g) Reset the zero-span trigger of the spectrum analyzer, then repeat 7.11.2f) twice to ensure that the spectrum analyzer is reliably triggered, resetting the EUT (e.g., cycle ac/dc power) after each oscillation event if necessary.
h) Reset the zero-span sweep trigger of the spectrum analyzer, and reset the EUT (e.g., cycle ac/dc power).
i) Force the EUT into oscillation by reducing the attenuation.
j) Use the marker function of the spectrum analyzer to measure the time from the onset of oscillation until the EUT turns off, by setting Marker 1 on the leading edge of the oscillation signal and Marker 2 on the trailing edge. The spectrum analyzer sweep time may be adjusted to improve the time resolution of these cursors.
k) Capture the spectrum analyzer zero-span trace for inclusion in the test report. Report the power level associated with the oscillation separately if it can't be displayed on the trace.
l) Repeat 7.11.2b) to 7.11.2k) for all operational uplink and downlink bands.
m) Set the spectrum analyzer zero-span sweep time for longer than 60 seconds, then measure the restart time for each operational uplink and downlink band.
n) Replace the normal-operating mode EUT with the EUT that supports an anti-oscillation test mode.
o) Set the spectrum analyzer zero-span time for a minimum of 120 seconds, and a single sweep.
p) Manually trigger the spectrum analyzer zero-span sweep, and manually force the booster into oscillation as described in 7.11.2i).
q) When the sweep is complete, place cursors between the first two oscillation detections, and save the plot for inclusion in the test report. The time between restarts must match the manufacturer's timing for the test mode, and there shall be no more than 5 restarts.
r) Repeat 7.11.2m) to 7.11.2q) for all operational uplink and downlink bands.

Oscillation mitigation or shutdown

According to section 7.11.3 of KDB 935210 D03 Signal Booster Measurement v04r04:
a) Connect the normal-operating mode EUT to the test equipment as shown in Figure 7.
b) Set the spectrum analyzer center frequency to the center of band under test, and use the following settings:
1) RBW=30 kHz, VBW ≥ 3 × RBW,
2) power averaging (rms) detector,
3) trace averages ≥ 100,
4) span ≥ 120% of operational band under test,
5) number of sweep points ≥ 2 × Span/RBW.
c) Configure the signal generator for AWGN operation with a 99% OBW of 4.1 MHz, tuned to the frequency of 2.5 MHz above the lower edge or below the upper edge of the operating band under test. Adjust the RF output level of the signal generator such that the measured power level of the AWGN signal at the output port of the booster is 30 dB less than the maximum power of the booster for the band under test. Affirm that the input signal is not obstructing the measurement of the strongest oscillation peak in the band, and is not included within the span in the measurement.
1) Boosters with operating spectrum passbands of 10 MHz or less may use a CW signal source at the band edge rather than AWGN.
2) For device passbands greater than 10 MHz, standard CMRS signal sources (i.e., CDMA, W-CDMA, LTE) may be used instead of AWGN at the band edge.
d) Set the variable attenuator to a high attenuation setting such that the booster will operate at maximum gain when powered on. Reset the EUT (e.g., cycle ac/dc power). Allow the EUT to

complete its boot-up process, to reach full operational gain, and to stabilize its operation.

e) Set the variable attenuator such that the insertion loss for the center of the band under test (isolation) between the booster donor port and server port is 5 dB greater than the maximum gain, as recorded in the maximum gain test procedure (see 7.3), for the band under test.

f) Verify the EUT shuts down, i.e., to mitigate the oscillations. If the booster does not shut down, measure and verify the peak oscillation level as follows.

1) Allow the spectrum analyzer trace to stabilize.

2) Place the marker at the highest oscillation level occurring within the span, and record its output level and frequency.

3) Set the spectrum analyzer center frequency to the frequency with the highest oscillation signal level, and reduce the span such that the upper and lower adjacent oscillation peaks are within the span.

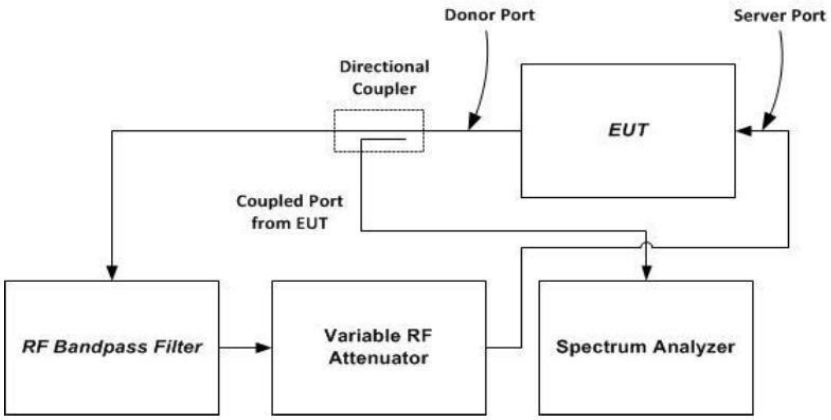
4) Use the Minimum Search Marker function to find the lowest output level that is within the span, and within the operational band under test, and record its output level and frequency.

5) Affirm that the peak oscillation level measured in 7.11.3f2), does not exceed by 12.0 dB the minimal output level measured in 7.11.3f)4). Record the measurement results of 7.11.3f2) and 7.11.3f4) in tabular format for inclusion in the test report.

6) The procedure of 7.11.3f1) to 7.11.3.f5) allows the spectrum analyzer trace to stabilize, and verification of shutdown or oscillation level measurement must occur within 300 seconds.20

g) Decrease the variable attenuator in 1 dB steps, and repeat step 7.11.3f) for each 1 dB step. Continue testing to the level when the insertion loss for the center of band under test (isolation) between the booster donor port and server port is 5 dB lower than the maximum gain (see 7.3).

h) Repeat 7.11.3a) to 7.11.3g) for all operational uplink and downlink bands.



NOTE—This figure shows the test setup for uplink bands transmission path tests; i.e., signal flow is out from the donor port into the directional coupler. For downlink bands transmission path tests, the feedback signal flow path direction and equipment connections shall be reversed, i.e., signal flow is out from the server port into the directional coupler, and signal flow is into the donor port from the variable RF attenuator.

Figure 6 – Oscillation detection (7.11.2) test setup

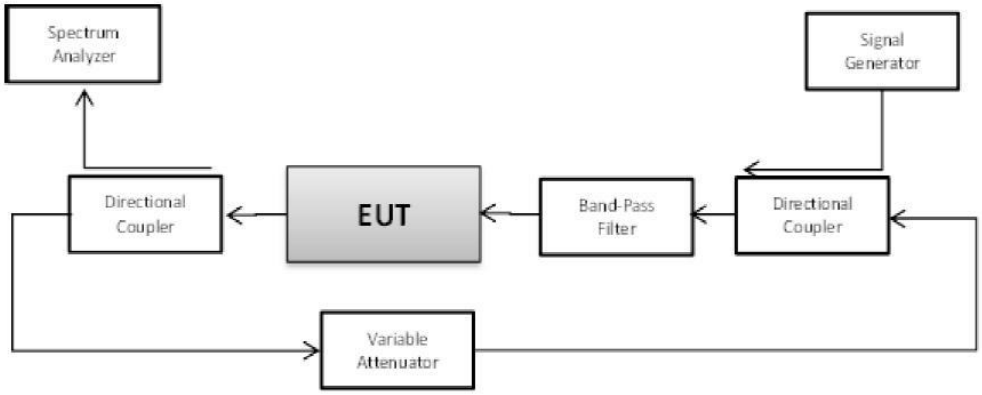


Figure 7 – Oscillation mitigation/shutdown test setup

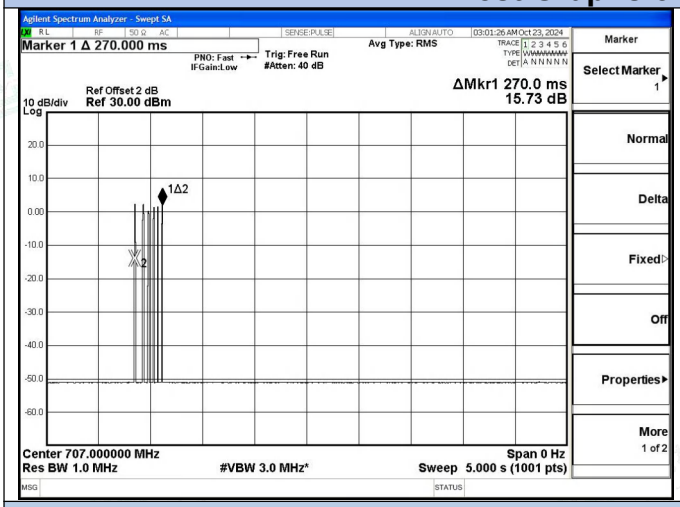
6.5.3 Test data

Temperature	23.6℃	Humidity	52.3%
Test Engineer	Paddi Chen	Test Mode	Transmitting

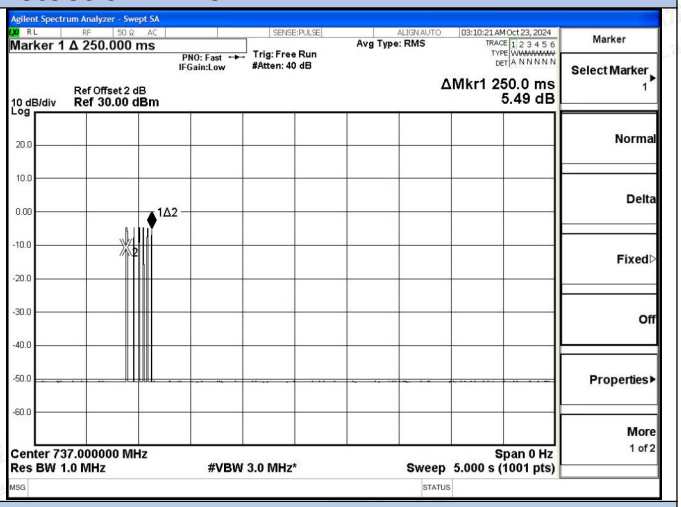
Test Results Of Detection Time				
Operation Band		Detection Time (s)	Limit (s)	Result
Uplink	Lower 700 Band	0.270	0.300	PASS
	Upper 700 Band	0.265	0.300	PASS
	Cellular Band	0.255	0.300	PASS
	PCS Band	0.165	0.300	PASS
	AWS Band	0.230	0.300	PASS
Downlink	Lower 700 Band	0.250	1.000	PASS
	Upper 700 Band	0.275	1.000	PASS
	Cellular Band	0.240	1.000	PASS
	PCS Band	0.270	1.000	PASS
	AWS Band	0.255	1.000	PASS

