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Starry, Inc.
TEST REPORT

SCOPE OF WORK
Emissions Testing – 24 GHz Titan Radio, Model Titan 24X45

REPORT NUMBER
104910448BOX-001

ISSUE DATE	**[LAST REVISED DATE]**
February 16, 2022	Original Issue

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EMISSIONS TEST REPORT

(FULL COMPLIANCE)

Report Number: 104910448BOX-001
Project Number: G104910448

Report Issue Date: February 16, 2022

Model(s) Tested: Titan 24X45

Standards: FCC 47 CFR Part 30 Subpart C: 2022
FCC 47 CFR Part 2: 2022
FCC KDB 842590 D01 Upper Microwave Flexible Use Service v01r02, April 20, 2021 (Class II Permissive Change)

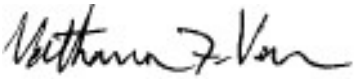
Tested by:
Intertek
70 Codman Hill Road
Boxborough, MA 01719
USA

Client:
Starry, Inc.
38 Chauncy St. Suite 200
Boston, MA 02111
USA

Report prepared by

Kouma Sinn / EMC Engineering Supervisor

Report reviewed by



Vathana Ven / EMC Engineering Supervisor

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1 Introduction and Conclusion

The tests indicated in section 2.0 were performed on the product constructed as described in section 4.0. The remaining test sections are the verbatim text from the actual data sheets used during the investigation. These test sections include the test name, the specified test Method, a list of the actual Test Equipment Used, documentation Photos, Results and raw Data. No additions, deviations, or exclusions have been made from the standard(s) unless specifically noted.

Based on the results of our investigation, we have concluded the product tested **complies** with the requirements of the standard(s) indicated. The results obtained in this test report pertain only to the item(s) tested. Intertek does not make any claims of compliance for samples or variants which were not tested.

2 Test Summary

Section	Test full name	Result
3	Client Information	--
4	Description of Equipment Under Test and Variant Models	--
5	System Setup and Method	--
6	Output Power FCC §2.1046, FCC §30.202 (a) FCC §30.207	Pass
7	Out of Band (OOB) Domain FCC §30.203 (a) (b)	Pass
8	Radiated Spurious Emissions FCC §30.203 (a) (b)	Pass
9	Occupied Bandwidths FCC §2.1049	Pass
10	Revision History	--
11	Appendix A – Mixer Conversion Loss	--
12	Appendix B – Mixer Verification Certificates	--
13	Appendix C – Test Laboratory Accreditation Scope	--

3 Client Information

This EUT was tested at the request of:

Client: Starry, Inc.
38 Chauncy St Suite 200
Boston, MA 02111
USA

Contact: Robert White
Telephone: None
Fax: None
Email: rwhite@starry.com

4 Description of Equipment Under Test and Variant Models

Manufacturer: Starry, Inc.
38 Chauncy St Suite 200
Boston, MA 02111
USA

Equipment Under Test			
Description	Manufacturer	Model Number	Serial Number
24 GHz Titan Radio	Starry, Inc.	Titan 24X45	2111000001

Receive Date:	June 10, 2021
Received Condition:	Good
Type:	Production

Description of Equipment Under Test (provided by client)
The equipment under test (EUT) is a Titan24 mmWave based station access point, operating between 24.25-25.25 GHz. It utilizes OFDMA IEEE 802.11ac, MCS0-MCS9. Channel bandwidths are 160 MHz and 20 MHz unconverted and transmitted/received at mmWave frequencies between 24.25 GHz and 25.25 GHz. Signals are conveyed in two polarizations – horizontal and vertical through patch array with a lens antenna. The antenna is a patch array (4x8) for each polarization and a lens. There are 4 1x8 columns per polarization. The Titan24 base station is typically pole-mounted or building mounted.

Equipment Under Test Power Configuration			
Rated Voltage	Rated Current	Rated Frequency	Number of Phases
48 VDC	5.84 A	DC	N/A

Operating modes of the EUT:

No.	Descriptions of EUT Exercising
1	Continuous Transmitting

Software used by the EUT:

No.	Descriptions of EUT Exercising
1	Proprietary Software that controls the operation of the radio.

Radio/Receiver Characteristics	
Frequency Band(s)	24.27-24.29 GHz, 24.77-25.09 GHz, 24.34-24.36 GHz, 24.84-25.16 GHz
Modulation Type(s)	OFDMA
Maximum Output Power	59.96 dBm EIRP (With 4 Paths and Beamforming)
Test Channels	24.27 GHz, 24.28 GHz, 24.29 GHz, 24.77 GHz, 24.97 GHz, 25.09 GHz, 24.34 GHz, 24.35 GHz, 24.36 GHz, 24.84 GHz, 25.04 GHz, 25.16 GHz
Occupied Bandwidths	20 MHz Bandwidth: 19.567 MHz (worst-case) 160 MHz Bandwidth: 159.831 MHz (worst-case)
MIMO Information (# of Transmit and Receive antenna ports)	8 TX / 8 RX ports, up to 4 spatial streams per polarization (8 in total), horizontal and vertical polarizations
Equipment Type	Proprietary upbanded and modified 802.11AC Radio
Antenna Type and Gain	Antenna Type and Gain*: 24.25-25.25 GHz Patch antenna array feeding lens, 20.3 dBi

*: Antenna Type and Gain are provided by Starry. Detail description of antenna is included in the *Operational Description* exhibit. Intertek takes no responsibility for the accuracy of the information provided.

Variant Models:

The following variant models were not tested as part of this evaluation, but have been identified by the manufacturer as being electrically identical models, depopulated models, or with reasonable similarity to the model(s) tested. Intertek does not make any claims of compliance for samples or variants which were not tested.

None

5 System Setup and Method

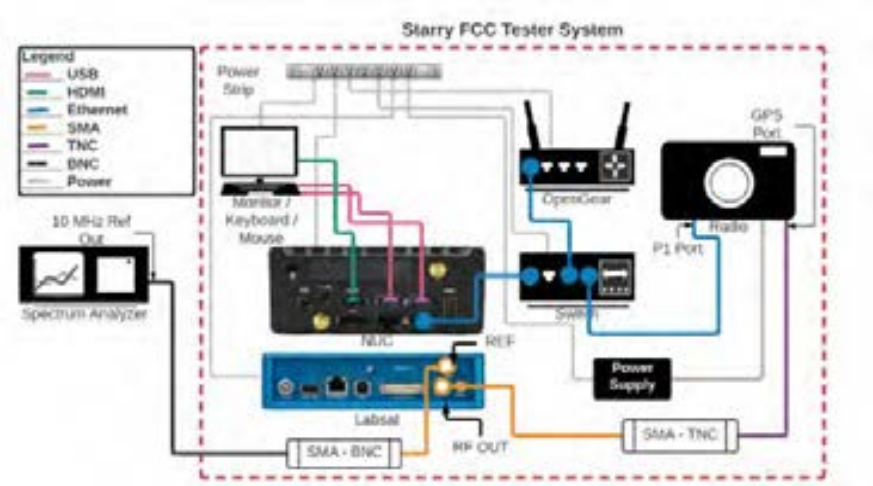
Cables					
ID	Description	Length (m)	Shielding	Ferrites	Termination
1	AC Cord	1	None	None	AC Mains
2	AC Adapter	1	None	Yes	Power Supply
3	Ethernet	10	None	None	Support Equipment
4	TNC	10	Yes	None	Support Equipment

Support Equipment			
Description	Manufacturer	Model Number	Serial Number
Monitor	Dell	P2317H	CN-03GJ21-74261-6BP-3TKM-A00
Keyboard	Dell	KB216t	CN-ORKRON-71616-6CD-1FLE-A03
Mouse	Dell	MS116t	CN-0DVORH-LO300-81G-1GFC
5-Port Gigabit Ethernet Switch	Netgear	GS305v3	5U81095VA3835
FCC System Tester	Starry	JBC313U591W-31ACB	19CF319X002872
Labsat GNSS Simulator	Racelogic	LS03	082600
Wireless Router	Opengear	ACM7004	70041901043136
Starry Link	Starry	500812	MAC: 00B6F2098A
48VDC Power Supply	Meanwell	GST200A48	None

5.1 Method:

Configuration as required by FCC 47CFR Part 30 Subpart C: 2022, FCC 47CFR Part 2: 2022, ANSI C63.26:2015, and FCC KDB 842590 D01 Upper Microwave Flexible Use Service v01r02 April 20, 2021.

5.2 EUT Block Diagram:



6 Output Power

6.1 Requirements

FCC §30.202(a) Power limits.

For fixed and base stations operating in connection with mobile systems, the average power of the sum of all antenna elements is limited to an equivalent isotopically radiated power (EIRP) density of +75dBm/100 MHz. For channel bandwidths less than 100 megahertz the EIRP must be reduced proportionally and linearly based on the bandwidth relative to 100 megahertz.

6.2 Method

Tests are performed in accordance with FCC 47CFR Part 30 Subparts C: 2022, FCC 47CFR Part 2: 2022, FCC KDB 842590 D01 v01r02 Subclause 4.2, ANSI C63.26:2015 Subclause 5.5.4.

The procedure described in Subclause 5.5.4 (field strength method) of ANSI C63.26-2015 was utilized to determine maximum power. A field strength measurement was performed, and the field strength level was mathematically converted to an equivalent power level for comparison to the applicable limit. Subclause 4.2 of FCC KDB 842590 D01 v01r02 was utilized where radiated power spectral density (EIRP density) is subject to the limit.

The EUT was transmitting at its maximum data rate with MCS8 modulation. During measurement, EIRP radiated power was converted to conducted power by using antenna gain and distance factor. Power shown on the screenshots are conducted power.

- Connect the test antenna to a spectrum analyzer.
- Set spectrum analyzer's RBW, VBW, detector, span, etc. to the proper values.
- Place the EUT 1.5 meters above the ground reference plane and the far field test distance of 3 meters from the edge of the EUT to the test antenna.
- Set the EUT to transmit continuously on a channel with modulation.
- As the surfaces of the EUT are scanned, keep the test antenna pointed toward the EUT and slowly vary the test antenna polarization to cover all possible polarizations and orientations of the emission. And vary the test antenna height from 1 to 4 meters to maximize the emission.
- Record the measured reading with the test antenna fixed at the maximized position, polarization, and orientation. Record the measurement distance.
- EIRP power is calculated by using the following equation:

$$EIRP = E_{Meas} + 20\log(d_{Meas}) - 104.7$$

where

EIRP is the equivalent isotopically radiated power, in dBm
E_{Meas} is the field strength of the emission at the measurement distance, in dBµV/m
d_{Meas} is the measurement distance, in m

- Measurements was made at 3 meters distance. Far Field Distance (Rm) Calculation: $Rm = 2D^2/\lambda$, where: D = largest dimension of the antenna aperture in meters, λ = wavelength of the emission under investigation [$300/f_{MHz}$] in meters.

TEST SITE: 10m ALSE

The 10m ALSE is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A Styrofoam table 80 cm high is used for table-top equipment.

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)
Radiated Emissions, 10m	30-1000 MHz	5.0 dB
Radiated Emissions, 3m	30-1000 MHz	4.6 dB
Radiated Emissions, 3m	1-6 GHz	4.9 dB
Radiated Emissions, 3m	6-15 GHz	5.1 dB
Radiated Emissions, 3m	15-18 GHz	4.7 dB
Radiated Emissions, 3m	18-40 GHz	4.7 dB

Sample Calculation

Cable loss, antenna factor, and path loss at 3 meters were compensated in the Spectrum Analyzer as a dB offset without the EUT antenna factor. The EIRP power is calculated from field strength reading at 3 meters as below.

EIRP (dBm) = E (dBµ/m) + 20 * LOG (D) – 104.7; where D is the measurement distance (in the far field region) in meters.

EIRP (dBm) = E (dBµV/m) – 95.26, where D = 3 m

EIRP Output Power(dBm) = EIRP (dBm) – EUT antenna gain (dBi)

6.3 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV007’	Weather Station Vantage Vue	Davis	6250	MS1912 12003	03/20/2021	03/20/2022
EMC04’	ANTENNA, RIDGED GUIDE, 18-40 GHZ	EMCO	3116	2090	01/28/2021	01/28/2022
ROS005-1’	Signal and Spectrum Analyzer	R&S	FSW43	100646	10/27/2020	11/02/2022
CBLHF2012-5M-2’	5m 9kHz-40GHz Coaxial Cable - SET2	Huber & Suhner	SF102	252676002	02/19/2021	02/19/2022

Software Utilized:

Name	Manufacturer	Version
None	N/A	N/A

6.4 Results – Output Power:

The sample tested was found to Comply.

Frequency (GHz)	Antenna Polarity	Bandwidth (MHz)	EIRP Power + (4 Path) from Plot (dBm)	EIRP Power (1 path) (dBm)	*Multiple Paths + Beam Forming (dB)	Total EIRP Power** (dBm/ 20MHz)	Total EIRP Power (dBm/ 100MHz)	Power Limits (dBm/ 100MHz)	Margin (dB)
24.27	V	20	42.38	36.36	12.02	48.38	55.37	75	-19.63
24.28	V	20	43.61	37.59	12.02	49.61	56.60	75	-18.40
24.29	V	20	41.13	35.11	12.02	47.13	54.12	75	-20.88
24.77	V	20	43.35	37.33	12.02	49.35	56.34	75	-18.66
24.97	V	20	46.70	40.95	12.02	52.97	59.96	75	-15.04
25.09	V	20	44.19	38.17	12.02	50.19	57.18	75	-17.82
24.27	H	20	43.21	37.19	12.02	49.21	56.20	75	-18.80
24.28	H	20	44.42	38.4	12.02	50.42	57.41	75	-17.59
24.29	H	20	41.87	35.85	12.02	47.87	54.86	75	-20.14
24.77	H	20	42.10	36.08	12.02	48.10	55.09	75	-19.91
24.97	H	20	39.50	33.48	12.02	45.50	52.49	75	-22.51
25.09	H	20	42.69	36.67	12.02	48.69	55.68	75	-19.32

Frequency (GHz)	Antenna Polarity	Bandwidth (MHz)	EIRP Power + (4 Path) from Plot (dBm)	EIRP Power (1 path) (dBm)	*Multiple Paths + Beam Forming (dB)	Total EIRP Power** (dBm/ 160MHz)	Total EIRP Power (dBm/ 100MHz)	Power Limits (dBm/ 100MHz)	Margin (dB)
24.34	V	160	42.67	36.65	12.02	48.67	46.63	75	-28.37
24.35	V	160	42.27	36.25	12.02	48.27	46.23	75	-28.77
24.36	V	160	45.64	39.62	12.02	51.64	49.6	75	-25.4
24.84	V	160	44.35	38.33	12.02	50.35	48.31	75	-26.69
25.04	V	160	45.19	39.17	12.02	51.19	49.15	75	-25.85
25.16	V	160	43.85	37.83	12.02	49.85	47.81	75	-27.19
24.34	H	160	44.53	38.51	12.02	50.53	48.49	75	-26.51
24.35	H	160	44.66	38.64	12.02	50.66	48.62	75	-26.38
24.36	H	160	43.78	37.76	12.02	49.78	47.74	75	-27.26
24.84	H	160	41.21	35.19	12.02	47.21	45.17	75	-29.83
25.04	H	160	43.28	37.26	12.02	49.28	47.24	75	-27.76
25.16	H	160	44.47	38.45	12.02	50.47	48.43	75	-26.57

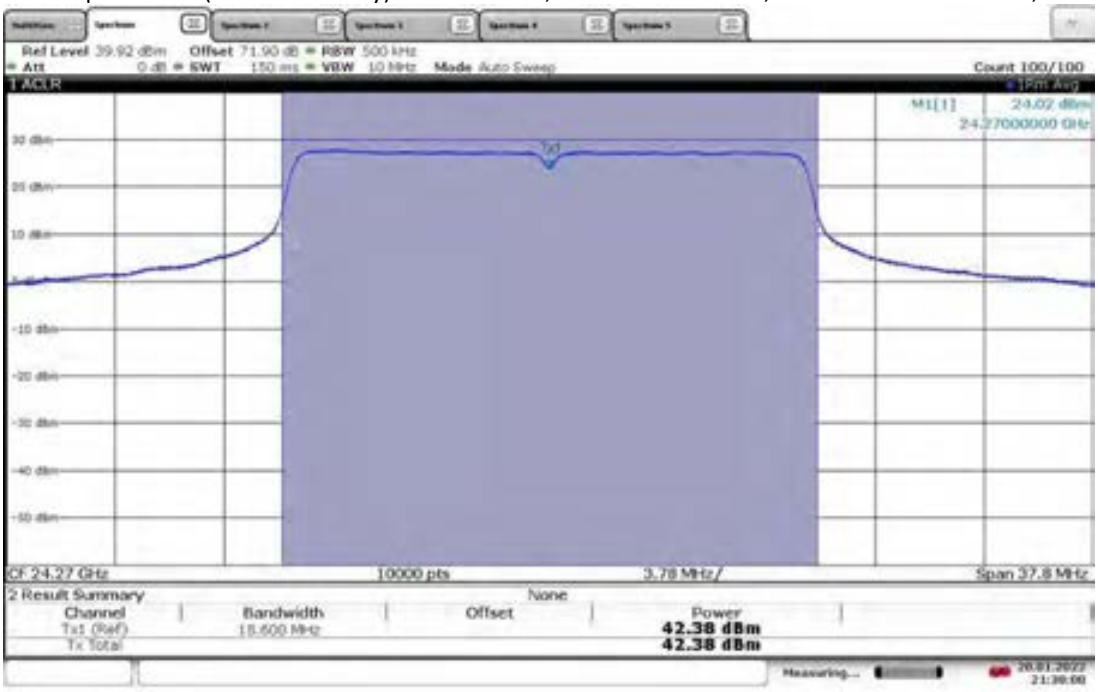
*: Multiple Paths (4 paths) + Beam Forming (6 dBi) = 10*Log(4) + 6 dBi = 12.02 dBi.
**: Total EIRP Power = EIRP power (1 path) + 12.02 dBi

6.5 Setup Photographs:

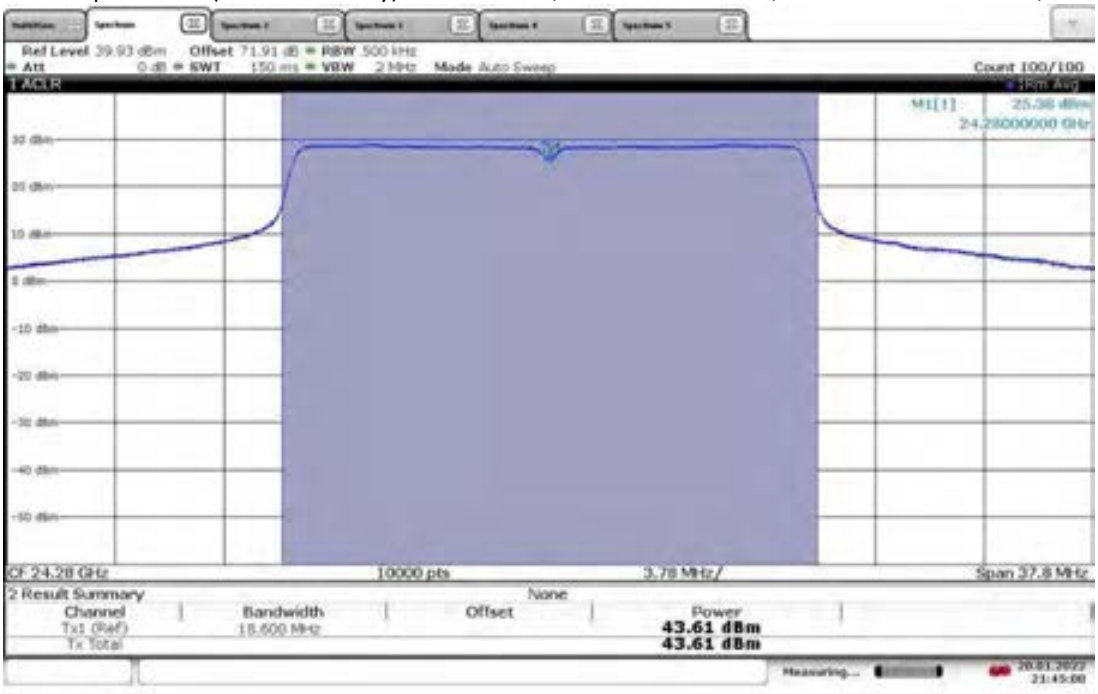
Setup Photographs are included in a separate file.

6.6 Plots:

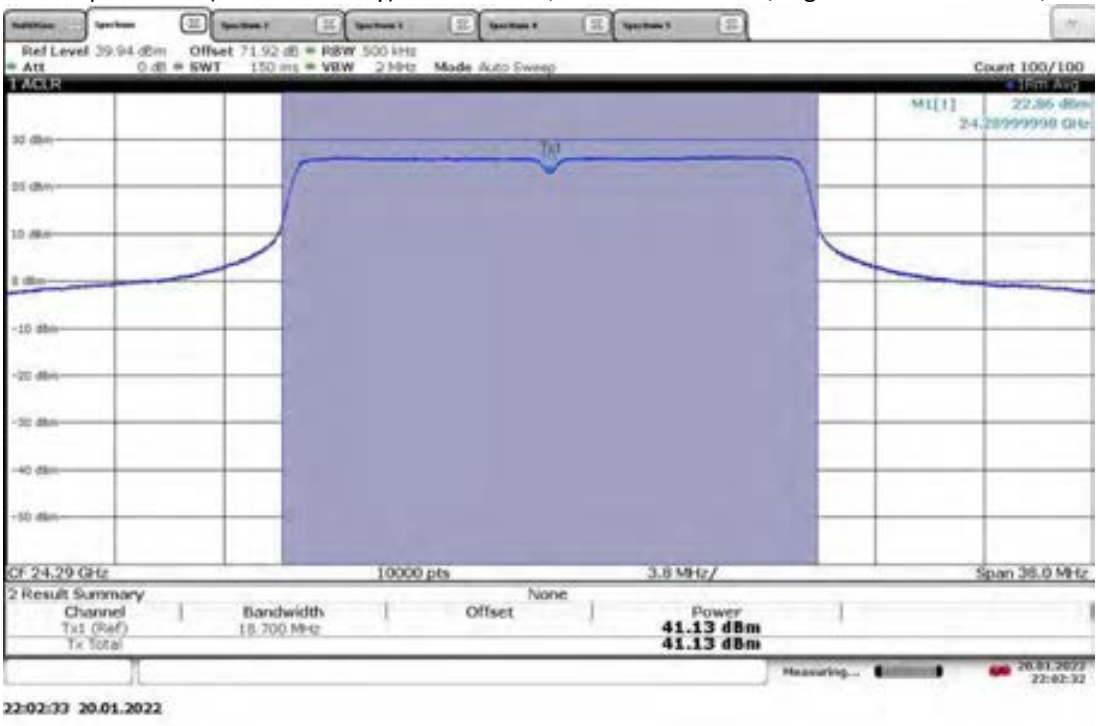
EIRP Output Power (Vertical Polarity) – Titan 24X45, 20 MHz Bandwidth, Low Channel 24.27 GHz, Att11



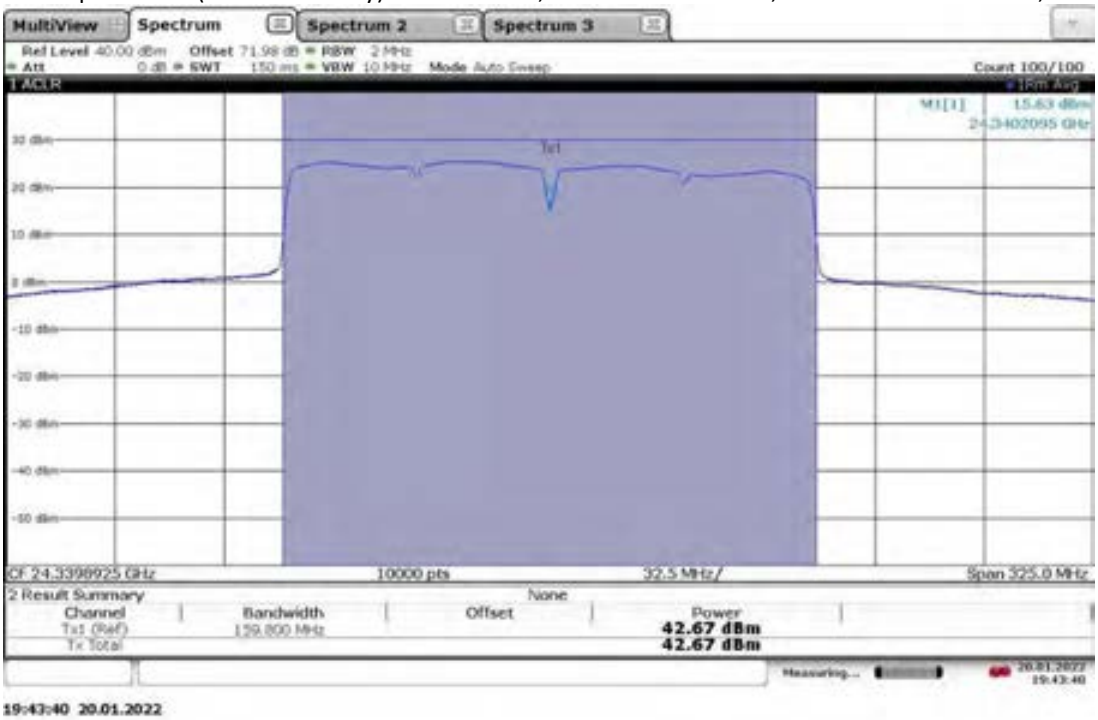
EIRP Output Power (Vertical Polarity) – Titan 24X45, 20 MHz Bandwidth, Mid Channel 24.28 GHz, Att9



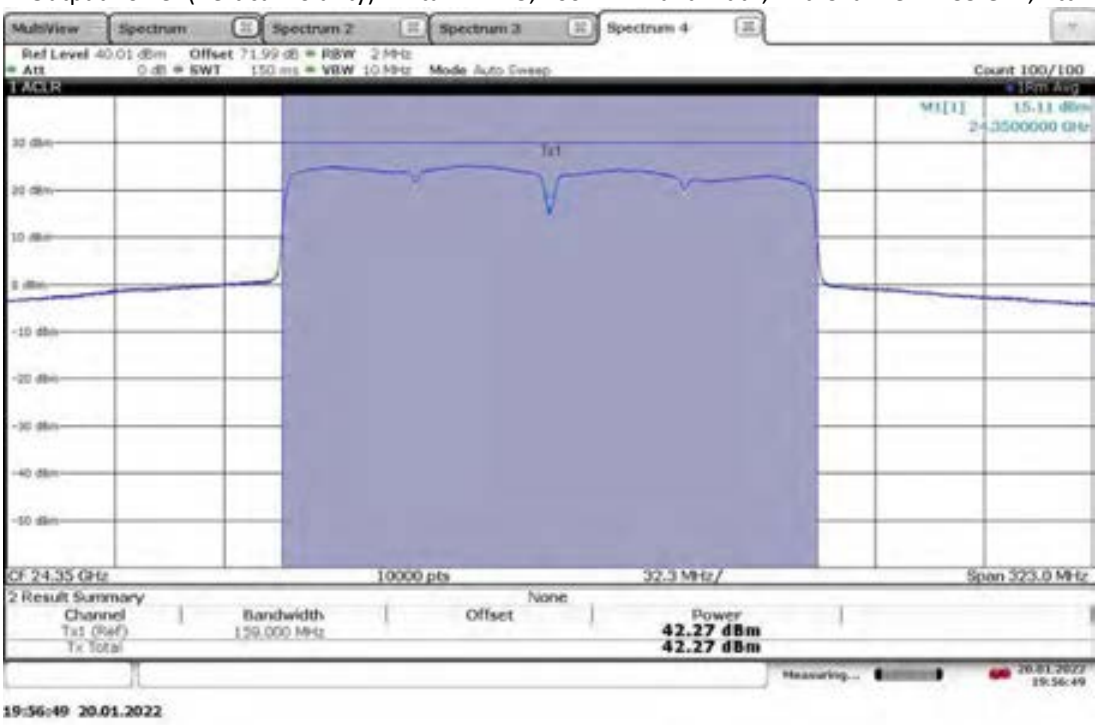
EIRP Output Power (Vertical Polarity) – Titan 24X45, 20 MHz Bandwidth, High Channel 24.29 GHz, Att9



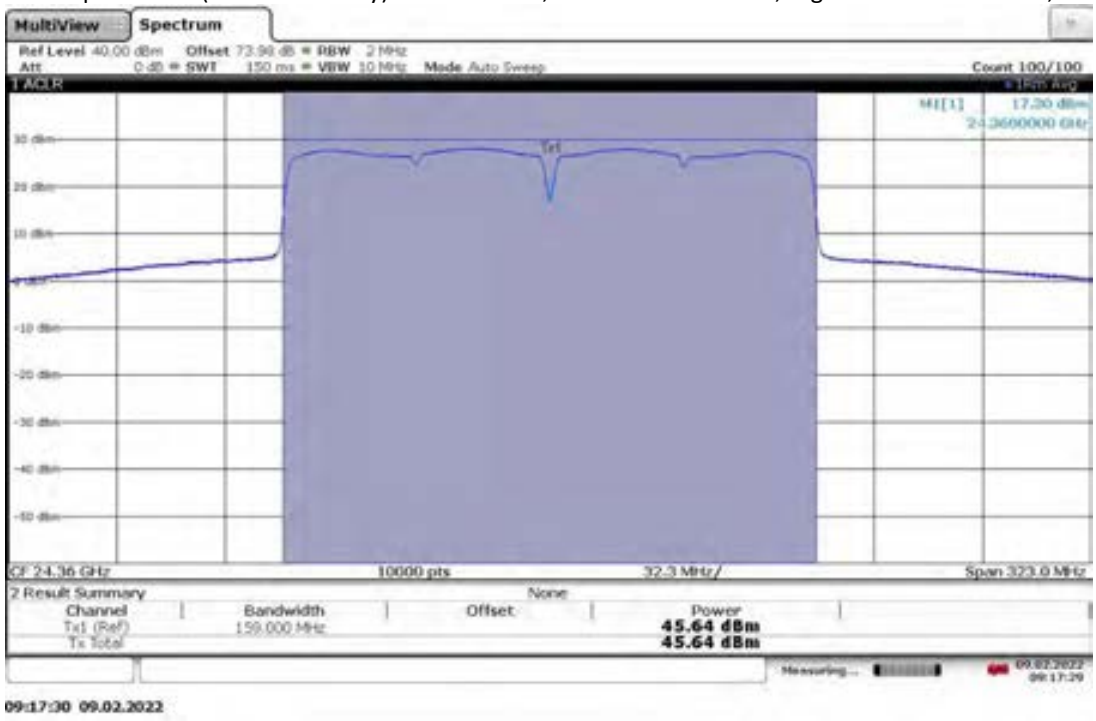
EIRP Output Power (Vertical Polarity) – Titan 24X45, 160 MHz Bandwidth, Low Channel 24.34 GHz, Att12



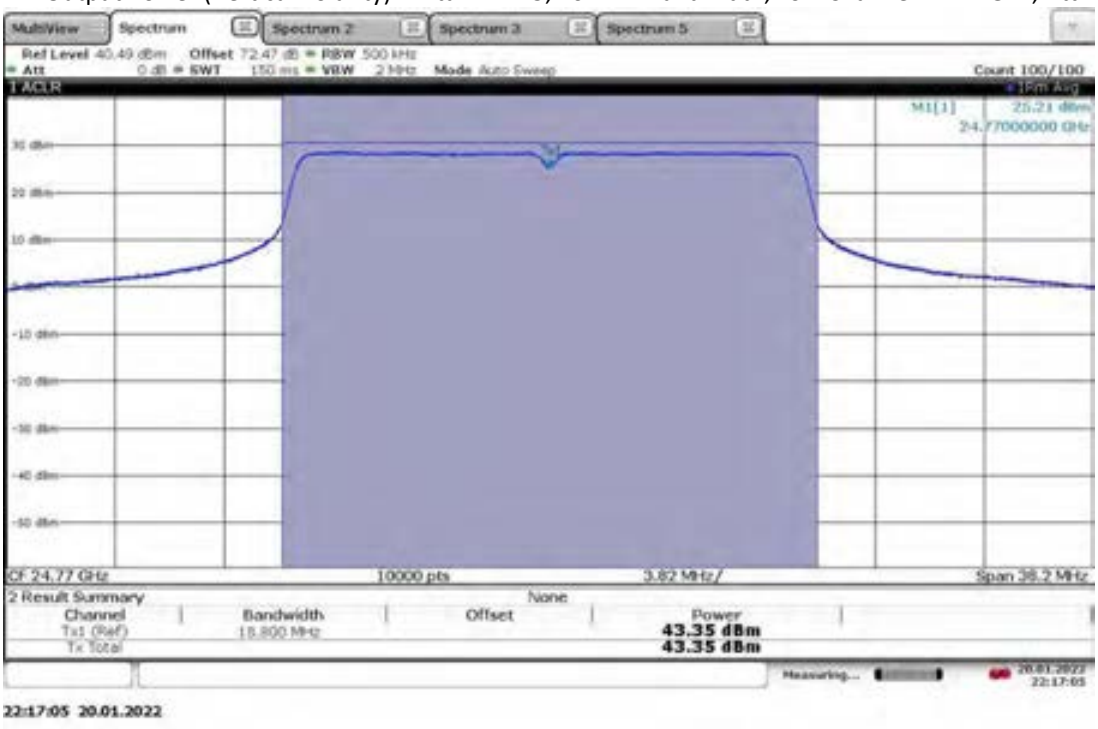
EIRP Output Power (Vertical Polarity) – Titan 24X45, 160 MHz Bandwidth, Mid Channel 24.35 GHz, Att12.5



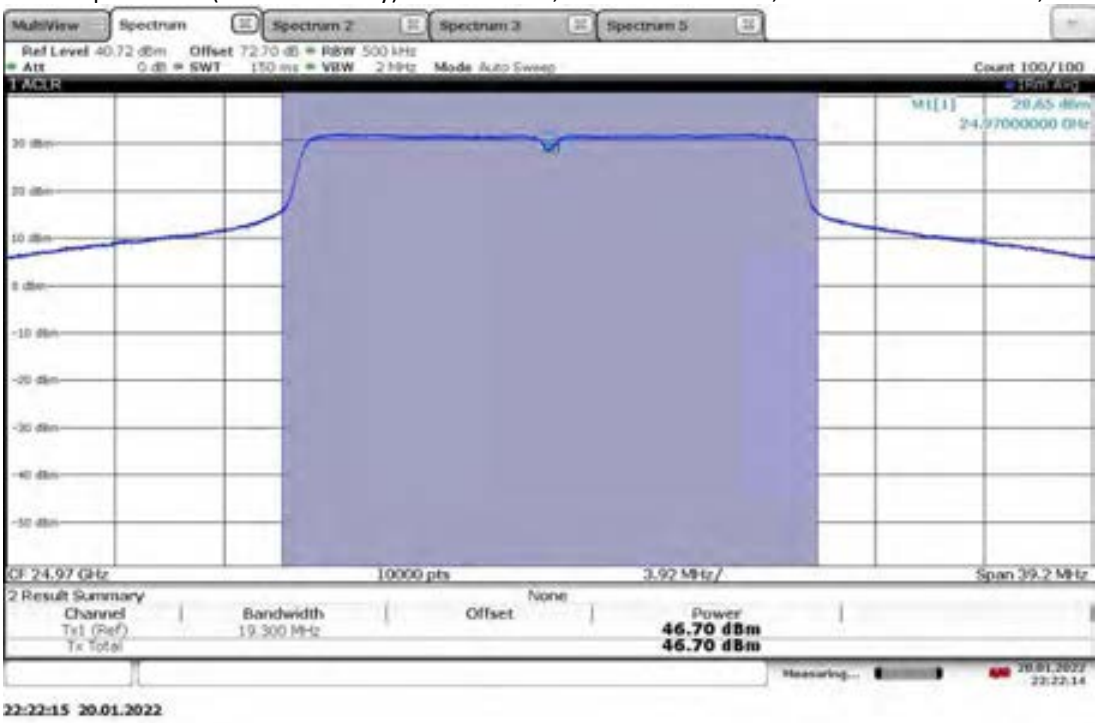
EIRP Output Power (Vertical Polarity) – Titan 24X45, 160 MHz Bandwidth, High Channel 24.36 GHz, Att9



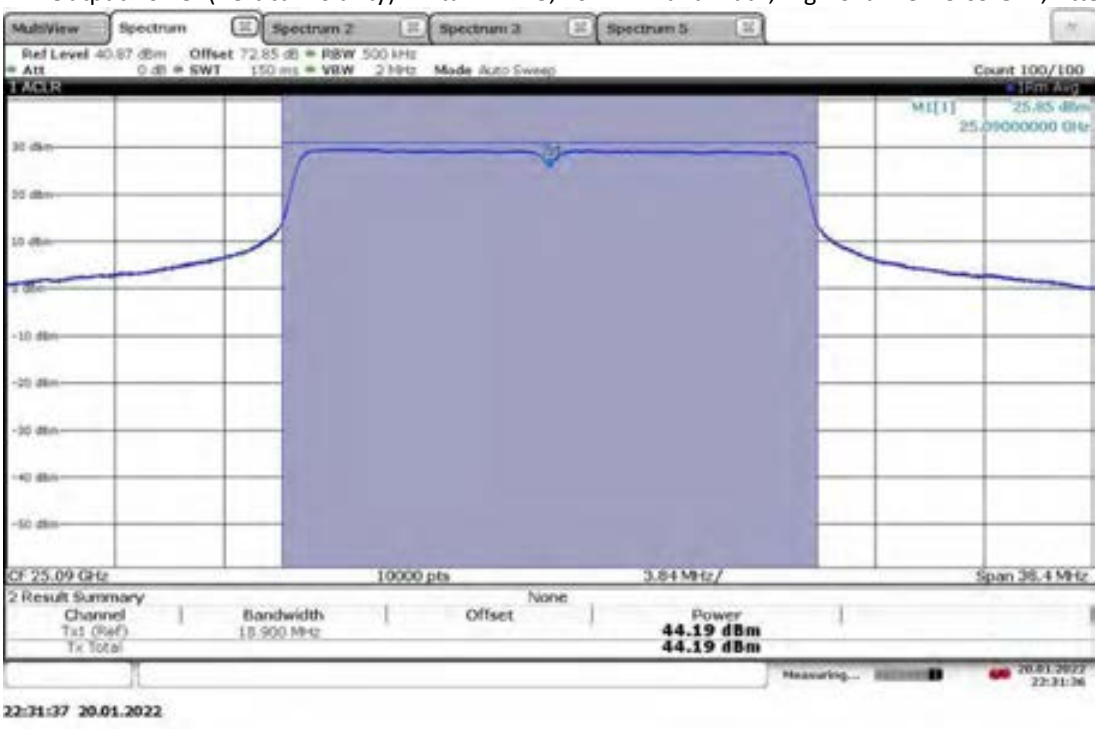
EIRP Output Power (Vertical Polarity) – Titan 24X45, 20 MHz Bandwidth, Low Channel 24.77 GHz, Att12



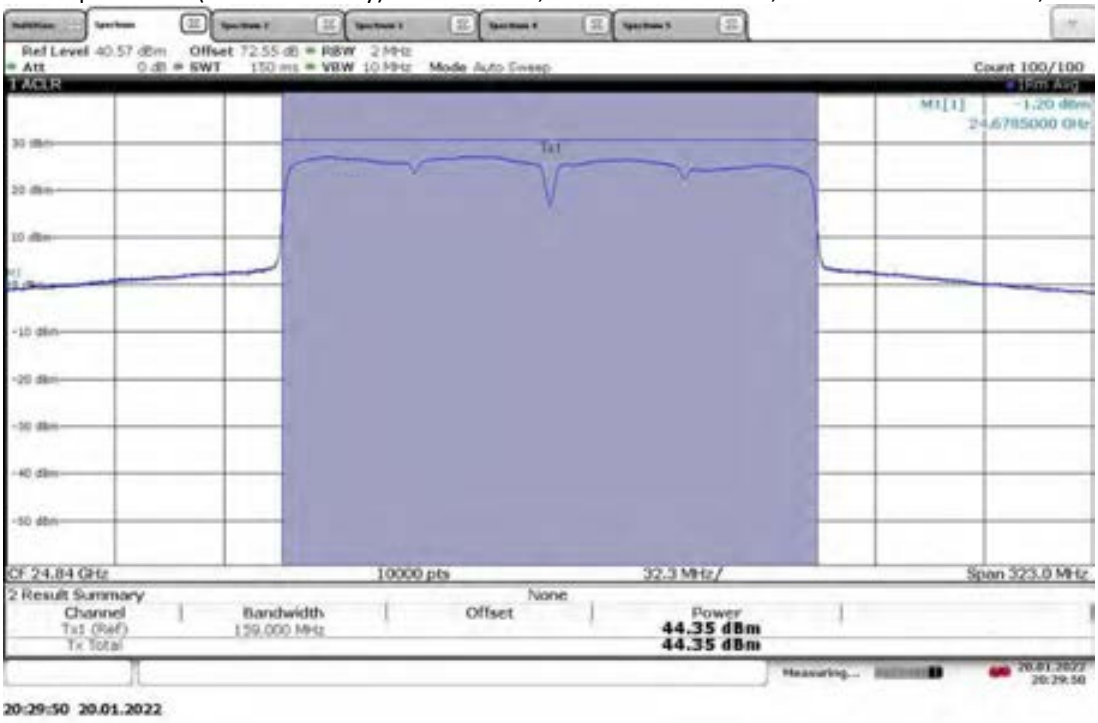
EIRP Output Power (Vertical Polarity) – Titan 24X45, 20 MHz Bandwidth, Mid Channel 24.97 GHz, Att8



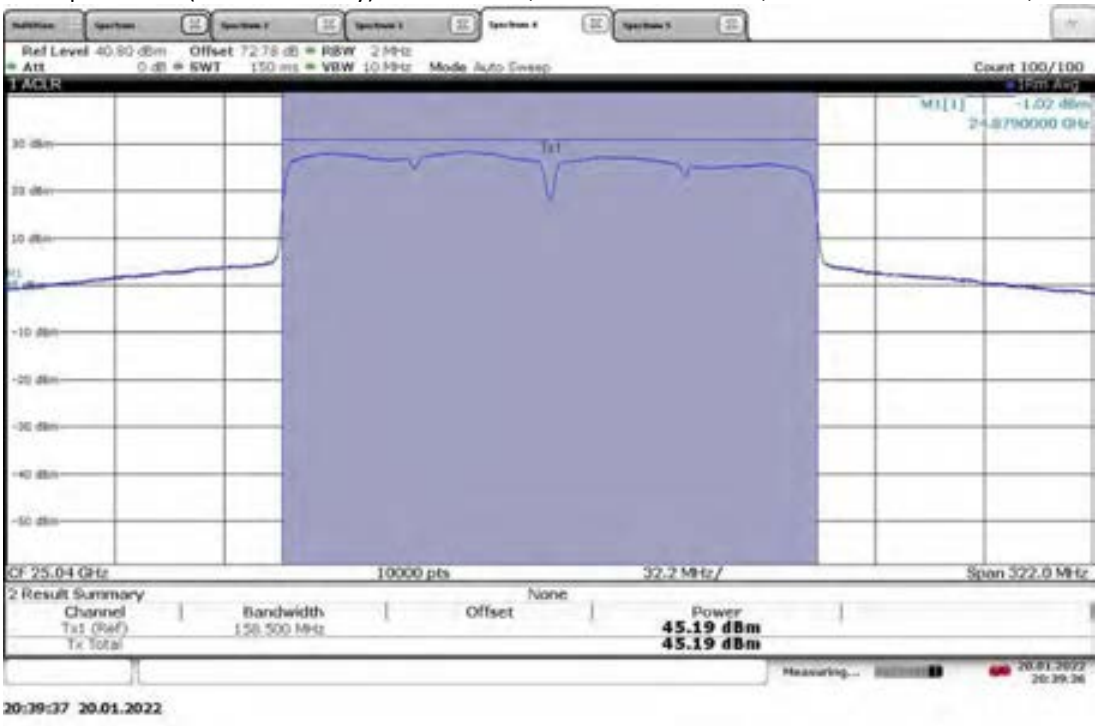
EIRP Output Power (Vertical Polarity) – Titan 24X45, 20 MHz Bandwidth, High Channel 25.09 GHz, Att8



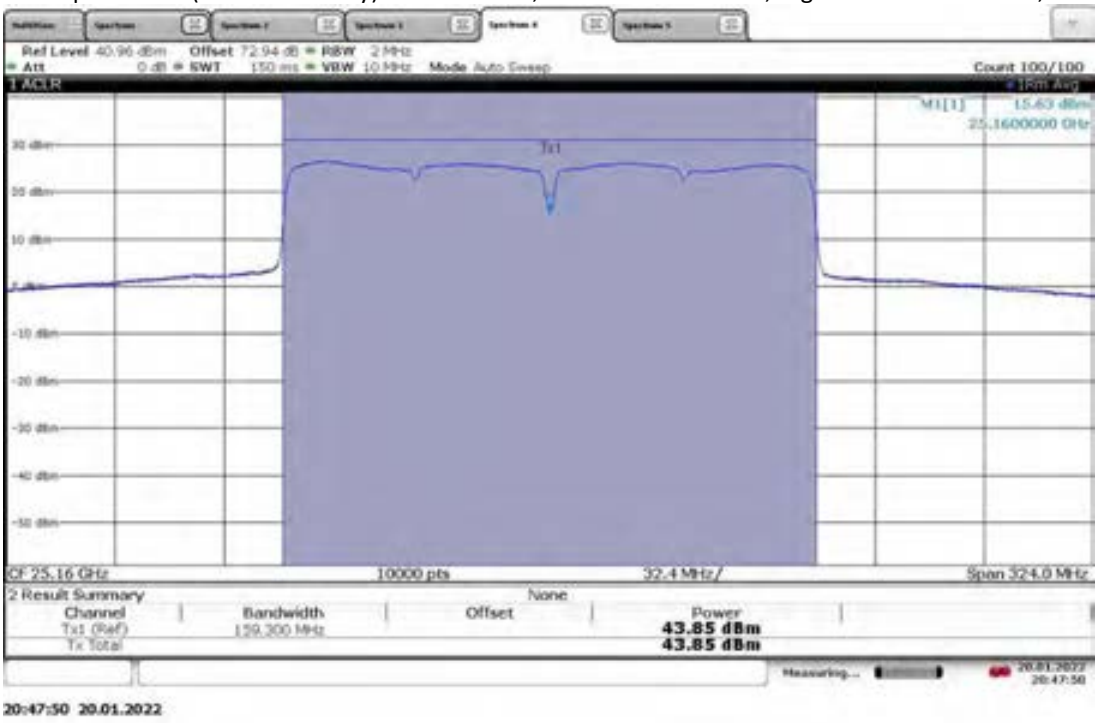
EIRP Output Power (Vertical Polarity) – Titan 24X45, 160 MHz Bandwidth, Low Channel 24.84 GHz, Att12



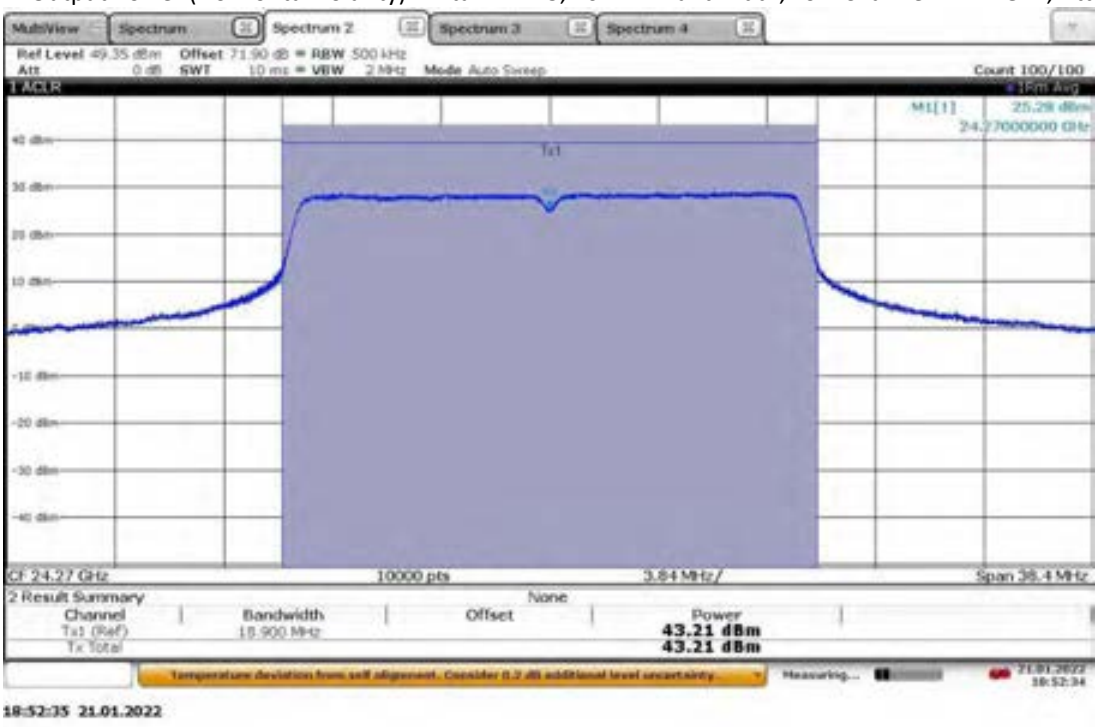
EIRP Output Power (Vertical Polarity) – Titan 24X45, 160 MHz Bandwidth, Mid Channel 25.04 GHz, Att11.5



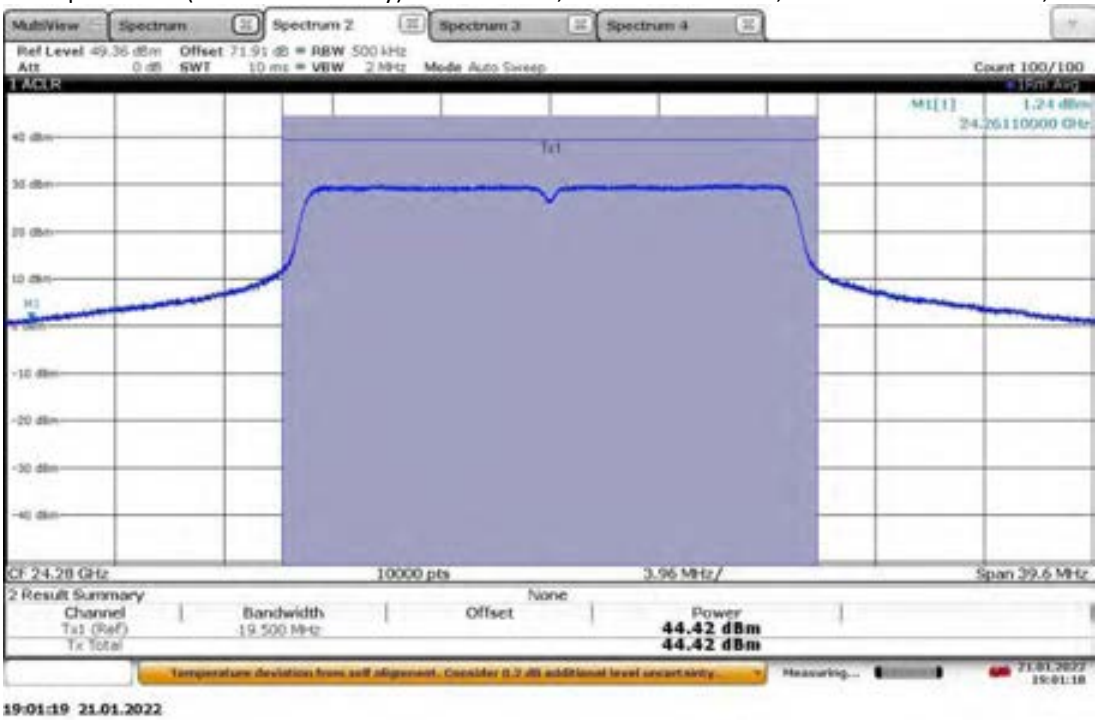
EIRP Output Power (Vertical Polarity) – Titan 24X45, 160 MHz Bandwidth, High Channel 25.16 GHz, Att9.5



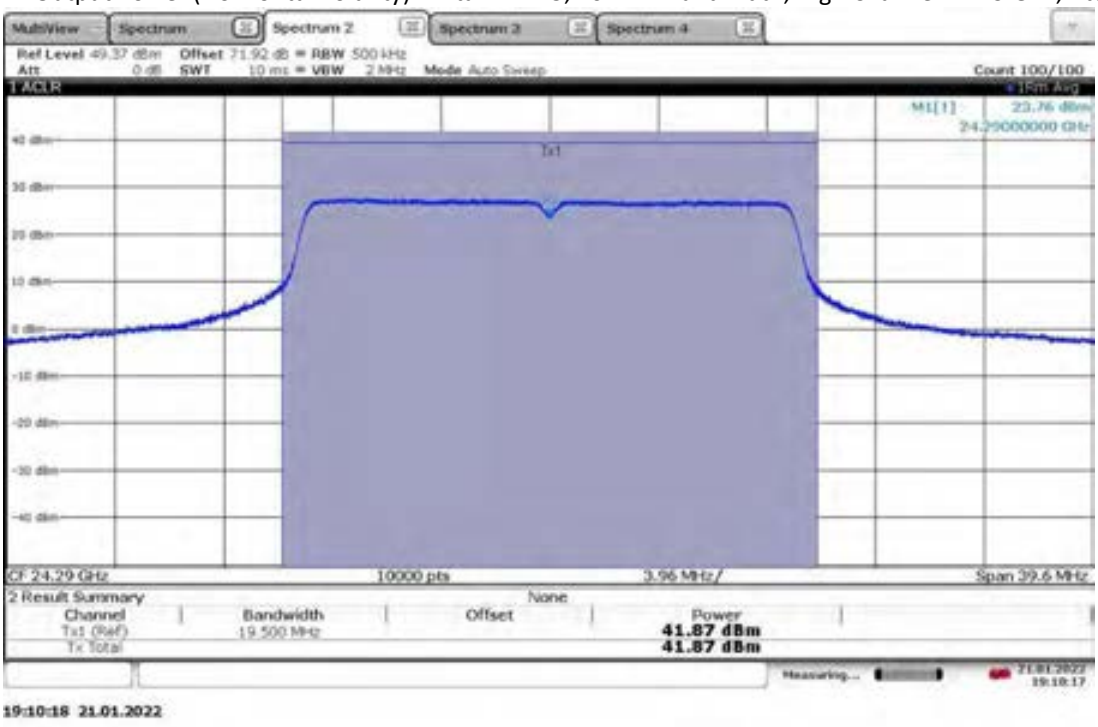
EIRP Output Power (Horizontal Polarity) – Titan 24X45, 20 MHz Bandwidth, Low Channel 24.27 GHz, Att10



