FCC / ISED Test Report

FOR:
Trimble Inc.

Model Name:
TRM900 MHZ TX/RX

Product Description:
Trimble designed limited single-modular transceiver (LMST) 50 hopping channels for FHSS radio, 902.0-928.0MHz, half-duplex, 127,381bps, BPSK modulation.

FCC ID: JUP-900MHZ
IC ID: 1756A-900MHZ

Applied Rules and Standards:
47 CFR Part 15.247 (DSS)
RSS-247 Issue 2 (FHSs) & RSS-Gen Issue 5

REPORT #: EMC_TRIMB-141-21001_15.247_ISM_DSS_R2

DATE: 2021-12-22

A2LA Accredited

IC recognized #
3462B-1
CABID: US0187

CETECOM **Inc.**
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CETECOM Inc. is a Delaware Corporation with Corporation number: 2905571

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1 Assessment

The following device was evaluated against the applicable criteria specified in FCC rules Parts 15.247 of Title 47 of the Code of Federal Regulations and the relevant ISED Canada standard RSS-247.

No deviations were ascertained.

Company	Description	Model #
Trimble Inc.	Trimble designed limited single-modular transceiver (LMST) 50 hopping channels for FHSS radio, 902.0-928.0MHz, half-duplex, 127,381bps, BPSK modulation.	TRM900 MHZ TX/RX

Responsible for Testing Laboratory:

Date	Section	Name	Signature
2021-12-22	Compliance	Kevin Wang (EMC Lab Manager)	kevin.wang@cetecom.com Digitally signed by: kevin.wang@cetecom.com DN: CN = kevin.wang@cetecom.com Date: 2021.12.22 15:07:42 -08'00'

Responsible for the Report:

Date	Section	Name	Signature
2021-12-22	Compliance	Cheng Song (Test Engineer)	cheng.song@cetecom.com Digitally signed by: cheng.song@cetecom.com DN: CN = cheng.song@cetecom.com Date: 2021.12.22 15:09:18 -08'00'

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the EMC Test Report

Company Name:	CETECOM Inc.
Department:	Compliance
Street Address:	411 Dixon Landing Road
City/Zip Code	Milpitas, CA 95035
Country	USA
Telephone:	+1 (408) 586 6200
Fax:	+1 (408) 586 6299
EMC Lab Manager:	Kevin Wang
Responsible Project Leader:	Rami Saman

2.2 Identification of the Client

Client's Name:	Trimble Inc.
Street Address:	935 Stewart Drive
City/Zip Code	Sunnyvale, CA 94085
Country	USA

2.3 Identification of the Manufacturer

Manufacturer's Name:	Same as Client
Manufacturers Address:	
City/Zip Code	
Country	

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Model No:	TRM900 MHZ TX/RX
HW Version :	80385-20
SW Version :	v5.xx
FCC-ID :	JUP-900MHZ
IC-ID:	1756A-900MHZ
FWIN:	N/A
HVIN:	TRM900 MHZ TX/RX
PMN:	TRM900
Product Description:	Trimble designed limited single-modular transceiver (LMST) 50 hopping channels for FHSS radio, 902.0-928.0MHz, half-duplex, 127,381bps, BPSK modulation.
Frequency Range / number of channels:	Nominal band: 902 MHz – 928 MHz Center to center: 902 MHz – 928 MHz, 50 Channels
Radio Information:	ISM: Module Name: TRM900 Module Number: TRM900 MHZ TX/RX Type(s) of Modulation: BPSK
Modes of Operation:	Hopping
Antenna Information as declared:	Model Name : Baracuda Dual Band Antenna Gain: 2.1 dBi
Max. declared output Powers:	Conducted Power 28.39 dBm
Power Supply/ Rated Operating Voltage Range:	Vmin: 3.5 VDC/ Vnom: 3.85 VDC / Vmax: 4.2 VDC
Operating Temperature Range	Low -35ºC, Nominal 25ºC, High 70ºC
Other Radios included in the device:	NA
Sample Revision	☐Prototype Unit; ■Production Unit; ☐Pre-Production
EUT Dimensions(mm)	69.8(L) X 46.6(W) X 8(H)

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	6133R05235	80385-20	v5.xx	Conducted RF and Radiated Emissions

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number
1	AC/DC adapter	ATS065T-A190	ADADAPTER TECH	-

3.4 Test Sample Configuration

EUT Set-up #	Combination of AE used for test set up	Comments
1	EUT#1 + AE#1	Special commands through command window used to configure the Bluetooth radio to low, mid and high channels provided by the client that will not be available to the end user. For radiated measurements, the external antenna was connected.
2	EUT#1 + AE#1	Special commands through command window used to configure the Bluetooth radio to low, mid and high channel provided by the client that will not be available to the end user. For conducted measurements, the equipment was connected to 50 ohm RF port of the EUT.

3.5 Justification for Worst Case Mode of Operation

During the testing process, the EUT was tested with transmitter sets on low, mid and high channels.

For radiated measurements, all data in this report shows the worst case between horizontal and vertical antenna polarizations and for all orientations of the EUT.

For conducted measurements, the highest power and the highest duty cycle were used to evaluate the worst case performance of the EUT, including the band edge compliance and TX radiated spurious emissions testing. Maximum peak conducted output power and spectrum bandwidth, were measured in all supported modulation modes for the EUT.

4 Subject of Investigation

The objective of the measurements done by CETECOM Inc. was to assess the performance of the EUT according to the relevant requirements specified in FCC rules Part 15.247 of Title 47 of the Code of Federal Regulations and Radio Standard Specification RSS-247 Issue 2 of ISED Canada.

This test report is to support a request for new equipment authorization under the:

- FCC ID: JUP-900MHZ
- IC ID: 1756A-900MHZ

Testing procedures are based on ANSI C63.10:2013 including section 7.8 for FHSS systems.

5 Measurement Results Summary

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	NA	NP	Result
§15.247(b)(1) RSS-247 5.4(b)	Maximum Peak Conducted Output Power	Nominal	BPSK	■	☐	☐	Complies
§15.247(d) RSS-247 5.5 RSS-Gen 8.10	Band Edge Compliance	Nominal	BPSK	■	☐	☐	Complies
§15.247(a)(1) RSS-247 5.1(b)	Spectrum Bandwidth	Nominal	BPSK	■	☐	☐	Complies
§15.247(a)(1) RSS-247 5.1(b)	Carrier Frequency Separation	Nominal	BPSK	■	☐	☐	Complies
§15.247(a)(1) RSS-247 5.1(d)	Number of Hopping Channels	Nominal	BPSK	■	☐	☐	Complies
§15.247(a)(1)(iii) RSS-247 5.1(d)	Time of occupancy	Nominal	BPSK	■	☐	☐	Complies
§15.247(d) §15.209 (a) RSS-Gen 6.13	TX Spurious emissions-Radiated	Nominal	BPSK	■	☐	☐	Complies
§15.207(a) RSS-Gen 8.8	AC Conducted Emissions	Nominal	BPSK	■	☐	☐	Complies

Note: NA= Not Applicable; NP= Not Performed.

6 Measurements

6.1 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus, with 95% confidence interval (in dB delta to result), based on a coverage factor k=1.

Measurement System		EMC 1	EMC 2
Conducted emissions (mains port)		1.12 dB	0.46 dB
Radiated emissions	(< 30 MHz)	3.66 dB	3.88 dB
	(30 MHz – 1GHz)	3.17 dB	3.34 dB
	(1 GHz – 3 GHz)	5.01 dB	4.45 dB
	(>3 GHz)	4.0 dB	4.79 dB

6.2 Environmental Conditions During Testing:

The following environmental conditions were maintained during the course of testing:

- Ambient Temperature: 20-25°C
- Relative humidity: 40-60%

6.3 Dates of Testing:

10/15/2021– 11/02/2021

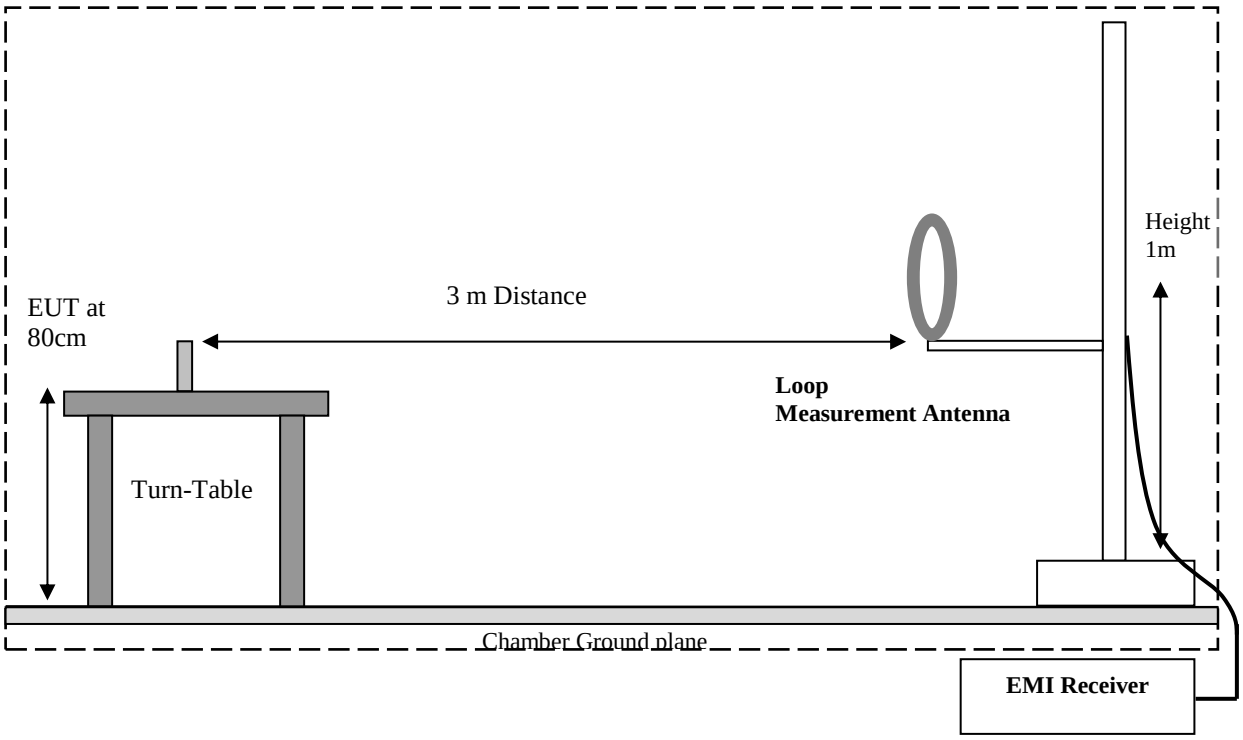
7 Measurement Procedures

7.1 Radiated Measurement

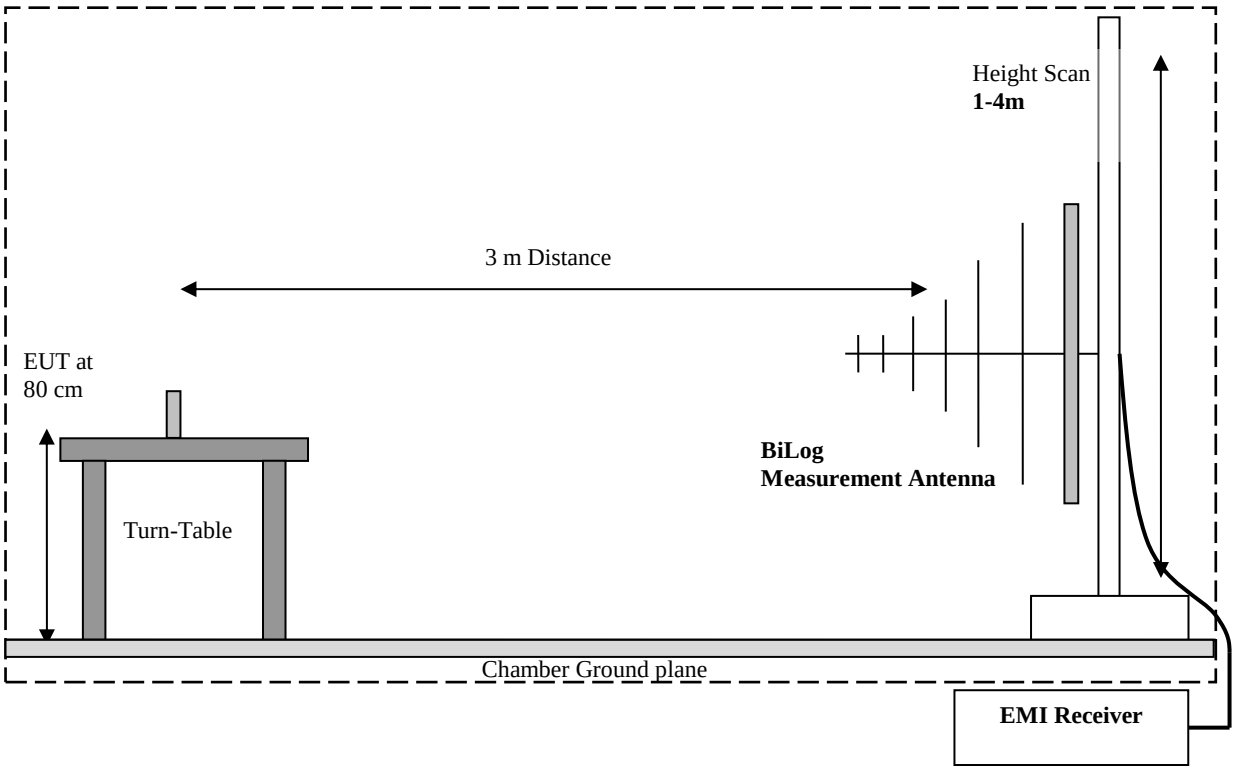
The radiated measurement is performed according to: ANSI C63.10 (2013)

- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 4 positions of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to cover the 3 orthogonal axis of the EUT. A max peak detector is utilized during the exploratory measurement. The Test-SW creates an overall maximum trace for all 12 sweeps and saves the settings for each point of this trace. The maximum trace is part of the test report.
- The 10 highest emissions are selected with an automatic algorithm of EMC32 searching for peaks in the noise floor and ensuring that broadband signals are not selected multiple times.
- The maxima are then put through the final measurement and again maximized in a 90deg range of the turntable, fine search in frequency domain and height scan between 1m and 4m.
- The above procedure is repeated for all possible ways of power supply to EUT and for all supported modulations.
- In case there are no emissions above noise floor level only the maximum trace is reported as described above.
- The results are split up into up to 4 frequency ranges due to antenna bandwidth restrictions. A magnetic loop is used from 9 kHz to 30 MHz, a Biconilog antenna is used from 30 MHz to 1 GHz, and two different horn antennas are used to cover frequencies up to 40 GHz.

