Test Report

Prepared for: Icom Incorporated

Model: MR-1010RII

Description: Marine Radar

Serial Number: 00000205

FCC ID: AFJ271420
ISED ID: 202D-271410

To

FCC Part 80
RSS-238 Issue 1 (July 2013)

Date of Issue: December 8, 2020

On the behalf of the applicant:	**Icom Incorporated** **1-1-32 Kamiminami Hirano-ku** **Osaka 547-0003** **Japan**
Attention of:	**Atsushi Tomiyama, General Manager of QA Department** **Ph: +81 6 6793 8424** **E-Mail: world_support@icom.co.jp**

Prepared by
Compliance Testing, LLC
1724 S. Nevada Way
Mesa, AZ 85204
(480) 926-3100 phone / (480) 926-3598 fax
www.compliancetesting.com

Project No: p20a0013

Greg Corbin

Project Test Engineer

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	December 8, 2020	Greg Corbin	Original Document

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ANAB

Compliance Testing, LLC, has been 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 the joint ISO-ILAC-IAF Communiqué dated January 2009).

The tests results contained within this test report all fall within our scope of accreditation, unless noted below.

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FCC Site Reg. #349717

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Non-accredited tests contained in this report:

N/A

Standard Test Conditions Engineering Practices

Except as noted herein, the following conditions and procedures were observed during the testing:

All tests and measurement data shown were performed in accordance with FCC Rules and Regulations, Volume II; Part 2, Sub-part J, Sections 2.947, 2.1033(c), 2.1041, 2.1046, 2.1047, 2.1051, 2.1053, 2.1055, 2.1057 and the following individual Parts: FCC Part 80, ANSI C63.26-2015, and ISED RSS-238, RSS-GEN.

Measurement results, unless otherwise noted, are worst-case measurements.

Environmental Conditions		
Temperature (ºC)	**Humidity (%)**	**Pressure (mbar)**
17.9 – 23.9	26.0 – 35.3	961.1 – 981

EUT Description
Model: MR-1010RII
Description: Marine Radar
Serial Number: 00000120
PMN: MR1010RII
HVIN: 271410-01
UPN: 271410

Additional Information
The EUT is a 4kW Marine Radar operating at 9415 MHz.
The radar operates from 10.2 – 42 volts DC. There is a 10 inch color TFT display that is used to control the radar and display the radar images. The RF output going to the antenna port is WR90 waveguide.
Type of emission = PON

The EUT has measurement ranges from 1/8, 1/4,1/2, 3/4, 1, 1.5, 2. 3. 4. 6, 8, 12, 16, 24, 32, 36 NM (NM = nautical mile)
The test results were recorded for 1/8, 3, and 36 NM.
Refer to Table 1 for pulse width and repetition rates for 1/8, 3, 36 NM.

Table 1 – Pulse Width/repetition rate vs distance

Nautical Miles	Measured PW and PRR		
	Pulse Width (ns)	PRR (us)	PRF (Hz)
1/8	80	462.96	2160
3	350	694.44	1440
36	900	1388.89	720

The manufacturer supplied the following antenna information.

Type	Gain	Side Lobe	Back Lobe	Size (mm)	
	dBi	dB	dB	Width	Height
Slotted Waveguide Array	25	-22	N/A	553	95.2

EUT Operation during Tests
The EUT was tested at 18 vdc under normal operation.
There was a waveguide coupler and 30 dB attenuator connected to the output for all tests unless otherwise noted for individual tests.

Test Results Summary

Specification		Test Name	Pass, Fail, N/A	Comments
FCC	ISED			
2.1047 80.213(g)	RSS-238 Section 3.2	Modulation Requirements	Pass	
2.1046 80.215 (a)	RSS-238 Section 4.2	Output Power (Conducted)	Pass	
2.1051 80.211(f)	RSS-238 Section 4.3	Conducted Spurious Emissions	Pass	
2.1053 80.211(f)	RSS-238 Section 4.3	Radiated Spurious Emissions	Pass	
2.1049 80.205	N/A	Emission Mask	Pass	
2.1049 80.205	RSS-238 Section 3.2	Occupied Bandwidth	Pass	
2.1055 80.209(b)	RSS-238 Section 4.1	Frequency Stability (Temperature Variation)	Pass	
2.1055, 80.209(b)	RSS-238 Section 4.1	Frequency Stability (Voltage Variation)	Pass	

Statements of conformity

Statements of conformity are reported as:

- Pass - the measured value is below the acceptance limit, *acceptance limit = test limit*.
- Fail - the measured value is above the acceptance limit, *acceptance limit = test limit*.

