FCC / ISED Test Report

For:
Elster Solutions, LLC

Model:
NXCMR300

Product Description:
900MHz ISM radio, LTE Cat-M1 MODEM, gas & water metering metrology

FCC ID: QZC-NXCMR300
IC: 4577A-NXCMR300

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

REPORT #: EMC_HONEY_229_23001_FCC_15_247_Rev2

DATE: 2023-11-09

A2LA Accredited

IC recognized # 3462B

***CETECOM* Inc.**
411 Dixon Landing Road ◆ Milpitas, CA 95035 ◆ U.S.A.
Phone: + 1 (408) 586 6200 ◆ Fax: + 1 (408) 586 6299 ◆ E-mail: contact@cetecom.com ◆ http://www.cetecom.com
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 #
Elster Solutions, LLC	900MHz ISM radio, LTE Cat-M1 MODEM, gas & water metering metrology	NXCMR300

Responsible for Testing Laboratory:

Date	Section	Name	Signature
2023-11-09	Compliance	Arndt Stoecker (Director of Regulatory Services)	Arndt Stoecker Digitally signed by: Arndt Stoecker DN: CN = Arndt Stoecker email = arndt.stoecker@cetecom.com C = US O = CETECOM Inc Date: 2023.11.16 16:31:28 -08'00'

Responsible for the Report:

Date	Section	Name	Signature
2023-11-09	Compliance	Art Thammanavarat (Senior EMC Engineer)	art. thammanavarat@cetecom.com Digitally signed by: art. thammanavarat@cetecom.com DN: CN = art. thammanavarat@cetecom.com Date: 2023.11.09 18:48:40 -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:	Arndt Stoecker
Responsible Project Leader:	Cathy Palacios

2.2 Identification of the Client

Client's Name:	Elster Solutions, LLC
Street Address:	208 South Rogers Lane
City/Zip Code	Raleigh, NC 27610
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 (1)

Model No:	NXCMR300
HW Version :	1.0
SW Version :	1.0
FCC-ID :	QZC-NXCMR300
IC-ID:	4577A-NXCMR300
PMN:	NXCMR300
Product Description:	Provides metrology for gas and water meters, communicates metering data over LTE Cat-M1. 900MHz ISM radio used for initial setup/configuration, or walk-by metering in areas of poor cellular coverage.
Frequency Range / number of channels:	902 – 928 MHz, 25 channels frequency hopping Data rate: 35.5 kbps or 142.2 kbps
Radios included in device	**ISM:** • SiLabs EFR32FG28 SoC • FSK modulation • 25 channels frequency hopping
Other Radios included in the device:	Sequans GM02S
Antenna Information as declared:	Max Gain 1.5 dBi
Max. declared output Powers:	6.05 dBm
Power Supply/ Rated Operating Voltage Range:	3.2 VDC – 3.8 VDC
Operating Temperature Range	-40º to 85º C
Sample Revision	■Production Unit; ☐Pre-Production
EUT Dimensions	17.78 x 11.43 x 7.62 cm
Weight	544.31 grams
EUT Diameter	☒< 60 cm ☐ Other _____

Note 1: information provided by the customer.

3.2 EUT Sample details (1)

EUT #	Model Number	HW Version	SW Version	Notes/Comments
1	NXCMR300	1.0	1.0	

Note 1: information provided by the customer.

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number
1	NoteBook PC	RTL8821CE	ASUS	M9N0CX06484836F

3.4 Test Sample Configuration

EUT Set-up #	Combination of AE used for test set up	Comments
1	EUT#1	

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, and maximum possible duty cycle.

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 EUT was tested with transmitter sets on frequency hopping mode with 35.5 kbps data rate and FSK modulation.

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: QZC-NXCMR300
- IC ID: 4577A-NXCMR300

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)(2) RSS-247 5.4(a)	Maximum Peak Conducted Output Power	Nominal	FSK	■	☐	☐	Complies
§15.247(d) RSS-247 5.5 RSS-Gen 8.10	Band Edge Compliance	Nominal	FSK	■	☐	☐	Complies
§15.247(a)(1) RSS-247 5.1(c)	Spectrum Bandwidth	Nominal	FSK	■	☐	☐	Complies
§15.247(a)(1) RSS-247 5.1(c)	Carrier Frequency Separation	Nominal	FSK	■	☐	☐	Complies
§15.247(a)(1) RSS-247 5.1(c)	Number of Hopping Channels	Nominal	FSK	■	☐	☐	Complies
§15.247(a)(1) RSS-247 5.1(c)	Time of occupancy	Nominal	FSK	■	☐	☐	Complies
§15.247(d) §15.209 (a) RSS-Gen 6.13	TX Spurious emissions-Radiated	Nominal	FSK	■	☐	☐	Complies
§15.207(a) RSS-Gen 8.8	AC Conducted Emissions	Nominal	FSK	☐	☐	■	Note 2

Note 1: NA= Not Applicable; NP= Not Performed.
Note 2: EUT on battery power

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=2.

Radiated measurement

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

RF conducted measurement ±0.5 dB

According to TR 102 273 a multiplicative propagation of error is assumed for RF measurement systems. For this reason the RMS method is applied to dB values and not to linear values as appropriate for additive propagation of error. Also used: http://physics.nist.gov/cuu/Uncertainty/typeb.html. The above calculated uncertainties apply to direct application of the Substitution method. The Substitution method is always used when the EUT comes closer than 3dB to the limit.

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:

2023-03-17 – 2023-05-02

6.4 Decision Rule:

Cetecom advanced follows ILAC G8:2019 chapter 4.2.1 (Simple Acceptance Rule).

Only the measured values related to their corresponding limits will be used to decide whether the equipment under test meets the requirements of the test standards listed in chapter 3. The measurement uncertainty is mentioned in this test report, See chapter 9, but is not taken into account – neither to the limits nor to the measurement results. Measurement results with a smaller margin to the corresponding limits than the measurement uncertainty have a potential risk of more than 5% that the decision might be wrong.

7 Measurement Procedures

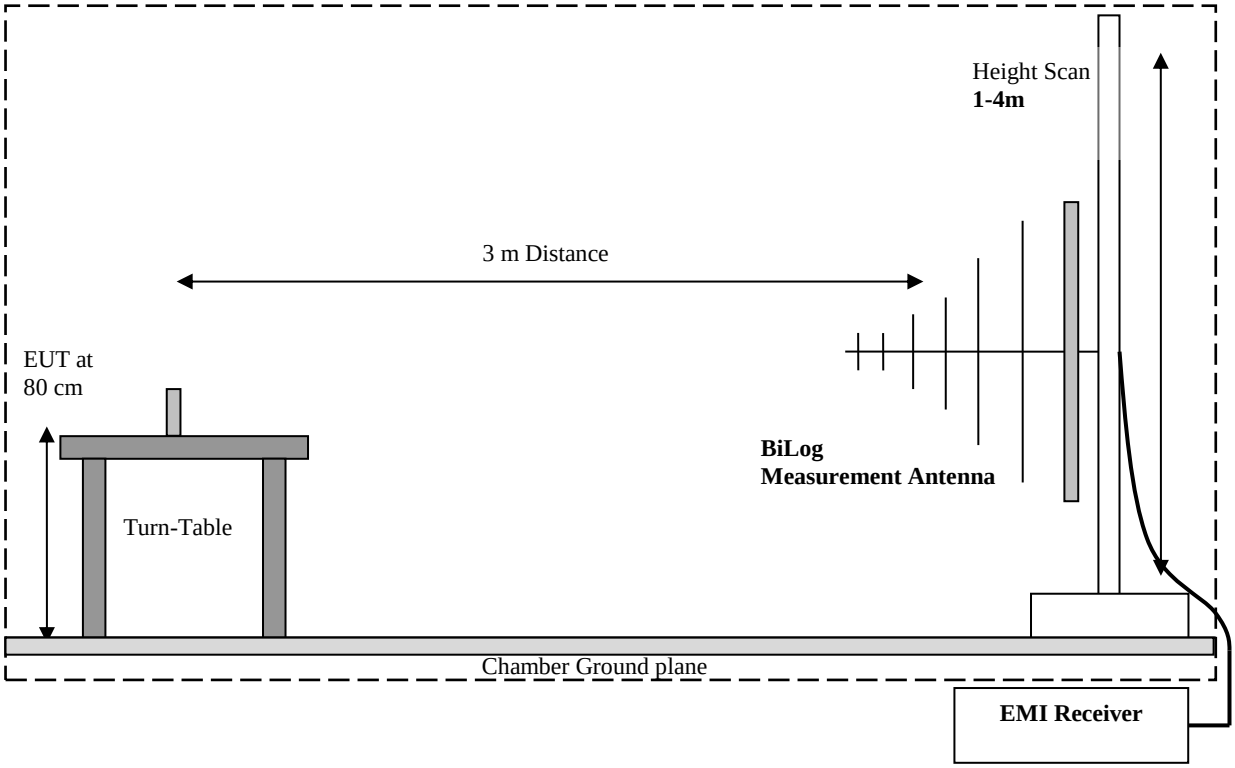
7.1 Radiated Measurement

Testing is performed according to the guidelines provided in 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

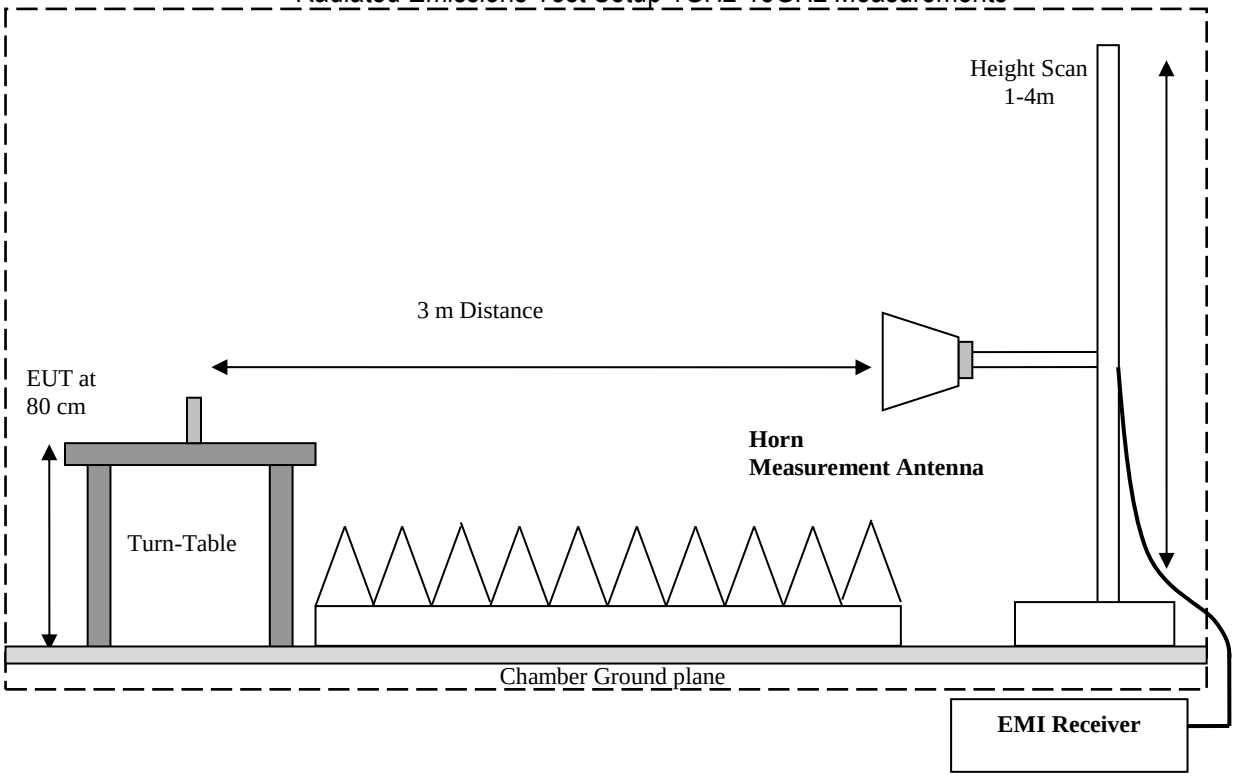
7.2 Radiated Measurement for EUT with diameter less than 60 cm

- 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.