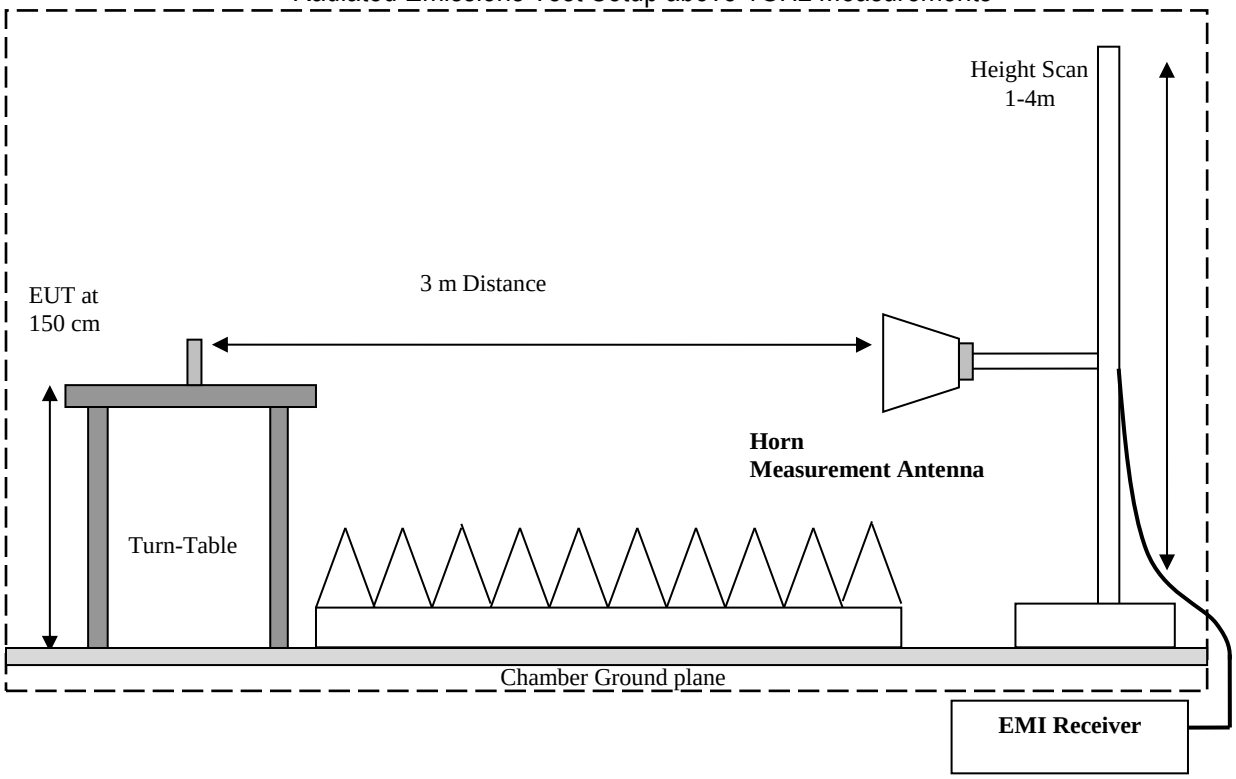
Radiated Emissions Test Setup below 30MHz Measurements



Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup above 1GHz Measurements



7.1.1 Sample Calculations for Field Strength Measurements

Field Strength is calculated from the Spectrum Analyzer/ Receiver readings, taking into account the following parameters:

1. Measured reading in dBµV
2. Cable Loss between the receiving antenna and SA in dB and
3. Antenna Factor in dB/m

All radiated measurement plots in this report are taken from a test SW that calculates the Field Strength based on the following equation:

FS (dBµV/m) = Measured Value on SA (dBµV) + Cable Loss (dB) + Antenna Factor (dB/m)

Example:

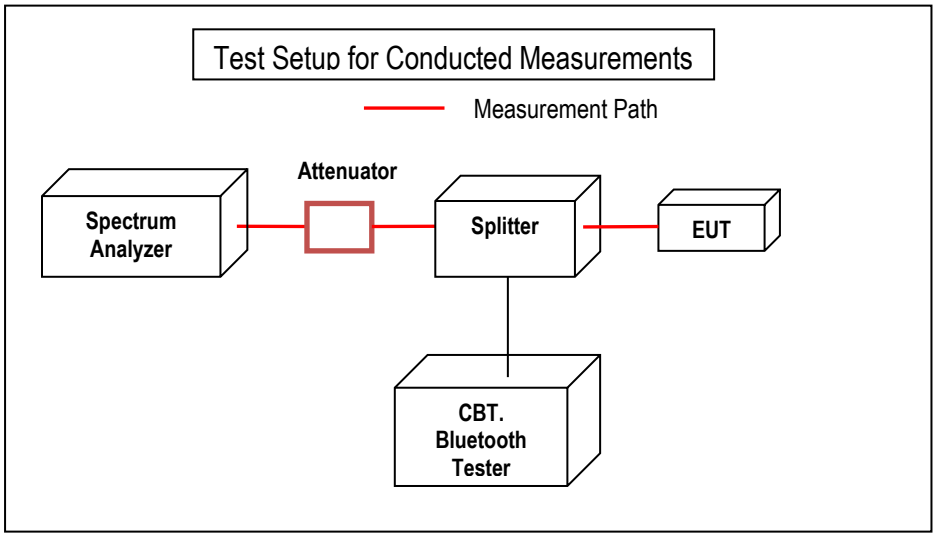
Frequency (MHz)	Measured SA (dBµV)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dBµV/m)
1000	80.5	3.5	14	98.0

7.2 Power Line Conducted Measurement Procedure

AC Power Line conducted emissions measurements performed according to: ANSI C63.4 (2014)

7.3 RF Conducted Measurement Procedure

Reference: ANSI C63.10 (2013) Section 6.9, 6.10, and 7.8



- Connect the equipment as shown in the above diagram.
- Adjust the settings of the SA (Rohde-Schwarz Spectrum Analyzer) to connect the EUT at the required mode of test.
- Measurements are to be performed with the EUT set to the low, middle and high channels and for worst case modulation schemes.

8 Test Result Data

8.1 Maximum Peak Conducted Output Power

8.1.1 Measurement according to ANSI C63.10 Section 7.8.5

Spectrum Analyzer settings:

- Span = approximately 5 times the 20 dB bandwidth
- RBW > the 20 dB bandwidth of the emission being measured
- VBW ≥ RBW
- Sweep = Auto Couple
- Detector function = Peak
- Trace = Max hold
- Use the marker-peak function to set the marker to the peak of the emission.

8.1.2 Limits:

Maximum Peak Output Power:

FCC §15.247: (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

- (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.

IC RSS-247 5.4:

- (a) For FHSs operating in the band 902-928 MHz, the maximum peak conducted output power shall not exceed 1.0 W, and the e.i.r.p. shall not exceed 4 W if the hopset uses 50 or more hopping channels; the maximum peak conducted output power shall not exceed 0.25 W and the e.i.r.p. shall not exceed 1 W if the hopset uses less than 50 hopping channels.

8.1.3 Test conditions and setup:

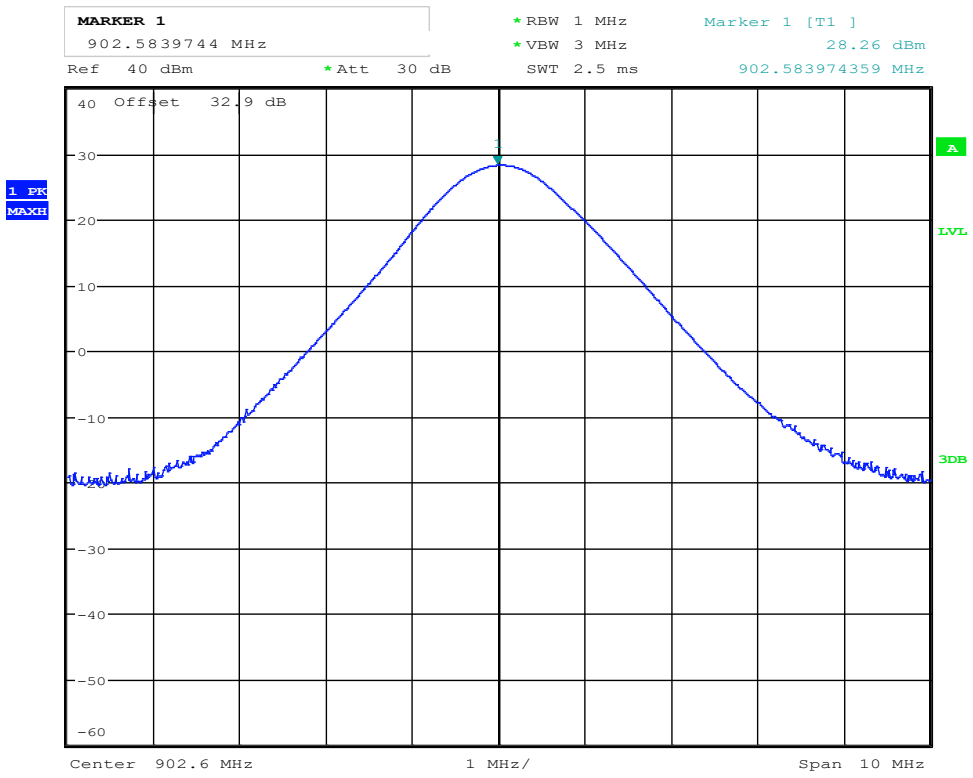
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23° C	2	BPSK	110 VAC	2.1 dBi

8.1.4 Measurement result:

Plot #	Frequency (MHz)	EUT operating mode	Maximum Peak Conducted Output Power (dBm)	EIRP (dBm)	Limit (dBm)	Result
1	902.6	BPSK	28.26	30.36	30(Pk) / 36(EIRP)	Pass
2	915.4	BPSK	28.39	30.49	30(Pk) / 36(EIRP)	Pass
3	927.6	BPSK	27.56	29.66	30(Pk) / 36(EIRP)	Pass

8.1.5 Measurement Plots:

Plot #1	
902.6 MHz	Modulation/Packet Type: BPSK



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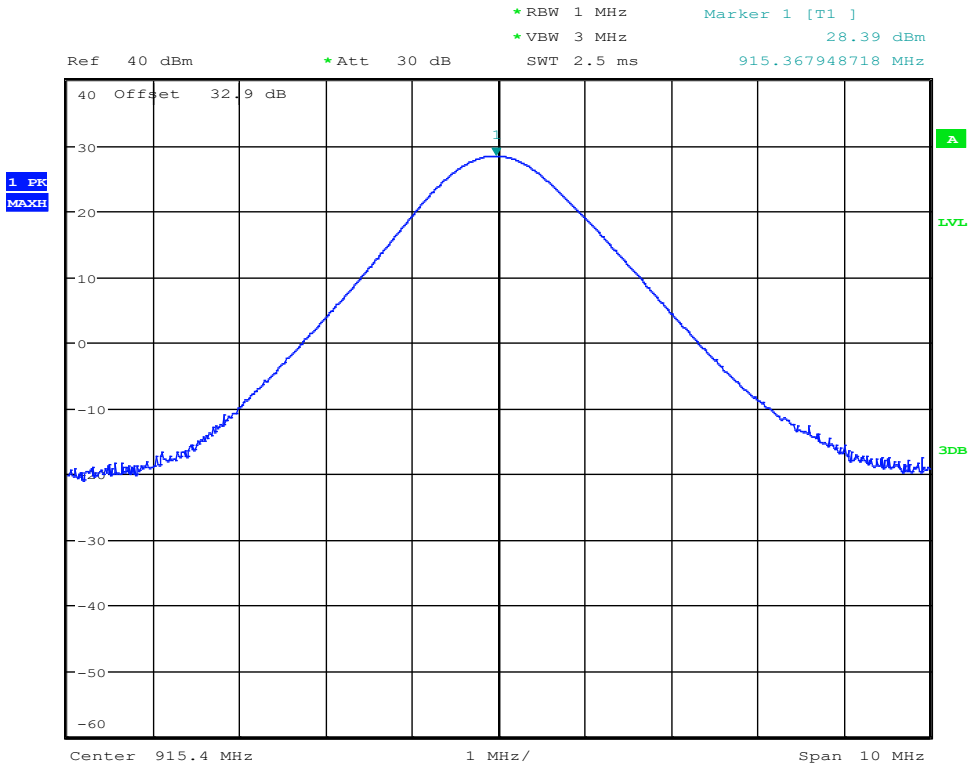
Plot #2

915.4 MHz	Modulation/Packet Type: BPSK



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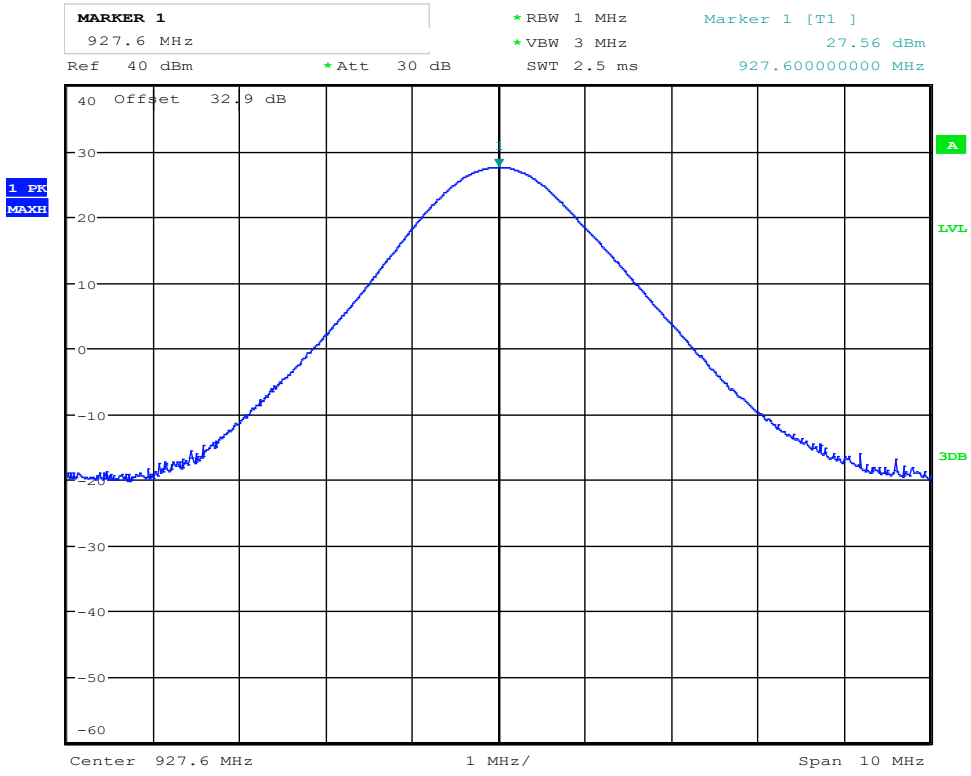
Plot #3

