Test Report Serial Number:	**45461679 R1.0**
Test Report Date:	**24 August 2021**
Project Number:	**1548**

EMC Test Report - C2PC

Applicant:

4RF Limited
PO Box 13-506
Wellington 6440
New Zealand

FCC ID:	IC Registration Number
UIPSQ450M140	**-**
Product Model Number / HVIN	Product Name / PMN
SQ450M140	**Aprisa SR+**

In Accordance With:

FCC 47 CFR Part 90, Subpart I

PRIVATE LAND MOBILE RADIO SERVICES
Licensed Non-Broadcast Station Transmitter (TNB)

Approved By:

Ben Hewson, President
Celltech Labs Inc.
21-364 Lougheed Rd.
Kelowna, BC, V1X 7R8
Canada

Test Lab Certificate: 2470.01

IC Registration 3874A

FCC Registration: CA3874

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1.0 DOCUMENT CONTROL

Revision History					
Samples Tested By:	Art Voss, P.Eng.		**Date(s) of Evaluation:**	23 July - 24 Aug, 2021	
Report Prepared By:	Art Voss, P.Eng.		**Report Reviewed By:**	Ben Hewson	
Report Revision	**Description of Revision**		**Revised Section**	**Revised By**	**Revision Date**
0.1	Draft Release		n/a	Art Voss	23 August 2021
0.2	Draft Release - Revised Conducted Power		7	Art Voss	24 August 2021
	Added Frequency Stability		11		
1.0	Initial Release		n/a	Art Voss	24 August 2021

2.0 CLIENT AND DUT INFORMATION

Client Information		
Applicant Name (FCC)	**4RF Limited**	
Applicant Address (FCC)	PO Box 13-506	
	Wellington 6440,	
	New Zealand	
Applicant Name (ISED)		
Applicant Address (ISED)		
DUT Information		
Device Identifier(s):	**FCC ID:**	**UIPSQ450M140**
	IC ID:	**-**
Device Type:	Digital Transceiver	
Device Model(s) / HVIN:	SQ450M140	
Device Marketing Name / PMN:	Aprisa SR+	
Firmware Version ID Number / FVIN:	-	
Host Marketing Name / HMN:	-	
Test Sample Serial No.:	169.254.50.10	
Equipment Class (FCC):	TNB - Licensed Non-Broadcast Station Transmitter	
Transmit Frequency Range:	450 - 521MHz, FCC: 450 - 512MHz	
Test Channels:	Programmable	
Manuf. Max. Rated Output Power:	QPSK: 37dBm, 16QAM: 35dBm, 64QAM: 34dBm	
Manuf. Max. Rated BW:	12.5kHz, 25kHz	
Manuf. Rated Spectrum Efficiency:	12.5kHz BW (QPSK) 18kbps = 9kbps per 6.25kHz Channel BW	
	25kHz BW (QPSK) 32kbps = 8kbps per 6.25kHz Channel BW	
Antenna Make and Model:	-	
Antenna Type and Gain:	15dBi	
Modulation:	QPSK, 16QAM, 64QAM	
Mode:	Half Duplex	
Emission Designator:	See Section 8.0	
DUT Power Source:	10 - 30VDC	
DUT Dimensions [HxWxD] (mm)	H x W x D: 40mm x 140mm x 210mm.	
Deviation(s) from standard/procedure:	None	
Modification of DUT:	None	

3.0 SCOPE

Preface:

This Certification Report was prepared on behalf of:

4RF Limited

,(the '*Applicant*"), in accordance with the applicable Federal Communications Commission (FCC) CFR 47 and Innovation, Scientific and Economic Development (ISED) Canada rules parts and regulations (the '*Rules*'). The scope of this investigation was limited to only the equipment, devices and accessories (the '*Equipment*') supplied by the *Applicant*. The tests and measurements performed on this *Equipment* were only those set forth in the applicable *Rules* and/or the Test and Measurement Standards they reference. The *Rules* applied and the Test and Measurement Standards used during this evaluation appear in the Normative References section of this report. The limits set forth in the technical requirements of the applicable *Rules* were applied to the measurement results obtained during this evaluation and ,unless otherwise noted, these limits were used as the Pass/Fail criteria. The Pass/Fail statements made in this report apply to only the tests and measurements performed on only the *Equipment* tested during this evaluation. Where applicable and permissible, information including test and measurement data and/or results from previous evaluations of same or similar equipment, devices and/or accessories may be cited in this report.

Device Description:

The Model/HVIN: SQ450M140 (Aprisa SR+) is a digital transceiver operating in the 450-512MHz band under FCC Part 90. It was originally certified on 13 March 2014.

Application:

This is an application for a Class II Permissive Change. The Power Supply and RF sections have been updated for improvement. The RF circuits have minor changes to the transmitter and receiver synthesiizer and demodulators.

Regulatory Requirement:

As per FCC 47 CFR 2 Subpart I, Equipment Authorization is require for this *Equipment* by means of Certification in accordance with FCC 47 CFR 90.

Scope of Work:

The scope of this investigation is limited only to the evaluation of the Aprisa SR+ to determine any degradation to the output power, occupied bandwidth, spurious emissions or frequency stability compared to that which it was orginally certified to the *Rules* identified herein.

RF Exposure:

As per FCC 47 CFR §2.1091 and Canada Health Safety Code 6, an RF Exposure (MPE) evaluation is required for this *Equipment* and the results of the RF Exposure (MPE) evaluation appear in a separate report.

4.0 TEST SUMMARY

TEST SUMMARY

Section	Description of Test	Procedure Reference	Applicable Rule Part(s) FCC	Test Date	Result
7.0	Conducted Pow er (Fundamental)	ANSI C63.26-2015 KDB 558074 D01v05	§2.1046 §90.205	23 July 2021 24 Aug 2021	Pass
8.0	Occupied Bandw idth	ANSI C63.26-2015 KDB 558074 D01v05	§2.1049 §90.209(b)(5)	23 July 2021	Pass
9.0	Emissions Mask	ANSI C63.26-2015 KDB 558074 D01v05	§90.210(b) §90.205(d)	23 July 2021	Pass
10.0	Conducted Tx Spurious Emissions	ANSI C63.26-2015 KDB 558074 D01v05	§90.210(b) §90.205(d)	23 July 2021 24 Aug 2021	Pass
11.0	Frequency Stability	ANSI C63.26-2015	§90.213	24 Aug 2021	Pass

Test Station Day Log

Date	Ambient Temp (°C)	Relative Humidity (%)	Barometric Pressure (kPa)	Test Station	Tests Performed Section(s)
23 July 2021	20.6	18	102.1	**EMC**	**7, 8, 9, 10**
24 Aug 2021	23.0	16	102.2	**EMC**	**7, 10**
24 Aug 2021	25.3	17	102.2	**TC**	**11**

EMC - EMC Test Bench
OATS - Open Area Test Site
LISN - LISN Test Area
IMM - Immunity Test Area
SAC - Semi-Anechoic Chamber
TC - Temperature Chamber
ESD - ESD Test Bench
RI - Radiated Immunity Chamber

I attest that the data reported herein is true and accurate w ithin the tolerance of the Measurement Instrument Uncertainty; that all tests and measurements w ere performed in accordance w ith accepted practices or procedures; and that all tests and measurements w ere performed by me or by trained personnel under my direct supervision. The results of this investigation are based solely on the test sample(s) provided by the client w hich w ere not adjusted, modified or altered in any manner w hatsoever, except as required to carry out specific tests or measurements. This test report has been completed in accordance w ith ISO/IEC 17025.

