Excellence in Compliance Testing

Certification Test Report

FCC ID: SDB520Q

FCC Rule Part: Part 90 Subpart I

ACS Report Number: 12-2066.W03.1A

Applicant: Sensus Metering Systems, Inc.
Model: 520Q

Test Begin Date: May 31, 2012
Test End Date: June 13, 2012

Report Issue Date: July 3, 2012

For The Scope of Accreditation Under Certificate Number AT-1533

For The Scope of Accreditation Under Lab Code 200612-0

This report must not be used by the client to claim product certification, approval, or endorsement by ACLASS, NVLAP, ANSI, or any agency of the Federal Government.

Project Manager:

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This report contains 35 pages

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1.0 GENERAL

1.1 Purpose

The purpose of this report is to demonstrate compliance with Part 2 Subpart J, and Part 90 Subpart I of the FCC's Code of Federal Regulations for a modular approval.

1.2 Product Description

The 520Q is a transceiver module that is configured using an RF interface. The unit provides wireless communication capability to a variety of register read, TouchCoupler water meters and TFRs. The 520Q can be connected to one or two meters simultaneously each of independent type and protocol. The device will communicate via the Sensus fixed wireless telemetry network to provide meter readings and diagnostic data from the meter to the utility provider via radio.

Manufacturer Information:
Sensus Metering Systems, Inc.
639 Davis Drive
Morrisville, NC 27560

Test Sample Serial Numbers: 14003004, 14003024

Test Sample Condition: The unit was in good operating conditions with no physical damages.

1.3 Test Methodology

1.3.1 Configurations and Justification

The 520Q was tested in accordance to WT Docket No. 11-56, DA 11-1316 which waives 47 CFR 90.203(j) from the test requirements.

For the RF conducted measurements, the EUT was modified with a temporary RF connector at the antenna port. For the Radiated emissions, the EUT was evaluated in the orientation of typical installation. The 520Q provides multiple modulations formats/modes all of which were evaluated and the worst case data are presented were applicable.

The evaluation for unintentional emissions is documented separately in a verification report.

1.3.2 In-Band Testing Methodology

The EUT band of operation is provided in the table below.

CFR Title 47 Rule Part	Frequency Band of Operation (MHz)
90	451.0375 – 463.7875

Based on the requirements set forth in accordance 47 CFR 2.1046-2.1057 as stated above, the methodology in selecting the places to test in the available bands of operation is outlined in the following table.

CFR Title 47 Rule Part	Frequency Band of Operation (MHz)	Location in the Range of Operation	Approx. Test Freq.
90	451.0375 – 463.7875	1 near top, 1 near middle and 1 near bottom	451.0375
			457.4125
			463.7875

1.4 Emission Designators

The 520Q transmitter produces seven distinct modulation formats. The emissions designators for the modulation types used by the 520Q transmitter are as follows:

EMISSIONS DESIGNATORS:

Boost Mode	1K10F2D
Normal Mode:	9K60F2D
Double Density Mode:	9K60F2D
C&I Mode (Half-Baud):	4K80F2D
Priority Mode:	4K80F2D
MPass Mode (5 kbps):	5K90F1D
MPass Mode (10 kbps):	11K8F1D

2.0 TEST FACILITIES

2.1 Location

Unless otherwise noted, the radiated and conducted emissions test sites are located at the following addresses.

Site 1
Advanced Compliance Solutions, Inc.
3998 FAU Blvd, Suite 310
Boca Raton, Florida 33431
Phone: (561) 961-5585
Fax: (561) 961-5587
www.acstestlab.com

Site 2
Advanced Compliance Solutions, Inc.
5015 B.U. Bowman Drive
Buford GA 30518
Phone: (770) 831-8048
Fax: (770) 831-8598
www.acstestlab.com

2.2 Laboratory Accreditations/Recognitions/Certifications

Site 1
ACS, Boca Raton, Florida, is accredited to ISO/IEC 17025 by ANSI-ASQ National Accreditation Board under their ACLASS program and has been issued certificate number AT-1533 in recognition of this accreditation.

Site 2
ACS, Buford, GA is accredited to ISO/IEC 17025 by the National Institute of Standards and Technology under their National Voluntary Laboratory Accreditation Program (NVLAP).

Unless otherwise specified, all test methods described within this report are covered under the respective test site ISO/IEC 17025 scope of accreditation.

2.3 Radiated & Conducted Emissions Test Site Description

2.3.1 Semi-Anechoic Chamber Test Site

The EMC radiated test facility consists of an RF-shielded enclosure. The interior dimensions of the indoor semi-anechoic chamber are approximately 48 feet (14.6 m) long by 36 feet (10.8 m) wide by 24 feet (7.3 m) high and consist of rigid, 1/8 inch (0.32 cm) steel-clad, wood core modular panels with steel framing. In the shielded enclosure, the faces of the panels are galvanized and the chamber is self-supporting. 8-foot RF absorbing cones are installed on 4 walls and the ceiling. The steel-clad ground plane is covered with vinyl floor.

The turntable is driven by pneumatic motor, which is capable of supporting a 2000 lb. load. The turntable is flushed with the chamber floor which it is connected to, around its circumference, with metallic loaded springs. An EMCO Model 1051 Multi-device Controller controls the turntable position.

A pneumatic motor is used to control antenna polarizations and height relative to the ground. The height information is displayed on the control unit EMCO Model 1050.

The control room is an RF shielded enclosure attached to the semi-anechoic chamber with two bulkhead panels for connecting RF, and control cables. The dimension of the room is 7.3 m x 4.9 m x 3 m high and the entrance doors of both control and conducted rooms are 3 feet (0.91 m) by 7 feet (2.13 m).

A diagram of the Semi-Anechoic Chamber Test Site is shown in Figure 2.3.1-1 below:

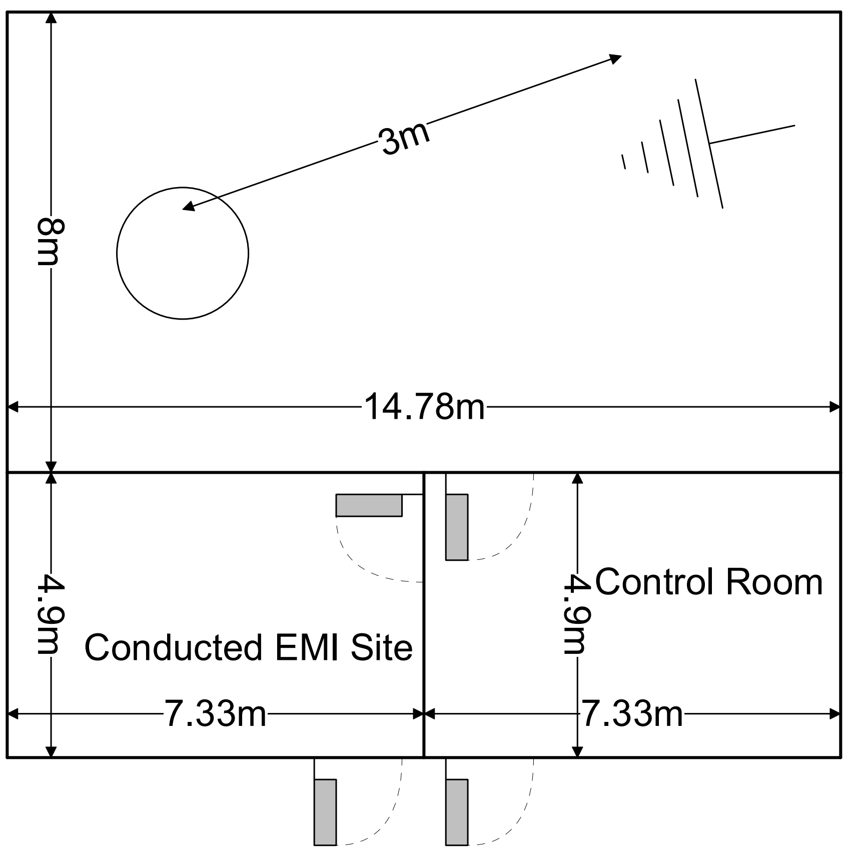

Figure 2.3.1-1: Semi-Anechoic Chamber Test Site

2.3.2 Conducted Emissions Test Site Description

The dimensions of the shielded conducted room are 7.3 x 4.9 x 3 m^3. As per ANSI C63.4 2003 requirements, the data were taken using two LISNs; a Solar Model 8028-50 50 Ω/50 μH and an EMCO Model 3825, which are installed as shown in Photograph 3. For 220 V, 50 Hz, a Polarad LISN (S/N 879341/048) is used in conjunction with a 1 kVA, 50 Hz/220 V EDGAR variable frequency generator, Model 1001B, to filter conducted noise from the generator.

A diagram of the room is shown below in figure 2.3.2-1:

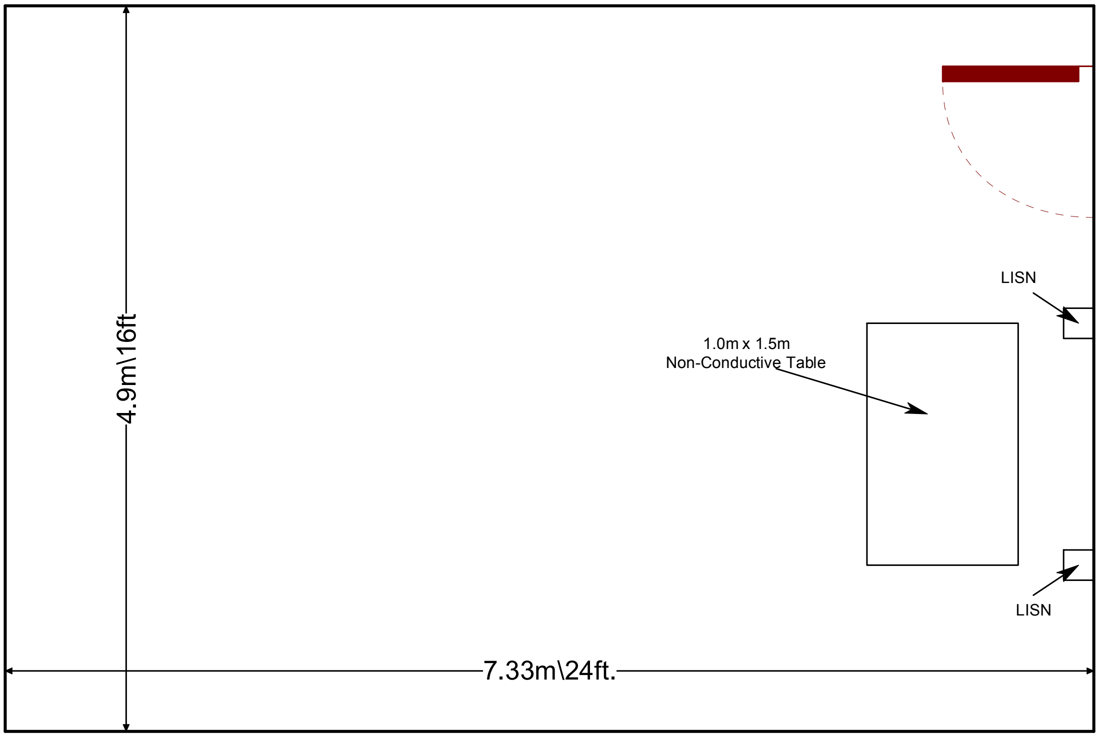

Figure 2.3.2-1: AC Mains Conducted EMI Site

3.0 APPLICABLE STANDARD REFERENCES

The following standards were used:

1 - ANSI C63.4-2003: Method of Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the 9 kHz to 40GHz - 2003
2 - US Code of Federal Regulations (CFR): Title 47, Part 2, Subpart J: Equipment Authorization Procedures - 2012
3 - US Code of Federal Regulations (CFR): Title 47, Part 90, Subpart I: Private Land Mobile Radio Services – 2012
4 – TIA-603-C: Land Mobile FM or PM - Communications Equipment - Measurement and Performance Standards – 2004

4.0 LIST OF TEST EQUIPMENT

The calibration interval of test equipment is annually or the manufacturer's recommendations. Where the calibration interval deviates from the annual cycle based on the instrument manufacturer's recommendations, it shall be stated below.

