

Test of: Comotech Corporation - Airlight

To: FCC CFR 47 Part 101

Test Report Serial No.: COMO01-U2 Rev B





Test of Comotech Corporation - Airlight
to
To FCC CFR 47 Part 101

Test Report Serial No.: COMO01-U2 Rev B

This report supersedes: None

Manufacturer: Comotech Corporation
908-6, UKIC, 812-1, Hyomun-Dong
Buk-Gu, Ulsan-City
South Korea 683-360

Product Function: Point to Point Radio Link for
network backhaul

Copy No: pdf **Issue Date:** 8th October 2015

This Test Report is Issued Under the Authority of:

MiCOM Labs, Inc.

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TESTING CERT # 2381.01

MiCOM Labs is an ISO 17025 Accredited Testing Laboratory



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1 ACCREDITATION, LISTINGS & RECOGNITION

1.1 ACCREDITATION - TESTING

MiCOM Labs, Inc. an accredited laboratory complies with the international standard BS EN ISO/IEC 17025. The company is accredited by the American Association for Laboratory Accreditation (A2LA) www.a2la.org test laboratory number 2381.01. MiCOM Labs test schedule is available at the following URL; <http://www.a2la.org/scopepdf/2381-01.pdf>



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1.2 RECOGNITION

MiCOM Labs, Inc has widely recognized Electrical testing capabilities. Our international recognition includes Conformity Assessment Body designation by APEC MRA** countries. Our test reports are widely accepted for global type approvals.

Country	Recognition Body	Status	Phase	Identification No.
USA	Federal Communications Commission (FCC)	TCB	-	US0159 Listing #: 102167
Canada	Industry Canada (IC)	FCB	APEC MRA 2	US0159 Listing #: 4143A-2 4143A-3
Japan	MIC (Ministry of Internal Affairs and Communication)	CAB	APEC MRA 2	RCB 210
	VCCI	--	--	A-0012
Europe	European Commission	NB	EU MRA	NB 2280
Australia	Australian Communications and Media Authority (ACMA)	CAB	APEC MRA 1	US0159
Hong Kong	Office of the Telecommunication Authority (OFTA)	CAB	APEC MRA 1	
Korea	Ministry of Information and Communication Radio Research Laboratory (RRL)	CAB	APEC MRA 1	
Singapore	Infocomm Development Authority (IDA)	CAB	APEC MRA 1	
Taiwan	National Communications Commission (NCC) Bureau of Standards, Metrology and Inspection (BSMI)	CAB	APEC MRA 1	
Vietnam	Ministry of Communication (MIC)	CAB	APEC MRA 1	

**APEC MRA – Asia Pacific Economic Community Mutual Recognition Agreement.

Is a recognition agreement under which test lab is accredited to regulatory standards of the APEC member countries.

Phase I - recognition for product testing

Phase II – recognition for both product testing and certification

N/A – Not Applicable

**EU MRA – European Union Mutual Recognition Agreement.

Is a recognition agreement under which test lab is accredited to regulatory standards of the EU member countries.

**NB – Notified Body

1.3 PRODUCT CERTIFICATION

MiCOM Labs, Inc. is an accredited Product Certification Body per the international standard EN ISO/IEC 17065. The company is accredited by the American Association for Laboratory Accreditation (A2LA) www.a2la.org test laboratory number 2381.02. MiCOM Labs test schedule is available at the following URL; <http://www.a2la.org/scopepdf/2381-02.pdf>



United States of America – Telecommunication Certification Body (TCB)

TCB Identifier – US0159

Industry Canada – Certification Body

CAB Identifier – US0159

Europe – Notified Body

Notified Body Identifier - 2280

Japan – Recognized Certification Body (RCB)

RCB Identifier - 210

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2 DOCUMENT HISTORY

Document History		
Revision	Date	Comments
Draft		
Rev A	8 th September 2015	Initial Release
Rev B	8 th October 2015	Correction to Section 7.1.2 Transmitter Output Power, amended the power limits

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3 TEST RESULT CERTIFICATE

Manufacturer :	Comotech Corporation 908-6, UKIC, 812-1, Hyomun-Dong Buk-Gu, Ulsan-City South Korea 683-360	Tested By:	MiCOM Labs, Inc. 575 Boulder Court Pleasanton California, 94566, USA
EUT:	Point to Point Radio Link for network backhaul	Telephone:	+1 925 462 0304
Model:	Unknown	Fax:	+1 925 462 0306
S/N:	BGWVBW10430022		
Test Date(s):	22nd July - 19th August 2015	Website:	www.micomlabs.com

STANDARD(S)	TEST RESULTS
FCC CFR 47 Part 101	EQUIPMENT COMPLIES

MiCOM Labs, Inc. tested the equipment mentioned in accordance with the requirements set forth in the above standards. Test results indicate that the equipment tested is capable of demonstrating compliance with the requirements as documented within this report.

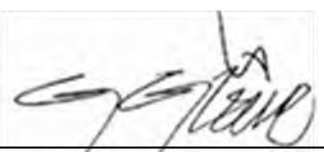
Notes:

1. This document reports conditions under which testing was conducted and the results of testing performed.
2. Details of test methods used have been recorded and kept on file by the laboratory.
3. Test results apply only to the item(s) tested.

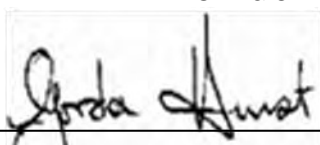
Approved & Released for MiCOM Labs, Inc. by:



TESTING CERT # 2381.01



Graeme Grieve
Quality Manager MiCOM Labs,



Gordon Hurst
President & CEO MiCOM Labs, Inc.

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4 REFERENCES AND MEASUREMENT UNCERTAINTY

4.1 Normative References

REF.	PUBLICATION	YEAR	TITLE
(i)	FCC 47 CFR Part 101	2015	Code of Federal Regulations
(iii)	ANSI C63.4	2009	American National Standards for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
(iv)	CISPR 22/ EN 55022	2008 / 2010	Limits and Methods of Measurements of Radio Disturbance Characteristics of Information Technology Equipment
(v)	M 3003	Nov. 2012 Edition 3	Expression of Uncertainty and Confidence in Measurements
(vi)	LAB34	Edition 1 Aug 2002	The expression of uncertainty in EMC Testing
(vii)	ETSI TR 100 028	2001-12	Parts 1 and 2 Electromagnetic compatibility and Radio Spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics
(viii)	A2LA	June 2015	Reference to A2LA Accreditation Status – A2LA Advertising Policy

4.2 Test and Uncertainty Procedures

Conducted and radiated emission measurements were conducted in accordance with American National Standards Institute ANSI C63.4, listed in the Normative References section of this report.

Measurement uncertainty figures are calculated in accordance with ETSI TR 100 028 Parts 1 and 2.

Measurement uncertainties stated are based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95 % in accordance with UKAS document M 3003 listed in the Normative References section of this report.



5 TEST SUMMARY

List of Measurements

The following table represents the list of measurements required under the FCC CFR47 Part 101.

Section(s)	Test Items	Description	Condition	Result	Test Report Section
101.113	Transmitter Output Power		Conducted	Complies	7.1.1
101.109 101.111	Spectral Mask + 99% Bandwidth	Occupied Bandwidth	Conducted	Complies	7.1.2
101.107	Frequency Tolerance + Voltage Variation	Frequency measurement Variation of supply voltage	Conducted	Complies	7.1.3
1.1310	Maximum Permissible Exposure	MPE for fixed location transmitters	Calculation	Not Performed	7.1.4
101.111	Spurious Emissions	Conducted Spurious Emissions 1 - 110 GHz	Conducted	Complies	7.1.5
15.205 / 15.209	Digital Emissions	Radiated digital emissions (0.03 - 6 GHz)	Radiated	Complies Class B limits	7.1.6

Note 1: Test results reported in this document relate only to the items tested

Note 2: The required tests demonstrated compliance as per client declaration of test configuration, monitoring methodology and associated pass/fail criteria

6 PRODUCT DETAILS AND TEST CONFIGURATIONS

6.1 Technical Details

Details	Description
Purpose:	Test of the Comotech Corporation - Airlight Point to Point Radio Link for network backhaul to FCC Part 101
Applicant:	As Manufacturer
Manufacturer:	Comotech Corporation 908-6, UKIC, 812-1, Hyomun-Dong Buk-Gu, Ulsan-City South Korea 683-360
Laboratory performing the tests:	MiCOM Labs, Inc. 575 Boulder Court Pleasanton, California 94566 USA
Test report reference number:	COMO01-U2 Rev B
Date EUT received:	22nd June 2015
Standard(s) applied:	FCC CFR 47 Part 101
Dates of test (from - to):	22nd July - 19th August 2015
No of Units Tested:	1
Serial Number(s):	S1011506002
Type of Equipment:	Point to Point Radio Link for network backhaul
Manufacturers Trade Name:	Comotech Corporation
Model:	Airlight
Location for use:	Outdoor use only
Declared Frequency Range(s):	71 – 76 GHz and 81 – 86 GHz
Type of Modulation:	QPSK, 16QAM, 64QAM, ACM
Declared Nominal Average Output Power:	+14 dBm
EUT Modes of Operation:	10/100/1000 MBit/s
Transmit/Receive Operation:	Full Duplex
T/R Spacing:	10 GHz
Rated Input Voltage and Current:	Nominal: -48 Vdc, 2.5 Amps Minimum: -42.5 Vdc Maximum: -57 Vdc
Operating Temperature Range:	Declared range -40° to +60°C
ITU Emission Designator:	250M0G7W
Equipment Dimensions:	Radio: 230x230x90(mm) + Antenna 2' : 620x620x490(mm) Antenna 1' : 340x340x220(mm)
Weight:	10.5kg (with 2ft antenna), 6.0kg (with 1ft antenna)
Primary function of equipment:	Point to Point Radio Link for network backhaul

6.2 Scope of Test Program

The scope of the test program was to test Comotech Corporation - Airlight Point to Point Radio Link for network backhaul in the frequency ranges 71 – 76 GHz and 81 – 86 GHz for compliance against FCC 47 CFR Part 101 subpart Q.

The Comotech Corporation - Airlight has an integral antenna which was not tested as part the radiated test program. The Comotech Corporation - Airlight has a 10.0 GHz duplex spacing.

Only the low transmit band (QPSK) was tested within this program (71 – 76 GHz).

§101.1507 FCC Permissible operations.

Licensees may use the 70 GHz, 80 GHz and 90 GHz bands for any point-to-point, non-broadcast service. The segments may be unpaired or paired, but pairing will be permitted only in a standardized manner (e.g., 71-72.25 GHz may be paired only with 81-82.25 GHz, and so on). The segments may be aggregated without limit.

6.3 Frequency Allocation

Frequency Band (GHz)	Emissions Bandwidth (MHz)	Band Designator	Note
Tx 71-76	250.0	E Band	Note 17
Rcr 81-86	250.0	E Band	Note 17

⁽¹⁷⁾ FCC Part 101.147 Frequencies in these bands are shared with Government fixed stations and stations in the Private Operational Fixed Point-to-Point Microwave Service.

6.4 Equipment Model(s) and Serial Number(s)

Type (EUT/Support)	Equipment Description (Including Brand Name)	Mfr	Model No.	Serial No.
EUT	Point to Point Radio Link for network backhaul	Comotech Corporation	Airlight	S1011506002
Support	Laptop PC	HP	--	None



6.5 Antenna Details

Antennas were not tested as part of the test program. Antenna details are provided for MPE (Maximum Permissible Exposure) calculations and information purposes.

Manufacturer	Antenna Type	Model Number	Frequency Band	Gain (dBi)
Cassegrain	1' Parabolic	Unknown	71-86 GHz	45.0
Cassegrain	2' Parabolic	Unknown	71-86 GHz	51.0

6.6 Cabling and I/O Ports

Type of I/O Ports	Description	Shielded (Y/N)	Length	Qty	Tested (Y/N)
Ethernet	Tributary & Management 10/100/1000 Base T with POE	N	> 100 meters	1	Y
dc	Vdc Input	N	> 3 meters	1	Y
RSSI Out	BNC-f	Y	Unknown	1	N
RF Tx/Rcr	Circular Waveguide	N/A	N/A	1	Y

6.7 Test Configurations

Number of available operational channels: 12

- 1).. 72.125/82.125
- 2).. 72.375/82.375
- 3).. 72.625/82.625
- 4).. 72.875/82.875
- 5).. 73.125/83.125
- 6).. 73.375/83.375
- 7).. 73.625/83.625
- 8).. 73.875/83.875
- 9).. 74.125/84.125
- 10).. 74.375/84.375
- 11).. 74.625/84.625
- 12).. 74.875/84.875

Tested Channels low 72.125, mid 73.375, high 74.875 GHz

NOTE:

EUT (Low band Channel #1 above) transmits: 72.125 GHz and receives 82.125 GHz
High Band Transmit: 82.125 GHz and receives on 72.125 GHz



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6.8 Equipment Modifications

The following modifications were required to bring the equipment into compliance:

1. NONE

6.9 Deviations from the Test Standard

The following deviations from the test standard were required in order to complete the test program:

1. NONE

7 TEST RESULTS

7.1 Device Characteristics

7.1.1 Occupied Bandwidth

FCC 47 CFR Part 101 Subpart 101.109

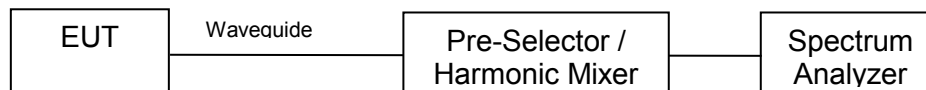
Test Procedure

The transmitter output was connected to a spectrum analyzer and the Occupied Bandwidth was measured with a modulated carrier.

