849 NW STATE ROAD 45
NEWBERRY, FL 32669 USA

PHONE: 352.472.5500
EMAIL: INFO@TIMCOENGR.COM
WEB: HTTP://WWW.TIMCOENGR.COM

TIMCO ENGINEERING, Inc.

An IIA Company

FCC CFR 47 Part 90 Radar Test Report

APPLICANT	APPLIED PHYSICAL SCIENCES CORP.
ADDRESS	475 BRIDGE STREET GROTON CT 06340 USA
FCC ID	2AUE82019
MODEL NUMBER	FutureWaves Wave-i 1.00
PRODUCT DESCRIPTION	X-BAND RADAR SYSTEM
DATE SAMPLE RECEIVED	08/27/2019
FINAL TEST DATE	09/10/2019
TESTED BY	Franklin Rose
APPROVED BY	Tim Royer
TEST RESULTS	☒ PASS ☐ FAIL

Report Number	Report Version	Description	Issue Date
2280AUT19_PT90 Radar TestReport_	Rev1	Initial Issue	09/18/2019

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This report relates only to the sample(s) tested.

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GENERAL REMARKS

Summary

The device under test does:

☒ Fulfill the general approval requirements as identified in this test report and was selected by the customer.

☐ Not fulfill the general approval requirements as identified in this test report

Attestations

This equipment has been tested in accordance with the standards identified in this test report. To the best of my knowledge and belief, these tests were performed using the measurement procedures described in this report.

All instrumentation and accessories used to test products for compliance to the indicated standards are calibrated regularly in accordance with ISO 17025 requirements.

I attest that the necessary measurements were made at:

Timco Engineering Inc.
849 NW State Road 45
Newberry, FL 32669
Designation #: US1070

Tested by:

Name and Title	Franklin Rose, Project Manager / EMC Specialist
Date	09/18/2019

Reviewed and Approved by:

Name and Title	Tim Royer, Project Manager / EMC Testing Engineer
Date	09/25/2019

GENERAL INFORMATION

Definitions: FCC Part 90.7

The EUT is a Radar Station operating as Maritime Radiodetermination Service

Radiodetermination. The determination of position, or the obtaining of information relating to position, by means of the propagation of radio waves.

Radiolocation. Radiodetermination used for purposes other than those of radionavigation.

Radionavigation. Radiodetermination used for the purposes of navigation, including obstruction warning.

Testing Information

EUT Description	X-BAND RADAR SYSTEM		
FCC ID	2AUE82019		
Model Number	FutureWaves Wave-i 1.00		
Operating Band(s)	Band 1: 9.3 – 9.5 GHz		
Emission Designator	144MP0N		
Measurement Method	40dB Occupied Bandwidth		
Modulation	FM Pulse/FM Chirp		
EUT Power Source	☒110–120 VAC	☐ DC Power (12 V)	☐ Battery Operated
Test Item	☐ Prototype	☒ Pre-Production	☐ Production
Type of Equipment	☒ Fixed	☐ Mobile	☐ Portable
Antenna Connector	WR-90 Waveguide output		
Modification to the EUT	The EUT was not modified.		
Test Exercise	The EUT was operated using control software provided by the manufacturer in accordance with the user manual.		
Applicable Standards	FCC CFR 47 Part 2, Part 90, using ANSI C63.26-2015 Referencing: ITU-R M.1177-4		
Test Conditions	Laboratory temperature: 26ºC, Relative humidity: 50%		
Test Facility	Timco Engineering Inc. at 849 NW State Road 45 Newberry, FL 32669 USA. Designation #: US1070		

GENERAL INFORMATION

Operating Frequencies

EUT Intended Band(s) of Operation

Band 1: 9.3 – 9.5 GHz

Rule Part No.: FCC Part 90.103

§90.103 Radiolocation Service.

(b) *Frequencies available.* The following table indicates frequencies available for assignment to stations in the Radiolocation Service, together with the class of station(s) to which they are normally assigned, and the specific assignment limitations, which are explained in paragraph (c) of this section:

RADIOLOCATION SERVICE FREQUENCY TABLE

Frequency or band	Class of station(s)	Limitation
	Megahertz	
9000 to 9200	.....do	10, 14
9200 to 9300	.....do	12
9300 to 9500	.....do	10, 15, 18

(10) Speed measuring devices will not be authorized in this band.

(12) This frequency is shared with and is on a secondary basis to the Government Radiolocation Service.

(14) This frequency band is shared with and is on a secondary basis to the Aeronautical Radionavigation Service (part 87) and to the Government Radiolocation Service.

(15) The non-Government Radiolocation Service in this band is secondary to the Maritime Radionavigation Stations (part 80), the Aeronautical Radionavigation Service (part 87) and the Government Radiolocation Service.

(18) Radiolocation installations will be coordinated with the Government Meteorological Aids Service, and insofar as practicable, will be adjusted to meet the needs of that service.

SUMMARY OF TESTING

FCC Rule Parts	Testing Performed	Result
2.1046(a), 90.205(r)	RF Power Output	**PASS**
2.1033(c)(4), 2.1049(i), 90.207(k), (n), 90.209(b)(5)	Occupied Bandwidth & Modulation Characteristics	**PASS**
90.210(n), (b)(1), (2)	Emission Masks	**PASS**
2.1051(a), 2.1057(a)(1), 90.210(n), (b)(3)	Spurious Emissions at Antenna Terminals	**PASS**
2.1053(a), 2.1057(a)(1), 90.210(n), (b)(3)	Field Strength of Spurious Emissions	**PASS**
2.1055(a)(2), 90.213(a)	Frequency Stability	**PASS**

MODULATION CHARACTERISTICS

Rule Part No.: Part 2.1033(c)(4), 80.207(d), 80.205(a)

§80.207 Classes of emission.

(d) The authorized classes of emission are as follows:

Types of stations	Classes of emission
Ship Stations[1]	
Radiodetermination:	
2.4-9.5 GHz	PON.
Land Stations[1]	
Radiodetermination:	
2.4-9.6 GHz	PON.

[1]Excludes distress, EPIRBs, survival craft, and automatic link establishment.

§80.205 Bandwidths.

(a) An emission designator shows the necessary bandwidth for each class of emission of a station except that in ship earth stations it shows the occupied or necessary bandwidth, whichever is greater. The following table gives the class of emission and corresponding emission designator and authorized bandwidth:

Class of emission	Emission designator	Authorized bandwidth (kHz)
PON	([12])	([12])

[12]Applicable to radiolocation and associated telecommand ship stations operating on 154.585 MHz, 159.480 MHz, 160.725 MHz. 160.785 MHz, 454.000 MHz, and 459.000 MHz; emergency position indicating radiobeacons operating in the 406.000-406.1000 MHz frequency bank; and data transmissions in the 156-162 MHz band.

Note: The EUT shall also be authorized to operate under FCC 47 CFR Part 80. The emission designation guidance from this rulepart is used where no specific guidance is given in Part 90.

Note: Per footnote 12, 80.205(a) does not state requirements for an emission designator or an Authorized bandwidth for radar operating above 2.4 GHz. However, the class of emission shall be P0N.

FCC Bandwidth

Worst-case 99% Occupied Bandwidth: **58.01 MHz**

Worst-case 40 dB Occupied Bandwidth: **143.58 MHz**

Emission Designation: **144MP0N**

Note: Please see "Occupied Bandwidth" section for details.

PULSE CHARACTERISTICS

Pulse Characteristics Table

The EUT employs 1 operational mode, consisting of one of three possible pulse widths.

Subpulse Name	Pulse On-Time	Pulse Repetition Factor	Pulse Rise Time (nS)	Pulse Fall Time (nS)
Pulse 1	50 nS	2000 Hz	10 nS	10 nS
Pulse 2	250 nS	400 Hz		
Pulse 3	750 nS	125 Hz		

Operational Mode(s) Table

Test Mode	Pulse Train	Total Pulse On-Time	Pulse Repetition Factor (kHz)	Pulse Repetition Period (µS)
Pulse 1	n/a	50 nS	2000	500

Note: This mode was selected using the following rationale:

1. Mode 1 is the worst-case mode as identified by the EUT Manufacturer.
2. Modes 2 & 3 were tested for redundancy. Analysis shows Modes 2 and 3 operated at a slightly lower power, and produced less spurious emissions.
3. It is the standard operational mode which is employed by the system. Other configurations were “non-standard” according to the EUT Manufacturer.

RF POWER OUTPUT

Rule Part No.: FCC Part 2.1046(a), 90.205(r)

Requirements:

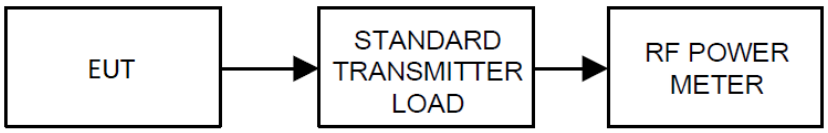
§90.205 Power and antenna height limits.

(r) *All other frequency bands.* Requested transmitter power will be considered and authorized on a case by case basis.

Note: the frequency bands referred to in 90.205 do not include 9.0 – 9.5 GHz. These frequencies are covered by clause (r).

