Report on the Testing of the

iKeyless LLC
GMSSL-G060

FCC ID: X32-GMSSG060
IC: 8797A-GMSSG060

America

Add value.
Inspire trust.

In accordance with:
FCC 47 CFR Part 15.231
FCC 47 CFR Part 15.109
ISED RSS-210 Issue 10, December 2019
ISED RSS-GEN Issue 5, April 2018

Prepared for: iKeyless LLC
12101 Sycamore Station Pl. Ste 140
Louisville, KY 40299

COMMERCIAL-IN-CONFIDENCE

Document Number: NC72173828.1 | Issue: 2

SIGNATURE			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Sean Sellergren	Sr. EMC Engineer	**Authorized Signatory**	07 February 2022

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD America, Inc. document control rules.

FCC Accreditation Designation Number US1148 New Brighton, MN Test Laboratory	Innovation, Science, and Economic Development Canada Accreditation Site Number 4512A New Brighton, MN Test Laboratory

EXECUTIVE SUMMARY
A sample of this product was tested and found to be compliant with the standards listed above and the tests shown in Table 1.3.1 of this report.

A2LA Cert. No. 2955.11

TÜV SÜD America Inc
141 14th Street NW
New Brighton, MN 55112

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Contents

1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Table 1.1-1 – Modification Record

Issue	Description of Change	Date of Issue
1	First Issue	07 February 2022
2	Antenna Gain corrected for both frequencies of EUT. Fundamental and Spurious limits corrected for EUT	30 March 2022

1.2 Introduction

Applicant	iKeyless LLC
Manufacturer	iKeyless LLC
Applicant's Email Address	nrichardson@ikeyless.com
Model Number(s)	GMSSL-G060
Serial Number(s)	1, 2, 3, 4, 5, 6
Number of Samples Tested	6
ISED PMN	GMSSL-G060
ISED HVIN	GMSSL-G060
ISED FVIN	GMSSL-F010-0
ISED HMN	n/a
Test Specification/Issue/Date	FCC 47 CFR Part 15.231 FCC 47 CFR Part 15.109 ISED RSS-210 Issue 10, December 2019 ISED RSS-GEN Issue 5, April 2018
Order Number	72173828
Date of Receipt of EUT	03 JAN 2022
Start of Test	18 JAN 2022
Finish of Test	21 JAN 2022
Related Document(s)	ANSI C63.10 2013

1.3 Scope of Testing

To perform certification testing to confirm that the wireless device(s) meet the requirements of the applicable standards.

1.4 Summary of Results

A summary of the tests carried out in accordance with the specifications shown below.

Table 1.4-1 – Summary of Results

Report Section	Specification Clause		Test Description	Accredit -ation	Base Standard
2.1	15.203	RSS-GEN	Antenna Requirements	A2LA	FCC Part 15.203
2.2	15.231(a)(1), (2)	RSS-210 A.1.1 a, b	Deactivation Period	A2LA	ANSI C63.10:2013
2.3	15.231(a)(3)	RSS-210 A.1.1 c	Pulse Characteristics & Duty Cycle of Transmitter	A2LA	ANSI C63.10:2013
2.4	15.231(b)(1), (e)	RSS-210 A.1.2; A.1.4	Field Strength of Fundamental	A2LA	ANSI C63.10:2013
2.5	15.231(b)(1), (e)	RSS-210 A.1.2; A.1.4	Field Strength of Emissions	A2LA	ANSI C63.10:2013
2.6	15.231(c)	RSS-210 A.1.3	Occupied Bandwidth	A2LA	ANSI C63.10:2013
2.7	15.231(d)	RSS-GEN 6.11	Frequency Stability (40 MHz TX only)	A2LA	ANSI C63.10:2013

Table 1.4-2 – Test Accreditation

Test Name	Name of Tester(s)	Results / Comments
Antenna Requirements	Franklin Rose	Pass
Deactivation Period	Franklin Rose	Pass
Pulse Characteristics &	Franklin Rose	Pass
Duty Cycle of Transmitter	Franklin Rose	Pass
Field Strength of Fundamental	Franklin Rose	Pass
Field Strength of Emissions	Franklin Rose	Pass
Occupied Bandwidth	Franklin Rose	Pass
Frequency Stability (40 MHz TX only)	n/a	n/a

Note: Tests marked with N/A were not tested due to EUT not meeting the full requirements for test applicability and therefore are not required.

1.5 Product Information

1.5.1 Technical Description

The Equipment Under Test (EUT): Key fob w/ momentary TX.

Table 1.5-1 – Wireless Module Technical Information

Detail	Description
FCC ID	X32-GMSSG060
IC	8797A-GMSSG060
Transceiver Model #	GMSSL-G060
Operating Frequency	314.9 MHz, 433.92 MHz
Modulation Format	ASK, FSK
Antenna Type	PCB Trace
Antenna Gain (314.9 MHz):	-15.8 dBi
Antenna Gain (433.92 MHz):	-11.7 dBi

A full description and detailed product specification details are available from the manufacturer.

Photo 1.5-1 – Front View of the EUT

Table 1.5-2 – Cable Descriptions

Cable/Port	Description
n/a	n/a

Table 1.5-3 – Support Equipment Descriptions

Make/Model	Description
n/a	n/a

1.5.2 Modes of Operation

Table 1.5-4 – Test Frequencies & Modes of Operation

Channel	Frequency (MHz)
Low	314.9 MHz
High	433.92 MHz

1.6 Deviations from the Standard

No deviations from the applicable test standard were made during testing.

1.7 EUT Modification Record

The table below details modifications made to the EUT during the test program. The modifications incorporated during each test are recorded on the appropriate test pages.

Table 1.7-1 – Modification Record

Modification State	Description of Modification fitted to EUT	Modification Fitted By	Date Modification Fitted
0	Initial State		

1.8 Test Location

TÜV SÜD conducted the following tests at our New Brighton, MN Test Laboratory.
Office address:

TÜV SÜD America
141 14th Street NW
New Brighton, MN 55112 USA

2 Test Details

2.1 Antenna Requirements

2.1.1 Specification Reference

FCC 47 CFR Part 15 Subpart C, 15.203
RSS-GEN Issue 5

2.1.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.1.3 Antenna Requirement

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of §§15.211, 15.213, 15.217, 15.219, 15.221, or §15.236. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

Note: Above statement is taken from FCC Part 15 Subpart C §15.203

Table 2.1-1 – Antenna Used In EUT

Antenna Type	TX Frequency	Connection Type	Antenna Gain
PCB Trace Antenna	314.90 MHz	Integral	-15.8 dBi
PCB Trace Antenna	433.92 MHz	Integral	-11.7 dBi

Note: The antenna and antenna connector are fully contained within the EUT and are inaccessible to the end user.

2.2 Deactivation Period

2.2.1 Specification Reference

FCC 47 CFR Part 15.231(a)
ISED RSS-210 A.1.1

2.2.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.2.3 Date of Test

2022-January-18

2.2.4 Test Method

The spectrum analyzer was triggered to sweep on the TX of the device. Sweep time was set equal to or greater than the specified time for periodic operation. The device was manually activated and to confirm that it ceases transmission within the specified time of deactivation. Periodic transmissions at regular predetermined intervals were verified to not exist, except where regulatory requirements allow polling or supervision transmissions, including data, to determine system integrity. In addition to this test data, compliance is addressed by an attestation supported by the equipment theory of operation.

2.2.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.2.6 Test Results

Test Summary: The EUT operated as intended before, during, and after testing.

Test Result: Pass

See data below for detailed results.

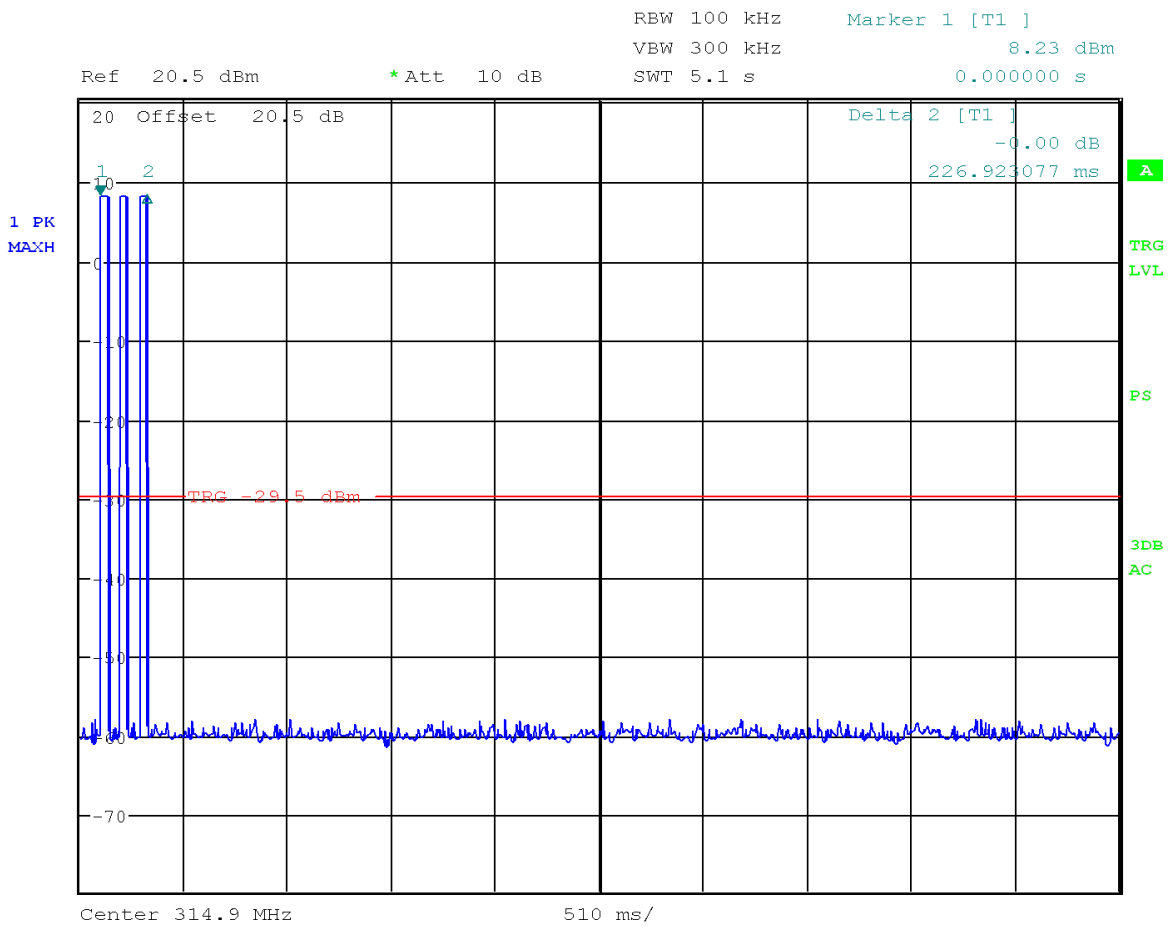


Figure 2-1 – Deactivation Period, 314.9 MHz, ASK Modulation

Sweep Duration (s) (after trigger)	Number of Burst Occurrences	TX End Time (s)	Limit (s)	Margin (s)
5	3	0.227	5	-4.773

Note: The TX uses Aperiodic Operation, and is not subject to the limit of 15.231(a)(3)

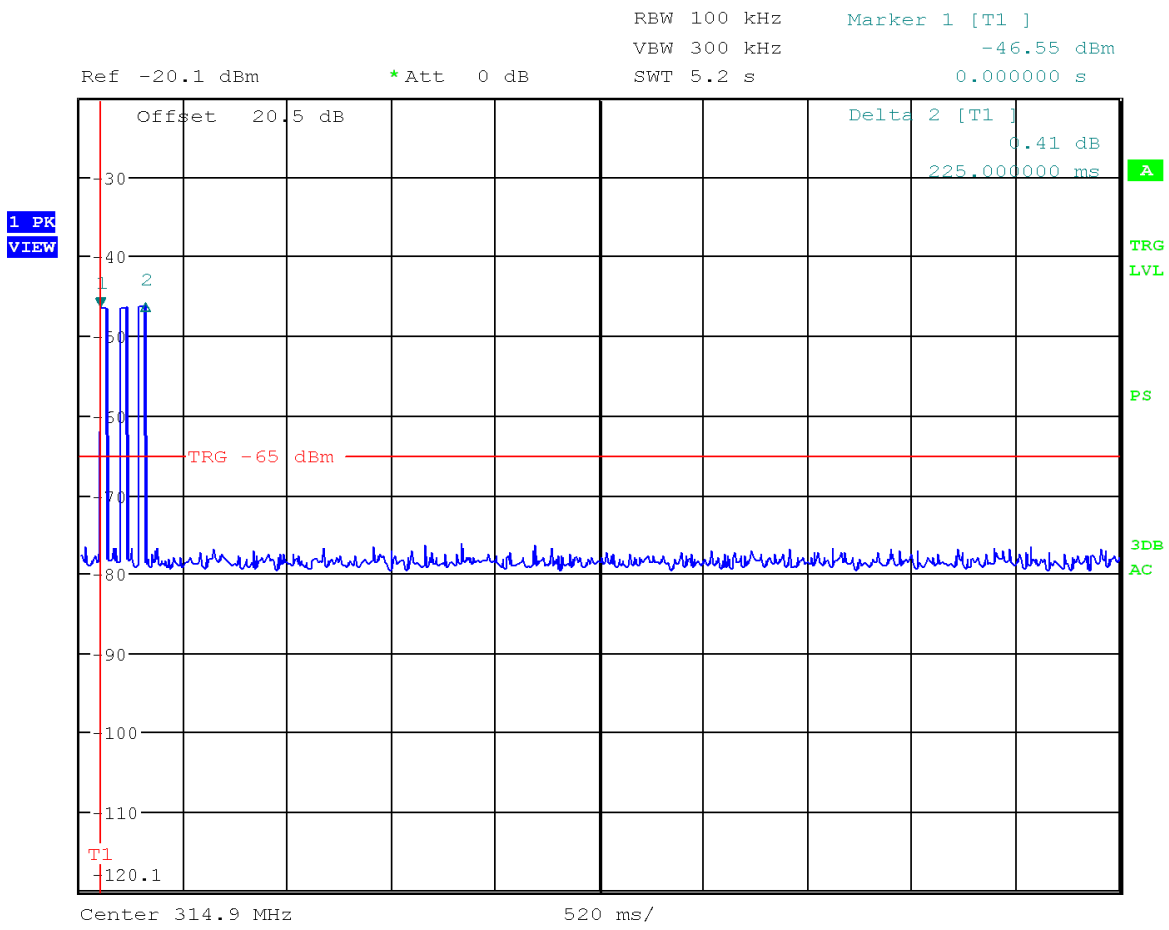


Figure 2-2 – Deactivation Period, 314.9 MHz, FSK Modulation

Sweep Duration (s) (after trigger)	Number of Burst Occurrences	TX End Time (s)	Limit (s)	Margin (s)
5	3	0.225	5	-4.775

Note: The TX uses Aperiodic Operation, and is not subject to the limit of 15.231(a)(3)

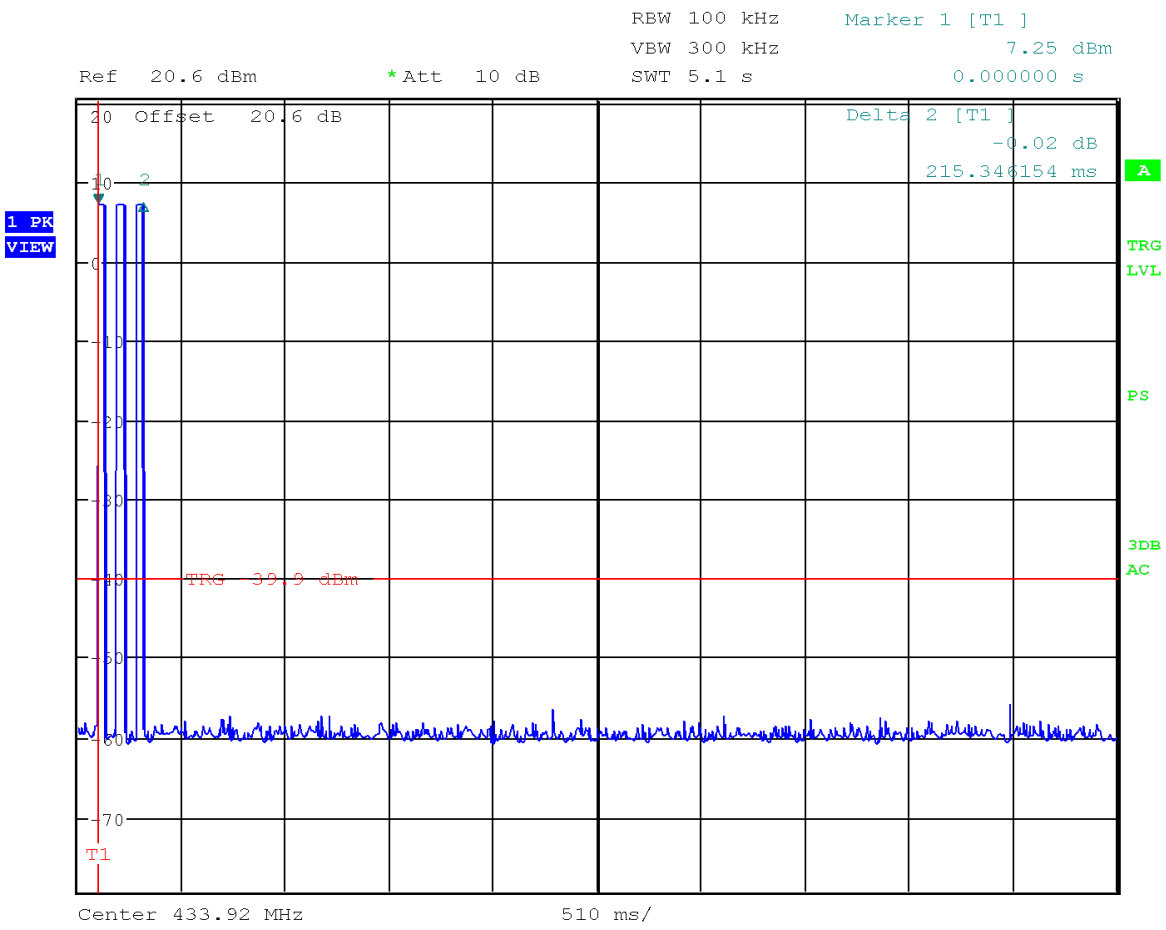


Figure 2-3 – Deactivation Period, 433.92 MHz, ASK Modulation

Sweep Duration (s) (after trigger)	Number of Burst Occurrences	TX End Time (s)	Limit (s)	Margin (s)
5	3	0.215	5	-4.785