Art Voss, P.Eng.
Technical Manager
Celltech Labs Inc.

24 August 2021
Date

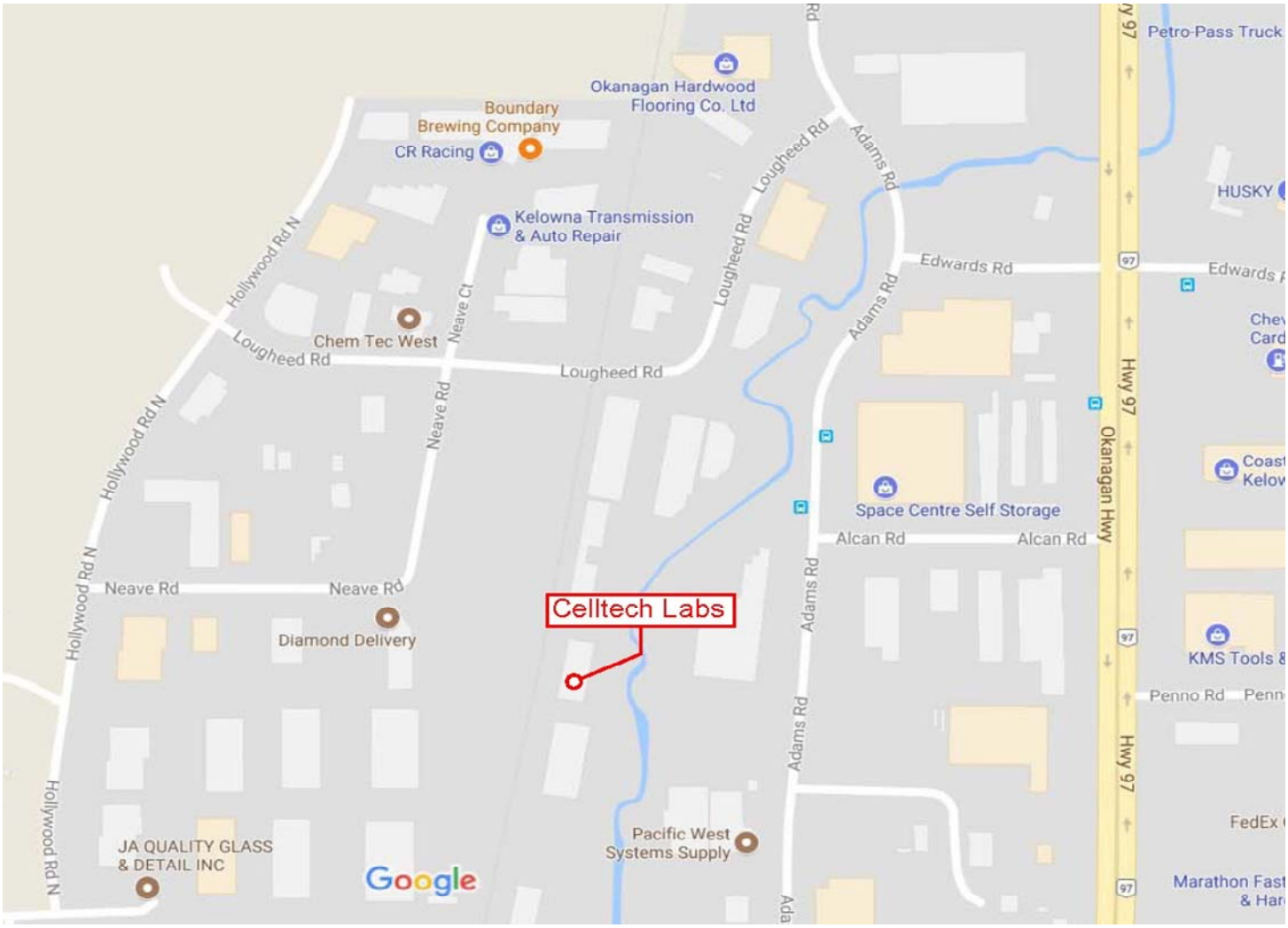
5.0 NORMATIVE REFERENCES

Normative References	
ISO/IEC 17025:2017	General requirements for the competence of testing and calibration laboratories
ANSI C63.26-2015	American National Standard of Procedures for Compliance Testing of Transmitters Used in Licensed Radio Services
ANSI/TIA-603-E	Land Mobile FM or PM Communications Equipment Measurement and Performance Standards (Revision of TIA-603-D)
CFR Title 47: Part 2:	Code of Federal Regulations Telecommunication Frequency Allocations and Radio Treaty Matters; General Rules and Regulations
CFR Title 47: Part 90: Sub Part I:	Code of Federal Regulations Telecommunication Private Land Mobile Radio Services General Technical Standards
FCC KDB 558074 D01v05r02	OET Major Guidance Publications, Knowledge Data Base Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under Section 15.247

6.0 FACILITIES AND ACCREDITATIONS

Facility and Accreditation:

The facilities used to evaluate this device outlined in this report are located at 21-364 Lougheed Road, Kelowna, British Columbia, Canada V1X 7R8. The radiated emissions site (OATS) conforms to the requirements set forth in ANSI C63.4 and is filed and listed with the FCC under Test Firm Registration Number CA3874 and Innovation, Science and Economic Development Canada under Test Site File Number ISED 3874A. Celltech is accredited to ISO 17025, through accrediting body A2LA and with certificate 2470.01.



7.0 CONDUCTED POWER

Test Procedure	
Normative References	FCC 47 CFR §2.1049, §90.205
	ANSI C63.26 (5.2.3.3)

Requirement / Limits	
47 CFR §90.209	**§90.205 Bandwidth limitations.**
	[2]Maximum ERP of 500 watts allowed. Signal strength at the service area contour may be less than 37 dBu.