Test Procedure: ANSI C63.26

Test Setup Block Diagram:



Test Data: Mode 1, Mean Power Output

Mode	Nominal Frequency (MHz)	Measured Mean Output Power (dBm)	Loss (dB)	Mean Power Output (dBm)	Mean Power Output (W)	Calculated Duty Cycle (%)	Peak Power Output (W)	Peak Power Output (dBm)
1	9400	-10.76	-67.760	57.00	501.19	2.00%	25059	73.990

Maximum Mean Power: **501.19 W**

Maximum Peak Power: **25.06 kW**

Note: The EUT shall be installed with a suitable antenna which complies with 80.215(n) power limitations.

POWER AT THE FINAL AMPLIFIER

Rule Part No.: FCC Part 2.1033(c)(8)

Requirement:

(c) Applications for equipment other than that operating under parts 15, 11 and 18 of this chapter shall be accompanied by a technical report containing the following information:

(8) The dc voltages applied to and dc currents into the several elements of the final radio frequency amplifying device for normal operation over the power range.

Test Data: Power at the Final Amplifier

INPUT POWER: (100 VAC) (10.5 A) = **1050 Watts Max**

OCCUPIED BANDWIDTH

Rule Part No.: Part 2.1033(c)(4), 2.1049(i)

99% Occupied Bandwidth Rule Parts

Rule Part No.: 90.207(k), (n), 90.209(b)(5)

§2.1049 Measurements required: Occupied bandwidth.

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured under the following conditions as applicable:

(i) Transmitters designed for other types of modulation—when modulated by an appropriate signal of sufficient amplitude to be representative of the type of service in which used. A description of the input signal should be supplied.

§90.207 Types of emissions.

(k) For radiolocation operations as may be authorized in accordance with subpart F, unless otherwise provided for any type of emission may be authorized upon a satisfactory showing of need.

(n) *Other emissions.* Requests for emissions other than those listed in paragraphs (c) through (e) of this section will be considered on a case-by-case basis to ensure that the requested emission will not cause more interference than other currently permitted emissions.

§90.209 Bandwidth limitations.

(b) The maximum authorized single channel bandwidth of emission corresponding to the type of emission specified in §90.207 is as follows:

STANDARD CHANNEL SPACING/BANDWIDTH

Frequency band (MHz)	Channel spacing (kHz)	Authorized bandwidth (kHz)
Above 2500[2]		

[2]Bandwidths for radiolocation stations in the 420-450 MHz band and for stations operating in bands subject to this footnote will be reviewed and authorized on a case-by-case basis.

Test Procedure: ANSI C63.26, 5.4.4

Note: The receiver's automatic 99% Occupied Bandwidth function was used. The function is identical in operation to the measurement method of ANSI C63.26, 5.4.4, Step e).

OCCUPIED BANDWIDTH

40dB Occupied Bandwidth Rule Parts

Rule Part No.: ITU-R M.1177-4

Test Procedure: ANSI C63.26, 5.4.3

Note: The receiver's automatic ndB Down Occupied Bandwidth function was used. The function is identical in operation to the measurement method of ANSI C63.26, 5.4.3.

Test Data: Occupied Bandwidth Measurement Table

Mode	99% Occupied Bandwidth (MHz)	40 dB Occupied Bandwidth (MHz)
1	58.01	143.58

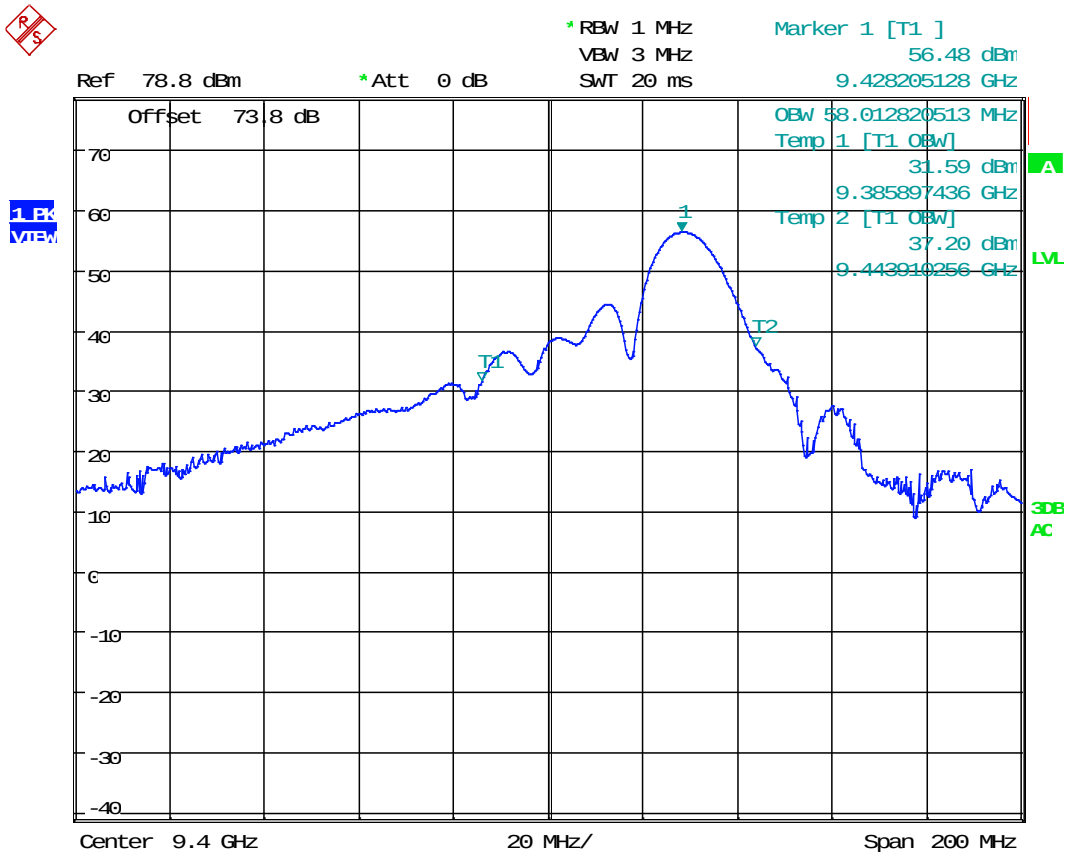
Max Occupied Bandwidth of EUT = **143.58 MHz**

Emission Designator = **144MP0N**

Method of Measurement = **40 dB Down**

OCCUPIED BANDWIDTH

Test Data: Mode 1 99% OBW Plot



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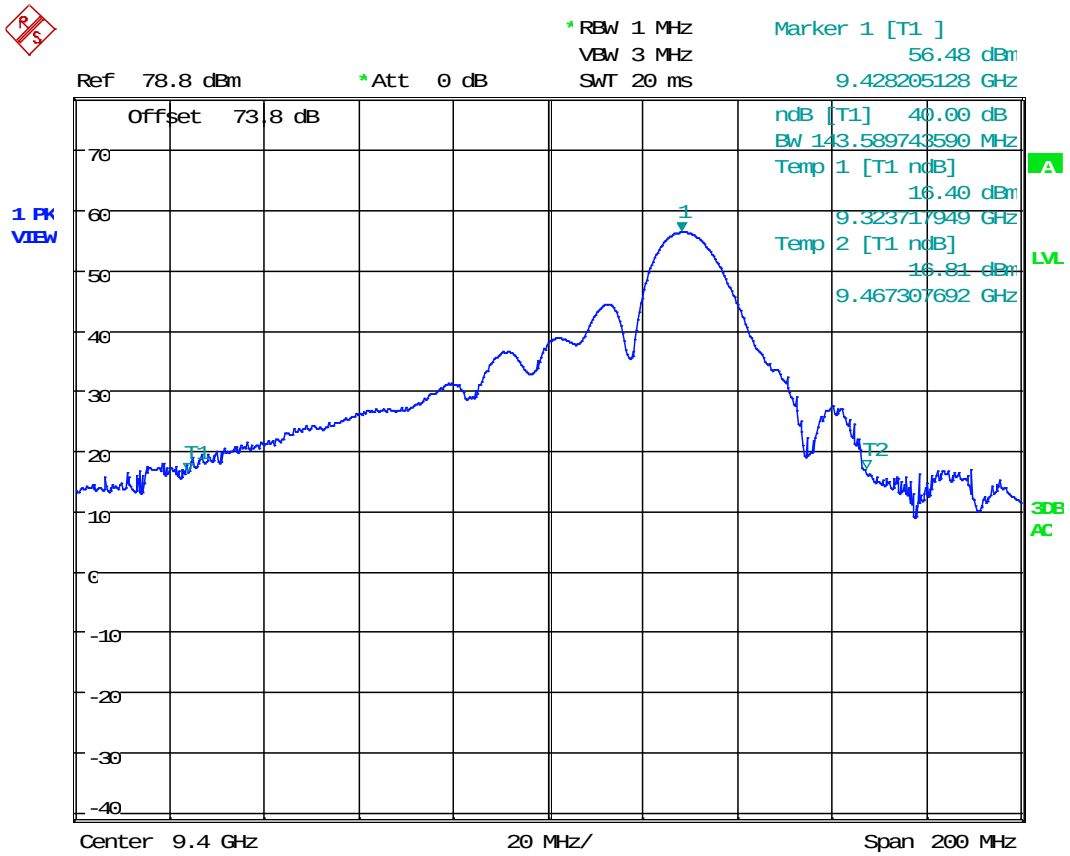
OCCUPIED BANDWIDTH

Test Data: Mode 1 40dB OBW Plot



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EMISSION MASK

Rule Part No.: 90.210(c)(1), (2), 90.210(n), 90.210(b)(1), (2)

Requirements:

(c) *Emission Mask C.* For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier output power (P) as follows:

(1) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5 kHz, but not more than 10 kHz: At least 83 log (f_d/5) dB;

(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 10 kHz, but not more than 250 percent of the authorized bandwidth: At least 29 log (f_d^2/11) dB or 50 dB, whichever is the lesser attenuation;

(n) *Other frequency bands.* Transmitters designed for operation under this part on frequencies other than listed in this section must meet the emission mask requirements of Emission Mask B. Equipment operating under this part on frequencies allocated to but shared with the Federal Government, must meet the applicable Federal Government technical standards.

