ENGINEERING TEST REPORT

900MHz OEM Wireless Module
Model: n920X2
FCC ID: NS9N920X2

Applicant:

Microhard Systems Inc.
150 Country Hills Landing NW
Calgary, Alberta
Canada T3K 5P3

In Accordance With

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

UltraTech's File No.: 19MCRS109_FCC15C247

This Test report is Issued under the Authority of Tri M. Luu Vice President of Engineering UltraTech Group of Labs Date: January 22, 2019	
Report Prepared by: Dan Huynh Issued Date: January 22, 2019	Tested by: Hung Trinh Test Dates: November 20 - December 1, 2018 January 16, 2019

- *The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.*
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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 for Part 15C Spread Spectrum Transmitter
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	2018	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
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:	Microhard Systems Inc.
Address:	150 Country Hills Landing NW Calgary, Alberta Canada T3K 5P3
Contact Person:	Mr. Hany Shenouda Phone #: 403 248-0028 Fax #: 403 248 2762 Email Address: shenouda@microhardcorp.com

MANUFACTURER	
Name:	Microhard Systems Inc.
Address:	150 Country Hills Landing NW Calgary, Alberta Canada T3K 5P3
Contact Person:	Mr. Hany Shenouda Phone #: 403 248-0028 Fax #: 403 248-2762 Email Address: shenouda@microhardcorp.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:	Microhard Systems Inc.
Product Name:	900MHz OEM Wireless Module
Model Name or Number:	n920X2
Serial Number:	Test Sample
Type of Equipment:	Spread Spectrum Transmitter
Input Power Supply Type:	External Regulated DC Sources
Primary User Functions of EUT:	Spread Spectrum OEM Transceiver

2.3. EUT'S TECHNICAL SPECIFICATIONS

Transmitter	
Equipment Type:	▪ Mobile ▪ Base Station (fixed use)
Intended Operating Environment:	Residential Commercial, industrial or business environment
Power Supply Requirement:	3.3 VDC
RF Output Power Rating:	14 - 30 dBm typical
Operating Frequency Range:	902.4 – 927.6 MHz
RF Output Impedance:	50 Ω
Duty Cycle:	Continuous
Modulation Type:	GFSK
Antenna Connector Type:	MMCX

2.4. ASSOCIATED ANTENNA DESCRIPTIONS

Antenna Type	Maximum Gain (dBi)
Rubber Duck Antenna	3
Yagi Antenna	13.15
Patch Antenna	8
Omni Directional Antenna	8.15
Puck Antenna	4

2.5. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	RF IN/OUT Port	1	MMCX	Shielded
2	DC Supply & I/O Port	1	Pin Header	No cable, direct connection

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:

Ancillary Equipment # 1	
Description:	Test Jig
Brand name:	Microhard Systems Inc.
Model Name or Number:	N/A
Connected to EUT's Port:	I/O Port

Ancillary Equipment # 2	
Description:	AC/DC Adapter
Brand name:	BI Switching Power Supply
Model Name or Number:	BI30-120200-AdU
Connected to EUT's Port:	Test Jig of the EUT

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:	3.3 VDC via test jig

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 as non-integral antenna equipment as described with the test results.

Transmitter Test Signals	
Frequency Band(s):	902.4 – 927.6 MHz
Frequency(ies) Tested: (Near lowest, near middle & near highest frequencies in the frequency range of operation.)	902.4 MHz, 915 MHz and 927.6 MHz
RF Power Output: (measured maximum output power at antenna terminals)	30.00 dBm, 1 W (conducted)
Normal Test Modulation:	GFSK
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	Yes
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. TEST DATA

5.1. POWER LINE CONDUCTED EMISSIONS [§15.207(a)]

5.1.1. Limit(s)

The equipment shall meet the limits of the following table:

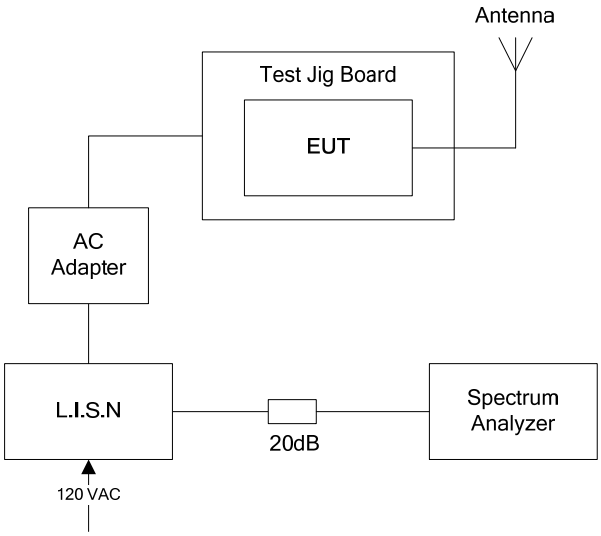
Frequency of emission (MHz)	Conducted Limits (dBμV)	
	Quasi-peak	Average
0.15–0.5 .....……...	66 to 56*	56 to 46*
0.5–5 .....……...	56	46
5-30 ……..	60 ..……..	50

*Decreases linearly with the logarithm of the frequency

5.1.2. Method of Measurements

ANSI C63.4

5.1.3. Test Arrangement

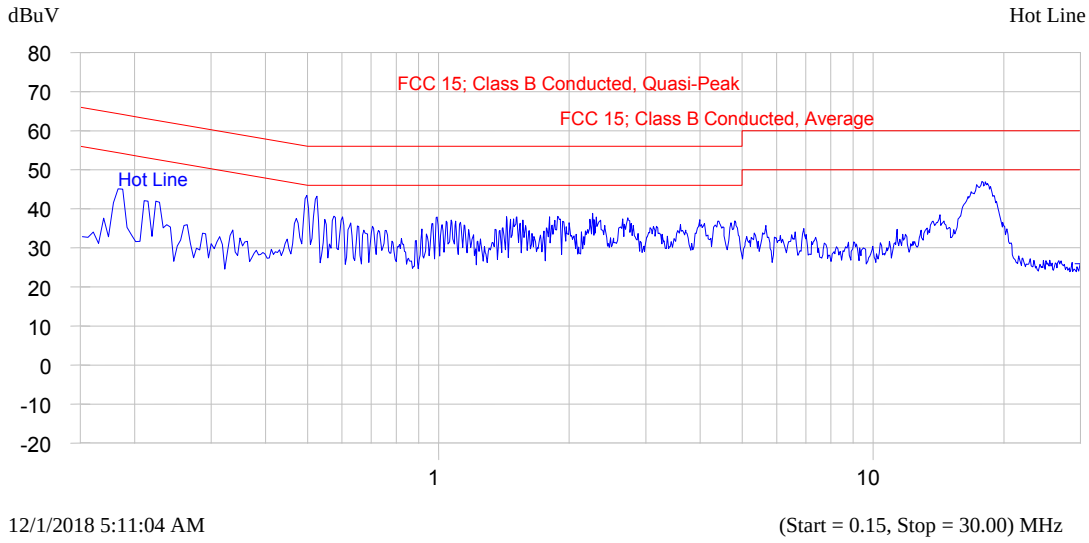


All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

5.1.4. Test Data

Plot 5.1.4.1. Power Line Conducted Emissions (Tx Mode)
Line Voltage: 120 VAC; Line Tested: Hot

Current Graph

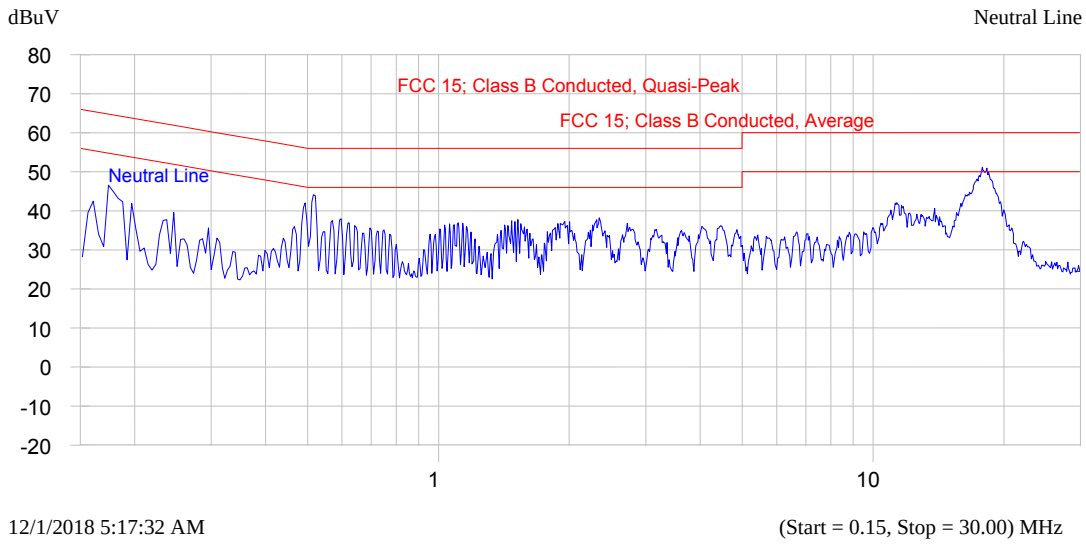


Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.180	51.5	44.9	-19.6	32.0	-22.5	Hot Line
0.489	45.0	42.6	-13.6	40.9	-5.3	Hot Line
17.953	48.2	45.4	-14.6	40.4	-9.6	Hot Line

Plot 5.1.4.2. Power Line Conducted Emissions (Tx Mode)
Line Voltage: 120 VAC; Line Tested: Neutral

Current Graph

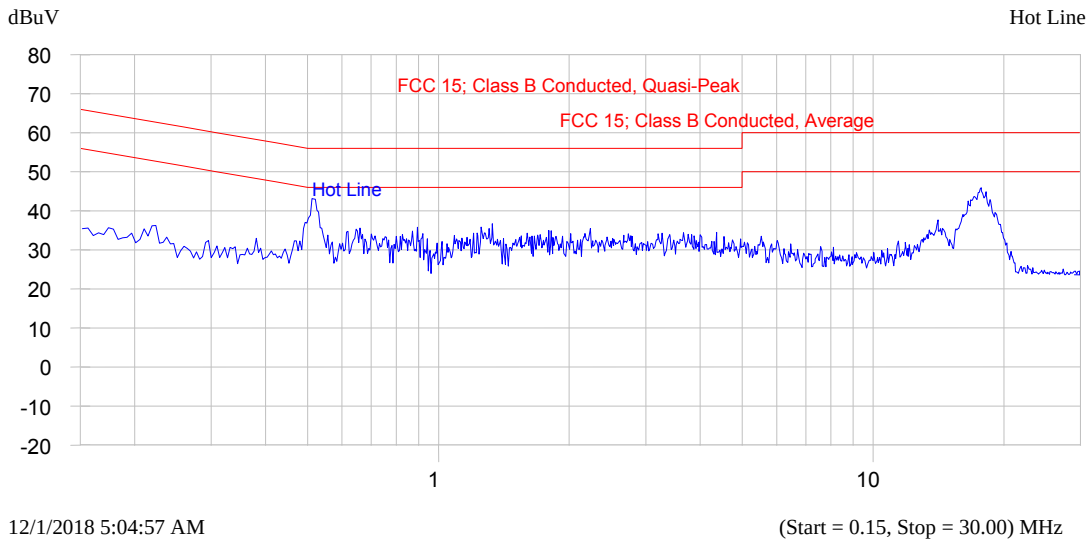


Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.158	52.7	45.0	-20.6	32.1	-23.4	Neutral Line
0.513	46.3	44.3	-11.7	43.3	-2.7	Neutral Line
11.254	42.2	38.7	-21.3	33.4	-16.6	Neutral Line
17.827	51.1	48.4	-11.6	42.9	-7.1	Neutral Line

Plot 5.1.4.3. Power Line Conducted Emissions (Rx Mode)
Line Voltage: 120 VAC; Line Tested: Hot

Current Graph

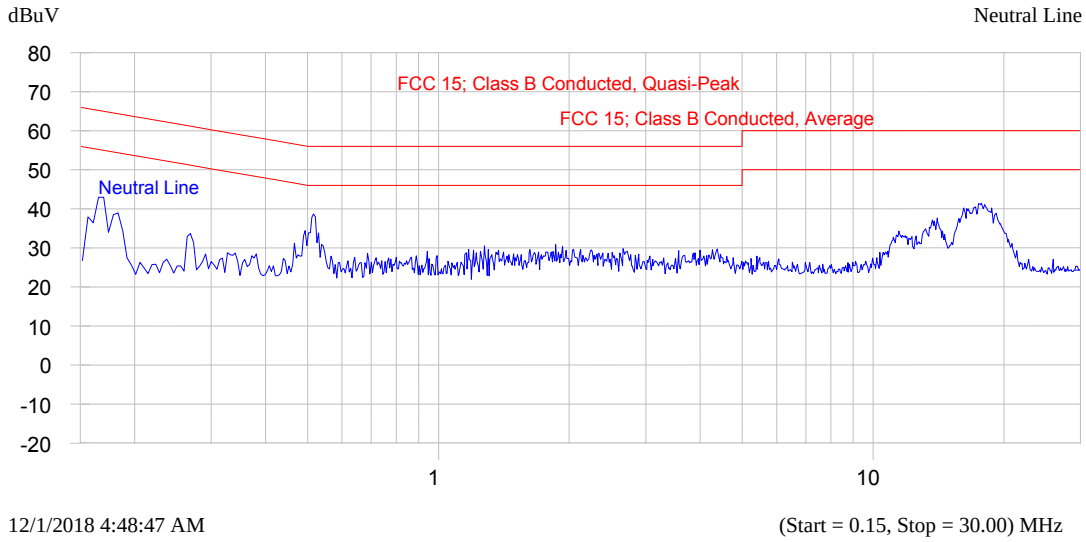


Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.515	45.4	42.2	-13.8	35.1	-10.9	Hot Line
14.130	36.7	31.3	-28.7	24.6	-25.4	Hot Line
17.746	45.3	41.2	-18.8	32.4	-17.6	Hot Line

Plot 5.1.4.4. Power Line Conducted Emissions (Rx Mode)
Line Voltage: 120 VAC; Line Tested: Neutral

Current Graph



Current List

Frequency MHz	Peak dBuV	QP dBuV	QP-QP Limit dB	Avg dBuV	Avg-Avg Limit dB	Trace Name
0.173	45.1	38.9	-25.9	30.6	-24.2	Neutral Line
0.510	41.3	37.1	-18.9	29.6	-16.4	Neutral Line
17.768	41.9	37.6	-22.4	28.7	-21.3	Neutral Line

5.2. 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 employs a unique antenna connector.
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 proposed antenna listed in user manual.
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
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

FCC Section	FCC Rules	Manufacturer's Clarification
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

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

5.3.1. Limits

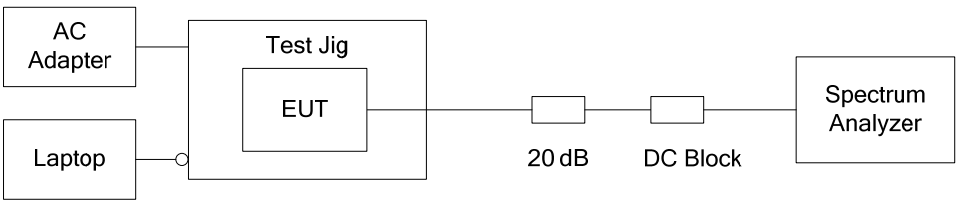
§ 15.247(a)(1): Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier 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.

5.3.2. Method of Measurements

ANSI C63.10-2013, Sections 6.9.2, 7.8.2, 7.8.3 and 7.8.4

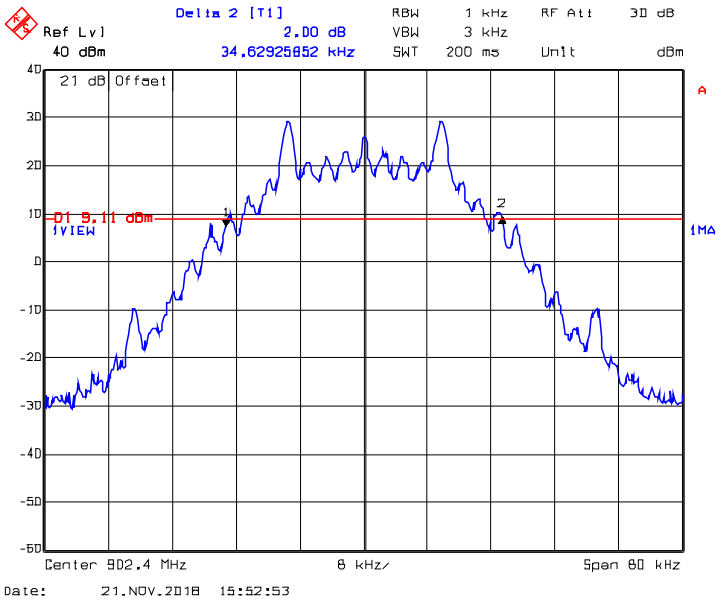
5.3.3. Test Arrangement



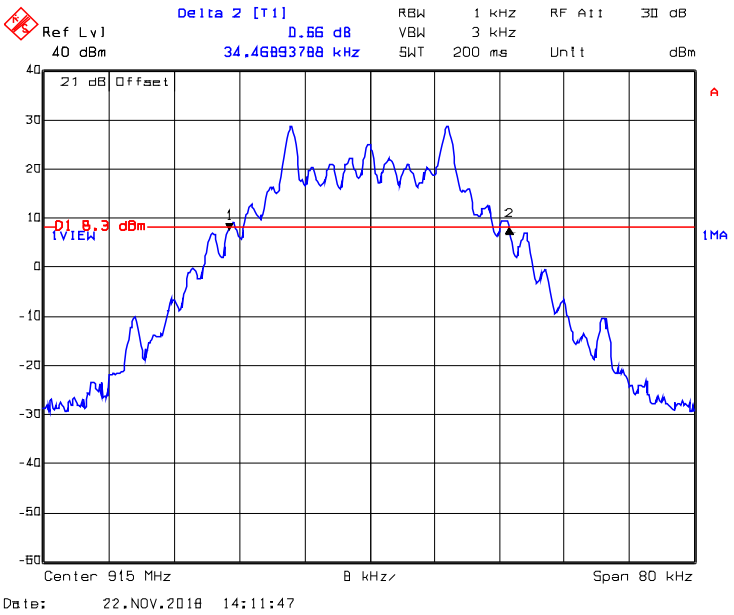
5.3.4. Test Data

<table>
<tr><th>Test Description</th><th>FCC Specification</th><th colspan="2">Measured Values</th><th>Comments</th></tr>
<tr><td>Frequency Hopping Systems Requirements</td><td>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.</td><td colspan="2">--</td><td>See Note 1</td></tr>
<tr><td rowspan="4">BW of the hopping channel</td><td rowspan="4">The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.</td><td>Channel Spacing</td><td>20 dB BW</td><td rowspan="4">See Note 2</td></tr>
<tr><td>50 kHz</td><td>34.63 kHz</td></tr>
<tr><td>280 kHz</td><td>197.40 kHz</td></tr>
<tr><td>400 kHz</td><td>367.84 kHz</td></tr>
<tr><td>Channel Hopping Frequency Separation</td><td>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.</td><td colspan="2">50.85 kHz for 50 kHz CS
291.33 kHz for 280 kHz CS
415.98 kHz for 400 kHz CS</td><td>See Note 2</td></tr>
<tr><td>Number of hopping frequencies</td><td>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</td><td colspan="2">50 hopping frequencies</td><td>See Note 1 and 2</td></tr>
<tr><td rowspan="4">Average Time of Occupancy</td><td rowspan="4">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</td><td>Channel Spacing</td><td>Dwell Time</td><td rowspan="4">See Note 2</td></tr>
<tr><td>50 kHz</td><td>79.36 ms
in 20s period</td></tr>
<tr><td>280 kHz</td><td>26.04 ms
in 10s period</td></tr>
<tr><td>400 kHz</td><td>19.48 ms
in 10s period</td></tr>
<tr><td colspan="5">Note 1: See operational description exhibit for details.
Note 2: See the following plots for details.</td></tr>
</table>

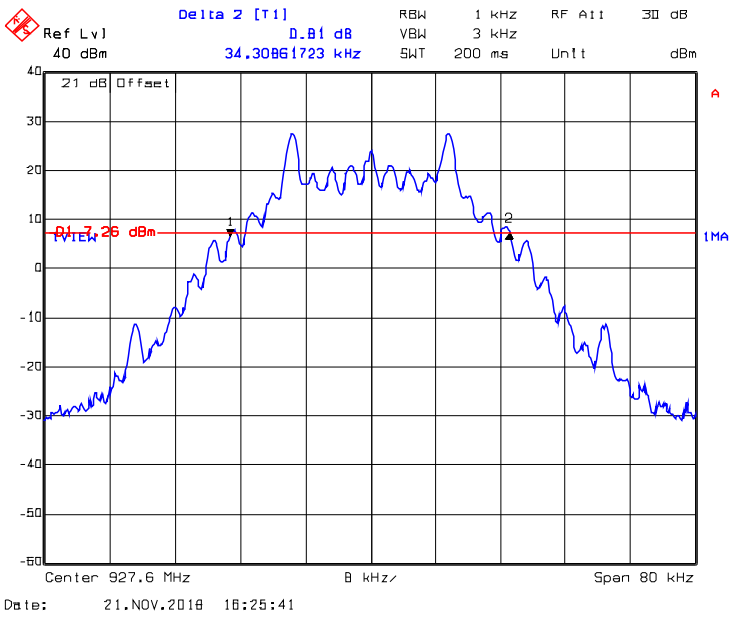
Plot 5.3.4.1. 20 dB Bandwidth, 902.4 MHz, Low Data Rate, 50 kHz CS, Raw Power Setting at 38



