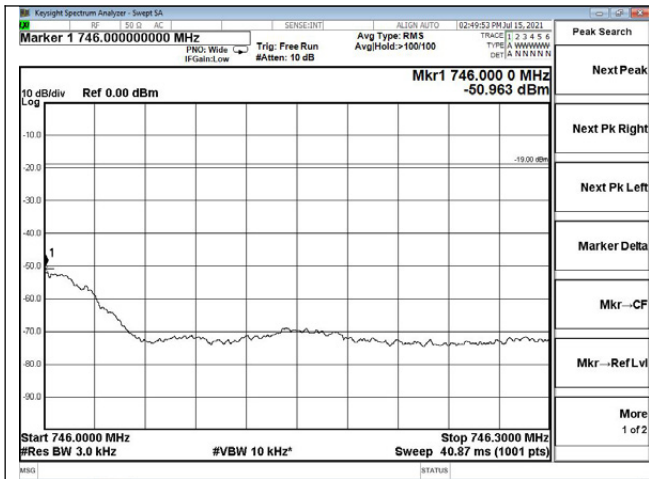
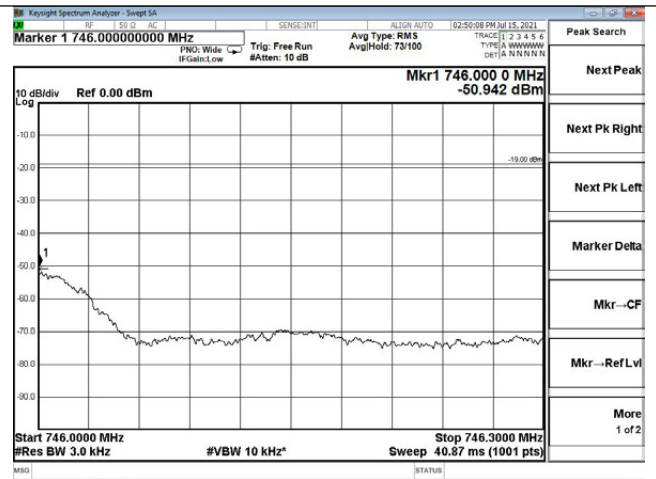
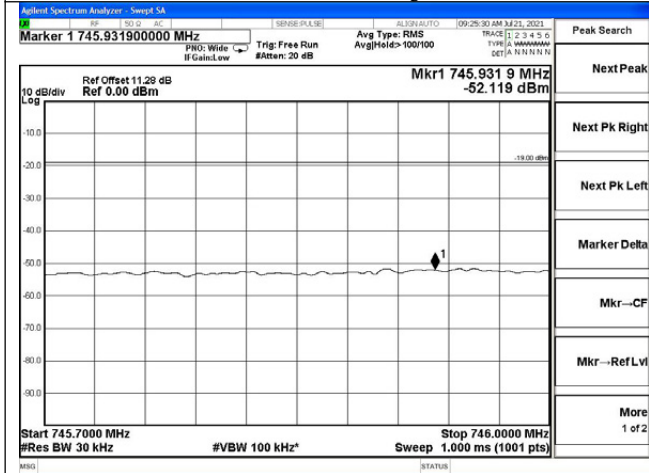




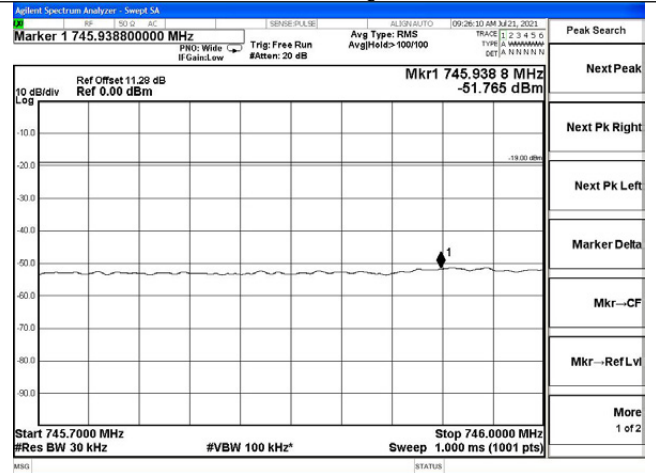
Lower 700MHz band CDMA DL Right Side Pre AGC



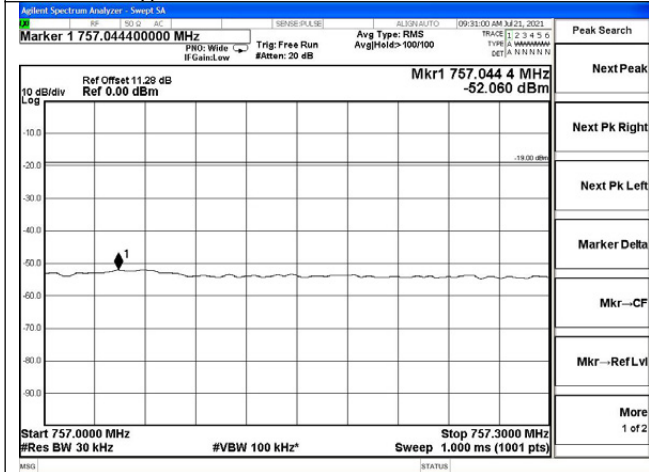
Lower 700MHz band CDMA DL Right Side 10dB Above AGC



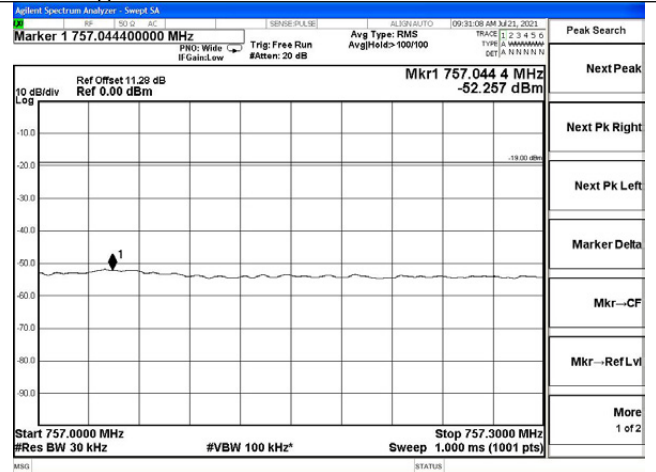
Upper 700MHz band CDMA DL Left Side Pre AGC



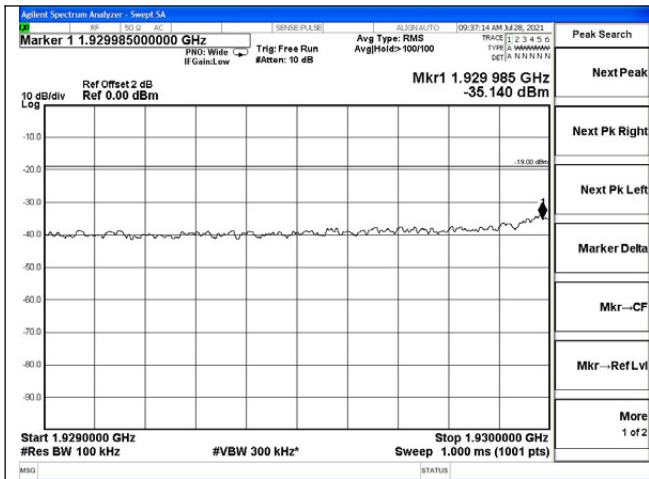
Upper 700MHz band CDMA DL Left Side 10dB Above AGC



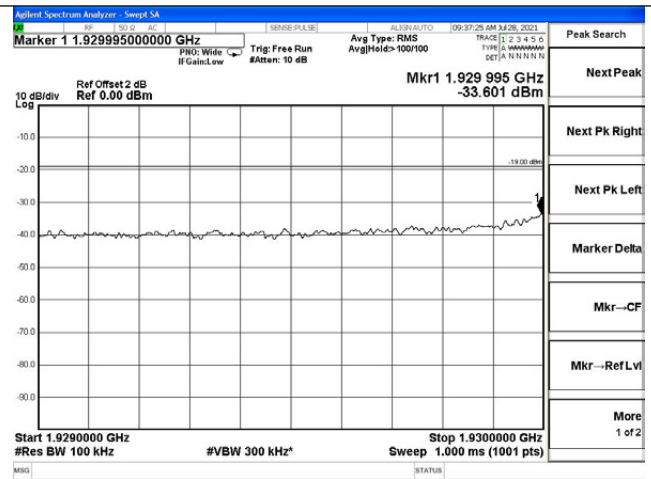
Upper 700MHz band CDMA DL Right Side Pre AGC



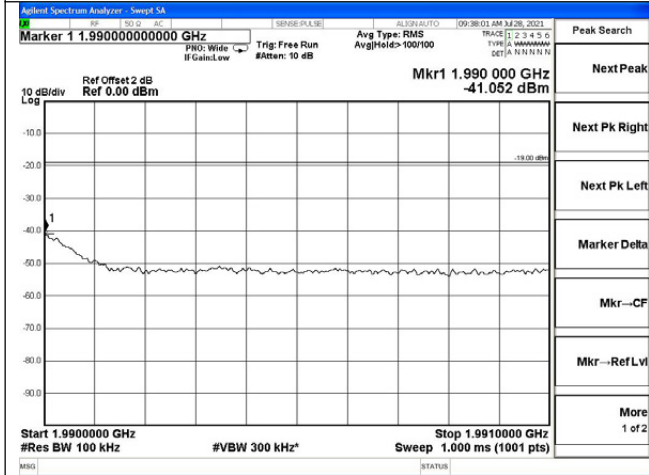
Upper 700MHz band CDMA DL Right Side 10dB Above AGC



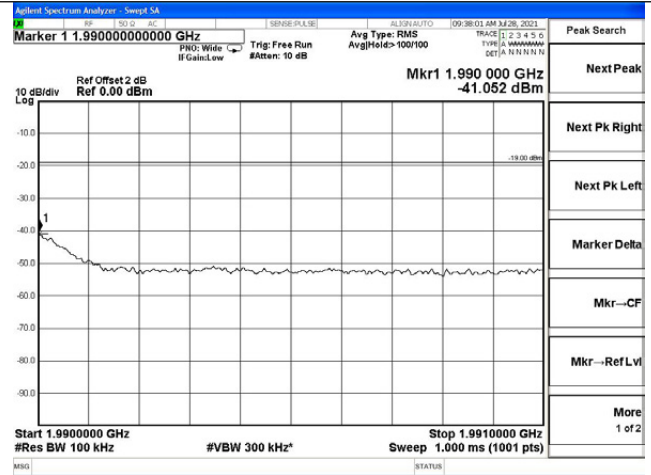
PCS Band LTE DL Left Side Pre AGC



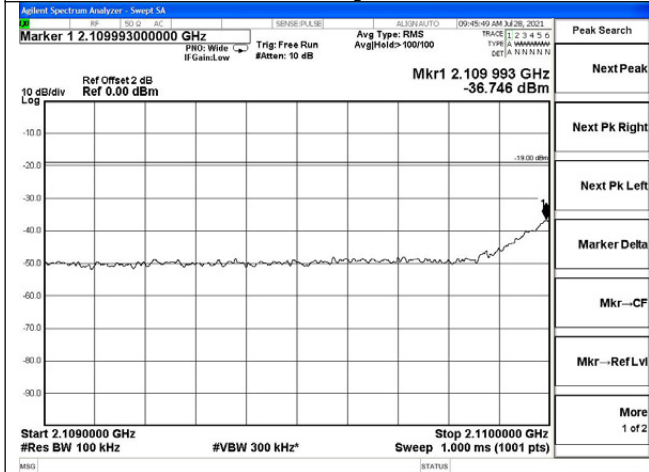
PCS Band LTE DL Left Side 10dB Above AGC



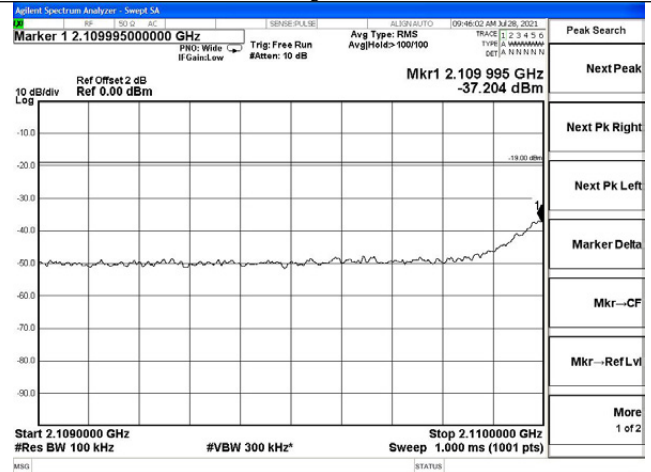
PCS Band LTE DL Right Side Pre AGC



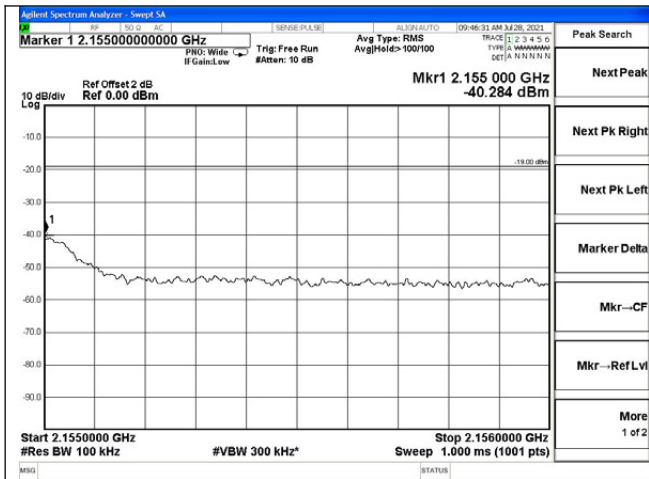
PCS Band LTE DL Right Side 10dB Above AGC