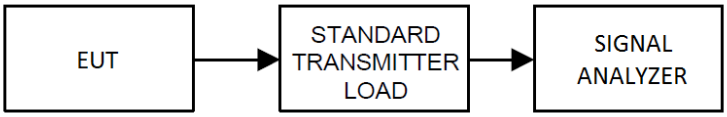
(b) *Emission Mask B.* For transmitters that are equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier power (P) as follows:

(1) On any frequency removed from the assigned frequency by more than 50 percent, but not more than 100 percent of the authorized bandwidth: At least 25 dB.

(2) On any frequency removed from the assigned frequency by more than 100 percent, but not more than 250 percent of the authorized bandwidth: At least 35 dB.

Test Procedure: ANSI C63.26, 5.4.4; ITU-R M.1177-4

Test Setup Block Diagram:



EMISSION MASK

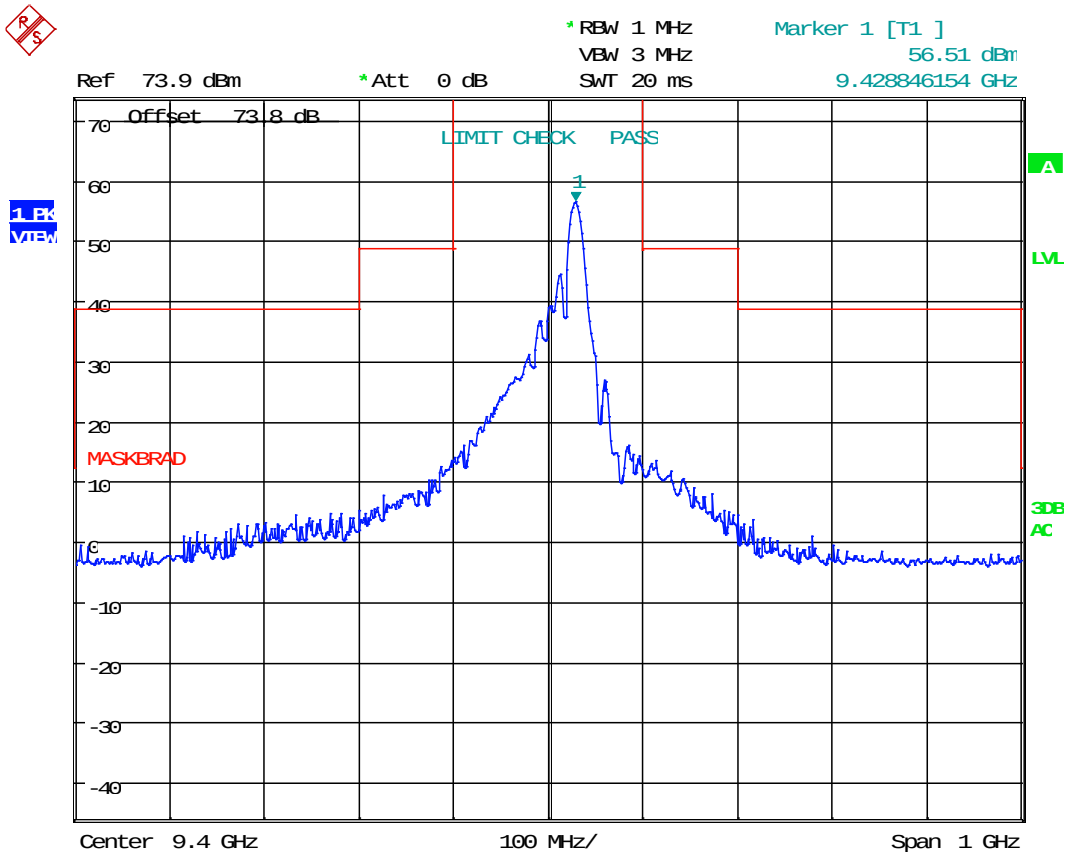
Test Data: Emission Mask Calculations

FCC CFR 47 Part 90 Emission Masks						
Frequency Band (MHz)	Mask for equipment with audio low pass filter			Mask for equipment without audio low pass filter		
	6.25 kHz	12.5 kHz	25 kHz	6.25 kHz	12.5 kHz	25 kHz
< 25	A (J3E emission only), B			A (J3E emission only), C		
25 - 50	B, 20 kHz ABW			C, 20 kHz ABW		
72 - 76	B, 20 kHz ABW			C, 20 kHz ABW		
150 - 174	E, 6 kHz ABW	D, 11.25 kHz ABW	B, 20 kHz ABW	E, 6 kHz ABW	D, 11.25 kHz ABW	C, 20 kHz ABW
150 PAGING ONLY	B, 6 kHz ABW	B, 11.25 kHz ABW	B, 20 kHz ABW	C, 6 kHz ABW	C, 11.25 kHz ABW	C, 20 kHz ABW
220 - 222	F, 4 kHz ABW, (see Aggregation allowances)					
406 - 421	B, 6 kHz ABW	B, 11.25 kHz ABW	B, 20 kHz ABW	C, 6 kHz ABW	C, 11.25 kHz ABW	C, 20 kHz ABW
421 - 512	E, 6 kHz ABW	D, 11.25 kHz ABW	B, 20 kHz ABW	E, 6 kHz ABW	D, 11.25 kHz ABW	C, 20 kHz ABW
450 PAGING ONLY	B, 6 kHz ABW	B, 11.25 kHz ABW	B, 20 kHz ABW	G, 6 kHz ABW	G, 11.25 kHz ABW	G, 20 kHz ABW
806 - 809	B, 20 kHz ABW			H, 20 kHz ABW		
809 - 817	D, 11.25 kHz ABW		B, 20 kHz ABW	D, 11.25 kHz ABW		G, 20 kHz ABW
817 - 824	D, 20 kHz ABW		B, 20 kHz ABW	D, 20 kHz ABW		G, 20 kHz ABW
851 - 854	B, 20 kHz ABW			H, 20 kHz ABW		
854 - 862	D, 11.25 kHz ABW		B, 20 kHz ABW	D, 11.25 kHz ABW		G, 20 kHz ABW
862 - 869	D, 20 kHz ABW		B, 20 kHz ABW	D, 20 kHz ABW		G, 20 kHz ABW
854 - 869 EA	90.691					
896 - 901	I, 13.6 kHz ABW			J, 13.6 kHz ABW		
902 - 928	K, see 90.209(b) note 4					
929 - 930	B, 20 kHz ABW			G, 20 kHz ABW		
935 - 940	I, 13.6 kHz ABW			J, 13.6 kHz ABW		
1427 - 1432	B, see 90.259(b)			C, see 90.259(b)		
2450 - 2483.5	B, see 90.209(b) note 3, 2			C, see 90.209(b) note 3, 2		
4940 - 4990	M, for Output Power > 20 dBm; L, for < 20 dBm					
5850 - 5925	K, see Part 90 subpart M, Intelligent Transportation Systems Radio Service					
All other bands	B			C		
Shared with Federal Bands	90.210(n) Must meed Federal Government Technical Standards					

Calculation	Limit (dBc)	dBc	dBm
#1 (Mask A, B, C, G, H)	43 + 10 * Log(P)	68.40	-13.00
#2 (Mask C)	83 * Log(5 / 5)	0.00	55.40
	83 * Log(10 / 5)	24.99	30.41
	Min dBc of: 50 or 29 * Log(10^2 / 11)	27.80	27.60
	Min dBc of: 50 or 29 * Log((250% ABW)^2 / 11)	50.00	5.40