Test Results Of Restarting Time						
Operation Band		Restarting Time (s)	Limit (s)	Restarting Counts	Limit	Result
Uplink	Lower 700 Band	See Test Graphs of Restarting Time	60	4	5	PASS
	Upper 700 Band		60	4	5	PASS
	Cellular Band		60	4	5	PASS
	PCS Band		60	3	5	PASS
	AWS Band		60	4	5	PASS
Downlink	Lower 700 Band		60	4	5	PASS
	Upper 700 Band		60	4	5	PASS
	Cellular Band		60	4	5	PASS
	PCS Band		60	3	5	PASS
	AWS Band		60	4	5	PASS

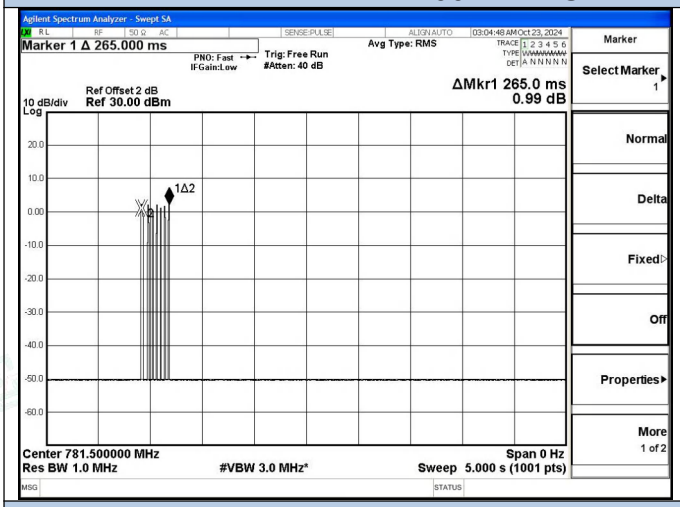
Test Graphs of Detection Time



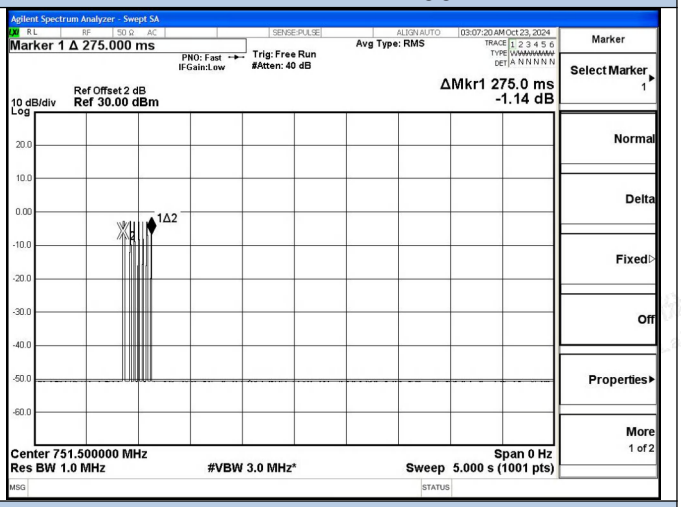
Detection Time-Lower 700 Band UL



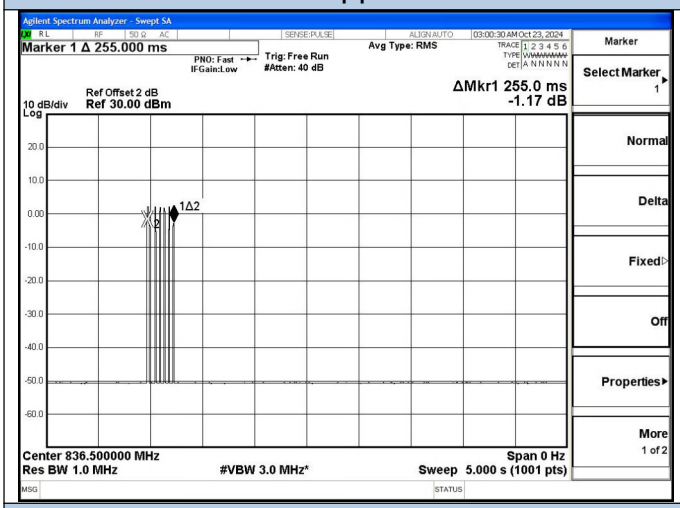
Detection Time-Lower 700 Band DL



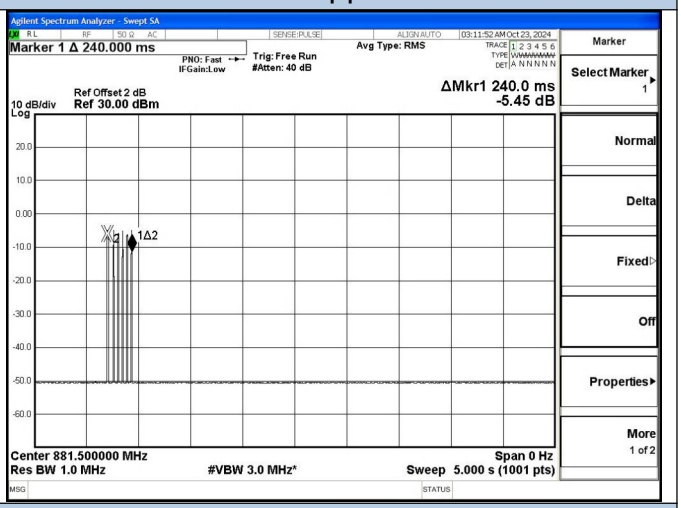
Detection Time-Upper 700 Band UL



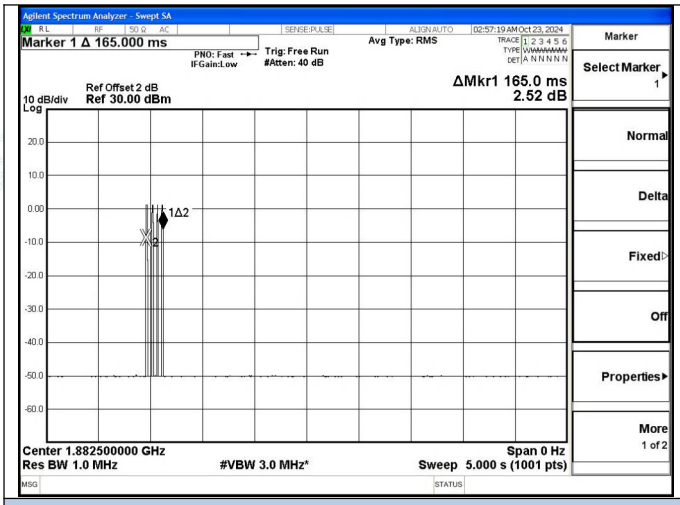
Detection Time-Upper 700 Band DL



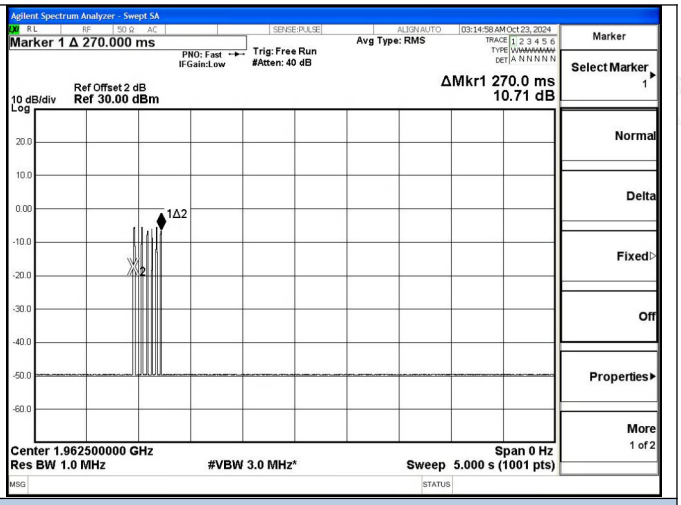
Detection Time-Cellular Band UL



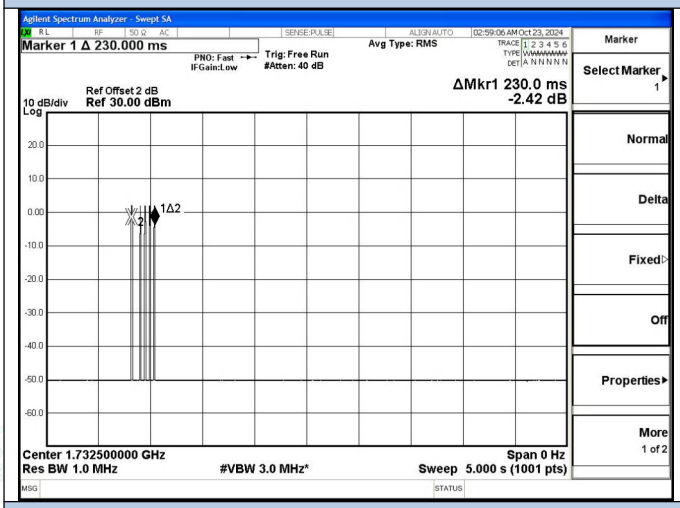
Detection Time-Cellular Band DL



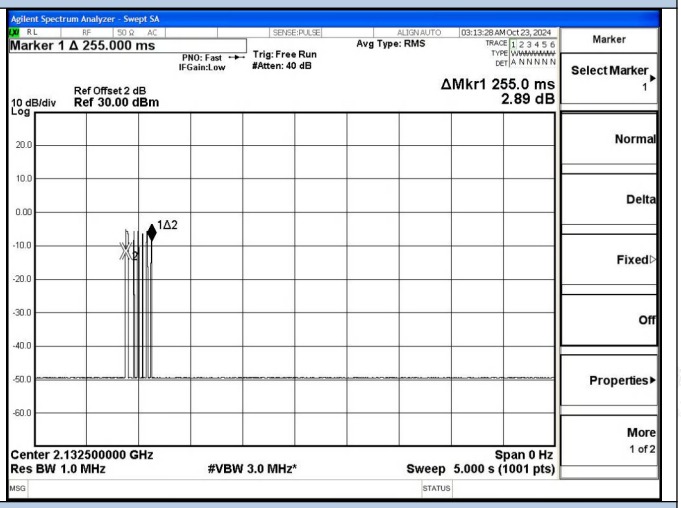
Detection Time-PCS Band UL



Detection Time-PCS Band DL

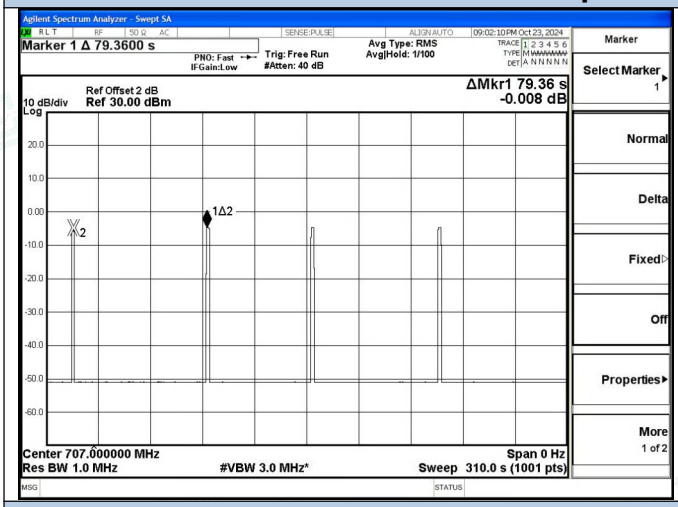


Detection Time-AWS Band UL

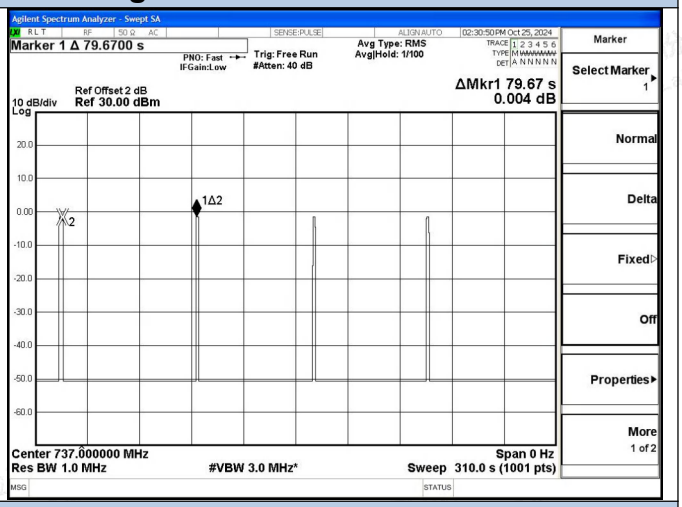


Detection Time-AWS Band DL

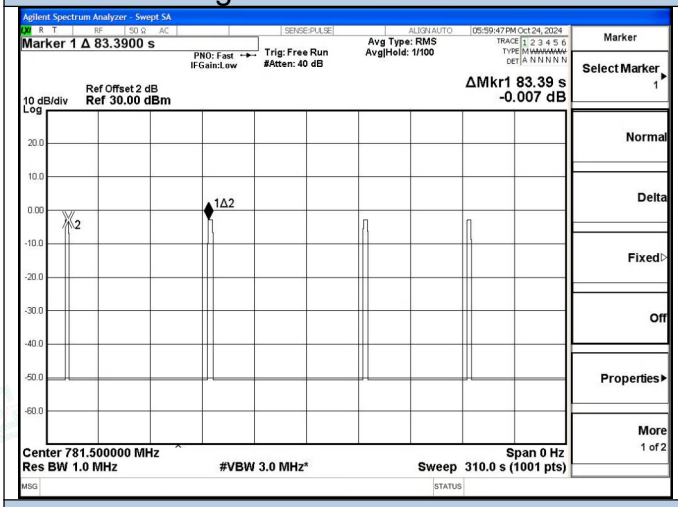
Test Graphs of Restarting Time



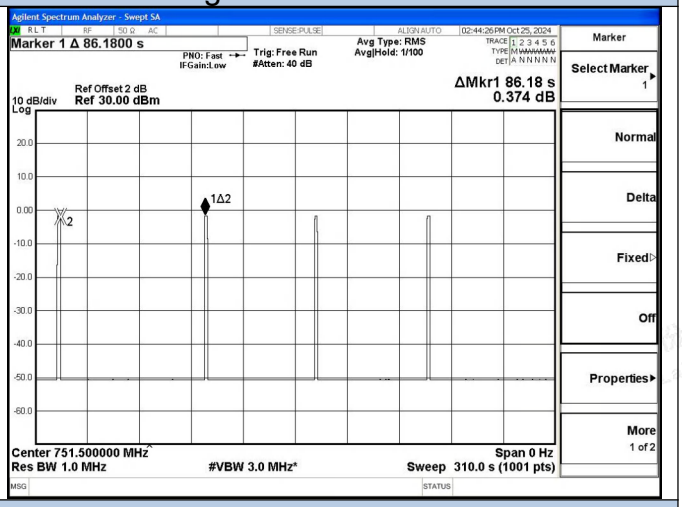
Restarting Time-Lower 700 Band UL



