Test_Graph_LE125K_ANT1_2440_125Kbps_PSD

Test_Graph_LE125K_ANT1_2480_125Kbps_PSD

10. Conducted Band Edge and Out-of-Band Emissions

10.1 Provisions Applicable

The limit for out-of-band spurious emissions at the band edge is 20dB below the fundamental emission level, as determined from the in-band power measurement of the DTS channel performed in a 100kHz bandwidth per the PSD procedure.

10.2 Measurement Procedure

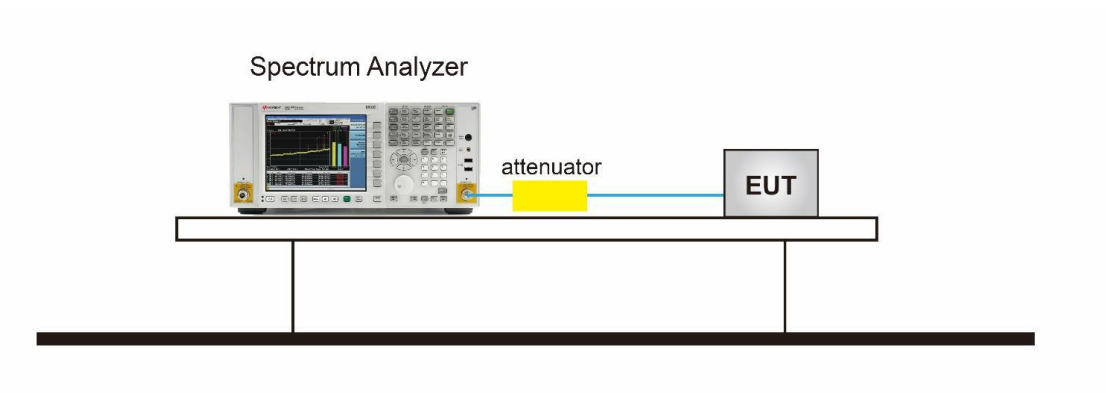
- Reference level measurement

1. Set instrument center frequency to DTS channel center frequency
2. Set the span to ≥ 1.5 times the DTS bandwidth
3. Set the RBW = 100 kHz
4. Set the VBW ≥ 3 x RBW
5. Detector = peak
6. Sweep time = auto couple
7. Trace mode = max hold
8. Allow trace to fully stabilize
9. Input compensation coefficient (dB) = Cable Loss (dB) + Attenuator attenuation value (dB)

- Emission level measurement

1. Set the center frequency and span to encompass frequency range to be measured
2. RBW = 100kHz
3. VBW = 300kHz
4. Detector = Peak
5. Trace mode = max hold
6. Sweep time = auto couple
7. The trace was allowed to stabilize
8. Input compensation coefficient (dB) = Cable Loss (dB) + Attenuator attenuation value (dB)

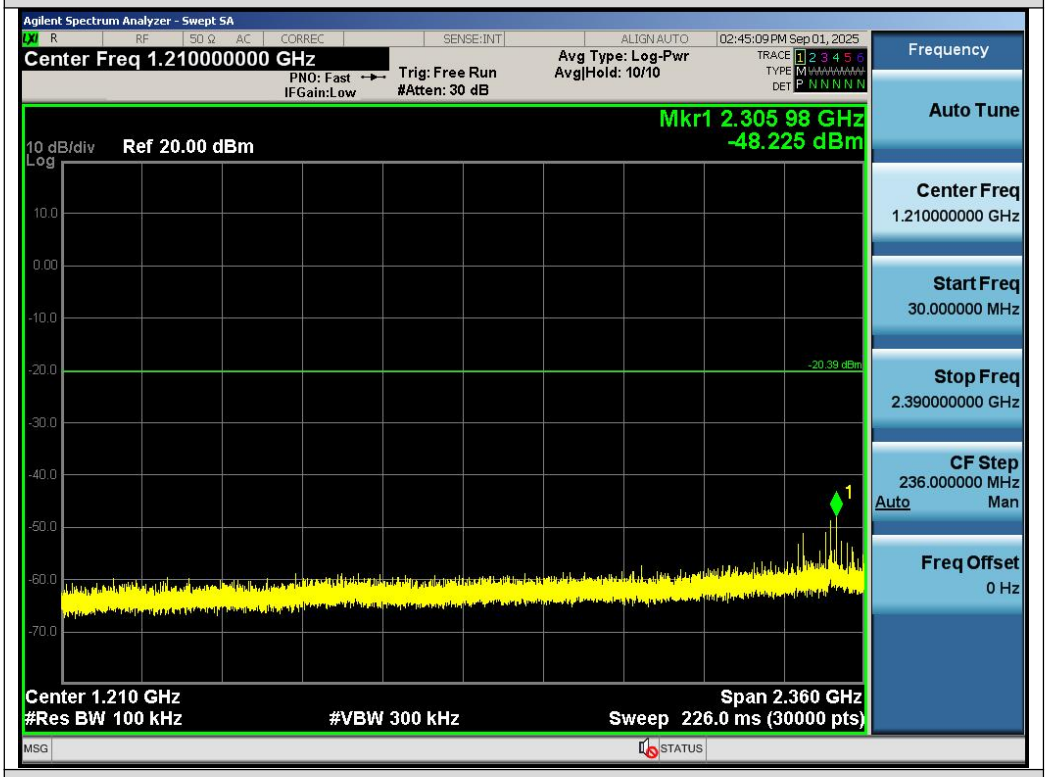
10.3 Measurement Setup (Block Diagram of Configuration)