Modulation Requirements

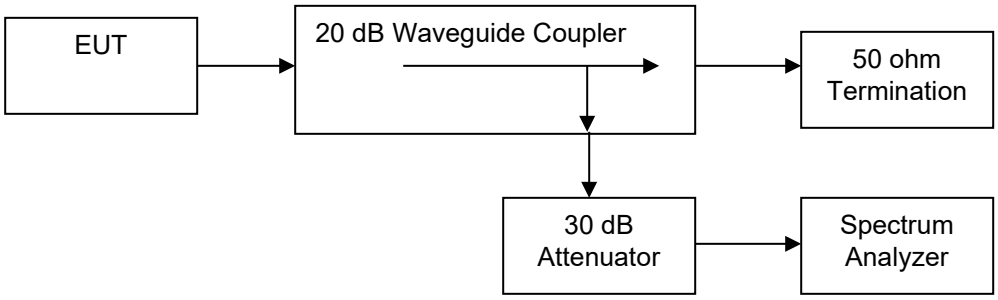
Engineer: Greg Corbin

Test Date: 11/18/2020

Test Procedure

The EUT was setup as shown.
The Pulse Width and Pulse Repetition Rate was measured for 1/8, 3, 36 nautical mile settings using a Real Time Spectrum Analyzer set to the zero-span mode.

Test Setup



Nautical Mile	Pulse Width (usec)	Pulse Repetition Rate (usec)	Pulse Repetition Frequency (Hz)
1/8	0.180	458.9	2179
3	0.460	690.2	1449
36	1.040	1387	721

Refer to Annex A for the modulation requirements

Output Power (Conducted)
Engineer: Greg Corbin
Test Date: 11/18/2020

Test Procedure

The channel power was measured for each distance listed in the table below.
The channel power was measured using the channel power tool on the spectrum analyzer with the integration bandwidth set to the measured occupied bandwidth.

Per ANSI C63.26-2015, section 5.2.4.4.2(j), the following formulas were utilized.

Duty Cycle Correction Factor (DCCR) =10*LOG(1/duty cycle)

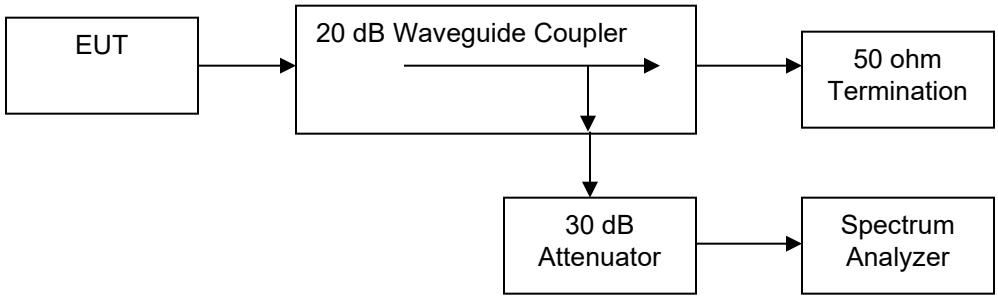
Duty Cycle = PW/PRR+PW (for 1 complete cycle)

Duty Cycle Correction Factor (DCCR) =10*LOG10(1/(PW/((PRR*1000)+PW)))

PEP (peak envelope power) = Channel Power + DCCR

PW = pulse width
PRR = pulse repetition rate

Test Setup



Nautical Mile (nm)	Pulse width (usec)	Pulse Rep. Rate (Hz)	Occupied BW (MHz)	Measured Channel Power		DCCR (dB)	Calculated PEP	
				dBm	watt		dBm	kw
1/8	0.18	458.9	44.38	29.95	0.9886	34.07	64.016	2.5212
3	0.46	690.2	23.79	34.67	2.9309	31.77	66.435	4.4005
36	1.04	1387	12.6	35.57	3.6058	31.25	66.824	4.8125

The FCC does not specify a output power limit in Part 80 for this type of emission (PON) and frequency range.