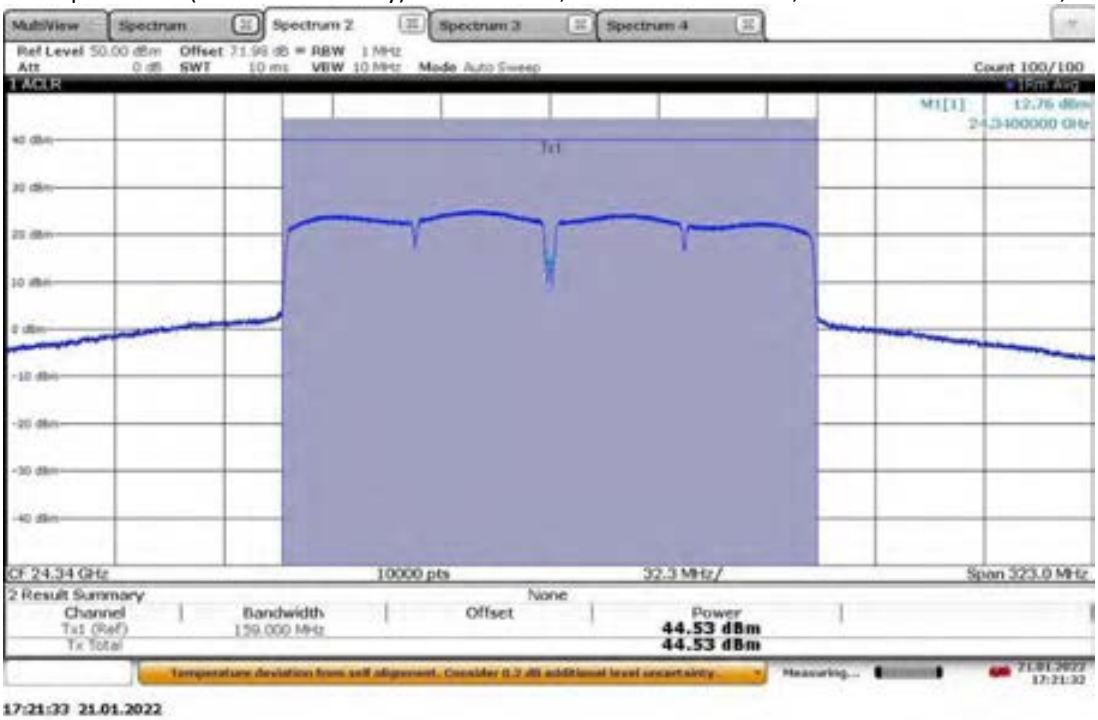
EIRP Output Power (Horizontal Polarity) – Titan 24X45, 20 MHz Bandwidth, Mid Channel 24.28 GHz, Att8.5



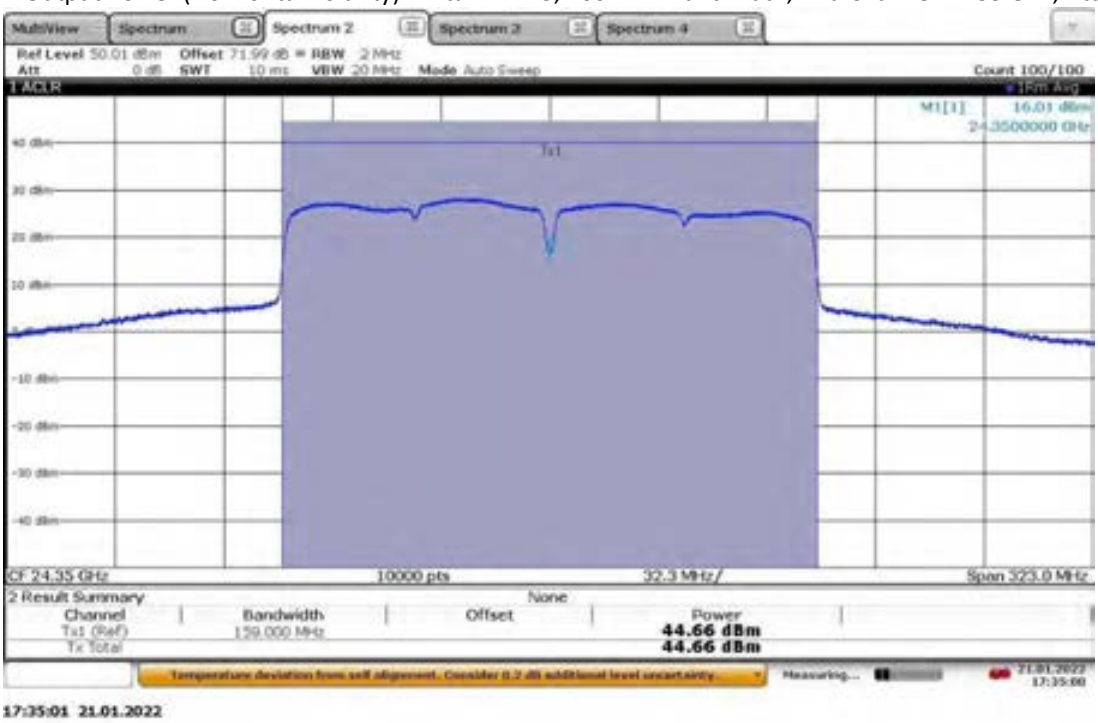
EIRP Output Power (Horizontal Polarity) – Titan 24X45, 20 MHz Bandwidth, High Channel 24.29 GHz, Att0



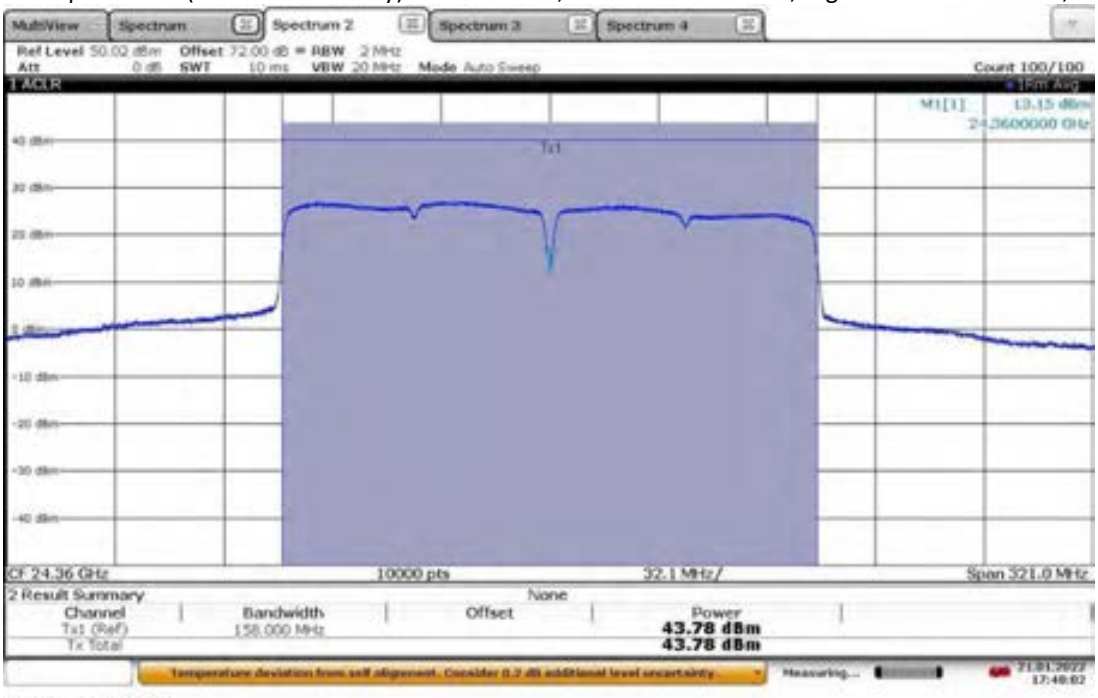
EIRP Output Power (Horizontal Polarity) – Titan 24X45, 160 MHz Bandwidth, Low Channel 24.34 GHz, Att0



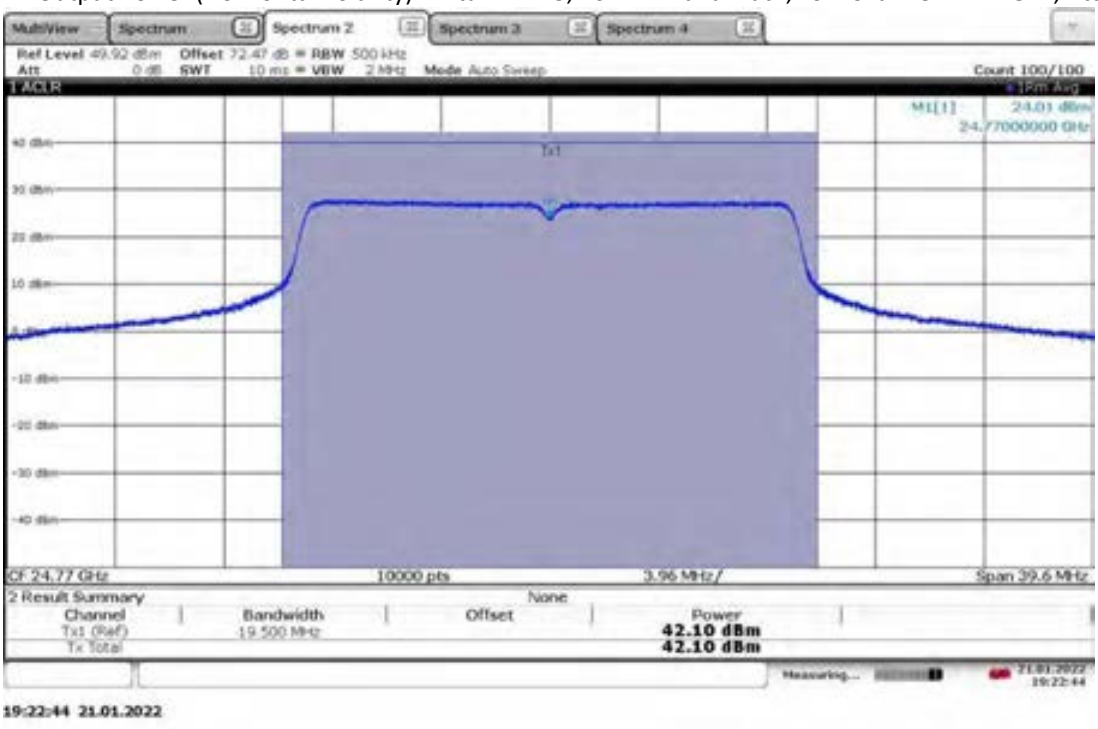
EIRP Output Power (Horizontal Polarity) – Titan 24X45, 160 MHz Bandwidth, Mid Channel 24.35 GHz, Att10



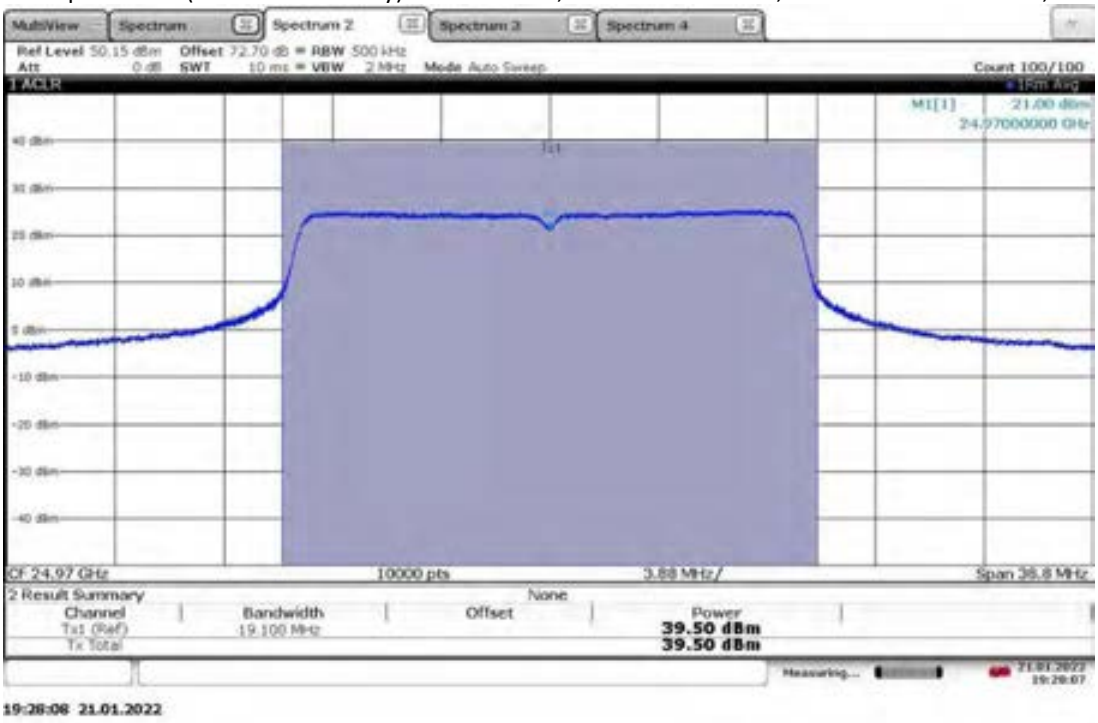
EIRP Output Power (Horizontal Polarity) – Titan 24X45, 160 MHz Bandwidth, High Channel 24.36 GHz, Att0



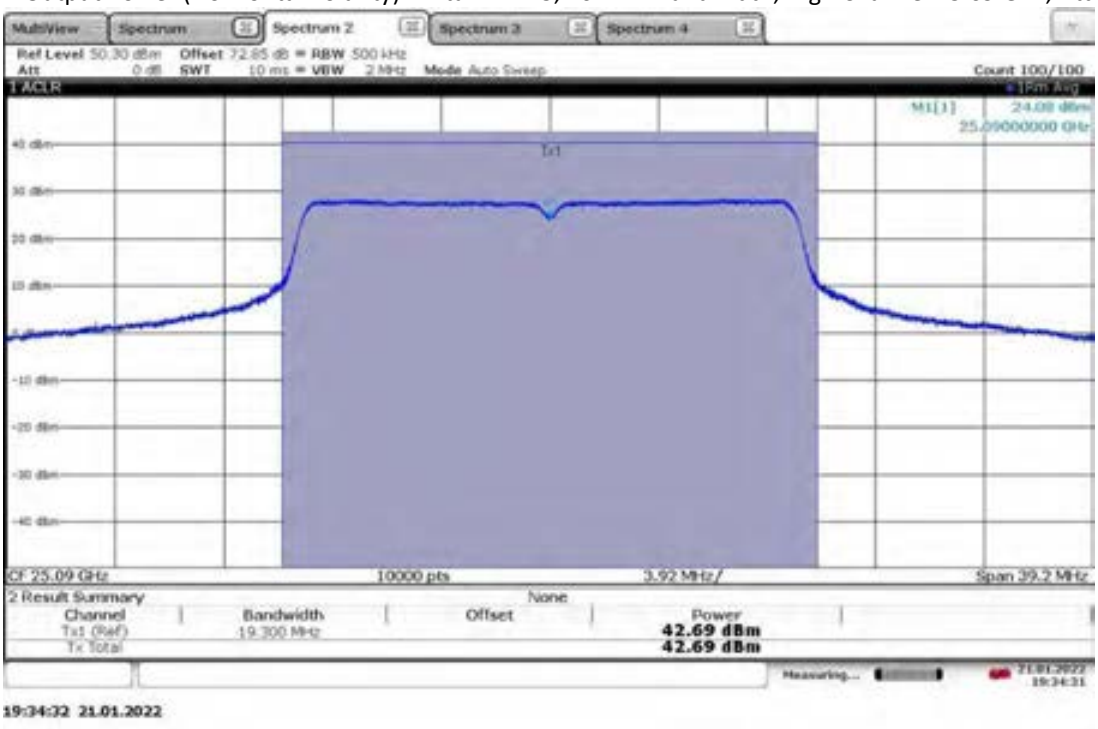
EIRP Output Power (Horizontal Polarity) – Titan 24X45, 20 MHz Bandwidth, Low Channel 24.77 GHz, Att9



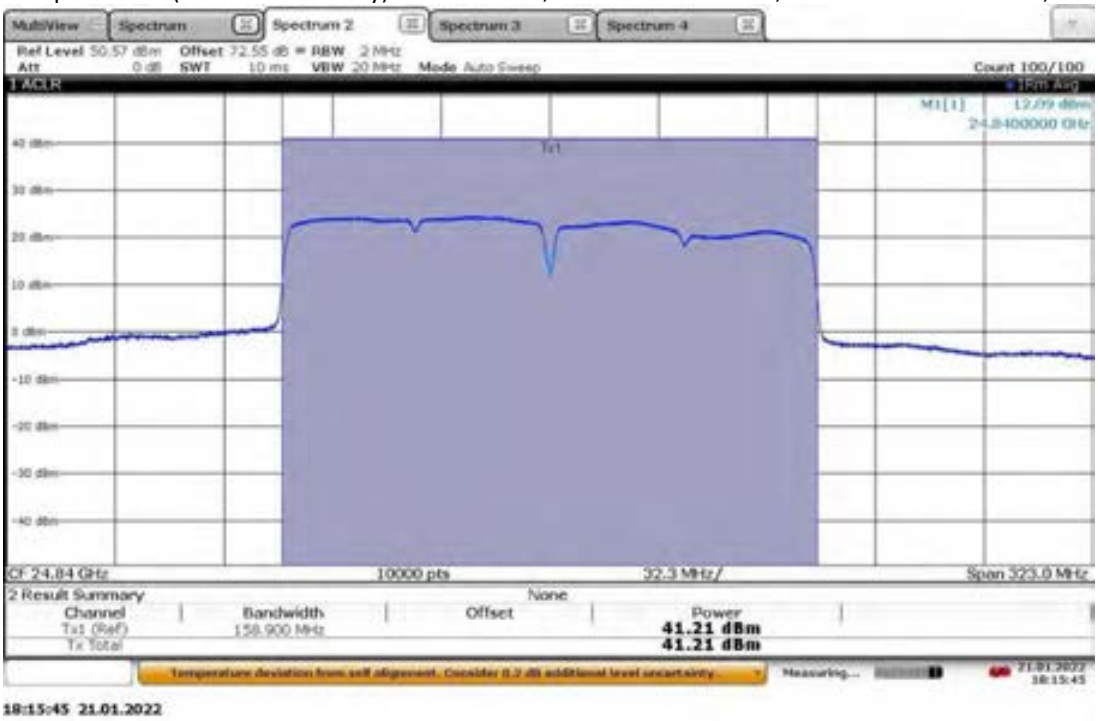
EIRP Output Power (Horizontal Polarity) – Titan 24X45, 20 MHz Bandwidth, Mid Channel 24.97 GHz, Att7.5



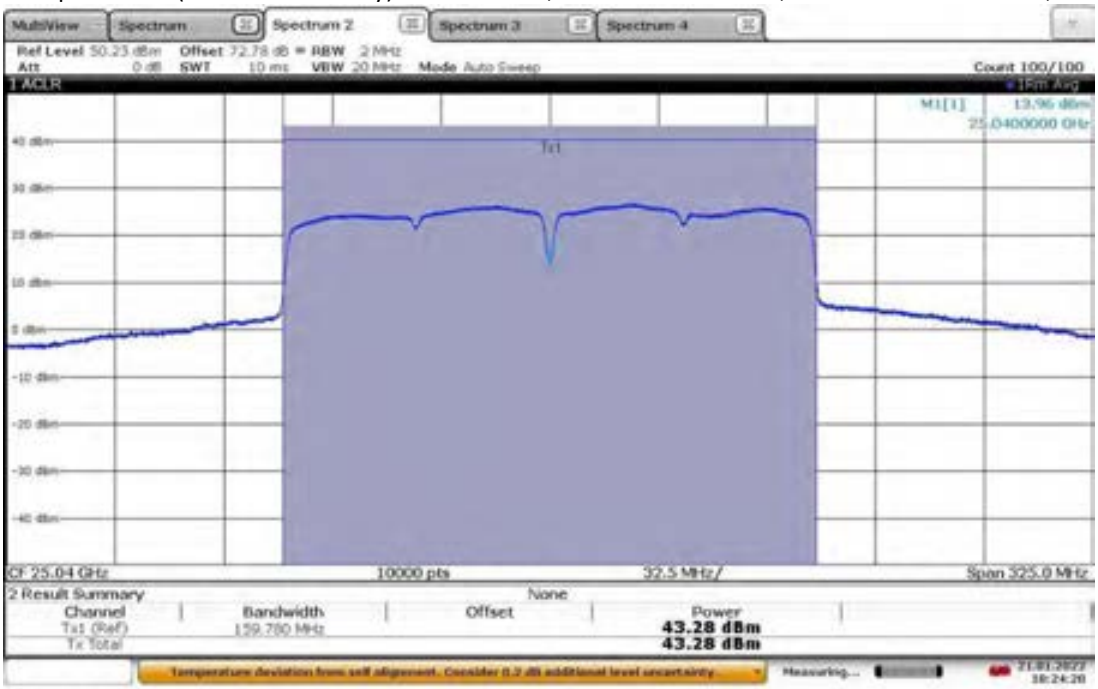
EIRP Output Power (Horizontal Polarity) – Titan 24X45, 20 MHz Bandwidth, High Channel 25.09 GHz, Att7.5



EIRP Output Power (Horizontal Polarity) – Titan 24X45, 160 MHz Bandwidth, Low Channel 24.84 GHz, Att10.5

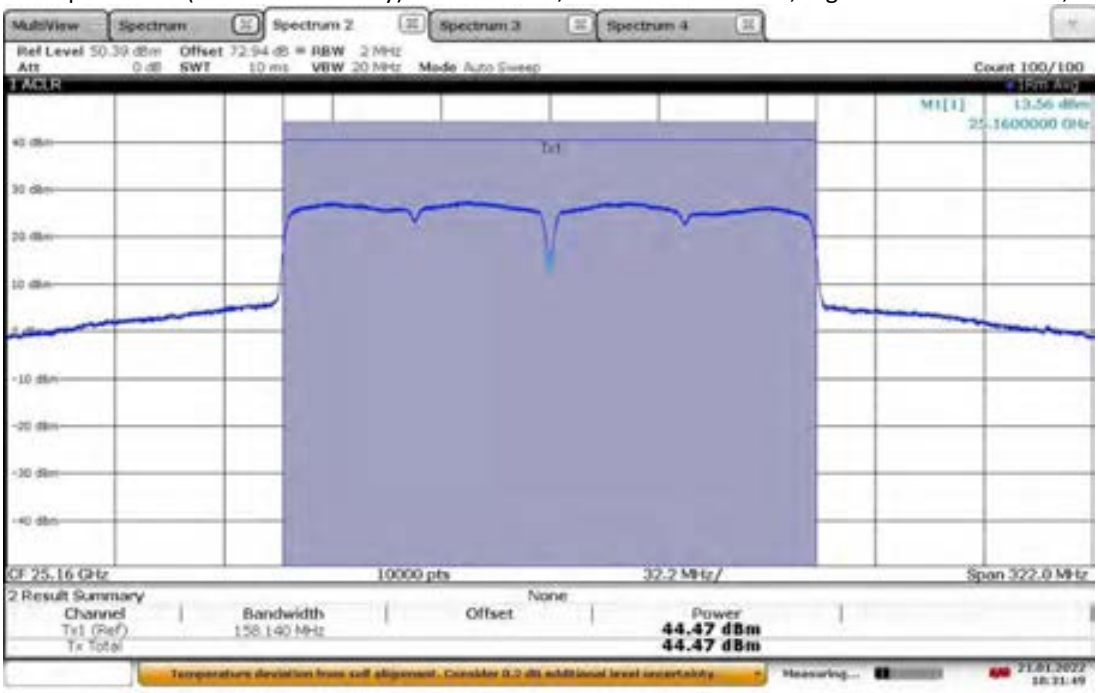


EIRP Output Power (Horizontal Polarity) – Titan 24X45, 160 MHz Bandwidth, Mid Channel 25.04 GHz, Att 5.5



18:24:21 21.01.2022

EIRP Output Power (Horizontal Polarity) – Titan 24X45, 160 MHz Bandwidth, High Channel 25.16 GHz, Att8



18:31:51 21.01.2022

Test Personnel:	Kouma Sinn	Test Date:	01/20/2022, 01/21/2022
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	FCC 47CFR Part 30 Subpart C	Limit Applied:	See Report Section 6.1
Input Voltage:	48 VDC Via External P/S	Ambient Temperature:	24, 24 ºC
Pretest Verification w/ BB Source:	**Yes**	Relative Humidity:	13, 9 %
		Atmospheric Pressure:	1018, 1025 mbars

Deviations, Additions, or Exclusions: None

7 Out of Band (OOB) Domain

7.1 Requirements

FCC §30.203 Emission limits.

(a) The conductive power or the total radiated power of any emission outside a licensee's frequency block shall be −13 dBm/MHz or lower. However, in the bands immediately outside and adjacent to the licensee's frequency block, having a bandwidth equal to 10 percent of the channel bandwidth, the conductive power or the total radiated power of any emission shall be −5 dBm/MHz or lower.

(b)

(1) Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater.

(2) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the licensee's frequency block edges as the design permits.

(3) The measurements of emission power can be expressed in peak or average values

7.2 Method

Tests are performed in accordance with FCC 47CFR Part 30 Subpart C and KDB 842590 D01 v01r02 Subclause 4.4.2. The measurement was made on the maximum field strength in the same worst-case orientation as in Section 6.1

For band edge measurement, the single column gain (14 dBi) was subtracted and the 4xconducted gain (10log(4)) was added to the offset.

TEST SITE: 10m ALSE

The 10m ALSE is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A Styrofoam table 80 cm high is used for table-top equipment.

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)
Radiated Emissions, 10m	30-1000 MHz	5.0 dB
Radiated Emissions, 3m	30-1000 MHz	4.6 dB
Radiated Emissions, 3m	1-6 GHz	4.9 dB
Radiated Emissions, 3m	6-15 GHz	5.1 dB
Radiated Emissions, 3m	15-18 GHz	4.7 dB
Radiated Emissions, 3m	18-40 GHz	4.7 dB

Sample Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF - AG
Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

Assume a receiver reading of 52.0 dBμV is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dBμV/m. This value in dBμV/m was converted to its corresponding level in μV/m.

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

To convert from dBμV to μV or mV the following was used:

$UF = 10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

Example:

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
$UF = 10^{(32\ dB\mu V / 20)}$ = 39.8 μV/m

Alternately, when BAT-EMC Emission Software is used, the “Level” includes all losses and gains and is compared directly in the “Margin” column to the “Limit”. The “Correction” includes Antenna Factor, Preamp, and Cable Loss. These are already accounted for in the “Level” column.

7.3 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV007’	Weather Station Vantage Vue	Davis	6250	MS1912 12003	03/20/2021	03/20/2022
EMC04’	ANTENNA, RIDGED GUIDE, 18-40 GHZ	EMCO	3116	2090	01/28/2021	01/28/2022
ROS005-1’	Signal and Spectrum Analyzer	R&S	FSW43	100646	10/27/2020	11/02/2022
CBLHF2012-5M-2’	5m 9kHz-40GHz Coaxial Cable - SET2	Huber & Suhner	SF102	252676002	02/19/2021	02/19/2022

Software Utilized:

Name	Manufacturer	Version
None	N/A	N/A

7.4 Results:

The sample tested was found to Comply.

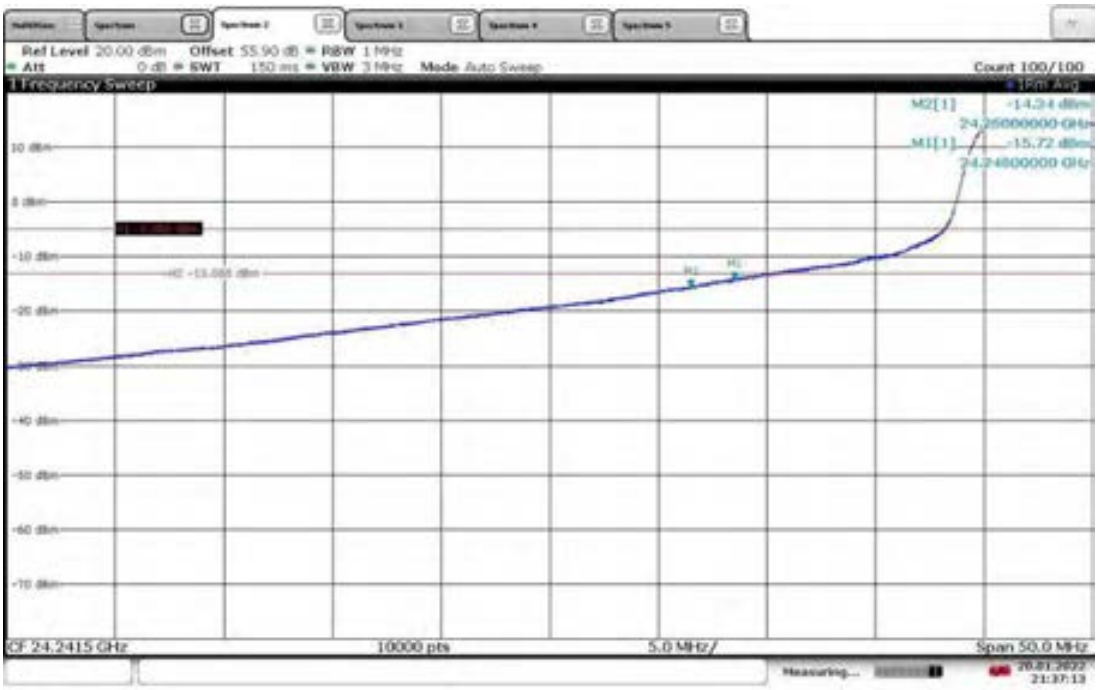
7.5 Setup Photographs:

Setup Photographs are included in a separate file.

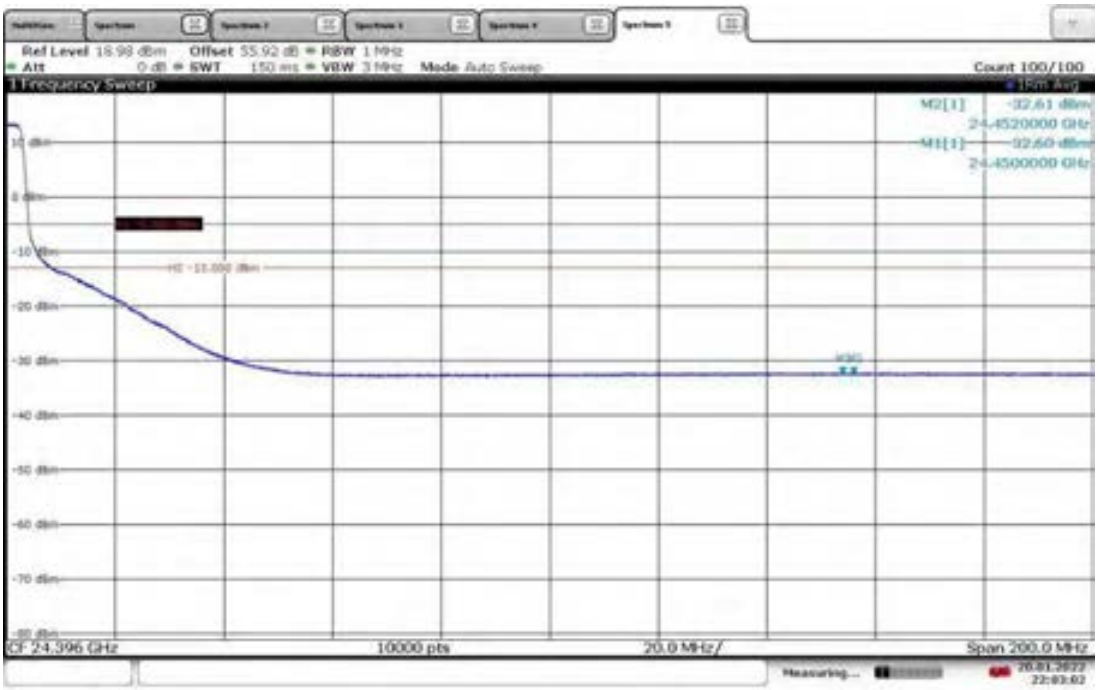
7.6 Plots/Data:

Authorized Band 24.25-24.45 GHz

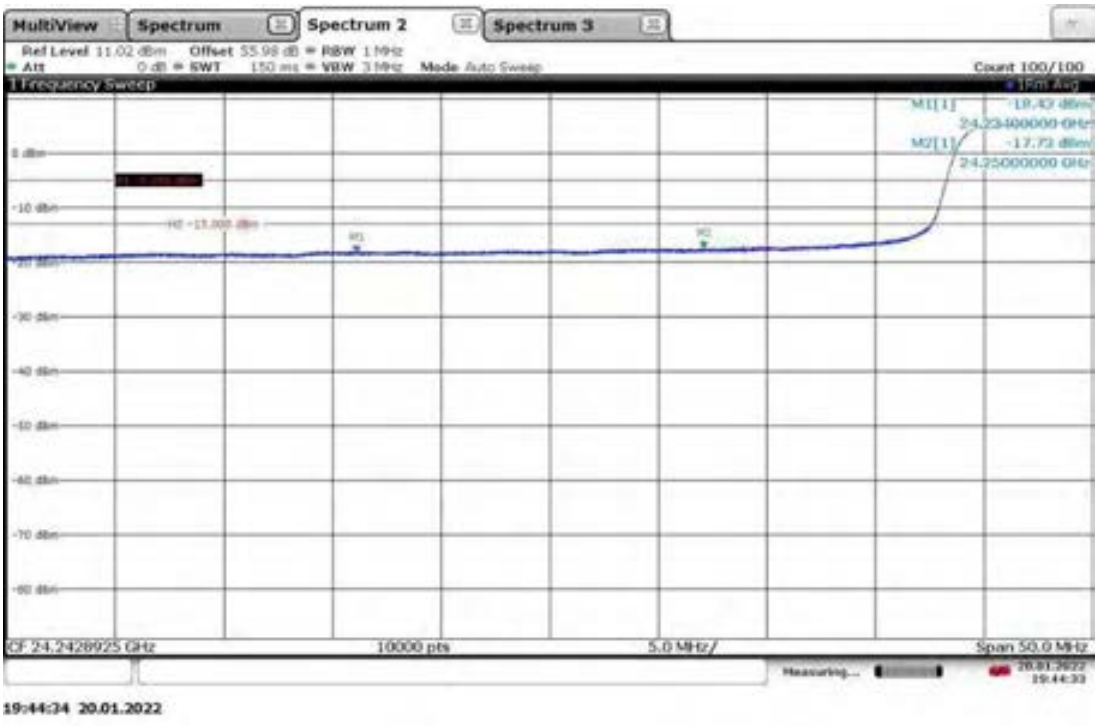
Emission Mask (Vertical Polarity)– Titan 24X45, 20 MHz Bandwidth, Low Channel 24.27 GHz, Att11
Lower Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 1 to the left the limit is -13 dBm



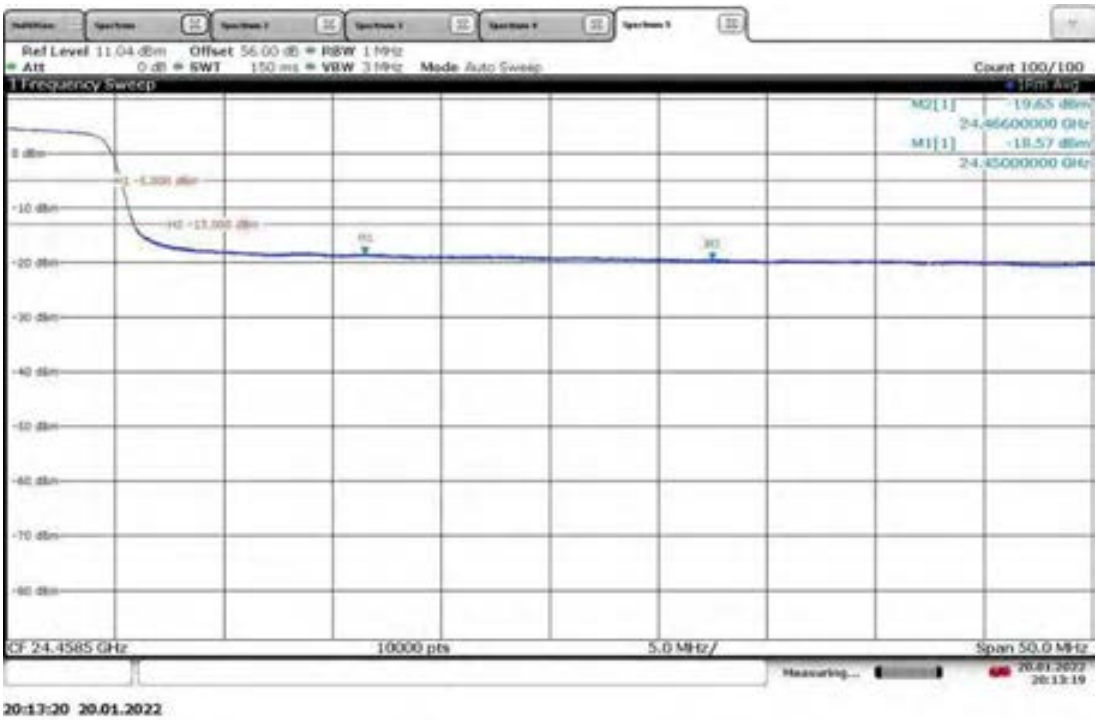
Emission Mask (Vertical Polarity)– Titan 24X45, 20 MHz Bandwidth, High Channel 24.29 GHz, Att9
Upper Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 2 to the right the limit is -13 dBm



Authorized Band 24.25-24.45 GHz
Emission Mask (Vertical Polarity)– Titan 24X45, 160 MHz Bandwidth, Low Channel 24.34 GHz, Att12
Lower Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 1 to the left the limit is -13 dBm

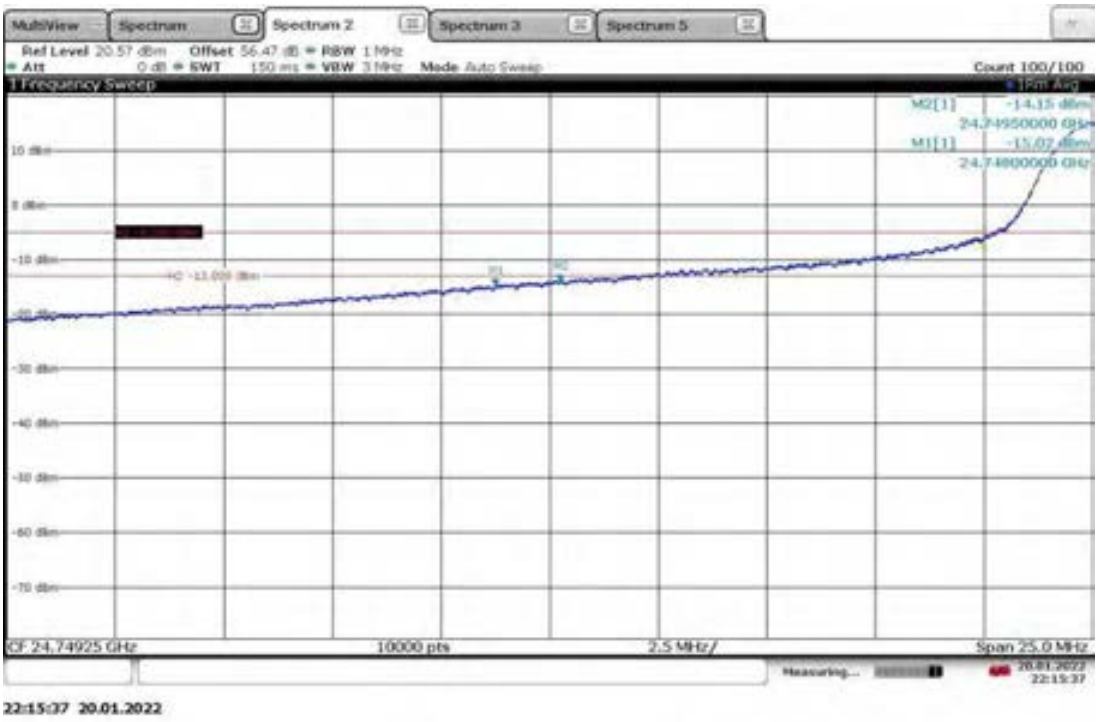


Emission Mask (Vertical Polarity)– Titan 24X45, 160 MHz Bandwidth, High Channel 24.36 GHz, Att9
Upper Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 2 to the right the limit is -13 dBm



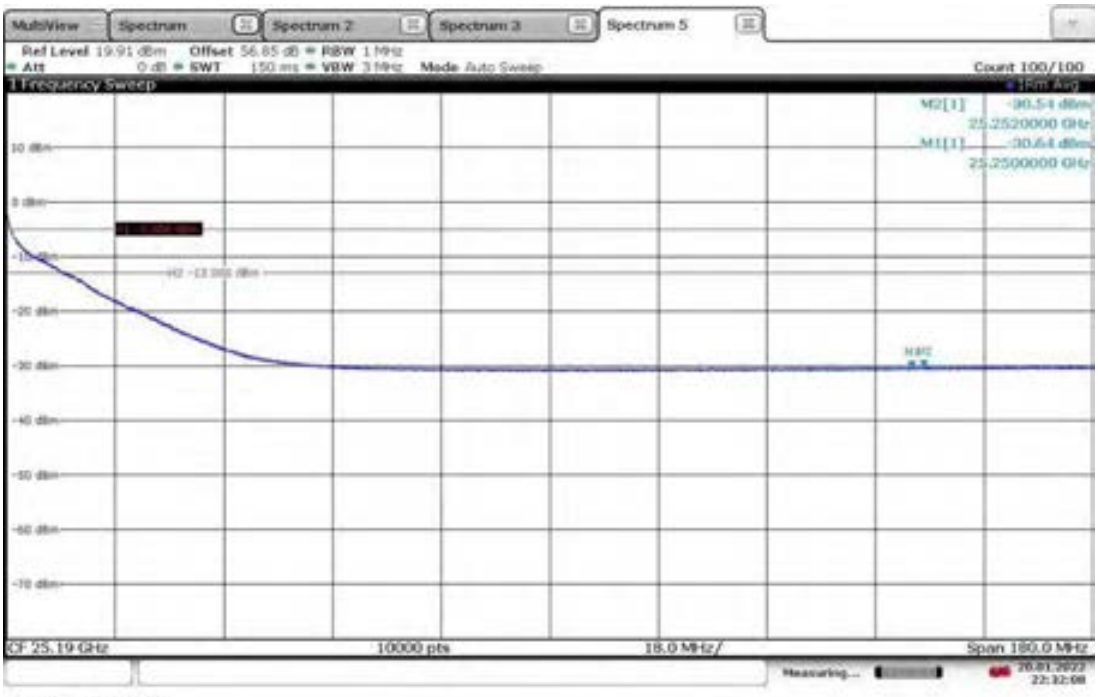
Authorized Band 24.75-25.25 GHz

Emission Mask (Vertical Polarity)– Titan 24X45, 20 MHz Bandwidth, Low Channel 24.77 GHz, Att12
Lower Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 1 to the left the limit is -13 dBm



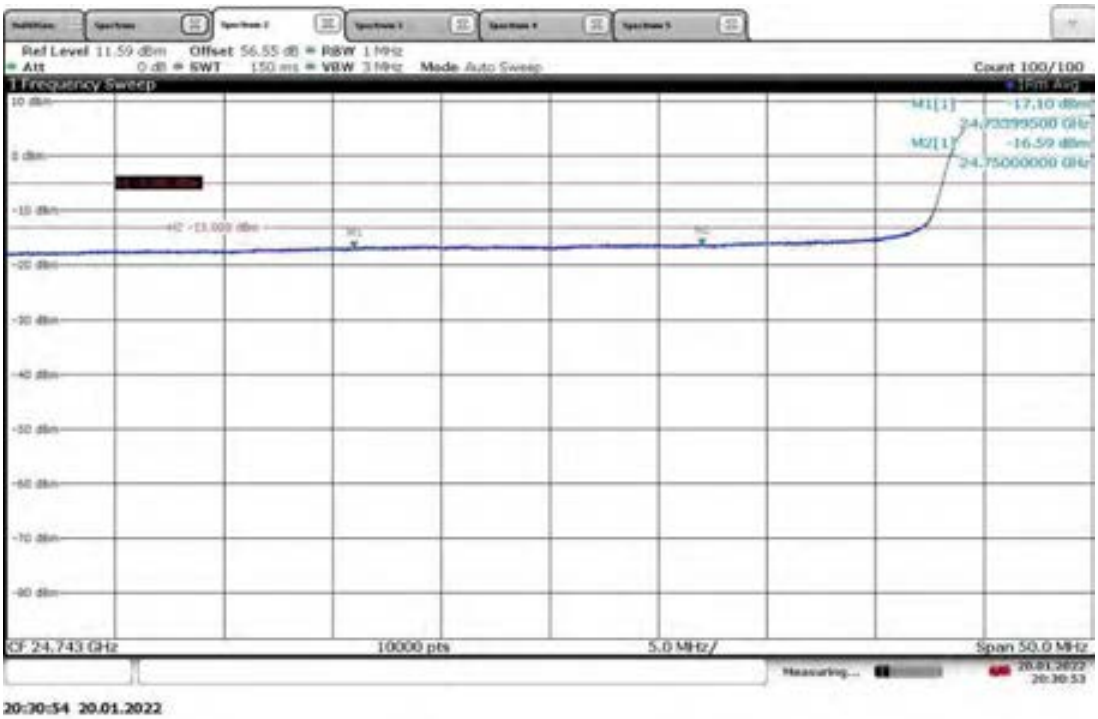
22:15:37 20.01.2022

Emission Mask (Vertical Polarity)– Titan 24X45, 20 MHz Bandwidth, High Channel 25.09 GHz, Att8
Upper Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 2 to the right the limit is -13 dBm

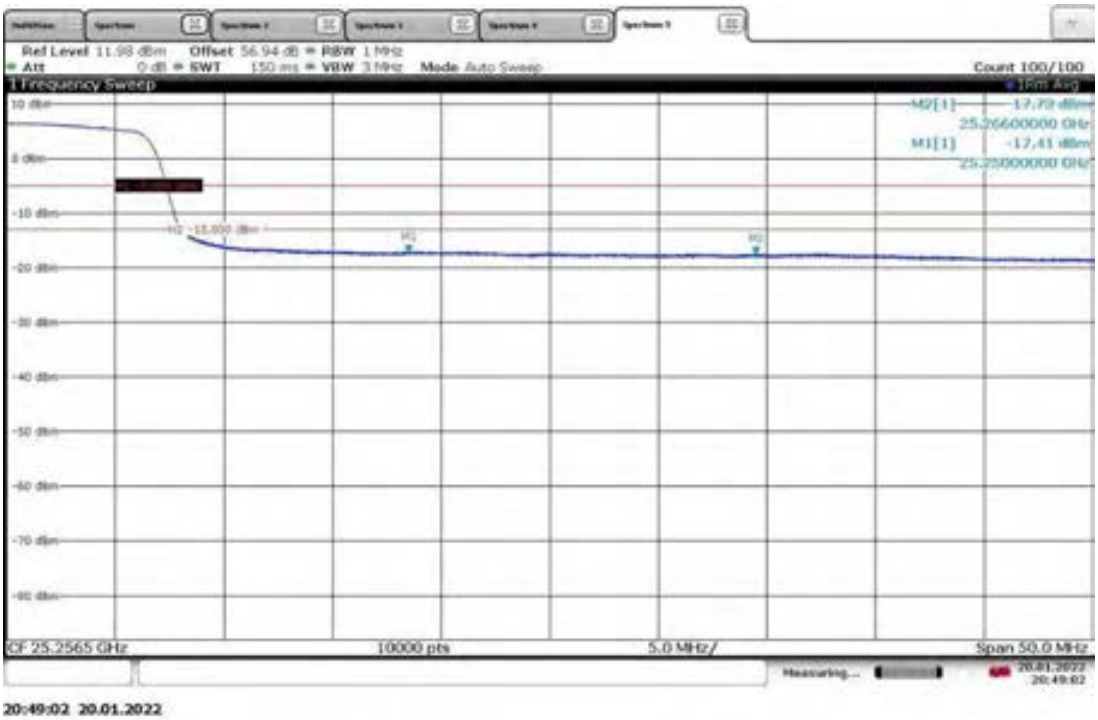


22:32:08 20.01.2022

Authorized Band 24.75-25.25 GHz
Emission Mask (Vertical Polarity)– Titan 24X45, 160 MHz Bandwidth, Low Channel 24.84 GHz, Att12
Lower Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 1 to the left the limit is -13 dBm



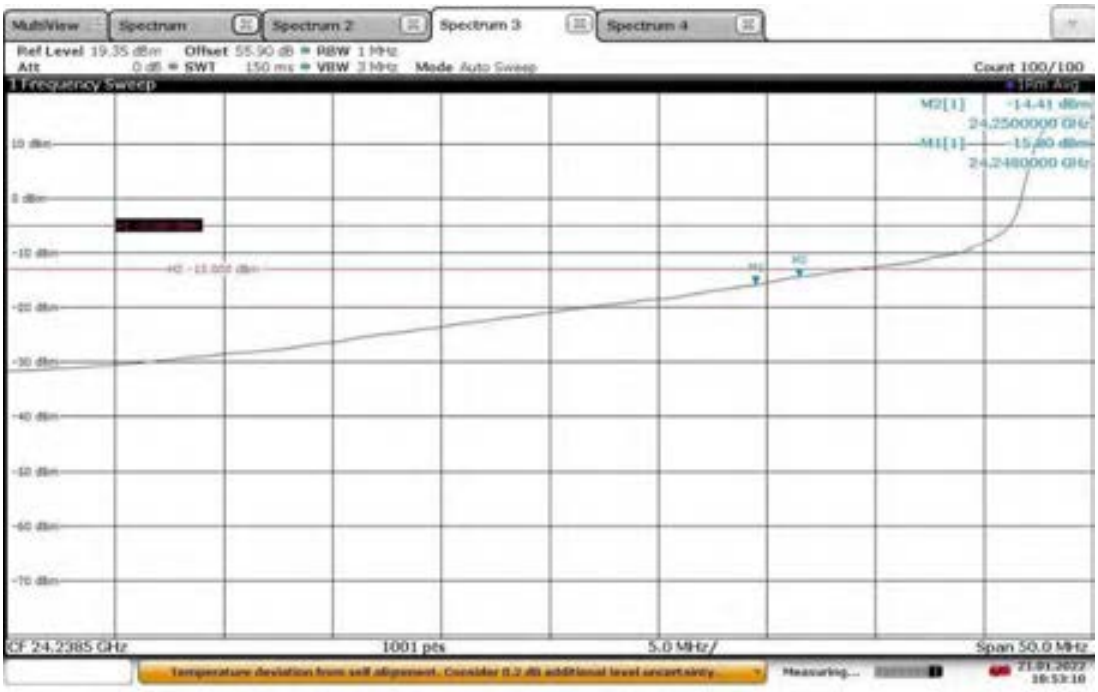
Emission Mask (Vertical Polarity)– Titan 24X45, 160 MHz Bandwidth, High Channel 25.16 GHz, Att9.5
Upper Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 2 to the right the limit is -13 dBm



Authorized Band 24.25-24.45 GHz

Emission Mask(Horizontal Polarity)– Titan 24X45, 20 MHz Bandwidth, Low Channel 24.27 GHz, Att10

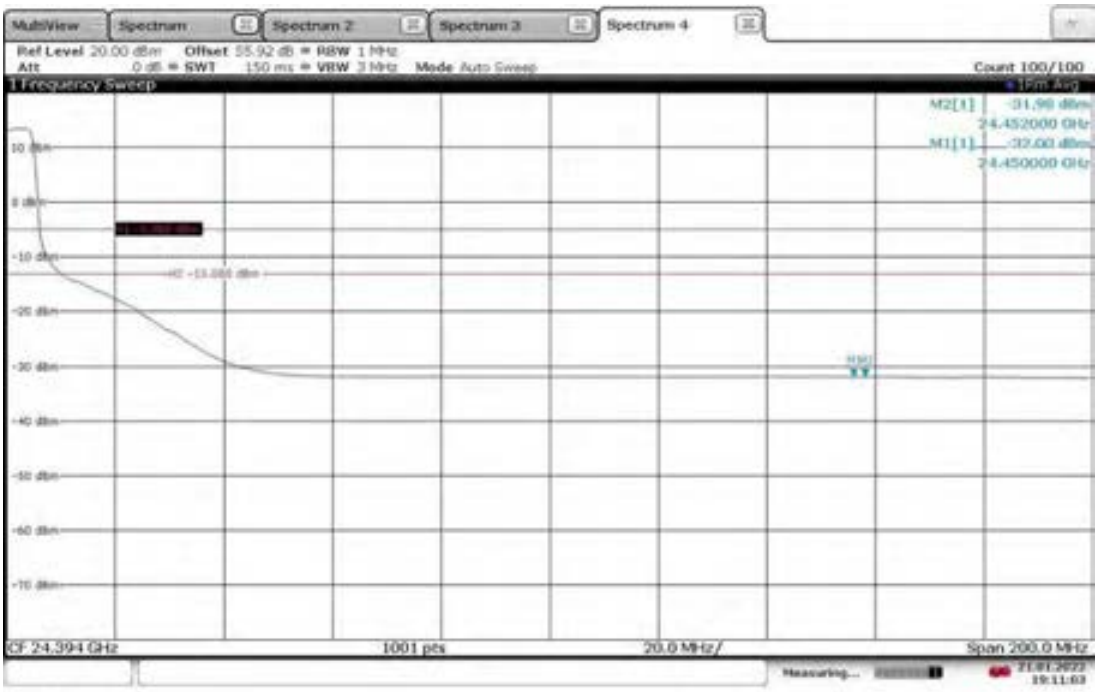
Lower Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 1 to the left the limit is -13 dBm