Occupied Bandwidth was measured under ambient conditions, nominal voltage for all modulations and rule parts on low, mid and high channels. The spectrum analyzer was set for a 2 MHz RBW and 3 MHz VBW which was based on the bandwidth of the output spectrum.

To position the mask relative to the output spectrum the EUT was initially set to transmit a CW (single) tone at the frequency of interest. The mask was then lined up with the peak of the CW tone. The EUT then was then set to modulate each modulation of interest and measurements reported.

Emissions above 40 GHz Test Configuration



Emission measurement configuration(s)

Laboratory Measurement Uncertainty for Power Measurements

Measurement uncertainty	±1.33 dB
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Traceability

Method	Test Equipment Used
Measurements were made per work instruction WI-03 'Measurement of RF Spectrum Mask'	088, 095, 0158, 0227, 0252, 0293, 0304



Occupied Bandwidth Limits FCC Part §101.109

(a) Each authorization issued pursuant to these rules will show, as the emission designator, a symbol representing the class of emission which must be prefixed by a number specifying the necessary bandwidth. This figure does not necessarily indicate the bandwidth actually occupied by the emission at any instant. In those cases where part 2 of this chapter does not provide a formula for the computation of the necessary bandwidth, the occupied bandwidth may be used in the emission designator.

(b) Stations in this service will be authorized any type of emission, method of modulation, and transmission characteristic, consistent with efficient use of the spectrum and good engineering practice, except that Type B, damped-wave emission will not be authorized.

(c) The maximum bandwidth which will be authorized per frequency assigned is set out in the table that follows. Regardless of the maximum authorized bandwidth specified for each frequency band, the Commission reserves the right to issue a license for less than the maximum bandwidth if it appears that a lesser bandwidth would be sufficient to support an applicant's intended communications.

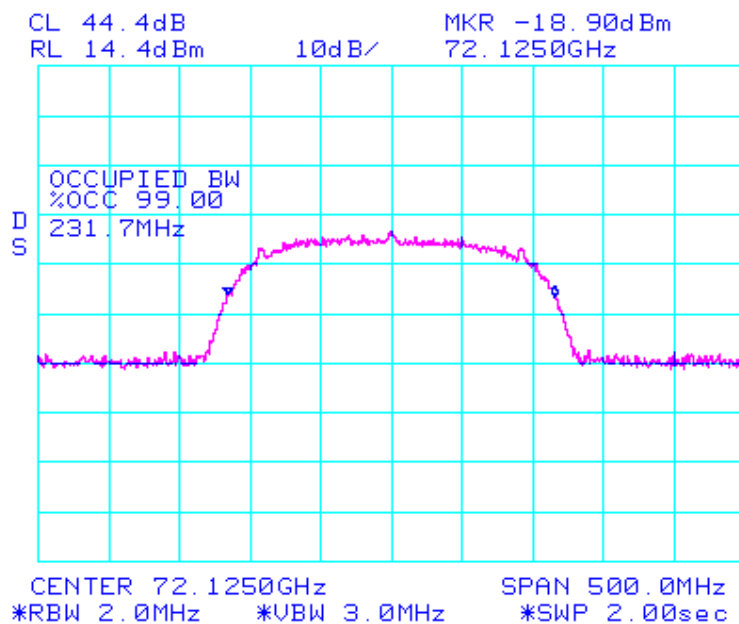
Occupied Bandwidth Limit 71 – 76 GHz, 81 – 86 GHz bands
Limit = 5000 MHz

Channel Frequency (GHz)	Voltage (Vdc)	Temperature (°C)	99% Occupied Bandwidth (MHz)	Limit (MHz)	Margin (MHz)
72.125	48.0	20	231.7	5000	-4768.30
73.375	48.0	20	241.7	5000	-4758.30
74.875	48.0	20	230.8	5000	-4769.20

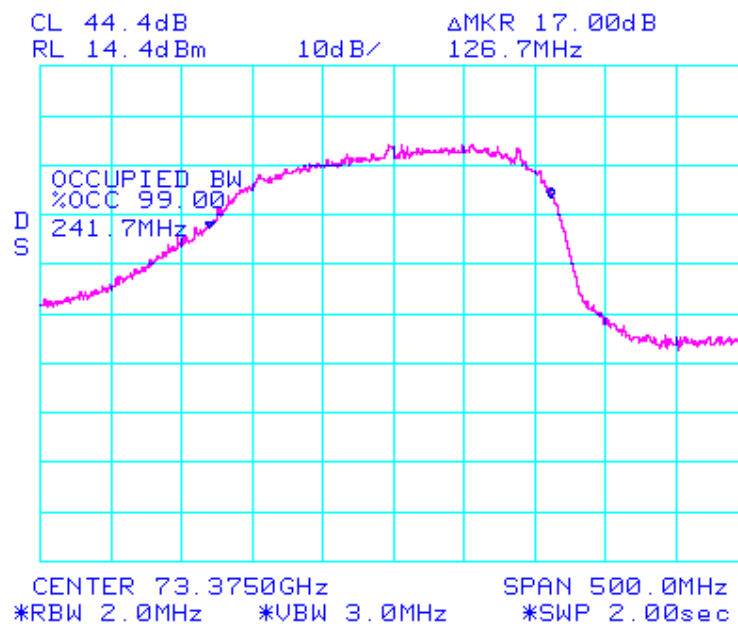
Ambient conditions.

Temperature: **17 to 23 °C** Relative humidity: **31 to 57 %** Pressure: **999 to 1012 mbar**

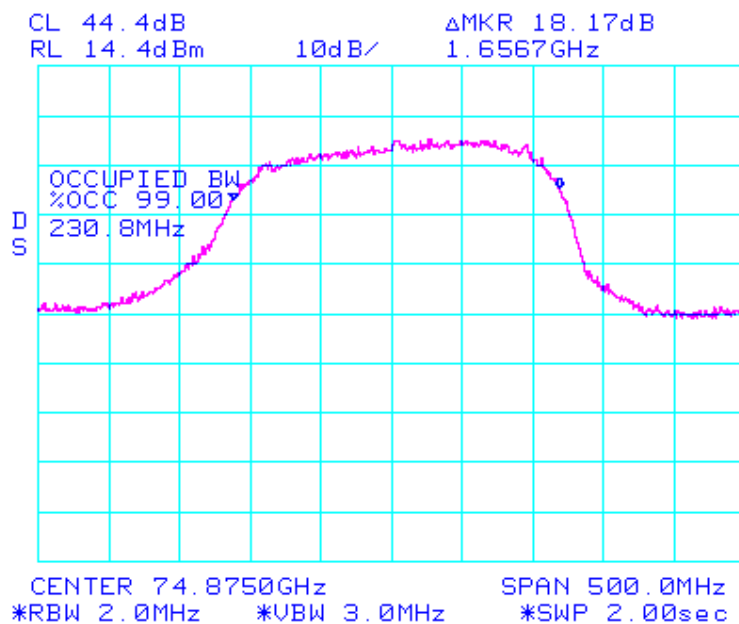
CHANNEL FREQUENCY 72.125 GHz



CHANNEL FREQUENCY 73.375 GHz



CHANNEL FREQUENCY 74.875 GHz



7.1.2 Transmitter Output Power

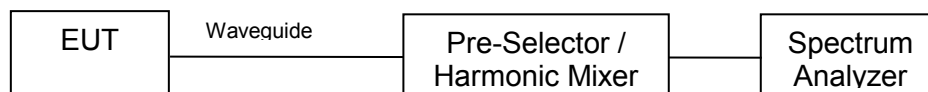
FCC 47 CFR Part 101 Subpart 101.113

Test Procedure

The transmitter output was connected to spectrum analyzer and the Output Power was calculated on a modulated carrier.

Output Power was measured under ambient conditions, nominal voltage for the applicable frequency channels.

Emissions above 40 GHz Test Configuration



Emission measurement configuration(s)

Ambient conditions.

Temperature: **17 to 23 °C** Relative humidity: **31 to 57 %** Pressure: **999 to 1012 mbar**

Power Limits

- (a) On any authorized frequency, the average power delivered to an antenna in this service must be the minimum amount of power necessary to carry out the communications desired. Application of this principle includes, but is not to be limited to, requiring a licensee who replaces one or more of its antennas with larger antennas to reduce its antenna input power by an amount appropriate to compensate for the increased primary lobe gain of the replacement antenna(s). In no event shall the average equivalent isotropically radiated power (EIRP), as referenced to an isotropic radiator, exceed the values specified below. In cases of harmful interference, the Commission may, after notice and opportunity for hearing, order a change in the effective radiated power of this station. Further, the output power of a transmitter on any authorized frequency in this service may not exceed the following:

71 – 76 and 81 – 86 GHz = +55 dBW/EIRP



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Laboratory Measurement Uncertainty for Power Measurement

Measurement uncertainty	± 1.33 dB
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Traceability

Method	Test Equipment Used
Measurements were made per work instruction WI-03 'Measurement of RF Output Power'	088, 095, 0158, 0227, 0252, 0293, 0304

Measurement Results

45 dBi Antenna

Part 101.113	Maximum Conducted Output Power (dBm)	EIRP dBm (1' 45 dBi Antenna)	EIRP dBW (1' 45 dBi Antenna)
Center Frequency (GHz)	Ambient, 48Vdc		
72.125	-4.17	+40.83	10.8
73.375	+9.6	+54.6	24.6
74.875	+9.2	+54.2	24.2

51 dBi Antenna

Part 101.113	Maximum Conducted Output Power (dBm)	EIRP dBm (1' 51 dBi Antenna)	EIRP dBW (1' 51 dBi Antenna)
Center Frequency (GHz)	Ambient, 48Vdc		
72.125	-4.17	+46.8	16.8
73.375	+9.6	+60.6	30.6
74.875	+9.2	+60.2	30.2

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7.1.3 Emission Mask

FCC 47 CFR Part 101 Subpart 101.111

Test Procedure

The transmitter output was connected to a spectrum analyzer and the Occupied Bandwidth was measured with a modulated carrier.

Spectrum mask was measured under ambient conditions, nominal voltage for all modulations on the low, mid and high frequency channels of operation. The spectrum analyzer was set for a 1 MHz RBW and 3 MHz VBW which was based on spectrum bandwidth.

To position the mask relative to the output spectrum the EUT was initially set to transmit a CW (single) tone at the frequency of interest. The mask was then lined up with the peak of the CW tone. The EUT then was then set to modulate each modulation of interest and measurements reported.

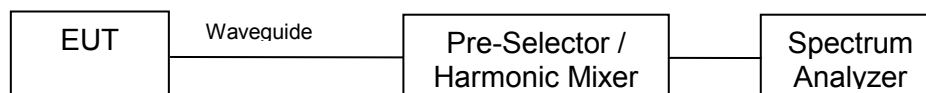
Emission Mask Limits

(ii) For operating frequencies above 15 GHz, in any 1 MHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 250 percent of the authorized bandwidth: As specified by the following equation but in no event less than 11 decibels:

$A = 11 + 0.4(P-50) + 10 \log_{10} B$. (Attenuation greater than 56 decibels or to an absolute power of less than -13 dBm/1MHz is not required.)

(iii) In any 1 MHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least $43 + 10 \log_{10}$ (the mean output power in watts) decibels, or 80 decibels, whichever is the lesser attenuation. The authorized bandwidth includes the nominal radio frequency bandwidth of an individual transmitter/modulator in block-assigned bands. Equipment licensed prior to April 1, 2005 shall only be required to meet this standard in any 4 kHz band.

