TÜV SÜD Canada

EMC & RF Test Report

As per

FCC Part 90 Subpart F:2015

Radio Location Service

Operation in the 9200 – 9500 MHz Band

on the

The Ranger®

R20SS ground-surveillance radar

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Testing produced for

FLIR®

See Appendix A for full customer & EUT details.

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Report Scope

This report addresses the EMC verification testing and test results of The Ranger® R20SS ground-surveillance radar, herein referred to as EUT (Equipment Under Test) performed at TÜV SÜD Canada Labs..

The EUT was tested for compliance against the following standards:

FCC Part 90 Subpart F:2015

Test procedures, results, justifications, and engineering considerations, if any, follow later in this report.

The results contained in this report relate only to the item(s) tested.

This report does not imply product endorsement by A2LA or any other accreditation agency, any government, or TÜV SÜD Canada.

Opinions/interpretations expressed in this report, if any, are outside the scope of TÜV SÜD Canada accreditation. Any opinions expressed do not necessarily reflect the opinions of TÜV SÜD Canada, unless otherwise stated.

Client	**Flir Radars**
Product	**The Ranger®** **R20SS ground-surveillance radar**
Standard(s)	FCC Part 90 Subpart F:2015

Summary

The results contained in this report relate only to the item(s) tested.

EUT FCC Certification #, FCC ID:	UMN-RANGER-R20
EUT Passed all tests performed.	Yes (see test results summary)
Tests conducted by	Scott Drysdale

Client	**Flir Radars**
Product	**The Ranger®** **R20SS ground-surveillance radar**
Standard(s)	FCC Part 90 Subpart F:2015

Test Results Summary

Standard/Method	Description	Limit	Result
FCC 2.1046	Output Power	N/A	Pass
FCC 90.210c	Occupied Bandwidth	N/A	Pass
FCC 2.1051	Spurious antenna port conducted emissions	$43 + 10 \log_{10} P_{max}$ dB.	Pass
FCC 2.1053	Spurious radiated emissions	$43 + 10 \log_{10} P_{max}$ dB.	Pass
FCC 2.1055	Frequency stability	2.5 ppm	Pass
Overall Result			**PASS**

All tests were performed by Scott Drysdale.

If the product as tested or otherwise complies with the specification, the EUT is deemed to comply with the requirement and is deemed a ‘PASS’ grade. If not ‘FAIL’ grade will be issued. Note that ‘PASS’ / ‘FAIL’ grade is independent of any measurement uncertainties. A ‘PASS’ / ‘FAIL’ grade within measurement uncertainty is marked with a ‘*’.

Justifications, Descriptions, or Deviations

The following justifications for tests not performed or deviations from the above listed specifications apply:

The EUT transmits a CW swept frequency signal.

This report does not guarantee acceptance by the FCC or a representative of the FCC (i.e. TCB) or continued product certification. It is recommended that the validity of the FCC certification be verified by looking up the FCC ID on www.fcc.gov.

Power line conducted emissions does not apply as this device is powered by 28 VDC and has no provisions for AC power.

Applicable Standards, Specifications and Methods

ANSI C63.4:2014	Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI/TIA-603-C-2004	Land Mobile FM or PM Communications Equipment Measurement and Performance Standards
CFR 47 FCC Part 2 Subpart J –	Code of Federal Regulations – Equipment Authorization Procedure
CFR 47 FCC Part 90	Code of Federal Regulations – Private Land Mobile Radio Services
FCC KDB 412172	D01 Determining ERP and EIRP v01
ISO 17025:2005	General Requirements for the competence of testing and calibration laboratories

Sample calculation(s)

Margin = limit – (received signal + antenna factor + cable loss – pre-amp gain)
Margin = 50.5dBuV/m – (50dBuV + 10dB + 2.5dB – 20dB)
Margin = 8.5 dB

Reference Offset = Attenuator + Cable Loss
Reference Offset = 10 dB + 0.4 dB
Reference Offset = 10.4 dB

Document Revision Status

Revision 1 – November 16, 2016
1st issue released to client. Not submitted to TCB.
Revision 2 – Jan 25, 2016
Revised as per client request. 1st issue to TCB
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Definitions and Acronyms

The following definitions and acronyms are applicable in this report.
See also ANSI C63.14.

AE – Auxiallary Equipment.

BW – Bandwidth. Unless otherwise stated, this is refers to the 6 dB bandwidth.

EMC – Electro-Magnetic Compatibility

EMI – Electro-Magnetic Immunity

EUT – Equipment Under Test

ITE – Information Technology Equipment with a primary function(s) of entry, storage, display, retrieval, transmission, processing, switching, or control, of data.

LISN – Line impedance stabilization network

NCR – No Calibration Required

RF – Radio Frequency

Testing Facility

Testing for EMC on the EUT was carried out at TÜV SÜD Canada labs in Laval (Montréal), Québec, Canada. The testing lab consists of a 3m semi-anechoic chamber calibrated to be able to allow measurements on an EUT with a maximum width or length of up to 2m and height up to 3m. The chamber is equipped with a turn table that is capable of testing devices up to 3300lb in weight. This facility is capable of testing products that are rated for 120 Vac and 240Vac single phase, or 208 Vac 3 phase input. DC capability is also available. The chamber is equipped with an antenna mast that controls polarization and height from the control room adjoining the shielded chamber. Radiated emissions measurements are performed using a Bilog, and Horn antenna where applicable. Conducted emissions, unless otherwise stated, are performed using a LISN and using the Vertical Ground plane.

Calibrations and Accreditations

The 3m semi-anechoic chamber is registered with Federal Communications Commission (FCC, 382292), and Industry Canada (IC, 6844B-1). This semi-anechoic chamber complies with the requirements of EN55016-2-3:2006, section 7.5 and the site attenuation requirements of EN55016-1-4. This chamber was additionally calibrated for Normalized Site Attenuation (NSA) using test procedures outlined in ANSI C63.4 “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz”. The chamber is lined with ferrite tiles and absorption cones to minimize any undesired reflections. The NSA data is kept on file at TÜV SÜD Canada. For radiated susceptibility testing, a 16 point field calibration has been performed on the chamber. The field uniformity data is kept on file at TÜV SÜD Canada. TÜV SÜD Canada is accredited to ISO/IEC 17025 by A2LA with Testing Certificate #2955.02. The laboratories current scope of accreditation listing can be found as listed on the A2LA website. All measuring equipment is calibrated on an annual or bi-annual basis as listed for each respective test.

Testing Environmental Conditions and Dates

Following were the environmental conditions in the facility during time of testing –

Date	Test	Init.	Temperature (ºC)	Humidity (%)	Pressure (kPa)
October 17, 2016	Output Power	SD	20-24ºC	35 – 41%	96 -102kPa
October 14, 2016	Occupied Bandwidth	SD	20-24ºC	35 – 41%	96 -102kPa
October 15, 2016	Spurious Antenna conducted	SD	20-24ºC	35 – 41%	96 -102kPa
October 14, 2016	Frequency stability	SD	20-24ºC	35 – 41%	96 -102kPa
October 17, 2016	Radiated spurious	SD	20-24ºC	35 – 41%	96 -102kPa

Detailed Test Results Section

Output Power

Purpose

The purpose of this test is to ensure that the maximum power conducted to the radiating element does not exceed the limits specified.

Limits

The limits are defined in FCC Part 90.205 (unrestricted) and FCC Part 2.1046(c).

Results

The EUT met the requirements. .

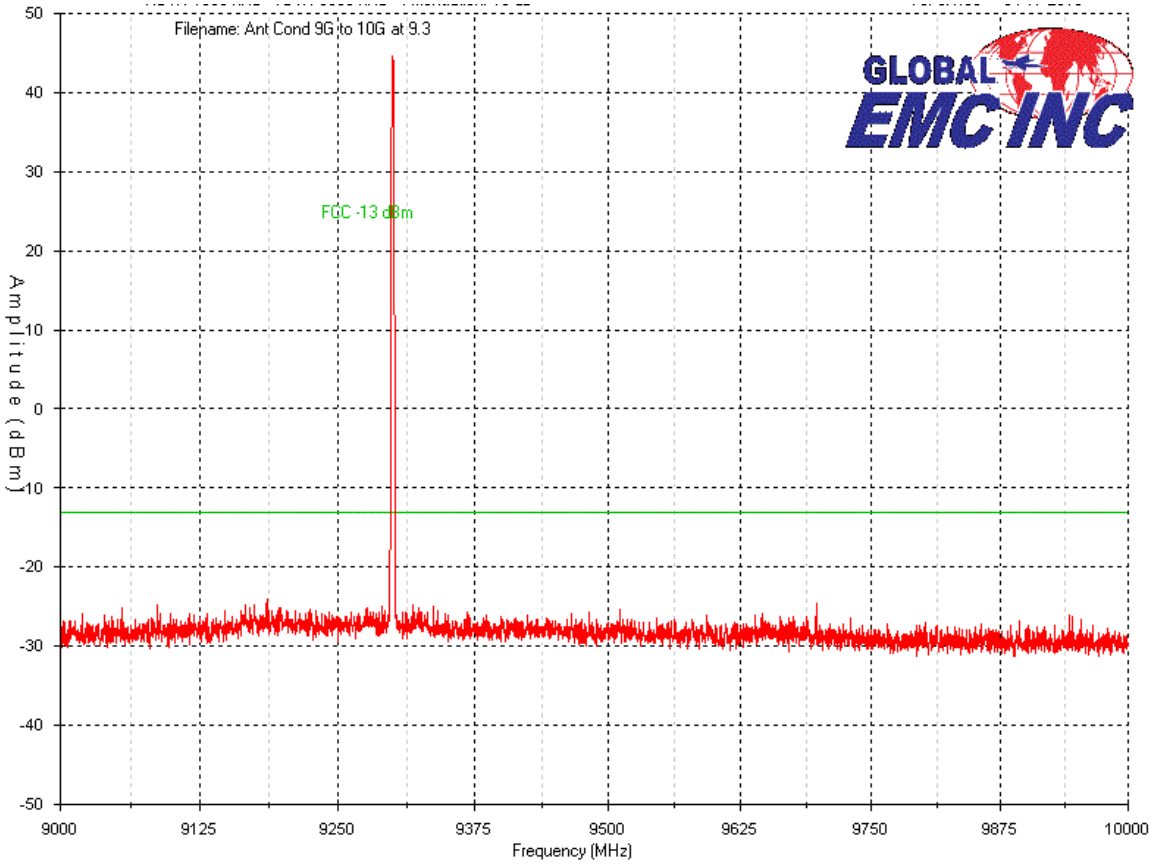
Table(s)

Channel	Frequency (MHz)	Power (dBm)	Antenna Gain (dBi)	EiRP (dBm)	EiRP (kW)
Low Channel	9300	43.4	16.5	59.9	977.2
Mid Channel	9400	44.3	16.5	60.8	1202.3
High Channel	9499	42.9	16.5	59.4	871.0

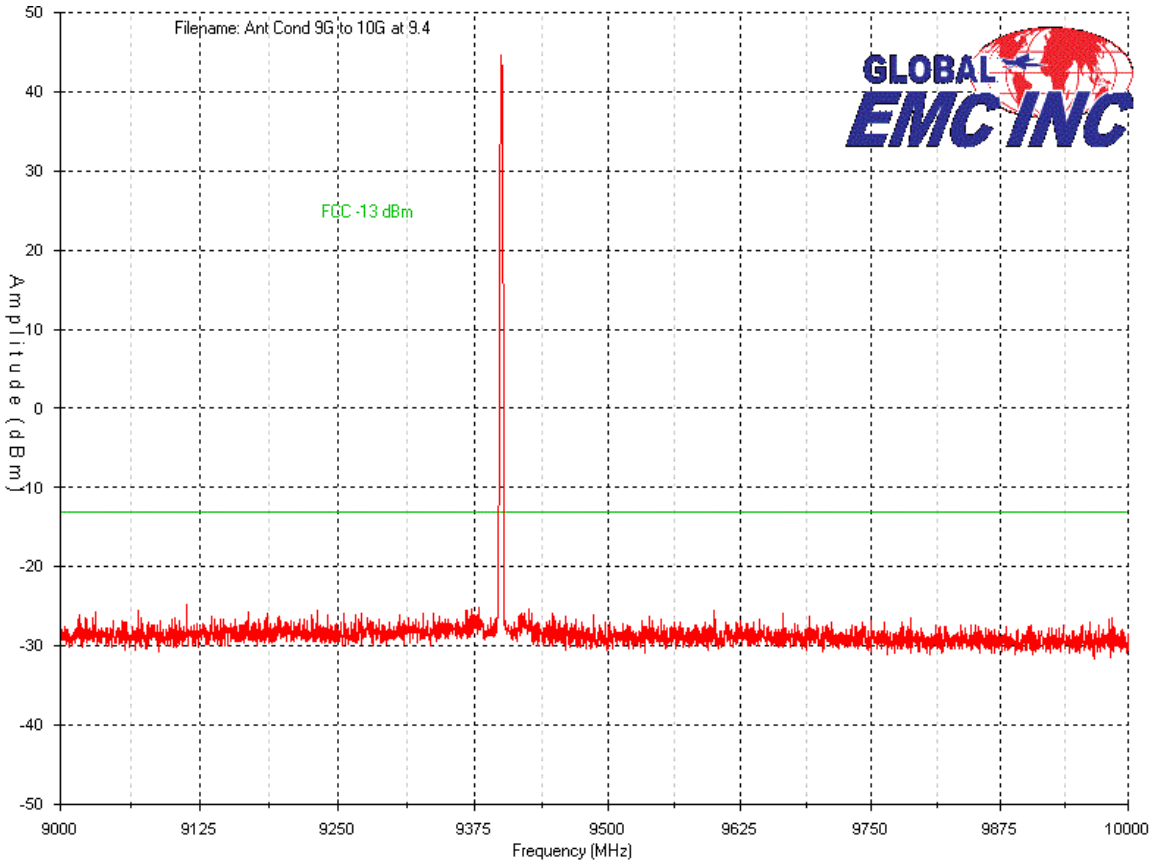
Graph(s)

The graphs below show examples of the Peak Power during the operation of the device. Measurements were performed using a spectrum analyzer with a Peak detector of 1 MHz RBW and the VBW is at least 3 x RBW. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute.

