Test Report

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

INTENTIONAL RADIATOR TESTS ACCORDING TO FCC PART 90 and INDUSTRY CANADA REQUIREMENTS

Equipment Under Test:	Radio modem
Type:	SATEL-TA23
Model:	SATELLINE-M3-TR4
Manufacturer:	Satel Oy P.O. Box 142 (Meriniitynkatu 17) 24101 SALO FINLAND
Customer:	Satel Oy P.O. Box 142 (Meriniitynkatu 17) 24101 SALO FINLAND
FCC Rule Part:	90: 2014
IC Rule Part:	RSS-119, Issue 12, 2015

Date:	February 10, 2016	Date:	February 10, 2016
Issued by:	Timo Hietala Testing Engineer	Checked by:	Pekka Kälviäinen Testing Engineer

Table of Contents

Equipment Under Test (EUT)

Radio modem

Type:	SATEL-TA23
Model:	SATELLINE-M3-TR4
FW-version:	07.22.2.8.7
Module ID:	SPL0020d, 8
Serial Number:	1513000843
FCC ID:	MRBSATEL-TA23
IC ID:	2422A-SATELTA23

One sample was used in tests. The EUT had an external antenna.

Conducted measurements were made with the sample having an external antenna connector. Measurements were made from the antenna connector (SMA).

Classification of the device

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

Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing

Ratings and declarations

Operating Frequency Range (OFR):	406.1 – 430.0 MHz and 450.0 – 470.0 MHz
Channels:	1
Channel separation:	12.5 kHz, 25kHz
Conducted power:	1 W (30 dBm)
Modulation:	4FSK, 8FSK, 16FSK
Integrated antenna gain:	N/A
Antenna connector:	HIROSE U.FL, (Test jig: SMA-connector)

Power Supply

DC	4V, (9 – 30V test jig)

Disclaimer

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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 90 days only. This document cannot be reproduced except in full, without prior approval of the Company.

Test Suite

Section in CFR 47	*Section in RSS-119, Issue 12*		*Result*
90.205 & 2.1046	*5.4*	*Transmitter power (conducted)*	PASS
90.210 & 2.1049	*5.5*	*99% Occupied bandwidth*	PASS
90.210 & 2.1049	*5.5*	*Spectrum emission mask*	PASS
90.210, 2.1057 & 2.1051	*5.8*	*Spurious emissions (conducted)*	PASS
90.210, 2.1057 & 2.1053	*5.8*	*Spurious emissions (radiated)*	PASS

According to the standard the measurement results have been compared directly with the limits without considering measurement uncertainties.

EUT Test Conditions during Testing

The EUT was configured into the wanted channel and was in continuous transmit mode during all the tests.

Following channels were used during the tests:

Channel	Frequency/ MHz
LOW	408.0
MID	428.0
HIGH	468.0

Test Facility

☐ Testing Location / address: FCC registration number: **90598**	SGS Fimko Ltd Särkiniementie 3 FI-00210, HELSINKI FINLAND
☒ Testing Location / address: FCC registration number: **178986** Industry Canada registration number: **8708A-2**	SGS Fimko Ltd Karakaarenkuja 4 FI-02610, ESPOO FINLAND

Maximum Peak Conducted Output Power

Standard:	FCC 2.1046	RSS119: 5.4
Tested by:	THA	
Date:	10.02.2016	
Humidity:	10 - 90 % RH	
Temperature:	10 - 40 °C	
Measurement uncertainty	± 0.47dB	Level of confidence 95 % (k = 2)
Limit:	± 1.0 dB from rated power	
Test results:	**PASS**	

Measurements were done with power sensor.

Test data:

Channel spacing	Frequency (MHz)	Modulation	Measured Output	
			Power (dBm)	Power (mW)
25 kHz	428.0	8FSK	**30.13**	**1030.4**
25 kHz	468.0	8FSK	**29.17**	**826.0**
25 kHz	428.0	16FSK	**30.13**	**1030.4**
25 kHz	468.0	16FSK	**29.17**	**826.0**
12.5 kHz	408.0	8FSK	**30.49**	**1119.4**
12.5 kHz	428.0	8FSK	**30.13**	**1030.4**
12.5 kHz	468.0	8FSK	**29.17**	**826.0**
12.5 kHz	408.0	16FSK	**30.49**	**1119.4**
12.5 kHz	428.0	16FSK	**30.13**	**1030.4**
12.5 kHz	468.0	16FSK	**29.17**	**826.0**

99% Occupied bandwidth

Standard:	FCC 2.1049	RSS119: 5.5
Tested by:	THA	
Date:	10.02.2016	
Humidity:	10 - 90 % RH	
Temperature:	10 - 40 °C	
Measurement uncertainty:	± 71 Hz	Level of confidence 95 % (k = 2)
Test results:	**PASS**	

The 99% occupied bandwidth of the carrier emission is measured using a spectrum analyzer with Resolution Bandwidth set to 1-3% of the necessary bandwidth of the transmitted carrier.

Transmitter was set to transmit random data file 19200 bps 25 kHz channel and 9600 bps 12.5 kHz channel.

Test data:

Channel spacing	Modulation	Frequency (MHz)	Measured 99% Occupied Bandwidth (kHz)
25 kHz	8FSK	428.0	**14.038**
25 kHz	8FSK	468.0	**14.038**
25 kHz	16FSK	428.0	**15.629**
25 kHz	16FSK	468.0	**15.412**
12.5 kHz	8FSK	408.0	**7.033**
12.5 kHz	8FSK	428.0	**7.033**
12.5 kHz	8FSK	468.0	**7.033**
12.5 kHz	16FSK	408.0	**7.424**
12.5 kHz	16FSK	428.0	**7.424**
12.5 kHz	16FSK	468.0	**7.467**

See attached plots.

Figure 1. Channel MID 25kHz 8FSK.

Figure 2. Channel HIGH 25kHz 8FSK.

Figure 3. Channel MID 25kHz 16FSK.

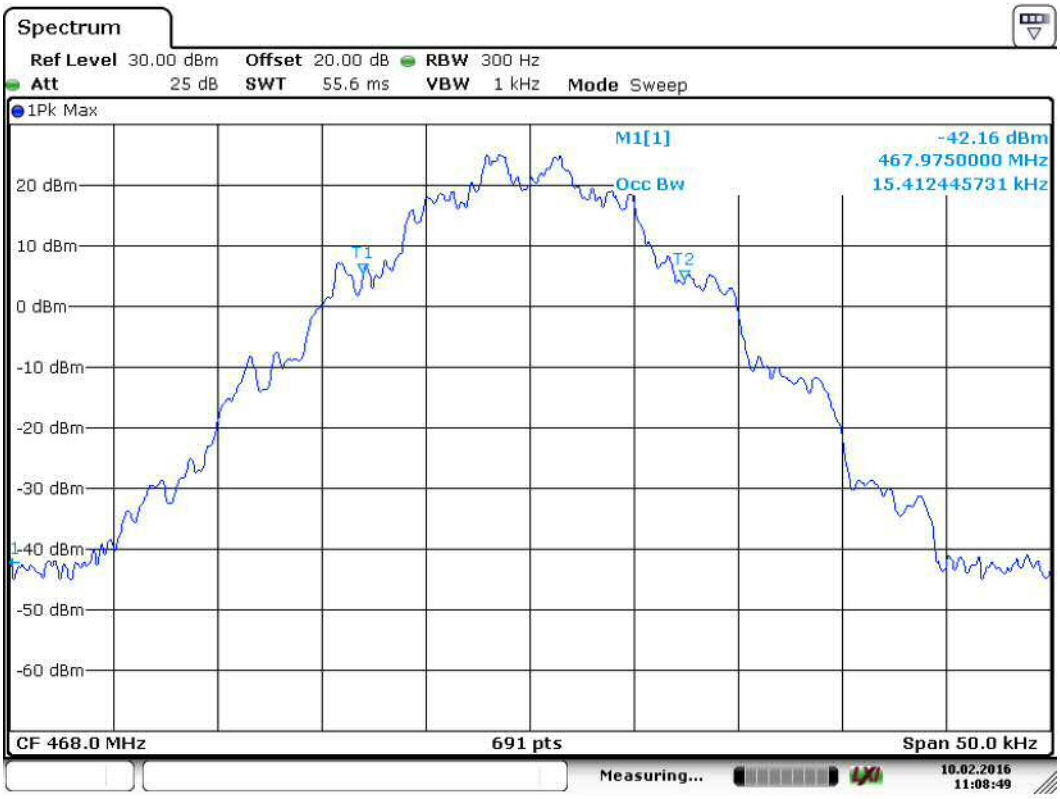


Figure 4. Channel HIGH 25kHz 16FSK.

Figure 5. Channel LOW 12.5kHz 8FSK.

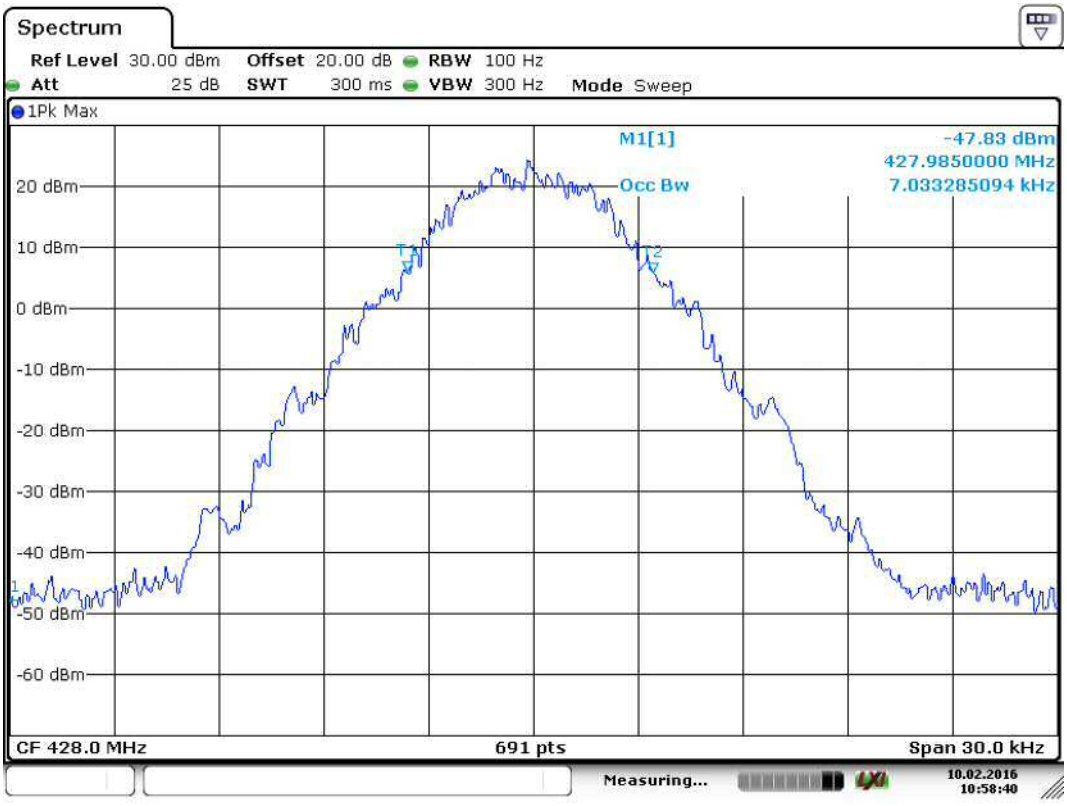


Figure 6. Channel MID 12.5kHz 8FSK.

Figure 7. Channel HIGH 12.5kHz 8FSK.

Figure 8. Channel LOW 12.5kHz 16FSK.

Figure 9. Channel MID 12.5kHz 16FSK.

Figure 10. Channel HIGH 12.5kHz 16FSK.

Spectrum emission mask

Standard:	FCC 2.1049	RSS119: 5.5
Tested by:	THA	
Date:	10.02.2016	
Humidity:	10 - 90 % RH	
Temperature:	10 - 40 °C	
Limit:	Mask C for 25kHz and mask D for 12.5kHz channel bandwidth	
Test results:	**PASS**	

The emission mask of the modulated carrier is measured by using a spectrum analyzer with resolution bandwidth set to 300 Hz for emission mask C (25kHz bandwidth) and 100 Hz for emission mask D (12.5kHz bandwidth).

Transmitter was set to transmit random data file 19200 bps 25kHz channel and 9600 bps 12.5kHz channel.

Test data:

Channel spacing	Modulation	Frequency (MHz)	SEM Result
25 kHz	8FSK	428.0	**PASS**
25 kHz	8FSK	468.0	**PASS**
25 kHz	16FSK	428.0	**PASS**
25 kHz	16FSK	468.0	**PASS**
12.5 kHz	8FSK	408.0	**PASS**
12.5 kHz	8FSK	428.0	**PASS**
12.5 kHz	8FSK	468.0	**PASS**
12.5 kHz	16FSK	408.0	**PASS**
12.5 kHz	16FSK	428.0	**PASS**
12.5 kHz	16FSK	468.0	**PASS**

See attached plots.

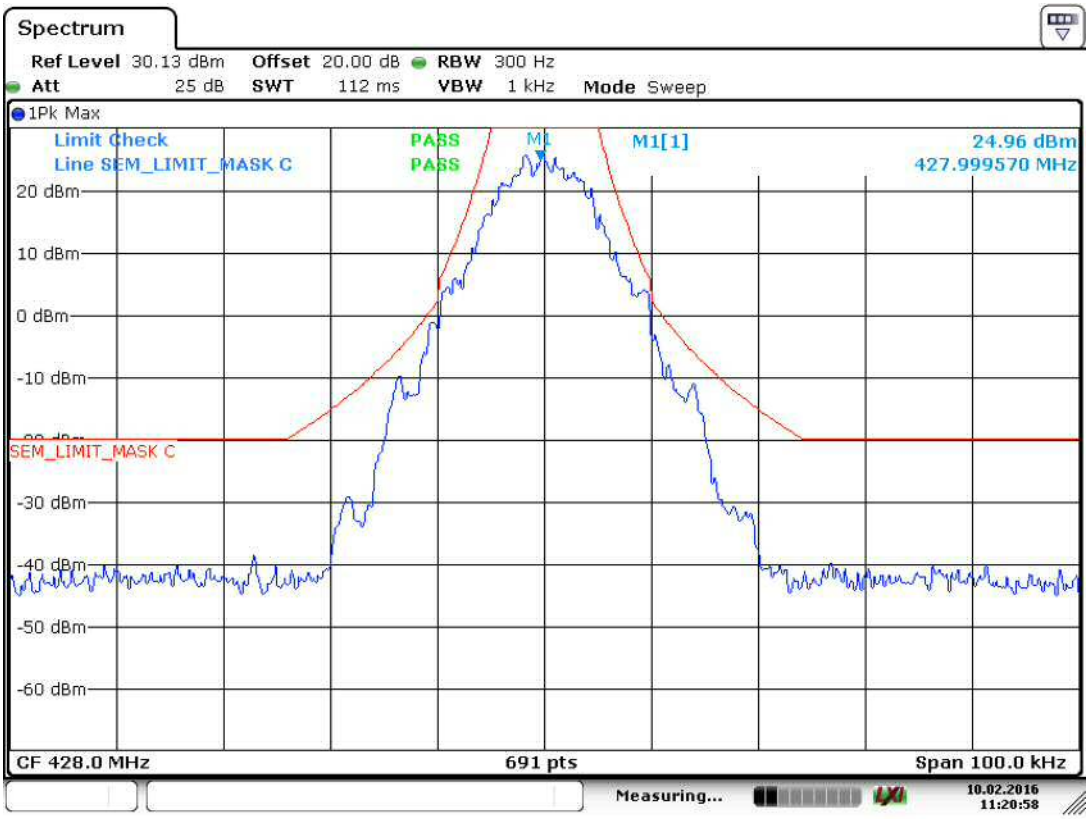


Figure 11. Channel MID 25kHz 8FSK.