EMISSION MASK

Test Data: Mode 1 Emission Mask B Plot



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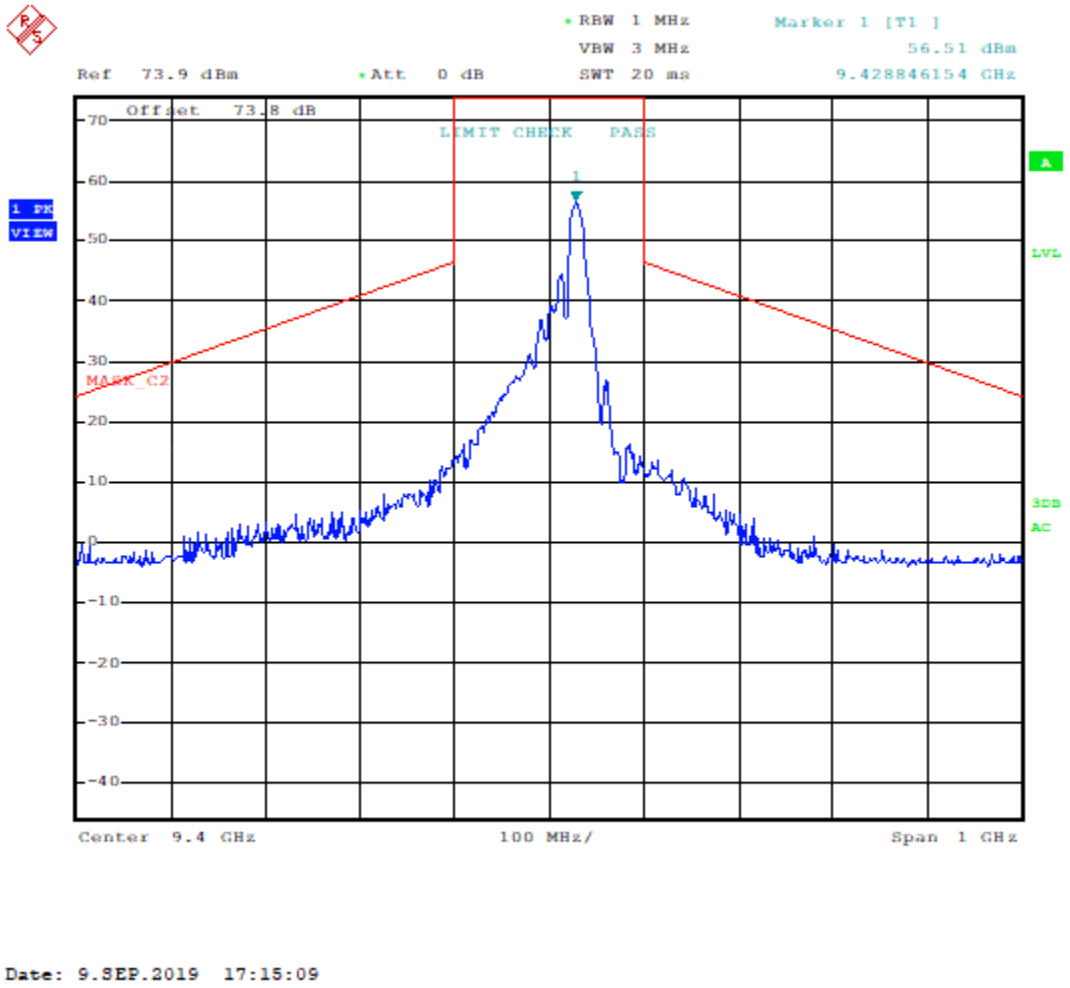
EMISSION MASK

Test Data: Mode 1 Emission Mask C Plot



SPURIOUS EMISSIONS AT ANTENNA TERMINAL (CONDUCTED)

Rule Part No.: Part 2.1051(a), 2.1057(a)(1), 90.210(c)(3), 90.210(n), 90.210(b)(3)

§2.1051 Measurements required: Spurious emissions at antenna terminals.

The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of each harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in §2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

§2.1057 Frequency spectrum to be investigated.

(a) In all of the measurements set forth in §§2.1051 and 2.1053, the spectrum shall be investigated from the lowest radio frequency signal generated in the equipment, without going below 9 kHz, up to at least the frequency shown below:

(1) If the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

(c) *Emission Mask C.* For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier output power (P) as follows:

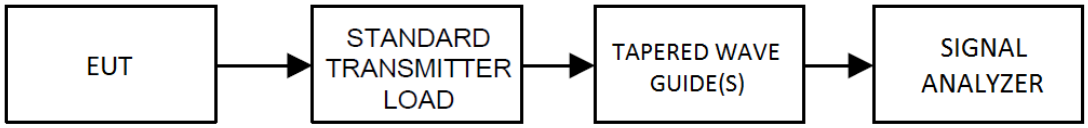
(3) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

(n) *Other frequency bands.* Transmitters designed for operation under this part on frequencies other than listed in this section must meet the emission mask requirements of Emission Mask B. Equipment operating under this part on frequencies allocated to but shared with the Federal Government, must meet the applicable Federal Government technical standards.

(b) *Emission Mask B.* For transmitters that are equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier power (P) as follows:

(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

Test Setup Block Diagram:



Note: The spectrum was pre-scanned from 30 kHz to 40 GHz, and frequencies of interest (particularly harmonic emissions) have been provided below in tabular format, using the bandwidth compensation formulae, found in ITU-R M.1177, Annex 1 (cited below) with the limit.

Note: The graphical data plotted below is a representative of the final results in relation to the limit, after all compensations were made.

UNWANTED SPURIOUS EMISSIONS

Test Procedure: TIA 603-E, 2.2.13; ITU-R M.1177-4, Annex 1

2 Reference bandwidth

For radar systems, the reference bandwidth, B_{ref}, used to define unwanted emission limits (Recommendations ITU-R SM.329 and ITU-R SM.1541, and RR Appendix 3) should be calculated for each particular radar system. For the four general types of radar pulse modulation utilized for radionavigation, radiolocation, acquisition, tracking and other radiodetermination functions, the reference bandwidth values are determined using the following formulas:

– for FM or chirped radar, the square root of the quantity obtained by dividing the chirp bandwidth (MHz) by the pulse length (µs) (e.g. if the FM is from 1 250 MHz to 1 280 MHz or 30 MHz during the pulse of 10 µs, then the reference bandwidth is $(30\ \text{MHz}/10\ \mu\text{s})^{1/2} = 1.73$ MHz);

In all cases, where the bandwidths above are greater than 1 MHz, then a reference bandwidth, B_{ref}, of 1 MHz should be used.

3 Measurement bandwidth and detector parameters

The measurement bandwidth, B_m, is defined as the impulse bandwidth of the receiver and is greater than the IF bandwidth, B_{if}, (sometimes referred to as resolution bandwidth for spectrum analyzers). The measurement bandwidth, B_m, may be derived from the following equation:

$$B_m = B_{if} \times MBR$$

The MBR needs to be determined for the measurement receiver being used. MBR is approximately 3/2 for a –3 dB IF bandwidth Gaussian filter as typically used in many commercial spectrum analyzer receivers (in some instruments the IF bandwidth is defined at the –6 dB point).

An appropriate receiver IF bandwidth should be selected to give one of the following recommended measurement bandwidths.

Measurement bandwidth B_m[1]	≤	$(B_c/T)^{1/2}$ for swept-frequency (FM, or chirp) radars, where B_c is the range of frequency sweep during each pulse and T is the pulse length (e.g. if radar sweeps (chirps) across the frequency range of 1 250-1 280 MHz (= 30 MHz of spectrum) during each pulse, and if the pulse length is 10 µs, then the measurement bandwidth should be $\leq ((30\ \text{MHz})/(10\ \mu\text{s}))^{1/2} = \sqrt{3}$ MHz ≈ 1.73 MHz. In accordance with footnote [1] a measurement bandwidth close to but less than or equal to 1 MHz should be used in this example.
Video bandwidth	≥	measurement system bandwidth.
Detector		positive peak.

[1] In all cases, if the above derived measurement bandwidth is greater than 1 MHz, then the corrections described in § 3.2 should be used.

UNWANTED SPURIOUS EMISSIONS

Test Procedures, Con't.

3.2 Measurements within the spurious domain

3.2.1 Correction of the measurement within the spurious domain

Where the measurement bandwidth, B_m, differs from the reference bandwidth, B_{ref}, a correction factor needs to be applied to the measurements conducted within the spurious domain to express the results in the reference bandwidth. Then the following correction factor should be applied:

$$\text{Spurious level, } B_{ref} = \text{Spurious level (measured in } B_m) + 10 \times \log(B_{ref}/B_m)$$

NOTE 1 – This correction factor should be used except where it is known that the spurious is not noise-like, where a factor between 10 and 20 $\log(B_{ref}/B_m)$ may apply and may be derived by measurements in more than one bandwidth. In all cases the most precise result will be obtained using a measurement bandwidth (B_m) equal to the reference bandwidth. For radars operating above 1 GHz the reference bandwidth (B_{ref}) is 1 MHz.