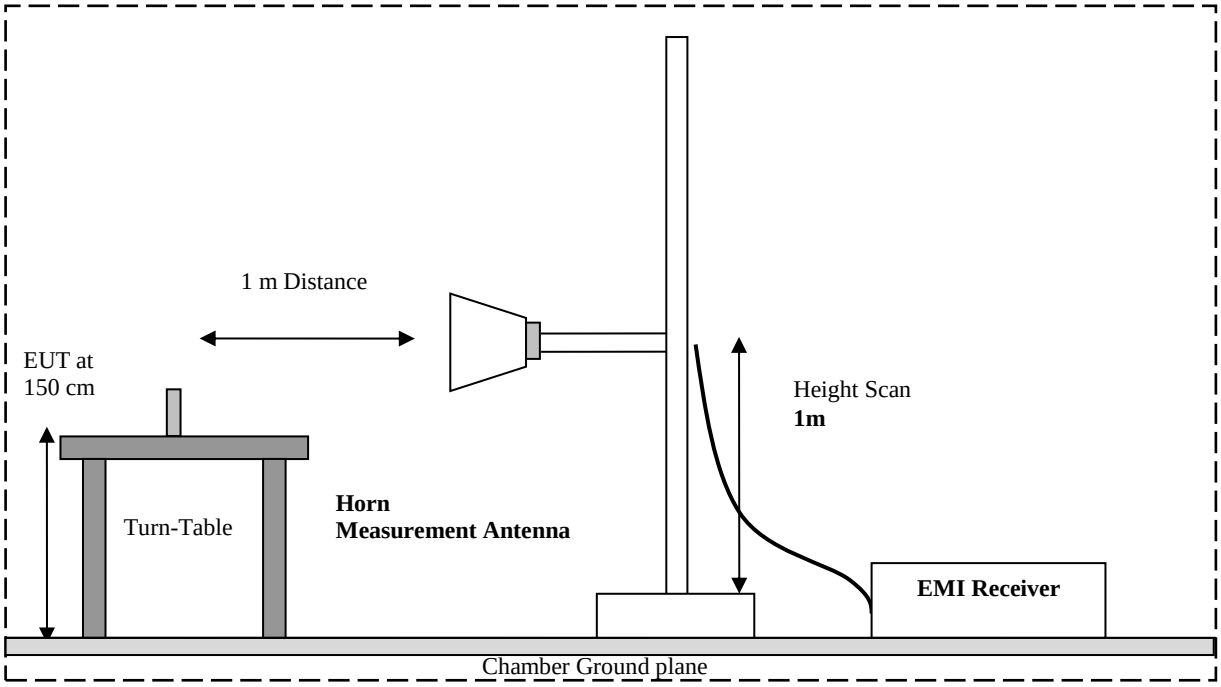
Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup 1GHz-18GHz Measurements



Radiated Emissions Test Setup 18GHz-40GHz Measurements



7.3 Sample Calculations for Field Strength Measurements

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

- Measured reading in dBµV
- Cable Loss between the receiving antenna and SA in dB and
- 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

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.

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:

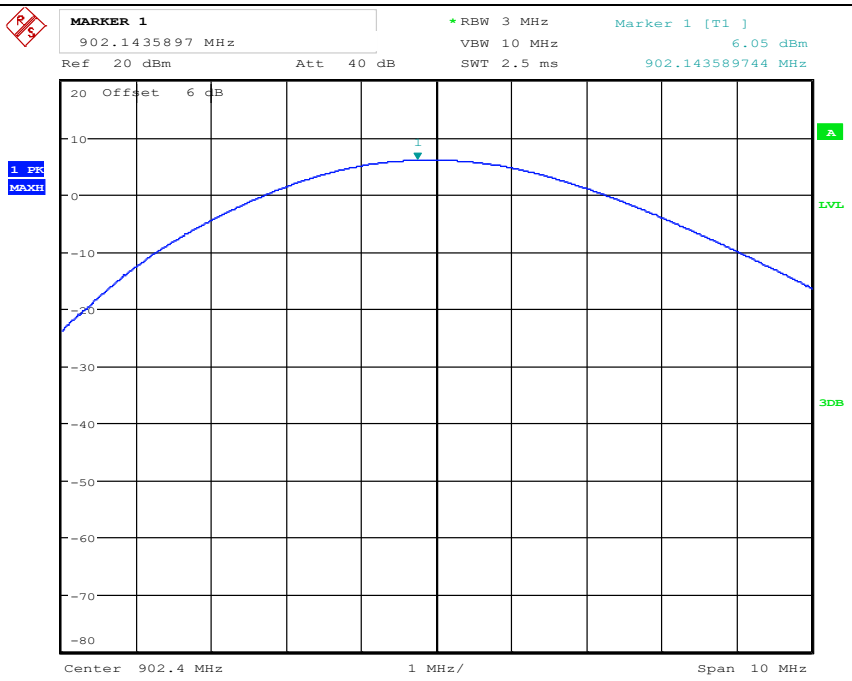
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23.8° C	1	Hopping	3.6 VDC	1.5 dBi

8.1.4 Measurement result:

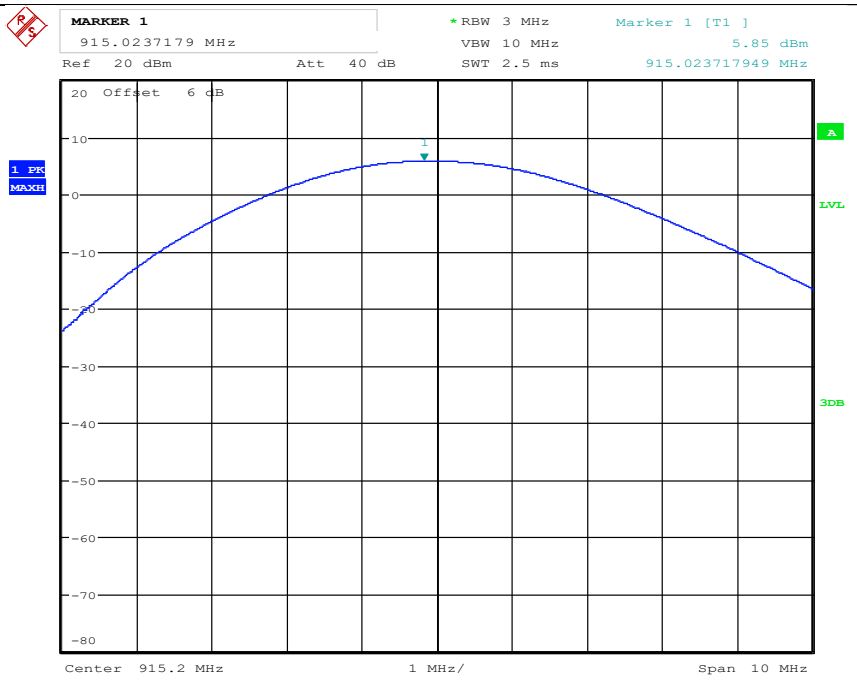
Plot #	Frequency (MHz)	EUT operating mode	Maximum Peak Conducted Output Power (dBm)	EIRP (dBm)	Limit (dBm)	Result
1	902.4	FSK	6.05	7.55	24(Pk) / 30(EIRP)	Pass
2	915.2	FSK	5.85	7.35	24(Pk) / 30(EIRP)	Pass
3	927.5	FSK	5.67	7.17	24(Pk) / 30(EIRP)	Pass

8.1.5 Measurement Plots:

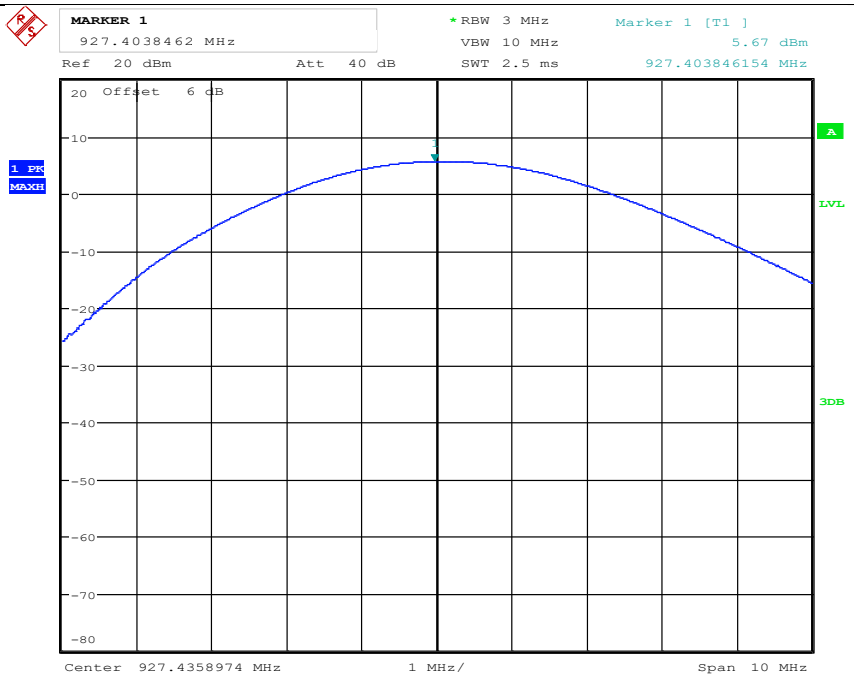
Plot # 1



Plot # 2


MARKER 1
915.0237179 MHz
RBW 3 MHz
VBW 10 MHz
SWT 2.5 ms
Marker 1 [T1]
5.85 dBm
915.023717949 MHz
Ref 20 dBm
Att 40 dB
20 Offset 6 dB
1 PK
MAXH
A
LVL
3DB
Center 915.2 MHz
1 MHz/
Span 10 MHz

Plot # 3


MARKER 1
927.4038462 MHz
RBW 3 MHz
VBW 10 MHz
SWT 2.5 ms
Marker 1 [T1]
5.67 dBm
927.403846154 MHz
Ref 20 dBm
Att 40 dB
20 Offset 6 dB
1 PK
MAXH
A
LVL
3DB
Center 927.4358974 MHz
1 MHz/
Span 10 MHz

8.2 Band Edge Compliance

8.2.1 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

8.2.2 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			

8.2.3 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.

8.2.4 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23.8° C	1	Hopping	3.6 VDC	1.5 dBi

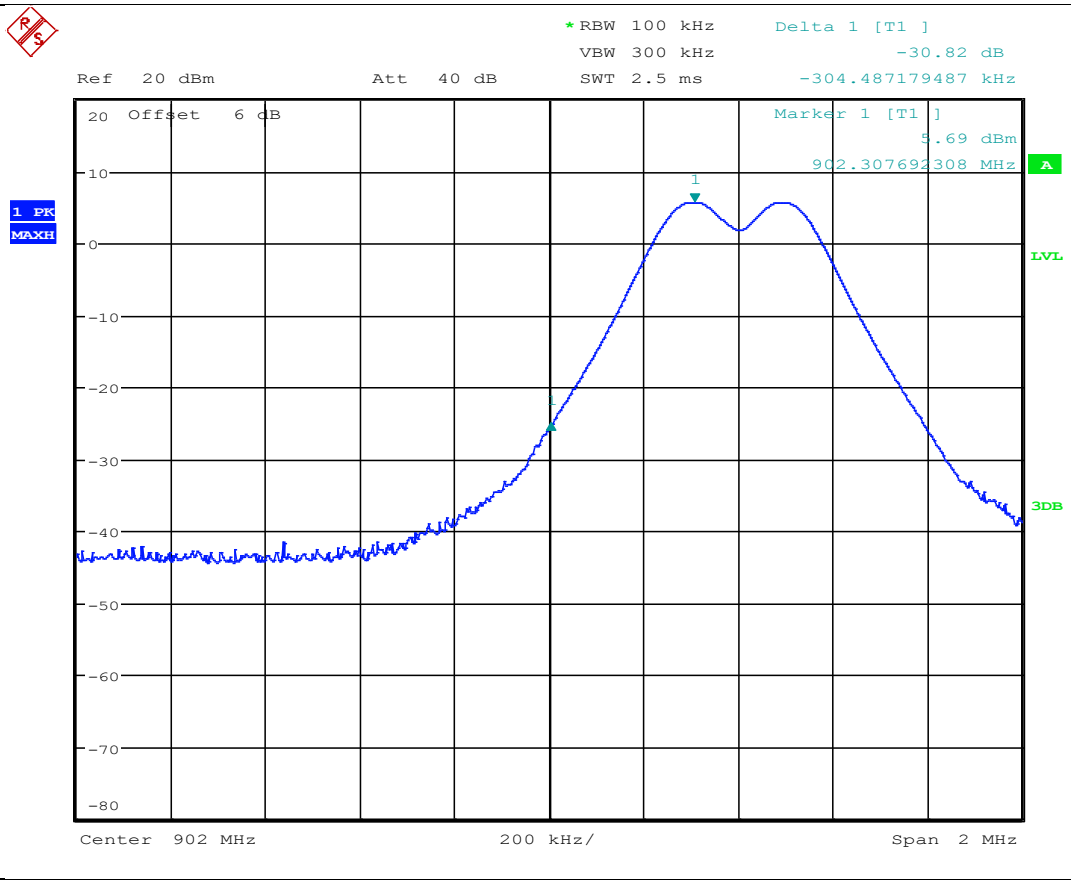
8.2.5 Measurement result:

Plot #	EUT operating mode	Band Edge	Band Edge Delta (dBc)	Limit (dBc)	Result
1	FSK	Lower, non-restricted	30.82	> 20	Pass

Plot #	EUT operating mode	Band Edge	Measured value (dBµV/m)	Limit (dBuV/m)	Result
2	FSK	Upper restricted Peak	35.03	74.00	Pass
	FSK	Upper restricted AVG	31.01	54.00	Pass

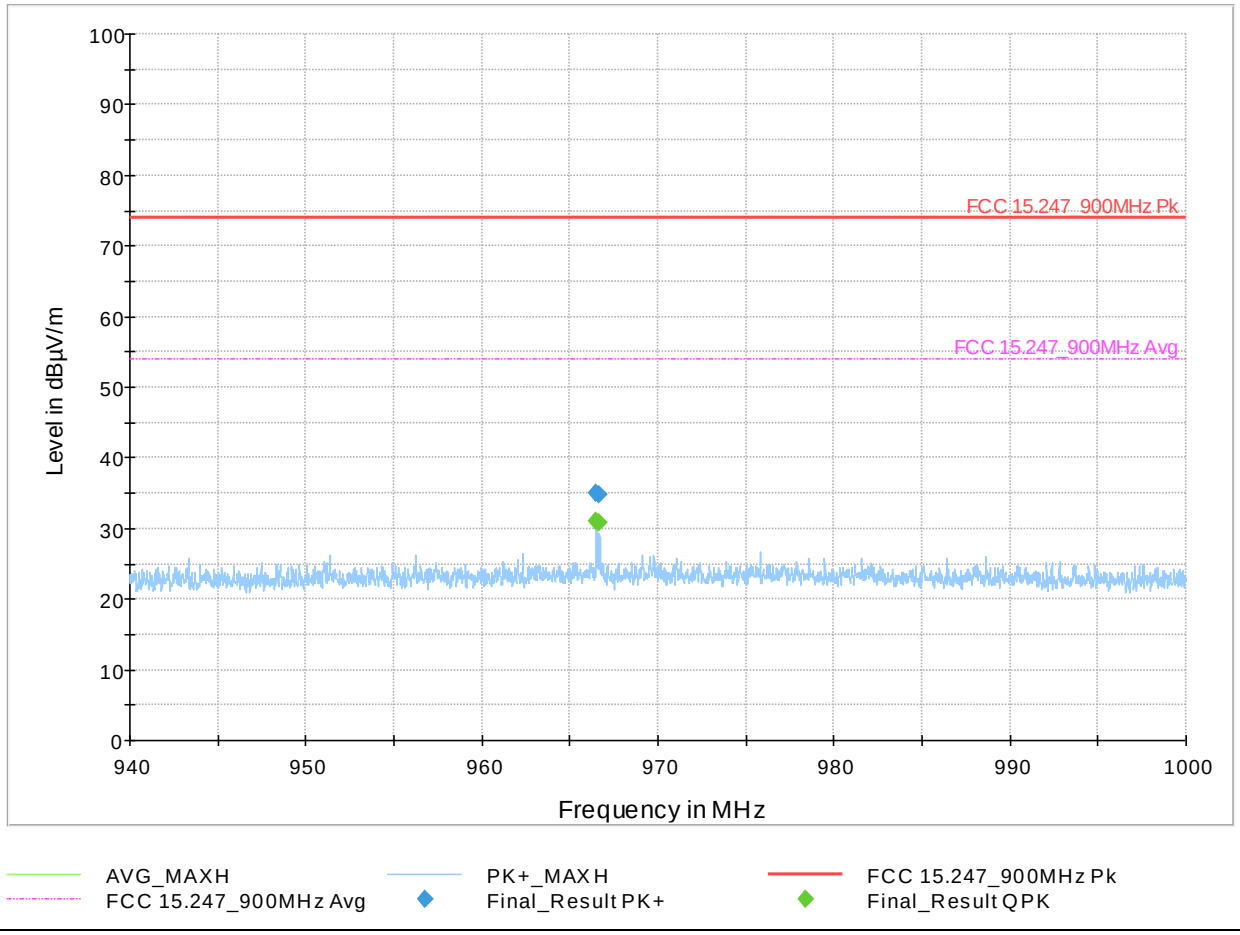
8.2.6 Measurement Plots:

Plot # 1



Plot # 2

Frequency	MaxPeak (dBµV/m	QuasiPeak	Limit (dBµV/m	Margin	Meas.	Bandwidth	Height	Pol	Azimuth	Corr. (dB/m	Sig Pat	Preamp	Trd Corr.	Raw Rec
966.507	35.03	---	74.00	38.97	500.0	120.000	154.0	H	127.0	-2.2	-	0.0	30.0	37.2
966.507	---	31.01	54.00	22.99	500.0	120.000	154.0	H	127.0	-2.2	-	0.0	30.0	33.2
966.681	34.88	---	74.00	39.12	500.0	120.000	120.0	H	133.0	-2.1	-	0.0	30.0	37.0
966.681	---	30.77	54.00	23.23	500.0	120.000	120.0	H	133.0	-2.1	-	0.0	30.0	32.9



8.3 20dB Bandwidth

8.3.1 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

8.3.2 Limits: FCC §15.247(a)(1), RSS-247 5.1(c)

FCC §15.247(a)(1):
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.

8.3.3 Test conditions and setup:

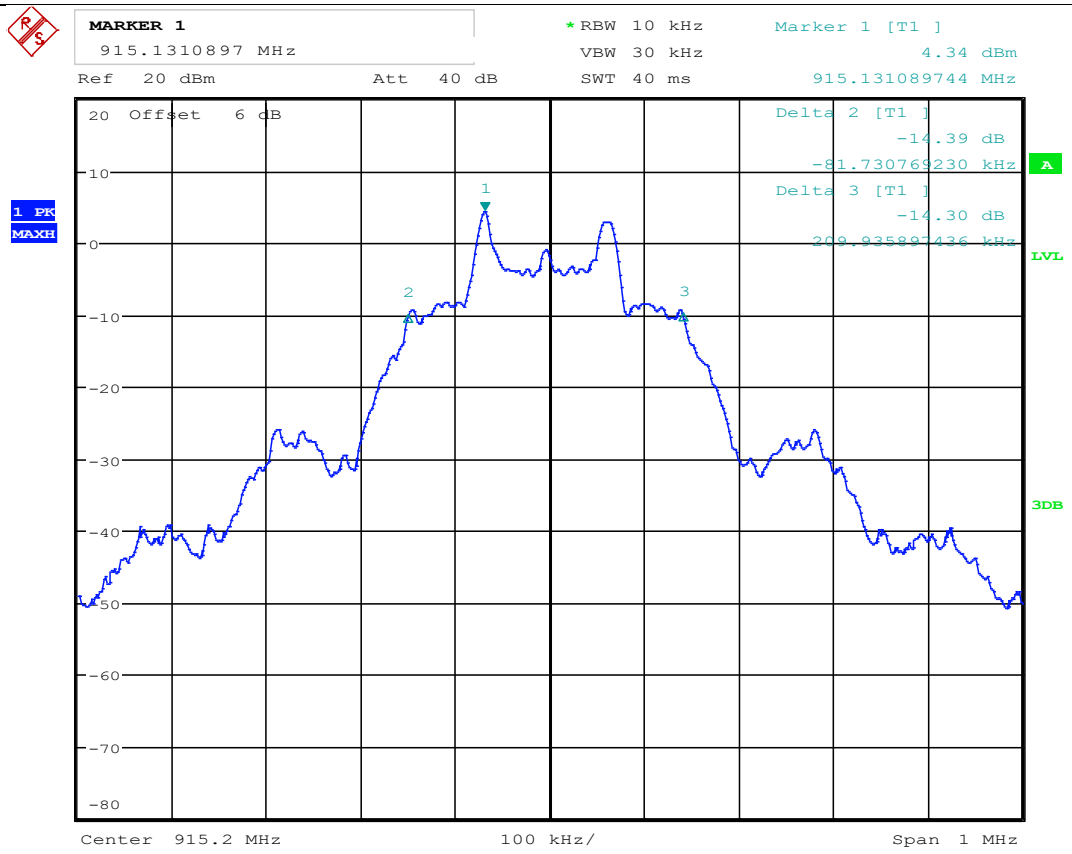
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23.8° C	1	Hopping	3.6 VDC	1.5 dBi

8.3.4 Measurement result:

Plot #	EUT operating mode	20 dB Bandwidth (MHz)
1	FSK	0.292

8.3.5 Measurement Plots:

Plot # 1



8.4 Carrier Frequency Separation

8.4.1 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.

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

FCC §15.247(a)(1):
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:

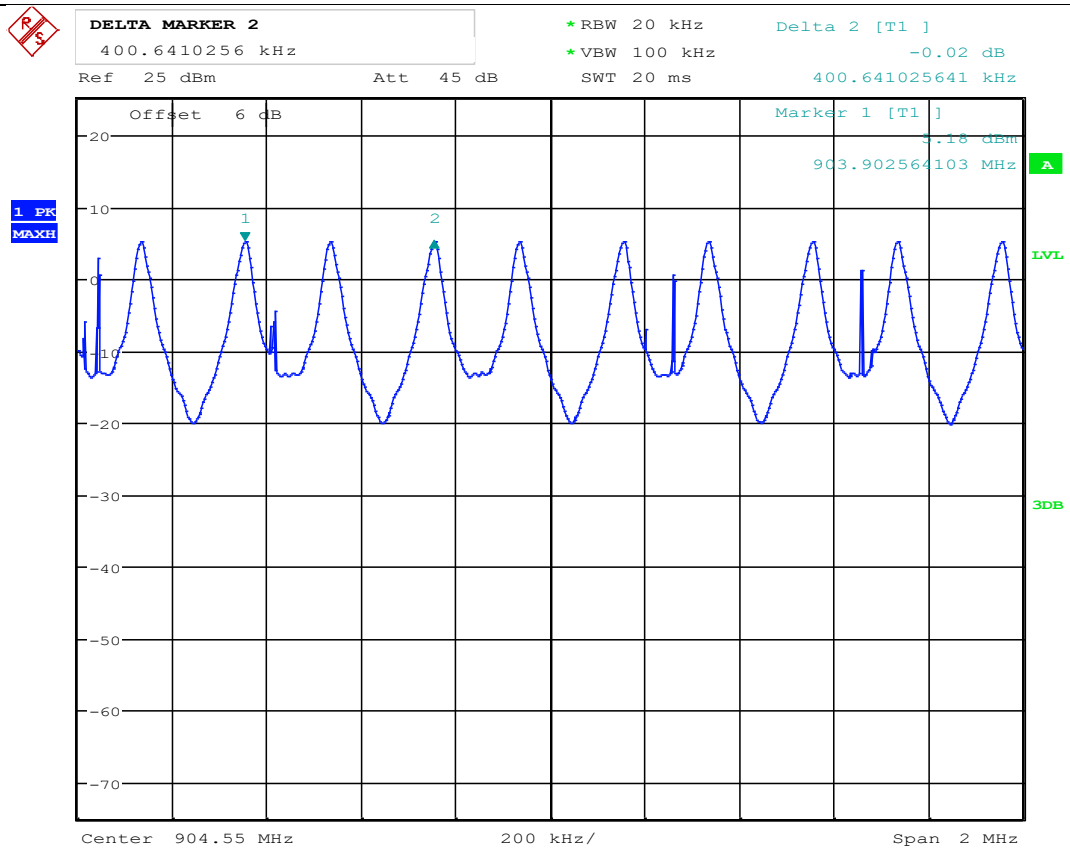
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23.8° C	1	Hopping	3.6 VDC	1.5 dBi

8.4.3.1 Measurement result:

Plot #	Carrier Frequency Separation (MHz)	Limit (MHz)	Result
1	0.401	$\Delta f \geq$ MAX { 25 kHz, BW20dB }=0.296	Pass

8.4.4 Measurement Plots:

Plot # 1



Date: 22.AUG.2023 09:56:26

8.5 Number of hopping channels

8.5.1 Measurement according to ANSI C63.10 Section 7.8.3

Spectrum Analyzer settings:

- Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
- RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- VBW ≥ RBW
- Sweep = Auto couple
- Detector function = Peak
- Trace = Max hold
- Allow the trace to stabilize

It might prove necessary to break the span up into subranges to show clearly all of the hopping frequencies. Compliance of an EUT with the appropriate regulatory limit shall be determined for the number of hopping channels.. A plot of the data shall be included in the test report.

