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Radio Test Report

FCC Part 80, 90 and 95 and RSS 119 (216 MHz to 222 MHz)

Model: TD220Max

COMPANY:	GE MDS LLC 175 Science Parkway Rochester, NY 14620
TEST SITE(S):	NTS Silicon Valley 41039 Boyce Road. Fremont, CA. 94538-2435
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REVISION HISTORY

Rev#	Date	Comments	Modified By
-	July 9, 2014	First release	
1	July 30, 2014	Added mask measurements at 220.00625 MHz and 221.99875 MHz for Part 90 and highest channel in segment A and lowest channel in segment B for Part 95	dwb

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SCOPE

Tests have been performed on the GE MDS LLC model TD220Max, pursuant to the relevant requirements of the following standard(s) in order to obtain device certification against the regulatory requirements of the Federal Communications Commission and Industry Canada.

- Code of Federal Regulations (CFR) Title 47 Part 2
- CFR 47 Part 80 (Stations In The Maritime Services), Subpart J—Public Coast Stations (AMTS)
- CFR 47 Part 90 (Private Land Mobile Radio Service), Subparts K and T
- CFR 47 Part 95 (Personal Radio Service), Subpart F – 218-219 MHz Service
- Industry Canada RSS-Gen Issue 3, December 2010
- RSS-119, Issue 11, June 2011 (Radio Transmitters and Receivers Operating in the Land Mobile and Fixed Radio Services in the Frequency Range 27.41 to 960 MHz)

Conducted and radiated emissions data has been collected, reduced, and analyzed within this report in accordance with measurement guidelines set forth in the following reference standards and as outlined in NTS Silicon Valley test procedures:

ANSI C63.4:2009
ANSI TIA-603-C August 17, 2004

The intentional radiator above has been tested in a simulated typical installation to demonstrate compliance with the relevant Industry Canada performance and procedural standards.

Every practical effort was made to perform an impartial test using appropriate test equipment of known calibration. All pertinent factors have been applied to reach the determination of compliance.

The test results recorded herein are based on a single type test of the GE MDS LLC model TD220Max and therefore apply only to the tested sample. The sample was selected and prepared by Dennis McCarthy of GE MDS LLC.

OBJECTIVE

The primary objective of the manufacturer is compliance with the regulations outlined in the previous section.

Prior to marketing in the USA, the device requires certification. Prior to marketing in Canada, Class I transmitters, receivers and transceivers require certification.

Certification is a procedure where the manufacturer submits test data and technical information to a certification body and receives a certificate or grant of equipment authorization upon successful completion of the certification body's review of the submitted documents. Once the equipment authorization has been obtained, the label indicating compliance must be attached to all identical units, which are subsequently manufactured.

Maintenance of compliance is the responsibility of the manufacturer. Any modification of the product which may result in increased emissions should be checked to ensure compliance has been maintained (i.e., printed circuit board layout changes, different line filter, different power supply, harnessing or I/O cable changes, etc.).

STATEMENT OF COMPLIANCE

The tested sample of GE MDS LLC model TD220Max complied with the requirements of the standards and frequency bands declared in the scope of this test report.

Maintenance of compliance is the responsibility of the manufacturer. Any modifications to the product should be assessed to determine their potential impact on the compliance status of the device with respect to the standards detailed in this test report.

DEVIATIONS FROM THE STANDARDS

No deviations were made from the published requirements listed in the scope of this report.

TEST RESULTS

FCC Part 90 and RSS-119 (217-220 MHz Band)

FCC	Canada	Description	Measured	Limit	Result
Transmitter Modulation, output power and other characteristics					
§2.1033 (c) (5) §90.35	RSP 100 7.2 (a) RSS 119	Frequency range(s)	217.00625 – 219.99375 MHz	217 – 220 MHz	Pass
§2.1033 (c) (6) §2.1033 (c) (7) §2.1046 §90.205, §90.259	-	RF power output at the antenna terminals	32.2 dBm to 32.2 dBm	33 dBm	Pass
-	RSP 100 7.2 (a) RSS-119	RF power output at the antenna terminals	32.2 dBm to 32.2 dBm	37 dBm	Pass
§2.1033 (c) (4) §2.1047 § 90.210	RSP 100 7.2 (b) (iii) RSS-119	Emission types	CPFSK (F1D, F2D, F3D)		
		Emission mask	Within Mask	FCC Mask C, RSS-119 Mask D	Pass
§2.1049 § 90.209		Occupied Bandwidth	9.47 kHz	11.25 kHz	Pass
Transmitter spurious emissions					
§2.1051 §2.1057		At the antenna terminals	All emissions < -25 dBm	-25 dBm	Pass
§2.1053 §2.1057		Field strength	-50.2 dBm	-25 dBm	Pass
Receiver spurious emissions					
15.109	-	At the antenna terminals	-69.7 dBm @ 177.00 MHz (-12.7 dB)	2nW (-57dBm)	Pass
15.109	RSS GEN 7.2.3 Table 1	Field strength	23.0 dBuV/m	See limit table on page 21	Pass
Other details					
§2.1055 § 90.213	RSS-119	Frequency stability	0.3 ppm	1 ppm	
§2.1093	RS 102	RF Exposure			
§2.1033 (c) (8)	RSP 100 7.2 (a)	Final radio frequency amplifying circuit's dc voltages and currents for normal operation over the power range	13.8V, 6A	Information only	-
-	-	Antenna Gain	Maximum 16.5 dBi	Any allowed subject to licensing	Pass
Notes -					

FCC Part 90 and RSS-119 (220-222 MHz Band)

FCC	Canada	Description	Measured	Limit	Result
Transmitter Modulation, output power and other characteristics					
§2.1033 (c) (5) § 90.35	RSP 100 7.2 (a) RSS 119	Frequency range(s)	220.00625-221.99375 MHz	220-222 MHz	Pass
§2.1033 (c) (6) §2.1033 (c) (7) §2.1046 §90.205, §90.729	RSP 100 7.2 (a) RSS-119	ERP	33.4 dBm to 44.4 dBm Conducted (ERP based on licensing)	Varies according to antenna height and frequency up to 57 dBm	Pass
§2.1033 (c) (4) §2.1047 § 90.210	RSP 100 7.2 (b) (iii) RSS-119	Emission types	CPFSK (F1D)		
		Emission mask	Within Mask	Mask F [3]	Pass
§2.1049 § 90.209	RSS-119	Occupied Bandwidth	5.24 kHz	12.5 kHz [2]	Pass
Transmitter spurious emissions					
§2.1051 §2.1057		At the antenna terminals	All emissions < -25 dBm	-25 dBm	Pass
§2.1053 §2.1057		Field strength	-50.2 dBm	-25 dBm	Pass
Receiver spurious emissions					
15.109	-	At the antenna terminals	-69.7 dBm @ 177.00 MHz (-12.7 dB)	2nW (-57dBm)	Pass
15.109	RSS GEN 7.2.3 Table 1	Field strength	23.0 dBuV/m	See limit table on page 21	Pass
Other details					
§2.1055 § 90.213		Frequency stability	0.3 ppm	0.1 ppm [1]	
§2.1093	RS 102	RF Exposure			
§2.1033 (c) (8)	RSP 100 7.2 (a)	Final radio frequency amplifying circuit's dc voltages and currents for normal operation over the power range	13.8V, 6A	Information only	-
-	-	Antenna Gain	Maximum 16.5 dBi	Any allowed subject to licensing	Pass

Notes
[1] See letter from Keller and Heckman LLP regarding stability required for the 220-222 MHz band.
[2] Per FCC 90 and SRSP-512, 5 kHz segments may be aggregated to allow wider bandwidths.
3 See derivation of mask for aggregated channels in Appendix C.

FCC Part 80

FCC		Description	Measured	Limit	Result
Transmitter Modulation, output power and other characteristics					
§2.1033 (c) (5) §80.385		Frequency range(s)	216.00625 – 221.99375 MHz	216-220 MHz	Pass
§2.1033 (c) (6) §2.1033 (c) (7) §2.1046 §80.215(h)(5)		RF power output at the antenna terminals	32.2 dBm to 44.6 dBm	47 dBm	Pass
§2.1033 (c) (4) §2.1047 §80.211		Emission types	CPFSK (F1D)		
		Emission mask	within Mask	Mask F	
§2.1049 §80.205		Occupied Bandwidth	5.24 kHz 9.47 kHz	20 kHz	Pass
Transmitter spurious emissions					
§2.1051 §2.1057		At the antenna terminals	All emissions < -25 dBm	-25 dBm	Pass
§2.1053 §2.1057		Field strength	-50.2 dBm	-25 dBm	Pass
Receiver spurious emissions					
15.111		At the antenna terminals	-69.7 dBm @ 177.00 MHz (-12.7 dB)	2nW (-57dBm)	Pass
15.109		Field strength	23.0 dBuV/m	See limit table on page 21	Pass
Other details					
§2.1055 §80.209		Frequency stability	0.3 ppm	5 ppm	Pass
§2.1093		RF Exposure			
§2.1033 (c) (8)		Final radio frequency amplifying circuit's dc voltages and currents for normal operation over the power range	13.8V, 6A	Information only	-
-	-	Antenna Gain	Maximum 16.5 dBi	Any allowed subject to licensing	Pass
Notes -					

FCC Part 95

FCC		Description	Measured	Limit	Result
Transmitter Modulation, output power and other characteristics					
§2.1033 (c) (5) §95.853		Frequency range(s)	218.00625 – 218.99375 MHz	218-219 MHz	
§2.1033 (c) (6) §2.1033 (c) (7) §2.1046 §95.855		ERP	33.6 dBm to 43.0 dBm Conducted (ERP based on licensing)	43 dBm	Pass
§2.1033 (c) (4) §2.1047 §95.857		Emission types	CPFSK (F1D)		
		Emission mask	within Mask	95.857 Mask	
§2.1049 §95.857		Occupied Bandwidth	5.24 kHz 9.47 kHz	Emission must stay in frequency segment	Pass
Transmitter spurious emissions					
§2.1051 §2.1057		At the antenna terminals	All emissions < -25 dBm	-25 dBm	Pass
§2.1053 §2.1057		Field strength	-50.2 dBm	-25 dBm	Pass
Receiver spurious emissions					
15.111		At the antenna terminals	-69.7 dBm @ 177.00 MHz (-12.7 dB)	2nW (-57dBm)	Pass
15.109		Field strength	23.0 dBuV/m	See limit table on page 21	Pass
Other details					
§2.1055		Frequency stability	0.3 ppm	Not specified, mask performed at worst case stability per 95.857(c)	-
§2.1093		RF Exposure			
§2.1033 (c) (8)		Final radio frequency amplifying circuit's dc voltages and currents for normal operation over the power range	13.8V, 6A	Information only	-
-	-	Antenna Gain	Maximum 16.5 dBi	Any allowed subject to licensing	Pass
Notes -					

EXTREME CONDITIONS

Frequency stability is determined over extremes of temperature and voltage. The extremes of voltage were 85 to 115 percent of the nominal value.

The extremes of temperature were -30°C to +50°C as specified in FCC §2.1055(a)(1).

MEASUREMENT UNCERTAINTIES

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level (based on a coverage factor (k=2) and were calculated in accordance with NAMAS document NIS 81 and M3003.

Measurement Type	Measurement Unit	Frequency Range	Expanded Uncertainty
RF frequency	Hz	25 to 7,000 MHz	1.7×10^{-7}
RF power, conducted	dBm	25 to 7,000 MHz	± 0.52 dB
Conducted emission of transmitter	dBm	25 to 40,000 MHz	± 0.7 dB
Conducted emission of receiver	dBm	25 to 40,000 MHz	± 0.7 dB
Radiated emission (substitution method)	dBm	25 to 40,000 MHz	± 2.5 dB
Radiated emission (field strength)	dBμV/m	25 to 1,000 MHz 1 to 40 GHz	± 3.6 dB ± 6.0 dB

EQUIPMENT UNDER TEST (EUT) DETAILS

GENERAL

The GE MDS LLC model TD220Max is a narrowband wireless transceiver which is designed to transmit and receive data in the 216 to 222 MHz bands. Normally, the EUT would be placed on a tabletop or in a rack during operation. The EUT was, therefore, placed on a table during emissions testing to simulate the end user environment. The electrical rating of the EUT is 13.8vdc, 6 Amps.

The sample was received on June 20, 2014 and tested on June 23, 24, July 8 and 30, 2014. The EUT consisted of the following component(s):

Company	Model	Description	Serial Number	FCC ID
GE MDS LLC	TD220Max	Narrowband Data Transceiver	2539706	E5MDS-TD220MAX

ENCLOSURE

The EUT enclosure is primarily constructed of diecast aluminum. It measures approximately 14.0cm wide by 17.0cm deep by 5.0cm high.

MODIFICATIONS

No modifications were made to the EUT during the time the product was at NTS Silicon Valley.

SUPPORT EQUIPMENT

The following equipment was used as support equipment for testing:

Company	Model	Description	Serial Number	FCC ID
Sorensen	DHP60-166	DC Power Supply, 0-60V/0-33Am	S103C0035	-

The following equipment was used as remote support equipment for emissions testing:

Company	Model	Description	Serial Number	FCC ID
Dell	INSPIRON 2200	Laptop	28123497073	-
GE MDS	TD220/RCL220	DB25 to RJ11 Adapter Board	2098333	-

EUT INTERFACE PORTS

The I/O cabling configuration during antenna port testing was as follows:

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length(m)
Data	DB25 to RJ11 Adapter Board	Multiwire Flat	Unshielded	0.2
Power Port	DC power supply	DC power cable	Unshielded	2.0
Antenna	Test system	Coax	Shielded	1.0
USB (Laptop)	DB9 to RJ11 cable	Multiwire	Unshielded	0.5
DB9 to RJ11 cable	DB25-RJ11 Adapter Board	Multiwire	Unshielded	2.0

The I/O cabling configuration during radiated spurious testing was as follows:

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length(m)
Data	DB25 to RJ11 Adapter Board	DB25 (Extension cable)	Shielded	10.0
Power	DC power supply	DC power cable	Unshielded	2.0
Antenna	40 dB Attenuator	Coax	Unshielded	0.1
40 dB Attenuator	50Ohm terminator	Coax	Unshielded	0.1
Chassis	GND	Single wire (braid)	Unshielded	3.0
USB (Laptop)	DB9 to RJ11 cable	Multiwire	Unshielded	0.5
DB9 - RJ11 cable	DB25-RJ11 Adapter Board	Multiwire	Unshielded	3.0
DB25-RJ11 Adapter Board	DB25(Extension cable)	Multiwire Flat	Unshielded	0.2

EUT OPERATION

During emissions testing the EUT was set to transmit mode at the desired frequency and specified power in either unmodulated or modulated as required for testing.

TESTING

GENERAL INFORMATION

Antenna port measurements were taken at the NTS Silicon Valley test site located at 41039 Boyce Road, Fremont, CA 94538-2435.

Radiated spurious emissions measurements were taken at the NTS Silicon Valley Anechoic Chambers and/or Open Area Test Site(s) listed below. The sites conform to the requirements of ANSI C63.4: 2003 *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* and CISPR 16-1-4:2007 - *Specification for radio disturbance and immunity measuring apparatus and methods Part 1-4: Radio disturbance and immunity measuring apparatus Ancillary equipment Radiated disturbances*. They are on file with the FCC and industry Canada.

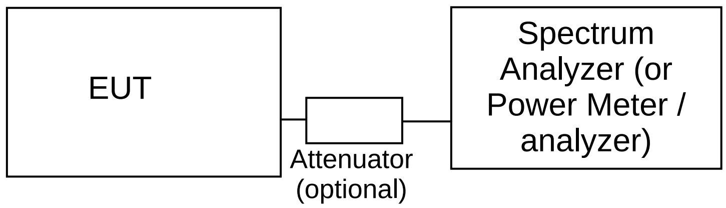
Site	Registration Numbers		Location
	FCC	Canada	
Chamber 7	A2LA Accredited	IC 2845B-7	41039 Boyce Road Fremont, CA 94538-2435

In the case of Open Area Test Sites, ambient levels are at least 6 dB below the specification limits with the exception of predictable local TV, radio, and mobile communications traffic.

Considerable engineering effort has been expended to ensure that the facilities conform to all pertinent requirements.

RF PORT MEASUREMENT PROCEDURES

Conducted measurements are performed with the EUT's rf input/output connected to the input of a spectrum analyzer, power meter or modulation analyzer. When required an attenuator, filter and/or dc block is placed between the EUT and the spectrum analyzer to avoid overloading the front end of the measurement device. Measurements are corrected for the insertion loss of the attenuators and cables inserted between the rf port of the EUT and the measurement equipment.



Test Configuration for Antenna Port Measurements

For devices with an integral antenna the output power and spurious emissions are measured as a field strength at a test distance of (typically) 3m and then converted to an eirp using a substitution measurement (refer to RADIATED EMISSIONS MEASUREMENTS). All other measurements are made as detailed below but with the test equipment connected to a measurement antenna directed at the EUT.

OUTPUT POWER

Output power is measured using a power meter and an average sensor head, a spectrum analyzer or a power meter and peak power sensor head as required by the relevant rule part(s). Where necessary measurements are gated to ensure power is only measured over periods that the device is transmitting.

Power measurements made directly on the rf power port are, when appropriate, converted to an EIRP by adding the gain of the highest gain antenna that can be used with the device under test, as specified by the manufacturer.

BANDWIDTH MEASUREMENTS

The 6dB, 20dB and/or 26dB signal bandwidth is measured in using the bandwidths recommended by ANSI C63.4. When required, the 99% bandwidth is measured using the methods detailed in RSS GEN. The measurement bandwidth is set to be at least 1% of the instrument's frequency span.

CONDUCTED SPURIOUS EMISSIONS

Initial scans are made using a peak detector (RBW=VBW) and using scan rates to ensure that the EUT transmits before the sweep moves out of each resolution bandwidth (for transmit mode measurements). Where the limits are expressed as an average power the spectrum analyzer is tunes to that frequency with a narrow span (wide enough to capture the emission and its sidebands) and the resolution and video bandwidths are adjusted as required by the reference measurement standards. For transmitter measurements the appropriate detector (average, peak, normal ,sample, quasi-peak) is used when making measurements for licensed devices. For receiver conducted spurious measurements the detector is set to peak.

TRANSMITTER MASK MEASUREMENTS

The transmitter mask measurements are made using resolution bandwidths as specified in the pertinent rule part(s). Where narrower bandwidths are used the measurement is corrected to account for the reduced bandwidth by either using the adjacent channel power function of the spectrum analyzer to sum the power across the required measurement bandwidth. The frequency span of the analyzer is set to ensure the fundamental signal and all significant sidebands are displayed.