Emissions above 40 GHz Test Configuration



Emission measurement configuration(s)



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Laboratory Measurement Uncertainty for Power Measurements

Measurement uncertainty	± 1.33 dB
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Traceability

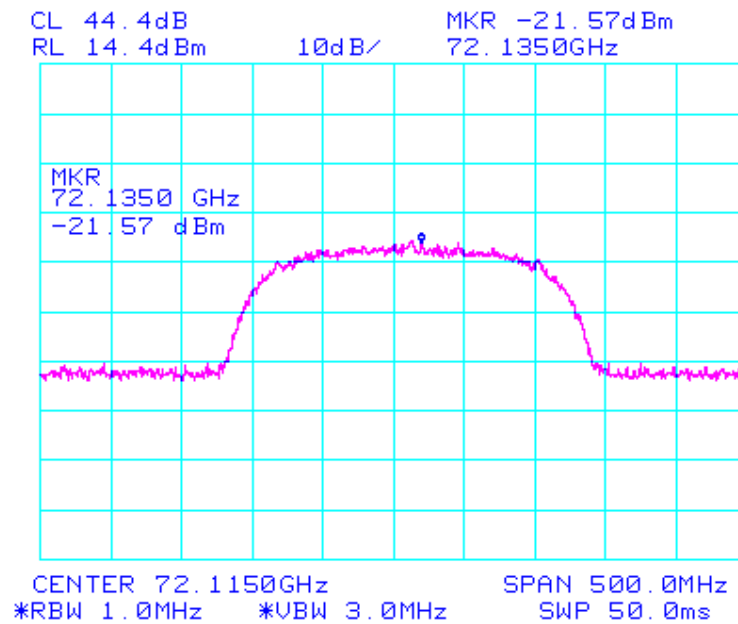
Method	Test Equipment Used
Measurements were made per work instruction WI-03 'Measurement of RF Spectrum Mask'	088, 095, 0158, 0227, 0252, 0293, 0304

Ambient conditions.

Temperature: **17 to 23 °C** Relative humidity: **31 to 57 %** Pressure: **999 to 1012 mbar**

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CHANNEL FREQUENCY 72.125 GHz



Emission Bandwidth (B) = 231.7 MHz

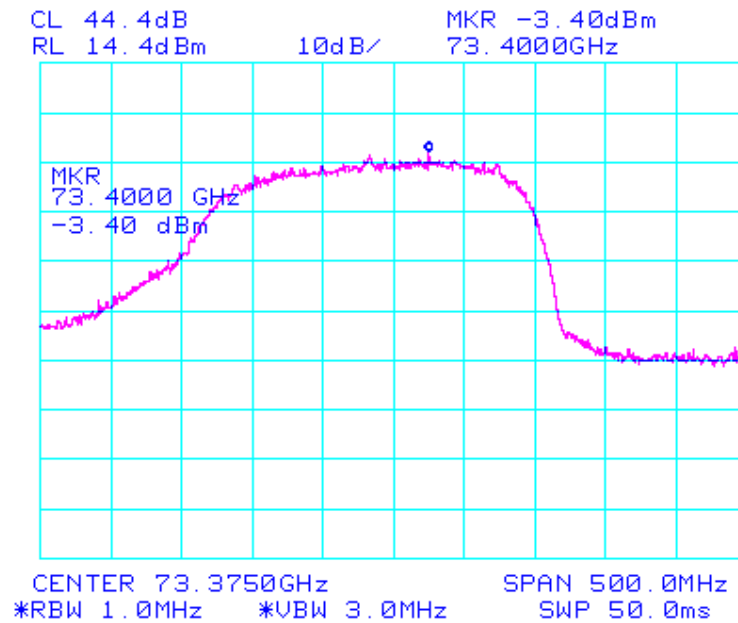
Limit at 50% Bandwidth = Power – Attenuation = -4.17 dBm – 34.6 dB attenuation = -38.77 dBm

Limit cannot be less than -13 dBm at 50% Bandwidth (115.85 MHz) = -13 dBm

Limit > 50% bandwidth = -13 dBm

Equipment complies with the emission mask criteria

CHANNEL FREQUENCY 73.375 GHz



Emission Bandwidth (B) = 241.7 MHz

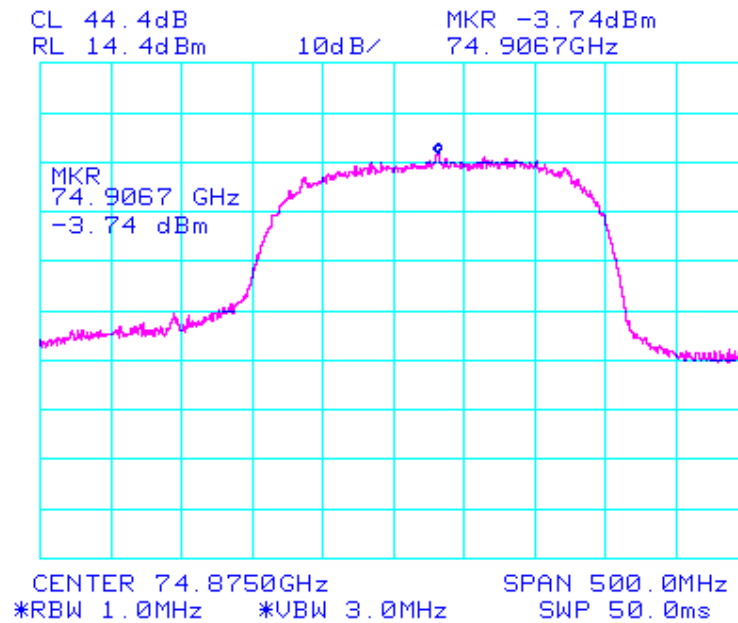
Limit at 50% Bandwidth = Power – Attenuation = +13.6 dBm – 34.8 dB attenuation = -21.2 dBm

Limit cannot be less than -13 dBm at 50% Bandwidth (120.85 MHz) = -13 dBm

Limit > 50% bandwidth = -13 dBm

Equipment complies with the emission mask criteria

CHANNEL FREQUENCY 74.875 GHz



Emission Bandwidth (B) = 230.8 MHz

Limit at 50% Bandwidth = Power – Attenuation = +13.2 dBm – 34.6 dB attenuation = -21.4 dBm

Limit cannot be less than -13 dBm at 50% Bandwidth (120.85 MHz) = -13 dBm

Limit > 50% bandwidth = -13 dBm

Equipment complies with the emission mask criteria

7.1.4 Frequency Stability

FCC 47 CFR Sections 101.107

Test Procedure

The EUT was placed inside an environmental chamber. The transmitter output was connected to a spectrum analyzer via a pre-selector mixer and the frequency stability was measured using a modulated carrier. A thermocouple was used to monitor chamber temperature. The EUT was attached to a variable power supply providing the primary supply voltage.

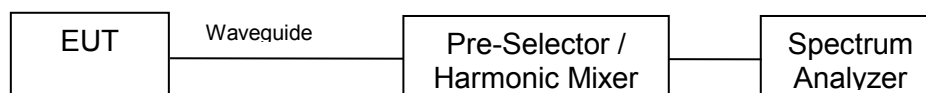
Frequency stability was measured through the extremes of temperature and voltage on the mid channel. Before measurements were taken at each temperature the equipment waited until thermal balance was obtained.

The delta marker method was used to measure frequency stability. A marker was placed on the rising edge of the occupied bandwidth at 10 dB below the peak of the spectrum. A delta marker was placed on the falling edge of the occupied bandwidth and the center frequency f_c calculated by using the following equation;

$$f_c = \text{Marker 1} + (\frac{1}{2} * \text{Delta Marker})$$

At +20°C the primary voltage was varied $\pm 10\%$ and measurements were taken at each voltage level.

Emissions above 40 GHz Test Configuration



Emission measurement configuration(s)



Limits

§ 101.107 Frequency tolerance.

(a) The carrier frequency of each transmitter authorized in these services must be maintained within the following percentage of the reference frequency except as otherwise provided in paragraph (b) of this section or in the applicable subpart of this part (unless otherwise specified in the instrument of station authorization the reference frequency will be deemed to be the assigned frequency):

Frequency Tolerance Limits

For the frequency bands 71 – 76 and 81 – 86 GHz no frequency tolerance is specified.

Laboratory Uncertainty for Frequency Measurements

Measurement uncertainty (dB)	±0.86ppm
------------------------------	----------

Traceability

Method	Test Equipment Used
Measurements were made per work instruction WI-02 'Frequency Measurement'	074, 088, 095, 0158, 0227, 0252, 0293, 0304

Center Frequency = 73.375 GHz

Temperature (°C)	Voltage (Vdc)	Marker 1	Delta Marker 1	Calculated Center Frequency (GHz)	% error
-40	48.0	73.2887	0.2018	73.3896	-0.0199
-30	48.0	73.2735	0.2158	73.3814	-0.0087
-20	48.0	73.2805	0.21	73.3855	-0.0143
-10	48.0	73.2758	0.0213	73.2864	0.1207
0	48.0	73.2712	0.2205	73.3815	-0.0088
10	48.0	73.2648	0.224	73.3768	-0.0025
20	48.0	73.2706	0.2193	73.3803	-0.0072
20	43.2	73.2729	0.2129	73.3794	-0.0059
20	52.8	73.2776	0.2059	73.3806	-0.0076
30	48.0	73.2729	0.2141	73.3800	-0.0067
40	48.0	73.2688	0.2217	73.3797	-0.0063
50	48.0	73.2776	0.2067	73.3810	-0.0081
60	48.0	73.2755	0.2115	73.3813	-0.0085

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7.1.5 Conducted Spurious Emissions

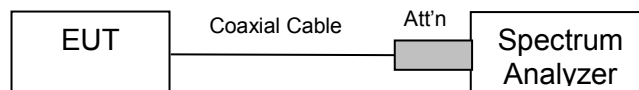
FCC, Part 101 Subpart 101.111 Emission Limitations

Test Procedure

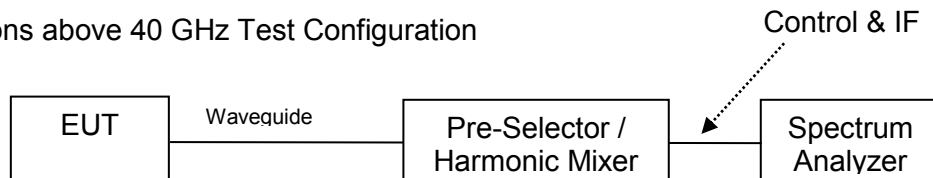
Conducted emissions were measured at a limit of -13 dBm/MHz. Emissions below 40 GHz were measured through direct connection to the spectrum analyzer. Emissions above 40 GHz were measured using a pre-selector or harmonic mixer. A 1 MHz resolution bandwidth was used to complete all measurements.

Test Measurement Set up

Emissions below 40 GHz Test Configuration



Emissions above 40 GHz Test Configuration



Conducted Spurious Emissions measurement configuration(s)

Measurement Results of Conducted Spurious Emissions

Ambient conditions.

Temperature: 17 to 23°C Relative humidity: 31 to 57% Pressure: 999 to 1012 mbar

Radio Parameters

Duty Cycle: 100%

Output: Modulated Carrier (QPSK)

Power: Maximum



7.1.5.1 Conducted Spurious Emissions 1 – 40 GHz

Due to the waveguide cut-off frequency spurious emissions below 40 GHz were not performed, see equation below;

Lowest cut-off frequency for circular waveguide 1.549 mm radius;

$$F_{\text{cut-off}} = (1.8412 \times c) / (2 \times \pi \times r)$$

c = speed of light (3×10^8 m/s)

r = radius of circular cross section of waveguide

$$F_c = \underline{56.7 \text{ GHz}}$$

The initial test start frequency is 40 GHz.

Frequency scans were performed with a maximum step size of 10 GHz. In some cases these plots have been replaced with a wider span. The original plots are kept on file by the laboratory.

