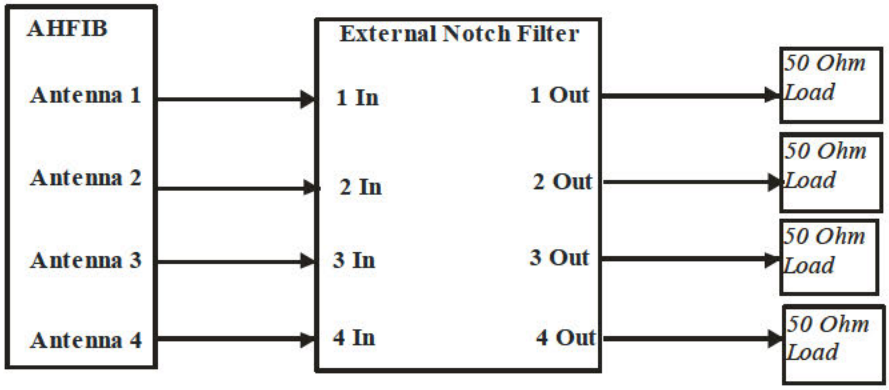
Transmitter Radiated Spurious Emissions

During radiated emission testing all antenna ports of the base station were terminated with 50ohm termination blocks via the external RF notch filter as shown in the diagram below.



Based on antenna port conducted spurious emissions tests results, preliminary scans for radiated spurious emissions were performed in 30MHz – 22GHz frequency range. One radiated emission test configuration (with the external notch filter and cooling fan) was used to prove compliance for both the AWS and PCS frequency bands. The 3GPP Band 25 and the 3GPP Band 66 transmitters were enabled simultaneously at maximum power using QPSK modulation on all four ports for this test. The test includes channel bandwidth with the highest spectral density (LTE5) for both frequency bands. The bottom, middle and top frequency channels for each band were enabled. The carrier configuration for the radiated emission testing is provided below. Final maximized peak radiated emissions were measured in these modes.

Frequency Band	Antenna Port	RF Bandwidth	EARFCN	Transmit Frequency
PCS	1	5 MHz	8065 (Bottom Channel)	1932.5 MHz
PCS	2	5 MHz	8365 (Middle Channel)	1962.5 MHz
PCS	3	5 MHz	8365 (Middle Channel)	1962.5 MHz
PCS	4	5 MHz	8665 (Top Channel)	1992.5 MHz
AWS	1	5 MHz	66461 (Bottom Channel)	2112.5 MHz
AWS	2	5 MHz	66886 (Middle Channel)	2155.0 MHz
AWS	3	5 MHz	66886 (Middle Channel)	2155.0 MHz
AWS	4	5 MHz	67261 (Top Channel with NF)	2192.5 MHz

See Appendix A for radiated emission results.

Frequency Stability/Accuracy

Carrier frequency stability at extreme temperatures and voltages, frequency error was measured as follows:

(1) Transmitting in 5MHz-QPSK-LTE mode at center channel (2155.0MHz) on port 2.
(2) The EUT temperature was stabilized at each temperature step (for a minimum of 30 minutes) prior to frequency accuracy measurement.

Nominal operating voltage of the product is declared as 48VDC.

Frequency error results are listed below for extreme voltages and temperatures.

Extreme Voltages:

Percentage of Rated Supply	DC Voltage (VDC)	Frequency Error (Hz) at 20°C
85%	40.8	0.039
100%	48.0	0.209
115%	55.2	0.060

Extreme Temperatures:

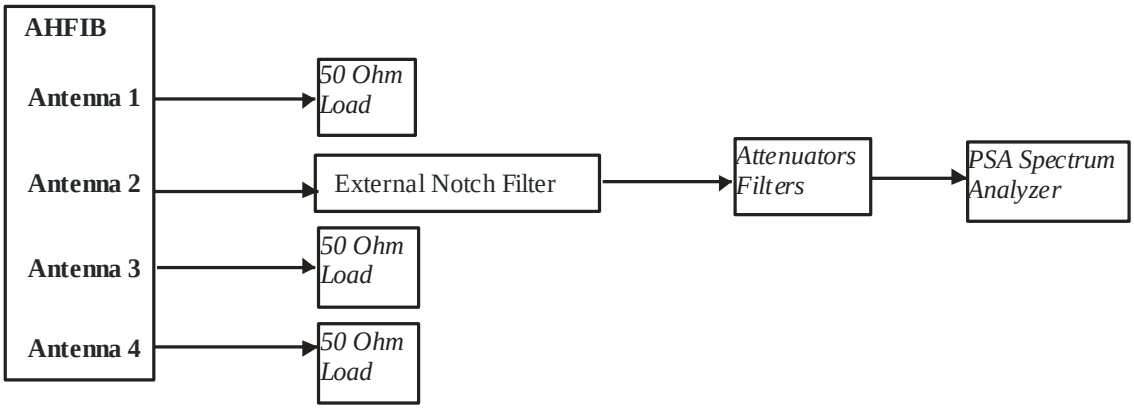
Temperature	Frequency Error (Hz) at 48VDC
-30 °C	2.648
-20 °C	2.709
-10 °C	2.879
0 °C	**3.700**
10 °C	3.640
20 °C	0.209
30 °C	0.211
40 °C	0.047
50 °C	0.185

Based on the results above, highest recorded frequency error (3.7Hz or 0.0017ppm) ensures that the transmitted signal remains in its authorized frequency block at extreme voltages and temperatures.

The results above are deemed sufficient to demonstrate carrier frequency stability for all other channel bandwidth modes and modulations since all carriers are controlled by the same frequency stabilization circuitry that was subjected to the extreme conditions under this test.

APPENDIX C: ANTENNA PORT TEST DATA FOR THE AWS BAND WITH NOTCH FILTER

All conducted RF measurements for this test effort in this section were made at the external notch filter (Filtronics P/N: US-PSD015-F1V1) output port. The notch filter was connected to RRH antenna port 2 (highest power antenna port) via low loss cable. The test setup used is provided below.



Test Setup Used for Conducted RF Measurements on the RRH with External Notch Filter

RF Output Power

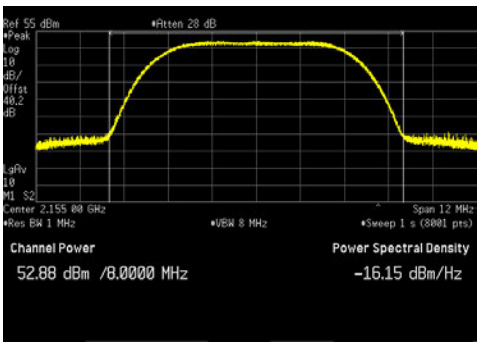
Peak and RMS Average RF output power were measured at the external notch filter (Filtronics P/N: USPSD015-F1V1) output port using RRH antenna port 2. Measurements were made on the middle and top channels using 256QAM modulation for LTE bandwidths of 5MHz, 10MHz, 15MHz, and 20MHz. Peak to average power ratio (PAPR) has been calculated as described in section 5.7.2 of KDB971168 D01 v02r02. The results of the power measurements and PAPR calculations are provided in the table below. Power measurements are not repeated for the PCS band or bottom channel of the AWS band because the power level will be smaller (due to line losses) than test cases without notch filter. Highlighted numbers are maximum values.

FRIJ Ant 4 Port	LTE Bandwidth	LTE - 256QAM		
		Peak (dBm)	Average (dBm)	PAPR (dB)
Middle Channel	5M	52.88	**45.24**	7.64
	10M	52.93	45.16	7.77
	15M	52.93	45.16	7.77
	20M	52.96	45.22	7.74
Top Channel	5M	52.67	45.04	7.63
	10M	52.91	45.12	7.79
	15M	**52.97**	45.17	**7.80**
	20M	52.77	45.09	7.68

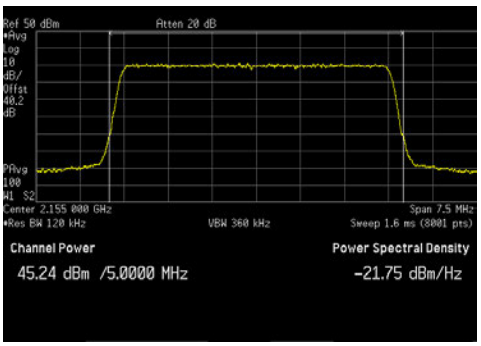
All measurement results are provided in the following pages. The total measurement RF path loss of the test setup (attenuator and test cables) was 40.2 dB and is accounted for by the spectrum analyzer reference level offset.

LTE5 and LTE10 Channel Power Plots for external Notch Filter Output and 256QAM Modulation:

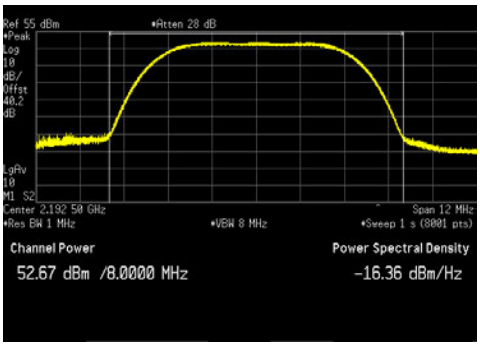
LTE5_Middle Channel_Peak



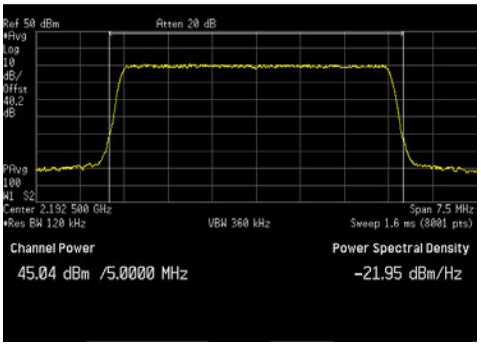
LTE5_Middle Channel_Average



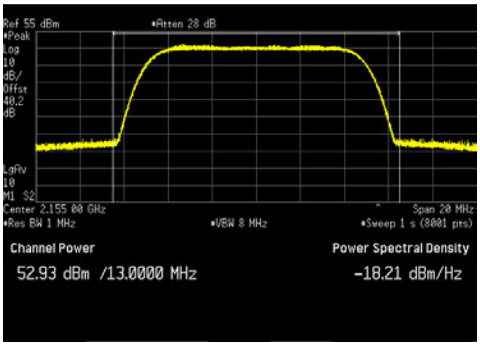
LTE5_Top Channel_Peak



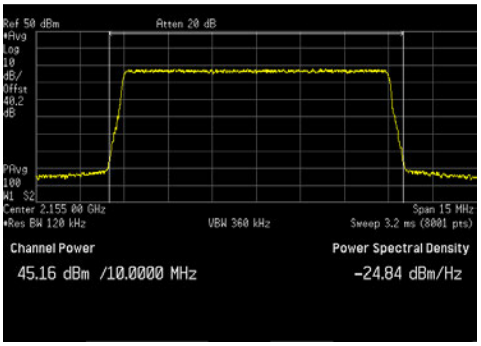
LTE5_Top Channel_Average



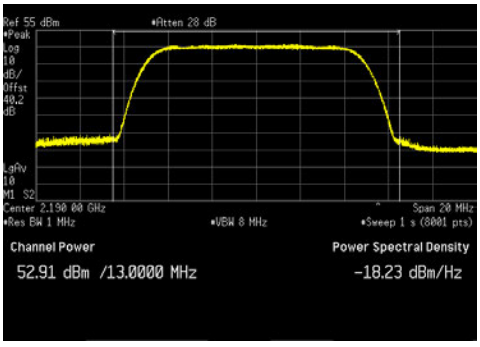
LTE10_Middle Channel_Peak



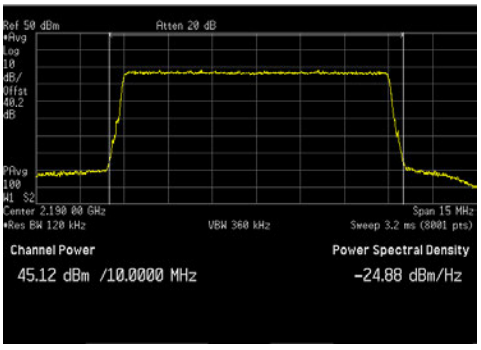
LTE10_Middle Channel_Average



LTE10_Top Channel_Peak

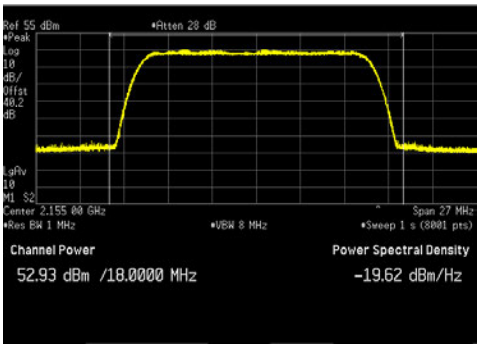


LTE10_Top Channel_Average

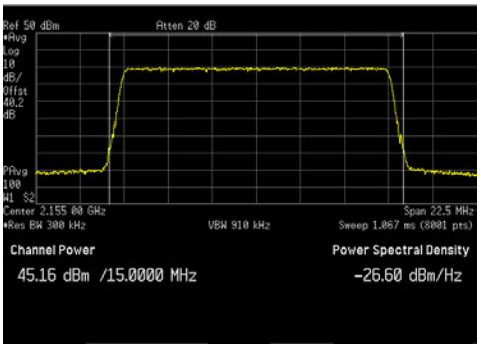


LTE15 and LTE20 Channel Power Plots for external Notch Filter Output and 256QAM Modulation:

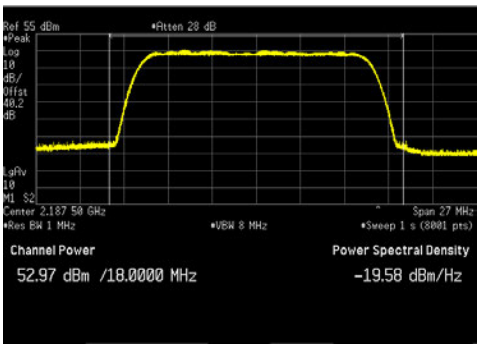
LTE15_Middle Channel_Peak



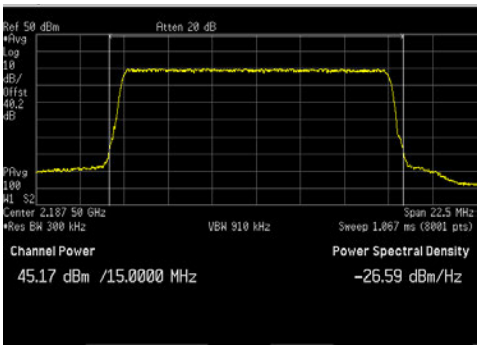
LTE15_Middle Channel_Average



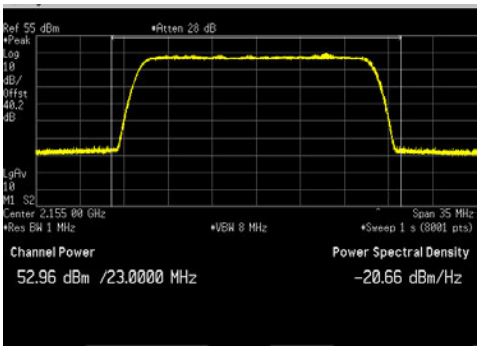
LTE15_Top Channel_Peak



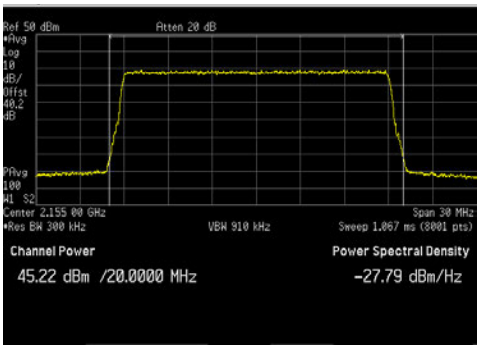
LTE15_Top Channel_Average



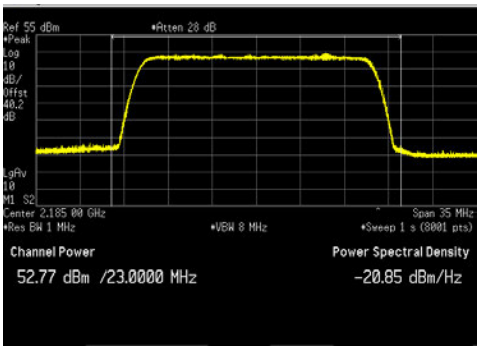
LTE20_Middle Channel_Peak



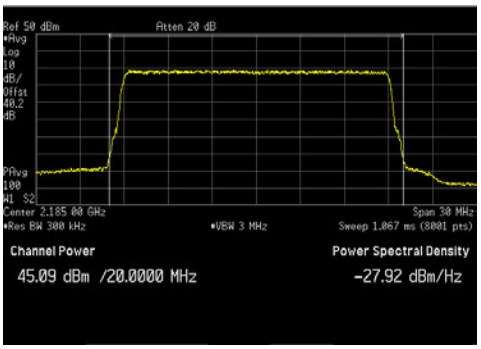
LTE20_Middle Channel_Average



LTE20_Top Channel_Peak



LTE20_Top Channel_Average



Emission Bandwidth (26 dB down and 99%)

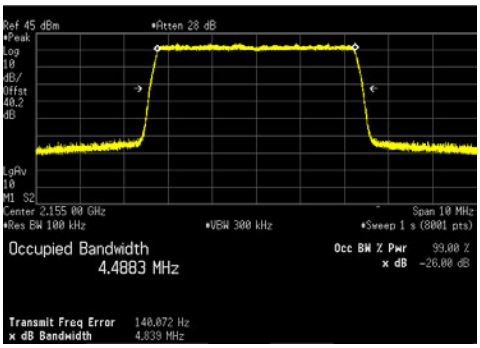
Emission bandwidth measurements were made at the external notch filter (Filtronics P/N: US-PSD015-F1V1) output port using RRH antenna port 2. Measurements were made on the middle channel with maximum RF output power. All available LTE modulations (QPSK, 16QAM, 64QAM and 256QAM) were used. All available LTE channel bandwidths (5MHz, 10MHz, 15MHz, and 20MHz) were used. The results are provided in the following table (highlighted numbers are maximum values for emission types).

LTE Channel Bandwidth	Modulation Type							
	QPSK		16QAM		64QAM		256QAM	
	26dB (MHz)	99% (MHz)	26dB (MHz)	99% (MHz)	26dB (MHz)	99% (MHz)	26dB (MHz)	99% (MHz)
5M	**4.839**	4.4883	4.822	4.4803	4.825	4.4905	4.835	**4.4929**
10M	9.619	8.9677	**9.658**	**8.9874**	9.642	8.9705	9.648	8.9708
15M	14.442	13.4579	14.421	**13.4874**	**14.487**	13.4547	14.445	13.4544
20M	19.243	17.9243	19.201	**17.9551**	19.304	17.9399	**19.308**	17.9378

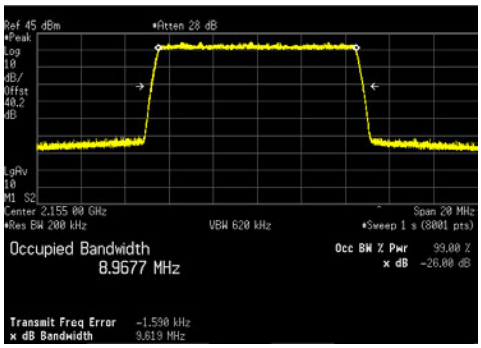
Emission bandwidth measurement data are provided in the following pages.

LTE5 and LTE10 Emission Bandwidth Plots on the Middle Channel using Antenna Port 2 via RF Notch Filter:

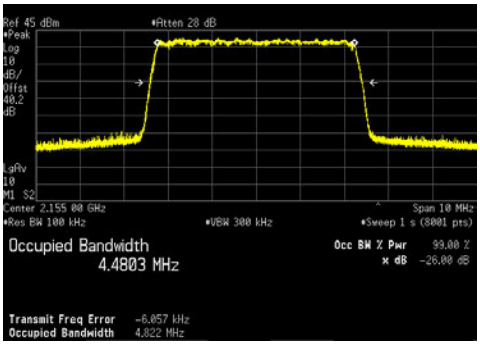
LTE5_QPSK



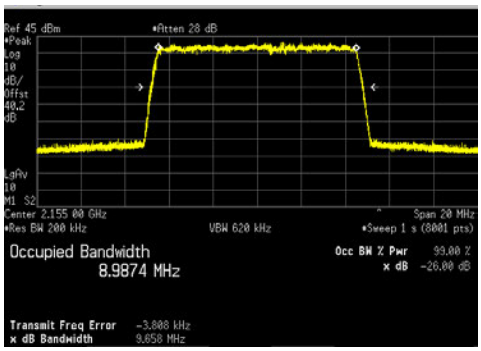
LTE10_ QPSK



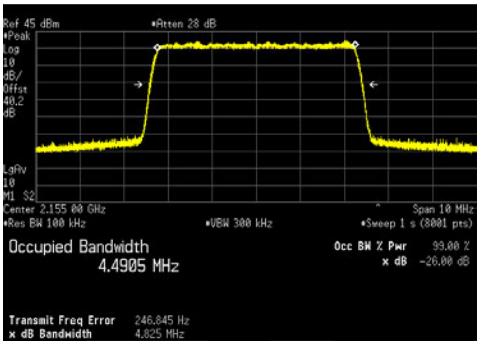
LTE5_16QAM



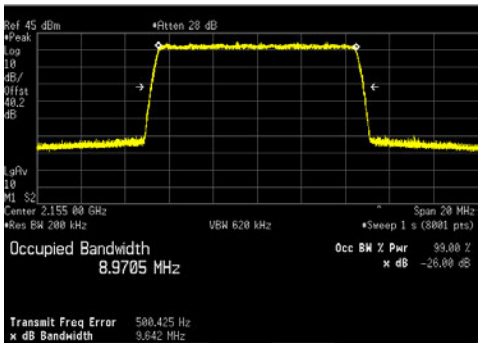
LTE10_16QAM



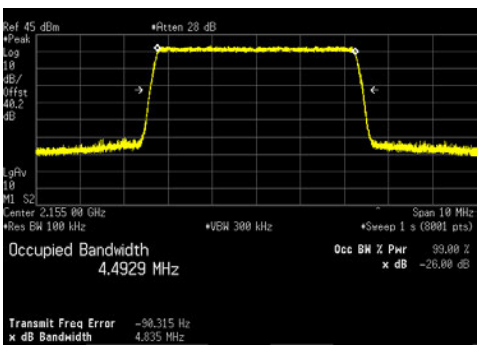
LTE5_64QAM



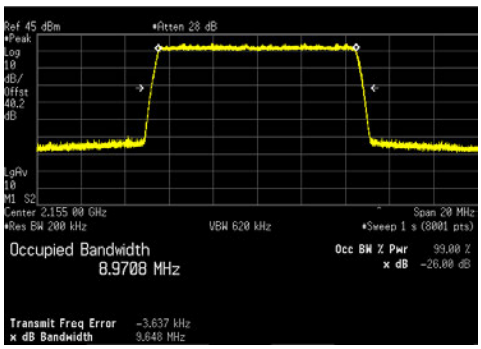
LTE10_64QAM



LTE5_256QAM

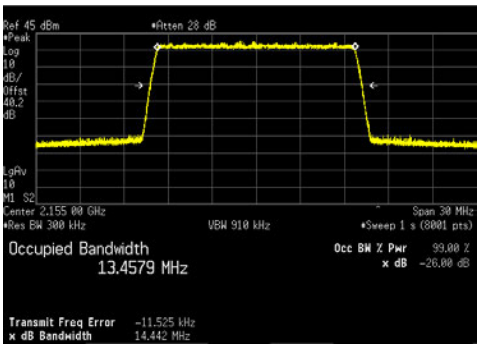


LTE10_256QAM

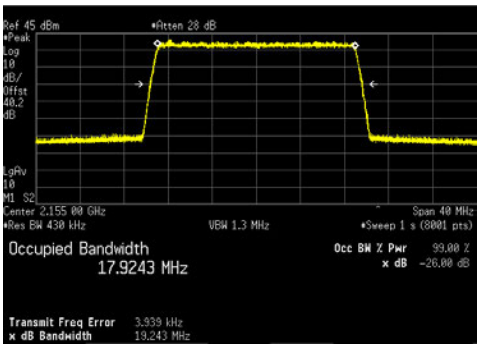


LTE15 and LTE20 Emission Bandwidth Plots on the Middle Channel for Antenna Port 2 via RF Notch Filter:

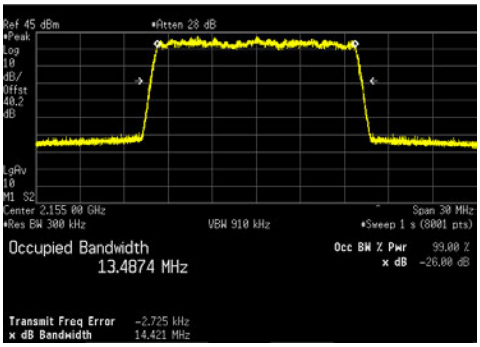
LTE15_QPSK



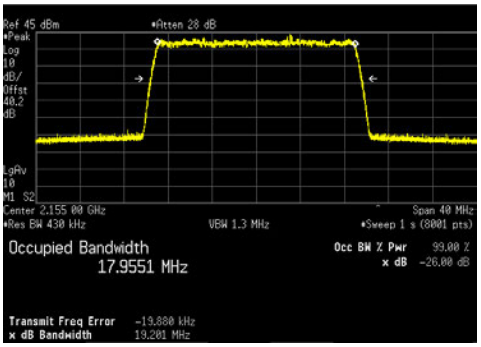
LTE20_ QPSK



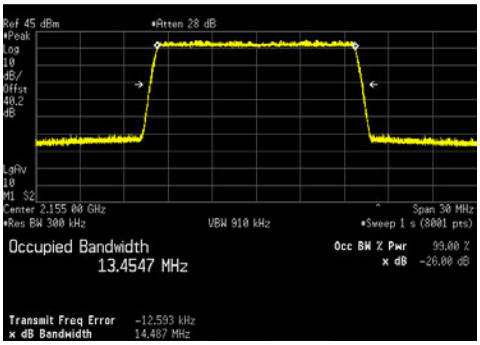
LTE15_16QAM



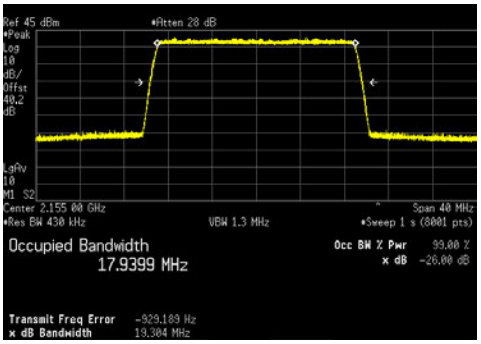
LTE20_16QAM



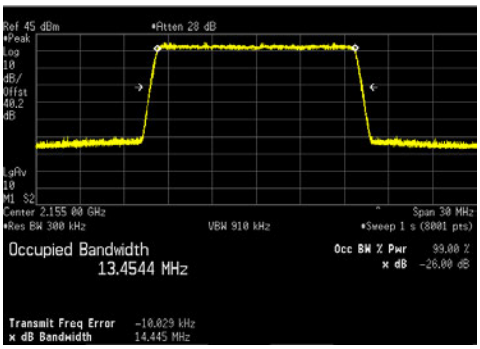
LTE15_64QAM



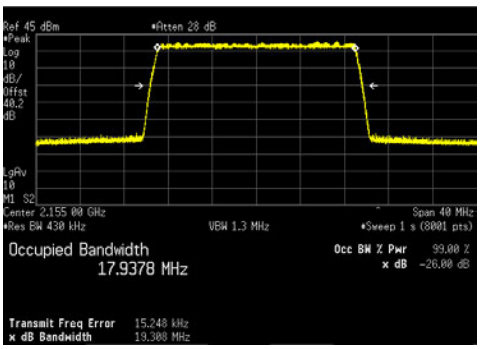
LTE20_64QAM



LTE15_256QAM



LTE20_256QAM



Antenna Port Conducted Band Edge

Conducted band edge measurements are made at the external notch filter (Filtronics P/N: US-PSD015-F1V1) output port using RRH antenna port 2. The RRH is operated at the top band edge frequencies with all modulation types (QPSK, 16QAM, 64QAM and 256QAM) for 5MHz, 10MHz, 15MHz and 20MHz LTE bandwidths. Conducted band edge measurements are not repeated for the PCS band or bottom channel of the AWS band because the power levels are smaller (due to line losses) than test cases without notch filter.

The limit of -19dBm is used in the certification testing. The limit is adjusted to -19dBm [-13dBm -10 log (4)] per FCC KDB 662911D01 v02r01 because the BTS may operate as a 4 port MIMO transmitter.

Measurements are performed with the spectrum analyzer in the RMS average mode over 100 traces. In the 5MHz band outside and adjacent to the upper band edge frequency (i.e.: 2200 to 2205MHz bands) a 1MHz RBW and 3MHz VBW is used.

The results are summarized in the following table. The highest (worst case) emissions from the measurement data are provided.

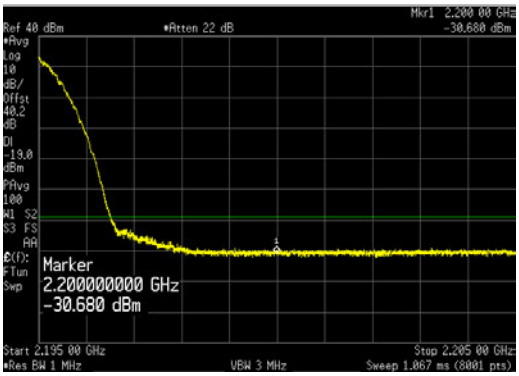
LTE Bandwidth	LTE - QPSK	LTE - 16QAM	LTE - 64QAM	LTE - 256QAM
	Top Channel	Top Channel	Top Channel	Top Channel
5M	-30.680	-30.705	-30.809	-30.870
10M	-29.685	-30.779	-30.875	-30.958
15M	-30.398	-30.964	-31.317	-30.562
20M	-30.941	-30.932	-30.942	-31.148
Dual 5M	-30.987	-30.359	-29.980	-31.027

The total measurement RF path loss of the test setup (attenuator and test cables) was 40.2 dB and is accounted for by the spectrum analyzer reference level offset.

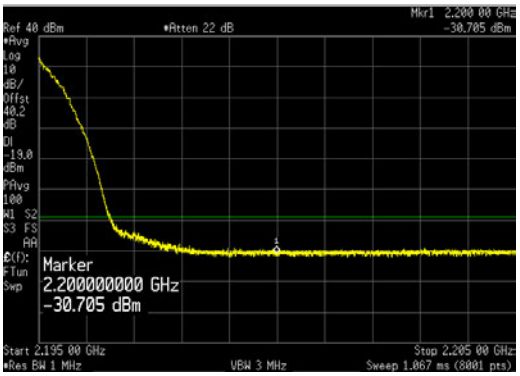
Conducted band edge measurements are provided in the following pages.

LTE 5 Top Channel Band Edge Plots for external Notch Filter Output:

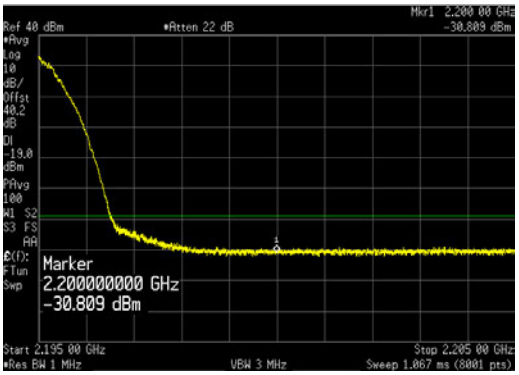
Upper Band Edge_2195 to 2205MHz_QPSK



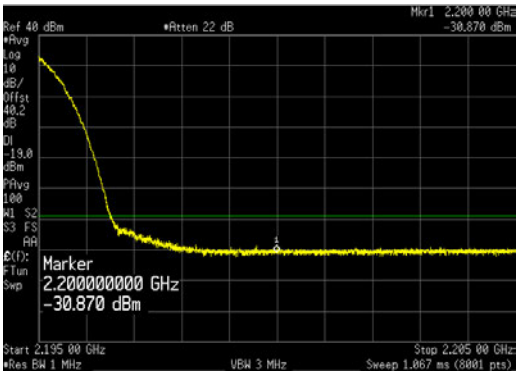
Upper Band Edge_2195 to 2205MHz_16QAM



Upper Band Edge_2195 to 2205MHz_64QAM

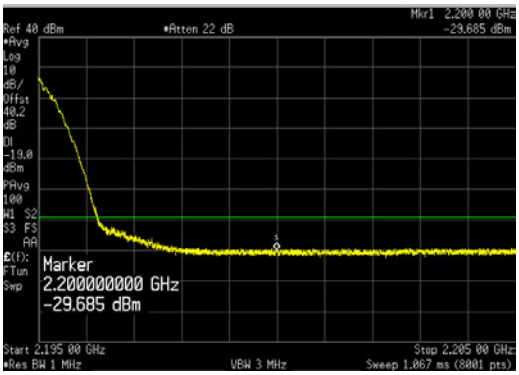


Upper Band Edge_2195 to 2205MHz_256QAM

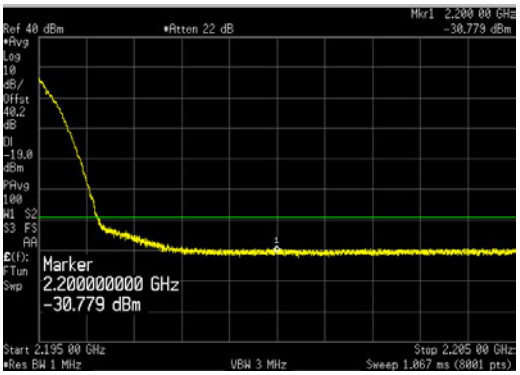


LTE 10 Top Channel Band Edge Plots for external Notch Filter Output:

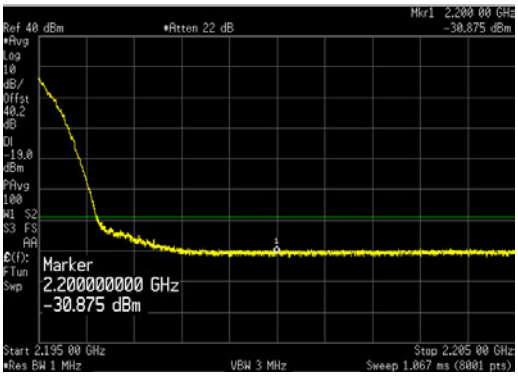
Upper Band Edge_2195 to 2205MHz_QPSK



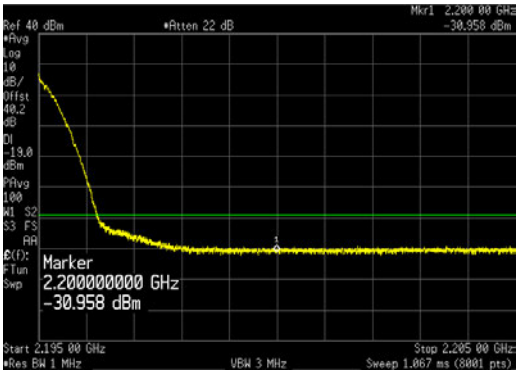
Upper Band Edge_2195 to 2205MHz_16QAM



Upper Band Edge_2195 to 2205MHz_64QAM

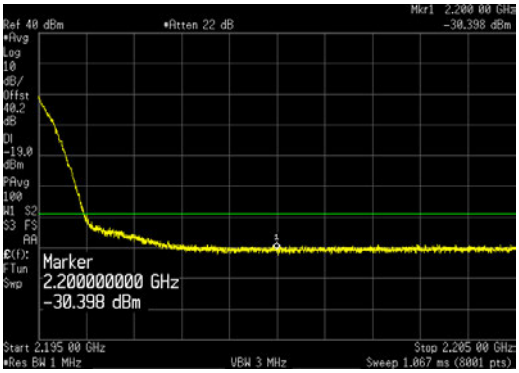


Upper Band Edge_2195 to 2205MHz_256QAM

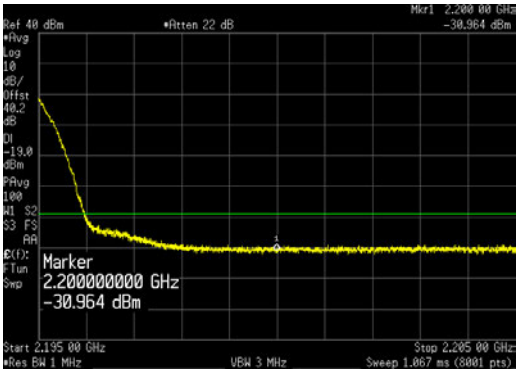


LTE 15 Top Channel Band Edge Plots for external Notch Filter Output:

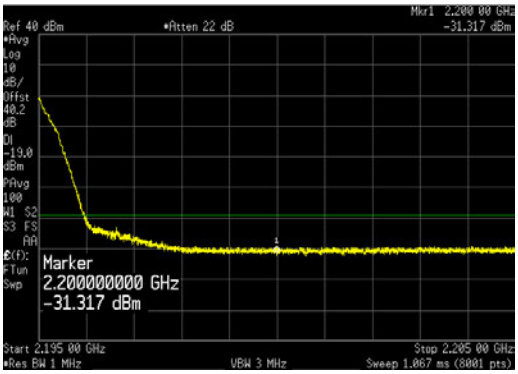
Upper Band Edge_2195 to 2205MHz_QPSK



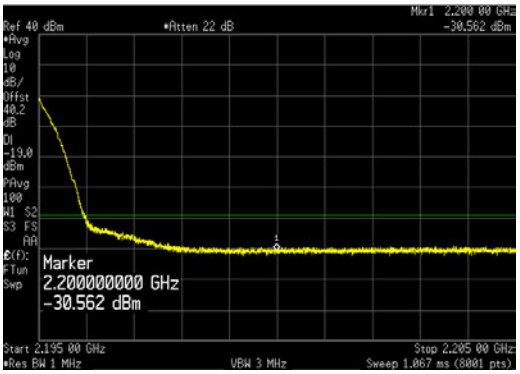
Upper Band Edge_2195 to 2205MHz_16QAM



Upper Band Edge_2195 to 2205MHz_64QAM

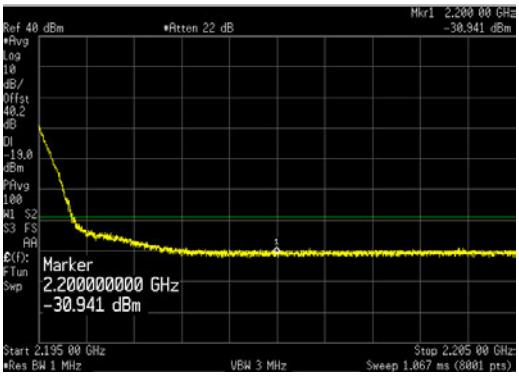


Upper Band Edge_2195 to 2205MHz_256QAM

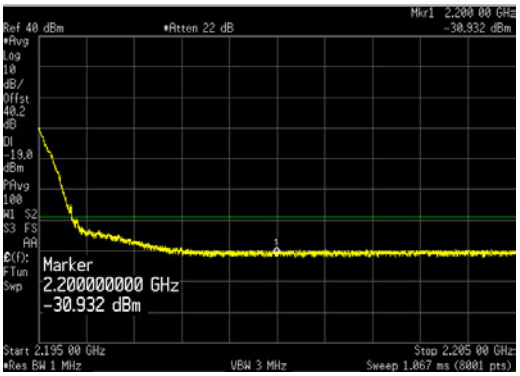


LTE 20 Top Channel Band Edge Plots for external Notch Filter Output:

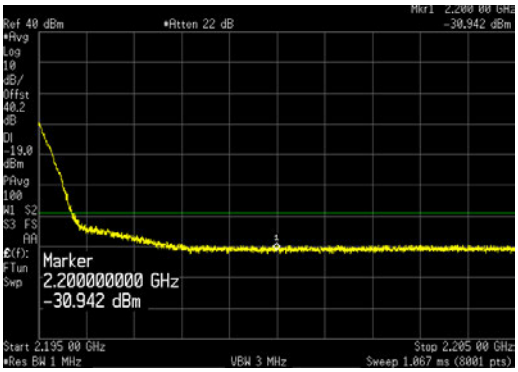
Upper Band Edge_2195 to 2205MHz_QPSK



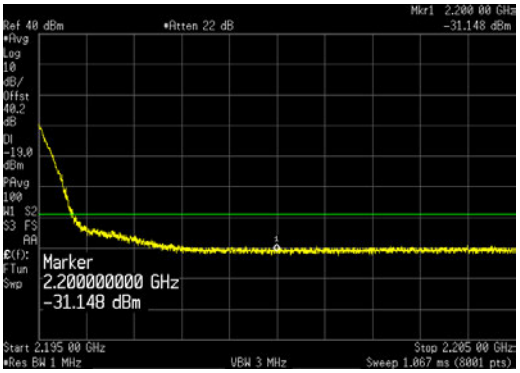
Upper Band Edge_2195 to 2205MHz_16QAM



Upper Band Edge_2195 to 2205MHz_64QAM

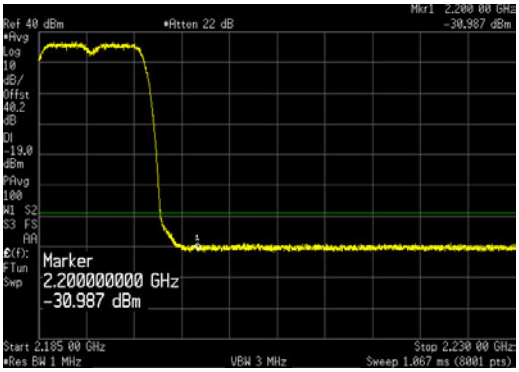


Upper Band Edge_2195 to 2205MHz_256QAM

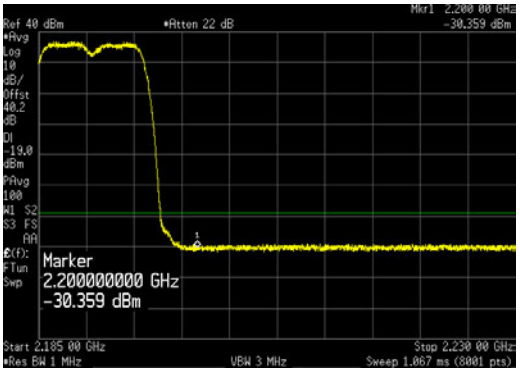


Dual LTE5 Top Channel Band Edge Plots for external Notch Filter Output:

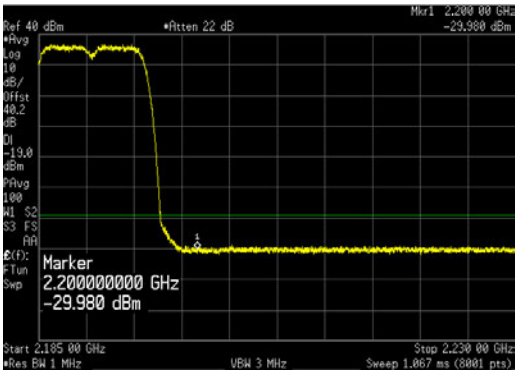
Upper Band Edge_2185 to 2230MHz_QPSK



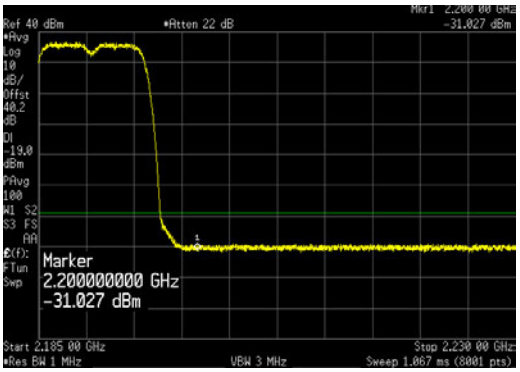
Upper Band Edge_2185 to 2230MHz _16QAM



Upper Band Edge_2185 to 2230MHz _64QAM



Upper Band Edge_2185 to 2230MHz _256QAM



AWS-4 Band Out of Band Emission Requirement (2200MHz to 2290MHz)

Measurements are made at the external notch filter (Filtronics P/N: US-PSD015-F1V1) output port using RRH antenna port 2. The RRH was operated at the upper band edge frequencies with all modulation types (QPSK, 16QAM, 64QAM, and 256QAM) for 5MHz, 10MHz, 15MHz and 20MHz LTE bandwidths.

The EIRP limit (-100.6dBW/4kHz) is reduced by 10Log(4) per FCC KDB 662911D01 v02r01 due to four port MIMO transmitter operation. The limit at the output of the external notch filter is determined as follows:

-100.6dBW/4kHz (EIRP Limit) + 30dB (dBW to dBm conversion) + 24dB (BW conversion: 10Log[1MHz/4kHz]) - 6dB (4 Port MIMO: 10Log[4]) – 17dBi (Nokia assumed BTS Antenna Gain) = -69.6dBm/1MHz

Measurements are performed with the spectrum analyzer in the RMS average mode over 100 traces. In the 1MHz band outside and adjacent to the frequency block, a resolution bandwidth of 1% of the emission bandwidth was used. In the 1 to 2MHz frequency range outside the upper band edge (i.e.: 2201 to 2202MHz bands) the RBW was again reduced to 1% of the emission bandwidth and the power integrated over 1MHz. In the 2 to 90MHz frequency range outside the upper band edge (i.e.: 2202 to 2290MHz bands) a 1MHz RBW and 3MHz VBW was used.

The results are summarized in the following table. The worst case emissions from the measurement data are provided (highest measurement is highlighted).

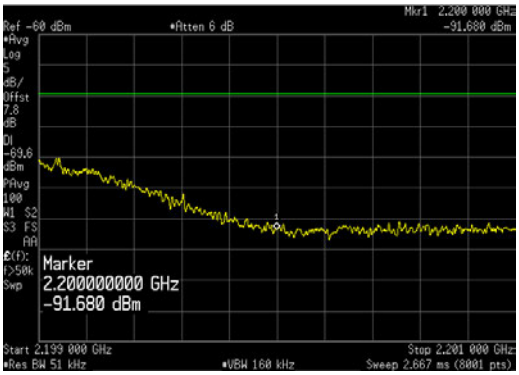
LTE Bandwidth	Carrier Frequency at Top Channel	2200 to 2290MHz Range - Maximum Conducted Emission (dBm)			
		LTE - QPSK	LTE – 16QAM	LTE - 64QAM	LTE - 256QAM
5M	2192.5MHz	-79.889	-80.266	-80.141	-79.802
10M	2190.0MHz	-79.913	-79.880	-79.948	-79.955
15M	2187.5MHz	-80.18	-80.23	-80.22	-80.21
20M	2185.0MHz	-80.01	-80.04	-79.99	-80.02
Dual 5M	2192.5MHz and 2187.5MHz	**-79.480**	-79.661	-79.647	-79.722

The total measurement RF path loss of the test setup (Creowave carrier blocking filter and test cables) was accounted for by the spectrum analyzer reference level offset. The RF path loss was 7.8dB for the 2200 to 2201 MHz range, 6.0dB for the 2201 to 2202MHz range and 5.0dB for the 2202 to 2290MHz range. The display line on the plots reflects the required limit.