Table 4-1: ACS Test Equipment

AssetID	Manufacturer	Model #	Equipment Type	Serial #	Last Calibration Date	Calibration Due Date
283	Rohde & Schwarz	FSP40	Spectrum Analyzers	1000033	8/26/2011	8/26/2012
340	Aeroflex/Weinschel	AS-20	Attenuators	7136	8/29/2011	8/29/2012
426	Thermotron	S-8 Mini Max	Environmental Chamber	25-2888-10	8/29/2011	8/29/2012
523	Agilent	E7405	Spectrum Analyzers	MY45103293	1/5/2011	1/5/2013
524	Chase	CBL6111	Antennas	1138	1/7/2011	1/7/2013
562	United Microwave Products, Inc.	AA-190-00.48.0	Cables	562	8/11/2011	8/11/2012
2002	EMCO	3108	Antennas	2147	11/30/2011	11/30/2013
2004	EMCO	3146	Antennas	1385	11/30/2011	11/30/2013
2006	EMCO	3115	Antennas	2573	3/2/2011	3/2/2013
2007	EMCO	3115	Antennas	2419	1/18/2012	1/18/2014
2011	Hewlett-Packard	HP 8447D	Amplifiers	2443A03952	1/2/2012	1/2/2013
2037	ACS Boca	Chamber EMI Cable Set	Cable Set	2037	1/2/2012	1/2/2013
2071	Trilithic, Inc.	4HC1400-1-KK	Filter	9643263	1/19/2012	1/19/2013
2073	Mini Circuits	NHP-800	Filter	10247	1/19/2012	1/19/2013
2075	Hewlett Packard	8495B	Attenuators	2626A11012	1/2/2012	1/2/2013
2082	Teledyne Storm Products	90-010-048	Cables	2082	5/31/2012	5/31/2013
2091	Agilent Technologies, Inc.	8573A	Spectrum Analyzers	2407A03233	12/12/2011	12/12/2013
RE563	Hewlett Packard	8673D	Signal Generators	3034A01078	2/22/2011	2/22/2013
RE586	Agilent Technologies, Inc.	83017A	Amplifiers	3123A00168	9/23/2011	9/23/2012

NCR=No Calibration Required

Table 4-2: Transient Frequency Behavior Test Equipment

Manufacturer	Model	Equipment Type	Serial Number	Due Date
LeCroy	LT364	Oscilloscope	00414	9/8/2013
IFR/ Aeroflex	IFR500A	Service Monitor Receiver	5182	6/14/2013
Agilent	6286A	Power supply	1744A03842	12/29/2012
Agilent	8648C	Signal generator	3847A04696	6/12/2013
Agilent	8471D	Detector	29612	12/31/2013

5.0 SUPPORT EQUIPMENT

Table 5-1: Support Equipment

Item #	Type Device	Manufacturer	Model/Part #	Serial #
1	EUT	Sensus Metering Systems, Inc.	520Q	14003004, 14003024
2	DC Power Supply	MPJA	HY5003	003700278

Table 5-2: Cable Description

Cable #	Cable Type	Length	Shield	Termination
A	2 Wire Conductor	1.75 m	No	EUT to Power Supply
B	Power Cord	1.8m	No	Power Supply to AC Mains

6.0 EQUIPMENT UNDER TEST SETUP AND BLOCK DIAGRAM

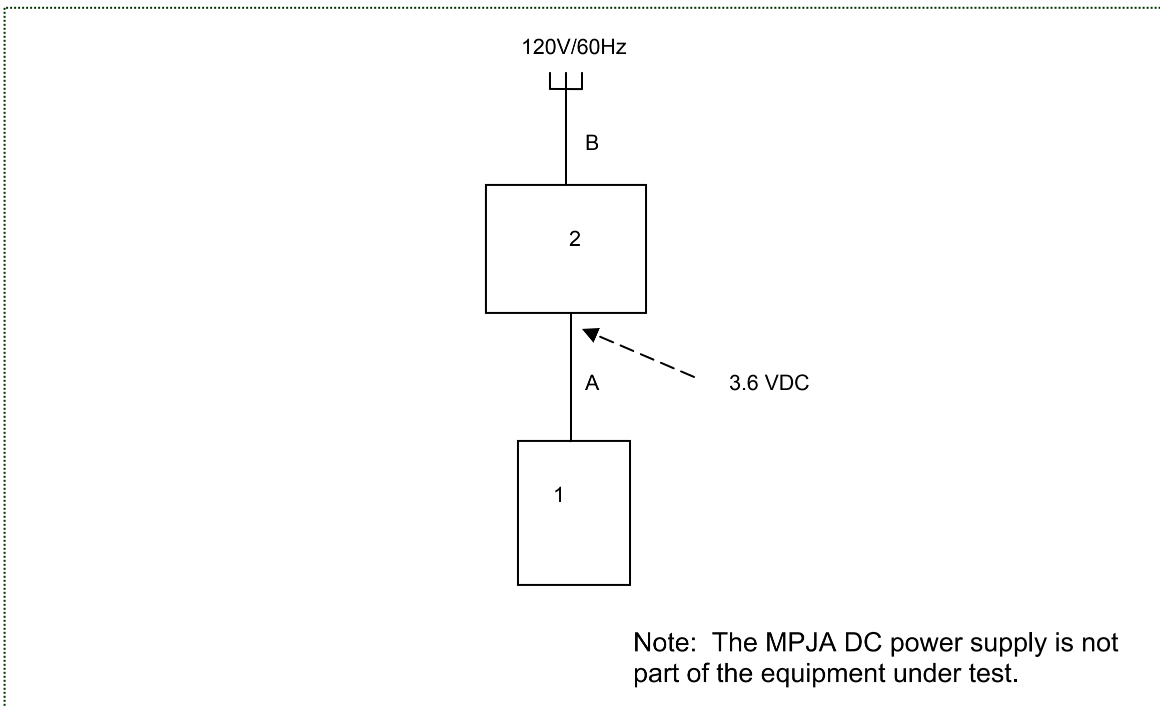

Figure 6-1: EUT Test Setup

7.0 SUMMARY OF TESTS

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

Table 7-1: Test Results Summary

Test Parameter	Test Site	Test Summary
RF Power Output	1	Pass
Occupied Bandwidth (Emissions Limits)	1	Pass
Spurious Emissions at Antenna Terminals	1	Pass
Field Strength of Spurious Emissions	1	Pass
Frequency Stability	2	Pass
Transient Frequency Behavior	N/A[1]	Pass

7.1 RF Power Output

7.1.1 Measurement Procedure

The RF output of the equipment under test was directly connected to the input of the Spectrum Analyzer through 20 dB of passive attenuation. The resolution and video bandwidths of the spectrum analyzer were set at sufficient levels, >> signal bandwidth, to produce accurate results. The internal correction factors of the spectrum analyzer were employed to correct for any cable or attenuator losses. Results are shown below.

7.1.2 Measurement Results

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Table 7.1.2-1: Peak Output Power

Frequency (MHz)	FCC Rule Part	Output Power (dBm)
451.0375	90	28.87
457.4125	90	28.10
463.7875	90	27.44

[1] The Transient Frequency Behavior evaluation was performed at Timco Engineering, Inc. which is accredited to ISO/IEC 17025 by American Association for Laboratory Accreditation (A2LA) and was issued a certificate number 0955.01.