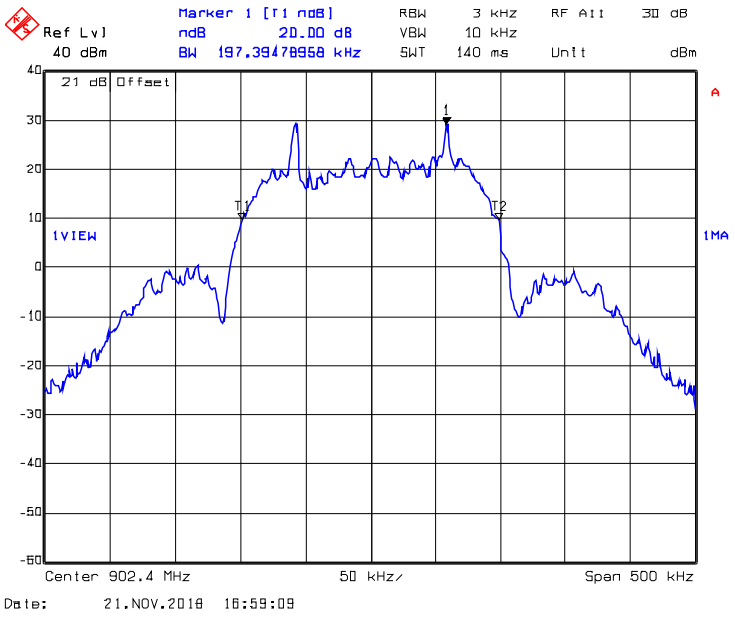
Plot 5.3.4.2. 20 dB Bandwidth, 915 MHz, Low Data Rate, 50 kHz CS, Raw Power Setting at 38



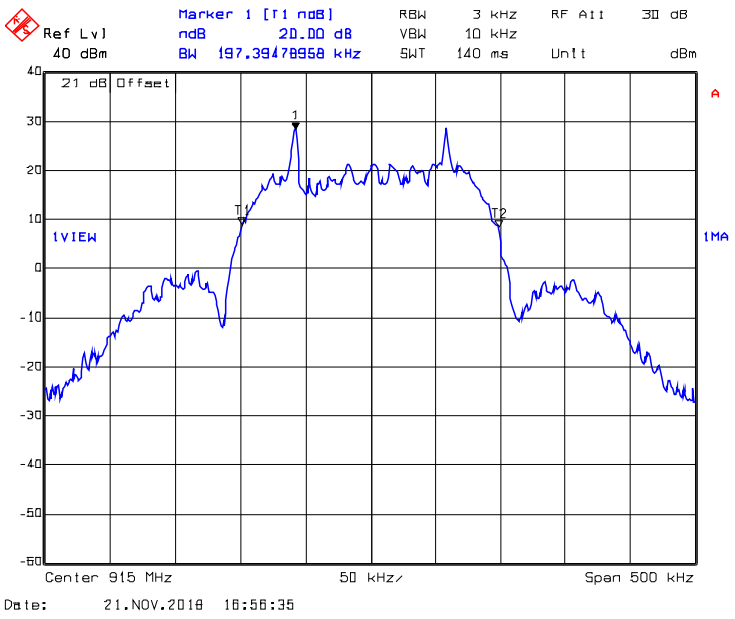
Plot 5.3.4.3. 20 dB Bandwidth, 927.6 MHz, Low Data Rate, 50 kHz CS, Raw Power Setting at 38



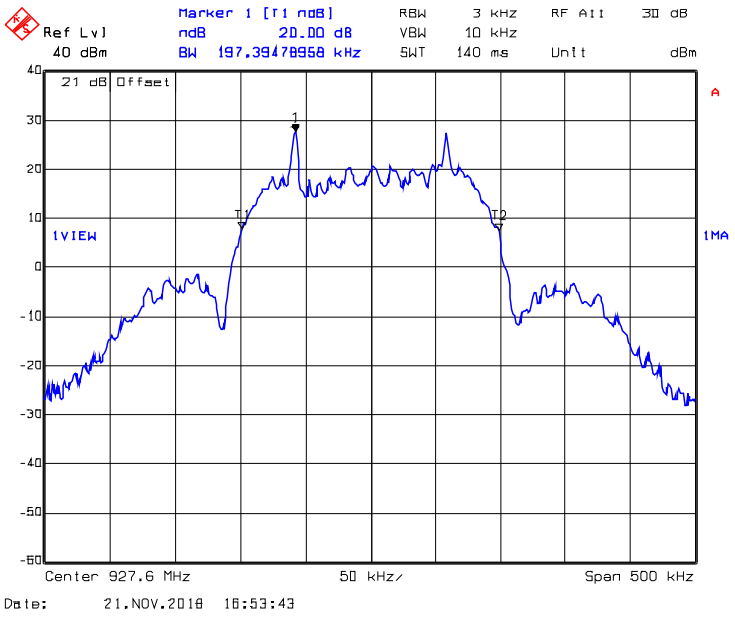
Plot 5.3.4.4. 20 dB Bandwidth, 902.4 MHz, Middle Data Rate, 280 kHz CS, Raw Power Setting at 38



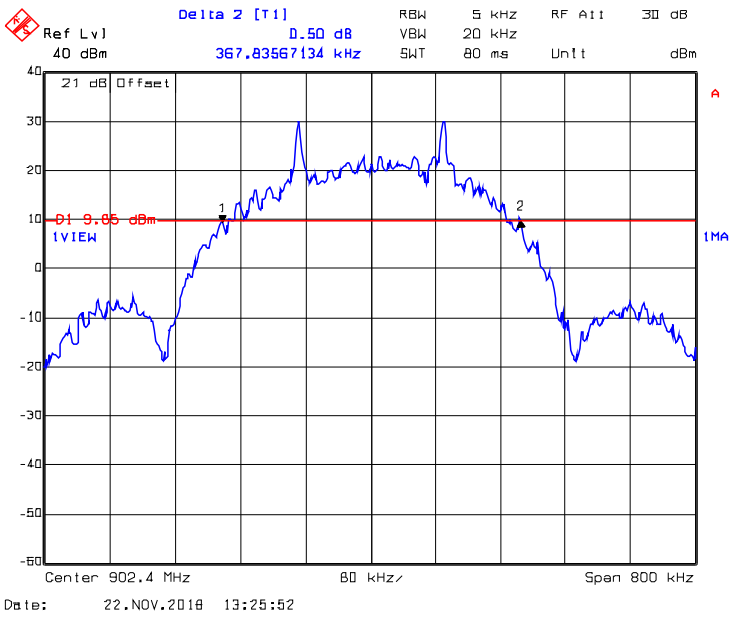
Plot 5.3.4.5. 20 dB Bandwidth, 915 MHz, Middle Data Rate, 280 kHz CS, Raw Power Setting at 38



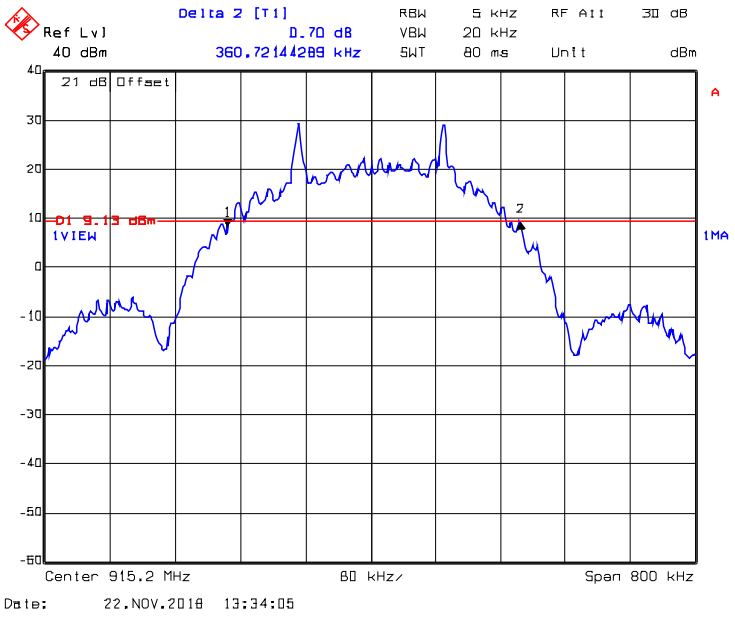
Plot 5.3.4.6. 20 dB Bandwidth, 927.6 MHz, Middle Data Rate, 280 kHz CS, Raw Power Setting at 38



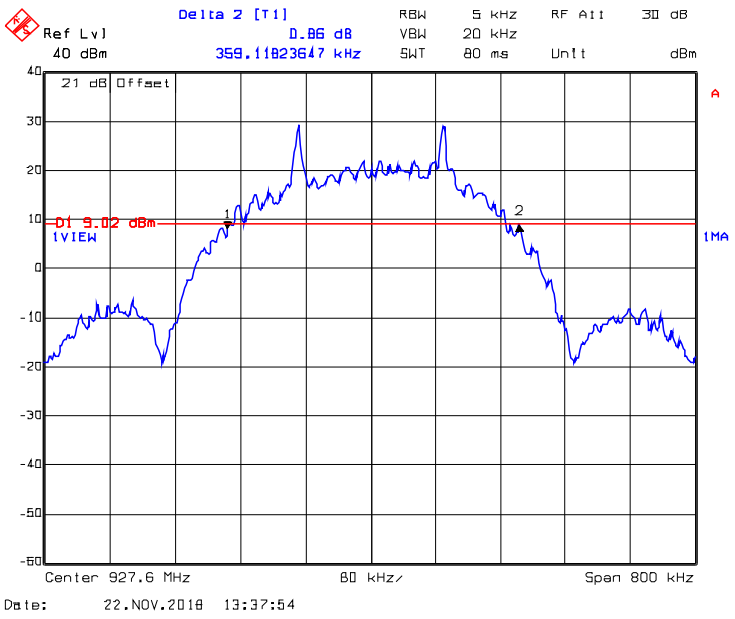
Plot 5.3.4.7. 20 dB Bandwidth, 902.4 MHz, High Data Rate, 400 kHz CS, Raw Power Setting at 35



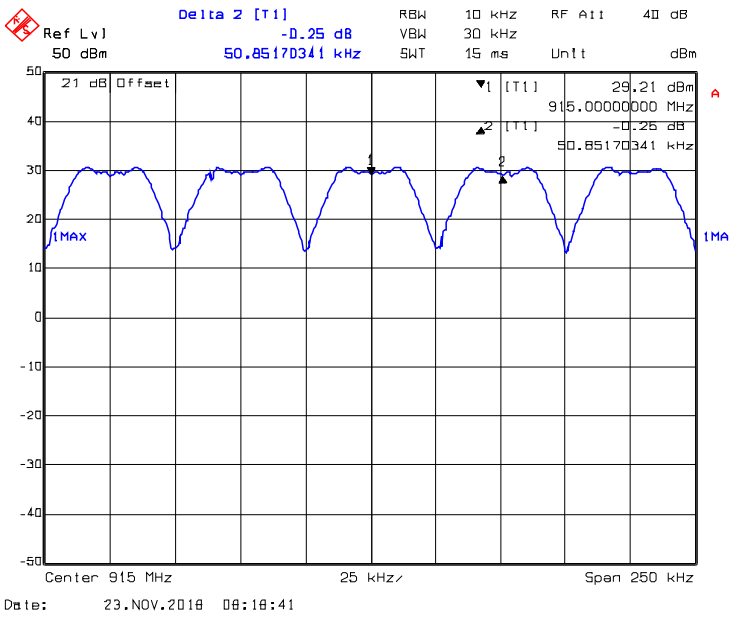
Plot 5.3.4.8. 20 dB Bandwidth, 915.2 MHz, High Data Rate, 400 kHz CS, Raw Power Setting at 35



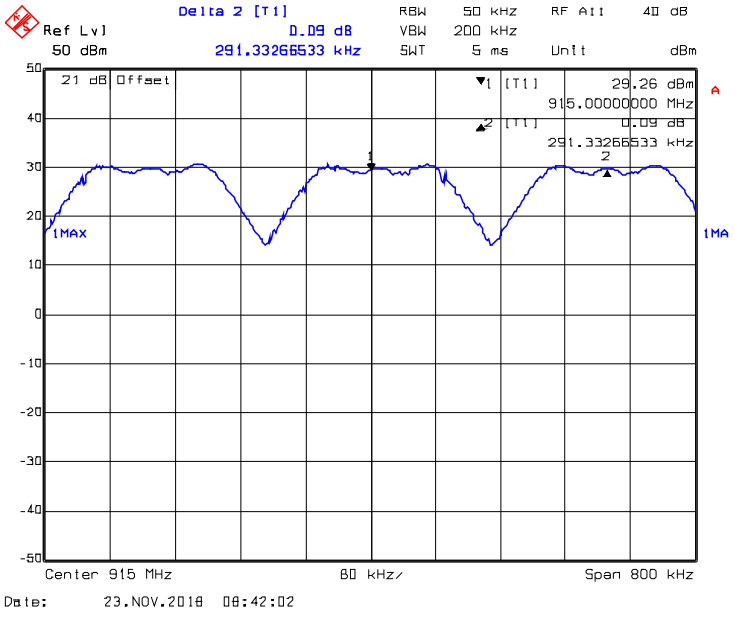
Plot 5.3.4.9. 20 dB Bandwidth, 927.6 MHz, High Data Rate, 400 kHz CS, Raw Power Setting at 35



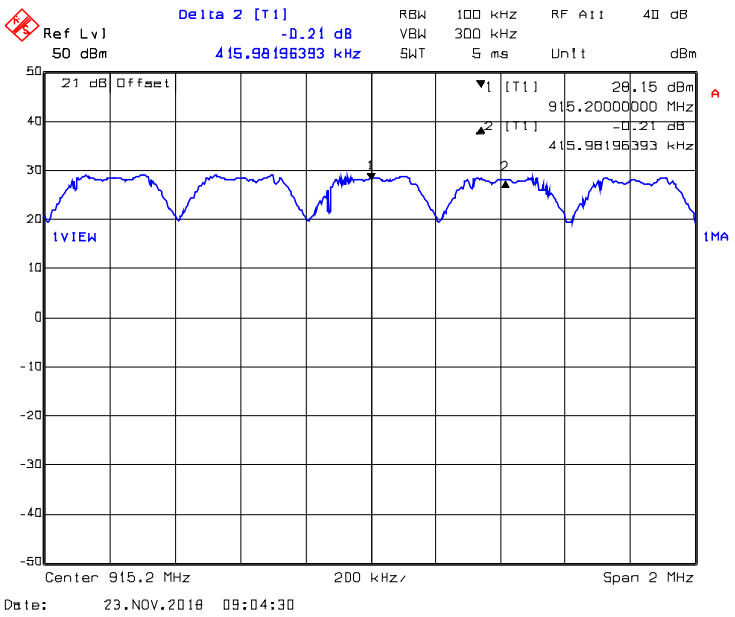
Plot 5.3.4.10. Carrier Frequency Separation, 915 MHz, Low Data Rate, 50 kHz CS



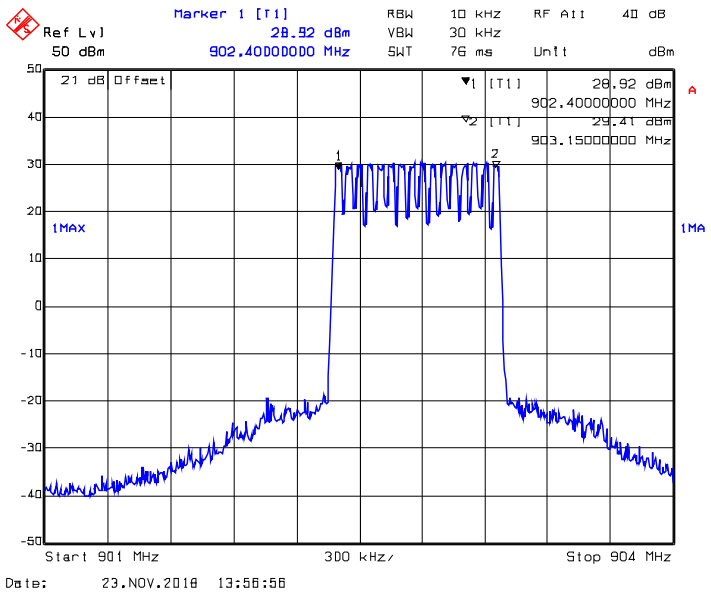
Plot 5.3.4.11. Carrier Frequency Separation, 915 MHz, Middle Data Rate, 280 kHz CS



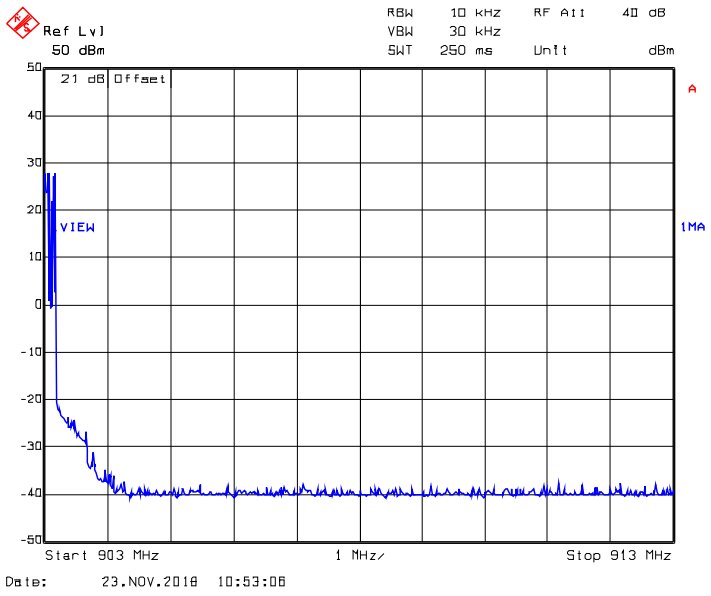
Plot 5.3.4.12. Carrier Frequency Separation, 915 MHz, High Data Rate, 400 kHz CS



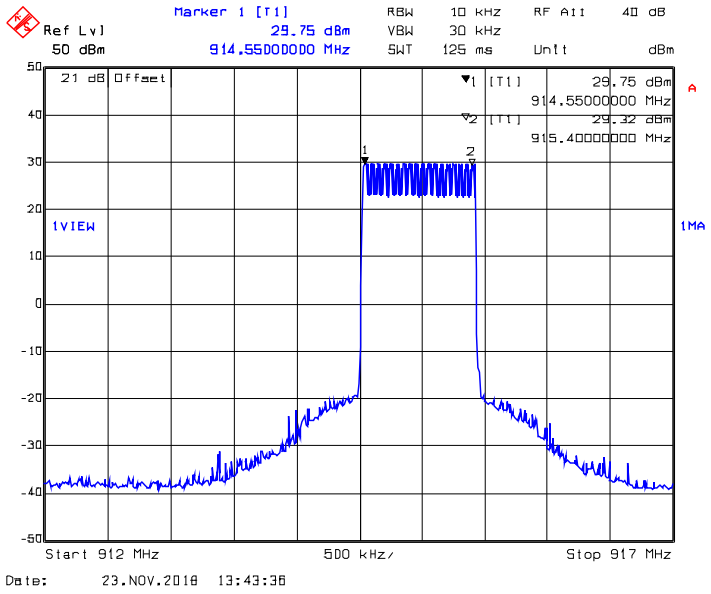
Plot 5.3.4.13. Number of Hopping Frequencies, Low Data Rate, 50 kHz CS
16 Hopping Channels from 902 – 904 MHz



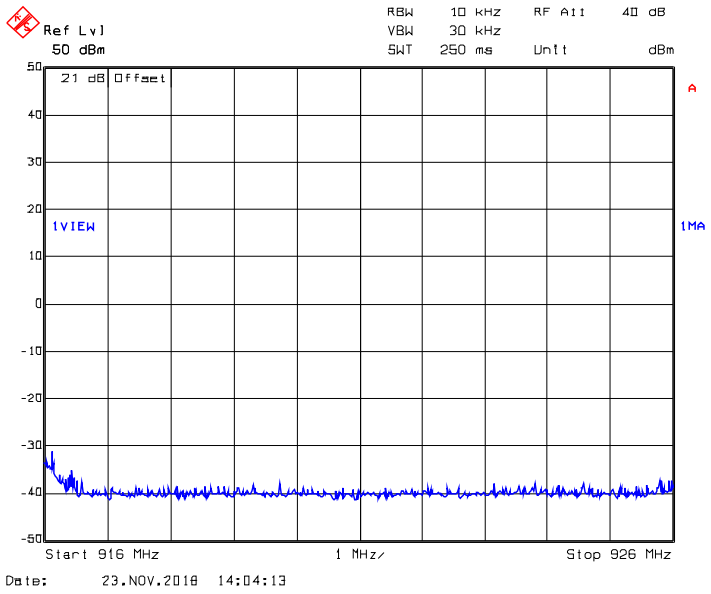
Plot 5.3.4.14. Number of Hopping Frequencies, Low Data Rate, 50 kHz CS
0 Hopping Channel from 904 – 913 MHz



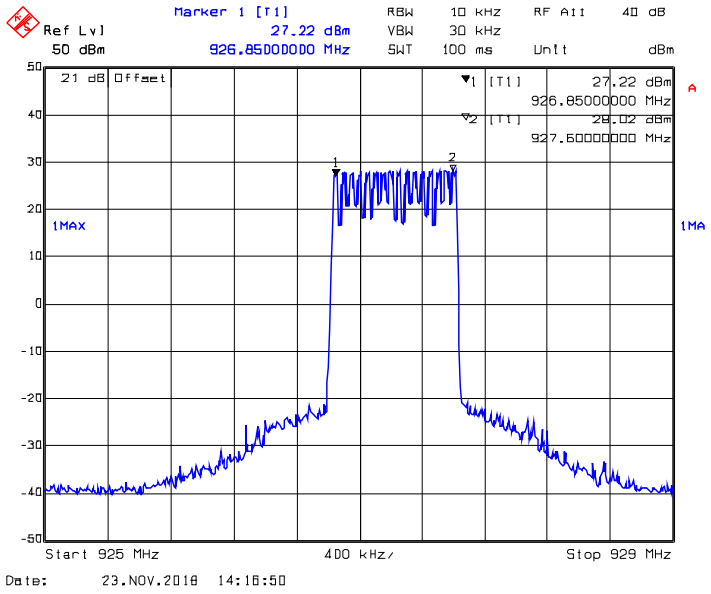
Plot 5.3.4.15. Number of Hopping Frequencies, Low Data Rate, 50 kHz CS
18 Hopping Channels from 913 – 917 MHz