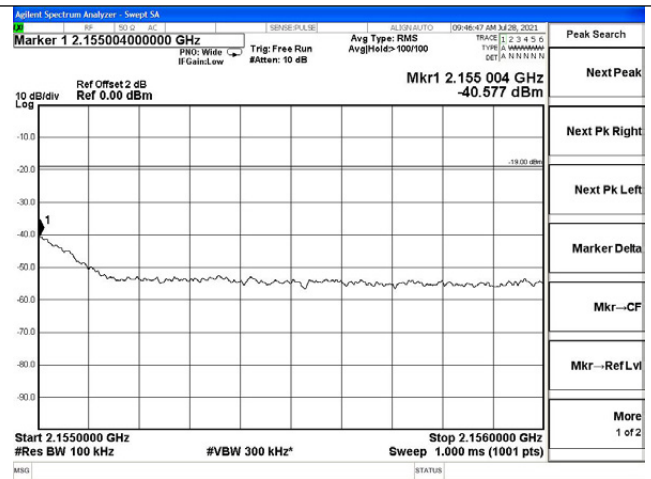
AWS Band LTE DL Left Side Pre AGC



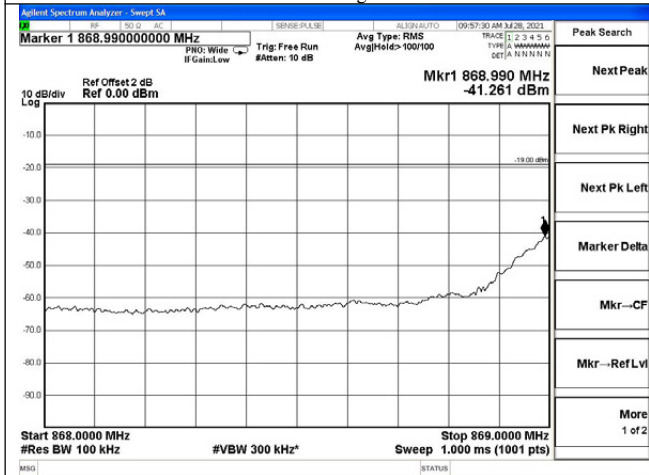
AWS Band LTE DL Left Side 10dB Above AGC



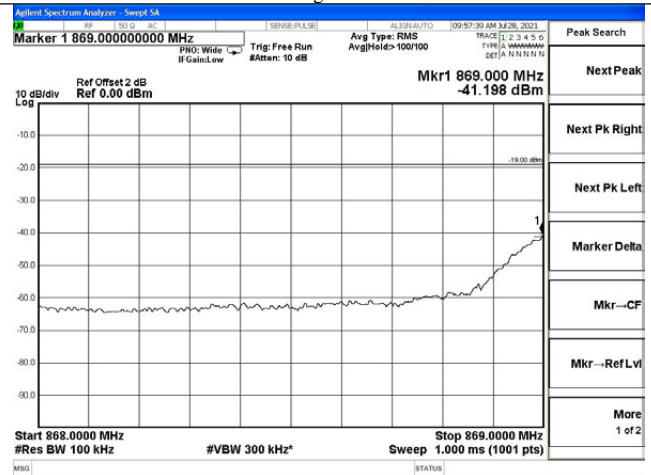
AWS Band LTE DL Right Side Pre AGC



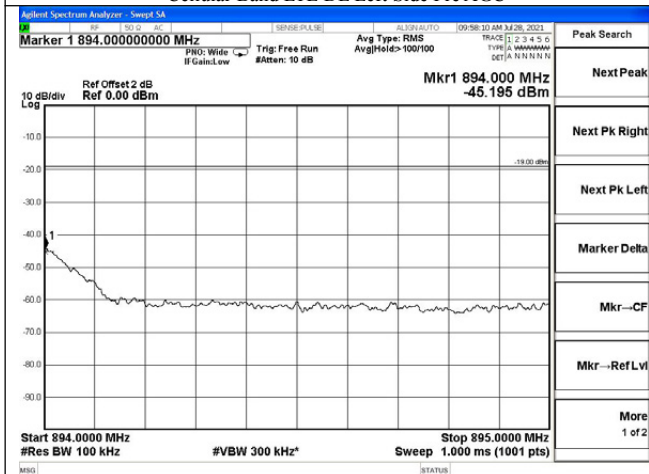
AWS Band LTE DL Right Side 10dB Above AGC



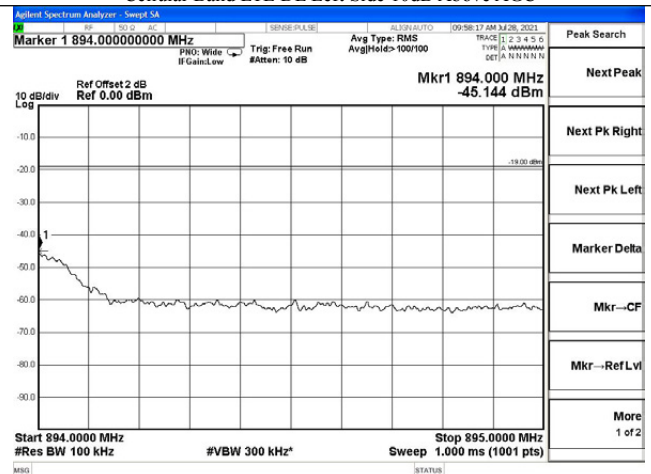
Cellular Band LTE DL Left Side Pre AGC



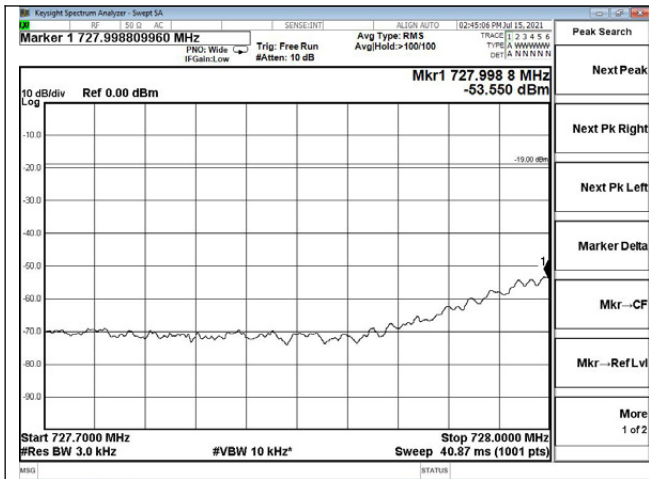
Cellular Band LTE DL Left Side 10dB Above AGC



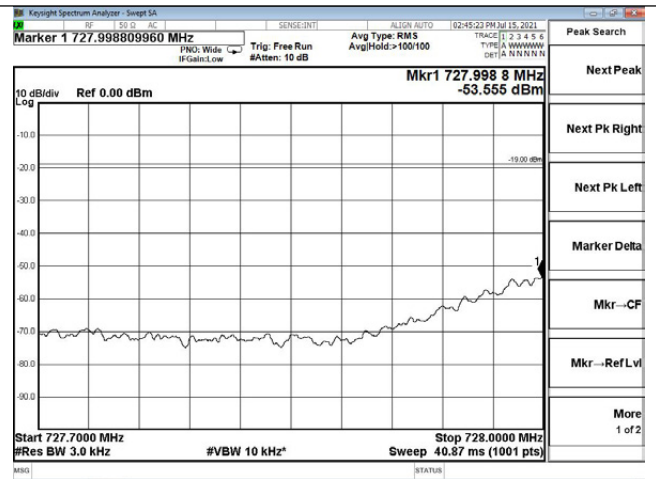
Cellular Band LTE DL Right Side Pre AGC



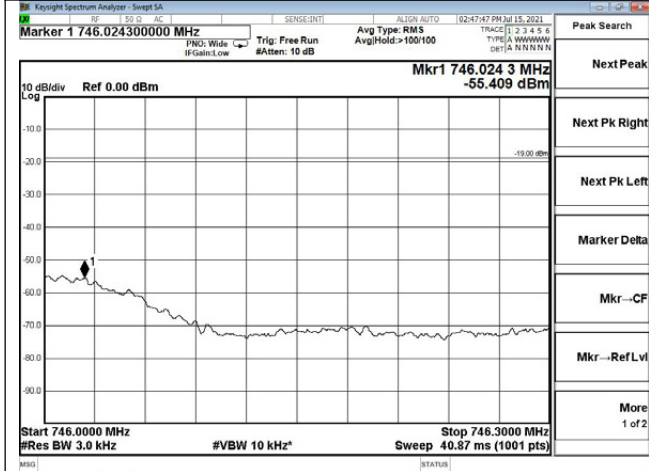
Cellular Band LTE DL Right Side 10dB Above AGC



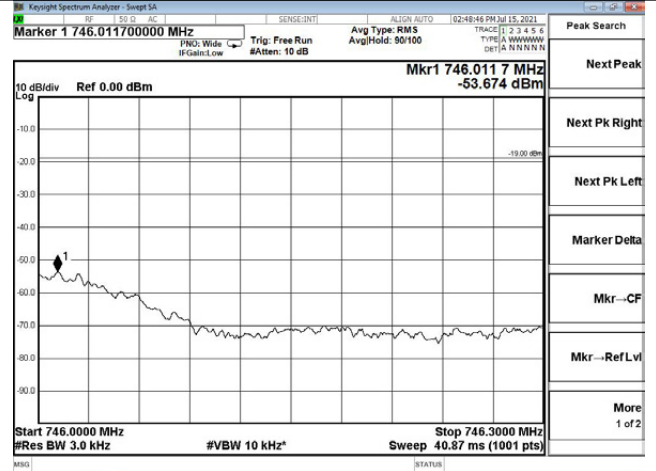
Lower 700MHz band LTE DL Left Side Pre AGC



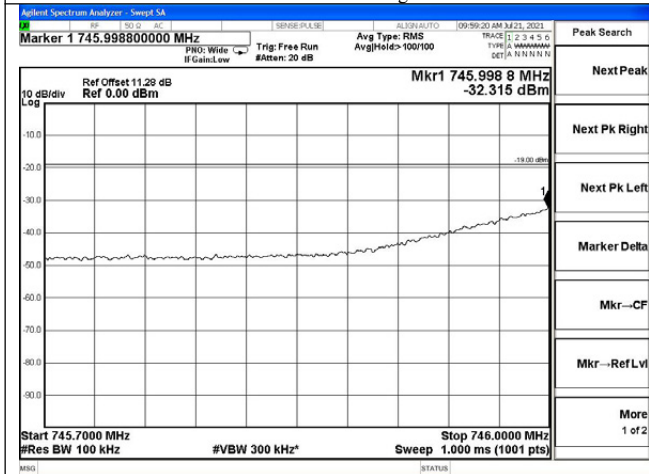
Lower 700MHz band LTE DL Left Side 10dB Above AGC



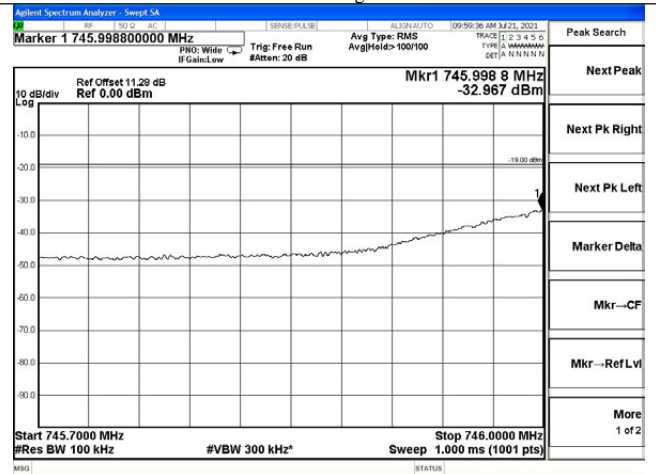
Lower 700MHz band LTE DL Right Side Pre AGC



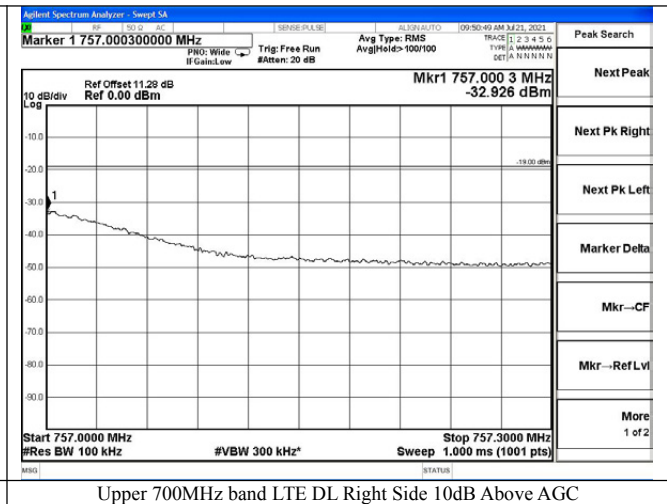
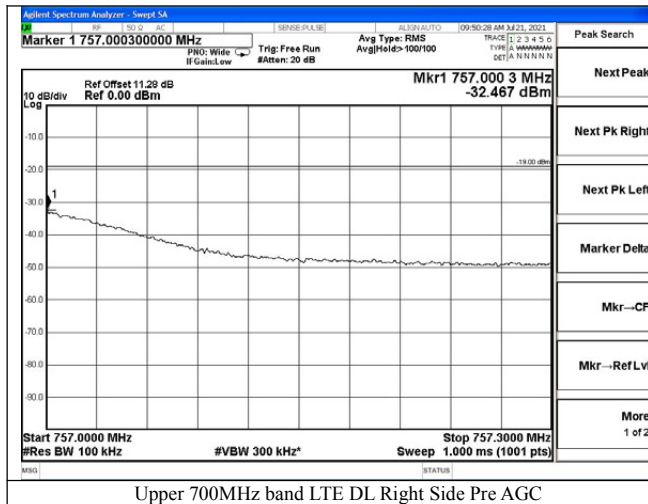
Lower 700MHz band LTE DL Right Side 10dB Above AGC



Upper 700MHz band LTE DL Left Side Pre AGC



Upper 700MHz band LTE DL Left Side 10dB Above AGC



6.6. Conducted Spurious Emission

Applicable Standard

According to § 2.1051 Spurious emissions at antenna terminals.

Test Procedure

The following procedures shall be used to demonstrate compliance to the applicable conducted spurious emissions limits as per Section 2.1051.