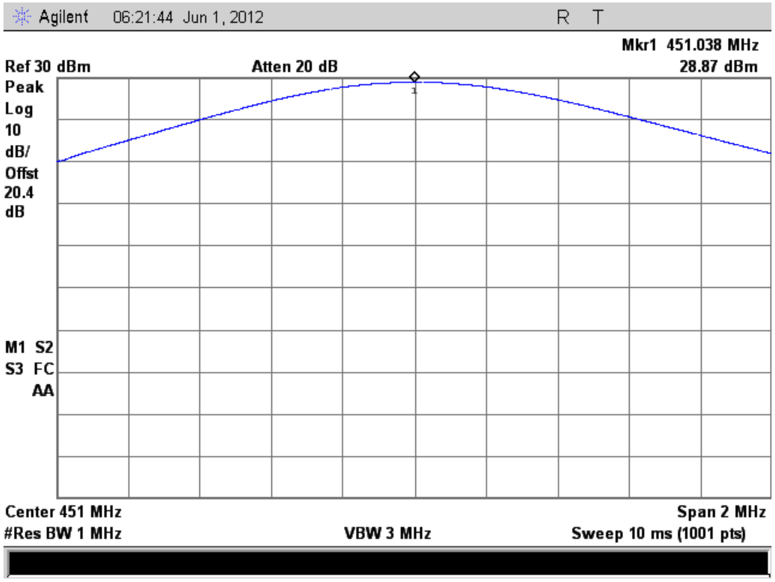

Figure 7.1.2-1: Peak Output Power – 451.0375 MHz

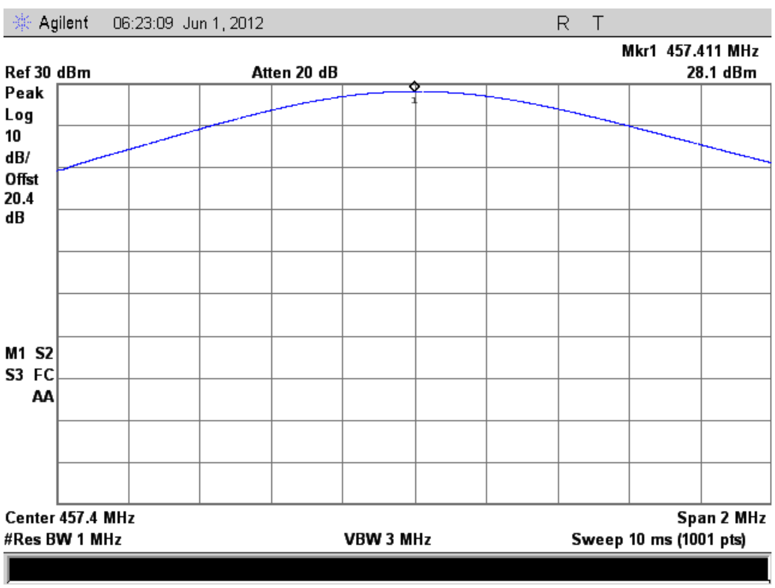

Figure 7.1.2-2: Peak Output Power – 457.4125 MHz

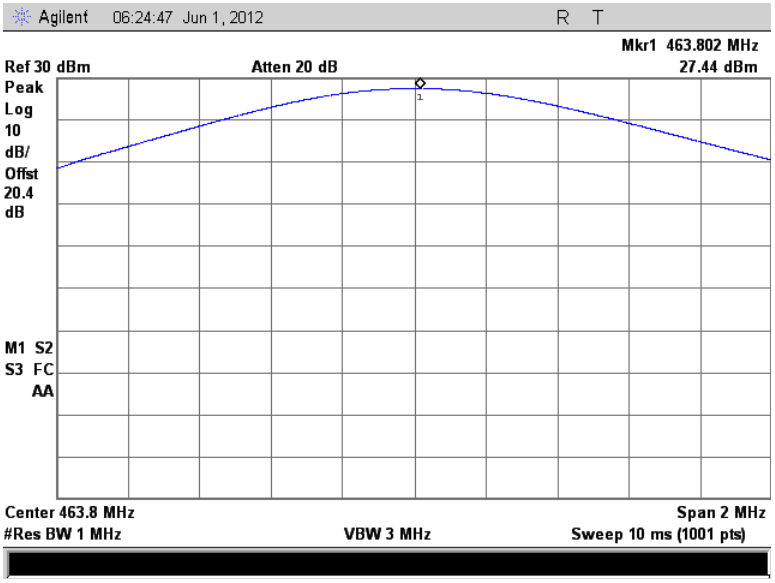

Figure 7.1.2-3: Peak Output Power – 463.7875 MHz

7.2 Occupied Bandwidth (Emission Limits)

7.2.1 Measurement Procedure

The RF output of the equipment under test was directly connected to the input of the Spectrum Analyzer through 20 dB of passive attenuation. The spectrum analyzer resolution and video bandwidths were set to 300 Hz and 3000 Hz respectively. The internal correction factors of the spectrum analyzer were employed to correct for any cable or attenuator losses. Results of the test are shown below for all modes of operation.

7.2.2 Measurement Results

Part 90.210(c)

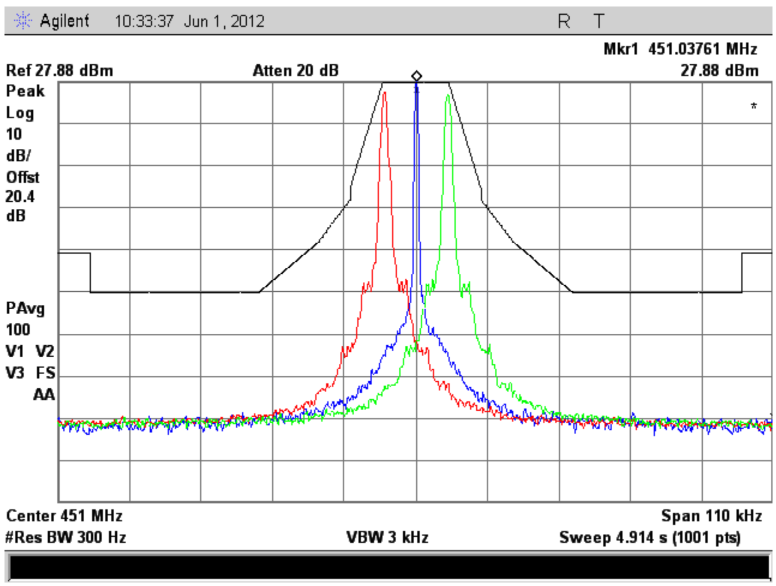

Figure 7.2.2-1: 451.0375 MHz – Boost Mode
Offset Channel +/- 8 (+/- 4800)

