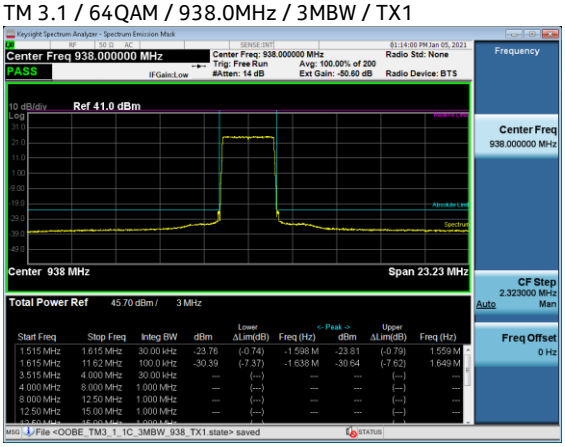
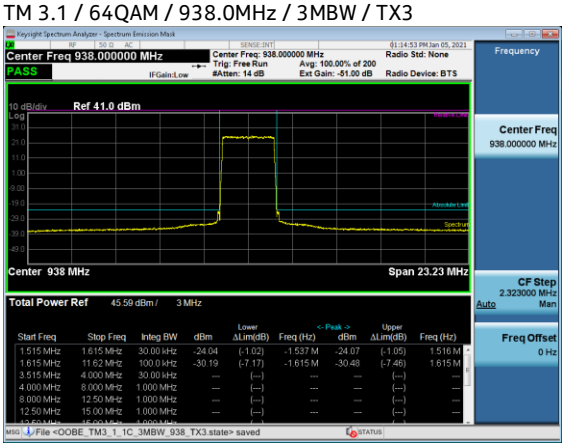
TM 3.1 / 64QAM / 938.0MHz / 3MBW / TX1

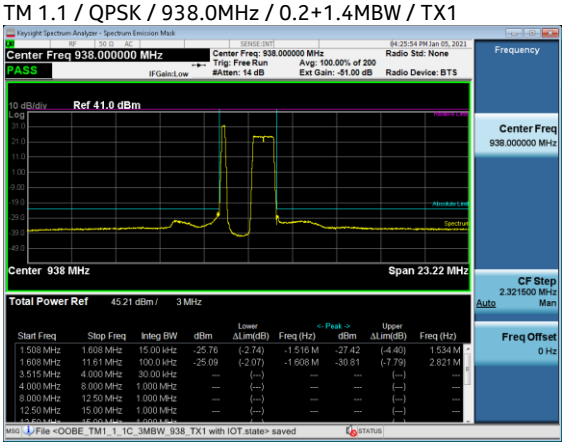


TM 3.1 / 64QAM / 938.0MHz / 3MBW / TX3

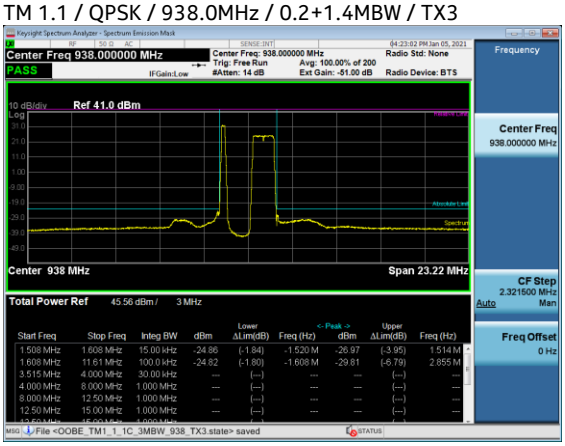


4.3.1.2 1-Carrier with NB-IoT Plots (40W)

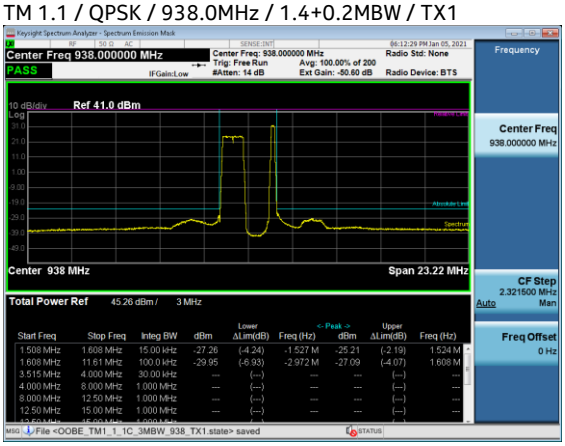
TM 1.1 / QPSK / 938.0MHz / 0.2+1.4MBW / TX1



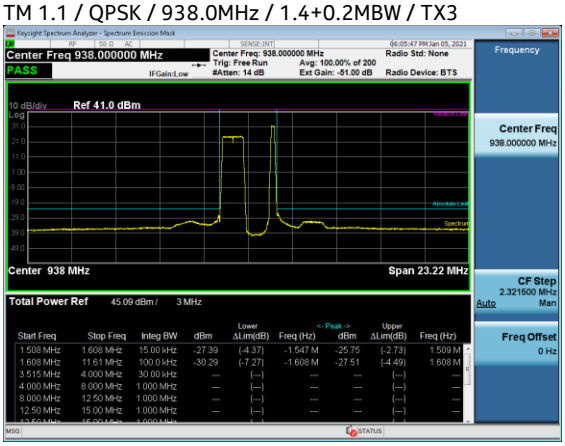
TM 1.1 / QPSK / 938.0MHz / 0.2+1.4MBW / TX3



TM 1.1 / QPSK / 938.0MHz / 1.4+0.2MBW / TX1

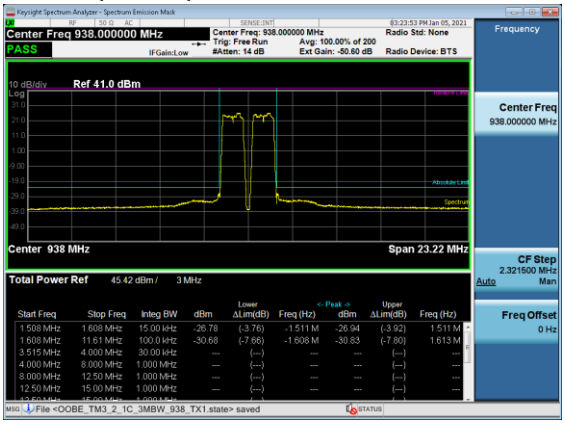


TM 1.1 / QPSK / 938.0MHz / 1.4+0.2MBW / TX3

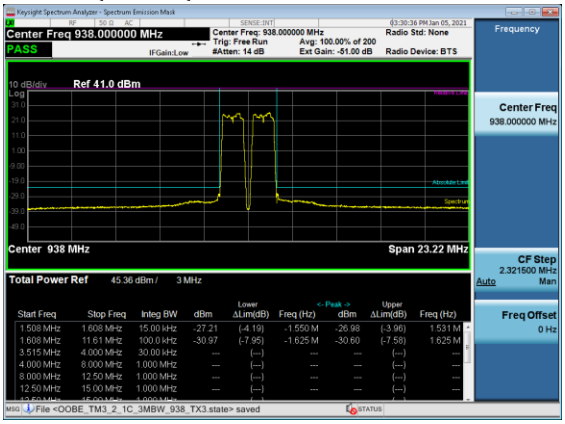


4.3.1.3 2-Carrier Plots (40W)