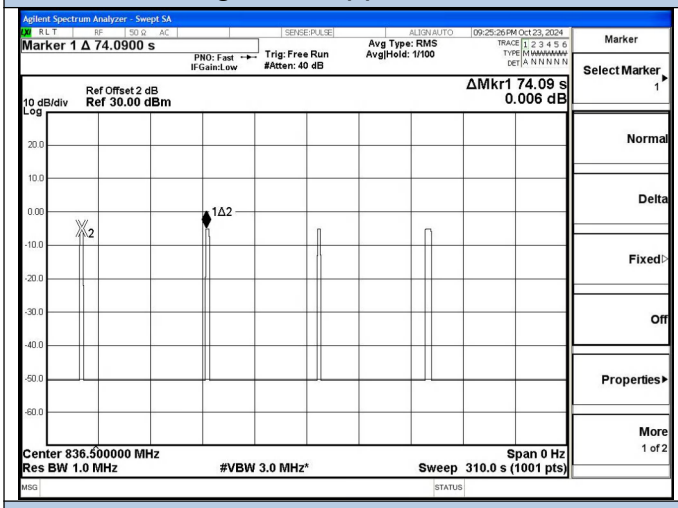
Restarting Time-Lower 700 Band DL



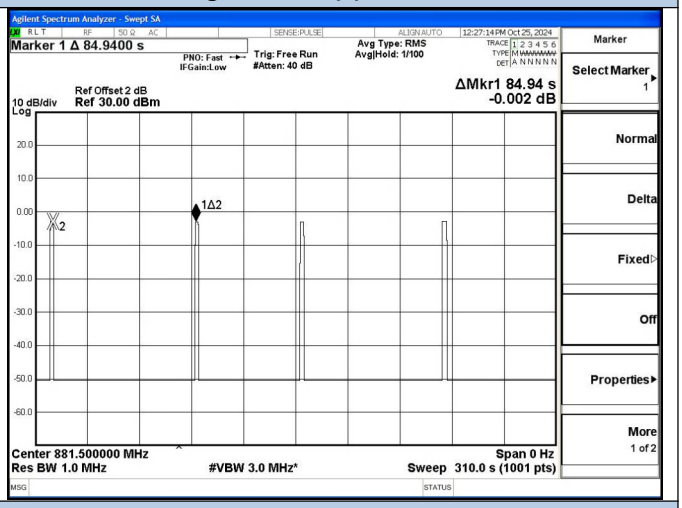
Restarting Time-Upper 700 Band UL



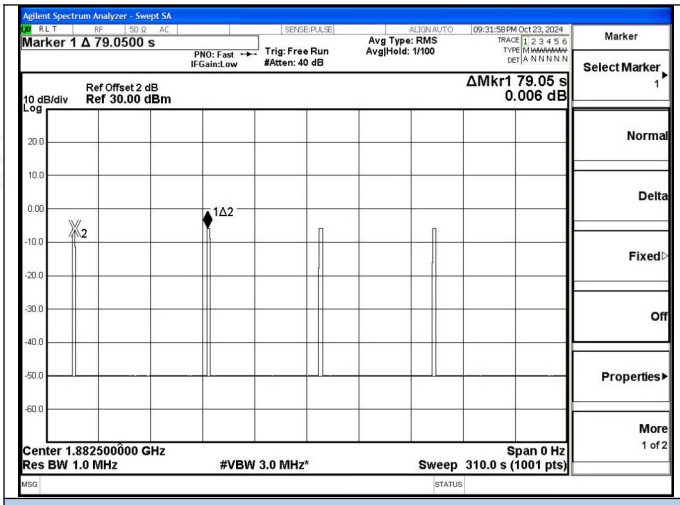
Restarting Time-Upper 700 Band DL



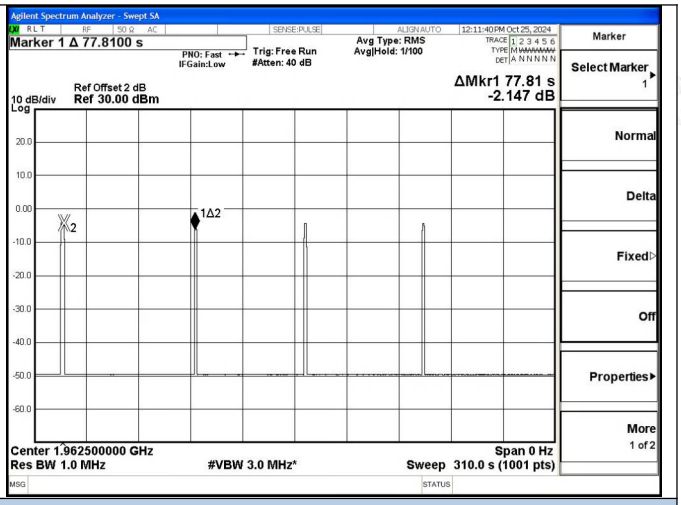
Restarting Time-Cellular Band UL



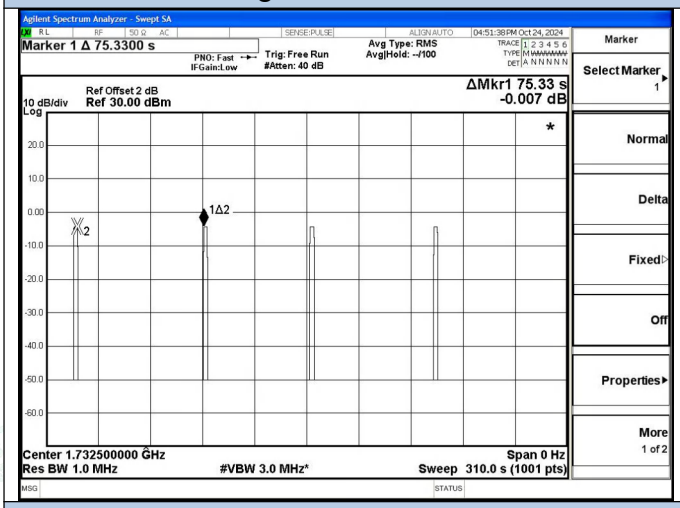
Restarting Time-Cellular Band DL



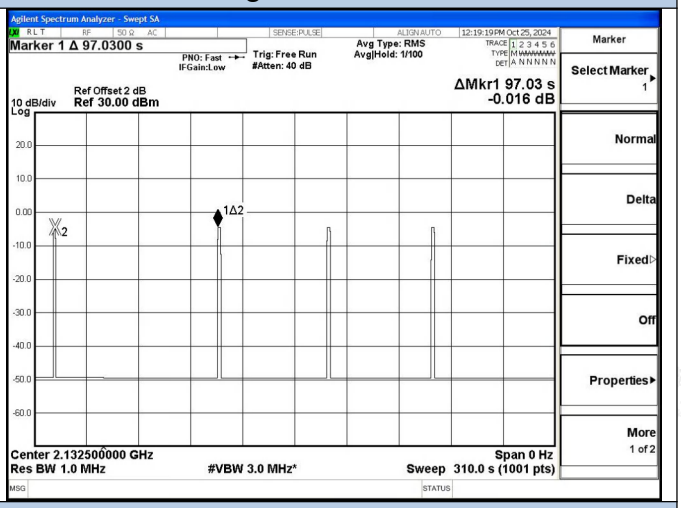
Restarting Time-PCS Band UL



Restarting Time-PCS Band DL



Restarting Time-AWS Band UL



Restarting Time-AWS Band DL

Oscillation mitigation or shutdown:

Lower 700 Band	Uplink		
Signal Type	AWGN		
Isolation	Deffrence	Limit	Result
dB	dB	dB	
+5	6.21	<12	Pass
+4	7.86	<12	Pass
+3	7.54	<12	Pass
+2	9.41	<12	Pass
+1	10.02	<12	Pass
0	shutdown		

Lower 700 Band	Downlink		
Signal Type	AWGN		
Isolation	Deffrence	Limit	Result
dB	dB	dB	
+5	6.35	<12	Pass
+4	6.96	<12	Pass
+3	7.78	<12	Pass
+2	9.47	<12	Pass
+1	10.21	<12	Pass
0	11.18	<12	Pass
-1	shutdown		

Upper 700 Band	Uplink		
Signal Type	AWGN		
Isolation	Deffrence	Limit	Result
dB	dB	dB	
+5	6.24	<12	Pass
+4	7.09	<12	Pass
+3	8.29	<12	Pass
+2	9.02	<12	Pass
+1	9.75	<12	Pass
0	10.57	<12	Pass
-1	shutdown		

Upper 700 Band	Downlink		
Signal Type	AWGN		
Isolation	Deffrence	Limit	Result
dB	dB	dB	
+5	6.27	<12	Pass
+4	7.25	<12	Pass
+3	8.42	<12	Pass
+2	9.23	<12	Pass
+1	10.84	<12	Pass
0	shutdown		

Cellular Band	Uplink		
