

6.7. Dwell Time

6.7.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.247 (a)(1)
Test Method:	ANSI C63.10:2020
Limit:	The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.
Test Setup:	 Spectrum Analyzer EUT
Test Mode:	Hopping mode
Test Procedure:	1. The testing follows ANSI C63.10:2020 Measurement Guidelines. 2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement. 3. Set to the maximum power setting and enable the EUT transmit continuously. 4. Enable the EUT hopping function. 5. Use the following spectrum analyzer settings: Span = zero span, centered on a hopping channel; RBW shall be $\leq$ channel spacing and where possible RBW should be set $\gg 1/T$, where T is the expected dwell time per channel; VBW $\geq$ RBW; Sweep = as necessary to capture the entire dwell time per hopping channel; Detector function = peak; Trace = max hold. 6. Measure and record the results in the test report.
Test Result:	PASS

6.7.2. Test Data

Mode	Frequency (MHz)	Pulse Time (ms)	Total Dwell Time (ms)	Burst Count	Period Time (ms)	Limit (ms)	Verdict
1-DH1	2402	0.405	127.575	315	31600	400	Pass
1-DH1	2441	0.406	129.108	318	31600	400	Pass
1-DH1	2480	0.406	129.514	319	31600	400	Pass
1-DH3	2402	1.661	264.099	159	31600	400	Pass
1-DH3	2441	1.662	269.244	162	31600	400	Pass
1-DH3	2480	1.662	284.202	171	31600	400	Pass
1-DH5	2402	2.91	317.19	109	31600	400	Pass
1-DH5	2441	2.91	325.92	112	31600	400	Pass
1-DH5	2480	2.91	305.55	105	31600	400	Pass

Note: 1. In normal mode, hopping rate is 1600 hops/s with 6 slots in 79 hopping channels.

For DH1, With channel hopping rate (1600 / 2 / 79) in Occupancy Time Limit (0.4 x 79) (s), Hops Over Occupancy Time comes to (1600 / 2 / 79) x (0.4 x 79) = 320 hops

For DH3, With channel hopping rate (1600 / 4 / 79) in Occupancy Time Limit (0.4 x 79) (s), Hops Over Occupancy Time comes to (1600 / 4 / 79) x (0.4 x 79) = 160 hops

For DH5, With channel hopping rate (1600 / 6 / 79) in Occupancy Time Limit (0.4 x 79) (s), Hops Over Occupancy Time comes to (1600 / 6 / 79) x (0.4 x 79) = 106.67 hops

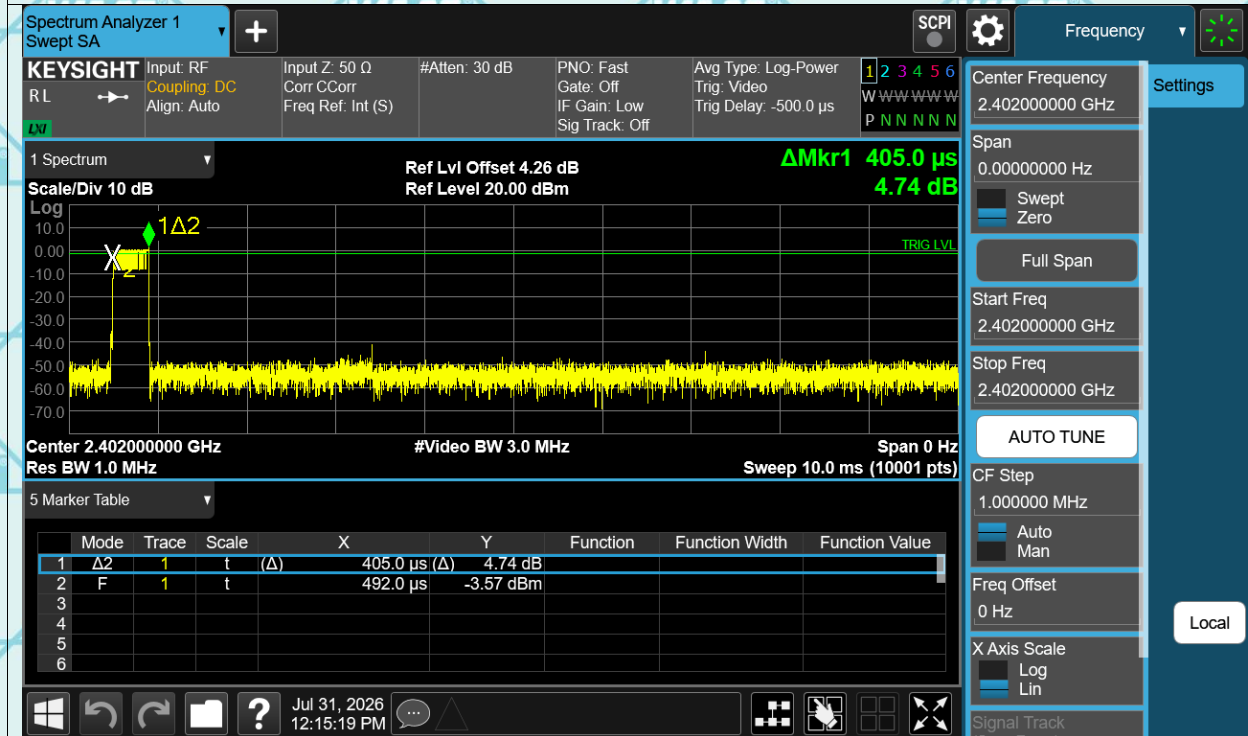
2. Dwell Time(s) = Hops Over Occupancy Time (hops) x Package Transfer Time

Test plots as follows:

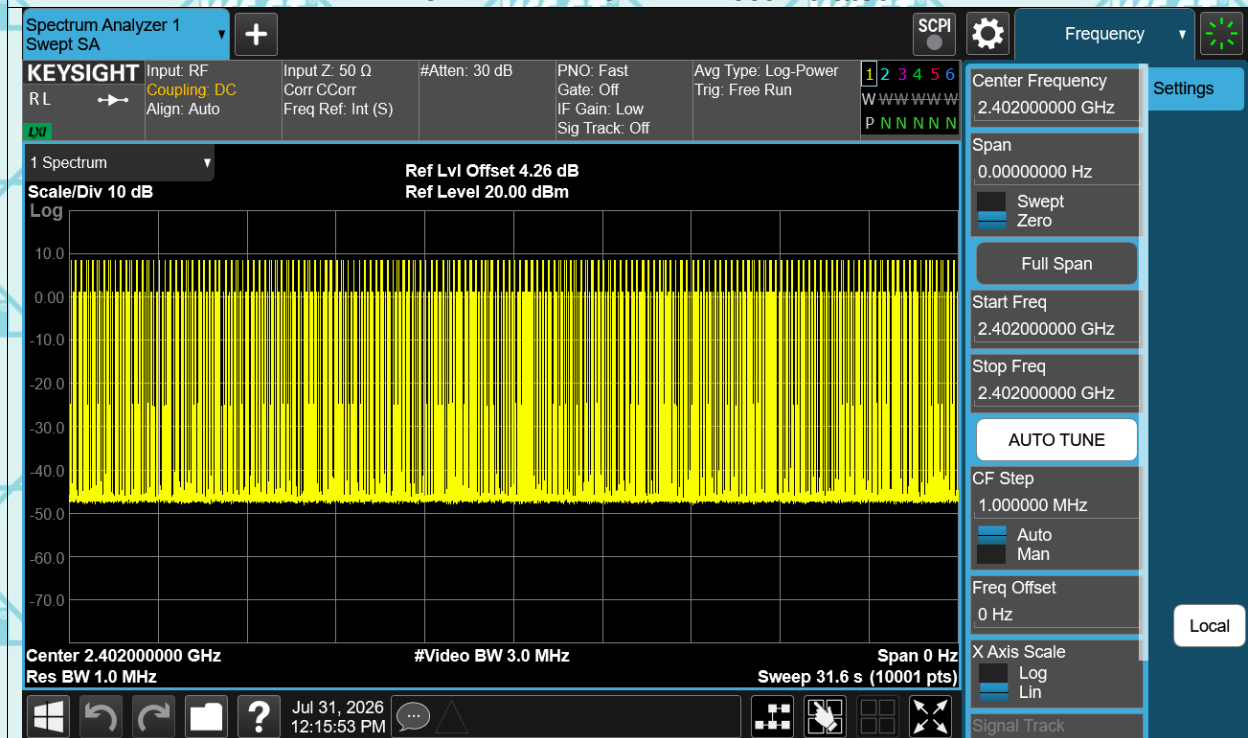
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Test Graphs

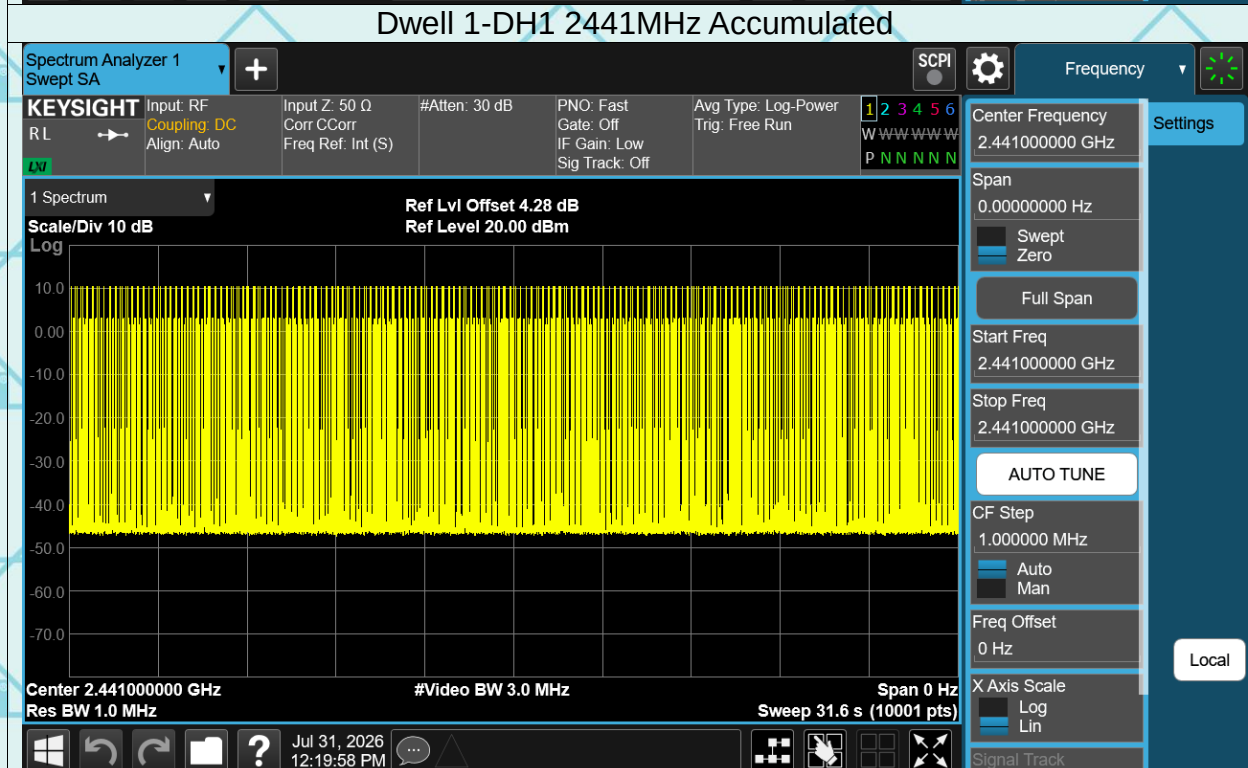
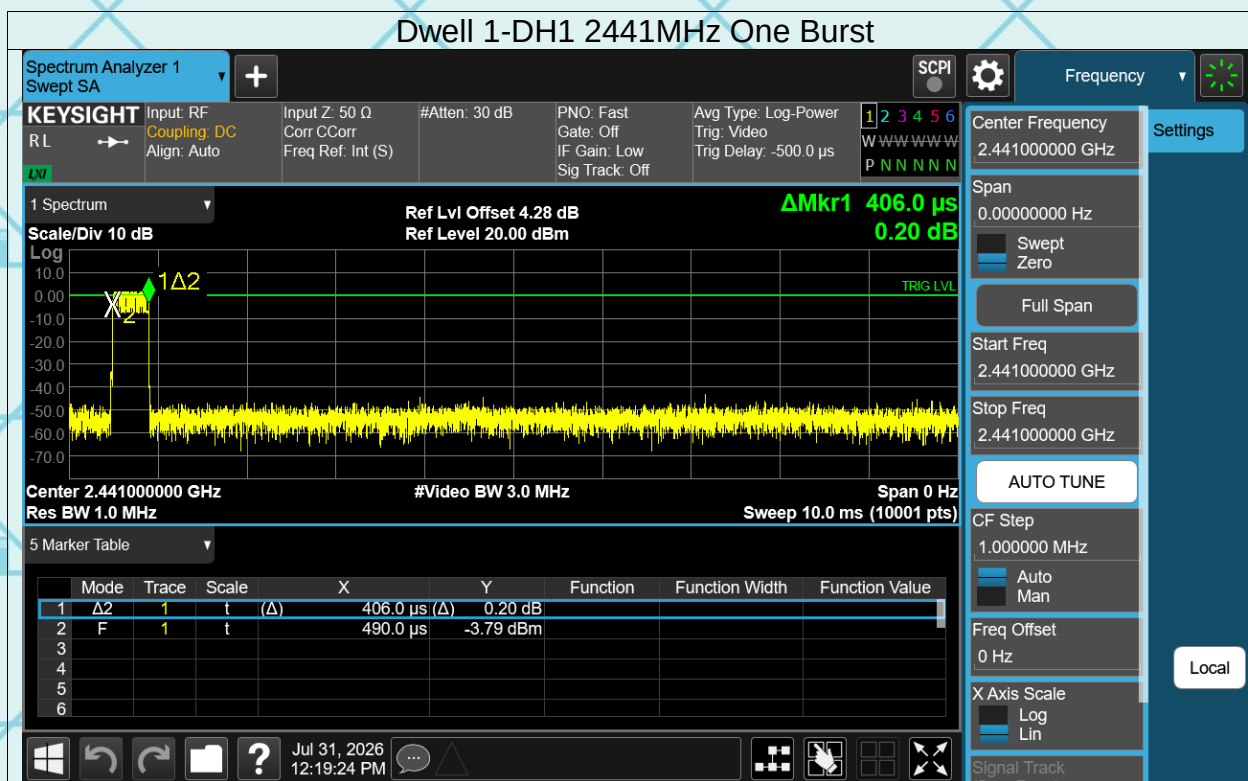
Dwell 1-DH1 2402MHz One Burst



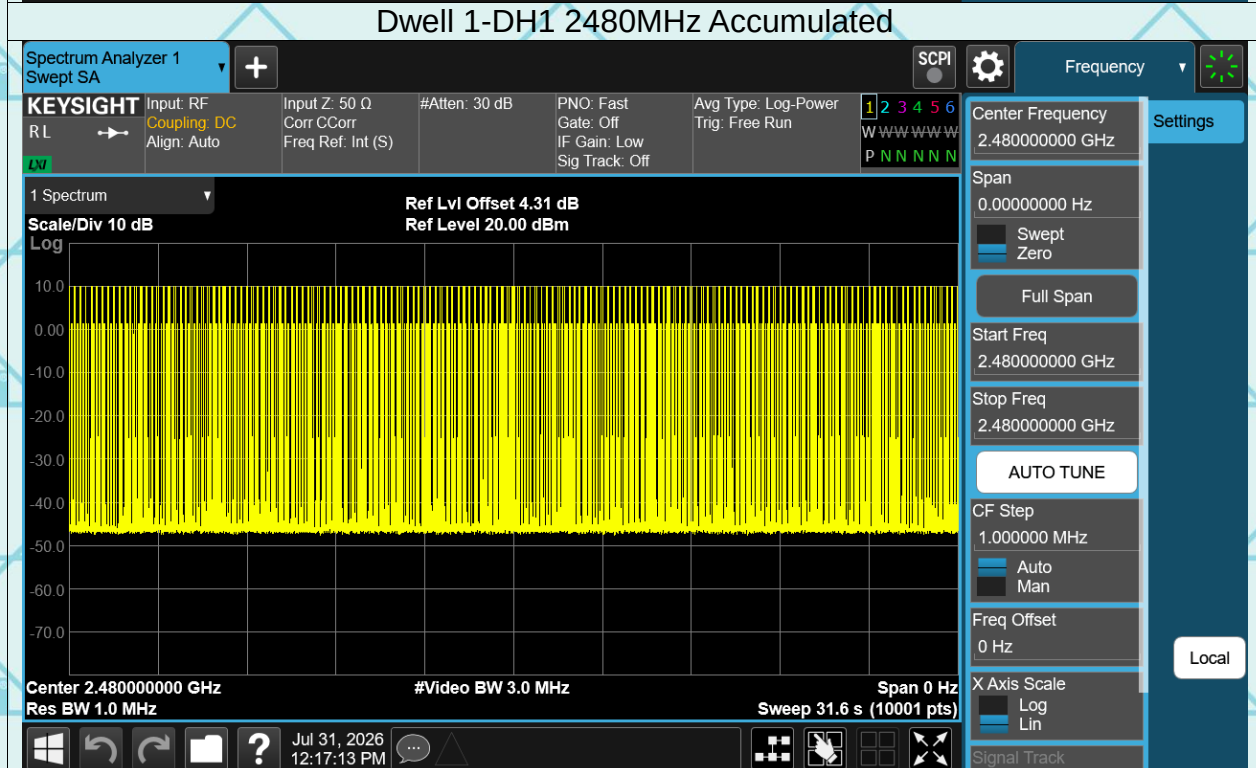
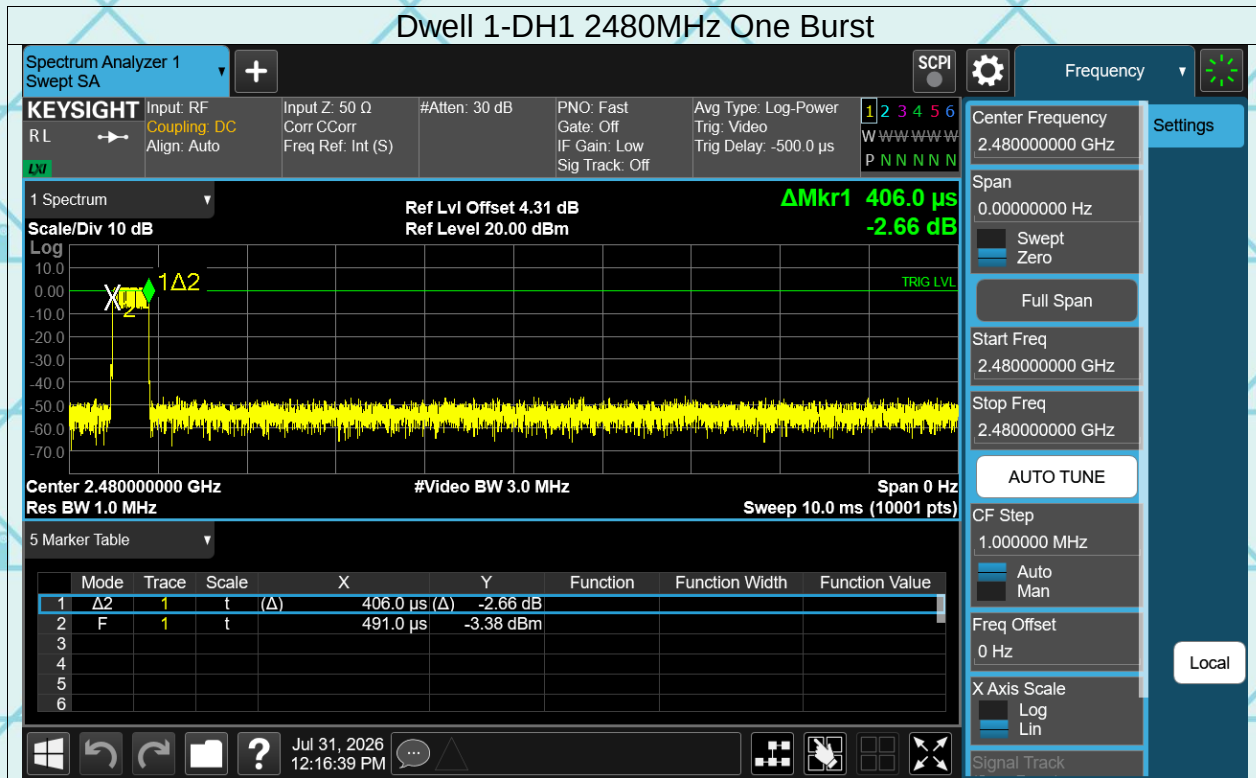
Dwell 1-DH1 2402MHz Accumulated