TM 3.2 / QPSK-16QAM / 938.0MHz / 1.4+1.4MBW / TX1

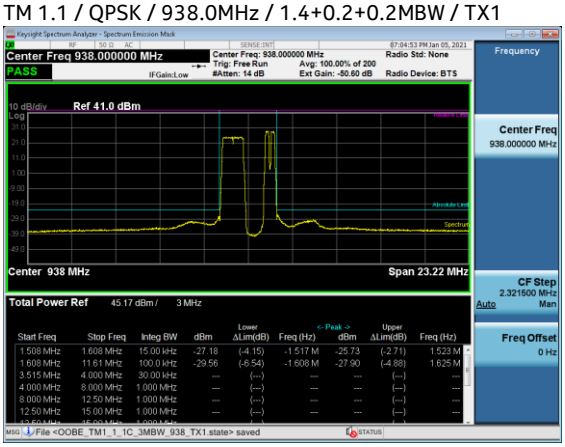


TM 3.2 / QPSK-16QAM / 938.0MHz / 1.4+1.4MBW / TX3

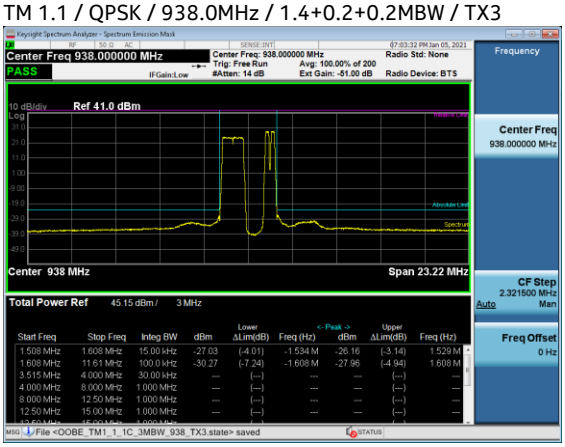


4.3.1.4 3-Carrier Plots (40W)

TM 1.1 / QPSK / 938.0MHz / 1.4+0.2+0.2MBW / TX1

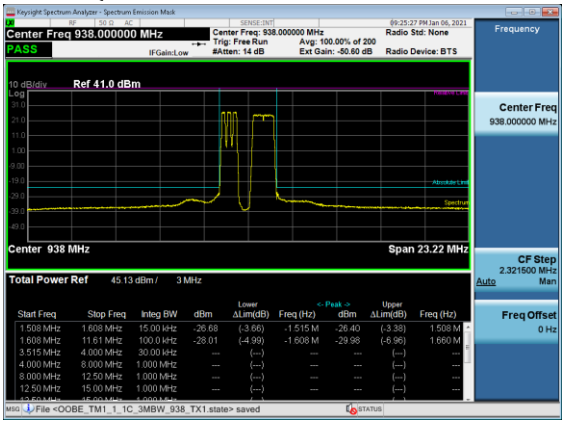


TM 1.1 / QPSK / 938.0MHz / 1.4+0.2+0.2MBW / TX3

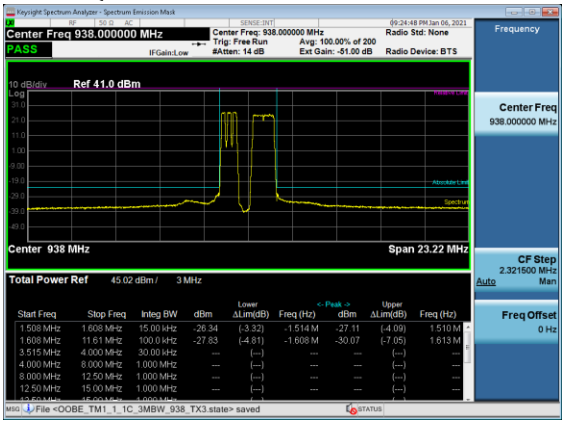


4.3.1.5 4-Carrier Plots (40W)