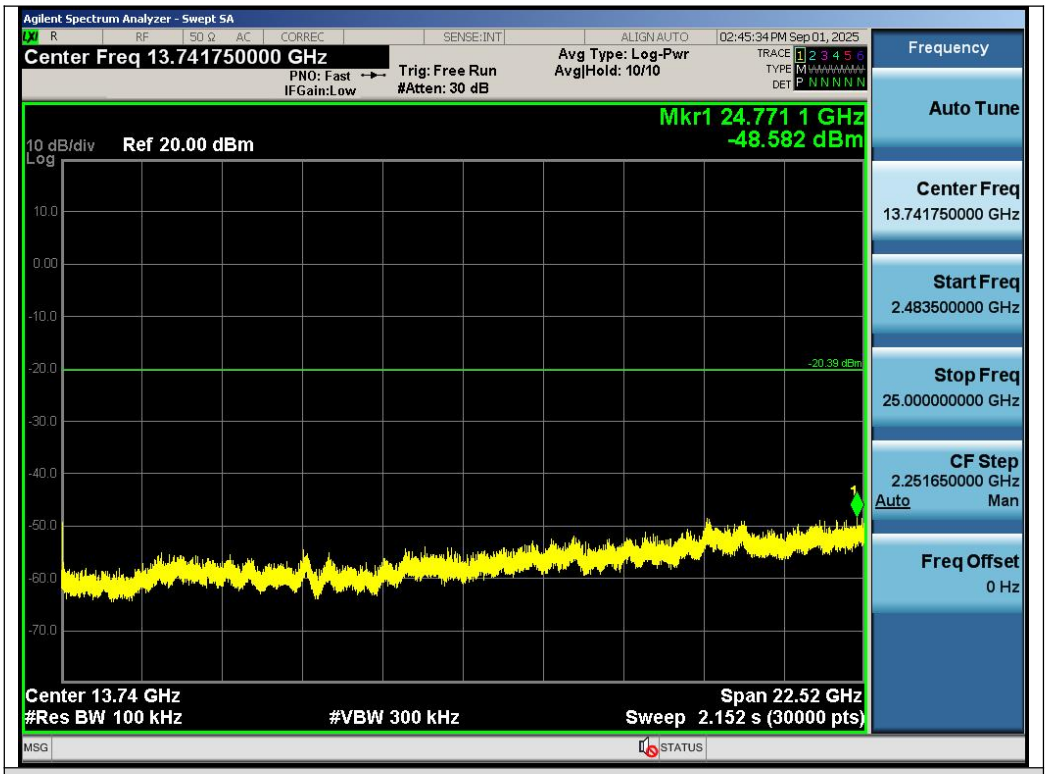
10.4 Measurement Results

Test Graphs of Spurious Emissions in Non-Restricted Frequency Bands

Test_Graph_LE1M_ANT1_2402_1Mbps_Reference Level

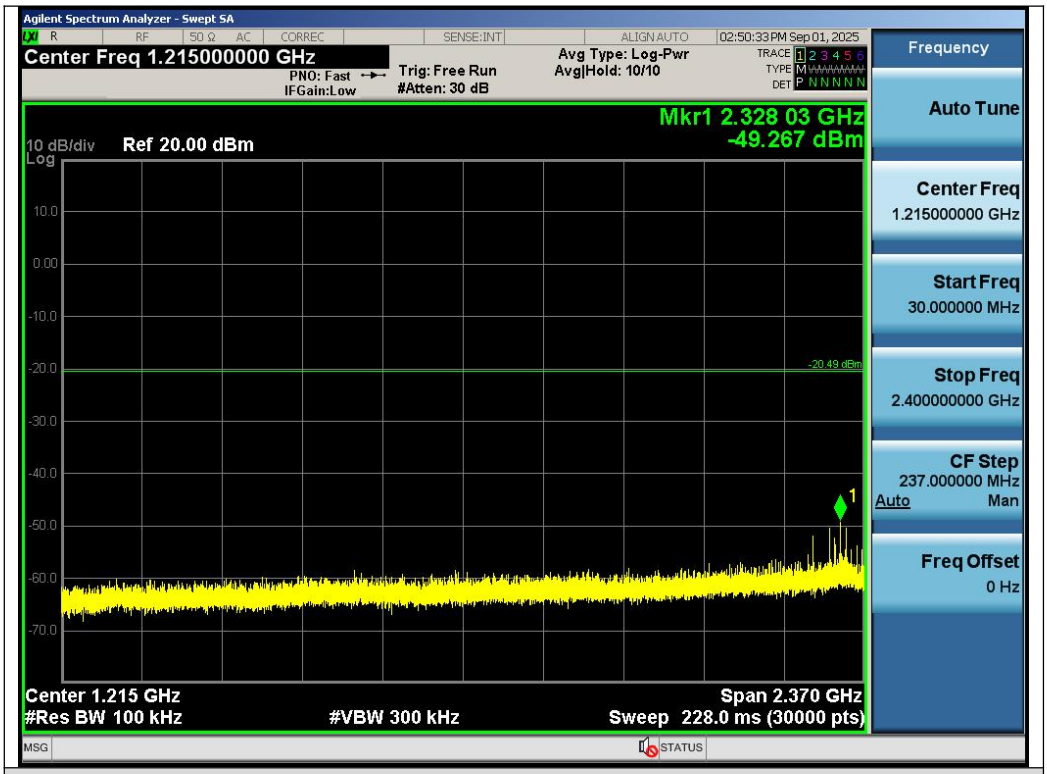


Test_Graph_LE1M_ANT1_2402_1Mbps_Lower Band Emissions

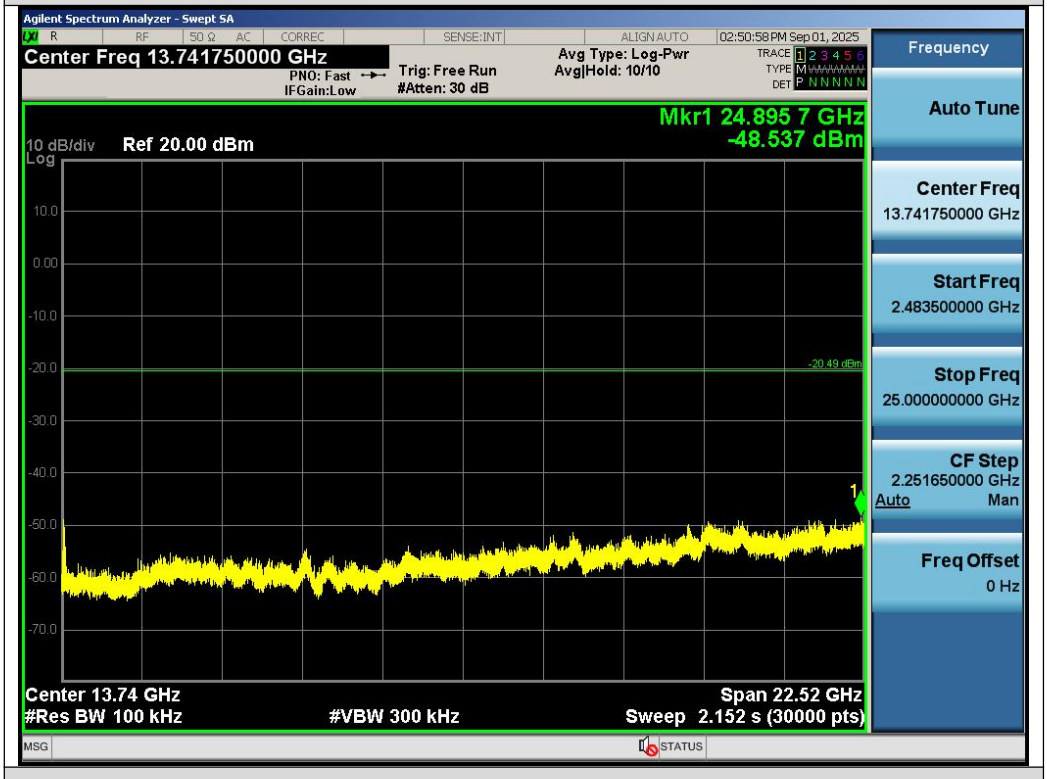


Test_Graph_LE1M_ANT1_2402_1Mbps_Higher Band Emissions

Test_Graph_LE1M_ANT1_2440_1Mbps_Reference Level

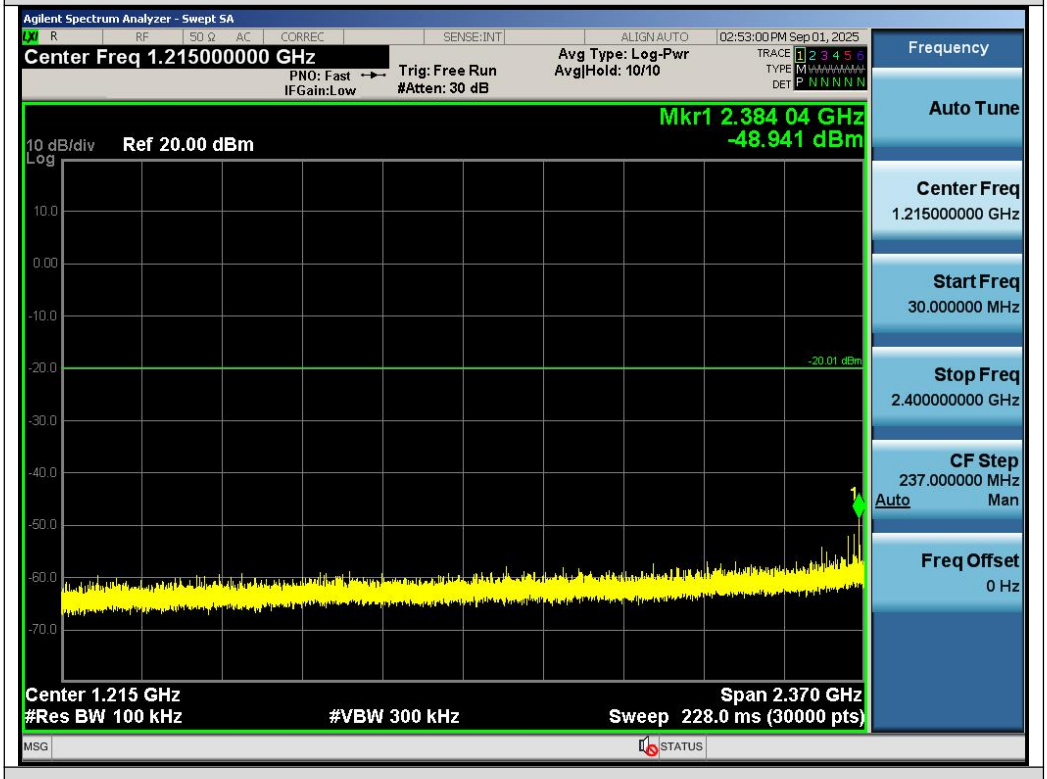


Test_Graph_LE1M_ANT1_2440_1Mbps_Lower Band Emissions

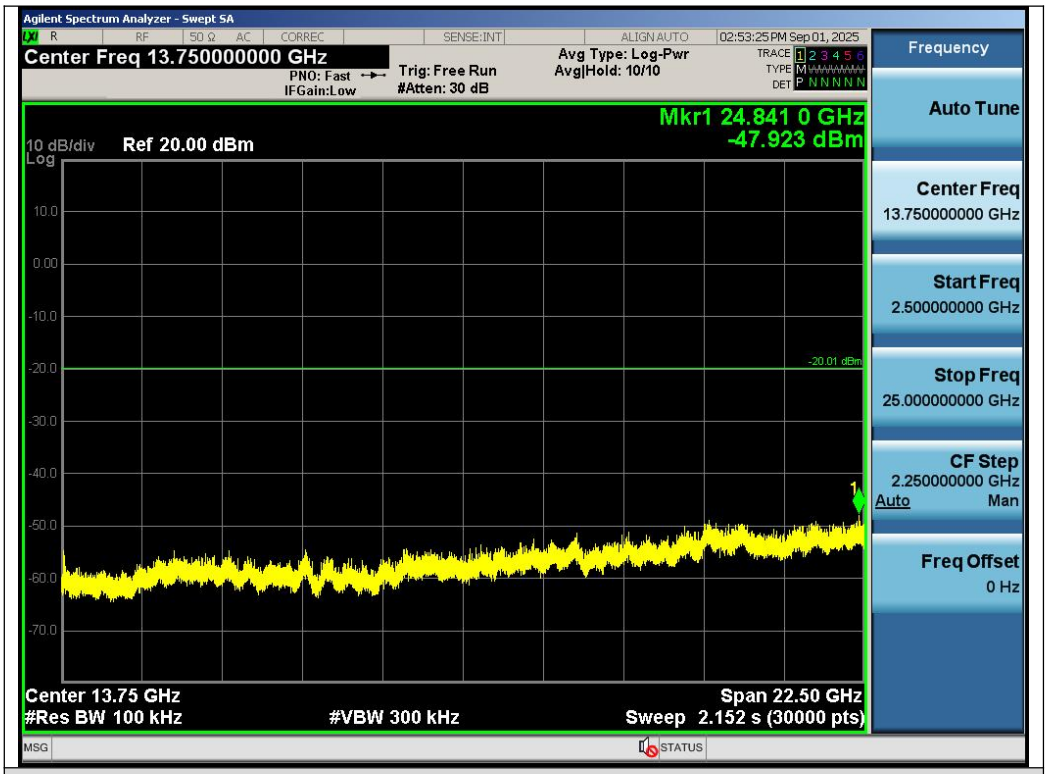