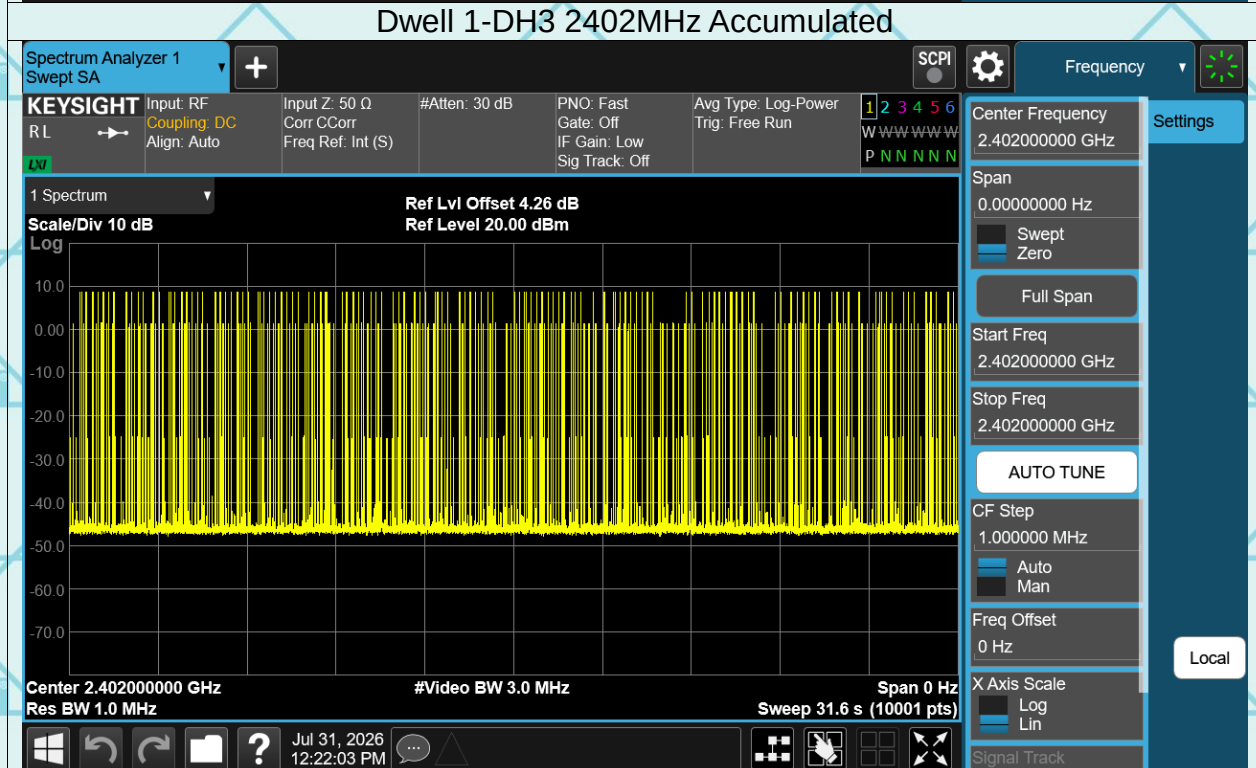
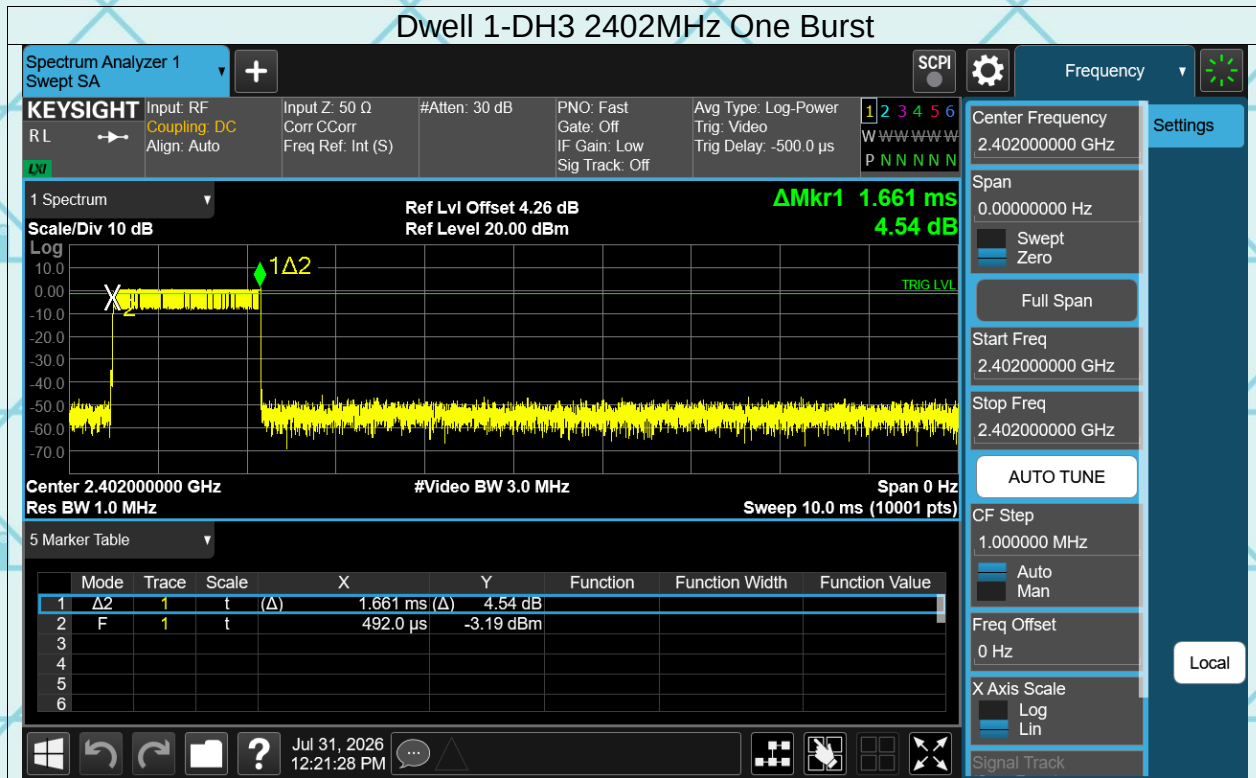
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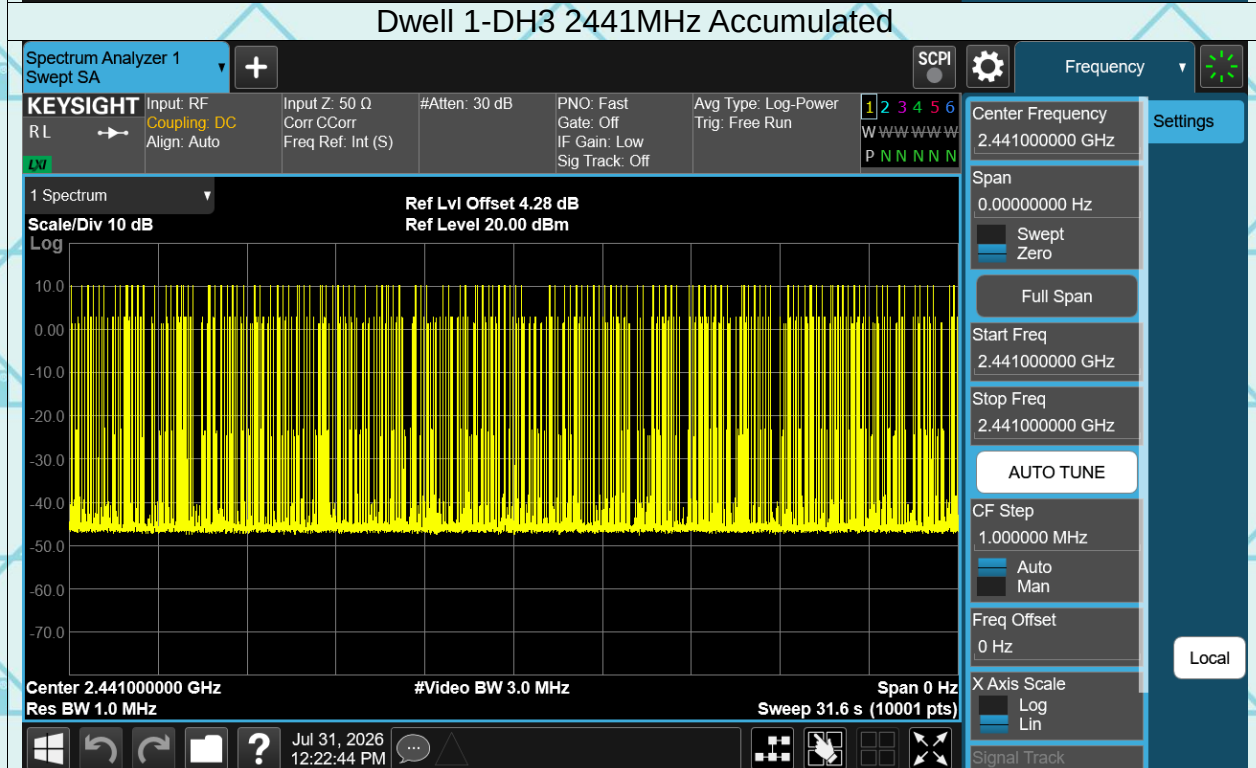
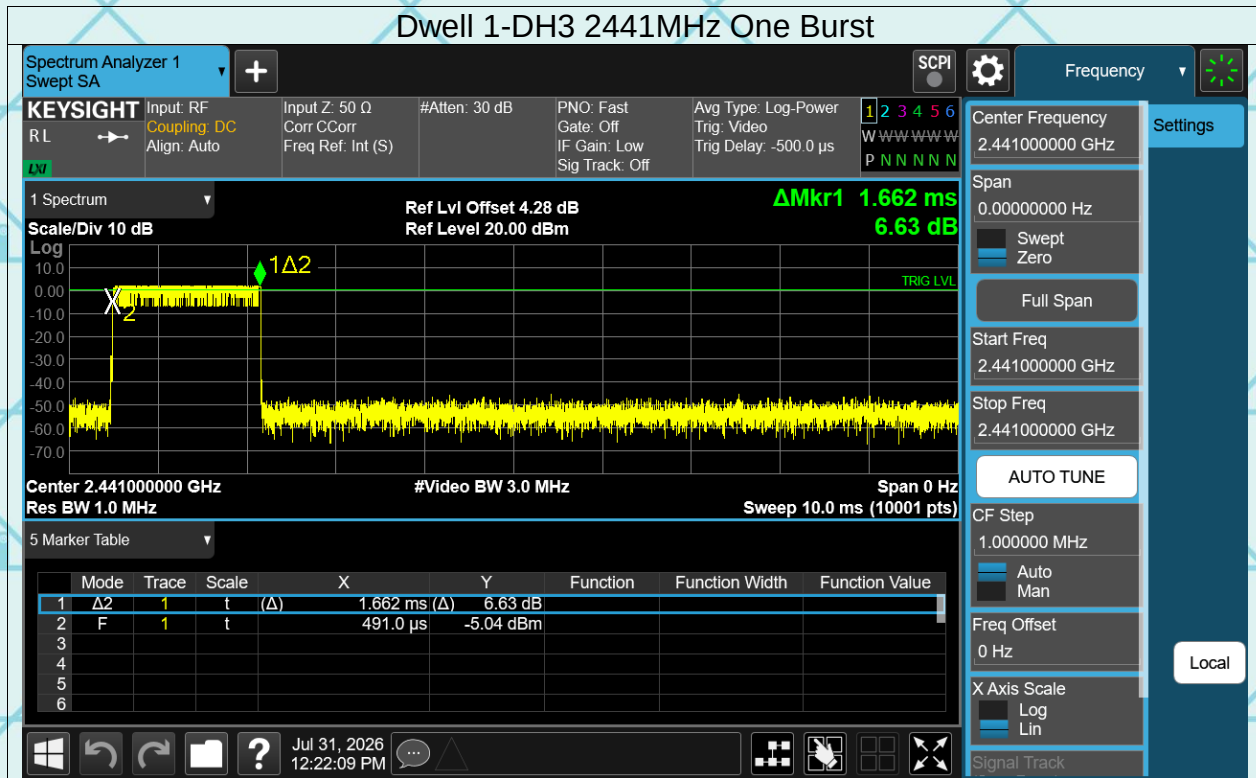
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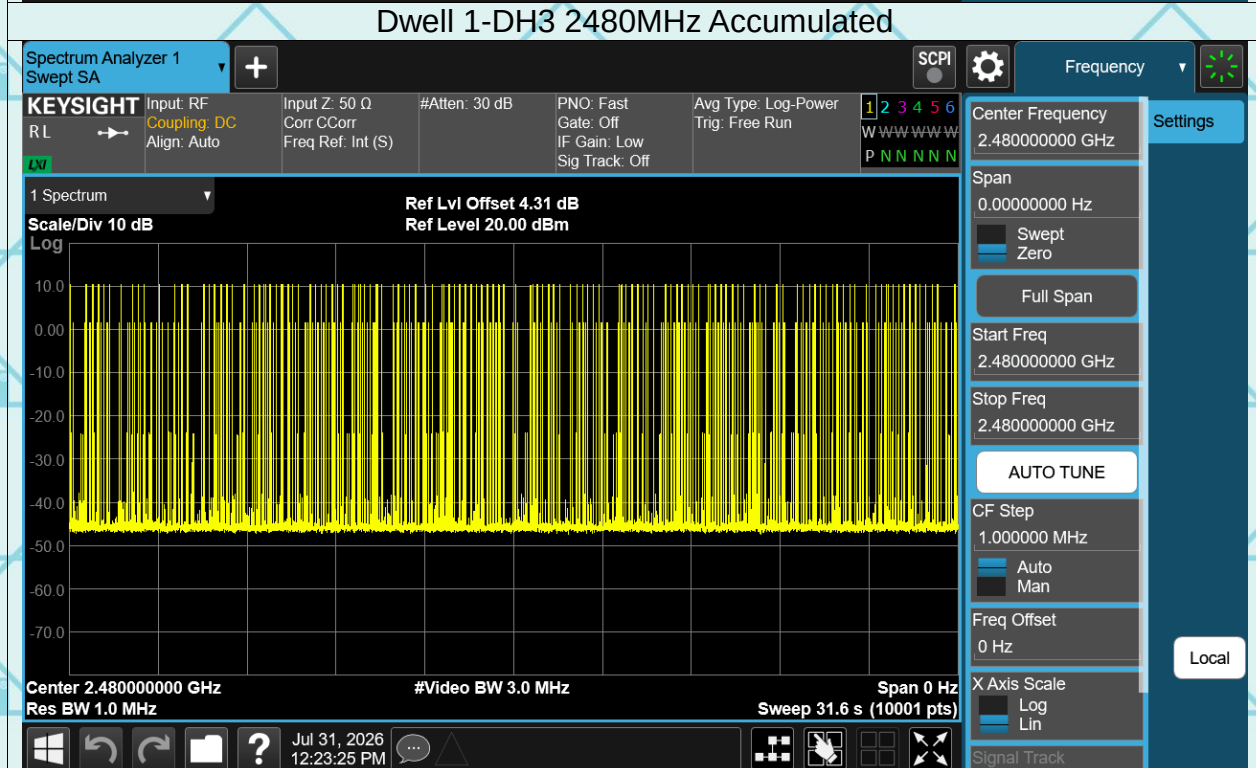
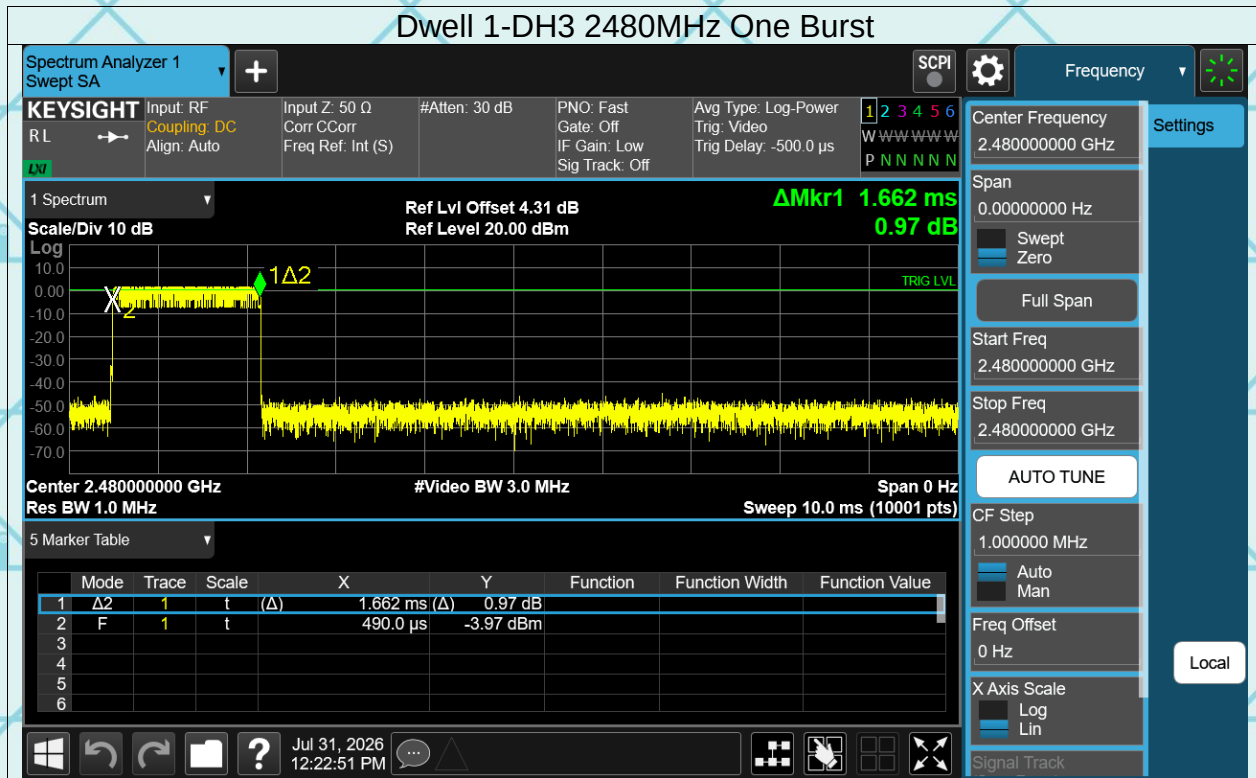