Signal Type	AWGN		
Isolation	Deffrence	Limit	Result
dB	dB	dB	
+5	7.09	<12	Pass
+4	8.67	<12	Pass
+3	9.36	<12	Pass
+2	10.21	<12	Pass
+1	shutdown		

Cellular Band	Downlink		
Signal Type	AWGN		
Isolation	Deffrence	Limit	Result
dB	dB	dB	
+5	5.28	<12	Pass
+4	7.95	<12	Pass
+3	8.50	<12	Pass
+2	9.42	<12	Pass
+1	10.19	<12	Pass
0	shutdown		

PCS Band	Uplink		
Signal Type	AWGN		
Isolation	Deffrence	Limit	Result
dB	dB	dB	
+5	5.97	<12	Pass
+4	6.38	<12	Pass
+3	7.11	<12	Pass
+2	7.83	<12	Pass
+1	9.53	<12	Pass
0	10.15	<12	Pass
-1	shutdown		

PCS Band	Downlink		
Signal Type	AWGN		
Isolation	Deffrence	Limit	Result
dB	dB	dB	
+5	7.42	<12	Pass
+4	8.83	<12	Pass
+3	9.66	<12	Pass
+2	10.28	<12	Pass
+1	11.15	<12	Pass
0	shutdown		

AWS Band	Uplink		
Signal Type	AWGN		
Isolation	Deffrence	Limit	Result
dB	dB	dB	
+5	7.26	<12	Pass
+4	8.66	<12	Pass
+3	9.42	<12	Pass
+2	9.79	<12	Pass
+1	10.61	<12	Pass
0	shutdown		

AWS Band	Downlink		
Signal Type	AWGN		
Isolation	Deffrence	Limit	Result
dB	dB	dB	
+5	6.77	<12	Pass
+4	7.78	<12	Pass
+3	8.32	<12	Pass
+2	9.52	<12	Pass
+1	10.43	<12	Pass
0	shutdown		

6.6 Intermodulation Limits

6.6.1 Applicable Standard

According to §20.21(e)(8)(i)(F) Intermodulation Limits:

The transmitted intermodulation products of a consumer booster at its uplink and downlink ports shall not exceed the power level of −19 dBm for the supported bands of operation.