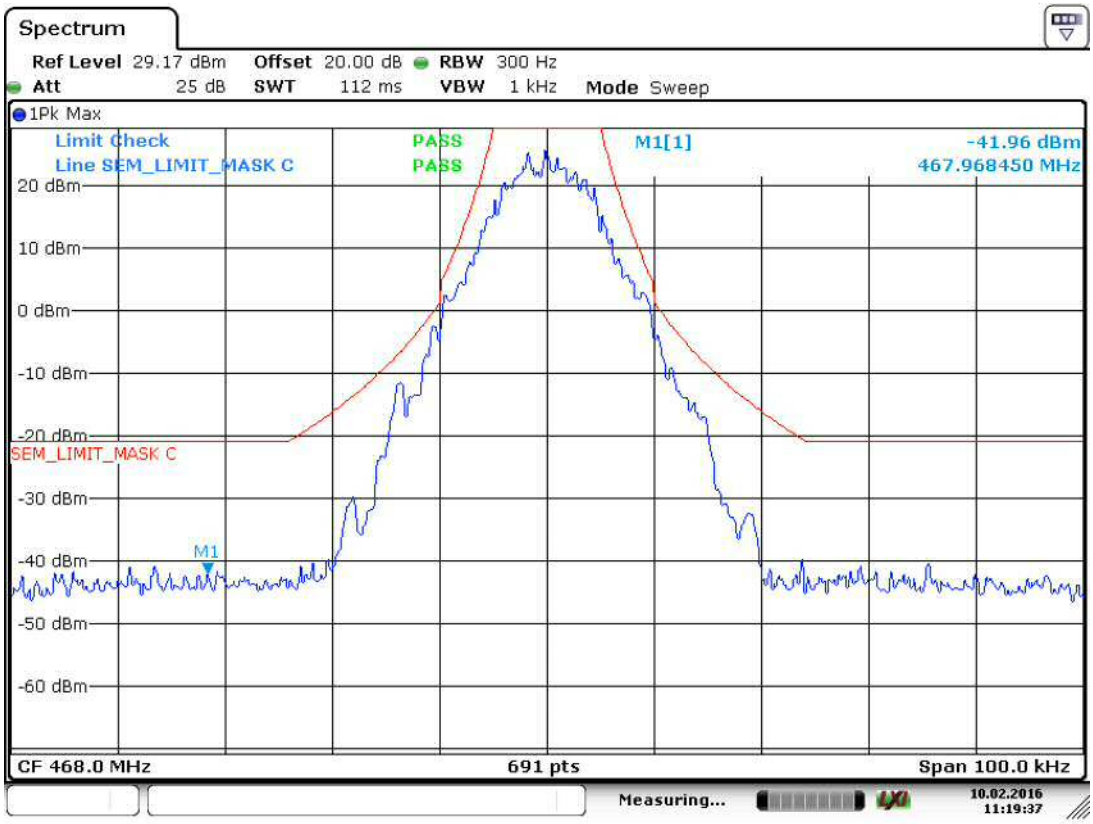


Figure 12. 1 Channel HIGH 25kHz 8FSK.

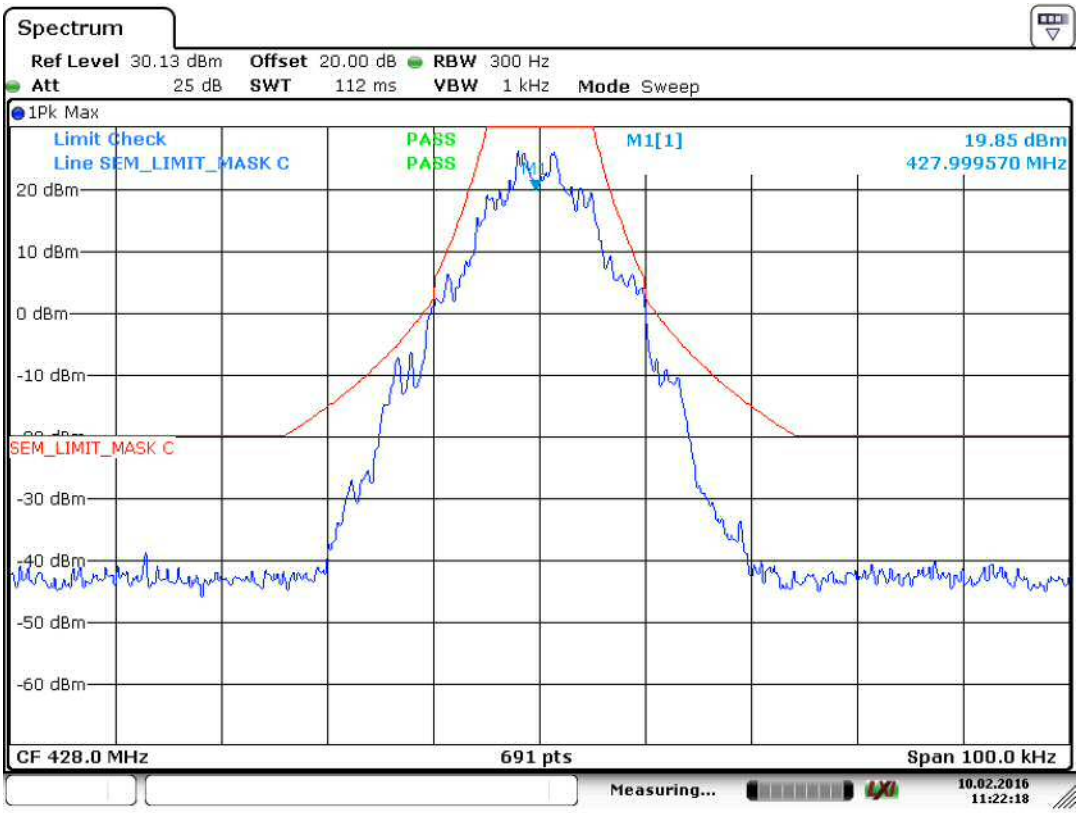


Figure 13. 1 Channel MID 25kHz 16FSK

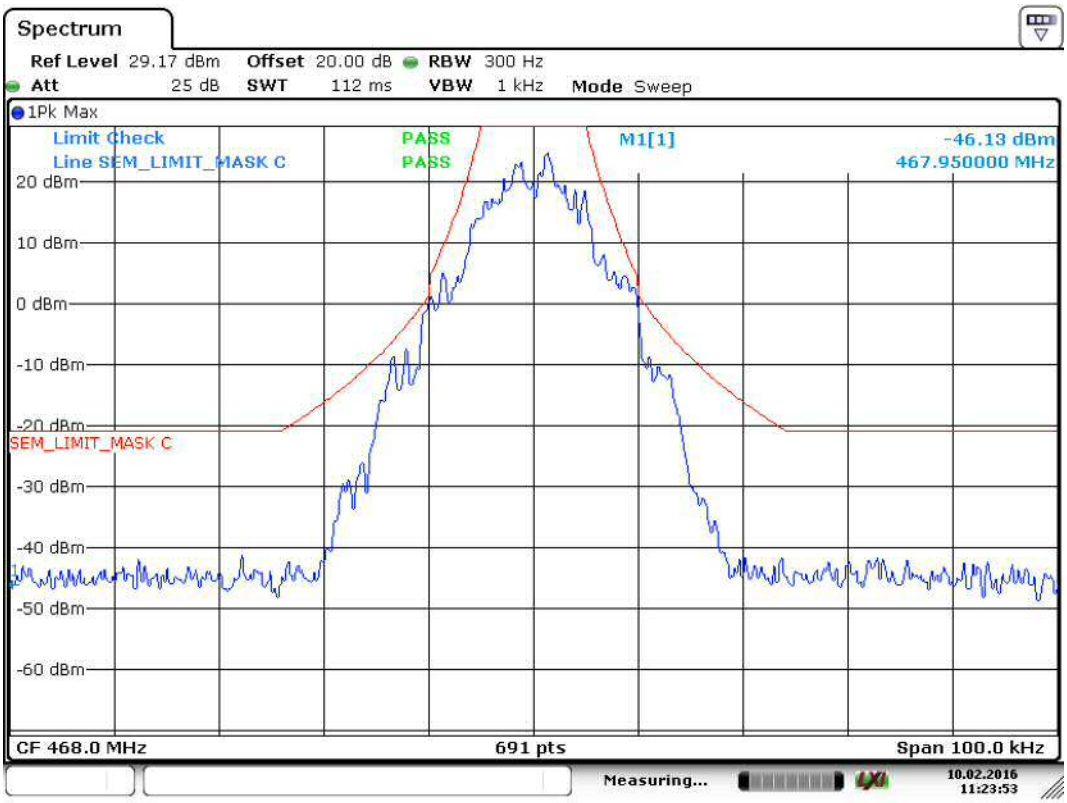


Figure 14. 1 Channel HIGH 25kHz16FSK

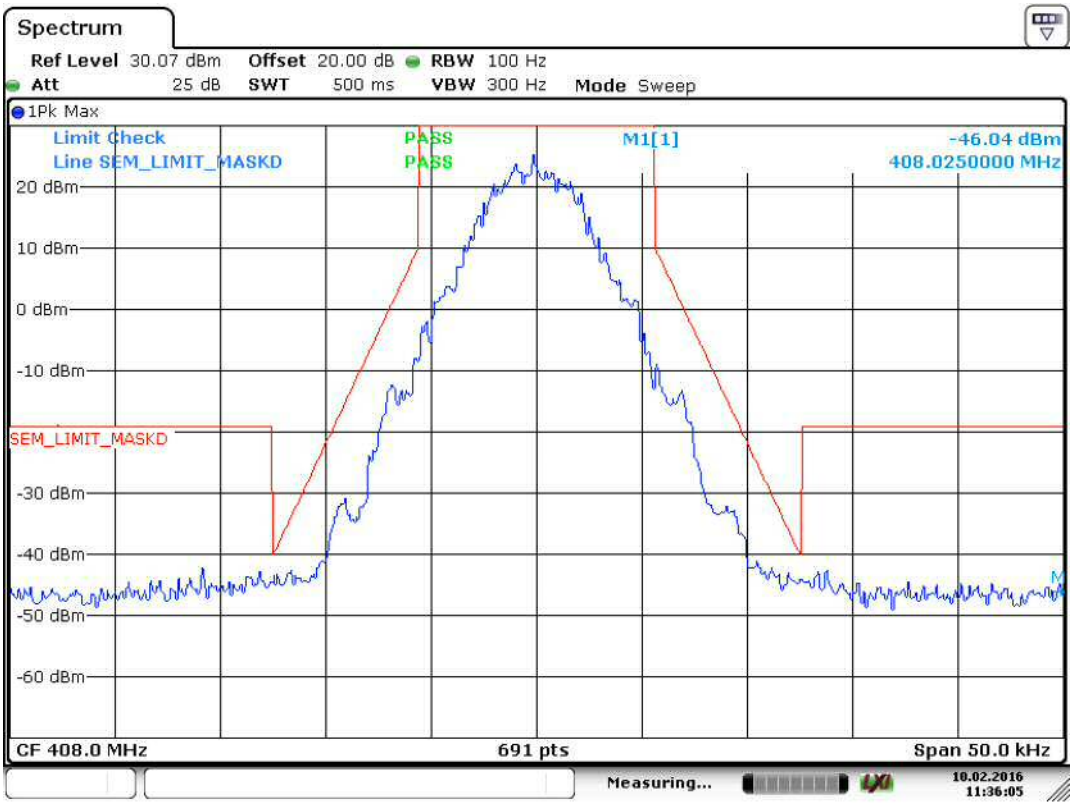


Figure 15. Channel LOW 12.5kHz 8FSK.

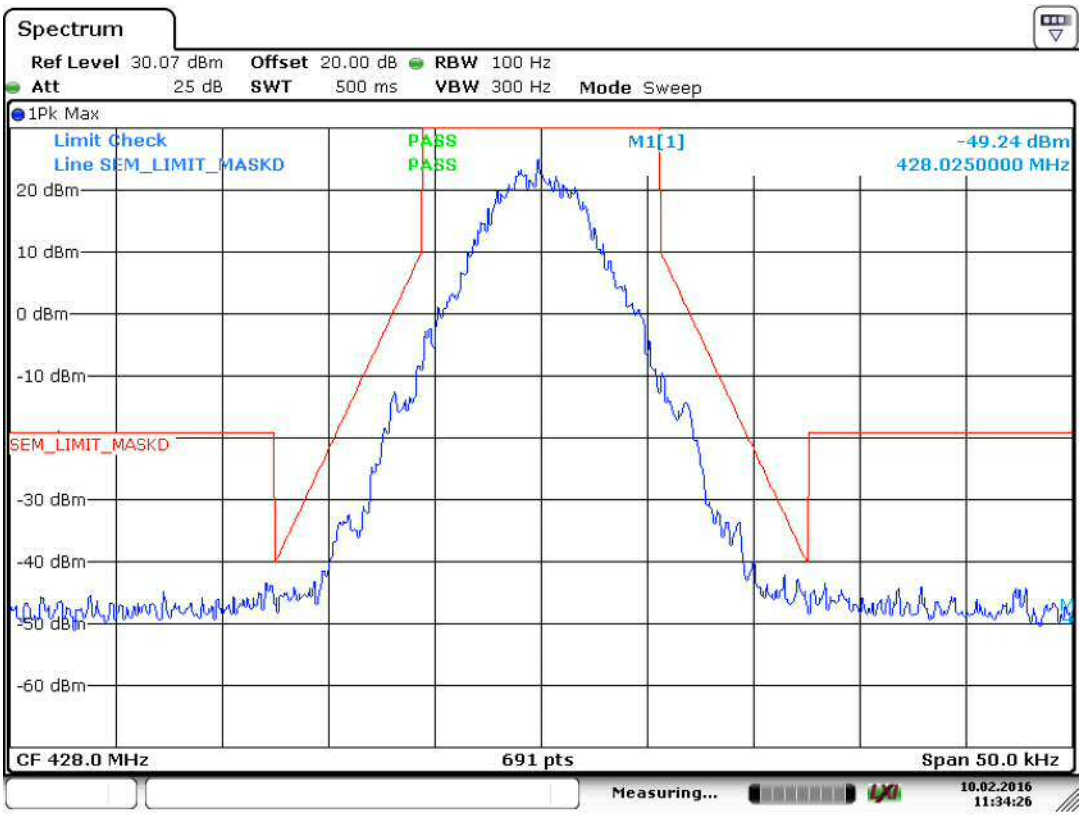


Figure 16. Channel MID 12.5kHz 8FSK.

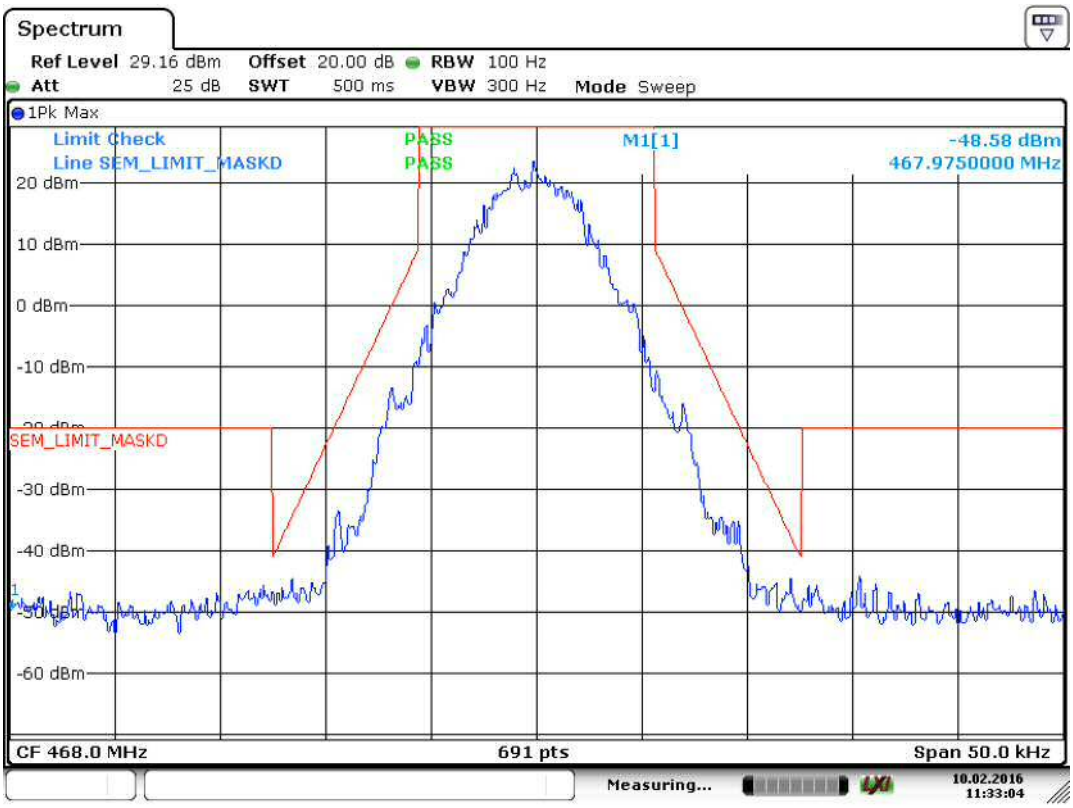


Figure 17. 1 Channel HIGH 12.5kHz 8FSK.