The top of the mask may be set by the total output power of the signal, the power of the unmodulated signal or the peak value of the signal in the reference bandwidth being used for the mask measurement.

FREQUENCY STABILITY

The EUT is placed inside a temperature chamber with all support and test equipment located outside of the chamber. The temperature is varied across the specified frequency range in 10 degree increments with frequency measurements made at each temperature step. The EUT is allowed enough time to stabilize at each temperature variation.

The spectrum analyzer is configured to give a 5- or 6-digit display for the marker-frequency function. The spectrum analyzer's built-in frequency counter is used to measure the maximum deviation of the fundamental frequency at each temperature. Where possible the device is set to transmit an unmodulated signal. Where this is not possible the frequency drift is determined by finding a stable point on the signal (e.g. the null at the centre of an OFDM signal) or by calculating a centre frequency based on the upper and lower XdB points (where X is typically 6dB or 10dB) on the signal’s skirts.

TRANSIENT FREQUENCY BEHAVIOR:

The TIA/EIA 603 procedure is used to determine compliance with transient frequency timing requirements as the radio is keyed on and off.

The EUTs rf output is connected via a combiner/splitter to the test receiver/spectrum analyzer and to a diode detector. The test receiver or spectrum analyzer video output is connected to an oscilloscope, which is triggered by the output from the diode detector.

Plots showing Ton, T1, and T2 are made when turning on the transmitter and showing T3 when turning off the transmitter.

RADIATED EMISSIONS MEASUREMENTS

Receiver radiated spurious emissions measurements are made in accordance with ANSI ANSI C63.4:2003 by measuring the field strength of the emissions from the device at a specific test distance and comparing them to a field strength limit. Where the field strength limit is specified at a longer distance than the measurement distance the measurement is extrapolated to the limit distance.

Transmitter radiated spurious emissions are initially measured as a field strength. The eirp or erp limit as specified in the relevant rule part(s) is converted to a field strength at the test distance and the emissions from the EUT are then compared to that limit. Emissions within 20dB of this limit are the subjected to a substitution measurement.

All radiated emissions measurements are performed in two phases. A preliminary scan of emissions is conducted in either an anechoic chamber or on an OATS during which all significant EUT frequencies are identified with the system in a nominal configuration. At least two scans are performed across the complete frequency range of interest and at each operating frequency identified in the reference standard. One or more of these is with the antenna polarized vertically while the one or more of these is with the antenna polarized horizontally. Initial scans are made using a peak detector (RBW=VBW) and using scan rates to ensure that the EUT transmits before the sweep moves out of each resolution bandwidth (for transmit mode).

During the preliminary scans, the EUT is rotated through 360°, the antenna height is varied and cable positions are varied to determine the highest emission relative to the limit. For transmitter spurious emissions, where the limit is expressed as an effective radiated power, the eirp or erp is converted to a field strength limit.

Final measurements are made on an OATS or in a semi-anechoic chamber at the significant frequencies observed during the preliminary scan(s) using the same process of rotating the EUT and raising/lowering the measurement antenna to find the highest level of the emission. The field strength is recorded and, for receiver spurious emissions, compared to the field strength limit. For the final measurement the appropriate detectors (average, peak, normal, sample, quasi-peak) are used. For receiver measurements below 1GHz the detector is a Quasi-Peak detector, above 1GHz a peak detector is used and the peak value (RB=VB=1MHz) and average value (RB=1MHz, VB=10Hz) are recorded.

For transmitter spurious emissions, the radiated power of all emissions within 20dB of the calculated field strength limit are determined using a substitution measurement. The substitution measurement is made by replacing the EUT with an antenna of known gain (typically a dipole antenna or a double-ridged horn antenna), connected to a signal source. The output power of the signal generator is adjusted until the maximum field strength from the substitution antenna is similar to the field strength recorded from the EUT. The erp of the EUT is then calculated.

INSTRUMENTATION

An EMI receiver as specified in CISPR 16-1-1 is used for radiated emissions measurements. The receivers used can measure over the frequency range of 9 kHz up to 7000 MHz. These receivers allow both ease of measurement and high accuracy to be achieved. The receivers have Peak, Average, and CISPR (Quasi-peak) detectors built into their design so no external adapters are necessary.

For measurements above the frequency range of the receivers and for all conducted measurements a spectrum analyzer is utilized because it provides visibility of the entire spectrum along with the precision and versatility required to support engineering analysis.

Measurement bandwidths for the test instruments are set in accordance with the requirements of the standards referenced in this document.

Software control is used to correct the measurements for transducer factors (e.g. antenna) and the insertion loss of cables, attenuators and other series elements to obtain the final measurement value. This provides faster, more accurate readings by performing the conversions described under Sample Calculations within the Test Procedures section of this report. Results are exported in a graphic and/or tabular format, as appropriate.

FILTERS/ATTENUATORS

External filters and precision attenuators are often connected between the EUT antenna port or receiving antenna and the test receiver. This eliminates saturation effects and non-linear operation due to high amplitude transient events.

ANTENNAS

A combination of biconical, log periodic or bi-log antennas are used to cover the range from 30 MHz to 1000 MHz. Broadband antennas or tuned dipole antennas are used over the entire 25 to 1000 MHz frequency range as the reference antenna for substitution measurements.

Above 1000 MHz, a dual-ridge guide horn antenna or octave horn antenna are used as reference and measurement antennas.

The antenna calibration factors are included in site factors that are programmed into the test receivers and instrument control software when measuring the radiated field strength.

ANTENNA MAST AND EQUIPMENT TURNTABLE

The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor-drive to vary the antenna height.

Table mounted devices are placed on a non-conductive table at a height of 80 centimeters above the floor. Floor mounted equipment is placed on the ground plane if the device is normally used on a conductive floor or separated from the ground plane by insulating material from 3 to 12 mm if the device is normally used on a non-conductive floor. The EUT is positioned on a motorized turntable to allow it to be rotated during testing to determine the angel with the highest level of emissions.

SAMPLE CALCULATIONS

SAMPLE CALCULATIONS - CONDUCTED SPURIOUS EMISSIONS

Measurements are compared directly to the conducted emissions specification limit (decibel form). The calculation is as follows:

$$R_r - S = M$$

where:

R_r = Measured value in dBm
S = Specification Limit in dBm
M = Margin to Specification in +/- dB

SAMPLE CALCULATIONS –RADIATED FIELD STRENGTH

Measurements of radiated field strength are compared directly to the specification limit (decibel form). The receiver and/or control software corrects for cable loss, preamplifier gain, and antenna factor. The calculations are in the reverse direction of the actual signal flow, thus cable loss is added and the amplifier gain is subtracted. The Antenna Factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

A distance factor is sued when measurements are made at a test distance that is different to the specified limit distance by using the following formula:

$$F_d = 20*LOG_{10} (D_m/D_s)$$

where:

F_d = Distance Factor in dB

D_m = Measurement Distance in meters

D_s = Specification Distance in meters

For electric field measurements below 30MHz the extrapolation factor is either determined by making measurements at multiple distances or a theoretical value is calculated using the formula:

$$F_d = 40*LOG_{10} (D_m/D_s)$$

The margin of a given emission peak relative to the limit is calculated as follows:

$$R_c = R_r + F_d$$

and

$$M = R_c - L_s$$

where:

R_r = Receiver Reading in dBuV/m

F_d = Distance Factor in dB

R_C = Corrected Reading in dBuV/m

L_S = Specification Limit in dBuV/m

M = Margin in dB Relative to Spec

SAMPLE CALCULATIONS –RADIATED POWER

The erp/eirp limits for transmitter spurious measurements are converted to a field strength in free space using the following formula:

$$E = \frac{\sqrt{30 P G}}{d}$$

where:

E = Field Strength in V/m
P = Power in Watts
G = Gain of isotropic antenna (numeric gain) = 1
D = measurement distance in meters

The field strength limit is then converted to decibel form (dBuV/m) and the margin of a given emission peak relative to the limit is calculated (refer to *SAMPLE CALCULATIONS –RADIATED FIELD STRENGTH*).

When substitution measurements are required (all signals with less than 20dB of margin relative to the calculated field strength limit) the eirp of the spurious emission is calculated using:

$$P_{EUT} = P_S - (E_S - E_{EUT})$$

and

$$P_S = G + P_{in}$$

where:

P_S = effective isotropic radiated power of the substitution antenna (dBm)
P_{in} = power input to the substitution antenna (dBm)
G = gain of the substitution antenna (dBi)
E_S = field strength the substitution antenna (dBm) at eirp P_S
E_{EUT} = field strength measured from the EUT

Where necessary the effective isotropic radiated power is converted to effective radiated power by subtracting the gain of a dipole (2.2dBi) from the eirp value.

RECEIVER RADIATED SPURIOUS EMISSIONS SPECIFICATION LIMITS

The table below shows the limits for the spurious emissions from receivers as detailed in FCC Part 15.109, RSS 210 Table 2, RSS GEN Table 1 and RSS 310 Table 3. Note that receivers operating outside of the frequency range 30 MHz – 960 MHz are exempt from the requirements of 15.109.

Frequency Range (MHz)	Limit (uV/m @ 3m)	Limit (dBuV/m @ 3m)
30 to 88	100	40
88 to 216	150	43.5
216 to 960	200	46.0
Above 960	500	54.0

Appendix A Test Equipment Calibration Data

Radio Antenna Port (Power and Spurious Emissions), 23-Jun-14

Manufacturer	Description	Model	Asset #	Cal Due
Rohde & Schwarz	Power Meter, Single Channel	NRVS	1290	12/10/2014
Rohde & Schwarz	Power Sensor 100 uW - 2 Watts (w/ 20 dB pad, SN BJ5155)	NRV-Z32	1536	12/19/2014
Agilent Technologies	3Hz -44GHz PSA Spectrum Analyzer	E4446A	2796	2/6/2015

Radiated Emissions, 30 - 2,300 MHz, 24-Jun-14

Manufacturer	Description	Model	Asset #	Cal Due
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	785	10/31/2014
EMCO	Antenna, Horn, 1-18 GHz (SA40-Red)	3115	1142	8/23/2014
Hewlett Packard	SpecAn 30 Hz -40 GHz, SV (SA40) Red	8564E (84125C)	1148	9/14/2014
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1538	12/14/2014
Sorensen	DC Power Supply, 0-60V/0-33Am	DHP60-166	1734	N/A
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	2197	2/13/2016
Com-Power	Preamplifier, 30-1000 MHz	PA-103	2465	9/13/2014

Radiated Emissions, Signal Substitution, 24-Jun-14

Manufacturer	Description	Model	Asset #	Cal Due
Rohde & Schwarz	Power Meter, Single Channel	NRVS	1422	1/24/2015
Rohde & Schwarz	Power Sensor 100 uW - 2 Watts use with 20dB attenuator sn:1031.6959.00 only	NRV-Z32	1423	9/17/2014
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1538	12/14/2014
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	1549	5/30/2015
Anritsu	Anritsu 68347C Signal Generator, 10MHz-20GHz	68347C	1785	5/30/2015
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	2197	2/13/2016

Conducted Emissions - AC Power Ports, 01-Jul-14

Manufacturer	Description	Model	Asset #	Cal Due
EMCO	LISN, 10 kHz-100 MHz, 25A	3825/2	1292	2/13/2015
Rohde & Schwarz	Pulse Limiter	ESH3 Z2	1401	5/15/2015
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1538	12/14/2014

Radio Antenna Port (Power and Spurious Emissions), 08-Jul-14

Manufacturer	Description	Model	Asset #	Cal Due
Agilent Technologies	3Hz -44GHz PSA Spectrum Analyzer	E4446A	2796	2/6/2015

Radio Antenna Port (Mask), 30-Jul-14

Manufacturer	Description	Model #	Asset #	Cal Due
Agilent Technologies	PSA, Spectrum Analyzer	E4446A	2139	4/8/92015

Appendix B Test Data

T95356 Pages 24 - 62

Client:	GE MDS LLC	Job Number:	J95325
Product	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Emissions Standard(s):	FCC Parts 80, 90 and 95, RSS-119	Class:	-
Immunity Standard(s):	EN 50121-3-2	Environment:	Radio

EMC Test Data

For The

GE MDS LLC

Product

TD220Max

Date of Last Test: 7/30/2014

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

RSS 119 and FCC Parts 80, 90 and 95

Power, Occupied Bandwidth, Frequency Stability and Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

General Test Configuration

With the exception of the radiated spurious emissions tests, all measurements are made with the EUT's rf port connected to the measurement instrument via an attenuator or dc-block if necessary. All amplitude measurements are adjusted to account for the attenuation between EUT and measuring instrument. For frequency stability measurements the EUT was place inside an environmental chamber.

Radiated measurements are made with the EUT located on a non-conductive table, 3m from the measurement antenna.

Ambient Conditions:

Temperature: 22.3 °C
Rel. Humidity: 37 %

Summary of Results

Run #			Test Performed	Limit	Pass / Fail	Result / Margin
1			Output Power	Part 80	Pass	44.6dBm
			Output Power (217-220 MHz)	Part 90	Pass	32.2dBm
			Output Power (220-222 MHz)	Part 90	Pass	44.4dBm
			Output Power	Part 95	Pass	43.0dBm
2			Spectral Mask	Within Mask	Pass	Within Mask
3			99% or Occupied Bandwidth	less than authorized	Pass	5.24 kHz or 9.47kHz
4			Spurious Emissions (conducted)	Part 90	Pass	All emissions are <-25dBm
5			Spurious emissions (radiated)	Part 90	Pass	-50.2 dBm @ 438.01 MHz (-25.2 dB)
6			Frequency Stability	Depends on Rule part	Pass	0.3 ppm

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Test Notes

Power and Mask tests at lowest and highest power settings
Part 80 (216-220 MHz, 25W), necessary bandwidth <= 16 kHz, Part 90 (217-220 MHz, 2W and 220-222 MHz, 25W), authorized bandwidth 20/11/25/6 for 217-220 MHz, 4 for 220-222 MHz, Part 95 (218-219 MHz, 25W) 500 kHz segments

Run #1: Output Power

Date of Test: 6/23/2014
Test Engineer: Jack Liu
Test Location: FT Lab# 4B
Config. Used: 1
Config Change: None
EUT Voltage: 13.8 VDC

Power Setting[2]	Frequency (MHz)	Output Power (dBm) [1]	Output Power mW	Antenna Gain (dBi)	Result	EIRP dBm	EIRP W	
Part 80								
Low	216.00625	33.7	2344.2	16.5	Pass	50.2	104.7	
High	216.00625	44.6	28840.3	12.0	Pass	56.6	457.1	§80.215(h)(5)
Low	219.99375	33.5	2238.7	16.5	Pass	50.0	100.0	
High	219.99375	44.4	27542.3	12.0	Pass	56.4	436.5	§80.215(h)(5)
Part 90								
FPWR 049	217.00625	32.2	1659.6	16.5	Pass	48.7	74.1	§90.259
FPWR 049	219.99375	32.1	1621.8	16.5	Pass	48.6	72.4	§90.259
Low	220.00625	33.5	2238.7	16.5	Pass	50.0	100.0	
High	220.00625	44.4	27542.3	12.0	Pass	56.4	436.5	§90.729
Low	221.99375	33.4	2187.8	16.5	Pass	49.9	97.7	
High	221.99375	44.3	26915.3	12.0	Pass	56.3	426.6	§90.729
Part 95								
Low	218.5	33.6	2290.9	9.0	Pass	42.6	18.2	
FPWR 105	218.5	43.0	19952.6	0.0	Pass	43.0	20.0	§95.855

Note 1:	Output power measured using a peak power meter
Note 2:	Power setting - the software power setting used during testing, included for reference only.
Note 3:	FPWR105 = 20Watts, FPWR120 = High , FPWR 052 = Low , FPWR 049= >2Watts

EMC Test Data

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

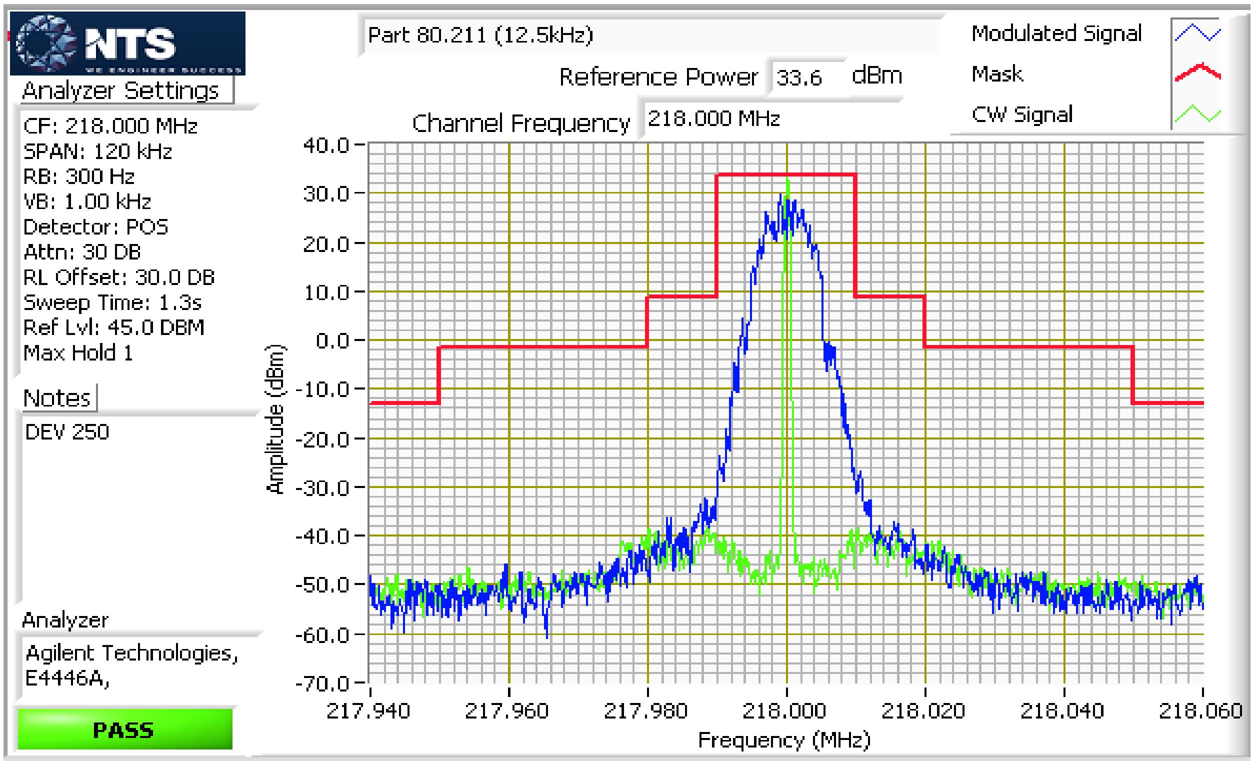
Run #2a: Spectral Mask, FCC Part 80.211 Mask F (216-220 MHz)