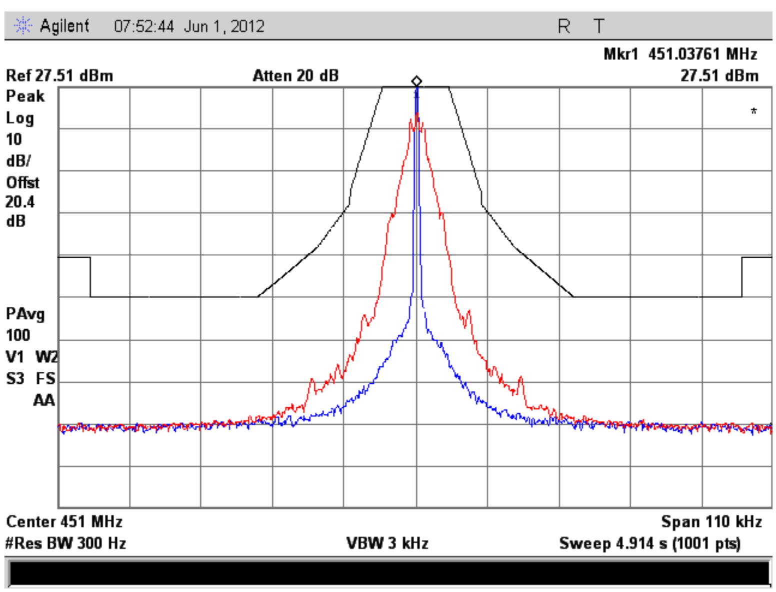

Figure 7.2.2-2: 451.0375 MHz – C&I Mode

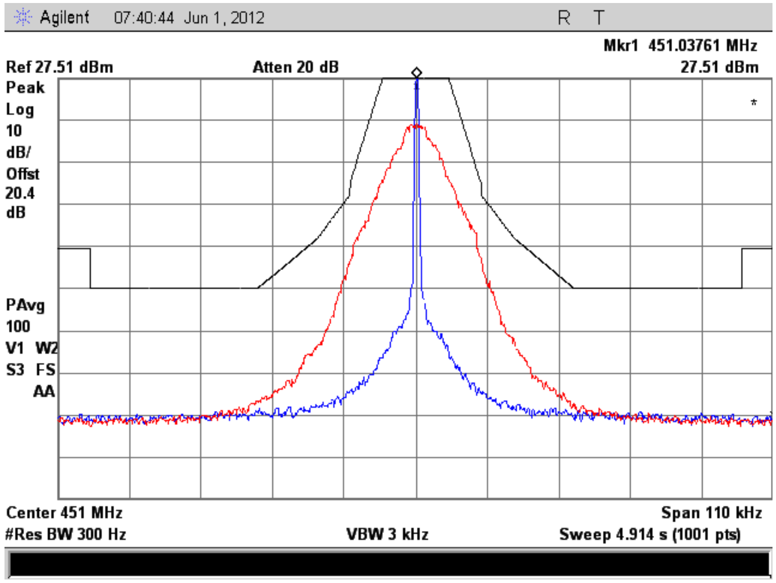

Figure 7.2.2-3: 451.0375 MHz – Double Density Mode

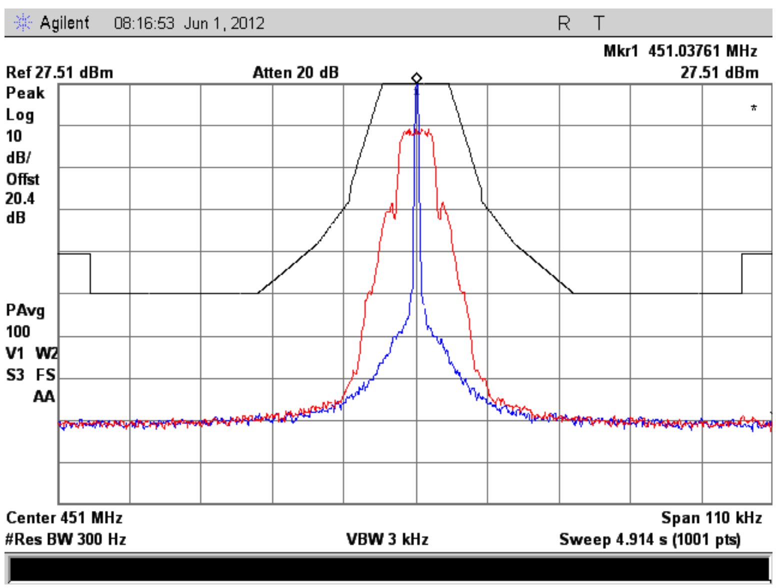

Figure 7.2.2-4: 451.0375 MHz – MPass 5k Mode

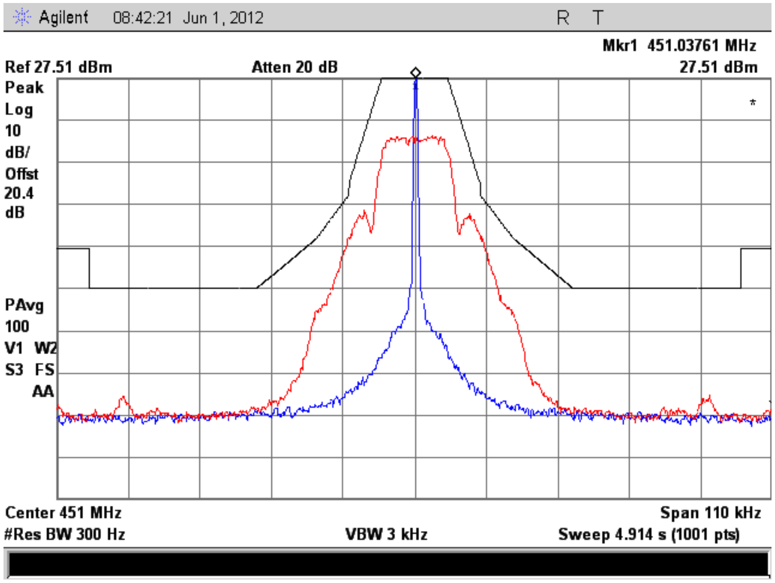

Figure 7.2.2-5: 451.0375 MHz – MPass 10k Mode

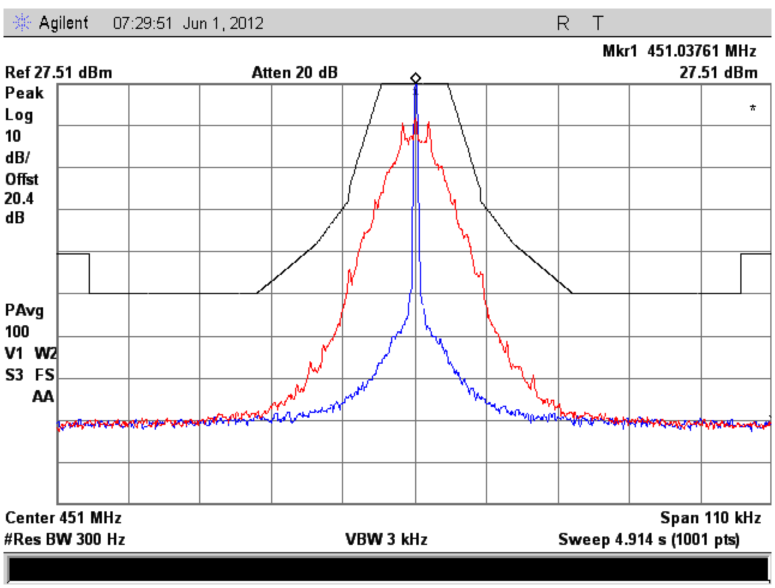

Figure 7.2.2-6: 451.0375 MHz –Normal Mode

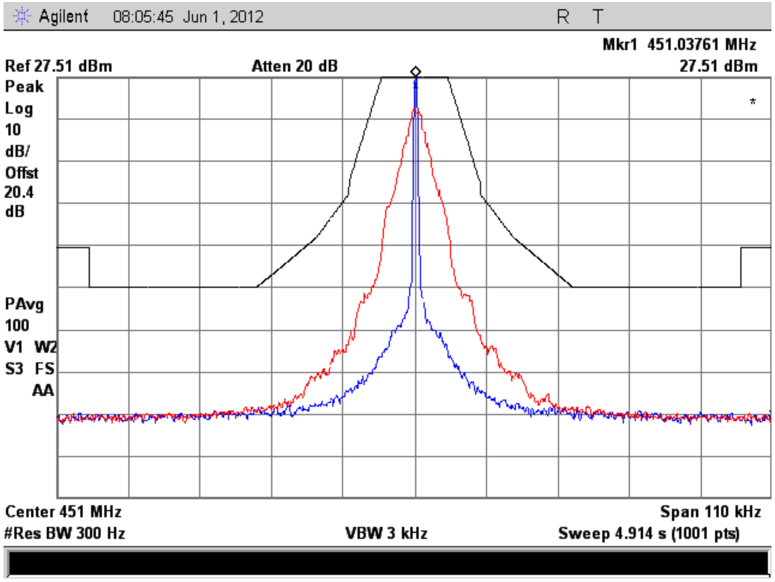

Figure 7.2.2-7: 451.0375 MHz – Priority Mode

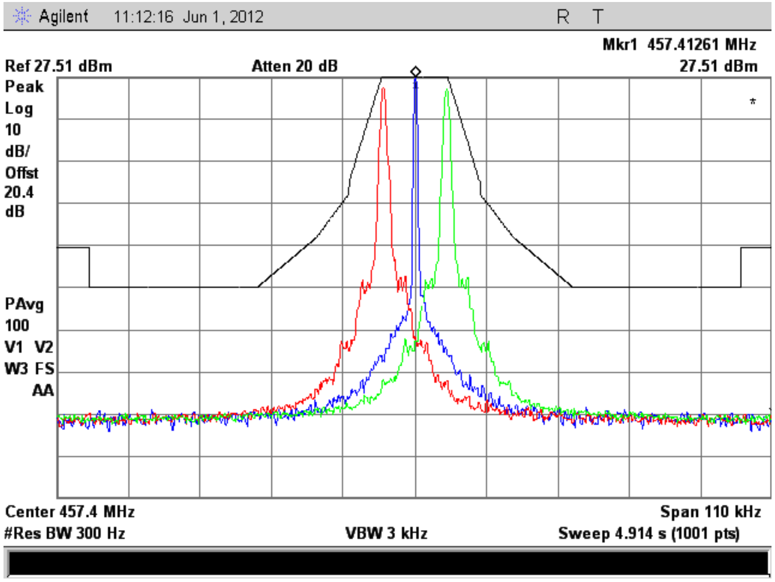

Figure 7.2.2-8: 457.4125 MHz – Boost Mode
Offset Channel +/- 8 (+/- 4800)