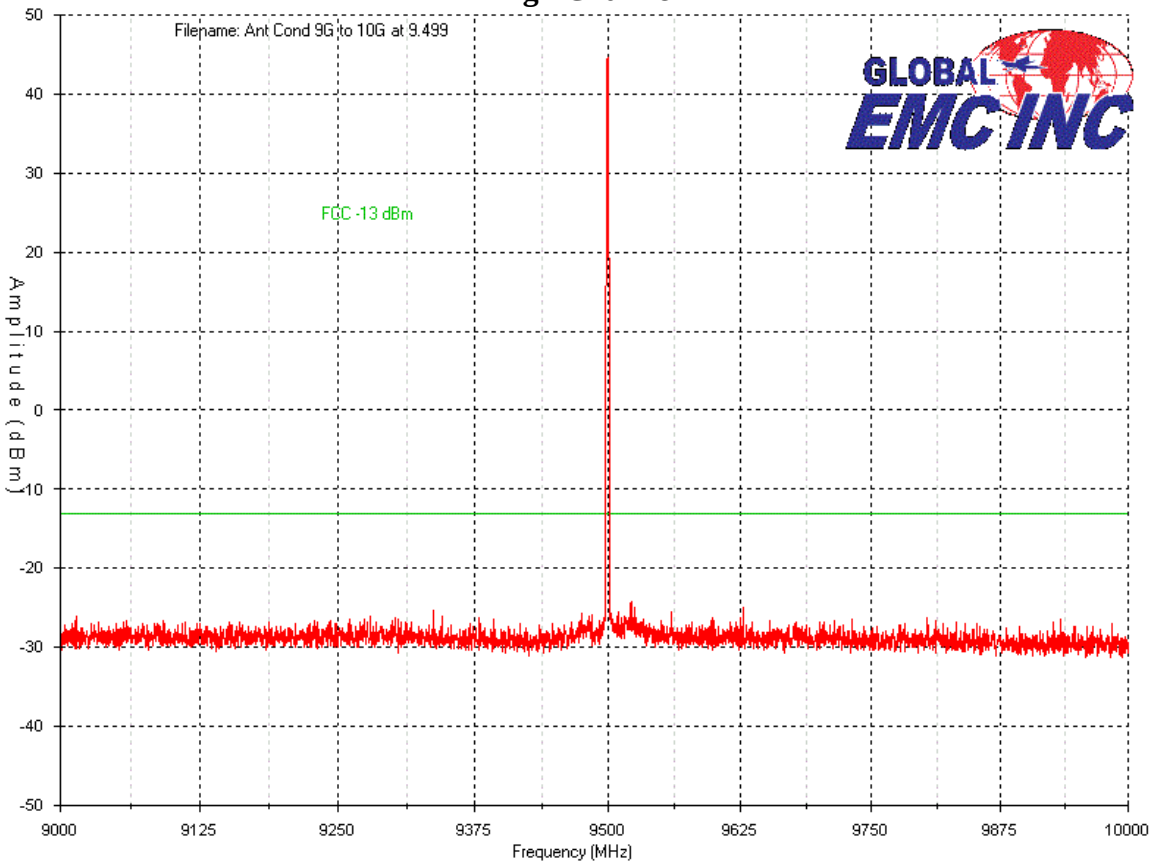
Low Channel



Mid Channel



High Channel



Note: See 'Appendix B – EUT & Test Setup Photographs' for photos showing the test set-up.

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date[1]	Next Calibration Date[1]	Asset #
Spectrum Analyzer Display	8566B	HP	1-28-15	1-28-17	4168
Spectrum Analyzer	8566B	HP	1-28-15	1-28-17	4169
Power Attenuator 20 dB	25-A-FFN-20	Bird / Hutton	NCR	NCR	GEMC 49
RF Cable 1m	LMR-400-1M-50OHM-MN-MN	LexTec	NCR	NCR	GEMC 29

Occupied Bandwidth

Purpose

The purpose of this test is to ensure that the bandwidth occupied exceeds a stated minimum. This helps ensure the utilization of the frequency allocation is sufficiently wide. This also helps prevent corruption of data by ensuring adequate data separation to distinguish the reception of the intended information.

Limits

Occupied bandwidth was performed by coupling the output of the EUT to the input of a spectrum analyzer. The mask was determined using the criteria specified in FCC Part §90.210(c).
For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier output power (P) as follows:
(1) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 5 kHz, but not more than 10 kHz: At least 83 log (fd/5) dB;
(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 10 kHz, but not more than 250 percent of the authorized bandwidth: At least 29 log (fd 2/11) dB or 50 dB, whichever is the lesser attenuation;
(3) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

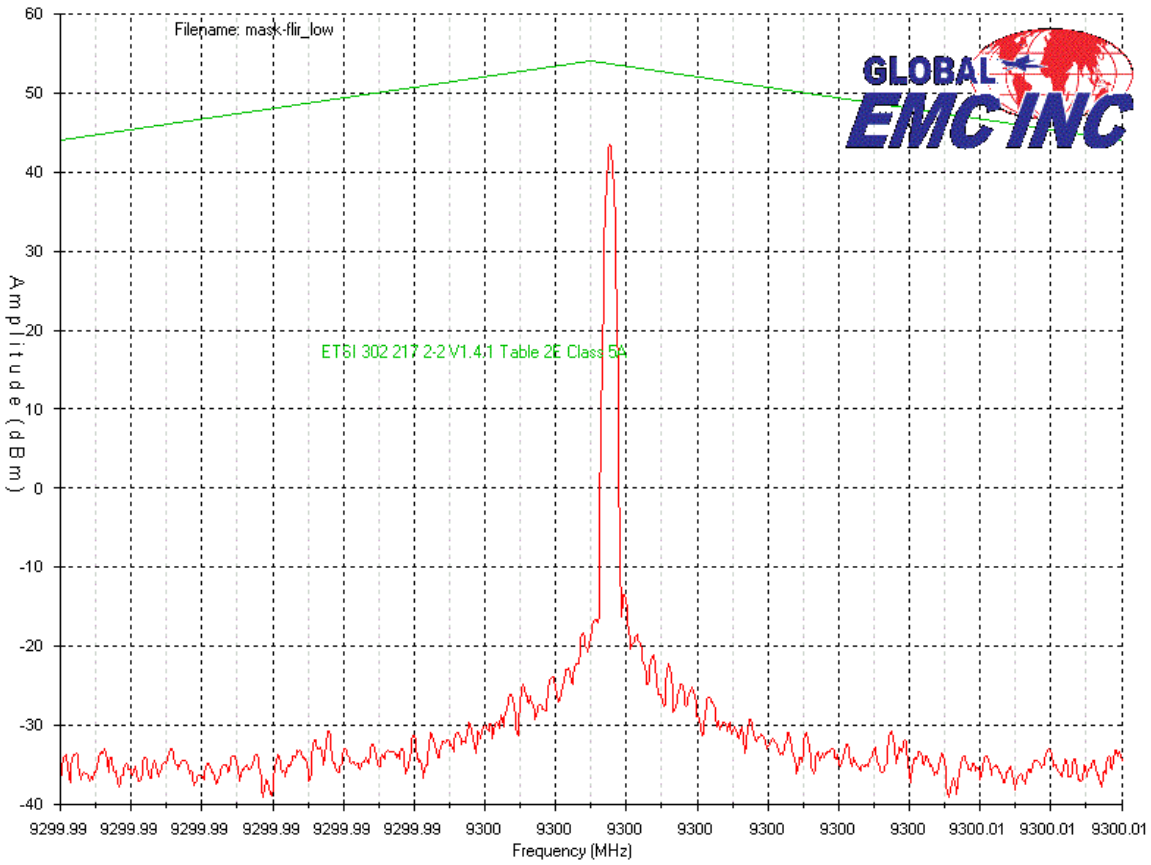
Results

The EUT passed. Note: As the signal is a swept CW signal, there isn't a bandwidth. The plots below are to demonstrate

Graph(s)

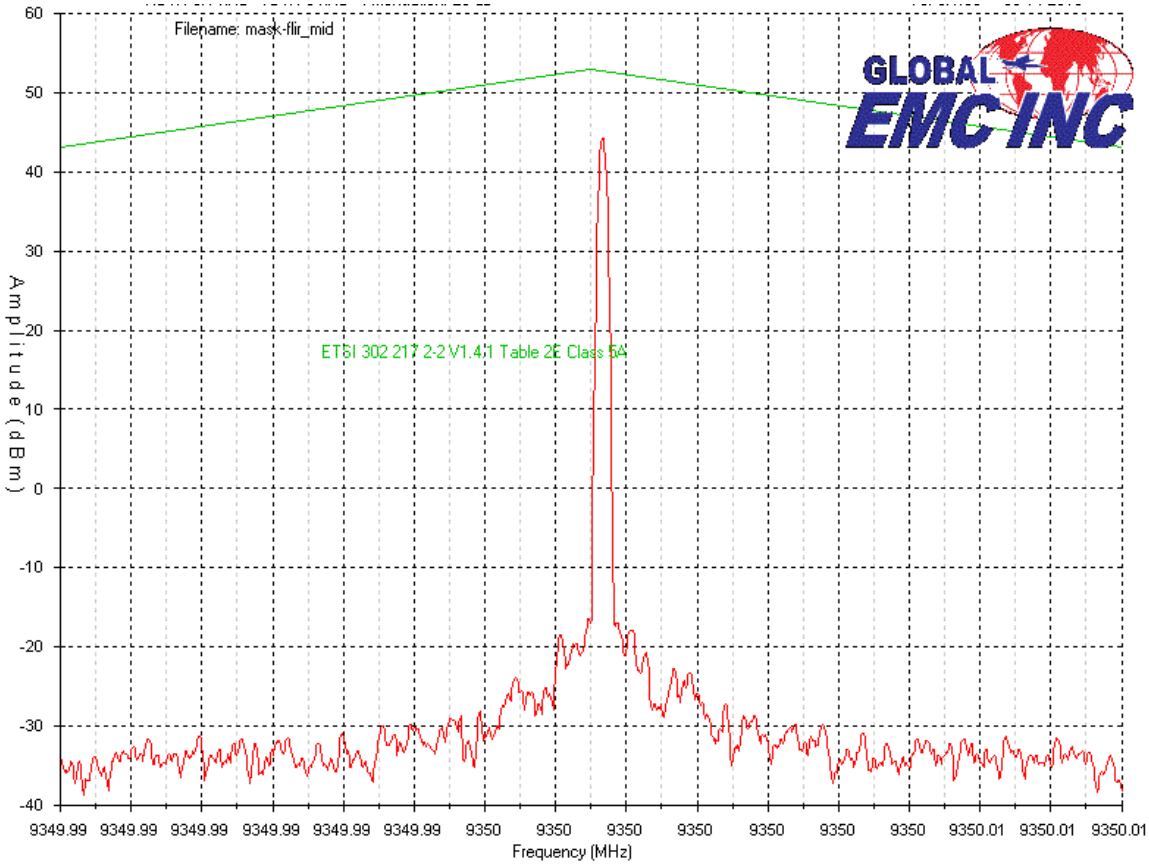
The graphs showed below shows the OBW during the operation of the device. This is measured by a max hold on the spectrum analyzer and the highest resolution bandwidth that is sufficiently low to exhibit the 99% bandwidth of a channel during operation of the EUT, or the lowest available Bandwidth on the spectrum analyzer. This measurement is a peak measurement. Max hold is performed for a duration of not less then 1 minute.

Low Channel



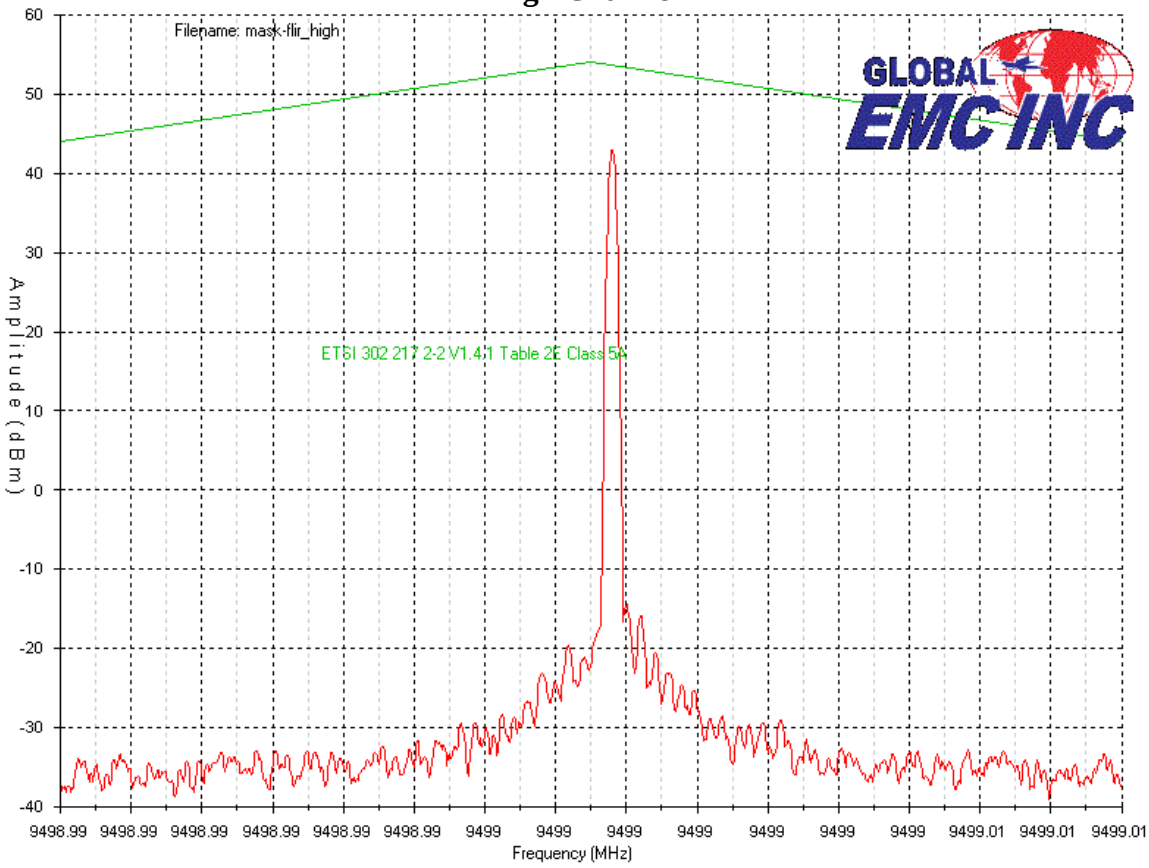
Note: and RBW of 0.1 kHz and VBW of 3 kHz was used.