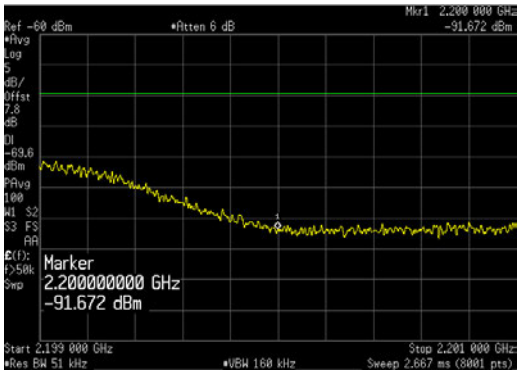
Conducted AWS-4 Out of Band emission measurements are provided in the following pages.

AWS-4 Out of Band Conducted Emissions using LTE5 Top Channel Carrier for external Notch Filter Output:

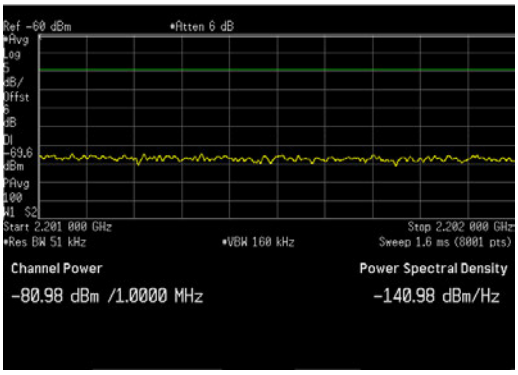
LTE5_QPSK_AWS-4 OBE_2199 to 2201MHz



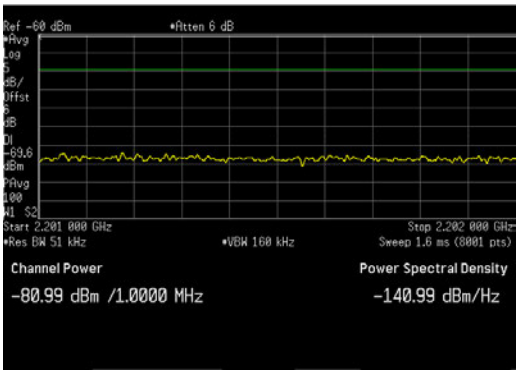
LTE5_16QAM_AWS-4 OBE_2199 to 2201MHz



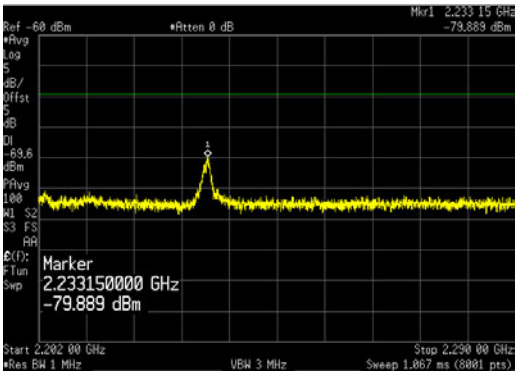
LTE5_QPSK_AWS-4 OBE_2201 to 2202MHz



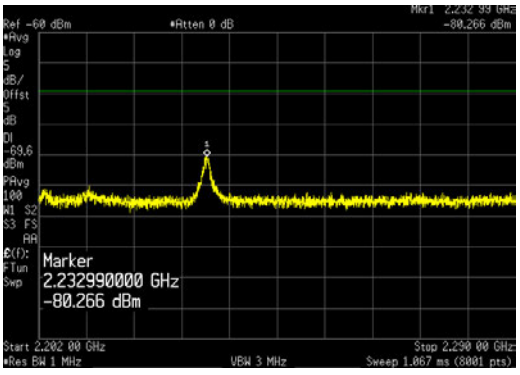
LTE5_16QAM_AWS-4 OBE_2201 to 2202MHz



LTE5_QPSK_AWS-4 OBE_2202 to 2290MHz

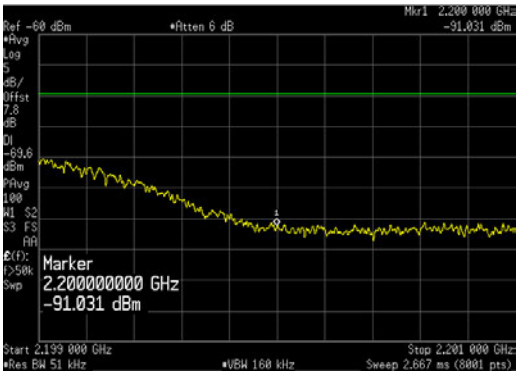


LTE5_16QAM_AWS-4 OBE_2202 to 2290MHz

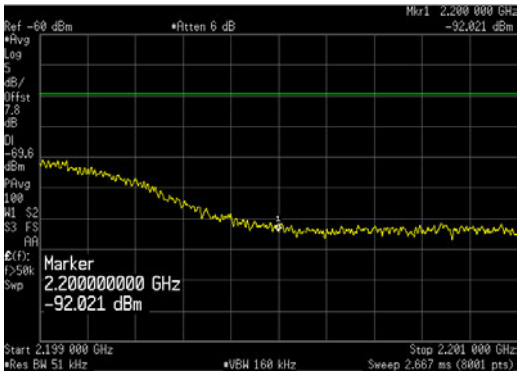


AWS-4 Out of Band Conducted Emissions using LTE5 Top Channel Carrier for external Notch Filter Output:

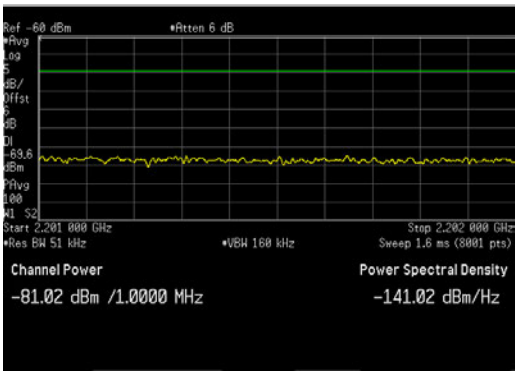
LTE5_64QAM_AWS-4 OBE_2199 to 2201MHz



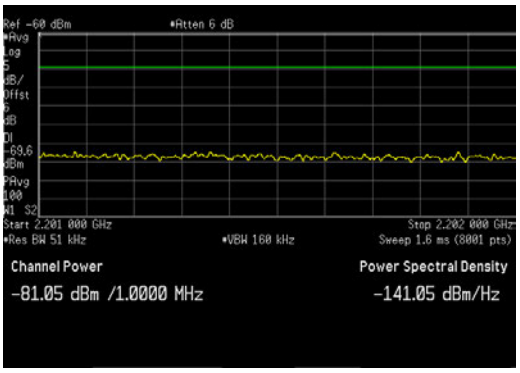
LTE5_256QAM_AWS-4 OBE_2199 to 2201MHz



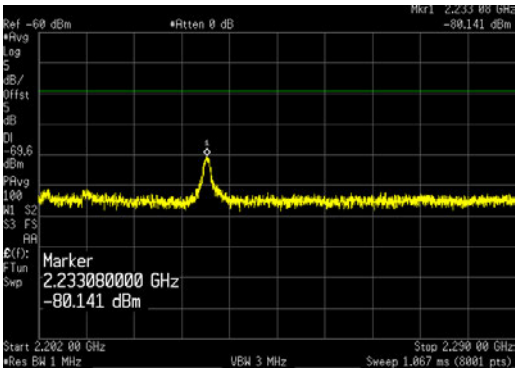
LTE5_64QAM_AWS-4 OBE_2201 to 2202MHz



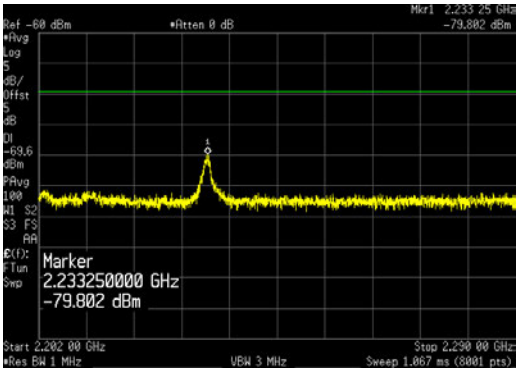
LTE5_256QAM_AWS-4 OBE_2201 to 2202MHz



LTE5_64QAM_AWS-4 OBE_2202 to 2290MHz

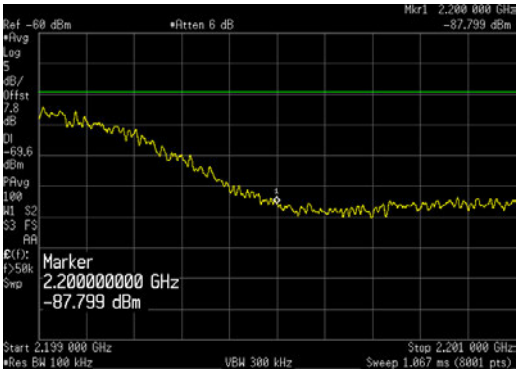


LTE5_256QAM_AWS-4 OBE_2202 to 2290MHz

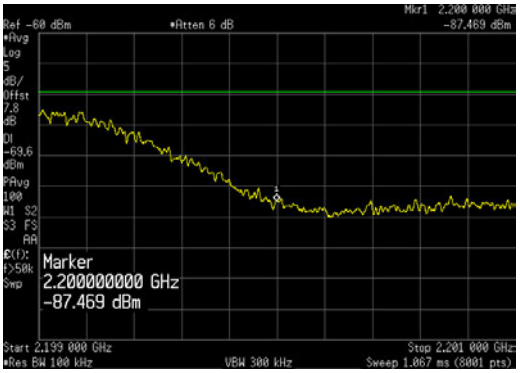


AWS-4 Out of Band Conducted Emissions using LTE10 Top Channel Carrier for external Notch Filter Output:

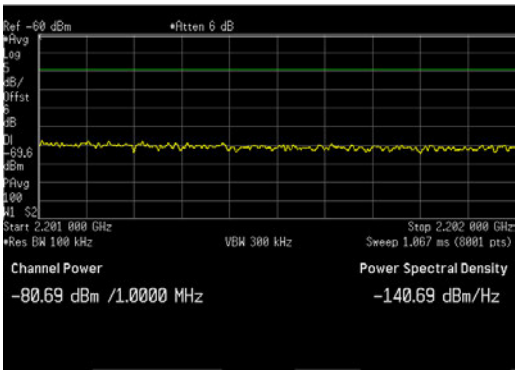
LTE10_QPSK_AWS-4 OBE_2199 to 2201MHz



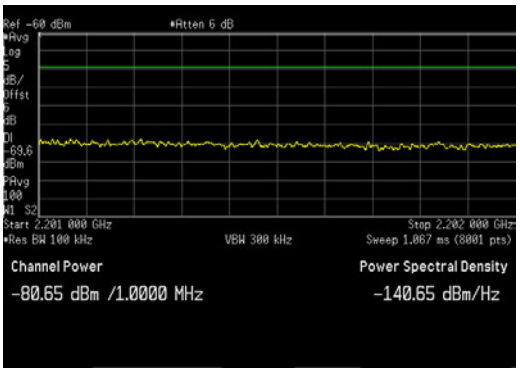
LTE10_16QAM_AWS-4 OBE_2199 to 2201MHz



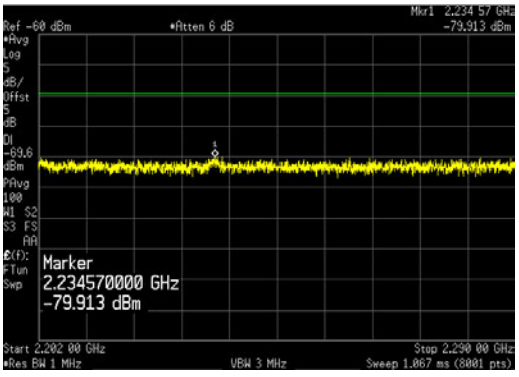
LTE10_QPSK_AWS-4 OBE_2201 to 2202MHz



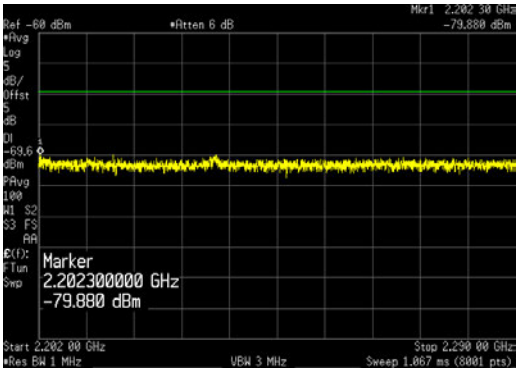
LTE10_16QAM_AWS-4 OBE_2201 to 2202MHz



LTE10_QPSK_AWS-4 OBE_2202 to 2290MHz

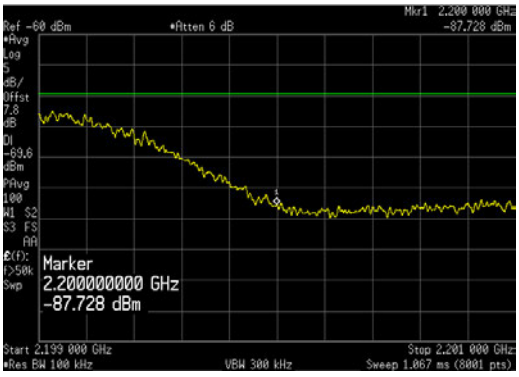


LTE10_16QAM_AWS-4 OBE_2202 to 2290MHz

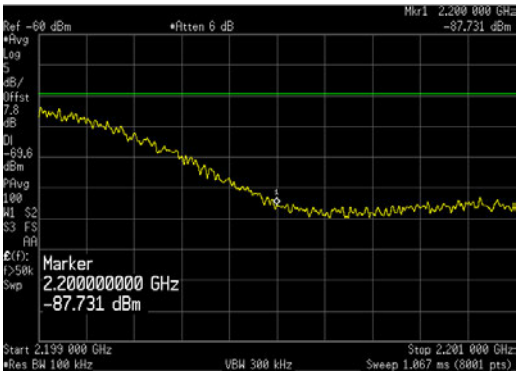


AWS-4 Out of Band Conducted Emissions using LTE10 Top Channel Carrier for external Notch Filter Output:

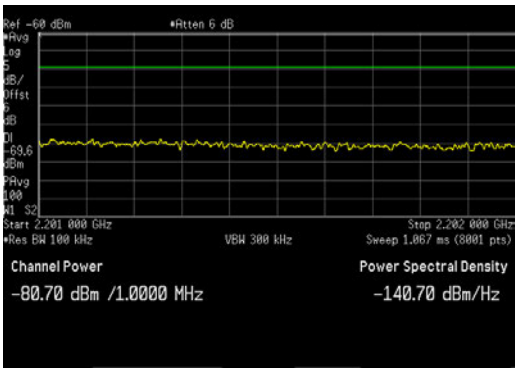
LTE10_64QAM_AWS-4 OBE_2199 to 2201MHz



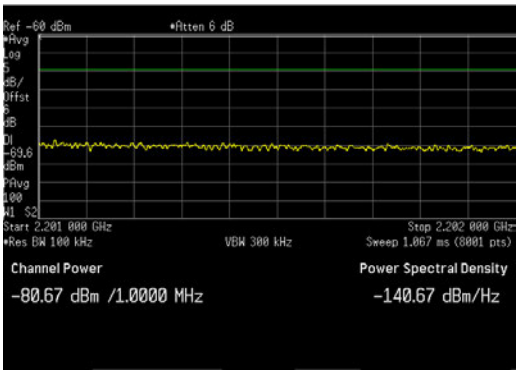
LTE10_256QAM_AWS-4 OBE_2199 to 2201MHz



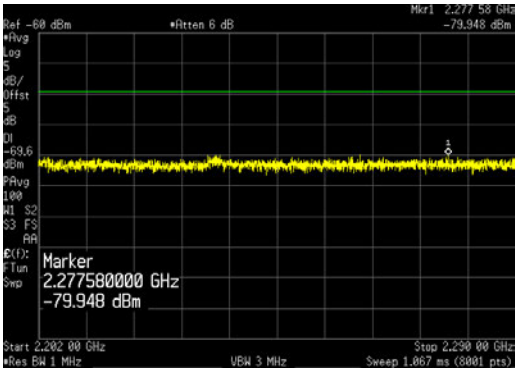
LTE10_64QAM_AWS-4 OBE_2201 to 2202MHz



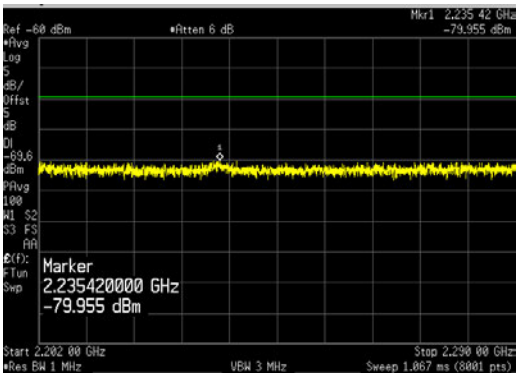
LTE10_256QAM_AWS-4 OBE_2201 to 2202MHz



LTE10_64QAM_AWS-4 OBE_2202 to 2290MHz

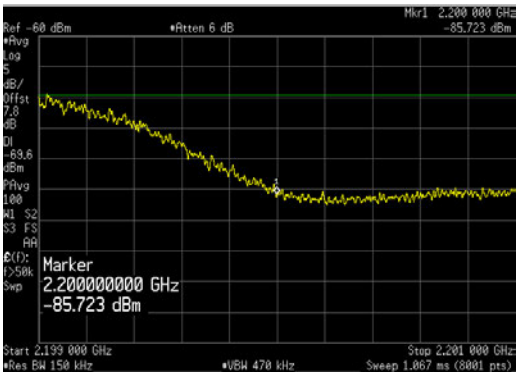


LTE10_256QAM_AWS-4 OBE_2202 to 2290MHz

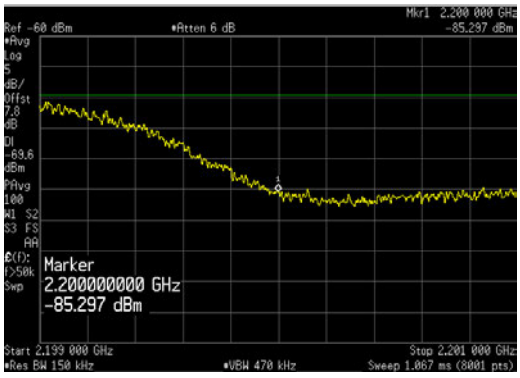


AWS-4 Out of Band Conducted Emissions using LTE15 Top Channel Carrier for external Notch Filter Output:

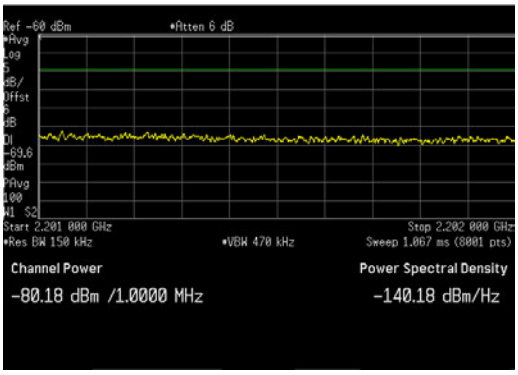
LTE15_QPSK_AWS-4 OBE_2199 to 2201MHz



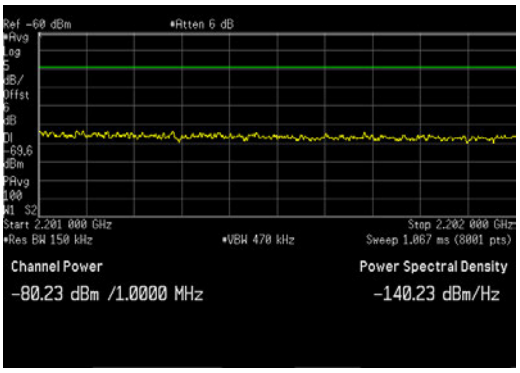
LTE15_16QAM_AWS-4 OBE_2199 to 2201MHz



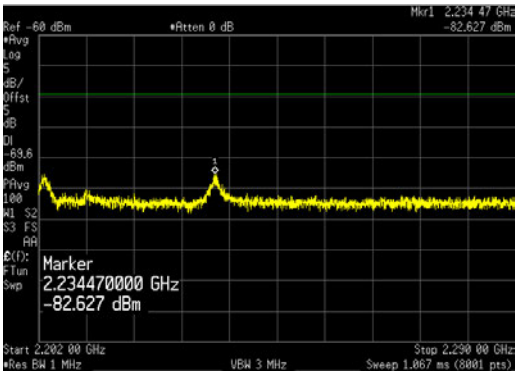
LTE15_QPSK_AWS-4 OBE_2201 to 2202MHz



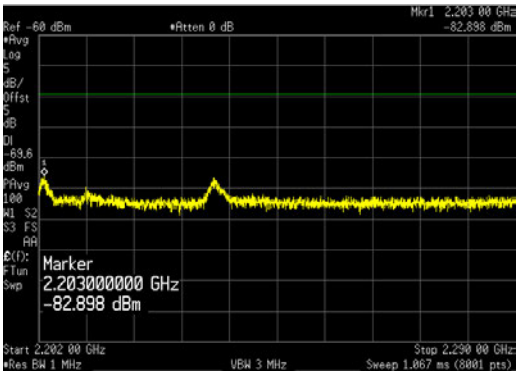
LTE15_16QAM_AWS-4 OBE_2201 to 2202MHz



LTE15_QPSK_AWS-4 OBE_2202 to 2290MHz

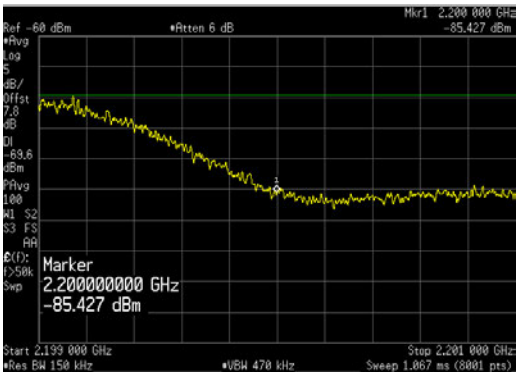


LTE15_16QAM_AWS-4 OBE_2202 to 2290MHz

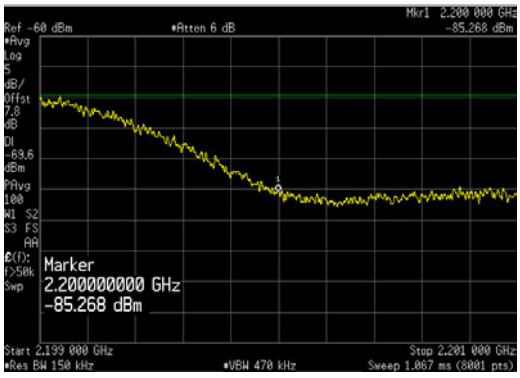


AWS-4 Out of Band Conducted Emissions using LTE15 Top Channel Carrier for external Notch Filter Output:

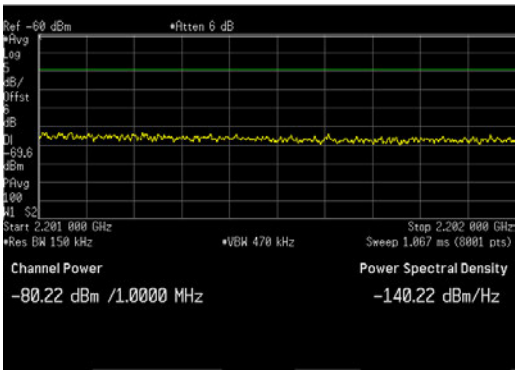
LTE15_64QAM_AWS-4 OBE_2199 to 2201MHz



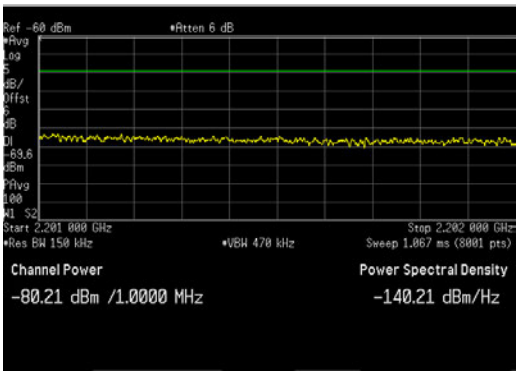
LTE15_256QAM_AWS-4 OBE_2199 to 2201MHz



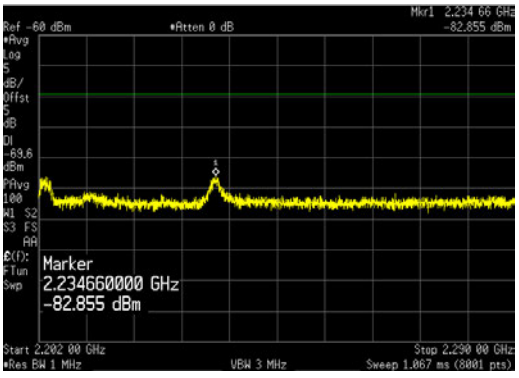
LTE15_64QAM_AWS-4 OBE_2201 to 2202MHz



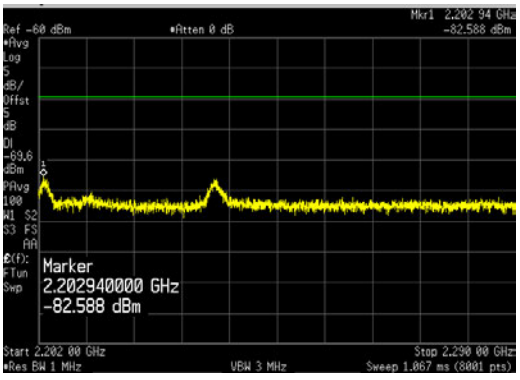
LTE15_256QAM_AWS-4 OBE_2201 to 2202MHz



LTE15_64QAM_AWS-4 OBE_2202 to 2290MHz

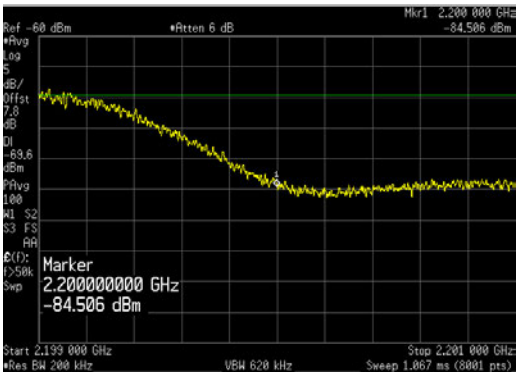


LTE15_256QAM_AWS-4 OBE_2202 to 2290MHz

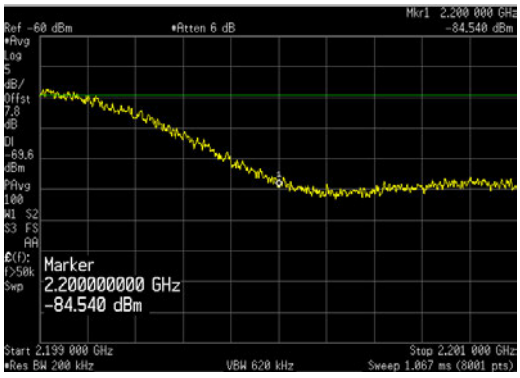


AWS-4 Out of Band Conducted Emissions using LTE20 Top Channel Carrier for external Notch Filter Output:

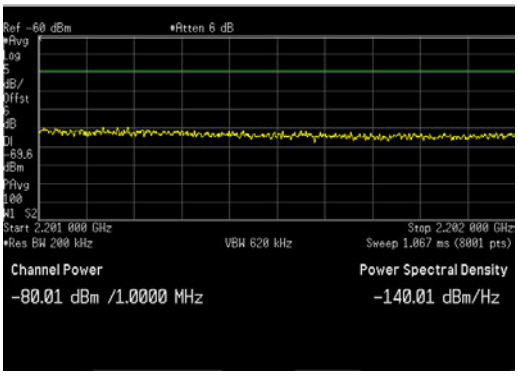
LTE20_QPSK_AWS-4 OBE_2199 to 2201MHz



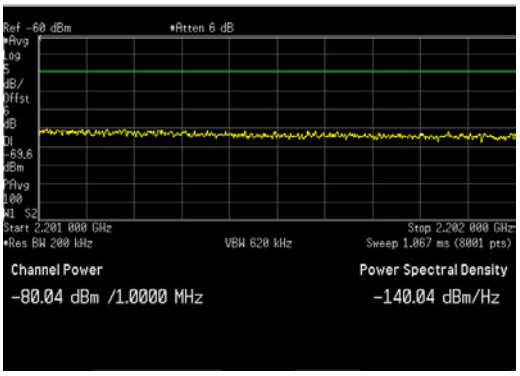
LTE20_16QAM_AWS-4 OBE_2199 to 2201MHz



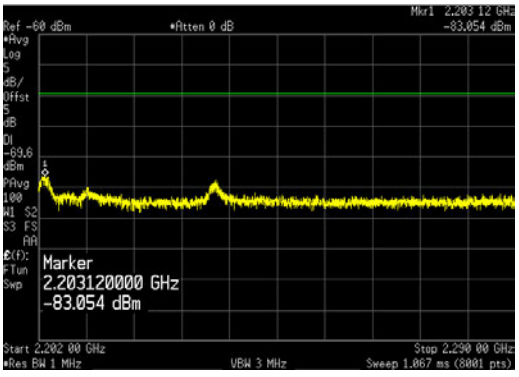
LTE20_QPSK_AWS-4 OBE_2201 to 2202MHz



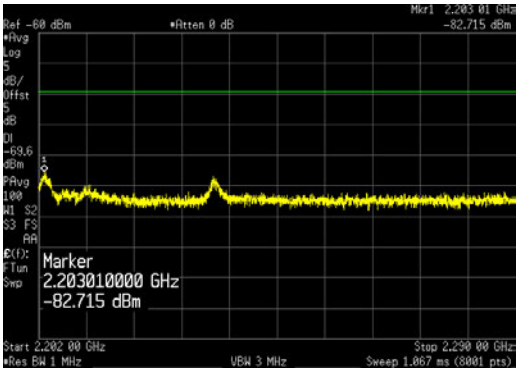
LTE20_16QAM_AWS-4 OBE_2201 to 2202MHz



LTE20_QPSK_AWS-4 OBE_2202 to 2290MHz

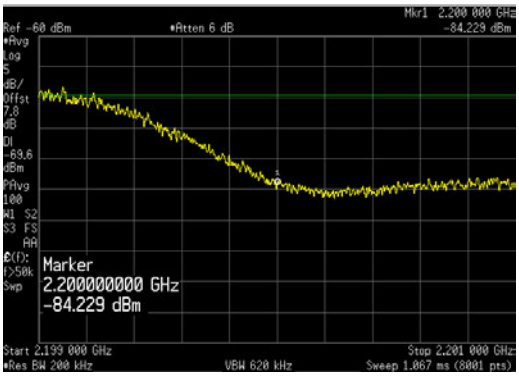


LTE20_16QAM_AWS-4 OBE_2202 to 2290MHz

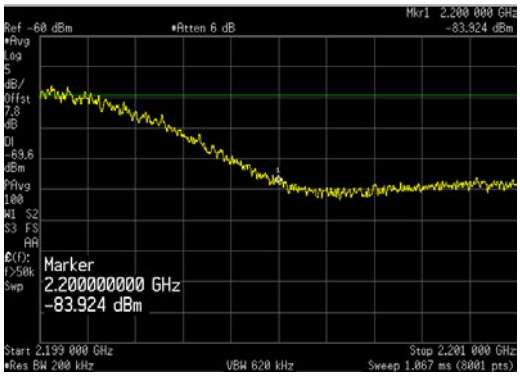


AWS-4 Out of Band Conducted Emissions using LTE20 Top Channel Carrier for external Notch Filter Output:

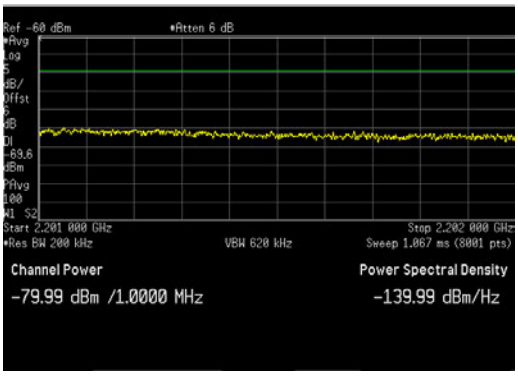
LTE20_64QAM_AWS-4 OBE_2199 to 2201MHz



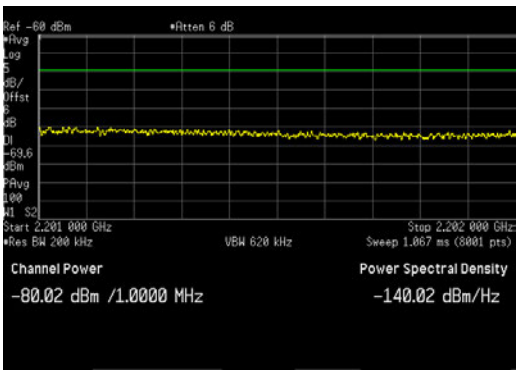
LTE20_256QAM_AWS-4 OBE_2199 to 2201MHz



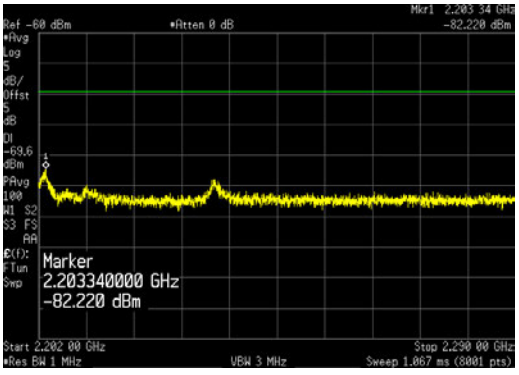
LTE20_64QAM_AWS-4 OBE_2201 to 2202MHz



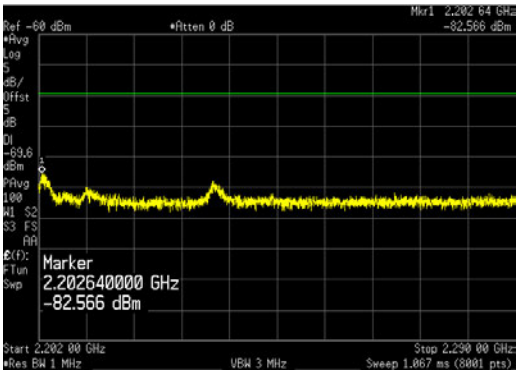
LTE20_256QAM_AWS-4 OBE_2201 to 2202MHz



LTE20_64QAM_AWS-4 OBE_2202 to 2290MHz

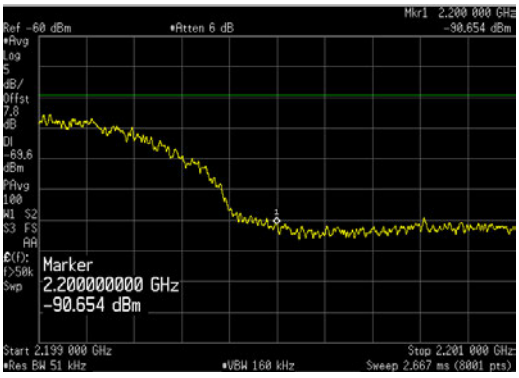


LTE20_256QAM_AWS-4 OBE_2202 to 2290MHz

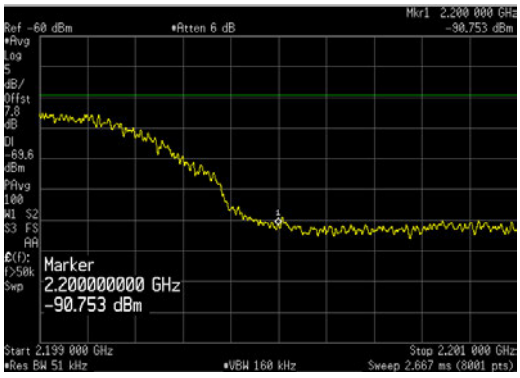


AWS-4 Out of Band Conducted Emissions using Dual LTE5 Top Channel Carriers for external Notch Filter Output:

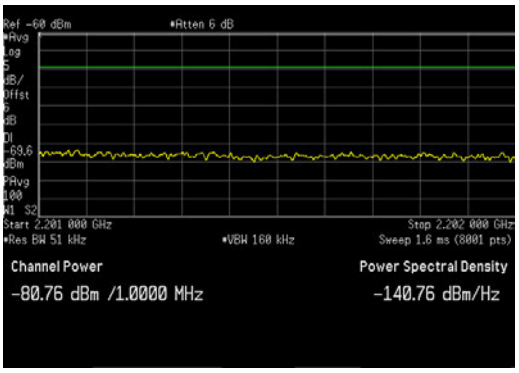
Dual LTE5_QPSK_AWS-4 OBE_2199 to 2201MHz



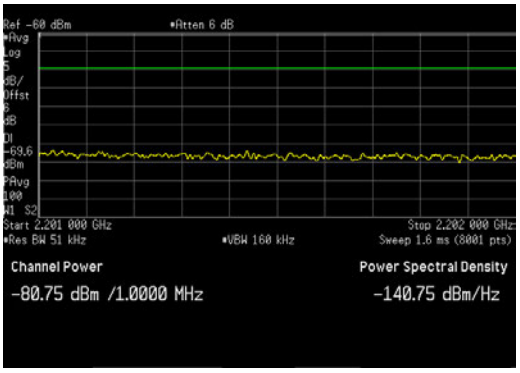
Dual LTE5_16QAM_AWS-4 OBE_2199 to 2201MHz



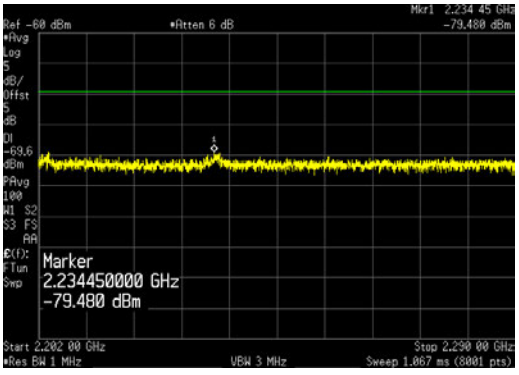
Dual LTE5_QPSK_AWS-4 OBE_2201 to 2202MHz



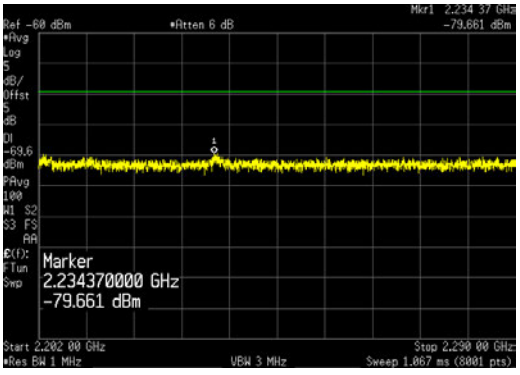
Dual LTE5_16QAM_AWS-4 OBE_2201 to 2202MHz



Dual LTE5_QPSK_AWS-4 OBE_2202 to 2290MHz

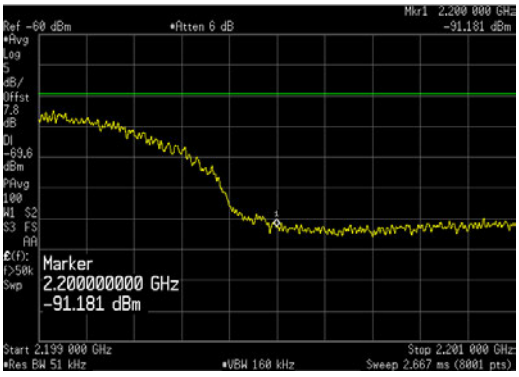


Dual LTE5_16QAM_AWS-4 OBE_2202 to 2290MHz

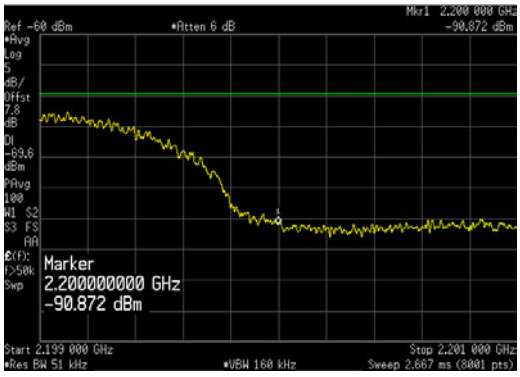


AWS-4 Out of Band Conducted Emissions using Dual LTE5 Top Channel Carriers for external Notch Filter Output:

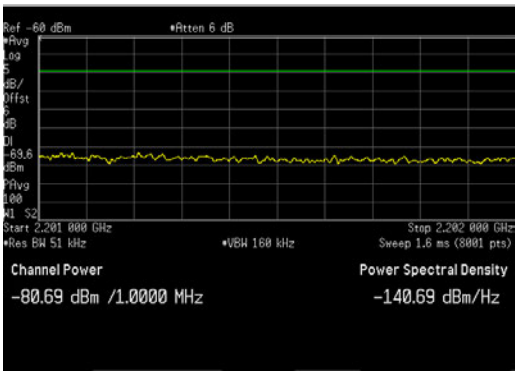
Dual LTE5_64QAM_AWS-4 OBE_2199 to 2201MHz



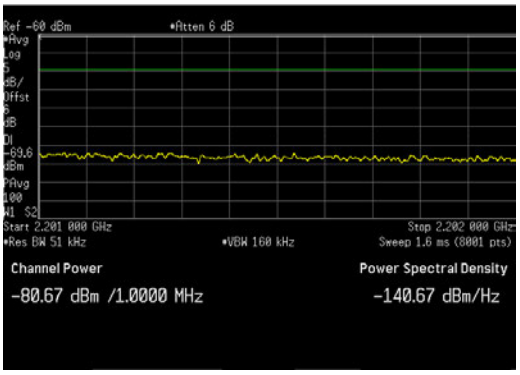
Dual LTE5_256QAM_AWS-4 OBE_2199 to 2201MHz



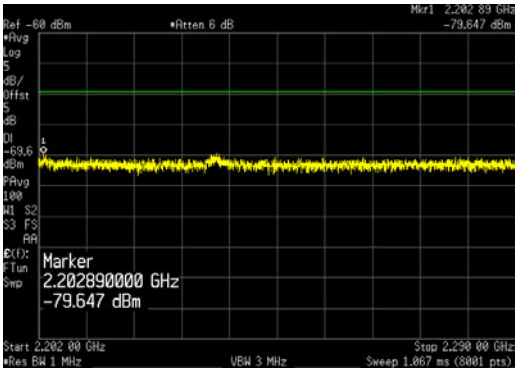
Dual LTE5_64QAM_AWS-4 OBE_2201 to 2202MHz



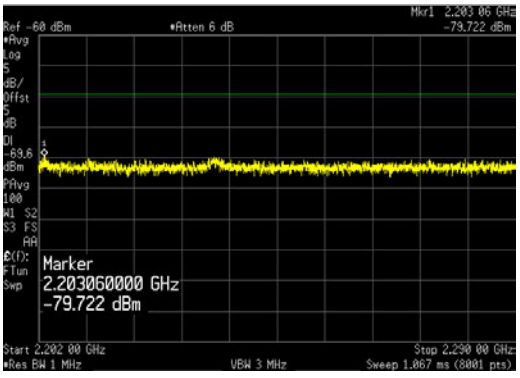
Dual LTE5_256QAM_AWS-4 OBE_2201 to 2202MHz



Dual LTE5_64QAM_AWS-4 OBE_2202 to 2290MHz



Dual LTE5_256QAM_AWS-4 OBE_2202 to 2290MHz



Transmitter Antenna Port Conducted Emissions

Transmitter conducted emission measurements were made at the external notch filter (Filtronics P/N: US-PSD015-F1V1) output port using RRH antenna port 2. Measurements were performed over the 9kHz to 22GHz frequency range. The RRH was operated on the PCS middle channel (1962.5MHz) and AWS middle channel (2155.0MHz) simultaneously with all LTE modulation types (QPSK, 16QAM, 64QAM and 256QAM) for LTE bandwidths of 5MHz, 10MHz, 15MHz and 20MHz.

The limit of -19dBm was used in the certification testing. The limit is adjusted to -19dBm [-13dBm -10 log (4)] per FCC KDB 662911D01 v02r01 because the BTS may operate as a 4 port MIMO transmitter. The required measurement parameters include a 1MHz bandwidth with power measured in average value (since transmitter power was measured in average value).

Measurements were performed with a spectrum analyzer using a peak detector with max hold over 50 sweeps (except for the 20MHz to 3GHz frequency range). Measurements for the 20MHz to 3GHz frequency range were performed with the spectrum analyzer in the RMS average mode over 100 traces.

The limit for the 9kHz to 150kHz frequency range was adjusted to –49dBm to correct for a spectrum analyzer RBW of 1kHz versus required RBW of 1MHz [i.e.: -49dBm = -19dBm -10log(1MHz/1kHz)]. The limit for the 150kHz to 20MHz frequency range was adjusted to –29dBm to correct for a spectrum analyzer RBW of 100kHz versus required RBW of 1MHz [i.e.: -29dBm = -19dBm -10log(1MHz/100kHz)]. The required limit of -19dBm with a RBW of 1MHz was used for all other frequency ranges.

The spectrum analyzer settings that were used for this test are summarized in the following table.

Frequency Range	RBW	VBW	Number of Data Points	Detector	Sweep Time	Max Hold over	Offset Note (1)
9kHz to 150kHz	1kHz	3kHz	8001	Peak	Auto	50 Sweeps	28.0dB
150kHz to 20MHz	100kHz	300kHz	8001	Peak	Auto	50 Sweeps	28.0dB
20MHz to 3GHz	1MHz	3MHz	8001	Average	Auto	Note (2)	40.2dB
3GHz to 6GHz	1MHz	3MHz	8001	Peak	Auto	50 Sweeps	40.0dB
6GHz to 10GHz	1MHz	3MHz	8001	Peak	Auto	50 Sweeps	30.6dB
10GHz to 14GHz	1MHz	3MHz	8001	Peak	Auto	50 Sweeps	32.5dB
14GHz to 18GHz	1MHz	3MHz	8001	Peak	Auto	50 Sweeps	34.0dB
18GHz to 22GHz	1MHz	3MHz	8001	Peak	Auto	50 Sweeps	39.5dB

Note 1: The total measurement RF path loss of the test setup (attenuators, test cables and filters) is accounted for by the spectrum analyzer reference level offset.
Note 2: Max Hold not used and instead measurements were performed with the spectrum analyzer in the RMS average mode over 100 traces.

A low pass filter was used to reduce measurement instrumentation noise floor for the frequency ranges less than 20MHz. A high pass filter was used to reduce measurement instrumentation noise floor for the frequency ranges above 6GHz. The total measurement RF path loss of the test setup (attenuators, low pass filter, high pass filter and test cables) as shown in the table is accounted for by the spectrum analyzer reference level offset. The display line on the plots reflects the required limit.
Conducted spurious emission plots/measurements are provided in the following pages.