Test_Graph_LE1M_ANT1_2440_1Mbps_Higher Band Emissions

Test_Graph_LE1M_ANT1_2480_1Mbps_Reference Level

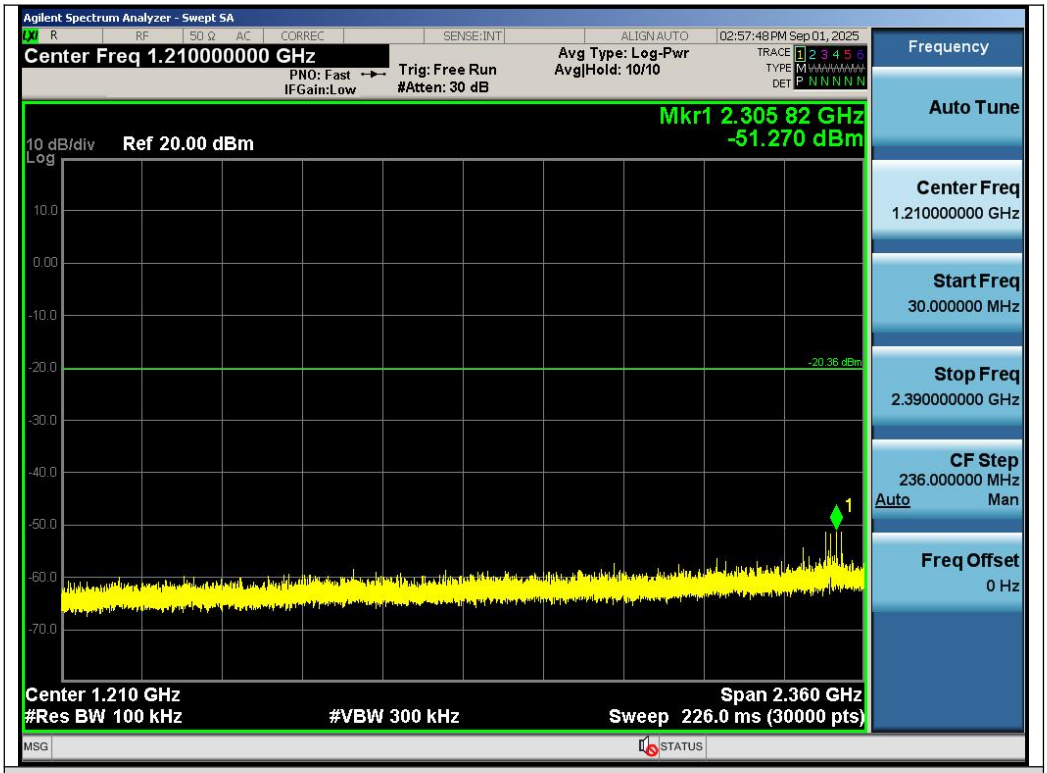


Test_Graph_LE1M_ANT1_2480_1Mbps_Lower Band Emissions

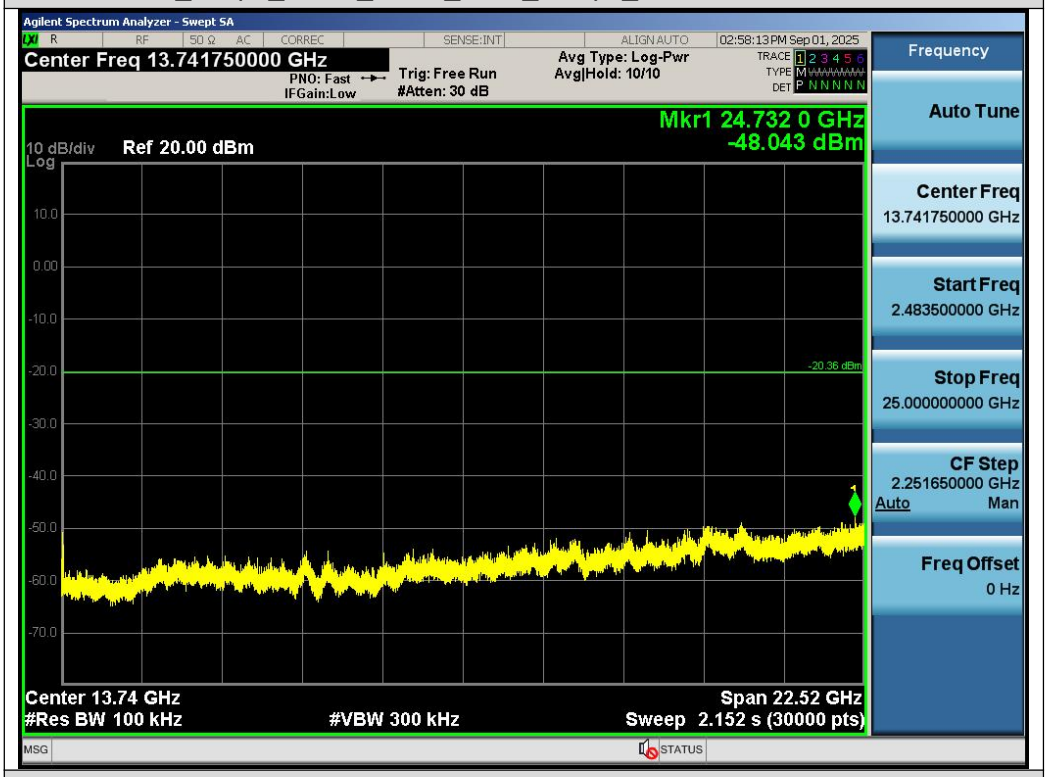


Test_Graph_LE1M_ANT1_2480_1Mbps_Higher Band Emissions

Test_Graph_LE2M_ANT1_2402_2Mbps_Reference Level

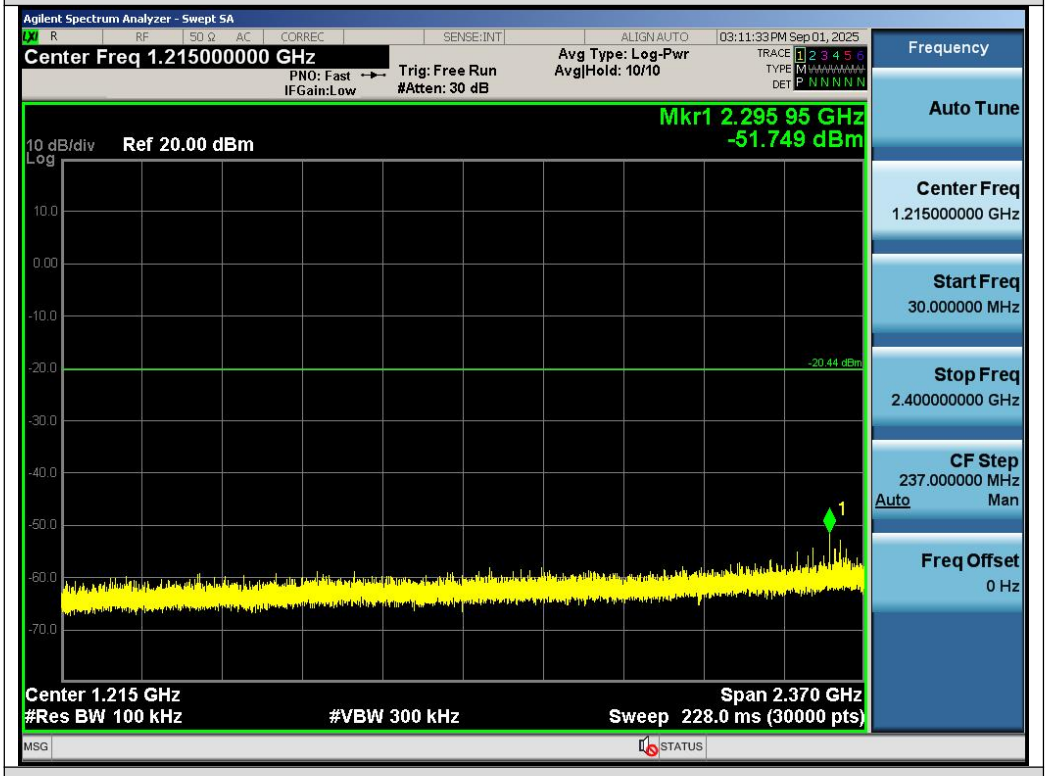


Test_Graph_LE2M_ANT1_2402_2Mbps_Lower Band Emissions

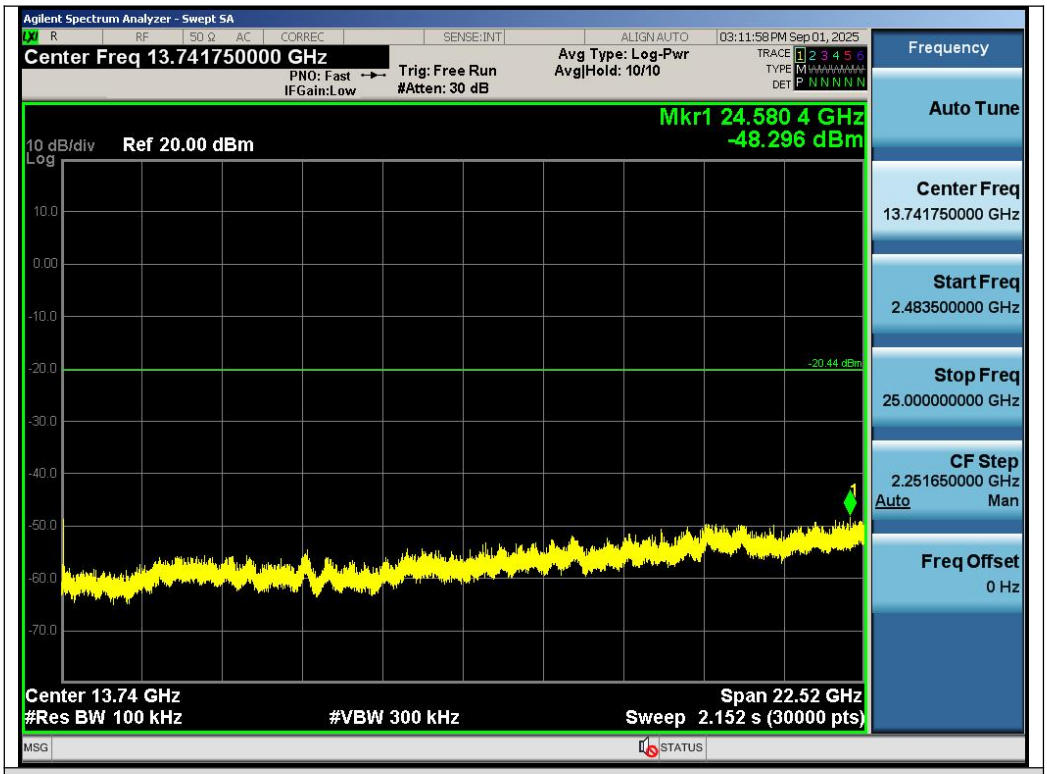


Test_Graph_LE2M_ANT1_2402_2Mbps_Higher Band Emissions

Test_Graph_LE2M_ANT1_2440_2Mbps_Reference Level

