FCC Test Report

For:
Banner Engineering Corp.

Brand:
Banner Engineering Corp.

Marketing Name:
60 GHz Industrial Radar Presence Detector

Model Name:
Q90R2-12040-6KDQ

Product Description:
Industrial Radar Presence Detector

FCC ID: UE3Q90R2-6

Applied Rules and Standards:
47 CFR Part 15.255

REPORT #: EMC_BANNE-008-24001_FCC15.255

DATE: 2024-03-26

A2LA Accredited

IC recognized #
3462B
CABID: US0187

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CETECOM Inc. is a Delaware Corporation with Corporation number: 2905571

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1 Assessment

The following device was evaluated against the applicable criteria specified in

- FCC rule Part 15.255 of Title 47 of the Code of Federal Regulations

No deviations were ascertained.

Company	Description	Model #
Banner Engineering Corp.	Industrial Radar Presence Detector	Q90R2-12040-6KDQ

Responsible for the Report:

Date	Section	Name	Signature
2024-03-26	Compliance	Guangcheng Huang (Senior EMC Test Engineer)	

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the EMC Test Report

Company Name:	CETECOM Inc.
Department:	Compliance
Street Address:	411 Dixon Landing Road
City/Zip Code	Milpitas, CA 95035
Country	USA
Telephone:	+1 (408) 586 6200
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EMC Lab Manager:	Issa Ghanma
Project Manager:	Akanksha Baskaran

2.2 Identification of the Client

Client's Name:	Banner Engineering Corp.
Street Address:	9714 10th Avenue North
City/Zip Code	Minneapolis, MN 55441
Country	USA

2.3 Identification of the Manufacturer

Manufacturer's Name:	Same as Client
Manufacturers Address:	Same as Client
City/Zip Code	----------
Country	----------

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Model No:	Q90R2-12040-6KDQ
Marketing Name:	60 GHz Industrial Radar Presence Detector
HW Version :	Rev A
SW Version :	1.0
FCC ID :	UE3Q90R2-6
FWIN:	N/A
HVIN:	Q90R2-6
PMN:	Q90R
Product Description:	Industrial Radar Presence Detector
Frequency Range / number of channels:	60 – 61.56 GHz
Radio Information:	Radar Chip: TI IWR6843
Modes of Operation:	1: FMCW 2: continuous wave transmission mode (for compliance test purpose only)
Antenna Information as declared:	Microstrip patch antenna
Power Supply / Rated operating Voltage Range:	Nominal 24 V DC Range 10 - 30 V DC
Operating Temperature Range	-40 °C to +65 °C
Other Radios included in the device:	None
Sample Revision	■ Production; ☐ Pre-Production
EUT Diameter	90mm X 90mm X 25mm
Note: All information provided by the client.	

3.2 EUT Sample details

EUT #	Serial Number	HW Version	SW Version	Notes/Comments
1	----------	Rev A	1.0	----------

3.3 Accessory Equipment (AE) details

AE #	Type	Model	Manufacturer	Serial Number
1	Test Laptop	HP EliteBook 840 G6	HP	5CG95101D1
2	Cable harness	-	-	805287

3.4 Test Sample Configuration

EUT Set-up #	Combination of AE used for test set up	Comments
1	EUT#1 + AE#1	The radio of the EUT is configured according to requirement of each test case

3.5 Mode of Operation

Mode #	Mode of Operation	Comments
1	FMCW	Continuously transmitting FMCW signal
2	CW	Continuously transmitting continuous wave (for compliance test purpose only)

3.6 Justification for Worst Case Mode of Operation

During the testing process, the EUT was tested with transmitter sets on low, mid and high channels, and continuous wave transmission.

For radiated measurements, all data in this report shows the worst case between horizontal and vertical antenna polarizations and for all orientations of the EUT.

4 Subject of Investigation

The objective of the measurements done by CETECOM Inc. was to evaluate the compliance of the EUT against the relevant requirements specified in section 1 Assessment.

5 Measurement Results Summary

Test Specification	Test Case	Temperature and Voltage Conditions	Mode [2]	Pass	NA	NP	Result
§15.255(c)(2)(ii)	Equivalent Isotropic Radiated Power	Nominal	1	■	☐	☐	Complies
§15.255(c)(2)(ii)	99% Occupied Bandwidth	Nominal	1	■	☐	☐	Complies
§15.255(f)	Frequency Stability	Nominal and extreme	1	■	☐	☐	Complies
§15.255(h)	Group Installation	Nominal	-	☐	■ *	☐	Complies
§15.255(d) §15.209(a)	TX Spurious emissions-Radiated	Nominal	1 & 2	■	☐	☐	Complies
§15.207	AC Conducted Emissions	Nominal	1	■	☐	☐	Complies

Note: NA= Not Applicable; NP= Not Performed.
*): see manufacturer's product manual.
Note 2. See section 3.5 Mode of Operation

6 Measurements

6.1 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus, with 95% confidence interval (in dB delta to result), based on a coverage factor k=2.

Radiated measurement

9 kHz to 30MHz	±2.5 dB (Magnetic Loop Antenna)
30 MHz to 1000 MHz	±2.0 dB (Biconilog Antenna)
1 GHz to 40 GHz	±2.3 dB (Horn Antenna)
40-60 GHz	±3.95 dB (Horn Antenna)
60-90 GHz	±3.32 dB (External Mixer, Horn Antenna)
90-140 GHz	±4.94 dB (External Mixer, Horn Antenna)
140-225 GHz	±5.42 dB (External Mixer, Horn Antenna)

Conducted measurement

RF conducted measurement	±0.5 dB

6.2 Environmental Conditions During Testing:

The following environmental conditions were maintained during the course of testing:

- Ambient Temperature: 20-25 ˚C
- Relative humidity: 40-60%

6.3 Dates of Testing:

2024-02-10 to 2024-03-01

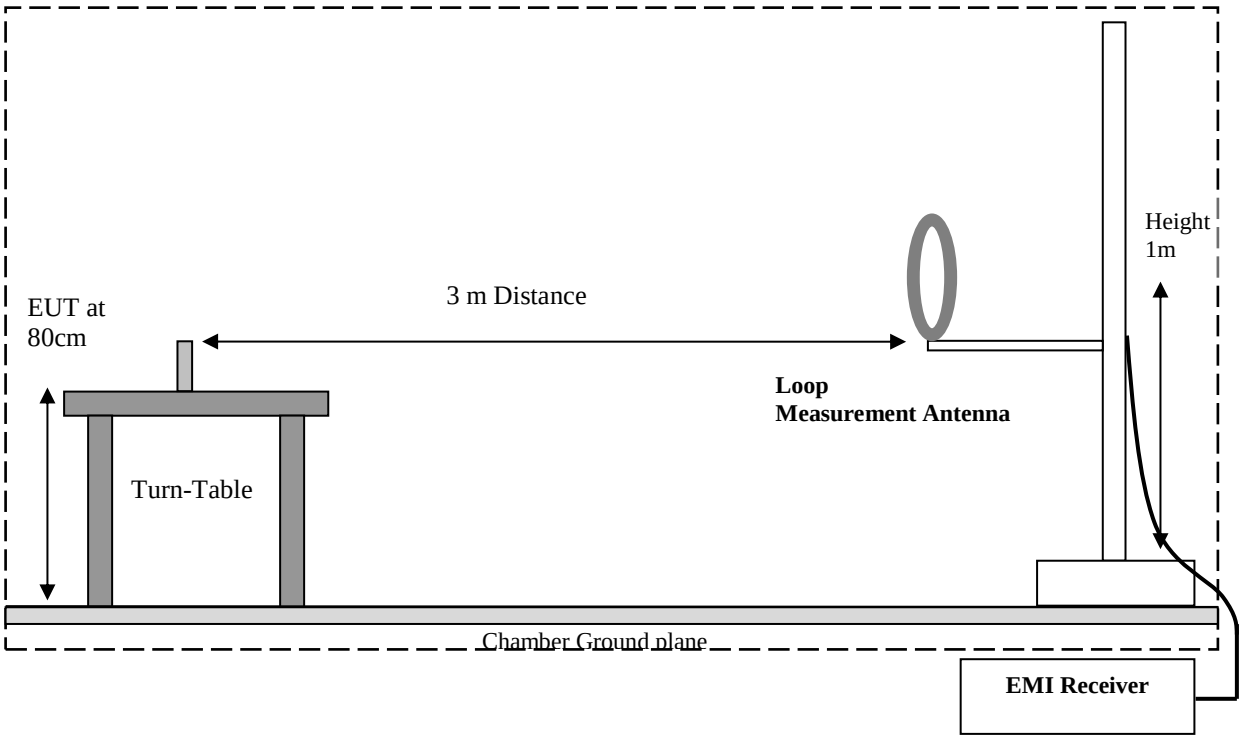
7 Measurement Procedures

7.1 Radiated Measurement

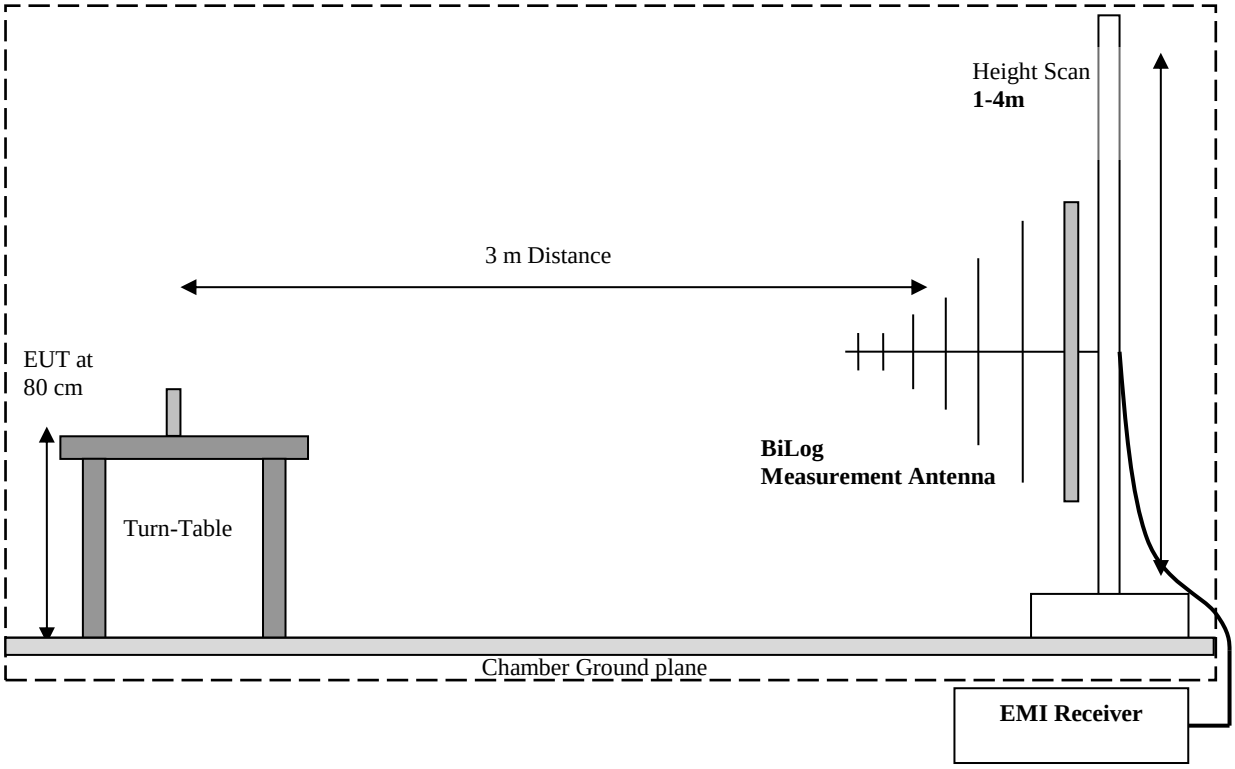
The radiated measurement is performed according to: ANSI C63.10 (2013)

- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 4 positions of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to cover the 3 orthogonal axis of the EUT. A max peak detector is utilized during the exploratory measurement. The Test-SW creates an overall maximum trace for all 12 sweeps and saves the settings for each point of this trace. The maximum trace is part of the test report.
- The 10 highest emissions are selected with an automatic algorithm of EMC32 searching for peaks in the noise floor and ensuring that broadband signals are not selected multiple times.
- The maxima are then put through the final measurement and again maximized in a 90deg range of the turntable, fine search in frequency domain and height scan between 1m and 4m.
- The above procedure is repeated for all possible ways of power supply to EUT and for all supported modulations.
- In case there are no emissions above noise floor level only the maximum trace is reported as described above.
- The results are split up into up to 4 frequency ranges due to antenna bandwidth restrictions. A magnetic loop is used from 9 kHz to 30 MHz, a Biconilog antenna is used from 30 MHz to 1 GHz, and two different horn antennas are used to cover frequencies up to 40 GHz.

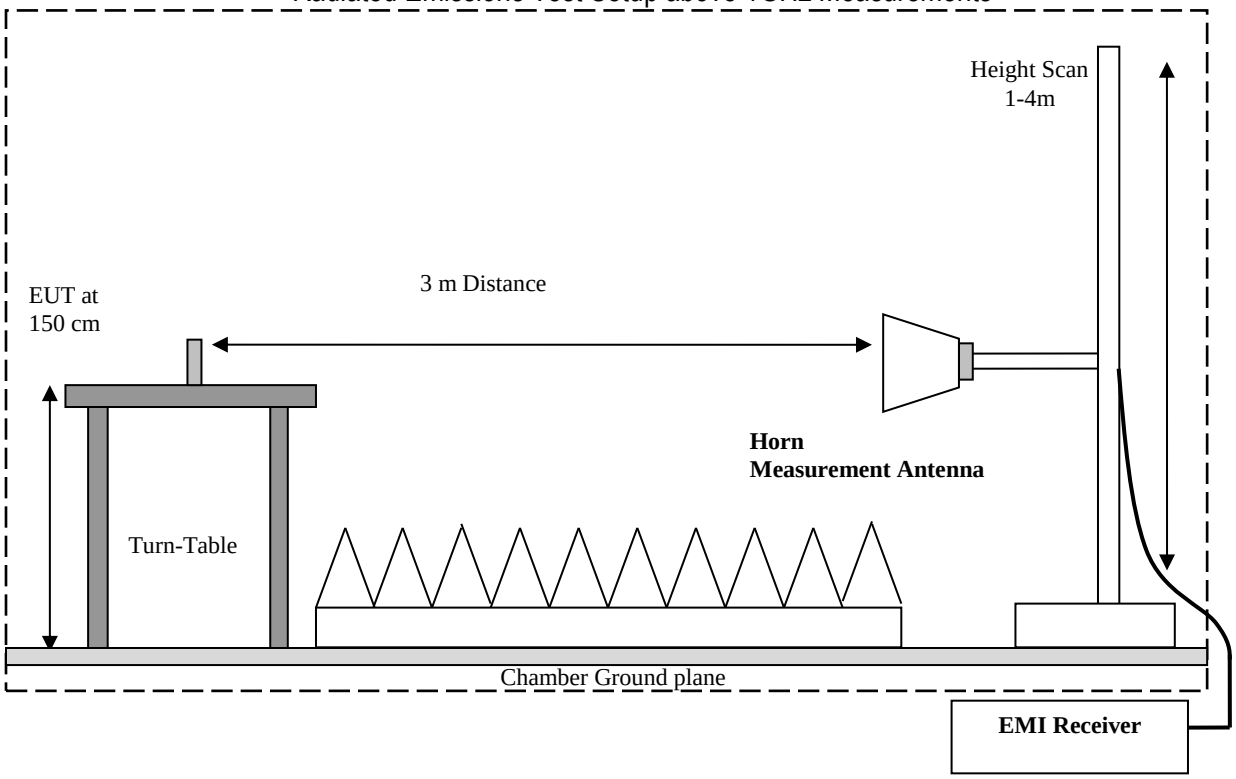
Radiated Emissions Test Setup below 30MHz Measurements



Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup above 1GHz Measurements



7.1.1 Sample Calculations for Field Strength Measurements

Field Strength is calculated from the Spectrum Analyzer/ Receiver readings, taking into account the following parameters:

1. Measured reading in dBµV
2. Cable Loss between the receiving antenna and SA in dB and
3. Antenna Factor in dB/m

All radiated measurement plots in this report are taken from a test SW that calculates the Field Strength based on the following equation:

FS (dBµV/m) = Measured Value on SA (dBµV) + Cable Loss (dB) + Antenna Factor (dB/m)

Example:

Frequency (MHz)	Measured SA (dBµV)	Cable Loss (dB)	Antenna Factor Correction (dB/m)	Field Strength Result (dBµV/m)
1000	80.5	3.5	14	98.0

7.1.2 Sample Calculations for Radiated Emission above 40 GHz

Radiated emission measurement over 40 GHz is measured in EIRP. It's done with help of external mixers, which have intrinsic conversion loss (including also cable loss from the external mixer to the spectrum analyzer). The spectrum analyzer includes the table of conversion loss while measuring. At the same time, the spectrum analyzer includes free space loss and the antenna gain of the measurement antenna.