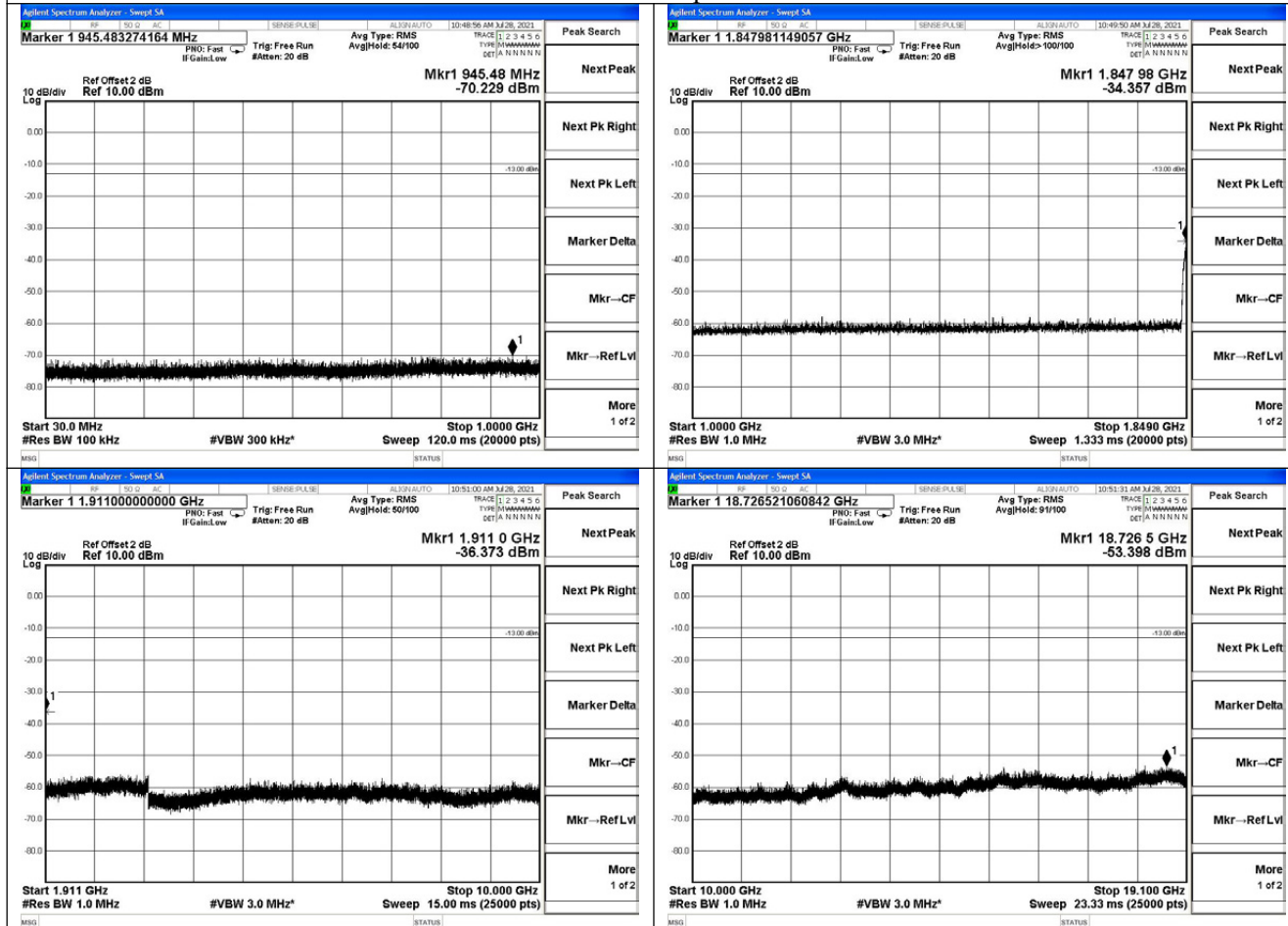
NOTE—For frequencies below 1 GHz, an RBW of 1 MHz may be used in a preliminary measurement. If non-compliant emissions are detected, a final measurement shall be made with a 100 kHz RBW. Additionally, a peak detector may also be used for the preliminary measurement. If non-compliant emissions are detected then a final measurement of these emissions shall be made with the power averaging (rms) detector.

- a) Connect the EUT to the test equipment as shown in Figure 1. Begin with the uplink output (donor) port connected to the spectrum analyzer.
- b) Configure the signal generator for AWGN with a 99% OBW of 4.1 MHz, with a center frequency corresponding to the center of the CMRS band under test.
- c) Set the signal generator amplitude to the level determined in the power measurement procedure in 7.2.
- d) Turn on the signal generator RF output and measure the spurious emission power levels with an appropriate measuring instrument as follows.
 - 1) Set RBW = measurement bandwidth specified in the applicable rule section for the operational frequency band under consideration (see Appendix A for relevant cross-references). Note that many of the individual rule sections permit the use of a narrower RBW [typically $\geq 1\%$ of the emission bandwidth (EBW)] to enhance measurement accuracy, but the result must then be integrated over the specified measurement bandwidth.
 - 2) Set VBW = 3 RBW.
 - 3) Select the power averaging (rms) detector. (See above note regarding the use of a peak detector for preliminary measurements.)
 - 4) Sweep time = auto-couple.
 - 5) Set the analyzer start frequency to the lowest radio frequency signal generated in the equipment, without going below 9 kHz, and the stop frequency to the lower band/block edge frequency minus 100 kHz or 1 MHz, as specified in the applicable rule part. Note that the number of measurement points in each sweep must be $\geq (2 \times \text{span/RBW})$, which may require that the measurement range defined by the preceding start and stop frequencies be subdivided, depending on the available number of measurement points of the spectrum analyzer. Trace average at least 10 traces in power averaging (i.e., rms) mode.
 - 6) Sweep time = auto-couple.
 - 7) Use the peak marker function to identify the highest amplitude level over each measured frequency range. Record the frequency and amplitude and capture a plot for inclusion in the test report.
 - 8) Reset the analyzer start frequency to the upper band/block edge frequency plus 100 kHz or 1 MHz, as specified in the applicable rule part, and the analyzer stop frequency to 10 times the highest frequency of the fundamental emission. Note that the number of measurement points in each sweep must be $\geq (2 \times \text{span/RBW})$ which may require that the measurement range defined by the start and stop frequencies above be subdivided, depending on the available number of measurement points provided by the spectrum analyzer.
 - 9) Use the peak marker function to identify the highest amplitude level over each of the measured frequency ranges. Record the frequency and amplitude and capture a plot for inclusion in the test report.
- e) Repeat 7.6b) through 7.6d) for each supported frequency band of operation.

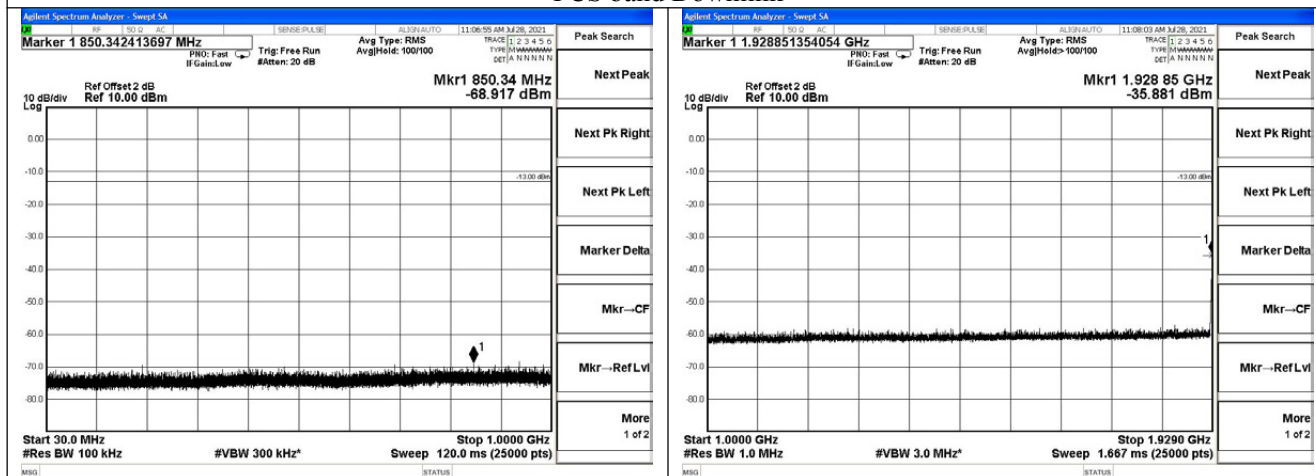
Test data

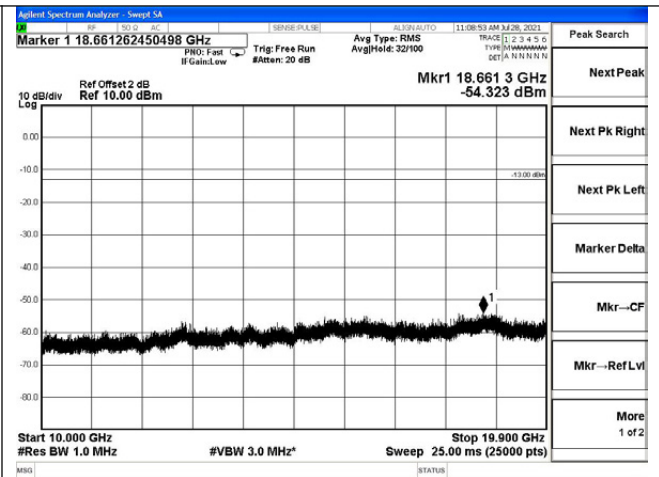
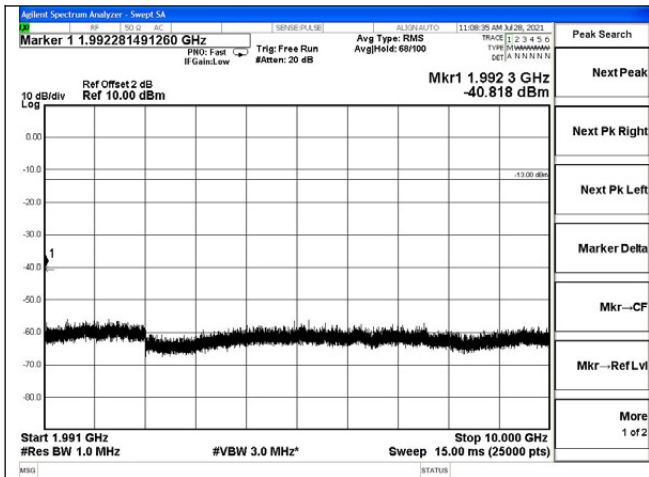
Temperature	21.8°C	Humidity	53.6%
Test Engineer	Diamond Lu	Test Mode	Transmitting

PCS band Uplink

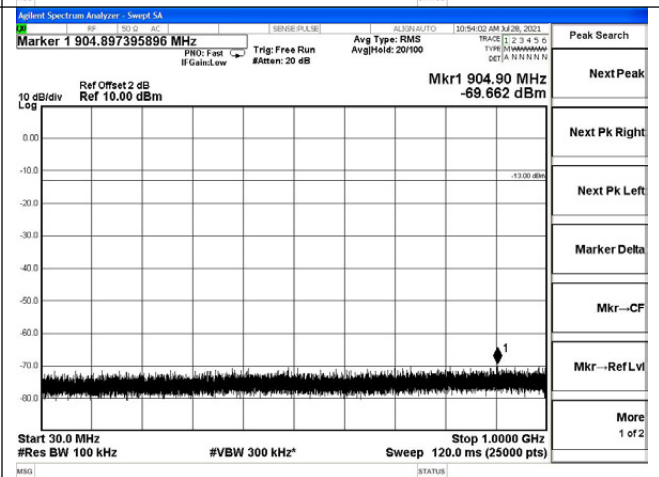
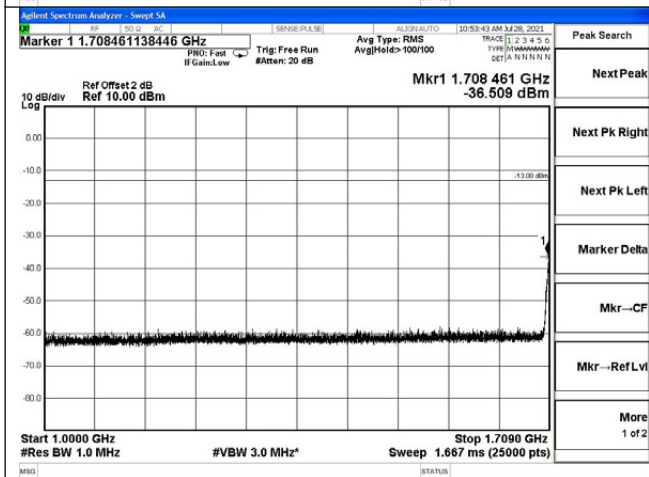
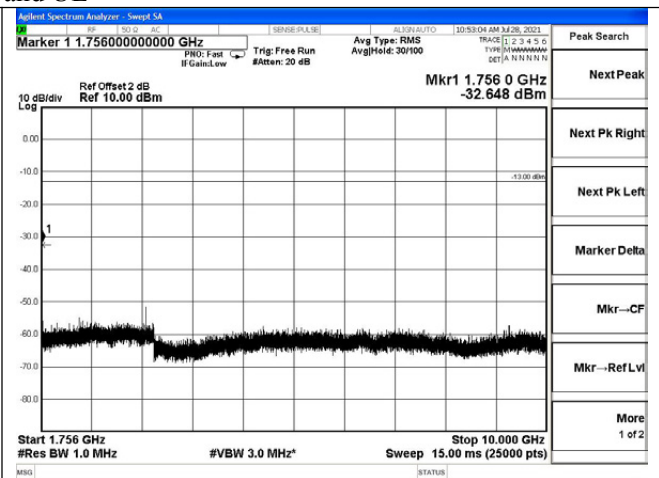
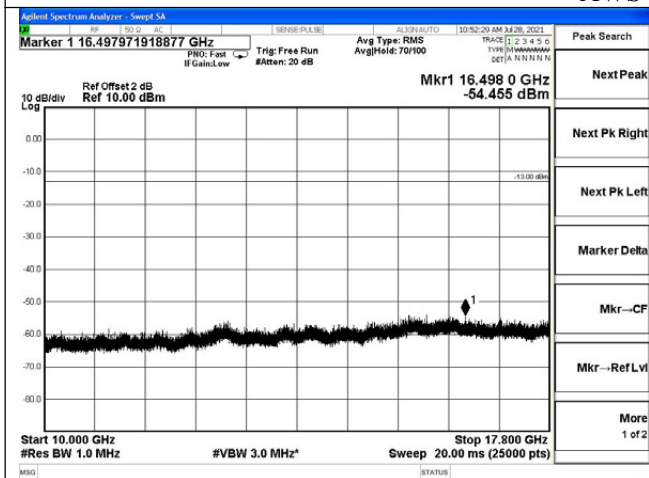