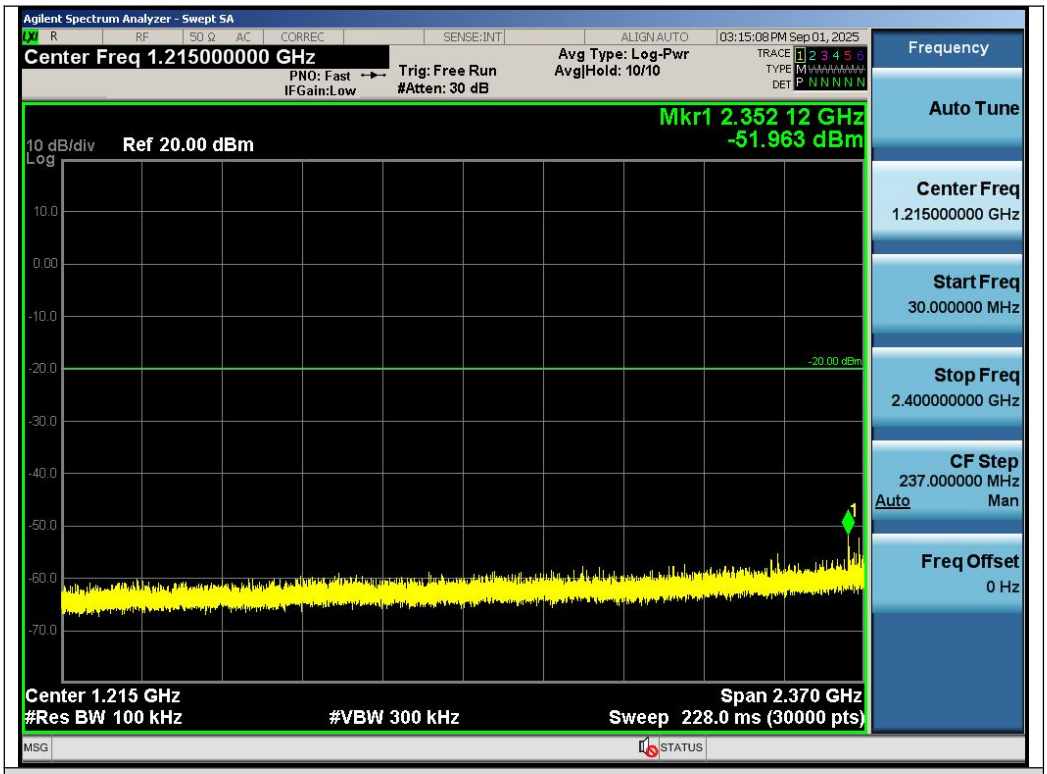


Test_Graph_LE2M_ANT1_2440_2Mbps_Lower Band Emissions

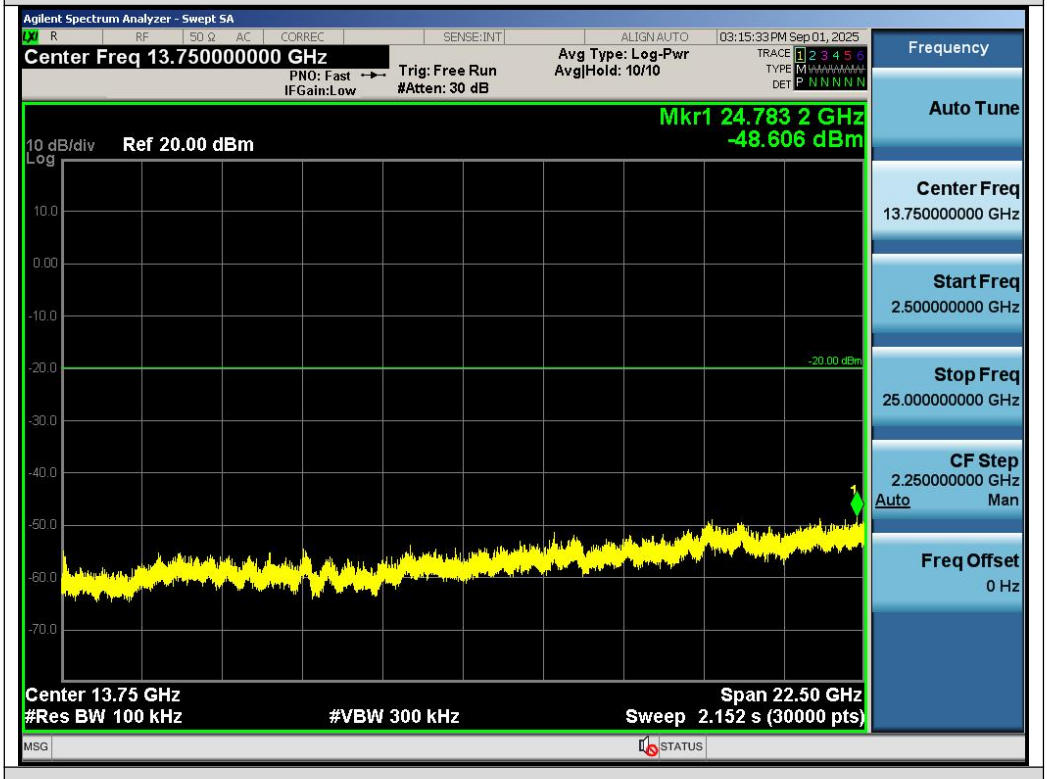


Test_Graph_LE2M_ANT1_2440_2Mbps_Higher Band Emissions

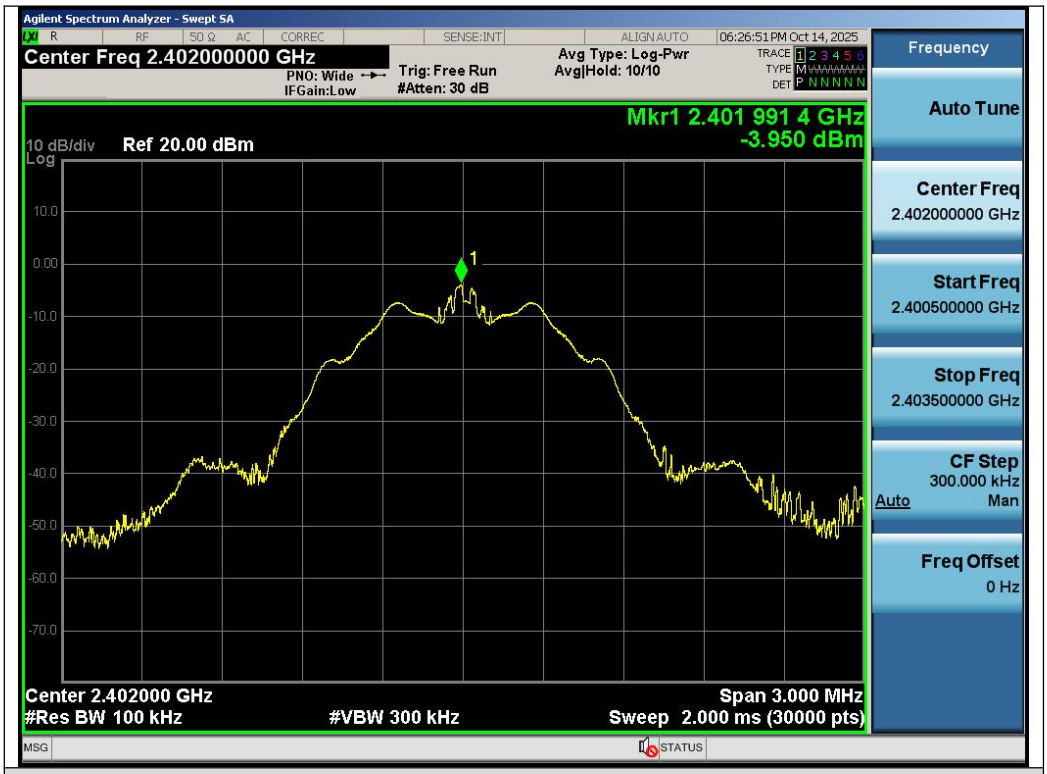
Test_Graph_LE2M_ANT1_2480_2Mbps_Reference Level



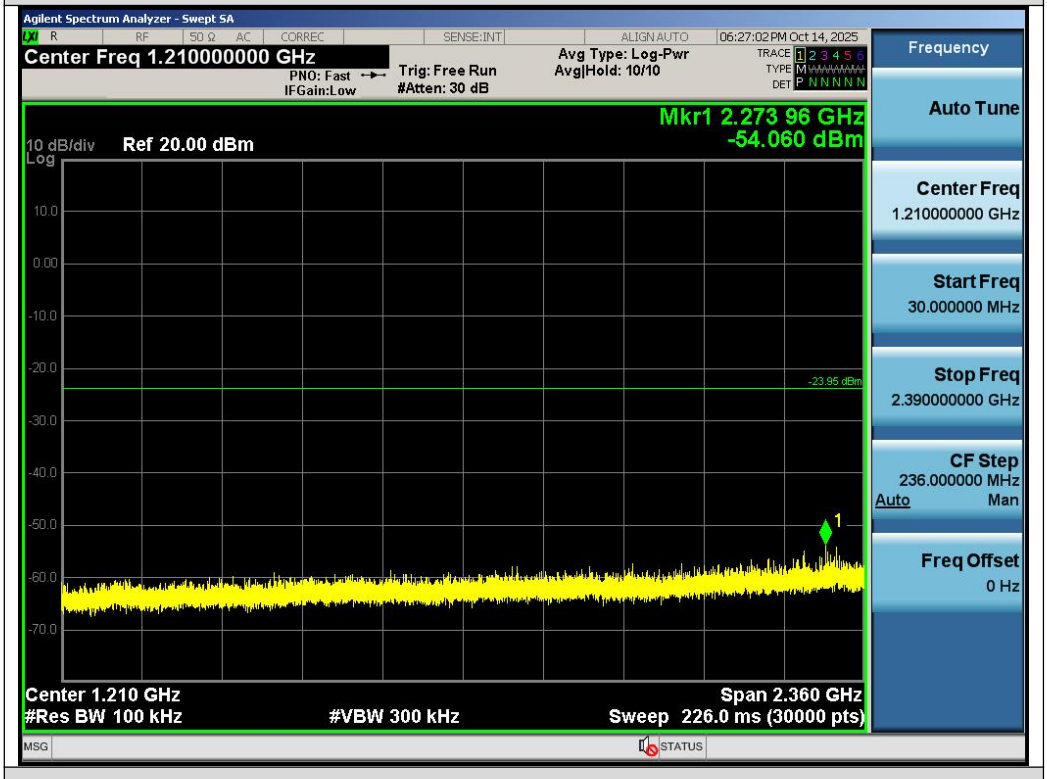
Test_Graph_LE2M_ANT1_2480_2Mbps_Lower Band Emissions



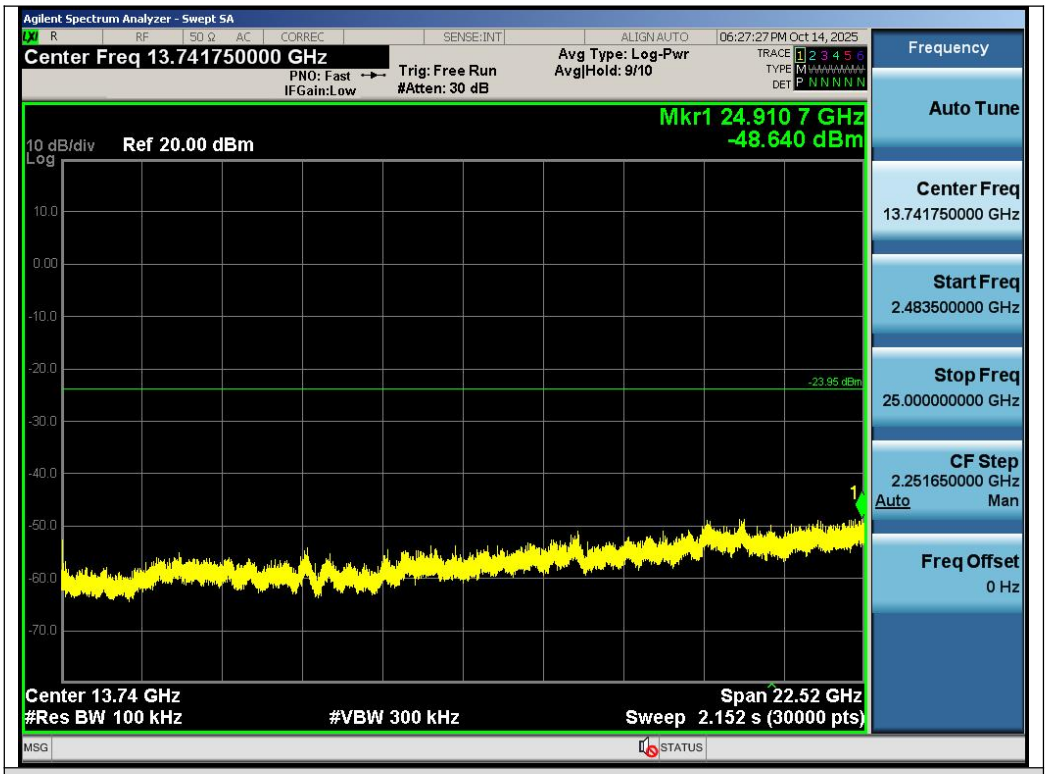
Test_Graph_LE2M_ANT1_2480_2Mbps_Higher Band Emissions



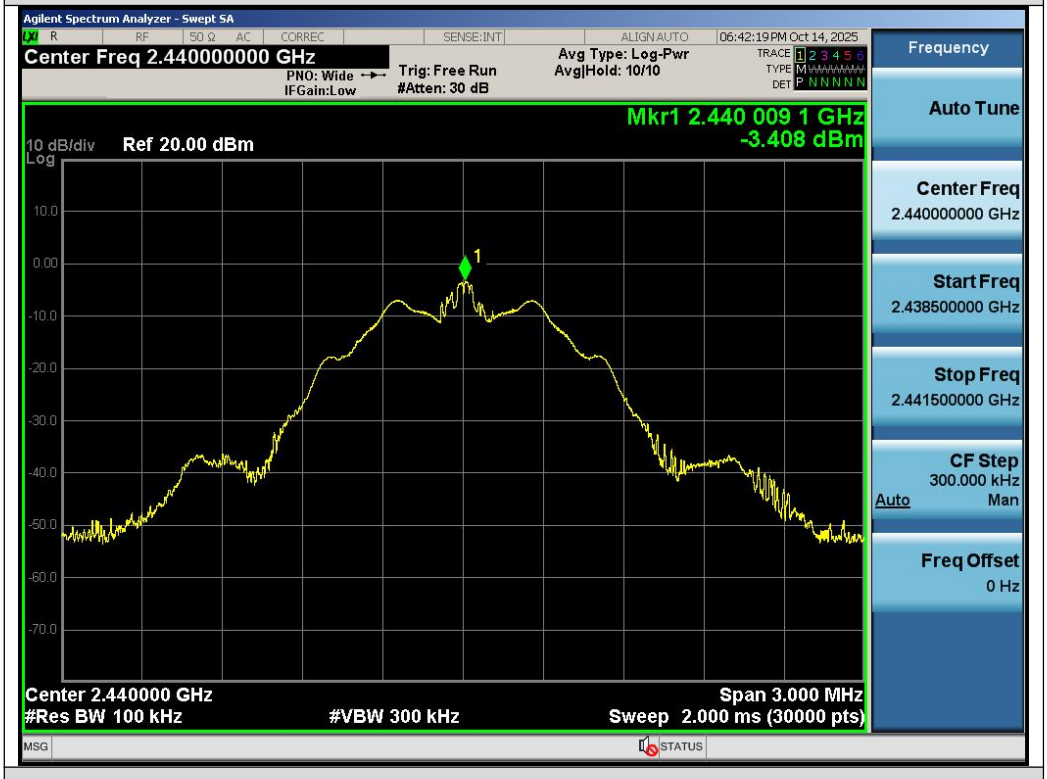
Test_Graph_LE125K_ANT1_2402_125Kbps_Reference Level



