Test Report

FINAS
Finnish Accreditation Service
T004 (EN ISO/IEC 17025)

INTENTIONAL RADIATOR TESTS ACCORDING TO FCC PART 90 AND ISED CANADA REQUIREMENTS

Equipment Under Test:	Radio modem module
Model:	SATEL-TR4+
Manufacturer:	Satel Oy P.O. Box 142 (Meriniitynkatu 17) FI-24101, SALO FINLAND
Customer:	Satel Oy P.O. Box 142 (Meriniitynkatu 17) FI-24101, SALO FINLAND
FCC Rule Part: IC Rule Part: KDB:	90: October 2019 RSS-119, Issue 12, May 2015 971168 D01 Power Meas License Digital Systems v03r01 Measurement Guidance for Certification of Licensed Digital Transmitters (April 9, 2018)

Date:	5 March 2020	Date:	5 March 2020
Issued by:	Pekka Kalviäinen Testing Engineer	Checked by:	Mikko Halonen Development Engineer

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GENERAL REMARKS

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Unless otherwise stated the results shown in this test report refer only to the sample(s) tested and such sample(s) are retained for 30 days only.

RELEASE HISTORY

Version	Changes	Issued
1.0	Initial release	5 March 2020

PRODUCT DESCRIPTION

Equipment Under Test

Trade mark:	Satel
Model:	SATEL-TR4+
Type:	SATEL-TRA40
Serial no:	2002000014
FCC ID:	MRBSATEL-TA40
IC:	2422A-SATELTA40

General Description

SATEL-TR4+ is a radio modem module. It uses 400 MHz frequency band.

Classification

Fixed device	☒
Mobile Device (Human body distance > 20cm)	☒
Portable Device (Human body distance < 20cm)	☐

Modifications Incorporated in the EUT

No modifications.

Ports and cables

Cable / Port	Description
Serial port RS232	Device configuration and data communication. Unshielded
DC input port	3.8 – 5.5 VDC
Antenna port	50Ω TNC (female)

Specifications

Frequency:	410 – 430 MHz and 450 – 470 MHz
Channel width:	12.5 kHz / 25 kHz
Channel spacing:	12.5 kHz, 20 kHz (uses 12.5 kHz channel width), 25 kHz
Modulation:	4FSK, 8FSK, 16FSK
Carrier power:	0.1, 0.2, 0.5, 1 W
Power supply:	3.8 – 5.5 VDC

Mechanical Size of the EUT

Height: 6 mm Width: 35 mm Length: 56 mm

Peripherals

Peripheral	Description / Usage
Test PC	Device configuration and monitoring with programs supplied by customer.

SUMMARY OF TESTING

Test Specification	Description of Test	Result
§90.205 / RSS-119 5.4	Transmitter output power	PASS
§90.210 / RSS-119 5.5	Occupied bandwidth	PASS
§90.210 / RSS-119 5.5	Spectrum emission mask	PASS
§90.210 / RSS-119 5.8	Spurious emissions (conducted)	PASS
§90.210 / RSS-119 5.8	Spurious emissions (radiated)	PASS
§90.213 / RSS-119 5.3	Frequency stability	PASS
§90.214 / RSS-119 5.9	Transient frequency behaviour	PASS

The decision rule applied for the tests results stated in this test report is according to the requirements of section 1.3 of ANSI C63.26-2015.

EUT Test Conditions

The EUT was in continuous transmit mode during all the tests. The EUT was configured into the wanted channel using software provided by the manufacturer. During the tests the EUT was mounted on an evaluation kit provided by the manufacturer (model M3-TR3 Evaluation kit).

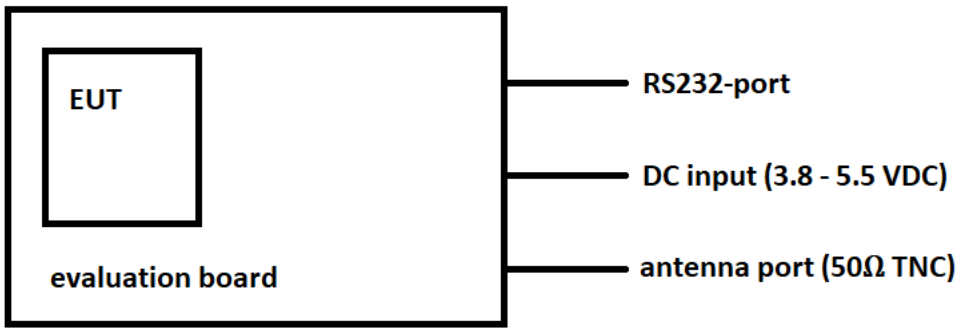


Figure 1: Test setup block diagram

Table 1: Transmission mode of the EUT

Channel width (kHz)	Modulation	On-air data rate
12.5	4 FSK	9600
	8 FSK	14400
	16 FSK	19200
25	4 FSK	19200
	8 FSK	28800
	16 FSK	38400

Table 2: Test frequencies used in the tests

Channel	Frequency (MHz)
low	410.0
middle 1	429.5
middle 2	450.4
high	469.5

Test Facility

Testing Laboratory / address: FCC designation number: **FI0002** ISED CAB identifier: **T004**	SGS Fimko Ltd Takomotie 8 FI-00380, HELSINKI FINLAND
Test Site:	☐ K10LAB, ISED Canada registration number: **8708A-1** ☒ K5LAB, ISED Canada registration number: **8708A-2** ☐ T10LAB

TEST RESULTS

Transmitter output power

Standard:	ANSI C63.26 (2015)	
Tested by:	PKA	
Date:	12 January 2020	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 %RH	
Measurement uncertainty:	± 0.470 dB	Level of confidence 95.45 % (k = 2)
Test result:	**PASS**	

FCC Rule: 90.205
RSS-119 5.4

The output power shall be within ±1 dB of the manufacturer's rated power listed in the equipment specifications.

The measurements were performed with a spectrum analyser.

Test results

Table 3. Rated output power 100 mW (20.00 dBm)

Frequency (MHz)	Ch. Spacing (kHz)	Modulation	Measured Output Power (dBm)	Result
410.0	12.5	4 FSK	20.25	PASS
410.0	12.5	8 FSK	20.25	PASS
410.0	12.5	16 FSK	20.28	PASS
410.0	25	4 FSK	20.26	PASS
410.0	25	8 FSK	20.29	PASS
410.0	25	16 FSK	20.39	PASS
429.5	12.5	4 FSK	20.34	PASS
429.5	12.5	8 FSK	20.35	PASS
429.5	12.5	16 FSK	20.27	PASS
429.5	25	4 FSK	20.35	PASS
429.5	25	8 FSK	20.32	PASS
429.5	25	16 FSK	20.31	PASS
450.5	12.5	4 FSK	19.93	PASS
450.5	12.5	8 FSK	19.89	PASS
450.5	12.5	16 FSK	19.87	PASS
450.5	25	4 FSK	19.92	PASS
450.5	25	8 FSK	19.91	PASS
450.5	25	16 FSK	19.91	PASS
469.5	12.5	4 FSK	20.01	PASS
469.5	12.5	8 FSK	20.00	PASS
469.5	12.5	16 FSK	20.02	PASS
469.5	25	4 FSK	19.99	PASS
469.5	25	8 FSK	20.01	PASS
469.5	25	16 FSK	20.03	PASS

Table 4. Rated output power 200 mW (23.01 dBm)

Frequency (MHz)	Ch. Spacing (kHz)	Modulation	Measured Output Power (dBm)	Result
410.0	12.5	4 FSK	23.05	PASS
410.0	12.5	8 FSK	23.07	PASS
410.0	12.5	16 FSK	23.10	PASS
410.0	25	4 FSK	23.06	PASS
410.0	25	8 FSK	23.11	PASS
410.0	25	16 FSK	23.20	PASS
429.5	12.5	4 FSK	23.16	PASS
429.5	12.5	8 FSK	23.16	PASS
429.5	12.5	16 FSK	23.11	PASS
429.5	25	4 FSK	23.16	PASS
429.5	25	8 FSK	23.14	PASS
429.5	25	16 FSK	23.14	PASS
450.5	12.5	4 FSK	22.78	PASS
450.5	12.5	8 FSK	22.75	PASS
450.5	12.5	16 FSK	22.64	PASS
450.5	25	4 FSK	22.78	PASS
450.5	25	8 FSK	22.77	PASS
450.5	25	16 FSK	22.76	PASS
469.5	12.5	4 FSK	22.88	PASS
469.5	12.5	8 FSK	22.88	PASS
469.5	12.5	16 FSK	22.89	PASS
469.5	25	4 FSK	22.88	PASS
469.5	25	8 FSK	22.89	PASS
469.5	25	16 FSK	22.89	PASS

Table 5. Rated output power 500 mW (26.99 dBm)

Frequency (MHz)	Ch. Spacing (kHz)	Modulation	Measured Output Power (dBm)	Result
410.0	12.5	4 FSK	27.21	PASS
410.0	12.5	8 FSK	27.26	PASS
410.0	12.5	16 FSK	27.34	PASS
410.0	25	4 FSK	27.18	PASS
410.0	25	8 FSK	27.27	PASS
410.0	25	16 FSK	27.36	PASS
429.5	12.5	4 FSK	27.32	PASS
429.5	12.5	8 FSK	27.32	PASS
429.5	12.5	16 FSK	27.29	PASS
429.5	25	4 FSK	27.32	PASS
429.5	25	8 FSK	27.29	PASS
429.5	25	16 FSK	27.30	PASS
450.5	12.5	4 FSK	26.92	PASS
450.5	12.5	8 FSK	26.91	PASS
450.5	12.5	16 FSK	26.90	PASS
450.5	25	4 FSK	26.93	PASS
450.5	25	8 FSK	26.92	PASS
450.5	25	16 FSK	26.92	PASS
469.5	12.5	4 FSK	26.94	PASS
469.5	12.5	8 FSK	26.95	PASS
469.5	12.5	16 FSK	26.96	PASS
469.5	25	4 FSK	26.94	PASS
469.5	25	8 FSK	26.95	PASS
469.5	25	16 FSK	26.96	PASS

Table 6. Rated output power 1000 mW (30.00 dBm)

Frequency (MHz)	Ch. Spacing (kHz)	Modulation	Measured Output Power (dBm)	Result
410.0	12.5	4 FSK	29.92	PASS
410.0	12.5	8 FSK	29.97	PASS
410.0	12.5	16 FSK	30.06	PASS
410.0	25	4 FSK	29.93	PASS
410.0	25	8 FSK	29.97	PASS
410.0	25	16 FSK	30.06	PASS
429.5	12.5	4 FSK	30.00	PASS
429.5	12.5	8 FSK	30.01	PASS
429.5	12.5	16 FSK	29.97	PASS
429.5	25	4 FSK	30.01	PASS
429.5	25	8 FSK	29.97	PASS
429.5	25	16 FSK	29.99	PASS
450.5	12.5	4 FSK	29.56	PASS
450.5	12.5	8 FSK	29.55	PASS
450.5	12.5	16 FSK	29.55	PASS
450.5	25	4 FSK	29.57	PASS
450.5	25	8 FSK	29.56	PASS
450.5	25	16 FSK	29.56	PASS
469.5	12.5	4 FSK	29.26	PASS
469.5	12.5	8 FSK	29.27	PASS
469.5	12.5	16 FSK	29.29	PASS
469.5	25	4 FSK	29.26	PASS
469.5	25	8 FSK	29.28	PASS
469.5	25	16 FSK	29.29	PASS

Occupied bandwidth

Standard:	ANSI C63.26 (2015)	
Tested by:	PKA	
Date:	25 February 2020	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 %RH	
Measurement uncertainty:	± 0.0005 %	Level of confidence 95.45 % (k = 2)
Test result:	**PASS**	

FCC Rule: 90.210
RSS-119 5.5

The occupied bandwidth is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained.

The maximum permissible occupied bandwidth shall not exceed the authorized bandwidth specified for the equipment's frequency band. The authorized bandwidth is defined as the maximum width of the band of frequencies used to derive spectrum masks and is not necessarily equivalent to the bandwidth found on radio and spectrum licenses.

Frequency Band (MHz)	Channel Bandwidth (kHz)	Authorized Bandwidth (kHz)
406.1-430 and 450-470	12.5	11.25
	25	20

Test results

Table 7: Occupied bandwidth test results

Frequency (MHz)	Ch. Spacing (kHz)	Modulation	Occupied Bandwidth (kHz)	Result
410.0	12.5	4 FSK	8.32	PASS
410.0	12.5	8 FSK	7.66	PASS
410.0	12.5	16 FSK	8.26	PASS
410.0	25	4 FSK	16.04	PASS
410.0	25	8 FSK	16.86	PASS
410.0	25	16 FSK	18.09	PASS
429.5	12.5	4 FSK	8.25	PASS
429.5	12.5	8 FSK	7.66	PASS
429.5	12.5	16 FSK	8.26	PASS
429.5	25	4 FSK	16.04	PASS
429.5	25	8 FSK	16.87	PASS
429.5	25	16 FSK	18.09	PASS
450.5	12.5	4 FSK	8.26	PASS
450.5	12.5	8 FSK	7.63	PASS
450.5	12.5	16 FSK	8.26	PASS
450.5	25	4 FSK	16.04	PASS
450.5	25	8 FSK	16.86	PASS
450.5	25	16 FSK	18.09	PASS
469.5	12.5	4 FSK	8.26	PASS
469.5	12.5	8 FSK	7.66	PASS
469.5	12.5	16 FSK	8.26	PASS
469.5	25	4 FSK	16.03	PASS
469.5	25	8 FSK	16.84	PASS
469.5	25	16 FSK	18.08	PASS

EUT frequency 410.0 MHz

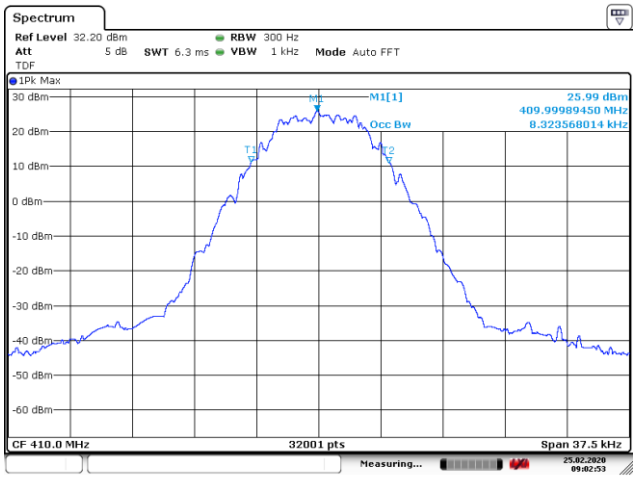


Figure 2: OBW (4 FSK, 12.5 kHz)

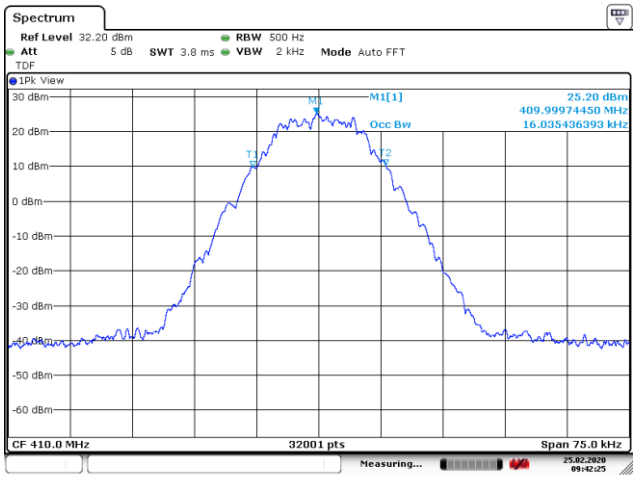


Figure 3: OBW (4 FSK, 25 kHz)

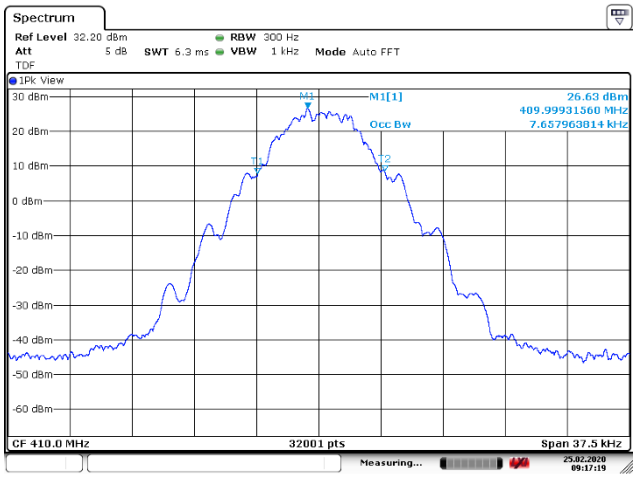


Figure 4: OBW (8 FSK, 12.5 kHz)

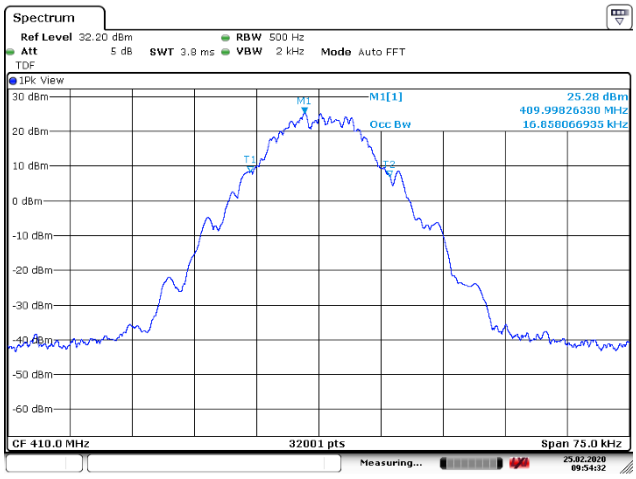


Figure 5: OBW (8 FSK, 25 kHz)

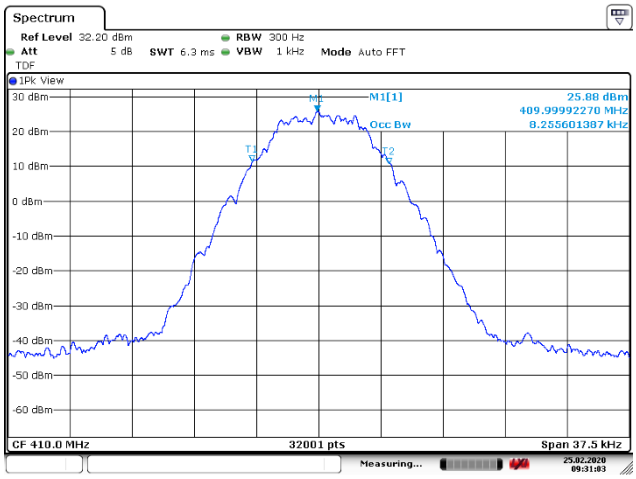


Figure 6: OBW (16 FSK, 12.5 kHz)

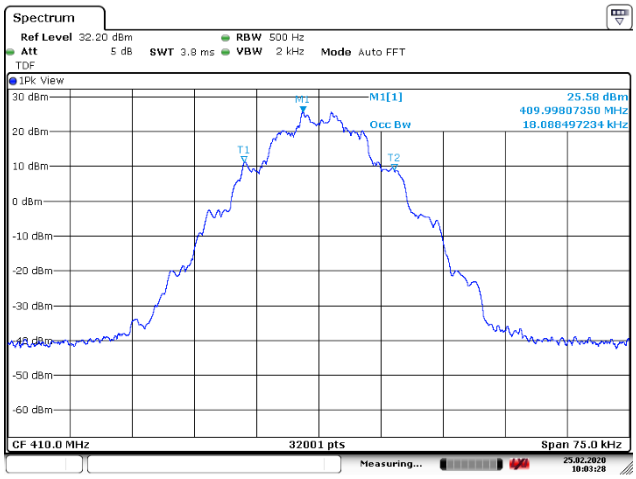


Figure 7: OBW (16 FSK, 25 kHz)

EUT frequency 429.5 MHz

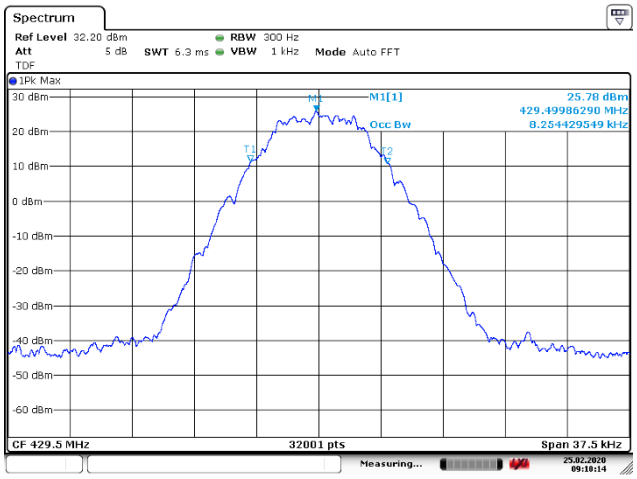


Figure 8: OBW (4 FSK, 12.5 kHz)

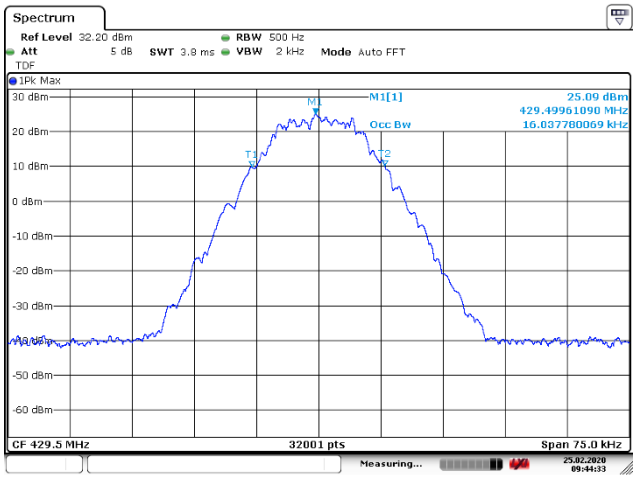


Figure 9: OBW (4 FSK, 25 kHz)

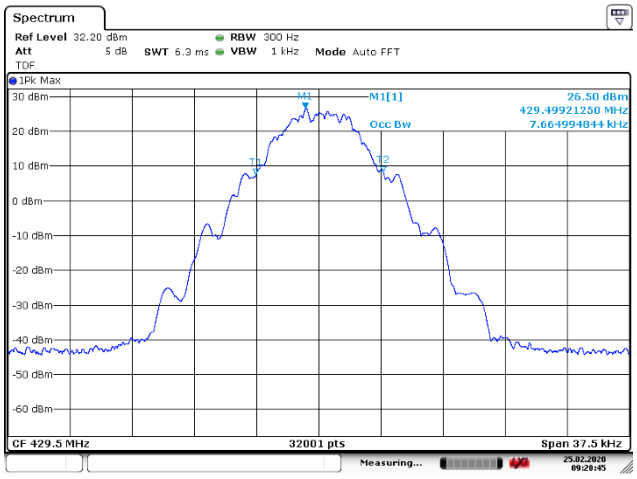


Figure 10: OBW (8 FSK, 12.5 kHz)

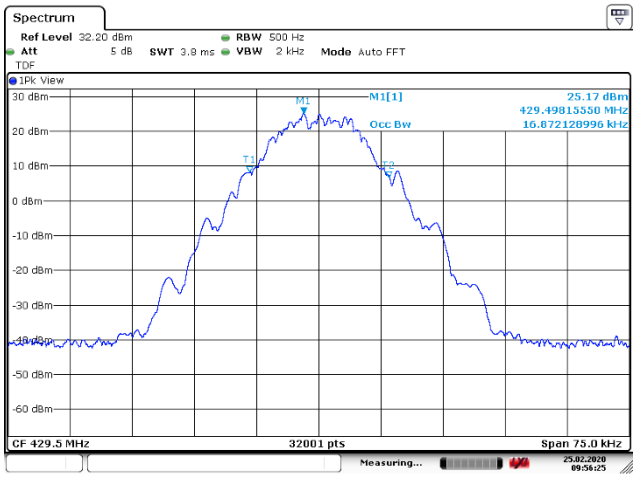


Figure 11: OBW (8 FSK, 25 kHz)

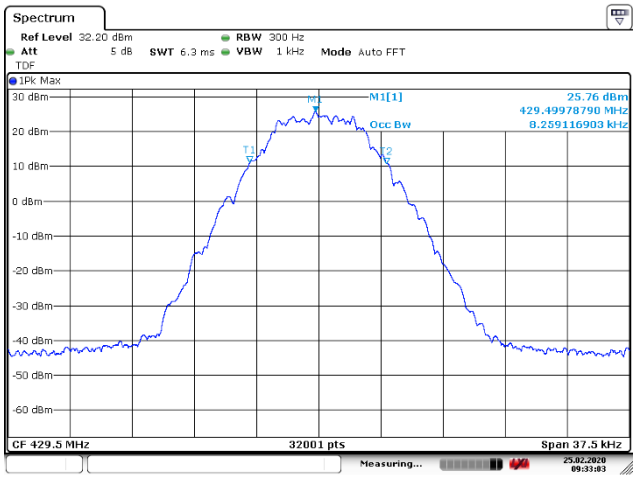


Figure 12: OBW (16 FSK, 12.5 kHz)

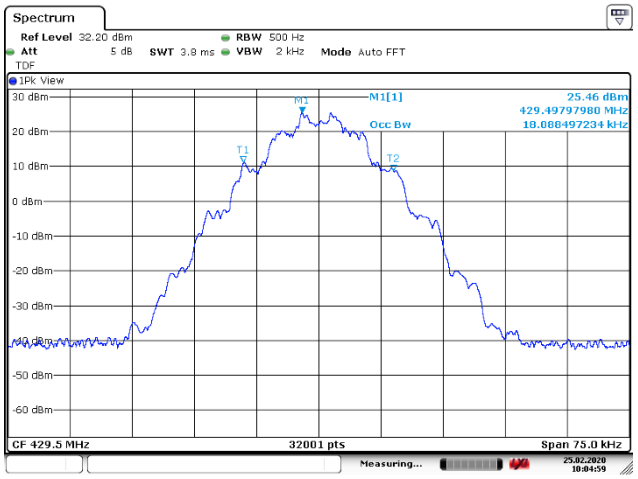


Figure 13: OBW (16 FSK, 25 kHz)

EUT frequency 450.5 MHz

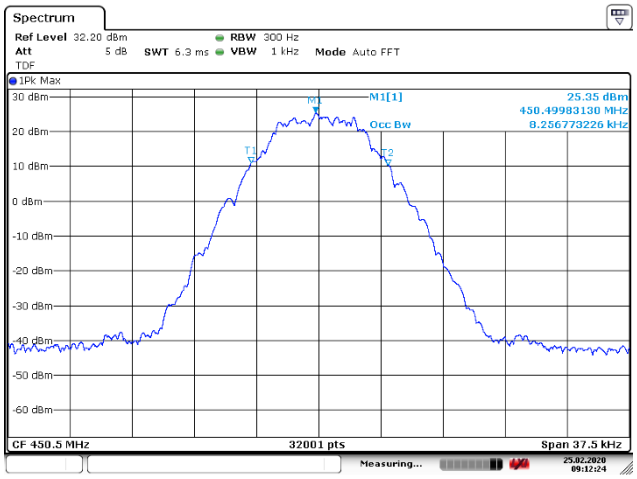


Figure 14: OBW (4 FSK, 12.5 kHz)

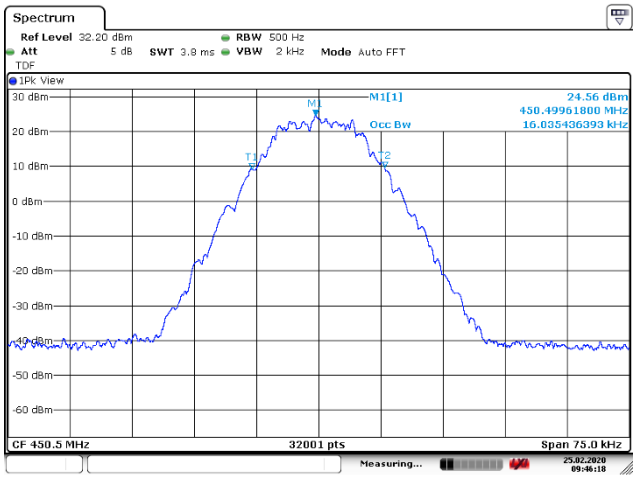


Figure 15: OBW (4 FSK, 25 kHz)

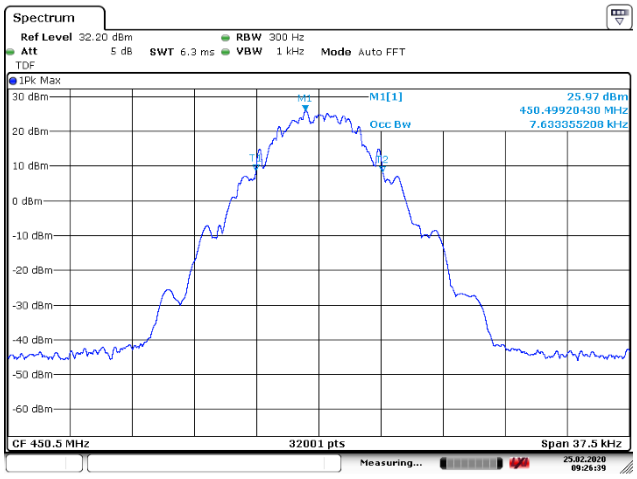


Figure 16: OBW (8 FSK, 12.5 kHz)

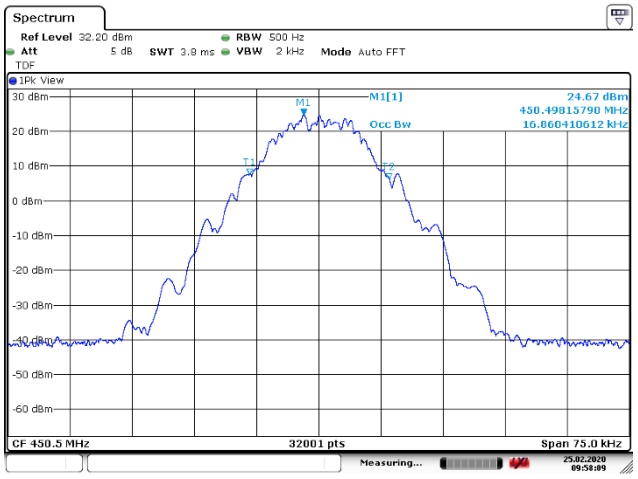


Figure 17: OBW (8 FSK, 25 kHz)