All radiated measurement plots in this report show EIRP level are based on the following equation:

EIRP (dBm) = Measured Value on SA (dBm) + Conversion Loss (dB) + Antenna Gain (dB) + Free Space Loss (dB)

Example:

Frequency (MHz)	Measured SA (dBm)	Conversion Loss (dB)	Antenna Gain (dB)	FSL (dB)	EIRP (dBm)
60000	-68	20	-25	78	5

7.2 Power Line Conducted Measurement Procedure

AC Power Line conducted emissions measurements performed according to: ANSI C63.4 (2014)

8 Test Result Data

8.1 EIRP and Maximum Peak Conducted Output Power

8.1.1 Measurement according to ANSI C63.10 Section 9.9

1. An RF detector with a bandwidth encompassing the entire authorized frequency band is used. An appropriate test horn antenna is connected to it and put in the main beam of the EUT. The video output of the RF detector is feed to a DSO.
2. The EUT is set to transmission with max. power level. Frequent sweeps have been done on the DSO to capture the highest level of the video output.

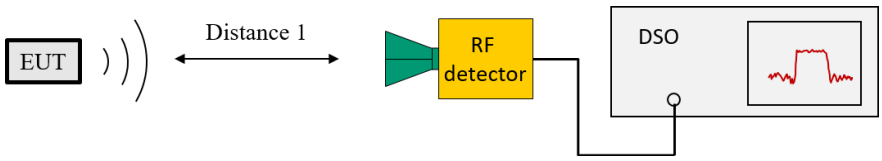


Fig. 1: Test setup 1. $EIRP_{EUT} - FSL_1 + AG_{meas} = P_{detector}$

3. Replace the EUT with a setup generating unmodulated mm-wave at the center frequency of the EUT frequency range. The setup includes a signal generator, a frequency multiplier, a variable attenuator and a horn antenna.
4. Adjust the level of the generated mm-wave till the DSO shows the same voltage level as the highest level captured measuring the EUT.

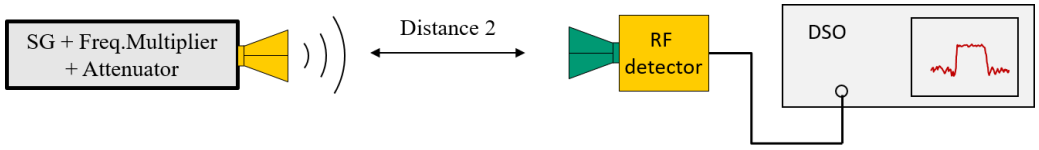


Fig. 2: Test setup 2. $P_{SG} + AG_{TX} - FSL_2 + AG_{meas} = P_{detector}$

5. Without making any other change, disconnect the transmitting antenna on this signal generating setup and measure the output level of the setup with a wideband mm-wave power meter with a thermocouple detector in the conducted way.

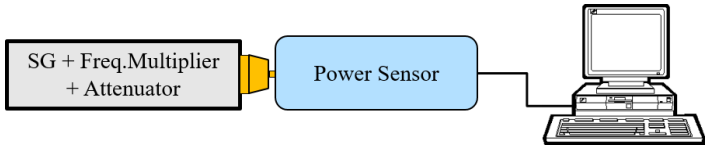


Fig. 3: Test setup 3. $P_{SG} = P_{sensor}$

6. Applying ANCI C63.10-2020 the equations G.9 & G.10 to calculate the EIRP and conducted output of the EUT

8.1.2 Limits:

Maximum Radiated Power and Timing:

FCC §15.255 (c) Radiated power limits:

- (2)(ii) 57.0–61.56 GHz: the peak EIRP shall not exceed 3 dBm except that the peak EIRP shall not exceed 20 dBm if the sum of continuous transmitter off-times of at least two milliseconds equals at least 16.5 milliseconds within any contiguous interval of 33 milliseconds;

8.1.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
23 °C	1	1	nominal

8.1.4 Measurement result:

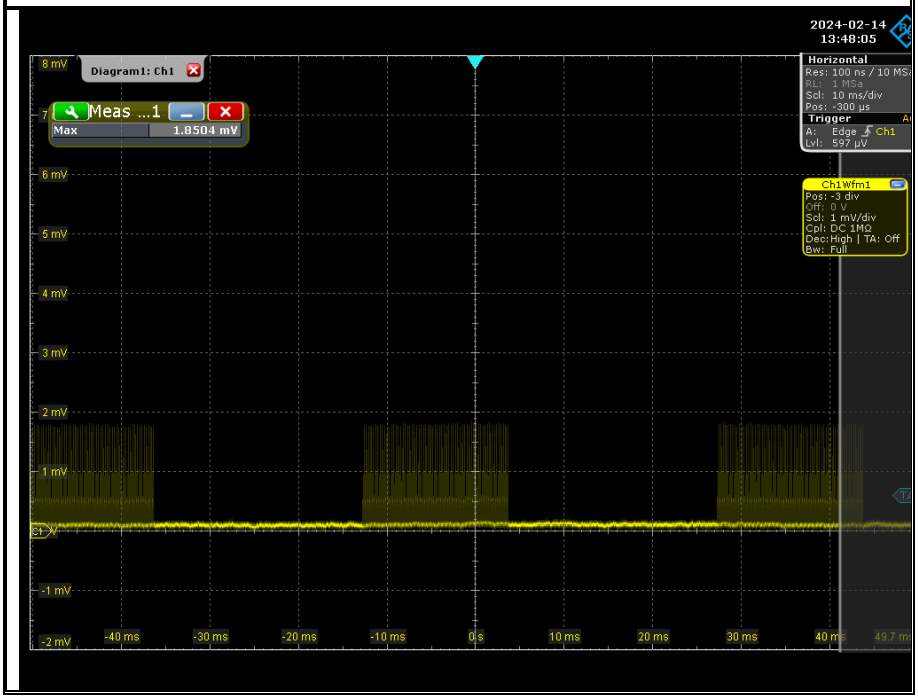
FCC §15.255

Plot #	EUT operating mode	EIRP (dBm)	Limit (dBm)	Result
1-3	1	14.45	20	Pass

Plot #	EUT operating mode	TX off-time within any 33 ms	Limit TX off-time within any 33 ms	Result
4	1	16.65 ms	min. 16.5 ms	Pass

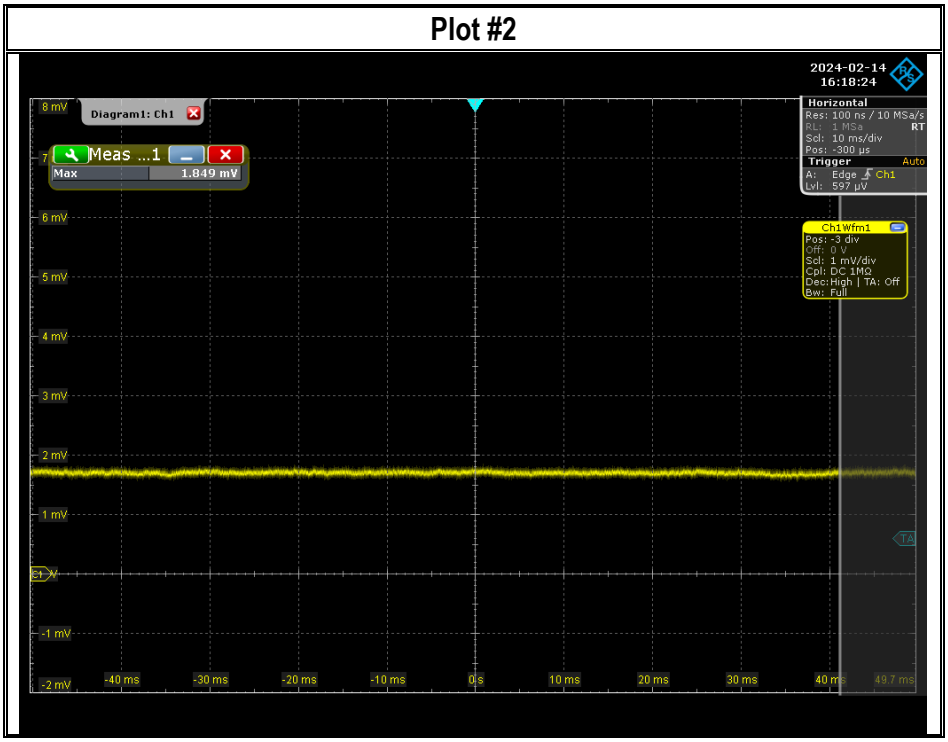
8.1.5 Measurement Plots:

Plot #1



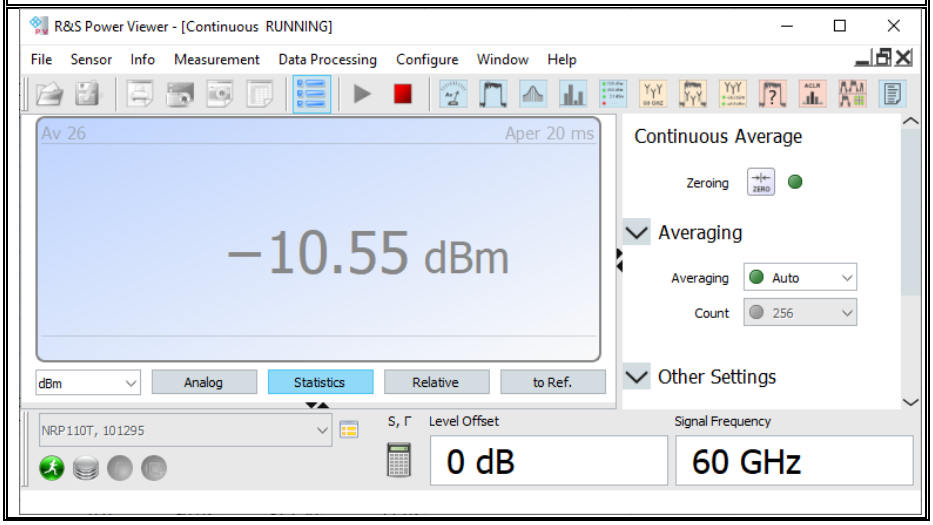
Note: measured with the DSO, shows max. voltage = 1.85 mV at a distance of 80 cm to EUT.

Plot #2



Note: reproduce the max. voltage level of 1.85 mV on the DSO, by replacing the EUT with a signal generator and transmitting antenna at a distance of 80 cm.

Plot #3

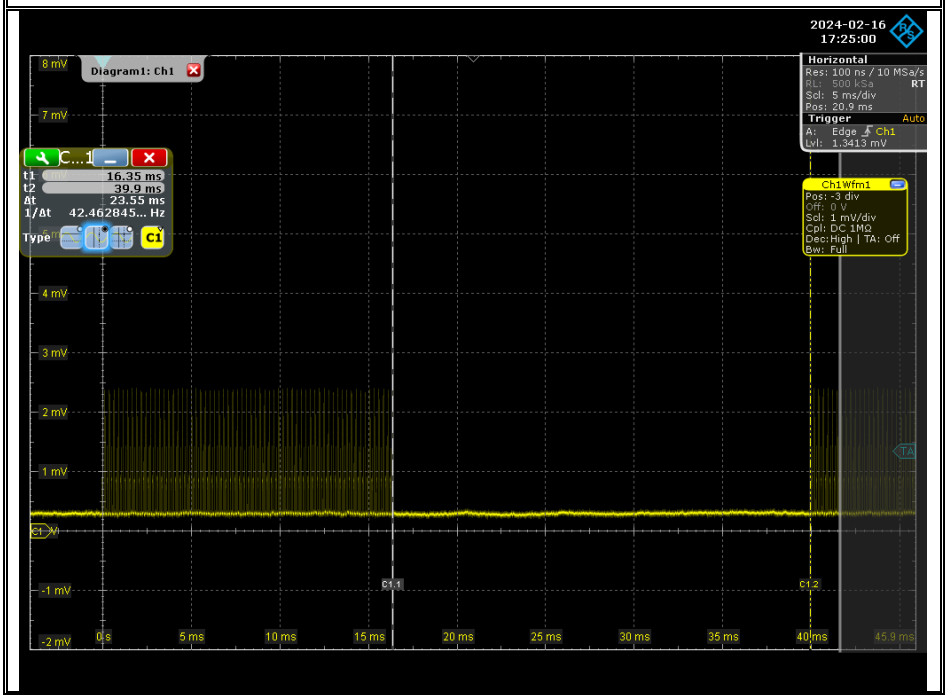


Note: measured the conducted power from the signal generator of -10.55 dBm.

Antenna gain of the TX antenna AG_{TX}, which is attached to the signal generator: 25 dBi,
Free space loss FSL_1 of a signal at 60 GHz at a distance of 80 cm: 66.12 dB,
Free space loss FSL_2 of a signal at 60 GHz at a distance of 80 cm: 66.12 dB,
Thus the equivalent radiated power of the EUT calculates:

$EIRP_{EUT}$ $= P_{sensor} + AG_{TX} - FSL_2 + FSL_1$
$= -10.55\ dBm + 25\ dB - 66.12\ dB + 66.12\ dB$
$= 14.45\ dBm$

Plot #4



Note: Within 33 ms time frame, TX-on time marked by the cursor is 16.35 ms

Total TX-off time within 33 ms is

(33 – 16.35) ms = 16.65 ms

Which is more than 16.5 ms, complies with the rule part requirement.

8.2 99% Occupied Bandwidth

8.2.1 Measurement according to ANSI C63.10-2020, section 9.4

Spectrum Analyzer settings:

- Span: approximately 1.5 times the OBW, centered on the carrier frequency
- RBW, prefer 1% to 5% of OBW, or a minimum of 1 MHz
- VBW approx. 3 x RBW
- Sweep Time = Auto couple
- Detector = Peak
- Trace = Max-hold

8.2.2 Limits: FCC §15.255(c)(2)(ii): 57.0-61.56 GHz

8.2.3 Test conditions and setup:

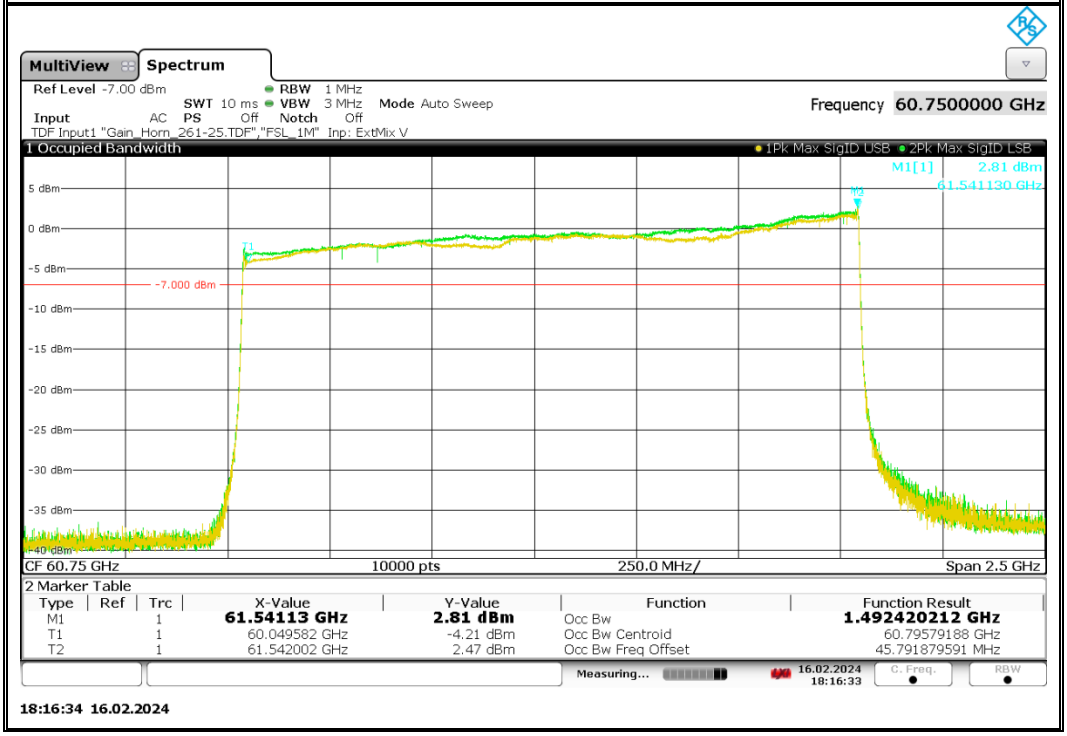
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
22 °C	1	1	nominal