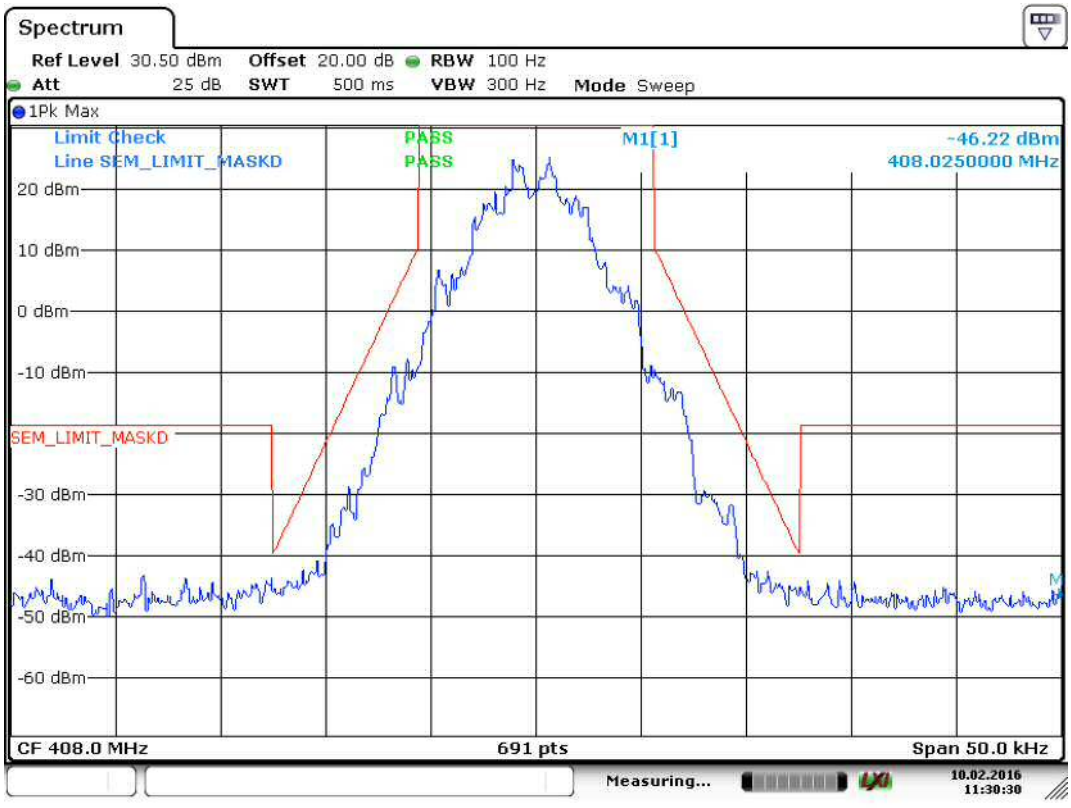


Figure 18. 1 Channel LOW 12.5kHz 16FSK

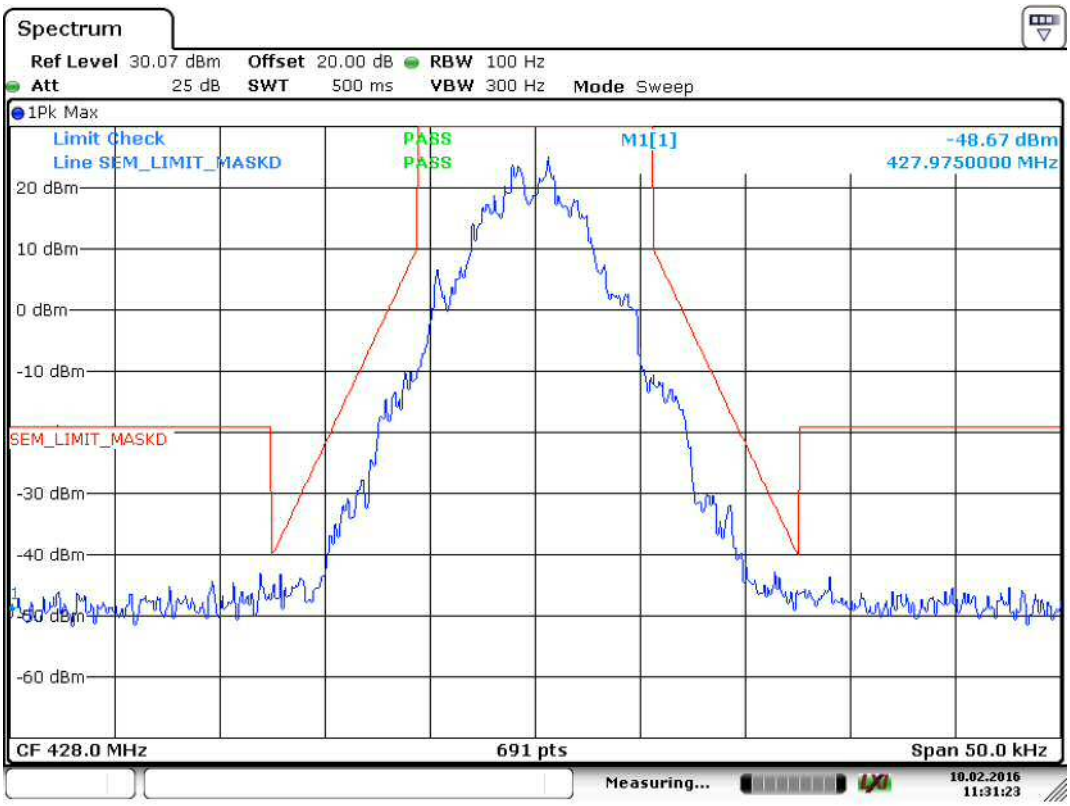


Figure 19. 1 Channel MID 12.5kHz 16FSK

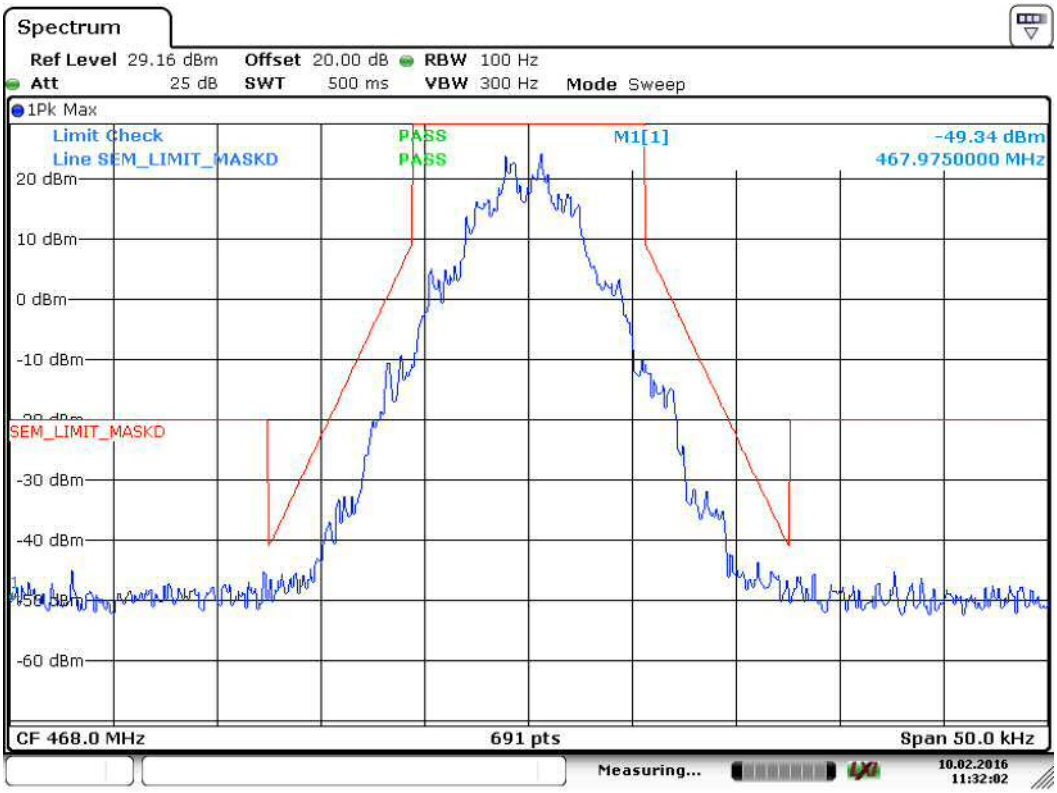


Figure 20. 1 Channel HIGH 12.5kHz 16FSK

Transmitter Spurious Emissions (conducted) 9 kHz to 5 GHz

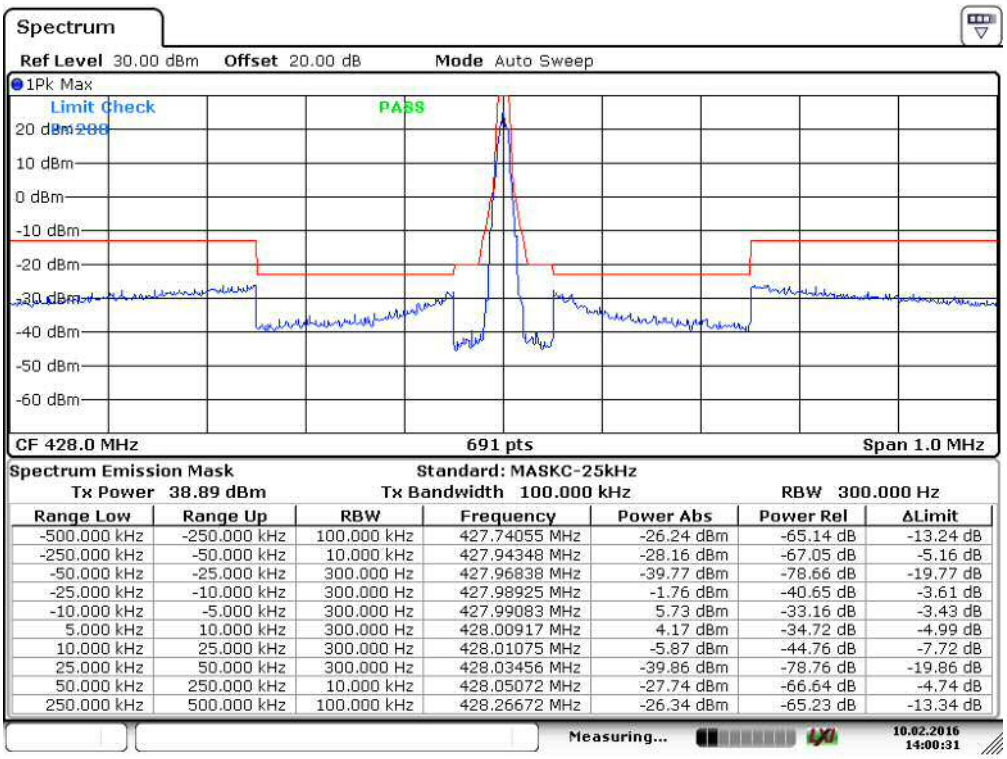
Standard:	FCC 90.210, 2.1051, RSS119 5.8
Tested by:	THA
Date:	26.08.2015, 14.09.2015, 10.02.2016
Temperature:	10 - 90 % RH
Humidity:	10 - 40 °C
Measurement uncertainty	± 2.87 dB Level of confidence 95 % (k = 2)
Limit:	43 + 10 log (P) dB, (-13 dBm)

The spectrum was searched from 9 kHz to the 10th harmonic of the carrier (5GHz).

Measurement offset from 50kHz to 250kHz 10kHz RBW was used and -13dBm limit integrated to -23dBm.

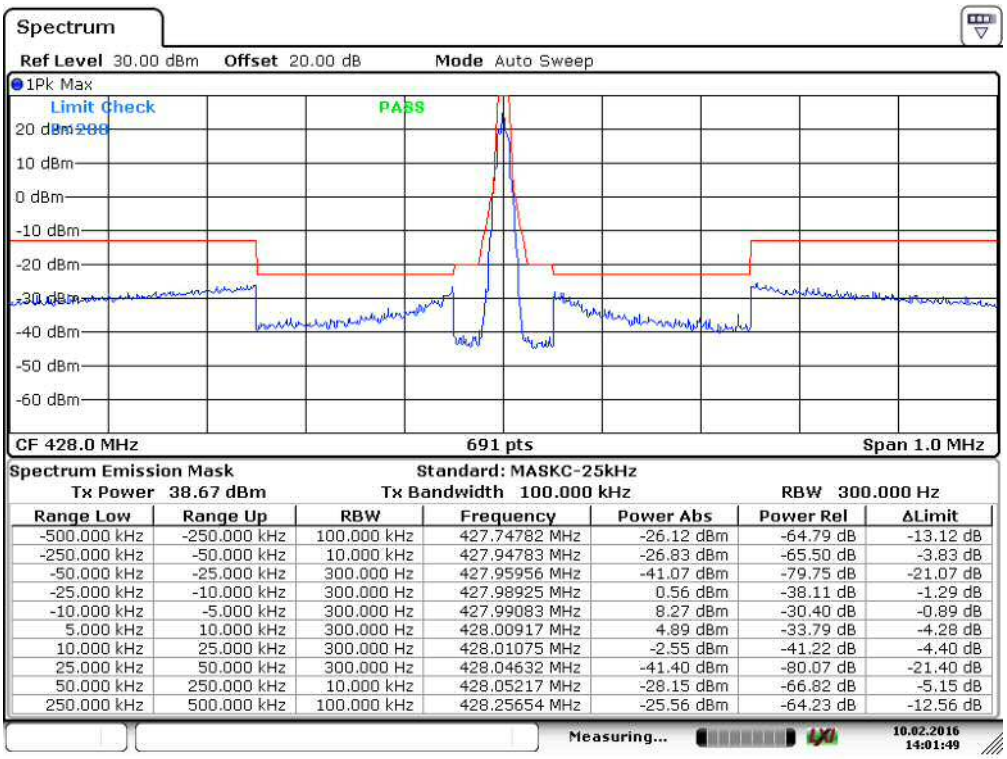
Test results

See attached plots.



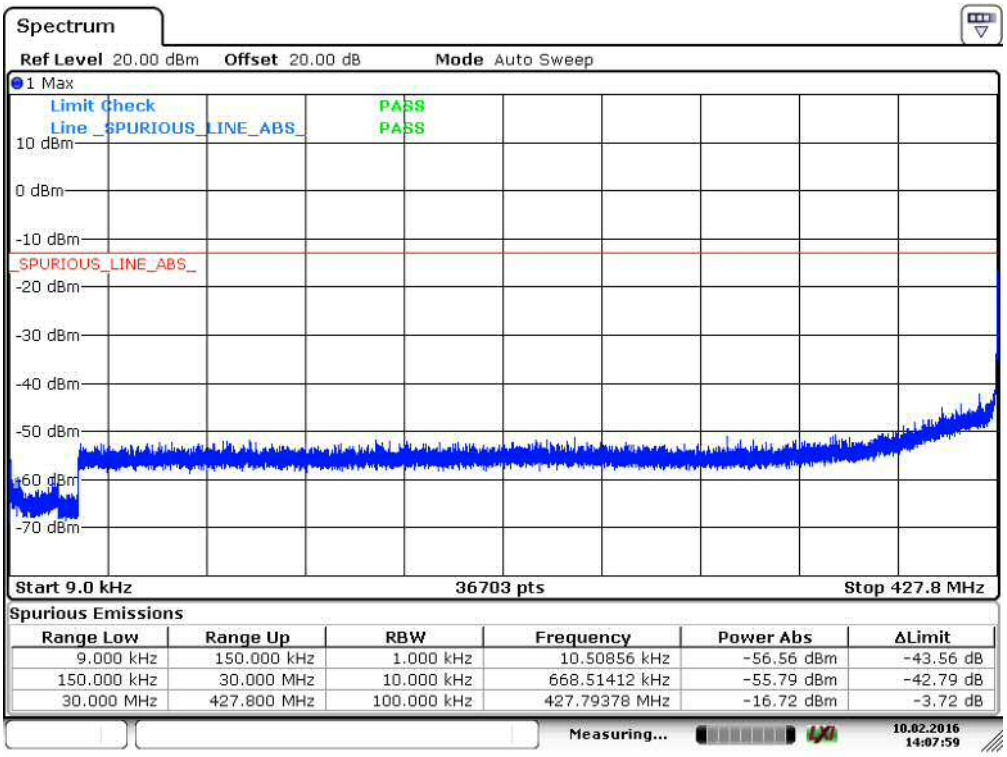
Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-500.000 kHz	-250.000 kHz	100.000 kHz	427.74055 MHz	-26.24 dBm	-65.14 dB	-13.24 dB
-250.000 kHz	-50.000 kHz	10.000 kHz	427.94348 MHz	-28.16 dBm	-67.05 dB	-5.16 dB
-50.000 kHz	-25.000 kHz	300.000 Hz	427.96838 MHz	-39.77 dBm	-78.66 dB	-19.77 dB
-25.000 kHz	-10.000 kHz	300.000 Hz	427.98925 MHz	-1.76 dBm	-40.65 dB	-3.61 dB
-10.000 kHz	-5.000 kHz	300.000 Hz	427.99083 MHz	5.73 dBm	-33.16 dB	-3.43 dB
5.000 kHz	10.000 kHz	300.000 Hz	428.00917 MHz	4.17 dBm	-34.72 dB	-4.99 dB
10.000 kHz	25.000 kHz	300.000 Hz	428.01075 MHz	-5.87 dBm	-44.76 dB	-7.72 dB
25.000 kHz	50.000 kHz	300.000 Hz	428.03456 MHz	-39.86 dBm	-78.76 dB	-19.86 dB
50.000 kHz	250.000 kHz	10.000 kHz	428.05072 MHz	-27.74 dBm	-66.64 dB	-4.74 dB
250.000 kHz	500.000 kHz	100.000 kHz	428.26672 MHz	-26.34 dBm	-65.23 dB	-13.34 dB

Figure 21. Measured curve with peak-detector. Channel MID 25kHz 8FSK.



Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-500.000 kHz	-250.000 kHz	100.000 kHz	427.74782 MHz	-26.12 dBm	-64.79 dB	-13.12 dB
-250.000 kHz	-50.000 kHz	10.000 kHz	427.94783 MHz	-26.83 dBm	-65.50 dB	-3.83 dB
-50.000 kHz	-25.000 kHz	300.000 Hz	427.95956 MHz	-41.07 dBm	-79.75 dB	-21.07 dB
-25.000 kHz	-10.000 kHz	300.000 Hz	427.98925 MHz	0.56 dBm	-38.11 dB	-1.29 dB
-10.000 kHz	-5.000 kHz	300.000 Hz	427.99083 MHz	8.27 dBm	-30.40 dB	-0.89 dB
5.000 kHz	10.000 kHz	300.000 Hz	428.00917 MHz	4.89 dBm	-33.79 dB	-4.28 dB
10.000 kHz	25.000 kHz	300.000 Hz	428.01075 MHz	-2.55 dBm	-41.22 dB	-4.40 dB
25.000 kHz	50.000 kHz	300.000 Hz	428.04632 MHz	-41.40 dBm	-80.07 dB	-21.40 dB
50.000 kHz	250.000 kHz	10.000 kHz	428.05217 MHz	-28.15 dBm	-66.82 dB	-5.15 dB
250.000 kHz	500.000 kHz	100.000 kHz	428.25654 MHz	-25.56 dBm	-64.23 dB	-12.56 dB

Figure 22. Measured curve with peak-detector. Channel MID 25kHz 16FSK.



Range Low	Range Up	RBW	Frequency	Power Abs	ΔLimit
9.000 kHz	150.000 kHz	1.000 kHz	10.50856 kHz	-56.56 dBm	-43.56 dB
150.000 kHz	30.000 MHz	10.000 kHz	668.51412 kHz	-55.79 dBm	-42.79 dB
30.000 MHz	427.800 MHz	100.000 kHz	427.79378 MHz	-16.72 dBm	-3.72 dB

Figure 23. Measured curve with peak-detector. Channel MID 25kHz 8FSK and 16FSK.

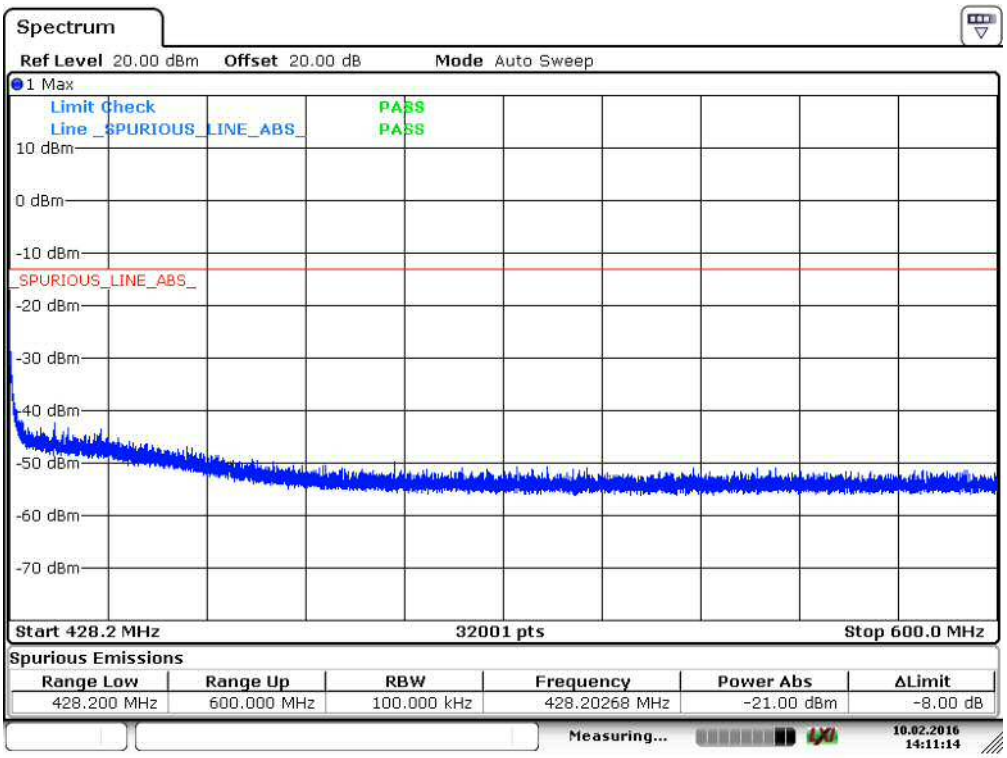


Figure 24. Measured curve with peak-detector. Channel MID 25kHz 8FSK and 16FSK.

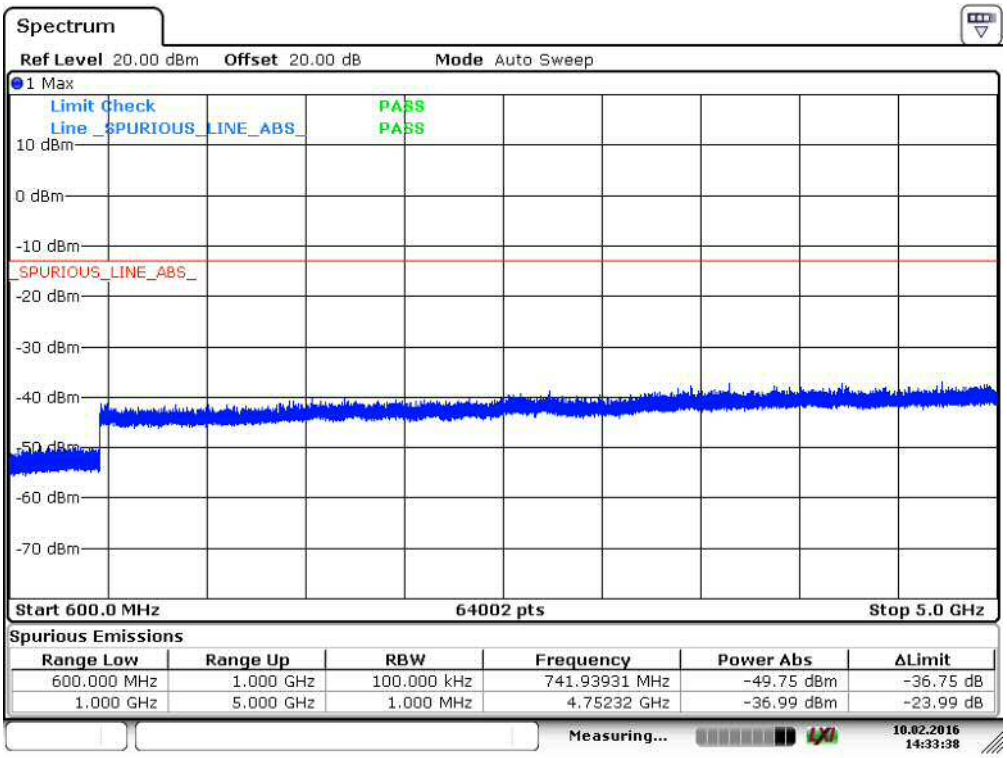


Figure 25. Measured curve with peak-detector. Channel MID 25kHz 8FSK.

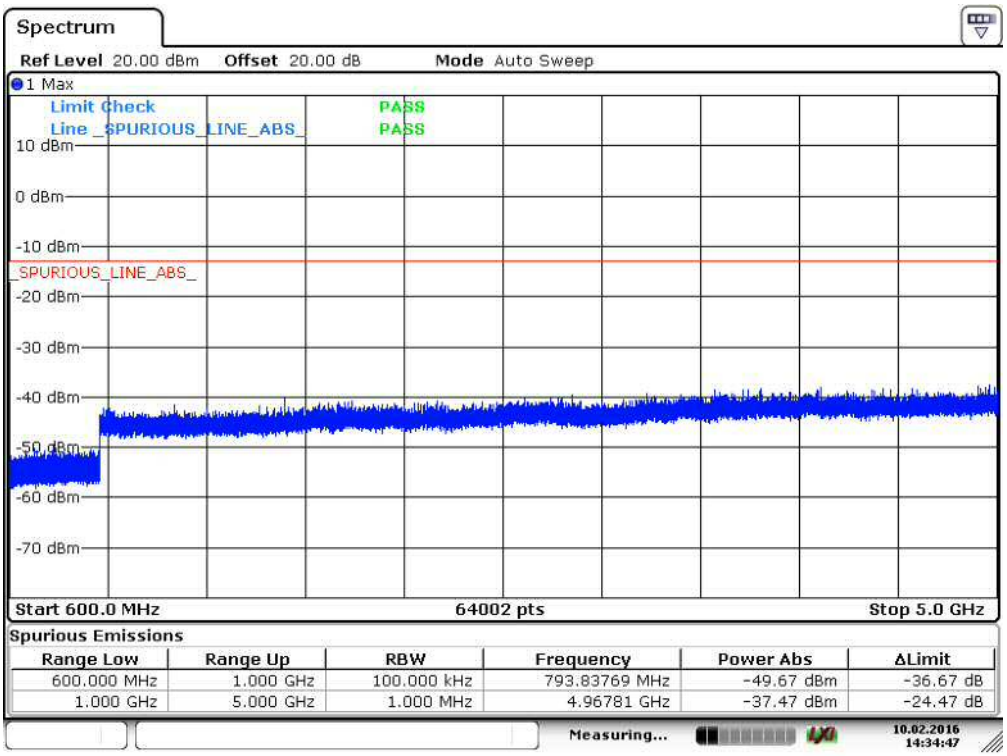


Figure 26. Measured curve with peak-detector. Channel MID 25kHz 16FSK.

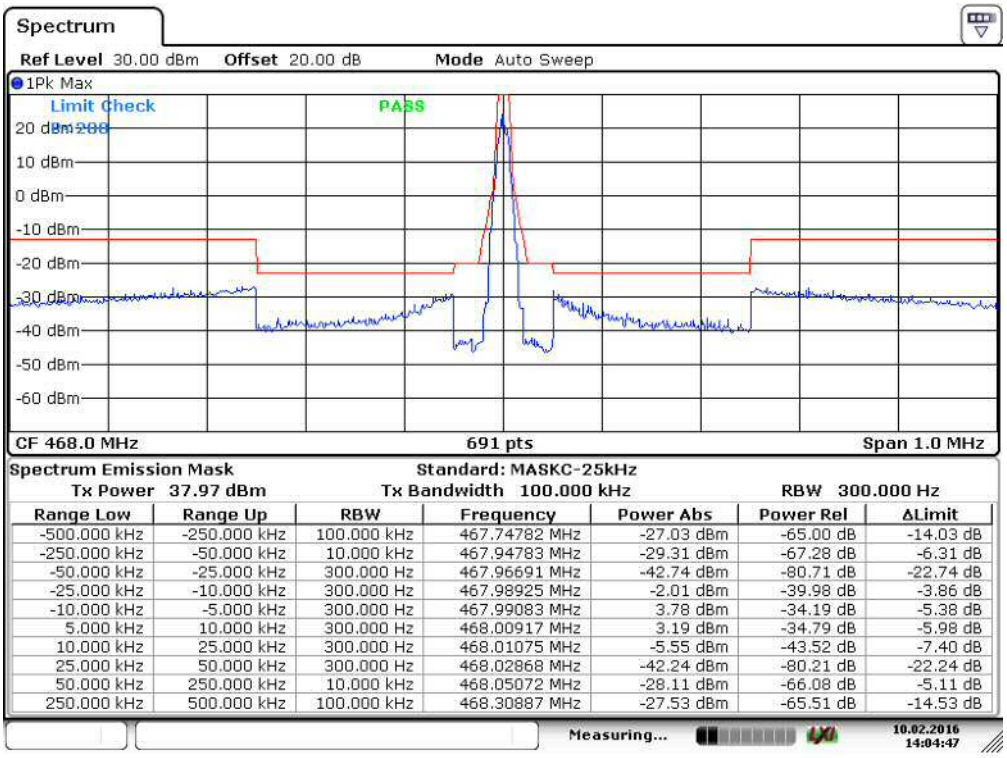


Figure 27. Measured curve with peak-detector. Channel HIGH 25kHz 8FSK.

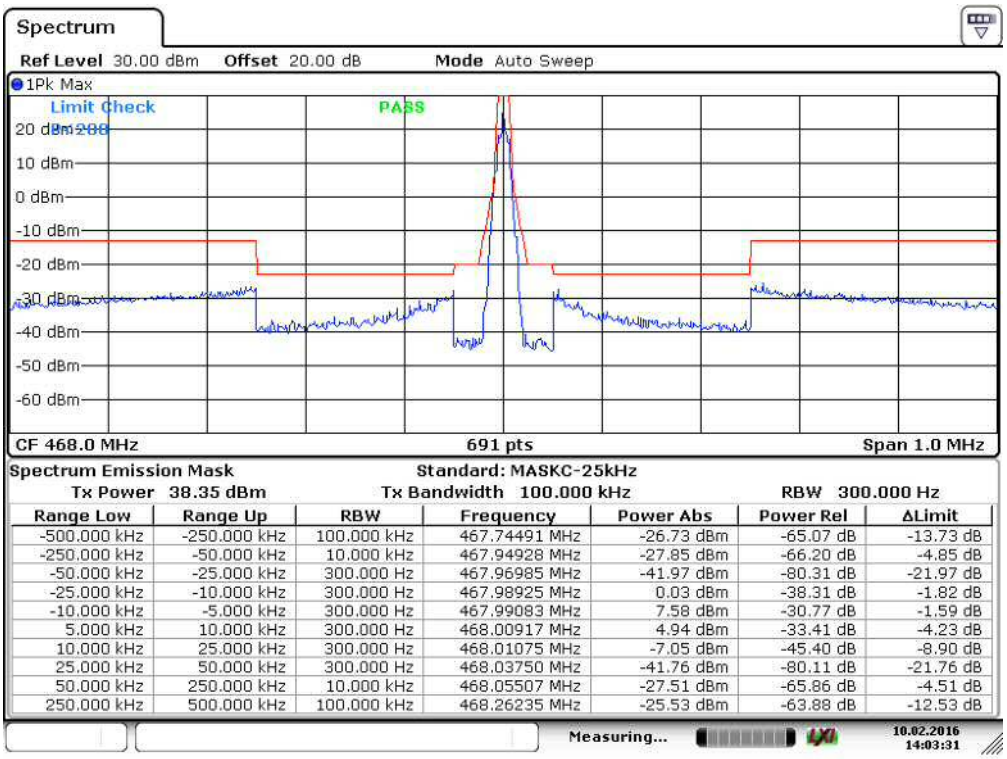


Figure 28. Measured curve with peak-detector. Channel HIGH 25kHz 16FSK.

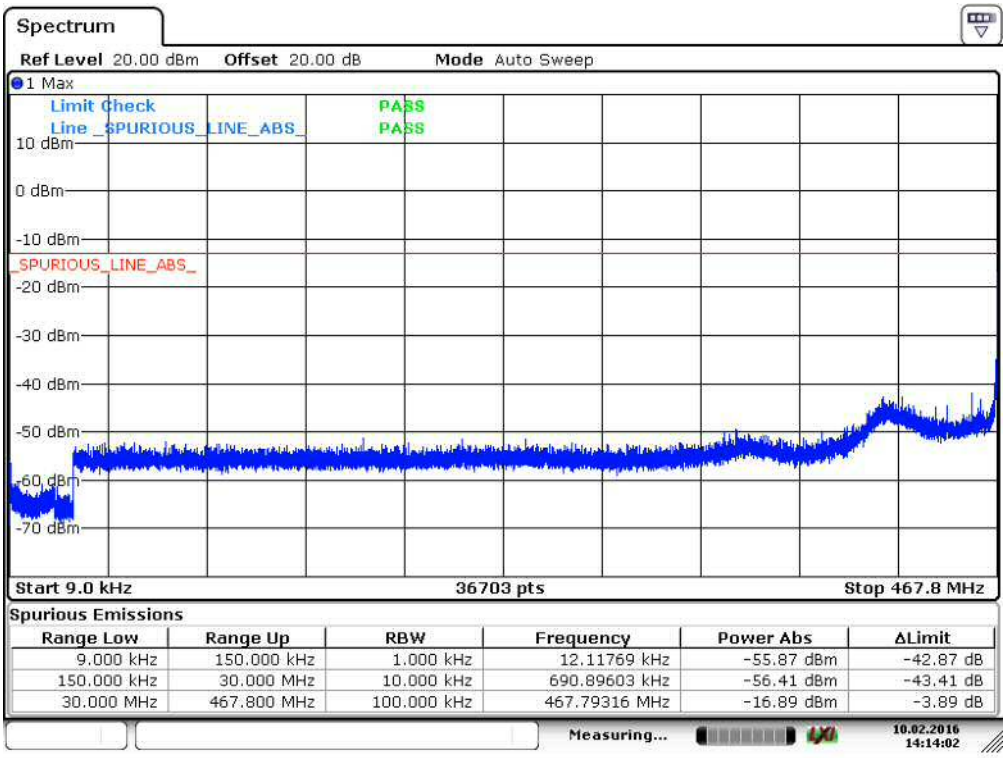


Figure 29. Measured curve with peak-detector. Channel HIGH 25kHz 8FSK and 16FSK.