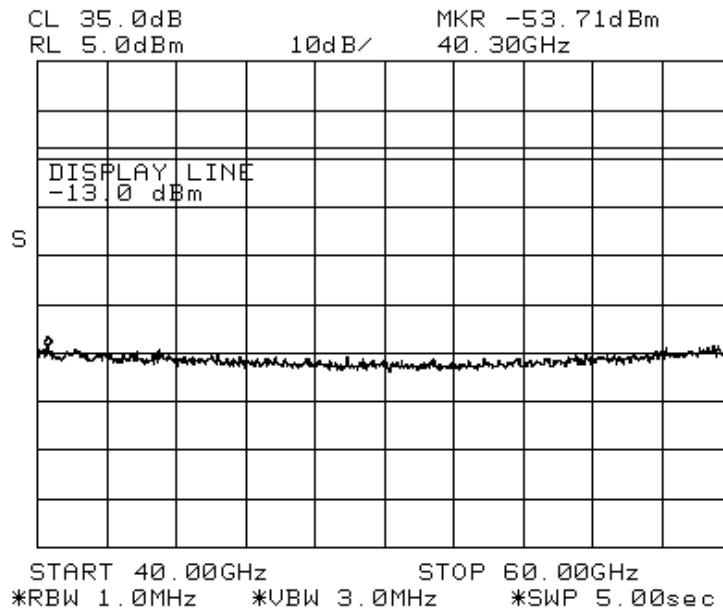


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7.1.5.2 Conducted Spurious Emissions (Low Channel)

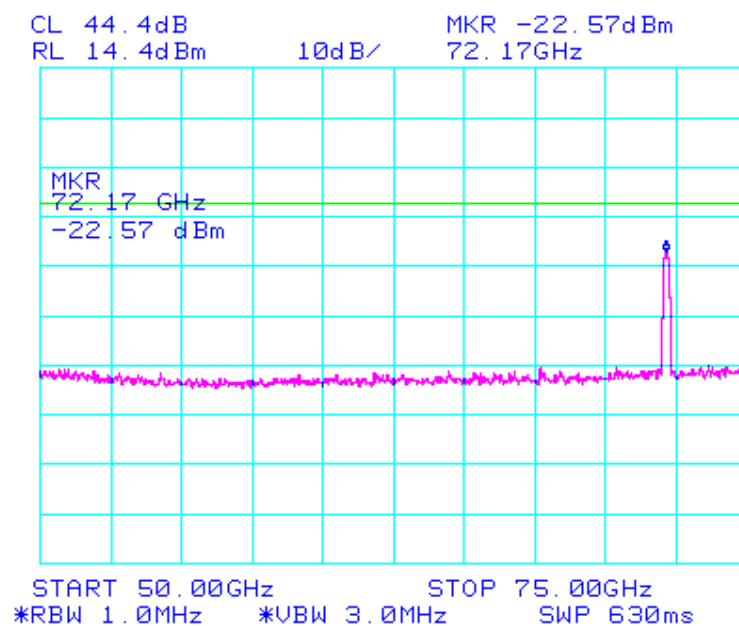
Pre-selector Mixer

Conducted Spurious Emissions 40 - 50 GHz Channel 72.125 GHz



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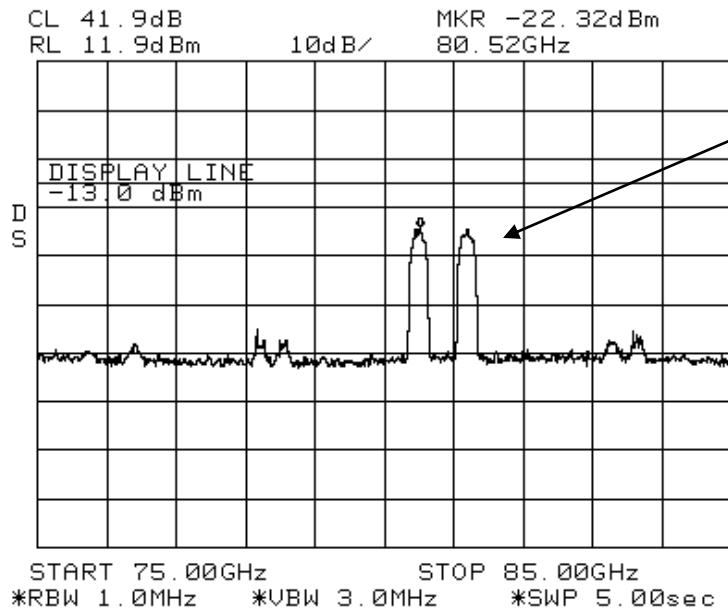
Pre-selector Mixer



The emission close to the limit line is the fundamental frequency

Harmonic Mixer

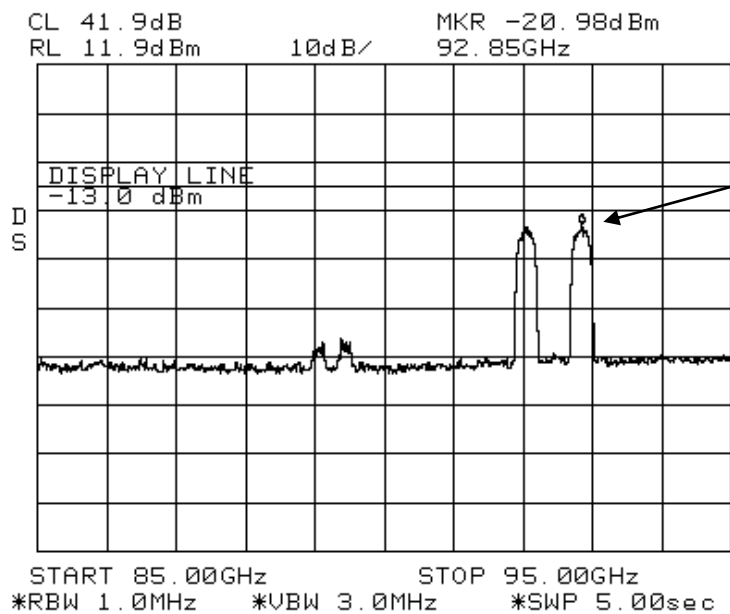
Conducted Spurious Emissions 75 - 85 GHz Channel 72.125 GHz



GHOST IMAGE DUE
 TO HARMONIC
 MIXER LIMITATIONS

Harmonic Mixer

Conducted Spurious Emissions 85 - 95 GHz Channel 72.125 GHz



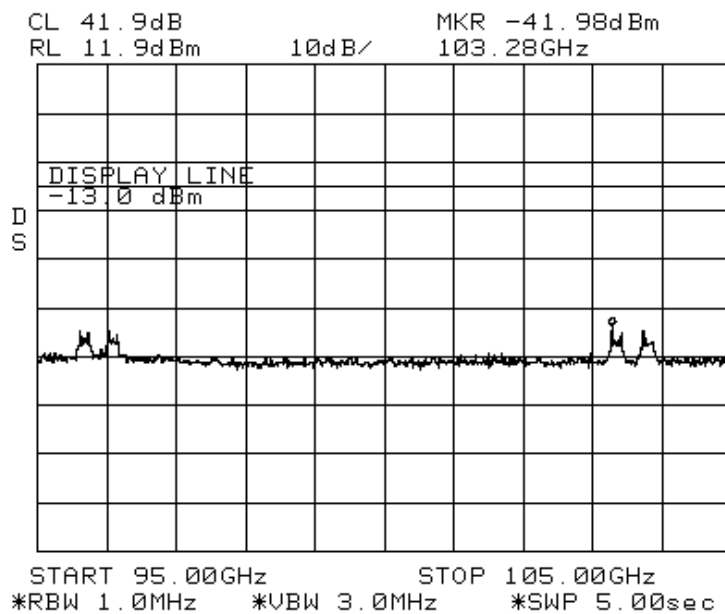
GHOST IMAGE DUE
TO HARMONIC
MIXER LIMITATIONS



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Harmonic Mixer

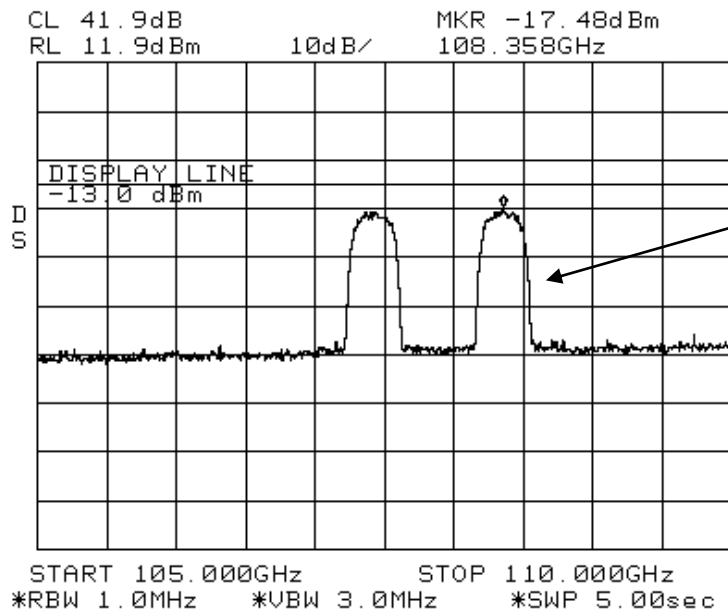
Conducted Spurious Emissions 95 - 105 GHz Channel 72.125 GHz



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Harmonic Mixer

Conducted Spurious Emissions 105 - 110 GHz Channel 72.125 GHz



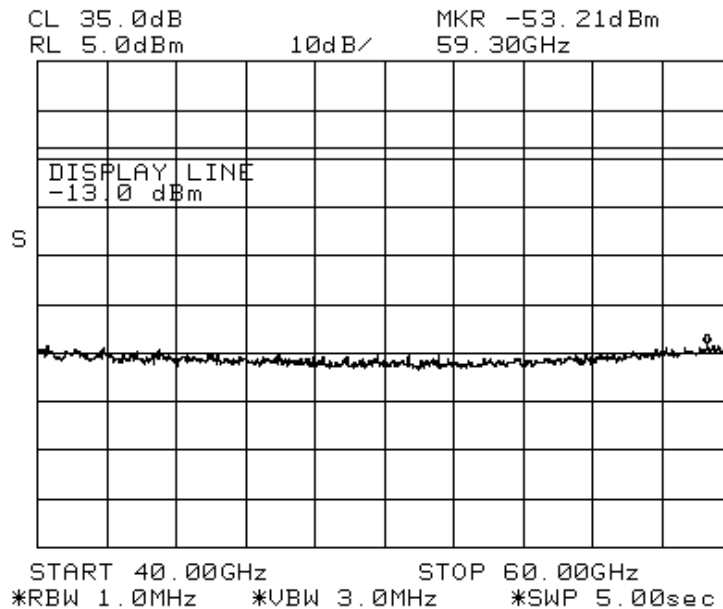
GHOST IMAGE DUE
 TO HARMONIC
 MIXER LIMITATIONS



7.1.5.3 Conducted Spurious Emissions (Mid Channel)

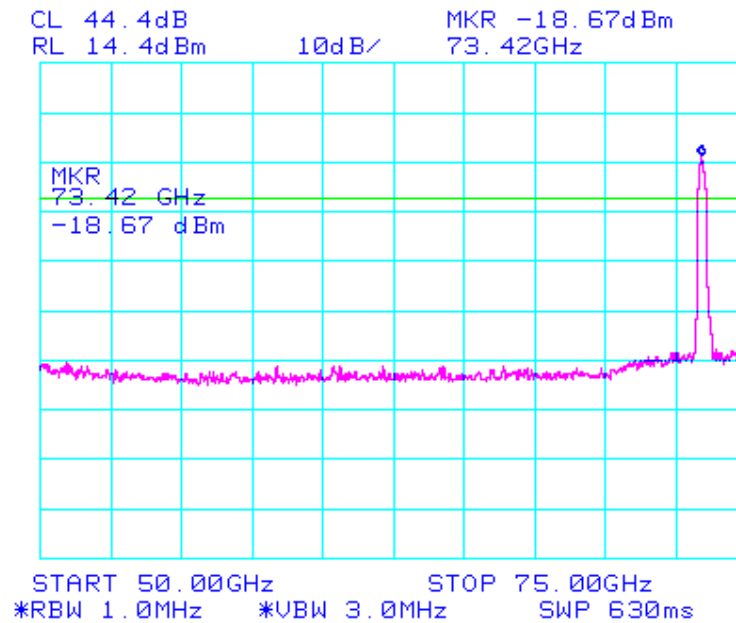
Pre-selector Mixer

Conducted Spurious Emissions 40 - 50 GHz Channel 73.375 GHz



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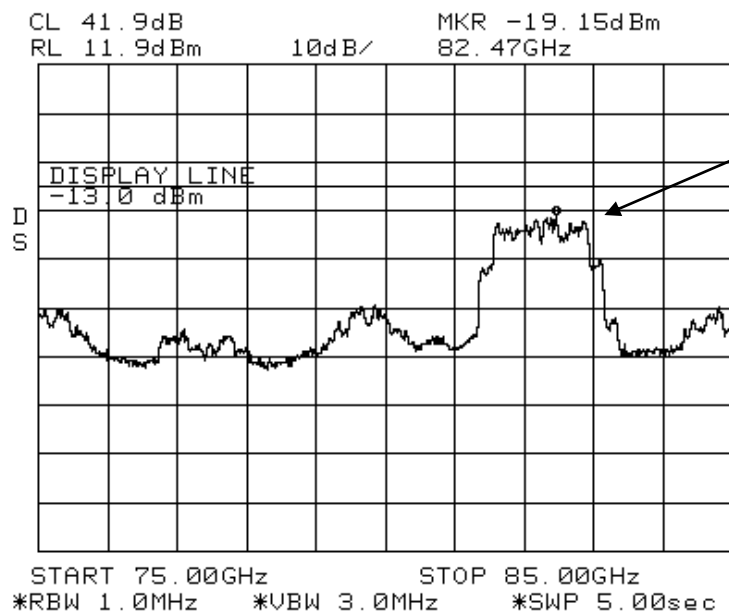
Pre-selector Mixer



