Project 20131-15

Sagetech Avionics, Inc.

MXS, MXS-NC, MXR, MX12B

Transponder
1090 & 1030 MHz Transceiver

Wireless Certification Report

FCC Part 87

Prepared for:

Sagetech Avionics, Inc.
1000 E Jewett Blvd
PO Box 832
White Salmon, WA 98672

By

Professional Testing (EMI), Inc.
1601 North A.W. Grimes Blvd., Suite B
Round Rock, Texas 78665

3 Oct 2018

Reviewed by

Larry Finn
Chief Technical Officer

Written by

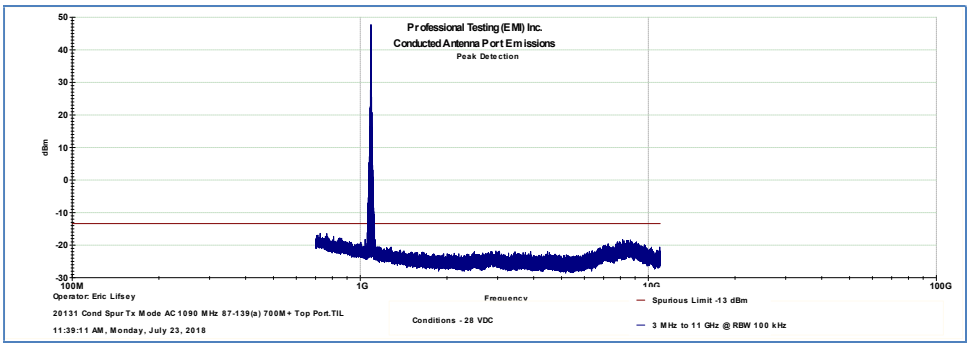
Eric Lifsey
EMC Engineer

Revision History

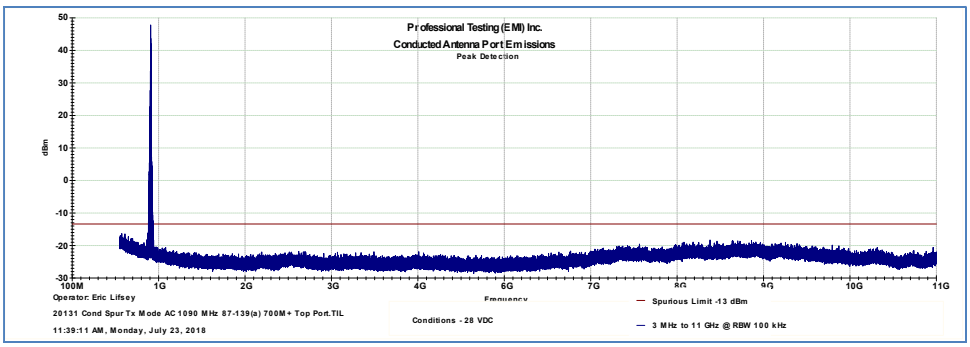
Revision Number	Description	Date
DRAFT 02	Draft for review.	11 Sep 2018
Final 04A	Revised applicant name/address, page headers/title. No change to data.	22 Feb 2021

Errata:

Regarding plotted peak conducted emission data in sections 5.3.1 through 5.3.3. The 700 MHz to 11 GHz plots have an X axis frequency artifact (due to conversion from log to linear scale to overcome graph compression) that misaligns the data with the X axis scale markings for frequency. The effect makes the fundamental signal appear low in frequency. The same dataset is used for the Mask Detail presentation, below these same graphs, and they are precisely on the operating frequency. The effect is shown below.



Example Original Measurement in Log Scale



Same Dataset in Linear Scale Presentation

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Certificate of Compliance

Applicant	Device & Test Identification	
Sagetech Avionics, Inc. 1000 E Jewett Blvd PO Box 832 White Salmon, WA 98672 Certificate Date: 3 Oct 2018	Model(s): FCC ID: Laboratory Project ID:	MXS, MXR, MXS-NC, and MX12B YT5MX 20131-15

The EUT model(s) listed above were tested utilizing the following documents and found to be in compliance with the required criteria.

47 CFR, FCC Part 87 and Part 2	
Section	**Description**
87.131; 2.1046	Power and emissions; conducted output power
87.135; 87.137; 2.1049	Bandwidth of & type of emission; occupied bandwidth: 14M0M1D
2.1047	Modulation characteristics
87.139(a); 2.1051	Emission limitations; Spurious/harmonic emissions at antenna terminals
87.139(a); 2.1053	Emission limitations; radiated/conducted emissions 30 MHz - 11 GHz
87.133; 2.1055(a)(1)	Frequency stability; *Aeronautical utility mobile stations on 1090 MHz; 1000 ppm.*
87.143	Transmitter control requirements

I, Eric Lifsey, for Professional Testing (EMI), Inc., being familiar with the above rules and test procedures have reviewed the test setup, measured data, and this report. I believe them to be true and accurate.

Eric Lifsey
EMC Engineer

This report has been reviewed and accepted by the Applicant**.** The undersigned is responsible for ensuring that this device will continue to comply with the requirements listed above.

_____
Representative of Applicant

1.0 Introduction

1.1 Scope

This report describes the extent to which the equipment under test (EUT) conformed to the intentional radiator requirements of the United States.

1.2 EUT Description

Table 1.2.1 Equipment Under Test			
Manufacturer & Description	**Model**	**Serial #**	**Photo**
Sagetech Avionics, Inc. Transponder for 1090 MHz and 1030 MHz	MXS (1090 MHz) MXR (1030 MHz) and MX12B	none	
Model(s) Represented By Above:	MXS-NC		
Operating Voltage:	14 VDC nominal; 10 – 32 VDC overall		

Table 1.2.2 Compliance Statements	
Requirement	**Compliance Statement**
FCC 87.143	Power control requirement; power is removed at the aircraft operator's position by the user either removing power from the EUT itself, pulling the circuit breaker, or removing the power plug at the end of the power cable.

This device operates in two modes/frequencies allocated for aircraft transponders. The electronics are identical on both operating frequencies. The operating frequency is associated with a unique model designation for each frequency.

The MXS 1090 MHz model employs two antenna ports designated Top and Bottom.

The MXR 1030 MHz model uses only the Bottom antenna port.

The MX12B is identical hardware with characteristics confidential to the US military.

1.3 EUT Operation

The EUT was exercised in a manner consistent with normal operations. To insure accurate measurement, the EUT was placed into higher than normal duty cycle modes.

The EUT operates on two fixed frequencies separated by 60 MHz. These serve as the highest

and lowest test frequencies. There are no frequencies in between so there is no center channel to measure.

1.4 Modifications to EUT

None.

1.5 Test Site

Radiated measurements were made at the PTI semi-anechoic facility designated Site 45 (FCC 459644, IC 3036B-1) in Austin, Texas. The site is registered with the FCC under Section 2.948 and Industry Canada per RS-GEN, and is subsequently confirmed by laboratory accreditation (NVLAP). The test site is located at 11400 Burnet Road, Austin, Texas 78758, while the main office is located at 1601 North A.W. Grimes Boulevard, Suite B, Round Rock, Texas, 78665.

Professional Testing (EMI), Inc., (PTI) follows the guidelines of National Institute of Standards and Technology (NIST) for all uncertainty calculations, estimates, and expressions thereof for electromagnetic compatibility testing.

1.6 Measurement Correction Methods

Table 1.6 1 Measurement Corrections

Parameter	From Sums Of
Radiated Field Strength	Raw Measured Level + Antenna Factor + Cable Losses – Amplifier Gain
Conducted Antenna Port	Raw Measured Level + Attenuator Factor + Cable Losses
Conducted Mains Port	Raw Measured Level + LISN Factor + Cable/Filter/Limiter Losses

Additionally, measurement distance extrapolation factors (such as 1/d above 30 MHz) are applied and documented where used.

2.0 Applicable Documents

Table 2.0.1: Applicable Documents	
Document #	**Title/Description**
TIA/EIA 603C 2004	Land Mobile FM or PM Communications Equipment, Measurement and Performance Standards
47 CFR	FCC Part 87 – Subpart D – Technical requirements FCC Part 2 – Subpart J – Equipment authorization procedures
RTCA DO-185B	MINIMUM OPERATIONAL PERFORMANCE STANDARDS FOR TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM II (TCAS II)

3.0 Conducted Output Power at Antenna Terminal

3.1 Test Procedure

The output of the EUT was connected directly to an attenuator and then to the spectrum analyzer. A peak detector was used for the measurement. The transmitter was switched on, and the measurement receiver was tuned to the frequency of the transmitter under test. Power was measured with added fixed external attenuation. The spectrum analyzer used a resolution bandwidth greater than the measured occupied bandwidth of the transmitter.

3.2 Test Criteria

Table 3.2.1 Authorized Power, 87.131 (Radionavigation Unspecified), 2.1046
Minimum 125 Watts per RTCA/DO-181D

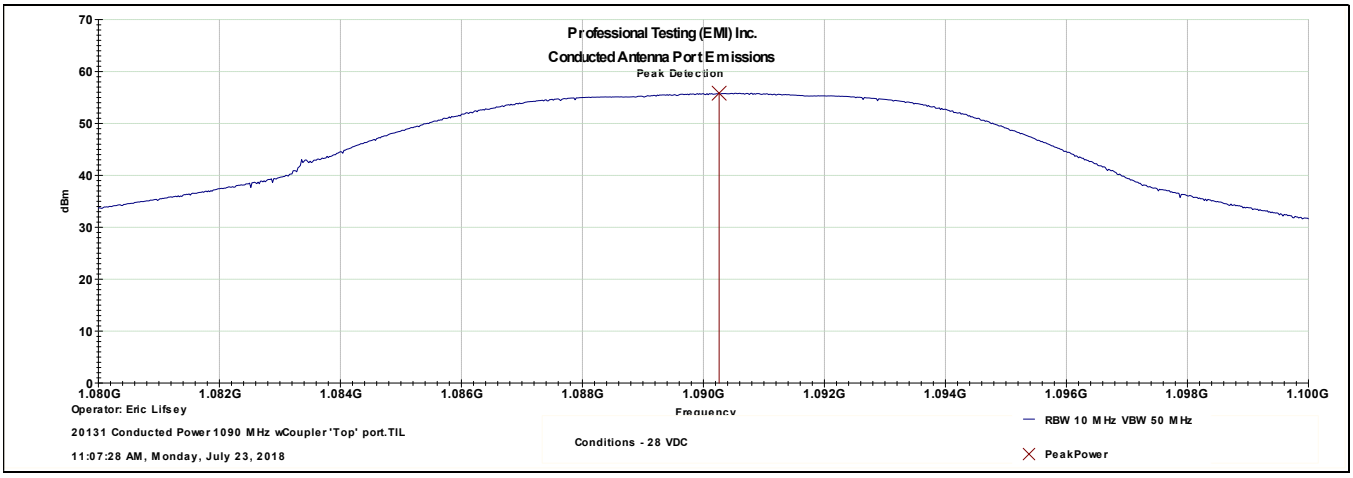
3.3 Test Results

Table 3.3.1 Peak Power Measured In 10 MHz RBW, 50 MHz VBW	
1090 MHz; Top Port	55.8 dBm or 380 Watts
1090 MHz; Bottom Port	55.4 dBm or 347 Watts
1030 MHz; Top Port	*Not supported, not applicable.*
1030 MHz; Bottom Port	57.2 dBm or 525 Watts

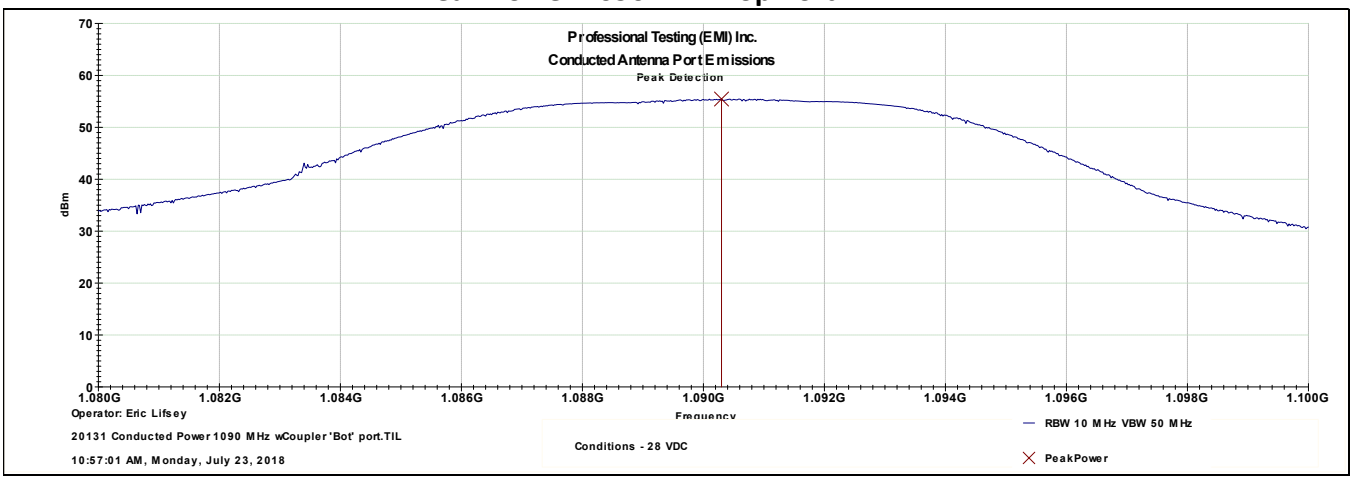
Table 3.3.2 Calculated Duty Cycle and Average Power; 1090 MHz	
Measured Power (P_{peak})	55.8 dBm or 380 Watts
Transmit Times (µs)	Per DO-181E: 500 Mode A/C, 50 Mode S replies, 6.2 Squitters/second
Total Transmit Time	7215 **µs**
Maximum Duty Cycle	0.72 %
Averaging Factor$_{avg}$	10 $\log_{10}$ (0.72%) = -21.4 dB
Average Power; 1090 MHz	P_{peak} + Factor$_{avg}$ = 55.8 – 21.4 = 34.4 dBm or 2754 mW

Table 3.3.3 Calculated Duty Cycle and Average Power; 1030 MHz	
Measured Power (P_{peak})	57.2 dBm or 525 Watts
Transmit Times (µs)	Per RTCA DO-185B, see diagrams in section 4.3.3
Total Transmit Time	25.8 **µs**
Maximum Duty Cycle	0.29 %
Averaging Factor$_{avg}$	10 $\log_{10}$ (0.29%) = -25.4 dB
Average Power; 1030 MHz	P_{peak} + Factor$_{avg}$ = 57.2 – 21.4 = 31.8 dBm or 1514 mW

