



MET Laboratories, Inc. *Safety Certification - EMI - Telecom Environmental Simulation*

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May 3, 2018

Thales Communications
22605 Gateway Center Drive
Clarksburg, MD 20871

Dear Steve Barr,

Enclosed is the EMC Wireless test report for compliance testing of the Thales Communications, VF350BM, Terminal with Maritime Antenna. The Thales Communications VF350BM, Terminal with Maritime Antenna was tested to the requirements of the FCC Certification rules under Title 47 of the CFR Part 25 for Satellite Communications.

Thank you for using the services of MET Laboratories, Inc. If you have any questions regarding these results or if MET can be of further service to you, please feel free to contact me.

Sincerely yours,

MET LABORATORIES, INC.

Jennifer Warnell
Documentation Department

Reference: (\Thales Communications\EMC94508B-FCC25 Rev. 2)

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**Electromagnetic Compatibility Criteria
Test Report**

For the

**Thales Communications
Model VF350BM, Terminal with Maritime Antenna**

Tested under

**FCC Certification Rules
Title 47 of the CFR, Part 25 for Satellite Communications**

MET Report: EMC94508B-FCC25 Rev. 2

May 3, 2018

Prepared For:

**Thales Communications
22605 Gateway Center Drive
Clarksburg, MD 20871**

**Prepared By:
MET Laboratories, Inc.
914 W. Patapsco Ave.
Baltimore, MD 21230**



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Donald Salguero
Electromagnetic Compatibility Lab

Jennifer Warnell
Documentation Department

Engineering Statement: The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of Part 25 of the FCC Rules under normal use and maintenance.

John Mason, Director
Electromagnetic Compatibility Lab



Report Status Sheet

Revision	Report Date	Reason for Revision
Ø	February 26, 2018	Initial Issue.
1	April 24, 2018	Added antenna information and measurement uncertainty.
2	May 3, 2018	Added RF Exposure.



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List of Terms and Abbreviations

AC	Alternating Current
ACF	Antenna Correction Factor
Cal	Calibration
<i>d</i>	Measurement Distance
dB	Decibels
dB μ A	Decibels above one microamp
dB μ V	Decibels above one microvolt
dB μ A/m	Decibels above one microamp per meter
dB μ V/m	Decibels above one microvolt per meter
DC	Direct Current
E	Electric Field
DSL	Digital Subscriber Line
ESD	Electrostatic Discharge
EUT	Equipment Under Test
<i>f</i>	Frequency
FCC	Federal Communications Commission
GRP	Ground Reference Plane
H	Magnetic Field
HCP	Horizontal Coupling Plane
Hz	Hertz
IEC	International Electrotechnical Commission
kHz	kilohertz
kPa	kilopascal
kV	kilovolt
LISN	Line Impedance Stabilization Network
MHz	Megahertz
μ H	microhenry
μ	microfarad
μ s	microseconds
NEBS	Network Equipment-Building System
PRF	Pulse Repetition Frequency
RF	Radio Frequency
RMS	Root-Mean-Square
TWT	Traveling Wave Tube
V/m	Volts per meter
VCP	Vertical Coupling Plane



I. Executive Summary

A. Purpose of Test

An EMC evaluation to determine compliance of the Thales Communications model VF350BM, Terminal with Maritime Antenna with the requirements of Part 25, was performed. All references are to the most current version of Title 47 of the Code of Federal Regulations in effect. In accordance with §2.1033, the following data is presented in support of the Certification of the Thales Communications model VF350BM, Terminal with Maritime Antenna. Thales Communications should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the VF350BM, Terminal with Maritime Antenna has been **permanently** discontinued.

B. Requirements Summary

The following tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 25, in accordance with Thales Communications, purchase order RCI-712589. All tests were conducted using measurement procedure ANSI C63.4-2014.

FCC Reference	Description	Compliance
§25.216	Protection of Aeronautical Satellite Service	Compliant
§25.202(f)	Emissions Mask	Compliant
§25.204	Conducted RF Output Power	Compliant
§2.1049	Occupied Bandwidth	Compliant
§25.202(f), §2.1051	Spurious Emissions at Antenna Terminals	Compliant
§25.202(d), §2.1055	Frequency Stability	Compliant
§25.202(f), §2.1053	Radiated Spurious Emissions	Compliant

Table 1. Requirements Summary of EMC Part 25 Compliance Testing



II. Equipment Configuration

A. Overview

MET Laboratories, Inc. was contracted by Thales Communications to perform testing on the VF350BM, Terminal with Maritime Antenna, under Thales Communications’ purchase order RCI-712589.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Thales Communications, VF350BM, Terminal with Maritime Antenna.

The results obtained relate only to the item(s) tested.

Model(s) Tested:	VF350BM, Terminal with Maritime Antenna	
Model(s) Covered:	VF350BM, Terminal with Maritime Antenna	
EUT Specifications:	Primary Power: +12VDC	
	FCC ID: OKCMF350BM	
	Type of Modulations:	2x C8 16 APSK
	EUT Frequency Ranges:	1616.333 – 1625.666 MHz
Analysis:	The results obtained relate only to the item(s) tested.	
Environmental Test Conditions:	Temperature: 15-35° C	
	Relative Humidity: 30-60%	
	Barometric Pressure: 860-1060 mbar	
Evaluated by:	Donald Salguero	
Date(s):	May 3, 2018	

Table 2. EUT Summary Table

B. References

CFR 47, Part 25	Federal Communication Commission, Code of Federal Regulations, Title 47, Part 25: Satellite Communications
ANSI C63.4:2014	Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the Range of 9 kHz to 40 GHz
ISO/IEC 17025:2005	General Requirements for the Competence of Testing and Calibration Laboratories
ANSI C63.26:2015	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services.

Table 3. Standard References



C. Measurement Uncertainty

Test Method	Typical Expanded Uncertainty	K	Confidence Level
RF Frequencies	±4.52 Hz	2	95%
RF Power Conducted Emissions	±2.32 dB	2	95%
RF Power Conducted Spurious Emissions	±2.25 dB	2	95%
RF Power Radiated Emissions	±3.01 dB	2	95%

Table 4. Uncertainty Calculations Summary

D. Antenna Information

Type: Phased Array
Gain: 48.3dBi
Land Antenna - 1600899-1 (seems to be the model number)
Maxtena

E. Test Site

All testing was performed at MET Laboratories, Inc., 914 W. Patapsco Ave., Baltimore, MD 21230. All equipment used in making physical determinations is accurate and bears recent traceability to the National Institute of Standards and Technology.

Radiated Emissions measurements were performed in a 3 meter semi-anechoic chamber (equivalent to an Open Area Test Site). In accordance with §2.948(a)(3), a complete site description is contained at MET Laboratories.

F. Description of Test Sample

The Thales Land Mobile Certus Product will be used to support voice and data communications in a land mobile or terrestrial fixed environment. The Terminal and Antenna are capable of supporting wireless voice and data that links the user with the Iridium satellite network. As a wireless access point, the Terminal provides Wi-Fi (802.11) access for data. Three RJ-45 Ethernet connectors and one RJ14 jack enables the user to tether directly to the Terminal if desired. The Management Portal lets the user modify settings and indicates status. The Terminal is powered by either an external 12 Volt AC to DC power source or a wider input voltage range (10-32V) that can come from vehicle power or a battery.

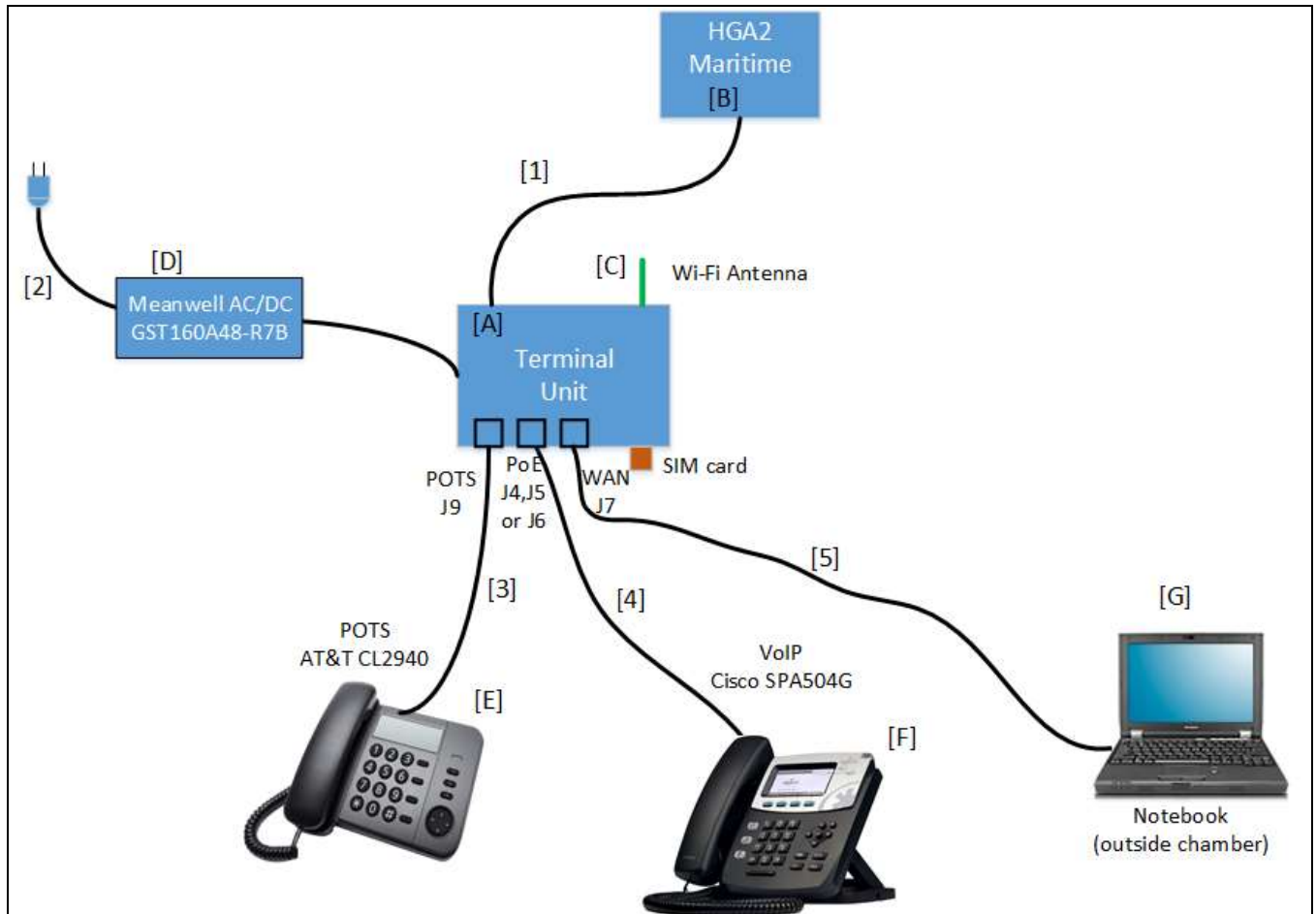


Figure 1. Block Diagram of Test Configuration



G. Equipment Configuration

The EUT was set up as outlined in Figure 1, Block Diagram of Test Setup. All cards, racks, etc., incorporated as part of the EUT is included in the following list.

Ref. ID	Name / Description	Model Number	Part Number	Serial Number	Revision
A	Certus Terminal	VF350BM	4102947-501 (Maritime)	10009	5
B	Certus Maritime High Gain Antenna	Maritime HGA2	1600901-1	424	4
C	Wi-Fi Antenna	LS Research 001-0001	85728-001	N/A	
D	AC/DC Power Supply	Meanwell GST160A12-TDSI	84670-001	EB73571759	A

Table 5. Equipment Configuration

H. Support Equipment

Support equipment necessary for the operation and testing of the EUT is included in the following list.