927.6 MHz	Modulation/Packet Type: BPSK



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8.2 Duty cycle

8.2.1 Measurement according to FCC 558074 D01 DTS Meas Guidance v05r02

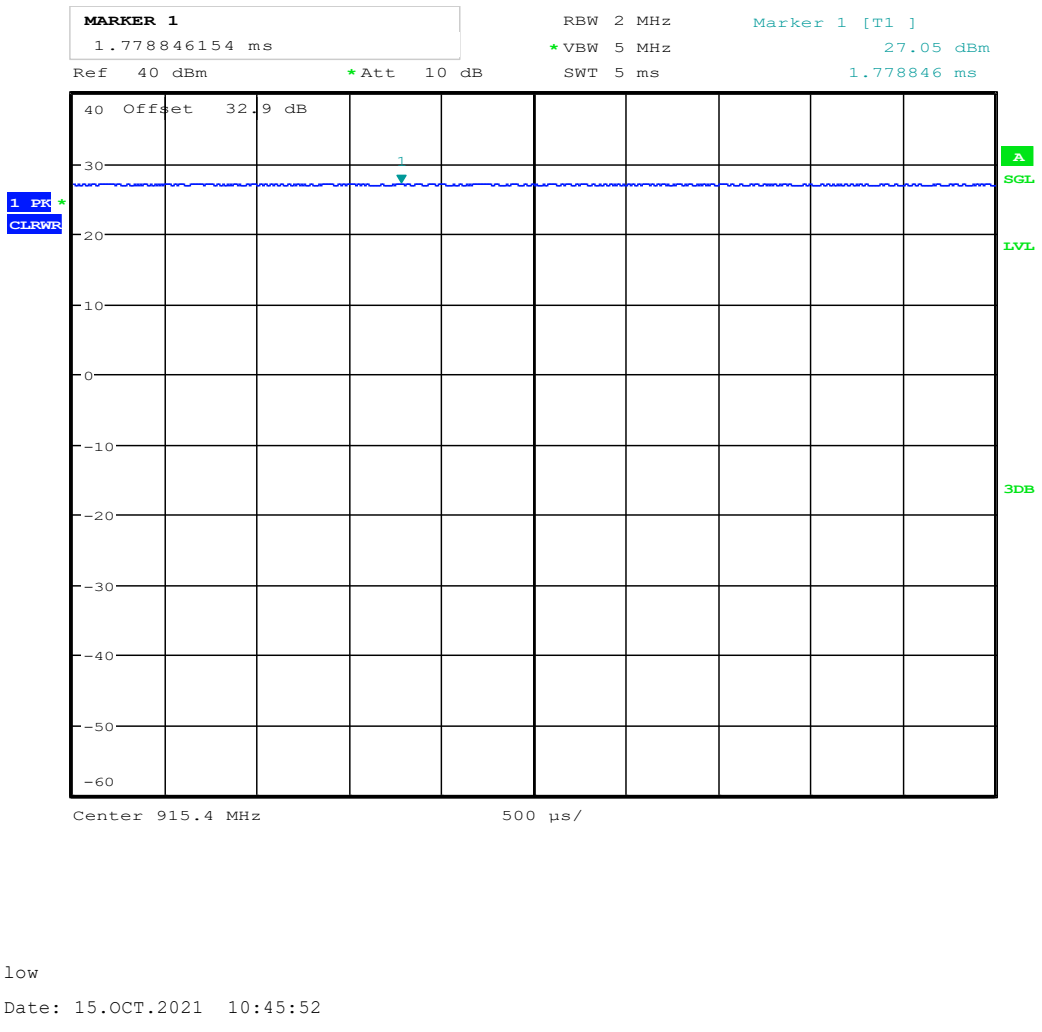
Spectrum Analyzer settings:

- Set the center frequency and of the instrument to the center frequency of the transmission
- Zero span
- Set RBW >=OBW if possible; otherwise, set RBW to the largest available value
- Detector = Peak or average

8.2.2 Measurement result

Duty cycle measurement

Mid channel / 915.4 MHz	Modulation/Packet Type: BPSK



Duty cycle =100%
Duty cycle correction factor =0 dB

8.3 Band Edge Compliance

8.3.1 Measurement according to ANSI C63.10 Section 6.10

Spectrum Analyzer settings for non-restricted band edge:

- Span: wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation.
- RBW ≥ 1% of the span
- VBW ≥ RBW
- Sweep Time: Auto couple
- Detector = Peak
- Trace = Max hold
- Allow the trace to stabilize. Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge.
- Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.
- Now, using the same instrument settings, enable the hopping function of the EUT.
- Allow the trace to stabilize. Follow the same procedure listed above to determine if any spurious emissions caused by the hopping function also comply with the specified limit.

Spectrum Analyzer settings for restricted band:

- Peak measurements are made using a peak detector and RBW=1 MHz

8.3.2 Limits: Restricted Band FCC 15.209 and RSS-Gen 8.10

- PEAK LIMIT= 74 dBµV/m @3 m =-21.23 dBm
- AVG. LIMIT= 54 dBµV/m @3 m =-41.23 dBm
- Start frequency & stop frequency according to frequency range specified in the restricted band table in FCC section 15.205

Restricted bands of operation:

- Except as shown in CFR 47 Part 15.205 paragraph (d), only spurious emissions are permitted in any of the frequency bands listed below

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
[10].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	2690-2900	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	Above 38.6
13.36-13.41			

8.3.3 Limits: Non-restricted Band §15.247 and RSS-247 5.5

FCC15.247 (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)).

RSS-247 5.5

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

8.3.4 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna gain
22° C	2	BPSK - fixed channel BPSK - hopping	110 VAC	2.1 dBi

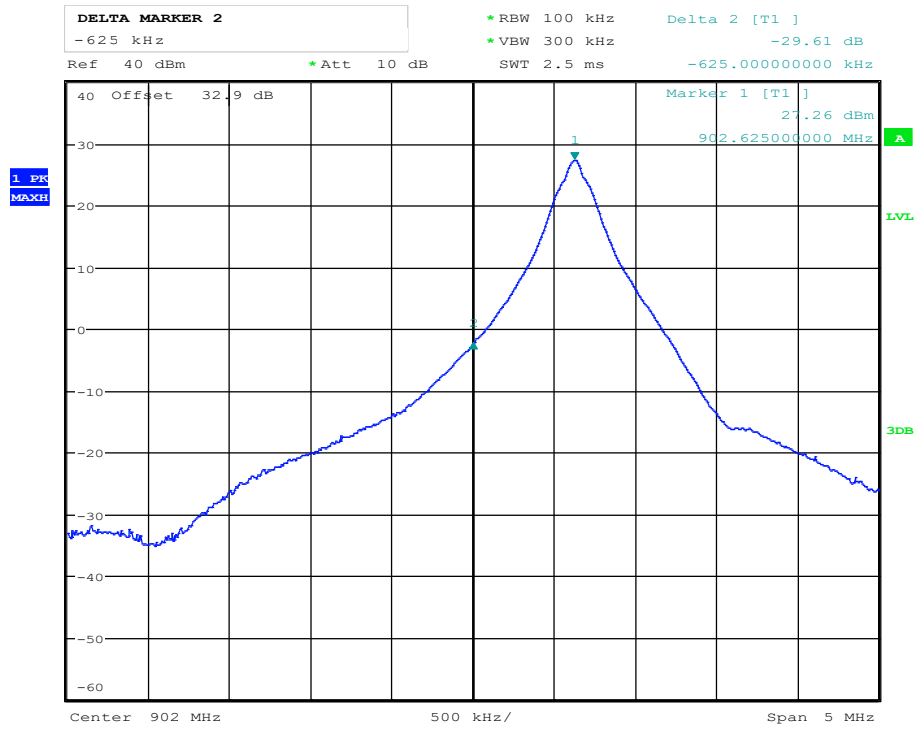
8.3.5 Measurement result:

Plot #	EUT operating mode	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
1	BPSK fixed channel	Lower, non-restricted	-29.61	-20	Pass
2	BPSK hopping	Lower, non-restricted	-28.99	-20	Pass
3	BPSK fixed channel	Upper, non-restricted	-22.55	-20	Pass
4	BPSK hopping	Upper, non-restricted	-22.15	-20	Pass

Plot #	EUT operating mode	Band Edge	Measured value	Corrected by duty cycle	Corrected by Antenna gain	Limit (dBm)	Result
5	BPSK fixed channel	Upper restricted peak	-36.81	NA due to peak detector	-34.71	-21.23 Peak	Pass
6	BPSK hopping	Upper restricted peak	-37.34	NA due to peak detector	-35.24	-21.23 Peak	Pass
7	BPSK fixed channel	Upper restricted average	-47.02	-47.02	-44.92	-41.23 AVG	Pass
8	BPSK hopping	Upper restricted average	-49.53	-49.53	-47.43	-41.23 AVG	Pass

8.3.6 Measurement Plots:

Plot #1 Lower Band Edge			
Low Band-edge	Hopping Disabled	Peak	BPSK



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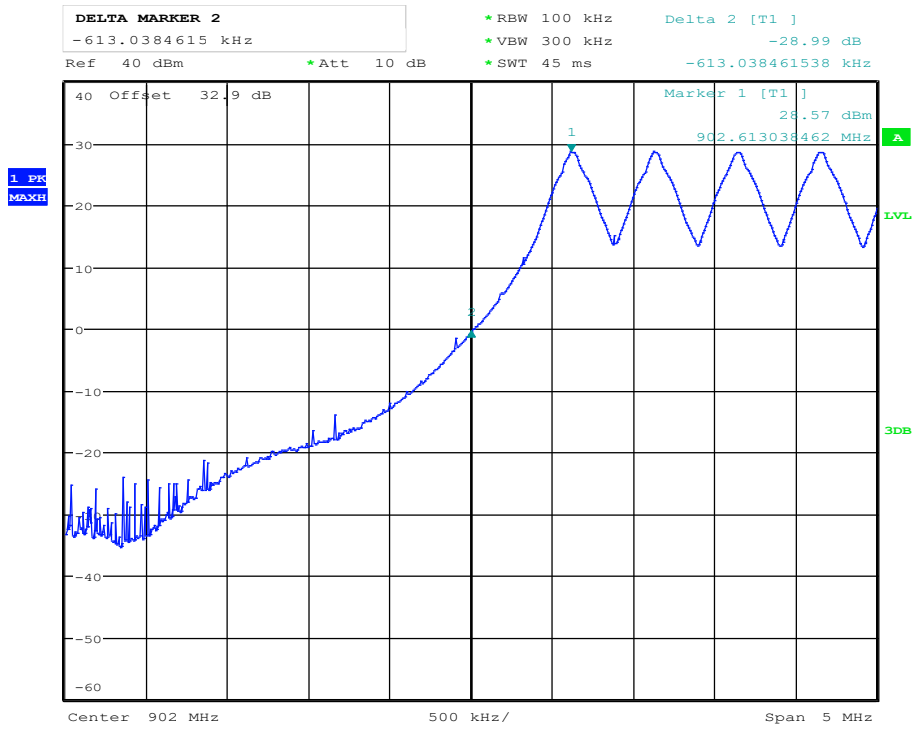
Plot #2 Lower Band Edge

Low Band-edge	Hopping	Peak	BPSK



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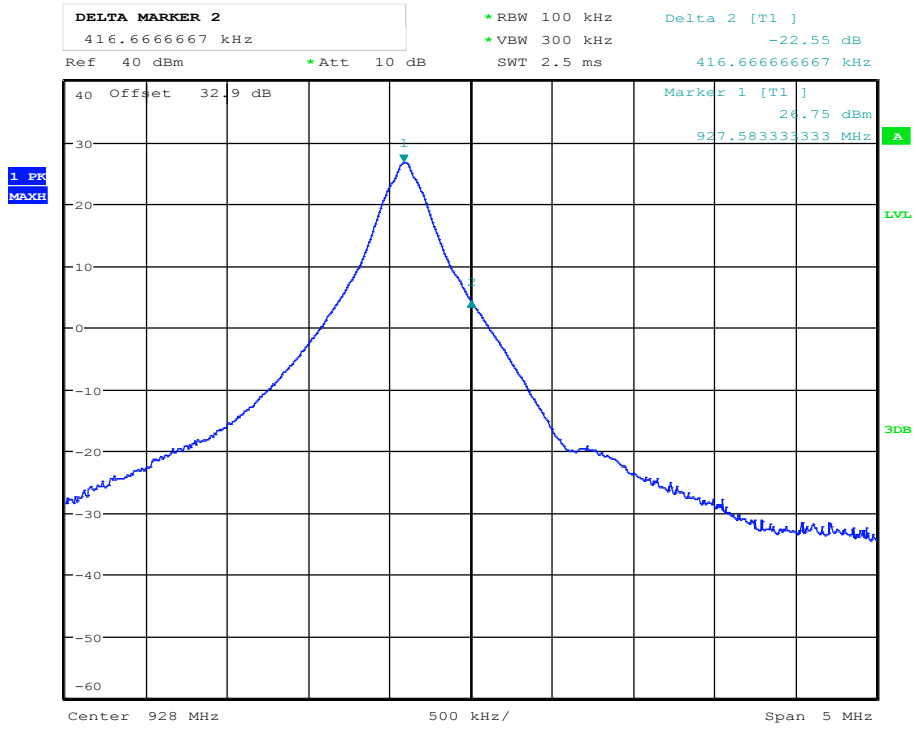
Plot #3 Upper Band Edge