8.2.4 Measurement result:

Plot #	EUT operating mode	OBW lower edge (GHz)	OBW higher edge (GHz)	99% OBW (GHz)	Limit	Result
1	1	60.049	61.545	1.496	Band 57-61.56 GHz OBW 4.56 GHz	Pass

8.2.5 Measurement Plots:

Plot #1: 99% OBW



8.3 Frequency Stability

8.3.1 Measurement according to ANSI C63.10-2020, section 9.5

Spectrum Analyzer settings:

- Span: approximately 2 to 3 times the emission bandwidth, centered on the carrier frequency
- RBW = 1 MHz
- VBW = 3 MHz
- Sweep Time = Auto couple
- Detector = Peak
- Trace = Max hold

8.3.2 Limits: FCC §15.255(f)

FCC §15.255(f):
Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the temperature range −20 to + 50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

8.3.3 Test conditions and setup:

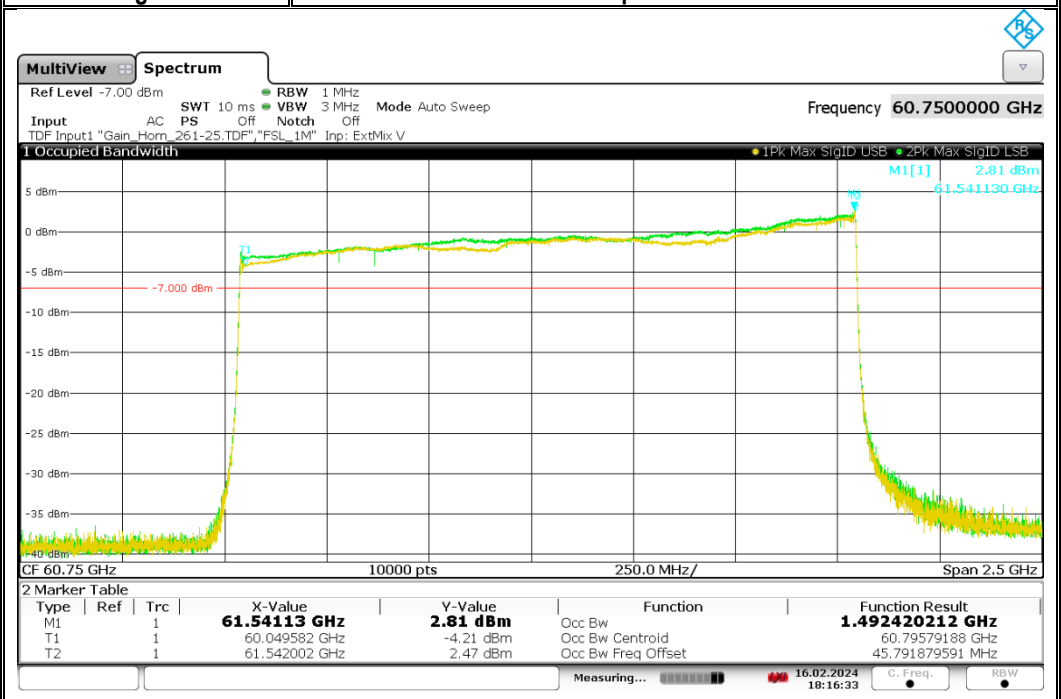
Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
20 °C	1	1	Nominal and extreme

8.3.4 Measurement result:

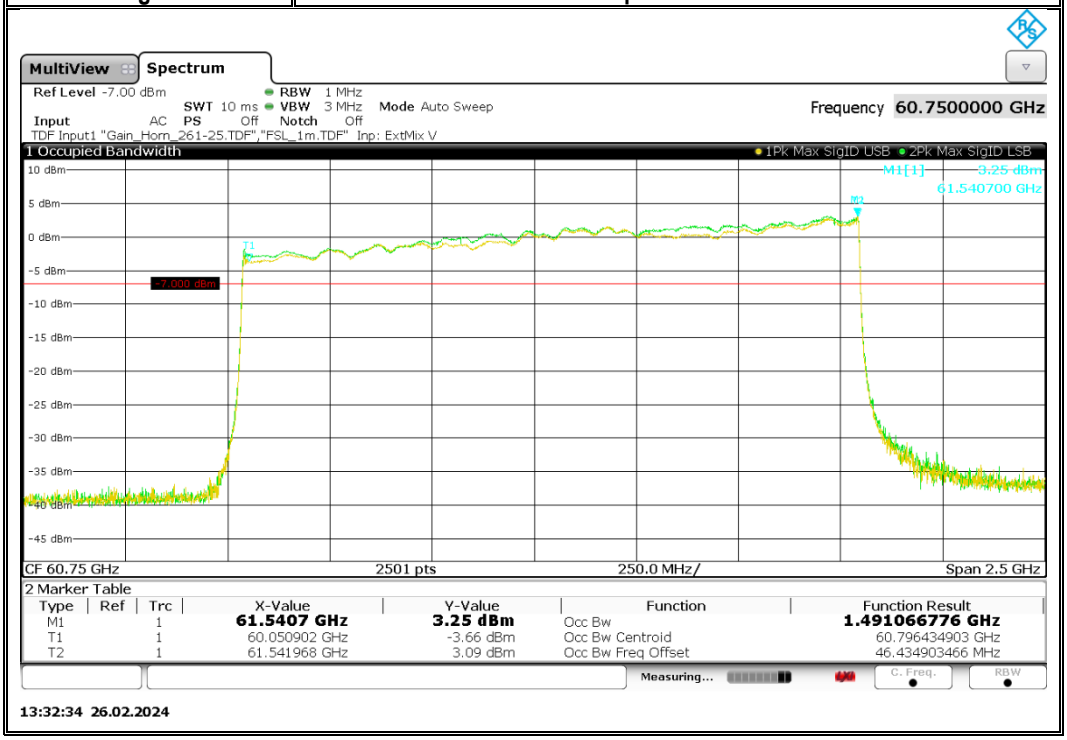
Plot #	Voltage (V)	Temperature (°C)	F_low (GHz)	F_high (GHz)	Limit (GHz)	Verdict
1	24	20	60.049582	61.542002	57-61.56	Complies
2	10	20	60.050902	61.541968	57-61.56	Complies
3	30	20	60.050823	61.54163	57-61.56	Complies
4	24	-40	60.053624	61.542531	57-61.56	Complies
5	24	-20	60.052669	61.542163	57-61.56	Complies
6	24	-10	60.053534	61.542261	57-61.56	Complies
7	24	0	60.053498	61.542379	57-61.56	Complies
8	24	10	60.053612	61.542347	57-61.56	Complies
9	24	30	60.053177	61.542293	57-61.56	Complies
10	24	40	60.052541	61.5423	57-61.56	Complies
11	24	50	60.052308	61.542225	57-61.56	Complies
12	24	65	60.052624	61.541982	57-61.56	Complies

8.3.5 Measurement Plots:

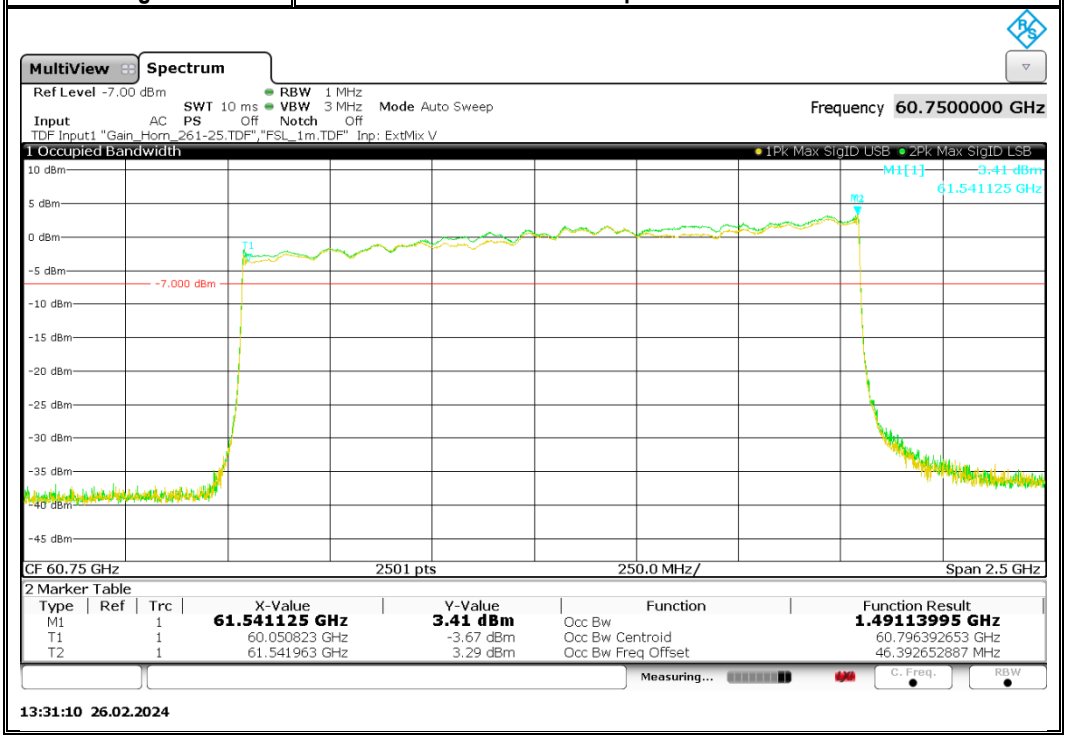
Plot # 1. 99% OBW	
Voltage 24 V	Temperature 20 °C



Plot # 2. 99% OBW	
Voltage 10 V	Temperature 20 °C



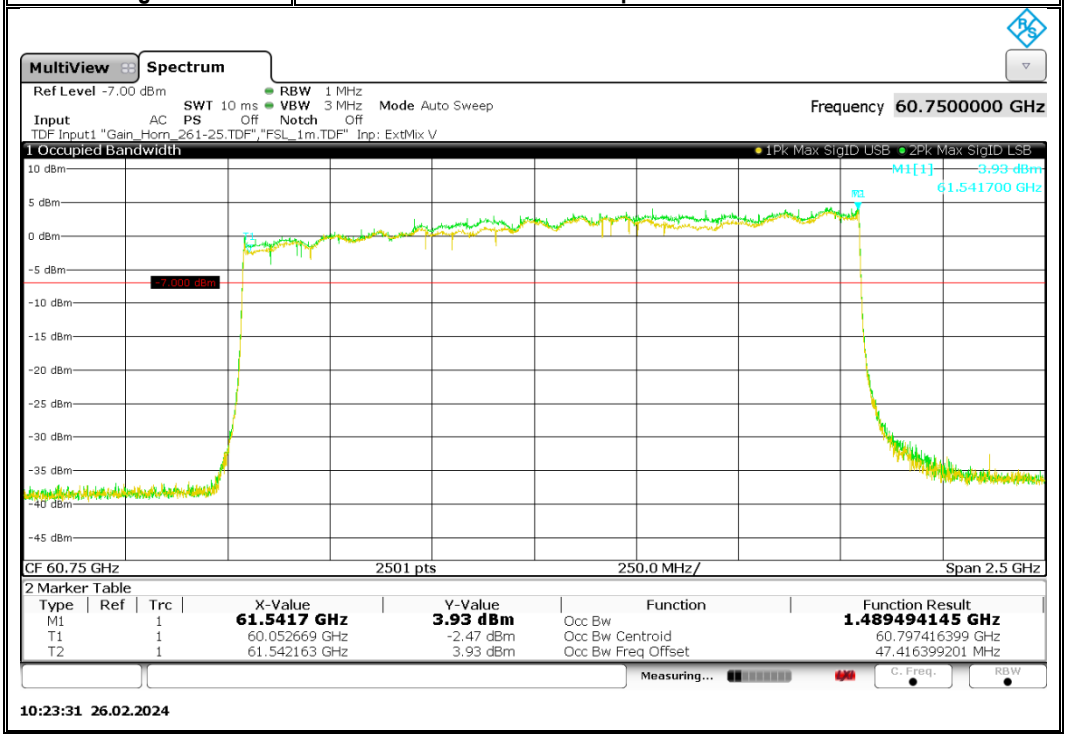
Plot # 3. 99% OBW	
Voltage 30 V	Temperature 20 °C