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

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

8.5.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23.8° C	1	Hopping	3.6 VDC	1.5 dBi

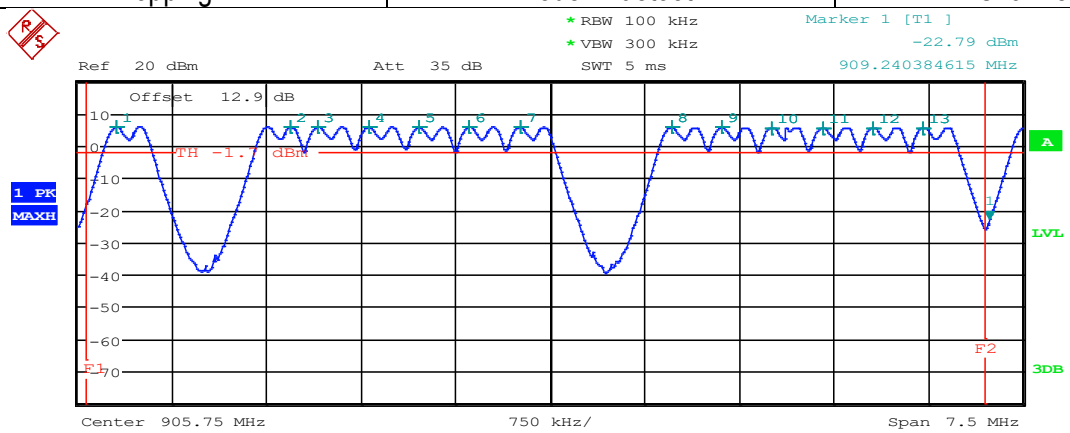
8.5.4 Measurement result:

Plot #	Number of Hopping Frequencies	Limit	Result
1-3	25	25 ≤ Nch < 50	Pass

8.5.5 Measurement Plots:

Plot # 1

Hopping	Mode: Bluetooth	Channel: 0-13

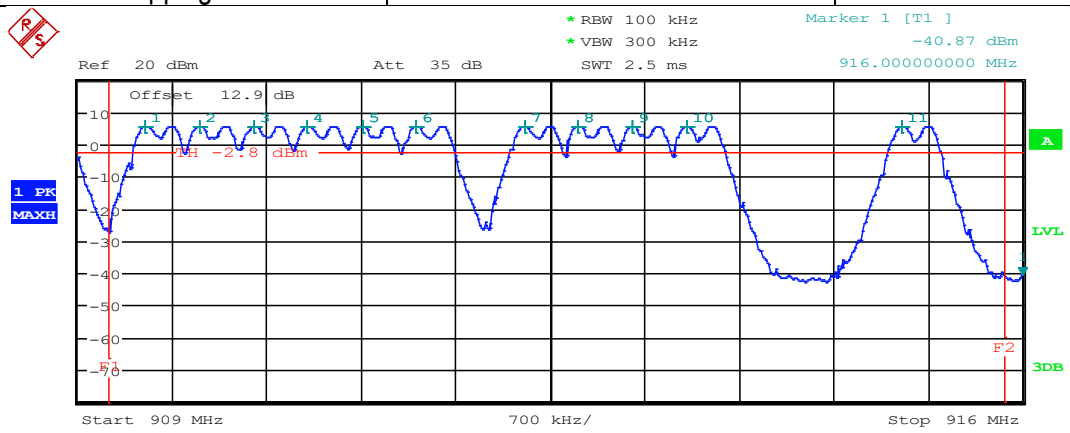


#	Frequency	Level	#	Frequency	Level
1	902.300481 MHz	5.51 dBm	13	908.706731 MHz	5.44 dBm
2	903.682692 MHz	5.48 dBm			
3	903.899038 MHz	5.49 dBm			
4	904.307692 MHz	5.49 dBm			
5	904.704327 MHz	5.47 dBm			
6	905.100962 MHz	5.46 dBm			
7	905.509615 MHz	5.46 dBm			
8	906.711538 MHz	5.45 dBm			
9	907.108173 MHz	5.45 dBm			
10	907.504808 MHz	5.44 dBm			
11	907.913462 MHz	5.43 dBm			
12	908.310096 MHz	5.42 dBm			

Date: 9.NOV.2023 13:36:02

Plot # 2

Hopping	Mode: Bluetooth	Channel: 14-24



#	Frequency	Level
1	909.493590 MHz	5.40 dBm
2	909.897436 MHz	5.41 dBm
3	910.301282 MHz	5.40 dBm
4	910.693910 MHz	5.39 dBm
5	911.108974 MHz	5.38 dBm
6	911.501603 MHz	5.39 dBm
7	912.309295 MHz	5.36 dBm
8	912.701923 MHz	5.37 dBm
9	913.105769 MHz	5.35 dBm
10	913.509615 MHz	5.35 dBm
11	915.102564 MHz	5.33 dBm

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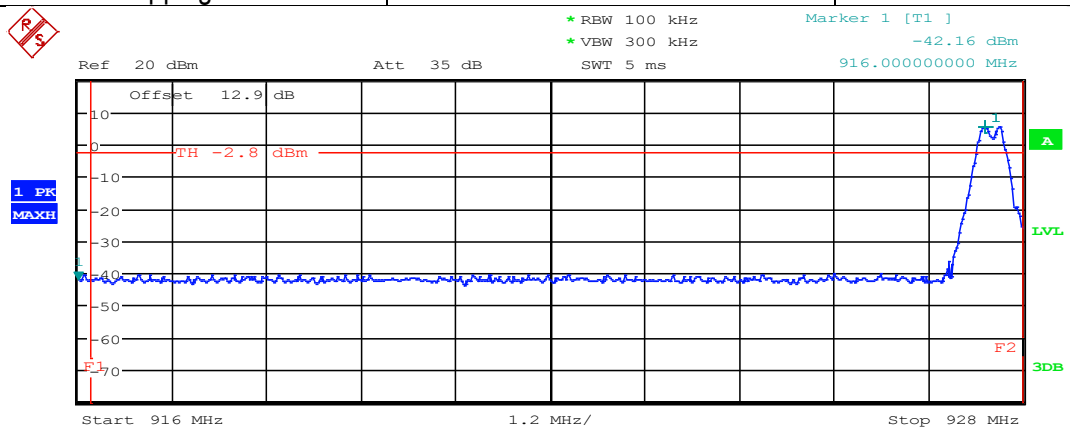
Plot # 3

Hopping	Mode: Bluetooth	Channel: 25



#	Frequency	Level
1	927.519231 MHz	5.18 dBm

Date: 9.NOV.2023 13:42:42

8.6 Time of Occupancy (Dwell Time)

8.6.1 Measurement according to ANSI C63.10 Section 7.8.4

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

a. Span: Zero span, centered on a hopping channel.
b. RBW shall be ≤ channel spacing and where possible RBW should be set >> 1/*T*, where *T* is the expected dwell time per channel.
c. Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. Trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
d. Detector function: Peak.
e. Trace: Max hold.
f. Allow the trace to stabilize.

Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time.
Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than the period specified in the requirements. Determine the number of hops over the sweep time and calculate the total number of hops in the period specified in the requirements, using the following equation:

(Number of hops in the period specified in the requirements) =
(number of hops on spectrum analyzer) x (period specified in the requirements / analyzer sweep time)

The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the period specified in the requirements. If the number of hops in a specific time varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation.
The measured transmit time and time between hops shall be consistent with the values described in the operational description of the EUT.

Spectrum analyzer settings for the duration of pulse:

a. Span: Zero
b. RBW: 100 kHz
c. VBW: 300 kHz
d. Sweep: Auto (5 ms).
e. Detector function: Peak.
f. Trace: Max hold.

Spectrum analyzer settings for the observation period:

a. Span: Zero
b. RBW: 100 kHz
c. VBW: 300 kHz
d. Sweep: 20.5 s
e. Detector function: Peak.
f. Trace: Max hold.

Observation Period = 0.4 x Number of hopping channels = 0.4 x 25 = 10 s

8.6.2 Limits: FCC §15.247(a)(1)(i) & RSS-247 5.1(c)

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.

8.6.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23.8° C	1	Hopping	3.6 VDC	1.5 dBi

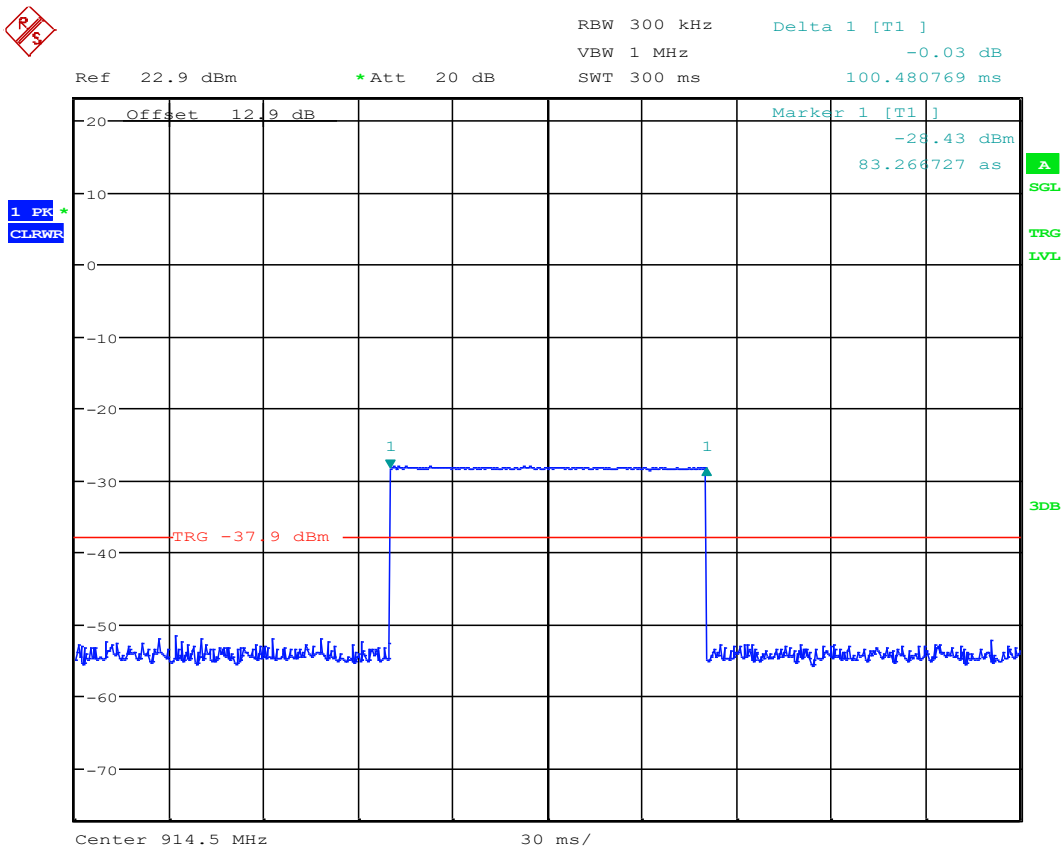
8.6.4 Measurement result:

Plot #	Modulation	Number of hops 10s	Pulse Width (s)	Total Dwell Time in 10s (s)	Limit (s)
1-2	FSK	2	0.10048	0.20096	< 0.4 in 10

8.6.5 Measurement Plots:

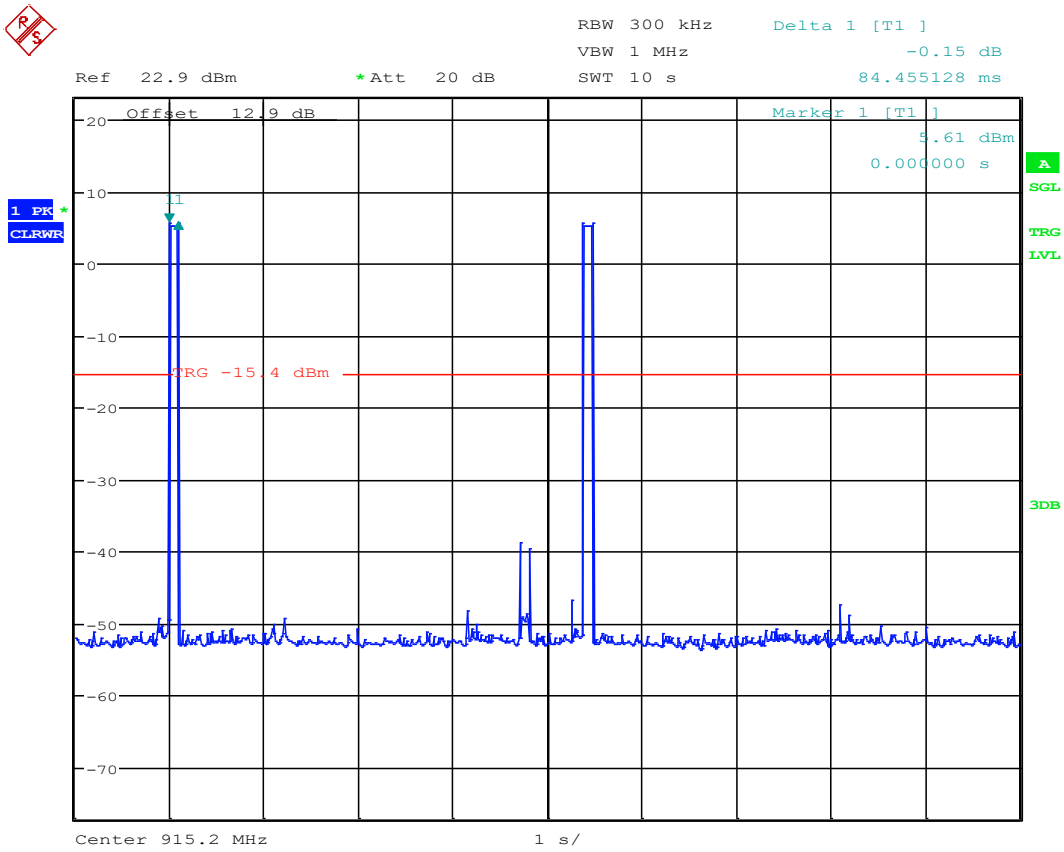
Plot # 1 Pulse duration

FSK



Plot # 2 Transmission time in observation period > 10 s

FSK



8.7 Transmitter Spurious Emissions and Restricted Bands

8.7.1 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.

8.7.2 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

8.7.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input	Antenna Gain
23.8° C	1	Hopping	3.6 VDC	1.5 dBi

8.7.4 Measurement result:

Plot #	Channel #	Scan Frequency	Limit	Result
1-3	Low	30 MHz – 18 GHz	See section 7.7.2	Pass
4-8	Mid	9 kHz – 40 GHz	See section 7.7.2	Pass
9-11	High	30 MHz – 18 GHz	See section 7.7.2	Pass

8.7.5 Measurement Plots:

Plot # 1 Radiated Emissions: 30 MHz – 1 GHz

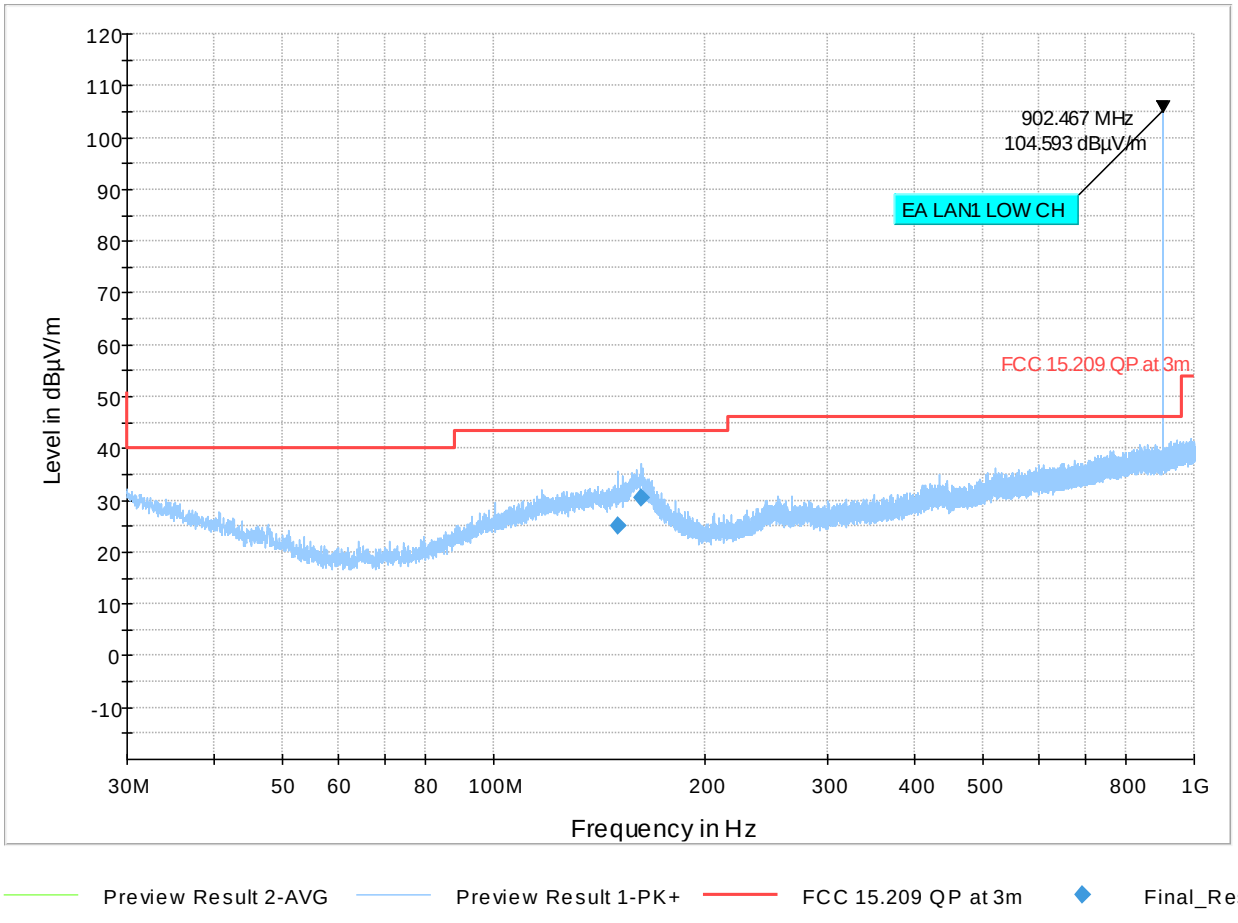
Tx Frequency: 902.3 MHz	PN9

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)	Sig Path (dB)	Preamp (dB)	Trd Corr. (dB/m)
150.38	25.09	43.50	18.41	500.0	120.0	142.0	V	274.0	-9.5	-34.7	0.0	25.2
162.77	30.62	43.50	12.88	500.0	120.0	100.0	V	320.0	-9.3	-34.6	0.0	25.3

(continuation of the "Final_Result" table from column 19 ...)

Frequency (MHz)	Raw Rec (dBµV)
150.38	34.6
162.77	39.9



Plot # 2 Radiated Emissions: 1 – 3 GHz

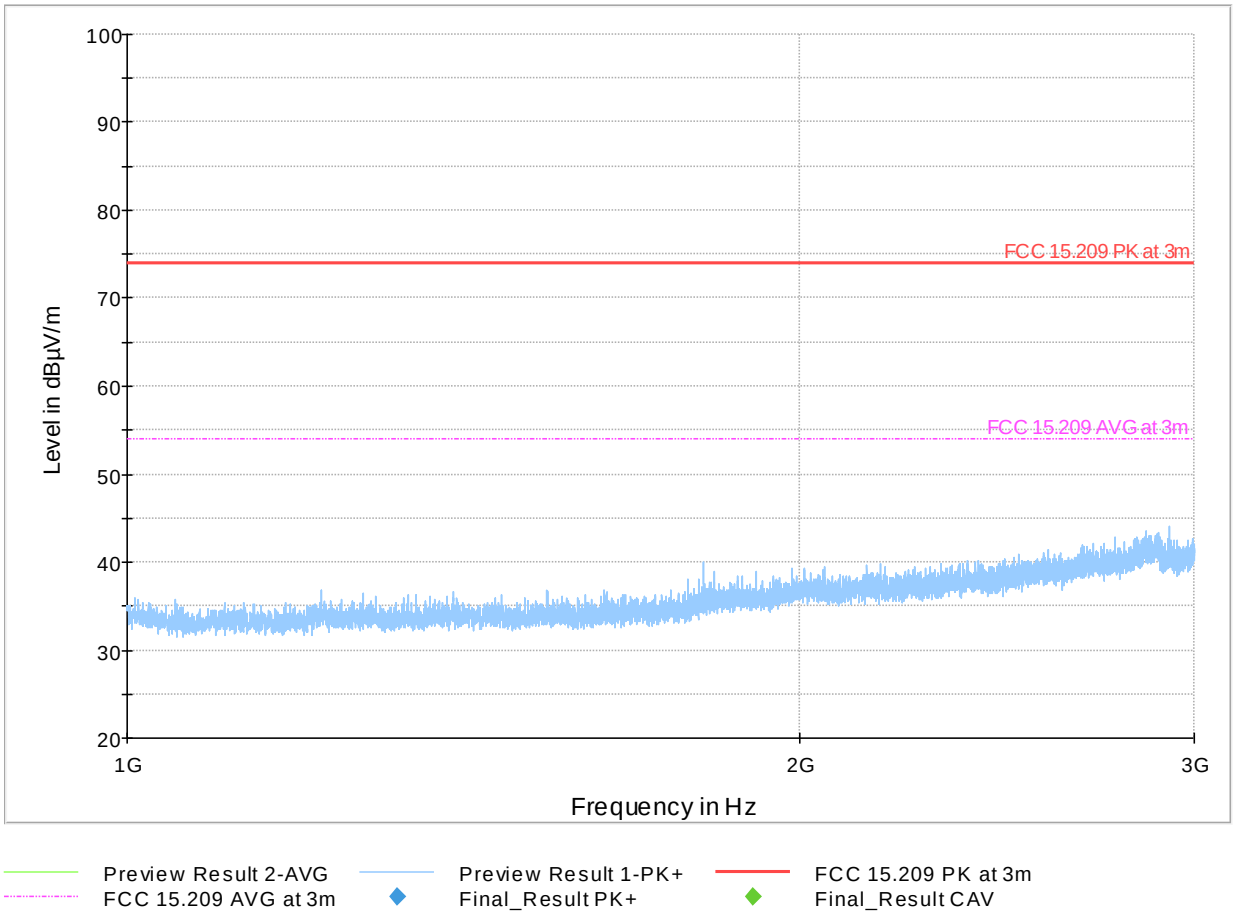
Tx Frequency: 902.3 MHz	PN9

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)	Sig Path (dB)	Preamp (dB)
---	---	---	---	---	---	---	---		---	---	---	---

(continuation of the "Final_Result" table from column 18 ...)

