



Compliance Testing, LLC

Previously Flom Test Lab

EMI, EMC, RF Testing Experts Since 1963

toll-free: (866) 311-3268

fax: (480) 926-3598

<http://www.ComplianceTesting.com>

info@ComplianceTesting.com

Test Report

Prepared for: Fortem Technologies

Model: R20

Description: Navigation Radar (Ground Based)

Serial Number: 20-A00088

FCC ID: 2APIM-FTR20SKYD

To

FCC Part 87

Date of Issue: June 7, 2018

On the behalf of the applicant:

**Fortem Technologies
2015 West Grove Pkwy
Pleasant Grove, UT 84062**

Attention of:

**Ernie Morales
(801) 671-2664
Ernie.Morales@Fortemtech.com**

**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: p1820012**

**Poona Saber
Project Test Engineer**

This report may not be reproduced, except in full, without written permission from Compliance Testing.
All results contained herein relate only to the sample tested.

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	May 4, 2018	Poona Saber	Original Document
2.0	May 21, 2018	Poona Saber	Revised antenna gain to 12 dBi from 15 dBi and revised values of conducted power measurement -added average factor and average measurement on page 8 Updated annex A for new table and signal identity off plots -updated test procedure on page 12
3.0	May 30, 2018	Poona Saber	Added emissions designator on page 5
4.0	June 6, 2018	Poona Saber	-Updated the watts value in table on page 7 -Updated Annex A units for antenna and mixer factors

Table of Contents

<u>Description</u>	<u>Page</u>
Standard Test Conditions Engineering Practices	5
Test Results Summary	6
Carrier Output Power	7
Spurious Emissions	8
Emission Masks (Occupied Bandwidth)	10
Frequency Stability (Temperature Variation)	11
Frequency Stability (Voltage Variation)	12
Necessary Bandwidth and Emission Bandwidth	13
Test Equipment Utilized	14

ILAC / A2LA

Compliance Testing, LLC, has been accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer 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 in the table below

Please refer to <http://www.compliancetesting.com/labscope.html> for current scope of accreditation.

Testing Certificate Number: **2152.01**



FCC Site Reg. #349717

IC Site Reg. #2044A-2

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 87.

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

Environmental Conditions		
Temperature (°C)	Humidity (%)	Pressure (mbar)
25.1	36.4	970.6

EUT Description

Model: R20 and DAN-C (DAN-C is identical to tested R20 but with limited software)

Description: Radio Navigation Land radar

Firmware: N/A

Software: N/A

Serial Number: N/A

Emission Designator: 300MQXN

Additional Information

R-20 is a small, compact, powerful radar detection system providing tracking capabilities that monitor a marked or defined airspace, and reports all airborne activity within that space.

EUT Operation during Tests

Antenna gain is 12 dBi and the maximum clock/ processor is 50 MHz. Device is 24V DC power operated. It's using FMCW (frequency modulation with a continuous wave) modulation technique. For testing purposes the sweeping function is stopped and device is put on Low, Mid and High channels. Peak measurements of the signal is made and average is calculated for FMCW based on procedures on KDB 890966.

Test Results Summary

Specification	Test Name	Pass, Fail, N/A	Comments
2.1046, 87.131	Carrier Output Power (Conducted)	Pass	
2.1051, 87.139(i)(1)	Unwanted Emissions (Transmitter Conducted)	Pass	
2.1053	Field Strength of Spurious Radiation	Pass	
2.1049, 87.139(i)(3)	Emission Masks (Occupied Bandwidth)	Pass	
2.1047	Audio Low Pass Filter (Voice Input)	N/A	The EUT does not contain an audio input
2.1047	Audio Frequency Response	N/A	The EUT does not contain an audio input
2.1047	Modulation Limiting	N/A	The EUT does not contain an audio input
2.1055, 87.133(a)	Frequency Stability (Temperature Variation)	Pass	
2.1055, 87.133(a)	Frequency Stability (Voltage Variation)	Pass	

Carrier Output Power

Engineer: Poona Saber

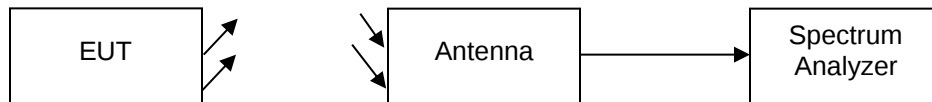
Test Date: 5/1/2018

Test Procedure

The Equipment Under Test (EUT) was located in anechoic chamber at 1 meter away from measuring antenna at 1.5 meter high and the carrier power was maximized by rotating the turn table and changing measuring antenna's height.

