ENGINEERING TEST REPORT

Eddy H2O Sensor v2.0
Model: Eddy H2O Sensor v2.0 (NA)
FCC ID: 2AKHG-H2OV2

Applicant:

Eddy Home Inc.
1600-25 Sheppard Avenue West
Toronto, Ontario
Canada M2N 6S6

In Accordance With

Federal Communications Commission (FCC)
Part 15, Subpart C, Section 15.247 Frequency Hopping Spread Spectrum (FHSS)

UltraTech's File No.: 17EDDY003_FCC15C247DSS

This Test report is Issued under the Authority of Tri M. Luu Vice President of Engineering UltraTech Group of Labs Date: August 3, 2017	
Report Prepared by: Dan Huynh Issued Date: August 3, 2017	Tested by: Hung Trinh Test Dates: December 1 - 16, 2016

- *The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.*
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91038 | 1309 | 46390-2049 | AT-1945 | SL2-IN-E-1119R | Korea KCC-RRA CA2049

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EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	FCC Part 15, Subpart C, Section 15.247
Title:	Code of Federal Regulations (CFR), Title 47 – Telecommunication, Part 15
Purpose of Test:	Equipment Certification
Test Procedures:	▪ ANSI C63.4 ▪ ANSI C63.10 ▪ FCC Public Notice DA 00-705
Environmental Classification:	[x] Commercial, industrial or business environment [x] Residential environment

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

None.

1.3. NORMATIVE REFERENCES

Publication	Year	Title
47 CFR Parts 0-19	2016	Code of Federal Regulations (CFR), 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 C63.10	2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
CISPR 22 & EN 55022	2008-09, Edition 6.0 2006	Information Technology Equipment - Radio Disturbance Characteristics - Limits and Methods of Measurement
CISPR 16-1-1 +A1 +A2	2006 2006 2007	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-1: Measuring Apparatus
CISPR 16-1-2 +A1 +A2	2003 2004 2006	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-2: Conducted disturbances
FCC Public Notice DA 00-705	2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
FCC ET Docket No. 99-231	2002	Amendment to FCC Part 15 of the Commission's Rules Regarding to Spread Spectrum Devices

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

APPLICANT	
Name:	Eddy Home Inc.
Address:	1600-25 Sheppard Avenue West Toronto, Ontario Canada M2N 6S6
Contact Person:	Mr. Joe Deu-Ngoc Phone #: 647-955-3061 Fax #: N/A Email Address: jdeungoc@eddyhome.com

MANUFACTURER	
Name:	Eddy Home Inc.
Address:	1919 Leslie Street Toronto, Ontario Canada M3B 2M3
Contact Person:	Mr. Joe Deu-Ngoc Phone #: 647-955-3061 Fax #: N/A Email Address: jdeungoc@eddyhome.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:	Eddy Home Inc.
Product Name:	Eddy H2O Sensor v2.0
Model Name or Number:	Eddy H2O Sensor v2.0 (NA)
Serial Number:	Test Sample
Type of Equipment:	Spread Spectrum Transmitter
Input Power Supply Type:	3V LiMnO2 Battery
Primary User Functions of EUT:	Leak detection, temperature measurement, humidity measurement, wireless event reporting.

2.3. EUT'S TECHNICAL SPECIFICATIONS

Transmitter	
Equipment Type:	Mobile
Intended Operating Environment:	▪ Commercial, industrial or business environment ▪ Residential environment
Power Supply Requirement:	3 V LiMnO2 Battery
RF Output Power Rating:	18.90 dBm Peak Power
Operating Frequency Range:	902.3 - 927.7 MHz
RF Output Impedance:	50 Ω
Duty Cycle:	Continuous
Modulation Type:	LoRa™ (CSS)
Antenna Connector Type:	Spring contact

2.4. ASSOCIATED ANTENNA DESCRIPTIONS

Manufacturer:	Eddy Home Inc.
Type:	PIFA
Model:	ANT-100102-002
Frequency Range:	863-928 MHz
Gain (dBi):	-5.0

2.5. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
No I/O ports.				

2.6. ANCILLARY EQUIPMENT

The EUT was tested while connected to the following representative configuration of ancillary equipment necessary to exercise the ports during tests:

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 to 23 ^{o}C
Humidity:	45 to 58%
Pressure:	102 kPa
Power Input Source:	3 VDC

3.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TESTS

Operating Modes:	▪ Each of lowest, middle and highest channel frequencies transmits continuously for emissions measurements. ▪ The EUT operates in normal Frequency Hopping mode for occupancy duration, and frequency separation.
Special Test Software & Hardware:	Test software provided by the Applicant is installed to allow the EUT to operate in hopping mode or at each channel frequency continuously. For example, the transmitter will be operated at each of lowest, middle and highest frequencies individually continuously during testing.
Transmitter Test Antenna:	The EUT is tested with the antenna fitted in a manner typical of normal intended use, antenna is enclosed in the chassis of the EUT.

Transmitter Test Signals	
Frequency Band(s):	902.3 - 927.7 MHz
Frequency(ies) Tested: (Near lowest, near middle & near highest frequencies in the frequency range of operation.)	902.3 MHz, 915.0 MHz and 927.7 MHz
RF Power Output: (measured maximum output power at antenna terminals)	18.90 dBm (77.62 mW)
Normal Test Modulation:	LoRa™ (CSS)
Modulating Signal Source:	Internal

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.

- AC Power Line Conducted Emissions were performed in UltraTech's shielded room, 24'(L) by 16'(W) by 8'(H).
- 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 EMC EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Compliance (Yes/No)
15.203	Antenna requirements	Yes
15.207(a)	AC Power Line Conducted Emissions	N/A
15.247(a)	Provisions for Frequency Hopping Systems	Yes
15.247(b)(2)	Peak Conducted Output Power	Yes
15.247(d), 15.209 & 15.205	Transmitter Spurious Radiated Emissions	Yes
15.247(i), 1.1307, 1.1310, 2.1091	RF Exposure	Yes

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None.

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

5.1. COMPLIANCE WITH FCC PART 15 – GENERAL TECHNICAL REQUIREMENTS

FCC Section	FCC Rules	Manufacturer's Clarification
15.203	Described how the EUT complies with the requirement that either its antenna is permanently attached, or that it employs a unique antenna connector, for every antenna proposed for use with the EUT. The exception is in those cases where EUT must be professionally installed. In order to demonstrate that professional installation is required, the following 3 points must be addressed: ➢ The application (or intended use) of the EUT ➢ The installation requirements of the EUT ➢ The method by which the EUT will be marketed	The antenna is enclose in the chassis of the EUT.
15.204	Provided the information for every antenna proposed for use with the EUT: ➢ type (e.g. Yagi, patch, grid, dish, etc…), ➢ manufacturer and model number ➢ gain with reference to an isotropic radiator	See section 2.4 of this report for associated antenna.
15.247(a)	Description of how the EUT meets the definition of a frequency hopping spread spectrum, found in Section 2.1. Based on the technical description.	See Operational Description
15.247(a)	Pseudo Frequency Hopping Sequence: Describe how the hopping sequence is generated. Provide an example of the hopping sequence channels, in order to demonstrate that the sequence meets the requirements specified in the definition of a frequency hopping spread spectrum system, found in Section 2.1	See Operational Description
15.247(a)	Equal Hopping Frequency Use: Describe how each individual EUT meets the requirement that each of its hopping channels is used equally on average (e.g. that each new transmission event begins on the next channel in the hopping sequence after final channel used in the previous transmission events).	See Operational Description

FCC Section	FCC Rules	Manufacturer's Clarification
15.247(a)	System Receiver Input Bandwidth: Describe how the associated receiver(s) complies with the requirement that its input bandwidth (either RF or IF) matches the bandwidth of the transmitted signal.	See Operational Description
15.247(a)	System Receiver Hopping Capability: Describe how the associated receiver(s) has the ability to shift frequencies in synchronization with the transmitted signals	See Operational Description
15.247(g)	Describe how the EUT complies with the requirement that it be designed to be capable of operating as a true frequency hopping system	See Operational Description
15.247(h)	Describe how the EUT complies with the requirement that it not have the ability to coordinated with other FHSS is an effort to avoid the simultaneous occupancy of individual hopping frequencies by multiple transmitters	See Operational Description

5.2. PROVISIONS FOR FREQUENCY HOPPING SYSTEMS [§ 15.247(a)(1)]

5.2.1. Limits

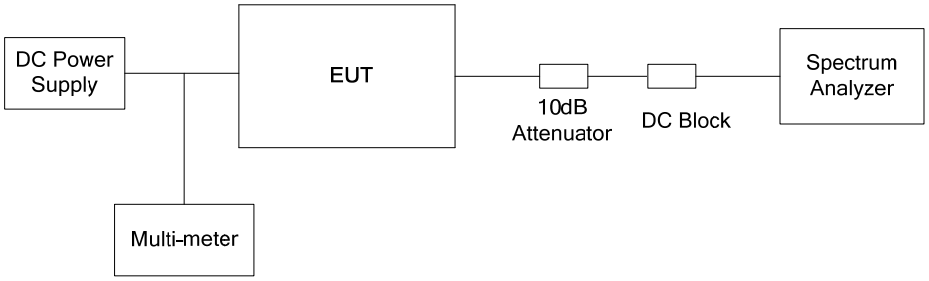
§ 15.247(a)(1): Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier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

§ 15.247(a)(1)(i): For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

5.2.2. Method of Measurements

FCC Public Notice DA 00-705 and ANSI C63.10

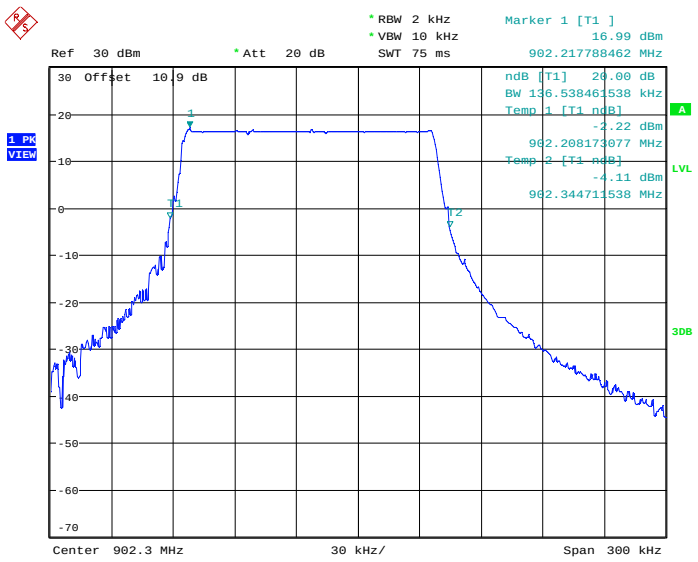
5.2.3. Test Arrangement



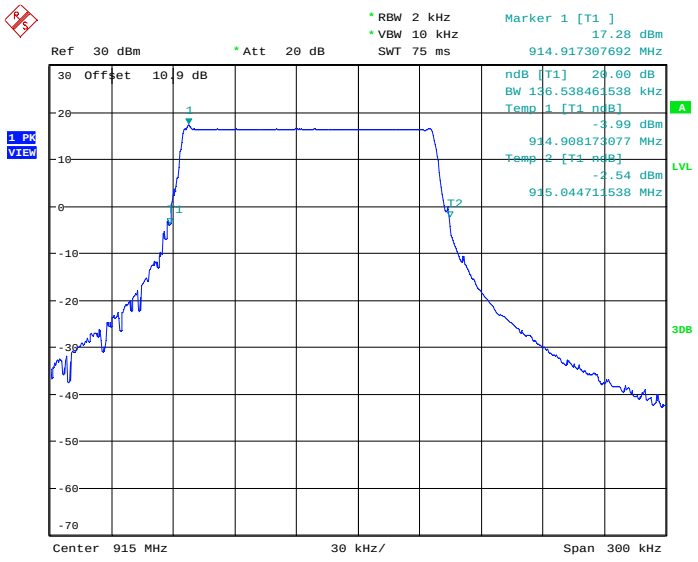
5.2.4. Test Data

Test Description	FCC Specification	Measured Values	Comments
Frequency Hopping Systems Requirements	The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.	--	See Note 1
20 dB BW of the hopping channel	The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz	Max. 20dB Bandwidth: 137.019 kHz	See Note 2
Channel Hopping Frequency Separation	Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.	204.41 kHz (for 980, 1760 and 3125 kbps data rates) 198.40 kHz (for 5470 kbps data rate)	See Note 2
Number hopping frequencies	If the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies. If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies.	Minimum hopping frequencies used: 58	See Note 1 and 2
Average Time of Occupancy	If the 20 dB bandwidth of the hopping channel is less than 250 kHz, the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period. If the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period.	Maximum average time of occupancy within a 20 second period: 326.1522 ms	See Note 2
Note 1: See operational description exhibit for details. **Note 2**: See the following plots for details.			

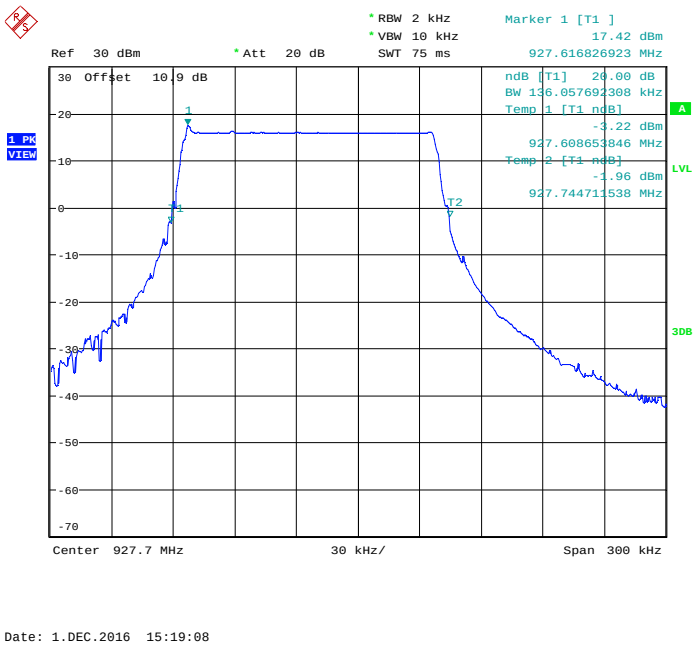
Plot 5.2.4.1. 20 dB Bandwidth, 902.3 MHz, 980 bps



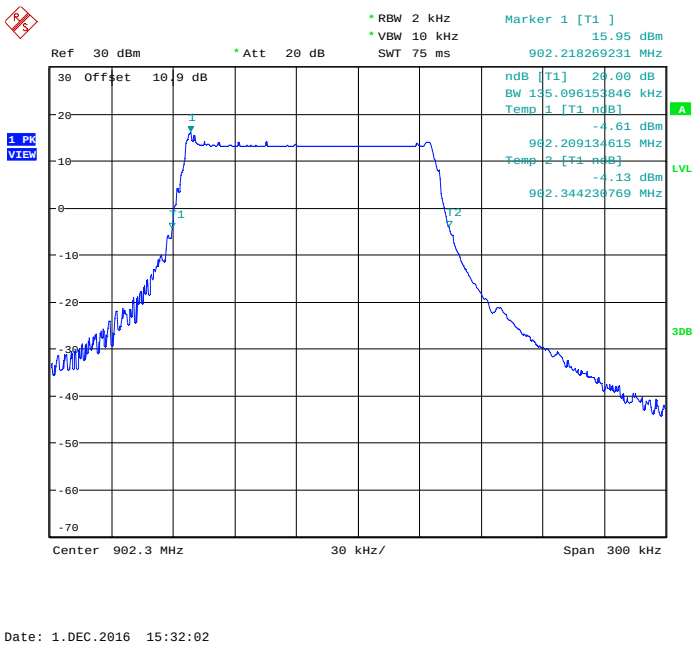
Plot 5.2.4.2. 20 dB Bandwidth, 915.0 MHz, 980 bps



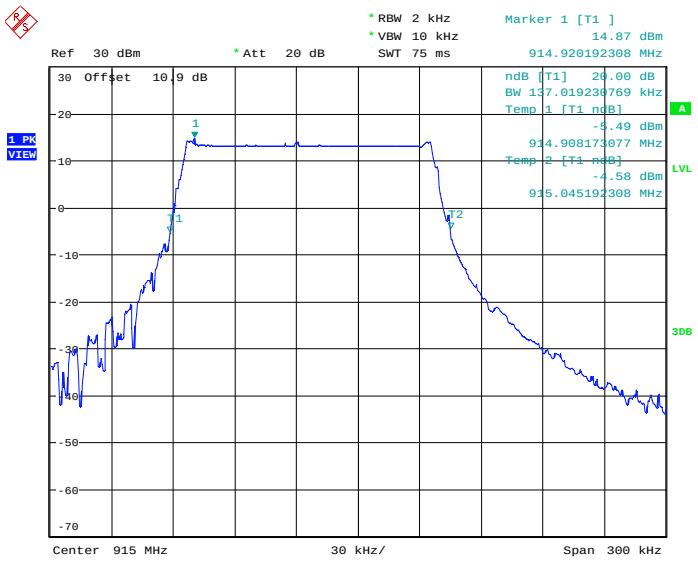
Plot 5.2.4.3. 20 dB Bandwidth, 927.7 MHz, 980 bps



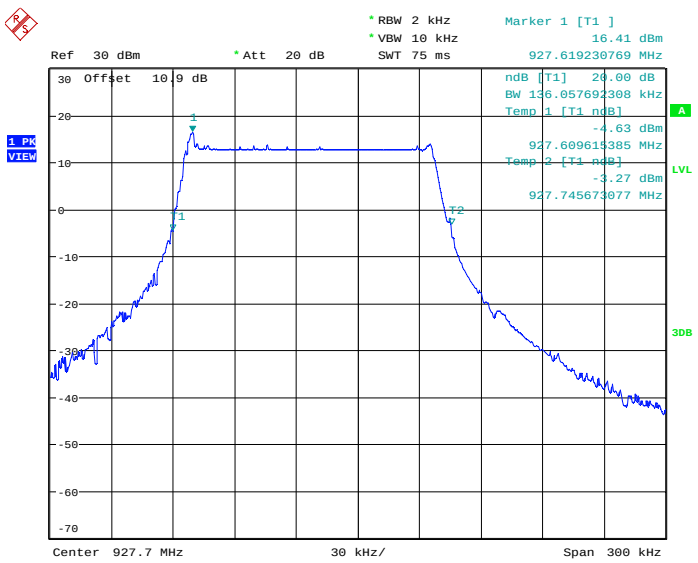
Plot 5.2.4.4. 20 dB Bandwidth, 902.3 MHz, 1760 bps



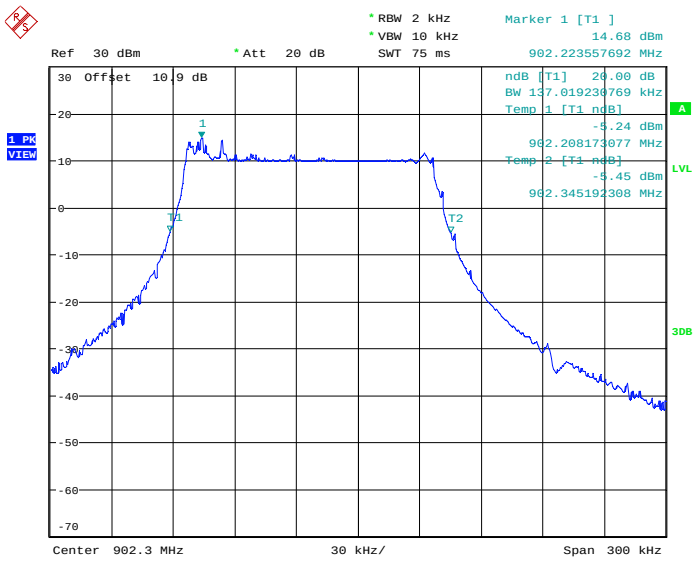
Plot 5.2.4.5. 20 dB Bandwidth, 915.0 MHz, 1760 bps



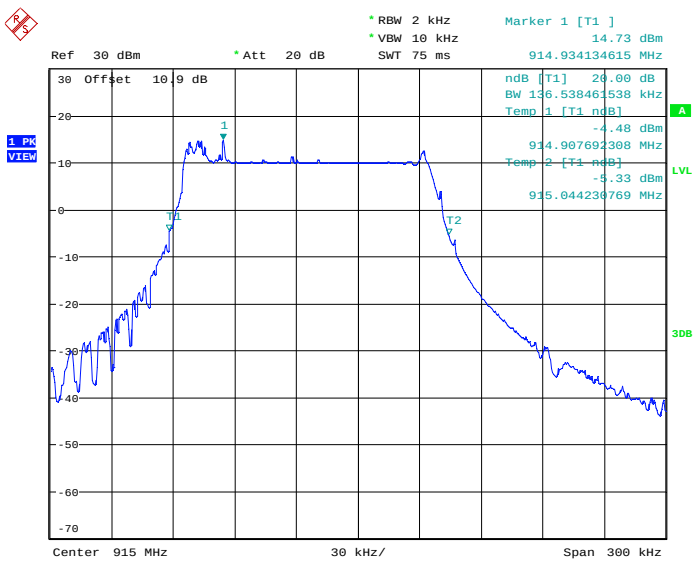
Plot 5.2.4.6. 20 dB Bandwidth, 927.7 MHz, 1760 bps



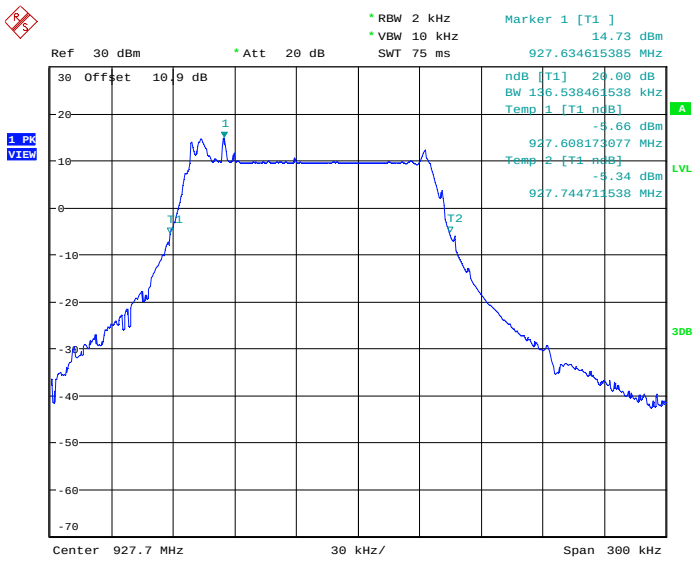
Plot 5.2.4.7. 20 dB Bandwidth, 902.3 MHz, 3125 bps



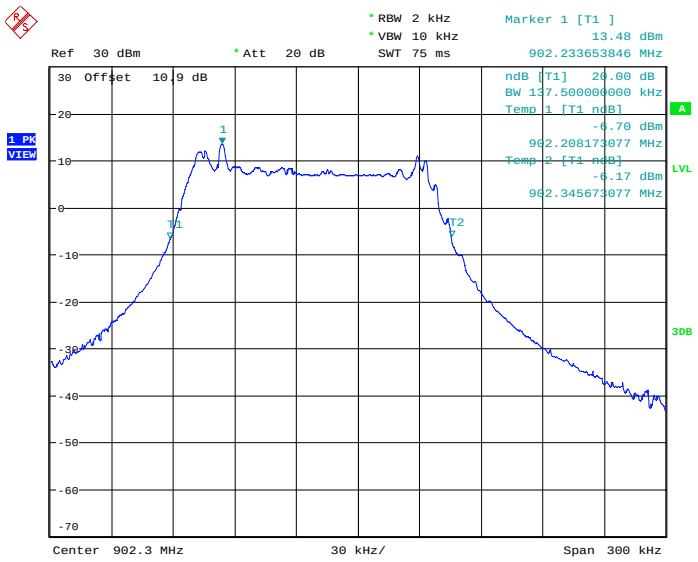
Plot 5.2.4.8. 20 dB Bandwidth, 915.0 MHz, 3125 bps



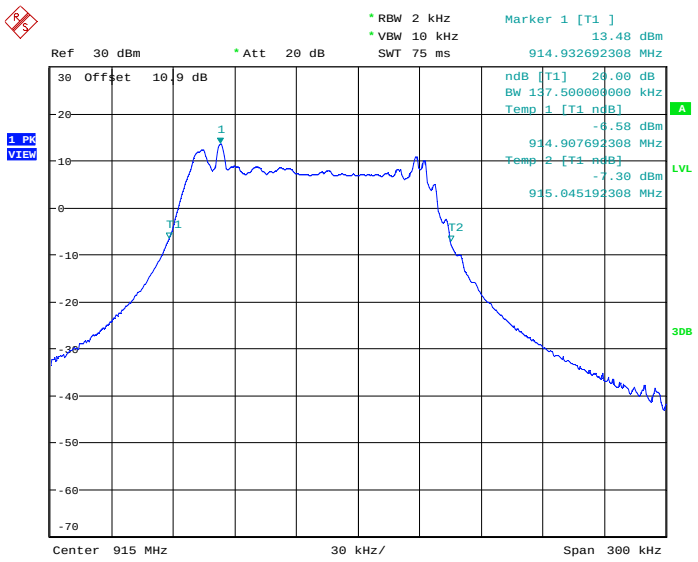
Plot 5.2.4.9. 20 dB Bandwidth, 927.7 MHz, 3125 bps



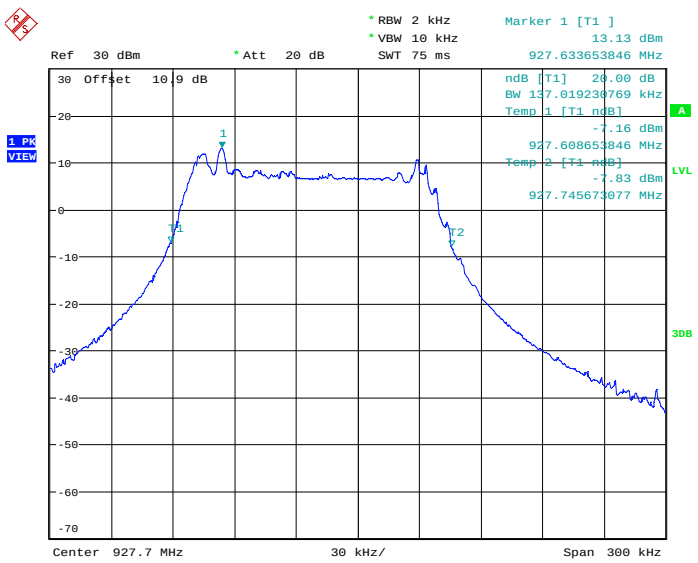
Plot 5.2.4.10. 20 dB Bandwidth, 902.3 MHz, 5470 bps