ISED Limit = 60 kw and the antenna gain shall not exceed 35 dBi.

Antenna Gain: 25 dBi

Conducted Spurious Emissions

Engineer: Greg Corbin

Test Date: 12/3/2020

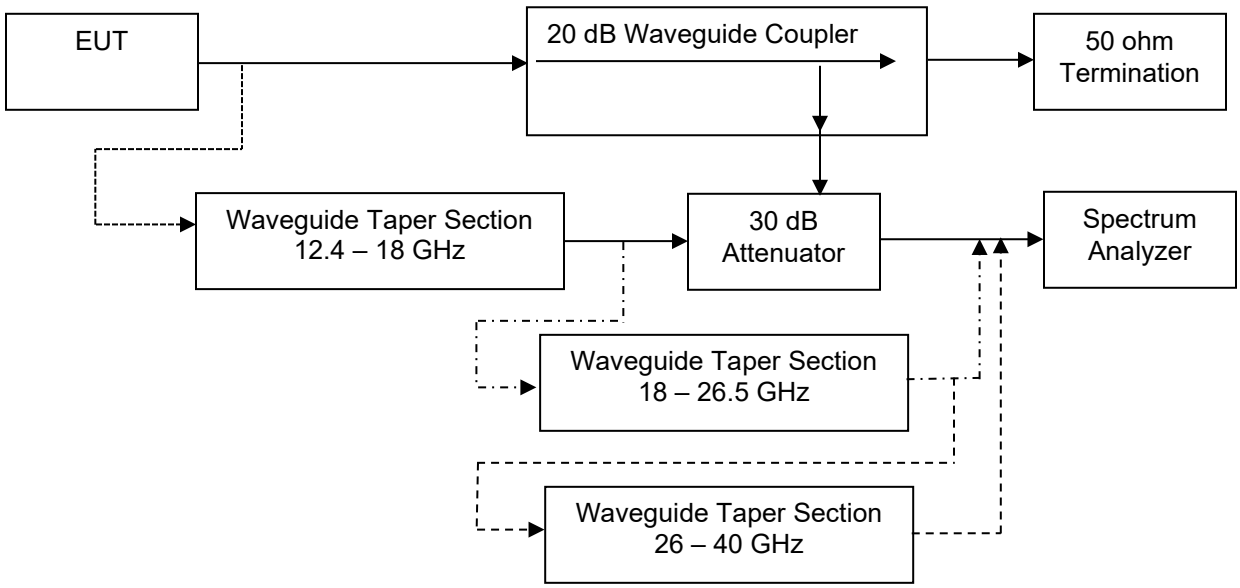
Test Procedure

Conducted spurious emissions were measured at the waveguide RF output as follows.
Spurious emissions were measured for each combination of PW/PRR and are referenced by the distance; 0.125, 3, 36 nautical miles.
RBW below 1 GHz = 100 kHz
RBW above 1 GHz = 1 MHz
When used, the waveguide coupler, 30 dB attenuator and RF cable insertion loss correction factors was input to the spectrum analyzer as correction factors or reference level offsets before recording the spurious emissions data.
From 30 MHz to 12.4 GHz the waveguide coupler and 30 dB attenuator were installed and the spurious was measured at the 30 dB attenuator output.
From 12.4 – 40 GHz, waveguide taper sections were installed at the EUT WR90 output.
From 12.4 – 18 GHz the waveguide coupler was removed and the 30 dB attenuator was moved to the waveguide taper output.
From 18 – 40 GHz, the 30 dB attenuator was removed and the spurious emissions were measured at the output of each taper section.
The following waveguide taper sections were used.