The RBW was set to 1 MHz and the VBW set to 3 X RBW which set the RBW greater than the transmit signal ensuring there was no signal suppression while measuring a modulated signal. The peak readings were taken for each modulation type and the result was then compared to the limit.

Test Setup



Tuned Frequency (MHz)	Measured Power Peak EIRP Not Corrected (dBm)	Cable Loss	Antenna Correction Factor	Measured Power Peak EIRP Corrected (dBm)	Measured Power Peak Conducted (dBm)	Measured Power Peak (W)	Limit (W)	Result
15484.5	-4.63	10.9	38.33	44.6	32.6	1.81	N/A	N/A
15550	-4.44	10.8	38.24	44.6	32.6	1.81	N/A	N/A
15611	-3.39	11	38.11	45.7	33.7	2.34	N/A	N/A

Note: Power is measured without antenna correction factor and cable loss included in the measurement to get enough dynamic range on the spectrum analyzer. The measurement is corrected in the table above for these values and antenna gain is subtracted from EIRP to get the conducted value.

Note: Based on part 87.131 for radio navigation devices frequency, emission, and maximum power will be determined after coordination with appropriate Government agencies.

Spurious Emissions

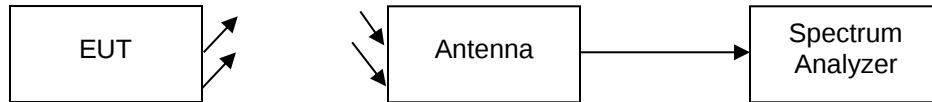
Engineer: Poona Saber

Test Date: 5/2/2018

Test Procedure

The EUT was located in anechoic chamber at 1 meter away from receive antenna for emissions above 1GHz and at 3 meters for emissions below 1GHz. RBW was set according to the requirements of 87.139 (d) to meet the -13 dBm limit. The power was corrected for antenna correction factor, distance correction factor and RBW correction factor. Frequency was measured up to 100 GHz and mixers + waveguide antennas were used to measure for the whole range.

Test Setup



Radiated Spurious Emissions

Frequency Range (GHz)	Emission Frequency (GHz)	Peak Measured Level Peak EIRP (dBm)	Average Factor	Average Measured Level Peak EIRP (dBm)	Limit (dBm)	Margin
30 MHz-1GHz	0.0591	-51.03	0.005	-74	-13	-61
1-18 GHz	17.2	7.5	0.005	-15.5	-13	-2.5
18-40 GHz	31.23	-13.02	0.005	-36	-13	-23
33-50 GHz	38.99	-30.46	0.005	-53.47	-13	-40.47
50-75 GHz	56.25	-14.27	0.005	-37.21	-13	-24.21
75-100 GHz	88.37	-1.92	0.005	-24.94	-13	-11.94

Note: In order to have enough dynamic range for measurements above noise floor below considerations has been made:

- 30 MHz-1GHz measured at 3 meters and cable factors include but antenna and preamp factors are not
- 1-26.5 GHz Measured at 1 meter and cable factor was included but ACF is not included
- 26.5-100 GHz Measured at 1 meter and cable factor was included but ACF and Mixer factors are not.

Average Factor is calculated as below:

Dwell time TD of the sweep frequency signal per MHz of the sweep frequency span:

Ts= 0.92 ms = 0.00092 s

DeltaF= 155 MHz

TD= Ts/deltaF = 5.9 us

Cycle time= 1 ms

Average factor= TD/ cycle time

Average factor= 5.9 us /1 ms = 0.005

Cycle time= is the total time for a complete cycle of the signal including retrace and any other latency times. In this case since it's a continuous sweep and there is no latency or retrace time the cycle time is equal to signal sweep time

Ts= signal sweep frequency time in seconds

DeltaF= signal sweep frequency span in MHz

Please Refer to Annex A for spurious emission plots

Emission Masks (Occupied Bandwidth)

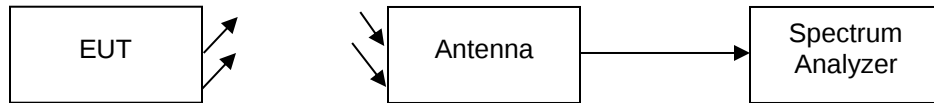
Engineer: Poona Saber

Test Date: 5/2/2018

Test Procedure

The EUT was located in anechoic chamber at 1 meter away from receive antenna for measuring Mask (a) requirement of part 87.139 (a). The Authorized Bandwidth is declared as 300 MHz based on manufacture and this Bandwidth is used to make the limits for Mask A.