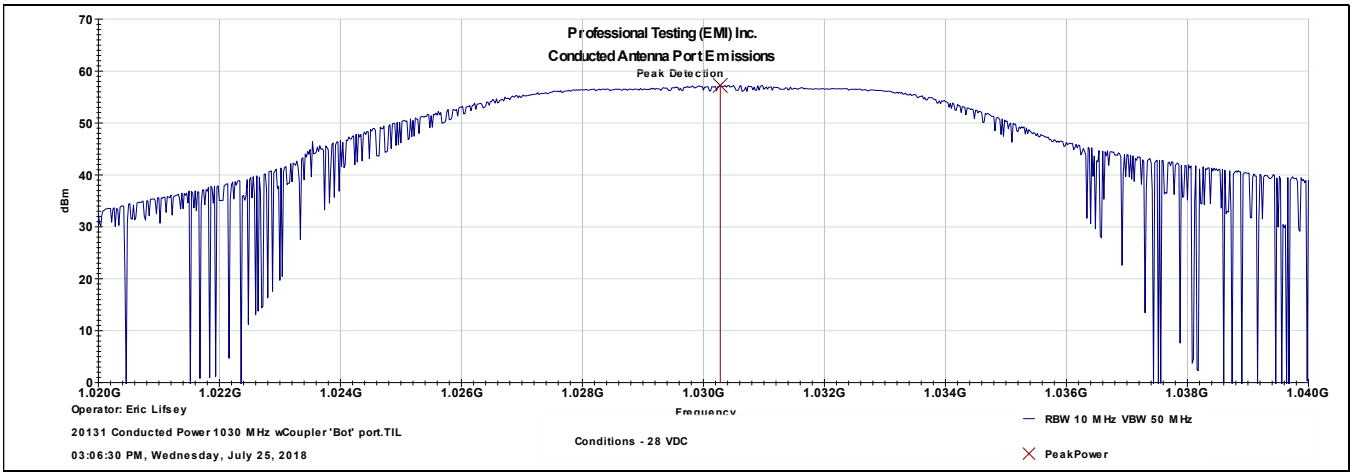
The EUT satisfied the requirements. Plotted results included below.



Peak Power 1090 MHz Top Port



Peak Power 1090 MHz Bottom Port



Peak Power 1030 MHz Bottom Port

4.0 Occupied Bandwidth and Modulation Characteristics

4.1 Test Procedure

The output of the EUT was connected directly to an attenuator and then to the spectrum analyzer. The spectrum analyzer was tuned to the frequency of the transceiver under test and the EUT activated in continuous transmit mode. Bandwidth is measured relative to the peak power measurement measured separately in full bandwidth. Modulation is a pulse train; to verify modulation a time-domain capture of the pulse train was recorded and compared to expected timings.

4.2 Test Criteria

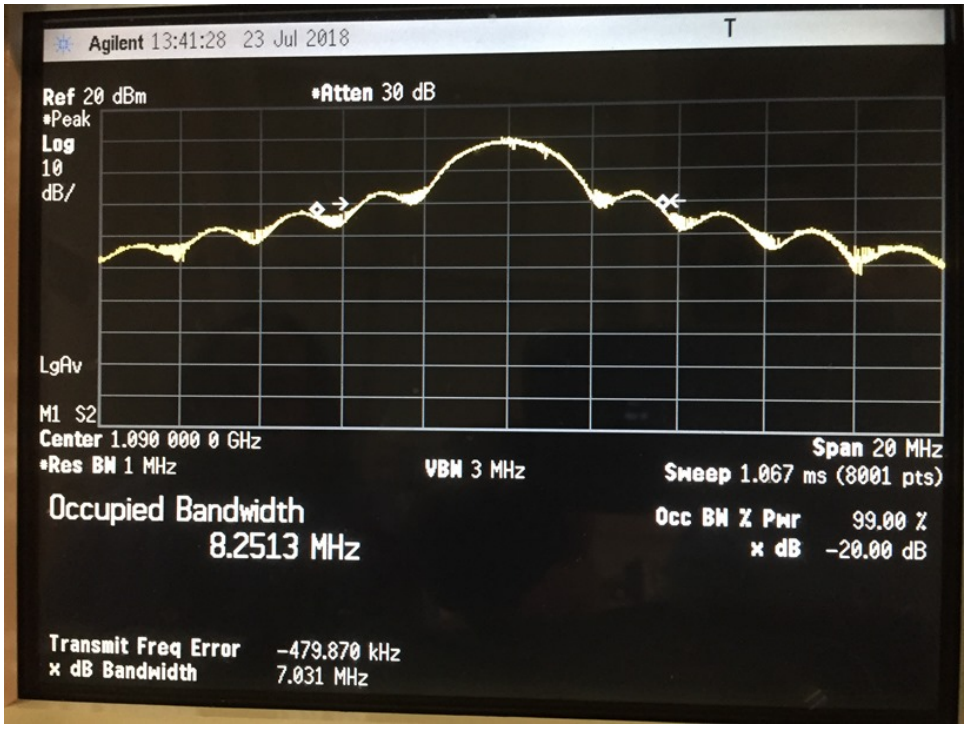
Table 4.2.1 Authorized Bandwidth, 87.135; 87.137; 2.1049
14 MHz per 87.137 table; emission designator 14M0M1D

4.3 Test Results

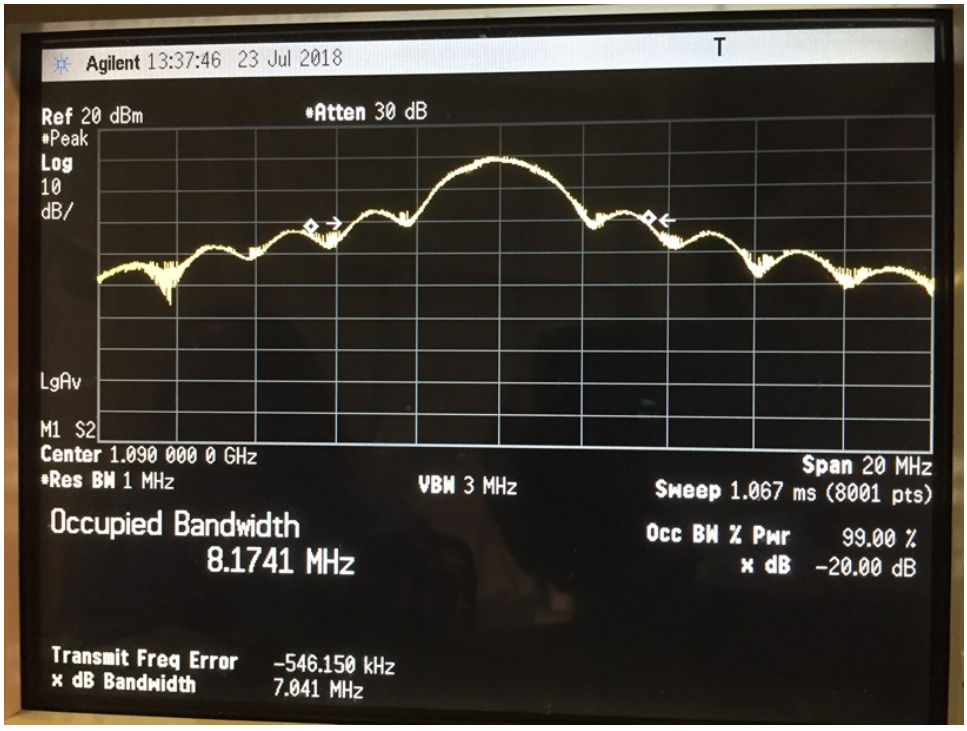
4.3.1 Bandwidth

Table 4.3.1.1 Bandwidth In 20 dB (1 MHz RBW 3 MHz VBW)	
Reference Power Level	55.8 dBm or 380 Watts
1090 MHz **Measured 20 dB Bandwidth**	Top Port: 7031 kHz Bottom Port: 7041 kHz
1030 MHz **Measured 20 dB Bandwidth**	Top Port: *Not applicable.* Bottom Port: 7041 kHz
Emission Designator	12M7M1D

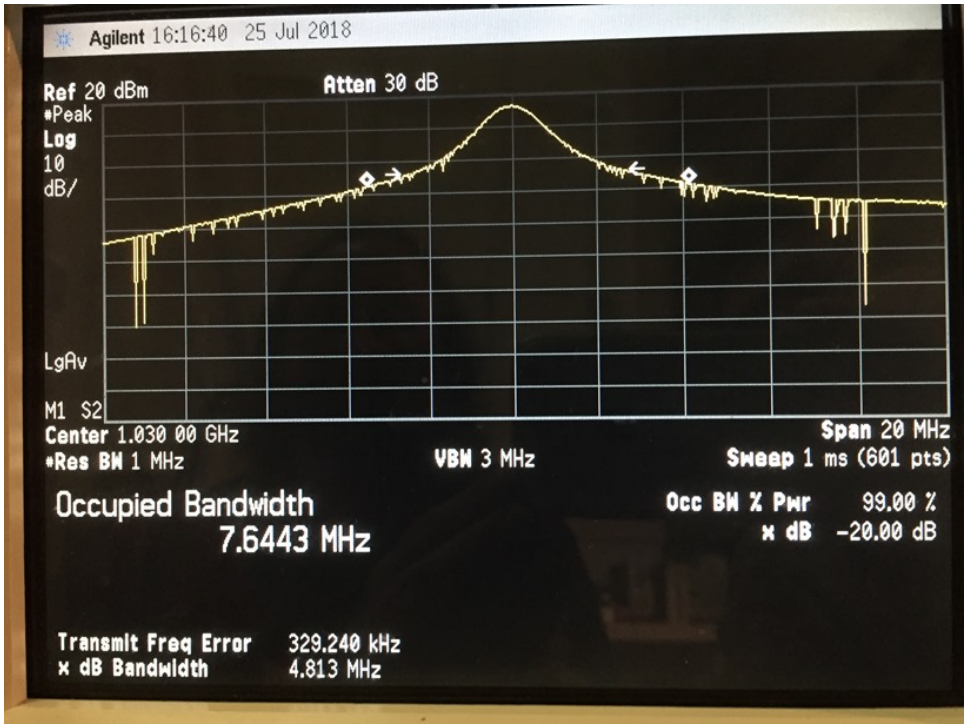
The EUT satisfied the requirements. Results appear below.



1090 MHz Bandwidth Measured, Top Port



1090 MHz, Bandwidth Measured, Bottom Port

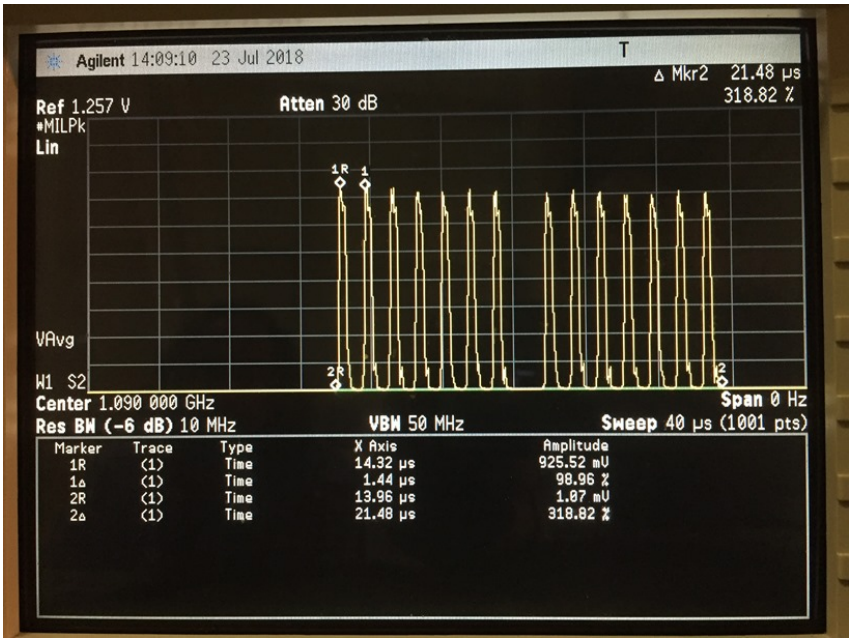


1030 MHz, Bandwidth Measured, Bottom Port

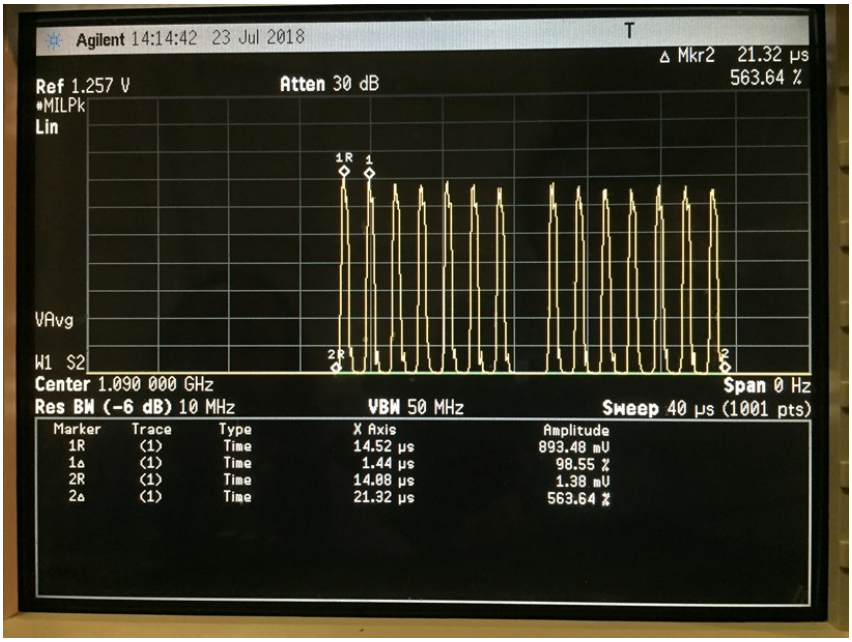
4.3.2 Modulation, 1090 MHz

The modulation pulse train was captured and found to be within the expected limits.