Plot # 4. 99% OBW	
Voltage 24 V	Temperature -40 °C

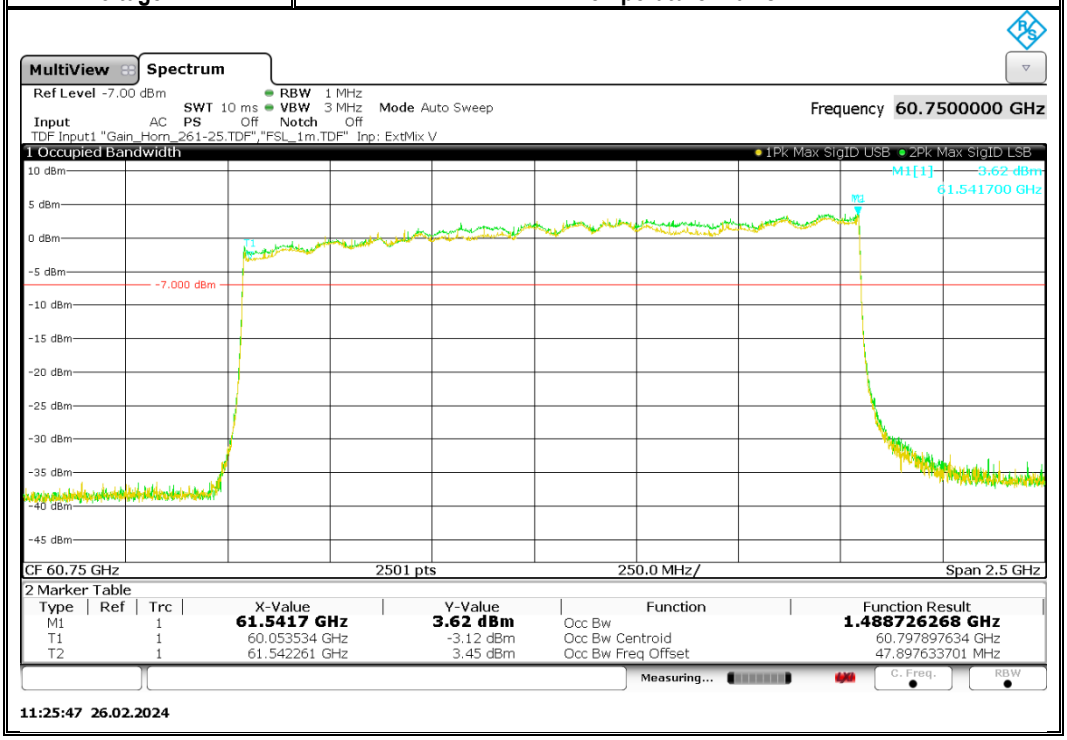
Plot # 5. 99% OBW

Voltage 24 V	Temperature -20 °C



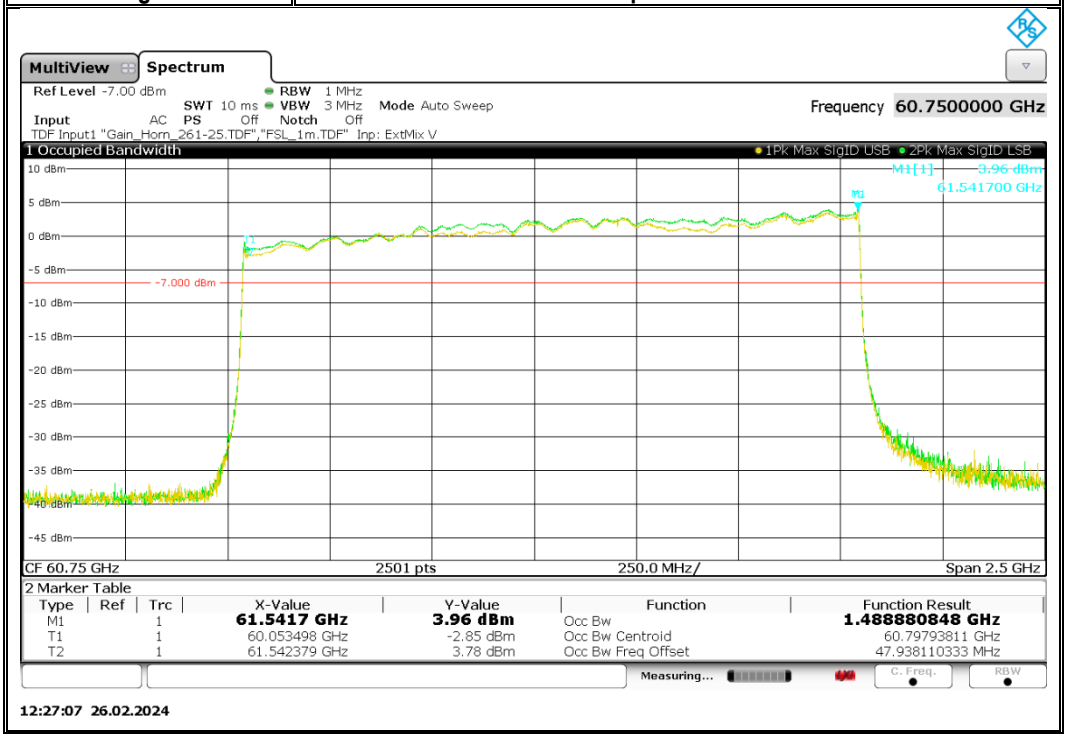
Plot # 6. 99% OBW

Voltage 24 V	Temperature -10 °C



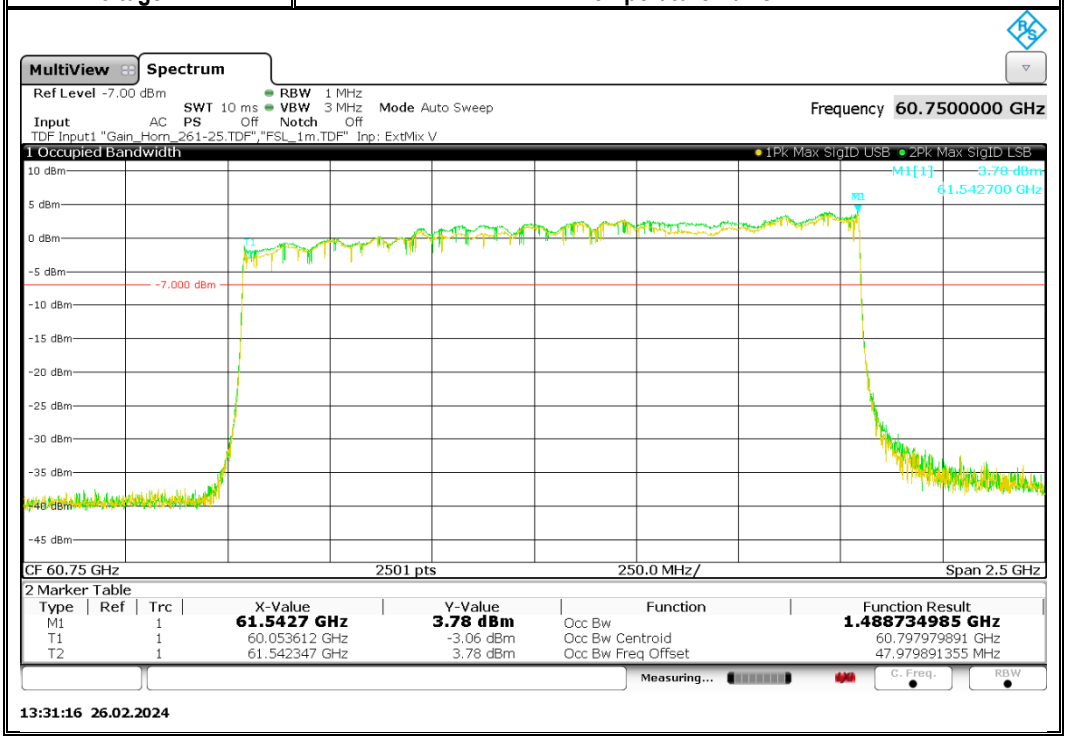
Plot # 7. 99% OBW

Voltage 24 V	Temperature 0 °C



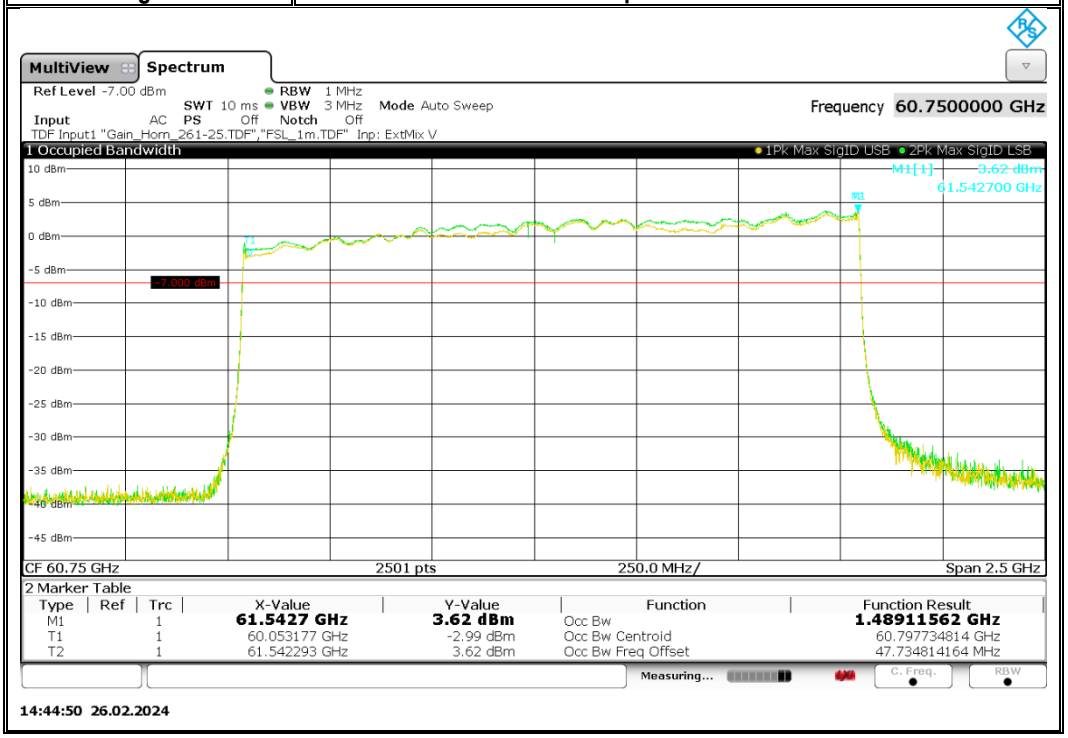
Plot # 8. 99% OBW

Voltage 24 V	Temperature 10 °C



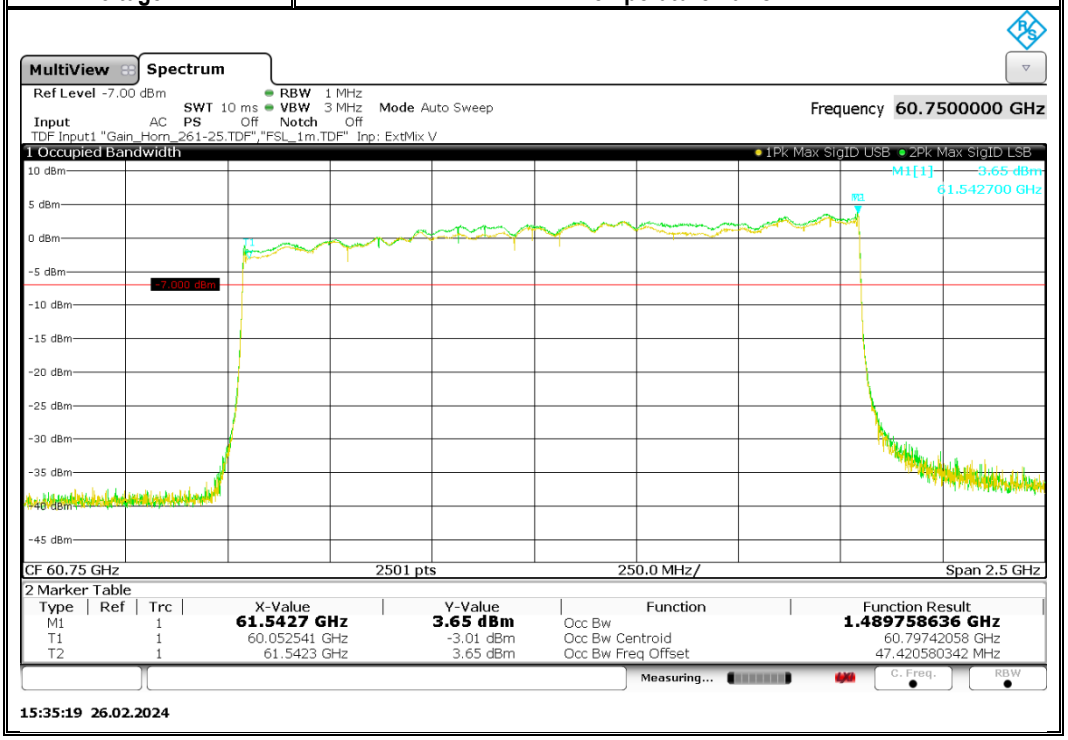
Plot # 9. 99% OBW

Voltage 24 V	Temperature 30 °C



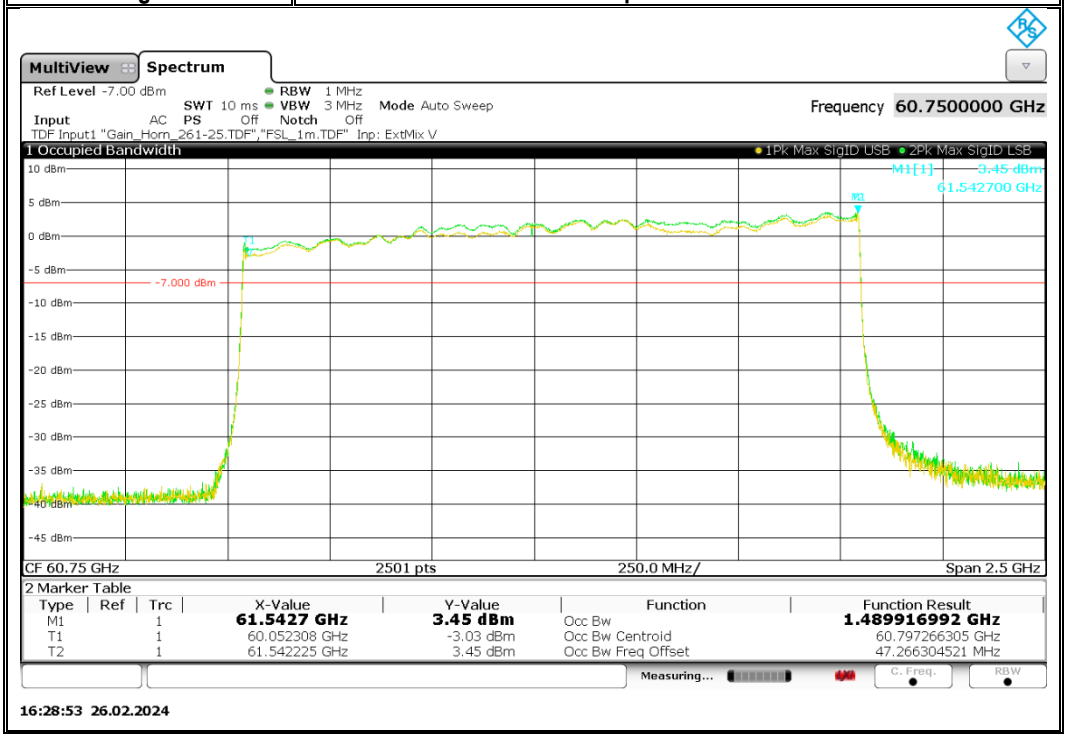
Plot # 10. 99% OBW

Voltage 24 V	Temperature 40 °C



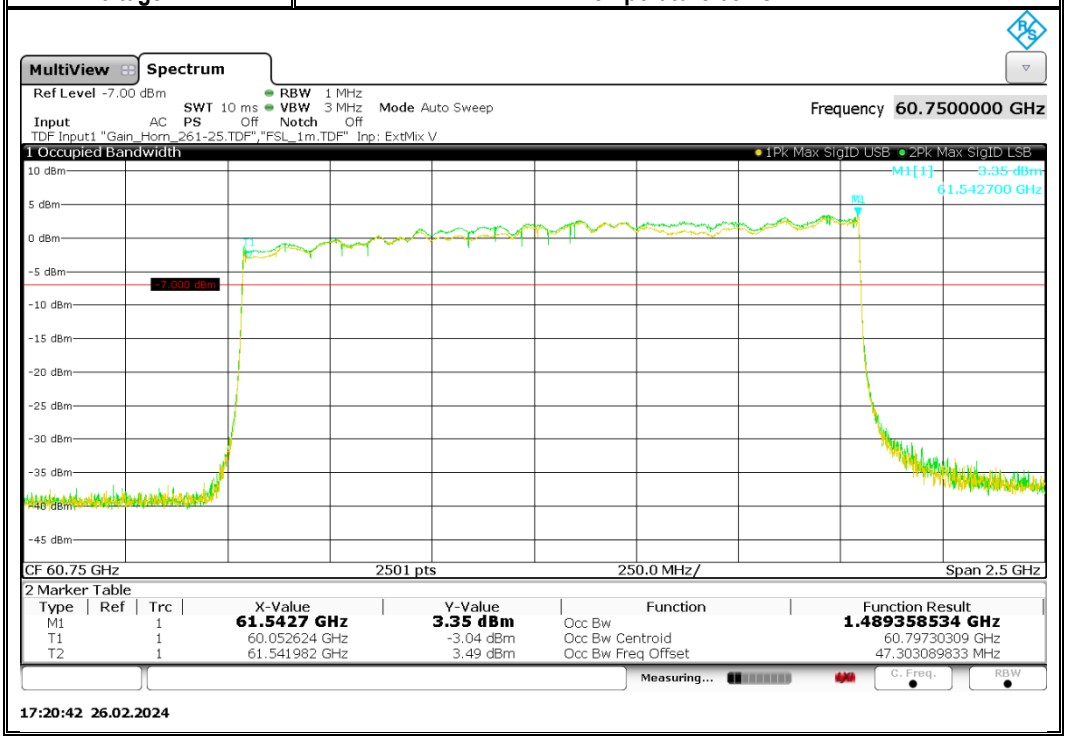
Plot # 11. 99% OBW

Voltage 24 V	Temperature 50 °C



Plot # 12. 99% OBW

Voltage 24 V	Temperature 65 °C



8.4 Transmitter Spurious Emissions and Restricted Bands

8.4.1 Measurement according to ANSI C63.10

Analyzer Settings:

- Frequency = 9 KHz – 30 MHz
- RBW = 9 KHz
- Detector = Peak

- Frequency = 30 MHz – 1 GHz
- Detector = Peak / Quasi-Peak
- RBW = 120 KHz (<1 GHz)

- Frequency > 1 GHz
- Detector = Peak / Power Average
- RBW = 1 MHz

- Radiated spurious emissions shall be measured for the transmit frequencies, transmit power, and data rate for the lowest, middle and highest channel in each frequency band of operation and for the highest gain antenna for each antenna type, and using the appropriate parameters and test requirements.
- The highest (or worst-case) emission level shall be recorded for each measurement.
- For testing frequencies below 30 MHz at distance other than the specified in the standard, the limit conversion is calculated by using the FCC materials for the ANSI 63 committee issued on January, 27 1991.
- For testing frequencies above 40 GHz external harmonic mixers are applied to down-convert the signal for the spectrum analyzer. The lack of tracking preselector for the external mixer can result in image frequencies, which requires confirmation. The spectrum analyzer applies the signal ID function to identify the image frequencies.

Measuring distance:

All measurements in the frequency range 40-200 GHz are done in far-field of the measurement antenna. The far-field boundary $d_{\text{far-field}}$ is

$$d_{far-field} = {D^2}/{\lambda}$$

Where
D is the max. dimension size of the transmitting antenna
λ is the wavelength of the measured emission.

The following table illustrates the far-field boundary for the setup of each test frequency range:

Frequency range	Min. Wavelength	Max. dimension size of the transmitting ant.	Far-field boundary
GHz	m	m	m
40-60	0.0050	0.01	0.04
50-75	0.0040	0.01	0.05
60-90	0.0033	0.01	0.06
90-140	0.0021	0.01	0.09
140-200	0.0015	0.01	0.13

In order to conduct measurements in the far-field and acquire adequate dynamic, the measurement antenna is set at a distance less than 3 m to the EUT for frequency range above 40 GHz.