Mid Channel



Note: and RBW of 0.1 kHz and VBW of 3 kHz was used.

High Channel



Note: and RBW of 0.1 kHz and VBW of 3 kHz was used.

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date[1]	Next Calibration Date[1]	Asset #
Spectrum Analyzer Display	8566B	HP	1-28-15	1-28-17	4168
Spectrum Analyzer	8566B	HP	1-28-15	1-28-17	4169
Power Attenuator 20 dB	25-A-FFN-20	Bird / Hutton	NCR	NCR	GEMC 49
RF Cable 1m	LMR-400-1M-50OHM-MN-MN	LexTec	NCR	NCR	GEMC 29
RF Cable 1m	LMR-400-1M-50OHM-MN-MN	LexTec	NCR	NCR	GEMC 29

This report module is based on GEMC template "FCC – Power Line Conducted Emissions Class B_Rev1"

Spurious Conducted Emissions

Purpose

The purpose of this test is to ensure that the maximum power conducted to the radiating element at frequencies outside of the authorized spectrum does not exceed the limits specified. This ensures that the only the intended signal is delivered to the radiating element.

Limits

FCC Part §90.210(c) states:
For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier output power (P) as follows:
(1) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 5 kHz, but not more than 10 kHz: At least 83 log (fd/5) dB;
(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 10 kHz, but not more than 250 percent of the authorized bandwidth:
At least 29 log (fd 2/11) dB or 50 dB, whichever is the lesser attenuation;
(3) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.
The EUT antenna was removed and the cable was connected directly into a spectrum analyzer through a 30 dB attenuator. An offset was programmed into the spectrum analyzer to compensate for the loss of the external attenuator and cables. The spectrum analyzer resolution bandwidth was set to 100 kHz and the video bandwidth was set to 1MHz. The amplitude of the EUT carrier frequency was measured to
determine the emissions limit. The emissions outside of the allocated frequency band were then scanned from 30 MHz up to 40GHz.

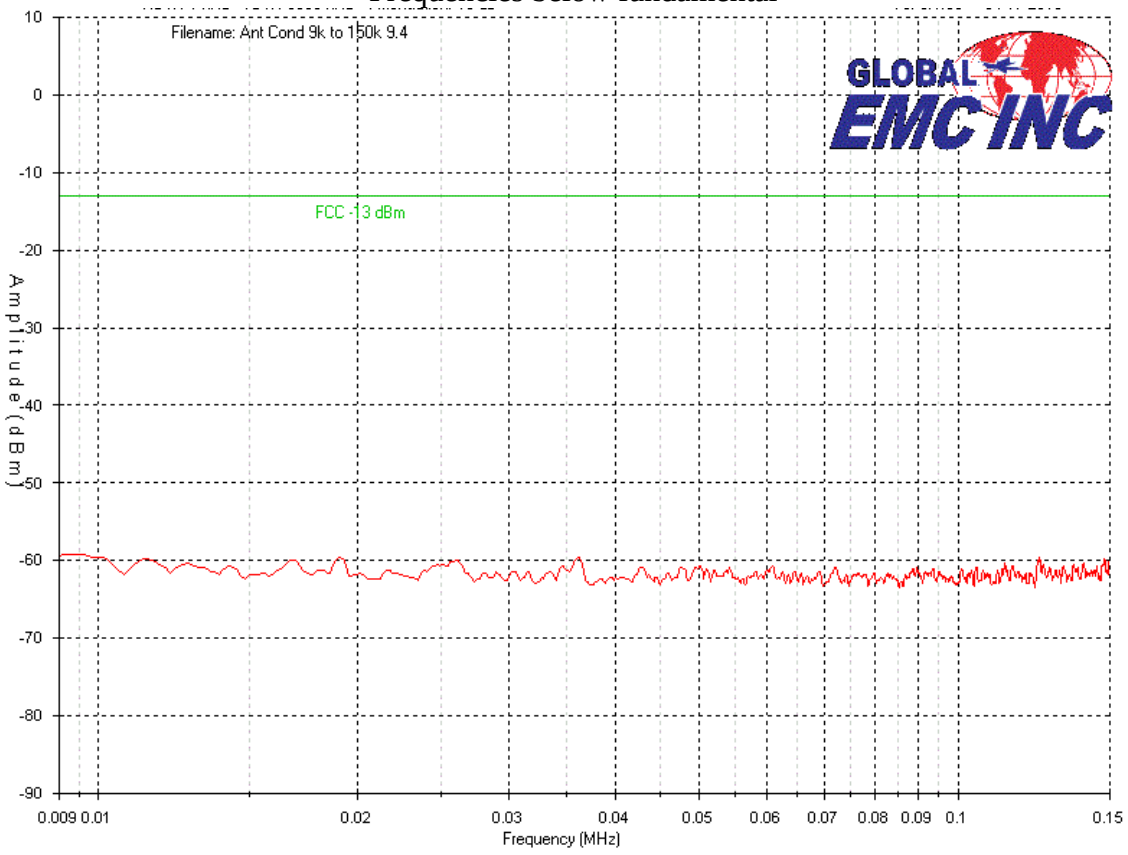
Results

The EUT passed the requirements. Low, middle and high band was measured. The worst case for each band is presented as a graph for the spectrum.

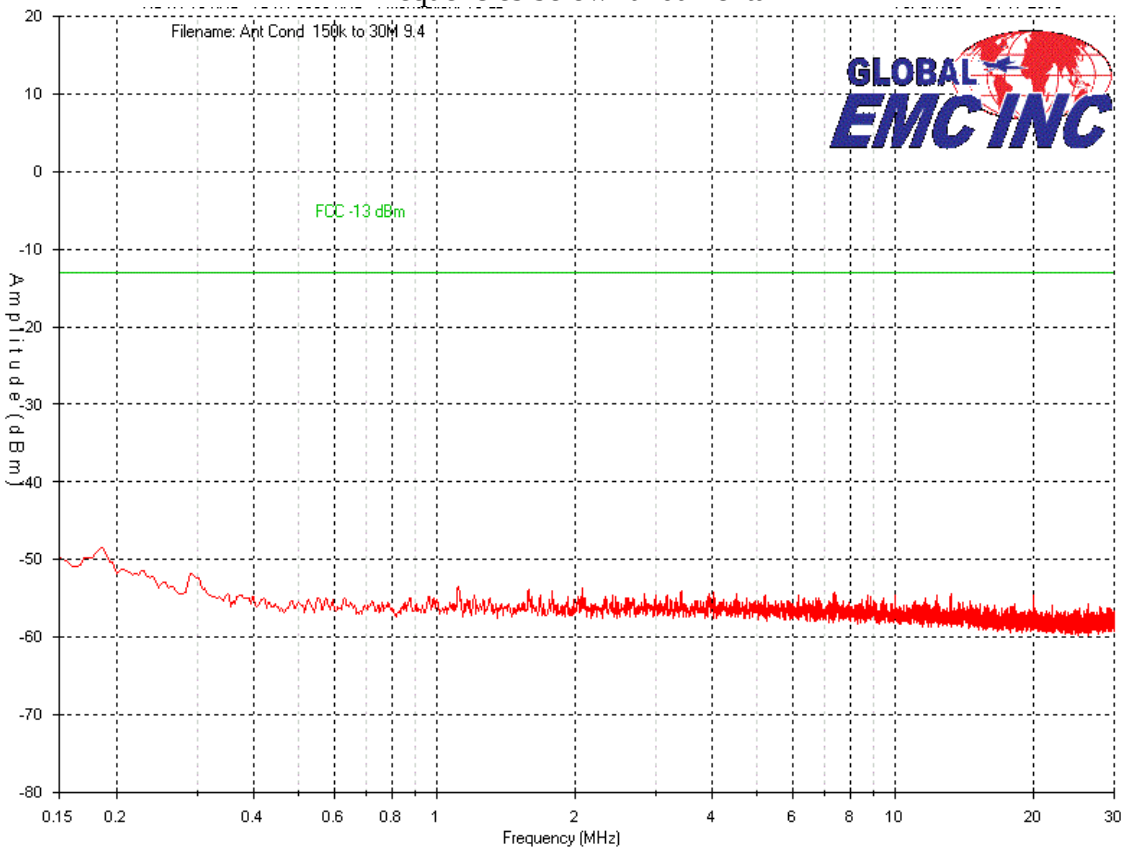
Graph(s)

The graphs shown below shows the peak power output of the device during the antenna conducted measurement during transmit operation of the EUT. Note there was 30 dB of external attenuation taken during this measurement.

