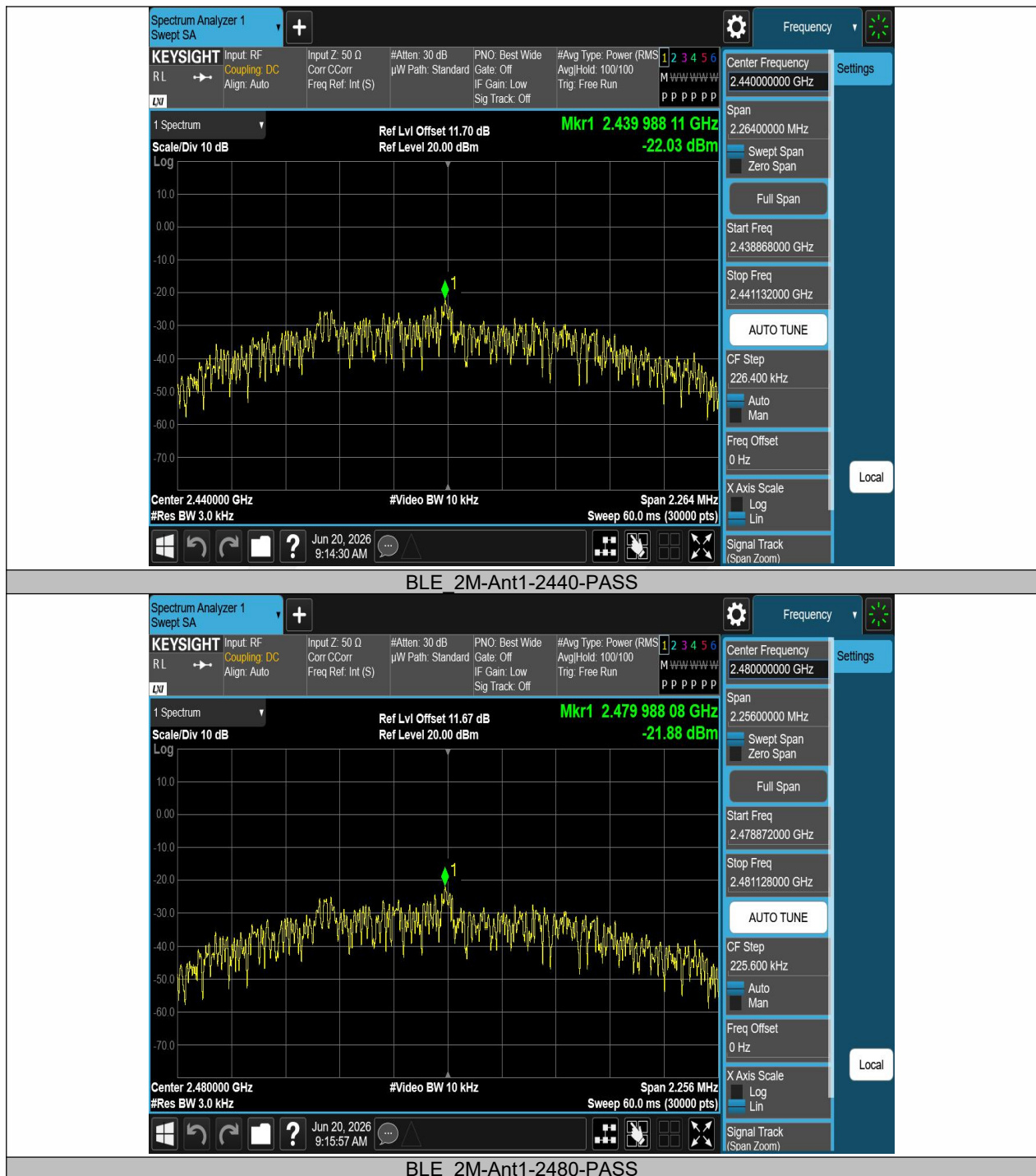




8.5 UNWANTED EMISSIONS IN NON-RESTRICTED FREQUENCY BANDS

8.5.1 Applicable Standard

According to FCC Part 15.247(d) and KDB 558074 D01 15.247 Meas Guidance v05r02
According to RSS-247 6.6

8.5.2 Conformance Limit

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.

8.5.3 Test Configuration

Test according to clause 7.1 radio frequency test setup 1

8.5.4 Test Procedure

The transmitter output (antenna port) was connected to the spectrum analyzer

■ Reference level measurement

Establish a reference level by using the following procedure:

Set instrument center frequency to DTS channel center frequency.

Set the span to = 1.5 times the DTS bandwidth.

Set the RBW = 100 kHz.

Set the VBW $\geq 3 \times$ RBW.

Set Detector = peak.

Set Sweep time = auto couple.

Set Trace mode = max hold.

Allow trace to fully stabilize.

Use the peak marker function to determine the maximum PSD level.

Note that the channel found to contain the maximum PSD level can be used to establish the reference level.

■ Band-edge measurement

Use the following spectrum analyzer settings:

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 which fall outside of the authorized band of operation

Set RBW $\geq 1\%$ of the span=100kHz Set VBW $\geq 3 \times$ RBW

Set Sweep = auto Set Detector function = peak Set Trace = max hold

Allow the trace to stabilize. Set the marker on the emission at the bandedge, or on the highest modulation product outside of the band, if this level is greater than that at the bandedge. Enable the marker-delta function, then use the marker-to-peak function to move the marker to the peak of the in-band emission. The marker-delta value now displayed must comply with the limit specified in this Section.

■ Emission level measurement

Set the center frequency and span to encompass frequency range to be measured.

Set the RBW = 100 kHz.

Set the VBW =300 kHz.

Set Detector = peak

Sweep time = auto couple.

Trace mode = max hold.

Allow trace to fully stabilize.

Use the peak marker function to determine the maximum amplitude level.

Ensure that the amplitude of all unwanted emissions outside of the authorized frequency band (excluding restricted frequency bands) are attenuated by at least the minimum requirements. Report the three highest emissions relative to the limit.