Ref. ID	Name / Description	Manufacturer	Model Number
E	POTS Phone	AT&T	CL2940
F	VoIP Phone	Cisco	SPA504G
G	Notebook Computer (outside chamber)	DELL	Lattitude E6320

Table 6. Support Equipment

I. Ports and Cabling Information

Ref. ID	Port Name on EUT	Cable Description	Qty.	Length (m)	Shielded (Y/N)	Termination Point
1	Antenna Cable	LMR-300 Coaxial Cable for Maritime (855023-082)	1	2 (10 ft.)	Yes	Maritime HGA2, Ant
2	AC input to AC/DC Power Supply	Cable AC Power USA Plug Type B	1	1.8	No	AC input to power supply
3	POTs Phone	POTS phone cable	1	~7 ft.	No	POTs Connector
4	RJ-45	Tera Grand 10' CAT7 Shielded Ethernet Cable	1	10'	Yes	Any of three RJ-45 Connectors (J4, J5, or J6)
5	WAN	Tera Grand 25' Shielded Ethernet Cable	1	25'+	Yes	WAN port, J7

Table 7. Ports and Cabling Information

J. Mode of Operation

The Terminal is set to a Test Mode that transmits two C8-16 APSK modulation with a data rate of 352 kbps. This test mode was written by Iridium and uses a JSON script to initiate. The transmission data payload contains random bits. The format is two uplink transmit slots in the 90 millisecond Iridium TDMA frame structure. This should be representative of the worst case EMI mode.

K. Method of Monitoring EUT Operation

There are 3 LEDs on the Terminal. All three must be solid green to indicate Terminal health. The left LED is overall terminal operation, the middle is the on-board Modem proper operation, and the right LED is the status of the Wi-Fi operation. If any of these LEDs are blinking or red there is a problem.

The other indication the terminal is working is the presence of the RF transmit signal in the 1616 to 1626 MHz frequency range.

L. Modifications

a) Modifications to EUT

No modifications were made to the EUT.

b) Modifications to Test Standard

No modifications were made to the Test Standard.

M. Disposition of EUT

The test sample including all support equipment submitted to the Electro-Magnetic Compatibility Lab for testing was returned to Thales Communications upon completion of testing.



III. Electromagnetic Compatibility Criteria for Intentional Radiators



Electromagnetic Compatibility Criteria for Satellite Communications

§25.216 Limits on Emissions from Mobile Earth Stations for Protection of Aeronautical Radio Navigation-Satellite Service

Test Requirements:

- (g) Mobile earth stations manufactured more than six months after FEDERAL REGISTER publication of the rule changes adopted in FCC 03–283 with assigned uplink frequencies in the 1610–1626.5 MHz band shall suppress the power density of emissions in the 1605–1610 MHz band-segment to an extent determined by linear interpolation from -70 dBW/MHz at 1605 MHz to -10 dBW/MHz at 1610 MHz averaged over any 2 millisecond active transmission interval. The e.i.r.p of discrete emissions of less than 700 Hz bandwidth from such stations shall not exceed a level determined by linear interpolation from -80 dBW at 1605 MHz to -20 dBW at 1610 MHz, averaged over any 2 millisecond active transmission interval.
- (i) The e.i.r.p density of carrier-off state emissions from mobile earth stations manufactured more than six months after FEDERAL REGISTER publication of the rule changes adopted in FCC 03–283 with assigned uplink frequencies between 1 and 3 GHz shall not exceed -80 dBW/MHz in the 1559–1610 MHz band averaged over any two millisecond interval.
- (j) A Root-Mean-Square detector shall be used for all power density measurements.

Test Procedures:

The EUT was set to transmit at maximum power using 2 x C8 16 APSK modulations. The EUT was connected to a spectrum analyzer thru an attenuator. Plots were corrected with path loss factors and attenuator value as offsets. The spectrum analyzer was set to 1MHz RBW and 3MHz VBW with an RMS detector and average trace.

With the EUT set to transmit, measurements were performed on the low, middle and high channels. Procedure was repeated with the EUT in carrier off state.

Test Results:

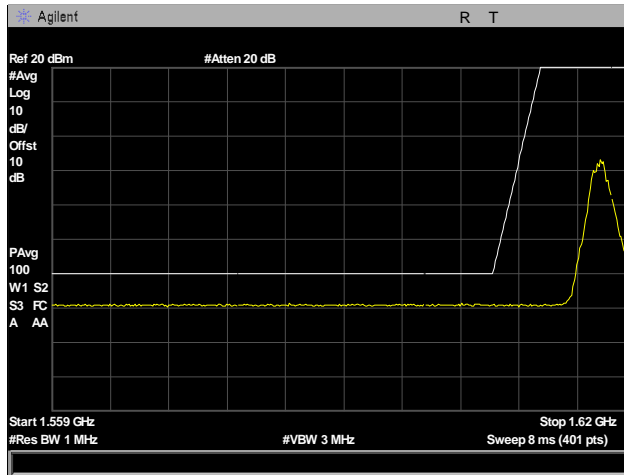
The EUT was compliant with the requirement(s) of this section.

Test Engineer(s):

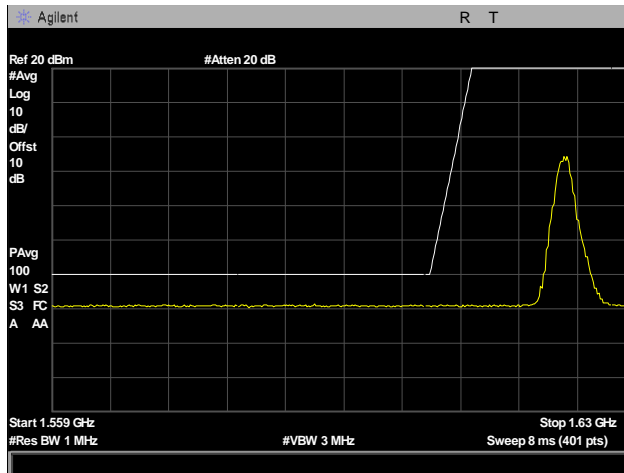
Donald Salguero

Test Date(s):

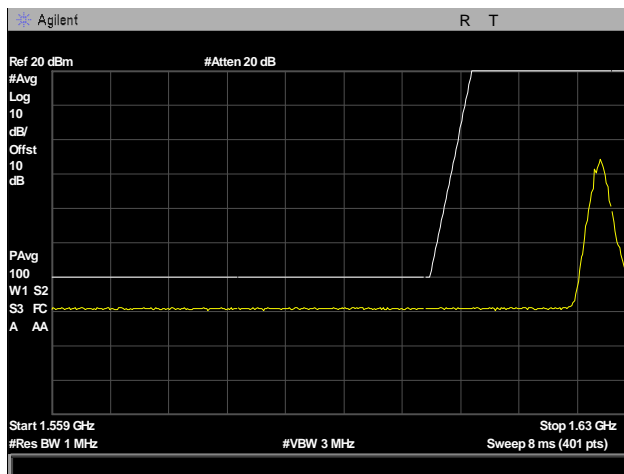
02/19/18



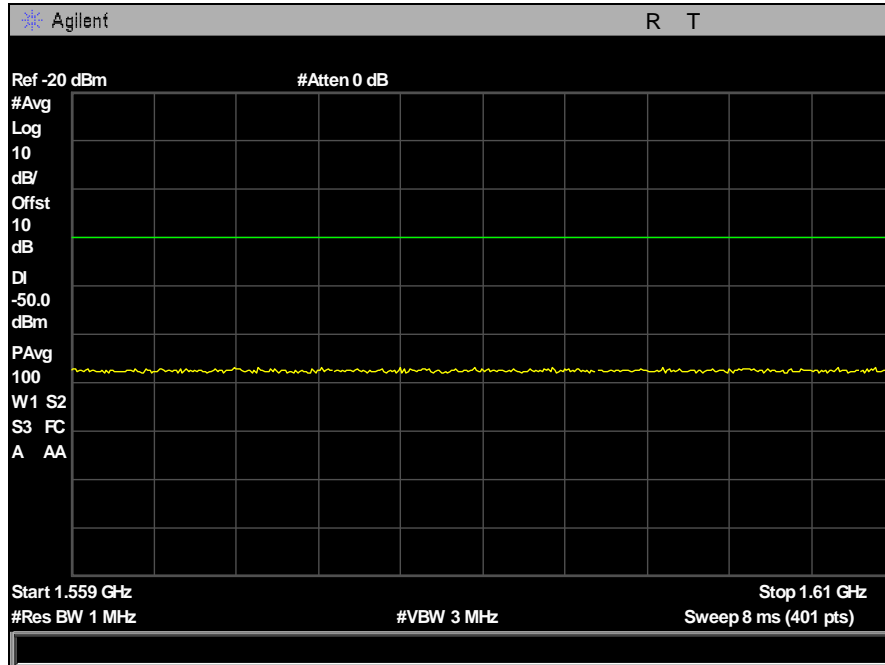
Plot 1. Aeronautical Radio Protection, EIRP, M424, Channel 1, 1616.333 MHz



Plot 2. Aeronautical Radio Protection, EIRP, M424, Channel 121, 1621.333 MHz



Plot 3. Aeronautical Radio Protection, EIRP, M424, Channel 232, 1625.666 MHz



Plot 4. Aeronautical Radio Protection, Carrier Off



Electromagnetic Compatibility Criteria for Satellite Communications

§25.202(f) Emissions Mask

Test Requirement(s): §25.202(f) **Emission Limitations:** Except for SDARS terrestrial repeaters, the mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the schedule set forth in paragraphs (f)(1) through (f)(4) of this section. The out-of-band emissions of SDARS terrestrial repeaters shall be attenuated in accordance with the schedule set forth in paragraph (h) of this section.

- 1) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;
- 2) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB;
- 3) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts;
- 4) In any event, when an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in paragraphs (f) (1), (2) and (3) of this section.

Test Procedures: The EUT was connected directly to a spectrum analyzer through an attenuator and the center frequency of the analyzer was set as the frequency of the low, middle and high channels. Each channel's emissions were observed and compared to the emissions limitations of §25.202(f).

Due to spectrum analyzer limitations, measurements were performed with a 3kHz RBW, the bandwidth correction factor was added as an offset (10 Log[4/3]).

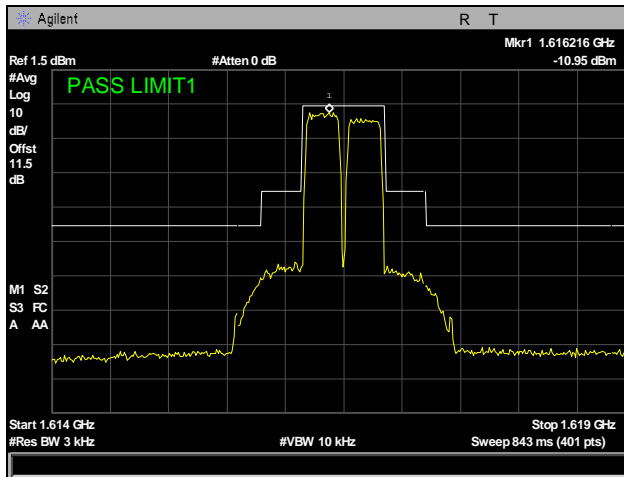
An RMS detector was used to perform the measurements.

Test Results: The EUT is compliant with the requirements of this section.

