

3.7 Spurious Emission, Band edge and Restricted Bands

3.7.1 Regulation

§15.247(d) : In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

§15.209(a) : Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (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

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§15.231 and 15.241.



§15.205(a) : Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
¹ 0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	(²)
13.36-13.41			

¹Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.

²Above 38.6

§15.205 (b) : Except as provided in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements.

3.7.2 Test Procedure

Band-edge Compliance for RF Conducted Emissions

These procedures are applicable for determining compliance at authorized-band band-edges where the requirements are expressed as a value relative to the in-band signal level. Procedures for determining compliance with field strength limits at or close to the band-edges are given in 6.10.6 (see also Table A.2).

Band-edge tests are typically performed as a conducted test but may be performed as radiated measurements on a test site meeting the specifications in 5.2, at the measurement distances specified in 5.3. The instrumentation shall meet the requirements in 4.1.1 using the bandwidths and detectors specified in 4.1.4.2.

When performing radiated measurements, the measurement antenna(s) shall meet the specifications in 4.3. The EUT shall be connected to an antenna and operated at the highest power settings following procedures in 6.3.

For other than frequency-hopping devices, this test sequence shall be performed once. For devices that support frequency hopping, this test sequence shall be performed twice: once with the hopping function turned OFF and then repeated with the hopping function turned ON. The purpose of the test with the hopping function turned on is to confirm that the RF power remains OFF while the device is changing frequencies, and that the oscillator stabilizes at the new frequency before RF power is turned back ON. Overshoot of any oscillator, including phase-lock-loop stabilized oscillators, can cause the device to be temporarily tuned to frequencies outside the authorized band, and it is important that no transmissions occur during such temporary periods. Particular attention to the hopping sequence requirements specified below is needed in the case of adaptive frequency-hopping devices:

- a) Connect the EMI receiver or spectrum analyzer to the EUT using an appropriate RF cable connected to the EUT output. Configure the spectrum analyzer settings as described in step e) (be sure to enter all losses between the unlicensed wireless device output and the spectrum analyzer).
- b) Set the EUT to the lowest frequency channel (for the hopping on test, the hopping sequence shall include the lowest frequency channel).
- c) Set the EUT to operate at maximum output power and 100% duty cycle, or equivalent “normal mode of operation” as specified in 6.10.3.
- d) If using the radiated method, then use the applicable procedure(s) of 6.4, 6.5, or 6.6, and orient the EUT and measurement antenna positions to produce the highest emission level.
- e) Perform the test as follows:
 - 1) Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products that fall outside of the authorized band of operation.
 - 2) Reference level: As required to keep the signal from exceeding the maximum instrument input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than $[10 \log (\text{OBW}/\text{RBW})]$ below the reference level. Specific guidance is given in 4.1.5.2.
 - 3) Attenuation: Auto (at least 10 dB preferred).
 - 4) Sweep time: Coupled.
 - 5) Resolution bandwidth: 100 kHz.
 - 6) Video bandwidth: 300 kHz.
 - 7) Detector: Peak.
 - 8) Trace: Max hold.
- f) Allow the trace to stabilize. For the test with the hopping function turned ON, this can take several minutes to achieve a reasonable probability of intercepting any emissions due to oscillator overshoot.
- g) Set the marker on the emission at the band edge, or on the highest modulation product outside of the band, if this level is greater than that at the band edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.
- h) Repeat step c) through step e) for every applicable modulation.
- i) Set the EUT to the highest frequency channel (for the hopping on test, the hopping sequence shall include the highest frequency channel) and repeat step c) through step d).
- j) The band-edge measurement shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

Spurious RF Conducted Emissions

Conducted spurious emissions shall be measured for the transmit frequency, per 5.5 and 5.6, and at the maximum transmit powers.

Connect the primary antenna port through an attenuator to the spectrum analyzer input; in the results, account for all losses between the unlicensed wireless device output and the spectrum analyzer. The instrument shall span 30 MHz to 10 times the operating frequency in GHz, with a resolution bandwidth of 100 kHz, video bandwidth of 300 kHz, and a coupled sweep time with a peak detector. The band 30 MHz to the highest frequency may be split into smaller spans, as long as the entire spectrum is covered.

Spurious Radiated Emissions

1. The preliminary radiated measurement were performed to determine the frequency producing the maximum emissions in an semi-anechoic chamber at a distance of 3 meters.
2. The EUT was placed on the top of the 0.8-meter height, 1 x 1.5 meter non-metallic table. To find the maximum emission levels, the height of a measuring antenna was changed and the turntable was rotated 360°.
3. The antenna polarization was also changed from vertical to horizontal. The spectrum was scanned from 9 kHz to 30 MHz using the loop antenna, and from 30 to 1000 MHz using the Bi-Log antenna, and from 1000 MHz to 26500 MHz using the horn antenna.
4. To obtain the final measurement data, the EUT was arranged on a turntable situated on a 4 x 4 meter in an semi-anechoic chamber. The EUT was tested at a distance 3 meters.
5. Each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.
6. The 0.8 m height is for below 1 GHz testing, and 1.5 m is for above 1GHz testing.

- Procedure for unwanted emissions measurements below 1 000 MHz

The procedure for unwanted emissions measurements below 1 000 MHz is as follows:

- a) Follow the requirements in 12.7.4.
- b) Compliance shall be determined using CISPR quasi-peak detection; however, peak detection is permitted as an alternative to quasi-peak detection.

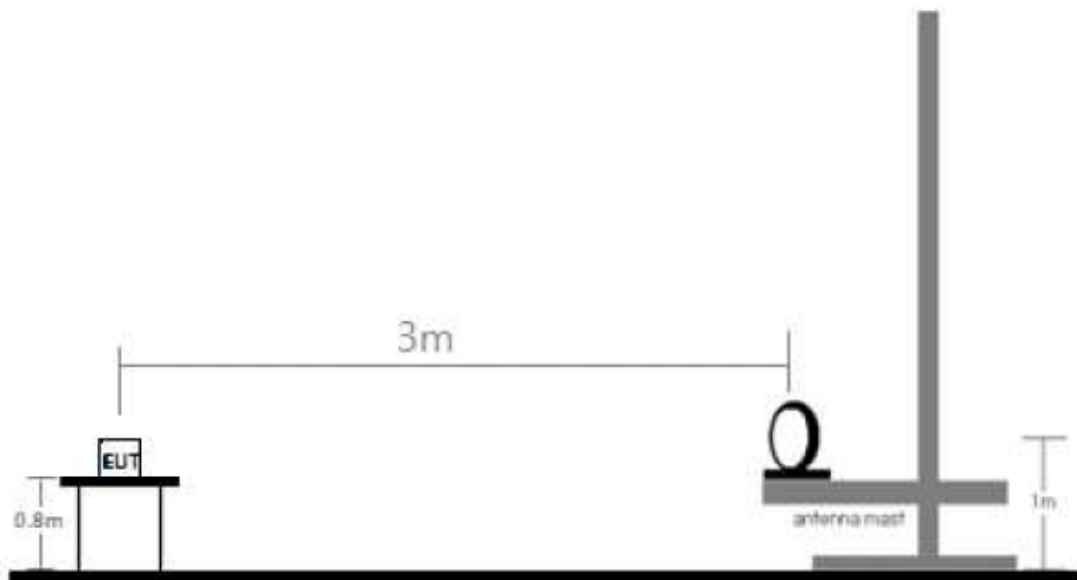
- Procedure for peak unwanted emissions measurements above 1 000 MHz

- a) The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 1 MHz for Peak detection and frequency above 1 GHz.
- b) The result of Average measurement is calculated using PK result and duty correction factor

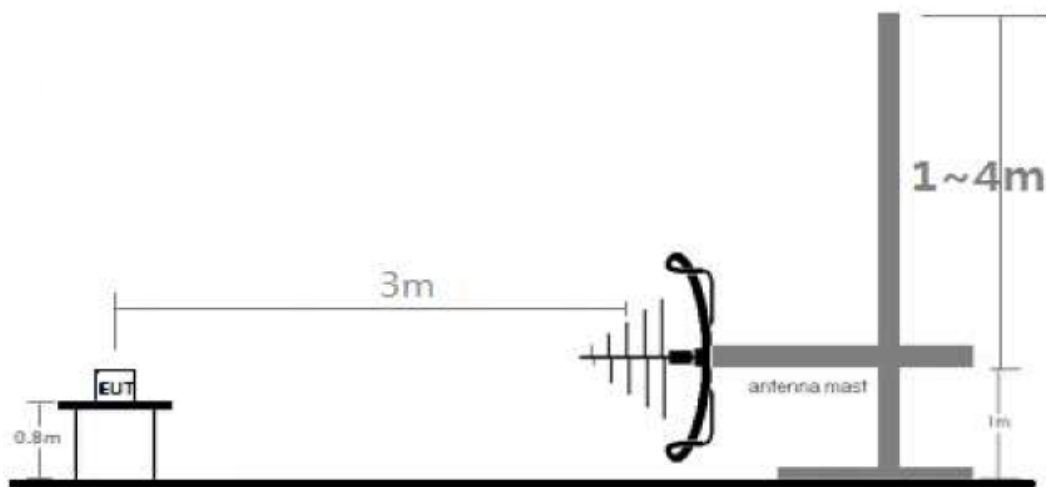
- Sample Calculation

- Field Strength Level [dB μ V/m] = Analyzer Level [dBm] + 107 + AFCL [dB/m] + Duty Cycle Correction [dB]
- AFCL [dB/m] = Antenna Factor [dB/m] + Cable loss [dB]
- Margin [dB] = Field Strength Level [dB μ V/m] – Limit [dB μ V/m]