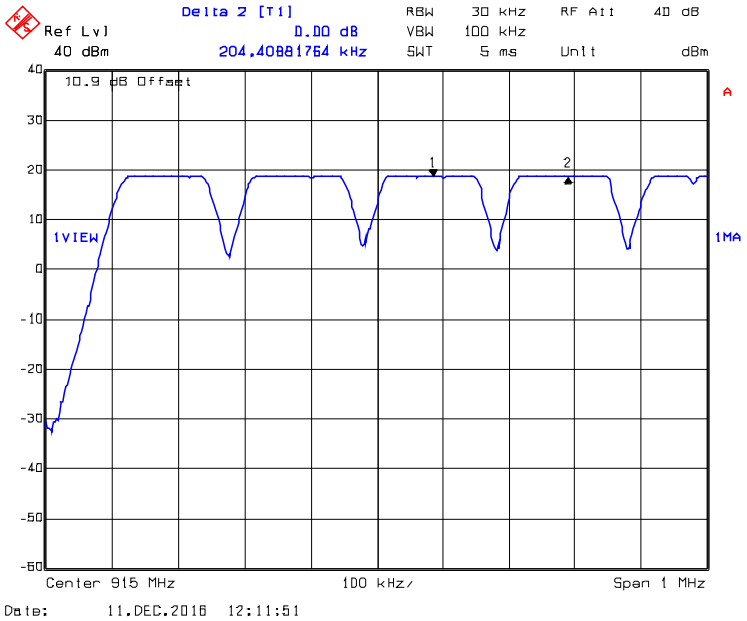
Plot 5.2.4.11. 20 dB Bandwidth, 915.0 MHz, 5470 bps



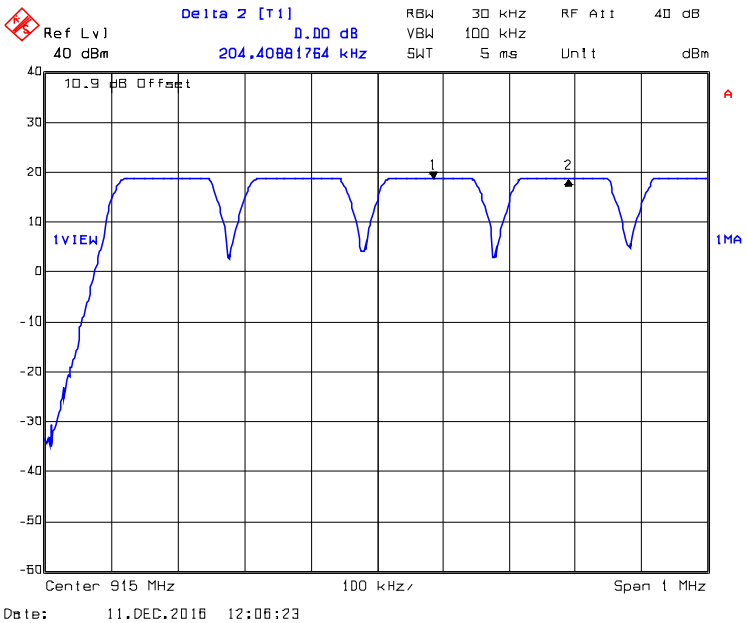
Plot 5.2.4.12. 20 dB Bandwidth, 927.7 MHz, 5470 bps



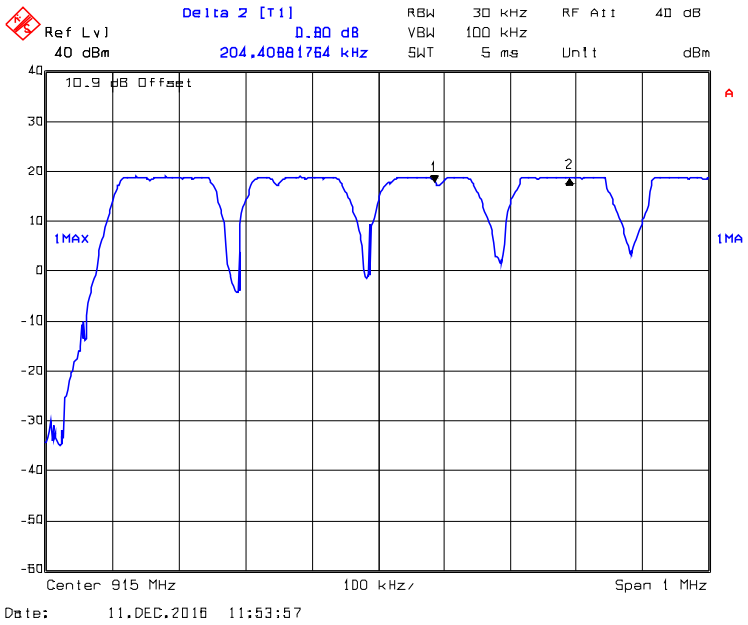
Plot 5.2.4.13. Carrier Frequency Separation, 915.0 MHz, 980 bps, Pseudorandom Hopping Sequence



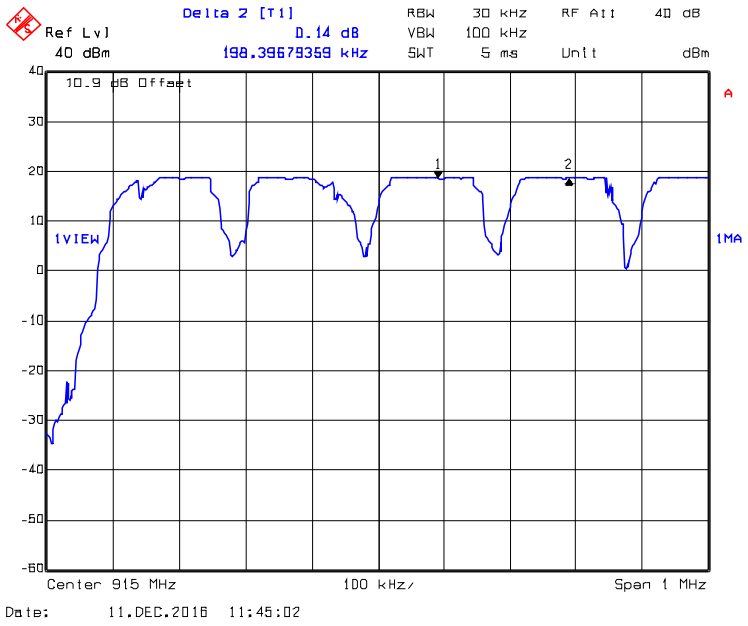
Plot 5.2.4.14. Carrier Frequency Separation, 915.0 MHz, 1760 bps, Pseudorandom Hopping Sequence



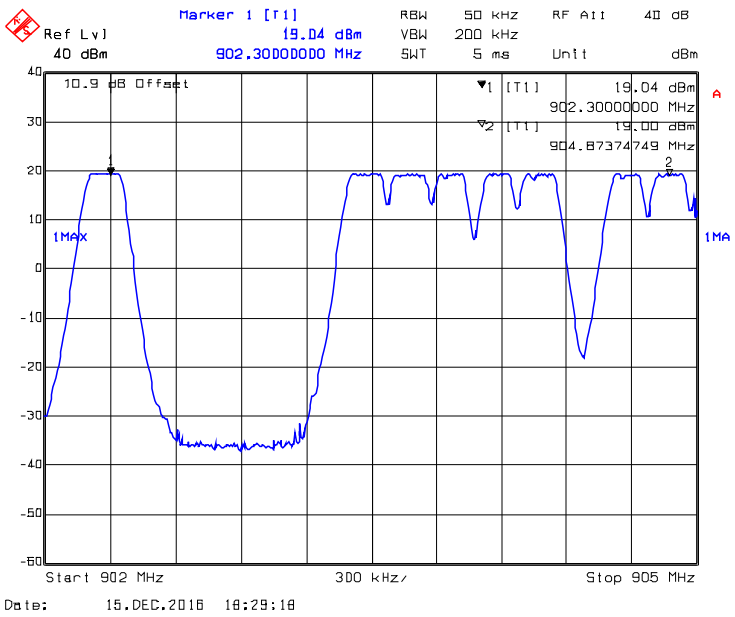
Plot 5.2.4.15. Carrier Frequency Separation, 915.0 MHz, 3125 bps, Pseudorandom Hopping Sequence



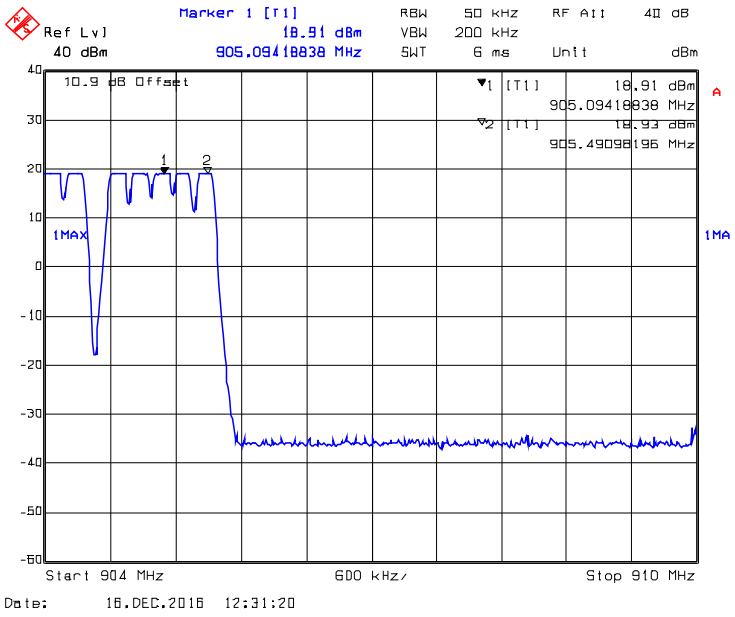
Plot 5.2.4.16. Carrier Frequency Separation, 915.0 MHz, 5470 bps, Pseudorandom Hopping Sequence



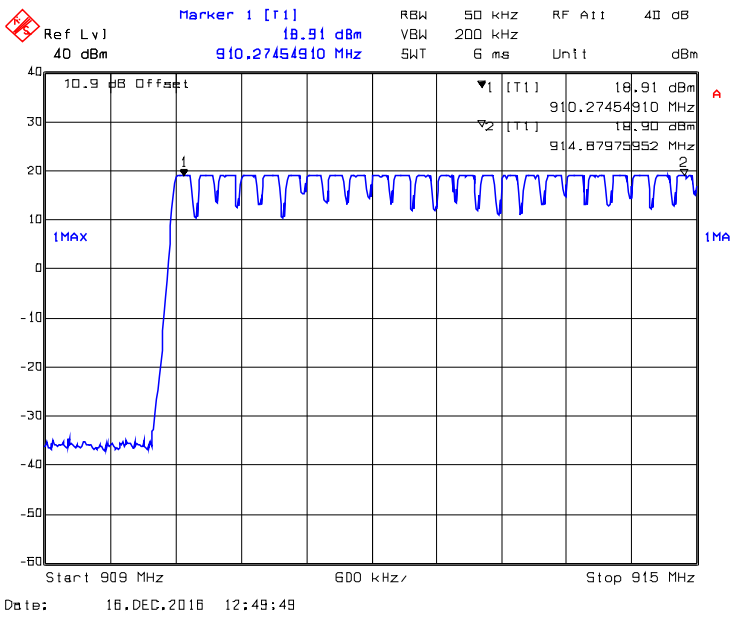
Plot 5.2.4.17. Number of Hopping Frequencies, 980 bps
8 Hopping Channels from 902 – 905 MHz



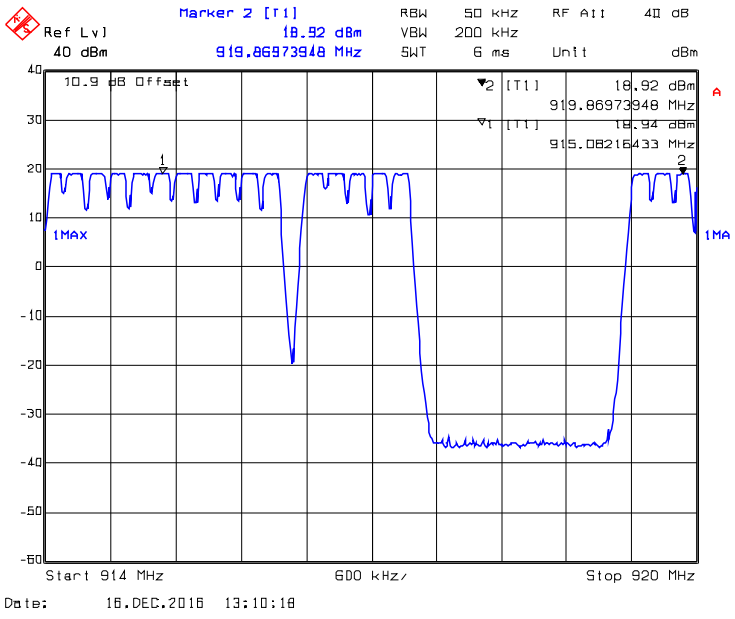
Plot 5.2.4.18. Number of Hopping Frequencies, 980 bps
3 Hopping Channels from 905 – 910 MHz



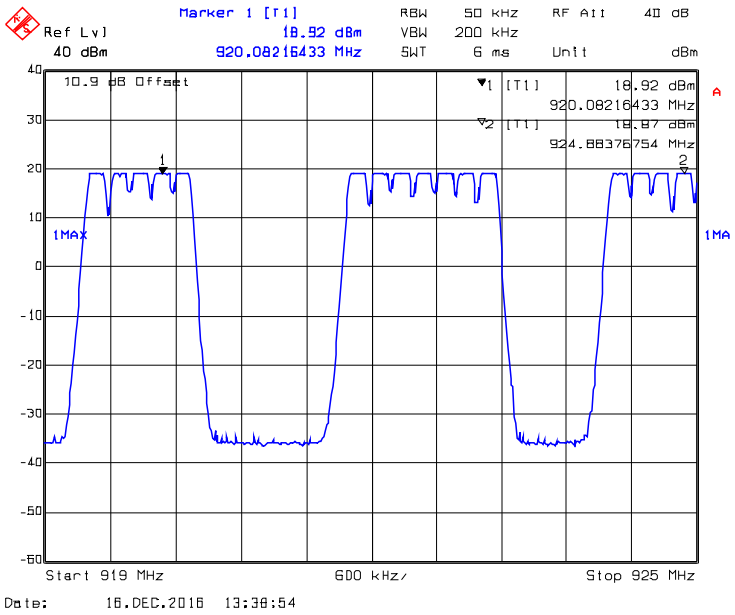
Plot 5.2.4.19. Number of Hopping Frequencies, 980 bps
24 Hopping Channels from 910 – 915 MHz



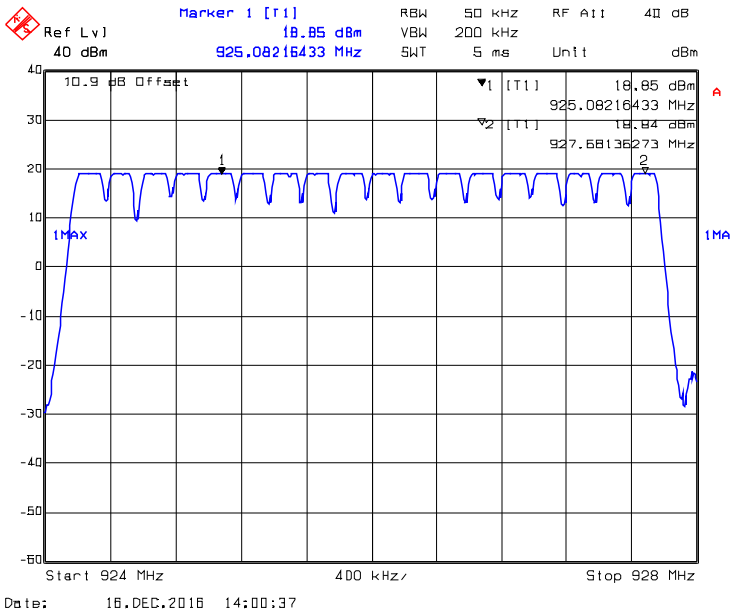
Plot 5.2.4.20. Number of Hopping Frequencies, 980 bps
14 Hopping Channels from 915 – 920 MHz



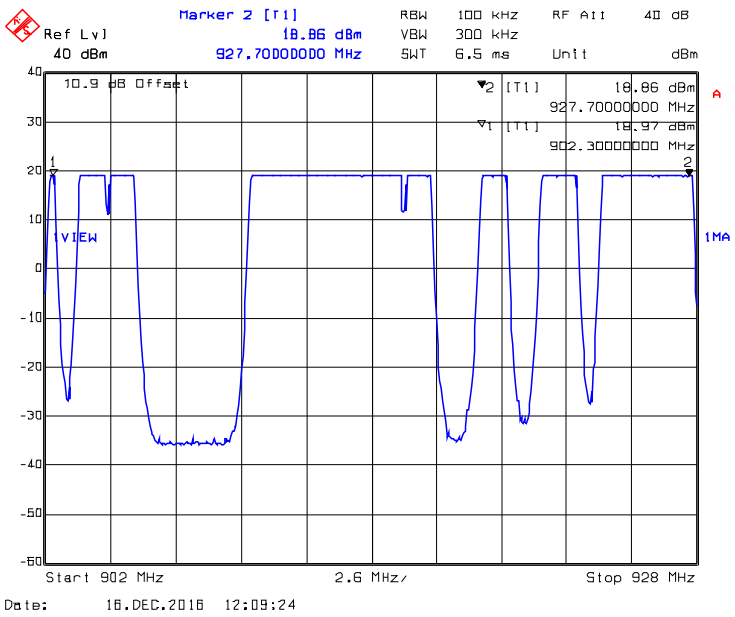
Plot 5.2.4.21. Number of Hopping Frequencies, 980 bps
13 Hopping Channels from 920 – 925 MHz



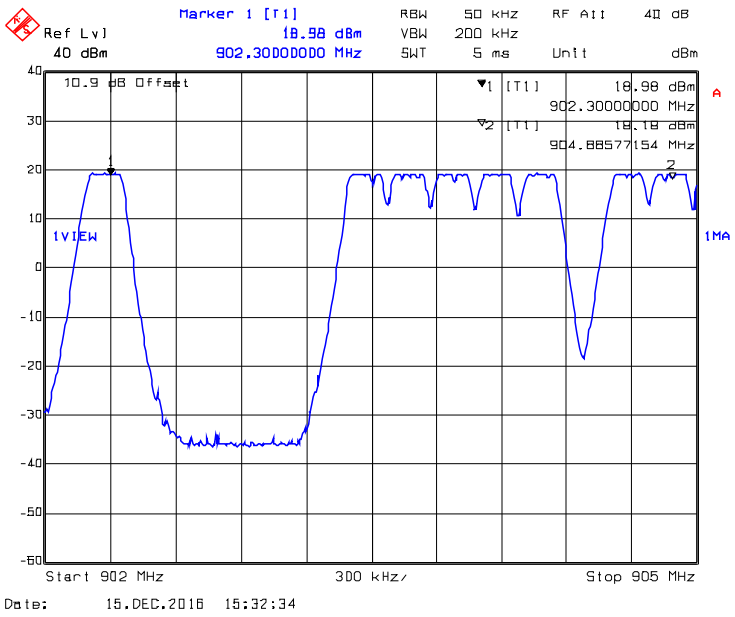
Plot 5.2.4.22. Number of Hopping Frequencies, 980 bps
14 Hopping Channels from 925 – 928 MHz



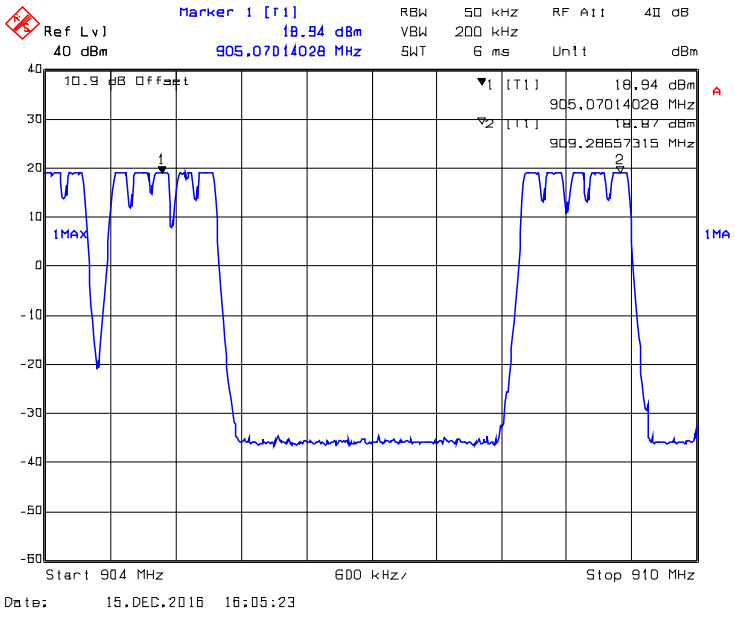
Plot 5.2.4.23. Number of Hopping Frequencies, 980 bps
Total Number of Hopping Channels is 76 (8+3+24+14+13+14) from 902 – 928 MHz



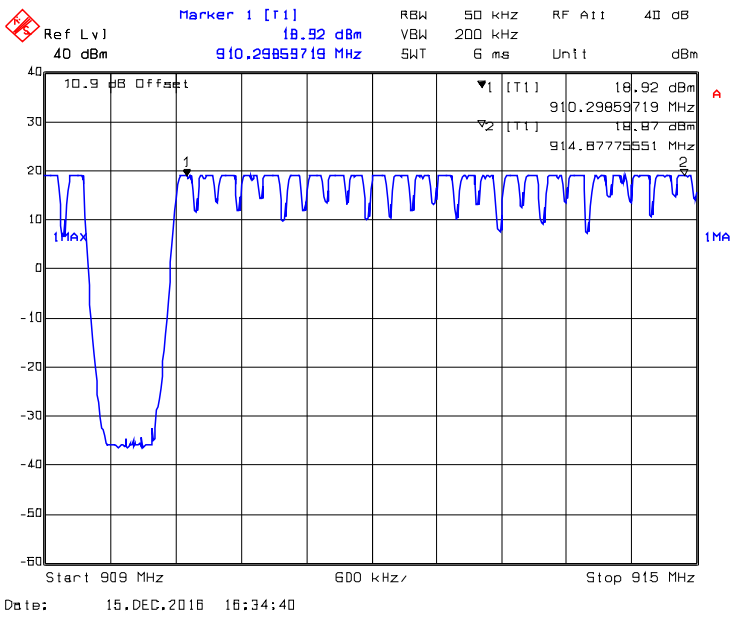
Plot 5.2.4.24. Number of Hopping Frequencies, 1760 bps
8 Hopping Channels from 902 – 905 MHz



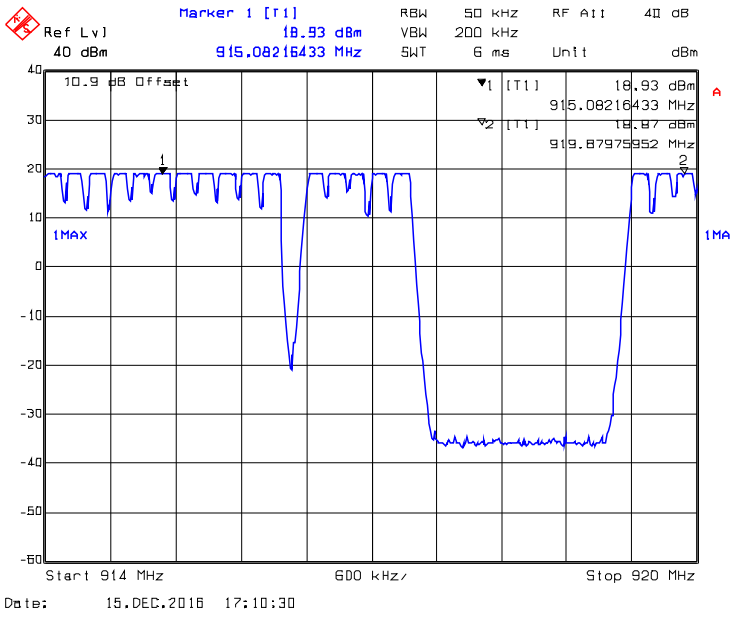
Plot 5.2.4.25. Number of Hopping Frequencies, 1760 bps
8 Hopping Channels from 905 – 910 MHz



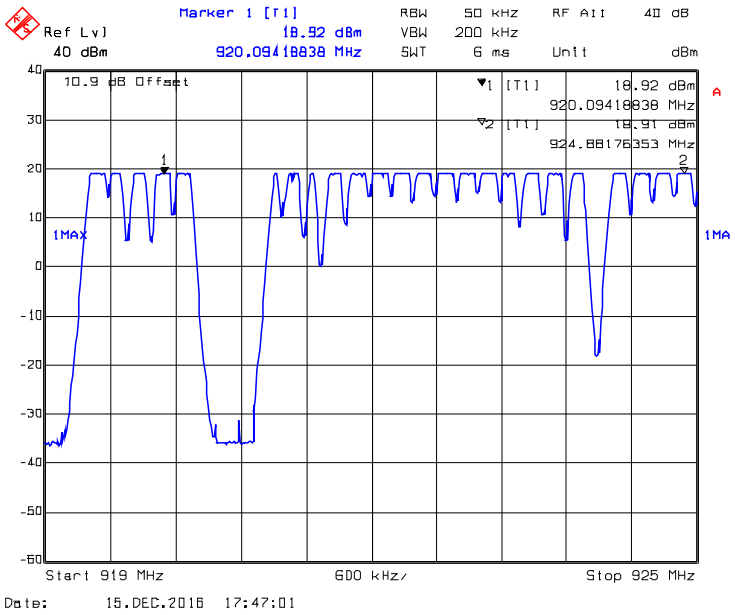
Plot 5.2.4.26. Number of Hopping Frequencies, 1760 bps
24 Hopping Channels from 910 – 915 MHz