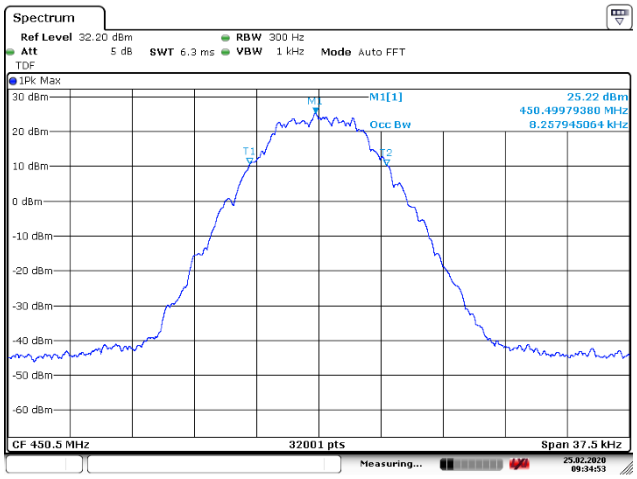


Figure 18: OBW (16 FSK, 12.5 kHz)

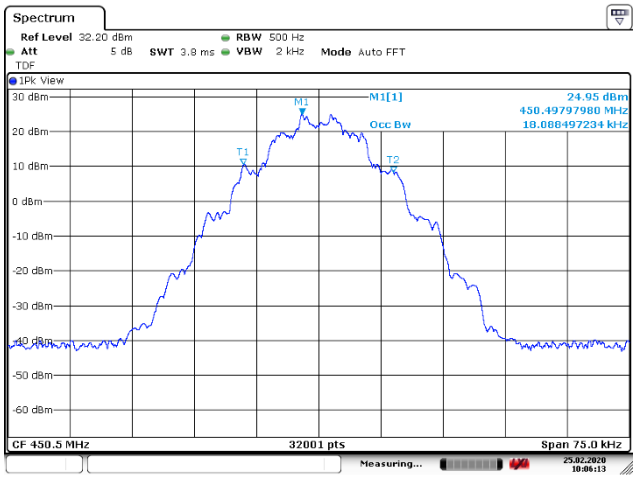


Figure 19: OBW (16 FSK, 25 kHz)

EUT frequency 469.5 MHz

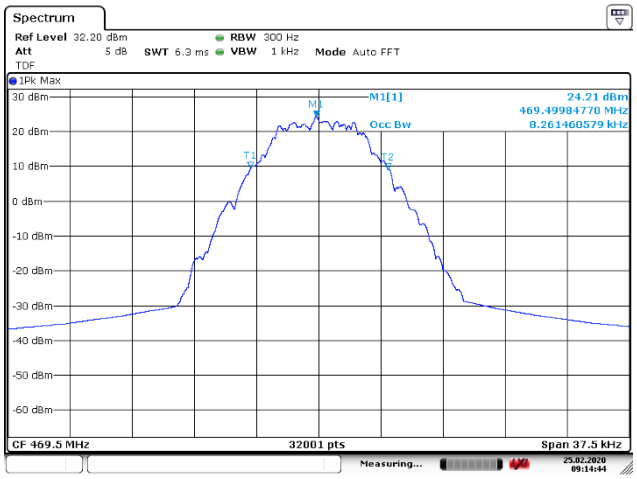


Figure 20: OBW (4 FSK, 12.5 kHz)

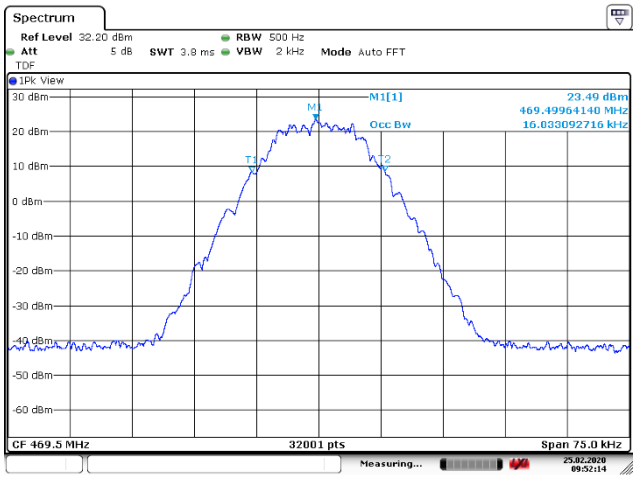


Figure 21: OBW (4 FSK, 25 kHz)

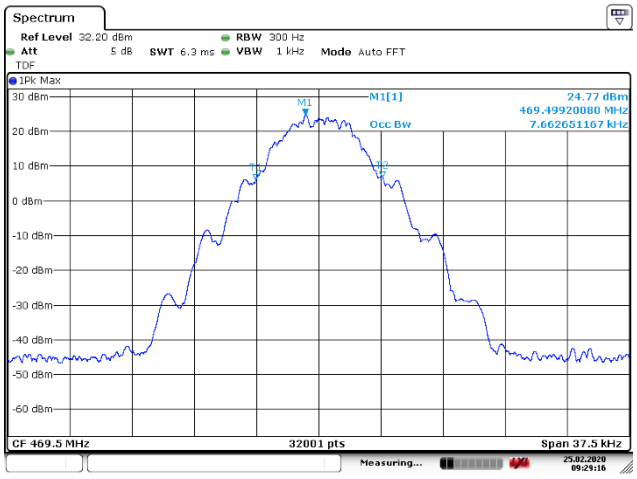


Figure 22: OBW (8 FSK, 12.5 kHz)

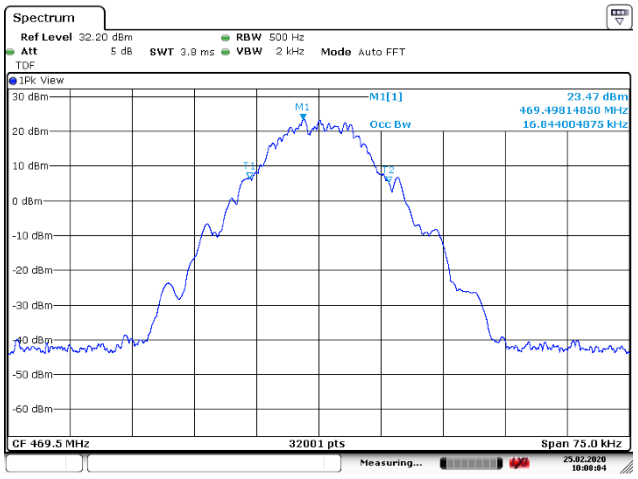


Figure 23: OBW (8 FSK, 25 kHz)

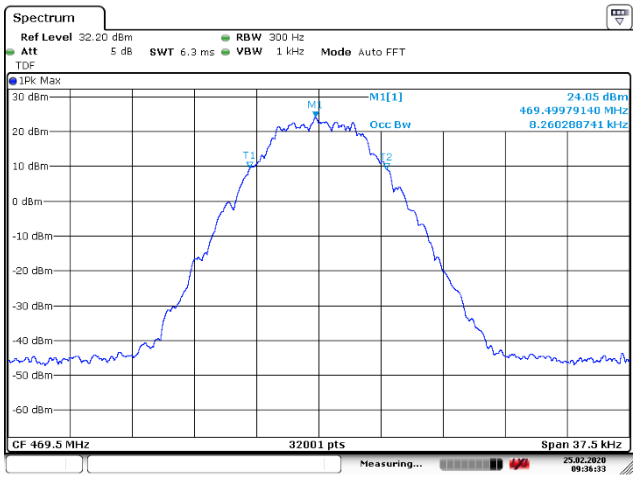


Figure 24: OBW (16 FSK, 12.5 kHz)

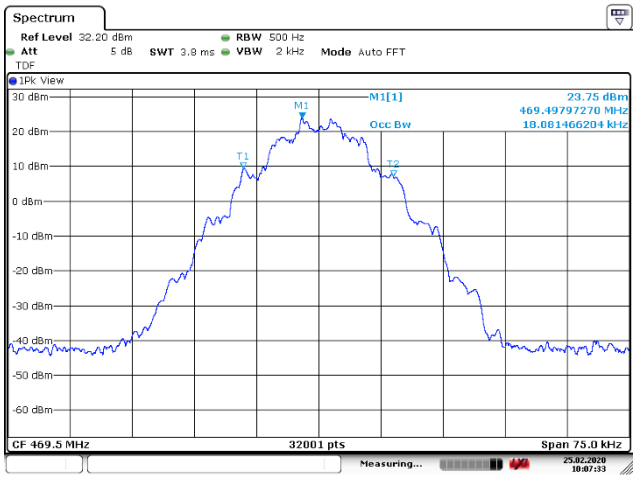


Figure 25: OBW (16 FSK, 25 kHz)

Spurious emission mask

Standard:	ANSI C63.26 (2015)	
Tested by:	PKA	
Date:	25 February 2020	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 %RH	
Measurement uncertainty:	± 2.90 dB	Level of confidence 95.45 % (k = 2)
Test result:	**PASS**	

FCC Rule: 90.210
RSS-119 5.5

Emission Mask C. For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier output power (P) as follows:

1) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5 kHz, but not more than 10 kHz: At least 83 log (f_d/5) dB

2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 10 kHz, but not more than 250 percent of the authorized bandwidth: At least 29 log (f_d^2/11) dB or 50 dB, whichever is the lesser attenuation

3) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth; At least 43 + 10 log (P) dB

Emission Mask D – 12.5 kHz channel bandwidth equipment. For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:

1) On any frequency from the center of the authorized bandwidth f_0 to 5.625 kHz removed from f_0: Zero dB

2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least 7.27(f_d – 2.88 kHz) dB

3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz: At least 50 + 10 log (P) or 70 dB, whichever is the lesser attenuation