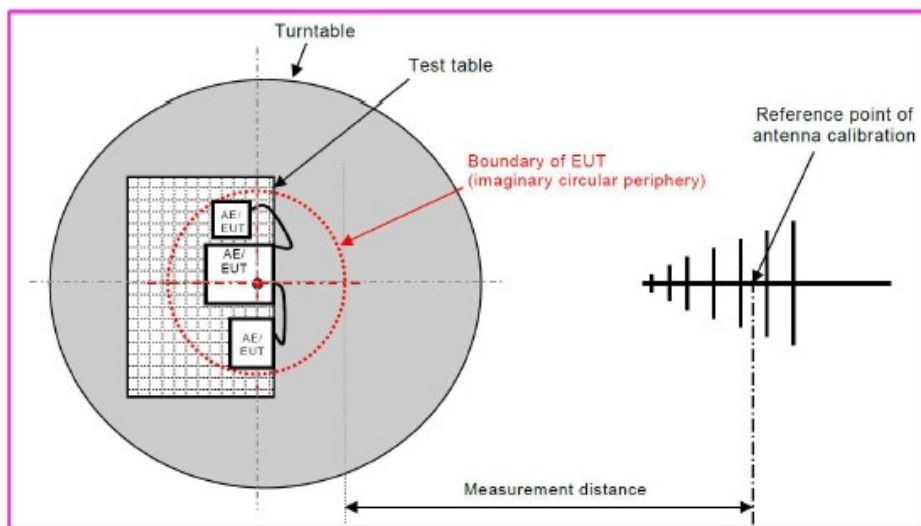
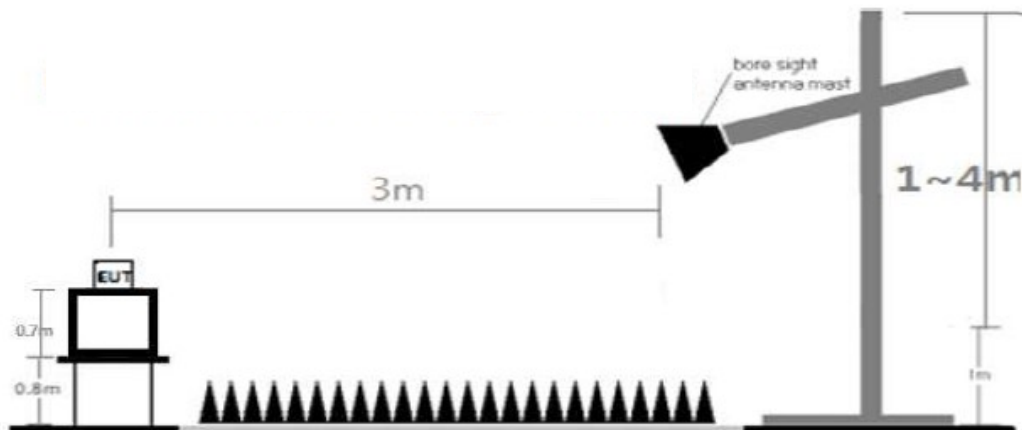
3.7.3 Test Setup



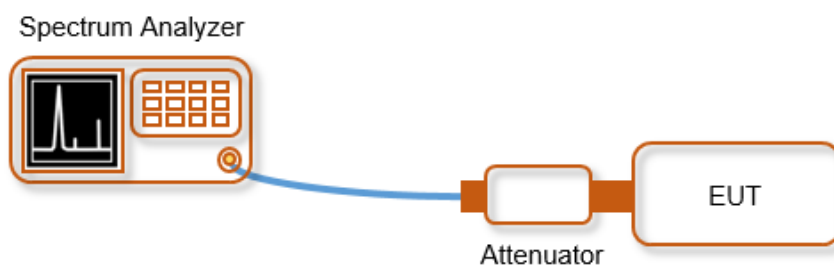
[Radiated Emission Test Setup Below 30 MHz]



[Radiated Emission Test Setup Below 1 GHz]



[Radiated Emission Test Setup Above 1 GHz]



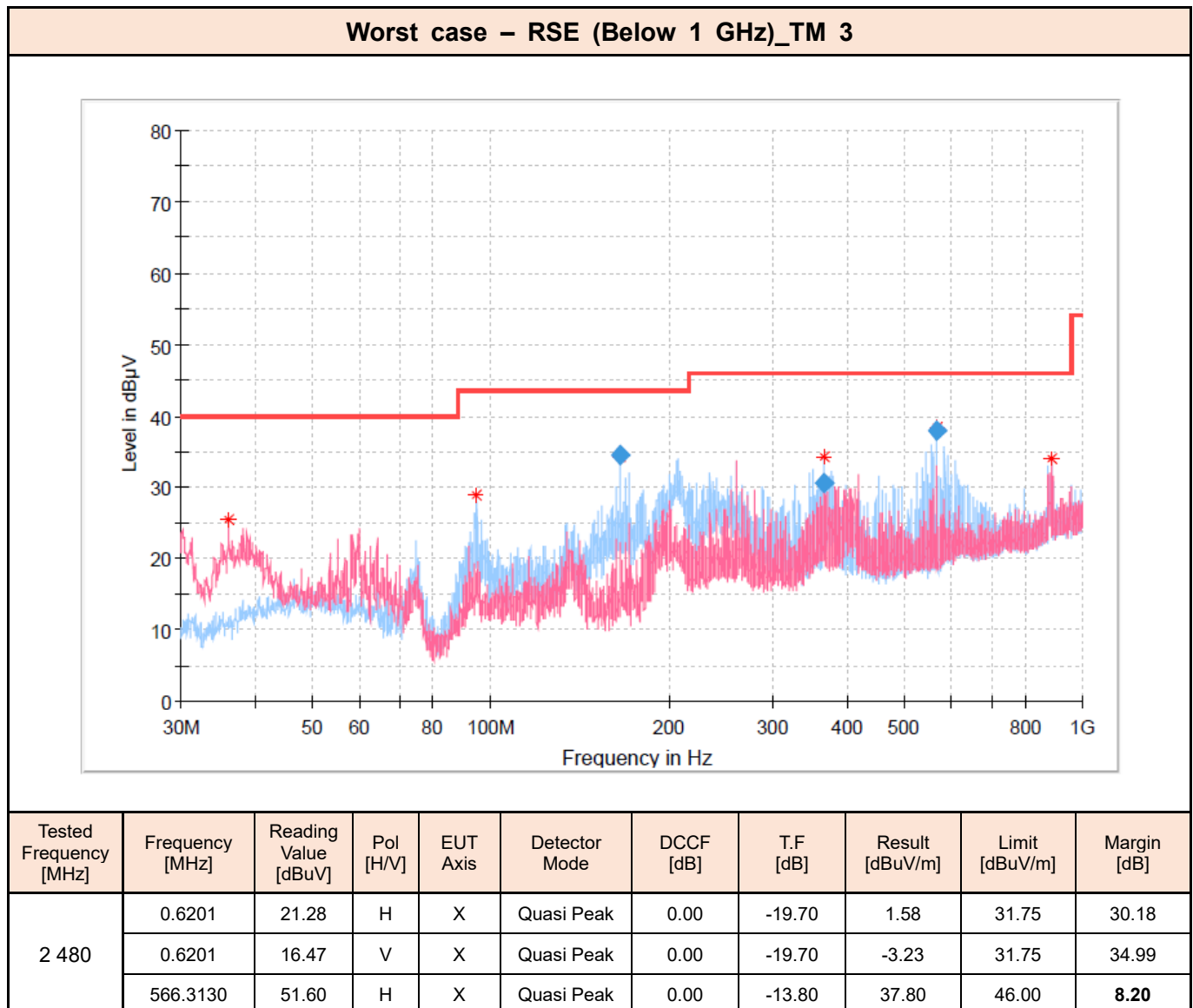
[Conducted Spurious Emission]

3.7.4 Test Result of Radiated Spurious Emission

Remarks

1. Field Strength (dB μ V/m) = S/A Reading Value(dB μ V) + Total Factor(dB/m) + DCCF(dB)
2. Total Factor(dB/m) = T.F (dB/m) = Antenna Factor(dB/m) + Cable Loss(dB) – Pre-Amplifier Gain(dB)
3. Margin(dB) = Field Strength (dB μ V/m) – Limit (dB μ V/m)
4. Measurement Distance = 3 m
5. Duty Cycle > 98 % (Refer to section 3.7)
6. DCCF = Duty Cycle Correction Factor.
7. No other spurious and harmonic emissions were found greater than listed emissions on above table
8. If the measured peak value satisfies the AVG LIMIT, the AVG value was not written.

3.7.4.1 Radiated Emissions (Below 1 GHz)





3.7.4.2 Radiated Emissions (Above 1 GHz)

TM 1_12 V

Tested Frequency [MHz]	Frequency [MHz]	Reading Value [dBuV]	Pol [H/V]	EUT Axis	Detector Mode	DCCF [dB]	T.F [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]
2 402	2 386.14	45.02	H	X	Peak	0.00	3.40	48.42	74.00	25.58
	2 386.14	33.03	H	X	Average	0.00	3.40	36.43	54.00	17.57
	2 124.31	51.49	V	X	Peak	0.00	2.80	54.29	74.00	19.71
	5 760.00	39.10	V	X	Average	0.00	4.80	43.90	54.00	10.10
2 440	7 320.47	45.25	V	X	Peak	0.00	8.00	53.25	74.00	20.75
	7 320.47	39.91	V	X	Average	0.00	8.00	47.91	54.00	6.09
2 480	2 483.83	45.70	H	X	Peak	0.00	3.90	49.60	74.00	24.40
	2 483.83	33.26	H	X	Average	0.00	3.90	37.16	54.00	16.84
	7 440.47	47.23	H	X	Peak	0.00	8.40	55.63	74.00	18.37
	7 440.47	43.25	H	X	Average	0.00	8.40	51.65	54.00	2.35