Waveguide Taper sections

Measured Frequency (GHz)	Waveguide Flange	Frequency Range (GHz)	Waveguide Flange	Frequency Range (GHz)
12.4 – 18	WR90	8.2 – 12.4	WR62	12.4 – 18
18 – 26.5	WR62	12.4 – 18	WR42	18 – 26.5
26.5 – 40	WR42	18 – 26.5	WR28	26.5 - 40

Test Setup



Conducted Spurious Emissions Test Results

Nautical Miles	Frequency Range GHz	Measured Spurious Emission (Peak)		DCCF dB	Final Spurious Emissions (avg) dBm	Limit dBm	Pass / Fail
		MHz	dBm				
0.125	0.010 - 1000	555.92	-45.3	0	-45.3	-13	Pass
3	0.010 - 1000	603.5	-45.6	0	-45.6	-13	Pass
36	0.010 - 1000	464.97	-45.2	0	-45.2	-13	Pass
0.125	1 - 12.4	10830.1	-6.2	-34.07	-40.27	-13	Pass
3	1 - 12.4	10727.1	-10.3	-31.77	-42.07	-13	Pass
36	1 - 12.4	10748	-7.7	-31.25	-38.95	-13	Pass
0.125	12.4 - 18	15823.2	-44.4	0	-44.4	-13	Pass
3	12.4 - 18	14956.3	-44.3	0	-44.3	-13	Pass
36	12.4 - 18	15128.6	-44.6	0	-44.6	-13	Pass
0.125	18 - 26.5	18830.9	-60.1	-34.07	-94.17	-13	Pass
3	18 - 26.5	18824.6	-47.1	-31.77	-78.87	-13	Pass
36	18 - 26.5	18822.5	-44.5	-31.25	-75.75	-13	Pass
0.125	26.5 - 40, 3rd Harmonic	28245.1	-25.8	-34.07	-59.87	-13	Pass
3	26.5 - 40, 3rd Harmonic	28234.7	-15.8	-31.77	-47.57	-13	Pass
36	26.5 - 40, 3rd Harmonic	28228.7	-17.2	-31.25	-48.45	-13	Pass

The DCCF applies to spurious emissions that are a by-product of the fundamental emissions.
If the entry in the DCCF column = 0, then the emission is not a by-product of the fundamental emission and the DCCR does not apply to that emission.
Where applicable, the antenna and cable correction factors were input to the spectrum analyzer before recording the final data.

Per ANSI C63.26-2015, section 5.2.4.4.2(j), DCCF = 10LOG(1/duty cycle)

Duty Cycle = PW/PRR+PW (1 complete cycle), PW = pulse width, PRR = pulse rep rate

All spurious emissions were below the -13 dBm limit.

No other spurious emissions were observed.

Refer to Annex B for Conducted Emission test plots.

Radiated Spurious Emissions
Engineer: Greg Corbin
Test Date: 12/7/2020

Test Procedure

The EUT was tested in a semi-anechoic chamber with the turntable set 3m from the receiving antenna.
A spectrum analyzer was used to verify that the EUT met the requirements for Radiated Emissions.
The EUT was tested by rotating it 360 degrees with the antenna in both the vertical and horizontal orientation while raised from 1 to 4 meters to ensure that the signal levels were maximized.

Spurious emissions were measured for 3 combinations of PW/PRR and are referenced by the distance; 0.125, 3, 36 nautical miles.

Per 80.211(f), the spurious emissions are referenced to the mean (avg) power.

The peak emissions were measured and the average emission was calculated and compared to the limit.
If a peak value was near the limit an average measurement was performed

The following formula was used for calculating the limits:

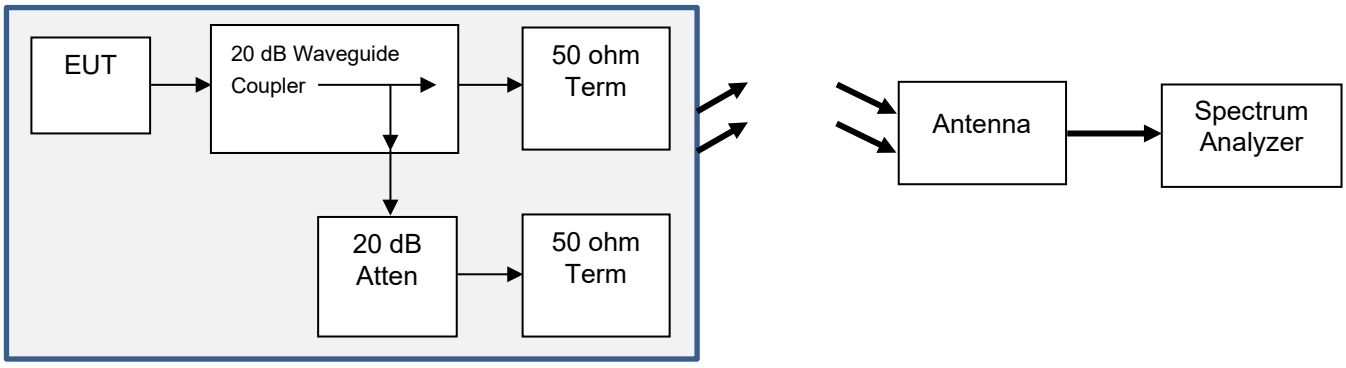
Duty Cycle Correction Factor (DCCR) =10*LOG10(1/(PW/((PRR*1000)+PW)))

Final Spurious emissions (avg) = Measured Spurious (Peak) + Antenna Corr Factor + Cable Corr Factor – DCCF

Radiated Spurious Emissions Limit
Wideband = P1 – (43+ 10Log(P2)) = -13dBm
P1 = power in dBm
P2 = power in Watts

The RBW was set to 100 kHz for measurements below 1 GHz and 1 MHz for measurements above 1 GHz.
The VBW was set to 3 times the RBW.

Test Setup



Radiated Spurious Emissions Test Results

Nautical Miles	Frequency Range GHz	Measured Spurious Emission (Peak)		Antenna Correction Factor dB	Cable Correction Factor dB	DCCF dB	Final Spurious Emissions (avg) dBm	Limit dBm	Pass / Fail
		MHz	dBm						
0.125	30 - 1000	180.4	-40.8	0	0	0	-40.8	-13	Pass
3	30 - 1000	180.4	-33.8	0	0	0	-33.8	-13	Pass
36	30 - 1000	32.4	-35.1	0	0	0	-35.1	-13	Pass
0.125	1 - 18	1589.4	-49.5	25.02	4.4	0	-20.08	-13	Pass
3	1 - 18	1616.4	-50	25.46	4.7	0	-19.84	-13	Pass
36	1 - 18	1587.4	-49.5	25.02	4.4	0	-20.08	-13	Pass
0.125	18 - 26.5,	18832.8	-55.6	44.93	16.2	-34.07	-28.54	-13	Pass
3	18 - 26.5	18831.2	-44.6	44.93	16.2	-31.77	-15.24	-13	Pass
36	18 - 26.5	18827.7	-42.5	43.93	16.2	-31.25	-13.62	-13	Pass
0.125	26.5 - 40	30008.9	-69.6	46.52	20.9	-34.07	-36.25	-13	Pass
0.125	26.5 - 40	28253.8	-69.6	46.4	20.45	-34.07	-36.82	-13	Pass
3	26.5 - 40	30236.4	-69.4	46.62	20.95	-31.77	-33.6	-13	Pass
3	26.5 - 40	28274.4	-69.3	46.4	20.45	-31.77	-34.22	-13	Pass
36	26.5 - 40	32530.6	-68.8	46.4	20.3	-31.25	-33.35	-13	Pass
36	26.5 - 40	28240.4	-68.5	46.4	20.3	-31.25	-33.05	-13	Pass

Below 1 GHz, the antenna and cable correction factors were input to the spectrum analyzer before recording the peak measurement.
Above 1 GHz the antenna and cable correction factors were added to the peak measurement in the test results table.

All spurious emissions were below the -13 dBm limit.

No other spurious emissions were observed.

Refer to Annex C for Radiated Spurious Emission test results.