The emission breaking the limit line is the fundamental frequency

Harmonic Mixer

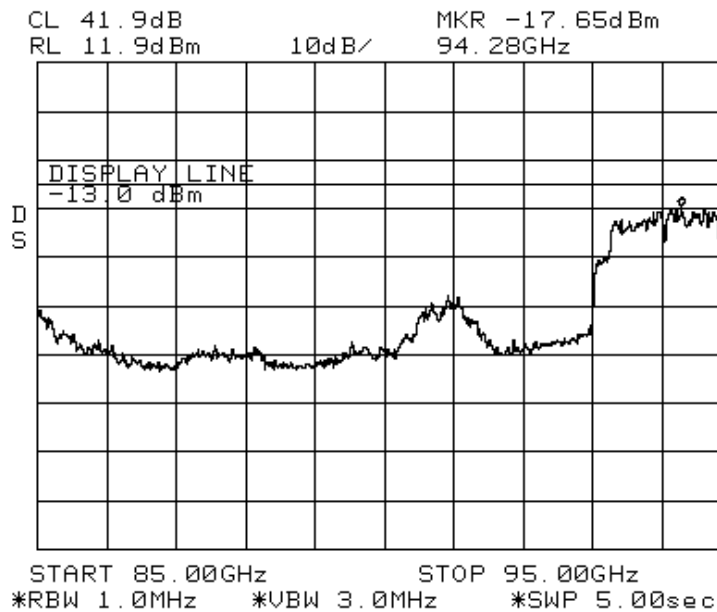
Conducted Spurious Emissions 75 - 85 GHz Channel 73.375 GHz



GHOST IMAGE DUE
 TO HARMONIC
 MIXER LIMITATIONS

Harmonic Mixer

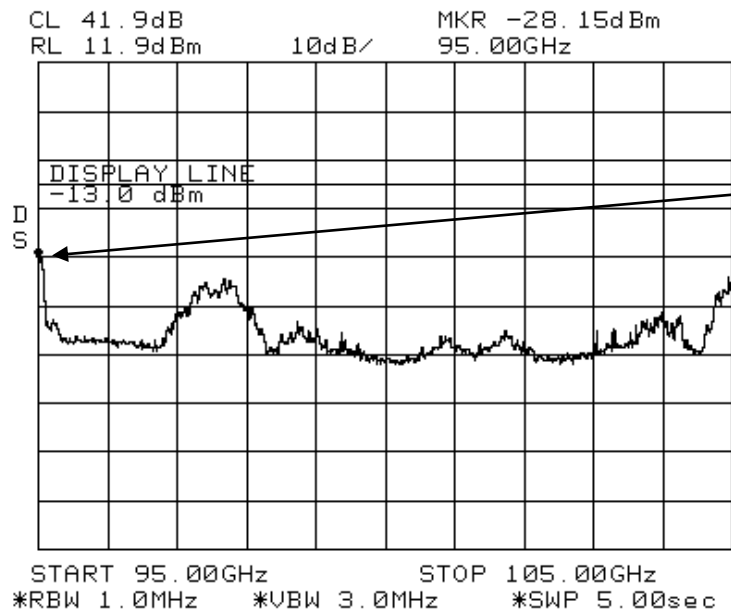
Conducted Spurious Emissions 85 - 95 GHz Channel 73.375 GHz



GHOST IMAGE DUE TO HARMONIC MIXER LIMITATIONS

Harmonic Mixer

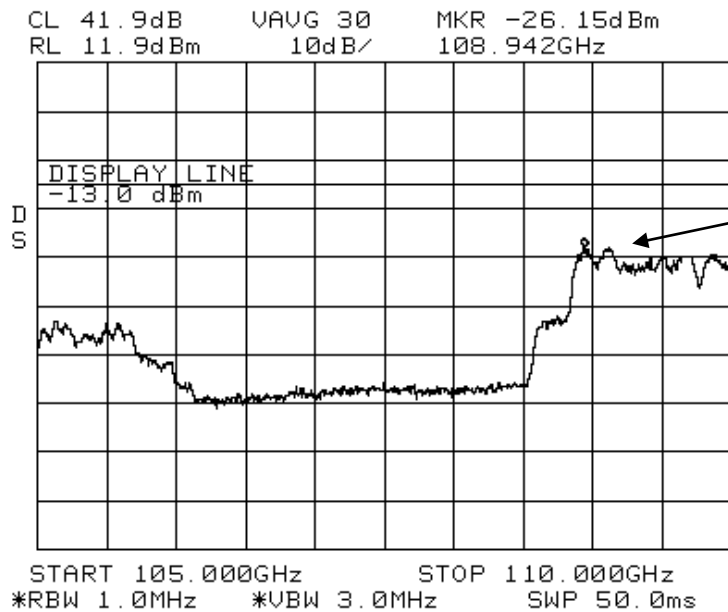
Conducted Spurious Emissions 95 - 105 GHz Channel 73.375 GHz



GHOST IMAGE DUE
TO HARMONIC
MIXER LIMITATIONS

Harmonic Mixer

Conducted Spurious Emissions 105 - 110 GHz Channel 73.375 GHz



GHOST IMAGE DUE
TO HARMONIC
MIXER LIMITATIONS

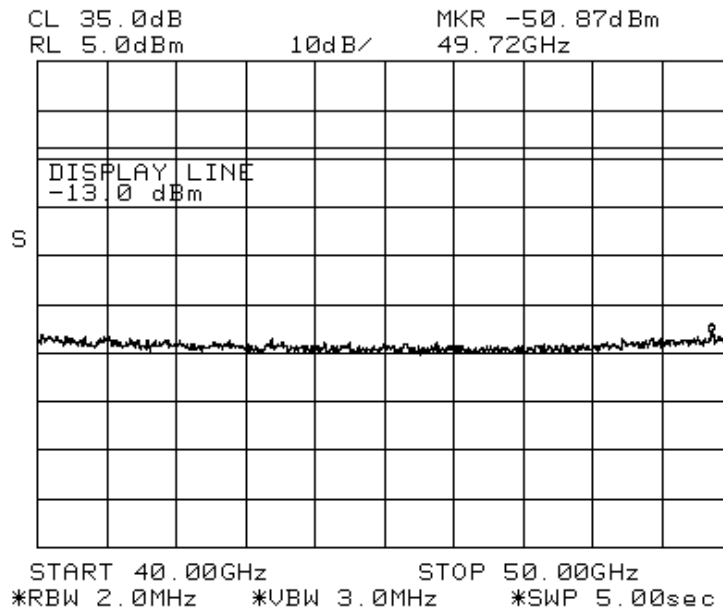


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7.1.5.4 Conducted Spurious Emissions (High Channel)

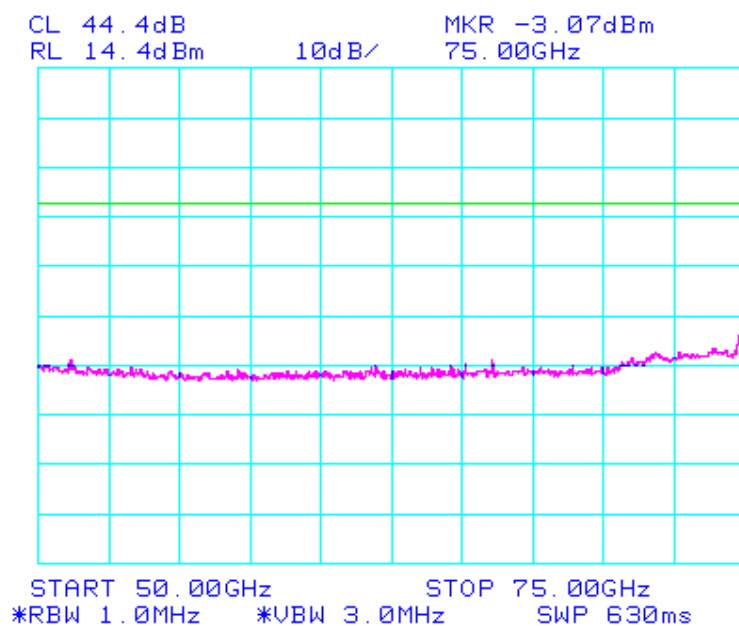
Pre-selector Mixer

Conducted Spurious Emissions 40 - 50 GHz Channel 74.875 GHz



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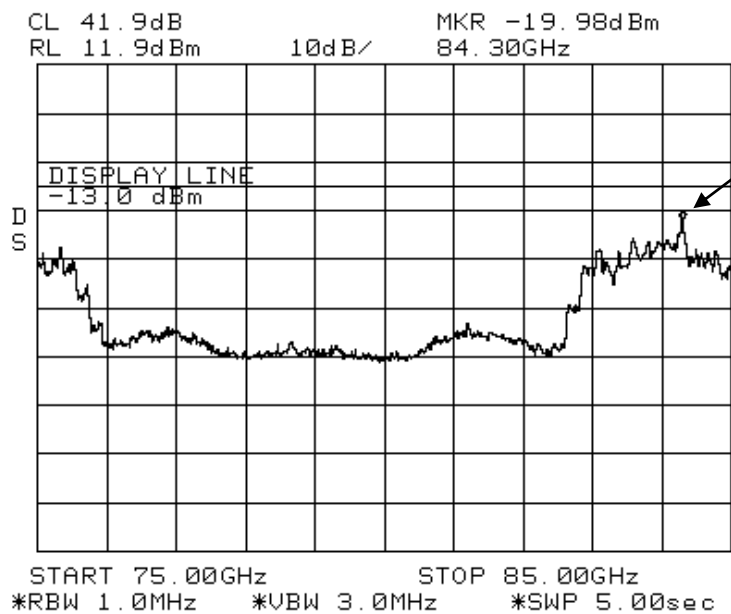
Pre-selector Mixer



The emission breaking the limit line is the fundamental frequency

Harmonic Mixer

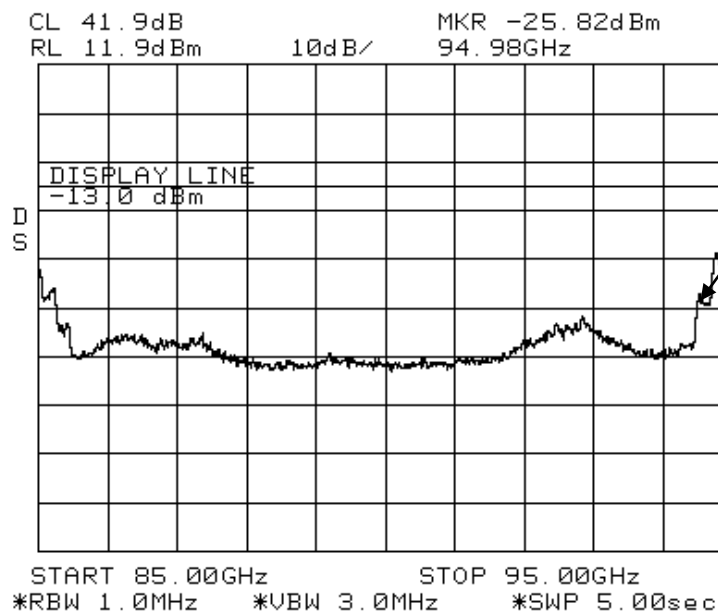
Conducted Spurious Emissions 75 - 85 GHz Channel 74.875 GHz



GHOST IMAGE DUE
TO HARMONIC
MIXER LIMITATIONS

Harmonic Mixer

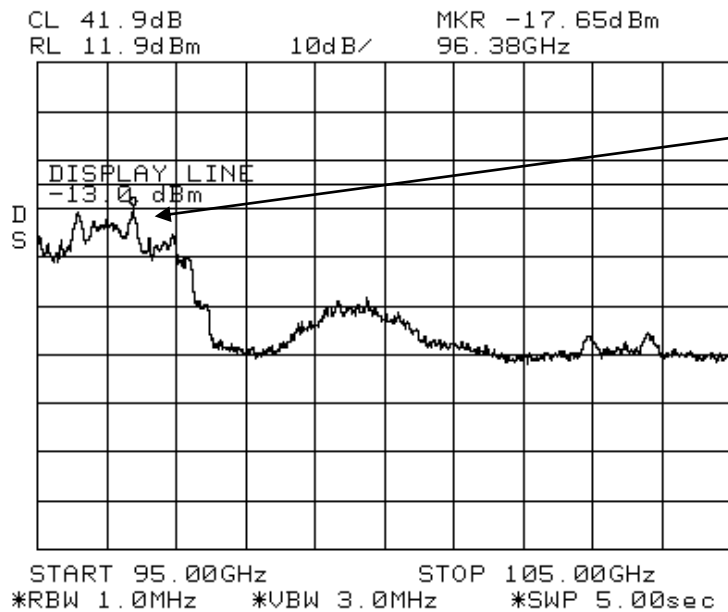
Conducted Spurious Emissions 85 - 95 GHz Channel 74.875 GHz



GHOST IMAGE DUE
 TO HARMONIC
 MIXER LIMITATIONS

Harmonic Mixer

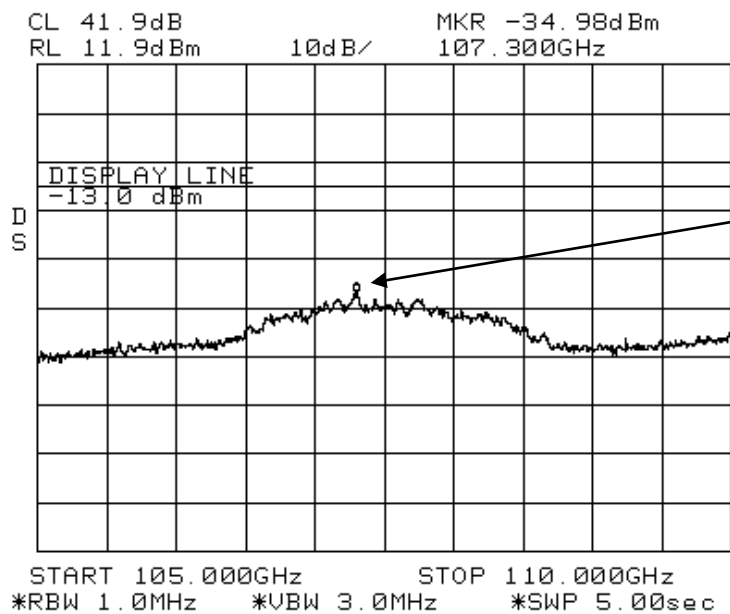
Conducted Spurious Emissions 95 - 105 GHz Channel 74.875 GHz



GHOST IMAGE DUE TO HARMONIC MIXER LIMITATIONS

Harmonic Mixer

Conducted Spurious Emissions 105 - 110 GHz Channel 74.875 GHz



GHOST IMAGE DUE
TO HARMONIC
MIXER LIMITATIONS



Specification

§101.111

(ii) For operating frequencies above 15 GHz, in any 1 MHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 250 percent of the authorized bandwidth: As specified by the following equation but in no event less than 11 decibels:

$$A = 11 + 0.4(P-50) + 10 \log_{10} B.$$

Where;

A = Attenuation (in decibels) below the mean output power level.

