ENGINEERING TEST REPORT

MOBEXCOM DVR Vehicular Repeater
Model No.: MOBEXCOM DVRS 800

FCC ID: LO6-DVRS800

Applicant:

Futurecom Systems Group, ULC
3277 Langstaff Road
Concord, Ontario
Canada, L4K 5P8

Tested in Accordance With

Federal Communications Commission (FCC)
47 CFR, PARTS 2 and 90 (Subpart S)

UltraTech's File No.: 18FSG175_FCC90S

This Test report is Issued under the Authority of *Tri M. Luu* *Vice President of Engineering* *UltraTech Group of Labs* *Date: December 4, 2018*	
Report Prepared by: Santhosh Fernandez *Issued Date: December 4, 2018*	*Tested by: Nimisha Desai* *Test Dates: October 23 - 30, 2018*

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EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	FCC Parts 2 and 90 (Subpart S)
Title:	Code of Federal Regulations (CFR) Title 47 Telecommunication, Parts 2 & 90
Purpose of Test:	To obtain FCC Certification Authorization for Radio operating in the frequency bands 806-825 MHz and 851-870 MHz.
Test Procedures:	Both conducted and radiated emissions measurements were conducted in accordance with American National Standards Institute ANSI C63.4 - American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

1.2. RELATED SUBMITTAL(S)/GRANT(S)

None.

1.3. NORMATIVE REFERENCES

Publication	Year	Title
FCC CFR Parts 0-19, 80-End	2018	Code of Federal Regulations, Title 47 – Telecommunication
ANSI C63.4	2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 KHz to 40 GHz
ANSI C63.26	2015	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
ANSI/TIA-603-E	2016	Land Mobile FM or PM Communications Equipment Measurement and Performance Standards

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

APPLICANT	
Name:	Futurecom Systems Group, ULC
Address:	3277 Langstaff Road Concord, ON Canada L4K 5P8
Contact Person:	Mr. Tony Bombera Phone #: 905 532 1114 Fax #: 905 660 6858 Email Address: tony.bombera@futurecom.com

MANUFACTURER	
Name:	Futurecom Systems Group, ULC
Address:	3277 Langstaff Road Concord, ON Canada L4K 5P8
Contact Person:	Mr. Tony Bombera Phone #: 905 532 1114 Fax #: 905 660 6858 Email Address: tony.bombera@futurecom.com

2.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information (with the exception of the Date of Receipt) has been supplied by the applicant.

Brand Name:	**Futurecom Systems Group, ULC**
Product Name:	MOBEXCOM DVR Vehicular Repeater
Model Name or Number:	MOBEXCOM DVRS 800
Serial Number:	Preproduction
Type of Equipment:	Non-broadcast Radio Communication Equipment
External Power Supply:	None
Transmitting/Receiving Antenna Type:	Non-integral
Operational Description:	The Futurecom MOBEXCOM DVR Vehicular Repeater is designed to interface to a range of mobile radios. It permits expanded operation of portable radios. The MOBEXCOM DVR Vehicular Repeater communicates with the mobile radio using a serial data protocol.

2.3. EUT'S TECHNICAL SPECIFICATIONS

Transmitter	
Equipment Type:	Mobile
Intended Operating Environment:	[x] Commercial [x] Light Industry & Heavy Industry
Power Supply Requirement:	13.8 Vdc
RF Output Power Rating:	1 to 20 W (programmable per channel)
Operating Frequency Range:	806-824 MHz, 851-869 MHz
RF Output Impedance:	50 Ohms
Channel Spacing:	12.5 kHz & 25.0 kHz
Type Of Modulation:	Analog Voice and P25 Digital (voice, data)
Emission Designation*:	▪ 11K0F3E for 12.5 kHz channel spacing (Analog Voice) ▪ 16K0F3E for 25 kHz channel spacing (Analog Voice) ▪ 8K10F1E, 8K10F2E, 8K10F1D & 8K10F2D for 12.5kHz & 25kHz Channel spacing (Digital Voice, Data)
Oscillator Frequencies:	Digital signal frequencies: 32.768 kHz, 16.0 MHz, 29.4912 MHz, 144.0 MHz and 120 MHz Analogue signal frequency: LO1: Rx Freq - 109.65 MHz (Rx), LO2: 107.85 MHz & LO3: Tx Freq + 110.51875 MHz Reference Oscillator: 14.4 MHz
Antenna Connector Type:	TNC female

* For an average case of commercial telephony, the Necessary Bandwidth is calculated as follows:

For FM Voice Modulation:

Channel Spacing = 12.5 KHz, D = 2.5 KHz max., K = 1, M = 3 KHz
B_n = 2M + 2DK = 2(3) + 2(2.5)(1) = **11 KHz**
emission designation: 11K0F3E

Channel Spacing = 25 KHz, D = 5 KHz max., K = 1, M = 3 KHz
B_n = 2M + 2DK = 2(3) + 2(5)(1) = **16 KHz**
emission designation: 16K0F3E

For P25 Digital Modulation:

Emission Designation: Voice: 8K10F1E, 8K10F2E & Data: 8K10F1D, 8K10F2D

2.3.1. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	DC Input Port	1	6 pin male circular	Non-shielded
2	RF IN/OUT Port	2	TNC female	Shielded
3	AUX Port (RS-232)	1	9 pin male circular	Non-shielded
4	Mobile Radio Port	1	20 pin male circular	Non-shielded
5	USB Port	1	USB	Non-shielded

2.4. ANCILLARY EQUIPMENT

None

EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

3.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21°C
Humidity:	51%
Pressure:	102 kPa
Power input source:	13.8 Vdc

3.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TEST SIGNALS

Operating Modes:	The transmitter was operated in a continuous transmission mode with the carrier modulated as specified in the Test Data.
Special Test Software:	Operating software provided by Futurecom for selecting operating channel frequency and power
Special Hardware Used:	N/A
Transmitter Test Antenna:	The EUT is tested with the transmitter antenna port terminated to a 50 Ohms RF Load.

Transmitter Test Signals	
Frequency Band(s):	▪ 806-824 MHz ▪ 851-869 MHz
Frequency(ies) Tested: (near top, near middle and near bottom in the frequency range of operation.)	▪ 806.1, 815.1 and 823.9 MHz ▪ 851.1, 860.1 and 868.9 MHz
Transmitter Wanted Output Test Signals:	
▪ RF Power Output (measured maximum output power):	22.86 W
▪ Normal Test Modulation:	FM Voice & Data
▪ Modulating signal source:	External

EXHIBIT 4. SUMMARY OF TEST RESULTS

4.1. LOCATION OF TESTS

All of the measurements described in this report were performed at Ultratech Group of Labs located in the city of Oakville, Province of Ontario, Canada.

- Radiated Emissions were performed at the Ultratech's 3-10 TDK Semi-Anechoic Chamber situated in the Town of Oakville, province of Ontario. This test site been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Sec. 2.948 of the FCC Rules. The descriptions and site measurement data of the Oakville 3-10 TDK Semi-Anechoic Chamber has been filed with ANAB File No.: AT-1945.

4.2. APPLICABILITY & SUMMARY OF EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Applicability (Yes/No)
90.635 & 2.1046	RF Power Output	Yes
1.1307, 1.1310, 2.1091 & 2.1093	RF Exposure Limit	N/A
90.213 & 2.1055	Frequency Stability	Yes
2.1047(a)	Audio Frequency Response	N/A
2.1047(b)	Modulation Limiting	N/A
90.209, 90.210 & 2.1049	Emissions Mask	Yes
90.210, 90.669, 2.1057 & 2.1051	Emission Limits - Spurious Emissions at Antenna Terminal	Yes
90.210, 90.669, 2.1057 & 2.1051	Emission Limits - Field Strength of Spurious Emissions	Yes

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None.

4.4. DEVIATION OF STANDARD TEST PROCEDURES

None.

EXHIBIT 5. MEASUREMENTS, EXAMINATIONS & TEST DATA FOR EMC EMISSIONS

5.1. TEST PROCEDURES

This section contains test results only. Details of test methods and procedures can be found in Exhibit 8 of this report.

5.2. MEASUREMENT UNCERTAINTIES

The measurement uncertainties stated were calculated in accordance with requirements of UKAS Document NIS 81 with a confidence level of 95%. Please refer to Exhibit 7 for Measurement Uncertainties.

5.3. MEASUREMENT EQUIPMENT USED

The measurement equipment used complied with the requirements of the Standards referenced in the Methods & Procedures ANSI C63.4 and CISPR 16-1.

5.4. ESSENTIAL/PRIMARY FUNCTIONS AS DECLARED BY THE MANUFACTURER

The essential function of the EUT is to correctly communicate data/voice to and from radios over RF link.

5.5. RF POWER OUTPUT [§§ 2.1046 & 90.635]

5.5.1. Limits

(d) § 90.635 : limitations on power and antenna heights: The maximum output power of the transmitter for mobile station is 100 watts (20 dBw).

5.5.2. Method of Measurements

Refer to Exhibit 8, Sections 8.1 (Conducted) and 8.2 (Radiated) of this report for measurement details

5.5.3. Test Data

Fundamental Frequency (MHz)	Measured Power (dBm)	Measured Power (Watts)	Output Power Rating (Watts)
RF Output Power Setting (High)			
806.100	43.07	20.28	20
815.100	43.00	19.95	20
823.900	43.16	20.70	20
851.100	43.09	20.37	20
860.100	43.30	21.38	20
868.900	43.59	22.86	20
RF Output Power Setting (Low)			
806.100	29.79	0.95	1
815.100	30.06	1.01	1
823.900	30.44	1.11	1
851.100	30.29	1.07	1
860.100	30.02	1.00	1
868.900	30.19	1.04	1

5.6. FREQUENCY STABILITY [§§ 2.1055 & 90.213]

5.6.1. Limits

Refer to FCC 47 CFR 90.213 for specification details.

Frequency Range	Fixed and Base Stations
(MHz)	(ppm)
806-809/ 851-854	1.0
809-824/854-869	1.5

5.6.2. Method of Measurements

Refer to Exhibit 8, Section 8.3 of this report for measurement details

5.6.3. Test Data

Product Name: Model No.:	MOBEXCOM DVR Vehicular Repeater MOBEXCOM DVRS 800
Center Frequency:	806.1 MHz
Full Power Level:	20 W
Frequency Tolerance Limit:	1.0 ppm or 806.1 Hz
Max. Frequency Tolerance Measured:	-152 Hz (-0.19ppm)
Input Voltage Rating:	13.8 Vdc

FREQUENCY VARIATION			
Ambient Temperature (^{o}C)	**Supply Voltage (Nominal) 13.8 Volts**	**Supply Voltage (85% of Nominal) 11.73 Volts**	**Supply Voltage (115% of Nominal) 15.87 Volts**
	Hz	**Hz**	**Hz**
-30	-130	--	--
-20	-131	--	--
-10	-142	--	--
0	-152	--	--
10	-109	--	--
20	-61	-64	-64
30	26	--	--
40	66	--	--
50	79	--	--
60	75	--	--

5.7. EMISSION MASK [§§ 2.1049, 90.209, 90.210 & 90.691]

5.7.1. Limits

§ 90.209 Bandwidth limitations: Transmitters designed to operate in 806-824 MHz and 851-869 MHz frequency band must meet the bandwidth limitations in this section.

Emissions shall be attenuated below the mean output power of the transmitter as follows:

Frequency Range (MHz)	Channel Spacing (KHz)	Maximum Authorized BW (KHz)	Recommended Frequency Deviation (KHz)	FCC Applicable Mask
809-824/854-869	25.0	20.0	5.0	As per § 90.691
806-809/851-854	12.5	20.0	2.5	Mask B & H

Masks Selected as per below table:
Channel Bandwidth
12.5KHz & 25KHz

Frequency (MHz)		Analog	Digital
806-809	851-854	B	H
809-824	854-869	B	G

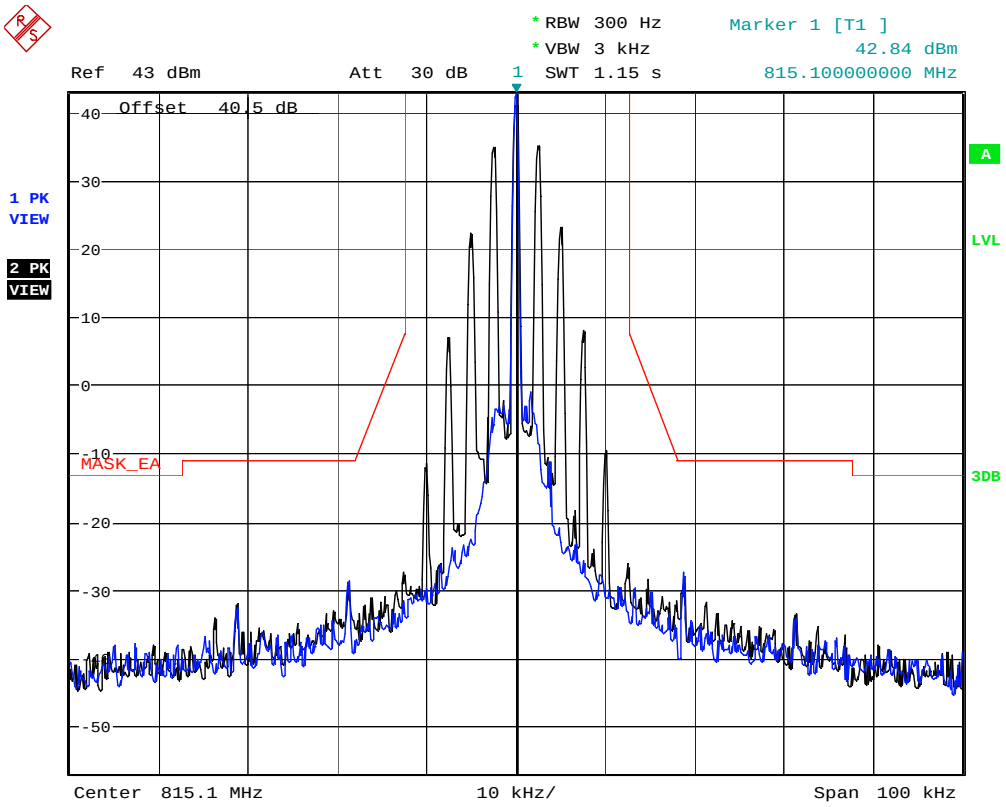
Frequency (MHz)	Analog	Mask	Authorized BW	Mask 90.691
806.1	12.5& 25kHz	B	20KHz	
815.1	12.5 & 25kHz	B	20KHz	90.691
823.9	12.5 & 25kHz	B	20KHz	90.691
851.1	12.5 & 25kHz	B	20KHz	
860.1	12.5 & 25kHz	B	20KHz	90.691
868.9	12.5 & 25kHz	B	20KHz	90.691

Frequency (MHz)	Digital	Mask	Authorized BW	Mask 90.691
806.1	Voice & Data	H	20KHz	
815.1	Voice & Data	G	20KHz	90.691
823.9	Voice & Data	G	20KHz	90.691
851.1	Voice & Data	H	20KHz	
860.1	Voice & Data	G	20KHz	90.691
868.9	Voice & Data	G	20KHz	90.691

5.7.2. Test Data

Rule Part: FCC 90 (90.691)

5.7.2.1. Configuration: Mask 90.691, 815.1MHz, 12.5 KHz, Analog, High power



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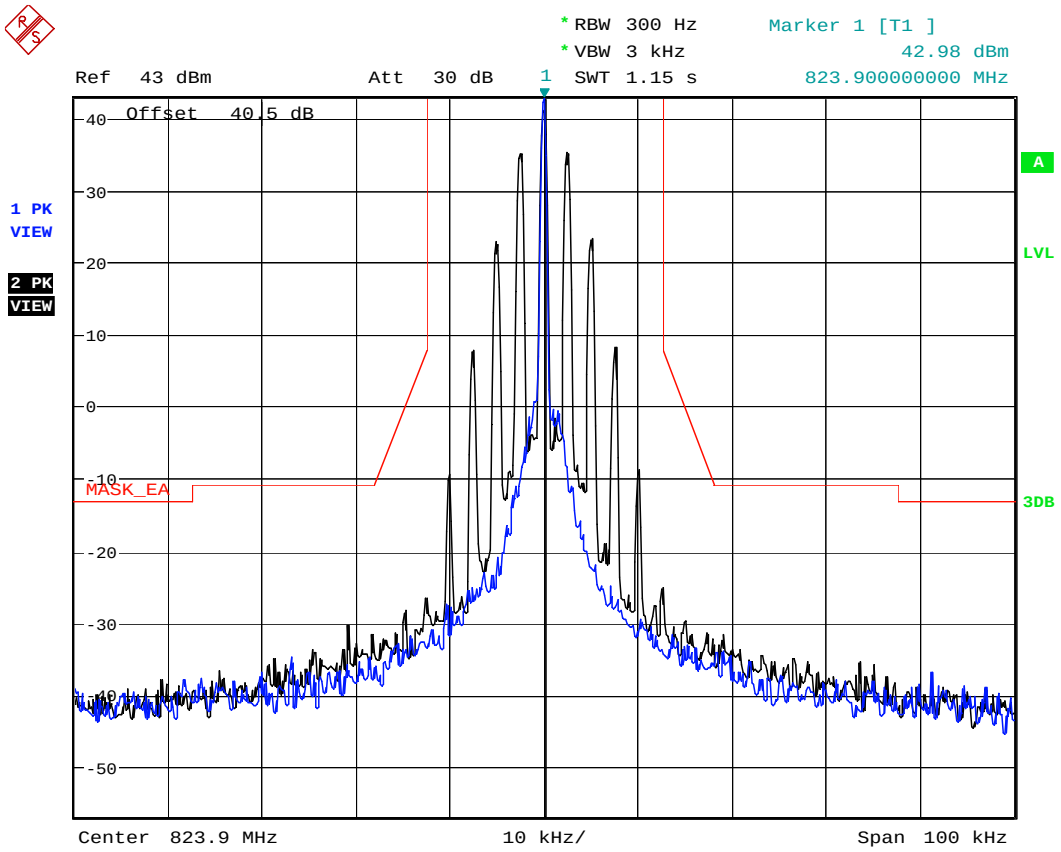
5.7.2.2. Configuration: Mask 90.691, 823.9MHz, 12.5 KHz, Analog, High power



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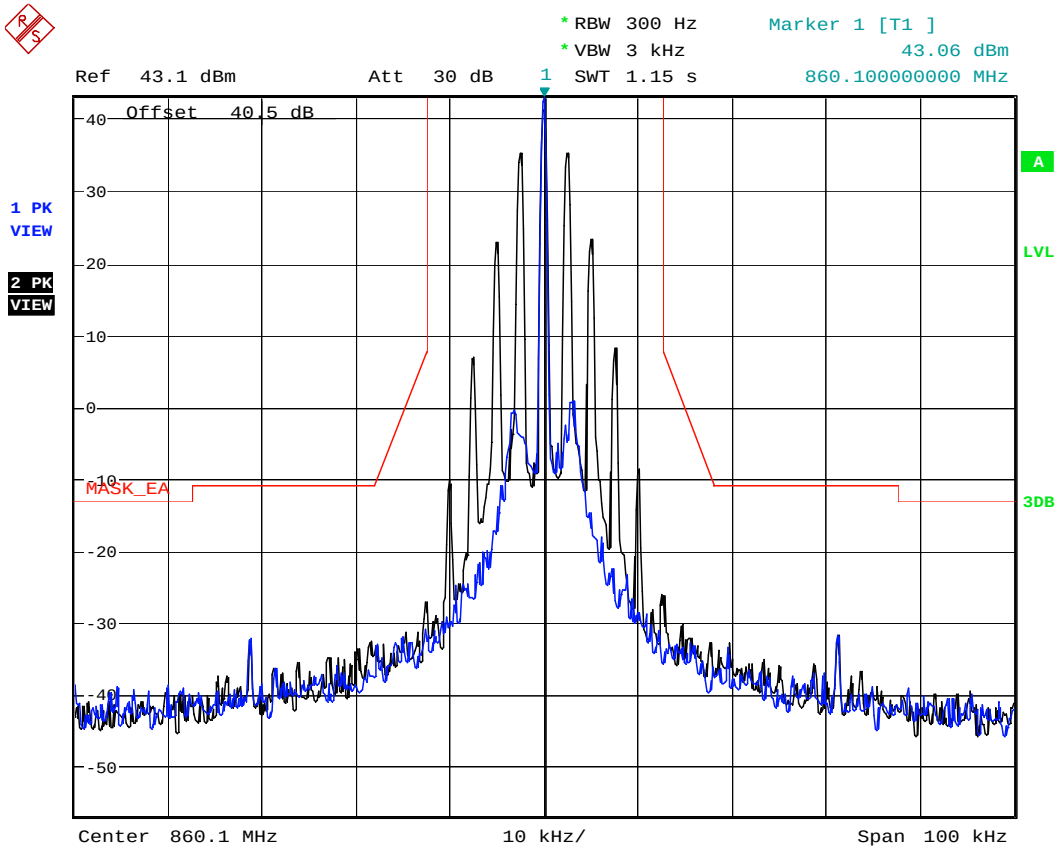
5.7.2.3. Configuration: Mask 90.691, 860.1MHz, 12.5 KHz, Analog, High power



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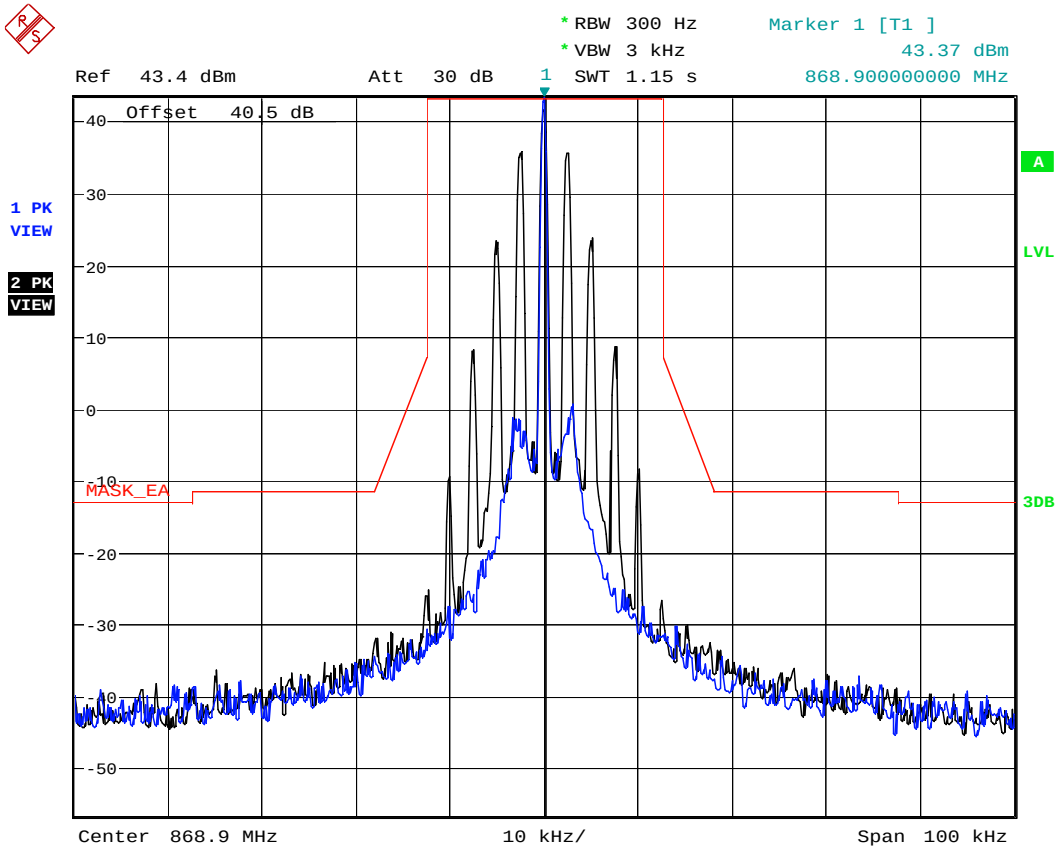
5.7.2.4. Configuration: Mask 90.691, 868.9MHz, 12.5 KHz, Analog, High power



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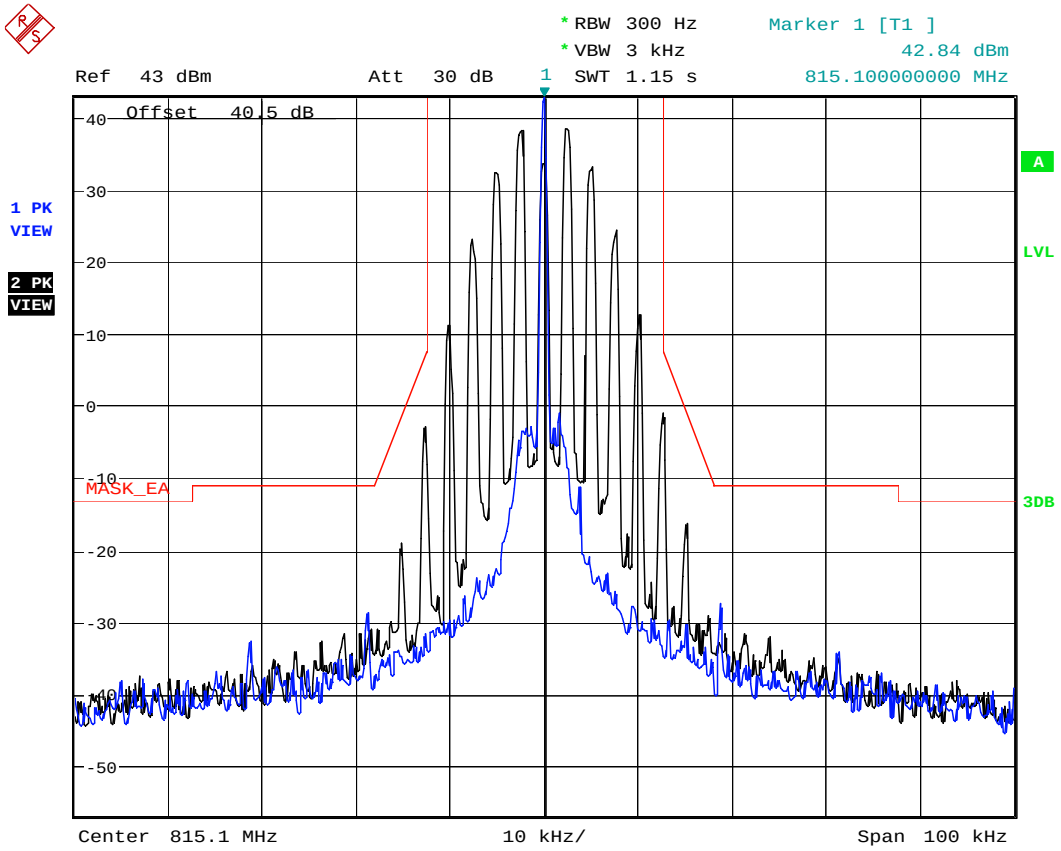
5.7.2.5. Configuration: Mask 90.691, 815.1MHz, 25 KHz, Analog, High power



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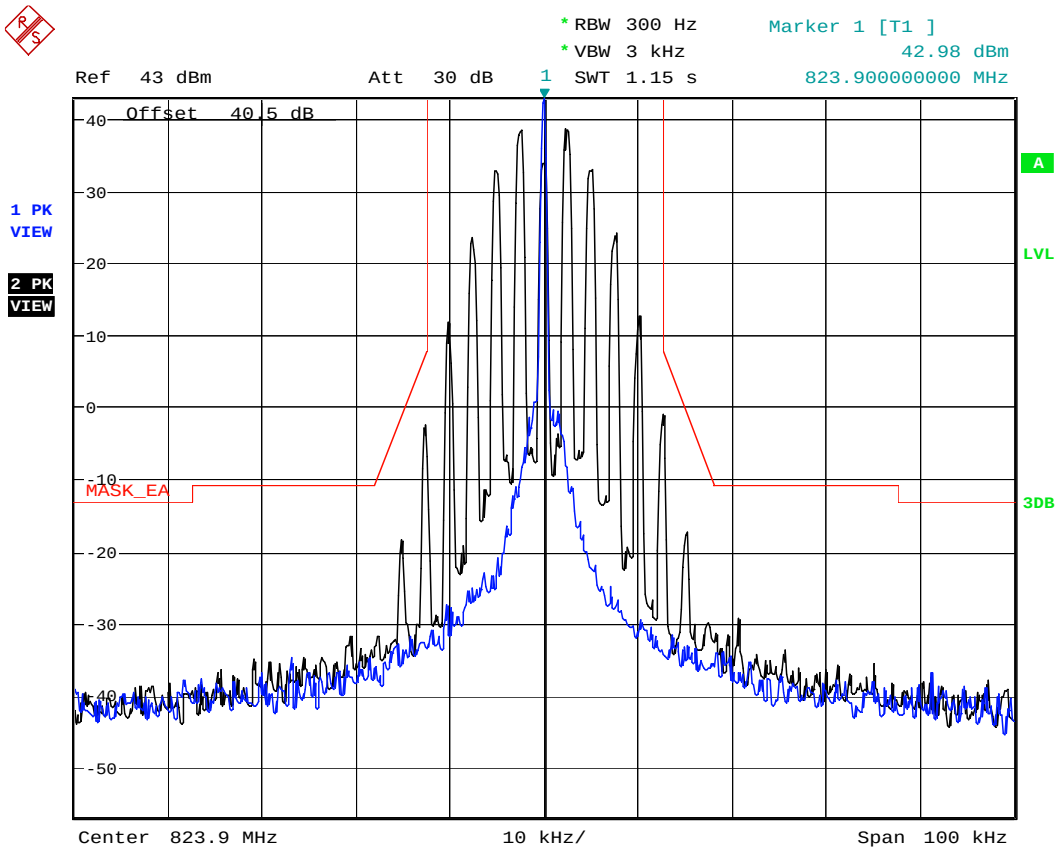
5.7.2.6. Configuration: Mask 90.691, 823.9MHz, 25 KHz, Analog, High power



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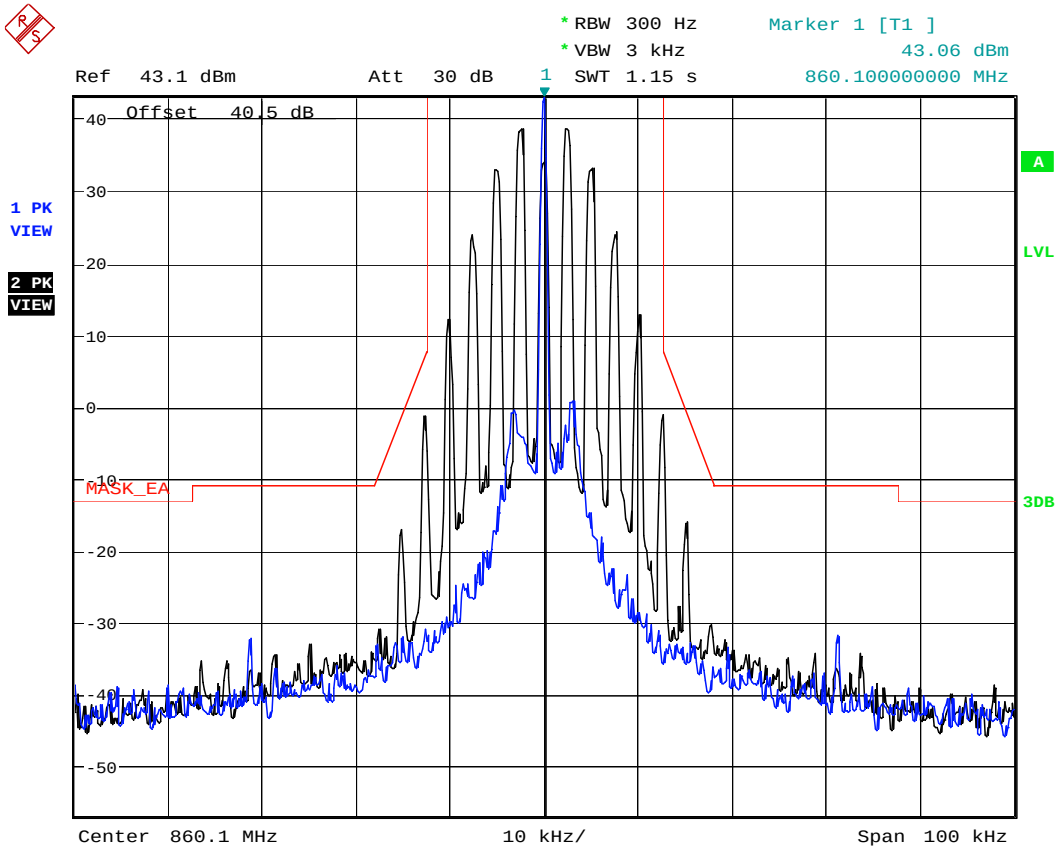
5.7.2.7. Configuration: Mask 90.691, 860.1MHz, 25 KHz, Analog, High power



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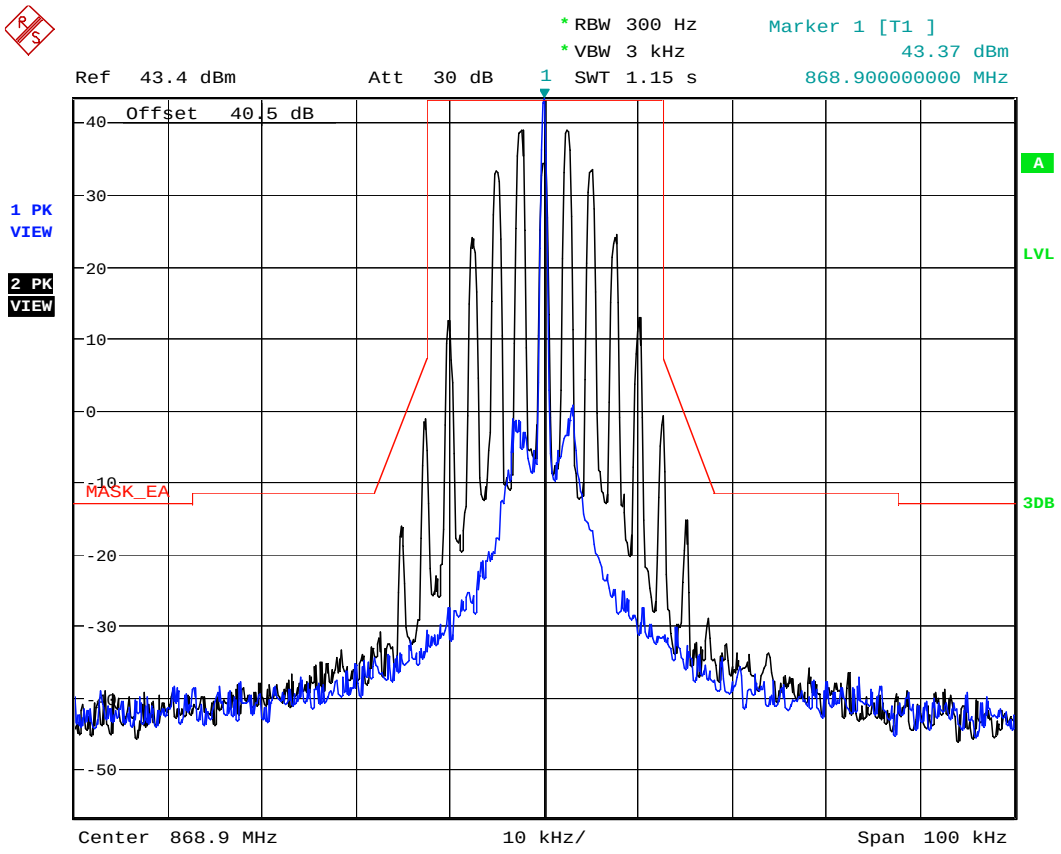
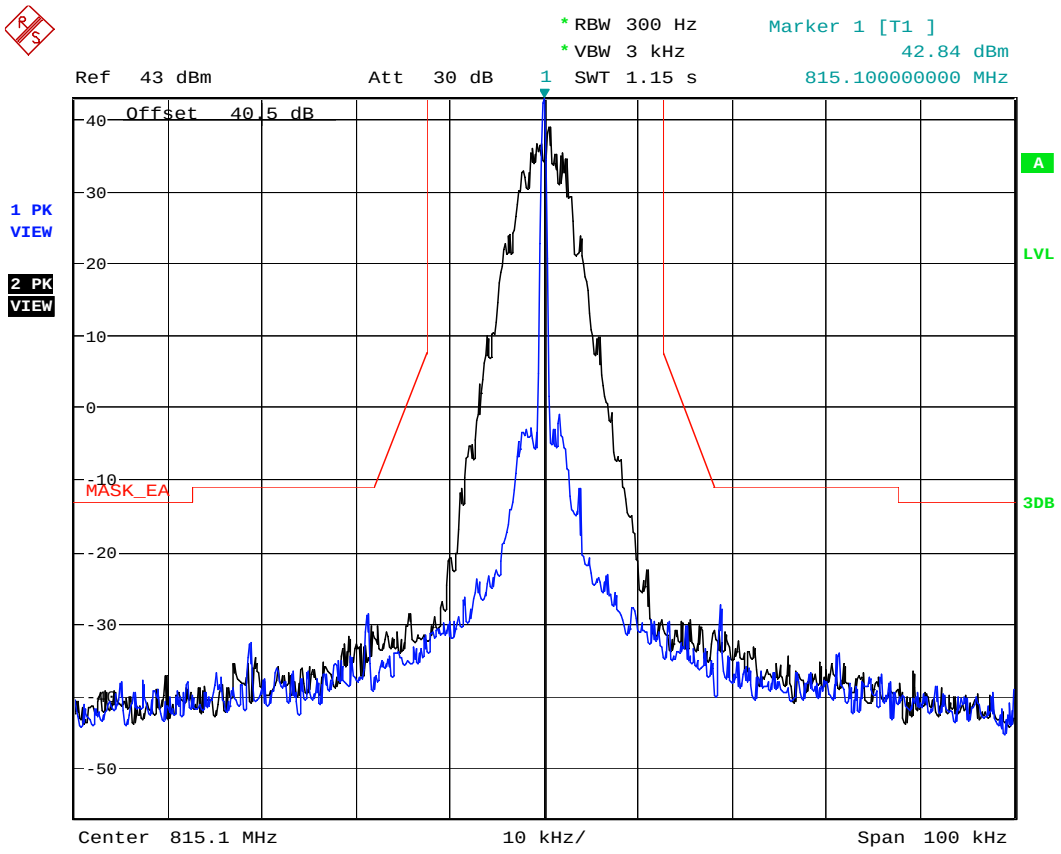
5.7.2.8. Configuration: Mask 90.691, 868.9MHz, 25 KHz, Analog, High power