18:53:11 21.01.2022

Emission Mask(Horizontal Polarity)– Titan 24X45, 20 MHz Bandwidth, High Channel 24.29 GHz, Att0.0

Upper Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 2 to the right the limit is -13 dBm

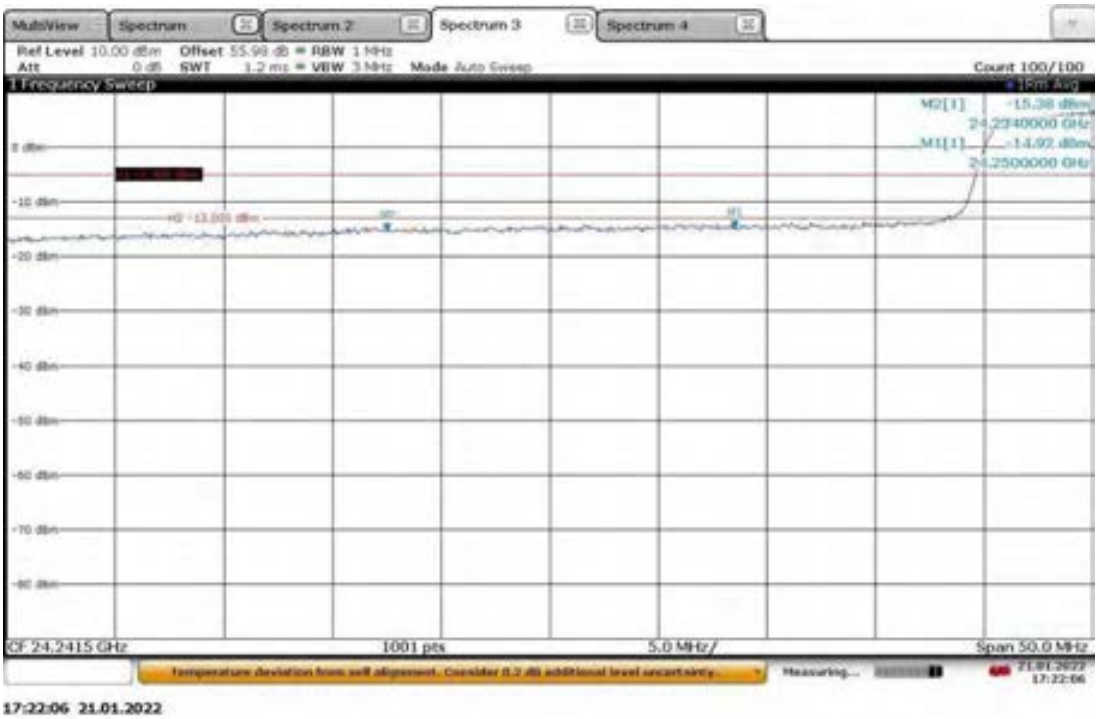


19:11:03 21.01.2022

Authorized Band 24.25-24.45 GHz

Emission Mask(Horizontal Polarity)– Titan 24X45, 160 MHz Bandwidth, Low Channel 24.34 GHz, Att10

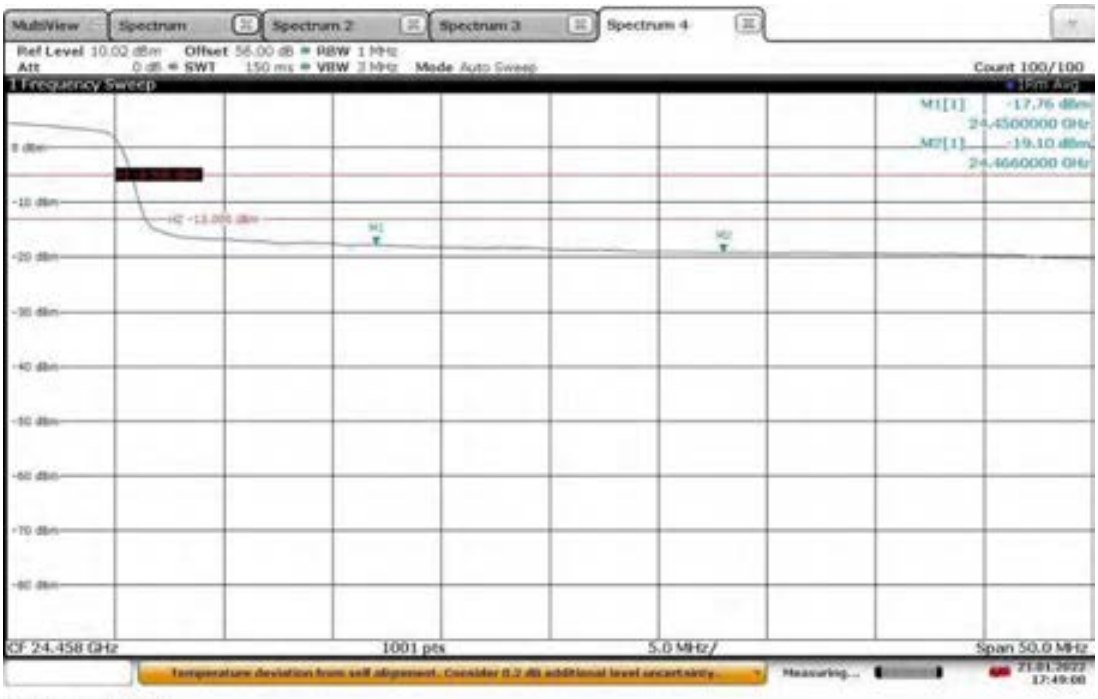
Lower Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 1 to the left the limit is -13 dBm



17:22:06 21.01.2022

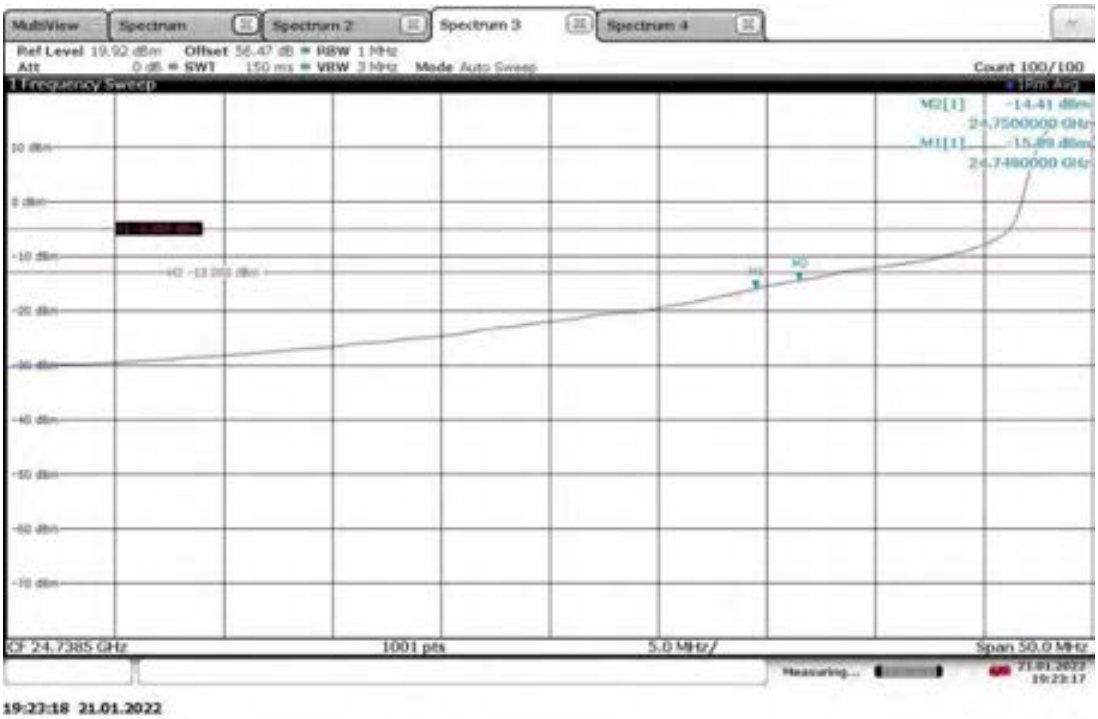
Emission Mask(Horizontal Polarity)– Titan 24X45, 160 MHz Bandwidth, High Channel 24.36 GHz, Att0.0

Upper Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 2 to the right the limit is -13 dBm

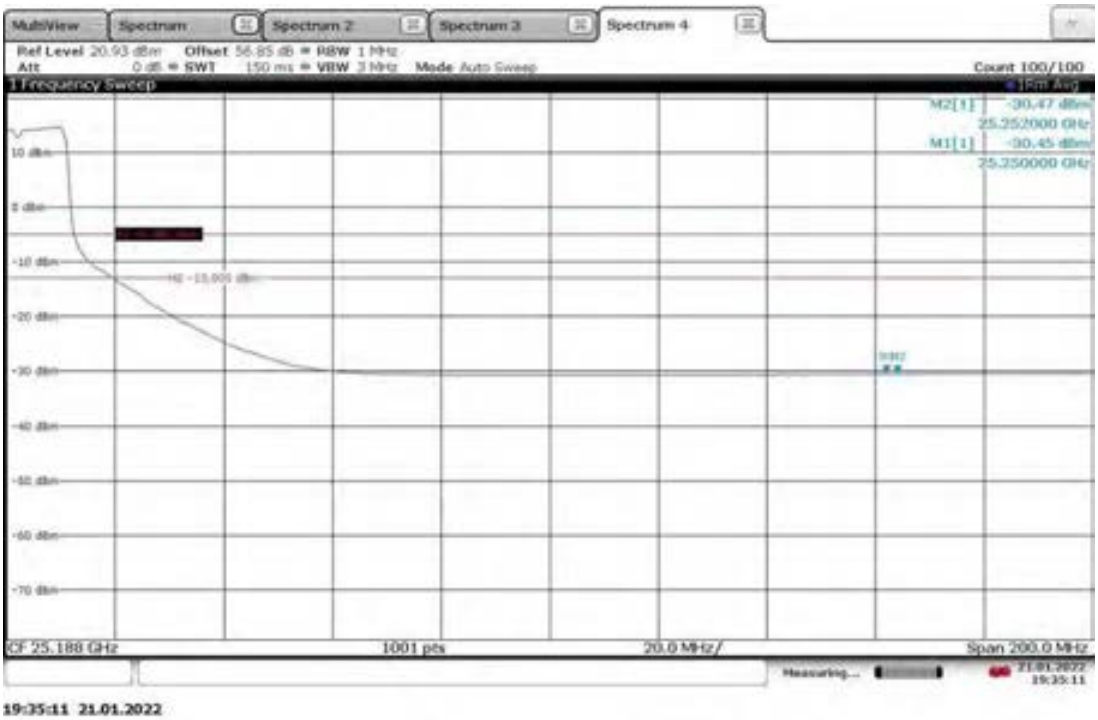


17:49:01 21.01.2022

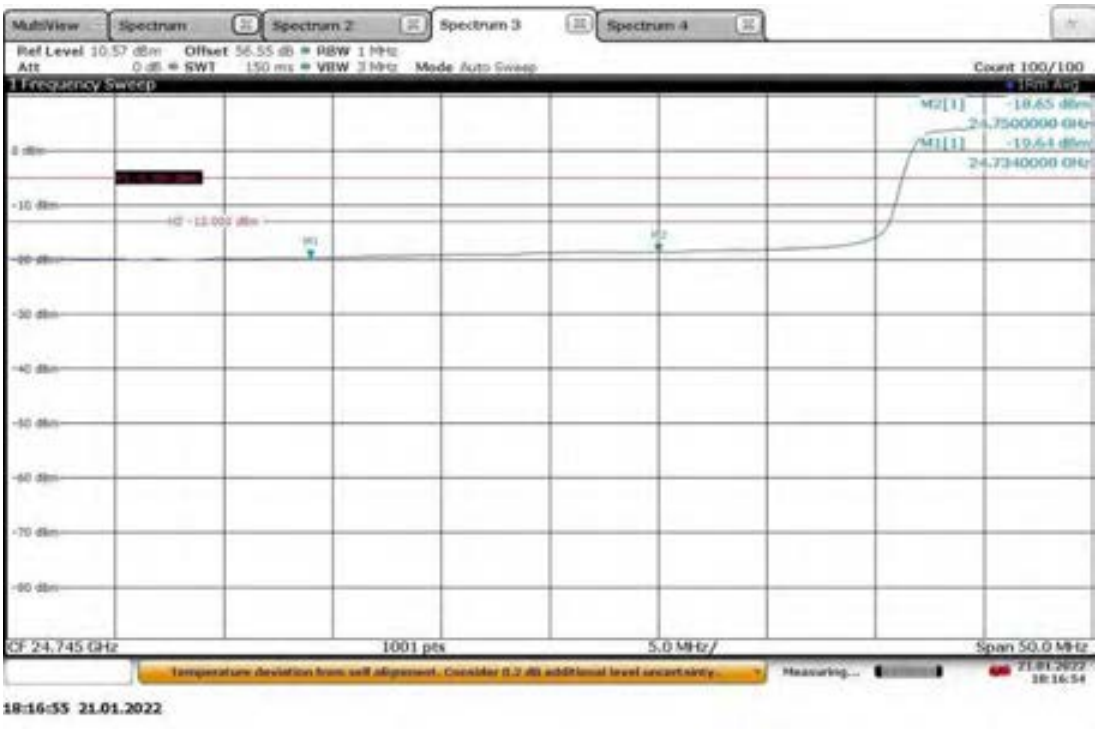
Authorized Band 24.75-25.25 GHz
Emission Mask(Horizontal Polarity)– Titan 24X45, 20 MHz Bandwidth, Low Channel 24.77 GHz, Att9
Lower Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 1 to the left the limit is -13 dBm



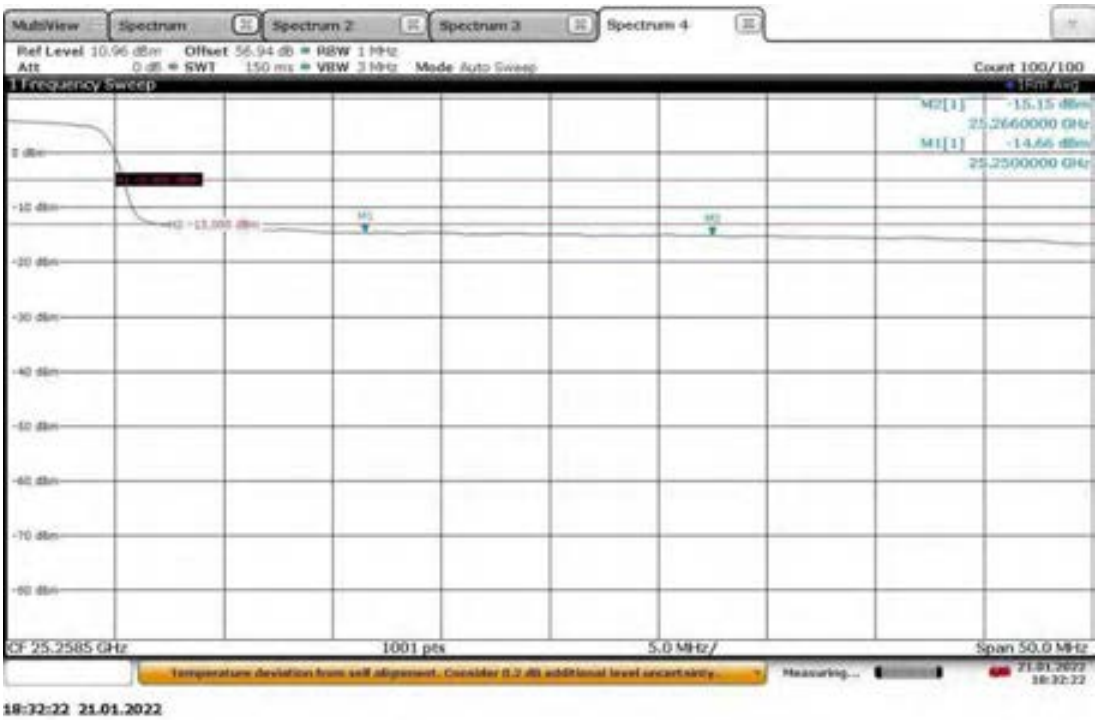
Emission Mask(Horizontal Polarity)– Titan 24X45, 20 MHz Bandwidth, High Channel 25.09 GHz, Att7.5
Upper Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 2 to the right the limit is -13 dBm



Authorized Band 24.75-25.25 GHz
Emission Mask(Horizontal Polarity)– Titan 24X45, 160 MHz Bandwidth, Low Channel 24.84 GHz, Att10.5
Lower Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 1 to the left the limit is -13 dBm



Emission Mask(Horizontal Polarity)– Titan 24X45, 160 MHz Bandwidth, High Channel 24.16 GHz, Att8
Upper Edge – From Mark 1 to Mark 2 the limit is -5 dBm and outside of Mark 2 to the right the limit is -13 dBm



Test Personnel:	Kouma Sinn	Test Date:	01/20/2022, 01/21/2022
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	FCC 47CFR Part 30 Subpart C	Limit Applied:	See Report Section 7.1
Input Voltage:	48 VDC Via External P/S	Ambient Temperature:	24, 24 ºC
Pretest Verification w/ BB Source:	**Yes**	Relative Humidity:	13, 9 %
		Atmospheric Pressure:	1018, 1025 mbars

Deviations, Additions, or Exclusions: None

8 Radiated Spurious Emissions

8.1 Requirements

FCC §30.203 Emission limits.

(c) The conductive power or the total radiated power of any emission outside a licensee's frequency block shall be −13 dBm/MHz or lower. However, in the bands immediately outside and adjacent to the licensee's frequency block, having a bandwidth equal to 10 percent of the channel bandwidth, the conductive power or the total radiated power of any emission shall be −5 dBm/MHz or lower.

(d)

(4) Compliance with this provision is based on the use of measurement instrumentation employing a resolution bandwidth of 1 megahertz or greater.

(5) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the licensee's frequency block edges as the design permits.

(6) The measurements of emission power can be expressed in peak or average values

8.2 Method

Tests are performed in accordance with FCC 47CFR Part 30 Subpart C, KDB 842590 D01 v01r02 Subclause 4.4.3. From 9 kHz-1000 MHz testing was performed manually and from 1-13 GHz measurements were made using the BAT-EMC automated software. From 13-100 GHz measurement was made manually at 3 meters with test antenna and EUT fixed at 1.5 meters high. The EUT was rotated from 0 to 360 degrees to find the worst-case emissions.

TEST SITE: 10m ALSE

The 10m ALSE is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A Styrofoam table 80 cm high is used for table-top equipment.

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)
Radiated Emissions, 10m	30-1000 MHz	5.0 dB
Radiated Emissions, 3m	30-1000 MHz	4.6 dB
Radiated Emissions, 3m	1-6 GHz	4.9 dB
Radiated Emissions, 3m	6-15 GHz	5.1 dB
Radiated Emissions, 3m	15-18 GHz	4.7 dB
Radiated Emissions, 3m	18-40 GHz	4.7 dB

Sample Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF - AG
Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

Assume a receiver reading of 52.0 dBμV is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dBμV/m. This value in dBμV/m was converted to its corresponding level in μV/m.

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

To convert from dBμV to μV or mV the following was used:

$UF = 10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

Example:

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
$UF = 10^{(32\ dB\mu V / 20)}$ = 39.8 μV/m

Alternately, when BAT-EMC Emission Software is used, the “Level” includes all losses and gains and is compared directly in the “Margin” column to the “Limit”. The “Correction” includes Antenna Factor, Preamp, and Cable Loss. These are already accounted for in the “Level” column.

8.3 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV007'	Weather Station Vantage Vue	Davis	6250	MS191212003	03/20/2021	03/20/2022
145108'	EMI Test Receiver (20Hz - 40GHz)	Rohde & Schwarz	ESIB40	100209	06/22/2021	06/22/2022
145-414'	Cables 145-400 145-403 145-405 145-409	Huber + Suhner	3m Track A cables	multiple	07/09/2021	07/09/2022
145-420'	Receiver to floor cable	Utiflex	UFB311A-2-0591-70070	145-420	02/17/2021	02/17/2022
145-422'	10Amp Pre-amp to under floor	Utiflex	UFB311A-0-2756-70070	145-422	02/17/2021	02/17/2022
IW003'	8.4 meter cable	Insulated Wire	2800-NPS	003	10/152021	10/15/2022
ETS002'	1-18GHz DRG Horn Antenna	ETS Lindgren	3117	00143260	08/24/2021	08/24/2022
REA007'	Band reject filter--5500MHz reject	Reactel, Inc	20R2-5500-X1000-S11	17-01	07/28/2021	07/28/2022
REA001'	6.0GHz High Pass Filter	Reactel, Inc	11HS-6G/18G-S11	06-1	02/19/2021	02/19/2022
PRE12'	Pre-amplifier	Com Power	PAM-118A	18040117	12/27/2021	12/27/2022
CBLHF2012-5M-2'	5m 9kHz-40GHz Coaxial Cable - SET2	Huber & Suhner	SF102	252676002	02/19/2021	02/19/2022
CBLHF2012-2M-2'	2m 9kHz-40GHz Coaxial Cable - SET2	Huber & Suhner	SF102	252675002	02/10/2021	02/10/2022
PRE8'	PREAMPLFIER 1- 40 GHz	MITEQ	NSP4000-NF	507145	12/06/2021	12/06/2022
ROS005-1'	Signal and Spectrum Analyzer	Rohde and Shwartz	FSW43	100646	11/02/2021	11/02/2022
EMC04'	ANTENNA, RIDGED GUIDE, 18-40 GHZ	EMCO	3116	2090	01/28/2021	01/28/2022*
TES004'	Compact Immunity Test System	Teseq	NSG 4070A-75	34295	06/29/2021	06/29/2022
145108'	EMI Test Receiver (20Hz - 40GHz)	Rohde & Schwarz	ESIB40	100209	06/22/2021	06/22/2022
145145'	Broadband Hybrid Antenna 30 MHz - 3 GHz	Sunol Sciences Corp.	JB3	A122313	06/09/2021	06/09/2022
PRE10'	30-1000MHz pre-amp	ITS	PRE10	PRE10	02/17/2021	02/17/2022
145-420'	Receiver to floor cable	Utiflex	UFB311A-2-0591-70070	145-420	02/17/2021	02/17/2022
145-424'	9kHz to 40GHz Cable	Huber and Suhner	Sucoflex	145-424	02/17/2021	02/17/2022
IW001'	2 meter cable	Insulated Wire	2801-NPS	001	09/23/2021	09/23/2022
HS003'	10m under floor cable	Huber-Schuner	10m-1	HS003	02/17/2021	02/17/2022
--	40-60 GHz External Mixer	Virginia Diodes, Inc.	VDIWR19.OSAX-F	See Report Section 12	See Report Section 12	See Report Section 12
--	60-90 GHz External Mixer	Virginia Diodes, Inc.	VDIWR12.OSAX-F	See Report Section 12	See Report Section 12	See Report Section 12
--	90-140 GHz External Mixer	Virginia Diodes, Inc.	VDIWR8.OSAX-F	See Report Section 12	See Report Section 12	See Report Section 12

*Antenna used prior to 01/28/2022. Antenna TES004 was used after 01/28/2022.

Software Utilized:

Name	Manufacturer	Version
BAT-EMC	Nexio	3.18.0.16
EMI Boxborough.xls	Intertek	08/27/2010

8.4 Results:

The sample tested was found to Comply.

8.5 Setup Photographs:

Setup Photographs are included in a separate file.

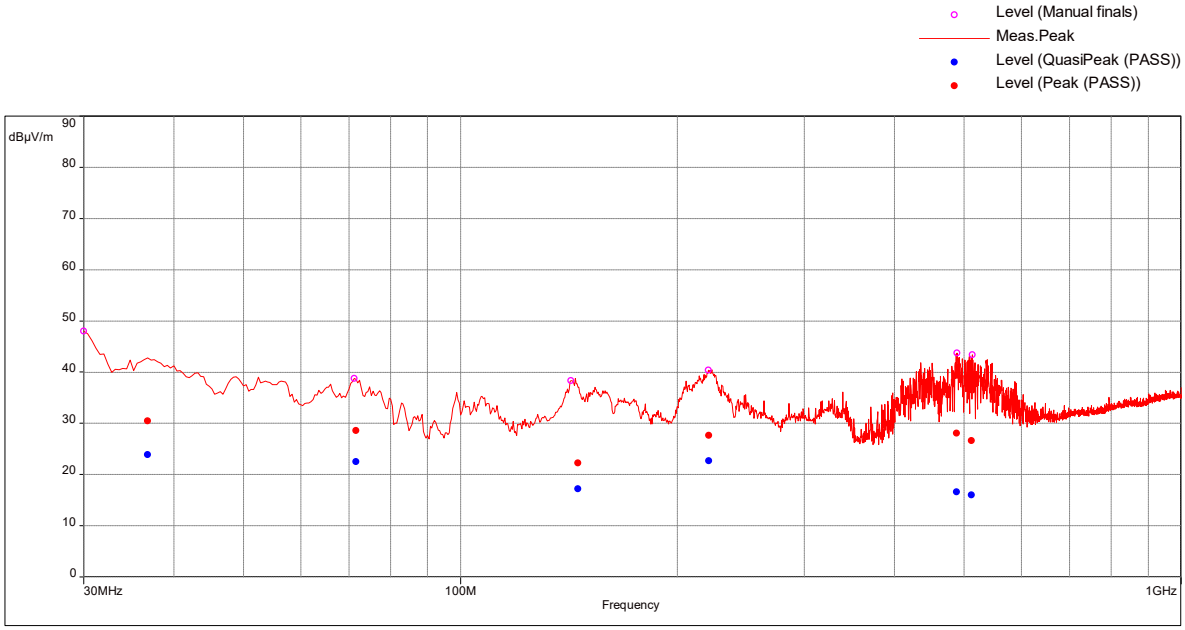
8.6 Plots/Data:

Transmit 24.34 GHz, RE 30-1000 MHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0

Test Information:

Date and Time	2/1/2022 1:18:28 PM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	24 C
Humidity	9 %
Atmospheric Pressure	1026 mbar
Comments	Scan 1a: Transmit 24.34, 160 MHz, MCS0, Tx Path 3, Att 10.0, RE 30-1000 MHz SA mode

Graph:



Results:

Peak Level – Manual scan with 1 MHz RBW using Maxhold detector

Frequency (MHz)	Peak Level (dBµV/m)	EIRP (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
36.71052632	46.56	-38.24	-13.00	-25.24	242.00	2.29	Vertical	1000000.00	-16.91
71.72631579	41.16	-43.64	-13.00	-30.64	97.00	2.43	Vertical	1000000.00	-24.80
145.5578947	37.40	-47.40	-13.00	-34.40	249.00	1.68	Vertical	1000000.00	-19.29
221.0631579	43.50	-41.30	-13.00	-28.30	257.00	1.00	Vertical	1000000.00	-20.70
487.8736842	47.18	-37.62	-13.00	-24.62	0.00	1.00	Vertical	1000000.00	-12.82
511.6210526	49.30	-35.50	-13.00	-22.50	215.00	1.00	Vertical	1000000.00	-12.83

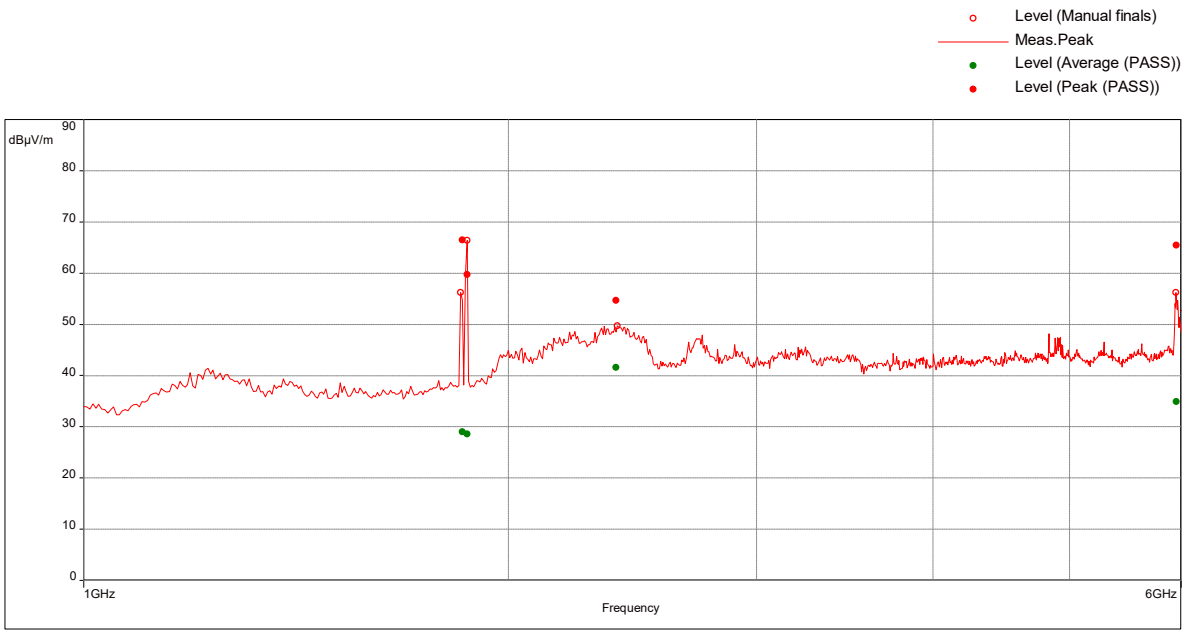
Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 24.34 GHz, RE 1-6 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0

Test Information:

Date and Time	2/2/2022 9:57:16 AM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	25 C
Humidity	16 %
Atmospheric Pressure	1022 mbar
Comments	Scan 7: Transmit 24.34 GHz, 160 MHz, MCS0, Tx Path 3, Att 10, RE 1-6 GHz SA mode

Graph:



Results:

Peak EIRP

Frequency (MHz)	Peak Level (dBµV/m)	EIRP Level (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
1852.631579	66.48	-28.72	-13	-15.72	242.00	1.00	Vertical	1000000.00	-4.13
1869.210526	59.71	-35.49	-13	-22.49	4.00	1.02	Vertical	1000000.00	-3.96
2386.315789	54.67	-40.53	-13	-27.53	22.00	2.10	Horizontal	1000000.00	-2.62
5953.947368	65.42	-29.78	-13	-16.78	338.00	1.11	Horizontal	1000000.00	5.32

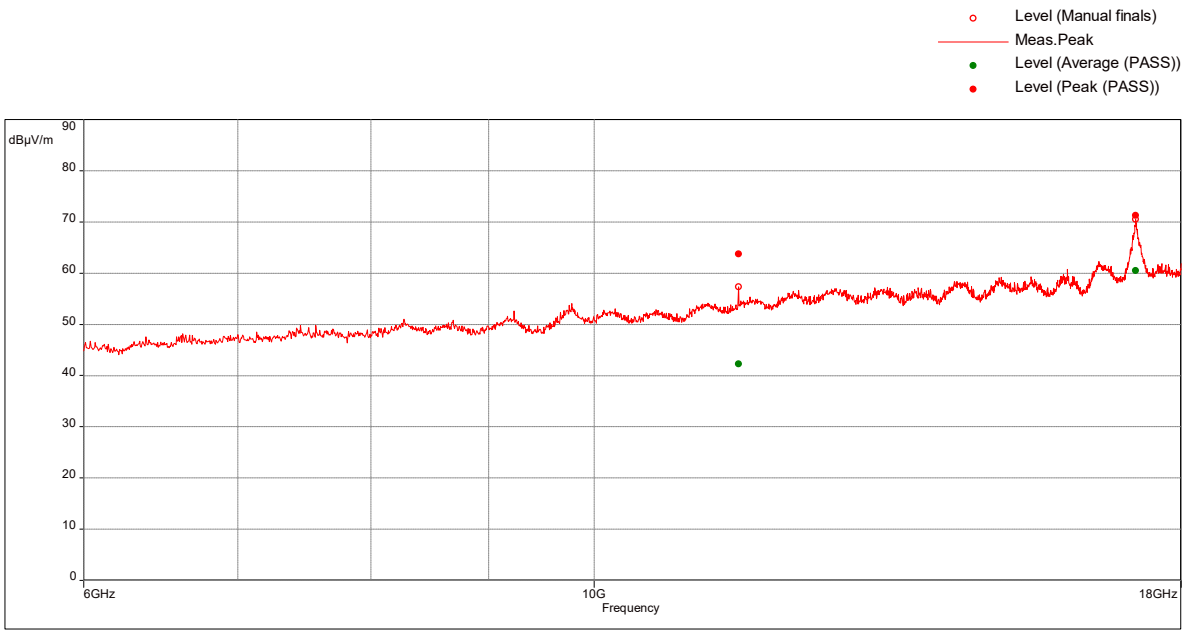
Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 24.34 GHz, RE 6-18 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0

Test Information:

Date and Time	2/2/2022 10:03:59 AM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	25 C
Humidity	16 %
Atmospheric Pressure	1022 mbar
Comments	Scan 8: Transmit 24.34 GHz, 160 MHz, MCS0, Tx Path 3, Att 10, RE 6-18 GHz SA mode

Graph:



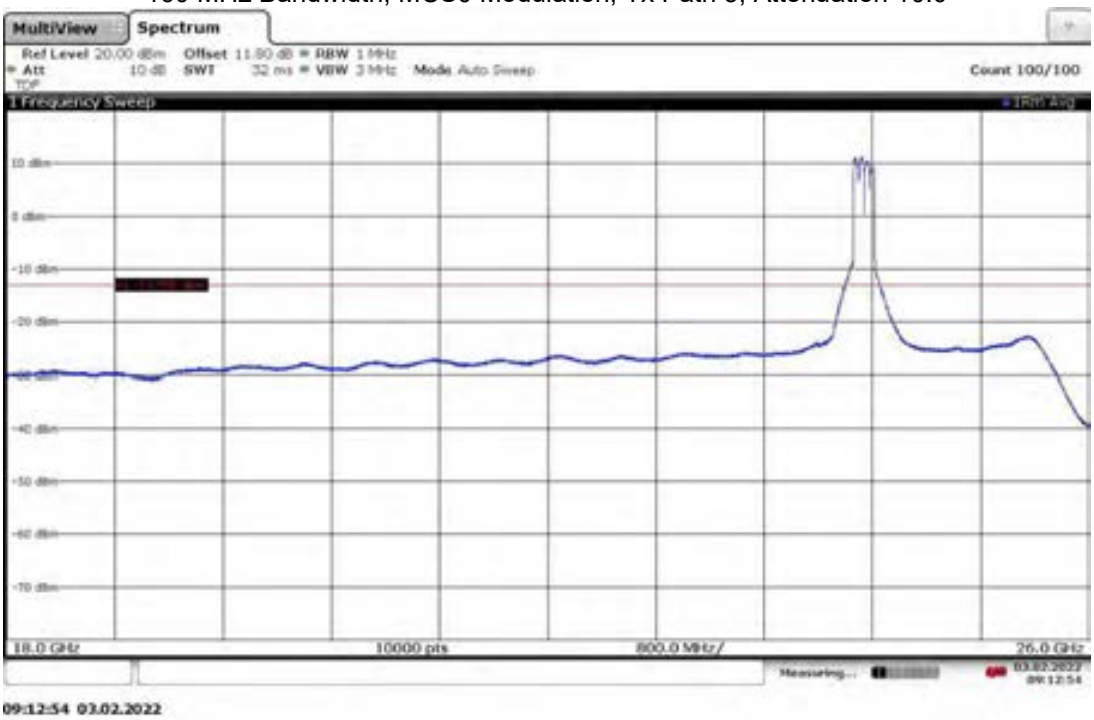
Results:

Peak EIRP

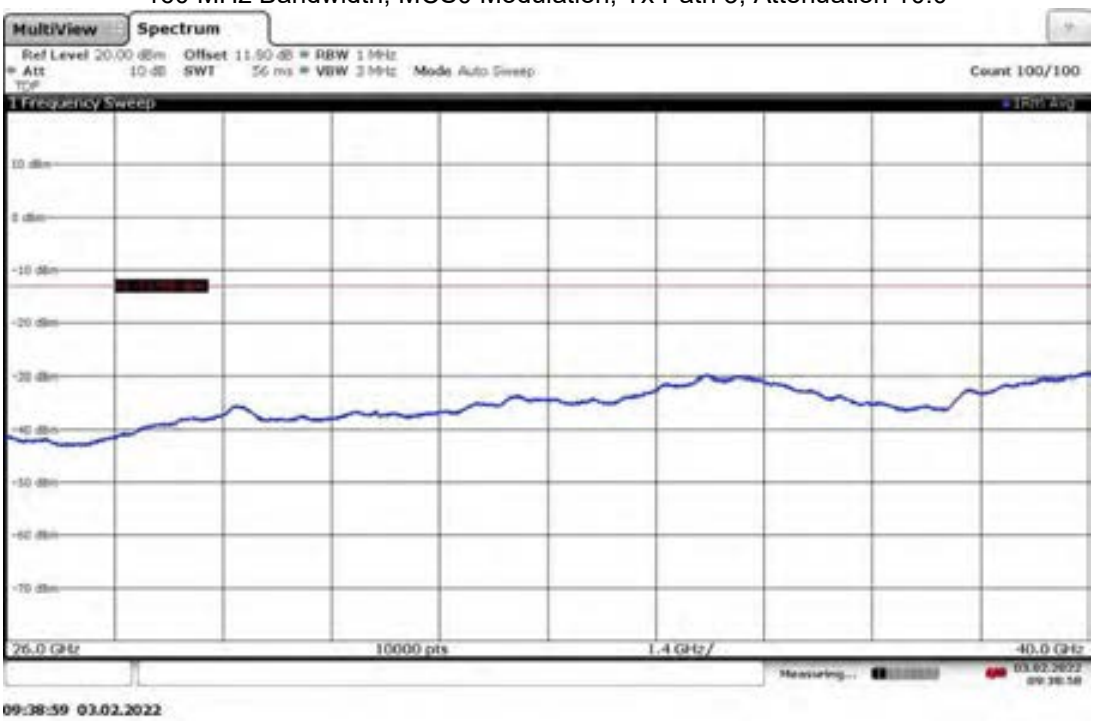
Frequency (MHz)	Peak Level (dBµV/m)	EIRP Level (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
11559.21053	63.78	-31.42	-13	-18.42	358.00	1.11	Horizontal	1000000.00	14.39
17200.26316	71.30	-23.9	-13	-10.9	118.00	1.06	Vertical	1000000.00	34.36

Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 24.34 GHz, RE 18-26 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0

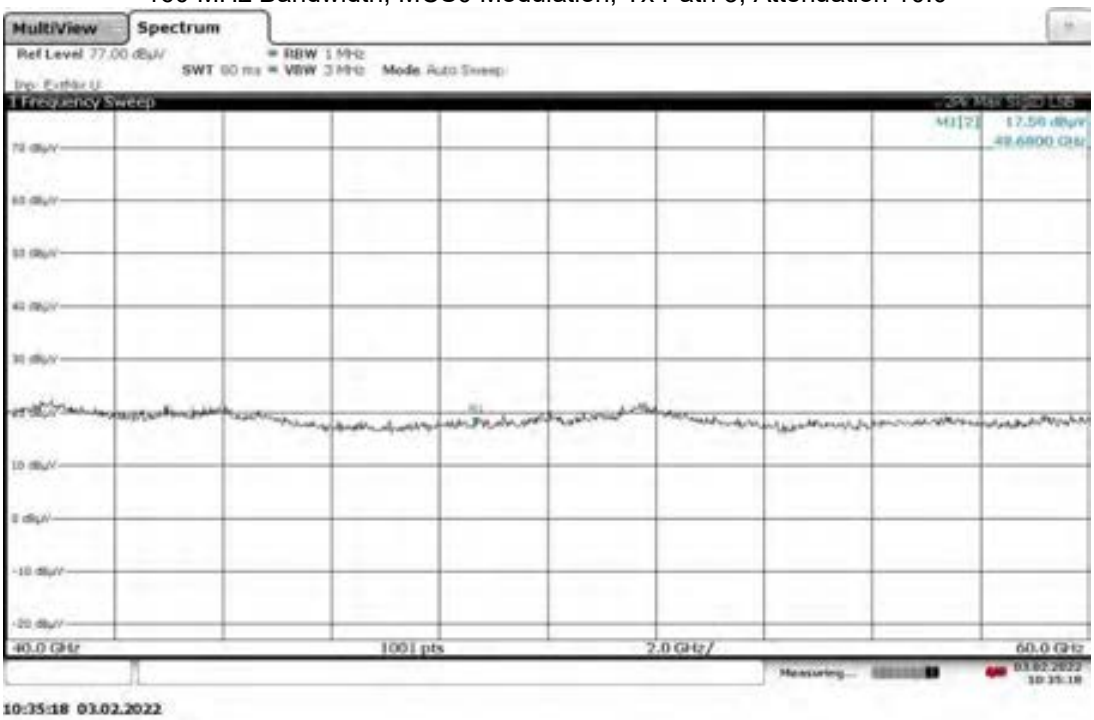


Transmit 24.34 GHz, RE 26-40 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0

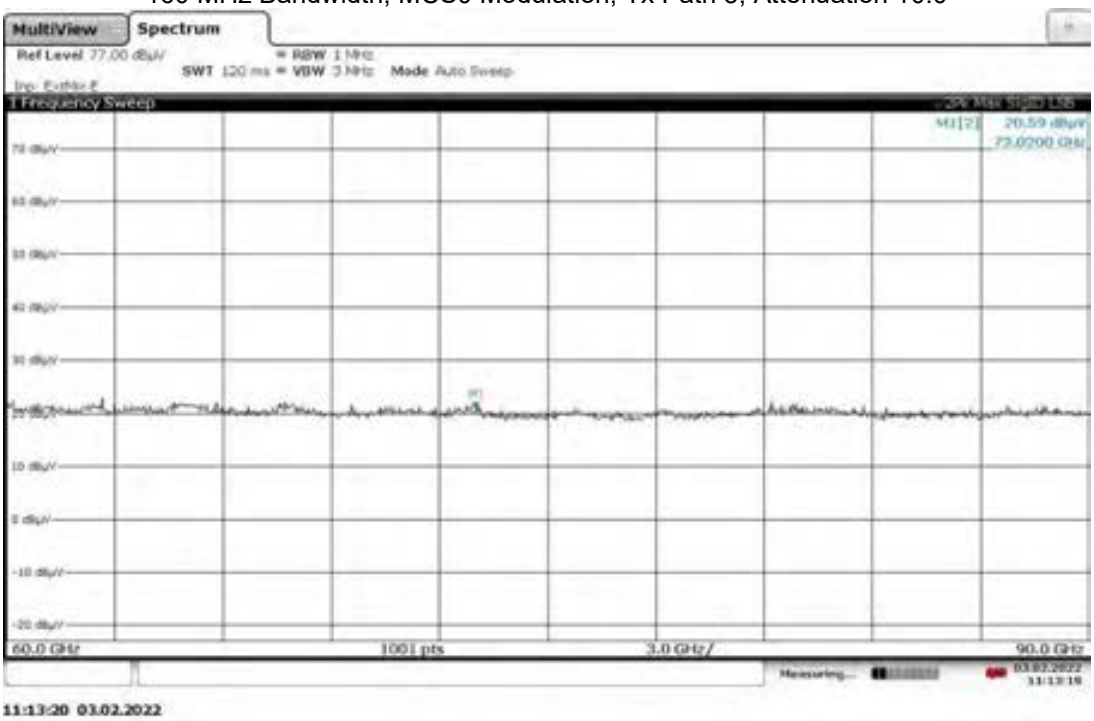


Notes: RMS Average detector was used. The cable loss, antenna factor, and pre-amp were compensated internally as transducer factor. The dB off-set of 11.8 dB was used for path loss of - 95.2 dB and 107 dB to covert the reading to dBm on the receiver.

Transmit 24.34 GHz, RE 40-60 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0

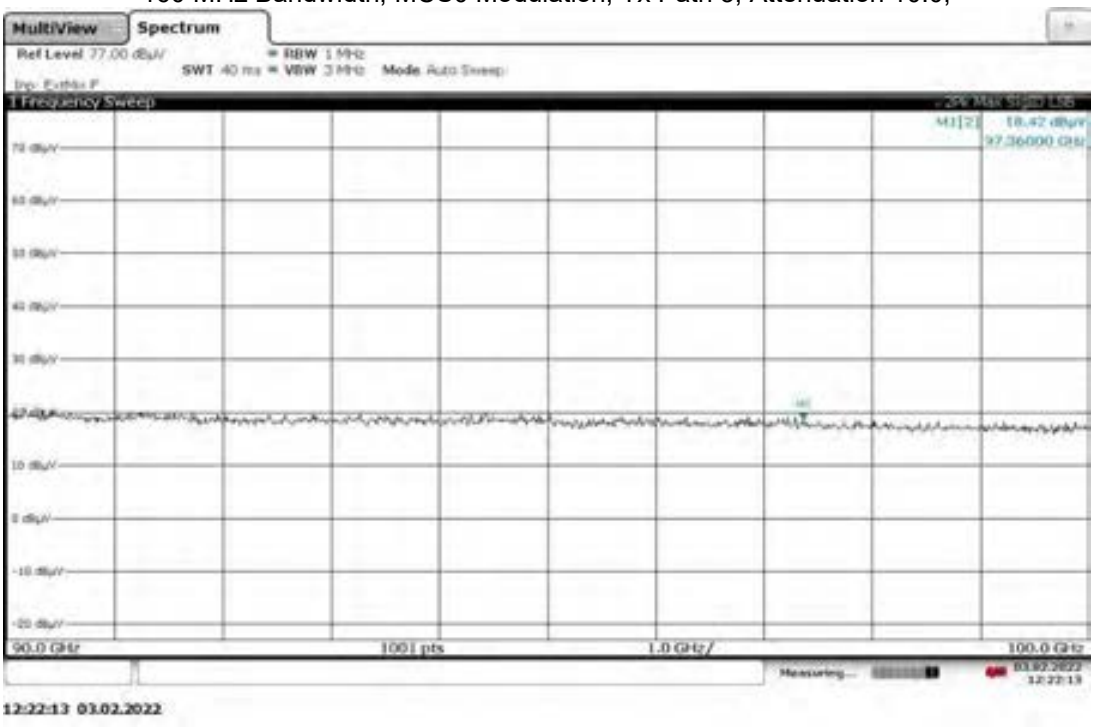


Transmit 24.34 GHz, RE 60-90 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0



Notes: Peak detector was used. No emission was detected above the instrument noise floor.

Transmit 24.34 GHz, RE 90-100 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0,



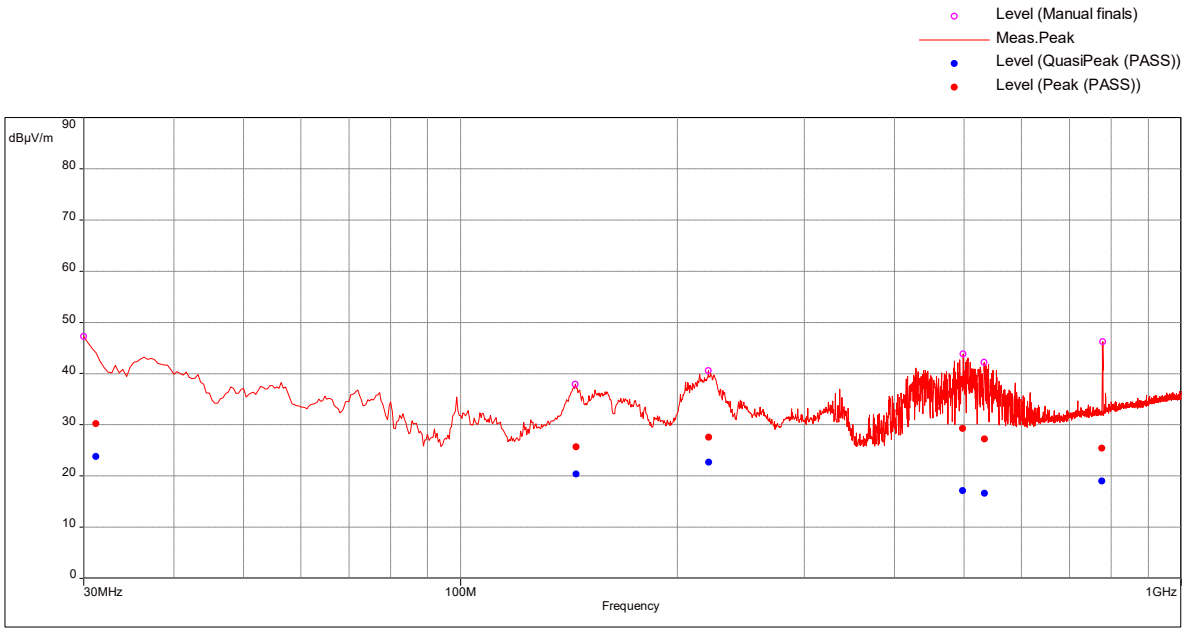
Notes: Peak detector was used. No emission was detected above the instrument noise floor.