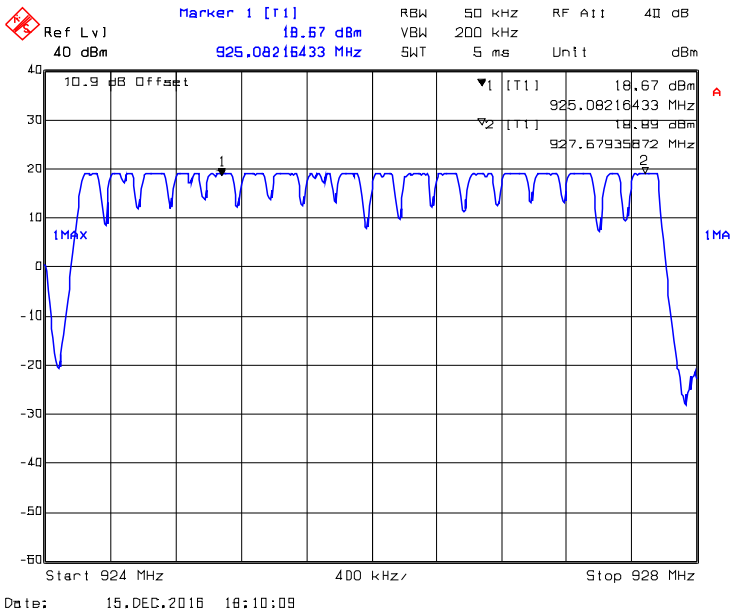
Plot 5.2.4.27. Number of Hopping Frequencies, 1760 bps
14 Hopping Channels from 915 – 920 MHz



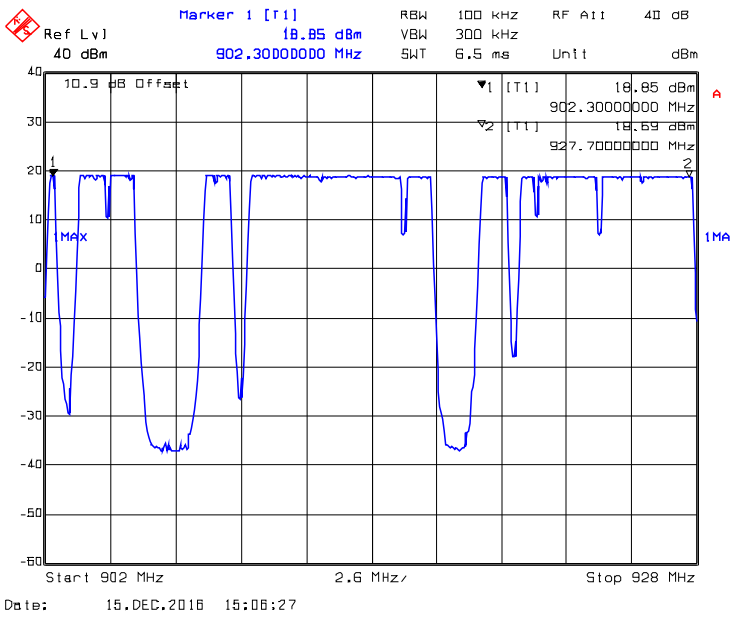
Plot 5.2.4.28. Number of Hopping Frequencies, 1760 bps
21 Hopping Channels from 920 – 925 MHz



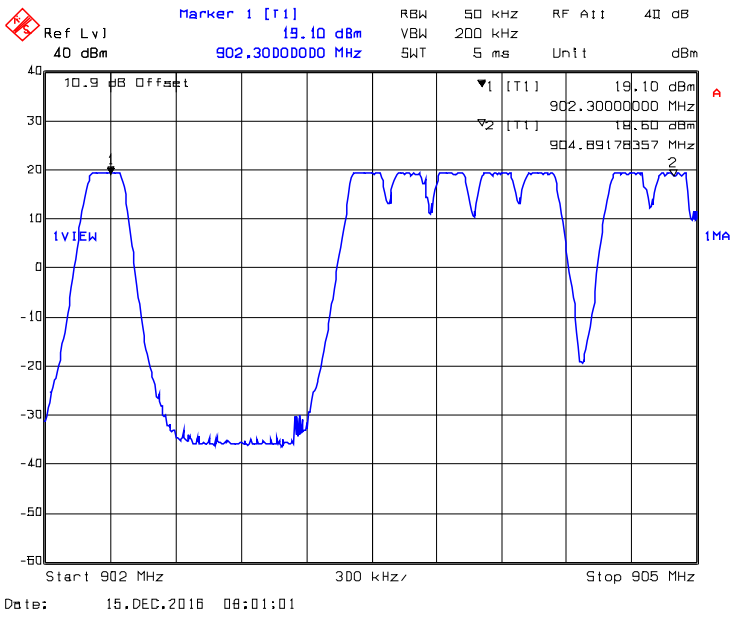
Plot 5.2.4.29. Number of Hopping Frequencies, 1760 bps
14 Hopping Channels from 925 – 928 MHz



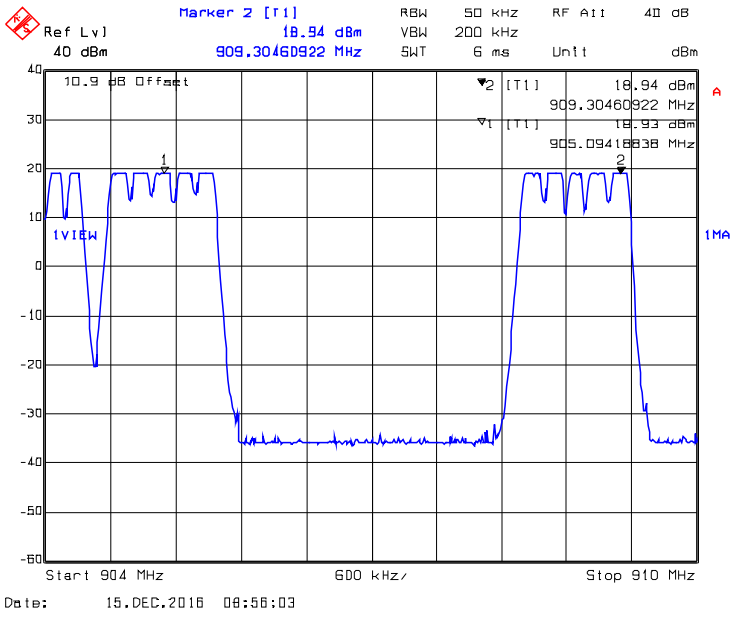
Plot 5.2.4.30. Number of Hopping Frequencies, 1760 bps
Total Number of Hopping Channel is 89 (8+8+24+14+21+14) from 902 – 928 MHz



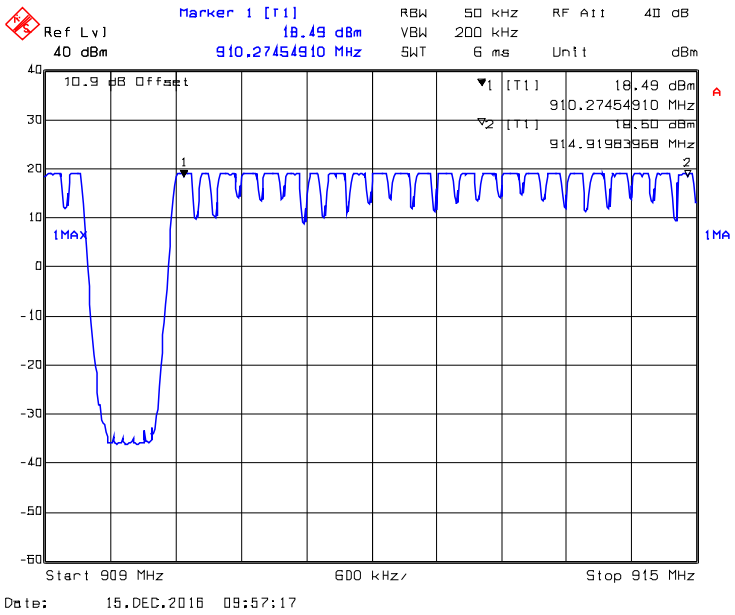
Plot 5.2.4.31. Number of Hopping Frequencies, 3125 bps
8 Hopping Channels from 902 – 905 MHz



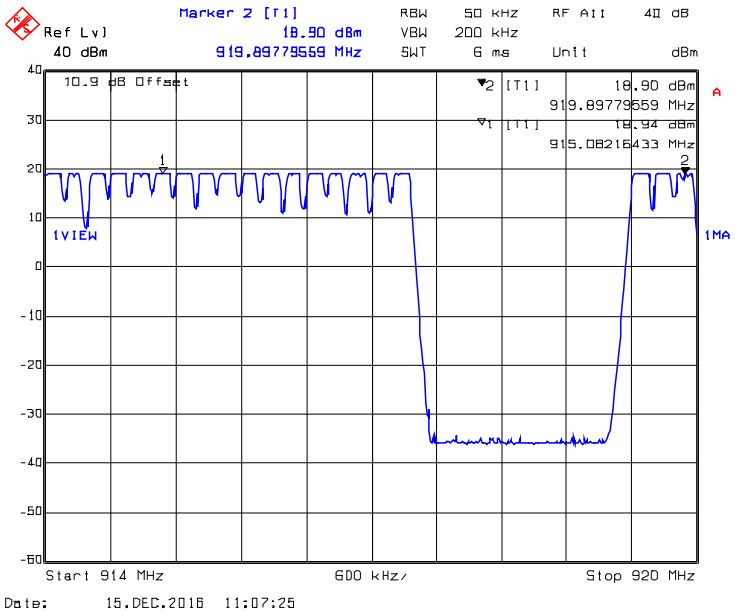
Plot 5.2.4.32. Number of Hopping Frequencies, 3125 bps
8 Hopping Channels from 905 – 910 MHz



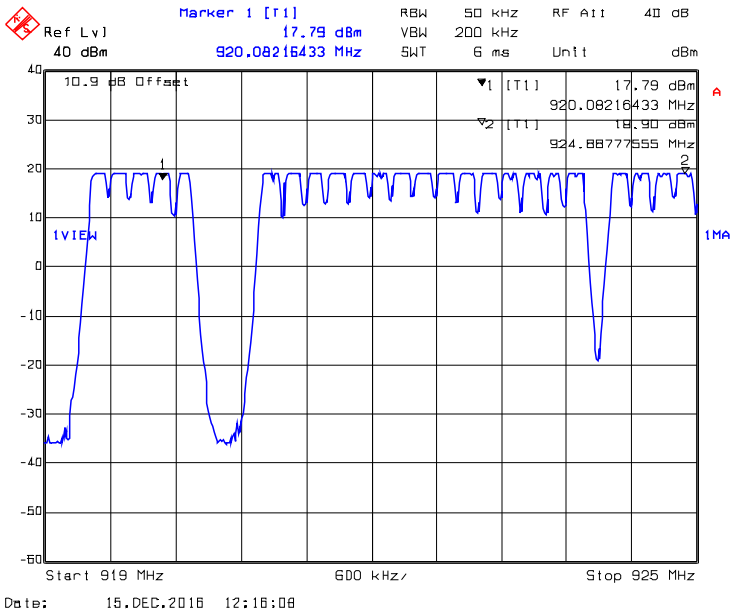
Plot 5.2.4.33. Number of Hopping Frequencies, 3125 bps
24 Hopping Channels from 910 – 915 MHz



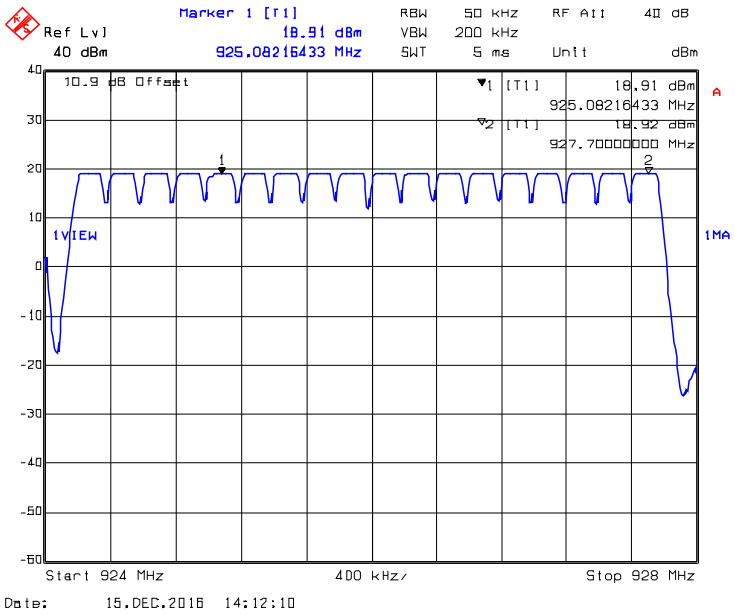
Plot 5.2.4.34. Number of Hopping Frequencies, 3125 bps
15 Hopping Channels from 915 – 920 MHz



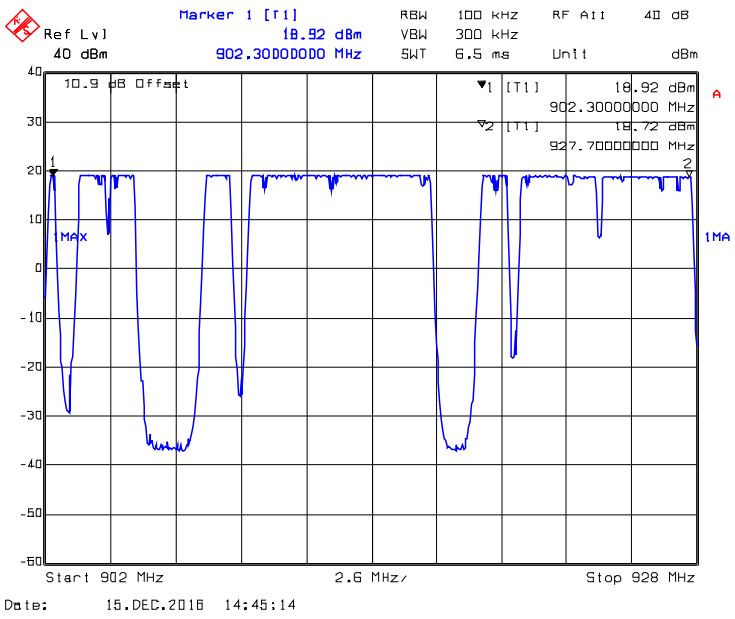
Plot 5.2.4.35. Number of Hopping Frequencies, 3125 bps
21 Hopping Channels from 920 – 925 MHz



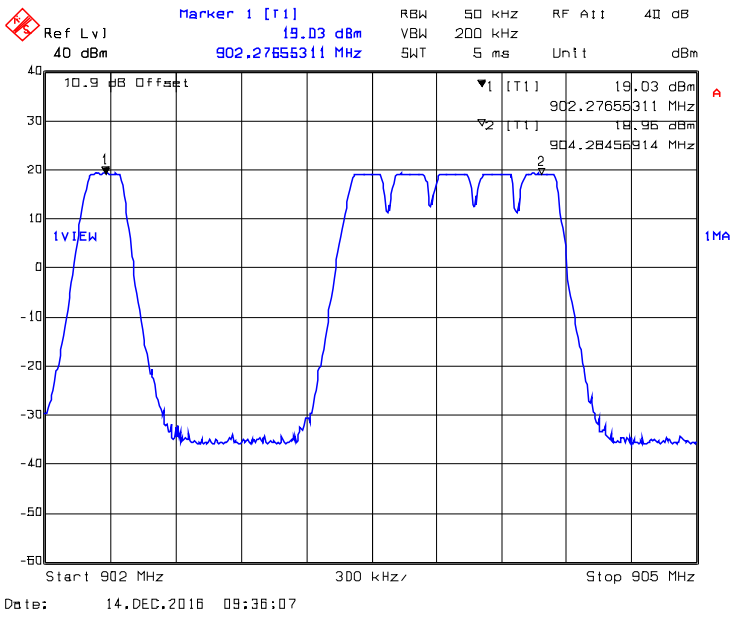
Plot 5.2.4.36. Number of Hopping Frequencies, 3125 bps
14 Hopping Channels from 925 – 928 MHz



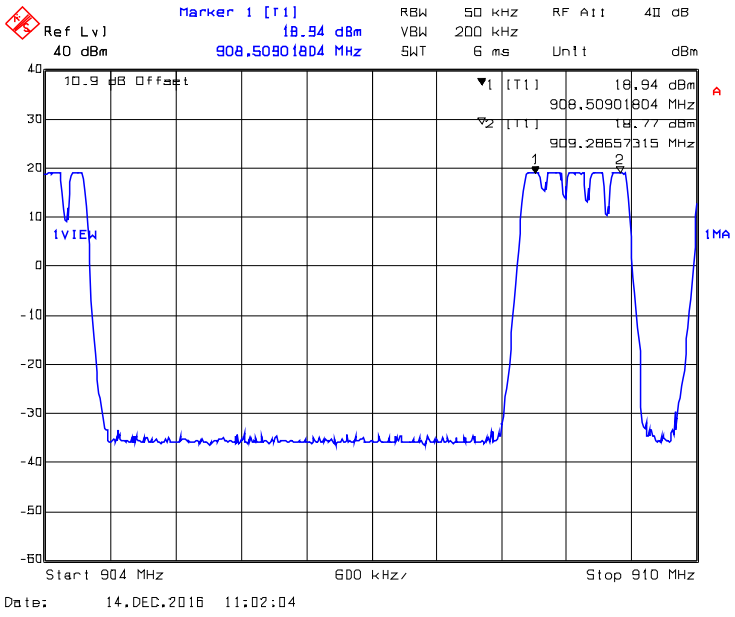
Plot 5.2.4.37. Number of Hopping Frequencies, 3125 bps
Total Number of Hopping Channel is 90 (8+8+24+15+21+14) from 902 – 928 MHz



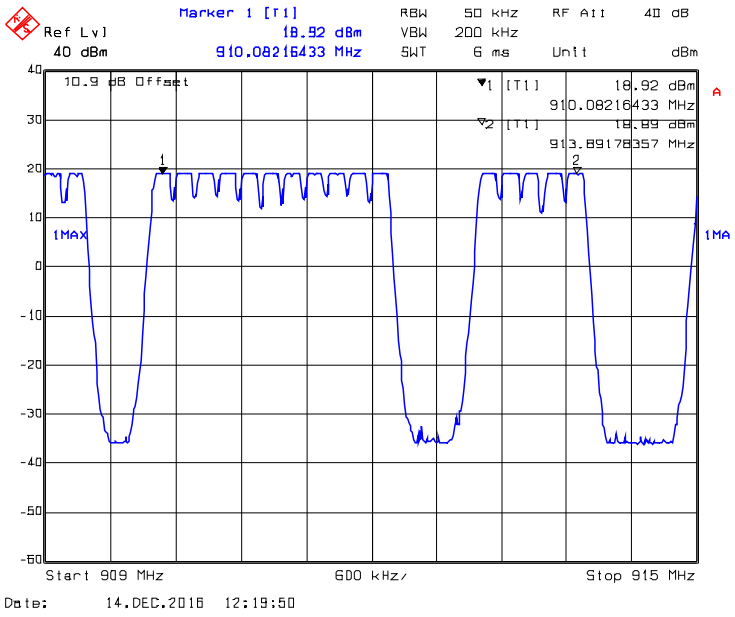
Plot 5.2.4.38. Number of Hopping Frequencies, 5470 bps
6 Hopping Channels from 902 – 905 MHz



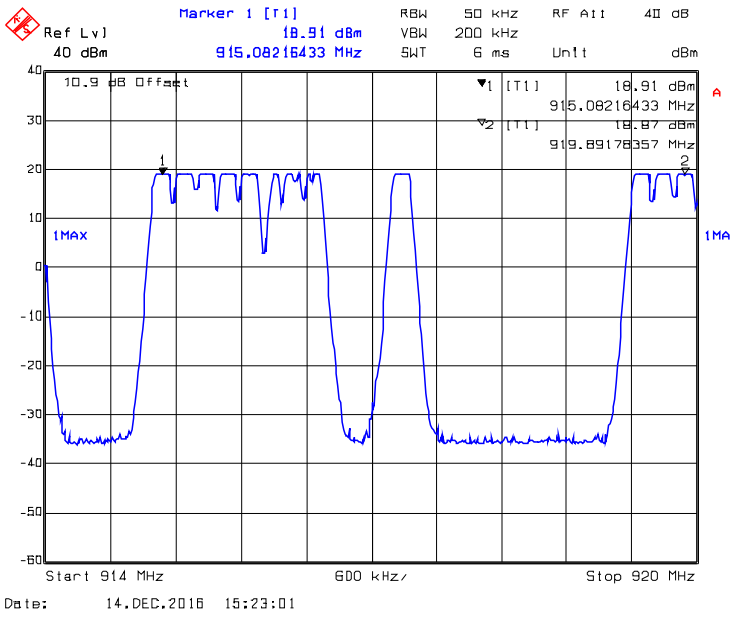
Plot 5.2.4.39. Number of Hopping Frequencies, 5470 bps
5 Hopping Channels from 905 – 910 MHz



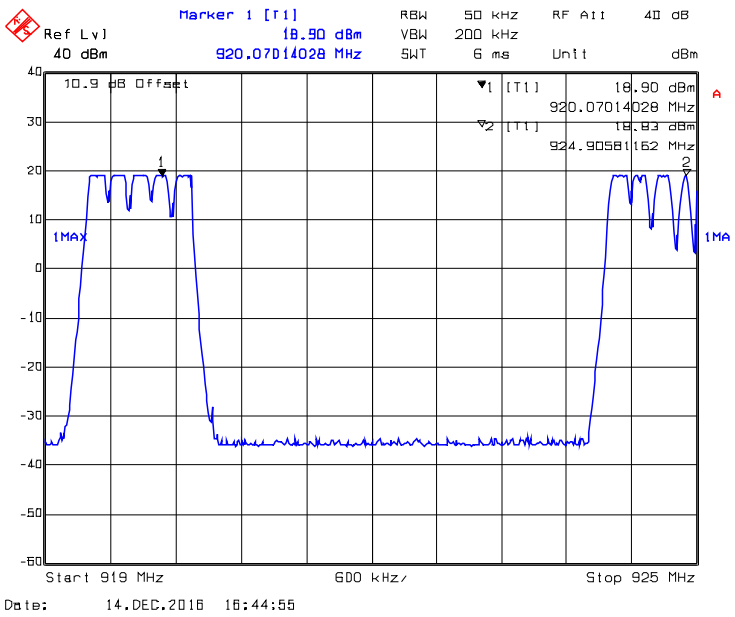
Plot 5.2.4.40. Number of Hopping Frequencies, 5470 bps
16 Hopping Channels from 910 – 915 MHz



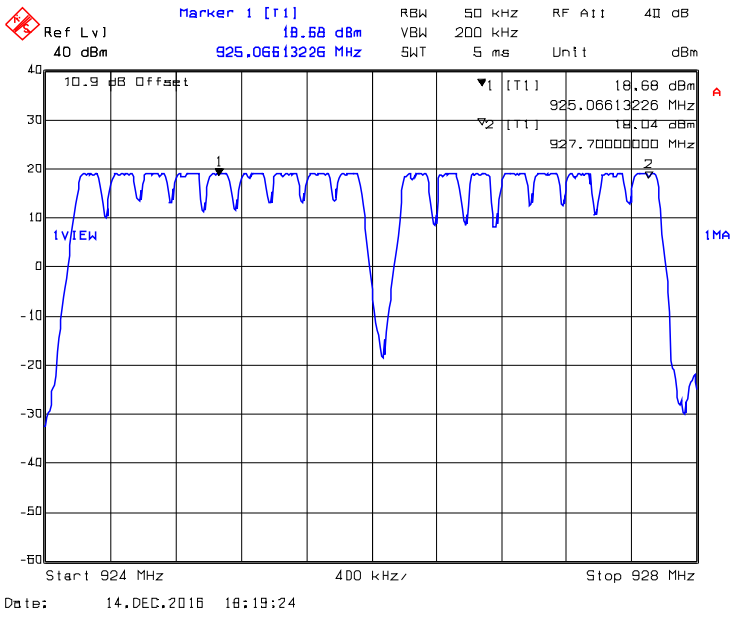
Plot 5.2.4.41. Number of Hopping Frequencies, 5470 bps
12 Hopping Channels from 915 – 920 MHz



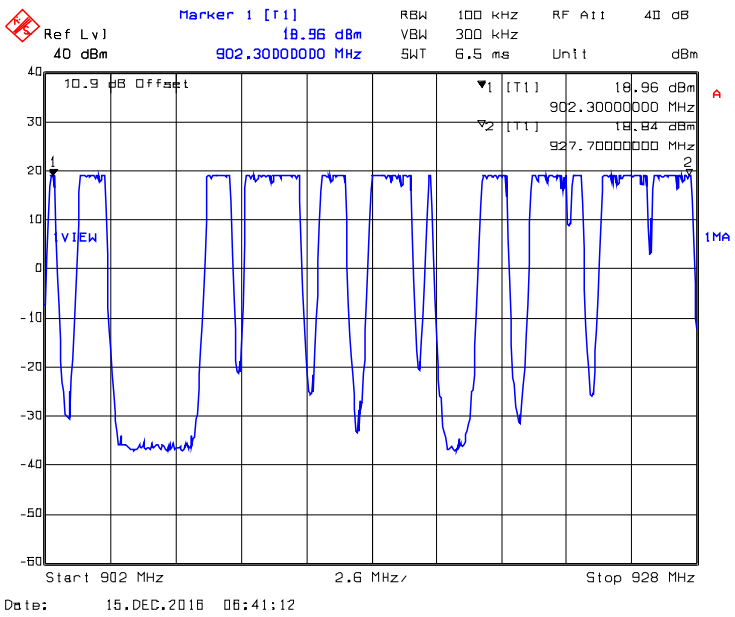
Plot 5.2.4.42. Number of Hopping Frequencies, 5470 bps
6 Hopping Channels from 920 – 925 MHz



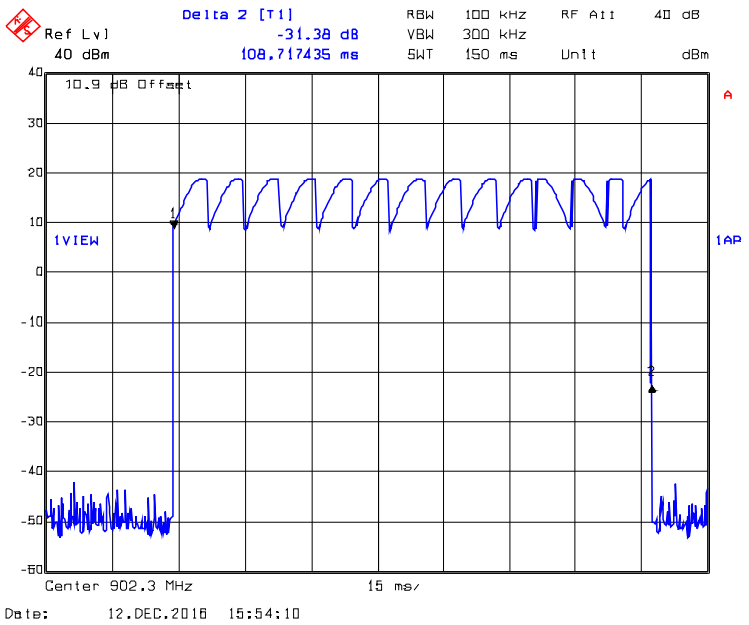
Plot 5.2.4.43. Number of Hopping Frequencies, 5470 bps
13 Hopping Channels from 925 – 928 MHz