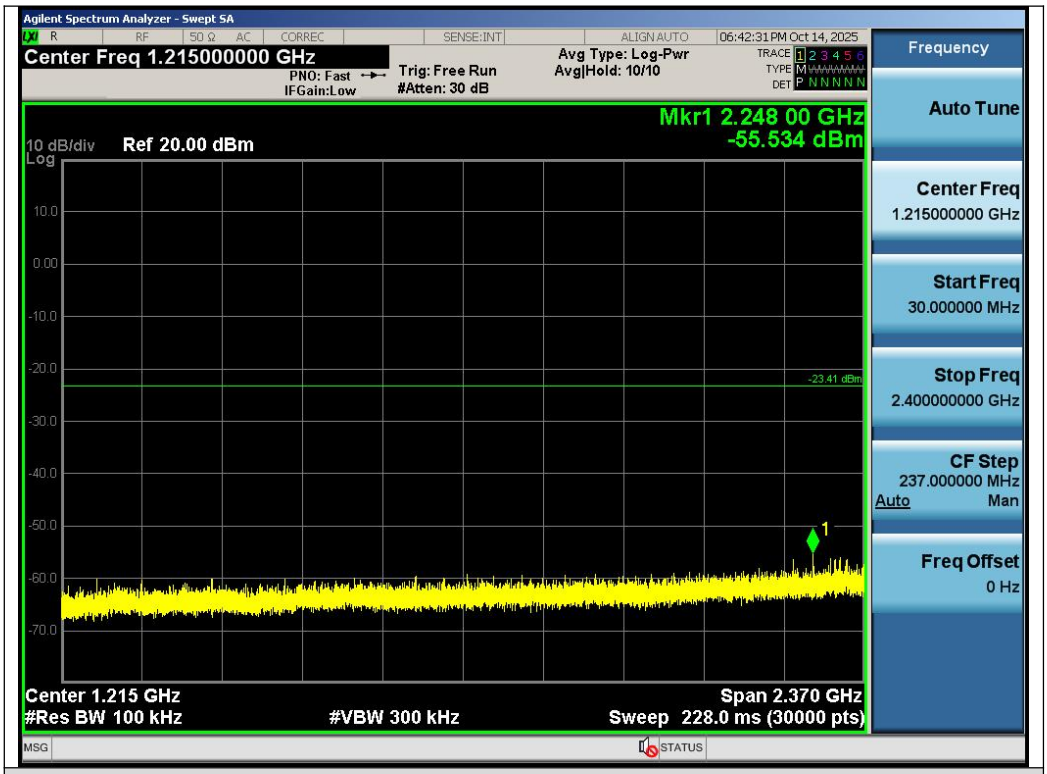
Test_Graph_LE125K_ANT1_2402_125Kbps_Lower Band Emissions



Test_Graph_LE125K_ANT1_2402_125Kbps_Higher Band Emissions



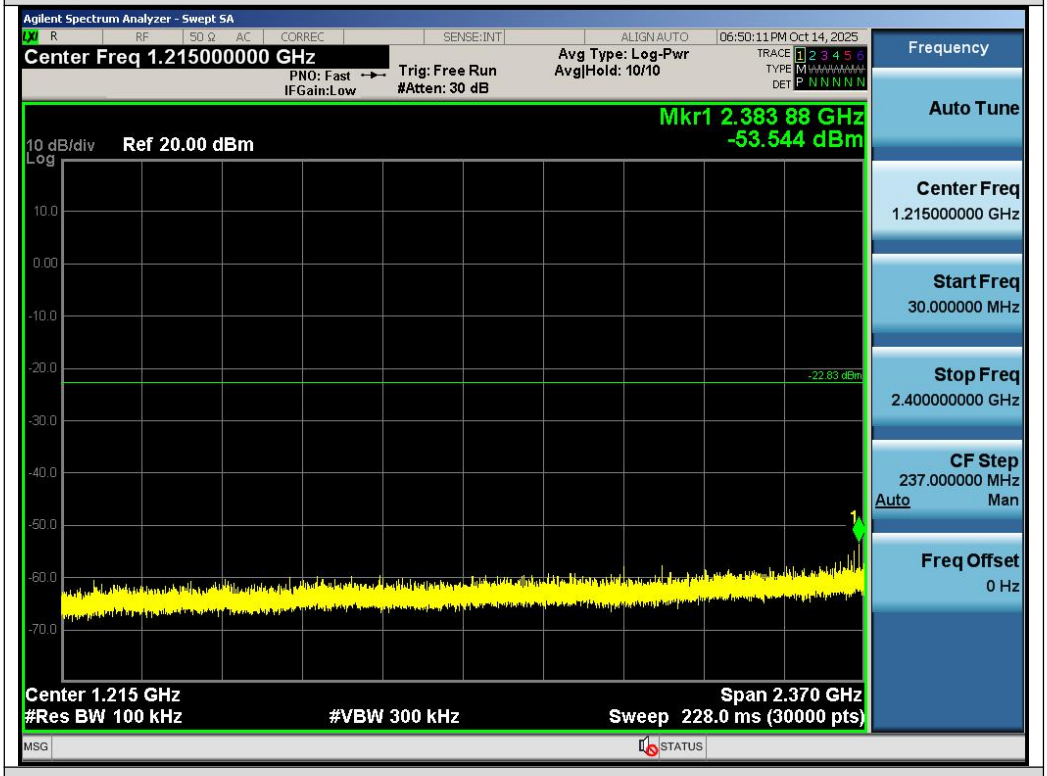
Test_Graph_LE125K_ANT1_2440_125Kbps_Reference Level



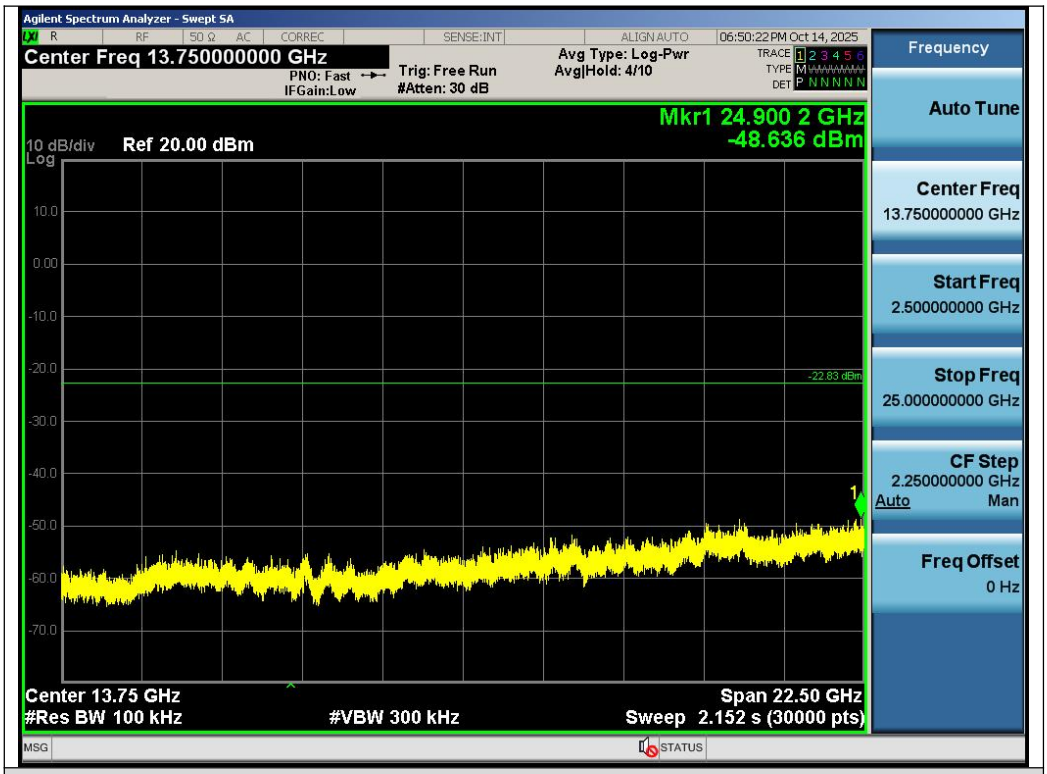
Test_Graph_LE125K_ANT1_2440_125Kbps_Lower Band Emissions