Bandwidth Compensation Calculation Table

Mode	40 dB Occupied Bandwidth (MHz)	40dB Bref (MHz)		MBR (MHz)	Bm (MHz)	Spurious Noise Correction (dBm)	Spurious Emissions Correction (dBm)
		(Bc/T)^0.5 = Bref (MHz)	If Bref > 1, Bref = 1 (MHz)	If 3/2 > Bref, MBR = Bref; Else MBR = 3/2 (MHz)	Bif x MBR = Bm (MHz)	If Bm > 1, 10 x Log(Bref/Bm)	If Bm > 1, 20 x Log(Bref/Bm)
1	143.580	535.87	1.00	1.50	4.50	-6.53	-13.06

Limit Calculation 80.211(f)(3)

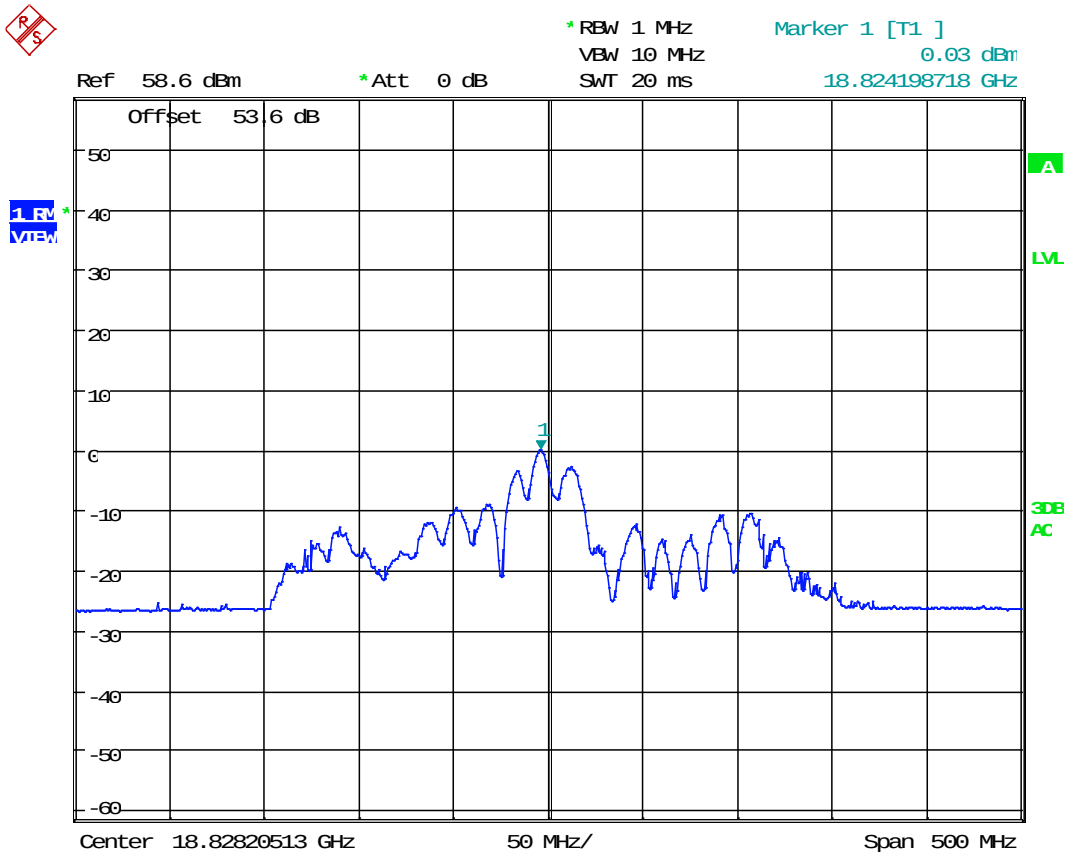
43 + 10 x Log(Power, in Watts)

Mode	Maximum Mean Power Output (W)	Relative Limit (dBc)	Absolute Limit (dBm)
1	501.19	70.00	-13.00

Note: The offset in the measurement equipment represents all losses and compensation factors. The following plots show corrected data.

UNWANTED SPURIOUS EMISSIONS

Test Data: Mode 1, 2nd Harmonic Plot

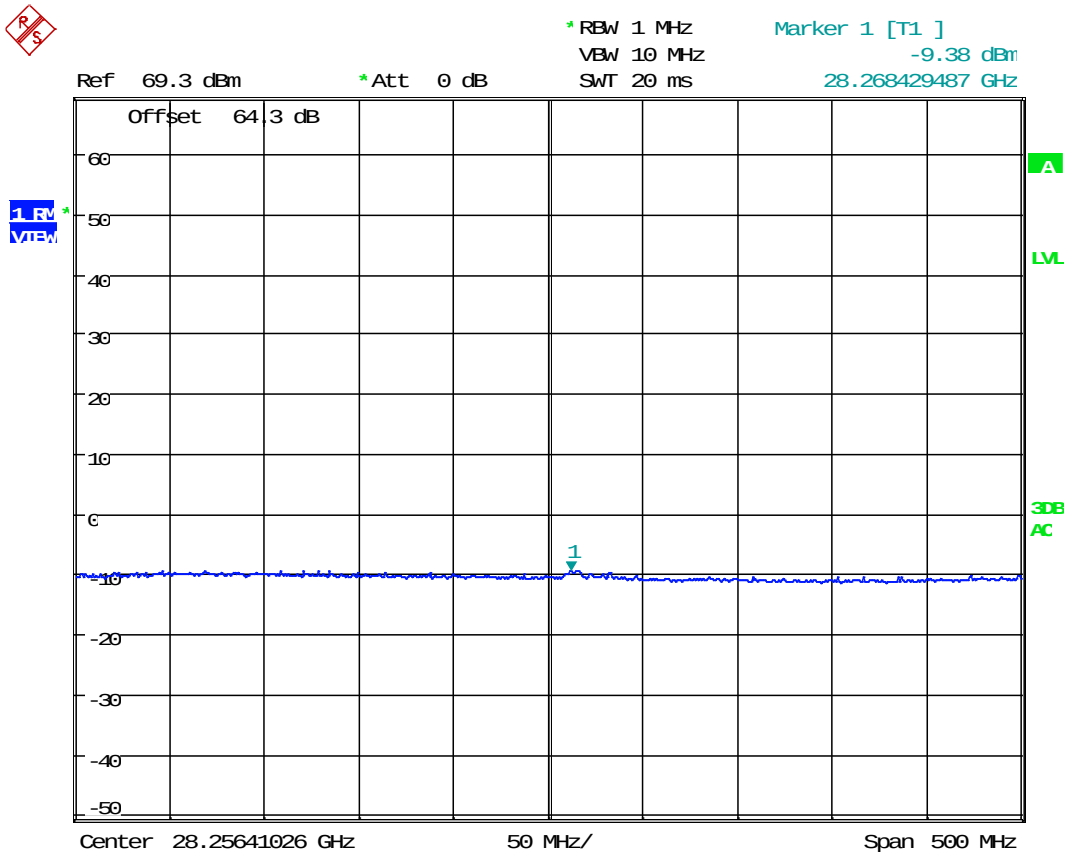


Date: 9.SEP.2019 17:01:17

2nd Harmonic						
Harmonic Frequency (MHz)	Measured Peak in Bref (dBm)	Corrected to Bm (dBm)	Meas. Loss (dB)	Actual Peak (dBm)	43+10 x Log(P) Limit (dBm)	Margin (dB)
18824.2	0.03	-13.034	0.000	-13.034	-13.00	0.03

UNWANTED SPURIOUS EMISSIONS

Test Data: Mode 1, 3rd Harmonic Plot

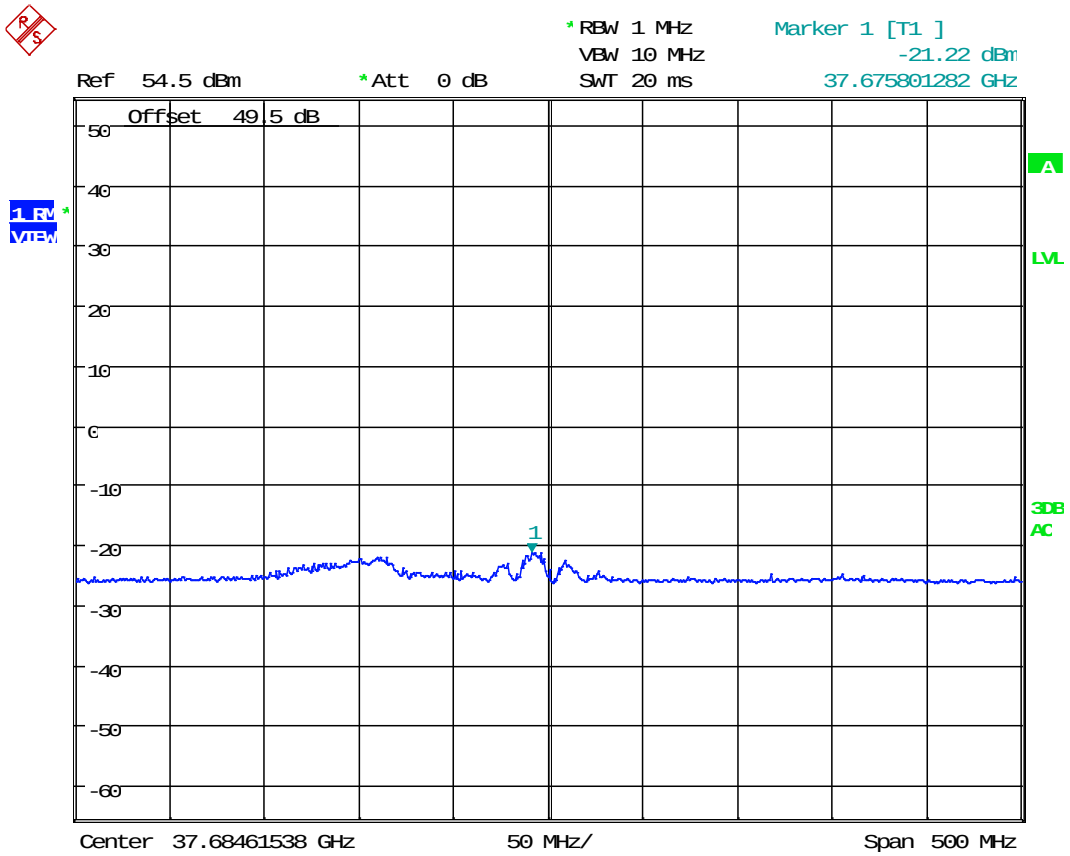


Date: 9.SEP.2019 17:02:35

3rd Harmonic						
Harmonic Frequency (MHz)	Measured Peak in Bref (dBm)	Corrected to Bm (dBm)	Meas. Loss (dB)	Actual Peak (dBm)	43+10 x Log(P) Limit (dBm)	Margin (dB)
28268.4	-9.38	-22.444	0.000	-22.444	-13.00	9.44