Date of Test: 6/23/2014
Test Engineer: Jack Liu
Test Location: FT Lab# 4B

Config. Used: 1
Config Change: None
EUT Voltage: 13.8 VDC

Note 1:	RBW = 300 Hz, VBW = 1 kHz

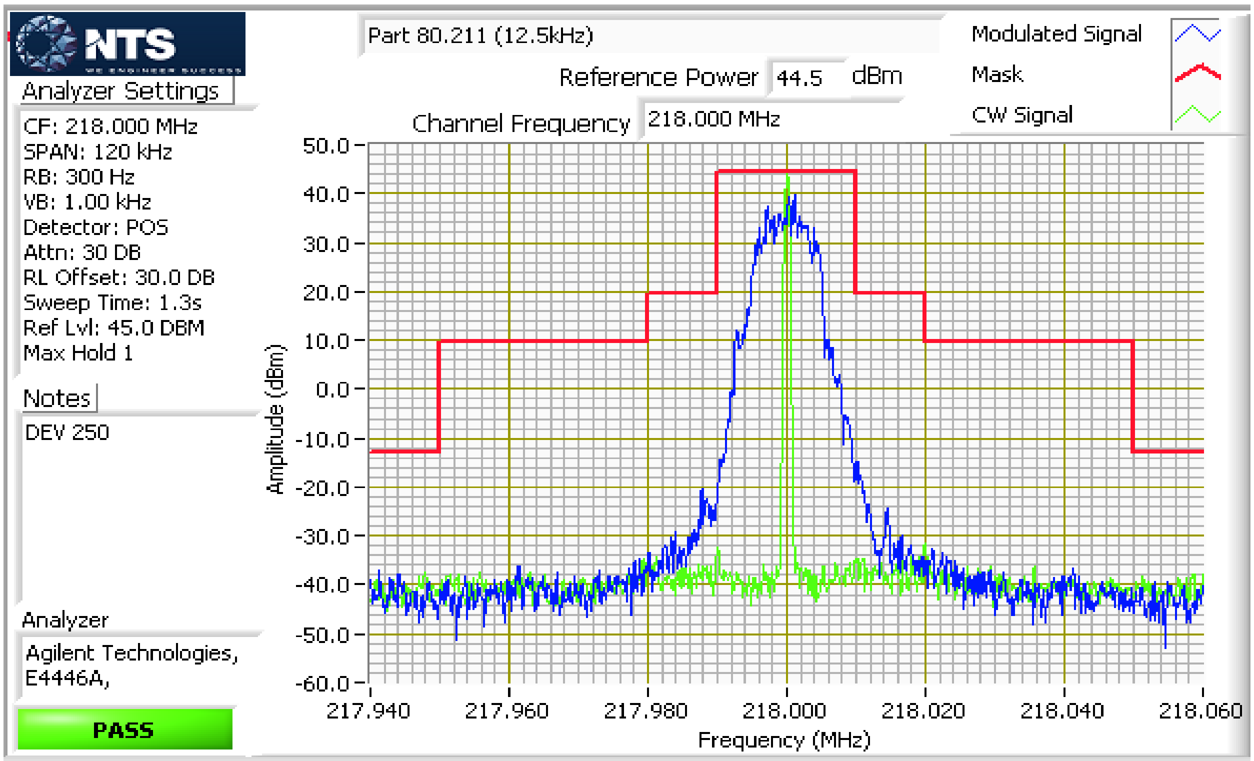
218 MHz 2W Part 80 Mask F performed at temperature with highest frequency error



EMC Test Data

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

218 MHz 25W Part 80 Mask F performed at temperature with highest frequency error



Run #2b: Spectral Mask, FCC Part 80.481

Note :	Passed 80.211 Mask F, No test required

EMC Test Data

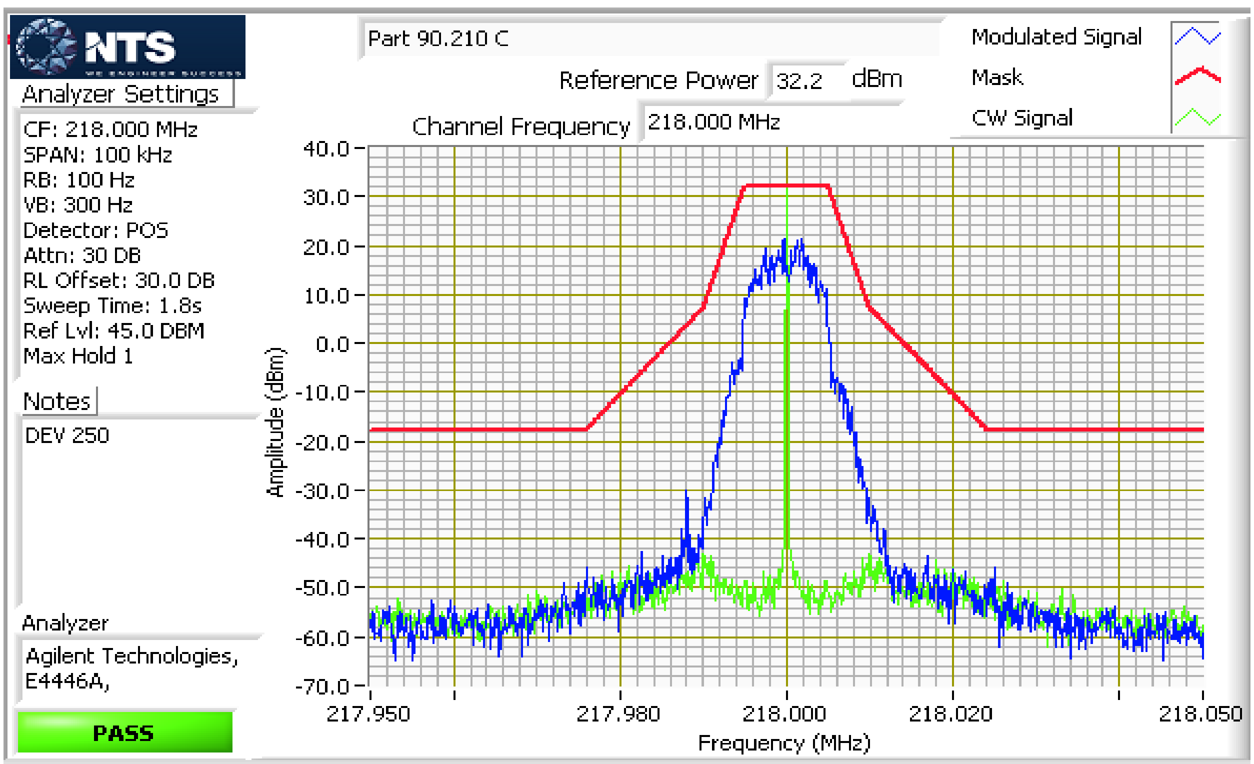
Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

Run #2c: Spectral Mask, FCC Part 90.210 Mask C (217-220 MHz), Mask F (220-222 MHz)

Date of Test:	6/23/2014	Config. Used:	1
Test Engineer:	Jack Liu	Config Change:	None
Test Location:	FT Lab# 4B	EUT Voltage:	13.8 VDC

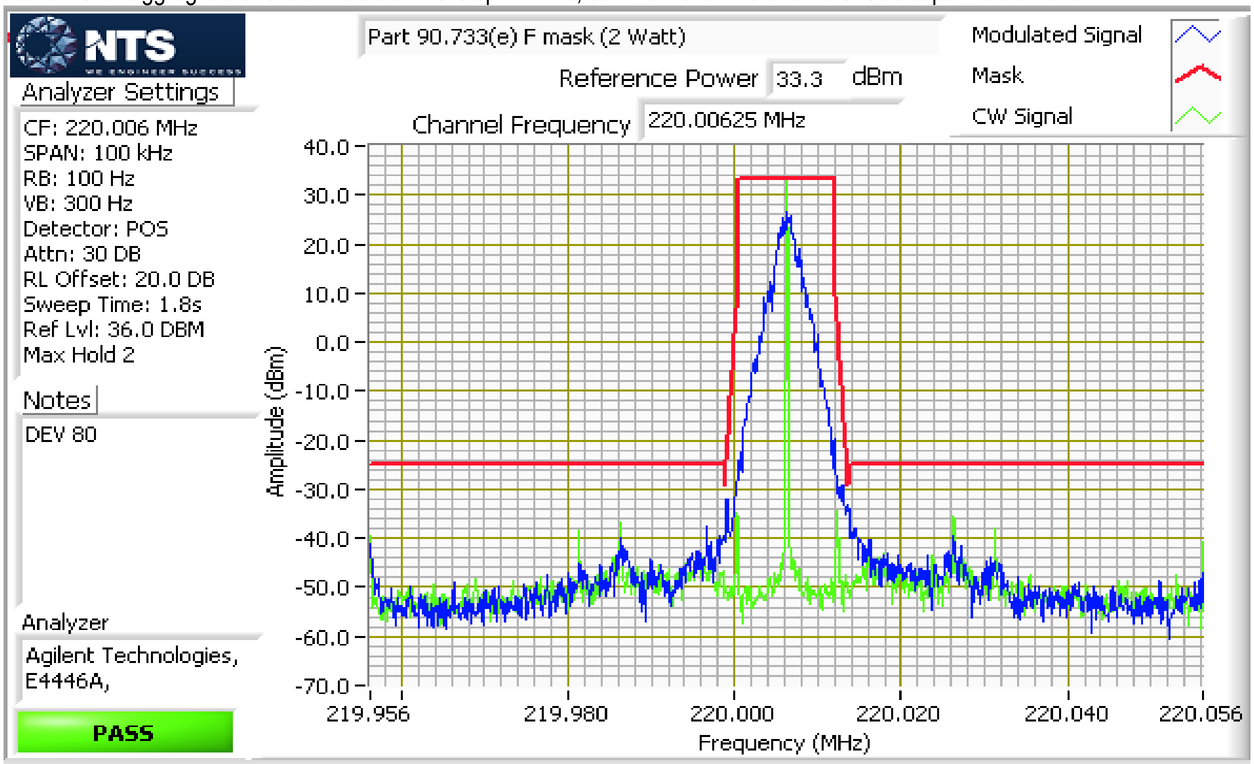
Note 1: RBW = 100 Hz, VBW = 300 Hz

218 MHz 2W Part 90 Mask C performed at temperature with highest frequency error



Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

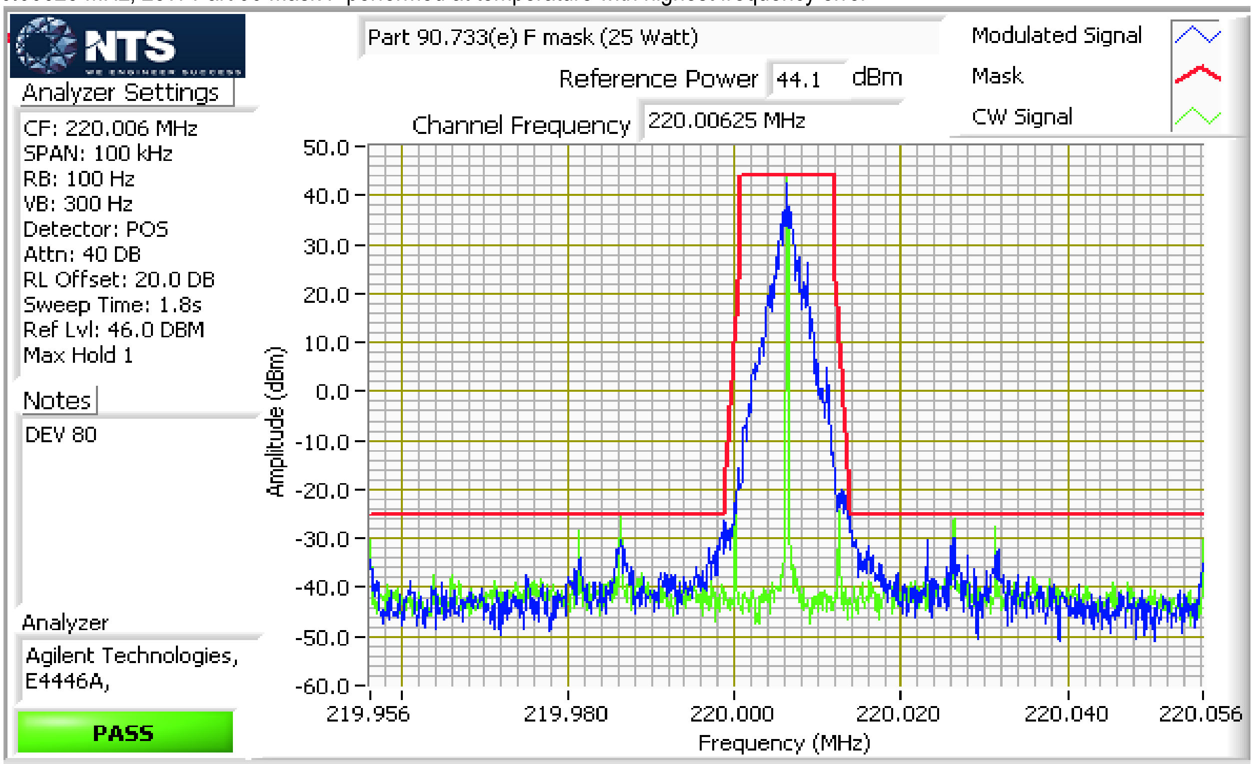
220.00625 MHz, 2W Part 90 Mask F performed at temperature with highest frequency error
Allocation is for aggregate of 5 channels but this is split in two, so mask is for 2.5 channels. See separate derivation.



EMC Test Data

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

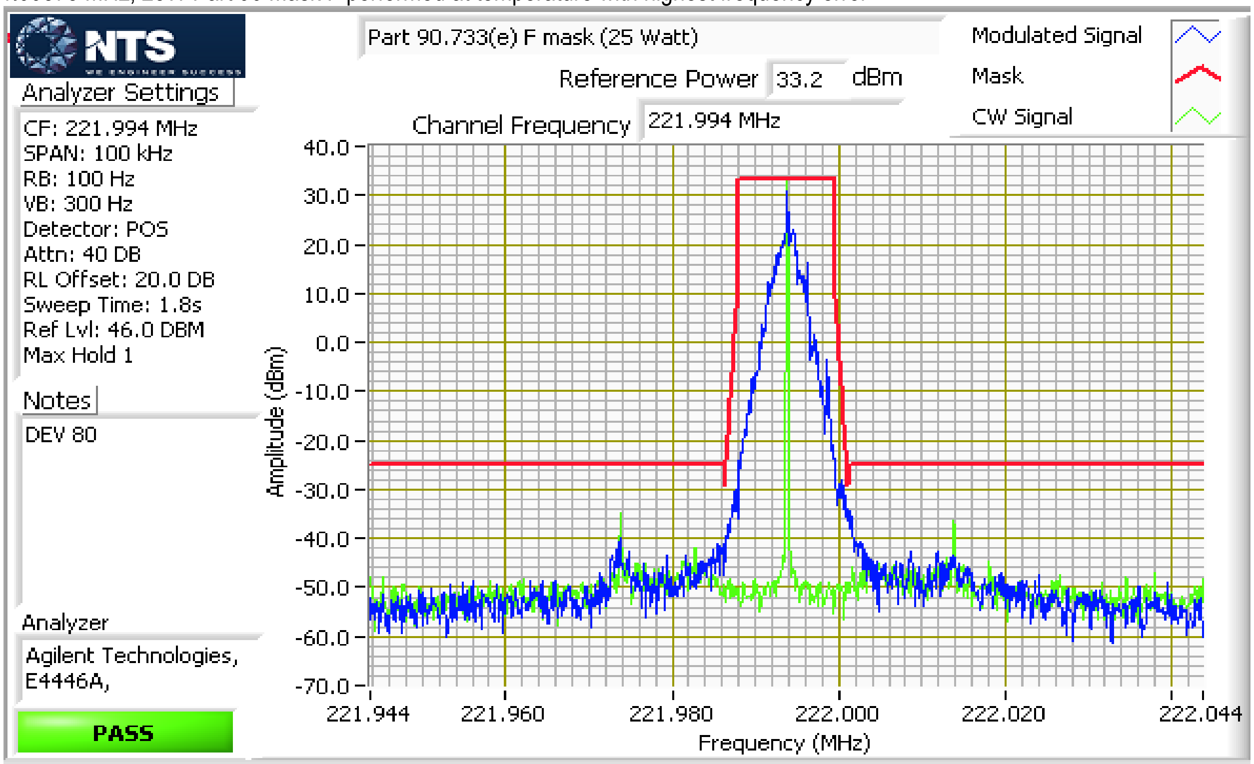
220.00625 MHz, 25W Part 90 Mask F performed at temperature with highest frequency error



EMC Test Data

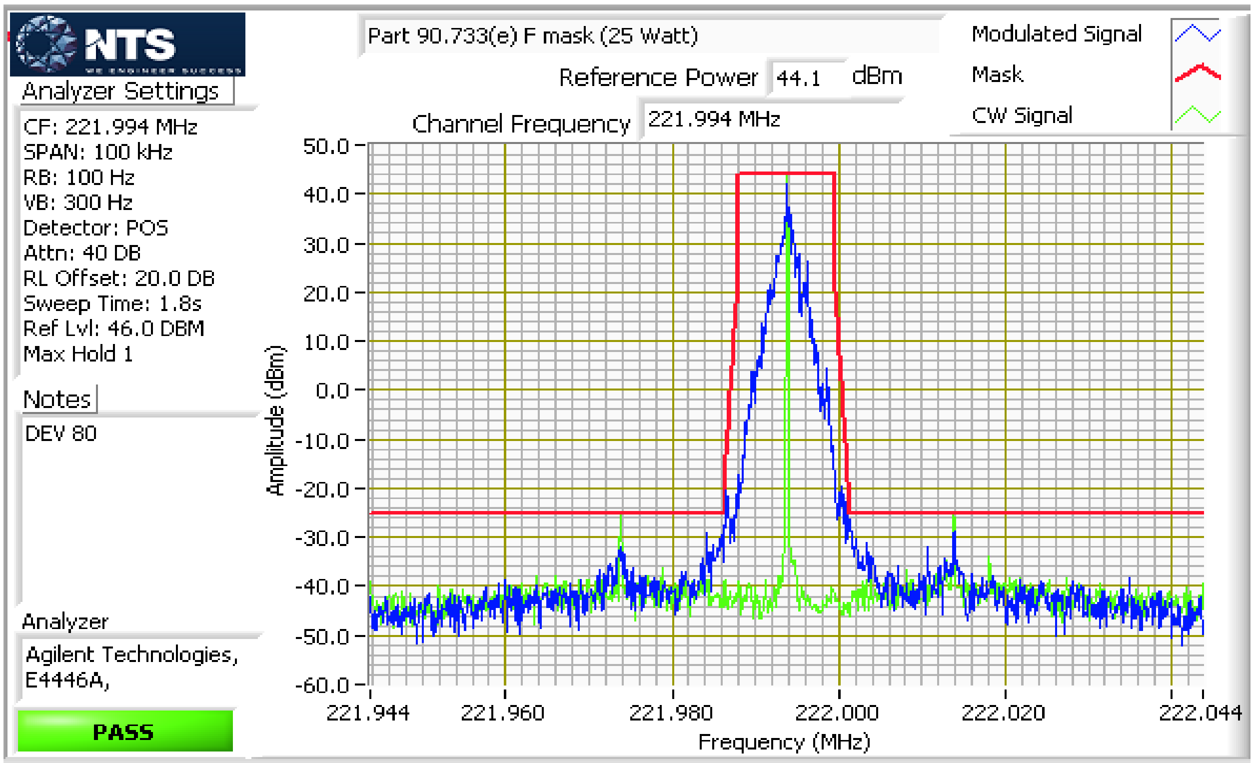
Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