TM 1.1 / QPSK / 938.0MHz / 0.2+0.2+0.2+1.4MBW / TX1

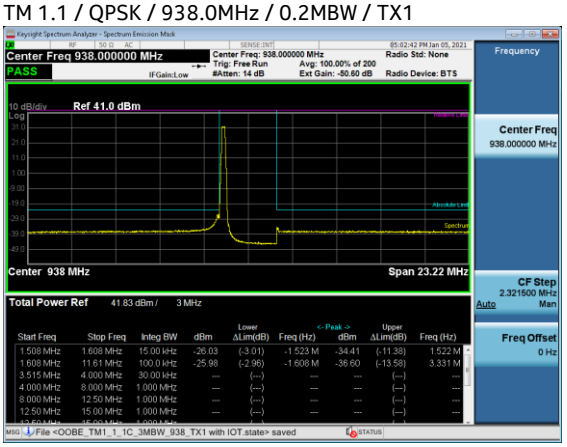


TM 1.1 / QPSK / 938.0MHz / 0.2+0.2+0.2+1.4MBW / TX3

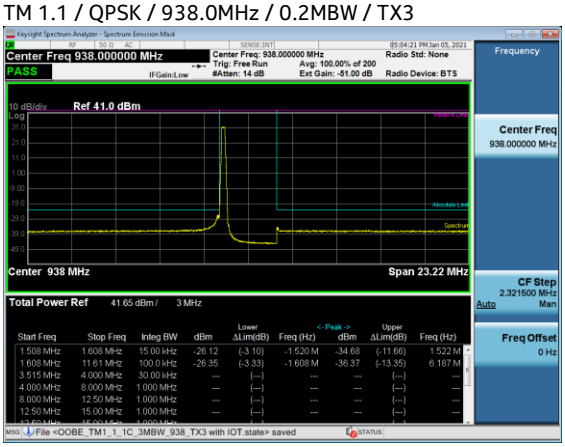


4.3.1.6 NB-IoT Only Plots (40W)

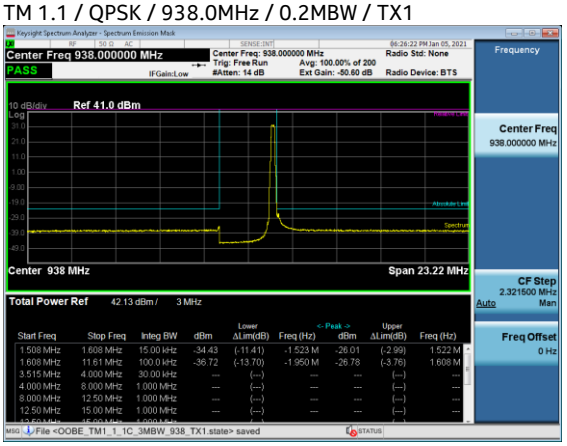
TM 1.1 / QPSK / 938.0MHz / 0.2MBW / TX1



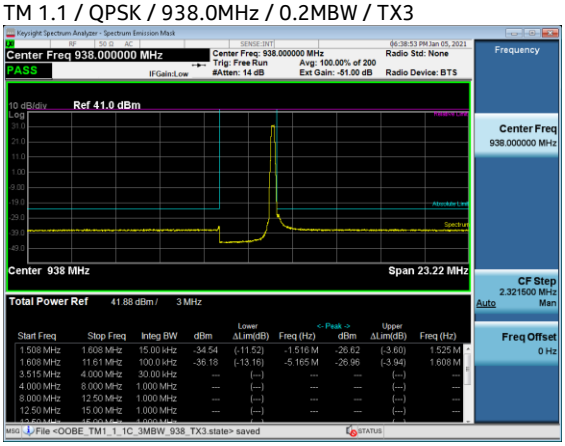
TM 1.1 / QPSK / 938.0MHz / 0.2MBW / TX3



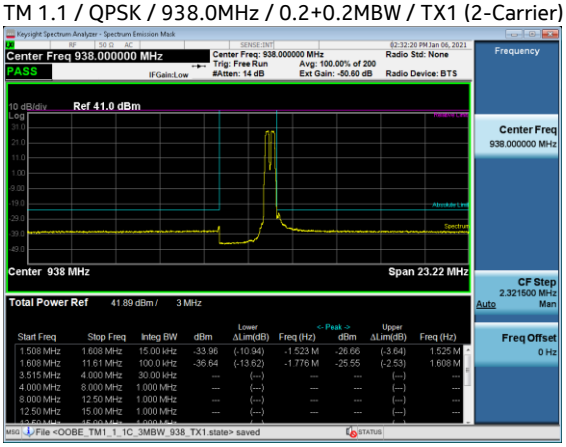
TM 1.1 / QPSK / 938.0MHz / 0.2MBW / TX1



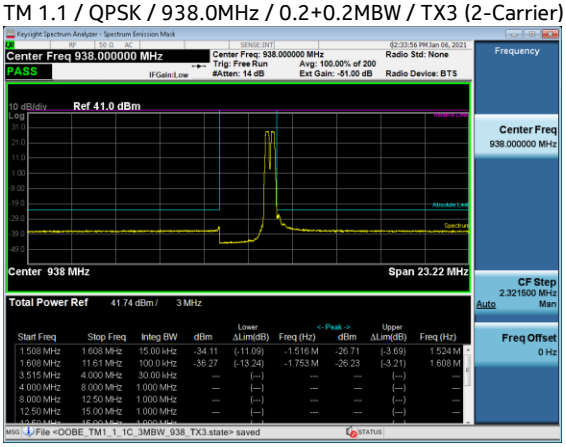
TM 1.1 / QPSK / 938.0MHz / 0.2MBW / TX3



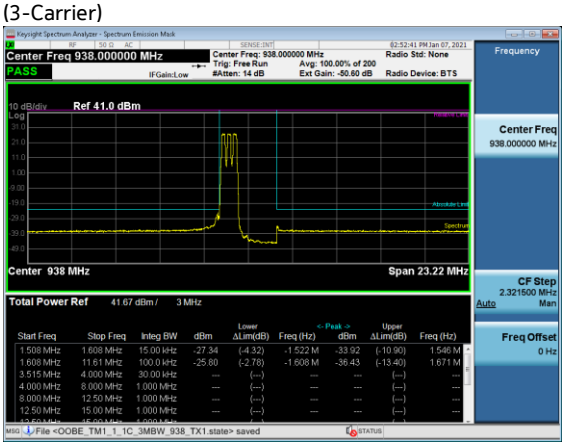
TM 1.1 / QPSK / 938.0MHz / 0.2+0.2MBW / TX1 (2-Carrier)



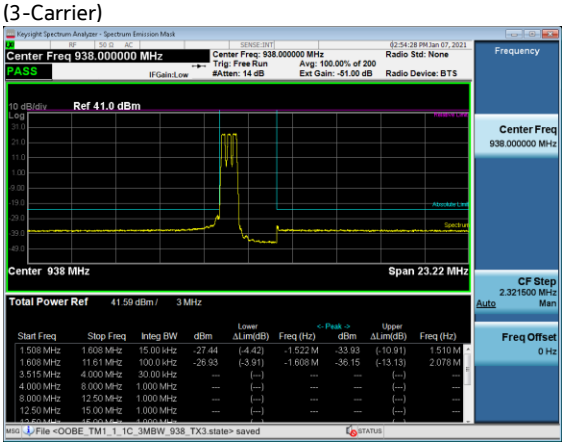
TM 1.1 / QPSK / 938.0MHz / 0.2+0.2MBW / TX3 (2-Carrier)



TM 1.1 / QPSK / 938.0MHz / 0.2+0.2+0.2MBW / TX1 (3-Carrier)



TM 1.1 / QPSK / 938.0MHz / 0.2+0.2+0.2MBW / TX3 (3-Carrier)



5. FCC Section 2.1051 - Spurious Emissions at Transmit Antenna Port

5.1 Measurement of Spurious Emissions at Transmit Antenna Port

Spurious Emissions at the transmit-antenna terminals were investigated over the frequency range of 10 MHz to beyond the 10th harmonic of the specific transmit band. Carrier Bandwidth is exempt. For this band of operation, the measurements were performed up to 10 GHz. Measurements were made using a Keysight MXA Signal Analyzer. The RF output from the transmitter was reduced (to an amplitude usable by the receivers) using calibrated attenuators. The RF power level was continuously monitored via a coupled RF Power Meter.

The required emission limitation is specified as appropriate in 27.53. The measured spurious emission levels were plotted for the frequency range as specified in 2.1057. There were no reportable emissions. Data below documents performance up to 27 GHz.

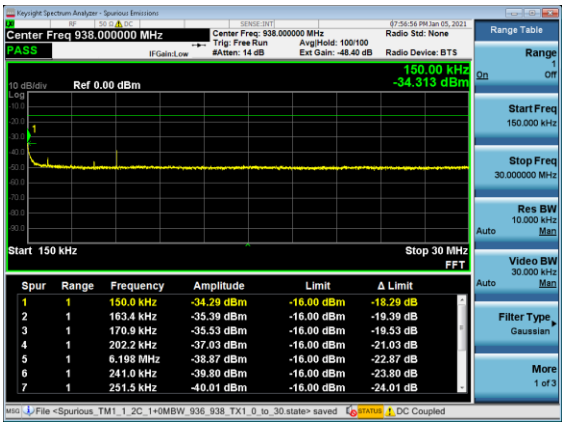
5.1.1 Spurious Emissions at Tx Port - Plots

5.1.1.1 1-Carrier with NB-IoT Plots (40W)

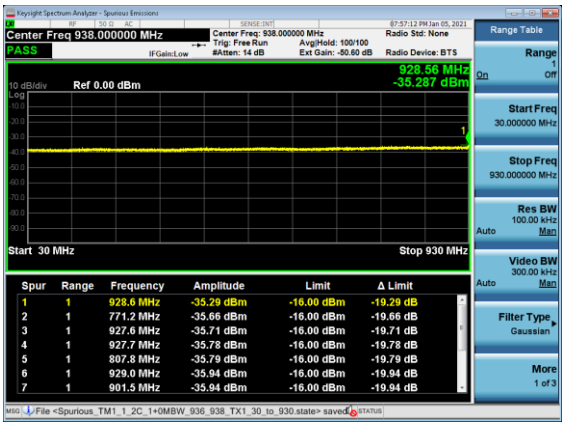
1.4 + 0.2 MHz BW
Test Model 1.1
Modulation QPSK
Channel Frequency 938.0MHz
TX1

9KHz – 150kHz

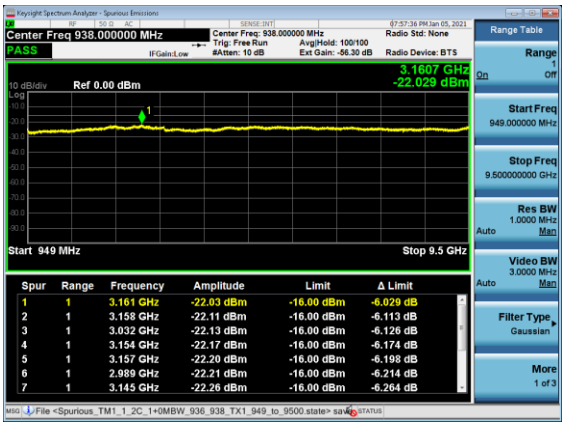
150kHz – 30MHz



30MHz – 930MHz



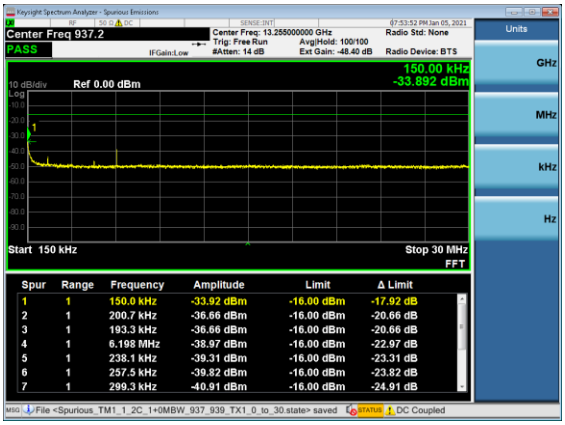
949MHz – 9.5GHz



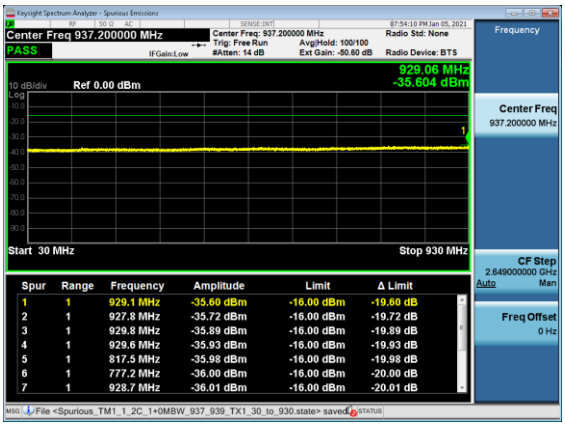
1.4 + 0.2 MHz BW
Test Model 1.1
Modulation QPSK
Channel Frequency 937.2MHz
TX1