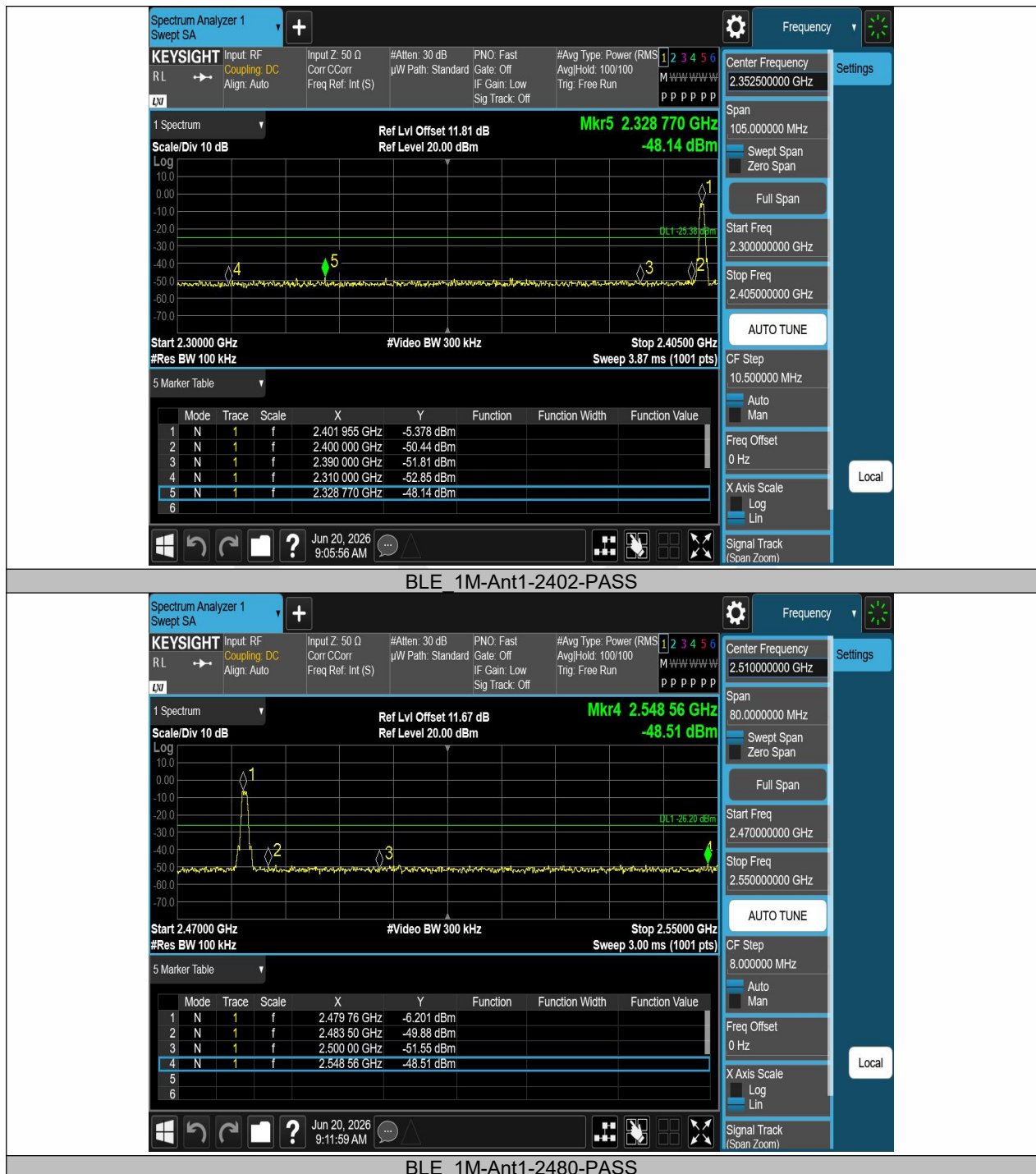
8.5.5 Test Results

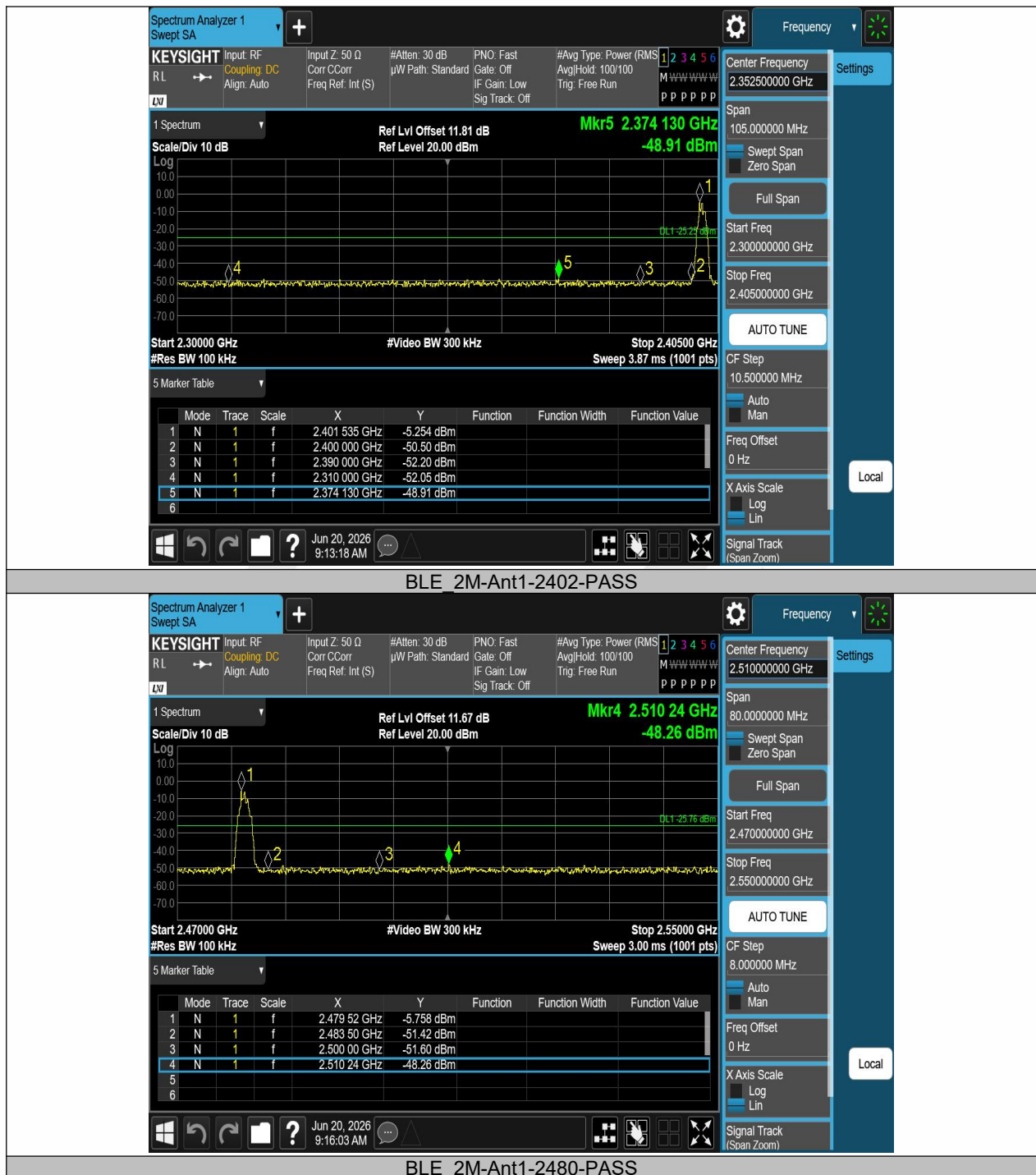
Temperature:	25 °C
Relative Humidity:	45%
ATM Pressure:	1011 mbar

Note: N/A

Band edge

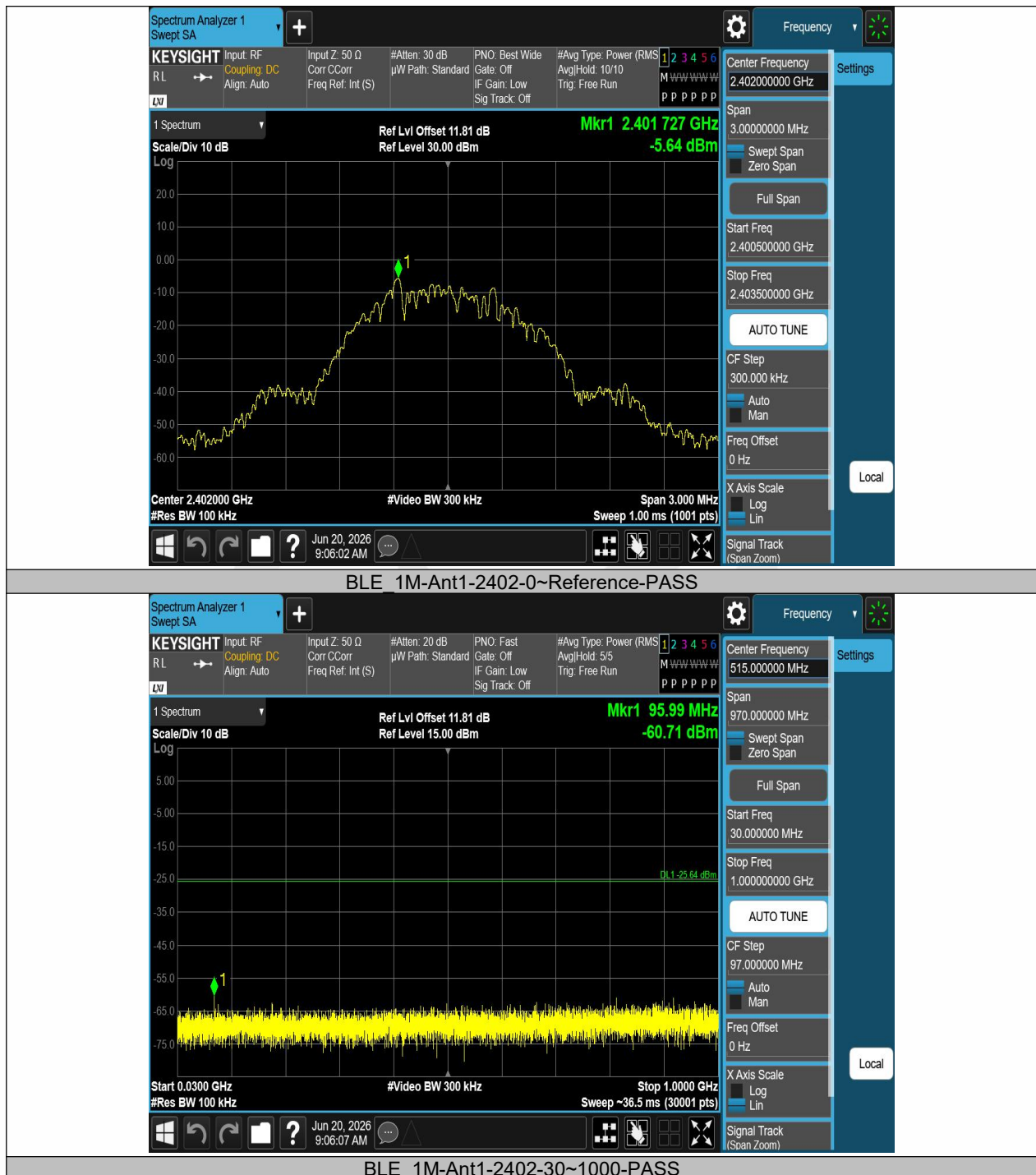
TestMode	Antenna	ChName	Frequency[MHz]	RefLevel[dBm]	Result[dBm]	Limit[dBm]	Verdict
BLE_1M	Ant1	Low	2402	-5.38	-48.14	≤-25.38	PASS
BLE_1M	Ant1	High	2480	-6.20	-48.51	≤-26.2	PASS
BLE_2M	Ant1	Low	2402	-5.25	-48.91	≤-25.25	PASS
BLE_2M	Ant1	High	2480	-5.76	-48.26	≤-25.76	PASS