Note: The TX uses Aperiodic Operation, and is not subject to the limit of 15.231(a)(3)

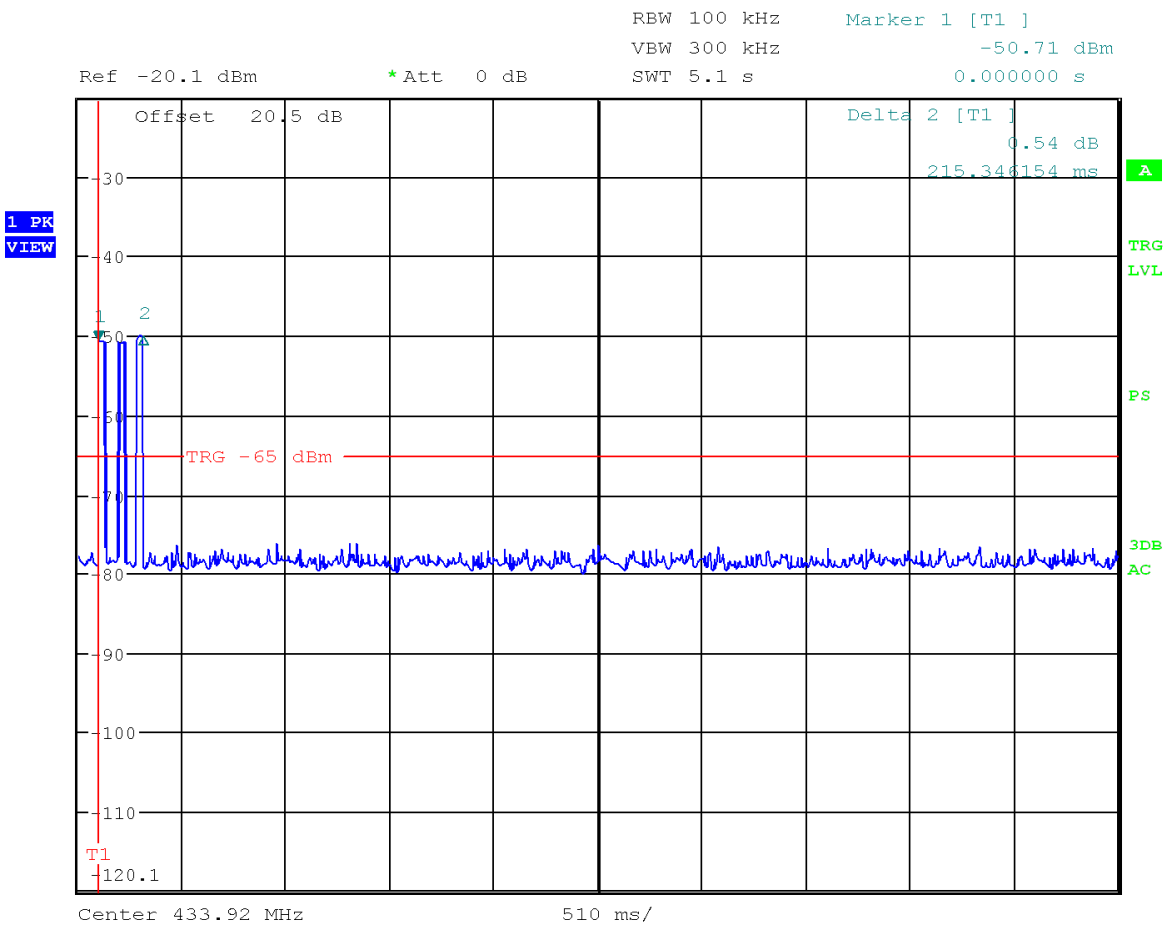


Figure 2-4 – Deactivation Period, 433.92 MHz, FSK Modulation

Sweep Duration (s) (after trigger)	Number of Burst Occurrences	TX End Time (s)	Limit (s)	Margin (s)
5	3	0.226	5	-4.774

Note: The TX uses Aperiodic Operation, and is not subject to the limit of 15.231(a)(3)

2.2.7 Test Location and Test Equipment Used

The tests were carried out in New Brighton, MN.
Test Area: 3mSAC

Table 2.2-1 – Conducted Emissions Test Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
NBLE03509	Florida RF Labs	Cable, SMA 6ft	FL200	6ft-4	B	03/21/2021	03/21/2022
WRLE10998	Rohde & Schwarz	Receiver, 20 Hz-26.5 GHz	ESU 26	100379	G	12/03/2021	12/03/2022
WRLE11397	Meca	Attenuator, 20 dB	603-20-1F18	11397	B	12/02/2021	12/02/2022

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.3 Pulse Characteristics / Duty Cycle

2.3.1 Specification Reference

FCC 47 CFR Part 15.231(b)(2)
ISED RSS-210 A.1.2 a

2.3.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.3.3 Date of Test

2022-January-18

2.3.4 Test Method

The EUT switches, controls, or input data streams were adjusted to ensure that the EUT is transmitting or encoded to obtain the “worst-case” pulse ON time. A radiated, direct connection (i.e., conducted) or a “near-field” coupling method was used to assess the EUT. The RBW was adjusted to be equal or larger than the occupied bandwidth of the signal; the center frequency of the spectrum analyzer was set to the center of the RF signal, and the spectrum analyzer was put into Time Domain analysis (Zero Hz Span). The Sweep Time was adjusted to obtain at least a 100 ms period of time on the horizontal display axis of the spectrum analyzer.

The EUT pulse train is **aperiodic** (i.e., consists of a series of pulses that do not repeat in a characteristic pattern over a constant time period), or the period (T) is greater than 100 ms. The Trigger was set to capture at least 100 ms. The maximum pulse “On time” (tON) over 100 ms was chosen, and Total Pulse On time was determined by summing the duration of all of the pulses within the pulse train [i.e., tON = Σ(t1 + t2 + …tn), and the duty cycle was then determined by dividing the total maximum “ON time” by the period of the pulse train (tON/T).

The duty cycle correction factor was then determined by applying the following equation to the duty cycle determined in the preceding steps:

*20 * Log(numeric duty cycle) = Duty Correction (dB)*

2.3.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.3.6 Test Results

Test Summary: During normal operation the EUT will be limited to the operation(s) specified in this section.

Test Result: Pass

See data below for detailed results.