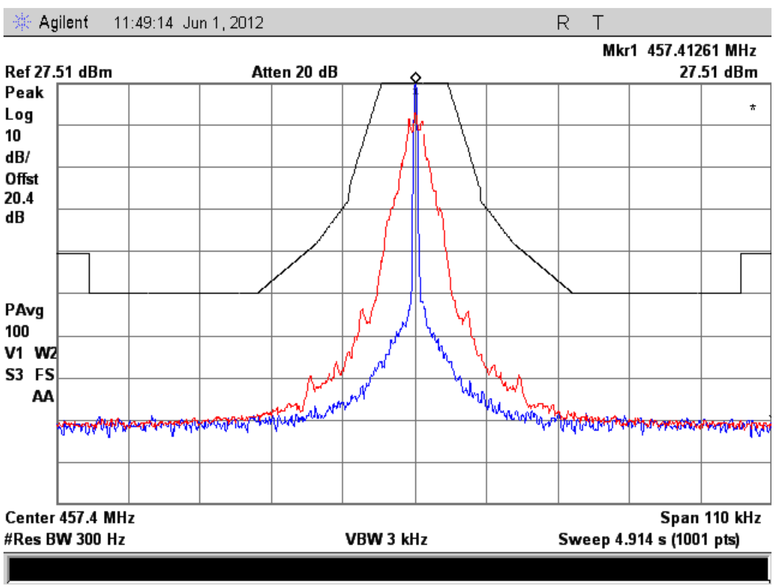

Figure 7.2.2-9: 457.4125 MHz – C&I Mode

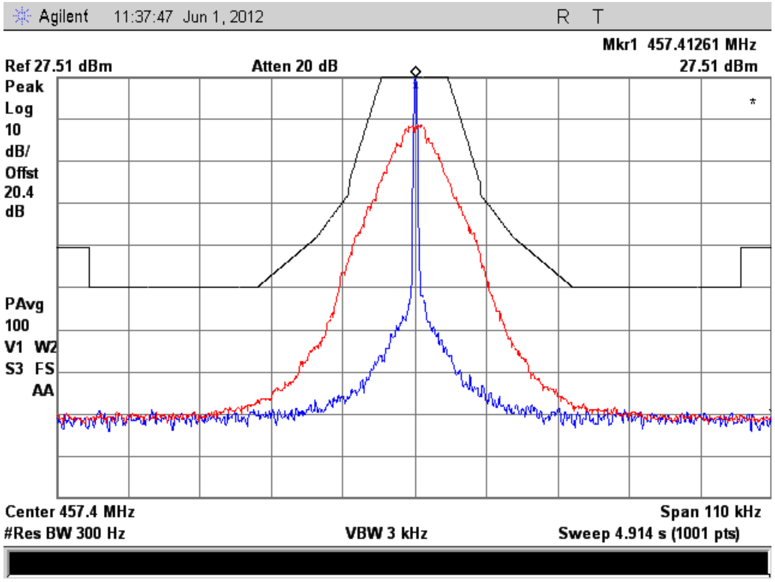

Figure 7.2.2-10: 457.4125 MHz – Double Density Mode

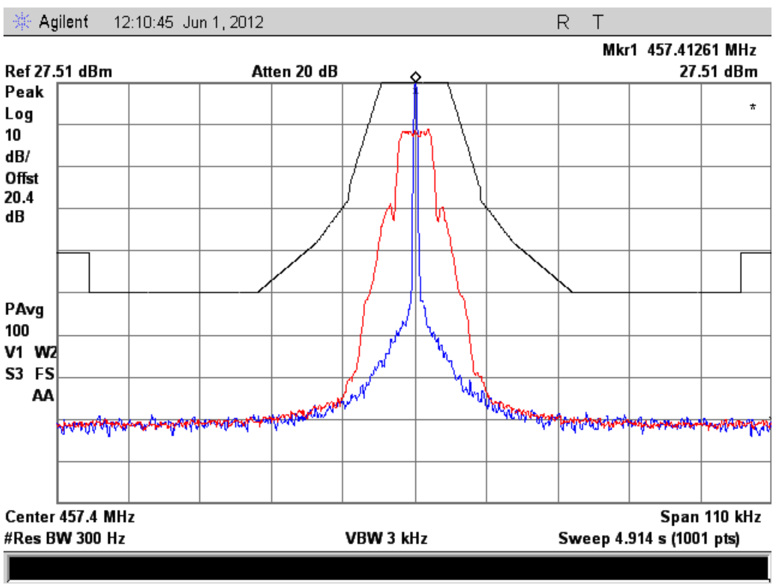

Figure 7.2.2-11: 457.4125 MHz – MPass 5k Mode

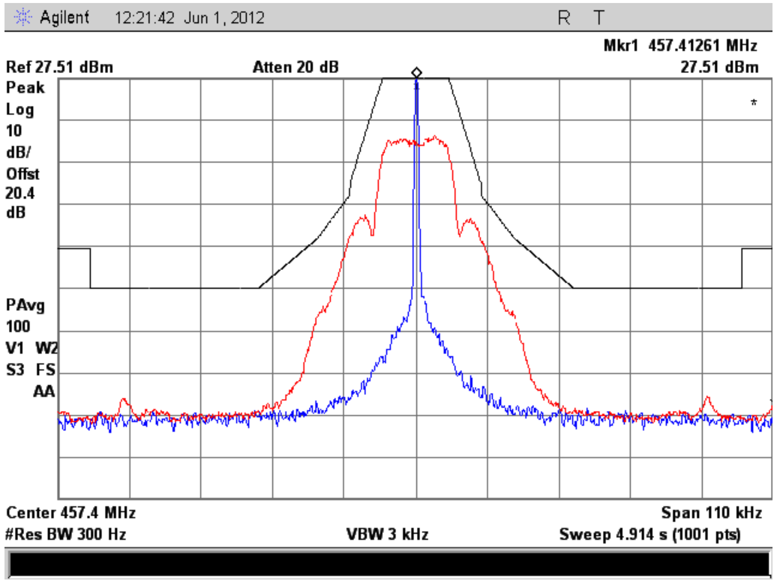

Figure 7.2.2-12: 457.4125 MHz – MPass 10k Mode

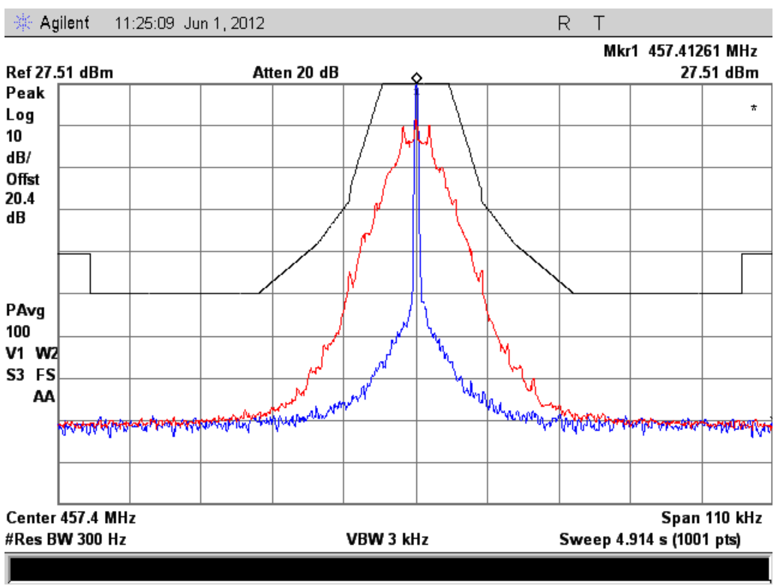

Figure 7.2.2-13: 457.4125 MHz –Normal Mode

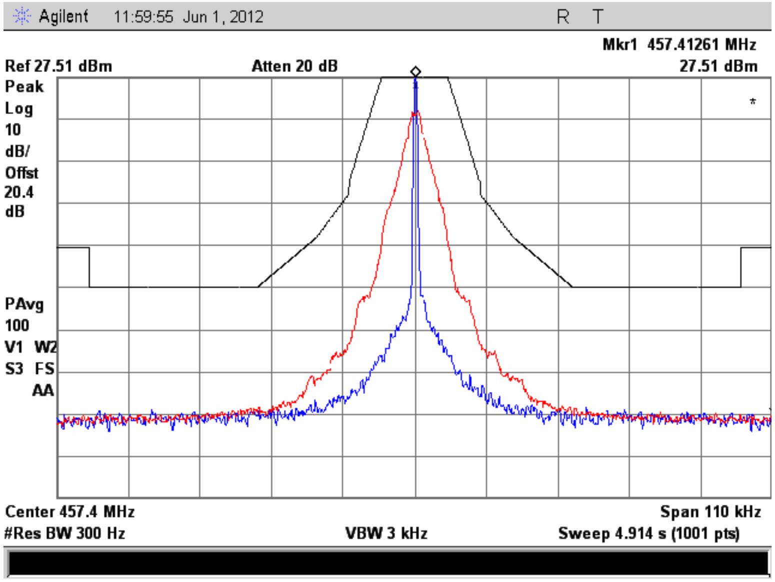

Figure 7.2.2-14: 457.4125 MHz – Priority Mode

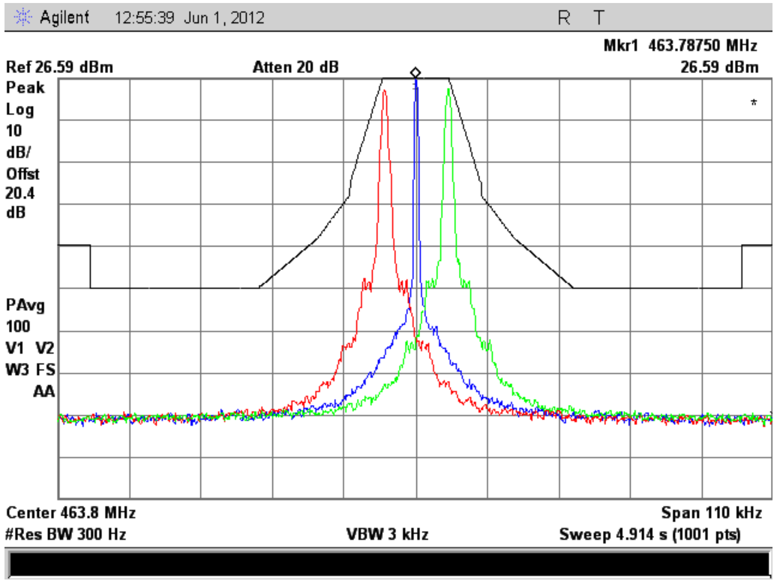

Figure 7.2.2-15: 463.7875 MHz – Boost Mode Offset Channel +/- 8 (+/- 4800)