Transmit 24.35 GHz, RE 30-1000 MHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0

Test Information:

Date and Time	2/1/2022 12:41:08 PM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	24 C
Humidity	9 %
Atmospheric Pressure	1026 mbar
Comments	Scan 2a: Transmit 24.35, 160 MHz, MCS0, Tx Path 3, Att 10.0, RE 30-1000 MHz SA mode

Graph:



Results:

Peak Level – Manual scan with 1 MHz RBW using Maxhold detector

Frequency (MHz)	Peak Level (dBµV/m)	EIRP (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
31.31578947	41.22	-43.58	-13	-30.58	75.00	1.46	Vertical	1000000.00	-13.33
144.6631579	39.29	-45.51	-13	-32.51	287.00	1.35	Vertical	1000000.00	-19.20
221.3263158	43.56	-41.24	-13	-28.24	265.00	1.00	Vertical	1000000.00	-20.73
497.6105263	47.09	-37.71	-13	-24.71	0.00	1.00	Vertical	1000000.00	-12.83
533.8526316	49.59	-35.21	-13	-22.21	212.00	1.00	Vertical	1000000.00	-12.33
776.5578947	31.92	-52.88	-13	-39.88	74.00	1.00	Vertical	1000000.00	-8.41

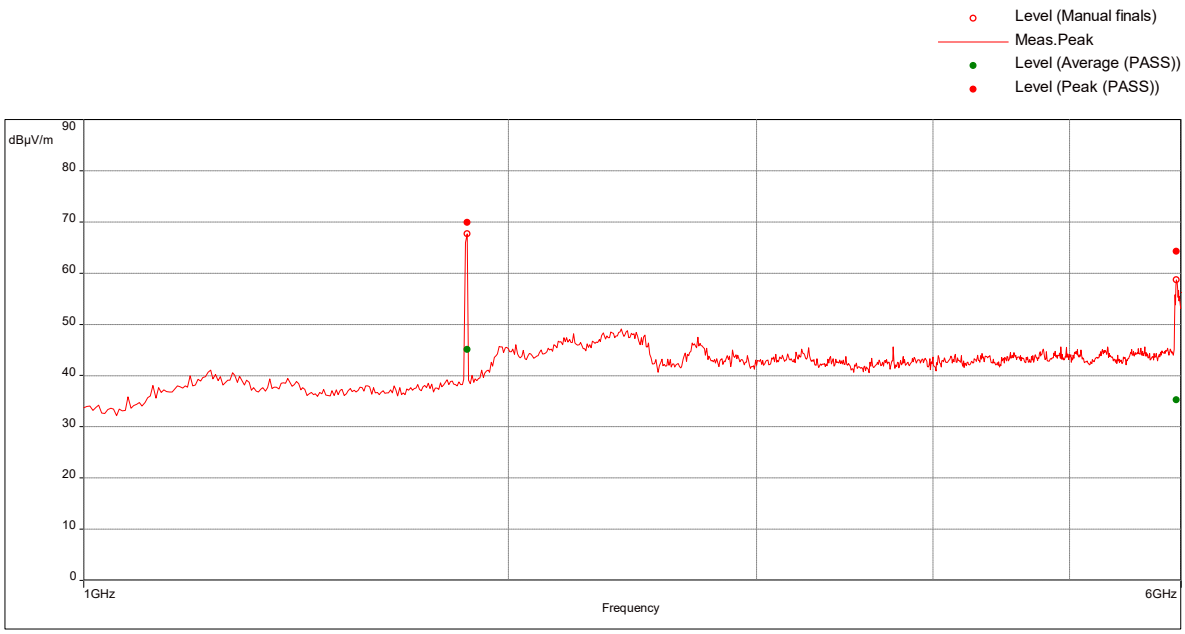
Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 24.35 GHz, RE 1-6 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0

Test Information:

Date and Time	2/2/2022 10:38:53 AM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	25 C
Humidity	16 %
Atmospheric Pressure	1022 mbar
Comments	Scan 10: Transmit 24.35 GHz, 160 MHz, MCS0, Tx Path 3, Att 10, RE 1-6 GHz SA mode

Graph:



Results:

Peak EIRP

Frequency (MHz)	Peak Level (dBµV/m)	EIRP Level (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
1867.894737	69.89	-25.31	-13	-12.31	46.00	1.20	Vertical	1000000.00	-3.98
5953.947368	64.27	-30.93	-13	-17.93	9.00	1.30	Horizontal	1000000.00	5.32

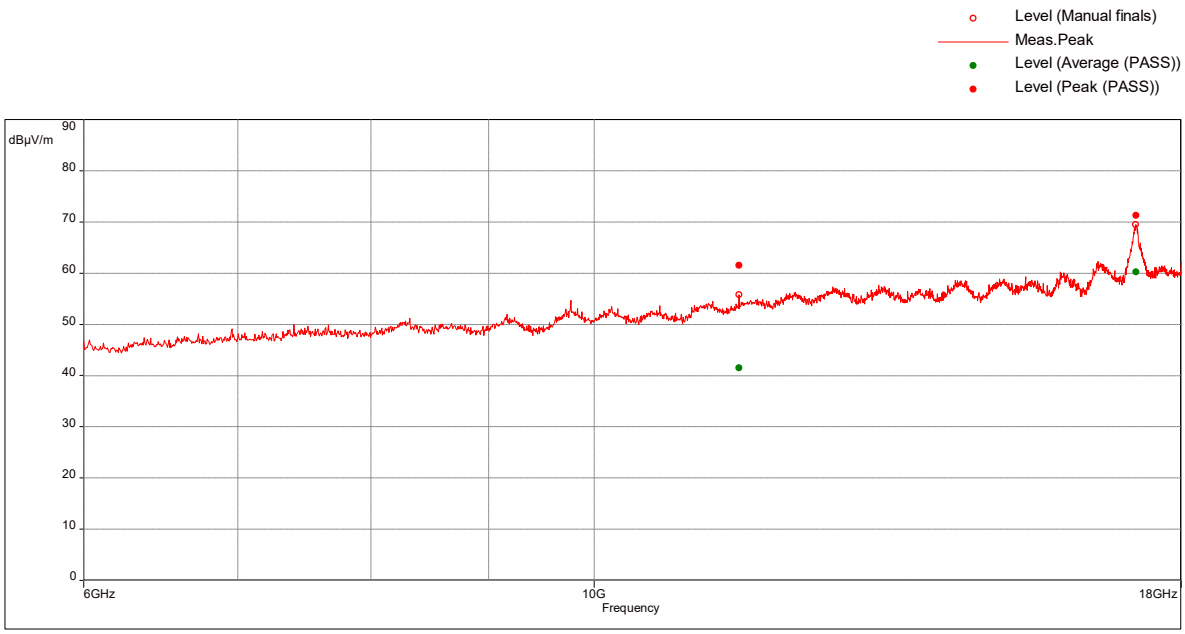
Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 24.35 GHz, RE 6-18 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0

Test Information:

Date and Time	2/2/2022 10:20:35 AM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	25 C
Humidity	16 %
Atmospheric Pressure	1022 mbar
Comments	Scan 9: Transmit 24.35 GHz, 160 MHz, MCS0, Tx Path 3, Att 10, RE 6-18 GHz SA mode

Graph:



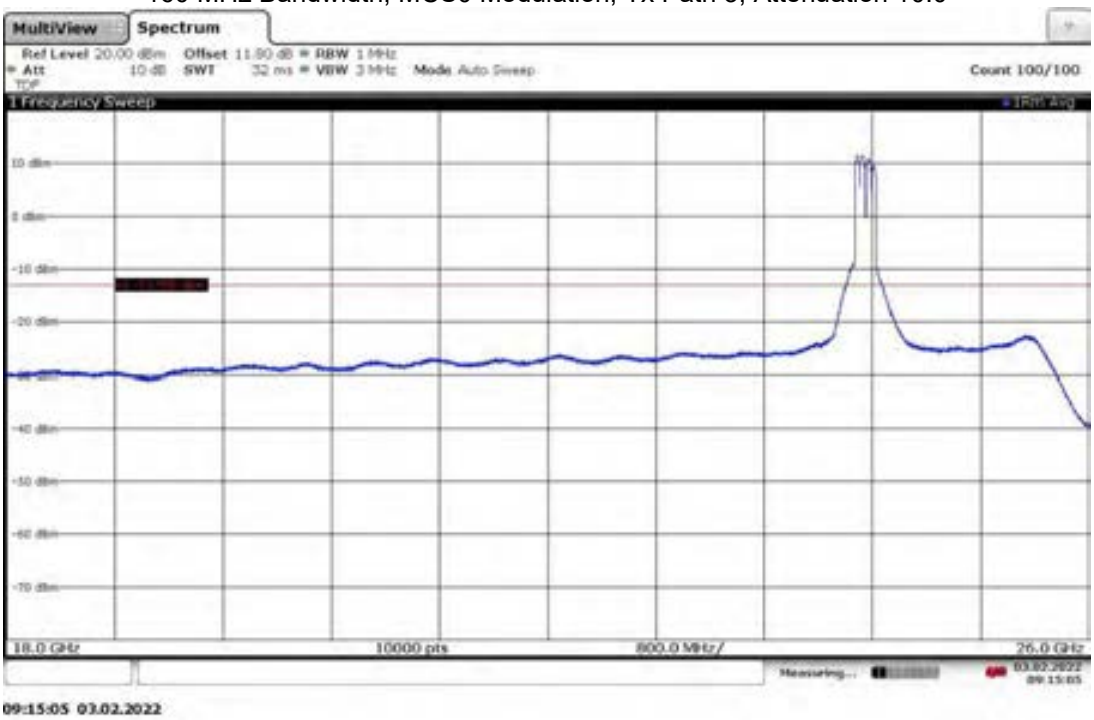
Results:

Peak EIRP

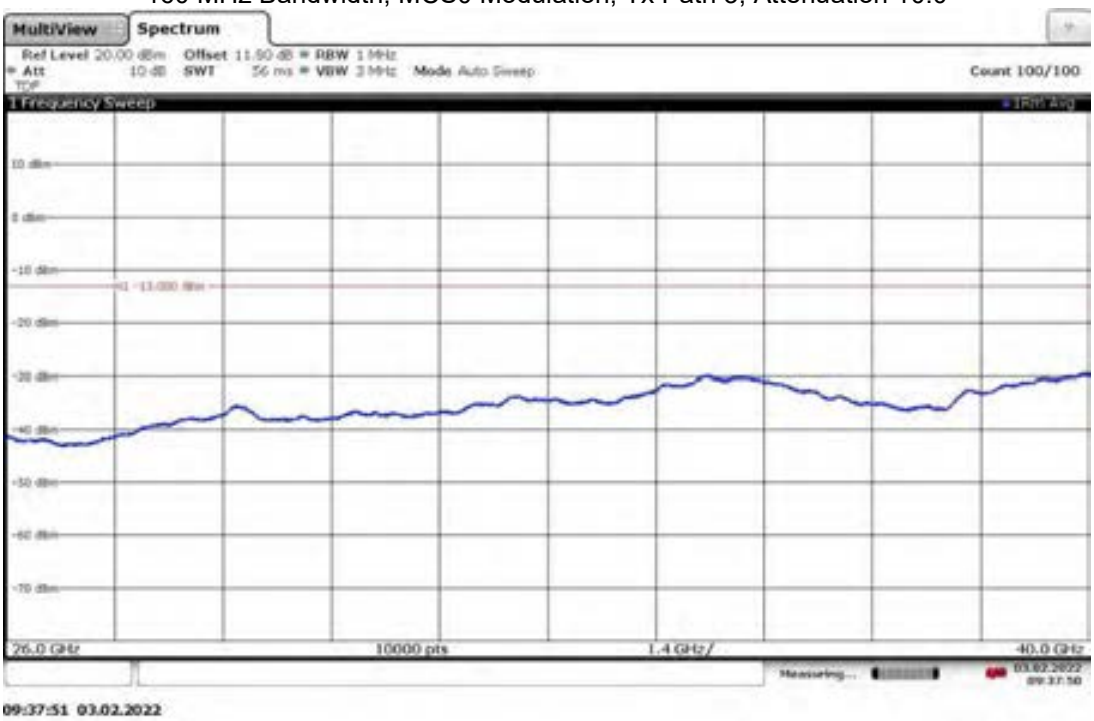
Frequency (MHz)	Peak Level (dBµV/m)	EIRP Level (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
11567.10526	61.50	-33.7	-13	-20.7	343.00	1.45	Vertical	1000000.00	14.42
17203.94737	71.29	-23.91	-13	-10.91	248.00	3.00	Horizontal	1000000.00	34.09

Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 24.35 GHz, RE 18-26 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0

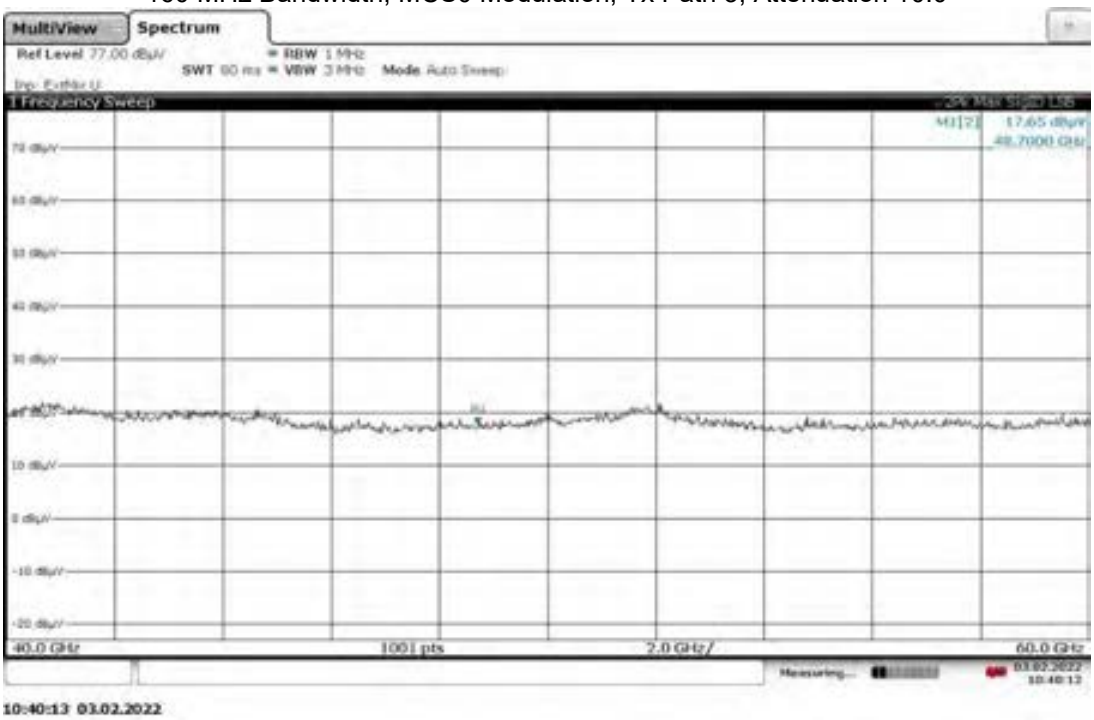


Transmit 24.35 GHz, RE 26-40 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0

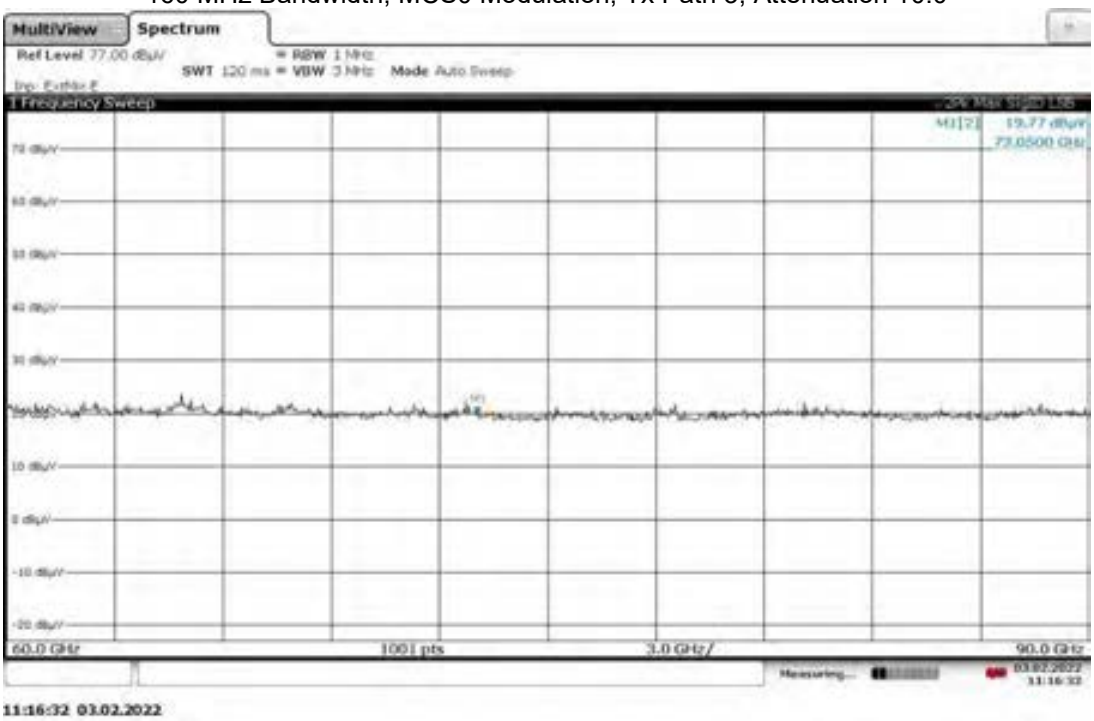


Notes: RMS Average detector was used. The cable loss, antenna factor, and pre-amp were compensated internally as transducer factor. The dB off-set of 11.8 dB was used for path loss of - 95.2 dB and 107 dB to covert the reading to dBm on the receiver.

Transmit 24.35 GHz, RE 40-60 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0

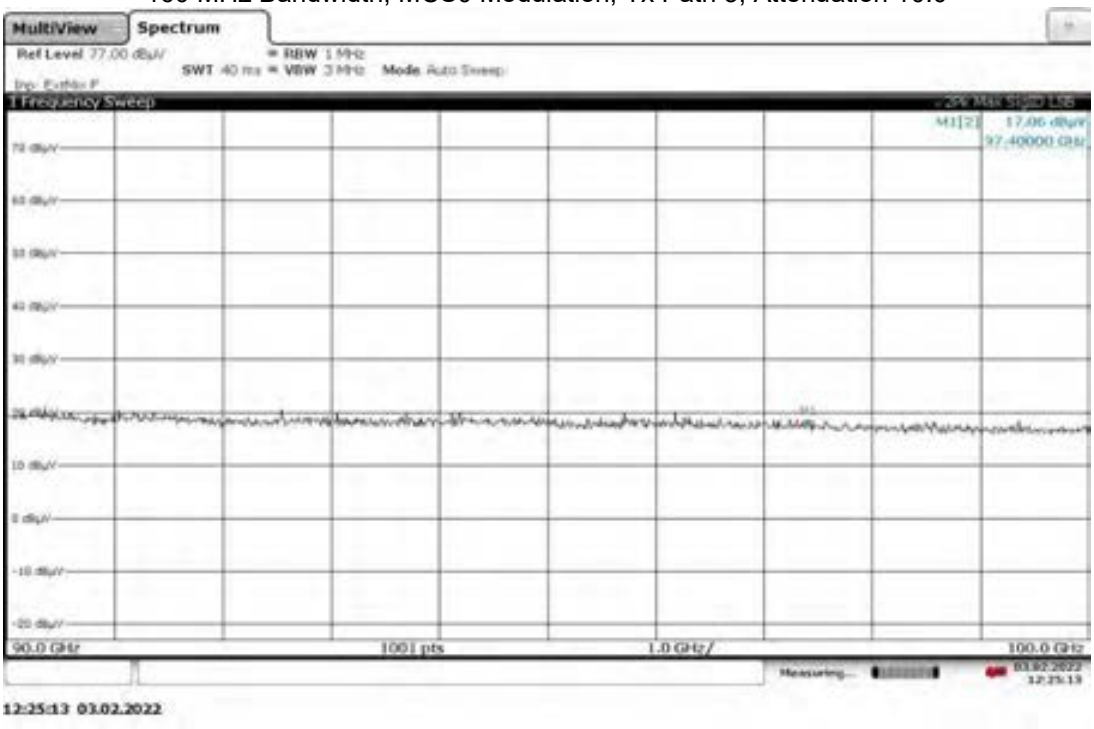


Transmit 24.35 GHz, RE 60-90 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0



Notes: Peak detector was used. No emission was detected above the instrument noise floor.

Transmit 24.35 GHz, RE 90-100 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.0



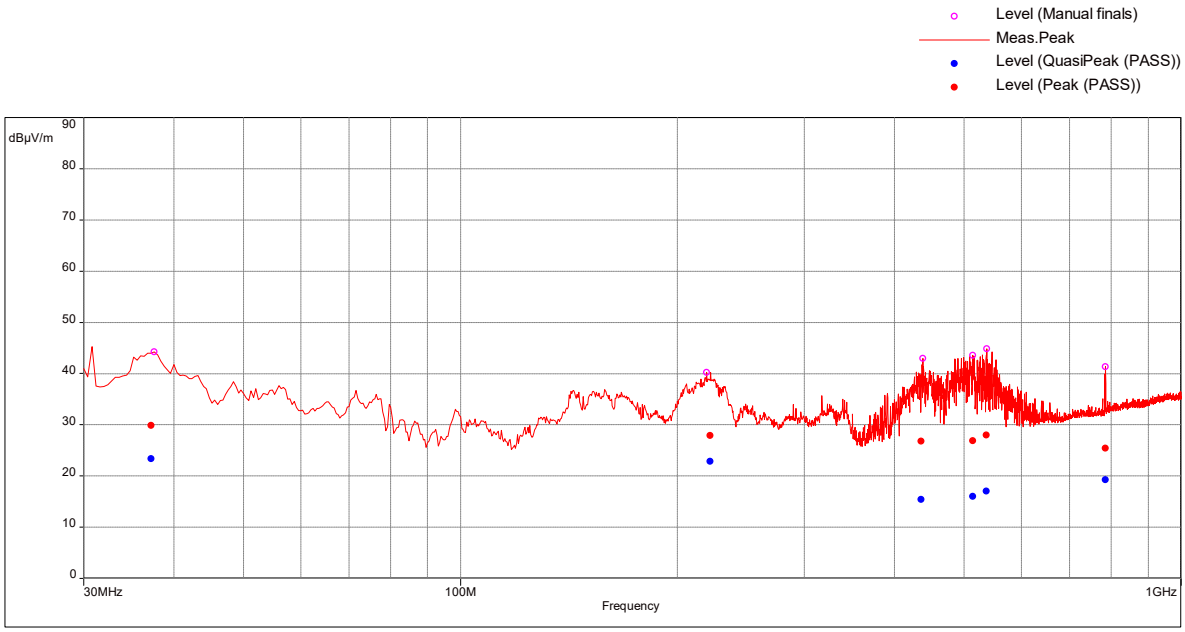
Notes: Peak detector was used. No emission was detected above the instrument noise floor.

Transmit 24.36 GHz, RE 30-1000 MHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 0.0

Test Information:

Date and Time	2/1/2022 12:03:09 PM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	24 C
Humidity	9 %
Atmospheric Pressure	1026 mbar
Comments	Scan 3a: Transmit 24.36, 160 MHz, MCS0, Tx Path 3, Att 0, RE 30-1000 MHz SA mode

Graph:



Results:

Peak Level – Manual scan with 1 MHz RBW using Maxhold detector

Frequency (MHz)	Peak Level (dBµV/m)	EIRP (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
37.23684211	46.39	-38.41	-13	-25.41	270.00	1.46	Vertical	1000000.00	-17.24
221.9684211	42.63	-42.17	-13	-29.17	255.00	1.00	Vertical	1000000.00	-20.79
436.1578947	45.91	-38.89	-13	-25.89	292.00	1.00	Vertical	1000000.00	-14.36
513.7368421	44.78	-40.02	-13	-27.02	214.00	1.00	Vertical	1000000.00	-12.71
536.9368421	47.53	-37.27	-13	-24.27	198.00	1.00	Vertical	1000000.00	-12.20
784.6736842	32.79	-52.01	-13	-39.01	54.00	1.58	Horizontal	1000000.00	-8.06

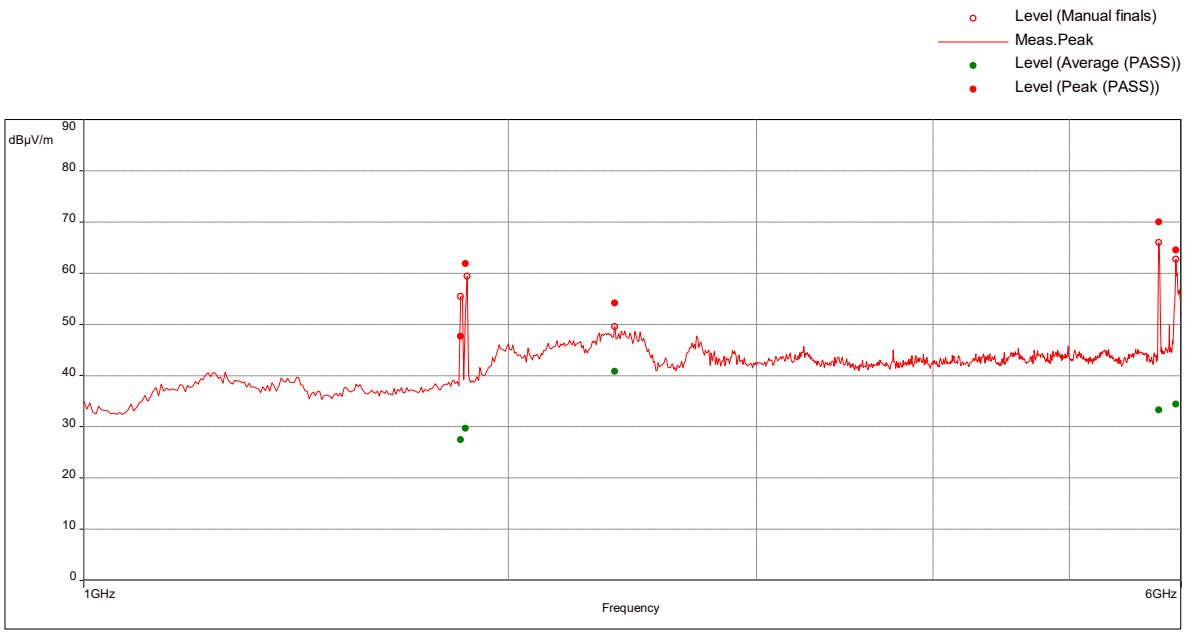
Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 24.36 GHz, RE 1-6 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 0.0

Test Information:

Date and Time	2/2/2022 10:51:47 AM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	25 C
Humidity	16 %
Atmospheric Pressure	1022 mbar
Comments	Scan 11: Transmit 24.36 GHz, 160 MHz, MCS0, Tx Path 3, Att 0, RE 1-6 GHz SA mode

Graph:



Results:

Peak EIRP

Frequency (MHz)	Peak Level (dBµV/m)	EIRP Level (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
1851.315789	47.63	-47.57	-13	-34.57	31.00	2.60	Horizontal	1000000.00	-4.14
1866.578947	61.82	-33.38	-13	-20.38	321.00	1.65	Horizontal	1000000.00	-3.99
2378.947368	54.15	-41.05	-13	-28.05	32.00	1.85	Horizontal	1000000.00	-2.61
5784.210526	70.00	-25.2	-13	-12.2	10.00	3.79	Vertical	1000000.00	4.84
5948.421053	64.47	-30.73	-13	-17.73	349.00	1.40	Horizontal	1000000.00	5.31

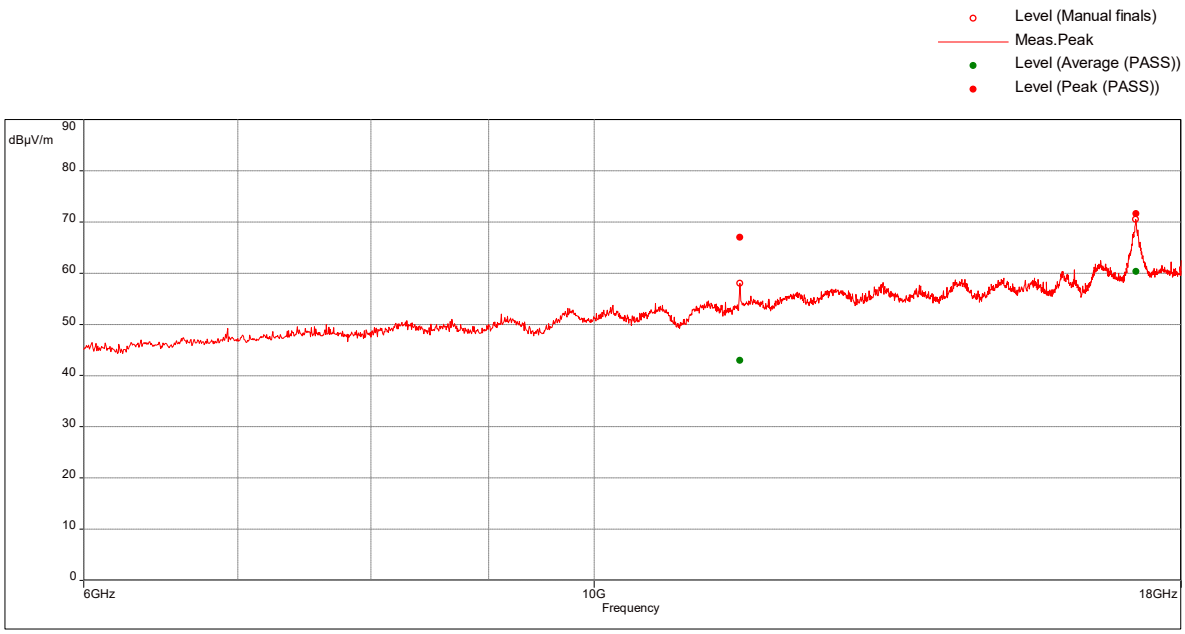
Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 24.36 GHz, RE 6-18 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 0.0

Test Information:

Date and Time	2/2/2022 11:22:38 AM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	25 C
Humidity	16 %
Atmospheric Pressure	1022 mbar
Comments	Scan 12: Transmit 24.36 GHz, 160 MHz, MCS0, Tx Path 3, Att 0, RE 6-18 GHz SA mode

Graph:



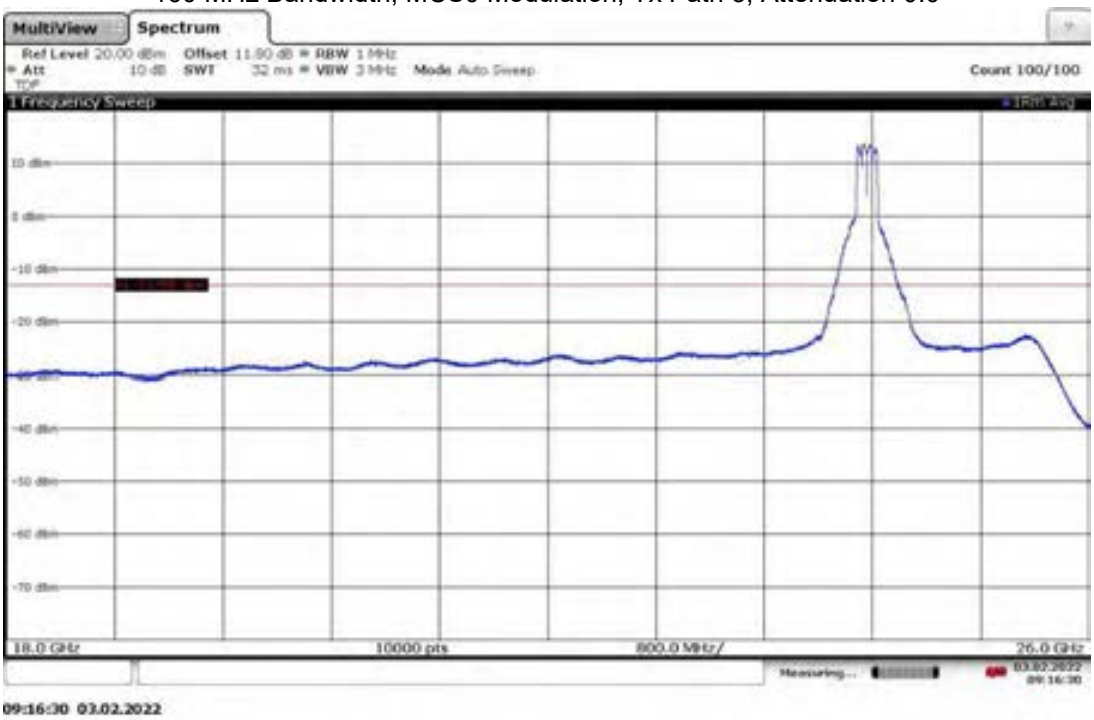
Results:

Peak EIRP

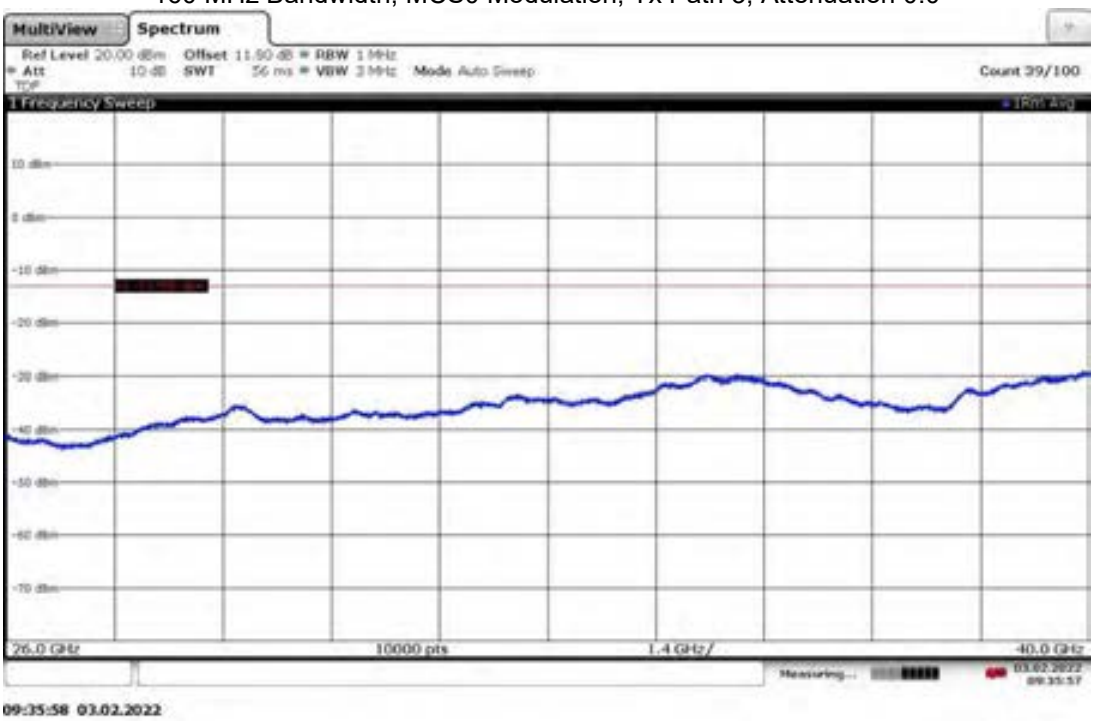
Frequency (MHz)	Peak Level (dBµV/m)	EIRP Level (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
11574.73684	66.97	-28.23	-13	-15.23	0.00	1.25	Vertical	1000000.00	14.45
17205	71.61	-23.59	-13	-10.59	4.00	2.05	Vertical	1000000.00	34.01

Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 24.36 GHz, RE 18-26 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 0.0

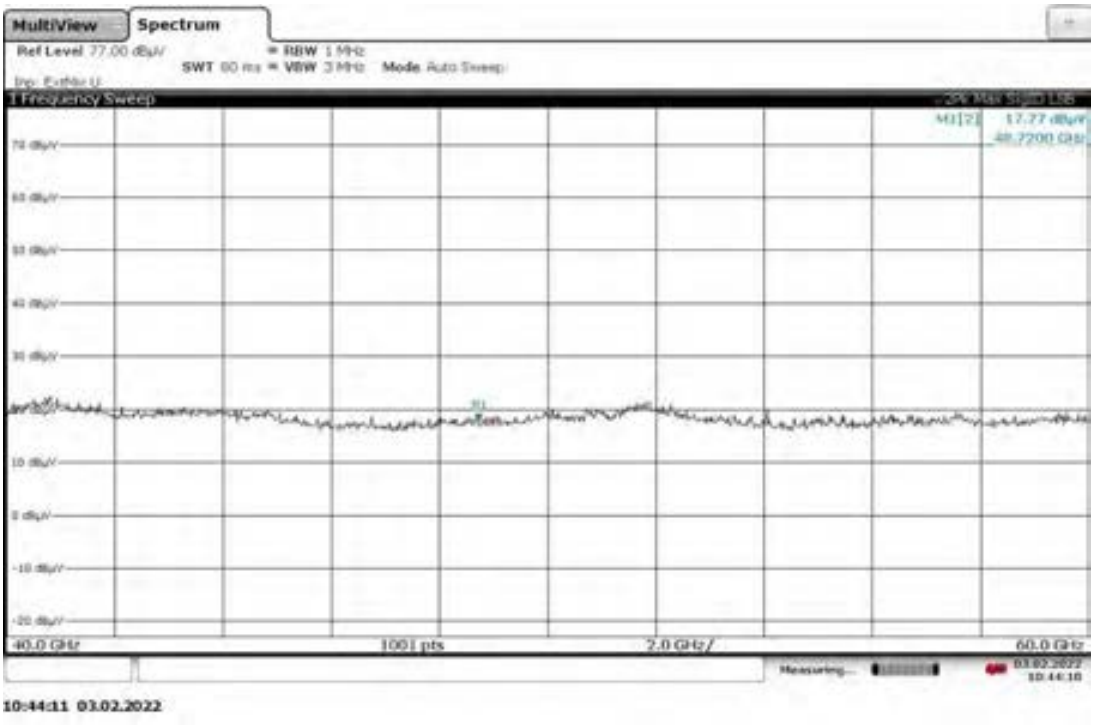


Transmit 24.36 GHz, RE 26-40 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 0.0

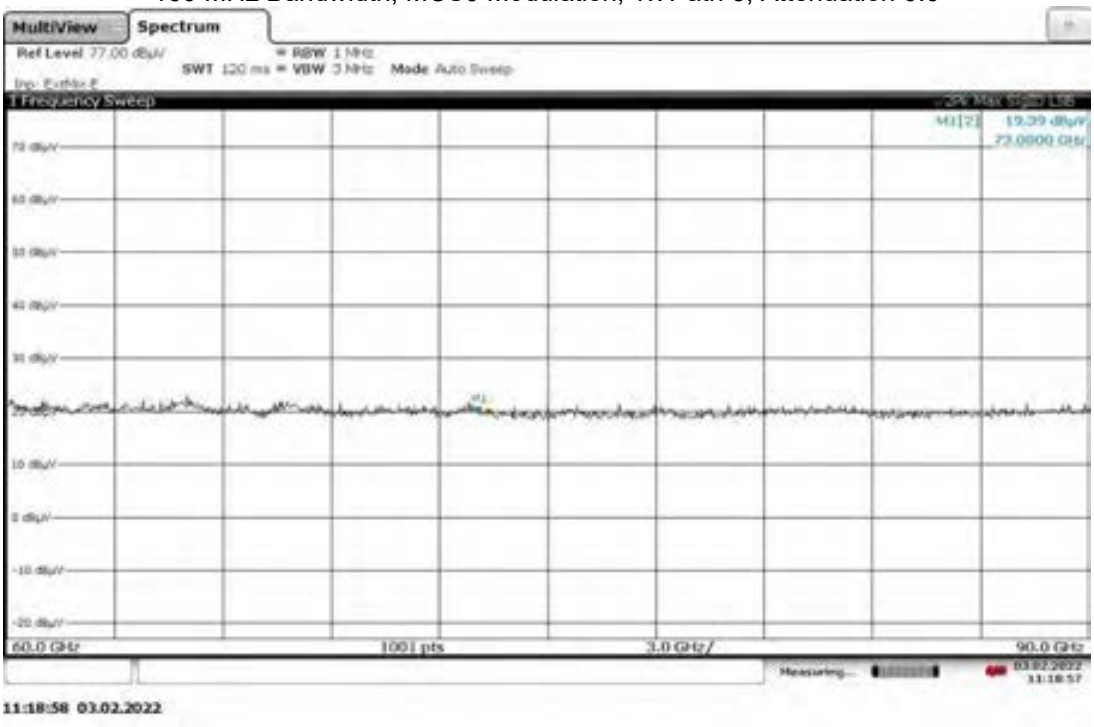


Notes: RMS Average detector was used. The cable loss, antenna factor, and pre-amp were compensated internally as transducer factor. The dB off-set of 11.8 dB was used for path loss of - 95.2 dB and 107 dB to covert the reading to dBm on the receiver.

Transmit 24.36 GHz, RE 40-60 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 0.0

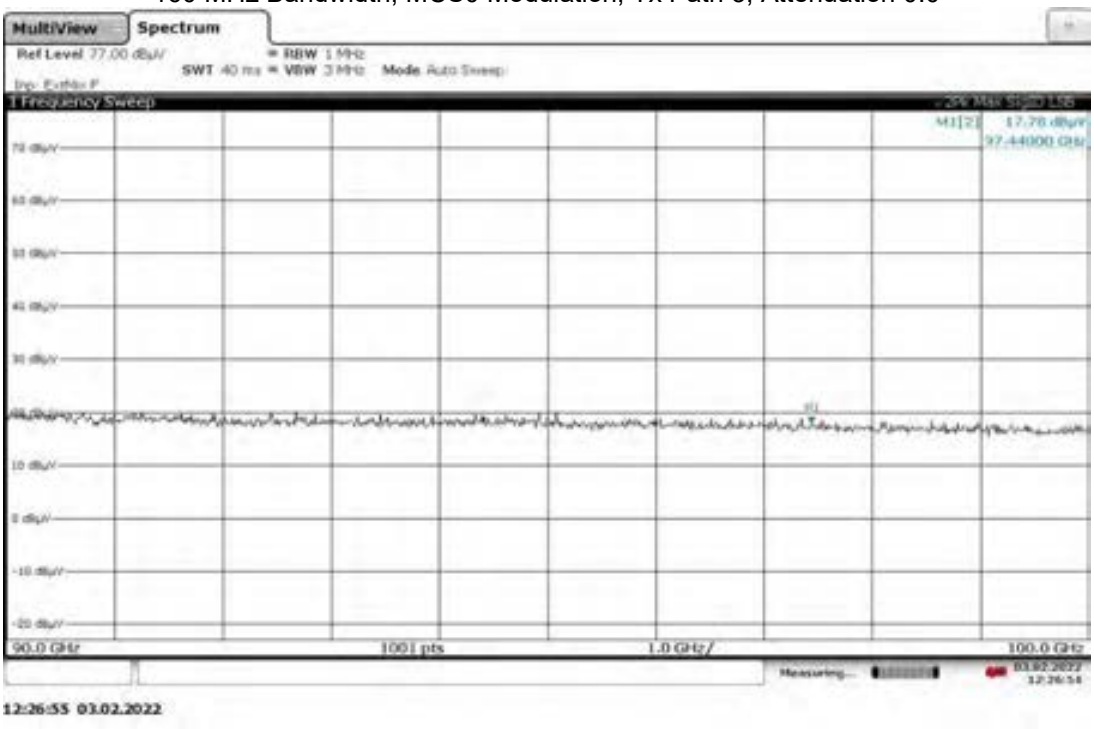


Transmit 24.36 GHz, RE 60-90 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 0.0



Notes: Peak detector was used. No emission was detected above the instrument noise floor.

Transmit 24.36 GHz, RE 90-100 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 0.0



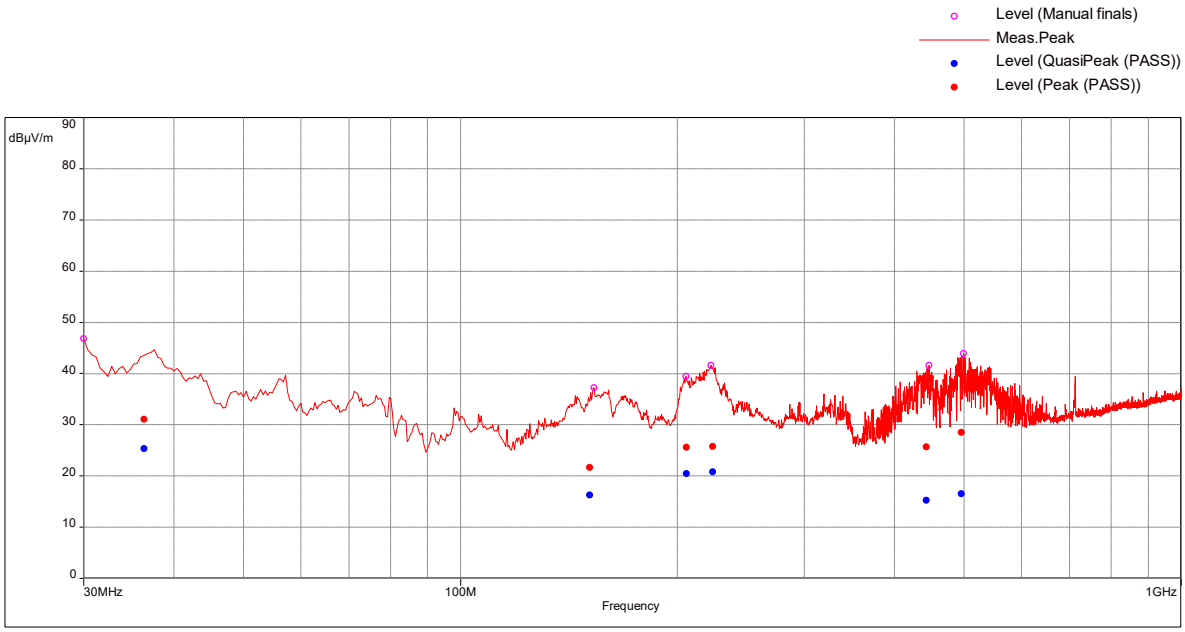
Notes: Peak detector was used. No emission was detected above the instrument noise floor.

Transmit 24.84 GHz, RE 30-1000 MHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.5

Test Information:

Date and Time	2/1/2022 1:56:34 PM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	24 C
Humidity	9 %
Atmospheric Pressure	1026 mbar
Comments	Scan 4: Transmit 24.84, 160 MHz, MCS0, Tx Path 3, Att 10.5, RE 30-1000 MHz SA mode

Graph:



Results:

Peak Level – Manual scan with 1 MHz RBW using Maxhold detector

Frequency (MHz)	Peak Level (dBµV/m)	EIRP (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
36.44736842	46.73	-38.07	-13	-25.07	243.00	1.47	Vertical	1000000.00	-16.73
151.0947368	37.54	-47.26	-13	-34.26	249.00	1.52	Vertical	1000000.00	-19.59
206.1263158	40.94	-43.86	-13	-30.86	280.00	1.00	Vertical	1000000.00	-20.94
224.1157895	40.14	-44.66	-13	-31.66	271.00	1.69	Vertical	1000000.00	-20.78
443.1157895	43.26	-41.54	-13	-28.54	0.00	1.00	Vertical	1000000.00	-14.20
495.3789474	47.09	-37.71	-13	-24.71	0.00	1.00	Vertical	1000000.00	-12.79

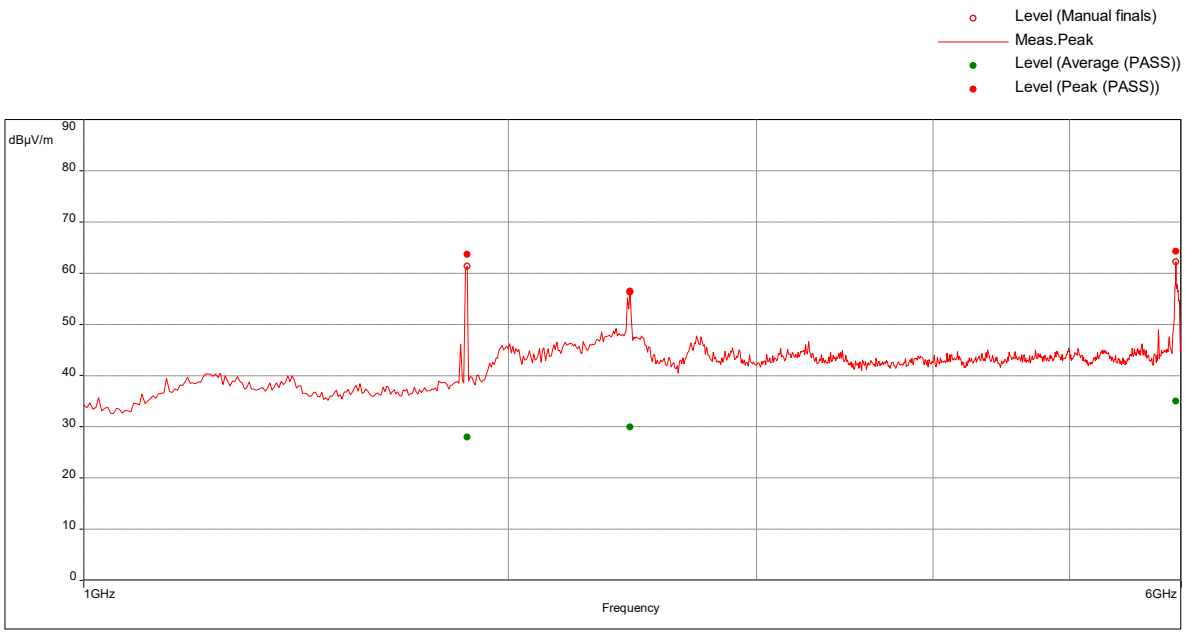
Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 24.84 GHz, RE 1-6 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.5

Test Information:

Date and Time	2/2/2022 12:35:52 PM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	25 C
Humidity	16 %
Atmospheric Pressure	1022 mbar
Comments	Scan 14: Transmit 24.84 GHz, 160 MHz, MCS0, Tx Path 3, Att 10.5, RE 1-6 GHz SA mode

Graph:



Results:

Peak EIRP

Frequency (MHz)	Peak Level (dBµV/m)	EIRP Level (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
1868.684211	63.65	-31.55	-13	-18.55	350.00	2.10	Vertical	1000000.00	-3.97
2438.947368	56.28	-38.92	-13	-25.92	39.00	1.00	Vertical	1000000.00	-2.30
5951.052632	64.27	-30.93	-13	-17.93	328.00	1.06	Horizontal	1000000.00	5.31

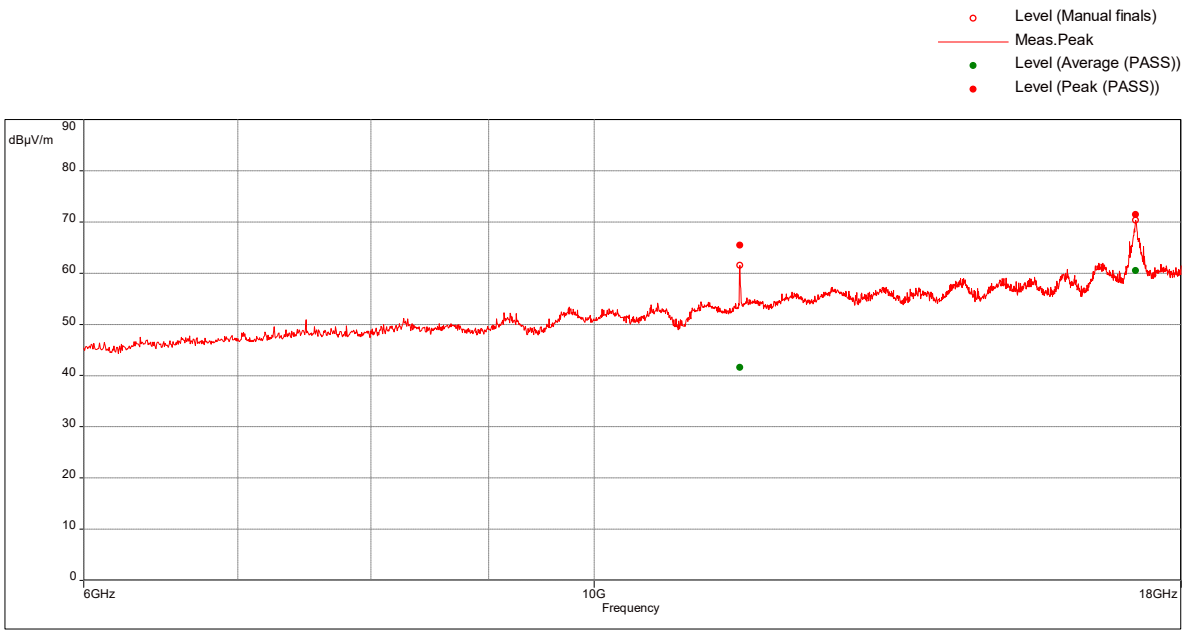
Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 24.84 GHz, RE 6-18 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.5

Test Information:

Date and Time	2/2/2022 11:43:23 AM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	25 C
Humidity	16 %
Atmospheric Pressure	1022 mbar
Comments	Scan 13: Transmit 24.84 GHz, 160 MHz, MCS0, Tx Path 3, Att 10.5, RE 6-18 GHz SA mode

Graph:



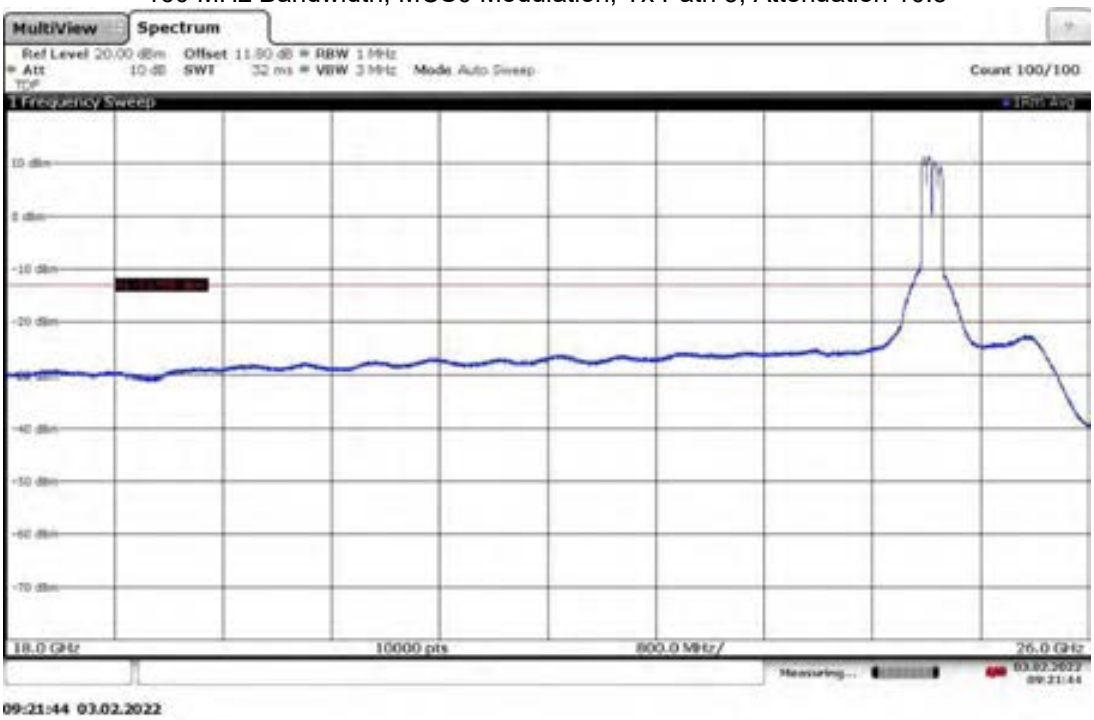
Results:

Peak EIRP

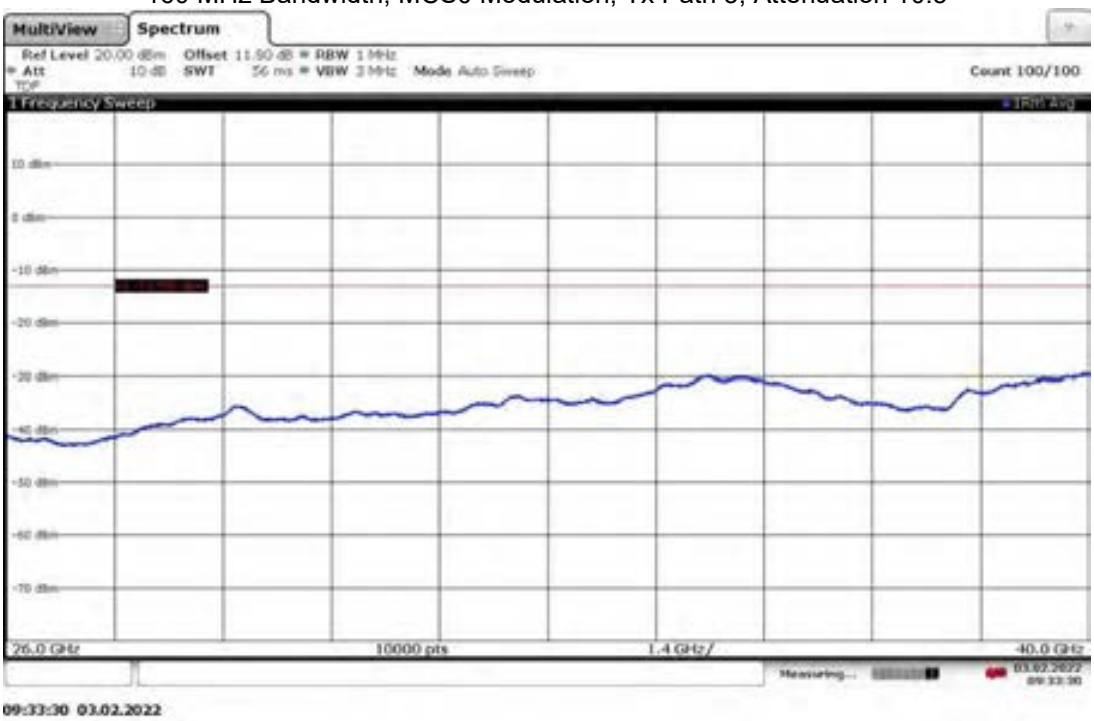
Frequency (MHz)	Peak Level (dBµV/m)	EIRP Level (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
11572.63158	65.48	-29.72	-13	-16.72	4.00	1.06	Vertical	1000000.00	14.44
17199.47368	71.40	-23.8	-13	-10.8	125.00	2.35	Horizontal	1000000.00	34.34

Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 24.84 GHz, RE 18-26 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.5

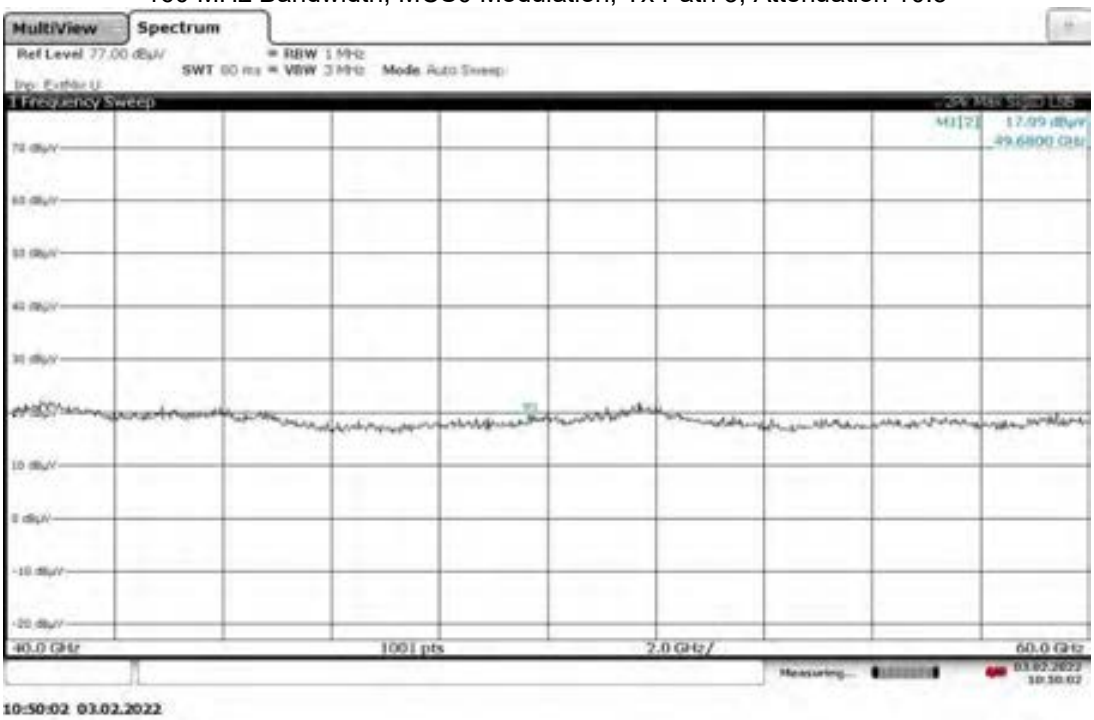


Transmit 24.84 GHz, RE 26-40 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.5

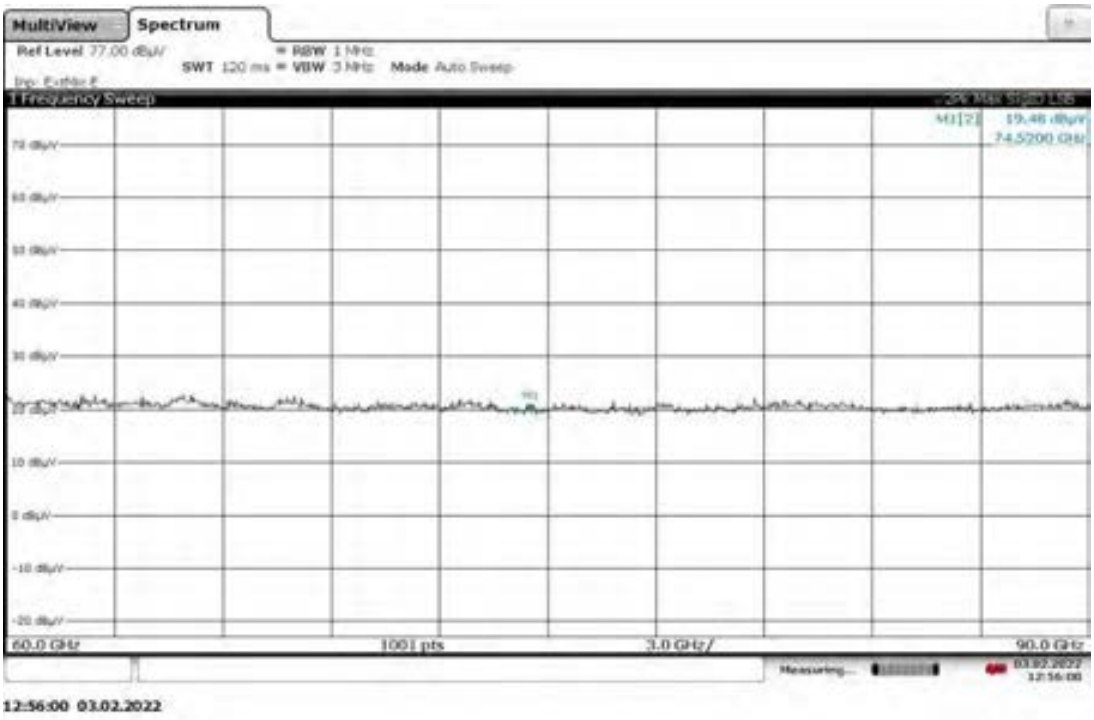


Notes: RMS Average detector was used. The cable loss, antenna factor, and pre-amp were compensated internally as transducer factor. The dB off-set of 11.8 dB was used for path loss of - 95.2 dB and 107 dB to covert the reading to dBm on the receiver.