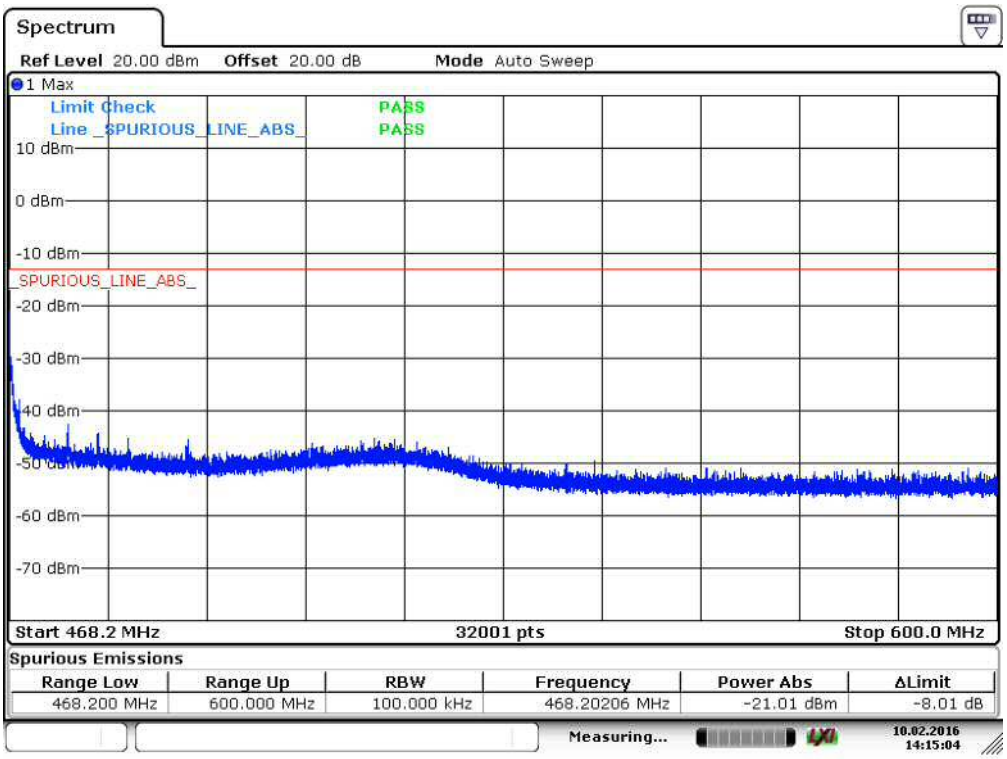


Figure 30. Measured curve with peak-detector. Channel HIGH 25kHz 8FSK and 16FSK.

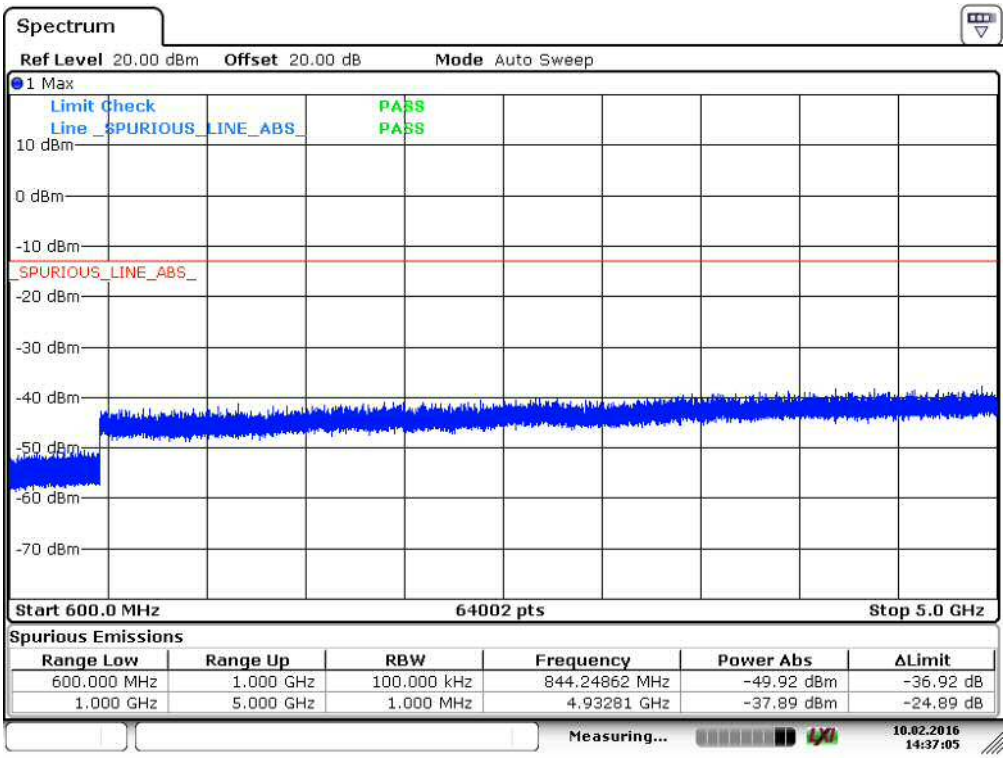


Figure 31. Measured curve with peak-detector. Channel HIGH 25kHz 8FSK.

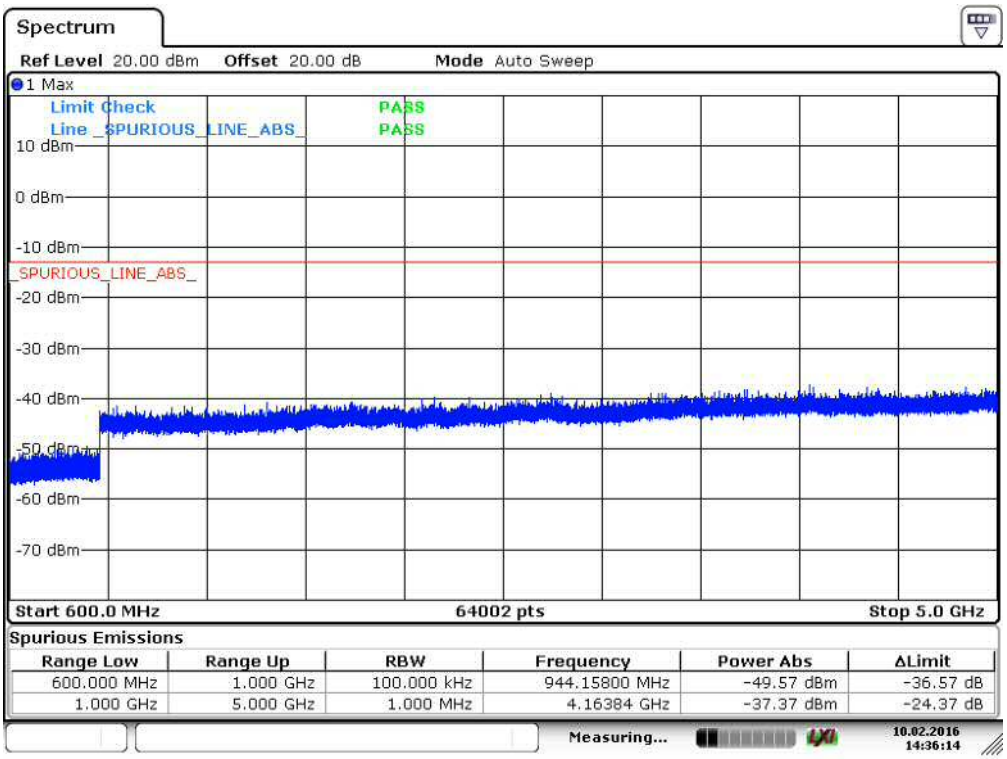


Figure 32. Measured curve with peak-detector. Channel HIGH 25kHz 16FSK.

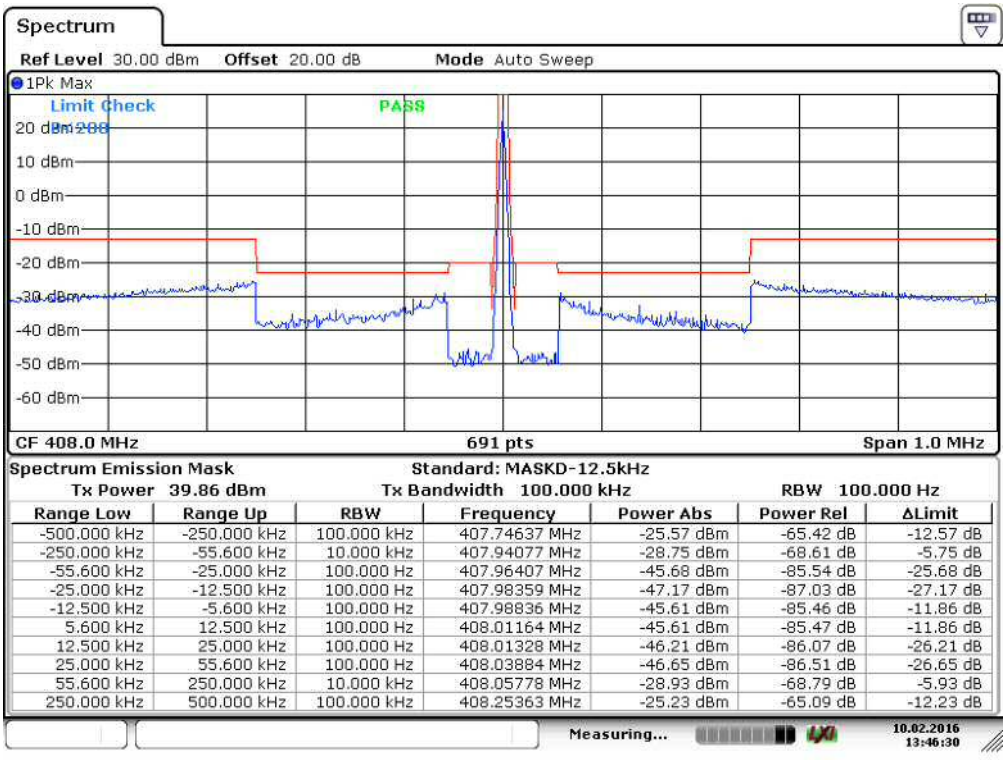


Figure 33. Measured curve with peak-detector. Channel LOW 12.5kHz 8FSK.

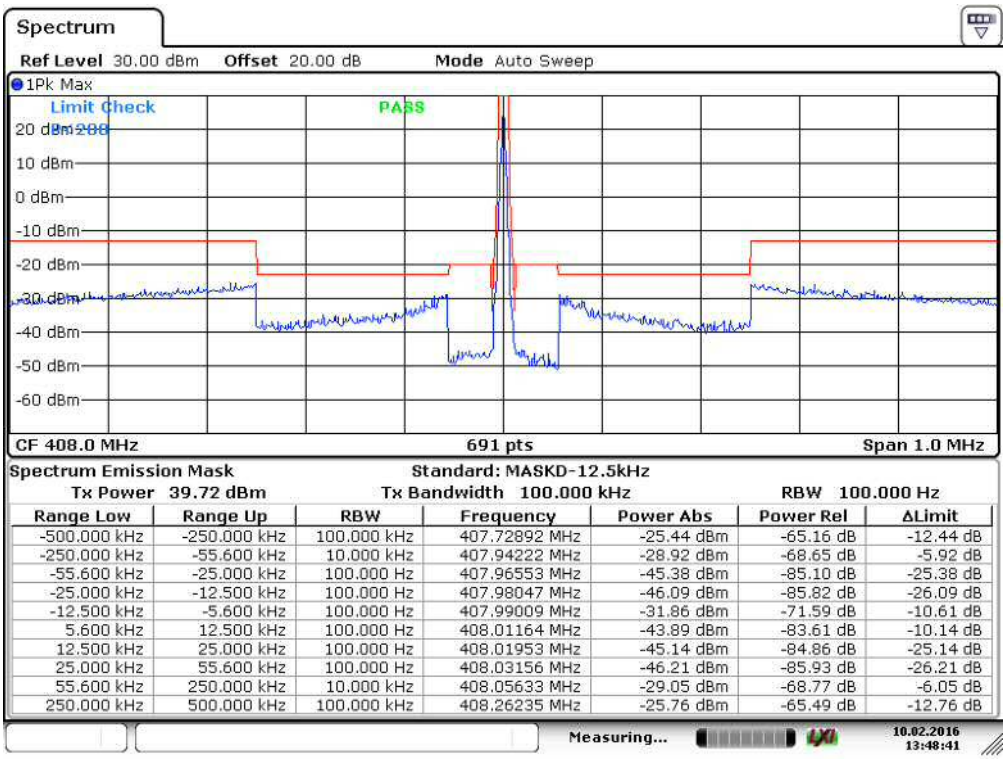


Figure 34. Measured curve with peak-detector. Channel LOW 12.5kHz 16FSK.

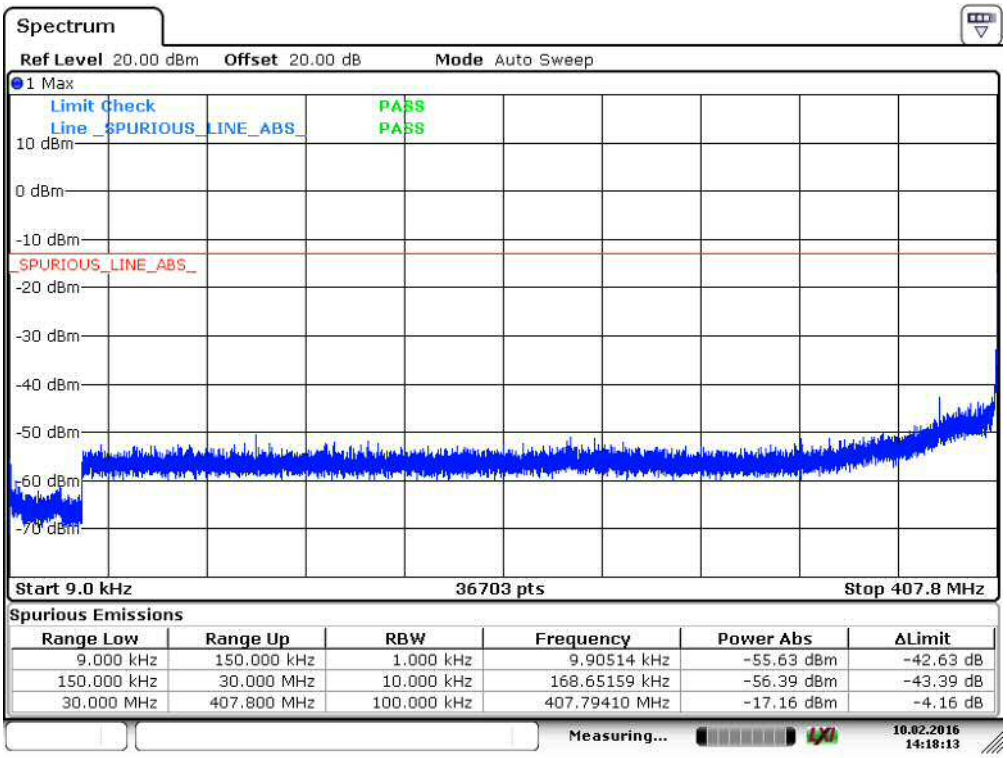


Figure 35. Measured curve with peak-detector. Channel LOW 12.5kHz 8FSK and 16FSK.