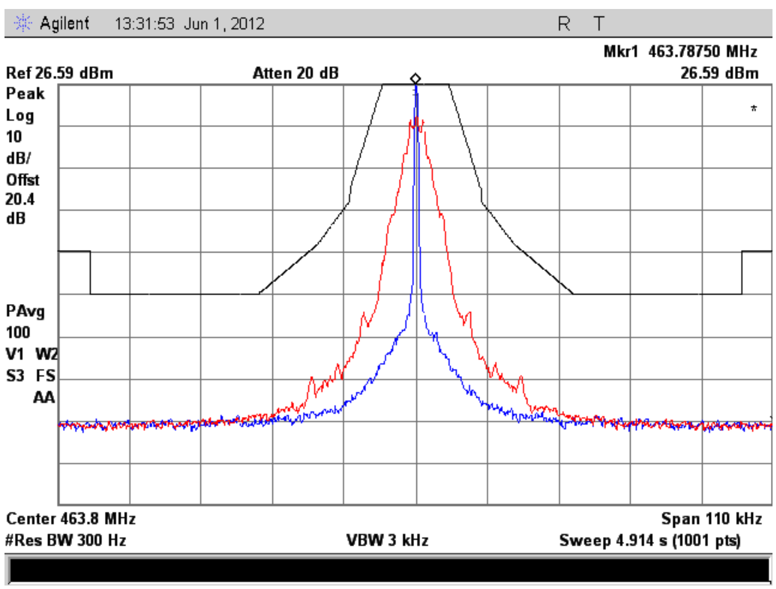

Figure 7.2.2-16: 463.7875 MHz – C&I Mode

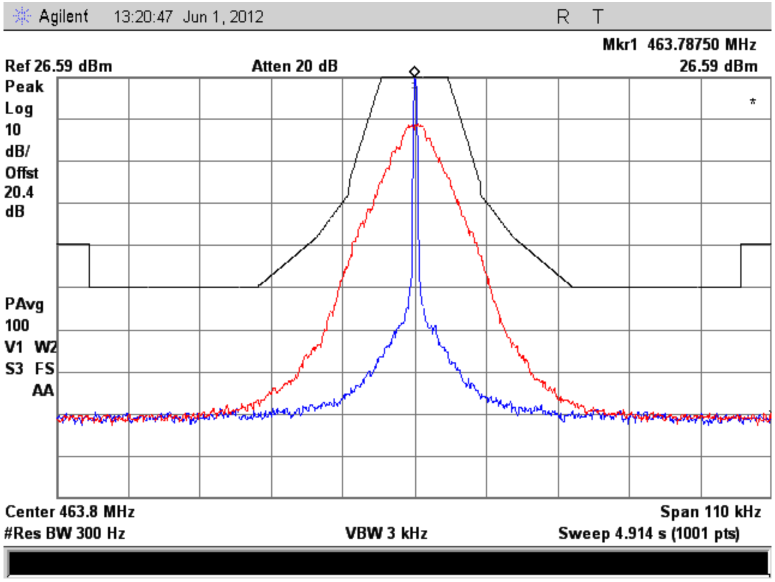

Figure 7.2.2-17: 463.7875 MHz – Double Density Mode

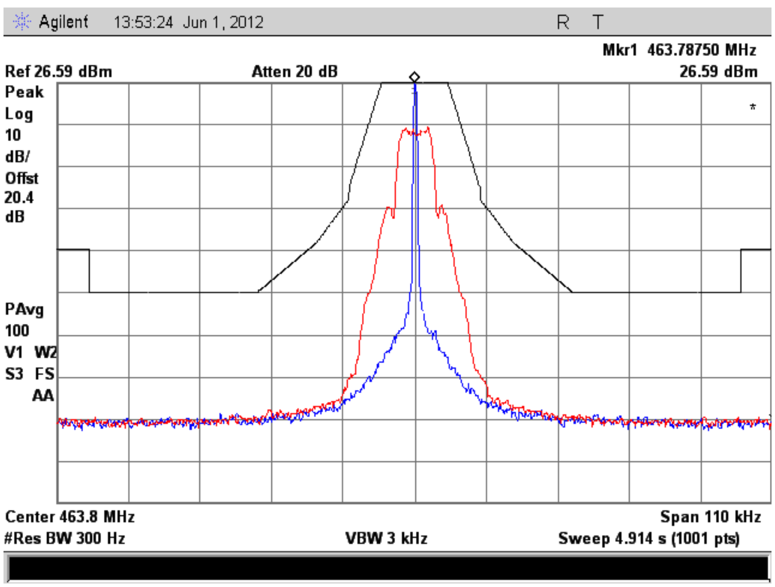

Figure 7.2.2-18: 463.7875 MHz – MPass 5k Mode

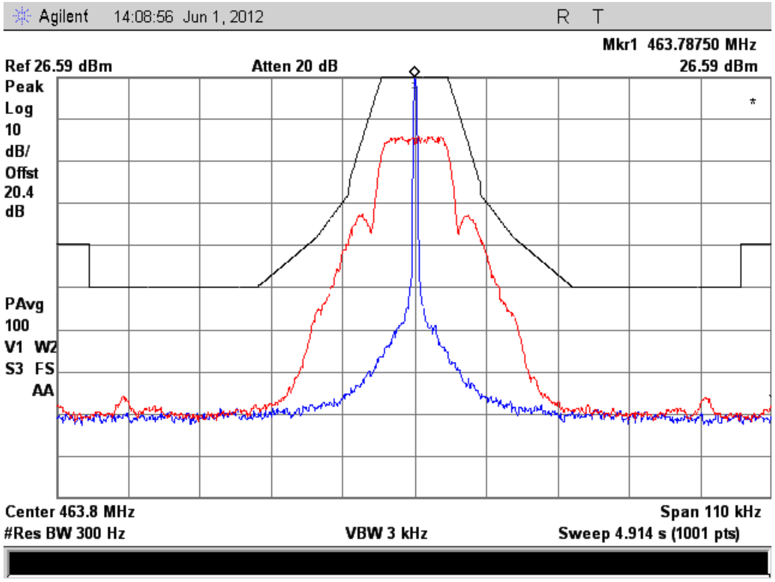

Figure 7.2.2-19: 463.7875 MHz – MPass 10k Mode

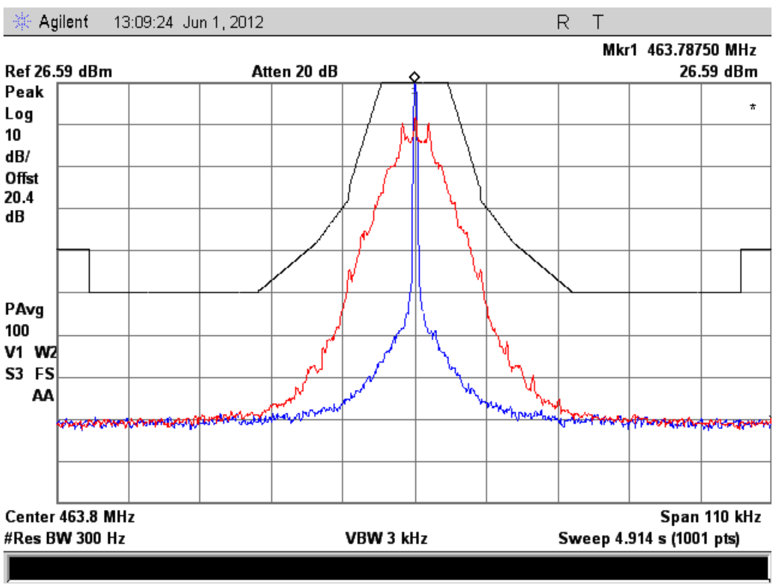

Figure 7.2.2-20: 463.7875 MHz –Normal Mode

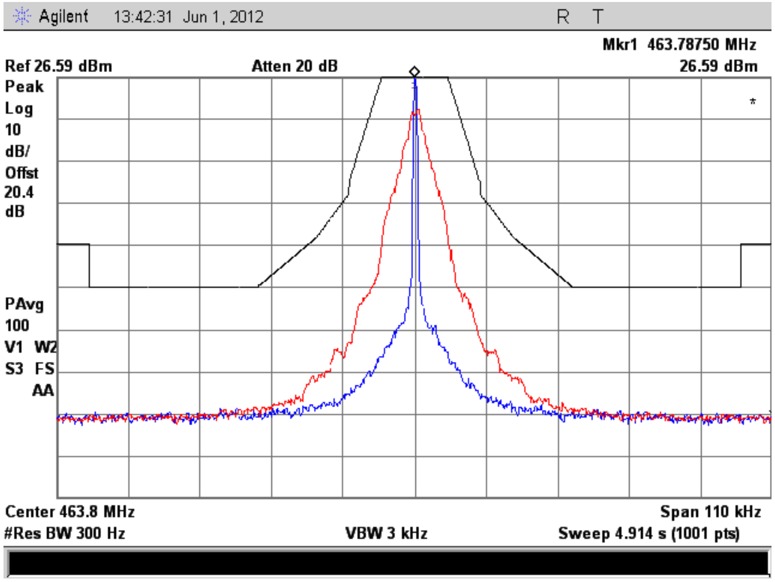

Figure 7.2.2-21: 463.7875 MHz – Priority Mode

7.3 Spurious Emissions at Antenna Terminals

7.3.1 <u>Measurement Procedure</u>

The RF output of the equipment under test was directly connected to the input of the Spectrum Analyzer through 20 dB of passive attenuation. The spectrum analyzer resolution bandwidth was set to 100 kHz below 1000 MHz and 1 MHz above 1000 MHz. The internal correction factors of the spectrum analyzer were employed to correct for any cable, attenuator or filter losses. The spectrum was investigated in accordance to CFR 47 Part 2.1057. Results are shown below.