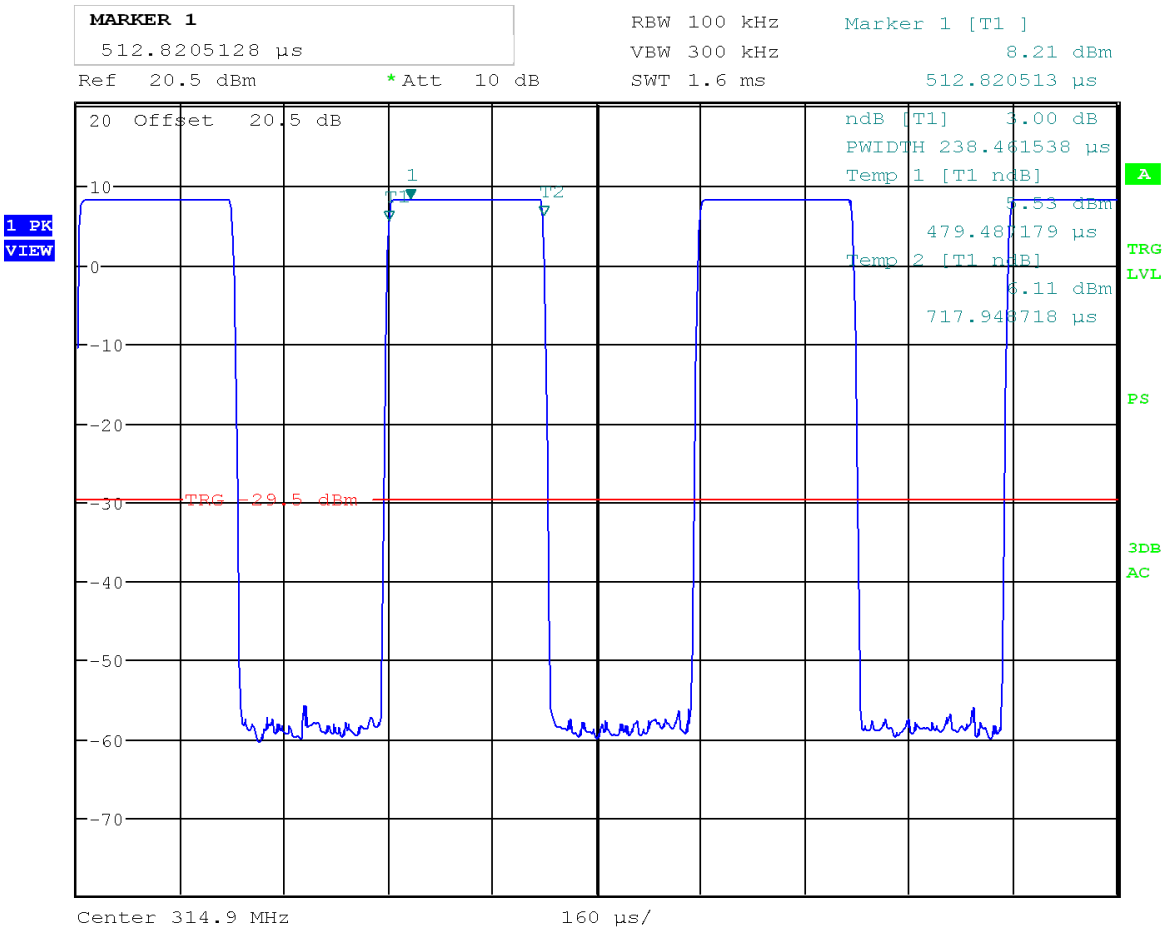


Figure 2-5 – ASK Pulse Width, 314.9 MHz – 238.46 us

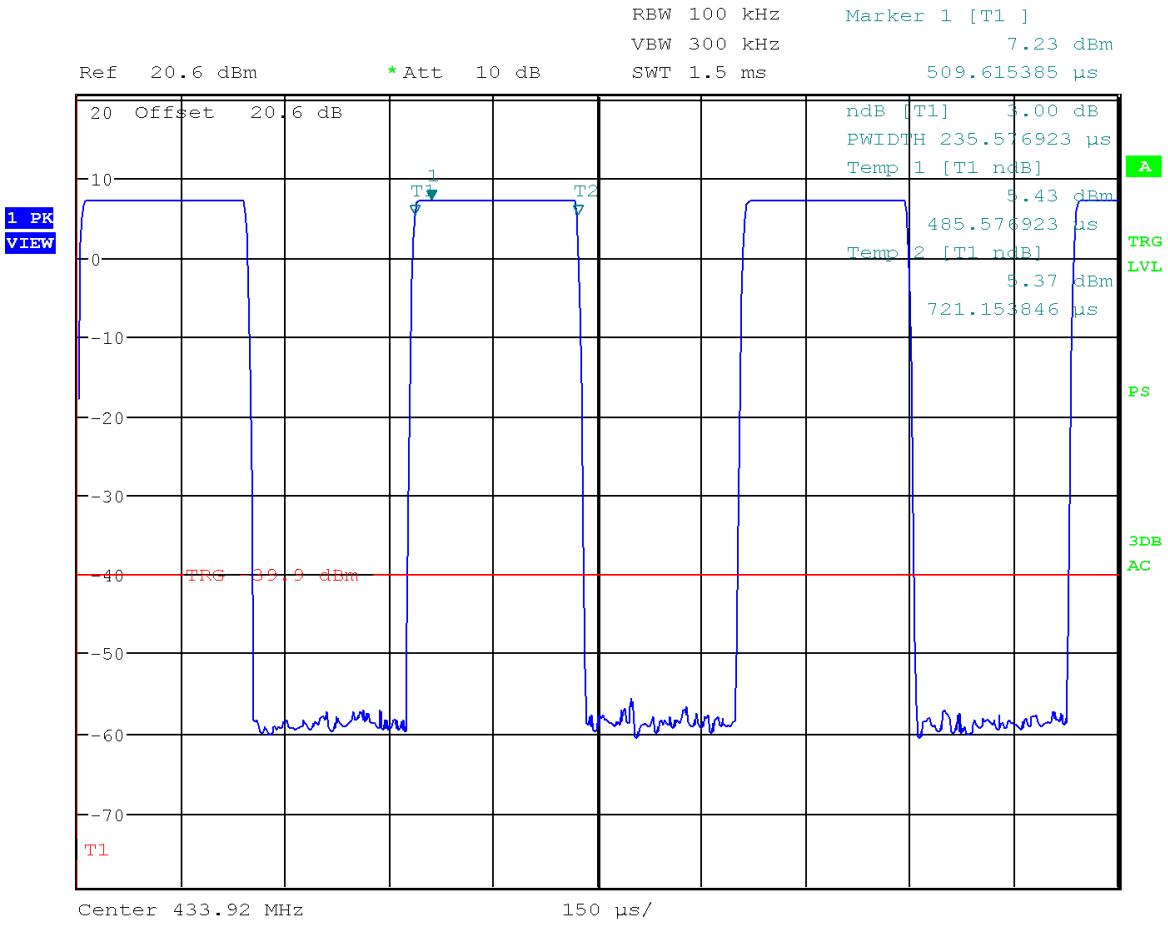


Figure 2-6 – ASK Pulse Width, 433.92 MHz – 235.58 us

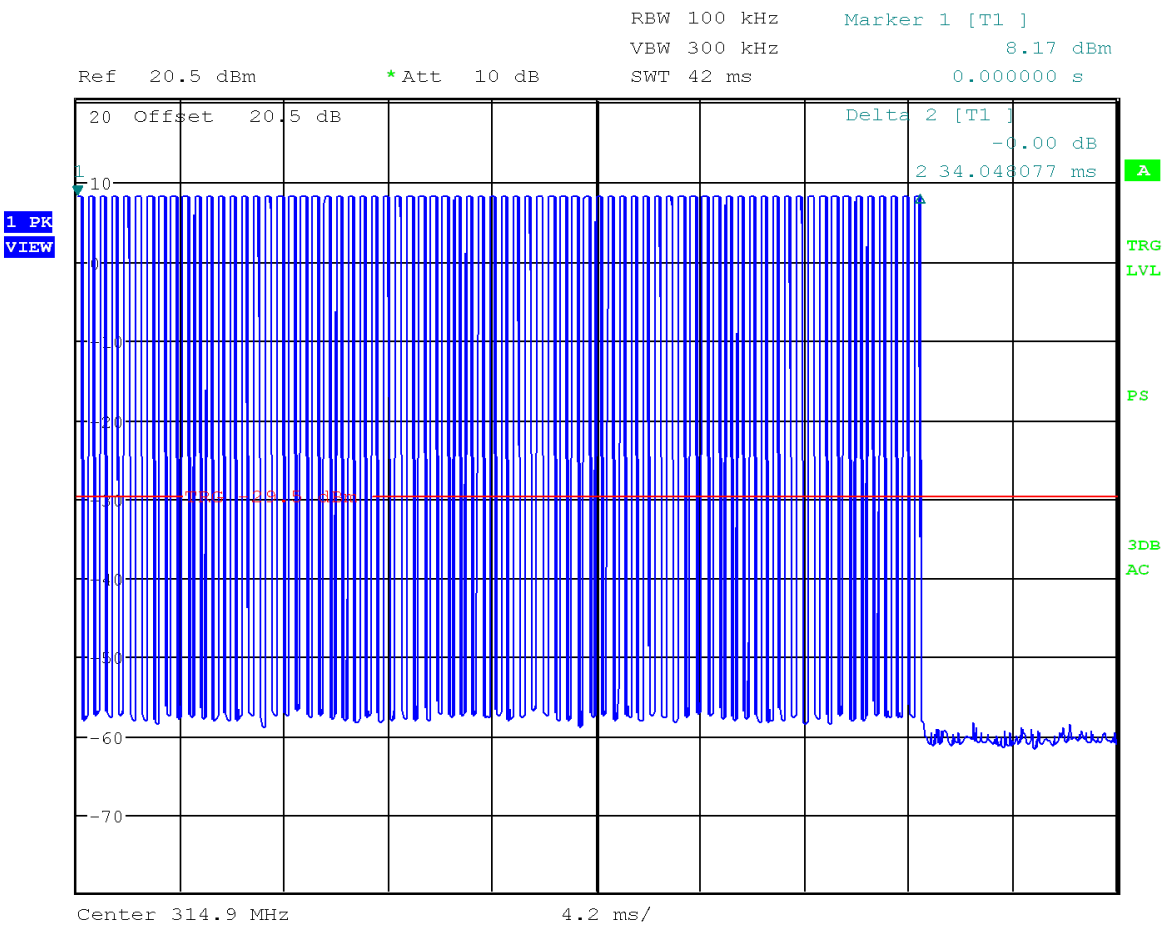


Figure 2-7 – ASK Burst 1 314.9 MHz, 34.05 ms, 72 Occurrences of Pulse 1

TX On-time per Burst = (pulse width 238.46 us) * 72 = **17.17 ms / Burst**

EUT Duty Cycle (per Burst) = 17.17 ms / 34.05 ms = **50.43%**

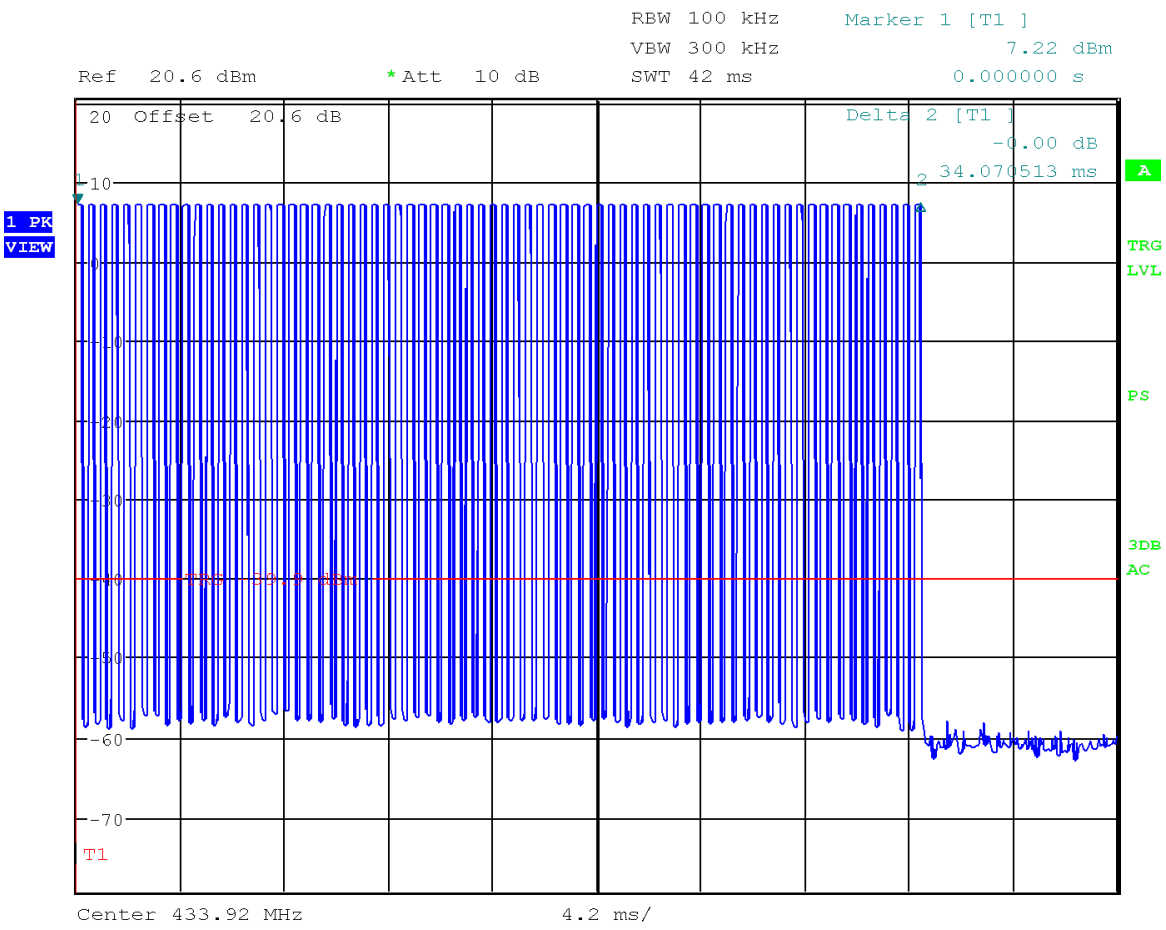
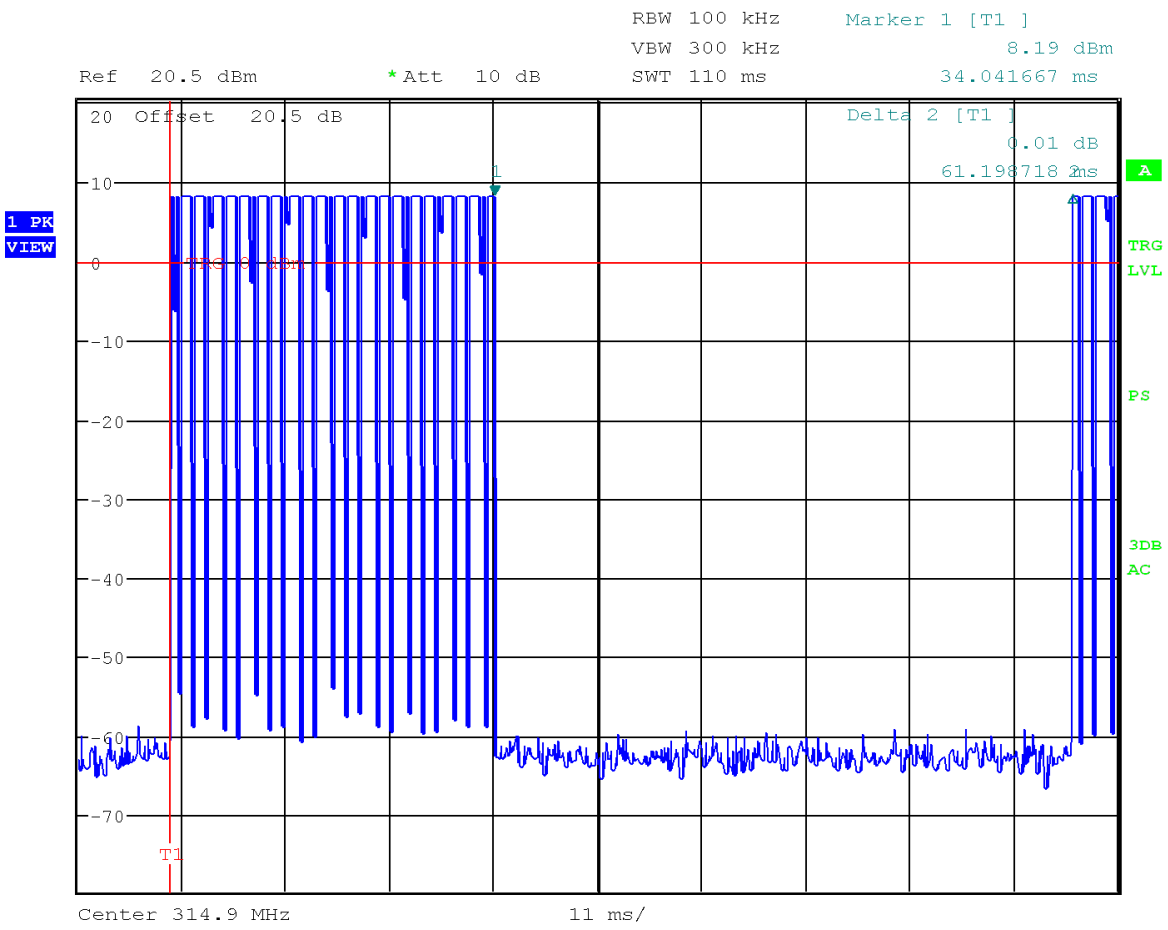


Figure 2-8 – ASK Burst 1 433.92 MHz, 34.07 ms, 72 Occurrences of Pulse 1

TX On-time per Burst = (pulse width 235.58 us) * 72 = **16.96 ms / Burst**

EUT Duty Cycle (per Burst) = 16.96 ms / 34.07 ms = **49.78%**



Date: 18.JAN.2022 08:25:27

Figure 2-9 – ASK Bursts in 100ms 314.9 MHz, 1.14 Bursts
Note: For pulse "offtime" refer to delta measurement of Marker 1 and Marker 2, above.