TM 1_24 V

Tested Frequency [MHz]	Frequency [MHz]	Reading Value [dBuV]	Pol [H/V]	EUT Axis	Detector Mode	DCCF [dB]	T.F [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]
2 402	2 389.69	45.20	H	X	Peak	0.00	3.40	48.60	74.00	25.40
	2 388.24	32.69	H	X	Average	0.00	3.40	36.09	54.00	17.91
	2 879.81	46.40	V	X	Peak	0.00	5.20	51.60	74.00	22.40
	6 946.88	37.70	V	X	Average	0.00	7.20	44.90	54.00	9.10
2 440	7 320.47	45.43	V	X	Peak	0.00	8.00	53.43	74.00	20.57
	7 320.47	40.63	V	X	Average	0.00	8.00	48.63	54.00	5.37
2 480	2 505.82	44.69	H	X	Peak	0.00	4.10	48.79	74.00	25.21
	2 483.67	33.04	H	X	Average	0.00	3.90	36.94	54.00	17.06
	7 440.47	47.34	H	X	Peak	0.00	8.40	55.74	74.00	18.26
	7 440.47	42.96	H	X	Average	0.00	8.40	51.36	54.00	2.64



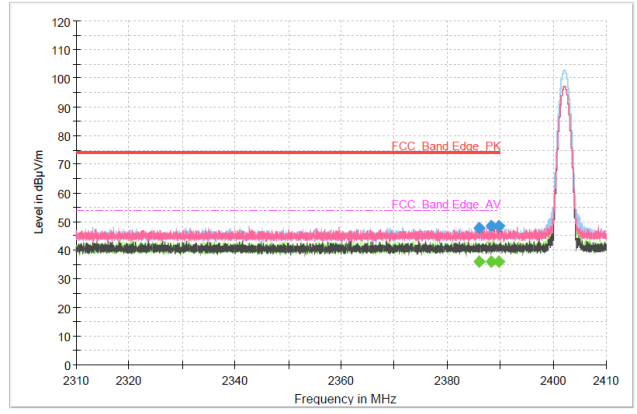
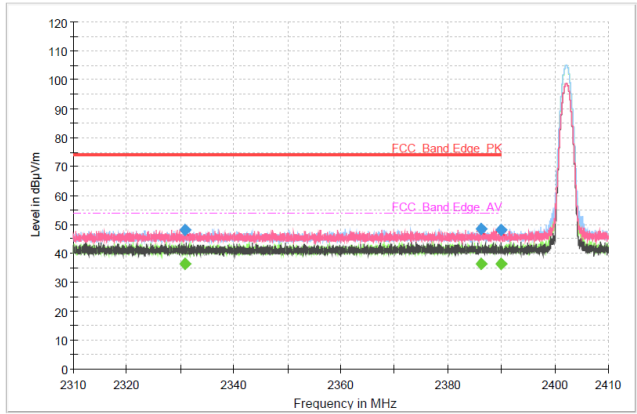
TM 1

12 V

24 V

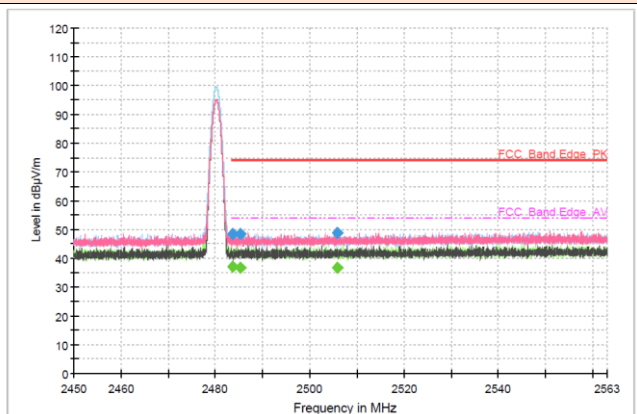
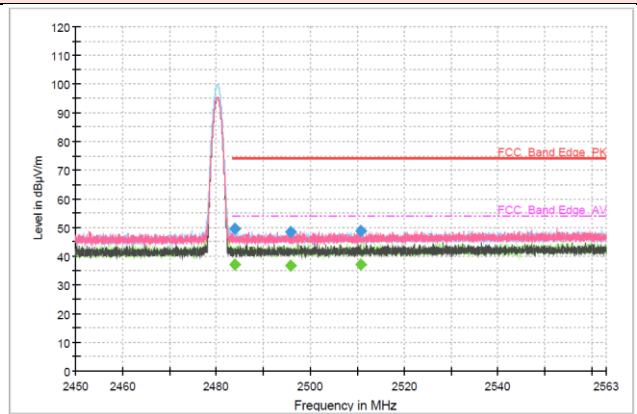
Bandedge_2 402 MHz

Bandedge_2 402 MHz



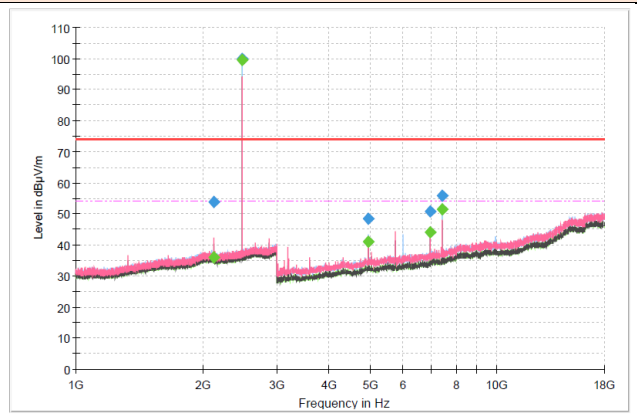
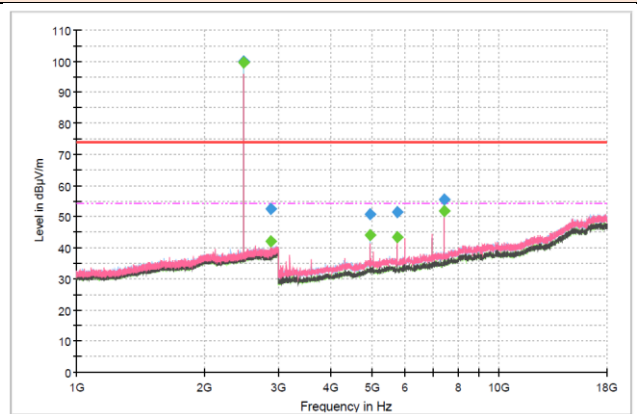
Bandedge_2 480 MHz

Bandedge_2 480 MHz



Spurious_Worst case

Spurious_Worst case





TM 2_12 V

Tested Frequency [MHz]	Frequency [MHz]	Reading Value [dBuV]	Pol [H/V]	EUT Axis	Detector Mode	DCCF [dB]	T.F [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]
2 402	2 388.44	44.93	H	X	Peak	0.00	3.40	48.33	74.00	25.67
	2 388.44	33.00	H	X	Average	0.00	3.40	36.40	54.00	17.60
	2 879.94	46.14	H	X	Peak	0.00	5.20	51.34	74.00	22.66
	4 803.28	37.90	H	X	Average	0.00	3.10	41.00	54.00	13.00
2 440	15 314.53	37.45	H	X	Peak	0.00	20.10	57.55	74.00	16.45
	15 314.53	25.67	H	X	Average	0.00	20.10	45.77	54.00	8.23
2 480	2 483.52	45.84	H	X	Peak	0.00	3.90	49.74	74.00	24.26
	2 483.52	33.99	H	X	Average	0.00	3.90	37.89	54.00	16.11
	7 438.59	43.01	H	X	Peak	0.00	8.40	51.41	74.00	22.59
	7 438.59	35.33	H	X	Average	0.00	8.40	43.73	54.00	10.27

TM 2_24 V

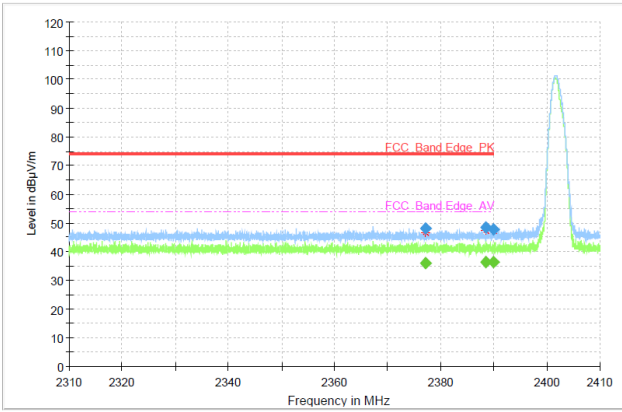
Tested Frequency [MHz]	Frequency [MHz]	Reading Value [dBuV]	Pol [H/V]	EUT Axis	Detector Mode	DCCF [dB]	T.F [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]
2 402	2 389.28	44.78	H	X	Peak	0.00	3.40	48.18	74.00	25.82
	2 389.84	32.84	H	X	Average	0.00	3.40	36.24	54.00	17.76
	15 099.38	37.42	H	X	Peak	0.00	20.10	57.52	74.00	16.48
	15 099.38	25.83	H	X	Average	0.00	20.10	45.93	54.00	8.07
2 440	6 946.41	42.59	H	X	Peak	0.00	7.20	49.79	74.00	24.21
	6 946.41	34.53	H	X	Average	0.00	7.20	41.73	54.00	12.27
2 480	2 483.67	44.76	H	X	Peak	0.00	3.90	48.66	74.00	25.34
	2 483.67	32.87	H	X	Average	0.00	3.90	36.77	54.00	17.23
	2 659.63	49.69	H	X	Peak	0.00	5.00	54.69	74.00	19.31
	7 439.53	35.70	H	X	Average	0.00	8.40	44.10	54.00	9.90