7.3.2 <u>Measurement Results</u>

<u>Part 90.210(c)</u>

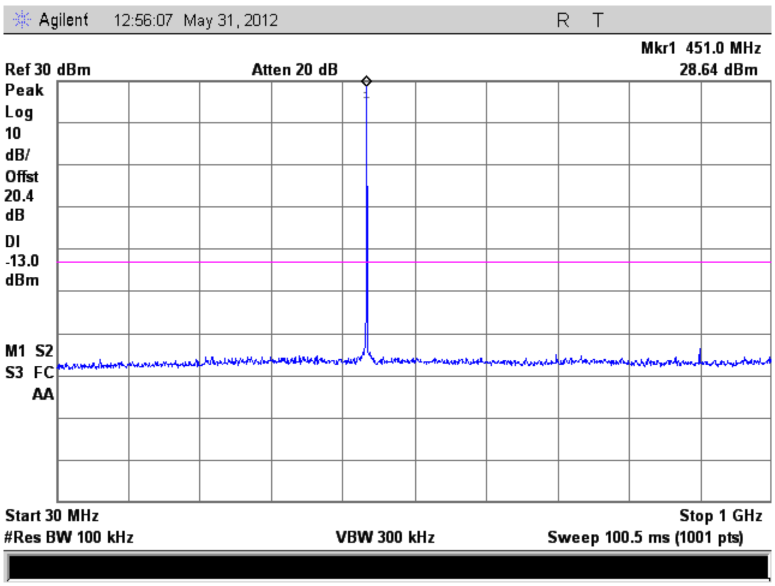

Figure 7.3.2-1: 451.0375 MHz – 30MHz to 1GHz

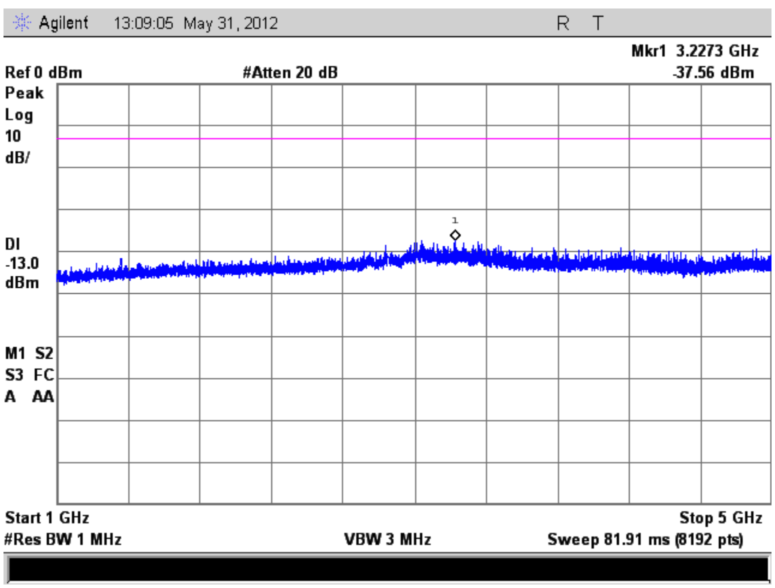

Figure 7.3.2-2: 451.0375 MHz – 1GHz to 5GHz

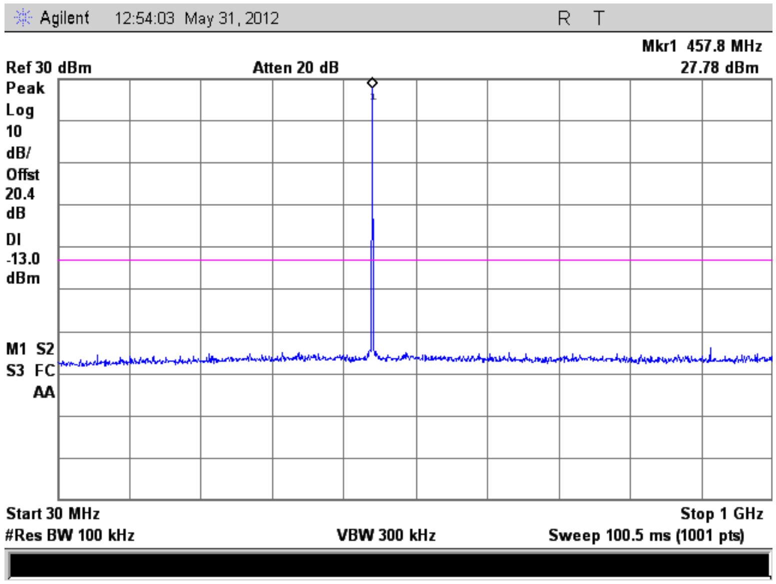

Figure 7.3.2-3: 457.4125 MHz – 30MHz to 1GHz

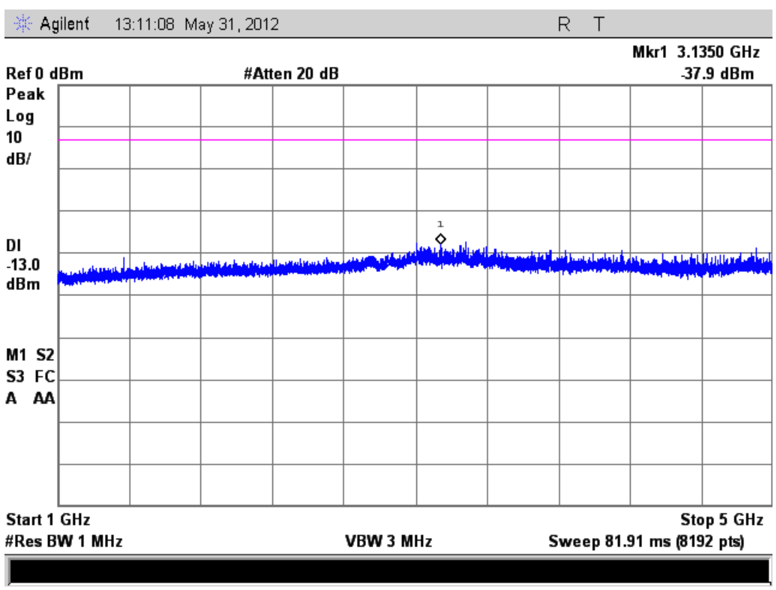

Figure 7.3.2-4: 457.4125 MHz – 1GHz to 5GHz

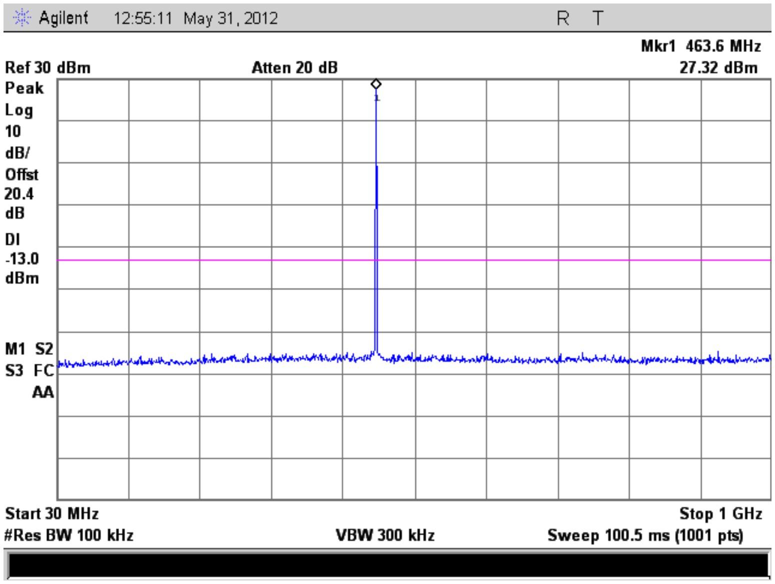

Figure 7.3.2-5: 463.7875 MHz – 30MHz to 1GHz

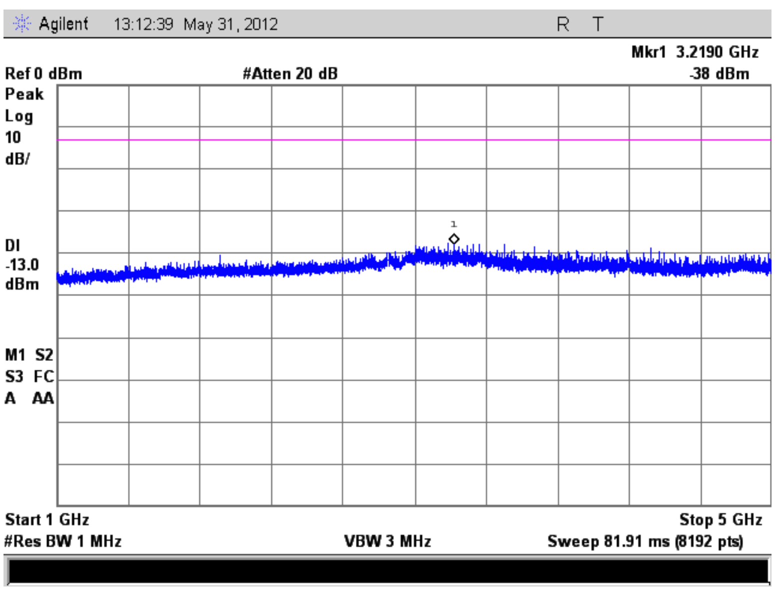

Figure 7.3.2-6: 463.7875 MHz – 1GHz to 5GHz

7.4 Field Strength of Spurious Emissions

7.4.1 Measurement Procedure

The equipment under test is placed in the Semi-Anechoic Chamber (described in section 2.3.1) on a wooden table at the turntable center. For each spurious emission, the antenna mast is raised and lowered from one (1) to four (4) meters and the turntable is rotated 360º and the maximum reading on the spectrum analyzer is recorded. This was repeated for both horizontal and vertical polarizations of the receive antenna.

The equipment under test is then replaced with a substitution antenna fed by a signal generator. The signal generator's frequency is set to that of the spurious emission recorded from the equipment under test. The antenna mast is raised and lowered from one (1) to four (4) meters to obtain a maximum reading on the spectrum analyzer. The output of the signal generator is then adjusted until the reading on the spectrum analyzer matches that obtained from the equipment under test. The signal generator level is recorded. The power in dBm of each spurious emission is calculated by correcting the signal generator level for the cable loss and gain of the substitution antenna referenced to a dipole. The spectrum was investigated in accordance to CFR 47 Part 2.1057.

The magnitude of all spurious emissions not reported were attenuated below the noise floor of the measurement system and therefore not specified in this report. Results are shown below.

7.4.2 Measurement Results

Part 90.210(c)

Table 7.4.2-1: Field Strength of Spurious Emissions – 451.0375 MHz

Frequency (MHz)	Spectrum Analyzer Level (dBm)	Antenna Polarity (H/V)	Spurious ERP (dBm)	Limit (dBm)	Margin (dB)
902.075	-46.20	H	-34.63	-13.00	21.63
1353.1125	-37.85	H	-40.63	-13.00	27.63
1804.15	-54.55	H	-63.32	-13.00	50.32
902.075	-48.35	V	-35.23	-13.00	22.23
1353.1125	-39.05	V	-42.63	-13.00	29.63
1804.15	-51.80	V	-57.42	-13.00	44.42
2255.1875	-55.50	V	-56.27	-13.00	43.27
902.075	-48.35	V	-35.23	-13.00	22.23

NOTE: All frequencies not listed were below the noise floor of the spectrum analyzer.

Table 7.4.2-2: Field Strength of Spurious Emissions – 457.4125 MHz

Frequency (MHz)	Spectrum Analyzer Level (dBm)	Antenna Polarity (H/V)	Spurious ERP (dBm)	Limit (dBm)	Margin (dB)
914.825	-47.40	H	-37.61	-13.00	24.61
1372.2375	-39.35	H	-42.98	-13.00	29.98
1829.65	-50.80	H	-54.82	-13.00	41.82
914.825	-50.45	V	-38.86	-13.00	25.86
1372.2375	-34.80	V	-38.58	-13.00	25.58
1829.65	-51.50	V	-56.37	-13.00	43.37
2287.0625	-55.50	V	-66.37	-13.00	53.37

NOTE: All frequencies not listed were below the noise floor of the spectrum analyzer.

Table 7.4.2-3: Field Strength of Spurious Emissions – 463.7875 MHz

Frequency (MHz)	Spectrum Analyzer Level (dBm)	Antenna Polarity (H/V)	Spurious ERP (dBm)	Limit (dBm)	Margin (dB)
927.575	-45.60	H	-36.75	-13.00	23.75
1391.3625	-38.20	H	-41.03	-13.00	28.03
1855.15	-52.75	H	-57.32	-13.00	44.32
927.575	-49.80	V	-39.35	-13.00	26.35
1391.3625	-38.90	V	-41.68	-13.00	28.68
1855.15	-52.65	V	-57.62	-13.00	44.62
2318.9375	-54.45	V	-61.71	-13.00	48.71

NOTE: All frequencies not listed were below the noise floor of the spectrum analyzer.

7.5 Frequency Stability

7.5.1 Measurement Procedure

The equipment under test is placed inside an environmental chamber. The RF output is directly coupled to the input of the measurement equipment and a power supply is attached to the primary supply voltage.

Frequency measurements were made at the extremes of the of temperature range -30º C to +50º C and at intervals of 10º C at normal supply voltage. A period of time sufficient to stabilize all components of the equipment was allowed at each frequency measurement. At a temperature 20º C the measurements were performed at 85% and 115% of the EUT nominal voltage. The maximum variation of frequency was recorded.

7.5.2 Measurement Results

Part 90.213

Frequency Stability

Frequency (MHz): 451.0375

Temperature	Frequency	Frequency Error	Voltage	Voltage
C	MHz	(PPM)	(%)	(VDC)
-30 C	451.037434	-0.146	100%	3.60
-20 C	451.037474	-0.058	100%	3.60
-10 C	451.037504	0.009	100%	3.60
0 C	451.037566	0.146	100%	3.60
10 C	451.037577	0.171	100%	3.60
20 C	451.037493	-0.016	100%	3.60
30 C	451.037514	0.031	100%	3.60
40 C	451.037546	0.102	100%	3.60
50 C	451.037540	0.089	100%	3.60
20 C	451.037494	-0.013	85%	3.06
20 C	451.037501	0.002	115%	4.14

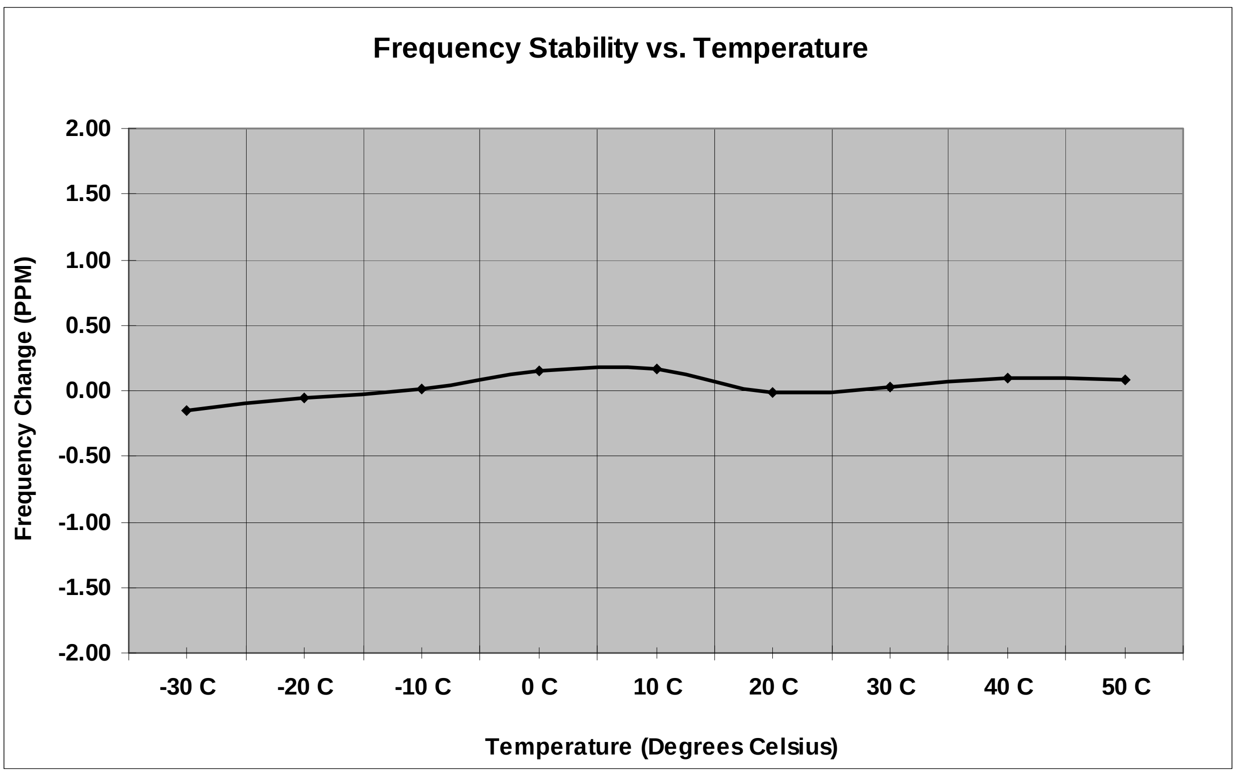

Figure 7.5.2-1: Frequency Stability – 451.0375 MHz

Frequency Stability

Frequency (MHz): 457.4125

Temperature	Frequency	Frequency Error	Voltage	Voltage
C	MHz	(PPM)	(%)	(VDC)
-30 C	**457.412426**	**-0.162**	100%	3.60
-20 C	**457.412475**	**-0.055**	100%	3.60
-10 C	**457.412503**	**0.007**	100%	3.60
0 C	**457.412571**	**0.155**	100%	3.60
10 C	**457.412574**	**0.162**	100%	3.60
20 C	**457.412494**	**-0.013**	100%	3.60
30 C	**457.412517**	**0.037**	100%	3.60
40 C	**457.412535**	**0.077**	100%	3.60
50 C	**457.412530**	**0.066**	100%	3.60
20 C	**457.412493**	**-0.015**	85%	3.06
20 C	**457.412494**	**-0.013**	115%	4.14