Transmit On-Time (per 100ms) = 100ms - (offtime 61.20 ms) = **38.8 ms**

EUT Duty Cycle (per 100ms) = (ontime 38.8 ms) * (burst DC 0.5043) = **19.57%**

Duty Cycle Correction Factor = 20 * Log(0.1957) = **-14.17 dB**

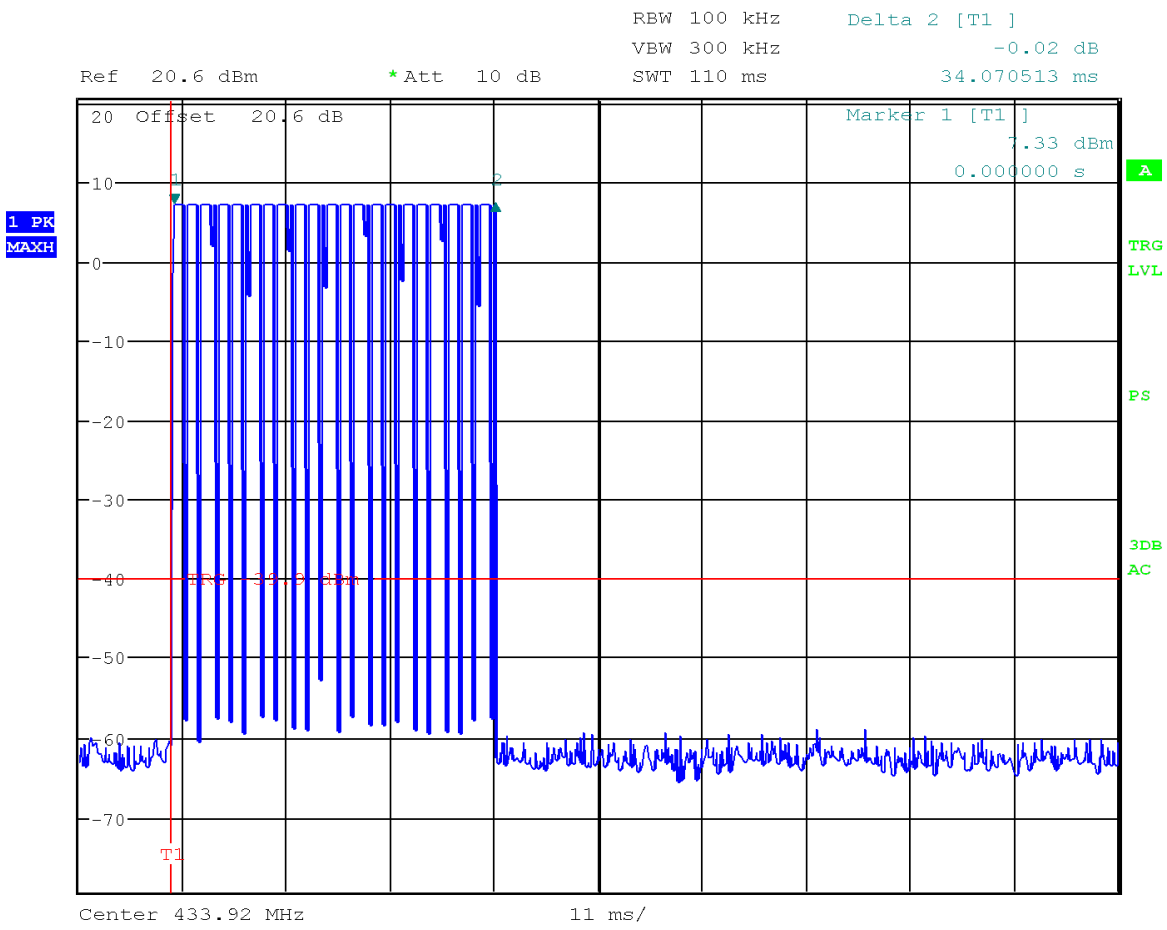


Figure 2-10 – ASK Bursts in 100ms 433.92 MHz, 1 Burst

Transmit On-Time (per 100ms) = 34.07 ms

EUT Duty Cycle (per 100ms) = (on time 34.07 ms) * (burst DC 0.4978) = **16.96%**

Duty Cycle Correction Factor = 20 * Log(0.1696) = **-15.41 dB**

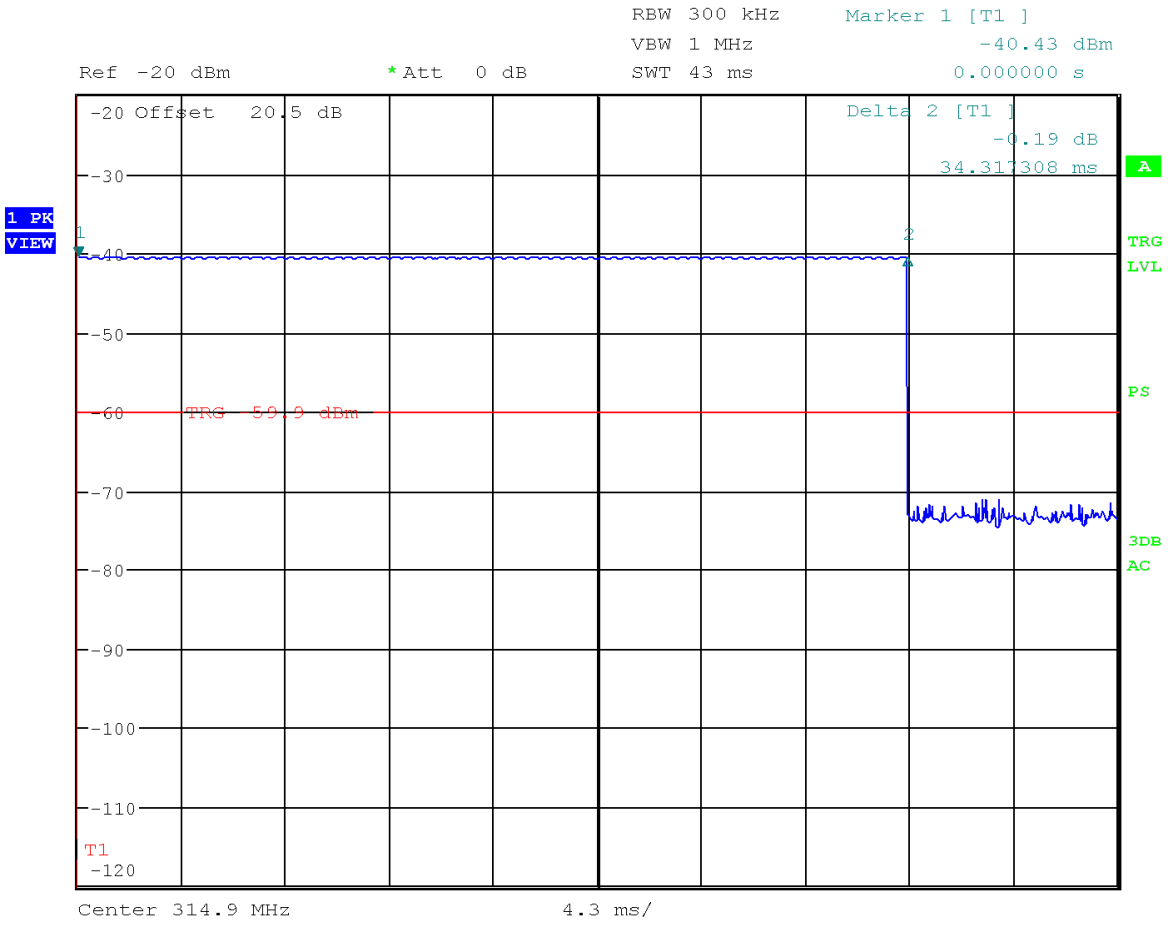


Figure 2-11 – FSK Burst 1 314.9 MHz, 34.32 ms

TX On-time per Burst = 34.32 ms / Burst

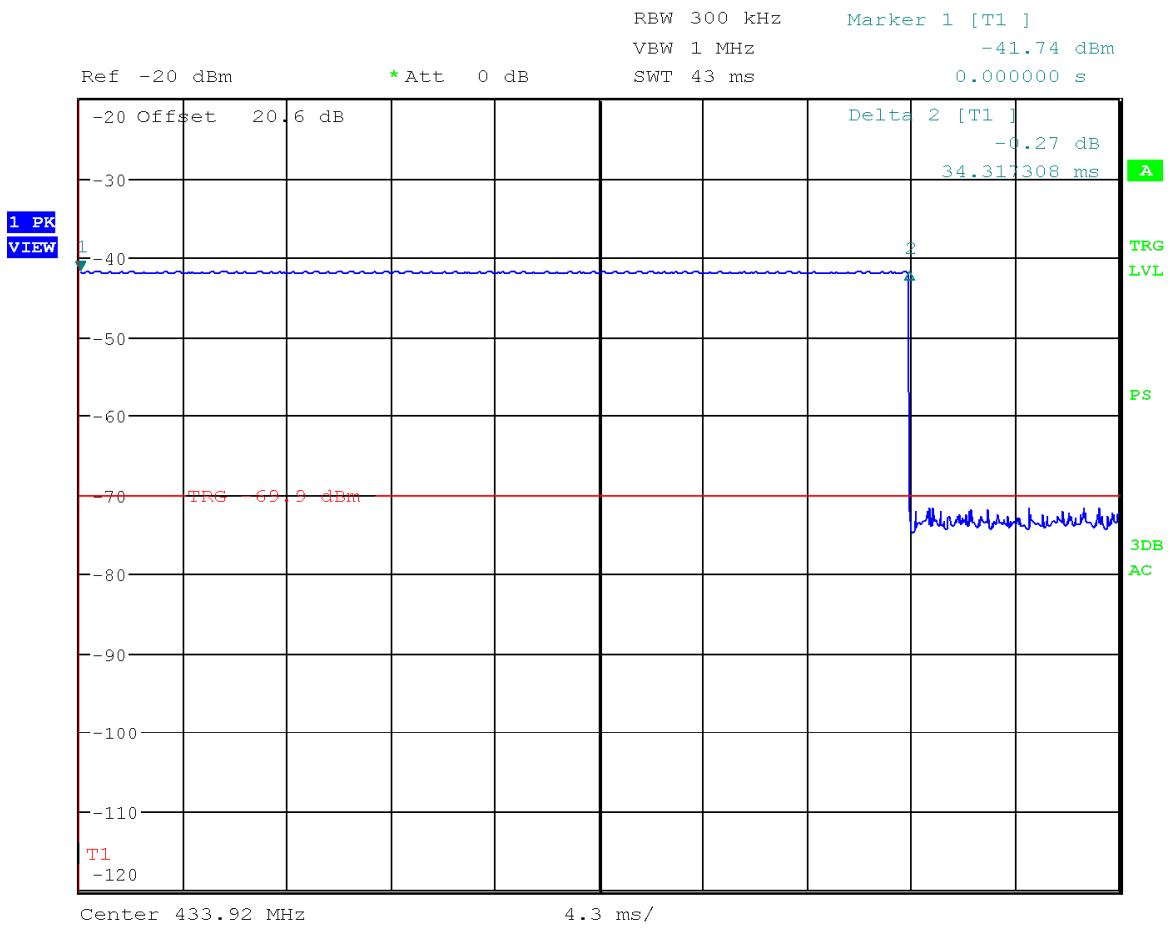


Figure 2-12 – FSK Burst 1 433.92 MHz, 34.32 ms

TX On-time per Burst = 34.32 ms / Burst

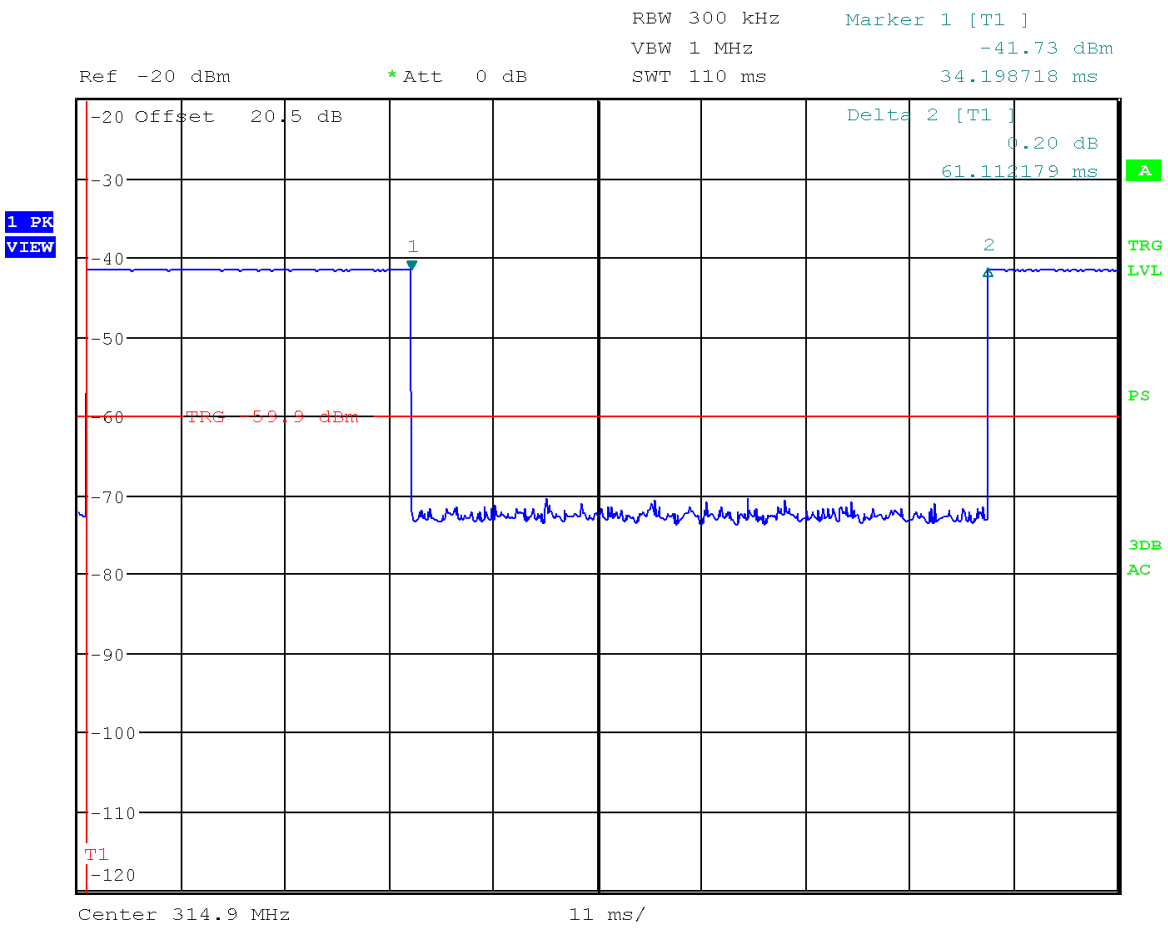


Figure 2-13 – FSK Bursts in 100ms 314.9 MHz, 1.13 Bursts
Note: For pulse "off time" refer to delta measurement of Marker 1 and Marker 2, above.

Transmit On-Time (per 100ms) = 100ms - (off time 61.11 ms) = **38.89 ms**

EUT Duty Cycle (per 100ms) = (on time 38.89 ms) /100 ms = **38.89%**

Duty Cycle Correction Factor = 20 * Log(0.3889) = **-8.20 dB**

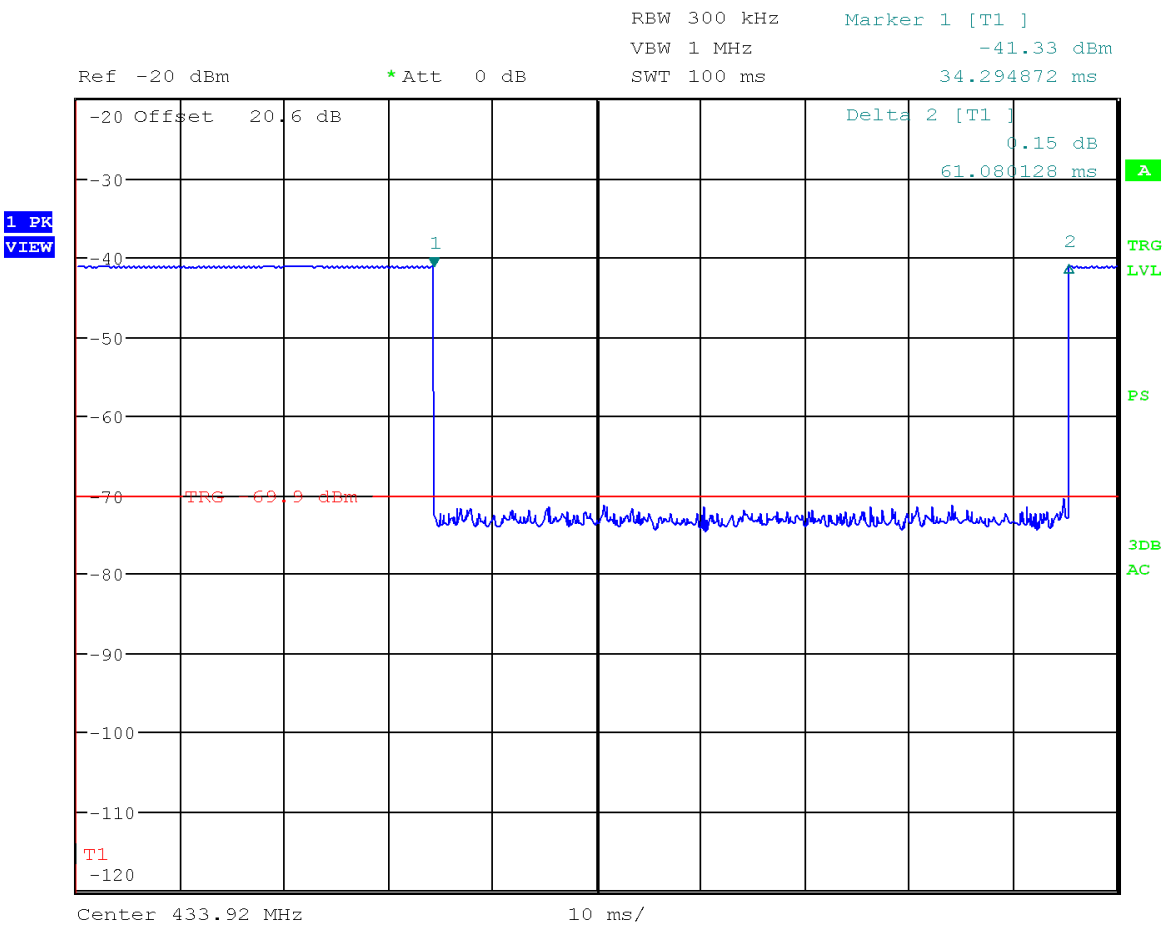


Figure 2-14 – FSK Bursts in 100ms 433.92 MHz, 1.13 Bursts

Transmit On-Time (per 100ms) = 100ms - (off time 61.08 ms) = **38.92 ms**

EUT Duty Cycle (per 100ms) = (on time 38.92 ms) /100 ms = **38.92%**

Duty Cycle Correction Factor = 20 * Log(0.3892) = **-8.20 dB**

2.3.7 Test Location and Test Equipment Used

The tests were carried out in New Brighton, MN.
Test Area: 3mSAC

Table 2.3-1 – Conducted Emissions Test Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
NBLE03509	Florida RF Labs	Cable, SMA 6ft	FL200	6ft-4	B	03/21/2021	03/21/2022
WRLE10998	Rohde & Schwarz	Receiver, 20 Hz-26.5 GHz	ESU 26	100379	G	12/03/2021	12/03/2022
WRLE11397	Meca	Attenuator, 20 dB	603-20-1F18	11397	B	12/02/2021	12/02/2022

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.4 Radiated Fundamental Field Strength

2.4.1 Specification Reference

FCC 47 CFR Part 15.231(b)(1), (3), or 15.231 (e)
ISED RSS-210 A.1.2, Table A1, or RSS-210 A.1.3, Table A2

2.4.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.4.3 Date of Test

2022-January-19

2.4.4 Test Method

The EUT is evaluated according to its operation characteristics in FCC 15.231(b) and RSS-210 Annex 1.1.
If the EUT meets these requirements for operation, it will be evaluated using the field strength limits of FCC 15.231(e) & RSS-210 A.1.2. If the EUT cannot meet these requirements for operation, it will be evaluated using the reduced field strength limits of FCC 15.231(e) & RSS-210 Table A2.

The EUT was set up in a semi-anechoic chamber on a remotely controlled turntable and placed on a non-conductive table 0.8 m above a reference ground plane for 30-1000 MHz and 1.5m above the ground plane for above 1 GHz.

For 30-1000 MHz a pre-scan of the EUT emissions profile was made while varying the antenna-to-EUT azimuth and antenna-to-EUT polarization using a peak detector; measurements were taken at a 3m distance.

For above 1 GHz a pre-scan of the EUT emissions profile was made while varying the antenna-to-EUT azimuth and antenna-to-EUT polarization using peak and average detectors; measurements were taken at a 3m distance.

For all frequency ranges the final readings were maximized by adjusting the antenna height, polarization and turntable azimuth, in accordance with the specification. For final measurements the analyzer was then corrected by adding all necessary offset(s) for the measurement and duty cycle, with a Peak, Quasi-Peak, or Average measurement detector, as per the standard.

2.4.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.4.6 Additional Observations

The highest frequency to which the DUT was measured in accordance with §15.33(a)(1).

Automated measurements used BAT-EMC (v3.18) software. Measurements were done at a 3m distance. Reported level is the actual level with all the correction factors factored in. Correction Factor column is for informational purposes only.

2.4.7 Sample Computation (Radiated Emissions)

Measuring equipment raw measurement (dBµV) @ 30 MHz			20.0
Correction Factor (dB)	Cable 2	0.24	18.94
	TEMC00011 (antenna)	18.70	
Reported Quasi-peak Final Measurement (dBµV/m) @ 30 MHz			38.94

2.4.8 Test Results

Test Summary: The EUT was measured in accordance with both 15.231(b)(2) and 15.35(c), and the duty cycle correction factor and the measurement correction factor(s) have been applied.

Test Result: Pass

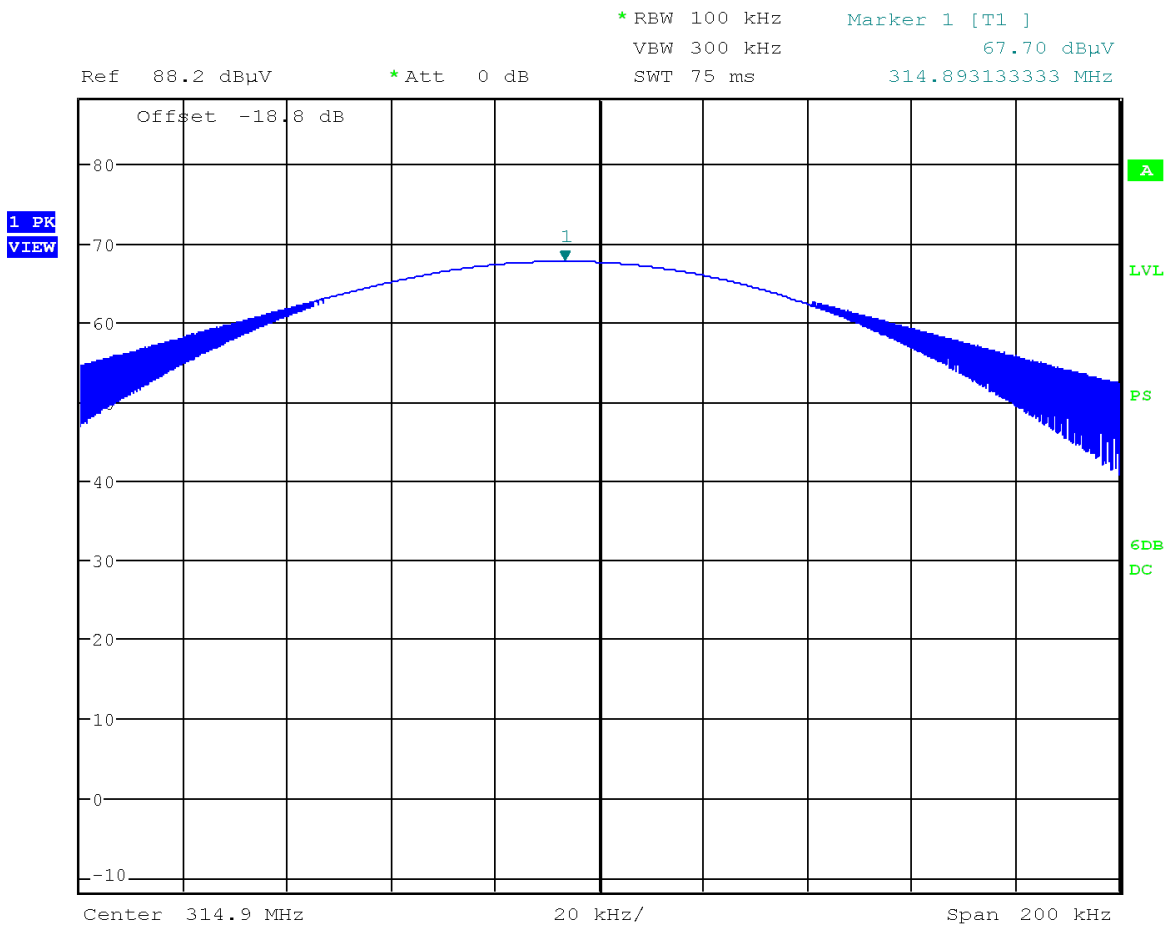


Figure 2-15 – Fundamental Field Strength, ASK 314.9 MHz

Note: Analyzer reading has been corrected for measurement system losses & gains, as well as the Duty Cycle Correction Factor of the EUT.

Table 2.4-1 – Fundamental Field Strength

Tuned Frequency (MHz)	Detector	Distance (m)	Field Strength (dBµV/m)	Fundamental Limit (dBuV/m)	Margin (dB)
314.9	PK	3	67.70	75.62	-7.92

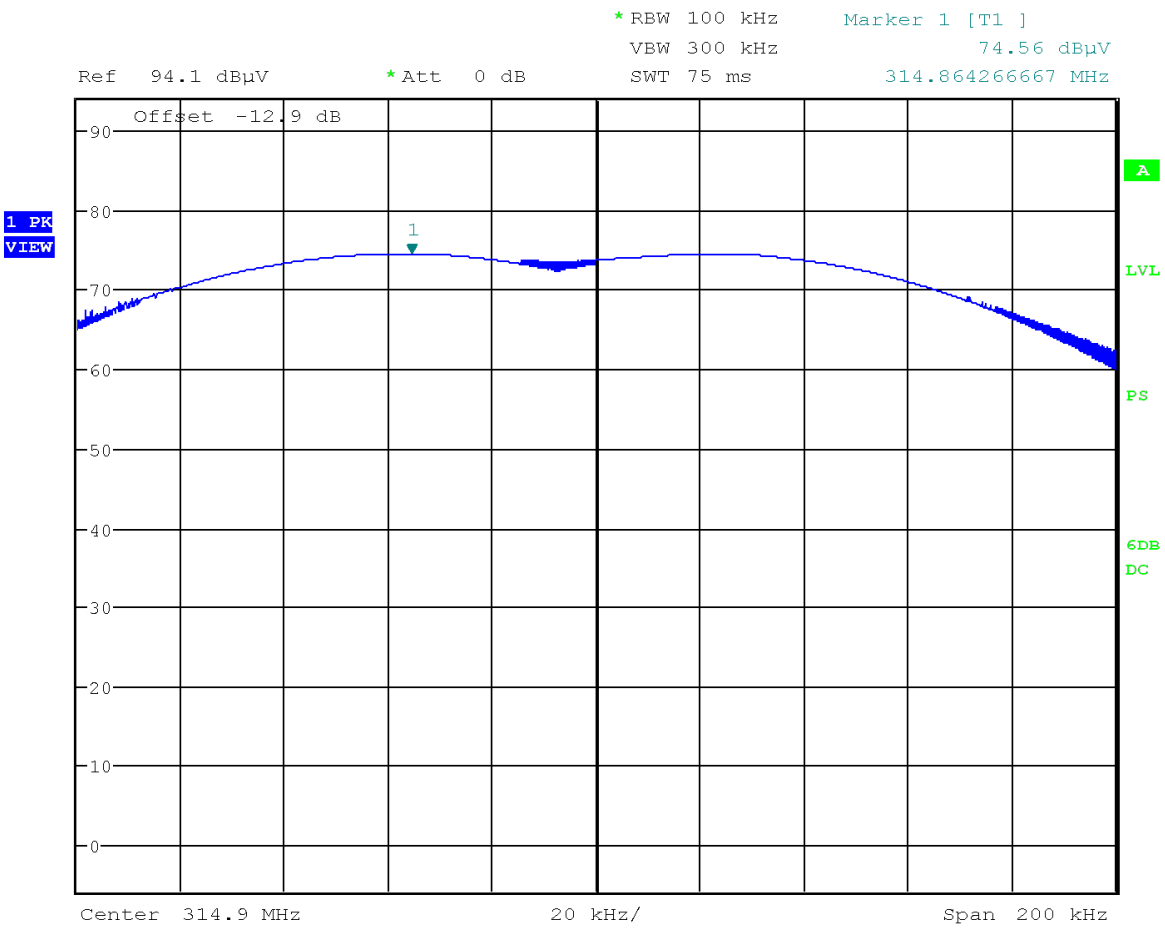


Figure 2-16 – Fundamental Field Strength, FSK 314.9 MHz

Note: Analyzer reading has been corrected for measurement system losses & gains, as well as the Duty Cycle Correction Factor of the EUT.