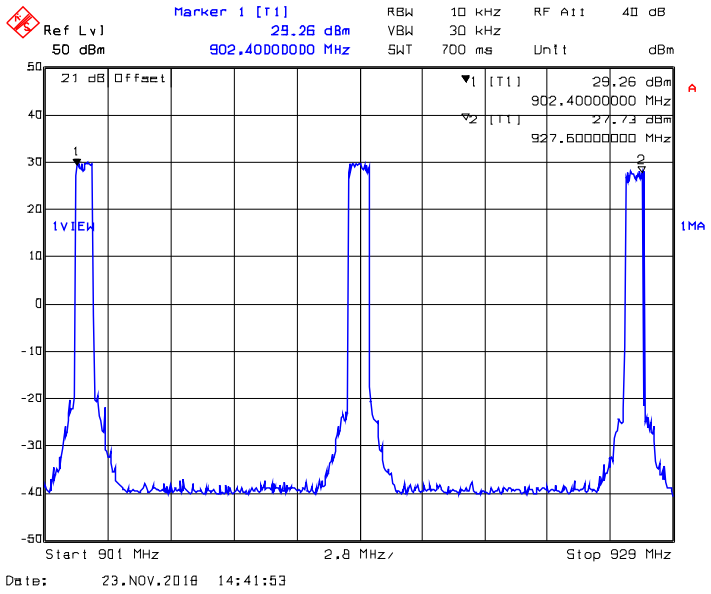
Plot 5.3.4.16. Number of Hopping Frequencies, Low Data Rate, 50 kHz CS
0 Hopping Channel from 917 – 926 MHz



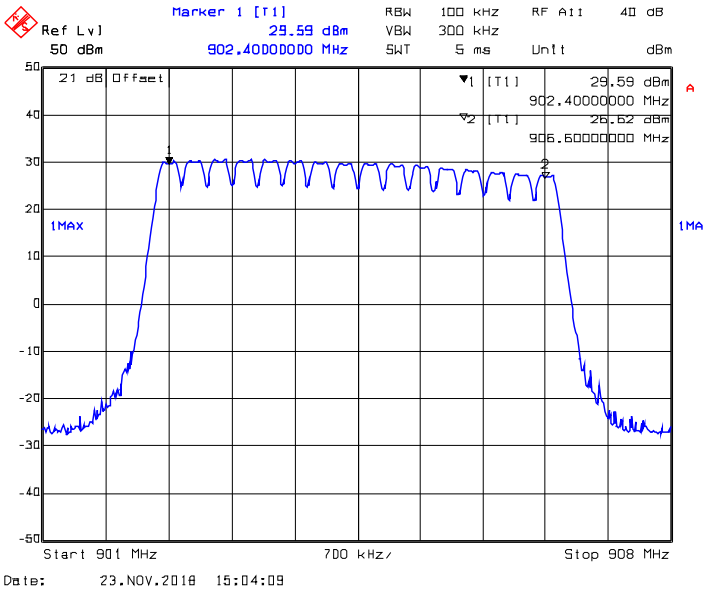
Plot 5.3.4.17. Number of Hopping Frequencies, Low Data Rate, 50 kHz CS
16 Hopping Channels from 926 – 928 MHz



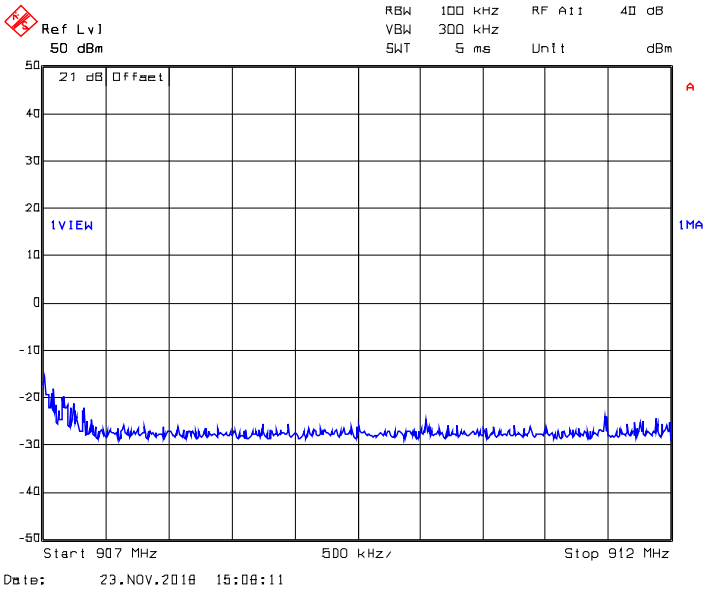
Plot 5.3.4.18. Number of Hopping Frequencies, Low Data Rate, 50 kHz CS
The Total Number of Hopping Channel in 902 – 928 MHz Band is 50 (16 + 18 +16)



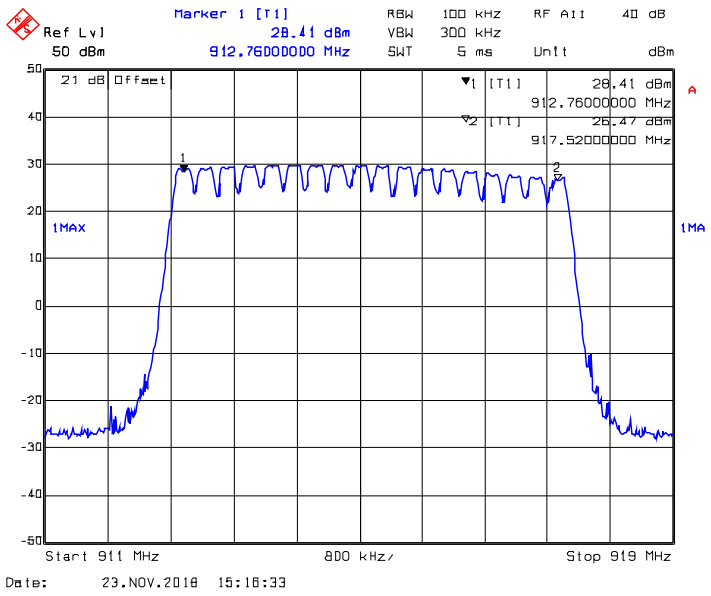
Plot 5.3.4.19. Number of Hopping Frequencies, Middle Data Rate, 280 kHz CS
16 Hopping Channels from 902 – 908 MHz



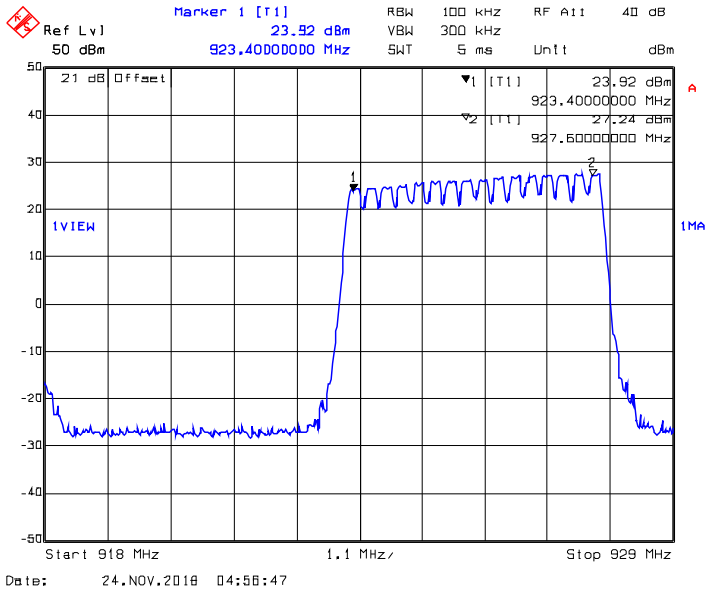
Plot 5.3.4.20. Number of Hopping Frequencies, Middle Data Rate, 280 kHz CS
0 Hopping Channels from 908 – 912 MHz



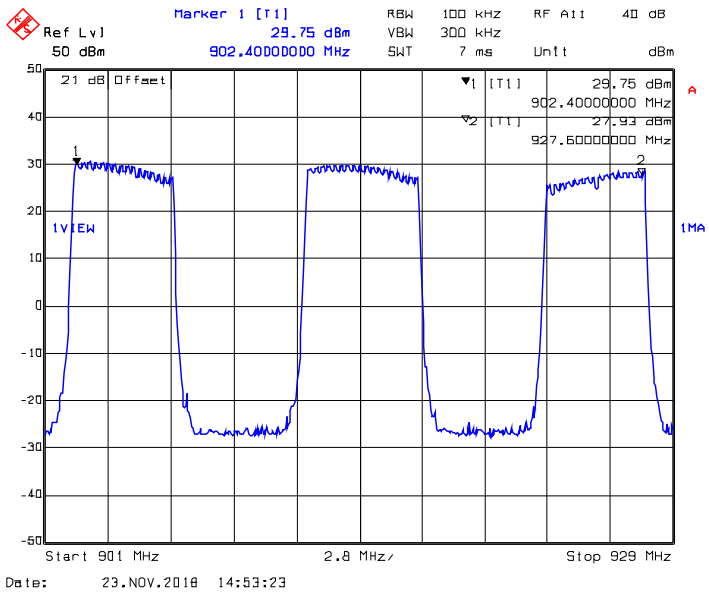
Plot 5.3.4.21. Number of Hopping Frequencies, Middle Data Rate, 280 kHz CS
18 Hopping Channels from 912 - 919 MHz



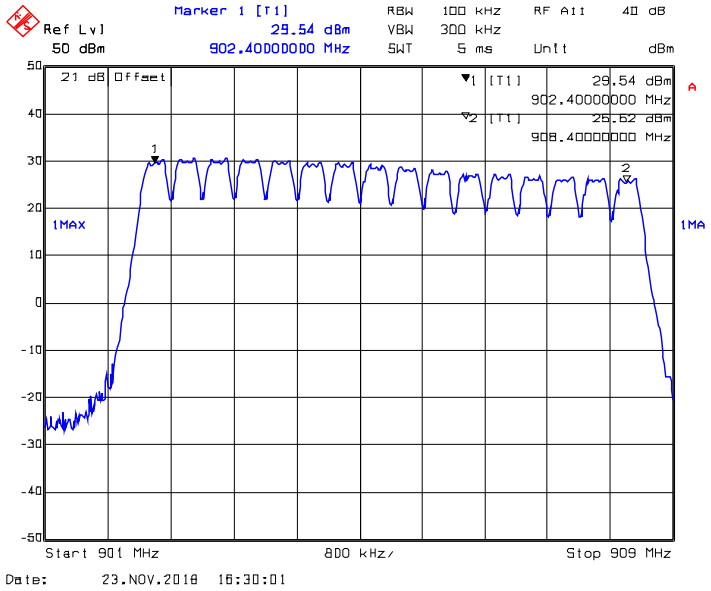
Plot 5.3.4.22. Number of Hopping Frequencies, Middle Data Rate, 280 kHz CS
16 Hopping Channels from 919 - 928 MHz



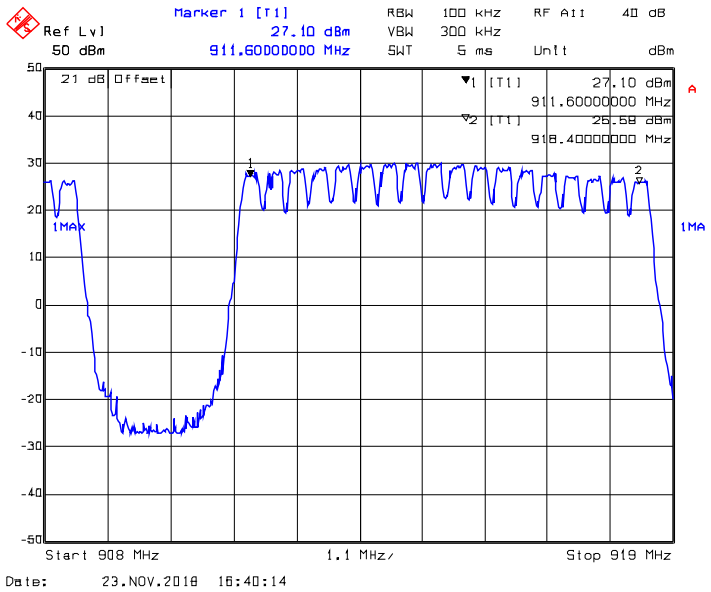
Plot 5.3.4.23. Number of Hopping Frequencies, Middle Data Rate, 280 kHz CS
The Total Number of Hopping Channel in 902 – 928 MHz Band is 50 (16 + 18 +16)



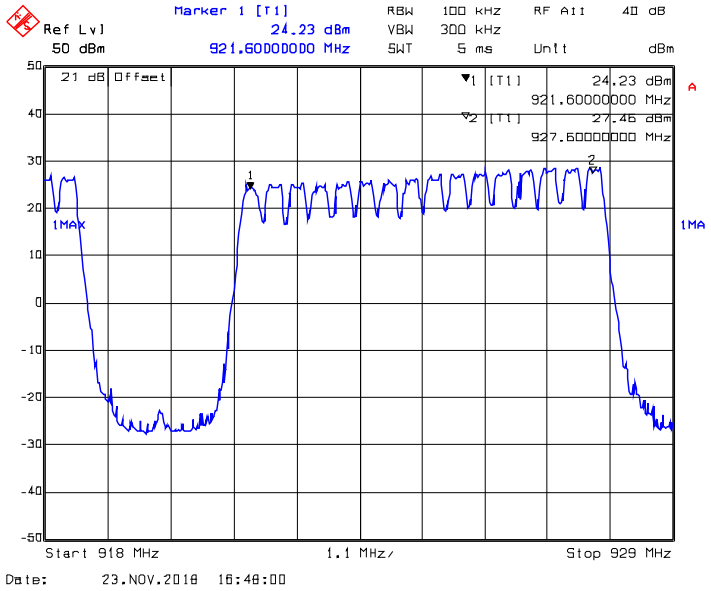
Plot 5.3.4.24. Number of Hopping Frequencies, High Data Rate, 400 kHz CS
16 Hopping Channels from 902 - 909 MHz



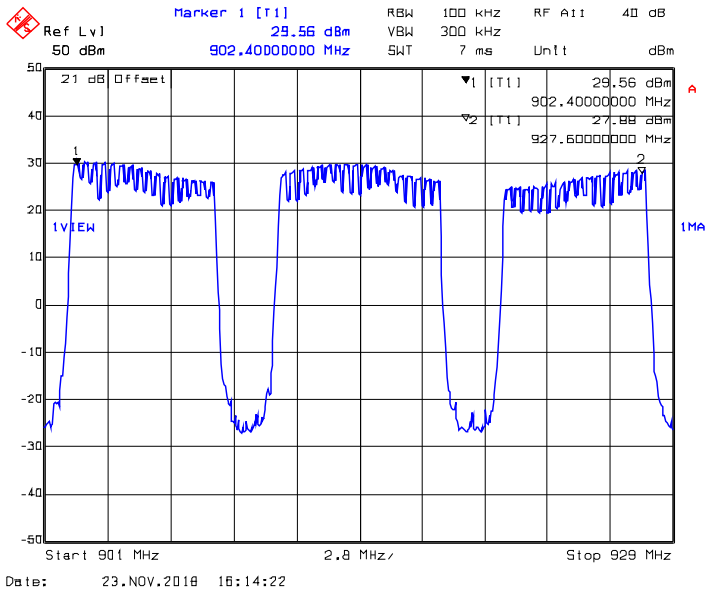
Plot 5.3.4.25. Number of Hopping Frequencies, High Data Rate, 400 kHz CS
18 Hopping Channels from 909 – 919 MHz



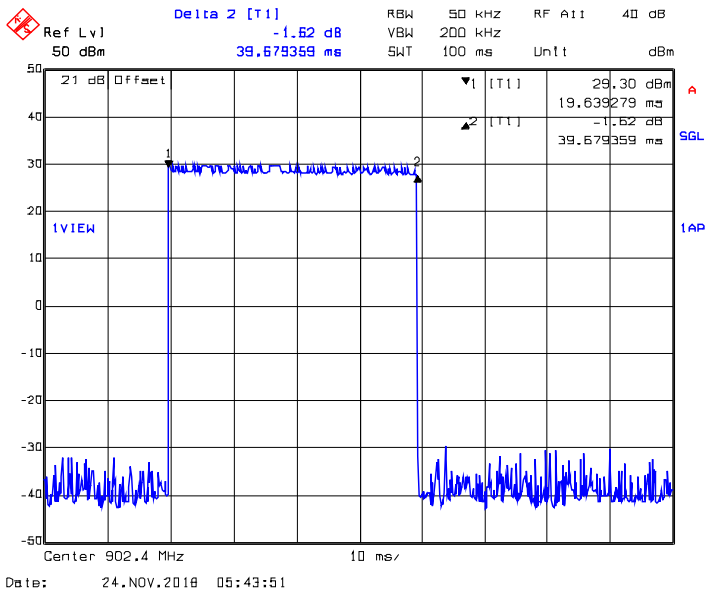
Plot 5.3.4.26. Number of Hopping Frequencies, High Data Rate, 400 kHz CS
16 Hopping Channels from 919 - 928 MHz



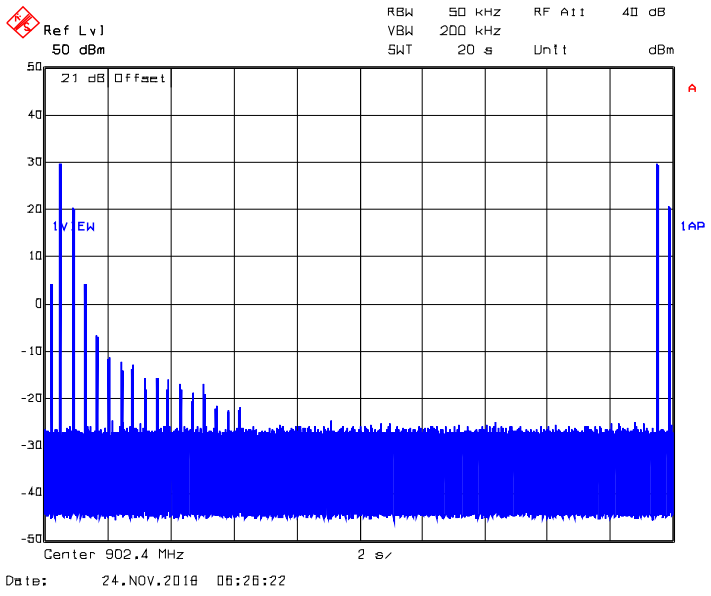
Plot 5.3.4.27. Number of Hopping Frequencies, High Data Rate, 400 kHz CS
The Total Number of Hopping Channel in 902 – 928 MHz Band is 50 (16 + 18 +16)



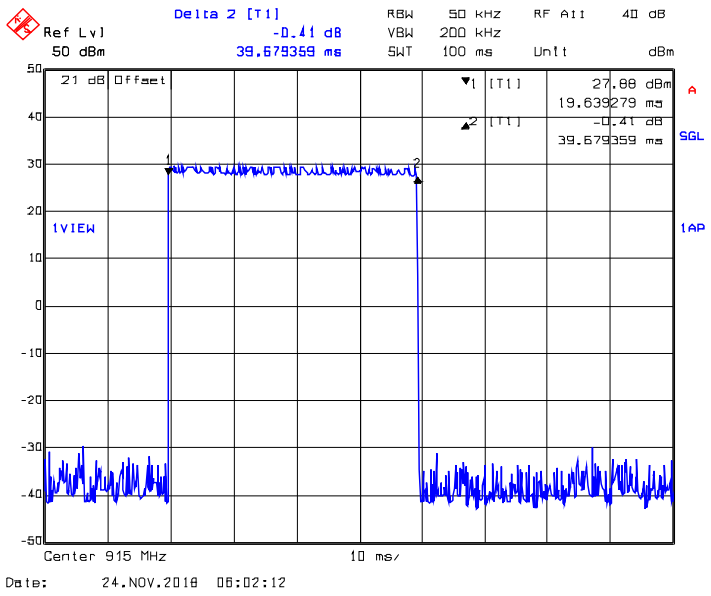
Plot 5.3.4.28. Time of Occupancy, 902.4 MHz, Low Data Rate, 50 kHz CS
Dwell Time @ 902.4 MHz = 39.68 ms



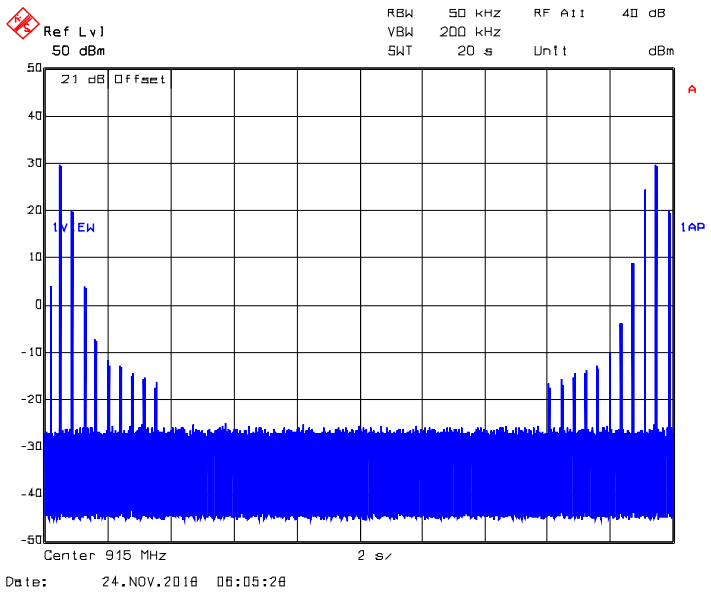
Plot 5.3.4.29. Time of Occupancy, 902.4 MHz, 24686 bps, 50 kHz CS
Average time of occupancy = (Dwell Time) x (number of hops within a 20s period) = 39.68 ms x 2 = 79.36 ms