221.99375 MHz, 25W Part 90 Mask F performed at temperature with highest frequency error



EMC Test Data

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A



EMC Test Data

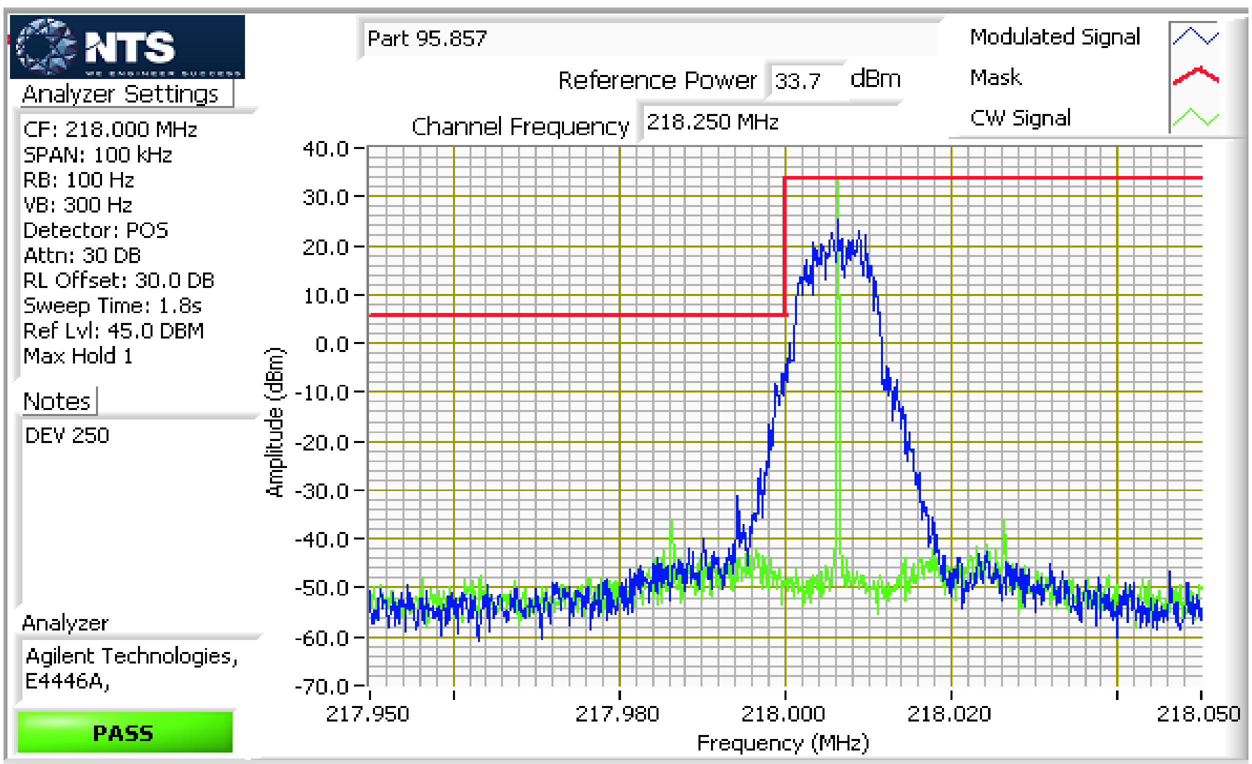
Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

Run #2d: Spectral Mask, FCC Part 95.857 Mask A (218-219 MHz)

Date of Test: 6/23/2014, 7/30/2014 | Config. Used: 1
Test Engineer: Jack Liu / David Bare | Config Change: None
Test Location: FT Lab# 4B | EUT Voltage: 13.8 VDC

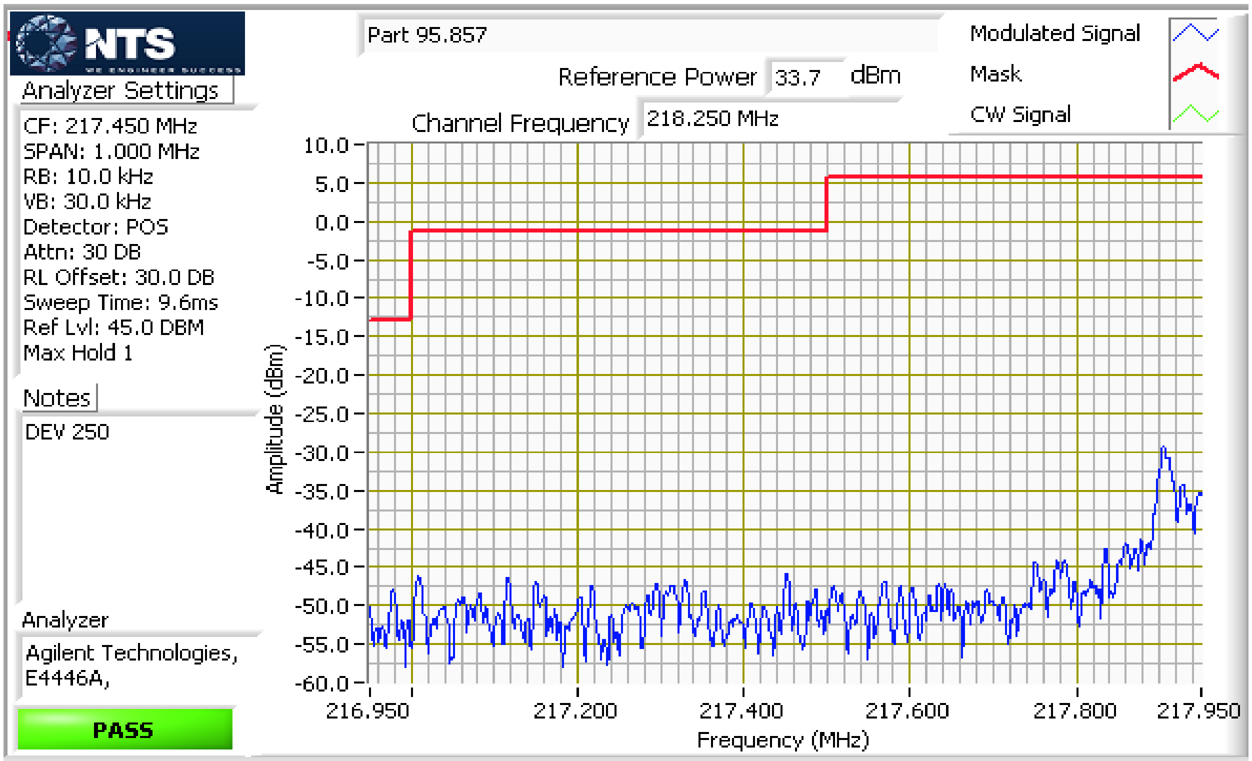
Note 1:	RBW = 100 Hz, VBW = 300Hz inband and RBW = 10 kHz, VBW = 30 kHz below 217.75 MHz and above 218.75 MHz. Channel frequency in plots refers to the center of the segment. Actual EUT frequencies were 218.00625 and 218.99375 MHz. These are the closest frequencies to the segment edges.

lowest channel low segment 2W Part 95 Mask A performed at temperature with highest frequency error



EMC Test Data

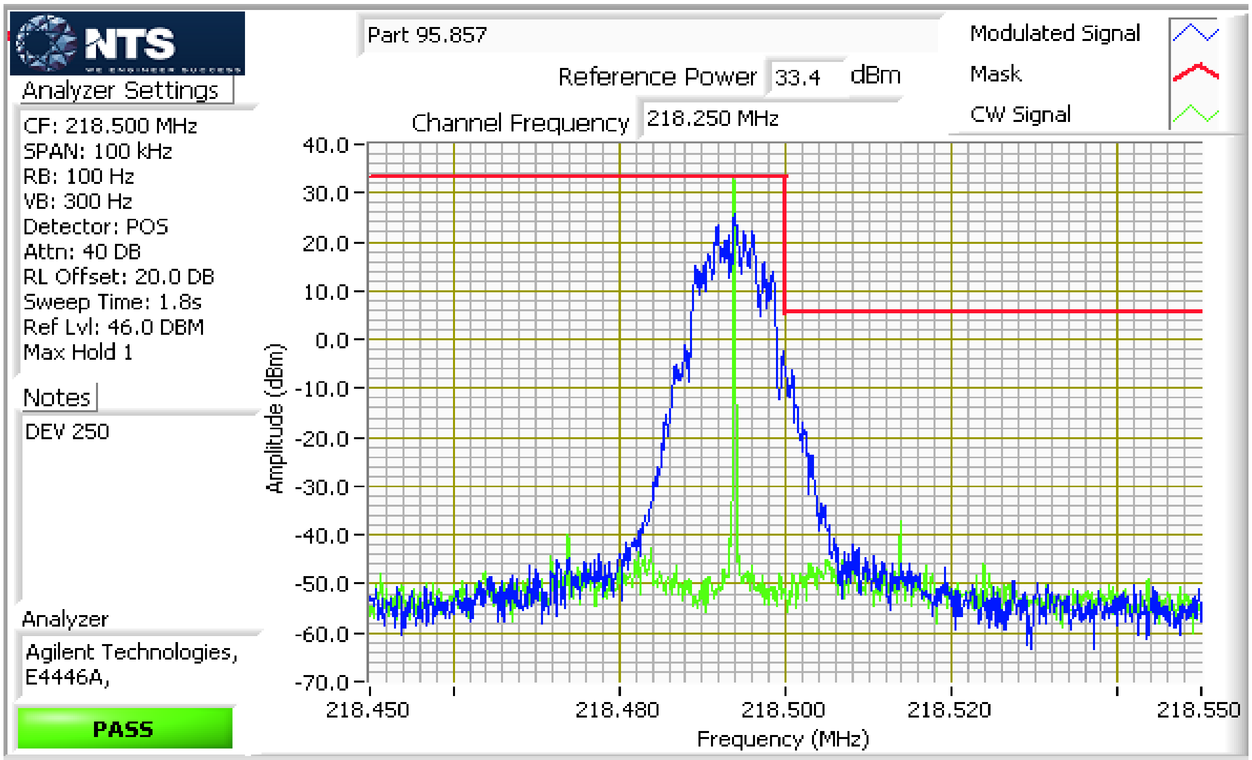
Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A



EMC Test Data

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

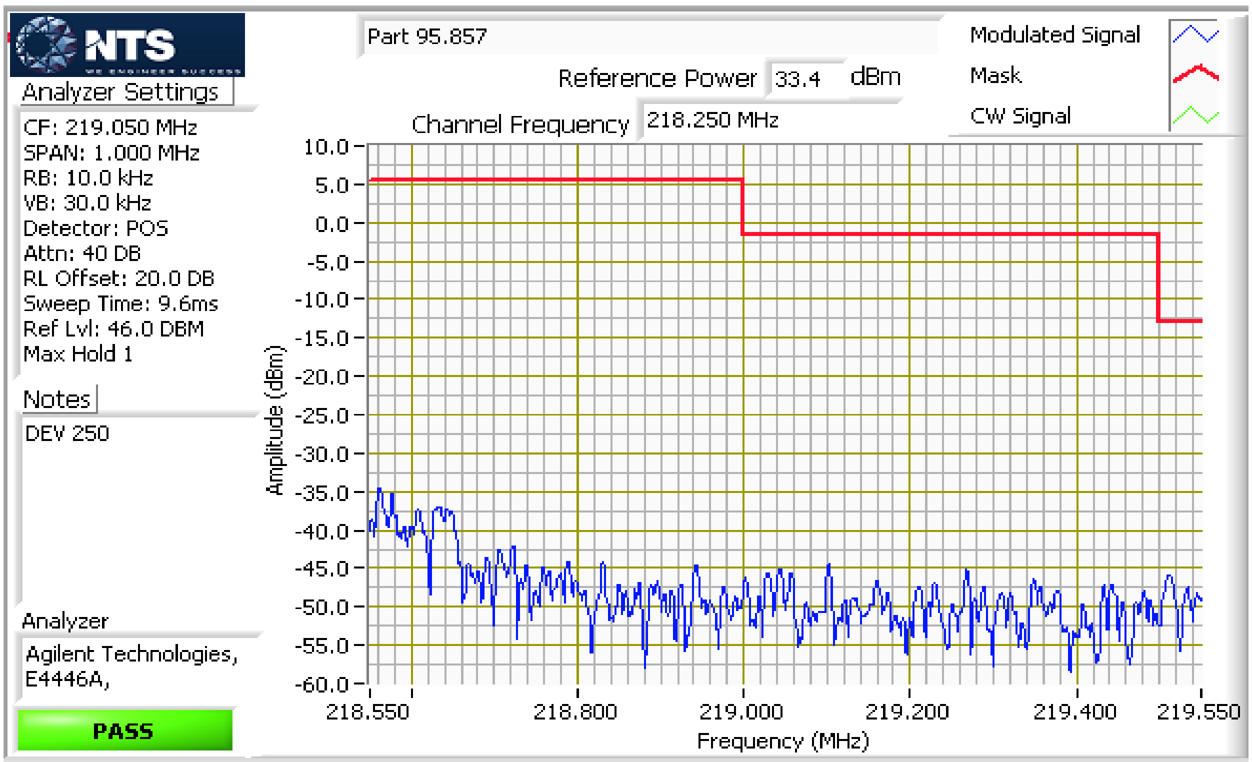
highest channel low segment 2W Part 95 Mask A performed at temperature with highest frequency error



NTS
WE ENGINEER SUCCESS

EMC Test Data

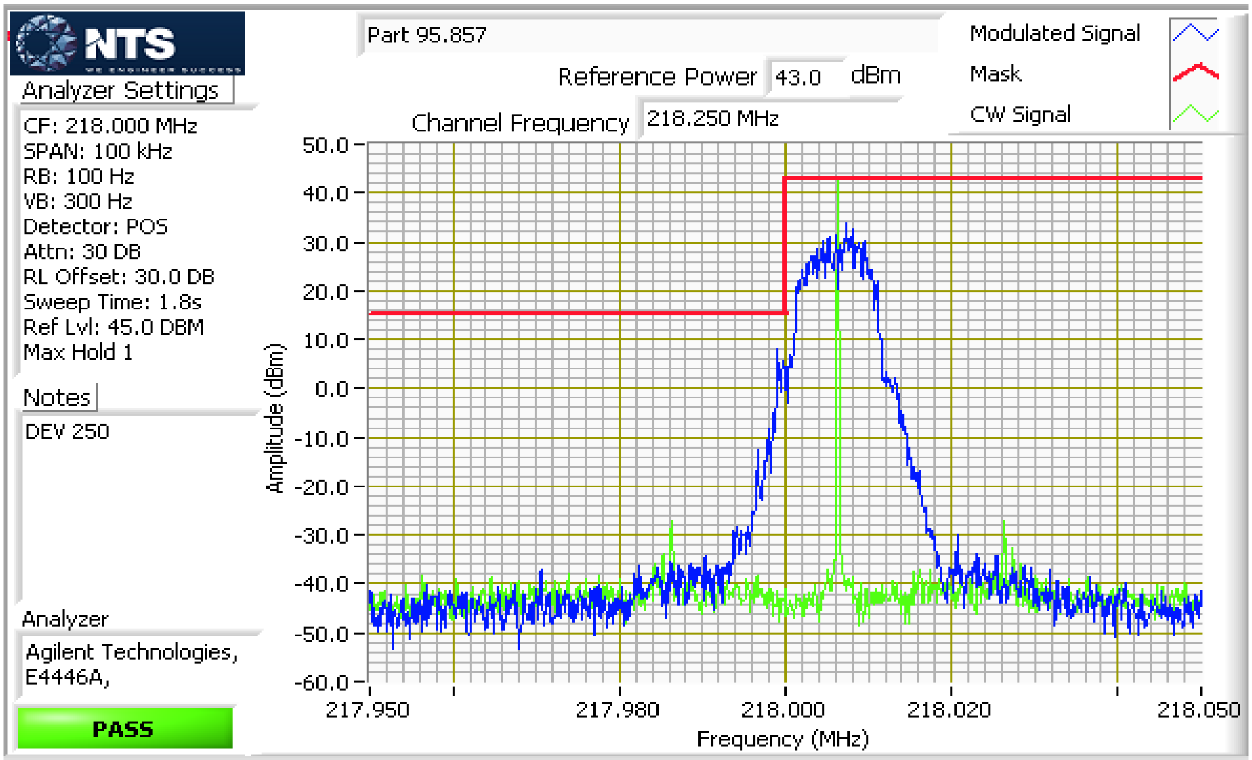
Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A