UNWANTED SPURIOUS EMISSIONS

Test Data: Mode 1, 4th Harmonic Plot



Date: 9.SEP.2019 17:08:59

4th Harmonic						
Harmonic Frequency (MHz)	Measured Peak in Bref (dBm)	Corrected to Bm (dBm)	Meas. Loss (dB)	Actual Peak (dBm)	43+10 x Log(P) Limit (dBm)	Margin (dB)
37675.8	-21.22	-34.284	0.000	-34.284	-13.00	21.28

FIELD STRENGTH OF SPURIOUS EMISSIONS

Rule Part No.: Part 2.1053(a), 2.1057(a)(1), 90.210(c)(3), 90.210(n), 90.210(b)(3)

Requirements:

§2.1053 Measurements required: Field strength of spurious radiation.

(a) Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data shall be supplied showing the magnitude of each harmonic and other spurious emission. For this test, single sideband, independent sideband, and controlled carrier transmitters shall be modulated under the conditions specified in paragraph (c) of §2.1049, as appropriate. For equipment operating on frequencies below 890 MHz, an open field test is normally required, with the measuring instrument antenna located in the far-field at all test frequencies. In the event it is either impractical or impossible to make open field measurements (e.g. a broadcast transmitter installed in a building) measurements will be accepted of the equipment as installed. Such measurements must be accompanied by a description of the site where the measurements were made showing the location of any possible source of reflections which might distort the field strength measurements. Information submitted shall include the relative radiated power of each spurious emission with reference to the rated power output of the transmitter, assuming all emissions are radiated from halfwave dipole antennas.

(b) The measurements specified in paragraph (a) of this section shall be made for the following equipment:

(1) Those in which the spurious emissions are required to be 60 dB or more below the mean power of the transmitter.

(2) All equipment operating on frequencies higher than 25 MHz.

(3) All equipment where the antenna is an integral part of, and attached directly to the transmitter.

(4) Other types of equipment as required, when deemed necessary by the Commission.

§2.1057 Frequency spectrum to be investigated.

(a) In all of the measurements set forth in §§2.1051 and 2.1053, the spectrum shall be investigated from the lowest radio frequency signal generated in the equipment, without going below 9 kHz, up to at least the frequency shown below:

(1) If the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

(c) *Emission Mask C.* For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier output power (P) as follows:

(3) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

(n) *Other frequency bands.* Transmitters designed for operation under this part on frequencies other than listed in this section must meet the emission mask requirements of Emission Mask B. Equipment operating under this part on frequencies allocated to but shared with the Federal Government, must meet the applicable Federal Government technical standards.

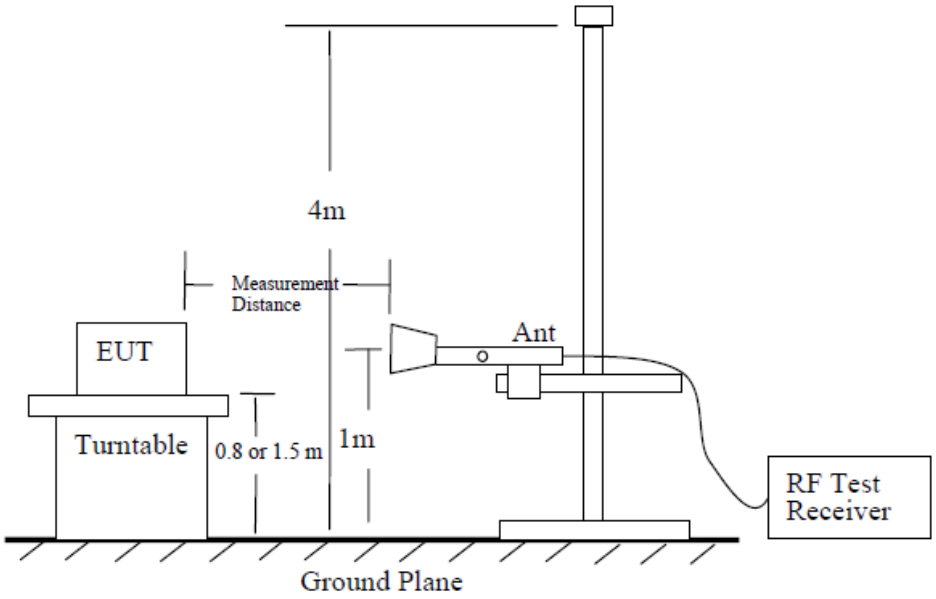
FIELD STRENGTH OF SPURIOUS EMISSIONS

(b) *Emission Mask B.* For transmitters that are equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier power (P) as follows:

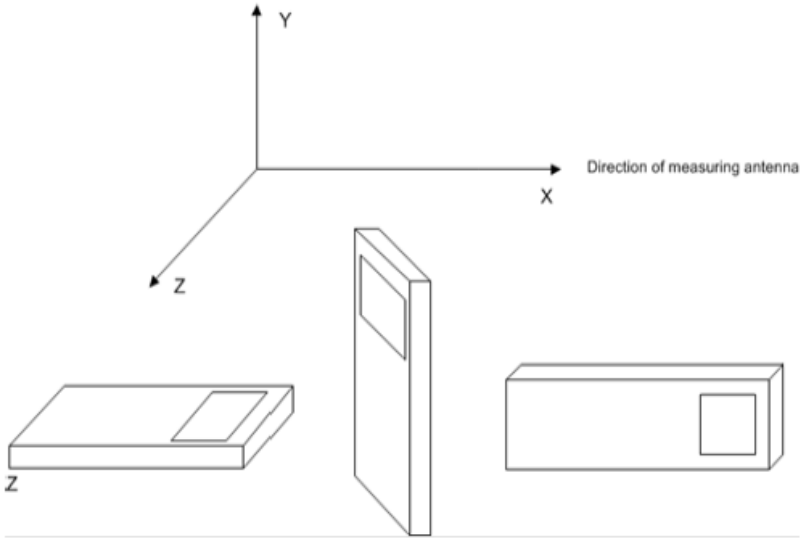
(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

Test Procedure: ANSI C63.26, 5.5.4; ITU-R M.1177-4, ANNEX 1

Test Site Setup:



EUT Orientation(s):



FIELD STRENGTH OF SPURIOUS EMISSIONS

Test Procedure: TIA 603-E, 2.2.13; ITU-R M.1177-4, Annex 1

2 Reference bandwidth

For radar systems, the reference bandwidth, B_{ref}, used to define unwanted emission limits (Recommendations ITU-R SM.329 and ITU-R SM.1541, and RR Appendix 3) should be calculated for each particular radar system. For the four general types of radar pulse modulation utilized for radionavigation, radiolocation, acquisition, tracking and other radiodetermination functions, the reference bandwidth values are determined using the following formulas:

– for FM or chirped radar, the square root of the quantity obtained by dividing the chirp bandwidth (MHz) by the pulse length (µs) (e.g. if the FM is from 1 250 MHz to 1 280 MHz or 30 MHz during the pulse of 10 µs, then the reference bandwidth is $(30\ \text{MHz}/10\ \mu\text{s})^{1/2} = 1.73$ MHz);

In all cases, where the bandwidths above are greater than 1 MHz, then a reference bandwidth, B_{ref}, of 1 MHz should be used.

3 Measurement bandwidth and detector parameters

The measurement bandwidth, B_m, is defined as the impulse bandwidth of the receiver and is greater than the IF bandwidth, B_{if}, (sometimes referred to as resolution bandwidth for spectrum analyzers). The measurement bandwidth, B_m, may be derived from the following equation:

$$B_m = B_{if} \times MBR$$

The MBR needs to be determined for the measurement receiver being used. MBR is approximately 3/2 for a –3 dB IF bandwidth Gaussian filter as typically used in many commercial spectrum analyzer receivers (in some instruments the IF bandwidth is defined at the –6 dB point).

An appropriate receiver IF bandwidth should be selected to give one of the following recommended measurement bandwidths.

Measurement bandwidth B_m[1]	≤	$(B_c/T)^{1/2}$ for swept-frequency (FM, or chirp) radars, where B_c is the range of frequency sweep during each pulse and T is the pulse length (e.g. if radar sweeps (chirps) across the frequency range of 1 250-1 280 MHz (= 30 MHz of spectrum) during each pulse, and if the pulse length is 10 µs, then the measurement bandwidth should be $\leq ((30\ \text{MHz})/(10\ \mu\text{s}))^{1/2} = \sqrt{3}$ MHz ≈ 1.73 MHz. In accordance with footnote [1] a measurement bandwidth close to but less than or equal to 1 MHz should be used in this example.
Video bandwidth	≥	measurement system bandwidth.
Detector		positive peak.