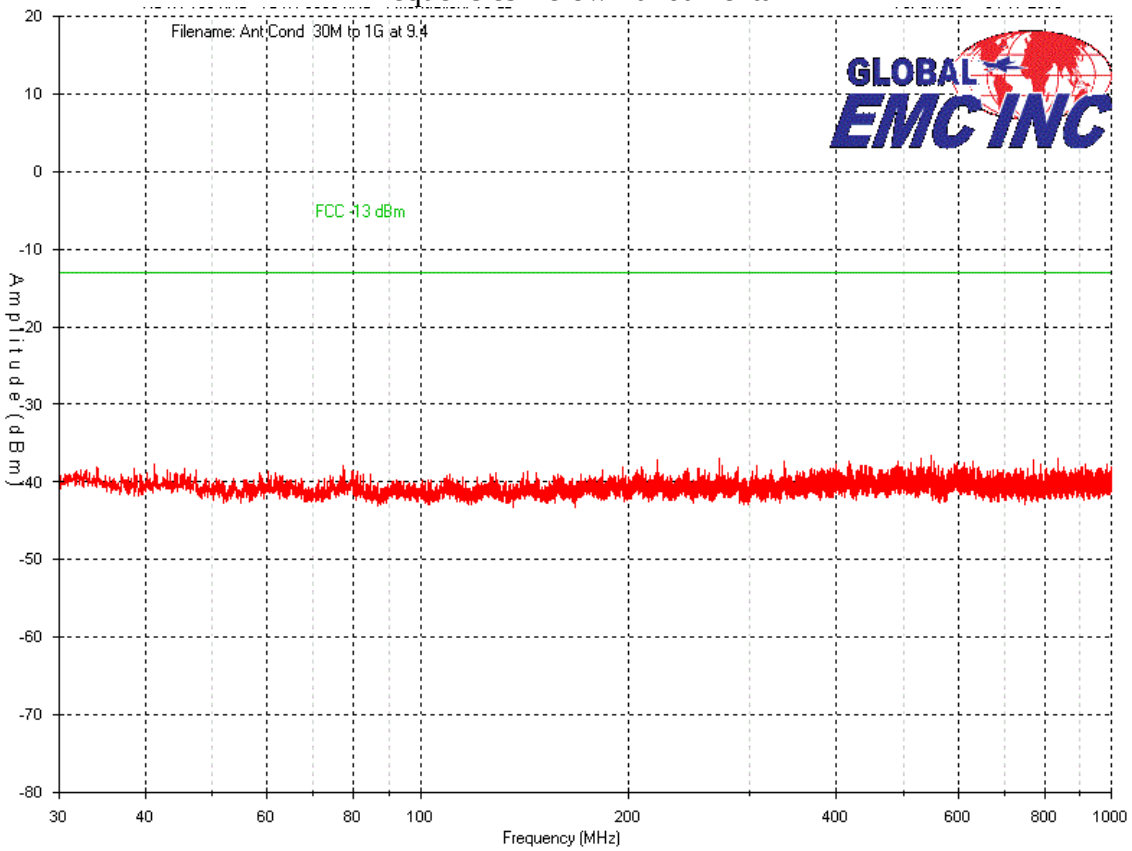
Frequencies below fundamental



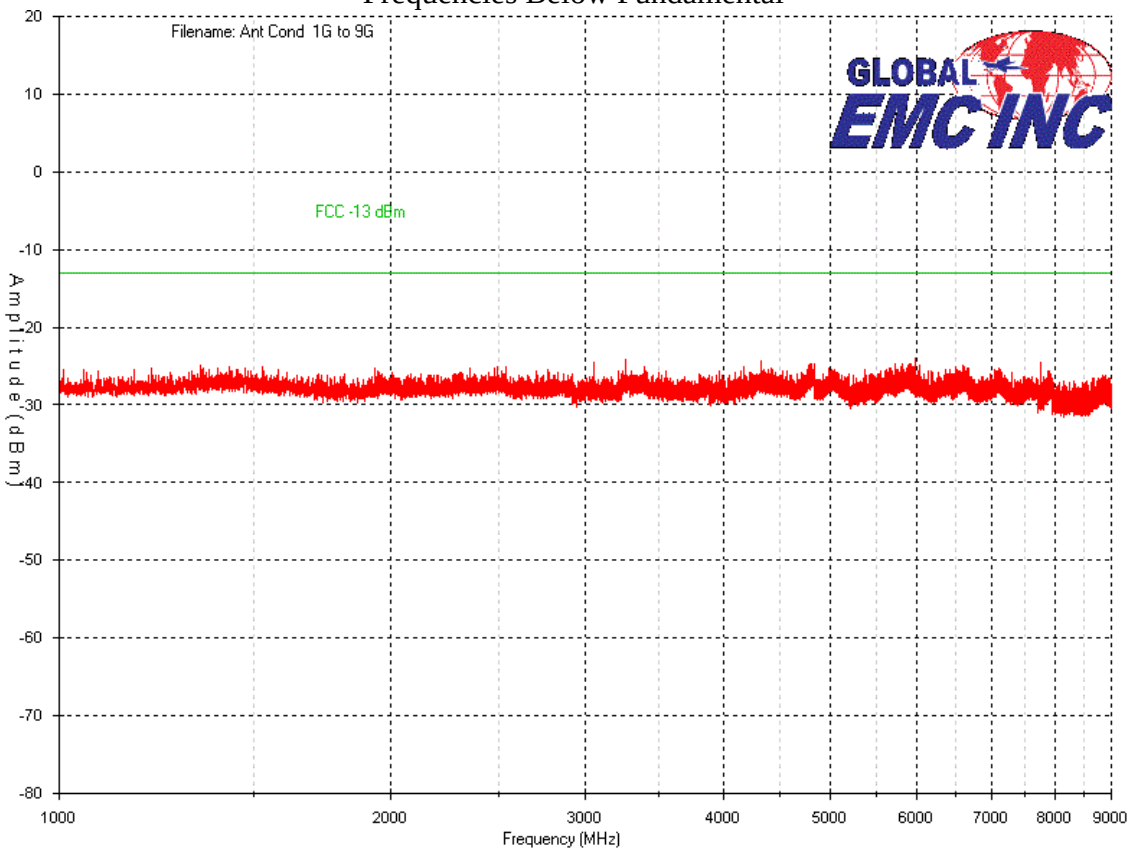
Frequencies below fundamental



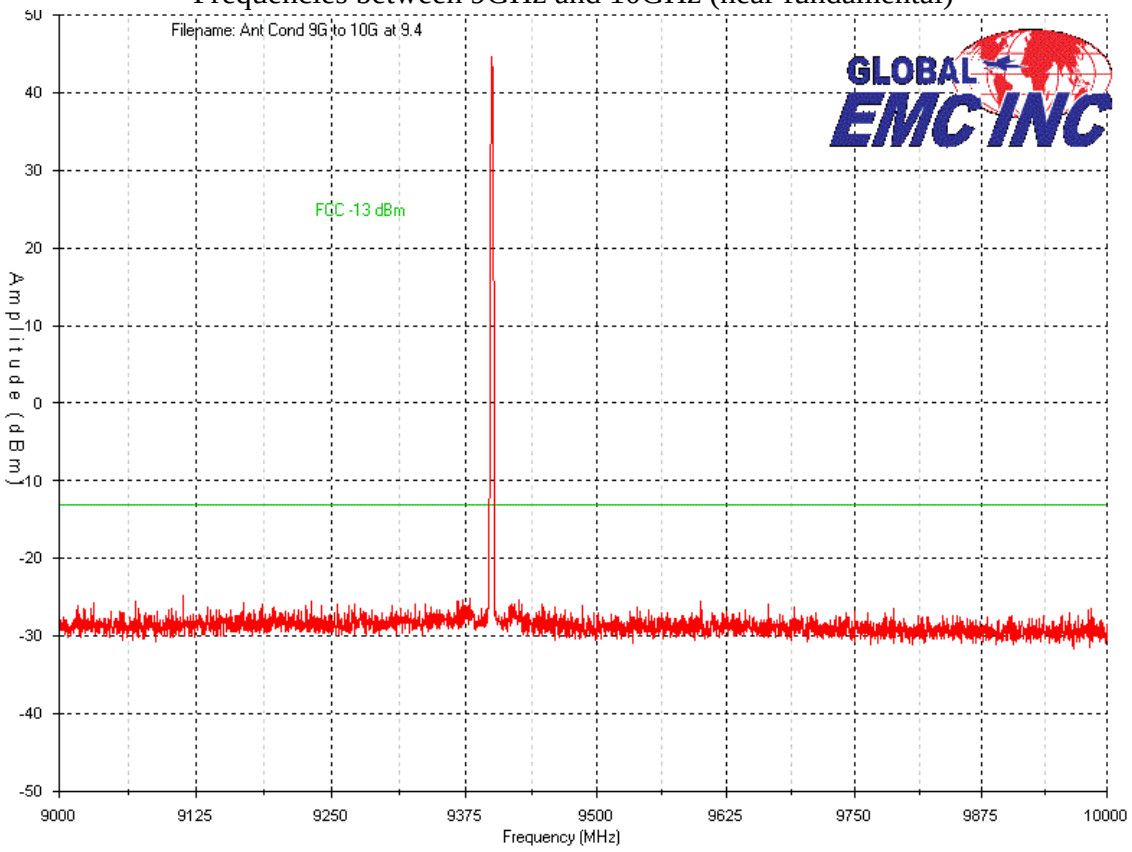
Frequencies Below Fundamental



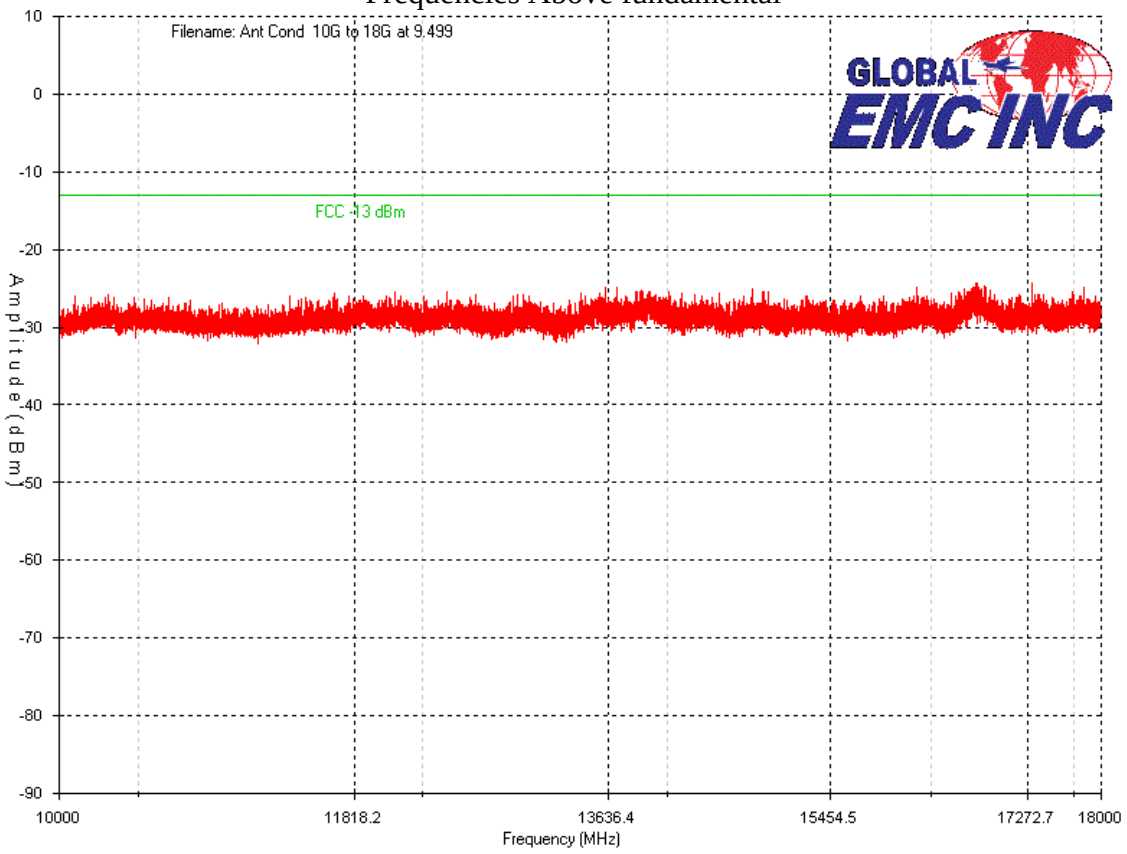
Frequencies Below Fundamental



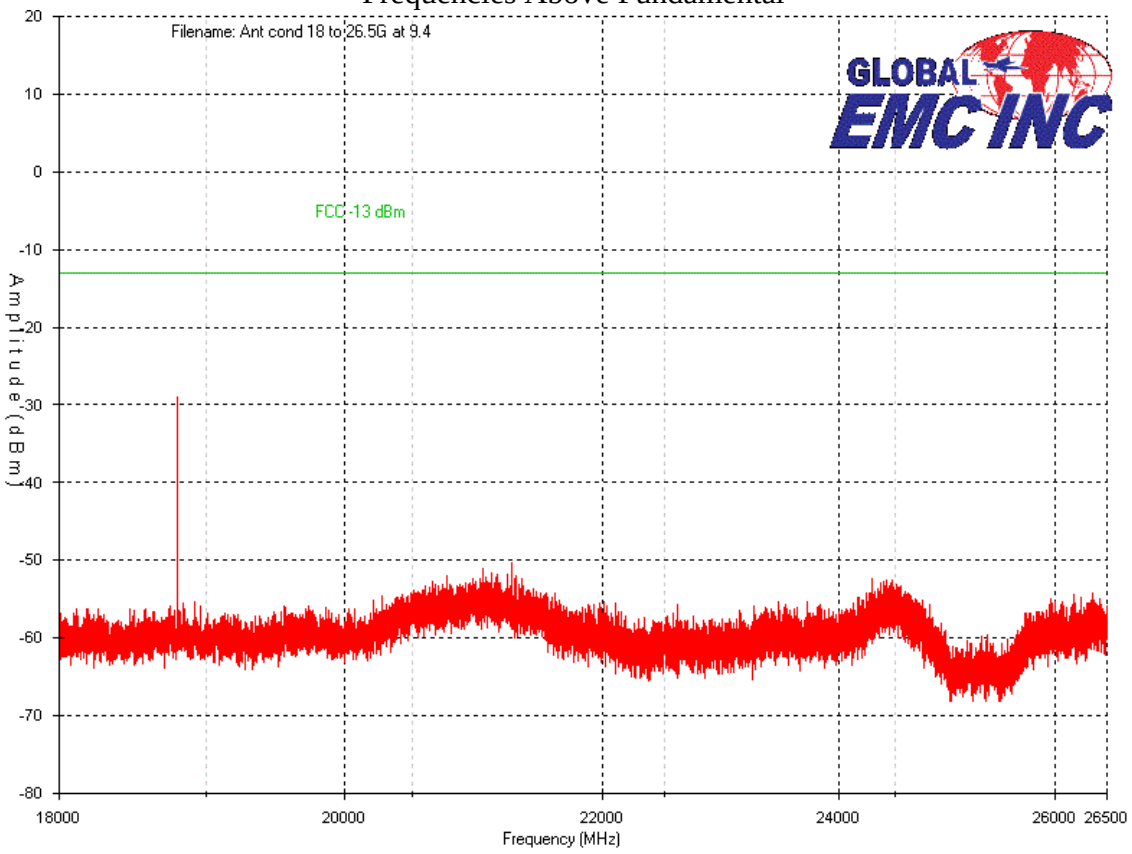
Frequencies between 9GHz and 10GHz (near fundamental)



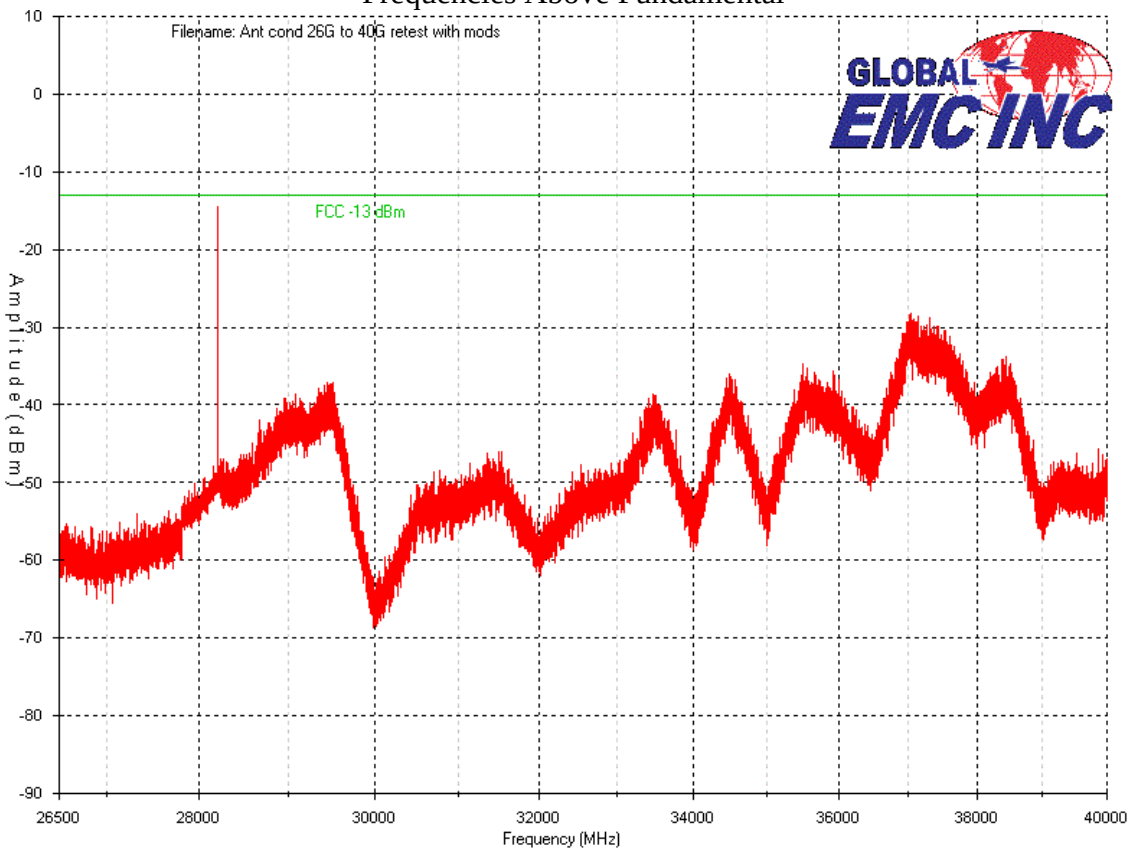
Frequencies Above fundamental



Frequencies Above Fundamental



Frequencies Above Fundamental



Note: See 'Appendix B – EUT & Test Setup Photographs' for photos showing the test set-up.

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date[1]	Next Calibration Date[1]	Asset #
Spectrum analyzer	ESU-40	Rohde & Schwarz	1/28/16	1/28/2018	4092
Horn Antenna	ATH1G18G	AR	4-23-15	4-23-17	4003
Biconical Antenna	EM-6913	Electro-Metrics	4/28/15	4/28/17	4060
Log Periodic Antenna	LPA-25	Electro-Metrics	4/14/15	4/14/17	4087
Attenuator 3 dB	FP-50-3	Trilithic	1-28-15	1-28-17	4028
LNA pre-amp	LNA-1450	RF Bay Inc.	7-22-16	7-22-17	4089
1-26.5GHz preamp	8449B	Agilent	9-9-15	9-9-17	6351
RF Cable 10m	LMR-400-10M-50OHM-MN-MN	LexTec	1-28-15	1-28-17	4025
RF Cable 7m	LMR-400-7M-50OHM-MN-MN	LexTec	1-28-15	1-28-17	4026
Emission software	0.1.87	TÜV SÜD Canada	1-28-15	1-28-17	58

Note: For cables, amplifiers and attenuators, verification applies."