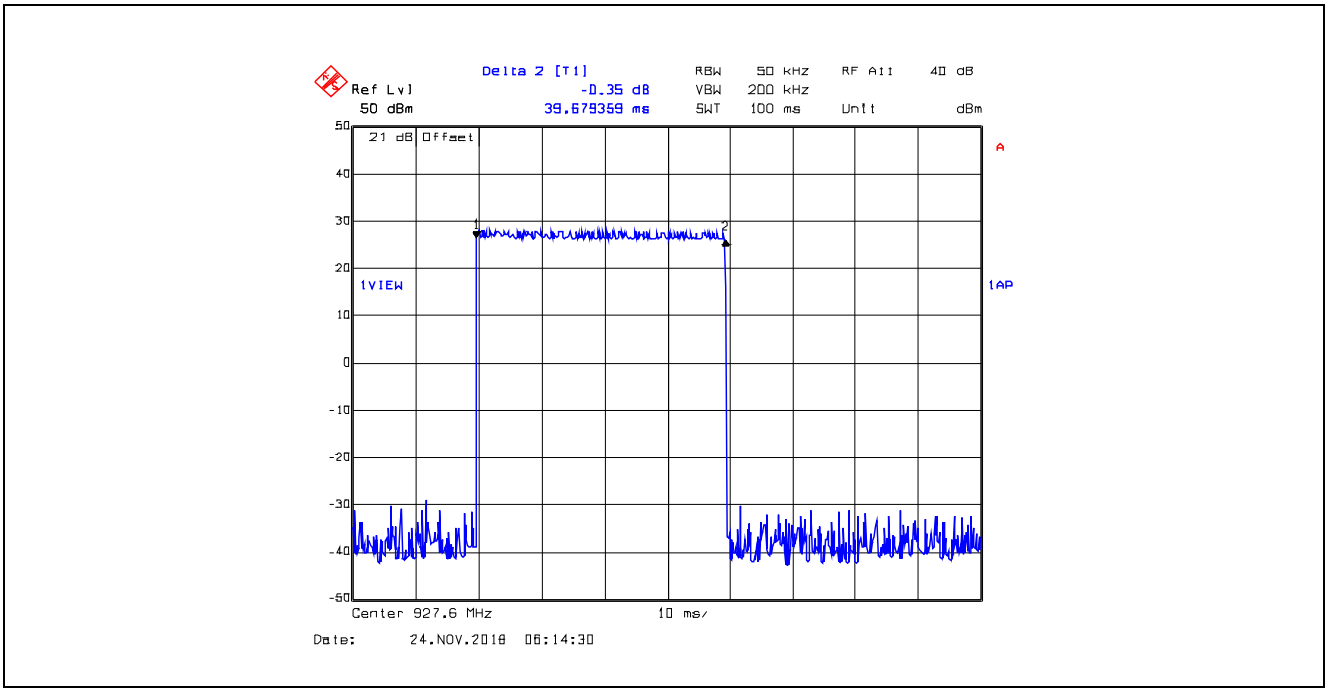
Plot 5.3.4.30. Time of Occupancy, 915 MHz, Low Data Rate, 50 kHz CS
Dwell Time @ 915 MHz = 39.68 ms



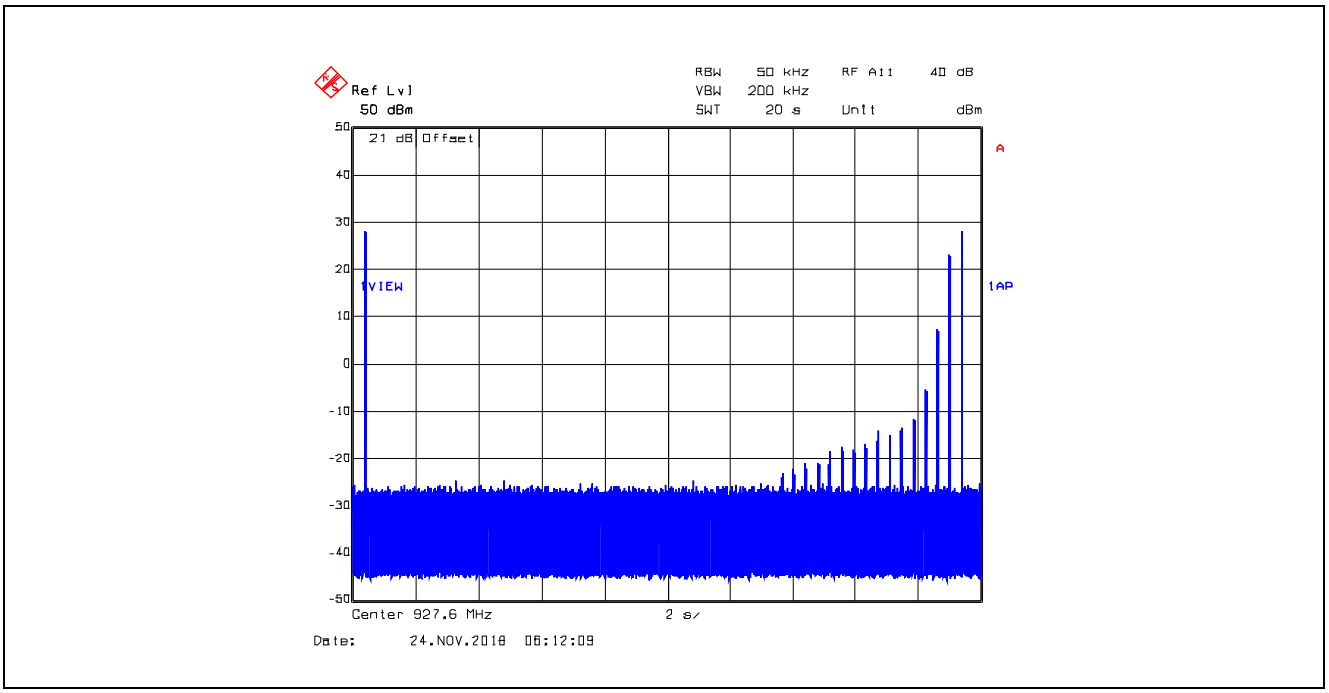
Plot 5.3.4.31. Time of Occupancy, 915 MHz, 24686 bps, 50 kHz CS
Average time of occupancy = (Dwell Time) x (number of hops within a 20s period) = 39.68 ms x 2 = 79.36 ms



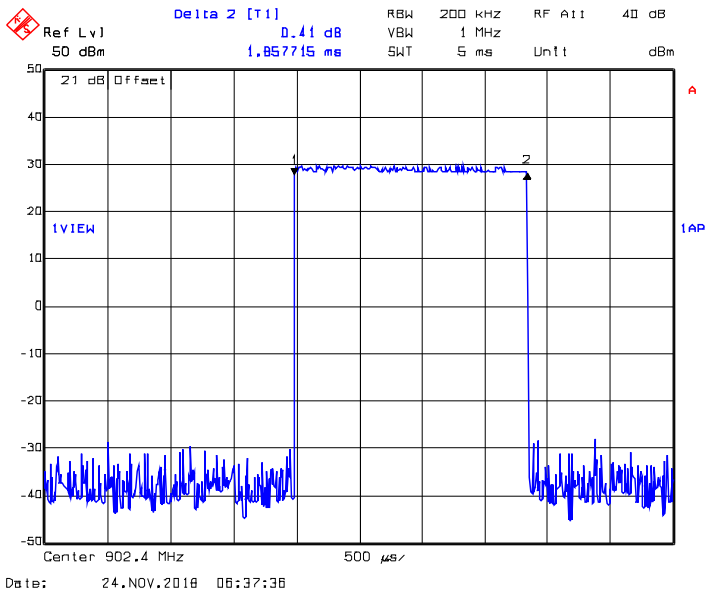
Plot 5.3.4.32. Time of Occupancy, 927.6 MHz, Low Data Rate, 50 kHz CS
Dwell Time @ 927.6 MHz = 39.68 ms



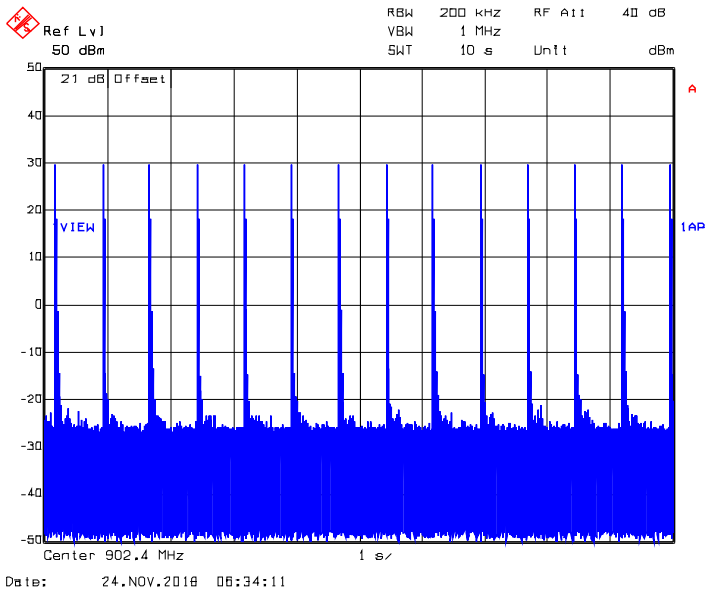
Plot 5.3.4.33. Time of Occupancy, 927.6 MHz, Low Data Rate, 50 kHz CS
Average time of occupancy = (Dwell Time) x (number of hops within a 20s period) = 39.68 ms x 2 = 79.36 ms



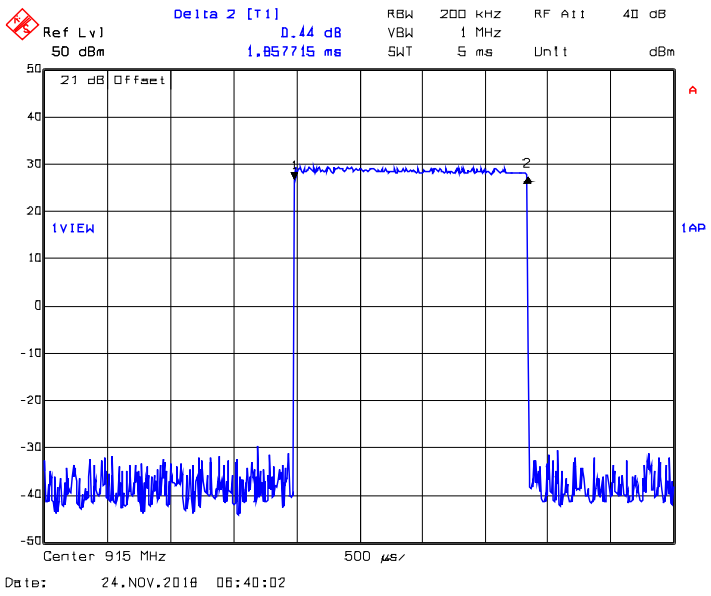
Plot 5.3.4.34. Time of Occupancy, 902.4 MHz, Middle Data Rate, 280 kHz CS
Dwell Time @ 902.4 MHz = 1.86 ms



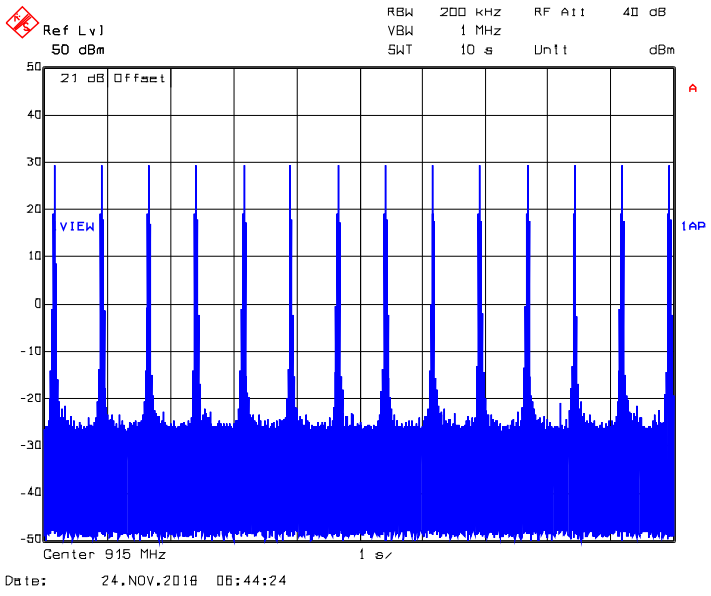
Plot 5.3.4.35. Time of Occupancy, 902.4 MHz, Middle Data Rate, 280 kHz CS
Average time of occupancy = (Dwell Time) x (number of hops within a 10s period) = 1.86 ms x 14 = 26.04 ms



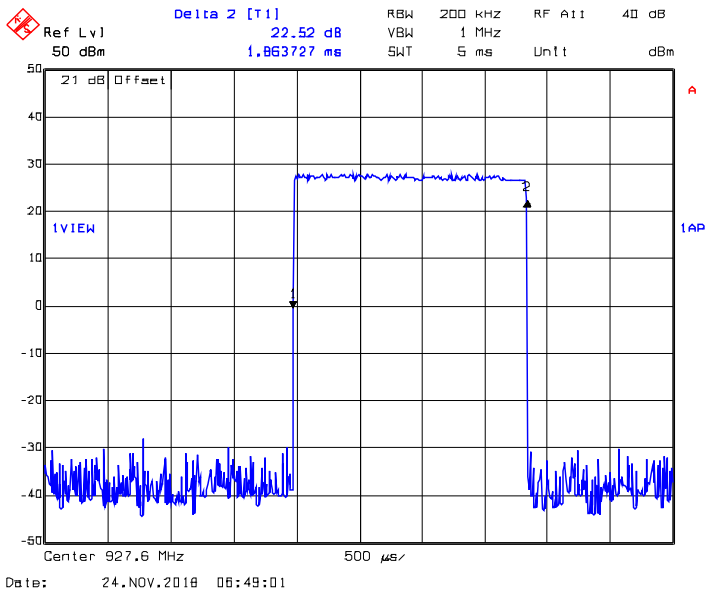
Plot 5.3.4.36. Time of Occupancy, 915 MHz, Middle Data Rate, 280 kHz CS
Dwell Time @ 915 MHz = 1.86 ms



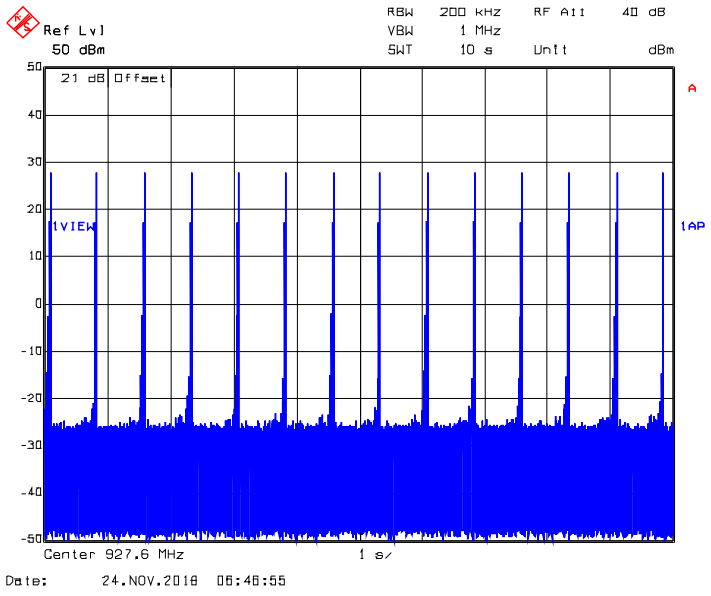
Plot 5.3.4.37. Time of Occupancy, 915 MHz, Middle Data Rate, 280 kHz CS
Average time of occupancy = (Dwell Time) x (number of hops within a 10s period) = 1.86 ms x 14 = 26.04 ms



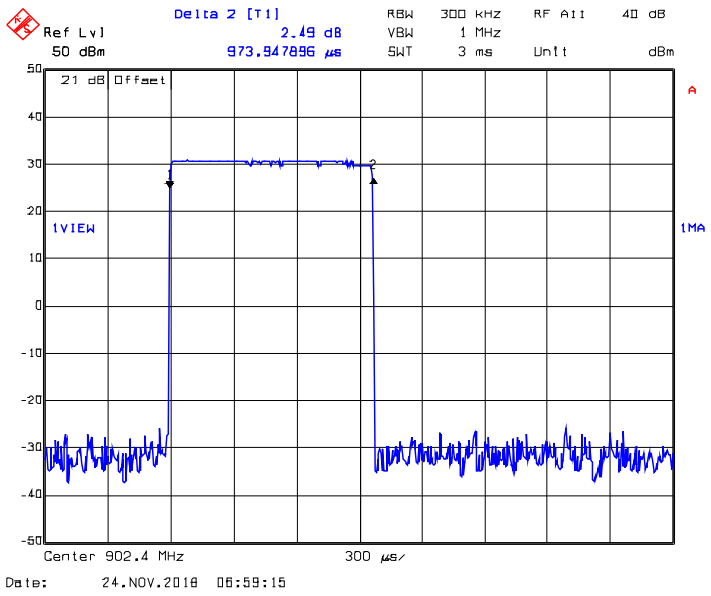
Plot 5.3.4.38. Time of Occupancy, 927.6 MHz, Middle Data Rate, 280 kHz CS
Dwell Time @ 927.6 MHz = 1.86 ms



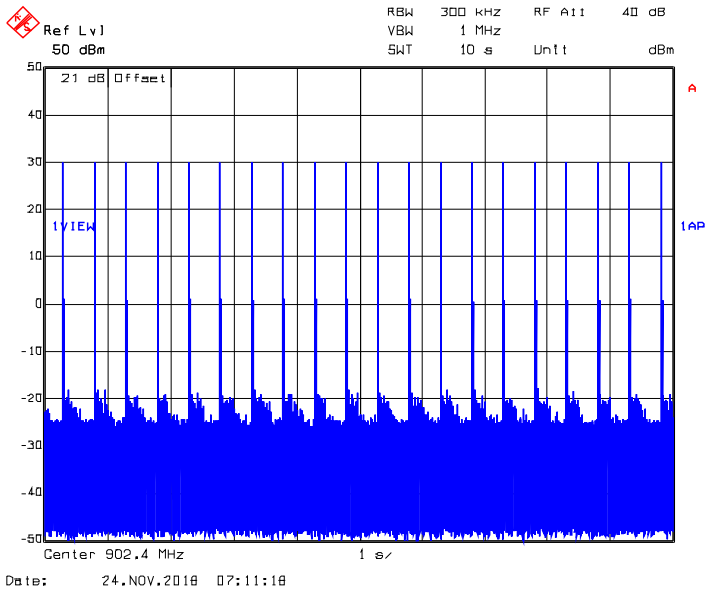
Plot 5.3.4.39. Time of Occupancy, 927.6 MHz, Middle Data Rate, 280 kHz CS
Average time of occupancy = (Dwell Time) x (number of hops within a 10s period) = 1.86 ms x 14 = 26.04 ms



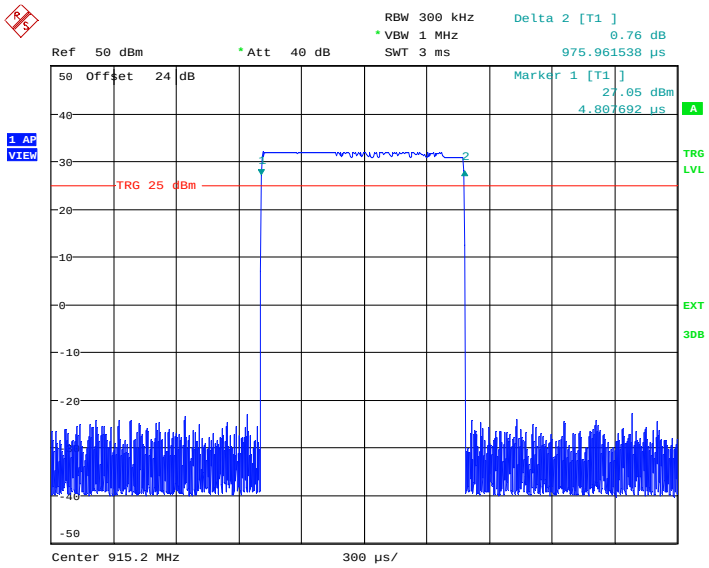
Plot 5.3.4.40. Time of Occupancy, 902.4 MHz, High Data Rate, 400 kHz CS
Dwell Time @ 902.4 MHz = 973.95 µs



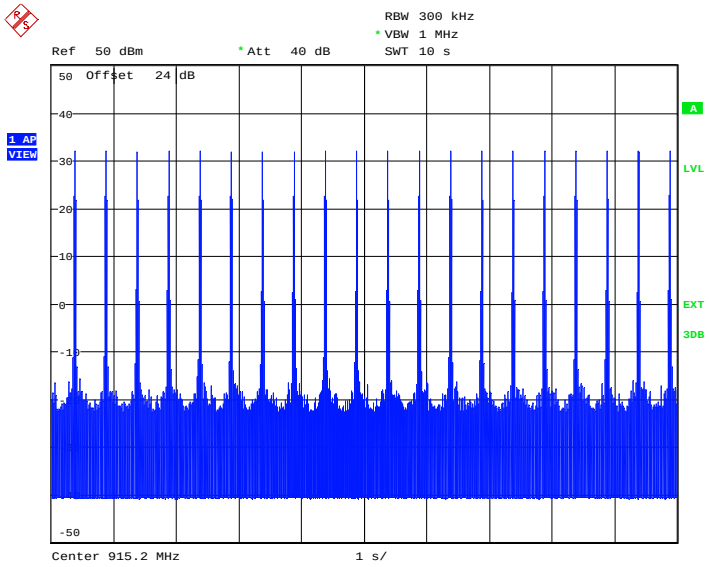
Plot 5.3.4.41. Time of Occupancy, 902.4 MHz, High Data Rate, 400 kHz CS
Average time of occupancy = (Dwell Time) x (number of hops within a 10s period) = 973.95 µs x 20 = 19.48 ms



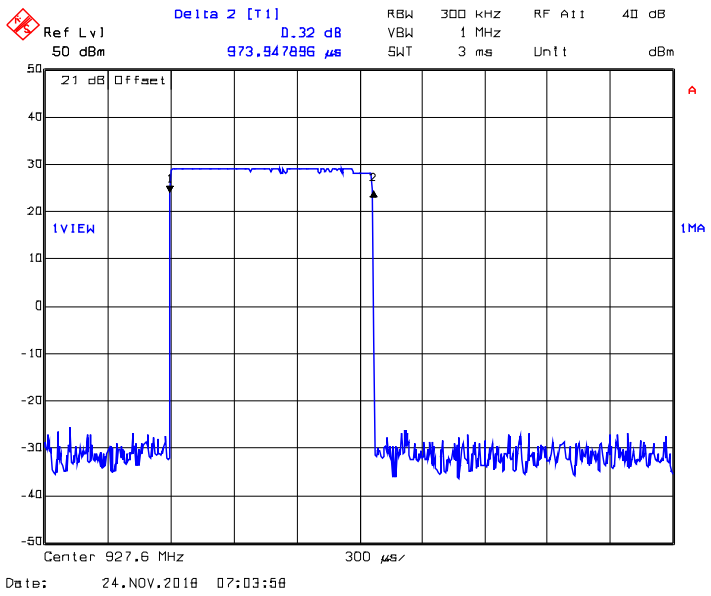
Plot 5.3.4.42. Time of Occupancy, 915.2 MHz, High Data Rate, 400 kHz CS
Dwell Time @ 915.2 MHz = 975.96 µs



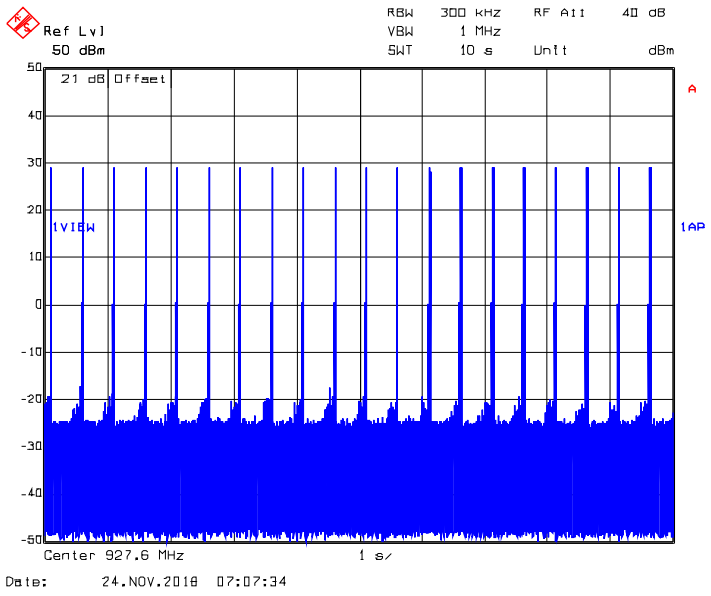
Plot 5.3.4.43. Time of Occupancy, 915.2 MHz, High Data Rate, 400 kHz CS
Average time of occupancy = (Dwell Time) x (number of hops within a 10s period) = 975.96 µs x 20 = 19.52 ms



Plot 5.3.4.44. Time of Occupancy, 927.6 MHz, High Data Rate, 400 kHz CS
Dwell Time @ 927.6 MHz = 973.95 µs



Plot 5.3.4.45. Time of Occupancy, 927.6 MHz, High Data Rate, 400 kHz CS
Average time of occupancy = (Dwell Time) x (number of hops within a 10s period) = 973.95 µs x 20 = 19.48 ms



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

5.4.1. Limits

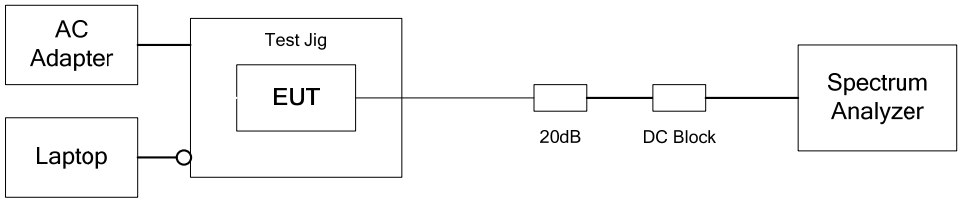
§15.247(b)(2): For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

§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.