Test_Graph_LE125K_ANT1_2440_125Kbps_Higher Band Emissions

Test_Graph_LE125K_ANT1_2480_125Kbps_Reference Level

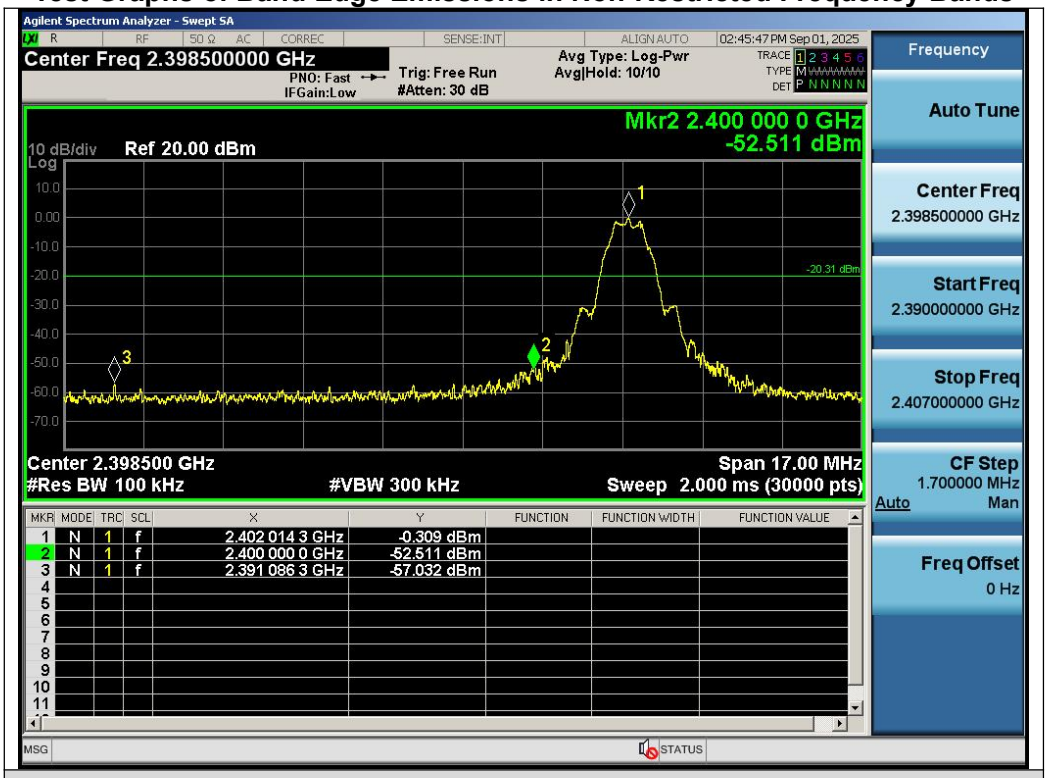


Test_Graph_LE125K_ANT1_2480_125Kbps_Lower Band Emissions

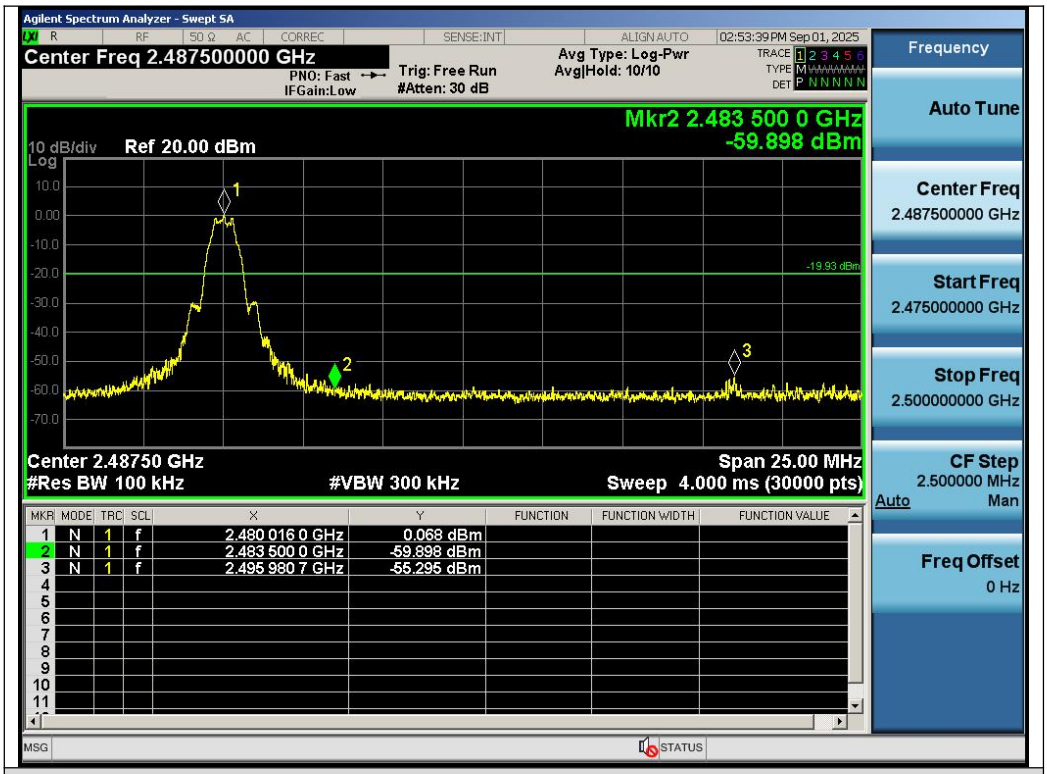


Test_Graph_LE125K_ANT1_2480_125Kbps_Higher Band Emissions

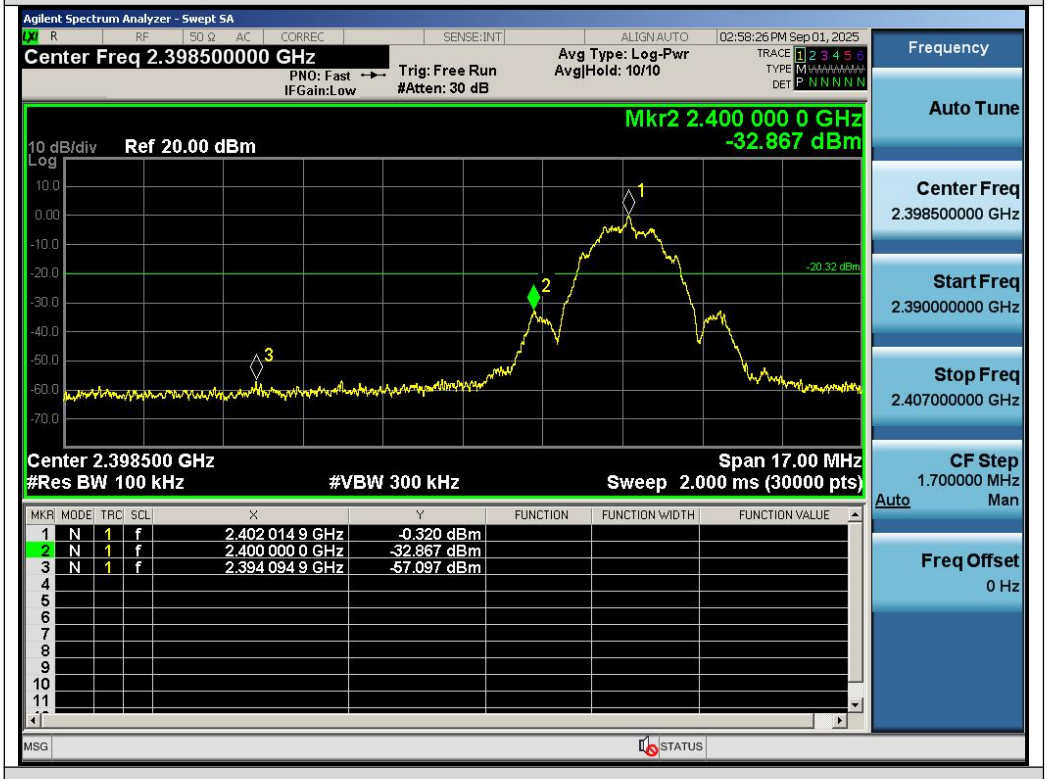
Test Graphs of Band Edge Emissions in Non-Restricted Frequency Bands



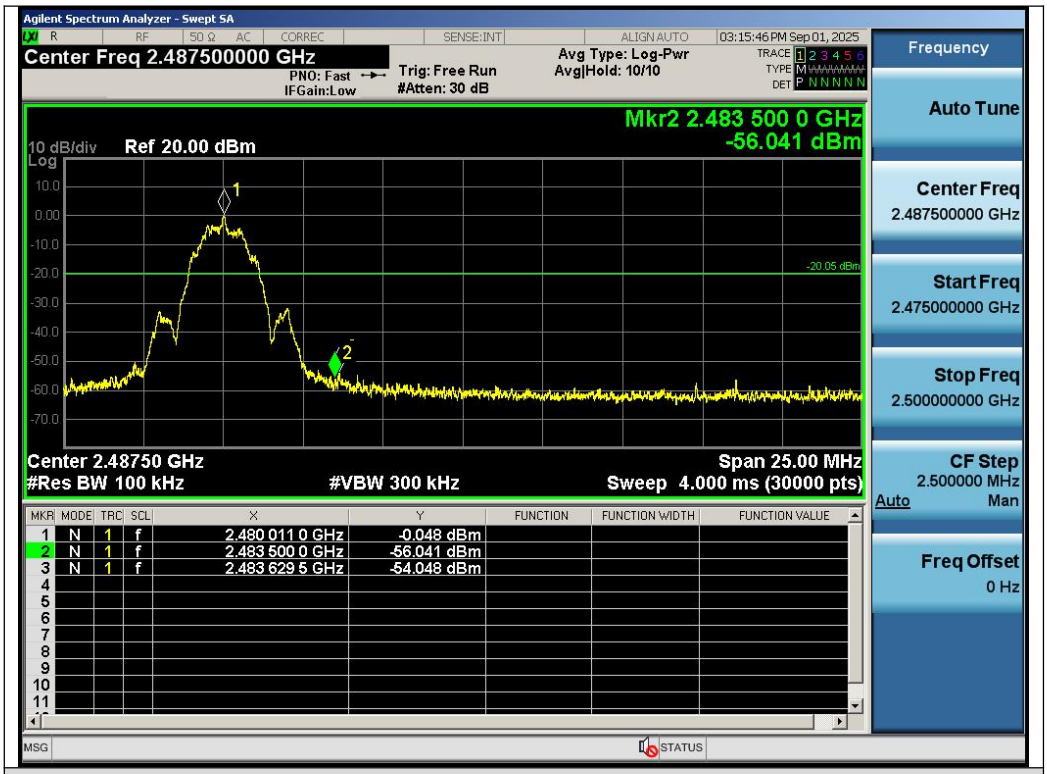
Test_Graph_LE1M_ANT1_2402_1Mbps_Lower Band Edge Emissions



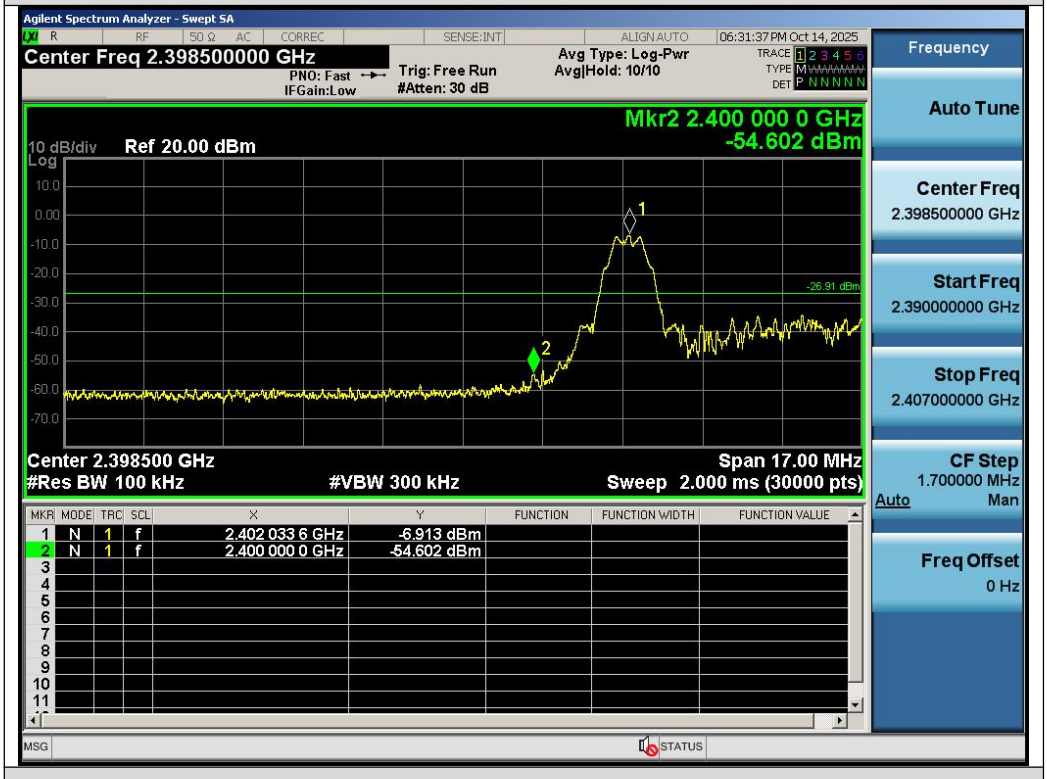
Test_Graph_LE1M_ANT1_2480_1Mbps_Higher Band Edge Emissions