Test results

Emission Mask C

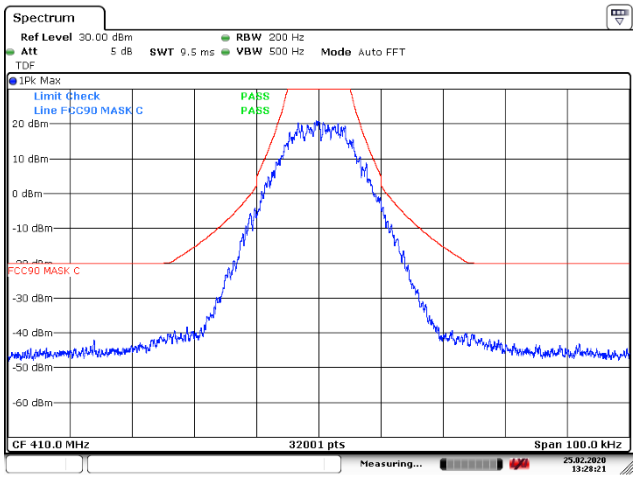


Figure 26: 410.0 MHz, 25 kHz, 4 FSK

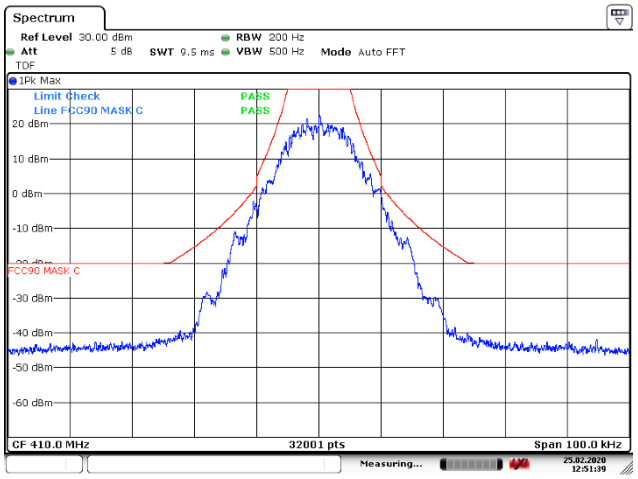


Figure 27: 410.0 MHz, 25 kHz, 8 FSK

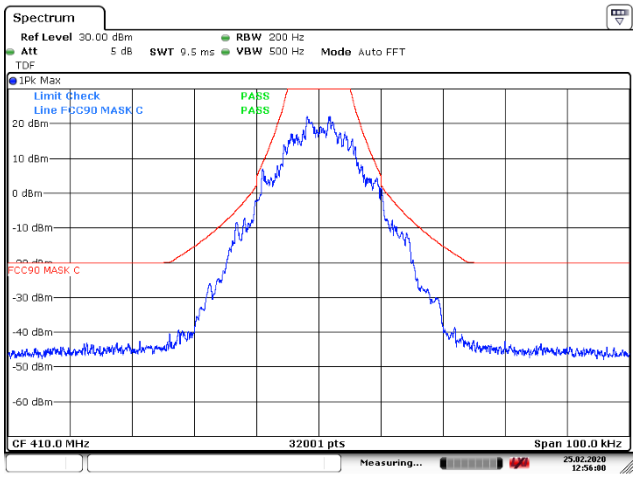


Figure 28: 410.0 MHz, 25 kHz, 16 FSK

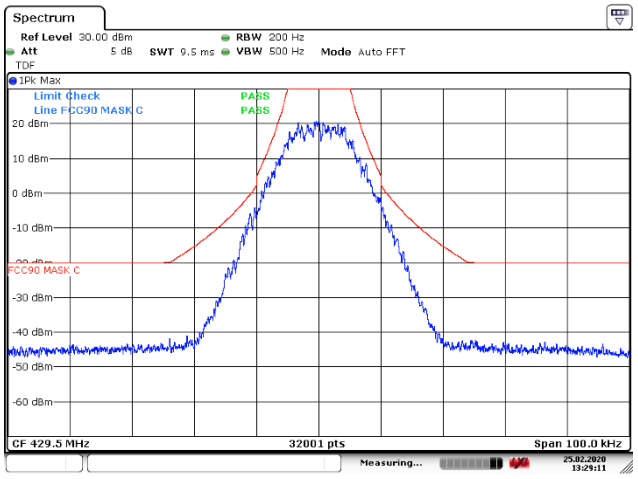


Figure 29: 429.5 MHz, 25 kHz, 4 FSK

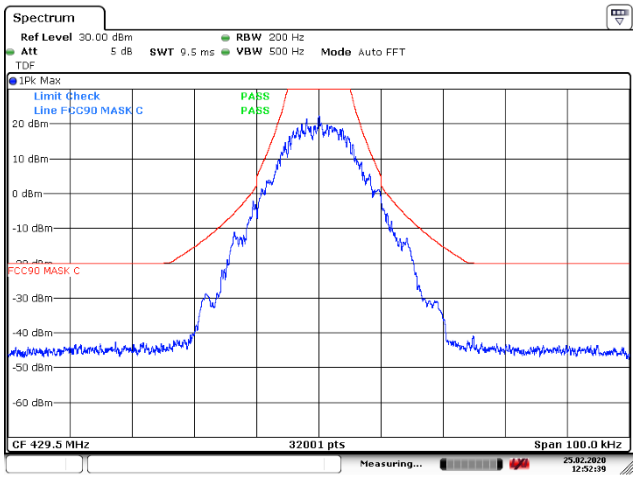


Figure 30: 429.5 MHz, 25 kHz, 8 FSK

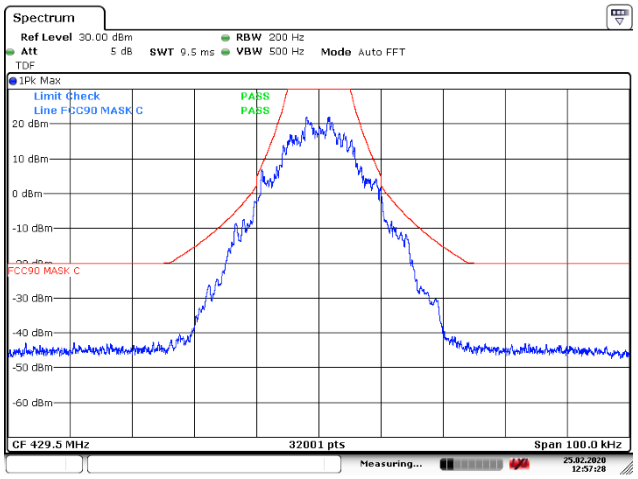


Figure 31: 429.5 MHz, 25 kHz, 16 FSK

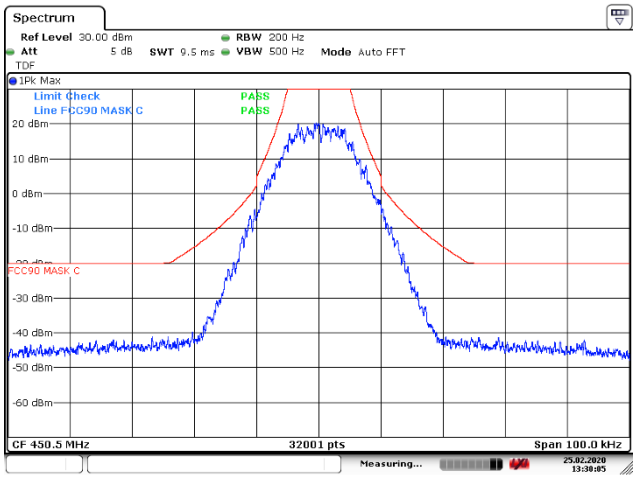


Figure 32: 450.5 MHz, 25 kHz, 4 FSK

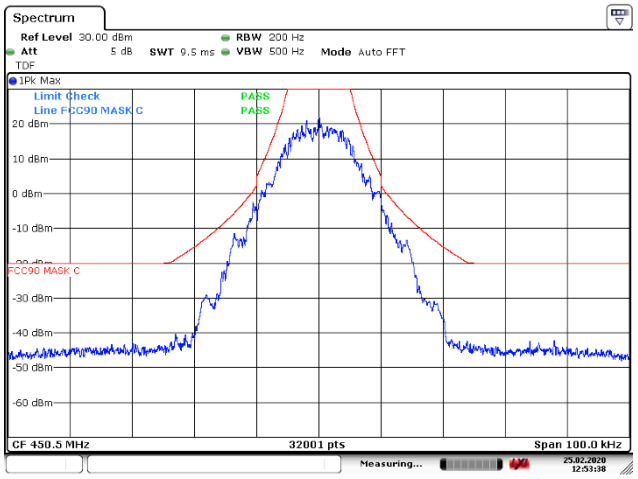


Figure 33: 450.5 MHz, 25 kHz, 8 FSK

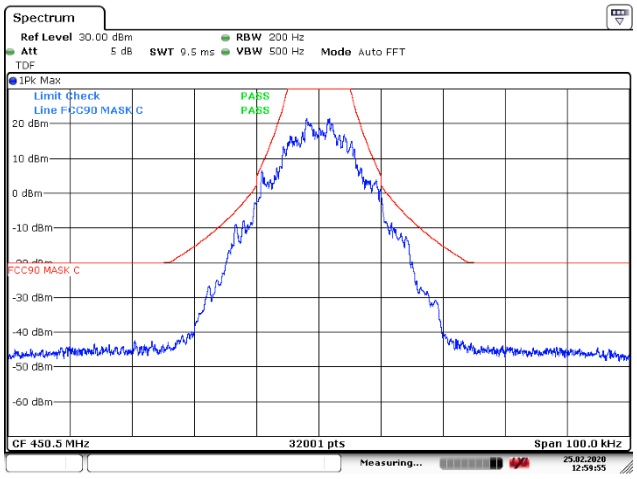


Figure 34: 450.5 MHz, 25 kHz, 16 FSK

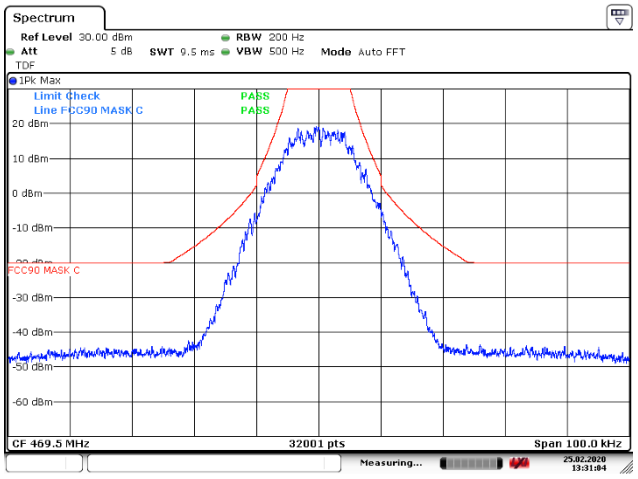


Figure 35: 469.5 MHz, 25 kHz, 4 FSK

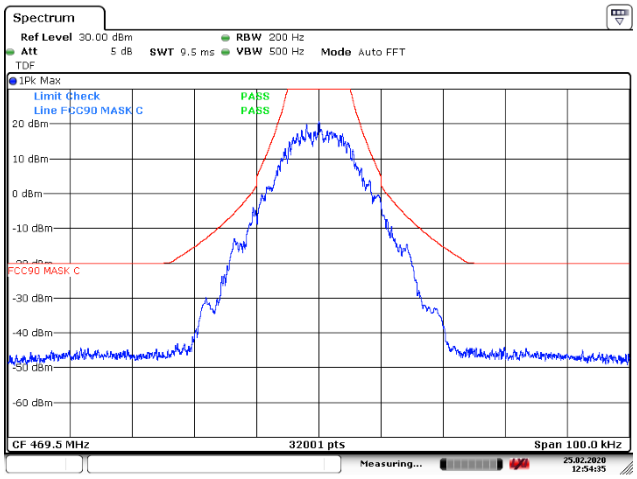


Figure 36: 469.5 MHz, 25 kHz, 8 FSK

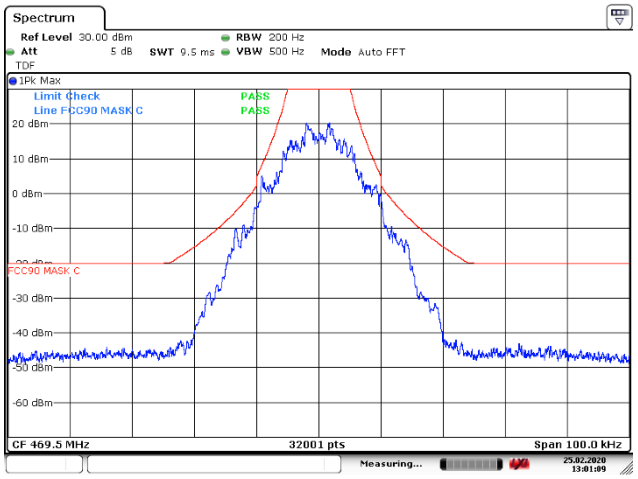


Figure 37: 469.5 MHz, 25 kHz, 16 FSK

Emission Mask D

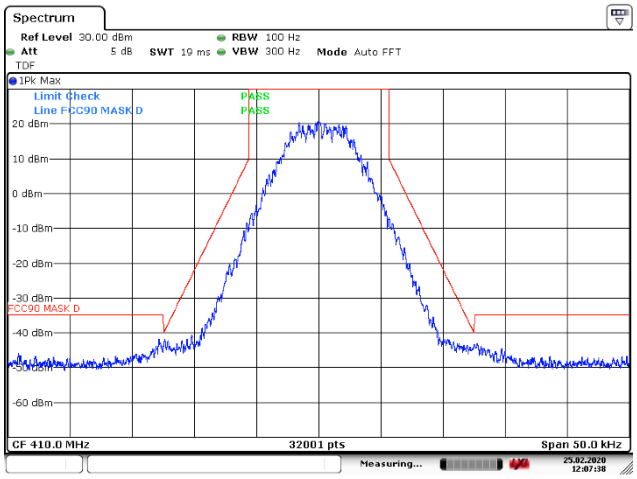


Figure 38: 410.0 MHz, 12.5 kHz, 4 FSK

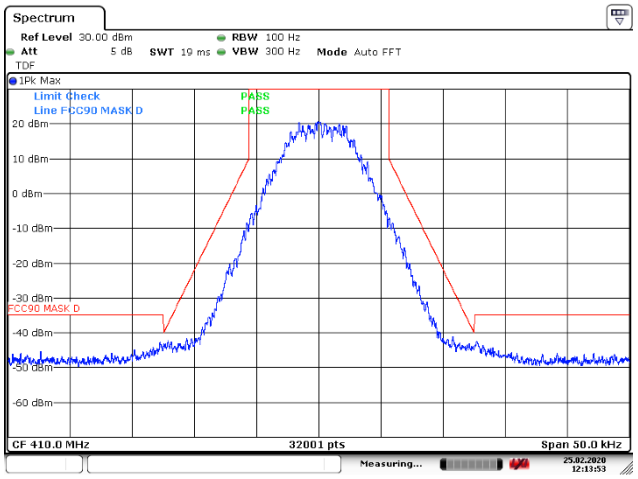


Figure 39: 410.0 MHz, 12.5 kHz, 8 FSK

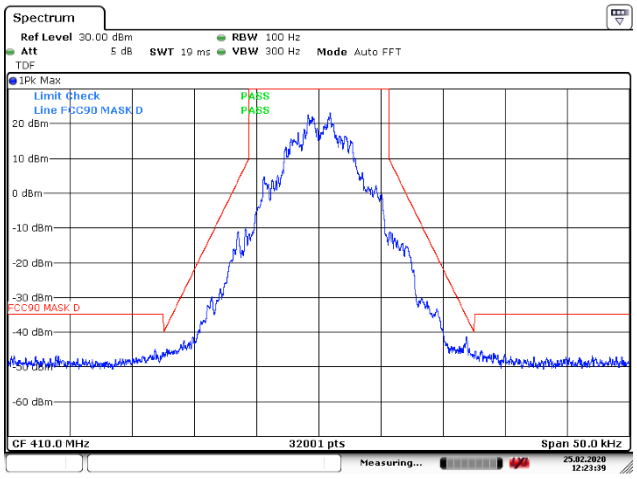


Figure 40: 410.0 MHz, 12.5 kHz, 16 FSK

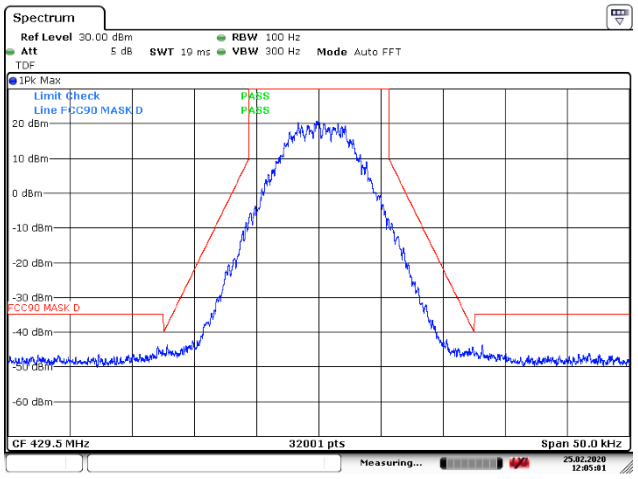


Figure 41: 429.5 MHz, 12.5 kHz, 4 FSK

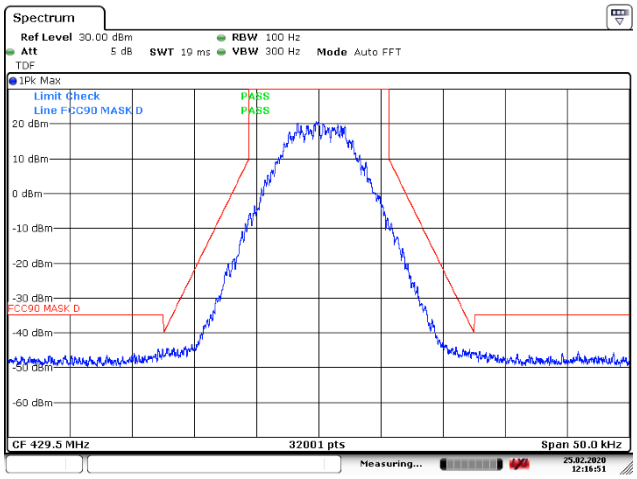


Figure 42: 429.5 MHz, 12.5 kHz, 8 FSK

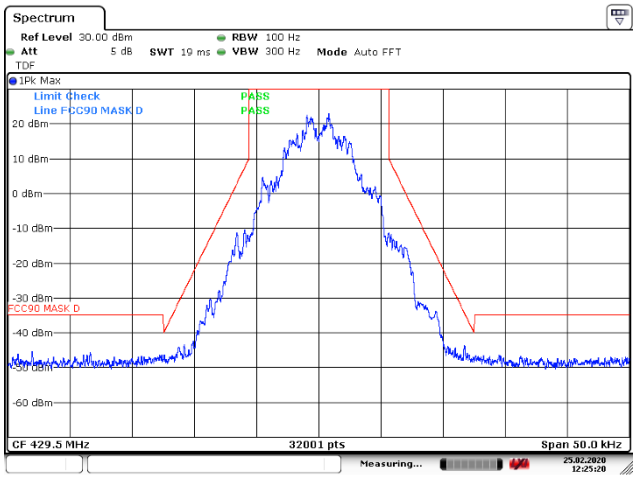


Figure 43: 429.5 MHz, 12.5 kHz, 16 FSK

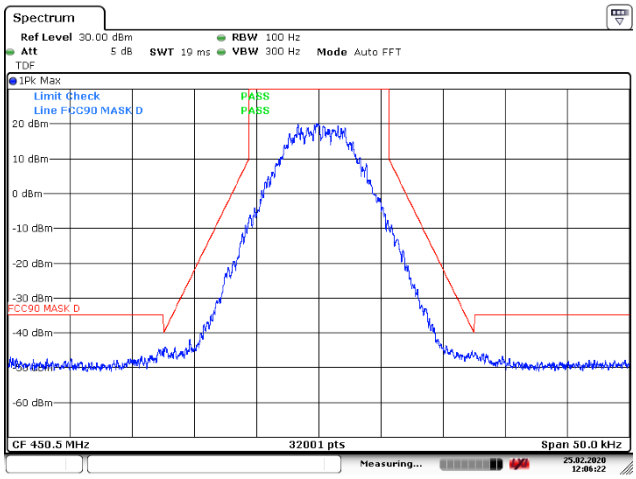


Figure 44: 450.5 MHz, 12.5 kHz, 4 FSK

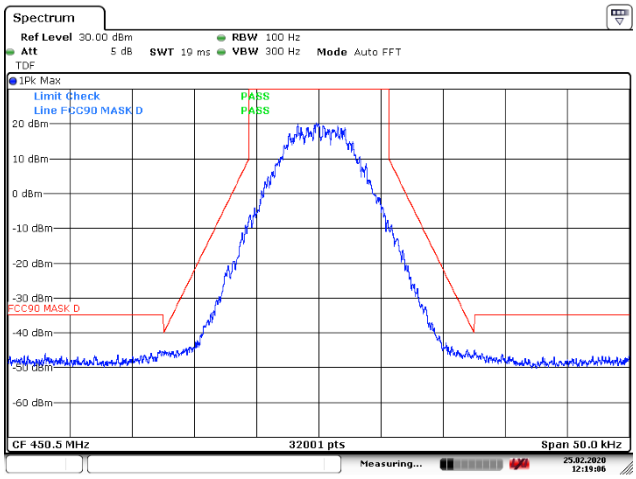


Figure 45: 450.5 MHz, 12.5 kHz, 8 FSK

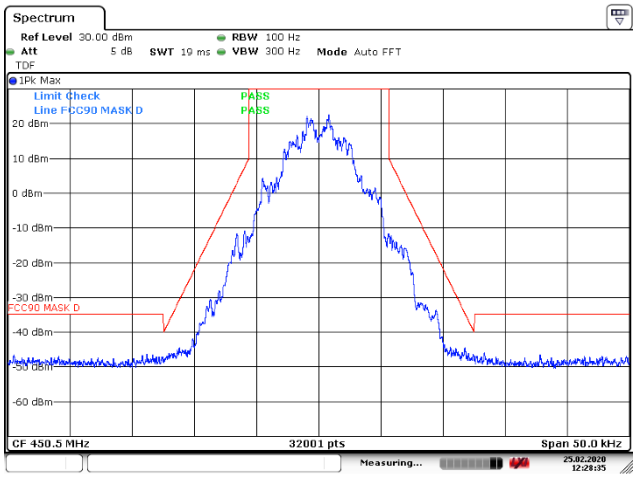


Figure 46: 450.5 MHz, 12.5 kHz, 16 FSK

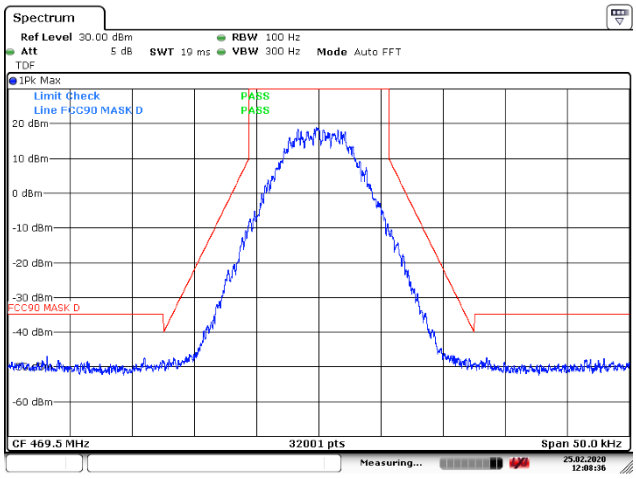


Figure 47: 469.5 MHz, 12.5 kHz, 4 FSK

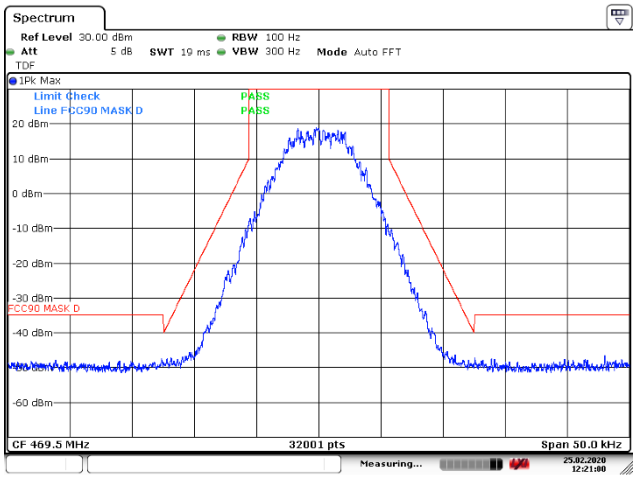


Figure 48: 469.5 MHz, 12.5 kHz, 8 FSK

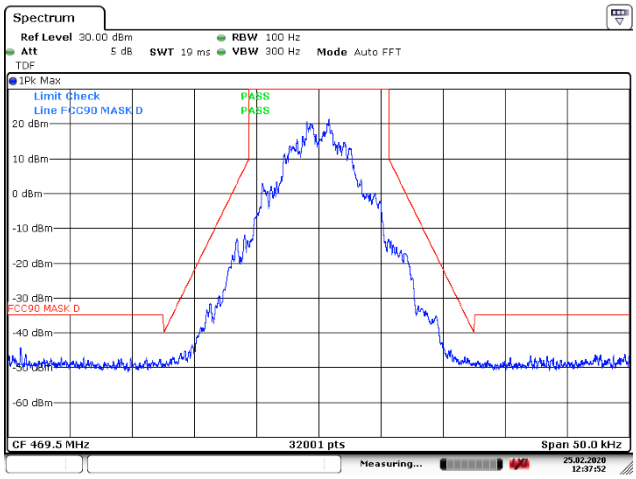


Figure 49: 469.5 MHz, 12.5 kHz, 16 FSK

Spurious emissions (conducted) 9 kHz – 5 GHz

Standard:	ANSI C63.26 (2015)	
Tested by:	HEM	
Date:	5 March 2020	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 %RH	
Measurement uncertainty:	± 2.90 dB	Level of confidence 95.45 % (k = 2)
Test result:	**PASS**	

FCC Rule: 90.210

RSS-119 5.8

For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier output power (P) as follows: on any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth; at least 43 + 10 log (P) dB.

For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows: on any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz: at least 50 + 10 log (P) or 70 dB, whichever is the lesser attenuation.

Frequency Band (MHz)	Channel Bandwidth (kHz)	Authorized Bandwidth (kHz)	Limit (dBm)
406.1-430 and 450-470	12.5	11.25	-20
	25	20	-13

The test was performed at maximum power level.

Test results

Table 8: Spurious emissions (conducted) test results

EUT Frequency (MHz)	Ch. Bandwidth (kHz)	Modulation	Spurious Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)
410.0	12.5	4 FSK	820.0340	-38.13	-20	18.13
410.0	12.5	4 FSK	4681.430	-24.69	-20	4.69
410.0	12.5	8 FSK	820.0340	-37.55	-20	17.55
410.0	12.5	8 FSK	4952.200	-23.98	-20	3.98
410.0	12.5	16 FSK	820.0340	-38.01	-20	18.01
410.0	12.5	16 FSK	4505.450	-24.40	-20	4.40
410.0	25	4 FSK	4763.020	-24.74	-13	11.74
410.0	25	8 FSK	4880.610	-24.66	-13	11.66
410.0	25	16 FSK	4857.410	-24.30	-13	11.30
429.5	12.5	4 FSK	859.0250	-36.34	-20	16.34
429.5	12.5	4 FSK	4966.600	-24.41	-20	4.41
429.5	12.5	8 FSK	859.0250	-36.21	-20	16.21
429.5	12.5	8 FSK	4901.810	-24.40	-20	4.40
429.5	12.5	16 FSK	859.0250	-36.45	-20	16.45
429.5	12.5	16 FSK	4442.660	-24.91	-20	4.91
429.5	25	4 FSK	4928.610	-24.75	-13	11.75
429.5	25	8 FSK	4641.440	-24.30	-13	11.30
429.5	25	16 FSK	4920.210	-24.74	-13	11.74
450.5	12.5	4 FSK	901.0210	-36.56	-20	16.56
450.5	12.5	4 FSK	4878.610	-25.01	-20	5.01
450.5	12.5	8 FSK	901.0210	-36.54	-20	16.54
450.5	12.5	8 FSK	4626.640	-24.87	-20	4.87
450.5	12.5	16 FSK	901.0210	-36.42	-20	16.42
450.5	12.5	16 FSK	4582.640	-24.52	-20	4.52
450.5	25	4 FSK	4765.020	-24.79	-13	11.79
450.5	25	8 FSK	4943.410	-24.69	-13	11.69
450.5	25	16 FSK	4945.410	-25.19	-13	12.19
469.5	12.5	4 FSK	939.0420	-38.99	-20	18.99
469.5	12.5	4 FSK	4907.010	-24.49	-20	4.49
469.5	12.5	8 FSK	939.0420	-38.92	-20	18.92
469.5	12.5	8 FSK	4742.230	-24.52	-20	4.52
469.5	12.5	16 FSK	939.0420	-39.67	-20	19.67
469.5	12.5	16 FSK	4811.420	-25.08	-20	5.08
469.5	25	4 FSK	3643.140	-24.71	-13	11.71
469.5	25	8 FSK	4395.460	-24.81	-13	11.81
469.5	25	16 FSK	4732.230	-25.21	-13	12.21