8.4.2 Limits: FCC 15.255(d) / 15.209(a)

Restricted bands

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	Above 38.6
13.36-13.41			

- 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)).
- PEAK LIMIT = 74 dBµV/m
- AVG. LIMIT = 54 dBµV/m

- Except as shown in CFR 47 Part 15.205 paragraph (d), only spurious emissions are permitted in any of the frequency bands listed below

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

Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm^2 at a distance of 3 meters, as defined in §15.255(d), which is equivalent to -9.92 dBm EIRP. The limit conversion is according to ANSI C63.10 formula (25):

$$PD = \frac{EIRP_{Linear}}{4\pi d^2}$$

Where

PD is the power density at the distance specified by the limit, in W/m^2
EIRP$_{Linear}$ is the equivalent isotropic radiated power, in watts
D is the distance at which the power density limit is specified, in m

8.4.3 Test conditions and setup:

Ambient Temperature	EUT Set-Up #	EUT operating mode	Power Input
20 °C	1	1 & 2	nominal

8.4.4 Measurement result:

Plot #	Operation mode	Frequency	Scan Frequency	Spurious emission level with lowest margin	Limit	Result
1-5	1 (FMCW)	Full bandwidth	9 kHz – 40 GHz	50.75 dBµV/m (AV) *	See section 8.4.2	Complies

Note *: noise floor level.

Plot #	Operation mode	Frequency	Scan Frequency	Spurious emission level with lowest margin	Limit	Result
6-7 10 13 16 19	2 (CW)	Low	40 GHz - 200 GHz	-13.89 dBm (AV) *	See section 8.4.2	Complies
8 11 14 17 20	2 (CW)	Mid	40 GHz - 200 GHz	-14.16 dBm (AV) *	See section 8.4.2	Complies
9 12 15 18 21	2 (CW)	High	40 GHz - 200 GHz	-13.63 dBm (AV) *	See section 8.4.2	Complies

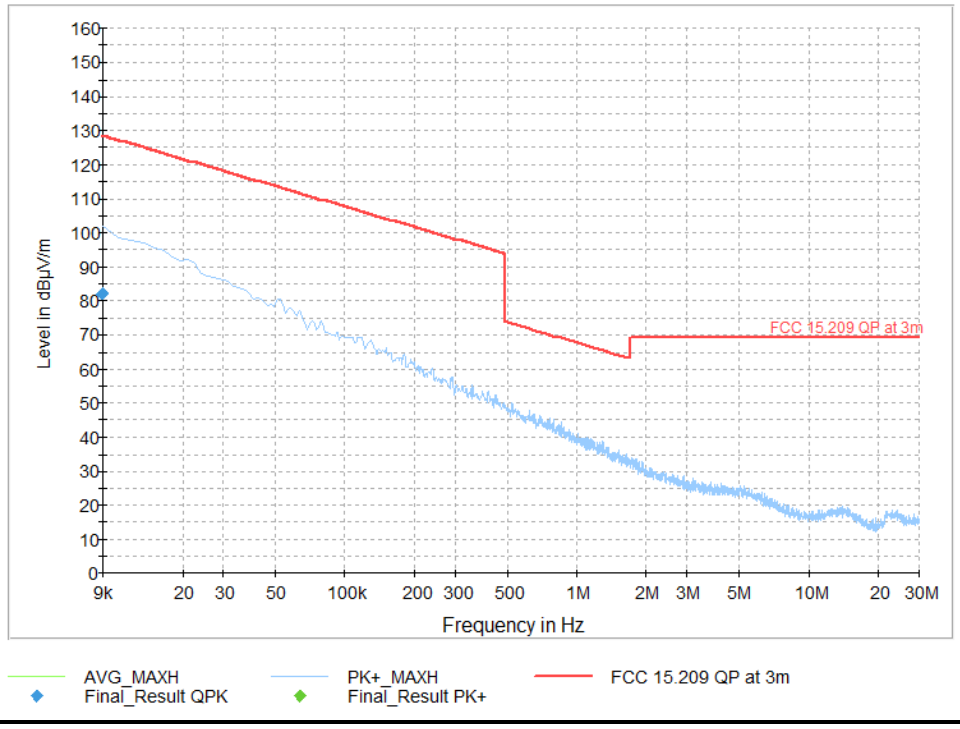
Note *: noise floor level.

8.4.5 Measurement Plots:

The worst case EUT position is determined by comparing fundamental emission level before the test. The tests are carried out at worst case position, which is standing position.
The frequency range below 40 GHz is tested while the EUT is set to FMCW mode, with the measurement time adjusted. The frequency above 40 GHz is tested while the EUT is set to CW mode (low/middle/high frequencies tested separately).

8.4.5.1 Measurement result: below 40 GHz, FMCW mode

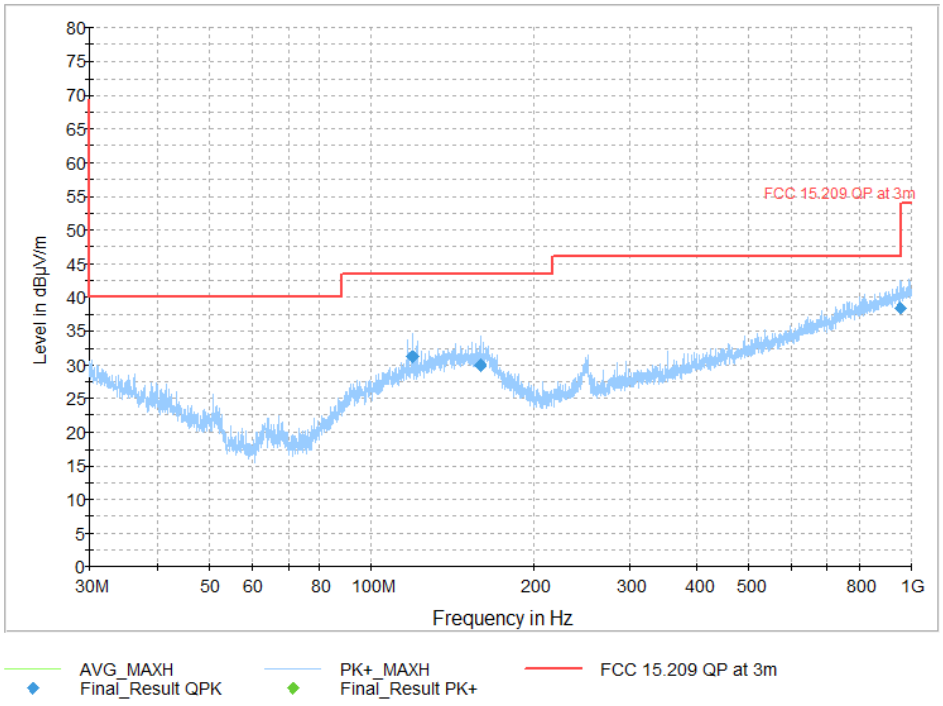
Plot # 1 Radiated Emissions: 9 kHz – 30 MHz



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path (dB)	Preamp (dB)	Trd Corr. (dB/m)	Raw Rec (dBµV)
0.009	82.00	---	128.50	46.50	500.0	0.200	100.0	H	327.0	60.3	0.0	-25.7	86.0	21.7

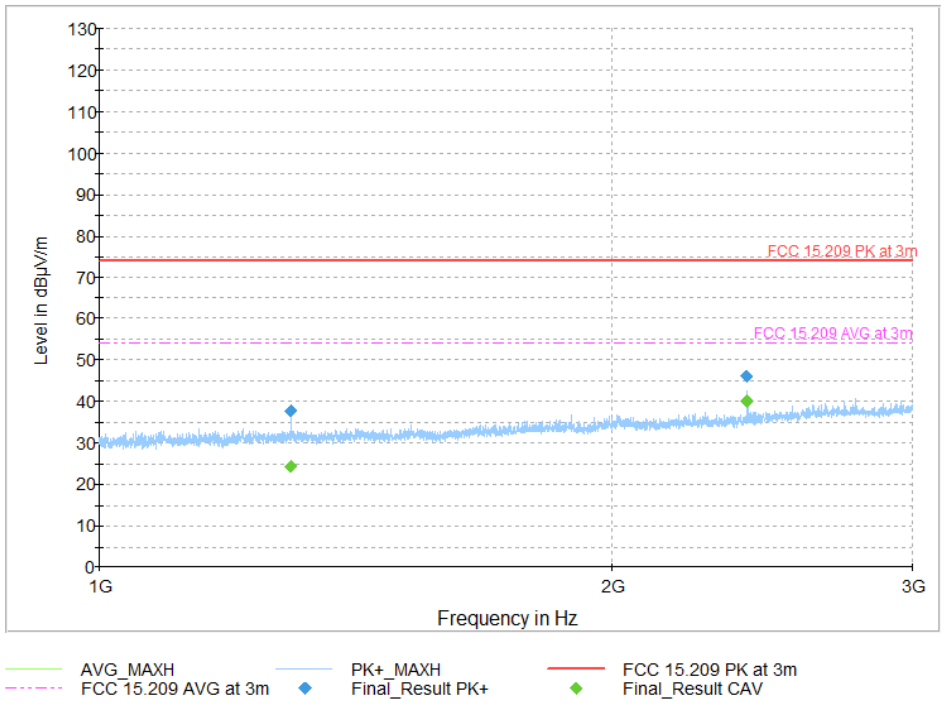
Plot # 2 Radiated Emissions: 30 MHz – 1 GHz



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path (dB)	Preamp (dB)	Trd Corr. (dB/m)	Raw Rec (dBµV)
119.119	31.23	---	43.50	12.27	500.0	120.000	154.0	V	-12.0	-11.9	-	0.0	23.1	43.1
158.858	29.98	---	43.50	13.52	500.0	120.000	166.0	V	251.0	-10.1	-	0.0	24.6	40.0
954.986	38.44	---	46.02	7.58	500.0	120.000	342.0	H	87.0	-2.7	-	0.0	29.5	41.1

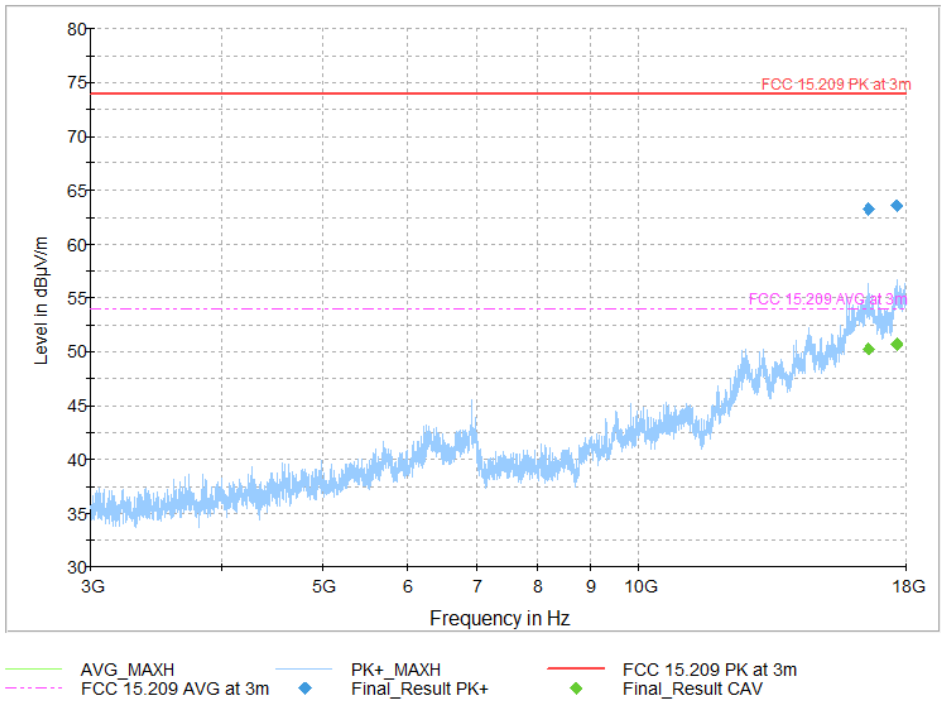
Plot # 3 Radiated Emissions: 1-3 GHz



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path (dB)	Preamp (dB)	Trd Corr. (dB/m)	Raw Rec (dBµV)
1296.000	37.80	---	73.98	36.17	500.0	1000.000	267.0	V	85.0	1.9	-	0.0	25.1	36.0
1296.000	---	24.23	53.98	29.75	500.0	1000.000	267.0	V	85.0	1.9	-	0.0	25.1	22.4
2400.143	46.15	---	73.98	27.83	500.0	1000.000	147.0	H	353.0	5.6	-	0.0	28.1	40.5
2400.143	---	40.20	53.98	13.78	500.0	1000.000	147.0	H	353.0	5.6	-	0.0	28.1	34.6

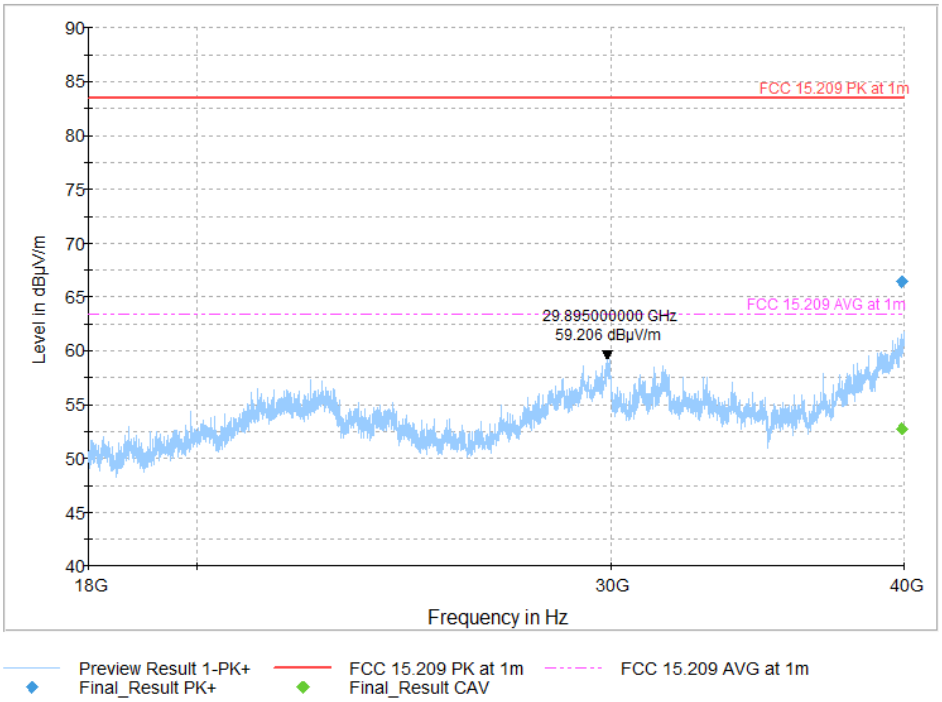
Plot # 4 Radiated Emissions: 3-18 GHz



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path (dB)	Preamp (dB)	Trd Corr. (dB/m)	Raw Rec (dBµV)
16578.750	63.25	---	73.98	10.72	500.0	1000.000	328.0	V	106.0	14.1	15.9	-43.0	41.2	49.2
16578.750	---	50.24	53.98	3.74	500.0	1000.000	328.0	V	106.0	14.1	15.9	-43.0	41.2	36.2
17641.406	63.55	---	73.98	10.42	500.0	1000.000	400.0	V	27.0	15.1	16.5	-42.8	41.4	48.4
17641.406	---	50.75	53.98	3.23	500.0	1000.000	400.0	V	27.0	15.1	16.5	-42.8	41.4	35.6

Plot # 5 Radiated Emissions: 18-40 GHz

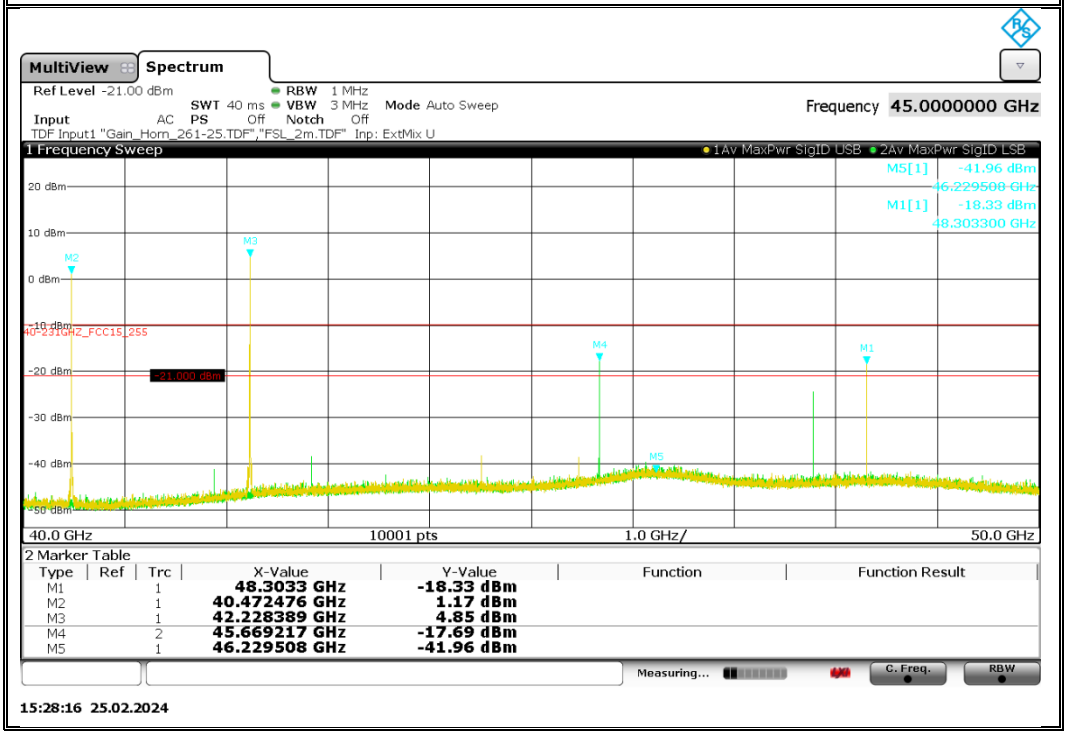


Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Sig Path (dB	Preamp (dB)	Trd Corr. (dB/m)	Raw Rec (dBµV)	Comment
39913.75	---	52.81	63.50	10.69	500.	1000.000	150.0	V	156.0	24.3	12.	0.0	11.6	28.5	
39913.75	66.48	---	83.50	17.02	500.	1000.000	150.0	V	156.0	24.3	12.	0.0	11.6	42.2	