EMC Test Data

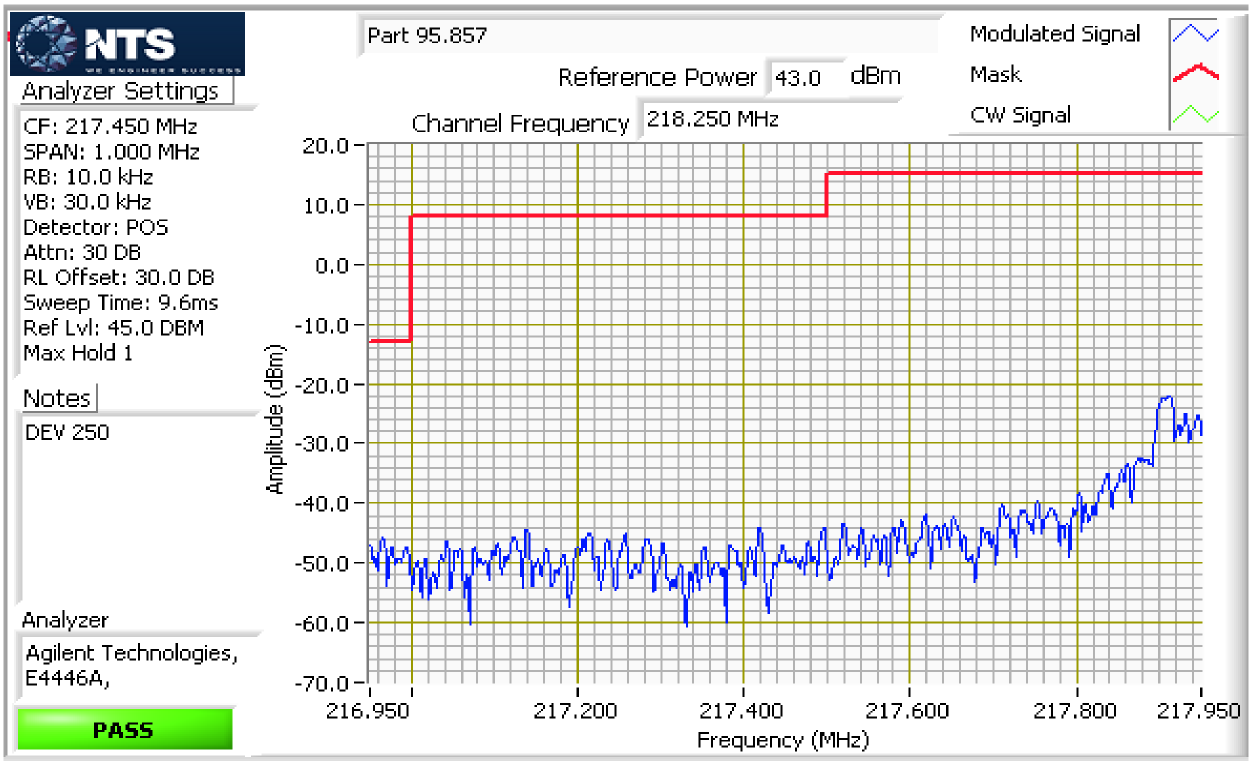
Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

lowest channel low segment 20W Part 95 Mask A performed at temperature with highest frequency error



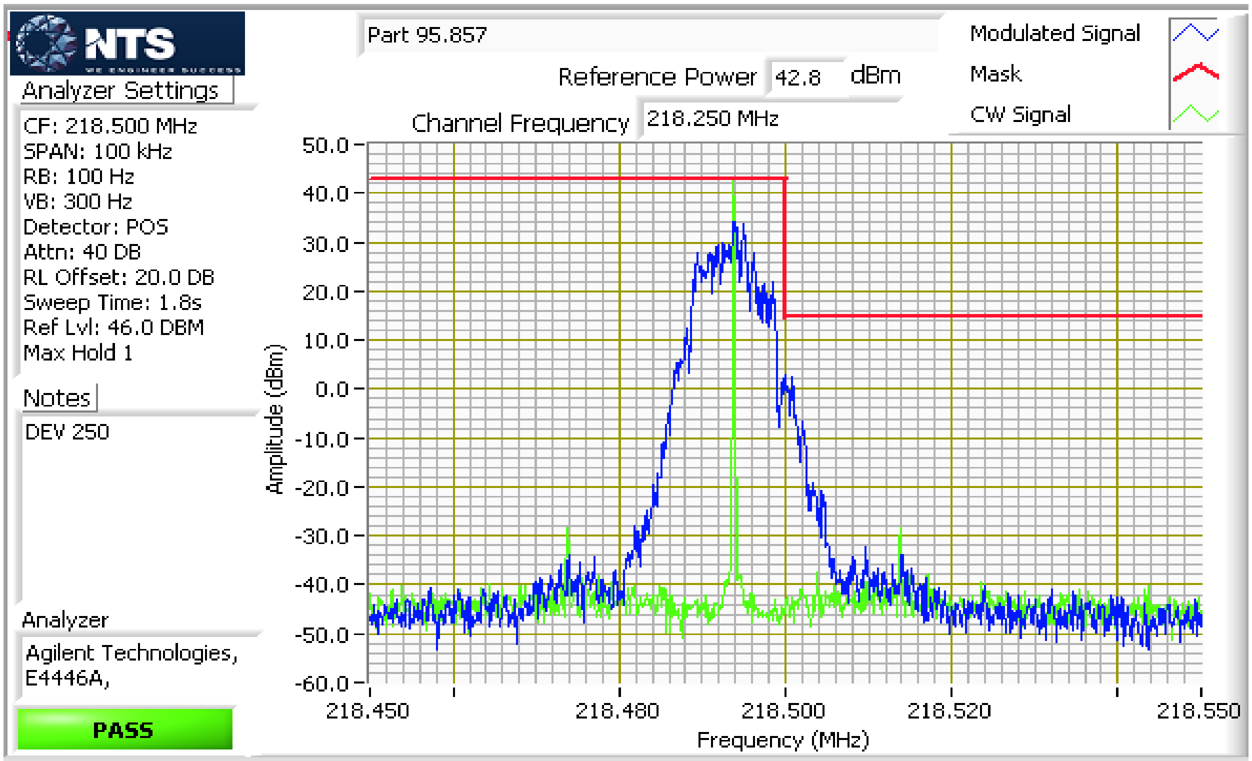
EMC Test Data

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A



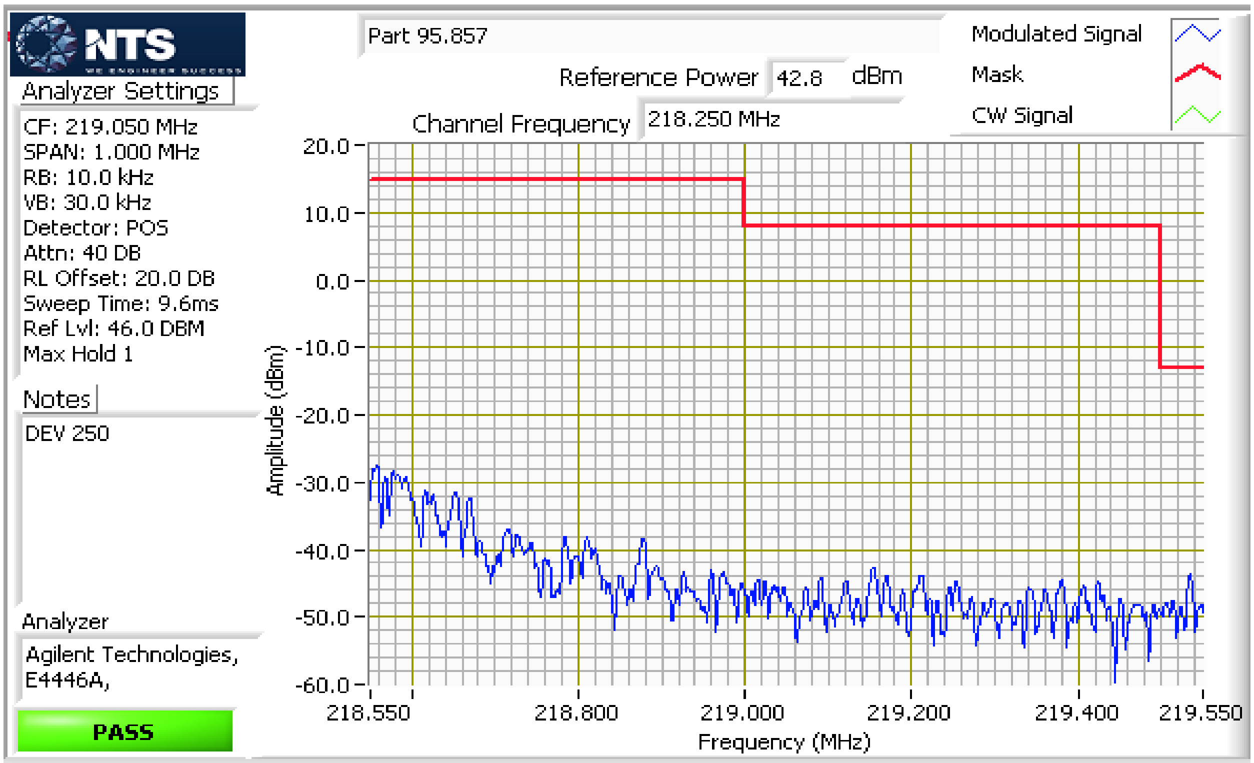
Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

highest channel low segment 20W Part 95 Mask A performed at temperature with highest frequency error



EMC Test Data

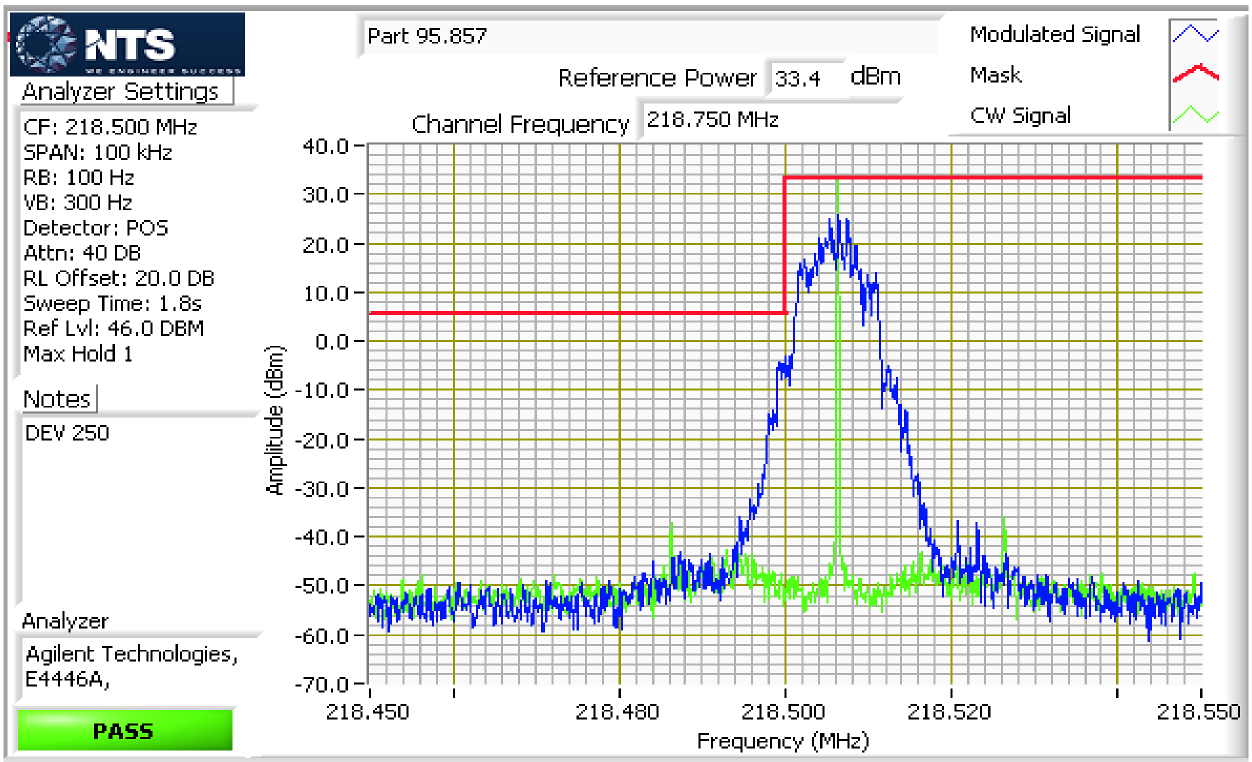
Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A



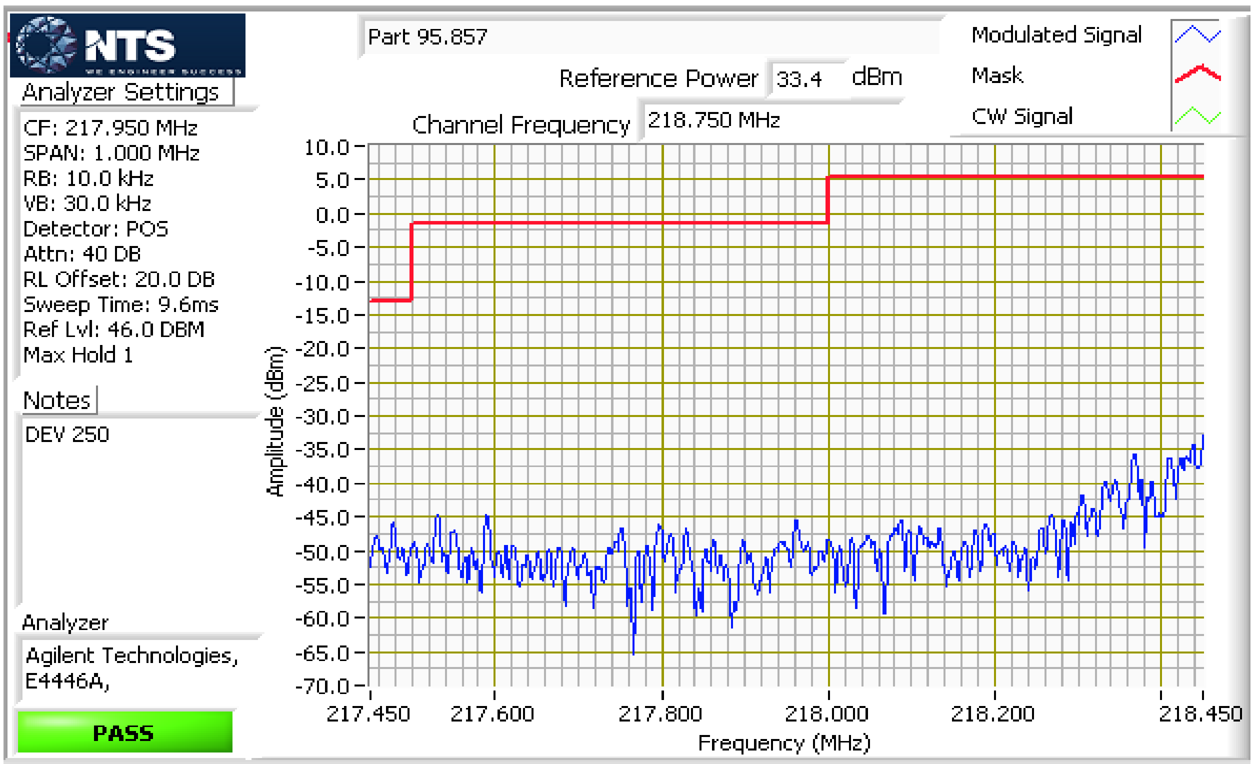
EMC Test Data

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

lowest channel high segment 2W Part 95 Mask A performed at temperature with highest frequency error



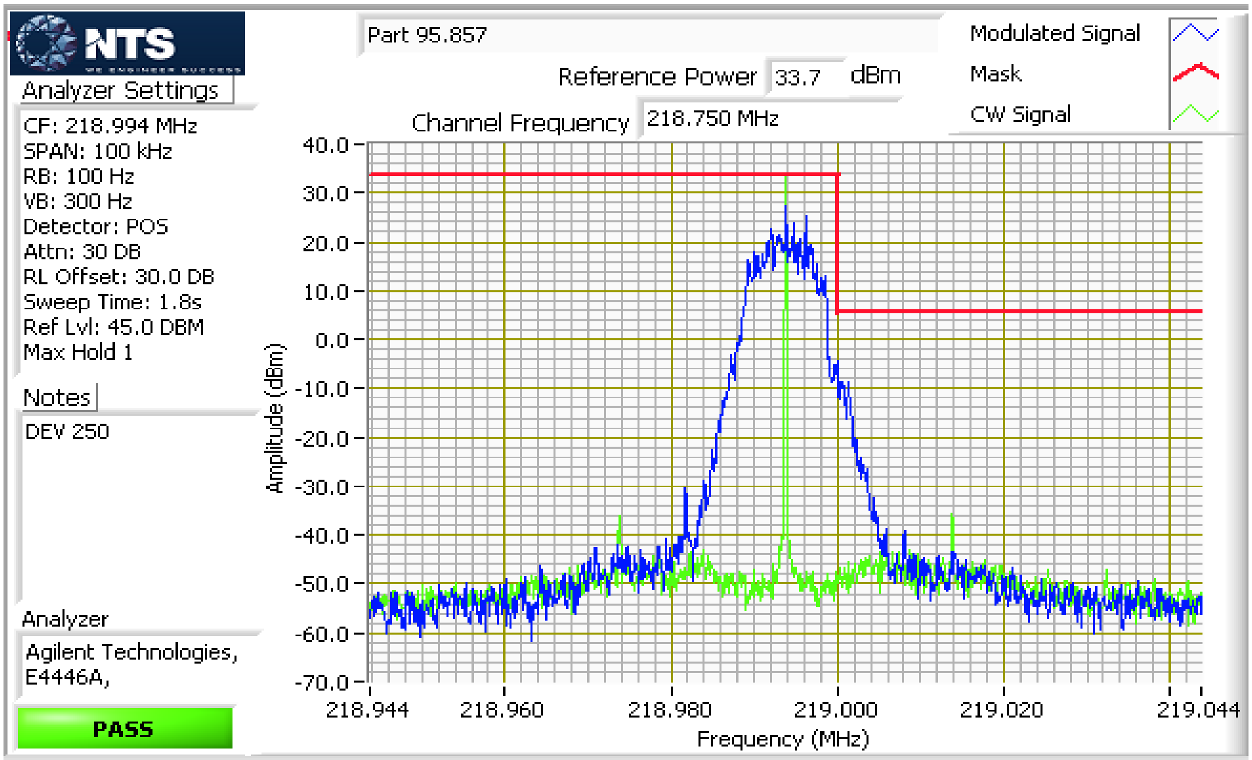
Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A