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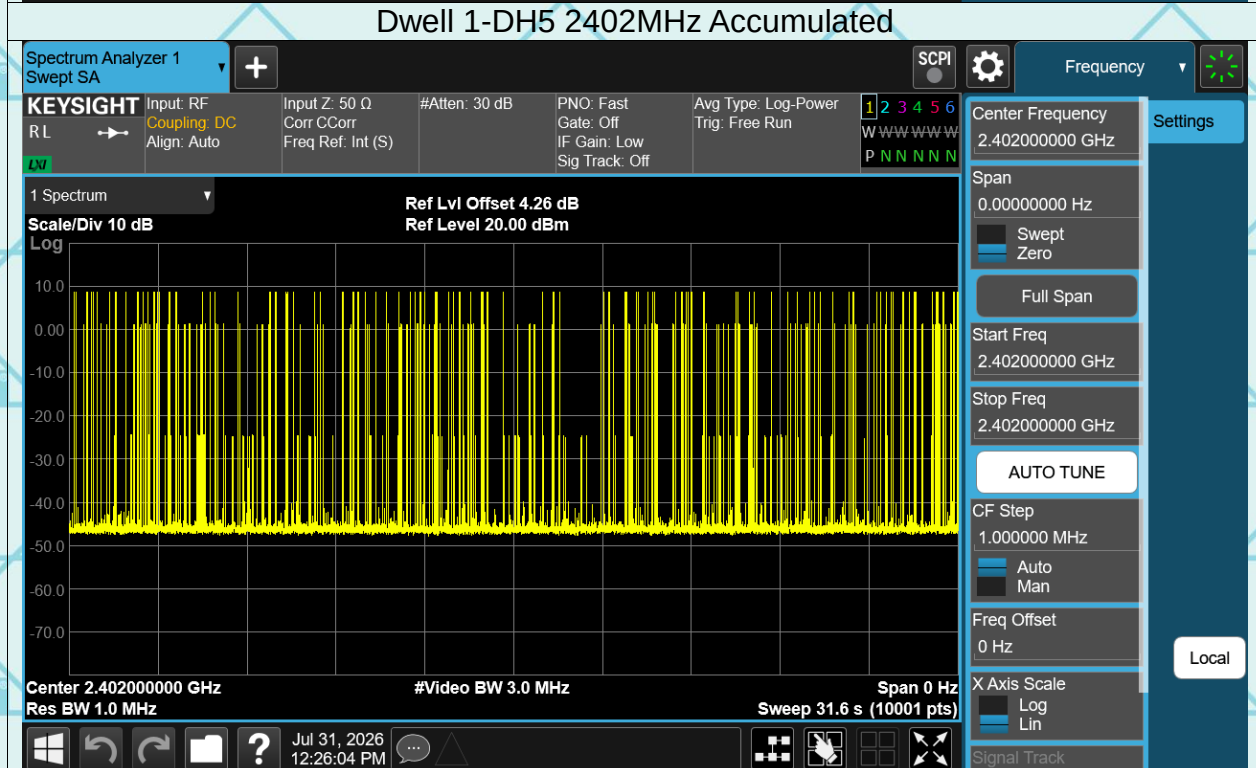
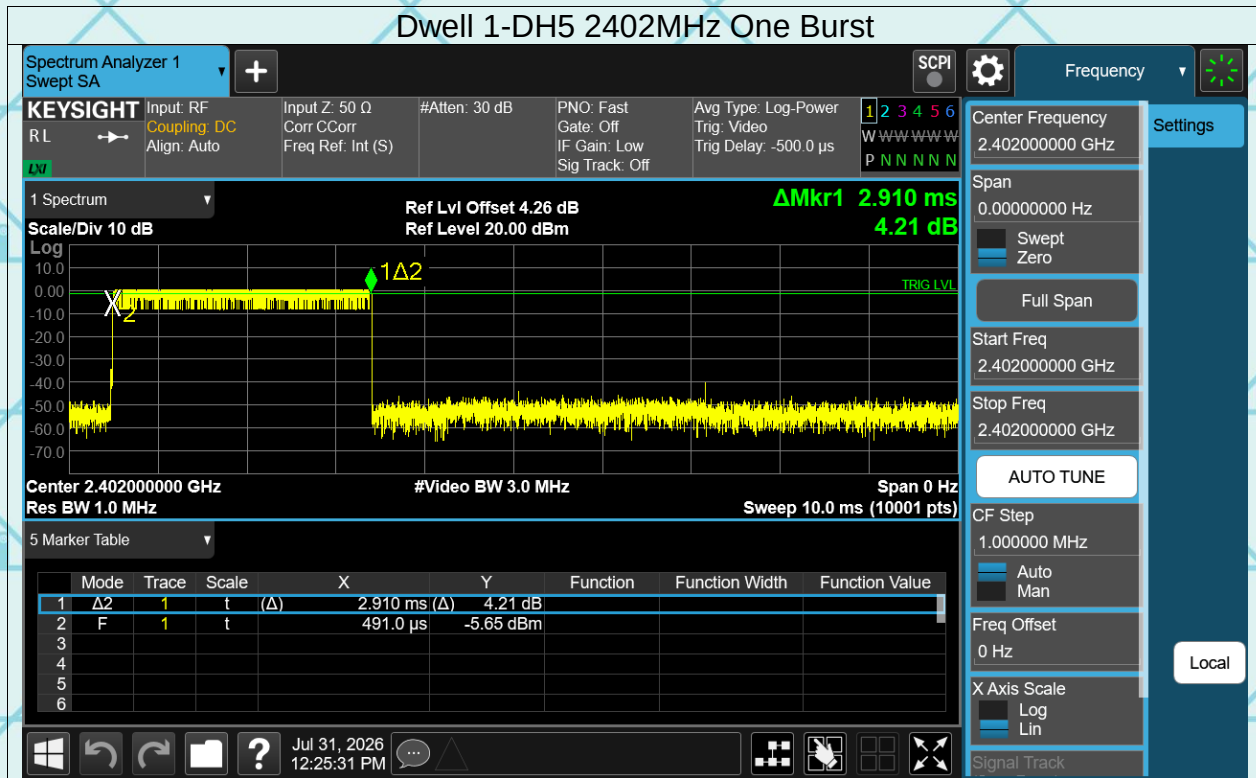
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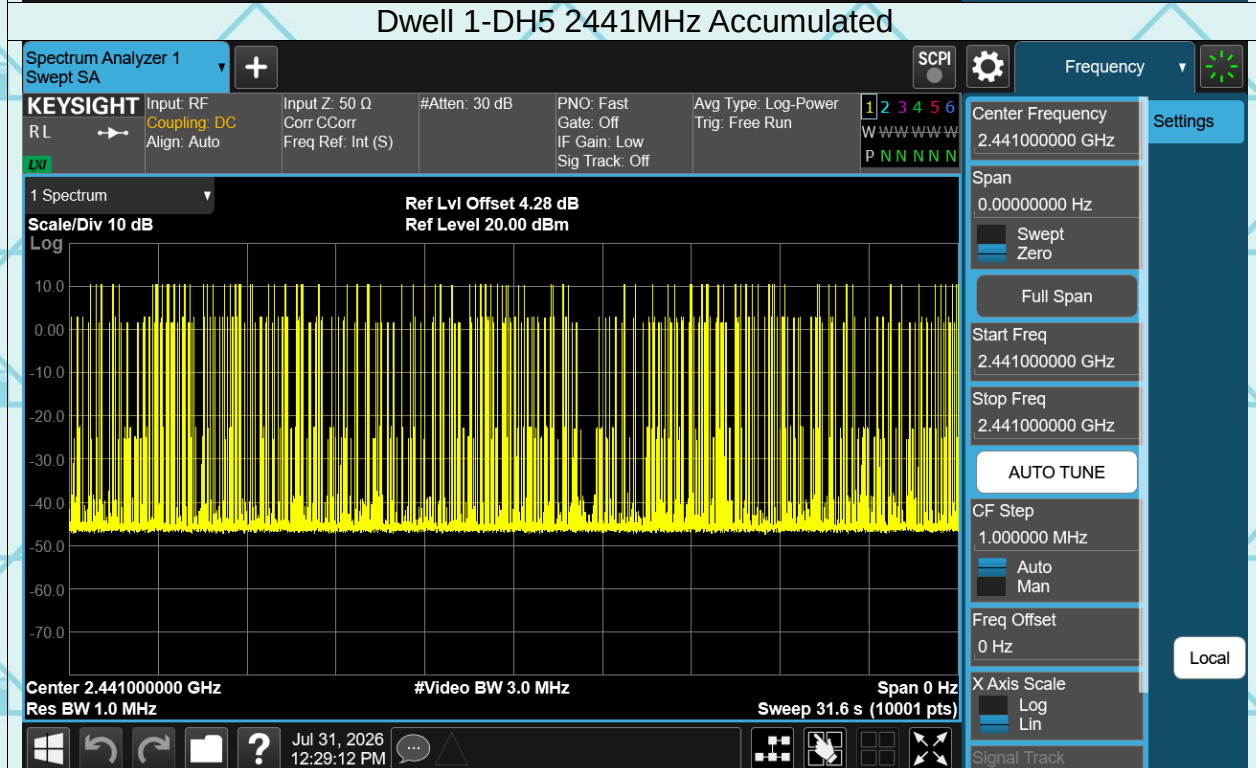
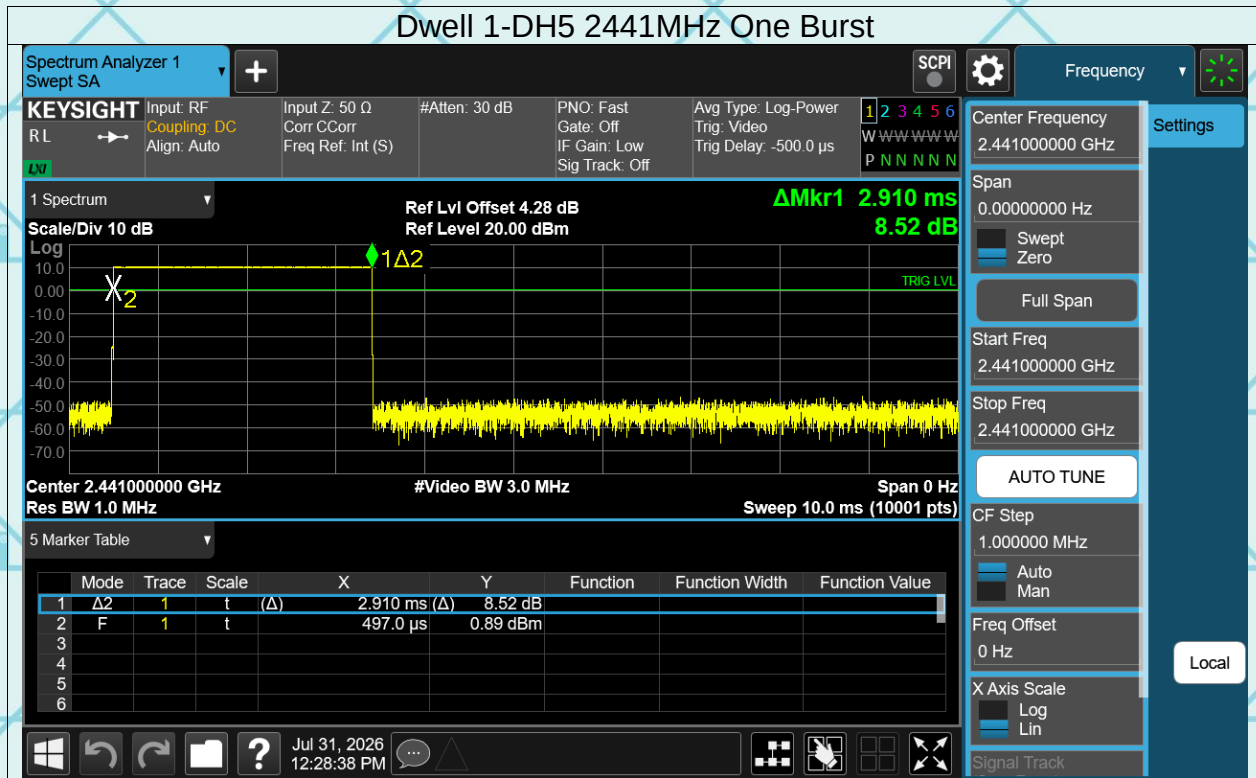
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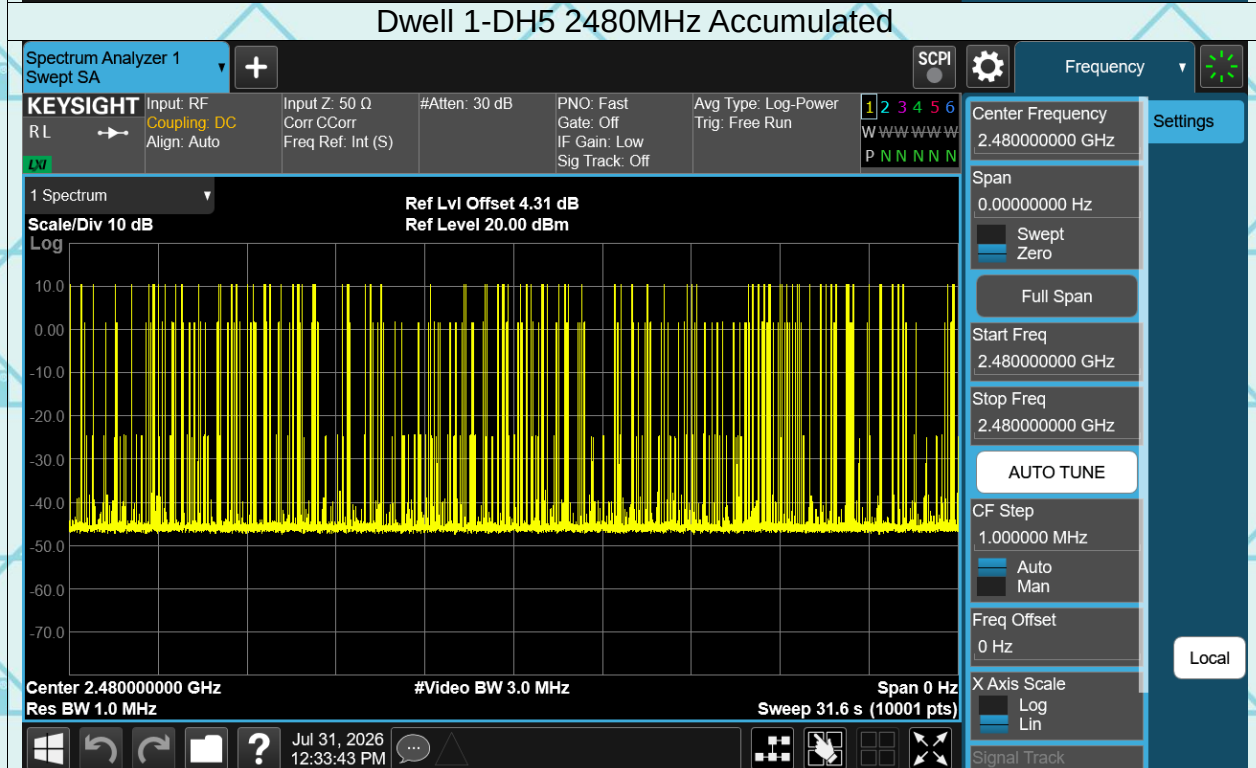
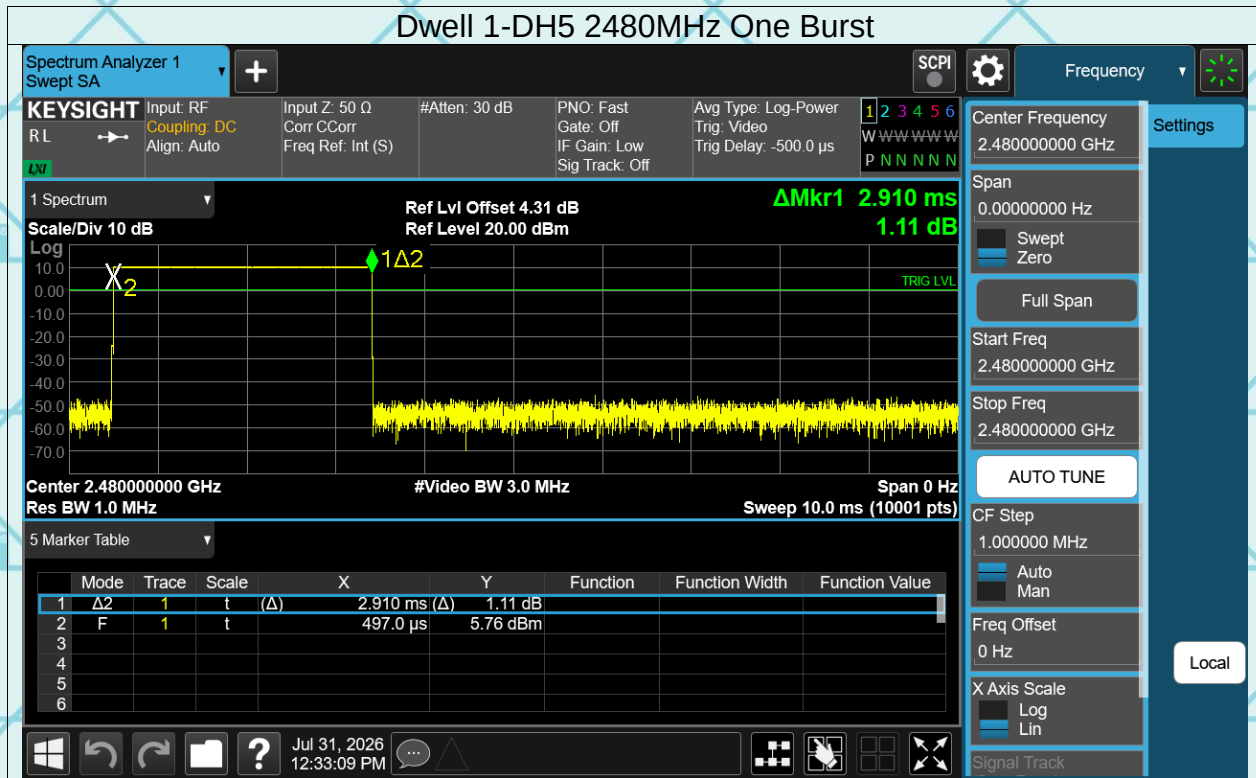