Emission Mask

Engineer: Greg Corbin

Test Date: 11/18/2020

Test Procedure

The EUT was setup as shown.
The spurious emissions is referenced to the mean power per 80.211(f)

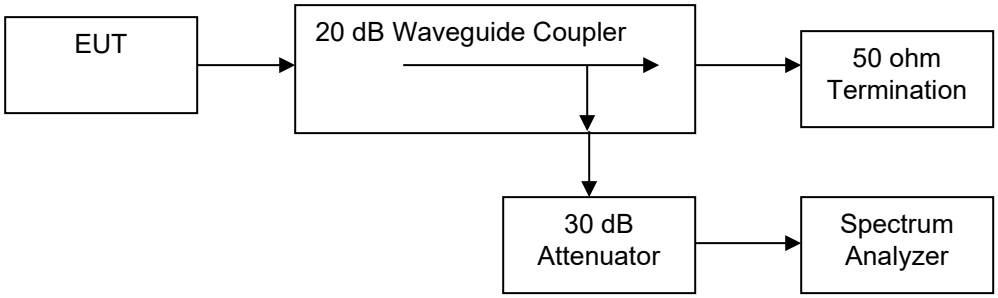
Emission masks were measured for each combination of PW/PRR and are referenced by the distance; 0.125, 3, 36 nautical miles.

The reference level was set to the channel power + the Duty Cycle Correction Factor so the mask could be displayed using a peak detector.

The waveguide coupler, 30 dB attenuator and RF cable insertion loss correction factors was input to the spectrum analyzer as correction factors or reference level offsets before recording the emission mask data.

The RBW was set between 1 – 5% of the occupied bandwidth.

Test Setup



Refer to Annex D for Emission Mask test data

Occupied Bandwidth
Engineer: Greg Corbin
Test Date: 11/19/2020

Test Procedure

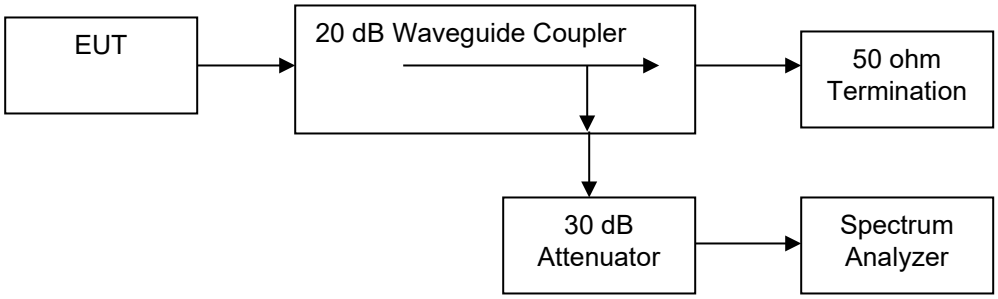
The EUT was setup as shown.

Occupied Bandwidth was measured for 3 PW/PRR settings, 0.125, 3, 36 nautical miles.

Th 99% occupied bandwidth was recorded for the FCC and the -40 dB bandwidth was recorded for ISED.

The waveguide coupler, 30 dB attenuator and RF cable insertion loss correction factors was input to the spectrum analyzer as correction factors or reference level offsets before recording the occupied bandwidth data.

Test Setup



Occupied Bandwidth Test Summary Table

Nautical Miles	99% Bandwidth (FCC)	-40 dB Bandwidth (ISED)
	MHz	MHz
0.125	44.384	169.774
3	23.797	70.930
36	12.602	50.756

Refer to Annex E for Occupied Bandwidth test data.

Frequency Stability (Temperature Variation)

Engineer: Greg Corbin

Test Date: 6/19/2018

Test Procedure

The EUT was placed in an environmental test chamber and the RF output was connected directly to a spectrum analyzer
The temperature was varied from -20ºC to 50ºC in 10ºC increments.
After a sufficient time for temperature stabilization the RF output frequency was measured.

Per part 80.209(b) When pulse modulation is used in land and ship radar stations operating in the bands above 2.4 GHz the frequency at which maximum emission occurs must be within the authorized bandwidth and must not be closer than 1.5/T MHz to the upper and lower limits of the authorized bandwidth where “T” is the pulse duration in microseconds.