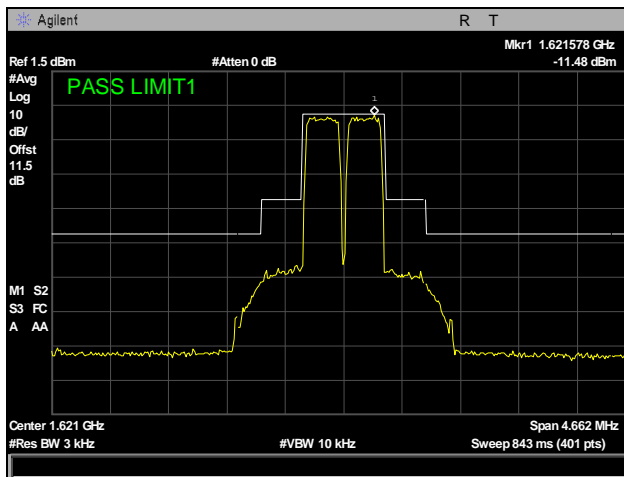
Test Engineer(s): Donald Salguero

Test Date(s): 02/19/18

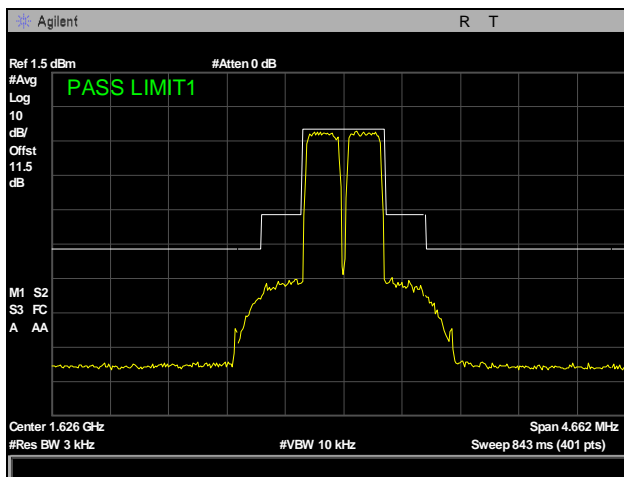
Emissions Mask, Test Results



Plot 5. Emissions Mask, M424, Channel 1, 1616.333 MHz



Plot 6. Emissions Mask, M424, Channel 121, 1621.333 MHz



Plot 7. Emissions Mask, M424, Channel 232, 1625.666 MHz

Electromagnetic Compatibility Criteria for Satellite Communications

§25.204(a) Conducted RF Output Power

Test Requirement(s): §25.204 Power Limits:

- (a) In bands shared coequally with terrestrial radio communication services, the equivalent isotropically radiated power transmitted in any direction towards the horizon by an earth station, other than an ESV, operating in frequency bands between 1 and 15 GHz, shall not exceed the following limits except as provided for in paragraph (c) of this section:

+40 dBW in any 4 kHz band for $\theta \leq 0^\circ$

+40 + 3 θ dBW in any 4 kHz band for $0^\circ < \theta \leq 5^\circ$

Where θ is the angle of elevation of the horizon viewed from the center of radiation of the antenna of the earth station and measured in degrees as positive above the horizontal plane and negative below it.

- (c) For angles of elevation of the horizon greater than 5° there shall be no restriction as to the equivalent isotropically radiated power transmitted by an earth station towards the horizon.
- (d) Notwithstanding the e.i.r.p. and e.i.r.p. density limits specified in the station authorization, each earth station transmission shall be conducted at the lowest power level that will provide the required signal quality as indicated in the application and further amended by coordination agreements.

Test Procedures:

ANSI C63.26 – 2015 Procedures for peak and average measurements of narrowband signal with a spectrum analyzer were used to determine the output conducted power. The EUT was set to transmit at full power. It was connected directly to a spectrum analyzer thru an attenuator. The measurements were performed on the low, middle and high channels.

The EIRP was calculated with:

$$EIRP = P + G$$

Where P is the conducted output power in dBm, and G is the antenna gain in dBi

Test Results:

The EUT is compliant with the requirements of this section.

Test Engineer(s):

Donald Salguero

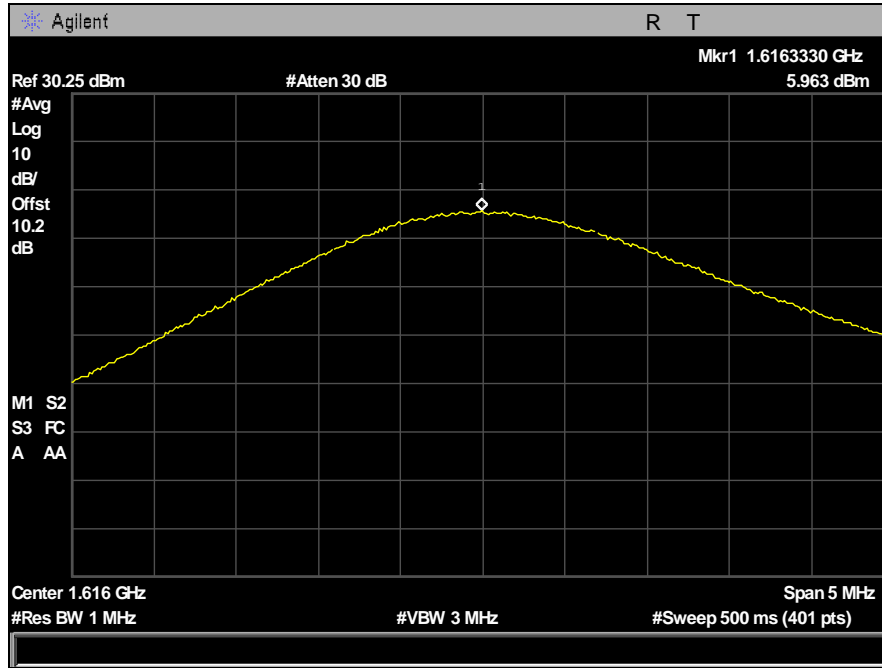
Test Date(s):

02/19/18

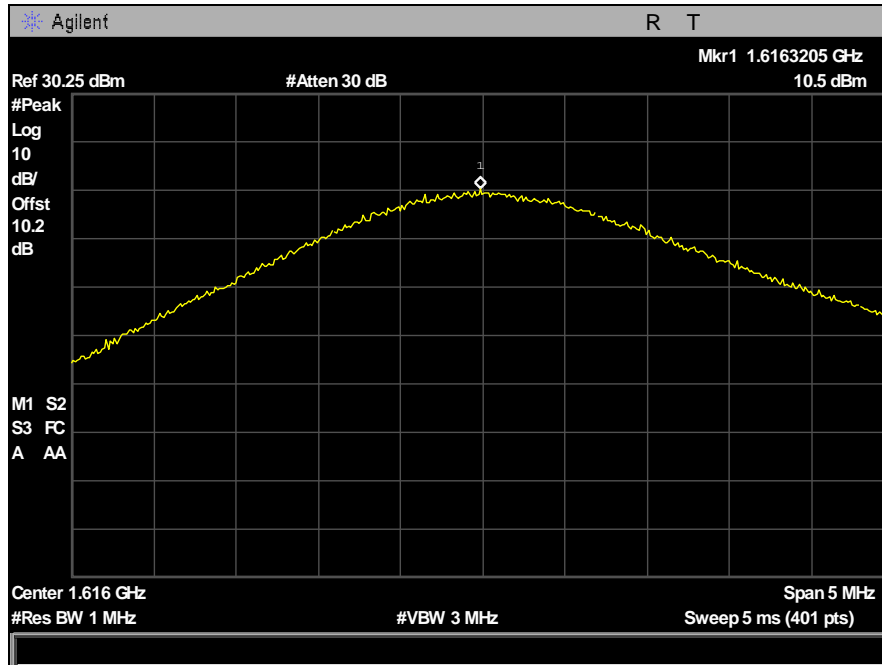
Channel	Center Frequency (MHz)	Peak Output Power (dBm)			Average Output Power (dBm)		
		Conducted	Antenna Gain	EIRP	Conducted	Antenna Gain	EIRP
1	1616.333	10.5	48.3	58.8	5.963	48.3	54.263
121	1621.333	10.03	48.3	58.33	5.437	48.3	53.737
232	1625.666	10.9	48.3	59.2	4.972	48.3	53.272

Table 8. Output Power, Results

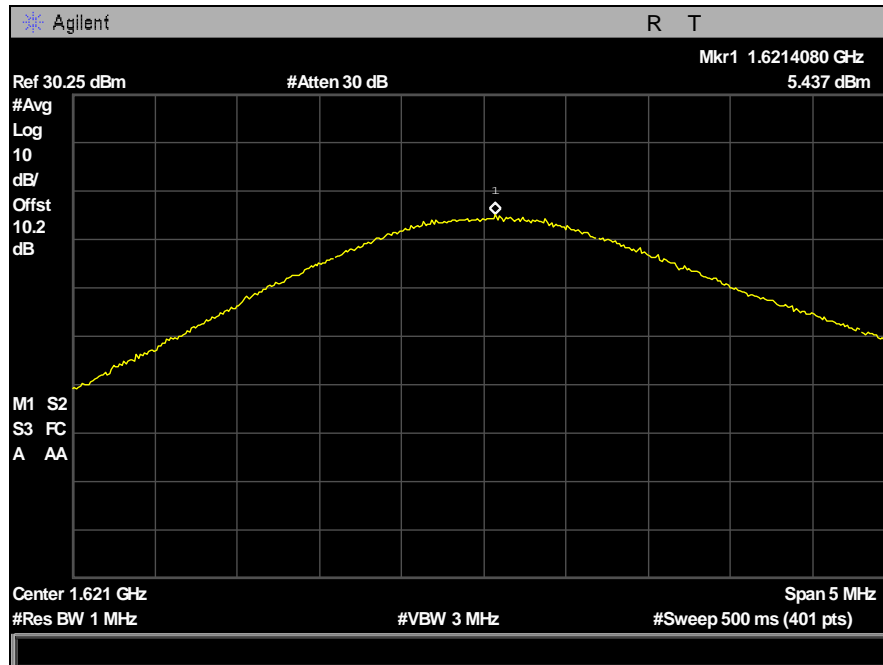
Conducted RF Output Power, Test Results



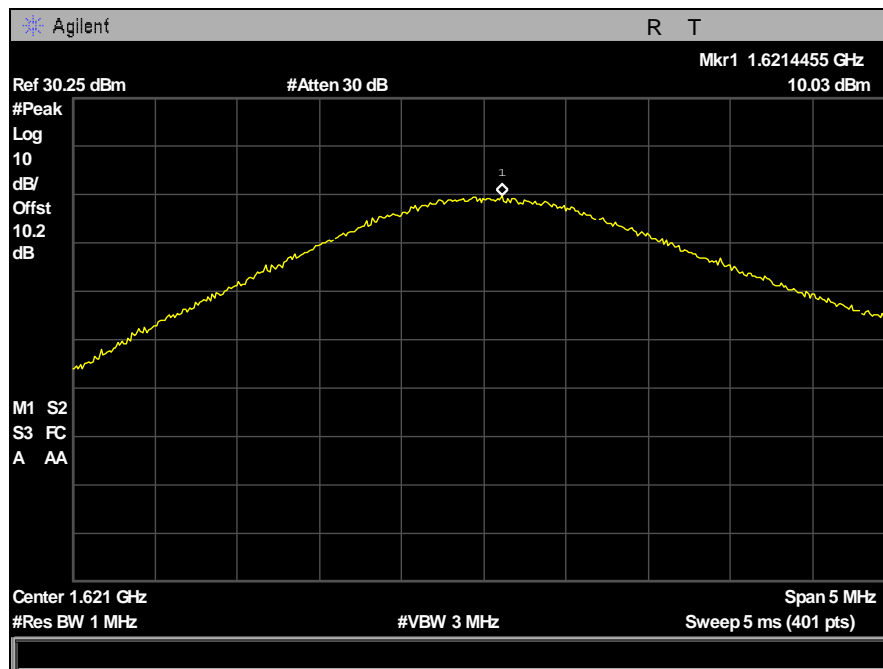
Plot 8. Conducted Power, Average, M424, Channel 1, 1616.333 MHz