Table 4.3.2.1 1090 MHz, Modulation Characteristics Measured, Short Packet	
Bit-Bit Time (Marker 1 delta)	Top Port: 1.44 µsec, Bottom Port 1.44 µsec
Payload Time (Marker 2 delta)	Top Port: 21.48 µsec, Bottom Port 21.32 µsec

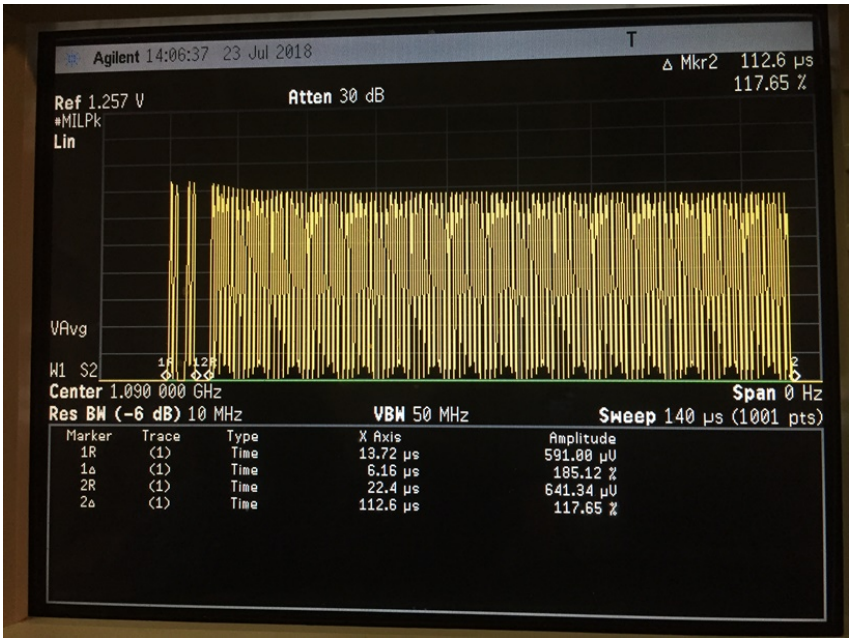


Captured Modulated Data Stream; Short Packet; Top Port

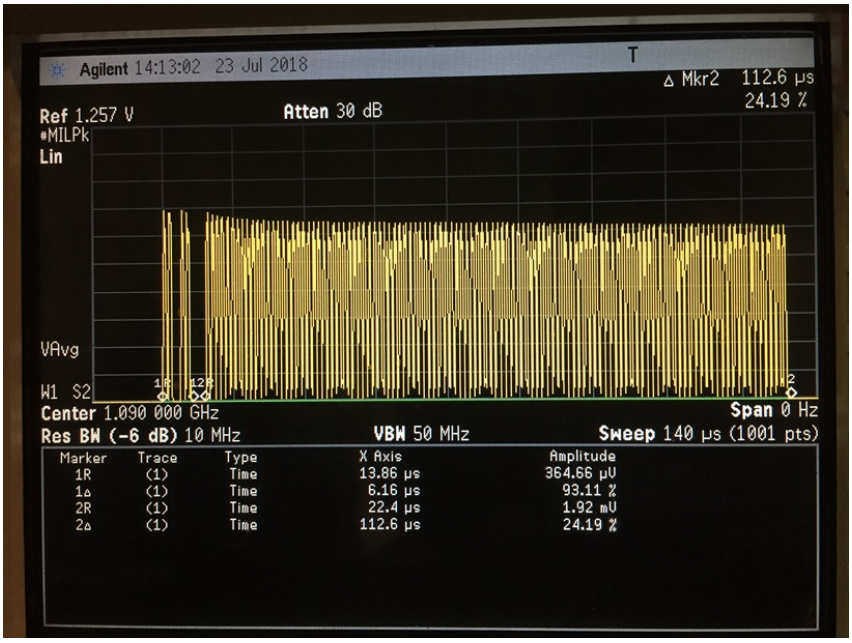


Captured Modulated Data Stream; Short Packet; Bottom Port

Table 4.3.2.2 1090 MHz, Modulation Characteristics Measured, Long Packet	
Preamble Time (Marker 1 delta)	Top Port: 6.16 µsec; Bottom Port: 6.16 µsec
Payload Time (Marker 2 delta)	Top Port: 112.6 µsec; Bottom Port: 112.6 µsec



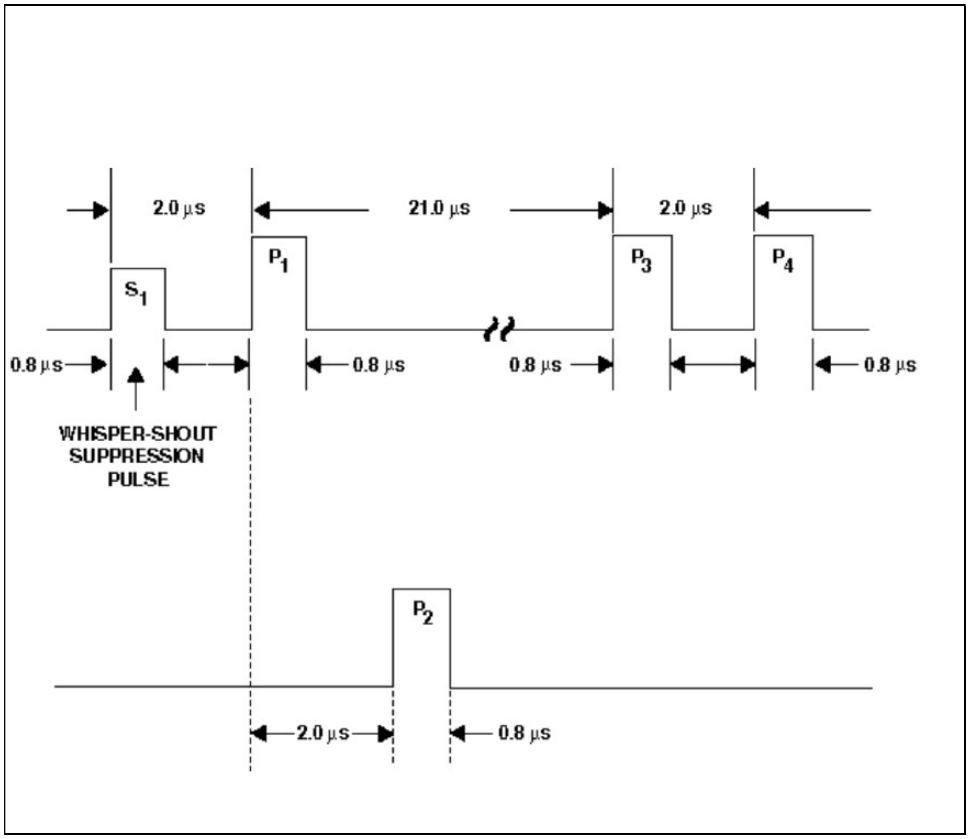
Captured Modulated Data Stream; Long Packet; Top Port



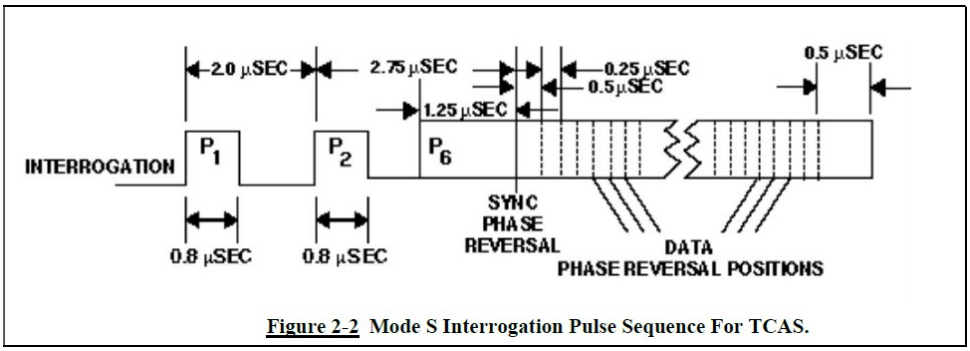
Captured Modulated Data Stream; Long Packet; Bottom Port

4.3.3 Modulation, 1030 MHz

The modulation scheme for this frequency is diagrammed as follows and is referenced directly from document RTCA DO-185B.



Mode A/C Only All Call Interrogation Pulse Sequence for TCAS (Mode A P1-P3 is 8us)



Mode S Interrogation Pulse Sequence

5.0 Spurious Emissions at Antenna Terminals

5.1 Test Procedure

The EUT was connected to a spectrum analyzer either via a power attenuator or a forward power coupler according to frequency range. The spectrum analyzer was swept with TILE V4 software up to the 10th harmonic. EUT could not operate in continuous transmit mode but was adjusted to a higher rate that the transmitter could sustain. Software was adjusted to insure capture of emissions using maximum point capability, slow sweep time, and multiple sweep ranges.

5.2 Test Criteria

Table 5.2.1 1090 MHz Spurious Limit, FCC 87.139(a) Basis for limit calculations.	
Measured Peak Transmitter Power:	55.8 dBm or 380 Watts
Average Power Calculated P_t:	P_t = 34.4 dBm or 2754 mW
Spurious Limit, FCC 87.139(a)(1)	
Attenuation & Frequency Range:	25 dB out to ±7 MHz (50% of BW)
Deduct Attenuation from Measured Power:	34.4 dBm – 25 dB = 9.4 dBm
Spurious Limit, FCC 87.139(a)(2)	
Attenuation & Frequency Range:	35 dB from ±7 to ±14 MHz (100% of BW)
Deduct Attenuation from Measured Power:	34.4 dBm – 35 dB = -0.6 dBm
Spurious Limit, FCC 87.139(a)(3)	
Attenuation & Frequency Range:	40 dB beyond ±35 MHz (250% of BW)
Deduct Attenuation from Measured Power:	35.1 dBm – 40 dB = -5.6 dBm

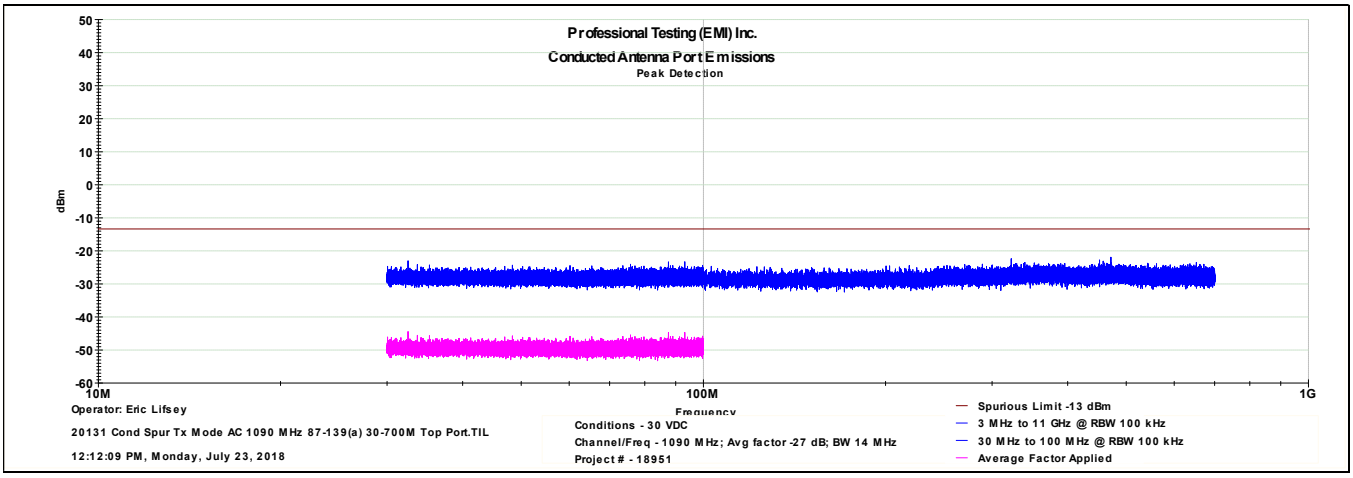
Table 5.2.2 1030 MHz Spurious Limit, FCC 87.139(a) Basis for limit calculations.	
Measured Peak Transmitter Power:	57.2 dBm or 525 Watts
Average Power Calculated P_t:	P_t = 31.8 dBm or 1513 mW
Spurious Limit, FCC 87.139(a)(1)	
Attenuation & Frequency Range:	25 dB out to ±7 MHz (50% of BW)
Deduct Attenuation from Measured Power:	31.8 dBm – 25 dB = 6.8 dBm
Spurious Limit, FCC 87.139(a)(2)	
Attenuation & Frequency Range:	35 dB from ±7 to ±14 MHz (100% of BW)
Deduct Attenuation from Measured Power:	31.8 dBm – 35 dB = -3.2 dBm
Spurious Limit, FCC 87.139(a)(3)	
Attenuation & Frequency Range:	40 dB beyond ±35 MHz (250% of BW)
Deduct Attenuation from Measured Power:	31.8 dBm – 40 dB = -8.2 dBm

5.3 Test Results

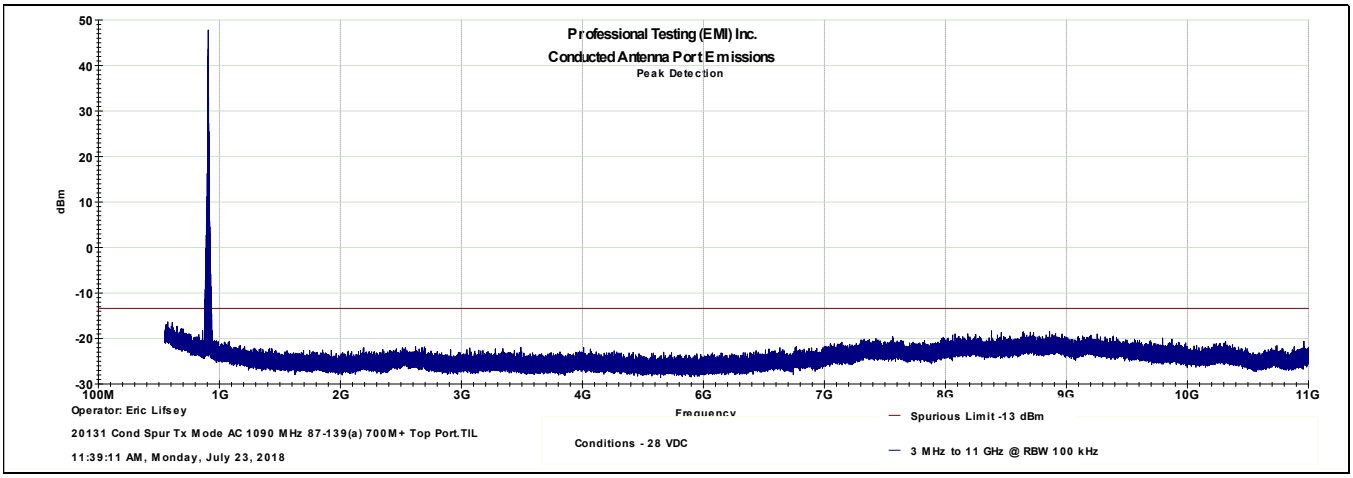
Limits are based on mean or average levels. The overall graphed data is peak detection. Where applicable the averaging factor is numerically applied with peak and average levels displayed.