6.6.2 Test Procedure

According to section 7.4 of KDB 935210 D03 Signal Booster Measurement v04r04:

a) Connect the signal booster to the test equipment as shown in Figure 9. Begin with the uplink output (donor) port connected to the spectrum analyzer.
b) Set the spectrum analyzer RBW = 3 kHz.
c) Set the VBW ≥ 3 RBW.
d) Select the rms detector.
e) Set the spectrum analyzer center frequency to the center of the supported operational band under test.
f) Set the span to 5 MHz. Affirm that the number of measurement points per sweep ≥ (2 × span)/RBW.
g) Configure the two signal generators for CW operation with generator #1 tuned 300 kHz below the operational band center frequency and generator #2 tuned 300 kHz above the operational band center frequency. If the maximum output power is not at the operational-band (booster pass band) center frequency, configure the test signal pair around the frequency with maximum output power as determined per 7.2.
h) Set the signal generator amplitudes so that the power from each into the EUT is equivalent, then turn on the RF output.
i) Simultaneously increase each signal generators' amplitude equally until just before the EUT begins AGC, then affirm that all intermodulation-product emissions (if any occur) are below the specified limit of −19 dBm.
j) Use the trace averaging function of the spectrum analyzer, and wait for the trace to stabilize. Place a marker at the highest amplitude intermodulation-product emission.
k) Record the maximum intermodulation product amplitude level that is observed.
l) Capture the spectrum analyzer trace for inclusion in the test report.
m) Repeat 7.4e) to 7.4l) for all uplink and downlink operational bands.
NOTE–If using a single signal generator with dual outputs, affirm that intermodulation products are not the result of the generator.
n) Increase the signal generator amplitude in 2 dB steps to 10 dB above the AGC threshold determined in 7.4i), but not exceeding the maximum input level of 5.5, to affirm that the EUT maintains compliance with the intermodulation limit. The test report shall include either a statement describing that the device complies at 10 dB above AGC or at the 5.5 power levels, or a table showing compliance at the additional input power(s) required.

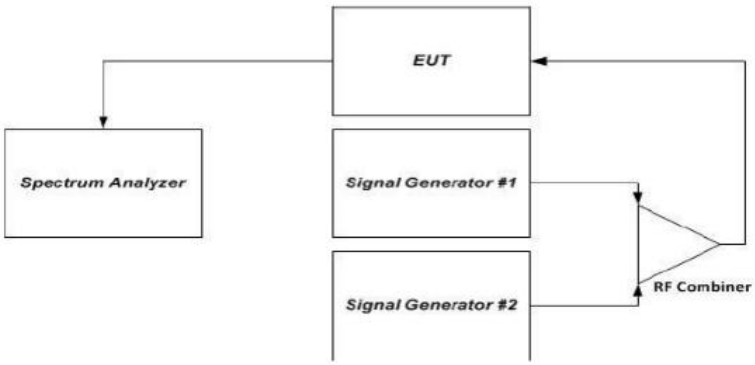
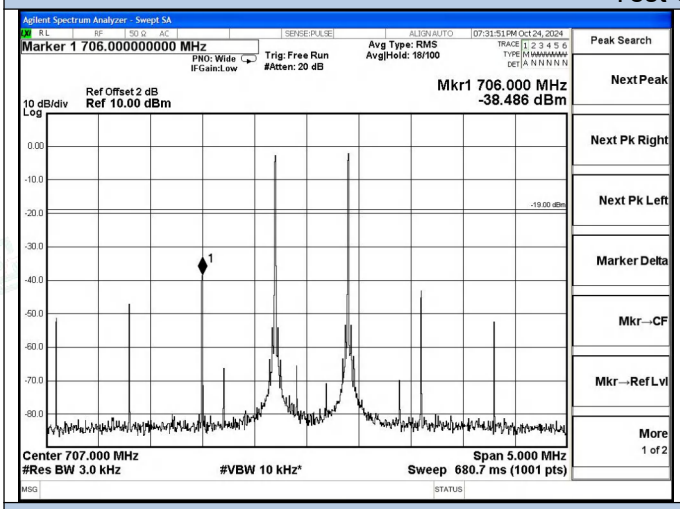