Upper Band-edge	Hopping Disabled	Peak	BPSK



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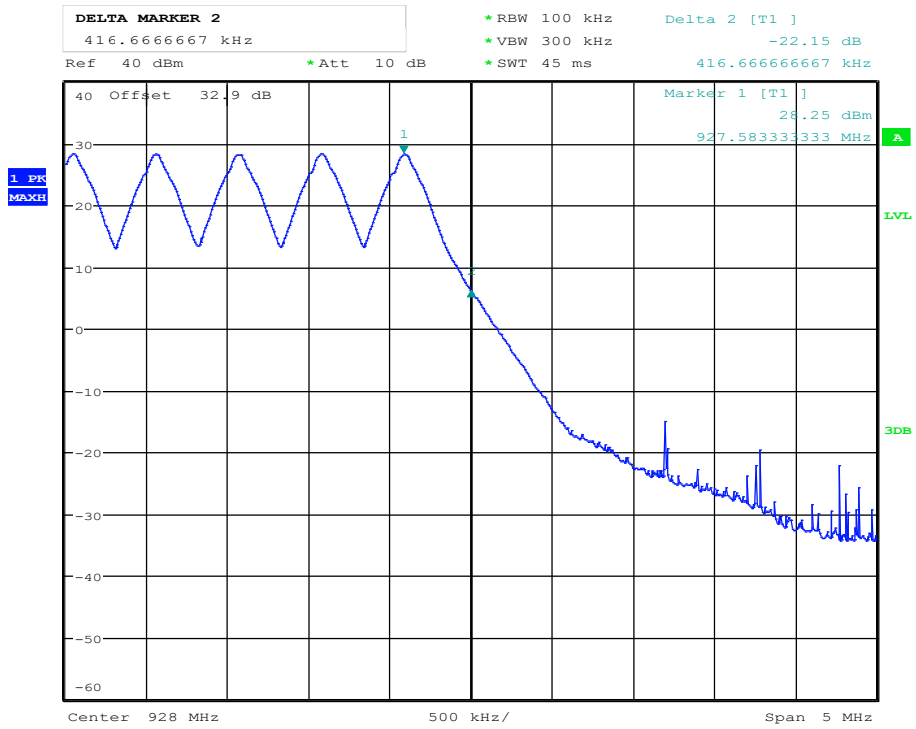
Plot #4 Upper Band Edge

Upper Band-edge	Hopping	Peak	BPSK



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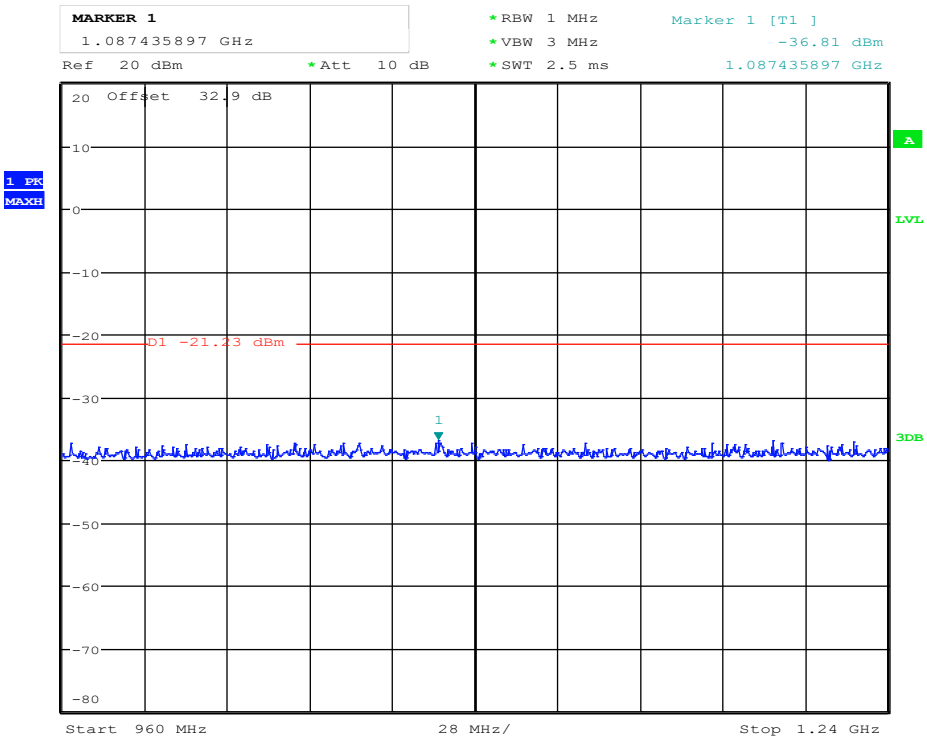
Plot #5 Upper Band Edge			
Upper Band-edge	**Hopping Disabled**	**Peak**	**BPSK**



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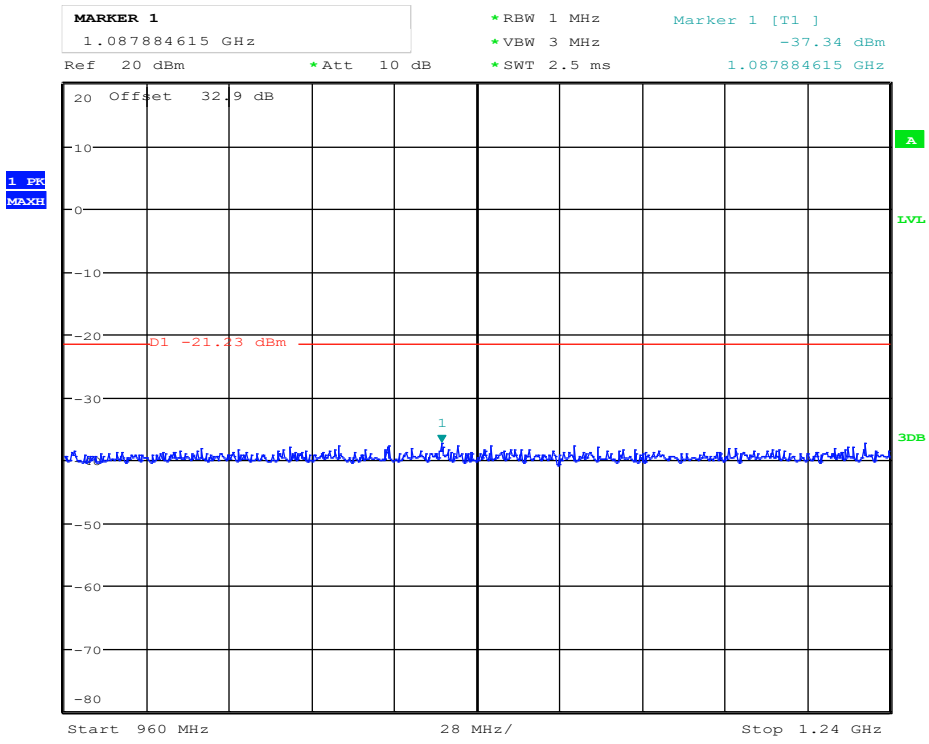
Plot #6 Upper Band Edge

Upper Band-edge	Hopping	Peak	BPSK



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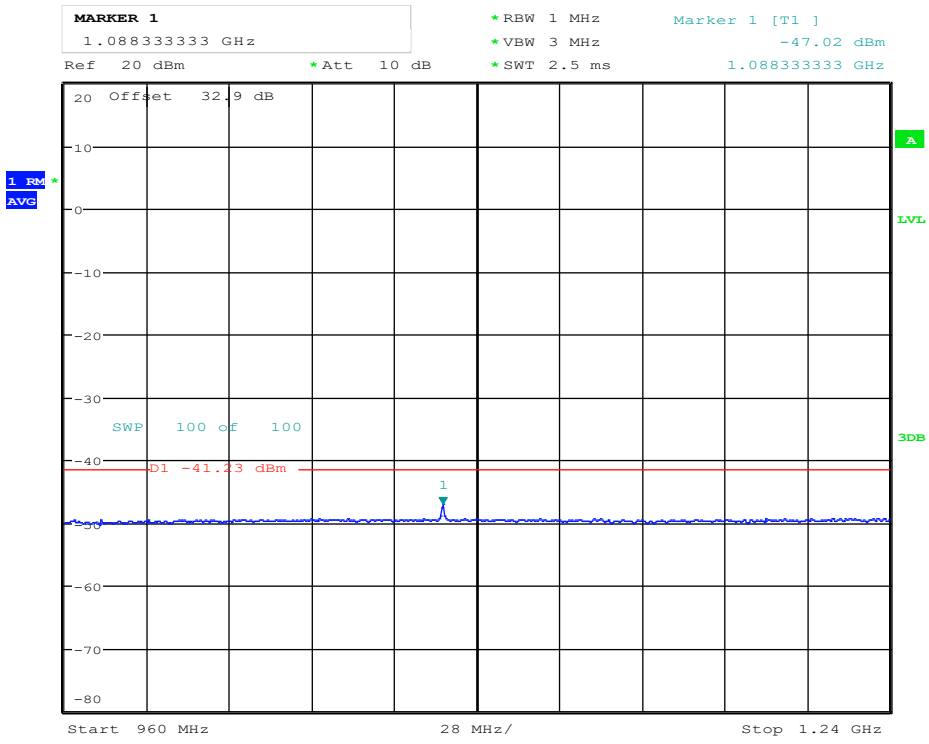
Plot #7 Upper Band Edge			
Upper Band-edge	**Hopping Disabled**	**AVG**	**BPSK**



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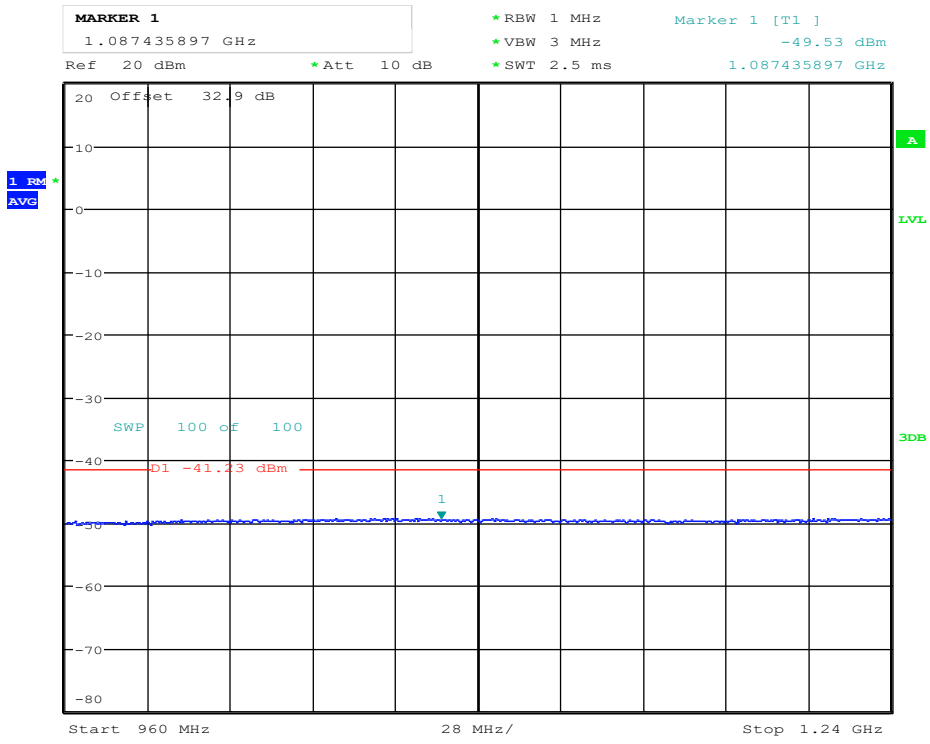
Plot #8 Upper Band Edge

Upper Band-edge	Hopping	AVG	BPSK



low

Date: 4.NOV.2021 15:09:37

8.4 20dB Bandwidth

8.4.1 Measurement according to ANSI C63.10 Section 6.9.2

Spectrum Analyzer settings:

- Span: approximately 2 to 5 times the 20 dB bandwidth, centered on the hopping channel
- RBW = 1% to 5% of the 20 dB bandwidth
- VBW = 3 x RBW
- Sweep Time = Auto couple
- Detector = Peak
- Trace = Max hold

8.4.2 Limits: FCC §15.247(a)(1), RSS-247 5.1(b)

FCC §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.

RSS-247 5.1(c):
For FHSs in the band 902-928 MHz: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels and the average time of occupancy on any channel 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 channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 10-second period. The maximum 20 dB bandwidth of the hopping channel shall be 500 kHz.