EMC Test Data

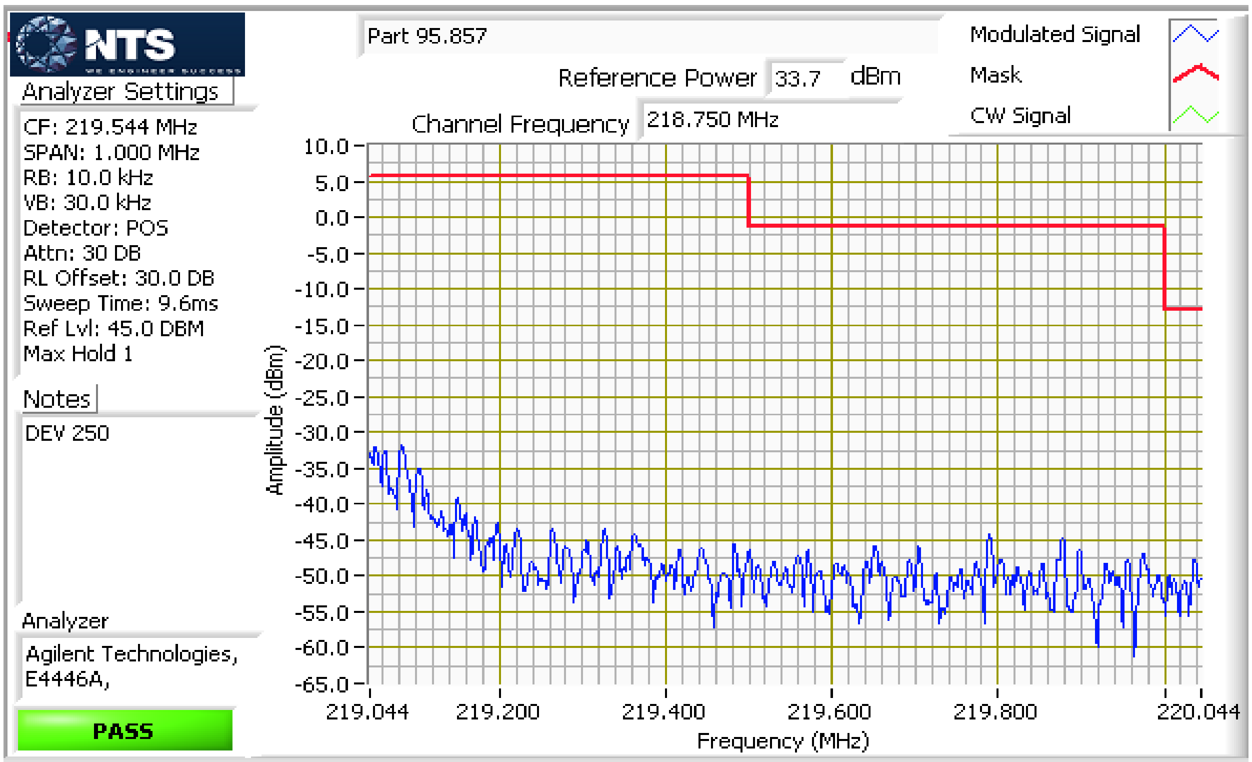
Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

highest channel high segment 2W Part 95 Mask A performed at temperature with highest frequency error



EMC Test Data

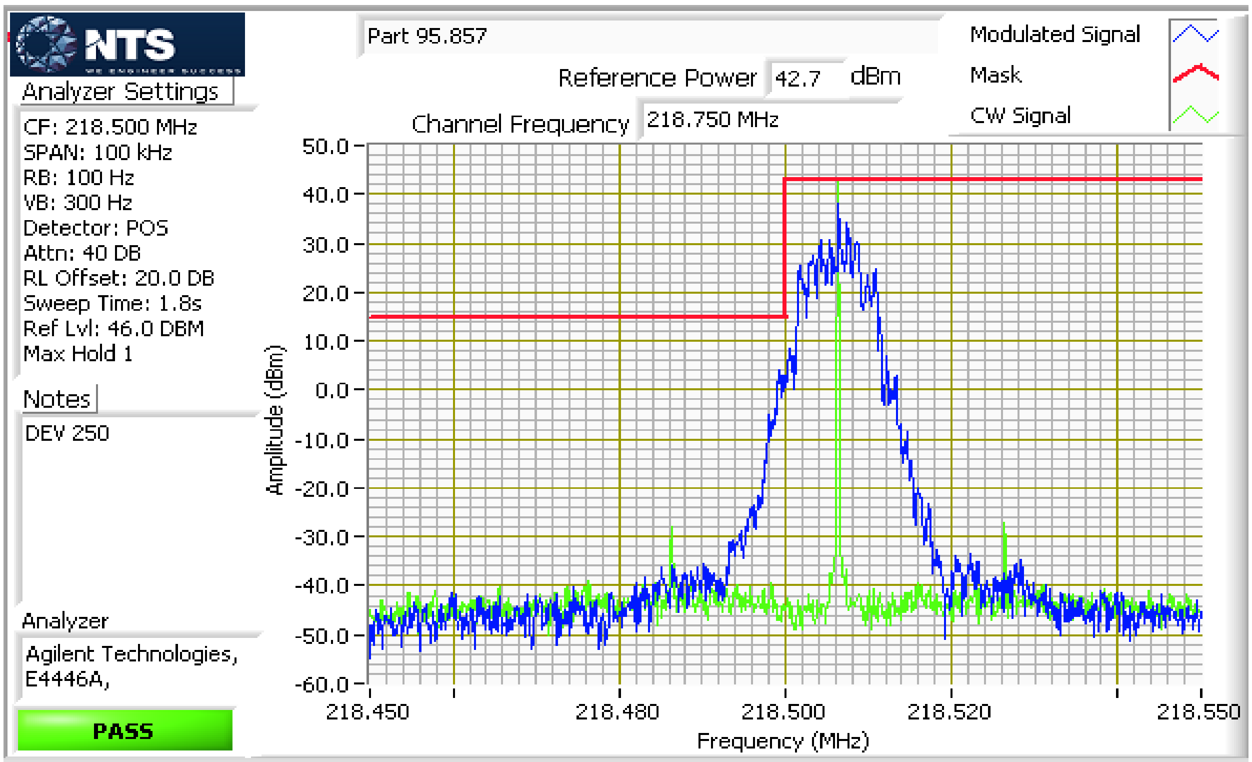
Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A



EMC Test Data

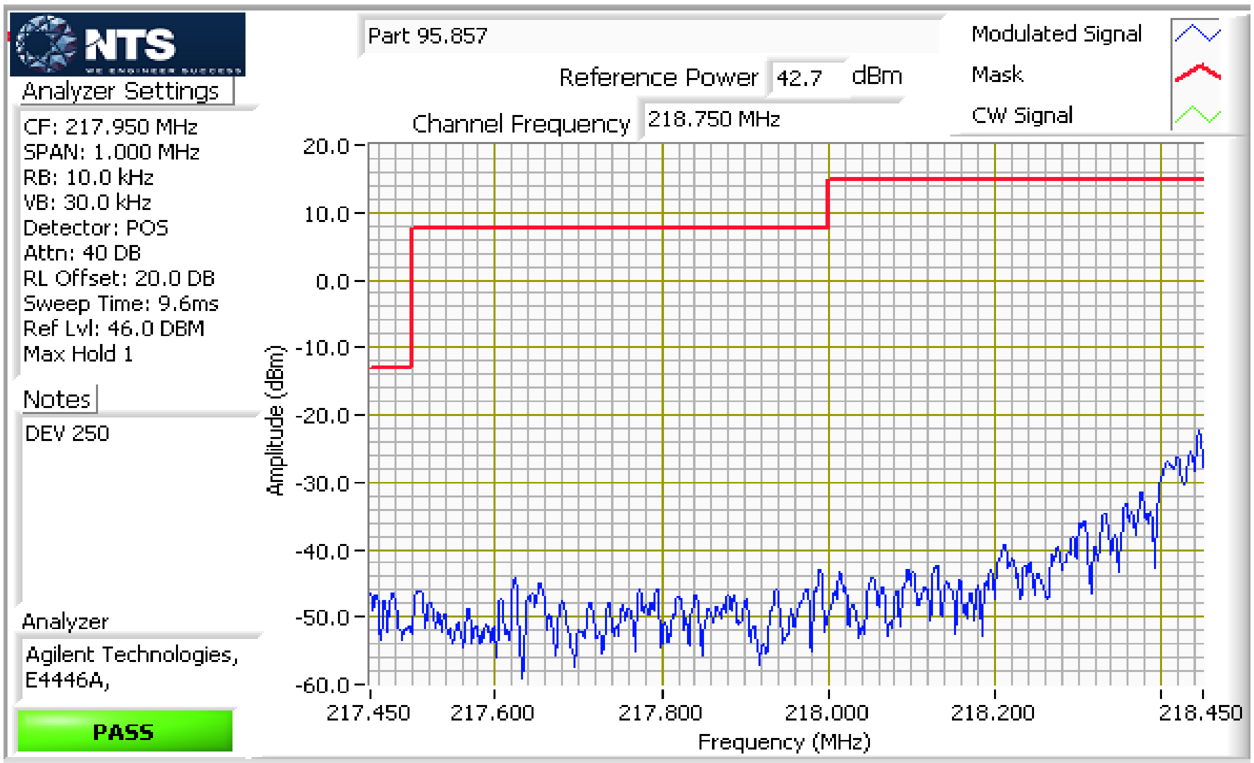
Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

lowest channel high segment 20W Part 95 Mask A performed at temperature with highest frequency error



EMC Test Data

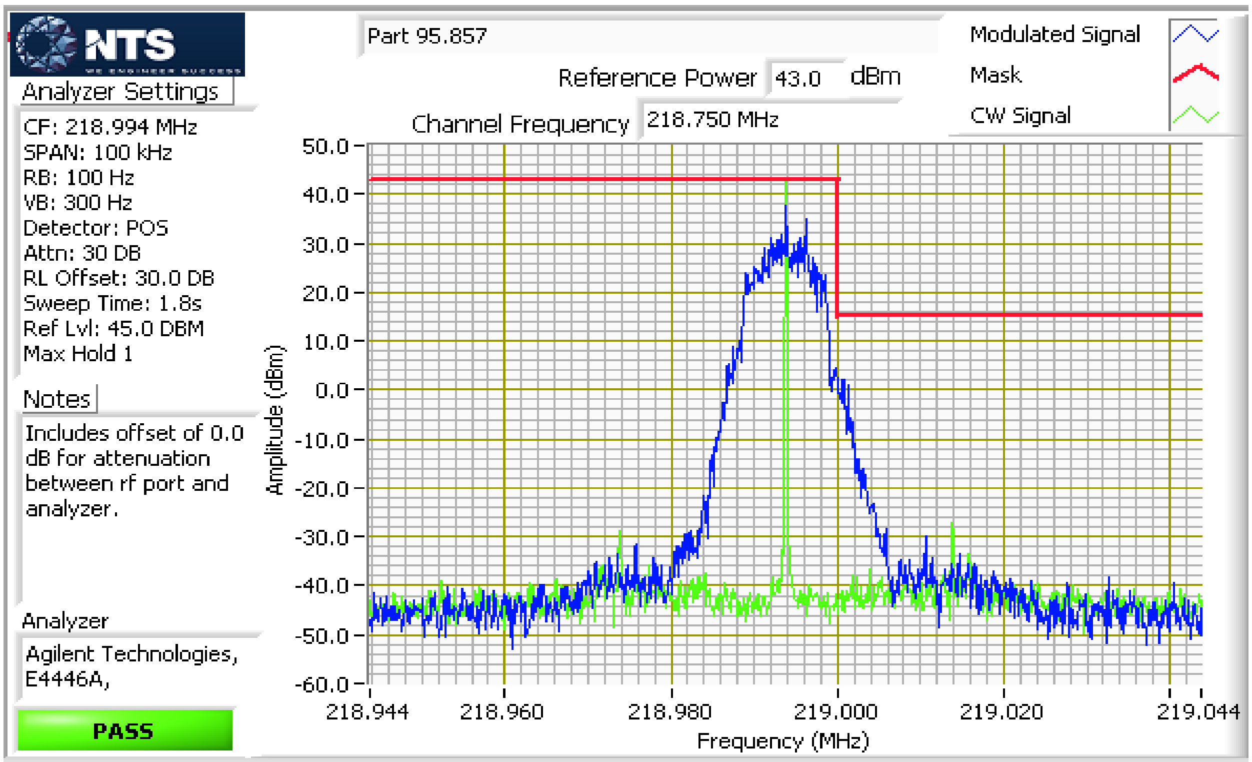
Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A



EMC Test Data

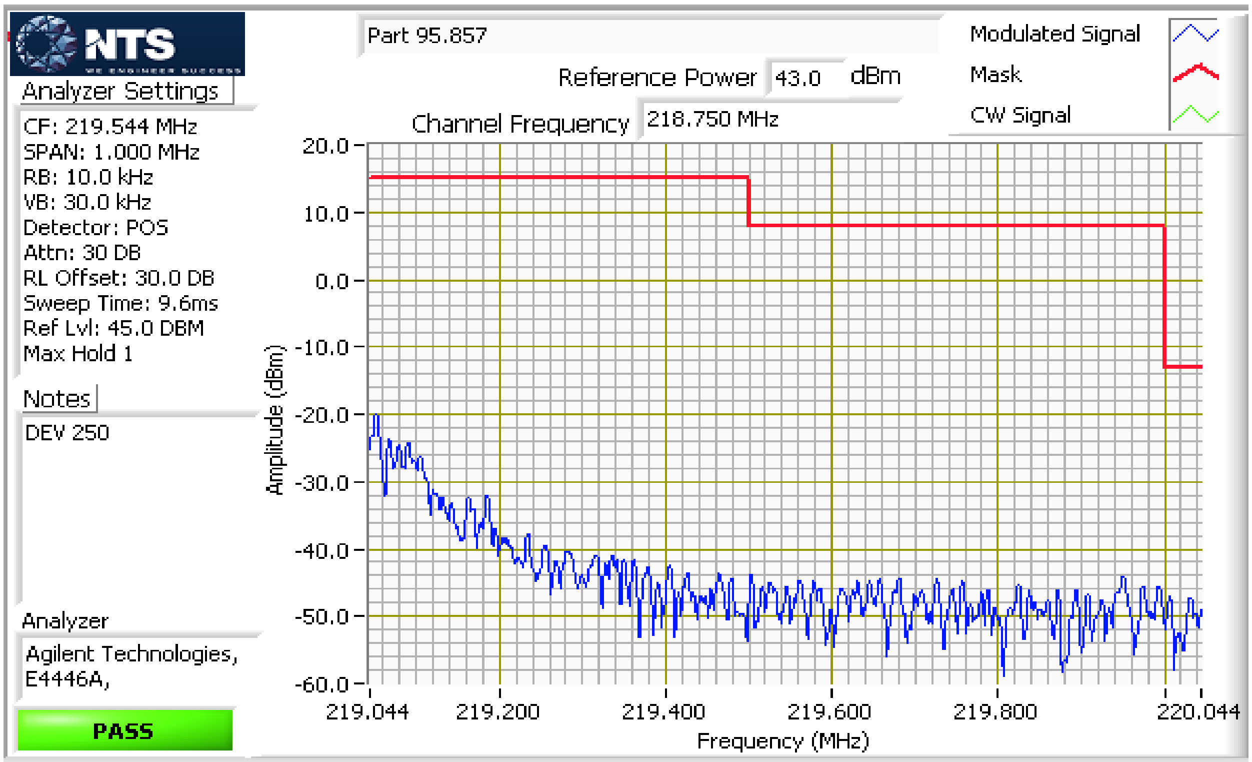
Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

highest channel high segment 20W Part 95 Mask A performed at temperature with highest frequency error



EMC Test Data

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

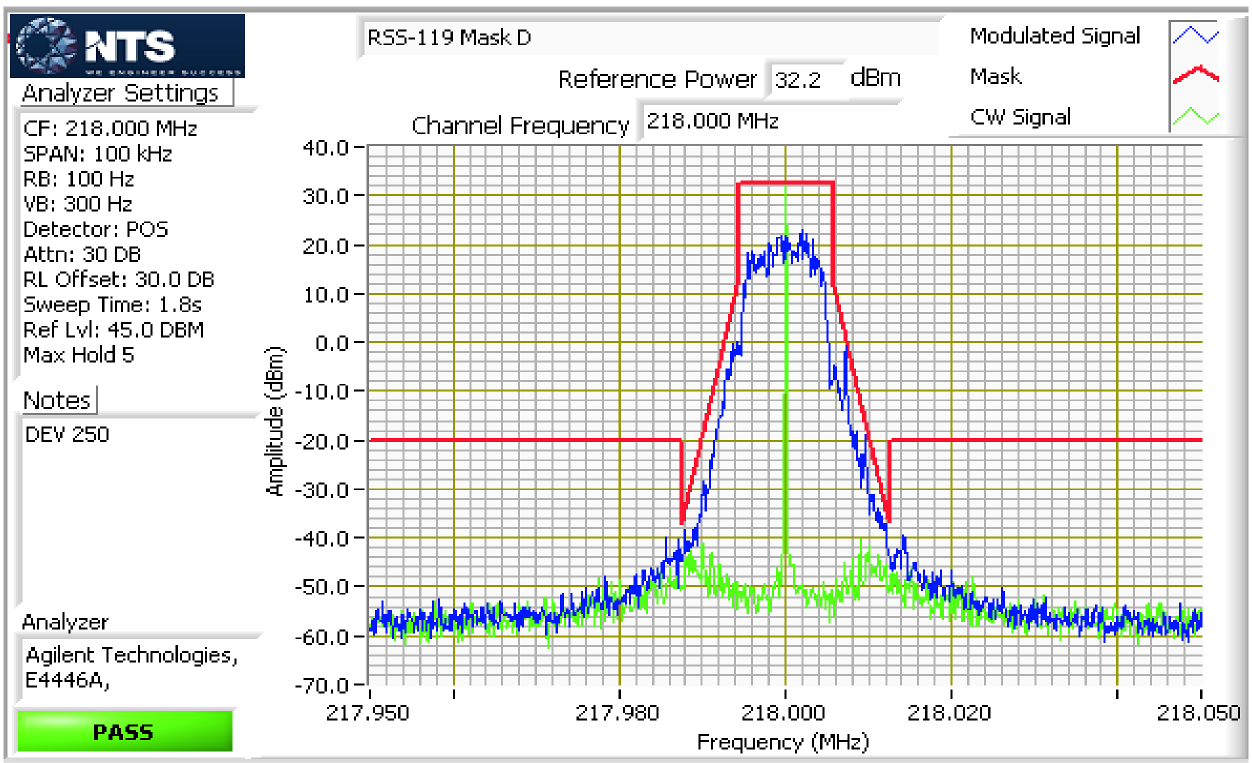


Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

Run #2e: Spectral Mask, RSS-119 Mask D (217-220 MHz)

Date of Test: 7/8/2014
Test Engineer: Jack Liu
Test Location: FT Lab# 4B
Config. Used: 1
Config Change: None
EUT Voltage: 13.8 VDC