Date: 23.OCT.2018 14:21:02

High Power Digital

5.7.2.9. Configuration: Mask 90.691, 815.1MHz, Digital, High power



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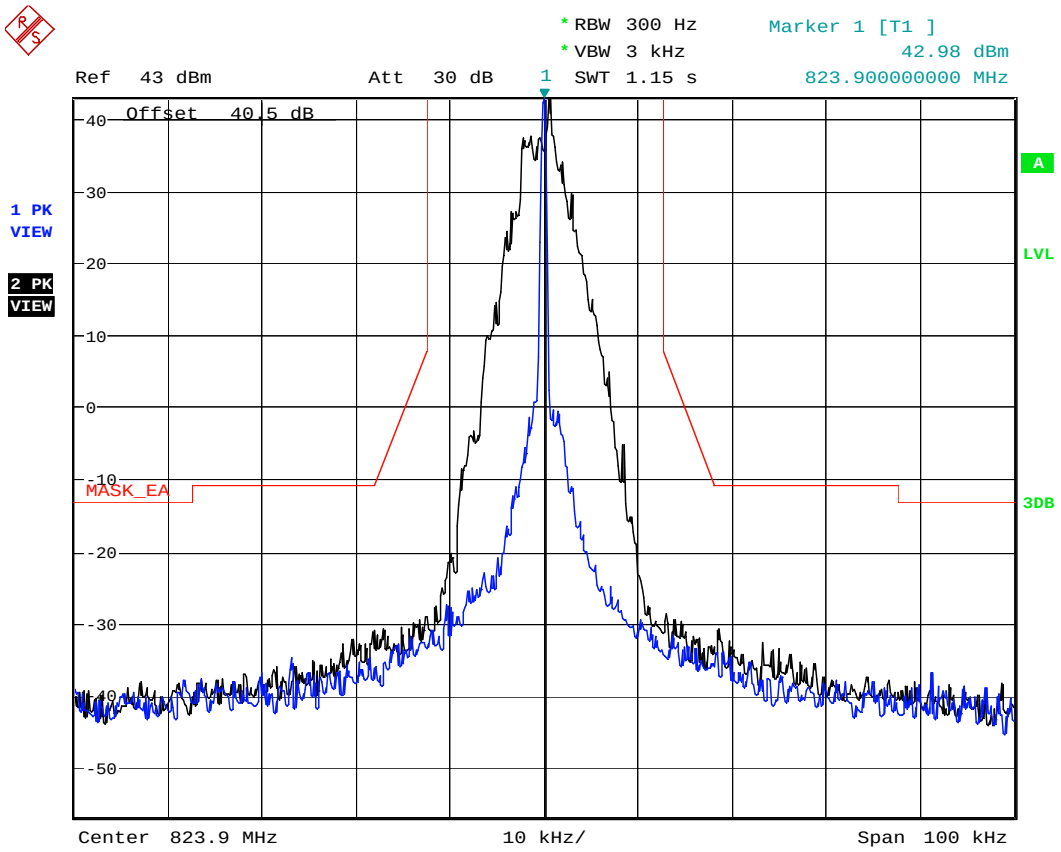
5.7.2.10. Configuration: Mask 90.691, 823.9MHz, Digital, High power



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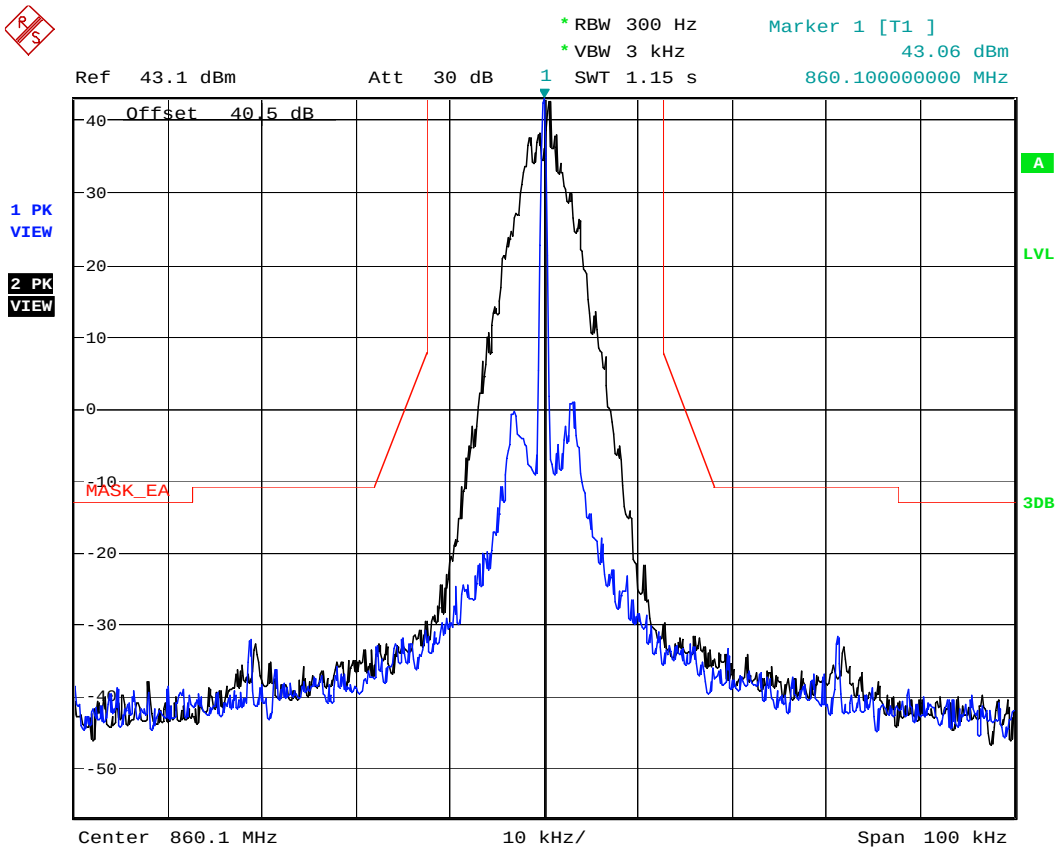
5.7.2.11. Configuration: Mask 90.691, 860.1MHz, Digital, High power



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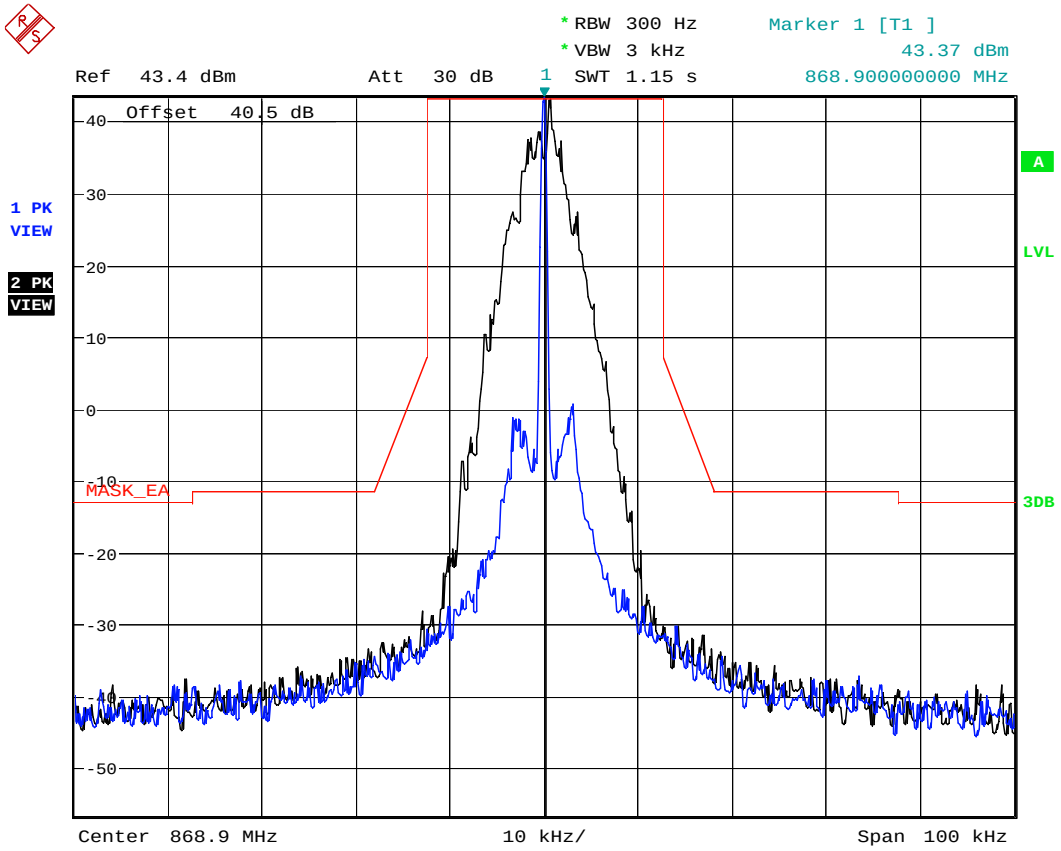
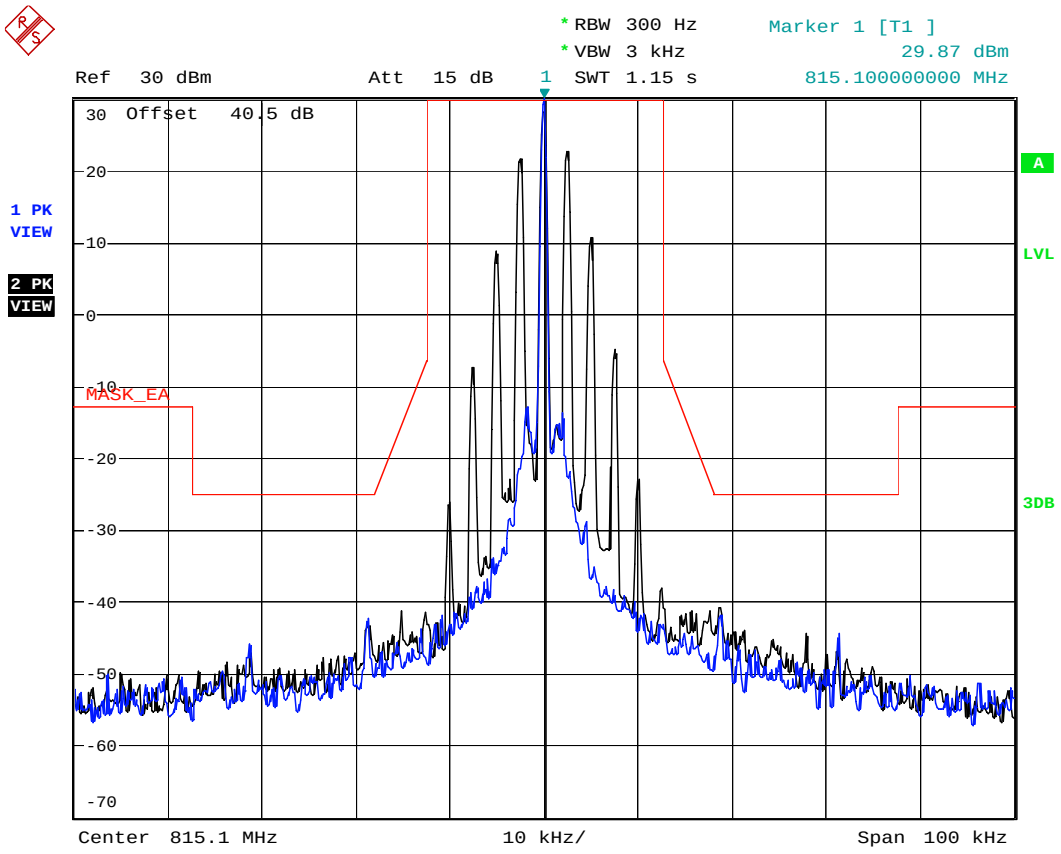
5.7.2.12. Configuration: Mask 90.691, 868.9MHz, Digital, High power



Date: 23.OCT.2018 14:21:57

Low Power Analog

5.7.2.13. Configuration: Mask 90.691, 815.1MHz, 12.5 KHz, Analog, Low power



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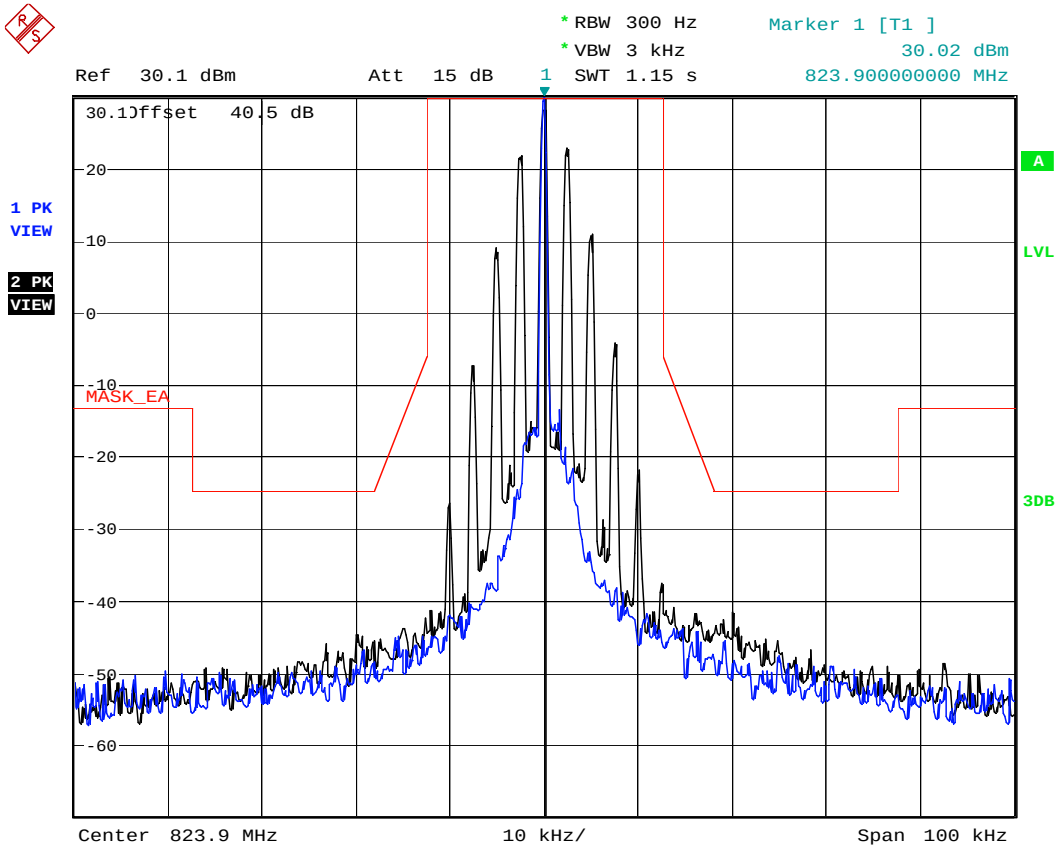
5.7.2.14. Configuration: Mask 90.691, 823.9MHz, 12.5 KHz, Analog, Low power



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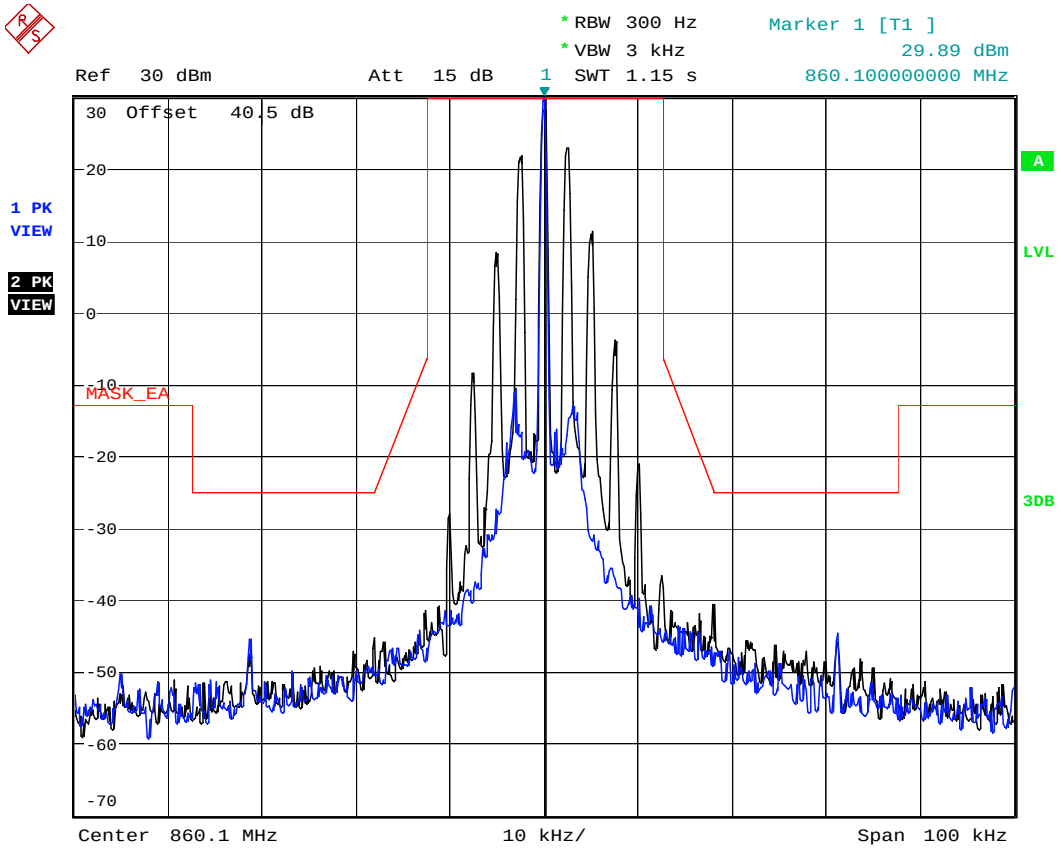
5.7.2.15. Configuration: Mask 90.691, 860.1MHz, 12.5 KHz, Analog, Low power



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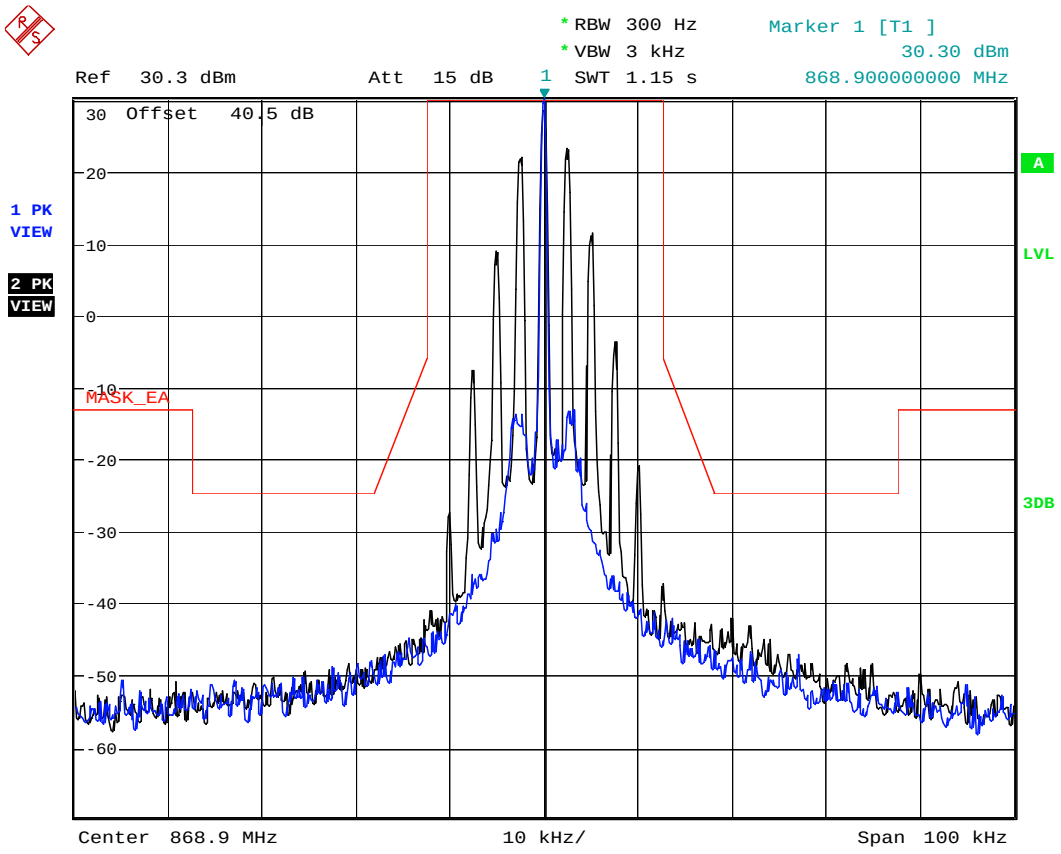
5.7.2.16. Configuration: Mask 90.691, 868.9MHz, 12.5 KHz, Analog, Low power



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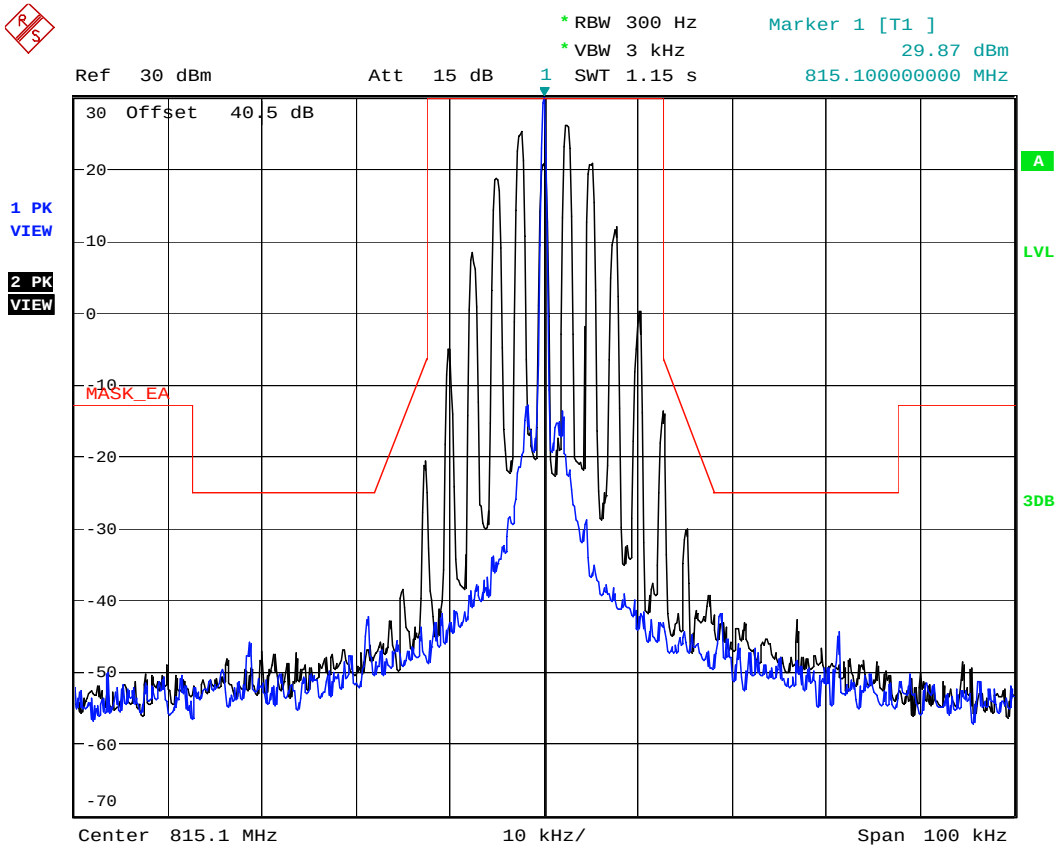
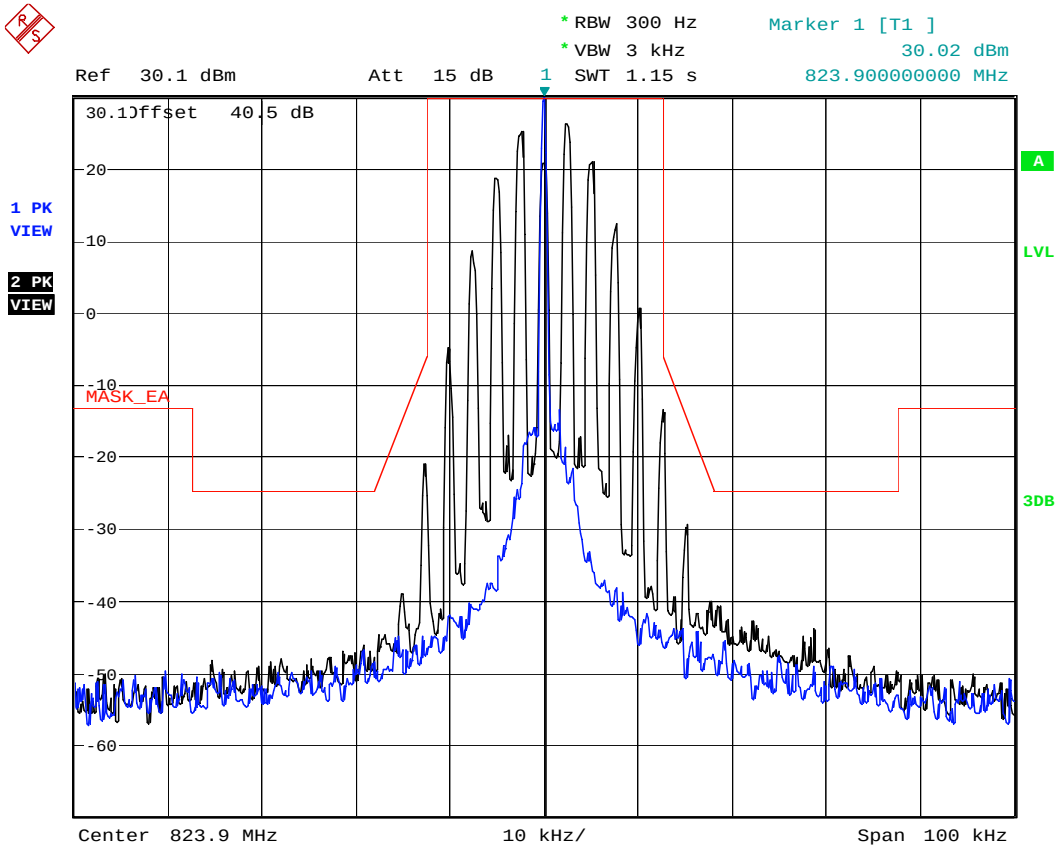
5.7.2.17. Configuration: Mask 90.691, 815.1MHz, 25 KHz, Analog, Low power



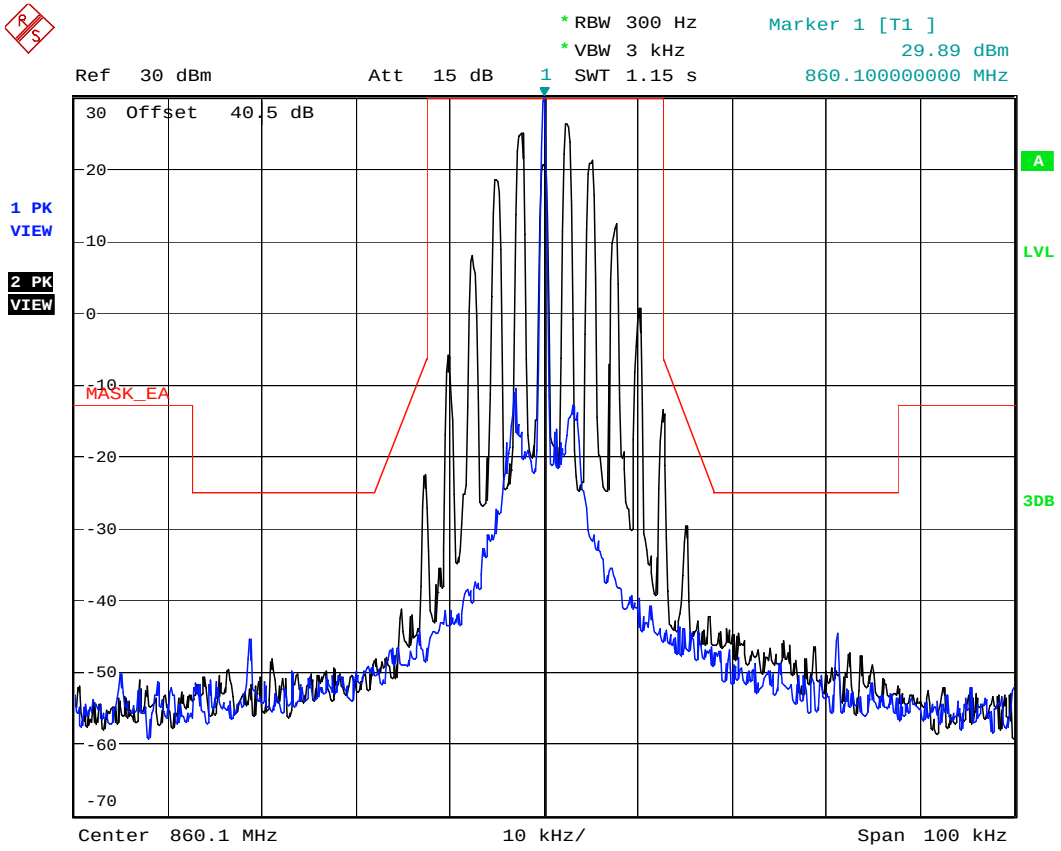
Date: 23.OCT.2018 14:26:09

5.7.2.18. Configuration: Mask 90.691, 823.9MHz, 25 KHz, Analog, Low power



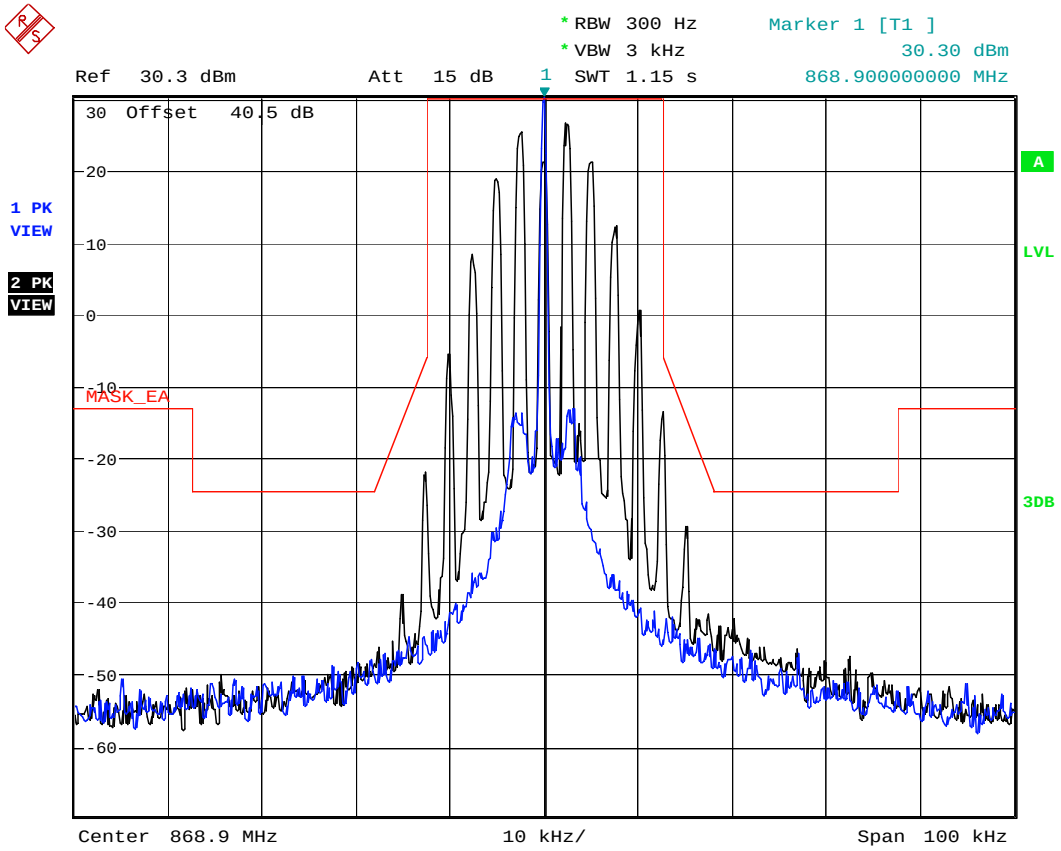
Date: 23.OCT.2018 14:31:31

5.7.2.19. Configuration: Mask 90.691, 860.1MHz, 25 KHz, Analog, Low power



Date: 23.OCT.2018 14:41:26

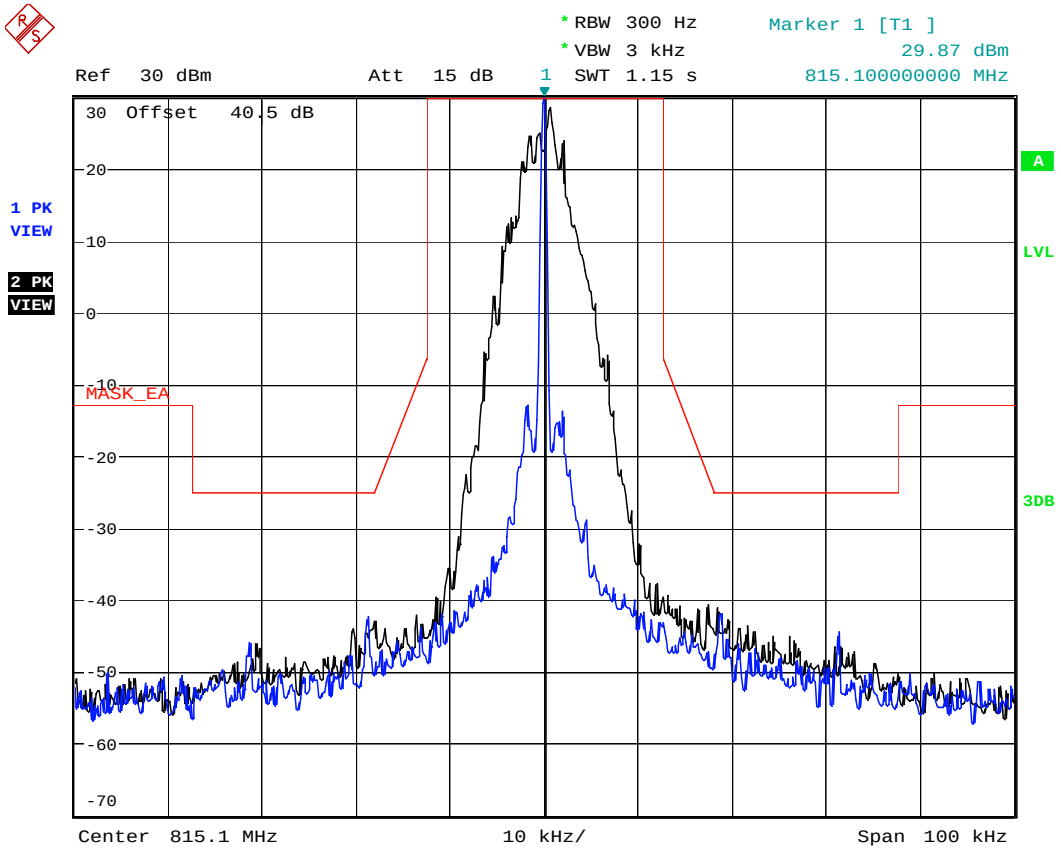
5.7.2.20. Configuration: Mask 90.691, 868.9MHZ, 25 KHz, Analog, Low power