12.5 kHz channel bandwidth, EUT frequency 410.0 MHz, 4 FSK

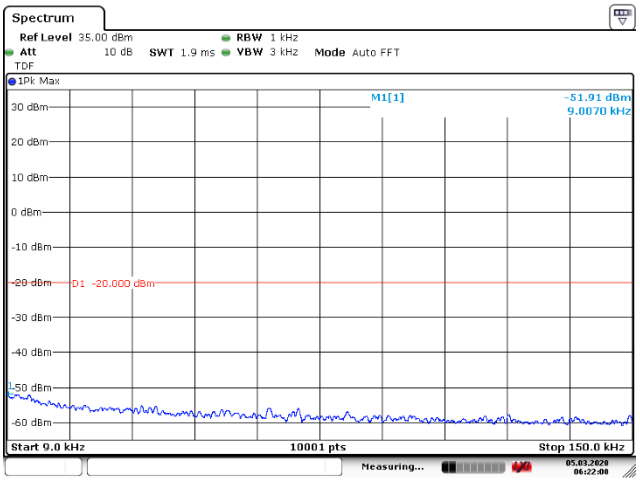


Figure 50: 9 – 150 kHz

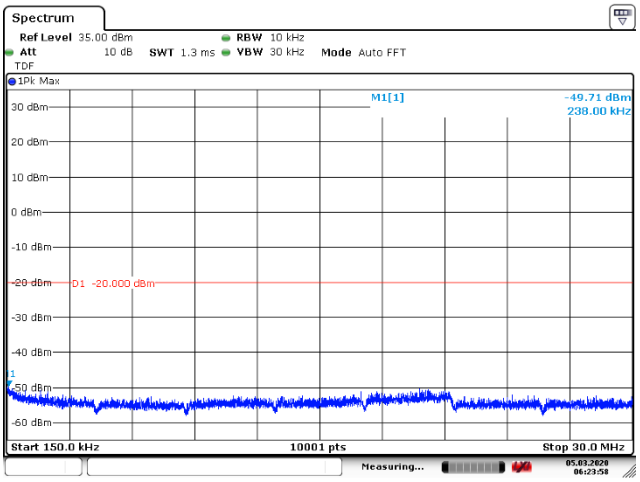


Figure 51: 150 kHz – 30 MHz

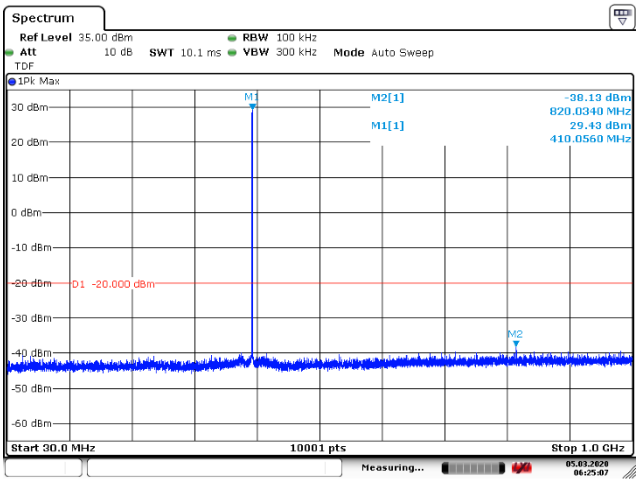


Figure 52: 30 – 1000 MHz

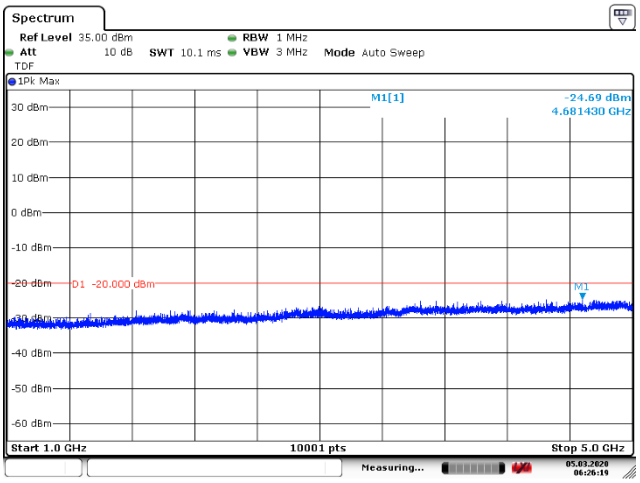


Figure 53: 1 – 5 GHz

12.5 kHz channel bandwidth, EUT frequency 410.0 MHz, 8 FSK

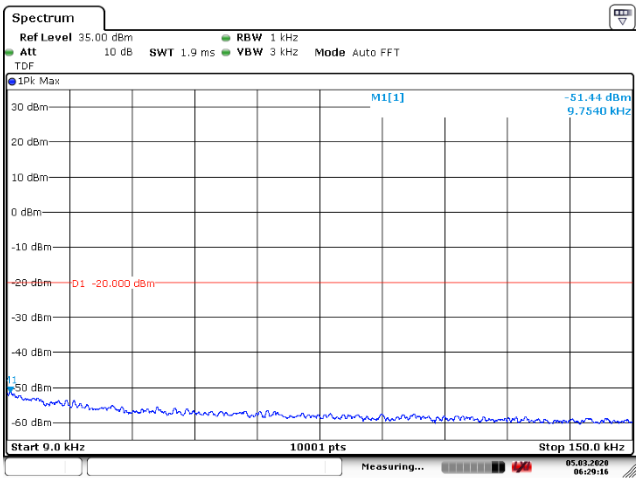


Figure 54: 9 – 150 kHz

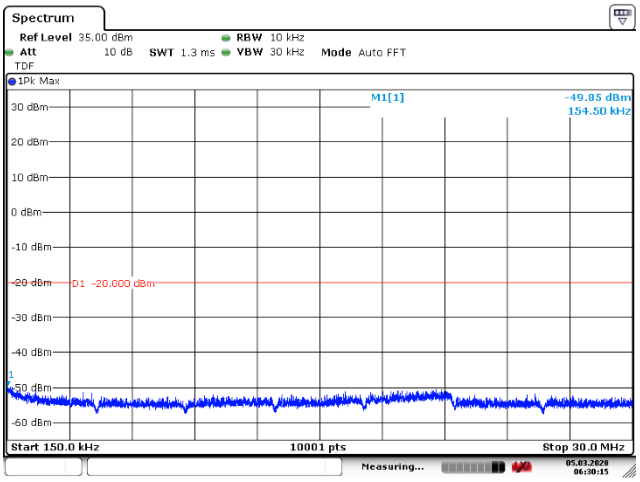


Figure 55: 150 kHz – 30 MHz

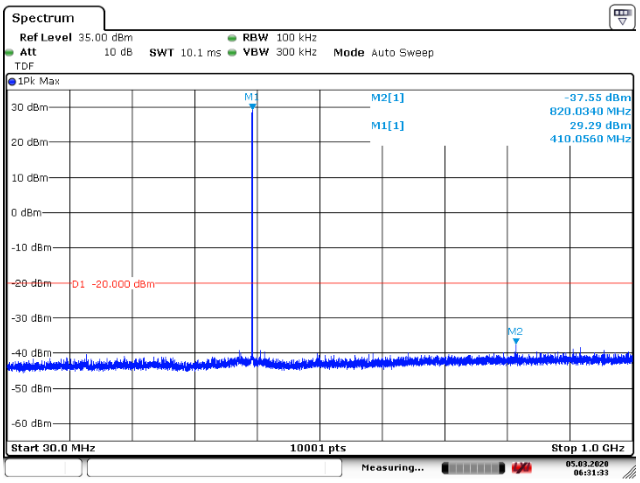


Figure 56: 30 – 1000 MHz

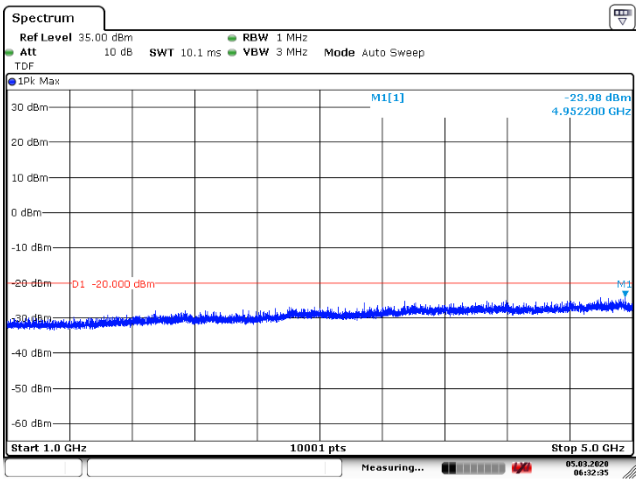


Figure 57: 1 – 5 GHz

12.5 kHz channel bandwidth, EUT frequency 410.0 MHz, 16 FSK

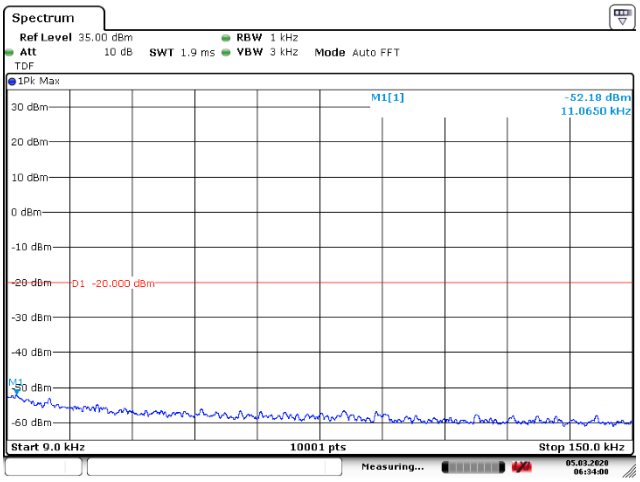


Figure 58: 9 – 150 kHz

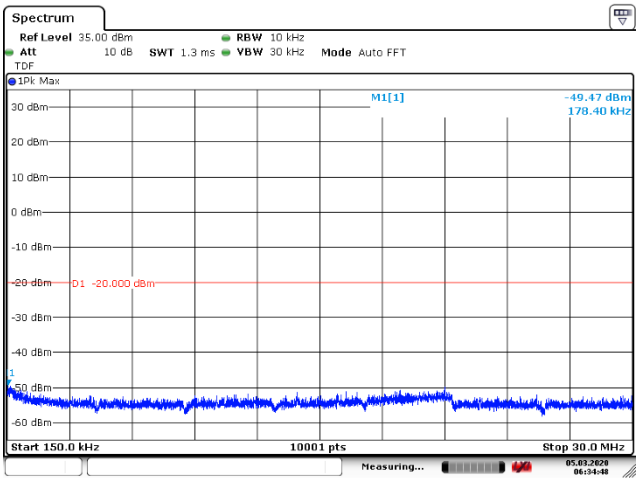


Figure 59: 150 kHz – 30 MHz

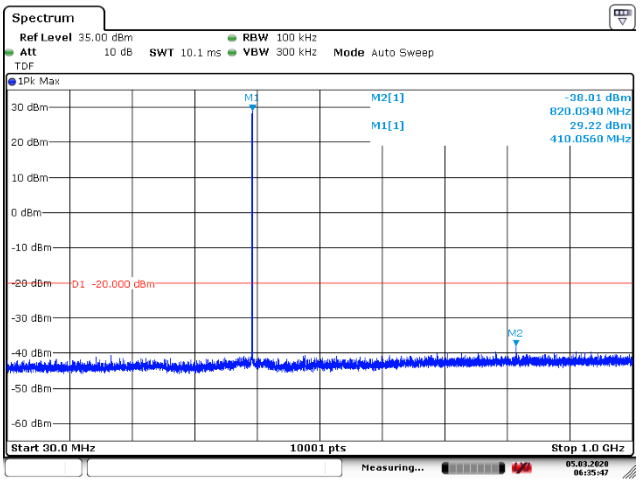


Figure 60: 30 – 1000 MHz

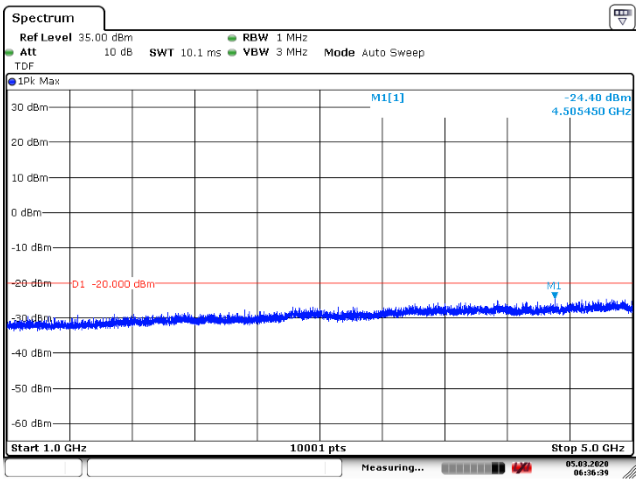


Figure 61: 1 – 5 GHz

12.5 kHz channel bandwidth, EUT frequency 429.5 MHz, 4 FSK

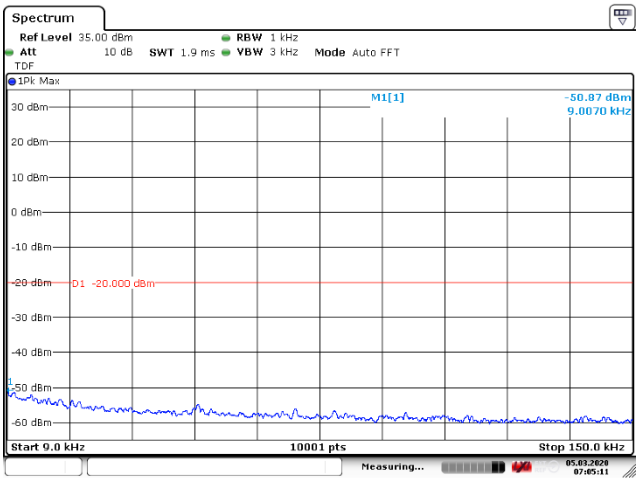


Figure 62: 9 – 150 kHz

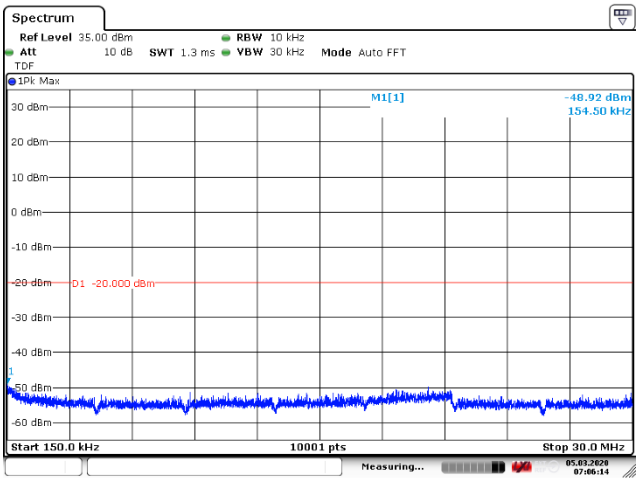


Figure 63: 150 kHz – 30 MHz

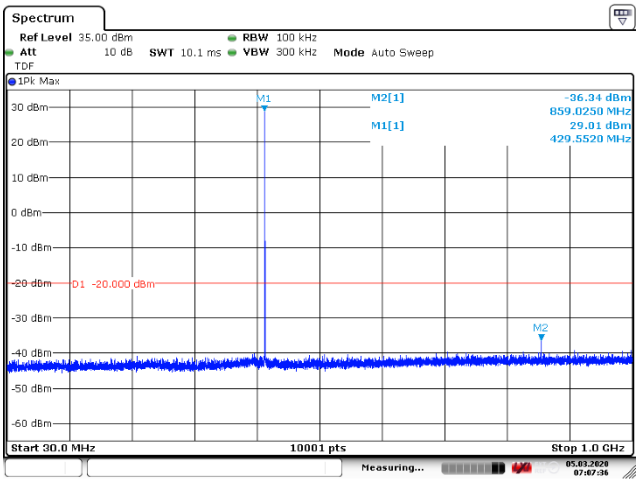


Figure 64: 30 – 1000 MHz

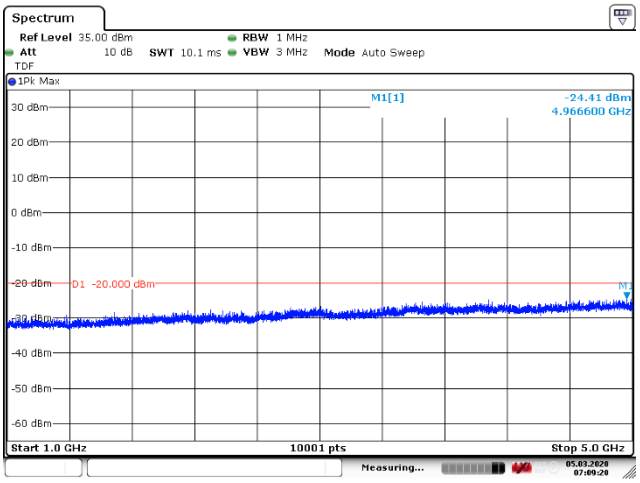


Figure 65: 1 – 5 GHz

12.5 kHz channel bandwidth, EUT frequency 429.5 MHz, 8 FSK

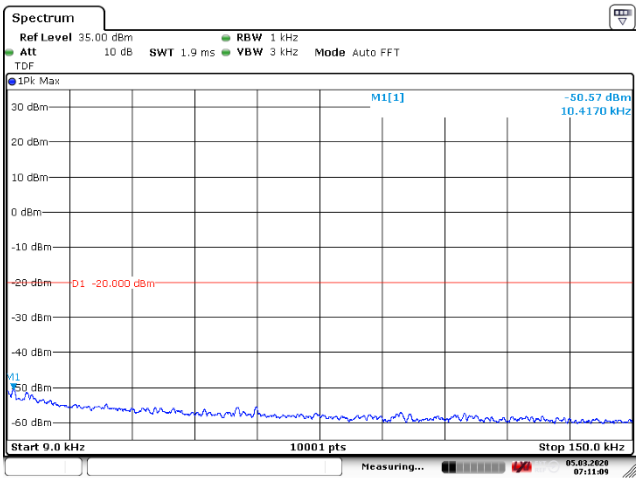


Figure 66: 9 – 150 kHz

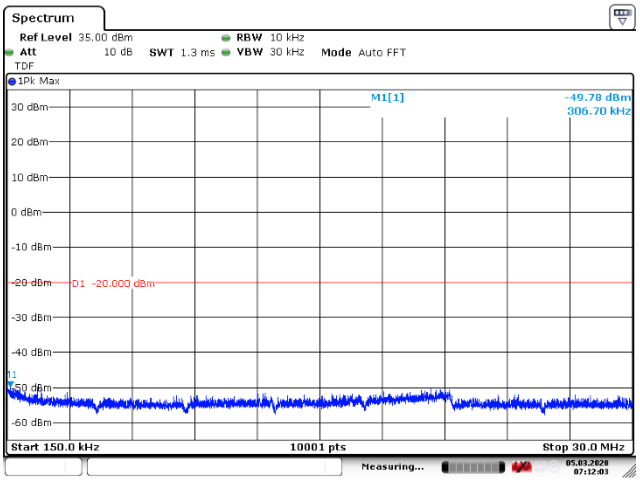


Figure 67: 150 kHz – 30 MHz

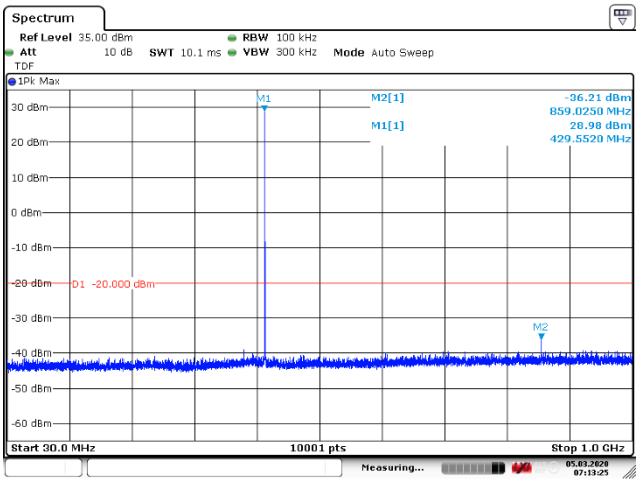


Figure 68: 30 – 1000 MHz

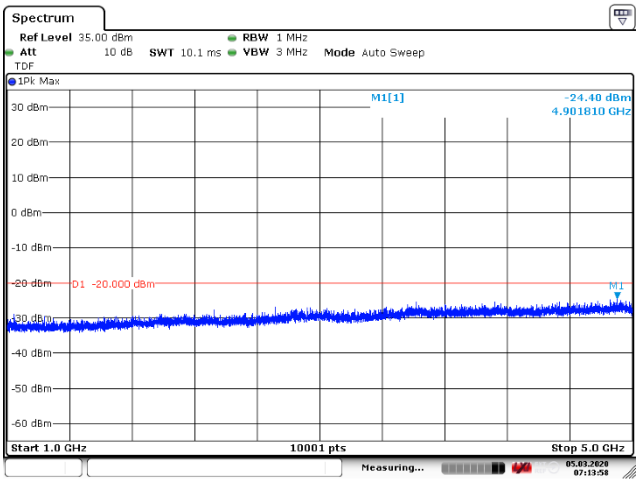


Figure 69: 1 – 5 GHz

12.5 kHz channel bandwidth, EUT frequency 429.5 MHz, 16 FSK

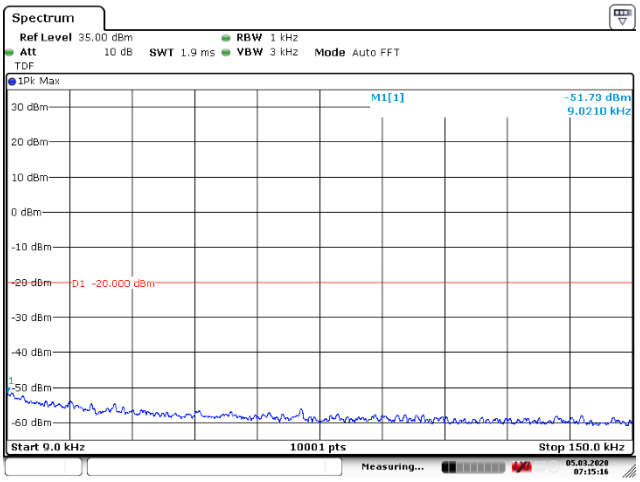


Figure 70: 9 – 150 kHz

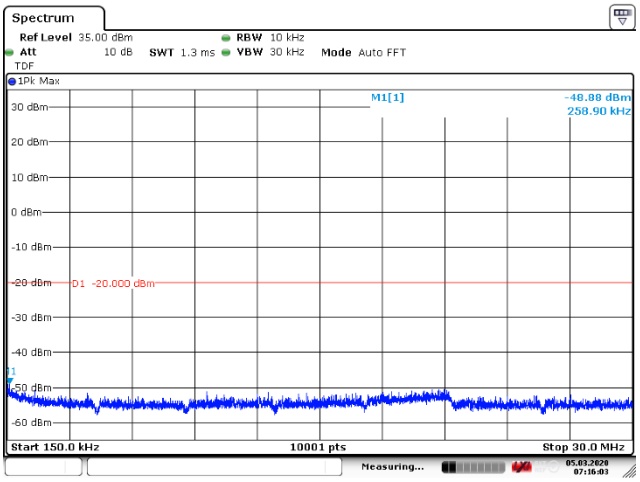


Figure 71: 150 kHz – 30 MHz

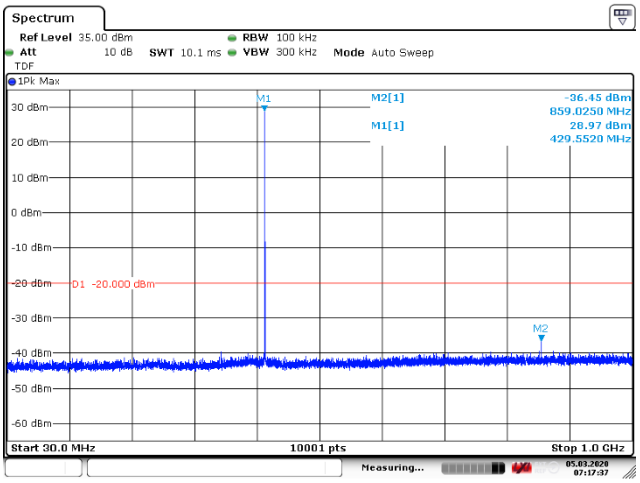


Figure 72: 30 – 1000 MHz

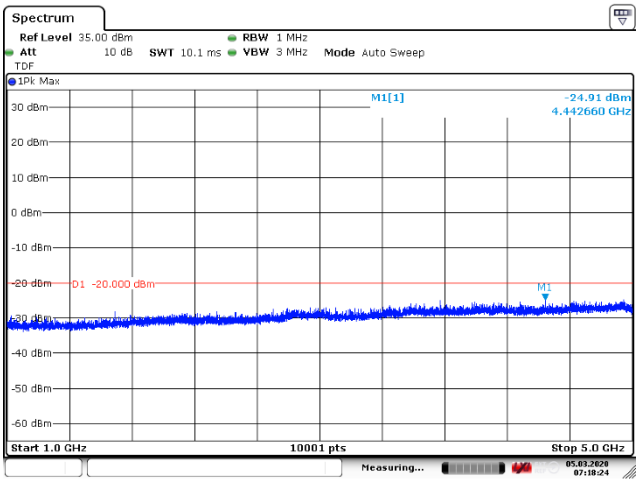


Figure 73: 1 – 5 GHz

12.5 kHz channel bandwidth, EUT frequency 450.5 MHz, 4 FSK

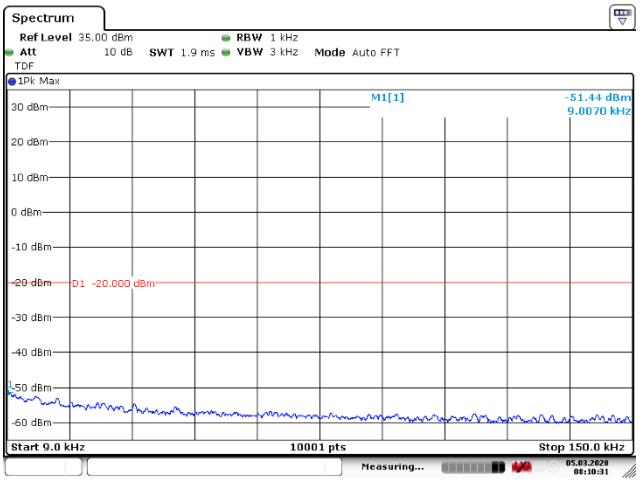


Figure 74: 9 – 150 kHz

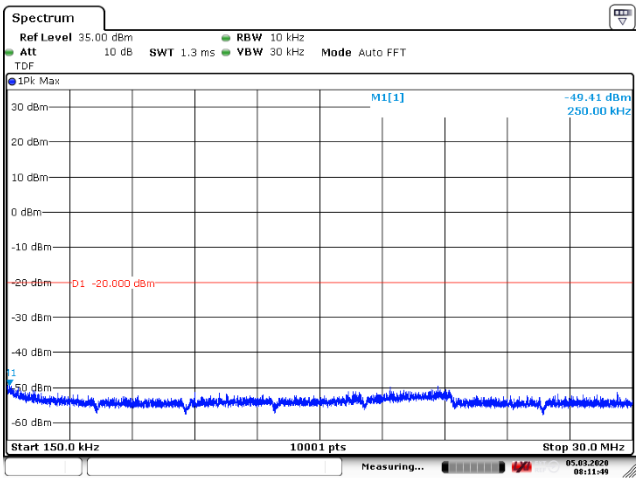


Figure 75: 150 kHz – 30 MHz

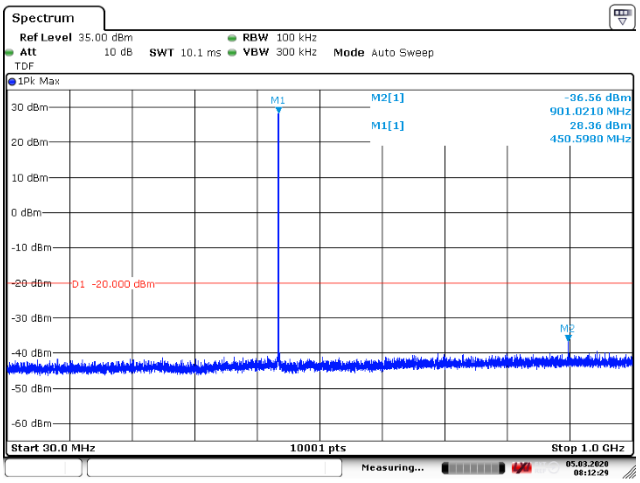


Figure 76: 30 – 1000 MHz

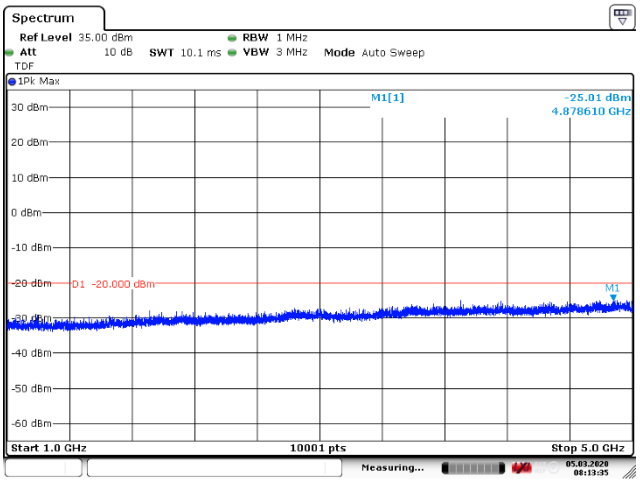


Figure 77: 1 – 5 GHz

12.5 kHz channel bandwidth, EUT frequency 450.5 MHz, 8 FSK

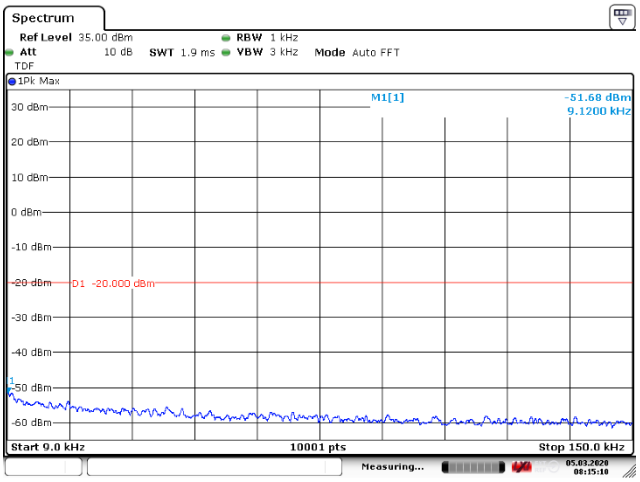


Figure 78: 9 – 150 kHz

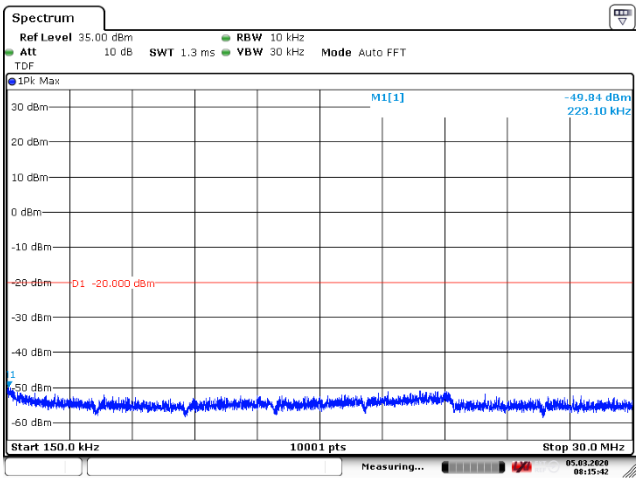


Figure 79: 150 kHz – 30 MHz

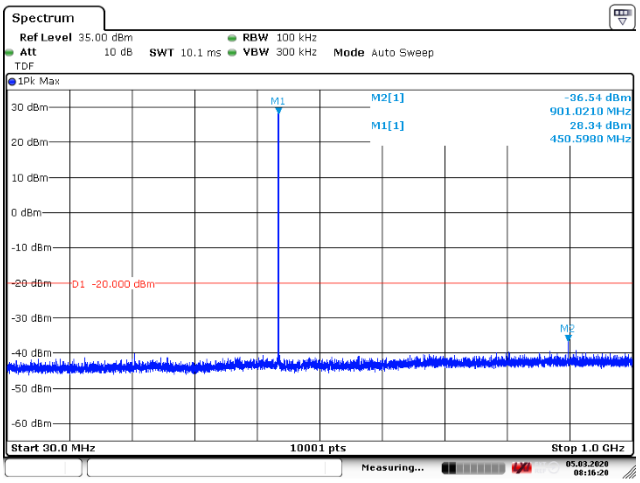


Figure 80: 30 – 1000 MHz

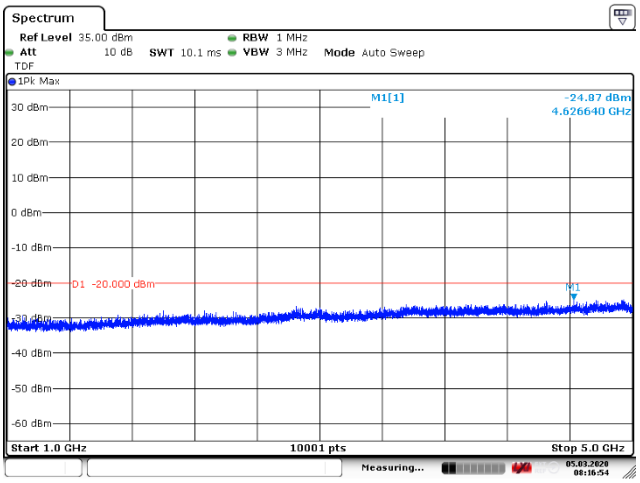


Figure 81: 1 – 5 GHz

12.5 kHz channel bandwidth, EUT frequency 450.5 MHz, 16 FSK

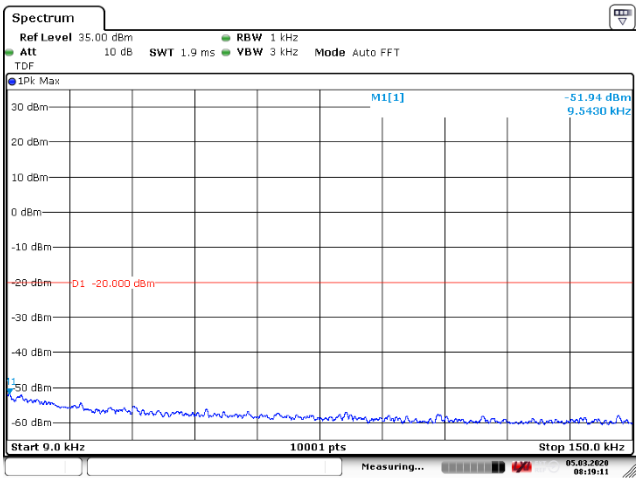


Figure 82: 9 – 150 kHz

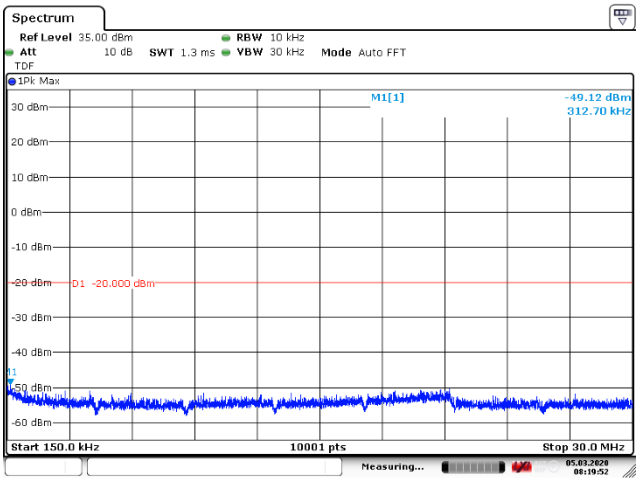


Figure 83: 150 kHz – 30 MHz

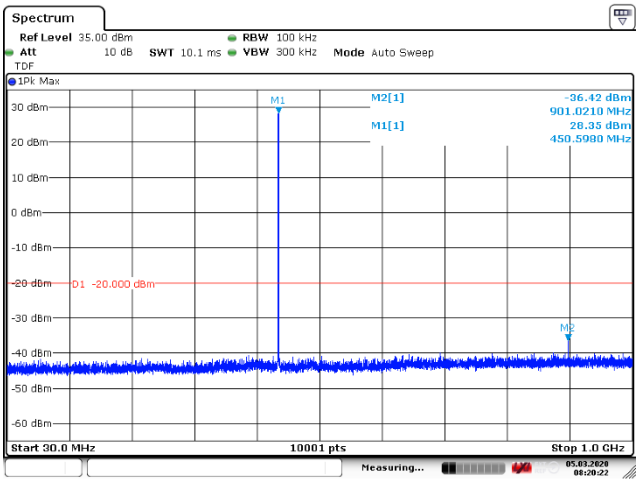


Figure 84: 30 – 1000 MHz

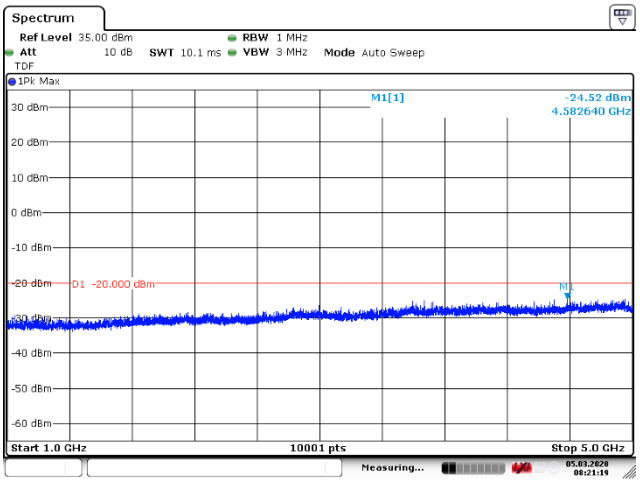


Figure 85: 1 – 5 GHz

12.5 kHz channel bandwidth, EUT frequency 469.5 MHz, 4 FSK

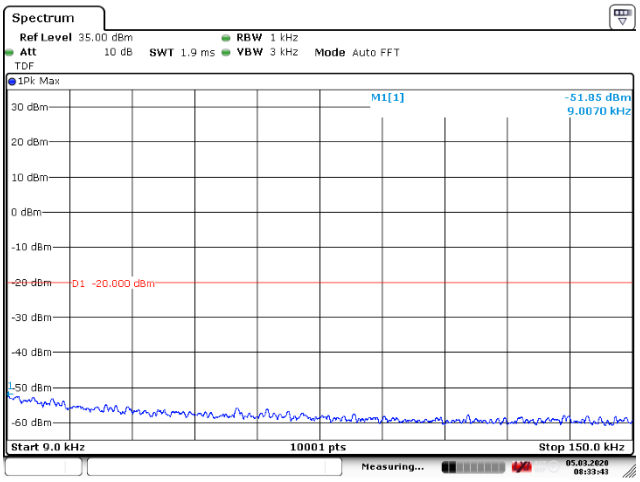


Figure 86: 9 – 150 kHz

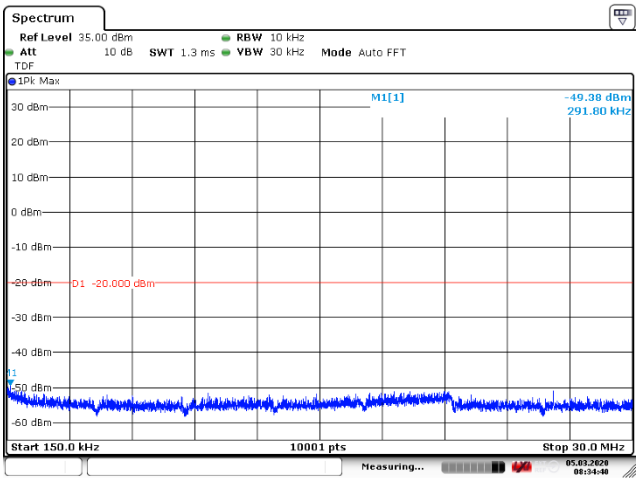


Figure 87: 150 kHz – 30 MHz

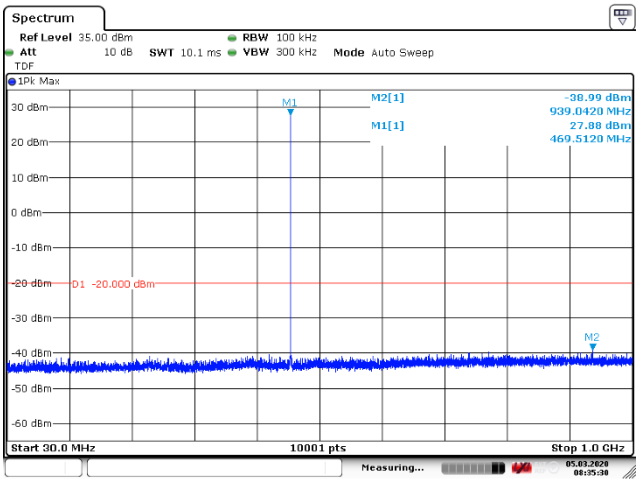


Figure 88: 30 – 1000 MHz

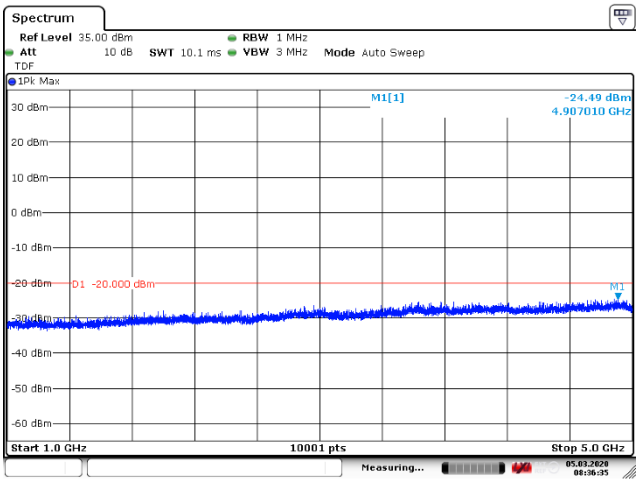


Figure 89: 1 – 5 GHz

12.5 kHz channel bandwidth, EUT frequency 469.5 MHz, 8 FSK