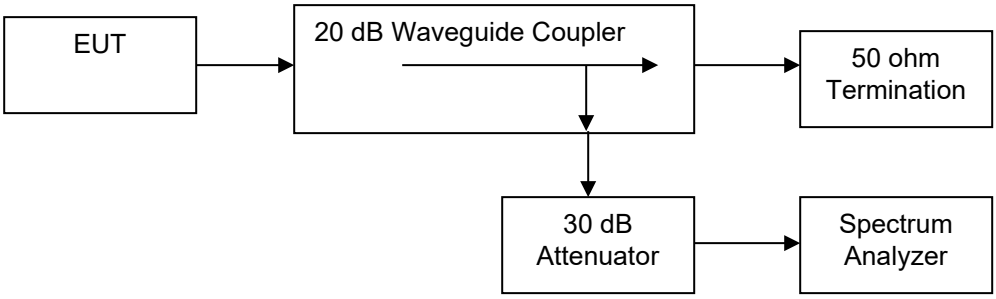
There is no authorized bandwidth for the PON class of emission in section 80.205 Bandwidth.

The frequency band in part 2.106 was used for the authorized Bandwidth

Per part 2.106 the authorized frequency band is 9.2 – 9.5 GHz.

The lower and upper limits were calculated as follows:
Lower limit (MHz)= 9200 + (1/T) MHz
Upper Limit(MHz) = 9500 – (1/T) MHz
T = PW in usec

Test Setup



Frequency Stability (Temperature Variation) Measurement Results

Temperature (°C)	Nautical Mile	Pulse Width (usec)	Measured Frequency (GHz)	Lower Limit (MHz)	Upper limit (GHz)	Pass / Fail
-20	0.125	0.18	9428.499586000	9205.555555556	9494.444444444	Pass
-20	3.0	0.46	9427.988243000	9202.173913043	9497.826086957	Pass
-20	36.0	1.04	9428.000688000	9200.961538462	9499.038461538	Pass
-10	0.125	0.18	9426.664346000	9205.555555556	9494.444444444	Pass
-10	3.0	0.46	9425.496642000	9202.173913043	9497.826086957	Pass
-10	36.0	1.04	9425.165868000	9200.961538462	9499.038461538	Pass
0	0.125	0.18	9425.497979000	9205.555555556	9494.444444444	Pass
0	3.0	0.46	9423.499154000	9202.173913043	9497.826086957	Pass
0	36.0	1.04	9423.344784000	9200.961538462	9499.038461538	Pass
10	0.125	0.18	9423.331100000	9205.555555556	9494.444444444	Pass
10	3.0	0.46	9421.500251000	9202.173913043	9497.826086957	Pass
10	36.0	1.04	9421.498757000	9200.961538462	9499.038461538	Pass
20	0.125	0.18	9420.832922000	9205.555555556	9494.444444444	Pass
20	3.0	0.46	9419.498744000	9202.173913043	9497.826086957	Pass
20	36.0	1.04	9419.163232000	9200.961538462	9499.038461538	Pass
30	0.125	0.18	9418.831502000	9205.555555556	9494.444444444	Pass
30	3.0	0.46	9417.664170000	9202.173913043	9497.826086957	Pass
30	36.0	1.04	9417.665595000	9200.961538462	9499.038461538	Pass
40	0.125	0.18	9417.165964000	9205.555555556	9494.444444444	Pass
40	3.0	0.46	9415.665860000	9202.173913043	9497.826086957	Pass
40	36.0	1.04	9415.666408000	9200.961538462	9499.038461538	Pass
50	0.125	0.18	9414.498290000	9205.555555556	9494.444444444	Pass
50	3.0	0.46	9413.163481000	9202.173913043	9497.826086957	Pass
50	36.0	1.04	9413.331697000	9200.961538462	9499.038461538	Pass

Frequency Stability (Voltage Variation)

Engineer: Greg Corbin

Test Date: 6/19/2018

Test Procedure

The EUT was placed in a temperature chamber at 20± 0.5°C and connected directly to a spectrum analyzer. The power supply voltage to the EUT was varied from 85% to 115% of the nominal value and the RF output was measured.