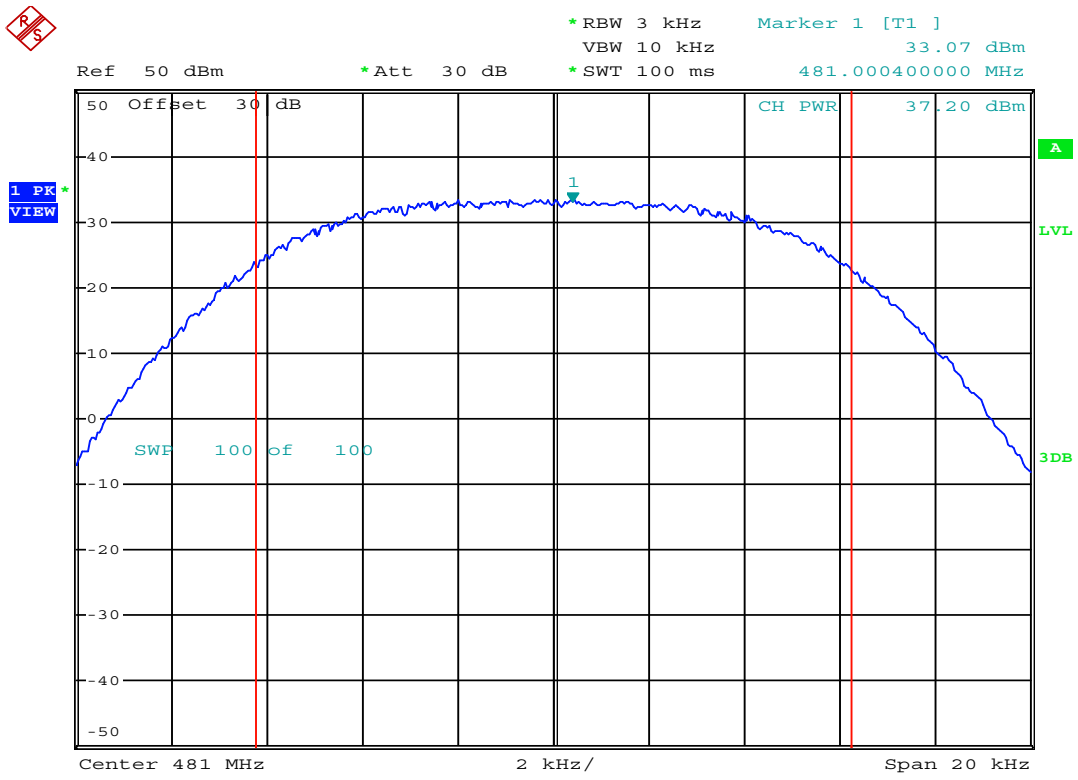
General Procedure	
C63.26	**5.2.3.3 Measurement of peak power in a narrowband signal with a spectrum/signal analyzer or EMI receiver** This procedure can be used to measure the peak power in either a CW-like or noise-like narrowband RF signal. The measurement instrument must have a RBW that is greater than or equal to the OBW of the signal to be measured and a VBW ≥ 3X RBW. e) Detector = peak. f) Trace mode = max hold. g) Allow trace to fully stabilize. h) Use the peak marker function to determine the peak amplitude level.

Test Setup	Appendix A - Figure A.1

Measurement Procedure
The DUT was connected to the SA as specified above via a 30dB attenuator. The Conducted Power was measured using the intrument's Channel Bandwidth Function and recorded.

Plot 7.1 – Conducted Power, 12.5kHz BW, QPSK

Conducted Channel Power:

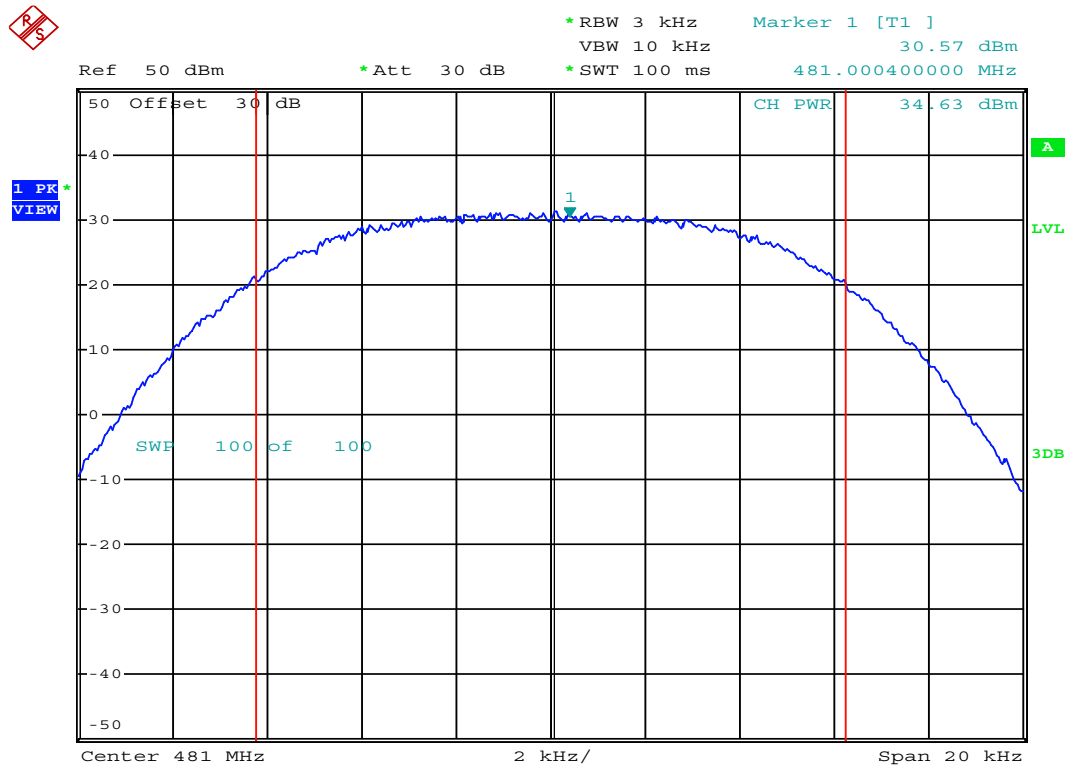


Date: 24.AUG.2021 09:46:59

Channel BW (kHz)	Channel Frequency (MHz)	Modulation	Conducted Power (dBm)
12.5	481	QPSK	37.20

Plot 7.2 – Conducted Power, 12.5kHz BW, 16QAM

Conducted Channel Power:

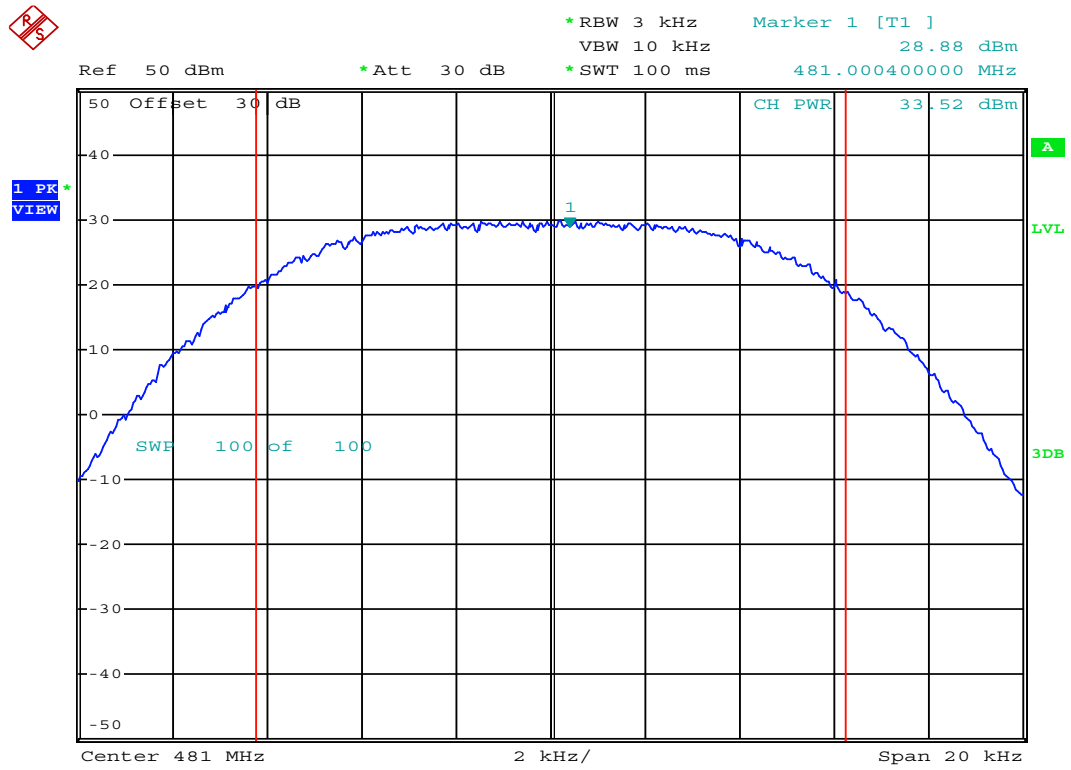


Date: 24.AUG.2021 09:48:24

Channel BW (kHz)	Channel Frequency (MHz)	Modulation	Conducted Power (dBm)
12.5	481	16QAM	34.63

Plot 7.3 – Conducted Power, 12.5kHz BW, 64QAM

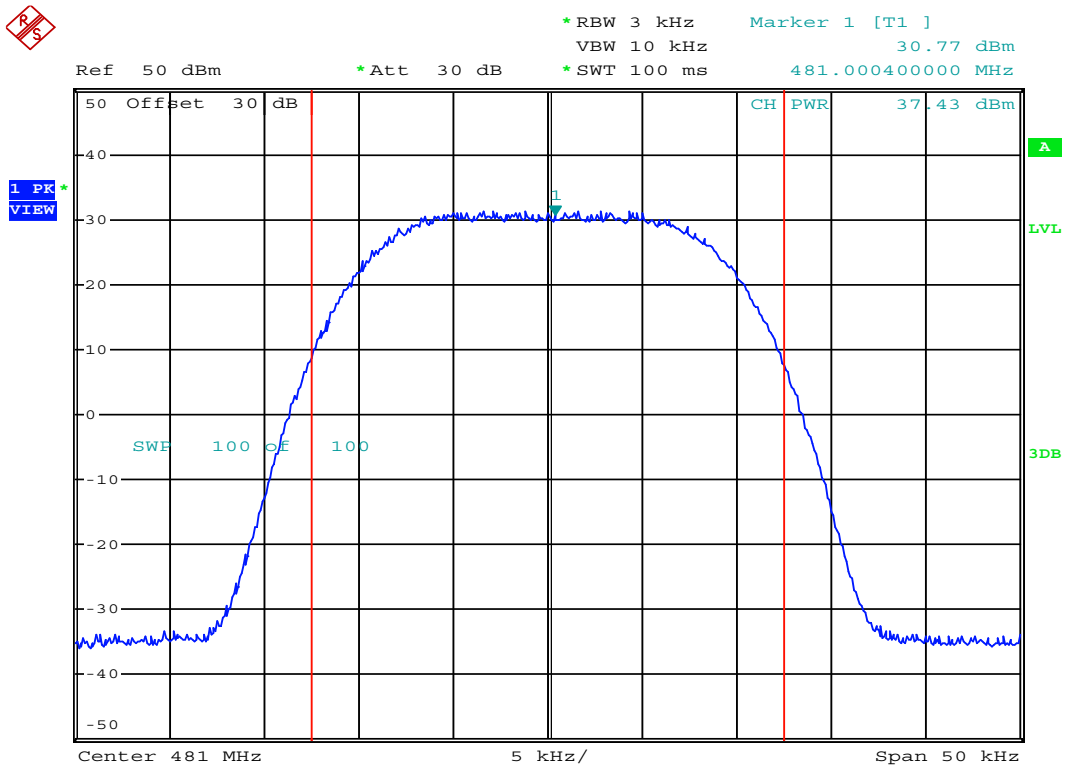
Conducted Channel Power:



Channel BW (kHz)	Channel Frequency *(MHz)*	Modulation	Conducted Power *(dBm)*
12.5	481	64QAM	33.52

Plot 7.4 – Conducted Power, 25kHz BW, QPSK

Conducted Channel Power:

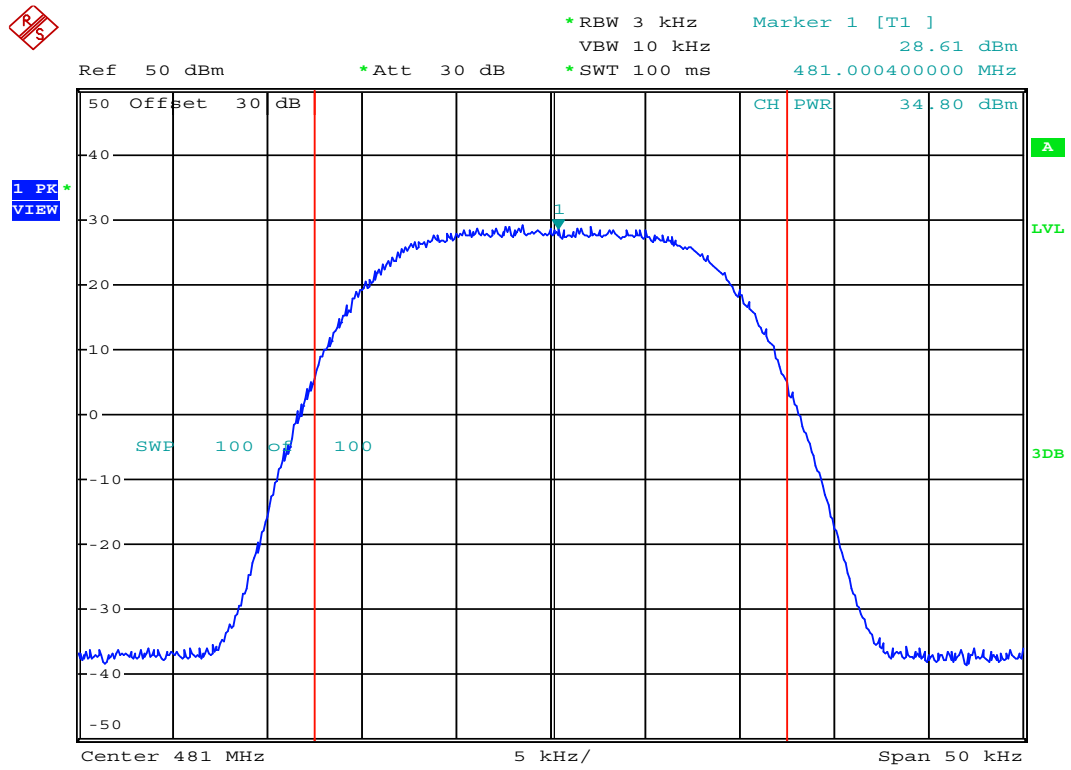


Date: 24.AUG.2021 09:18:49

Channel BW (kHz)	Channel Frequency (MHz)	Modulation	Conducted Power (dBm)
25	481	QPSK	37.43

Plot 7.5 – Conducted Power, 25kHz BW, 16QAM

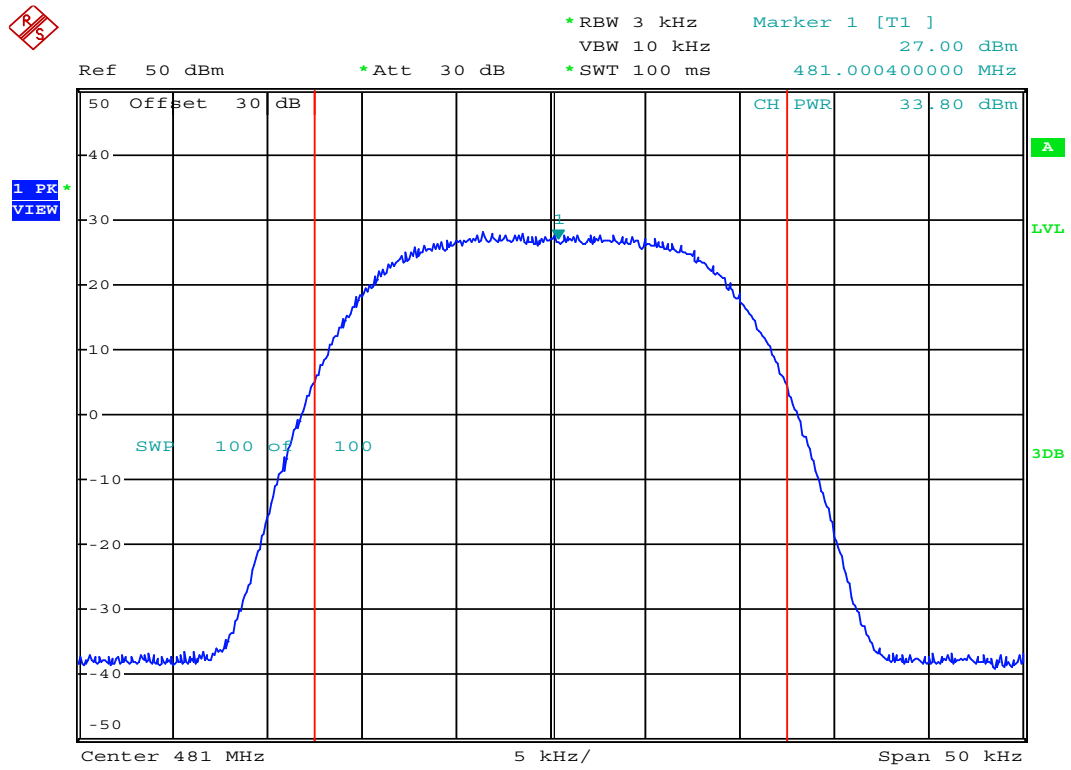
Conducted Channel Power:



Channel BW (kHz)	Channel Frequency *(MHz)*	Modulation	Conducted Power *(dBm)*
25	481	16QAM	34.80

Plot 7.6 – Conducted Power, 25kHz BW, 64QAM

Conducted Channel Power:



Date: 24.AUG.2021 09:40:57

Channel BW (kHz)	Channel Frequency *(MHz)*	Modulation	Conducted Power *(dBm)*
25	481	64QAM	33.80

Table 7.1 – Summary of Conducted Power Measurements

Conducted Power Measurement Results:										
Frequency (MHz)	Channel BW (kHz)	Modulation	Measured Power [P_{Meas}] (dBm)	Original Power(1) [P_{Orig}] (dBm)	Delta (dB)	Antenna Gain [G_T] (dBi)	dBi to dBd [C_{ERP}] (dB)	ERP [E_{Meas}] (dBm)	ERP Limit(2) [E_{Lim}] (dBm)	ERP Margin (dB)
481.0	12.5	QPSK	37.20	37.4	-0.2	15.0	-2.15	50.1	57	7.0
		16QAM	34.63	35.6	-1.0			47.5		9.5
		64QAM	33.52	34.2	-0.6			46.4		10.6
	25.0	QPSK	37.43	36.7	0.7			50.3		6.7
		16QAM	34.80	35.6	-0.8			47.7		9.4
		64QAM	33.80	34.0	-0.2			46.7		10.4
									Result:	Complies

Delta = [P_{Meas}] - [P_{Orig}]

ERP = [P_{Meas}] + [G_T] + [C_{ERP}]

Margin = [E_{Lim}] - [E_{Meas}]

(1) As Originally Filed

(2) Max EPR based on HAAT, = 500W

8.0 OCCUPIED BANDWIDTH

Test Procedure	
Normative References	FCC 47 CFR §2.1049, §90.209
	ANSI C63.26 (5.4.4)

Requirement / Limits	
47 CFR §90.209	**§90.209 Bandwidth limitations.**
	(b) The maximum authorized single channel bandwidth of emission corresponding to the type of emission specified in §90.207 is as follows:
	(5) Unless specified elsewhere, channel spacings and bandwidths that will be authorized in the following frequency bands are given in the following table.
	406 - 512MHz Channel Spacing: 6.25kHz Authorized Bandwidth[1 3 6]: 20kHz, 11kHz, 6kHz
	[3]Operations using equipment designed to operate with a 25 kHz channel bandwidth will be authorized a 20 kHz bandwidth. Operations using equipment designed to operate with a 12.5 kHz channel bandwidth will be authorized a 11.25 kHz bandwidth. Operations using equipment designed to operate with a 6.25 kHz channel bandwidth will be authorized a 6 kHz bandwidth. All stations must operate on channels with a bandwidth of 12.5 kHz or less beginning January 1, 2013, unless the operations meet the efficiency standard of §90.203(j)(3).
	[(6)(i)] Beginning January 1, 2011, no new applications for the 150-174 MHz and/or 421-512 MHz bands will be acceptable for filing if the applicant utilizes channels with an authorized bandwidth exceeding 11.25 kHz, unless specified elsewhere or the operations meet the efficiency standards of §90.203(j)(3).
	[(ii)] Beginning January 1, 2011, no modification applications for stations in the 150-174 MHz and/or 421-512 MHz bands that increase the station's authorized interference contour, will be acceptable for filing if the applicant utilizes channels with an authorized bandwidth exceeding 11.25 kHz, unless specified elsewhere or the operations meet the efficiency standards of §90.203(j)(3). See §90.187(b)(2)(iii) and (iv) for interference contour designations and calculations. Applications submitted pursuant to this paragraph must comply with frequency coordination requirements of §90.175.