Figure 9 – Intermodulation product instrumentation test setup

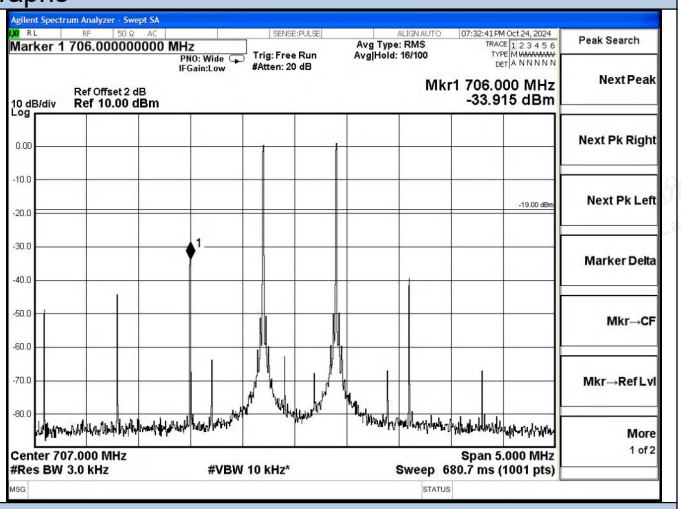
6.6.3 Test Data

Temperature	23.6℃	Humidity	52.3%
Test Engineer	Paddi Chen	Test Mode	Transmitting

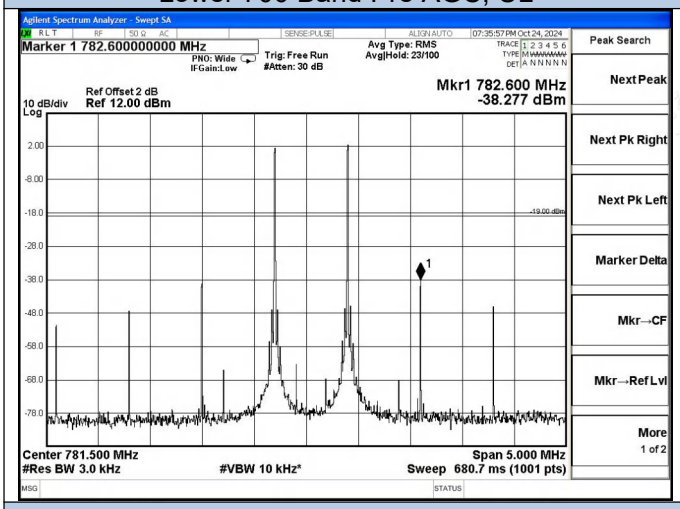
Test Graphs



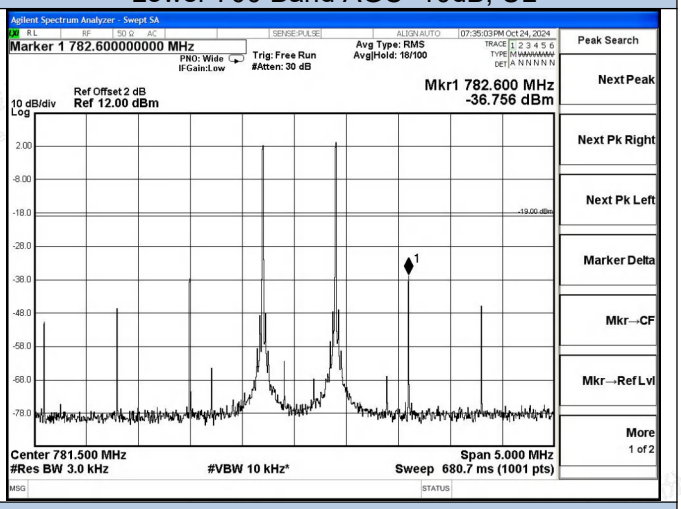
Lower 700 Band Pre AGC, UL



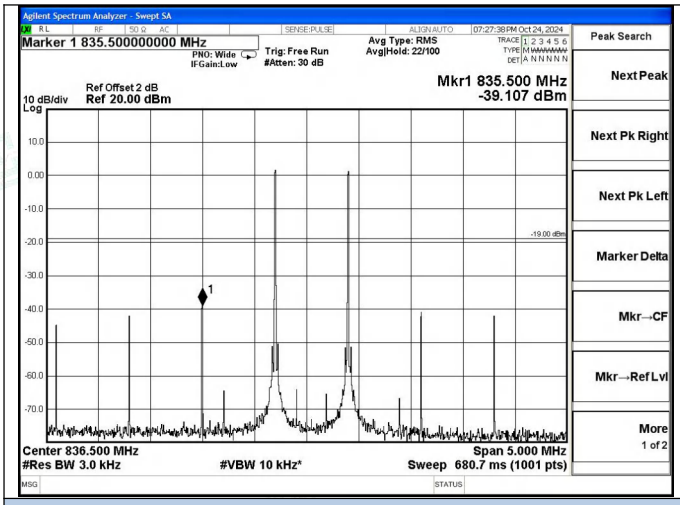
Lower 700 Band AGC+10dB, UL



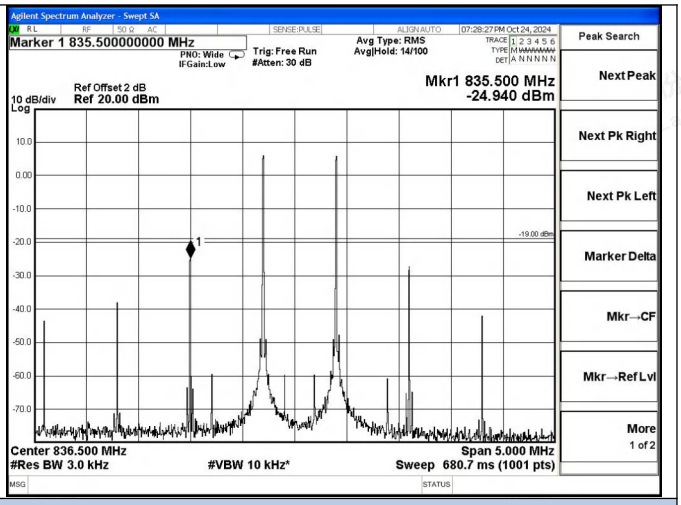
Upper 700 Band Pre AGC, UL



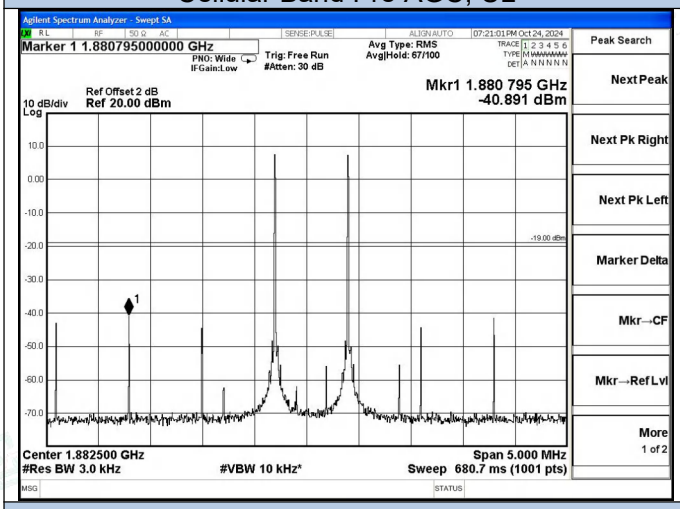
Upper 700 Band AGC+10dB, UL



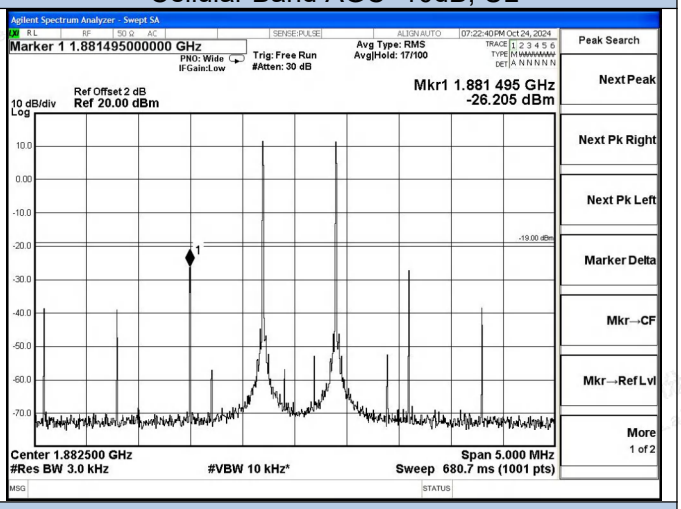
Cellular Band Pre AGC, UL



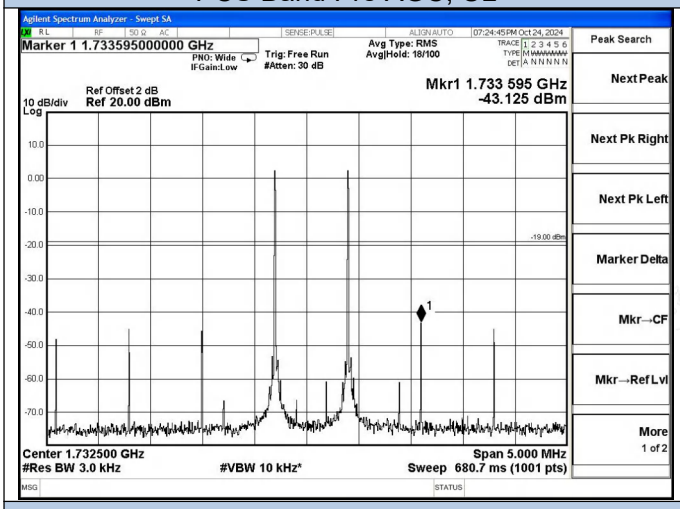
Cellular Band AGC+10dB, UL



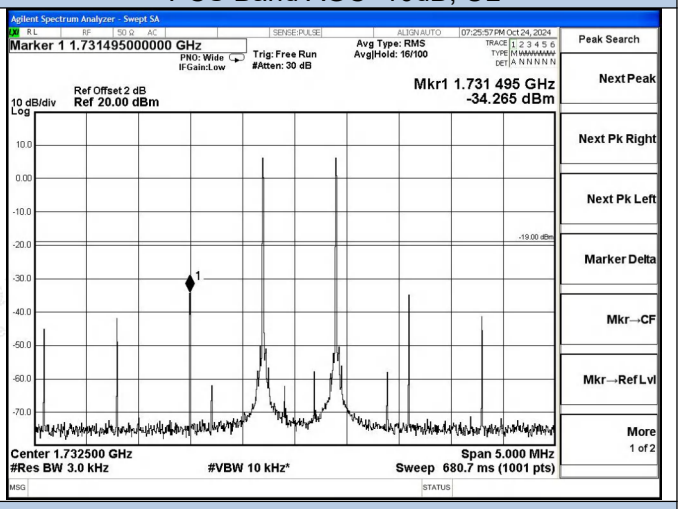
PCS Band Pre AGC, UL



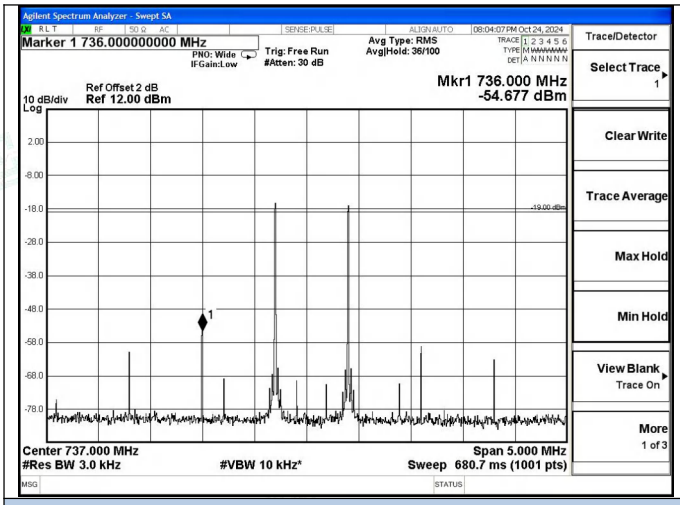
PCS Band AGC+10dB, UL



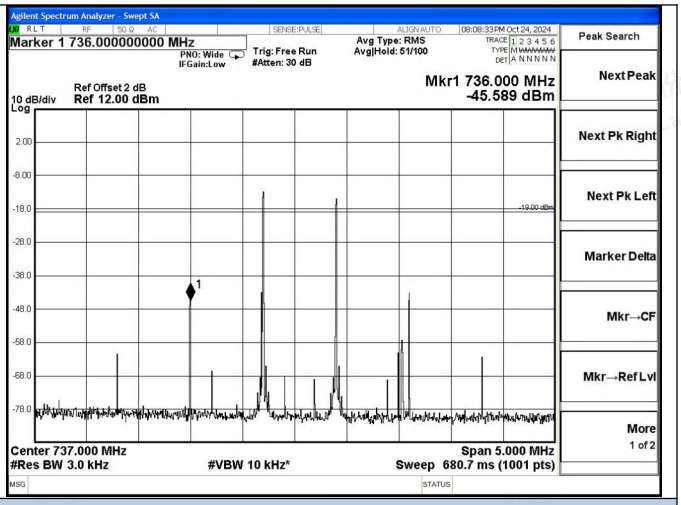
AWS Band Pre AGC, UL



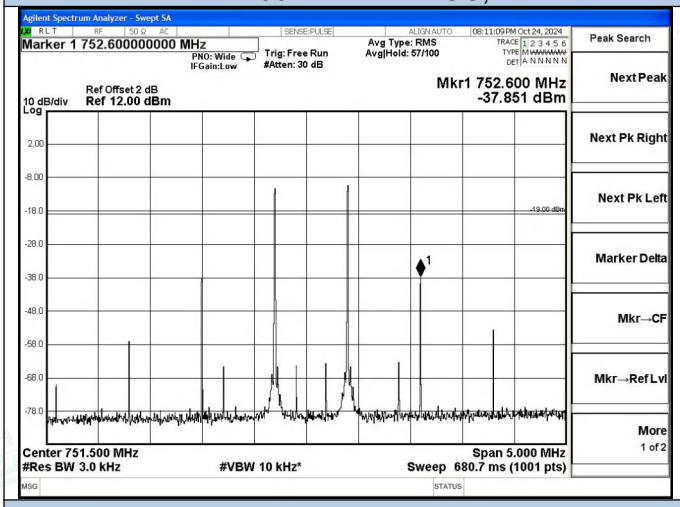
AWS Band AGC+10dB, UL



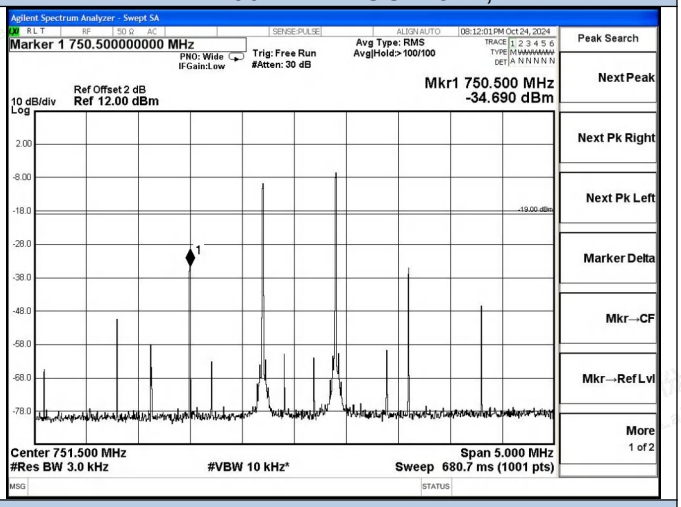
Lower 700 Band Pre AGC, DL



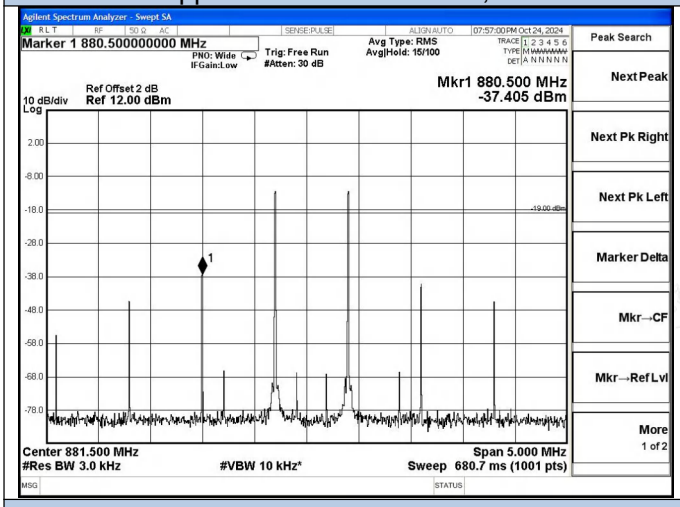
Lower 700 Band AGC+10dB, DL



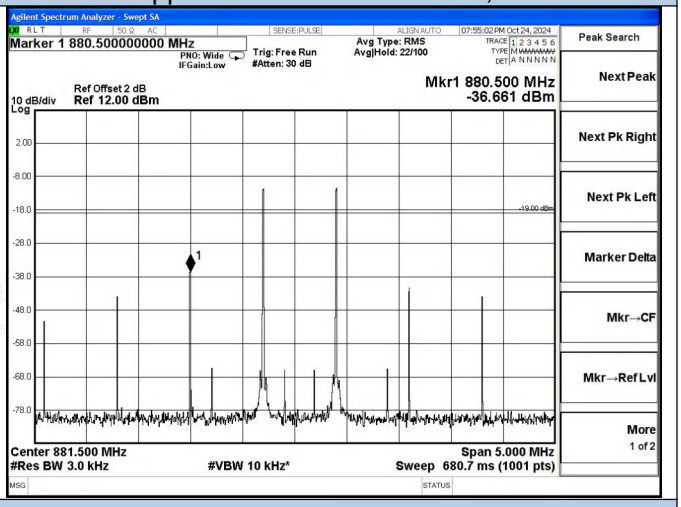
Upper 700 Band Pre AGC, DL



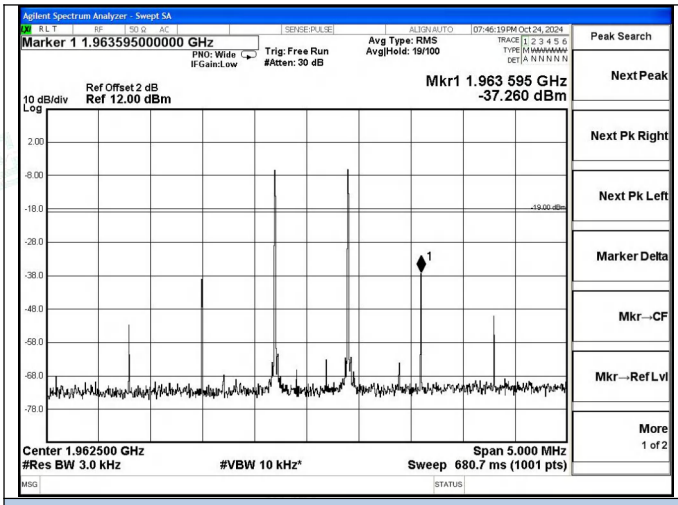
Upper 700 Band AGC+10dB, DL



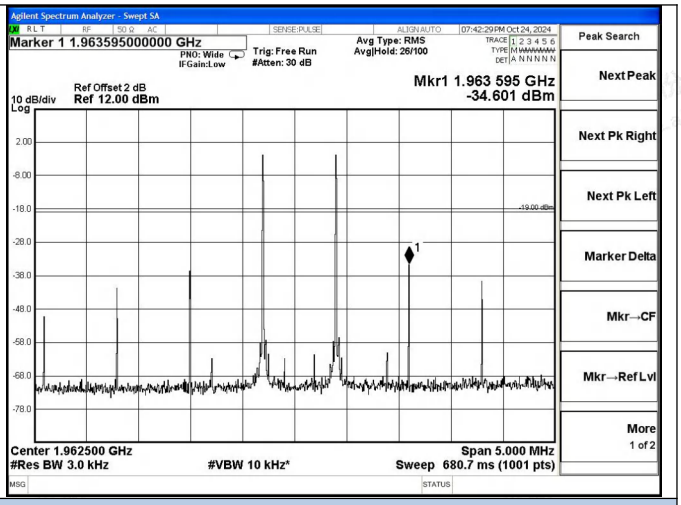
Cellular Band Pre AGC, DL



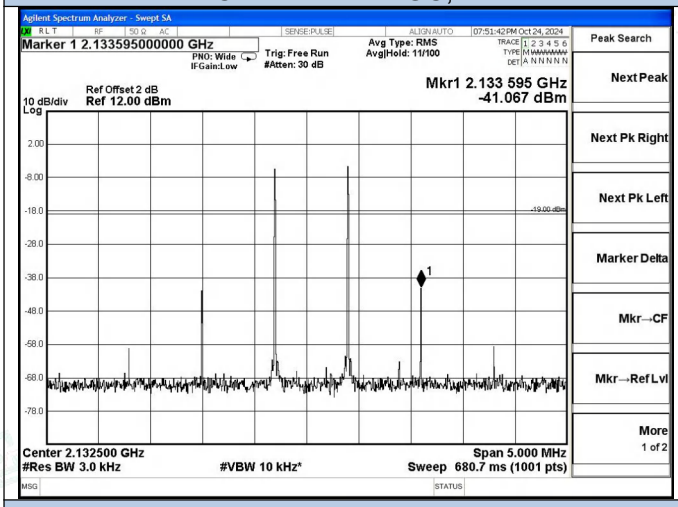
Cellular Band AGC+10dB, DL



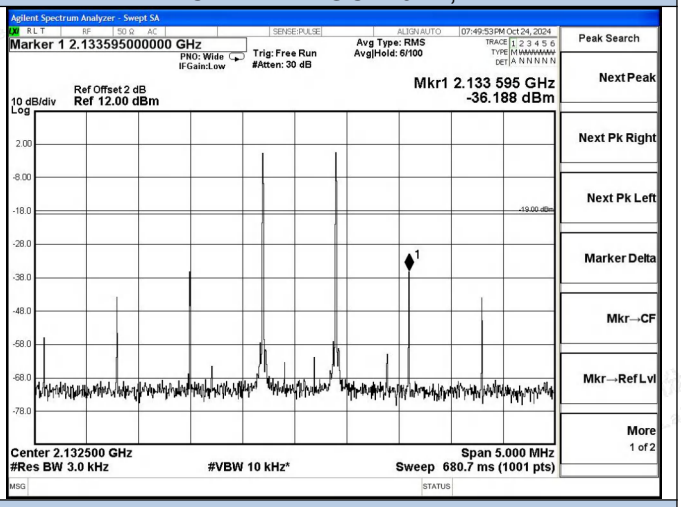
PCS Band Pre AGC, DL



PCS Band AGC+10dB, DL