PCS band Downlink

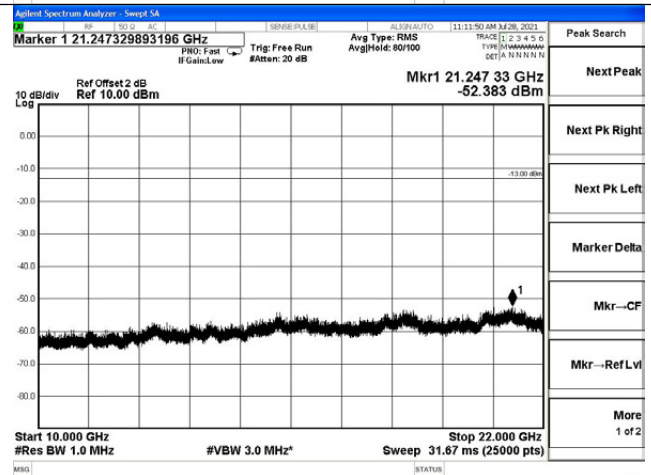
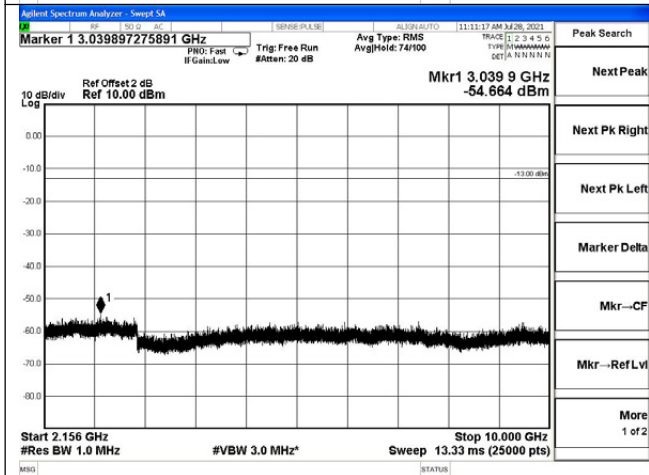
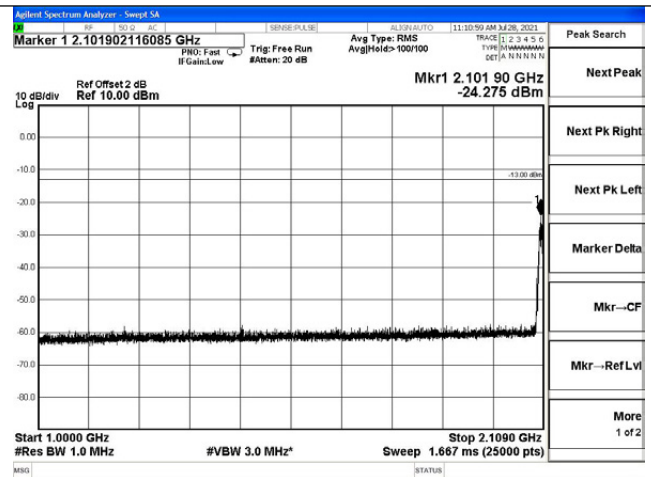
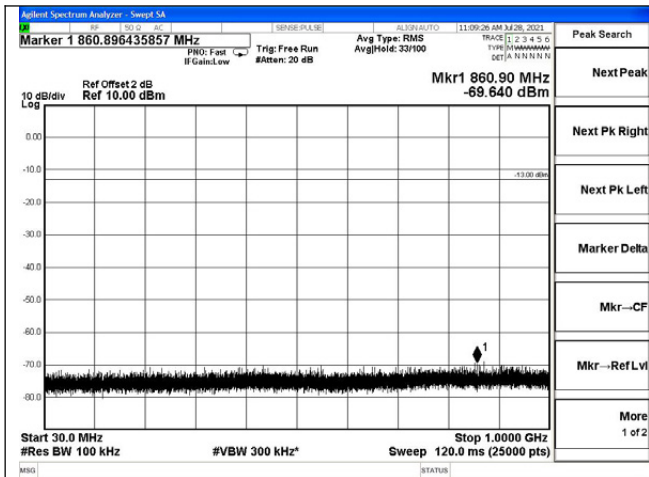




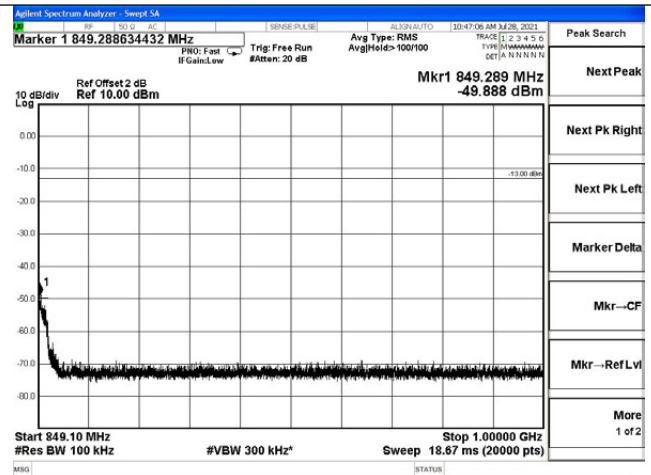
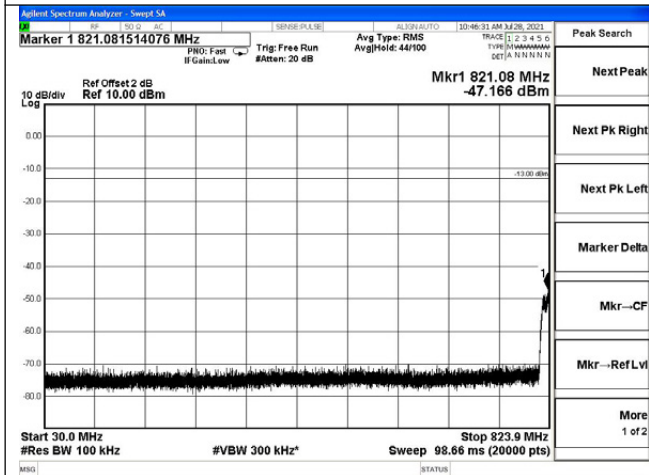
AWS Band UL

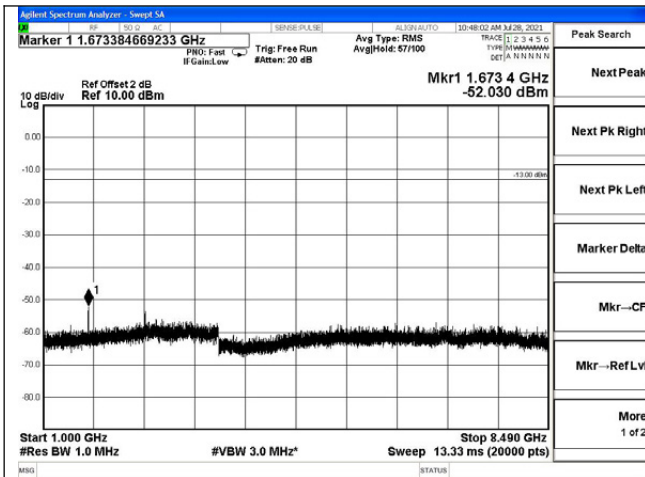


AWS Band DL

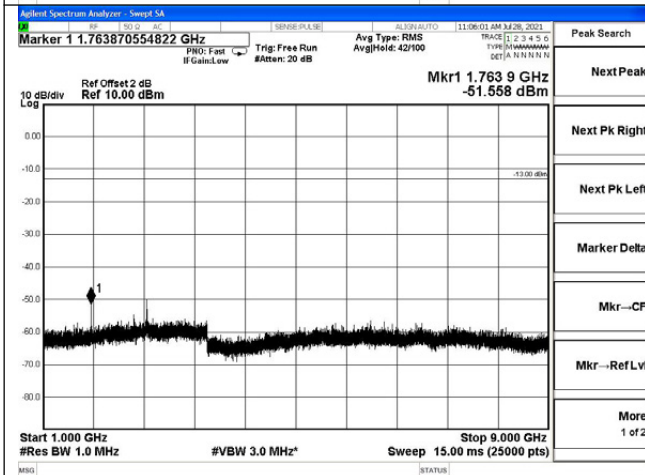
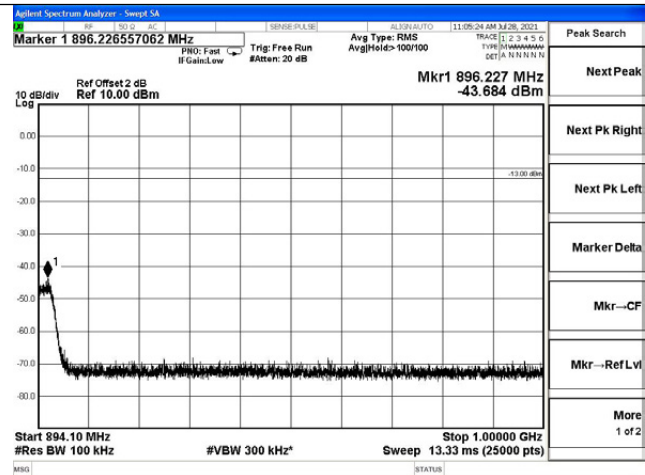
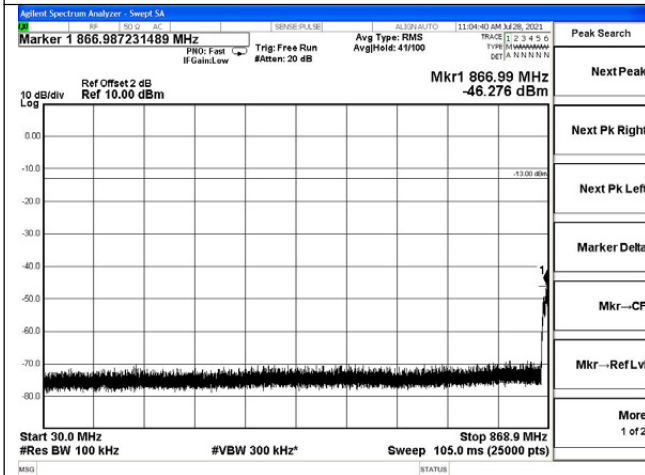


Cellular Band UL

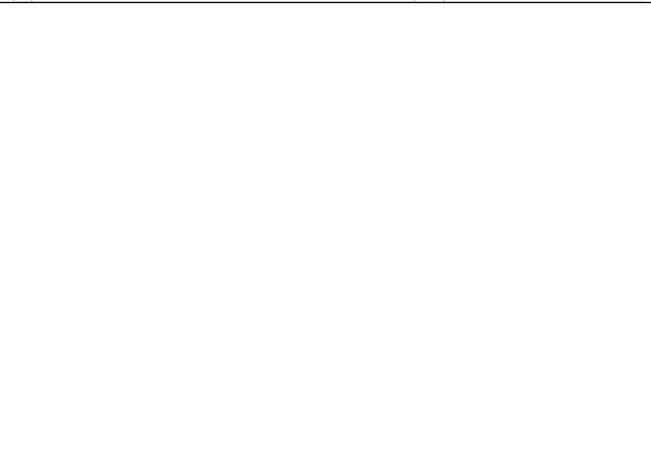
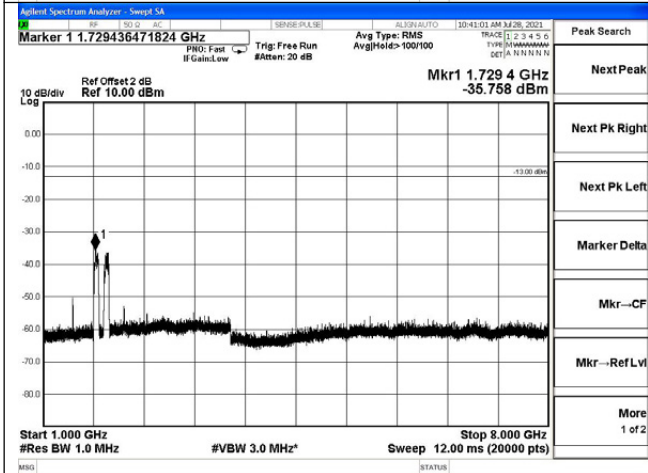
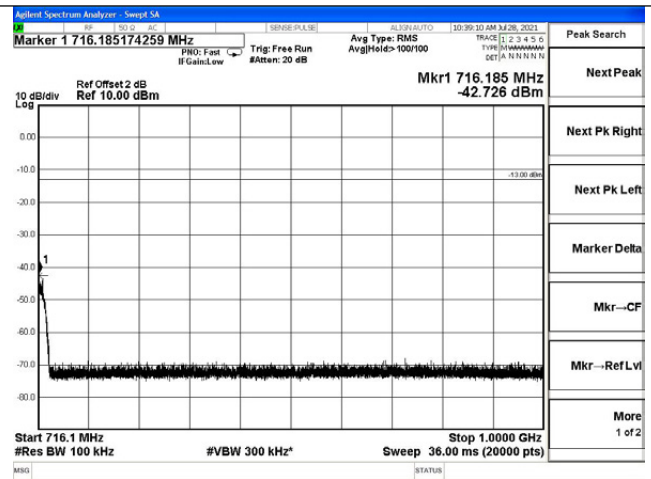
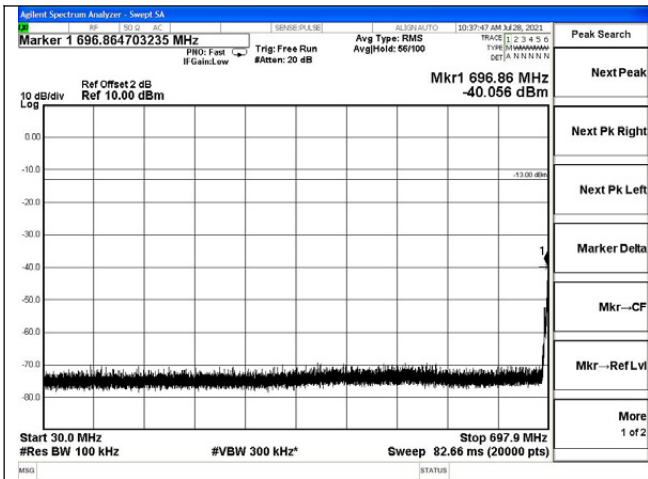