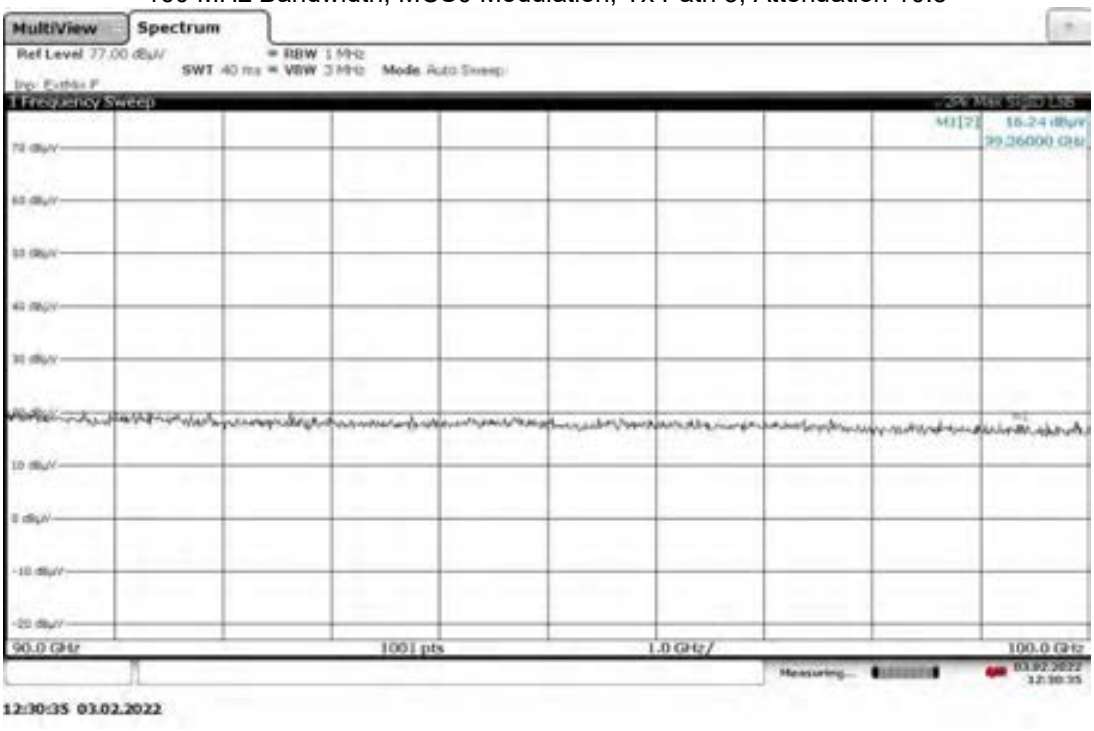
Transmit 24.84 GHz, RE 40-60 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.5



Transmit 24.84 GHz, RE 60-90 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.5
Notes: Peak detector was used. No emission was detected above the instrument noise floor.



Transmit 24.84 GHz, RE 90-100 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 10.5



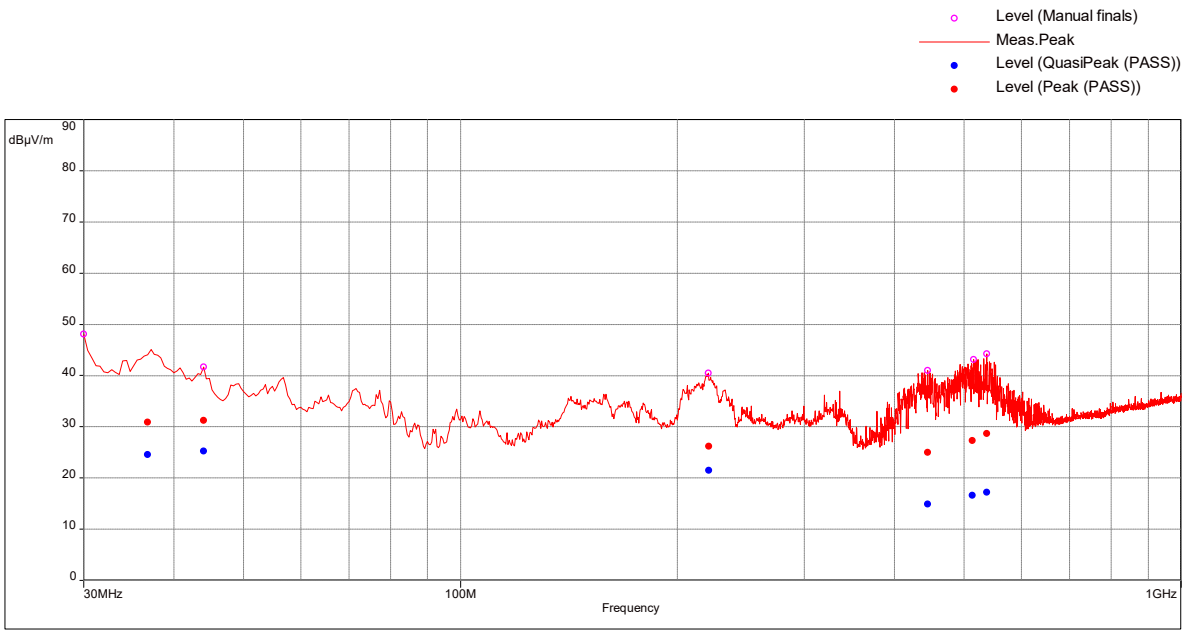
Notes: Peak detector was used. No emission was detected above the instrument noise floor.

Transmit 25.04 GHz, RE 30-1000 MHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 5.5

Test Information:

Date and Time	2/1/2022 2:38:20 PM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	24 C
Humidity	9 %
Atmospheric Pressure	1026 mbar
Comments	Scan 5: Transmit 25.04, 160 MHz, MCS0, Tx Path 3, Att 5.5, RE 30-1000 MHz SA mode

Graph:



Results:

Peak Level – Manual scan with 1 MHz RBW using Maxhold detector

Frequency (MHz)	Peak Level (dBµV/m)	EIRP (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
36.71052632	44.28	-40.52	-13	-27.52	250.00	1.59	Vertical	1000000.00	-16.91
44	44.69	-40.11	-13	-27.11	241.00	2.35	Vertical	1000000.00	-22.00
221.3263158	41.57	-43.23	-13	-30.23	264.00	1.47	Vertical	1000000.00	-20.73
444.8	31.42	-53.38	-13	-40.38	286.00	1.47	Vertical	1000000.00	-14.18
513.0947368	35.28	-49.52	-13	-36.52	198.00	1.00	Vertical	1000000.00	-12.72
537.7263158	35.81	-48.99	-13	-35.99	200.00	1.00	Vertical	1000000.00	-12.19

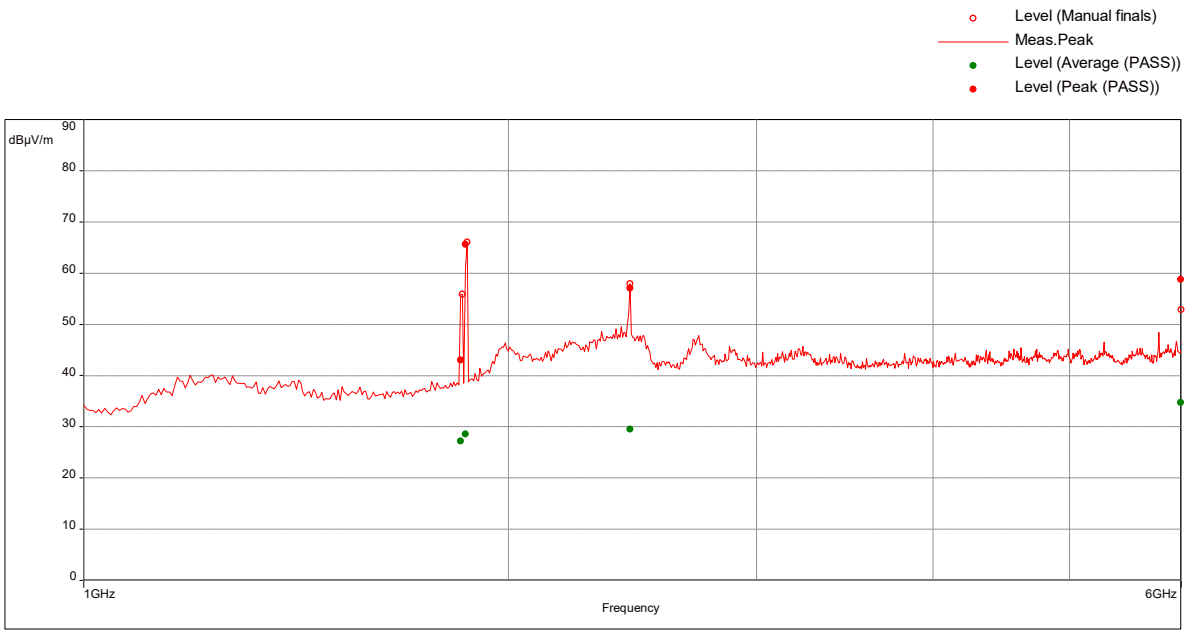
Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 25.04 GHz, RE 1-6 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 5.5

Test Information:

Date and Time	2/2/2022 12:55:22 PM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	25 C
Humidity	16 %
Atmospheric Pressure	1022 mbar
Comments	Scan 15: Transmit 25.04 GHz, 160 MHz, MCS0, Tx Path 3, Att 5.5, RE 1-6 GHz SA mode

Graph:



Results:

Peak EIRP

Frequency (MHz)	Peak Level (dBµV/m)	EIRP Level (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
1851.578947	43.07	-52.13	-13	-39.13	32.00	1.20	Horizontal	1000000.00	-4.14
1867.368421	65.65	-29.55	-13	-16.55	330.00	3.20	Vertical	1000000.00	-3.98
2438.684211	57.05	-38.15	-13	-25.15	241.00	1.15	Vertical	1000000.00	-2.30
5995.657895	58.82	-36.38	-13	-23.38	335.00	1.40	Horizontal	1000000.00	5.43

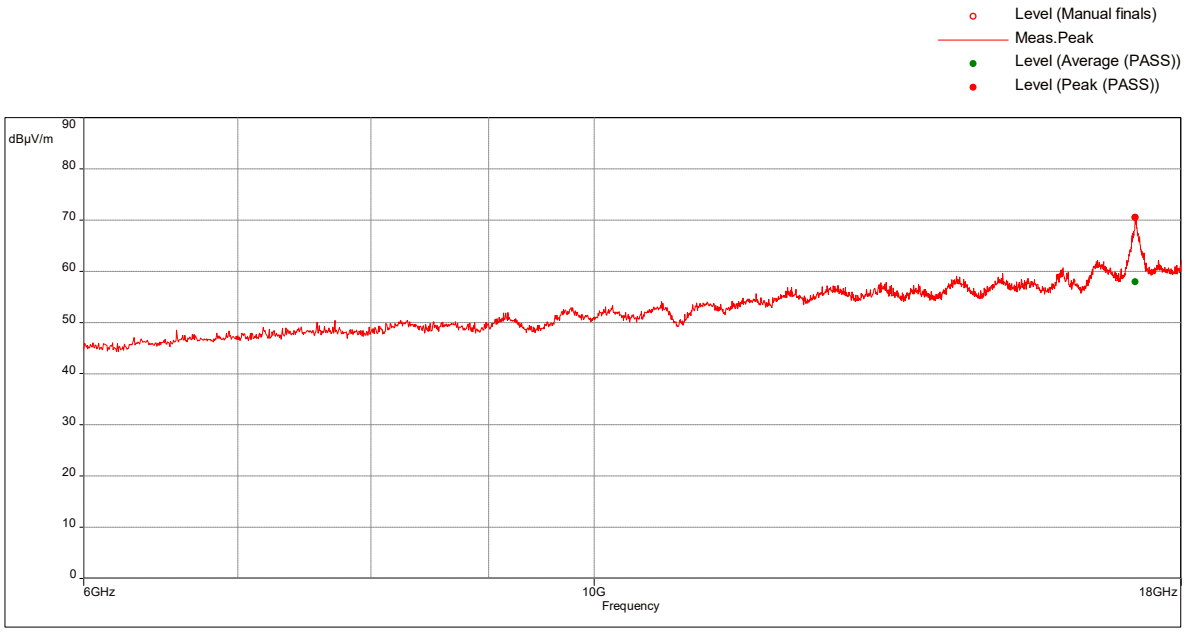
Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 25.04 GHz, RE 6-18 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 5.5

Test Information:

Date and Time	2/2/2022 1:21:33 PM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	25 C
Humidity	16 %
Atmospheric Pressure	1022 mbar
Comments	Scan 16: Transmit 25.04 GHz, 160 MHz, MCS0, Tx Path 3, Att 5.5, RE 6-18 GHz SA mode

Graph:



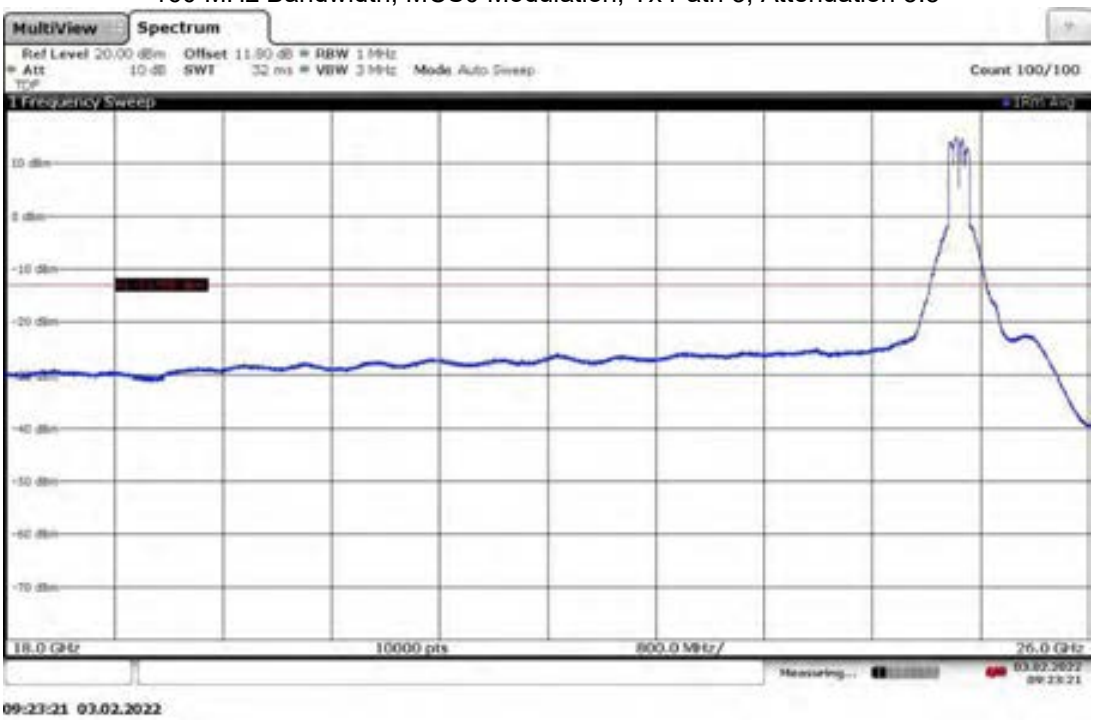
Results:

Peak EIRP

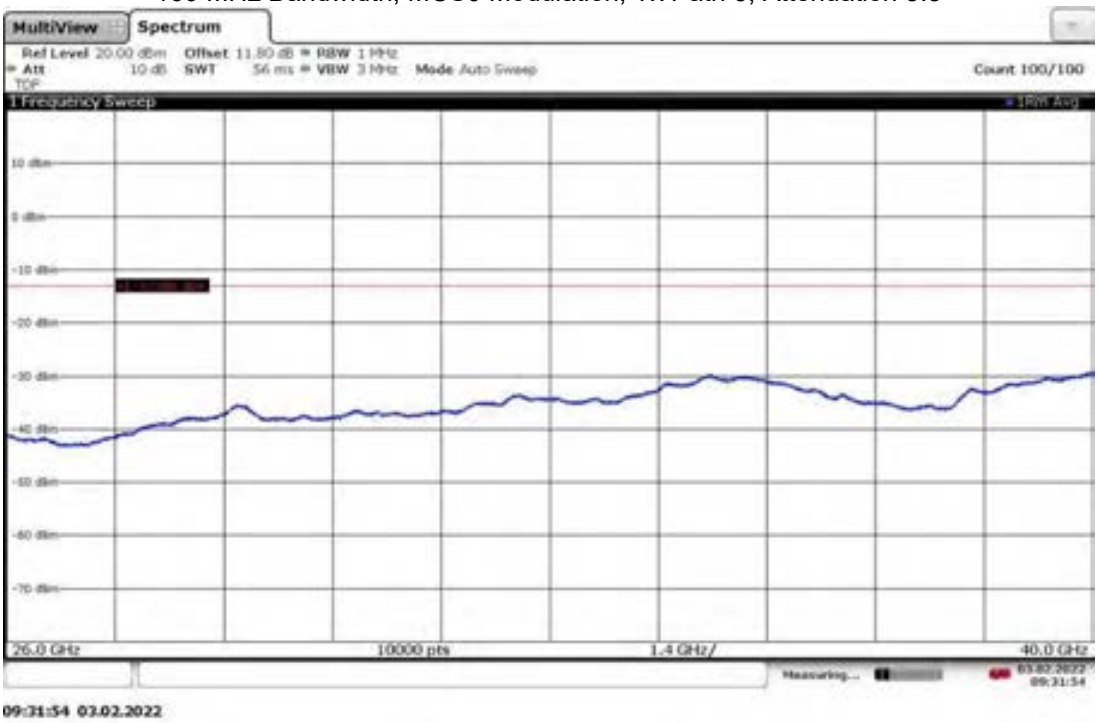
Frequency (MHz)	Peak Level (dBµV/m)	EIRP Level (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
17190	70.47	-24.73	-13	-11.73	221.00	2.95	Horizontal	1000000.00	33.53

Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 25.04 GHz, RE 18-26 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 5.5

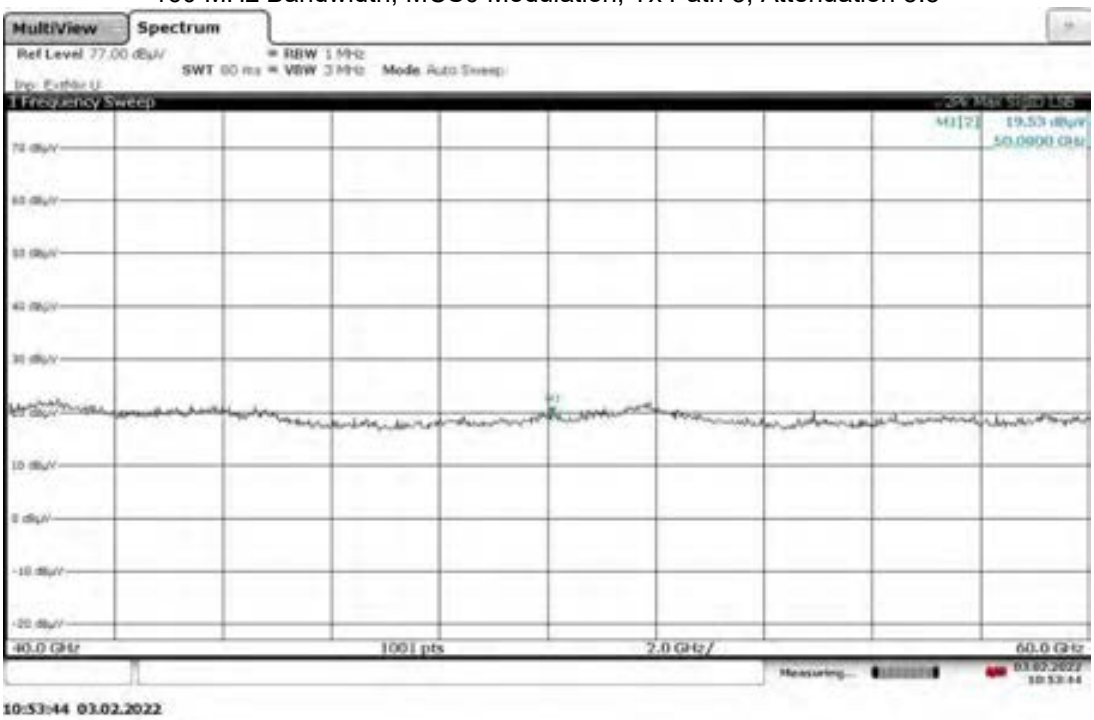


Transmit 25.04 GHz, RE 26-40 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 5.5

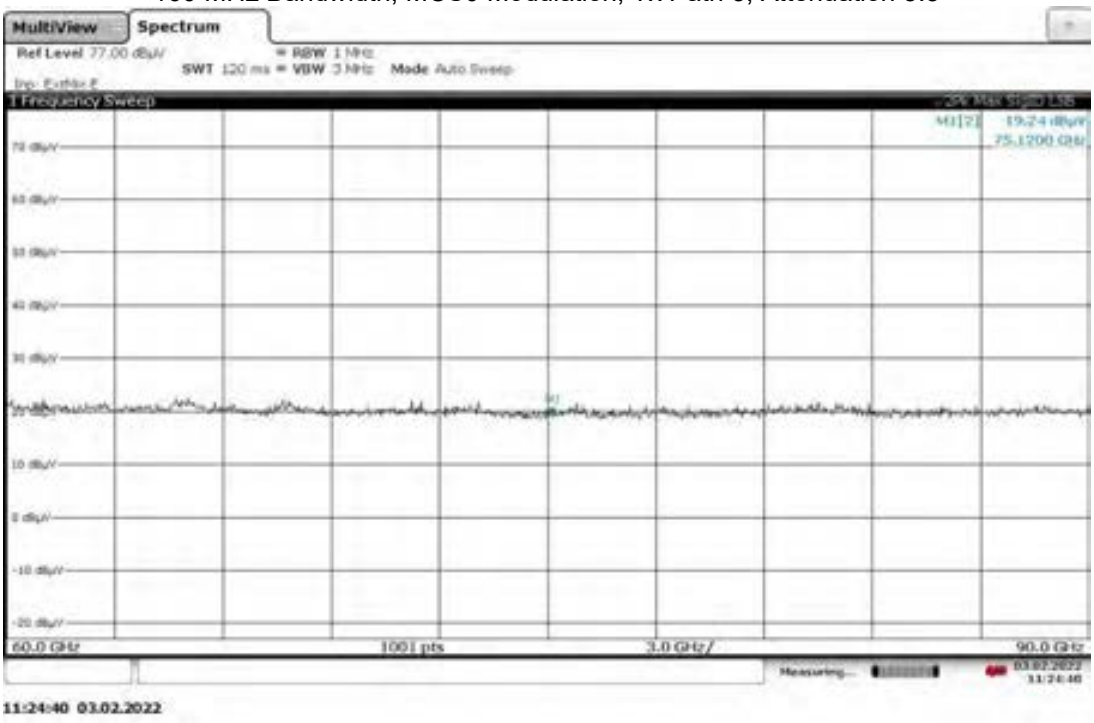


Notes: RMS Average detector was used. The cable loss, antenna factor, and pre-amp were compensated internally as transducer factor. The dB off-set of 11.8 dB was used for path loss of - 95.2 dB and 107 dB to covert the reading to dBm on the receiver.

Transmit 25.04 GHz, RE 40-60 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 5.5

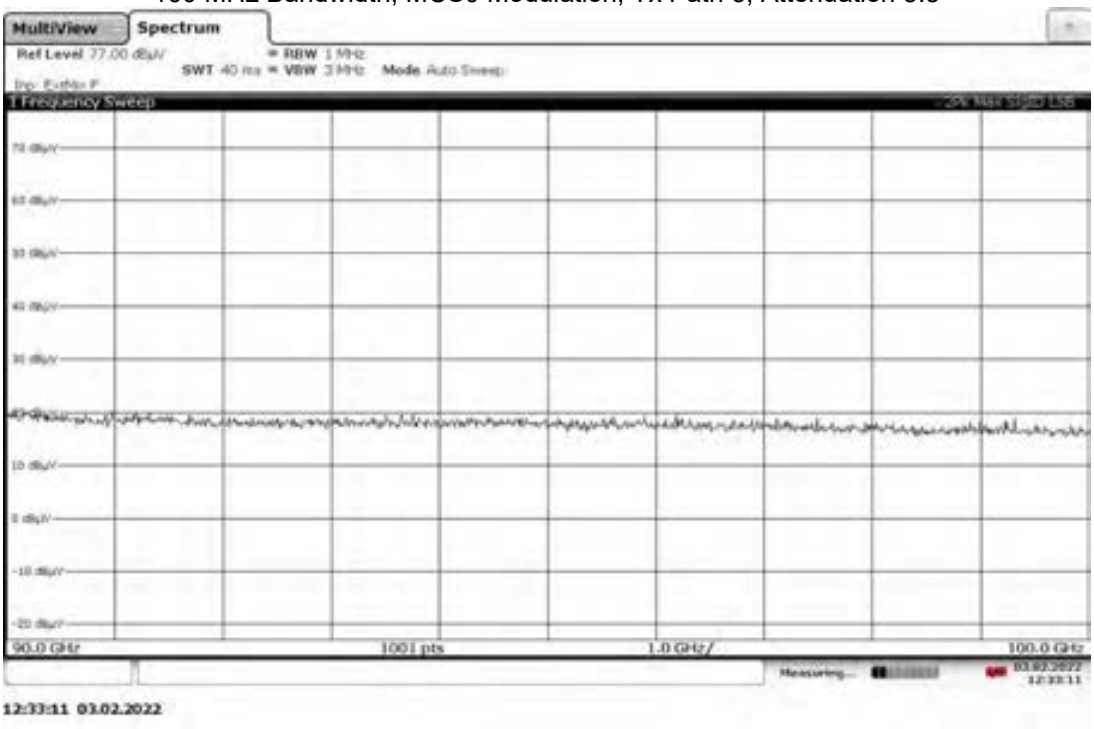


Transmit 25.04 GHz, RE 60-90 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 5.5



Notes: Peak detector was used. No emission was detected above the instrument noise floor.

Transmit 25.04 GHz, RE 90-100 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 5.5



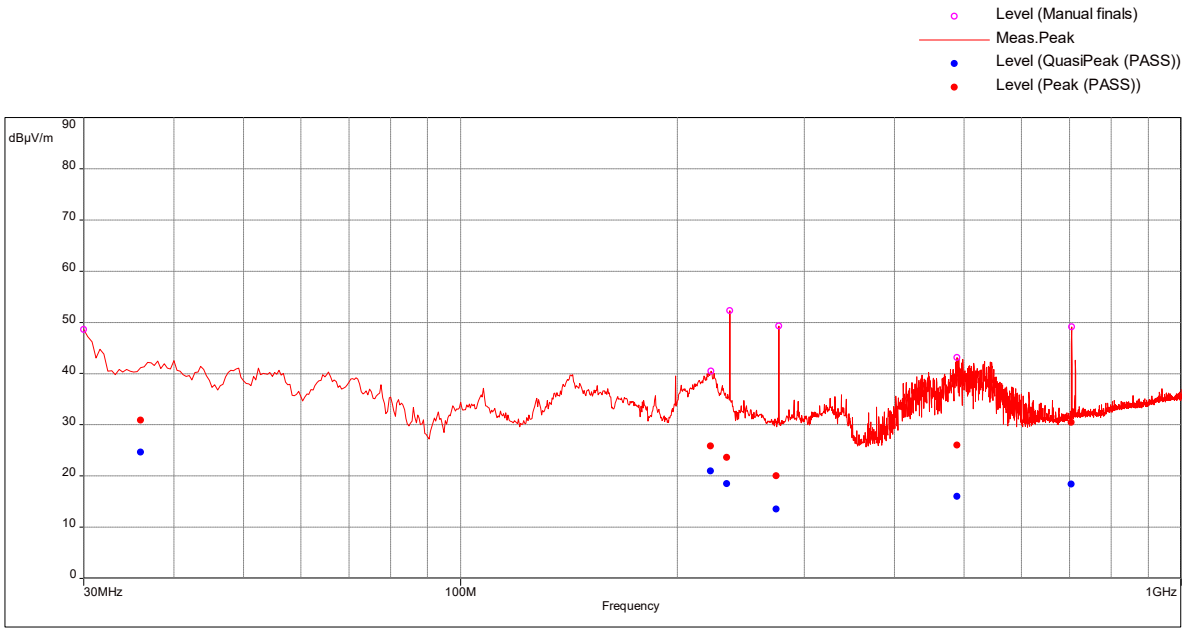
Notes: Peak detector was used. No emission was detected above the instrument noise floor.

Transmit 25.16 GHz, RE 30-1000 MHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 8

Test Information:

Date and Time	2/1/2022 3:11:19 PM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	24 C
Humidity	9 %
Atmospheric Pressure	1026 mbar
Comments	Scan 6: Transmit 25.16, 160 MHz, MCS0, Tx Path 3, Att 8, RE 30-1000 MHz SA mode

Graph:



Results:

Peak Level – Manual scan with 1 MHz RBW using Maxhold detector

Frequency (MHz)	Peak Level (dBµV/m)	EIRP (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
36.18421053	44.43	-40.37	-13	-27.37	272.00	1.00	Vertical	1000000.00	-16.57
222.2736842	42.37	-42.43	-13	-29.43	252.00	1.69	Vertical	1000000.00	-20.79
234.0315789	39.38	-45.42	-13	-32.42	273.00	1.31	Vertical	1000000.00	-20.36
274.5578947	33.91	-50.89	-13	-37.89	39.00	1.00	Vertical	1000000.00	-17.96
488.4	46.23	-38.57	-13	-25.57	9.00	1.41	Vertical	1000000.00	-12.77
704.5368421	31.73	-53.07	-13	-40.07	118.00	1.31	Vertical	1000000.00	-9.11

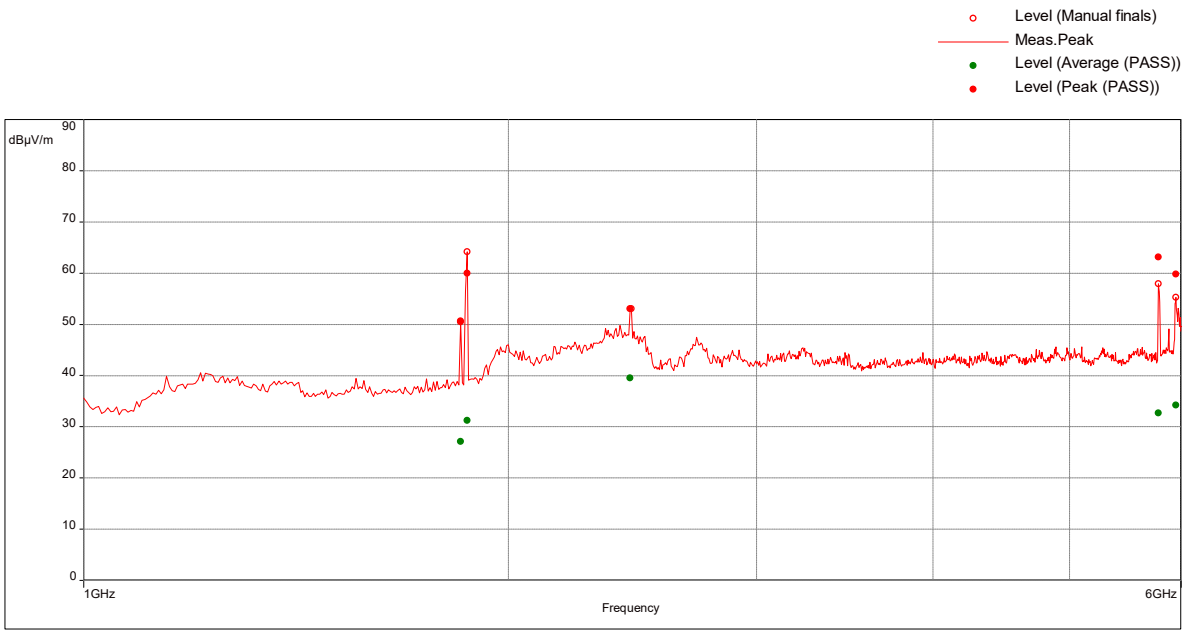
Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 25.16 GHz, RE 1-6 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 8

Test Information:

Date and Time	2/2/2022 2:08:52 PM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	25 C
Humidity	16 %
Atmospheric Pressure	1022 mbar
Comments	Scan 18: Transmit 25.16 GHz, 160 MHz, MCS0, Tx Path 3, Att 8, RE 1-6 GHz SA mode

Graph:



Results:

Peak EIRP

Frequency (MHz)	Peak Level (dBµV/m)	EIRP Level (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
1851.578947	50.66	-44.54	-13	-31.54	191.00	3.84	Vertical	1000000.00	-4.14
1868.684211	59.96	-35.24	-13	-22.24	200.00	3.79	Vertical	1000000.00	-3.97
2440.526316	53.08	-42.12	-13	-29.12	9.00	2.25	Vertical	1000000.00	-2.29
5778.684211	63.15	-32.05	-13	-19.05	0.00	1.20	Horizontal	1000000.00	4.82
5952.368421	59.84	-35.36	-13	-22.36	341.00	1.15	Vertical	1000000.00	5.32

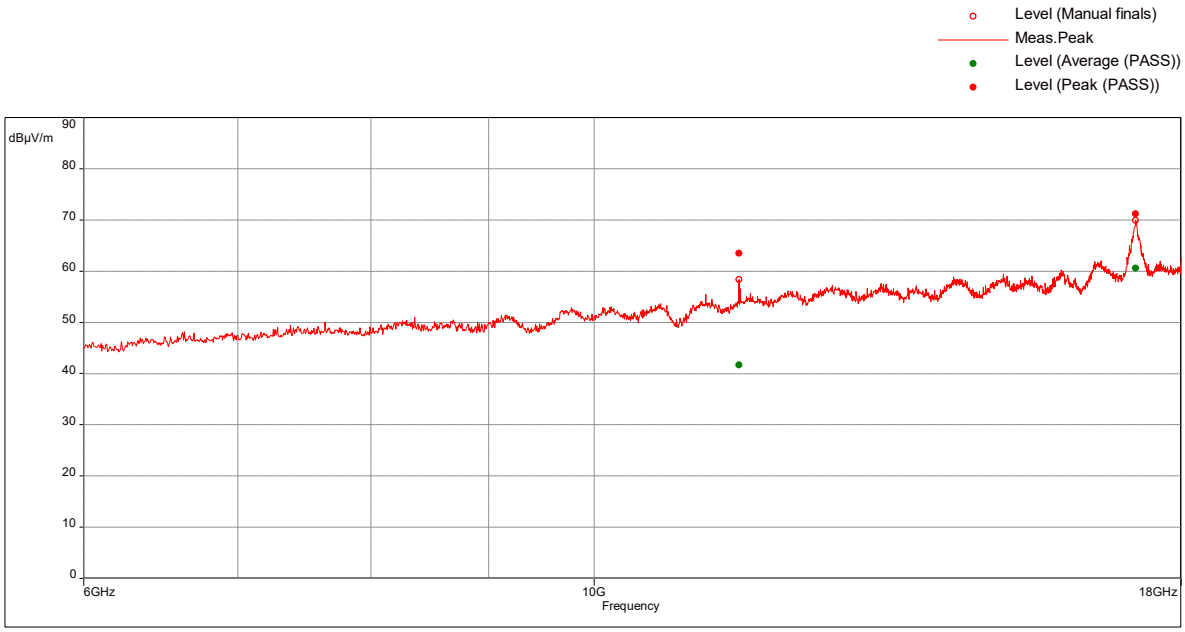
Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 25.16 GHz, RE 6-18 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 8

Test Information:

Date and Time	2/2/2022 1:44:23 PM
Client and Project Number	Starry, Inc.
Engineer	Kouma Sinn
Temperature	25 C
Humidity	16 %
Atmospheric Pressure	1022 mbar
Comments	Scan 17: Transmit 25.16 GHz, 160 MHz, MCS0, Tx Path 3, Att 8, RE 6-18 GHz SA mode

Graph:



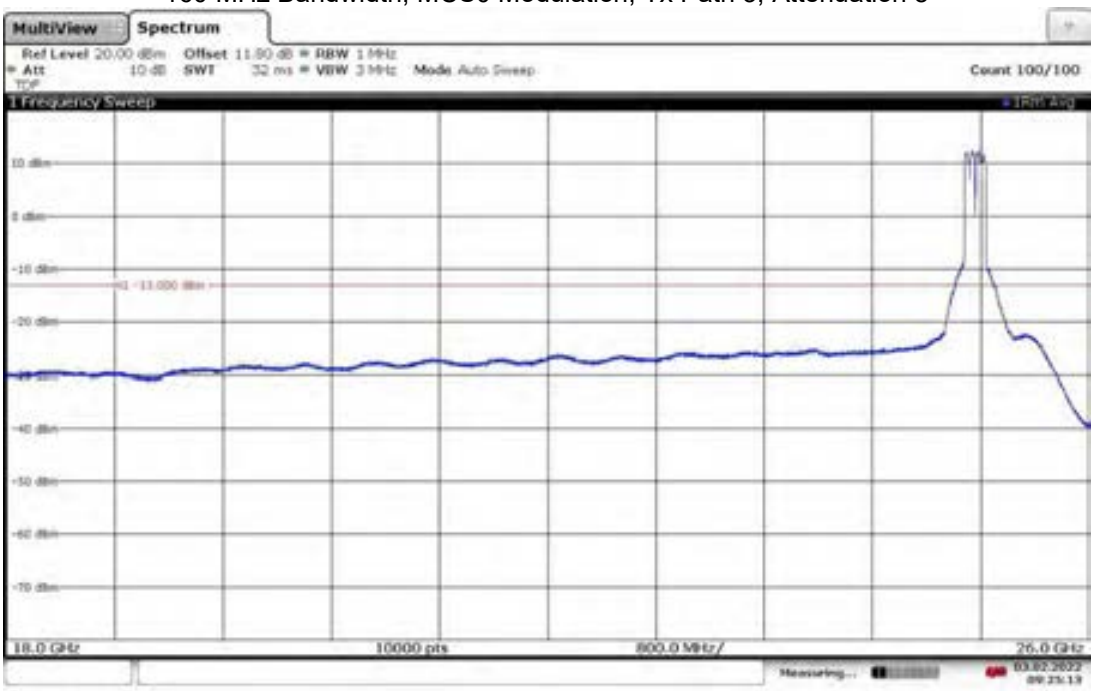
Results:

Peak EIRP

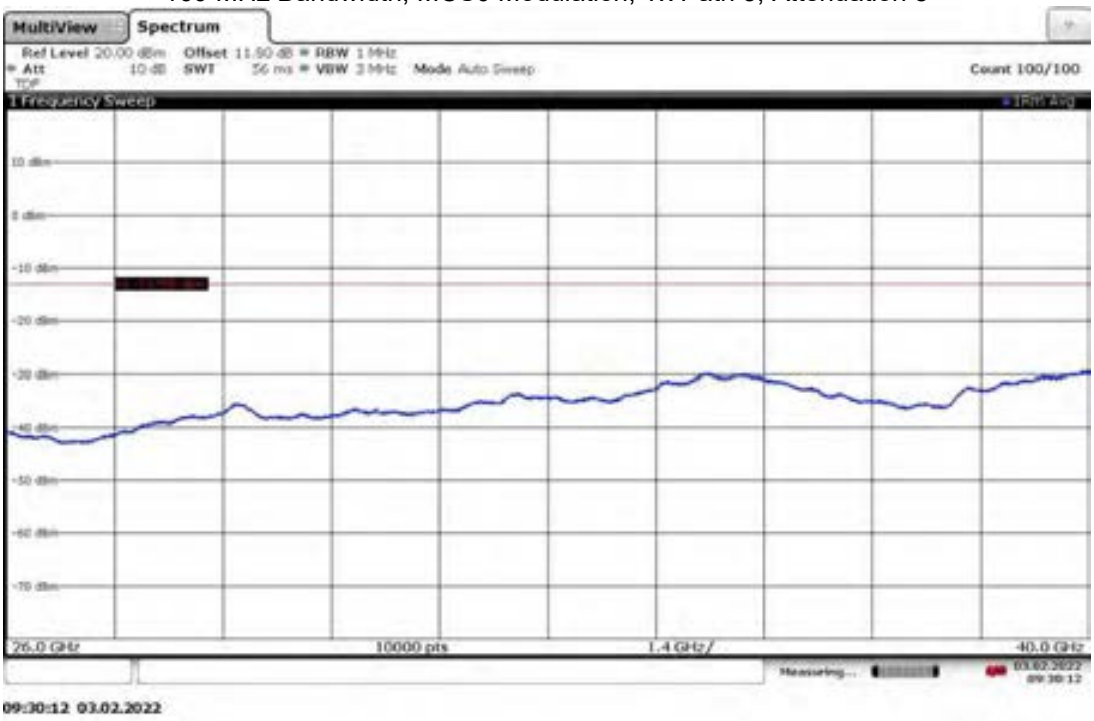
Frequency (MHz)	Peak Level (dBµV/m)	EIRP Level (dBm)	EIRP Limit (dBm)	EIRP Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW (Hz)	Correction (dB)
11565.26316	63.52	-31.68	-13	-18.68	357.00	1.00	Vertical	1000000.00	14.42
17200	71.18	-24.02	-13	-11.02	4.00	2.70	Vertical	1000000.00	34.38

Notes:
The level in E.I.R.P (dBm) is calculated from the peak readings as E.I.R.P (dBm) = E Peak (dBµV/m) + 20*Log(d) – 104.7, where d is the measurement distance (in the far field region) in meter.

Transmit 25.16 GHz, RE 18-26 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 8

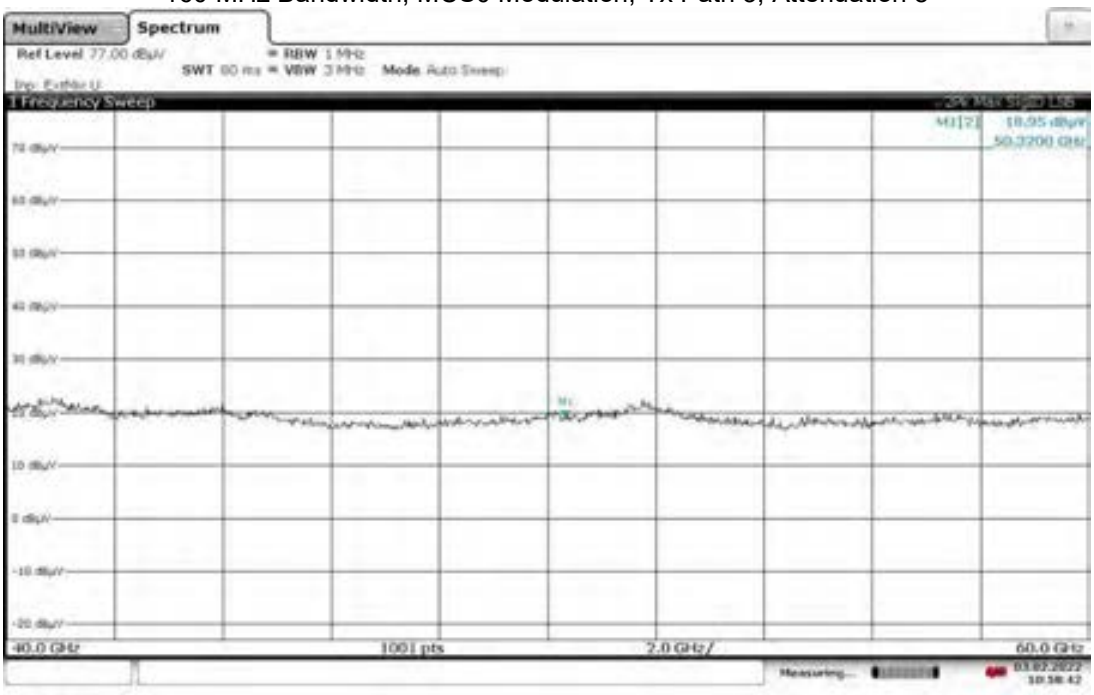


Transmit 25.16 GHz, RE 26-40 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 8

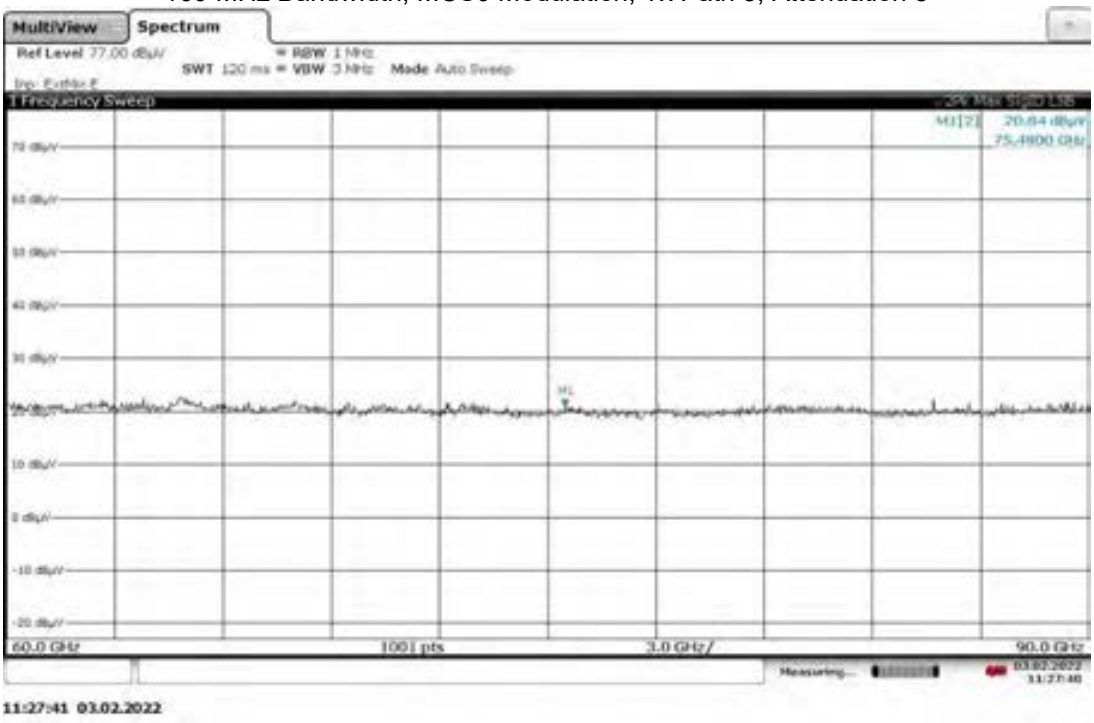


Notes: RMS Average detector was used. The cable loss, antenna factor, and pre-amp were compensated internally as transducer factor. The dB off-set of 11.8 dB was used for path loss of - 95.2 dB and 107 dB to covert the reading to dBm on the receiver.