P = Percent removed from the center frequency of the transmitter bandwidth.

B = Authorized bandwidth in MHz.

(Attenuation greater than 56 decibels or to an absolute power of less than -13 dBm/1MHz is not required).

(iii) In any 1 MHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least $43 + 10 \log_{10}$ (the mean output power in watts) decibels, or 80 decibels, whichever is the lesser attenuation.

Laboratory Measurement Uncertainty for Conducted Spurious Emissions

Measurement uncertainty	± 2.37 dB
-------------------------	---------------

Traceability

Method	Test Equipment Used
Measurements were made per work instruction WI-05 'Measurement of Spurious Emissions'	074, 088, 095, 0128, 0158, 0227, 0252, 0293, 0304



7.1.6 Digital Emissions (0.03 – 6 GHz)

FCC, Part 15 Subpart C 15.205; 15.209

Test Procedure

Testing 0.03-6 GHz was performed in a 3-meter anechoic chamber using a CISPR compliant receiver. Preliminary radiated emissions were measured on every azimuth and with the receiving antenna in both horizontal and vertical polarizations. To further maximize emissions the receive antenna was varied between 1 and 4 meters. The emissions are recorded with the analyzer in peak hold mode. Emissions closest to the limit(s) are investigated in detail;

Emissions below 1 GHz are measured in the quasi-peak mode with the tuned receiver using a bandwidth of 120 kHz

Emissions above 1 GHz are measured with an average detector with the tuned receiver using a bandwidth of 1 MHz

Only the highest emissions relative to the limit are listed. The anechoic chamber test set-up is identified in Section 6 Test Set-Up Photographs.

The EUT had two methods of powering on ac/dc converter and Power over Ethernet (POE). Both modes were tested for emissions below 1GHz.

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Loss, and subtracting Amplifier Gain from the measured reading. In this test facility, the Antenna Factor, Cable Loss, and Amplifier Gains are loaded into the Rohde & Schwarz Receiver and the corrected field strength can be read directly on the receiver.

$$FS = R + AF + CORR$$

where:

FS = Field Strength

R = Measured Receiver Input Amplitude

AF = Antenna Factor

CORR = Correction Factor = CL – AG + NFL

CL = Cable Loss

AG = Amplifier Gain



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For example:

Given a Receiver input reading of 51.5dB μ V; Antenna Factor of 8.5dB; Cable Loss of 1.3dB; Falloff Factor of 0dB, an Amplifier Gain of 26dB and Notch Filter Loss of 1dB. The Field Strength of the measured emission is:

$$FS = 51.5 + 8.5 + 1.3 - 26.0 + 1 = 36.3\text{dB}\mu\text{V/m}$$

Conversion between dB μ V/m (or dB μ V) and μ V/m (or μ V) are done as:

$$\text{Level (dB}\mu\text{V/m)} = 20 * \text{Log (level (\mu V/m))}$$

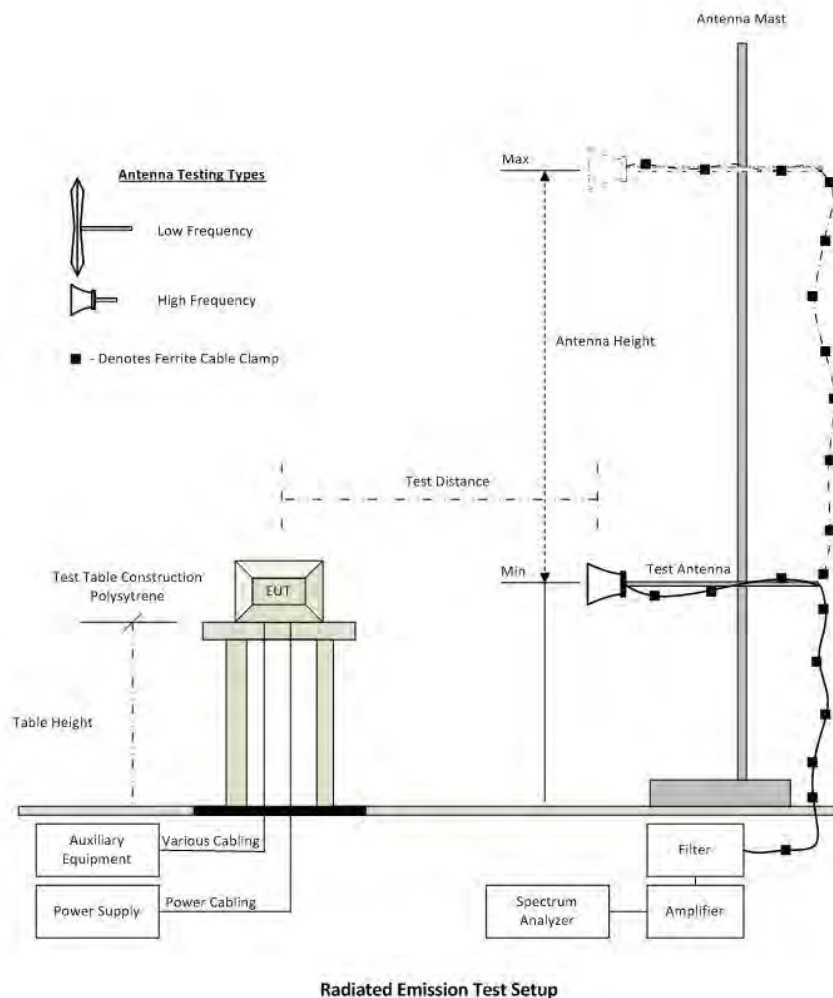
$$40 \text{ dB}\mu\text{V/m} = 100\mu\text{V/m}$$

$$48 \text{ dB}\mu\text{V/m} = 250\mu\text{V/m}$$

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The following tests were performed using the conducted test set-up shown in the diagram below.

1. Digital Emissions (0.03 - 1GHz and 1 - 6 GHz)



A full system calibration was performed on the test station and any resulting system losses (or gains) were taken into account in the production of all final measurement data.

Ambient test conditions.

Temperature: 17 to 23 °C Relative humidity: 31 to 57 % Pressure: 999 to 1012 mbar



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Measurement Results for Spurious Emissions (30 MHz – 1 GHz)

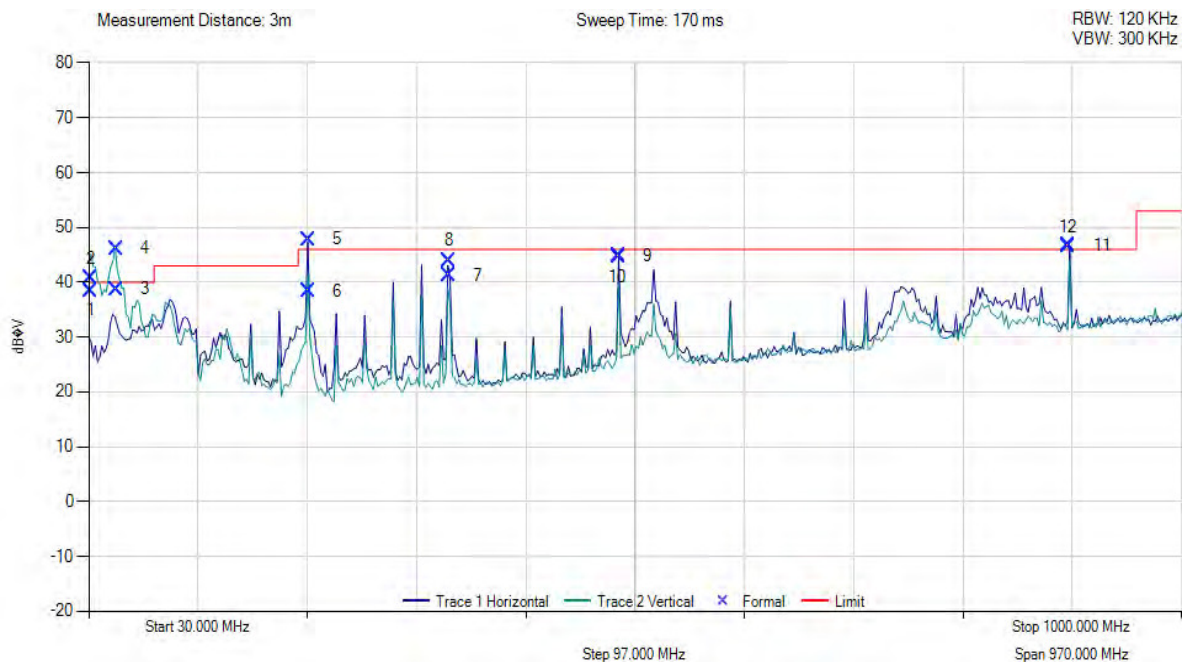
Equipment Configuration for Digital Emissions (0.03 - 1 GHz)

Antenna:	Not Connected	Variant:	Airlight
Antenna Gain (dBi):	Not Applicable	Modulation:	QPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	100
Channel Frequency (MHz):	72.125 GHz	Data Rate:	1000 Mbit/s
Power Setting:	Maximum	Tested By:	JMH

Test Measurement Results



Variant: Airlight, Test Freq: 72.125 GHz



Num	Frequency MHz	Raw dBμV	Cable Loss	AF dB	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	31.94	46.27	3.44	-11.21	38.50	MaxQP	Vertical	100	308	40.0	-1.5	Pass
2	31.94	48.57	3.44	-11.21	40.80	Peak (Scan)	Vertical					
3	54.21	59.04	3.60	-23.93	38.71	MaxQP	Vertical	117	193	40.0	-1.3	Pass
4	54.21	66.52	3.60	-23.93	46.19	Peak (Scan)	Vertical					
5	224.99	61.15	4.44	-19.65	45.94	MaxQP	Horizontal	124	115	46.0	-0.6	Pass
6	224.99	53.62	4.44	-19.65	38.41	Peak (Scan)	Horizontal					
7	349.96	52.06	4.87	-15.73	41.20	MaxQP	Horizontal	106	316	46.0	-4.8	Pass
8	349.96	54.89	4.87	-15.73	44.03	Peak (Scan)	Horizontal					
9	499.98	52.43	5.33	-12.85	44.91	Peak (Scan)	Horizontal					
10	499.98	52.10	5.33	-12.85	44.58	MaxQP	Horizontal	188	348	46.0	-1.4	Pass
11	899.98	48.23	6.34	-7.87	46.70	Peak (Scan)	Horizontal					
12	899.98	45.7	6.34	-7.87	44.17	MaxQP	Horizontal	157	1	46.0	-1.83	Pass

Test Notes: POE non shielded cables

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Measurement Results for Spurious Emissions (1 - 6 GHz)