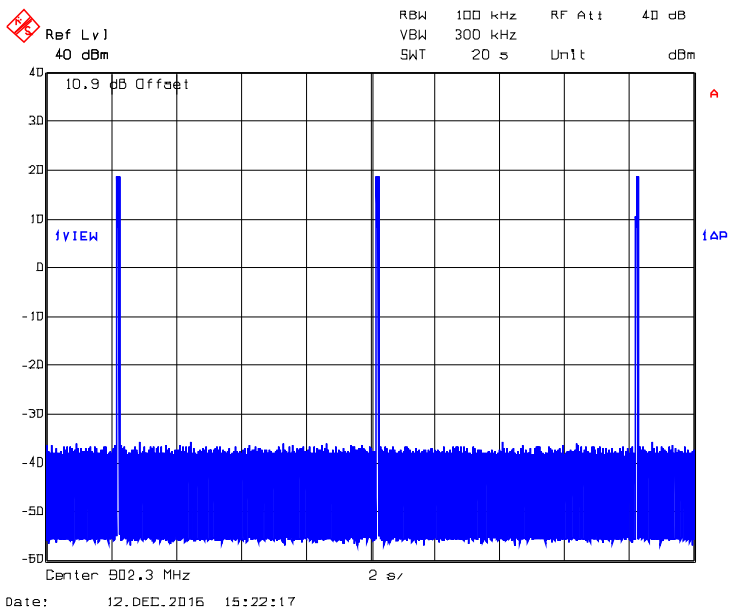
Plot 5.2.4.44. Number of Hopping Frequencies, 5470 bps
Total Number of Hopping Channel is 58 (6+5+16+12+6+13) from 902 – 928 MHz



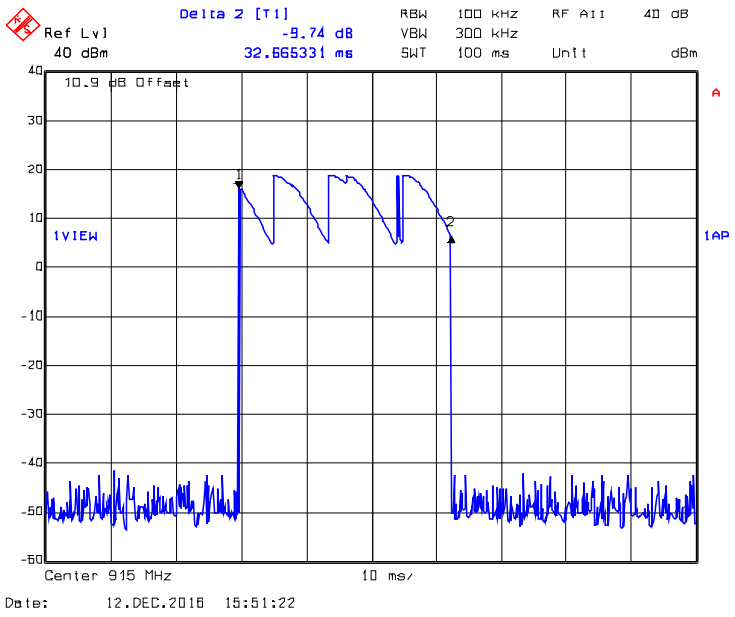
Plot 5.2.4.45. Time of Occupancy, 902.3 MHz, 980 bps
Dwell Time at 902.3 MHz = 108.7174 ms



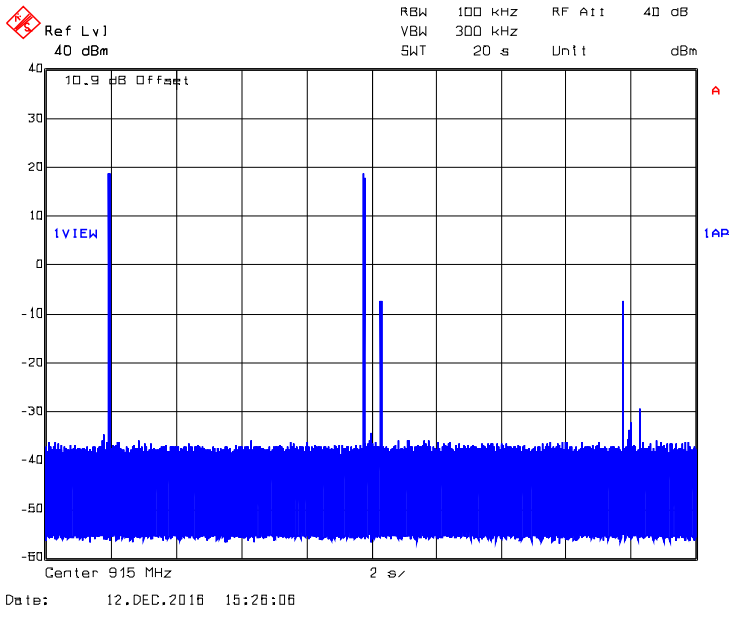
Plot 5.2.4.46. Time of Occupancy, 902.3 MHz, 980 bps
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 108.7174 ms x 3 = 326.1522 ms



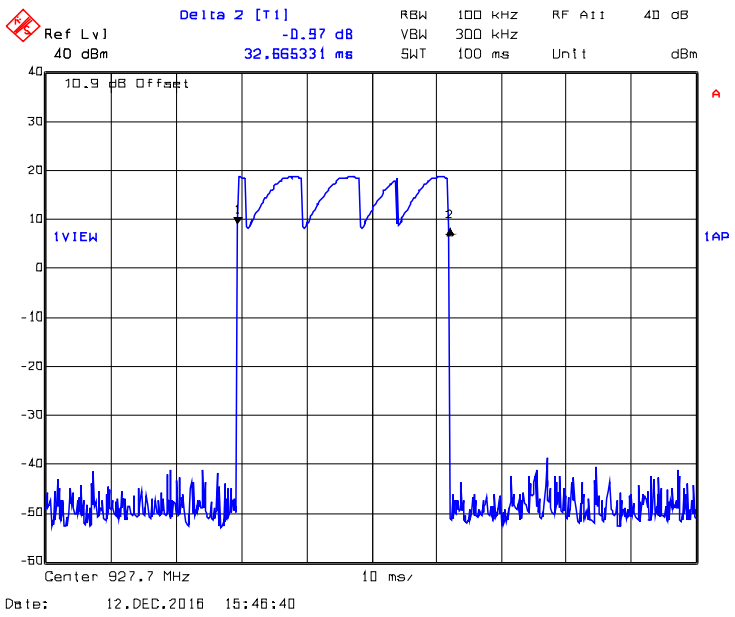
Plot 5.2.4.47. Time of Occupancy, 915.0 MHz, 980 bps
Dwell Time at 915.0 MHz = 32.6653 ms



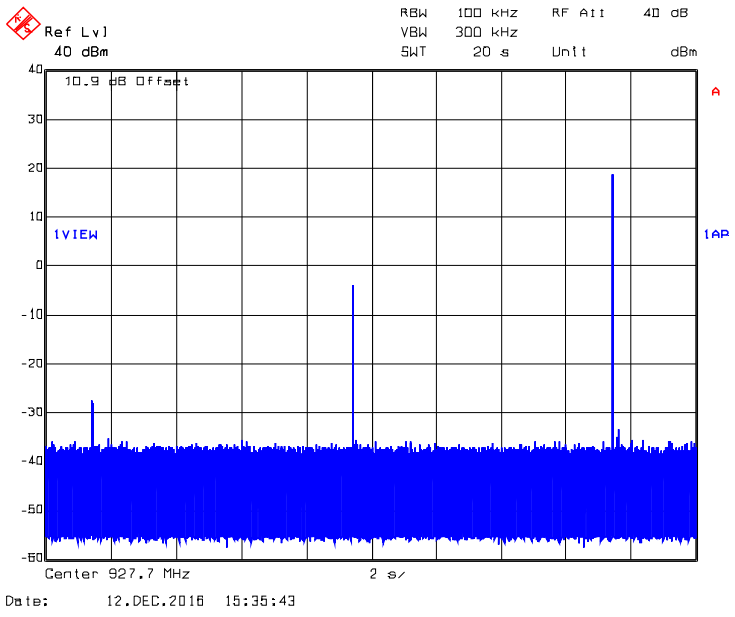
Plot 5.2.4.48. Time of Occupancy, 915.0 MHz, 980 bps
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 32.6653 ms x 2 = 65.3306 ms



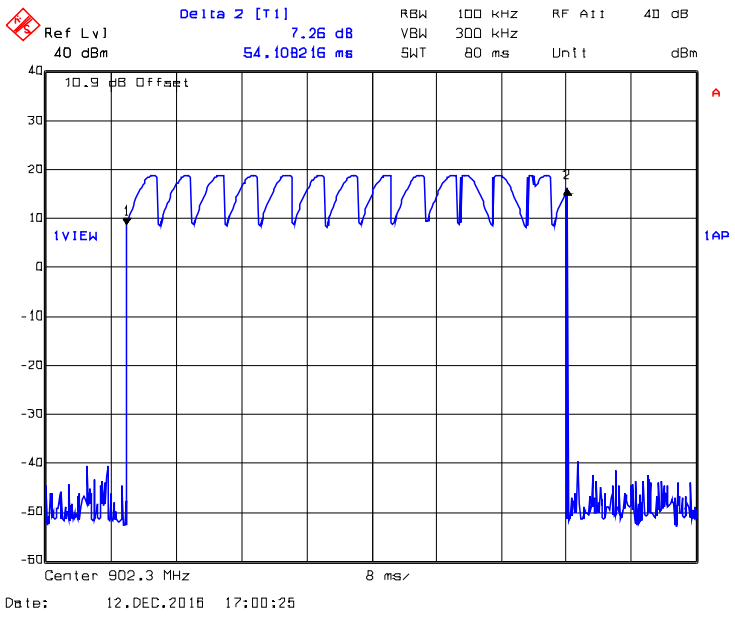
Plot 5.2.4.49. Time of Occupancy, 927.7 MHz, 980 bps
Dwell Time at 927.7 MHz = 32.6653 ms



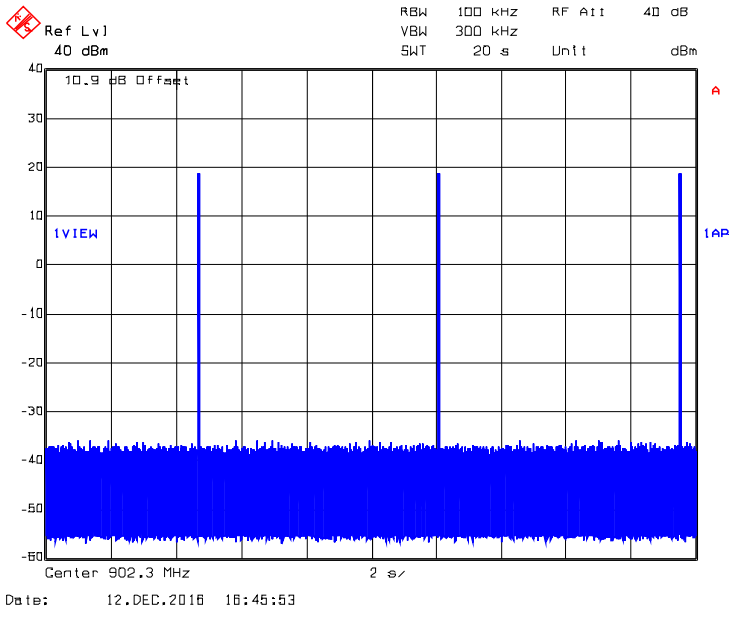
Plot 5.2.4.50. Time of Occupancy, 927.7 MHz, 980 bps
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 32.6653 ms x 1 = 32.6653 ms



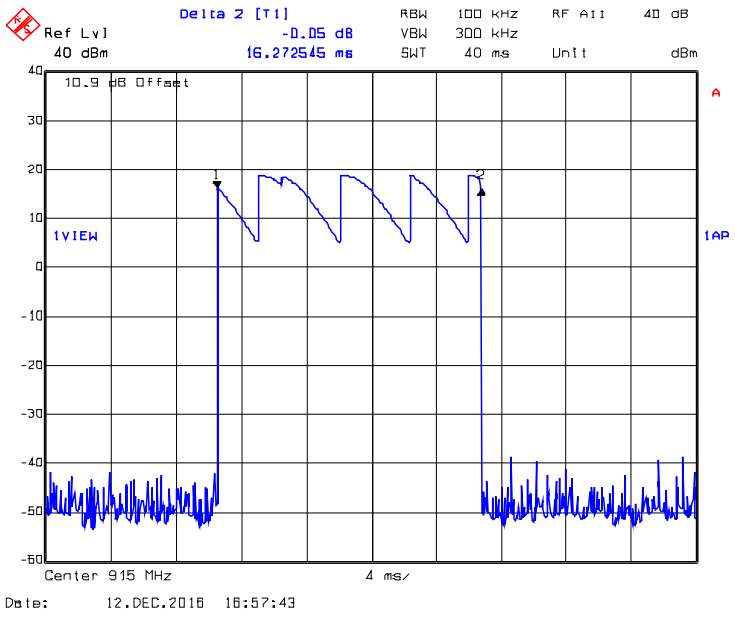
Plot 5.2.4.51. Time of Occupancy, 902.3 MHz, 1760 bps
Dwell Time at 902.3 MHz = 54.1082 ms



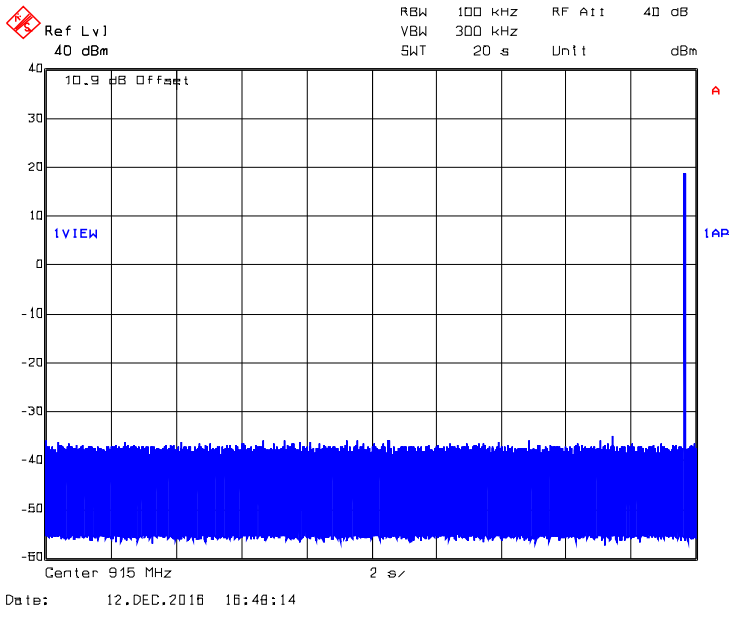
Plot 5.2.4.52. Time of Occupancy, 902.3 MHz, 1760 bps
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 54.1082 ms x 3 = 162.3246 ms



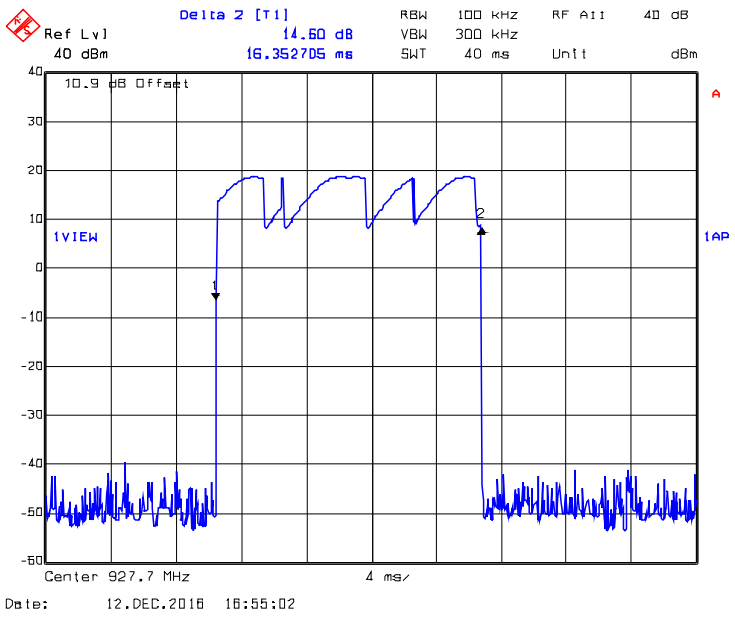
Plot 5.2.4.53. Time of Occupancy, 915.0 MHz, 1760 bps
Dwell Time at 915.0 MHz = 16.2725 ms



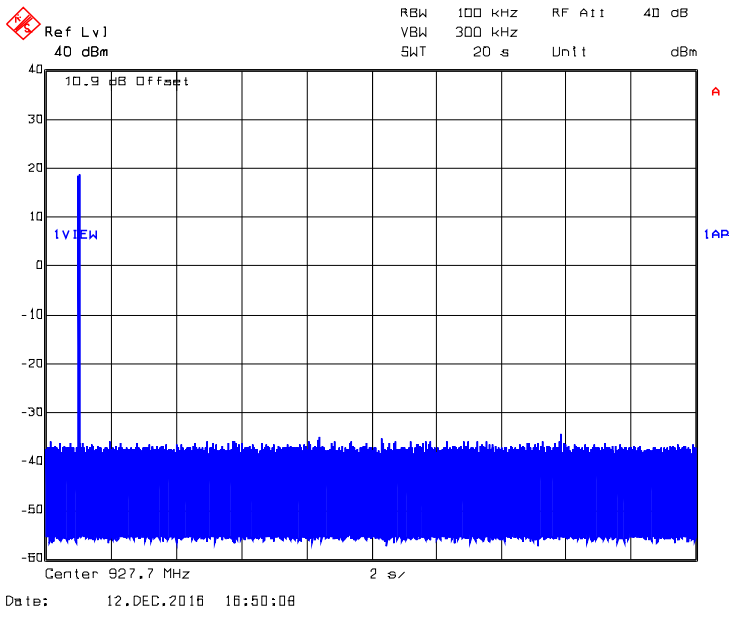
Plot 5.2.4.54. Time of Occupancy, 915.0 MHz, 1760 bps
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 16.2725 ms x 1 = 16.2725 ms



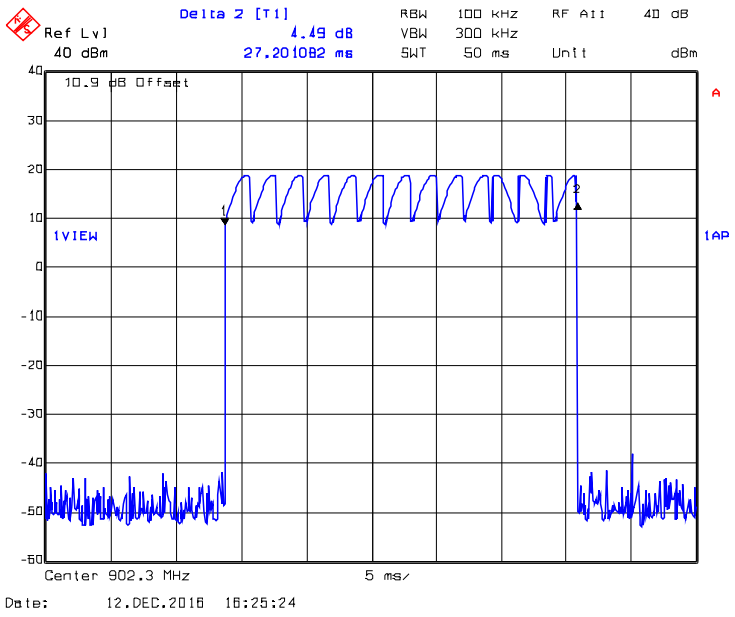
Plot 5.2.4.55. Time of Occupancy, 927.7 MHz, 1760 bps
Dwell Time at 927.7 MHz = 16.3527 ms



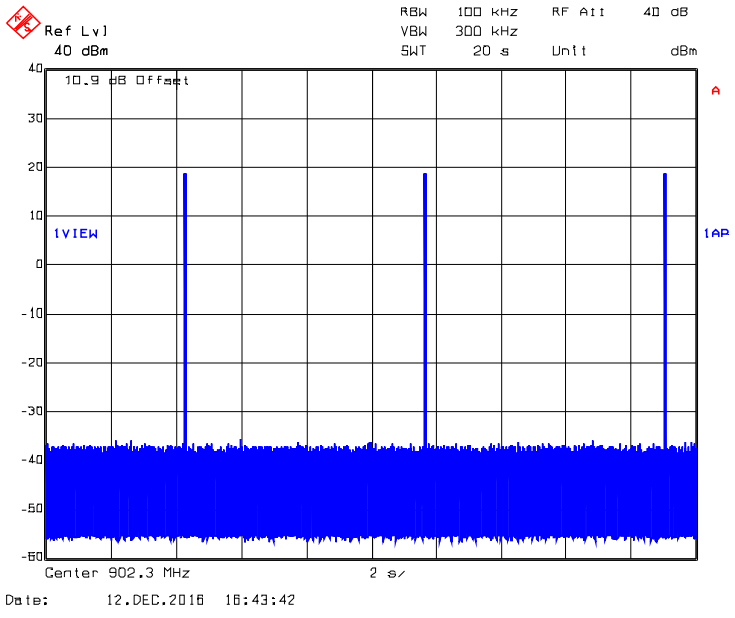
Plot 5.2.4.56. Time of Occupancy, 927.7 MHz, 1760 bps
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 16.3527 ms x 1 = 16.3527 ms



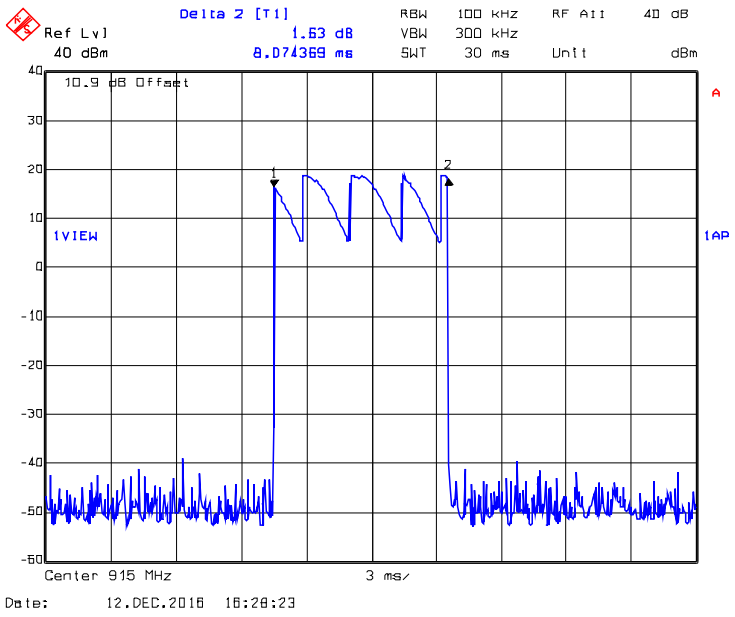
Plot 5.2.4.57. Time of Occupancy, 902.3 MHz, 3125 bps
Dwell Time at 902.3 MHz = 27.2011 ms



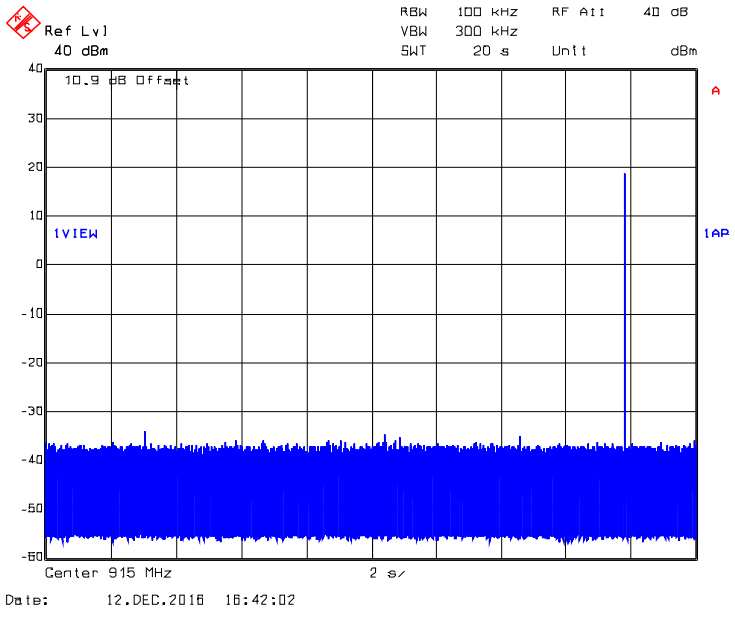
Plot 5.2.4.58. Time of Occupancy, 902.3 MHz, 3125 bps
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 27.2011 ms x 3 = 81.6033 ms



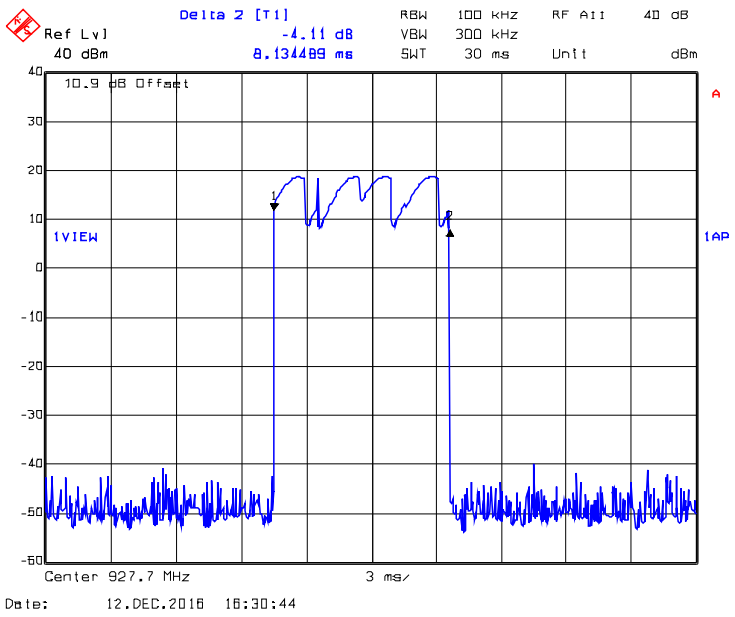
Plot 5.2.4.59. Time of Occupancy, 915.0 MHz, 3125 bps
Dwell Time at 915.0 MHz = 8.0744 ms