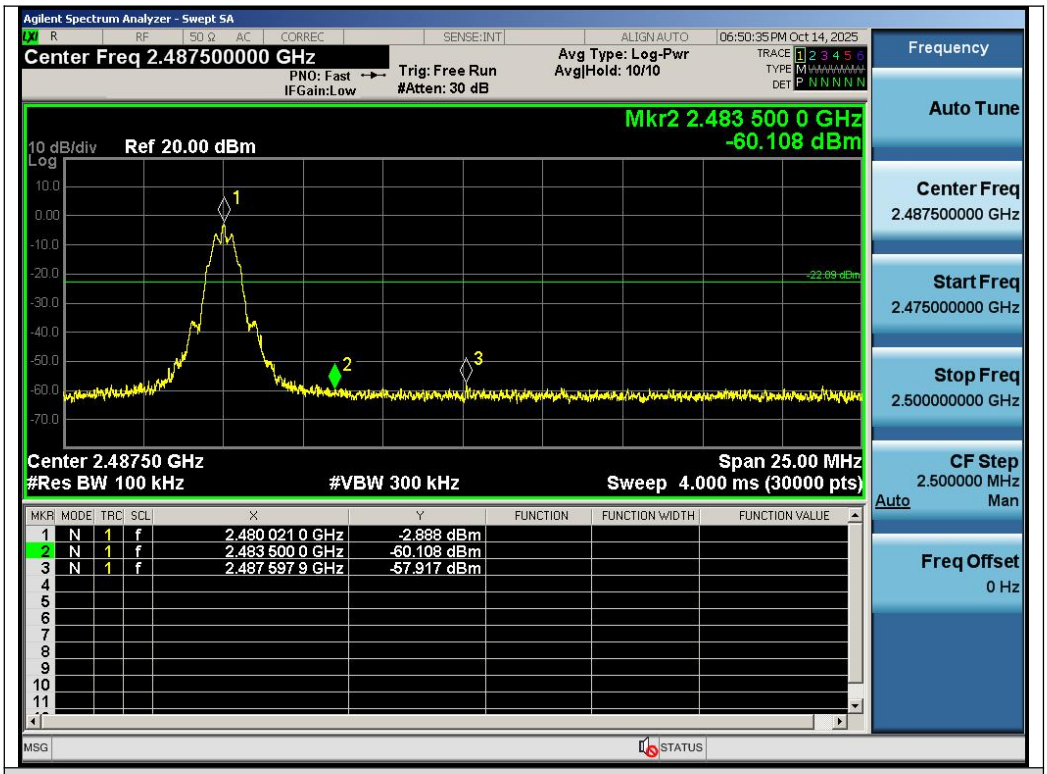
Test_Graph_LE2M_ANT1_2402_2Mbps_Lower Band Edge Emissions



Test_Graph_LE2M_ANT1_2480_2Mbps_Higher Band Edge Emissions



Test_Graph_LE125K_ANT1_2402_125Kbps_Lower Band Edge Emissions



Test_Graph_LE125K_ANT1_2480_125Kbps_Higher Band Edge Emissions

11. Radiated Spurious Emission

11.1 Measurement Limit

- FCC Part 15.209 Limit in the below table to be followed

Frequencies (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009~0.490	2400/F(kHz)	300
0.490~1.705	24000/F(kHz)	30
1.705~30.0	30	30
30~88	100	3
88~216	150	3
216~960	200	3
Above 960	500	3

Note: All modes were tested for restricted band radiated emission, the test records reported below are the worst result compared to other modes.

11.2 Measurement Procedure

1. The EUT was placed on the top of the turntable 0.8 or 1.5 meter above ground. The phase center of the receiving antenna mounted on the top of a height-variable antenna tower was placed 3 meters far away from the turntable.
2. Power on the EUT and all the supporting units. The turntable was rotated by 360 degrees to determine the position of the highest radiation.
3. The height of the broadband receiving antenna was varied between one meter and four meters above ground to find the maximum emissions field strength of both horizontal and vertical polarization.
4. For each suspected emission, the antenna tower was scan (from 1 M to 4 M) and then the turntable was rotated (from 0 degree to 360 degrees) to find the maximum reading.
5. Set the test-receiver system to Peak or CISPR quasi-peak Detect Function with specified bandwidth under Maximum Hold Mode.
6. For emissions above 1GHz, use 1MHz RBW and 3MHz VBW for peak reading. Place the measurement antenna away from each area of the EUT determined to be a source of emissions at the specified measurement distance, while keeping the measurement antenna aimed at the source of emissions at each frequency of significant emissions, with polarization oriented for maximum response. The measurement antenna may have to be higher or lower than the EUT, depending on the radiation pattern of the emission and staying aimed at the emission source for receiving the maximum signal. The final measurement antenna elevation shall be that which maximizes the emissions. The measurement antenna elevation for maximum emissions shall be restricted to a range of heights of from 1 m to 4 m above the ground or reference ground plane.
7. When the radiated emissions limits are expressed in terms of the average value of the emissions, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds.

8. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum values.
9. If the emissions level of the EUT in peak mode was 3 dB lower than the average limit specified, then testing will be stopped and peak values of EUT will be reported, otherwise, the emissions which do not have 3 dB margin will be repeated one by one using the quasi-peak method for below 1GHz.
10. For testing above 1GHz, the emissions level of the EUT in peak mode was lower than average limit (that means the emissions level in peak mode also complies with the limit in average mode), then testing will be stopped and peak values of EUT will be reported, otherwise, the emissions will be measured in average mode again and reported.
11. In case the emission is lower than 30MHz, loop antenna has to be used for measurement and the recorded data should be QP measured by receiver. High - Low scan is not required in this case.

The following table is the setting of spectrum analyzer and receiver.

Spectrum Parameter	Setting
Start ~Stop Frequency	9kHz~150kHz/RB 200Hz for QP
Start ~Stop Frequency	150kHz~30MHz/RB 9kHz for QP
Start ~Stop Frequency	30MHz~1000MHz/RB 120kHz for QP
Start ~Stop Frequency	1GHz~26.5GHz 1MHz/3MHz for Peak, 1MHz/3MHz for Average

Receiver Parameter	Setting
Start ~Stop Frequency	9kHz~150kHz/RB 200Hz for QP
Start ~Stop Frequency	150kHz~30MHz/RB 9kHz for QP
Start ~Stop Frequency	30MHz~1000MHz/RB 120kHz for QP

- **Quasi-Peak Measurements below 1GHz**

1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. Span was set greater than 1MHz
3. RBW = as shown in the table above
4. Detector = CISPR quasi-peak
5. Sweep time = auto couple
6. Trace was allowed to stabilize

- **Peak Measurements above 1GHz**

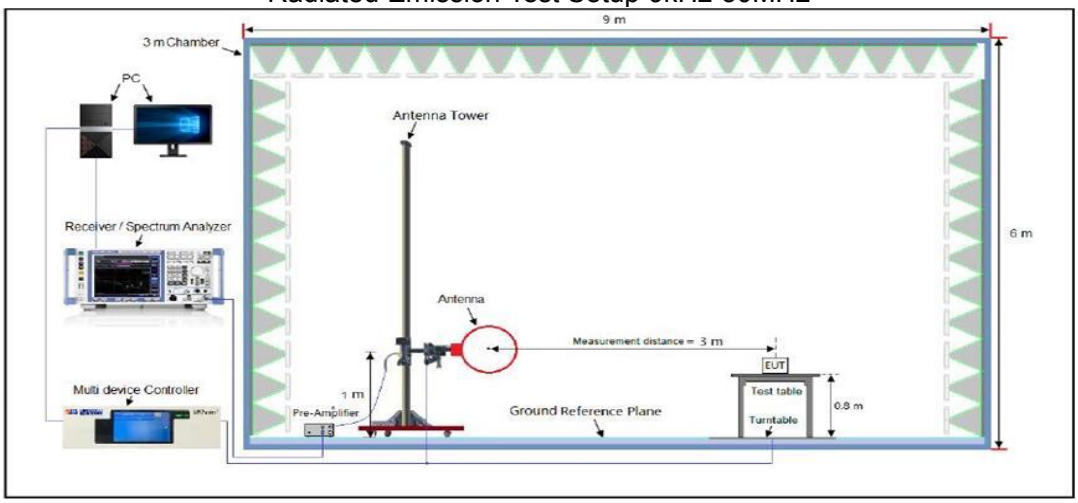
1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1MHz
3. VBW = 3MHz
4. Detector = peak
5. Sweep time = auto couple
6. Trace mode = max hold
7. Trace was allowed to stabilize

- **Average Measurements above 1GHz**

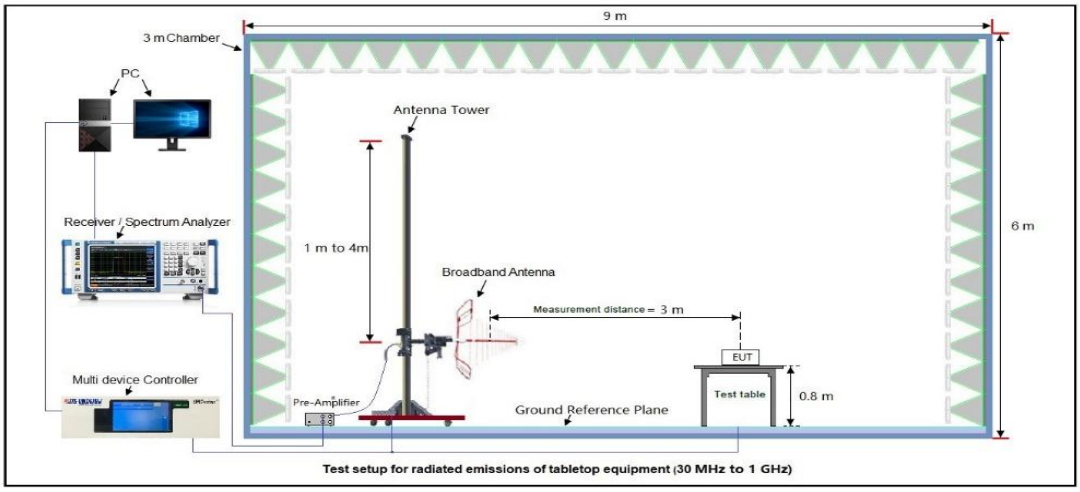
1. Analyzer center frequency was set to the frequency of the radiated spurious emission of interest
2. RBW = 1MHz
3. VBW ≥ [3 × RBW]
4. Detector = Power averaging (rms)
5. Averaging type = power (i.e., rms)
6. Sweep time = auto
7. Perform a trace average of at least 100 traces.
8. The applicable correction factor is [10*log (1 / D)], where D is the duty cycle. The factor had been edited in the “Input Correction” of the Spectrum Analyzer.