Frequency (MHz)	Trd Corr. (dB/m)	Raw Rec (dBµV)
---	---	---



Plot # 3 Radiated Emissions: 3 – 18 GHz

Tx Frequency: 902.3 MHz	PN9

Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)		Corr. (dB/m)	Sig Path	Preamp (dB)
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(continuation of the "Final_Result" table from column 18 ...)

Frequency (MHz)	Trd Corr. (dB/m)	Raw Rec (dBµV)
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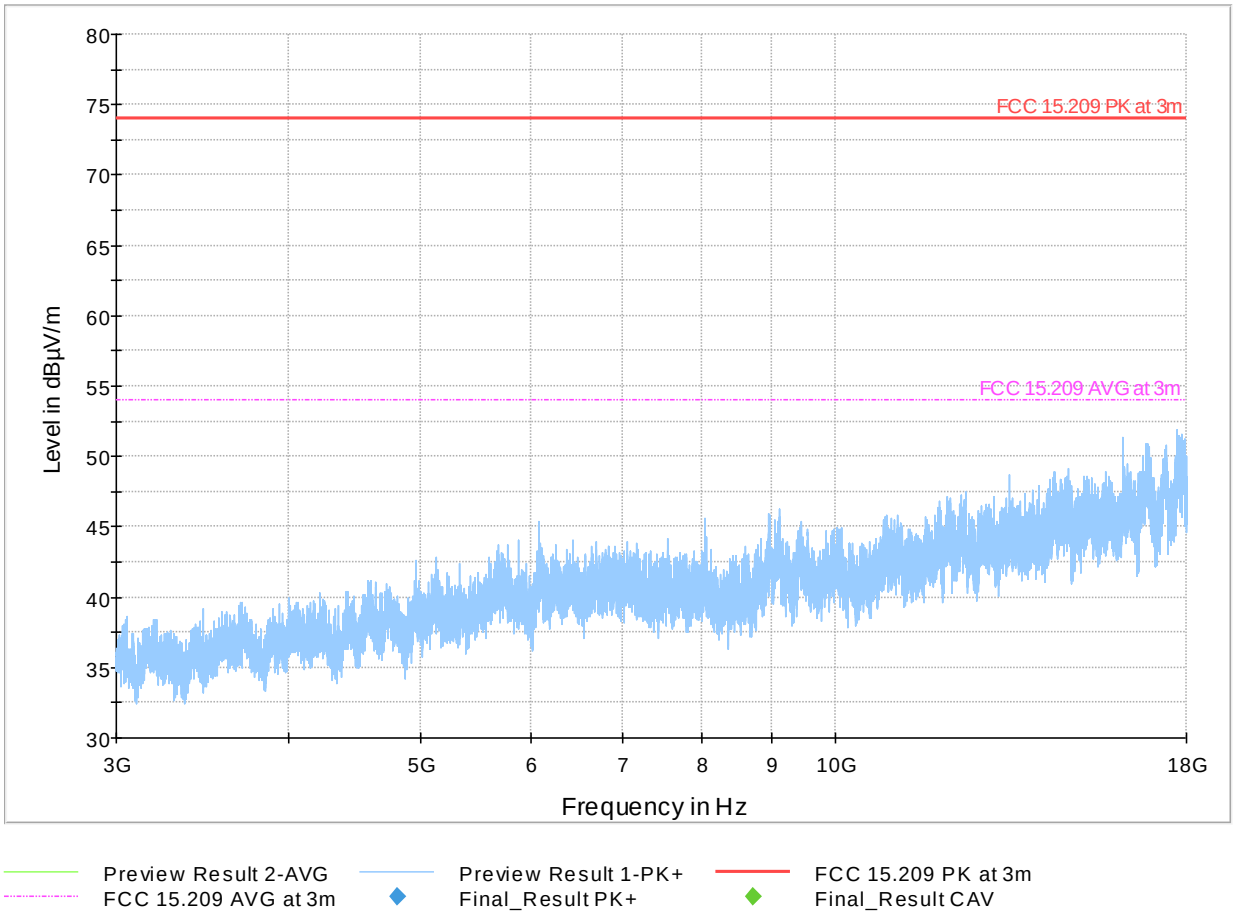
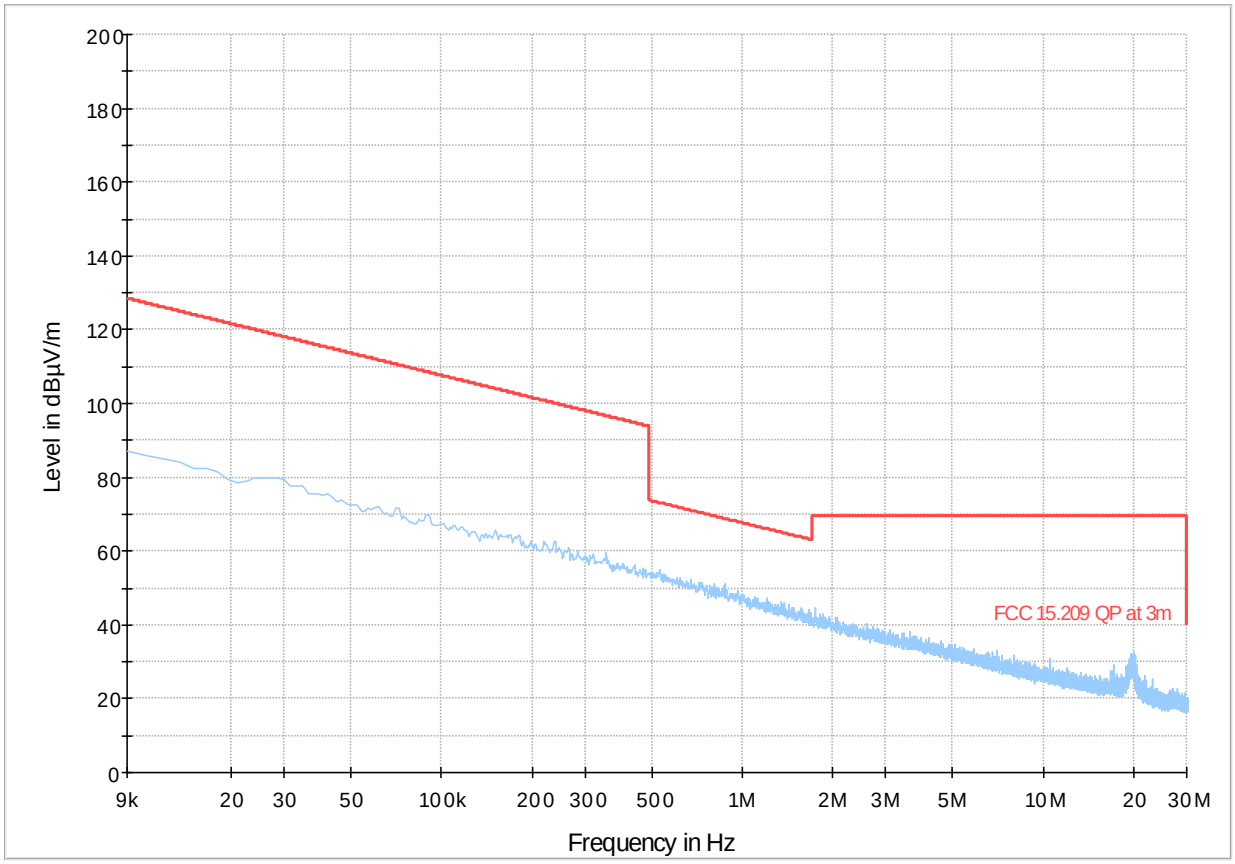


Plot # 4 Radiated Emissions: 9 KHz – 30 MHz

Tx Frequency: 915 MHz	PN9

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)
---	---	---	---	---	---	---		---	---



Plot # 5 Radiated Emissions: 30 MHz – 1 GHz

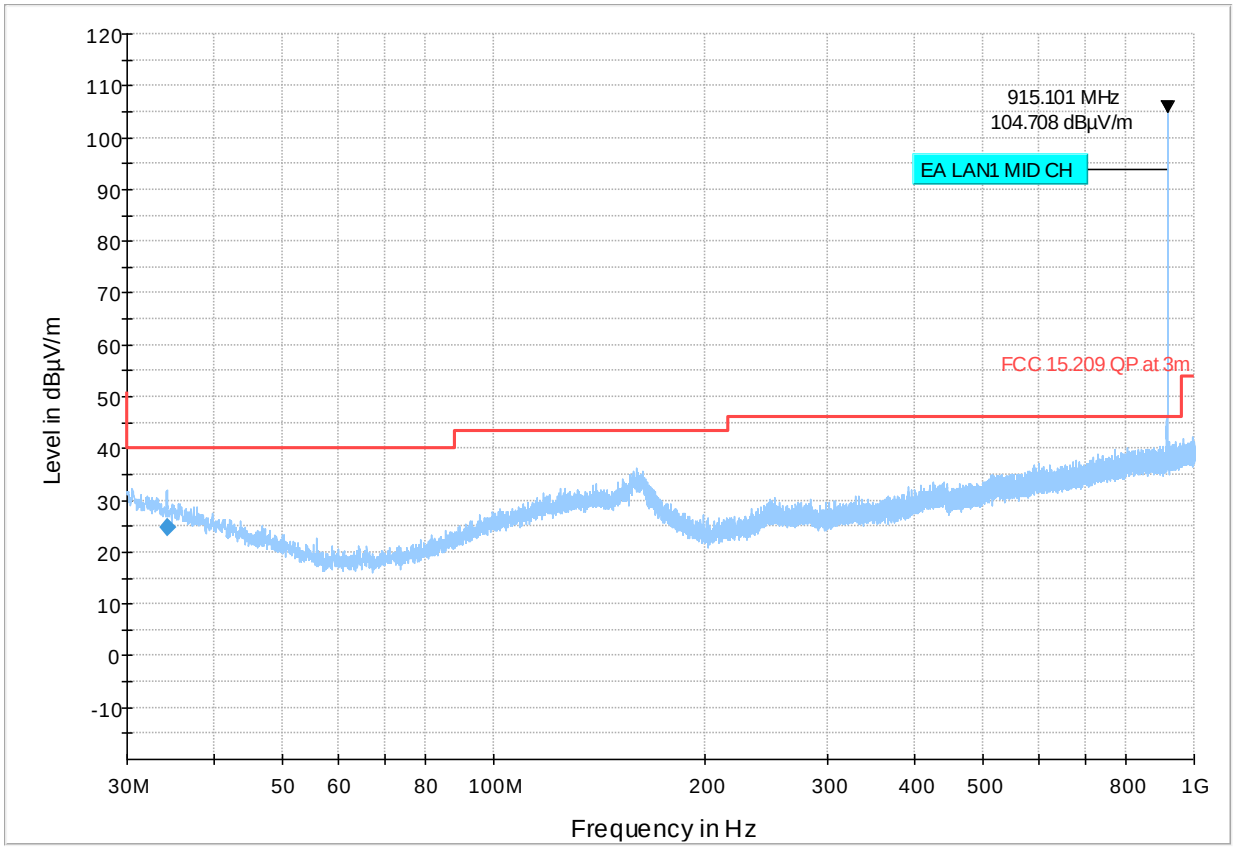
Tx Frequency: 915 MHz | **PN9**

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)	Sig Path (dB)	Preamp (dB)	Trd Corr. (dB/m)
34.17	24.65	40.00	15.35	500.0	120.0	270.0	H	29.0	-12.8	-35.4	0.0	22.6

(continuation of the "Final_Result" table from column 19 ...)

Frequency (MHz)	Raw Rec (dBµV)
34.17	37.5



Plot # 6 Radiated Emissions: 1 – 3 GHz

Tx Frequency: 915 MHz	PN9

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)	Sig Path (dB)	Preamp (dB)
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(continuation of the "Final_Result" table from column 18 ...)