5.4.2. Method of Measurements

ANSI C63.10-2013, section 7.8.5

5.4.3. Test Arrangement



5.4.4. Test Data

Power Setting 1: High Power Setting for 3 dBi Rubber Duck Antenna with 2.62 dBi Antenna Assembly Gain								
Raw Power Setting (3 – 63)	Data Rate	Frequency (MHz)	Peak Output Power at Antenna Terminal		Antenna Assembly Gain (dBi)	EIRP (dBm)	Peak Conducted Output Power Limit (dBm)	EIRP Limit (dBm)
			(dBm)	(W)				
38	Low	902.4	29.99	0.9977	2.62	32.61	30	36
38	Low	915.0	30.00	1.0000	2.62	32.62	30	36
38	Low	927.6	29.74	0.9419	2.62	32.36	30	36
38	Middle	902.4	30.00	1.0000	2.62	32.62	30	36
38	Middle	915.0	29.98	0.9954	2.62	32.60	30	36
38	Middle	927.6	29.73	0.9397	2.62	32.35	30	36
35	High	902.4	29.97	0.9931	2.62	32.59	30	36
35	High	915.2	29.93	0.9840	2.62	32.55	30	36
35	High	927.6	29.44	0.8790	2.62	32.06	30	36

Power Setting 2: High Power Setting for 13.15 dBi Yagi Antenna with 12.29 dBi Antenna Assembly Gain								
Raw Power Setting (3 – 63)	Data Rate	Frequency (MHz)	Peak Output Power at Antenna Terminal		Antenna Assembly Gain (dBi)	EIRP (dBm)	Peak Conducted Output Power Limit (dBm)	EIRP Limit (dBm)
			(dBm)	(W)				
20	Low	902.4	23.70	0.2344	12.29	35.99	30	36
20	Low	915.0	23.54	0.2259	12.29	35.83	30	36
20	Low	927.6	22.01	0.1589	12.29	34.30	30	36
20	Middle	902.4	23.69	0.2339	12.29	35.98	30	36
20	Middle	915.0	23.64	0.2312	12.29	35.93	30	36
20	Middle	927.6	22.06	0.1607	12.29	34.35	30	36
20	High	902.4	23.70	0.2344	12.29	35.99	30	36
20	High	915.2	23.25	0.2113	12.29	35.54	30	36
20	High	927.6	22.22	0.1667	12.29	34.51	30	36

Power Setting 3: High Power Setting for 8 dBi Patch Antenna with 7.62 dBi Antenna Assembly Gain								
Raw Power Setting (3 – 63)	Data Rate	Frequency (MHz)	Peak Output Power at Antenna Terminal		Antenna Assembly Gain (dBi)	EIRP (dBm)	Peak Conducted Output Power Limit (dBm)	EIRP Limit (dBm)
			(dBm)	(W)				
32	Low	902.4	27.65	0.5821	7.62	35.27	30	36
32	Low	915.0	25.58	0.3614	7.62	33.20	30	36
32	Low	927.6	25.95	0.3936	7.62	33.57	30	36
32	Middle	902.4	27.80	0.6026	7.62	35.42	30	36
32	Middle	915.0	27.40	0.5495	7.62	35.02	30	36
32	Middle	927.6	25.86	0.3855	7.62	33.48	30	36
32	High	902.4	28.35	0.6839	7.62	35.97	30	36
32	High	915.2	28.07	0.6412	7.62	35.69	30	36
32	High	927.6	27.27	0.5333	7.62	34.89	30	36

Power Setting 4: High Power Setting for 8.15 dBi Omni Directional Antenna with 7.29 dBi Antenna Assembly Gain								
Raw Power Setting (3 – 63)	Data Rate	Frequency (MHz)	Peak Output Power at Antenna Terminal		Antenna Assembly Gain (dBi)	EIRP (dBm)	Peak Conducted Output Power Limit (dBm)	EIRP Limit (dBm)
			(dBm)	(W)				
32	Low	902.4	27.65	0.5821	7.29	34.94	30	36
32	Low	915.0	25.58	0.3614	7.29	32.87	30	36
32	Low	927.6	25.95	0.3936	7.29	33.24	30	36
32	Middle	902.4	27.80	0.6026	7.29	35.09	30	36
32	Middle	915.0	27.40	0.5495	7.29	34.69	30	36
32	Middle	927.6	25.86	0.3855	7.29	33.15	30	36
32	High	902.4	28.35	0.6839	7.29	35.64	30	36
32	High	915.2	28.07	0.6412	7.29	35.36	30	36
32	High	927.6	27.27	0.5333	7.29	34.56	30	36

Power Setting 5: High Power Setting for 4 dBi Puck Antenna with 3.62 dBi Antenna Assembly Gain								
Raw Power Setting (3 – 63)	Data Rate	Frequency (MHz)	Peak Output Power at Antenna Terminal		Antenna Assembly Gain (dBi)	EIRP (dBm)	Peak Conducted Output Power Limit (dBm)	EIRP Limit (dBm)
			(dBm)	(W)				
38	Low	902.4	29.99	0.9977	3.62	33.61	30	36
38	Low	915.0	30.00	1.0000	3.62	33.62	30	36
38	Low	927.6	29.74	0.9419	3.62	33.36	30	36
38	Middle	902.4	30.00	1.0000	3.62	33.62	30	36
38	Middle	915.0	29.98	0.9954	3.62	33.60	30	36
38	Middle	927.6	29.73	0.9397	3.62	33.35	30	36
35	High	902.4	29.97	0.9931	3.62	33.59	30	36
35	High	915.2	29.93	0.9840	3.62	33.55	30	36
35	High	927.6	29.44	0.8790	3.62	33.06	30	36

Power Setting 6: Low Power Setting for All Antenna Types				
Raw Power Setting (3 – 63)	Data Rate	Frequency (MHz)	Peak Output Power at Antenna Terminal	
			(dBm)	(W)
3	Low	902.4	15.62	0.0365
3	Low	915.0	15.23	0.0333
3	Low	927.6	13.50	0.0224
3	Middle	902.4	15.63	0.0366
3	Middle	915.0	15.21	0.0332
3	Middle	927.6	13.53	0.0225
3	High	902.4	16.90	0.0490
3	High	915.2	16.32	0.0429
3	High	927.6	14.77	0.0300

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

5.5.1. 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

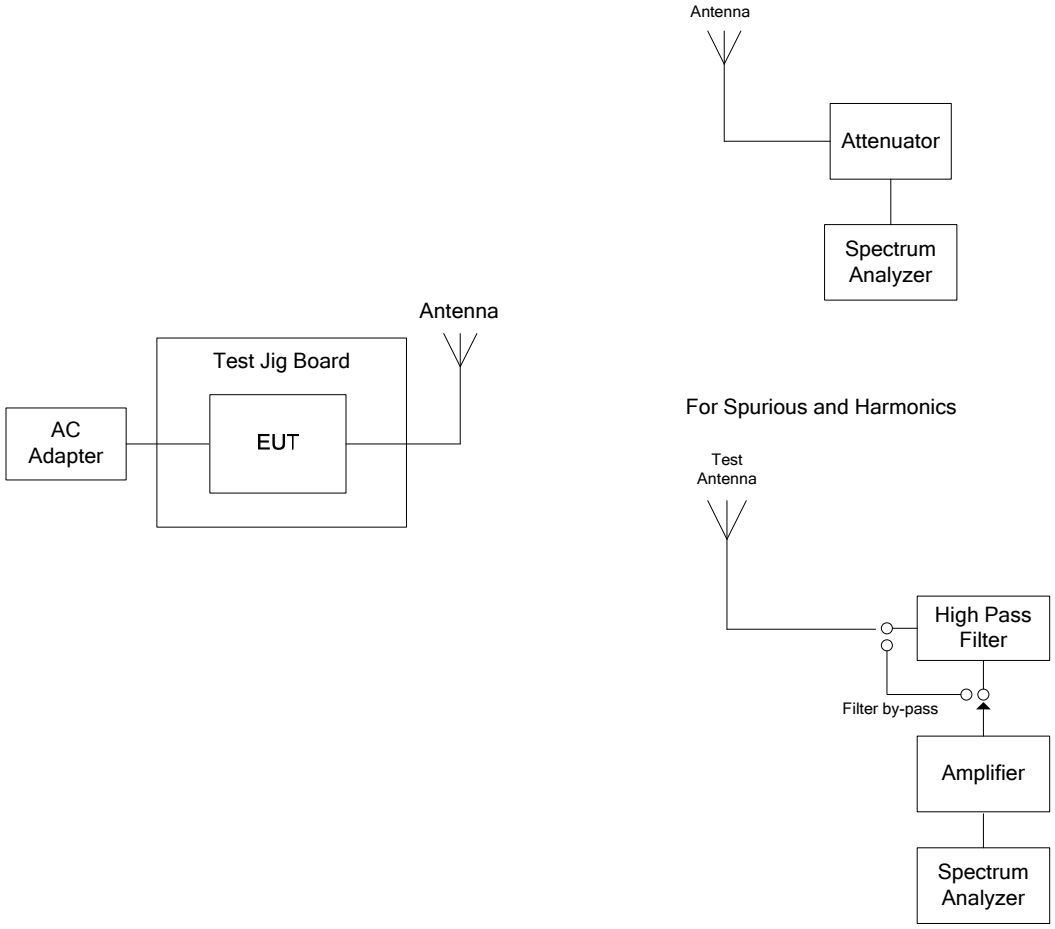
Section 15.209(a) - Field Strength Limits within Restricted Frequency Bands

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

5.5.2. Method of Measurements

ANSI C63.10 and ANSI 63.4 procedures.

5.5.3. Test Arrangement



5.5.4. 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.
- The following test data represent the worst-case derived from exploratory tests.

5.5.4.1. EUT with 3 dBi Rubber Duck Antenna, 2.62 dBi Antenna Assembly Gain, Low Data Rate

5.5.4.1.1. Spurious Radiated Emission

Fundamental Frequency:	902.4 MHz
Raw Power Setting:	38
Measured Conducted Power:	29.99 dBm
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
902.4	126.12	--	V	--	--	--	--
902.4	128.92	--	H	--	--	--	--
2707.2	49.09	42.55	V	54.0	108.9	-11.5	Pass*
2707.2	47.01	39.02	H	54.0	108.9	-15.0	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 MHz
Raw Power Setting:	38
Measured Conducted Power:	30.00 dBm
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	125.74	--	V	--	--	--	--
915.0	128.55	--	H	--	--	--	--
2745.0	45.74	37.55	V	54.0	108.6	-16.5	Pass*
2745.0	44.81	34.77	H	54.0	108.6	-19.2	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.

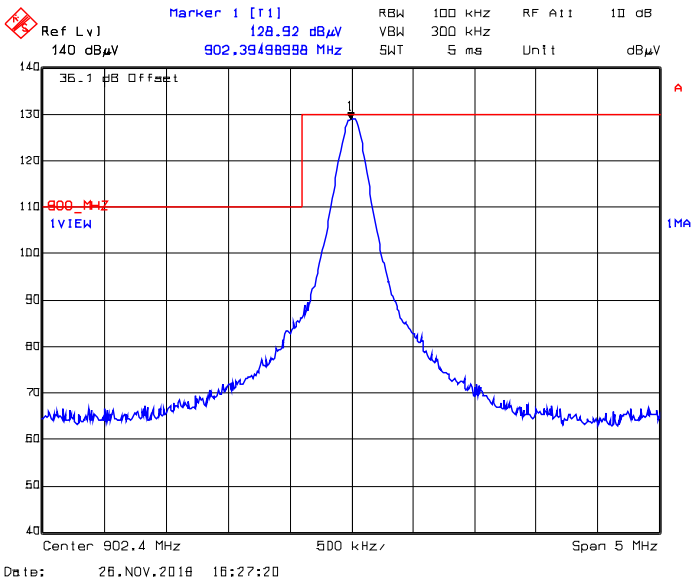
Fundamental Frequency:	927.6 MHz
Raw Power Setting:	38
Measured Conducted Power:	29.74 dBm
Frequency Test Range:	30 MHz – 10 GHz

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
927.6	125.46	--	V	--	--	--	--
927.6	125.76	--	H	--	--	--	--
30 - 10000	*	*	V/H	*	*	*	*

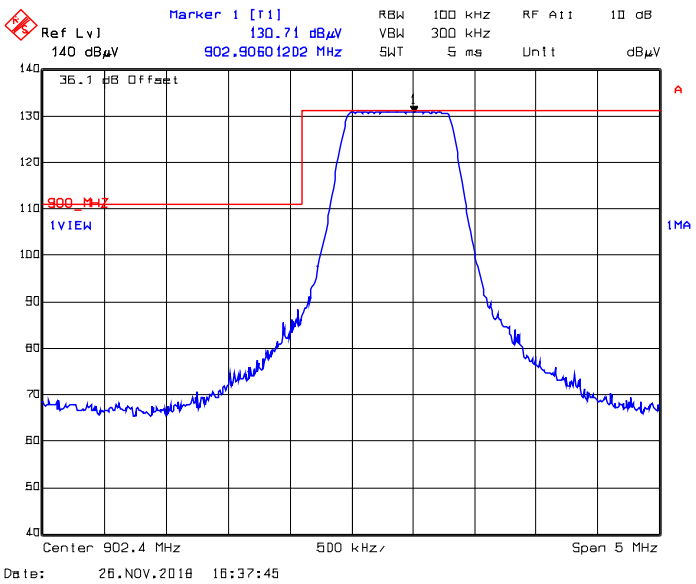
*Spurious emissions and harmonics are more than 20 dB below the applicable limit.

5.5.4.1.2. Band –Edge RF Radiated Emissions

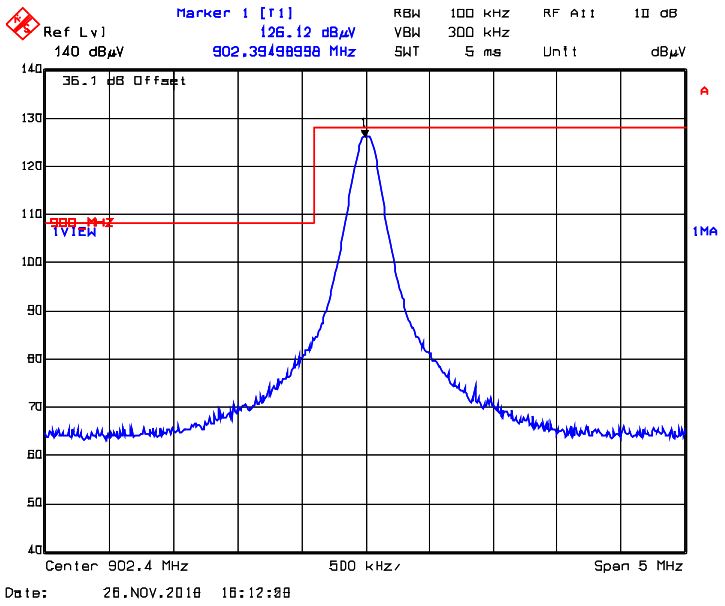
Plot 5.5.4.1.2.1. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Single Frequency Mode, Low End of Frequency Band



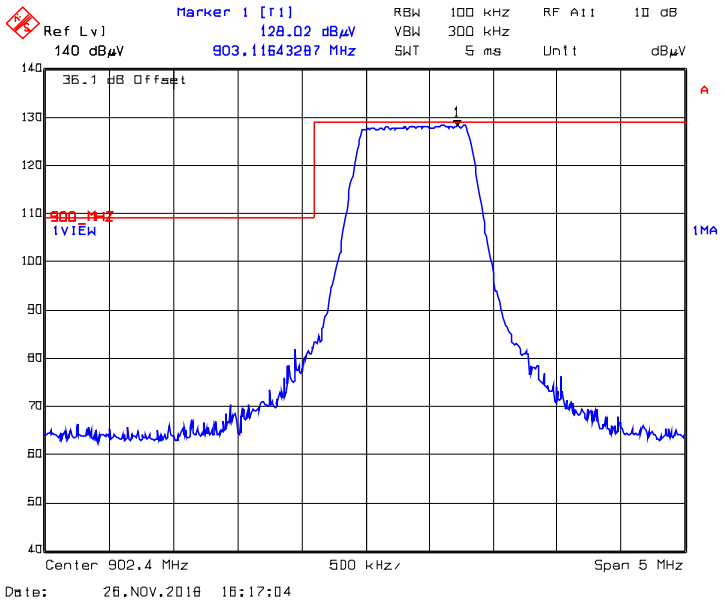
Plot 5.5.4.1.2.2. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



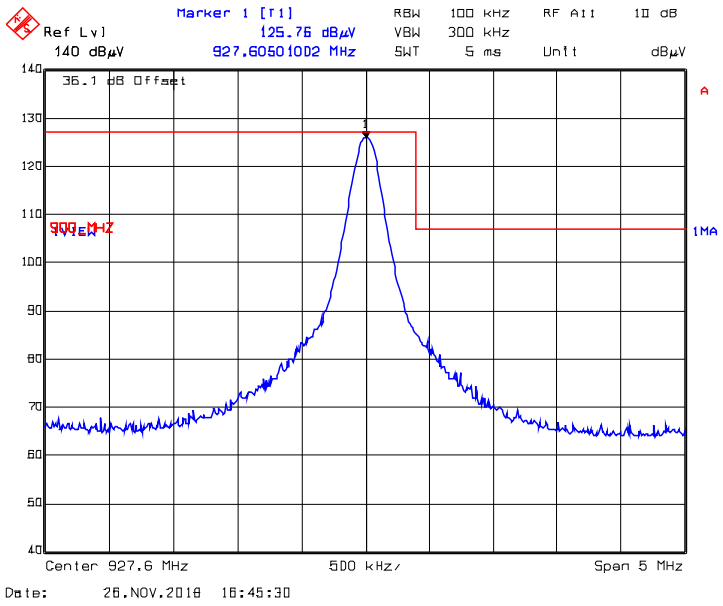
Plot 5.5.4.1.2.3. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Single Frequency Mode, Low End of Frequency Band



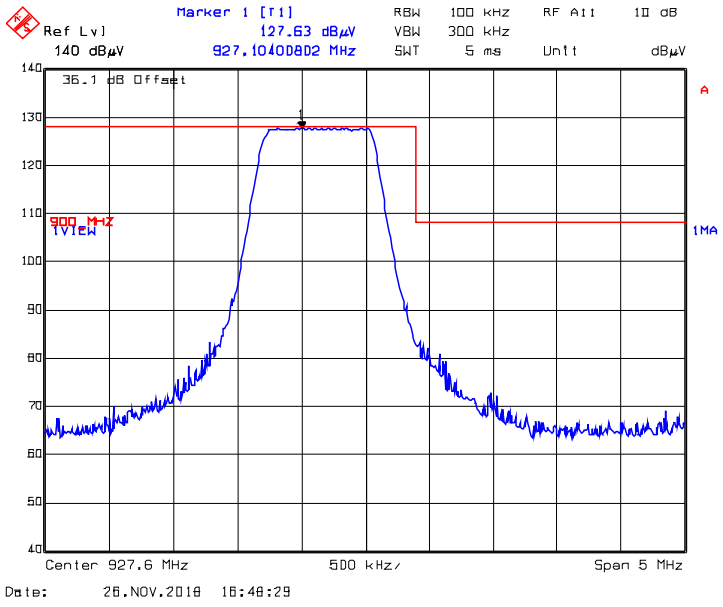
Plot 5.5.4.1.2.4. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