TM 2

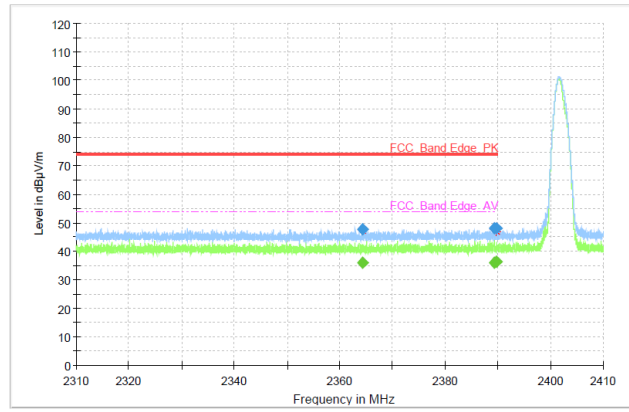
12 V

Bandedge_2 402 MHz

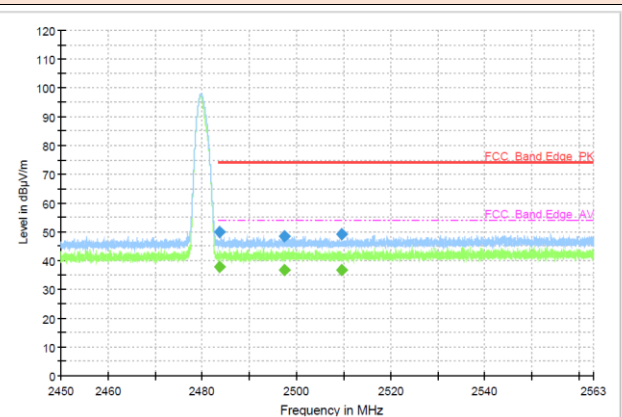


24 V

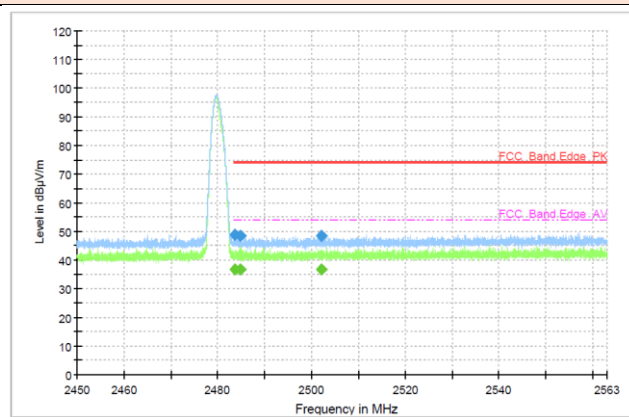
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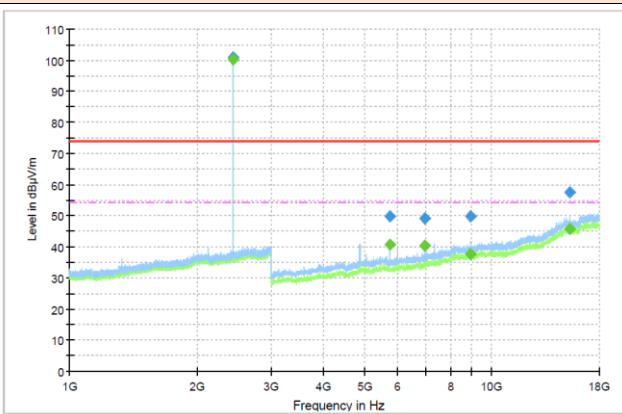
Bandedge_2 480 MHz



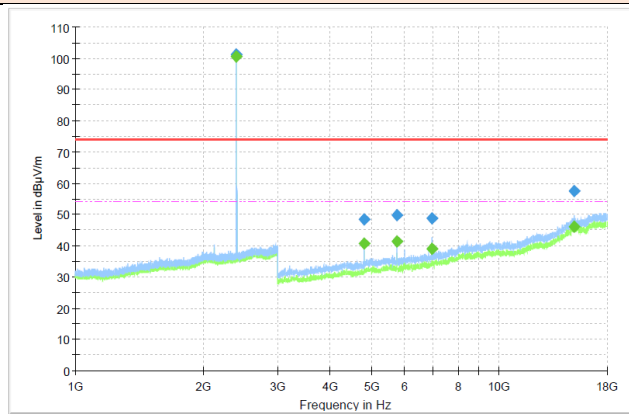
Bandedge_2 480 MHz



Spurious_Worst case



Spurious_Worst case





TM 3_12 V

Tested Frequency [MHz]	Frequency [MHz]	Reading Value [dBuV]	Pol [H/V]	EUT Axis	Detector Mode	DCCF [dB]	T.F [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]
2 402	2 384.53	45.00	H	X	Peak	0.00	3.40	48.40	74.00	25.60
	2 389.96	32.81	H	X	Average	0.00	3.40	36.21	54.00	17.79
	2 880.06	45.43	H	X	Peak	0.00	5.20	50.63	74.00	23.37
	6 946.41	34.60	H	X	Average	0.00	7.20	41.80	54.00	12.20
2 440	16 777.03	36.46	H	X	Peak	0.00	22.50	58.96	74.00	15.04
	16 777.03	24.73	H	X	Average	0.00	22.50	47.23	54.00	6.77
2 480	2 483.52	45.48	H	X	Peak	0.00	3.90	49.38	74.00	24.62
	2 521.21	32.59	H	X	Average	0.00	4.30	36.89	54.00	17.11
	14 874.38	38.05	H	X	Peak	0.00	19.80	57.85	74.00	16.15
	14 874.38	25.93	H	X	Average	0.00	19.80	45.73	54.00	8.27

TM 3_24 V

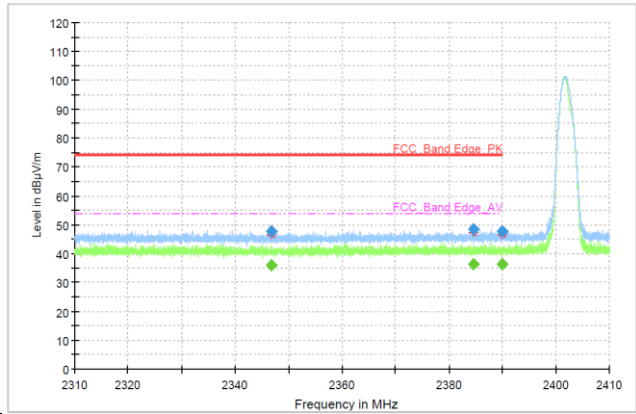
Tested Frequency [MHz]	Frequency [MHz]	Reading Value [dBuV]	Pol [H/V]	EUT Axis	Detector Mode	DCCF [dB]	T.F [dB]	Result [dBuV/m]	Limit [dBuV/m]	Margin [dB]
2 402	2 389.97	45.72	H	X	Peak	0.00	3.40	49.12	74.00	24.88
	2 389.97	33.14	H	X	Average	0.00	3.40	36.54	54.00	17.46
	2 660.00	45.84	H	X	Peak	0.00	5.00	50.84	74.00	23.16
	6 946.41	34.43	H	X	Average	0.00	7.20	41.63	54.00	12.37
2 440	6 946.41	42.42	H	X	Peak	0.00	7.20	49.62	74.00	24.38
	6 946.41	34.32	H	X	Average	0.00	7.20	41.52	54.00	12.48
2 480	2 483.56	45.96	H	X	Peak	0.00	3.90	49.86	74.00	24.14
	2 483.56	33.53	H	X	Average	0.00	3.90	37.43	54.00	16.57
	5 998.13	48.17	H	X	Peak	0.00	5.60	53.77	74.00	20.23
	6 946.88	34.60	H	X	Average	0.00	7.20	41.80	54.00	12.20



TM 3

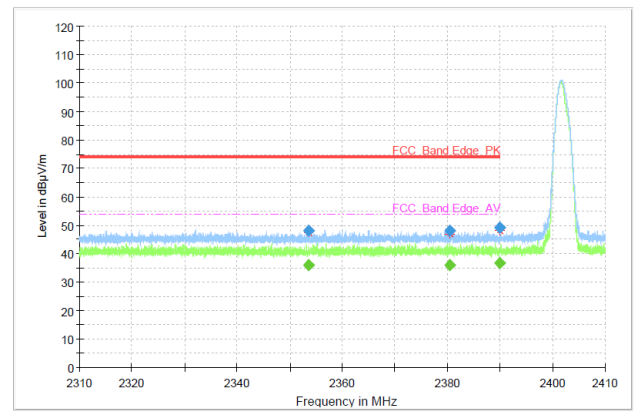
12 V

Bandedge_2 402 MHz

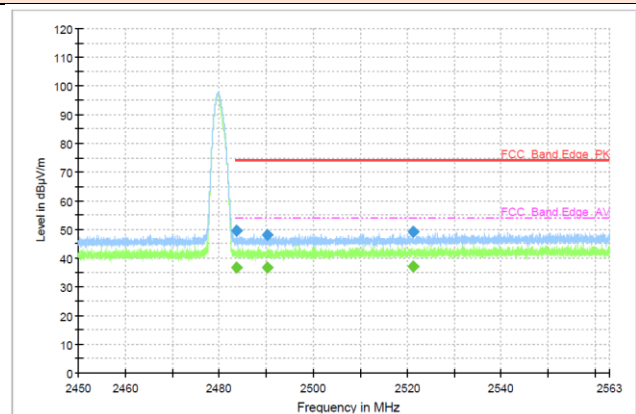


24 V

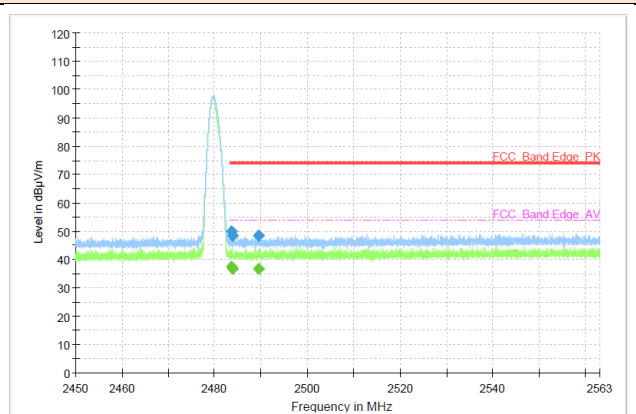
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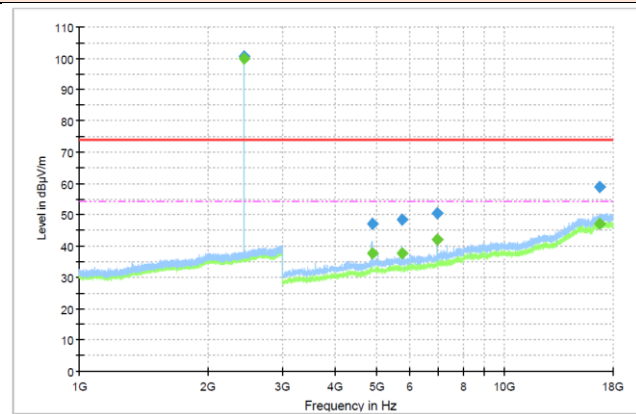
Bandedge_2 480 MHz