9KHz – 150kHz

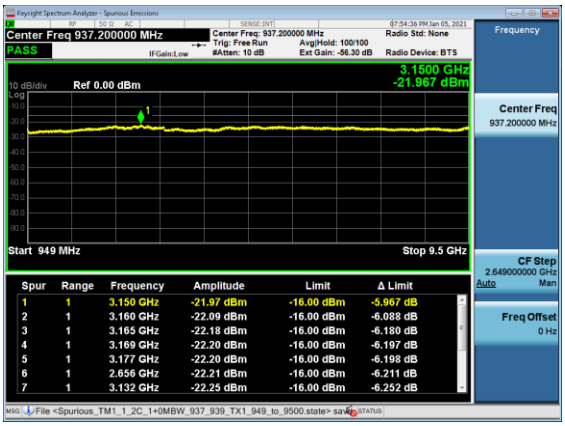
150kHz – 30MHz



30MHz – 930MHz



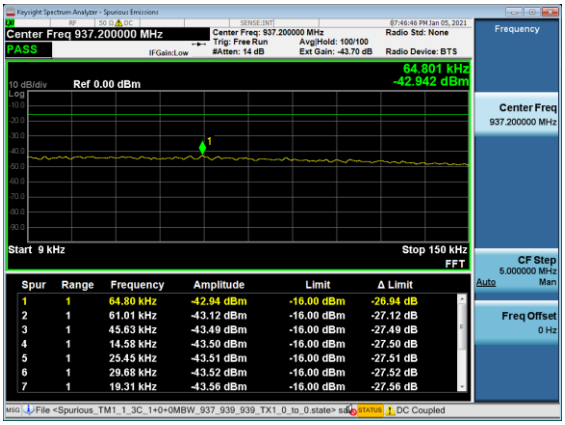
949MHz – 9.5GHz



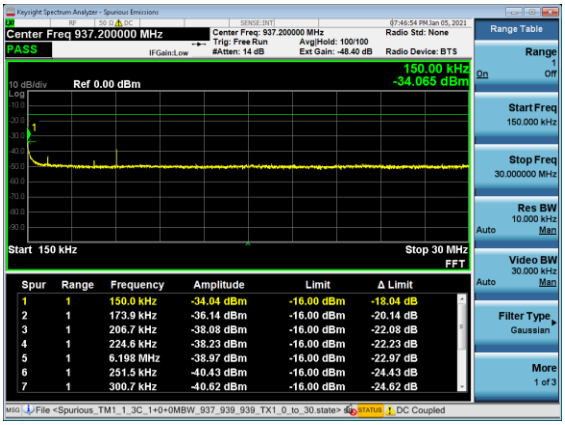
5.1.1.2 3-Carrier Plots (40W)

(3-Carrier) 1.4 + 0.2 + 0.2 MHz BW
Test Model 1.1
Modulation QPSK
Channel Frequency 937.2MHz
TX1

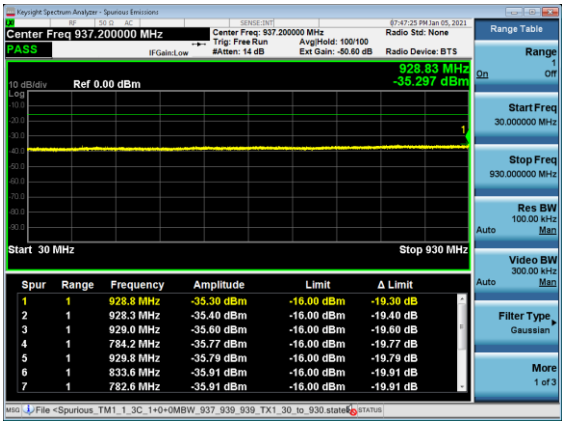
9KHz – 150kHz



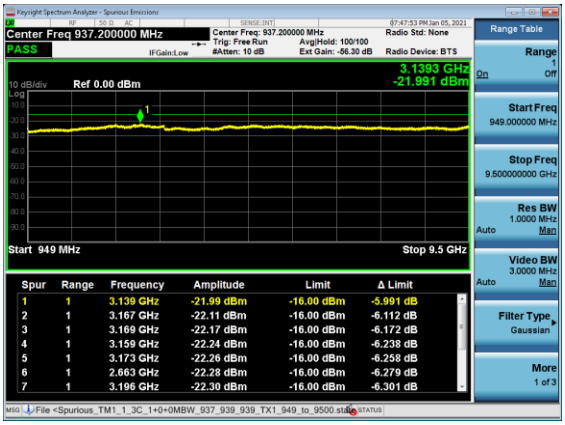
150kHz – 30MHz



30MHz – 930MHz



949MHz – 9.5GHz

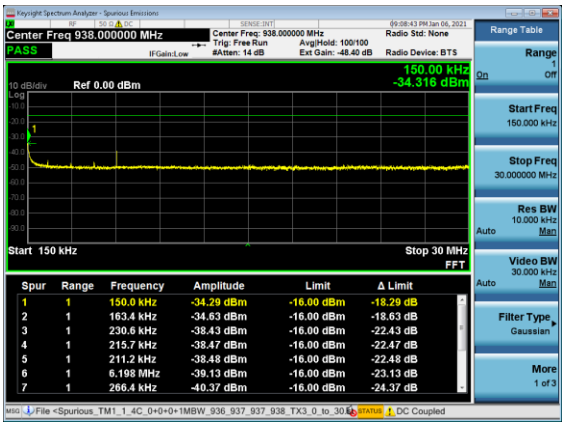


5.1.1.3 4-Carrier Plots (40W)

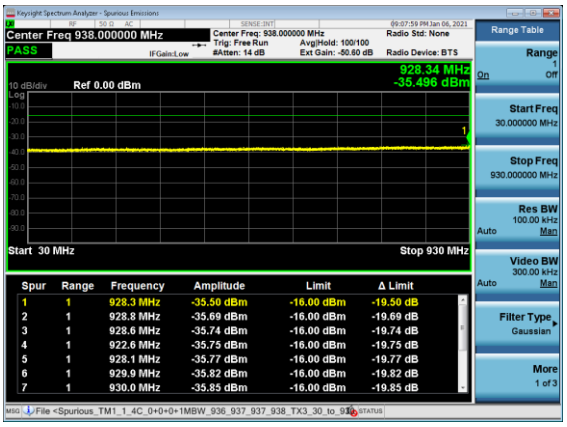
(4-Carrier) 0.2 + 0.2 + 0.2 + 1.4 MHz BW
Test Model 1.1
Modulation QPSK
Channel Frequency 938.0MHz
TX1

9KHz – 150kHz

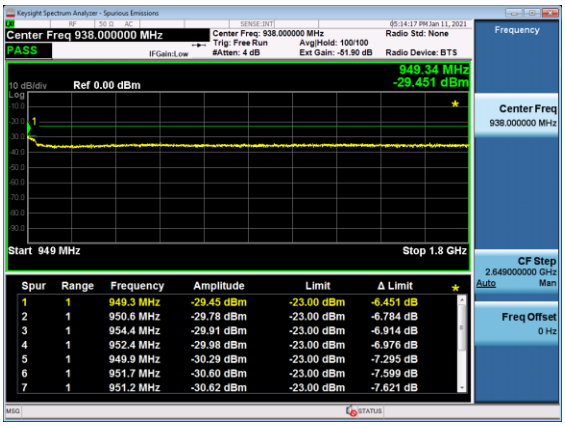
150kHz – 30MHz



30MHz – 930MHz



949MHz – 1.8GHz

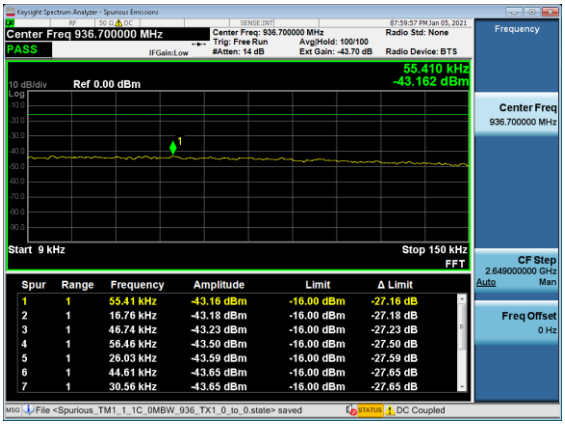


1.8GHz – 9.5GHz

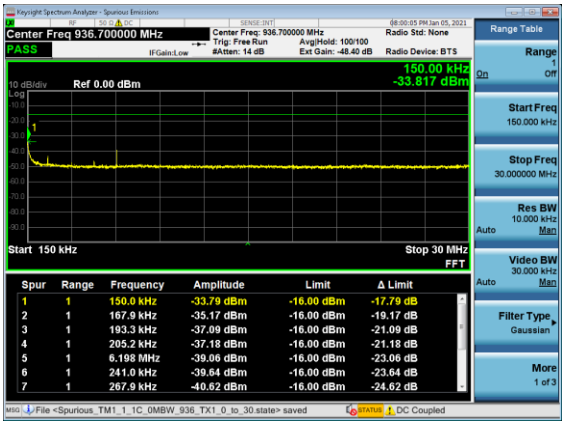
5.1.1.4 NB-IoT Only Plots (40W)