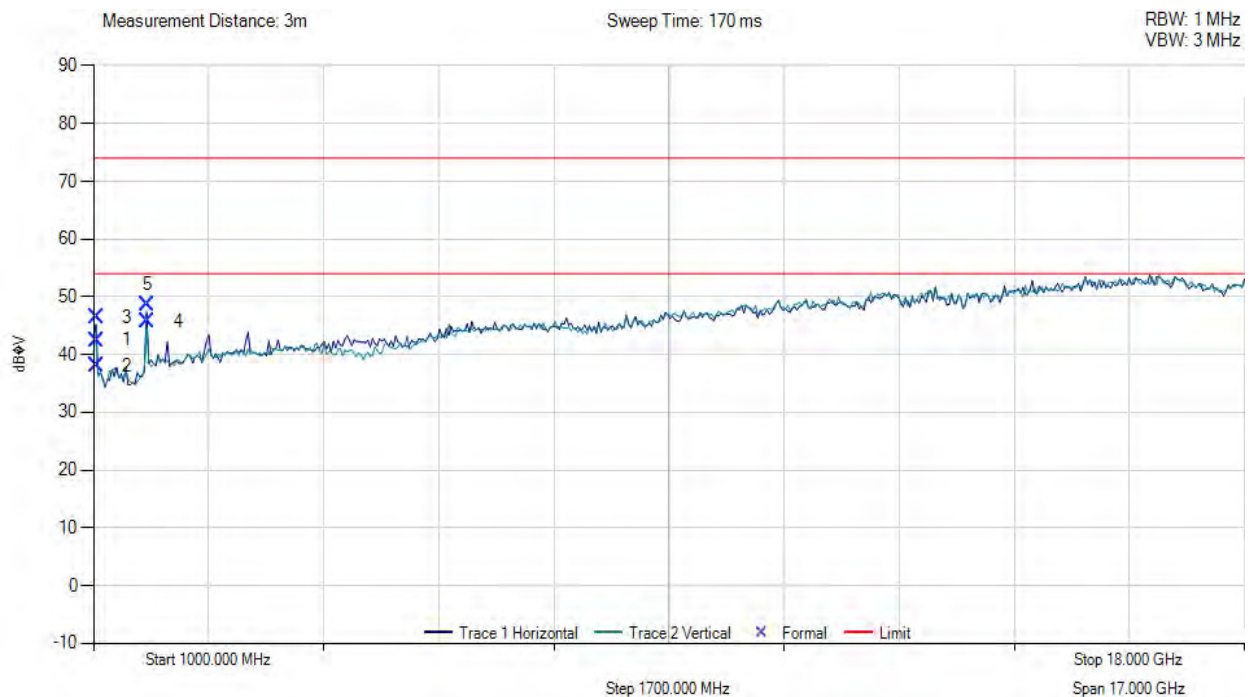
Equipment Configuration for Radiated Spurious - Restricted Band Emissions

Antenna:	Not Connected	Variant:	Airlight
Antenna Gain (dBi):	Not Applicable	Modulation:	QPSK
Beam Forming Gain (Y):	Not Applicable	Duty Cycle (%):	100
Channel Frequency (MHz):	72.125 GHz	Data Rate:	1000 Mbit/s
Power Setting:	Maximum	Tested By:	JMH

Test Measurement Results



Variant: Airlight, Test Freq: 72.125 GHz



Num	Frequency MHz	Raw dBμV	Cable Loss	AF dB	Level dBμV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBμV/m	Margin dB	Pass /Fail
1	1050.00	57.50	2.09	-17.11	42.48	Peak (NRB)	Horizontal					
2	1050.00	53.07	2.09	-17.11	38.05	Max Avg	Horizontal	121	149	54.0	16.0	Pass
3	1050.00	61.44	2.09	-17.11	46.42	Max Peak	Horizontal	121	149	74.0	-27.6	Pass
4	1800.08	56.89	2.47	-13.65	45.71	Max Avg	Horizontal	100	114	54.0	8.3	Pass
5	1800.08	59.77	2.47	-13.65	48.59	Max Peak	Horizontal	100	114	74.0	-25.4	Pass

Test Notes: POE non shielded cables

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Specification

Limits

§15.205 (a) Except as shown in paragraph (d) of 15.205 (a), only spurious emissions are permitted in any of the frequency bands listed.

§15.205 (a) Except as shown in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in Section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in Section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in Section 15.35 apply to these measurements.

§15.209 (a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table.

§15.209 (a) Limit Matrix

Frequency(MHz)	Field Strength (μ V/m)	Field Strength (dB μ V/m)	Measurement Distance (meters)
30-88	100	40.0	3
88-216	150	43.5	3
216-960	200	46.0	3
Above 960	500	54.0	3

Laboratory Measurement Uncertainty for Radiated Emissions

Measurement uncertainty	+5.6/ -4.5 dB
-------------------------	---------------

Traceability

Method	Test Equipment Used
Measurements were made per work instruction WI-03 'Measurement of Radiated Emissions'	0158, 0193, 0252, 0310, 0312, 0338, 0397, 0399, 0406, 0411, 0413, 0415

7.1.7 ac Wireline Emissions (0.15 – 30 MHz)

FCC, Part 15 Subpart C §15.207

Test Procedure

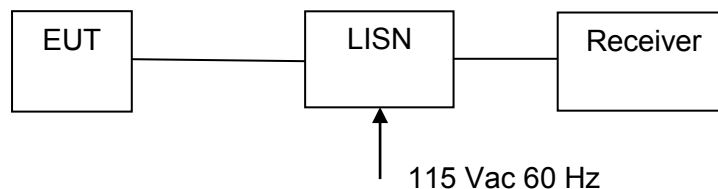
The EUT is configured in accordance with ANSI C63.4. The conducted emissions are measured in a shielded room with a spectrum analyzer in peak hold in the first instance. Emissions closest to the limit are measured in the quasi-peak mode (QP) with the tuned receiver using a bandwidth of 9 kHz. The emissions are maximized further by cable manipulation. The highest emissions relative to the limit are listed.

Test Set-Up

The following tests were performed using the conducted test set-up shown in the diagram below.

1. ac Wireline Conducted Emissions

Test Measurement Set up



Measurement set up for ac Wireline Conducted Emissions Test

Laboratory Measurement Uncertainty for Conducted Emissions

Measurement uncertainty	±2.64 dB
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Traceability

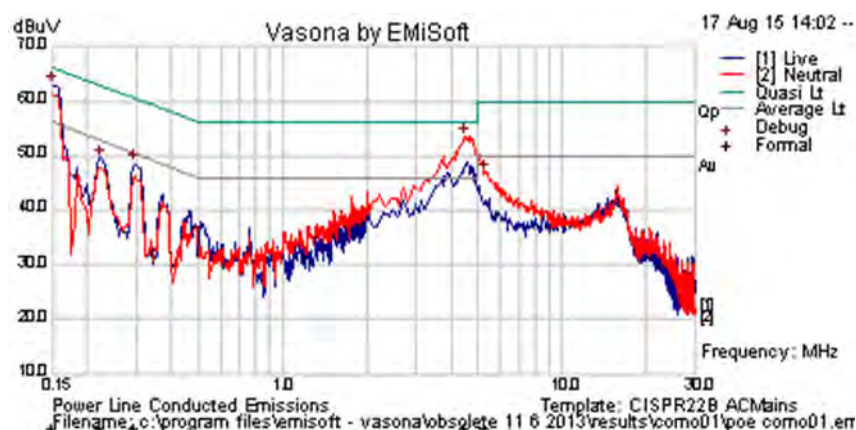
Method	Test Equipment Used
Measurements were made per work instruction WI-EMC-01 'Measurement of Conducted Emissions'	0158, 0184, 0190, 0287, 0310, 0312

Ambient test conditions.

Temperature: 17 to 23 °C Relative humidity: 31 to 57 % Pressure: 999 to 1012 mbar

Measurement Results for ac Wireline Conducted Emissions (150 kHz – 30 MHz)

Test Freq.	N/A	Engineer	SB
Variant	AC Line Emissions	Temp (°C)	
Freq. Range	0.150 MHz - 30 MHz	Rel. Hum.(%)	
Power Setting	N/A	Press. (mBars)	
Antenna	Integral		
Test Notes 1	SMC Networks 802.3at/af Gigabit PoE Adapter; Model:SMCPWR-INJ6		
Test Notes 2	S/N:A91305000070		



Formally measured emission peaks

Frequency MHz	Raw dBuV	Cable Loss	Factors dB	Level dBuV	Measurement Type	Line	Limit dBuV	Margin dB	Pass /Fail	Comments
3.906	40.2	9.8	0.2	50.1	Quasi Peak	Live	56	-5.9	Pass	
0.150	47.1	9.8	0.1	57.0	Quasi Peak	Live	66	-9.0	Pass	
0.274	38.2	9.8	0.1	48.1	Quasi Peak	Live	61.01	-13.0	Pass	
4.498	38.1	9.8	0.2	48.0	Quasi Peak	Live	56	-8.0	Pass	
0.150	46.7	9.8	0.1	56.6	Quasi Peak	Live	66	-9.4	Pass	
3.899	41.9	9.8	0.2	51.8	Quasi Peak	Neutral	56	-4.2	Pass	
4.495	38.7	9.8	0.2	48.6	Quasi Peak	Neutral	56	-7.4	Pass	
1.852	32.4	9.8	0.1	42.3	Quasi Peak	Neutral	56	-13.7	Pass	
3.906	29.4	9.8	0.2	39.3	Average	Live	46	-6.7	Pass	
0.150	30.4	9.8	0.1	40.3	Average	Live	56	-15.8	Pass	
0.274	24.8	9.8	0.1	34.6	Average	Live	51.01	-16.4	Pass	
4.498	34.1	9.8	0.2	44.0	Average	Live	46	-2.0	Pass	
0.150	30.2	9.8	0.1	40.1	Average	Live	56	-15.9	Pass	
3.899	30.7	9.8	0.2	40.7	Average	Neutral	46	-5.3	Pass	

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4.495	34.1	9.8	0.2	44.0	Average	Neutral	46	-2.0	Pass	
1.852	31.3	9.8	0.1	41.2	Average	Neutral	46	-4.8	Pass	
Legend:	DIG = Digital Device Emission; TX = Transmitter Emission; FUND = Fundamental Frequency									
	NRB = Non-Restricted Band, Limit is 20 dB below Fundamental; RB = Restricted Band									

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Specification

Limits

§15.207 (a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table, as measured using a 50 $\mu\Omega$ line impedance stabilization network (LISN), see §15.207 (a) matrix below. Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal.

§15.207 (a) Limit Matrix

The lower limit applies at the boundary between frequency ranges

Frequency of Emission (MHz)	Conducted Limit (dB μ V)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

* Decreases with the logarithm of the frequency

Traceability

Test Methodology	Laboratory Measurement Uncertainty
Measurements were made per work instruction WI-EMC-01 'Measurement of Conducted Emissions'	± 2.64 dB

8 PHOTOGRAPHS

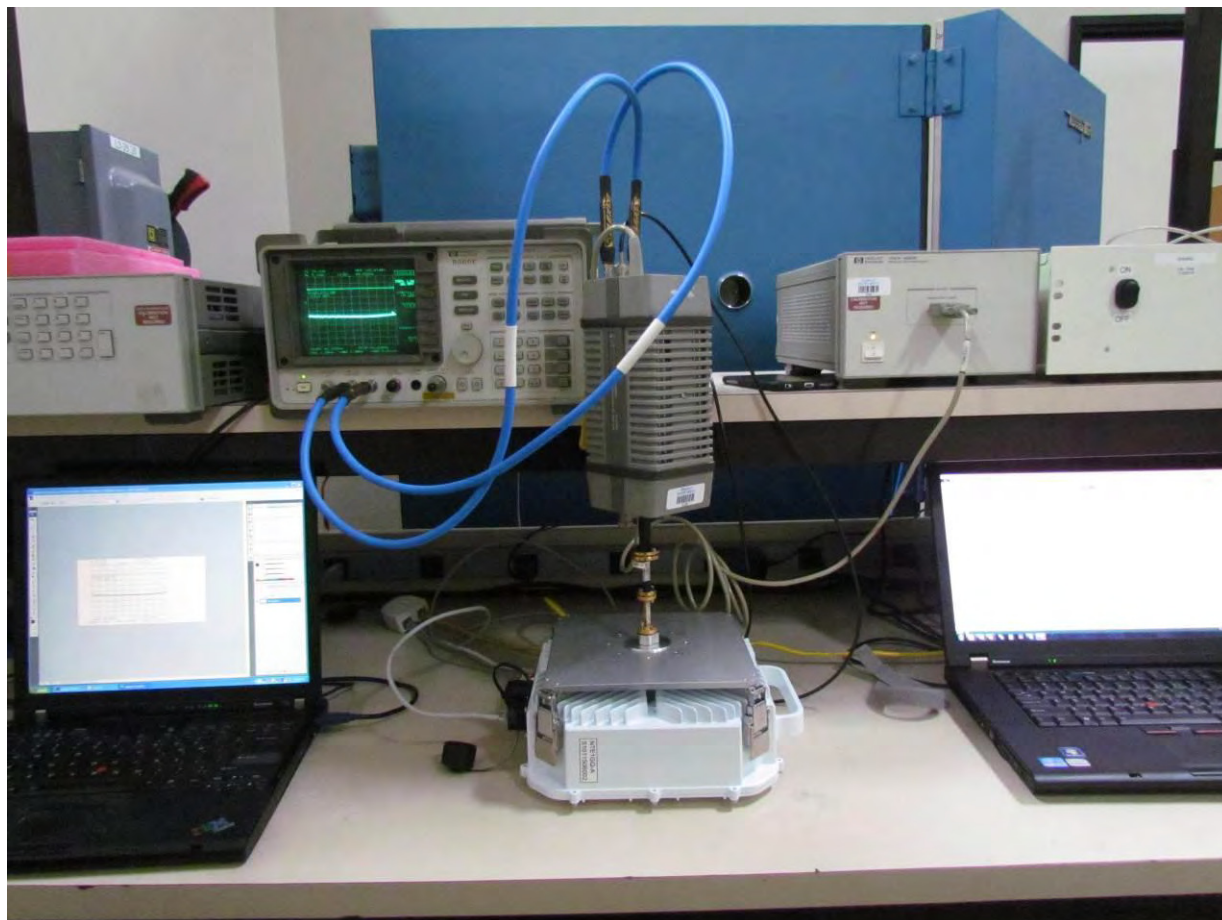
8.1 RF Conducted



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8.2 Conducted Spurious Emissions – Pre-Selector Mixer (40 – 75 GHz)