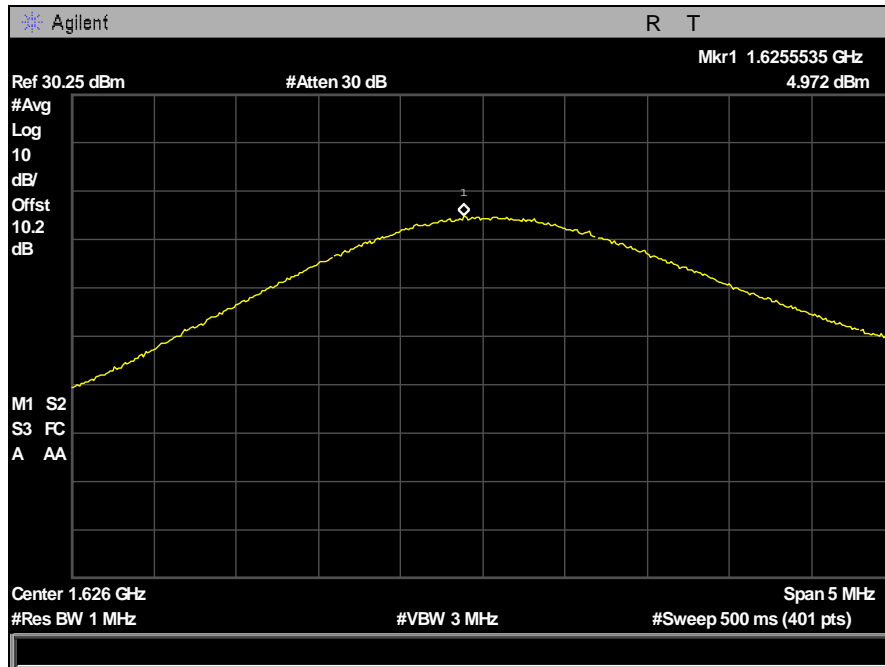
Plot 9. Conducted Power, Peak, M424, Channel 1, 1616.333 MHz



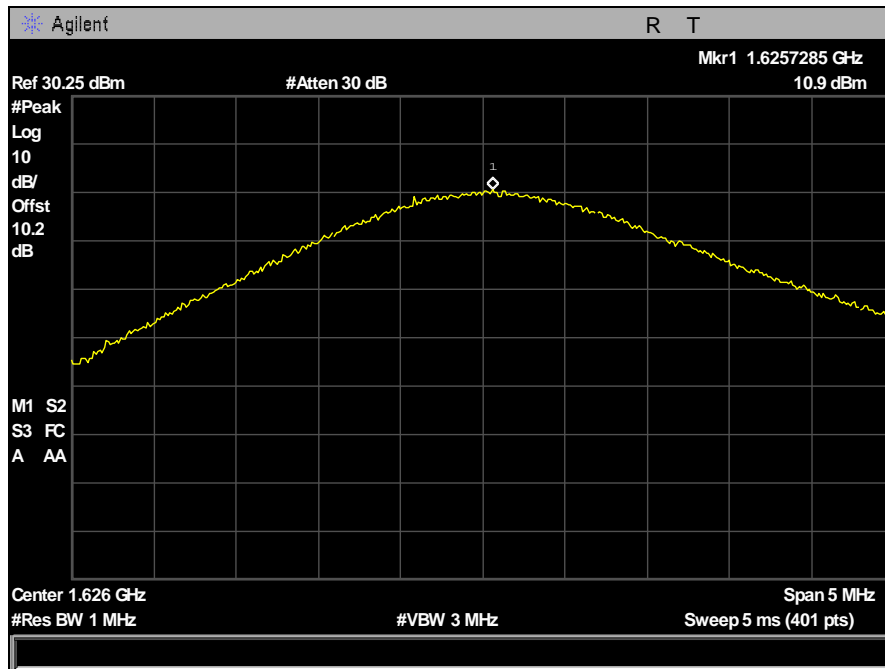
Plot 10. Conducted Power, Average, M424, Channel 121, 1621.333 MHz



Plot 11. Conducted Power, Peak, M424, Channel 121, 1621.333 MHz



Plot 12. Conducted Power, Average, M424, Channel 232, 1625.666 MHz



Plot 13. Conducted Power, Peak, M424, Channel 232, 1625.666 MHz



Electromagnetic Compatibility Criteria for Satellite Communications

§25.212(b) Occupied Bandwidth

The OBW is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission.

Test Requirement(s):

(b) Emissions with an occupied bandwidth of less than 2 MHz are not protected from interference from wider bandwidth transmissions if the r.f. carrier frequency of the narrowband signal is within ± 1 MHz of one of the frequencies specified in § 25.211(a).

Test Procedures:

The transmitter was on and transmitting at the highest output power. The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The bandwidth of the fundamental frequency was measured with the spectrum analyzer OBW built-in function using a RBW approximately 1-5% of the anticipated OBW, VBW = 3*RBW, the detector was set to peak, and trace mode was set to max-hold.

Test Results:

The EUT is compliant with the requirements of this section.

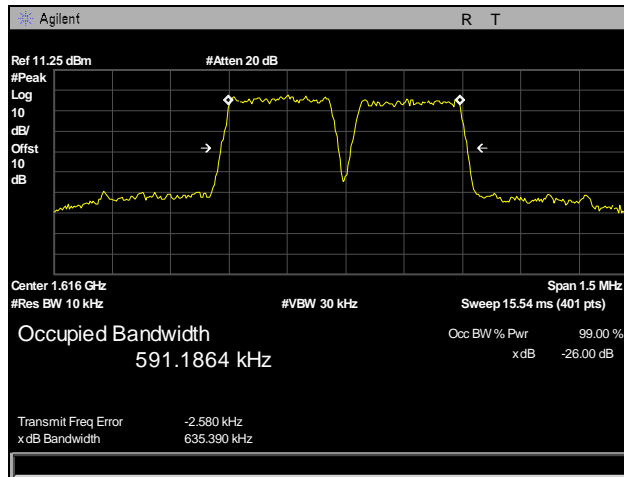
Test Engineer(s):

Donald Salguero

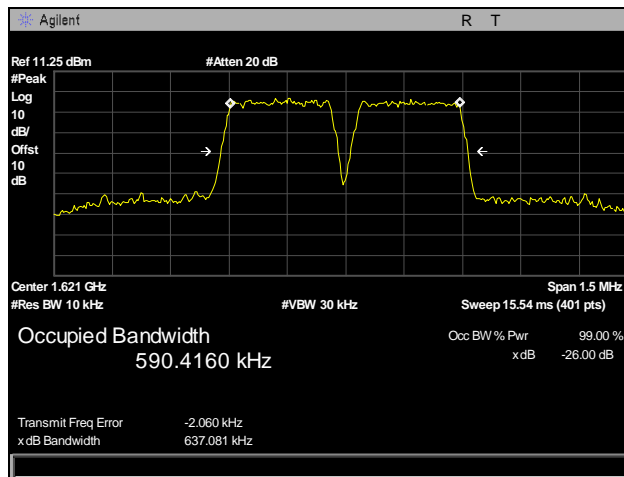
Test Date(s):

02/19/18

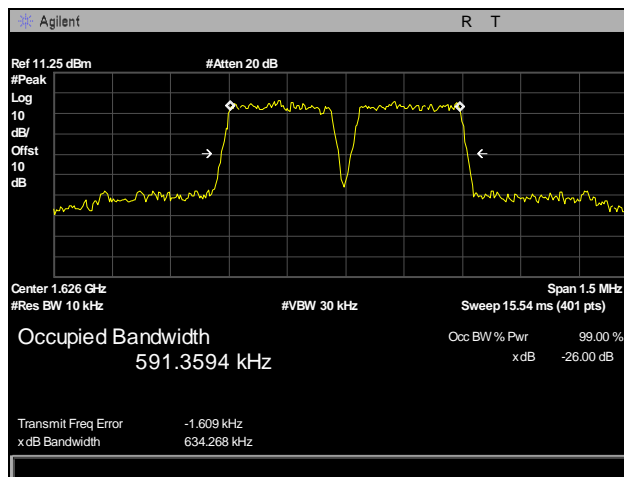
Occupied Bandwidth, Test Results



Plot 14. Occupied Bandwidth, M424, Channel 1, 1616.333 MHz



Plot 15. Occupied Bandwidth, M424, Channel 121, 1621.333 MHz



Plot 16. Occupied Bandwidth, M424, Channel 232, 1625.666 MHz



Electromagnetic Compatibility Criteria for Satellite Communications

§25.202(f) Spurious Emissions at Antenna Terminals

Test Requirement(s): §25.202 Emission Limitations:

(f) Except for SDARS terrestrial repeaters, the mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the schedule set forth in paragraphs (f)(1) through (f)(4) of this section. The out-of-band emissions of SDARS terrestrial repeaters shall be attenuated in accordance with the schedule set forth in paragraph (h) of this section.

- 1) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;
- 2) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB;
- 3) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts;
- 4) In any event, when an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in paragraphs (f) (1), (2) and (3) of this section.

Test Procedures: The EUT was connected directly to a spectrum analyzer through an attenuator and set to transmit on its low, middle and high channels at max transmit power. Emissions were measured and compared to the limits of 25.202(f).

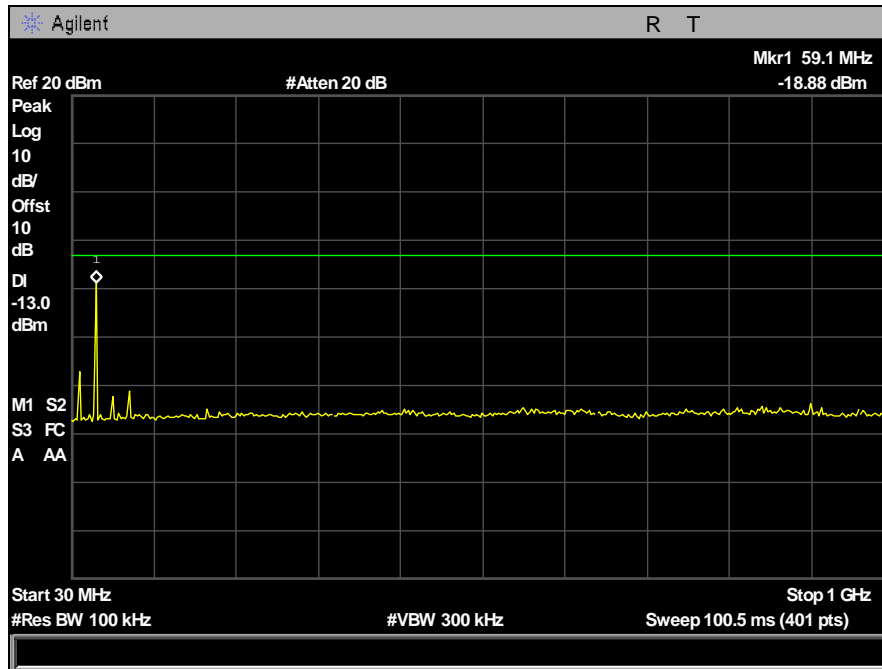
See following pages for detailed test results with RF Conducted Spurious Emissions.