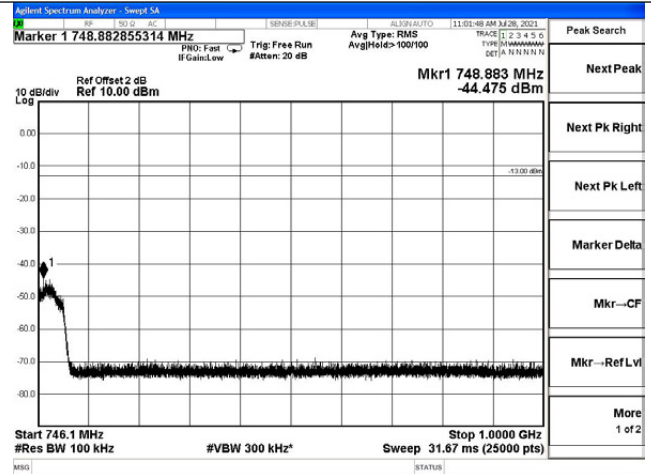
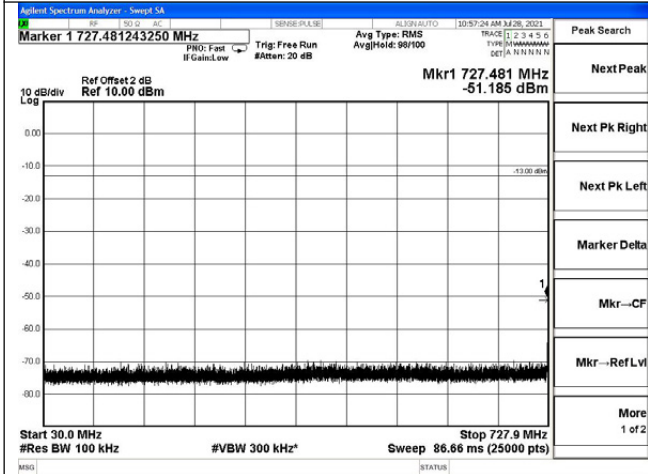
Cellular Band DL

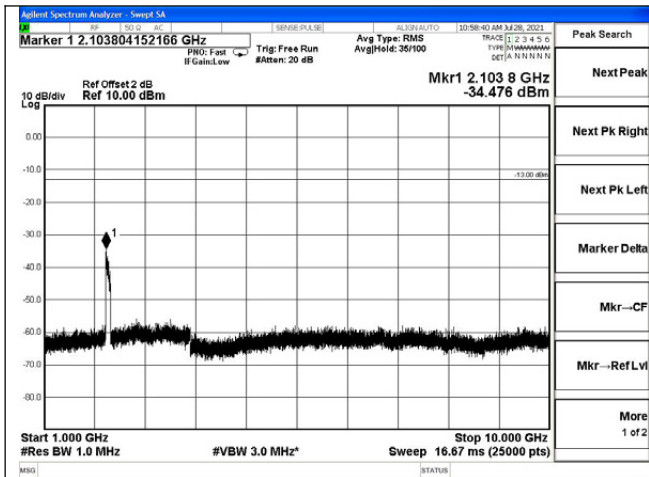


Lower 700MHz band UL

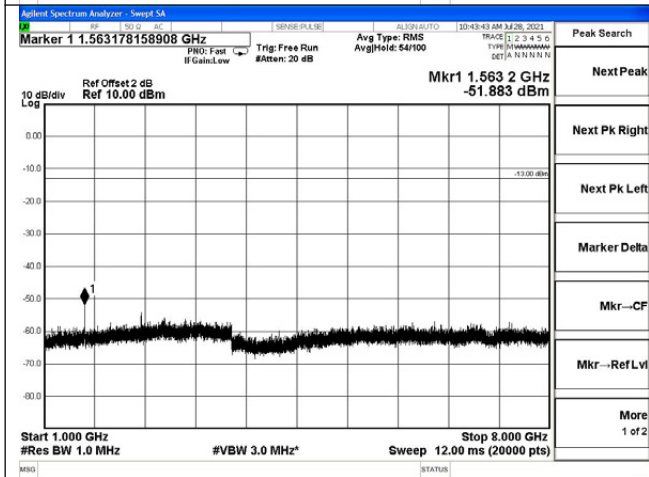
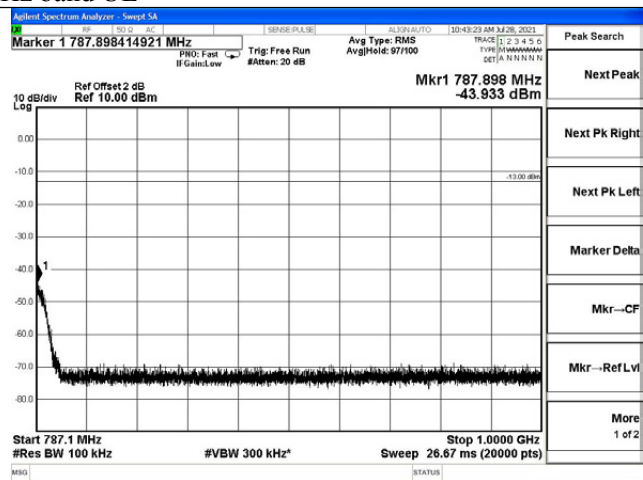
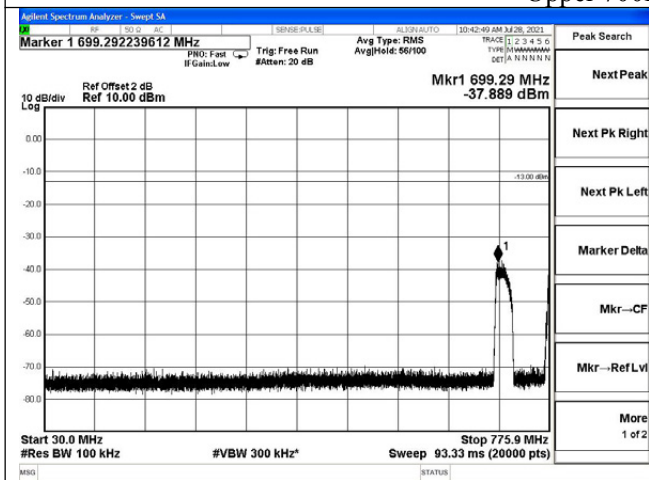


Lower 700MHz band DL

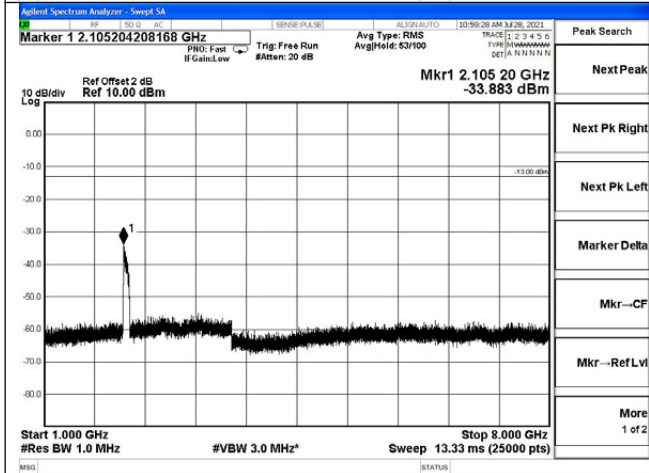
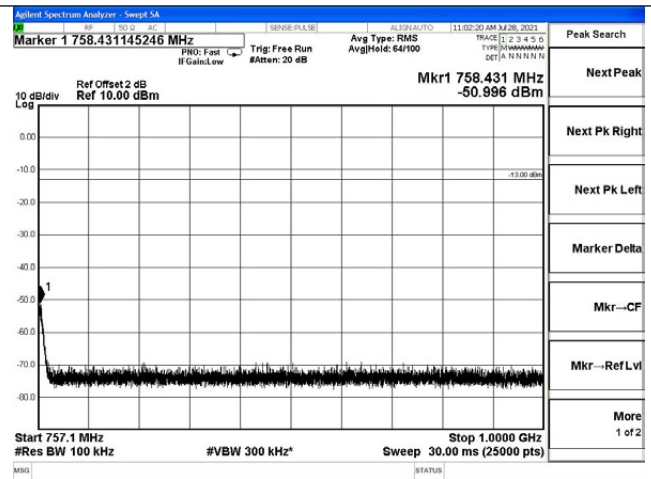
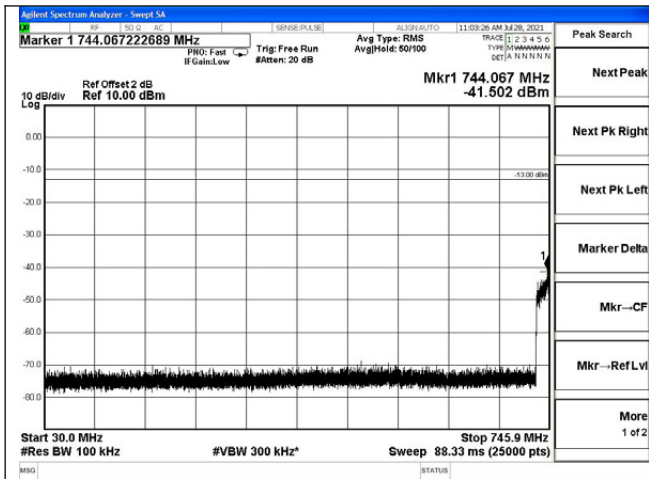




Upper 700MHz band UL



Upper 700MHz band DL



6.7 Noise Limits

Applicable Standard

According to §20.21(e)(8)(i)(A) Noise Limits (uplink); §20.21(e)(8)(i)(H) Transmit Power Off Mode (uplink and downlink noise power).

Test Procedure

Maximum transmitter noise power level

- a) Connect the EUT to the test equipment as shown in Figure 3. Begin with the uplink output (donor) port connected to the spectrum analyzer. When measuring downlink noise, connect the downlink output (server) port to the spectrum analyzer.
- b) Set the spectrum analyzer RBW to 1 MHz with the VBW ≥ 3 RBW.
- c) Select the power averaging (rms) detector and trace average over at least 100 traces.
- d) Set the center frequency of the spectrum analyzer to the center of the CMRS band under test with the span ≥ 2 the CMRS band.
- e) Measure the maximum transmitter noise power level.
- f) Save the spectrum analyzer plot as necessary for inclusion in the final test report.
- g) Repeat 7.7b) to 7.7f) for all operational uplink and downlink bands.
- h) Connect the EUT to the test equipment as shown in Figure 4 for uplink noise power measurement in the presence a downlink signal. Affirm the coupled path of the RF coupler is connected to the spectrum analyzer.
 - i) Configure the signal generator for AWGN operation with a 99% OBW of 4.1 MHz.
 - j) Set the spectrum analyzer RBW for 1 MHz, VBW ≥ 3 RBW, with a power averaging (rms) detector with at least 100 trace averages.
 - k) Set the center frequency of the spectrum analyzer to the center of the CMRS band under test, with the span ≥ 2 the CMRS band. This shall include all spectrum blocks in the particular CMRS band under test (see Appendix A).
 - l) For uplink noise measurements, set the spectrum analyzer center frequency for the uplink band under test, and tune the signal generator to the center of the paired downlink band.
 - m) Measure the maximum transmitter noise power level while varying the downlink signal generator output level from -90 dBm to -20 dBm, as measured at the input port (i.e., downlink signal level at the booster donor port node of Figure 4), in 1 dB steps inside the RSSI-dependent region, and in 10 dB steps outside the RSSI-dependent region. Report the six values closest to the limit, with at least two points within the RSSI-dependent region of the limit. See Appendix D for noise limits graphs.
 - n) Repeat 7.7.1h) through 7.7.1m) for all operational uplink bands.

Variable uplink noise timing

Variable uplink noise timing is to be measured as follows, using the test setup shown in Figure 4.

- a) Set the spectrum analyzer to the uplink frequency to be measured.
- b) Set the span to 0 Hz, with a sweep time of 10 seconds.
- c) Set the power level of signal generator to the lowest level of the RSSI-dependent noise [see 7.7.1m)].
- d) Select MAX HOLD and increase the power level of signal generator by 10 dB for mobile boosters, and 20 dB for fixed boosters.
- e) Confirm that the uplink noise decreases to the specified level within 1 second for mobile devices, and within 3 seconds for fixed devices.
- f) Repeat 7.7.2a) to 7.7.2e) for all operational uplink bands.
- g) Include plots and summary table in test report.

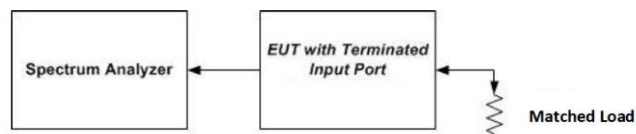


Figure 3 – Noise limit test setup

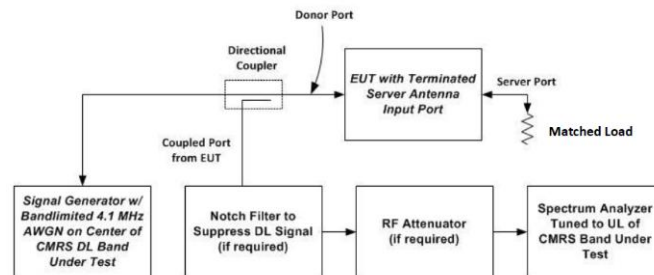


Figure 4 – Test setup for uplink noise power measurement in the presence of a downlink signal

Test Data

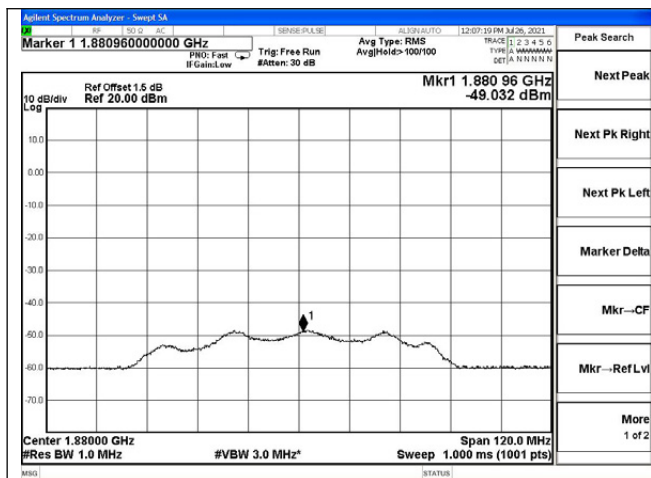
Temperature	21.8°C	Humidity	53.6%
Test Engineer	Diamond Lu	Test Mode	Transmitting

Max Noise Power			
Frequency Band (MHz)	Measured dBm/MHz	Limit dBm/MHz	Result (dB)
PCS Band Uplink	-49.03	-37.02	PASS
AWS Band Uplink	-49.09	-37.73	PASS
Cellular Band Uplink	-49.96	-44.05	PASS
Lower 700MHz band Uplink	-48.35	-45.51	PASS
Band13 Uplink	48.73	-44.64	PASS
PCS Band Downlink	-43.07	-37.02	PASS
AWS Band Downlink	-41.17	-37.73	PASS
Cellular Band Downlink	-47.29	-44.05	PASS
Lower 700MHz band Downlink	-48.53	-45.51	PASS
Lower 700MHz band Downlink	-49.08	-44.64	PASS

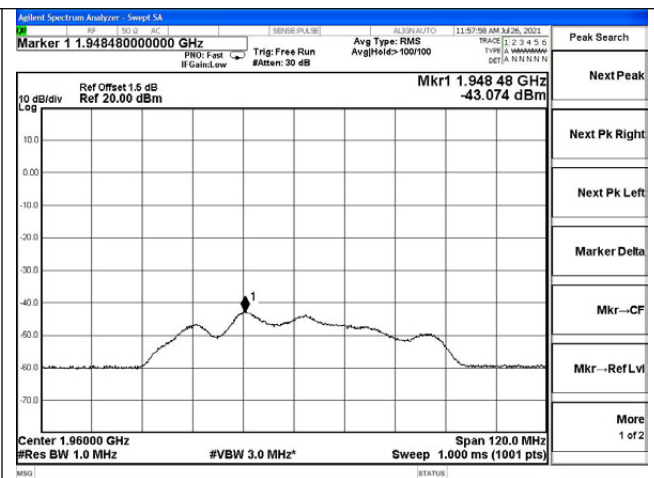
Note: Fixed booster maximum noise power shall not exceed $-102.5 \text{ dBm/MHz} + 20 \log (F)$, where Frequency is the uplink mid-band frequency of the supported spectrum bands in MHz.