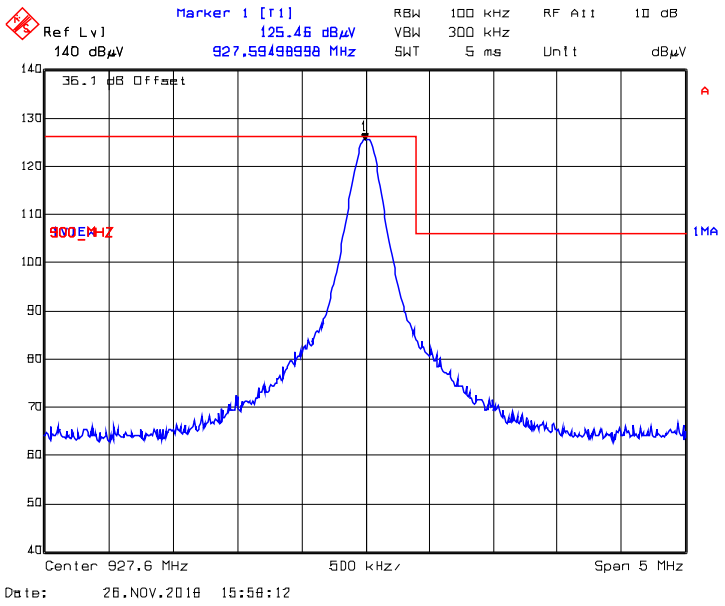
Plot 5.5.4.1.2.5. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Single Frequency Mode, High End of Frequency Band



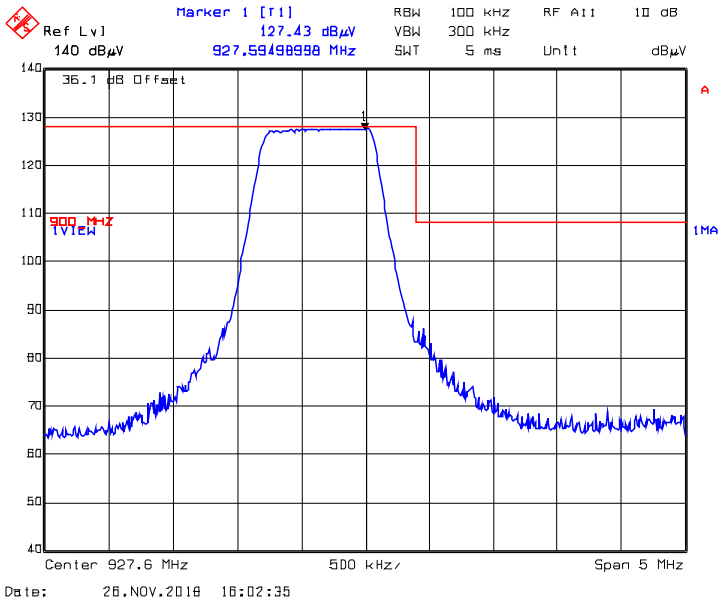
Plot 5.5.4.1.2.6. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Pseudorandom Channel Hopping Mode, High End of Frequency Band



Plot 5.5.4.1.2.7. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Single Frequency Mode, High of Frequency Band



Plot 5.5.4.1.2.8. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Pseudorandom Channel Hopping Mode, High End of Frequency Band



5.5.4.2. EUT with 13.15 dBi Yagi Antenna, 12.29 dBi Antenna Assembly Gain, Low Data Rate

5.5.4.2.1. Spurious Radiated Emissions

Fundamental Frequency:	902.4 MHz
Raw Power Setting:	20
Measured Conducted Power:	23.70 dBm
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
902.4	124.24	--	V	--	--	--	--
902.4	124.41	--	H	--	--	--	--
30 - 10000	*	*	V/H	*	*	*	*

*Spurious emissions and harmonics are more than 20 dB below the applicable limit.

Fundamental Frequency:	915 MHz
Raw Power Setting:	20
Measured Conducted Power:	23.54 dBm
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	124.32	--	V	--	--	--	--
915.0	124.17	--	H	--	--	--	--
30 - 10000	*	*	V/H	*	*	*	*

*Spurious emissions and harmonics are more than 20 dB below the applicable limit.

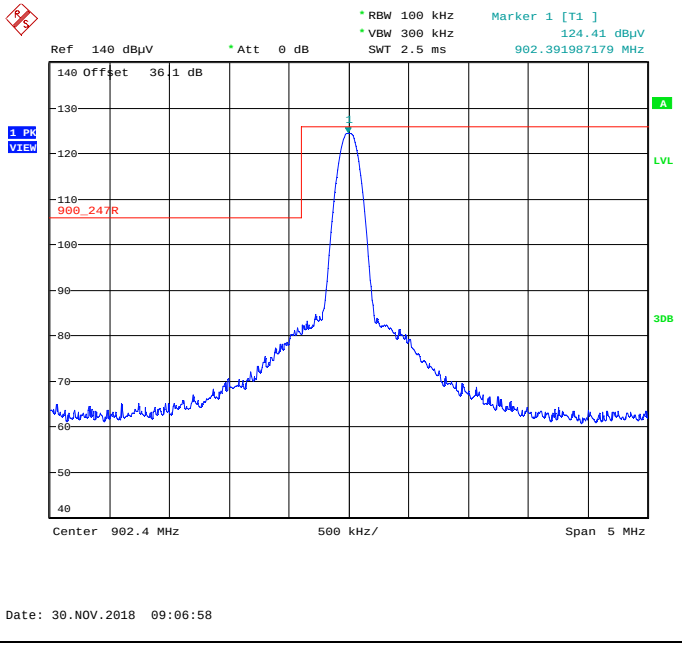
Fundamental Frequency:	927.6 MHz
Raw Power Setting:	20
Measured Conducted Power:	22.01 dBm
Frequency Test Range:	30 MHz – 10 GHz

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
927.6	125.21	--	V	--	--	--	--
927.6	124.86	--	H	--	--	--	--
30 - 10000	*	*	V/H	*	*	*	*

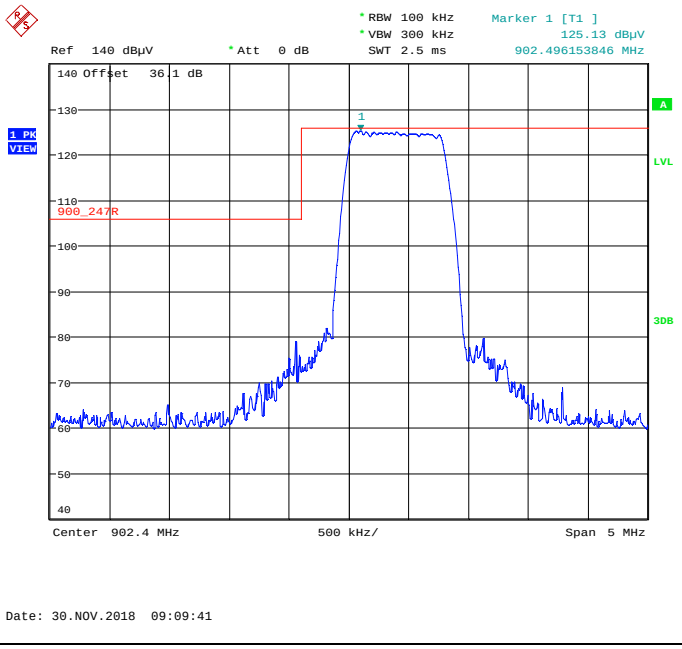
*Spurious emissions and harmonics are more than 20 dB below the applicable limit.

5.5.4.2.2. Band –Edge RF Radiated Emissions

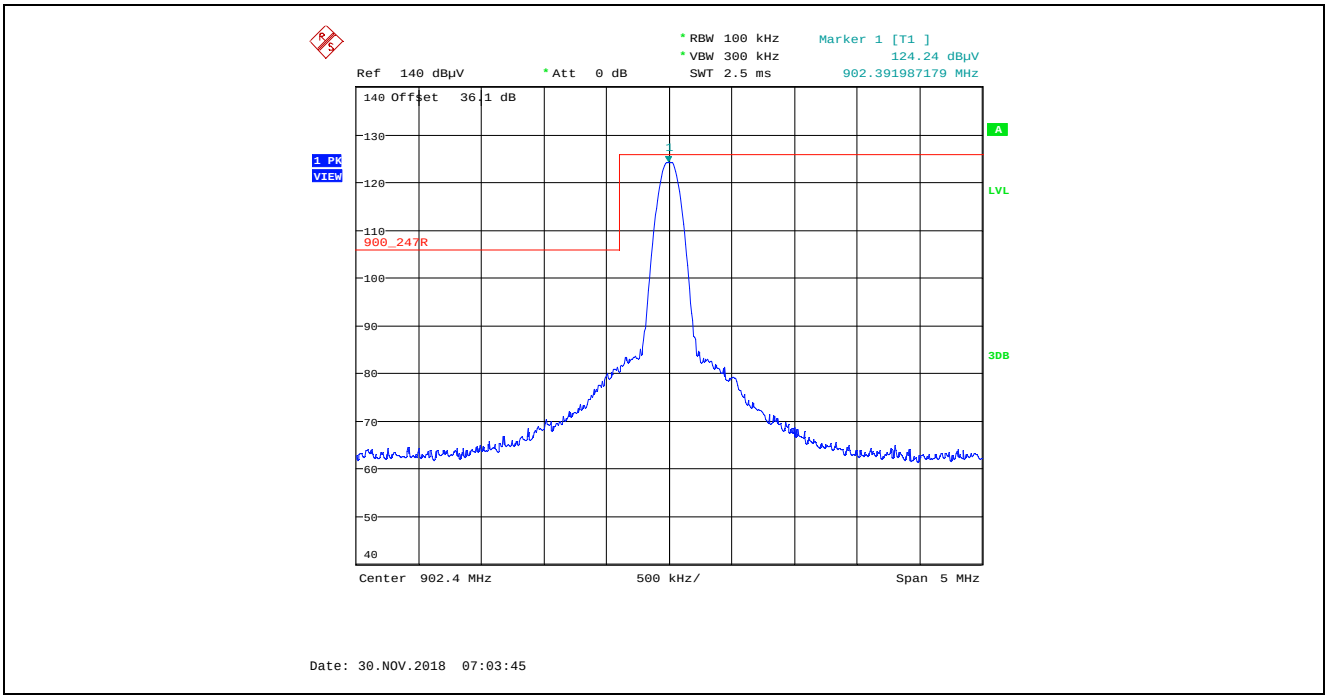
Plot 5.5.4.2.2.1. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Single Frequency Mode, Low End of Frequency Band



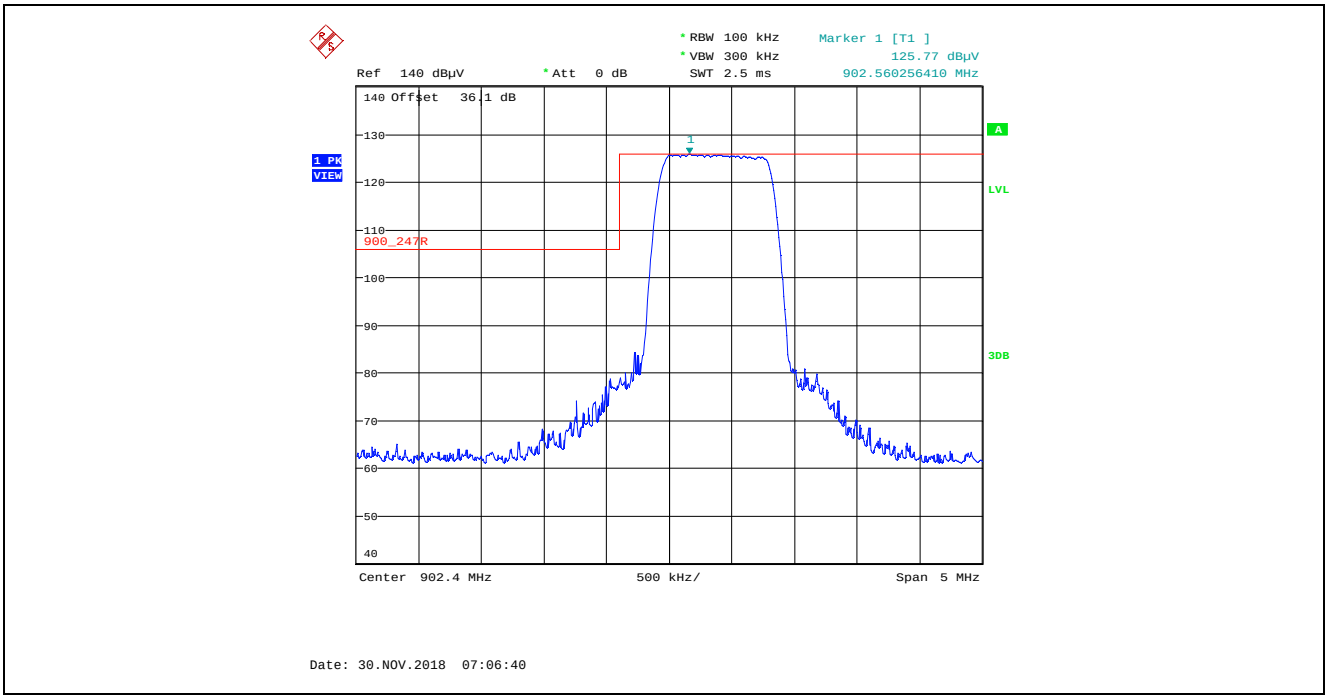
Plot 5.5.4.2.2.2. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



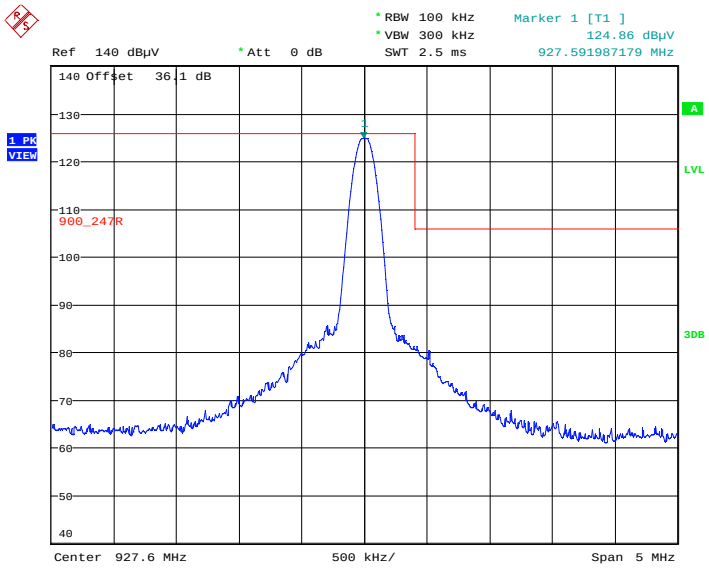
Plot 5.5.4.2.2.3. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Single Frequency Mode, Low End of Frequency Band



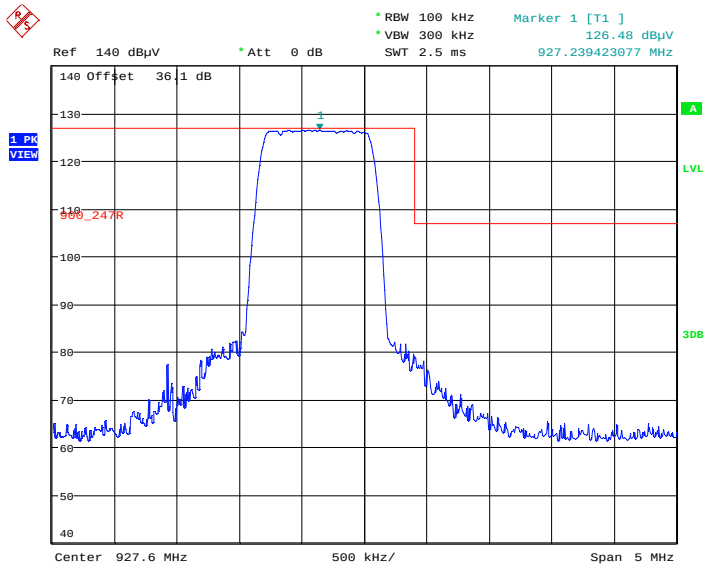
Plot 5.5.4.2.2.4. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



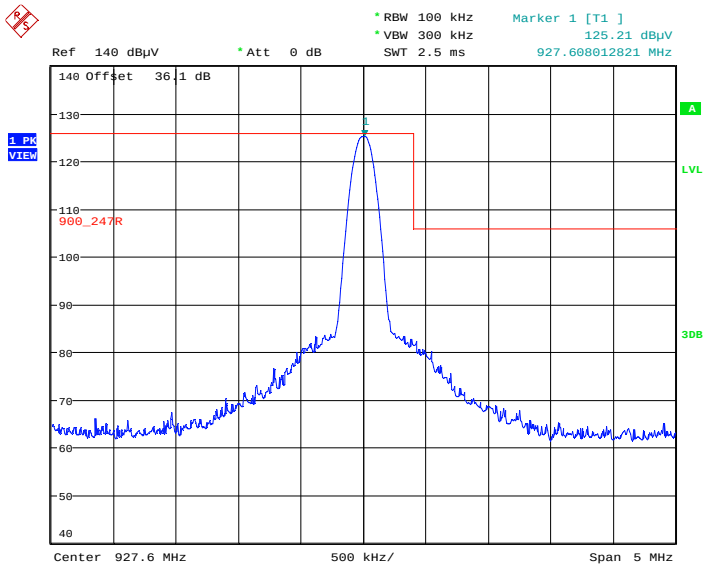
Plot 5.5.4.2.2.5. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Single Frequency Mode, High End of Frequency Band



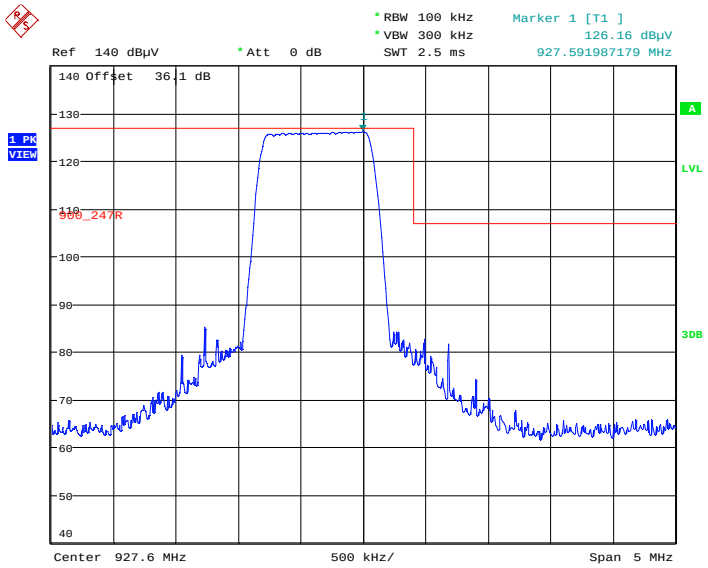
Plot 5.5.4.2.2.6. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Pseudorandom Channel Hopping Mode, High End of Frequency Band



Plot 5.5.4.2.2.7. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Single Frequency Mode, High of Frequency Band



Plot 5.5.4.2.2.8. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Pseudorandom Channel Hopping Mode, High End of Frequency Band



5.5.4.3. EUT with 8 dBi Patch Antenna, 7.62 dBi Antenna Assembly Gain, Low Data Rate

5.5.4.3.1. Spurious Radiated Emissions

Fundamental Frequency:	902.4 MHz
Raw Power Setting:	32
Measured Conducted Power:	27.65 dBm
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
902.4	127.30	--	V	--	--	--	--
902.4	127.27	--	H	--	--	--	--
2707.2	45.59	34.49	V	54.0	107.3	-19.5	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 MHz
Raw Power Setting:	32
Measured Conducted Power:	25.58 dBm
Frequency Test Range:	30 MHz – 10 GHz

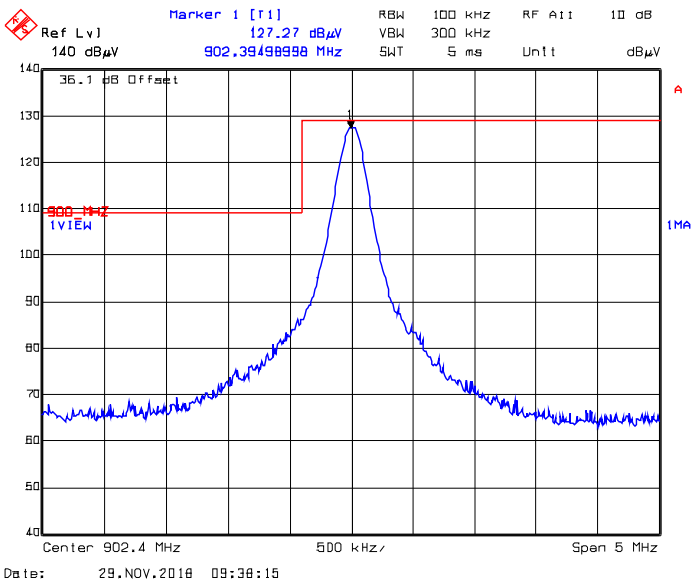
Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
915.0	125.66	--	V	--	--	--	--
915.0	126.49	--	H	--	--	--	--
30 - 10000	*	*	V/H	*	*	*	*
*Spurious emissions and harmonics are more than 20 dB below the applicable limit.							