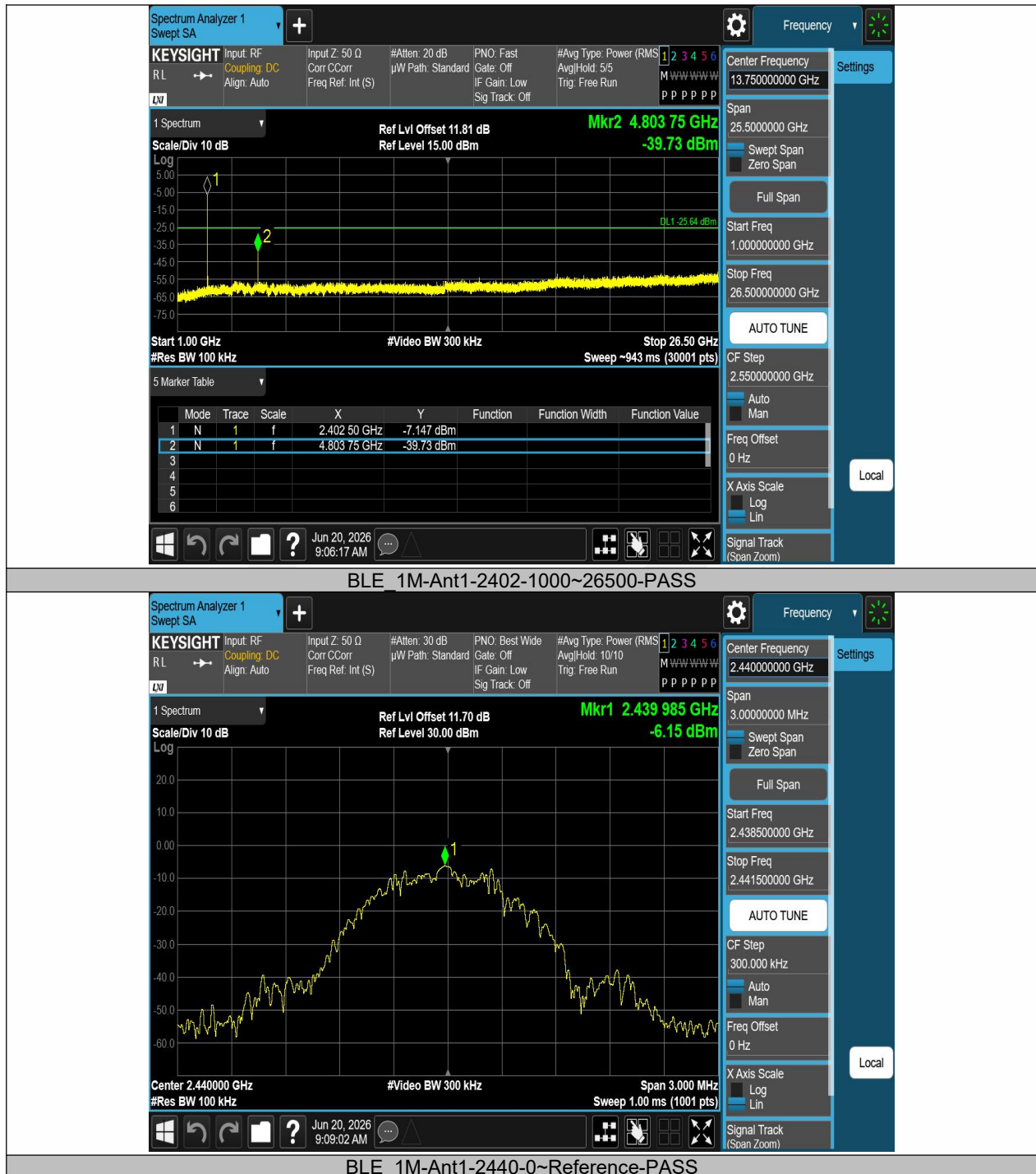


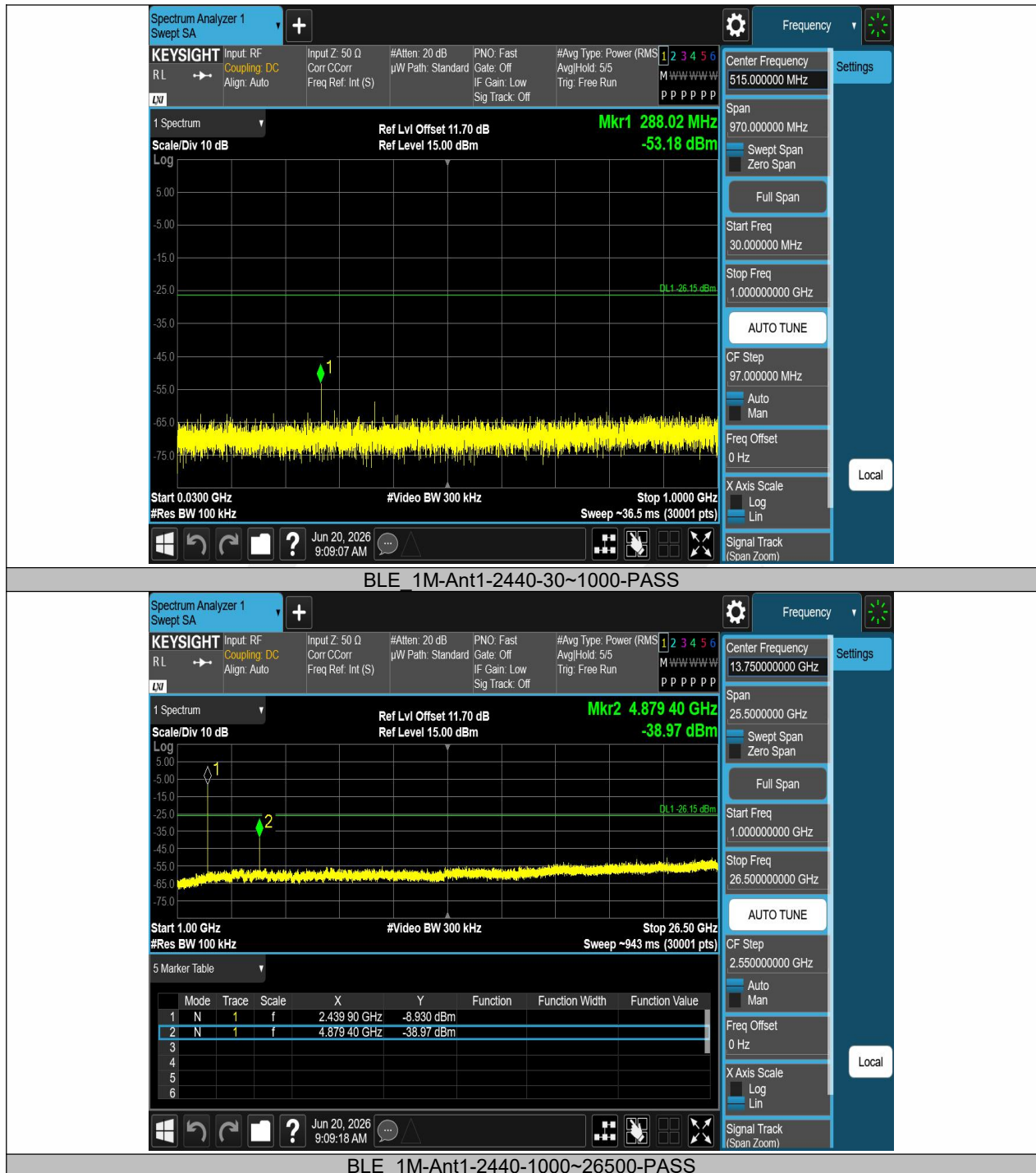


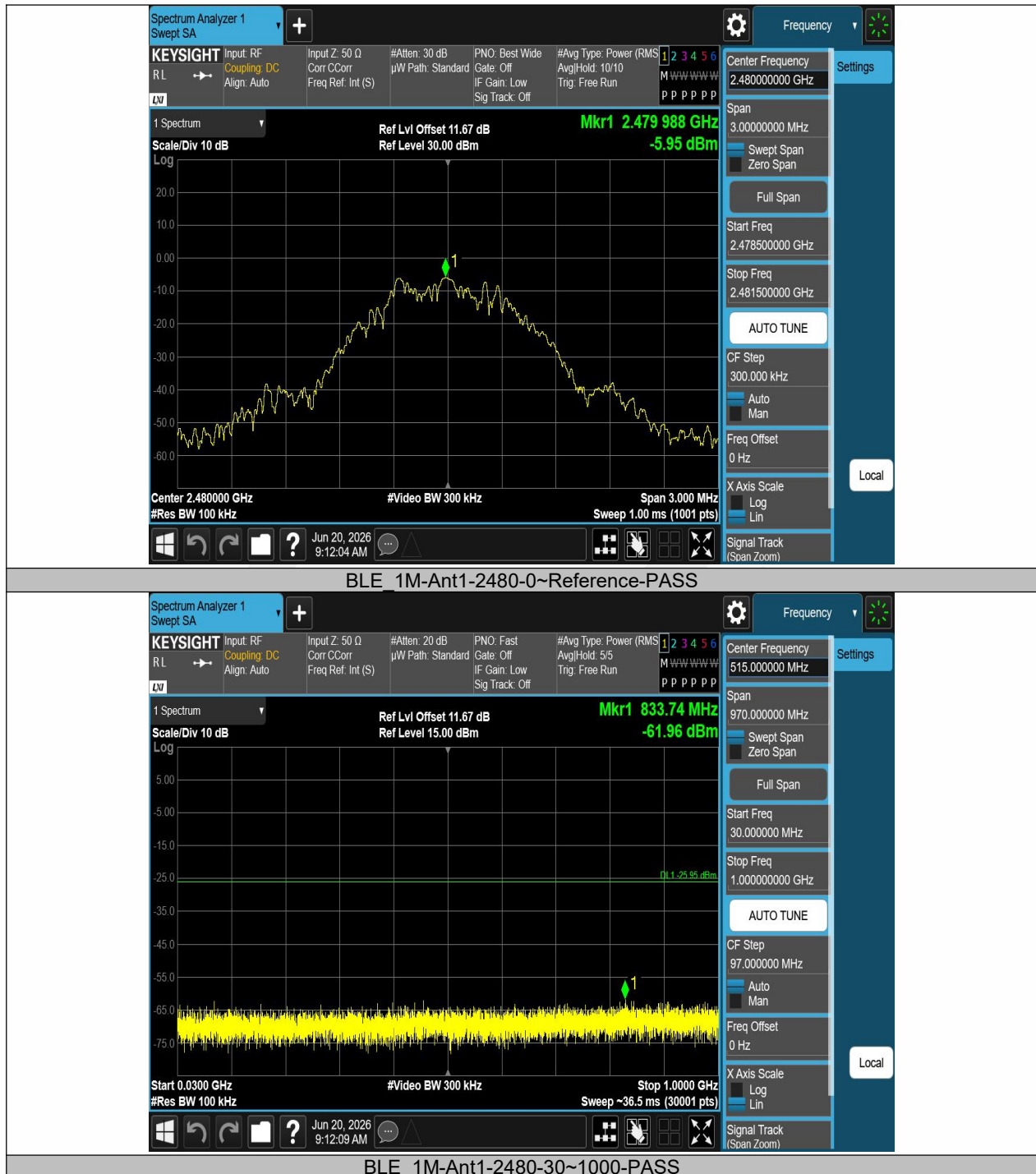
Conducted Spurious Emission

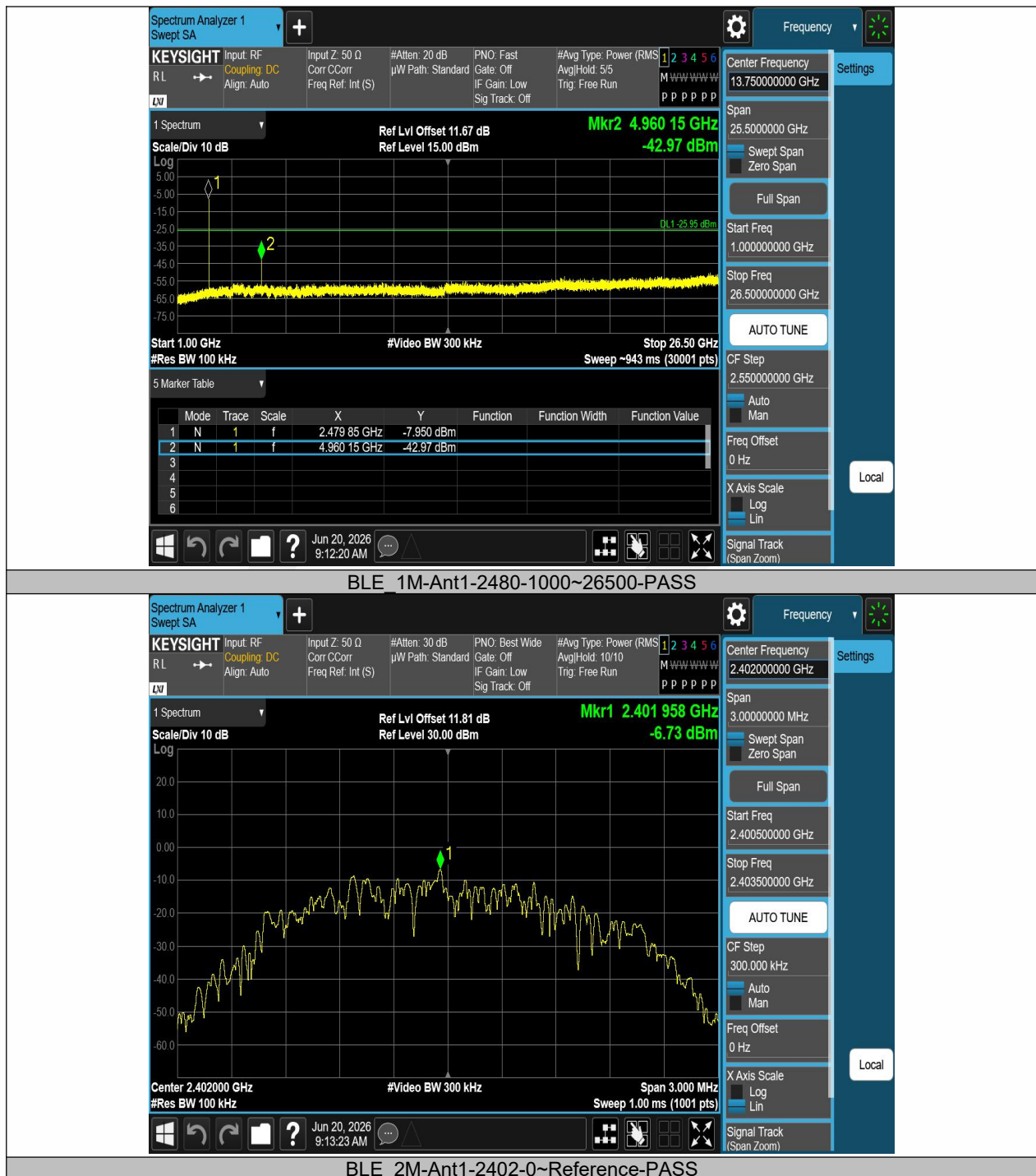
TestMode	Antenna	Frequency[MHz]	FreqRange [MHz]	RefLevel [dBm]	Result[dBm]	Limit[dBm]	Verdict
BLE_1M	Ant1	2402	0~Reference	-5.64	-5.64	---	PASS
BLE_1M	Ant1	2402	30~1000	-5.64	-60.71	≤-25.64	PASS
BLE_1M	Ant1	2402	1000~26500	-5.64	-39.73	≤-25.64	PASS
BLE_1M	Ant1	2440	0~Reference	-6.15	-6.15	---	PASS
BLE_1M	Ant1	2440	30~1000	-6.15	-53.18	≤-26.15	PASS
BLE_1M	Ant1	2440	1000~26500	-6.15	-38.97	≤-26.15	PASS
BLE_1M	Ant1	2480	0~Reference	-5.95	-5.95	---	PASS
BLE_1M	Ant1	2480	30~1000	-5.95	-61.96	≤-25.95	PASS
BLE_1M	Ant1	2480	1000~26500	-5.95	-42.97	≤-25.95	PASS
BLE_2M	Ant1	2402	0~Reference	-6.73	-6.73	---	PASS
BLE_2M	Ant1	2402	30~1000	-6.73	-61.71	≤-26.73	PASS
BLE_2M	Ant1	2402	1000~26500	-6.73	-38.47	≤-26.73	PASS
BLE_2M	Ant1	2440	0~Reference	-6.09	-6.09	---	PASS
BLE_2M	Ant1	2440	30~1000	-6.09	-61.86	≤-26.09	PASS
BLE_2M	Ant1	2440	1000~26500	-6.09	-45.68	≤-26.09	PASS
BLE_2M	Ant1	2480	0~Reference	-8.50	-8.50	---	PASS
BLE_2M	Ant1	2480	30~1000	-8.50	-60.84	≤-28.5	PASS
BLE_2M	Ant1	2480	1000~26500	-8.50	-38.15	≤-28.5	PASS