8.4.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22° C	2	BPSK	110 VAC

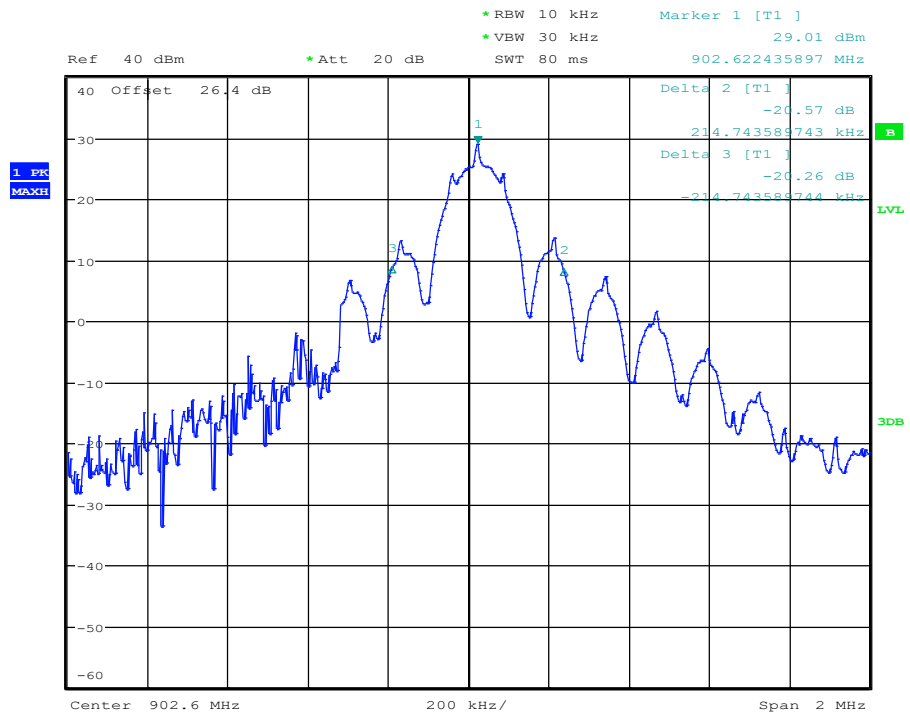
8.4.4 Measurement result:

Plot #	EUT operating mode	Channel	20 dB Bandwidth (MHz)
1	BPSK fixed channel	Low	0.429
2	BPSK fixed channel	Mid	0.420
3	BPSK fixed channel	High	0.426

8.4.5 Measurement Plots:

Plot #1 20dB Bandwidth

Ch Low / 902.6 MHz	Modulation: BPSK

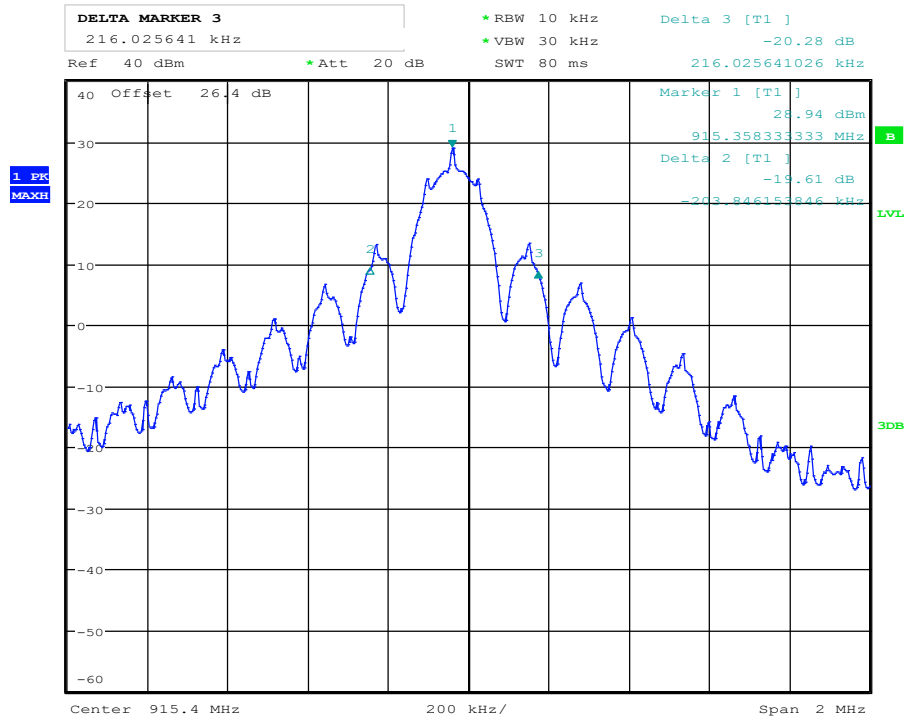


low

Date: 15.DEC.2021 13:13:29

Plot #2 20dB Bandwidth

Ch Mid / 915.4 MHz	Modulation: BPSK

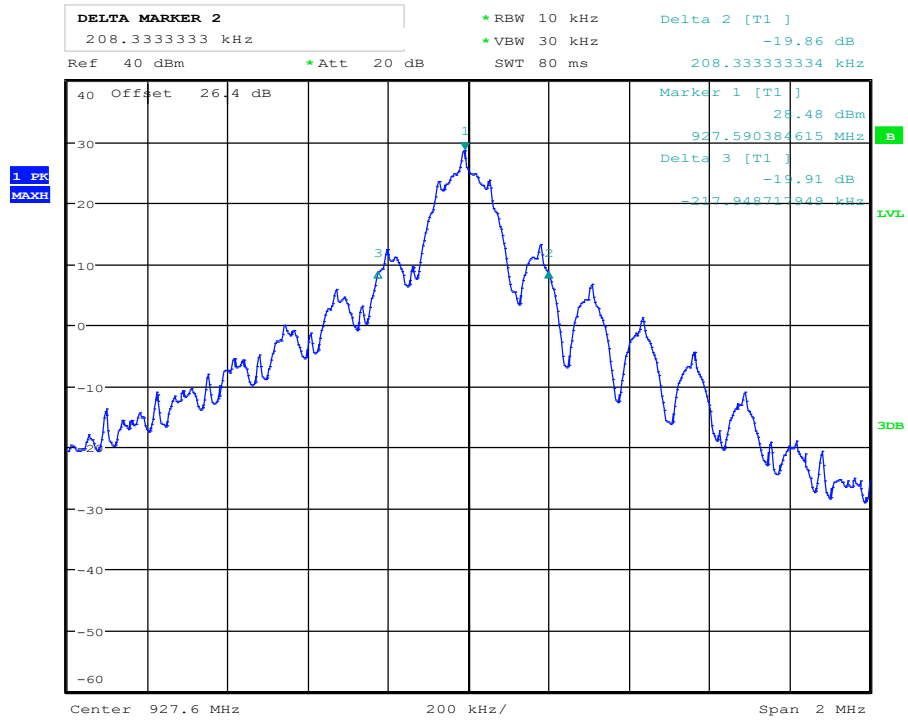


low

Date: 15.DEC.2021 13:18:48

Plot #3 20dB Bandwidth

Ch High / 927.6 MHz	Modulation: BPSK



low

Date: 15.DEC.2021 13:21:03

8.5 Carrier Frequency Separation

8.5.1 Measurement according to ANSI C63.10 Section 7.8.2

Spectrum Analyzer settings:

- Span = Wide enough to capture the peaks of the two adjacent channels
- RBW ≥ 1% of the span
- VBW ≥ RBW or 3 x
- Sweep = Auto couple
- Detector function = Peak
- Trace = Max hold
- Use marker-delta function to determine the separation between the peaks of the two adjacent channels.

8.5.2 Limits: FCC §15.247(a)(1) & RSS-247 5.1(b)

FCC §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.

RSS-247 5.1(c):
For FHSs in the band 902-928 MHz: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping channels and the average time of occupancy on any channel 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 channels and the average time of occupancy on any channel shall not be greater than 0.4 seconds within a 10-second period. The maximum 20 dB bandwidth of the hopping channel shall be 500 kHz.

8.5.3 Test conditions and setup:

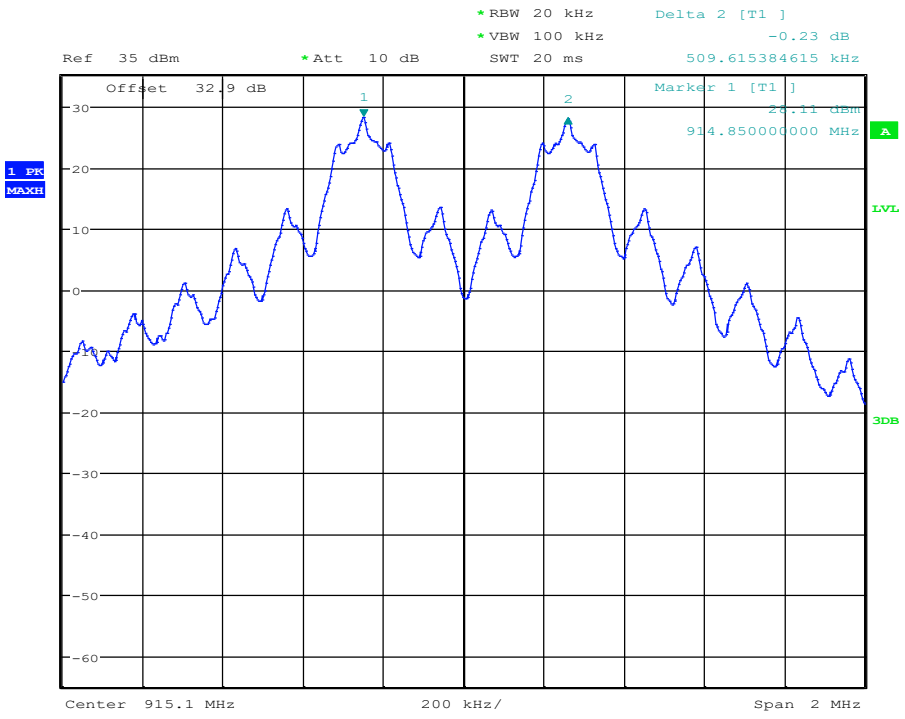
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	2	BPSK Hopping	110 VAC

8.5.4 Measurement result:

Plot #	Carrier Frequency Separation (MHz)	Limit (MHz)	Result
1	0.5096	> 2/3 * OBW = 0.286	Pass

8.5.5 Measurement Plots:

Plot # 1 Carrier Frequency Separation	
Modulation: BPSK	
Hopping On	Channel 18 & Channel 19



low

Date: 5.NOV.2021 09:14:20

8.6 Number of hopping channels

8.6.1 Measurement according to ANSI C63.10 Section 7.8.3

Spectrum Analyzer settings:

- Span = the entire frequency band of operation
- RBW ≥ 50 KHz
- VBW ≥ RBW or 3X
- Sweep = Auto couple
- Detector function = Peak
- Trace = Max hold

8.6.2 Limits: FCC §15.247(a)(1)(ii)(iii) & RSS-247 5.1(d)

At least 15 non-overlapping channels

8.6.3 Test conditions and setup:

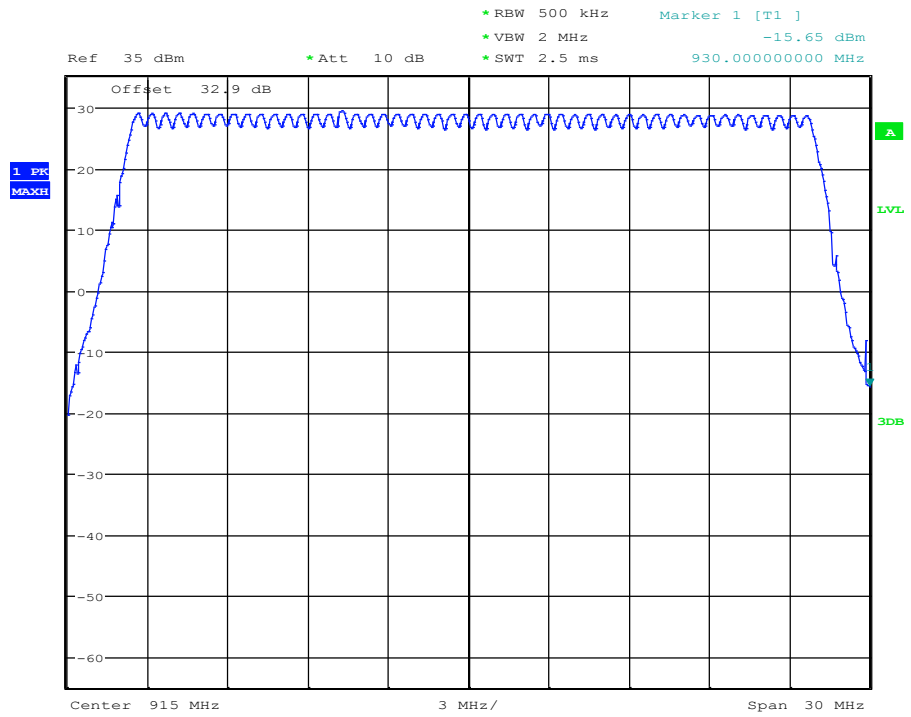
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	2	BPSK hopping	110 VAC

8.6.4 Measurement result:

Plot #	Number of Hopping Frequencies	Limit	Result
1	50	25 non-overlapping channels	Pass

8.6.5 Measurement Plots:

Plot # 1 Number of Hopping Frequencies	
Modulation: BPSK	
Hopping On	Total Hopping channels = 50



low

Date: 5.NOV.2021 09:03:53

8.7 Time of Occupancy (Dwell Time)

8.7.1 Measurement according to ANSI C63.10 Section 7.8.4

Spectrum Analyzer settings:

Duration of Pulse Measurement

- RBW = 1 MHz
- VBW = 3 MHz
- Span = Zero Span
- Sweep Time = 10 ms
- Sweep Mode = Single
- Detector =Peak
- Trigger = Video

Observation Period

- RBW = 1 MHz
- VBW = 3 MHz
- Span = Zero Span
- Sweep Time = 20 s
- Sweep Mode = Single
- Detector = Peak
- Trigger = Free Run

Observation Period = 0.4s x No. of hopping channels = 0.4 x 50 = 20 s

8.7.2 Limits: FCC §15.247(a)(1)(iii) & RSS-247 5.1(d)

FCC §15.247(a)(1)(i) & RSS-247:
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.