(1-Carrier) 0.2 MHz BW
Test Model 1.1
Modulation QPSK
Channel Frequency 936.7MHz
TX1

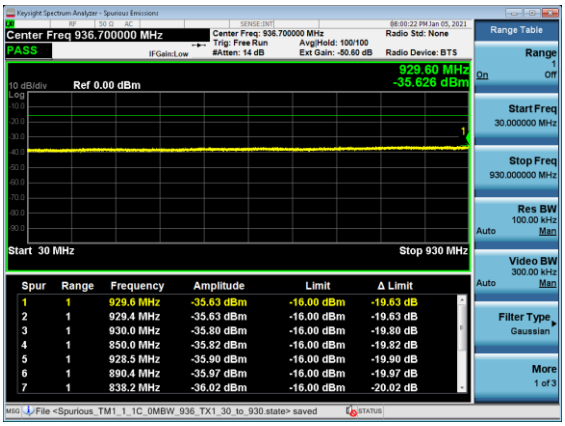
9KHz – 150kHz



150kHz – 30MHz



30MHz – 930MHz

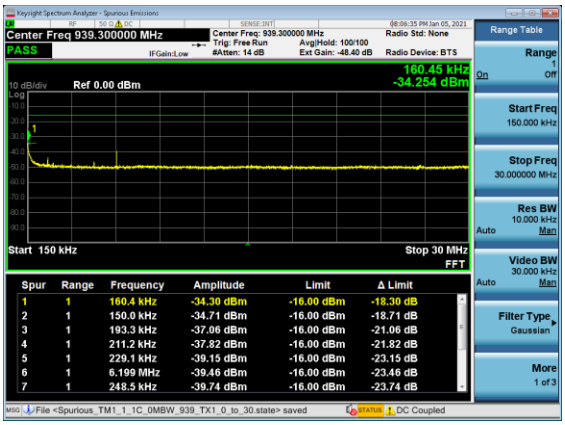


949MHz – 9.5GHz

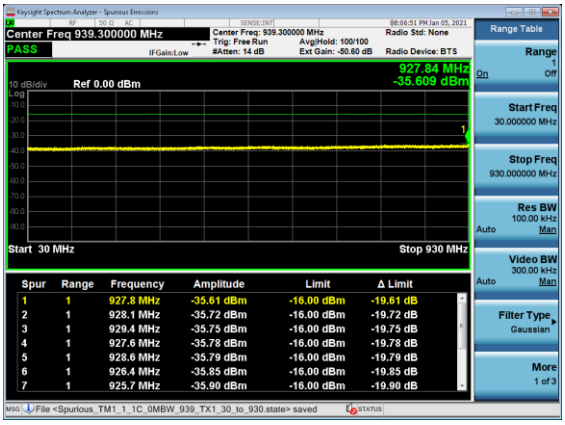
(1-Carrier) 0.2 MHz BW
Test Model 1.1
Modulation QPSK
Channel Frequency 939.3MHz
TX1

9KHz – 150kHz

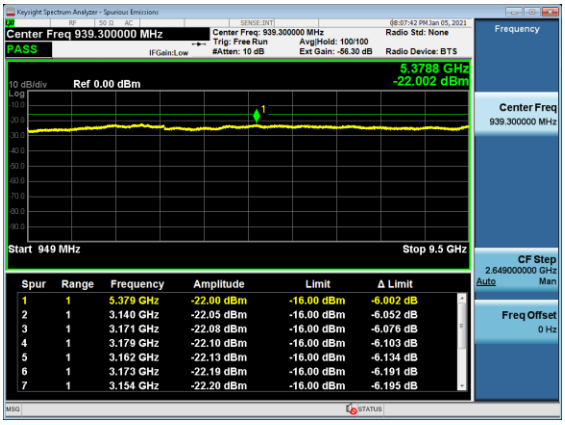
150kHz – 30MHz



30MHz – 930MHz

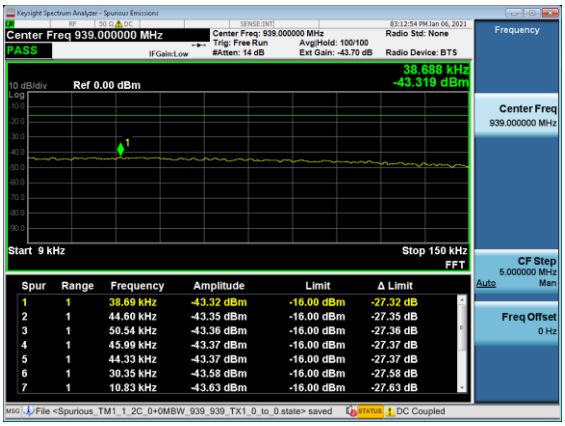


949MHz – 9.5GHz

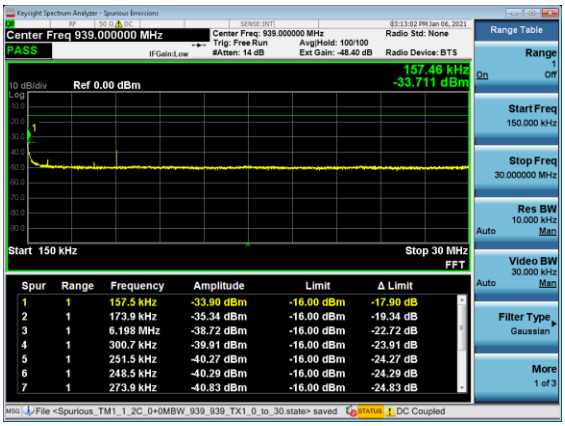


(2-Carrier) 0.2 + 0.2 MHz BW
Test Model 1.1
Modulation QPSK
Channel Frequency 939.0MHz
TX1