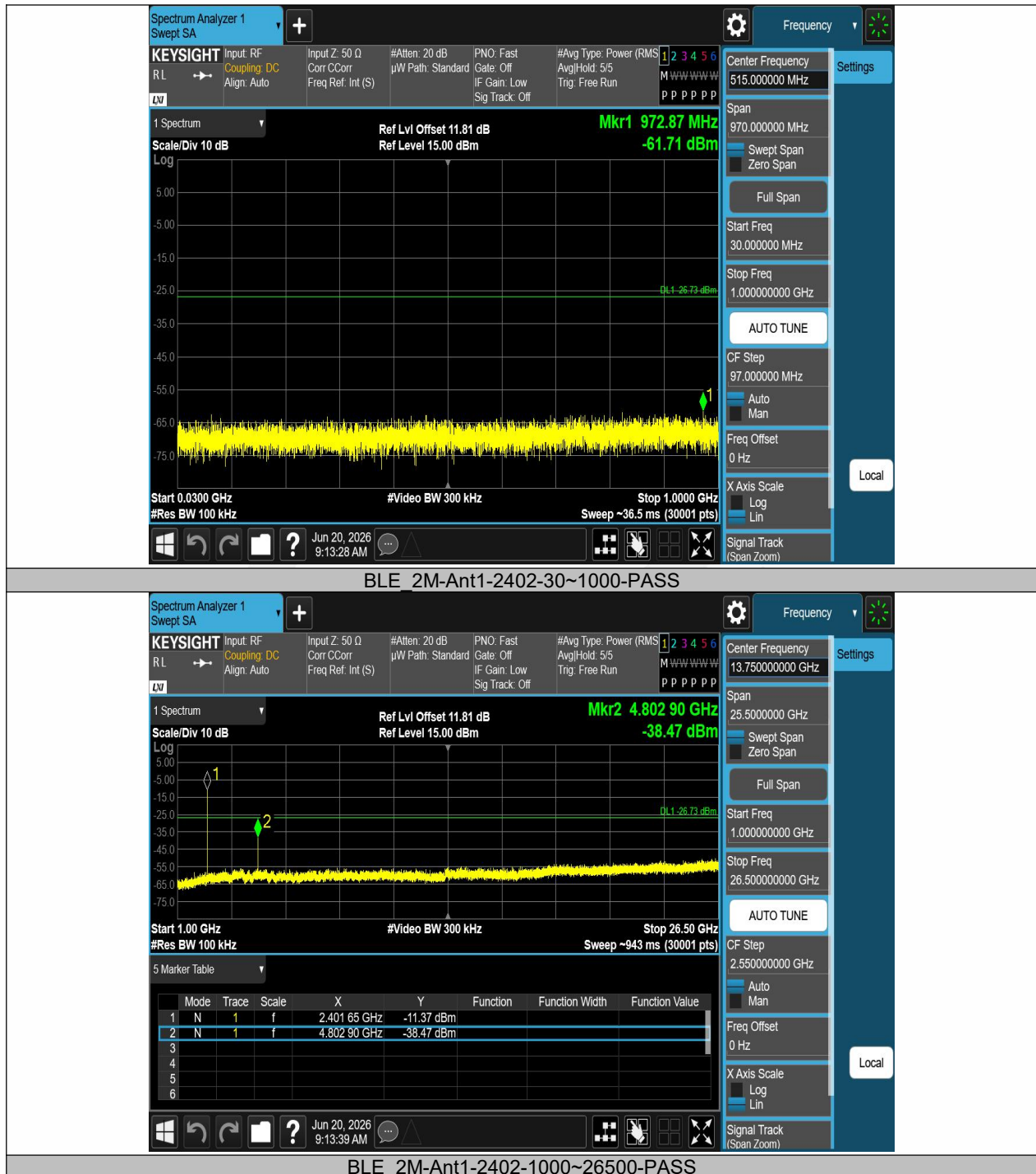


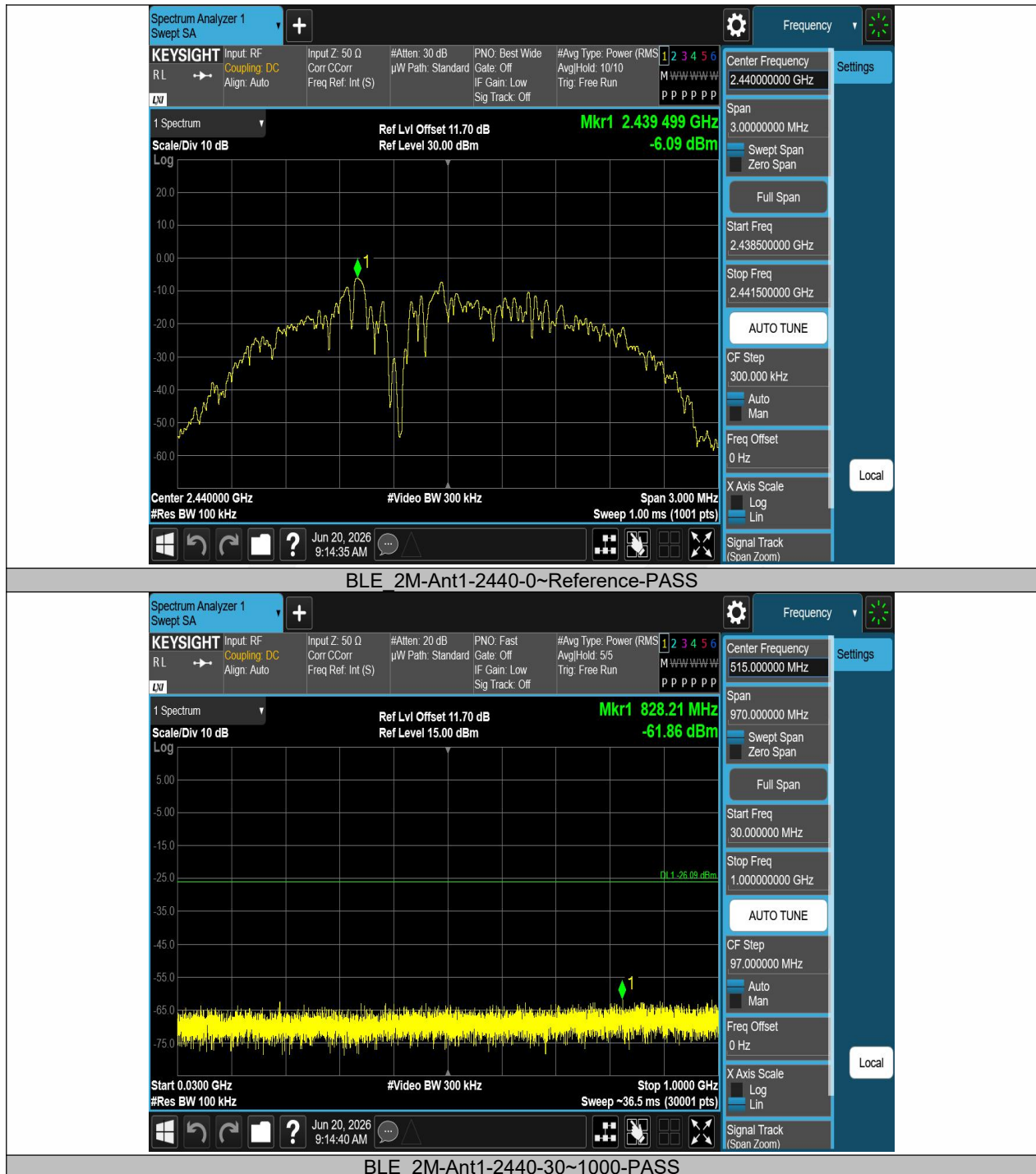


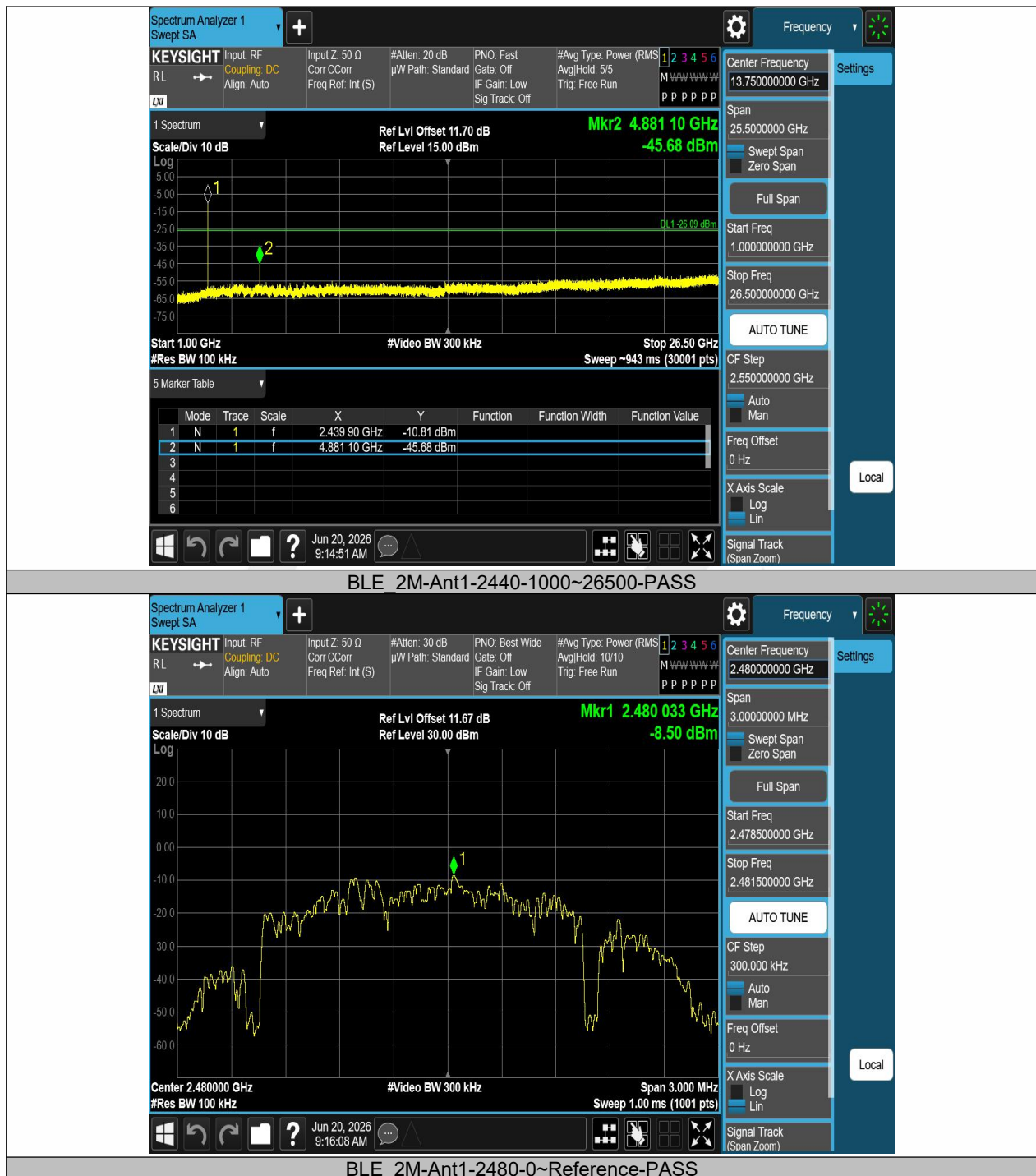


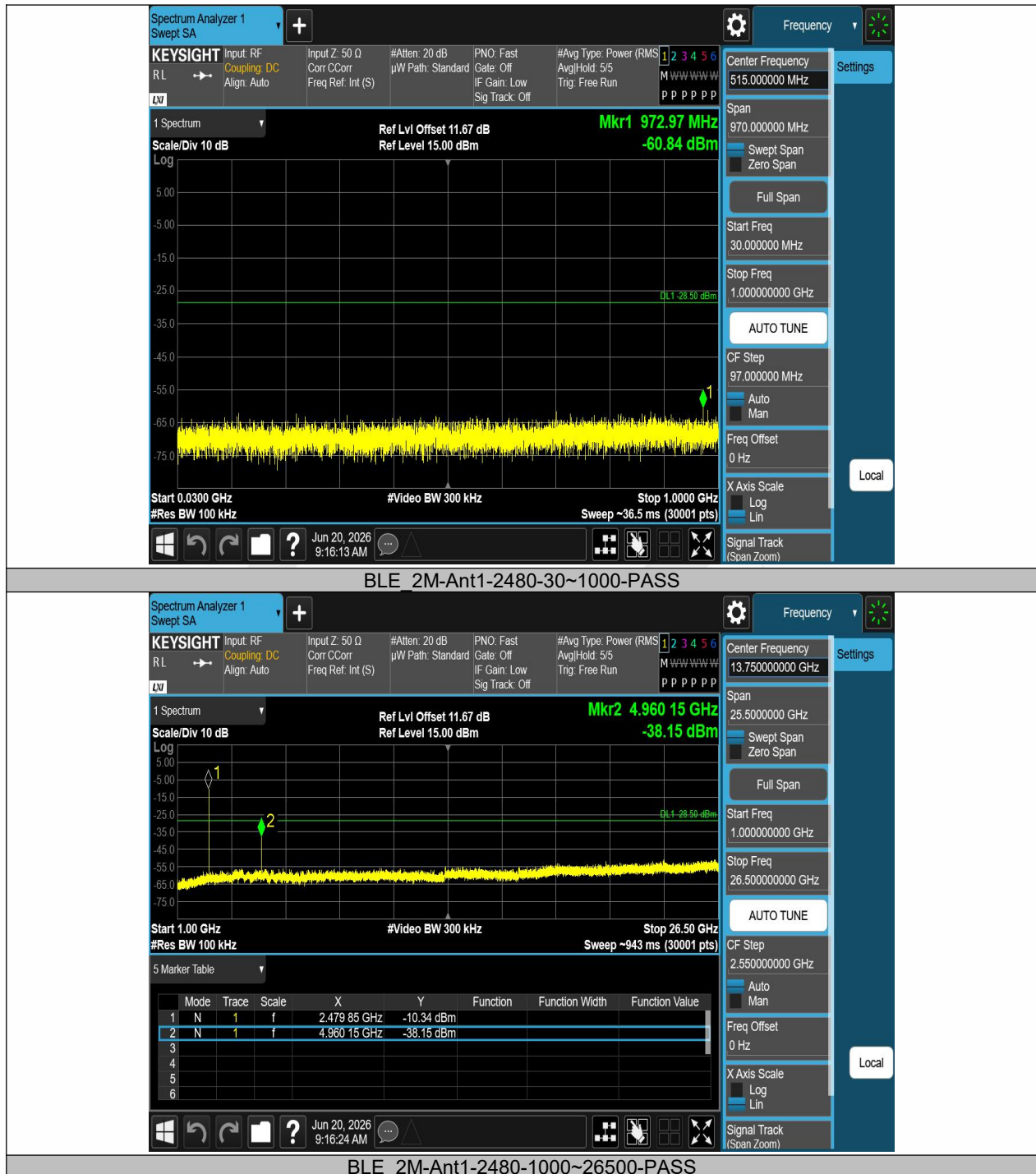












8.6 RADIATED SPURIOUS EMISSION

8.6.1 Applicable Standard

According to FCC Part 15.247(d), 15.205, 15.209 and KDB 558074 D01 15.247 Meas Guidance v05r02
According to IC RSS-Gen and RSS-247

8.6.2 Conformance Limit

According to FCC Part 15.247(d): 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)).
According to FCC Part 15.205, Restricted bands

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
10.495-0.505	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	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			

According to FCC Part 15.205, the level of any transmitter spurious emission in Restricted bands shall not exceed the level of the emission specified in the following table

Restricted Frequency(MHz)	Field Strength (μV/m)	Field Strength (dBμV/m)	Measurement Distance
0.009-0.490	2400/F(KHz)	20 log (uV/m)	300
0.490-1.705	24000/F(KHz)	20 log (uV/m)	30
1.705-30	30	29.5	30
30-88	100	40	3
88-216	150	43.5	3
216-960	200	46	3
Above 960	500	54	3

8.6.3 Test Configuration

Test according to clause 7.2 radio frequency test setup 2

8.6.4 Test Procedure

This test is required for any spurious emission that falls in a Restricted Band, as defined in Section 15.205. It must be performed with the highest gain of each type of antenna proposed for use with the EUT. Use the following spectrum analyzer settings:

The EUT was placed on a turn table which is 0.8m above ground plane.

Maximum procedure was performed on the highest emissions to ensure EUT compliance.

Span = wide enough to fully capture the emission being measured

RBW = 1 MHz for $f \geq 1$ GHz(1GHz to 25GHz), 100 kHz for $f < 1$ GHz(30MHz to 1GHz)

VBW $\geq$ RBW

Sweep = auto

Detector function = peak

Trace = max hold

Follow the guidelines in ANSI C63.10-2020 with respect to maximizing the emission by rotating the EUT, measuring the emission while the EUT is situated in three orthogonal planes (if appropriate), adjusting the measurement antenna height and polarization, etc. A pre-amp and a high pass filter are required for this test, in order to provide the measuring system with sufficient sensitivity. Allow the trace to stabilize. The peak reading of the emission, after being corrected by the antenna factor, cable loss, pre-amp gain, etc., is the peak field strength, which must comply with the limit specified in Section 15.35(b). Submit this data.