8.7.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	2	BPSK hopping	110 VAC

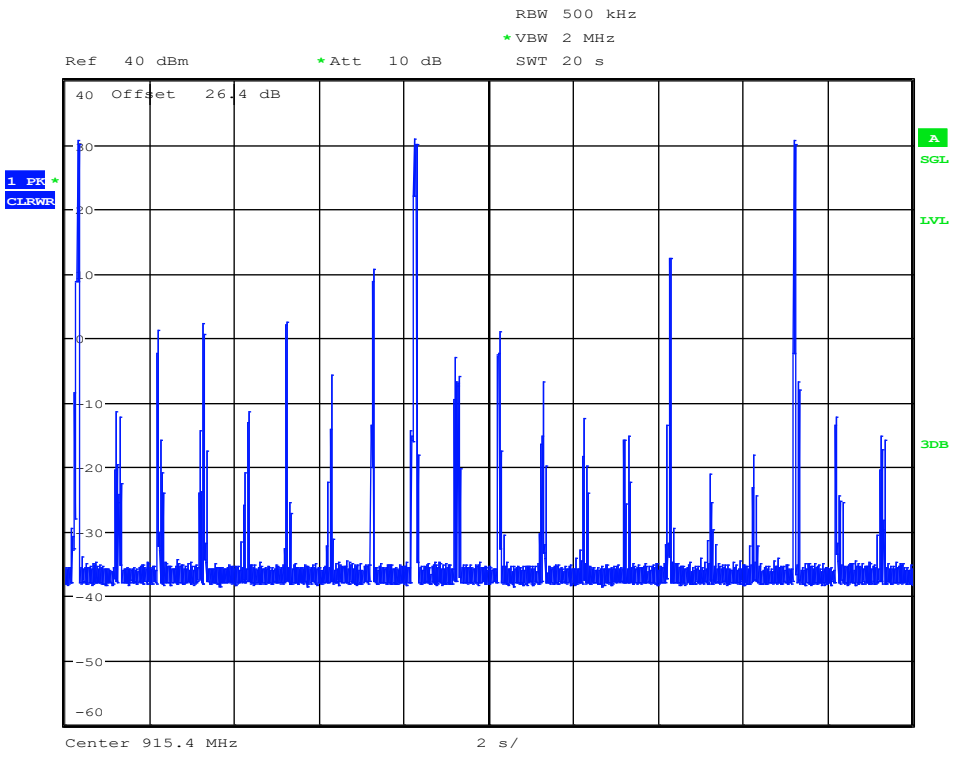
8.7.4 Measurement result:

Plot #	Modulation	Number of hops 20s	Pulse Width (ms)	Total Dwell Time in 20s (ms)	Limit (ms)	Result
1	BPSK	3	44	132	< 400 in 20000	Pass

8.7.5 Measurement Plots:

Plot #1 Transmission on Time in Observation Period (20s)

Modulation: BPSK

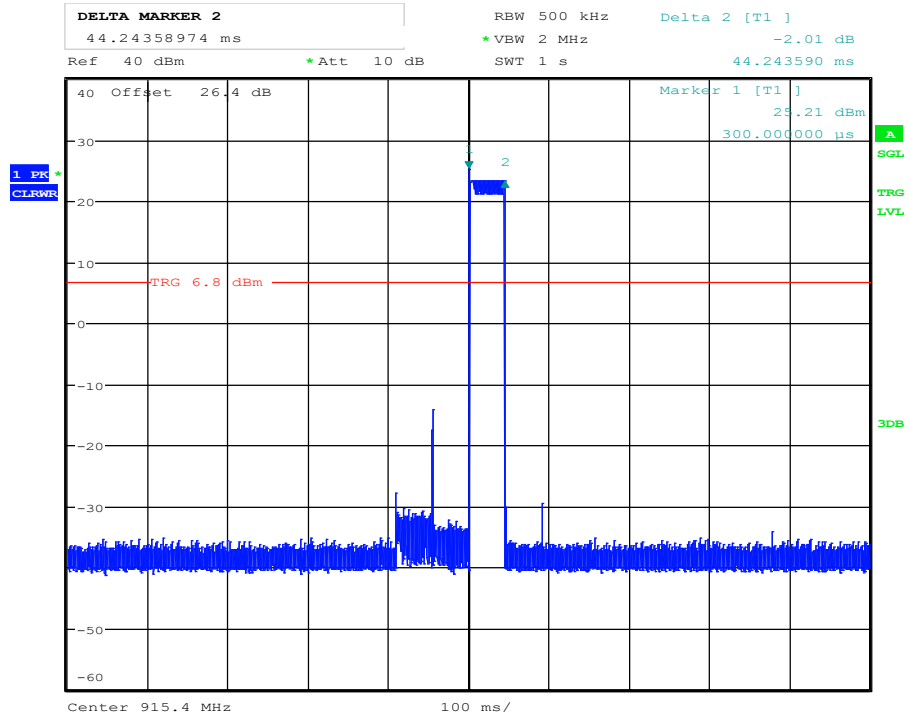


low

Date: 15.DEC.2021 14:30:41

Pulse Duration

Modulation: BPSK



low

Date: 15.DEC.2021 14:33:34

8.8 Transmitter Spurious Emissions and Restricted Bands

8.8.1 Measurement according to ANSI C63.10

Analyzer Settings:

- Frequency = 9 KHz – 30 MHz
- RBW = 9 KHz
- Detector = Peak

- Frequency = 30 MHz – 1 GHz
- Detector = Peak / Quasi-Peak
- RBW = 120 KHz (<1 GHz)

- Frequency > 1 GHz
- Detector = Peak / Average
- RBW = 1MHz

- Radiated spurious emissions shall be measured for the transmit frequencies, transmit power, and data rate for the lowest, middle and highest channel in each frequency band of operation and for the highest gain antenna for each antenna type, and using the appropriate parameters and test requirements.
- The highest (or worst-case) data rate shall be recorded for each measurement.
- For testing frequencies below 30 MHz at distance other than the specified in the standard, the limit conversion is calculated by using the FCC materials for the ANSI 63 committee issued on January, 27 1991.

8.8.2 Limits: FCC 15.247(d)/15.209(a) /RSS-Gen 6.13

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	2690-2900	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	Above 38.6
13.36-13.41			

- 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)).
- PEAK LIMIT= 74dB µV/m
- AVG. LIMIT= 54dB µV/m

- Except as shown in CFR 47 Part 15.205 paragraph (d), only spurious emissions are permitted in any of the frequency bands listed below

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/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

8.8.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23° C	1	BPSK fixed channel	110 VAC

8.8.4 Measurement result:

Plot #	Channel #	Scan Frequency	Limit	Result
1-3	Low	30 MHz – 18 GHz	See section 8.8.2	Pass
4-8	Mid	9 kHz – 26 GHz	See section 8.8.2	Pass
9-11	High	30 MHz – 18 GHz	See section 8.8.2	Pass

8.8.5 Measurement Plots:

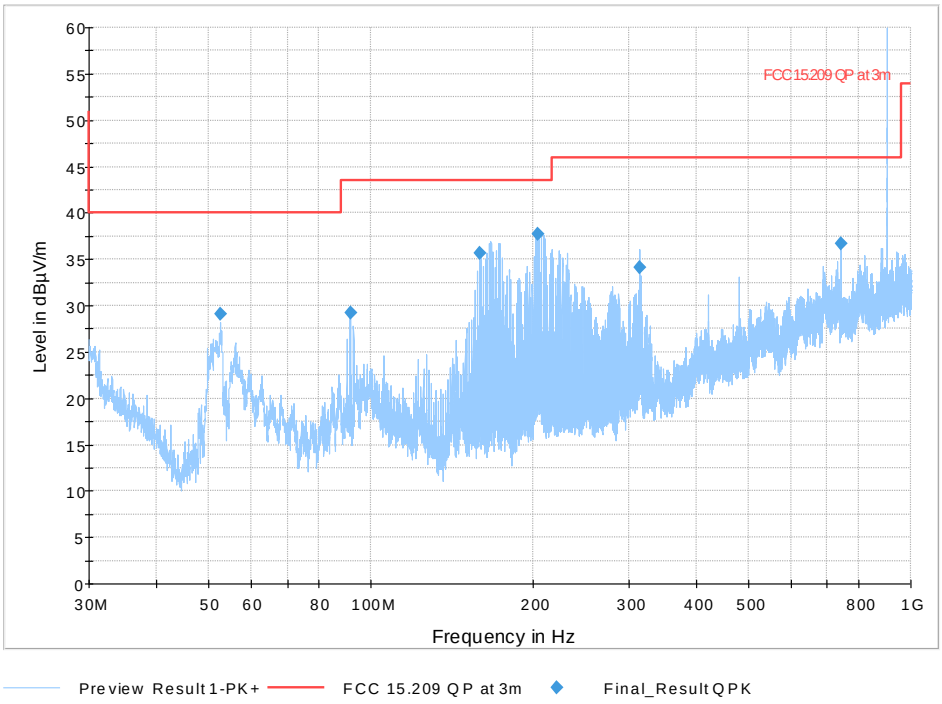
Plot #1 Radiated Emissions: 30 MHz – 1GHz

Modulation: BPSK	Channel: Low	100% Duty cycle

Disclaimer: Any measurement data within 2dB from the limit line is conditional PASS/FAIL due to measurement uncertainty considerations.

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
52.544	29.13	40.00	10.87	500.0	120.000	190.0	V	1.0	9.6	
91.430	29.28	43.50	14.22	500.0	120.000	190.0	V	159.0	12.2	
158.675	35.63	43.50	7.87	500.0	120.000	130.0	V	112.0	14.7	
203.088	37.68	43.50	5.82	500.0	120.000	214.0	V	111.0	15.1	
314.669	34.17	46.02	11.85	500.0	120.000	125.0	H	119.0	19.4	
742.136	36.70	46.02	9.32	500.0	120.000	125.0	H	-36.0	28.6	

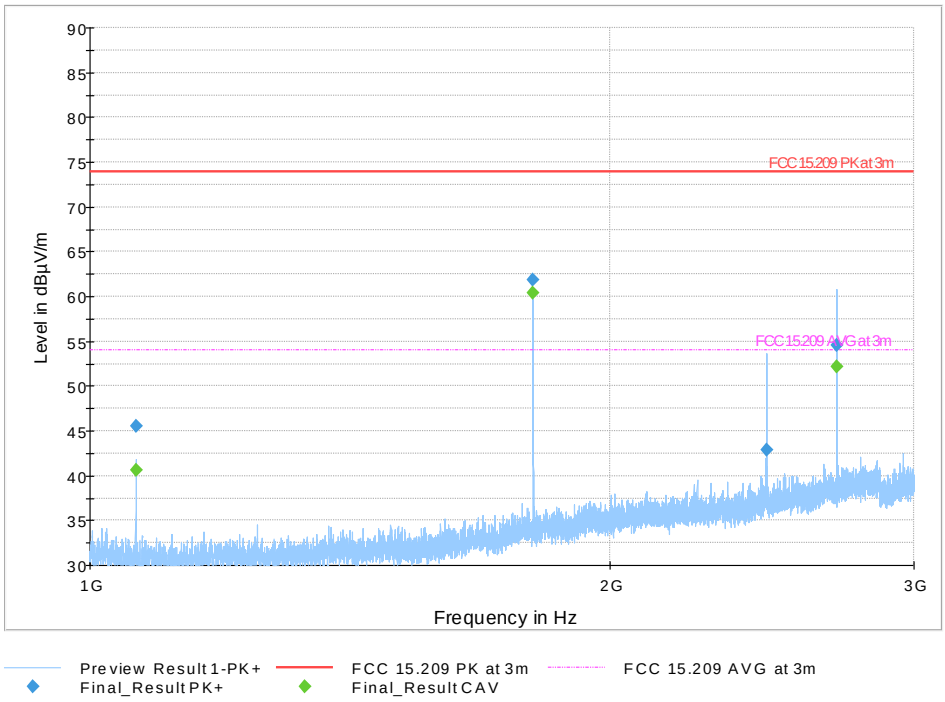


Plot # 2 Radiated Emissions: 1-3 GHz		
Modulation: BPSK	**Channel: Low**	**100% Duty cycle**

Disclaimer: Any measurement data within 2dB from the limit line is conditional PASS/FAIL due to measurement uncertainty considerations.

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
1063.243	45.47	---	73.98	28.51	500.0	1000.000	186.0	H	55.0	4.1	
1063.243	---	40.59	53.98	13.39	500.0	1000.000	186.0	H	55.0	4.1	
1805.386	---	60.45	53.98	-6.47	500.0	1000.000	242.0	H	216.0	6.6	
1805.386	61.88	---	73.98	12.10	500.0	1000.000	242.0	H	216.0	6.6	
2465.643	42.82	---	73.98	31.16	500.0	1000.000	304.0	H	289.0	9.4	
2465.643	---	29.64	53.98	24.34	500.0	1000.000	304.0	H	289.0	9.4	
2707.800	---	52.15	53.98	1.83	500.0	1000.000	138.0	H	73.0	10.5	
2707.800	54.53	---	73.98	19.45	500.0	1000.000	138.0	H	73.0	10.5	



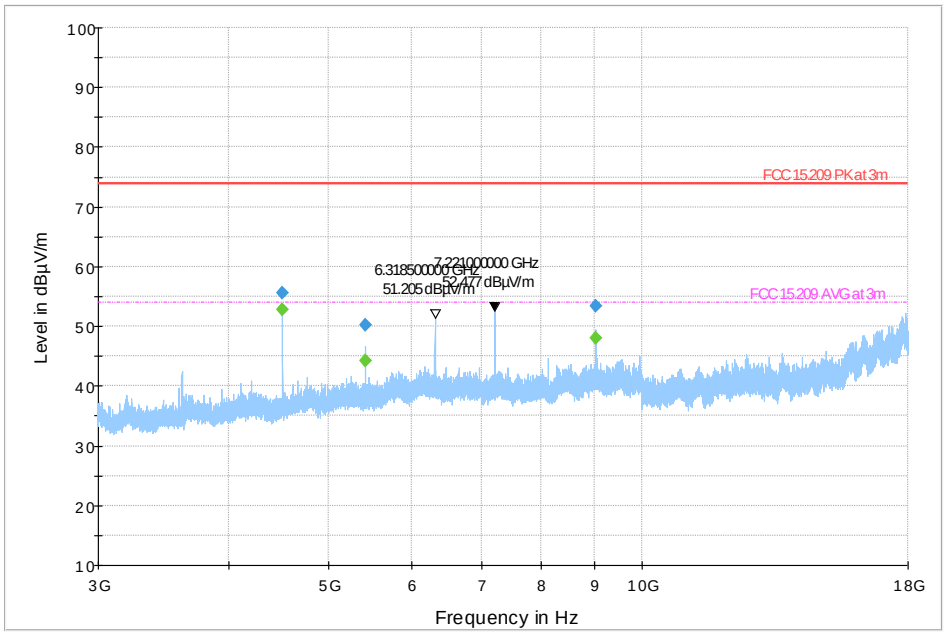
According to 15.209(a) /RSS-Gen 6.13, the emission at 1805.386MHz is out of restricted bands, so the result is pass.

Plot # 3 Radiated Emissions: 3-18 GHz		
Modulation: BPSK	**Channel: Low**	**100% Duty cycle**

Disclaimer: Any measurement data within 2dB from the limit line is conditional PASS/FAIL due to measurement uncertainty considerations.