Table 2.4-2 – Fundamental Field Strength

Tuned Frequency (MHz)	Detector	Distance (m)	Field Strength (dBµV/m)	Fundamental Limit (dBuV/m)	Margin (dB)
314.9	PK	3	74.56	75.62	-1.06

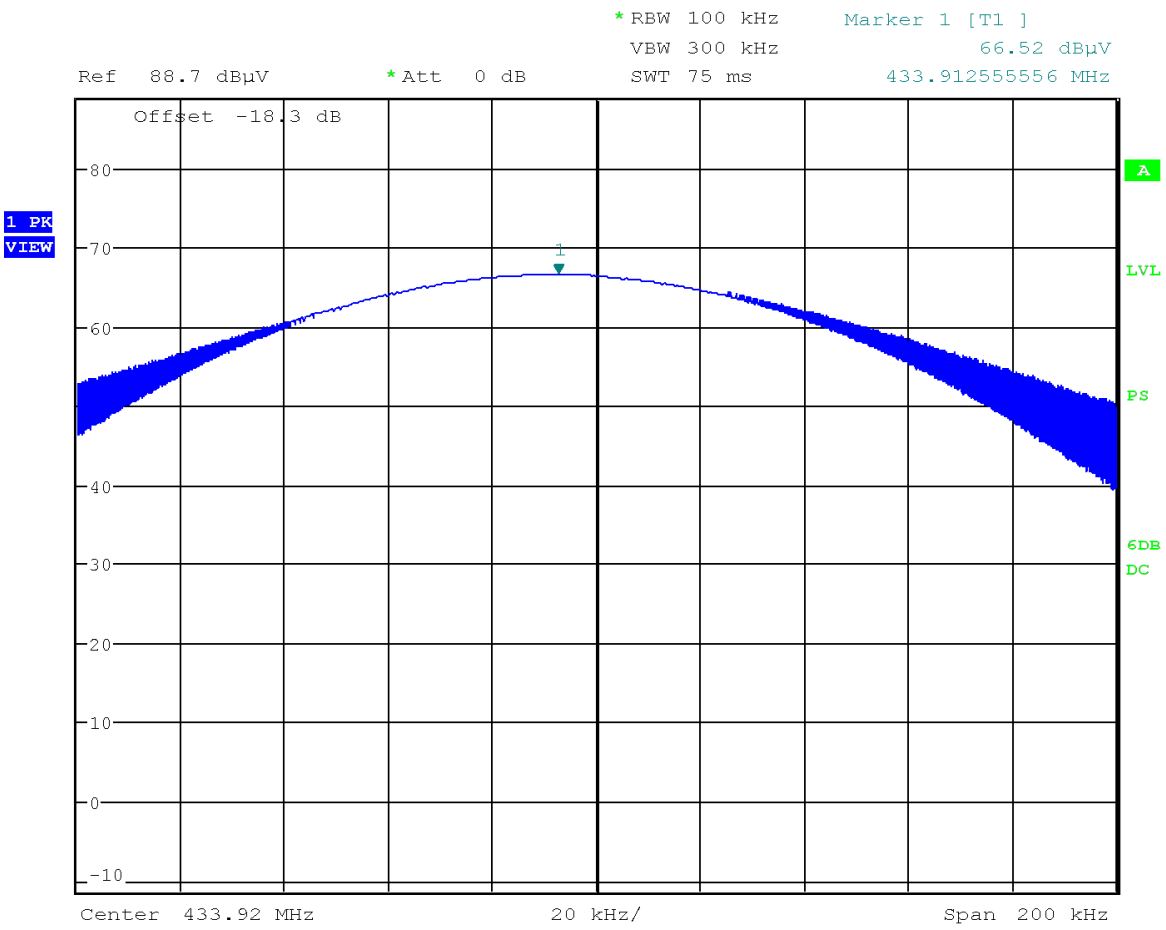


Figure 2-17 – Fundamental Field Strength, ASK 433.92 MHz

Note: Analyzer reading has been corrected for measurement system losses & gains, as well as the Duty Cycle Correction Factor of the EUT.

Table 2.4-3 – Fundamental Field Strength

Tuned Frequency (MHz)	Detector	Distance (m)	Field Strength (dBµV/m)	Fundamental Limit (dBuV/m)	Margin (dB)
433.92	PK	3	66.52	80.15	-13.63

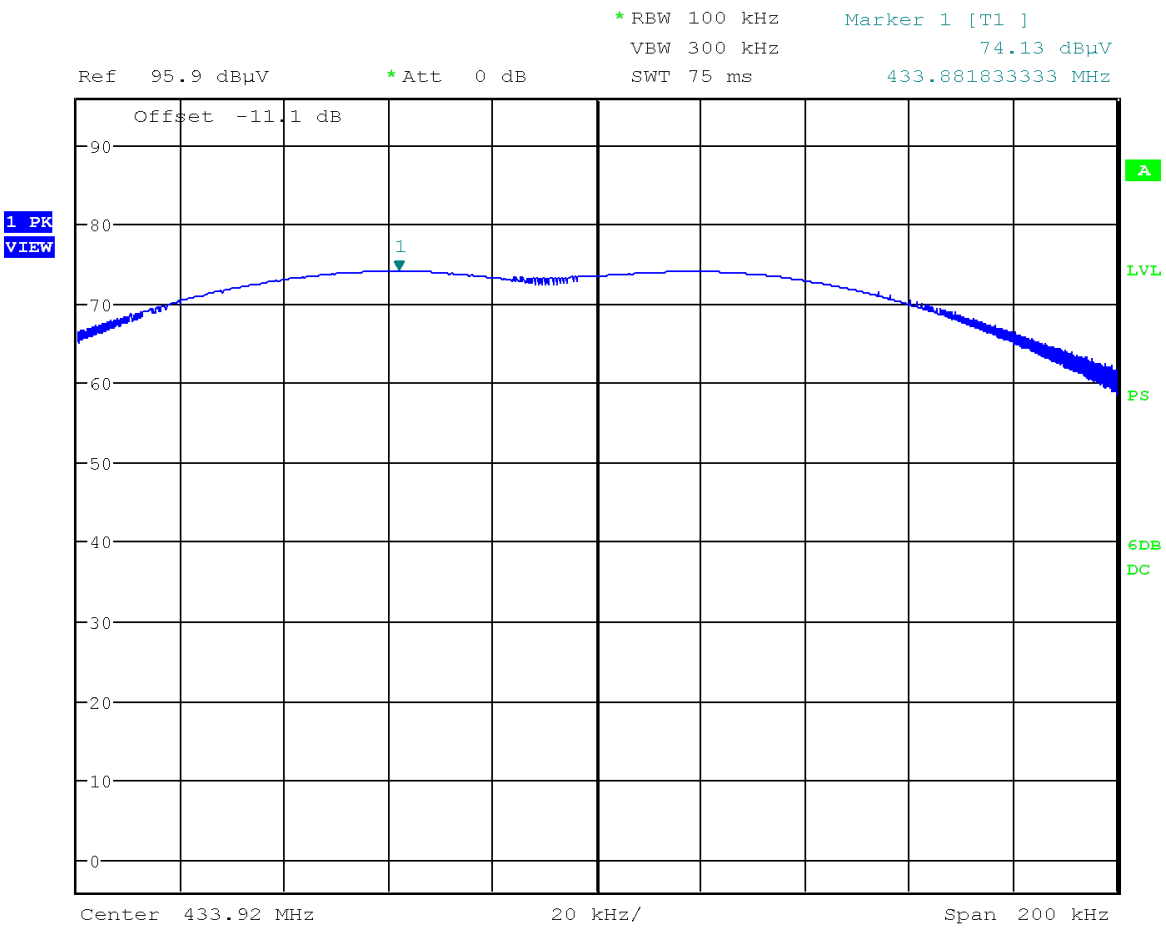


Figure 2-18 – Fundamental Field Strength, FSK 433.92 MHz

Note: Analyzer reading has been corrected for measurement system losses & gains, as well as the Duty Cycle Correction Factor of the EUT.

Table 2.4-4 – Fundamental Field Strength

Tuned Frequency (MHz)	Detector	Distance (m)	Field Strength (dBµV/m)	Fundamental Limit (dBuV/m)	Margin (dB)
433.92	PK	3	74.13	80.15	-6.02

2.4.9 Test Location and Test Equipment Used

The tests were carried out in New Brighton, MN.
Test Area: 3mSAC

Table 2.4-5 – Radiated Emissions Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
NBLE10985	Agilent Technologies	Pre Amplifier, 0.1-1300 MHz	8447D	2443A04180	B	04/07/2021	04/07/2022
WRLE11519	Com-Power Corp.	Preamp, 500 MHz-18 GHz	PAM-118A	18040002	B	01/08/2021	01/08/2022
WRLE10998	Rohde & Schwarz	Receiver, 20 Hz-26.5 GHz	ESU 26	100379	G	12/03/2021	12/03/2022
NBLE11578	ETS-Lindgren	Antenna, BiConiLog	3142C	00079889	G	09/14/2020	09/14/2022
NBLE11630	ETS-Lindgren	Antenna, 1-18 GHz	3117	00218816	G	09/04/2020	09/04/2022

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.5 Radiated Spurious Emissions

2.5.1 Specification Reference

FCC 47 CFR Part 15.231(b)(1), (e)
ISED RSS-210 A.1.2; A.1.4

2.5.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.5.3 Date of Test

2022-January-20

2.5.4 Test Method

The EUT was set up in a semi-anechoic chamber on a remotely controlled turntable and placed on a non-conductive table 0.8 m above a reference ground plane for 30-1000 MHz and 1.5m above the ground plane for above 1 GHz.

For 30-1000 MHz a pre-scan of the EUT emissions profile was made while varying the antenna-to-EUT azimuth and antenna-to-EUT polarization using a peak detector; measurements were taken at a 3m distance.

For above 1 GHz a pre-scan of the EUT emissions profile was made while varying the antenna-to-EUT azimuth and antenna-to-EUT polarization using peak and average detectors; measurements were taken at a 3m distance.

For all frequency ranges the final readings were maximized by adjusting the antenna height, polarization and turntable azimuth, in accordance with the specification. For final measurements below 1 GHz a quasi-peak detector was used and above 1 GHz final measurements were re-measured with peak and average detectors.

The EUT was assessed against the limits specified in FCC 47 CFR Part 15C §15.209.

2.5.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.5.6 Additional Observations

The highest frequency to which the DUT was measured in accordance with §15.33(a)(1).

Automated measurements used BAT-EMC (v3.18) software. Measurements were done at a 3m distance. Reported level is the actual level with all the correction factors factored in. Correction Factor column is for informational purposes only.

2.5.7 Sample Computation (Radiated Emissions)

Measuring equipment raw measurement (dBµV) @ 30 MHz			20.0
Correction Factor (dB)	Cable 2	0.24	18.94
	TEMC00011 (antenna)	18.70	
Reported Quasi-peak Final Measurement (dBµV/m) @ 30 MHz			38.94

2.5.8 Test Results

Test Summary: Device was pre-scanned about all 3 axes as used in normal operation, and worst-case emissions were noted when device was lying flat, facing upwards (labelled as the “Y axis” during this test).

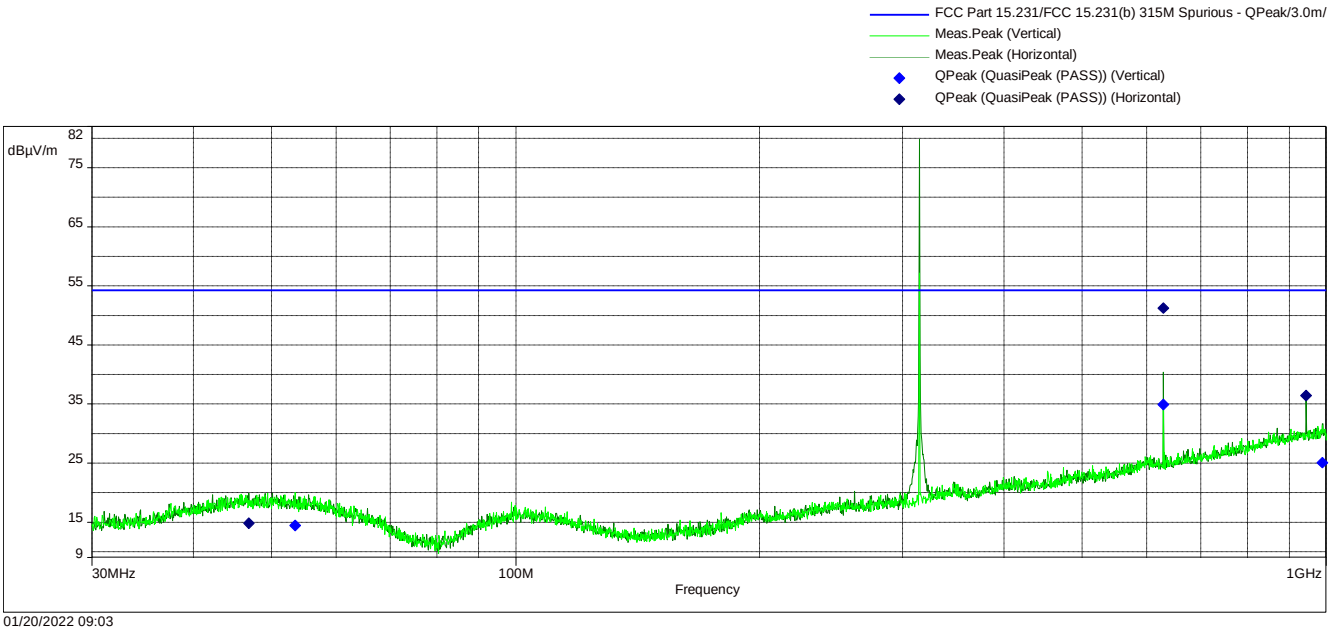
EUT operated as intended before, during, and after testing.

Test Result: Pass

See data below for detailed results.

Spurious Emissions 30M-1GHz (ASK 314.9 MHz)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
30MHz- 1GHz	Vertical	3m	100kHz	18001Pts	Auto
30MHz- 1GHz	Horizontal	3m	100kHz	18001Pts	Auto



Limit:
FCC 15.231(b)

Test Results:
Pass

Test Notes: The device's fundamental emission is not subject to the pictured limit.

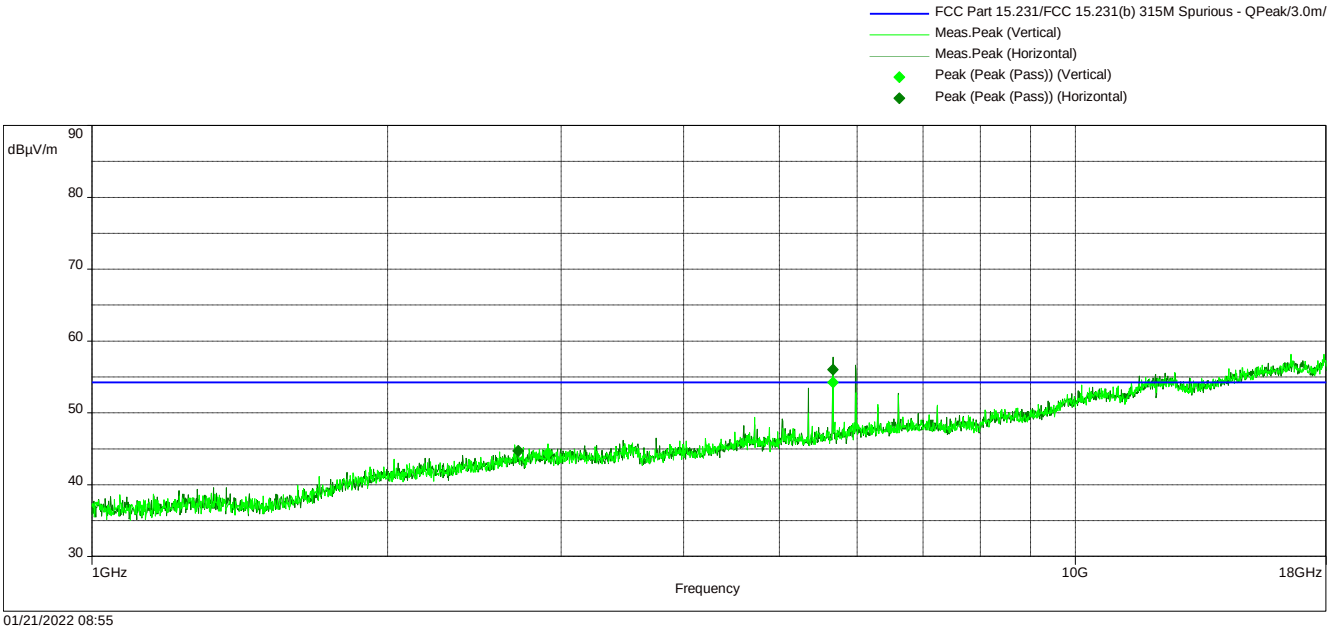
Figure 2-19 – RE Spurious Emissions 30-1000 MHz – ASK, Low Channel

Table 2.5-1 – RE Spurious Emissions 30-1000 MHz – ASK, Low Channel

Frequency	QP Level (dBuV/m)	QP Limit (dBuV/m)	Margin (dB)	Azimuth (º)	Height (m)	Polarity	Result
46.864978MHz	14.81	54.22	-39.41	86.00	1.09	Horizontal	PASS
53.487223MHz	14.38	54.22	-39.84	137.00	1.21	Vertical	PASS
629.78605MHz	34.94	54.22	-19.28	185.00	1.13	Vertical	PASS
629.78621MHz	51.25	54.22	-2.97	356.00	1.59	Horizontal	PASS
944.67907MHz	36.45	54.22	-17.77	17.00	1.02	Horizontal	PASS
988.94925MHz	25.13	54.22	-29.09	348.00	1.05	Vertical	PASS

Spurious Emissions 1-18GHz (ASK 314.9 MHz)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
1GHz- 18GHz	Vertical	3m	1MHz	18001Pts	Auto
1GHz- 18GHz	Horizontal	3m	1MHz	18001Pts	Auto



Limit:
FCC 15.231(b)