Test Results: The EUT is compliant with the requirements of this section.

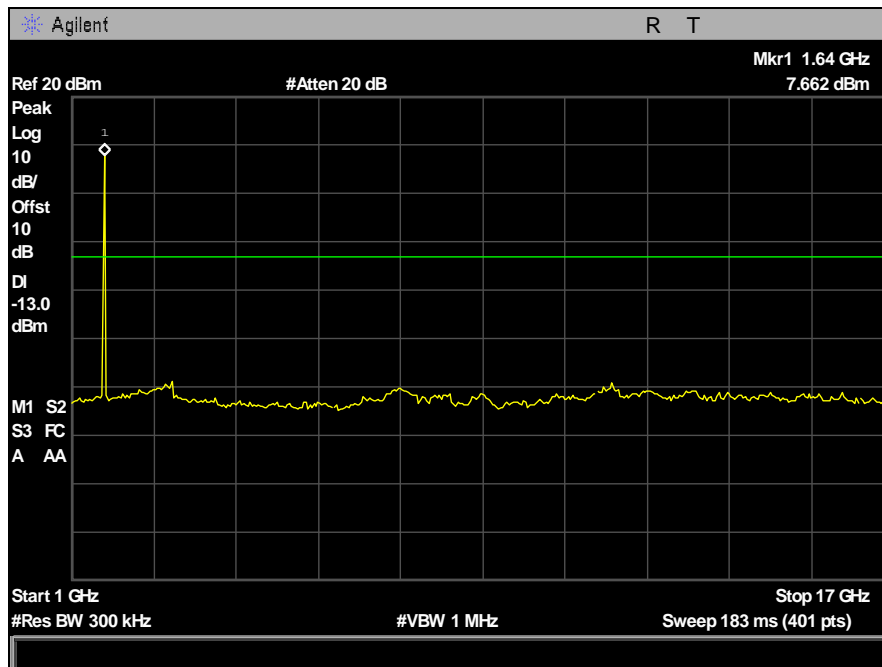
Test Engineer(s): Donald Salguero

Test Date(s): 02/19/18

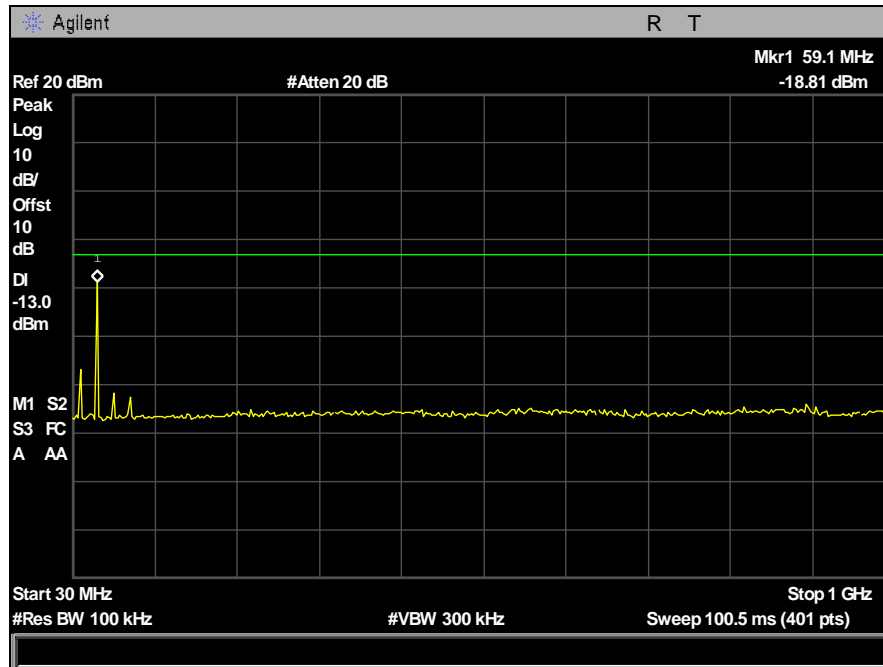
Conducted Spurious Emissions, Test Results



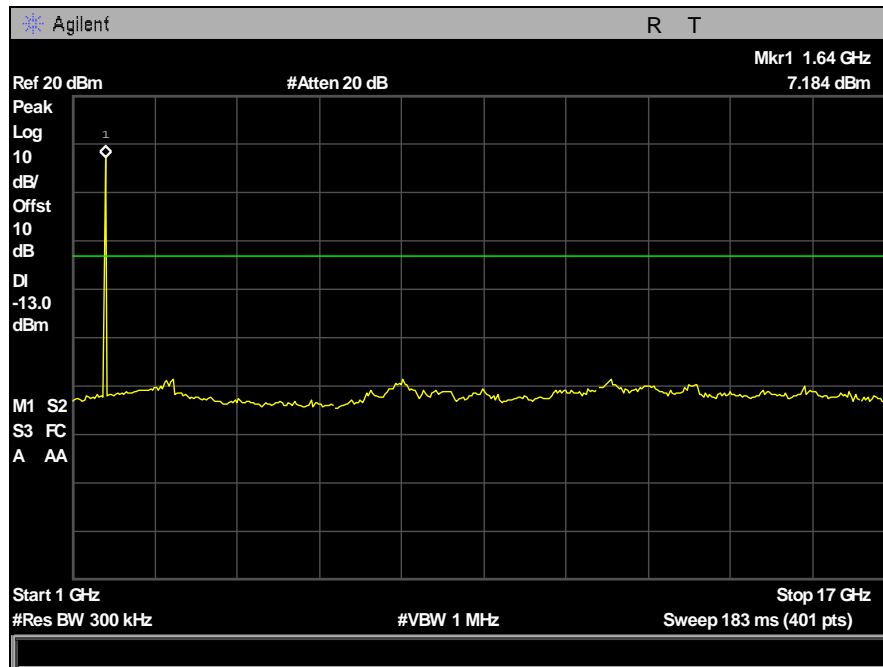
Plot 17. Conducted Spurious Emissions, M424, Channel 1, 1616.333 MHz, 30 MHz – 1 GHz



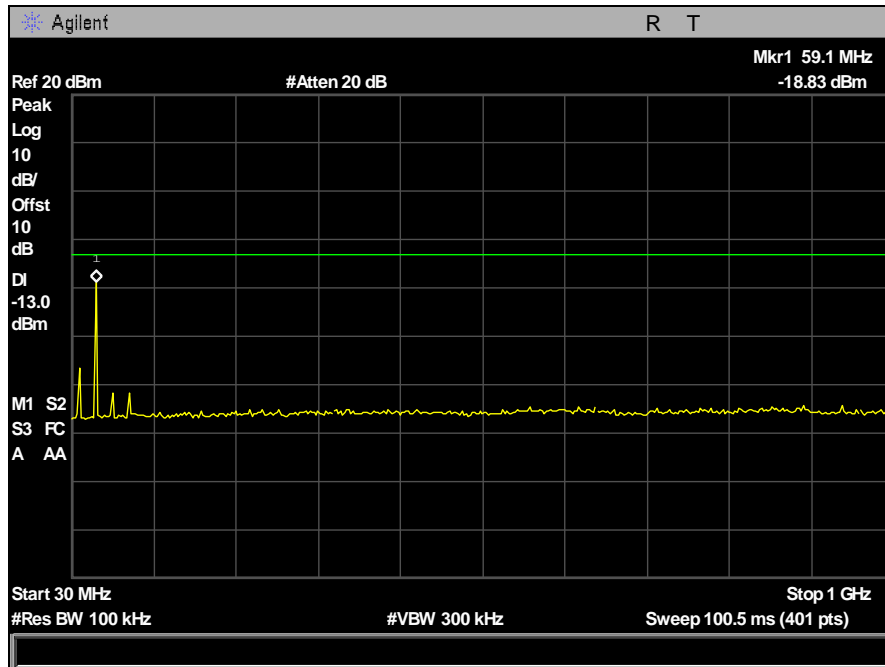
Plot 18. Conducted Spurious Emissions, M424, Channel 1, 1616.333 MHz, 1 GHz – 17 GHz



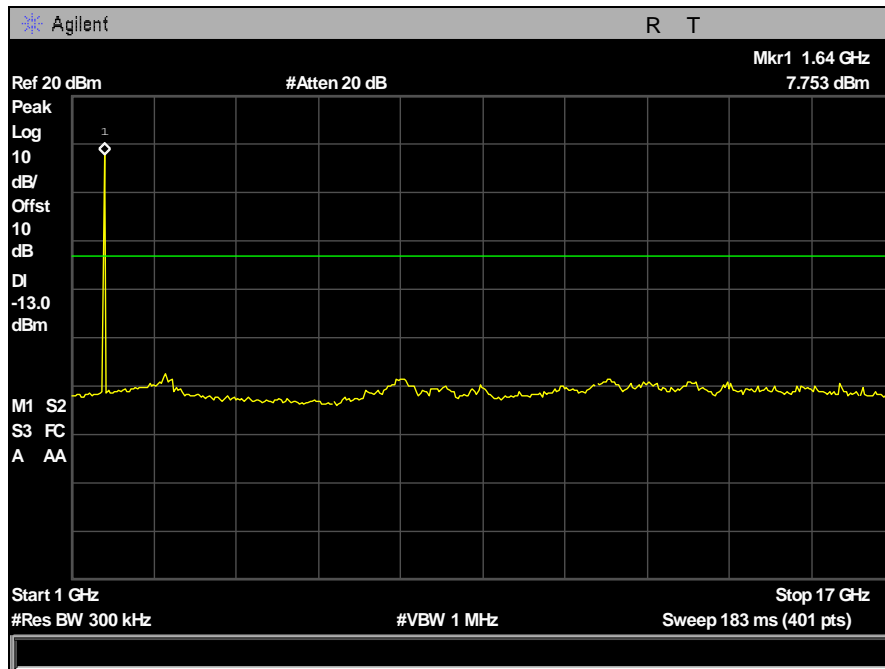
Plot 19. Conducted Spurious Emissions, M424, Channel 121, 1621.333 MHz, 30 MHz – 1 GHz



Plot 20. Conducted Spurious Emissions, M424, Channel 121, 1621.333 MHz, 1 GHz – 17 GHz



Plot 21. Conducted Spurious Emissions, M424, Channel 232, 1625.666 MHz, 30 MHz – 1 GHz



Plot 22. Conducted Spurious Emissions, M424, Channel 232, 1625.666 MHz, 1 GHz – 17 GHz

Electromagnetic Compatibility Criteria for Satellite Communications

§25.202(d) Frequency Stability

Test Requirement(s): §2.1055 Measurements required: Frequency stability.

- a) The frequency stability shall be measured with variation of ambient temperature as follows:
- (1) From -30° to $+50^{\circ}$ centigrade for all equipment except that specified in paragraphs (a) (2) and (3) of this section.
 - (2) From -20° to $+50^{\circ}$ centigrade for equipment to be licensed for use in the Maritime Services under part 80 of this chapter, except for Class A, B, and S Emergency Position Indicating Radiobeacons (EPIRBS), and equipment to be licensed for use above 952 MHz at operational fixed stations in all services, stations in the Local Television Transmission Service and Point-to-Point Microwave Radio Service under part 21 of this chapter, equipment licensed for use aboard aircraft in the Aviation Services under part 87 of this chapter, and equipment authorized for use in the Family Radio Service under part 95 of this chapter.
 - (3) From 0° to $+50^{\circ}$ centigrade for equipment to be licensed for use in the Radio Broadcast Services under part 73 of this chapter.
- (d) The frequency stability shall be measured with variation of primary supply voltage as follows:
- (1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.
 - (2) For hand carried, battery powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.
 - (3) The supply voltage shall be measured at the input to the cable normally provided with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.