Now set the VBW to 10 Hz, while maintaining all of the other instrument settings. This peak level, once corrected, must comply with the limit specified in Section 15.209. If the dwell time per channel of the hopping signal is less than 100 ms, then the reading obtained with the 10 Hz VBW may be further adjusted by a "duty cycle correction factor", derived from $20\log(\text{dwell time}/100 \text{ ms})$, in an effort to demonstrate compliance with the 15.209 limit. Submit this data.

Repeat above procedures until all frequency measured was complete.

8.6.5 Test Results

Temperature:	22° C
Relative Humidity:	43%
ATM Pressure:	1011 mbar

■ Spurious Emission below 30MHz (9KHz to 30MHz)

Freq. (MHz)	Ant.Pol. H/V	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Over(dB)	
		PK	AV	PK	AV	PK	AV
--	--	--	--	--	--	--	--

Note: the amplitude of spurious emission that is attenuated by more than 20dB below the permissible limit has no need to be reported.

Distance extrapolation factor = $40\log(\text{Specific distance}/\text{test distance})$ (dB);

Limit line = Specific limits(dBuV) + distance extrapolation factor

■ Spurious Emission Above 1GHz (1GHz to 25GHz)

All the antenna(Antenna 1) and modes(BLE_1M, BLE_2M) mode have been tested, and the worst(Antenna 1, BLE_2M) result recorded was report as below:

Test mode:		BLE_2M		Frequency:		Channel 0: 2402MHz	
Freq. (MHz)	Ant.Pol.	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Over(dB)	
	H/V	PK	AV	PK	AV	PK	AV
10444.91	V	57.28	44.09	74.00	54.00	-16.72	-9.91
16509.72	V	57.52	44.30	74.00	54.00	-16.48	-9.70
17901.42	V	57.03	43.89	74.00	54.00	-16.97	-10.11
11982.02	H	57.87	44.73	74.00	54.00	-16.13	-9.27
14300.55	H	58.06	45.03	74.00	54.00	-15.94	-8.97
16268.14	H	57.85	44.50	74.00	54.00	-16.15	-9.50

Test mode:		BLE_2M		Frequency:		Channel 19: 2440MHz	
Freq. (MHz)	Ant.Pol.	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Over(dB)	
	H/V	PK	AV	PK	AV	PK	AV
8551.45	V	57.90	45.29	74.00	54.00	-16.10	-8.71
10863.66	V	57.67	44.78	74.00	54.00	-16.33	-9.22
15983.82	V	58.45	45.43	74.00	54.00	-15.55	-8.57
10664.55	H	57.66	44.80	74.00	54.00	-16.34	-9.20
11279.63	H	57.37	44.93	74.00	54.00	-16.63	-9.07
12578.20	H	57.28	44.77	74.00	54.00	-16.72	-9.23

Test mode:		BLE_2M		Frequency:		Channel 39: 2480MHz	
Freq. (MHz)	Ant.Pol.	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Over(dB)	
	H/V	PK	AV	PK	AV	PK	AV
8553.92	V	57.66	44.73	74.00	54.00	-16.34	-9.27
12020.17	V	57.57	44.71	74.00	54.00	-16.43	-9.29
16291.67	V	57.66	44.75	74.00	54.00	-16.34	-9.25
13211.68	H	58.14	45.77	74.00	54.00	-15.86	-8.23
16113.71	H	58.40	45.91	74.00	54.00	-15.60	-8.09
17680.30	H	57.90	44.67	74.00	54.00	-16.10	-9.33

Note:

- (1) All Readings are Peak Value (VBW=3MHz) and Average Value (VBW=10Hz).
- (2) Emission Level= Reading Level+Correct Factor.
- (3) Correct Factor= Ant_F + Cab_L – Preamp
- (4) The reading of emissions are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.