The EUT satisfied the requirements. Plotted measurements appear below.

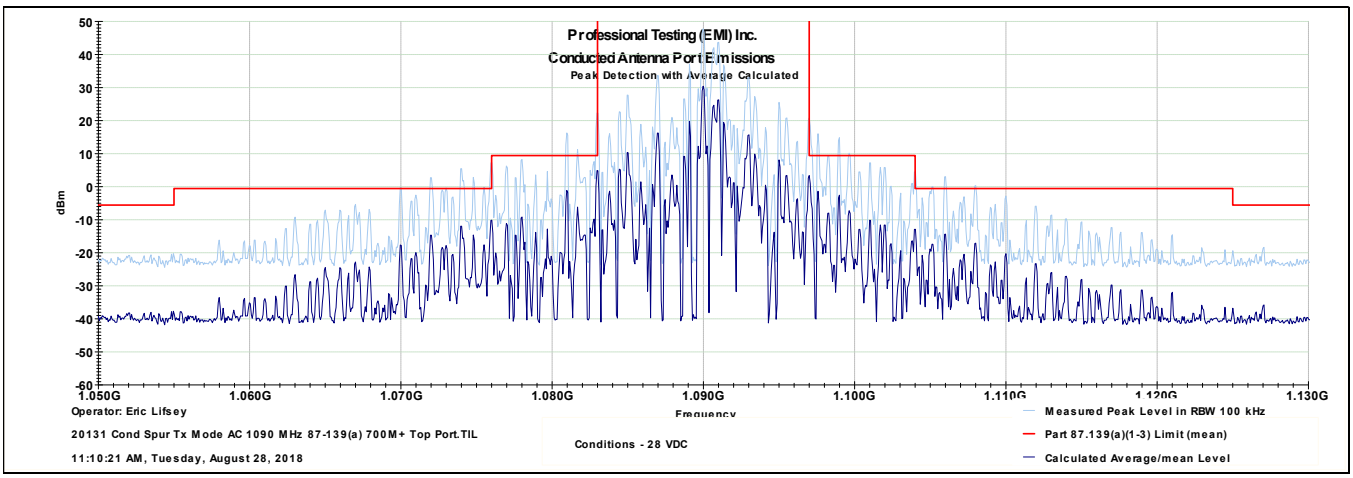
5.3.1 1090 MHz Top Port



Conducted Antenna Port Spurious; 30 MHz to 700 MHz; Measured Peak Levels

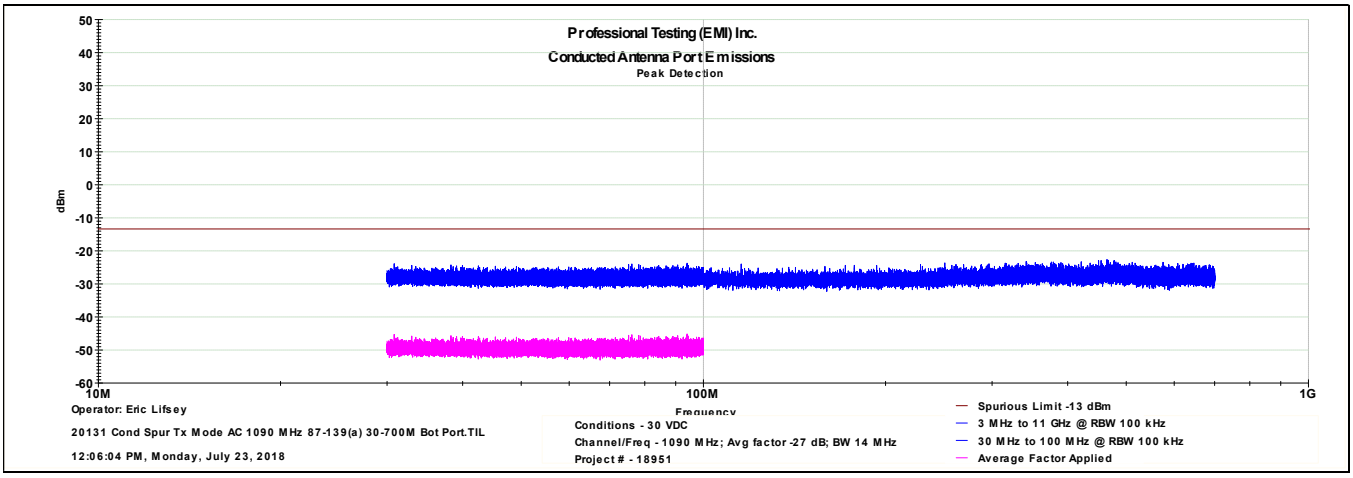


Conducted Antenna Port Spurious; 700 MHz to 11 GHz; Measured Peak Levels

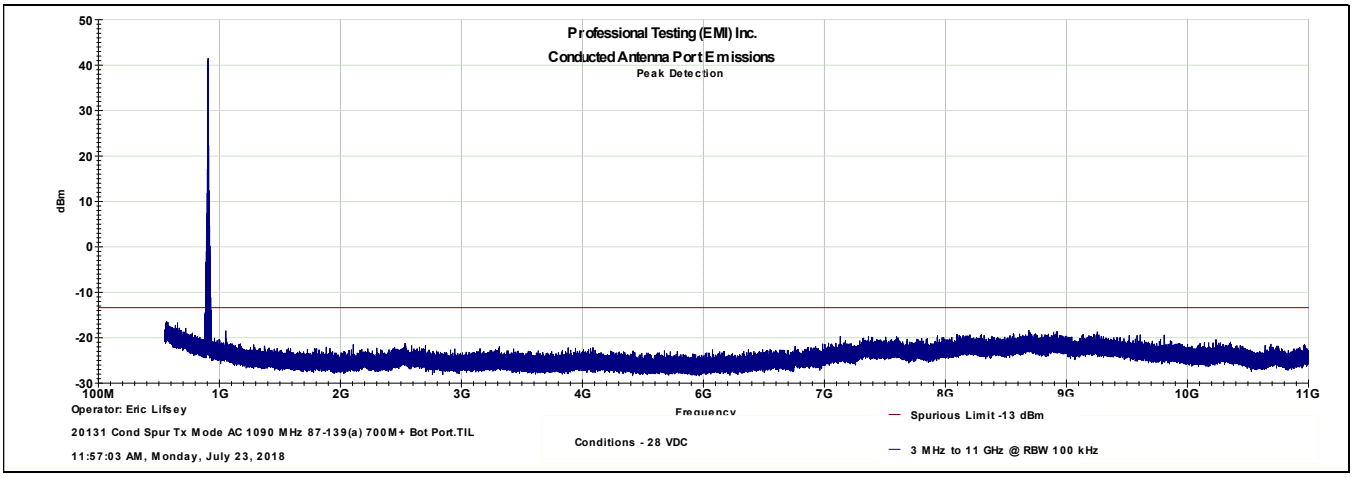


Conducted Antenna Port Spurious; 87.139(a)(1-3) Mask Detail
Measured Peak and Calculated Average Presented

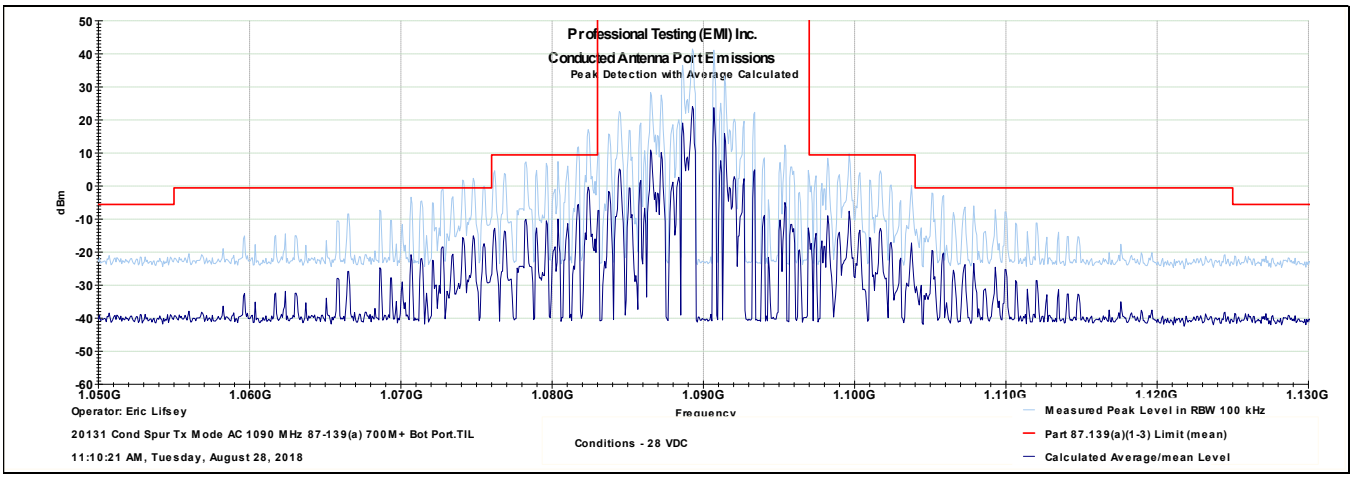
5.3.2 1090 MHz Bottom Port



Conducted Antenna Port Spurious; 30 MHz to 700 MHz; Measured Peak Levels

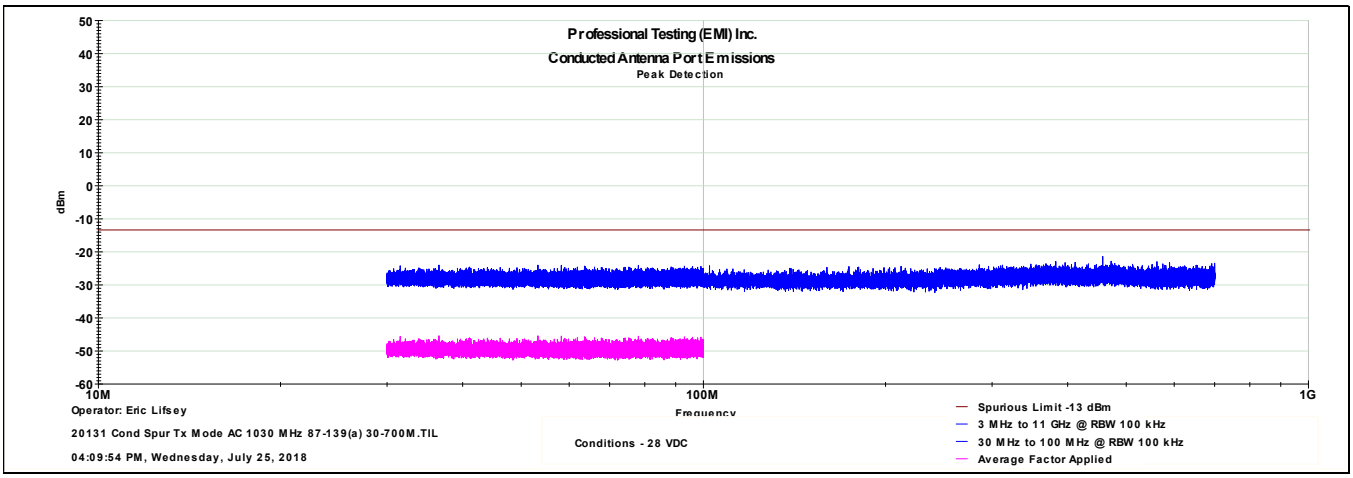


Conducted Antenna Port Spurious; 700 MHz to 11 GHz; Measured Peak Levels

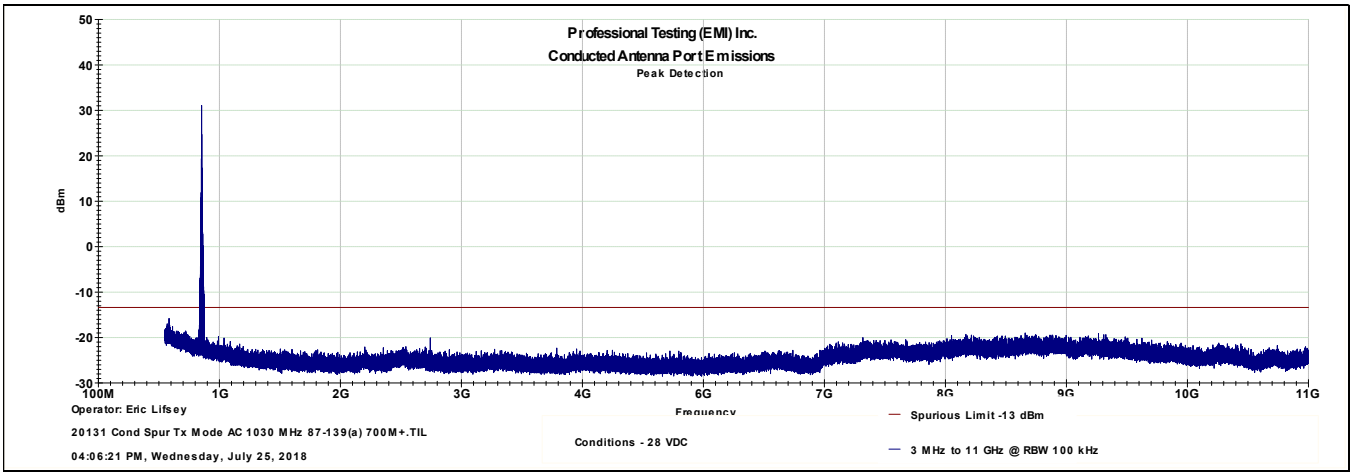


Conducted Antenna Port Spurious; 87.139(a)(1-3) Mask Detail
Measured Peak and Calculated Average Presented