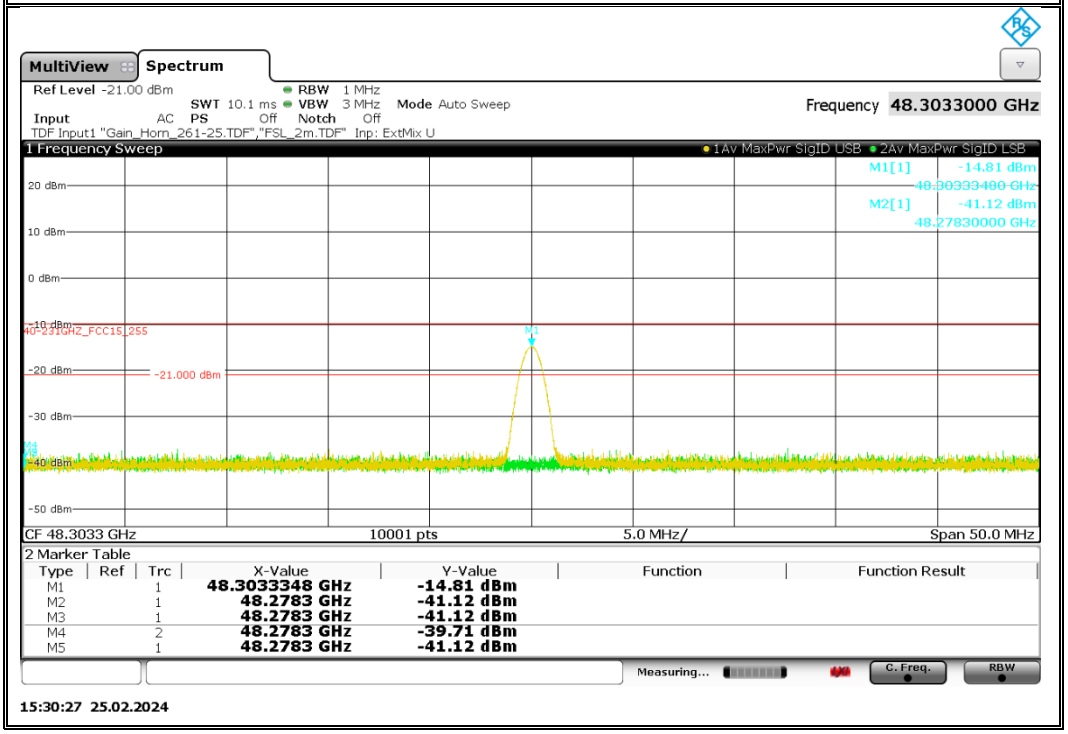
8.4.5.2 Measurement result: above 40 GHz, CW mode

Plot # 6 Radiated Emissions: 40-50 GHz – low frequency



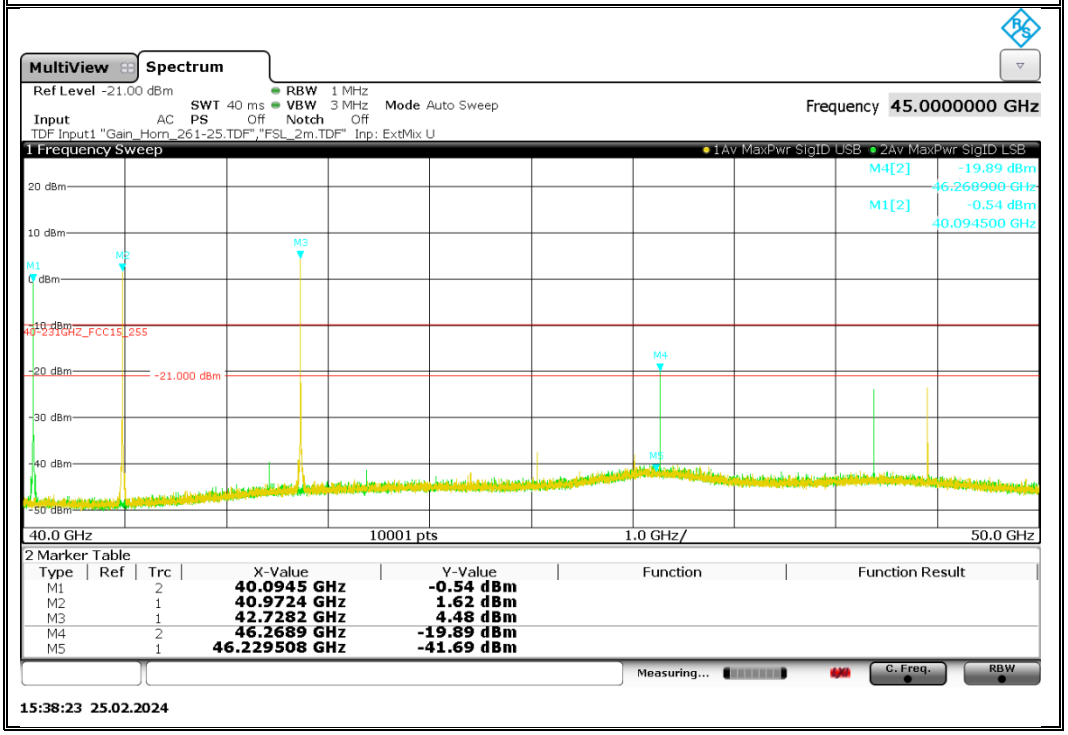
Note: The emission marked by M2, M3 and M4 are not real signal, because there is no USB and LSB trace overlapping. The emission marked by M1 is investigated in the following plot.

Plot # 7 Radiated Emissions: 40-50 GHz – low frequency



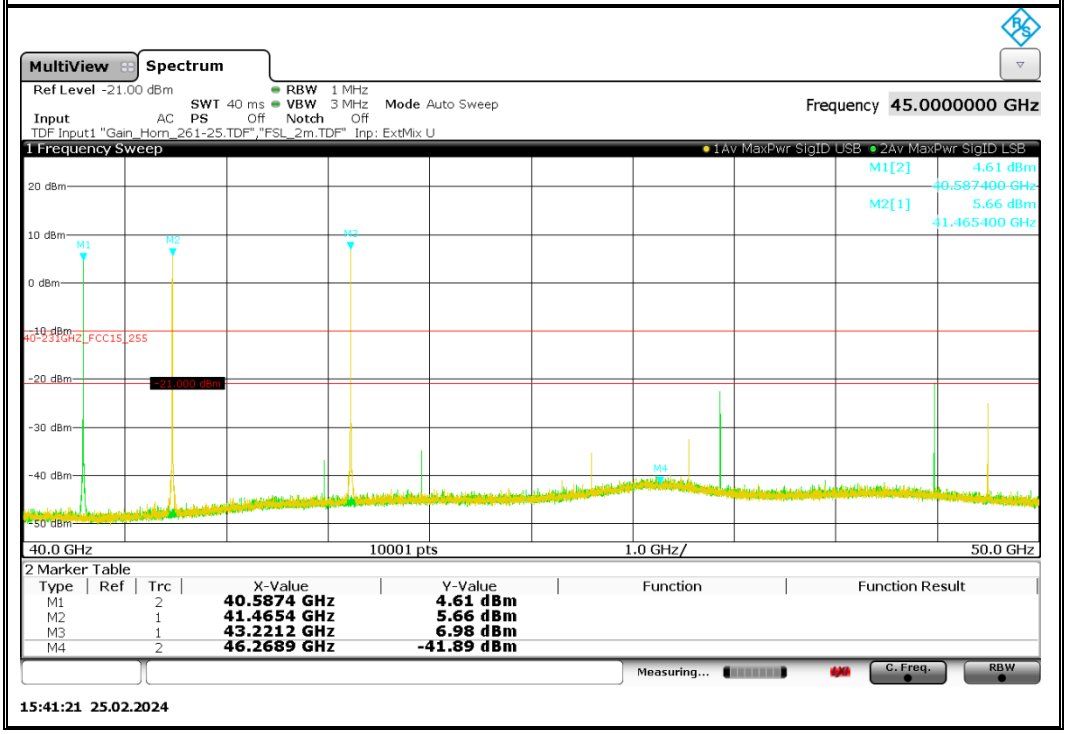
Note: The emission marked by M1 is not a real signal, because there is no USB and LSB trace overlapping.

Plot # 8 Radiated Emissions: 40-50 GHz – middle frequency



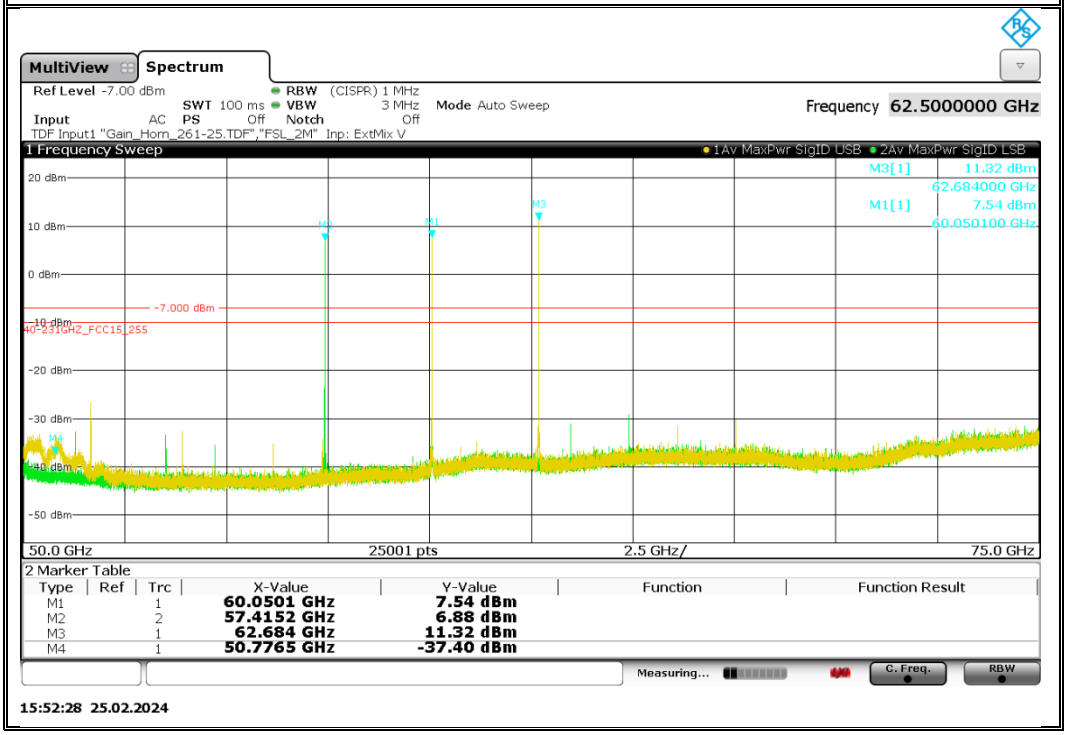
Note: The emissions marked by M1, M2, M3 and M4 are not real signal, because there is no USB and LSB trace overlapping.

Plot # 9 Radiated Emissions: 40-50 GHz – high frequency



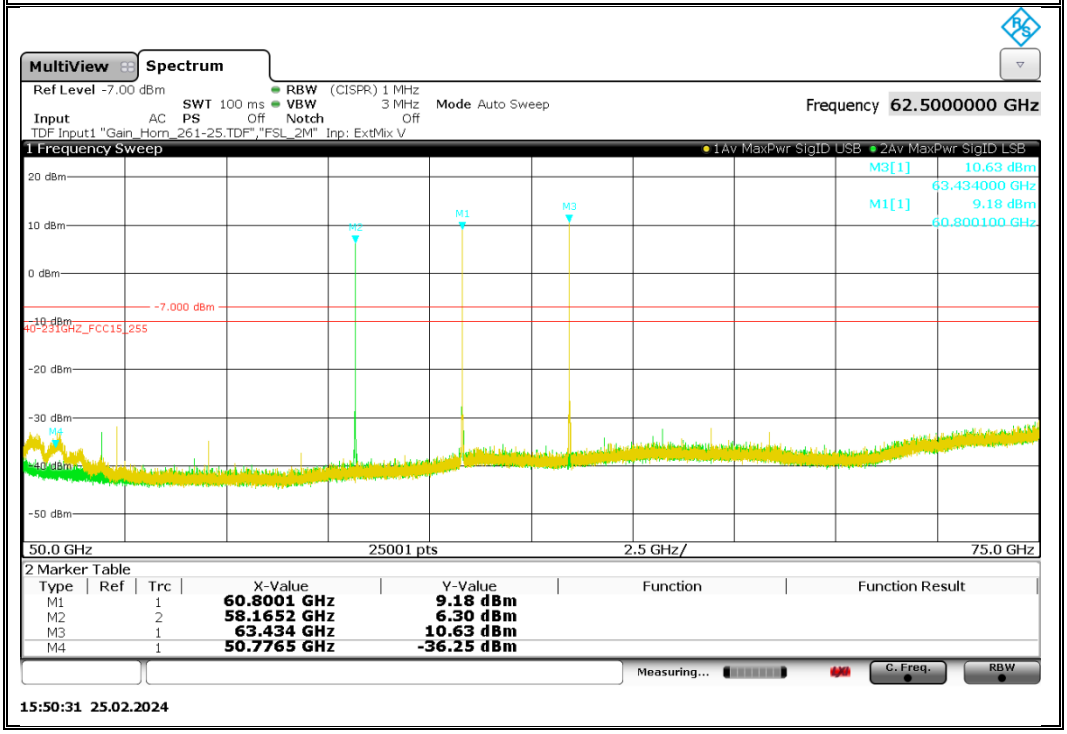
Note: The emission marked by M1, M2 and M3 are not real signal, because there is no USB and LSB trace overlapping.

Plot # 10 Radiated Emissions: 50-75 GHz – low frequency



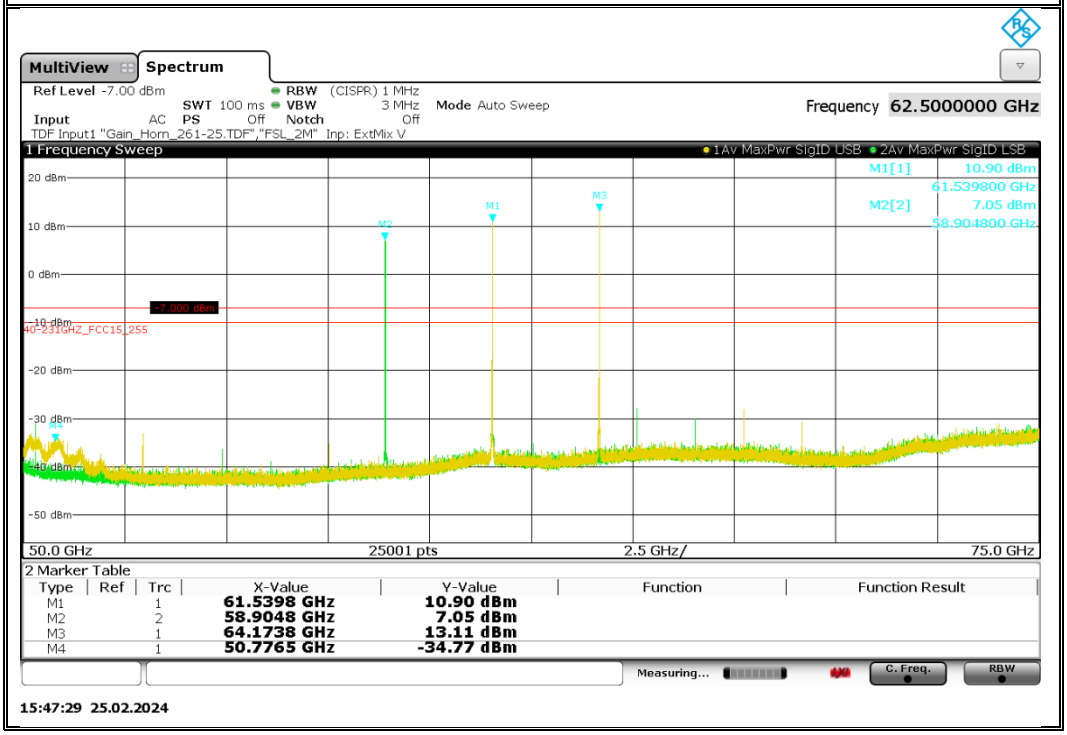
Note: The emission marked by M1 is the wanted signal, which is irrelevant to the limit. The emissions marked by M2 and M3 are not real signal, because there is no USB and LSB trace overlapping.