Channel 0: 2402MHz

80.0 dBuV/m



Site site #1

Polarization: **Horizontal**

Temperature: 22.5

80.0 dBuV/m



Site site #1

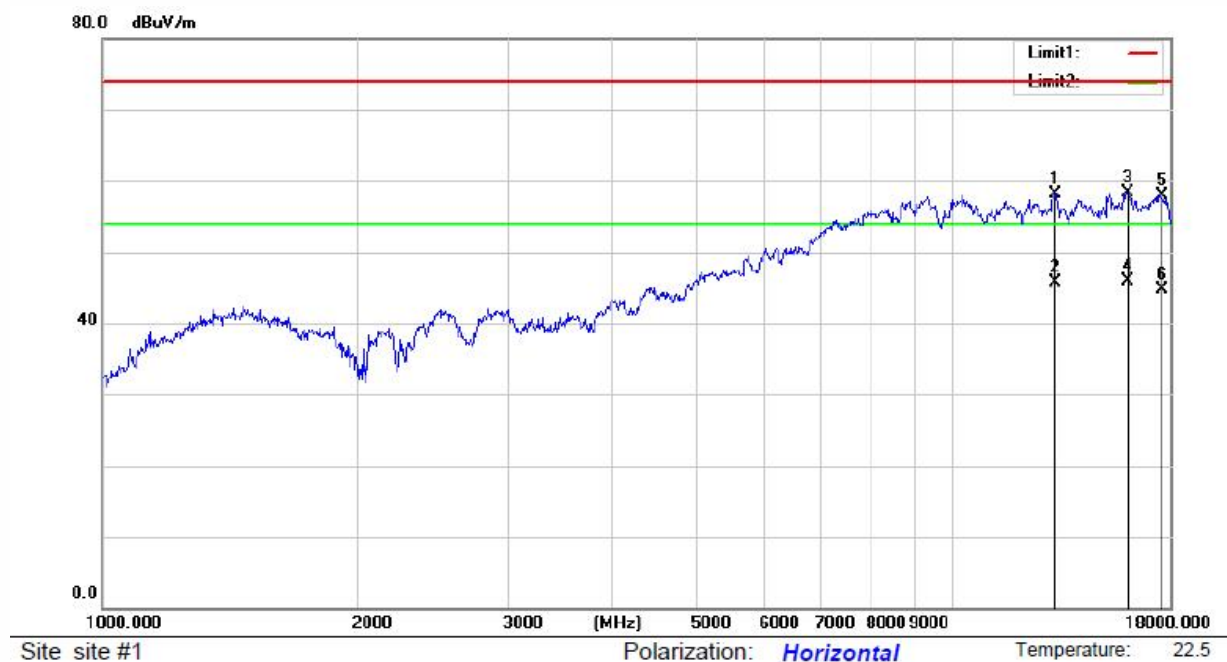
Polarization: **Vertical**

Temperature: 22.5

Channel 19: 2440MHz



Channel 39: 2480MHz



Note: Scan from 1GHz to 25GHz, the disturbance above 18GHz was very low. The points marked on above plots are the highest emissions could be found when testing, so only above points had been displayed.

■ Spurious Emission in Restricted Band 2310-2390MHz and 2483.5-2500MHz

All the antenna(Antenna 1) and modes(BLE_1M, BLE_2M) mode have been tested, and the worst(Antenna 1, BLE_2M) result recorded was report as below:

Test mode: BLE_2M		Frequency:		Channel 0: 2402MHz	
Frequency (MHz)	Polarity	PK(dBuV/m) (VBW=3MHz)	Limit 3m (dBuV/m)	AV(dBuV/m) (VBW=10Hz)	Limit 3m (dBuV/m)
2345.600	H	43.13	74.00	30.35	54.00
2374.000	V	43.11	74.00	29.95	54.00

Test mode: BLE_2M		Frequency:		Channel 39: 2480MHz	
Frequency (MHz)	Polarity	PK(dBuV/m) (VBW=3MHz)	Limit 3m (dBuV/m)	AV(dBuV/m) (VBW=10Hz)	Limit 3m (dBuV/m)
2489.374	H	43.62	74.00	30.10	54.00
2485.183	V	43.09	74.00	29.97	54.00

- Note:**
- (1) All Readings are Peak Value (VBW=3MHz) and Average Value (VBW=10Hz).
 - (2) Emission Level= Reading Level+Correct Factor.
 - (3) Correct Factor= Ant_F + Cab_L - Preamp
 - (4) The reading of emissions are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.

Test Model

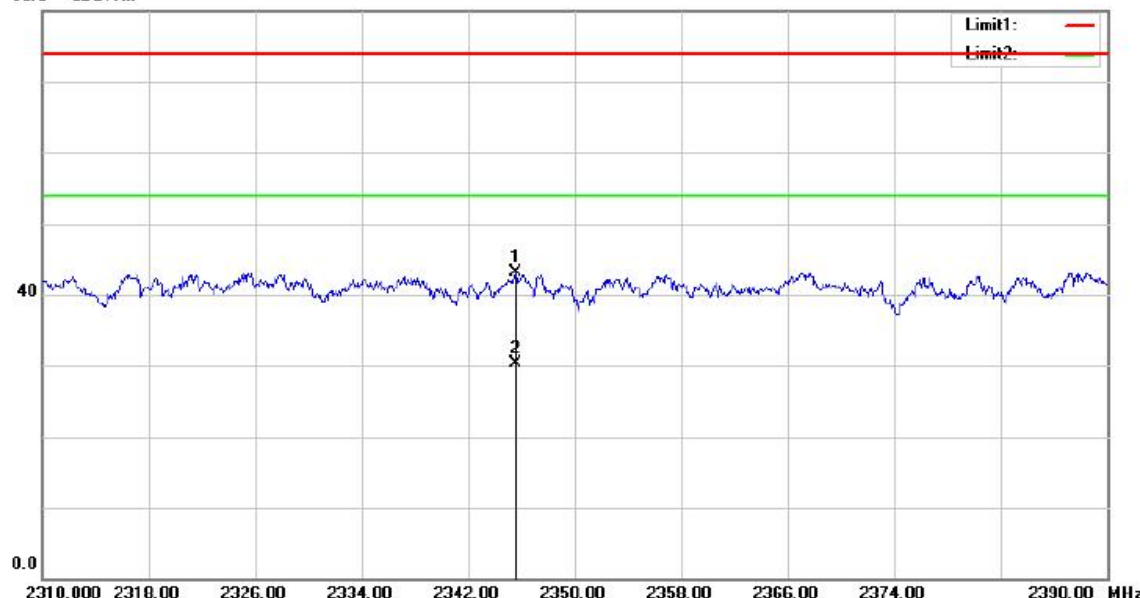
Spurious Emission in Restricted Band 2310-2390MHz