Fundamental Frequency:	927.6 MHz
Raw Power Setting:	32
Measured Conducted Power:	25.95 dBm
Frequency Test Range:	30 MHz – 10 GHz

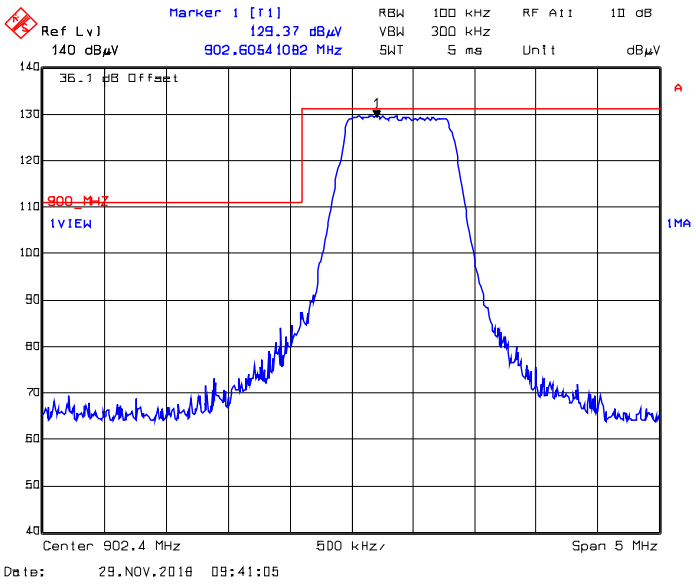
Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
927.6	124.57	--	V	--	--	--	--
927.6	126.12	--	H	--	--	--	--
30 - 10000	*	*	V/H	*	*	*	*
*Spurious emissions and harmonics are more than 20 dB below the applicable limit.							

5.5.4.3.2. Band –Edge RF Radiated Emissions

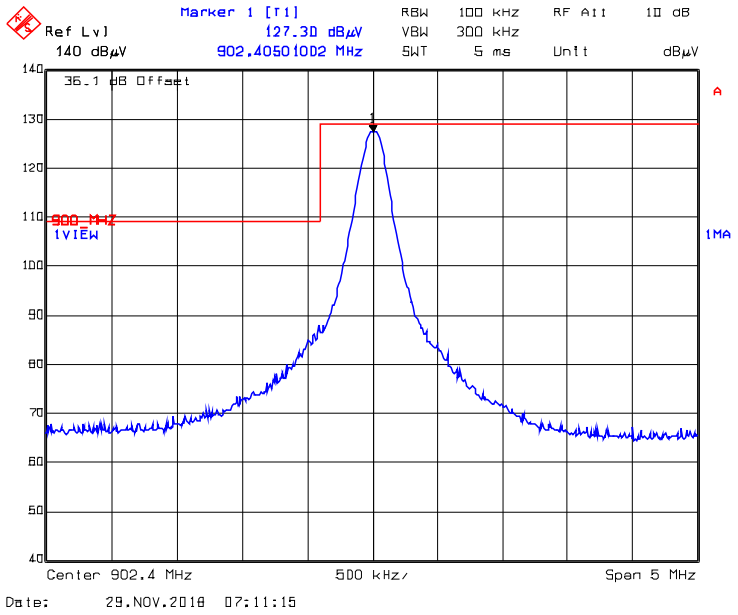
Plot 5.5.4.3.2.1. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Single Frequency Mode, Low End of Frequency Band



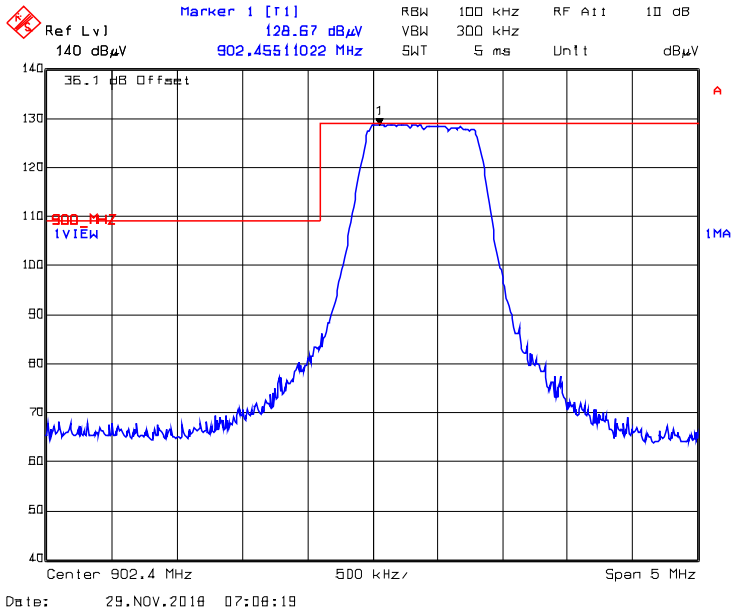
Plot 5.5.4.3.2.2. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



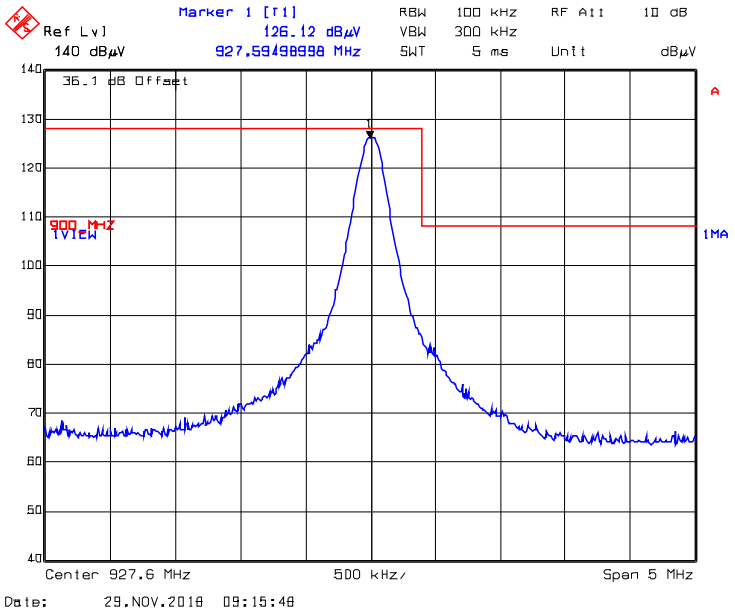
Plot 5.5.4.3.2.3. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Single Frequency Mode, Low End of Frequency Band



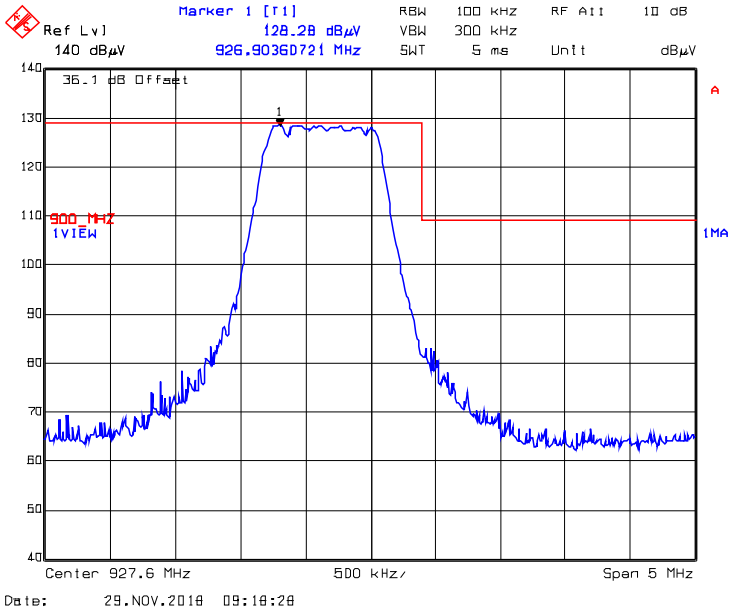
Plot 5.5.4.3.2.4. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



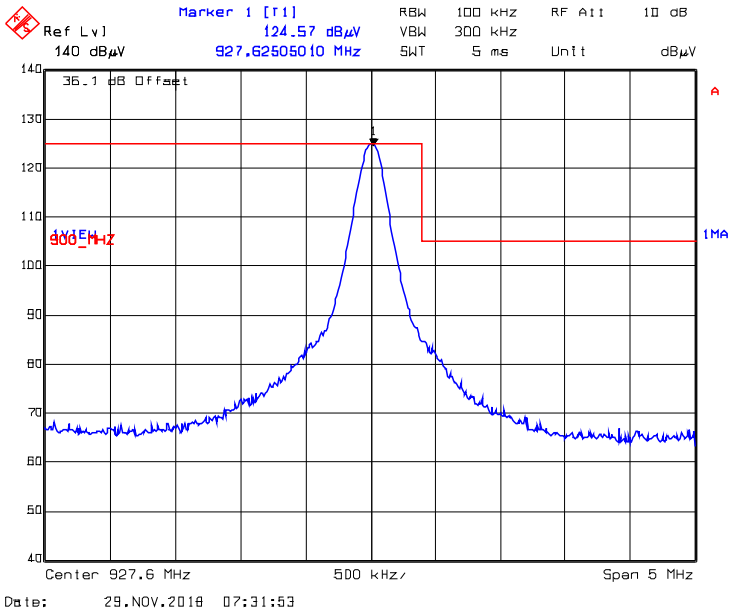
Plot 5.5.4.3.2.5. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Single Frequency Mode, High End of Frequency Band



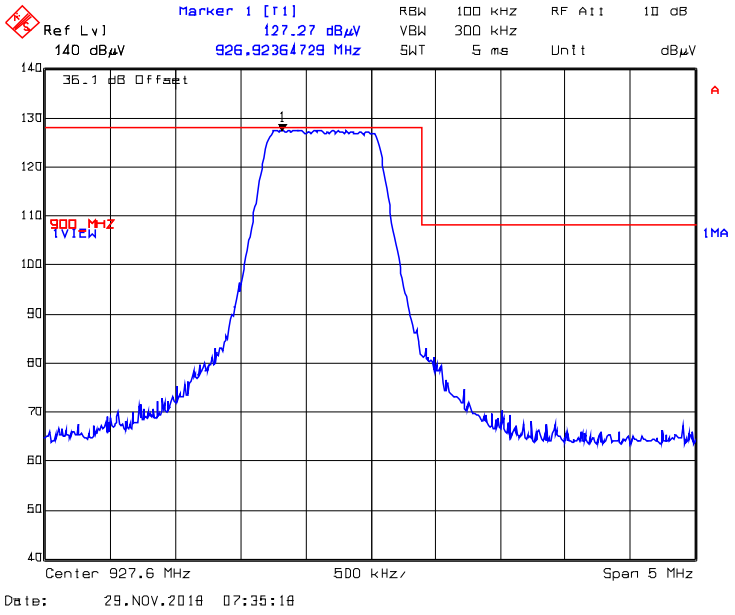
Plot 5.5.4.3.2.6. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Pseudorandom Channel Hopping Mode, High End of Frequency Band



Plot 5.5.4.3.2.7. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Single Frequency Mode, High of Frequency Band



Plot 5.5.4.3.2.8. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Pseudorandom Channel Hopping Mode, High End of Frequency Band



5.5.4.4. EUT with 8.15 dBi Omni Directional Antenna, 7.29 dBi Antenna Assembly Gain, Low Data Rate

5.5.4.4.1. Spurious Radiated Emissions

Fundamental Frequency:	902.4 MHz
Raw Power Setting:	32
Measured Conducted Power:	27.65 dBm
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
902.4	123.91	--	V	--	--	--	--
902.4	125.51	--	H	--	--	--	--
30 - 10000	*	*	V/H	*	*	*	*

*Spurious emissions and harmonics are more than 20 dB below the applicable limit.

Fundamental Frequency:	915 MHz
Raw Power Setting:	32
Measured Conducted Power:	25.58 dBm
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	121.59	--	V	--	--	--	--
915.0	122.49	--	H	--	--	--	--
30 - 10000	*	*	V/H	*	*	*	*

*Spurious emissions and harmonics are more than 20 dB below the applicable limit.

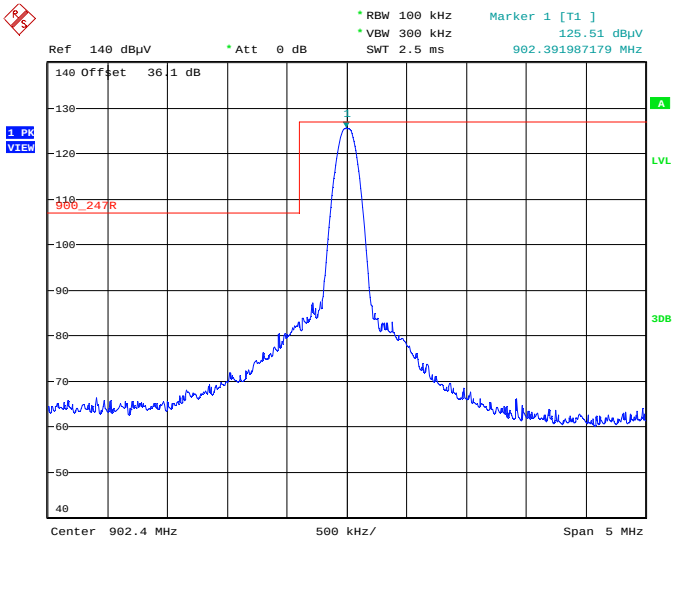
Fundamental Frequency:	927.6 MHz
Raw Power Setting:	32
Measured Conducted Power:	25.95 dBm
Frequency Test Range:	30 MHz – 10 GHz

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
927.6	120.67	--	V	--	--	--	--
927.6	121.08	--	H	--	--	--	--
30 - 10000	*	*	V/H	*	*	*	*

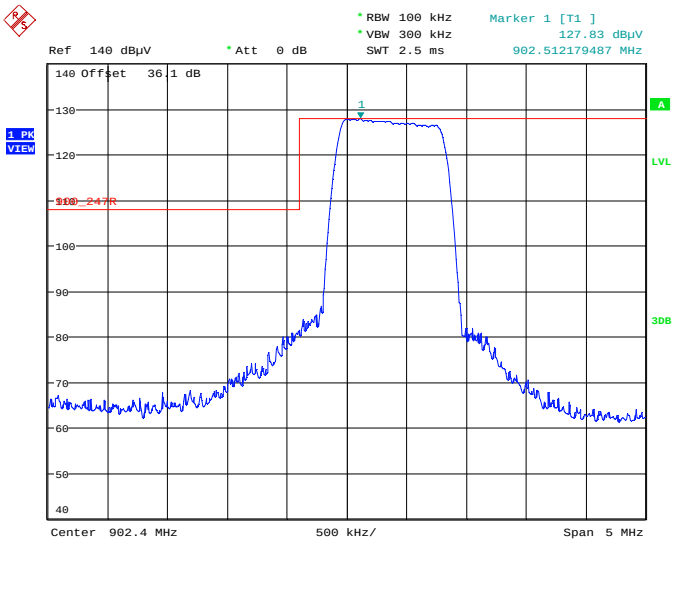
*Spurious emissions and harmonics are more than 20 dB below the applicable limit.

5.5.4.4.2. Band –Edge RF Radiated Emissions

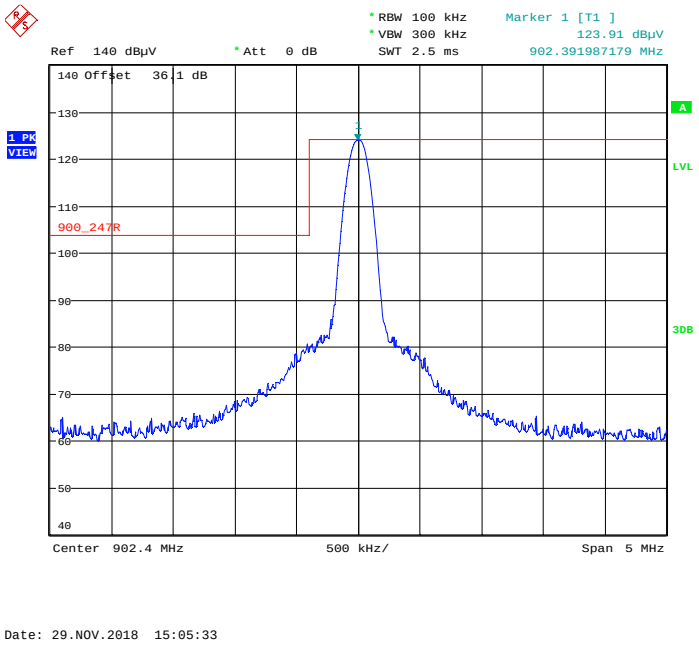
Plot 5.5.4.4.2.1. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Single Frequency Mode, Low End of Frequency Band



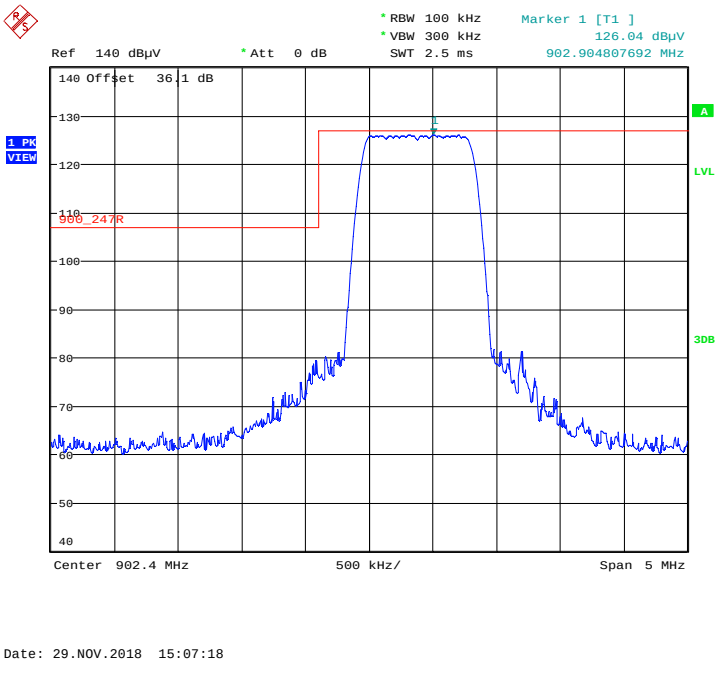
Plot 5.5.4.4.2.2. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



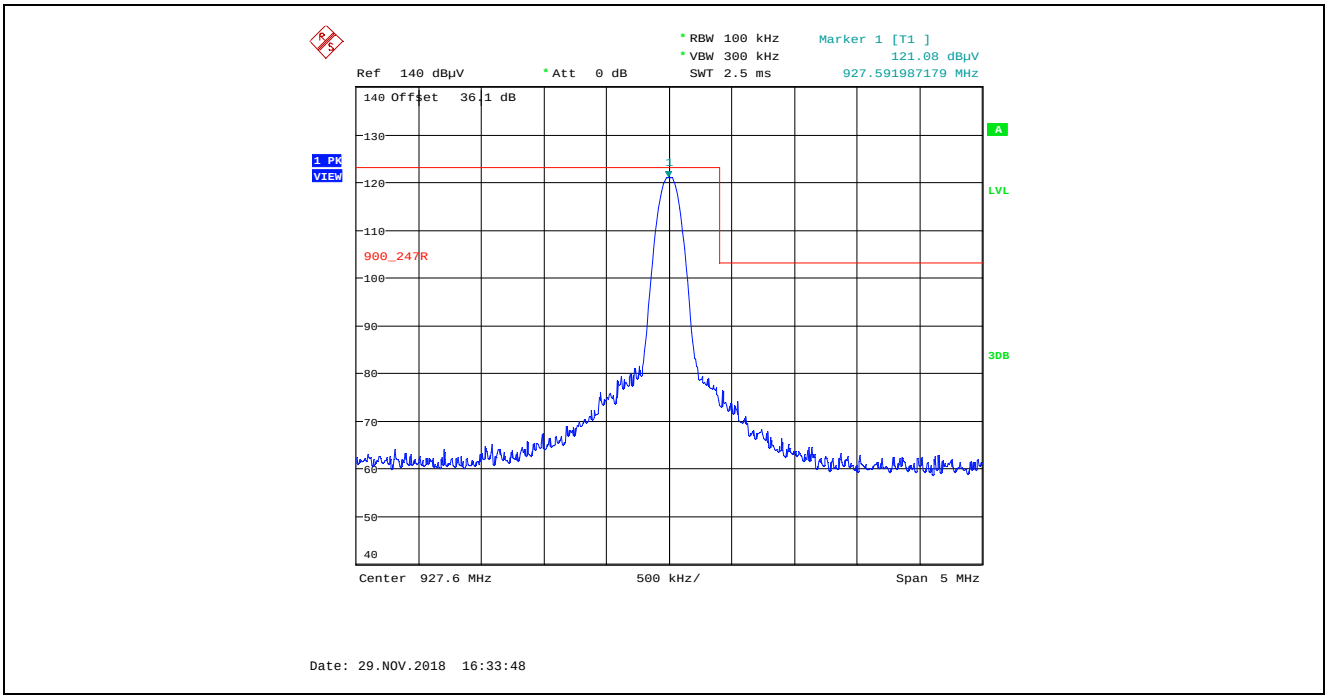
Plot 5.5.4.4.2.3. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Single Frequency Mode, Low End of Frequency Band



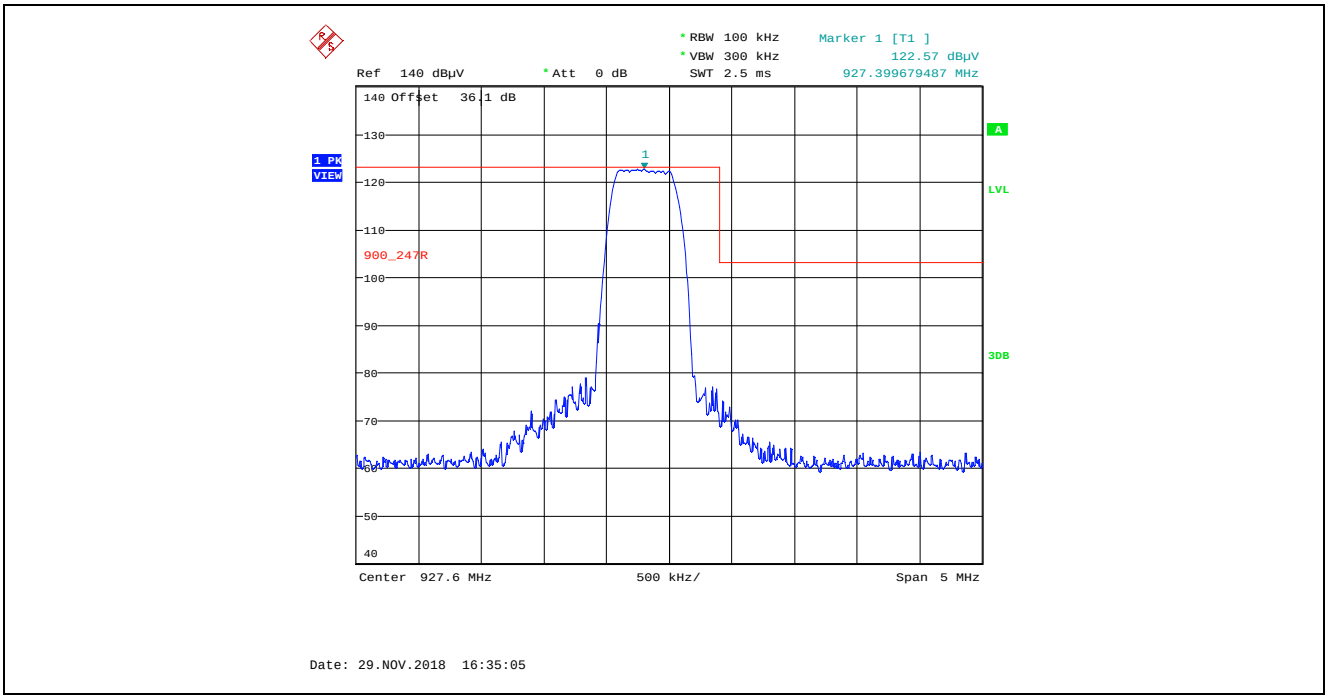
Plot 5.5.4.4.2.4. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