[1] In all cases, if the above derived measurement bandwidth is greater than 1 MHz, then the corrections described in § 3.2 should be used.

FIELD STRENGTH OF SPURIOUS EMISSIONS

3.2 Measurements within the spurious domain

3.2.1 Correction of the measurement within the spurious domain

Where the measurement bandwidth, B_m, differs from the reference bandwidth, B_{ref}, a correction factor needs to be applied to the measurements conducted within the spurious domain to express the results in the reference bandwidth. Then the following correction factor should be applied:

$$\text{Spurious level, } B_{ref} = \text{Spurious level (measured in } B_m) + 10 \times \log(B_{ref}/B_m)$$

NOTE 1 – This correction factor should be used except where it is known that the spurious is not noise-like, where a factor between 10 and 20 $\log(B_{ref}/B_m)$ may apply and may be derived by measurements in more than one bandwidth. In all cases the most precise result will be obtained using a measurement bandwidth (B_m) equal to the reference bandwidth. For radars operating above 1 GHz the reference bandwidth (B_{ref}) is 1 MHz.

Bandwidth Compensation Calculation Table

Mode	40 dB Occupied Bandwidth (MHz)	40dB Bref (MHz)		MBR (MHz)	Bm (MHz)	Spurious Noise Correction (dBm)	Spurious Emissions Correction (dBm)
		(Bc/T)^0.5 = Bref (MHz)	If Bref > 1, Bref = 1 (MHz)	If 3/2 > Bref, MBR = Bref; Else MBR = 3/2 (MHz)	Bif x MBR = Bm (MHz)	If Bm > 1, 10 x Log(Bref/Bm)	If Bm > 1, 20 x Log(Bref/Bm)
1	143.580	535.87	1.00	1.50	4.50	-6.53	-13.06

Limit Calculation 90.210(c)(3), 90.210(n), 90.210(b)(3)

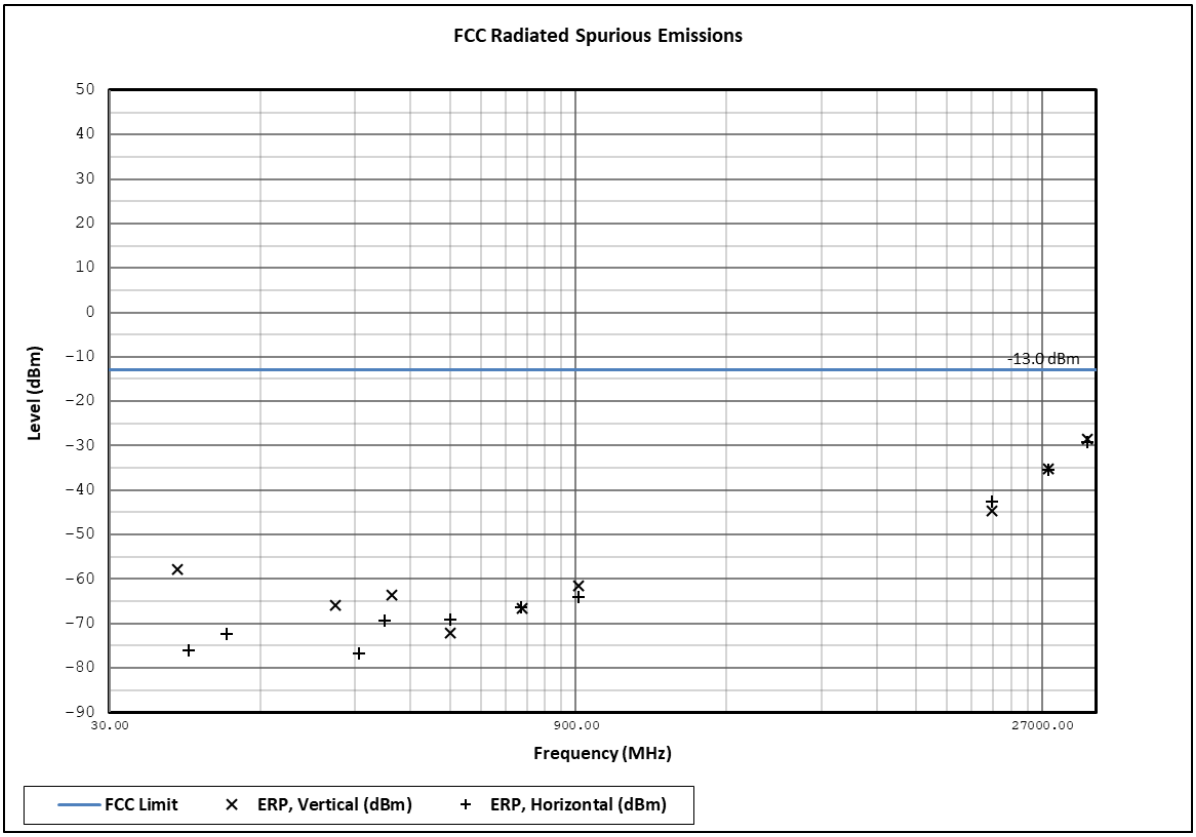
43 + 10 x Log(Power, in Watts)

Mode	Maximum Mean Power Output (W)	Relative Limit (dBc)	Absolute Limit (dBm)
1	501.19	70.00	-13.00

Note: The data shows the results of the radiated field strength emissions test. The spectrum was scanned from the lowest frequency generated internally to the tenth harmonic of the fundamental frequency or 40 GHz, whichever is less. This test was conducted in accordance with the referenced standards. Measurements were made at the test site of TIMCO ENGINEERING, INC. located at 849 NW State Road 45, Newberry, FL 32669. The measurements below represent the worst case of all the frequencies tested.

FIELD STRENGTH OF SPURIOUS EMISSIONS

Test Data: Mode 1, Radiated Spurious Emissions Plot



Note: All recorded data was plotted. Six (6) or more of the highest emissions of the worst-case operational mode of the EUT are represented below in tabular format. Emissions 20 dB below the limit are not required to be reported.

Test Data: Mode 1, Radiated Spurious Emissions Table

Tuned Frequency (MHz)	Emission Frequency (MHz)	Meter Reading (dBµV)	Antenna Polarity	Coax Loss (dB)	Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	ERP, Vertical (dBm)	Bandwidth Correction (dBm)	Limit (dBm)	Margin (dBm)
9400	49.04	40.41	V	0.81	11.49	3.00	52.71	-44.67	-57.73	-13.00	44.73
9400	53.26	23.46	H	0.85	10.02	3.00	34.33	-63.05	-76.11	-13.00	63.11
9400	70.53	31.09	H	0.99	6.05	3.00	38.13	-59.24	-72.30	-13.00	59.30
9400	155.94	26.53	V	1.43	16.60	3.00	44.56	-52.82	-65.88	-13.00	52.88
9400	184.77	18.77	H	1.57	13.40	3.00	33.74	-63.63	-76.69	-13.00	63.69
9400	223.68	29.04	H	1.71	10.30	3.00	41.05	-56.32	-69.38	-13.00	56.38
9400	235.84	34.63	V	1.76	10.42	3.00	46.81	-50.57	-63.63	-13.00	50.63
9400	360.00	24.73	H	2.16	14.50	3.00	41.39	-55.99	-69.05	-13.00	56.05
9400	360.00	21.77	V	2.16	14.50	3.00	38.43	-58.95	-72.01	-13.00	59.01
9400	605.12	22.82	H	2.88	18.50	3.00	44.20	-53.18	-66.24	-13.00	53.24
9400	606.40	22.33	V	2.88	18.53	3.00	43.74	-53.64	-66.70	-13.00	53.70
9400	916.16	20.21	H	3.57	22.53	3.00	46.31	-51.07	-64.13	-13.00	51.13
9400	916.80	22.89	V	3.57	22.49	3.00	48.95	-48.43	-61.49	-13.00	48.49
9400	18800.00	7.63	H	15.37	44.74	3.00	67.74	-29.63	-42.69	-13.00	29.69
9400	18800.00	5.72	V	15.37	44.74	3.00	65.83	-31.54	-44.60	-13.00	31.60
9400	28200.00	9.29	H	18.89	46.83	3.00	75.01	-22.37	-35.43	-13.00	22.43
9400	28200.00	9.58	V	18.89	46.83	3.00	75.30	-22.08	-35.14	-13.00	22.14
9400	37600.00	12.72	H	22.84	45.74	3.00	81.30	-16.08	-29.14	-13.00	16.14
9400	37600.00	13.33	V	22.84	45.74	3.00	81.91	-15.47	-28.53	-13.00	15.53

FREQUENCY STABILITY

Rule Part No.: Part 2.1055(a)(2), 90.213(a)

§90.213 Frequency stability.

(a) Unless noted elsewhere, transmitters used in the services governed by this part must have a minimum frequency stability as specified in the following table.