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6.8. Pseudorandom Frequency Hopping Sequence

Test Requirement: FCC Part15 C Section 15.247 (a)(1) requirement:

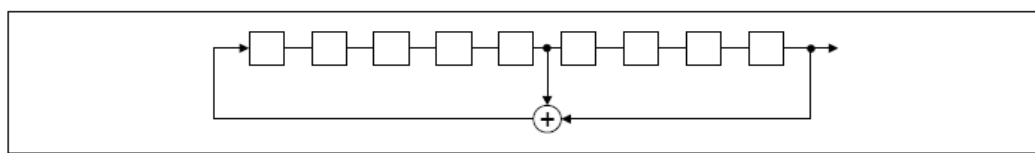
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

Alternatively. Frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a Pseudorandom ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

EUT Pseudorandom Frequency Hopping Sequence

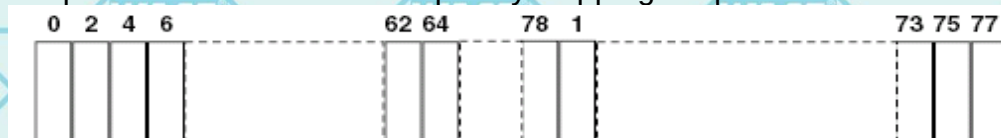
The pseudorandom sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first one of 9 consecutive ones; i.e. the shift register is initialized with nine ones.

- Number of shift register stages: 9
- Length of pseudo-random sequence: $2^9 - 1 = 511$ bits
- Longest sequence of zeros: 8 (non-inverted signal)



Linear Feedback Shift Register for Generation of the PRBS sequence

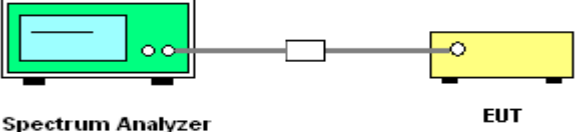
An example of Pseudorandom Frequency Hopping Sequence as follow:



Each frequency used equally on the average by each transmitter. The system receivers have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchronization with the transmitted signals.

6.9. Conducted Band Edge Measurement

6.9.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.247 (d)
Test Method:	ANSI C63.10:2020
Limit:	In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.
Test Setup:	 Spectrum Analyzer EUT
Test Mode:	Transmitting mode with modulation
Test Procedure:	1. The testing follows the guidelines in Band-edge Compliance of RF Conducted Emissions of ANSI C63.10:2020 Measurement Guidelines. 2. Set to the maximum power setting and enable the EUT transmit continuously. 3. Set RBW = 100 kHz ($\geq 1\%$ span=10MHz), VBW = 300 kHz ($\geq$RBW). Band edge emissions must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100kHz RBW. The attenuation shall be 30 dB instead of 20 dB when RMS conducted output power procedure is used. 4. Enable hopping function of the EUT and then repeat step 2 and 3. 5. Measure and record the results in the test report.
Test Result:	PASS

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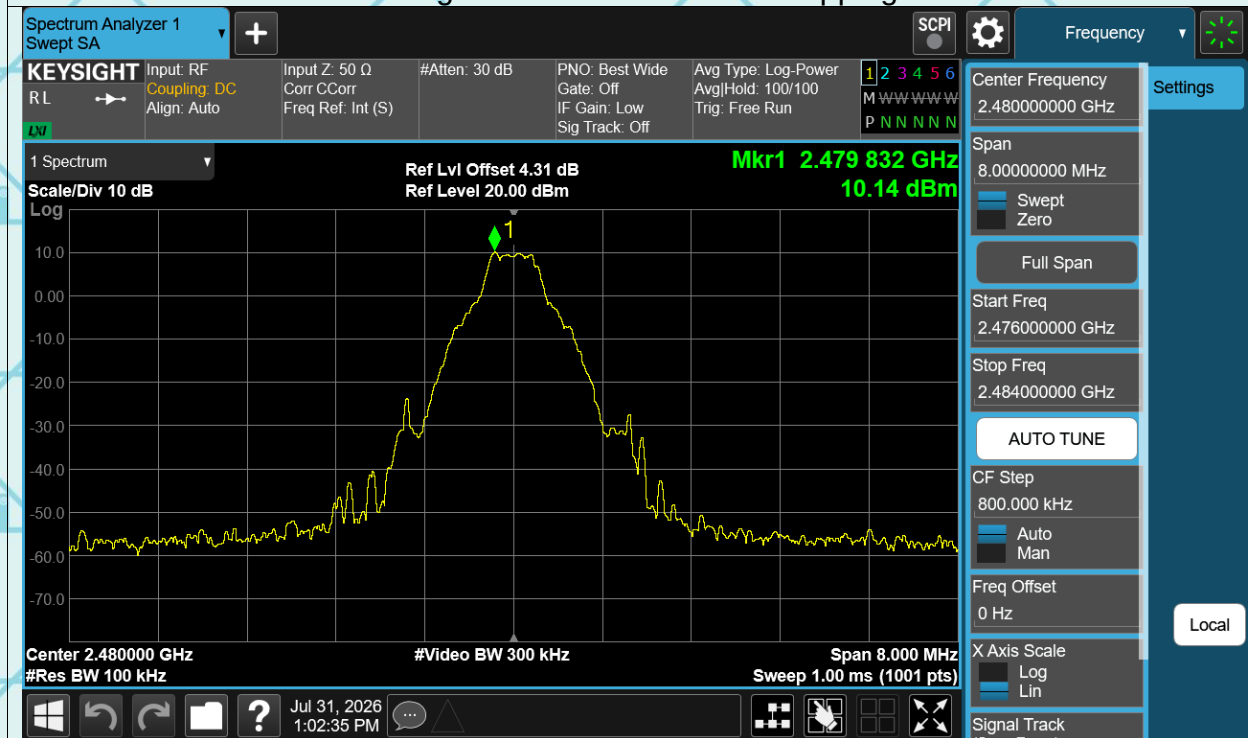
Test Data

GFSK Modulation (the worst case)

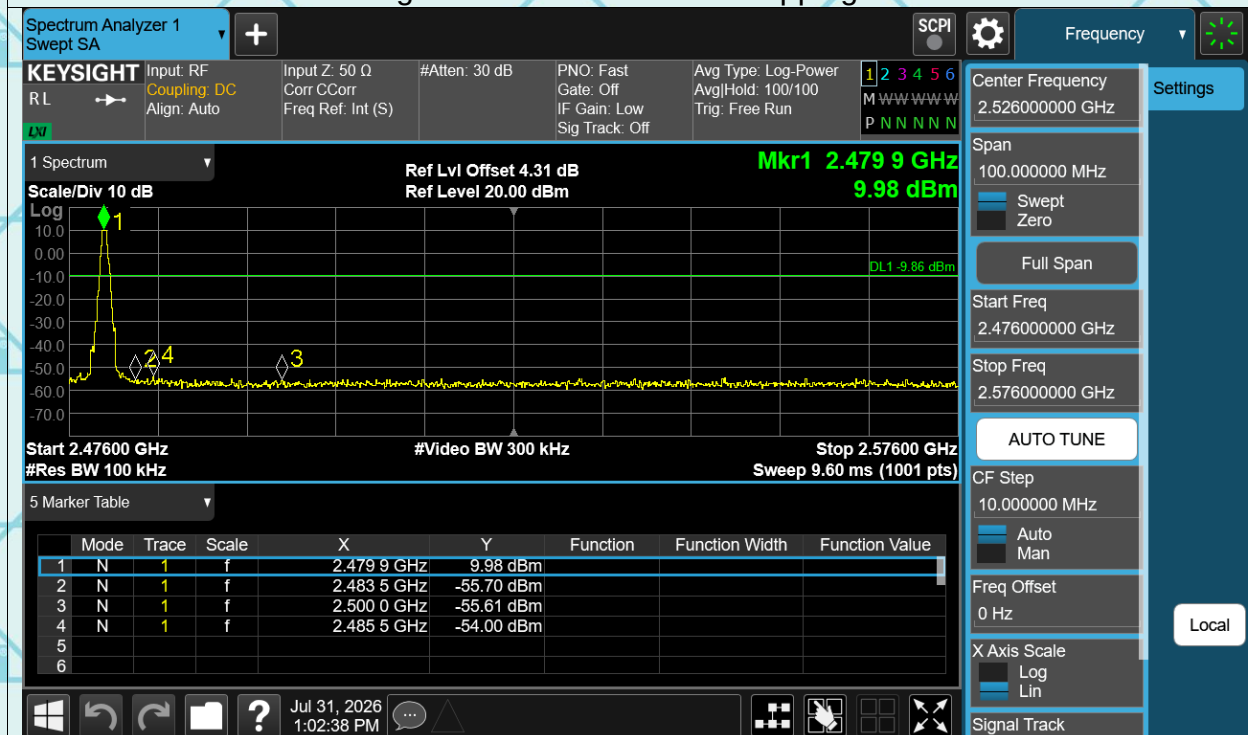


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Band Edge 1-DH5 2480MHz No-Hopping Ref



Band Edge 1-DH5 2480MHz No-Hopping Emission



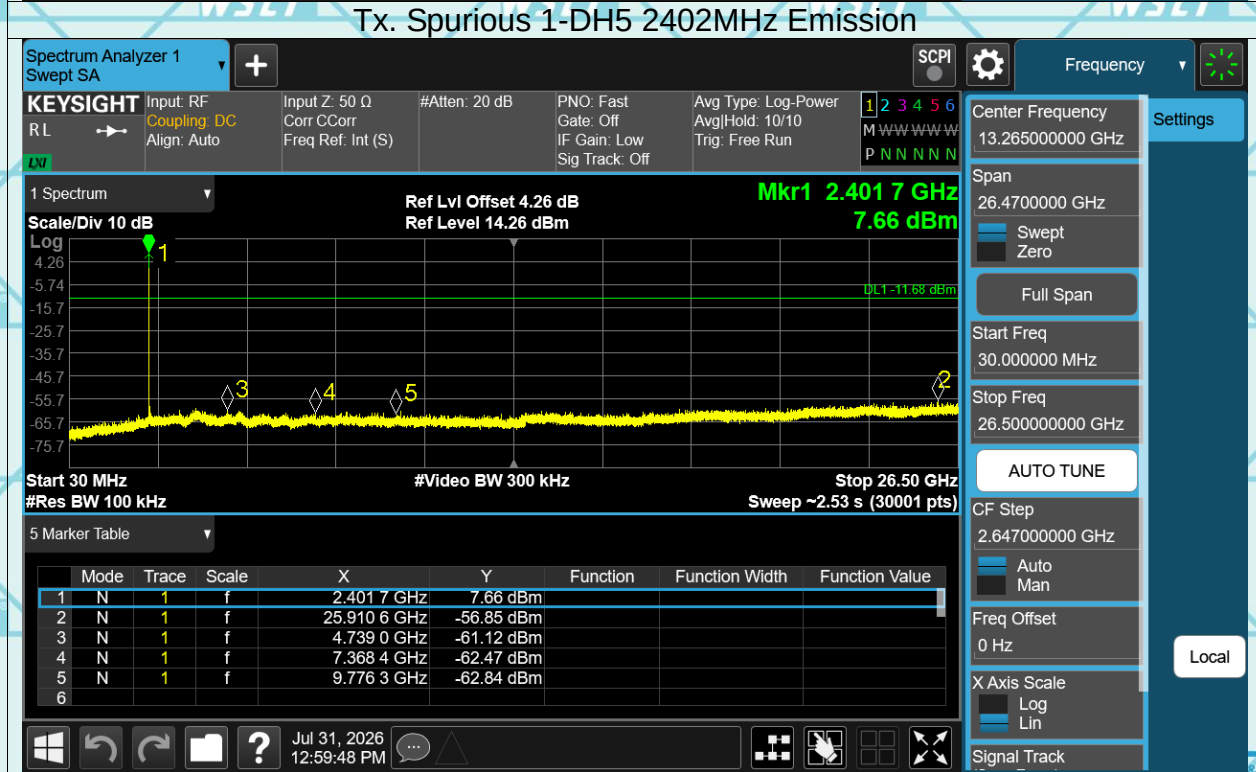
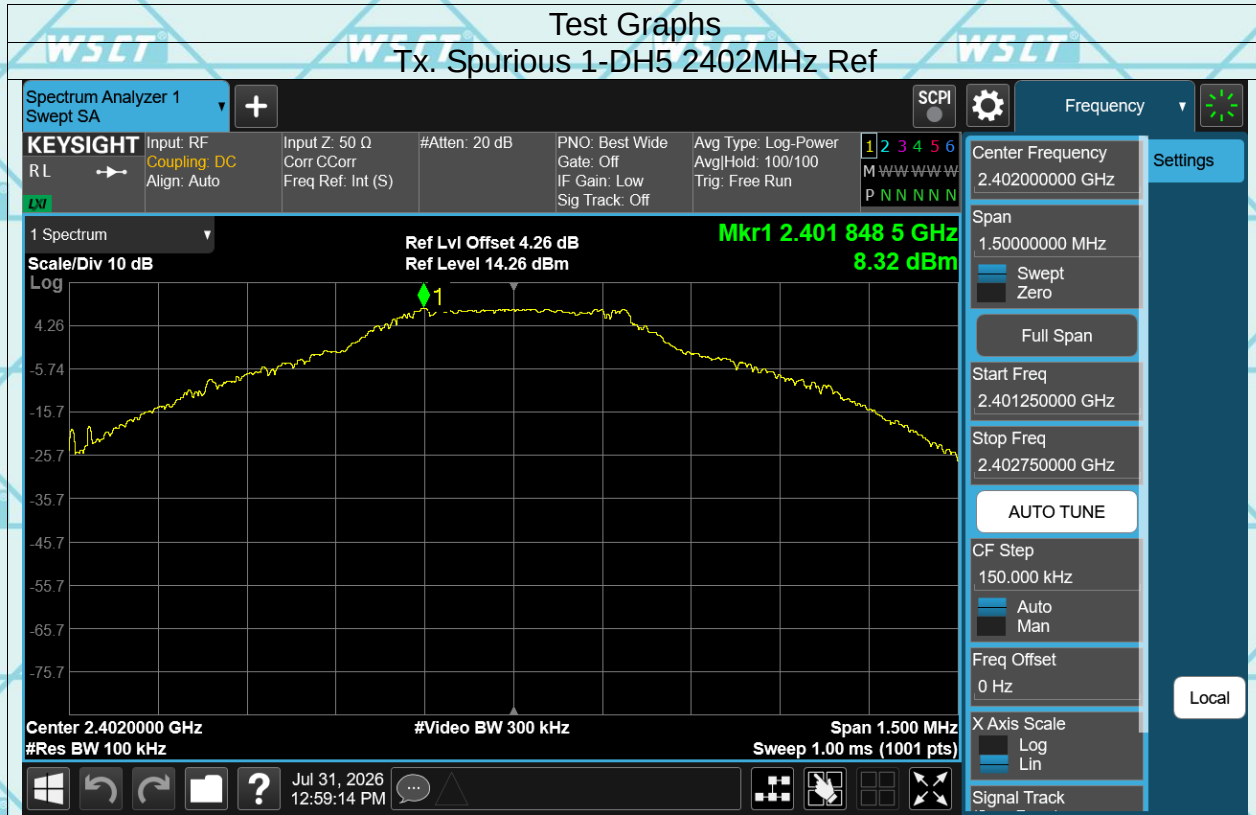
6.10. Conducted Spurious Emission Measurement