§25.202(d) Frequency Tolerance, Earth Stations – The carrier frequency of each earth station transmitter authorized in these services shall be maintained within 0.001 percent of the reference frequency.

Test Procedures: The resolution bandwidth of the spectrum analyzer was set to 1 kHz and the trace was set to max hold. The EUT was set to transmit on four channels. At nominal input voltage and at 20°C , the center frequency of each channel was measured using a frequency counter. At 20°C , the input voltage was varied between 85% and 115% of nominal and the measurement was repeated. The temperature was increased and decreased in increments of no more than 10°C and the center frequency measurement was repeated. For each case, the measured center frequency was compared to the reference frequency taken at 20°C and 12VDC. The temperature range at which the measurements were performed was from -30C to 50C . Procedure was repeated for the high channel.

Test Results: The EUT is compliant with the requirements of this section.

Test Engineer(s): Donald Salguero

Test Date(s): 02/19/18



Temperature (°C)	Frequency at Nominal Voltage (MHz)	Maximum deviation from frequency at 20°C (ppm)	Maximum deviation from frequency at 20°C (%)
Nominal frequency (MHz): 1616.333			
50	1616.33278	0.09280	-0.00000928
40	1616.33274	0.06806	-0.00000681
30	1616.33203	0.37121	0.00003712
20	1616.33263	0.00000	0.00000000
10	1616.33224	0.24129	0.00002413
0	1616.33233	0.18561	0.00001856
-10	1616.33211	0.32172	0.00003217
-20	1616.33219	0.27222	0.00002722
-30	1616.33194	0.42689	0.00004269
Voltage (DC)	Frequency at Nominal Voltage (MHz)	Maximum deviation from frequency at 20°C (ppm)	Maximum deviation from frequency at 20°C (%)
10.2	1616.33272	0.05568	-0.00000557
13.8	1616.33263	0.00000	0.00000000

Table 9. Frequency Stability, Test Results, Channel 1

Temperature (°C)	Frequency at Nominal Voltage (MHz)	Maximum deviation from frequency at 20°C (ppm)	Maximum deviation from frequency at 20°C (%)
Nominal frequency (MHz): 1625.666			
50	1625.66639	0.58438	-0.00005844
40	1625.66623	0.48595	-0.00004860
30	1625.66690	0.89809	-0.00008981
20	1625.66544	0.00000	0.00000000
10	1625.66514	0.18454	0.00001845
0	1625.66705	0.99036	-0.00009904
-10	1625.66478	0.40599	0.00004060
-20	1625.66522	0.13533	0.00001353
-30	1625.66528	0.09842	0.00000984
Voltage (DC)	Frequency at Nominal Voltage (MHz)	Maximum deviation from frequency at 20°C (ppm)	Maximum deviation from frequency at 20°C (%)
10.2	1625.66631	0.53517	-0.00005352
13.8	1625.66626	0.50441	-0.00005044

Table 10. Frequency Stability, Test Results, Channel 232

Electromagnetic Compatibility Criteria for Satellite Communications

§25.202(f) Radiated Spurious Emissions

Test Requirement(s): §25.202 Emission Limitations:

(f) Except for SDARS terrestrial repeaters, the mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the schedule set forth in paragraphs (f)(1) through (f)(4) of this section. The out-of-band emissions of SDARS terrestrial repeaters shall be attenuated in accordance with the schedule set forth in paragraph (h) of this section.

- 5) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;
- 6) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;
- 7) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts;
- 8) In any event, when an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in paragraphs (f) (1), (2) and (3) of this section.

Test Procedures:

As required by 47 CFR 2.1053, *field strength of radiated spurious measurements* were made in accordance with the procedures of TIA/EIA-603-A-2001 "Land Mobile FM or PM Communications Equipment Measurement and Performance Standards".

Radiated emission measurements were performed inside a 10 meter semi-anechoic chamber. The EUT was set at a distance of 3m from the receiving antenna. The EUT was set to transmit at the low, mid and high channels of the transmitter frequency range at its maximum power level. The EUT was rotated about 360° and the receiving antenna scanned from 1-4m in order to capture the maximum emission. These steps were carried out with the receiving antenna in both vertical and horizontal polarization. Harmonic emissions up to the 10th or 40 GHz, whichever was the lesser, were investigated.

The spectrum analyzer was set with a 100kHz RBW and 300kHz VBW for all frequencies from 30MHz to 18GHz

The field strength was corrected using antenna factors, cable loss. An offset of $10\log(100/4)$ was applied to the trace to account for a 4kHz RBW measurement as per the standard.

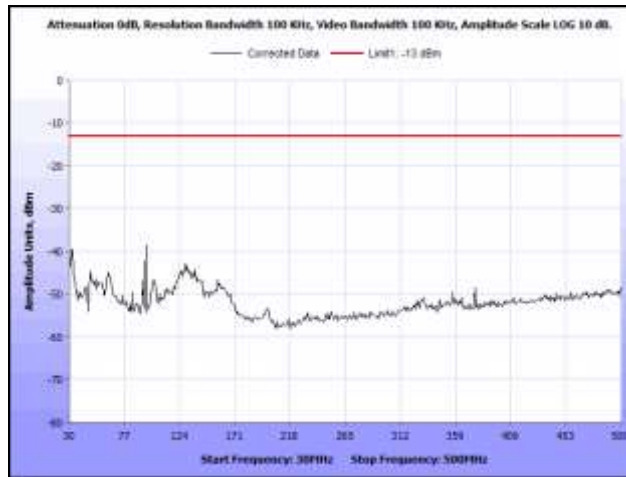
Test Results:

The EUT is compliant with the requirements of this section. The plots have been corrected to EIRP on dBm by way of: $EIRP = E + 20\log(d) - 104.77$
Where E is the measured field strength in dBuV/m, and 'd' is the measurement distance in meters.

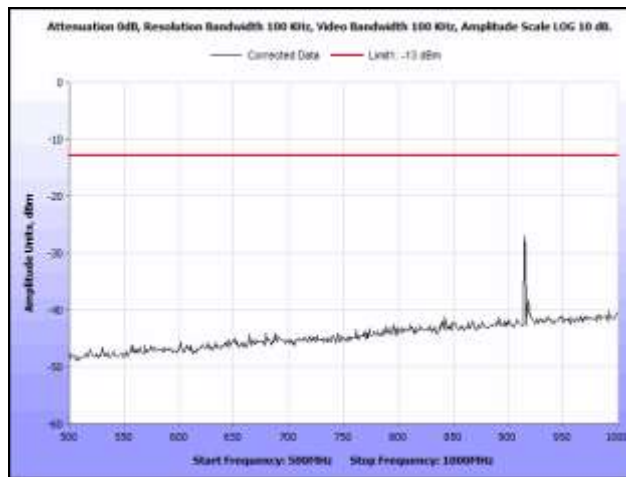
Test Engineer(s): Donald Salguero

Test Date(s): 02/19/18

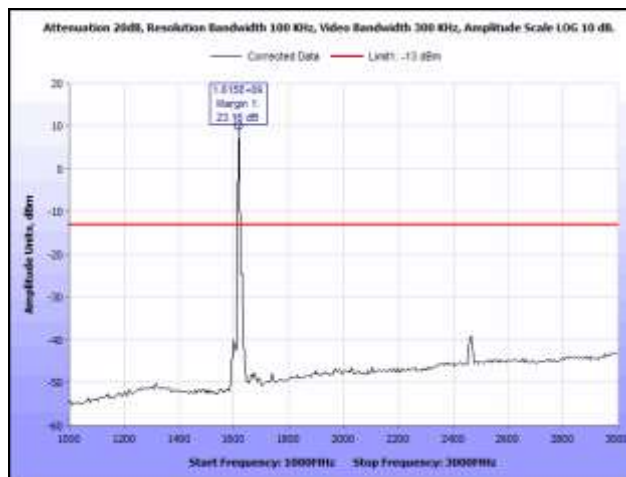
Radiated Spurious Emissions, Test Results



Plot 23. Radiated Spurious Emissions, M424, Channel 1, 1616.333 MHz, 30 MHz – 500 MHz



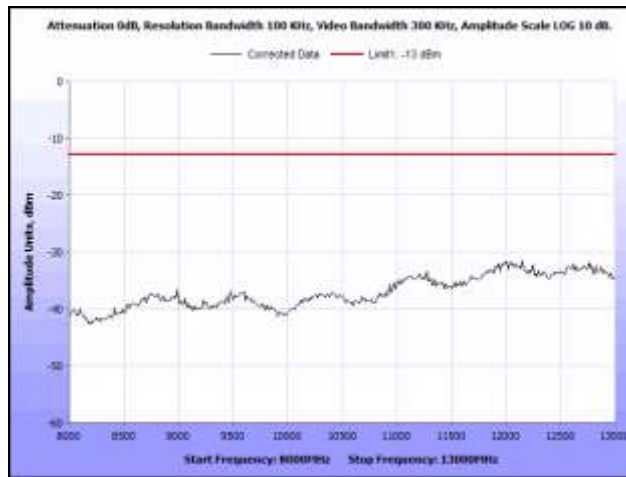
Plot 24. Radiated Spurious Emissions, M424, Channel 1, 1616.333 MHz, 500 MHz – 1 GHz



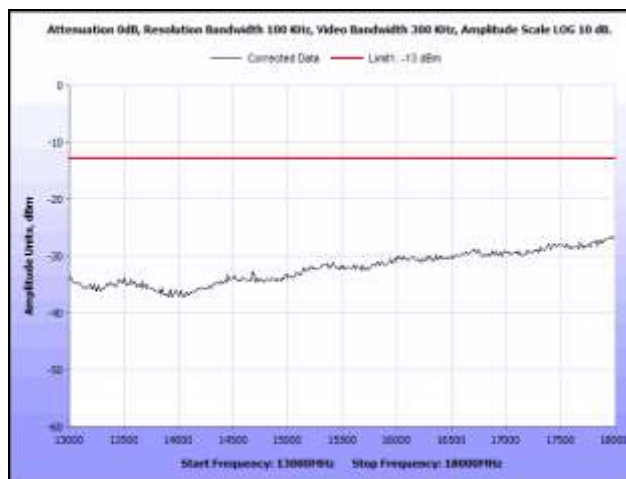
Plot 25. Radiated Spurious Emissions, M424, Channel 1, 1616.333 MHz, 1 GHz – 3 GHz



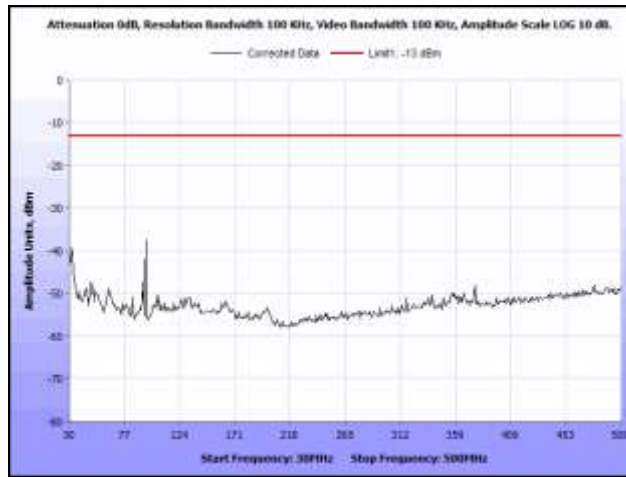
Plot 26. Radiated Spurious Emissions, M424, Channel 1, 1616.333 MHz, 3 GHz – 8 GHz