Transmitter Spurious Radiated Emissions

Purpose

The purpose of this test is to ensure that the RF energy unintentionally emitted from the EUT does not exceed the limits listed below as defined in the applicable test standard, as measured from a receiving antenna. This helps protect broadcast radio services such as television, FM radio, pagers, cellular telephones, emergency services, and so on, from unwanted interference.

Limit(s) and Method

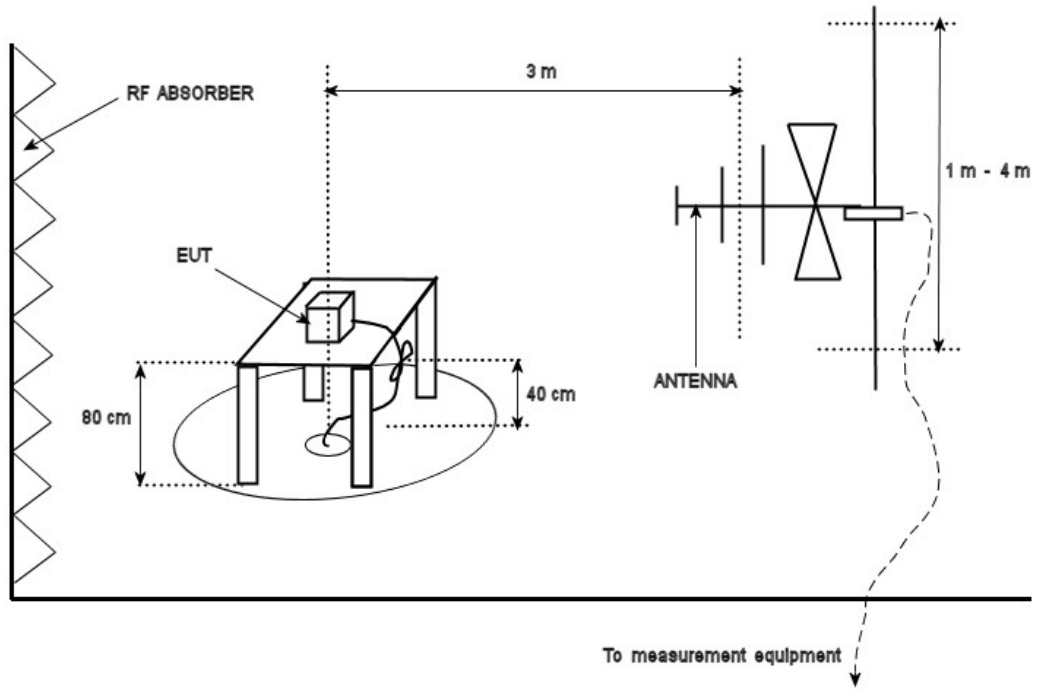
The EUT must comply with the requirements for radiated spurious emissions. These emissions must meet the limits specified in §90.210 (c) for peak measurements.

Spurious radiated emissions of the EUT was performed at 3 meters. The limit specified in FCC 90.210 (c) is 43 + 10 log(P) dBc. For all intensive purpose, the limit is -13 dBm. The approximate field strength limit for the EUT is give in the below:

E(dBµV/m) = EIRP(dBm) + 95.2
E(dBµV/m) = -13 dBm + 95.2 = 82.2 dBuV/m

This limit is applicable all emission at 3 meter measurement distance.
The Limit is with 100 kHz measurement bandwidth and using a Peak detector.

Typical Radiated Emissions Setup



Measurement Uncertainty

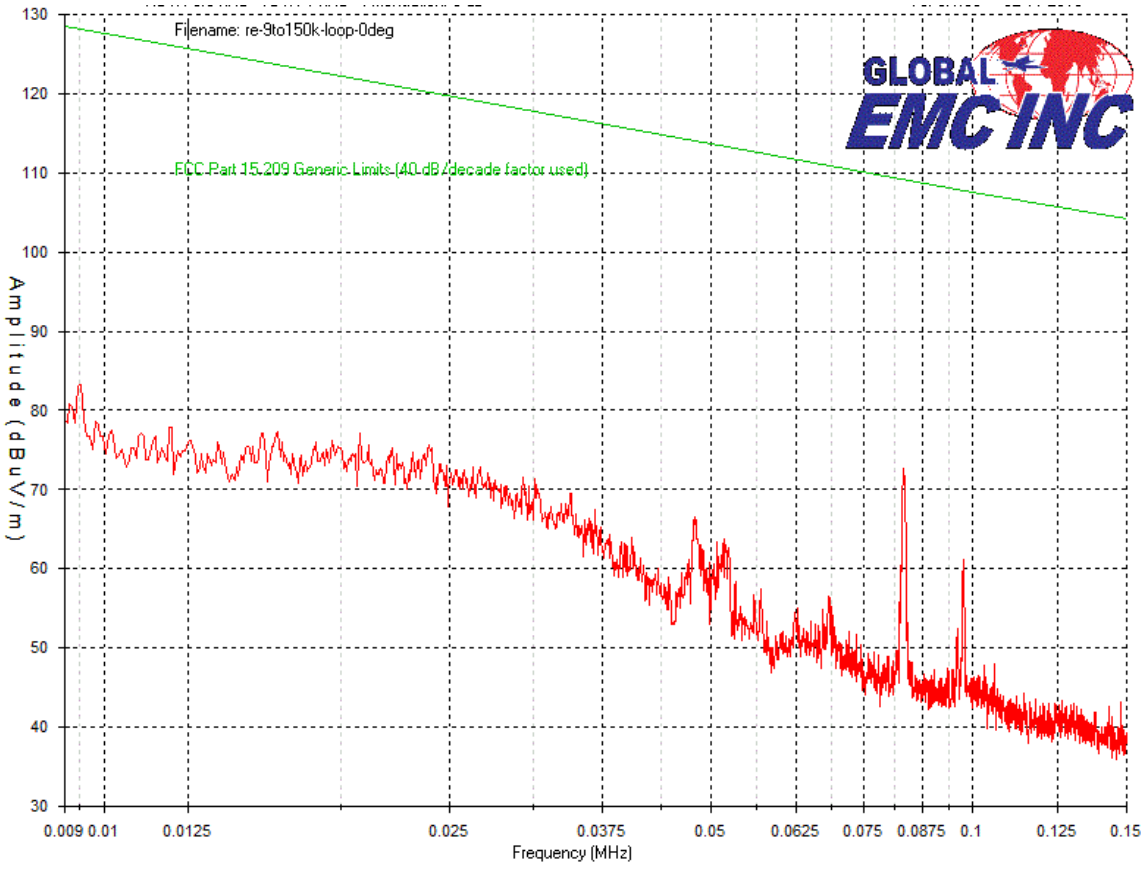
The expanded measurement uncertainty is calculated in accordance with CISPR 16-4-2 and is +/-4.4 dB with a 'k=2' coverage factor and a 95% confidence level.

Preliminary Graphs

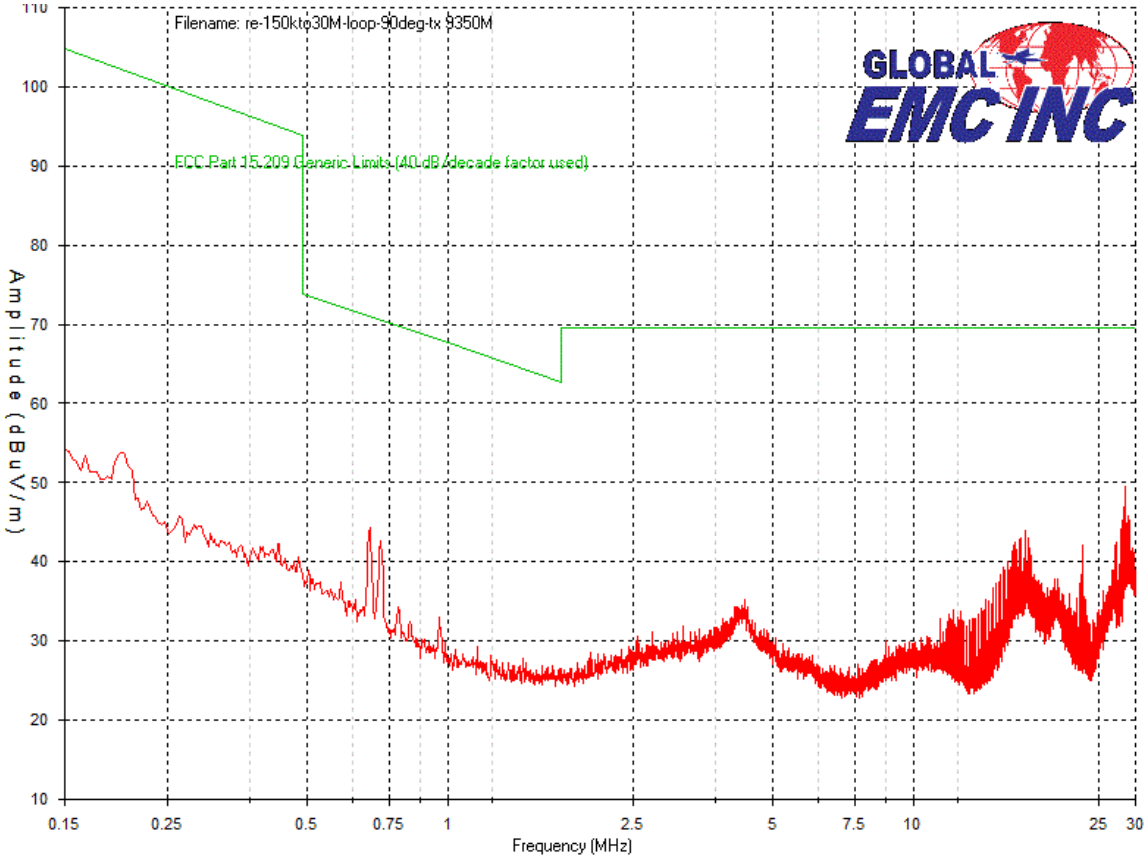
Note the graphs shown below are for graphical illustration only. For reference the 15.209 limits are graphed, but the FCC part 90 limits were applied. Once all emissions were measured, a substitute antenna was used to transmit frequencies and levels that matched the EUT emissions and EIRP was determined. ERP was calculated by subtracting 2.15 from the EIRP results and compared to the limit of -13dBm. Test results are tabulated in the Tables below. For final measurements with the appropriate detector, please refer to the final measurement table where applicable. The graph shown below is a maximized peak measurement graph, measured with a resolution bandwidth greater than the final required detector and over a full 0-360 rotation. This peaking process is done as a worst case measurement. This process enables the detection of frequencies of concern for final measurement, and provides considerable time savings.

The device was scanned to the 10^{th} harmonic or 40 GHz, whichever is lower.