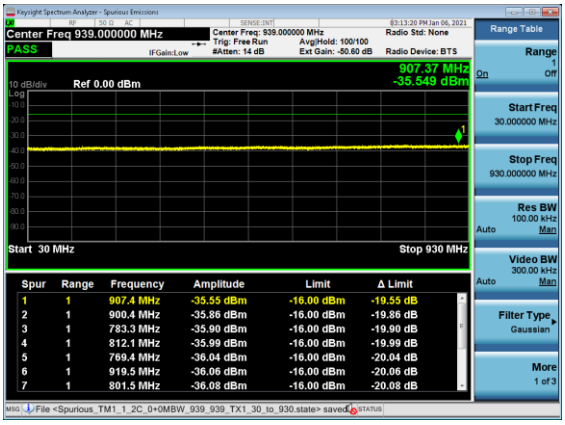
9KHz – 150kHz



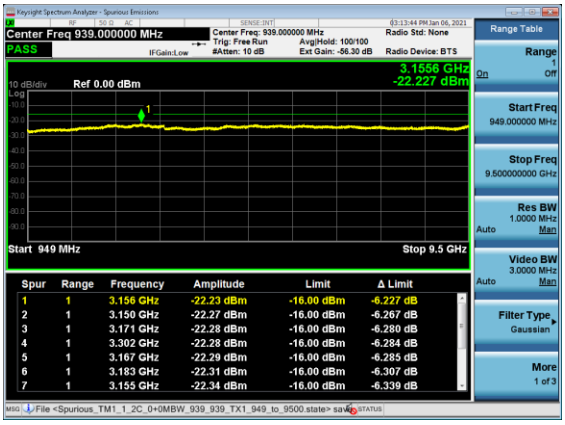
150kHz – 30MHz



30MHz – 930MHz

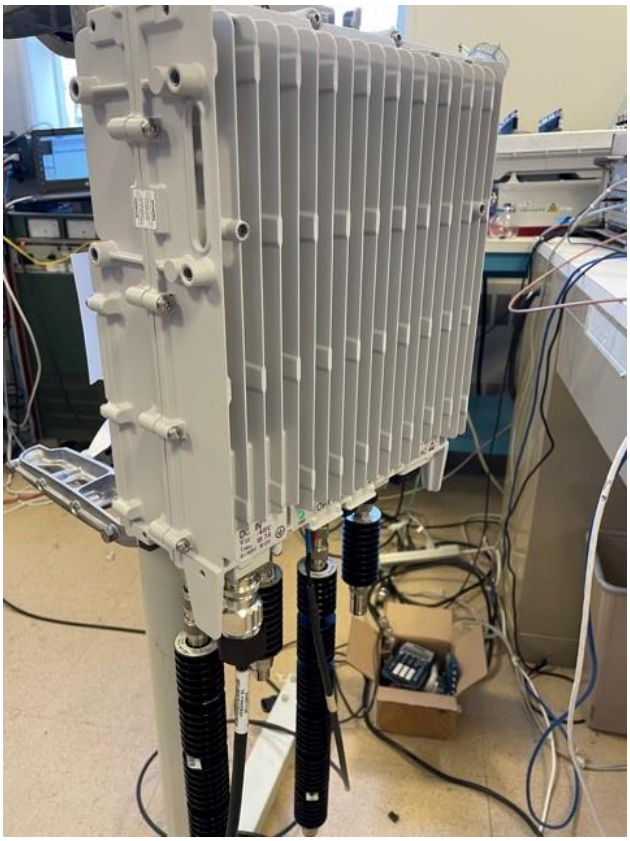


949MHz – 9.5GHz

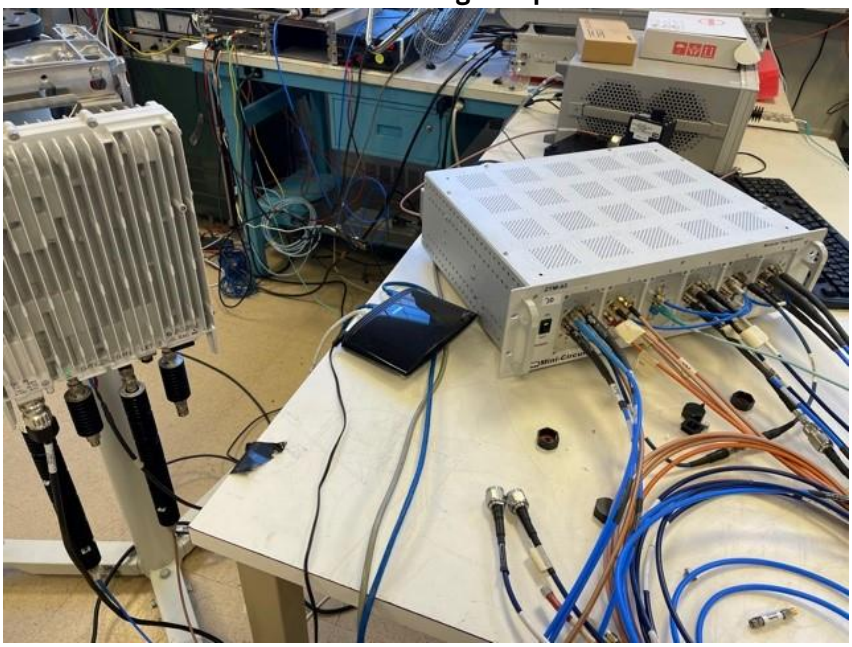


Photographs

AHDB Unit



Radio Testing Setup



Test Equipment

Asset ID	Manufacturer	Type	Description	Model	Serial	Calibration Date	Calibration Due
E1251	Aeroflex	Attenuator	30dB 150W DC-18GHz Attenuator	66-30-33	BV1667	CNR-V	CNR-V
E831	Agilent Technologies	MXA Signal Analyzer	20Hz-26.5GHz	N9020A	MY48011791	2020-06-16	2022-06-16
E896	Agilent Technologies	Network Analyzer	10 MHz - 40 GHz	N5230C	MY49000897	2019-01-31	2021-01-31
E1023	Weinschel	Attenuator	20 dB DC-18 GHz 25W	46-20-34	BJ4772	CNR-V	CNR-V
E1509	Weinschel	Attenuator	DC - 18 GHz, 30 dB, 150 W, N-Female - N-Female	66-30-34	BJ5923	CNR-V	CNR-V
	Mini Circuit	Modular Test System	ZTM-53	ZTM-52	11701250030	CNR-V	CNR-V

CNR-V: Calibration Not Required, Must Be Verified

Tests were performed between 12/15/2020 – 1/11/2021.

Environmental Conditions
Temperature: 24.1°C
Relative Humidity: 21.2%

6. FCC Section 2.1053 - Field strength of spurious radiation

6.1 Section 2.1053 Field Strength of Spurious Emissions

Field strength measurements of radiated spurious emissions were made in an FCC registered 3m Semi-Anechoic Chamber which is maintained by Nokia Bell Labs in Murray Hill, New Jersey. A complete description and full measurement data for the site is on file with the Commission (Site Registration Number: 515091).

The spectrum from 30 MHz to beyond the tenth harmonic of the carrier, 9.5 GHz, was searched for spurious radiation. Measurements were made using both horizontally and vertically polarized broadband antennas. Per FCC regulations, the comparison of out of band spurious emissions directly to the limit is appropriately made using the substitution method. However, when the emissions are more than 20 dB below the specification limit, the use of field strength measurements for compliance determination is acceptable and those emissions are considered not reportable (Section 2.1053 and the FCC Interpretive database for 2.1053). For this case the evaluation of acceptable radiated field strength is as follows.

6.2 Field Strength of Spurious Emissions - Limits

Sections 2.1053 and 27.53 contain the requirements for the levels of spurious radiation as a function of the level of the unmodulated carrier. The reference level for the unmodulated carrier is calculated as the field produced by an ideal dipole excited by the transmitter output power according to the following relation taken from Reference Data for Radio Engineers, page 676, 4th edition, IT&T Corp.

$$E = [(30*P)^{1/2}]/R$$

$$20 \log (E*10^{6}) - (43 + 10 \log P) = 82.23 \text{ dB}\mu\text{V/meter}$$

Where:
E = Field Intensity in Volts/meter P = Transmitted Power in Watts
R = Measurement distance in meters = 3 m

The Part 27 Limit is 82.23 dBµV/m at 3m and 91.77 dBuV/m at 1m
The Part 27 non-report level is 62.23 dBµV/m at 3m.

The calculated emission levels were found by:

Measured level (dBµV) + Cable Loss(dB)+Antenna Factor(dB) = Field Strength (dBµV/m)

RESULTS:

For compliance with 47CFR Parts 2 and 27, the field strength of any spurious radiation, measured at 3m, is required to be less than 82.23 dBµV/meter (82.23 @ 3m). Emissions equal to or less than 62.23 dBµV/meter at 3m are not reportable and may be verified using field strength measurements and broadband antennas. Over the out of band spectrum investigated from 30 MHz to beyond the tenth harmonic of the carrier (up to 9.5 GHz), no reportable spurious emissions were detected.

7. FCC Section 2.1055 - Measurement of Frequency Stability

Frequency Stability testing was completed on AHDB Unit with Center Frequency 938 MHz. Testing was performed from 01/27/2021 through 01/29/2021 on the radio, which was located in the T-16 Thermal chamber of the Global Product Compliance Laboratory (GPCL) test facility located in Building 4, Room 4-280, Murray Hill, NJ, by Joe Bordonaro from GPCL.

The temperatures to which the UUT were subjected ranged from a high temperature of +50ºC system ambient to a low temperature of -30ºC system ambient with measurements recorded at 10C increments

Frequency Stability performance was verified by measuring Frequency Tolerance using an MXE Signal Analyzer. Frequency Tolerance is a measurement of the difference between the actual transmit frequency and the assigned frequency (938 MHz).