Final_Result

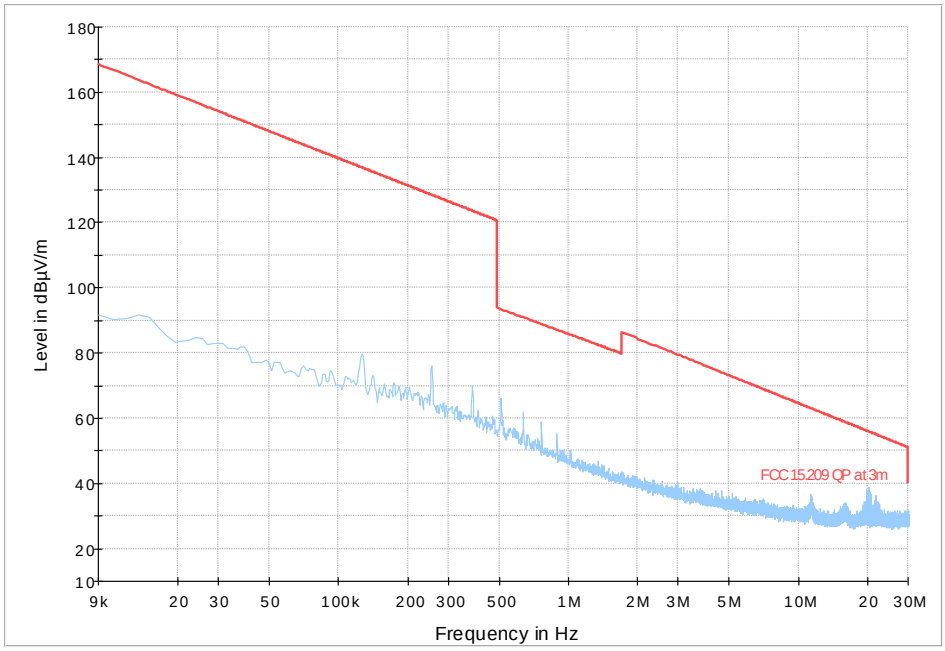
Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
4513.147	---	52.89	53.98	1.09	500.0	1000.000	218.0	H	200.0	-4.2	
4513.147	55.60	---	73.98	18.38	500.0	1000.000	218.0	H	200.0	-4.2	
5415.767	50.27	---	73.98	23.71	500.0	1000.000	130.0	V	345.0	-2.6	
5415.767	---	44.27	53.98	9.71	500.0	1000.000	130.0	V	345.0	-2.6	
9026.329	53.42	---	73.98	20.56	500.0	1000.000	125.0	H	202.0	3.3	
9026.329	---	47.94	53.98	6.04	500.0	1000.000	125.0	H	202.0	3.3	



According to 15.209(a) /RSS-Gen 6.13, the emissions at 6.3185GHz and 7.221GHz is out of restricted bands, so the result is pass.

Plot # 4 Radiated Emissions: 9 KHz - 30 MHz		
Modulation: BPSK	**Channel: Mid**	**100% Duty cycle**

Disclaimer: Any measurement data within 2dB from the limit line is conditional PASS/FAIL due to measurement uncertainty considerations.

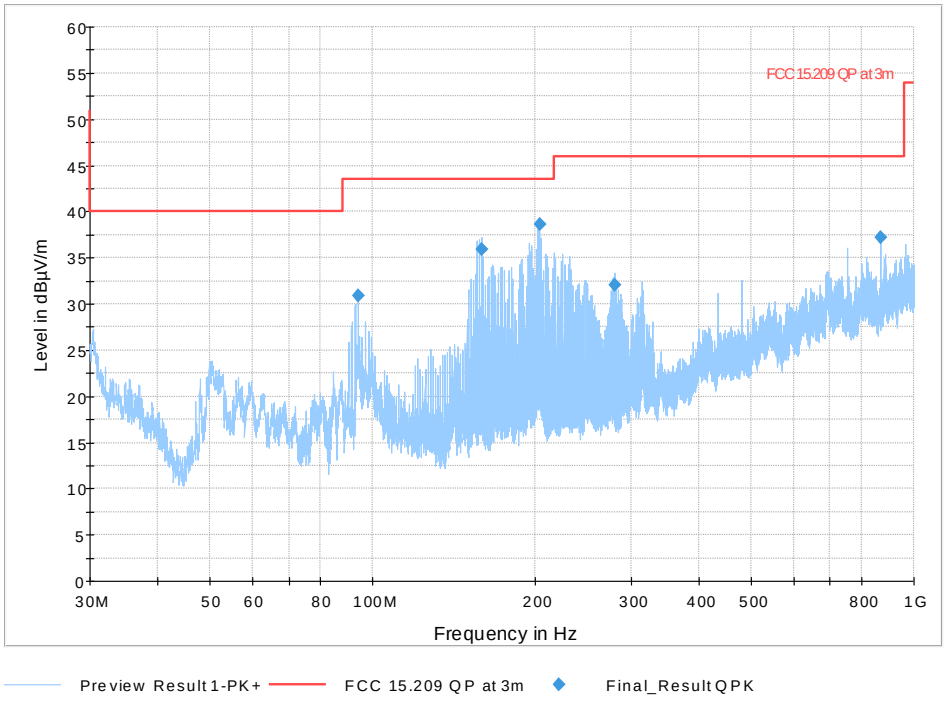


Plot #5 Radiated Emissions: 30 MHz – 1GHz		
Modulation: BPSK	**Channel: Mid**	**100% Duty cycle**

Disclaimer: Any measurement data within 2dB from the limit line is conditional PASS/FAIL due to measurement uncertainty considerations.

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
94.127	30.95	43.50	12.55	500.0	120.000	144.0	V	125.0	12.4	
158.681	35.95	43.50	7.55	500.0	120.000	130.0	V	96.0	14.7	
203.088	38.63	43.50	4.87	500.0	120.000	150.0	H	258.0	15.1	
279.712	32.11	46.02	13.91	500.0	120.000	137.0	H	264.0	17.7	
867.696	37.23	46.02	8.79	500.0	120.000	197.0	H	-17.0	29.1	

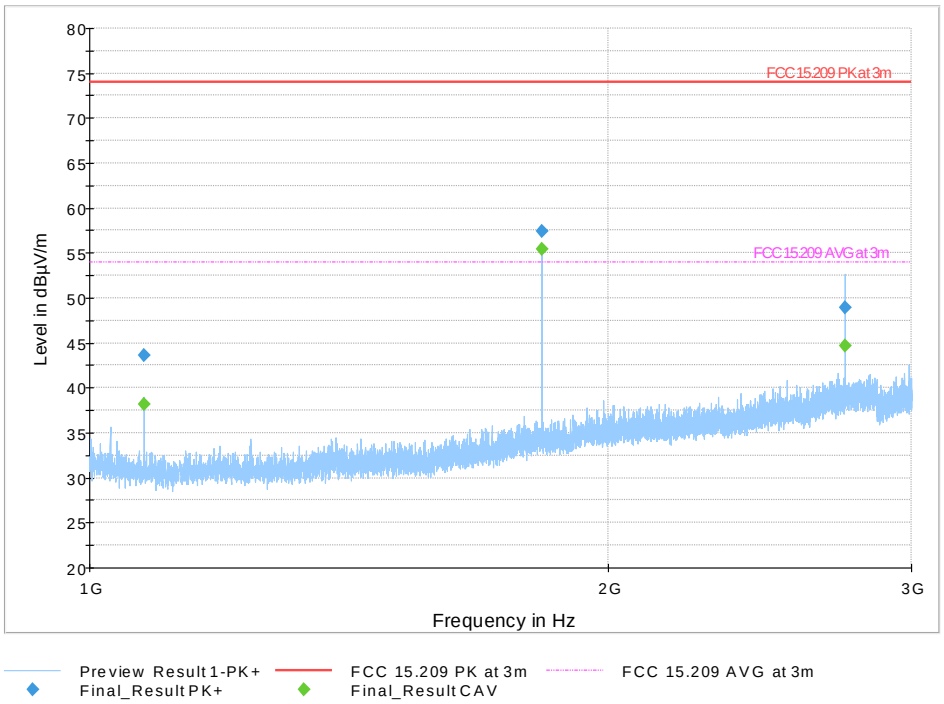


Plot #6 Radiated Emissions: 1-3 GHz		
Modulation: BPSK	**Channel: Mid**	**100% Duty cycle**

Disclaimer: Any measurement data within 2dB from the limit line is conditional PASS/FAIL due to measurement uncertainty considerations.

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
1075.957	---	38.15	53.98	15.83	500.0	1000.000	138.0	H	54.0	4.0	
1075.957	43.56	---	73.98	30.42	500.0	1000.000	138.0	H	54.0	4.0	
1830.657	57.45	---	73.98	16.53	500.0	1000.000	138.0	H	215.0	6.8	
1830.657	---	55.39	53.98	-1.41	500.0	1000.000	138.0	H	215.0	6.8	
2746.086	48.93	---	73.98	25.05	500.0	1000.000	215.0	H	200.0	11.0	
2746.086	---	44.67	53.98	9.31	500.0	1000.000	215.0	H	200.0	11.0	



According to 15.209(a) /RSS-Gen 6.13, the emission at 1830.657MHz is out of restricted bands, so the result is pass.

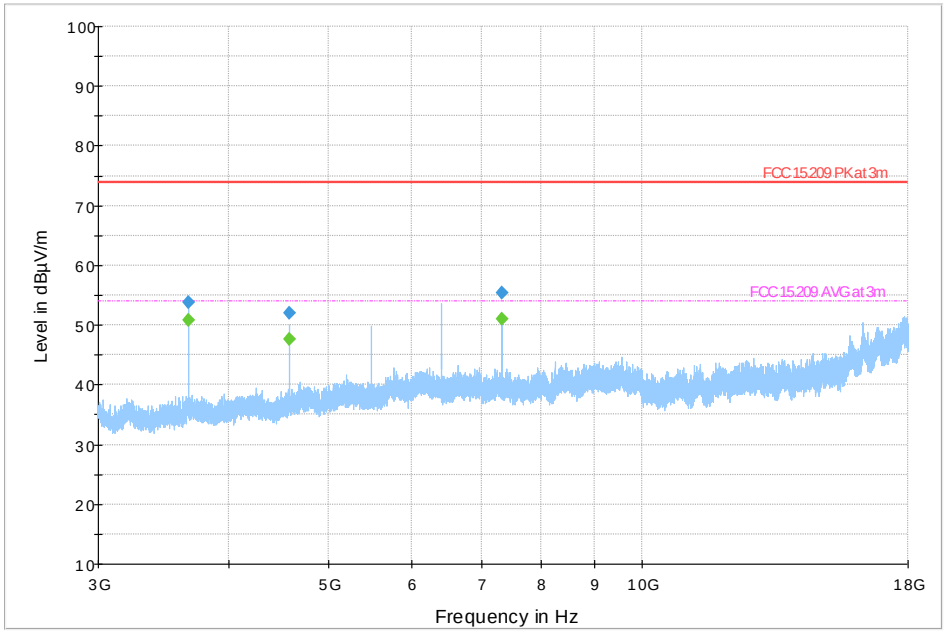
Plot #7 Radiated Emissions: 3-18 GHz

Modulation: BPSK	Channel: Mid	100% Duty cycle

Disclaimer: Any measurement data within 2dB from the limit line is conditional PASS/FAIL due to measurement uncertainty considerations.

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
3661.412	---	50.91	53.98	3.07	500.0	1000.000	125.0	H	140.0	-5.8	
3661.412	53.75	---	73.98	20.22	500.0	1000.000	125.0	H	140.0	-5.8	
4576.768	---	47.56	53.98	6.42	500.0	1000.000	208.0	H	197.0	-3.7	
4576.768	51.94	---	73.98	22.04	500.0	1000.000	208.0	H	197.0	-3.7	
7322.940	---	50.94	53.98	3.04	500.0	1000.000	138.0	H	155.0	1.3	
7322.940	55.30	---	73.98	18.68	500.0	1000.000	138.0	H	155.0	1.3	



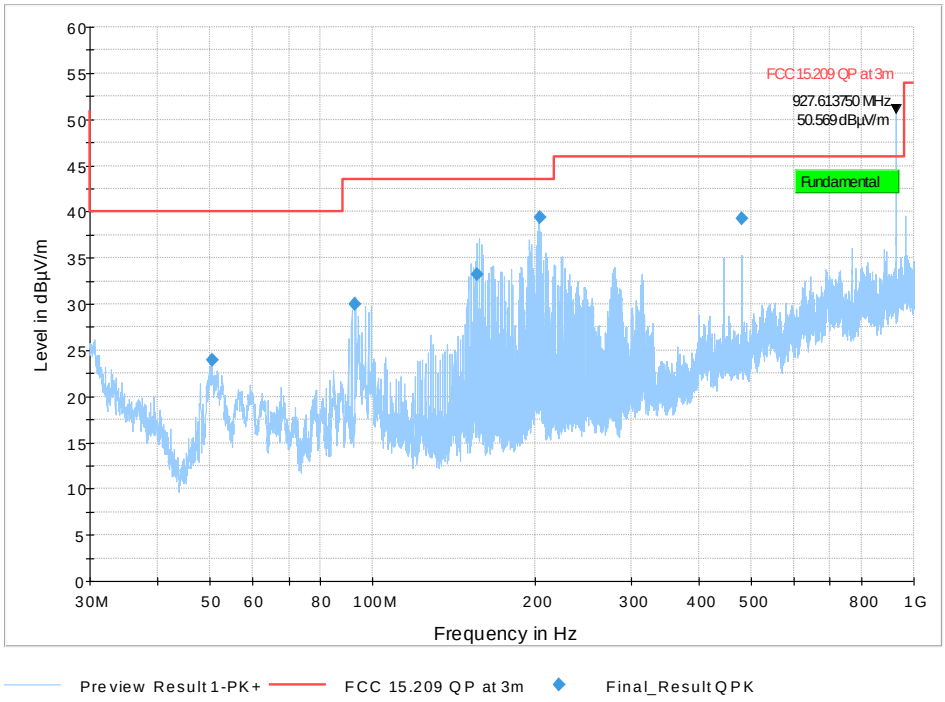
Plot #8 Radiated Emissions: 30 MHz – 1GHz

Modulation: BPSK	Channel: High	100% Duty cycle

Disclaimer: Any measurement data within 2dB from the limit line is conditional PASS/FAIL due to measurement uncertainty considerations.