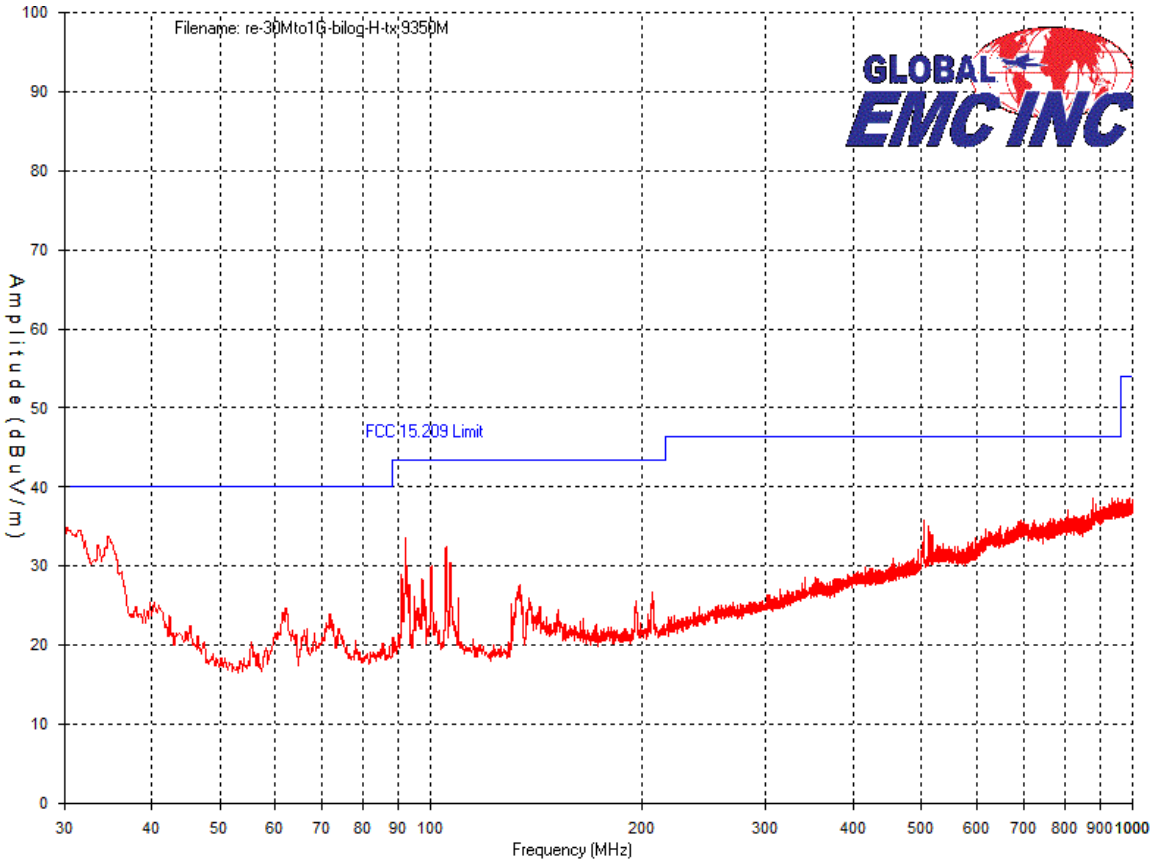
Peak Emissions
9 kHz to 150 kHz



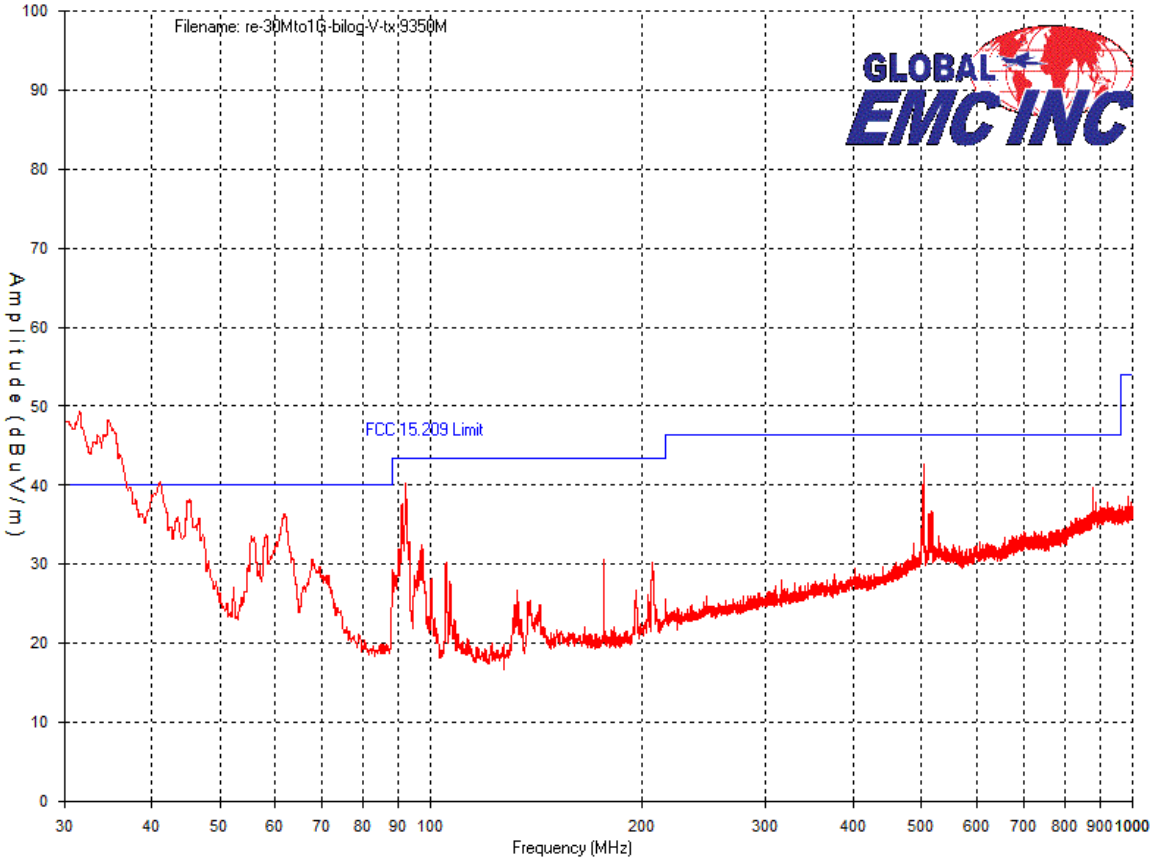
Peak Emissions
150 kHz to 30 MHz



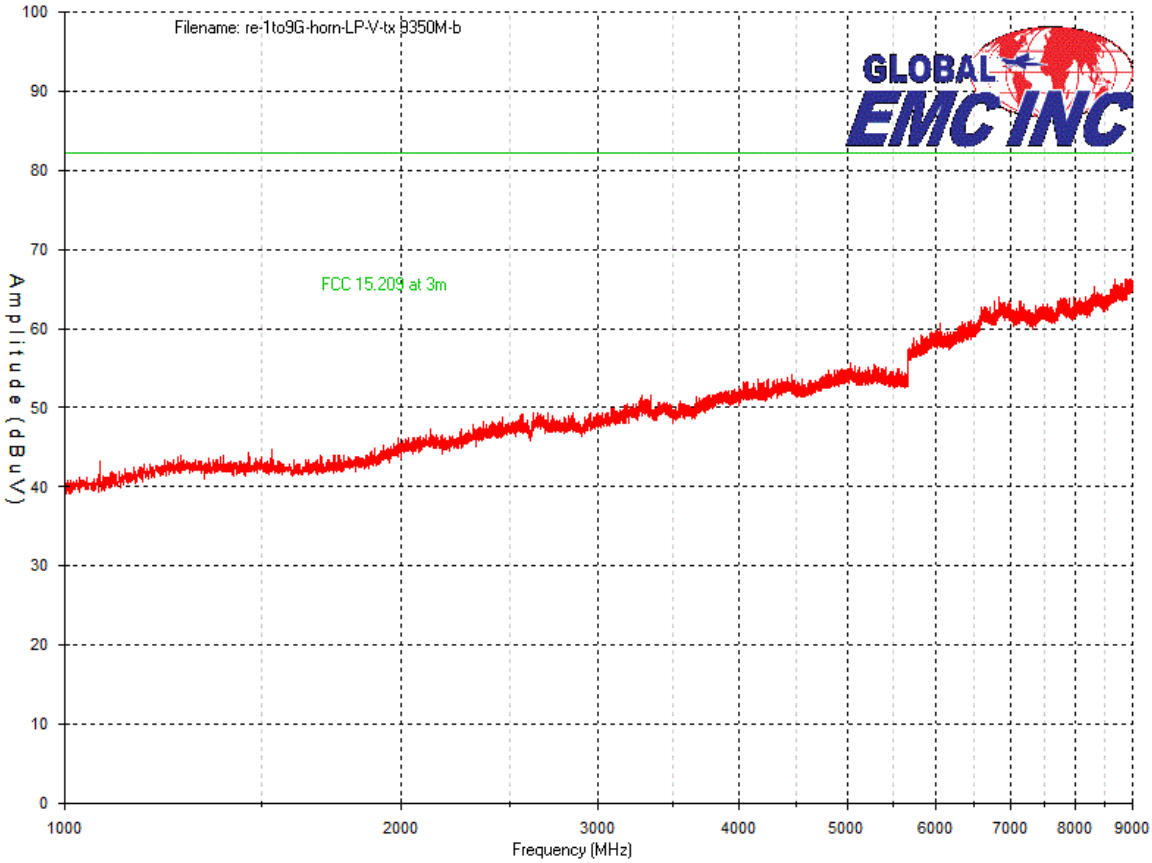
Peak Emissions – Vertical - 30 MHz to 1GHz



Peak Emissions – Horizontal - 30 MHz to 1GHz

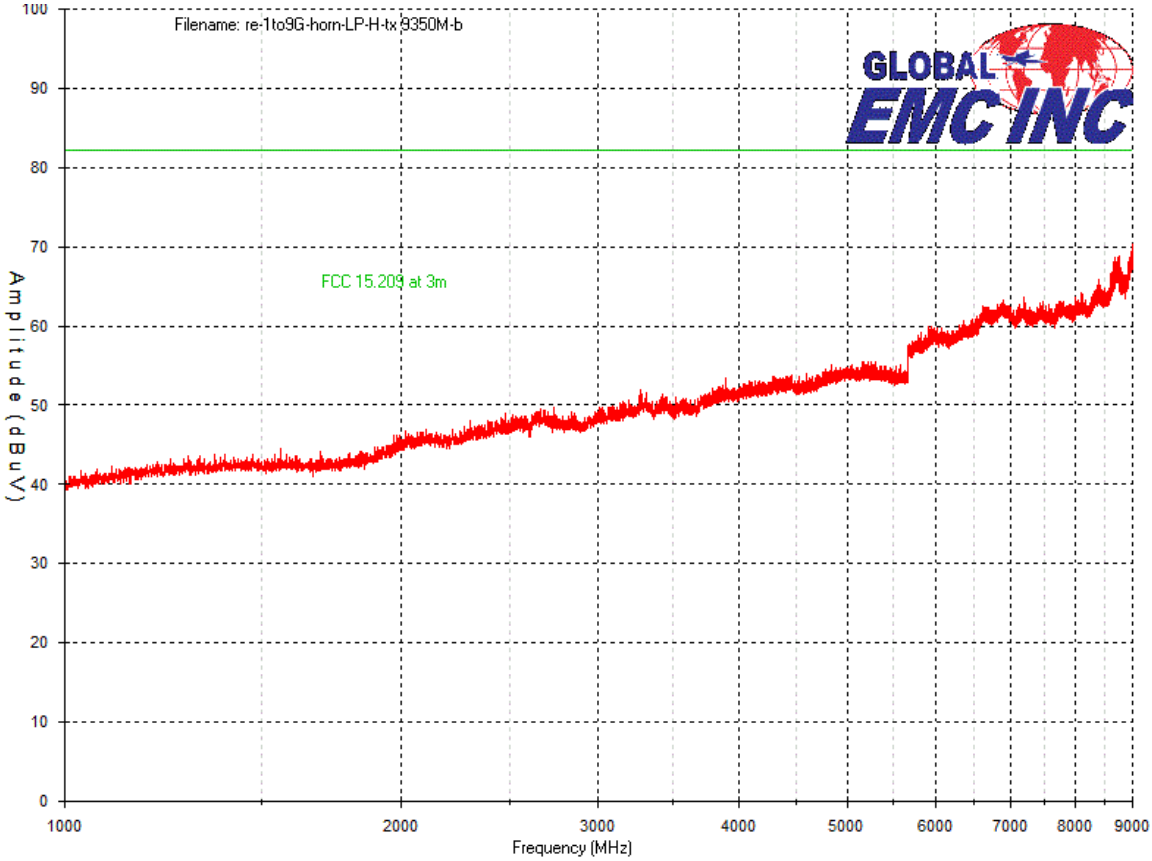


Vertical – Peak Emission Graph
1GHz – 9 GHz



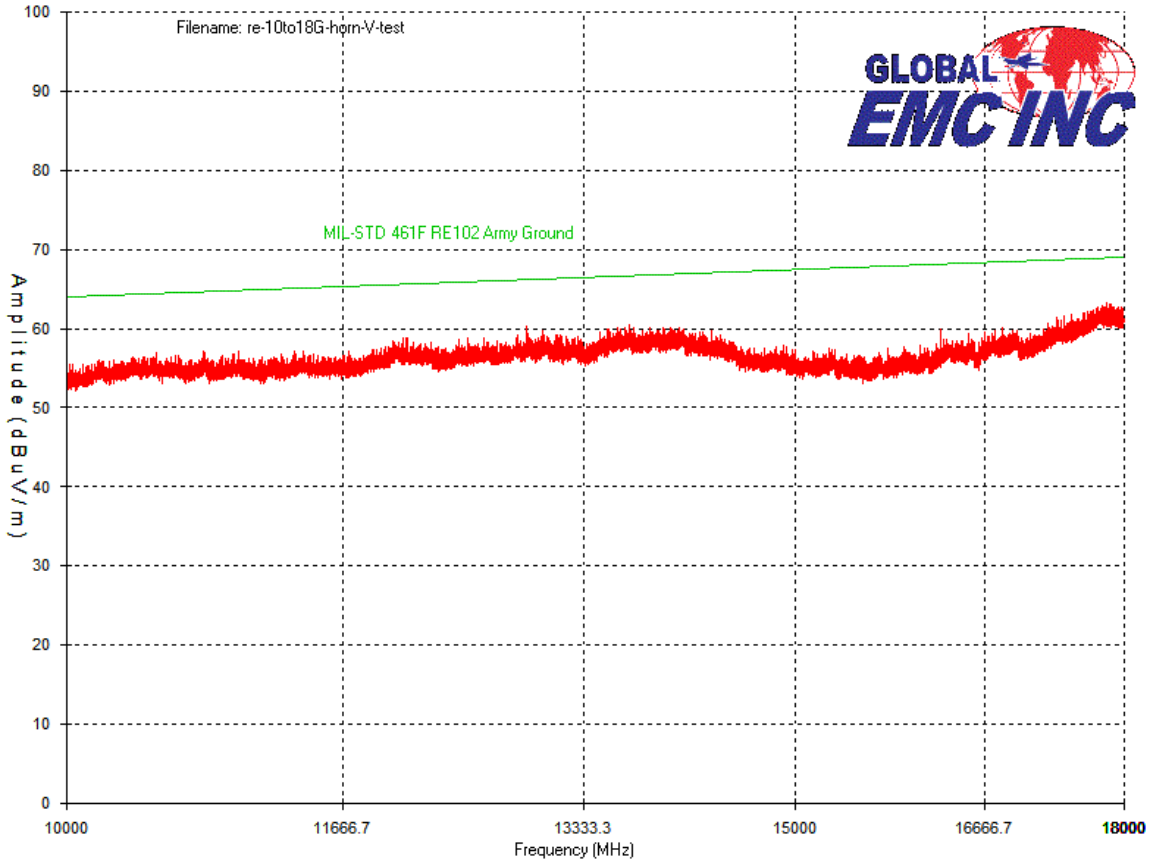
Note: no spurious emissions were detected between 9GHz and 10 GHz as per conducted spurious emissions

Horizontal – Peak Emisisons Graph
1GHz – 9 GHz

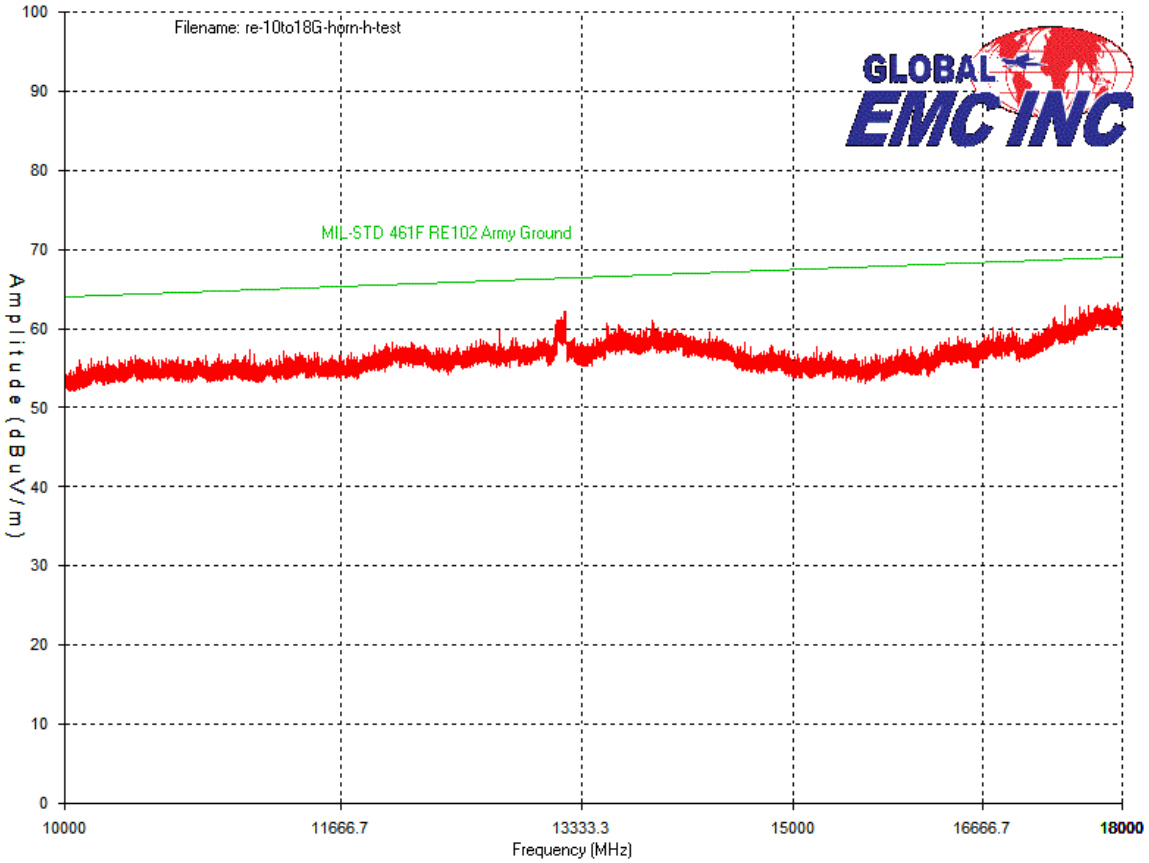


Note: no spurious emissions were detected between 9GHz and 10 GHz as per conducted spurious emissions