Frequency Block Tested: *AHDB 938MHz RRH (CF = 0MHz)*

1. (a) Set the power supply to nominal Voltage. (b) Record the frequency at ~25°C. (c) Raise EUT operating temperature to 50°C. (d) Record the frequency difference. (e) Repeat step (d) at each 10°C step down to -30°C. Result will be 10 readings and take temperature readings to establish thermal stability at each point.

Baseline Measurement at +25°C

Transmit Frequency Deviation at +25°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-6.9717
0.5	-7.9312
1.0	-8.5930
1.5	-8.4408
2.0	-7.6132
2.5	-8.4070
3.0	-9.5814
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +50°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-8.0262
0.5	-9.0724
1.0	-7.0709
1.5	-8.5319

2.0	-9.3304
2.5	-7.8133
3.0	-8.3132
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +40°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-8.7208
0.5	-9.1522
1.0	-7.2983
1.5	-7.8324
2.0	-9.5807
2.5	-7.0435
3.0	-8.3127
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +30°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-8.2066
0.5	-9.9952
1.0	-7.7693
1.5	-7.6645
2.0	-8.7533
2.5	-8.3297
3.0	-7.2761
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +20°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-8.7756
0.5	-7.6608
1.0	-7.7146

1.5	-8.1423
2.0	-7.8278
2.5	-8.2257
3.0	-9.0571
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +10°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-9.8806
0.5	-8.4087
1.0	-10.017
1.5	-8.3917
2.0	-8.0491
2.5	-7.9709
3.0	-7.7669
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at 0°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-8.0855
0.5	-7.4583
1.0	-8.4432
1.5	-7.8160
2.0	-9.5109
2.5	-7.6741
3.0	-8.4997
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at -10°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-9.6277
0.5	-9.0462

1.0	-8.2618
1.5	-6.8419
2.0	-9.0135
2.5	-8.4167
3.0	-7.9228
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at -20°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-8.7419
0.5	-8.0690
1.0	-7.6880
1.5	-8.0550
2.0	-8.6225
2.5	-8.9088
3.0	-9.8856
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at -30°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-7.2336
0.5	-8.9435
1.0	-9.1089
1.5	-7.7284
2.0	-9.2375
2.5	-8.4127
3.0	-7.7105
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Upon return to +25°C.

2. At ambient, vary voltage to +15% and -15% of nominal VAC and record frequency difference. Result will be 12 readings for each voltage (nominal, ~+ 3%, ~+6%, ~+%9, ~+12%, +15%, and nominal, ~- 3%, ~-6%, ~-%9, ~-12%, -15%).

Transmit Frequency Deviation at +25°C at 100% of Nominal Voltage, -48VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-9.7717
0.5	-8.1008
1.0	-6.6635
1.5	-8.9957
2.0	-7.5076
2.5	-8.6117
3.0	-8.4754
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at 103% of Nominal Voltage, -49.44VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-8.7786
0.5	-7.8625
1.0	-9.4527
1.5	-9.0073
2.0	-8.9239
2.5	-8.0889
3.0	-9.1828
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at 106% of Nominal Voltage, -50.88VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-8.2357
0.5	-7.7981
1.0	-8.9800
1.5	-8.0137
2.0	-7.6252
2.5	-8.9520
3.0	-7.2074

FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at 109% of Nominal Voltage, -52.32VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-8.5518
0.5	-9.2347
1.0	-7.5200
1.5	-8.7700
2.0	-9.0539
2.5	-8.1254
3.0	-8.6307
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at 112% of Nominal Voltage, -53.76VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-8.2594
0.5	-7.8696
1.0	-8.7552
1.5	-8.9975
2.0	-9.0467
2.5	-8.3330
3.0	-7.8859
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at 115% of Nominal Voltage, -55.20VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-7.8529
0.5	-8.9950
1.0	-10.419
1.5	-7.8187
2.0	-8.4167
2.5	-7.1369
3.0	-8.6373
FCC SPECIFICATION	938 MHz (±0.05ppm)

	±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at 100% of Nominal Voltage, -48.0VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-7.9162
0.5	-8.4950
1.0	-9.5241
1.5	-6.6127
2.0	-7.8254
2.5	-8.6726
3.0	-7.2843
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at -3% of Nominal Voltage, -46.56VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-8.7667
0.5	-9.4775
1.0	-8.8182
1.5	-9.6571
2.0	-7.9627
2.5	-8.8431
3.0	-9.8270
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at -6% of Nominal Voltage, -45.12VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-7.6479
0.5	-10.172
1.0	-6.7571
1.5	-8.1770
2.0	-7.9974
2.5	-7.6239
3.0	-8.7057

FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at -9% of Nominal Voltage, -43.68VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-8.0699
0.5	-8.2029
1.0	-9.0875
1.5	-7.3147
2.0	-7.9912
2.5	-8.2585
3.0	-7.7145
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Transmit Frequency Deviation at +25°C at -12% of Nominal Voltage, -42.24VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-8.0271
0.5	-6.8238
1.0	-7.6317
1.5	-9.2087
2.0	-8.4125
2.5	-8.9618
3.0	-9.2788
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

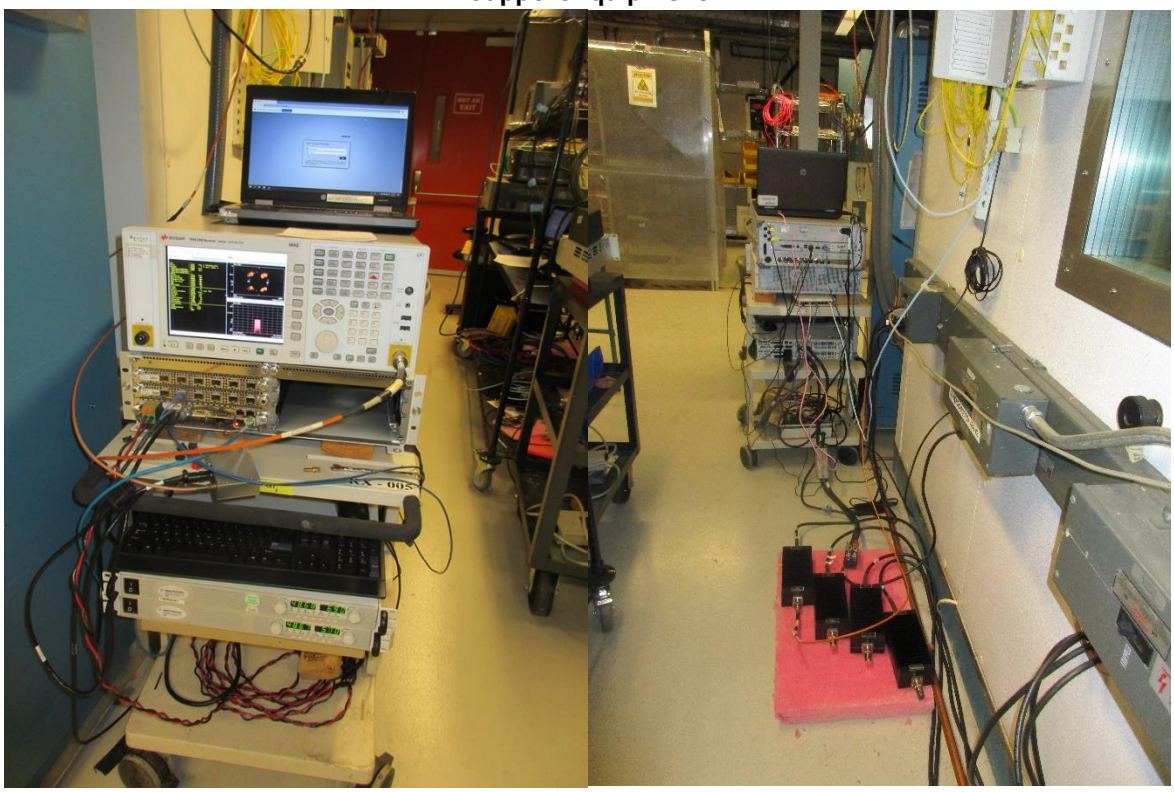
Transmit Frequency Deviation at +25°C at -15% of Nominal Voltage, -40.80VDC	
Time (minutes)	Transmit Carrier Deviation (Hz)
0	-8.0278
0.5	-7.8652
1.0	-9.0190
1.5	-8.2474
2.0	-9.8144
2.5	-8.0085