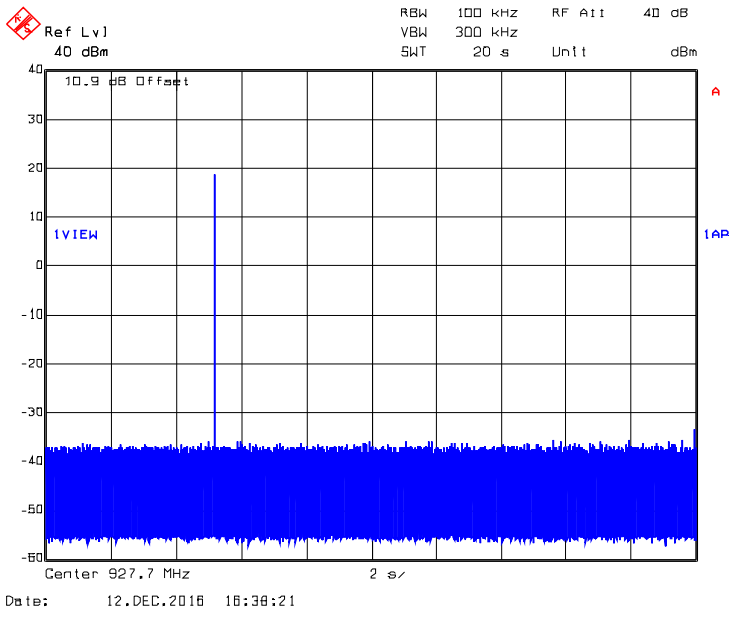
Plot 5.2.4.60. Time of Occupancy, 915.0 MHz, 3125 bps
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 8.0744 ms x 1 = 8.0744 ms



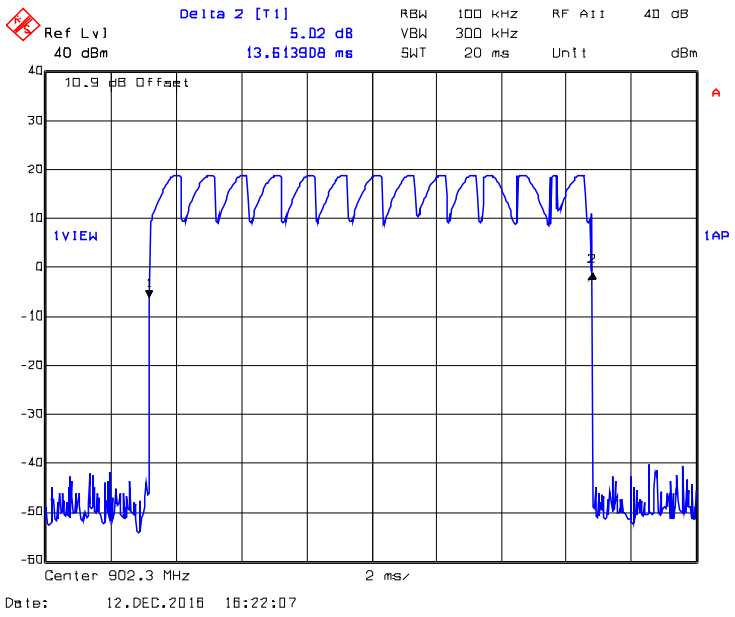
Plot 5.2.4.61. Time of Occupancy, 927.7 MHz, 3125 bps
Dwell Time at 927.7 MHz = 8.1345 ms



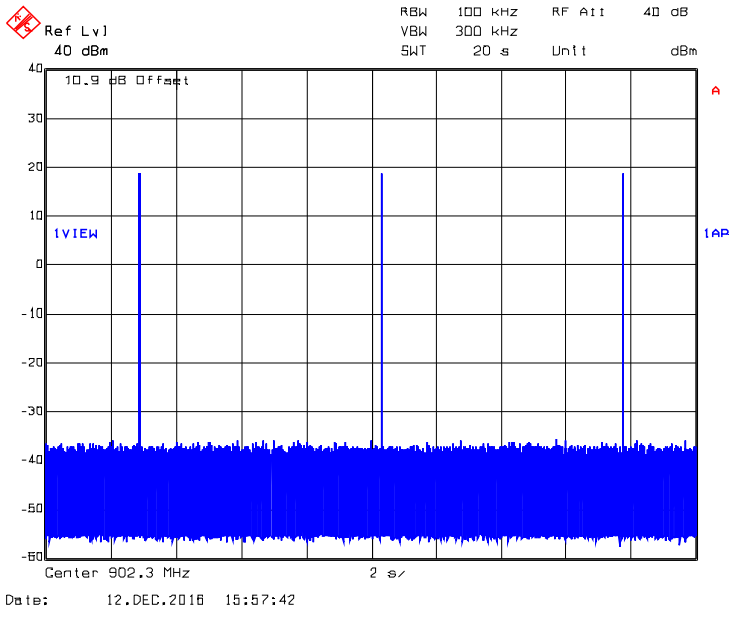
Plot 5.2.4.62. Time of Occupancy, 927.7 MHz, 3125 bps
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 8.1345 ms x 1 = 8.1345 ms



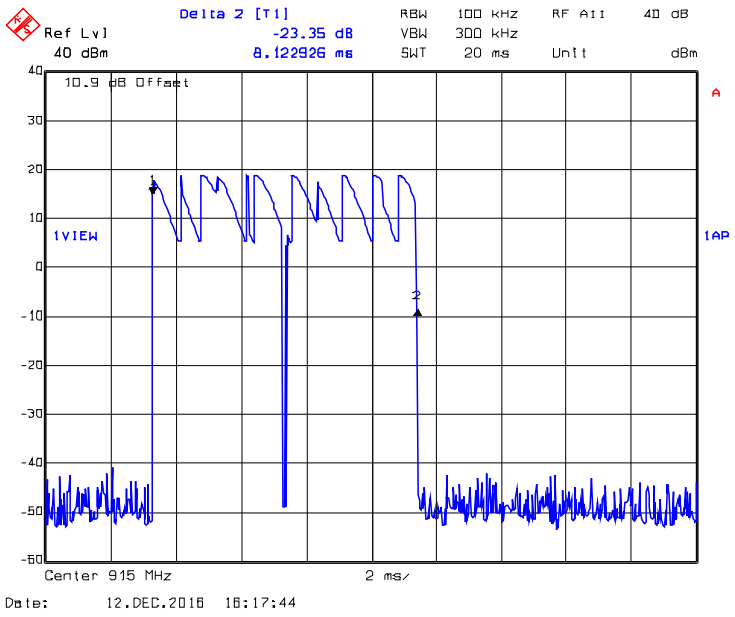
Plot 5.2.4.63. Time of Occupancy, 902.3 MHz, 5470 bps
Dwell Time at 902.3 MHz = 13.6139 ms



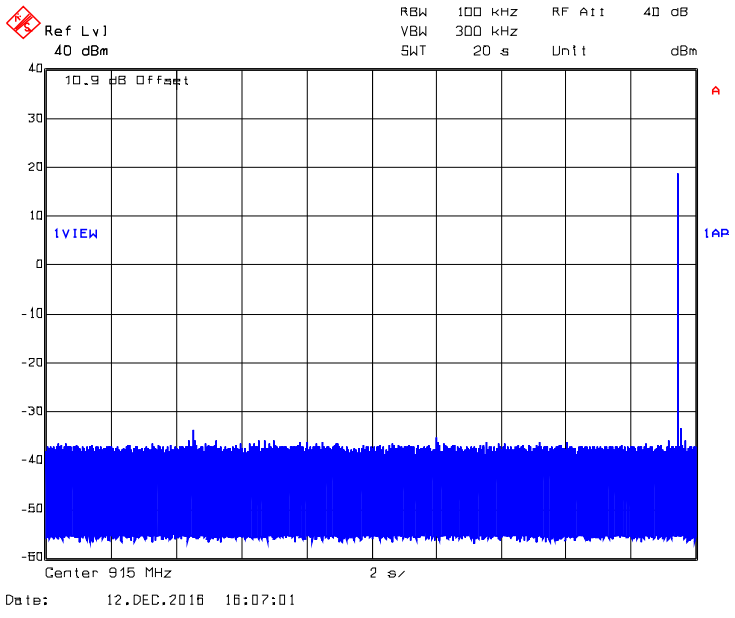
Plot 5.2.4.64. Time of Occupancy, 902.3 MHz, 5470 bps
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 13.6139 ms x 3 = 40.8417 ms



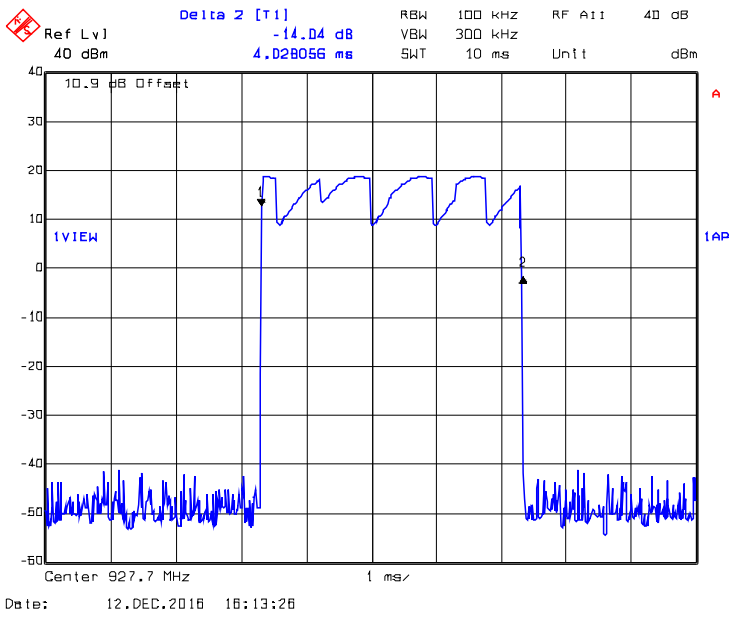
Plot 5.2.4.65. Time of Occupancy, 915.0 MHz, 5470 bps
Dwell Time at 915.0 MHz = 8.1229 ms



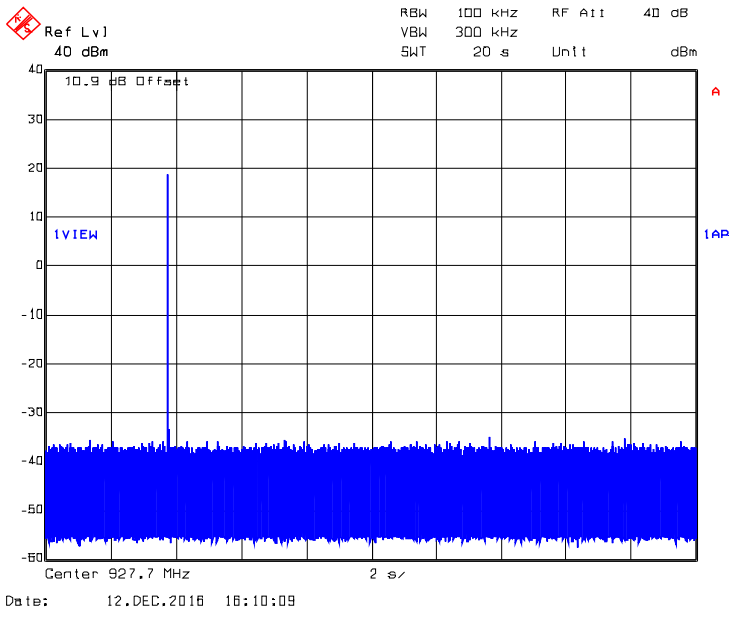
Plot 5.2.4.66. Time of Occupancy, 915.0 MHz, 5470 bps
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 8.1229 ms x 1 = 8.1229 ms



Plot 5.2.4.67. Time of Occupancy, 927.7 MHz, 5470 bps
Dwell Time at 927.7 MHz = 4.0281 ms



Plot 5.2.4.68. Time of Occupancy, 927.7 MHz, 5470 bps
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 4.0281 ms x 1 = 4.0281 ms



5.3. PEAK CONDUCTED OUTPUT POWER [§ 15.247(b)(2)]

5.3.1. Limits

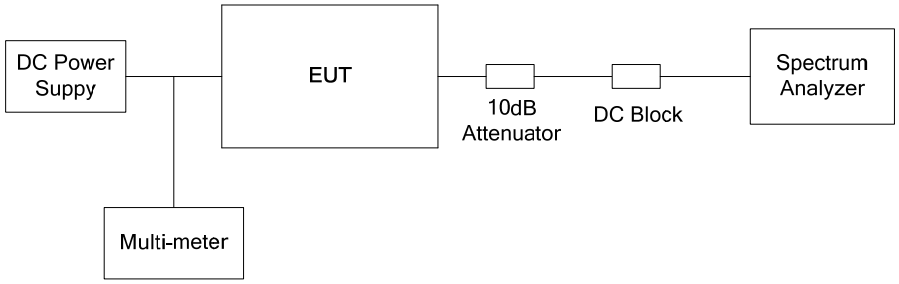
§15.247(b)(2): For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

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

5.3.2. Method of Measurements

FCC Public Notice DA 00-705 and ANSI C63.10.

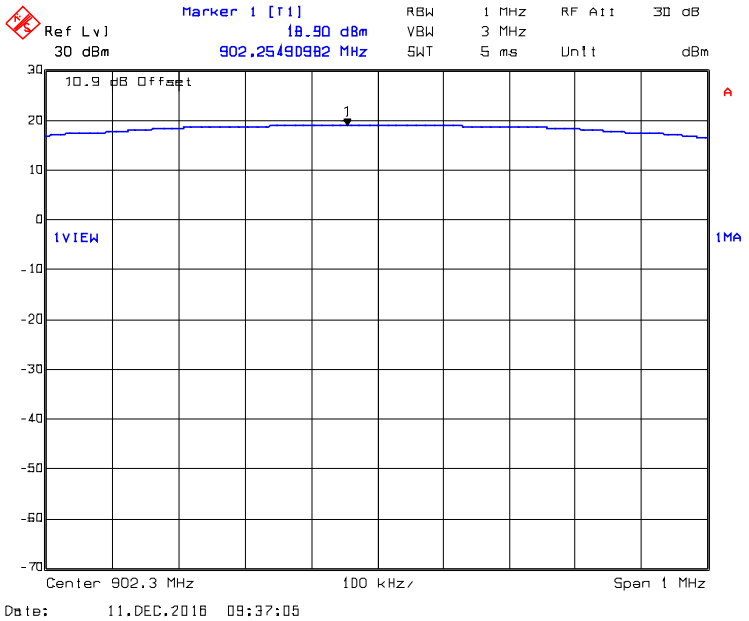
5.3.3. Test Arrangement



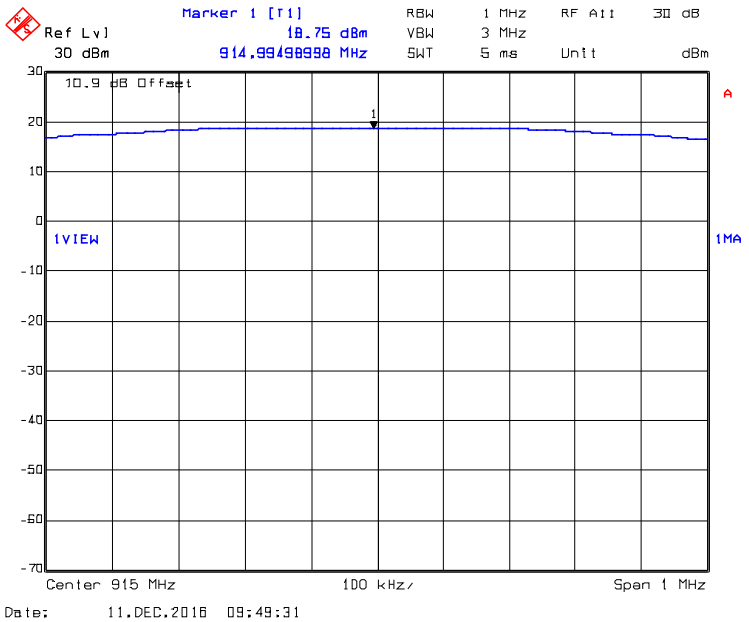
5.3.4. Test Data

Modulation	Data Rate (bps)	Frequency (MHz)	Peak Output Power at Antenna Terminal (dBm)	Max. Antenna Gain (dBi)	EIRP (dBm)	Peak Conducted Output Power Limit (dBm)	EIRP Limit (dBm)
LoRa (CSS)	980	902.3	18.90	-5	13.90	30	36
		915.0	18.75	-5	13.75	30	36
		927.7	18.59	-5	13.59	30	36
	1760	902.3	18.90	-5	13.90	30	36
		915.0	18.77	-5	13.77	30	36
		927.7	18.59	-5	13.59	30	36
	3125	902.3	18.84	-5	13.84	30	36
		915.0	18.77	-5	13.77	30	36
		927.7	18.59	-5	13.59	30	36
	5470	902.3	18.84	-5	13.84	30	36
		915.0	18.77	-5	13.77	30	36
		927.7	18.59	-5	13.59	30	36

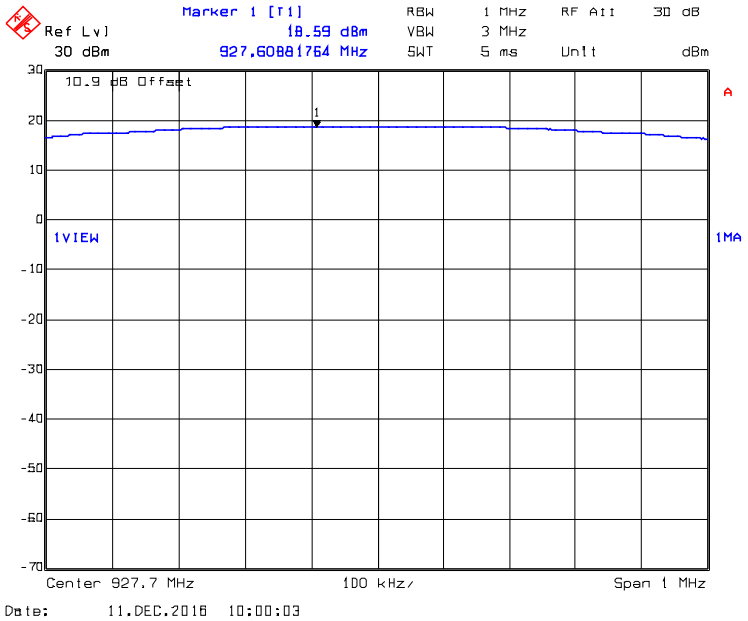
Plot 5.3.4.1. Peak Output Power, 902.3 MHz, 980 bps



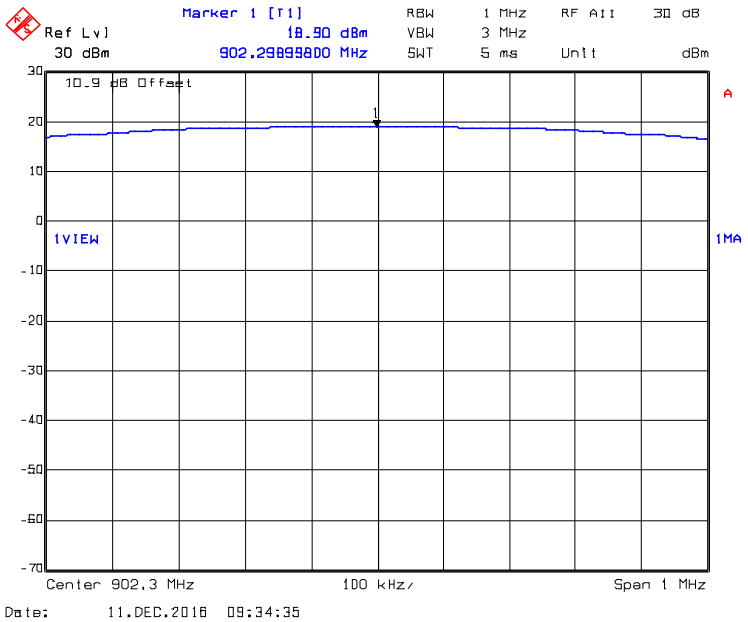
Plot 5.3.4.2. Peak Output Power, 915.0 MHz, 980 bps



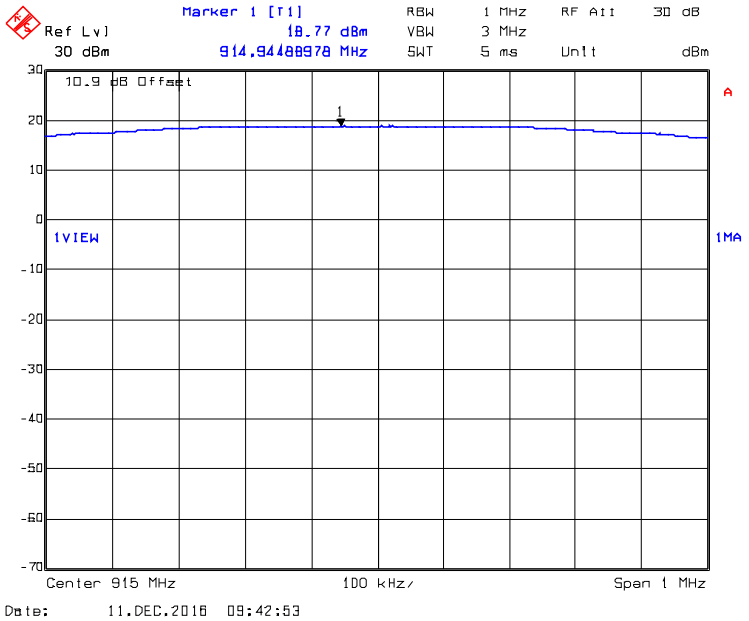
Plot 5.3.4.3. Peak Output Power, 927.7 MHz, 980 bps



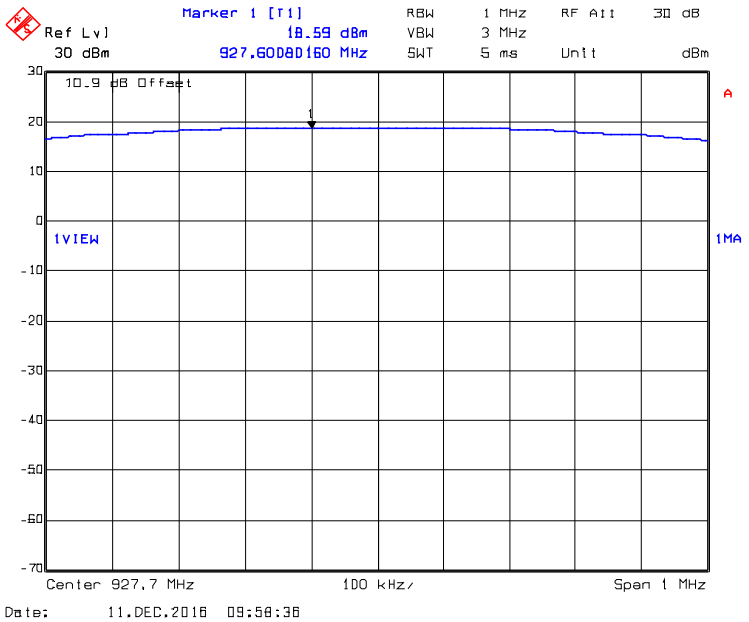
Plot 5.3.4.4. Peak Output Power, 902.3 MHz, 1760 bps



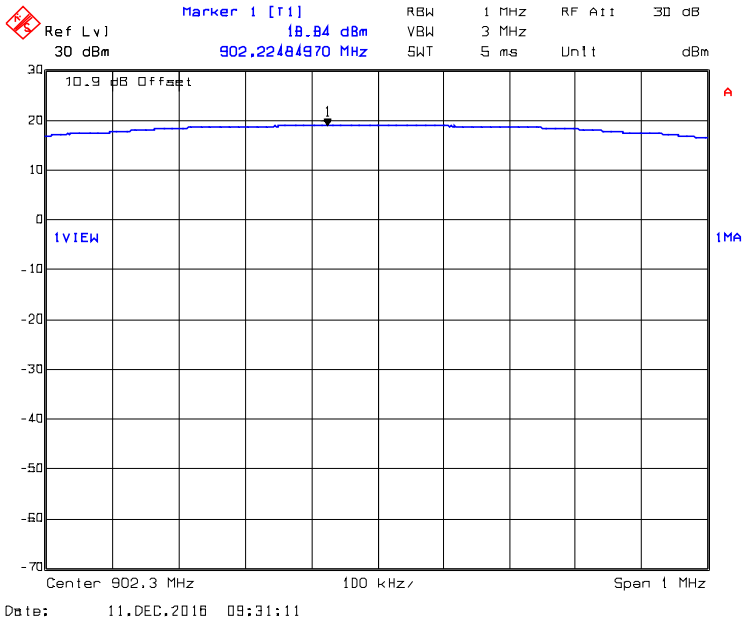
Plot 5.3.4.5. Peak Output Power, 915.0 MHz, 1760 bps



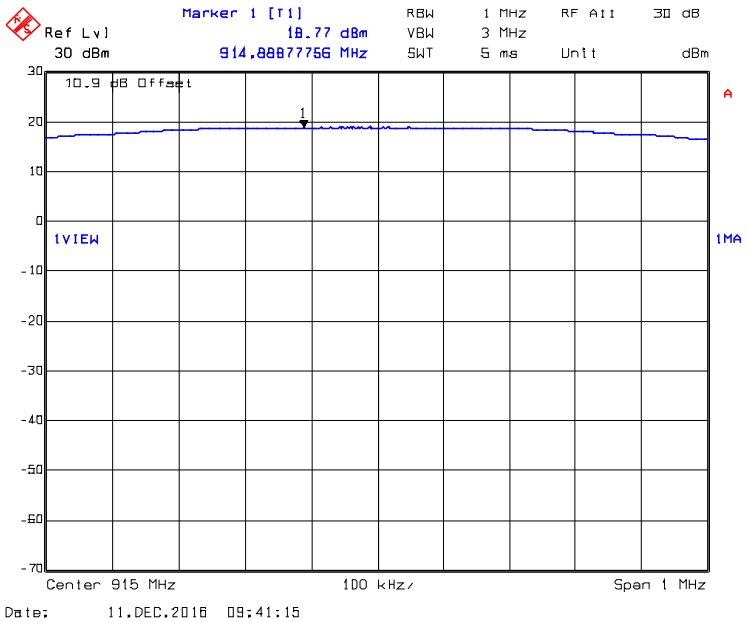
Plot 5.3.4.6. Peak Output Power, 927.7 MHz, 1760 bps