6.10.1. Test Specification

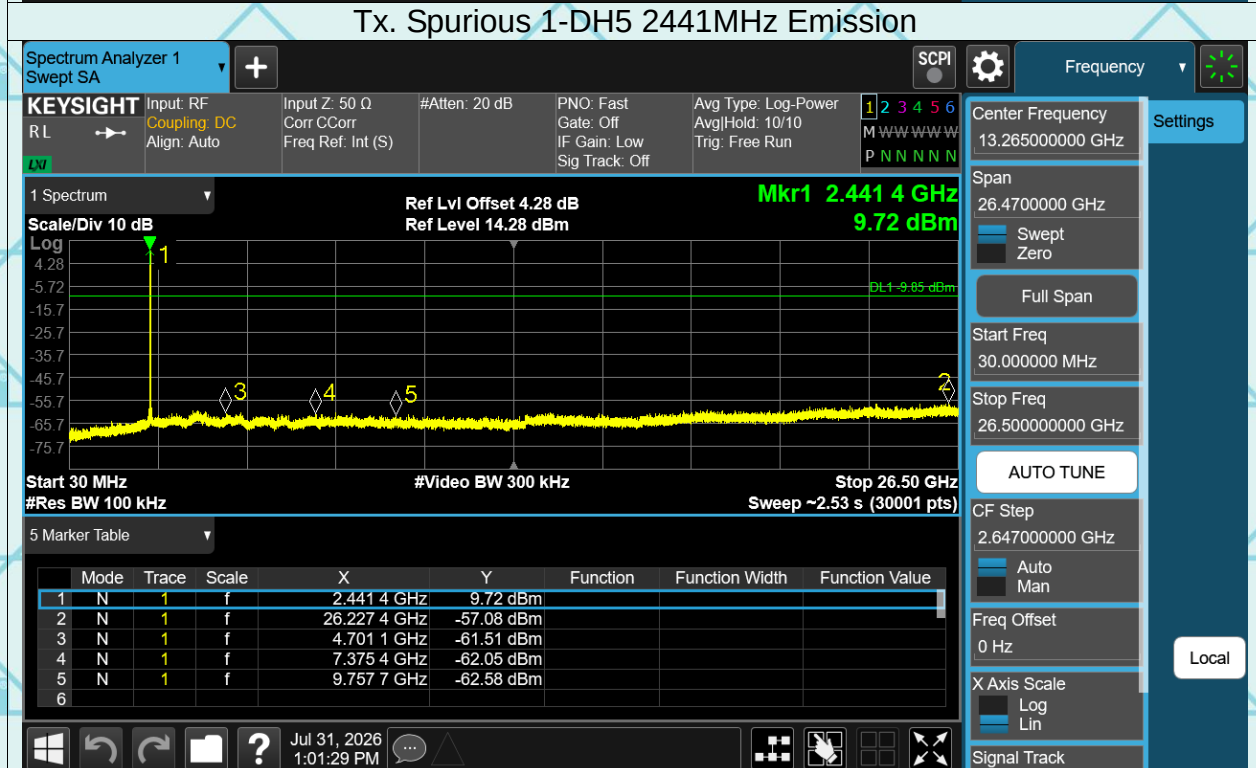
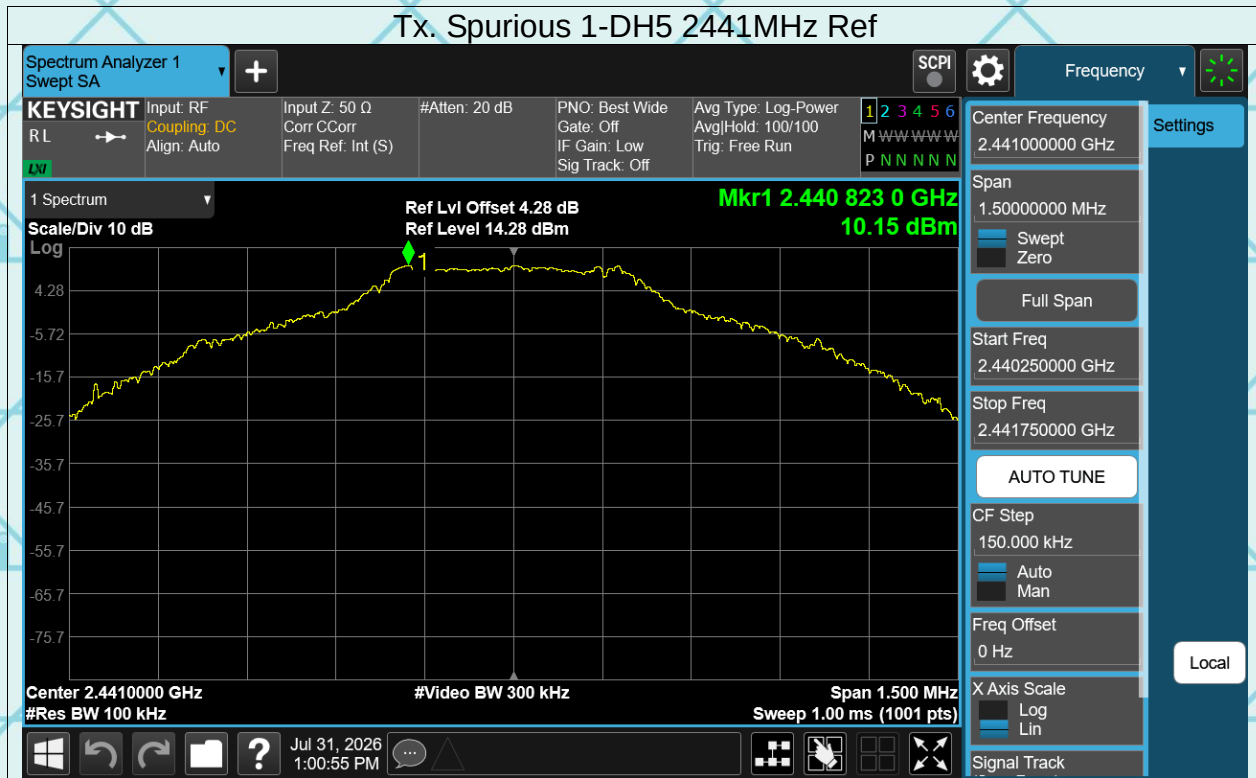
Test Requirement:	FCC Part15 C Section 15.247 (d)
Test Method:	ANSI C63.10:2020
Limit:	In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.
Test Setup:	 Spectrum Analyzer EUT
Test Mode:	Transmitting mode with modulation
Test Procedure:	1. The testing follows the guidelines in Spurious RF Conducted Emissions of ANSI C63.10:2020 Measurement Guidelines 2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement. 3. Set to the maximum power setting and enable the EUT transmit continuously. 4. Set RBW = 100 kHz, VBW = 300kHz, scan up through 10th harmonic. All harmonics / spurs must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100 kHz RBW. 5. Measure and record the results in the test report. 6. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.
Test Result:	PASS

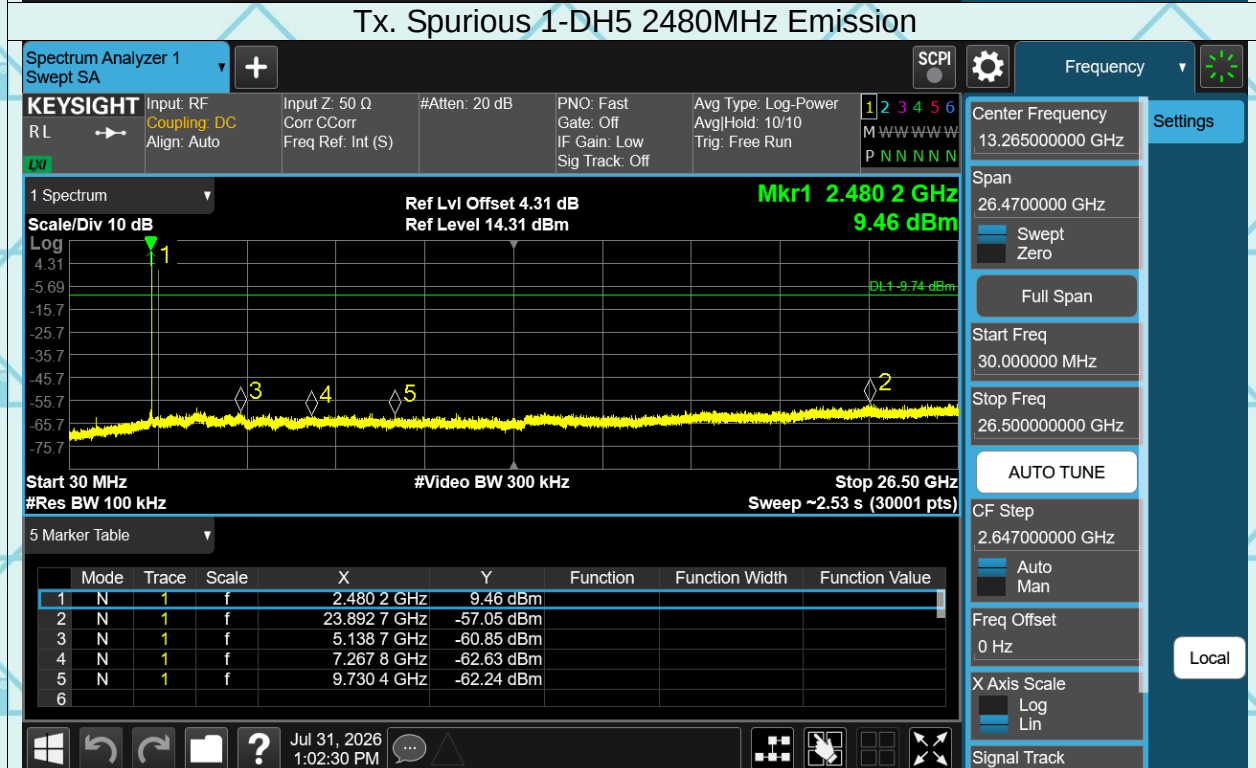
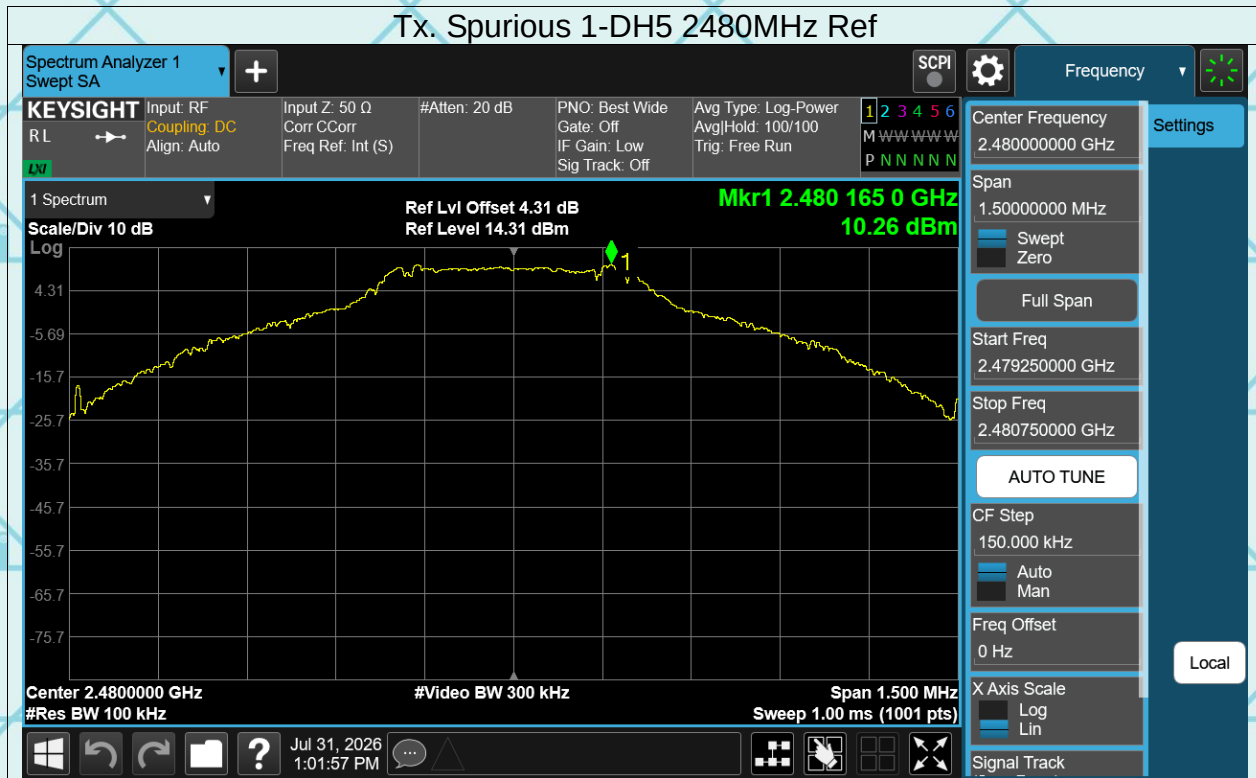
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Test Data

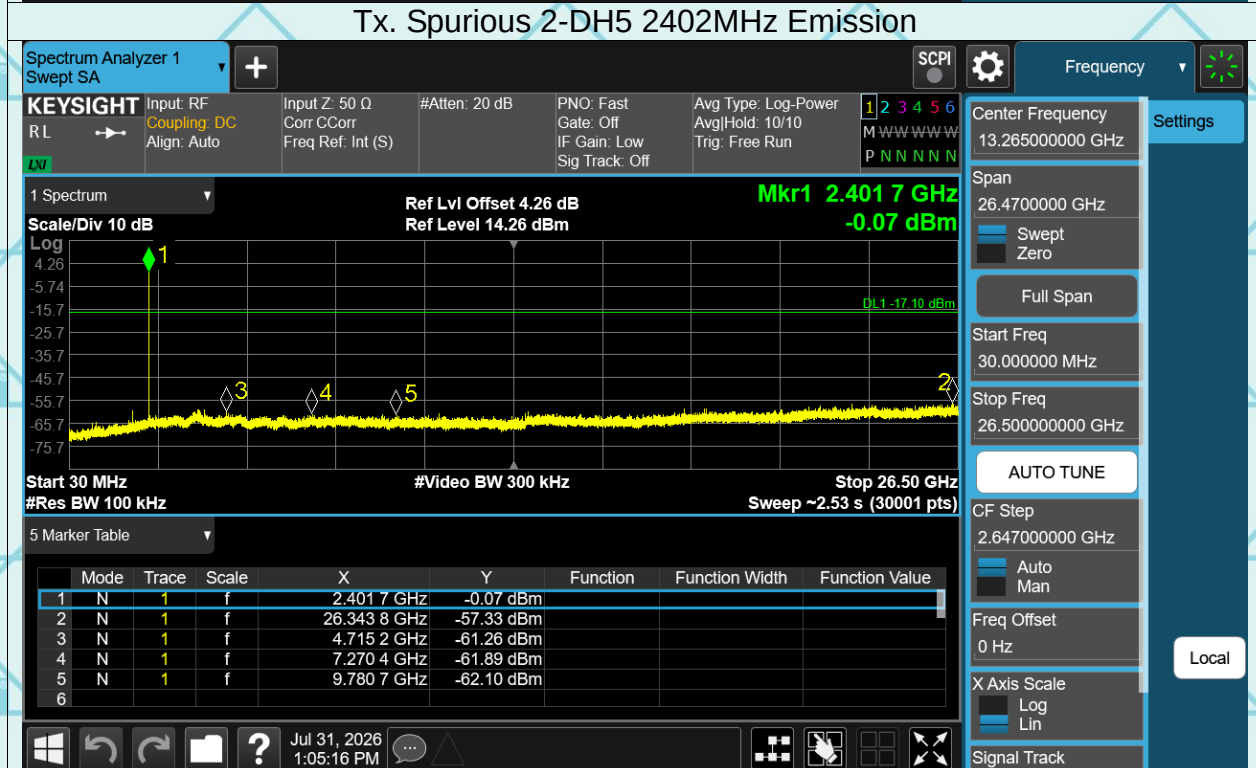
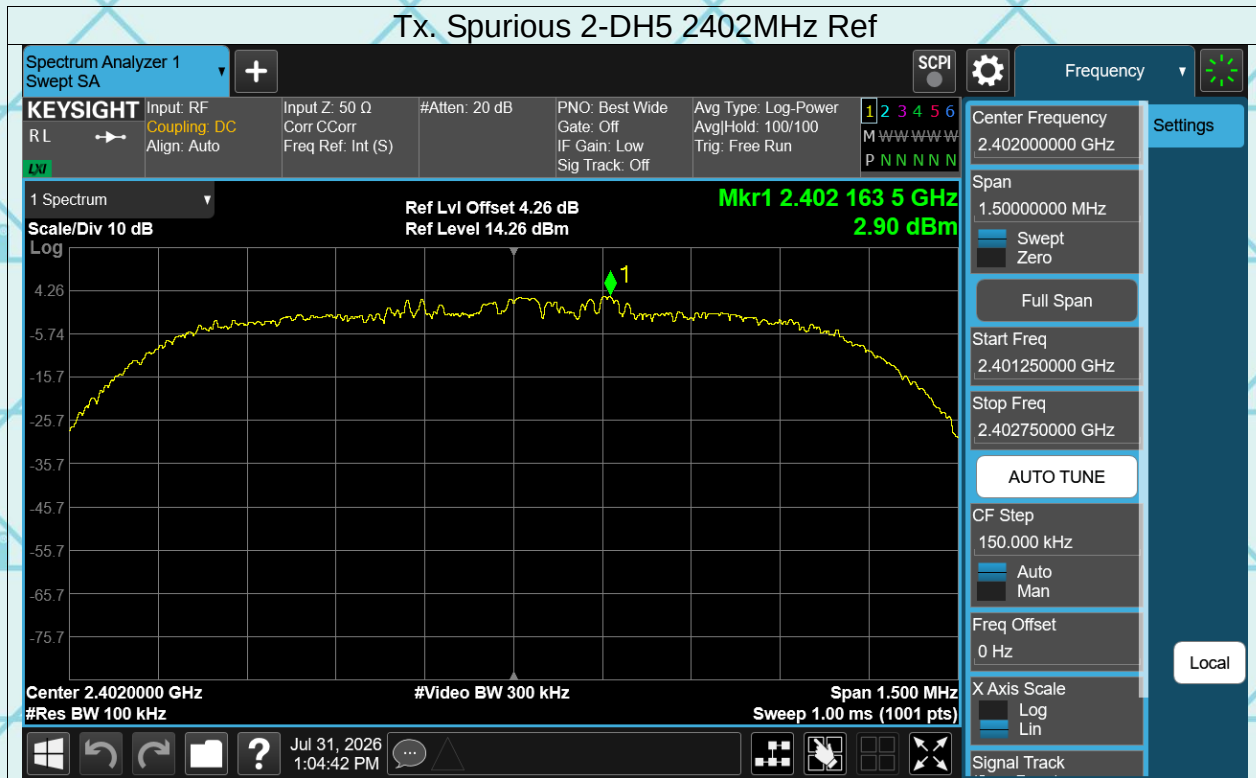


