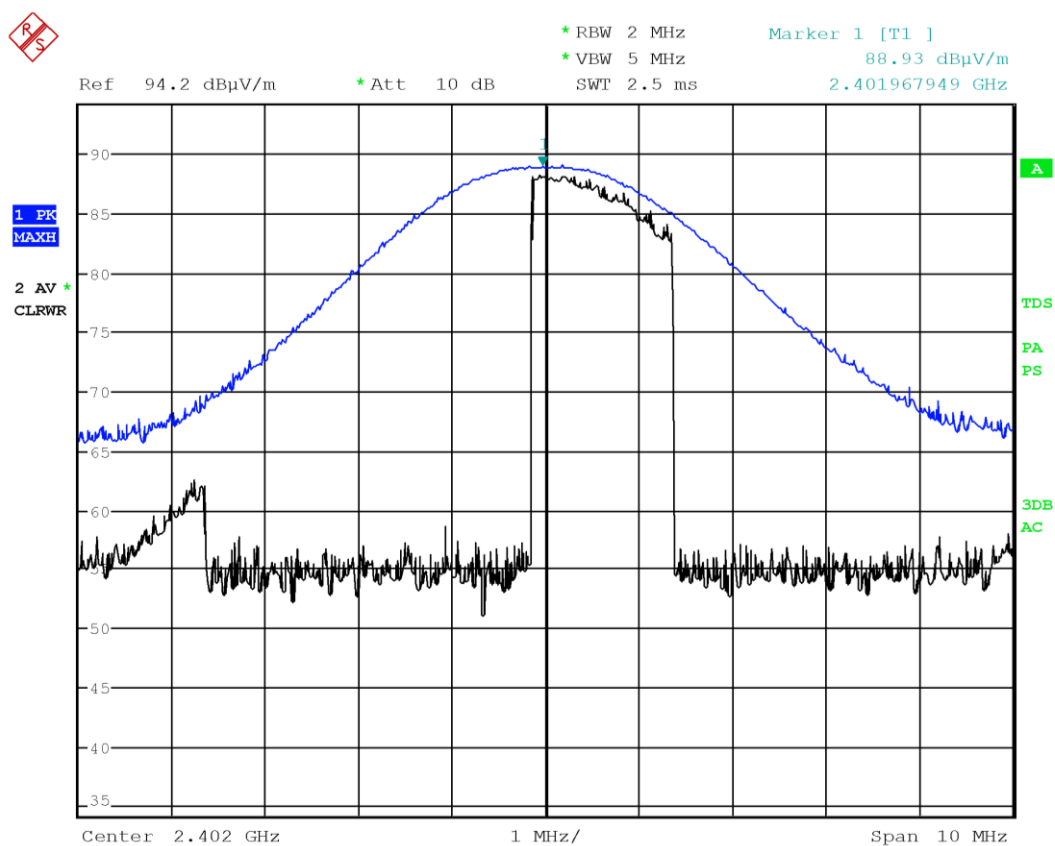
Note: EIRP [dBm] = Field Strength [dBμV/m] – 95.23 [dB]; Output power [dBm] = EIRP [dBm] – Antenna gain [dBi]

Table 8.4-3: Output power and EIRP results for 8-DPSK (radiated measurement)

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
2402	90.65	-4.51	36	-40.51	1.7	-6.21	30	-36.21
2440	90.68	-4.47	36	-40.47	1.7	-6.18	30	-36.18
2480	89.04	-6.12	36	-42.12	1.7	-7.82	30	-37.82

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

Test data, continued



Date: 23.MAR.2023 18:06:46

Figure 8.4-1: Output power on low channel for GFSK modulation