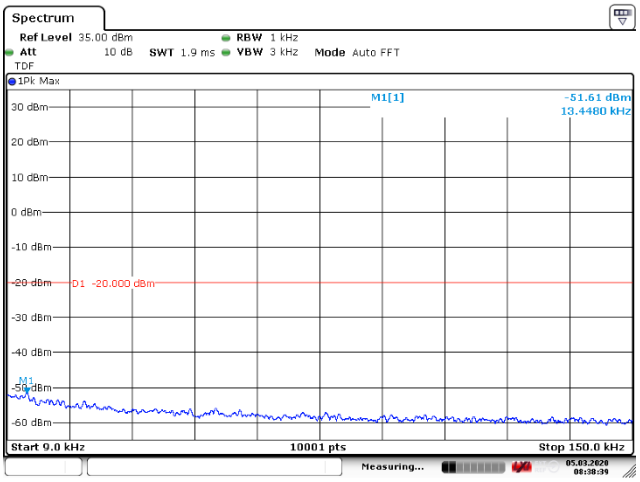


Figure 90: 9 – 150 kHz

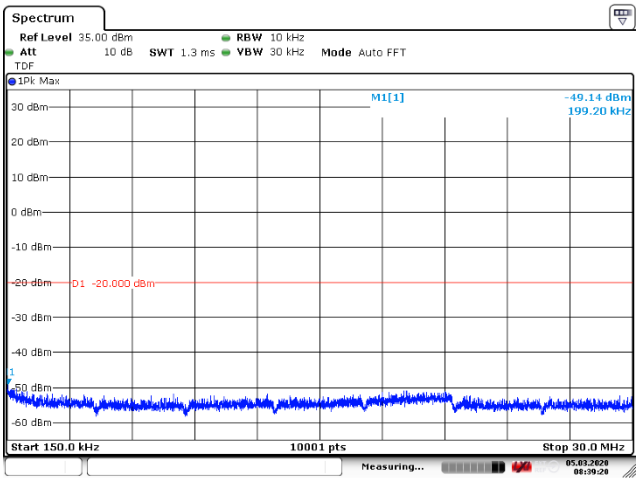


Figure 91: 150 kHz – 30 MHz

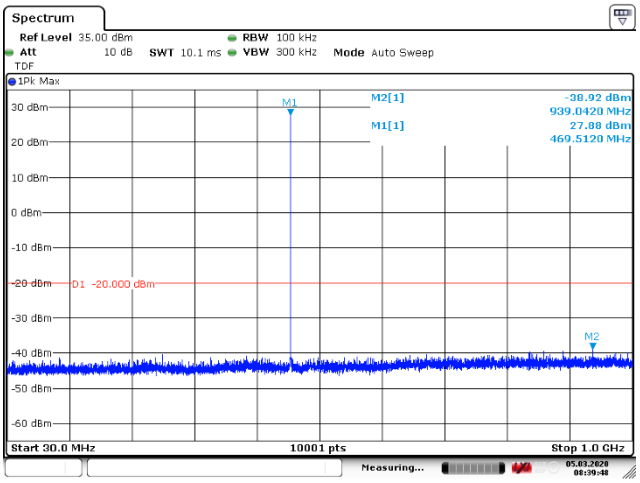


Figure 92: 30 – 1000 MHz

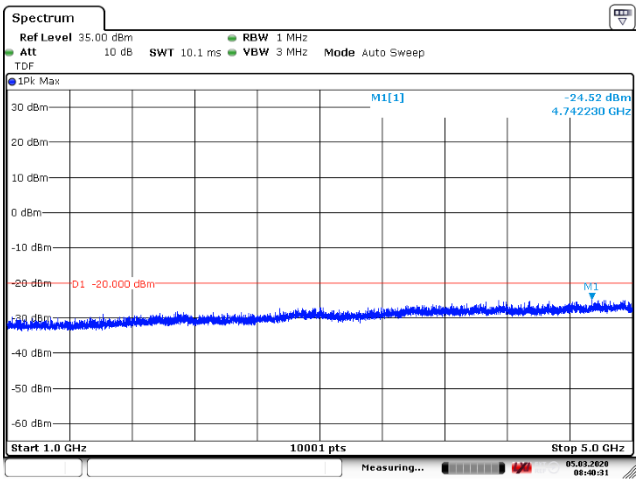


Figure 93: 1 – 5 GHz

12.5 kHz channel bandwidth, EUT frequency 469.5 MHz, 16 FSK

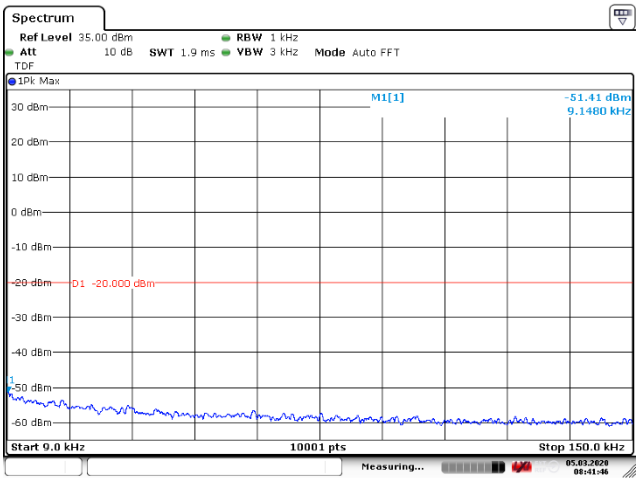


Figure 94: 9 – 150 kHz

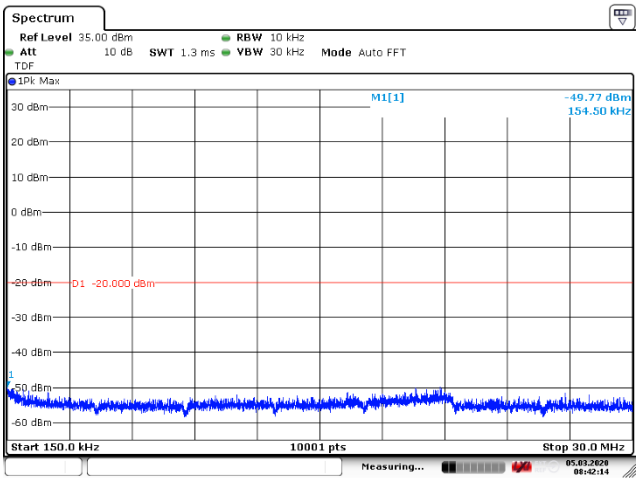


Figure 95: 150 kHz – 30 MHz

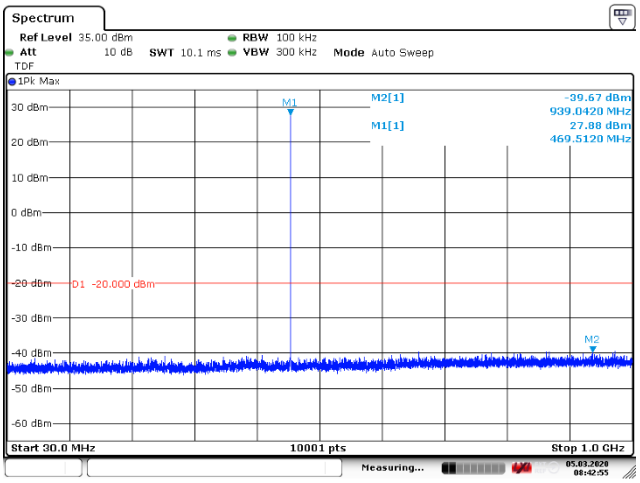


Figure 96: 30 – 1000 MHz

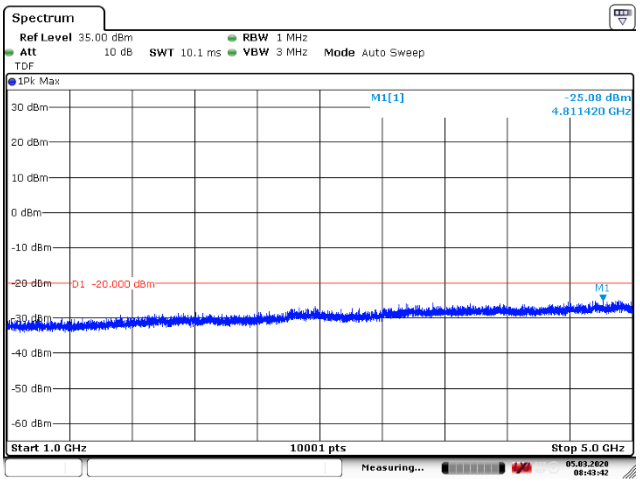


Figure 97: 1 – 5 GHz

25 kHz channel bandwidth, EUT frequency 410.0 MHz, 4 FSK

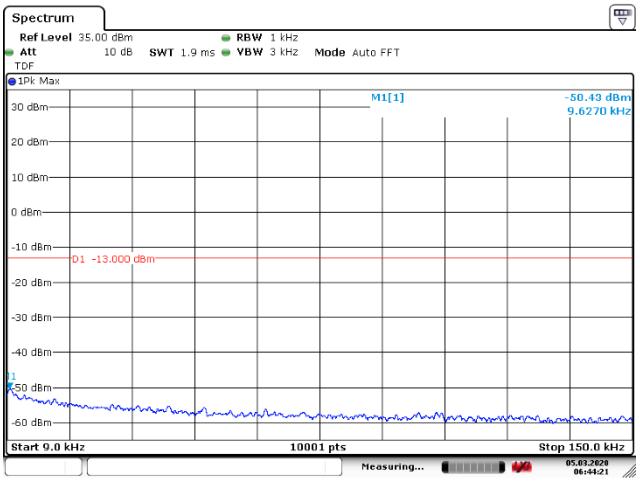


Figure 98: 9 – 150 kHz

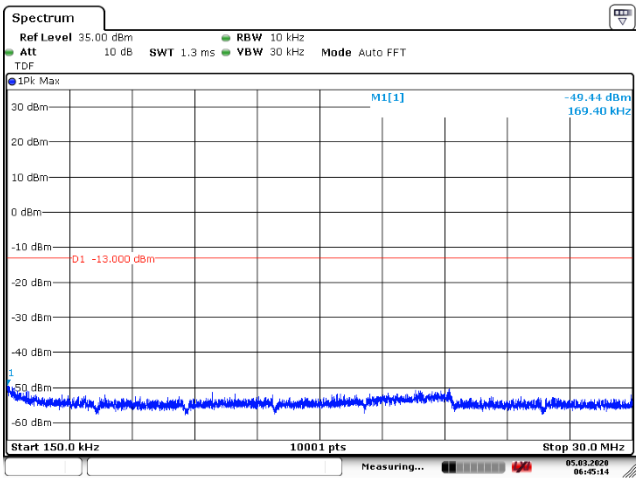


Figure 99: 150 kHz – 30 MHz

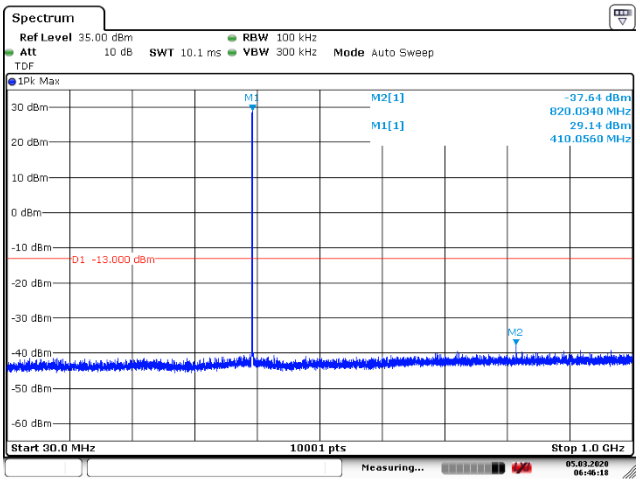


Figure 100: 30 – 1000 MHz

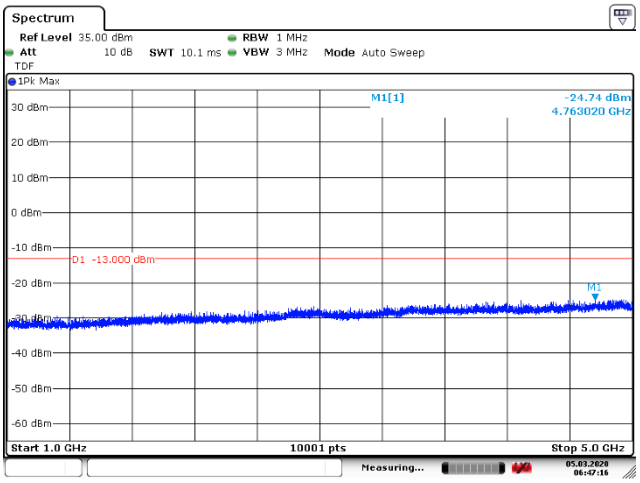


Figure 101: 1 – 5 GHz

25 kHz channel bandwidth, EUT frequency 410.0 MHz, 8 FSK

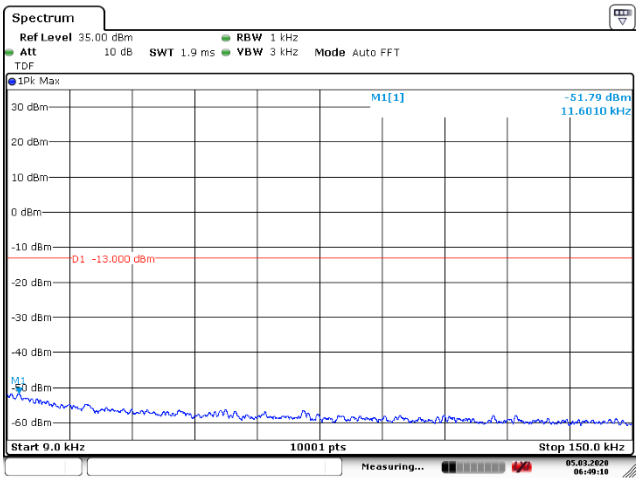


Figure 102: 9 – 150 kHz

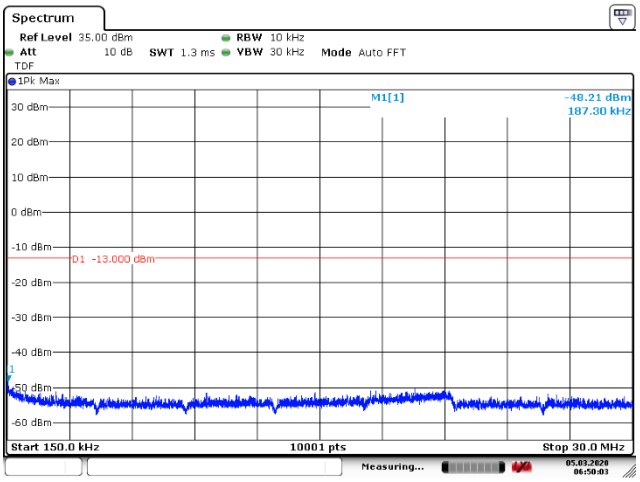


Figure 103: 150 kHz – 30 MHz

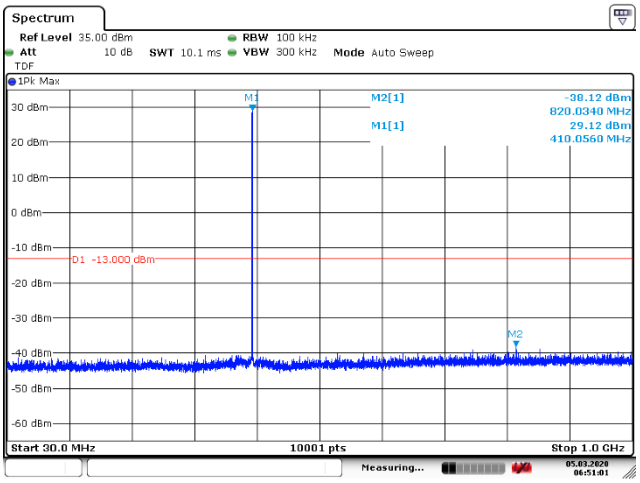


Figure 104: 30 – 1000 MHz

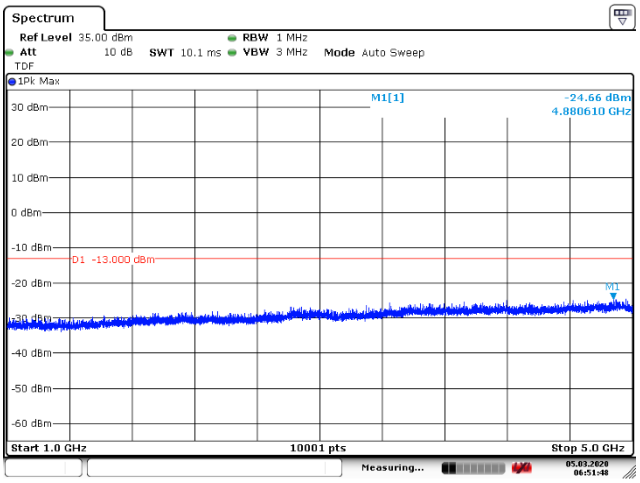


Figure 105: 1 – 5 GHz

25 kHz channel bandwidth, EUT frequency 410.0 MHz, 16 FSK

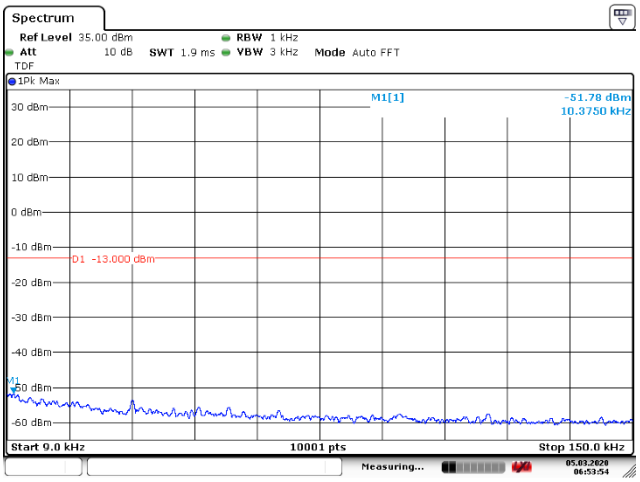


Figure 106: 9 – 150 kHz

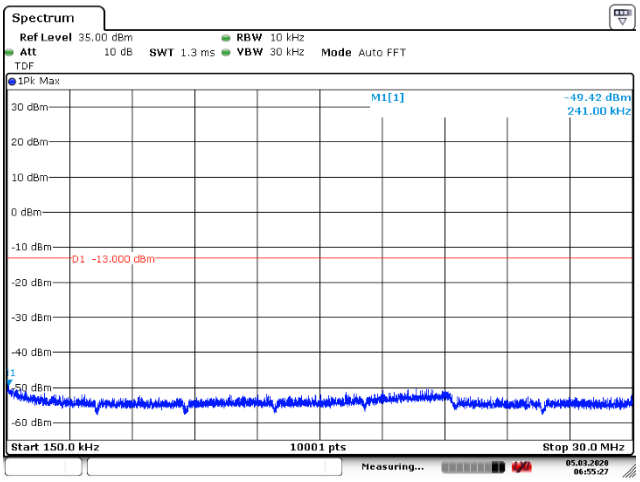


Figure 107: 150 kHz – 30 MHz

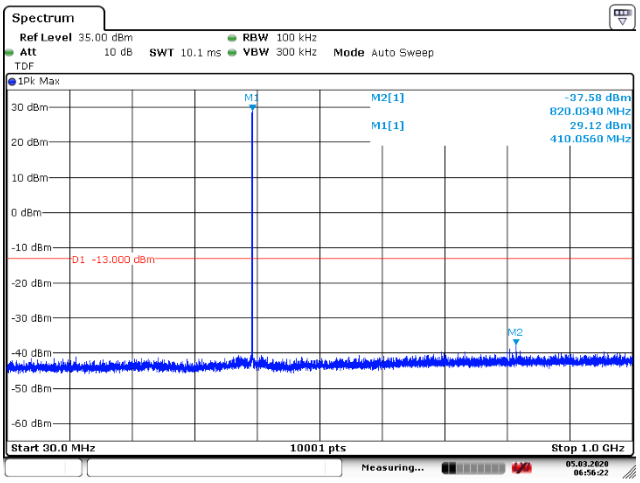


Figure 108: 30 – 1000 MHz

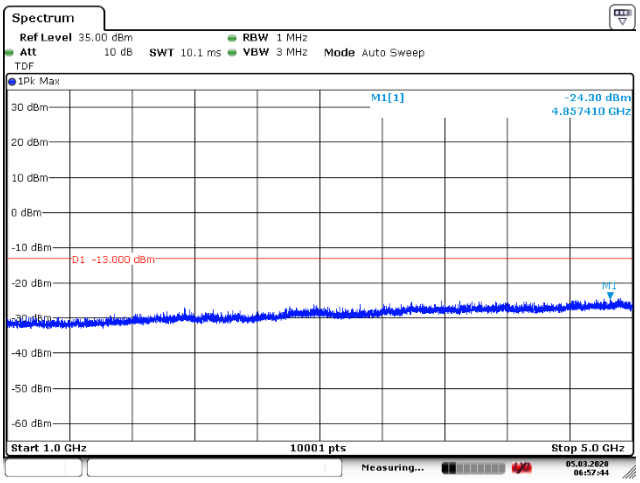


Figure 109: 1 – 5 GHz

25 kHz channel bandwidth, EUT frequency 429.5 MHz, 4 FSK

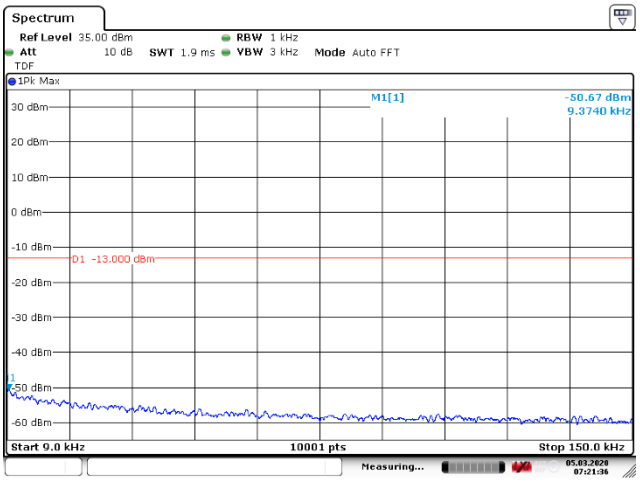


Figure 110: 9 – 150 kHz

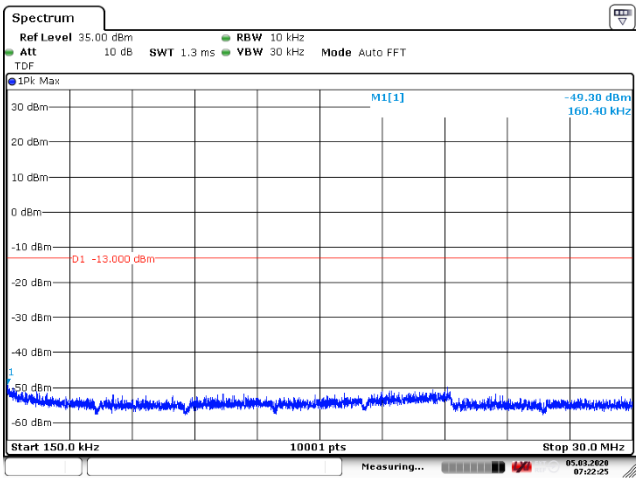


Figure 111: 150 kHz – 30 MHz

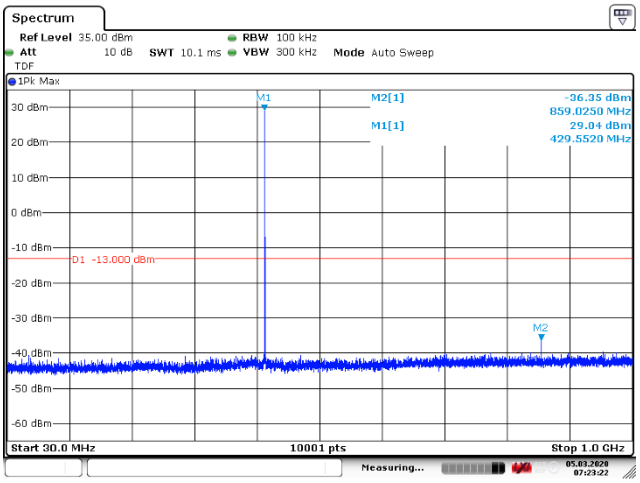


Figure 112: 30 – 1000 MHz

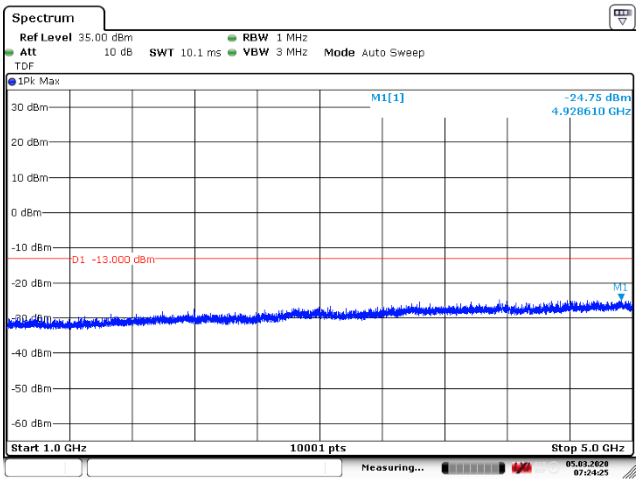


Figure 113: 1 – 5 GHz

25 kHz channel bandwidth, EUT frequency 429.5 MHz, 8 FSK

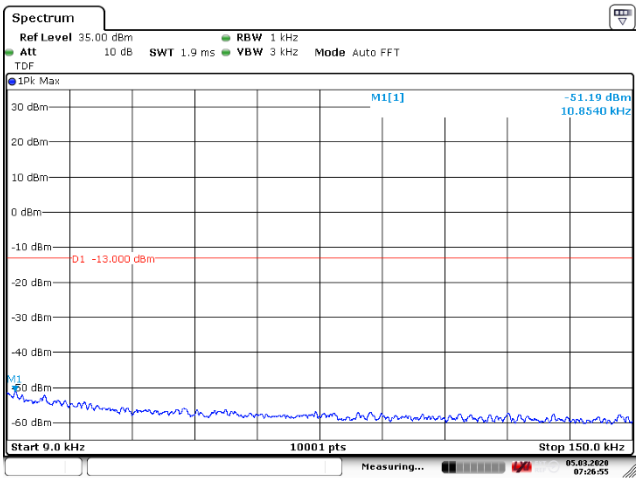


Figure 114: 9 – 150 kHz

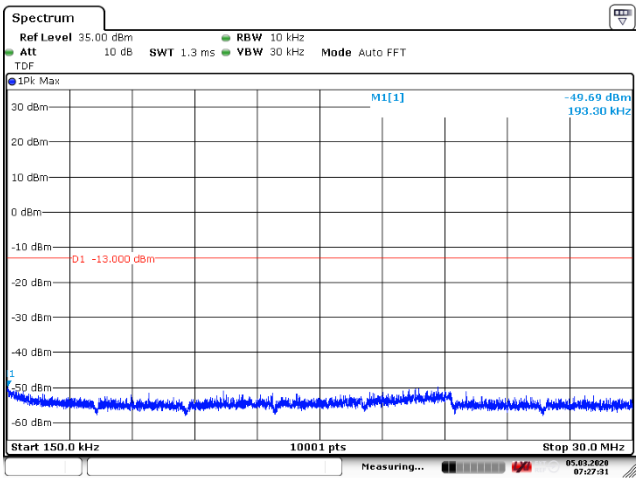


Figure 115: 150 kHz – 30 MHz

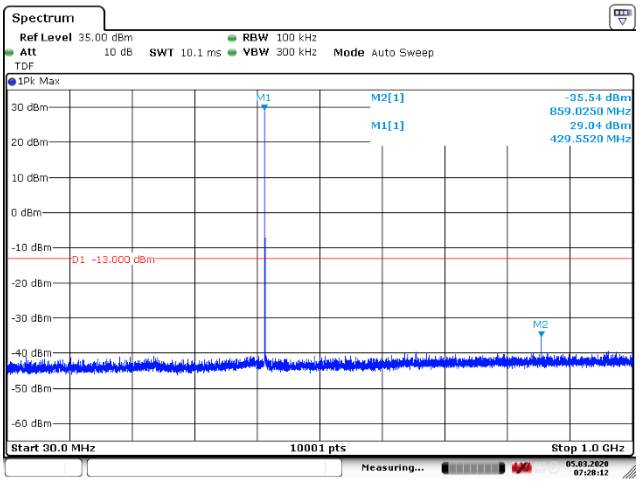


Figure 116: 30 – 1000 MHz

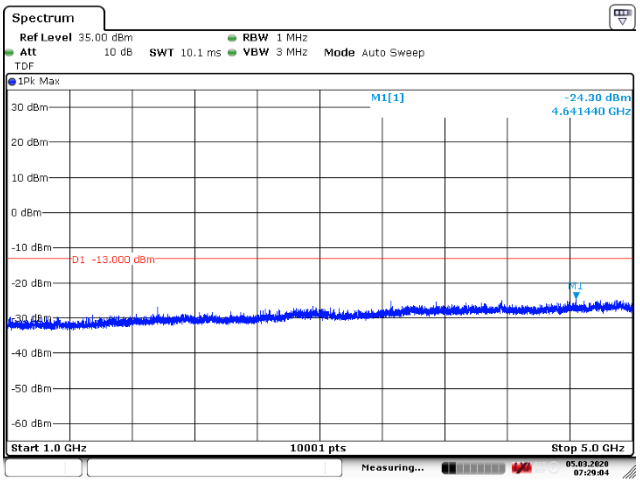


Figure 117: 1 – 5 GHz

25 kHz channel bandwidth, EUT frequency 429.5 MHz, 16 FSK

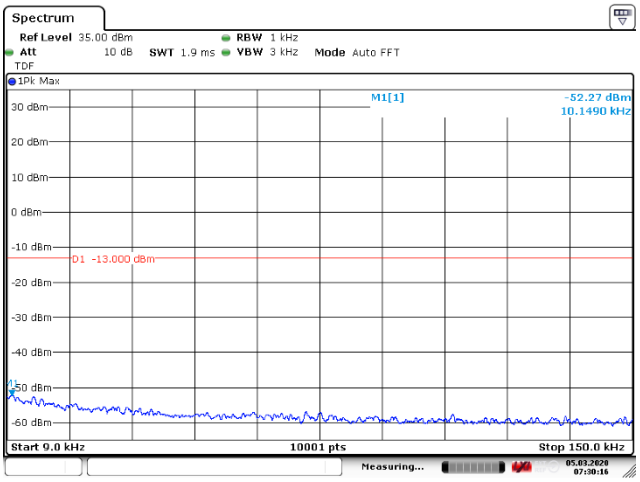


Figure 118: 9 – 150 kHz

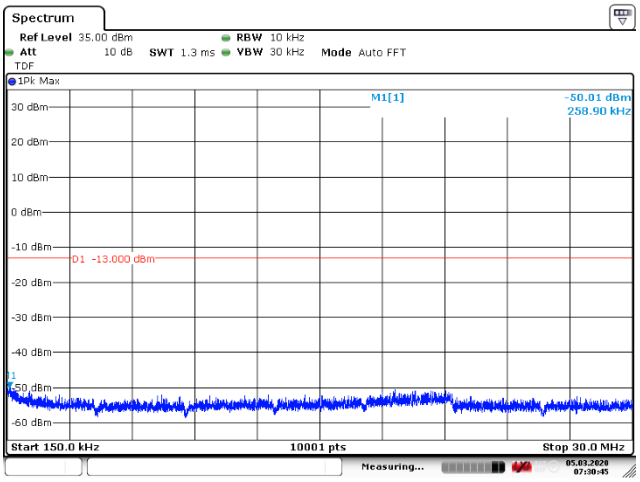


Figure 119: 150 kHz – 30 MHz

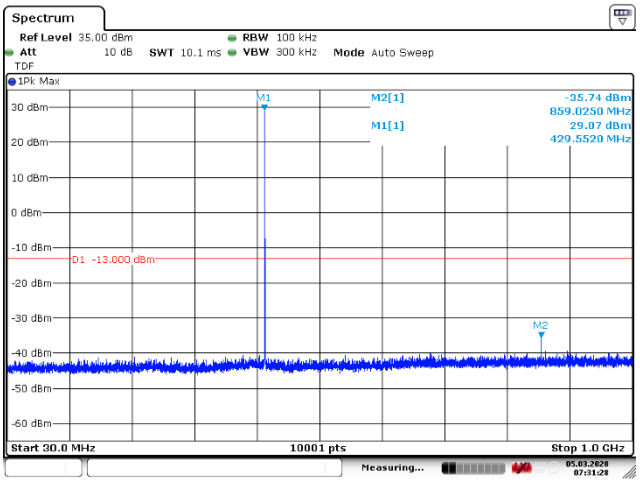


Figure 120: 30 – 1000 MHz

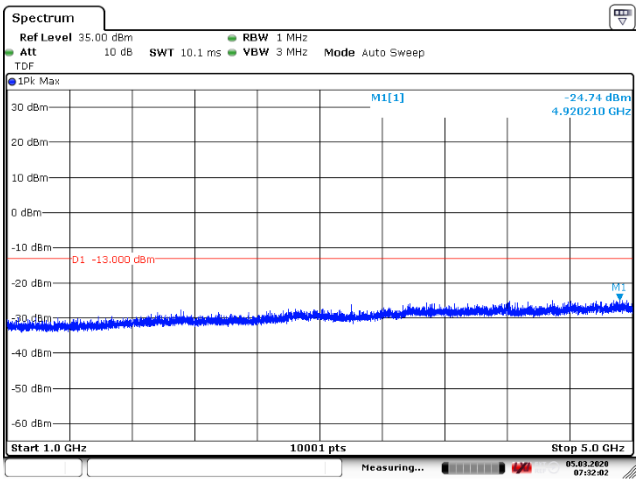


Figure 121: 1 – 5 GHz

25 kHz channel bandwidth, EUT frequency 450.5 MHz, 4 FSK

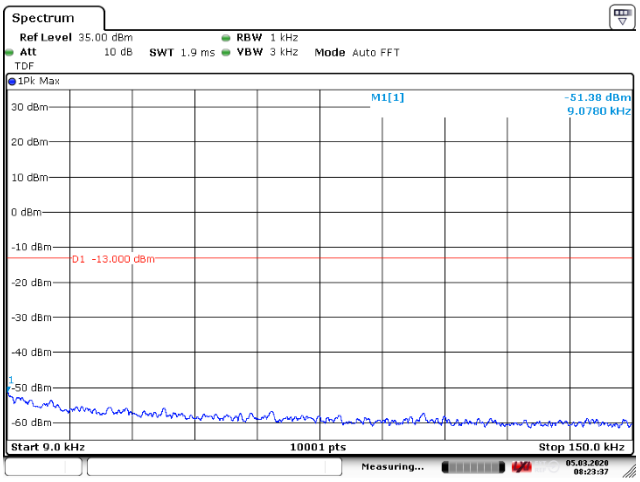


Figure 122: 9 – 150 kHz

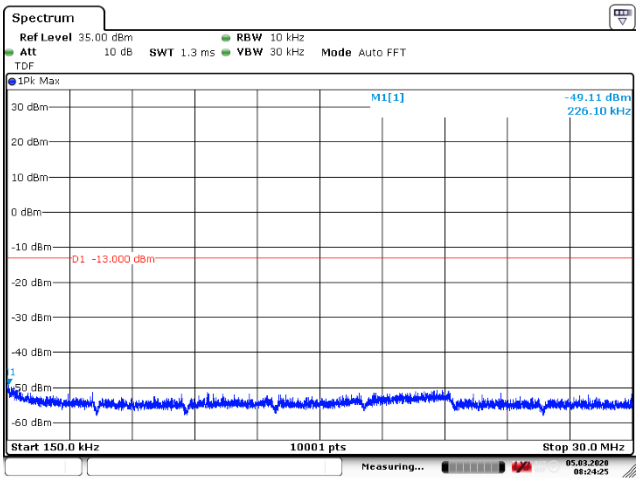


Figure 123: 150 kHz – 30 MHz

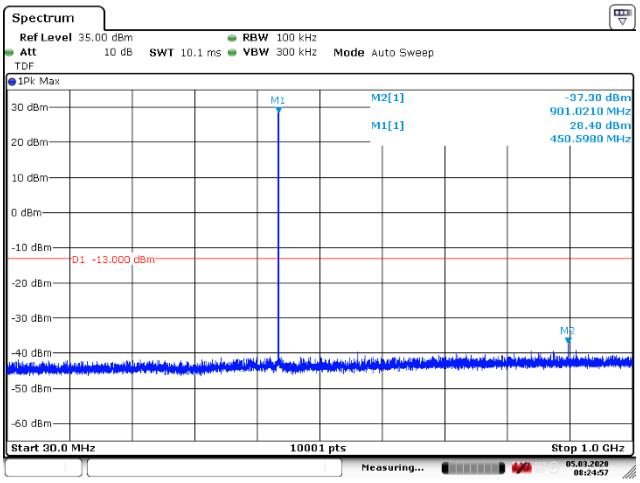


Figure 124: 30 – 1000 MHz

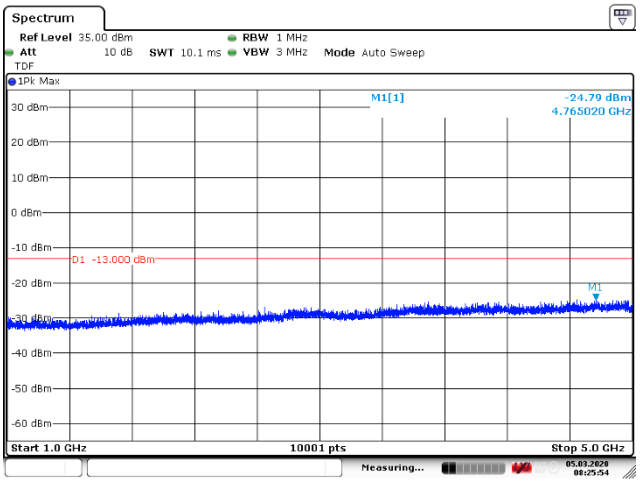


Figure 125: 1 – 5 GHz

25 kHz channel bandwidth, EUT frequency 450.5 MHz, 8 FSK

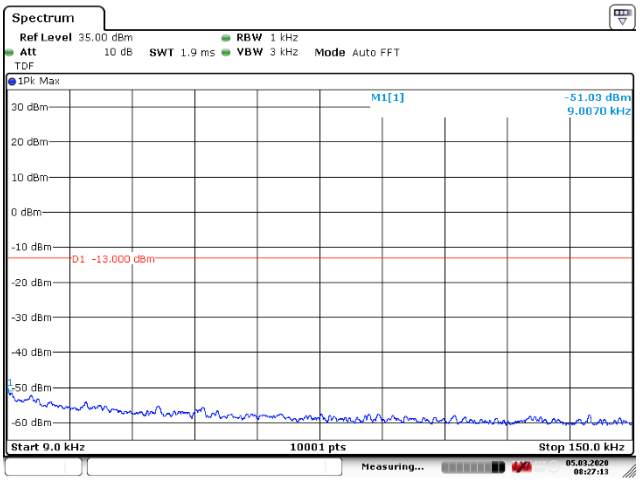


Figure 126: 9 – 150 kHz

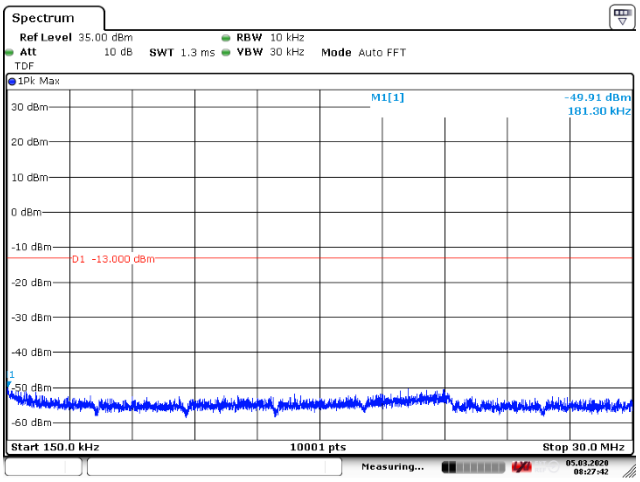


Figure 127: 150 kHz – 30 MHz

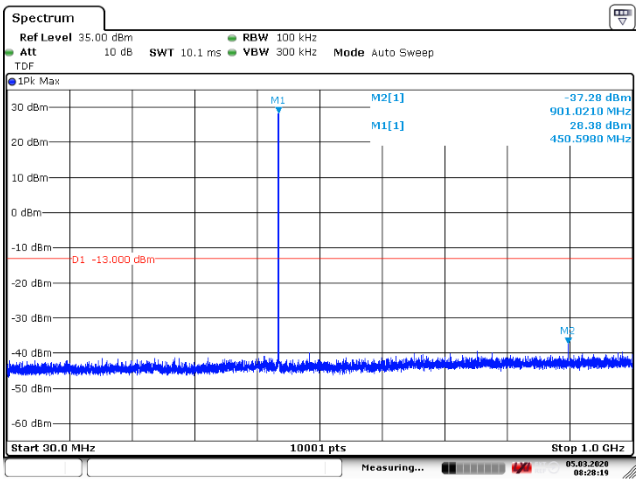


Figure 128: 30 – 1000 MHz

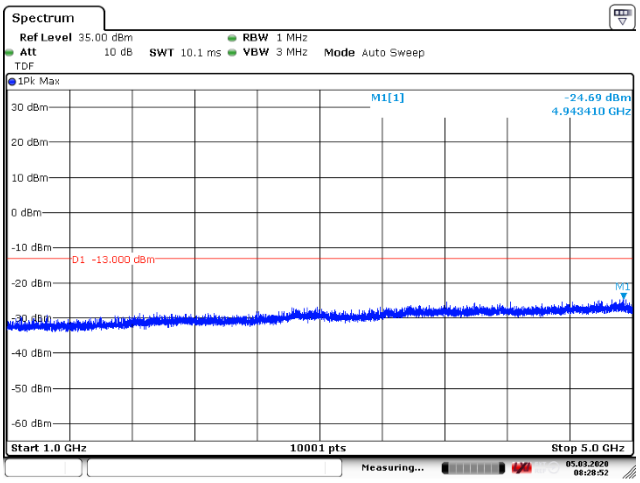


Figure 129: 1 – 5 GHz

25 kHz channel bandwidth, EUT frequency 450.5 MHz, 16 FSK

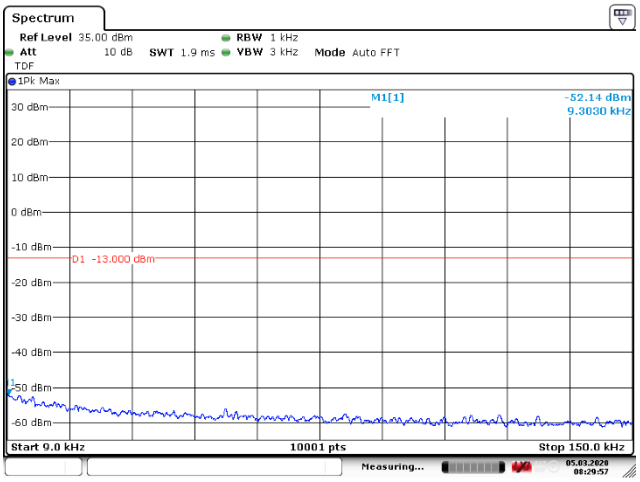