AWS Band Pre AGC, DL



AWS Band AGC+10dB, DL

6.7 Out of Band Emission

6.7.1 Applicable Standard

According to § 20.21(e)(8)(i)(E) Out of Band Emission Limits:

Booster out of band emissions (OOBE) shall be at least 6 dB below the FCC's mobile emission limits for the supported bands of operation. Compliance to OOBE limits will utilize high peak-to-average CMRS signal types.

For B2:Per FCC §24.238 the power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10log(P) dB.

For B4: Per §27.53(h): For operations in the 1710–1755 MHz and 2110–2155 MHz bands, the power of any emission outside a licensee's frequency block shall be attenuated below the transmitter power (P) by at least 43 + 10 log10(P) dB.

For B5:Per FCC §22.917 the power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least 43 + 10log(P) dB.

For B12: Per §27.53 (g): For operations in the 698–746 MHz band, the power of any emission outside a licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, by at least 43 + 10 log (P) dB.

For B13: Per §27.53 (c): For operations in the 776-788 MHz band, the power of any emission outside the licensee's frequency band(s) of operation shall be attenuated below the transmitter power (P) within the licensed band(s) of operation, measured in watts, in accordance with the following: On any frequency outside the 776-788 MHz band, the power of any emission shall be attenuated outside the band below the transmitter power (P) by at least 43 + 10 log (P) dB.