11.3 Measurement Setup (Block Diagram of Configuration)

Radiated Emission Test Setup 9kHz-30MHz

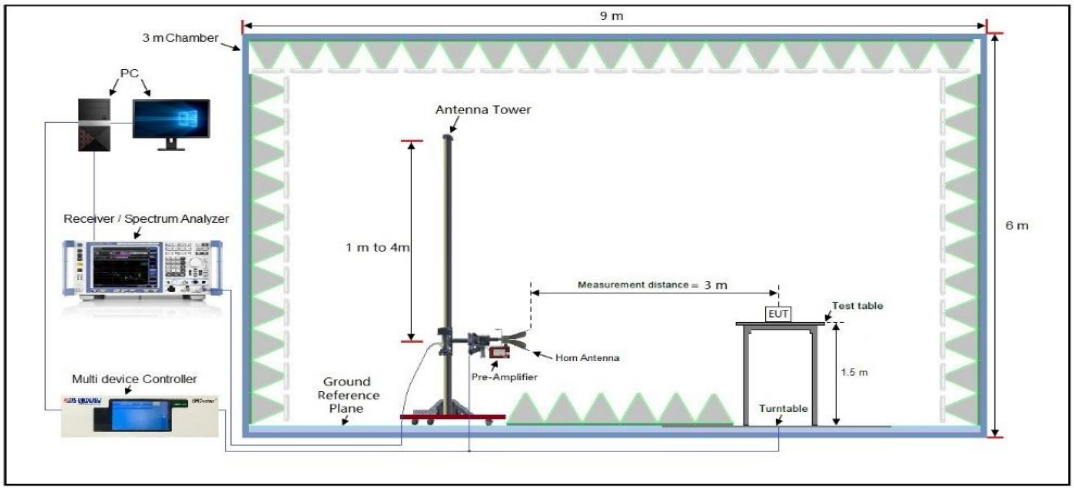


Radiated Emission Test Setup 30MHz-1000MHz



Test setup for radiated emissions of tabletop equipment (30 MHz to 1 GHz)

Radiated Emission Test Setup Above 1000MHz

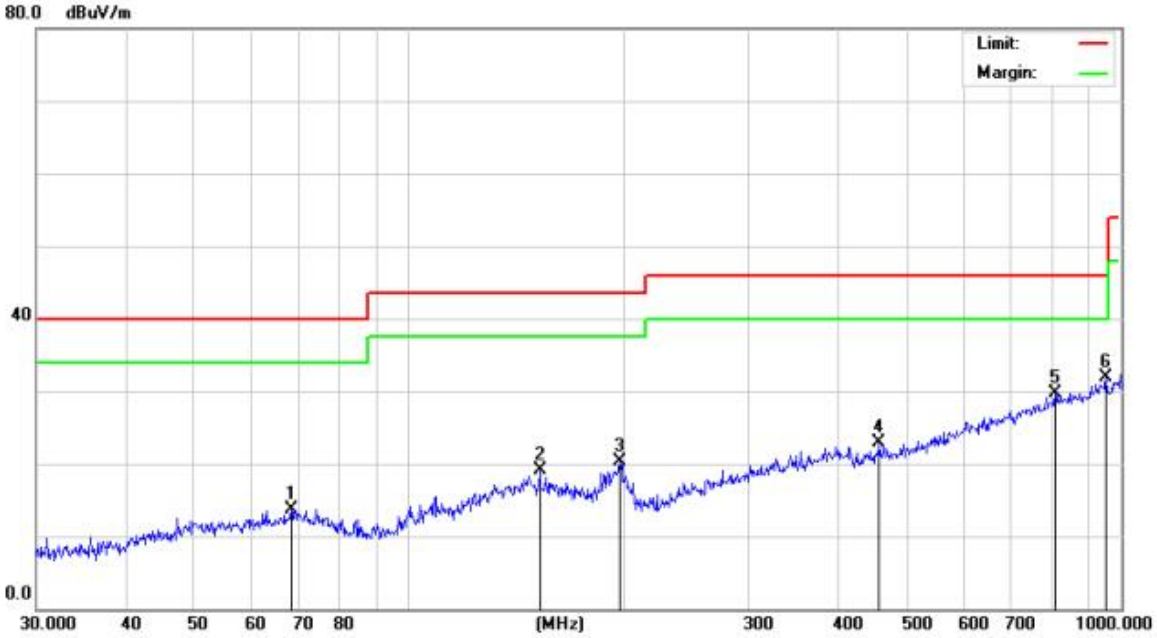


11.4 Measurement Result

Radiated Emission Below 30MHz

The amplitude of spurious emissions from 9kHz to 30MHz which are attenuated more than 20 dB below the permissible value need not be reported.

Radiated Emission Test Results at 30MHz-1GHz			
EUT Name	Ruuvi Air	Model Name	Ruuvi Air
Temperature	22.1℃	Relative Humidity	55.5 %
Pressure	960hPa	Test Voltage	DC 5V
Worst Mode	Mode 3	Antenna Polarity	Horizontal



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector
1		68.3908	39.01	-25.23	13.78	40.00	-26.22	peak
2		152.6641	39.83	-20.68	19.15	43.50	-24.35	peak
3		197.8928	43.43	-23.22	20.21	43.50	-23.29	peak
4		457.5073	40.32	-17.48	22.84	46.00	-23.16	peak
5		807.4291	39.50	-9.71	29.79	46.00	-16.21	peak
6	*	952.0937	40.24	-8.36	31.88	46.00	-14.12	peak

Radiated Emission Test Results at 30MHz-1GHz			
EUT Name	Ruuvi Air	Model Name	Ruuvi Air
Temperature	22.1℃	Relative Humidity	55.5 %
Pressure	960hPa	Test Voltage	DC 5V
Worst Mode	Mode 3	Antenna Polarity	Vertical

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector
1		58.2030	41.75	-21.35	20.40	40.00	-19.60	peak
2		106.0126	45.21	-24.08	21.13	43.50	-22.37	peak
3		144.3348	42.69	-19.90	22.79	43.50	-20.71	peak
4		416.1791	41.13	-16.30	24.83	46.00	-21.17	peak
5		645.1195	39.15	-10.58	28.57	46.00	-17.43	peak
6	*	938.8325	39.07	-6.31	32.76	46.00	-13.24	peak

RESULT: PASS

Note: 1. Factor=Antenna Factor + Cable loss - Pre-amplifier, Over=Measurement-Limit.
2. All test modes had been pre-tested. The mode 3 is the worst case and recorded in the report.

Radiated Emissions Test Results for Above 1GHz

EUT Name	Ruuvi Air	Model Name	Ruuvi Air
Temperature	22.1℃	Relative Humidity	55.5 %
Pressure	960hPa	Test Voltage	DC 5V
Test Mode	Mode 1	Antenna Polarity	Horizontal

Frequency (MHz)	Meter Reading (dBμV)	Factor (dB)	Emission Level (dBμV/m)	Limits (dBμV/m)	Margin (dB)	Value Type
4804.000	46.94	0.08	47.02	74	-26.98	peak
4804.000	37.13	0.08	37.21	54	-16.79	AVG
7206.000	41.94	2.21	44.15	74	-29.85	peak
7206.000	32.74	2.21	34.95	54	-19.05	AVG

Remark:
Factor = Antenna Factor + Cable Loss – Pre-amplifier.

EUT Name	Ruuvi Air	Model Name	Ruuvi Air
Temperature	22.1℃	Relative Humidity	55.5 %
Pressure	960hPa	Test Voltage	DC 5V
Test Mode	Mode 1	Antenna Polarity	Horizontal

Frequency (MHz)	Meter Reading (dBμV)	Factor (dB)	Emission Level (dBμV/m)	Limits (dBμV/m)	Margin (dB)	Value Type
4804.000	46.59	0.08	46.67	74	-27.33	peak
4804.000	37.32	0.08	37.40	54	-16.60	AVG
7206.000	41.72	2.21	43.93	74	-30.07	peak
7206.000	32.83	2.21	35.04	54	-18.96	AVG

Remark:
Factor = Antenna Factor + Cable Loss – Pre-amplifier.

Radiated Emissions Test Results for Above 1GHz

EUT Name	Ruuvi Air	Model Name	Ruuvi Air
Temperature	22.1℃	Relative Humidity	55.5 %
Pressure	960hPa	Test Voltage	DC 5V
Test Mode	Mode 2	Antenna Polarity	Horizontal

Frequency (MHz)	Meter Reading (dBμV)	Factor (dB)	Emission Level (dBμV/m)	Limits (dBμV/m)	Margin (dB)	Value Type
4880.000	46.08	0.08	46.16	74	-27.84	peak
4880.000	37.15	0.08	37.23	54	-16.77	AVG
7320.000	41.53	2.21	43.74	74	-30.26	peak
7320.000	33.00	2.21	35.21	54	-18.79	AVG

Remark:
Factor = Antenna Factor + Cable Loss – Pre-amplifier.

EUT Name	Ruuvi Air	Model Name	Ruuvi Air
Temperature	22.1℃	Relative Humidity	55.5 %
Pressure	960hPa	Test Voltage	DC 5V
Test Mode	Mode 2	Antenna Polarity	Vertical

Frequency (MHz)	Meter Reading (dBμV)	Factor (dB)	Emission Level (dBμV/m)	Limits (dBμV/m)	Margin (dB)	Value Type
4880.000	46.53	0.08	46.61	74	-27.39	peak
4880.000	37.65	0.08	37.73	54	-16.27	AVG
7320.000	41.50	2.21	43.71	74	-30.29	peak
7320.000	32.73	2.21	34.94	54	-19.06	AVG

Remark:
Factor = Antenna Factor + Cable Loss – Pre-amplifier.

Radiated Emissions Test Results for Above 1GHz

EUT Name	Ruuvi Air	Model Name	Ruuvi Air
Temperature	22.1℃	Relative Humidity	55.5 %
Pressure	960hPa	Test Voltage	DC 5V
Test Mode	Mode 3	Antenna Polarity	Horizontal

Frequency (MHz)	Meter Reading (dBμV)	Factor (dB)	Emission Level (dBμV/m)	Limits (dBμV/m)	Margin (dB)	Value Type
4960.000	46.36	0.08	46.44	74	-27.56	peak
4960.000	37.06	0.08	37.14	54	-16.86	AVG
7440.000	41.89	2.21	44.10	74	-29.90	peak
7440.000	32.85	2.21	35.06	54	-18.94	AVG

Remark:
Factor = Antenna Factor + Cable Loss – Pre-amplifier.

EUT Name	Ruuvi Air	Model Name	Ruuvi Air
Temperature	22.1℃	Relative Humidity	55.5 %
Pressure	960hPa	Test Voltage	DC 5V
Test Mode	Mode 3	Antenna Polarity	Vertical

Frequency (MHz)	Meter Reading (dBμV)	Factor (dB)	Emission Level (dBμV/m)	Limits (dBμV/m)	Margin (dB)	Value Type
4960.000	46.11	0.08	46.19	74	-27.81	peak
4960.000	37.62	0.08	37.70	54	-16.30	AVG
7440.000	41.65	2.21	43.86	74	-30.14	peak
7440.000	32.32	2.21	34.53	54	-19.47	AVG

Remark:
Factor = Antenna Factor + Cable Loss – Pre-amplifier.

Note:

1. The amplitude of other spurious emissions from 1G to 25 GHz which are attenuated more than 20 dB below the permissible value need not be reported.
2. Factor = Antenna Factor + Cable loss – Pre-amplifier gain, Margin =Emission Level-Limit.
3. The “Factor” value can be calculated automatically by software of measurement system.
4. All test modes had been pre-tested. The BLE GFSK 1MHz is the worst case and recorded in the report.