218 MHz 2W RSS-119 Mask D performed at temperature with highest frequency error



EMC Test Data

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

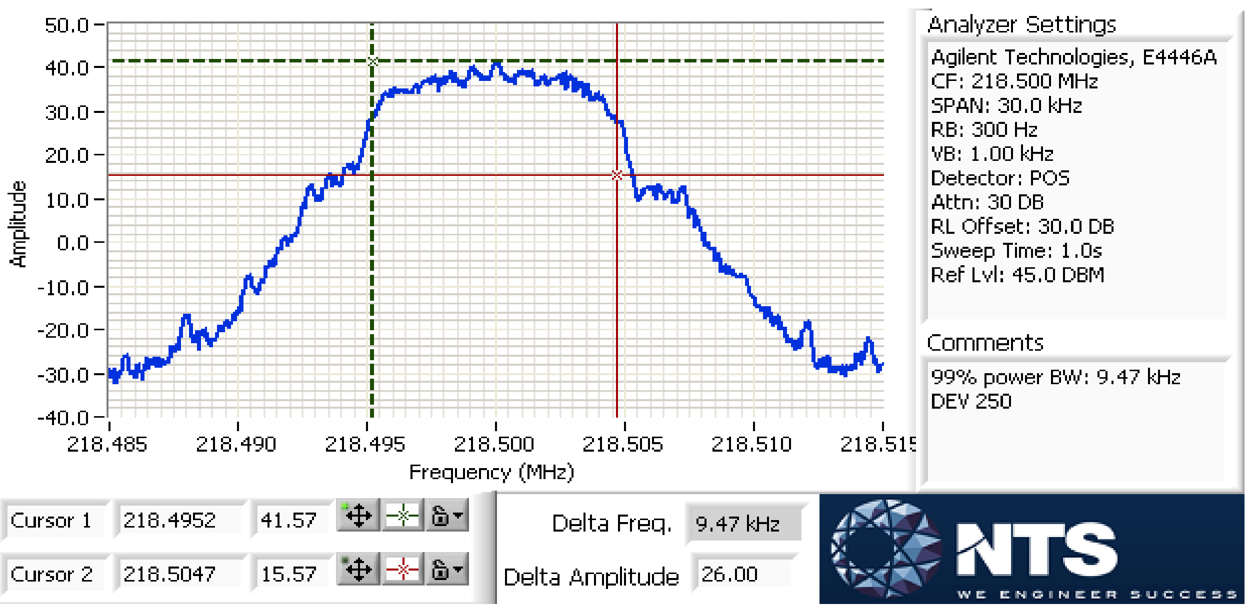
Run #3: Signal Bandwidth

Date of Test: 6/23/2014
Test Engineer: Jack Liu
Test Location: FT Lab# 4B

Config. Used: 1
Config Change: None
EUT Voltage: 13.8 VDC

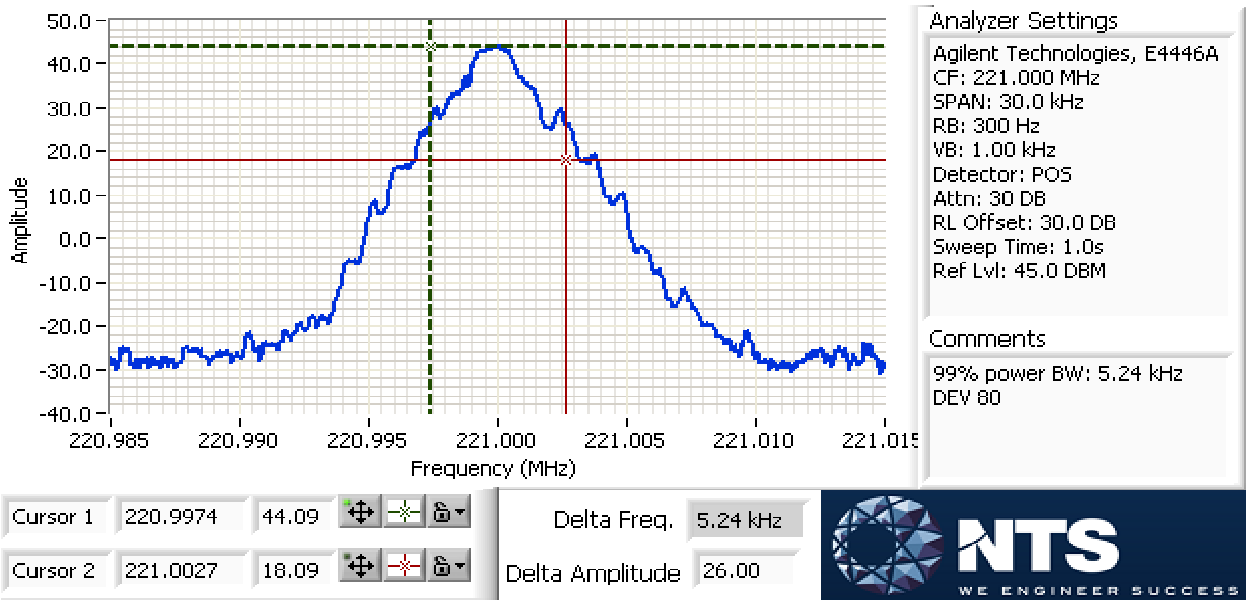
Power Setting	Frequency (MHz)	Resolution Bandwidth	Bandwidth (MHz)		Dev	
				99%		
High	218.5	300Hz		9.47	250	Parts 80, 90 (217-220 MHz band) and 95
High	221	300Hz		5.24	80	Part 90, (220-222 MHz band)

Note 1: 99% bandwidth measured in accordance with RSS GEN, with RB > 1% of the span and VB > 3xRB



EMC Test Data

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A



EMC Test Data

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

Run #4: Out of Band Spurious Emissions, Conducted

Date of Test: 6/23/2014
Test Engineer: Jack Liu
Test Location: FT Lab# 4B

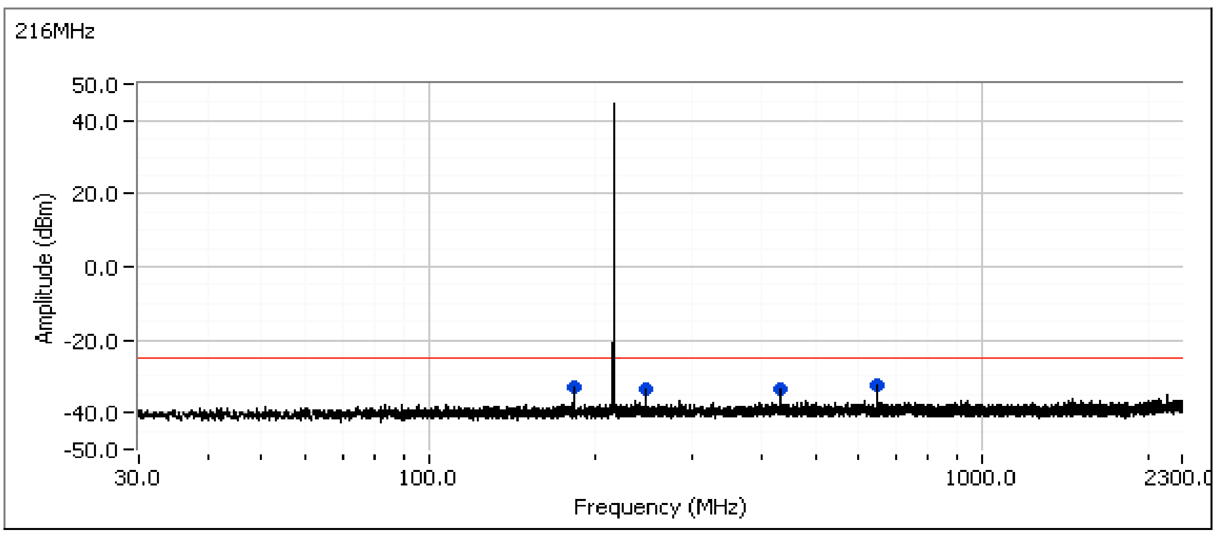
Config. Used: 1
Config Change: None
EUT Voltage: 13.8 VDC

Power Setting	Frequency (MHz)	Limit	Result
High	216	-25 dBm	Pass
High	220	-25 dBm	Pass
High	222	-25 dBm	Pass

Note : Test Out of Band Spurious Emissions with dsp md engt pd 0 setting

The limit is taken from FCC Part 90 Mask F

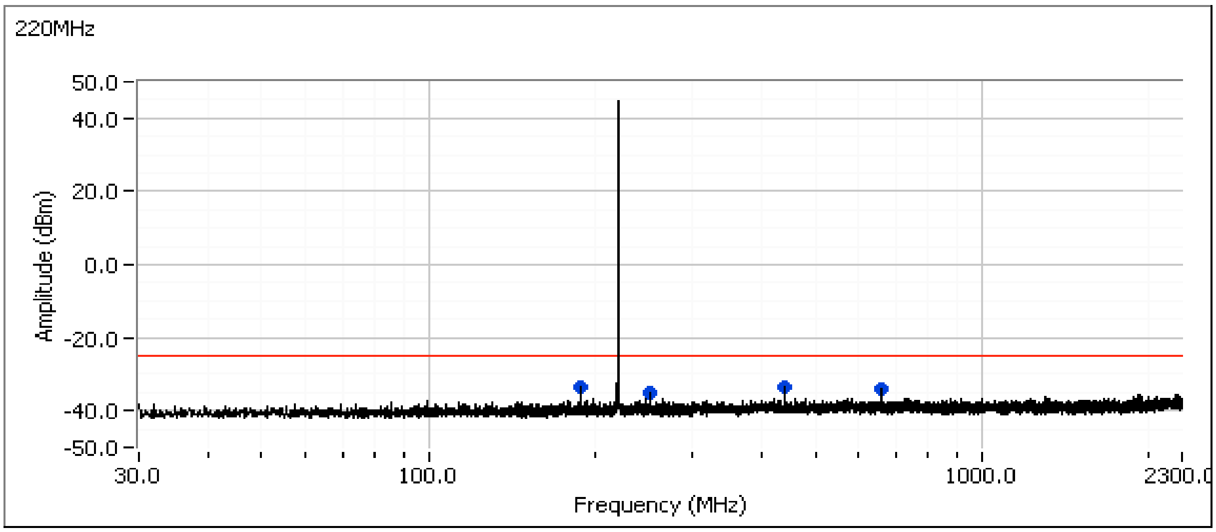
Plots for low channel, power setting(s) = H



Frequency	Level	Pol	Part 90 Mask F		Detector	Azimuth	Height	Comments
MHz	dBm	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
184.003	-33.1	RF Port	-25.0	-8.1	Peak	-	-	
247.996	-33.7	RF Port	-25.0	-8.7	Peak	-	-	
432.006	-33.6	RF Port	-25.0	-8.6	Peak	-	-	
648.012	-32.7	RF Port	-25.0	-7.7	Peak	-	-	

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

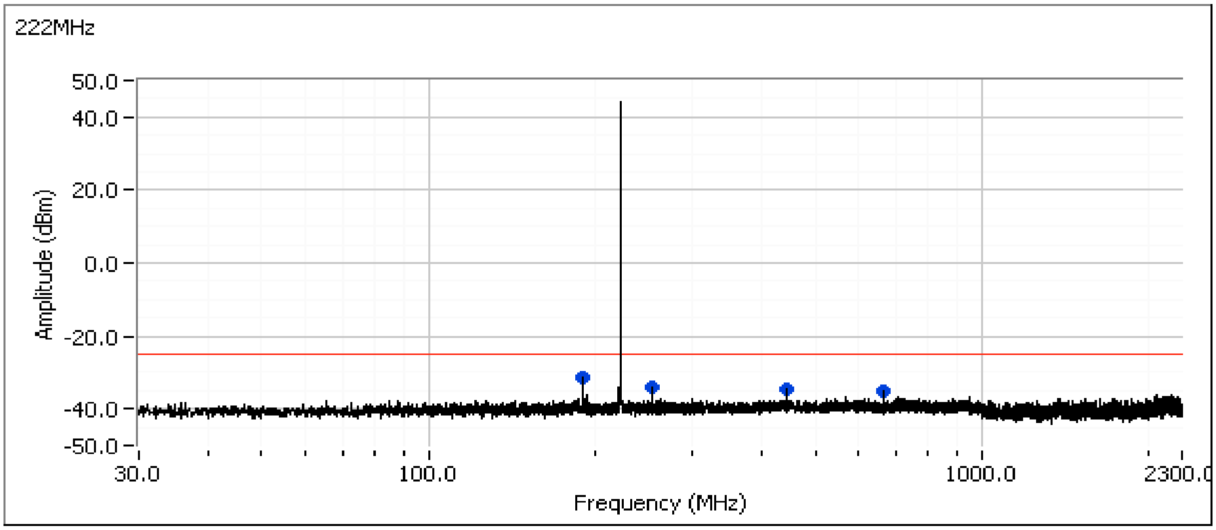
Plots for center channel, power setting(s) = H



Frequency	Level	Pol	Part 90 Mask F		Detector	Azimuth	Height	Comments
MHz	dBm	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
187.999	-33.6	RF Port	-25.0	-8.6	Peak	-	-	
252.001	-35.2	RF Port	-25.0	-10.2	Peak	-	-	
440.000	-33.4	RF Port	-25.0	-8.4	Peak	-	-	
660.002	-33.8	RF Port	-25.0	-8.8	Peak	-	-	

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

Plots for high channel, power setting(s) = H



Frequency	Level	Pol	Part 90 Mask F		Detector	Azimuth	Height	Comments
MHz	dBm	V/H	Limit	Margin	Pk/QP/Avg	degrees	meters	
189.998	-31.6	RF Port	-25.0	-6.6	Peak	-	-	
254.002	-33.9	RF Port	-25.0	-8.9	Peak	-	-	
666.001	-36.0	RF Port	-25.0	-11.0	Peak	-	-	
443.999	-35.9	RF Port	-25.0	-10.9	Peak	-	-	

EMC Test Data

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

Run #5: Out of Band Spurious Emissions, Radiated

Conducted limit (dBm): -25
Approximate field strength limit @ 3m: 70.2

The limit is taken from FCC Part 90 Mask F

Run #5a - Preliminary measurements

Date of Test: 6/24/2014
Test Engineer: Jack Liu
Test Location: FT Chamber #7

Config. Used: 2
Config Change: None
EUT Voltage: 13.8VDC

Frequency	Level	Pol	FCC 90		Detector	Azimuth	Height	Comments	Channel
MHz	dBμV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters		216
30.038	32.8	V	70.2	-37.4	Peak	2	1.0		216
40.258	24.7	V	70.2	-45.5	Peak	16	1.0		216
432.007	50.6	H	70.2	-19.6	Peak	203	1.5		216
647.994	42.4	H	70.2	-27.8	Peak	203	1.5		216
216.010	66.6	H	N/A	-	Peak	209	2.0	Fundamental	216
863.992	39.7	H	70.2	-30.5	Peak	290	1.0		216
53.335	25.2	V	70.2	-45.0	Peak	349	1.0		216
1008.040	35.1	H	70.2	-35.1	Peak	278	1.6		216
1080.040	37.7	V	70.2	-32.5	Peak	189	1.0		216
32.723	31.4	V	70.2	-38.8	Peak	44	1.0		219
242.815	25.1	V	70.2	-45.1	Peak	51	2.0		219
219.008	76.0	H	N/A	-	Peak	188	2.0	Fundamental	219
438.005	51.2	H	70.2	-19.0	Peak	200	1.5		219
657.011	42.8	H	70.2	-27.4	Peak	208	1.5		219
876.011	40.6	H	70.2	-29.6	Peak	290	1.0		219
132.093	27.7	H	70.2	-42.5	Peak	356	1.5		219
148.037	21.5	H	70.2	-48.7	Peak	356	1.5		219
1095.040	38.2	H	70.2	-32.0	Peak	157	1.0		219
1008.010	36.1	H	70.2	-34.1	Peak	268	1.0		219

EMC Test Data

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

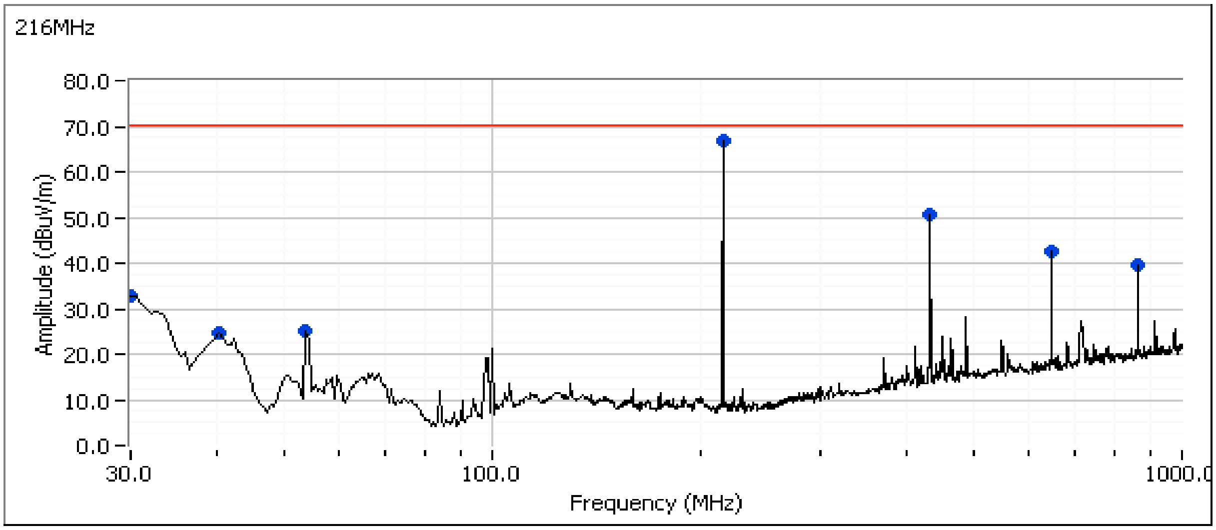
Frequency	Level	Pol	FCC 90		Detector	Azimuth	Height	Comments	Channel
MHz	dBμV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters		216
887.997	40.6	H	70.2	-29.6	Peak	30	1.5		222
189.676	19.9	H	70.2	-50.3	Peak	40	1.5		222
98.510	25.1	H	70.2	-45.1	Peak	52	4.0		222
67.496	26.7	V	70.2	-43.5	Peak	136	1.5		222
222.001	76.1	H	N/A	-	Peak	188	2.0	Fundamental	222
254.011	16.2	H	70.2	-54.0	Peak	216	1.0		222
444.009	49.5	H	70.2	-20.7	Peak	292	1.5		222
666.000	37.7	H	70.2	-32.5	Peak	294	1.5		222
32.717	32.2	V	70.2	-38.0	Peak	329	1.0		222
1000.010	47.8	V	70.2	-22.4	Peak	197	1.3		222

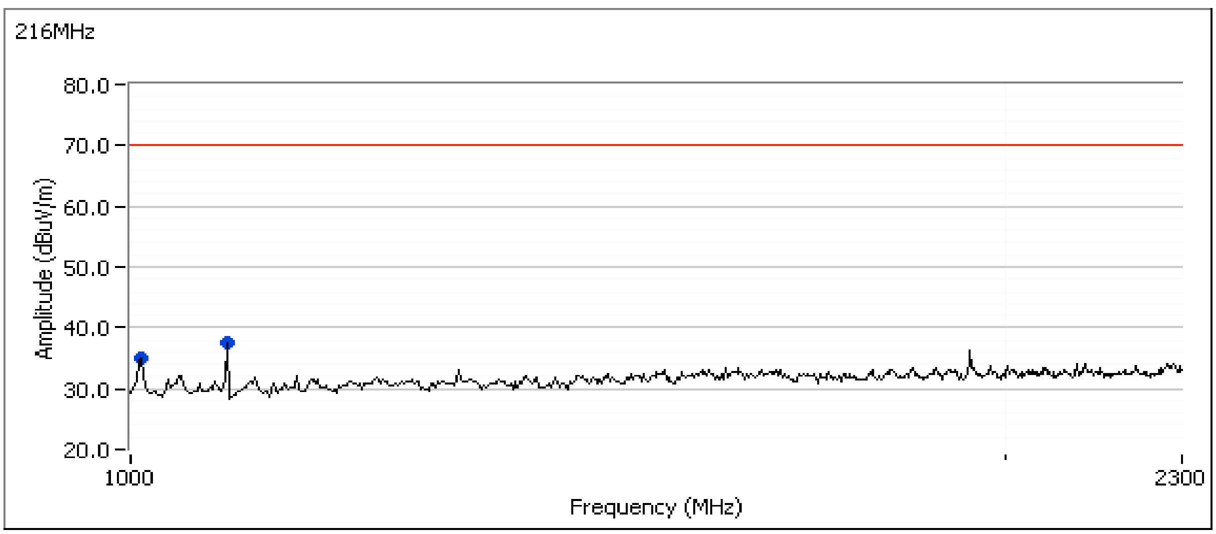
Note 1:	The field strength limit in the tables above was calculated from the erp/eirp limit detailed in the standard using the free space propagation equation: $E=\sqrt{(30PG)}/d$. This limit is conservative - it does not consider the presence of the ground plane and, for erp limits, the dipole gain (2.2dBi) has not been included. The erp or eirp for all signals with less than **20dB** of margin relative to this field strength limit is determined using substitution measurements.
Note 2:	Measurements are made with the antenna port terminated.