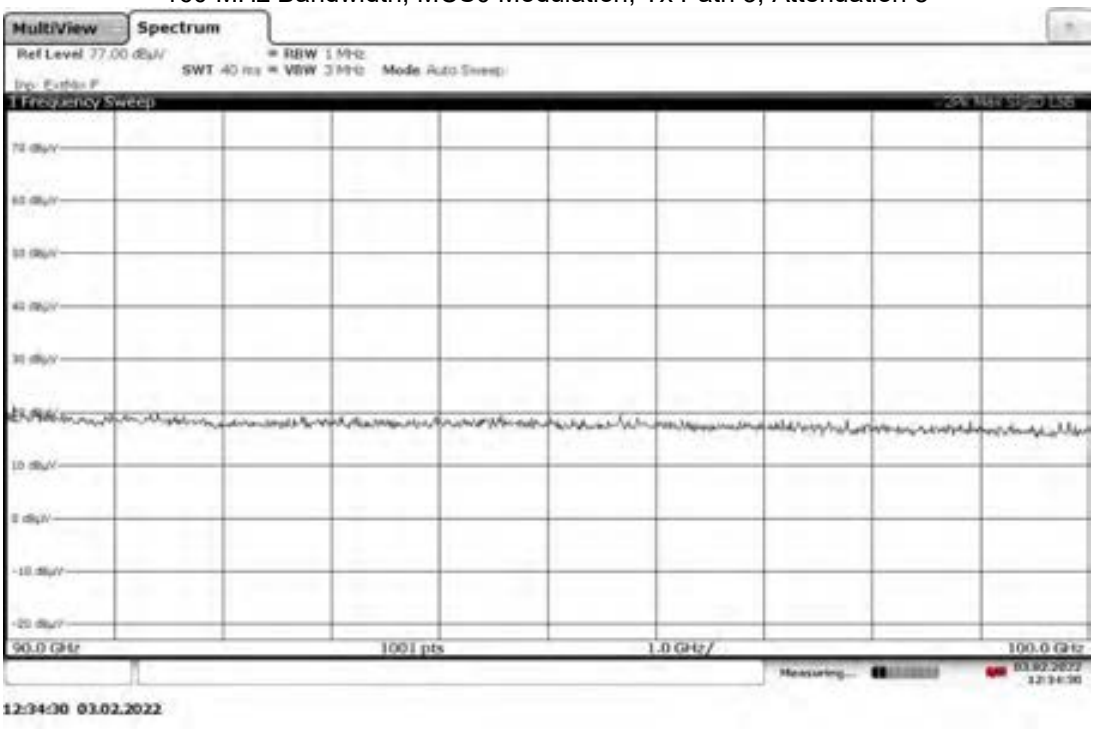
Transmit 25.16 GHz, RE 40-60 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 8



Transmit 25.16 GHz, RE 60-90 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 8



Transmit 25.16 GHz, RE 90-100 GHz
160 MHz Bandwidth, MCS0 Modulation, Tx Path 3, Attenuation 8



Notes: Peak detector was used. No emission was detected above the instrument noise floor.

Noise floor readings from the plots

Radiated Spurious Emissions

Company: Starry
Model #: Titan 24X45
Serial #: 2111000001
Engineers: Kouma Sinn
Project #: G104910448
Standard: FCC Part 30
Receiver: ROS005-1 (11-02-2022)
PreAmp: None
Date(s): 02/03/22
Location: 10m chamber
Limit Distance (m): 3
Test Distance (m): 3
PreAmp Used? (Y or N): N
Voltage/Frequency: 120VAC 60Hz
Antenna & Cables: N
Antenna: WR19, WR12, WR8
Cable(s): CBLHF2012-5M-2
Barometer: DAV007
Temp/Humidity/Pressure: 24 C 27% 1015mbar
Bands: N, LF, HF, SHF
NONE.
NONE.
Filter: NONE
Frequency Range: 40-100GHz

Net = Reading (dBuV/m) + Antenna Factor (dB1/m) + Cable Loss (dB) - Preamp Factor (dB) - Distance Factor (dB)
Peak: PK Quasi-Peak: QP Average: AVG RMS: RMS; NF = Noise Floor, RB = Restricted Band; Bandwidth denoted as RBW/VBW

Detector Type	Ant. Pol. (V/H)	Frequency GHz	Reading dB(uV/m)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Distance Factor dB	Net dB(uV/m)	Limit dB(uV/m)	Margin dB	Bandwidth	FCC
Note: 40-60 GHz range using WR19, Tx mode, Low CH 24.34GHz (Lower band), MCS0 160MHz BW, Path 3, Att10												
EIRP (dBm) = E (dBµV/m) + 20 * LOG (D) – 104.7 ; where D is the measurement distance (in the far field region) in m												
PK	V	48680.000	17.58	41.43	2.96	0.00	0.00	-33.19	-13.00	-20.19	1/3 MHz	Noise floor
PK	H	48680.000	17.80	41.43	2.96	0.00	0.00	-32.97	-13.00	-19.97	1/3 MHz	Noise floor
Note: 40-60 GHz range using WR19, Tx mode, Mid CH 24.35GHz (Lower band), MCS0 160MHz BW, Att10												
EIRP (dBm) = E (dBµV/m) + 20 * LOG (D) – 104.7 ; where D is the measurement distance (in the far field region) in m												
PK	V	48700.000	16.82	41.43	2.96	0.00	0.00	-33.95	-13.00	-20.95	1/3 MHz	Noise floor
PK	H	48700.000	17.13	41.43	2.96	0.00	0.00	-33.64	-13.00	-20.64	1/3 MHz	Noise floor
Note: 40-60 GHz range using WR19, Tx mode, High CH 24.36GHz (Lower band), MCS0 160MHz BW, Att0												
EIRP (dBm) = E (dBµV/m) + 20 * LOG (D) – 104.7 ; where D is the measurement distance (in the far field region) in m												
PK	V	48720.000	17.77	41.44	2.96	0.00	0.00	-32.99	-13.00	-19.99	1/3 MHz	Noise floor
PK	H	48720.000	17.49	41.44	2.96	0.00	0.00	-33.27	-13.00	-20.27	1/3 MHz	Noise floor
Note: 40-60 GHz range using WR19, Tx mode, Low CH 24.84GHz (Upper band), MCS0 160MHz BW, Att10.5												
EIRP (dBm) = E (dBµV/m) + 20 * LOG (D) – 104.7 ; where D is the measurement distance (in the far field region) in m												
PK	V	49680.000	17.85	41.61	2.96	0.00	0.00	-32.74	-13.00	-19.74	1/3 MHz	Noise floor
PK	H	49680.000	18.42	41.61	2.96	0.00	0.00	-32.17	-13.00	-19.17	1/3 MHz	Noise floor
Note: 40-60 GHz range using WR19, Tx mode, Mid CH 25.04GHz (Upper band), MCS0 160MHz BW, Att5.5												
EIRP (dBm) = E (dBµV/m) + 20 * LOG (D) – 104.7 ; where D is the measurement distance (in the far field region) in m												
PK	V	50080.000	19.53	41.68	2.96	0.00	0.00	-30.99	-13.00	-17.99	1/3 MHz	Noise floor
PK	H	50080.000	18.48	41.68	2.96	0.00	0.00	-32.04	-13.00	-19.04	1/3 MHz	Noise floor
Note: 40-60 GHz range using WR19, Tx mode, High CH 25.16GHz (Upper band), MCS0 160MHz BW, Att8												
EIRP (dBm) = E (dBµV/m) + 20 * LOG (D) – 104.7 ; where D is the measurement distance (in the far field region) in m												
PK	V	50320.000	18.95	41.72	2.96	0.00	0.00	-31.53	-13.00	-18.53	1/3 MHz	Noise floor
PK	H	50320.000	17.58	41.72	2.96	0.00	0.00	-32.90	-13.00	-19.90	1/3 MHz	Noise floor
Note: 60-100 GHz range using WR8 and WR12, Tx mode, Low CH 24.34GHz (Lower band), MCS0 160MHz BW												
EIRP (dBm) = E (dBµV/m) + 20 * LOG (D) – 104.7 ; where D is the measurement distance (in the far field region) in m												
PK	V	73020.000	19.74	45.95	2.96	0.00	0.00	-26.50	-13.00	-13.50	1/3 MHz	Noise floor
PK	H	73020.000	19.77	45.95	2.96	0.00	0.00	-26.47	-13.00	-13.47	1/3 MHz	Noise floor
Note: 60-100 GHz range using WR8 and WR12, Tx mode, Mid CH 24.35GHz (Lower band), MCS0 160MHz BW												
EIRP (dBm) = E (dBµV/m) + 20 * LOG (D) – 104.7 ; where D is the measurement distance (in the far field region) in m												
PK	V	73050.000	19.24	45.96	2.96	0.00	0.00	-27.00	-13.00	-14.00	1/3 MHz	Noise floor
PK	H	73050.000	20.39	45.96	2.96	0.00	0.00	-25.85	-13.00	-12.85	1/3 MHz	Noise floor
Note: 60-100 GHz range using WR8 and WR12, Tx mode, High CH 24.36GHz (Lower band), MCS0 160MHz BW												
EIRP (dBm) = E (dBµV/m) + 20 * LOG (D) – 104.7 ; where D is the measurement distance (in the far field region) in m												
PK	V	73080.000	19.39	45.96	2.96	0.00	0.00	-26.85	-13.00	-13.85	1/3 MHz	Noise floor
PK	H	73080.000	20.33	45.96	2.96	0.00	0.00	-25.91	-13.00	-12.91	1/3 MHz	Noise floor
Note: 60-100 GHz range using WR8 and WR12, Tx mode, Low CH 24.84GHz (Upper band), MCS0 160MHz BW												
EIRP (dBm) = E (dBµV/m) + 20 * LOG (D) – 104.7 ; where D is the measurement distance (in the far field region) in m												
PK	V	74520.000	20.50	46.13	2.96	0.00	0.00	-25.57	-13.00	-12.57	1/3 MHz	Noise floor
PK	H	74520.000	19.40	46.13	2.96	0.00	0.00	-26.67	-13.00	-13.67	1/3 MHz	Noise floor
Note: 60-100 GHz range using WR8 and WR12, Tx mode, Mid CH 25.04GHz (Upper band), MCS0 160MHz BW												
EIRP (dBm) = E (dBµV/m) + 20 * LOG (D) – 104.7 ; where D is the measurement distance (in the far field region) in m												
PK	V	75120.000	19.24	46.20	2.96	0.00	0.00	-26.76	-13.00	-13.76	1/3 MHz	Noise floor
PK	H	75120.000	20.23	46.20	2.96	0.00	0.00	-25.77	-13.00	-12.77	1/3 MHz	Noise floor
Note: 60-100 GHz range using WR8 and WR12, Tx mode, High CH 25.16GHz (Upper band), MCS0 160MHz BW												
EIRP (dBm) = E (dBµV/m) + 20 * LOG (D) – 104.7 ; where D is the measurement distance (in the far field region) in m												
PK	V	75480.000	20.84	46.24	2.96	0.00	0.00	-25.12	-13.00	-12.12	1/3 MHz	Noise floor
PK	H	75480.000	19.72	46.24	2.96	0.00	0.00	-26.24	-13.00	-13.24	1/3 MHz	Noise floor

Test Personnel:	Kouma Sinn	Test Date:	02/01/2022, 02/02/2022, 02/03/2022
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	FCC 47CFR Part 30 Subpart C	Limit Applied:	See Report Section 8.1
Input Voltage:	48 VDC Via External P/S	Ambient Temperature:	24, 25, 24 ºC
Pretest Verification w/ BB Source:	**Yes**	Relative Humidity:	9, 16, 31 %
		Atmospheric Pressure:	1026, 1022, 1013 mbars

Deviations, Additions, or Exclusions: None

9 Occupied Bandwidths

9.1 Requirements

FCC §2.1049 Measurements required: Occupied bandwidth

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured.

9.2 Method

Tests are performed in accordance with KDB 842590 D01 v01r02 Subclause 4.3 and ANSI C63.26-2015 Subclause 5.4. The measurement was made on the maximum field strength in the same worst-case orientation as in Section 6.1 with the Spectrum Analyzer setting as specified in ANSI C63.26-2015 Subclause 5.4.

TEST SITE: 10m ALSE

The 10m ALSE is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A Styrofoam table 80 cm high is used for table-top equipment.

9.3 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV007'	Weather Station Vantage Vue	Davis	6250	MS1912 12003	03/20/2021	03/20/2022
EMC04'	ANTENNA, RIDGED GUIDE, 18-40 GHZ	EMCO	3116	2090	01/28/2021	01/28/2022
ROS005-1'	Signal and Spectrum Analyzer	R&S	FSW43	100646	10/27/2020	11/02/2022
CBLHF2012-5M-2'	5m 9kHz-40GHz Coaxial Cable - SET2	Huber & Suhner	SF102	252676002	02/19/2021	02/19/2022

Software Utilized:

Name	Manufacturer	Version
None	N/A	N/A

9.4 Results:

The sample tested was found to Comply. Occupied bandwidths are within the band.

Frequency (GHz)	Transmitting Polarity	Modulation	Bandwidth (MHz)	Transmitting Path	Occupied Bandwidth (MHz)
24.27	Vertical	MCS8	20	3	18.620
24.28	Vertical	MCS8	20	3	19.299
24.29	Vertical	MCS8	20	3	18.701
24.77	Vertical	MCS8	20	3	18.808
24.97	Vertical	MCS8	20	3	19.342
25.09	Vertical	MCS8	20	3	18.926
24.27	Horizontal	MCS8	20	3	18.902
24.28	Horizontal	MCS8	20	3	19.504
24.29	Horizontal	MCS8	20	3	18.863
24.77	Horizontal	MCS8	20	3	19.567
24.97	Horizontal	MCS8	20	3	19.143
25.09	Horizontal	MCS8	20	3	19.391
24.34	Vertical	MCS0	160	3	159.831
24.35	Vertical	MCS0	160	3	159.050
24.36	Vertical	MCS0	160	3	159.022
24.84	Vertical	MCS0	160	3	159.035
25.04	Vertical	MCS0	160	3	158.541
25.16	Vertical	MCS0	160	3	159.338
24.34	Horizontal	MCS0	160	3	159.096
24.35	Horizontal	MCS0	160	3	159.030
24.36	Horizontal	MCS0	160	3	158.913
24.84	Horizontal	MCS0	160	3	159.780
25.04	Horizontal	MCS0	160	3	159.780
25.16	Horizontal	MCS0	160	3	158.147

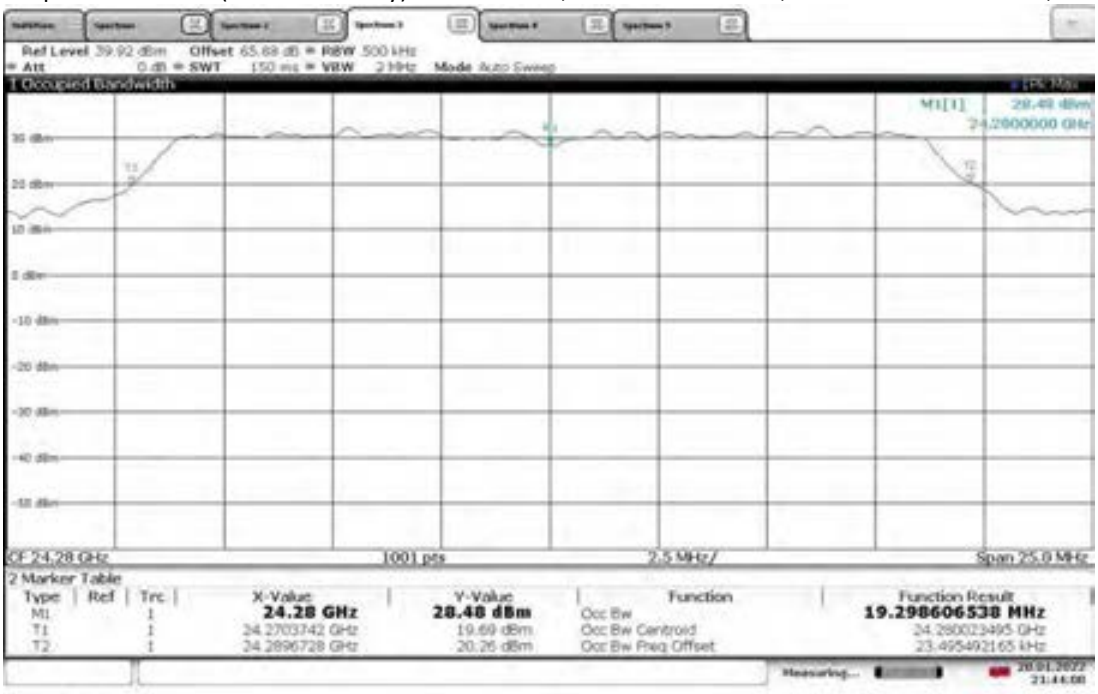
9.5 Setup Photographs:

Setup Photographs are included in a separate file.

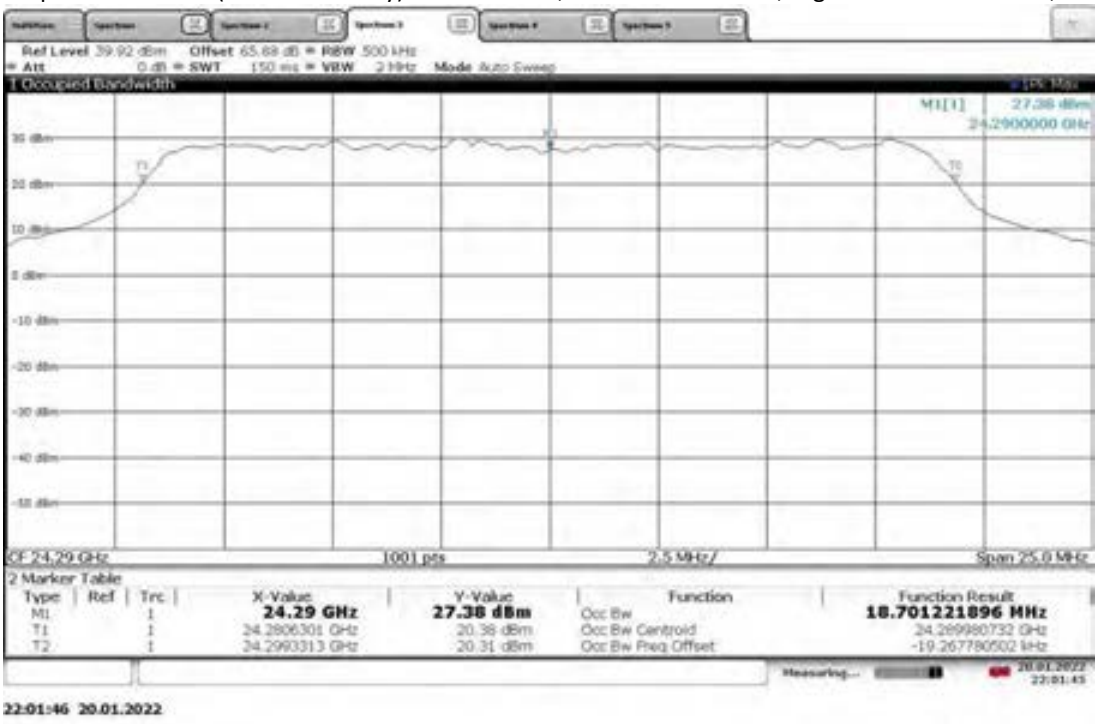
9.6 Plots/Data:

Occupied Bandwidth (Vertical Polarity) – Titan 24X45, 20 MHz Bandwidth, Low Channel 24.27 GHz, Att11

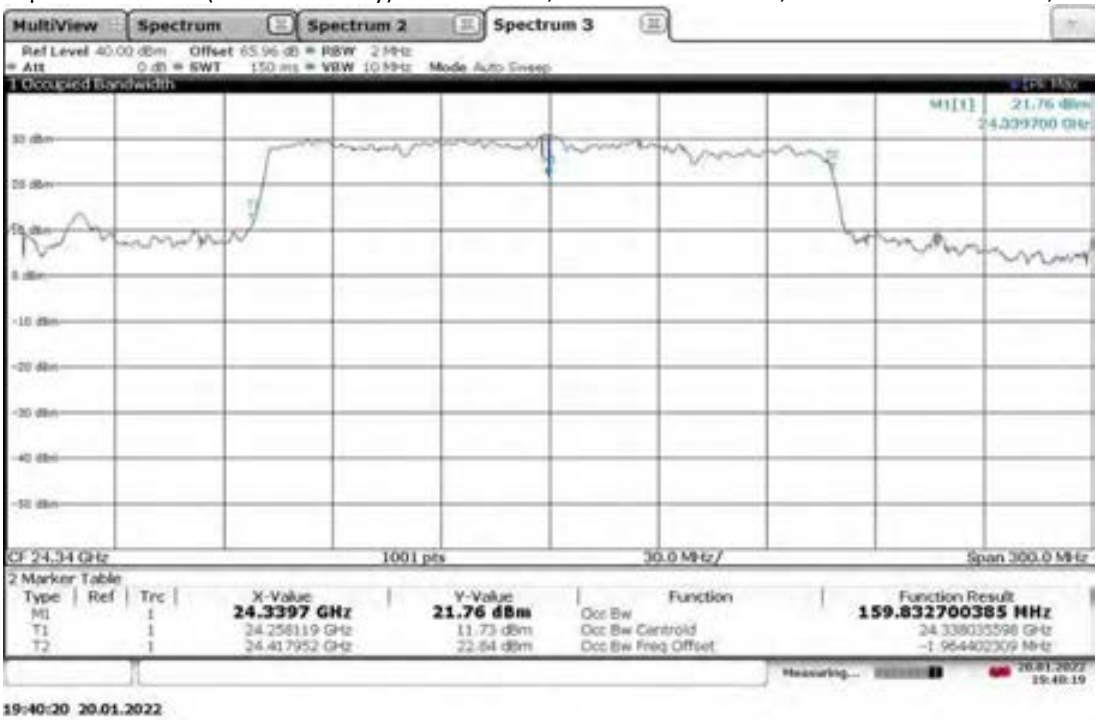
Occupied Bandwidth (Vertical Polarity) – Titan 24X45, 20 MHz Bandwidth, Mid Channel 24.28 GHz, Att9



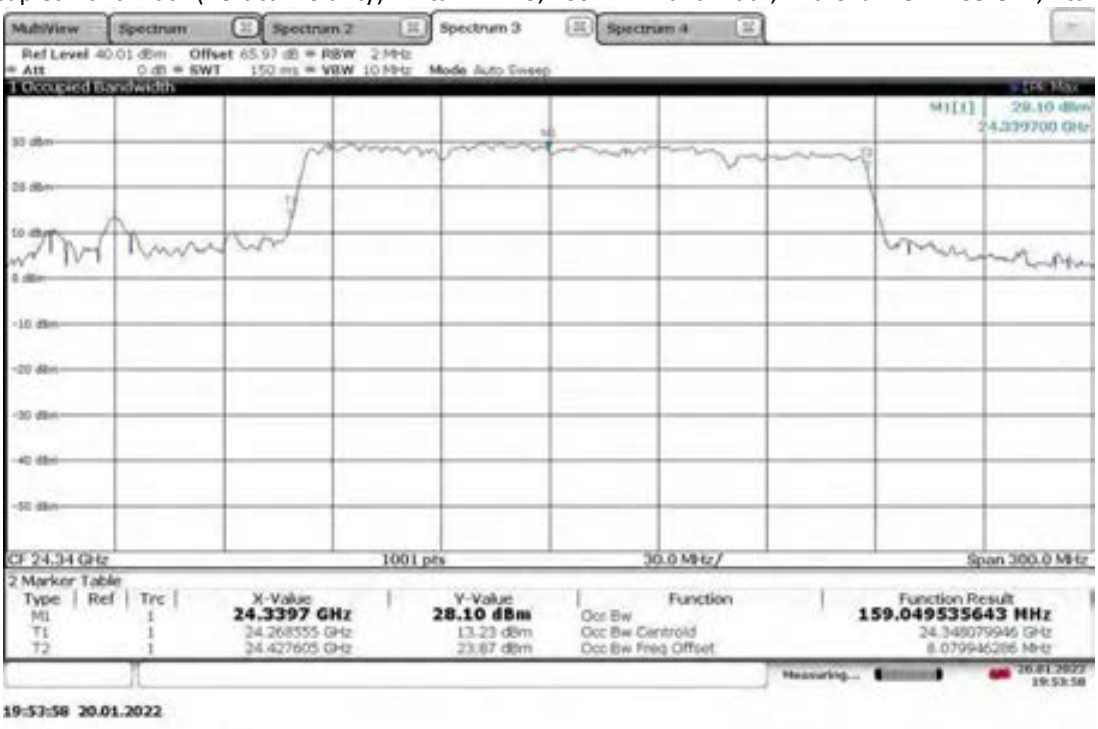
Occupied Bandwidth (Vertical Polarity) – Titan 24X45, 20 MHz Bandwidth, High Channel 24.29 GHz, Att9



Occupied Bandwidth (Vertical Polarity) – Titan 24X45, 160 MHz Bandwidth, Low Channel 24.34 GHz, Att12



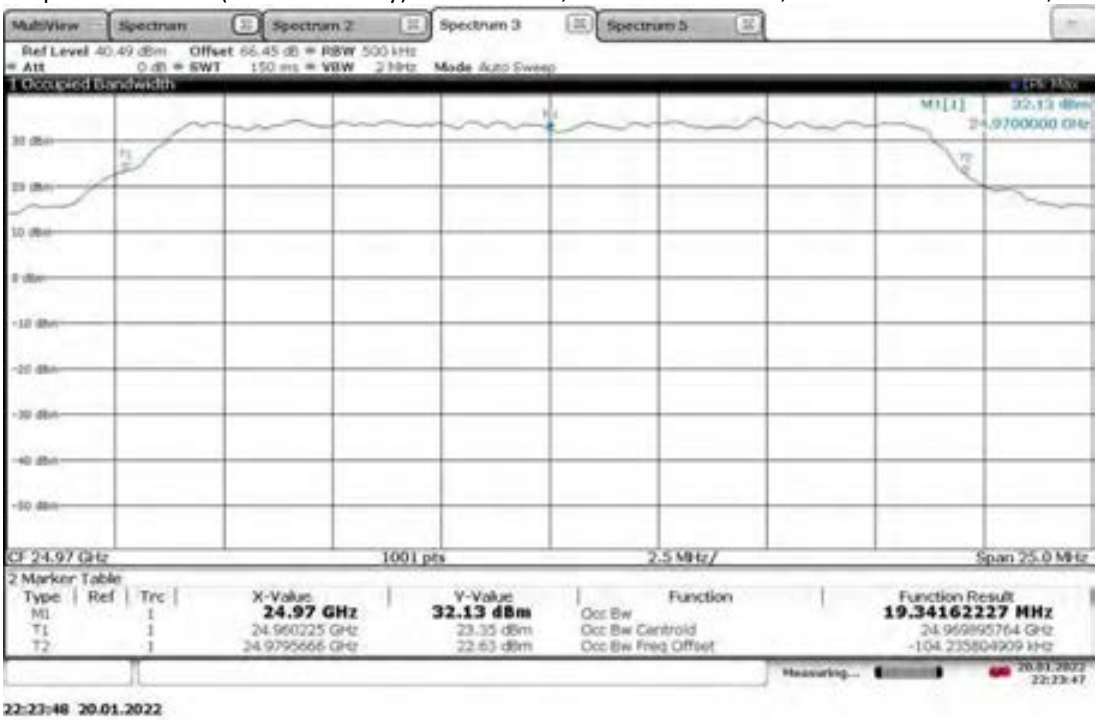
Occupied Bandwidth (Vertical Polarity) – Titan 24X45, 160 MHz Bandwidth, Mid Channel 24.35 GHz, Att12.5



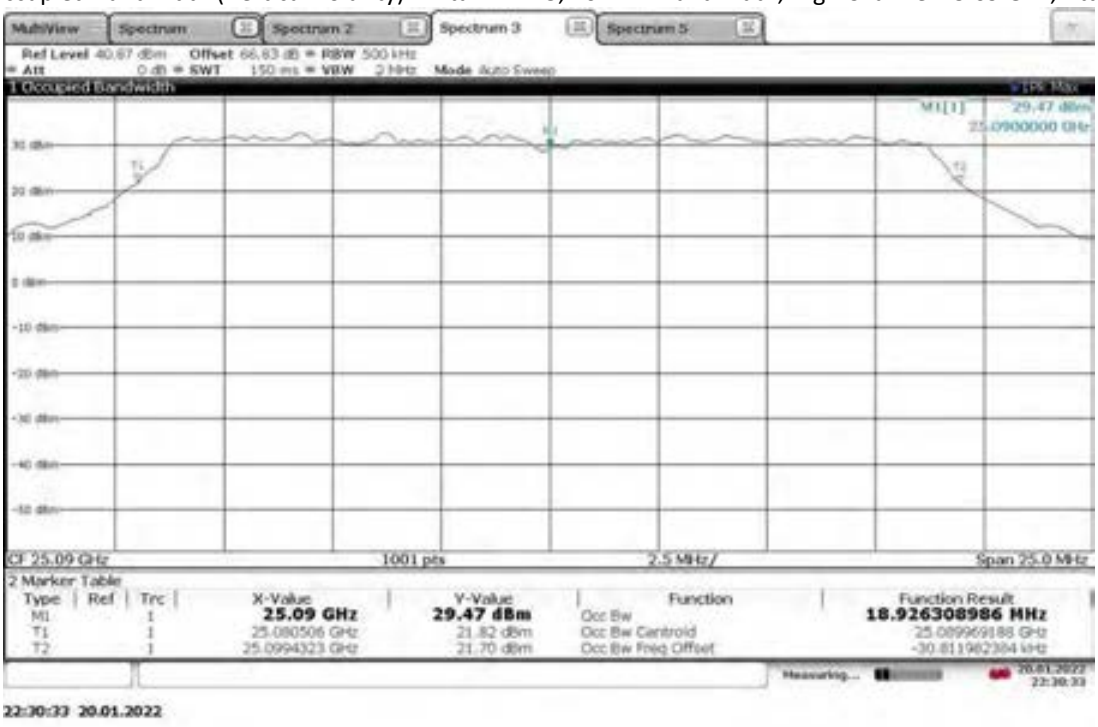
Occupied Bandwidth (Vertical Polarity) – Titan 24X45, 160 MHz Bandwidth, High Channel 24.36 GHz, Att9

Occupied Bandwidth (Vertical Polarity) – Titan 24X45, 20 MHz Bandwidth, Low Channel 24.77 GHz, Att12

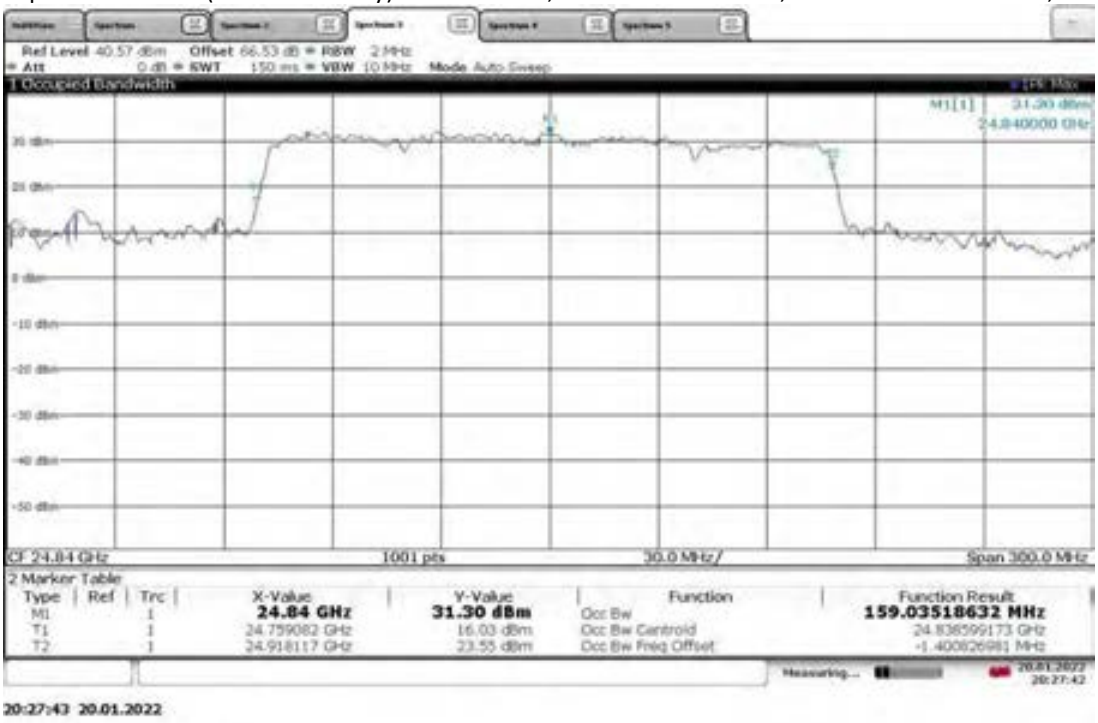
Occupied Bandwidth (Vertical Polarity) – Titan 24X45, 20 MHz Bandwidth, Mid Channel 24.97 GHz, Att8



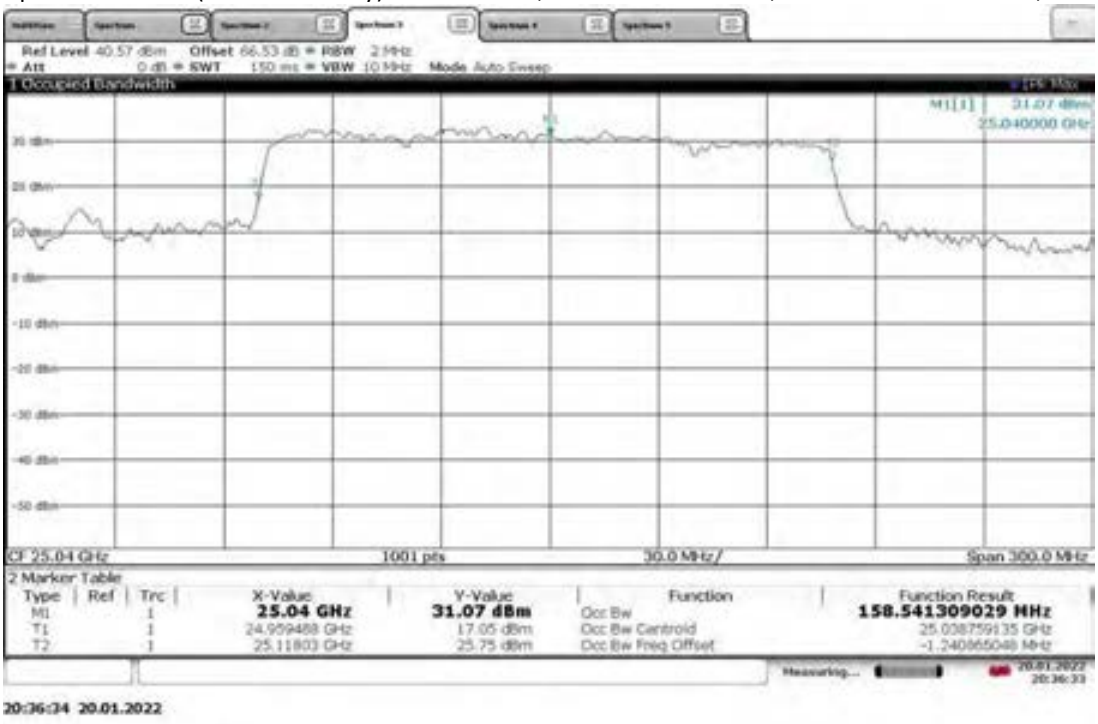
Occupied Bandwidth (Vertical Polarity) – Titan 24X45, 20 MHz Bandwidth, High Channel 25.09 GHz, Att8



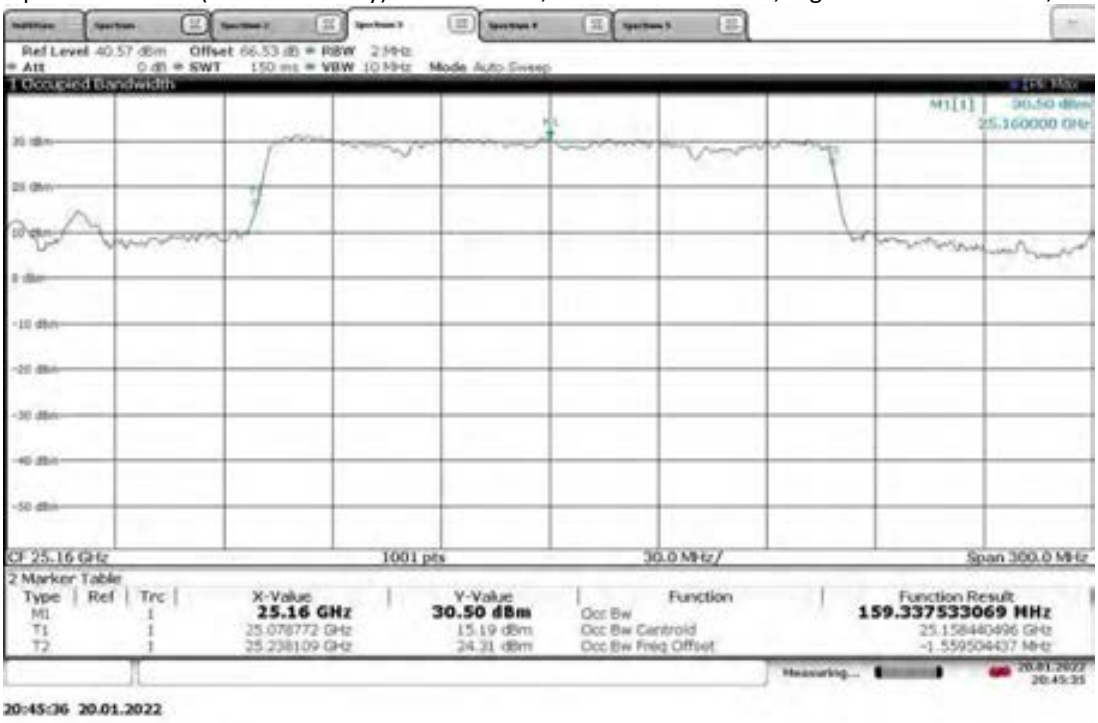
Occupied Bandwidth (Vertical Polarity) – Titan 24X45, 160 MHz Bandwidth, Low Channel 24.84 GHz, Att12



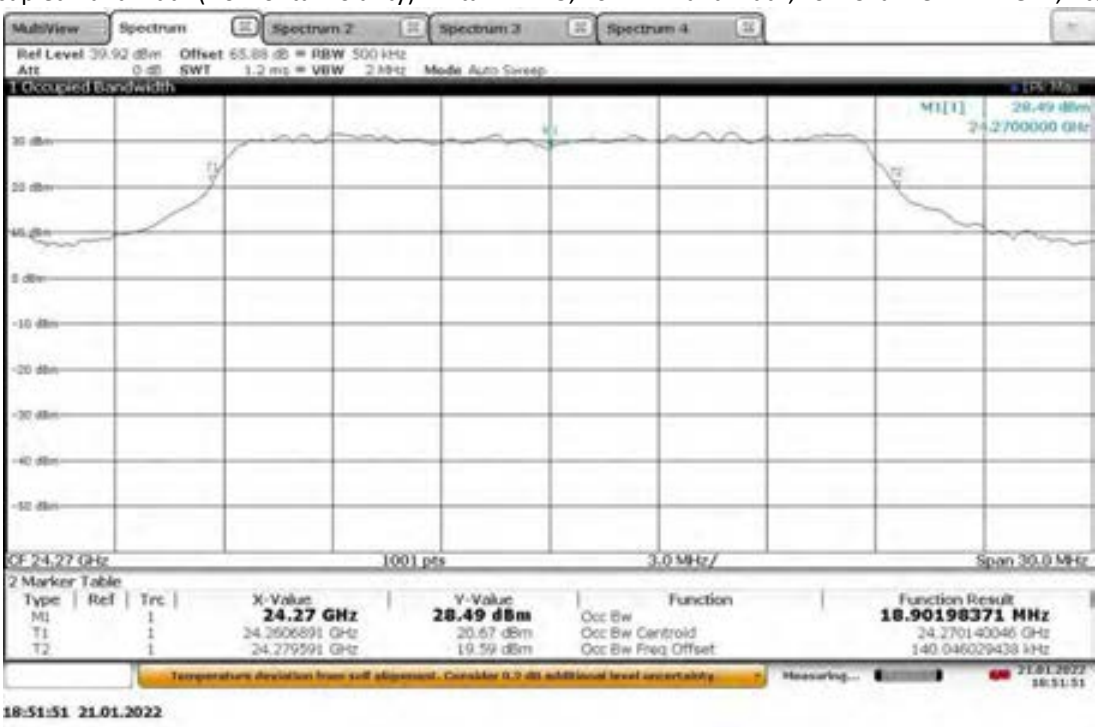
Occupied Bandwidth (Vertical Polarity) – Titan 24X45, 160 MHz Bandwidth, Mid Channel 25.04 GHz, Att11.5



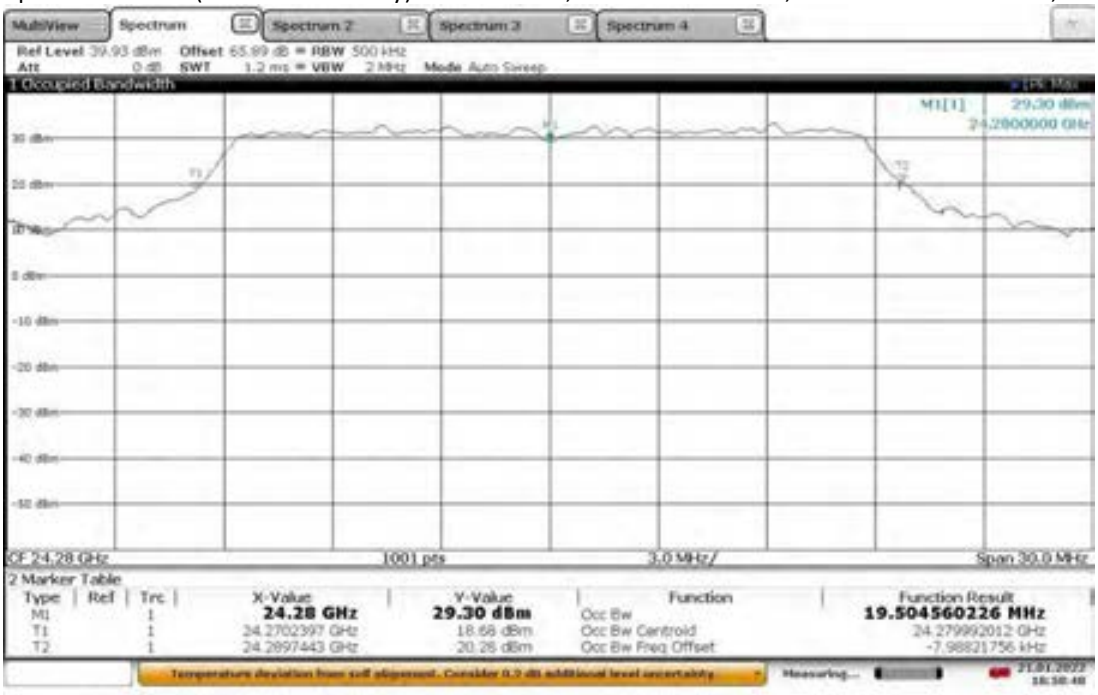
Occupied Bandwidth (Vertical Polarity) – Titan 24X45, 160 MHz Bandwidth, High Channel 25.16 GHz, Att9.5



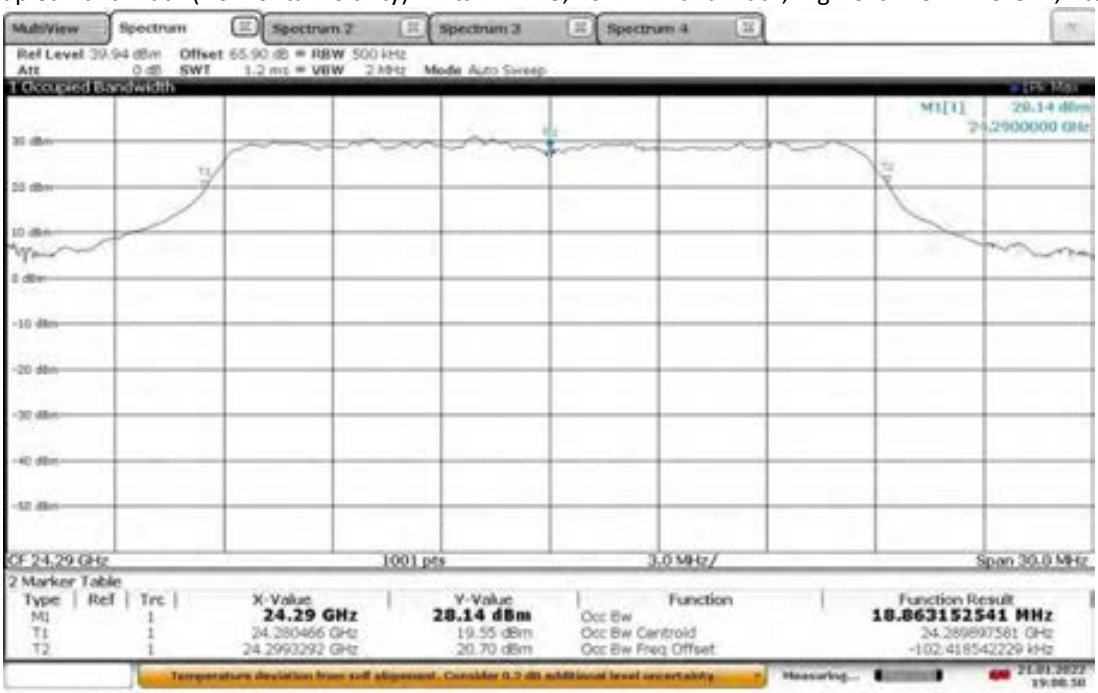
Occupied Bandwidth (Horizontal Polarity) – Titan 24X45, 20 MHz Bandwidth, Low Channel 24.27 GHz, Att10



Occupied Bandwidth (Horizontal Polarity) – Titan 24X45, 20 MHz Bandwidth, Mid Channel 24.28 GHz, Att8.5

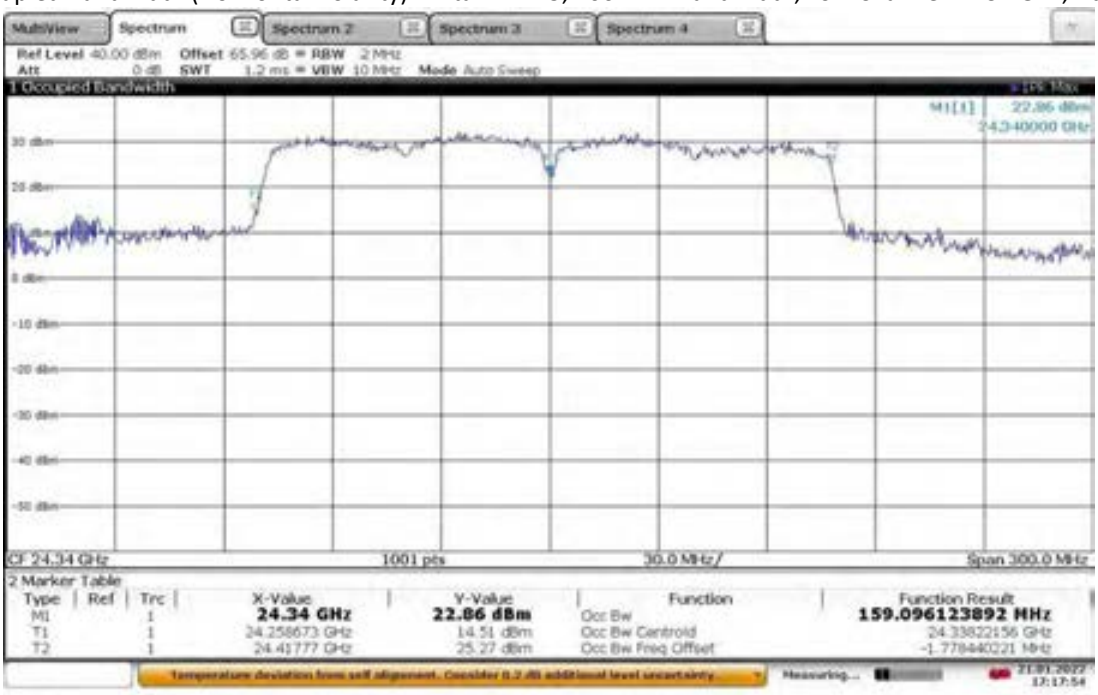


Occupied Bandwidth (Horizontal Polarity) – Titan 24X45, 20 MHz Bandwidth, High Channel 24.29 GHz, Att0.0



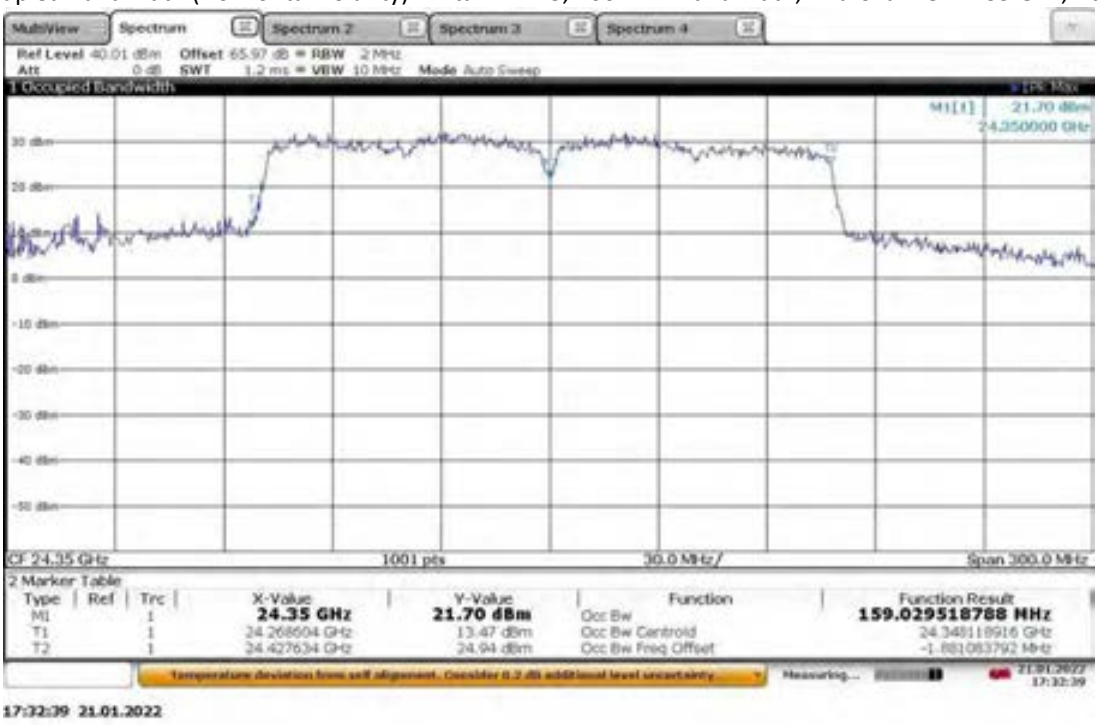
19:08:51 21.01.2022

Occupied Bandwidth (Horizontal Polarity) – Titan 24X45, 160 MHz Bandwidth, Low Channel 24.34 GHz, Att10

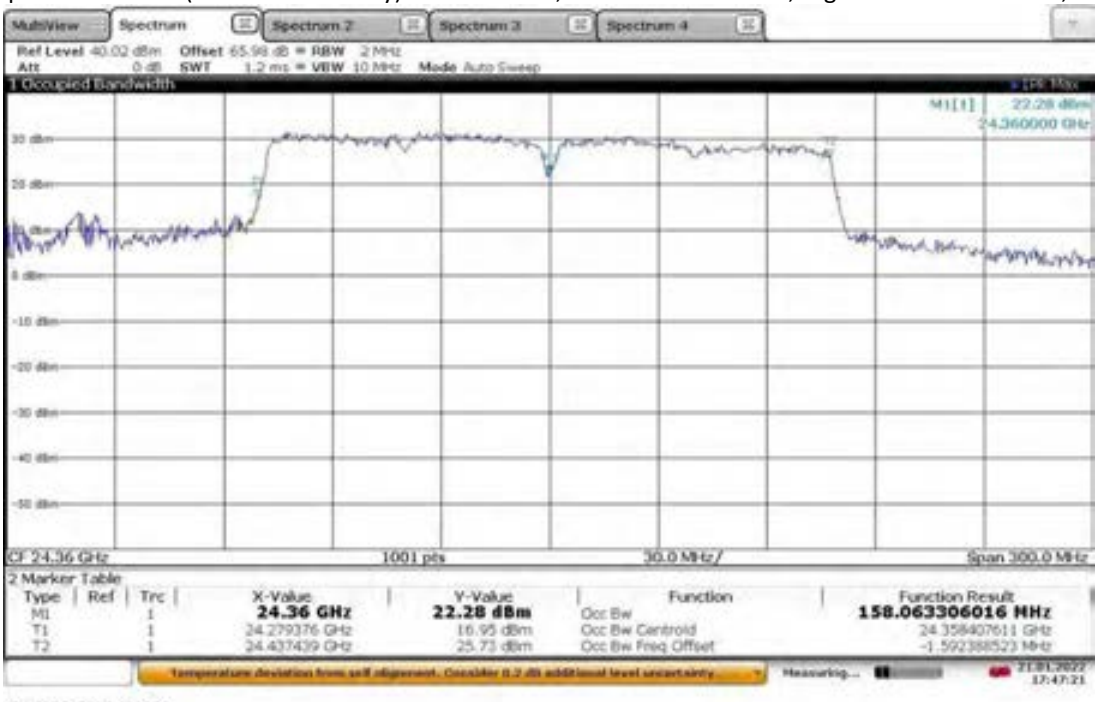


17:17:55 21.01.2022

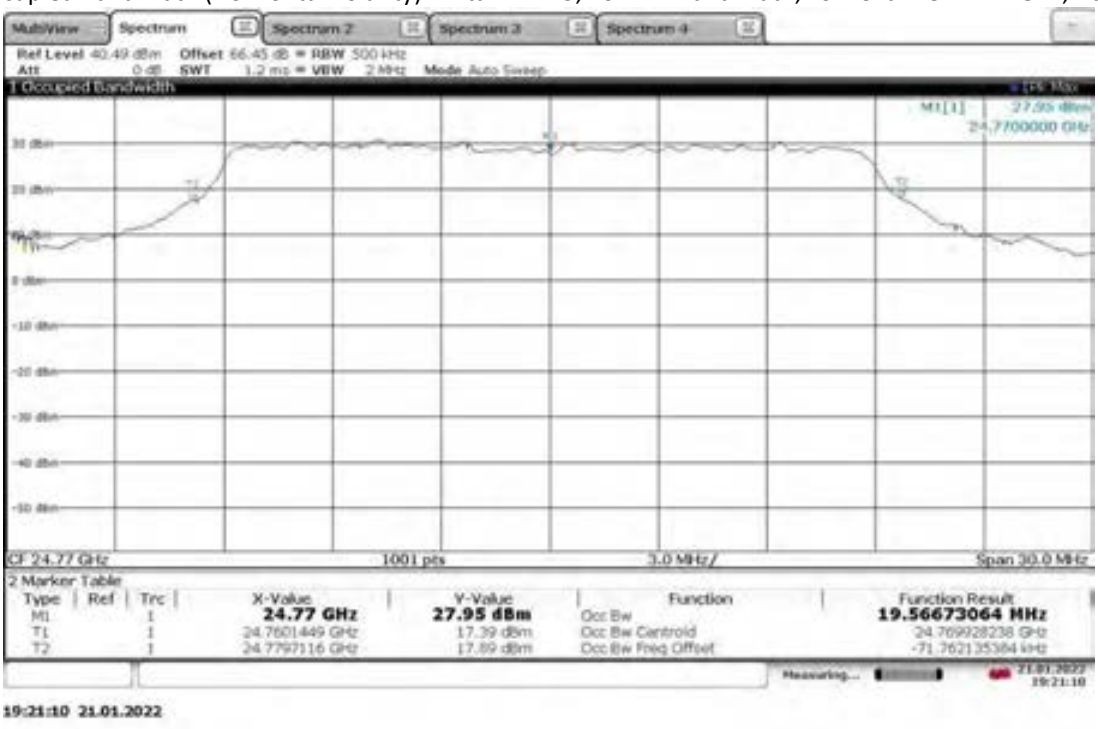
Occupied Bandwidth (Horizontal Polarity) – Titan 24X45, 160 MHz Bandwidth, Mid Channel 24.35 GHz, Att10