Date: 23.OCT.2018 14:49:04

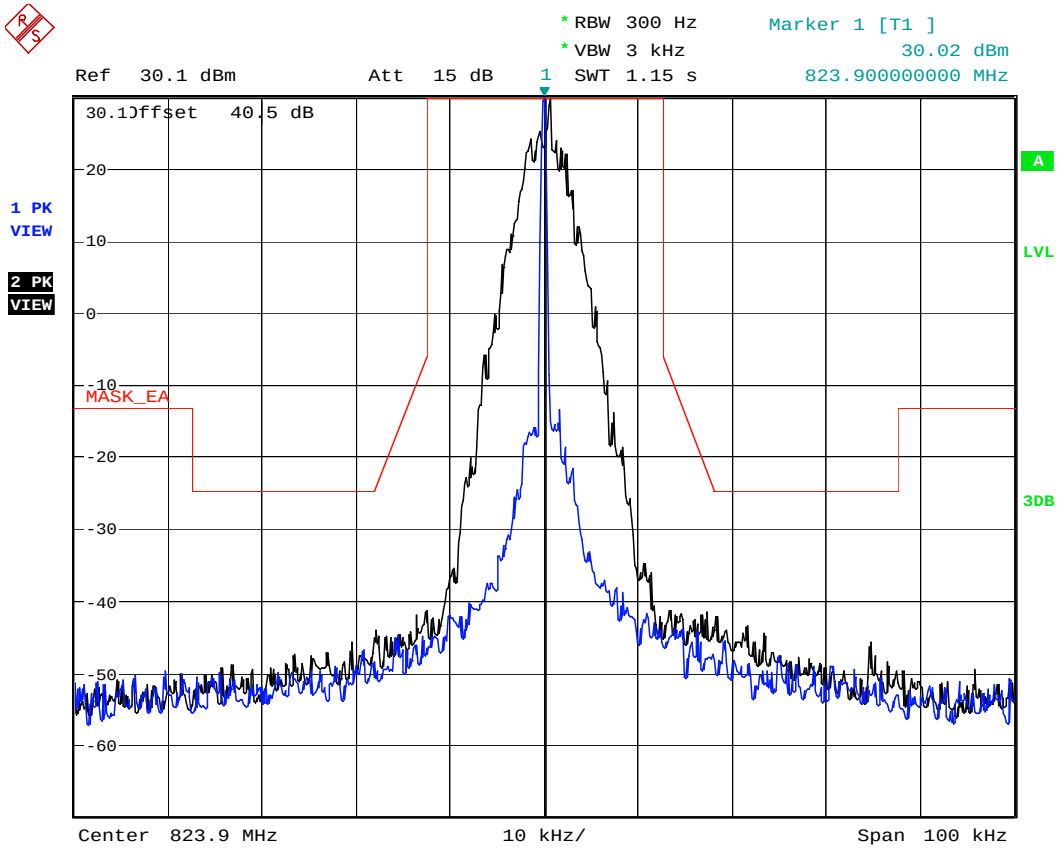
Low Power Digital

5.7.2.21. Configuration: Mask 90.691, 815.1MHz, Digital, Low power



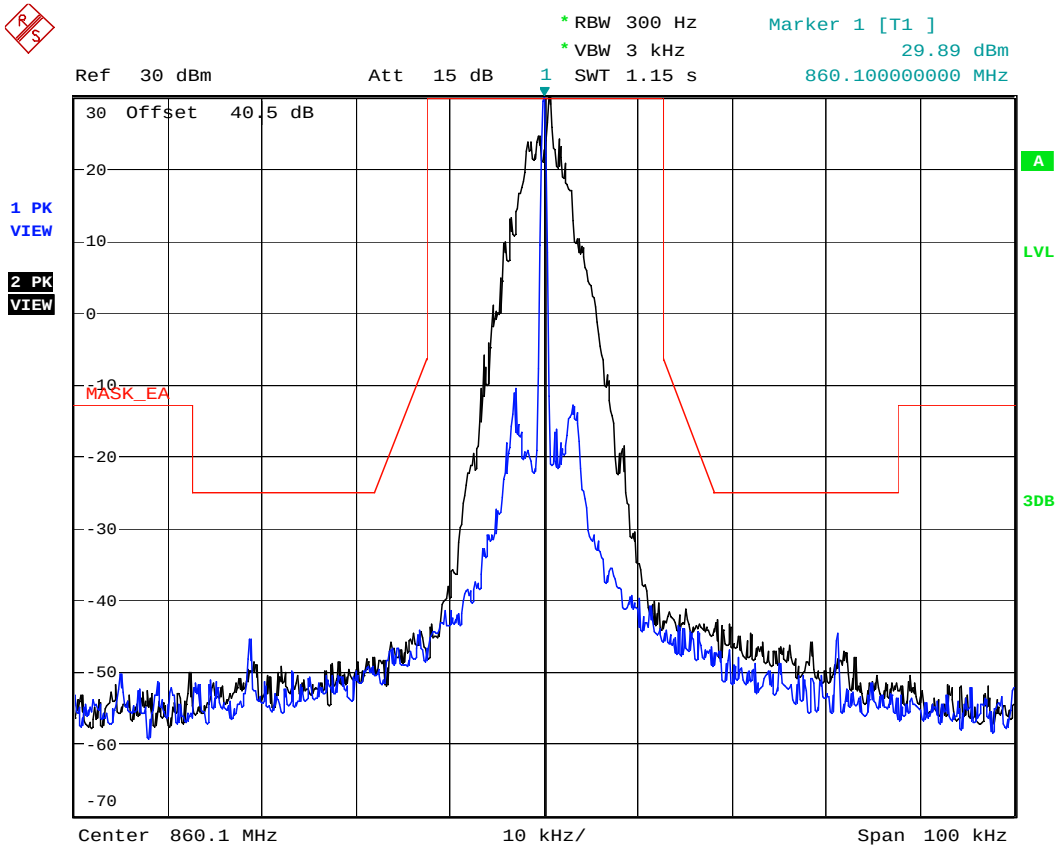
Date: 23.OCT.2018 14:27:32

5.7.2.22. Configuration: Mask 90.691, 823.9MHz, Digital, Low power



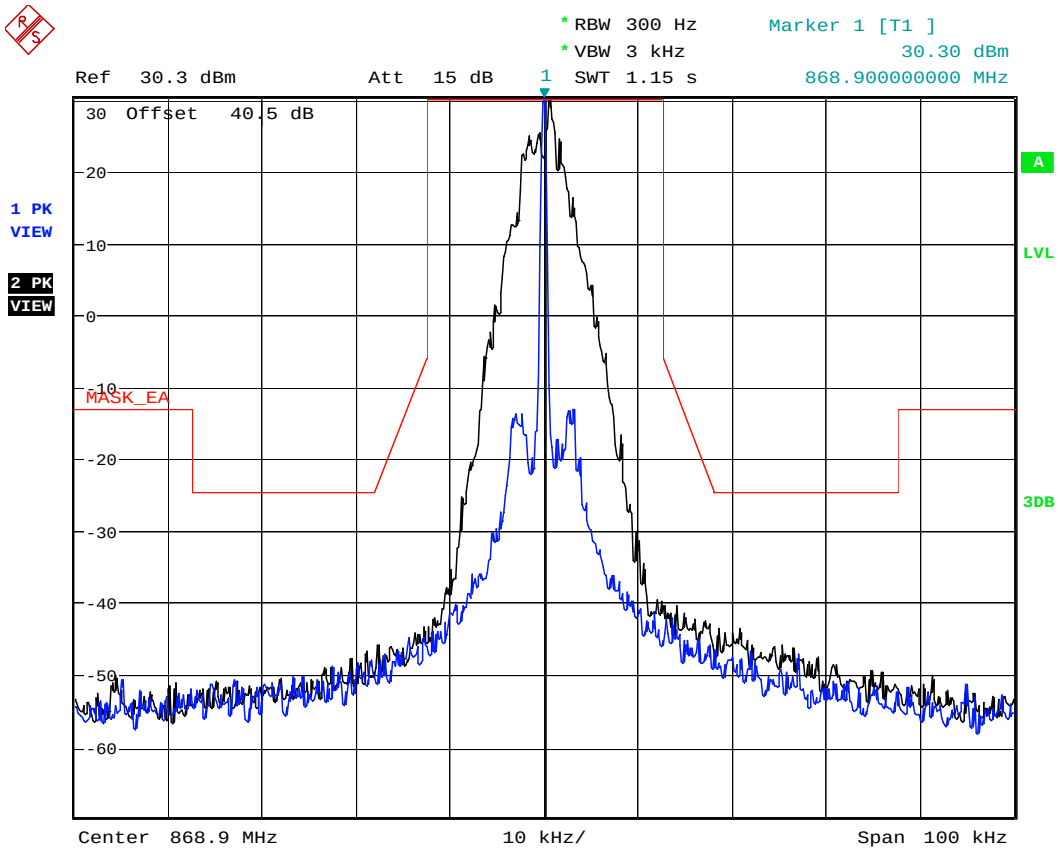
Date: 23.OCT.2018 14:32:47

5.7.2.23. Configuration: Mask 90.691, 860.1MHz, Digital, Low power



Date: 23.OCT.2018 14:43:02

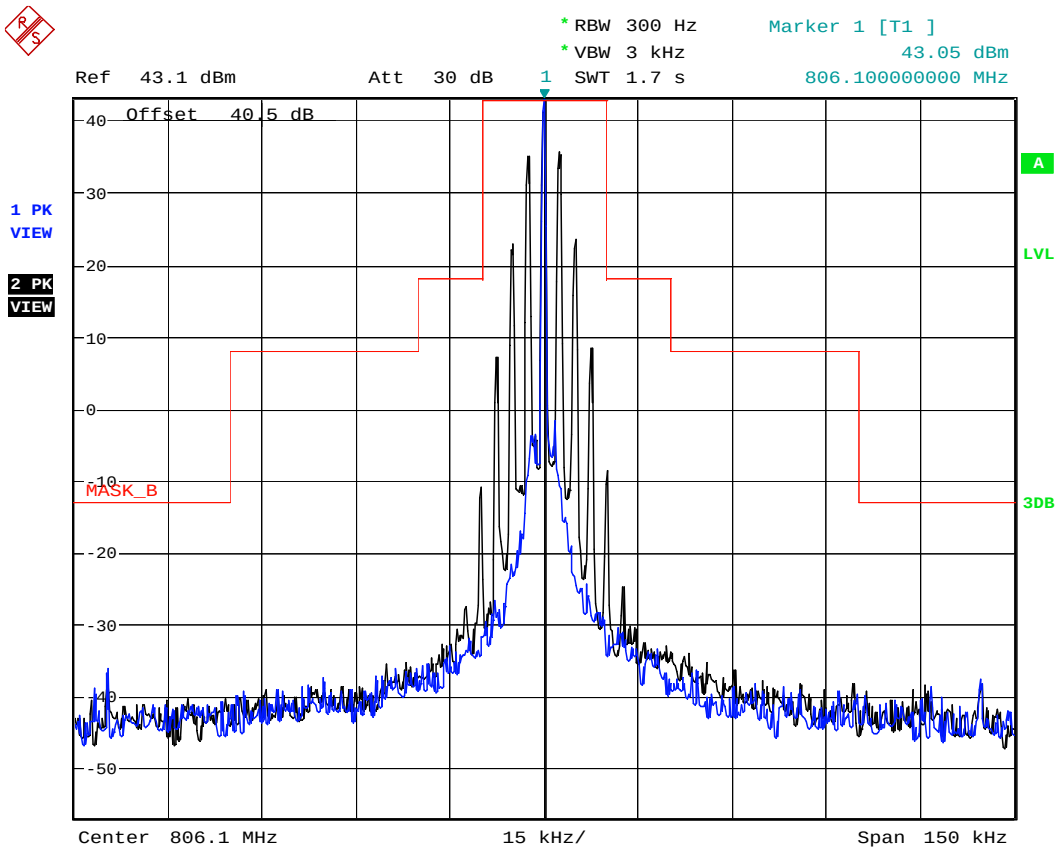
5.7.2.24. Configuration: Mask 90.691, 868.9MHz, Digital, Low power



Date: 23.OCT.2018 14:50:47

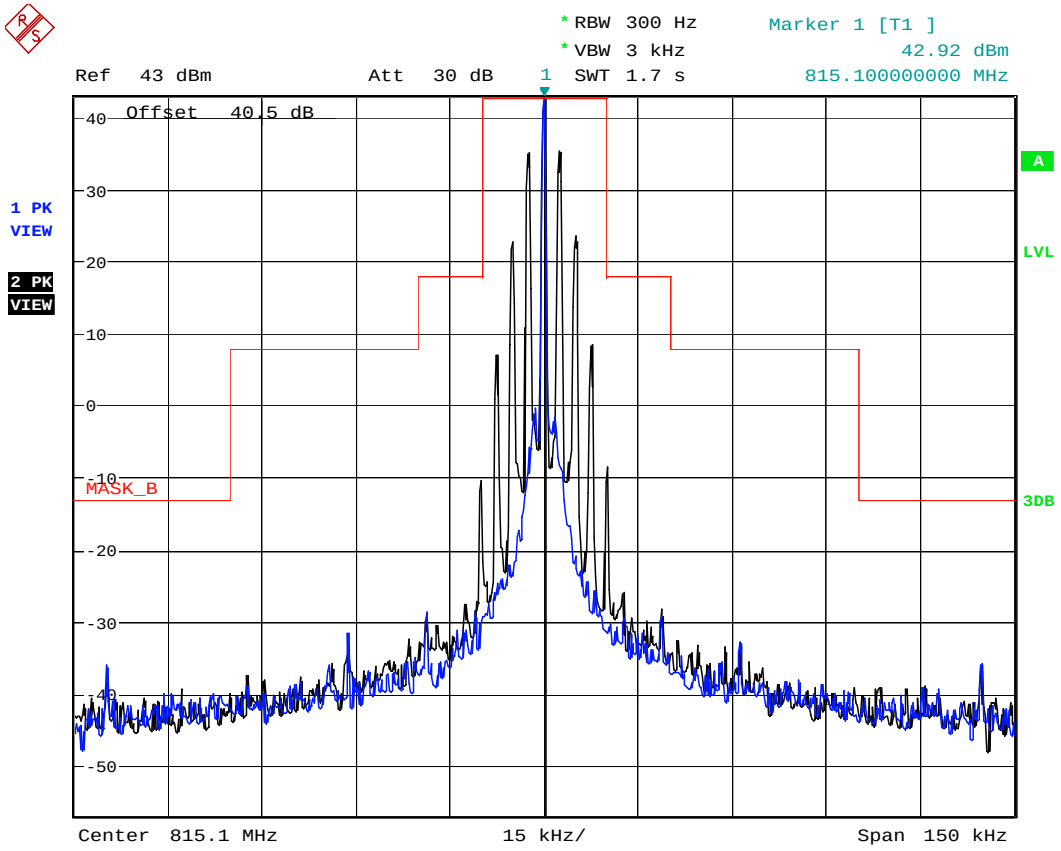
Rule Part: FCC 90 (90.210) & IC
High Power