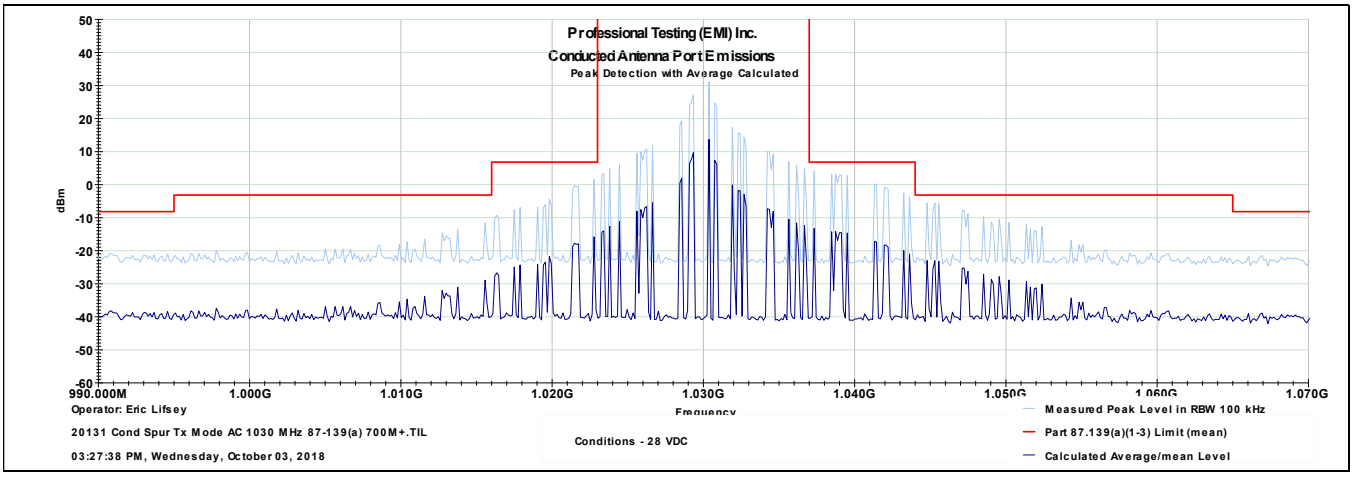
5.3.3 1030 MHz



Conducted Antenna Port Spurious; 30 MHz to 700 MHz; Measured Peak Levels



Conducted Antenna Port Spurious; 700 MHz to 11 GHz; Measured Peak Levels

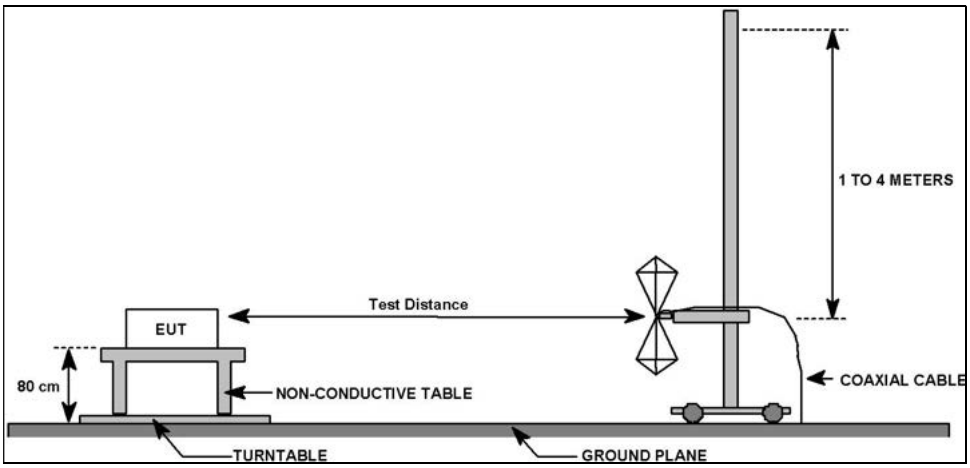


Conducted Antenna Port Spurious; 87.139(a)(1-3) Mask Detail
Measured Peak and Calculated Average Presented

6.0 Field Strength of Spurious Emissions

6.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The table was centered on a rotating turntable. Antennas were located from the EUT at distances of 10 meters for below 1 GHz and 3 meters for above 1 GHz. The EUT was placed into transmit mode with the antenna removed and a resistive terminator substituted. EUT duty cycle was raised to a safe maximum and the measurement software sweep count increased to capture the signals.



Field Strength of Radiated Emissions Test Setup

6.2 Test Criteria

Table 6.2.1 Radiated Spurious Limit, 87.139(a)(3) *(Calculated limit -13.0 dBm.)*	
Method:	$P_r = P_t + G_t + G_r + 20\log_{10}\left(\frac{\lambda}{4\pi R}\right)$
Path Loss Term:	10 m: 20 $\log_{10}$ (λ/ 4πR) = 20 $\log_{10}$ (0.30675 / 4π10) = -52.25 dB 3 m: 20 $\log_{10}$ (λ/ 4πR) = 20 $\log_{10}$ (0.30675 / 4π3) = -41.79 dB
Power at *R*:	10 m: -13.0 dBm + 0 dB + 0 dB + [-52.25 dB] = -65.25 dBm 3 m: -13.0 dBm + 0 dB + 0 dB + [-41.79 dB] = -54.79 dBm
Field Strength Limit Conversion Formula:	$E(dB\mu V/m) = P_{meas}(dBm) - P_{gain}(dB) + 77.2dB + 20\log(f, MHz) - G_{ant}(dB)$
Field Strength Limit Calculation, 10 m:	[-65.25 dBm] – 0 dB + 77.2 dB + 20 $\log_{10}$ (1090 MHz) - 0 dB = 72.7 dBµV/m
Field Strength Limit Calculation, 3 m:	[-54.79 dBm] – 0 dB + 77.2 dB + 20 $\log_{10}$ (1090 MHz) - 0 dB = 83.2 dBµV/m
Field Strength Limit Calculation, 10 m:	[-65.25 dBm] – 0 dB + 77.2 dB + 20 log10 (1030 MHz) - 0 dB = 72.2 dBµV/m
Field Strength Limit Calculation, 3 m:	[-54.79 dBm] – 0 dB + 77.2 dB + 20 log10 (1030 MHz) - 0 dB = 82.8 dBµV/m

6.3 Test Results

The EUT satisfied the requirements. Plotted measurements appear below.

Emissions were below the peak/QP limits of Part 15 and are reflected in the tabular data.

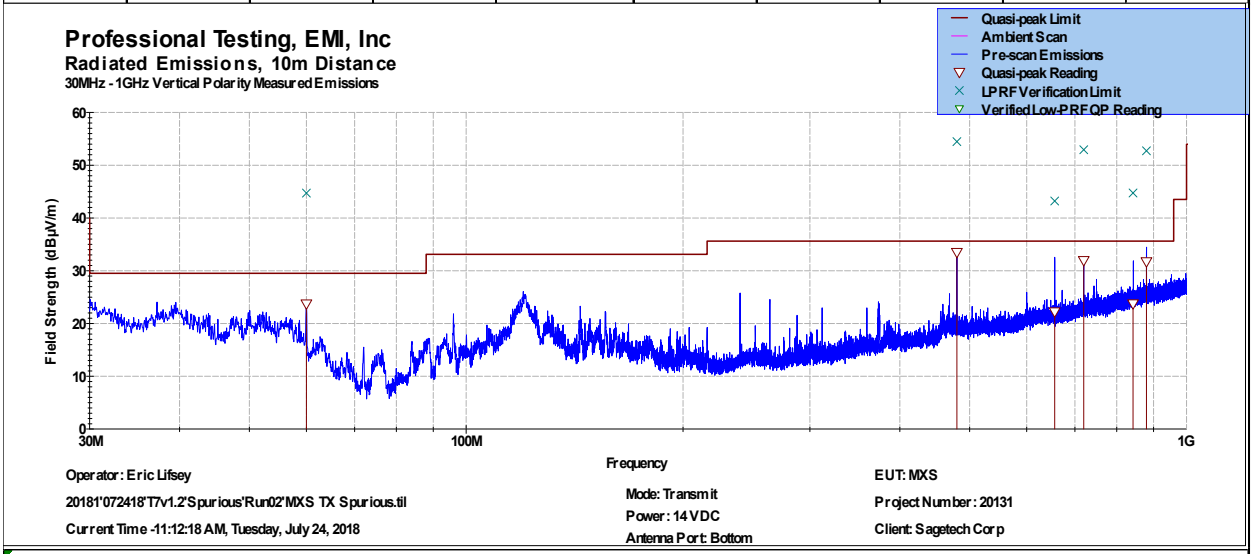
Where it applies, the 87.139 field limits calculated are included as the uppermost limit line in the plotted results.

6.3.1 Transmit Mode 1090 & 1030 MHz; 30 MHz to 1 GHz

Professional Testing, EMI, Inc.			
Test Method:	FCC Part 87		
In accordance with:	FCC Part 87		
Section:	Spurious Emissions		
Test Date(s):	7/24/2018	EUT Serial #:	4000002
Customer:	Sagetech Corporation	EUT Part #:	0
Project Number:	20131	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	MXS	Witness' Name:	Mark Sutcliffe

Radiated Emissions Test Results Data Sheet		Page: 1 of 1	
EUT Line Voltage:	14 VDC	EUT Power Frequency:	0 N/A
Antenna Orientation:	Vertical	Frequency Range:	30MHz to 1GHz
EUT Mode of Operation:		Transmit Mode	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
60.002	10	12	2.7	Quasi-peak	43.52	23.709	29.5	-5.8	Pass
480.003	10	201	3.97	Quasi-peak	38.934	33.463	35.6	-2.1	Pass
656.178	10	285	2.97	Quasi-peak	23.856	22.213	35.6	-13.4	Pass
720.005	10	268	1.36	Quasi-peak	32.136	31.932	35.6	-3.7	Pass
843.048	10	23	3.63	Quasi-peak	21.392	23.727	35.6	-11.9	Pass
880.002	10	13	3.63	Quasi-peak	28.245	31.713	35.6	-3.9	Pass



≤ 1GHz Vertical Antenna Polarity Measured Emissions

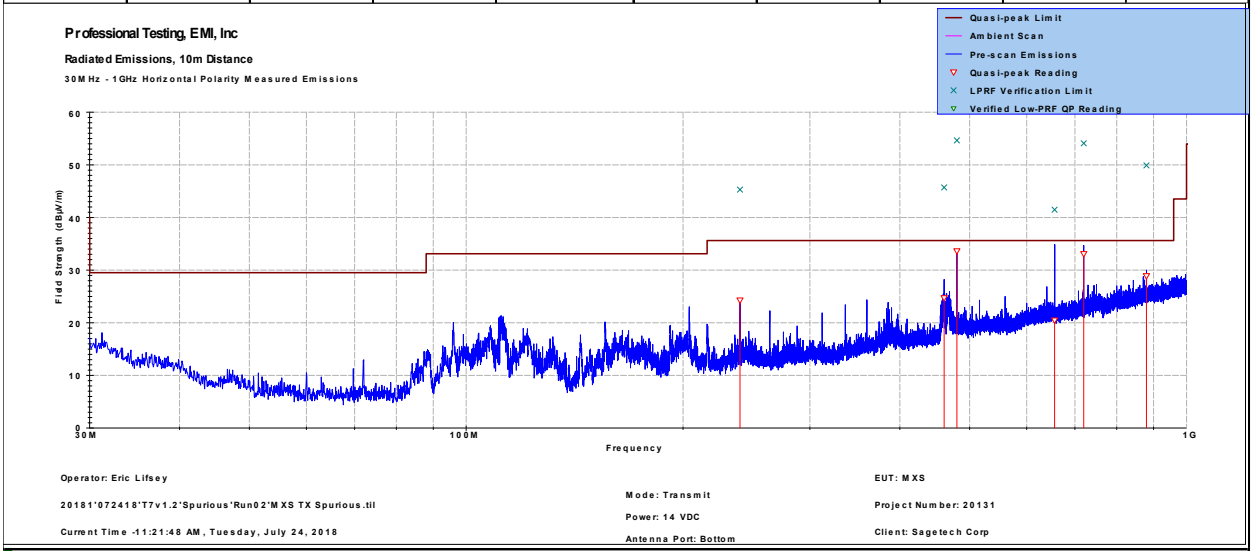
Professional Testing, EMI, Inc.

Test Method:	FCC Part 87		
In accordance with:	FCC Part 87		
Section:	Spurious Emissions		
Test Date(s):	7/24/2018	**EUT Serial #:**	4000002
Customer:	Sagetech Corporation	**EUT Part #:**	0
Project Number:	20131	**Test Technician:**	Eric Lifsey
Purchase Order #:	0	**Supervisor:**	Lisa Arndt
Equip. Under Test:	MXS	**Witness' Name:**	Mark Sutcliffe

Radiated Emissions Test Results Data Sheet — **Page: 1 of 1**

EUT Line Voltage:	14 VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	30MHz to 1GHz
EUT Mode of Operation:		Transmit Mode	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
239.991	10	3	3.98	Quasi-peak	36.332	24.276	35.6	-11.3	Pass
460.769	10	11	2.37	Quasi-peak	31.035	24.688	35.6	-10.9	Pass
480	10	232	3.17	Quasi-peak	39.097	33.626	35.6	-2.0	Pass
655.999	10	294	3.52	Quasi-peak	22.109	20.463	35.6	-15.1	Pass
720.004	10	332	2.37	Quasi-peak	33.287	33.083	35.6	-2.5	Pass
880.008	10	78	2.67	Quasi-peak	25.418	28.887	35.6	-6.7	Pass



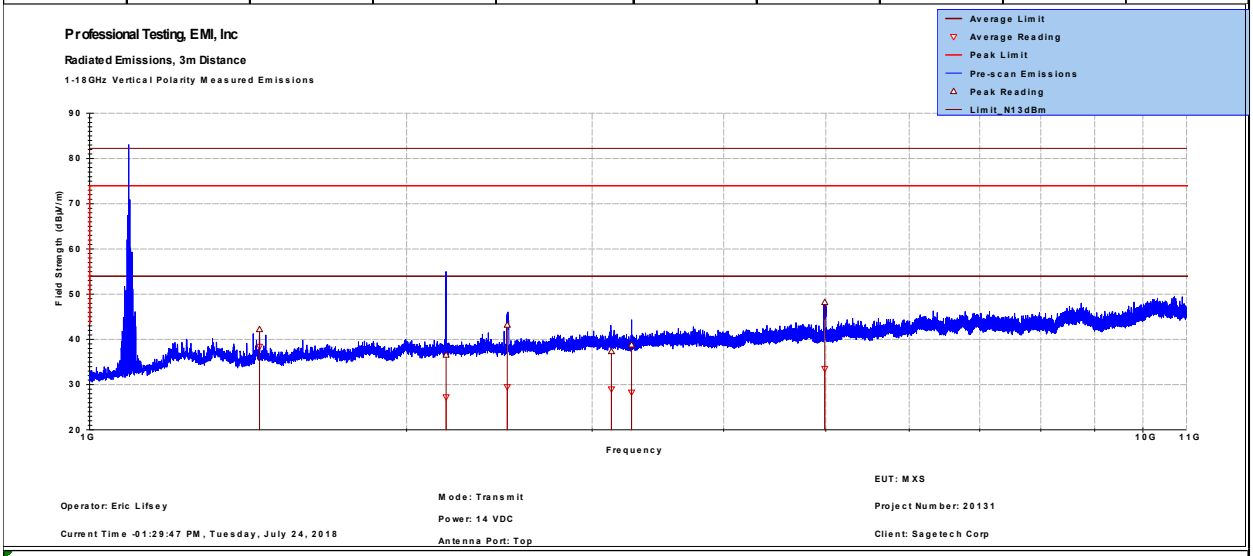
≤ 1GHz Horizontal Antenna Polarity Measured Emissions