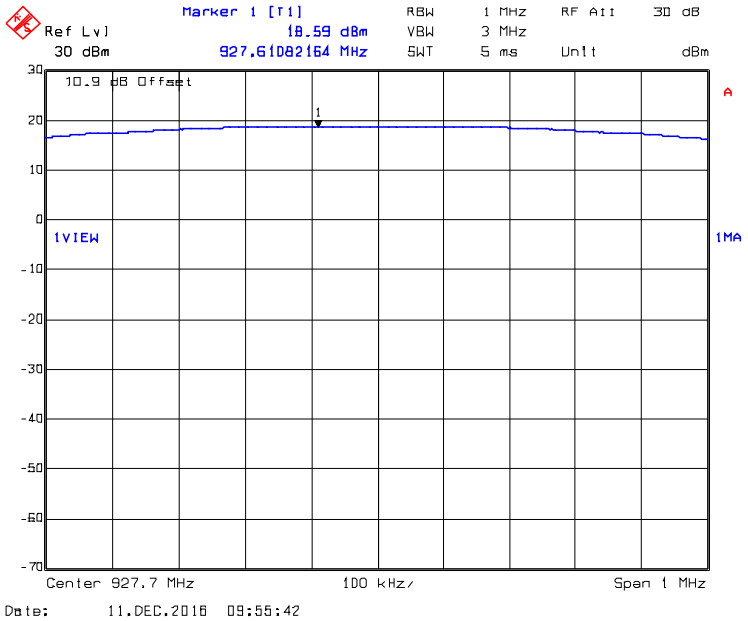
Plot 5.3.4.7. Peak Output Power, 902.3 MHz, 3125 bps



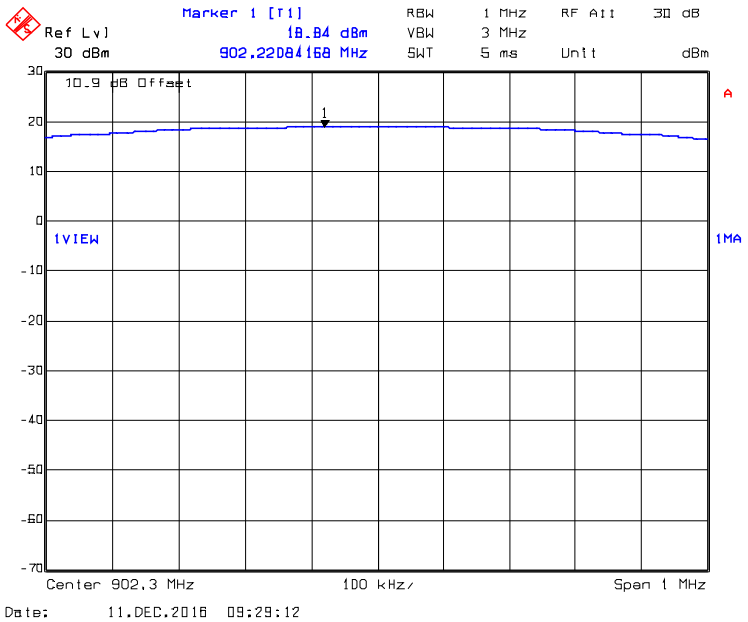
Plot 5.3.4.8. Peak Output Power, 915.0 MHz, 3125 bps



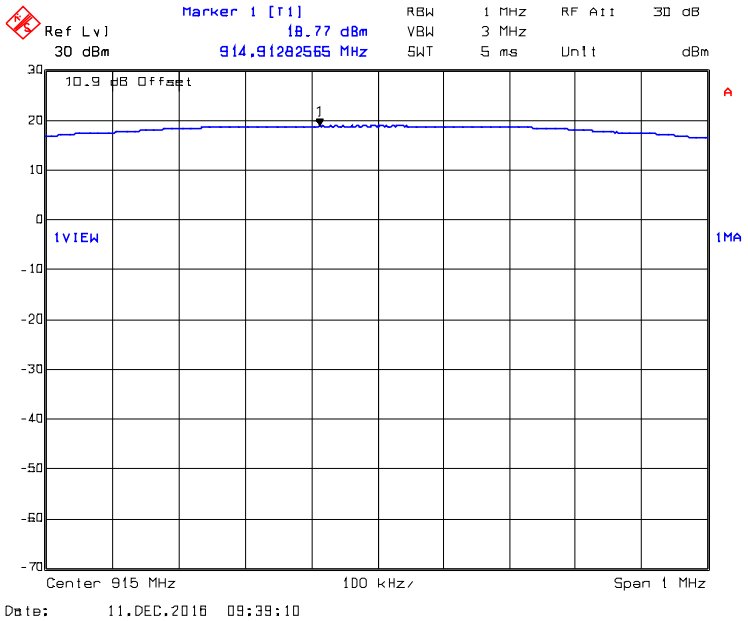
Plot 5.3.4.9. Peak Output Power, 927.7 MHz, 3125 bps



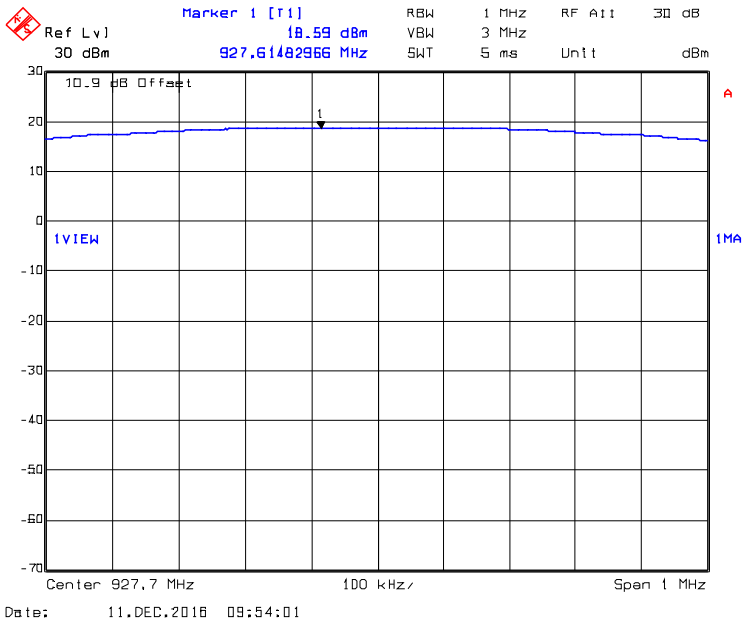
Plot 5.3.4.10. Peak Output Power, 902.3 MHz, 5470 bps



Plot 5.3.4.11. Peak Output Power, 915.0 MHz, 5470 bps



Plot 5.3.4.12. Peak Output Power, 927.7 MHz, 5470 bps



5.4. TRANSMITTER SPURIOUS RADIATED EMISSIONS AT 3 METERS [§§ 15.247(d), 15.209 & 15.205]

5.4.1. Limit

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

Section 15.205(a) - Restricted Bands of Operation

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
[1] 0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2655–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	([2])
13.36–13.41.			

[1] Until February 1, 1999, this restricted band shall be 0.490–0.510 MHz.
[2] Above 38.6

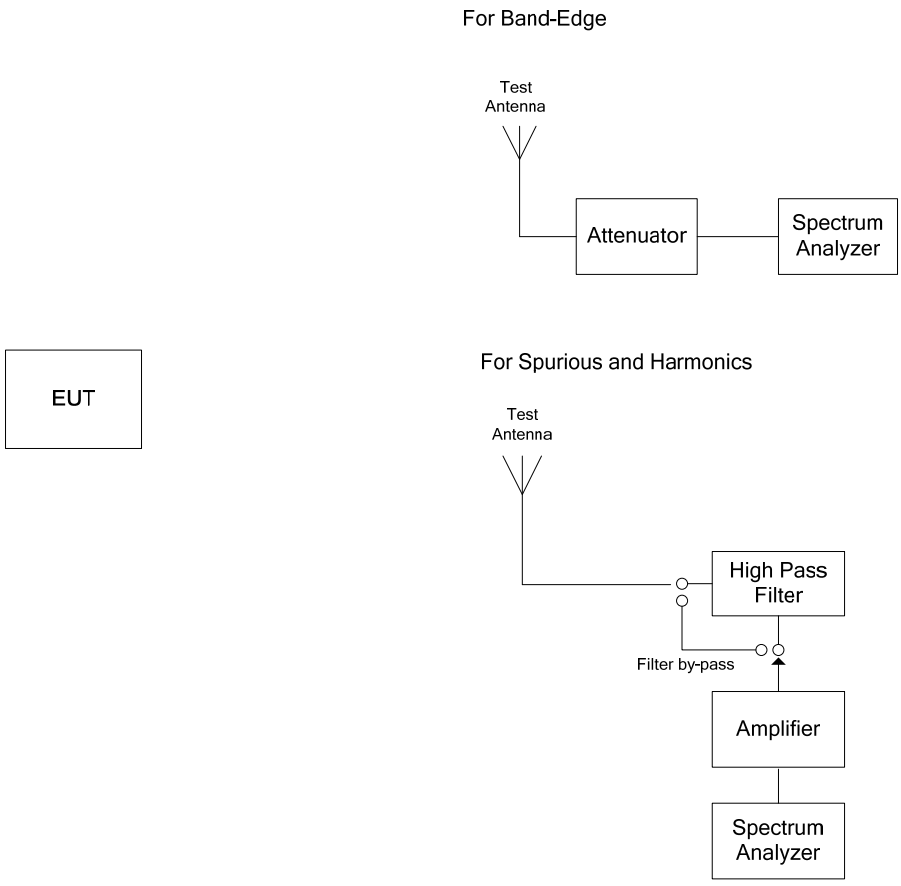
Section 15.209(a) - Field Strength Limits within Restricted Frequency Bands

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 - 0.490	2,400 / F (kHz)	300
0.490 - 1.705	24,000 / F (kHz)	30
1.705 - 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3

5.4.2. Method of Measurements

FCC Public Notice DA 00-705, ANSI C63.10 and ANSI 63.4 procedures.

5.4.3. Test Arrangement



5.4.4. Test Data

Remark(s):

- All spurious emissions that are in excess of 20 dB below the specified limit shall be recorded.
- EUT shall be tested in three orthogonal positions.
- Exploratory tests performed to determine worst-case test configurations, the following test results with the EUT operating at 980 bps data rate, represent the worst-case.

5.4.4.1. Spurious Radiated Emissions

Fundamental Frequency:	902.3 MHz						
Frequency Test Range:	30 MHz – 10 GHz						
Frequency (MHz)	**RF Peak Level (dBµV/m)**	**RF Avg Level (dBµV/m)**	**Antenna Plane (H/V)**	**Limit 15.209 (dBµV/m)**	**Limit 15.247 (dBµV/m)**	**Margin (dB)**	**Pass/ Fail**
902.3	108.01	--	V	--	--	--	--
902.3	110.39	--	H	--	--	--	--
3609.2	47.15	38.91	V	54.0	90.4	-15.1	Pass*
3609.2	47.76	39.75	H	54.0	90.4	-14.3	Pass*
4511.5	47.40	34.03	V	54.0	90.4	-20.0	Pass*
4511.5	46.51	34.79	H	54.0	90.4	-19.2	Pass*
5413.8	48.71	35.87	V	54.0	90.4	-18.1	Pass*
5413.8	48.22	34.32	H	54.0	90.4	-19.7	Pass*
All other spurious emissions and harmonics are more than 20 dB below the applicable limit.							

*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

Fundamental Frequency:	915.0 MHz						
Frequency Test Range:	30 MHz – 10 GHz						
Frequency (MHz)	**RF Peak Level (dBµV/m)**	**RF Avg Level (dBµV/m)**	**Antenna Plane (H/V)**	**Limit 15.209 (dBµV/m)**	**Limit 15.247 (dBµV/m)**	**Margin (dB)**	**Pass/ Fail**
915.0	107.25	--	V	--	--	--	--
915.0	109.71	--	H	--	--	--	--
3660.0	48.65	40.00	V	54.0	89.7	-14.0	Pass*
3660.0	48.01	41.41	H	54.0	89.7	-12.6	Pass*
All other spurious emissions and harmonics are more than 20 dB below the applicable limit.							

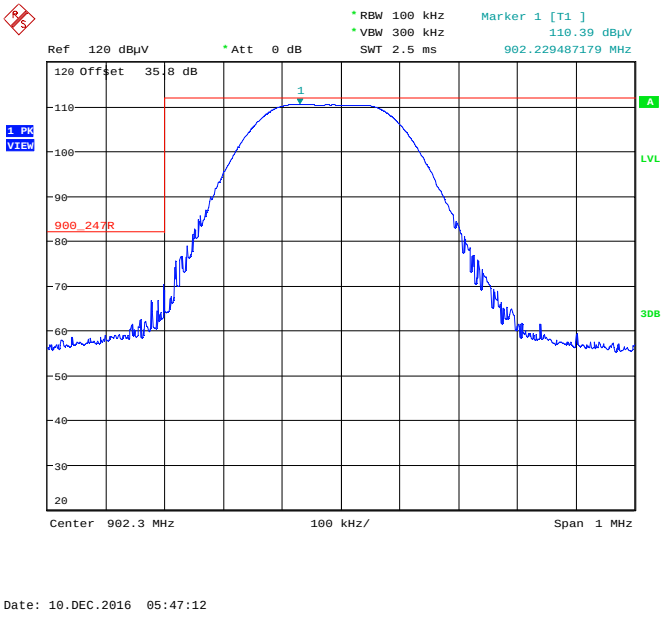
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

Fundamental Frequency:	927.7 MHz						
Frequency Test Range:	30 MHz – 10 GHz						
Frequency (MHz)	**RF Peak Level (dBµV/m)**	**RF Avg Level (dBµV/m)**	**Antenna Plane (H/V)**	**Limit 15.209 (dBµV/m)**	**Limit 15.247 (dBµV/m)**	**Margin (dB)**	**Pass/ Fail**
927.7	106.95	--	V	--	--	--	--
927.7	107.17	--	H	--	--	--	--
3710.8	48.97	42.73	V	54.0	87.2	-11.3	Pass*
4638.5	47.13	34.37	V	54.0	87.2	-19.6	Pass*
3710.8	45.18	43.05	H	54.0	87.2	-11.0	Pass*
4638.5	47.78	37.23	H	54.0	87.2	-16.8	Pass*
All other spurious emissions and harmonics are more than 20 dB below the applicable limit.							

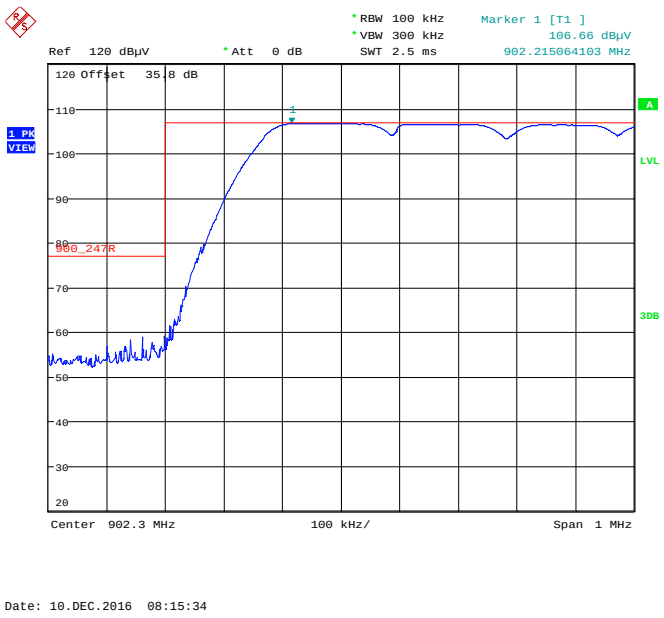
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

5.4.4.2. Band –Edge RF Radiated Emissions

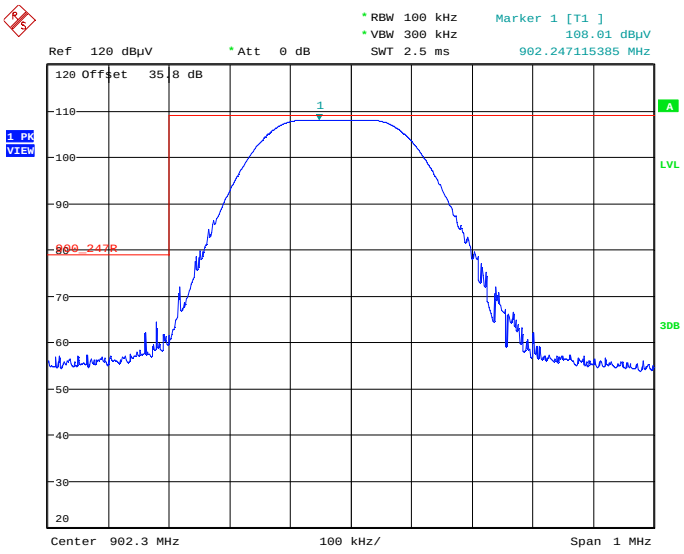
Plot 5.4.4.2.1. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 980 bps Data Rate Single Frequency Mode, Low End of Frequency Band



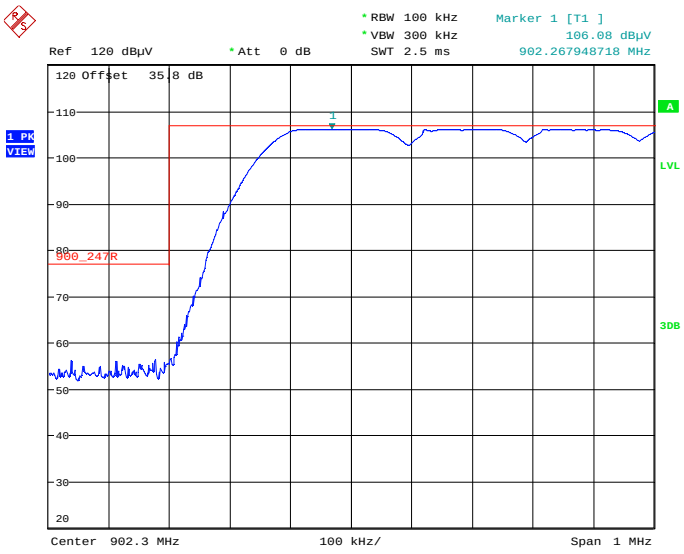
Plot 5.4.4.2.2. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 980 bps Data Rate Pseudorandom Channel Hopping Mode, Low End of Frequency Band



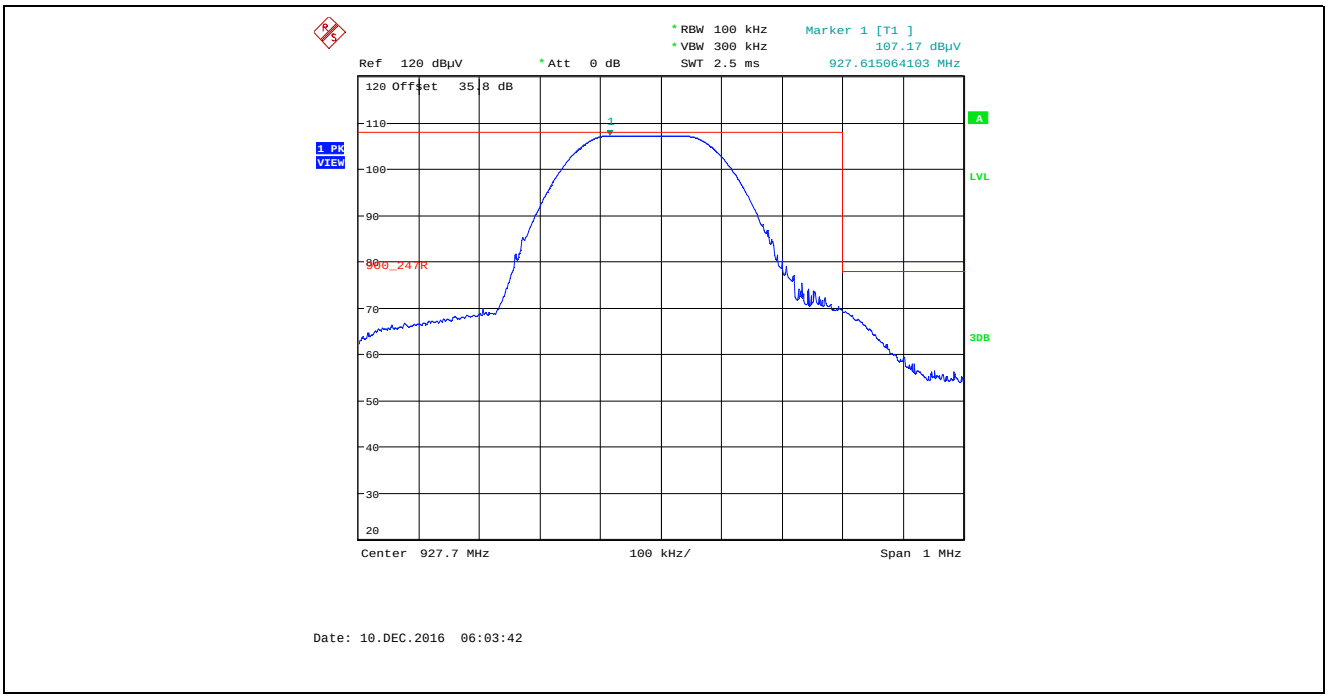
Plot 5.4.4.2.3. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 980 bps Data Rate
Single Frequency Mode, Low End of Frequency Band



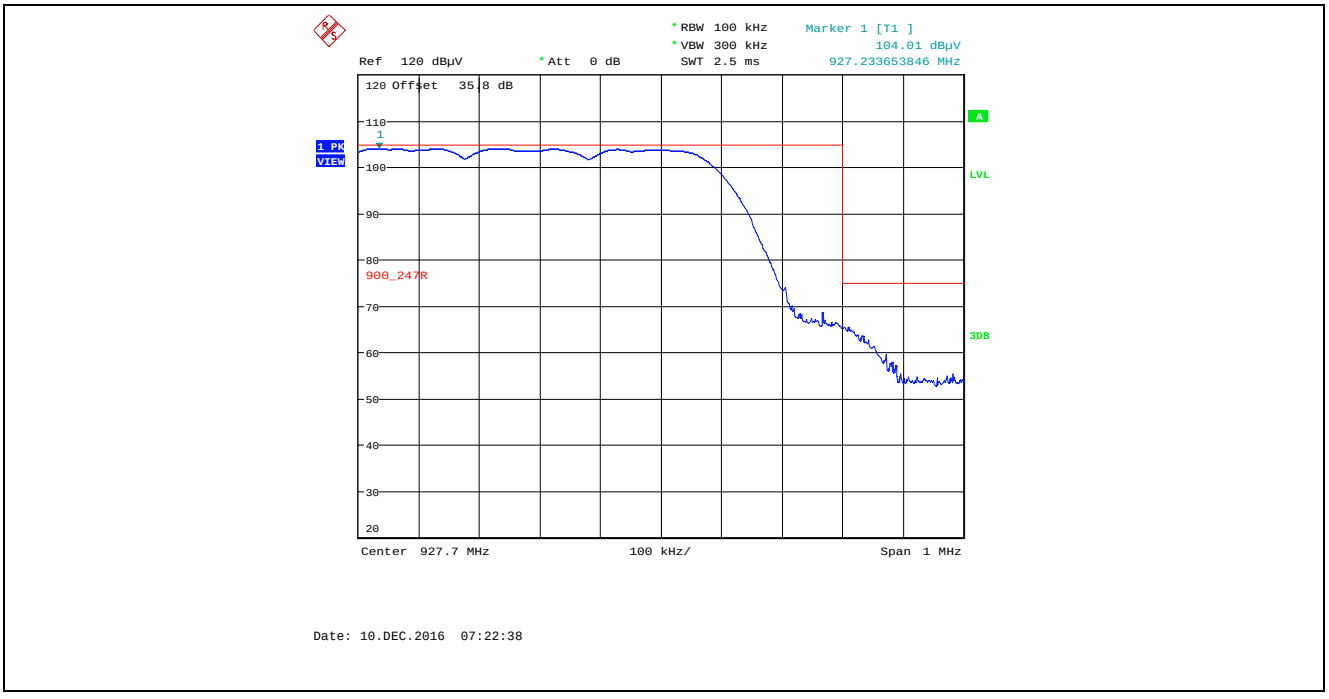
Plot 5.4.4.2.4. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 980 bps Data Rate
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



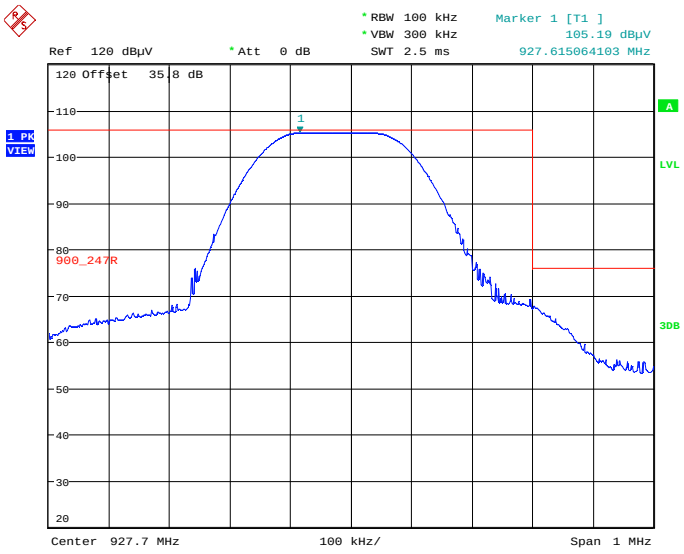
Plot 5.4.4.2.5. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 980 bps Data Rate
Single Frequency Mode, High End of Frequency Band



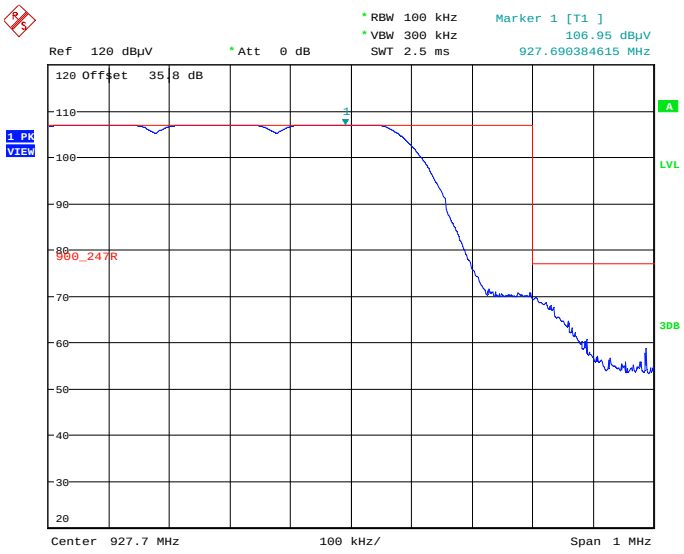
Plot 5.4.4.2.6. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 980 bps Data Rate
Pseudorandom Channel Hopping Mode, High End of Frequency Band