5.7.2.25. Configuration: Mask B, 806.1MHz, 12.5 KHz, Analog, High power



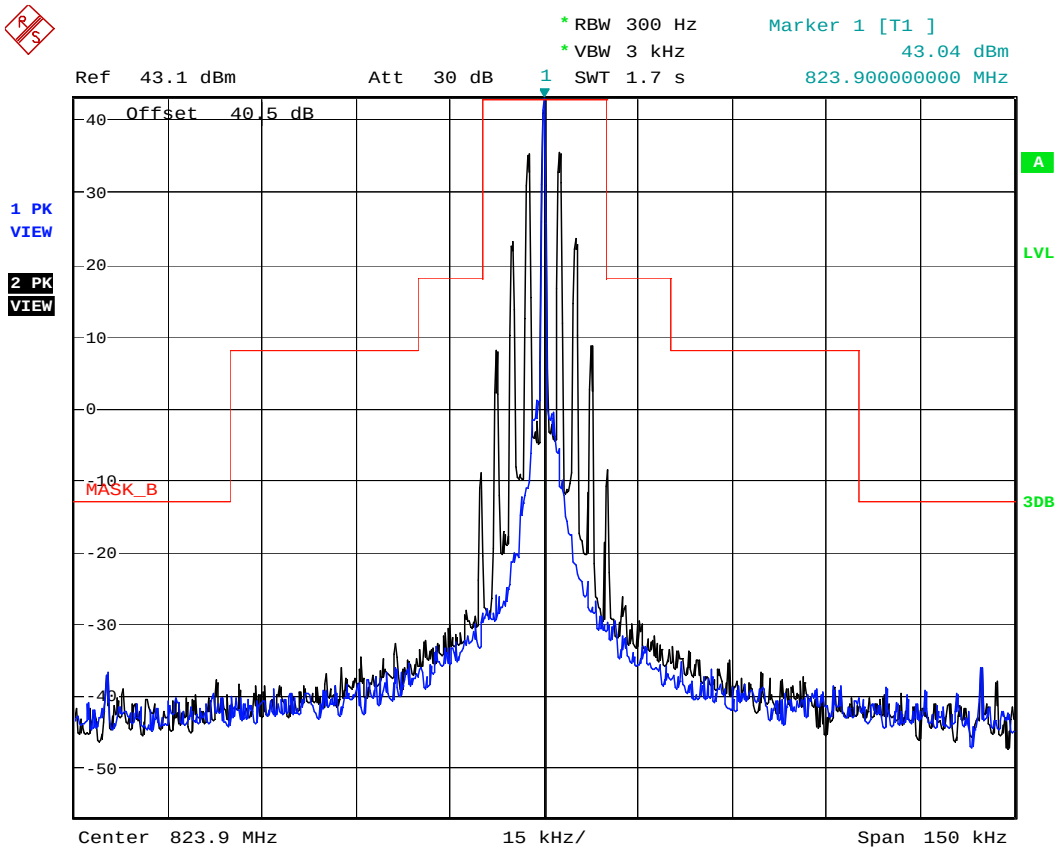
Date: 23.OCT.2018 10:04:13

5.7.2.26. Configuration: Mask B, 815.1MHz, 12.5 KHz, Analog, High power



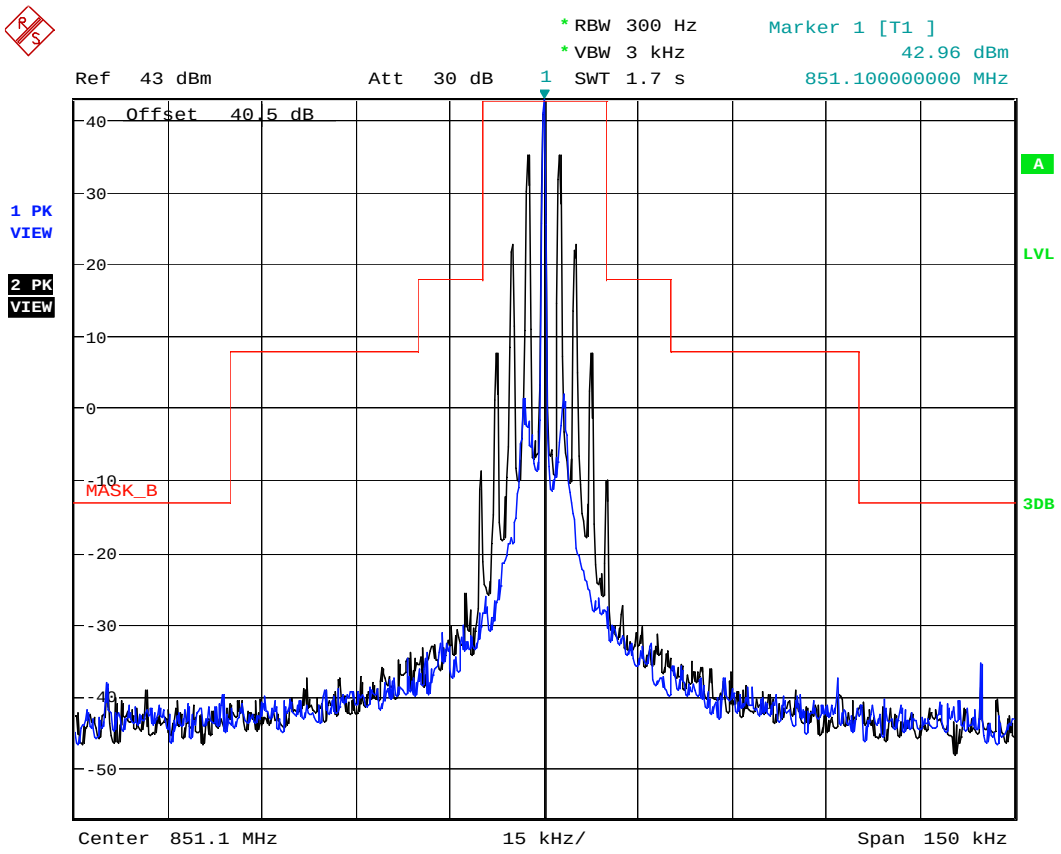
Date: 23.OCT.2018 11:05:44

5.7.2.27. Configuration: Mask B, 823.9MHz, 12.5 KHz, Analog, High power



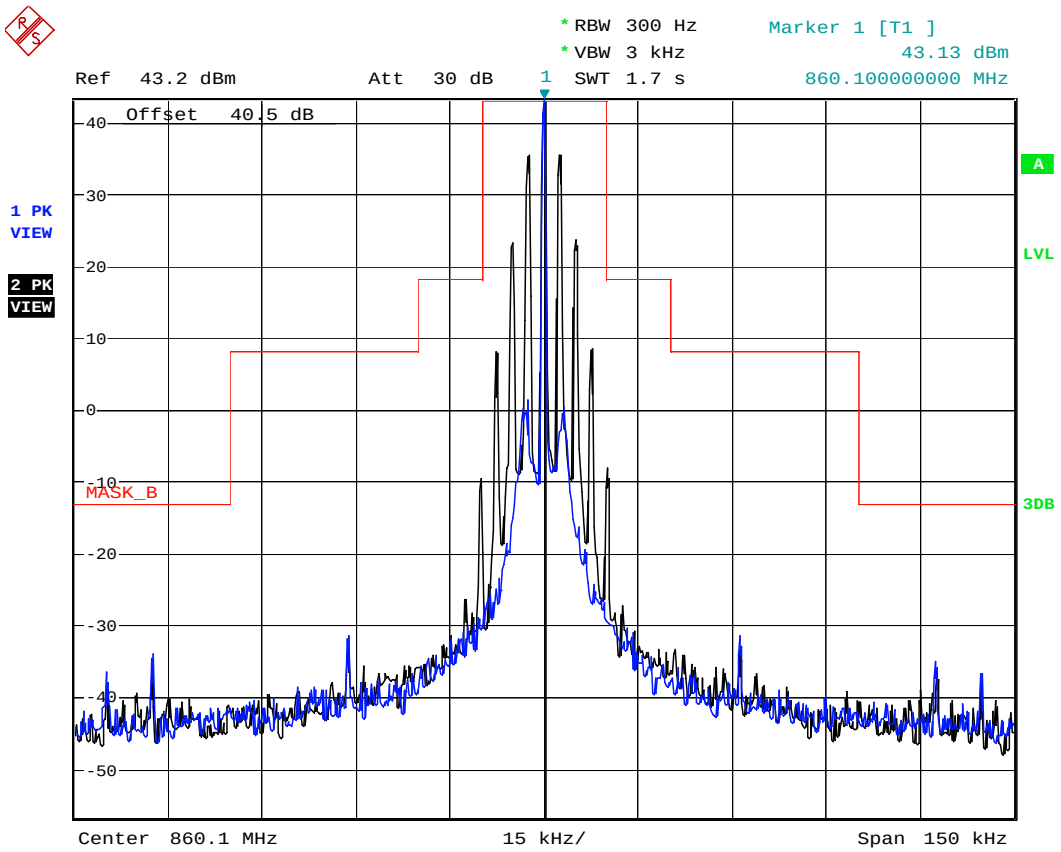
Date: 23.OCT.2018 11:10:35

5.7.2.28. Configuration: Mask B, 851.1MHz, 12.5 KHz, Analog, High power



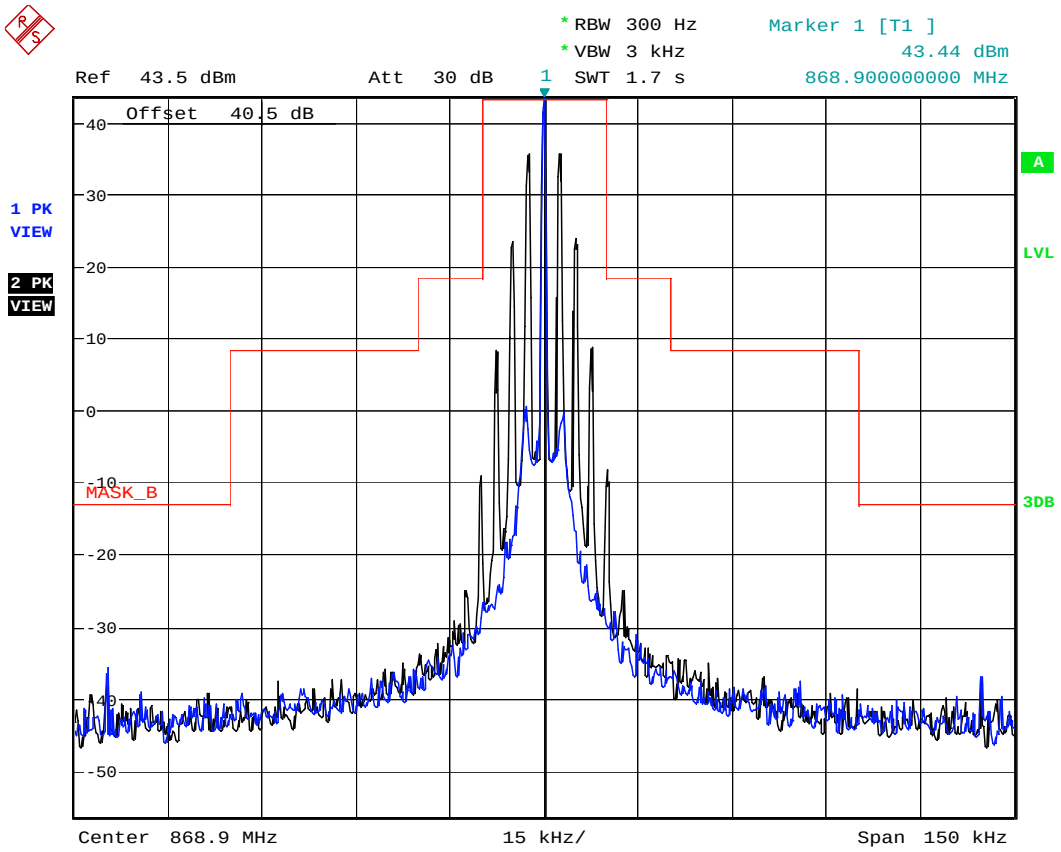
Date: 23.OCT.2018 11:32:02

5.7.2.29. Configuration: Mask B, 860.1MHz, 12.5 KHz, Analog, High power



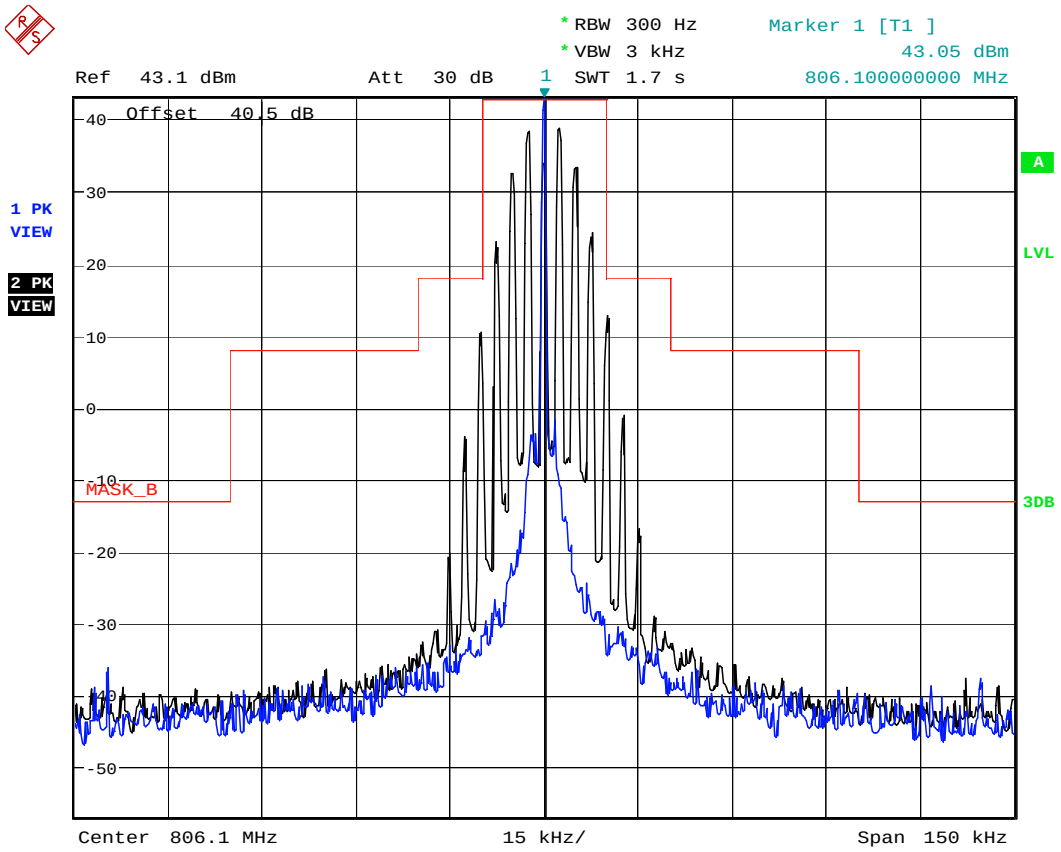
Date: 23.OCT.2018 11:44:41

5.7.2.30. Configuration: Mask B, 868.9MHz, 12.5 KHz, Analog, High power



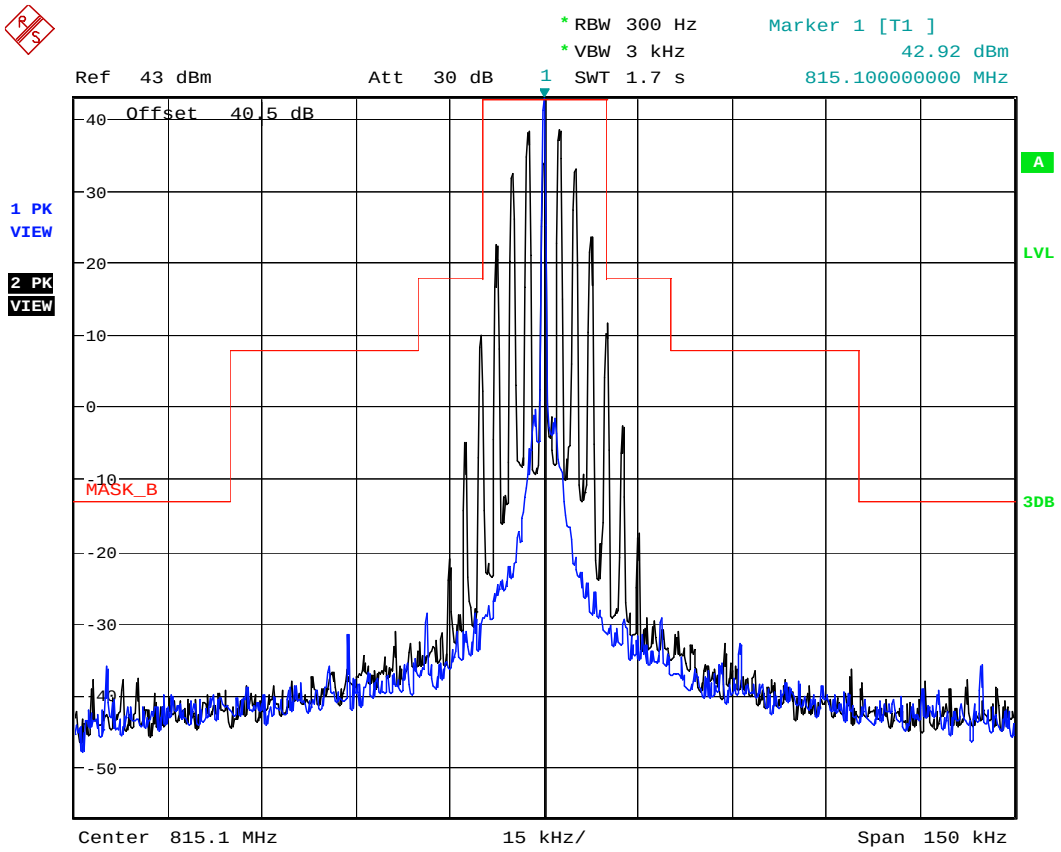
Date: 23.OCT.2018 11:49:23

5.7.2.31. Configuration: Mask B, 806.1MHz, 25 KHz, Analog, High power



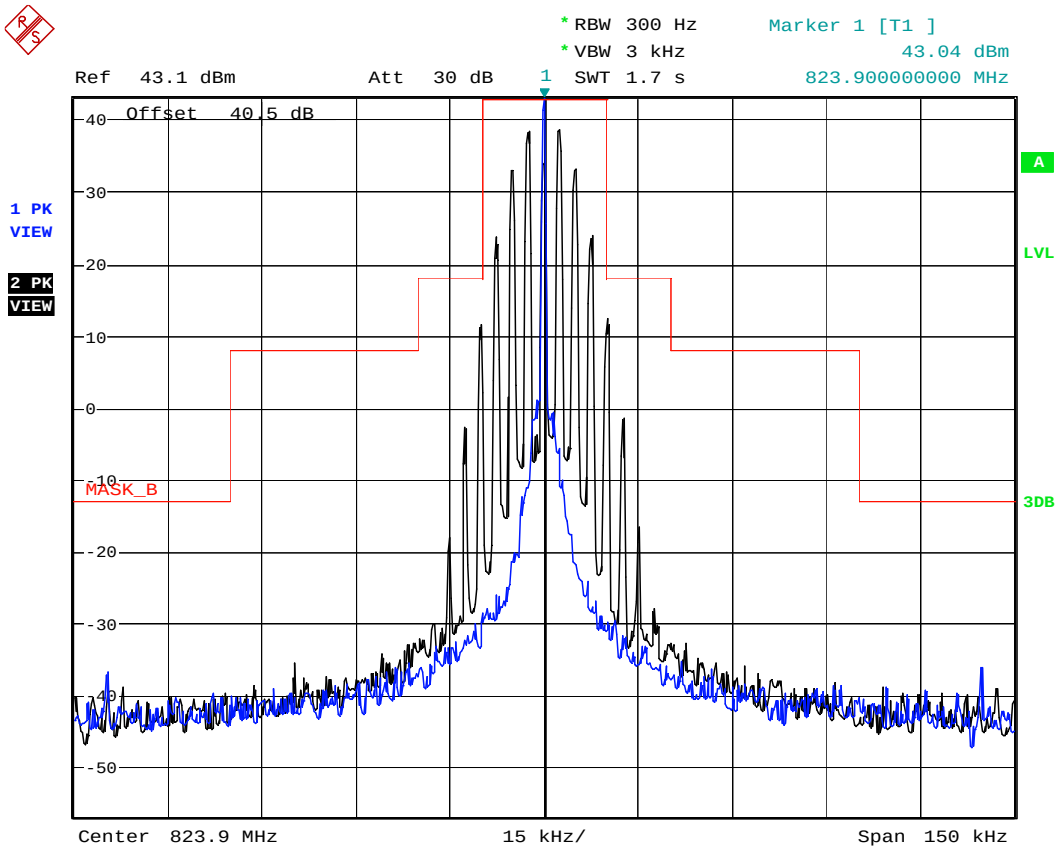
Date: 23.OCT.2018 10:18:44

5.7.2.32. Configuration: Mask B, 815.1MHz, 25 KHz, Analog, High power



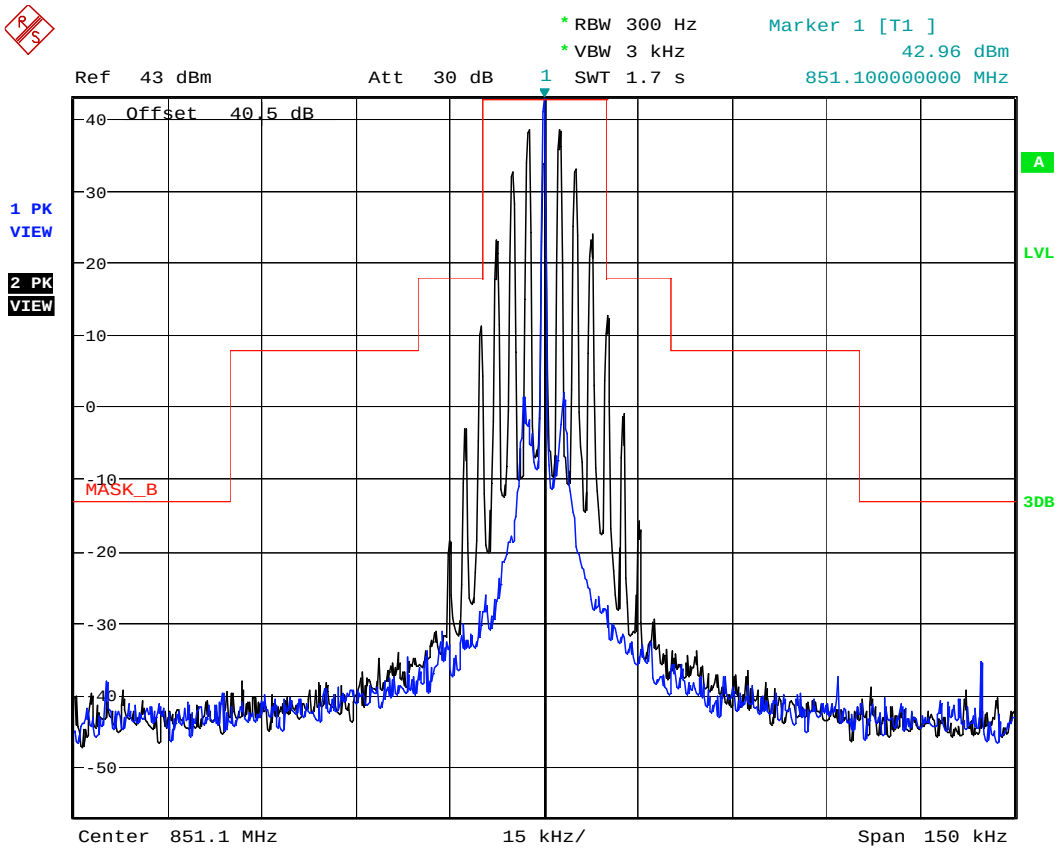
Date: 23.OCT.2018 11:07:30

5.7.2.33. Configuration: Mask B, 823.9MHz, 25 KHz, Analog, High power



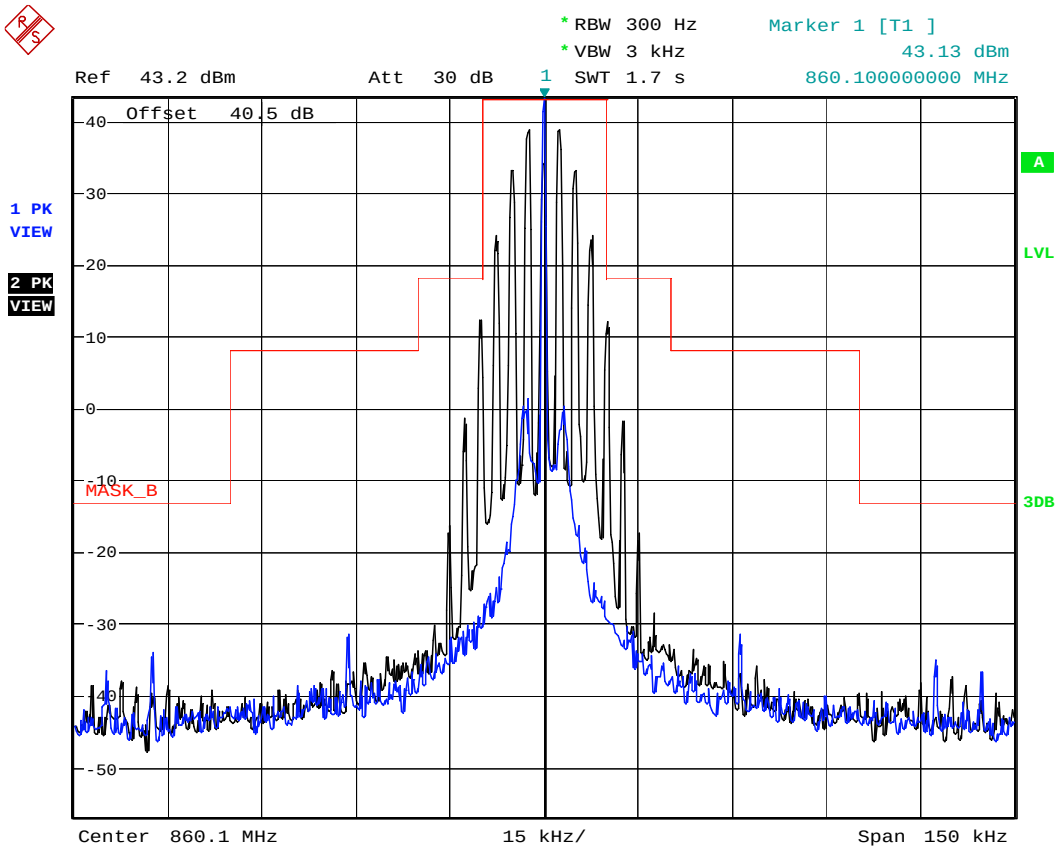
Date: 23.OCT.2018 11:12:15

5.7.2.34. Configuration: Mask B, 851.1MHz, 25 KHz, Analog, High power



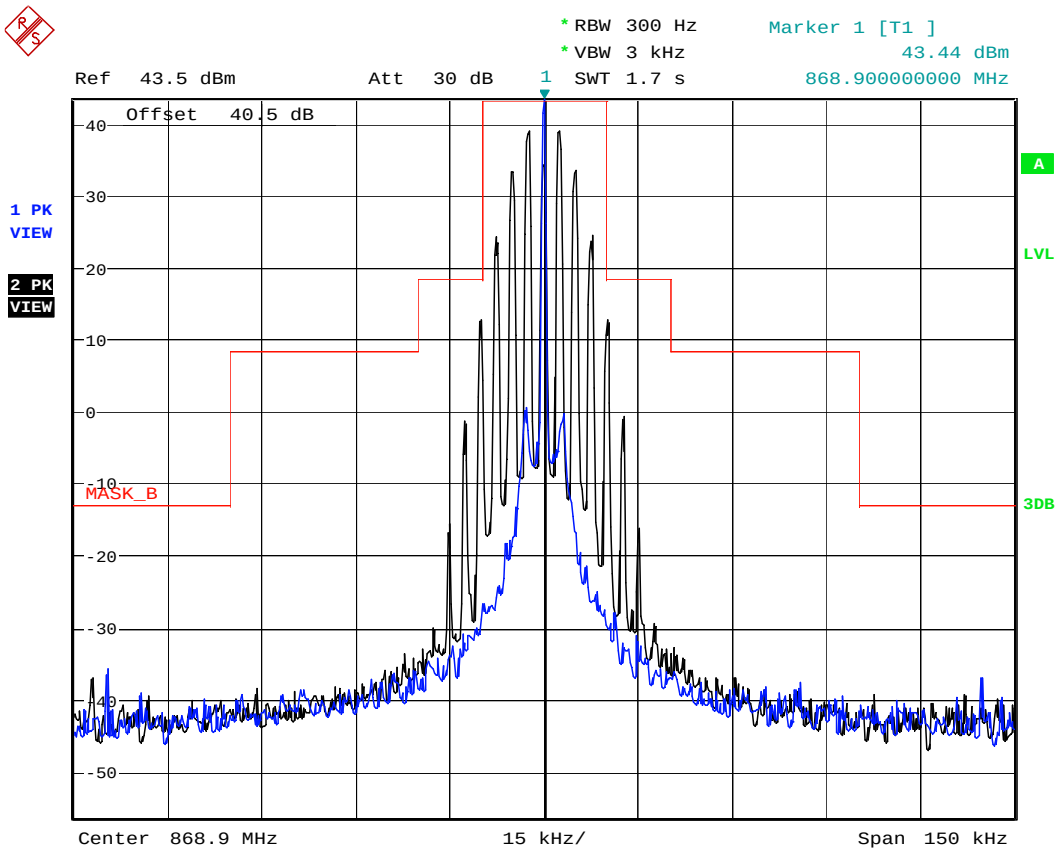
Date: 23.OCT.2018 11:33:33

5.7.2.35. Configuration: Mask B, 860.1MHz, 25 KHz, Analog, High power



Date: 23.OCT.2018 11:46:09

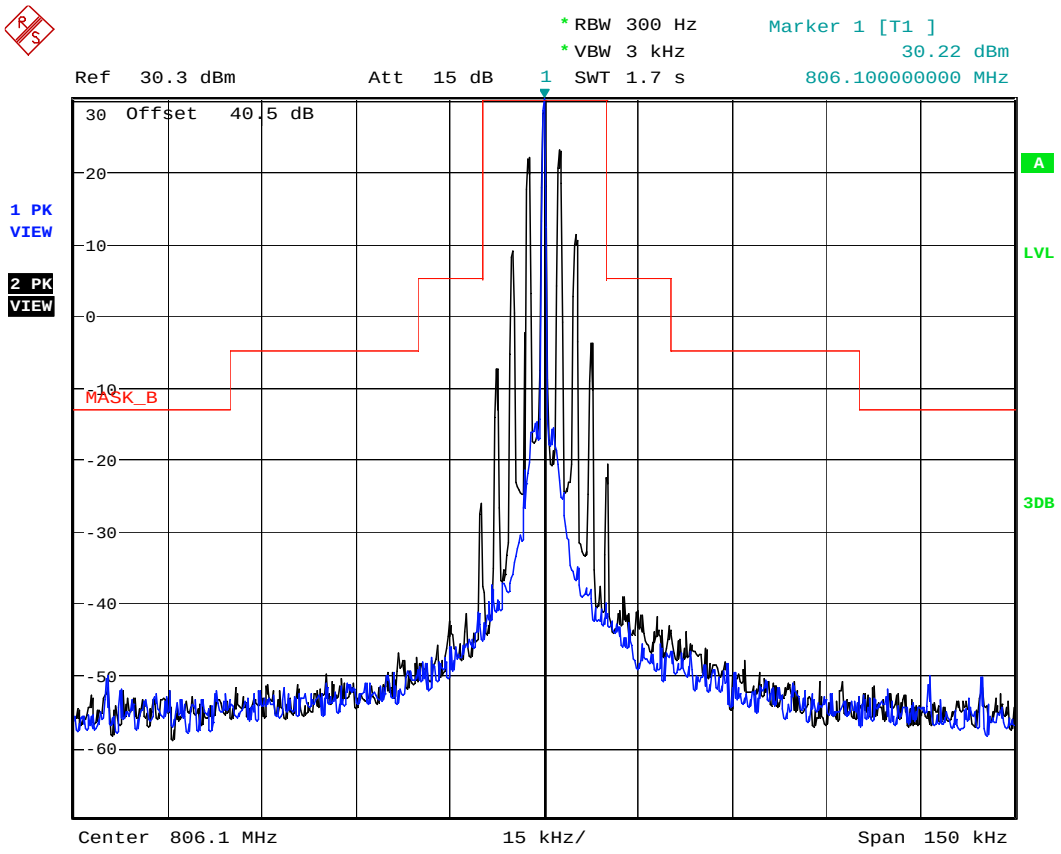
5.7.2.36. Configuration: Mask B, 868.9MHz, 25 KHz, Analog, High power