6.3.2 Transmit Mode 1090 MHz; 1 to 11 GHz, Top Port

Professional Testing, EMI, Inc.			
Test Method:	FCC Part 87		
In accordance with:	FCC Part 87		
Section:	Spurious Emissions		
Test Date(s):	7/24/2018	EUT Serial #:	4000002
Customer:	Sagetech Corporation	EUT Part #:	0
Project Number:	20131	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	MXS	Witness' Name:	Mark Sutcliffe

Radiated Emissions Test Results Data Sheet			Page: 1 of 1
EUT Line Voltage:	14 VDC	EUT Power Frequency:	0 N/A
Antenna Orientation:	Vertical	Frequency Range:	Above 1GHz
EUT Mode of Operation:		Transmit Mode: Top Port	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
1450	3	178	1.36	Peak	54.1	42.183	82.2	-40.0	Pass
2180.14	3	71	2.82	Peak	45.9	36.548	82.2	-45.7	Pass
2492.23	3	266	1.81	Peak	52.1	43.16	82.2	-39.1	Pass
3129	3	268	1.4	Peak	44.6	37.321	82.2	-44.9	Pass
3269.8	3	120	1.13	Peak	46.4	38.794	82.2	-43.4	Pass
4988.3	3	310	2.03	Peak	52.1	48.182	82.2	-34.0	Pass



> 1GHz Vertical Antenna Polarity Measured Emissions

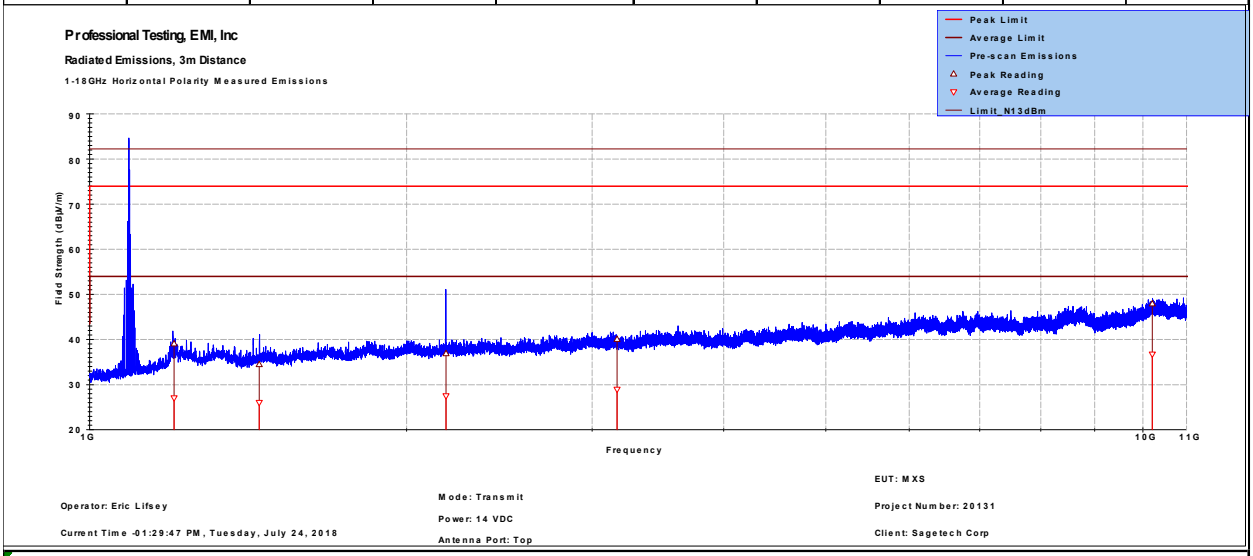
Professional Testing, EMI, Inc.

Test Method:	FCC Part 87		
In accordance with:	FCC Part 87		
Section:	Spurious Emissions		
Test Date(s):	7/24/2018	**EUT Serial #:**	4000002
Customer:	Sagetech Corporation	**EUT Part #:**	0
Project Number:	20131	**Test Technician:**	Eric Lifsey
Purchase Order #:	0	**Supervisor:**	Lisa Arndt
Equip. Under Test:	MXS	**Witness' Name:**	Mark Sutcliffe

Radiated Emissions Test Results Data Sheet — **Page: 1 of 1**

EUT Line Voltage:	14 VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	Above 1GHz
EUT Mode of Operation:		Transmit Mode: Top Port	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
1203.06	3	191	2.42	Peak	51.1	39.049	82.2	-43.2	Pass
1448.93	3	105	2.63	Peak	46.4	34.458	82.2	-47.8	Pass
2179.93	3	241	2.5	Peak	46.3	36.881	82.2	-45.3	Pass
3168.29	3	63	3.68	Peak	47.4	40.047	82.2	-42.2	Pass
10207.8	3	178	3.7	Peak	37	47.926	82.2	-34.3	Pass



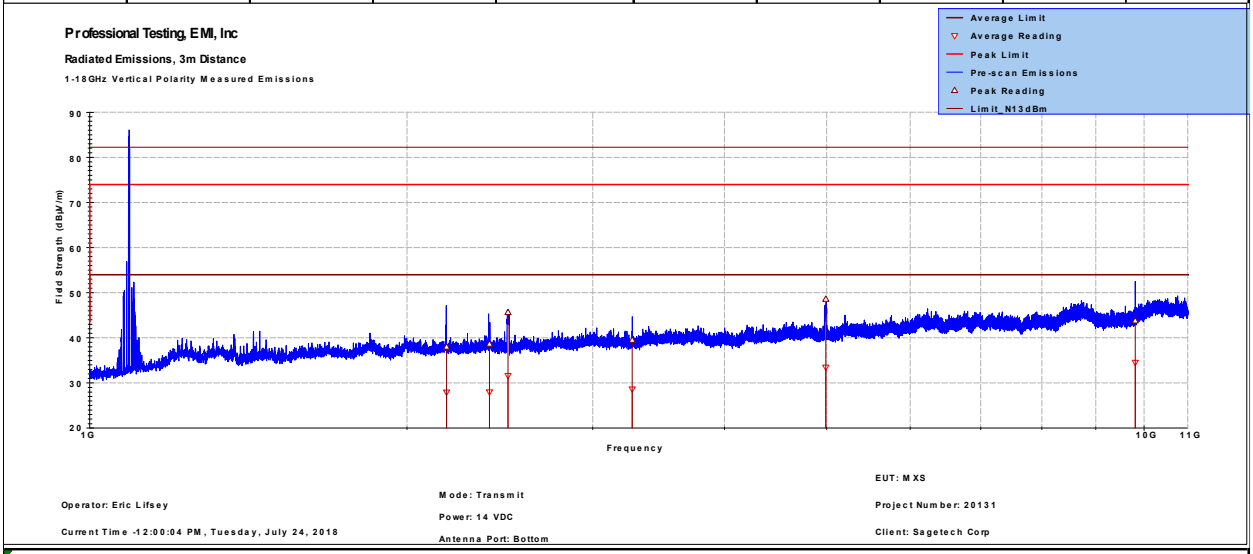
> 1GHz Horizontal Antenna Polarity Measured Emissions

6.3.3 Transmit Mode 1090 MHz; 1 to 11 GHz, Bottom Port

Professional Testing, EMI, Inc.			
Test Method:	FCC Part 87		
In accordance with:	FCC Part 87		
Section:	Spurious Emissions		
Test Date(s):	7/24/2018	EUT Serial #:	4000002
Customer:	Sagetech Corporation	EUT Part #:	0
Project Number:	20131	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	MXS	Witness' Name:	Mark Sutcliffe

Radiated Emissions Test Results Data Sheet		Page: 1 of 1	
EUT Line Voltage:	14 VDC	EUT Power Frequency:	0 N/A
Antenna Orientation:	Vertical	Frequency Range:	Above 1GHz
EUT Mode of Operation:		Transmit Mode: Bottom Port	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
2180.18	3	178	2.56	Peak	47.4	37.981	82.2	-44.2	Pass
2394.44	3	223	3.29	Peak	47.7	38.629	82.2	-43.6	Pass
2493.37	3	255	1.89	Peak	54.6	45.639	82.2	-36.6	Pass
3270.15	3	210	3.01	Peak	47.1	39.485	82.2	-42.7	Pass
4991.05	3	264	1.12	Peak	52.5	48.564	82.2	-33.7	Pass
9810.24	3	88	1.27	Peak	35.2	43.764	82.2	-38.5	Pass



> 1GHz Vertical Antenna Polarity Measured Emissions

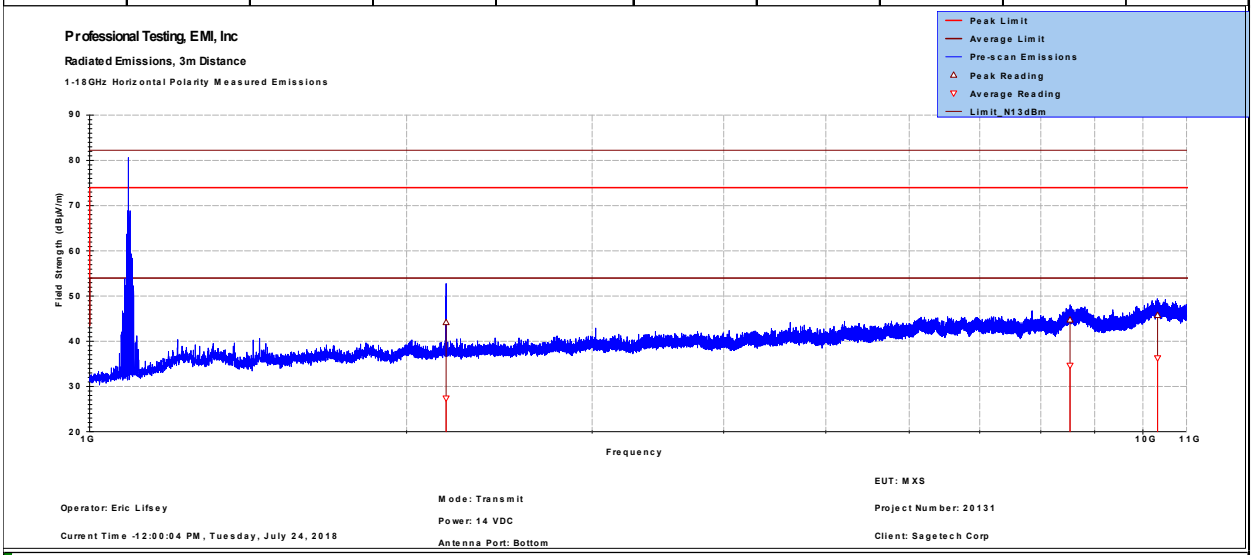
Professional Testing, EMI, Inc.

Test Method:	FCC Part 87		
In accordance with:	FCC Part 87		
Section:	Spurious Emissions		
Test Date(s):	7/24/2018	**EUT Serial #:**	4000002
Customer:	Sagetech Corporation	**EUT Part #:**	0
Project Number:	20131	**Test Technician:**	Eric Lifsey
Purchase Order #:	0	**Supervisor:**	Lisa Arndt
Equip. Under Test:	MXS	**Witness' Name:**	Mark Sutcliffe

Radiated Emissions Test Results Data Sheet — **Page: 1 of 1**

EUT Line Voltage:	14 VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	Above 1GHz
EUT Mode of Operation:		**Transmit Mode: Bottom Port**	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
2180	3	177	3.59	Peak	53.5	44.161	82.2	-38.1	Pass
8527.65	3	120	3.85	Peak	37.1	44.714	82.2	-37.5	Pass
10326.18	3	31	1.47	Peak	34.8	45.746	82.2	-36.5	Pass



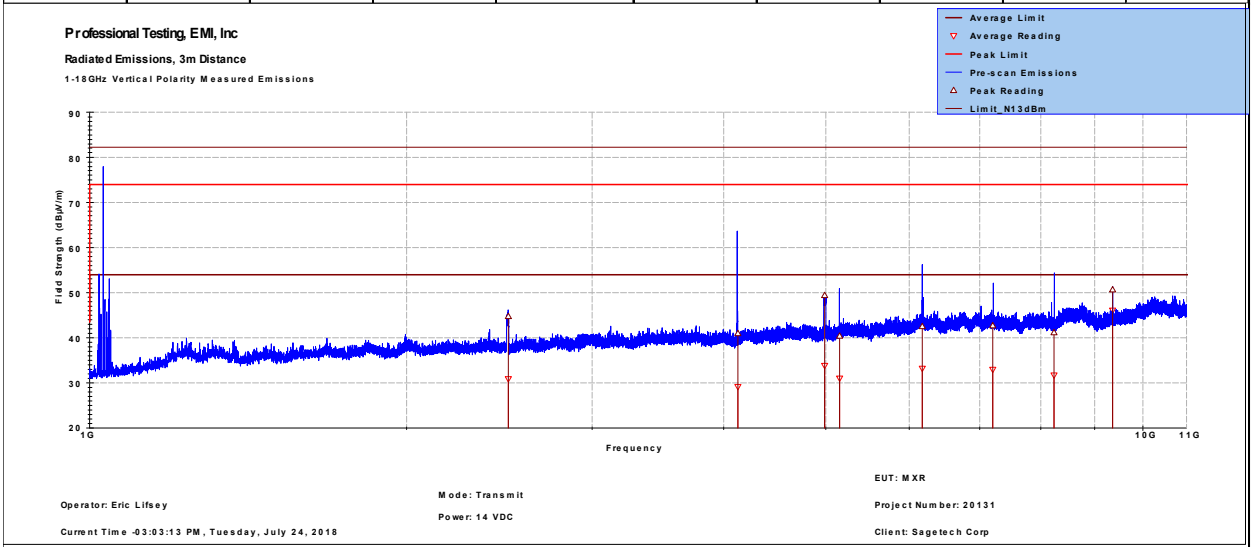
> 1GHz Horizontal Antenna Polarity Measured Emissions