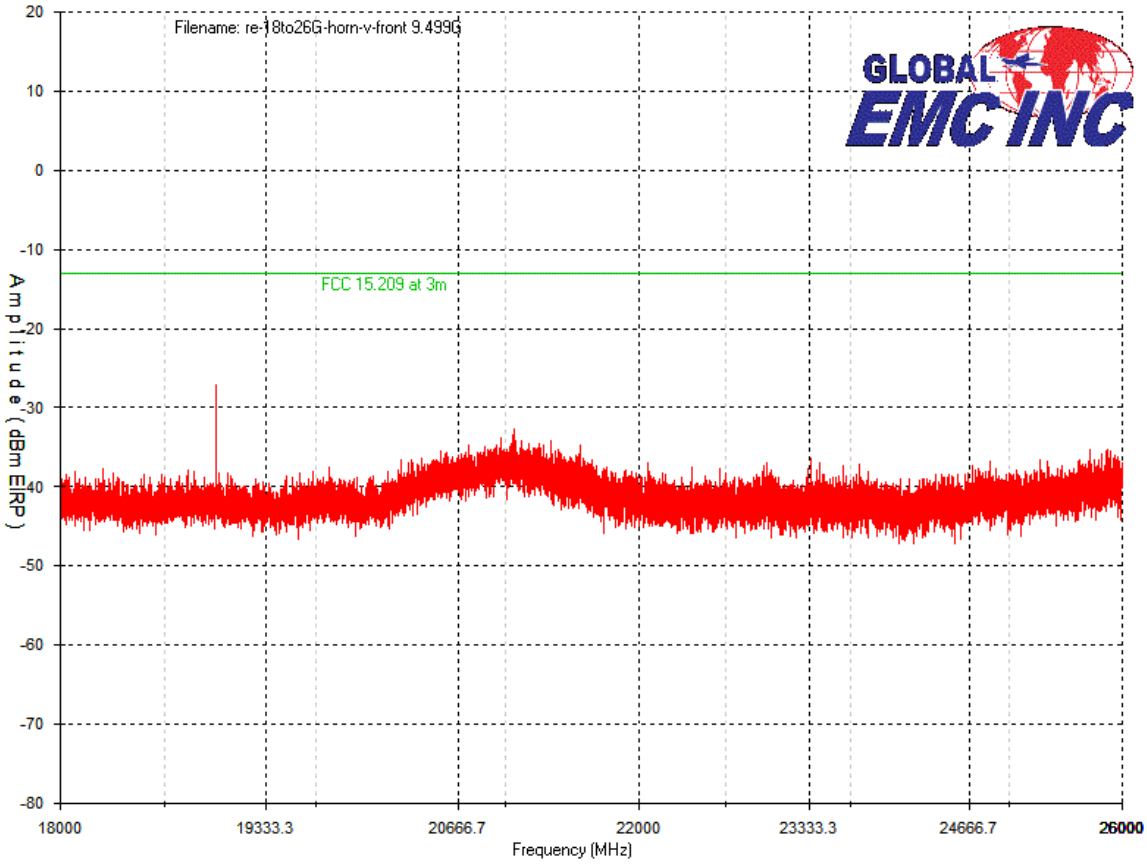
Peak Emission Graph
Vertical 10 GHz to 18 GHz



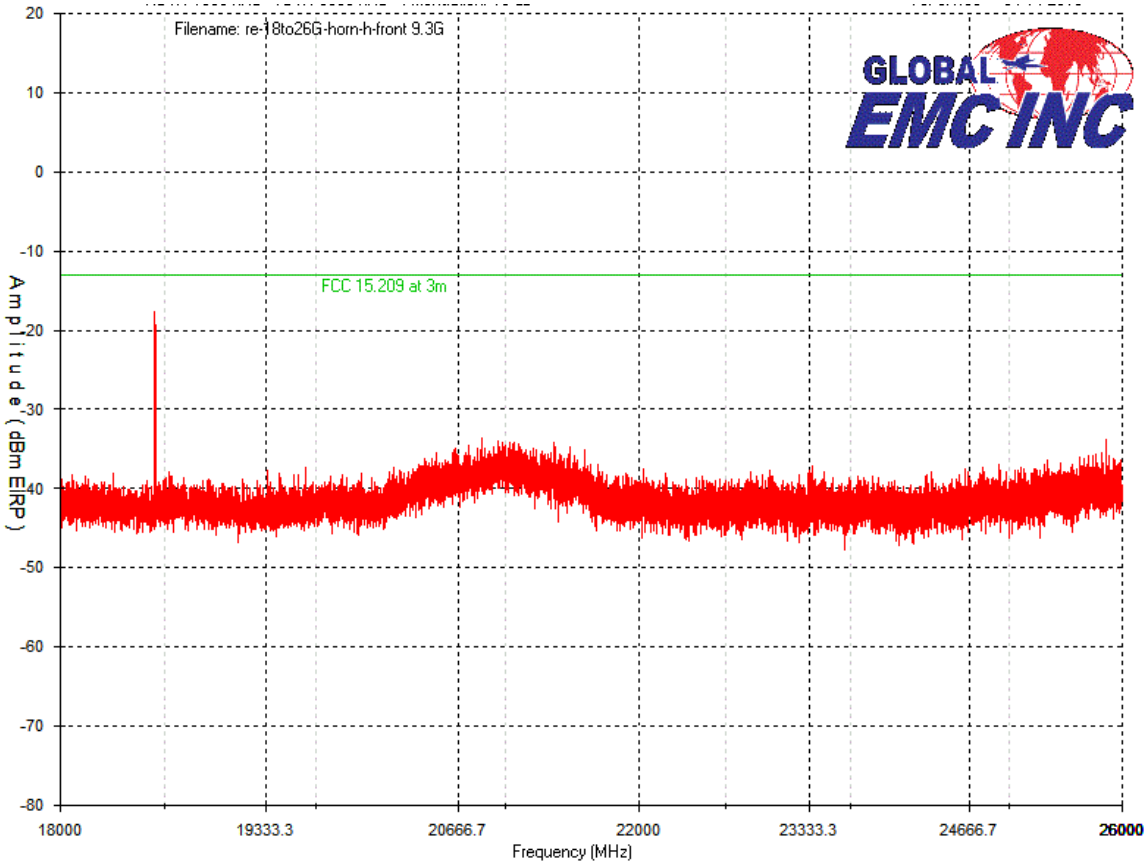
Peak Emission Graph
Horizontal
10 GHz to 18 GHz



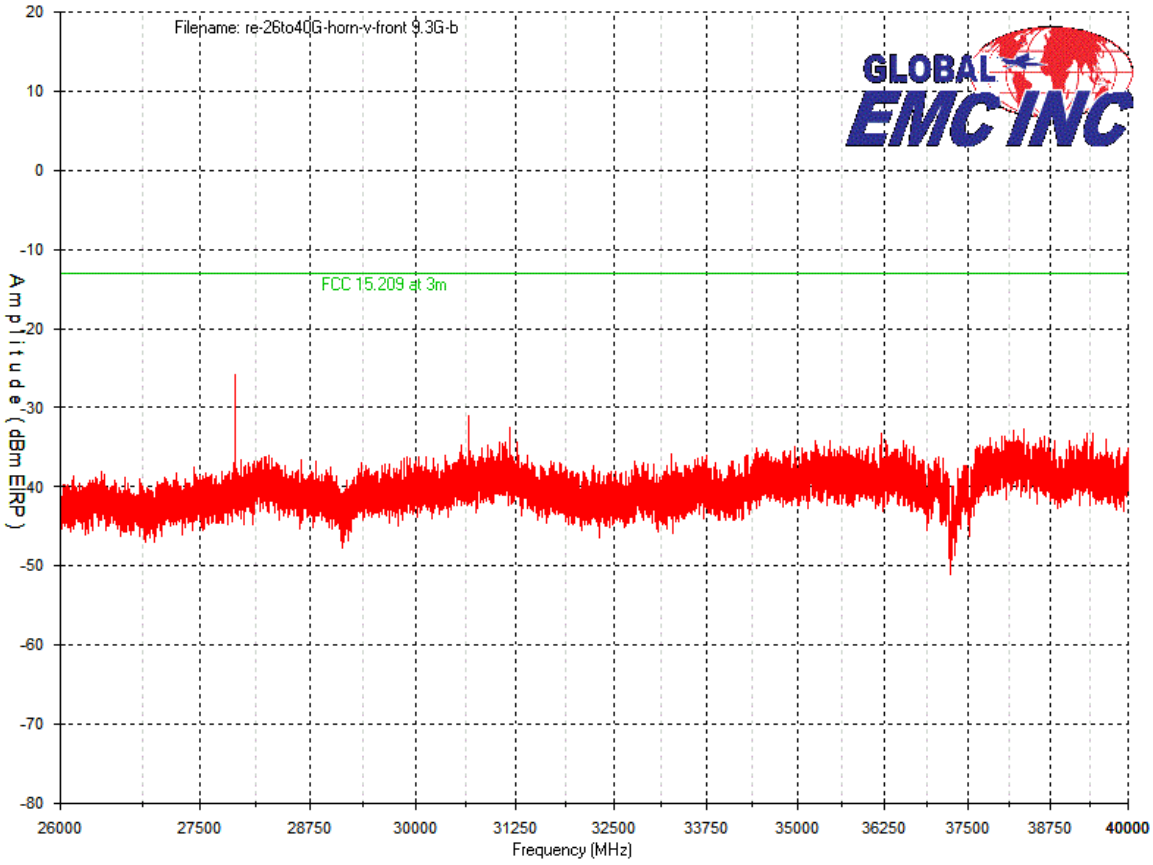
Peak Emissions Graph
Vertical 18G to 26GHz



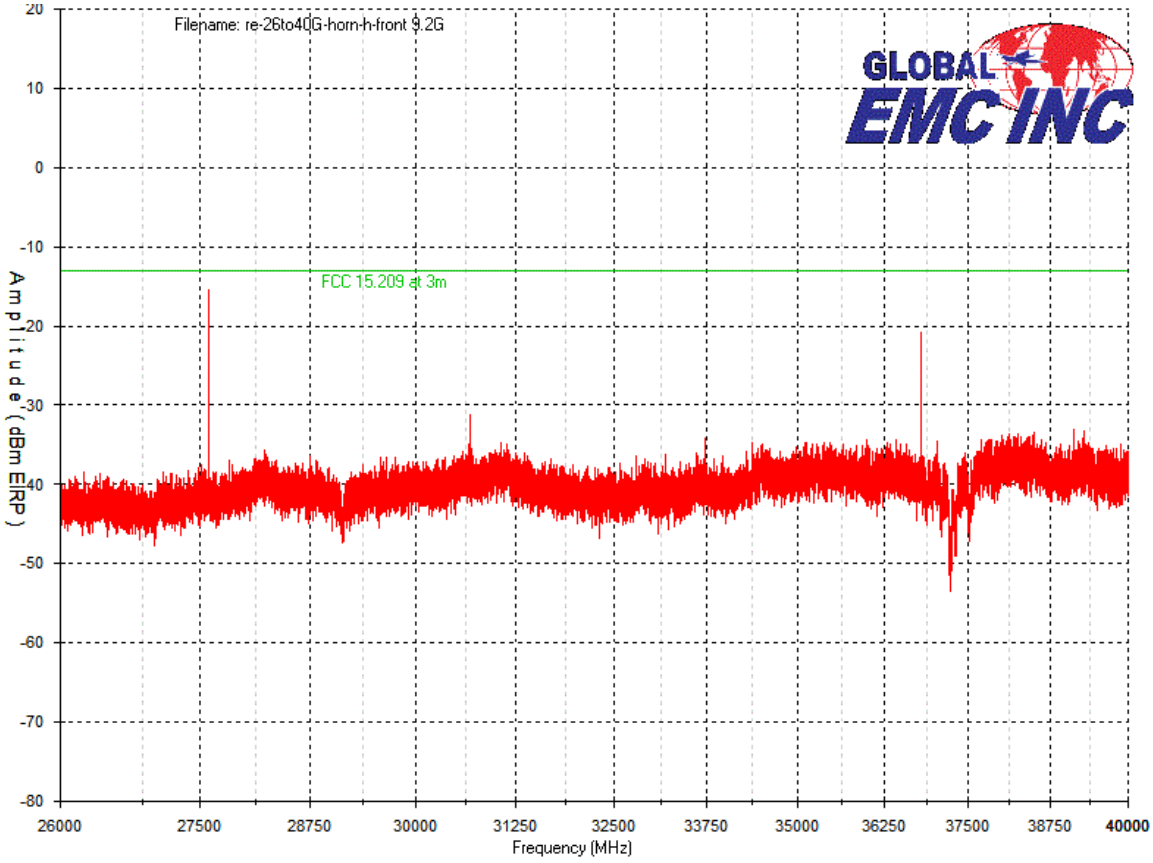
Peak Emissions Graph
Horizontal 18 GHz to 26 GHz



Peak Emissions Graph
Vertical 26GHz to 40 GHz



Peak Emissions Graph
Horizontal 26 GHz to 40 GHz



Results

Pass.