Variable Uplink Noise Timing

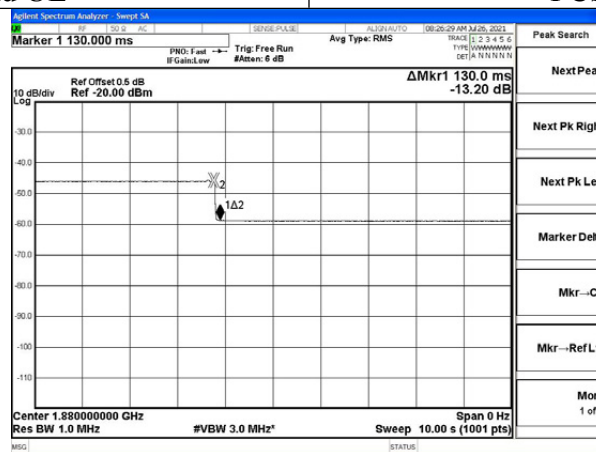
Operation Bands	Measured Sec	Limit Sec	Results
PCS	0.130	3	PASS
AWS	0.110	3	PASS
Cellular	0.110	3	PASS
Lower 700	0.106	3	PASS
Upper 700	0.210	3	PASS



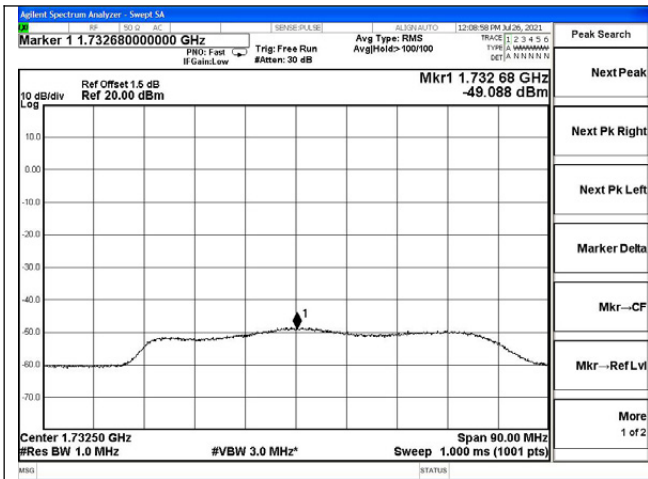
PCS band UL



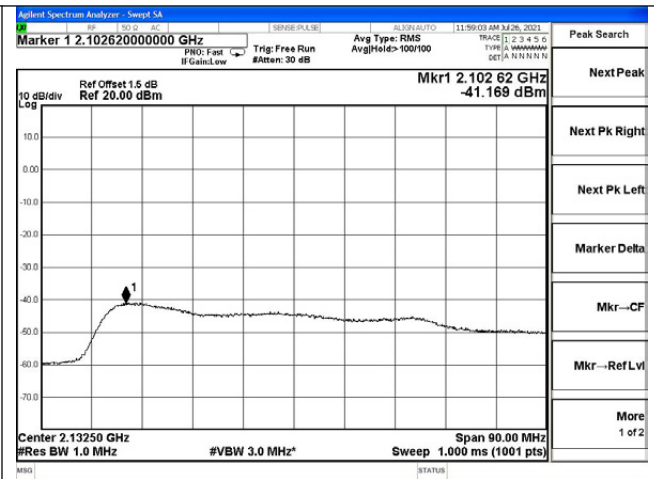
PCS band DL



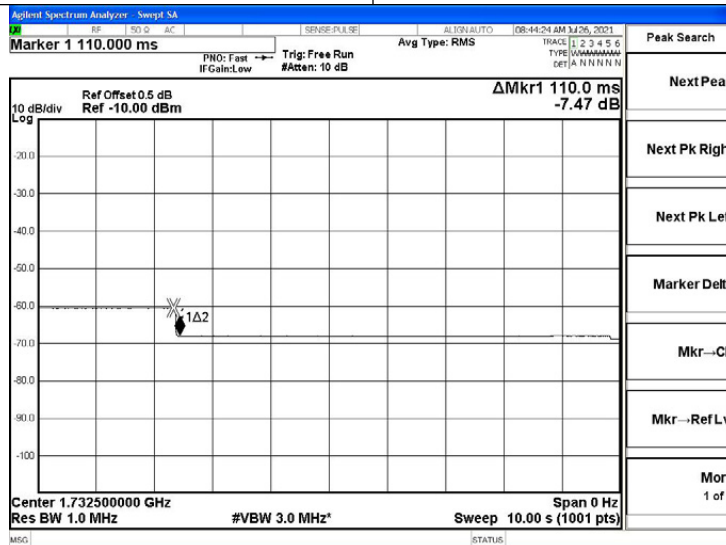
PCS band Variable Uplink Noise Timing



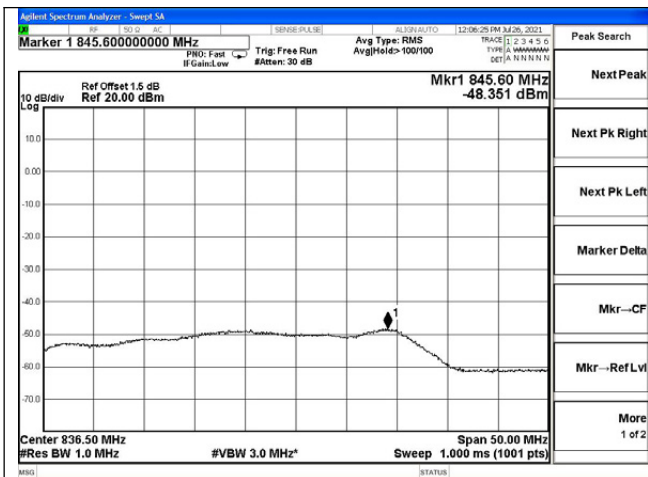
AWS band UL



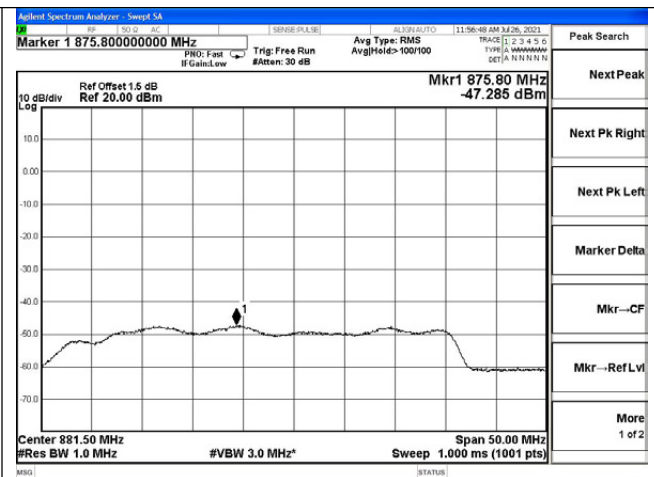
AWS band DL



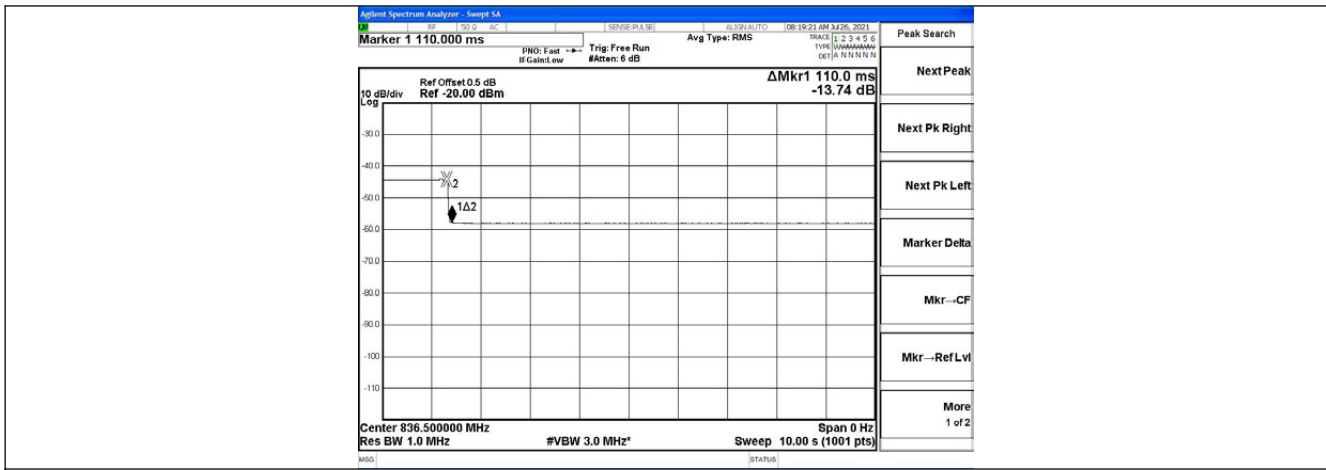
AWS band Variable Uplink Noise Timing



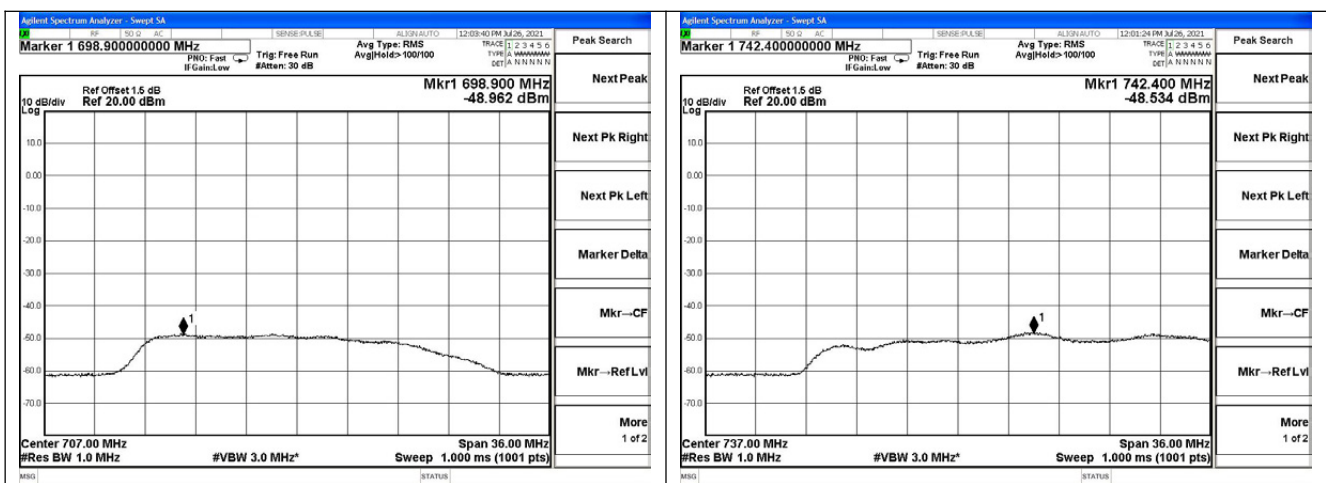
Cellular band UL



Cellular band DL

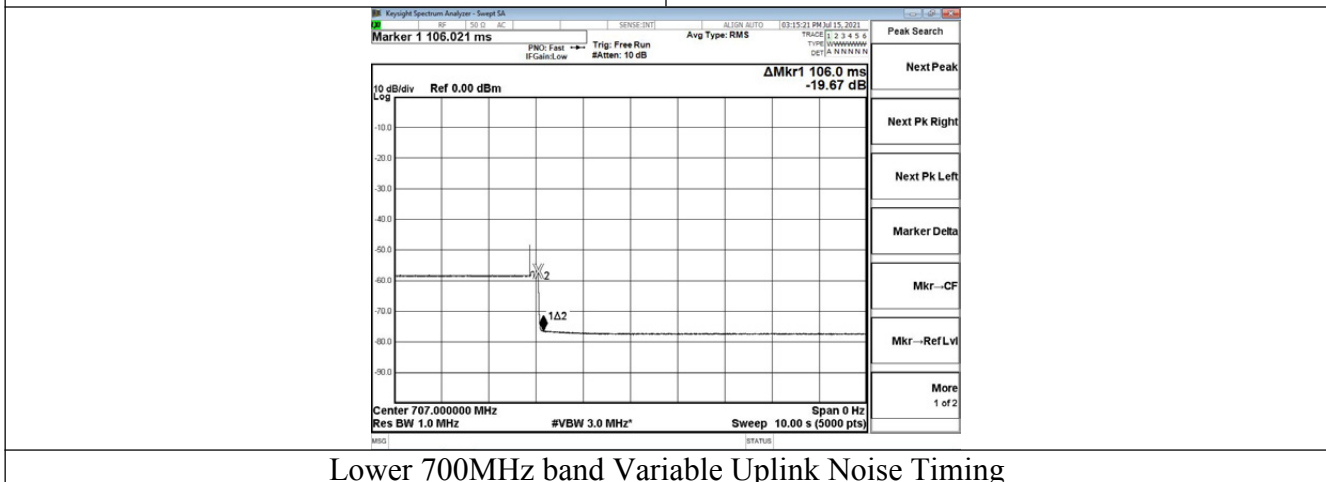


Cellular band Variable Uplink Noise Timing

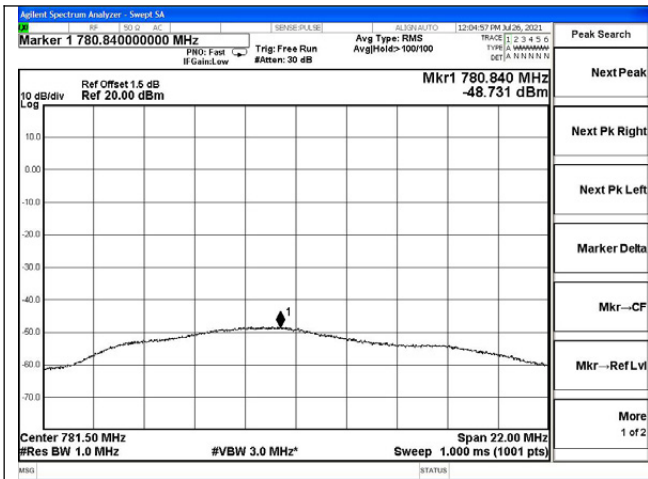


Lower 700MHz band UL

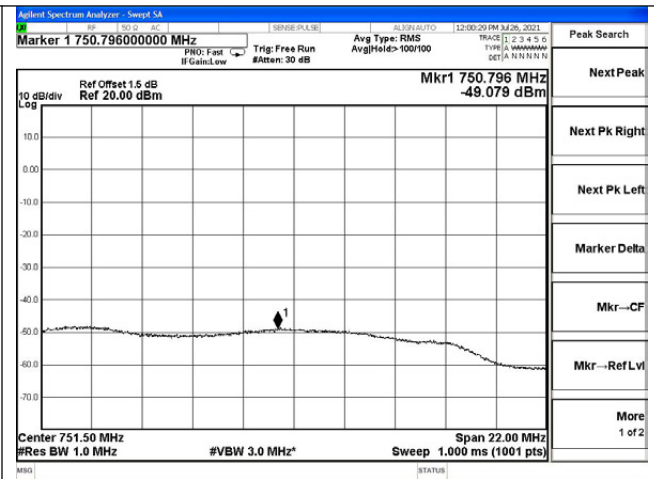
Lower 700MHz band DL



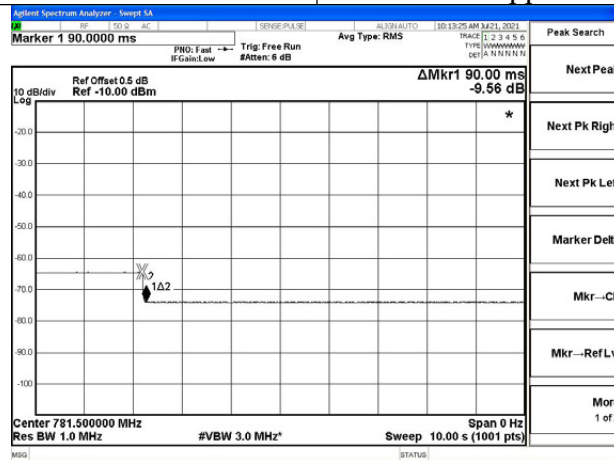
Lower 700MHz band Variable Uplink Noise Timing



Upper 700MHz band UL



Upper 700MHz band DL



Upper 700MHz band Variable Uplink Noise Timing

6.8 Uplink Inactivity

Applicable Standard

According to §20.21(e)(8)(i)(I) Uplink Inactivity.

This measurement procedure is intended to demonstrate compliance to the uplink inactivity requirements specified for wideband consumer signal boosters in Section 20.21(e)(8)(i)(I).

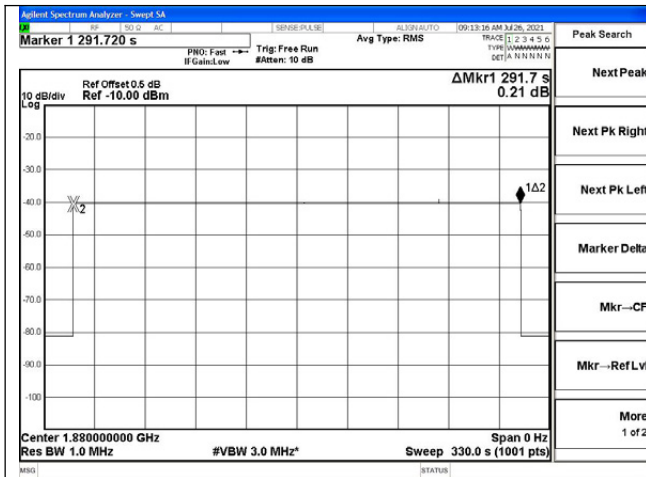
Test Procedure

- Connect the EUT to the test equipment as shown in Figure 3 with the uplink output (donor) port connected to the spectrum analyzer.
 - Select the power averaging (rms) detector.
 - Set the spectrum analyzer RBW for 1 MHz with the $VBW \geq 3$ RBW.
 - Set the center frequency of the spectrum analyzer to the center of the uplink operational band.
 - Set the span for 0 Hz with a single sweep time for a minimum of 330 seconds.
 - Start to capture a new trace using MAX HOLD.
 - After approximately 15 seconds, turn on the EUT power.
 - After the full spectrum analyzer trace is complete, place a MARKER on the leading edge of the pulse, then use the DELTA MARKER METHOD to measure the time until the uplink becomes inactive.
 - Affirm that the noise level is below the uplink inactivity noise power limit, as specified by the rules.
 - Capture the plot for inclusion in the test report.
 - Measure noise using procedures in 7.7.1a) to 7.7.1f).
- Repeat 7.8d) through 7.8k) for all operational uplink bands.

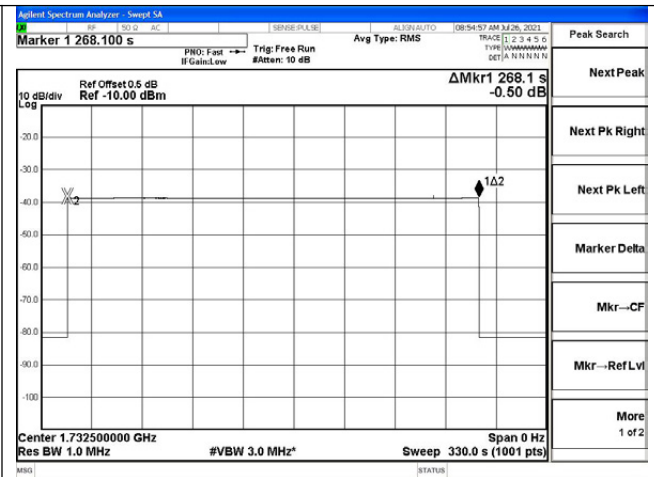
Test Data

Temperature	21.8°C	Humidity	53.6%
Test Engineer	Diamond Lu	Test Mode	Transmitting

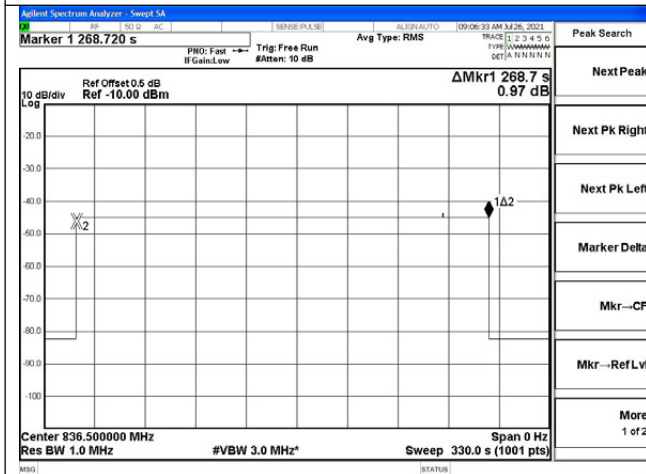
Uplink Inactivity			
Operation Bands	Measured (s)	Limit (s)	Result
PCS Band	291.7	300.0	PASS
AWS Band	268.1	300.0	PASS
Cellular Band	268.7	300.0	PASS
Lower 700MHz Band	268.3	300.0	PASS
Upper 700 Mhz Band	261.3	300.0	PASS



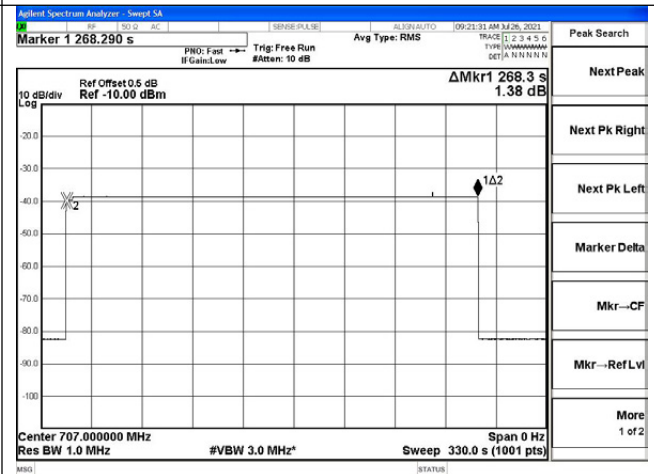
PCS band



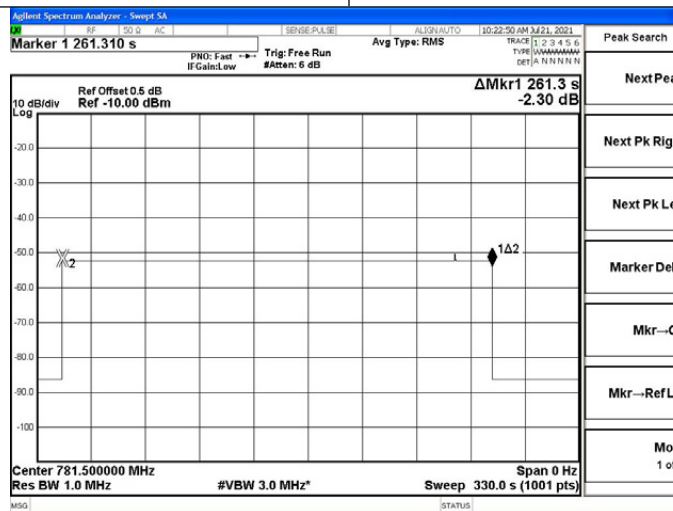
AWS band



Cellular band



Lower 700MHz band



Upper 700MHz band

6.9 Variable Booster Gain

Applicable Standard