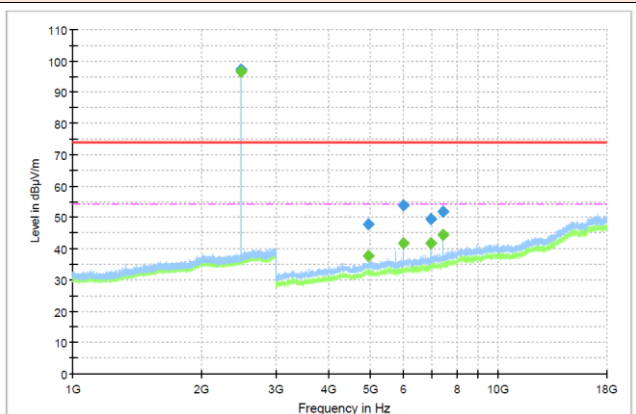
Bandedge_2 480 MHz



Spurious_Worst case



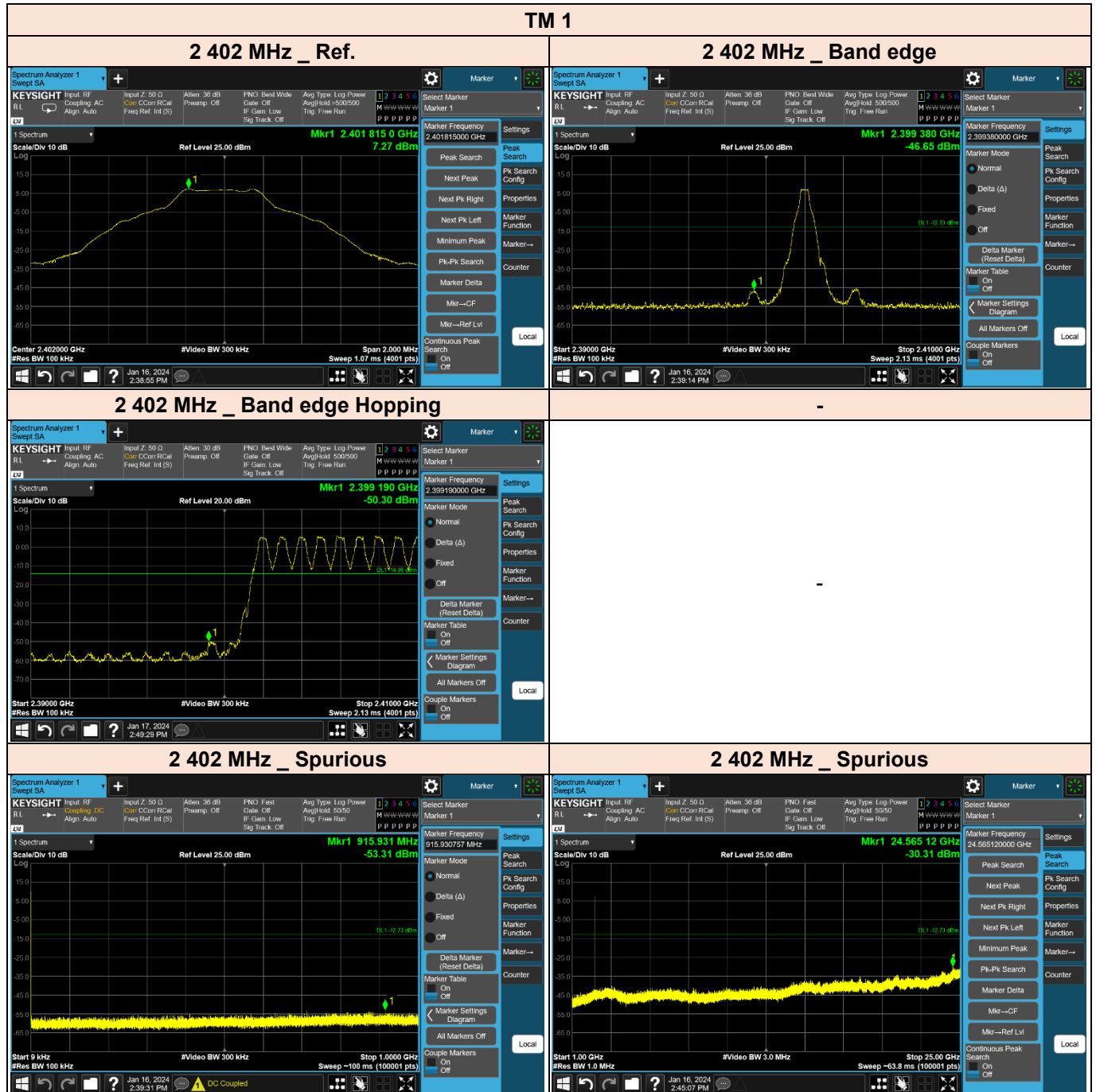
Spurious_Worst case





3.7.5 Test Result of Conducted Spurious Emission

[DC 12 V Spurious Emission]



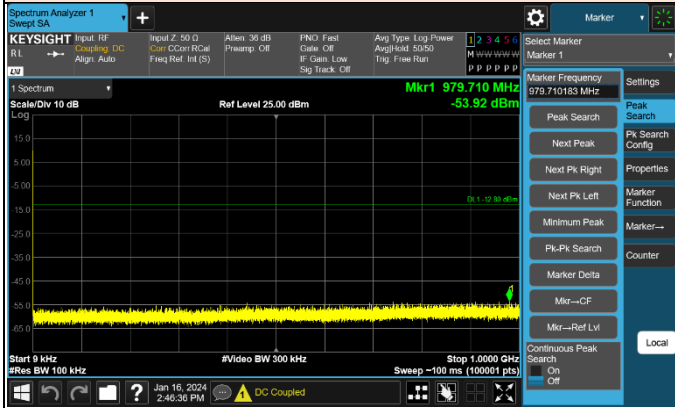


TM 1

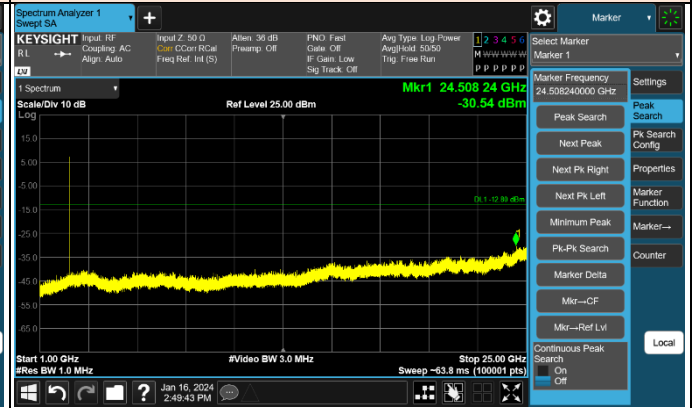
2 440 MHz _ Ref.



2 440 MHz _ Spurious



2 440 MHz _ Spurious





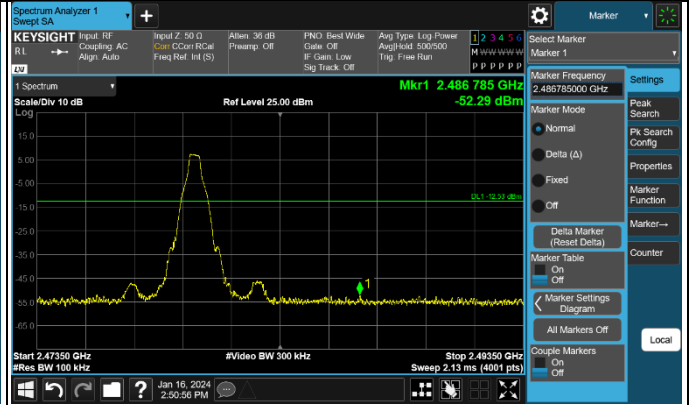
BUREAU VERITAS

TM 1

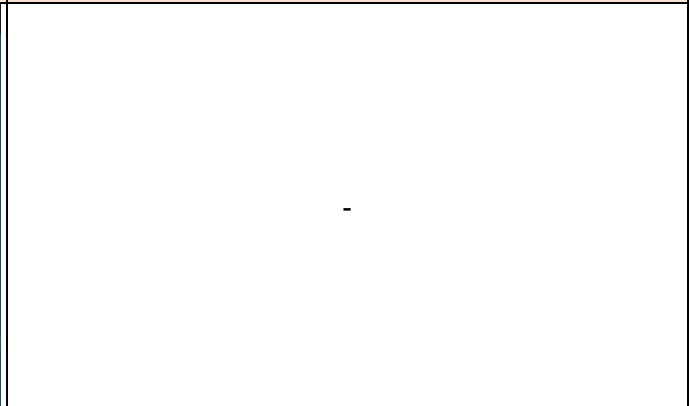
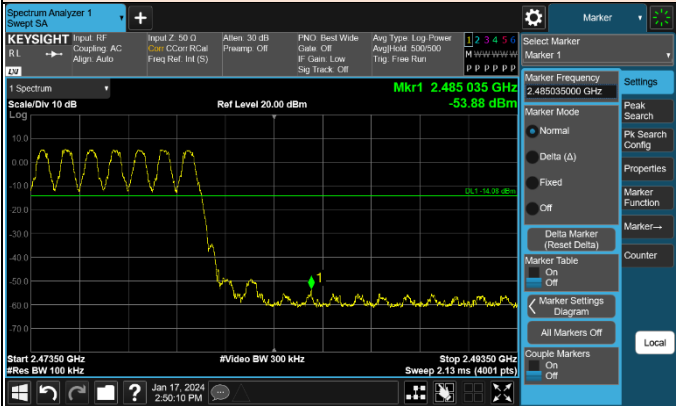
2 480 MHz _ Ref.