Date: 23.OCT.2018 11:51:04

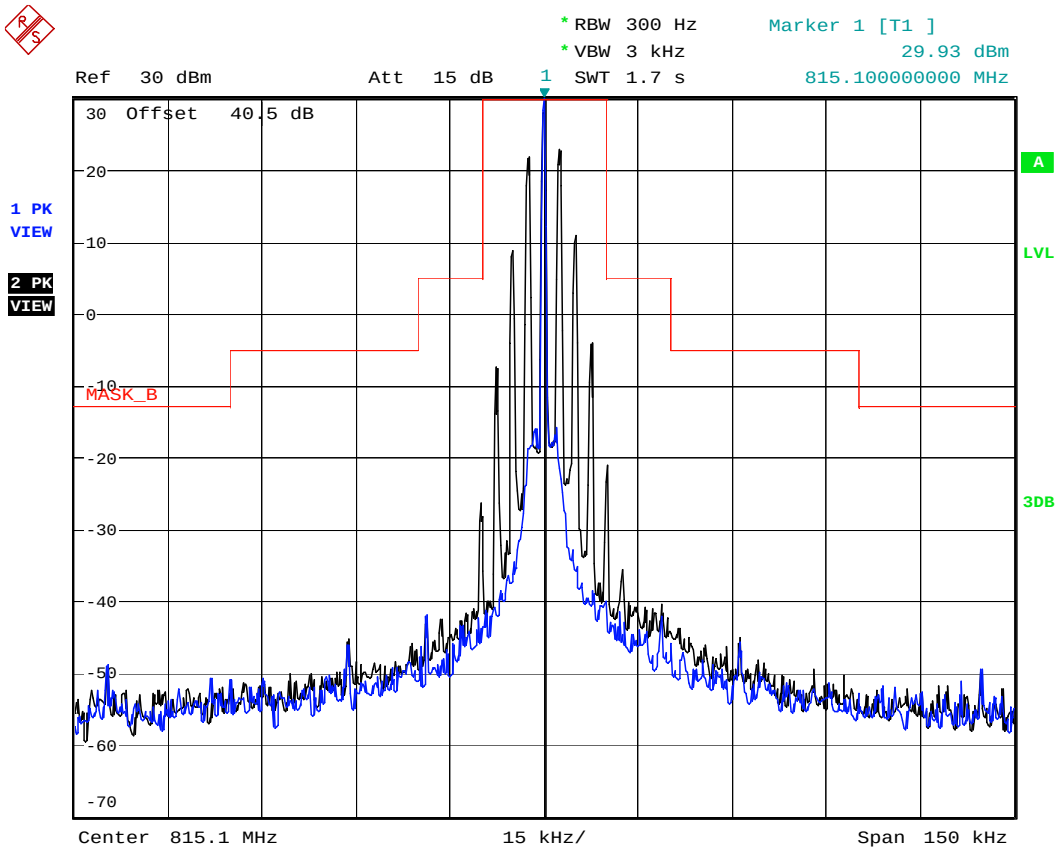
Low Power

5.7.2.37. Configuration: Mask B, 806.1MHz, 12.5 KHz, Analog, Low power



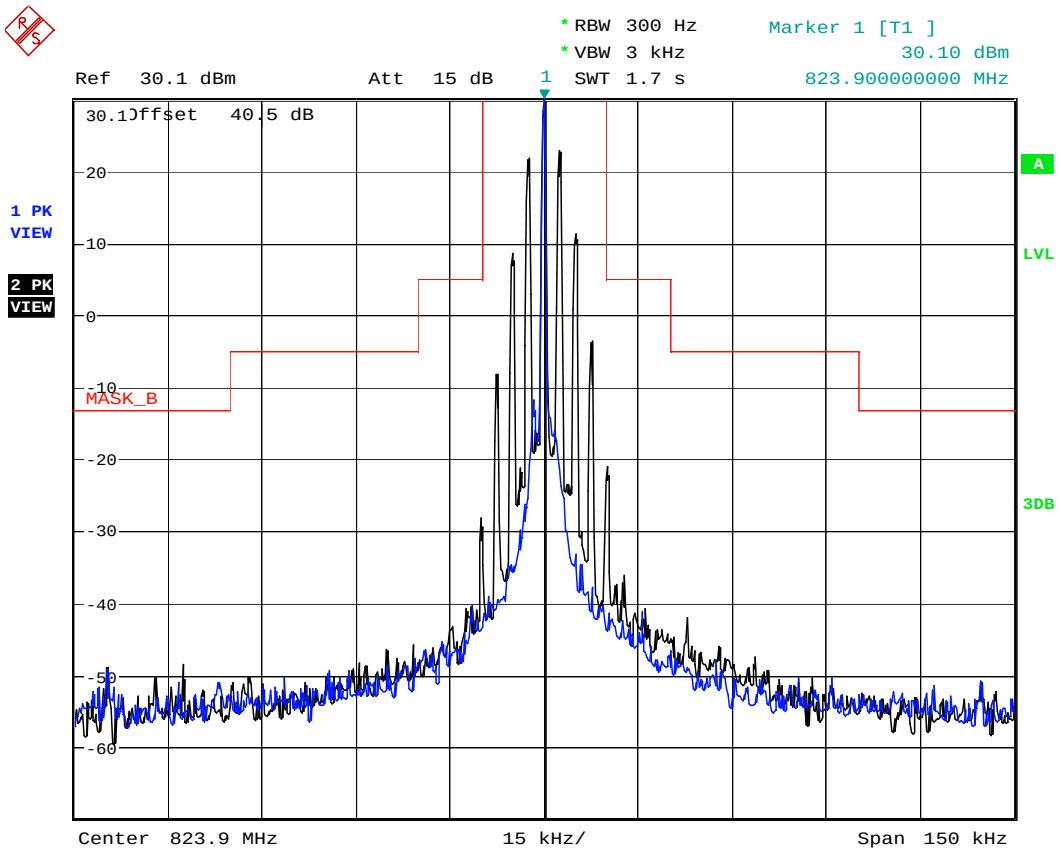
Date: 23.OCT.2018 12:04:18

5.7.2.38. Configuration: Mask B, 815.1MHz, 12.5 KHz, Analog, Low power



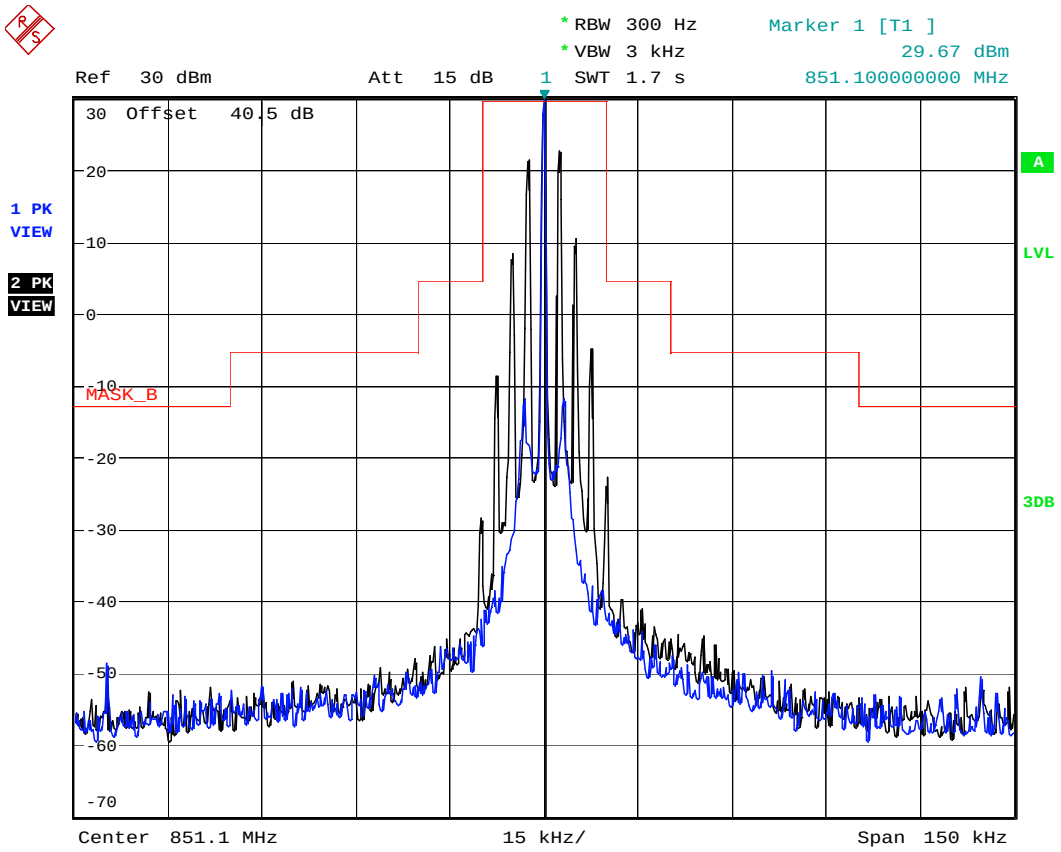
Date: 23.OCT.2018 12:12:46

5.7.2.39. Configuration: Mask B, 823.9MHz, 12.5 KHz, Analog, Low power



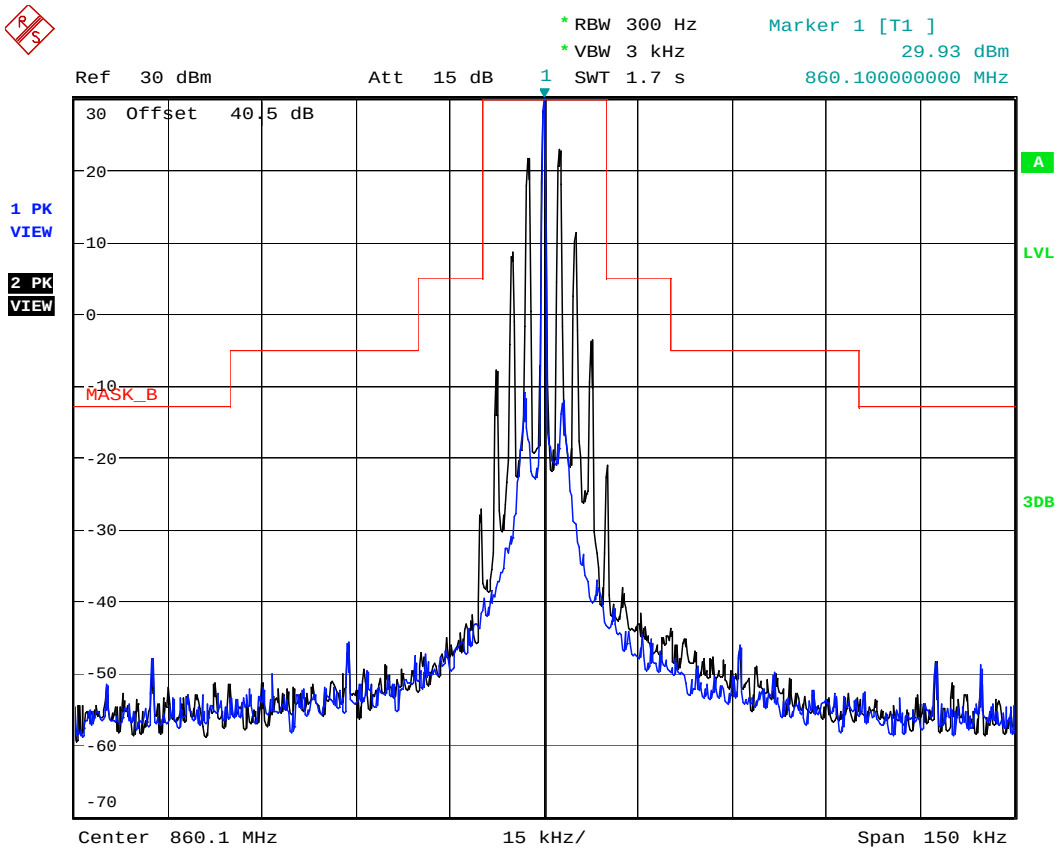
Date: 23.OCT.2018 12:19:01

5.7.2.40. Configuration: Mask B, 851.1MHz, 12.5 KHz, Analog, Low power



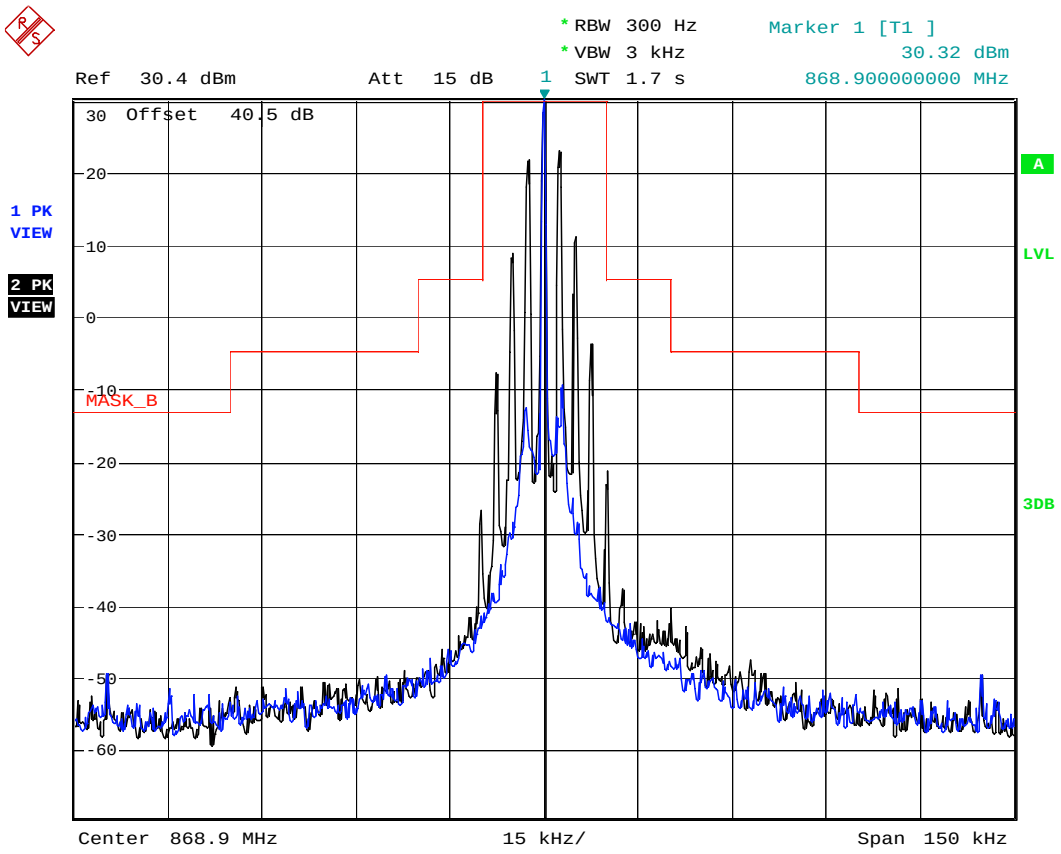
Date: 23.OCT.2018 12:23:19

5.7.2.41. Configuration: Mask B, 860.1MHz, 12.5 KHz, Analog, Low power



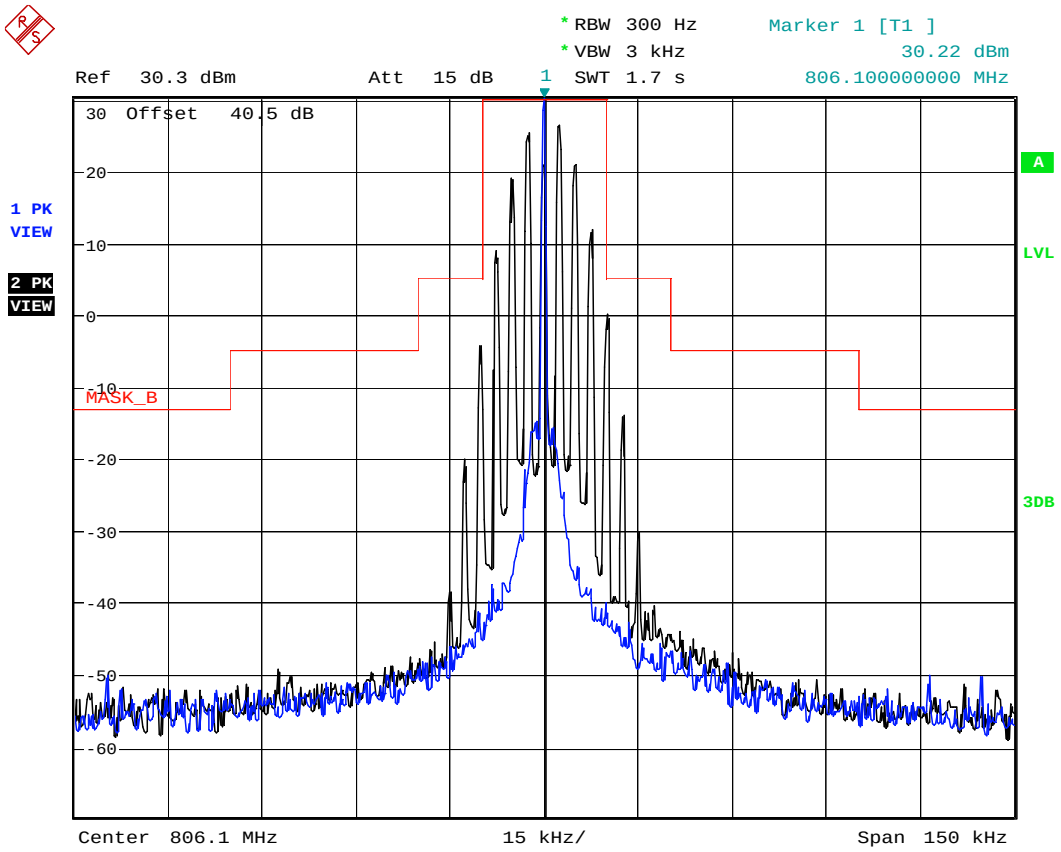
Date: 23.OCT.2018 12:28:13

5.7.2.42. Configuration: Mask B, 868.9MHz, 12.5 KHz, Analog, Low power



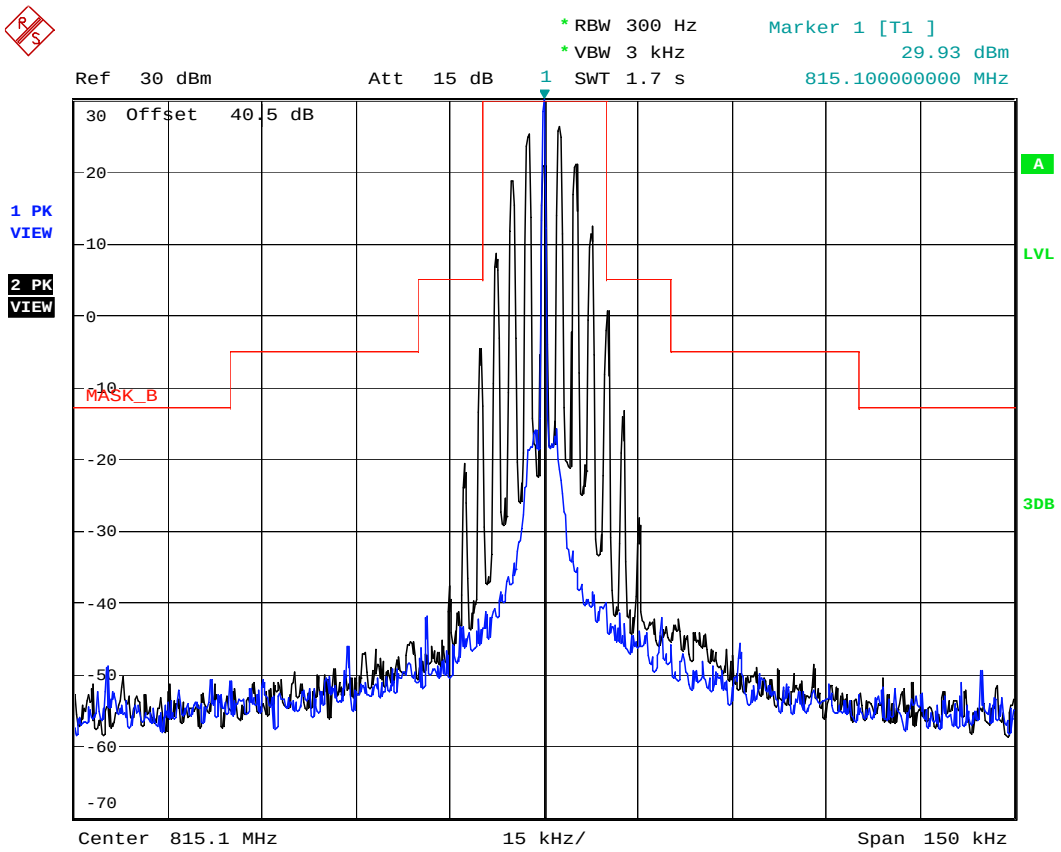
Date: 23.OCT.2018 12:32:54

5.7.2.43. Configuration: Mask B, 806.1MHz, 25 KHz, Analog, Low power



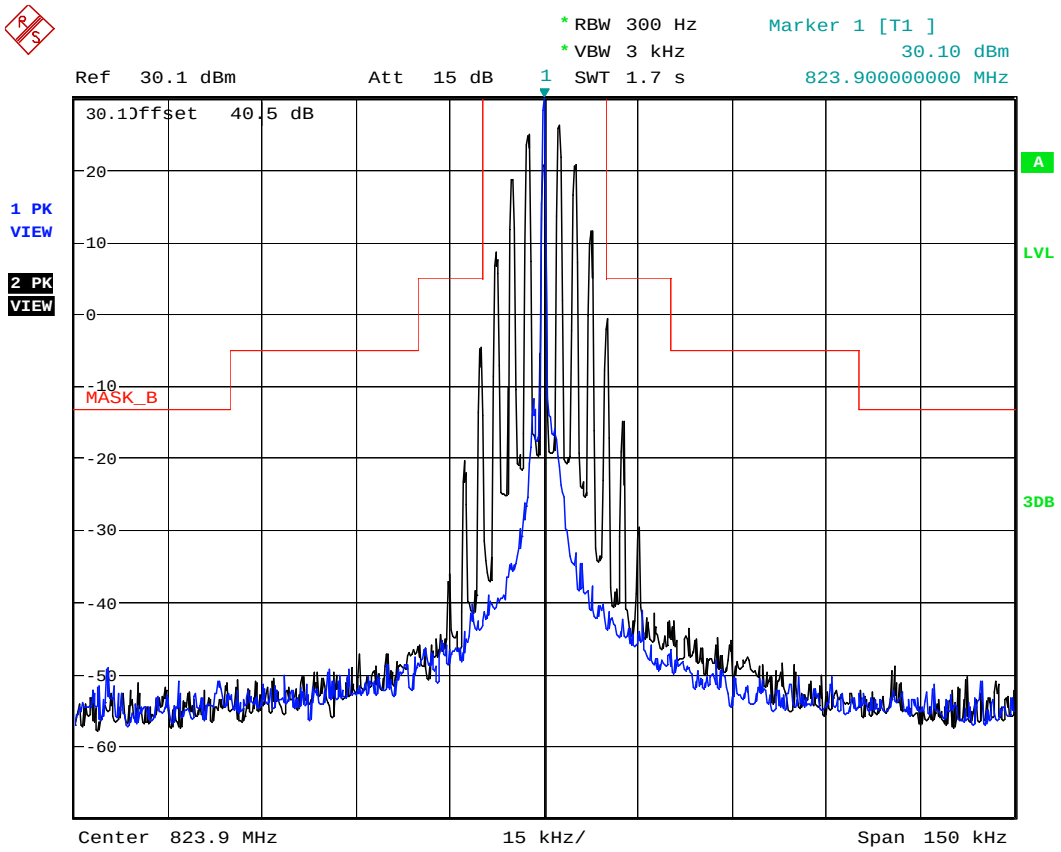
Date: 23.OCT.2018 12:05:52

5.7.2.44. Configuration: Mask B, 815.1MHz, 25 KHz, Analog, Low power



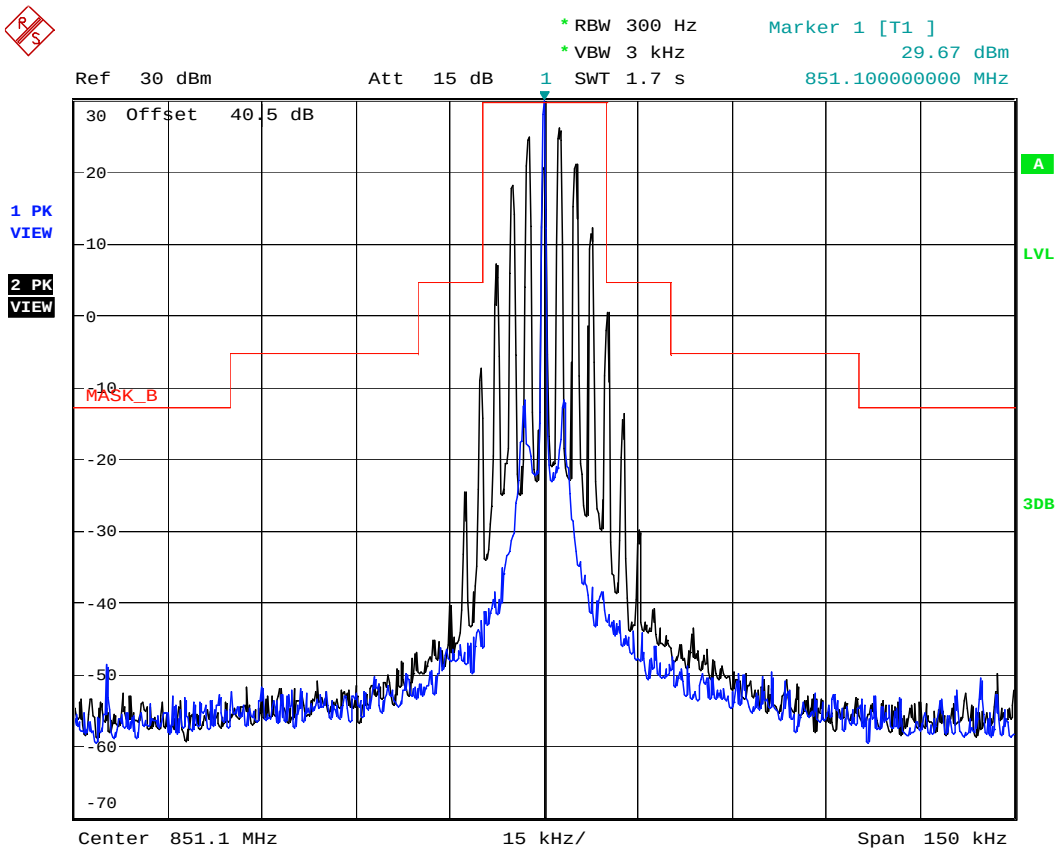
Date: 23.OCT.2018 12:14:50

5.7.2.45. Configuration: Mask B, 823.9MHz, 25 KHz, Analog, Low power



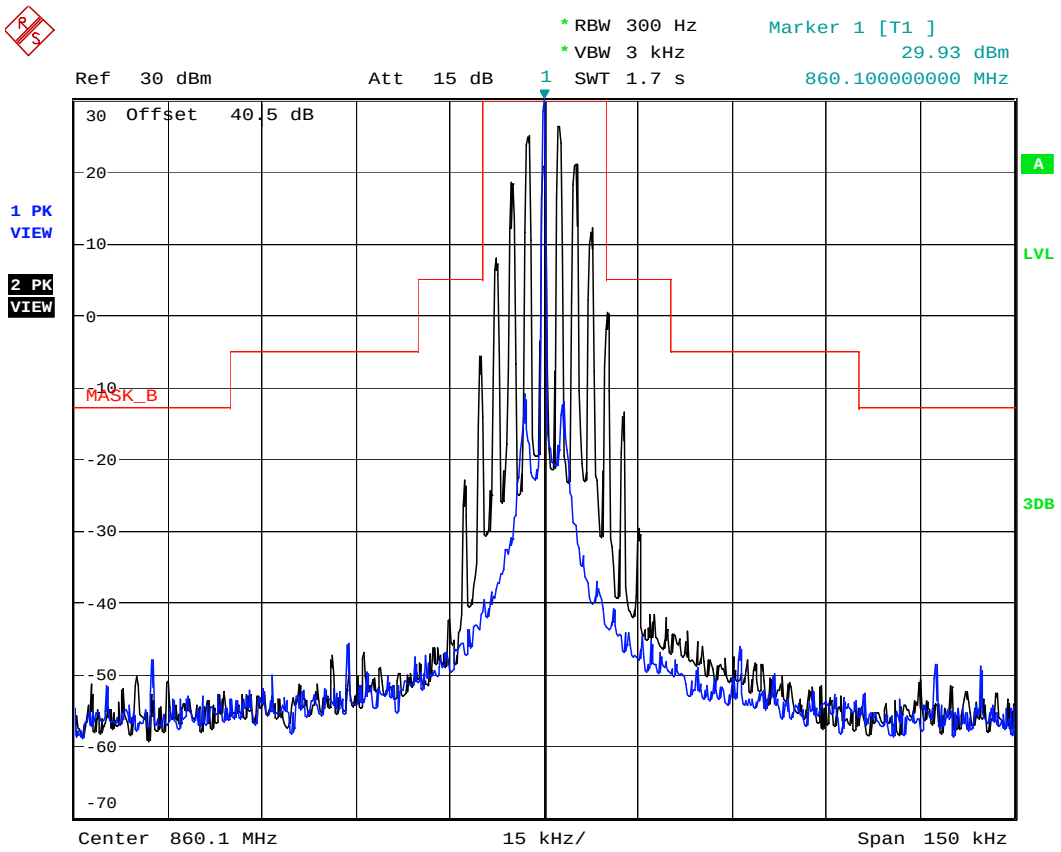
Date: 23.OCT.2018 12:20:23

5.7.2.46. Configuration: Mask B, 851.1MHz, 25 KHz, Analog, Low power



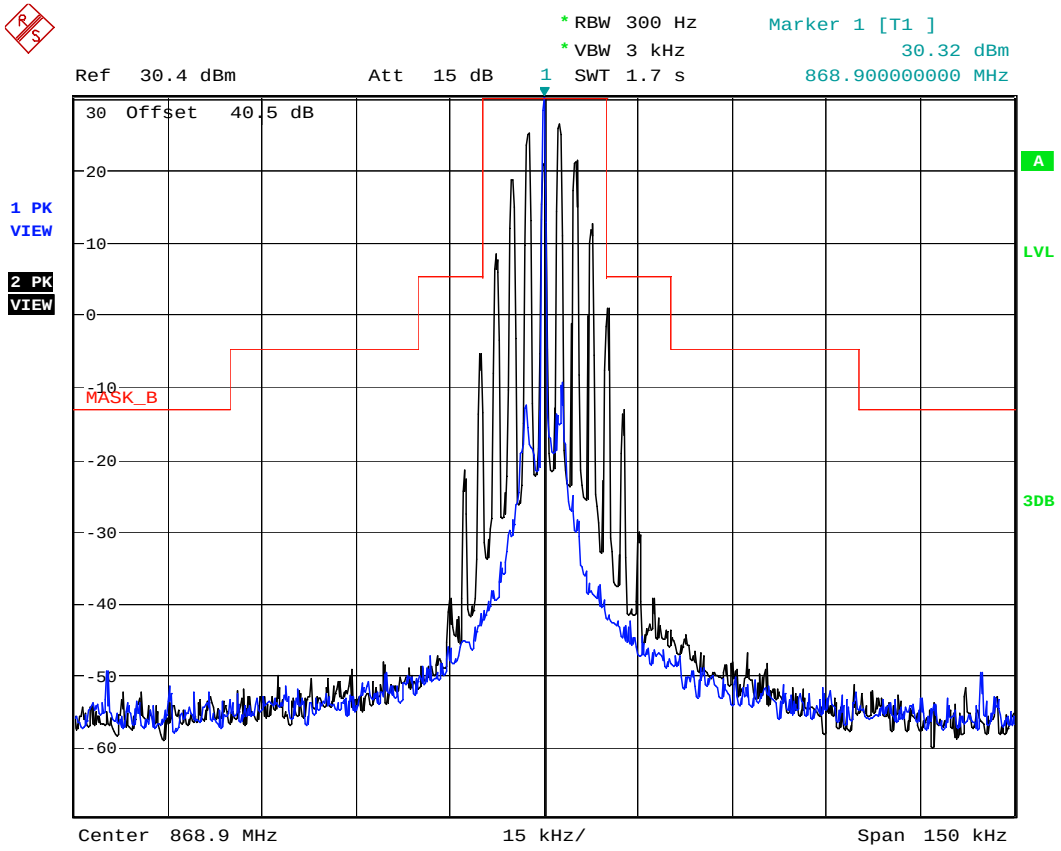
Date: 23.OCT.2018 12:24:43

5.7.2.47. Configuration: Mask B, 860.1MHz, 25 KHz, Analog, Low power



Date: 23.OCT.2018 12:29:16

5.7.2.48. Configuration: Mask B, 868.9MHz, 25 KHz, Analog, Low power

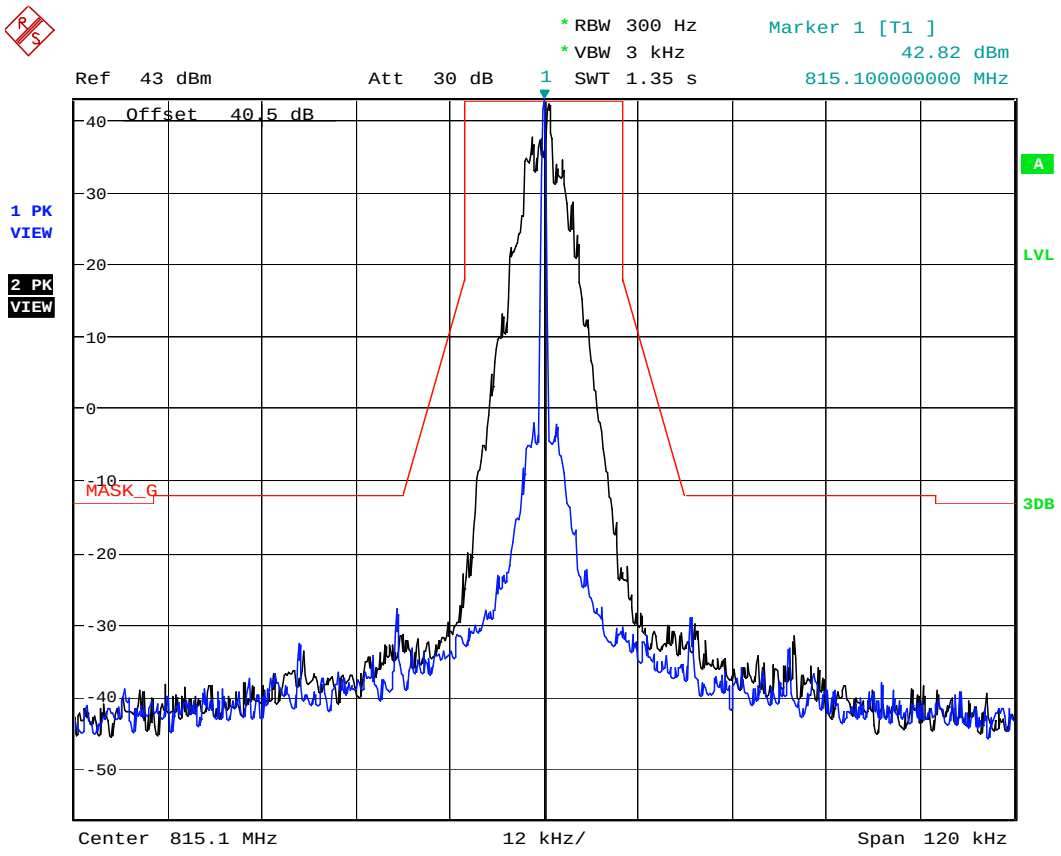


Date: 23.OCT.2018 12:34:00

Rule Part: FCC 90 (90.210)

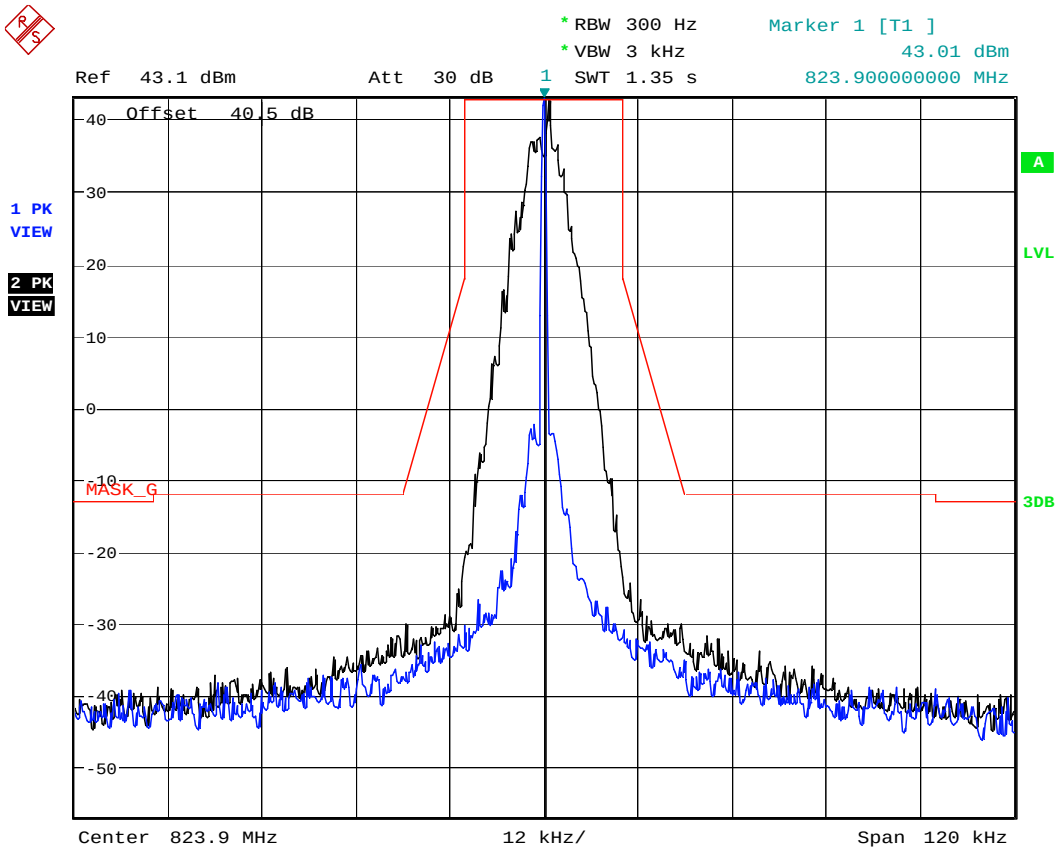
High Power

5.7.2.49. Configuration: Mask G, 815.1MHz, Digital, High power



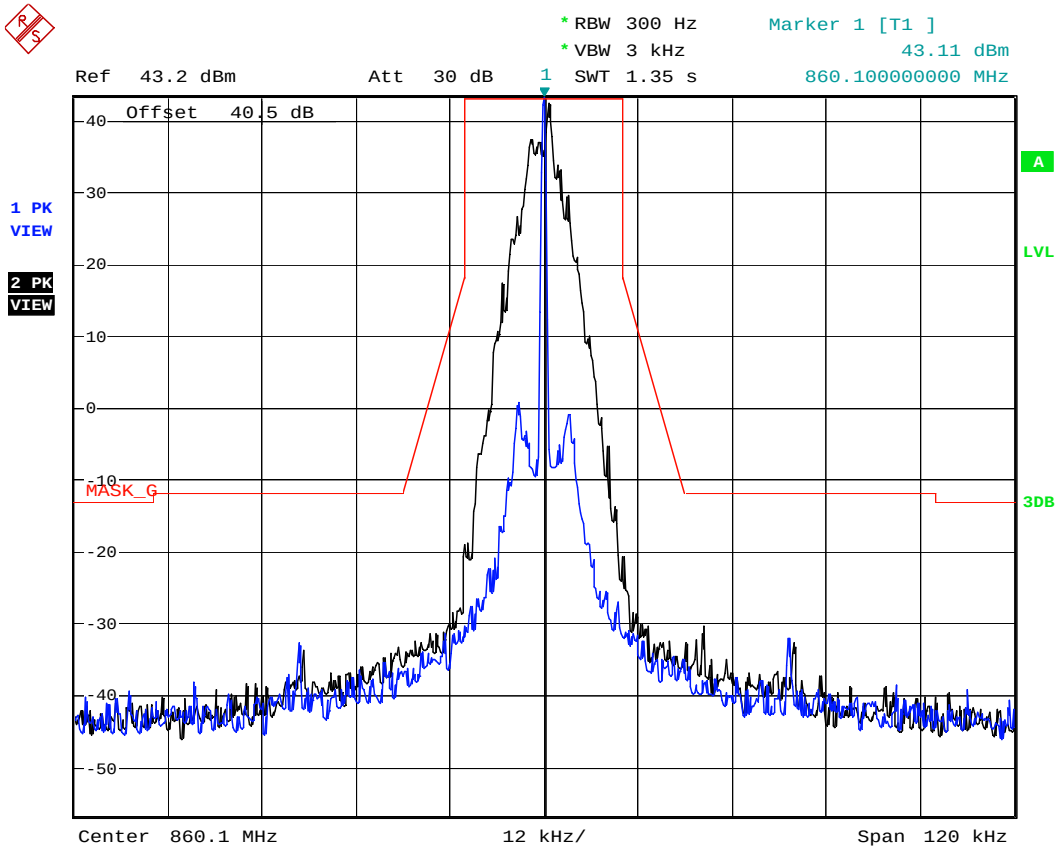
Date: 23.OCT.2018 12:52:23

5.7.2.50. Configuration: Mask G, 823.9MHz, Digital, High power



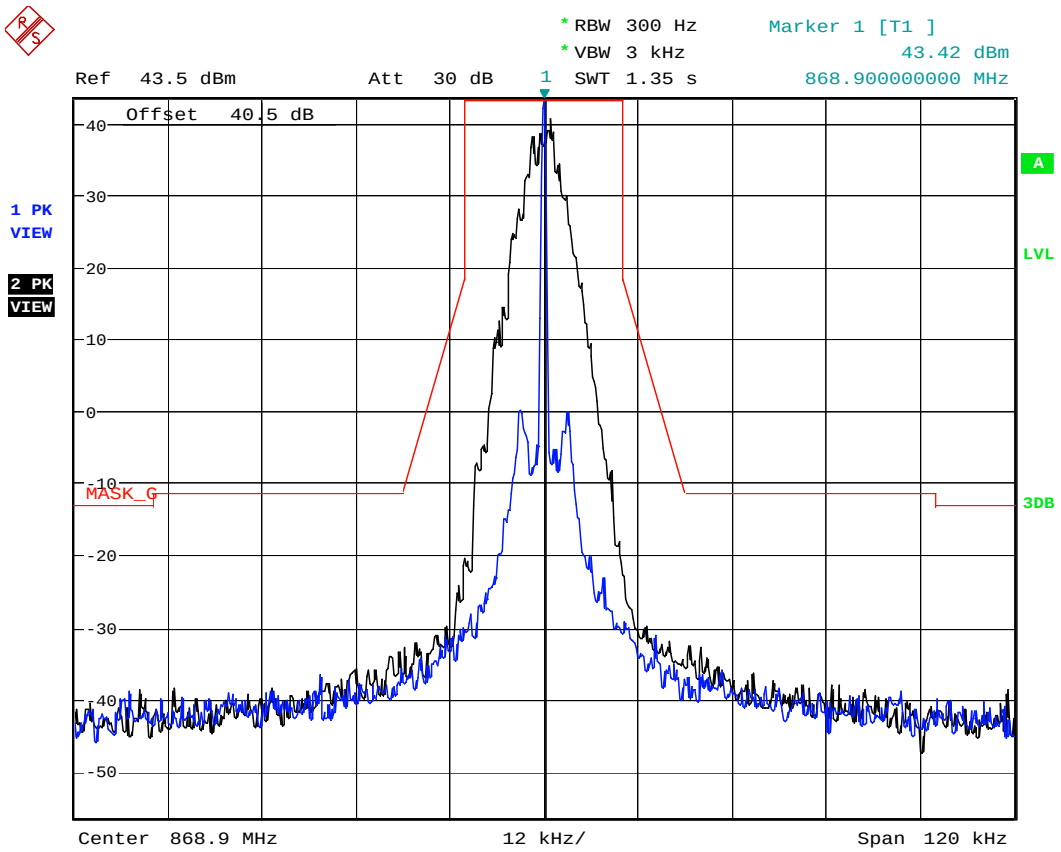
Date: 23.OCT.2018 12:55:54

5.7.2.51. Configuration: Mask G, 860.1MHz, Digital, High power



Date: 23.OCT.2018 12:59:07

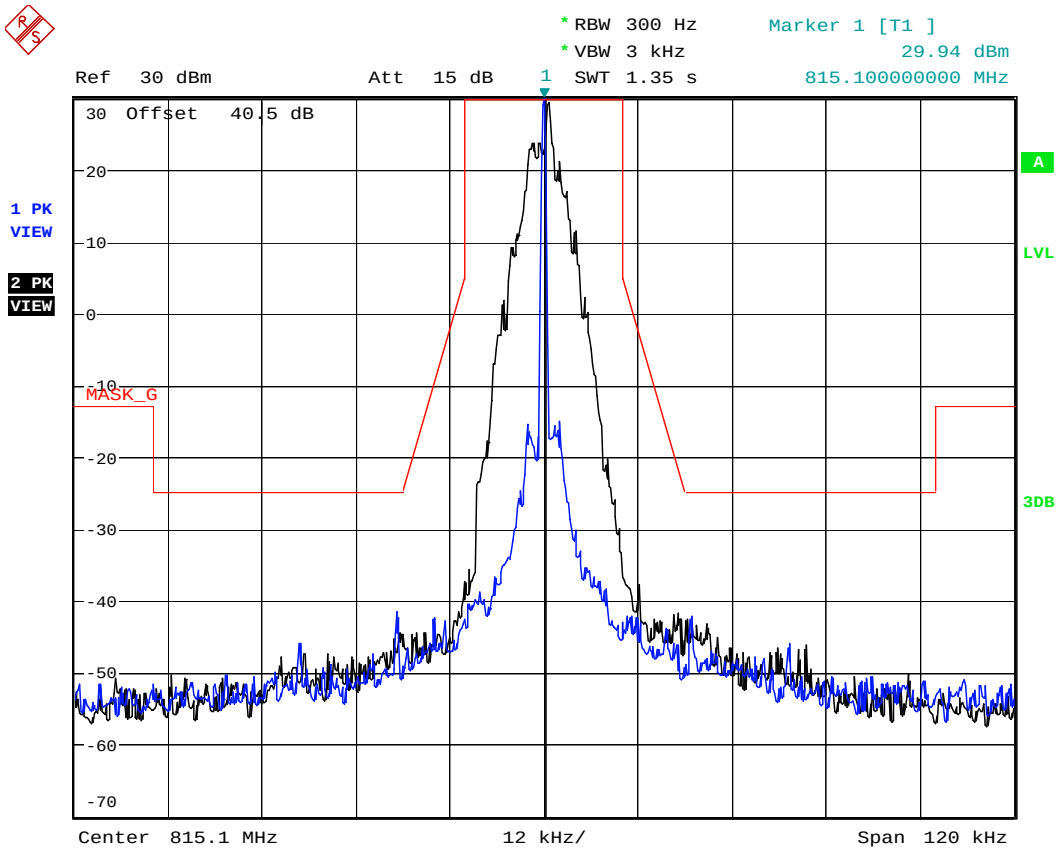
5.7.2.52. Configuration: Mask G, 868.9MHz, Digital, High power



Date: 23.OCT.2018 13:02:36

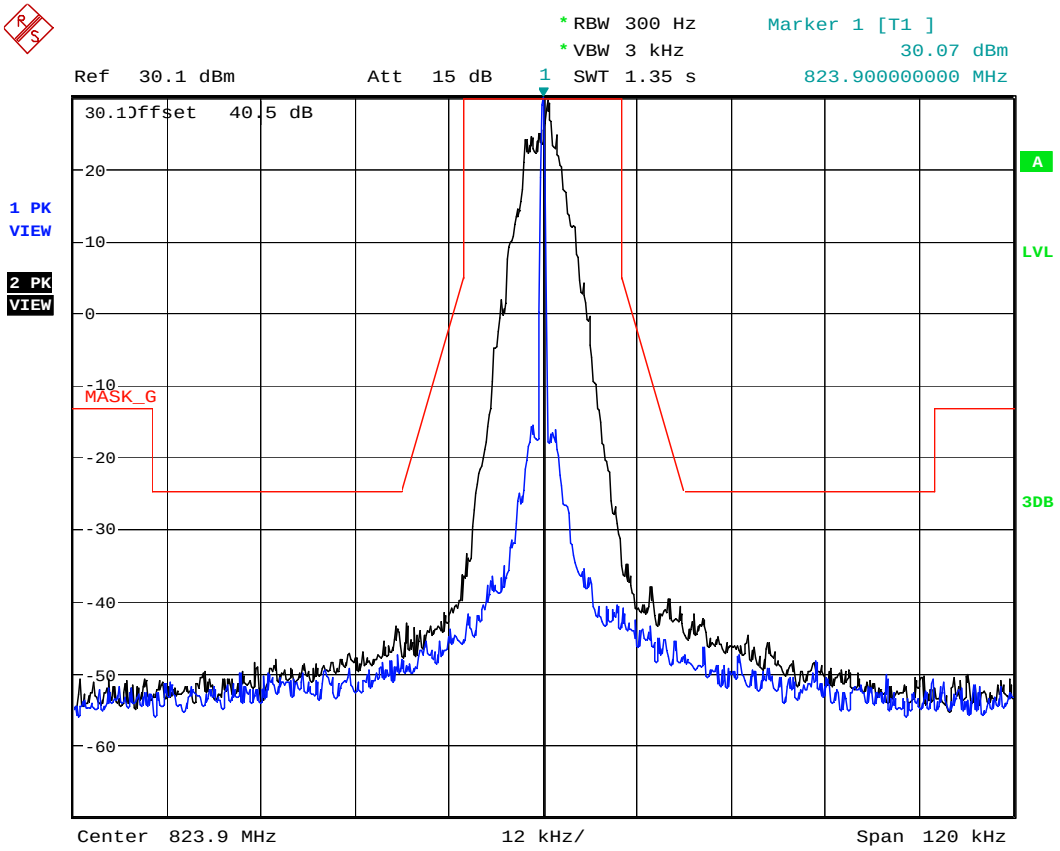
Low Power

5.7.2.53. Configuration: Mask G, 815.1MHz, Digital, Low power



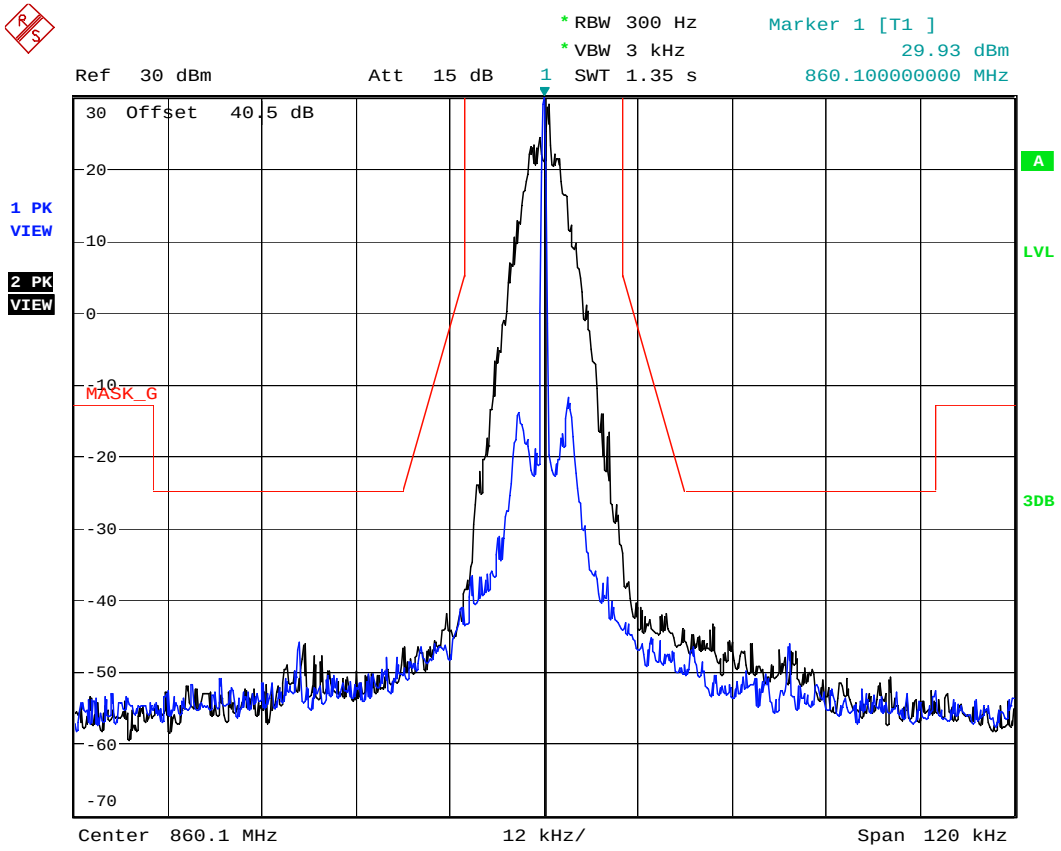
Date: 23.OCT.2018 13:10:31

5.7.2.54. Configuration: Mask G, 823.9MHz, Digital, Low power



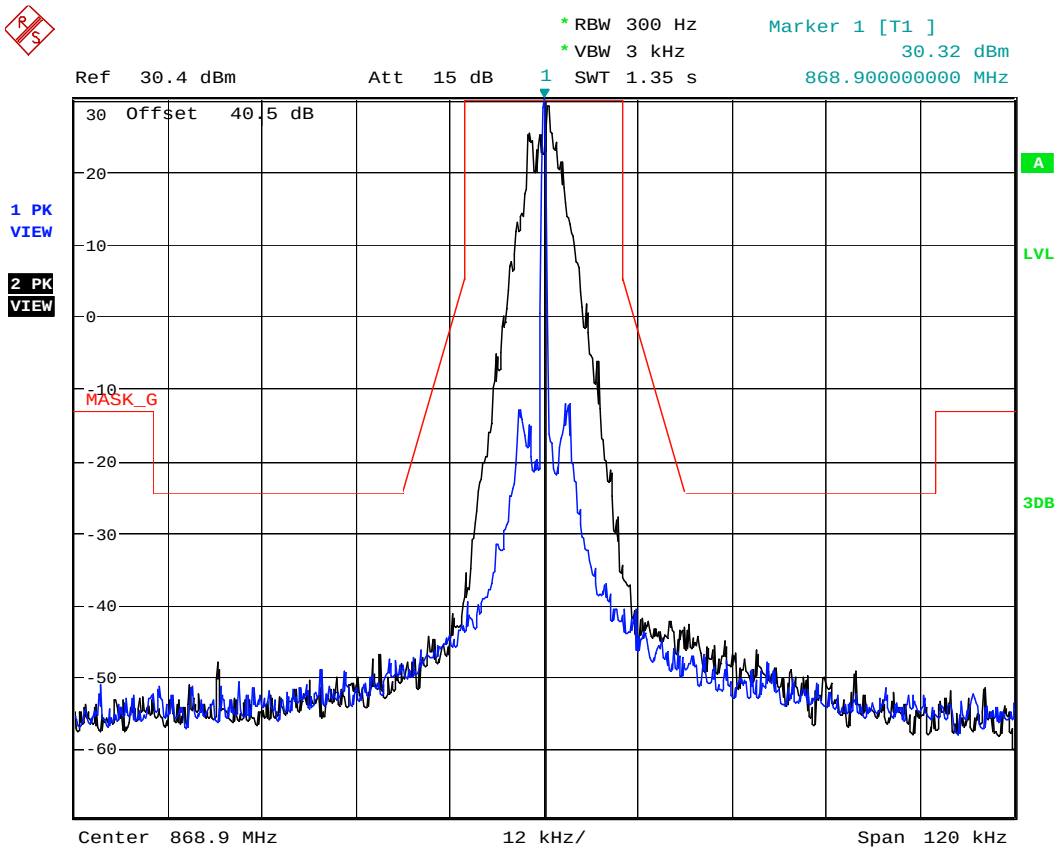
Date: 23.OCT.2018 13:14:35

5.7.2.55. Configuration: Mask G, 860.1MHz, Digital, Low power



Date: 23.OCT.2018 13:16:50

5.7.2.56. Configuration: Mask G, 868.9MHz, Digital, Low power

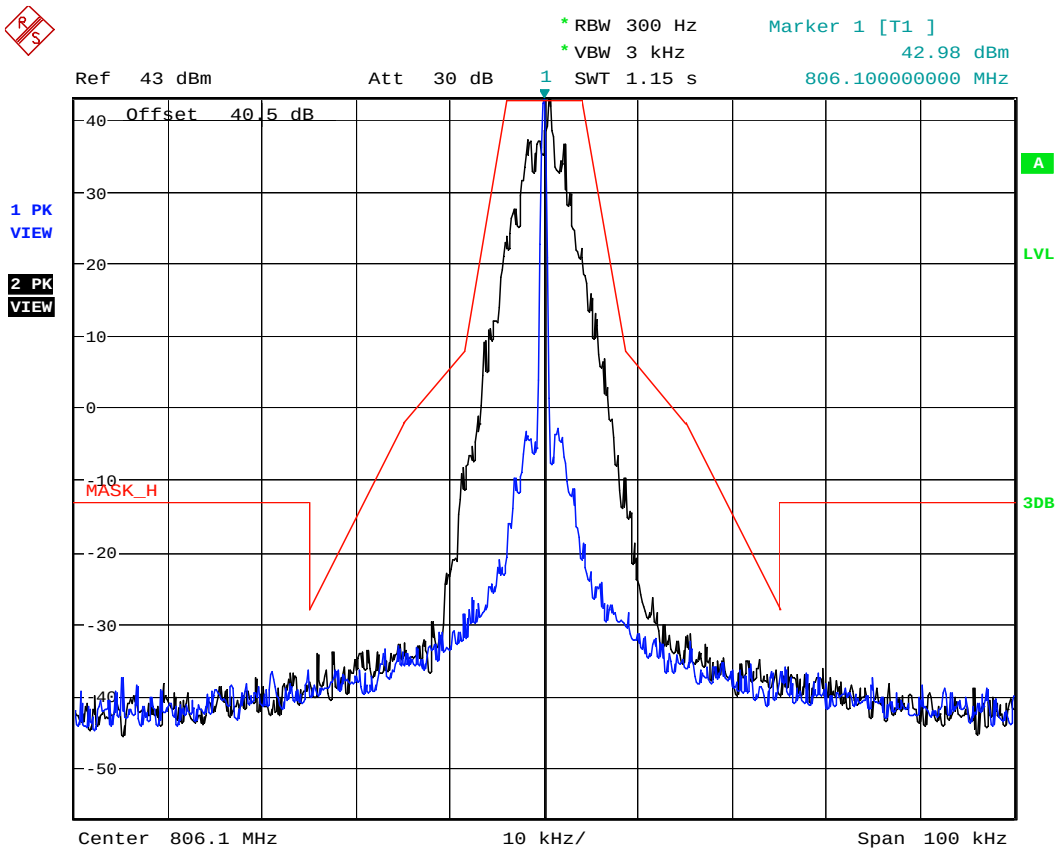


Date: 23.OCT.2018 13:19:47

Rule Part: FCC 90 (90.210)

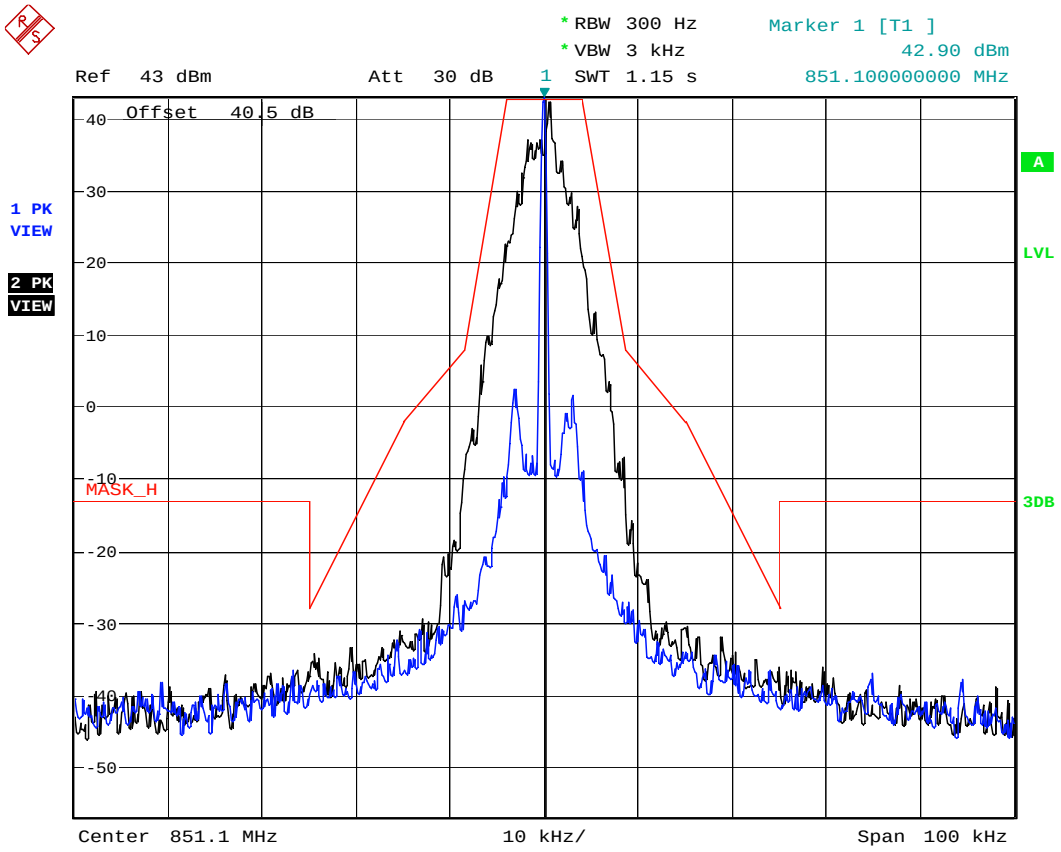
High Power

5.7.2.57. Configuration: Mask H, 806.1MHz, Digital, High power



Date: 23.OCT.2018 13:26:17

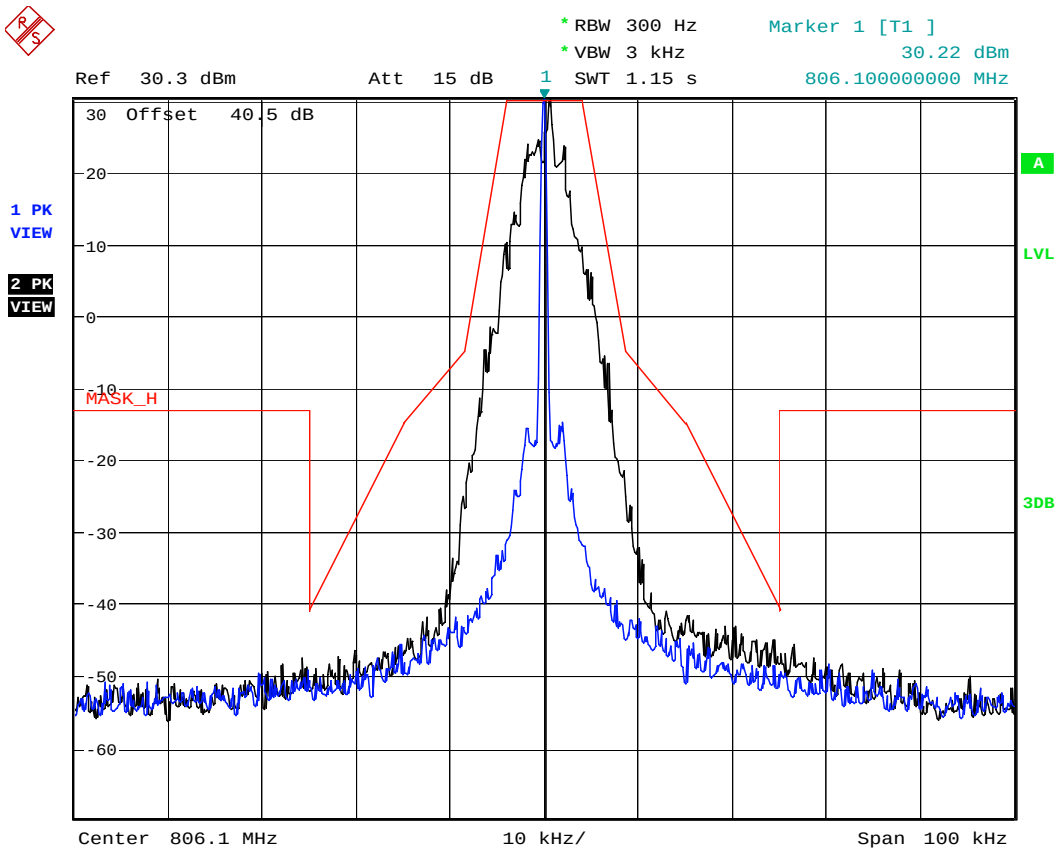
5.7.2.58. Configuration: Mask H, 851.1MHz, Digital, High power



Date: 23.OCT.2018 13:29:24

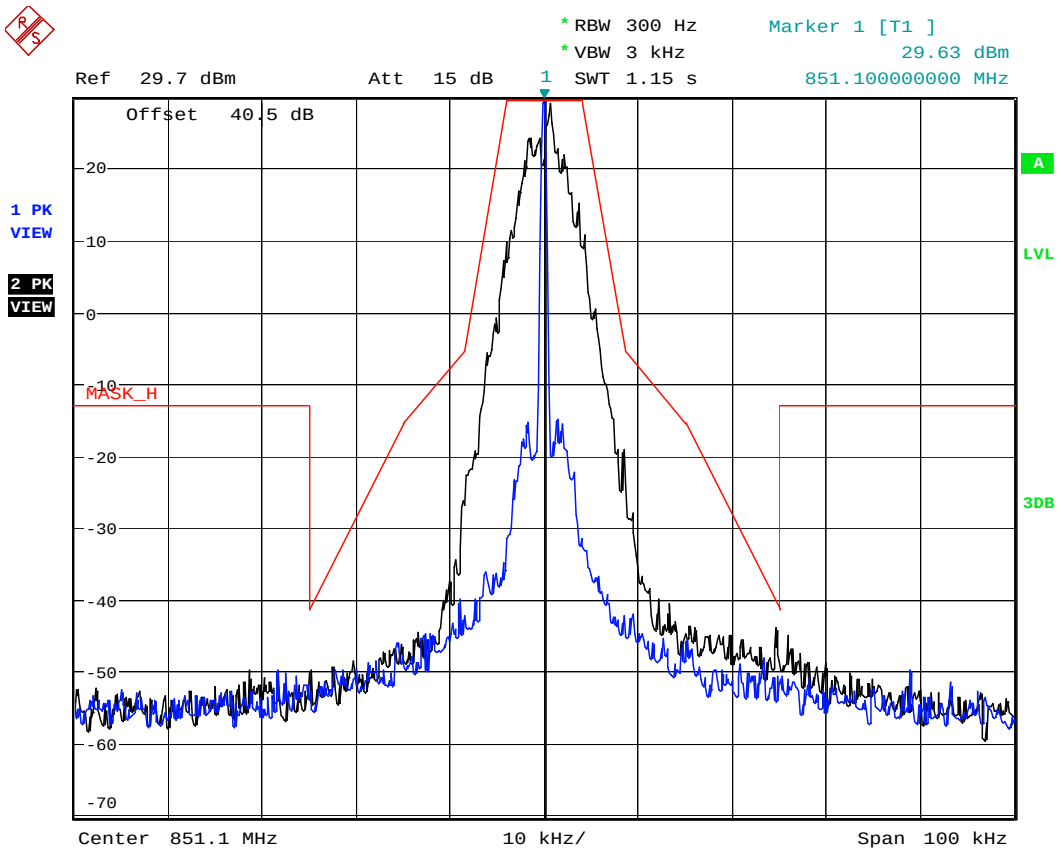
Low Power

5.7.2.59. Configuration: Mask H, 806.1MHz, Digital, Low power



Date: 23.OCT.2018 13:33:17

5.7.2.60. Configuration: Mask H, 851.1MHz, Digital, Low power



Date: 23.OCT.2018 13:36:27

5.8. TRANSMITTER ANTENNA POWER SPURIOUS/HARMONIC CONDUCTED EMISSIONS [§ 90.210(b & h) & 90.669]

5.8.1. Limits

Out-of-band emission limit. On any frequency outside of the frequency ranges, the power of any emission must be reduced below the unmodulated carrier power (P) by at least 43 + 10 log (P) dB or 80 dB, whichever is the lesser attenuation.