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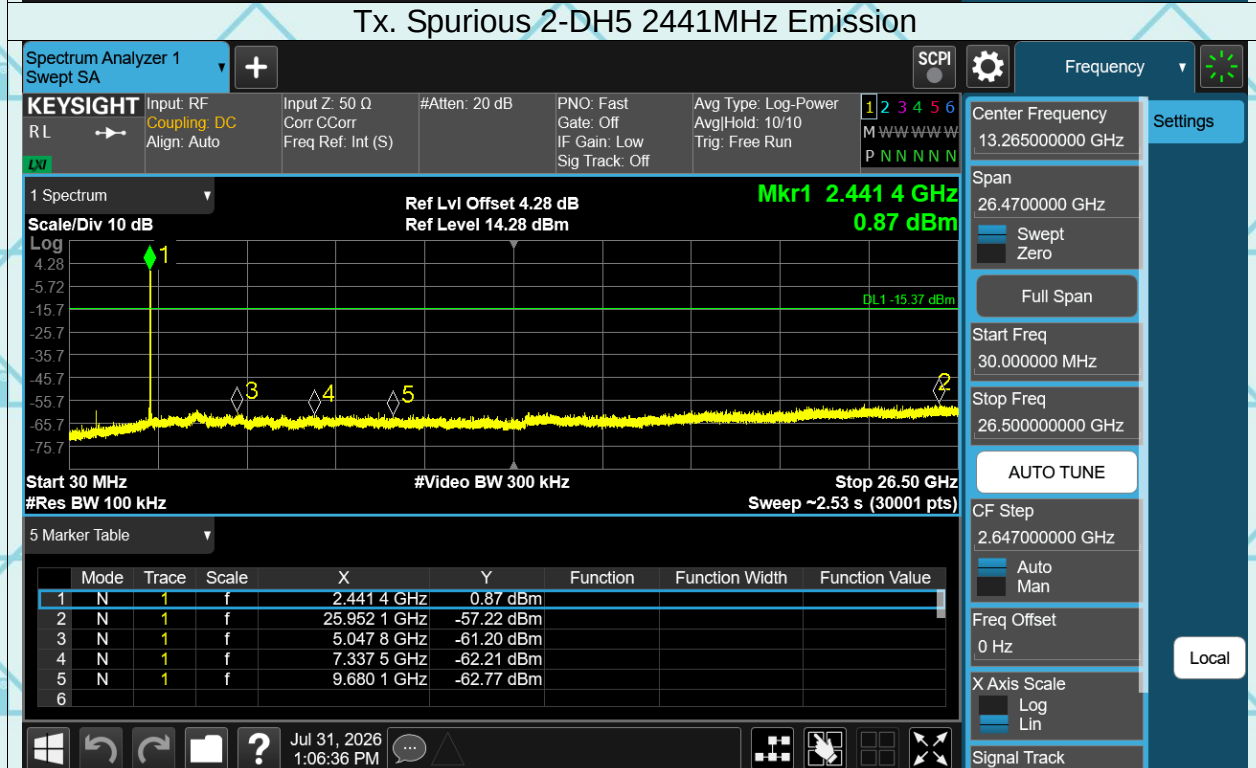
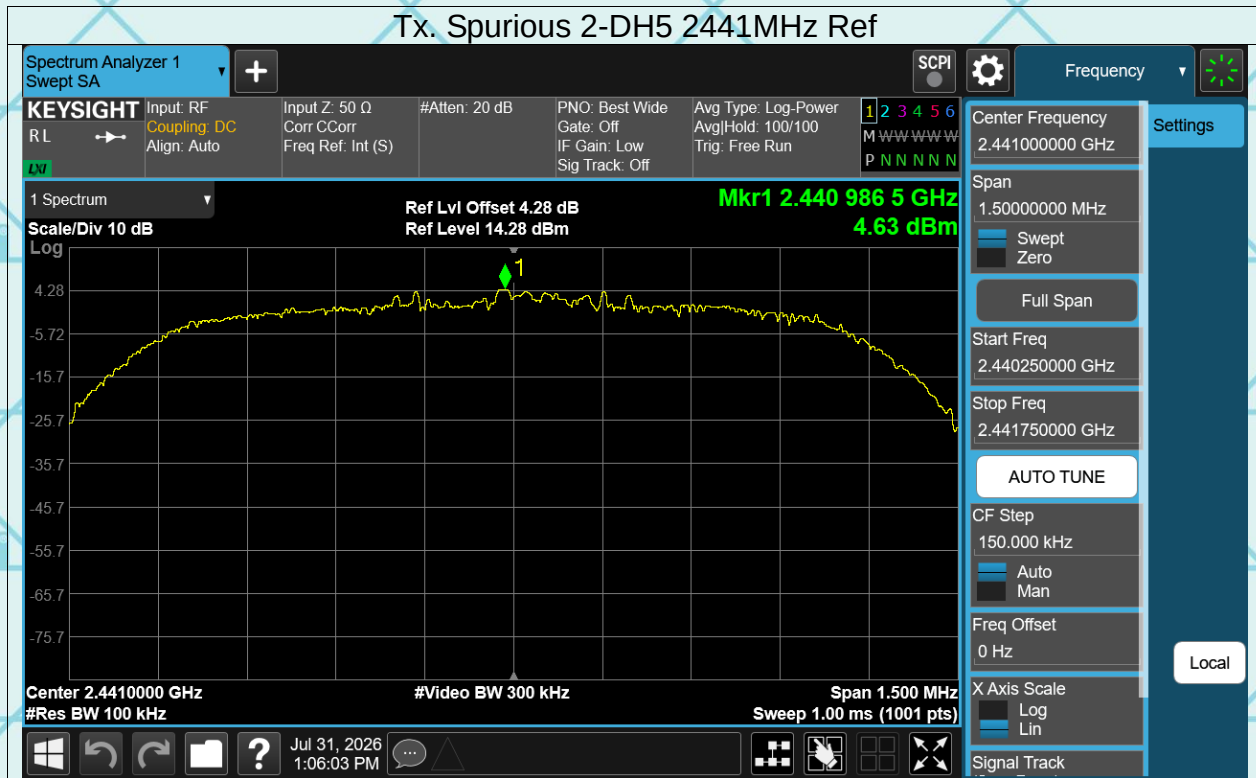


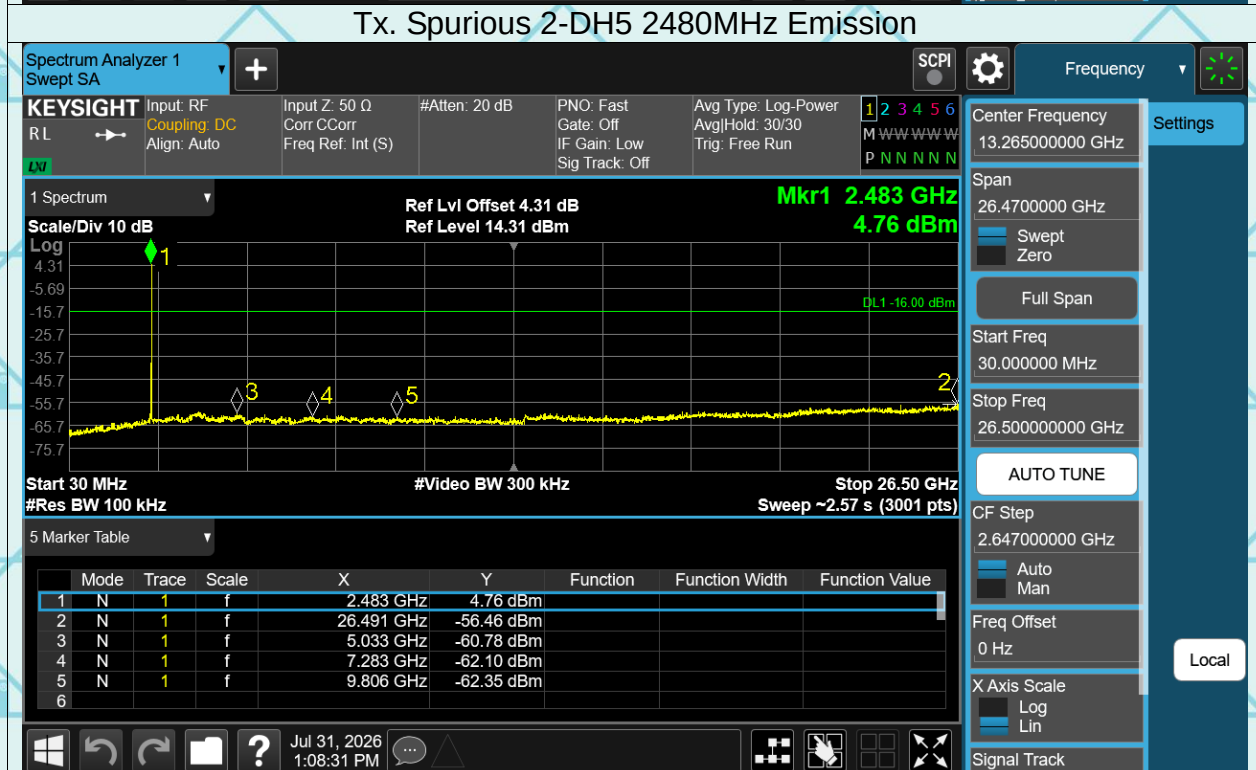
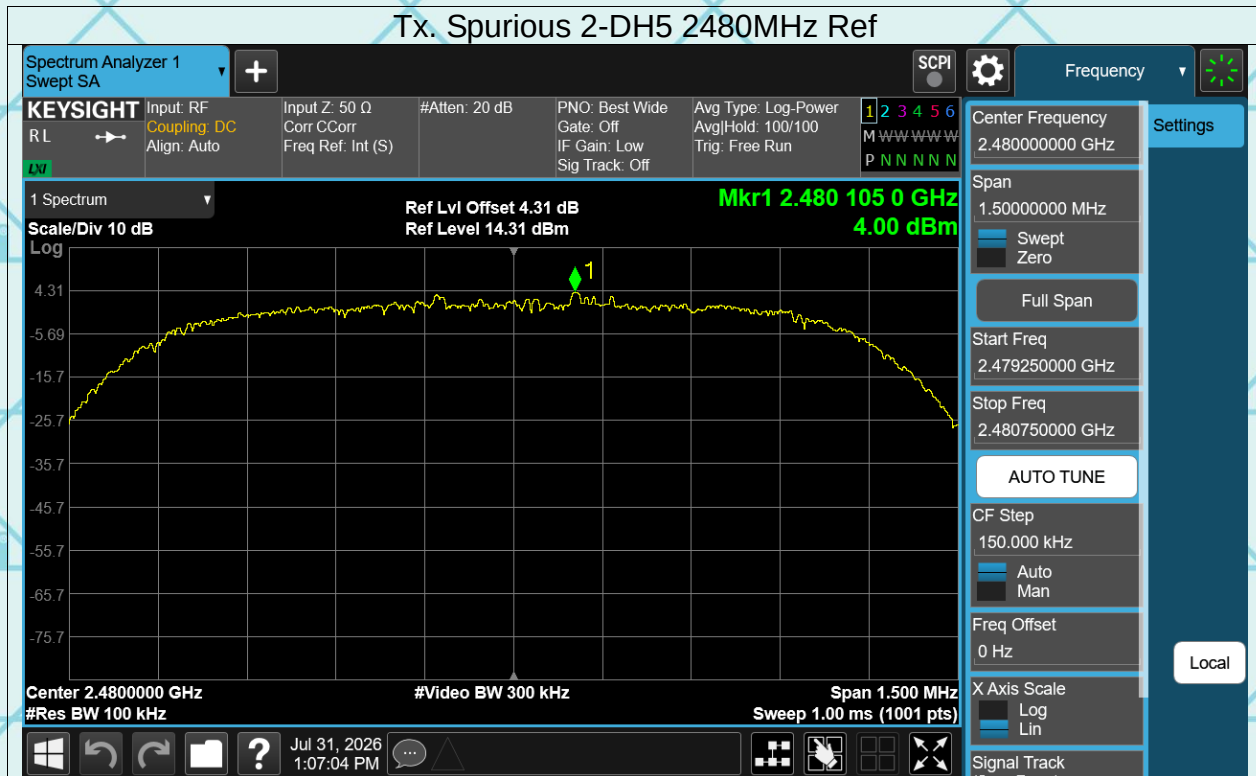


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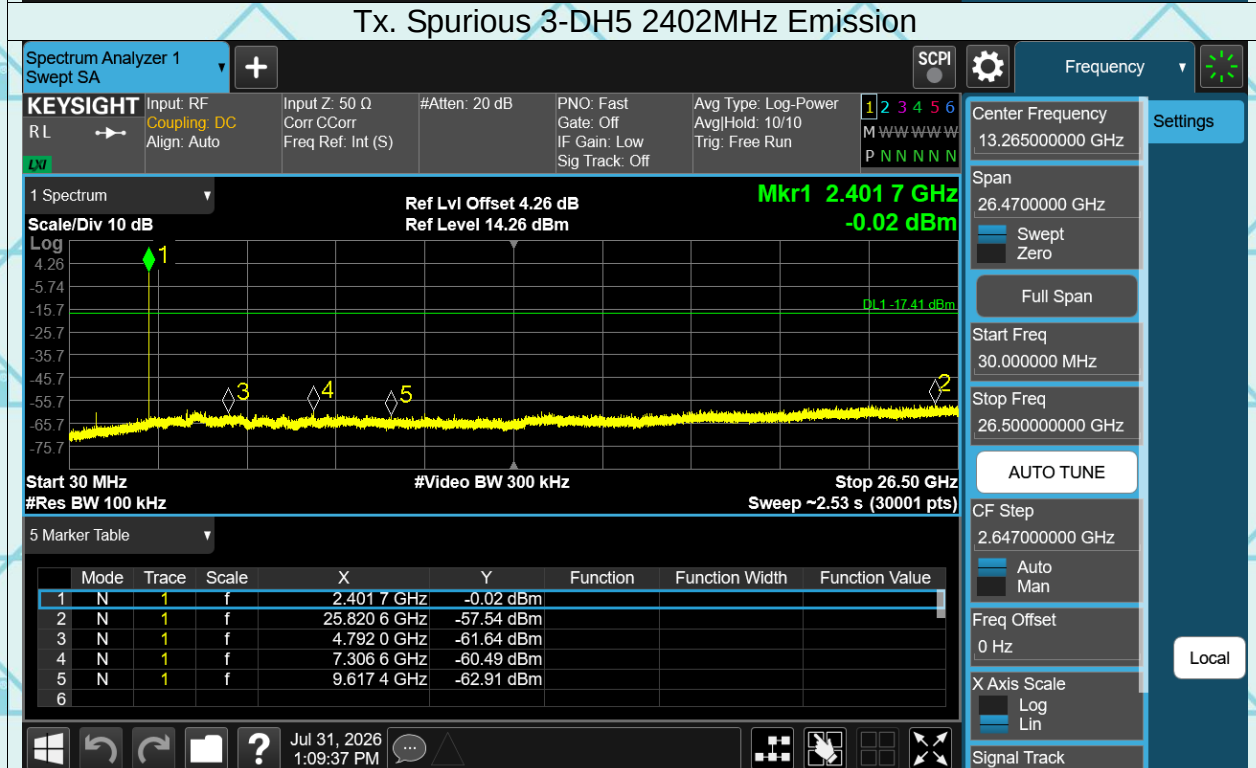
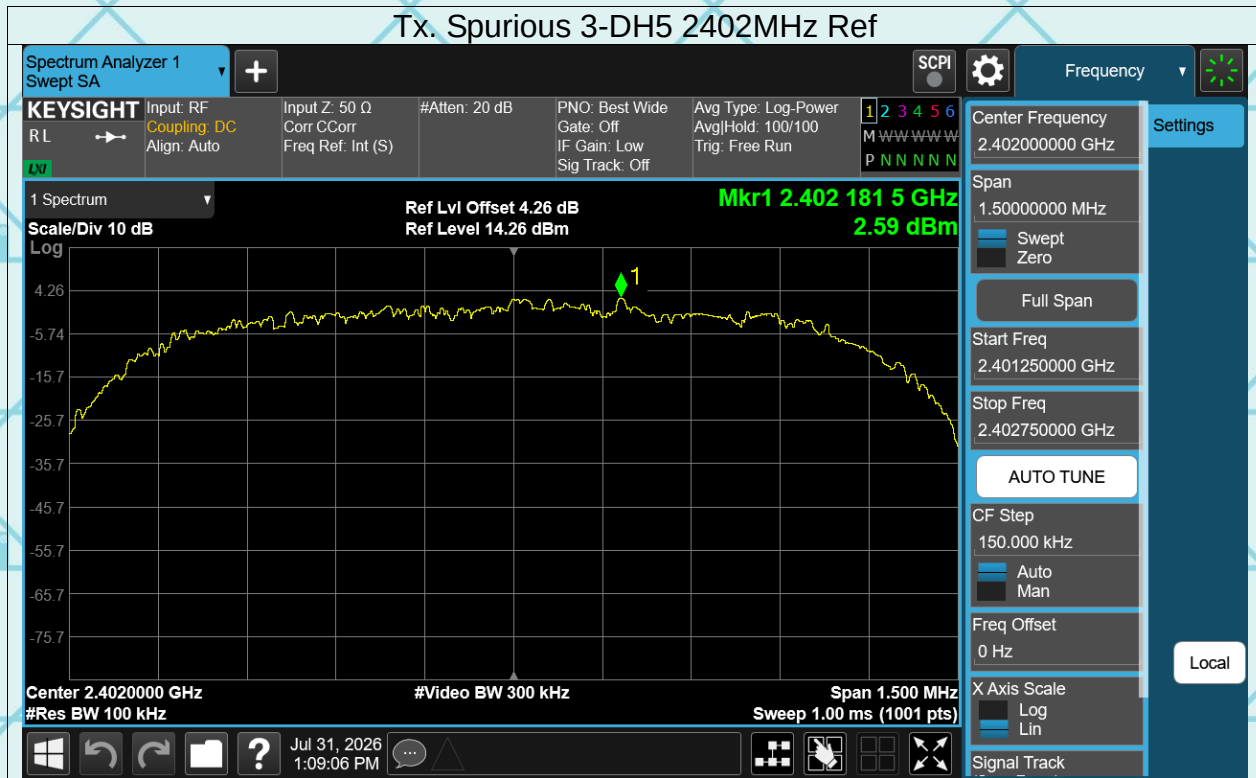