The EUT meets the Transmitter Spurious Radiated Emissions requirements.

All scan were perform with a measurement bandwidth greater than the required bandwidth. No peak emissions were above the limit.

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date[1]	Next Calibration Date[1]	Asset #
Spectrum Analyzer Display	8566B	HP	1-28-15	1-28-17	4168
Spectrum Analyzer	8566B	HP	1-28-15	1-28-17	4169
Spectrum analyzer	ESU-40	Rohde & Schwarz	1/28/16	1/28/2018	4092
Horn Antenna	ATH1G18G	AR	4-23-15	4-23-17	4003
Biconical Antenna	EM-6913	Electro-Metrics	4/28/15	4/28/17	4060
Log Periodic Antenna	LPA-25	Electro-Metrics	4/14/15	4/14/17	4087
Attenuator 3 dB	FP-50-3	Trilithic	1-28-15	1-28-17	4028
LNA pre-amp	LNA-1450	RF Bay Inc.	7-22-16	7-22-17	4089
1-26.5GHz preamp	8449B	Agilent	9-9-15	9-9-17	6351
RF Cable 10m	LMR-400-10M-50OHM-MN-MN	LexTec	1-28-15	1-28-17	4025
RF Cable 7m	LMR-400-7M-50OHM-MN-MN	LexTec	1-28-15	1-28-17	4026
Emission software	0.1.87	TÜV SÜD Canada	1-28-15	1-28-17	58

Temperature Frequency Stability

Purpose

The purpose of this test is to ensure that the RF energy unintentionally emitted from the EUT does not exceed the permitted bandwidth during extreme temperature variations. This helps protect radio broadcasts and receivers with spectrum nearby to the equipment under test from unwanted interference. This also helps ensure proper reception of the intended signal by ensuring the transmit frequency is correct in any temperature.

Limit(s) and Method

The methods are given in FCC Part 2.1055. Frequency tolerance is specified by the station authority.

However, the device meets the following condition:

Frequency tolerances measurements are taken for information purpose. Frequency must be maintained from -30 C to +50 C. The EUT is monitored at each 10 degree increment. At each temperature, the device is checked after a stabilization period required for the device to reach the temperature.

Measurement Graphs

The worst case results are presented, with the frequency shown. The device was checked at each 10 degree increment of temperature

-30 C (max cold)

+50C (max heat)

Table

Worst case readings appears at 9350 MHz.

Test Condition	Set Frequency	Measured Frequency (MHz)	Deviation (Hz)	Frequency Drift (ppm)
-30°C	9350	9349.998325	1675	0.179144385
20C (room temperature)	9350	9349.998320	1680	0.179679144
+50°C	9350	9349.998313	1687	0.180427807

Note: No frequency deviation was observable when the supplied voltage was varied from +85% to 115% of nominal.

Test Equipment List

Equipment	Model No.	Manufacturer	Last calibration date	Next calibration due date	Asset #
Spectrum Analyzer Display	8566B	HP	1-28-15	1-28-17	4168
Power Attenuator 20 dB	25-A-FFN-20	Bird / Hutton	NCR	NCR	GEMC 49
RF Cable 7m	LMR-400-7M-50OHM-MN-MN	LexTec	NCR	NCR	GEMC 28
Environmental Chamber	SM-32-7800	Thermotron	NCR	NCR	GEMC 153

This report module is based on GEMC template "FCC - 15.225 - RFID Freq Stab_Rev1.doc"

Appendix A – EUT Summary

For further details for filing purposes, refer to filing package.

General EUT Description

Client Details	
Organization / Address	FLIR Radars a subsidiary of FLIR Systems, Inc., Surveillance Group 120-3440 Francis-Hughes, Laval, QC H7L 5A9 Canada
EUT (Equipment Under Test) Details	
EUT Name (for report title)	**The Ranger®** **R20SS ground-surveillance radar**
EUT Model / SN (if known)	See FCC Label exhibit
EUT revision	On file at Flir Radars
Software version	N/A
Equipment category	Radar
Input voltage range(s) (V)	28VDC
Frequency range(s) (Hz)	N/A
Nominal power consumption (W)	
Number of power supplies in EUT	1
Transmits RF energy? (describe)	Yes
Testing is required for the following standards	FCC 90as transmitter and verification as receiver required under FCC 15.
Basic EUT functionality description	See separate document CONF FCCID_Operation Description
High level block diagram of EUT (attachment)	See separate document CONF FCCID_Operation Description
Modes of operation	See separate document CONF FCCID_Operation Description
Customer to setup EUT on site?	Yes
Frequency of all clocks present in EUT	See block diagram and schematics

I/O cable description Specify length and type	N/A
Available connectors on EUT	See separate document CONF FCCID_Operation Description
Peripherals required to exercise EUT Ex. Signal generator	None

Note the EUT is considered to have been received the date of the commencement of the first test, unless otherwise stated. For a close-up picture of the EUT, see 'Appendix B – EUT & Test Setup Photographs'.

EUT Configurations

Please see Appendix B for a picture of the unit running in normal conditions.

- During Transmitter spurious radiated emissions, RF output was dissipated in a 50 Ω load.
- Cables and earthing are connected as per manufacturer's specification.

Operational Setup

These devices are required to be attached to the EUT for its normal operation.

- The EUT transmits continuously, swept FM-CW.

Appendix B – EUT and Test Setup Photographs

Note: These photos are for information purposes only. Also refer to PDF files that are separate from this test report.

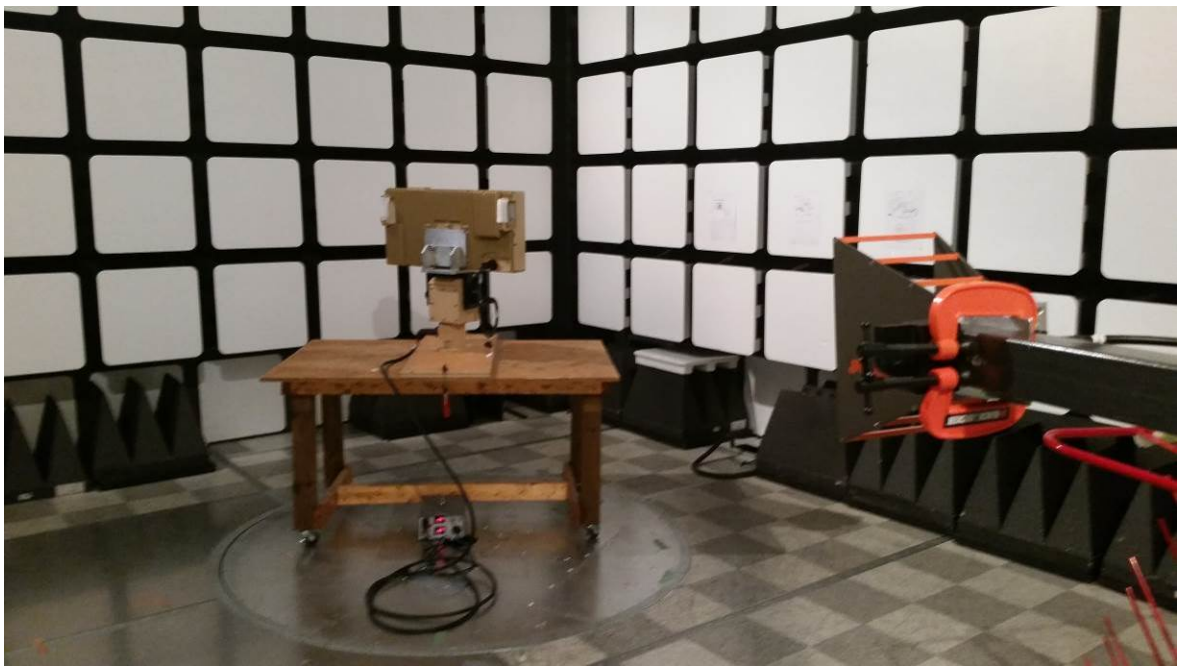
EUT

Antenna Conducted Emissions Setup Photo

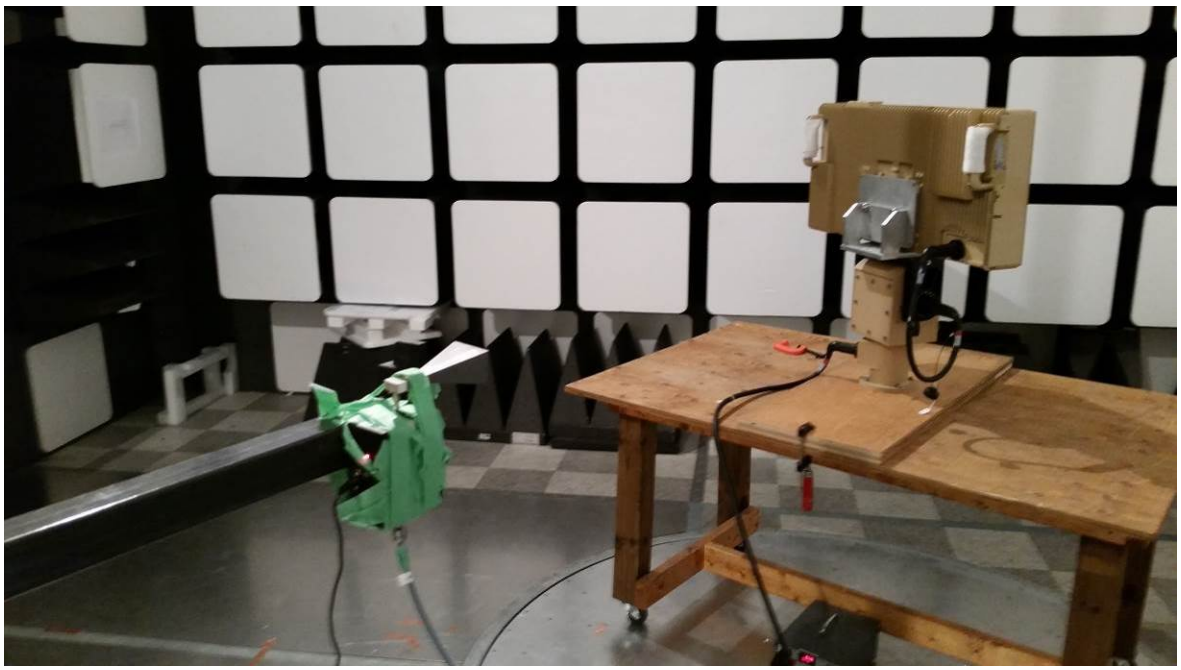
Radiated Emissions Photo – 9K to 30 MHz - Scan

Radiated Emissions – 30 MHz to 1 GHz – Scan

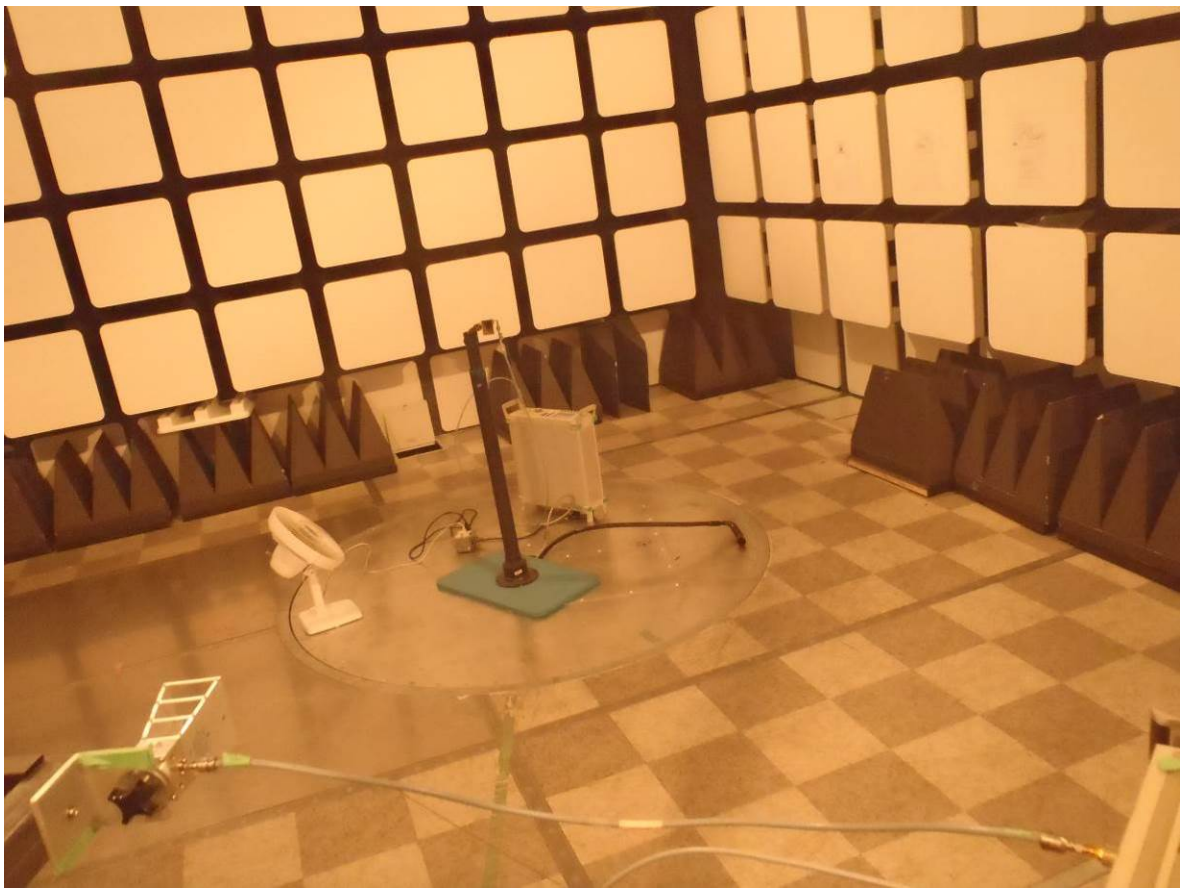
Radiated Emissions 1 GHz to 18 GHz – Scan



Radiated Emissions 18 GHz to 26 GHz scan



Radiated Emissions – 18 GHz to 26 GHz - Substitution



Radiated Emissions 26 GHz to 40 GHz – Scan