Test Results:
Pass

Figure 2-20 – RE Spurious Emissions 1-18 GHz – ASK, Low Channel

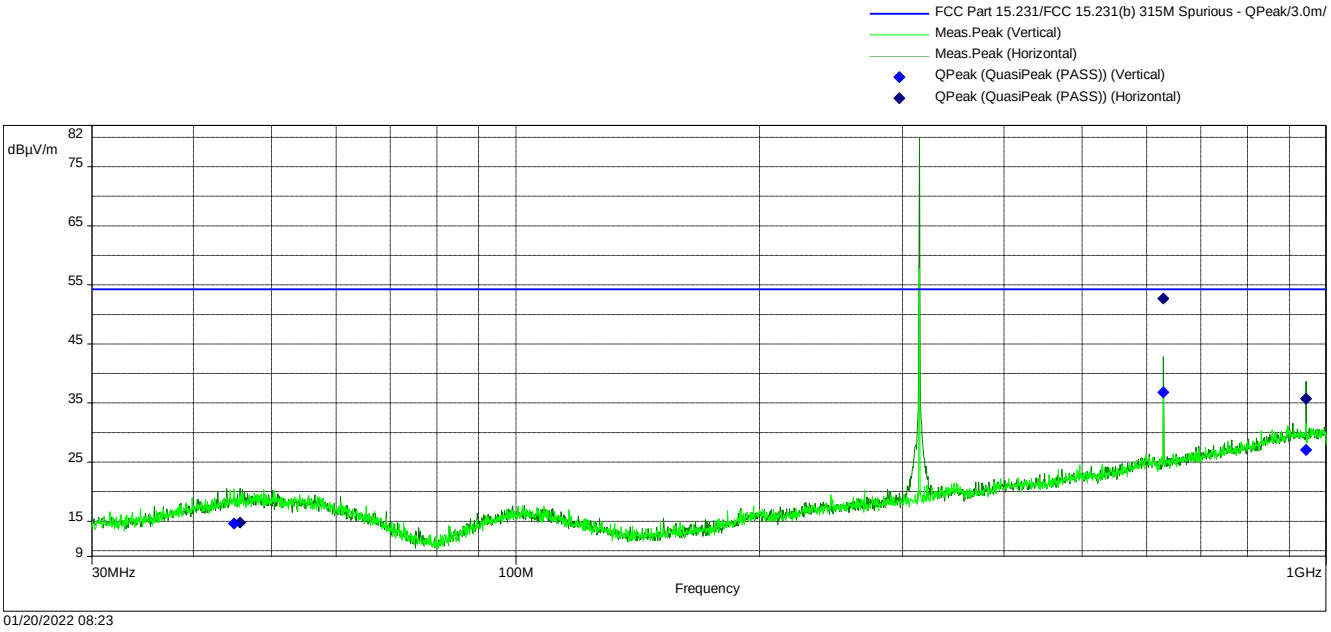
Table 2.5-2 – RE Spurious Emissions 1-18 GHz – ASK, Low Channel

Frequency	Peak Level (dBuV/m)	QPeak Limit (dBuV/m)	Margin (dB)	Azimuth (º)	Height (m)	Polarity	Average Result
2.7132222GHz	44.75	54.22	-9.47	3.00	2.86	Horizontal	PASS
2.9087222GHz	44.39	54.22	-9.83	5.00	3.10	Vertical	PASS
5.6674444GHz	54.23	n/a	n/a	247.00	1.00	Vertical	n/a

Note: Test results marked “n/a” are not necessary for compliance with the indicated standards, and are provided as informational only.

Spurious Emissions 30M-1GHz (FSK 314.9 MHz)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
30MHz- 1GHz	Vertical	3m	100kHz	18001Pts	Auto
30MHz- 1GHz	Horizontal	3m	100kHz	18001Pts	Auto



Limit:
FCC 15.231(b)

Test Results:
Pass

Test Notes: The device's fundamental emission is not subject to the pictured limit.

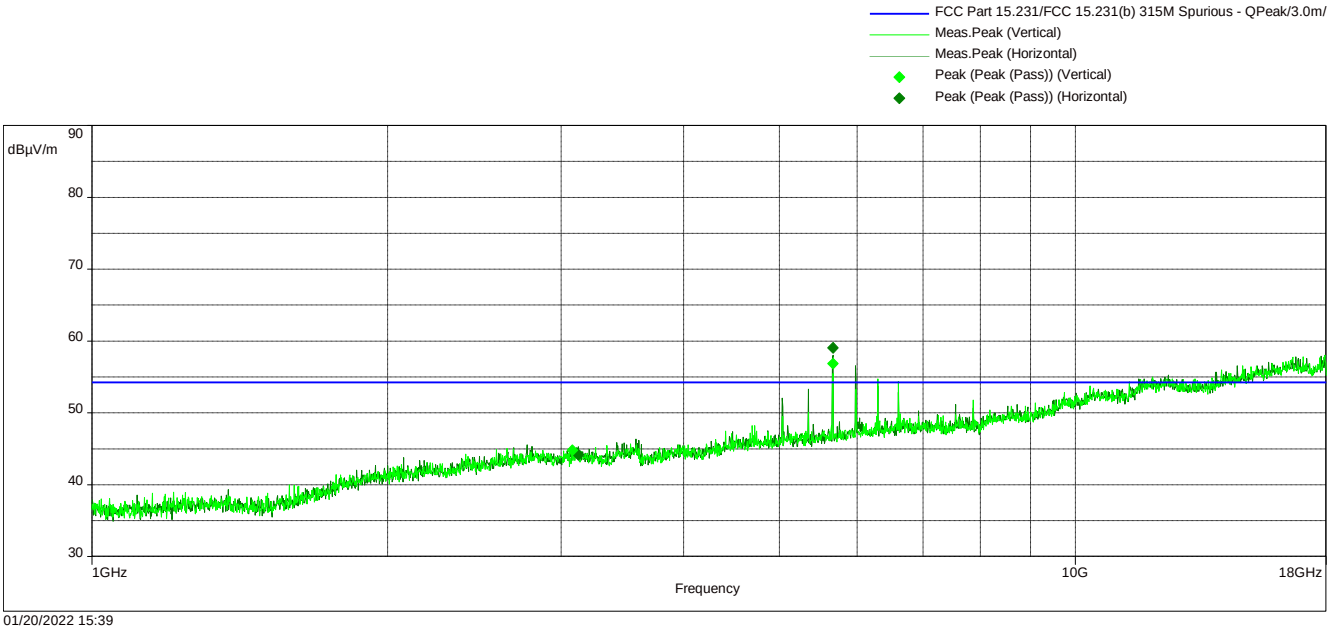
Figure 2-21 – RE Spurious Emissions 30-1000 MHz – FSK, Low Channel

Table 2.5-3 – RE Spurious Emissions 30-1000 MHz – FSK, Low Channel

Frequency	QP Level (dBuV/m)	QP Limit (dBuV/m)	Margin (dB)	Azimuth (º)	Height (m)	Polarity	Result
44.929786MHz	14.62	54.22	-39.60	318.00	1.05	Vertical	PASS
45.700898MHz	14.78	54.22	-39.44	17.00	2.04	Horizontal	PASS
629.7264MHz	52.64	54.22	-1.58	178.00	1.59	Horizontal	PASS
629.84395MHz	36.81	54.22	-17.41	0.00	1.05	Vertical	PASS
944.76806MHz	35.77	54.22	-18.45	226.00	1.05	Horizontal	PASS
944.76806MHz	27.09	54.22	-27.13	337.00	1.76	Vertical	PASS

Spurious Emissions 1-18GHz (FSK 314.9 MHz)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
1GHz- 18GHz	Vertical	3m	1MHz	18001Pts	Auto
1GHz- 18GHz	Horizontal	3m	1MHz	18001Pts	Auto



Limit:
FCC 15.231(b)

Test Results:
Pass

Figure 2-22 – RE Spurious Emissions 1-18 GHz – FSK, Low Channel

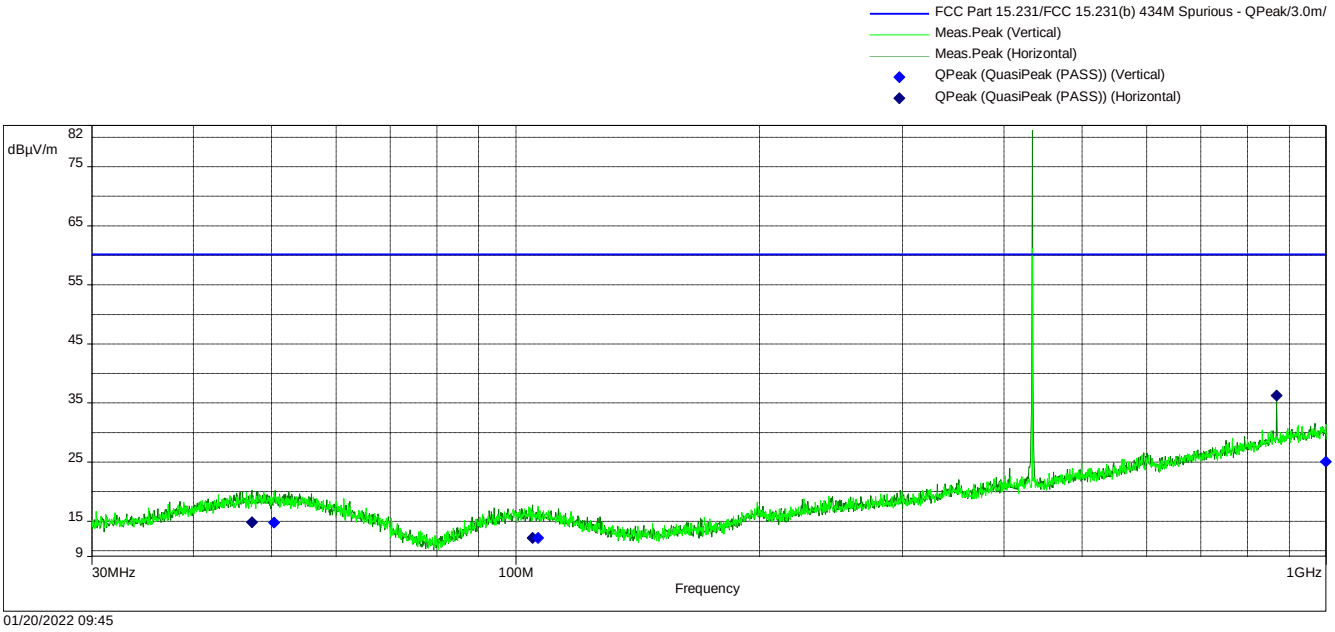
Table 2.5-4 – RE Spurious Emissions 1-18 GHz – FSK, Low Channel

Frequency	Peak Level (dBuV/m)	QPeak Limit (dBuV/m)	Margin (dB)	Azimuth (º)	Height (m)	Polarity	Average Result
3.0815556GHz	44.81	54.22	-9.41	192.00	2.75	Vertical	PASS
3.1231111GHz	44.21	54.22	-10.01	3.00	2.60	Horizontal	PASS
5.6674444GHz	59.03	n/a	n/a	226.00	1.09	Horizontal	n/a
5.6683889GHz	56.86	n/a	n/a	251.00	1.05	Vertical	n/a

Note: Test results marked “n/a” are not necessary for compliance with the indicated standards, and are provided as informational only.

Spurious Emissions 30M-1GHz (ASK 433.92 MHz)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
30MHz- 1GHz	Vertical	3m	100kHz	18001Pts	Auto
30MHz- 1GHz	Horizontal	3m	100kHz	18001Pts	Auto



Limit:
FCC 15.231(b)

Test Results:
Pass

Test Notes: The device's fundamental emission is not subject to the pictured limit.

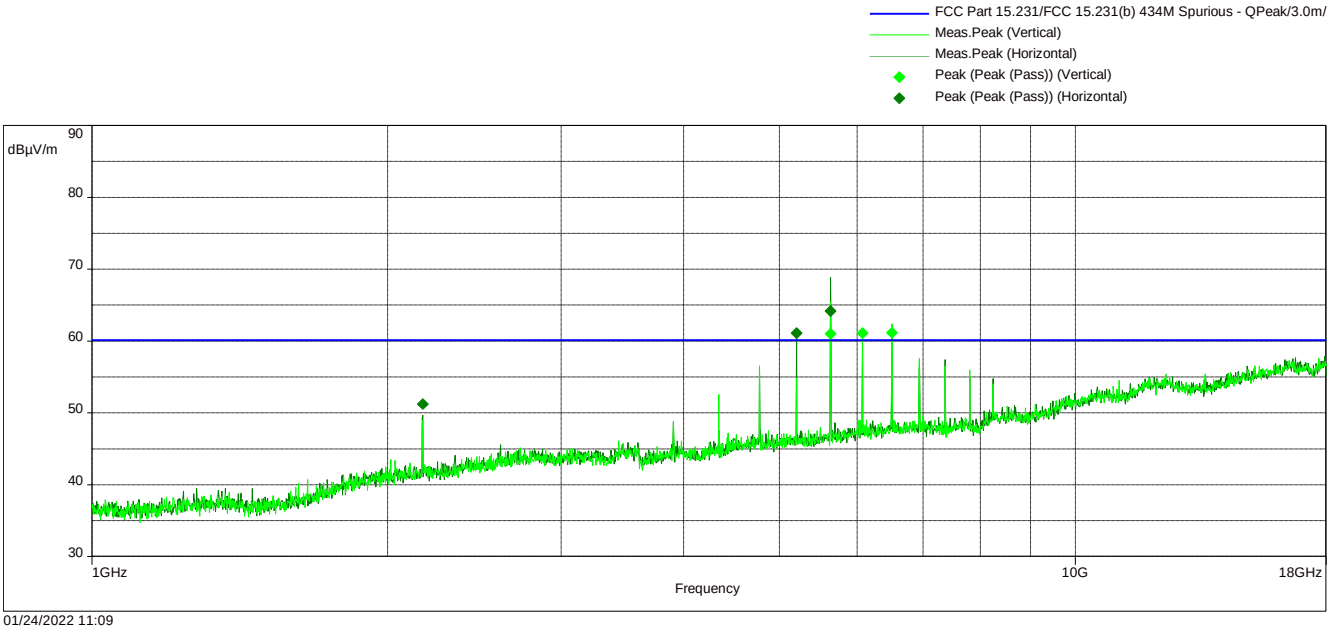
Figure 2-23 – RE Spurious Emissions 30-1000 MHz – ASK, High Channel

Table 2.5-5 – RE Spurious Emissions 30-1000 MHz – ASK, High Channel

Frequency	QP Level (dBuV/m)	QP Limit (dBuV/m)	Margin (dB)	Azimuth (º)	Height (m)	Polarity	Result
47.234829MHz	14.83	60.15	-45.32	293.00	1.33	Horizontal	PASS
50.324765MHz	14.73	60.15	-45.42	32.00	1.95	Vertical	PASS
104.92303MHz	12.20	60.15	-47.95	224.00	2.27	Horizontal	PASS
106.57723MHz	12.14	60.15	-48.01	212.00	1.29	Vertical	PASS
867.82454MHz	36.28	60.15	-23.87	17.00	1.13	Horizontal	PASS
998.38285MHz	25.12	60.15	-35.03	300.00	1.05	Vertical	PASS

Spurious Emissions 1-18GHz (ASK 433.92 MHz)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
1GHz- 18GHz	Vertical	3m	1MHz	18001Pts	Auto
1GHz- 18GHz	Horizontal	3m	1MHz	18001Pts	Auto



Limit:
FCC 15.231(b)

Test Results:
Pass

Figure 2-24 – RE Spurious Emissions 1-18 GHz – ASK, High Channel

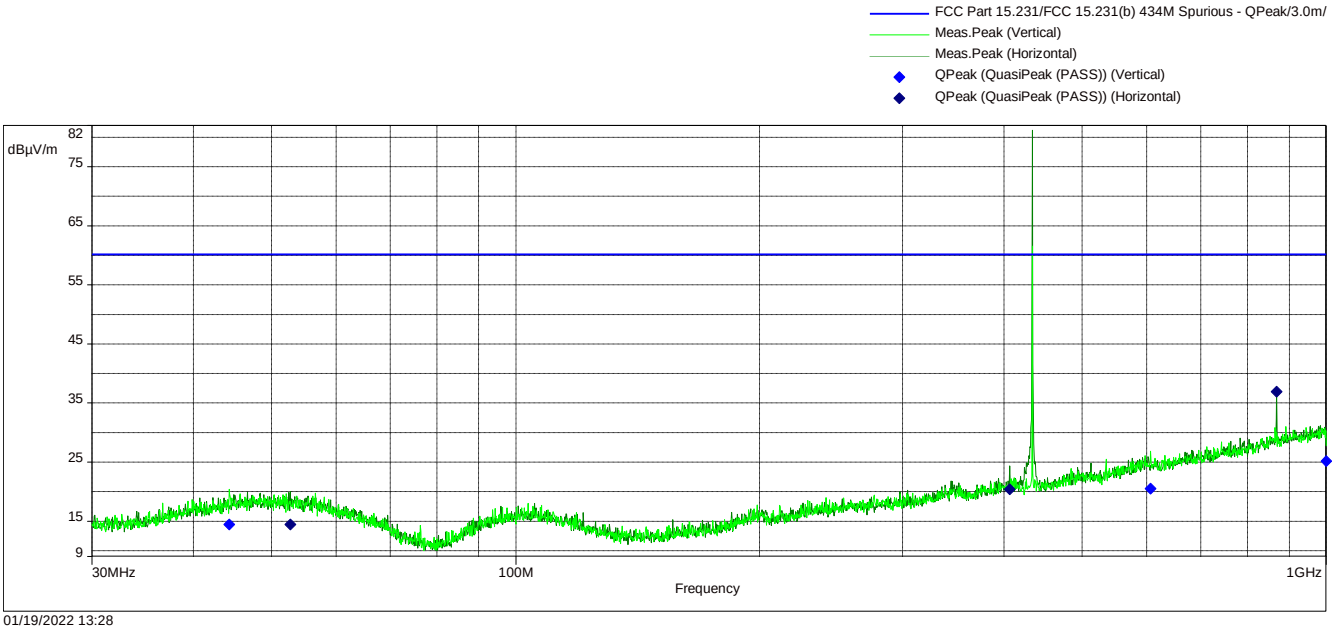
Table 2.5-6 – RE Spurious Emissions 1-18 GHz – ASK, High Channel

Frequency	Peak Level (dBuV/m)	QPeak Limit (dBuV/m)	Margin (dB)	Azimuth (º)	Height (m)	Polarity	Average Result
2.1692222GHz	51.27	60.15	-8.88	116.00	1.72	Horizontal	PASS
5.2065556GHz	61.08	n/a	n/a	67.00	1.01	Horizontal	n/a
5.6400556GHz	61.00	n/a	n/a	51.00	1.17	Vertical	n/a
6.0745GHz	61.12	n/a	n/a	171.00	3.40	Vertical	n/a
6.508GHz	61.19	n/a	n/a	40.00	3.72	Vertical	n/a

Note: Test results marked “n/a” are not necessary for compliance with the indicated standards, and are provided as informational only.