5.9. Method of Measurements

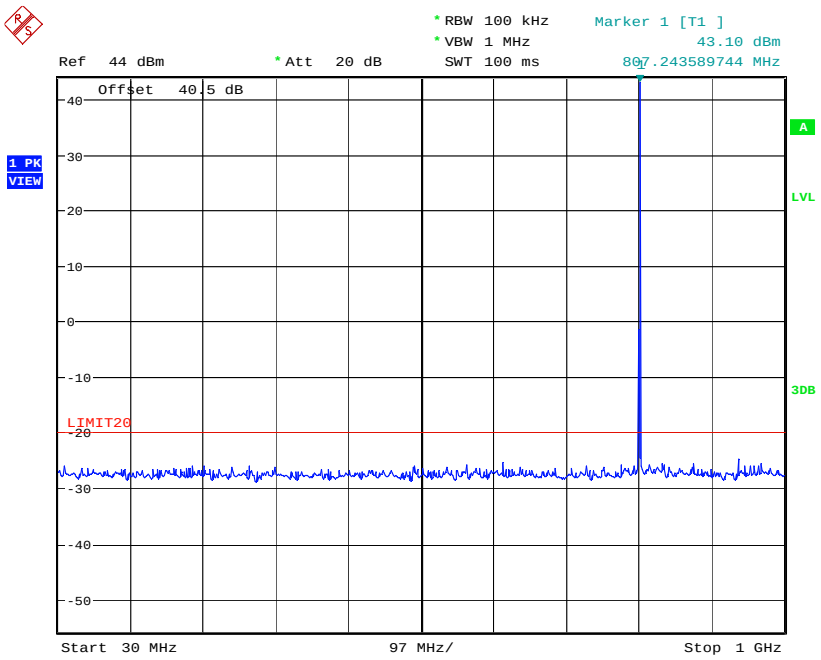
Refer to Exhibit 8 Section 8.4 of this report for measurement details

5.10. Test Data

Note: For IC Limit Line is -20dBm and for FCC Limit line is -13dBm, tested for worst case that is -20dBm. Test was performed on the radio set with 12.5 kHz channel spacing operation with digital modulation.

High Power

5.10.1.1. Configuration: Tx Conducted Emission, 806.1MHz, Digital, High power



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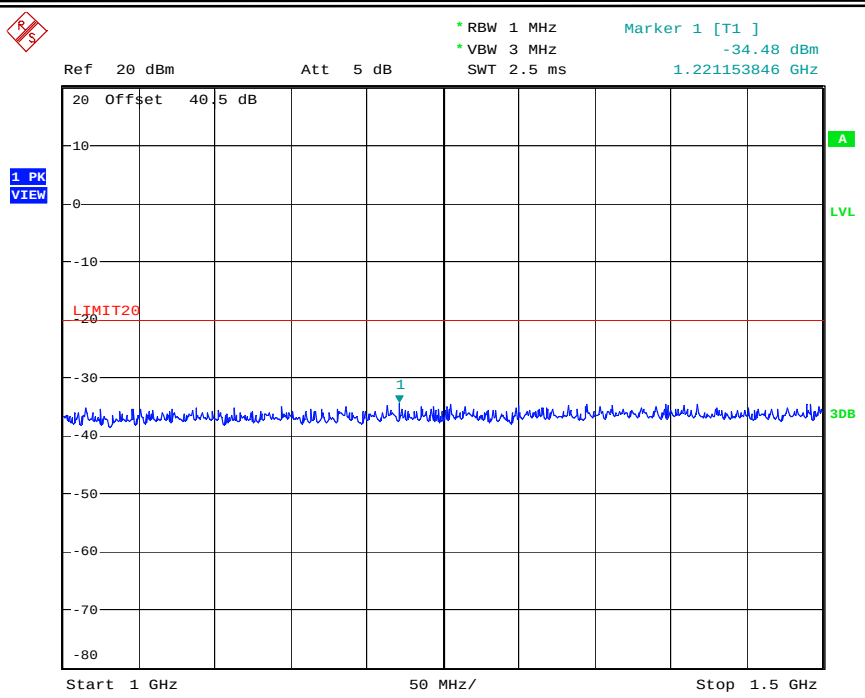

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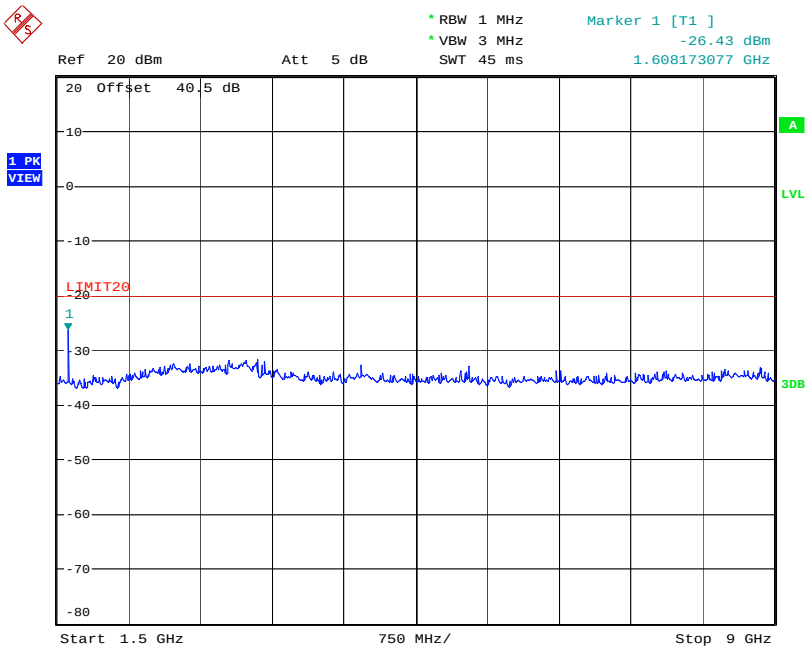

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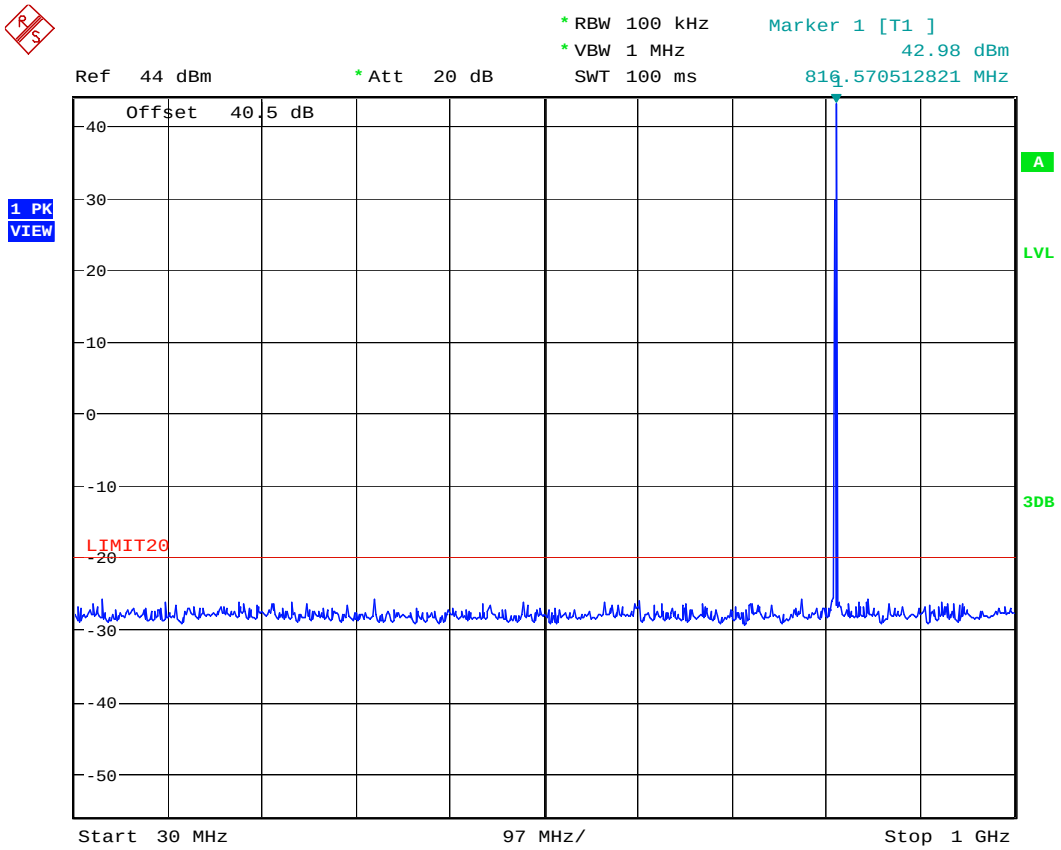
5.10.1.2. Configuration: Tx Conducted Emission, 815.1MHz, Digital, High power



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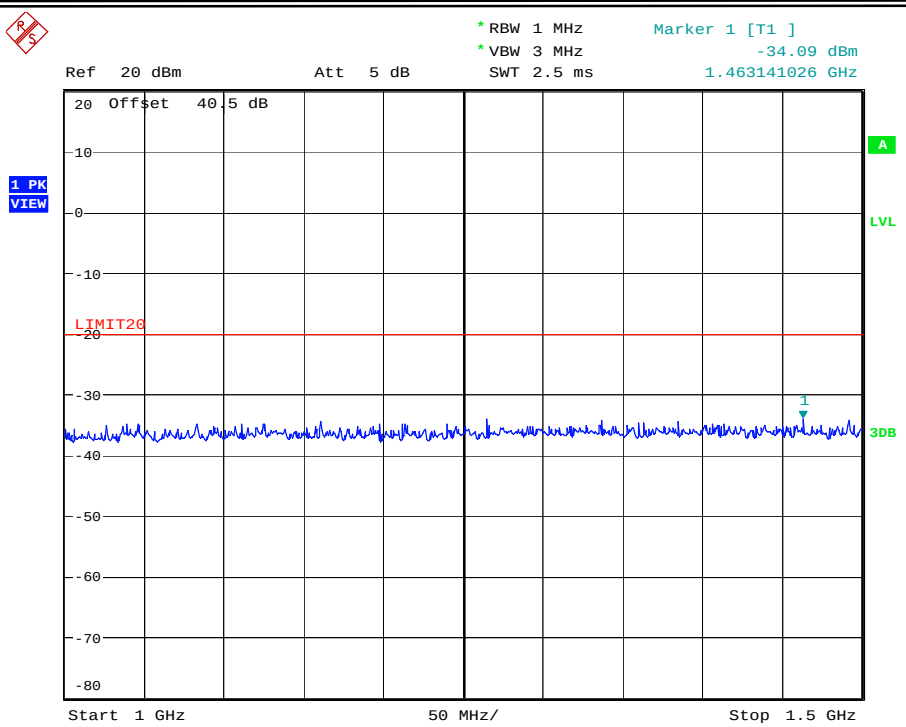

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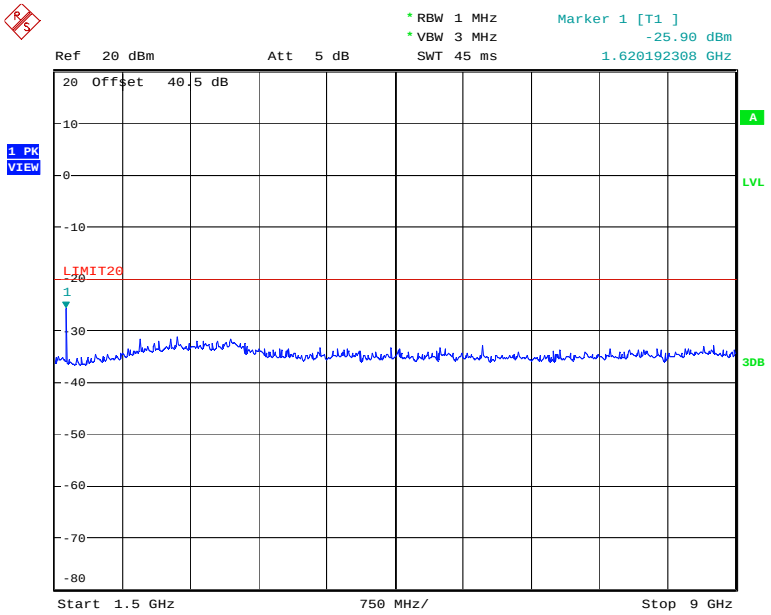

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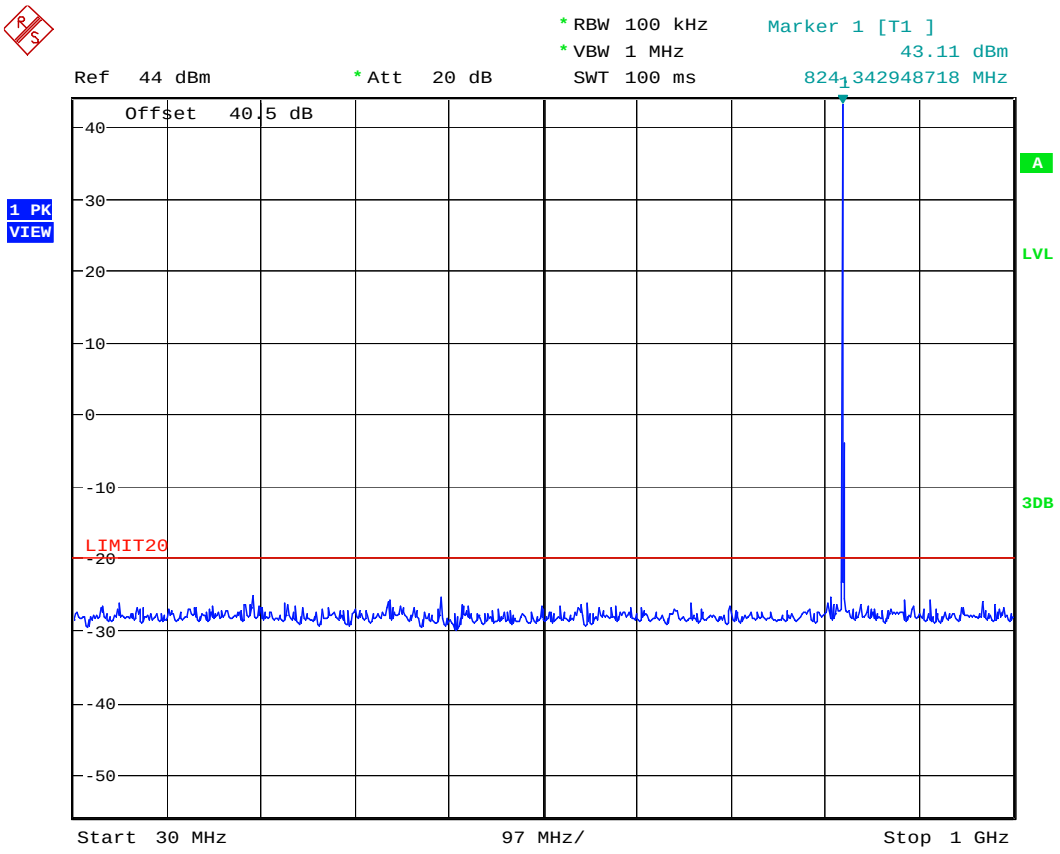
5.10.1.3. Configuration: Tx Conducted Emission, 823.9MHz, Digital, High power



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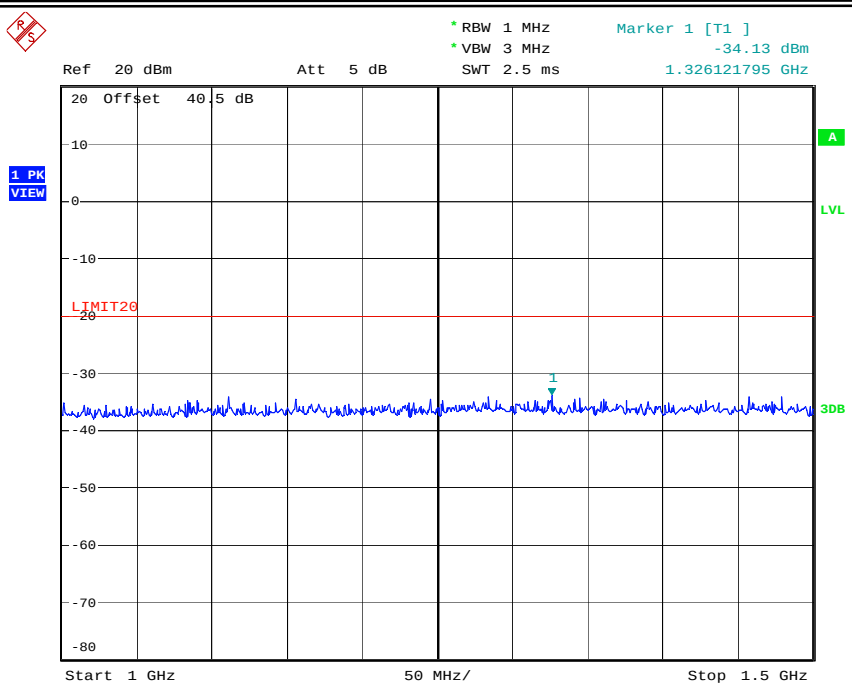

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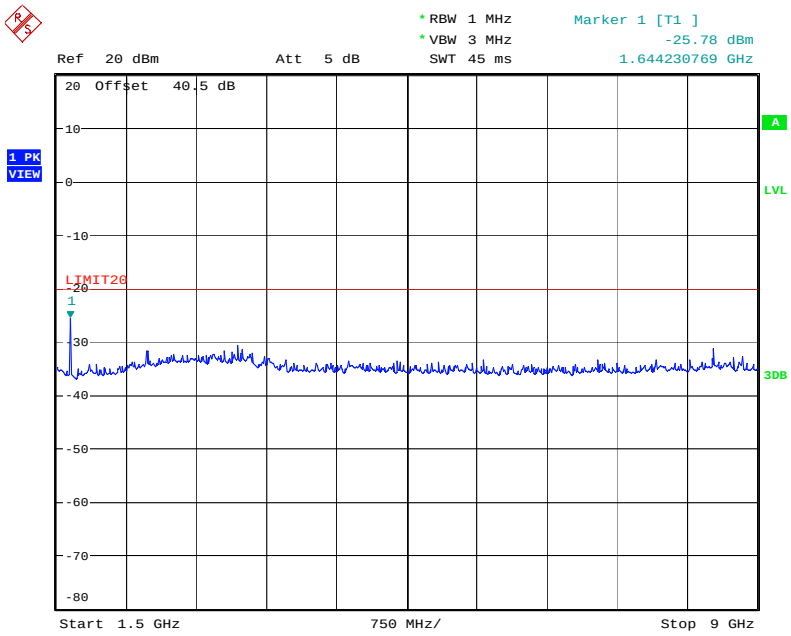
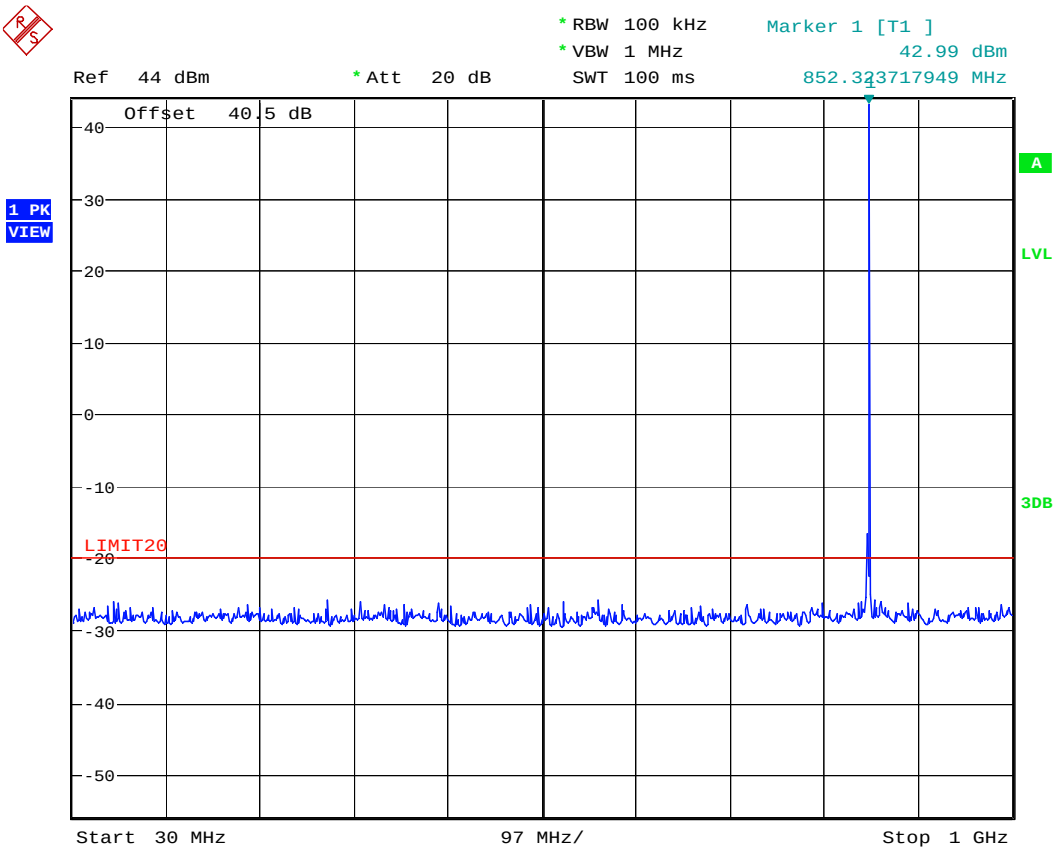


Date: 24.OCT.2018 12:28:57

5.10.1.4. Configuration: Tx Conducted Emission, 851.1MHz, Digital, High power



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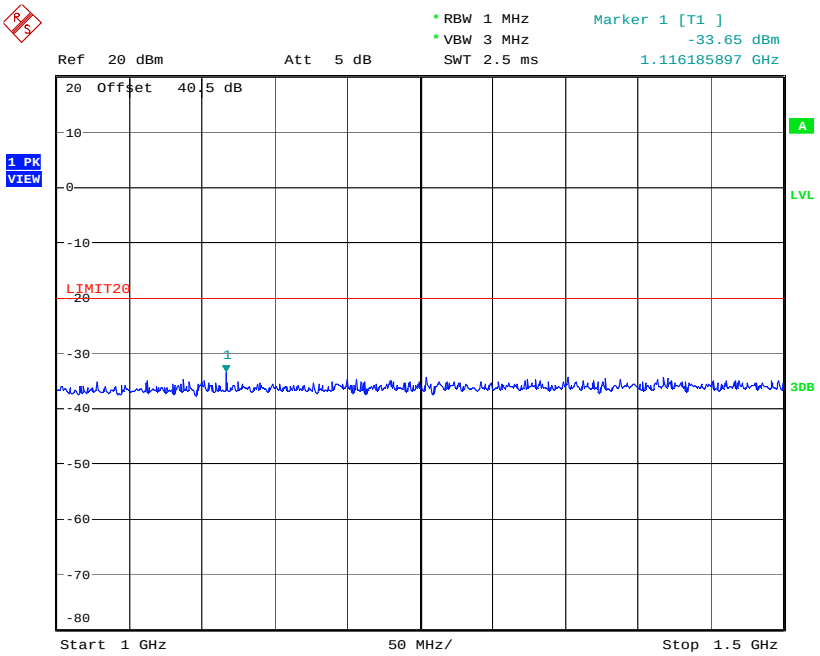

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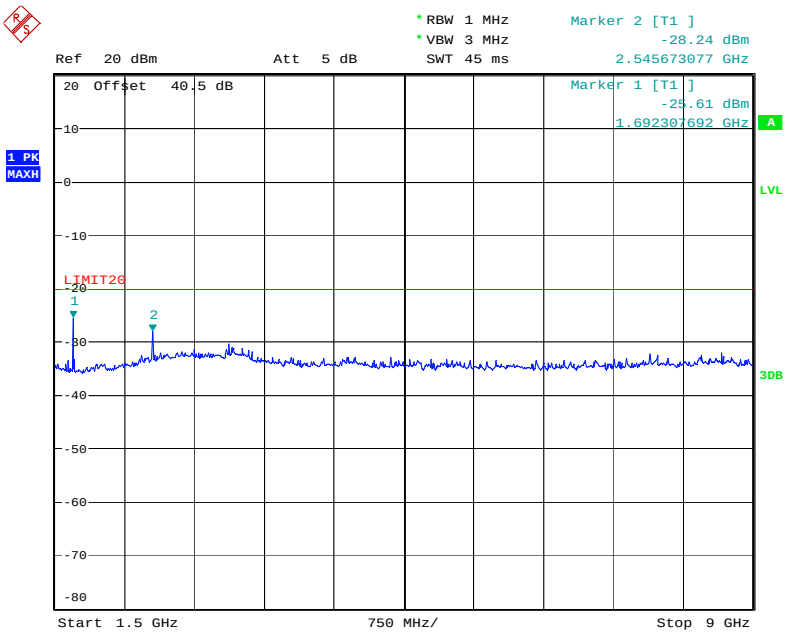

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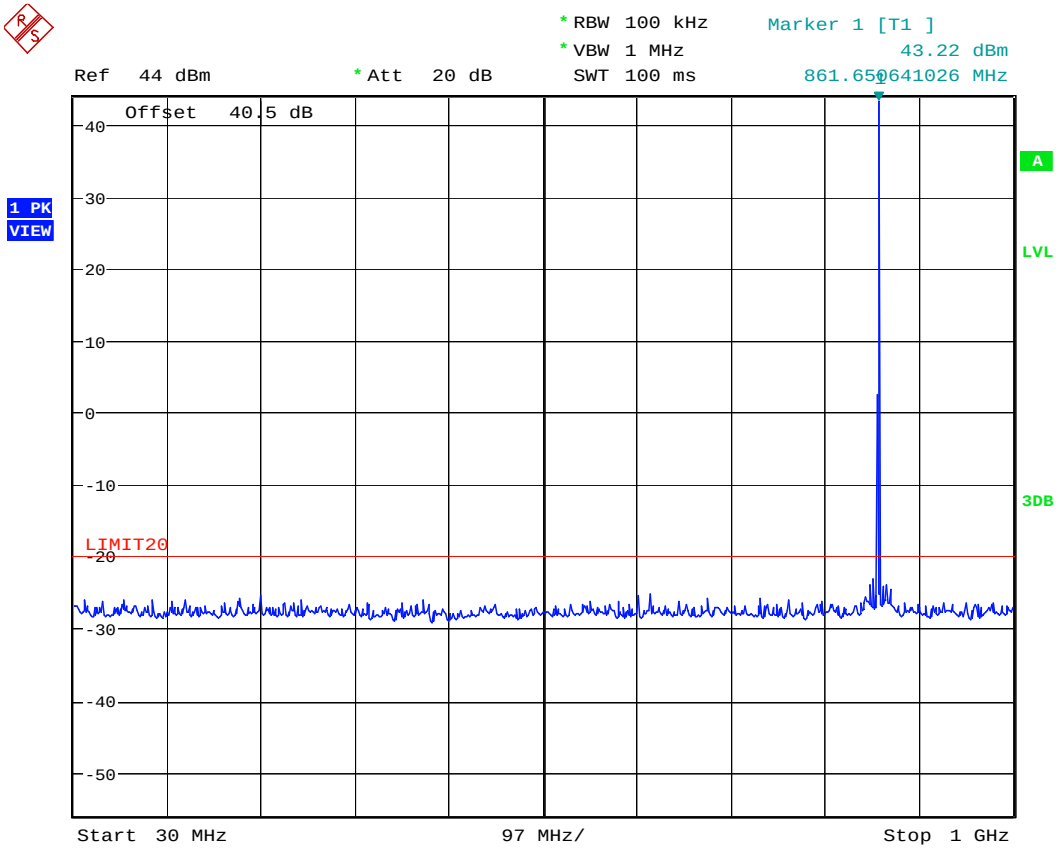
5.10.1.5. Configuration: Tx Conducted Emission, 860.1MHz, Digital, High power



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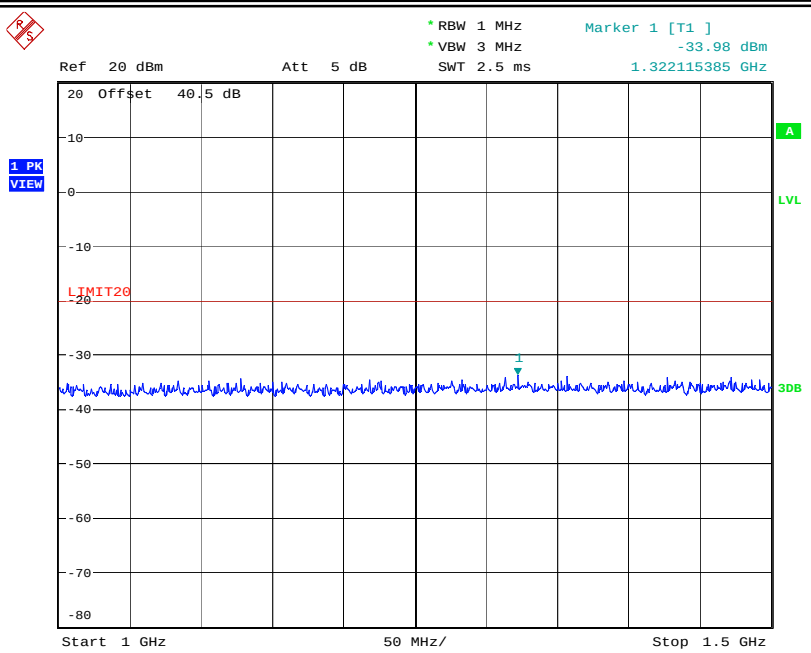

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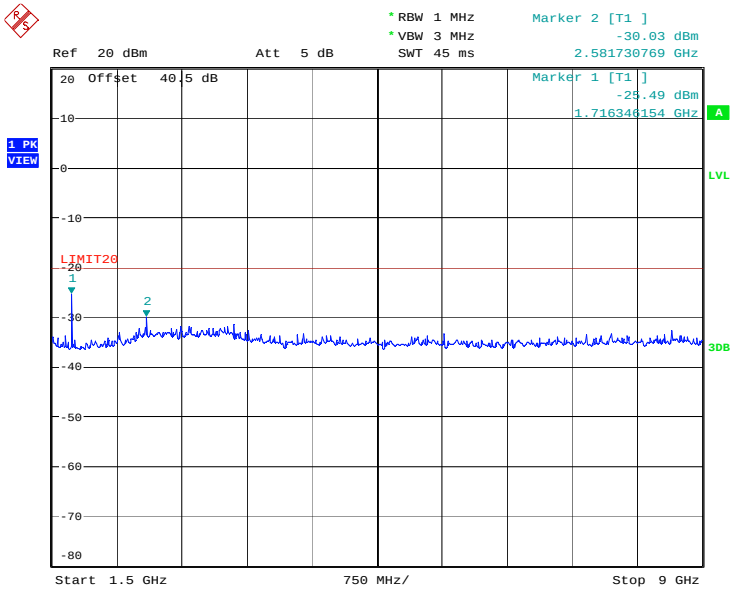

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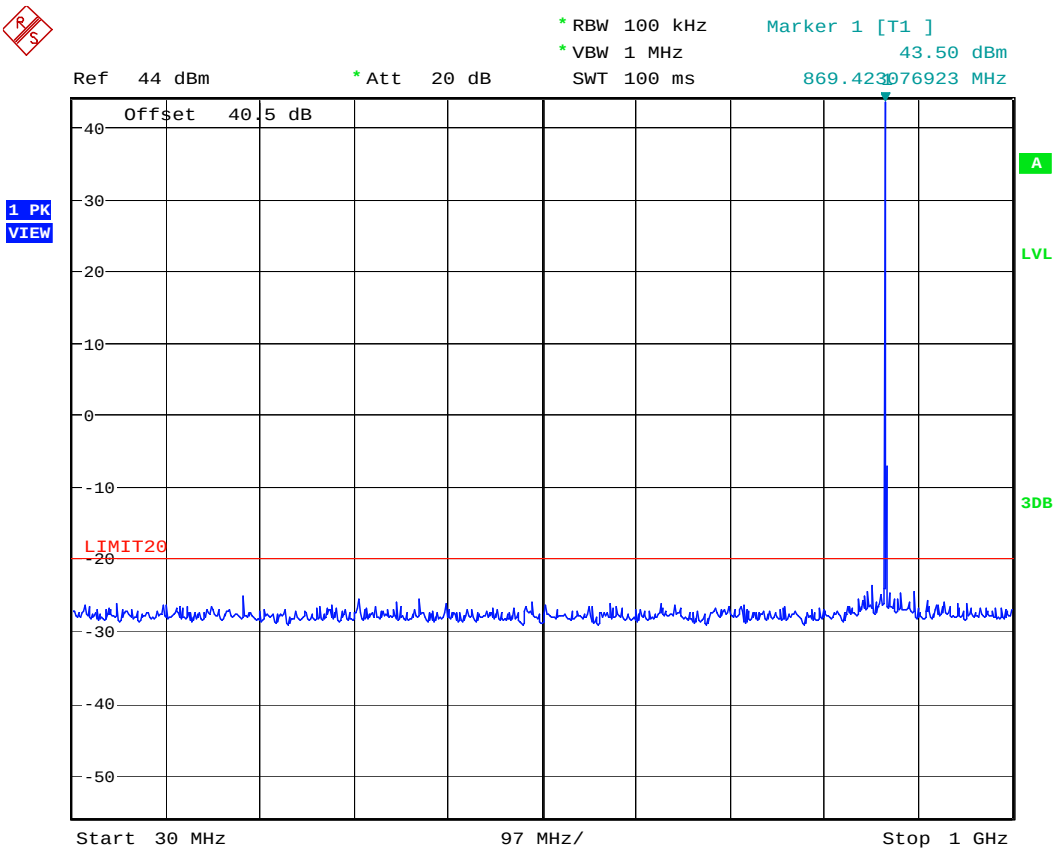
5.10.1.6. Configuration: Tx Conducted Emission, 868.9MHz, Digital, High power