6.3.4 Transmit Mode 1030 MHz; 1 to 11 GHz

Professional Testing, EMI, Inc.			
Test Method:	FCC Part 87		
In accordance with:	FCC Part 87		
Section:	Spurious Emissions		
Test Date(s):	7/24/2018	EUT Serial #:	4000003
Customer:	Sagetech Corporation	EUT Part #:	0
Project Number:	20131	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	MXR	Witness' Name:	Mark Sutcliffe

Radiated Emissions Test Results Data Sheet		Page: 1 of 1	
EUT Line Voltage:	14 VDC	EUT Power Frequency:	0 N/A
Antenna Orientation:	Vertical	Frequency Range:	Above 1GHz
EUT Mode of Operation:		Transmit Mode: Bottom Port	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
2497.7	3	265	1.4	Peak	53.7	44.743	82.2	-37.5	Pass
4125.45	3	8	3.19	Peak	46.5	40.962	82.2	-41.3	Pass
4987.57	3	271	1.09	Peak	53.3	49.385	82.2	-32.8	Pass
5153.35	3	300	0.98	Peak	43.4	40.389	82.2	-41.8	Pass
6174.14	3	193	3.22	Peak	42	42.525	82.2	-39.7	Pass
7202.79	3	53	3.97	Peak	39.4	42.693	82.2	-39.5	Pass
8234.04	3	307	3.69	Peak	35.5	41.153	82.2	-41.1	Pass
9359.96	3	123	3.05	Peak	41.8	50.649	82.2	-31.6	Pass



> 1GHz Vertical Antenna Polarity Measured Emissions

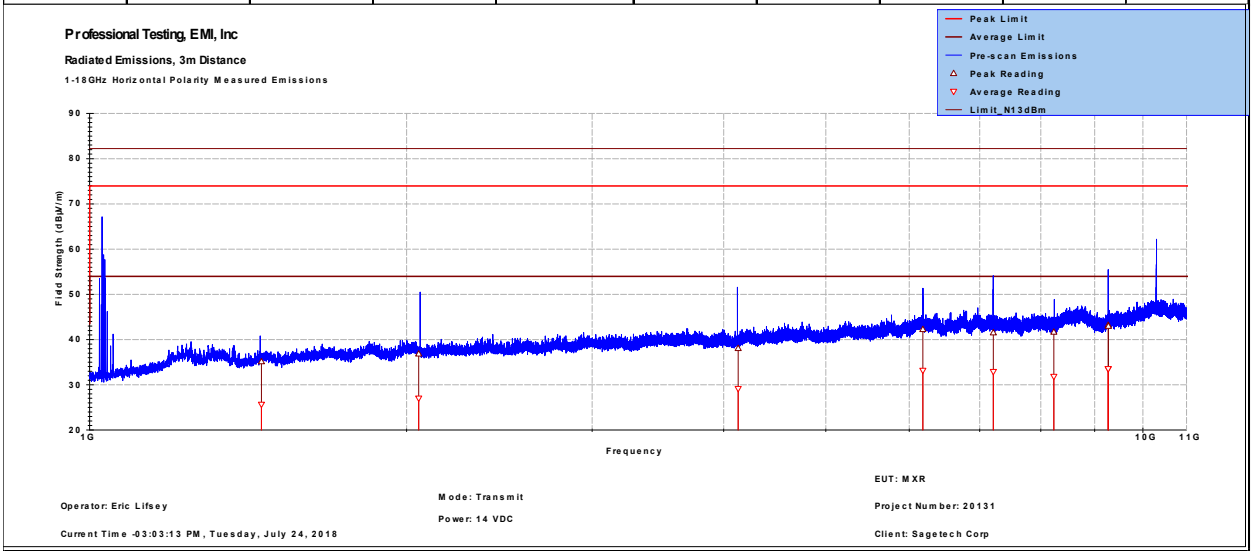
Professional Testing, EMI, Inc.

Test Method:	FCC Part 87		
In accordance with:	FCC Part 87		
Section:	Spurious Emissions		
Test Date(s):	7/24/2018	**EUT Serial #:**	4000003
Customer:	Sagetech Corporation	**EUT Part #:**	0
Project Number:	20131	**Test Technician:**	Eric Lifsey
Purchase Order #:	0	**Supervisor:**	Lisa Arndt
Equip. Under Test:	MXR	**Witness' Name:**	Mark Sutcliffe

Radiated Emissions Test Results Data Sheet — **Page: 1 of 1**

EUT Line Voltage:	14 VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	Above 1GHz
EUT Mode of Operation:		**Transmit Mode: Bottom Port**	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
1455.99	3	44	3.67	Peak	47.1	35.129	82.2	-47.1	Pass
2053.44	3	77	2.15	Peak	46.1	36.851	82.2	-45.4	Pass
4128.44	3	181	1.83	Peak	43.6	38.048	82.2	-44.2	Pass
6181.75	3	46	3.09	Peak	41.7	42.252	82.2	-40.0	Pass
7211.45	3	146	3.26	Peak	38.2	41.522	82.2	-40.7	Pass
8231.13	3	114	3.82	Peak	36.1	41.678	82.2	-40.6	Pass
9269.3	3	154	1.4	Peak	34.3	43.182	82.2	-39.0	Pass
9272.69	3	170	2.13	Peak	34.1	42.977	82.2	-39.3	Pass
9269.3	3	154	1.4	Peak	34.3	43.182	82.2	-39.0	Pass



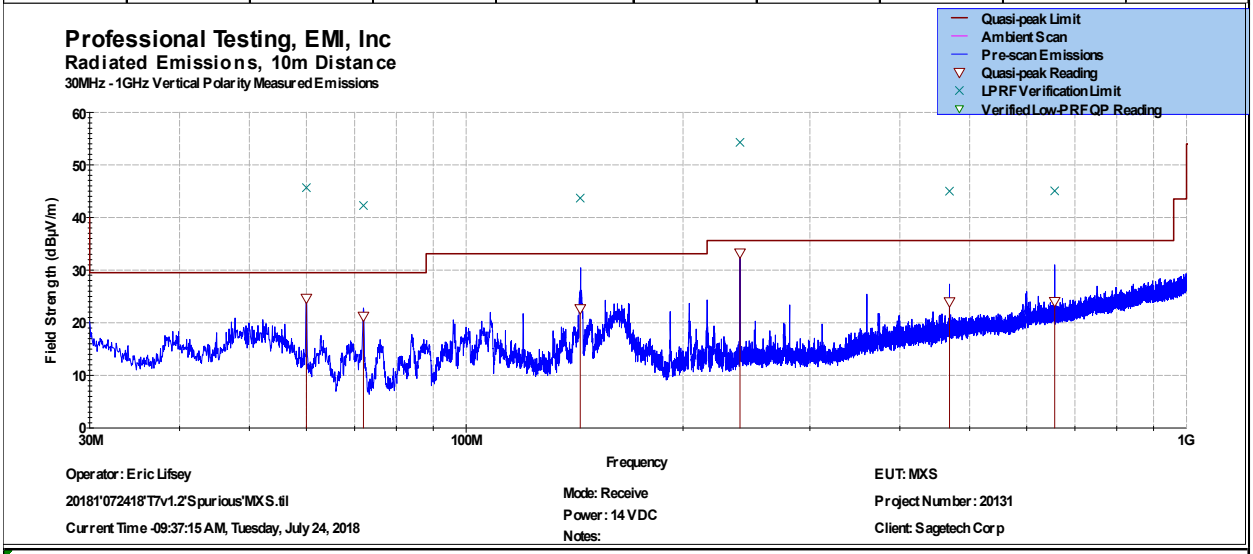
> 1GHz Horizontal Antenna Polarity Measured Emissions

6.3.5 Receive Mode; 1090 MHz & 1030 MHz, 30 MHz to 1 GHz

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz		
In accordance with:	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits		
Section:	15.109		
Test Date(s):	7/24/2018	EUT Serial #:	4000003
Customer:	Sagetech Corporation	EUT Part #:	0
Project Number:	20131	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	MXR	Witness' Name:	Mark Sutcliffe

Radiated Emissions Test Results Data Sheet			Page: 1 of 1
EUT Line Voltage:	14 VDC	EUT Power Frequency:	0 N/A
Antenna Orientation:	Vertical	Frequency Range:	30MHz to 1GHz
EUT Mode of Operation:		Receive Mode (Applies to MXS and MXR)	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
60.001	10	67	3.71	Quasi-peak	44.472	24.661	29.5	-4.8	Pass
72	10	224	1.75	Quasi-peak	40.991	21.253	29.5	-8.2	Pass
144.002	10	68	1.29	Quasi-peak	40.604	22.672	33.1	-10.4	Pass
239.992	10	269	1.26	Quasi-peak	45.32	33.264	35.6	-2.3	Pass
468.772	10	67	1.24	Quasi-peak	29.906	23.991	35.6	-11.6	Pass
656.201	10	259	3.27	Quasi-peak	25.692	24.049	35.6	-11.6	Pass



≤ 1GHz Vertical Antenna Polarity Measured Emissions

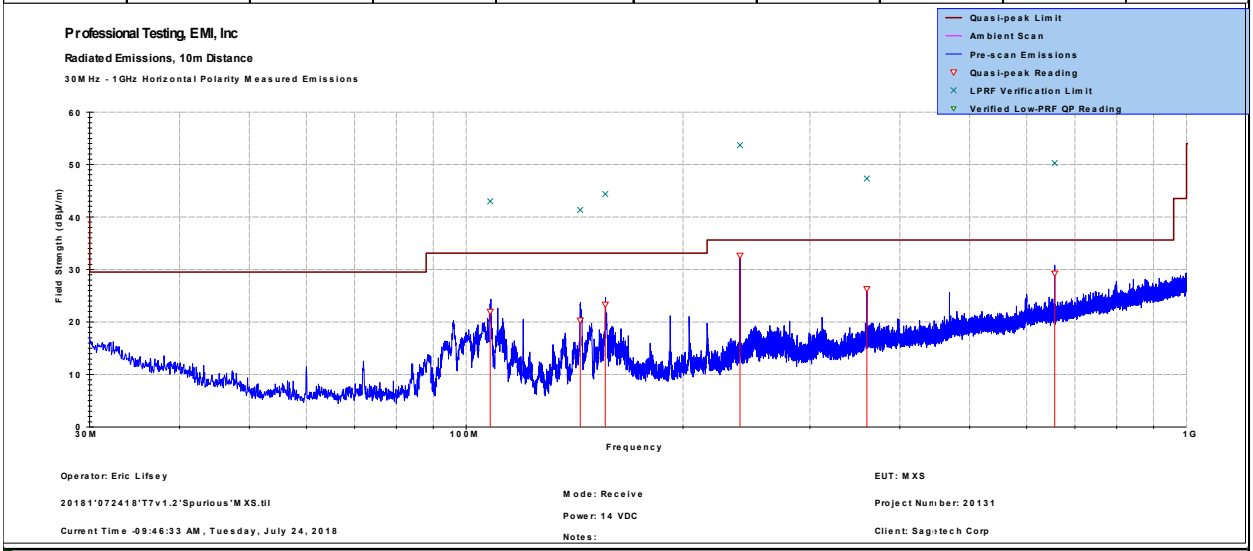
Professional Testing, EMI, Inc.

Test Method:	ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz		
In accordance with:	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits		
Section:	15.109		
Test Date(s):	7/24/2018	**EUT Serial #:**	4000003
Customer:	Sagetech Corporation	**EUT Part #:**	0
Project Number:	20131	**Test Technician:**	Eric Lifsey
Purchase Order #:	0	**Supervisor:**	Lisa Arndt
Equip. Under Test:	MXR	**Witness' Name:**	Mark Sutcliffe

Radiated Emissions Test Results Data Sheet — **Page: 1 of 1**

EUT Line Voltage:	14 VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	30MHz to 1GHz
EUT Mode of Operation:		Receive Mode (Applies to MXS and MXR)	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
107.995	10	79	3.87	Quasi-peak	40.133	21.987	33.1	-11.1	Pass
143.992	10	229	3.35	Quasi-peak	38.258	20.325	33.1	-12.8	Pass
155.995	10	218	3.69	Quasi-peak	40.523	23.35	33.1	-9.8	Pass
239.993	10	283	3.91	Quasi-peak	44.728	32.672	35.6	-2.9	Pass
359.988	10	208	2.91	Quasi-peak	35.222	26.31	35.6	-9.3	Pass
656.27	10	31	3.63	Quasi-peak	30.896	29.254	35.6	-6.3	Pass



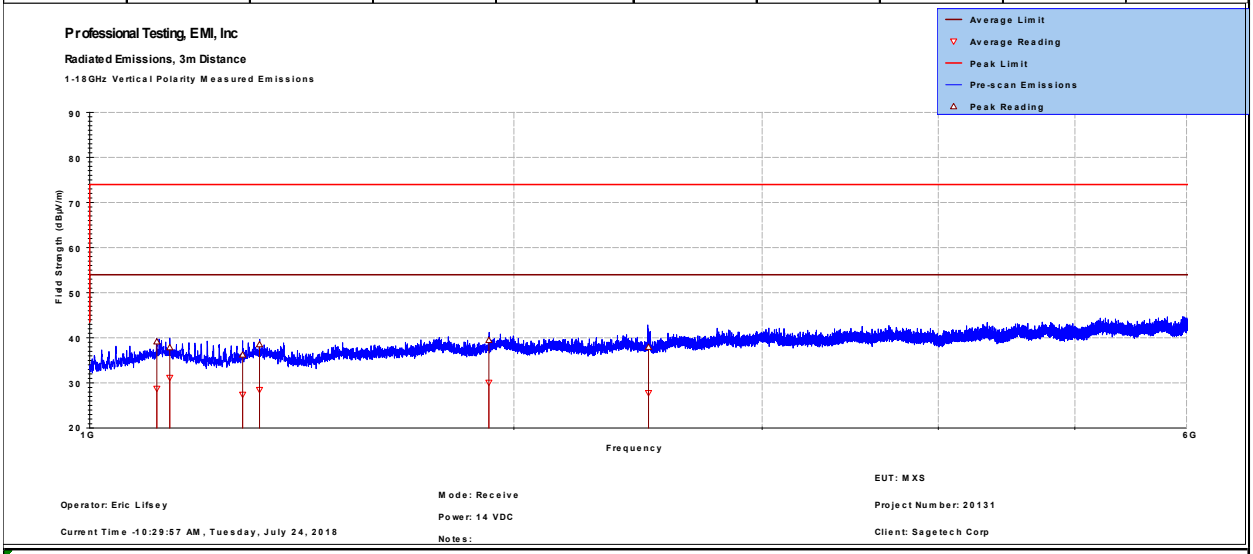
≤ 1GHz Horizontal Antenna Polarity Measured Emissions