Test Setup



Please Refer to Annex B for spurious emission plots

Frequency Stability (Temperature Variation)

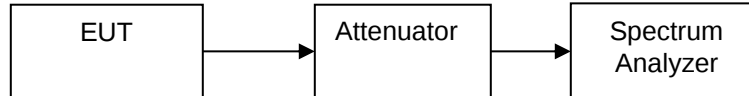
Engineer: Greg Corbin

Test Date: 2/23/2018

Test Procedure

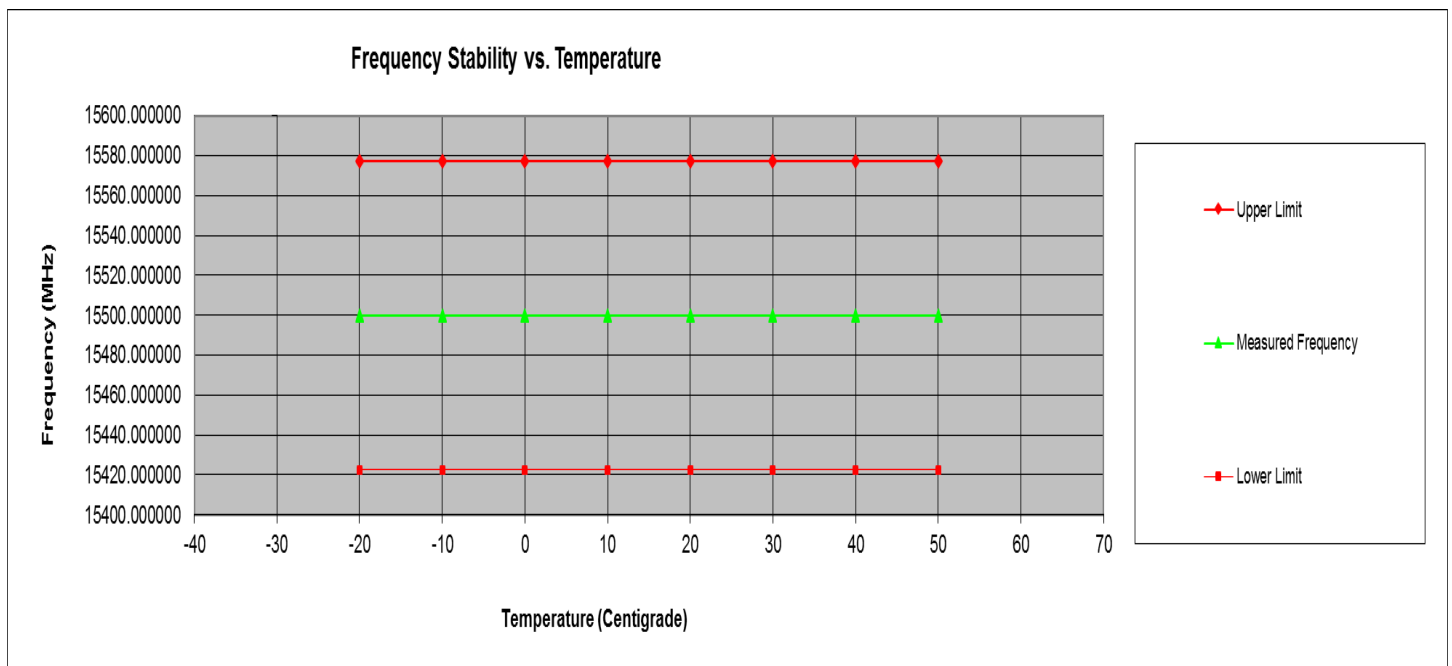
The EUT was placed in an environmental test chamber and the RF output was connected directly to a frequency counter. The temperature was varied from -20°C to 50°C in 10°C increments. After a sufficient time for temperature stabilization the RF output frequency was measured.