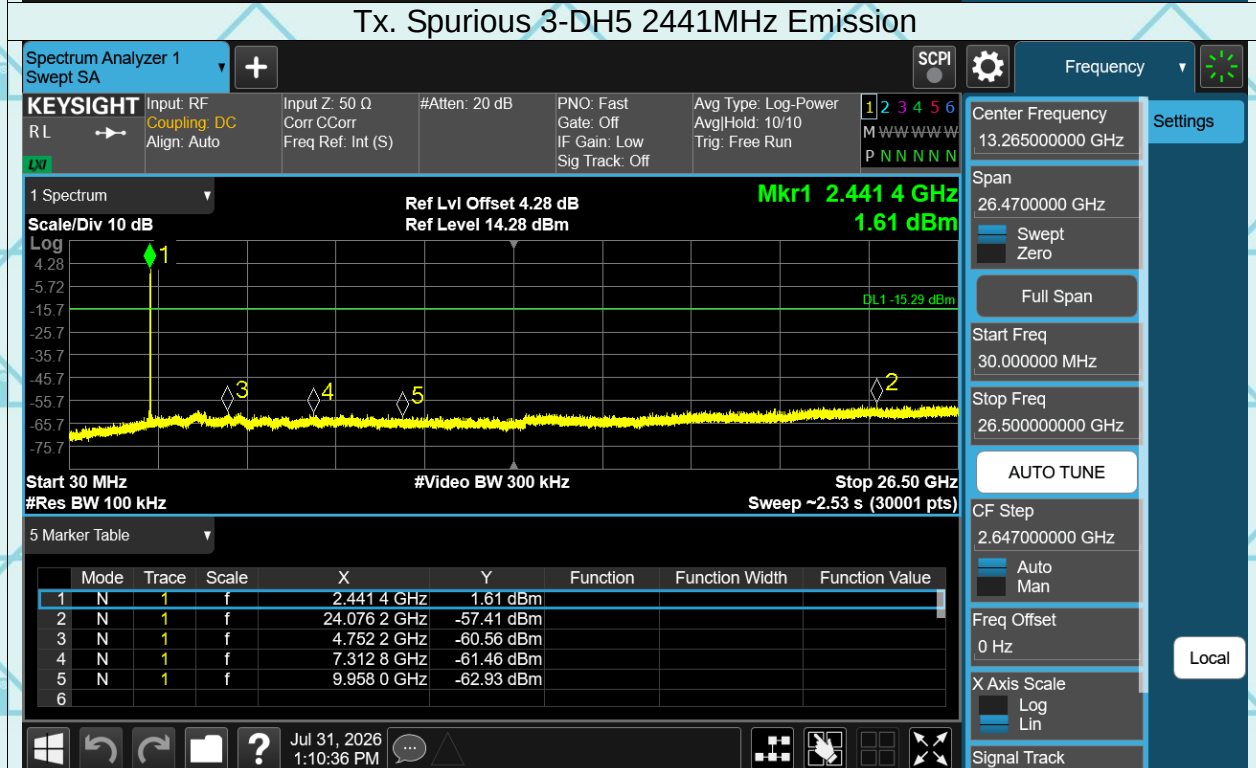
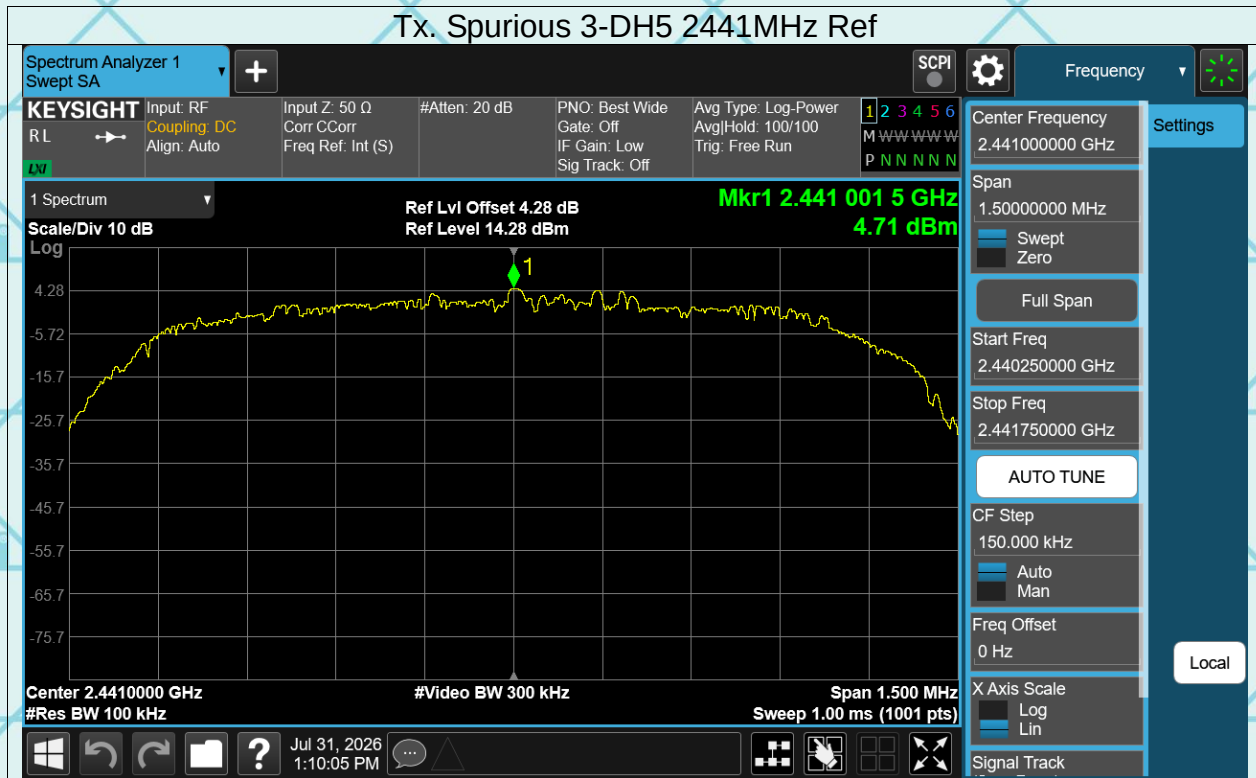
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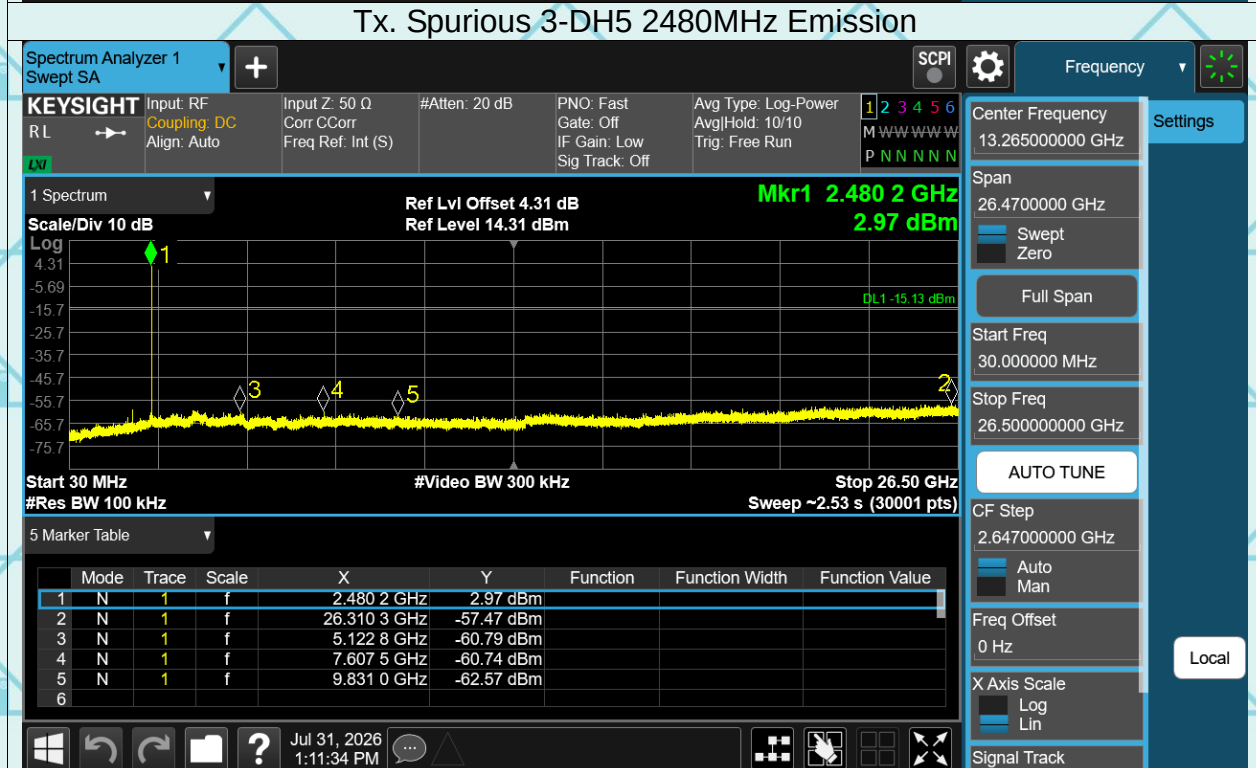
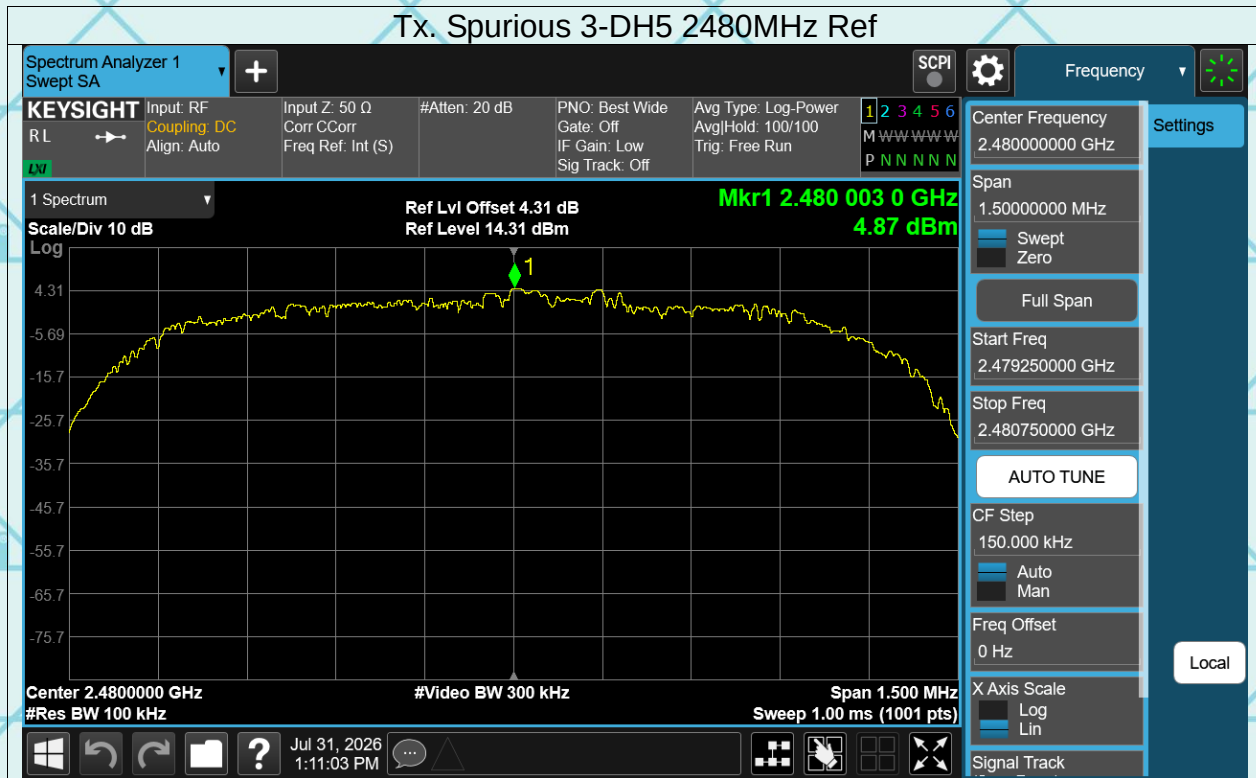




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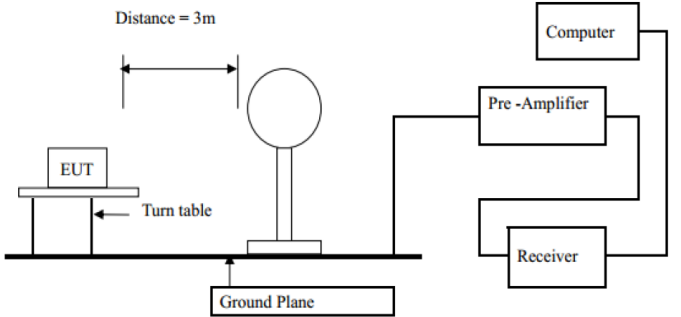


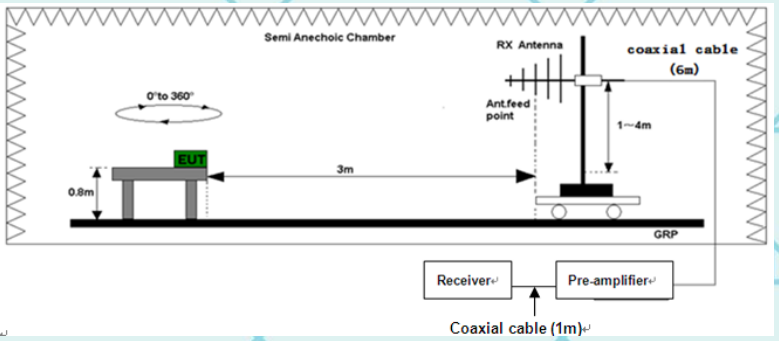
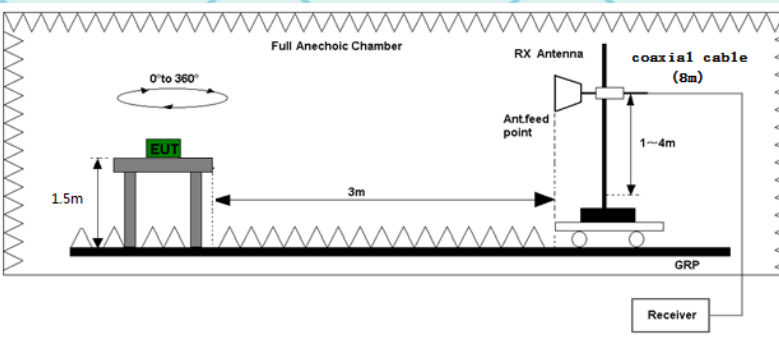




6.11. Radiated Spurious Emission Measurement

6.11.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.209			
Test Method:	ANSI C63.10:2020			
Frequency Range:	9 kHz to 25 GHz			
Measurement Distance:	3 m			
Antenna Polarization:	Horizontal & Vertical			
Receiver Setup:	Frequency	Detector	RBW	VBW
	9kHz- 150kHz	Quasi-peak	200Hz	1kHz
	150kHz- 30MHz	Quasi-peak	9kHz	30kHz
	30MHz-1GHz	Quasi-peak	100KHz	300KHz
	Above 1GHz	Peak	1MHz	3MHz
Limit:	Frequency	Field Strength (microvolts/meter)	Measurement Distance (meters)	Remark
	0.009-0.490	2400/F(KHz)	300	Quasi-peak Value
	0.490-1.705	24000/F(KHz)	30	Quasi-peak Value
	1.705-30	30	30	Quasi-peak Value
	30-88	100	3	Quasi-peak Value
Test setup:	Frequency	Field Strength (microvolts/meter)	Measurement Distance (meters)	Detector
	88-216	150	3	Average
	216-960	200	3	Peak
	Above 960	500	3	Peak
	Above 1GHz	500	3	Peak
	Above 1GHz	5000	3	Peak
For radiated emissions below 30MHz				
				
30MHz to 1GHz				

	 Above 1GHz 
Test Mode:	Transmitting mode with modulation
Test Procedure:	1. The testing follows the guidelines in Spurious Radiated Emissions of ANSI C63.10:2020 Measurement Guidelines. 2. For the radiated emission test below 1GHz: The EUT was placed on a turntable with 0.8 meter above ground. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower. The EUT was arranged to its worst case and then tune the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high PASS filter are used for the test in order to get better signal level. For the radiated emission test above 1GHz: Place the measurement antenna on a turntable with 1.5 meter above ground, which is 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. 3. Set to the maximum power setting and enable the EUT transmit continuously. 4. Use the following spectrum analyzer settings: (1) Span shall wide enough to fully capture the emission being measured; (2) Set RBW=100 kHz for $f < 1$ GHz, RBW=1MHz for $f > 1$GHz ; VBW$\geq$RBW; Sweep = auto; Detector function = peak; Trace = max hold for peak (3) For average measurement: use duty cycle correction factor method per 15.35(c). Duty cycle = On time/100 milliseconds On time = $N_1 \cdot L_1 + N_2 \cdot L_2 + \dots + N_{n-1} \cdot L_{n-1} + N_n \cdot L_n$ Where N_1 is number of type 1 pulses, L_1 is length of type 1 pulses, etc. Average Emission Level = Peak Emission Level + $20 \cdot \log(\text{Duty cycle})$ Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level
Test results:	PASS

Note 1: The symbol of "--" in the table which means not application.