6.3.6 Receive Mode; 1090 MHz & 1030 MHz, 1 to 6 GHz

Professional Testing, EMI, Inc.			
Test Method:	ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz		
In accordance with:	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits		
Section:	15.109		
Test Date(s):	7/24/2018	EUT Serial #:	4000003
Customer:	Sagetech Corporation	EUT Part #:	0
Project Number:	20131	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	MXR	Witness' Name:	Mark Sutcliffe

Radiated Emissions Test Results Data Sheet		Page: 1 of 1	
EUT Line Voltage:	14 VDC	EUT Power Frequency:	0 N/A
Antenna Orientation:	Vertical	Frequency Range:	Above 1GHz
EUT Mode of Operation:		Receive Mode (Applies to MXS and MXR)	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
1116.07	3	160	2.42	Average	41.3	28.753	54.0	-25.2	Pass
1140.05	3	37	1.02	Average	43.6	31.184	54.0	-22.8	Pass
1284.03	3	269	1.4	Average	39.2	27.434	54.0	-26.5	Pass
1320.02	3	260	1.12	Average	40.3	28.495	54.0	-25.5	Pass
1919.98	3	28	3.58	Average	39.4	30.09	54.0	-23.9	Pass
2491.95	3	303	1.63	Average	36.7	27.803	54.0	-26.2	Pass



> 1GHz Vertical Antenna Polarity Measured Emissions

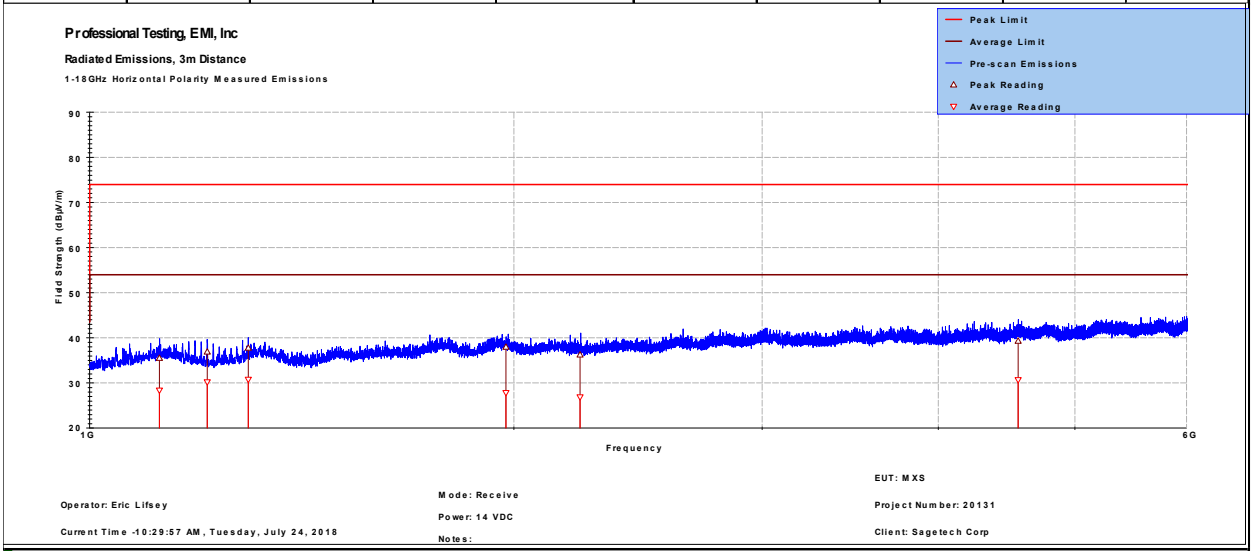
Professional Testing, EMI, Inc.

Test Method:	ANSI C63.4: 2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz		
In accordance with:	FCC Part 15.109 - Code of Federal Regulations Part 47, Subpart B - Unintentional Radiators, Radiated Emissions Limits		
Section:	15.109		
Test Date(s):	7/24/2018	**EUT Serial #:**	4000003
Customer:	Sagetech Corporation	**EUT Part #:**	0
Project Number:	20131	**Test Technician:**	Eric Lifsey
Purchase Order #:	0	**Supervisor:**	Lisa Arndt
Equip. Under Test:	MXR	**Witness' Name:**	Mark Sutcliffe

Radiated Emissions Test Results Data Sheet — **Page: 1 of 1**

EUT Line Voltage:	14 VDC	**EUT Power Frequency:**	0 N/A
Antenna Orientation:	Horizontal	**Frequency Range:**	Above 1GHz
EUT Mode of Operation:		Receive Mode (Applies to MXS and MXR)	

Frequency Measured (MHz)	Test Distance (Meters)	EUT Direction (Degrees)	Antenna Height (Meters)	Detector Function	Recorded Amplitude (dBµV)	Corrected Level (dBµV/m)	Limit Level (dBµV/m)	Margin (dB)	Test Results
1120.78	3	240	2.79	Average	40.9	28.333	54.0	-25.6	Pass
1211.89	3	149	1.6	Average	42.1	30.189	54.0	-23.8	Pass
1295.95	3	113	2.8	Average	42.5	30.74	54.0	-23.2	Pass
1974.28	3	321	2.33	Average	37	27.801	54.0	-26.2	Pass
2228.37	3	168	1.13	Average	36.3	26.845	54.0	-27.1	Pass
4557.64	3	279	2.04	Average	35	30.663	54.0	-23.3	Pass



> 1GHz Horizontal Antenna Polarity Measured Emissions

7.0 Frequency Stability

7.1 Test Procedure

The EUT was placed into a temperature chamber and connected by cable to a spectrum analyzer; attenuation added if needed. After soak time was satisfied, the EUT transmitter was powered on in transmit mode and the frequency was observed until it became stable; then the measurement of frequency was taken.

Operating voltage stability was also measured for selected extremes based on operating design.

The EUT was operated in a modulated mode.

7.2 Test Criteria

Table 7.2.1 Frequency Stability Criteria, 87.133; 2.1055(a)(1)
Parameter: Frequency Tolerance
1090 MHz: 1000 ppm or ±1,090,000 Hz 1030 MHz: 1000 ppm or ±1,030,000 Hz

Table 7.2.2 Test Conditions, Temperatures (Manufacturers specifications exceed Part 87.)
-40 C to 70 C and by 10 C steps

Table 7.2.3 Test Conditions, Voltages (From manufacturer's specifications.)	
Low Voltage	10 VDC
Nominal Voltage	14 VDC
High Voltage	32 VDC

7.3 Test Results

The EUT satisfies the requirement. Tabular results appear below.

7.3.1 1090 MHz Temperature

Temperature (C)	Reference Center Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
-40	1090.000000	1089.983100	-16900
-30	1090.000000	1089.983100	-16900
-20	1090.000000	1089.982100	-17900
-10	1090.000000	1089.981100	-18900
0	1090.000000	1089.983100	-16900
10	1090.000000	1089.984600	-15400
20	1090.000000	1089.983100	-16900
30	1090.000000	1089.981600	-18400
40	1090.000000	1089.981600	-18400
50	1090.000000	1089.982100	-17900
60	1090.000000	1089.982600	-17400
70	1090.000000	1089.983100	-16900

Max Deviation (Hz)	-15400
Min Deviation (Hz)	-18900

7.3.2 1090 MHz Voltage

Condition	**Voltage**	**Frequency**		
Voltage Extreme	Voltage (V DC)	Reference Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
Low	10.00	1090.000000	1089.983000	-17000
Nominal	14.00	1090.000000	1089.983000	-17000
High	32.00	1090.000000	1089.983000	-17000

7.3.3 1030 MHz Temperature

Temperature (C)	Reference Center Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
-40	1030.000000	1029.984100	-15900
-30	1030.000000	1029.986700	-13300
-20	1030.000000	1029.982600	-17400
-10	1030.000000	1029.984600	-15400
0	1030.000000	1029.984600	-15400
10	1030.000000	1029.983600	-16400
20	1030.000000	1029.983100	-16900
30	1030.000000	1029.982600	-17400
40	1030.000000	1029.983100	-16900
50	1030.000000	1029.981100	-18900
60	1030.000000	1029.980600	-19400
70	1030.000000	1029.979100	-20900

Max Deviation (Hz)	-13300
Min Deviation (Hz)	-20900

7.3.4 1030 MHz Voltage

Voltage Extreme	Voltage (V DC)	Reference Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
Low	10.00	1030.000000	1029.981600	-18400
Nominal	14.00	1030.000000	1029.984100	-15900
High	32.00	1030.000000	1029.980700	-19300

8.0 Equipment Lists

Table 8.1 Equipment List; Power, Bandwidth, Modulation, Spurious Conducted				
Asset #	**Manufacturer**	**Model #**	**Description**	**Calibration Due**
2295	Agilent	E4440A	Spectrum Analyzer	18 Dec 2018
0835	Narda	3293-1	Forward Power Coupler -10 dB	8 Oct 2018
A105	Narda	768-20	Attenuator, 20 W, 20 dB	5 Oct 2018
0856	Narda	702-60	Step Attenuator 60 dB in 10 dB Steps	7 Oct 2018
0463	Fluke	77	DMM	8 Aug 2018
1831	HP	6622A	Adjustable DC Power Supply	CIU

Table 8.2 Equipment List; Frequency Stability (In addition to equipment listed in 8.1.)				
Asset #	**Manufacturer**	**Model #**	**Description**	**Calibration Due**
2134	Tenny	TPC T2C	Temperature Chamber	10 Oct 2018
C247	Pasternack	RG type	Coaxial Cable, double shielded	CNR

Table 8.3 Equipment List; Radiated Emissions

Tile! Software Version:	Version: 7.1.2.17 (Jan 08, 2016 - 02:12:48 PM) or 4.1.A.0, April 14, 2009, 11:01:00PM
Test Profile:	2018_Radiated Emissions_TILE7_v1EL.til

Asset #	Manufacturer	Model	Equipment Nomenclature	Serial Number	Calibration Due Date
1509A	Braden	TDK 10M	TDK 10M Chamber, NSA < 1 GHz	DAC-012915-005	7/10/2019
1890	HP	8447F-H64	Preamp/Amp, 9kHz-1300MHz, 28/25dB	3313A05298	1/10/2020
1937	Agilent	E4440A	Spectrum Analyzer, 3 Hz - 26.5 GHz, Opt. AYZ	MY44808298	11/7/2018
1926	ETS-Lindgren	3142D	Antenna, Biconilog, 26 MHz - 6 GHz	135454	3/7/2019
C027D	PTI	None	Relay	none	N/A
1327	EMCO	1050	Controller, Antenna Mast	none	N/A
0942	EMCO	11968D	Turntable, 4ft.	9510-1835	N/A
1969	HP	11713A	Attenuator/Switch Driver	3748A04113	N/A
1509B	Braden	TDK 10M	TDK 10M Chamber,sVSWR > 1 GHz	DAC-012915-005	11/16/2019
2004	Miteq	AFS44-00101800-2S-10P-44	Amplifier, 40dB, .1-18GHz	0	1/10/2020
C030	none	none	Cable Coax, N-N, 30m, 30 MHz - 18GHz	none	9/28/2018
1325	EMCO	1050	Controller, Antenna Mast	9003-1461	N/A
1780	ETS-Lindgren	3117	Antenna, Double Ridged Guide Horn, 1 - 18 GHz	110313	3/15/2019

Appendix: Policy, Rationale, and Evaluation of EMC Measurement Uncertainty

All uncertainty calculations, estimates and expressions thereof shall be in accordance with NIST policy. Since PTI operates in accordance with NIST (NVLAP) Handbook 150-11: 2007, all instrumentation having an effect on the accuracy or validity of tests shall be periodically calibrated or verified traceable to national standards by a competent calibration laboratory. The certificates of calibration or verification on this instrumentation shall include estimates of uncertainty as required by NIST Handbook 150-11.

1. Rationale and Summary of Expanded Uncertainty.

Each piece of instrumentation at PTI that is used in making measurements for determining conformance to a standard (or limit), shall be assessed to evaluate its contribution to the overall uncertainty of the measurement in which it is used. The assessment of each item will be based on either a type A evaluation or a type B evaluation. Most of the evaluations will be type B, since they will be based on the manufacturer's statements or specifications of the calibration tolerances, or uncertainty will be stated along with a brief rationale for the type of evaluation and the resulting stated uncertainties.

The individual uncertainties included in the combined standard uncertainty for a specific test result will depend on the configuration in which the item of instrumentation is used. The combination will always be based on the law of propagation of uncertainty. Any systematic effects will be accommodated by including their uncertainties, in the calculation of the combined standard uncertainty; except that if the direction and amount of the systematic effect cannot be determined and separated from its uncertainty, the whole effect will be treated as uncertainty and combined along with the other elements of the test setup.

Type A evaluations of standard uncertainty will usually be based on calculating the standard deviation of the mean of a series of independent observations, but may be based on a least-squares curve fit or the analysis of variance for unusual situations. Type B evaluations of standard uncertainty will usually be based on manufacturer's specifications, data provided in calibration reports, and experience. The type of probability distribution used (normal, rectangular, a priori, or u-shaped) will be stated for each Type B evaluation.

In the evaluation of the uncertainty of each type of measurement, the uncertainty caused by the operator will be estimated. One notable operator contribution to measurement uncertainty is the manipulation of cables to maximize the measured values of radiated emissions. The operator contribution to measurement uncertainty is evaluated by having several operators independently repeat the same test. This results in a Type A evaluation of operator-contributed measurement uncertainty.

A summary of the expanded uncertainties of PTI measurements is shown as Table 1. These are the worst-case uncertainties considering all operative influence factors.

Table 1: Summary of Measurement Uncertainties for Site 45

Type of Measurement	Frequency Range	Meas. Dist.	Expanded Uncertainty U, dB (k=2)
Mains Conducted Emissions	150 kHz to 30 MHz	N/A	2.9
Telecom Conducted Emissions	150 kHz to 30 MHz	N/A	2.8
Radiated Emissions	30 to 1,000 MHz	10 m	4.8
	1 to 18 GHz	3 m	5.7

End of Report