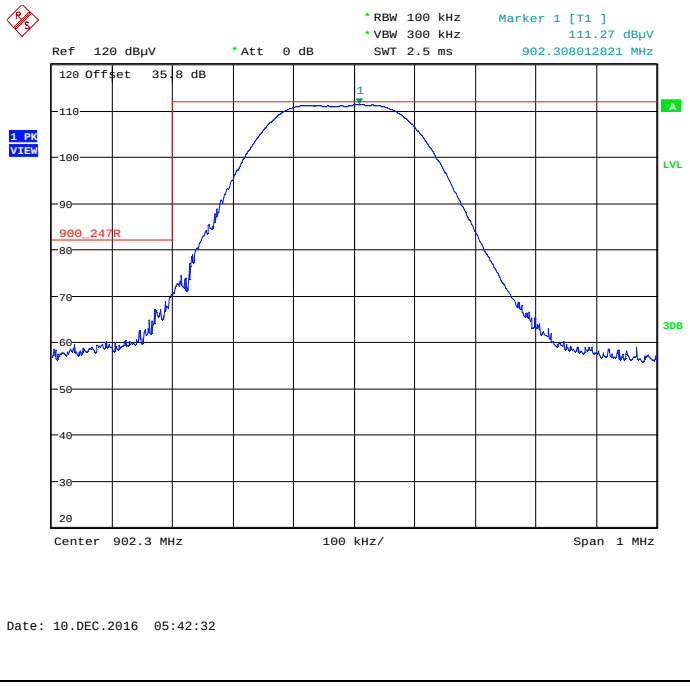
Plot 5.4.4.2.7. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 980 bps Data Rate
Single Frequency Mode, High End of Frequency Band



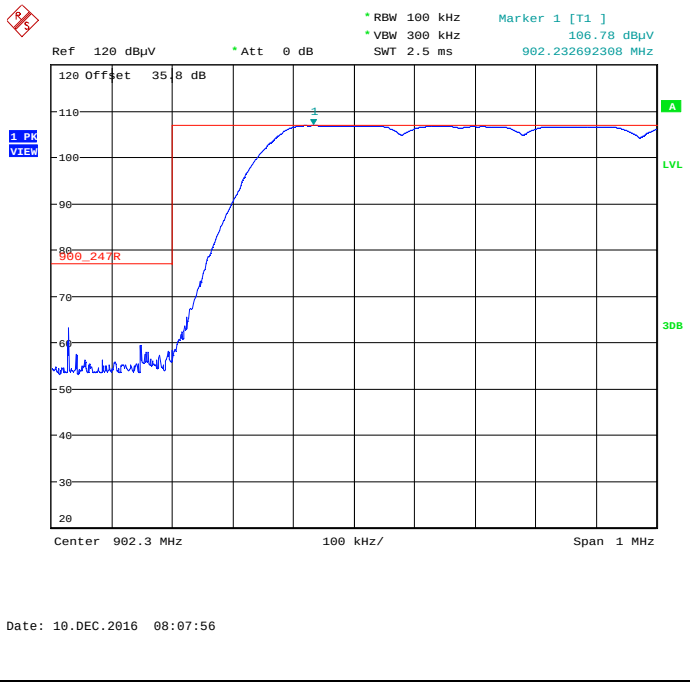
Plot 5.4.4.2.8. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 980 bps Data Rate
Pseudorandom Channel Hopping Mode, High End of Frequency Band



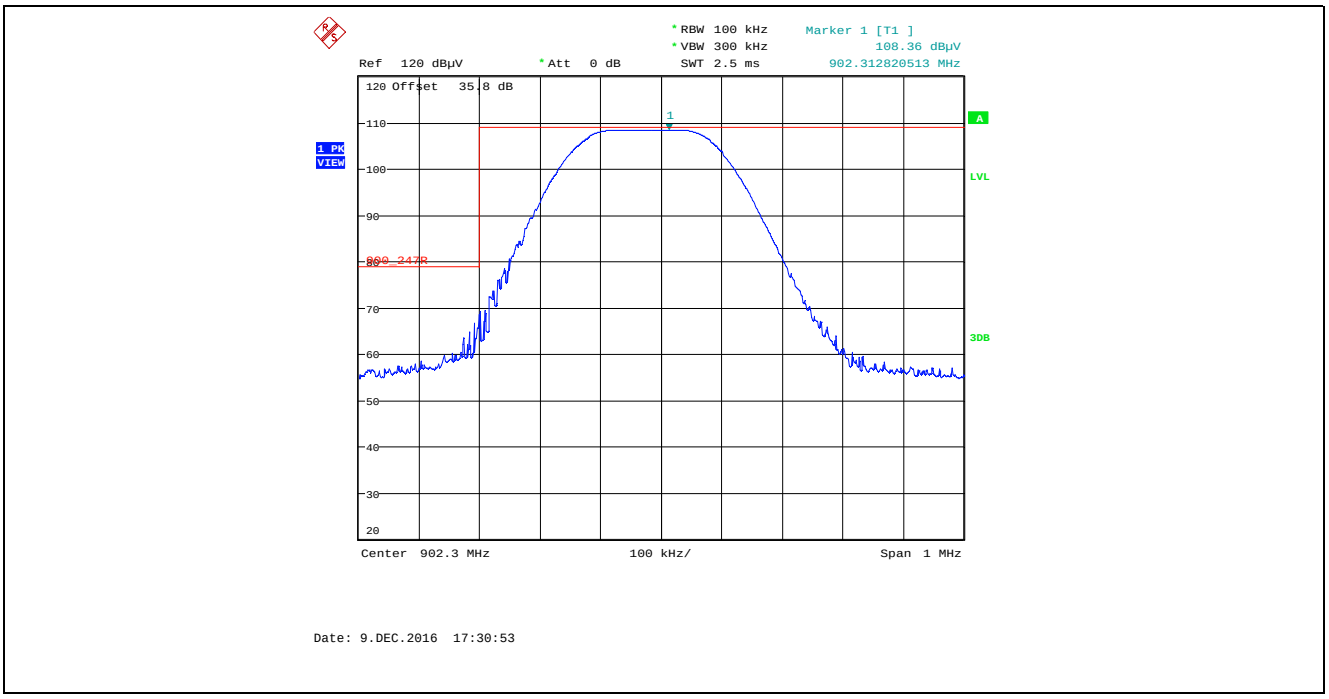
Plot 5.4.4.2.9. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 1760 bps Data Rate
Single Frequency Mode, Low End of Frequency Band



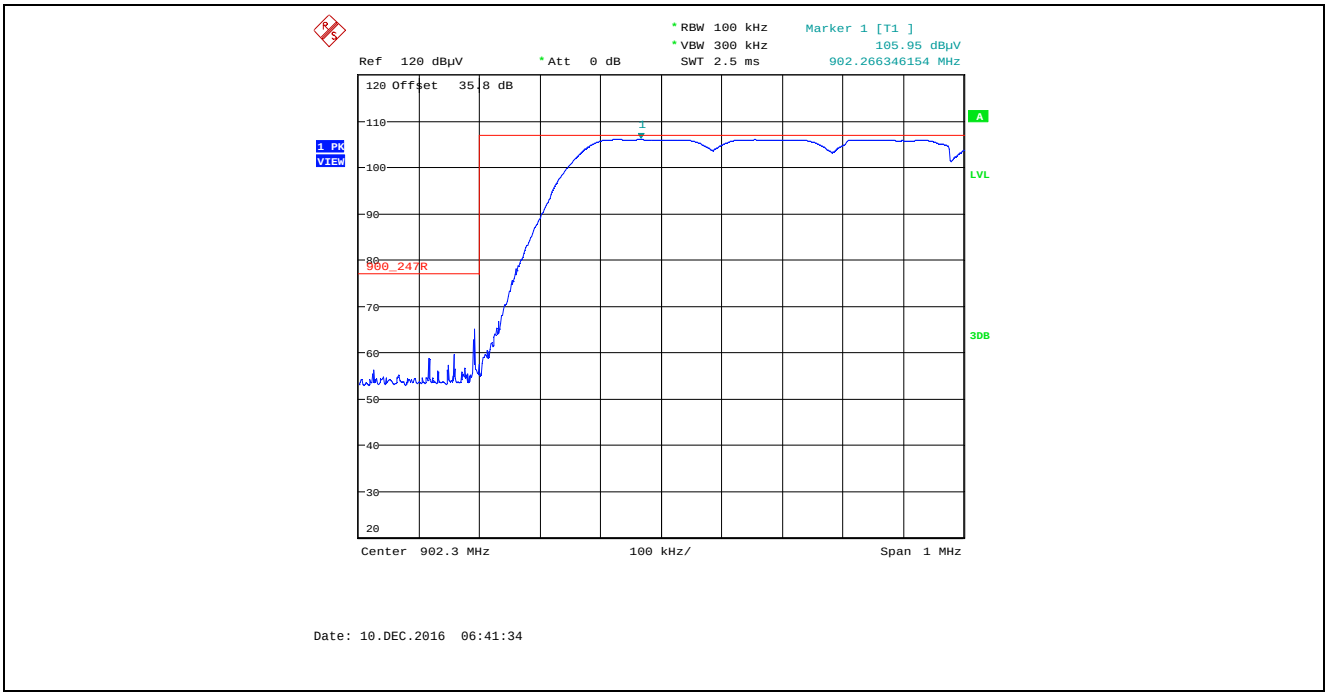
Plot 5.4.4.2.10. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 1760 bps Data Rate
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



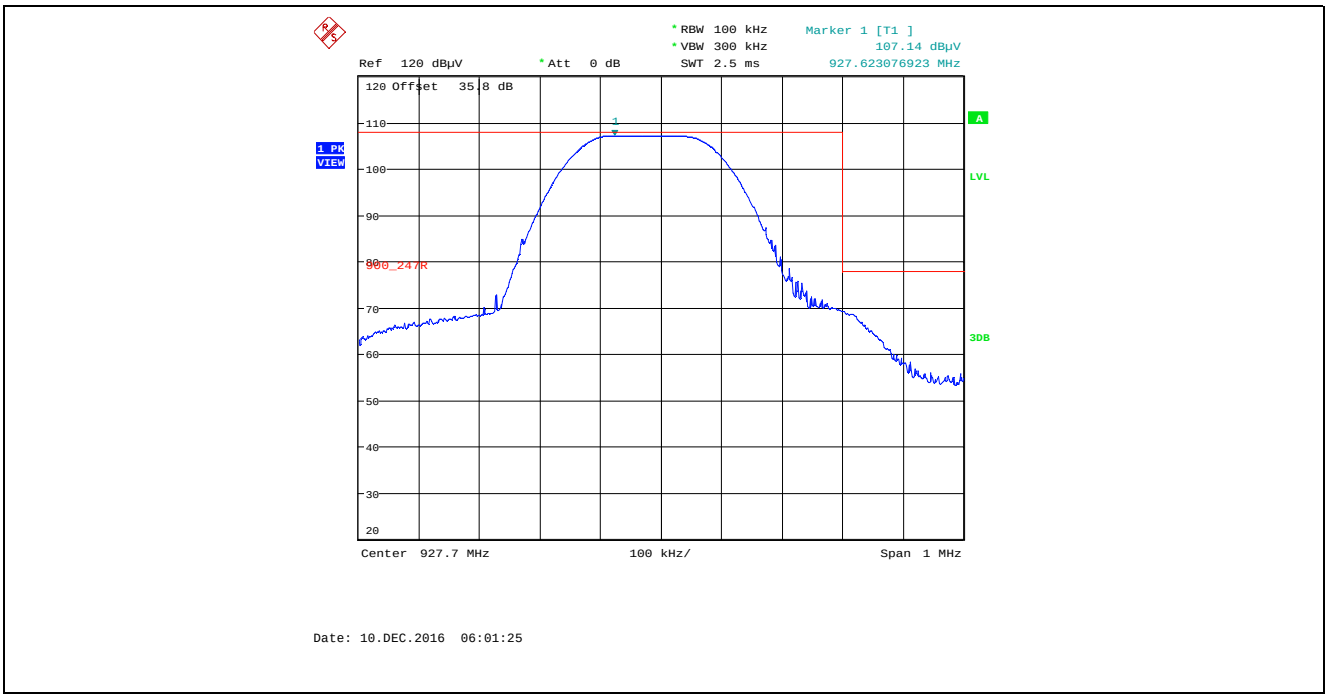
Plot 5.4.4.2.11. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 1760 bps Data Rate
Single Frequency Mode, Low End of Frequency Band



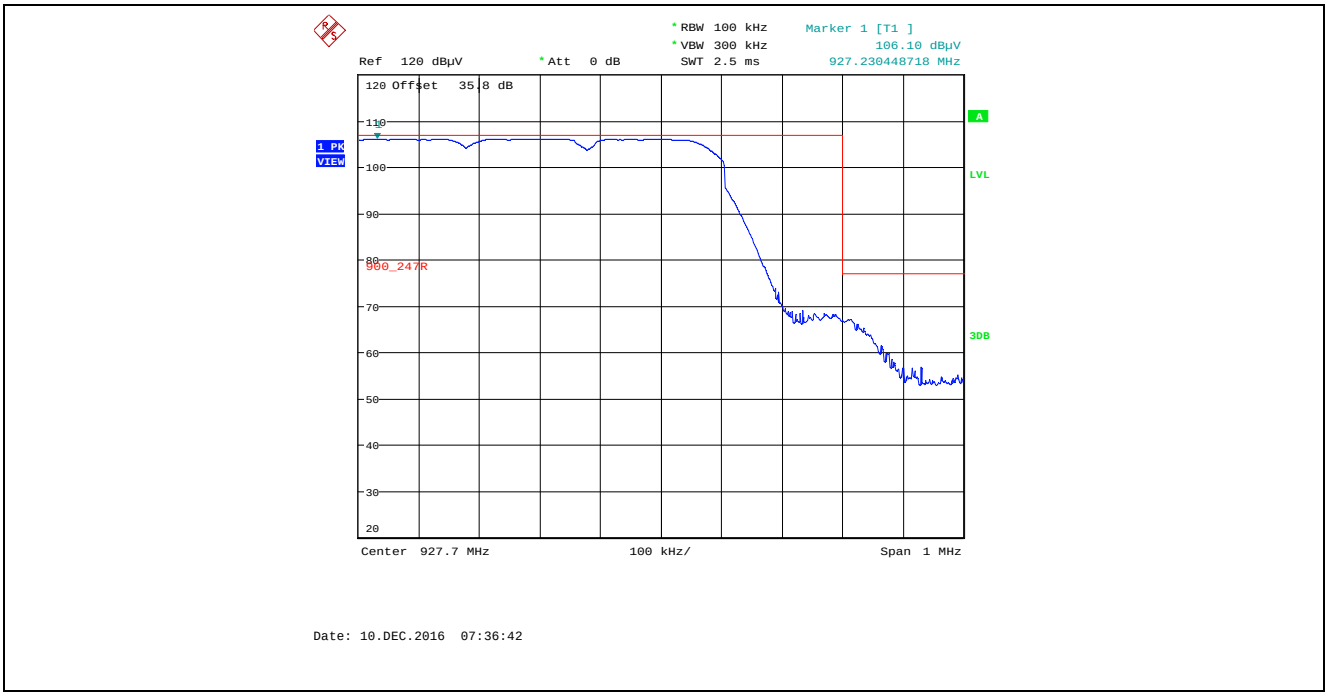
Plot 5.4.4.2.12. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 1760 bps Data Rate
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



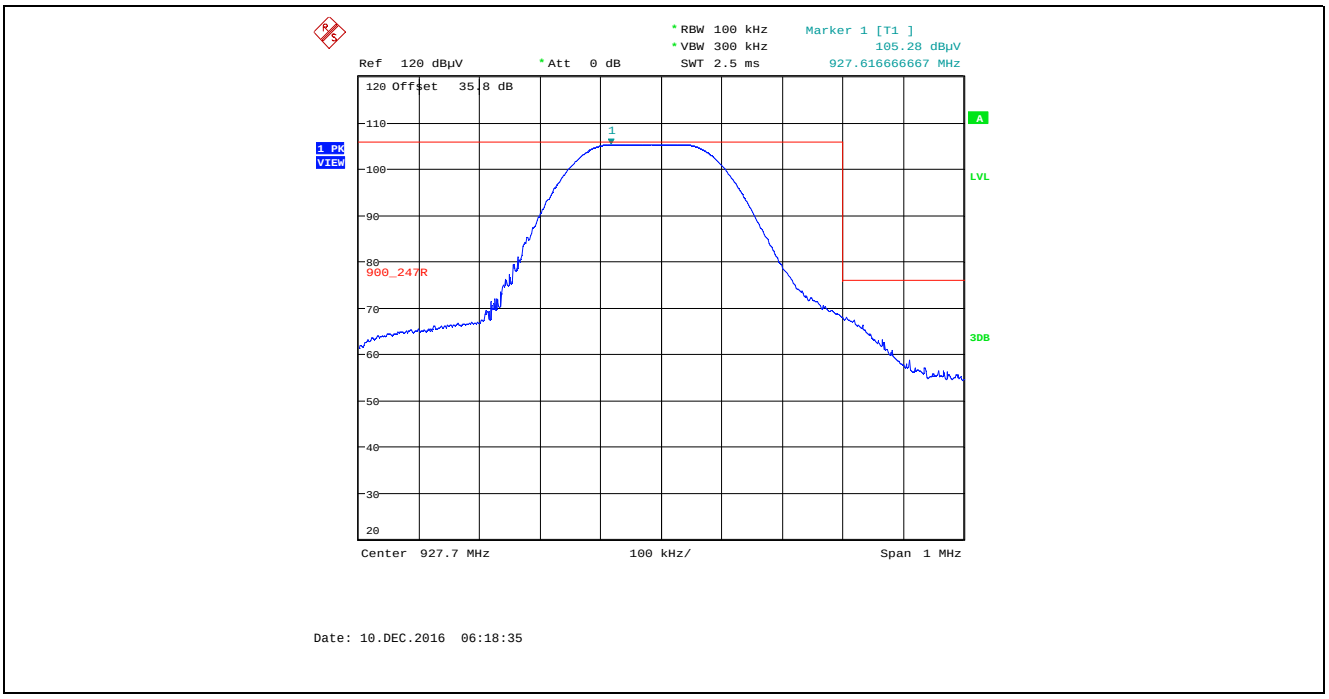
Plot 5.4.4.2.13. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 1760 bps Data Rate
Single Frequency Mode, High End of Frequency Band



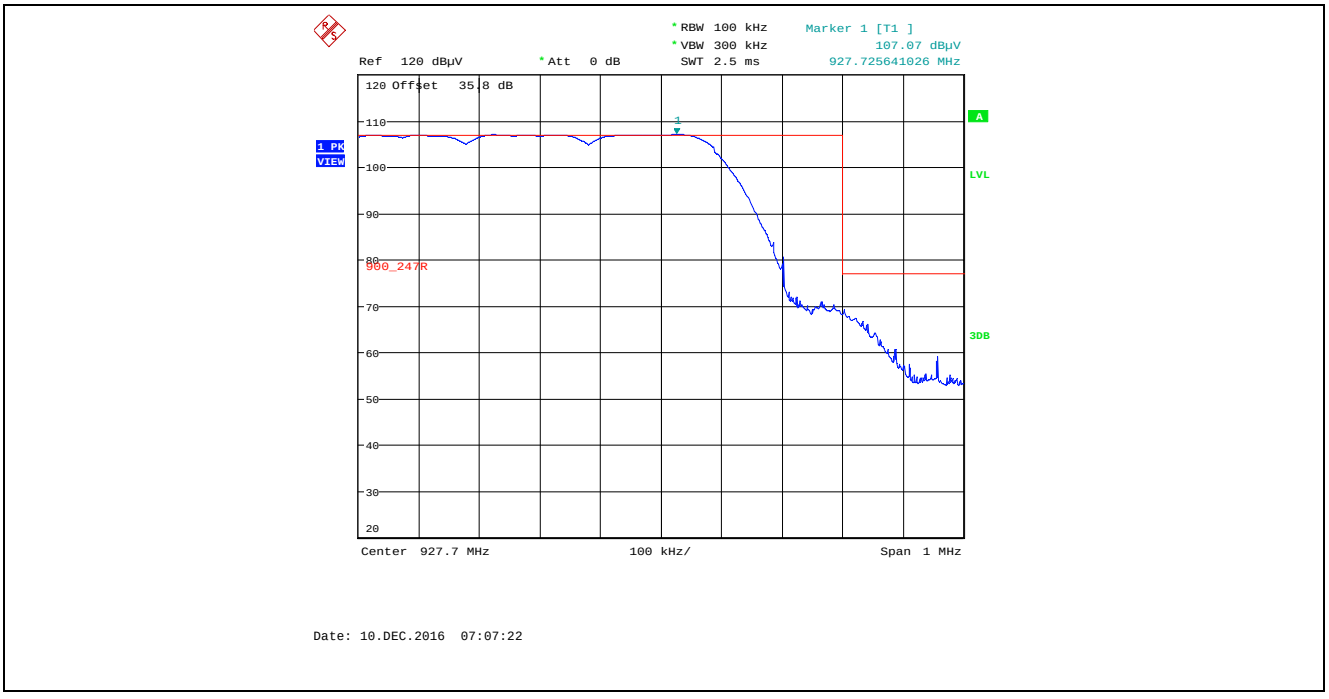
Plot 5.4.4.2.14. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 1760 bps Data Rate
Pseudorandom Channel Hopping Mode, High End of Frequency Band



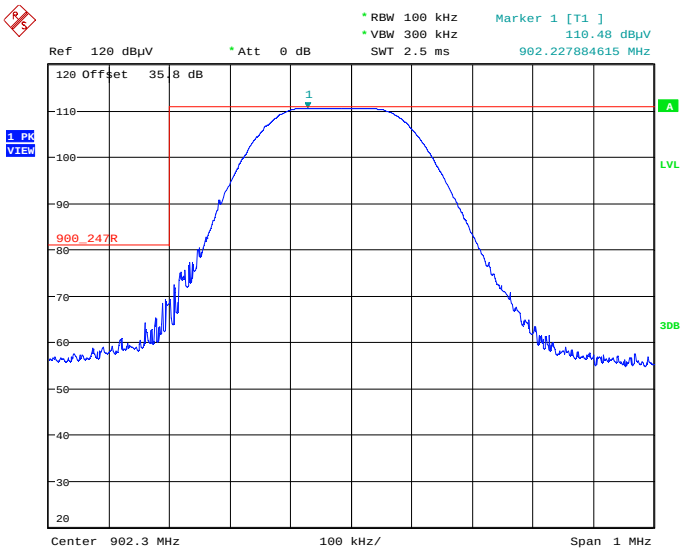
Plot 5.4.4.2.15. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 1760 bps Data Rate
Single Frequency Mode, High End of Frequency Band



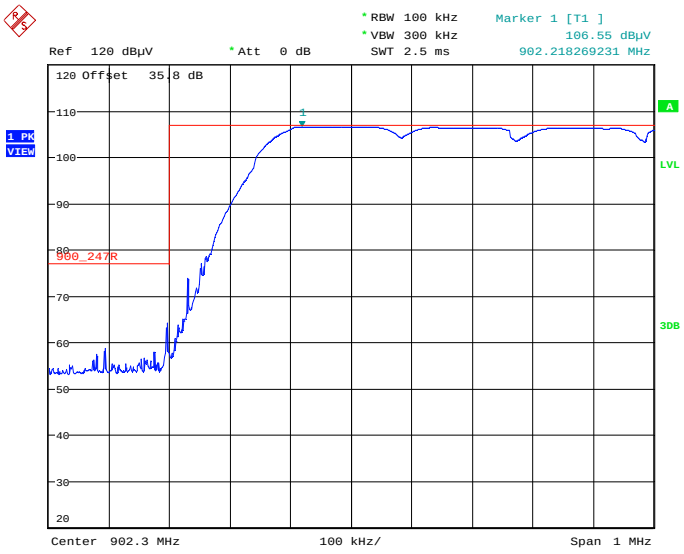
Plot 5.4.4.2.16. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 1760 bps Data Rate
Pseudorandom Channel Hopping Mode, High End of Frequency Band



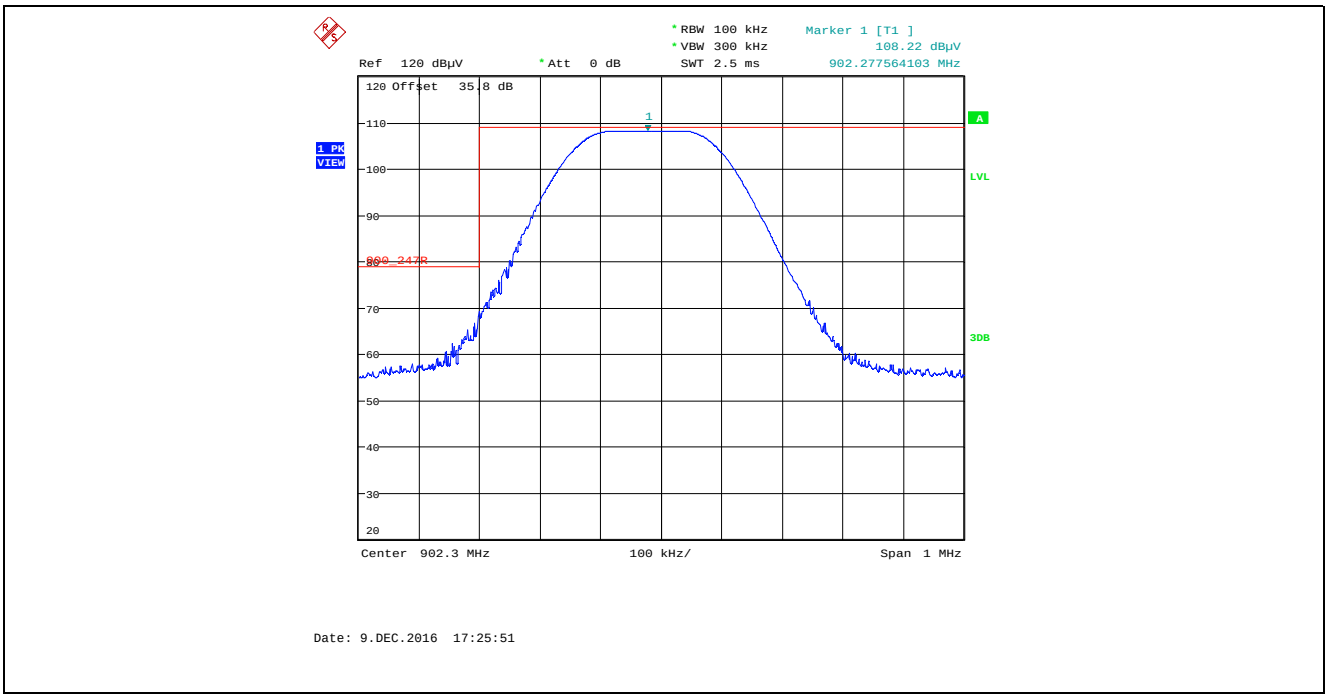
Plot 5.4.4.2.17. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 3125 bps Data Rate
Single Frequency Mode, Low End of Frequency Band