Occupied Bandwidth (Horizontal Polarity) – Titan 24X45, 160 MHz Bandwidth, High Channel 24.36 GHz, Att0.0

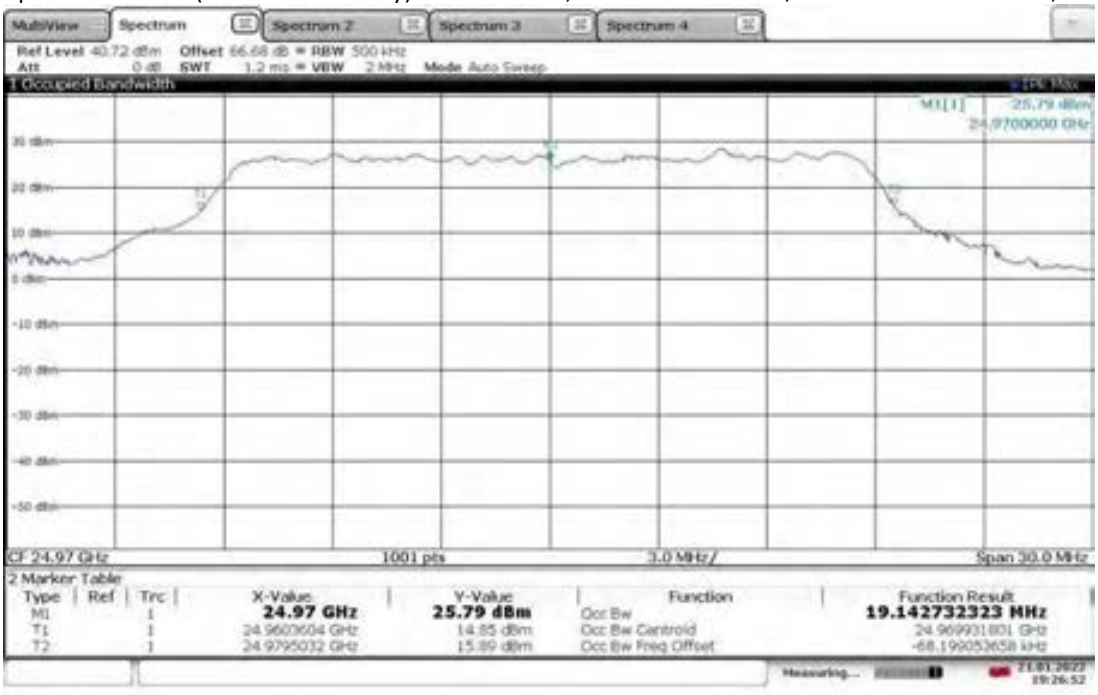


Occupied Bandwidth (Horizontal Polarity) – Titan 24X45, 20 MHz Bandwidth, Low Channel 24.77 GHz, Att9



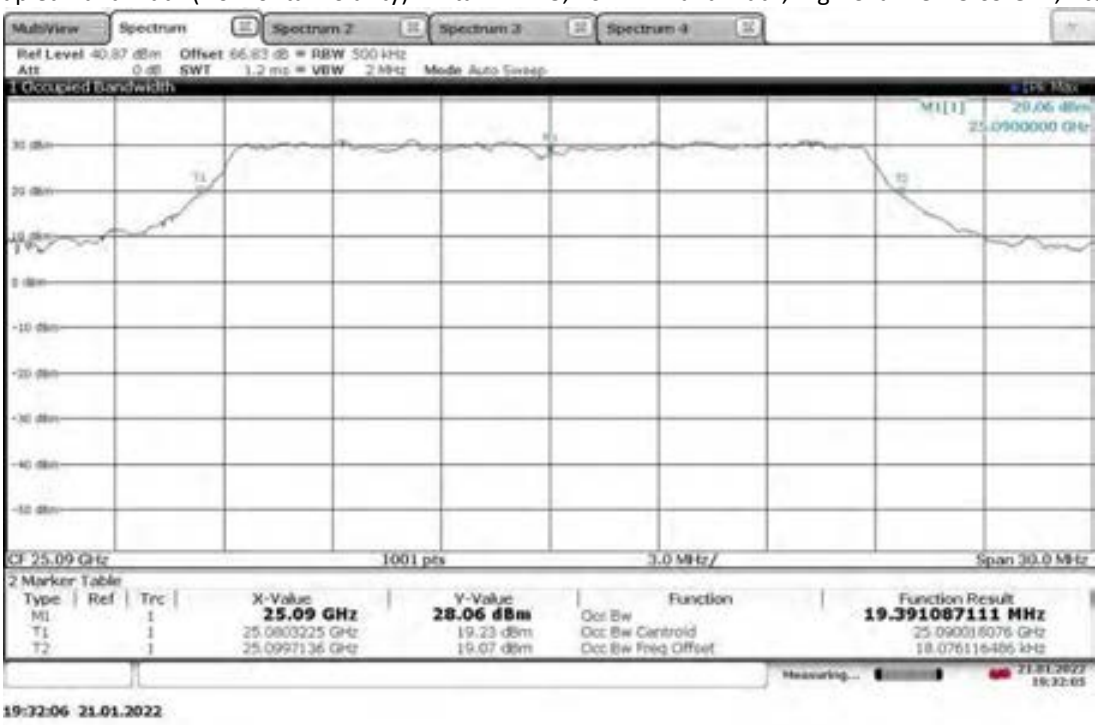
19:21:10 21.01.2022

Occupied Bandwidth (Horizontal Polarity) – Titan 24X45, 20 MHz Bandwidth, Mid Channel 24.97 GHz, Att7.5

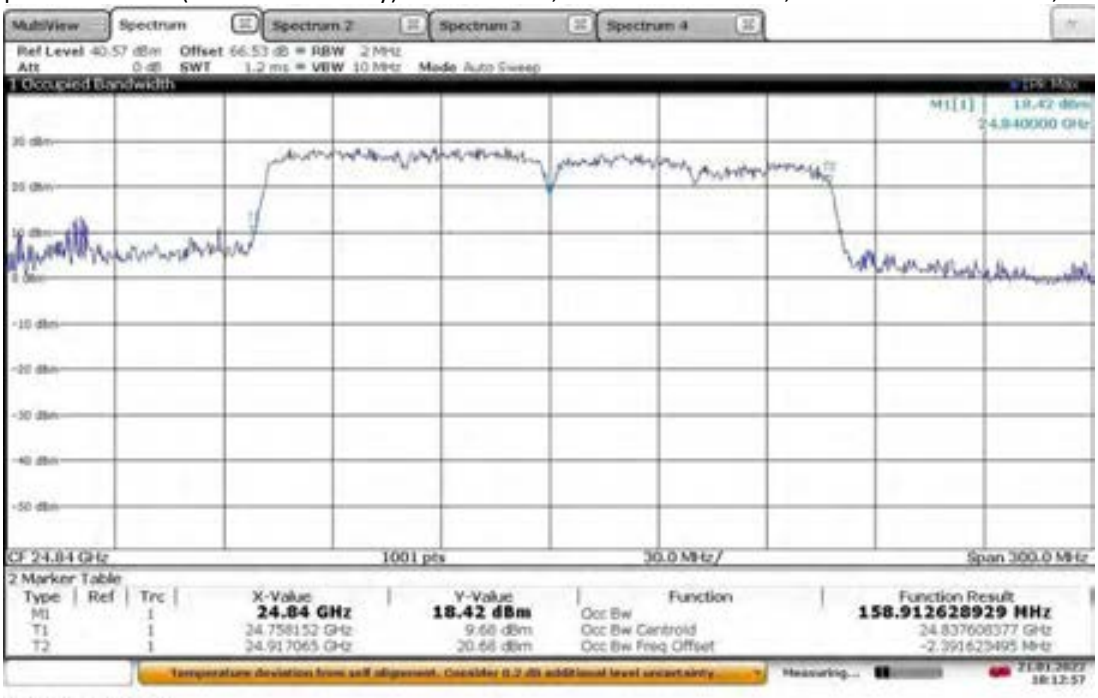


19:26:52 21.01.2022

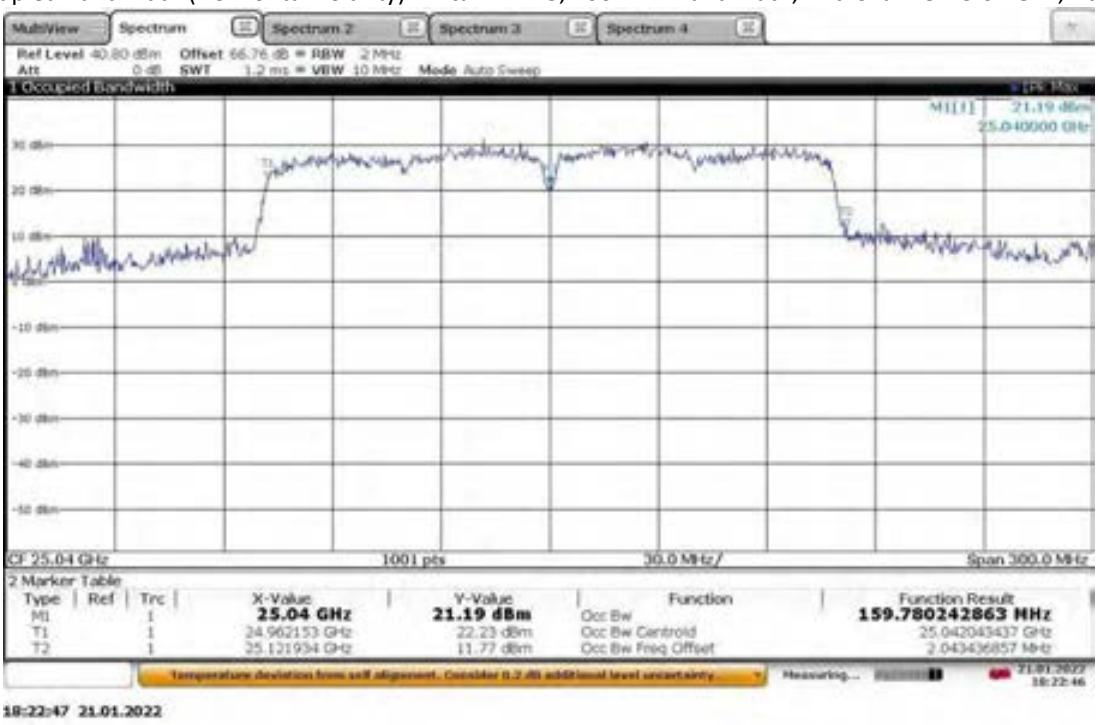
Occupied Bandwidth (Horizontal Polarity) – Titan 24X45, 20 MHz Bandwidth, High Channel 25.09 GHz, Att7.5



Occupied Bandwidth (Horizontal Polarity) – Titan 24X45, 160 MHz Bandwidth, Low Channel 24.84 GHz, Att10.5

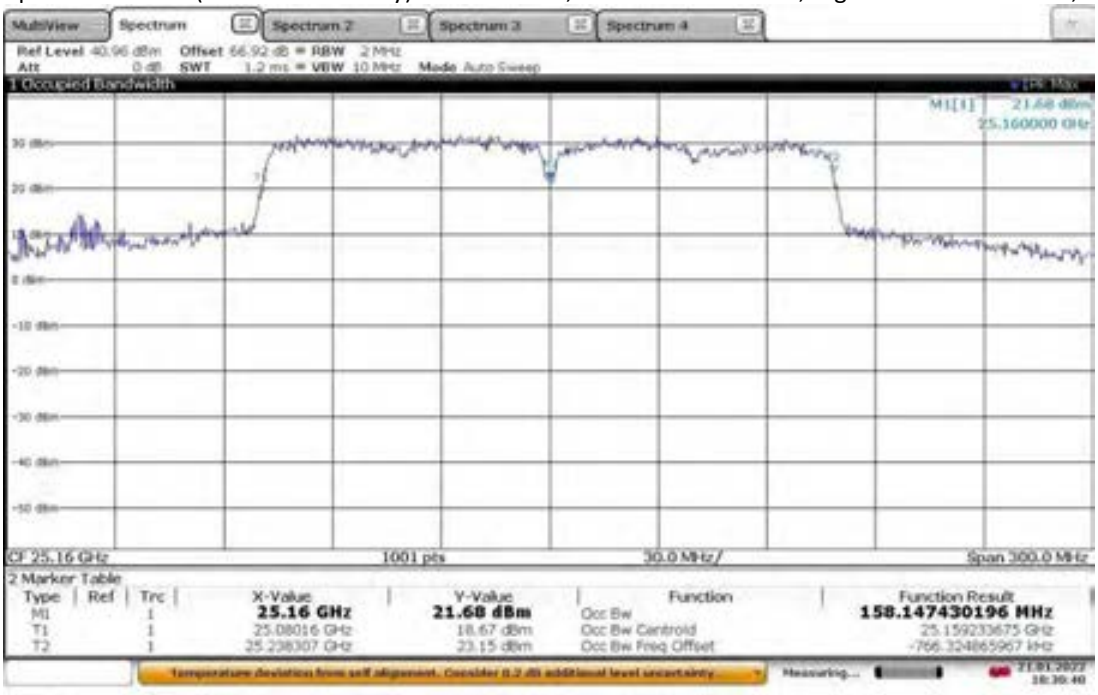


Occupied Bandwidth (Horizontal Polarity) – Titan 24X45, 160 MHz Bandwidth, Mid Channel 25.04 GHz, Att5.5



18:22:47 21.01.2022

Occupied Bandwidth (Horizontal Polarity) – Titan 24X45, 160 MHz Bandwidth, High Channel 24.16 GHz, Att8



18:30:41 21.01.2022

Test Personnel:	Kouma Sinn	Test Date:	01/20/2022, 01/21/2022
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	FCC 47CFR Part 30 Subpart C	Limit Applied:	See Report Section 9.1
Input Voltage:	48 VDC Via External P/S	Ambient Temperature:	24, 24 ºC
Pretest Verification w/ BB Source:	**Yes**	Relative Humidity:	13, 9 %
		Atmospheric Pressure:	1018, 1025 mbars

Deviations, Additions, or Exclusions: None

10 Revision History

Revision Level	Date	Report Number	Prepared By	Reviewed By	Notes
0	02/16/2022	104910448BOX-001	KPS	VFV	Original Issue

11 Appendix A – Mixer Conversion Loss

40-60 GHz Mixer Conversion Loss

WR19.0SAX-F

1 Product Overview

Product List (Quantity)	Serial Number(s)	Order No.	Date / Initials
WR19.0SAX-F (1)	SAX 835	21108A	03/26/2021 SAB

Product Description: This VDI product includes one WR19.0 Frequency Extender, intended for use with Rohde & Schwarz FSW spectrum analyzers. This user guide details the operation of the Frequency Extension Module.

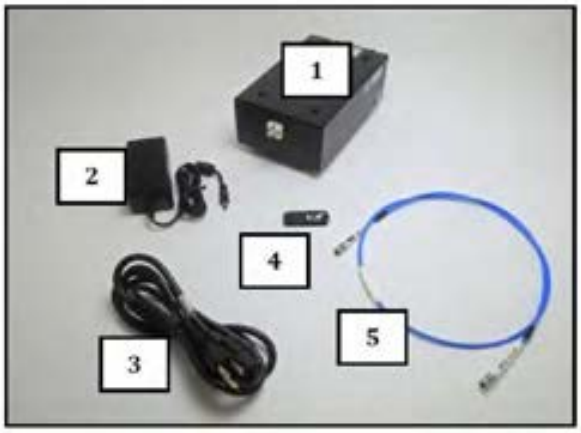


Figure 1: Photograph of typical configuration. All items may not be included.
Note: Photographs and specifications of accessories (horns, waveguide straights, etc.) are not included in this user guide.

No.	Part Description
1	SAX 835
2	9V Power Supply
3	AC Power Cable
4	USB Drive
5	LO Cable (not included)

2 Warning and Caution Statements

WARNING AND CAUTION STATEMENTS	
WARNING	This product can be permanently damaged by Electrostatic Discharge (ESD). It is recommended that engineers and technicians wear a special grounded wrist strap when handling this component. In addition, the work environment around the component should be well grounded.
WARNING	Opening the blocks, parts, or components will damage the internal components. VDI is not responsible for the warranty or guaranty of products damaged as a result of improper handling, testing, biasing, or use by customer.
CAUTION	VDI assumes the customer is familiar with microwave, millimeter wave, and VDI products. The user and customer are expected to understand all safety guidelines, health hazards, and general advisories that may exist and are associated with the use of this device. VDI is not responsible for any human hazards that may exist or may occur while using this device.

3 Product Specifications

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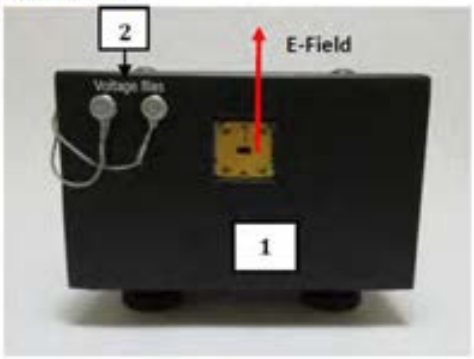

Description		Specification	Connector
RF Input [1]	Frequency Range	40-60GHz	WR19.0 UG-599/UM
	Power (Optimal / Damage)	<-20dBm / -10dBm	
Voltage Bias Port [2]	External Component Bias Voltage	+9V Output 50mA Maximum	LEMO 00 (f)
LO Input High Freq. [3]	Frequency Range	20-30GHz	2.9mm(f)
	Power (Typical† / Damage)	0dBm / 16dBm	
	Multiplication Factor	2	
LO Input Standard Freq. [4]*	Frequency Range	10-15GHz	2.9mm(f)
	Power (Typical† / Damage)	13dBm / 20dBm	
	Multiplication Factor	4	
IF Output Standard Freq. [4]*	Frequency Range	100MHz-2.5GHz	2.9mm(f)
IF Output High Freq. [5]	Frequency Range	100MHz-6GHz	2.9mm(f)
DC Input [6]	DC Power Connection	9V Output, 5A Maximum	2.1mm I.D. x 5.5mm O.D. x 9.5mm Male
Intrinsic Mixer**	SSB Conversion Loss***	9dB	-
Displayed Average Noise Level***		-152dBm/Hz	-

Table 1: General product specifications are shown.
† System is operational within +/- 3dB of nominal input power.
*Standard Freq. LO and IF share the same port.
**Intrinsic mixer conversion loss is measured before any IF amplification and cannot be accessed by user.
***See Section 5 for actual performance.

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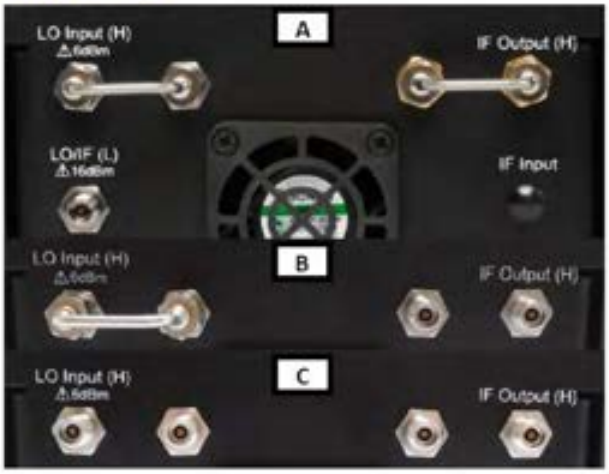

Configuration	LO Frequency	IF Frequency
A	Standard	Standard
B	Standard	High
C	High	High

Figure 2: Configuration details of dual LO input and dual IF output frequency modes are shown.

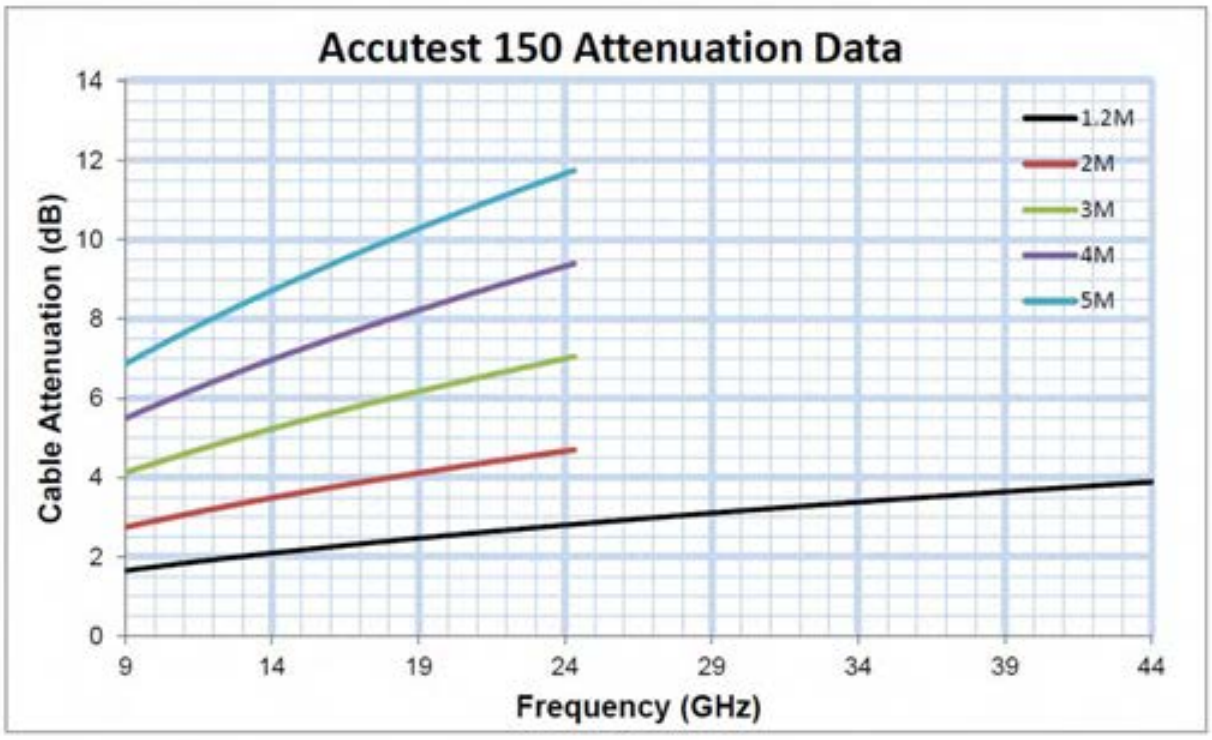

Figure 3: Insertion Loss of Accutest 150 (RF/LO Cable) with respect to frequency.

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4 General Operating Procedures and Guidelines

VDI assumes the customer is familiar with VDI products, and VDI is not responsible for the warranty or guaranty of products damaged as a result of improper handling, testing, biasing, or use by customer. VDI offers the following general guidelines for using these products and recommends the customer contact VDI at (434) 297-3257 for assistance if needed. The following procedures are a quick guide for turning on and off the product. In each case the individual steps must be followed in the proper sequence to avoid damaging critical components.

4.1 Required Operating Procedures

- DO NOT exceed damage limits listed in Table 1.
- DO NOT apply any external biases to the system.
- Make proper RF connections depending on desired configuration (i.e. Standard/High LO and Standard/High IF operation). Refer to Figure 2A-C for more information.

Failure to follow these procedures will damage or destroy the device.

4.2 Additional Guidelines, Limitations, and Recommendations

- The SAX is shipped with a reusable dust cover attached. Remove dust cover before operation.

4.3 Turn-On Procedure

1. The user and test bench must be properly grounded and protected against ESD.
2. With the LO and RF input power turned off, make all necessary connections (i.e. LO cable, AC cable, DC cable). See Figure 2A-C for configuration details.
3. Turn on the LO input power.
4. Turn on the small signal RF input power and monitor the IF output.

4.4 Turn-Off Procedure

1. The user and test bench must be properly grounded and protected against ESD.
2. Turn off the RF input power.
3. Turn off the LO input power.
4. Disconnect the DC Power Supply.
5. After completing turn-off procedures described above, it is now safe to turn off all other equipment on user test bench.

Contact VDI with questions or concerns regarding operational procedures and limitations.

5 Product Performance

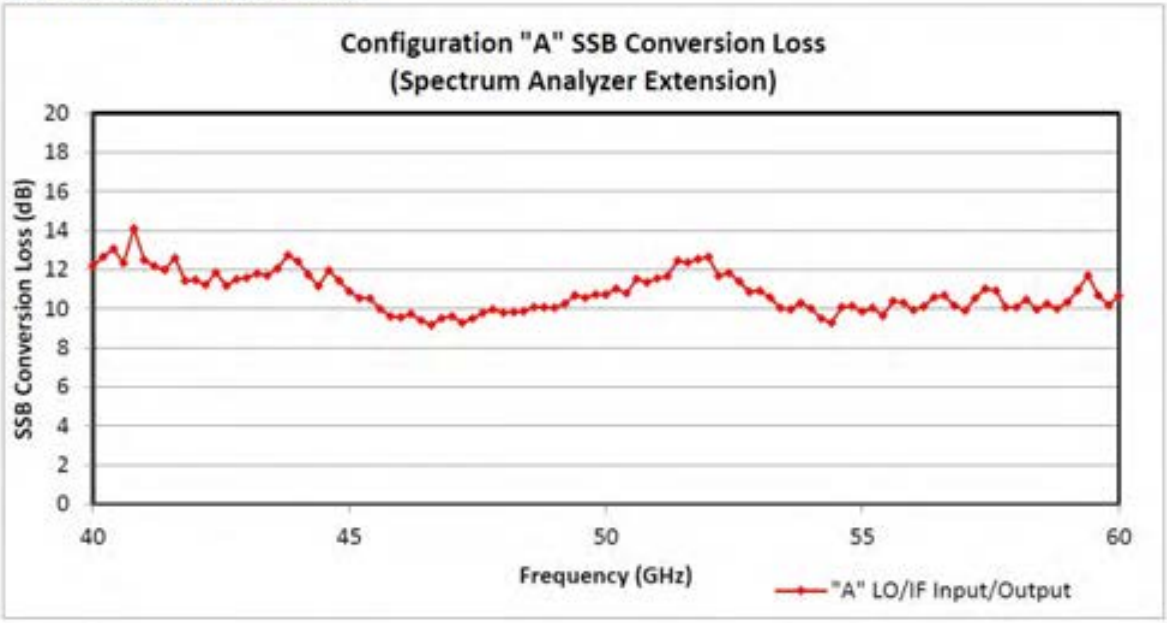

Figure 4: The product performance (SSB conversion loss vs. RF frequency) is shown for an LO input power of ~15dBm in Standard LO Frequency operation. IF power measured from "LO/IF" port with IF frequency fixed at 1.3GHz. CSV Data file included on USB Drive.

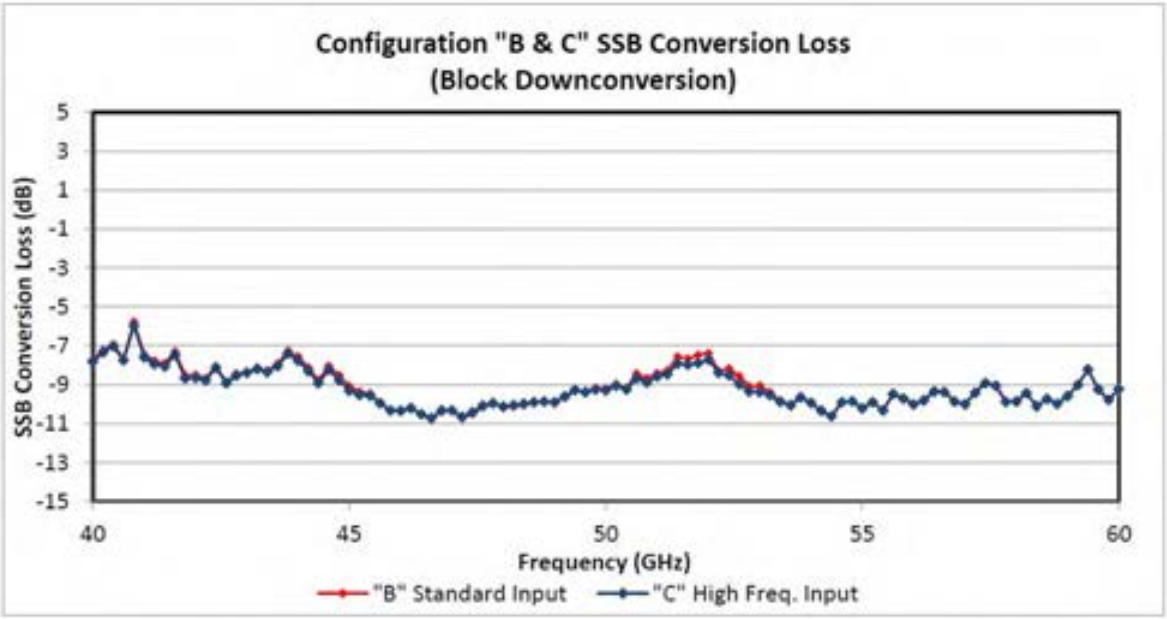

Figure 5: The product performance (SSB conversion loss vs. RF frequency) is shown for an LO input power of ~15dBm in Standard LO Frequency operation and LO input power of ~0dBm in High LO Frequency operation. IF power measured from "IF Output" port with IF frequency fixed at 1.3GHz. CSV Data file included on USB Drive.

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USER GUIDE

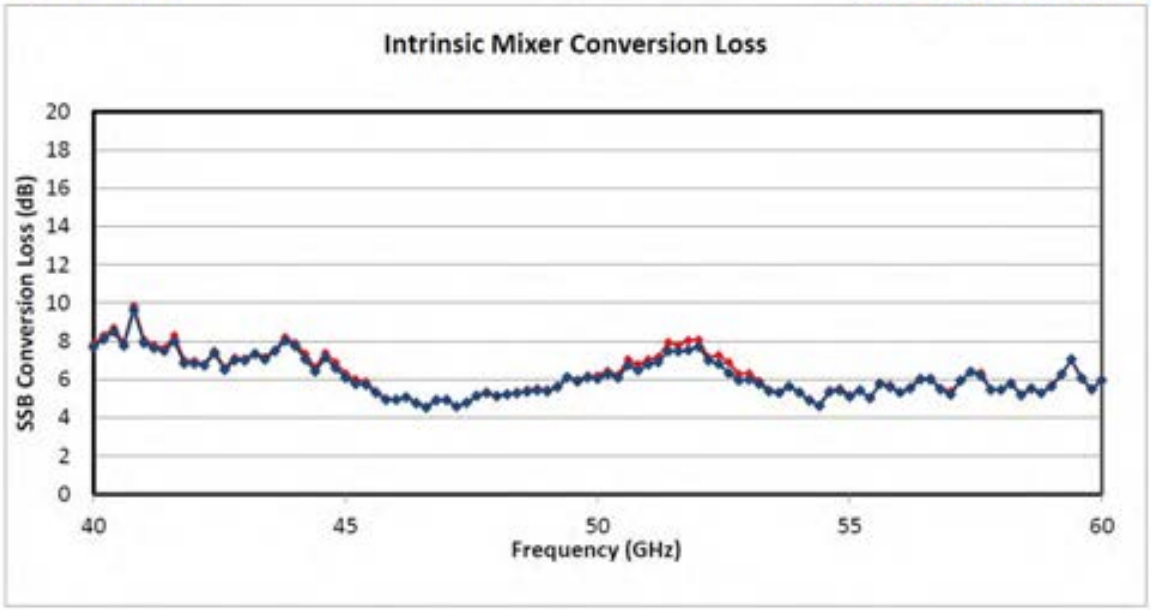

Figure 6: The product performance (SSB conversion loss vs. RF frequency) is shown for an LO input power of ~15dBm in Standard LO Frequency operation and LO input power of ~0dBm in High LO Frequency operation. IF power measured from mixer port with IF frequency fixed at 1.3GHz. Note: mixer port is not accessible for use by the user. CSV Data file included on USB Drive.

Measured Displayed Average Noise Level (dBm/Hz)	
Typical	-152.62

*Measured with a Keysight N9030A PXA Spectrum Analyzer.

SAX 835 Conversion Loss

Note: Out of band data is not guaranteed to be accurate

Freq(GHz)	"A" LO/IF Input/Output	"B" Standard Input	"C" High Freq. Input	High Freq. Intrinsic Mixer Loss	Standard Freq. Intrinsic Mixer Loss
40	12.18393	-7.73106531	-7.83106531	7.69093469	7.83793469
40.2	12.65257	-7.227428425	-7.346428425	8.089571575	8.295571575
40.4	13.04476	-6.935240346	-7.031240346	8.506759654	8.681759654
40.6	12.31643	-7.671565301	-7.756565301	7.763434699	7.913434699
40.8	14.09561	-5.784389207	-5.976389207	9.605610793	9.822610793
41	12.47222	-7.450776143	-7.586776143	7.911223857	8.075223857
41.2	12.17642	-7.766582166	-7.955582166	7.632417834	7.794417834
41.4	11.98468	-7.903316327	-8.068316327	7.491683673	7.628683673
41.6	12.58671	-7.300293808	-7.475293808	7.980706192	8.287706192
41.8	11.42126	-8.517743767	-8.682743767	6.840256233	6.992256233
42	11.46096	-8.504035139	-8.649035139	6.835964861	6.965964861
42.2	11.21847	-8.684527279	-8.781527279	6.735472721	6.799472721
42.4	11.83738	-8.055620485	-8.146620485	7.366379515	7.484379515
42.6	11.17569	-8.856309768	-8.917309768	6.502690232	6.599690232
42.8	11.49528	-8.435723496	-8.534723496	6.994276504	7.141276504
43	11.56904	-8.375963687	-8.395963687	6.987036313	7.103036313
43.2	11.79484	-8.120156119	-8.196156119	7.335843881	7.372843881
43.4	11.67951	-8.279490341	-8.364490341	7.050509659	7.176509659
43.6	12.05336	-7.943637944	-8.048637944	7.490362056	7.536362056
43.8	12.72018	-7.259817722	-7.400817722	8.024182278	8.205182278
44	12.40928	-7.555723107	-7.764723107	7.756276893	7.900276893
44.2	11.72591	-8.119091237	-8.296091237	7.052908763	7.335908763
44.4	11.15254	-8.774458098	-8.927458098	6.418541902	6.611541902
44.6	11.94911	-8.046893419	-8.235893419	7.146106581	7.381106581
44.8	11.41168	-8.535320915	-8.779320915	6.593679085	6.880679085
45	10.86545	-9.074546037	-9.315546037	6.077453963	6.296453963
45.2	10.52373	-9.371265586	-9.527265586	5.767734414	6.004734414
45.4	10.51426	-9.446741028	-9.563741028	5.714258972	5.882258972
45.6	9.986746	-9.939254477	-9.954254477	5.306745523	5.378745523
45.8	9.59202	-10.34998045	-10.33198045	4.939019546	4.994019546
46	9.54945	-10.34955021	-10.34255021	4.945449791	4.942449791
46.2	9.718601	-10.20139894	-10.20139894	5.06660106	5.08660106
46.4	9.4014	-10.51059989	-10.50859989	4.75540011	4.80640011
46.6	9.164813	-10.76618735	-10.72018735	4.525812655	4.559812655
46.8	9.49849	-10.37151002	-10.32451002	4.910489976	4.952489976
47	9.590663	-10.34933683	-10.32533683	4.919663167	4.930663167
47.2	9.264478	-10.73452184	-10.66252184	4.576478163	4.565478163
47.4	9.487929	-10.49307072	-10.42707072	4.788929277	4.774929277
47.6	9.782794	-10.16320569	-10.07820569	5.142794307	5.116794307

Freq(GHz)	"A" LO/IF Input/Output	"B" Standard Input	"C" High Freq. Input	High Freq. Intrinsic Mixer Loss	Standard Freq. Intrinsic Mixer Loss
47.8	9.95227	-9.987729761	-9.946729761	5.294270239	5.264270239
48	9.779821	-10.1941788	-10.1251788	5.128821195	5.129821195
48.2	9.817198	-10.11880169	-10.06180169	5.213198315	5.238198315
48.4	9.861049	-10.05895142	-9.99095142	5.29204858	5.22604858
48.6	10.07245	-9.889547923	-9.900547923	5.367452077	5.450452077
48.8	10.07077	-9.841233026	-9.876233026	5.424766974	5.527766974
49	10.02539	-9.862610661	-9.921610661	5.379389339	5.465389339
49.2	10.24586	-9.671136617	-9.615136617	5.606863383	5.561863383
49.4	10.6675	-9.289503278	-9.286503278	6.107496722	6.065496722
49.6	10.5412	-9.356800369	-9.393800369	5.891199631	5.991199631
49.8	10.71795	-9.170051536	-9.242051536	6.089948464	6.211948464
50	10.72015	-9.202846251	-9.294846251	6.036153749	6.207153749
50.2	11.01845	-8.967548981	-9.055548981	6.261451019	6.439451019
50.4	10.78694	-9.175059654	-9.246059654	6.097940346	6.231940346
50.6	11.51114	-8.446861426	-8.672861426	6.740138574	7.043138574
50.8	11.34446	-8.666536526	-8.891536526	6.471463474	6.789463474
51	11.54523	-8.420770486	-8.581770486	6.787229514	7.028229514
51.2	11.64424	-8.273764545	-8.461764545	6.912235455	7.159235455
51.4	12.45045	-7.554554578	-7.923554578	7.493445422	7.940445422
51.6	12.34762	-7.672378642	-7.986378642	7.465621358	7.783621358
51.8	12.53203	-7.48396897	-7.88396897	7.53103103	8.03103103
52	12.63471	-7.392294596	-7.710294596	7.710705404	8.068705404
52.2	11.66922	-8.296777367	-8.395777367	6.998222633	7.135222633
52.4	11.82163	-8.176370856	-8.512370856	6.820629144	7.266629144
52.6	11.38115	-8.567850502	-8.981850502	6.324149498	6.876149498
52.8	10.85834	-9.088660283	-9.362660283	5.949339717	6.282339717
53	10.90889	-9.054111321	-9.370111321	6.000888679	6.315888679
53.2	10.55653	-9.398471843	-9.553471843	5.768528157	5.922528157
53.4	10.02485	-9.857147743	-9.879147743	5.394852257	5.452852257
53.6	9.957231	-10.00976887	-10.05476887	5.300231127	5.343231127
53.8	10.28107	-9.656928444	-9.648928444	5.624071556	5.671071556
54	10.00557	-9.945426854	-9.944426854	5.313573147	5.316573147
54.2	9.483862	-10.38213777	-10.35113777	4.90986223	4.92486223
54.4	9.27475	-10.63425049	-10.62325049	4.602749509	4.658749509
54.6	10.07448	-9.899524203	-9.899524203	5.357475797	5.419475797
54.8	10.12309	-9.847914944	-9.861914944	5.428085056	5.530085056
55	9.843976	-10.19002385	-10.21402385	5.092976146	5.194976146
55.2	10.03561	-9.908389973	-9.910389973	5.416610027	5.438610027
55.4	9.643359	-10.31664094	-10.33464094	5.038359057	4.973359057
55.6	10.37222	-9.49677748	-9.48777748	5.76322252	5.79722252
55.8	10.30295	-9.680049143	-9.713049143	5.588950857	5.707950857
56	9.930571	-10.00042911	-10.01842911	5.310570886	5.301570886

Freq(GHz)	"A" LO/IF Input/Output	"B" Standard Input	"C" High Freq. Input	High Freq. Intrinsic Mixer Loss	Standard Freq. Intrinsic Mixer Loss
56.2	10.10271	-9.786290637	-9.816290637	5.528709363	5.602709363
56.4	10.57445	-9.318550175	-9.357550175	6.002449825	6.064449825
56.6	10.66912	-9.349881086	-9.393881086	6.004118914	6.076118914
56.8	10.14375	-9.840248304	-9.875248304	5.478751696	5.545751696
57	9.894501	-9.992499215	-10.01649921	5.211500785	5.371500785
57.2	10.52904	-9.407962195	-9.419962195	5.934037805	5.908037805
57.4	11.01629	-8.88670661	-8.91570661	6.39329339	6.41629339
57.6	10.9171	-9.033897975	-9.064897975	6.195102025	6.348102025
57.8	10.05695	-9.8670484	-9.8830484	5.4619516	5.4749516
58	10.06586	-9.834143573	-9.880143573	5.457856427	5.450856427
58.2	10.45513	-9.422873675	-9.434873675	5.770126325	5.841126325
58.4	9.959582	-10.09041812	-10.10741812	5.165581881	5.204581881
58.6	10.23535	-9.720652896	-9.738652896	5.511347104	5.584347104
58.8	9.987653	-9.967346763	-9.989346763	5.289653237	5.282653237
59	10.32975	-9.594251231	-9.600251231	5.624748769	5.691748769
59.2	10.94742	-9.004582916	-9.007582916	6.263417084	6.266417084
59.4	11.69635	-8.21964914	-8.21264914	7.04235086	7.01935086
59.6	10.67157	-9.294432287	-9.235432287	6.069567713	6.001567713
59.8	10.16657	-9.771428462	-9.783428462	5.485571538	5.447571538
60	10.64813	-9.237874856	-9.223874856	5.947125144	6.016125144

60-90 GHz Mixer Conversion Loss

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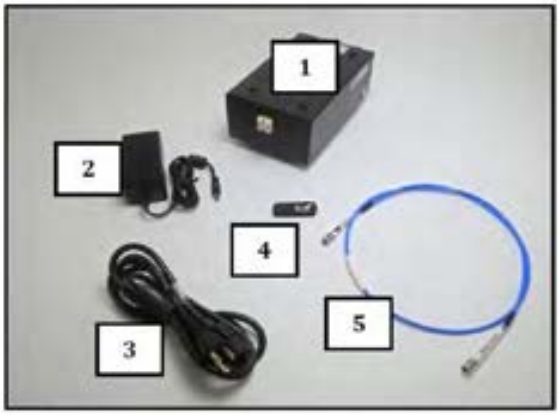
USER GUIDE

WR12.0SAX-F

1 Product Overview

Product List (Quantity)	Serial Number(s)	Order No.	Date / Initials
WR12.0SAX-F (1)	SAX 836	21108B	04/06/2021 CXS

Product Description: This VDI product includes one WR12.0 Frequency Extender, intended for use with Rohde & Schwarz FSW spectrum analyzers. This user guide details the operation of the Frequency Extension Module.



No.	Part Description
1	SAX 836
2	9V Power Supply
3	AC Power Cable
4	USB Drive
5	LO Cable (not included)

Figure 1: Photograph of typical configuration. All items may not be included.
Note: Photographs and specifications of accessories (horns, waveguide straights, etc.) are not included in this user guide.

2 Warning and Caution Statements

WARNING AND CAUTION STATEMENTS	
WARNING	This product can be permanently damaged by Electrostatic Discharge (ESD). It is recommended that engineers and technicians wear a special grounded wrist strap when handling this component. In addition, the work environment around the component should be well grounded.
WARNING	Opening the blocks, parts, or components will damage the internal components. VDI is not responsible for the warranty or guaranty of products damaged as a result of improper handling, testing, biasing, or use by customer.
CAUTION	VDI assumes the customer is familiar with microwave, millimeter wave, and VDI products. The user and customer are expected to understand all safety guidelines, health hazards, and general advisories that may exist and are associated with the use of this device. VDI is not responsible for any human hazards that may exist or may occur while using this device.

3 Product Specifications

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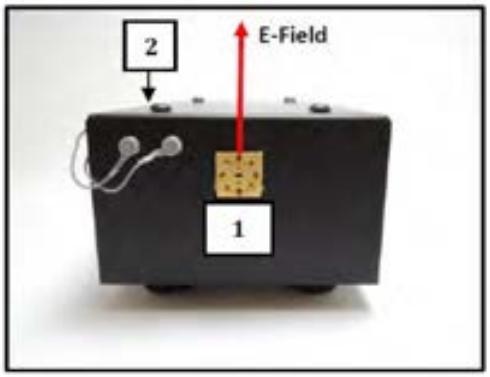
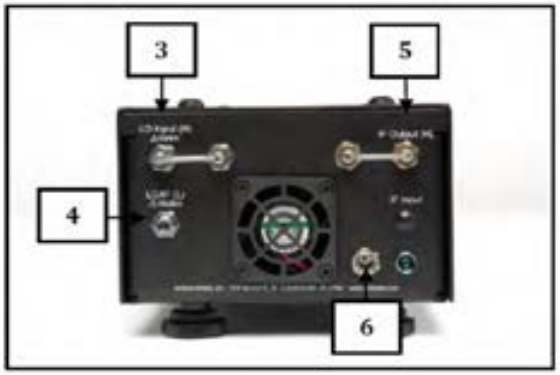
USER GUIDE





Description		Specification	Connector
RF Input [1]	Frequency Range	60-90GHz	WR12.0 UG-599/UM
	Power (Optimal / Damage)	<-20dBm / -10dBm	
Voltage Bias Port [2]	External Component Bias Voltage	+9V Output 50mA Maximum	LEMO 00 (f)
LO Input High Freq. [3]	Frequency Range	10-15GHz	2.9mm(f)
	Power (Typical† / Damage)	0dBm / 16dBm	
	Multiplication Factor	6	
LO Input Standard Freq. [4]*	Frequency Range	10-15GHz	2.9mm(f)
	Power (Typical† / Damage)	13dBm / 20dBm	
	Multiplication Factor	6	
IF Output Standard Freq. [4]*	Frequency Range	100MHz-2.5GHz	2.9mm(f)
IF Output High Freq. [5]	Frequency Range	100MHz-9GHz	2.9mm(f)
DC Input [6]	DC Power Connection	9V Output, 5A Maximum	2.1mm I.D. x 5.5mm O.D. x 9.5mm Male
Intrinsic Mixer**	SSB Conversion Loss***	10dB	-
Displayed Average Noise Level***		-152dBm/Hz	-

Table 1: General product specifications are shown.
† System is operational within +/- 3dB of nominal input power.
*Standard Freq. LO and IF share the same port.
**Intrinsic mixer conversion loss is measured before any IF amplification and cannot be accessed by user.
***See Section 5 for actual performance.

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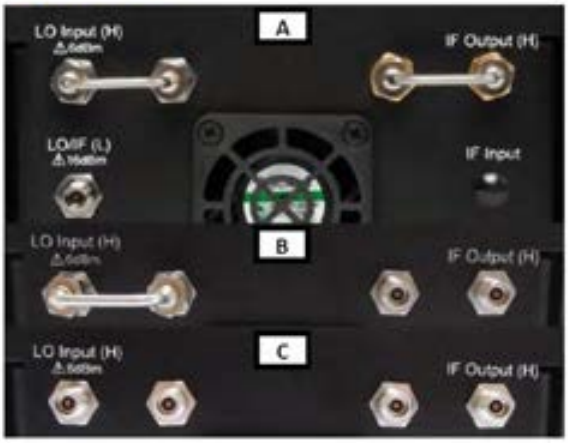

Configuration	LO Frequency	IF Frequency
A	Standard	Standard
B	Standard	High
C	High	High

Figure 2: Configuration details of dual LO input and dual IF output frequency modes are shown.

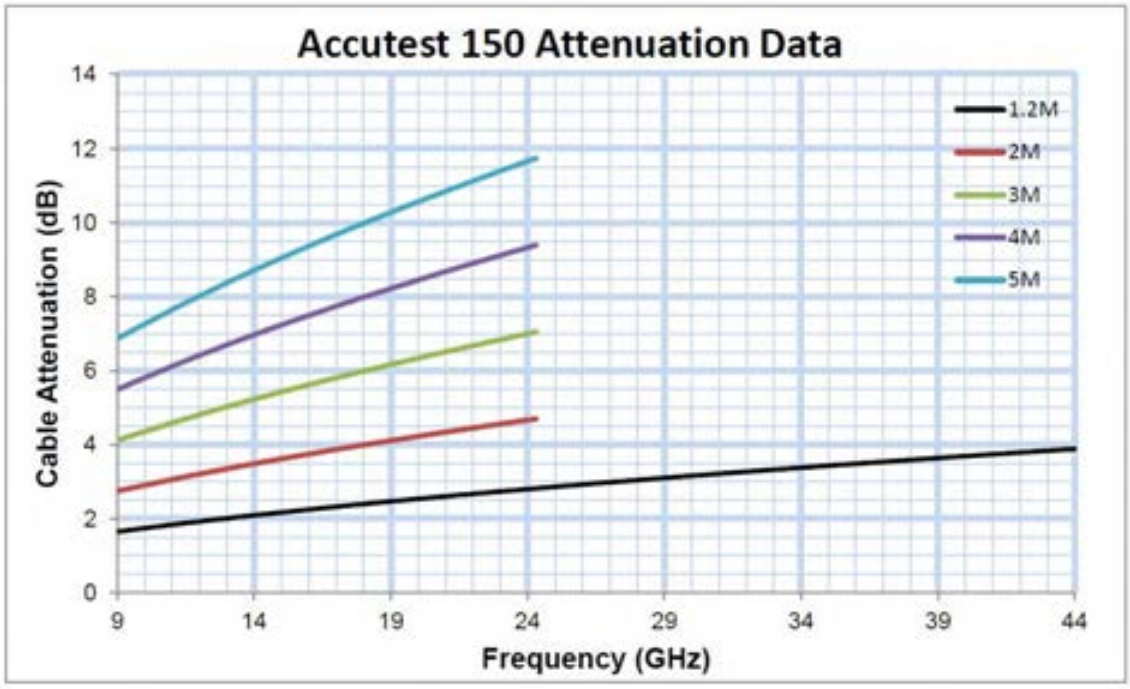

Figure 3: Insertion Loss of Accutest 150 (RF/LO Cable) with respect to frequency.

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4 General Operating Procedures and Guidelines

VDI assumes the customer is familiar with VDI products, and VDI is not responsible for the warranty or guaranty of products damaged as a result of improper handling, testing, biasing, or use by customer. VDI offers the following general guidelines for using these products and recommends the customer contact VDI at (434) 297-3257 for assistance if needed. The following procedures are a quick guide for turning on and off the product. In each case the individual steps must be followed in the proper sequence to avoid damaging critical components.

4.1 Required Operating Procedures

- DO NOT exceed damage limits listed in Table 1.
- DO NOT apply any external biases to the system.
- Make proper RF connections depending on desired configuration (i.e. Standard/High LO and Standard/High IF operation). Refer to Figure 2A-C for more information.

Failure to follow these procedures will damage or destroy the device.

4.2 Additional Guidelines, Limitations, and Recommendations

- The SAX is shipped with a reusable dust cover attached. Remove dust cover before operation.

4.3 Turn-On Procedure

1. The user and test bench must be properly grounded and protected against ESD.
2. With the LO and RF input power turned off, make all necessary connections (i.e. LO cable, AC cable, DC cable). See Figure 2A-C for configuration details.
3. Turn on the LO input power.
4. Turn on the small signal RF input power and monitor the IF output.

4.4 Turn-Off Procedure

1. The user and test bench must be properly grounded and protected against ESD.
2. Turn off the RF input power.
3. Turn off the LO input power.
4. Disconnect the DC Power Supply.
5. After completing turn-off procedures described above, it is now safe to turn off all other equipment on user test bench.

Contact VDI with questions or concerns regarding operational procedures and limitations.