Plot # 11 Radiated Emissions: 50-75 GHz – middle frequency



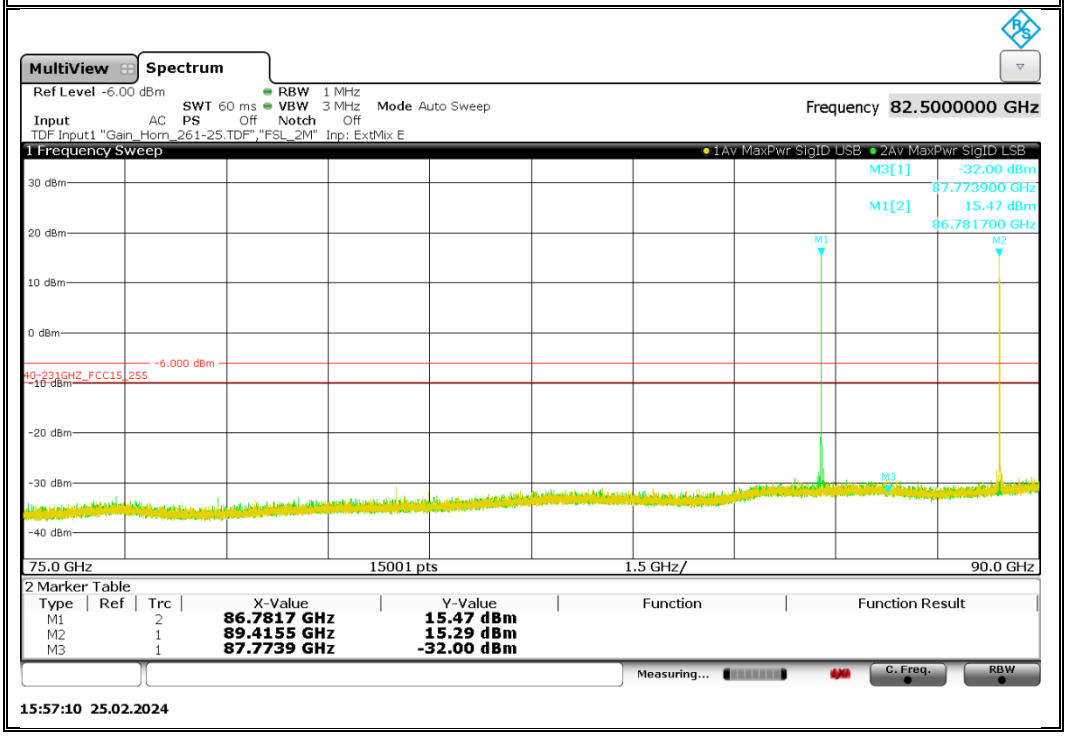
Note: The emission marked by M1 is the wanted signal, which is irrelevant to the limit. The emissions marked by M2 and M3 are not real signal, because there is no USB and LSB trace overlapping.

Plot # 12 Radiated Emissions: 50-75 GHz – high frequency



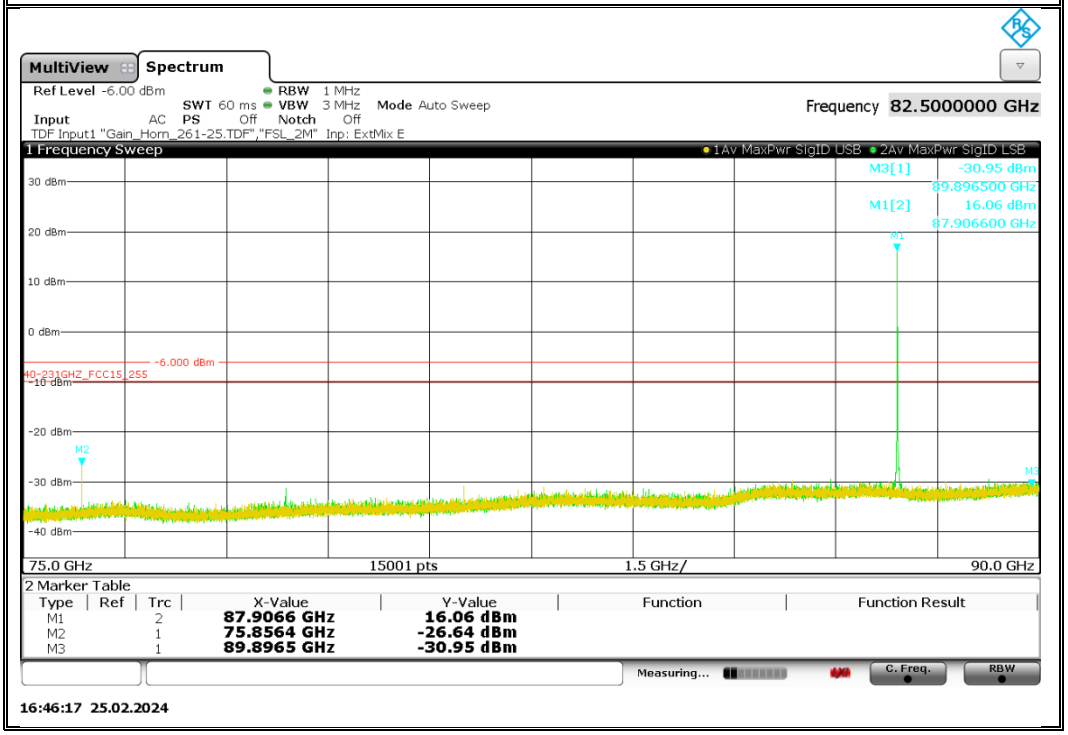
Note: The emission marked by M1 is the wanted signal, which is irrelevant to the limit. The emissions marked by M2 and M3 are not real signal, because there is no USB and LSB trace overlapping.

Plot # 13 Radiated Emissions: 75-90 GHz – low frequency



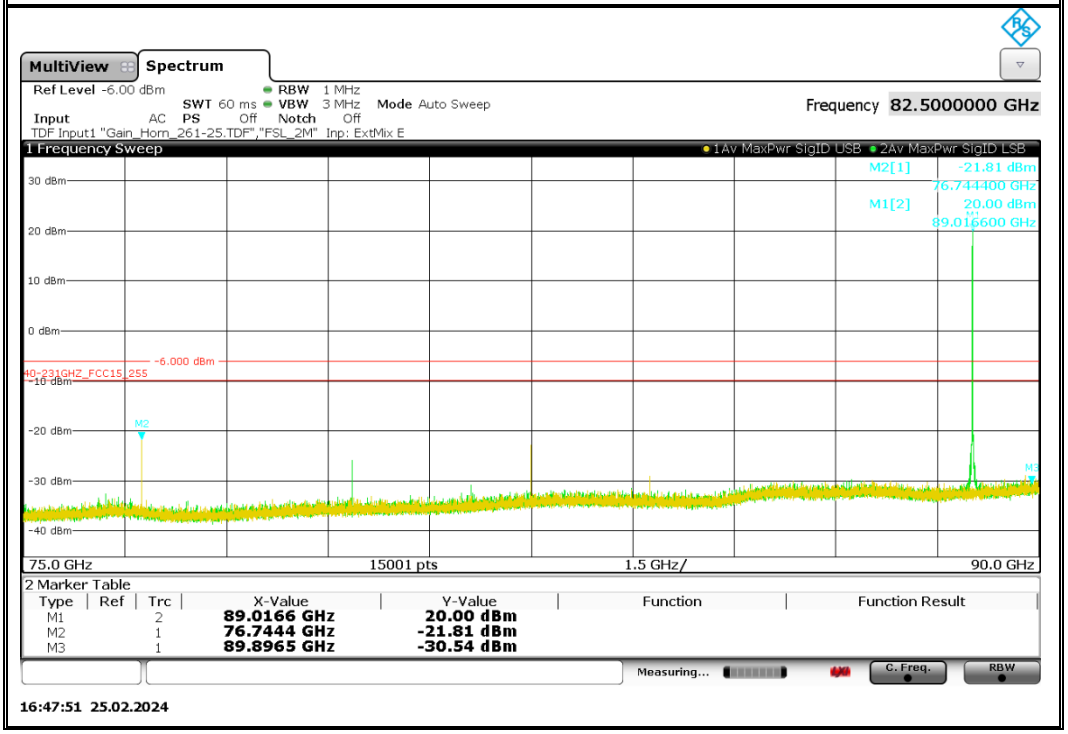
Note: The emissions marked by M1 and M2 are not real signal, because there is no USB and LSB trace overlapping.

Plot # 14 Radiated Emissions: 75-90 GHz – middle frequency



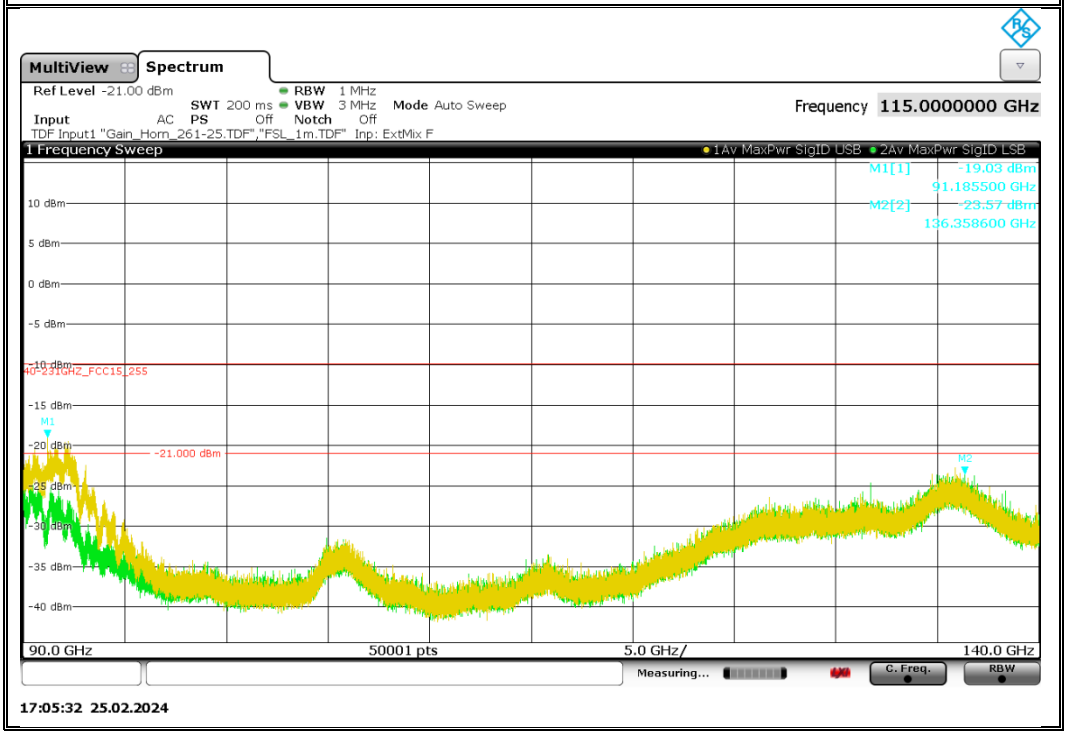
Note: The emission marked by M1 is not a real signal, because there is no USB and LSB trace overlapping.

Plot # 15 Radiated Emissions: 75-90 GHz – high frequency

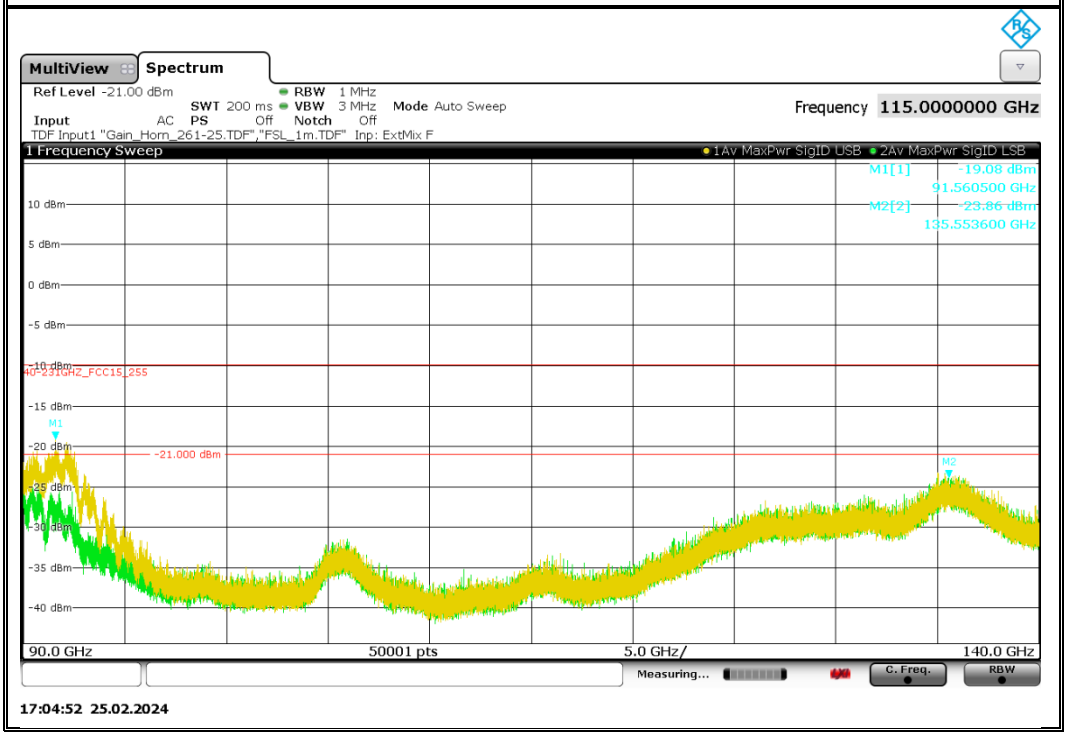


Note: The emission marked by M1 is not a real signal, because there is no USB and LSB trace overlapping.