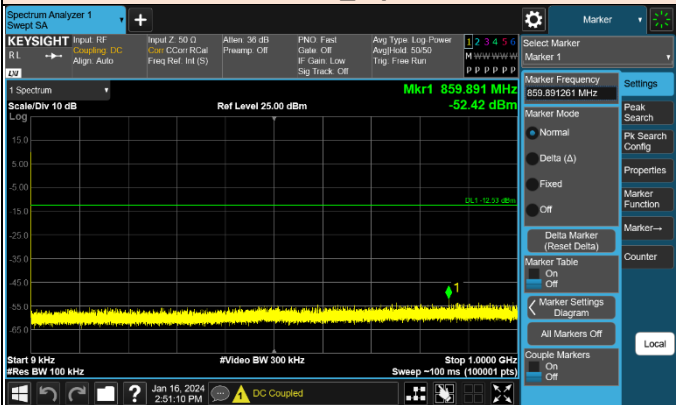
2 480 MHz _ Band edge



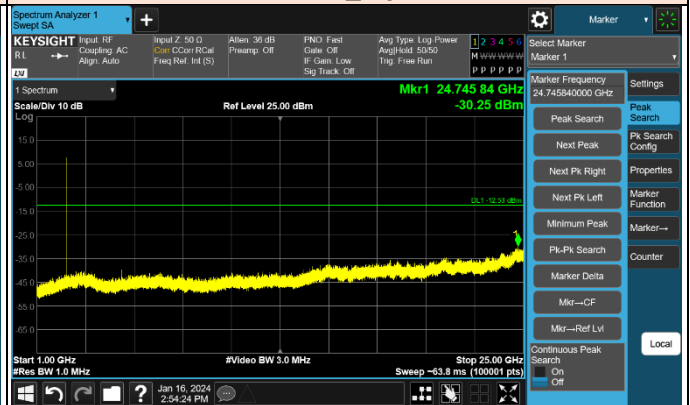
2 480 MHz _ Band edge Hopping



2 480 MHz _ Spurious



2 480 MHz _ Spurious





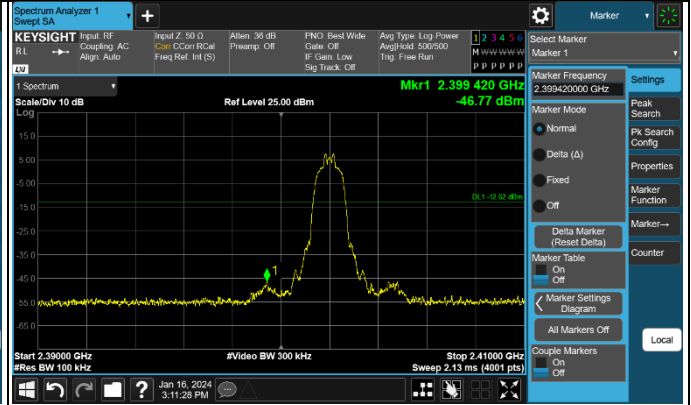
BUREAU VERITAS

TM 2

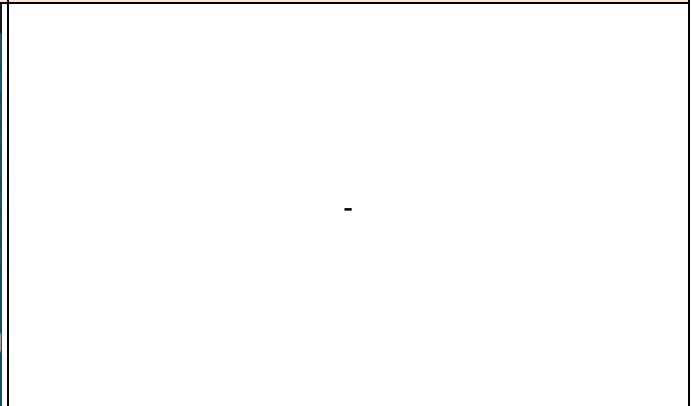
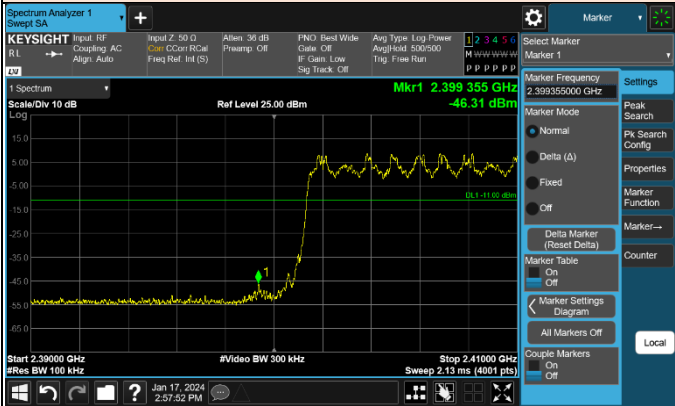
2 402 MHz _ Ref.



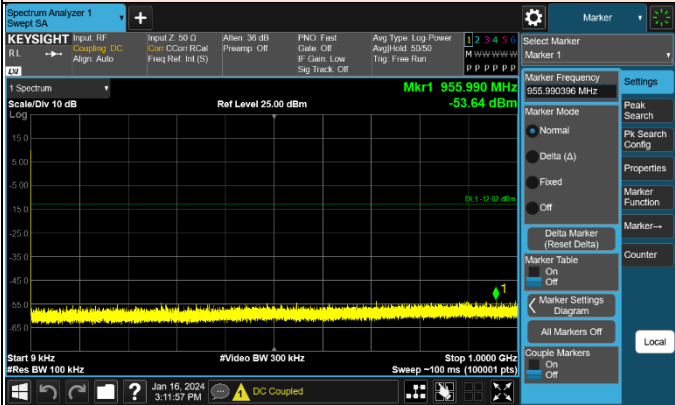
2 402 MHz _ Band edge



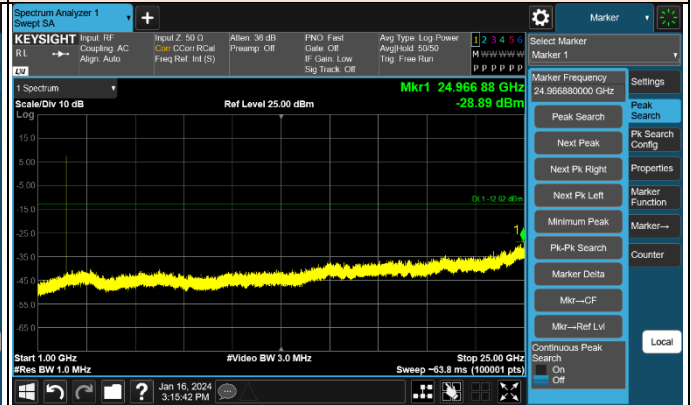
2 402 MHz _ Band edge Hopping



2 402 MHz _ Spurious



2 402 MHz _ Spurious





TM 2

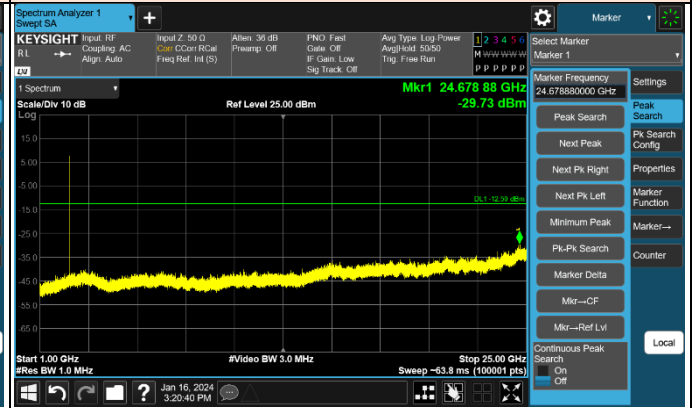
2 440 MHz _ Ref.