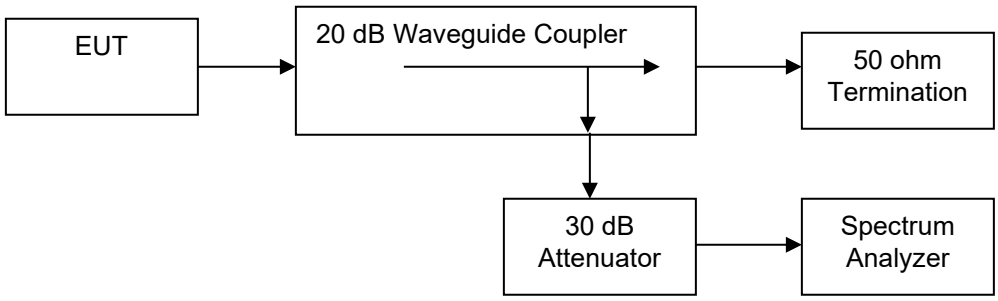
The rated voltage range for the EUT is 10.2 – 42 vdc.

The lower test input voltage = .85 x 10.2 = 8.67 vdc

The upper test input voltage = 1.15 x 42 = 48.3 vdc.

The system controller shutdown at 44.5 vdc, so 44 vdc was used as the upper limit.

Test Setup



Frequency Stability (Voltage Variation) Measurement Results

Supply Voltage (vdc)	Nautical Mile	Pulse Width (usec)	Measured Frequency (GHz)	Lower Limit (MHz)	Upper limit (GHz)	Pass / Fail
8.67	0.125	0.18	9419.664154000	9205.555555556	9494.444444444	Pass
8.67	3.0	0.46	9418.667214000	9202.173913043	9497.826086957	Pass
8.67	36.0	1.04	9418.664329000	9200.961538462	9499.038461538	Pass
44	0.125	0.18	9419.831438000	9205.555555556	9494.444444444	Pass
44	3.0	0.46	9418.831687000	9202.173913043	9497.826086957	Pass
44	36.0	1.04	9418.666536000	9200.961538462	9499.038461538	Pass

Test Equipment Utilized

Description	Manufacturer	Model Number	CT Asset Number	Last Cal Date	Cal Due Date
Horn Antenna	EMCO	3116	i00085	2/28/19	2/28/21
Waveguide Coupler	Narda	1080	i00187	Verified on: 11/18/20	
Dummy Load	Narda	320B	i00189	Verified on: 11/18/20	
Harmonic Mixer	Hewlett Packard	11970A	i00193	6/28/18	6/28/21
Bi-Log Antenna	Chase	CBL6111C	i00267	8/28/20	8/28/22
Horn Antenna	ARA	DRG-118/A	i00271	8/3/20	8/3/21
Data Logger	Fluke	Hydra Data Bucket	i00343	6/10/20	6/10/21
EMI Analyzer	Agilent	E7405A	i00379	1/21/20	1/21/21
Spectrum Analyzer	Textronix	RSA5126A	i00424	8/3/20	8/3/21
3 Meter Semi-Anechoic Chamber	Panashield	3 Meter Semi-Anechoic Chamber	i00428	7/17/20	7/17/21
EMI Receiver	Keysight	N9038A	i00552	11/20/20	11/20/21
Waveguide Taper	Demornay Bonardi	WR90 – WR62	i00538.2	Verified on: 12/3/20	
Waveguide Taper	N/A	WR62 – WR42	i00538.3	Verified on: 12/3/20	
Waveguide Taper	Demornay Bonardi	WR42 – WR28	i00538.4	Verified on: 12/3/20	
Waveguide adapter	Americon	WR62 - SMA	i00538.6	Verified on: 12/3/20	
Waveguide adapter	Wiltron	WR42 – 2.92 mm	i00538.7	Verified on: 12/3/20	
Waveguide adapter	HP	WR28 – 1.92 mm	S/N: 01806	Verified on: 12/3/20	
Waveguide adapter	HP	WR90 – type N	i00188	Verified on: 12/3/20	
Attenuator, 30 dB, 50w	Mini-Circuits	BW-N30W50+	i00474	Verified on: 12/3/20	

In addition to the above listed equipment standard RF connectors and cables were utilized in the testing of the described equipment. Prior to testing these components were tested to verify proper operation.

END OF TEST REPORT