Figure 130: 9 – 150 kHz

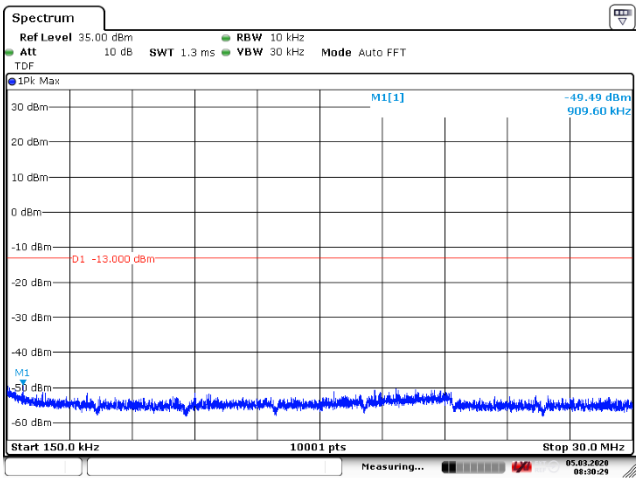


Figure 131: 150 kHz – 30 MHz

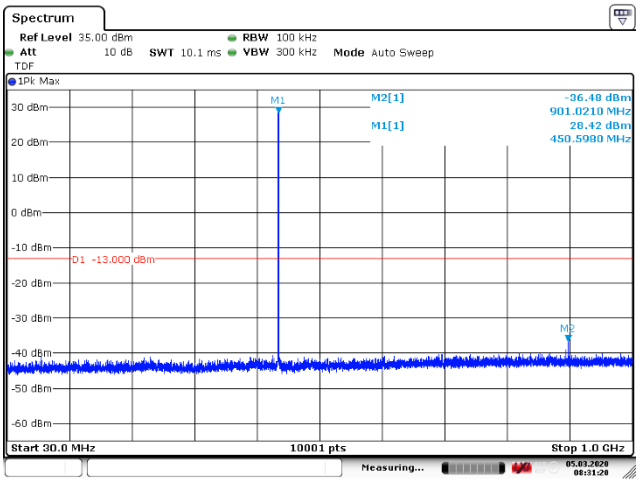


Figure 132: 30 – 1000 MHz

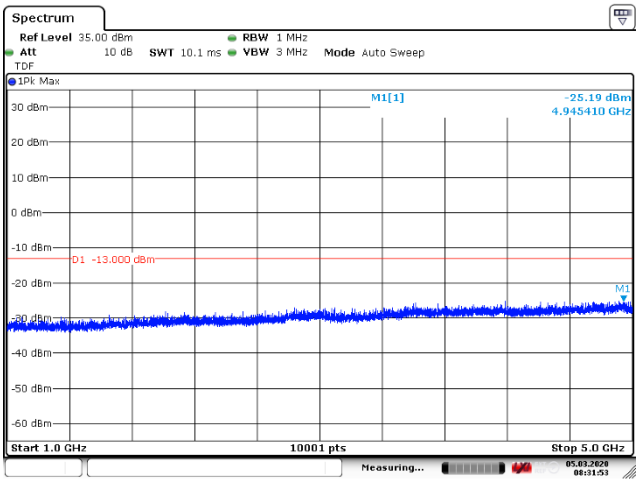


Figure 133: 1 – 5 GHz

25 kHz channel bandwidth, EUT frequency 469.5 MHz, 4 FSK

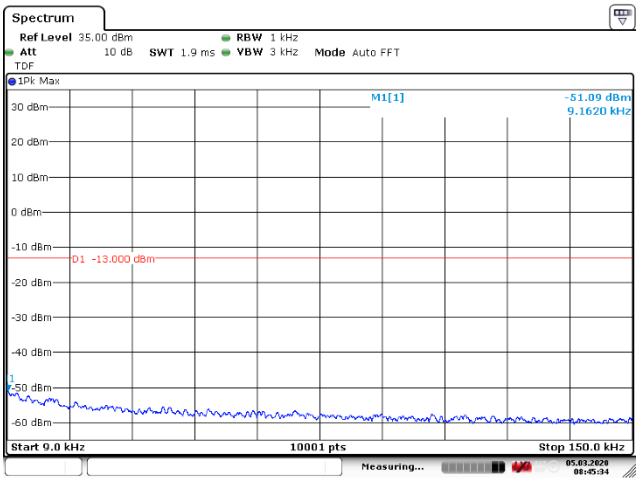


Figure 134: 9 – 150 kHz

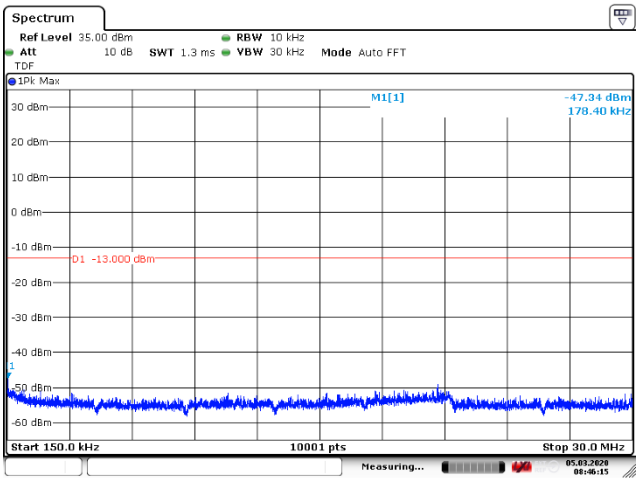


Figure 135: 150 kHz – 30 MHz

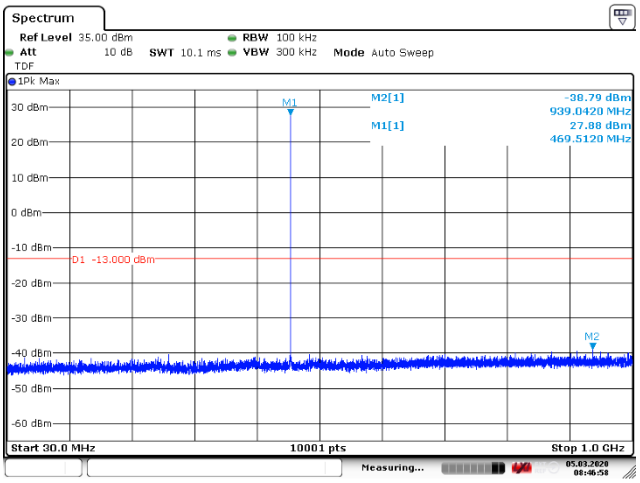


Figure 136: 30 – 1000 MHz

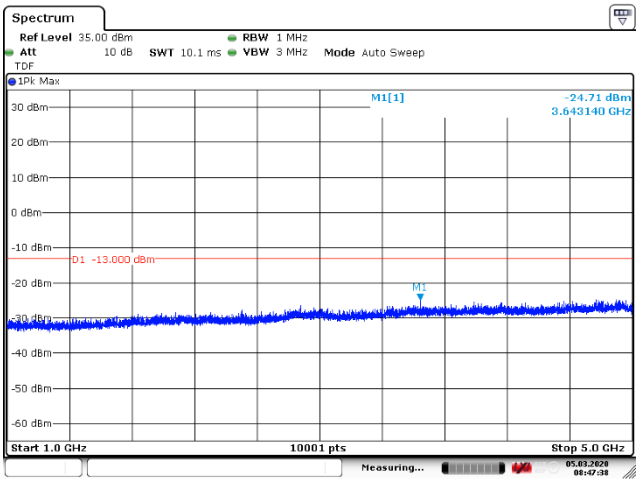


Figure 137: 1 – 5 GHz

25 kHz channel bandwidth, EUT frequency 469.5 MHz, 8 FSK

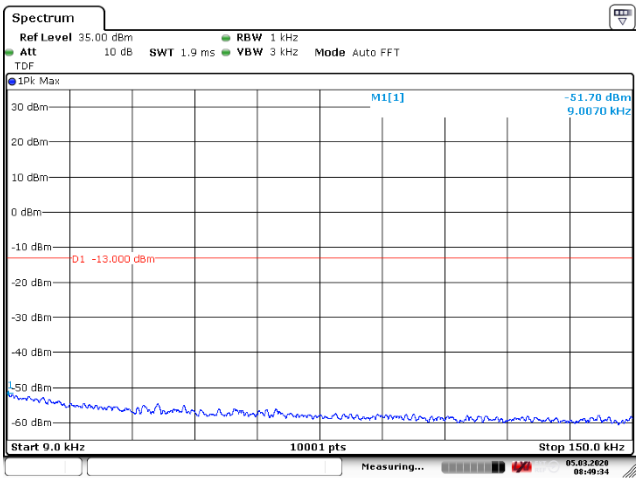


Figure 138: 9 – 150 kHz

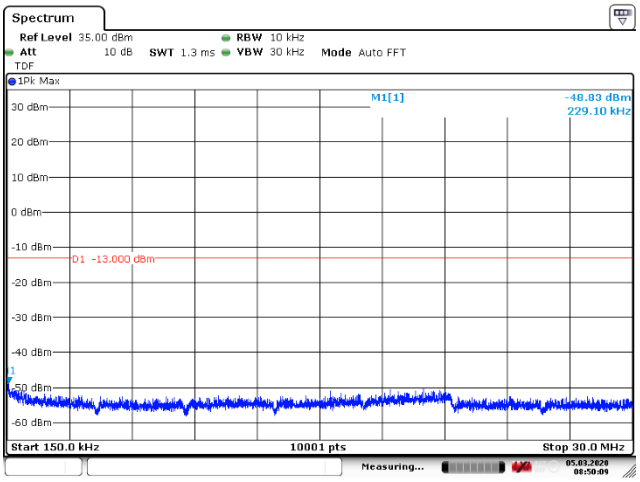


Figure 139: 150 kHz – 30 MHz

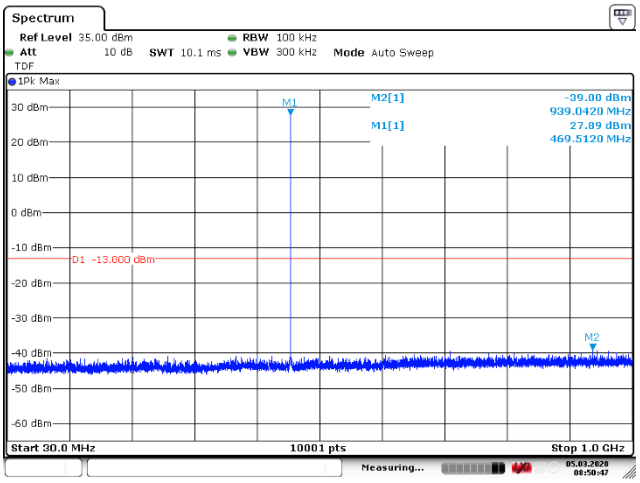


Figure 140: 30 – 1000 MHz

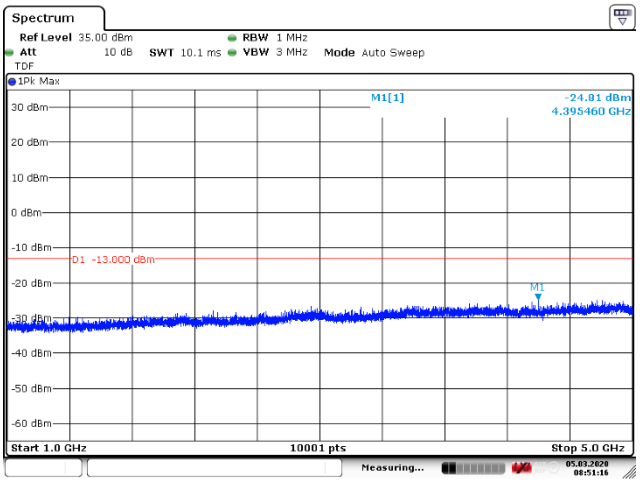


Figure 141: 1 – 5 GHz

25 kHz channel bandwidth, EUT frequency 469.5 MHz, 16 FSK

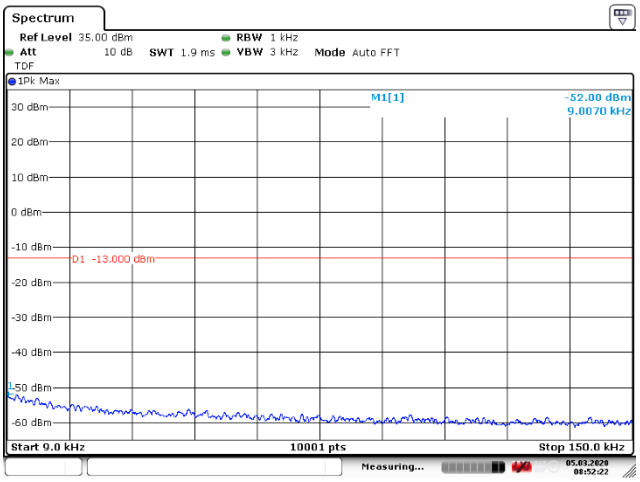


Figure 142: 9 – 150 kHz

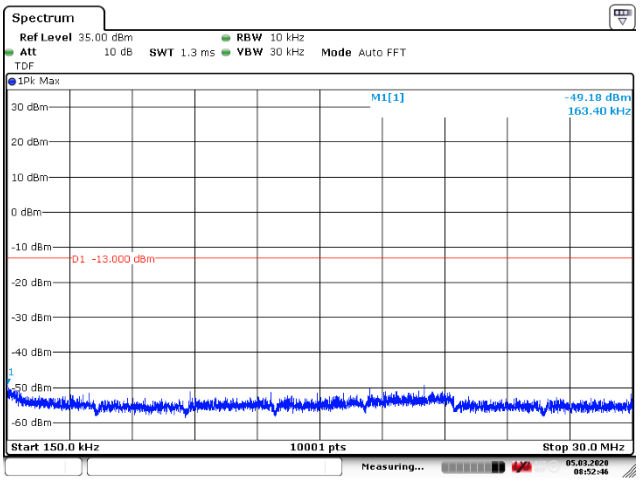


Figure 143: 150 kHz – 30 MHz

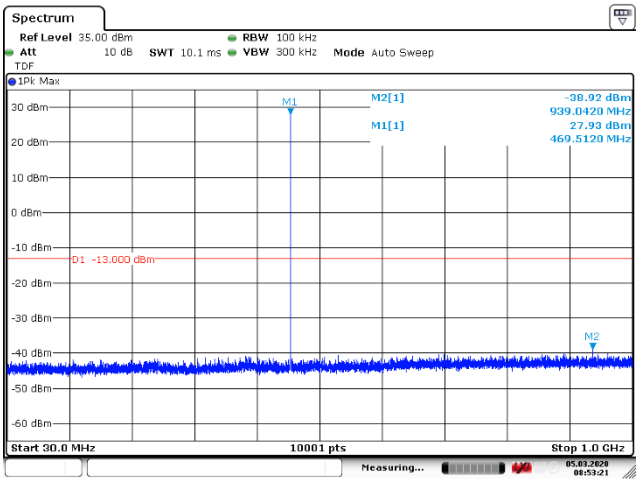


Figure 144: 30 – 1000 MHz

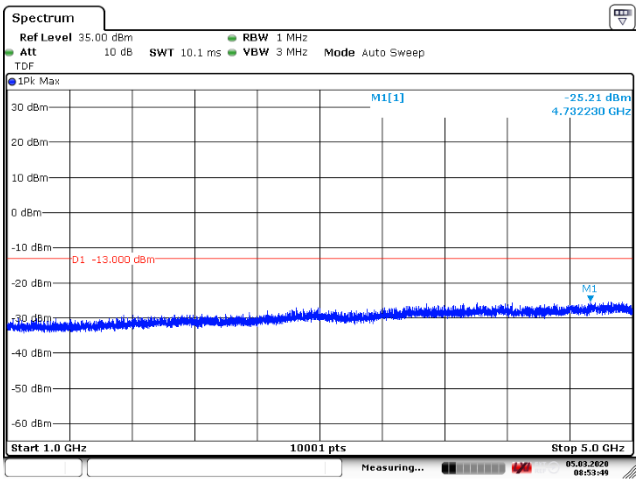


Figure 145: 1 – 5 GHz

Spurious emissions (radiated) 9 kHz – 5 GHz

Standard:	ANSI C63.26 (2015)	
Tested by:	HEM	PKA
Date:	15 January 2020	16 January 2020
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 %RH	
Measurement uncertainty:	± 5.29 dB	Level of confidence 95.45 % (k = 2)
Test result:	**PASS**	

FCC Rule: 90.210

RSS-119 5.8

For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier output power (P) as follows: on any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth; at least 43 + 10 log (P) dB.

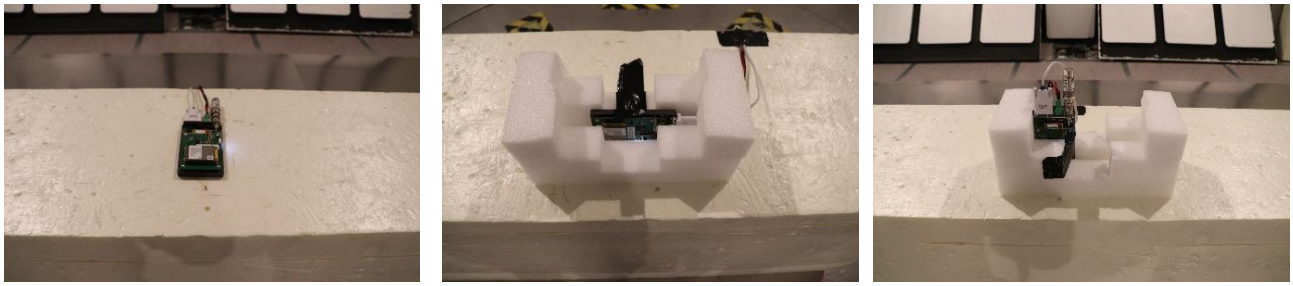
For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows: on any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz: at least 50 + 10 log (P) or 70 dB, whichever is the lesser attenuation.

Frequency Band (MHz)	Channel Bandwidth (kHz)	Authorized Bandwidth (kHz)	Limit (dBm)
406.1-430 and 450-470	12.5	11.25	-20
	25	20	-13

Test plan

The test was performed in a semi-anechoic chamber. The EUT was placed on a non-conductive 1.5 m high table standing on a turntable. The distance between the EUT and the measurement antenna was 3 m. In order to find the maximum levels of the disturbance radiation the angle of the turntable, and the height of the measuring antenna were varied during the tests. The test was performed with the measurement antenna in both horizontal and vertical polarizations.

Preliminary measurements were performed with different modulations in the frequency range 30-1000 MHz in order to determine the worst case. The final measurements were performed with 4FSK modulation, and at maximum power level. During the test the EUT frequency, channel bandwidth, and the EUT orientation on the turntable were varied. The antenna connector was terminated with a 50Ω load.



Photograph 1: EUT orientation during the test (X-, Y-, Z-orientation)

Table 9: EUT settings during the test

Measurement frequency range (MHz)	Channel Bandwidth (kHz)	EUT Frequency (MHz)	EUT orientation
0.009 – 30	12.5	429.5	Z
	25	450.5	Y
30 – 1000	12.5	410.0	X
		429.5	Y
		450.5	Z
		469.5	X
	25	410.0	Y
		429.5	Z
		450.5	X
		469.5	Y
1000 – 5000	12.5	410.0	Z
		429.5	X
		450.5	Y
		469.5	Z
	25	410.0	X
		429.5	Y
		450.5	Z
		469.5	X