5 Product Performance

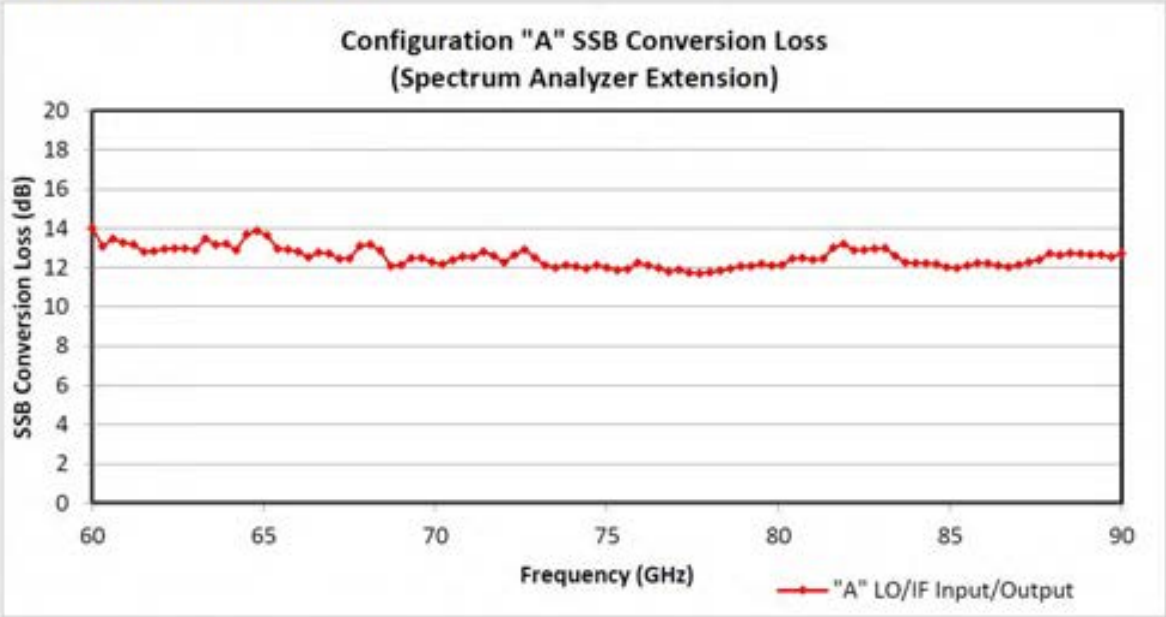

Figure 4: The product performance (SSB conversion loss vs. RF frequency) is shown for an LO input power of ~15dBm in Standard LO Frequency operation. IF power measured from "LO/IF" port with IF frequency fixed at 1.3GHz. CSV Data file included on USB Drive.

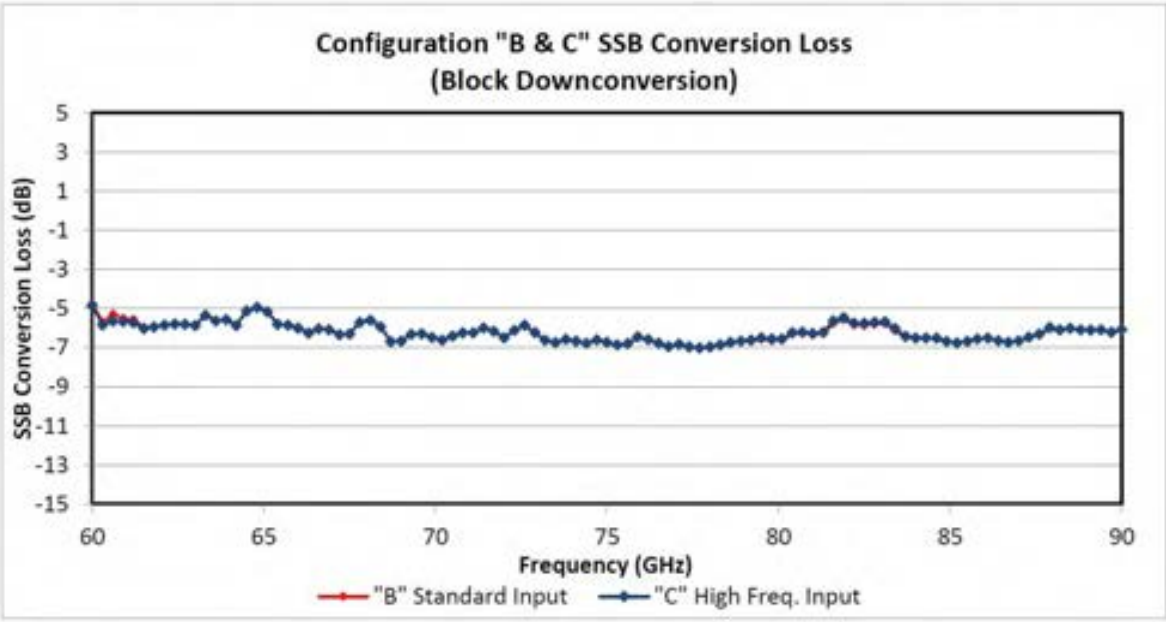

Figure 5: The product performance (SSB conversion loss vs. RF frequency) is shown for an LO input power of ~15dBm in Standard LO Frequency operation and LO input power of ~0dBm in High LO Frequency operation. IF power measured from "IF Output" port with IF frequency fixed at 1.3GHz. CSV Data file included on USB Drive.

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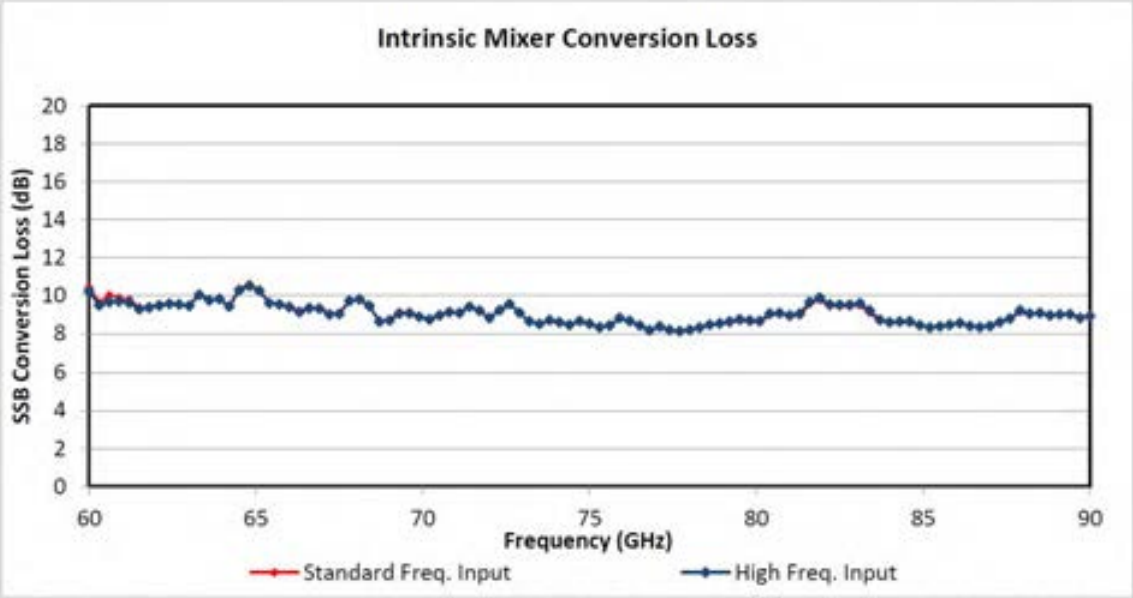


Figure 6: The product performance (SSB conversion loss vs. RF frequency) is shown for an LO input power of ~15dBm in Standard LO Frequency operation and LO input power of ~0dBm in High LO Frequency operation. IF power measured from mixer port with IF frequency fixed at 1.3GHz. Note: mixer port is not accessible for use by the user. CSV Data file included on USB Drive.

Measured Displayed Average Noise Level (dBm/Hz)	
Typical	-150.65

*Measured with a Keysight N9030A PXA Spectrum Analyzer.

SAX 836 Conversion Loss

Note: Out of band data is not guaranteed to be accurate

Freq(GHz)	"A" LO/IF Input/Output	"B" Standard Input	"C" High Freq. Input	High Freq. Intrinsic Mixer Loss	Standard Freq. Intrinsic Mixer Loss
60	14.00809673	-4.74690327	-4.86490327	10.22409673	10.40709673
60.3	13.08177247	-5.686227526	-5.842227526	9.482772474	9.645772474
60.6	13.44988267	-5.300117334	-5.655117334	9.656882666	10.01088267
60.9	13.26543128	-5.497568718	-5.666568718	9.689431282	9.877431282
61.2	13.17933468	-5.566665317	-5.739665317	9.610334683	9.782334683
61.5	12.80009579	-5.949904212	-6.025904212	9.275095788	9.380095788
61.8	12.82914386	-5.919856141	-5.953856141	9.363143859	9.427143859
62.1	12.94303505	-5.816964953	-5.851964953	9.468035047	9.537035047
62.4	12.97887686	-5.769123137	-5.797123137	9.562876863	9.595876863
62.7	12.96847511	-5.790524891	-5.806524891	9.521475109	9.549475109
63	12.90047744	-5.846522559	-5.880522559	9.443477441	9.500477441
63.3	13.47453136	-5.305468637	-5.358468637	10.03153136	10.09053136
63.6	13.16719015	-5.597809855	-5.631809855	9.743190145	9.784190145
63.9	13.21223698	-5.54176302	-5.57776302	9.80323698	9.83423698
64.2	12.89882197	-5.858178027	-5.877178027	9.423821973	9.472821973
64.5	13.68621534	-5.074784662	-5.137784662	10.27721534	10.35121534
64.8	13.87468986	-4.891310145	-4.952310145	10.50468986	10.58768986
65.1	13.63537185	-5.11962815	-5.16362815	10.24337185	10.29937185
65.4	12.96383529	-5.779164713	-5.809164713	9.594835287	9.641835287
65.7	12.90818146	-5.823818544	-5.864818544	9.523181456	9.563181456
66	12.79905144	-5.948948563	-6.018948563	9.387051437	9.445051437
66.3	12.52625358	-6.224746423	-6.264746423	9.128253577	9.178253577
66.6	12.77501349	-6.002986511	-6.044986511	9.332013489	9.386013489
66.9	12.70577709	-6.056222906	-6.098222906	9.304777094	9.340777094
67.2	12.44844547	-6.298554532	-6.348554532	8.999445468	9.058445468
67.5	12.45771307	-6.27928693	-6.30628693	9.03571307	9.05871307
67.8	13.09446348	-5.662536517	-5.710536517	9.711463483	9.745463483
68.1	13.18159215	-5.574407845	-5.614407845	9.789592155	9.842592155
68.4	12.86269872	-5.889301275	-5.932301275	9.452698725	9.498698725
68.7	12.06465654	-6.679343461	-6.704343461	8.624656539	8.651656539
69	12.12697909	-6.634020906	-6.663020906	8.681979094	8.730979094
69.3	12.47379099	-6.275209006	-6.320209006	9.048790994	9.109790994
69.6	12.49635632	-6.266643679	-6.302643679	9.061356321	9.119356321
69.9	12.29461412	-6.451385875	-6.487385875	8.877614125	8.913614125
70.2	12.15951216	-6.599487841	-6.628487841	8.725512159	8.760512159
70.5	12.38334399	-6.369656014	-6.416656014	8.946343986	8.999343986
70.8	12.55179008	-6.206209925	-6.243209925	9.126790075	9.154790075
71.1	12.53542905	-6.22657095	-6.25057095	9.07142905	9.11942905
71.4	12.80331874	-5.95168126	-6.00068126	9.40331874	9.41931874

Freq(GHz)	"A" LO/IF Input/Output	"B" Standard Input	"C" High Freq. Input	High Freq. Intrinsic Mixer Loss	Standard Freq. Intrinsic Mixer Loss
71.7	12.59441785	-6.142582148	-6.177582148	9.194417852	9.228417852
72	12.26506093	-6.485939069	-6.497939069	8.817060931	8.831060931
72.3	12.6529332	-6.105066802	-6.130066802	9.223933198	9.253933198
72.6	12.91123601	-5.84176399	-5.85376399	9.54023601	9.55323601
72.9	12.50543192	-6.253568082	-6.234568082	9.097431918	9.095431918
73.2	12.12384684	-6.638153158	-6.616153158	8.645846842	8.647846842
73.5	11.99820018	-6.767799823	-6.748799823	8.497200177	8.484200177
73.8	12.11430193	-6.643698071	-6.582698071	8.701301929	8.647301929
74.1	12.05944184	-6.710558164	-6.669558164	8.594441836	8.540441836
74.4	11.94565033	-6.811349671	-6.778349671	8.456650329	8.429650329
74.7	12.11754896	-6.642451036	-6.607451036	8.659548964	8.623548964
75	11.99113212	-6.768867875	-6.733867875	8.506132125	8.483132125
75.3	11.86630909	-6.900690911	-6.860690911	8.333309089	8.310309089
75.6	11.91810032	-6.838899678	-6.798899678	8.423100322	8.401100322
75.9	12.24548213	-6.500517867	-6.451517867	8.808482133	8.772482133
76.2	12.10239893	-6.643601074	-6.590601074	8.650398926	8.617398926
76.5	11.98551471	-6.789485292	-6.773485292	8.417514708	8.412514708
76.8	11.79713504	-6.968864956	-6.945864956	8.175135044	8.189135044
77.1	11.88064822	-6.869351775	-6.824351775	8.367648225	8.314648225
77.4	11.7419614	-7.018038601	-6.974038601	8.182961399	8.171961399
77.7	11.70070307	-7.05529693	-7.02129693	8.12070307	8.12070307
78	11.75970185	-6.99429815	-6.96829815	8.18070185	8.17970185
78.3	11.84442873	-6.900571271	-6.854571271	8.310428729	8.287428729
78.6	11.95018765	-6.799812349	-6.734812349	8.461187651	8.414187651
78.9	12.06854076	-6.706459237	-6.665459237	8.532540763	8.518540763
79.2	12.07851172	-6.674488276	-6.618488276	8.626511724	8.567511724
79.5	12.18083903	-6.574160969	-6.495160969	8.753839031	8.672839031
79.8	12.10740792	-6.654592085	-6.567592085	8.682407915	8.602407915
80.1	12.12624941	-6.617750592	-6.567750592	8.650249408	8.586249408
80.4	12.45676064	-6.305239365	-6.226239365	9.050760635	8.968760635
80.7	12.49277424	-6.273225761	-6.198225761	9.072774239	9.015774239
81	12.39938675	-6.35061325	-6.28161325	8.95738675	8.90238675
81.3	12.46230193	-6.292698068	-6.222698068	9.038301932	8.952301932
81.6	13.00393377	-5.757066234	-5.633066234	9.655933766	9.553933766
81.9	13.1857019	-5.5832981	-5.4612981	9.8847019	9.7637019
82.2	12.87742475	-5.848575252	-5.743575252	9.531424748	9.429424748
82.5	12.89518705	-5.867812949	-5.763812949	9.519187051	9.423187051
82.8	12.95150506	-5.81749494	-5.70349494	9.52050506	9.42650506
83.1	12.98575567	-5.77524433	-5.68224433	9.59075567	9.47675567
83.4	12.59718822	-6.140811779	-6.029811779	9.215188221	9.091188221
83.7	12.25796009	-6.493039911	-6.419039911	8.712960089	8.670960089
84	12.23114021	-6.524859786	-6.506859786	8.586140214	8.569140214

Freq(GHz)	"A" LO/IF Input/Output	"B" Standard Input	"C" High Freq. Input	High Freq. Intrinsic Mixer Loss	Standard Freq. Intrinsic Mixer Loss
84.3	12.20708834	-6.540911658	-6.506911658	8.629088342	8.584088342
84.6	12.18133493	-6.580665066	-6.515665066	8.645334934	8.565334934
84.9	12.01835551	-6.731644488	-6.691644488	8.437355512	8.409355512
85.2	11.97910956	-6.769890438	-6.757890438	8.310109562	8.331109562
85.5	12.09929486	-6.662705139	-6.685705139	8.368294861	8.384294861
85.8	12.22092835	-6.529071647	-6.559071647	8.449928353	8.487928353
86.1	12.21270567	-6.532294329	-6.513294329	8.549705671	8.545705671
86.4	12.10955656	-6.659443442	-6.661443442	8.391556558	8.413556558
86.7	12.01941635	-6.735583651	-6.734583651	8.320416349	8.351416349
87	12.12790597	-6.652094034	-6.659094034	8.388905966	8.431905966
87.3	12.2779043	-6.474095698	-6.469095698	8.598904302	8.628904302
87.6	12.39380025	-6.359199748	-6.316199748	8.776800252	8.773800252
87.9	12.70905543	-6.059944574	-5.963944574	9.212055426	9.121055426
88.2	12.63644451	-6.145555491	-6.093555491	9.051444509	8.987444509
88.5	12.72378687	-6.047213129	-6.017213129	9.075786871	9.078786871
88.8	12.69878056	-6.070219442	-6.093219442	8.943780558	8.993780558
89.1	12.64415049	-6.140849508	-6.113849508	8.990150492	8.997150492
89.4	12.66086495	-6.119135052	-6.096135052	9.011864948	9.040864948
89.7	12.54474949	-6.223250512	-6.212250512	8.804749488	8.861749488
90	12.70351072	-6.062489285	-6.075489285	8.899510715	8.976510715

90-140 GHz Mixer Conversion Loss

Virginia Diodes, Inc.

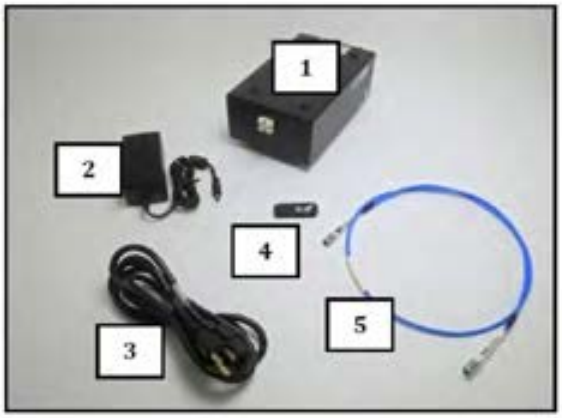
USER GUIDE

WR8.0SAX-F

1 Product Overview

Product List (Quantity)	Serial Number(s)	Order No.	Date / Initials
WR8.0SAX-F (1)	SAX 837	21108C	06/10/2021 DNS

Product Description: This VDI product includes one WR8.0 Frequency Extender, intended for use with Rohde & Schwarz FSW spectrum analyzers. This user guide details the operation of the Frequency Extension Module.



No.	Part Description
1	SAX 837
2	9V Power Supply
3	AC Power Cable
4	USB Drive
5	LO Cable (not included)

Figure 1: Photograph of typical configuration. All items may not be included.
Note: Photographs and specifications of accessories (horns, waveguide straights, etc.) are not included in this user guide.

2 Warning and Caution Statements

WARNING AND CAUTION STATEMENTS	
WARNING	This product can be permanently damaged by Electrostatic Discharge (ESD). It is recommended that engineers and technicians wear a special grounded wrist strap when handling this component. In addition, the work environment around the component should be well grounded.
WARNING	Opening the blocks, parts, or components will damage the internal components. VDI is not responsible for the warranty or guaranty of products damaged as a result of improper handling, testing, biasing, or use by customer.
CAUTION	VDI assumes the customer is familiar with microwave, millimeter wave, and VDI products. The user and customer are expected to understand all safety guidelines, health hazards, and general advisories that may exist and are associated with the use of this device. VDI is not responsible for any human hazards that may exist or may occur while using this device.

3 Product Specifications

Virginia Diodes, Inc.

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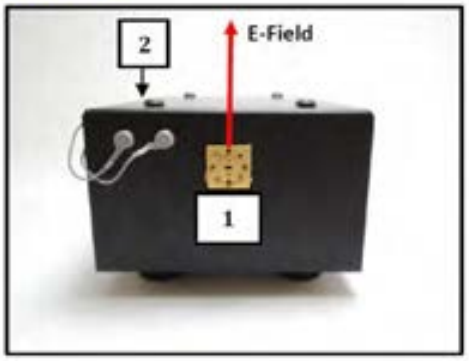

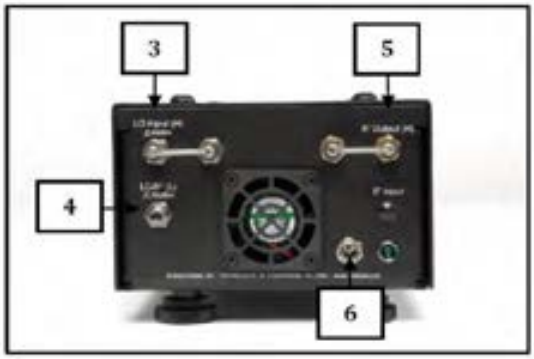

Description		Specification	Connector
RF Input [1]	Frequency Range	90-140GHz	WR8.0 UG-599/UM
	Power (Optimal / Damage)	<-20dBm / -10dBm	
Voltage Bias Port [2]	External Component Bias Voltage	+9V Output 50mA Maximum	LEMO 00 (f)
LO Input High Freq. [3]	Frequency Range	30-46.67GHz	2.9mm(f)
	Power (Typical† / Damage)	0dBm / 6dBm	
	Multiplication Factor	3	
LO Input Standard Freq. [4]*	Frequency Range	10-15.56GHz	2.9mm(f)
	Power (Typical† / Damage)	13dBm / 20dBm	
	Multiplication Factor	9	
IF Output Standard Freq. [4]*	Frequency Range	100MHz-2.5GHz	2.9mm(f)
IF Output High Freq. [5]	Frequency Range	100MHz-14GHz	2.9mm(f)
DC Input [6]	DC Power Connection	9V Output, 5A Maximum	2.1mm I.D. x 5.5mm O.D. x 9.5mm Male
Intrinsic Mixer**	SSB Conversion Loss***	10dB	-
Displayed Average Noise Level***		-150dBm/Hz	-

Table 1: General product specifications are shown.
† System is operational within +/- 3dB of nominal input power.
*Standard Freq. LO and IF share the same port.
**Intrinsic mixer conversion loss is measured before any IF amplification and cannot be accessed by user.
***See Section 5 for actual performance.

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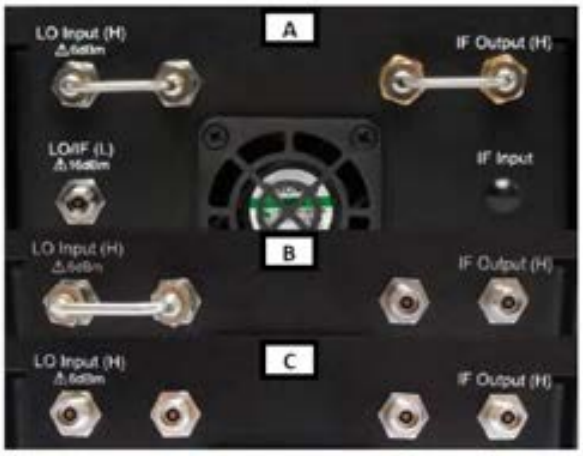

Configuration	LO Frequency	IF Frequency
A	Standard	Standard
B	Standard	High
C	High	High

Figure 2: Configuration details of dual LO input and dual IF output frequency modes are shown.

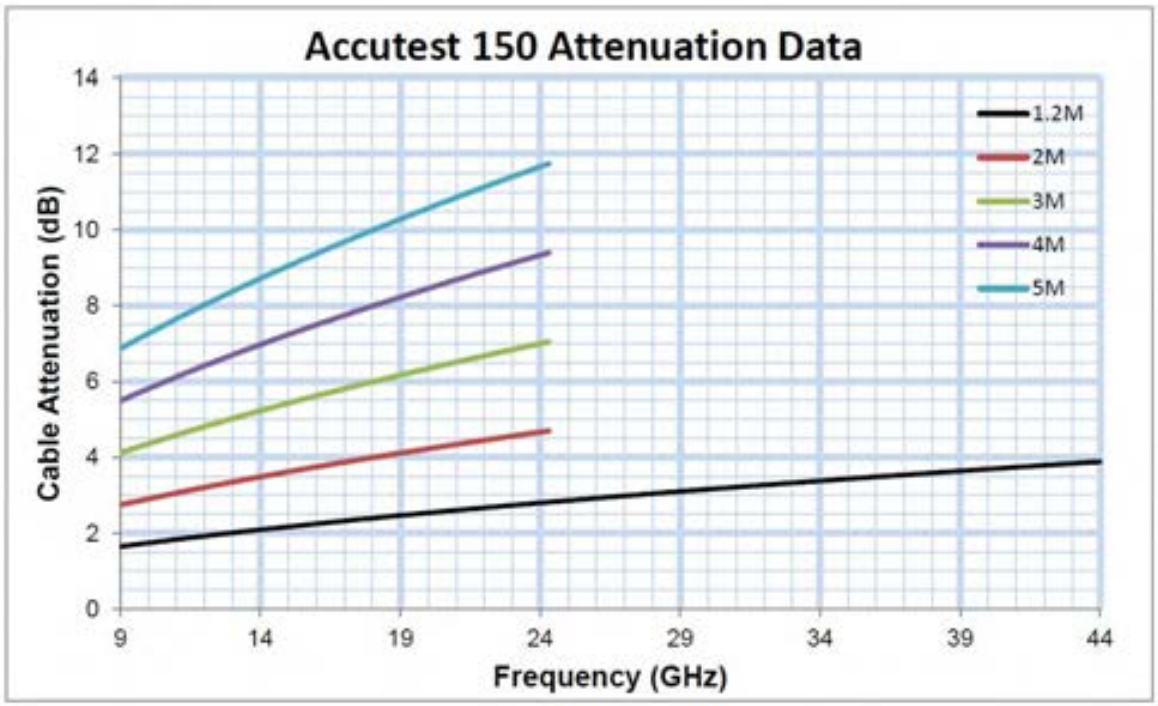

Figure 3: Insertion Loss of Accutest 150 (RF/LO Cable) with respect to frequency.

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USER GUIDE

4 General Operating Procedures and Guidelines

VDI assumes the customer is familiar with VDI products, and VDI is not responsible for the warranty or guaranty of products damaged as a result of improper handling, testing, biasing, or use by customer. VDI offers the following general guidelines for using these products and recommends the customer contact VDI at (434) 297-3257 for assistance if needed. The following procedures are a quick guide for turning on and off the product. In each case the individual steps must be followed in the proper sequence to avoid damaging critical components.

4.1 Required Operating Procedures

- DO NOT exceed damage limits listed in Table 1.
- DO NOT apply any external biases to the system.
- Make proper RF connections depending on desired configuration (i.e. Standard/High LO and Standard/High IF operation). Refer to Figure 2A-C for more information.

Failure to follow these procedures will damage or destroy the device.

4.2 Additional Guidelines, Limitations, and Recommendations

- The SAX is shipped with a reusable dust cover attached. Remove dust cover before operation.

4.3 Turn-On Procedure

1. The user and test bench must be properly grounded and protected against ESD.
2. With the LO and RF input power turned off, make all necessary connections (i.e. LO cable, AC cable, DC cable). See Figure 2A-C for configuration details.
3. Turn on the LO input power.
4. Turn on the small signal RF input power and monitor the IF output.

4.4 Turn-Off Procedure

1. The user and test bench must be properly grounded and protected against ESD.
2. Turn off the RF input power.
3. Turn off the LO input power.
4. Disconnect the DC Power Supply.
5. After completing turn-off procedures described above, it is now safe to turn off all other equipment on user test bench.

Contact VDI with questions or concerns regarding operational procedures and limitations.

5 Product Performance

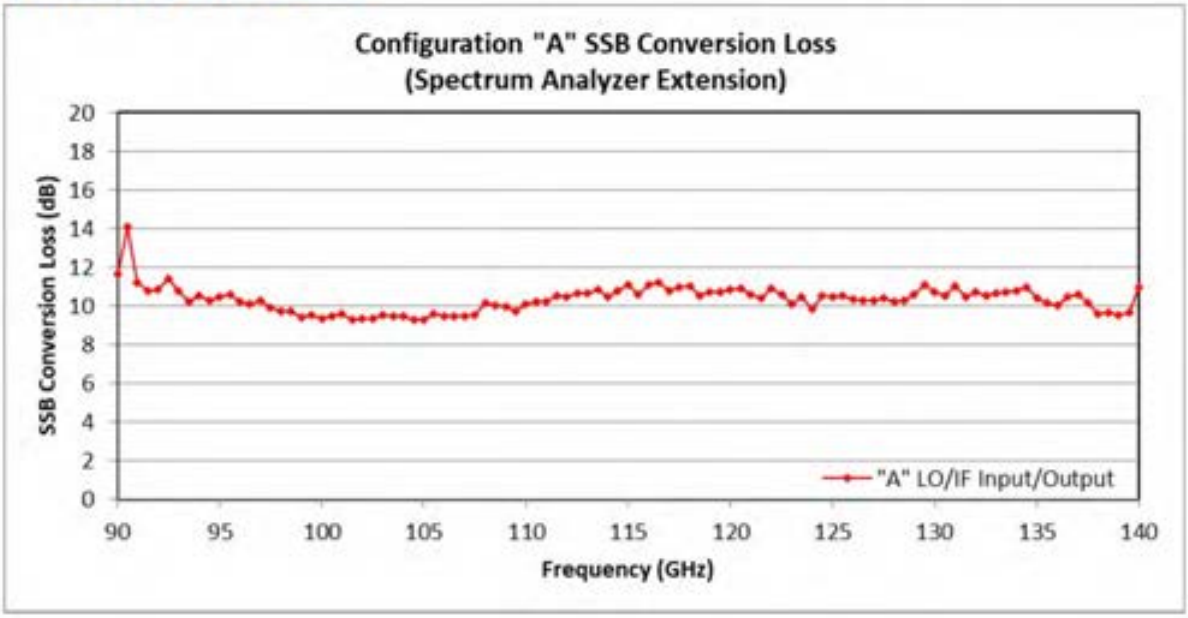

Figure 4: The product performance (SSB conversion loss vs. RF frequency) is shown for an LO input power of ~15dBm in Standard LO Frequency operation. IF power measured from "LO/IF" port with IF frequency fixed at 1.3GHz. CSV Data file included on USB Drive.

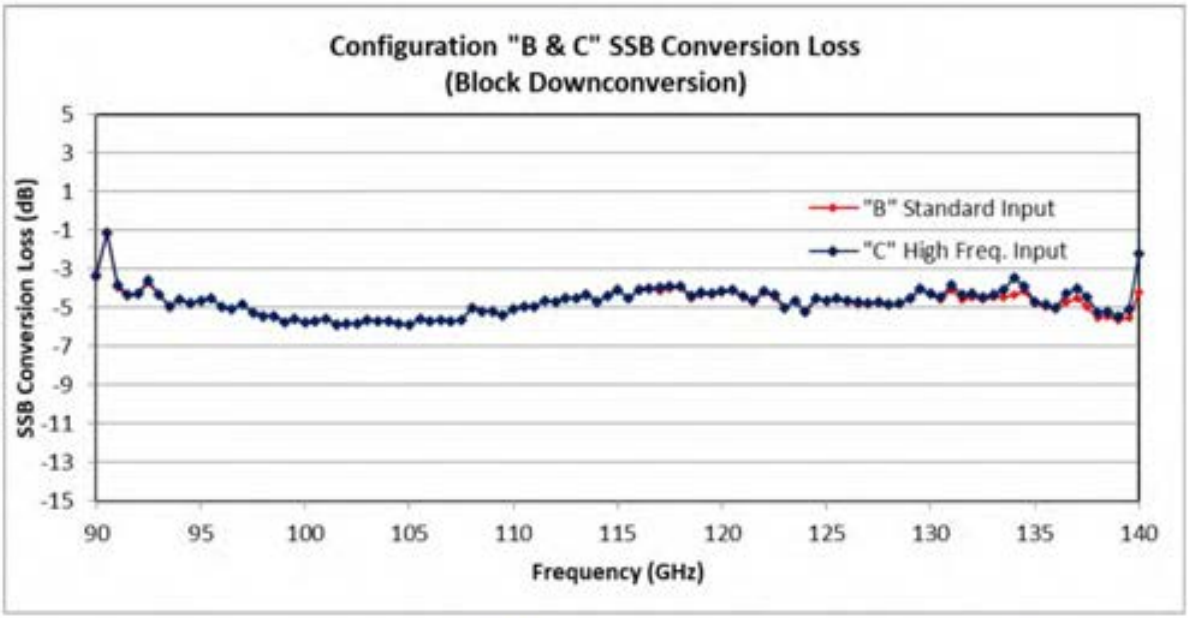

Figure 5: The product performance (SSB conversion loss vs. RF frequency) is shown for an LO input power of ~15dBm in Standard LO Frequency operation and LO input power of ~0dBm in High LO Frequency operation. IF power measured from "IF Output" port with IF frequency fixed at 1.3GHz. CSV Data file included on USB Drive.

Virginia Diodes, Inc.

USER GUIDE

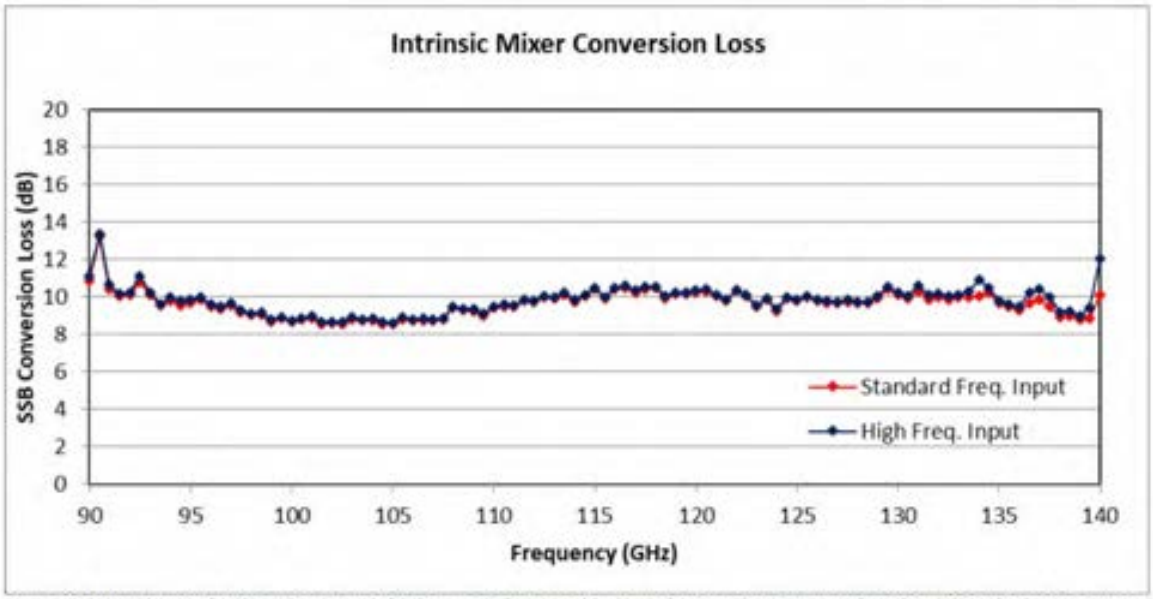

Figure 6: The product performance (SSB conversion loss vs. RF frequency) is shown for an LO input power of ~15dBm in Standard LO Frequency operation and LO input power of ~0dBm in High LO Frequency operation. IF power measured from mixer port with IF frequency fixed at 1.3GHz. Note: mixer port is not accessible for use by the user. CSV Data file included on USB Drive.

Measured Displayed Average Noise Level (dBm/Hz)	
Typical	-149.5

*Measured with a Keysight N9030A PXA Spectrum Analyzer.

SAX 837 Conversion Loss

Note: Out of band data is not guaranteed to be accurate.

Freq(GHz)	"A" LO/IF Input/Output	"B" Standard Input	"C" High Freq. Input	High Freq. Intrinsic Mixer Loss	Standard Freq. Intrinsic Mixer Loss
90	11.67514724	-3.451852763	-3.337852763	11.13014724	10.85114724
90.5	14.10568478	-1.079315219	-1.162315219	13.39768478	13.21768478
91	11.19284379	-3.952156213	-3.831156213	10.66284379	10.43484379
91.5	10.77353378	-4.372466216	-4.345466216	10.19653378	10.03853378
92	10.8156319	-4.3273681	-4.2933681	10.2776319	10.0966319
92.5	11.40549847	-3.724501532	-3.574501532	11.09249847	10.79149847
93	10.79724258	-4.331757419	-4.317757419	10.24124258	10.10624258
93.5	10.21914168	-4.91885832	-4.95285832	9.63014168	9.54914168
94	10.55024142	-4.587758581	-4.565758581	9.996241419	9.821241419
94.5	10.29788363	-4.822116373	-4.753116373	9.778883628	9.588883628
95	10.4741589	-4.669841103	-4.660841103	9.843158897	9.695158897
95.5	10.60265733	-4.50734267	-4.51534267	9.99665733	9.89265733
96	10.1907898	-4.953210203	-4.985210203	9.625789797	9.505789797
96.5	10.083555	-5.061445003	-5.079445003	9.479554997	9.372554997
97	10.30032929	-4.847670708	-4.859670708	9.661329292	9.553329292
97.5	9.894886965	-5.239113035	-5.255113035	9.296886965	9.162886965
98	9.696380637	-5.421619363	-5.441619363	9.135380637	9.034380637
98.5	9.728739538	-5.401260462	-5.427260462	9.168739538	9.038739538
99	9.401152675	-5.731847325	-5.746847325	8.803152675	8.707152675
99.5	9.542871349	-5.586128651	-5.600128651	8.951871349	8.840871349
100	9.367058164	-5.769941836	-5.782941836	8.777058164	8.658058164
100.5	9.496118475	-5.651881525	-5.678881525	8.901118475	8.787118475
101	9.563891248	-5.561108752	-5.575108752	8.981891248	8.875891248
101.5	9.294818879	-5.847181121	-5.869181121	8.686818879	8.578818879
102	9.32353949	-5.80946051	-5.83646051	8.70453949	8.60753949
102.5	9.312544107	-5.835455893	-5.854455893	8.691544107	8.586544107
103	9.538372928	-5.604627072	-5.619627072	8.933372928	8.824372928
103.5	9.440667741	-5.698332259	-5.705332259	8.834667741	8.727667741
104	9.473096285	-5.666903715	-5.678903715	8.866096285	8.770096285
104.5	9.295835708	-5.846164292	-5.856164292	8.670835708	8.571835708
105	9.26675987	-5.86924013	-5.87924013	8.63275987	8.53575987
105.5	9.587719809	-5.566280191	-5.585280191	8.920719809	8.823719809
106	9.447107698	-5.688892302	-5.696892302	8.806107698	8.722107698
106.5	9.47817723	-5.65582277	-5.66782277	8.86217723	8.77317723
107	9.445819292	-5.693180709	-5.715180709	8.831819292	8.718819292
107.5	9.506835045	-5.627164955	-5.646164955	8.896835045	8.804835045
108	10.15543137	-4.980568633	-5.021568633	9.515431367	9.429431367
108.5	10.01501141	-5.139988586	-5.184988586	9.375011414	9.292011414
109	9.986943402	-5.163056598	-5.180056598	9.359943402	9.259943402

Freq(GHz)	"A" LO/IF Input/Output	"B" Standard Input	"C" High Freq. Input	High Freq. Intrinsic Mixer Loss	Standard Freq. Intrinsic Mixer Loss
109.5	9.700311379	-5.427688621	-5.415688621	9.090311379	9.007311379
110	10.11440377	-5.034596231	-5.068596231	9.480403769	9.435403769
110.5	10.23931625	-4.896683751	-4.935683751	9.593316249	9.506316249
111	10.19914709	-4.941852911	-4.978852911	9.567147089	9.514147089
111.5	10.51961626	-4.630383737	-4.666383737	9.887616263	9.822616263
112	10.45156748	-4.687432519	-4.685432519	9.837567481	9.740567481
112.5	10.66102657	-4.482973427	-4.488973427	10.07402657	9.973026573
113	10.62316393	-4.517836074	-4.541836074	10.01716393	9.943163926
113.5	10.84547099	-4.287529014	-4.341529014	10.22647099	10.14647099
114	10.46605969	-4.667940312	-4.688940312	9.862059688	9.774059688
114.5	10.76937147	-4.369628526	-4.376628526	10.14637147	10.05437147
115	11.11837657	-4.04062343	-4.05262343	10.48737657	10.40737657
115.5	10.59959028	-4.534409721	-4.539409721	10.02759028	9.940590279
116	11.08255473	-4.042445266	-4.056445266	10.50855473	10.41955473
116.5	11.23473017	-3.950269828	-4.014269828	10.59973017	10.49673017
117	10.75491026	-4.152089736	-3.939089736	10.36291026	10.26991026
117.5	10.96623836	-4.013761637	-3.885761637	10.55123836	10.44823836
118	11.04450356	-3.973496442	-3.878496442	10.56050356	10.48550356
118.5	10.52617331	-4.502826691	-4.414826691	10.04817331	9.940173309
119	10.71214465	-4.310855347	-4.229855347	10.27714465	10.18914465
119.5	10.73550138	-4.318498616	-4.257498616	10.26750138	10.16450138
120	10.83361073	-4.226389267	-4.143389267	10.35961073	10.27661073
120.5	10.88819078	-4.15980922	-4.09380922	10.41419078	10.33619078
121	10.61391575	-4.435084247	-4.384084247	10.13691575	10.06591575
121.5	10.37585906	-4.697140936	-4.630140936	9.876859064	9.825859064
122	10.92118158	-4.177818422	-4.117818422	10.38918158	10.35018158
122.5	10.59706531	-4.452934691	-4.359934691	10.13506531	10.05606531
123	10.06564904	-5.02435096	-4.99135096	9.55564904	9.48764904
123.5	10.43854116	-4.643458841	-4.628458841	9.936541159	9.847541159
124	9.860132081	-5.249867919	-5.203867919	9.352132081	9.265132081
124.5	10.50591325	-4.589086747	-4.518086747	10.00491325	9.903913253
125	10.4479865	-4.673013497	-4.657013497	9.882986503	9.791986503
125.5	10.54246455	-4.560535451	-4.549535451	10.03846455	9.965464549
126	10.350356	-4.721644004	-4.674644004	9.874355996	9.804355996
126.5	10.27868628	-4.807313723	-4.735313723	9.805686277	9.713686277
127	10.26573962	-4.837260384	-4.798260384	9.773739616	9.685739616
127.5	10.39357186	-4.74042814	-4.71242814	9.85857186	9.76757186
128	10.2407497	-4.876250305	-4.819250305	9.737749695	9.661749695
128.5	10.27302715	-4.815972854	-4.774972854	9.753027146	9.666027146
129	10.57790721	-4.539092789	-4.493092789	10.04490721	9.944907211
129.5	11.06294687	-4.055053128	-4.017053128	10.52894687	10.44894687
130	10.74665017	-4.351349831	-4.264349831	10.25565017	10.14965017

Freq(GHz)	"A" LO/IF Input/Output	"B" Standard Input	"C" High Freq. Input	High Freq. Intrinsic Mixer Loss	Standard Freq. Intrinsic Mixer Loss
130.5	10.54234128	-4.571658716	-4.477658716	10.04334128	9.919341284
131	10.99784288	-4.095157118	-3.820157118	10.59784288	10.32284288
131.5	10.48624586	-4.582754137	-4.311754137	10.14424586	9.843245863
132	10.71127934	-4.428720663	-4.285720663	10.18227934	10.02627934
132.5	10.54574278	-4.587257219	-4.439257219	10.07174278	9.893742781
133	10.64369663	-4.477303375	-4.340303375	10.14769663	9.976696625
133.5	10.68664451	-4.43135549	-4.10535549	10.33764451	9.99364451
134	10.78700975	-4.313990247	-3.460990247	10.93500975	10.07700975
134.5	10.95997375	-4.161026252	-3.916026252	10.52797375	10.25597375
135	10.37279947	-4.751200533	-4.707200533	9.788799467	9.689799467
135.5	10.1724832	-4.934516804	-4.843516804	9.642483196	9.511483196
136	10.044754	-5.108245999	-4.999245999	9.512754001	9.332754001
136.5	10.45312533	-4.676874665	-4.252874665	10.25012533	9.695125335
137	10.61386016	-4.518139838	-3.994139838	10.42886016	9.852860162
137.5	10.14375506	-4.948244935	-4.476244935	9.965755065	9.481755065
138	9.604980629	-5.520019371	-5.270019371	9.185980629	8.939980629
138.5	9.663838852	-5.432161148	-5.190161148	9.272838852	9.004838852
139	9.512629562	-5.615370438	-5.452370438	9.013629562	8.813629562
139.5	9.644409056	-5.524590944	-5.063590944	9.413409056	8.893409056
140	10.95996759	-4.22003241	-2.22503241	12.05596759	10.15096759

Notes: The test equipment was provided by Starry, Inc. The vendor does not provide a calibration certificate.

12 Appendix B – Mixer Verification Certificates

VDIWR19.0SAX-F (40-60 GHz)

Virginia Diodes, Inc.
979 2nd St. SE
Suite 309
Charlottesville, VA 22902
Phone: 434-297-3257
Fax: 434-297-3258

Certificate of Conformance

To: Starry, Inc.
38 Chauncy Street
2nd Floor
Boston, MA 02111
United States

From: Virginia Diodes, Inc
979 2nd St. SE
Suite 309
Charlottesville, VA 22902

Packing List No: 211085 **Today's Date:** 03/31/21
Shipping Date: 03/30/21 **PO Number:** PO20183

Quantity Shipped	Unit	Description	Order-Job Number
1	EA	VDIWR19.0SAX-F S/N: SAX 835	21108A-01
1	EA	RCHO19R CONICAL HORN ANTENNA	21108A-02

The VDI product(s) in this shipment meet(s) the guidelines for performance specifications established in accordance with the corresponding Purchase Order. Data presented in the User Guide, where applicable, has been obtained in accordance with VDI's Quality Management System. All instruments, used to obtain data, which require calibration have been calibrated with equipment traceable to the National Institute of Standards and Technology (NIST) and through NIST to the International System of Units (SI).

Authorized Signature
Virginia Diodes, Inc

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VDIWR12.0SAX-F (60-90 GHz)

Virginia Diodes, Inc
979 2nd St. SE
Suite 309
Charlottesville, VA 22902
Phone: 434-297-3257
Fax: 434-297-3258

Certificate of Conformance

To: Starry, Inc.
38 Chauncy Street
2nd Floor
Boston, MA 02111
United States

From: Virginia Diodes, Inc
979 2nd St. SE
Suite 309
Charlottesville, VA 22902

Packing List No: 211211 **Today's Date:** 04/12/21
Shipping Date: 04/08/21 **PO Number:** PO20183

Quantity Shipped	Unit	Description	Order-Job Number
1	EA	VDIWR12.0SAX-F S/N: SAX 838	21108B-01
1	EA	RCHO12RL Conical Horn Antenna	21108B-02

The VDI product(s) in this shipment meet(s) the guidelines for performance specifications established in accordance with the corresponding Purchase Order. Data presented in the User Guide, where applicable, has been obtained in accordance with VDI's Quality Management System. All instruments, used to obtain data, which require calibration have been calibrated with equipment traceable to the National Institute of Standards and Technology (NIST) and through NIST to the International System of Units (SI).

Authorized Signature
Virginia Diodes, Inc

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VDIWR8.0SAX-F (90-140 GHz)

Virginia Diodes, Inc
979 2nd St. SE
Suite 309
Charlottesville, VA 22902
Phone: 434-297-3257
Fax: 434-297-3258

Certificate of Conformance

To: Starry, Inc.
38 Chauncy Street
2nd Floor
Boston, MA 02111
United States

From: Virginia Diodes, Inc
979 2nd St. SE
Suite 309
Charlottesville, VA 22902

Packing List No: 212029 **Today's Date:** 06/11/21
Shipping Date: 06/11/21 **PO Number:** PO20183

Quantity Shipped	Unit	Description	Order-Job Number
1	EA	VDIWR8.0SAX-F WR8.0SAX-F / SN: SAX 837	21108C-01
1	EA	RCHO8RL WR8.0CH - Conical Horn Antenna / RCHO8RL	21108C-02

The VDI product(s) in this shipment meet(s) the guidelines for performance specifications established in accordance with the corresponding Purchase Order. Data presented in the User Guide, where applicable, has been obtained in accordance with VDI's Quality Management System. All instruments, used to obtain data, which require calibration have been calibrated with equipment traceable to the National Institute of Standards and Technology (NIST) and through NIST to the International System of Units (SI).

Authorized Signature
Virginia Diodes, Inc

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VDIWR5.1SAX-F (140-220 GHz)

Virginia Diodes, Inc
979 2nd St. SE
Suite 309
Charlottesville, VA 22902
Phone: 434-297-3257
Fax: 434-297-3258

Certificate of Conformance

To: Starry, Inc.
38 Chauncy Street
2nd Floor
Boston, MA 02111
United States

From: Virginia Diodes, Inc
979 2nd St. SE
Suite 309
Charlottesville, VA 22902

Packing List No: 211604 **Today's Date:** 05/11/21
Shipping Date: 05/11/21 **PO Number:** PO20183

Quantity Shipped	Unit	Description	Order-Job. Number
1	EA	VDIWR5.1SAX-F WR5.1SAX-F / SN: SAX 838	21108D-01
1	EA	RCHO5RL WR5.1CH / SN: RCHO5RL	21108D-02

The VDI product(s) in this shipment meet(s) the guidelines for performance specifications established in accordance with the corresponding Purchase Order. Data presented in the User Guide, where applicable, has been obtained in accordance with VDI's Quality Management System. All instruments, used to obtain data, which require calibration have been calibrated with equipment traceable to the National Institute of Standards and Technology (NIST) and through NIST to the International System of Units (SI).

Authorized Signature
Virginia Diodes, Inc

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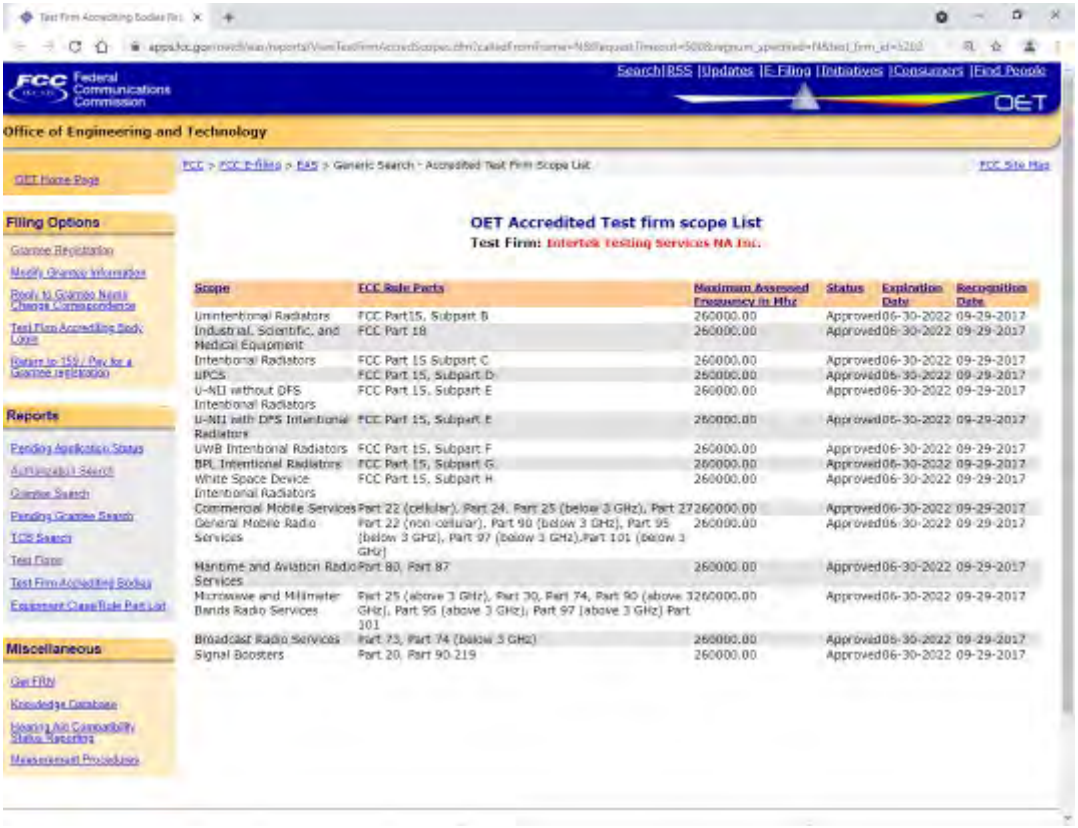
13 Appendix C – Test Laboratory Accreditation Scope



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OET Accredited Test firm scope List

Test Firm: Intertek Testing Services NA Inc.

Scope	FCC Rule Parts	Maximum Assessed Frequency in Mhz	Status	Expiration Date	Recognition Date
Unintentional Radiators	FCC Part15, Subpart B	260000.00	Approved	06-30-2022	09-29-2017
Industrial, Scientific, and Medical Equipment	FCC Part 18	260000.00	Approved	06-30-2022	09-29-2017
Intentional Radiators	FCC Part 15 Subpart C	260000.00	Approved	06-30-2022	09-29-2017
UPCS	FCC Part 15, Subpart D	260000.00	Approved	06-30-2022	09-29-2017
U-NII without DFS Intentional Radiators	FCC Part 15, Subpart E	260000.00	Approved	06-30-2022	09-29-2017
U-NII with DFS Intentional Radiators	FCC Part 15, Subpart E	260000.00	Approved	06-30-2022	09-29-2017
UWB Intentional Radiators	FCC Part 15, Subpart F	260000.00	Approved	06-30-2022	09-29-2017
BPL Intentional Radiators	FCC Part 15, Subpart G	260000.00	Approved	06-30-2022	09-29-2017
White Space Device Intentional Radiators	FCC Part 15, Subpart H	260000.00	Approved	06-30-2022	09-29-2017
Commercial Mobile Services	Part 22 (cellular), Part 24, Part 25 (below 3 GHz), Part 27	260000.00	Approved	06-30-2022	09-29-2017
General Mobile Radio Services	Part 22 (non-cellular), Part 90 (below 3 GHz), Part 95 (below 3 GHz), Part 97 (below 3 GHz),Part 101 (below 3 GHz)	260000.00	Approved	06-30-2022	09-29-2017
Maritime and Aviation Radio Services	Part 80, Part 87	260000.00	Approved	06-30-2022	09-29-2017
Microwave and Millimeter Bands Radio Services	Part 25 (above 3 GHz), Part 30, Part 74, Part 90 (above 3 GHz), Part 95 (above 3 GHz), Part 97 (above 3 GHz) Part 101	260000.00	Approved	06-30-2022	09-29-2017
Broadcast Radio Services	Part 73, Part 74 (below 3 GHz)	260000.00	Approved	06-30-2022	09-29-2017
Signal Boosters	Part 20, Part 90.219	260000.00	Approved	06-30-2022	09-29-2017