According to §20.21(e)(8)(i)(C)(1) Booster Gain Limits (variable gain); §20.21(e)(8)(i)(H) Transmit Power Off Mode (uplink gain).

This procedure shall be used to demonstrate compliance to the booster gain limits specified for wideband consumer signal boosters in Section 20.21(e)(8)(i)(C) or Section 20.21(e)(8)(i)(H). The variable booster gain limits are expressed as a function of RSSI and MSCL, and are shown graphically in Appendix D. The RSSI is varied over a range of values as specified within the procedure. Refer to Appendix B of this document for guidance on determining the applicable MSCL value.

Test Procedure

- a) Connect the EUT to the test equipment as shown in Figure 5 with the uplink output (donor) port connected to signal generator #1. Affirm that the coupled path of the RF coupler is connected to the spectrum analyzer.
- b) Configure downlink signal generator #1 for AWGN operation with a 99% OBW of 4.1 MHz, tuned to the center of the operational band.
- c) Set the power level and frequency of signal generator #2 to a value that is 5 dB below the AGC level determined from 7.2. The signal type is AWGN with a 99% OBW of 4.1 MHz.
- d) Set RBW = 100 kHz.
- e) Set VBW $\geq$ 300 kHz.
- f) Select the CHANNEL POWER measurement mode.
- g) Select the power averaging (rms) detector.
- h) Affirm that the number of measurement points per sweep $\geq$ (2 span)/RBW.
- i) Sweep time = auto couple or as necessary (but no less than auto couple value).
- j) Trace average at least 10 traces in power averaging (i.e., rms) mode.
- k) Measure the maximum channel power and compute maximum gain when varying the signal generator #1 output to a level from -90 dBm to -20 dBm, as measured at the input port (i.e., downlink signal level at the booster donor port node of Figure 5), in 1 dB steps inside the RSSI-dependent region, and 10 dB steps outside the RSSI-dependent region. Report the six values closest to the limit, including at least two points from within the RSSI-dependent region of operation. See gain limit in charts in Appendix D for uplink gain requirements. Additionally, document that the EUT provides equivalent uplink and downlink gain, and when operating in shutoff mode that the uplink and downlink gain is within the transmit power off mode gain limits.
- l) Repeat 7.9.1b) to 7.9.1k) for all operational uplink bands.

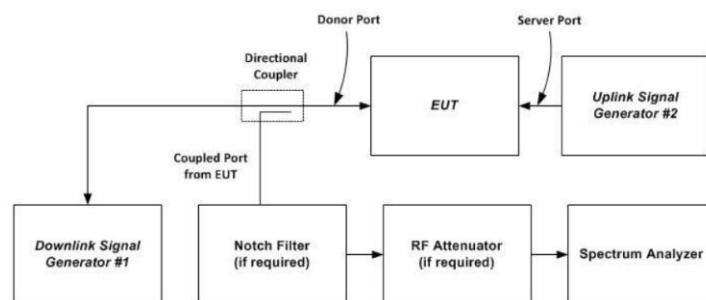


Figure 5—Variable gain instrumentation test setup

Mobile station coupling loss (MSCL): the minimum coupling loss (in dB) between the wireless device and the input (server) port of the consumer booster. MSCL must be calculated or measured for each band of operation and provided in compliance test reports. MSCL includes the path loss from the wireless device, and the booster's server antenna gain and cable loss. The wireless device is assumed to be an isotropic (0 dBi) antenna reference. Minimum standoff distances from inside wireless devices to the booster's server antenna must be reasonable and specified by the manufacturer in customer provided installation manuals.