Spurious Emissions 30M-1GHz (FSK 433.92 MHz)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
30MHz- 1GHz	Vertical	3m	100kHz	18001Pts	Auto
30MHz- 1GHz	Horizontal	3m	100kHz	18001Pts	Auto



Limit:
FCC 15.231(b)

Test Results:
Pass

Test Notes: The device's fundamental emission is not subject to the pictured limit.

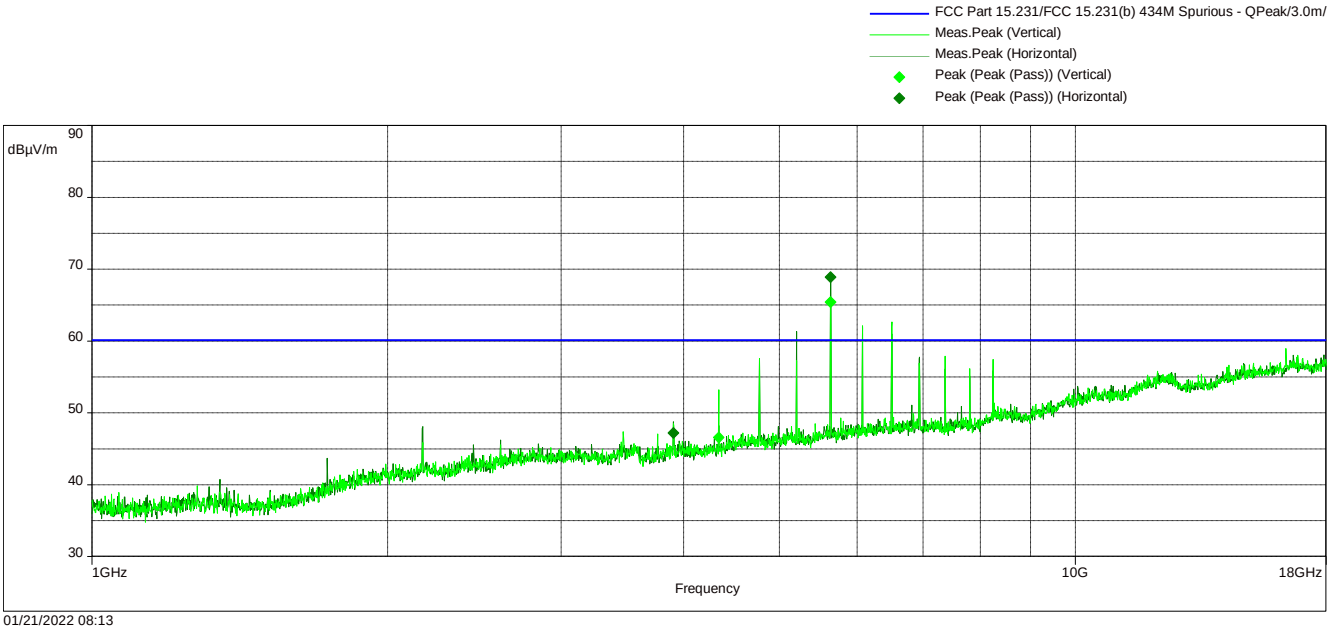
Figure 2-25 – RE Spurious Emissions 30-1000 MHz – FSK, High Channel

Table 2.5-7 – RE Spurious Emissions 30-1000 MHz – FSK, High Channel

Frequency	QP Level (dBuV/m)	QP Limit (dBuV/m)	Margin (dB)	Azimuth (º)	Height (m)	Polarity	Result
44.308162MHz	14.46	60.15	-45.69	276.00	1.17	Vertical	PASS
52.713664MHz	14.41	60.15	-45.74	110.00	1.13	Horizontal	PASS
406.76322MHz	20.39	60.15	-39.76	296.00	1.33	Horizontal	PASS
606.65346MHz	20.51	60.15	-39.64	136.00	1.44	Vertical	PASS
867.76324MHz	36.95	60.15	-23.20	343.00	1.05	Horizontal	PASS
999.9679MHz	25.16	60.15	-34.99	172.00	3.12	Vertical	PASS

Spurious Emissions 1-18GHz (FSK 433.92 MHz)

Frequency Range	Polarity	Antenna Distance	RBW	Step Size	Sweep Time
1GHz- 18GHz	Vertical	3m	1MHz	18001Pts	Auto
1GHz- 18GHz	Horizontal	3m	1MHz	18001Pts	Auto



Limit:
FCC 15.231(b)

Test Results:
Pass

Figure 2-26 – RE Spurious Emissions 1-18 GHz – FSK, High Channel

Table 2.5-8 – RE Spurious Emissions 1-18 GHz – FSK, High Channel

Frequency	Peak Level (dBuV/m)	QPeak Limit (dBuV/m)	Margin (dB)	Azimuth (º)	Height (m)	Polarity	Average Result
3.9041667GHz	47.16	60.15	-12.99	315.00	3.58	Horizontal	PASS
4.3376667GHz	46.57	60.15	-13.58	309.00	1.87	Vertical	PASS
5.6400556GHz	68.88	n/a	n/a	72.00	1.00	Horizontal	n/a

Note: Test results marked “n/a” are not necessary for compliance with the indicated standards, and are provided as informational only.

2.5.9 Test Location and Test Equipment Used

The tests were carried out in New Brighton, MN.
Test Area: 3mSAC

Table 2.5-9 – Radiated Emissions Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
NBLE10985	Agilent Technologies	Pre Amplifier, 0.1-1300 MHz	8447D	2443A04180	B	04/07/2021	04/07/2022
WRLE11519	Com-Power Corp.	Preamp, 500 MHz-18 GHz	PAM-118A	18040002	B	01/08/2021	01/08/2022
WRLE10998	Rohde & Schwarz	Receiver, 20 Hz-26.5 GHz	ESU 26	100379	G	12/03/2021	12/03/2022
NBLE11578	ETS-Lindgren	Antenna, BiConiLog	3142C	00079889	G	09/14/2020	09/14/2022
NBLE11630	ETS-Lindgren	Antenna, 1-18 GHz	3117	00218816	G	09/04/2020	09/04/2022

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.6 Occupied Bandwidth

2.6.1 Specification Reference

FCC 47 CFR Part 15.231(c)
ISED RSS-210 A.1.3

2.6.2 Equipment Under Test and Modification State

As shown in §1.4 with modification state “0”, as noted in §1.6.

2.6.3 Date of Test

2022-January-18

2.6.4 Test Method

A signal source was connected to the input of the EUT and configured to transmit the appropriate test signal as specified by the standard(s). The center frequency of the Spectrum Analyzer was set to the nominal EUT channel center frequency. The span range for the spectrum analyzer was set between 2 × to 5 × the EBW (or OBW). The RBW was set to 1% to 5% of the anticipated OBW, and the VBW shall be set ≥ 3 × RBW. The reference level of the spectrum analyzer was set to accommodate the maximum input amplitude level, with the detection mode set to peak, and trace mode set to max hold. The OBW automatic measurement function in the spectrum analyzer was utilized to produce either the Power Bandwidth or XdB down Bandwidth.

2.6.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.6.6 Test Results

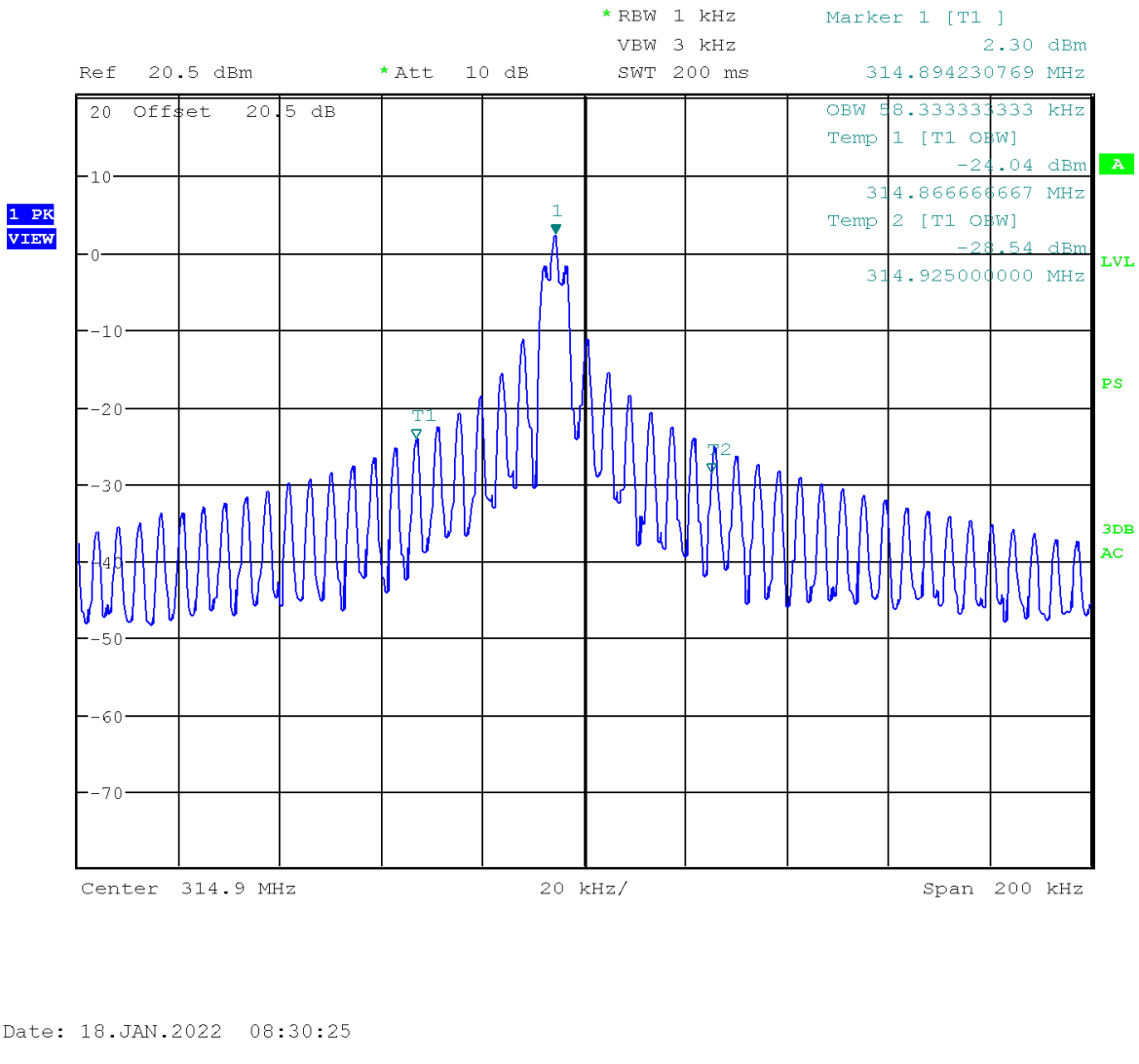


Figure 2-27 – Occupied Bandwidth – ASK Modulation, 314.9 MHz

Table 2.6-1 – Occupied Bandwidth

Frequency (MHz)	Occupied Bandwidth Type	Occupied Bandwidth (kHz)	Limit (kHz)	Margin (kHz)
314.9	99% OBW	58.33	78725.0	-78666.67

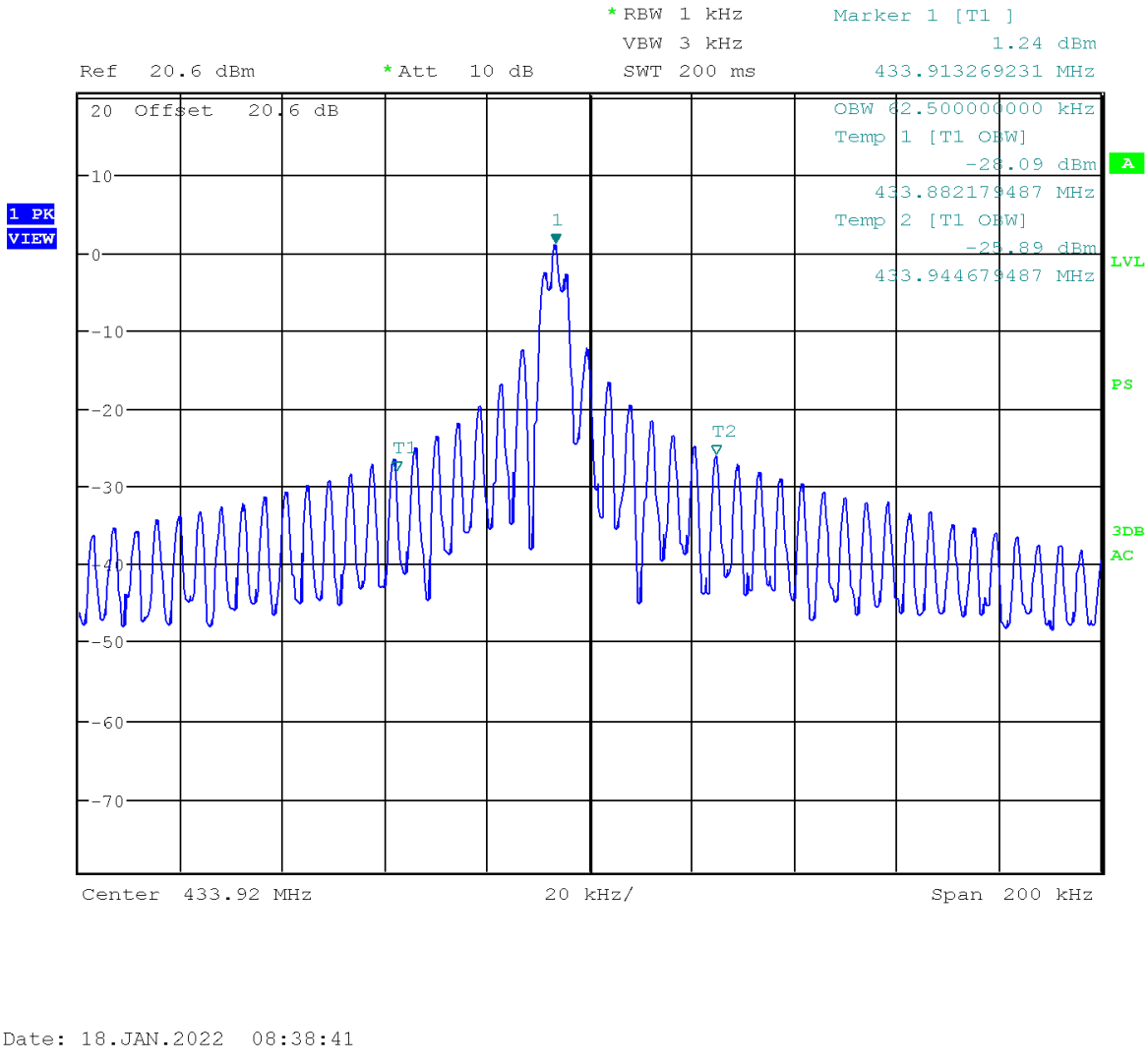


Figure 2-28 – Occupied Bandwidth – ASK Modulation, 433.92 MHz

Table 2.6-2 – Occupied Bandwidth

Frequency (MHz)	Occupied Bandwidth Type	Occupied Bandwidth (kHz)	Limit (kHz)	Margin (kHz)
314.9	99% OBW	62.5	108480.0	-108417.5

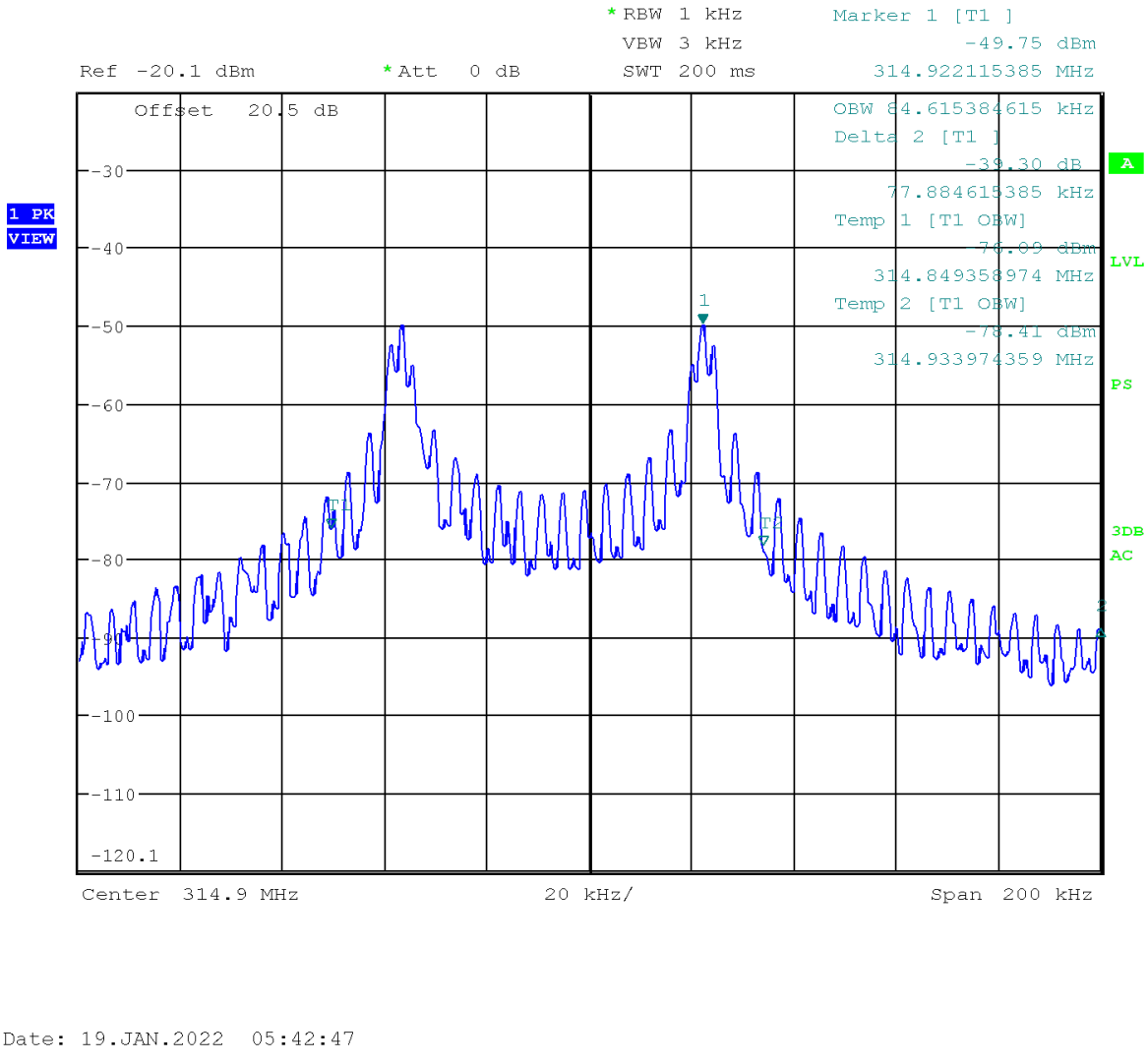


Figure 2-29 – Occupied Bandwidth – FSK Modulation, 314.9 MHz

Table 2.6-3 – Occupied Bandwidth

Frequency (MHz)	Occupied Bandwidth Type	Occupied Bandwidth (kHz)	Limit (kHz)	Margin (kHz)
314.9	99% OBW	84.62	78725.0	-78640.38