Calculation: Limit (dBm) =[P-43 + 10 log (P)] - 6= -19 dBm

6.7.2 Test Procedure

According to section 7.5 of KDB 935210 D03 Signal Booster Measurement v04r04:

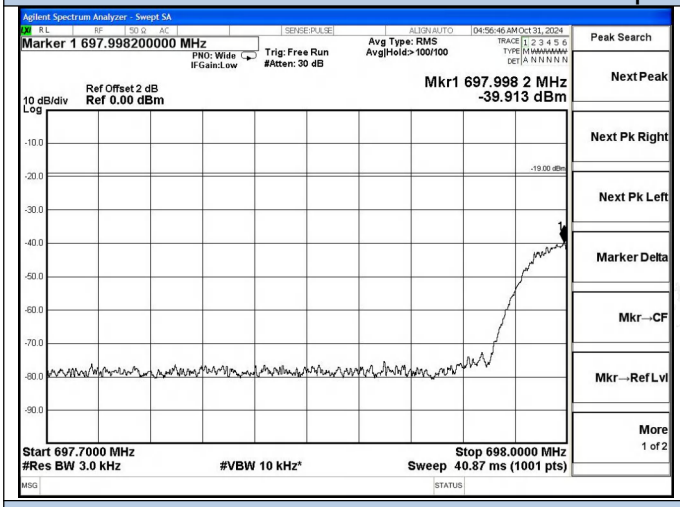
a) Connect the EUT to the test equipment as shown in Figure 1. Begin with the uplink output (donor) port connected to the spectrum analyzer.
b) Configure the signal generator for the appropriate operation for all uplink and downlink bands:
1) GSM: 0.2 MHz from upper and lower band edges.
2) LTE (5 MHz): 2.5 MHz from upper and lower band edges.
3) CDMA: 1.25 MHz from upper and lower band edges, except for cellular band as follows (only the upper and lower frequencies need to be tested):
824.88 MHz, 845.73 MHz, 836.52 MHz, 848.10 MHz,
869.88 MHz, 890.73 MHz, 881.52 MHz, 893.10 MHz.
NOTE 1–Alternative test modulation types:
• CDMA (alternative 1.25 MHz AWGN)
• LTE 5 MHz (alternative W-CDMA or 4.1 MHz AWGN)
NOTE 2–For LTE, the signal generator should use the uplink and downlink signal types for these modulations in uplink and downlink tests, respectively. LTE shall use 5 MHz signal, 25 resource blocks transmitting.

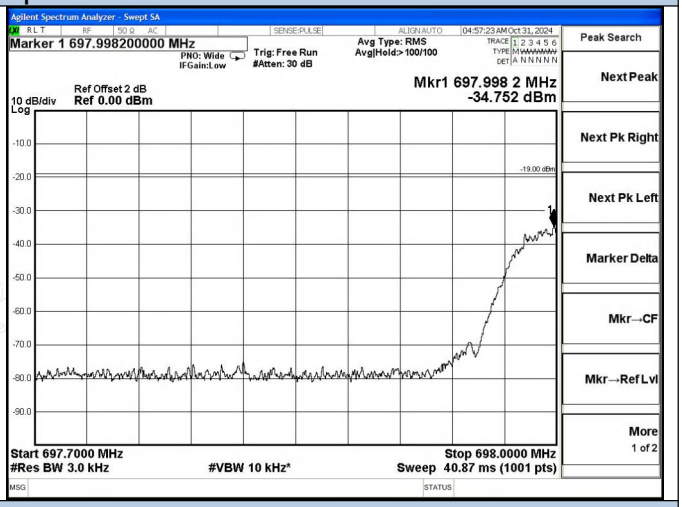
NOTE 3–When using an AWGN test signal, the bandwidth shall be the measured 99% OBW.
c) Set the signal generator amplitude to the maximum power level prior to AGC similar to 7.2.2e) to7.2.2f) of the power measurement procedures for the appropriate modulations.
d) Set RBW = measurement bandwidth specified in the applicable rule section for the supported frequency band (see Appendix A for cross-reference to applicable rule section).
e) NOTE 3–Within 300 kHz and 3 MHz away from band edge, if smaller RBW is used (i.e., RBW < 100 kHz or 1 MHz, for above and below 1 GHz, respectively), per Parts 24 and 27 the smaller RBW is applicable only for frequencies within 100 kHz or 1 MHz (for above and below 1 GHz, respectively) away from the band edge.
f) Set VBW = 3 RBW.
g) Select the power averaging (rms) detector.
h) Sweep time = auto-couple.
i) Set the analyzer start frequency to the upper band/block edge frequency and the stop frequency to the upper band/block edge frequency plus: 300 kHz (when operational frequency is < 1 GHz), or 3 MHz (when operational frequency is ≥ 1 GHz).
j) Trace average at least 100 traces in power averaging (i.e., rms) mode.
k) Use peak marker function to find the maximum power level.
l) Capture the spectrum analyzer trace of the power level for inclusion in the test report.
m) Increase the signal generator amplitude in 2 dB steps until the maximum input level per 5.5 is reached. Affirm that the EUT maintains compliance with the OOBE limits. The test report shall include either a statement describing that the device complies at 10 dB above AGC or at the 5.5 power levels, or a table showing compliance at the additional input power(s) required.
n) Reset the analyzer start frequency to the lower band/block edge frequency minus: 300 kHz (when operational frequency is < 1 GHz), or 3 MHz (when operational frequency is ≥ 1 GHz), and the stop frequency to the lower band/block edge frequency, then repeat 7.5i) to 7.5l). Repeat 7.5b) through 7.5m) for each uplink and downlink operational band.

6.7.3 Test data

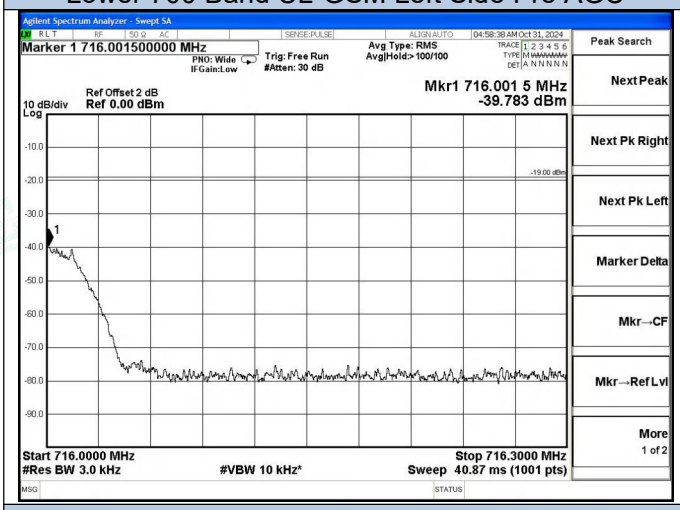
Temperature	23.6℃	Humidity	52.3%
Test Engineer	Paddi Chen	Test Mode	Transmitting

Test Graphs-Uplink-GSM

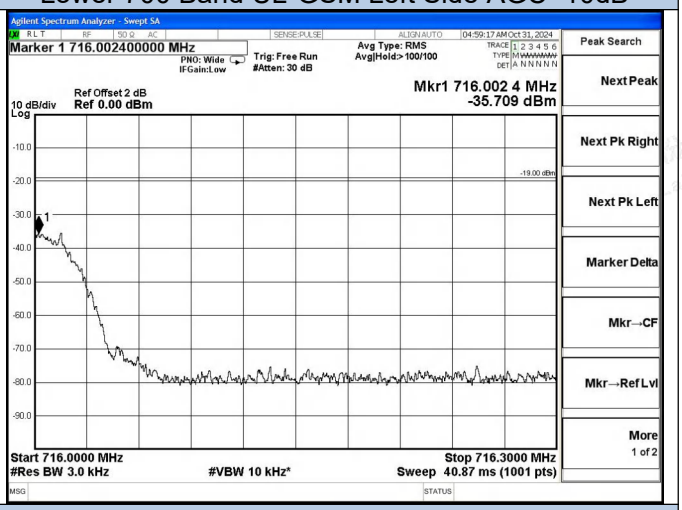




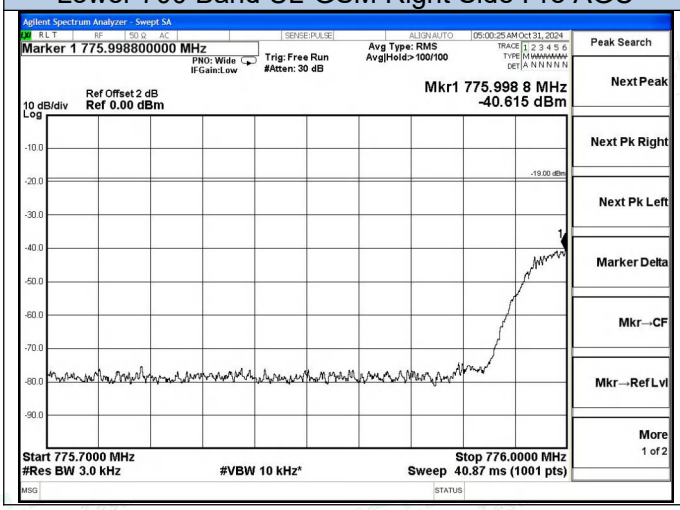
Lower 700 Band UL-GSM Left Side Pre AGC



Lower 700 Band UL-GSM Left Side AGC+10dB



Lower 700 Band UL-GSM Right Side Pre AGC



Lower 700 Band UL-GSM Right Side AGC+10dB