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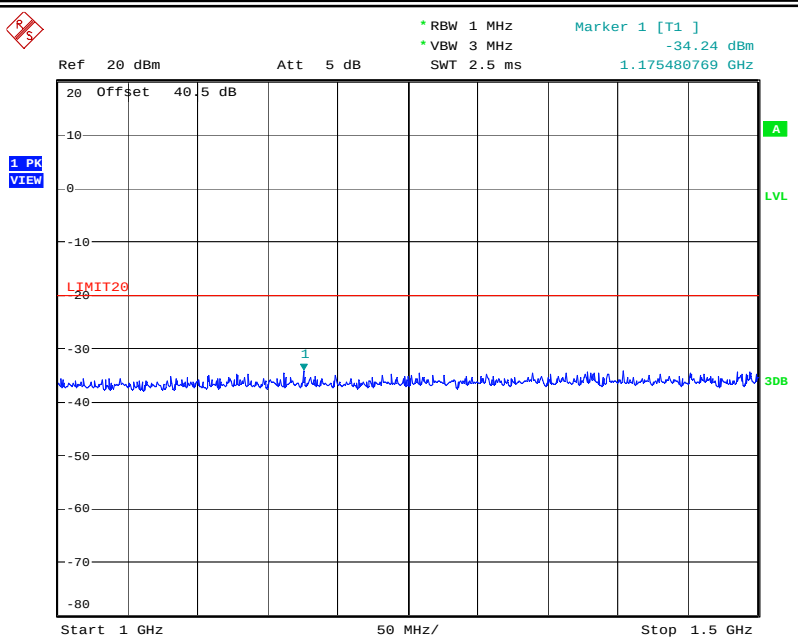

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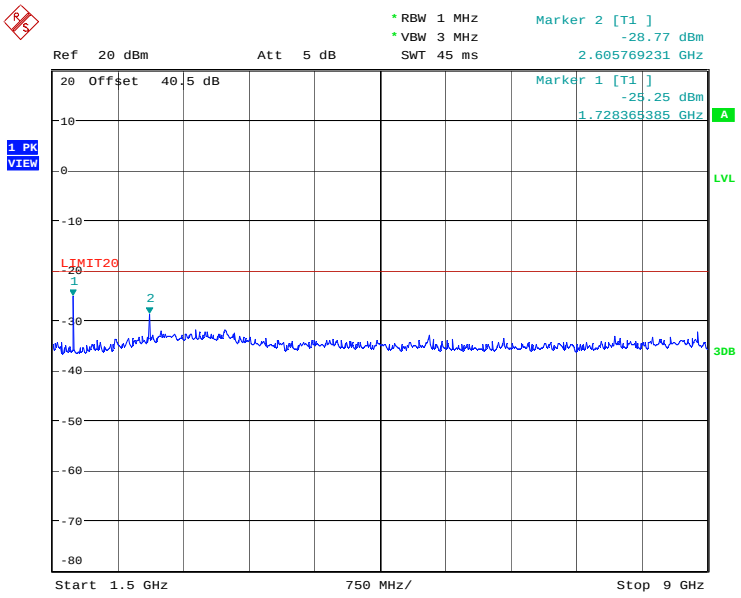
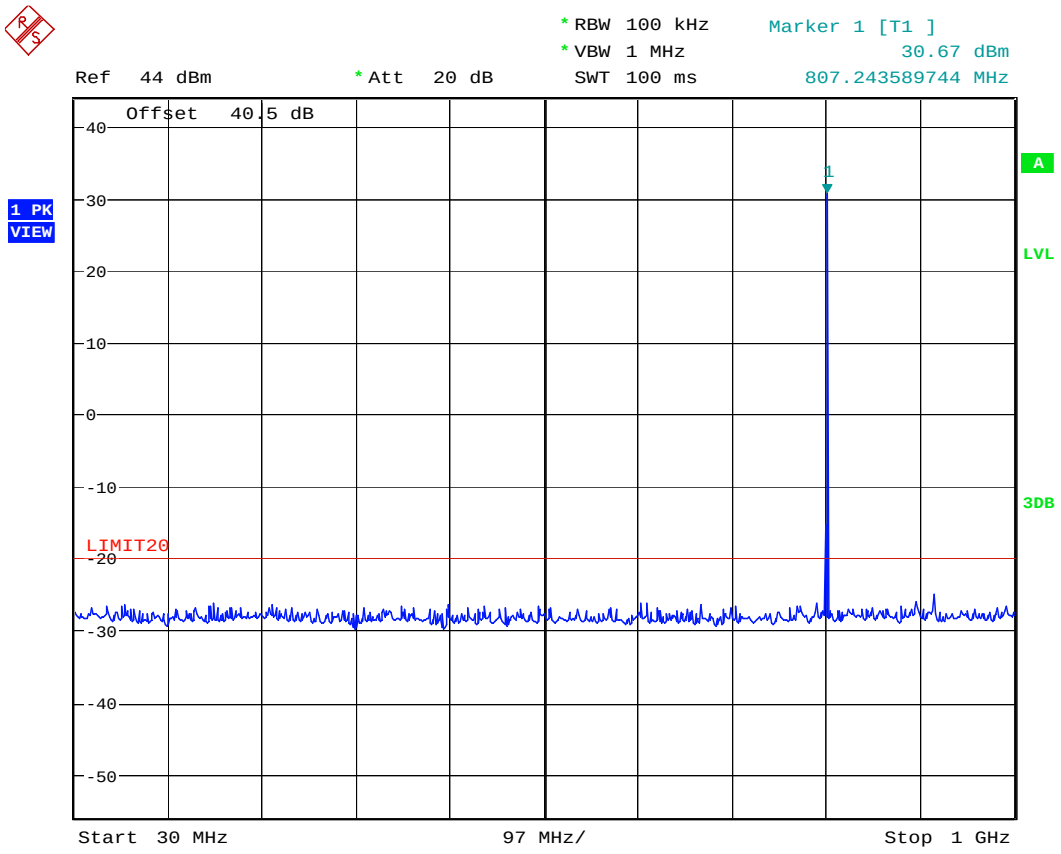


Date: 24.OCT.2018 12:34:20

Low Power

5.10.1.7. Configuration: Tx Conducted Emission, 806.1MHz, Digital, Low power



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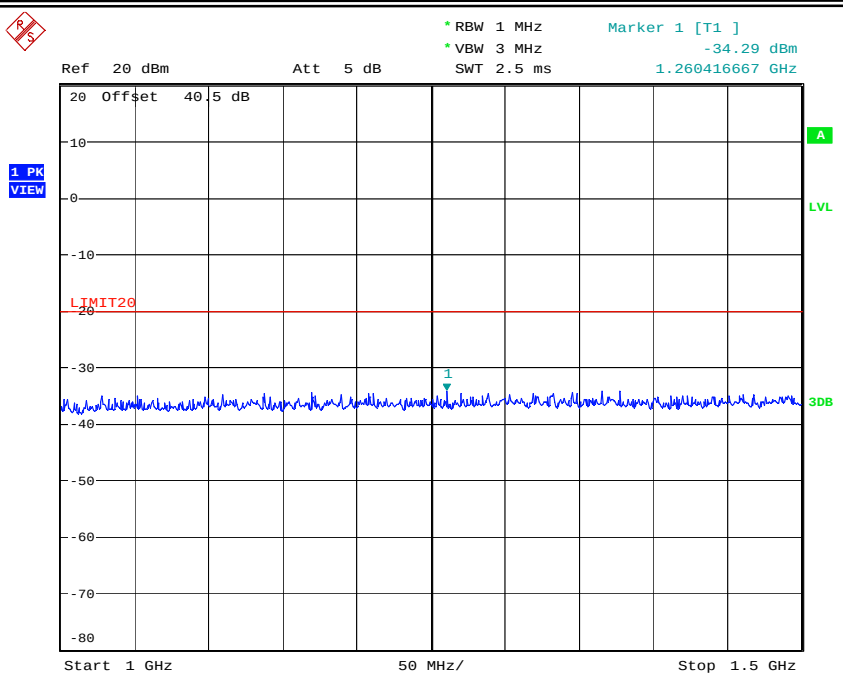

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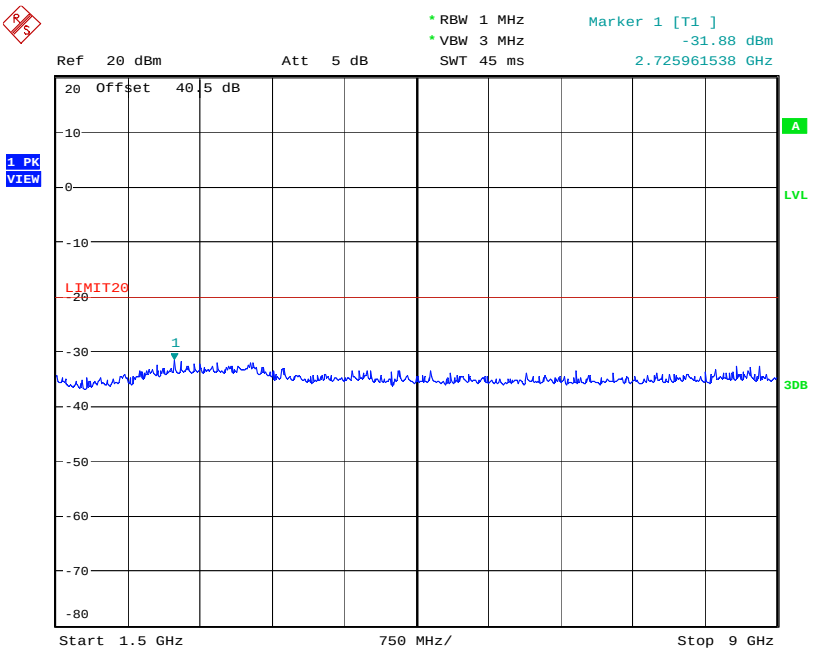

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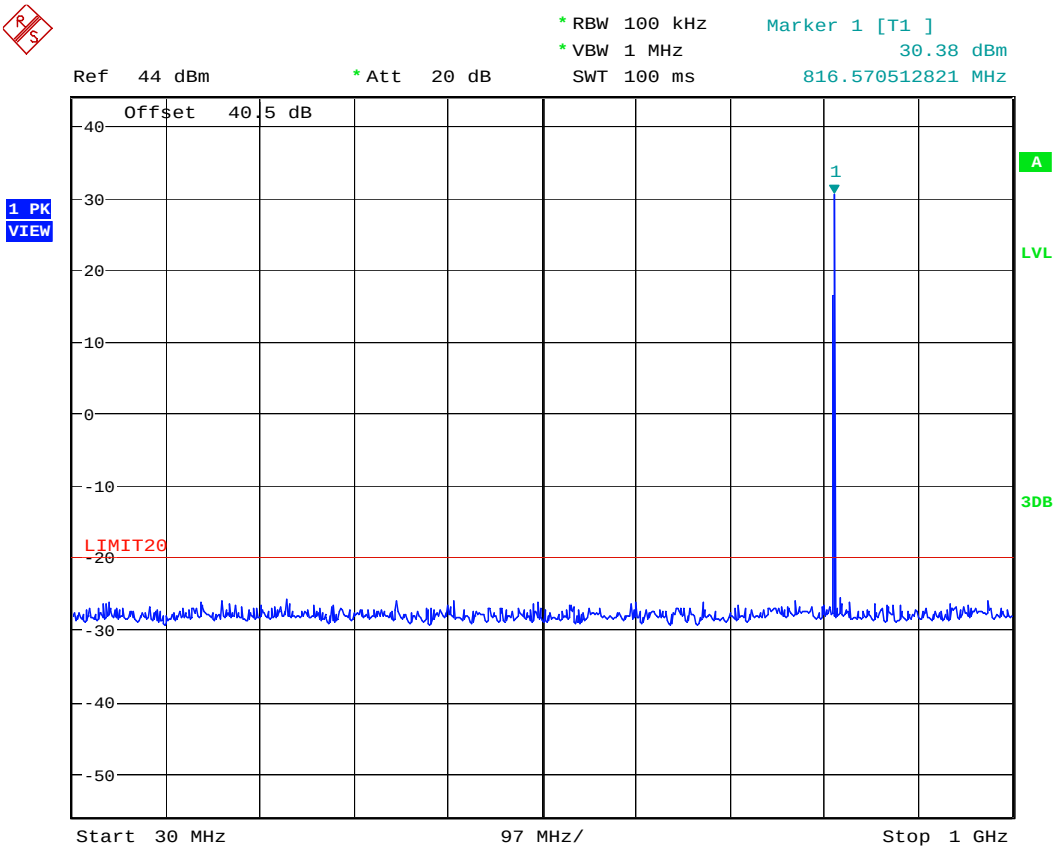
5.10.1.8. Configuration: Tx Conducted Emission, 815.1MHz, Digital, Low power



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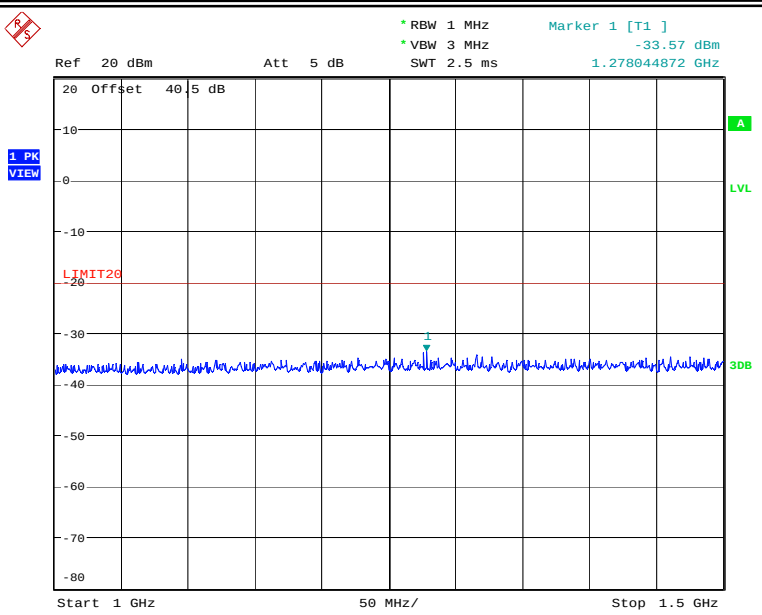

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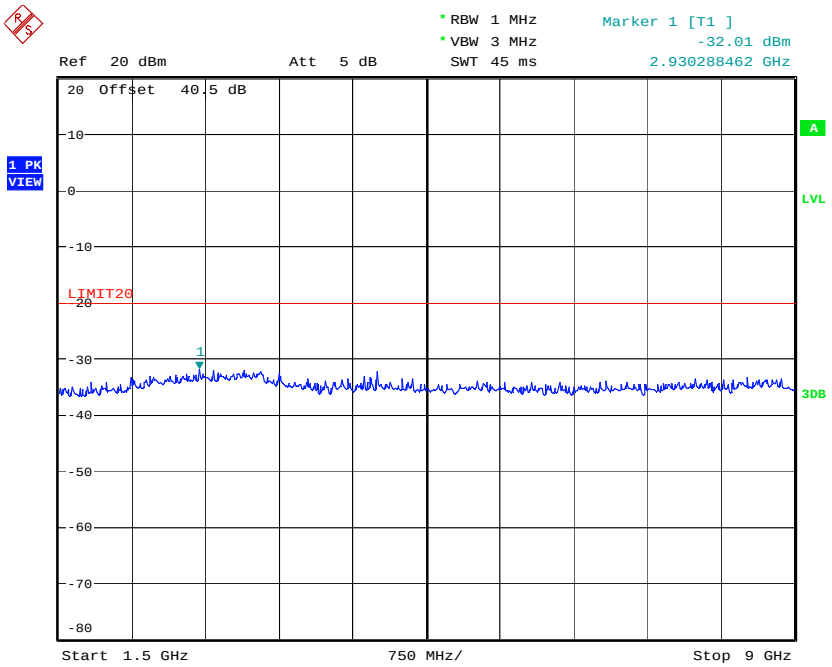

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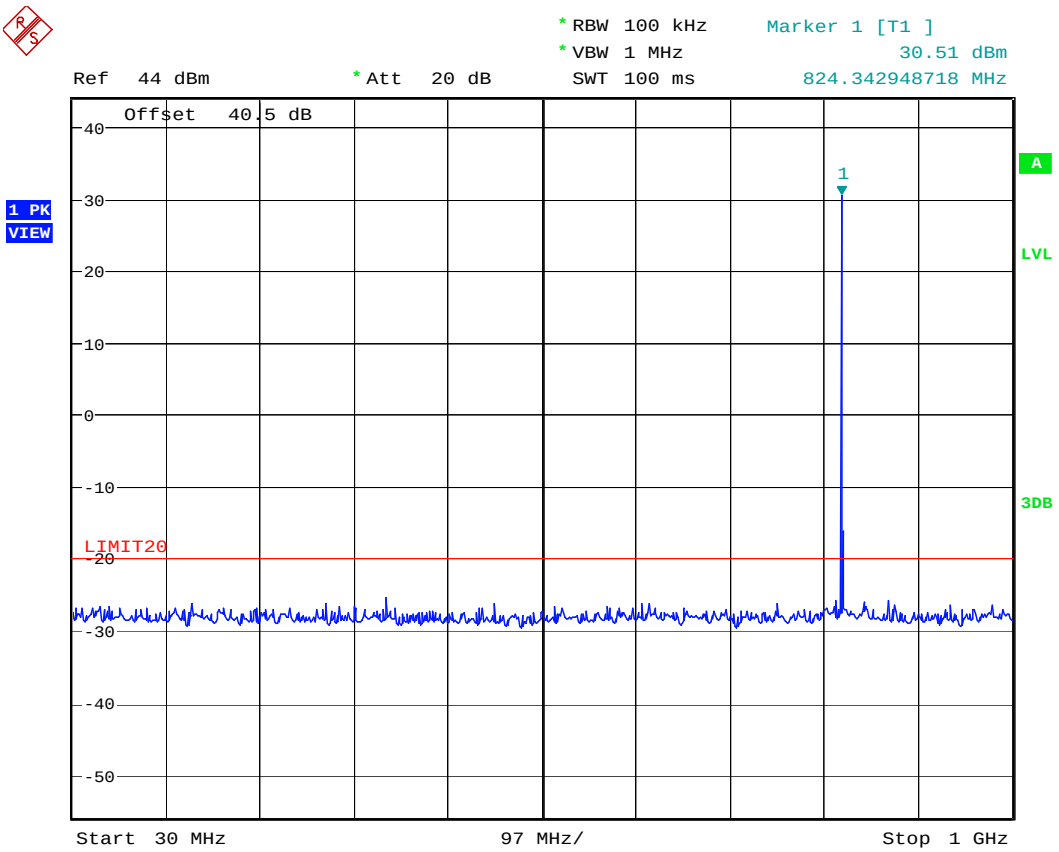
5.10.1.9. Configuration: Tx Conducted Emission, 823.9MHz, Digital, Low power



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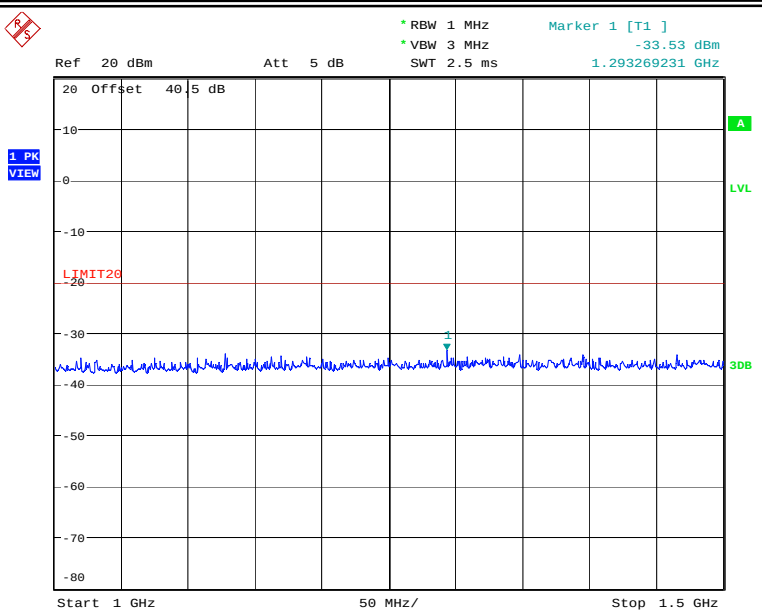

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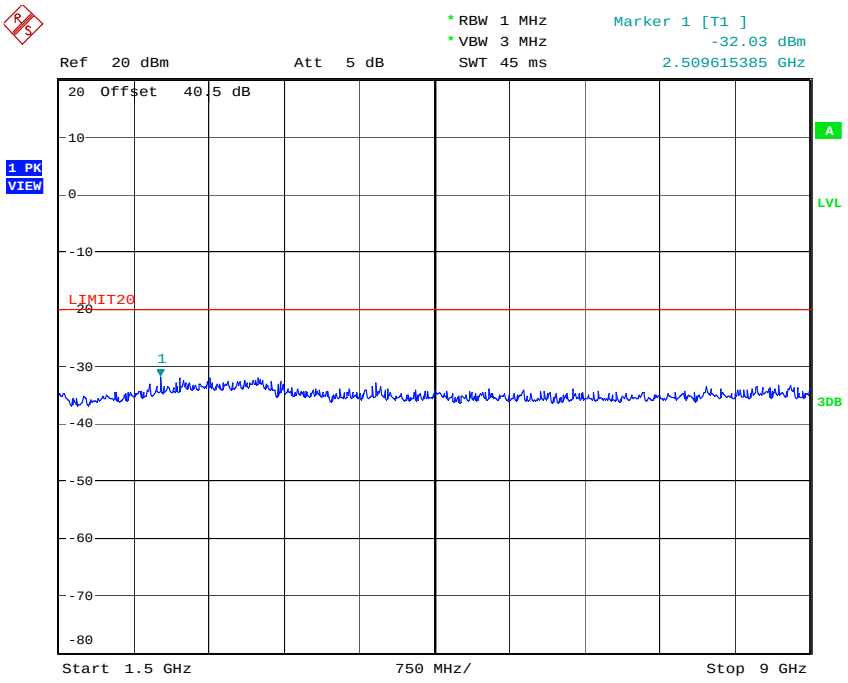

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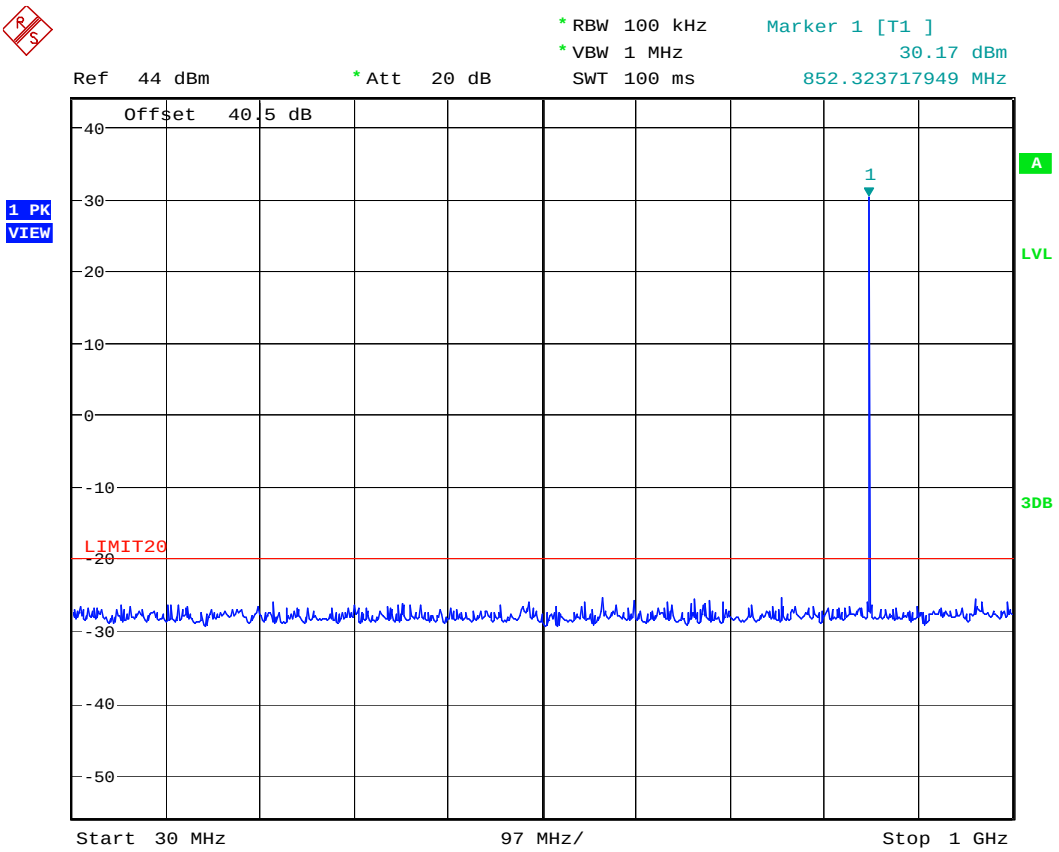
5.10.1.10. Configuration: Tx Conducted Emission, 851.1MHz, Digital, Low power



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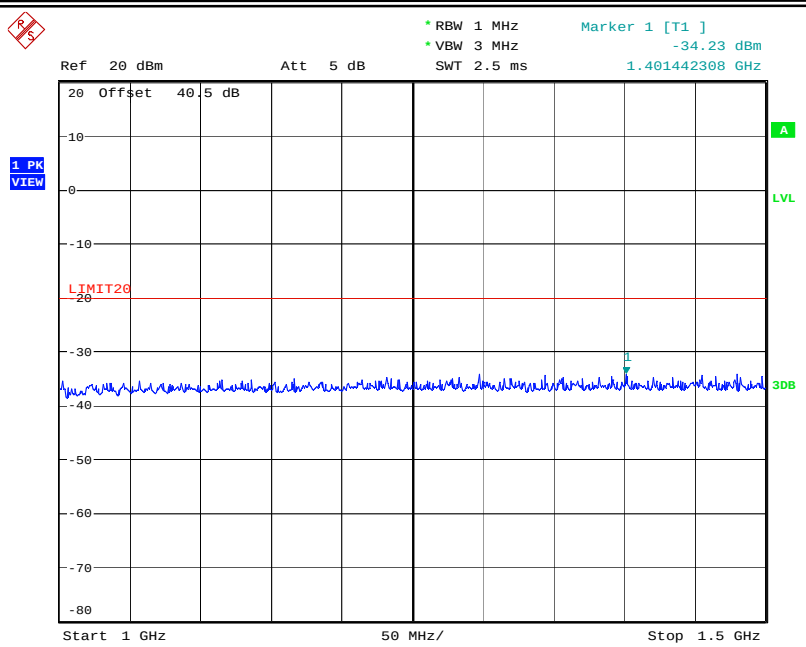

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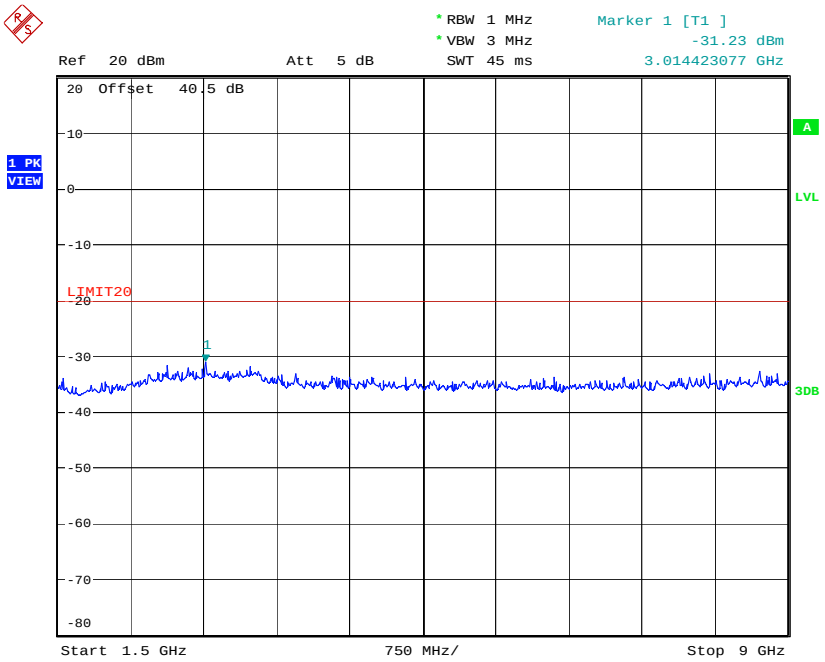
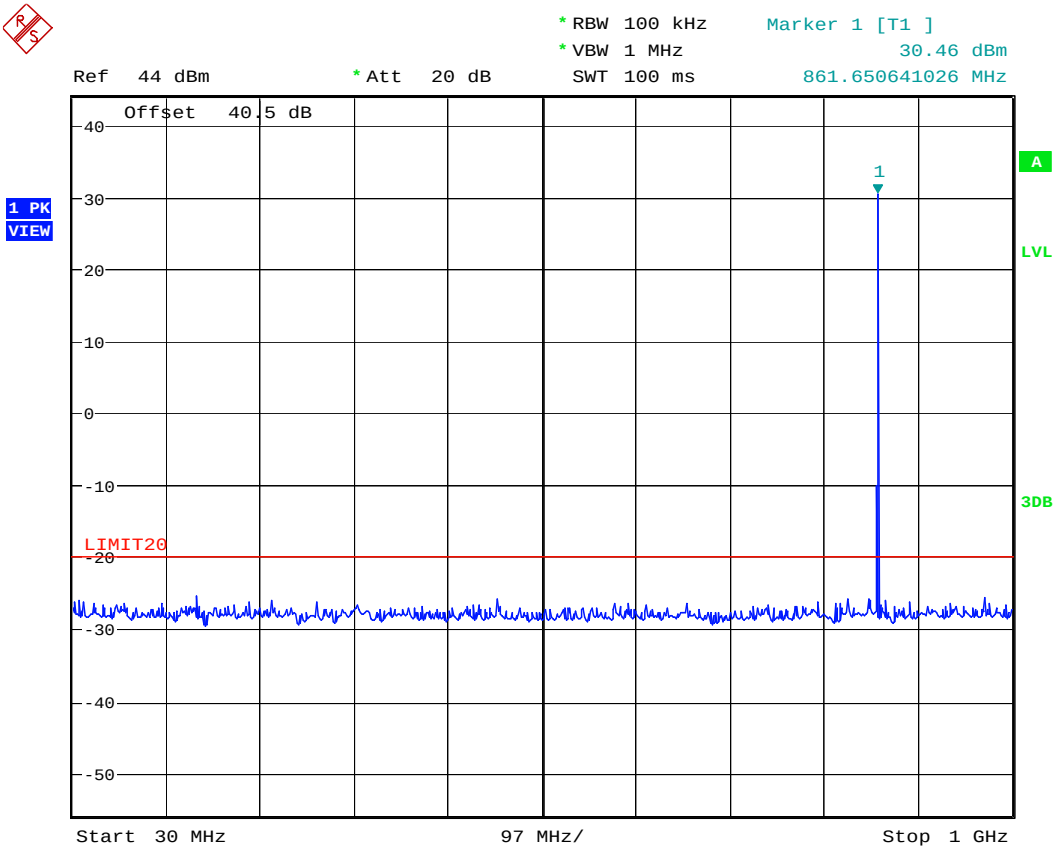


Date: 24.OCT.2018 12:38:46

5.10.1.11. Configuration: Tx Conducted Emission, 860.1MHz, Digital, Low power



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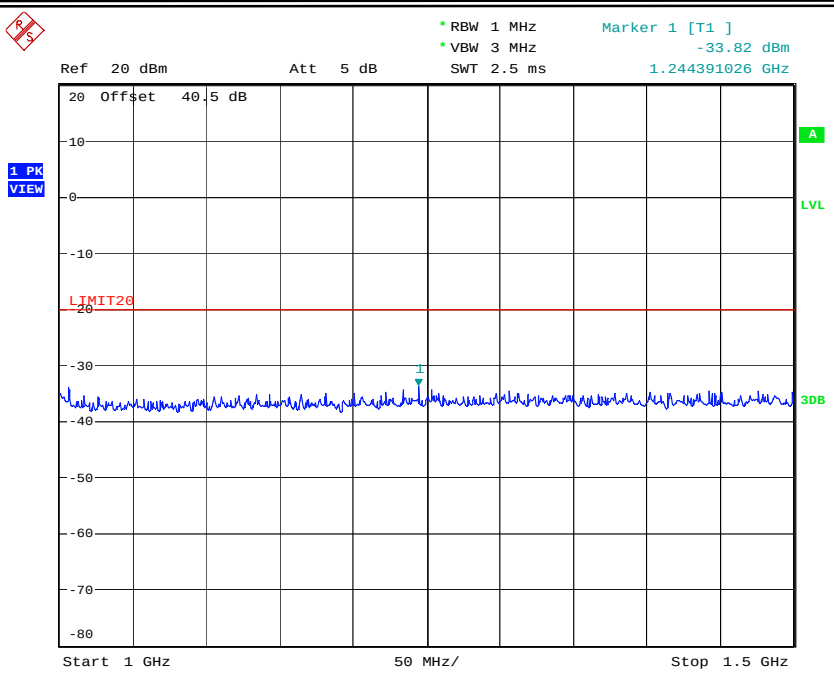
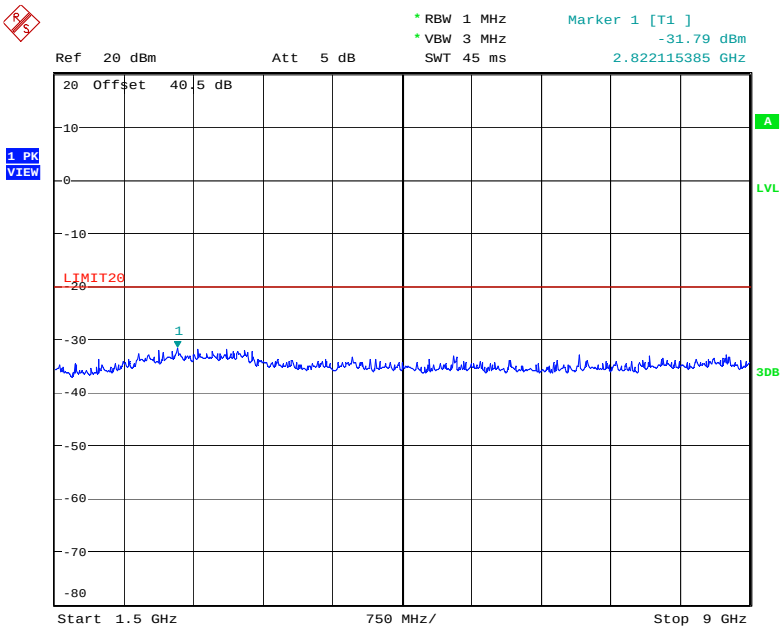
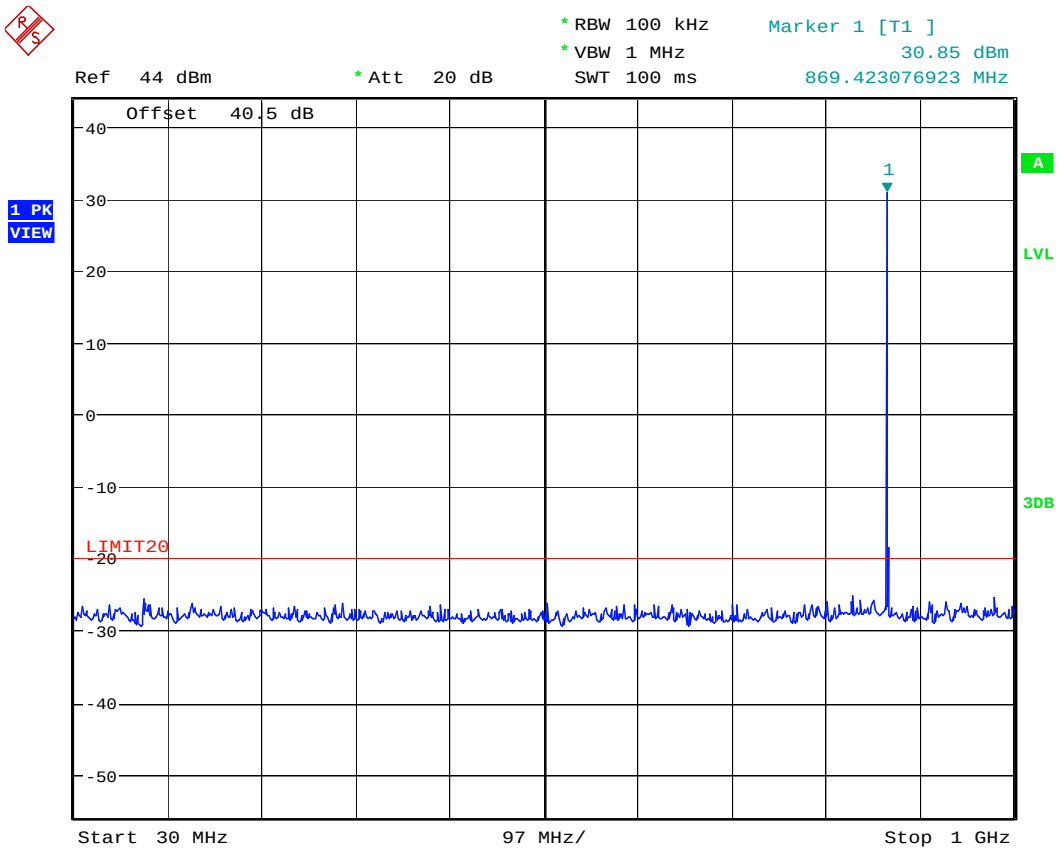


Date: 24.OCT.2018 11:06:53



Date: 24.OCT.2018 12:39:47

5.10.1.12. Configuration: Tx Conducted Emission, 868.9MHz, Digital, Low power



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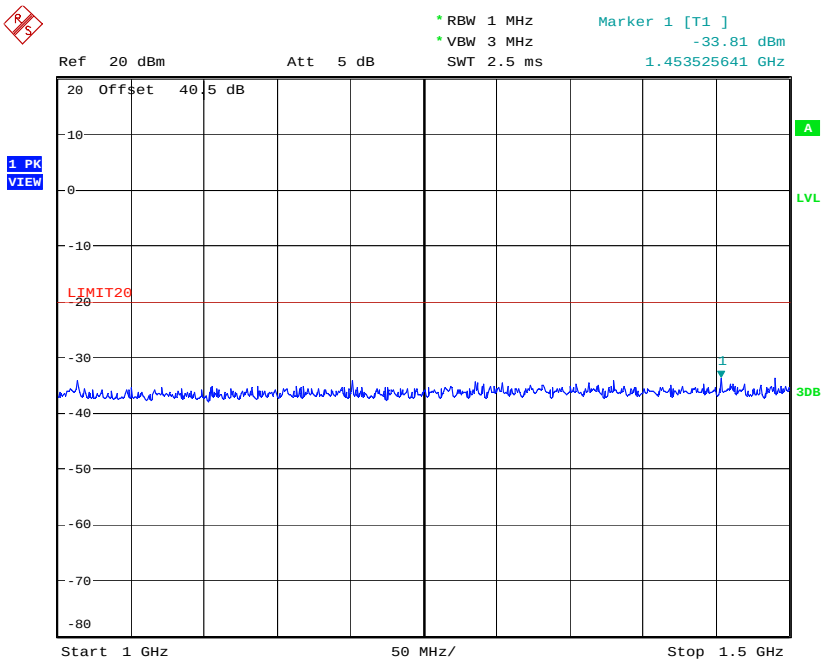

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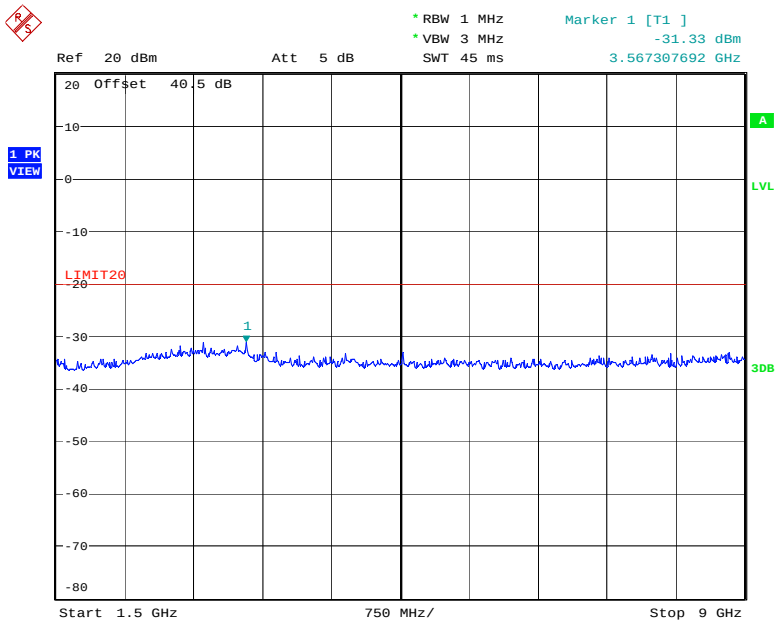


Date: 24.OCT.2018 12:40:48

5.11. TRANSMITTER SPURIOUS/HARMONIC RADIATED EMISSIONS [§ 90.210(b & h) & 90.669]

5.11.1. Limits

Out-of-band emission limit. On any frequency outside of the frequency ranges, the power of any emission must be reduced below the unmodulated carrier power (P) by at least 43 + 10 log (P) dB or 80 dB, whichever is the lesser attenuation.