Test results

Table 10: Spurious emissions (radiated) results

No final measurements were made; no emissions near the limit

9 kHz – 30 MHz

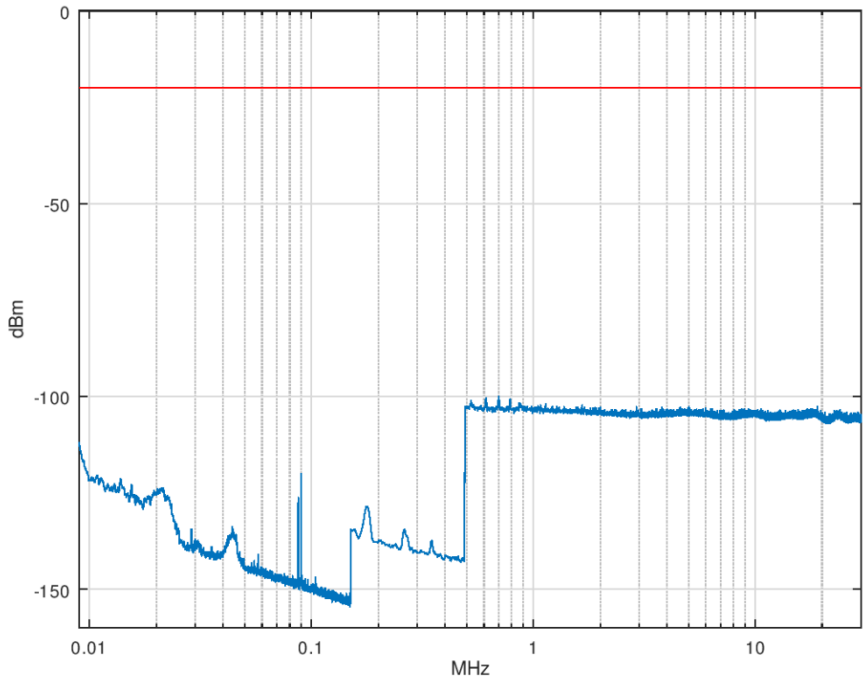


Figure 146: 429.5 MHz, 12.5 kHz, Z-orientation

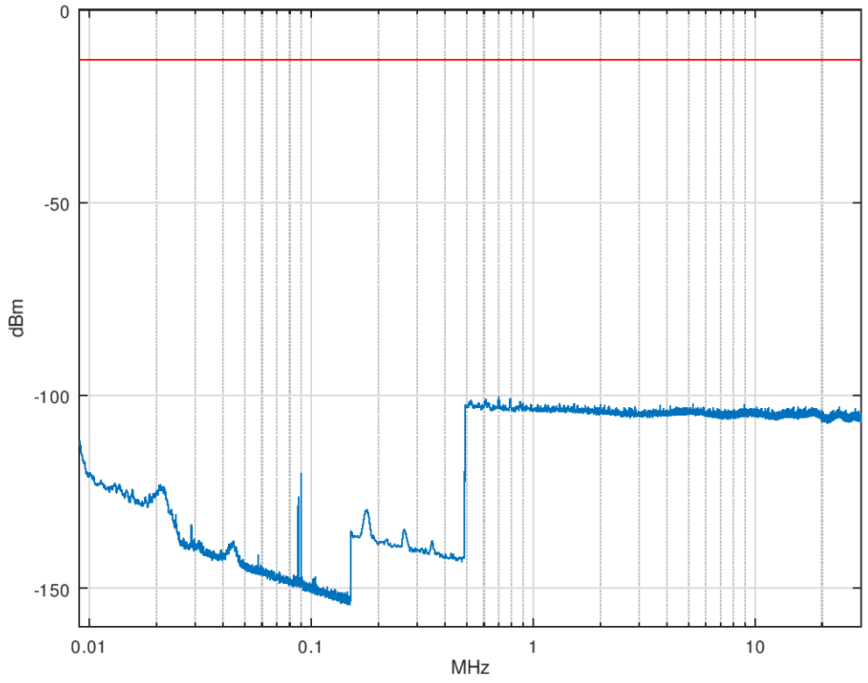


Figure 147: 450.5 MHz, 25 kHz, Y-orientation

30 – 1000 MHz, 12.5 kHz channel bandwidth

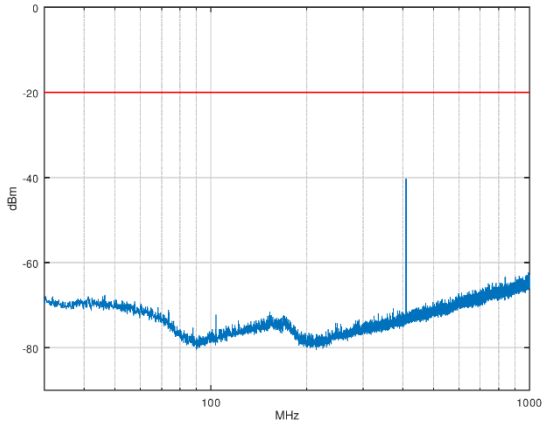


Figure 148: 410.0 MHz, X-orientation

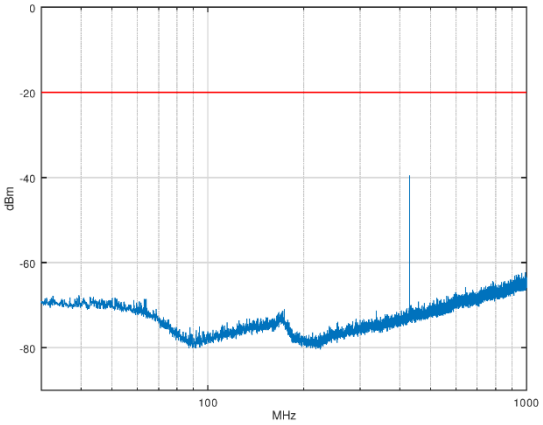


Figure 149: 429.5 MHz, Y-orientation

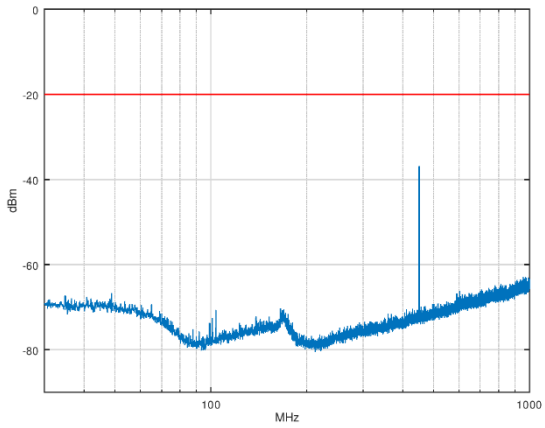


Figure 150: 450.5 MHz, Z-orientation

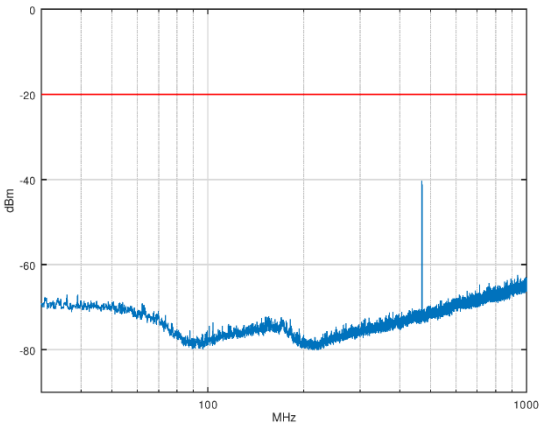


Figure 151: 469.5 MHz, X-orientation

30 – 1000 MHz, 25 kHz channel bandwidth

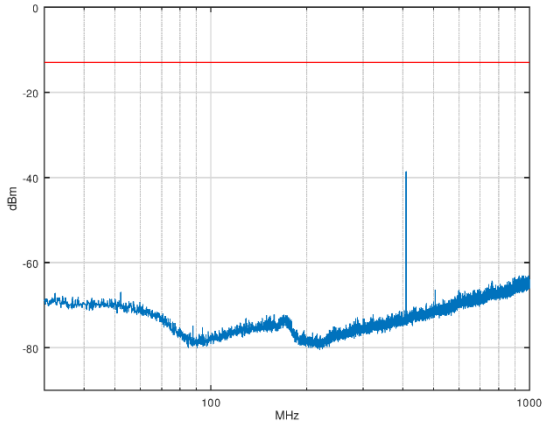


Figure 152: 410.0 MHz, Y-orientation

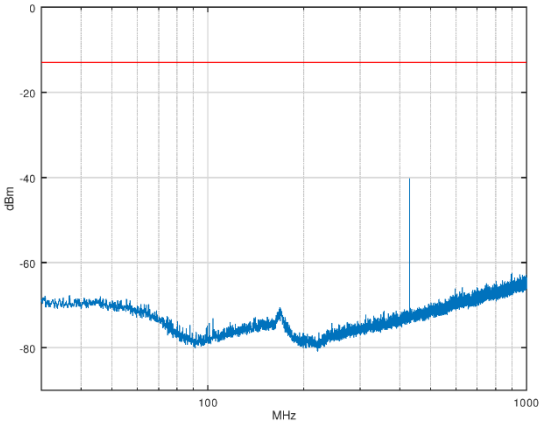


Figure 153: 429.5 MHz, Z-orientation

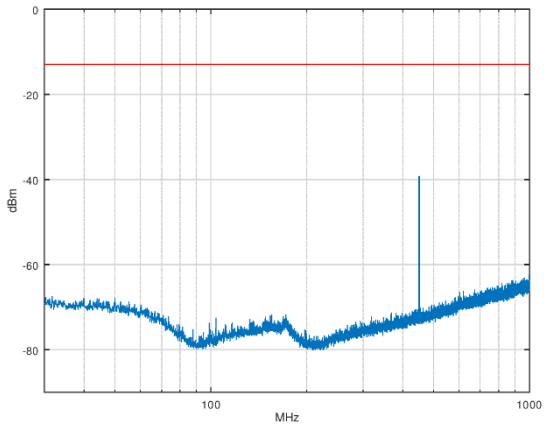


Figure 154: 450.5 MHz, X-orientation

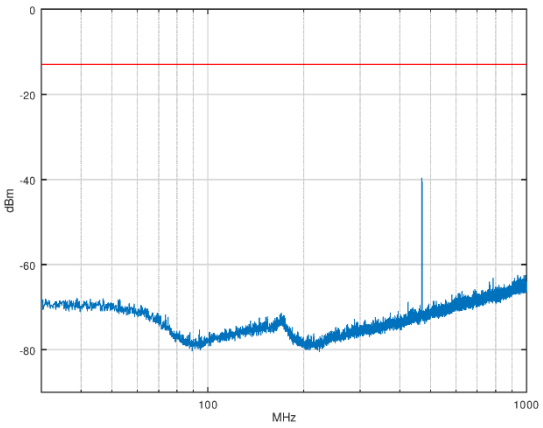


Figure 155: 469.5 MHz, Y-orientation

1000 – 5000 MHz, 12.5 kHz channel bandwidth

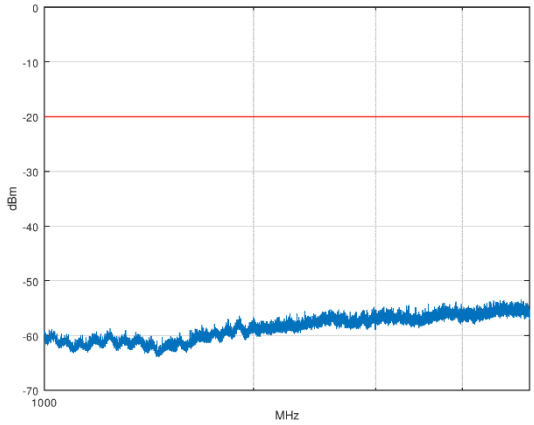


Figure 156: 410.0 MHz, Z-orientation

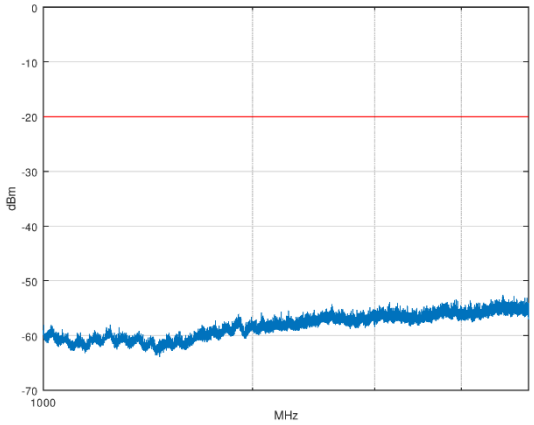


Figure 157: 429.5 MHz, X-orientation

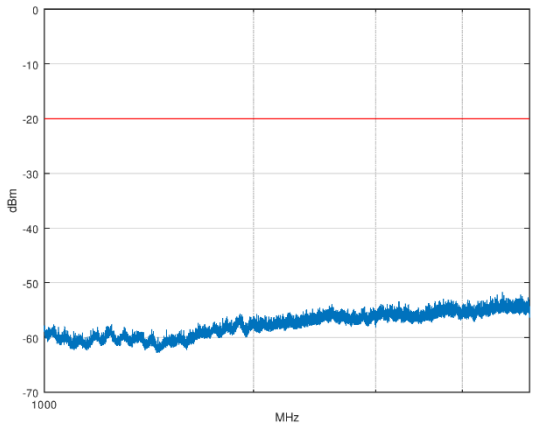


Figure 158: 450.5 MHz, Y-orientation

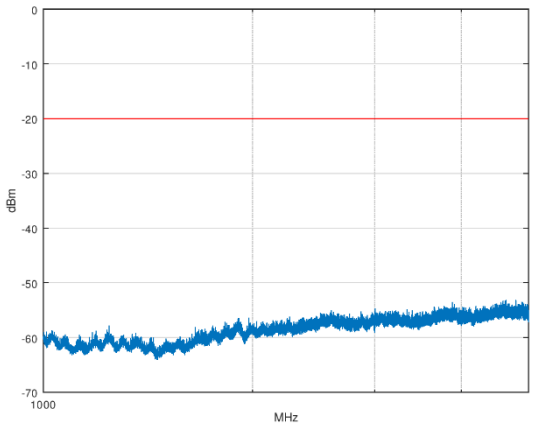


Figure 159: 469.5 MHz, Z-orientation

1000 – 5000 MHz, 25 kHz channel bandwidth

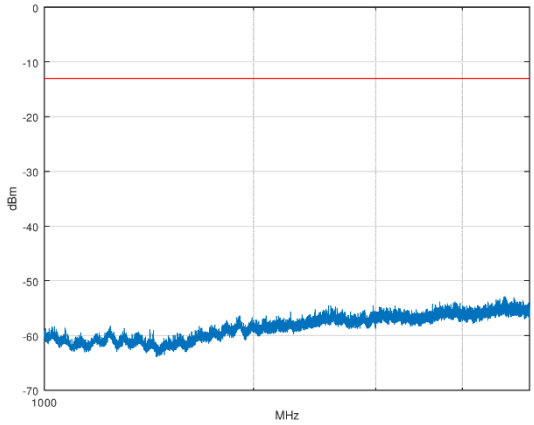


Figure 160: 410.0 MHz, X-orientation

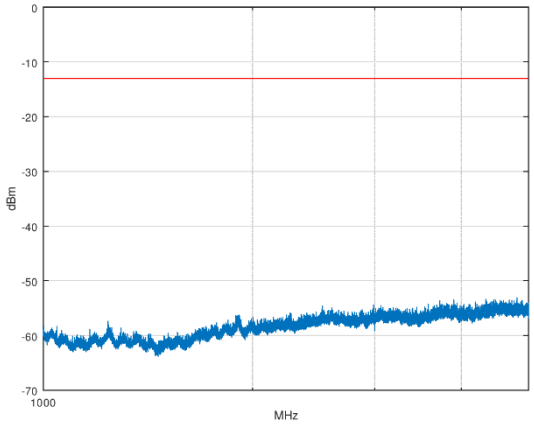


Figure 161: 429.5 MHz, Y-orientation

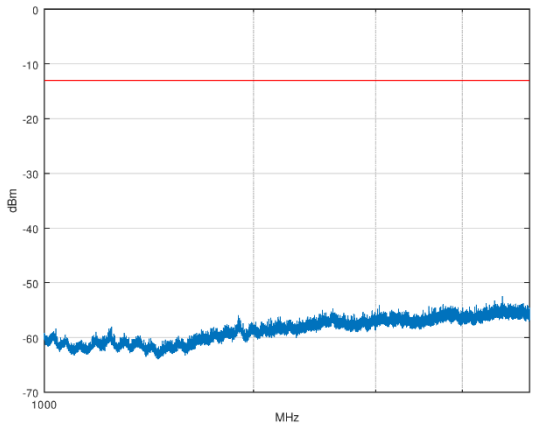


Figure 162: 450.5 MHz, Z-orientation

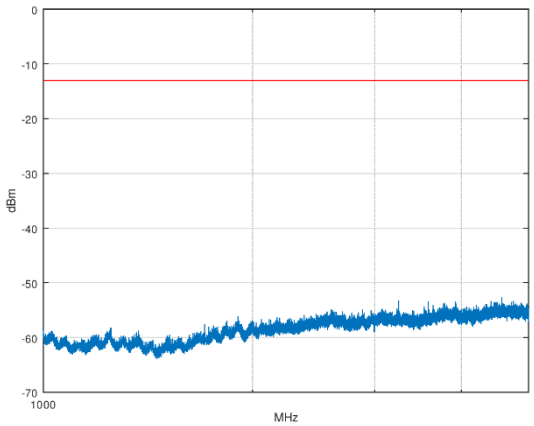


Figure 163: 469.5 MHz, X-orientation

Frequency stability

Standard:	ANSI C63.26 (2015)	
Tested by:	PKA	
Date:	15 January 2020	
Temperature:	23 ± 3 °C	
Humidity:	20 - 60 %RH	
Measurement uncertainty:	± 0.470 dB	Level of confidence 95.45 % (k = 2)
Test result:	**PASS**	

FCC Rule: 90.213

RSS-119 5.3

Frequency stability is a measure of drift due to temperature and supply voltage variations, with reference to the frequency measured at an appropriate reference temperature and the rated supply voltage. The carrier frequency shall not depart from the nominal frequency in excess of the values specified for the equipment's frequency band:

Frequency Band (MHz)	Channel Bandwidth (kHz)	Frequency Stability (ppm)
406.1-430 and 450-470	12.5	± 2.5
	25	± 5

The test was performed with unmodulated carrier at maximum power level.

Test results

Table 11: Frequency stability (normal temperature, 12.5 kHz channel bandwidth)

Test Conditions		Frequency (MHz)		Deviation from Nominal (ppm)	Result
Temperature (°C)	Voltage (V)	Nominal	Measured		
22	3.8	410.0	410.00000340	0.0083	PASS
		469.5	469.50005800	0.1235	PASS
	4.5	410.0	410.00000250	0.0061	PASS
		469.5	469.50008700	0.1853	PASS
	5.5	410.0	410.00000620	0.0151	PASS
		469.5	469.50006680	0.1423	PASS

Table 12: Frequency stability (normal temperature, 25 kHz channel bandwidth)

Test Conditions		Frequency (MHz)		Deviation from Nominal (ppm)	Result
Temperature (°C)	Voltage (V)	Nominal	Measured		
22	3.8	410.0	410.00000150	0.0037	PASS
		469.5	469.50008700	0.1853	PASS
	4.5	410.0	410.00000020	0.0005	PASS
		469.5	469.50008700	0.1853	PASS
	5.5	410.0	410.00000280	0.0068	PASS
		469.5	469.50006620	0.1410	PASS

Table 13: Frequency stability (extreme temperature, 4.5 V, 12.5 kHz channel bandwidth)

Temperature (°C)	Frequency (MHz)		Deviation from Nominal (ppm)	Result
	Nominal	Measured		
-30	410.0	409.99981300	-0.4561	PASS
	469.5	469.49973030	-0.5744	PASS
-20	410.0	409.99981300	-0.4561	PASS
	469.5	469.49978460	-0.4588	PASS
-10	410.0	409.99992960	-0.1717	PASS
	469.5	469.49984520	-0.3297	PASS
0	410.0	409.99995350	-0.1134	PASS
	469.5	469.49999498	-0.0107	PASS
+10	410.0	409.99999930	-0.0017	PASS
	469.5	469.49998430	-0.0334	PASS
+20	410.0	409.99999120	-0.0214	PASS
	469.5	469.50000410	0.0087	PASS
+30	410.0	410.00003140	0.0766	PASS
	469.5	469.50001110	0.0236	PASS
+40	410.0	410.00004300	0.1049	PASS
	469.5	469.50001930	0.0411	PASS
+50	410.0	410.00000060	0.0015	PASS
	469.5	469.50005160	0.1099	PASS
+60	410.0	410.00000160	0.0039	PASS
	469.5	469.50007520	0.1602	PASS

Table 14: Frequency stability (extreme temperature, 4.5 V, 25 kHz channel bandwidth)

Temperature (°C)	Frequency (MHz)		Deviation from Nominal (ppm)	Result
	Nominal	Measured		
-30	410.0	409.99981150	-0.4596	PASS
	469.5	469.49975850	-0.5144	PASS
-20	410.0	409.99985410	-0.3559	PASS
	469.5	469.49976990	-0.4901	PASS
-10	410.0	409.99993930	-0.1480	PASS
	469.5	469.49980145	-0.4229	PASS
0	410.0	409.99997240	-0.0673	PASS
	469.5	469.49995640	-0.0929	PASS
+10	410.0	410.00000320	0.0078	PASS
	469.5	469.49999645	-0.0076	PASS
+20	410.0	409.99999630	-0.0090	PASS
	469.5	469.50000760	0.0162	PASS
+30	410.0	410.00003620	0.0883	PASS
	469.5	469.49999860	-0.0030	PASS
+40	410.0	410.00003810	0.0929	PASS
	469.5	469.50002120	0.0451	PASS
+50	410.0	409.99999230	-0.0188	PASS
	469.5	469.50002980	0.0635	PASS
+60	410.0	409.99998670	-0.0324	PASS
	469.5	469.50007260	0.1546	PASS

Transient frequency behaviour

Standard:	ANSI C63.26 (2015)
Tested by:	PKA
Date:	27 February 2020
Temperature:	23 ± 3 °C
Humidity:	20 - 60 %RH
Test result:	**PASS**

FCC Rule: 90.214

RSS-119 5.9

When a transmitter is turned on or off, the radio frequency may take some time to stabilize. During this initial period, the frequency error or frequency difference (i.e., between the instantaneous and the steady state frequencies) shall not exceed the limits specified for the equipment's frequency band and channel bandwidth:

Channel Bandwidth (kHz)	Time Intervals	Maximum Frequency Difference (kHz)	Transient Duration Limit (ms)
12.5	t_1	±12.5	10
	t_2	±6.25	25
	t_3	±12.5	10
25	t_1	±25	10
	t_2	±12.5	25
	t_3	±25	10

- t_{on} is the instant when a 1 kHz test signal is completely suppressed, including any capture time due to phasing
- t_1 is the time period immediately following t_{on}
- t_2 is the time period immediately following t_1
- t_3 is the time period from the instant when the transmitter is turned off until t_{off}
- t_{off} is the instant when the 1 kHz test signal starts to rise

The test was performed with unmodulated carrier at maximum power level.

Test results

Transmitter OFF to ON (12.5 kHz channel bandwidth)

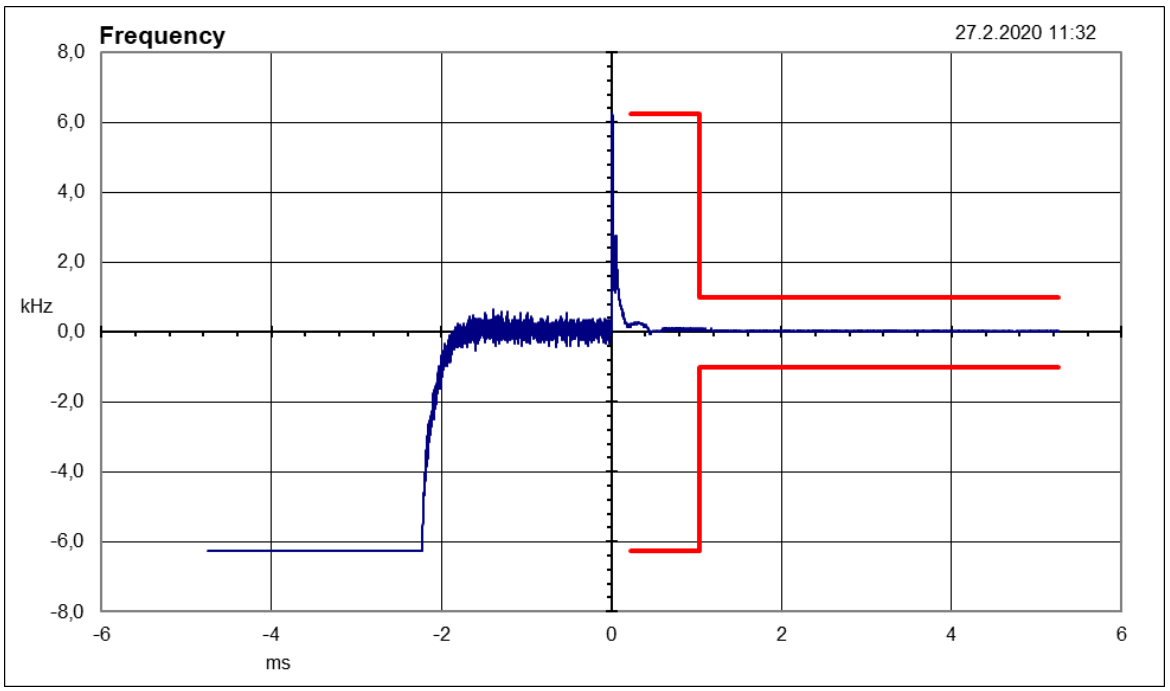


Figure 164: 410.0 MHz

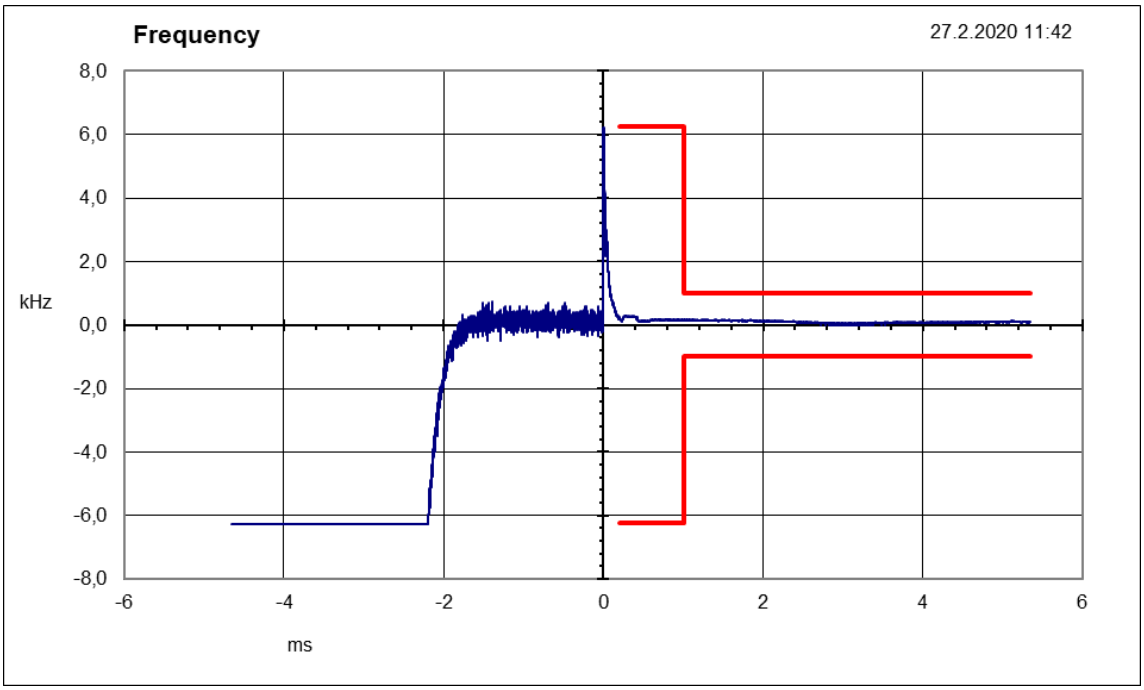


Figure 165: 429.5 MHz

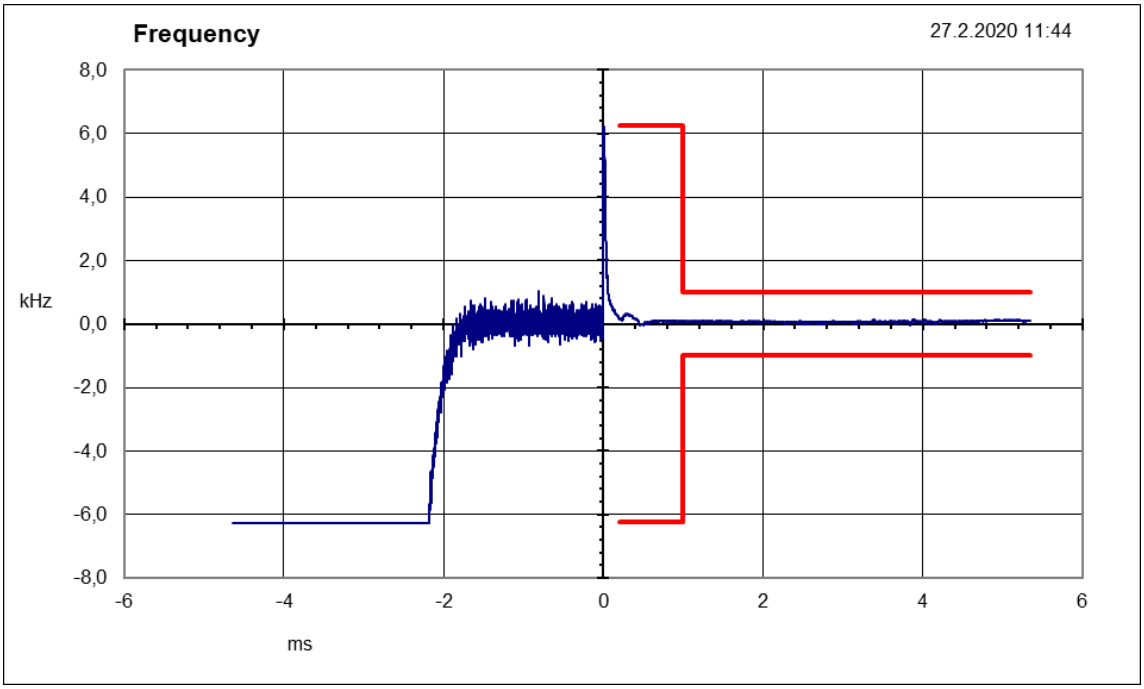


Figure 166: 450.5 MHz

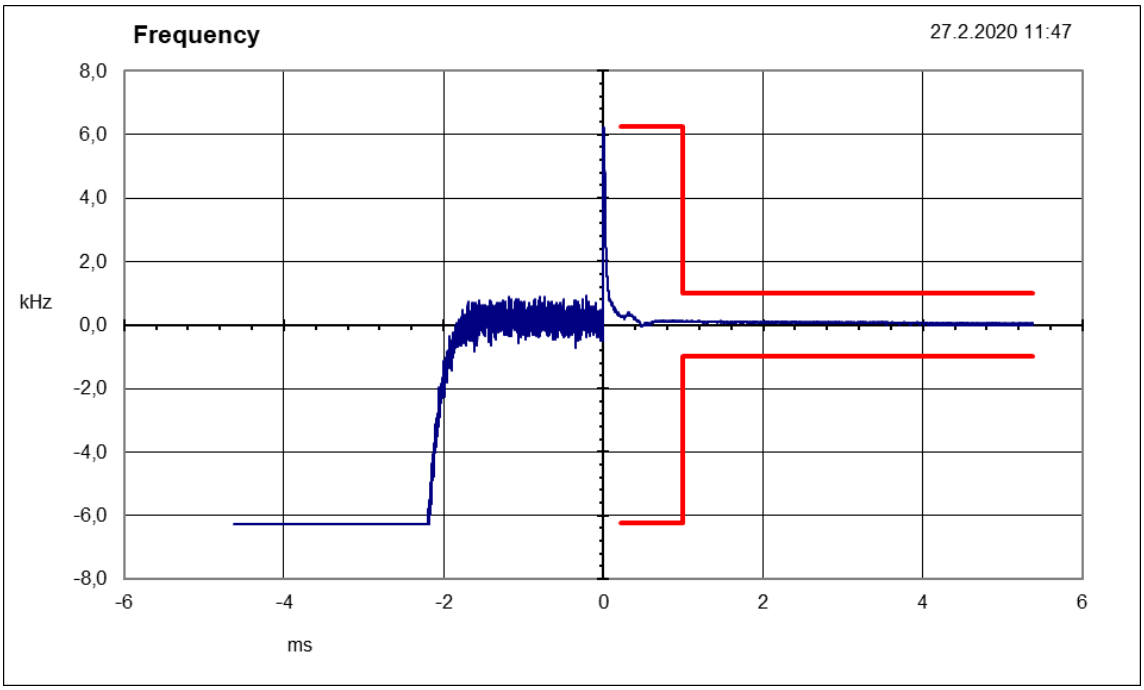


Figure 167: 469.5 MHz

Transmitter OFF to ON (25 kHz channel bandwidth)