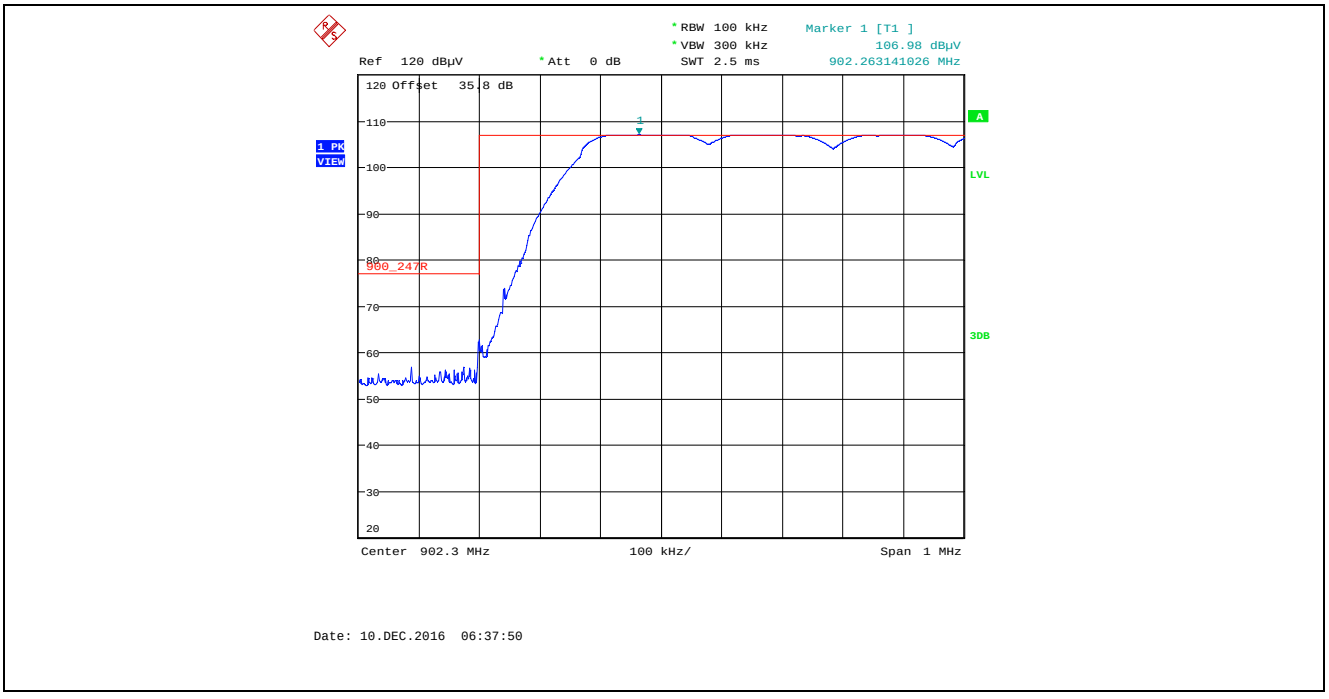
Plot 5.4.4.2.18. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 3125 bps Data Rate
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



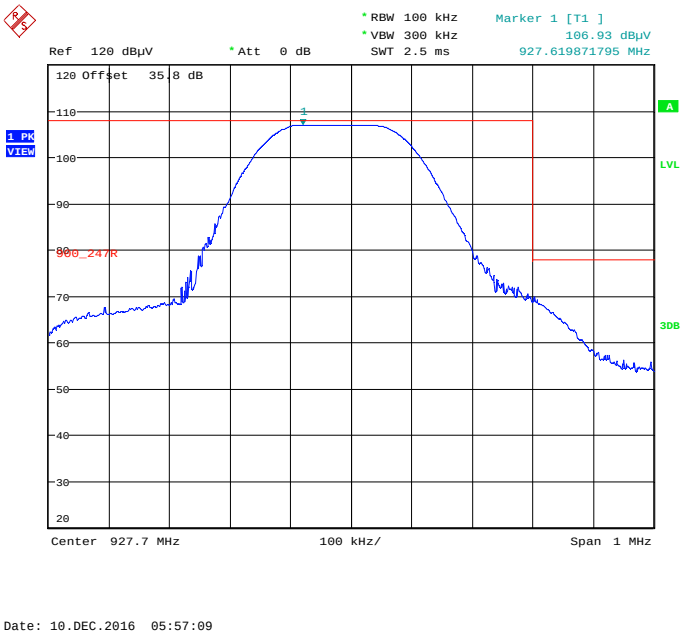
Plot 5.4.4.2.19. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 3125 bps Data Rate
Single Frequency Mode, Low End of Frequency Band



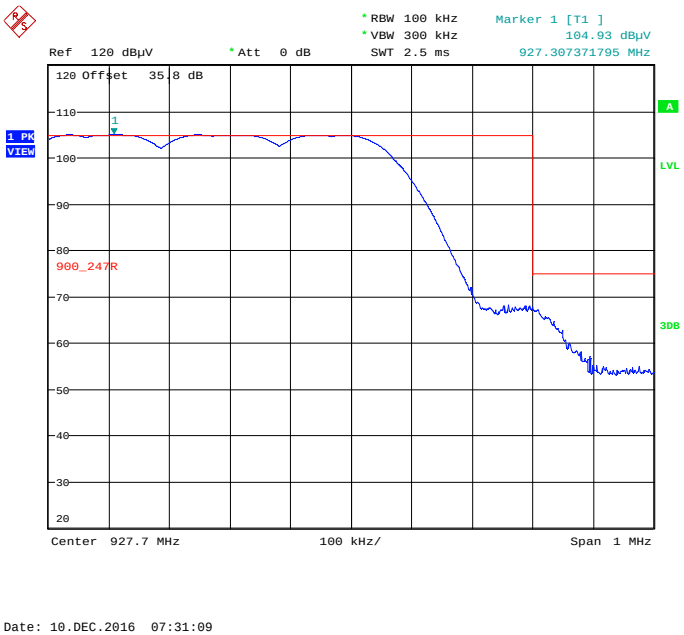
Plot 5.4.4.2.20. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 3125 bps Data Rate
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



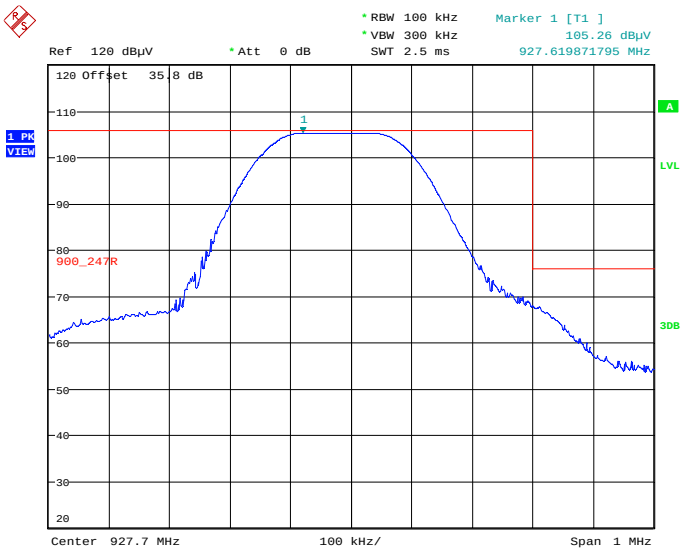
Plot 5.4.4.2.21. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 3125 bps Data Rate
Single Frequency Mode, High End of Frequency Band



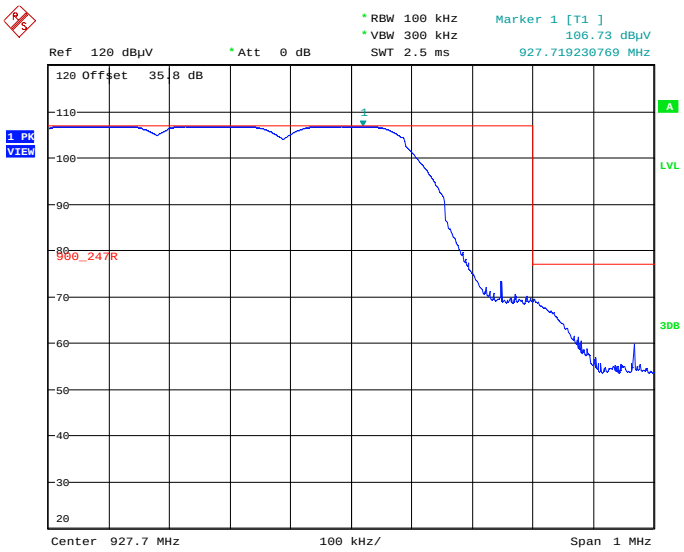
Plot 5.4.4.2.22. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 3125 bps Data Rate
Pseudorandom Channel Hopping Mode, High End of Frequency Band



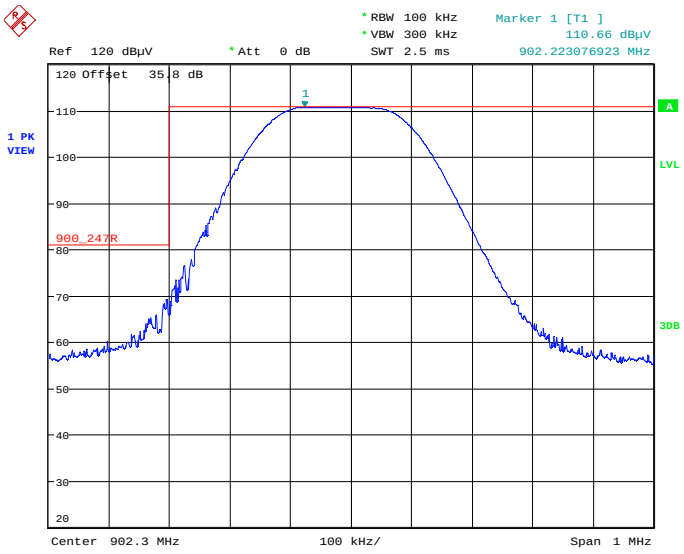
Plot 5.4.4.2.23. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 3125 bps Data Rate
Single Frequency Mode, High End of Frequency Band



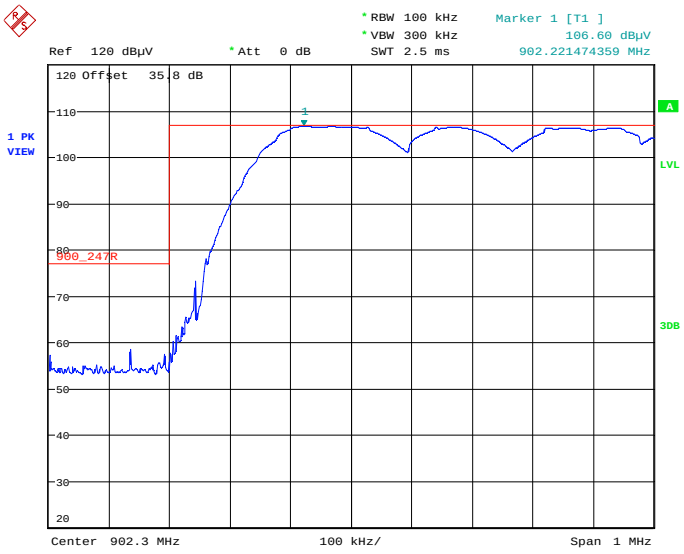
Plot 5.4.4.2.24. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 3125 bps Data Rate
Pseudorandom Channel Hopping Mode, High End of Frequency Band



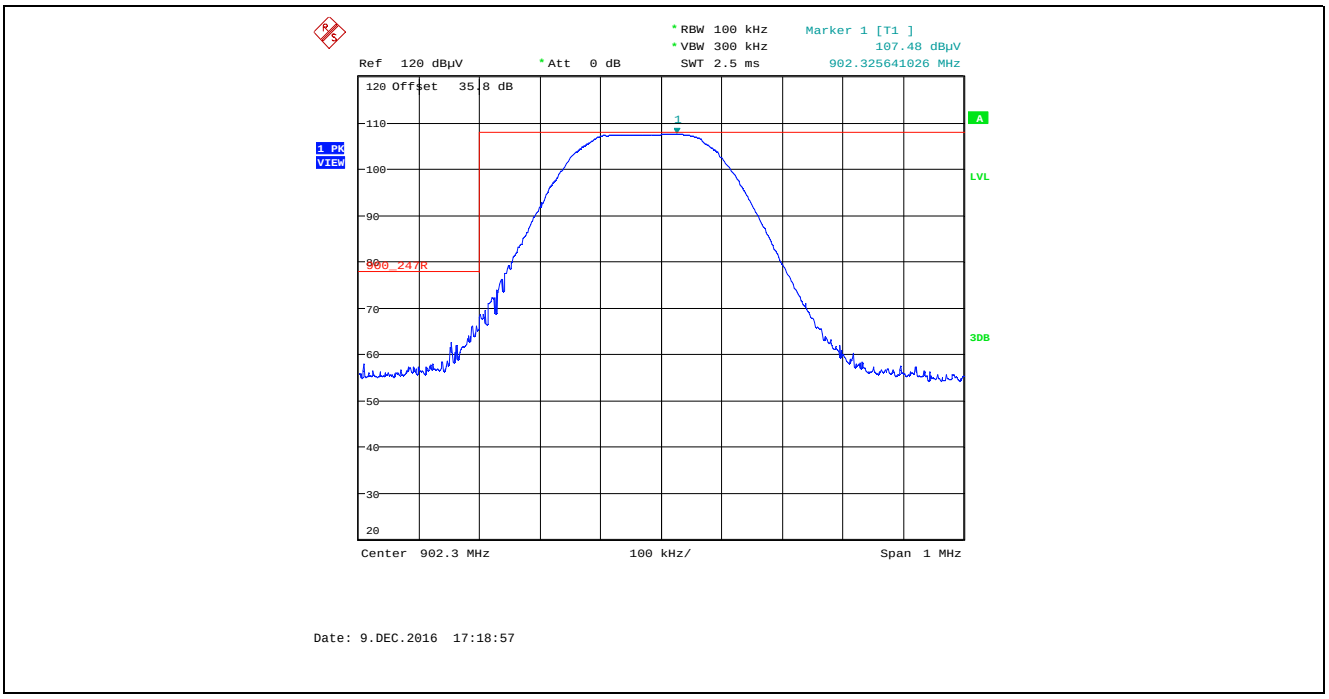
Plot 5.4.4.2.25. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 5470 bps Data Rate Single Frequency Mode, Low End of Frequency Band



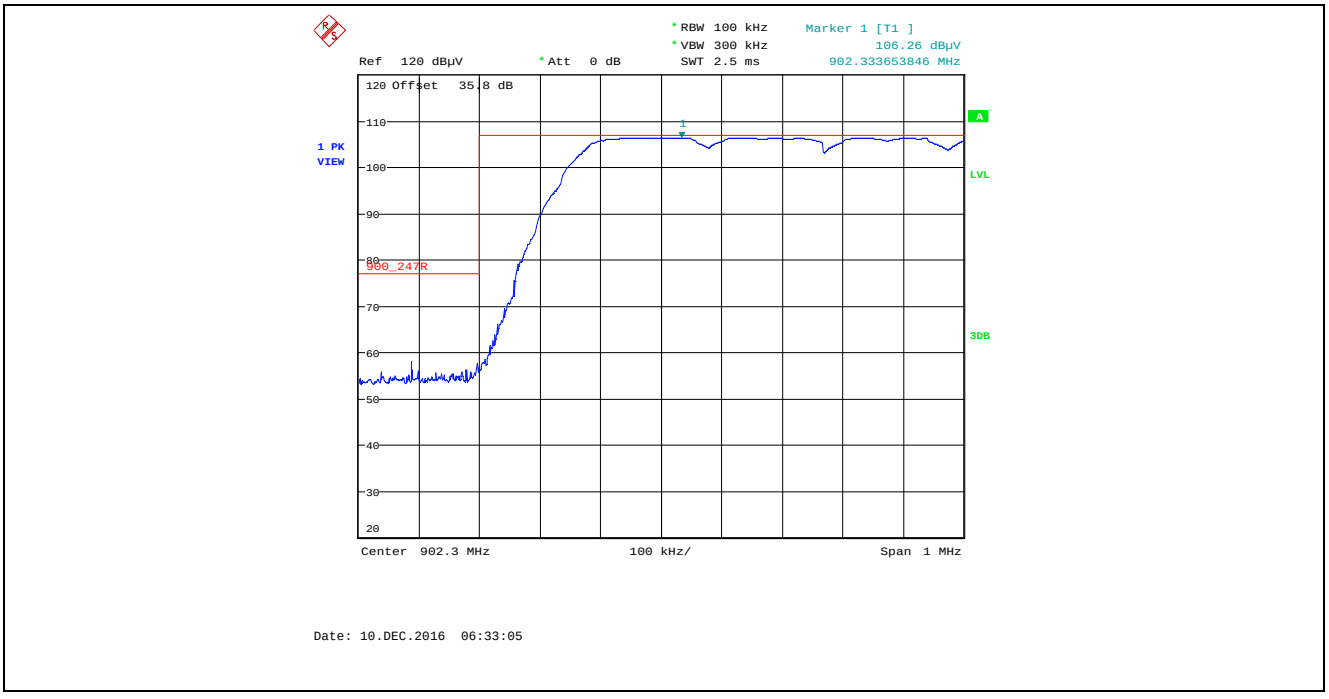
Plot 5.4.4.2.26. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 5470 bps Data Rate Pseudorandom Channel Hopping Mode, Low End of Frequency Band



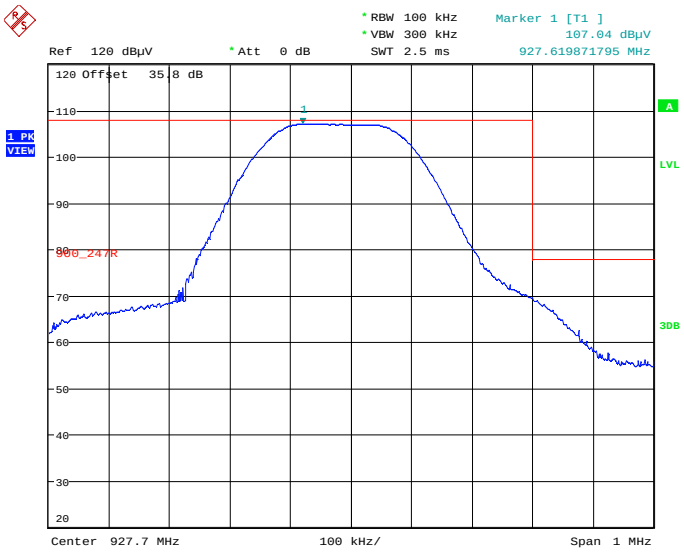
Plot 5.4.4.2.27. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 5470 bps Data Rate
Single Frequency Mode, Low End of Frequency Band



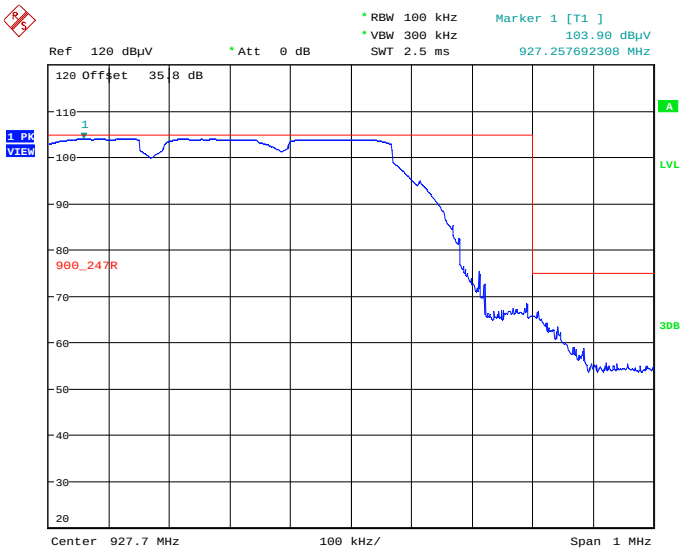
Plot 5.4.4.2.28. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 5470 bps Data Rate
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



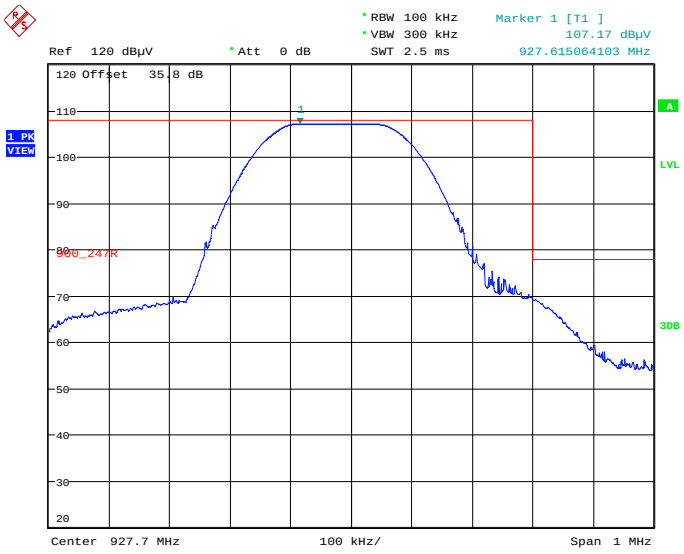
Plot 5.4.4.2.29. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 5470 bps Data Rate Single Frequency Mode, High End of Frequency Band



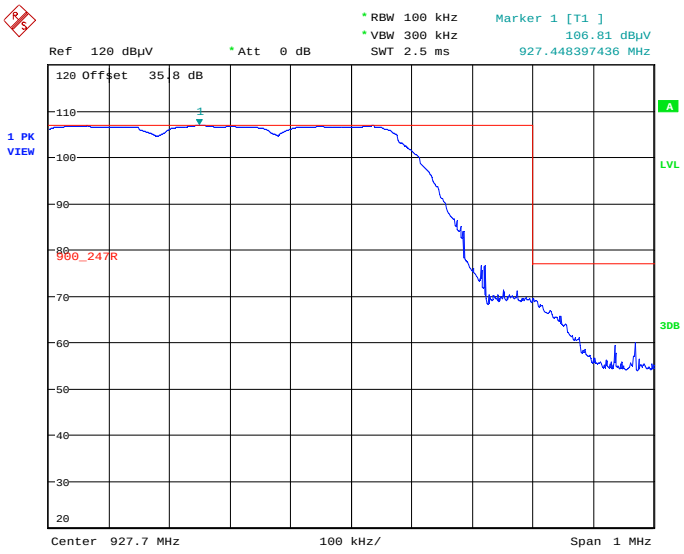
Plot 5.4.4.2.30. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization, 5470 bps Data Rate Pseudorandom Channel Hopping Mode, High End of Frequency Band



Plot 5.4.4.2.31. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 5470 bps Data Rate
Single Frequency Mode, High End of Frequency Band



Plot 5.4.4.2.32. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization, 5470 bps Data Rate
Pseudorandom Channel Hopping Mode, High End of Frequency Band



5.5. RF EXPOSURE REQUIRMENTS [§§ 15.247(i), 1.1310 & 2.1091]

§ **1.1310:** The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b).

Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3-3.0	614	1.63	*(100)	6
3.0-30	1842/f	4.89/f	*($900/f^2$)	6
30-300	61.4	0.163	1.0	6
300-1500			f/300	6
1500-100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*($180/f^2$)	30
30-300	27.5	0.073	0.2	30
300-1500			f/1500	30
1500-100,000			1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density

Note 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

Note 2: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

5.5.1. Method of Measurements

Calculation Method of Power Density/RF Safety Distance:

$$S = \frac{PG}{4\pi \cdot r^2} = \frac{EIRP}{4\pi \cdot r^2}$$

Where, P: power input to the antenna in mW
EIRP: Equivalent (effective) isotropic radiated power.
S: power density mW/cm^2
G: numeric gain of antenna relative to isotropic radiator
r: distance to centre of radiation in cm

5.5.2. RF Evaluation

Frequency (MHz)	Max. Conducted Power (dBm)	Antenna Gain (dBi)	EUT EIRP (dBm)	EUT EIRP (mW)	Evaluation Distance (cm)	Power Density (mW/cm^2)	FCC MPE Limit (mW/cm^2)	Margin (mW/cm^2)
902.3	18.90	-5.0	13.90	24.547	20	0.005	0.602	-0.597

EXHIBIT 6. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Cal. Due Date
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	21 Jul 2018
Attenuator	Pasternack	7024-10	4	DC–26.5 GHz	Cal on use
DC Block	Hewlett Packard	11742A	12460	0.045 – 26.5 GHz	Cal on use
DC Power Supply	Xantrex	HPD 60-5SX	63903	0-60 VDC	-
Multi-meter	Extech	EX530	12070737	0.01mV - 1kV	14 May 2017
Spectrum Analyzer	Rohde & Schwarz	FSEK30	100077	20Hz–40 GHz	05 Dec 2018
EMI Receiver	Rohde & Schwarz	ESU40	100037	20Hz–40 GHz	08 May 2017
RF Amplifier	Com-Power	PAM-0118A	551016	0.5 – 18 GHz	14 Jul 2017
RF Amplifier	Hewlett Packard	84498	3008A00769	1 – 26.5 GHz	05 May 2017
Biconilog	EMCO	3142	9601-1005	26-1000 MHz	12 May 2018
Horn Antenna	EMCO	3155	5955	1 – 18 GHz	21 Apr 2017
High Pass Filter	K & L	11SH10-1500/T8000	2	Cut off 900 MHz	Cal on use
Log Periodic	ETS-Lindgren	3148	23845	200 – 2000 MHz	20 Jul 2018

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. LINE CONDUCTED EMISSION MEASUREMENT UNCERTAINTY

	Line Conducted Emission Measurement Uncertainty (9 kHz – 30 MHz):	**Measured**	**Limit**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$	**± 1.44**	**± 1.8**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 2.89**	**± 3.6**

7.2. RADIATED EMISSION MEASUREMENT UNCERTAINTY

	Radiated Emission Measurement Uncertainty @ 3m, Horizontal (30-1000 MHz):	**Measured (dB)**	**Limit (dB)**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$	**± 2.39**	**± 2.6**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 4.79**	**± 5.2**

	Radiated Emission Measurement Uncertainty @ 3m, Vertical (30-1000 MHz):	**Measured (dB)**	**Limit (dB)**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$	**± 2.39**	**± 2.6**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 4.78**	**± 5.2**

	Radiated Emission Measurement Uncertainty @ 3 m, Horizontal & Vertical (1 – 18 GHz):	**Measured (dB)**	**Limit (dB)**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$	**± 1.87**	**Under consideration**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 3.75**	**Under consideration**