Frequency (MHz)	Trd Corr. (dB/m)	Raw Rec (dBµV)
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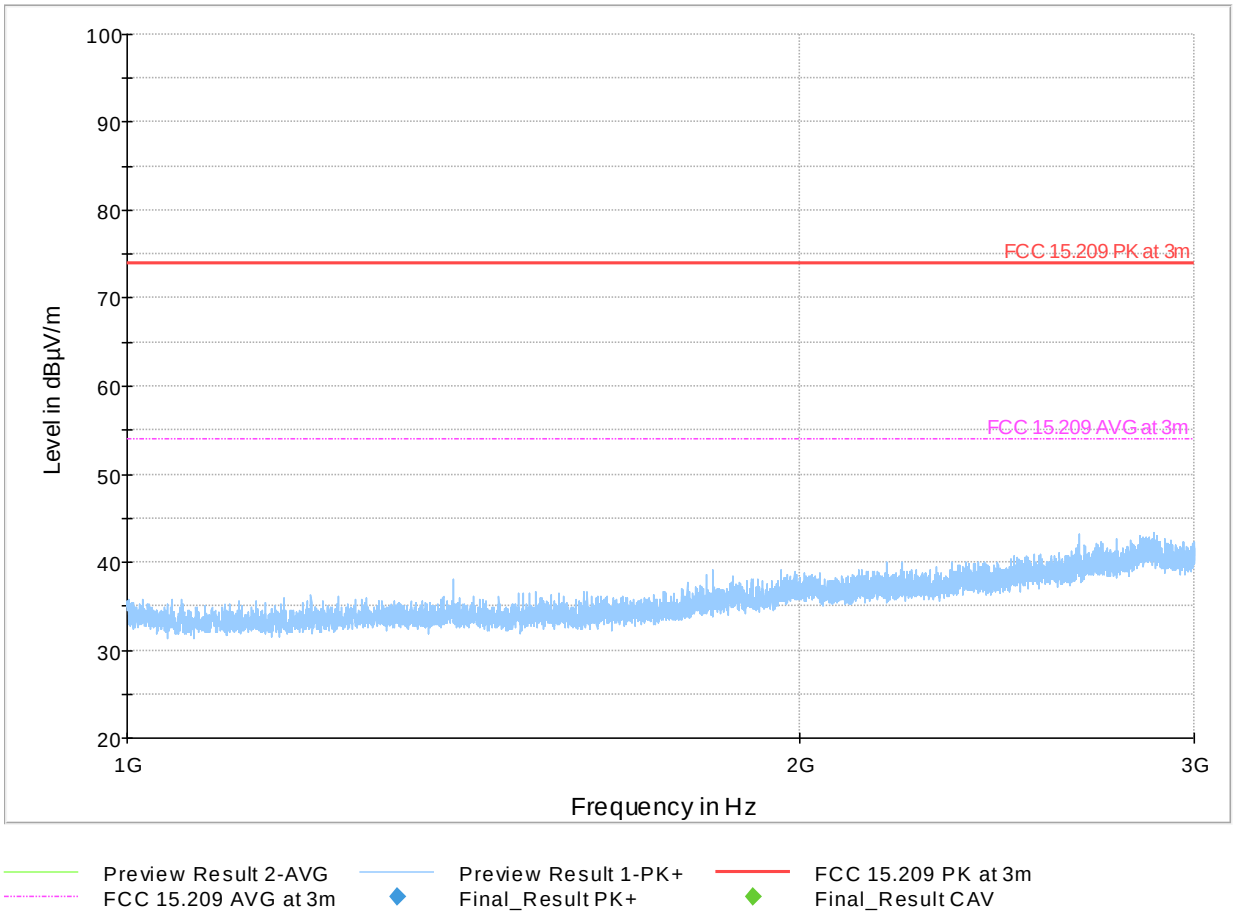

Plot # 7 Radiated Emissions: 3 – 18 GHz

Tx Frequency: 915 MHz	PN9

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)	Sig Path (dB)	Preamp (dB)
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(continuation of the "Final_Result" table from column 18 ...)

Frequency (MHz)	Trd Corr. (dB/m)	Raw Rec (dBµV)
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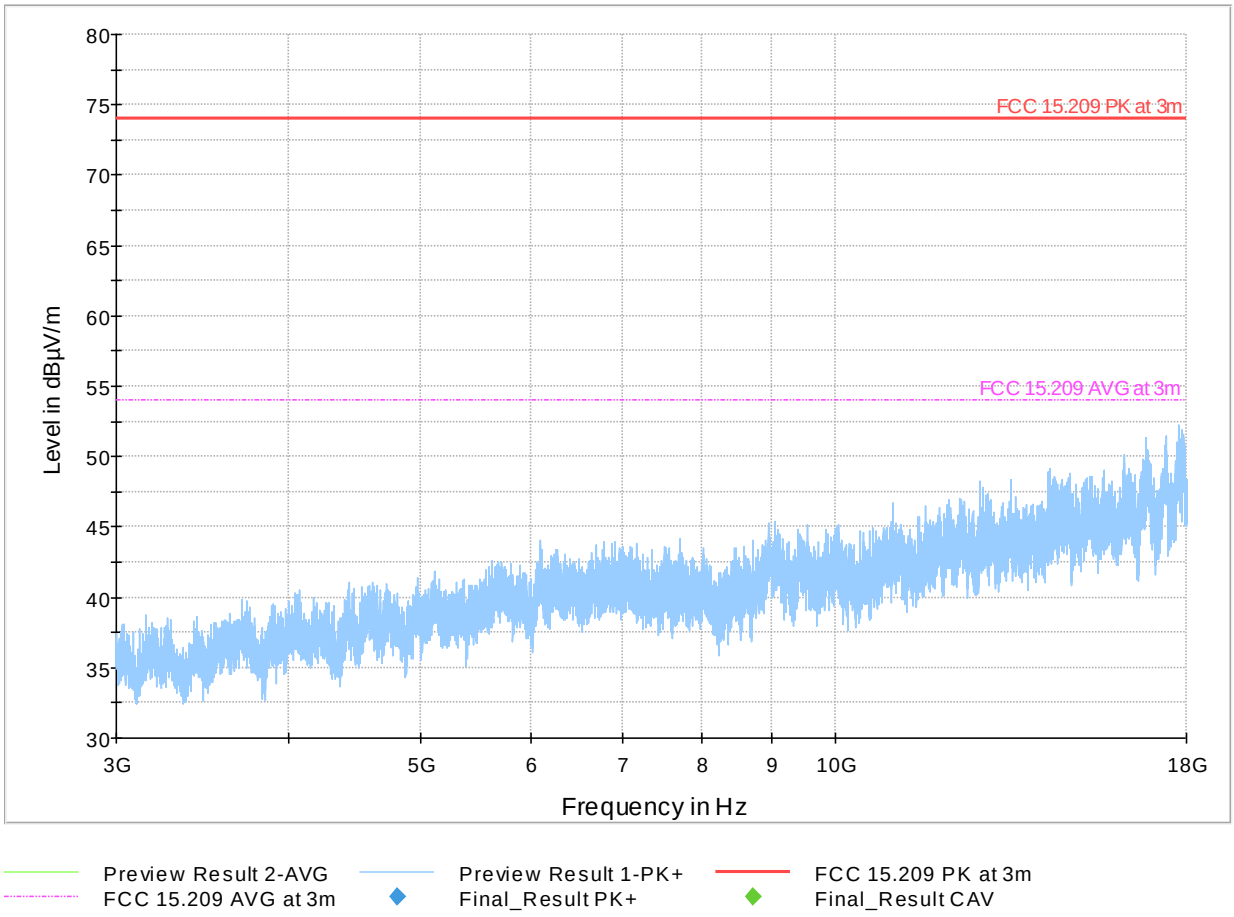
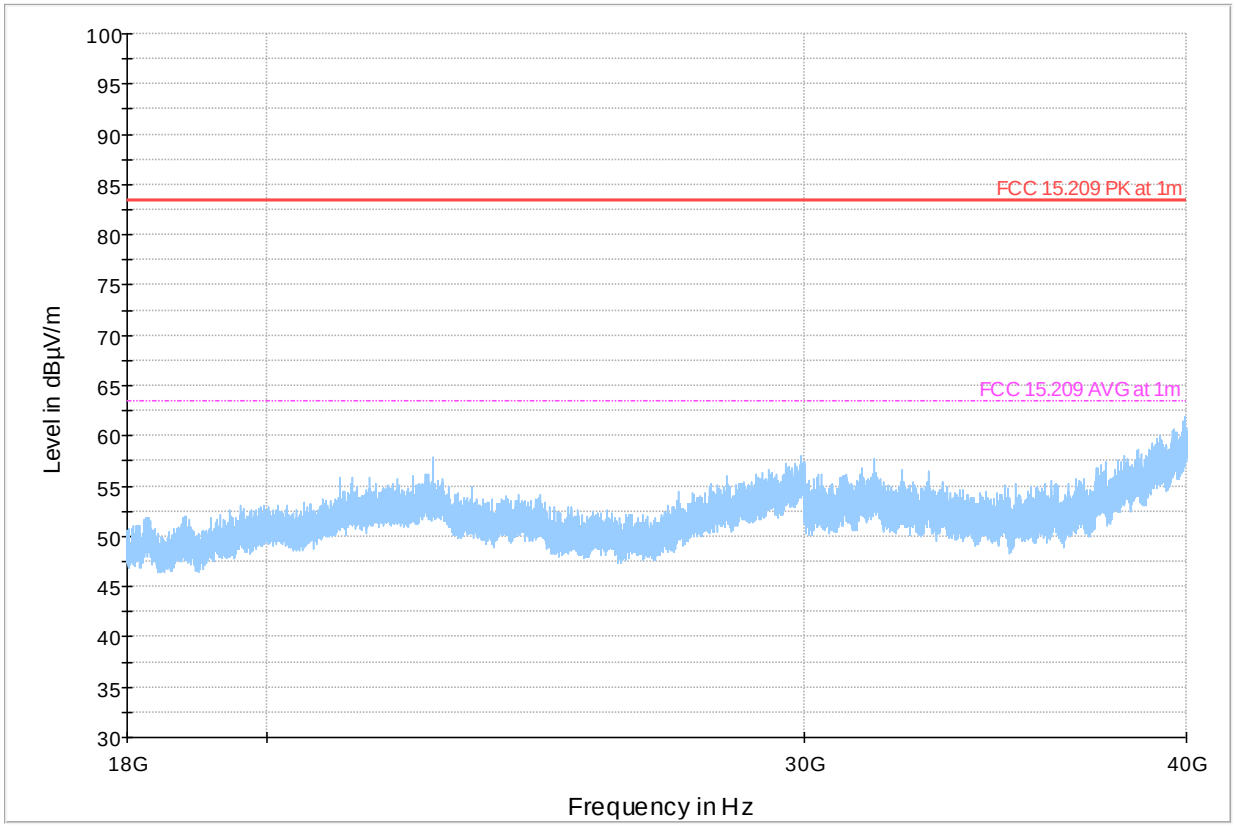


Plot # 8 Radiated Emissions: 18 – 40 GHz

Tx Frequency: 915 MHz	PN9

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)
---	---	---	---	---	---	---	---		---	---



Plot # 9 Radiated Emissions: 30 MHz – 1 GHz

Tx Frequency: 927.5 MHz	PN9

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)	Sig Path (dB)	Preamp (dB)	Trd Corr. (dB/m)
---	---	---	---	---	---	---		---	---	---	---	---

(continuation of the "Final_Result" table from column 19 ...)