MINIMUM FREQUENCY STABILITY

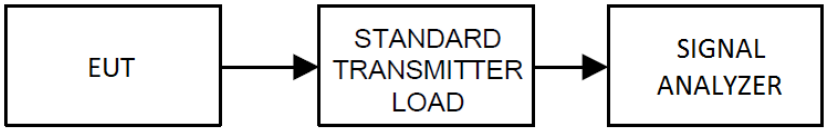
[Parts per million (ppm)]

Frequency range (MHz)	Fixed and base stations	Mobile stations	
		Over 2 watts output power	2 watts or less output power
Above 2450[10]			

[10]Except for DSRCS equipment in the 5850-5925 MHz band, frequency stability is to be specified in the station authorization. Frequency stability for DSRCS equipment in the 5850-5925 MHz band is specified in subpart M of this part.

Test Procedure: TIA 603-E, 2.2.2

Test Setup Block Diagram:

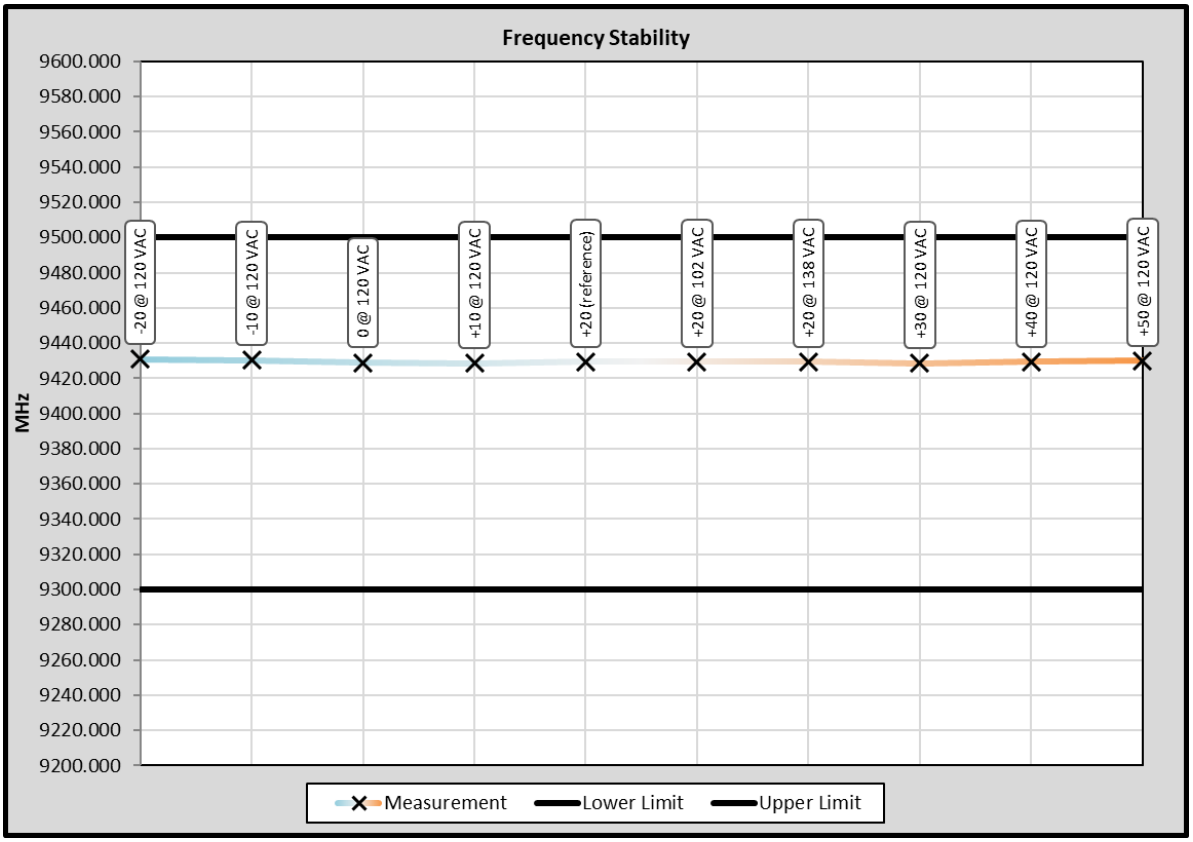


Note: This EUT is designed to operate within FCC Parts 80, and 90. Therefore, in lieu of FCC Part 90 unspecified stability limit, the EUT shall meet Frequency Stability limits from FCC Part 80.

Note: The EUT's built-in power supply is designed to run stable, and eliminated voltage differences from AC Mains. Therefore, input voltage variation had no effect on the testing.

FREQUENCY STABILITY

Test Data: Frequency Error Measurement Plot



FREQUENCY STABILITY

Test Data: Frequency Error Measurement Table

Shortest Pulse Duration:	50.000	µs
Limit:	0.030	MHz from Auth. BW
Authorized Bandwidth	200.000	MHz
80.209(b) Limit:	9499.970	MHz (upper)
	9300.030	MHz (lower)
Rated Supply Voltage	120.0	◉ AC ○ DC

Temperature / Voltage Variation

Temperature (°C)	Supplied Voltage (V)	Frequency (MHz)	Deviation (kHz)
-20	120.0	9430.88000	-1440.000
-10	120.0	9430.24000	-800.000
0	120.0	9428.96000	480.000
+10	120.0	9428.48000	960.000
+20 (reference)	120.0	9429.44000	0.000
+20	102.0	9429.44000	0.000
+20	138.0	9429.44000	0.000
+30	120.0	9428.48000	960.000
+40	120.0	9429.28000	160.000
+50	120.0	9430.08000	-640.000

STATEMENT OF MEASUREMENT UNCERTAINTY

The data and results referenced in this document are true and accurate. The measurement uncertainty was calculated for all measurements listed in this test report according To CISPR 16–4 or ENTR 100-028 Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: "Uncertainty in EMC Measurements" and is documented in the Timco Engineering, Inc. quality system according to DIN EN ISO/IEC 17025. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

Hereafter the best measurement capability for Timco Engineering, Inc. is reported:

Test Items	Measurement Uncertainty	Notes
RF Frequency Accuracy	±49.5 Hz	(1)
RF Conducted Power	±0.93dB	(1)
Conducted spurious emission of transmitter to 40GHz	±1.86dB	
Occupied Bandwidth	±2.65%	
Radiated RF Power	±1.4dB	
Rad Emissions of transmitter up to 26.5GHz	±2.14dB	
Rad Emissions of transmitter to 40GHz	±2.36dB	
Temperature	±1.0°C	(1)
Humidity	±5.0%	

Note: (1) This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=1.96.

EMC EQUIPMENT LIST

Device	Manufacturer	Model	Serial Number	Cal/Char Date	Due Date
CHAMBER	Panashield	3M	N/A	03/12/19	03/12/21
Antenna: Biconical 1057	Eaton	94455-1	1057	12/13/17	12/13/19
Antenna: Log-Periodic 1243	Eaton	96005	1243	04/20/18	04/20/21
Antenna: Double-Ridged Horn/ETS Horn 1	ETS-Lindgren	3117	00035923	01/30/17	01/30/20
Antenna: Double-Ridged Horn 18-40 GHz	EMCO	3116	9011-2145	12/08/17	12/08/19
Coaxial Cable - Chamber 3 cable set (backup)	Micro-Coax	Chamber 3 cable set (backup)	KMKM-0244-02 KMKM-0670-01 KFKF-0197-00	02/27/19	02/27/21
Chamber Pre-amplifier	RF-LAMBDA	RLNA00M45GA	NA	02/27/19	02/27/21
Software: Field Strength Program	Timco	N/A	Version 4.10.7.0	N/A	N/A
EMI Test Receiver R & S ESU 40	Rohde & Schwarz	ESU 40	100320	08/28/18	08/28/20
Comb Generator	Com-Power Corp	CGO-515	291728	NA	NA
Power Sensor	Boonton	51072A	34647	01/12/17	01/12/20
Temperature Chamber LARGE	Tenney Engineering	TTRC	11717-7	NA	NA
Type K J Thermometer	Martel	303	080504494	11/06/17	11/06/19
Attenuator N 30dB 100W DC-6G	Pasternack	PE7214-30	#110	07/16/19	07/16/21
Attenuator N 3dB 10W DC-18G	Pasternack	PE7015-3	#21	07/16/19	07/16/21
Coaxial Cable #101 - NMNM-0180-01 Aqua DC-40G	Micro-Coax	UFB311A-0-0720-50U50U	225362-002 (#101)	07/16/19	07/16/21
Coaxial Cable #102 - KMKM-0180-00 Aqua	Micro-Coax	UFB142A-0-0720-200200	225363-001 (#102)	07/16/19	07/16/21
Terminator N 20W DC-18G	Narda	8205	#14	07/16/19	07/16/21
Load WR-90 90W	Pasternack	PE6824	NA	07/16/19	07/16/21
Adapter WR-90 to SMA	Pasternack	PE9804	NA	07/16/19	07/16/21
Adapter WR-90 to N	HP	X281A	334	07/16/19	07/16/21
Adapter WR-90 to N	Narda	601A	236	07/16/19	07/16/21

***EMI RECEIVER SOFTWARE VERSION**

The receiver firmware used was version 4.43 Service Pack 3

END OF REPORT