Channel 0: 2402MHz

BLE_2M

H

80.0 dBuV/m



Site site #1

Polarization: **Horizontal**

Temperature: 22.5

Test Model

Spurious Emission in Restricted Band 2310-2390MHz

Channel 0: 2402MHz

BLE_2M

V

80.0 dBuV/m



Site site #1

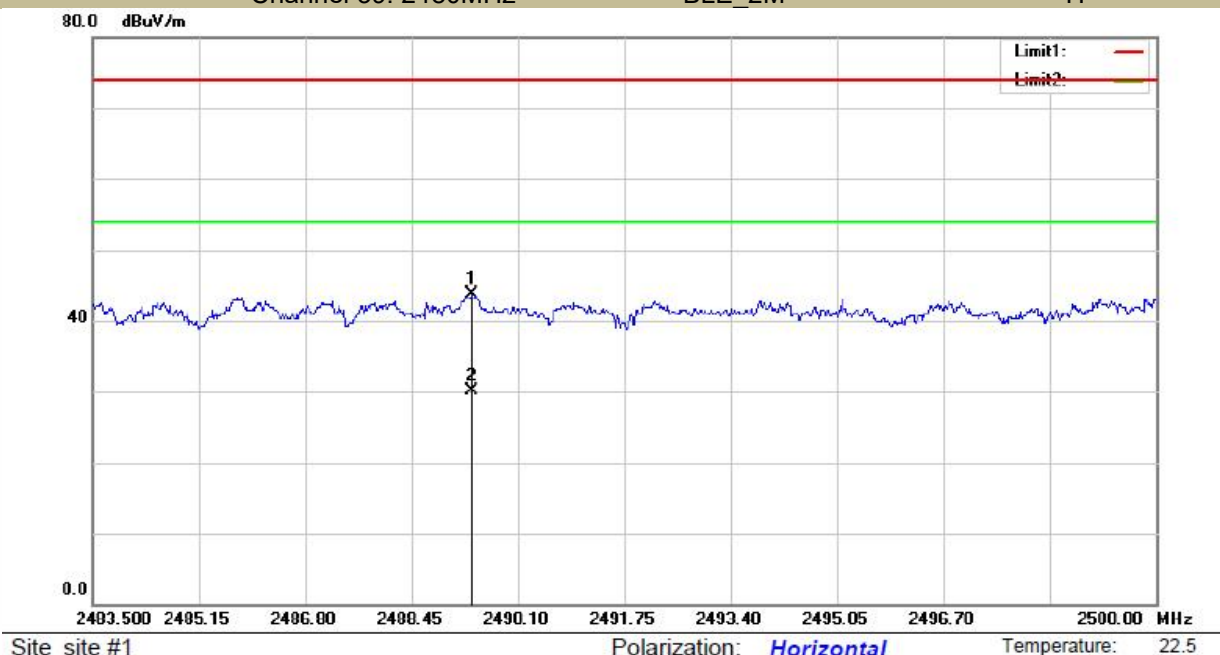
Polarization: **Vertical**

Temperature: 22.5

Test Model

Spurious Emission in Restricted Band 2483.5-2500MHz
Channel 39: 2480MHz BLE_2M

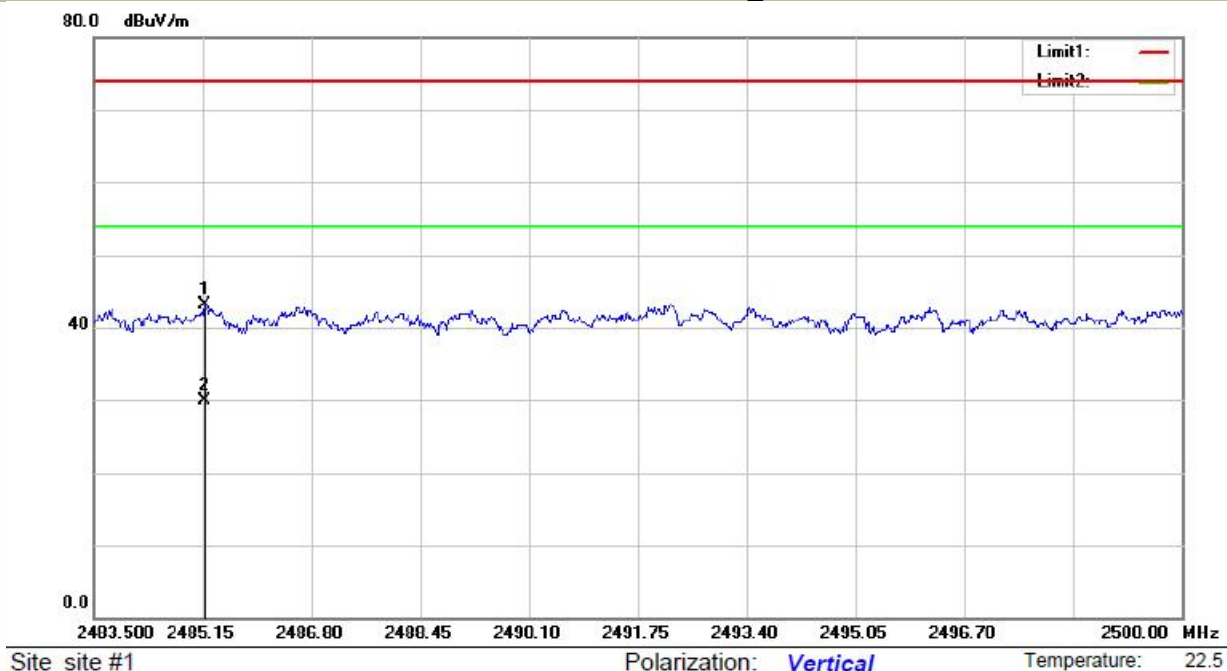
H



Test Model

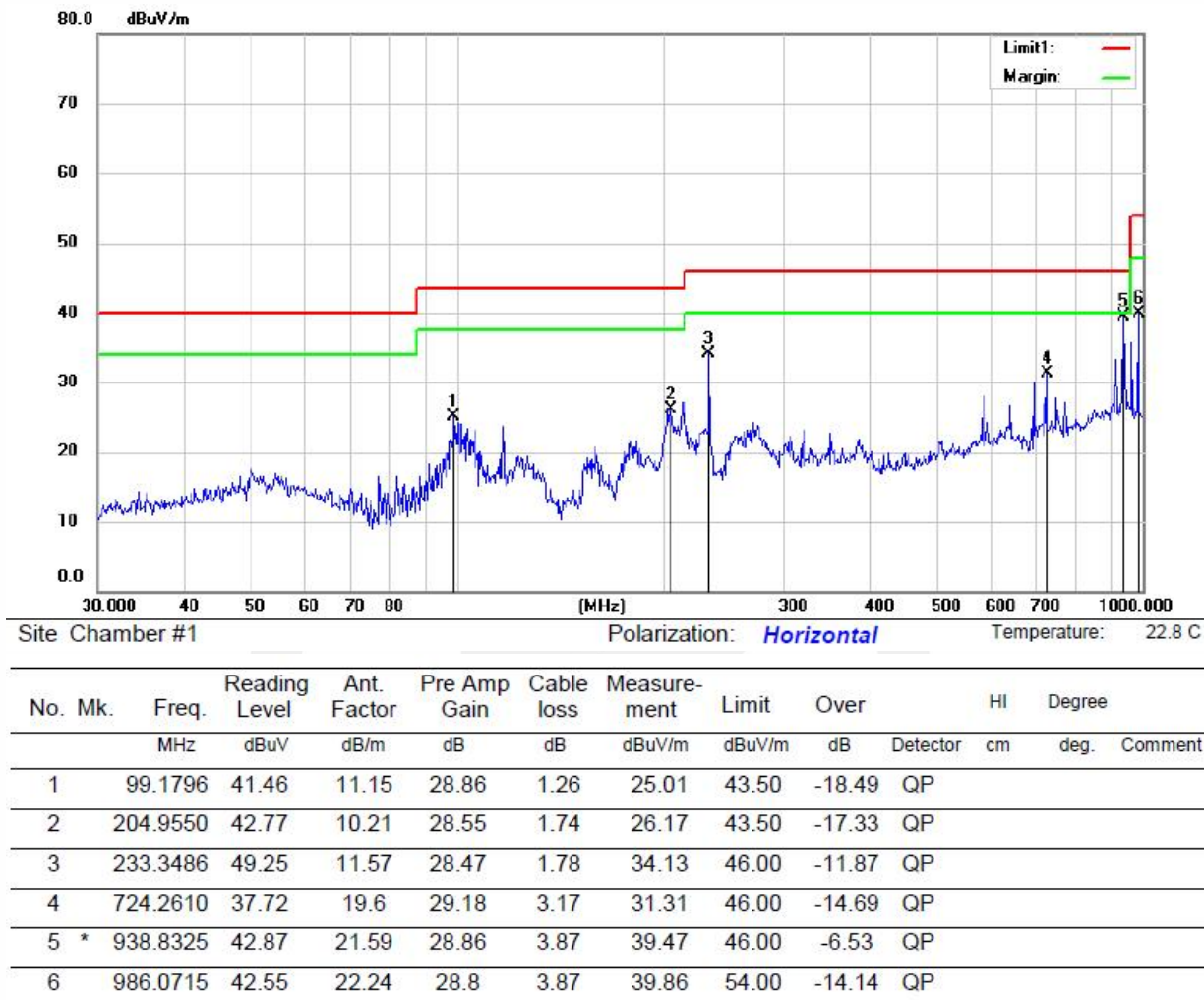
Spurious Emission in Restricted Band 2483.5-2500MHz
Channel 39: 2480MHz BLE_2M

V



■ Spurious Emission below 1GHz (30MHz to 1GHz)

All the antenna(Antenna 1) and modes(BLE_1M, BLE_2M) mode have been tested, and the worst(Antenna 1, BLE_2M) result recorded was report as below:

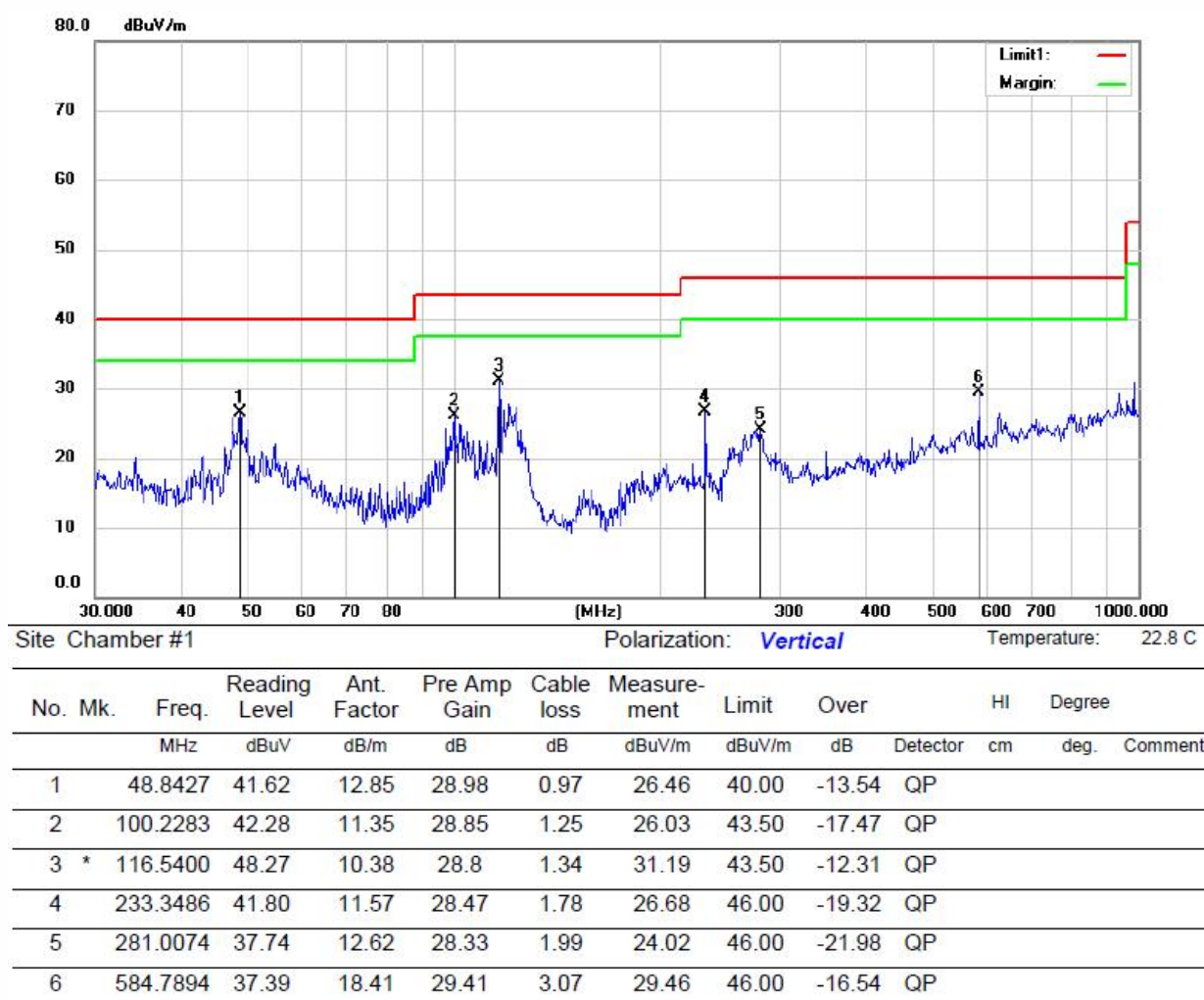


*:Maximum data x:Over limit !:over margin

Operator: chenchao

Remark:

1. Measurement (dBuV/m) = Antenna Factor(dB) -Amp Factor(dB) +Cable Loss(dB) + Reading(dBuV/m)
2. Over (dB) = Measurement (dBuV/m) - Limit (dBuV/m)



*:Maximum data x:Over limit !:over margin

Operator: chenchao

Remark:

1. Measurement (dBuV/m) = Antenna Factor(dB) -Amp Factor(dB) +Cable Loss(dB) + Reading(dBuV/m)
2. Over (dB) = Measurement (dBuV/m) - Limit (dBuV/m)

8.7 CONDUCTED EMISSIONS TEST

8.7.1 Applicable Standard

According to FCC Part 15.207(a)
According to IC RSS-Gen 8.8

8.7.2 Conformance Limit

Frequency(MHz)	Conducted Emission Limit	
	Quasi-peak	Average
0.15-0.5	66-56	56-46
0.5-5.0	56	46
5.0-30.0	60	50

Note: 1. The lower limit shall apply at the transition frequencies
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50MHz.