Frequency (MHz)	Raw Rec (dBµV)
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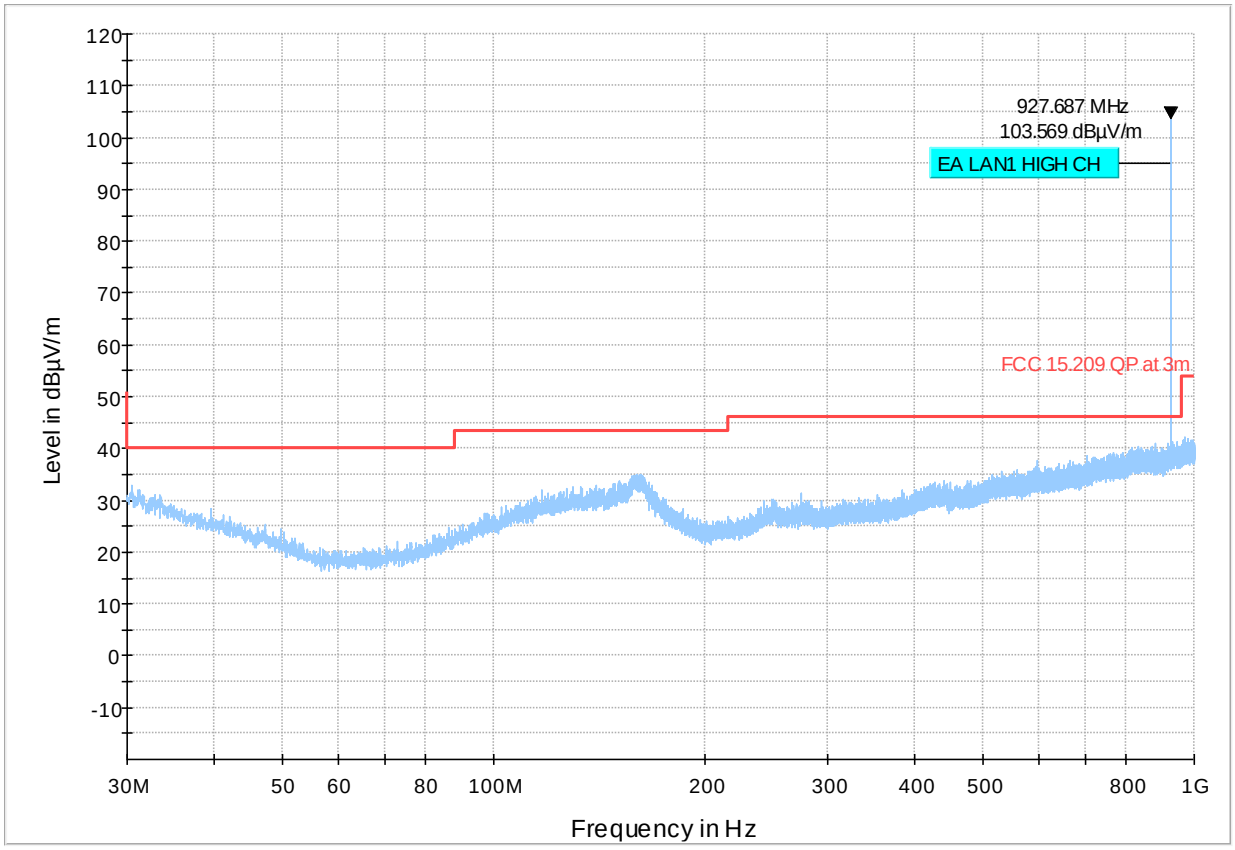


Plot # 10 Radiated Emissions: 1 – 3 GHz

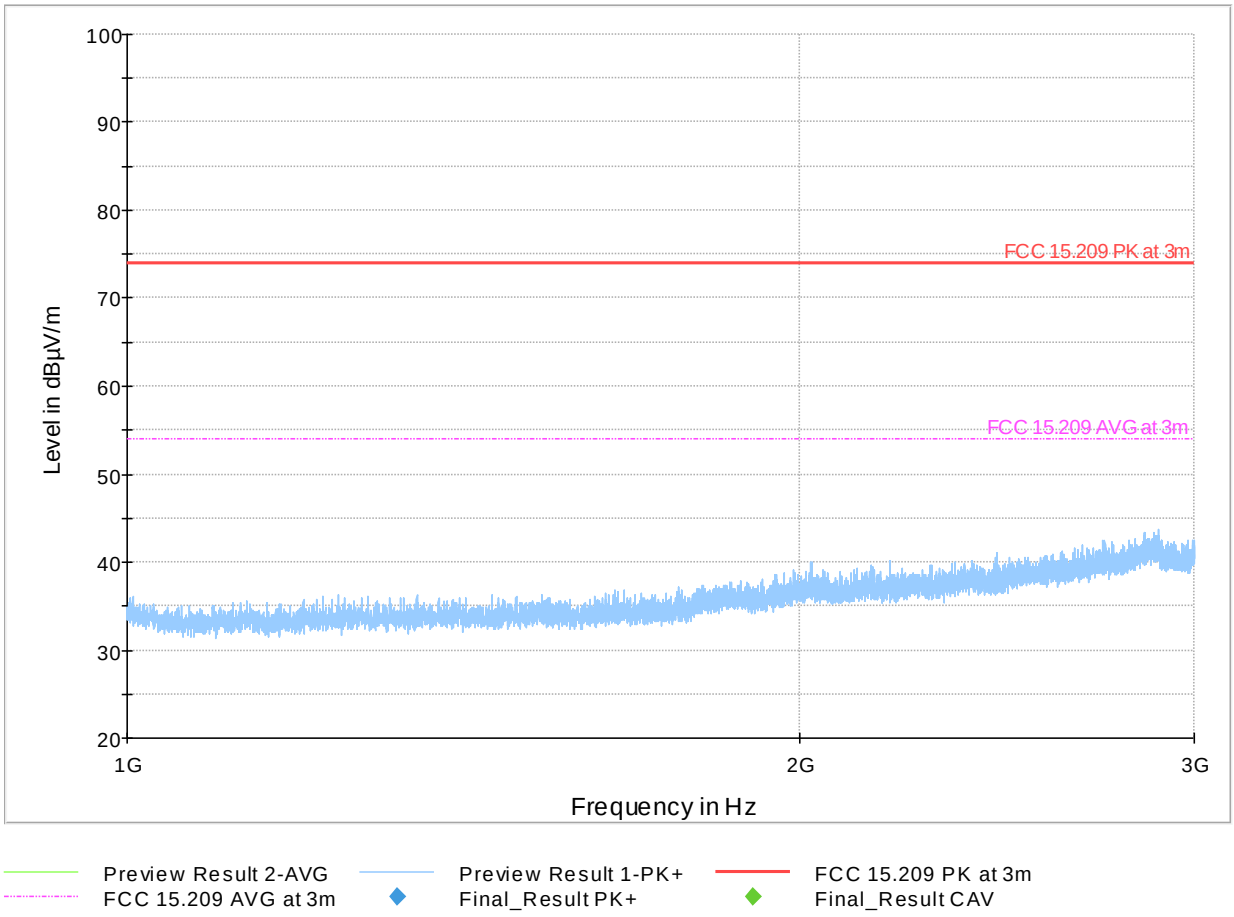
Tx Frequency: 927.5 MHz	PN9

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)	Sig Path (dB)	Preamp (dB)
---	---	---	---	---	---	---	---		---	---	---	---

(continuation of the "Final_Result" table from column 18 ...)

Frequency (MHz)	Trd Corr. (dB/m)	Raw Rec (dBµV)
---	---	---



Plot # 11 Radiated Emissions: 3 – 18 GHz

Tx Frequency: 927.5 MHz	PN9

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)	Sig Path (dB)	Preamp (dB)
---	---	---	---	---	---	---	---		---	---	---	---

(continuation of the "Final_Result" table from column 18 ...)

Frequency (MHz)	Trd Corr. (dB/m)	Raw Rec (dBµV)
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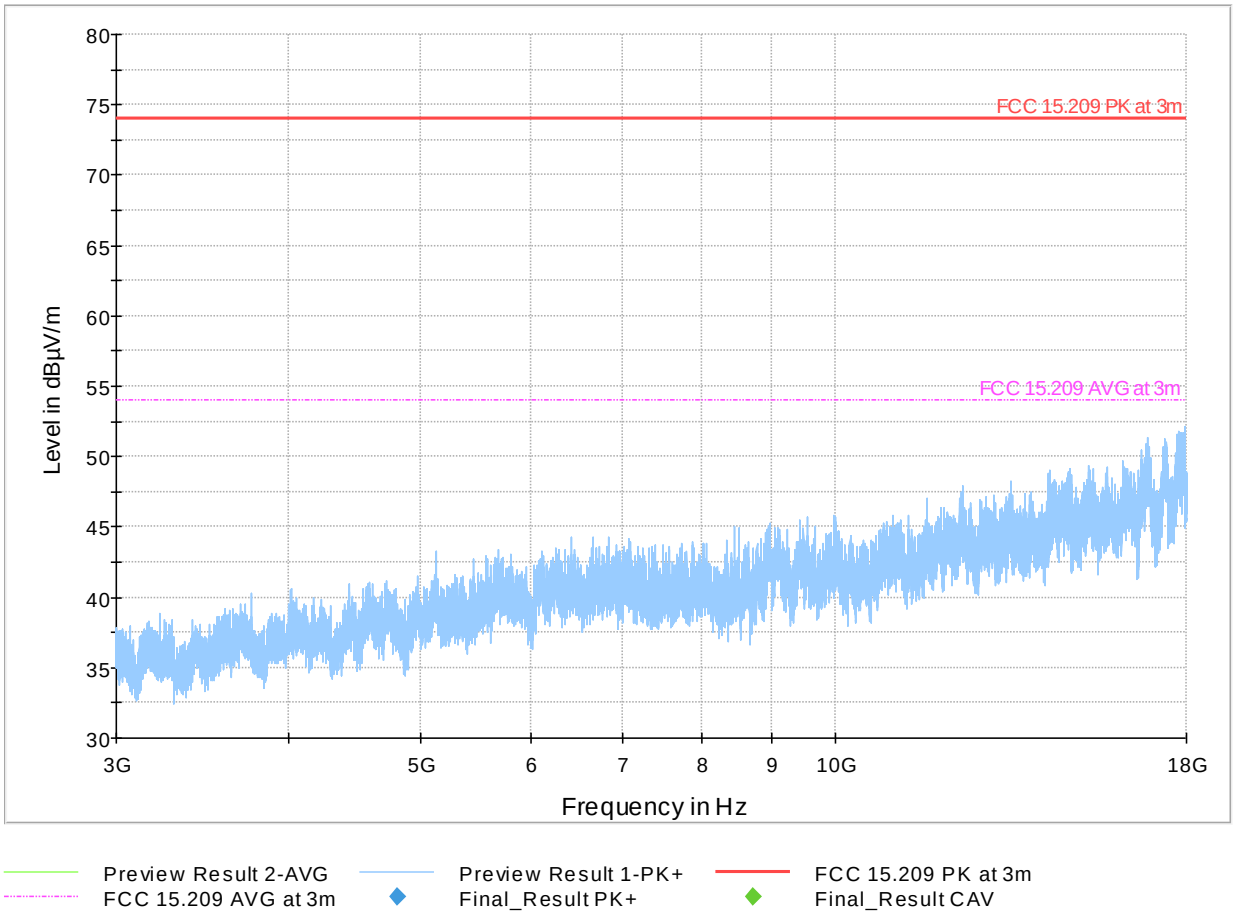

9 Test setup photos

Setup photos are included in supporting file name: "EMC_HONEY_229_23001_FCC_Setup_Photos"

10 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
BILOG ANTENNA	A.H. SYSTEMS	BiLA2G	569	3 YEARS	11/16/2021
HORN ANTENNA	EMCO	3115	00035111	3 YEARS	9/30/2021
HORN ANTENNA	ETS LINDGREN	3117-PA	00169547	3 YEARS	9/1/2020
HORN ANTENNA	ETS LINDGREN	3116C-PA	00169535	3 YEARS	9/23/2020
ESW.EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW44	101715	3 YEARS	9/14/2021
Spectrum Analyzer	Rohde & Schwarz	FSU. Spectrum Analyzer	100189	3 Years	5/27/2022

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	Report Name	Changes to report	Prepared by
2023-08-30	EMC_HONEY_229_23001_FCC_15_247	Initial Version	Art Thammanavarat
2023-10-23	EMC_HONEY_229_23001_FCC_15_247_Rev1	Updated Company Name	Art Thammanavarat
2023-11-09	EMC_HONEY_229_23001_FCC_15_247_Rev2	**Report Revised** 1. Section 8.5: Updated test method and added new plots to be more visibility. 2. Section 8.6: Updated test method and added new plots. 3. Section 8.7.5: Updated Plot for 9kHz-30MHz.	Art Thammanavarat

<<< The End >>>