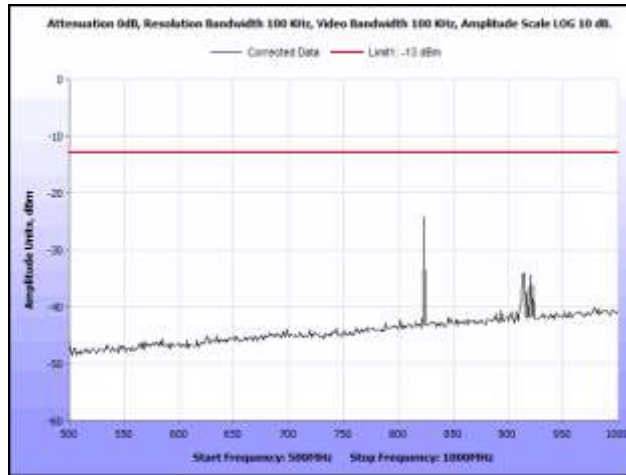
Plot 27. Radiated Spurious Emissions, M424, Channel 1, 1616.333 MHz, 8 GHz – 13 GHz



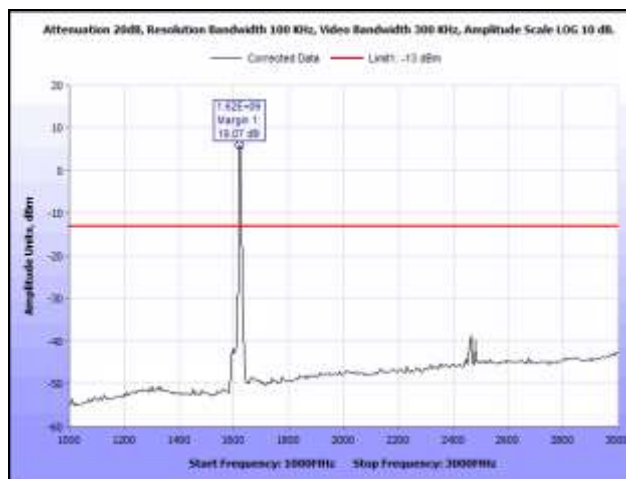
Plot 28. Radiated Spurious Emissions, M424, Channel 1, 1616.333 MHz, 13 GHz – 18 GHz



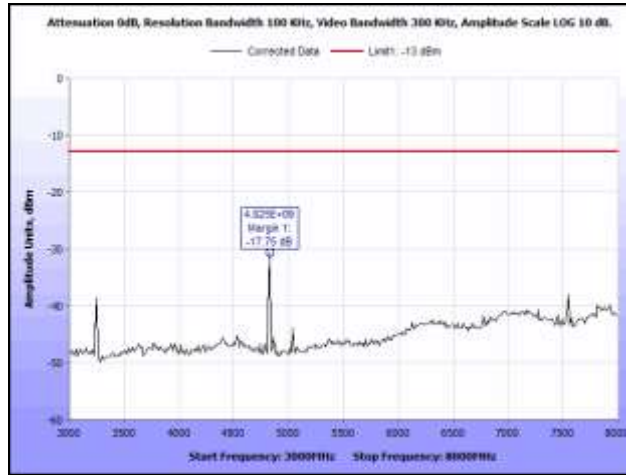
Plot 29. Radiated Spurious Emissions, M424, Channel 121, 1621.333 MHz, 30 MHz – 500 MHz



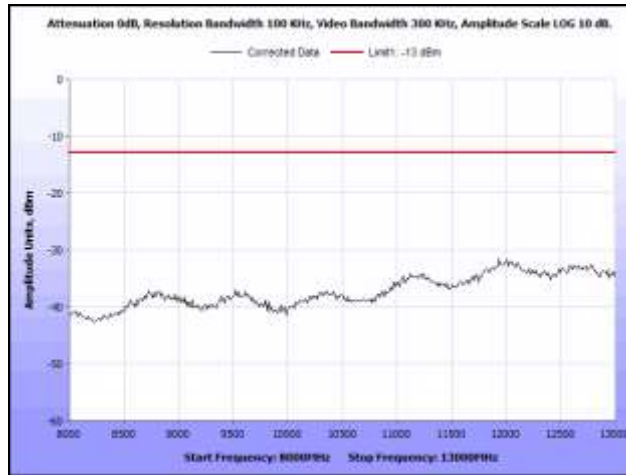
Plot 30. Radiated Spurious Emissions, M424, Channel 121, 1621.333 MHz, 500 MHz – 1 GHz



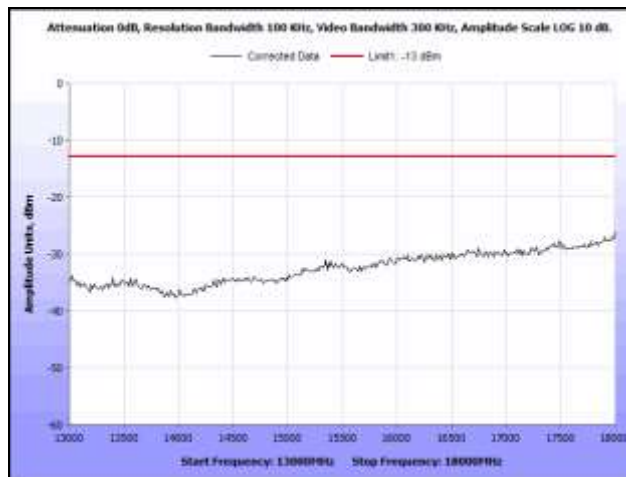
Plot 31. Radiated Spurious Emissions, M424, Channel 121, 1621.333 MHz, 1 GHz – 3 GHz



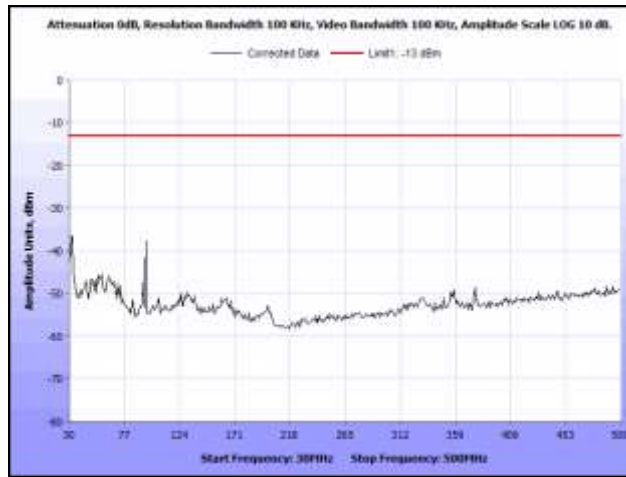
Plot 32. Radiated Spurious Emissions, M424, Channel 121, 1621.333 MHz, 3 GHz – 8 GHz



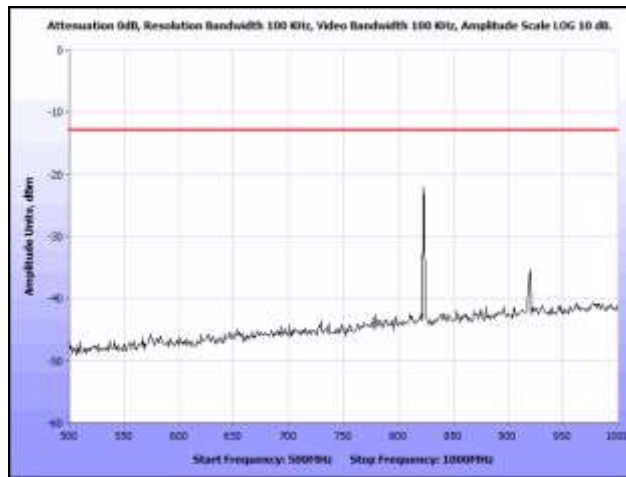
Plot 33. Radiated Spurious Emissions, M424, Channel 121, 1621.333 MHz, 8 GHz – 13 GHz



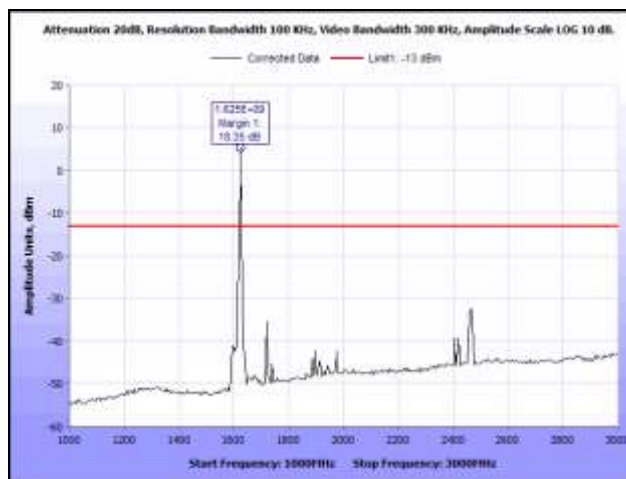
Plot 34. Radiated Spurious Emissions, M424, Channel 121, 1621.333 MHz, 13 GHz – 18 GHz



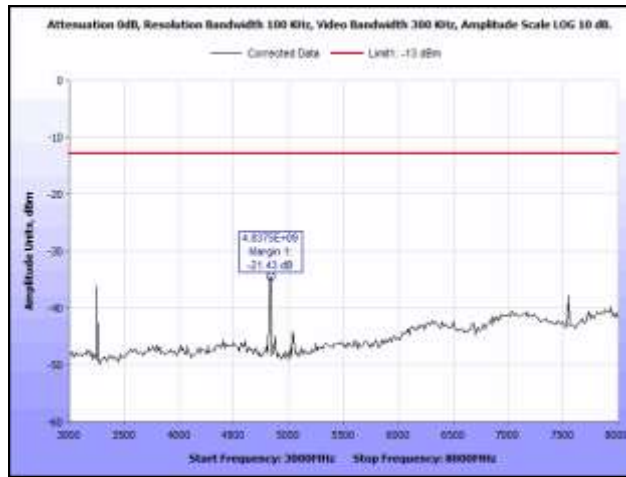
Plot 35. Radiated Spurious Emissions, M424, Channel 232, 1625.666 MHz, 30 MHz – 500 MHz



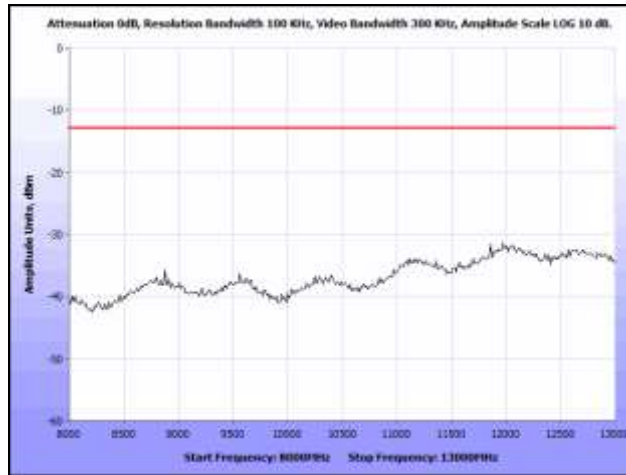
Plot 36. Radiated Spurious Emissions, M424, Channel 232, 1625.666 MHz, 500 MHz – 1 GHz



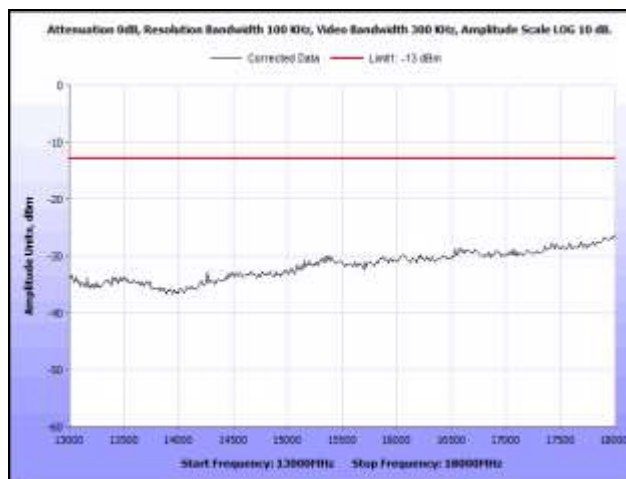
Plot 37. Radiated Spurious Emissions, M424, Channel 232, 1625.666 MHz, 1 GHz – 3 GHz



Plot 38. Radiated Spurious Emissions, M424, Channel 232, 1625.666 MHz, 3 GHz – 8 GHz



Plot 39. Radiated Spurious Emissions, M424, Channel 232, 1625.666 MHz, 8 GHz – 13 GHz



Plot 40. Radiated Spurious Emissions, M424, Channel 232, 1625.666 MHz, 13 GHz – 18 GHz

Electromagnetic Compatibility Criteria for Satellite Communications

§ 1.1310 Radiofrequency radiation exposure limits.