Test Setup



Measurement Results

Tuned Frequency (MHz)	Frequency Tolerance PPM	Upper Limit (MHz)	Lower Limit (MHz)	Temperature centigrade	Measured Frequency (MHz)	Upper Margin (MHz)	Lower Margin (MHz)
15500.000	5000.0	15577.500000	15422.500000				
		15577.500000	15422.500000				
		15577.500000	15422.500000	-20	15500.018750	-77.481250	77.518750
		15577.500000	15422.500000	-10	15500.016625	-77.483375	77.516625
		15577.500000	15422.500000	0	15500.012437	-77.487563	77.512437
		15577.500000	15422.500000	10	15500.010750	-77.489250	77.510750
		15577.500000	15422.500000	20	15500.010125	-77.489875	77.510125
		15577.500000	15422.500000	30	15500.009562	-77.490438	77.509562
		15577.500000	15422.500000	40	15500.009312	-77.490688	77.509312
		15577.500000	15422.500000	50	15500.009000	-77.491000	77.509000



Frequency Stability (Voltage Variation)

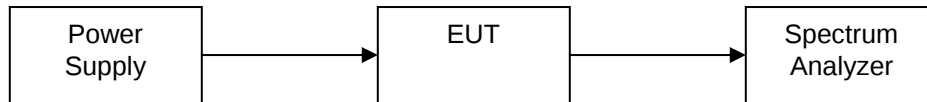
Engineer: Greg Corbin

Test Date: 2/23/2018

Test Procedure

The EUT was placed in a temperature chamber at $20 \pm 5^\circ\text{C}$ 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. This was measured with a variable DC voltage source.

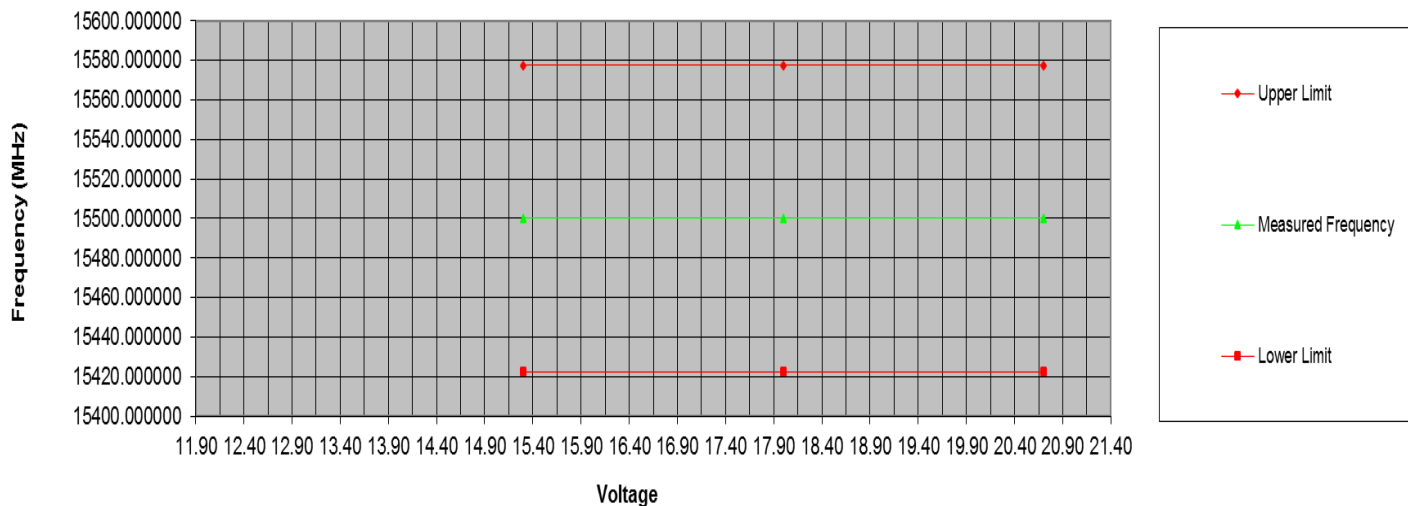
Test Setup



Test Results

Tuned Frequency (MHz)	Frequency Tolerance PPM	Upper Limit (MHz)	Lower Limit (MHz)	Nominal Voltage	Voltage	Measured Frequency (MHz)	Upper Margin (MHz)	Lower Margin (MHz)
15500.000	5000.0	15577.500000	15422.500000	18.00	15.30	15500.010125	-77.489875	77.510125
		15577.500000	15422.500000		18.00	15500.010125	-77.489875	77.510125
		15577.500000	15422.500000		20.70	15500.009937	-77.490063	77.509937

Frequency Stability vs. Voltage



Necessary Bandwidth and Emission Bandwidth

Engineer: Poona Saber

Test Date: 5/2/2018

Per FCC part 2.202 (c) the EUT's FMCW system does not contain digital information and so number 4 applies to it

(c) The necessary bandwidth may be determined by one of the following methods:

1) Use of the formulas included in the table, in paragraph (g) of this section, which also gives examples of necessary bandwidths and designation of corresponding emissions;