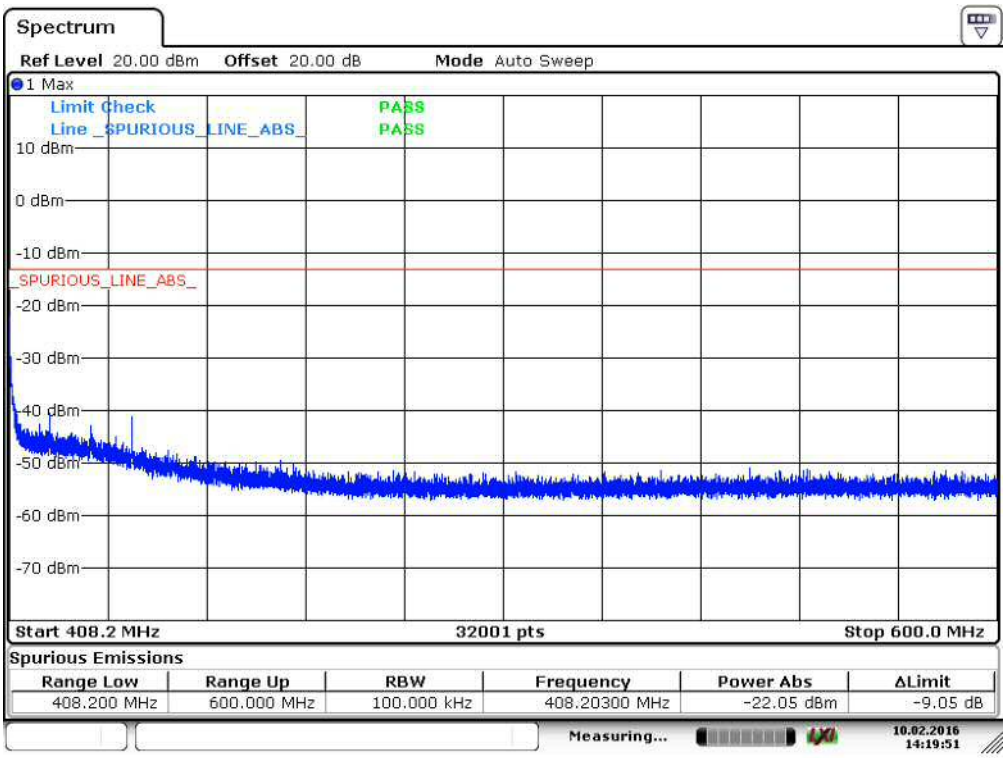


Figure 36. Measured curve with peak-detector. Channel LOW 12.5kHz 8FSK and 16FSK.

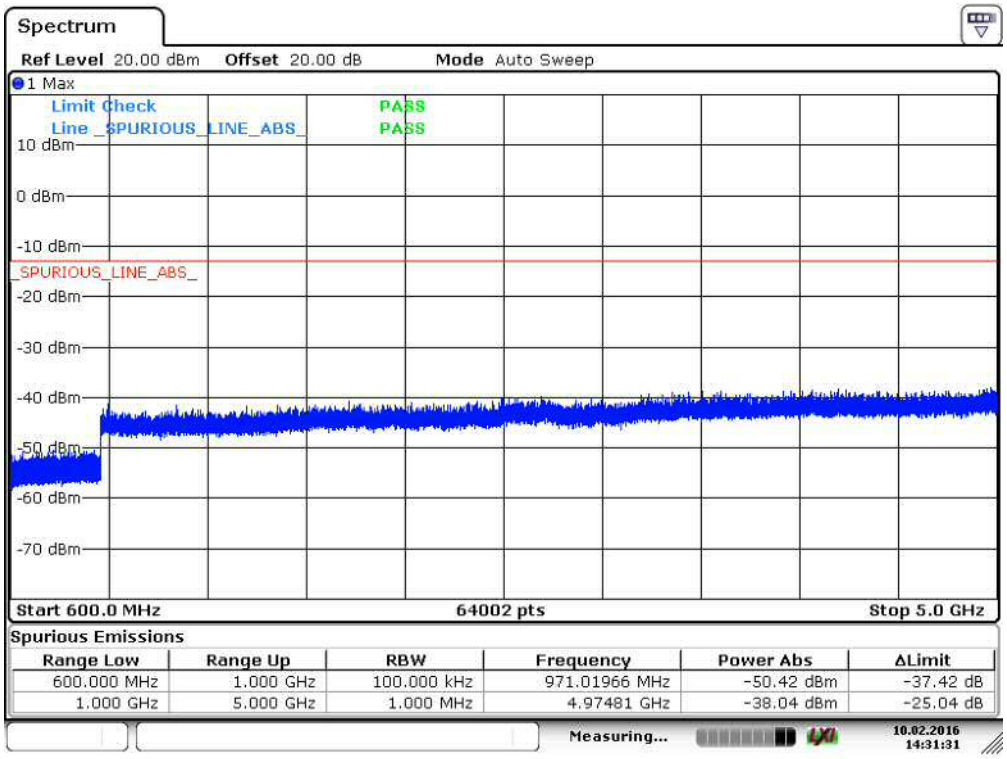
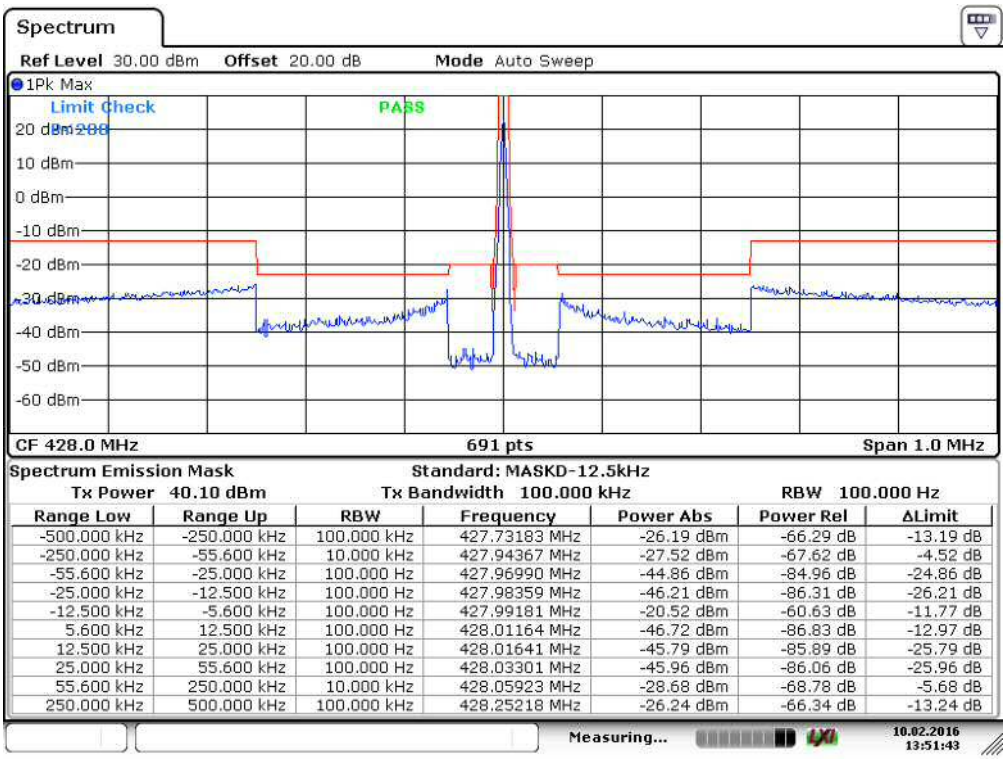
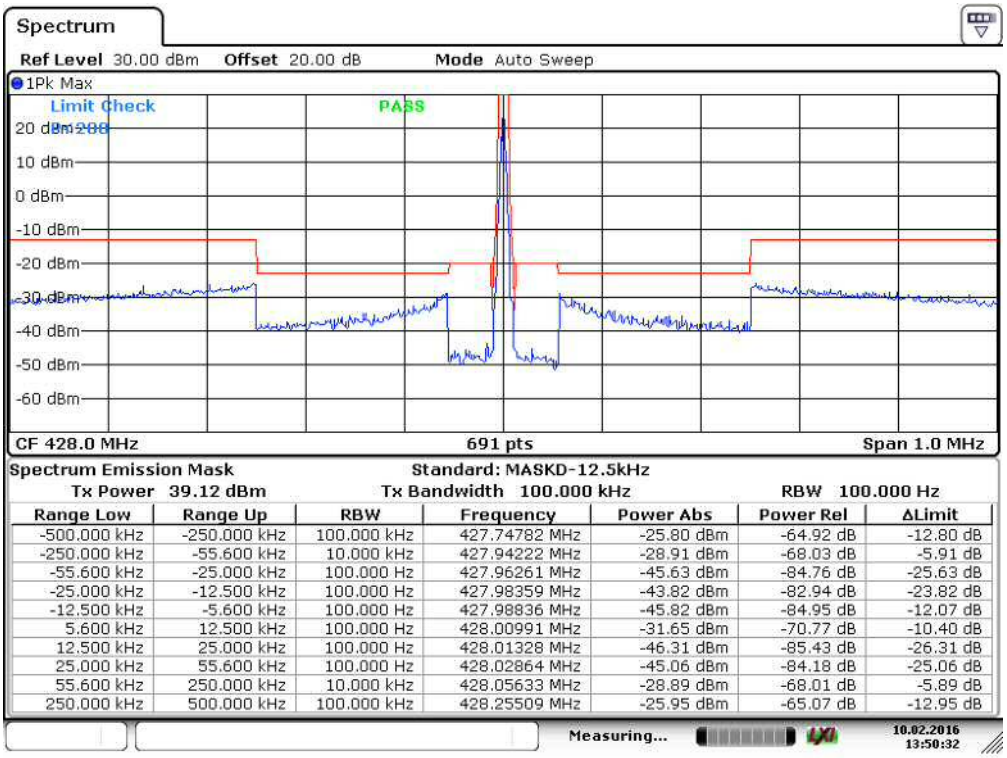


Figure 37. Measured curve with peak-detector. Channel LOW 12.5kHz 8FSK and 16FSK.



Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-500.000 kHz	-250.000 kHz	100.000 kHz	427.73183 MHz	-26.19 dBm	-66.29 dB	-13.19 dB
-250.000 kHz	-55.600 kHz	10.000 kHz	427.94367 MHz	-27.52 dBm	-67.62 dB	-4.52 dB
-55.600 kHz	-25.000 kHz	100.000 Hz	427.96990 MHz	-44.86 dBm	-84.96 dB	-24.86 dB
-25.000 kHz	-12.500 kHz	100.000 Hz	427.98359 MHz	-46.21 dBm	-86.31 dB	-26.21 dB
-12.500 kHz	-5.600 kHz	100.000 Hz	427.99181 MHz	-20.52 dBm	-60.63 dB	-11.77 dB
5.600 kHz	12.500 kHz	100.000 Hz	428.01164 MHz	-46.72 dBm	-86.83 dB	-12.97 dB
12.500 kHz	25.000 kHz	100.000 Hz	428.01641 MHz	-45.79 dBm	-85.89 dB	-25.79 dB
25.000 kHz	55.600 kHz	100.000 Hz	428.03301 MHz	-45.96 dBm	-86.06 dB	-25.96 dB
55.600 kHz	250.000 kHz	10.000 kHz	428.05923 MHz	-28.68 dBm	-68.78 dB	-5.68 dB
250.000 kHz	500.000 kHz	100.000 kHz	428.25218 MHz	-26.24 dBm	-66.34 dB	-13.24 dB

Figure 38. Measured curve with peak-detector. Channel MID 12.5kHz 8FSK.



Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-500.000 kHz	-250.000 kHz	100.000 kHz	427.74782 MHz	-25.80 dBm	-64.92 dB	-12.80 dB
-250.000 kHz	-55.600 kHz	10.000 kHz	427.94222 MHz	-28.91 dBm	-68.03 dB	-5.91 dB
-55.600 kHz	-25.000 kHz	100.000 Hz	427.96261 MHz	-45.63 dBm	-84.76 dB	-25.63 dB
-25.000 kHz	-12.500 kHz	100.000 Hz	427.98359 MHz	-43.82 dBm	-82.94 dB	-23.82 dB
-12.500 kHz	-5.600 kHz	100.000 Hz	427.98836 MHz	-45.82 dBm	-84.95 dB	-12.07 dB
5.600 kHz	12.500 kHz	100.000 Hz	428.00991 MHz	-31.65 dBm	-70.77 dB	-10.40 dB
12.500 kHz	25.000 kHz	100.000 Hz	428.01328 MHz	-46.31 dBm	-85.43 dB	-26.31 dB
25.000 kHz	55.600 kHz	100.000 Hz	428.02864 MHz	-45.06 dBm	-84.18 dB	-25.06 dB
55.600 kHz	250.000 kHz	10.000 kHz	428.05633 MHz	-28.89 dBm	-68.01 dB	-5.89 dB
250.000 kHz	500.000 kHz	100.000 kHz	428.25509 MHz	-25.95 dBm	-65.07 dB	-12.95 dB

Figure 39. Measured curve with peak-detector. Channel MID 12.5kHz 16FSK.

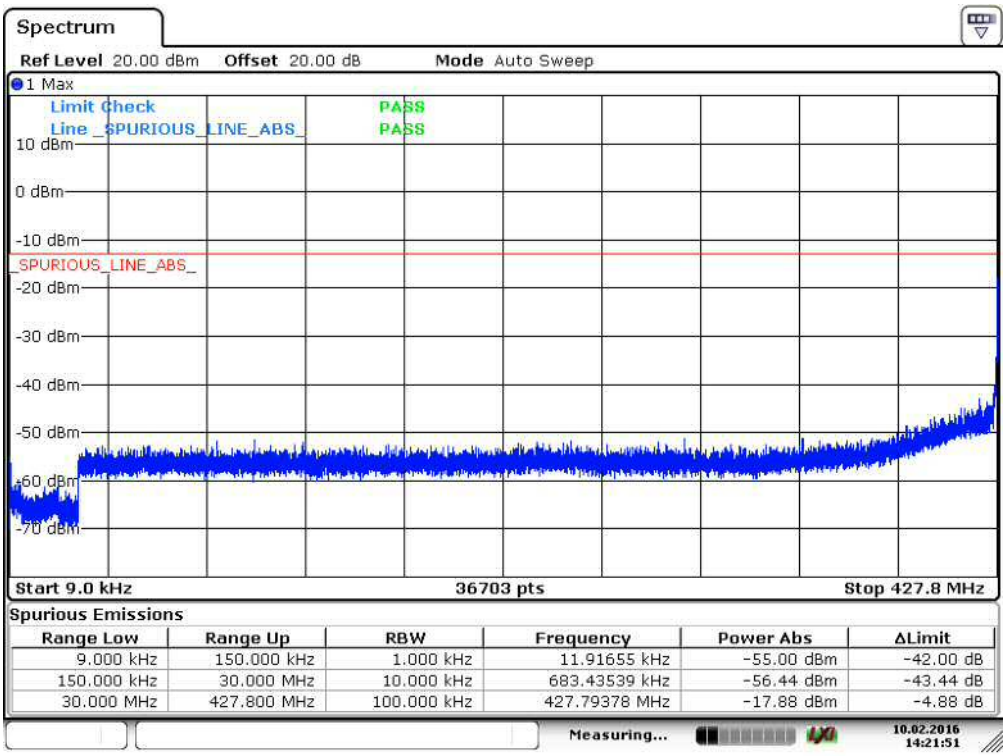


Figure 40. Measured curve with peak-detector. Channel MID 12.5kHz 8FSK and 16FSK.

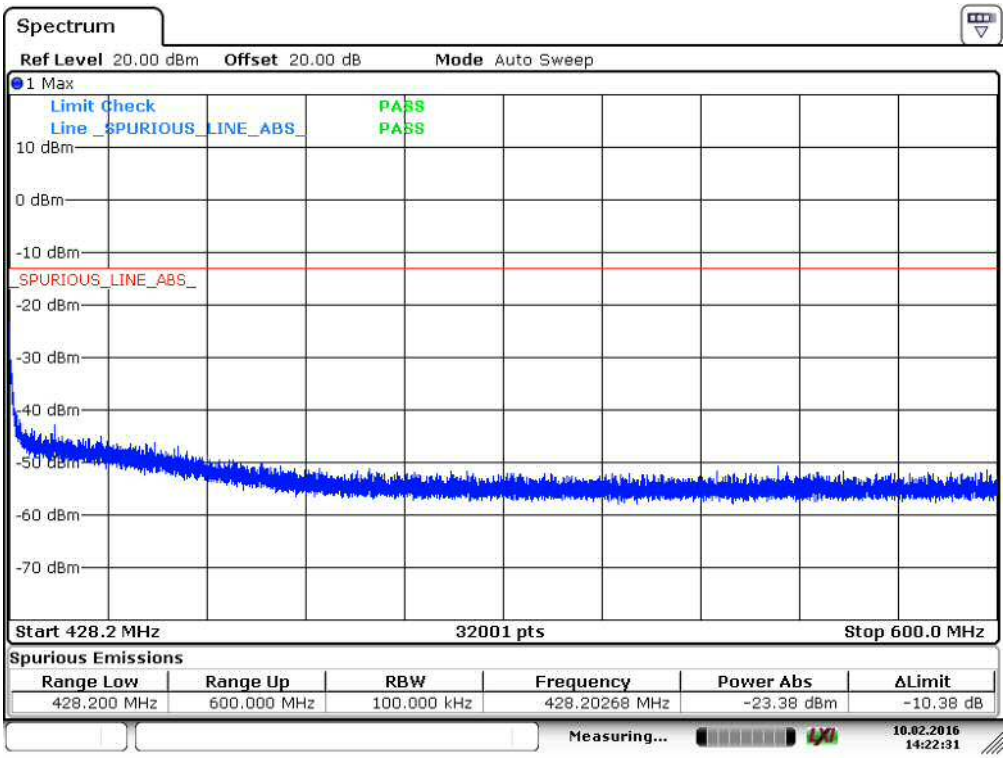


Figure 41. Measured curve with peak-detector. Channel MID 12.5kHz 8FSK and 16FSK.