2 440 MHz _ Spurious



2 440 MHz _ Spurious





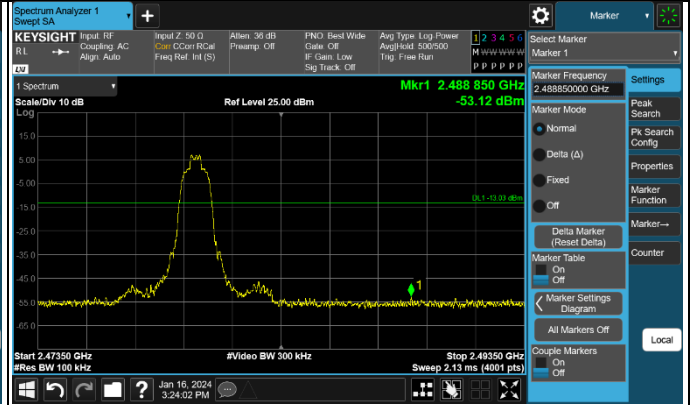
BUREAU VERITAS

TM 2

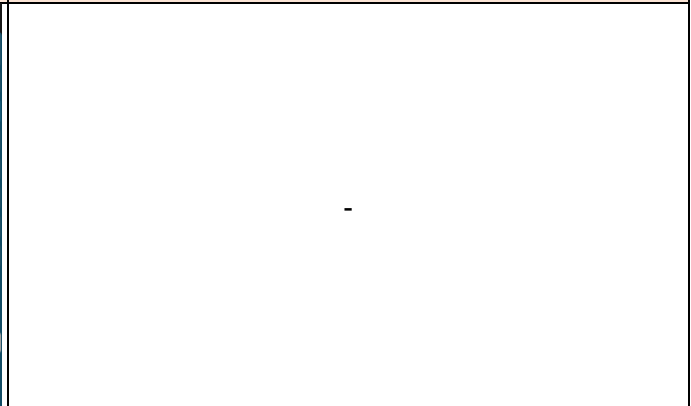
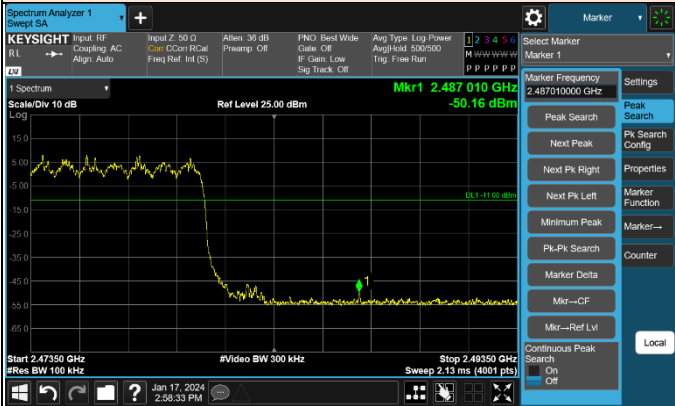
2 480 MHz _ Ref.



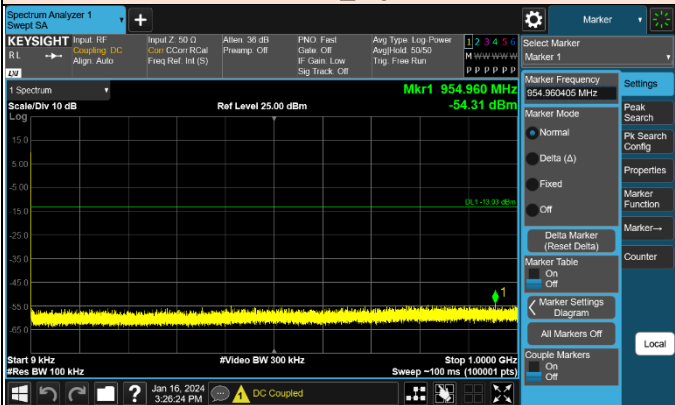
2 480 MHz _ Band edge



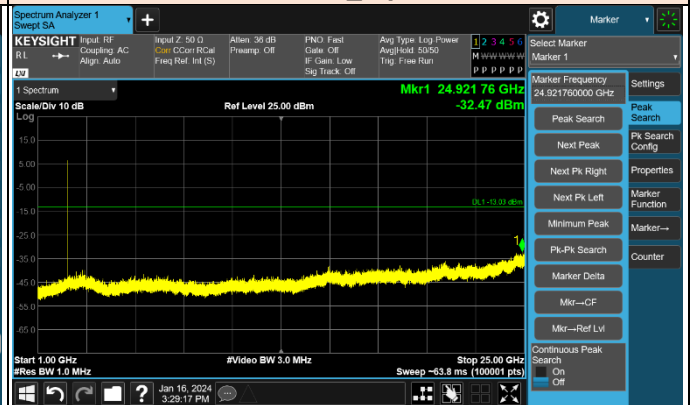
2 480 MHz _ Band edge Hopping



2 480 MHz _ Spurious



2 480 MHz _ Spurious





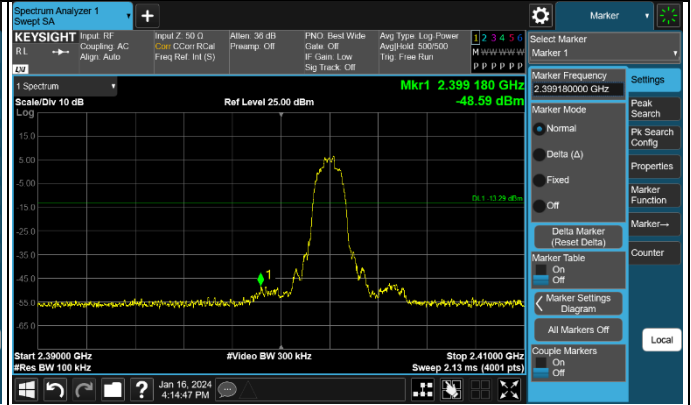
BUREAU VERITAS

TM 3

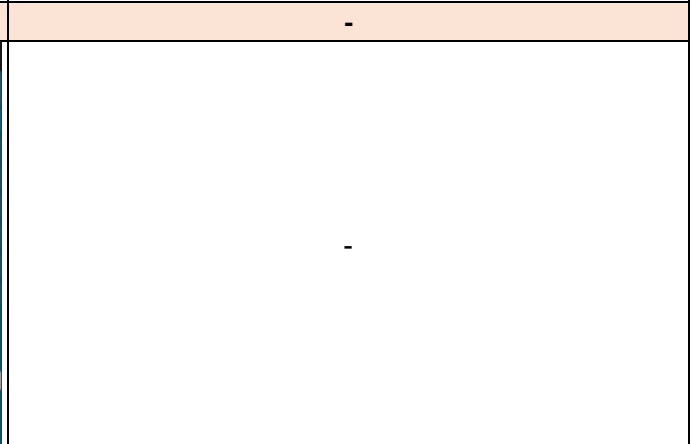
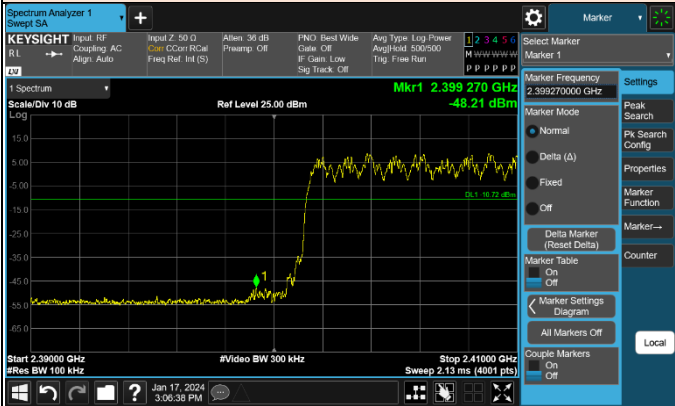
2 402 MHz _ Ref.



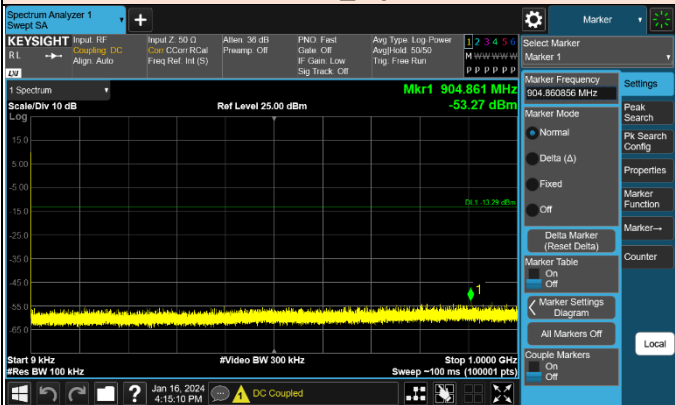
2 402 MHz _ Band edge



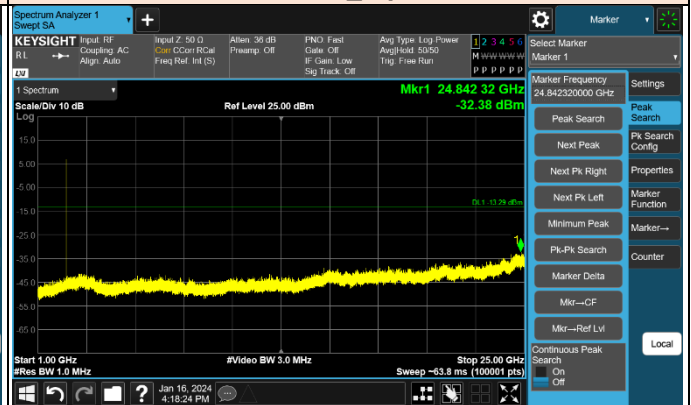
2 402 MHz _ Band edge Hopping



2 402 MHz _ Spurious



2 402 MHz _ Spurious





TM 3

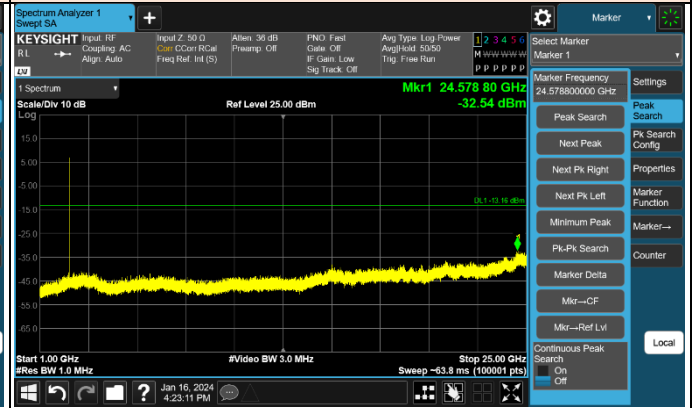
2 440 MHz _ Ref.