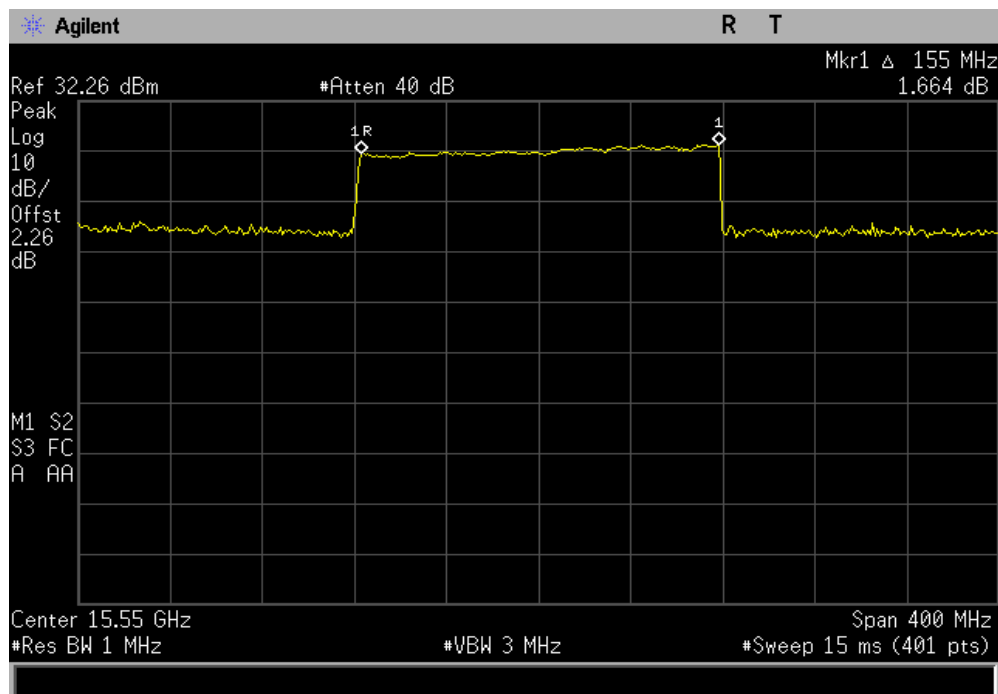
(2) For frequency modulated radio systems which have a substantially linear relationship between the value of input voltage to the modulator and the resulting frequency deviation of the carrier and which carry either single sideband suppressed carrier frequency division multiplex speech channels or television, computation in accordance with provisions of paragraph (f) of this section and formulas and methods indicated in the table, in paragraph (g) of this section;

(3) Computation in accordance with Recommendations of the International Radio Consultative Committee (C.C.I.R.);

(4) Measurement in cases not covered by paragraph (c) (1), (2), or (3) of this section.

$$BW = (\text{speed of light})/2/(\text{rangeRes}) + 32.3 \text{ MHz rise slope} + 7.7 \text{ MHz cushion} = 300 \text{ MHz}$$

Measured Bandwidth for highest data rate of communication currently available with the unit is shown below:



Test Equipment Utilized

Description	MFG	Model Number	CT Asset #	Last Cal Date	Cal Due Date
Spectrum Analyzer	Agilent	4407B	i00331	11/21/17	11/21/18
Harmonic mixer 26.5-40 GHz	HP	11970 A	i00193	6/4/15	6/4/18
Waveguide Adapter	HP	R281A	NA	Functional Verification	Functional Verification
Harmonic mixer 33-50 GHz	HP	11970 Q	i00465	6/4/15	6/4/18
Harmonic mixer 50-75 GHz	HP	11970 V	i00463	6/20/15	6/20/18
Harmonic mixer 75-110 GHz	HP	11970 W	i00464	6/4/15	6/4/18
High gain WR22 waveguide Horn Antenna (33-50 GHz)	cmi	HO22R	i00484	NA	NA
High gain WR22 waveguide Horn Antenna (50-75 GHz)	cmi	HO15R	i00477	NA	NA
High gain WR22 waveguide Horn Antenna (75-110 GHz)	cmi	HO10R	i00476	NA	NA
Horn Antenna (18-40 GHz)	EMCO	3116	i00085	2/6/17	2/6/19
Preamplifier 18-40 GHz	MITEQ	AMF-18004000-29-8P	i00461	Verified on: 5/2/16	
Horn Antenna (1-18GHz)	ARA	DRG-118/A	i00271	6/16/16	6/16/18

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