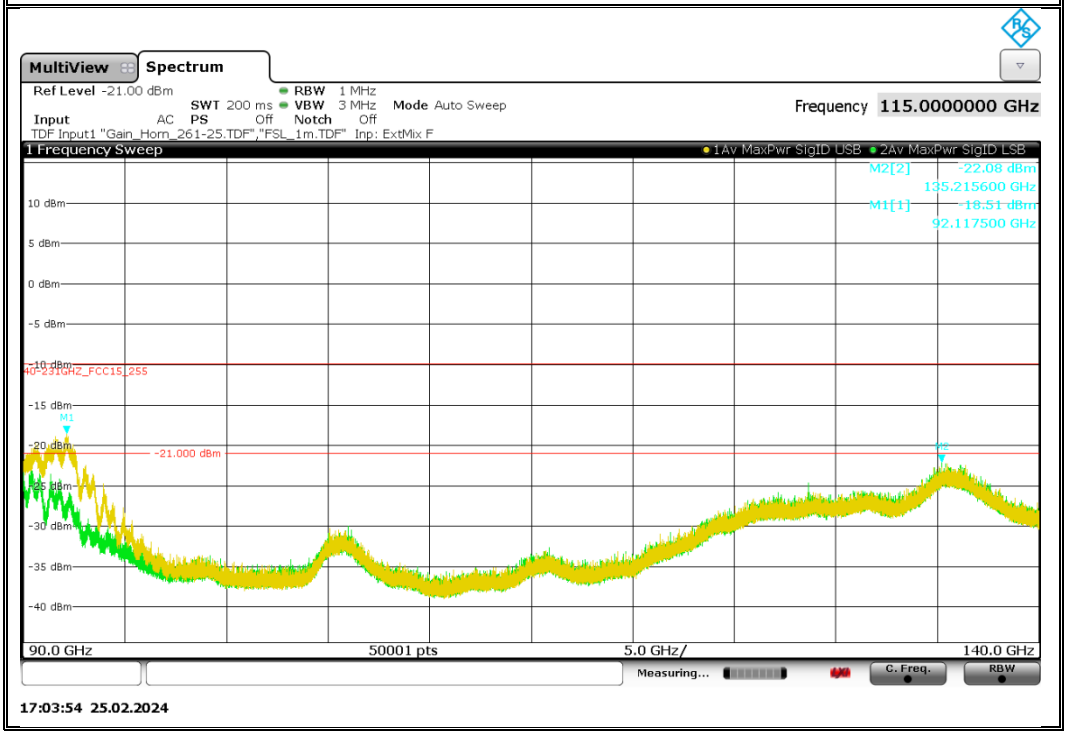
Plot # 16 Radiated Emissions: 90-140 GHz – low frequency



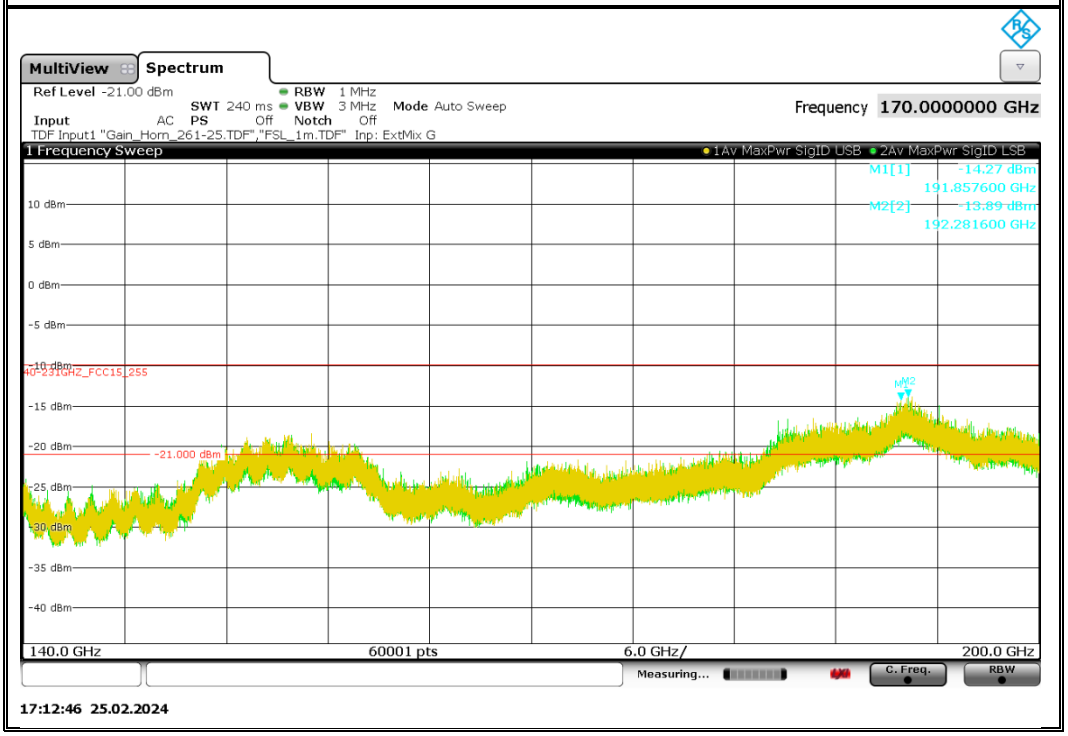
Plot # 17 Radiated Emissions: 90-140 GHz – middle frequency



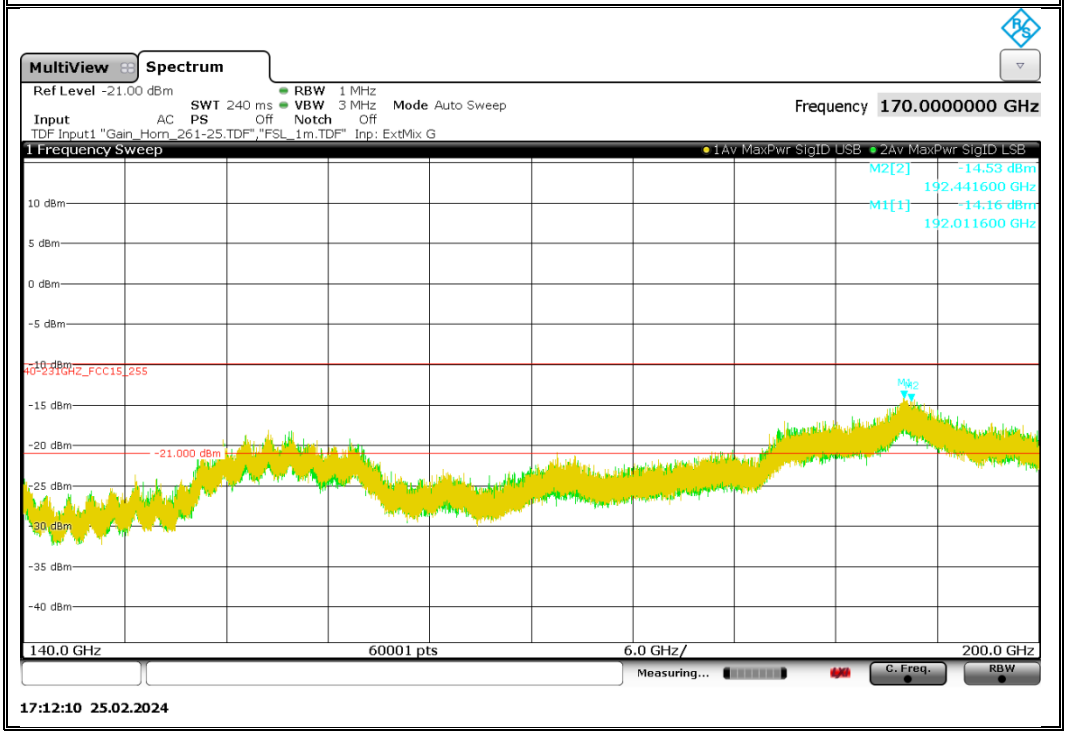
Plot # 18 Radiated Emissions: 90-140 GHz – high frequency



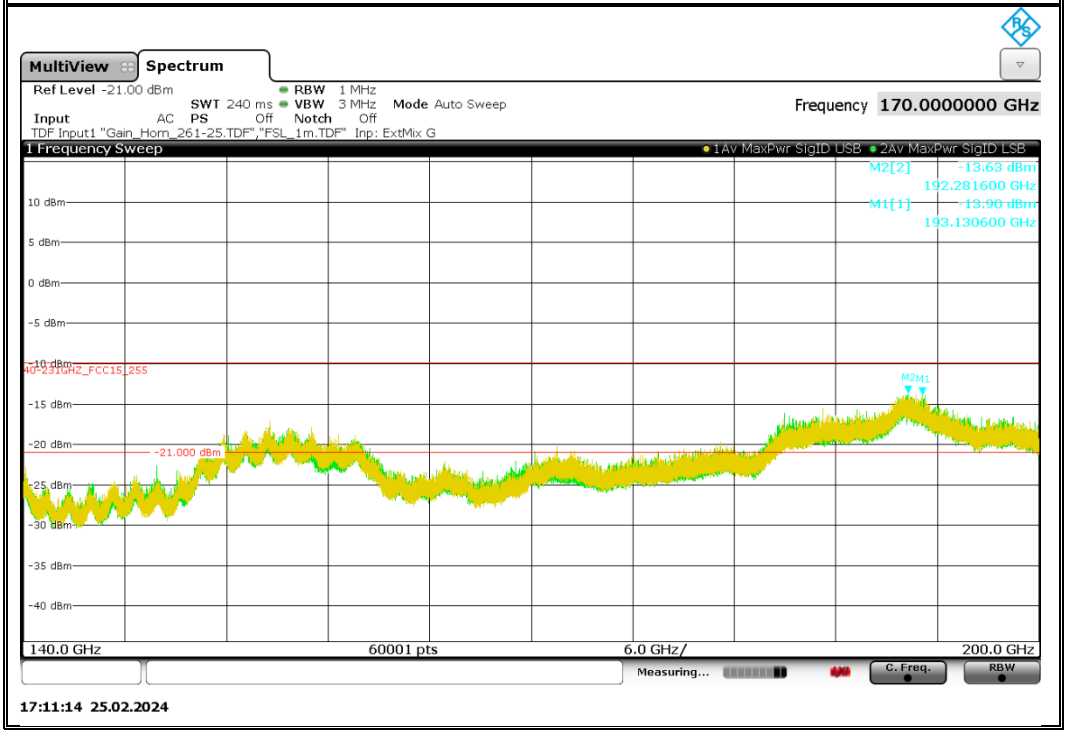
Plot # 19 Radiated Emissions: 140-220 GHz – low frequency



Plot # 20 Radiated Emissions: 140-220 GHz – middle frequency



Plot # 21 Radiated Emissions: 140-220 GHz – high frequency



8.5 AC Conducted Emissions

8.5.1 Measurement according to ANSI C63.4

Analyzer Settings:

- RBW = 9 KHz (CISPR Bandwidth)
- Pre-scan Detector = Peak / Average for
- Final Measurements Detector = Quasi-Peak / Average

8.5.2 Limits: FCC 15.207

(a) Except as shown in paragraphs (b) and (c) of this section of the CFR, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table (1), as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between frequency ranges.

Frequency of emission (MHz)	Conducted limit (dBμV)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

*Decreases with the logarithm of the frequency.

8.5.3 Test conditions and setup:

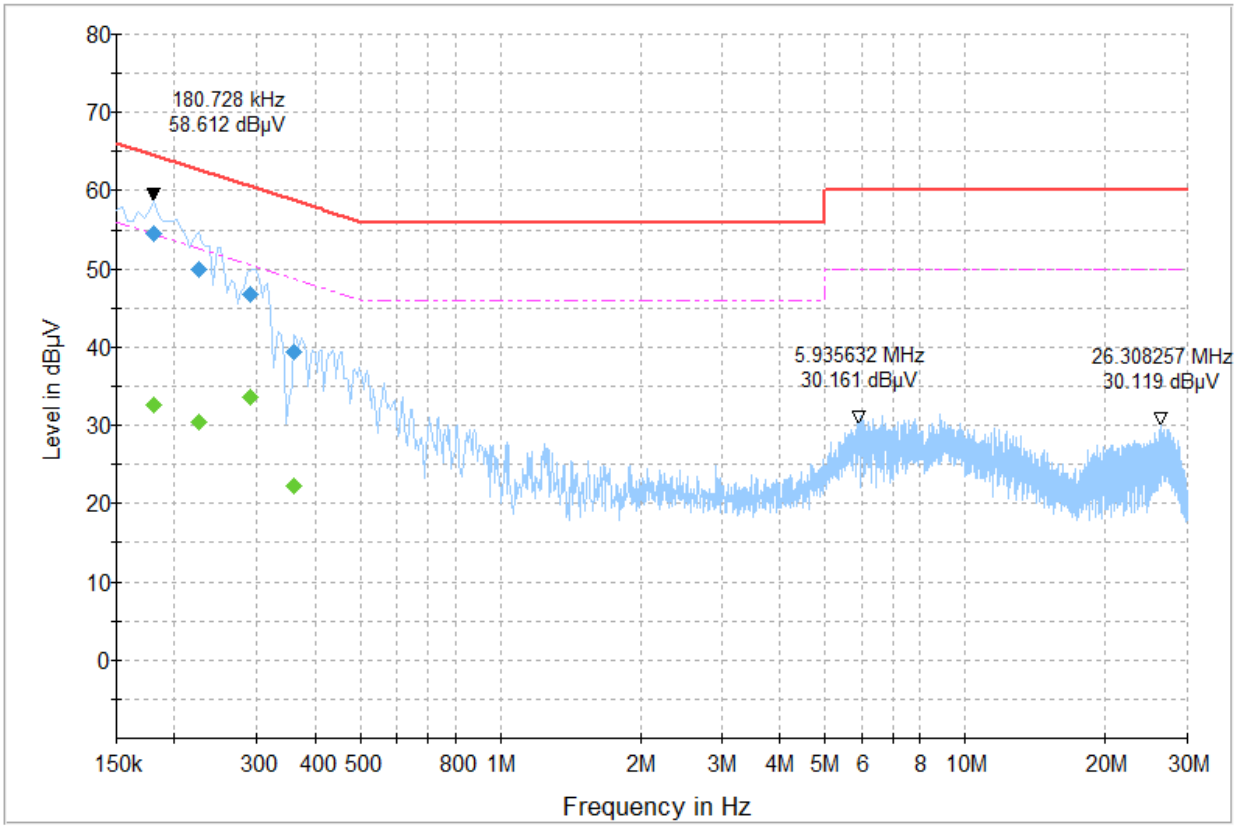
Ambient Temperature (°C)	EUT Set-Up #	EUT operating mode	Power line (L1, L2, L3, N)	Power Input
20	1	1	Line & Neutral	110 V / 60 Hz

8.5.4 Measurement Result:

Plot #	Port	Scan Frequency	Spurious emission level with lowest margin	Limit	Result
1	AC Mains	150 kHz – 30 MHz	54.426 dBμV (QP) *	See section 8.5.2	Complies

8.5.5 Measurement Plots:

Plot # 1



Final_Result

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	PE	Corr. (dB)
0.181	---	32.572	54.45	21.88	500.0	9.000	N	GND	10.3
0.181	54.426	---	64.45	10.03	500.0	9.000	N	GND	10.3
0.225	---	30.330	52.65	22.32	500.0	9.000	N	GND	10.2
0.225	49.985	---	62.65	12.66	500.0	9.000	N	GND	10.2
0.290	---	33.642	50.51	16.87	500.0	9.000	N	GND	10.1
0.290	46.672	---	60.51	13.84	500.0	9.000	N	GND	10.1
0.361	---	22.221	48.71	26.49	500.0	9.000	N	GND	10.0
0.361	39.393	---	58.71	19.32	500.0	9.000	N	GND	10.0

9 Test setup photos

Setup photos are included in supporting file name:
"EMC_BANNE-008-24001_FCC15.255_Setup_Photos.pdf"

10 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
Standard gain horn antenna 40-60 GHz	MI-WAVE	261U-25/383	2021	-	N/A
Standard gain horn antenna 60-90 GHz	MI-WAVE	261E-25/387	2021	-	N/A
Standard gain horn antenna 90-140 GHz	MI-WAVE	261F-25/387	2021	-	N/A
Standard gain horn antenna 140-220 GHz	MI-WAVE	261G-25/387	-	-	N/A
External Mixer 40-60 GHz	R&S	FS-Z60	101025	3 Years	2/01/2022*
External Mixer 50-75 GHz	R&S	FS-Z75	102261	3 Years	2/01/2022*
External Mixer 60-90 GHz	R&S	FS-Z90	102088	3 Years	02/01/2022*
External Mixer 90-140 GHz	R&S	FS-Z140	101145	3 Years	2/01/2022*
External Mixer 140-220 GHz	R&S	FS-Z220	101037	3 Years	2/01/2022*
EMI Test Receiver	R&S	ESW 44	101715	3 Years	10/24/2023
V Band Amplitude Detector	ERAVANT	SFD-503753-15SF-P1	18541-02	-	N/A
Standard gain horn antenna 49.9-75.8 GHz	FLANN MICROWAVE	25240-20	273463	-	N/A
Oscilloscope	R&S	RTO 1014	1316.1000K14-300087-rf	2 Years	09/27/2023
Signal Generator	R&S	SMF 100A	105358	2 Year	09/27/2023
Frequency Multiplier	MI-WAVE	936EF-10/387	192	-	N/A
Level Setting Attenuator WR-12	ERAVANT	STA-30-12-M2	04778-01	-	N/A
Thermal Power Sensor	R&S	NRP110T	1424.6215K02-101295-xJ	3 years	11/25/2022
BILOG ANTENNA	A.H. SYSTEMS	BiLA2G	569	3 YEARS	10/30/2023
HORN ANTENNA	EMCO	3115	00035111	3 YEARS	10/26/2023
HORN ANTENNA	ETS LINDGREN	3117-PA	00167061	3 YEARS	9/25/2023
HORN ANTENNA	ETS LINDGREN	3116C-PA	00166821	3 YEARS	10/26/2023
ESW.EMI TEST RECEIVER	ROHDE & SCHWARZ	ESW44	101715	3 YEARS	10/24/2023
DIGITAL THRMOMETER	Control Company	4410,90080-03	230712972	3 YEARS	10/18/2023

Note: Equipment used meets the measurement uncertainty requirements as required per applicable standards for 95% confidence levels. Calibration due dates, unless defined specifically, falls on the last day of the month. Items indicated "N/A" for cal status either do not specifically require calibration or is internally characterized before use.
Note *: In service date

11 Revision History

Date	Report name	Changes to report	Prepared by
2024-03-26	EMC_BANNE-008-24001_FCC15.255	Initial version	Guangcheng Huang

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