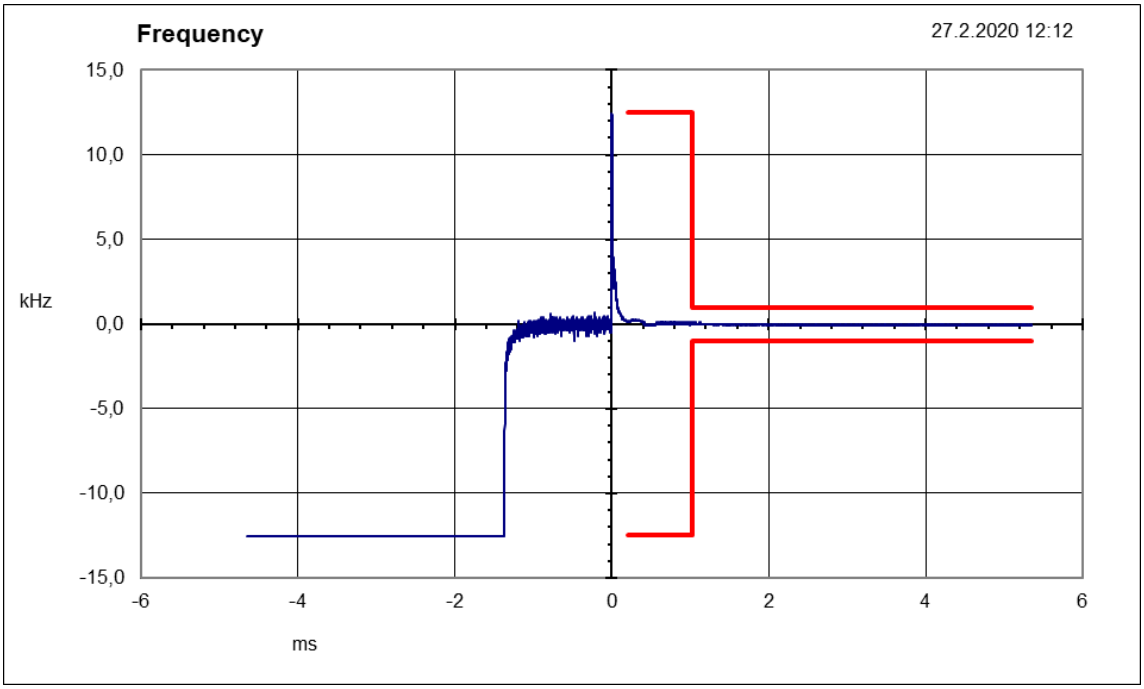


Figure 168: 410.0 MHz

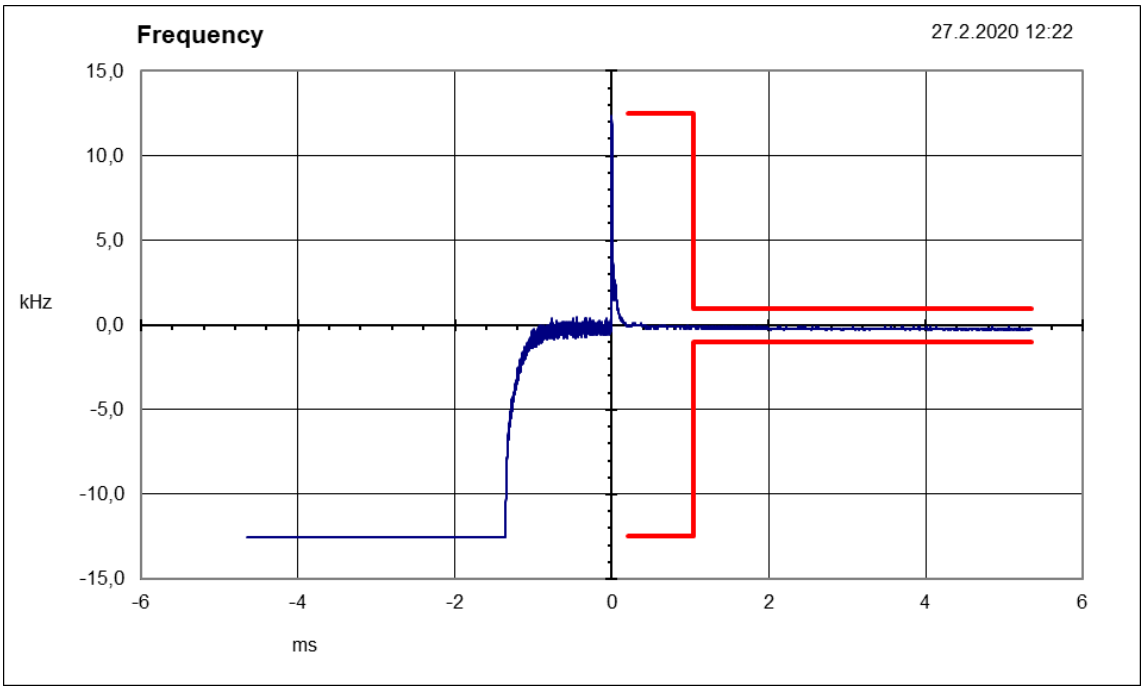


Figure 169: 429.5 MHz

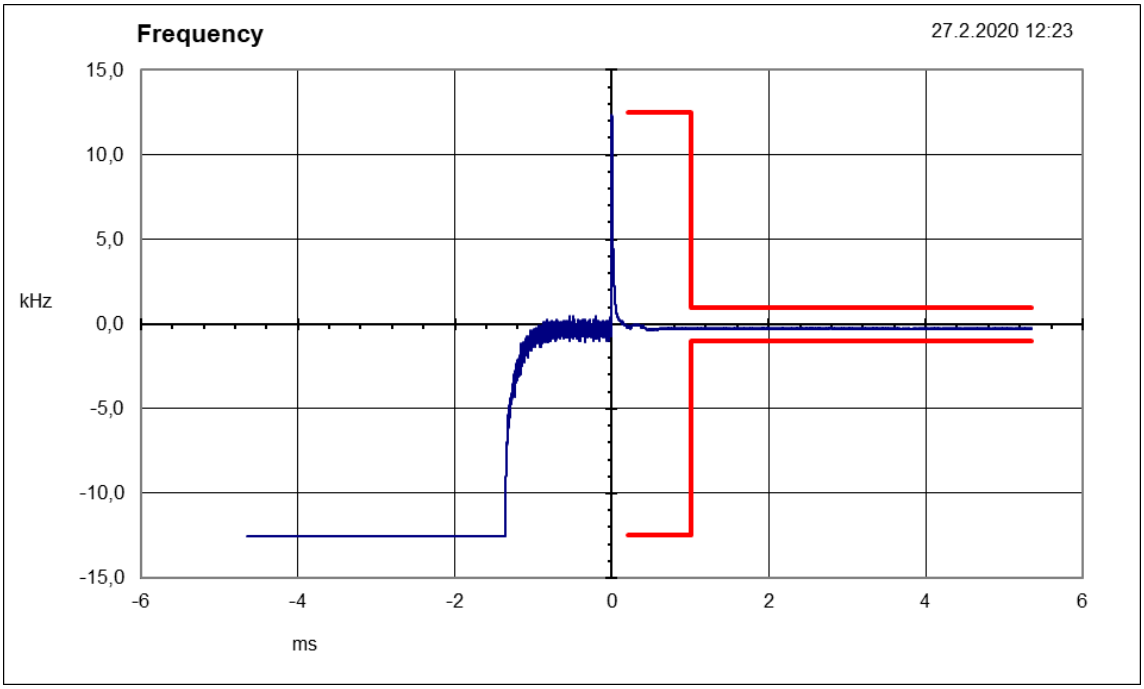


Figure 170: 450.5 MHz

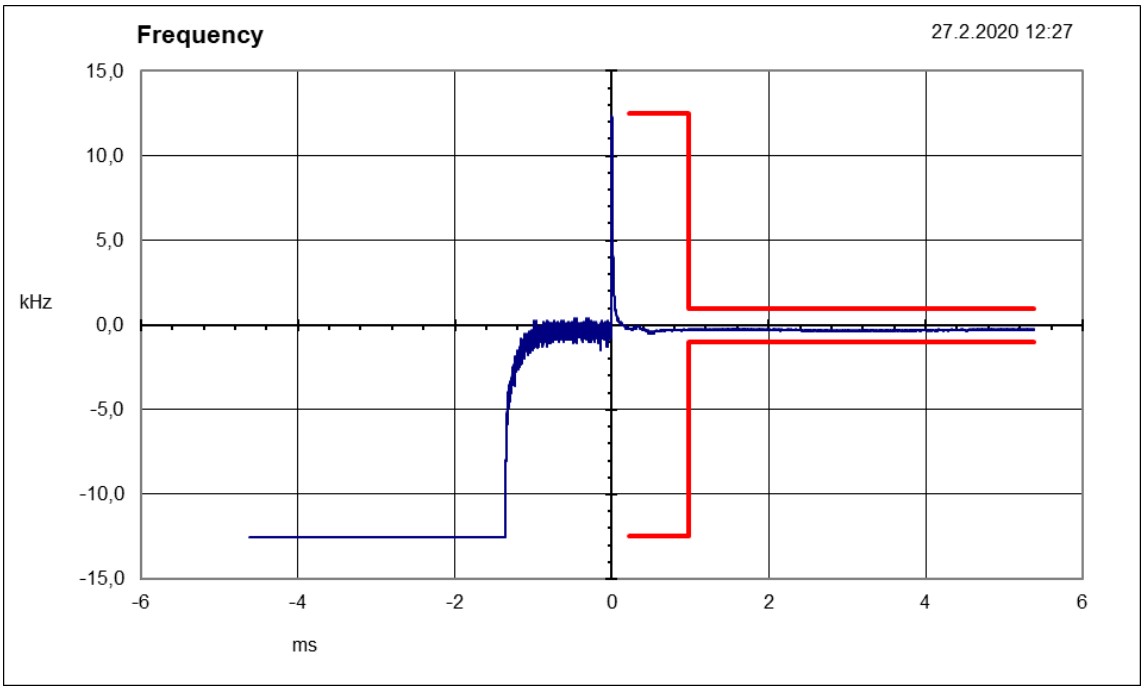


Figure 171: 469.5 MHz

Transmitter ON to OFF (12.5 kHz channel bandwidth)

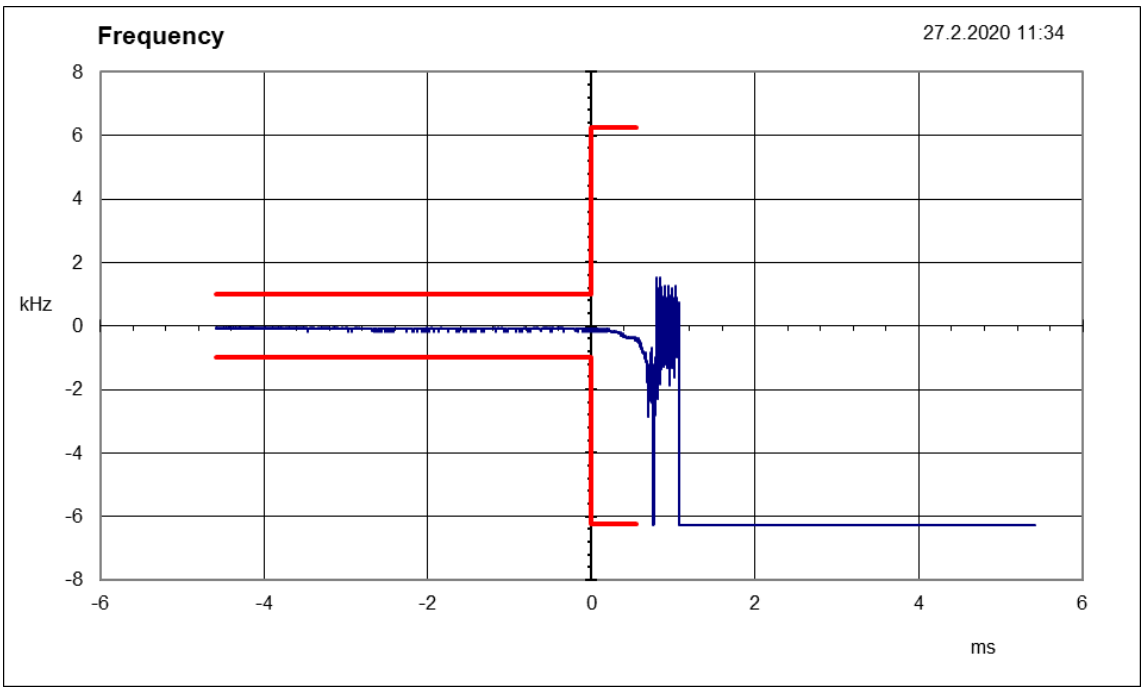


Figure 172: 410.0 MHz

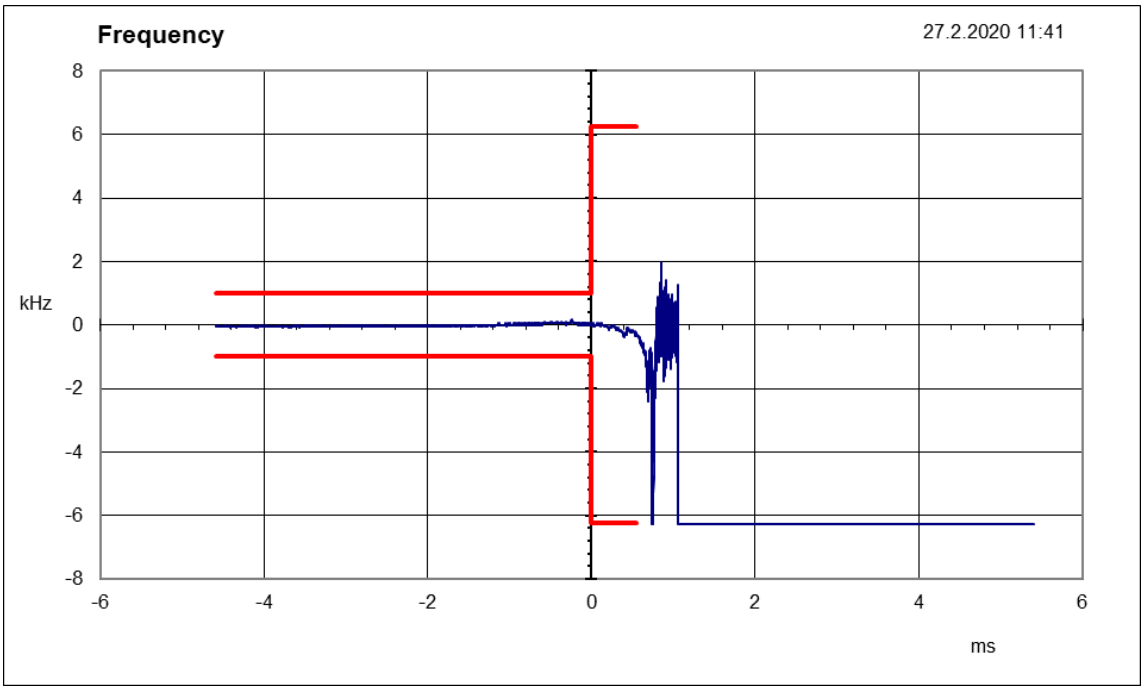


Figure 173: 429.5 MHz

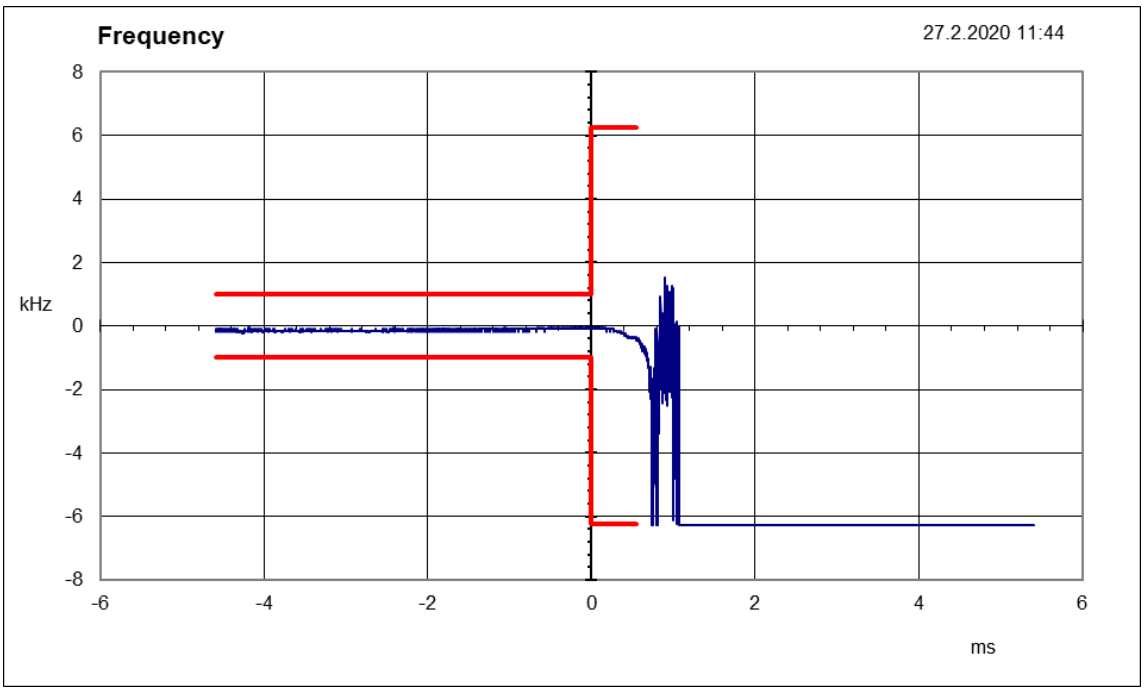


Figure 174: 450.5 MHz

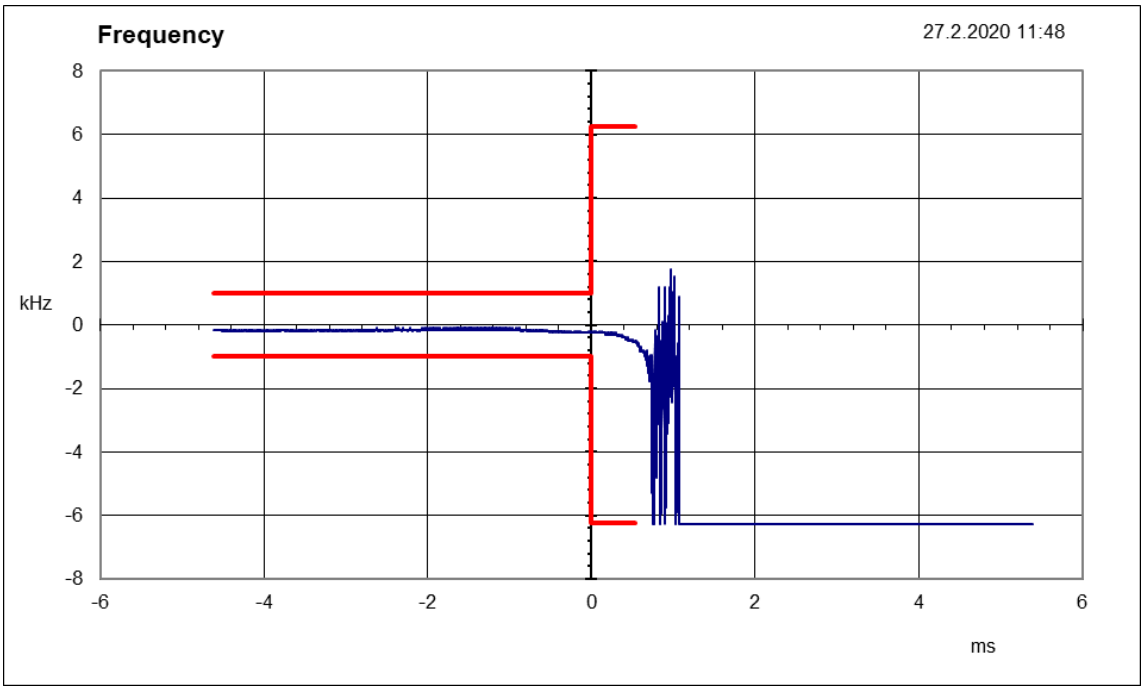


Figure 175: 469.5 MHz

Transmitter ON to OFF (25 kHz channel bandwidth)

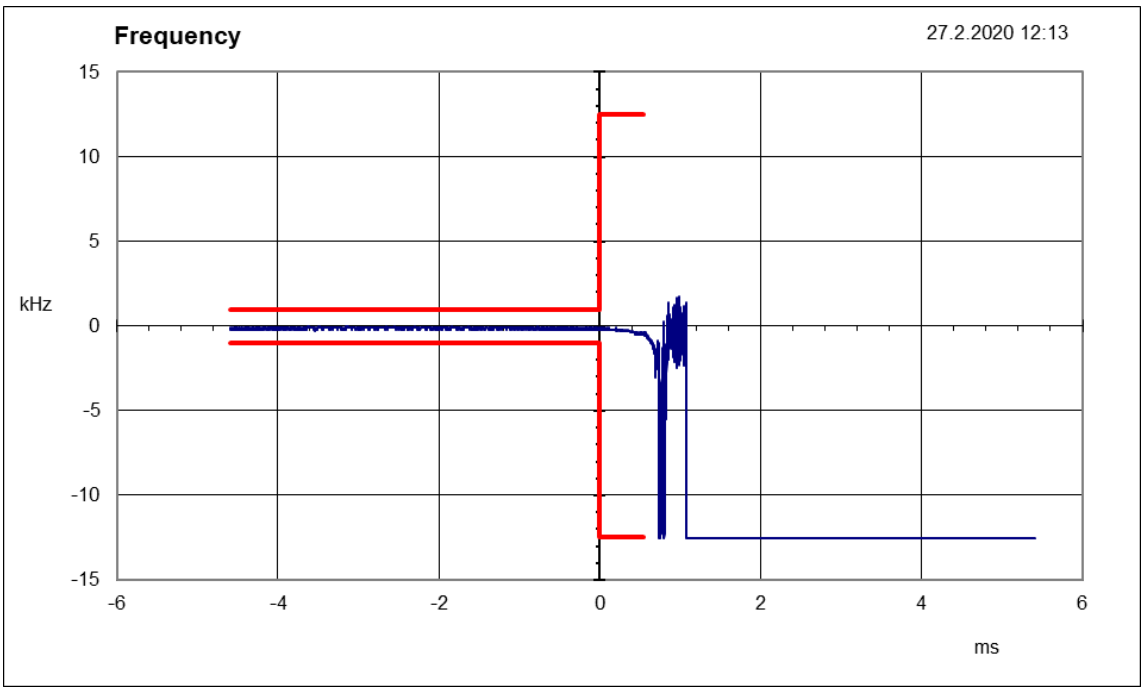


Figure 176: 410.0 MHz

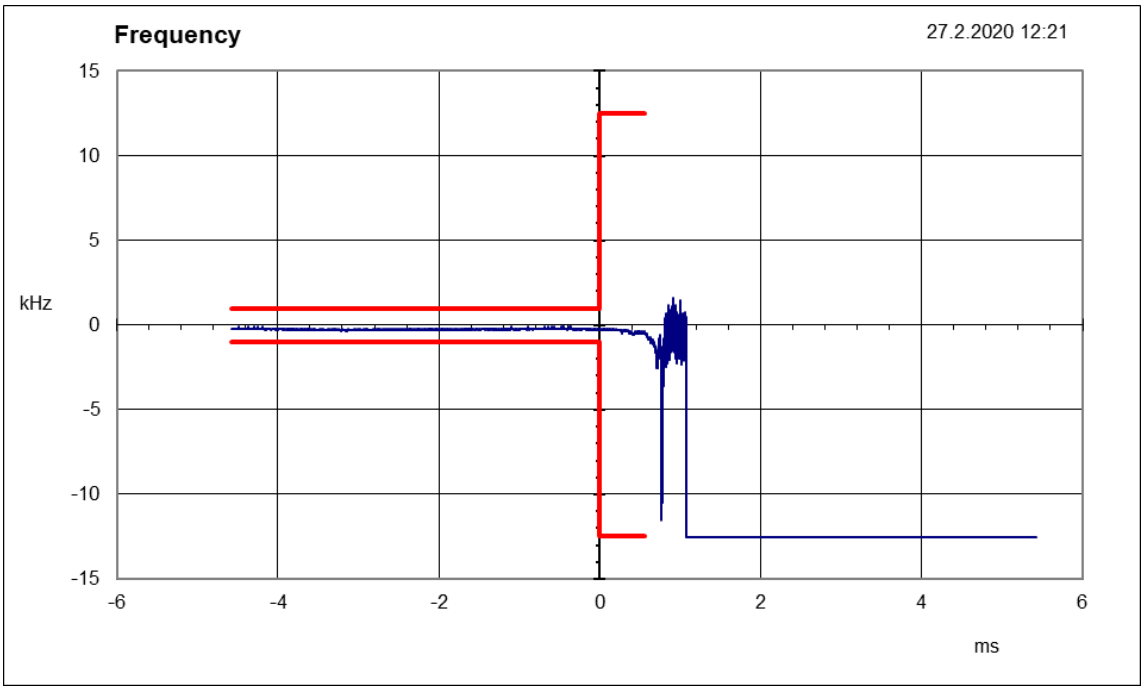


Figure 177: 429.5 MHz

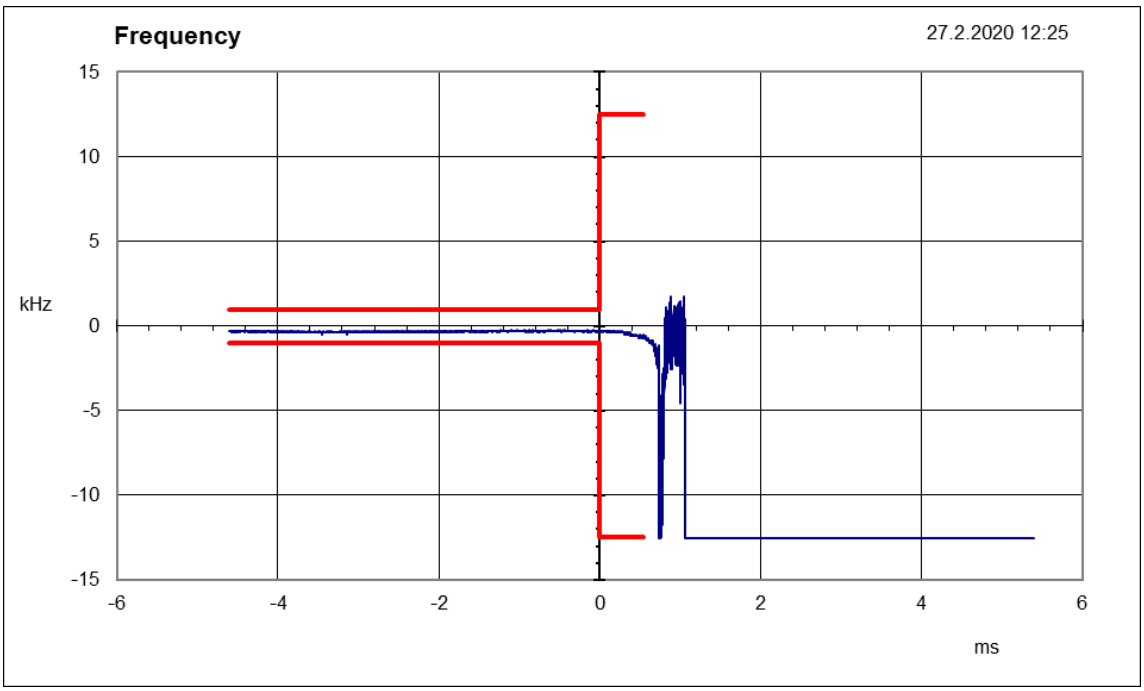


Figure 178: 450.5 MHz

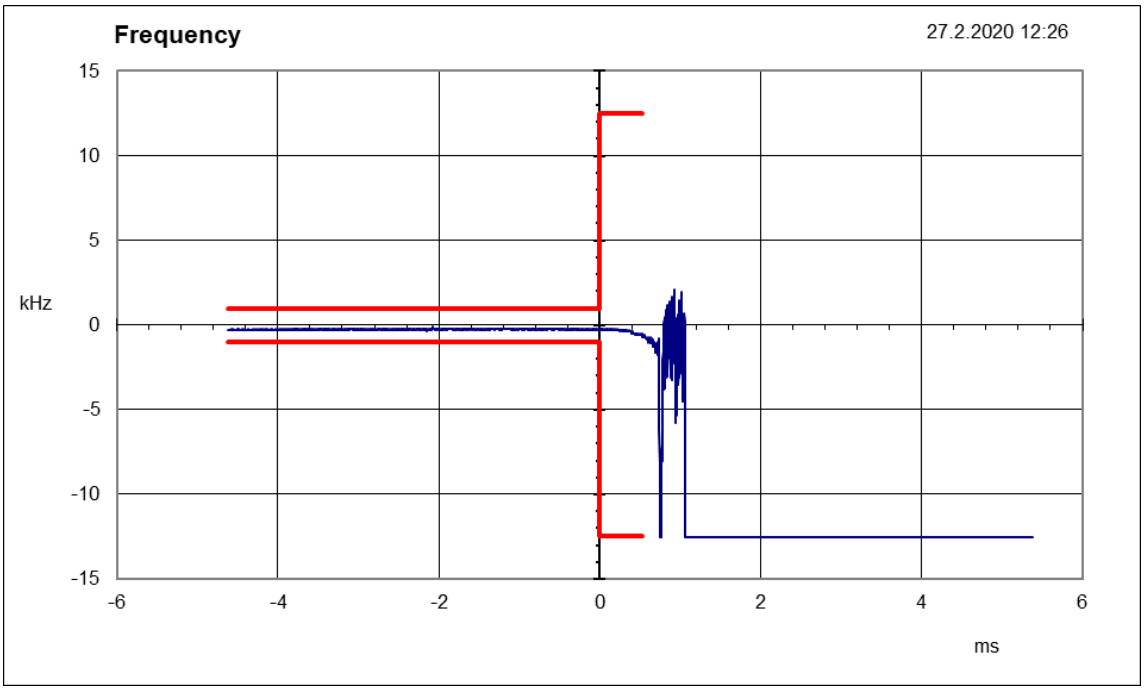


Figure 179: 469.5 MHz

TEST EQUIPMENT

Equipment	Manufacturer	Type	Inv or serial	Prev Calib	Next Calib
RF PREAMPLIFIER	CIAO	CA118-3123	inv:10278	2019-10-09	2020-10-09
ANTENNA	SCHWARZBECK	VULB 9168, 30-2000MHz	inv:8911	2018-10-25	2020-10-25
ANTENNA	EMCO	3117, 1-18GHz	inv:7293	2018-03-14	2020-03-14
ATTENUATOR	PASTERNACK	PE 7004-4	inv:10126	2019-04-01	2021-04-01
TURNTABLE	MATURO	DS430 UPGRADED	inv:10182	NCR	-
MAST & TURNTABLE CONTROLLER	MATURO	NCD	inv:10183	NCR	-
ANTENNA MAST	MATURO	TAM 4.0E	inv:10181	NCR	-
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	NCR	-
EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW26	inv:10679	2019-06-28	2020-06-27
FILTER	WAINWRIGHT	HP, WHKX1.0/15G-10SS	inv:8267	2019-04-01	2021-04-01
MULTIMETER	FLUKE	189	inv:9781	2019-10-30	2020-10-30
PRECISION DC POWER SUPPLY	THANDAR	TS3021S	inv:3484	NCR	-
TEMPERATURE CHAMBER	CTS	T-65/50	inv:10521	NCR	-
OSCILLOSCOPE	LECROY	WAVE SURFER 42Xs	inv:9737	2020-01-27	2021-01-27
SIGNAL ANALYZER	ROHDE & SCHWARZ	FSV40	inv:9093	2019-11-18	2020-11-18
POWER SUPPLY	THANDAR	PL330TP	inv:9787	NCR	-
MODULATION ANALYZER	HEWLETT PACKARD	HP 8901B	inv:9739	2020-02-20	2022-02-20
AUDIO AMPLIFIER	SGS FIMKO	PRL	inv:9366	NCR	-
HYBRID	ANZAC	H 9	inv:9383	1)	-
SPECTRUM ANALYZER	AGILENT	E7405A	inv:9746	2020-02-17	2022-02-17
ANTENNA	ROHDE & SCHWARZ	HFH2-Z2 , 335.4711.52	inv:8013	2018-10-28	2020-10-28

1) The equipment was calibrated for this test case

NCR = No Calibration Required

END OF TEST REPORT