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
50.396	24.01	40.00	15.99	500.0	120.000	155.0	V	276.0	10.1	
92.793	30.06	43.50	13.44	500.0	120.000	142.0	V	133.0	12.3	
155.929	33.24	43.50	10.26	500.0	120.000	130.0	V	121.0	14.7	
203.088	39.41	43.50	4.09	500.0	120.000	177.0	H	262.0	15.1	
481.527	39.32	46.02	6.70	500.0	120.000	246.0	H	303.0	23.5	

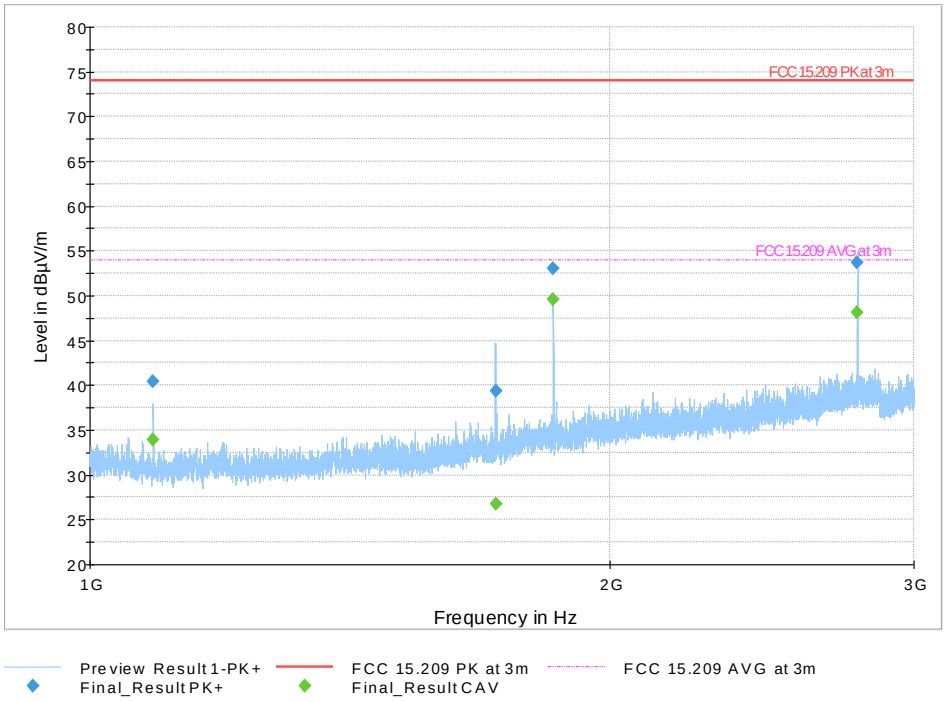


Plot # 9 Radiated Emissions: 1-3 GHz and Restricted Bands		
Modulation: BPSK	**Channel: High**	**100% Duty cycle**

Disclaimer: Any measurement data within 2dB from the limit line is conditional PASS/FAIL due to measurement uncertainty considerations.

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
1088.100	---	33.96	53.98	20.02	500.0	1000.000	143.0	V	118.0	3.1	
1088.100	40.44	---	73.98	33.54	500.0	1000.000	143.0	V	118.0	3.1	
1717.400	---	26.76	53.98	27.22	500.0	1000.000	129.0	V	175.0	5.8	
1717.400	39.38	---	73.98	34.60	500.0	1000.000	129.0	V	175.0	5.8	
1855.086	53.08	---	73.98	20.90	500.0	1000.000	197.0	H	214.0	6.9	
1855.086	---	49.67	53.98	4.31	500.0	1000.000	197.0	H	214.0	6.9	
2782.657	53.78	---	73.98	20.20	500.0	1000.000	197.0	H	186.0	11.0	
2782.657	---	48.18	53.98	5.80	500.0	1000.000	197.0	H	186.0	11.0	



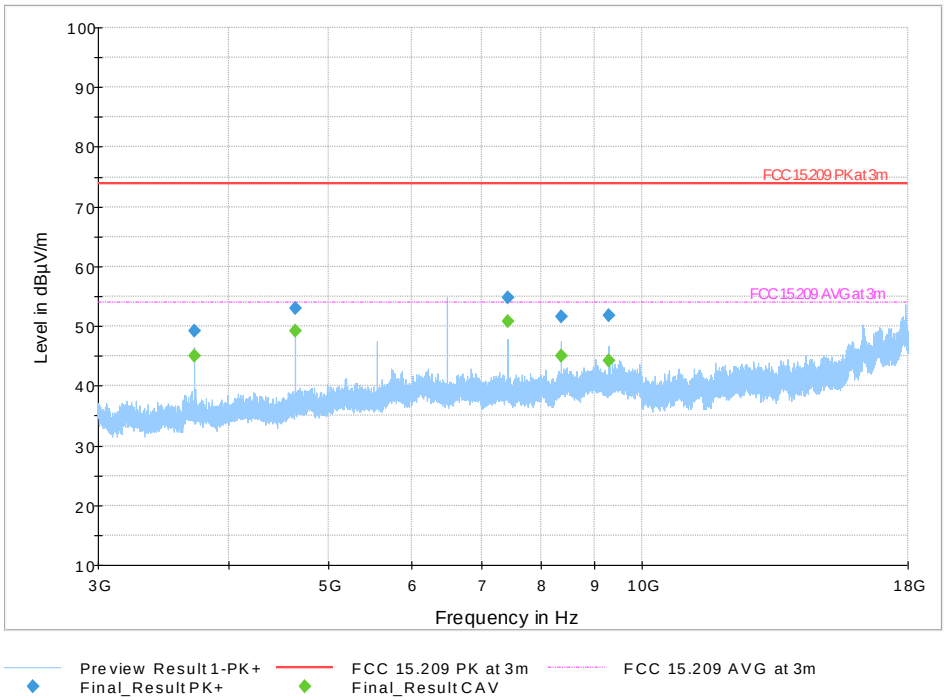
Plot #10 Radiated Emissions: 3-18 GHz

Modulation: BPSK	Channel: High	100% Duty cycle

Disclaimer: Any measurement data within 2dB from the limit line is conditional PASS/FAIL due to measurement uncertainty considerations.

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
3710.473	49.27	---	73.98	24.71	500.0	1000.000	240.0	H	143.0	-5.6	
3710.473	---	45.04	53.98	8.94	500.0	1000.000	240.0	H	143.0	-5.6	
4638.018	52.99	---	73.98	20.99	500.0	1000.000	125.0	H	133.0	-3.4	
4638.018	---	49.29	53.98	4.69	500.0	1000.000	125.0	H	133.0	-3.4	
7420.640	54.83	---	73.98	19.15	500.0	1000.000	125.0	H	217.0	1.5	
7420.640	---	50.73	53.98	3.25	500.0	1000.000	125.0	H	217.0	1.5	
8348.283	---	45.08	53.98	8.89	500.0	1000.000	125.0	H	151.0	2.8	
8348.283	51.67	---	73.98	22.31	500.0	1000.000	125.0	H	151.0	2.8	
9275.915	51.89	---	73.98	22.09	500.0	1000.000	196.0	H	155.0	3.0	
9275.915	---	44.29	53.98	9.69	500.0	1000.000	196.0	H	155.0	3.0	



8.9 AC Power Line Conducted Emissions

8.9.1 Measurement according to ANSI C63.4

Analyzer Settings:

- RBW = 9 KHz (CISPR Bandwidth)
- Pre-scan Detector = Peak / Average for
- Final Measurements Detector = Quasi-Peak / Average

8.9.2 Limits: FCC 15.207 & RSS-Gen 8.8

(a) Except as shown in paragraphs (b) and (c) of this section of the CFR, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table (1), as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between frequency ranges.

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

*Decreases with the logarithm of the frequency.

8.9.3 Test conditions and setup:

Ambient Temperature (C)	EUT Set-Up #	EUT operating mode	Power line (L1, L2, L3, N)	Power Input
22	1	BPSK continuous fixed channel	Line & Neutral	110 V / 60 Hz

8.9.4 Measurement Result:

Plot #	Port	EUT Set-Up #	EUT operating mode	Scan Frequency	Limit	Result
1	AC Mains	1	BPSK continuous fixed channel	150 kHz – 30 MHz	See section 8.9.2	Pass

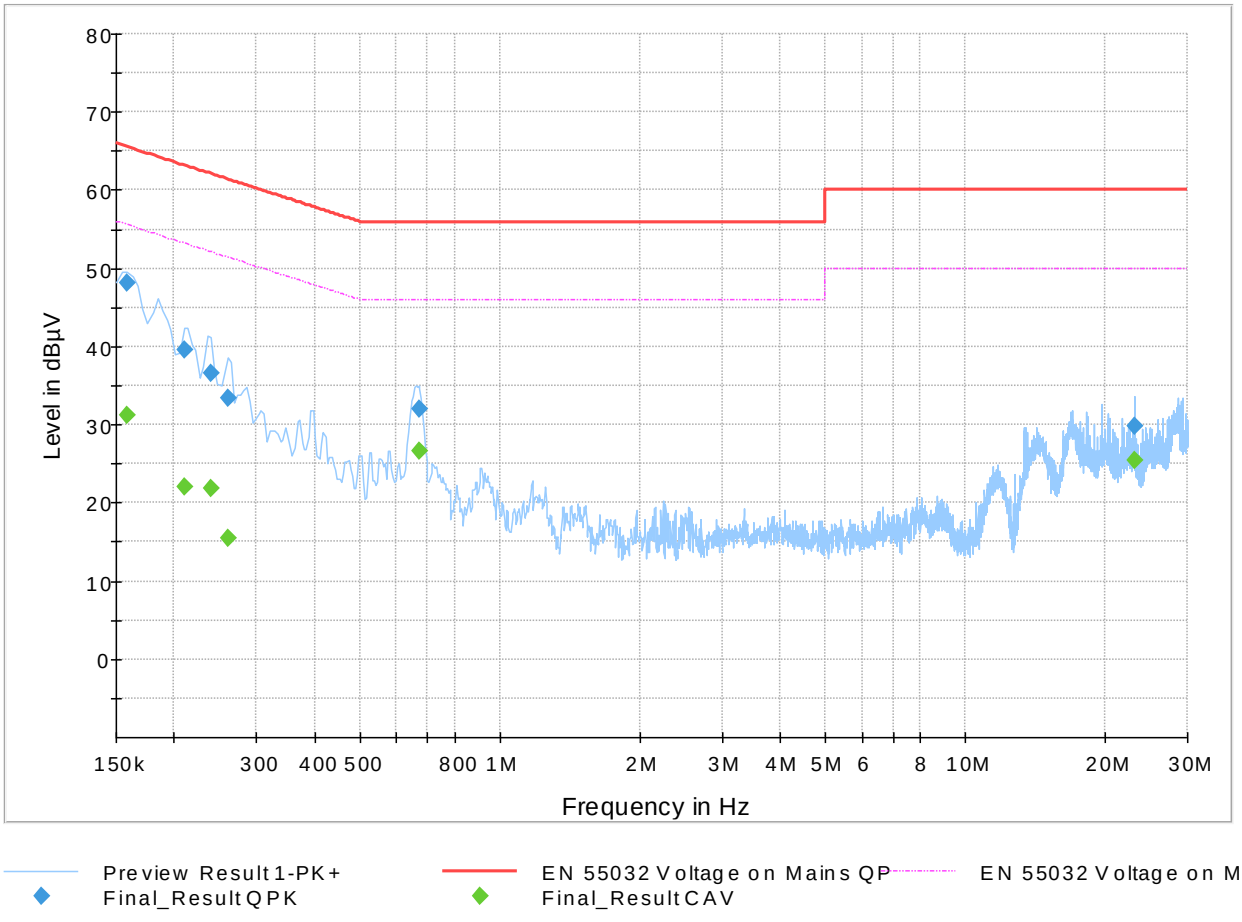
8.9.5 Measurement Plots:

Plot # 1

Disclaimer: Any measurement data within 2dB from the limit line is conditional PASS/FAIL due to measurement uncertainty considerations.

Final_Result

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)	Comment
0.159	---	31.23	55.54	24.31	500.0	9.000	N	GND	10.4	
0.159	48.16	---	65.54	17.38	500.0	9.000	N	GND	10.4	
0.210	---	22.05	53.22	31.17	500.0	9.000	N	GND	10.2	
0.210	39.58	---	63.22	23.63	500.0	9.000	N	GND	10.2	
0.240	---	21.88	52.11	30.23	500.0	9.000	N	GND	10.2	
0.240	36.69	---	62.11	25.43	500.0	9.000	N	GND	10.2	
0.261	---	15.49	51.40	35.92	500.0	9.000	N	GND	10.1	
0.261	33.49	---	61.40	27.91	500.0	9.000	N	GND	10.1	
0.670	---	26.56	46.00	19.44	500.0	9.000	N	GND	10.0	
0.670	32.03	---	56.00	23.97	500.0	9.000	N	GND	10.0	
23.130	---	25.49	50.00	24.51	500.0	9.000	N	GND	10.4	
23.130	29.78	---	60.00	30.22	500.0	9.000	N	GND	10.4	



9 Test setup photos

Setup photos are included in supporting file name: "EMC_TRIMB-141-21001_Setup_Photos.pdf"

10 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
ACTIVE LOOP ANTENNA	ETS LINDGREN	6507	00161344	2 YEARS	10/30/2020
BILOG ANTENNA	ETS.LINDGREN	3142E	00166067	2 YEARS	03/12/2020
HORN ANTENNA	EMCO	3115	00035114	2 YEARS	08/10/2020
HORN ANTENNA	ETS.LINDGREN	3117	00215984	2 YEARS	01/31/2021
HORN ANTENNA	ETS.LINDGREN	3116	00070497	2 YEARS	11/23/2020
SPECTRUM ANALYZER	R&S	FSU26	200065	2 YEARS	08/25/2021
SIGNAL ANALAYZER	R&S	FSV 40	101022	2 YEARS	09/15/2021
TEST RECEIVER	R&S	ESU40	100251	2 YEARS	09/13/2021
COMPACT DIGITAL BAROMETER	CONTROL COMPANY	10510-922	200236891	2 YEARS	04/13/2020
DIGITAL THRMOMETER	CONTROL COMPANY	36934-164	181230565	3 YEARS	01/10/2019
LINE IMPEDANCE STABILIZATION NETWORK	FCC	FCC-LISN-50-25-2-08	08014	2 YEARS	08/31/2021

Note: Equipment used meets the measurement uncertainty requirements as required per applicable standards for 95% confidence levels. Calibration due dates, unless defined specifically, falls on the last day of the month. Items indicated "N/A" for cal status either do not specifically require calibration or is internally characterized before use.

11 Revision History

Date	Template Revision	Changes to report	Prepared by
2021-12-16	EMC_TRIMB-141-21001_15.247_ISM_DSS	Initial Version	Yuchan Lu
2021-12-17	EMC_TRIMB-141-21001_15.247_ISM_DSS_R1	Page 48 of test report Note “the emission at 180.657MHz is out of restricted bands” changed to “1830.657 MHz”	Yuchan Lu
2021-12-22	EMC_TRIMB-141-21001_15.247_ISM_DSS_R2	Updated table data in section 8.7.4	Cheng Song

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