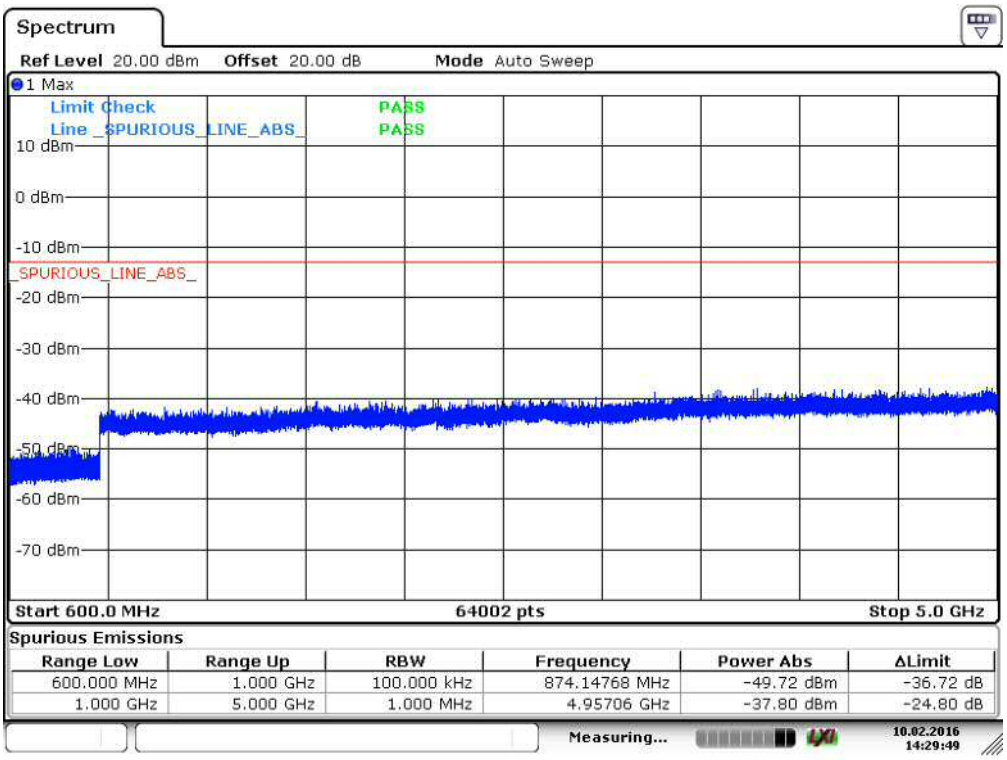


Figure 42. Measured curve with peak-detector. Channel MID 12.5kHz 8FSK and 16FSK.

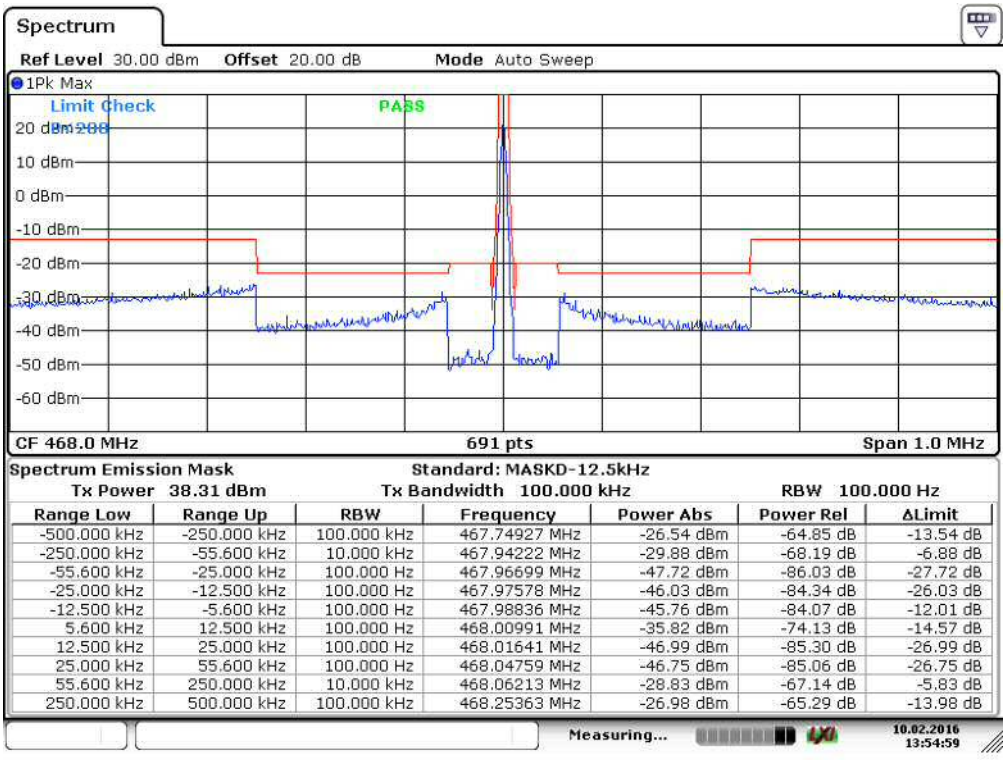


Figure 43. Measured curve with peak-detector. Channel HIGH 12.5kHz 8FSK.

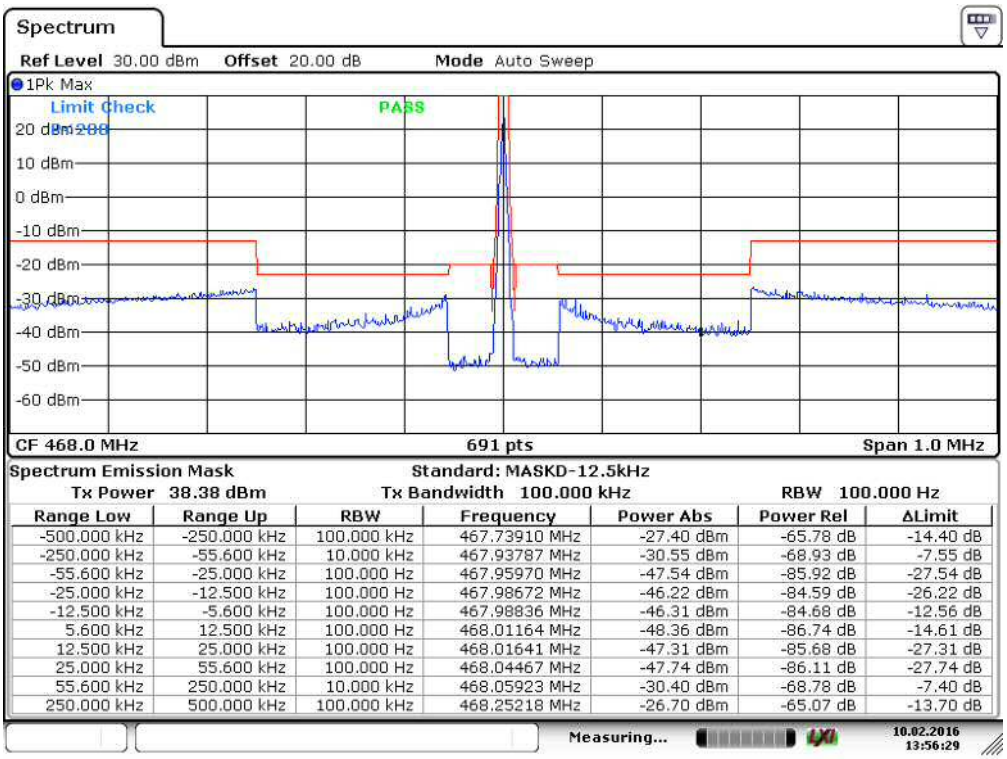


Figure 44. Measured curve with peak-detector. Channel HIGH 12.5kHz 16FSK.

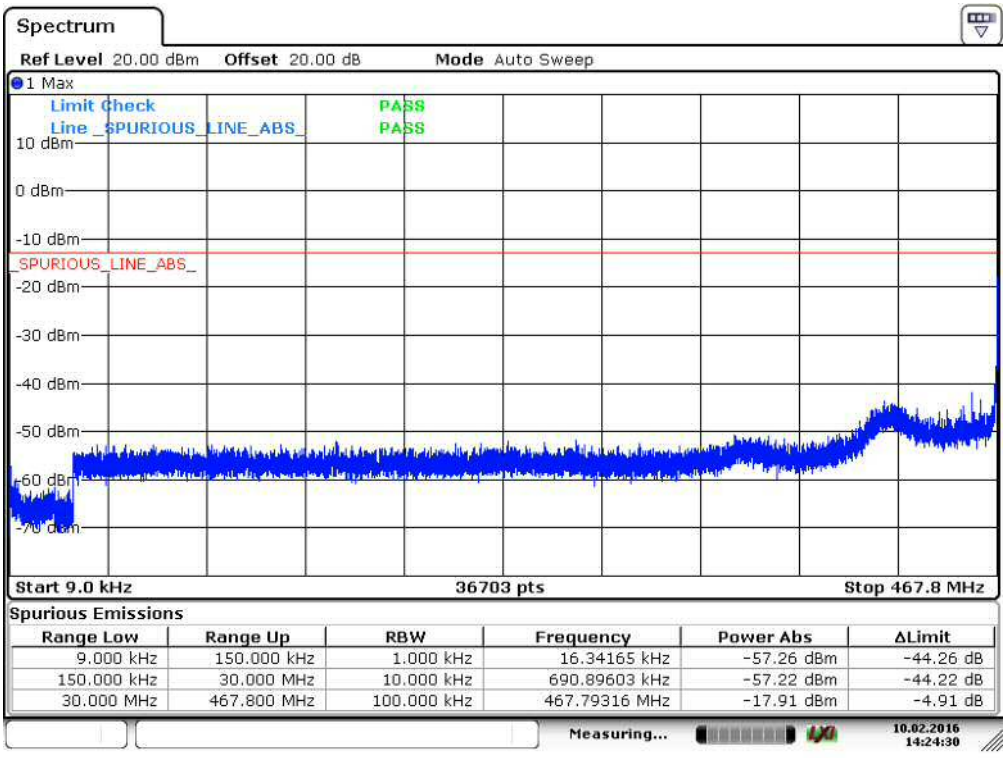


Figure 45. Measured curve with peak-detector. Channel HIGH 12.5kHz 8FSK and 16FSK.

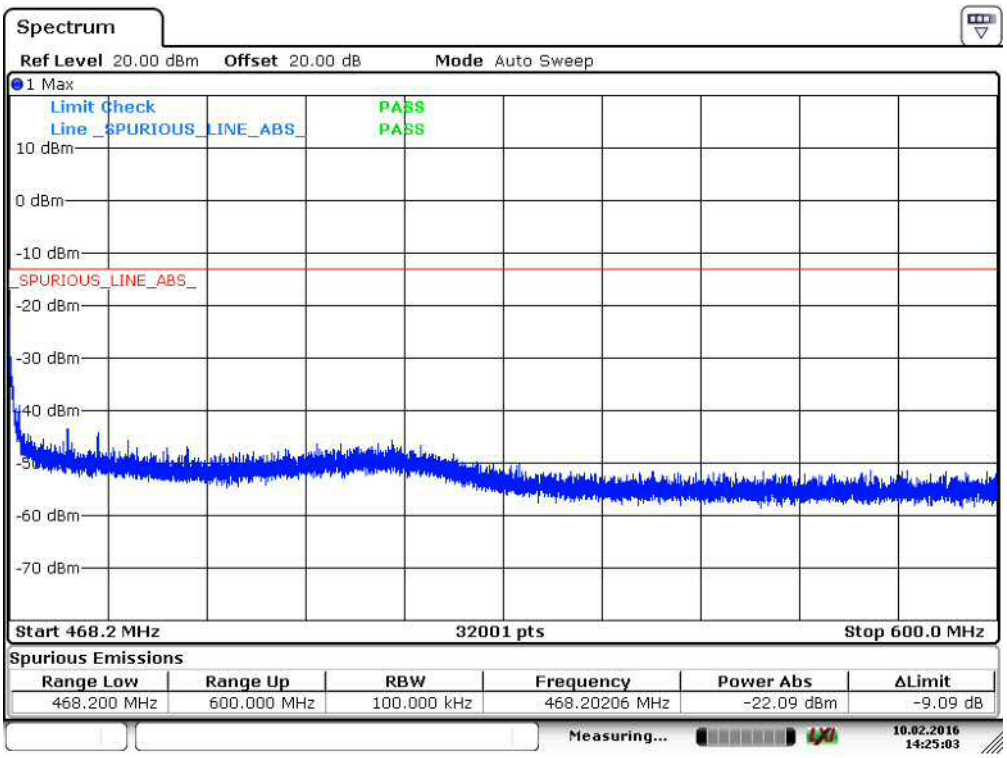


Figure 46. Measured curve with peak-detector. Channel HIGH 12.5kHz 8FSK and 16FSK.

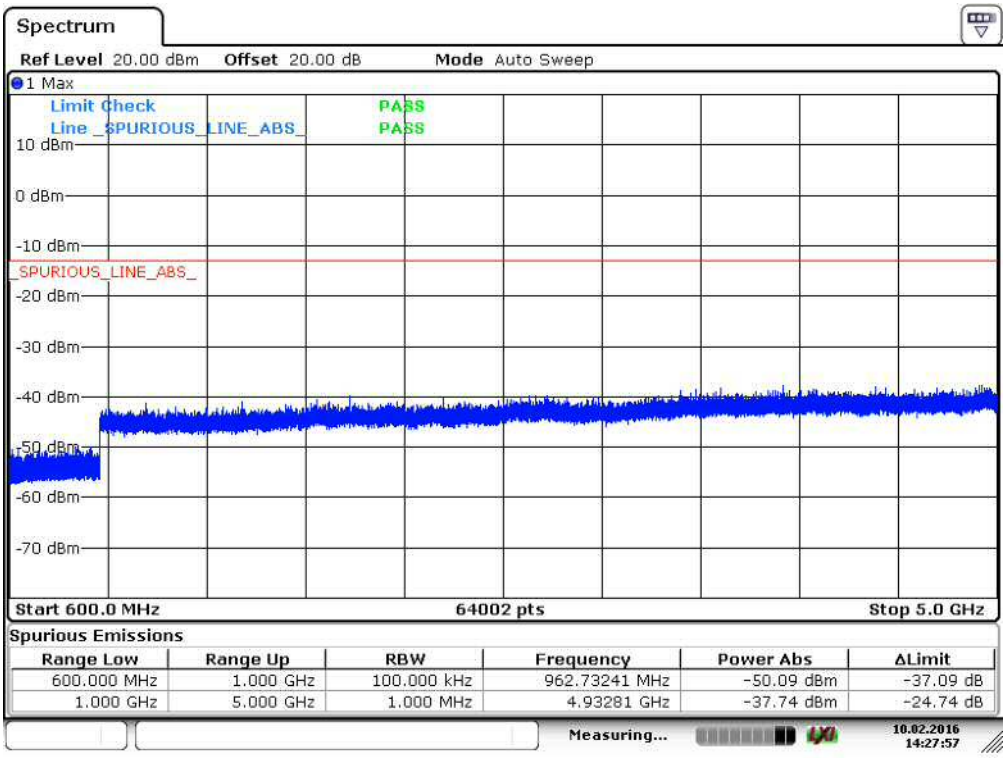


Figure 47. Measured curve with peak-detector. Channel HIGH 12.5kHz 8FSK and 16FSK.

Transmitter Spurious Emissions (Radiated) 30 MHz to 5 GHz

Standard:	FCC 90.210, 2.1053, RSS119 5.8	
Tested by:	THA	
Date:	25.08.2015, 9.2.2016	
Temperature:	10 - 90 % RH	
Humidity:	10 - 40 °C	
Measurement uncertainty	± 5.29 dB	Level of confidence 95 % (k = 2)
Limit:	43 + 10 log (P) dB, (-13 dBm)	

The spectrum was searched from 30 MHz to the 10th harmonic of the carrier (5GHz).