5.11.2. Method of Measurements

The spurious/harmonic ERP measurements are using substitution method specified in Exhibit 8, Section 8.2 of this report and its value in dBc is calculated as follows:

(1) If the transmitter's antenna is an integral part of the EUT, the ERP is measured using substitution method.
(2) If the transmitter's antenna is non-integral and diverse, the lowest ERP of the carrier with 0 dBi antenna gain is used for calculation of the spurious/harmonic emissions in dBc:
Lowest ERP of the carrier = EIRP – 2.15 dB = Pc + G - 2.15 dB = xxx dBm (conducted) + 0 dBi – 2.15 dB
(3) Spurious /harmonic emissions levels expressed in dBc (dB below carrier) are as follows:

ERP of spurious/harmonic (dBc) = ERP of carrier (dBm) – ERP of spurious/harmonic emission (dBm)

5.11.3. Test Data

Remarks:

- The rf spurious/harmonic emission characteristics between 2 different channel spacing operations and different modulations (voice/digital) are identical. Therefore, the following radiated emissions were performed on the radio set with 12.5 kHz channel spacing operation with digital modulation.
- The radiated emissions were performed at 3 meters distance. At its maximum power for worst case.
- The emissions were scanned from 30 MHz to 9 GHz; all emissions that are within 20 dB below the limit are recorded.
- Note: For IC Limit Line is -20dBm and for FCC Limit line is -13dBm, tested for worst case that is -20dBm.

5.11.3.1. 806-824 MHz Band

5.11.3.1.1. Lowest Frequency (806.1 MHz)

Carrier Frequency (MHz): 806.1
Power (W): 20
Limit (dBm): -20

Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP measured by Substitution Method (dBm)	Limit (dBm)	Margin (dB)
1612.2	58.42	Peak	H	-38.86	-20	-18.86

5.11.3.1.2. Middle Frequency (815.1 MHz)

Carrier Frequency (MHz): 815.1
Power (W): 20
Limit (dBm): -20

Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP measured by Substitution Method (dBm)	Limit (dBm)	Margin (dB)
All emissions were 20dB below the limit						

5.11.3.1.3. Highest Frequency (823.9 MHz)

Carrier Frequency (MHz): 823.9
Power (W): 20
Limit (dBm): -20

Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP measured by Substitution Method (dBm)	Limit (dBm)	Margin (dB)
All emissions were 20dB below the limit						

5.11.3.2. 851-869 MHz Band

5.11.3.2.1. Lowest Frequency (851 MHz)

Carrier Frequency (MHz): 851
Power (W): 20
Limit (dBm): -20

Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP measured by Substitution Method (dBm)	Limit (dBm)	Margin (dB)
3404.4	65.09	Peak	V	-32.11	-20	-12.11
3404.4	60.74	Peak	H	-38.75	-20	-18.75
5106.6	61.4	Peak	V	-39.16	-20	-19.16

5.11.3.2.2. Middle Frequency (860.1 MHz)

Carrier Frequency (MHz): 860.1
Power (W): 20
Limit (dBm): -20

Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP measured by Substitution Method (dBm)	Limit (dBm)	Margin (dB)
3440.4	61.48	Peak	V	-34.9	-20	-14.9

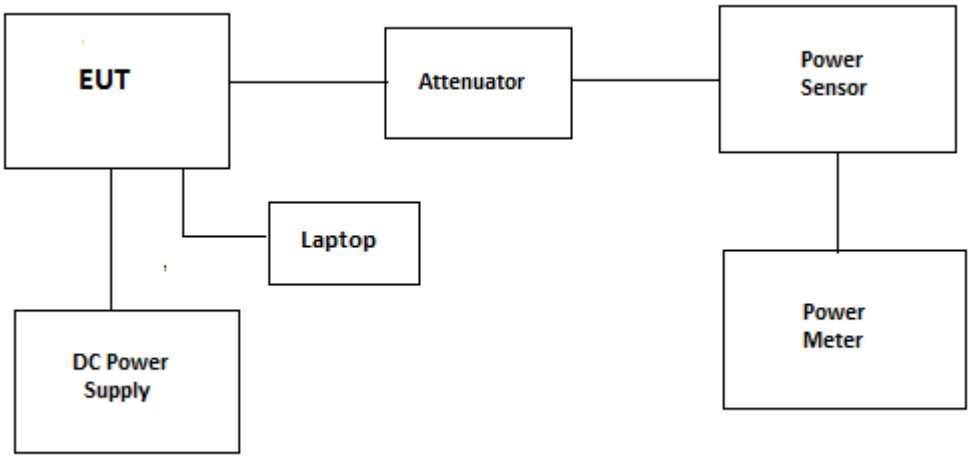
5.11.3.2.3. Highest Frequency (869.9 MHz)

Carrier Frequency (MHz): 869.9
Power (W): 20
Limit (dBm): -20

Frequency (MHz)	E-Field (dBµV/m)	EMI Detector (Peak/QP)	Antenna Polarization (H/V)	ERP measured by Substitution Method (dBm)	Limit (dBm)	Margin (dB)
All emissions were 20dB below the limit						

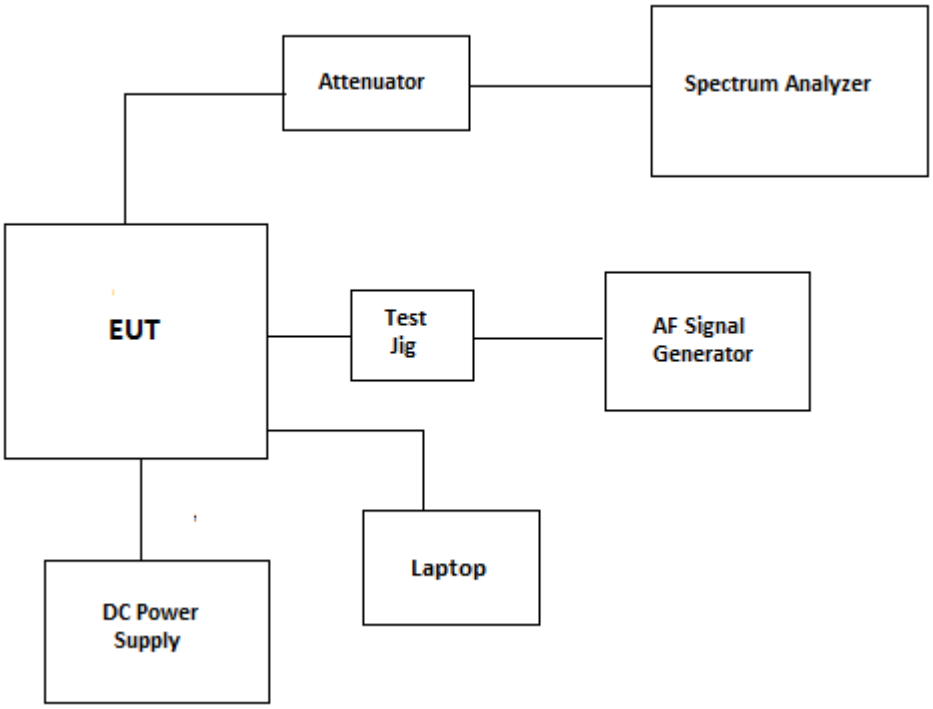
EXHIBIT 6. Block Diagram and Test Equipment

6.1. Conducted Power



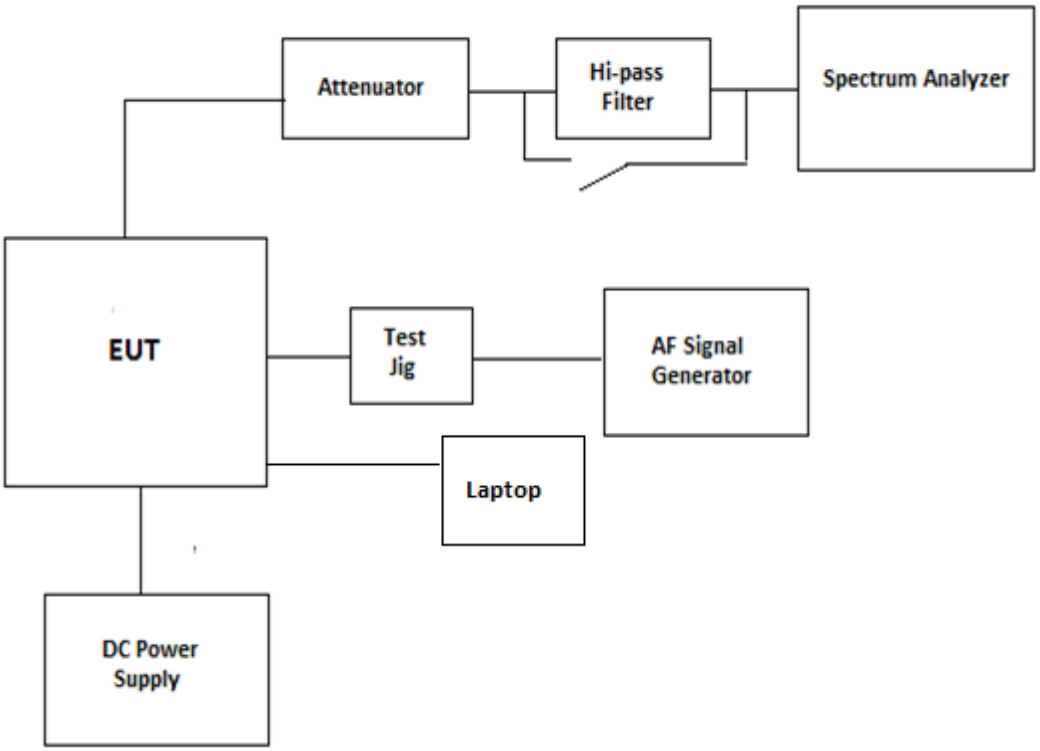
Test Instrument	Manufacturer	Model No	Serial No	Frequency Range	Cal Due date
Power Meter	HP	436A	2709A27515	100KHz-sensor dependant	04 May 2019
Power Sensor	HP	8482A	MY41172054	10MHz-18GHz	26 Oct 2019
Attenuator(20dB)	Narda	26298	A577	DC-1GHz	Cal on use
Attenuator(20dB)	Aeroflex\Weinschel	23-20-34	BH7876	DC-18GHz	Cal on use
Power Supply	Dr. meter	HY5020E	013141252	1-40V, DC 20A	----
Multimeter	Tenma	72-6202	02080027	---	14 Dec 2019

6.2. Mask



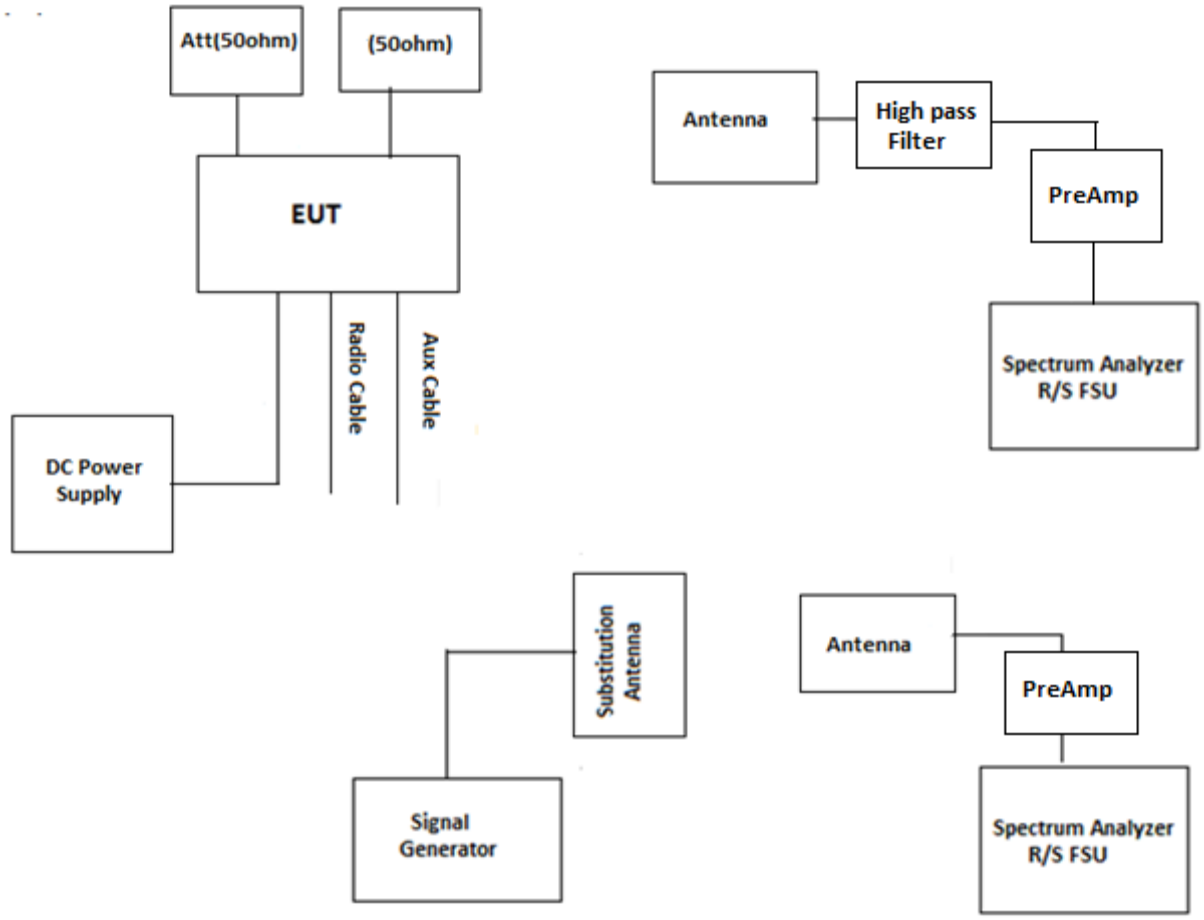
Test Instrument	Manufacturer	Model No	Serial No	Frequency Range	Cal Due date
Spectrum Analyzer	Rohde & Schwarz	FSU	100398	20Hz-26.5GHz	06 Oct 2019
AF Signal Generator	HP	HP-8920B	US39064699	30MHz-1GHz	20 Mar 2020
Attenuator(20dB)	Narda	26298	A577	DC-1GHz	Cal on use
Attenuator(20dB)	Aeroflex\Weinschel	23-20-34	BH7876	DC-18GHz	Cal on use
Power Supply	Dr. meter	HY5020E	013141252	1-40V, DC 20A	----
Multimeter	Tenma	72-6202	02080027	---	14 Dec 2019

6.3. Tx Conducted Emission



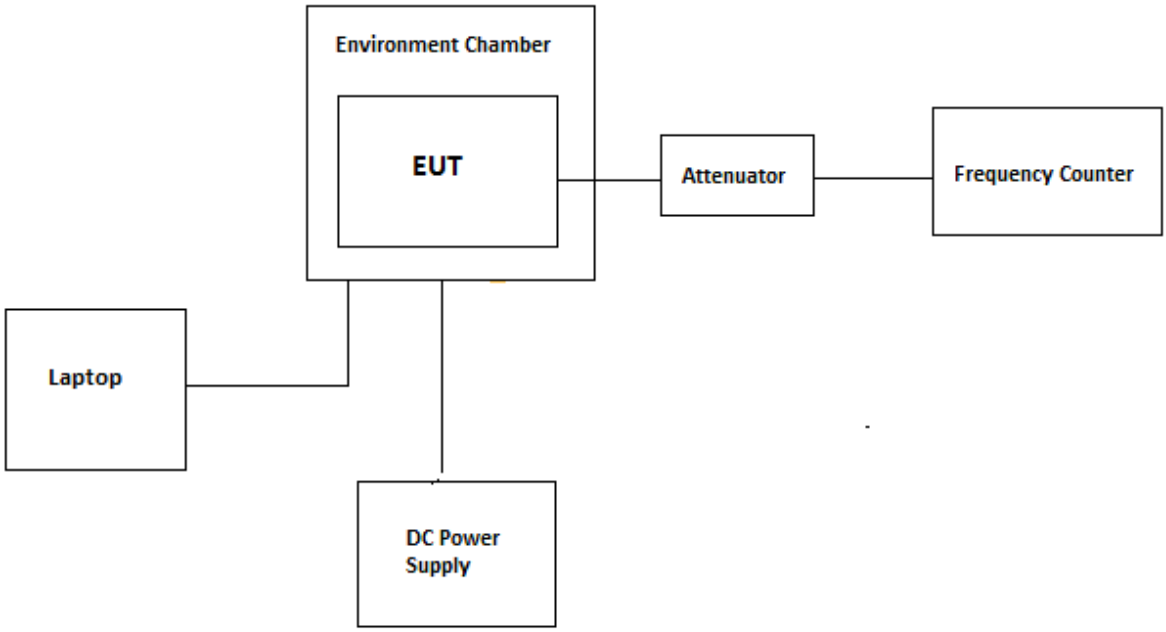
Test Instrument	Manufacturer	Model No	Serial No	Frequency Range	Cal Due date
Spectrum Analyzer	Rohde & Schwarz	FSU	100398	20Hz-26.5GHz	06 Oct 2019
AF Signal Generator	HP	HP-8920B	US39064699	30MHz-1GHz	20 Mar 2020
Hi-pass filter	Mini-Circuit	SHP-250	--	Cut off 250MHz	Cal on use
Attenuator(20dB)	Narda	26298	A577	DC-1GHz	Cal on use
Attenuator(20dB)	Aeroflex\Weinschel	23-20-34	BH7876	DC-18GHz	Cal on use
Power Supply	Dr. meter	HY5020E	013141252	1-40V, DC 20A	----
Multimeter	Tenma	72-6202	02080027	---	14 Dec 2019

6.4. Tx Radiated



Test Instrument	Manufacturer	Model No	Serial No	Frequency Range	Cal Due date
Spectrum Analyzer	Rohde & Schwarz	FSU	100398	20Hz-26.5GHz	06 Oct 2019
Log Periodic Antenna	ETS	3148	00023845	200-2000MHz	02 Aug 2020
Dipole	ETS-Lindgren	3121C-DB4	434	400-1000	03 Aug 2020
Preamplifier	Com-Power	PAM-118A	551016	500MHz-18GHz	09 Mar 2019
Preamplifier	Com-Power	PA-103	161040	1-1000MHz	16 May 2019
Bicon Antenna	ETS	3110B	3379	30-200MHz	06 Feb 2020
Horn Antenna	ETS	3117	00119425	1-18GHz	29 Jun 2019
Horn Antenna	ETS	3115	5955	1-18GHz	14 Jun 2020
Hi-pass filter	Mini-Circuit	SHP-600	--	Cut off 600MHz	Cal on use
Hi-pass filter	Mini-Circuit	SHP-800	--	Cut off 800MHz	Cal on use
Attenuator(20dB)	Narda	26298	A577	DC-1GHz	Cal on use
Attenuator(20dB)	Aeroflex\Weinschel	23-20-34	BH7876	DC-18GHz	Cal on use

6.5. Frequency Stability



Test Instrument	Manufacturer	Model No	Serial No	Frequency Range	Cal Due date
Frequency Counter	EIP	545A	2683	10MHz-1GHz	07 Aug 2020
Attenuator(20dB)	Weinschel	WA 35-20-33	A164	DC-8.5GHz	Cal on use
Attenuator(20dB)	Aeroflex\Weinschel	34-20-34	BP6023	DC-18GHz	Cal on use
Power Supply	Tenma	72-6153	-	1-18Vdc, 0-10A	----
Multimeter	Fluke	8842A	5021295	---	23 Oct 2019

EXHIBIT 7. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of CISPR 16-4-2 @ IEC:2003 and JCGM 100:2008 (GUM 1995) – Guide to the Expression of Uncertainty in Measurement.

7.1. RADIATED EMISSION MEASUREMENT UNCERTAINTY

	Radiated Emission Measurement Uncertainty @ 3m, Horizontal (30-1000 MHz):	**Measured (dB)**	**Limit (dB)**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{I=1}^{m} u_i^2(y)}$	**± 2.15**	**± 2.6**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 4.30**	**± 5.2**

	Radiated Emission Measurement Uncertainty @ 3m, Vertical (30-1000 MHz):	**Measured (dB)**	**Limit (dB)**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{I=1}^{m} u_i^2(y)}$	**± 2.14**	**± 2.6**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 4.29**	**± 5.2**

	Radiated Emission Measurement Uncertainty @ 3 m, Horizontal & Vertical (1 – 18 GHz):	**Measured (dB)**	**Limit (dB)**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{I=1}^{m} u_i^2(y)}$	**± 1.52**	**Under consideration**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 3.04**	**Under consideration**

EXHIBIT 8. MEASUREMENT METHODS

8.1. CONDUCTED POWER MEASUREMENTS

- The following shall be applied to the combination(s) of the radio device and its intended antenna(e).
- If the RF level is user adjustable, all measurements shall be made with the highest power level available to the user for that combination.
- The following method of measurement shall apply to both conducted and radiated measurements.
- The radiated measurements are performed at the Ultratech Calibrated Open Field Test Site.
- The measurement shall be performed using normal operation of the equipment with modulation.

Test procedure shall be as follows:

Step 1: Duty Cycle measurements if the transmitter's transmission is transient

- Using a EMI Receiver with the frequency span set to 0 Hz and the sweep time set at a suitable value to capture the envelope peaks and the duty cycle of the transmitter output signal;
- The duty cycle of the transmitter, x = Tx on / (Tx on + Tx off) with 0<x<1, is measure and recorded in the test report. For the purpose of testing, the equipment shall be operated with a duty cycle that is equal or more than 0.1.

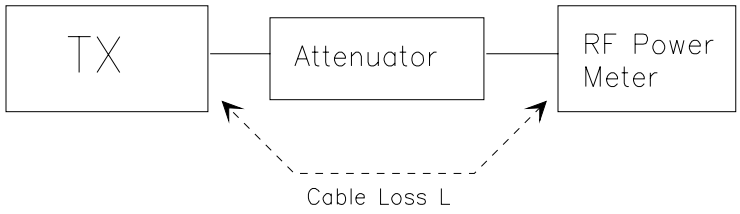
Step 2: Calculation of Average EIRP. See Figure 1

- The average output power of the transmitter shall be determined using a wideband, calibrated RF average power meter with the power sensor with an integration period that exceeds the repetition period of the transmitter by a factor 5 or more. The observed value shall be recorded as "A" (in dBm);
- The e.i.r.p. shall be calculated from the above measured power output "A", the observed duty cycle x, and the applicable antenna assembly gain "G" in dBi, according to the formula:

  EIRP = A + G + 10log(1/x)

  { X = 1 for continuous transmission => 10log(1/x) = 0 dB }

  Figure 1.



8.2. RADIATED POWER MEASUREMENTS (ERP & EIRP) USING SUBSTITUTION METHOD

8.2.1. Maximizing RF Emission Level (E-Field)

(a) The measurements were performed with full rf output power and modulation.
(b) Test was performed at listed 3m open area test site (listed with FCC, IC, ITI, NVLAP, ACA & VCCI).
(c) The transmitter under test was placed at the specified height on a non-conducting turntable (80 cm height)
(d) The BICONILOG antenna (20 MHz to 1 GHz) or HORN antenna (1 GHz to 18 GHz) was used for measuring.
(e) Load an appropriate correction factors file in EMI Receiver for correcting the field strength reading level

Total Correction Factor recorded in the EMI Receiver = Cable Loss + Antenna Factor
E (dBμV/m) = Reading (dBμV) + Total Correction Factor (dB/m)

(f) Set the EMI Receiver and #2 as follows:

Center Frequency:	test frequency
Resolution BW:	100 kHz
Video BW:	same
Detector Mode:	positive
Average:	off
Span:	3 x the signal bandwidth

(g) The test antenna was lowered or raised from 1 to 4 meters until the maximum signal level was detected.
(h) The transmitter was rotated through 360° about a vertical axis until a higher maximum signal was received.
(i) The test antenna was lowered or raised again from 1 to 4 meters until a maximum was obtained. This level was recorded.
(j) The recorded reading was corrected to the true field strength level by adding the antenna factor, cable loss and subtracting the pre-amplifier gain.
(k) The above steps were repeated with both transmitters' antenna and test receiving antenna placed in vertical and horizontal polarization. Both readings with the antennas placed in vertical and horizontal polarization shall be recorded.
(l) Repeat for all different test signal frequencies.

8.2.2.

8.2.3.

8.2.4. Measuring the EIRP of Spurious/Harmonic Emissions using Substitution Method

(a) Set the EMI Receiver (for measuring E-Field) and Receiver #2 (for measuring EIRP) as follows:

Center Frequency:	equal to the signal source
Resolution BW:	10 kHz
Video BW:	same
Detector Mode:	positive
Average:	off
Span:	3 x the signal bandwidth

(b) Load an appropriate correction factors file in EMI Receiver for correcting the field strength reading level

Total Correction Factor recorded in the EMI Receiver = Cable Loss + Antenna Factor
E (dBuV/m) = Reading (dBuV) + Total Correction Factor (dB/m)

(c) Select the frequency and E-field levels obtained in the Section 8.2.1 for ERP/EIRP measurements.
(d) Substitute the EUT by a signal generator and one of the following transmitting antenna (substitution antenna):
- DIPOLE antenna for frequency from 30-1000 MHz or
- HORN antenna for frequency above 1 GHz }.

(e) Mount the transmitting antenna at 1.5 meter high from the ground plane.
(f) Use one of the following antenna as a receiving antenna:
- DIPOLE antenna for frequency from 30-1000 MHz or
- HORN antenna for frequency above 1 GHz }.

(g) If the DIPOLE antenna is used, tune it's elements to the frequency as specified in the calibration manual.
(h) Adjust both transmitting and receiving antenna in a VERTICAL polarization.
(i) Tune the EMI Receivers to the test frequency.
(j) Lower or raise the test antenna from 1 to 4 meters until the maximum signal level was detected.
(k) The transmitter was rotated through 360° about a vertical axis until a higher maximum signal was received.
(l) Lower or raise the test antenna from 1 to 4 meters until the maximum signal level was detected.
(m) Adjust input signal to the substitution antenna until an equal or a known related level to that detected from the transmitter was obtained in the test receiver.
(n) Record the power level read from the Average Power Meter and calculate the ERP/EIRP as follows:

P = P1 - L1 = (P2 + L2) – L1 = P3 + A + L2 - L1
EIRP = P + G1 = P3 + L2 - L1 + A + G1
ERP = EIRP – 2.15 dB
Total Correction factor in EMI Receiver # 2 = L2 – L1 + G1

Where:	P:	Actual RF Power fed into the substitution antenna port after corrected.
	P1:	Power output from the signal generator
	P2:	Power measured at attenuator A input
	P3:	Power reading on the Average Power Meter
	EIRP:	EIRP after correction
	ERP:	ERP after correction

(o) Adjust both transmitting and receiving antenna in a HORIZONTAL polarization, then repeat step (k) to (o)
(p) Repeat step (d) to (o) for different test frequency
(q) Repeat steps (c) to (j) with the substitution antenna oriented in horizontal polarization.
(r) Actual gain of the EUT's antenna is the difference of the measured EIRP and measured RF power at the RF port. Correct the antenna gain if necessary.

Figure 2

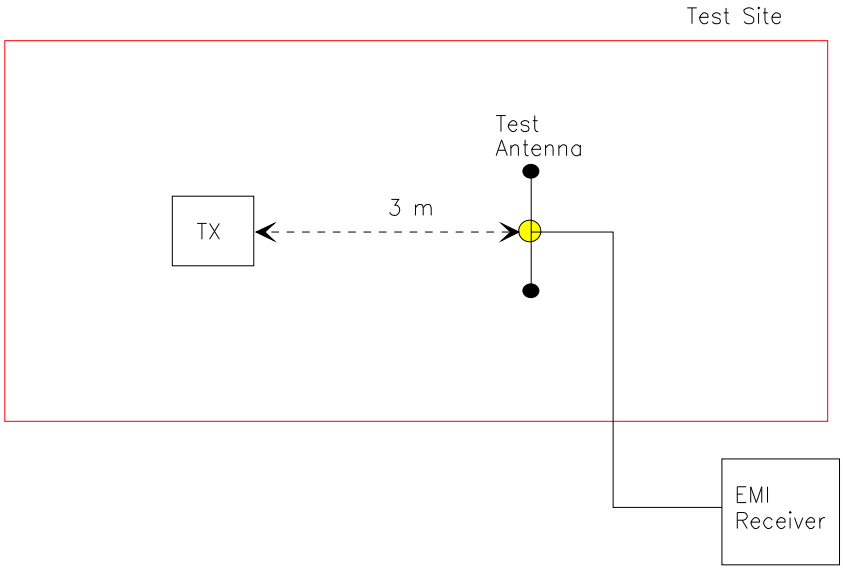
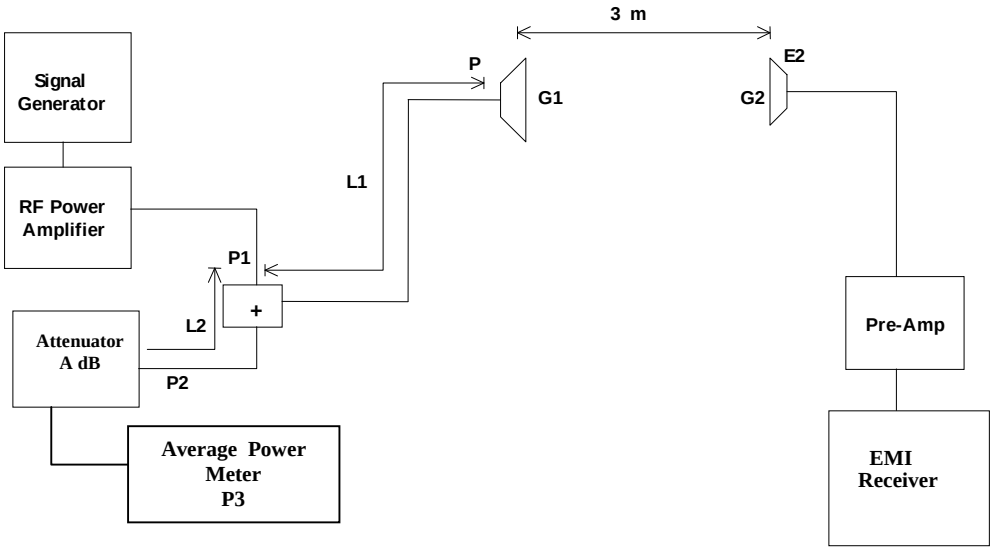


Figure 3



8.3. FREQUENCY STABILITY

Refer to FCC @ 2.1055.

(a) The frequency stability shall be measured with variation of ambient temperature as follows: From -30 to +50 centigrade except that specified in subparagraph (2) & (3) of this paragraph.

(b) Frequency measurements shall be made at extremes of the specified temperature range and at intervals of not more than 10 centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. The short-term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stability circuitry need be subjected to the temperature variation test.

(d) The frequency stability supply shall be measured with variation of primary supply voltage as follows:

(1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.

(2) For hand carried, battery powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.

(3) The supply voltage shall be measured at the input to the cable normally provide with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.

(e) When deemed necessary, the Commission may require tests of frequency stability under conditions in addition to those specifically set out in paragraphs (a), (b), (c) and (d) of this section. (For example, measurements showing the effect of proximity to large metal objects, or of various types of antennas, may be required for portable equipment).

8.4. SPURIOUS EMISSIONS (CONDUCTED)

With transmitter modulation characteristics described in Out-of-Band Emissions measurements @ 2.1049, the transmitter spurious and harmonic emissions were scanned. The spurious and harmonic emissions were measured with the EMI Receiver controls set as RBW = 30 kHz minimum , VBW $\geq$ RBW and SWEEP TIME = AUTO). The transmitter was operated at a full rated power output, and modulated as follows:

FCC CFR 47, Para. 2.1057 - Frequency spectrum to be investigated:- The spectrum was investigated from the lowest radio generated in the equipment up to at least the 10th harmonic of the carrier frequency or to the highest frequency practicable in the present state of the art of measuring techniques, whichever is lower. Particular attention should be paid to harmonics and subharmonics of the carrier frequency. Radiation at the frequencies of multiplier stages should be checked. The
amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.

FCC CFR 47, Para. 2.1051 - Spurious Emissions at Antenna Terminal:- The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of the harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in 2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.