Note 2: For the test data above 1 GHz, According the ANSI C63.10-2020, where limits are specified for both average and peak (or quasi-peak) detector functions, if the peak (or quasi-peak) measured value complies with the average limit, it is unnecessary to perform an average measurement.

Note 3: The low frequency, which started from 9 kHz to 30 MHz, was pre-scanned and the result which was 20 dB lower than the limit line per 15.31(o) was not reported.

Note 4: The EUT is working in the Normal link mode below 1 GHz. All modes have been tested and normal link mode is worst.

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6.11.2. Test Data(worst case)

The worst mode is GFSK

Please refer to following diagram for individual

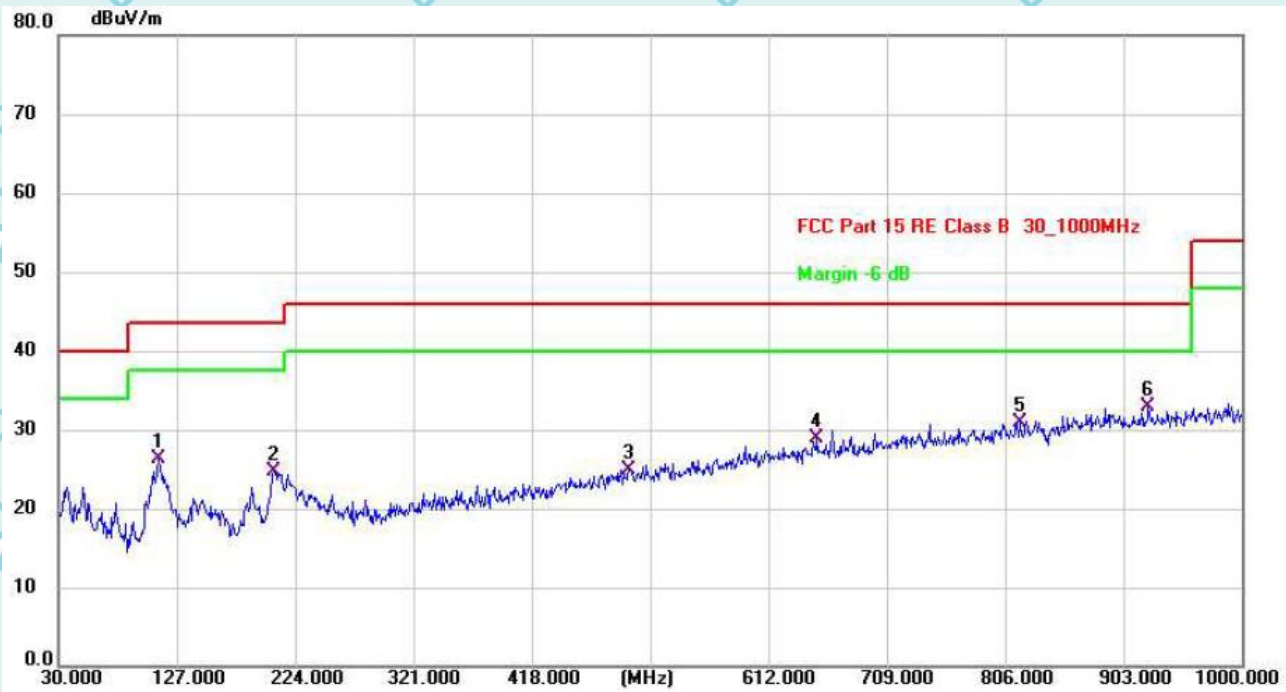
Below 1GHz

Horizontal:



No.	Mk.	Freq. MHz	Reading Level dBuV	Correct Factor dB	Measure- ment dBuV/m	Limit dB/m	Over dB	Detector
1	*	35.8200	49.57	-20.53	29.04	40.00	10.96	QP
2		111.4800	48.44	-20.15	28.29	43.50	15.21	QP
3		190.0500	40.86	-19.72	21.14	43.50	22.36	QP
4		495.6000	43.11	-18.28	24.83	46.00	21.17	QP
5		692.5100	46.44	-17.24	29.20	46.00	16.80	QP
6		892.3300	48.95	-16.03	32.92	46.00	13.08	QP

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Vertical:



No.	Mk.	Freq. MHz	Reading Level dBuV	Correct Factor dB	Measure- ment dBuV/m	Limit dB/m	Over dB	Detector
1		111.4800	36.03	-9.81	26.22	43.50	17.28	QP
2		206.5399	35.51	-10.74	24.77	43.50	18.73	QP
3		497.5400	25.89	-1.02	24.87	46.00	21.13	QP
4		651.7700	26.59	2.35	28.94	46.00	17.06	QP
5		818.6100	25.66	5.24	30.90	46.00	15.10	QP
6	*	923.3700	26.02	6.90	32.92	46.00	13.08	QP

Note1:

Freq. = Emission frequency in MHz

Reading level (dBuV) = Receiver reading

Corr. Factor (dB) = Antenna factor + Cable loss - Amplifier factor.

Measurement (dBuV) = Reading level (dBuV) + Corr. Factor (dB)

Limit (dBuV) = Limit stated in standard

Margin (dB) = Over(dB) = Measurement (dBuV) – Limits (dBuV)

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Above 1GHz

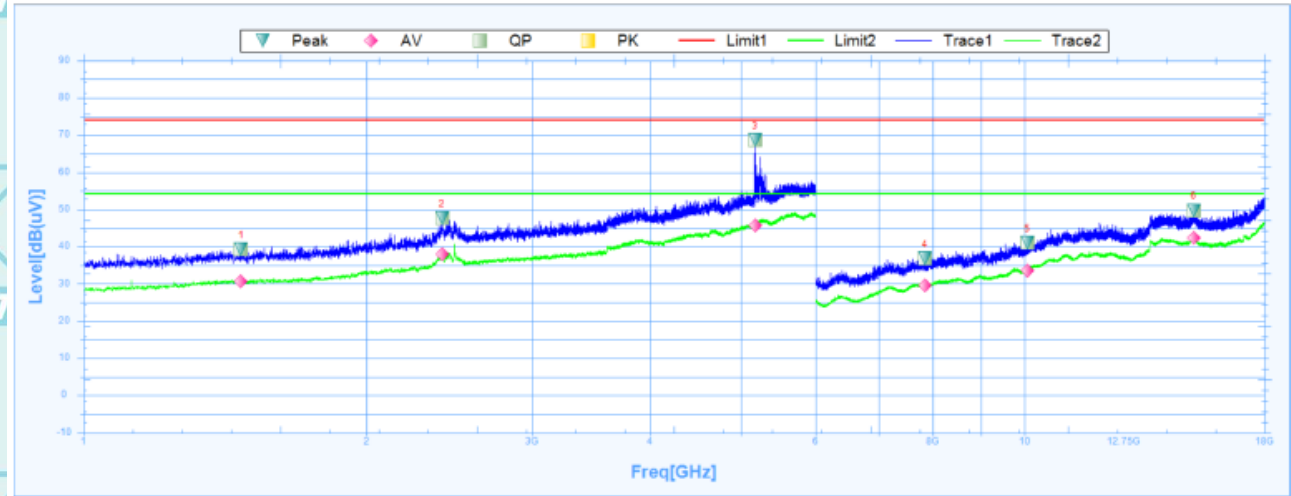
Note 1: The marked spikes near 2400 MHz with circle should be ignored because they are Fundamental signal.

Note 2: The spurious above 18G is noise only, do not show on the report.

GFSK

Low channel: 2402MHz

Horizontal:

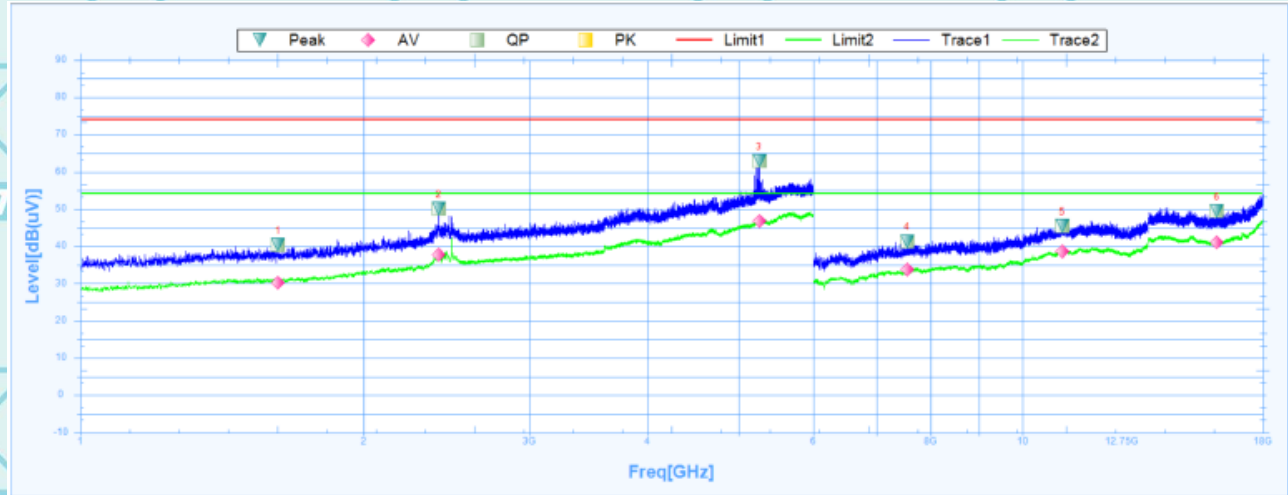


Suspected Data List

NO.	Freq. [MHz]	Level [dB(uV)]	Factor [dB]	Reading [dB(uV)]	Limit [dB]	Margin [dB]	Deg [°]	Polarity	Trace	Verdict
1	1470.6250	39.23	25.03	14.2	74	-34.77	350.7	Horizontal	PK	Pass
1	1470.6250	30.66	25.03	5.63	54	-23.34	350.7	Horizontal	AV	Pass
2	2404.3750	47.63	27.27	20.36	74	-26.37	358.3	Horizontal	PK	Pass
2	2404.3750	37.89	27.27	10.62	54	-16.11	358.3	Horizontal	AV	Pass
3	5175.6250	68.7	31.74	36.96	74	-5.3	318.9	Horizontal	PK	Pass
3	5175.6250	45.63	31.74	13.89	54	-8.37	318.9	Horizontal	AV	Pass
4	7839.0000	36.91	8	28.91	74	-37.09	261.1	Horizontal	PK	Pass
4	7839.0000	29.46	8	21.46	54	-24.54	261.1	Horizontal	AV	Pass
5	10074.0000	41.06	12.57	28.49	74	-32.94	194.2	Horizontal	PK	Pass
5	10074.0000	33.63	12.57	21.06	54	-20.37	194.2	Horizontal	AV	Pass
6	15132.0000	49.75	19.67	30.08	74	-24.25	59	Horizontal	PK	Pass
6	15132.0000	42.39	19.67	22.72	54	-11.61	59	Horizontal	AV	Pass

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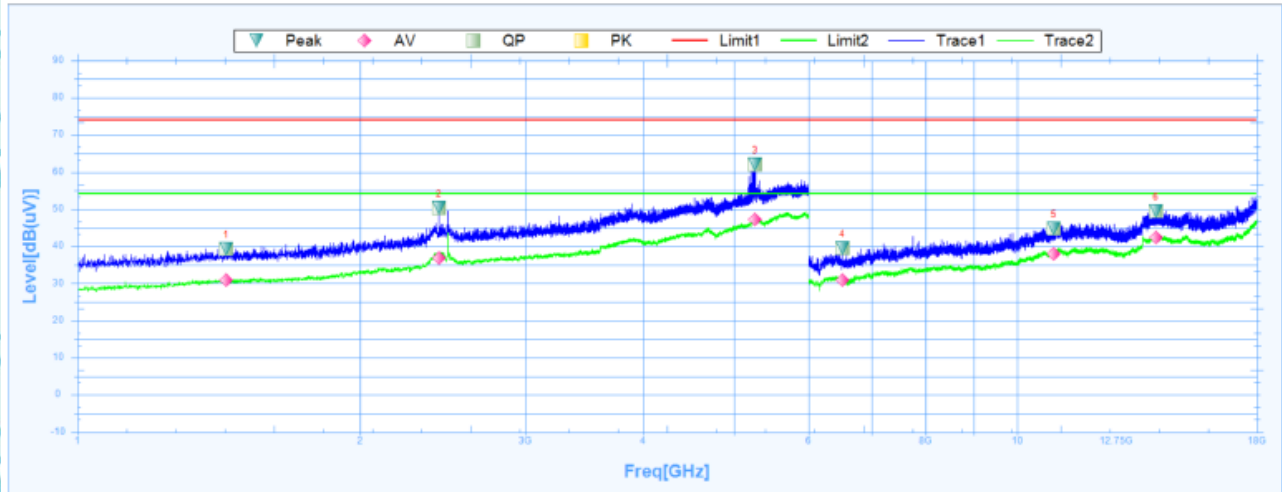
Vertical:



Susputed Data List										
NO.	Freq. [MHz]	Level [dB(uV)]	Factor [dB]	Reading [dB(uV)]	Limit [dB]	Margin [dB]	Deg [°]	Polarity	Trace	Verdict
1	1621.2500	40.32	24.91	15.41	74	-33.68	3.6	Vertical	PK	Pass
1	1621.2500	30.29	24.91	5.38	54	-23.71	3.6	Vertical	AV	Pass
2	2402.5000	50.14	27.27	22.87	74	-23.86	0	Vertical	PK	Pass
2	2402.5000	37.69	27.27	10.42	54	-16.31	0	Vertical	AV	Pass
3	5256.2500	62.8	31.8	31	74	-11.2	336.8	Vertical	PK	Pass
3	5256.2500	46.81	31.8	15.01	54	-7.19	336.8	Vertical	AV	Pass
4	7545.0000	41.36	7.7	33.66	74	-32.64	347	Vertical	PK	Pass
4	7545.0000	33.78	7.7	26.08	54	-20.22	347	Vertical	AV	Pass
5	11020.5000	45.49	15.68	29.81	74	-28.51	252.7	Vertical	PK	Pass
5	11020.5000	38.69	15.68	23.01	54	-15.31	252.7	Vertical	AV	Pass
6	16090.5000	49.43	18.55	30.88	74	-24.57	360	Vertical	PK	Pass
6	16090.5000	41.14	18.55	22.59	54	-12.86	360	Vertical	AV	Pass

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Middle channel: 2441MHz
Horizontal:



Suspected Data List

NO.	Freq. [MHz]	Level [dB(uV)]	Factor [dB]	Reading [dB(uV)]	Limit [dB]	Margin [dB]	Deg [°]	Polarity	Trace	Verdict
1	1439.3750	39.32	25.06	14.26	74	-34.68	104.9	Horizontal	PK	Pass
1	1439.3750	30.87	25.06	5.81	54	-23.13	104.9	Horizontal	AV	Pass
2	2426.2500	50.28	27.35	22.93	74	-23.72	310.6	Horizontal	PK	Pass
2	2426.2500	36.9	27.35	9.55	54	-17.1	310.6	Horizontal	AV	Pass
3	5265.6250	62.06	31.81	30.25	74	-11.94	61.8	Horizontal	PK	Pass
3	5265.6250	47.22	31.81	15.41	54	-6.78	61.8	Horizontal	AV	Pass
4	6517.5000	39.51	4.69	34.82	74	-34.49	268.2	Horizontal	PK	Pass
4	6517.5000	30.87	4.69	26.18	54	-23.13	268.2	Horizontal	AV	Pass
5	10947.0000	44.83	15.33	29.5	74	-29.17	326.9	Horizontal	PK	Pass
5	10947.0000	38.05	15.33	22.72	54	-15.95	326.9	Horizontal	AV	Pass
6	14050.5000	49.44	19.07	30.37	74	-24.56	360	Horizontal	PK	Pass
6	14050.5000	42.32	19.07	23.25	54	-11.68	360	Horizontal	AV	Pass