8.7.3 Test Configuration

Test according to clause 7.3 conducted emission test setup

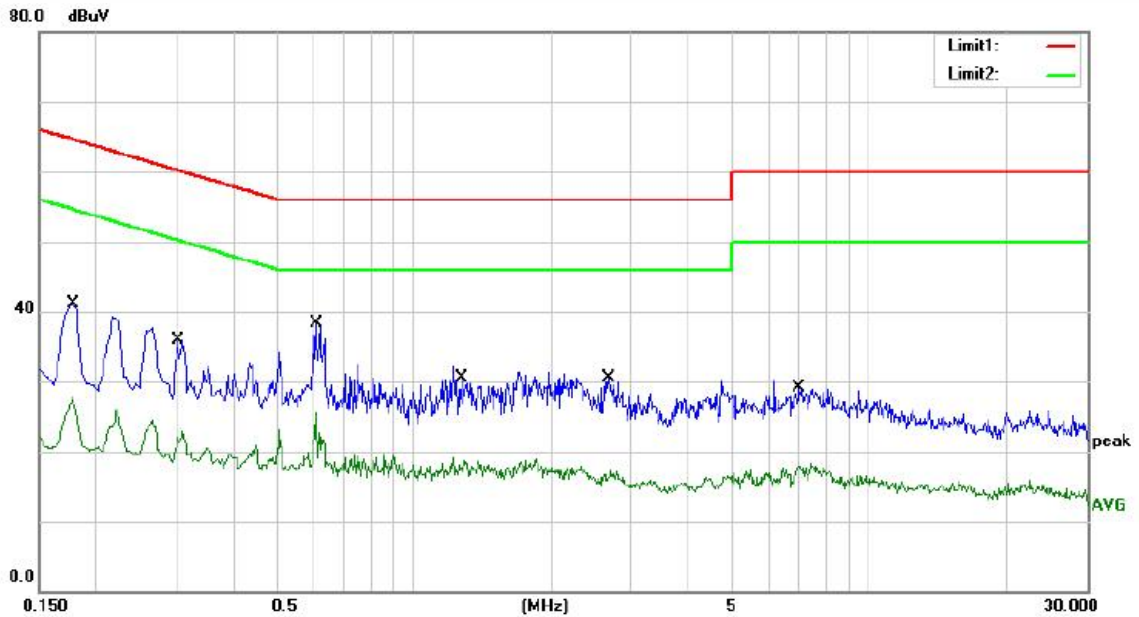
8.7.4 Test Procedure

The EUT was placed on a table which is 0.8m above ground plane.
Maximum procedure was performed on the highest emissions to ensure EUT compliance.
Repeat above procedures until all frequency measured were complete.

8.7.5 Test Results

Pass

The AC120V &240V voltage have been tested, and the worst result recorded was report as below:



Site site #1 Phase: L1 Temperature: 26.0

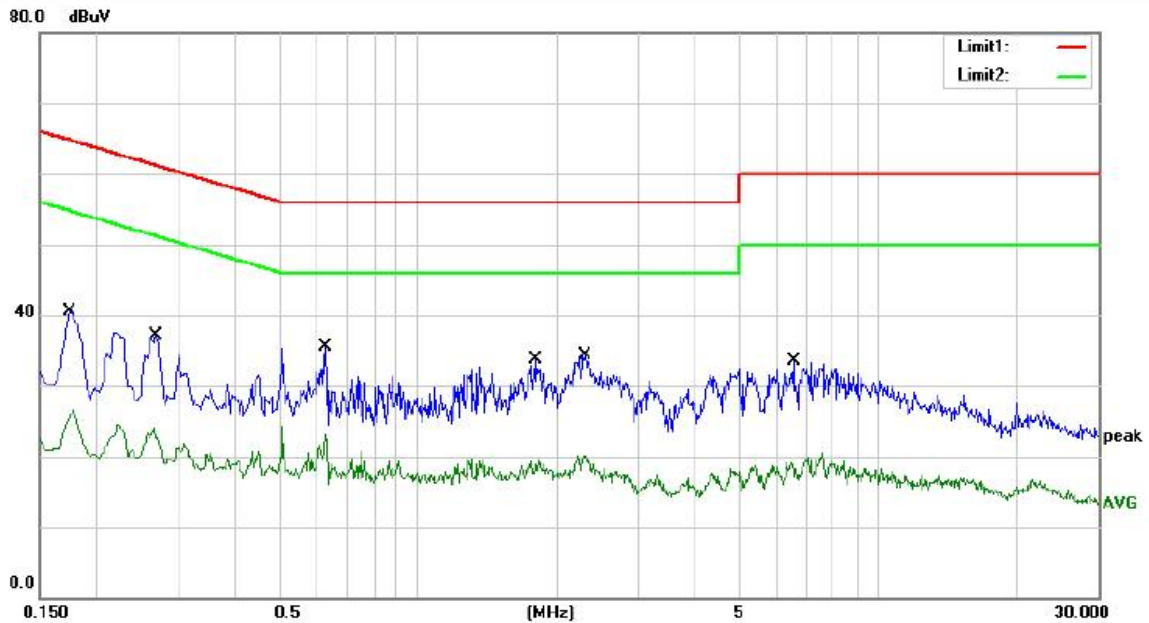
No.	Mk.	Freq. MHz	Reading Level dBuV	Correct Factor dB	Measure- ment dBuV	Limit dBuV	Over dB	Detector	Comment
1		0.1768	22.67	18.35	41.02	64.63	-23.61	QP	
2		0.1768	8.84	18.35	27.19	54.63	-27.44	AVG	
3		0.3020	17.91	18.04	35.95	60.19	-24.24	QP	
4		0.3020	3.35	18.04	21.39	50.19	-28.80	AVG	
5	*	0.6100	20.71	17.55	38.26	56.00	-17.74	QP	
6		0.6100	6.68	17.55	24.23	46.00	-21.77	AVG	
7		1.2740	12.85	17.58	30.43	56.00	-25.57	QP	
8		1.2740	1.20	17.58	18.78	46.00	-27.22	AVG	
9		2.6740	12.78	17.65	30.43	56.00	-25.57	QP	
10		2.6740	-0.29	17.65	17.36	46.00	-28.64	AVG	
11		6.9220	11.41	17.76	29.17	60.00	-30.83	QP	
12		6.9220	-0.30	17.76	17.46	50.00	-32.54	AVG	

*:Maximum data x:Over limit !:over margin Comment: Factor build in receiver. Operator: Lusi

Remark:

1. Measurement (dBμV) = AMN Factor (dB) + Cable Loss (dB) + Reading (dBμV)

2. Over (dB) = Measurement (dBμV) - Limit (dBμV)



Site site #1 Phase: **N** Temperature: 26.0

No.	Mk.	Freq. MHz	Reading Level dBuV	Correct Factor dB	Measure- ment dBuV	Limit dBuV	Over dB	Detector	Comment
1		0.1740	22.19	18.36	40.55	64.77	-24.22	QP	
2		0.1740	8.33	18.36	26.69	54.77	-28.08	AVG	
3		0.2660	19.00	18.13	37.13	61.24	-24.11	QP	
4		0.2660	6.06	18.13	24.19	51.24	-27.05	AVG	
5	*	0.6300	17.94	17.56	35.50	56.00	-20.50	QP	
6		0.6300	5.58	17.56	23.14	46.00	-22.86	AVG	
7		1.8020	16.11	17.61	33.72	56.00	-22.28	QP	
8		1.8020	1.90	17.61	19.51	46.00	-26.49	AVG	
9		2.2860	16.57	17.63	34.20	56.00	-21.80	QP	
10		2.2860	2.48	17.63	20.11	46.00	-25.89	AVG	
11		6.4740	15.76	17.76	33.52	60.00	-26.48	QP	
12		6.4740	1.39	17.76	19.15	50.00	-30.85	AVG	

*:Maximum data x:Over limit !:over margin Comment: Factor build in receiver. Operator: Lusi

Remark:

1. Measurement (dBμV) = AMN Factor (dB) + Cable Loss (dB) + Reading (dBμV)

2. Over (dB) = Measurement (dBμV) - Limit (dBμV)

8.8 ANTENNA APPLICATION

8.8.1 Antenna Requirement

Standard	Requirement
FCC CRF Part 15.203	An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.
FCC 47 CFR Part 15.247 (b)	If transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.
RSS-Gen Section 6.8	The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.
RSS-247 Section 6.5	If the transmitter employs an antenna system that emits multiple directional beams, but does not emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device (i.e. the sum of the power supplied to all antennas, antenna elements, staves, etc., and summed across all carriers or frequency channels) shall not exceed the applicable output power limit. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

8.8.2 Result

PASS.

- Note:
- ☒ Antenna use a permanently attached antenna which is not replaceable.
 - ☐ Not using a standard antenna jack or electrical connector for antenna replacement
 - ☐ The antenna has to be professionally installed (please provide method of installation)

Please refer to the attached document Internal Photos to show the antenna connector.

Detail of Factor For Radiated Emission

Frequency(MHz)	Ant_F(dB)	Cab_L(dB)	Preamp(dB)	Correct Factor(dB)
0.009	20.6	0.03	\	20.63
0.15	20.7	0.1	\	20.8
1	20.9	0.15	\	21.05
10	20.1	0.28	\	20.38
30	18.8	0.45	\	19.25
30	11.7	0.62	27.9	-15.58
100	12.5	1.02	27.8	-14.28
300	12.9	1.91	27.5	-12.69
600	19.2	2.92	27	-4.88
800	21.1	3.54	26.6	-1.96
1000	22.3	4.17	26.2	0.27
1000	25.6	1.76	41.4	-14.04
3000	28.9	3.27	43.2	-11.03
5000	31.1	4.2	44.6	-9.3
8000	36.2	5.95	44.7	-2.55
10000	38.4	6.3	43.9	0.8
12000	38.5	7.14	42.3	3.34
15000	40.2	8.15	41.4	6.95
18000	45.4	9.02	41.3	13.12
18000	37.9	1.81	47.9	-8.19
21000	37.9	1.95	48.7	-8.85
25000	39.3	2.01	42.8	-1.49
28000	39.6	2.16	46.0	-4.24
31000	41.2	2.24	44.5	-1.06
34000	41.5	2.29	46.6	-2.81
37000	43.8	2.30	46.4	-0.3
40000	43.2	2.50	42.2	3.5

----- END OF REPORT -----