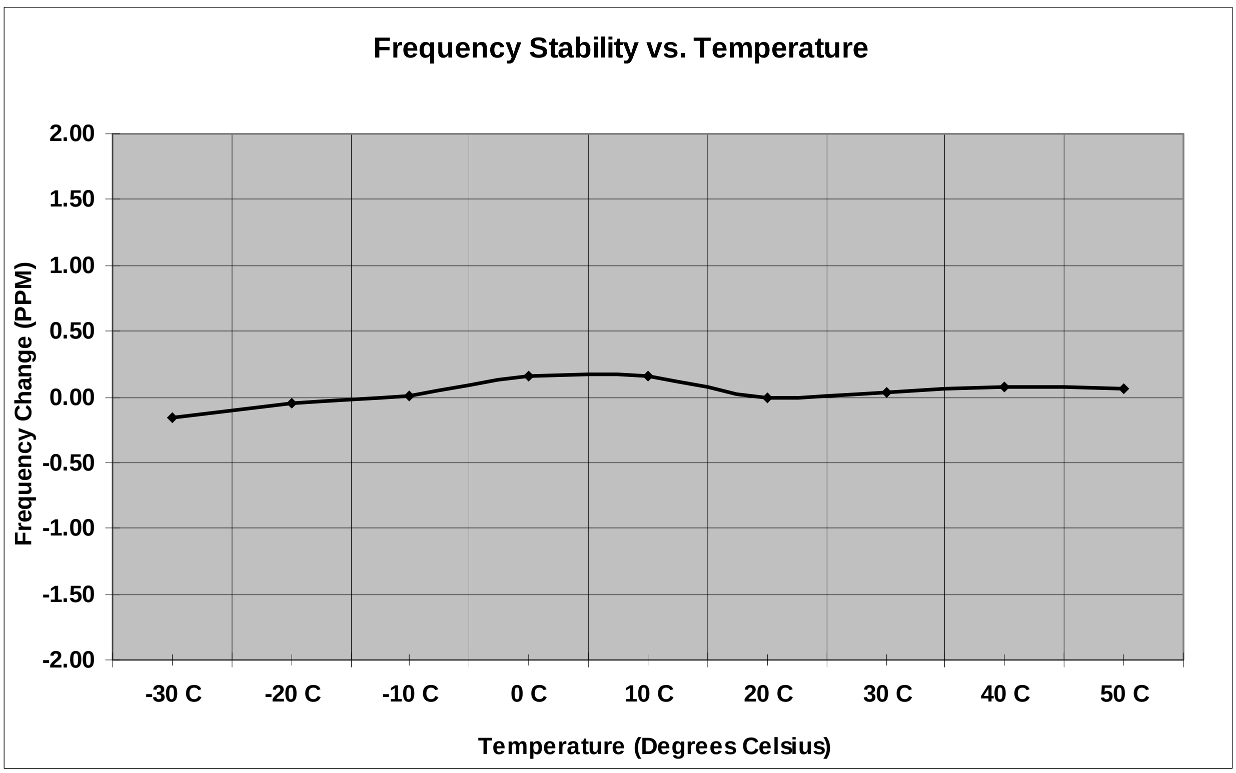

Figure 7.5.2-2: Frequency Stability – 457.4125 MHz

Frequency Stability

Frequency (MHz): 463.7875

Temperature	Frequency	Frequency Error	Voltage	Voltage
C	MHz	(PPM)	(%)	(VDC)
-30 C	**463.787422**	**-0.168**	100%	3.60
-20 C	**463.787475**	**-0.054**	100%	3.60
-10 C	**463.787501**	**0.002**	100%	3.60
0 C	**463.787573**	**0.157**	100%	3.60
10 C	**463.787576**	**0.164**	100%	3.60
20 C	**463.787493**	**-0.015**	100%	3.60
30 C	**463.787522**	**0.047**	100%	3.60
40 C	**463.787538**	**0.082**	100%	3.60
50 C	**463.787537**	**0.080**	100%	3.60
20 C	**463.787492**	**-0.017**	85%	3.06
20 C	**463.787492**	**-0.017**	115%	4.14

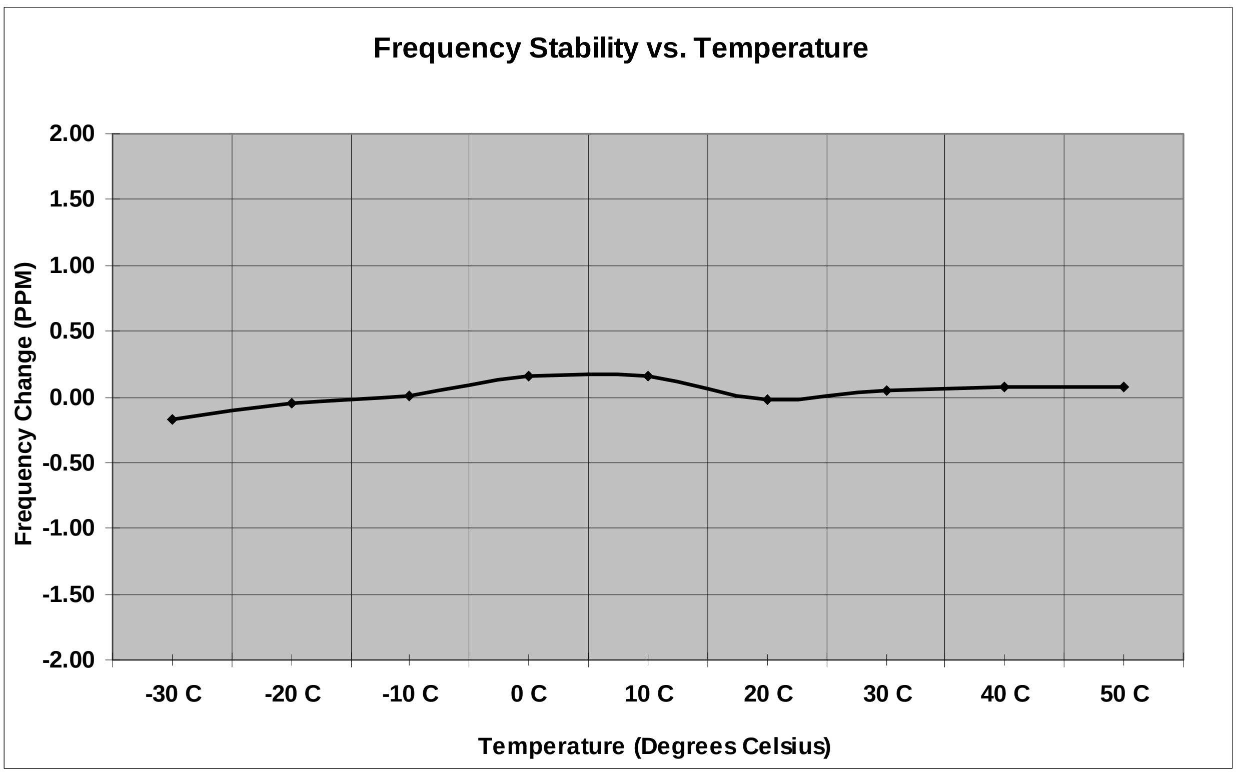

Figure 7.5.2-3: Frequency Stability – 463.7875 MHz

7.6 Transient Frequency Behavior

7.6.1 Measurement Procedure

The measurements were performed using a test receiver. The EUT was connected using the variable attenuator and a 4-way resistive coupler. The transmitter level was set to 40 dB below the test receivers maximum input level, and then the transmitter was turned off.   With the transmitter off the signal generator was set 20 dB below the level of the transmitter and maintained at the same amplitude through-out the test. Then, the attenuation between the transmitter and the RF detector was reduced by 30 dB. The Transient Frequency Behavior is reported below.

7.6.2 Measurement Results

Part 90.214

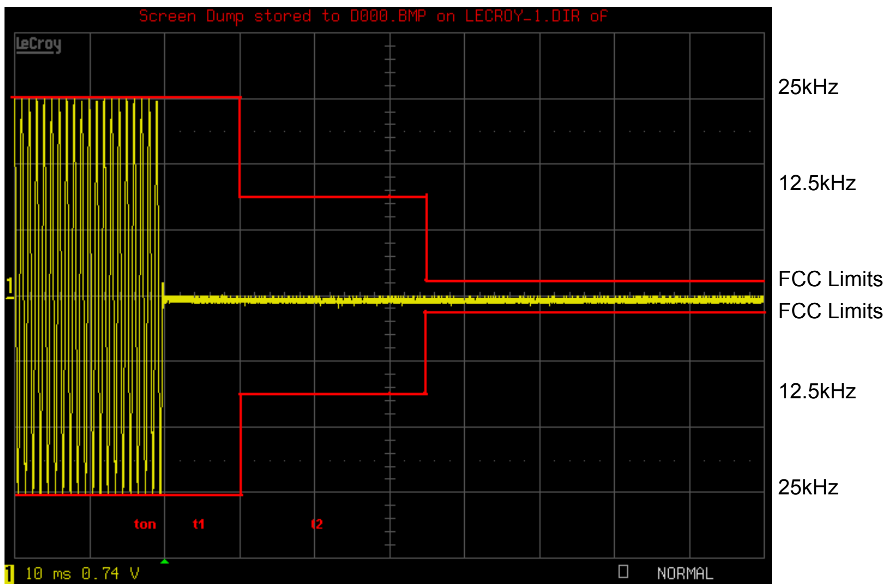

Figure 7.6.2-1: Transient Frequency Behavior – Transmitter On

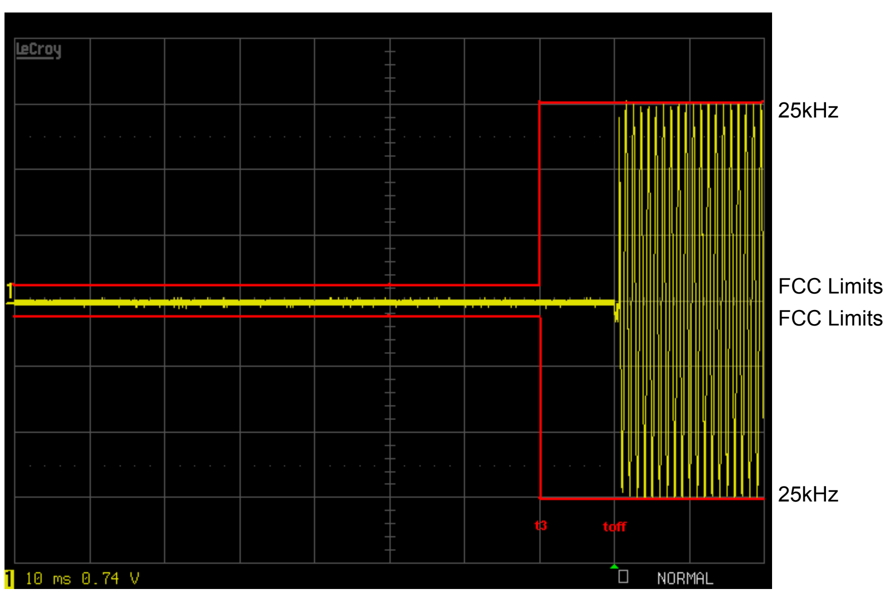

Figure 7.6.2-2: Transient Frequency Behavior – Transmitter Off

8.0 CONCLUSION

In the opinion of ACS, Inc. the model 520Q, manufactured by Sensus Metering Systems, Inc., meets all the requirements of FCC Part 90 Subpart I, were applicable.

End Report