EMC Test Data

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

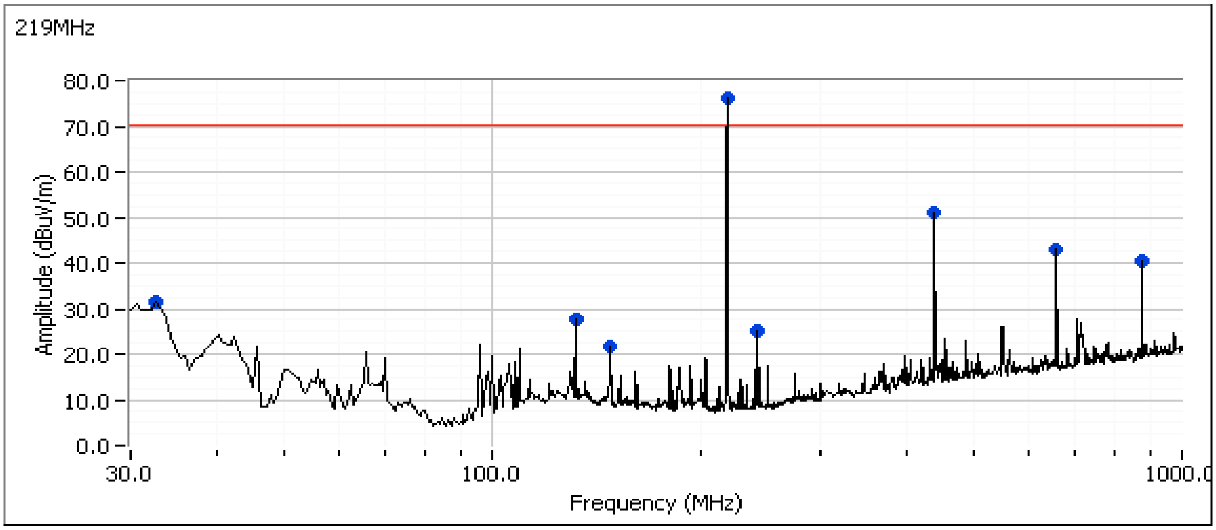
Plots for low channel 216MHz, power setting(s) = H

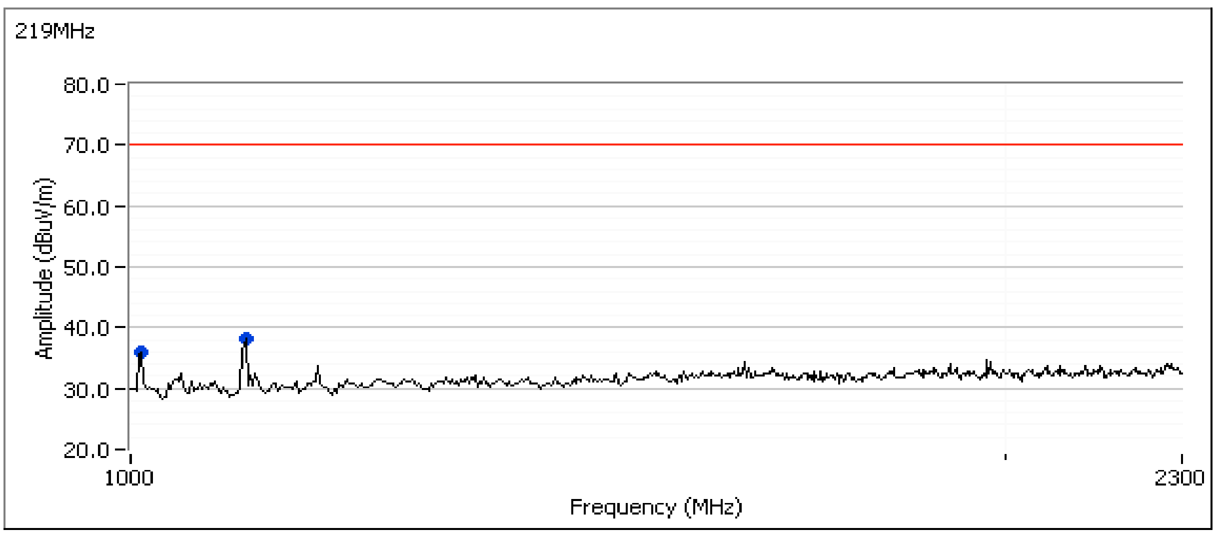




Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

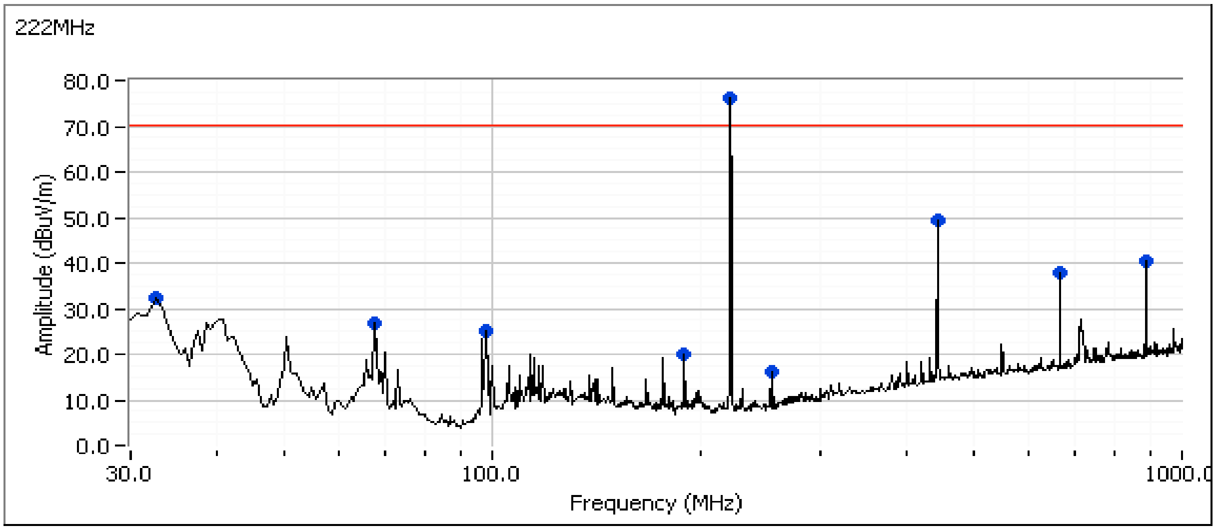
Plots for center channel 219MHz, power setting(s) = H

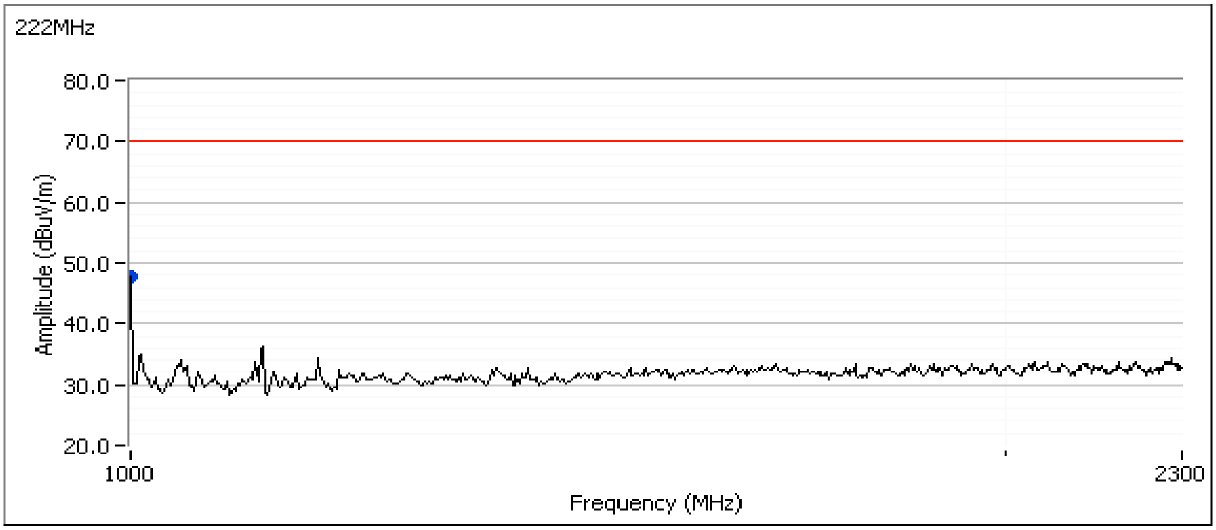




Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

Plots for high channel 222MHz, power setting(s) = H





Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

Run #5b: - Final Field Strength and Substitution Measurements

Date of Test: 6/24/2014 — Config. Used: 1
Test Engineer: Rafael Varelas — Config Change: None
Test Location: FT Chamber #7 — EUT Voltage: 13.8 VDC

EUT Field Strength

Frequency	Level	Pol	FCC 90		Detector	Azimuth	Height	Comments	Channel
MHz	dBμV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters		
432.007	50.6	H	70.2	-19.6	Peak	203	1.5		216
438.005	51.2	H	70.2	-19.0	Peak	200	1.5		219

Note 1:	The field strength limit in the tables above was calculated from the erp/eirp limit detailed in the standard using the free space propagation equation: $E=\sqrt{(30PG)}/d$. This limit is conservative - it does not consider the presence of the ground plane and, for erp limits, the dipole gain (2.2dBi) has not been included. The erp or eirp for all signals with less than **20dB** of margin relative to this field strength limit is determined using substitution measurements.
Note 2:	Measurements are made with the antenna port terminated.

Substitution measurements
Horizontal

Frequency	Substitution measurements			Site	EUT measurements			eirp Limit	erp Limit	Margin
MHz	Pin[1]	Gain[2]	FS[3]	Factor[4]	FS[5]	eirp (dBm)	erp (dBm)	dBm	dBm	dB
432.007	-0.6	5.9	104.4	99.1	50.6	-48.5	-50.7		-25.0	-25.7
438.005	-0.6	6.0	104.6	99.2	51.2	-48.0	-50.2		-25.0	-25.2

Note 1:	Pin is the input power (dBm) to the substitution antenna
Note 2:	Gain is the gain (dBi) for the substitution antenna.
Note 3:	FS is the field strength (dBuV/m) measured from the substitution antenna.
Note 4:	Site Factor - this is the site factor to convert from a field strength in dBuV/m to an eirp in dBm.
Note 5:	EUT field strength as measured during initial run.

Client:	GE MDS LLC	Job Number:	J95325
Model:	TD220Max	T-Log Number:	T95356
		Project Manager:	Christine Krebill
Contact:	Dennis McCarthy	Project Coordinator:	-
Standard:	FCC Parts 80, 90 and 95, RSS-119	Class:	N/A

Run #8: Frequency Stability

Date of Test: 6/23/2014
Test Engineer: Rafael Varelas
Test Location: FT Lab# 4B

Config. Used: 1
Config Change: None
EUT Voltage: 13.8 VDC

Nominal Frequency: 218.5 MHz

Frequency Stability Over Temperature

The EUT was soaked at each temperature for a minimum of 30 minutes prior to making the measurements to ensure the EUT and chamber had stabilized at that temperature.

Temperature	Frequency Measured	Drift	
(Celsius)	(MHz)	(Hz)	(ppm)
-30	218.500035	35	0.2
-20	218.500025	25	0.1
-10	218.500058	58	0.3
0	218.500035	35	0.2
10	218.500033	33	0.2
20	218.500075	75	0.3
30	218.500023	23	0.1
40	218.500013	13	0.1
50	218.500017	17	0.1
	Worst case:	75	0.3

Frequency Stability Over Input Voltage

Nominal Voltage is 13.8Vdc.

Voltage	Frequency Measured	Drift		
(DC)	(MHz)	(Hz)	(ppm)	
85%	218.500075	75	0.3	11.7 V
115%	218.500075	75	0.3	15.9 V
	Worst case:	75	0.3	

Note 1: Maximum drift of fundamental frequency before it shut down at 6.4 Vdc was 0 Hz.

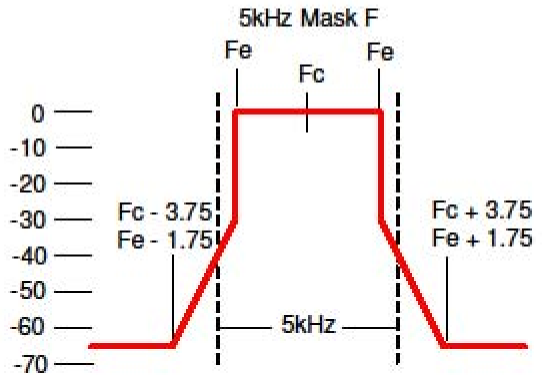
Appendix C Mask Calculation

FCC Mask F Calculations:

Part 90.209 states that the channel spacing for 220-222MHz is 5kHz and the authorized BW is 4kHz.

Part 90.210 emission mask F states that any emission must be attenuated below the power (P) as follows:

1. On any freq from the center Fo to the edge of the authorized bw, Fe (2kHz); 0dB.
2. On any frequency removed from the center of the authorized bw by a displacement frequency (Fd in kHz) of more than 2kHz (Fe) up to and including 3.75kHz: 30 + 20(Fd –2) dB or 55 + 10 log (P), or 65 dB whichever is less.
3. On any freq beyond 3.75kHz removed from the center of the authorized bw Fd: At least 55 + 10 log (P)dB.



Subpart T 90.733e states that for aggregated channels in the 220MHz range mask F must be met only at the channel edges. So we will take the edge of the 5kHz mask F and move it to coincide with the edge of the aggregated channels.

For the 5kHz mask F, the channel edge is 2.5kHz from the center and Fe is 2kHz from the center. So Fe is .5kHz from the channel edge.

For a 12.5kHz channel the channel edge is 6.25kHz from the center and Fe will be 6.25 - .5kHz = 5.75kHz from center.

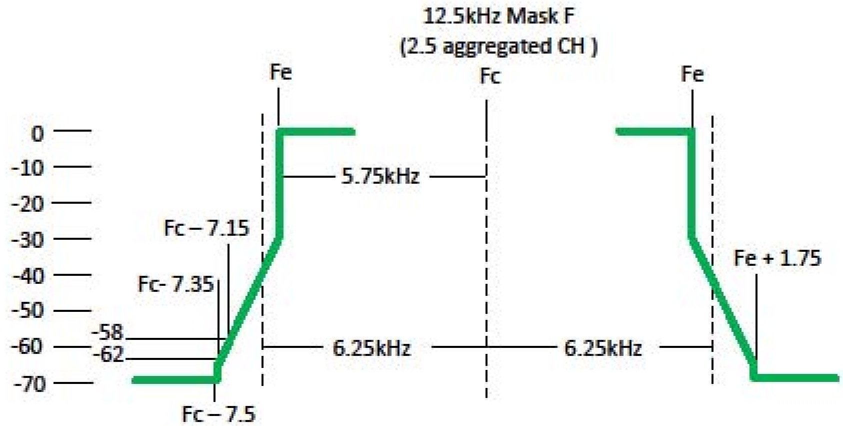
The rules for the mask become:

1. On any freq from the center Fo to the edge, 5.75kHz; 0dB.
2. On any frequency removed from the center of the authorized bw by a displacement frequency (Fd in kHz) of more than 5.75kHz (Fe) up to and including 7.5kHz: 30 + 20(Fd –5.75) dB or 55 + 10 log (P), or 65 dB whichever is less.
3. On any freq beyond 7.5kHz removed from the center of the authorized bw Fd: At least 55 + 10 log (P)dB.

For low power radios the maximum attenuation will be determined by 55 + 10 log (P). (90.210F sub 2)

For a 2 watt radio that equals 55 + 10 log (2). Equals 58dB. Which meets the sloping line when 30 + 20 (Fd –5.75) = 58. At Fd = 7.15kHz
For a 5 watt radio that equals 62dB. Which meets the sloping line when Fd = 7.35kHz
For a 10 watt radio that equals 65dB. Which meets the sloping line when Fd = 7.5kHz
For any higher power radio this is the limit where the sloping line ends.
For Fd > 7.5kHz then 55 + 10 log (P)dB. For 25 watts this is 55 + 10 log (25)dB = 69dB.

The final mask F for a 25 watt radio using 2.5 aggregated channels (12.5kHz) looks like this:



End of Report

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