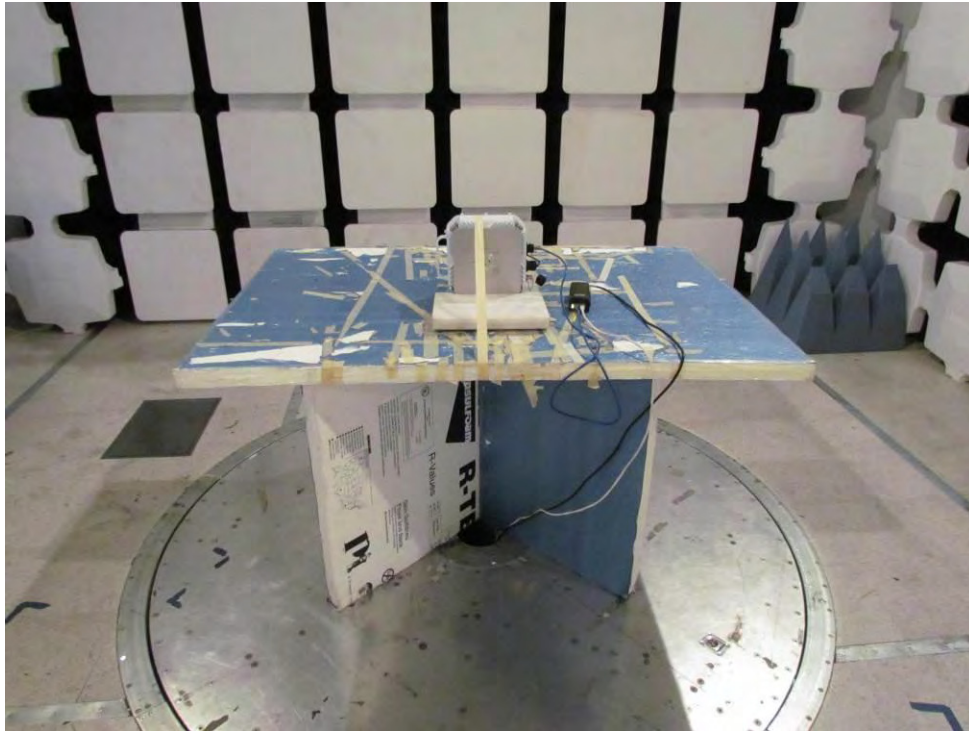
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8.3 Conducted Spurious Emissions – Harmonic Mixer (75 – 110 GHz)



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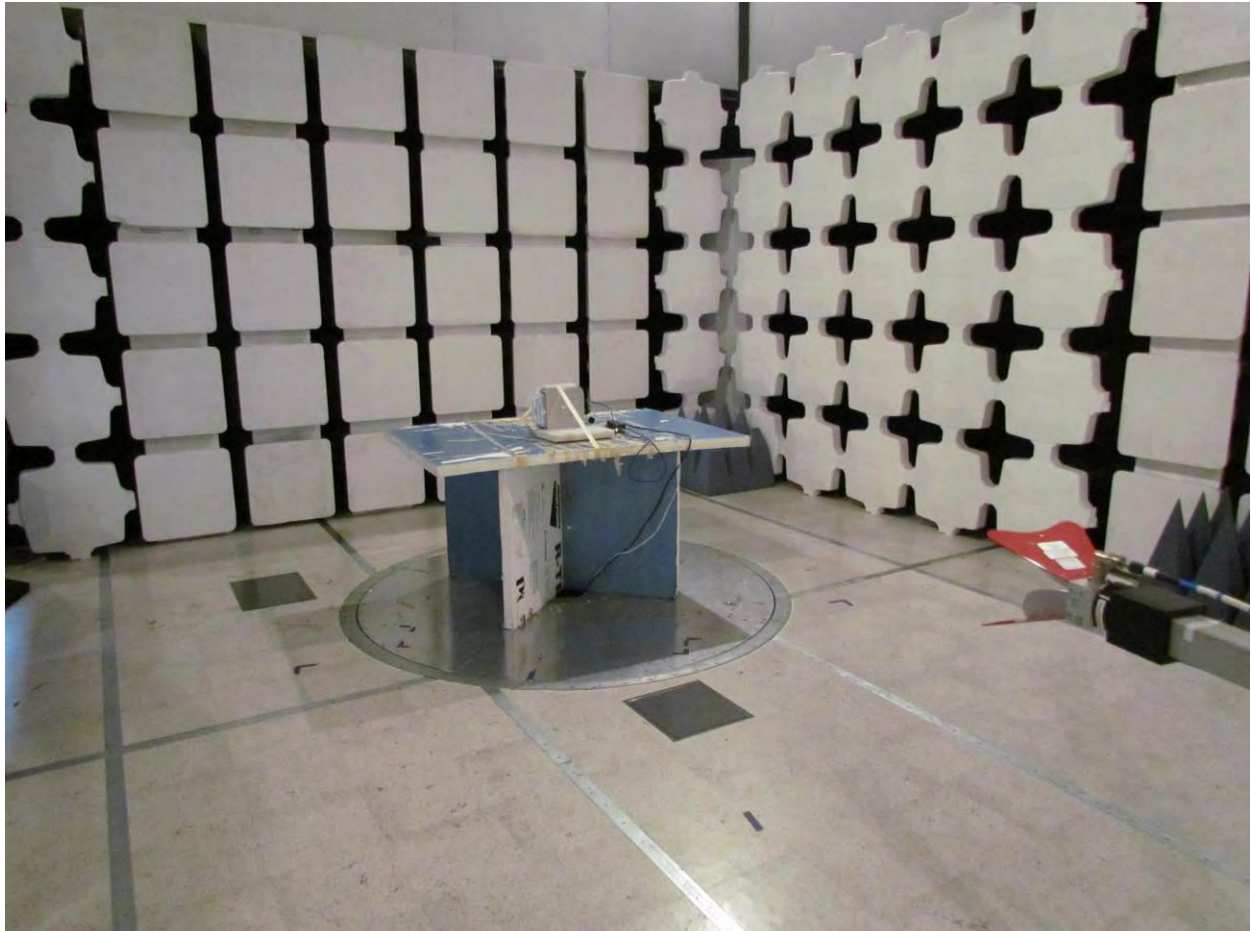
8.4 Digital Emissions – 0.03 - 1 GHz



Equipment tested for digital emissions without integral antenna connected

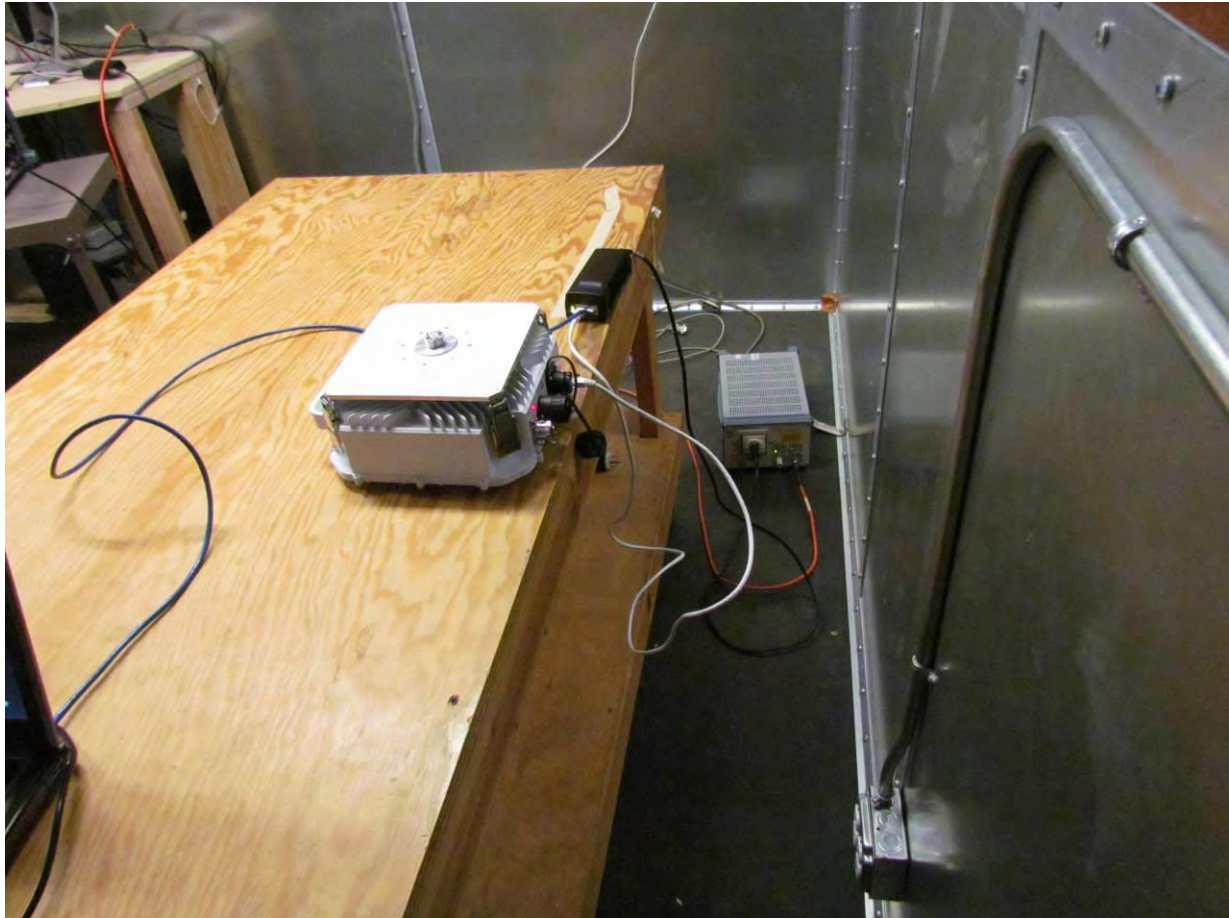
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8.5 Digital Emissions 1 – 6 GHz



Equipment tested for digital emissions without integral antenna connected

8.6 ac Wireline Emissions (0.15 – 30 MHz)



Equipment tested for digital emissions without integral antenna connected



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9 TEST EQUIPMENT DETAILS

Asset #	Instrument	Manufacturer	Part #	Serial #
0074	Environmental Chamber	Tenney	TTC	12808-1
0088	Spectrum Analyzer	Hewlett Packard	8564E	3410A00141
0095	Pre-Selector PSU	Hewlett Packard	HP11974-60028	3001A00134
0128	Pre-Selector Mixer	Hewlett Packard	HP 11974U	3001A00107
0158	Barometer /Thermometer	Control Co.	4196	E2846
0184	Pulse Limiter	Rhode & Schwartz	ESH3Z2	357.8810.52
0190	LISN	Rhode & Schwartz	ESH3Z5	836679/006
0193	EMI Receiver	Rhode & Schwarz	ESI 7	838496/007
0227	Pre-Selector Mixer	Hewlett Packard	HP 11974V	3001A00134
0252	SMA Cable	Megaphase	Sucoflex 104	None
0287	EMI Receiver	Rhode & Schwartz	ESI 40	100201
0293	BNC Cable	Megaphase	1689 1GVT4	15F50B001
0304	Harmonic Mixer	Hewlett Packard	HP11970W	2521A01085
0310	2m SMA Cable	Micro-Coax	UFA210A-0-0787-3G03G0	209089-001
0312	3m SMA Cable	Micro-Coax	UFA210A-1-1181-3G0300	209092-001
0338	Antenna	Sunol Sciences	JB-3	A052907
397	Preamp 10-2500 MHz	MiCOM Labs		0397
399	Horn Antenna 1-18G	ETS	3117	00154575
406	Preamp 1-18 GHz	MiCOM Labs		0406
411	Mast/Turntable Control	Sunol Sciences	SC98V	060199-1D
413	Mast Controller	Sunol Sciences	TWR95-4	030801-3
415	Turntable Controller	Sunol Sciences		0415

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