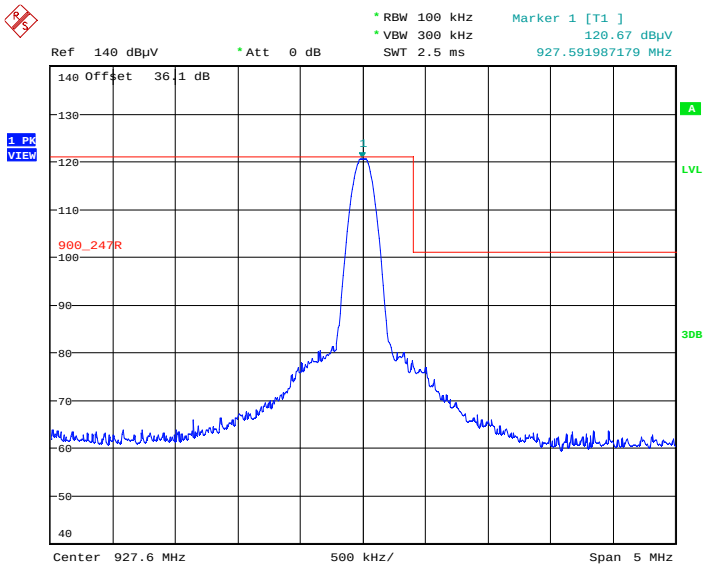
Plot 5.5.4.4.2.5. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Single Frequency Mode, High End of Frequency Band



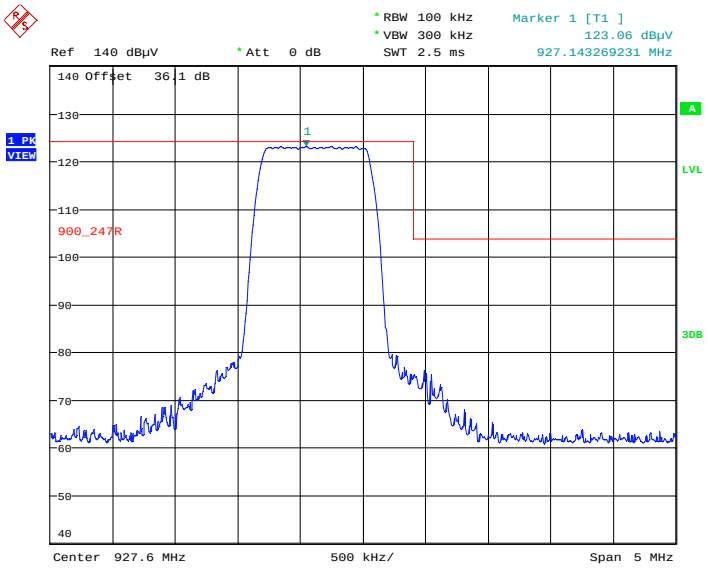
Plot 5.5.4.4.2.6. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Pseudorandom Channel Hopping Mode, High End of Frequency Band



Plot 5.5.4.4.2.7. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Single Frequency Mode, High of Frequency Band



Plot 5.5.4.4.2.8. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Pseudorandom Channel Hopping Mode, High End of Frequency Band



5.5.4.5. EUT with 4 dBi Puck Antenna, 3.62 dBi Antenna Assembly Gain, Low Data Rate

5.5.4.5.1. Spurious Radiated Emissions

Fundamental Frequency:	902.4 MHz
Raw Power Setting:	38
Measured Conducted Power:	29.99 dBm
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
902.4	121.55	--	V	--	--	--	--
902.4	121.48	--	H	--	--	--	--
2707.2	48.51	42.56	V	54.0	101.6	-11.4	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 MHz
Raw Power Setting:	38
Measured Conducted Power:	30.00 dBm
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	120.12	--	V	--	--	--	--
915.0	120.79	--	H	--	--	--	--
2745.0	47.83	41.51	V	54.0	100.8	-12.5	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:	927.6 MHz
Raw Power Setting:	38
Measured Conducted Power:	29.74 dBm
Frequency Test Range:	30 MHz – 10 GHz

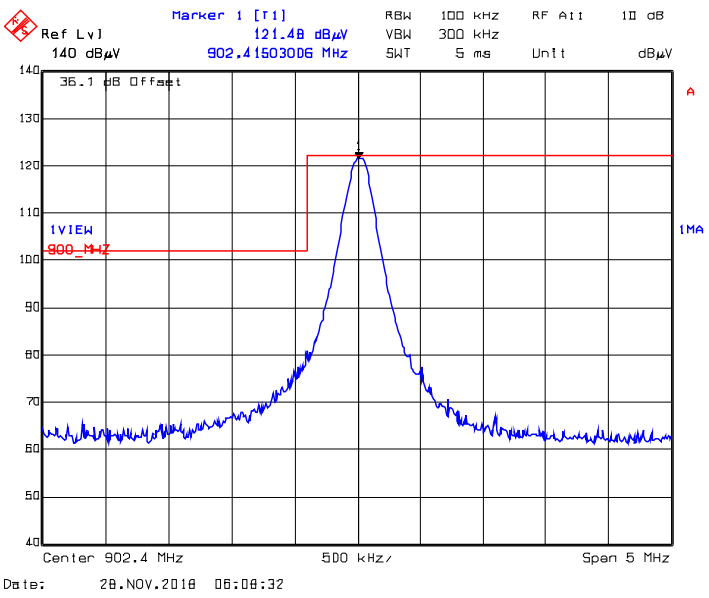
Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
927.6	120.32	--	V	--	--	--	--
927.6	120.32	--	H	--	--	--	--
2782.8	45.79	37.40	V	54.0	100.3	-16.6	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

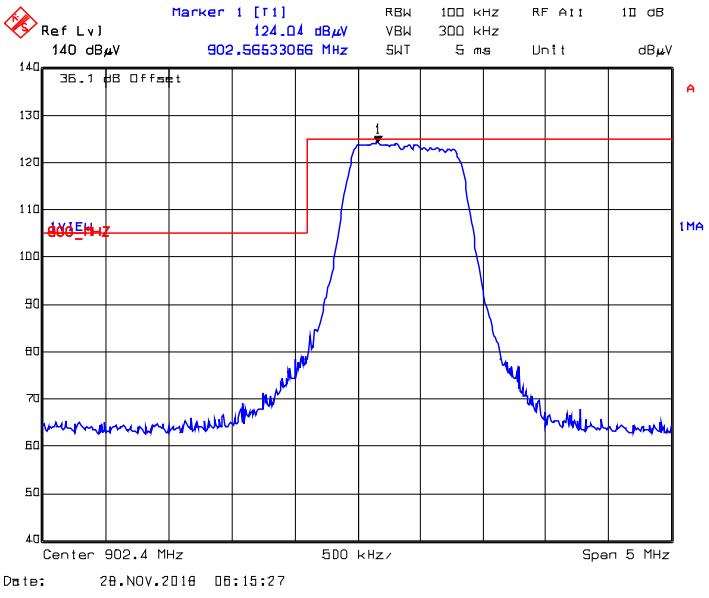
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

5.5.4.5.2. Band –Edge RF Radiated Emissions

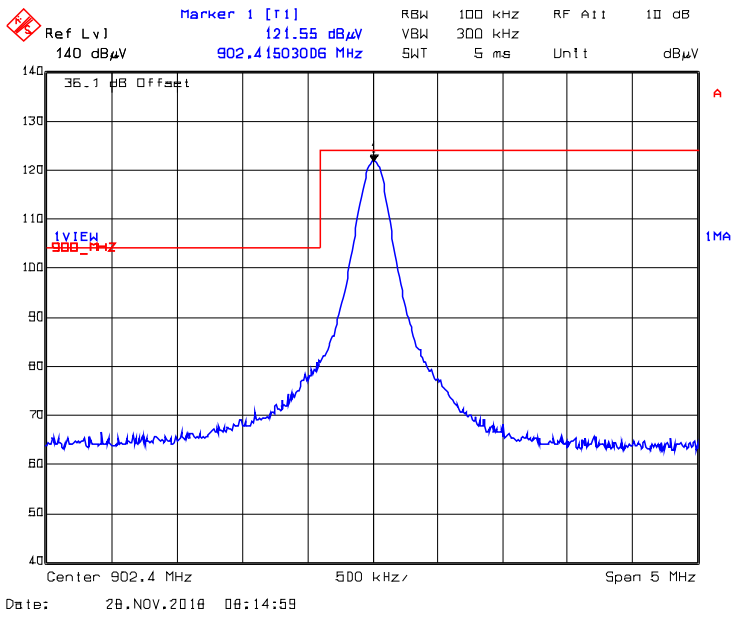
Plot 5.5.4.5.2.1. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Single Frequency Mode, Low End of Frequency Band



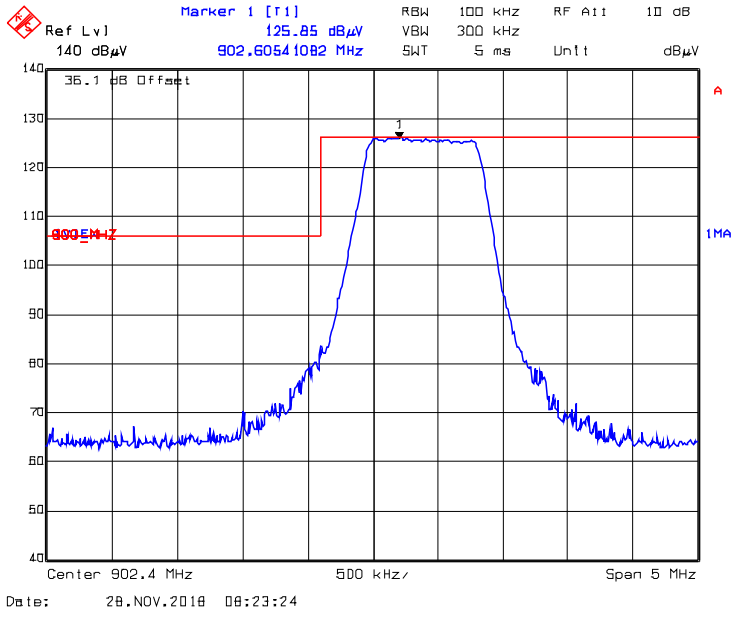
Plot 5.5.4.5.2.2. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



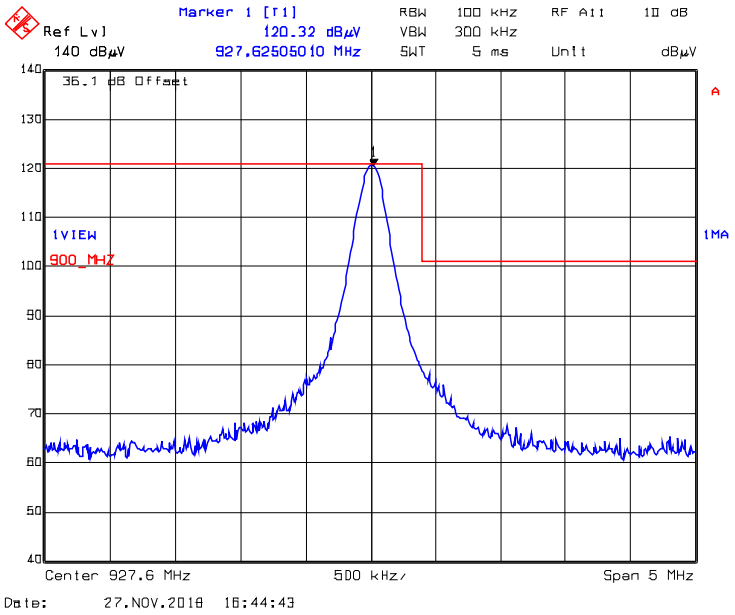
Plot 5.5.4.5.2.3. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Single Frequency Mode, Low End of Frequency Band



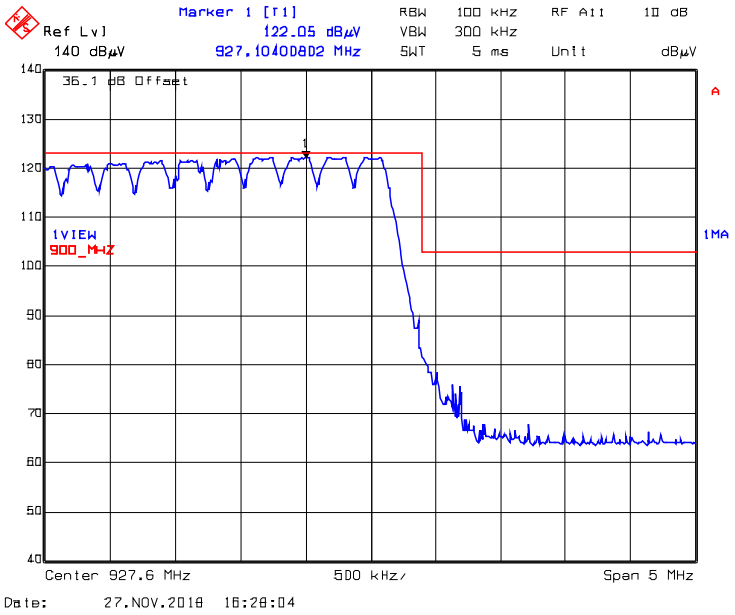
Plot 5.5.4.5.2.4. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Pseudorandom Channel Hopping Mode, Low End of Frequency Band



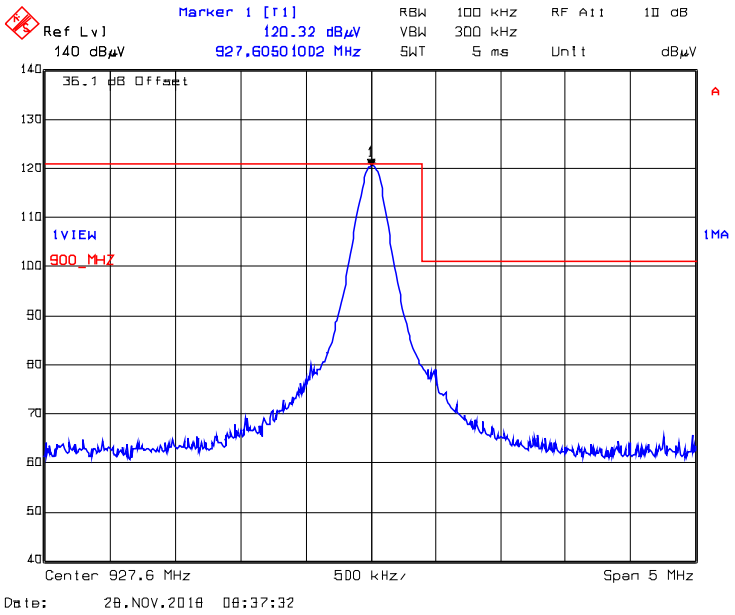
Plot 5.5.4.5.2.5. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Single Frequency Mode, High End of Frequency Band



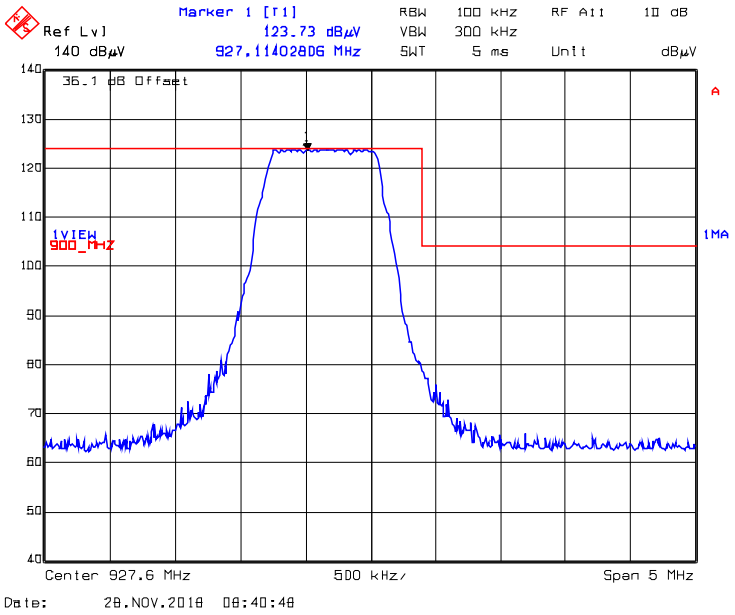
Plot 5.5.4.5.2.6. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Pseudorandom Channel Hopping Mode, High End of Frequency Band



Plot 5.5.4.5.2.7. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Single Frequency Mode, High of Frequency Band



Plot 5.5.4.5.2.8. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Pseudorandom Channel Hopping Mode, High End of Frequency Band



5.6. 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.

5.6.1. 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

All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

5.6.2. RF Evaluation

5.6.2.1. Standalone

Frequency (MHz)	EIRP (dBm)	EIRP (mW)	Evaluation Distance, r (cm)	Power Density, S (mW/cm^2)	MPE Limit (mW/cm^2)	Margin (mW/cm^2)
902.4	36	3981.072	35	0.259	0.602	-0.343

5.6.2.2. Co-location

Pursuant to KDB 447498 D01 General RF Exposure Guidance v06, Section 7.2:

Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0, according to calculated/estimated, numerically modeled, or measured field strengths or power density.

Co-location will only applies to EUT with 3 dBi dipole antenna, worst case EIRP of 33 dBm will be used in co-location at the minimum 35 cm evaluation separation distance required by the operating configurations and exposure conditions of the host device.

The maximum calculated MPE ratio of the EUT with 3 dBi dipole antenna (rubber ducky antenna)

Frequency (MHz)	EUT EIRP (dBm)	EUT EIRP (mW)	Evaluation Distance (cm)	Power Density (mW/cm^2)	FCC MPE Limit (mW/cm^2)	MPE Ratio
902.4	33	1995.262	35	0.130	0.602	0.216

The maximum calculated MPE ratio for the EUT with 3 dBi dipole antenna is 0.216, this configuration can be co-located with other antennas provided the sum of the MPE ratios for all the other simultaneous transmitting antennas incorporated in a host device is $\leq$ 1.0 - 0.216 $\leq$ 0.784.

The following table addresses the co-location of the EUT with 3 dBi antenna with the specified radio modules.

EUT with 3 dBi dipole antenna co-location with radio module identified in this table

*Radio Module	Frequency (MHz)	EIRP (dBm)	EIRP (mW)	Evaluation Distance (cm)	Power Density (mW/cm^2)	FCC MPE Limit (mW/cm^2)	MPE Ratio	MPE Ratio of EUT with 2.5 dBi antenna	Sum of MPE Ratio	Verdict
LE910NA V2 LTE/3G Module (FCC ID: RI7LE910NAV2, IC: 5131A-LE910NAV2)	699.0	30.63	1156.112	35	0.075	0.466	0.161	0.216	0.377	Compliant
LM940 Module (FCC ID: RI7LM940 IC: 5131A-LM940)	2307.5	34.00	2511.886	35	0.163	1.000	0.163	0.216	0.379	Compliant
SARA-R410M LTE Cat-M1 Module (FCC ID: XPY2AGQN4NNN, IC: 8595A-2AGQN4NNN)	1850.0	32.12	1629.296	35	0.106	1.000	0.106	0.216	0.322	Compliant
L850 LTE Module (FCC ID: ZMOL850GL, IC: 21374-L850GL)	826.4	--	501.19	35	0.033	0.551	0.060	0.216	0.276	Compliant

* The test data of the radio modules represented in this table is the worst-case configuration (maximum MPE ratio) derived from the original radio modules MPE reports. Refer to these reports for detail.

EXHIBIT 6. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Cal. Due Date
Spectrum Analyzer	Hewlett Packard	HP 8593EM	3412A00103	9 kHz–26.5 GHz	22 May 2019
Attenuator	Pasternack	PE7010-20	ATT13	DC–2 GHz	21 Mar 2019
LISN Used	EMCO	3825/2R	1165	10 kHz–30 MHz	18 Oct 2019
Spectrum Analyzer	Rohde & Schwarz	FSEK30	100077	20Hz–40 GHz	05 Dec 2018*
Attenuator	Pasternack	PE7024-20	6	DC–26.5 GHz	See Note 1
DC Block	Hewlett Packard	11742A	12460	0.045–26.5 GHz	See Note 1
Spectrum Analyzer	Rohde & Schwarz	FSU26	200946	20Hz–26.5 GHz	25 Jul 2020
DC Block	Hewlett Packard	11742A	12460	0.045–26.5 GHz	See Note 1
EMI Receiver	Rohde & Schwarz	ESU40	100037	20Hz–40 GHz	04 May 2019
RF Amplifier	Com-Power	PAM-0118A	551052	0.5 – 18 GHz	26 Jun 2019
RF Amplifier	Hewlett Packard	84498	3008A00769	1 – 26.5 GHz	01 Oct 2019
Biconilog	EMCO	3142C	00026873	26-3000 MHz	27 Apr 2020
Horn Antenna	EMCO	3155	6570	1 – 18 GHz	11 Oct 2020
High Pass Filter	K & L	11SH10-1500/T8000	2	Cut off 900 MHz	See Note 1
Log Periodic	ETS-Lindgren	3148	23845	200-2000 MHz	02 Aug 2020
Attenuator	Hewlett Packard	8493C	0465	DC–18 GHz	See Note 1
Laptop	HP Pro Book	6455b	CNU1163L8Z	-	-
Note 1: Internal Verification/Calibration check					

* Equipment used before calibration due date.

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**