RF Exposure Requirements: §1.1307(b)(1) and §1.1307(b)(2): Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission’s guidelines.

RF Radiation Exposure Limit: §1.1310: As specified in this section, the Maximum Permissible Exposure (MPE) Limit shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Sec. 1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of Sec. 2.1093 of this chapter.

MPE Limit: EUT’s operating frequencies @ 1616.333 – 1625.666 MHz; **Limit for Uncontrolled exposure: 1 mW/cm² or 10 W/m²**

Equation from page 18 of OET 65, Edition 97-01

$$S = PG / 4\pi R^2 \quad \text{or} \quad R = \sqrt{PG / 4\pi S}$$

where, S = Power Density (mW/cm²)
P = Power Input to antenna (mW)
G = Antenna Gain (numeric value)
R = Distance (cm)

Result:

FCC									
Frequency (MHz)	Con. Pwr. (dBm)	Con. Pwr. (mW)	Ant. Gain (dBi)	Ant. Gain numeric	Pwr. Density (mW/cm ²)	Limit (mW/cm ²)	Margin	Distance (cm)	Result
1625.666	10.9	12.303	48.3	67608.298	1	1	0	257.274	Pass

The safe distance where Power Density is less than the MPE Limit listed above was found to be 260 cm.



Test Equipment

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ISO/IEC 17025:200.

Test Equipment					
MET Asset #	Nomenclature	Manufacturer	Model	Last Cal Date	Cal Due Date
1T8818	SPECTRUM ANALYZER	AGILENT TECHNOLOGIES	E4407B	2/24/2017	2/24/2018
1T4771	PSA SPECTRUM ANALYZER	AGILENT TECHNOLOGIES	E4446A	8/10/2016	2/10/2018
1T4483	ANTENNA; HORN	ETS-LINDGREN	3117	4/19/2017	10/19/2018
1T4753	ANTENNA - BILOG	SUNOL SCIENCES	JB6	10/24/2016	4/24/2018
1T4505	TEMPERATURE CHAMBER	TEST EQUITY	115	2/11/2017	2/11/2018
1T4149	HIGH-FREQUENCY ANECHOIC CHAMBER	RAY PROOF	81	NOT REQUIRED	
1T4442	PRE-AMPLIFIER, MICROWAVE	MITEQ	AFS42-01001800-30-10P	SEE NOTE	
1T8743	PREAMPLIFIER	A.H. SYSTEMS, INC.	PAM-0118P	SEE NOTE	
1T4300	SEMI-ANECHOIC CHAMBER # 1 (NSA)	EMC TEST SYSTEMS	NONE	2/6/2015	2/6/2018
1T4149	HIGH-FREQUENCY ANECHOIC CHAMBER	RAY PROOF	81	NOT REQUIRED	

Note: Functionally tested equipment is verified using calibrated instrumentation at the time of testing.



Certification & User's Manual Information

Certification Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart I — Marketing of Radio frequency devices:

§ 2.801 Radio-frequency device defined.

As used in this part, a radio-frequency device is any device which in its operation is capable of Emitting radio-frequency energy by radiation, conduction, or other means. Radio- frequency devices include, but are not limited to:

- (a) The various types of radio communication transmitting devices described throughout this chapter.
- (b) The incidental, unintentional and intentional radiators defined in Part 15 of this chapter.*
- (c) The industrial, scientific, and medical equipment described in Part 18 of this chapter.
- (d) Any part or component thereof which in use emits radio-frequency energy by radiation, conduction, or other means.

§ 2.803 Marketing of radio frequency devices prior to equipment authorization.

- (a) Except as provided elsewhere in this chapter, no person shall sell or lease, or offer for sale or lease (including advertising for sale or lease), or import, ship or distribute for the purpose of selling or leasing or offering for sale or lease, any radio frequency device unless:
 - (1) In the case of a device subject to certification, such device has been authorized by the Commission in accordance with the rules in this chapter and is properly identified and labeled as required by §2.925 and other relevant sections in this chapter; or
 - (2) In the case of a device that is not required to have a grant of equipment authorization issued by the Commission, but which must comply with the specified technical standards prior to use, such device also complies with all applicable administrative (including verification of the equipment or authorization under a Declaration of Conformity, where required), technical, labeling and identification requirements specified in this chapter.
- (d) Notwithstanding the provisions of paragraph (a) of this section, the offer for sale solely to business, commercial, industrial, scientific or medical users (but not an offer for sale to other parties or to end users located in a residential environment) of a radio frequency device that is in the conceptual, developmental, design or pre-production stage is permitted prior to equipment authorization or, for devices not subject to the equipment authorization requirements, prior to a determination of compliance with the applicable technical requirements *provided* that the prospective buyer is advised in writing at the time of the offer for sale that the equipment is subject to the FCC rules and that the equipment will comply with the appropriate rules before delivery to the buyer or to centers of distribution.
- (e)(1) Notwithstanding the provisions of paragraph (a) of this section, prior to equipment authorization or determination of compliance with the applicable technical requirements any radio frequency device may be operated, but not marketed, for the following purposes and under the following conditions:
 - (i) Compliance testing;*



- (ii) Demonstrations at a trade show provided the notice contained in paragraph (c) of this section is displayed in a conspicuous location on, or immediately adjacent to, the device;
 - (iii) Demonstrations at an exhibition conducted at a business, commercial, industrial, scientific or medical location, but excluding locations in a residential environment, provided the notice contained in paragraphs (c) or (d) of this section, as appropriate, is displayed in a conspicuous location on, or immediately adjacent to, the device;
 - (iv) Evaluation of product performance and determination of customer acceptability, provided such operation takes place at the manufacturer's facilities during developmental, design or pre-production states; or
 - (v) Evaluation of product performance and determination of customer acceptability where customer acceptability of a radio frequency device cannot be determined at the manufacturer's facilities because of size or unique capability of the device, provided the device is operated at a business, commercial, industrial, scientific or medical user's site, but not at a residential site, during the development, design or pre-production stages.
- (e)(2) For the purpose of paragraphs (e)(1)(iv) and (e)(1)(v) of this section, the term *manufacturer's facilities* includes the facilities of the party responsible for compliance with the regulations and the manufacturer's premises, as well as the facilities of other entities working under the authorization of the responsible party in connection with the development and manufacture, but not the marketing, of the equipment.
- (f) For radio frequency devices subject to verification and sold solely to business, commercial, industrial, scientific and medical users (excluding products sold to other parties or for operation in a residential environment), parties responsible for verification of the devices shall have the option of ensuring compliance with the applicable technical specifications of this chapter at each end user's location after installation, provided that the purchase or lease agreement includes a proviso that such a determination of compliance be made and is the responsibility of the party responsible for verification of the equipment.



**The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart J —
Equipment Authorization Procedures:**

§ 2.901 Basis and Purpose

- (a) In order to carry out its responsibilities under the Communications Act and the various treaties and international regulations, and in order to promote efficient use of the radio spectrum, the Commission has developed technical standards for radio frequency equipment and parts or components thereof. The technical standards applicable to individual types of equipment are found in that part of the rules governing the service wherein the equipment is to be operated.¹ *In addition to the technical standards provided, the rules governing the service may require that such equipment be verified by the manufacturer or importer*, be authorized under a Declaration of Conformity, or receive an equipment authorization from the Commission by one of the following procedures: certification or registration.
- (b) The following sections describe the verification procedure, the procedure for a Declaration of Conformity, and the procedures to be followed in obtaining certification from the Commission and the conditions attendant to such a grant.

§ 2.907 Certification.

- (a) Certification is an equipment authorization issued by the Commission, based on representation and test data submitted by the applicant.
- (b) Certification attaches to all units subsequently marketed by the grantee which are identical (see Section 2.908) to the sample tested except for permissive changes or other variations authorized by the Commission pursuant to Section 2.1043.

¹ In this case, the equipment is subject to the rules of Part 15. More specifically, the equipment falls under Subpart B (of Part 15), which deals with unintentional radiators.



§ 2.948 Description of measurement facilities.

- (a) Each party making measurements of equipment that is subject to an equipment authorization under Part 15 or Part 18 of this chapter, regardless of whether the measurements are filed with the Commission or kept on file by the party responsible for compliance of equipment marketed within the U.S. or its possessions, shall compile a description of the measurement facilities employed.
 - (1) If the measured equipment is subject to the verification procedure, the description of the measurement facilities shall be retained by the party responsible for verification of the equipment.
 - (i) *If the equipment is verified through measurements performed by an independent laboratory, it is acceptable for the party responsible for verification of the equipment to rely upon the description of the measurement facilities retained by or placed on file with the Commission by that laboratory. In this situation, the party responsible for the verification of the equipment is not required to retain a duplicate copy of the description of the measurement facilities.*
 - (ii) If the equipment is verified based on measurements performed at the installation site of the equipment, no specific site calibration data is required. It is acceptable to retain the description of the measurement facilities at the site at which the measurements were performed.
 - (2) If the equipment is to be authorized by the Commission under the certification procedure, the description of the measurement facilities shall be filed with the Commission's Laboratory in Columbia, Maryland. The data describing the measurement facilities need only be filed once but must be updated as changes are made to the measurement facilities or as otherwise described in this section. At least every three years, the organization responsible for filing the data with the Commission shall certify that the data on file is current.

N. Label and User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart A — General:

§ 15.19 Labeling requirements.

(a) *In addition to the requirements in Part 2 of this chapter, a device subject to certification or verification shall be labeled as follows:*

- (1) Receivers associated with the operation of a licensed radio service, e.g., FM broadcast under Part 73 of this chapter, land mobile operation under Part 90, etc., shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference.

- (2) A stand-alone cable input selector switch, shall bear the following statement in a conspicuous location on the device:

This device is verified to comply with Part 15 of the FCC Rules for use with cable television service.

- (3) All other devices shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

- (4) Where a device is constructed in two or more sections connected by wires and marketed together, the statement specified under paragraph (a) of this section is required to be affixed only to the main control unit.

- (5) When the device is so small or for such use that it is not practicable to place the statement specified under paragraph (a) of this section on it, the information required by this paragraph shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed. However, the FCC identifier or the unique identifier, as appropriate, must be displayed on the device.

§ 15.21 Information to user.

The users manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.



The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart B — Unintentional Radiators:

§ 15.105 Information to the user.

- (a) For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.



End of Report