Test data

Temperature	21.8°C	Humidity	53.6%
Test Engineer	Diamond Lu	Test Mode	Transmitting

MSCL Calculation							
Operation Bands	Frequency (MHz)	Distance (m)	Path loss (dB)	Indoor Antenna Gain(dBi)	Indoor Cable Loss(dB)	Polarity Loss(dB)	MSCL(dB)
PCS band	1850	2	43.8	8.5	2.55	3	40.9
Cellular band	824	2	36.8	7	2.29	3	35.1
Lower 700MHz band	698	2	35.3	7	2.19	3	33.5
Upper 700MHz band	776	2	36.3	7	2.19	3	34.5
AWS band	1710	2	43.1	8.5	2.42	3	40.0

Note :Path loss = $20\log f + 20\log d - 27.5$

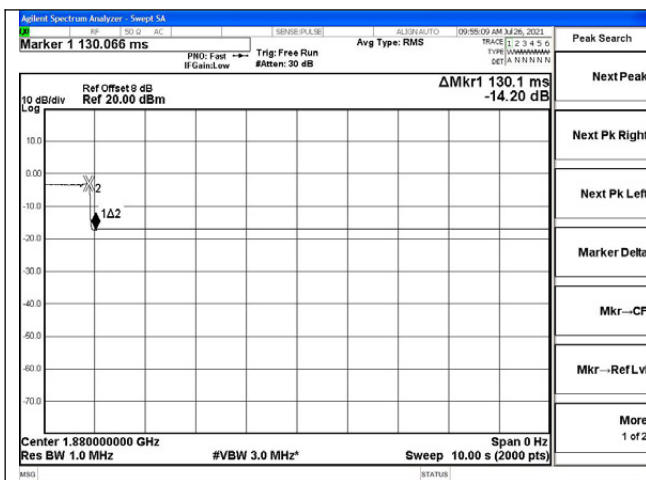
Polarity loss = $20\log (1/\sin (45\text{deg})) \text{ dB} = 3.01\text{dB}$

Variable booster gain							
Operation Band	RSSI (dBm)	Input Power (dBm)	Output Power (dBm)	Measured Gain (dB)	MSCL	Limit	Results
PCS band	-49	-49.3	-2.07	47.23	40.9	55.9	PASS
	-46	-49.3	-3.26	46.04	40.9	52.9	PASS
	-45	-49.3	-4.87	44.43	40.9	51.9	PASS
	-40	-49.3	-6.59	42.71	40.9	46.9	PASS
	-38	-49.3	-9.03	40.27	40.9	44.9	PASS
	-35	-49.3	-12.14	37.16	40.9	41.9	PASS
Cellular band	-50	-46.1	-2.68	43.42	35.1	51.1	PASS
	-48	-46.1	-4.16	41.94	35.1	49.1	PASS
	-43	-46.1	-6.37	39.73	35.1	44.1	PASS
	-39	-46.1	-8.53	37.57	35.1	40.1	PASS
	-36	-46.1	-10.41	35.69	35.1	37.1	PASS
	-35	-46.1	-11.97	34.13	35.1	36.1	PASS
Lower 700MHz band	-51	-43.6	-3.68	39.92	33.5	50.5	PASS
	-49	-43.6	-4.20	39.4	33.5	48.5	PASS
	-46	-43.6	-6.28	37.32	33.5	45.5	PASS
	-44	-43.6	-7.39	36.21	33.5	43.5	PASS
	-38	-43.6	-9.04	34.56	33.5	37.5	PASS
	-35	-43.6	-12.58	31.02	33.5	34.5	PASS
Upper 700MHz band	-43	-44.5	-1.96	42.54	34.5	43.5	PASS
	-41	-44.5	-3.87	40.63	34.5	41.5	PASS
	-40	-44.5	-5.24	39.26	34.5	40.5	PASS
	-38	-44.5	-7.93	36.57	34.5	38.5	PASS
	-35	-44.5	-10.11	34.39	34.5	35.5	PASS
	-32	-44.5	-11.59	32.91	34.5	32.5	PASS
AWS band	-53	-47.3	-3.68	43.62	40.0	59.0	PASS
	-49	-47.3	-4.75	42.55	40.0	55.0	PASS
	-48	-47.3	-6.01	41.29	40.0	54.0	PASS
	-45	-47.3	-8.49	38.81	40.0	51.0	PASS
	-40	-47.3	-10.32	36.98	40.0	46.0	PASS
	-38	-47.3	-12.49	34.81	40.0	44.0	PASS

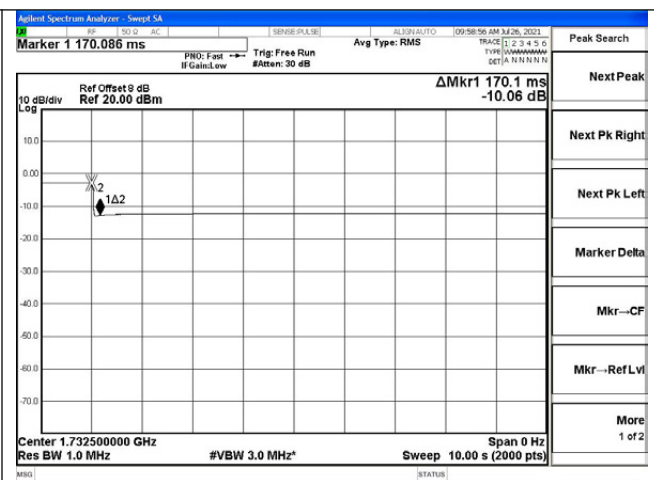
Note: Variable booster gain Limit: $-34\text{-RSSI} + \text{MSCL}$;

Variable Uplink Gain Timing

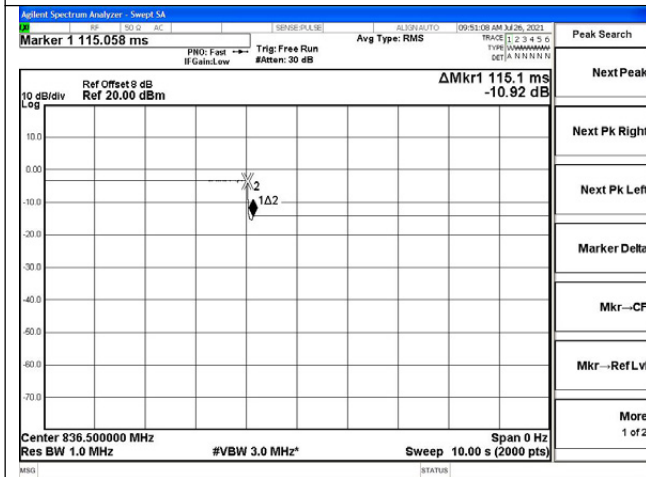
Operation Band	Measured Sec	Limit Sec	Result
PCS band	0.130	3.0	PASS
AWS band	0.170	3.0	PASS
Cellular band	0.115	3.0	PASS
Lower 700MHz band	0.100	3.0	PASS
Upper 700MHz band	0.130	3.0	PASS



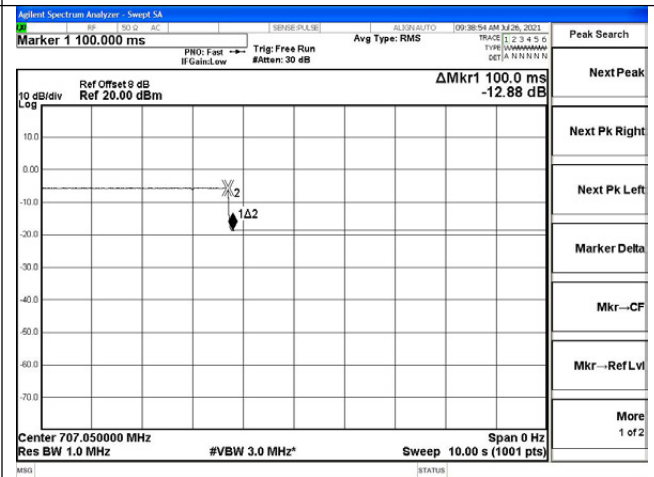
PCS band



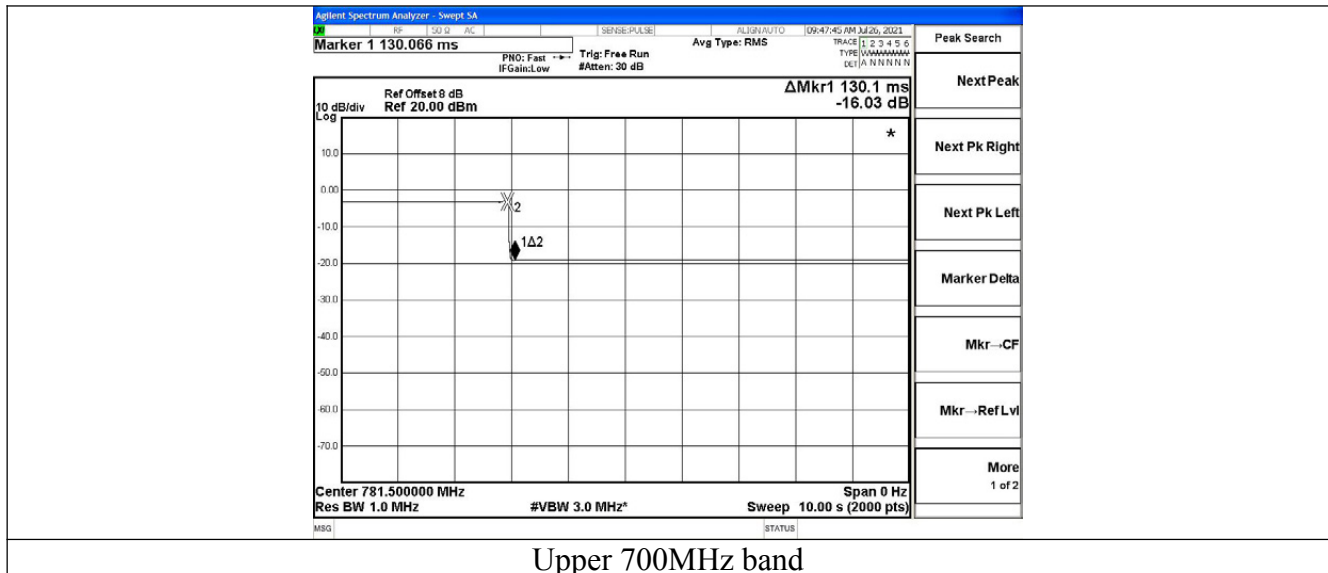
AWS band



Cellular band



Lower 700MHz band



6.10 Occupied Bandwidth

Applicable Standard

According to §2.1049 Measurements required: Occupied bandwidth.

This measurement is required to compare the consistency of the output signal relative to the input signal, and to satisfy the requirements of Section 2.1049.

Test Procedure

- a) Connect the test equipment as shown in Figure 6 to firstly measure the characteristics of the test signals produced by the signal generator.
- b) Set $VBW \geq 3$ RBW.
- c) Set the center frequency of the spectrum analyzer to the center of the operational band. The span will be adjusted for each modulation type and OBW as necessary for accurately viewing the signals.
- d) Set the signal generator for power level to match the values obtained from the tests of 7.2.
- e) Set the signal generator modulation type for GSM with a PRBS pattern and allow the trace on the signal generator to stabilize adjusting the span as necessary.
- f) Set the spectrum analyzer RBW for 1% to 5% of the EBW.
- g) Capture the spectrum analyzer trace for inclusion in the test report.
- h) Repeat 7.10c) to 7.10g) for CDMA and W-CDMA modulation, adjusting the span as necessary. AWGN or LTE may be used in place of W-CDMA, as an option.
- i) Repeat 7.10c) to 7.10h) for all uplink and downlink operational bands.
- j) Connect the test equipment as shown in Figure 1, with the uplink output (donor) port connected to the spectrum analyzer, and the server port connected to the signal generator.
- k) Repeat 7.10c) to 7.10i) with this EUT uplink path test setup.
- l) Connect the test equipment as shown in Figure 1, with the downlink output (server) port connected to the spectrum analyzer, and the donor port connected to the signal generator.
- m) Repeat 7.10c) to 7.10i) with this EUT downlink path test setup.

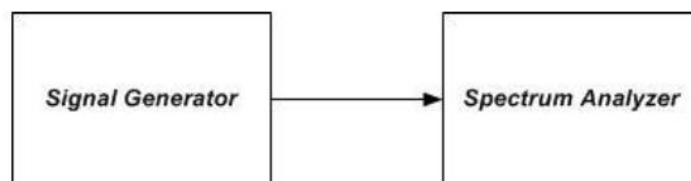


Figure 6 – Test setup for measuring characteristics of test signals used for subsequent EUT occupied bandwidth testing

Test data

Temperature	21.8°C	Humidity	53.6%
Test Engineer	Diamond Lu	Test Mode	Transmitting

Operation Band		Signal Type	Input OBW [MHz]	Output OBW [MHz]	Results
Uplink	PCS	GSM	0.246	0.246	PASS
		CDMA	1.234	1.235	PASS
		AWGN	4.414	4.414	PASS
	AWS	GSM	0.247	0.246	PASS
		CDMA	1.230	1.230	PASS
		AWGN	4.430	4.434	PASS
	Cellular	GSM	0.247	0.245	PASS
		CDMA	1.224	1.238	PASS
		AWGN	4.427	4.434	PASS
	Lower 700	GSM	0.247	0.245	PASS
		CDMA	1.236	1.236	PASS
		AWGN	4.410	4.423	PASS
Downlink	PCS	GSM	0.238	0.247	PASS
		CDMA	1.228	1.225	PASS
		AWGN	4.463	4.479	PASS
	AWS	GSM	0.248	0.243	PASS
		CDMA	1.234	1.234	PASS
		AWGN	4.467	4.439	PASS
	Cellular	GSM	0.247	0.244	PASS
		CDMA	1.234	1.247	PASS
		AWGN	4.511	4.434	PASS
	Lower 700	GSM	0.245	0.245	PASS
		CDMA	1.242	1.235	PASS
		AWGN	4.480	4.420	PASS
	Upper 700	GSM	0.247	0.247	PASS
		CDMA	1.235	1.235	PASS
		AWGN	4.446	4.413	PASS
	Upper 700	GSM	0.235	0.235	PASS
		CDMA	1.231	1.236	PASS
		AWGN	4.452	4.396	PASS