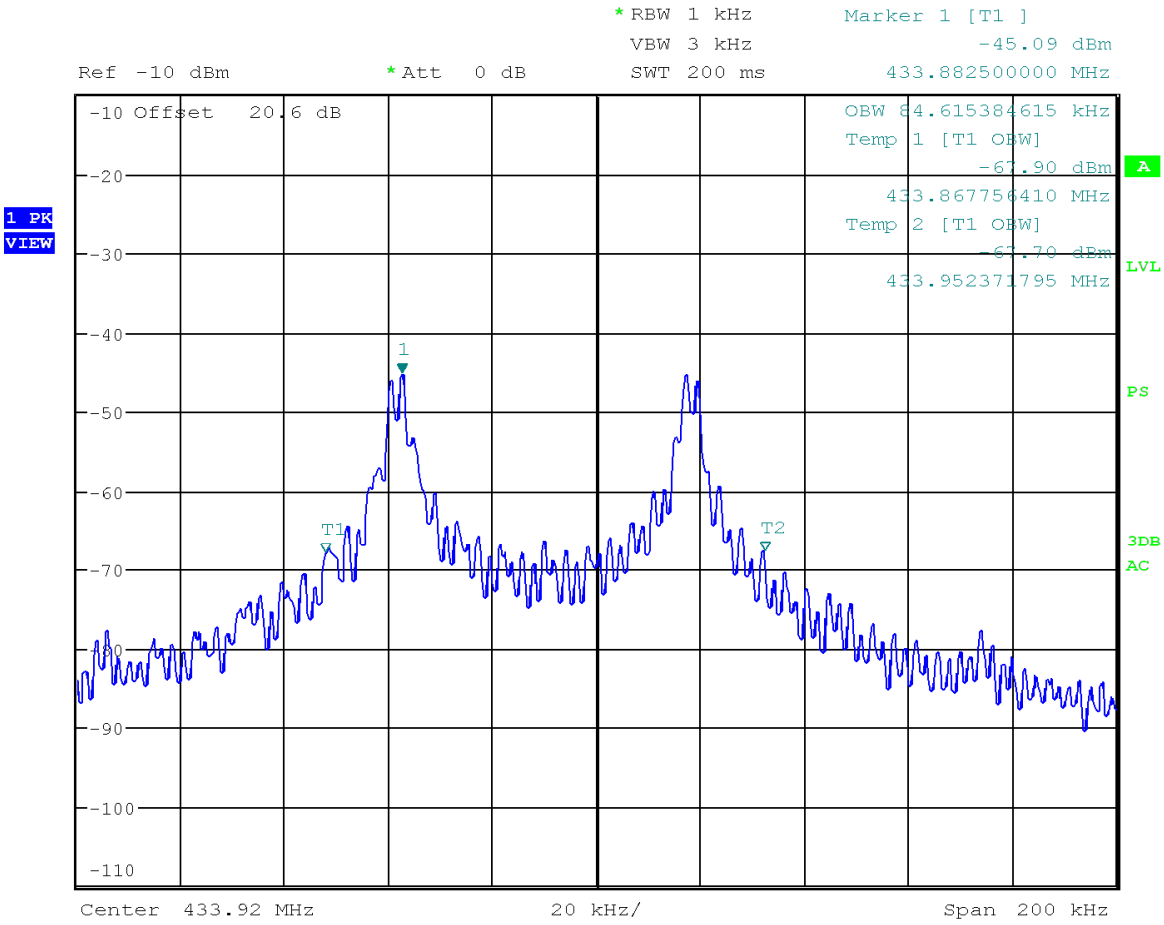


Figure 2-30 – Occupied Bandwidth – FSK Modulation, 433.92 MHz

Table 2.6-4 – Occupied Bandwidth

Frequency (MHz)	Occupied Bandwidth Type	Occupied Bandwidth (kHz)	Limit (kHz)	Margin (kHz)
433.92	99% OBW	84.62	108480.0	-108395.38

2.6.7 Test Location and Test Equipment Used

The tests were carried out in New Brighton, MN.
Test Area: 3mSAC

Table 2.6-5 – Conducted Emissions Test Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
NBLE03509	Florida RF Labs	Cable, SMA 6ft	FL200	6ft-4	B	03/21/2021	03/21/2022
WRLE10998	Rohde & Schwarz	Receiver, 20 Hz-26.5 GHz	ESU 26	100379	G	12/03/2021	12/03/2022
WRLE11397	Meca	Attenuator, 20 dB	603-20-1F18	11397	B	12/02/2021	12/02/2022

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.7 Frequency Stability

2.7.1 Specification Reference

FCC 47 CFR Part 15.231(d)
ISED RSS-GEN 6.11

2.7.2 Test Method

The equipment under test is placed inside an environmental chamber. The RF output is directly coupled to the input of the measurement equipment and a power supply is attached to the primary supply voltage.

Frequency measurements were made at the extremes of the of temperature range -30º C to +50º C and at intervals of 10º C at normal supply voltage. Sufficient time to stabilize all components of the equipment was allowed at each frequency measurement. At a temperature 20º C the supply voltage was reduced to the battery operating endpoint. The maximum variation of frequency was recorded.

2.7.3 Environmental Conditions

Ambient Temperature	26.7 °C
Relative Humidity	36.8 %
Atmospheric Pressure	1017.4 mbar

2.7.4 Test Results

N/A. EUT does not operate between 40.66 – 40.70 MHz and therefore not applicable to this device.

3 Diagram of Test Setups

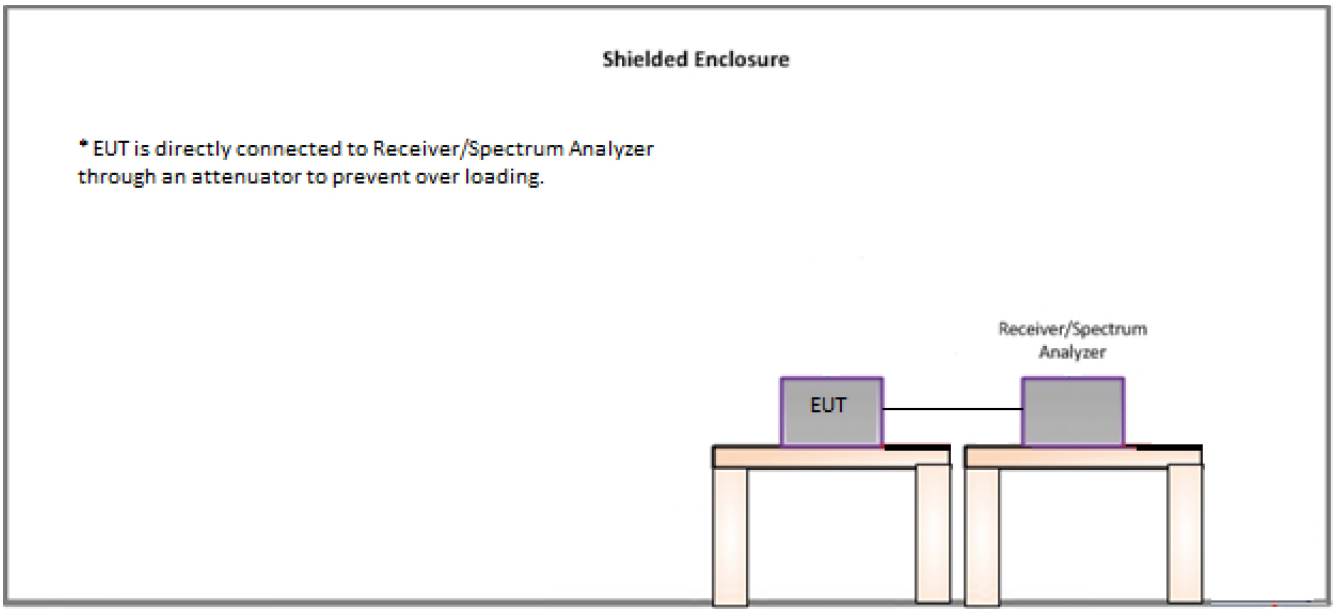


Figure 3-1 – Conducted Test Setup

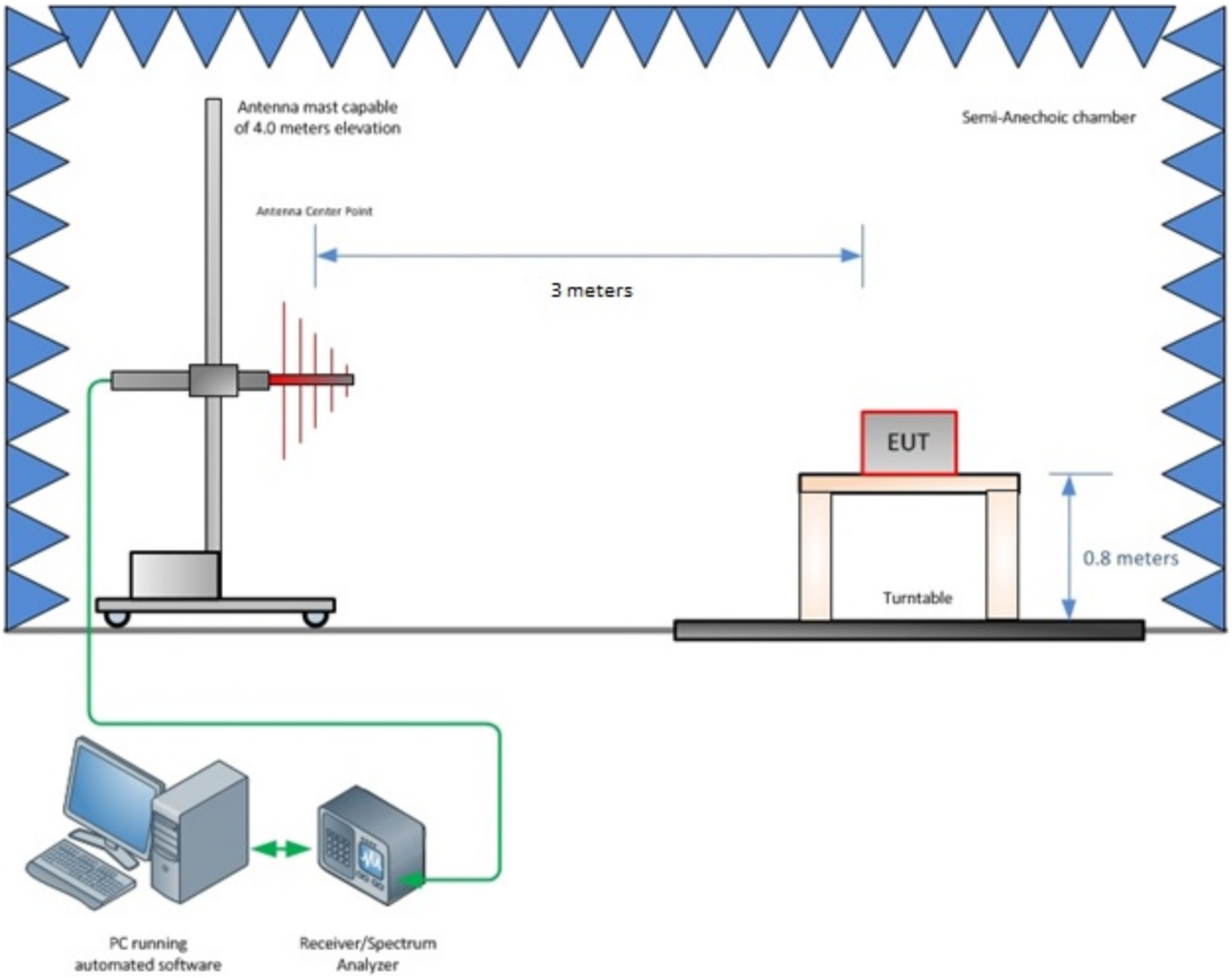


Figure 3-2 – Radiated Emissions Test Setup up to 1 GHz

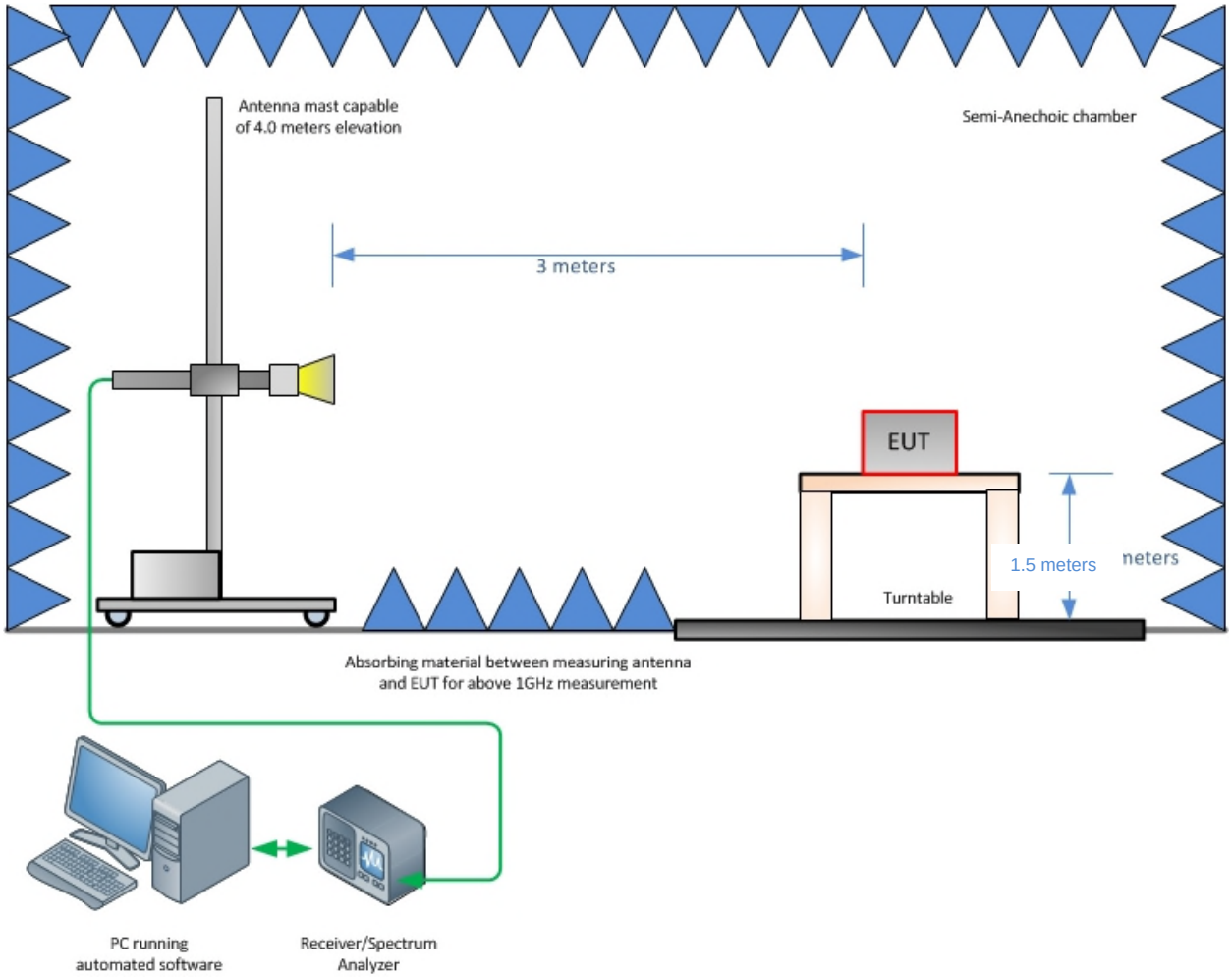


Figure 3-3 – Radiated Emissions Test Setup above 1 GHz

4 Accreditation, Disclaimers and Copyright

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STATEMENT OF MEASUREMENT UNCERTAINTY – Emissions

The test system for conducted emissions is defined as the LISN, tuned receiver or spectrum analyzer, and coaxial cable. This test system has a measurement uncertainty of ±3.30 dB. The test system for radiated emissions is defined as the antenna, the pre-amplifier, the spectrum analyzer and the coaxial cable. This test system for 30 MHz-1000 MHz has a measurement uncertainty of ±5.88 dB and above 1 GHz a measurement uncertainty of ±4.47 dB. The measurement uncertainty values for conducted and radiated emissions meet the requirements as expressed in CISPR 16-4-2. The equipment comprising the test systems is calibrated on an annual basis.

TEST EQUIPMENT

All measurement instrumentation is traceable to the National Institute of Standards and Technology and is calibrated to meet test method standard requirements and/or manufacturer's specifications