3.0	-7.2662
FCC SPECIFICATION	938 MHz (±0.05ppm) ±0.05ppm = ±46.9Hz
FCC RESULT	PASS

Photographs

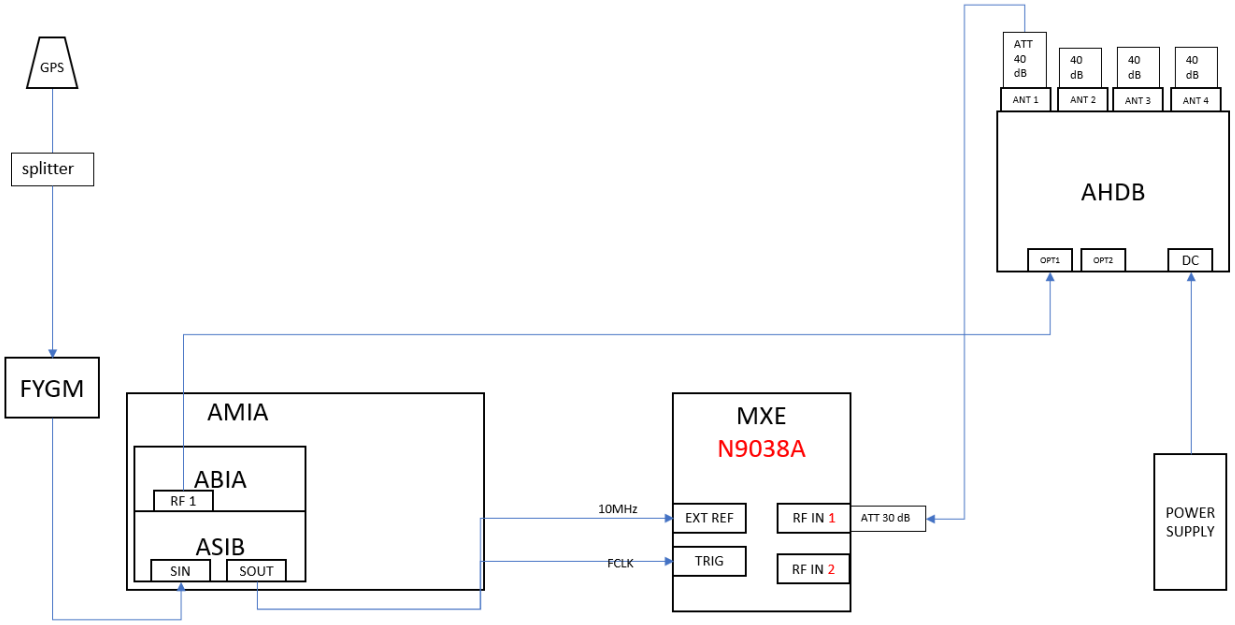
Radio in thermal chamber

Support Equipment

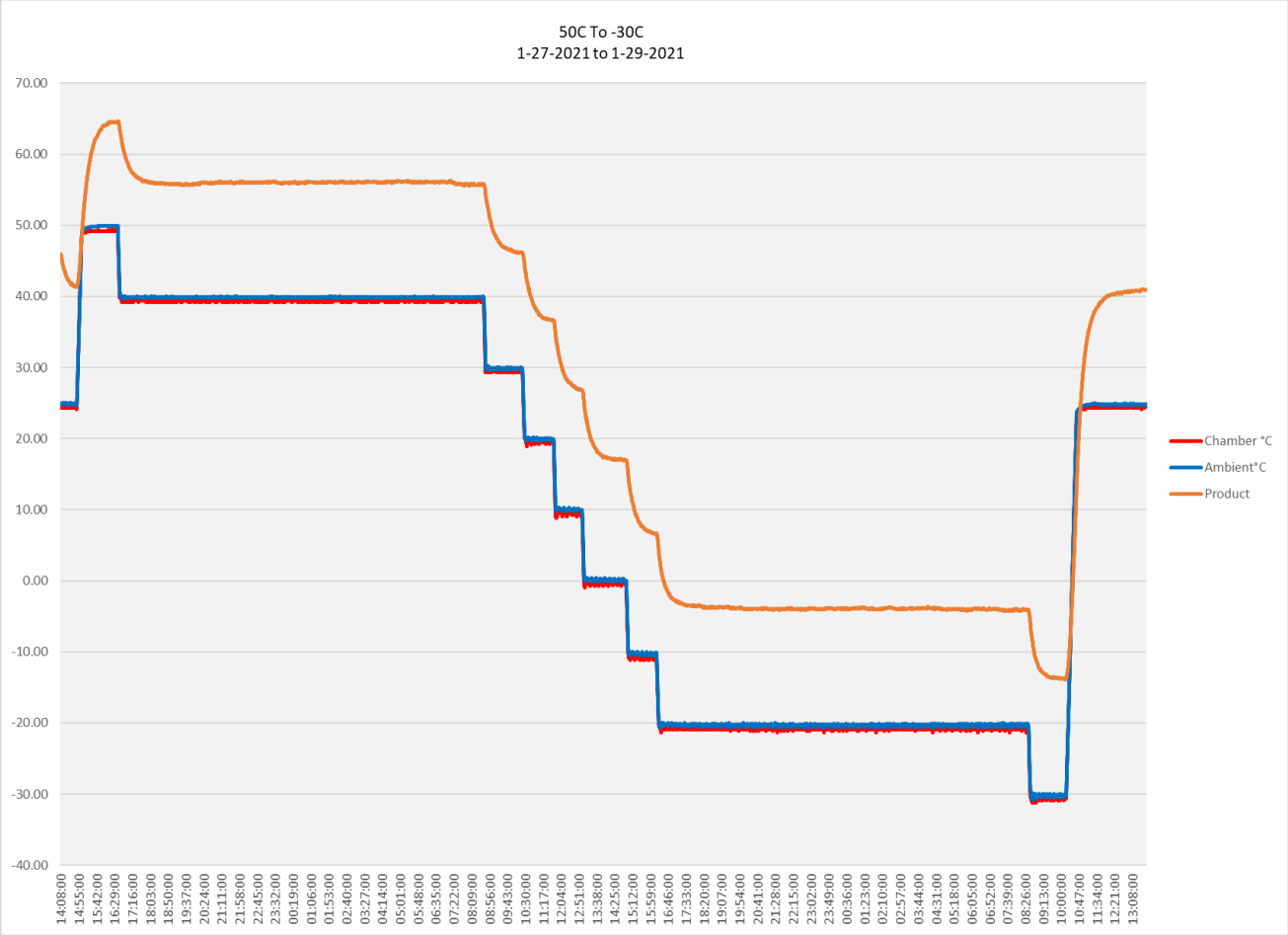


Serial Number

TEST BLOCK DIAGRAM



Chamber Temperature Plot



Test Equipment

Asset ID	Manufacturer	Type	Description	Model	Serial	Calibration Date	Calibration Due
TH514-T16	Envirotronics	Controller		Envirotronics SPPCM	SP000637	2019-05-22	2021-05-22
TH-T16	Envirotronics	Thermal Chamber		N/A	3015243	N/A	N/A
TH149	Fluke	Multimeter	Digital Multimeter	87III	7519030337	2019-07-22	2021-07-22
E1217	KeySight Technologies	EMI Receiver	MXE EMI Receiver 26.5GHz	N9038A	MY54130087	2019-02-13	2021-02-13
TH288	Yokogawa	Data Acquisition Unit	Recorder	MV2048-2-4-2-1-1D	S5JC04071	2019-02-26	2021-02-26

Test performed between 01/27/2021 - 01/29/2021.

8. NVLAP Certificate of Accreditation

United States Department of Commerce
National Institute of Standards and Technology

Certificate of Accreditation to ISO/IEC 17025:2017

NVLAP LAB CODE: 100275-0

Nokia, Global Product Compliance Lab
Murray Hill, NJ

is accredited by the National Voluntary Laboratory Accreditation Program for specific services, listed on the Scope of Accreditation, for:

Electromagnetic Compatibility & Telecommunications

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communique dated January 2009).

2020-09-25 through 2021-09-30
Effective Dates

For the National Voluntary Laboratory Accreditation Program