The test was performed in a semi-anechoic shielded room. The EUT was placed on a non-conductive 1.5 m high table standing on the turntable. During the test in the frequency range 30-5000 MHz the distance from the EUT to the measuring antenna was 3 m. In order to find the maximum levels of the disturbance radiation the angle of the turntable, the height of the measuring antenna were varied during the tests. The test was performed with the measuring antenna being both in horizontal and vertical polarizations. Spectrum analyzer settings were: 30MHz-1000MHz RBW 100kHz, 1000-5000MHz RBW 1MHz.

Vertical and horizontal polarizations in the frequency range 30 – 5000 MHz was first measured by using the peak detector. During the peak detector scan the turntable was rotated from 0° to 360° with 30° step with the antenna heights 1.0 m and 2.5 m.

The antenna substitution method was used to determine the equivalent radiated power at spurious frequencies. The EUT was replaced with a reference substitution antenna with a known gain referenced to an isotropic radiator $G_{Antenna[dBi]}$. This antenna was fed with a signal at the spurious frequency $P_{Gen[dBm]}$. The level of the signal was adjusted to repeat the previously measured level. The resulting EIRP is the signal level fed to the reference antenna corrected for gain referenced to an isotropic.

The formula below was used to calculate the EIRP of the EUT.

$$P_{EIRP[dbm]} = P_{Gen[dBm]} - L_{Cable[dB]} + G_{Antenna[dBi]}$$

Measurements were done with 8FSK and 16FSK modulations with antenna connector 50ohm terminated.

Test results

Measured level was more than 20 dB below the limit value (-13 dBm) in the frequency range 30-5000 MHz at the channels low, mid and high.

Channel	Channel spacing	Modulation	Frequency (MHz)	Spurious Result (dBm/eirp)
LOW	12.5 kHz	8FSK	2040.556	**-45.7**
MID	25 kHz	8FSK	2140.072	**-44.4**
HIGH	25 kHz	8FSK	1872.112	**-47.9**
LOW	12.5 kHz	16FSK	1224.108	**-44.9**
MID	25 kHz	16FSK	2140.072	**-41.6**
HIGH	25 kHz	16FSK	1872.112	**-48.6**

Table 1. Final measurements from the worst frequencies

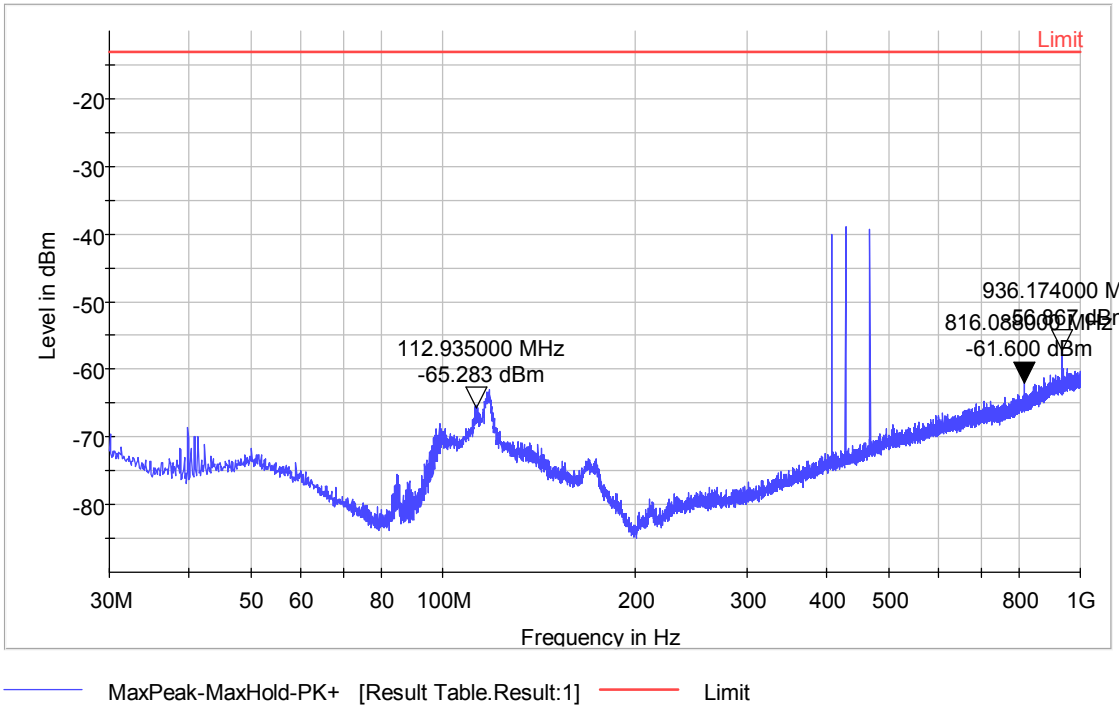


Figure 48. Measured curve with peak-detector. Channel LOW, MID and HIGH 25/12.5kHz 8FSK.

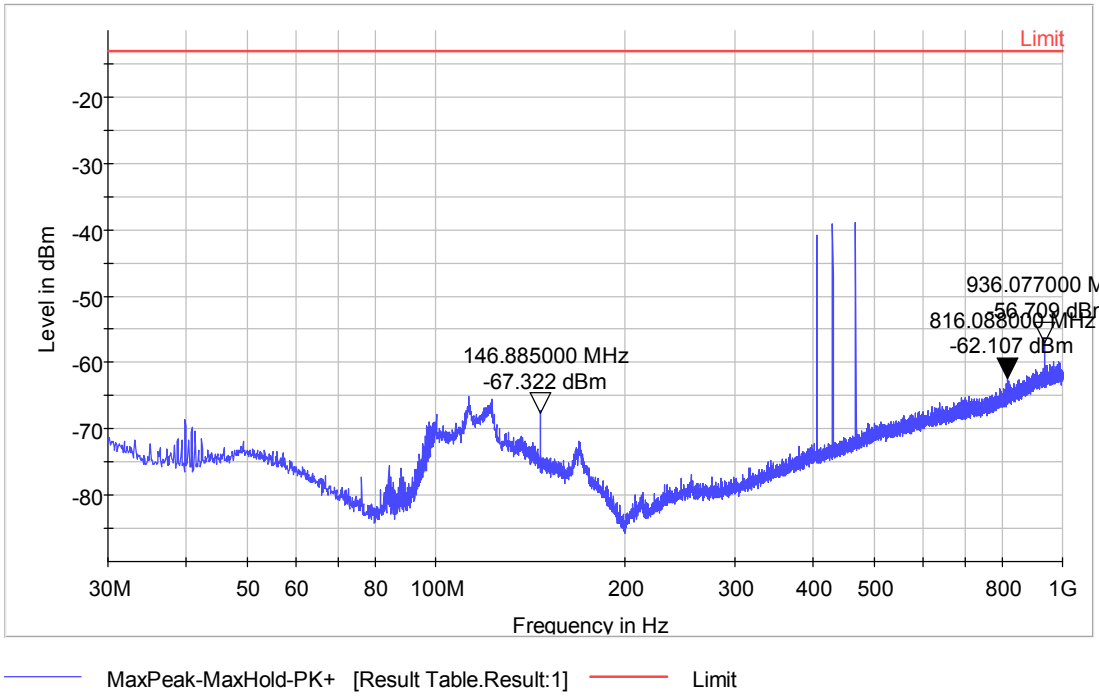


Figure 49. Measured curve with peak-detector. Channel LOW, MID and HIGH 25/12.5kHz 16FSK.

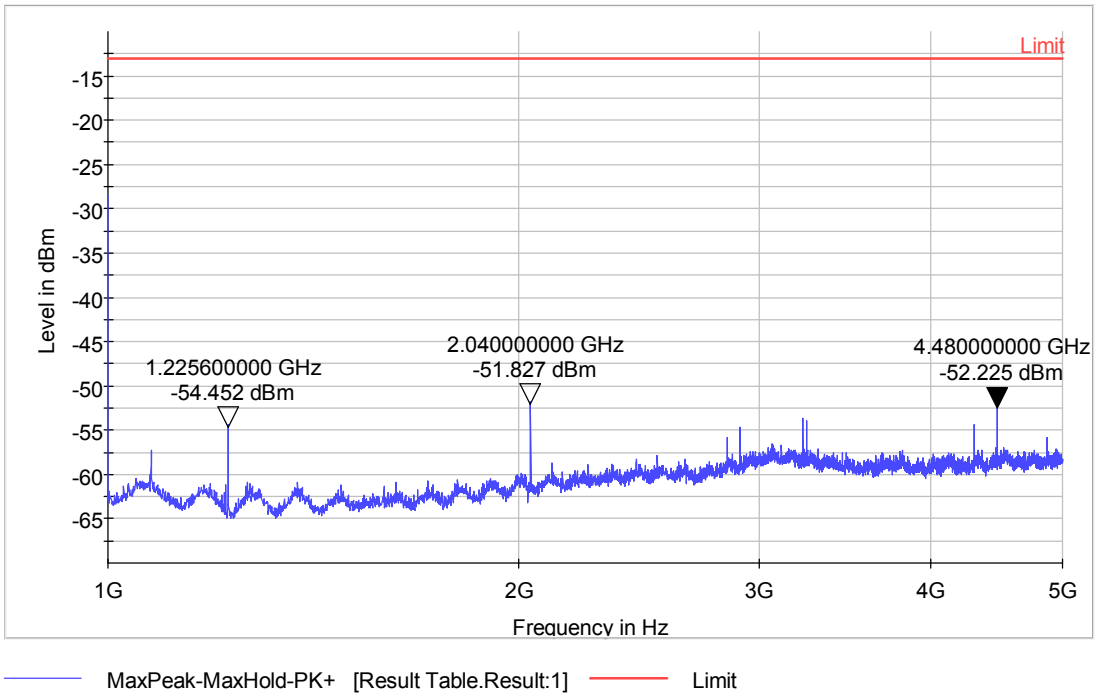


Figure 50. Measured curve with peak-detector. Channel LOW 12.5kHz 8FSK.

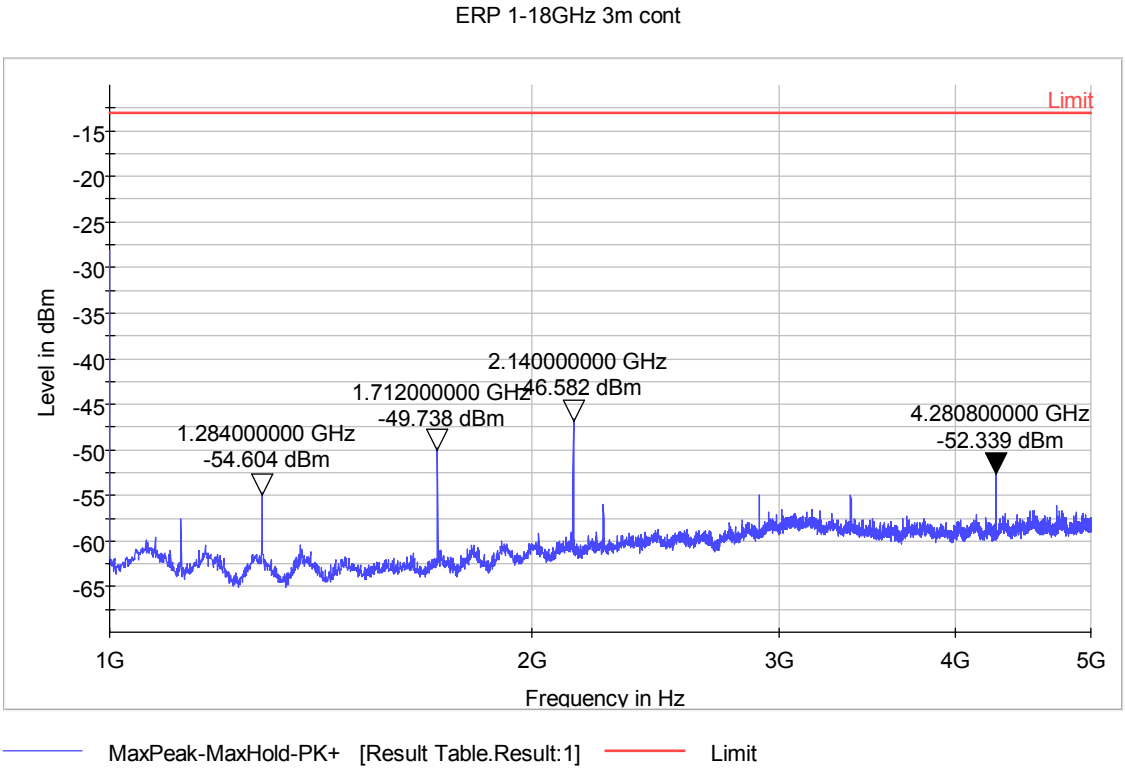


Figure 51. Measured curve with peak-detector. Channel MID 25kHz 16FSK.

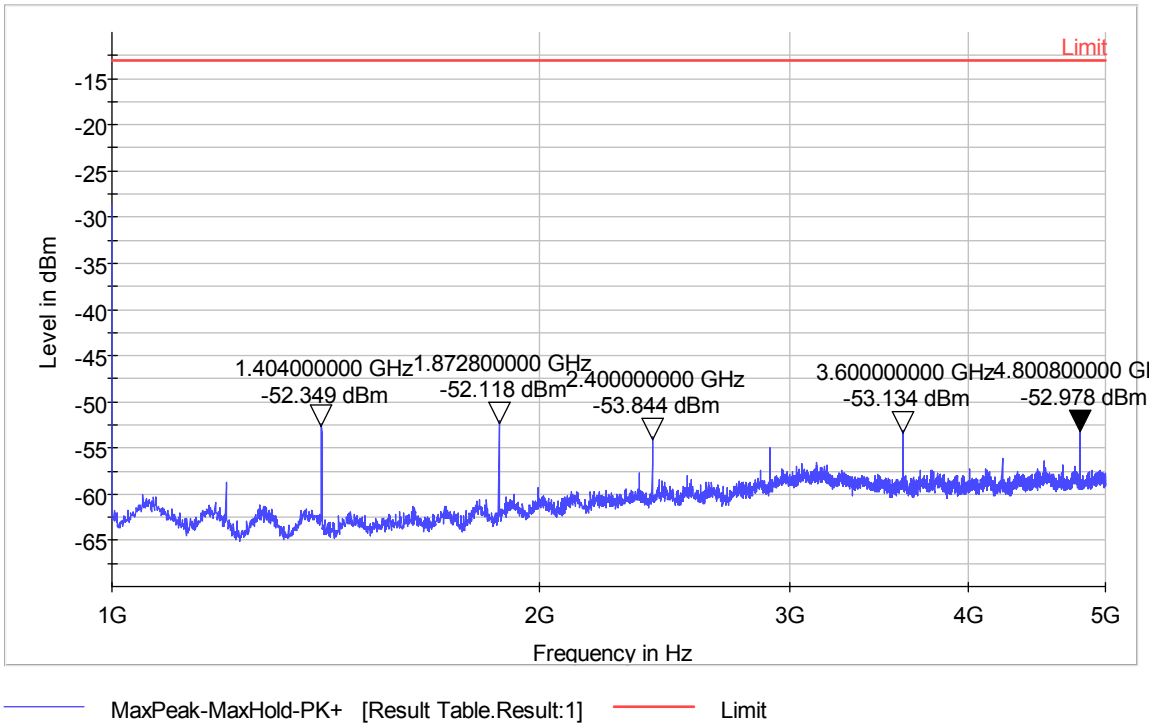


Figure 52. Measured curve with peak-detector. Channel HIGH 25kHz 16FSK.

RF-Test Equipment

Equipment	Manufacturer	Type	Inv.no	Cal.date	Cal due
TEST RECEIVER	ROHDE & SCHWARZ	ESU 26	8453	1.7.2015	7/2016
TEST SOFTWARE	ROHDE & SCHWARZ	EMC-32	-	-	-
SIGNAL ANALYZER	ROHDE & SCHWARZ	FSV40	9093	3.7.2015	7/2016
ANTENNA (30-1000 MHz)	SCHWARZBECK	VULB 9168	8911	4.11.2015	5/2016
ANTENNA MAST	DEISEL	MA240	5017	-	-
TURNTABLE	DEISEL	DS420	5015	-	-
CONTROLLER	COMTEST	HD100	5018	-	-
POWER SENSOR	ROHDE & SCHWARZ	NRP-Z91	9878	11.3.2015	09/2016
ANTENNA (1-18 GHz)	EMCO	3117	7293	2.3.2015-	09/2016
PREAMPLIFIER (0.5-26GHz)	HP	83017A	5226	15.8.2015	8/2016
ATTENUATOR 20 dB	HP	8493B	S/N:3037	23.1.2015	1/2017
HIGH PASS FILTER	WAINWRIGHT	WHK0.6/13G-10SS	9562	27.8.2015	8/2017

All used measurement equipment was calibrated (if required).