2 440 MHz _ Spurious



2 440 MHz _ Spurious





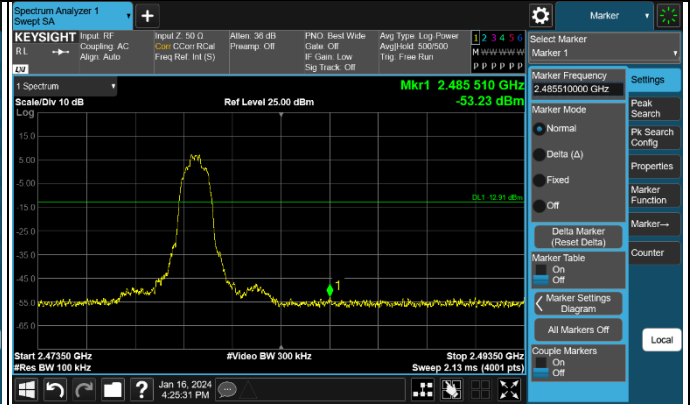
BUREAU VERITAS

TM 3

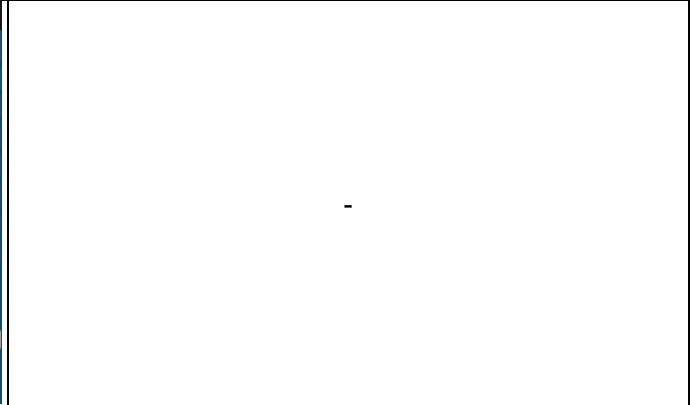
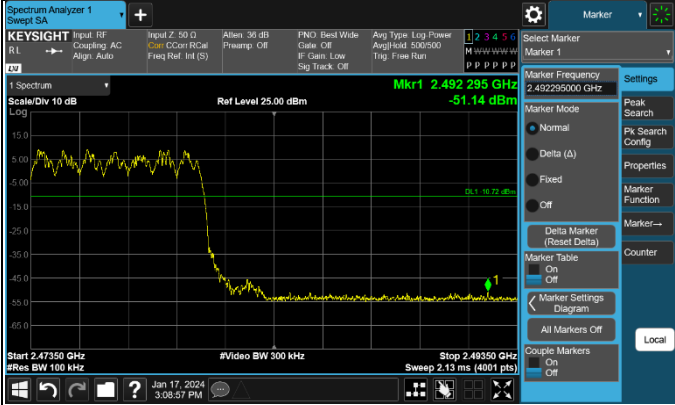
2 480 MHz _ Ref.



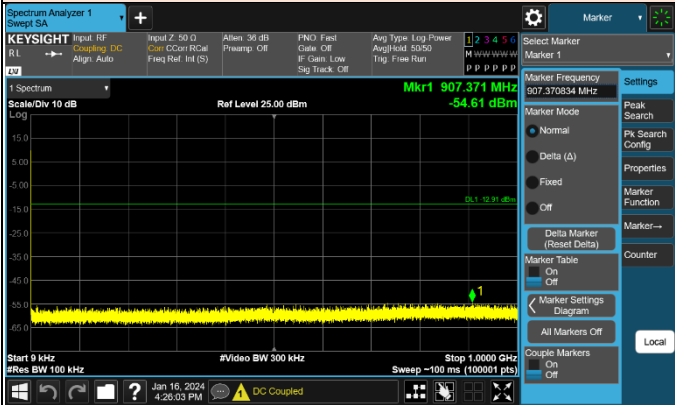
2 480 MHz _ Band edge



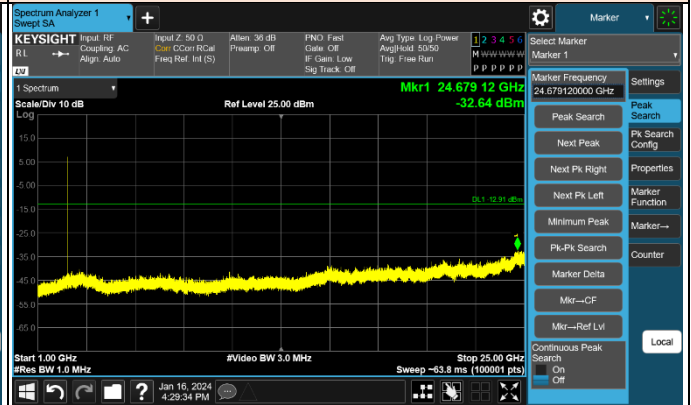
2 480 MHz _ Band edge Hopping



2 480 MHz _ Spurious



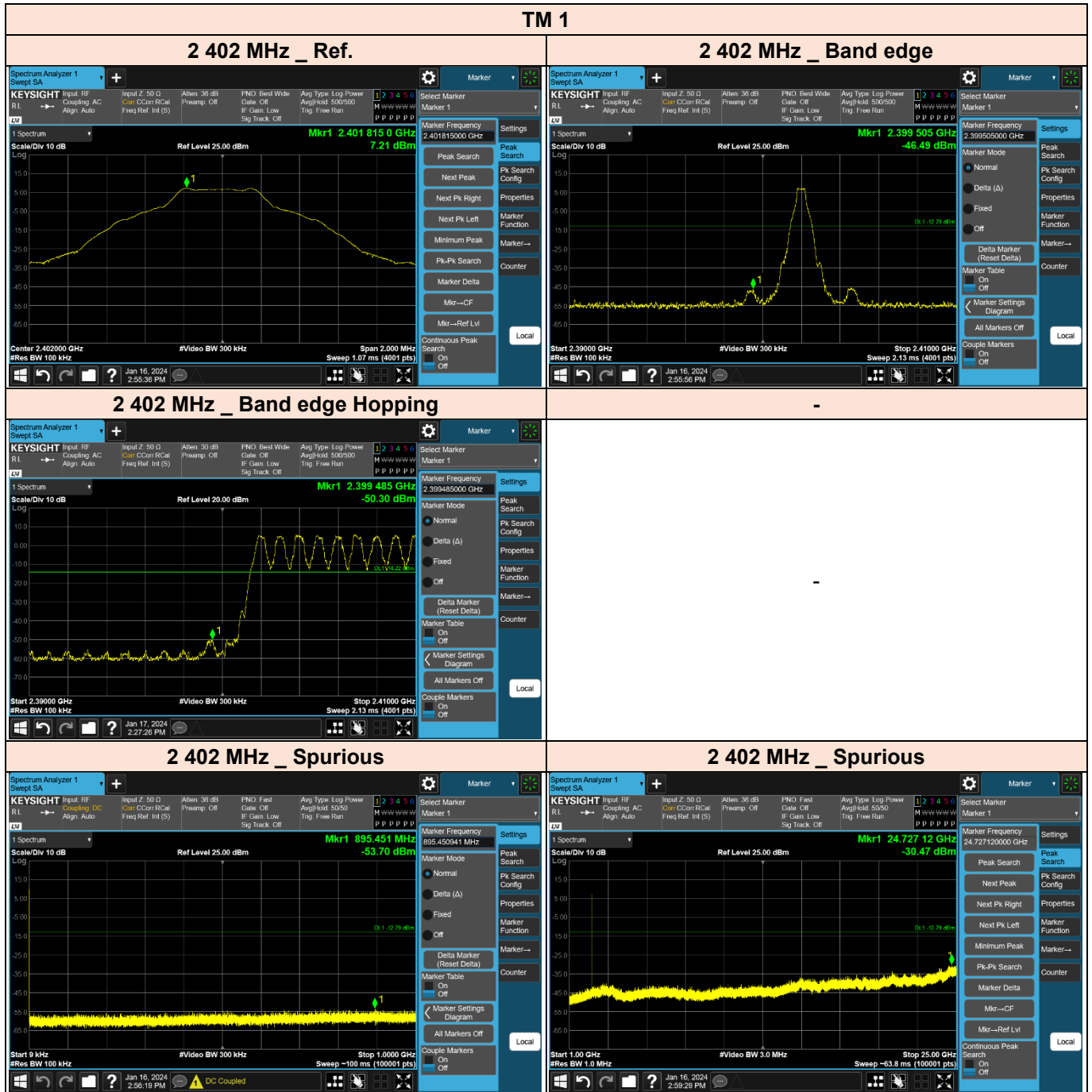
2 480 MHz _ Spurious





BUREAU VERITAS

[DC 24 V Spurious Emission]



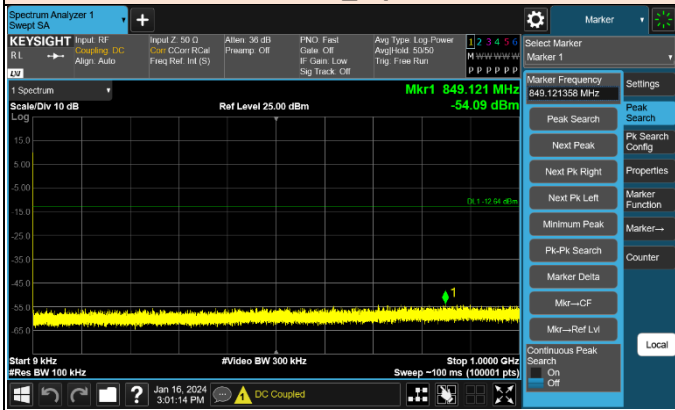


TM 1

2 440 MHz _ Ref.



2 440 MHz _ Spurious



2 440 MHz _ Spurious