Test Procedure	
Normative References	FCC 47 CFR §2.1049, §90.209
	ANSI C63.26 (5.4.4)

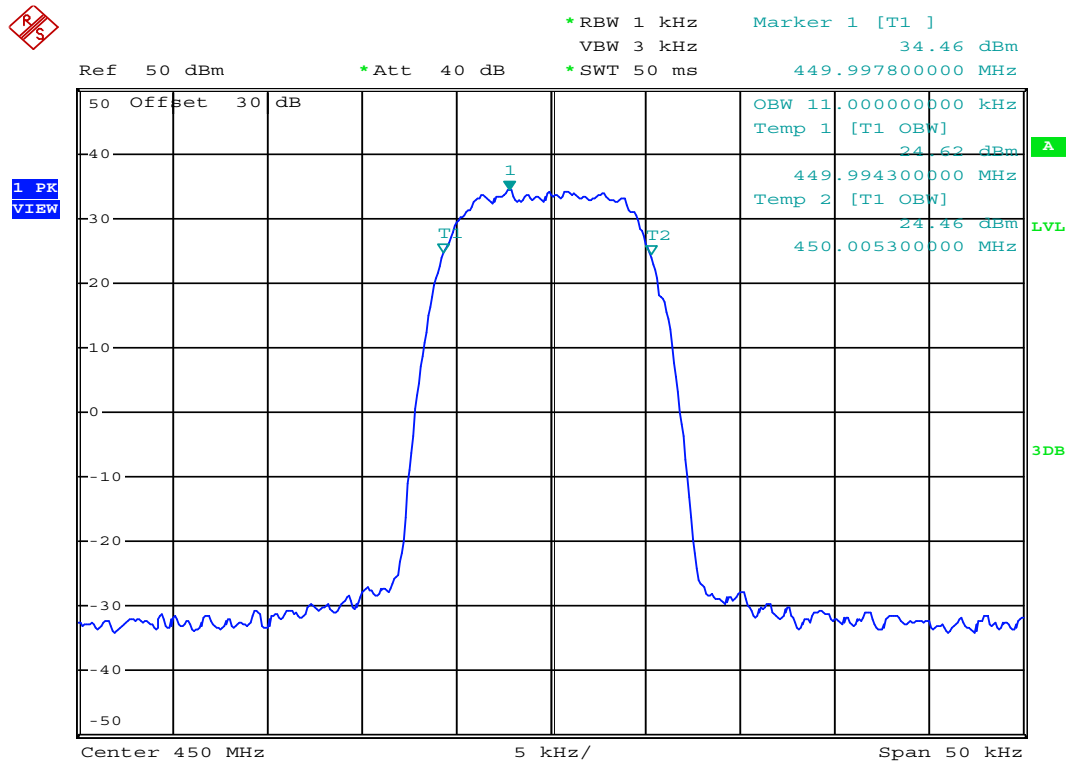
General Procedure	
C63.26	**5.4.4 Occupied bandwidth—Power bandwidth (99%) measurement procedure** 5.4.4 Occupied bandwidth—Power bandwidth (99%) measurement procedure30 The OBW is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission. The following procedure shall be used for measuring (99%) power bandwidth: a) The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be set wide enough to capture all modulation products including the emission skirts (typically a span of 1.5 × OBW is sufficient). b) The nominal IF filter 3 dB bandwidth (RBW) shall be in the range of 1% to 5% of the anticipated OBW, and the VBW shall be ≥ 3 × RBW. c) Set the reference level of the instrument as required to prevent the signal amplitude from exceeding the maximum spectrum analyzer input mixer level for linear operation. See guidance provided in 4.2.3. NOTE—Step a), step b), and step c) may require iteration to adjust within the specified tolerances. d) Set the detection mode to peak, and the trace mode to max-hold. e) If the instrument does not have a 99% OBW function, recover the trace data points and sum directly in linear power terms. Place the recovered amplitude data points, beginning at the lowest frequency, in a running sum until 0.5% of the total is reached. Record that frequency as the lower OBW frequency. Repeat the process until 99.5% of the total is reached and record that frequency as the upper OBW frequency. The 99% power OBW can be determined by computing the difference these two frequencies. f) The OBW shall be reported and plot(s) of the measuring instrument display shall be provided with the test report. The frequency and amplitude axis and scale shall be clearly labeled. Tabular data can be reported in addition to the plot(s).

Test Setup	Appendix A - Figure A.1

Measurement Procedure
The DUT was connected to the SA as specified above via a 30dB attenuator. The Occupied Bandwidth was measured using the intrument's 99% BW Function and recorded.

Plot 8.1 – Occupied Bandwidth, 12.5kHz BW, 450MHz, QPSK

Occupied Bandwidth:

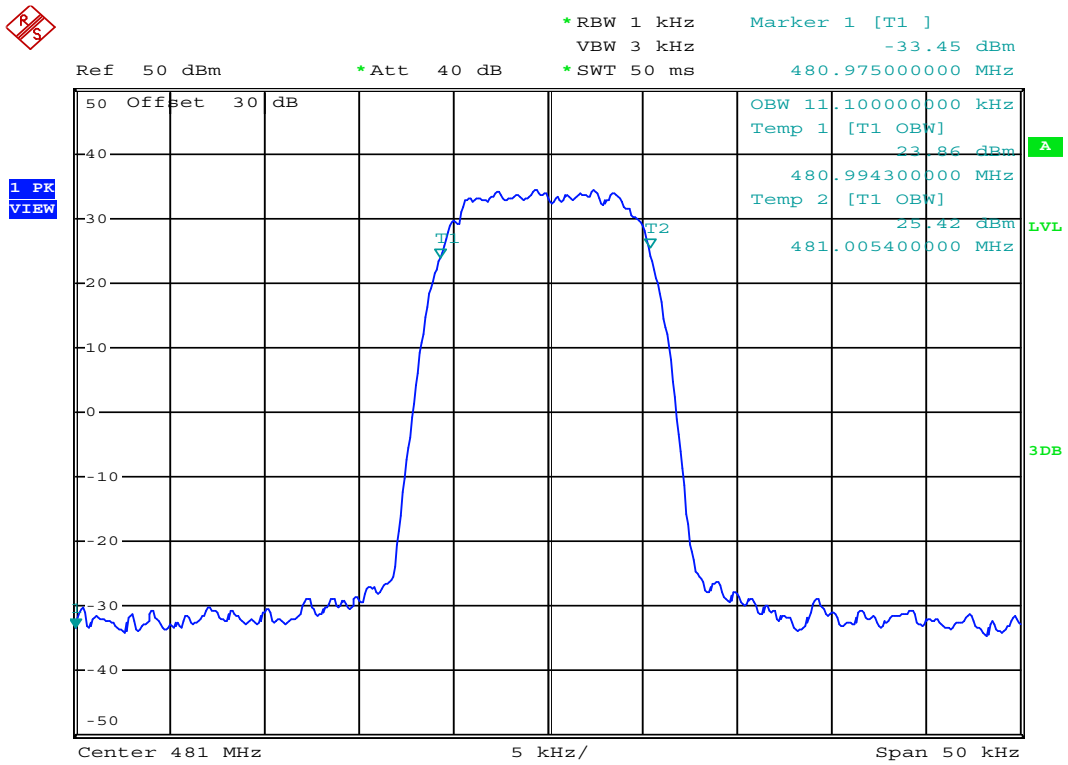


Date: 23.JUL.2021 13:10:06

Channel BW *(kHz)*	Channel Frequency *(MHz)*	DUT Modulation	Occupied Bandwidth *(kHz)*
12.5	450	QPSK	11.0

Plot 8.2 – Occupied Bandwidth, 12.5kHz BW, 481MHz, QPSK

Occupied Bandwidth:

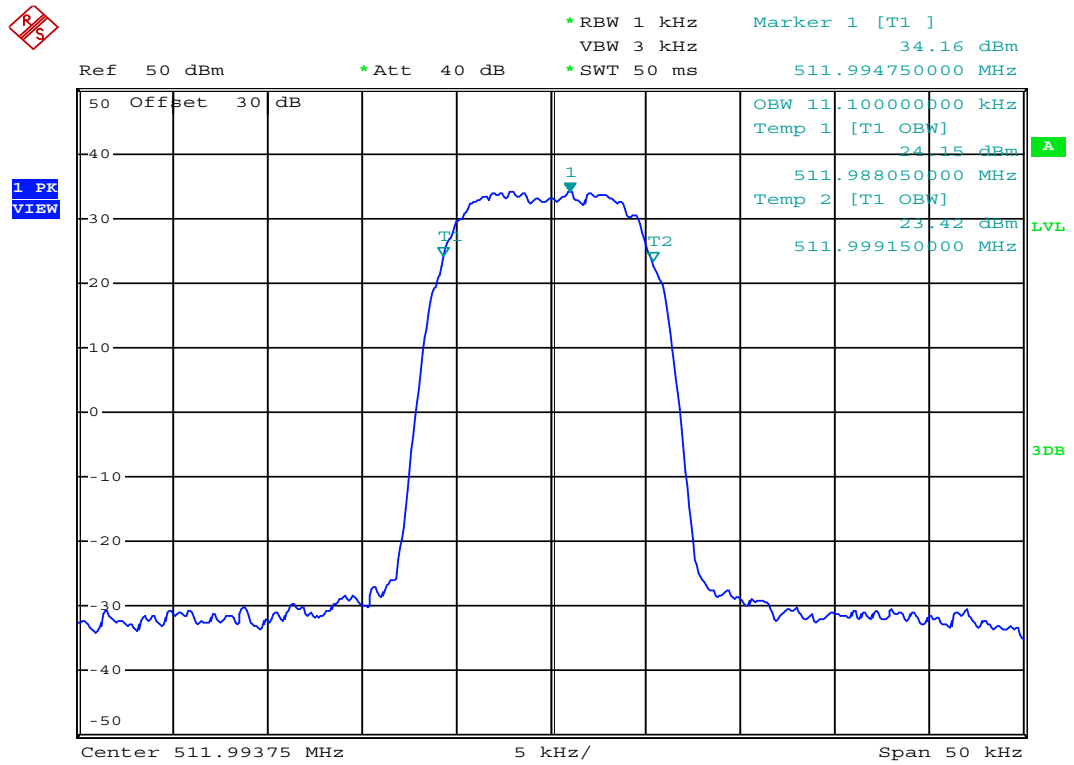


Date: 23.JUL.2021 13:09:14

Channel BW *(kHz)*	Channel Frequency *(MHz)*	DUT Modulation	Occupied Bandwidth *(kHz)*
12.5	481	QPSK	11.1

Plot 8.3 – Occupied Bandwidth, 12.5kHz BW, 512MHz, QPSK

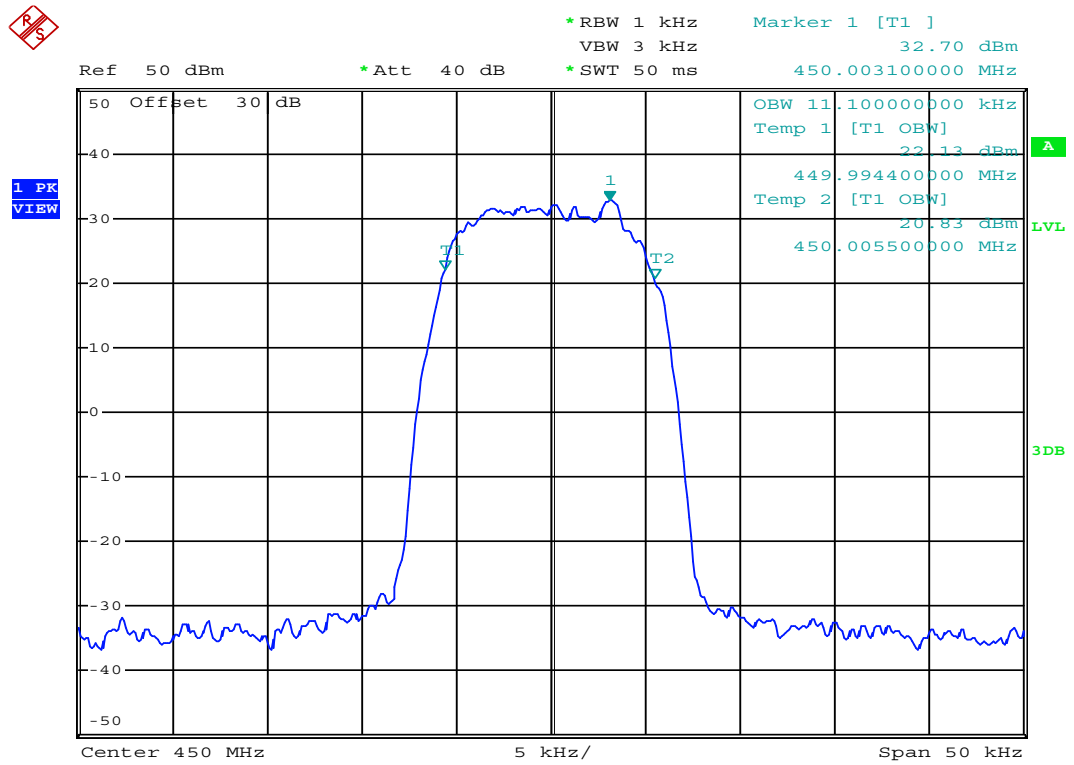
Occupied Bandwidth:



Channel BW *(kHz)*	Channel Frequency *(MHz)*	DUT Modulation	Occupied Bandwidth *(kHz)*
12.5	512	QPSK	11.1

Plot 8.4 – Occupied Bandwidth, 12.5kHz BW, 450MHz, 16QAM

Occupied Bandwidth:

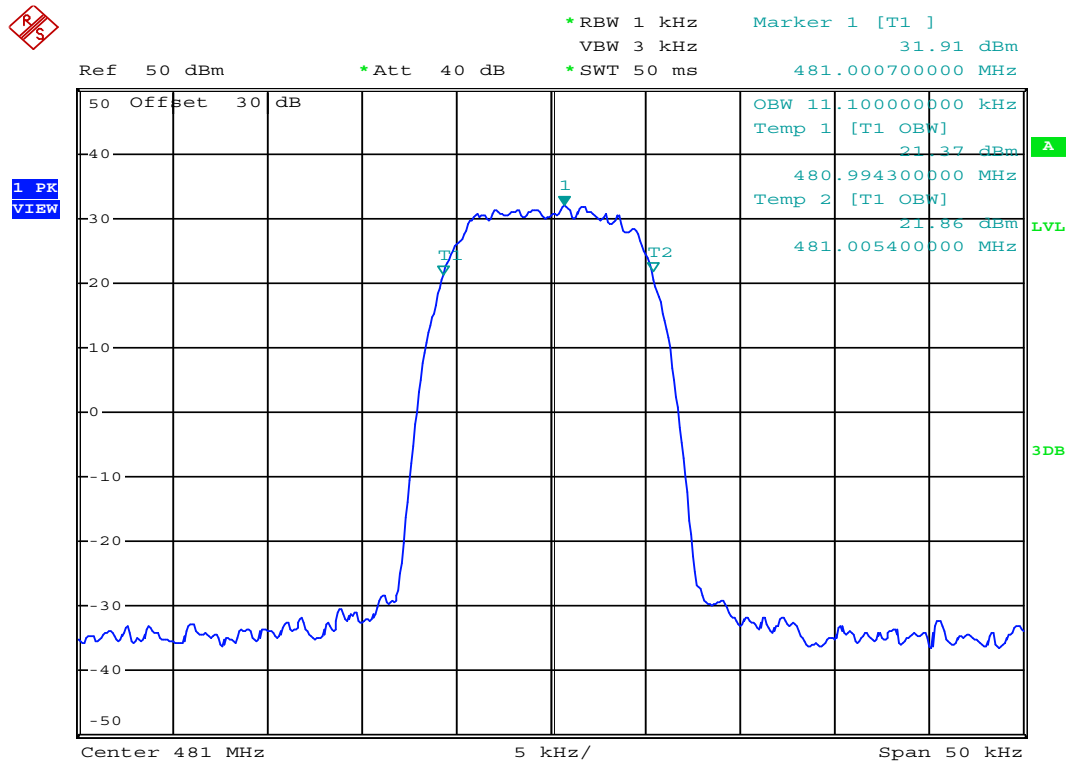


Date: 23.JUL.2021 13:14:21

Channel BW (kHz)	Channel Frequency (MHz)	DUT Modulation	Occupied Bandwidth (kHz)
12.5	450	16QAM	11.1

Plot 8.5 – Occupied Bandwidth, 12.5kHz BW, 481MHz, 16QAM

Occupied Bandwidth:

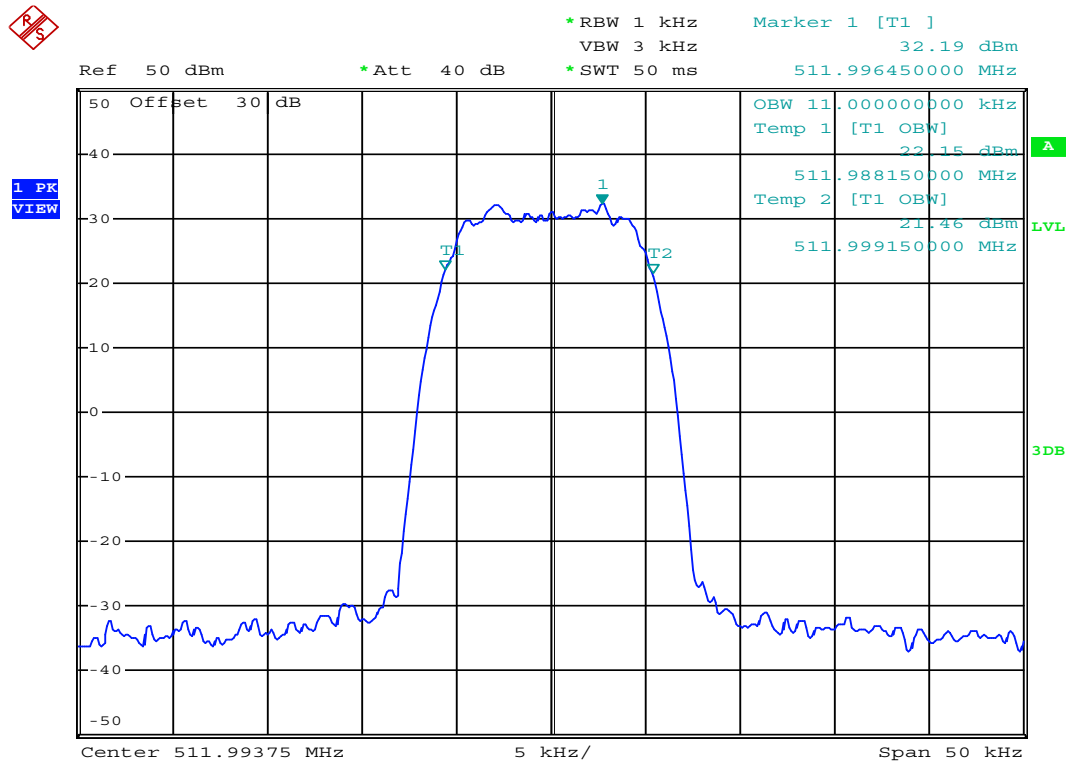


Date: 23.JUL.2021 13:16:39

Channel BW (kHz)	Channel Frequency (MHz)	DUT Modulation	Occupied Bandwidth (kHz)
12.5	481	16QAM	11.1

Plot 8.6 – Occupied Bandwidth, 12.5kHz BW, 520MHz, 16QAM

Occupied Bandwidth:

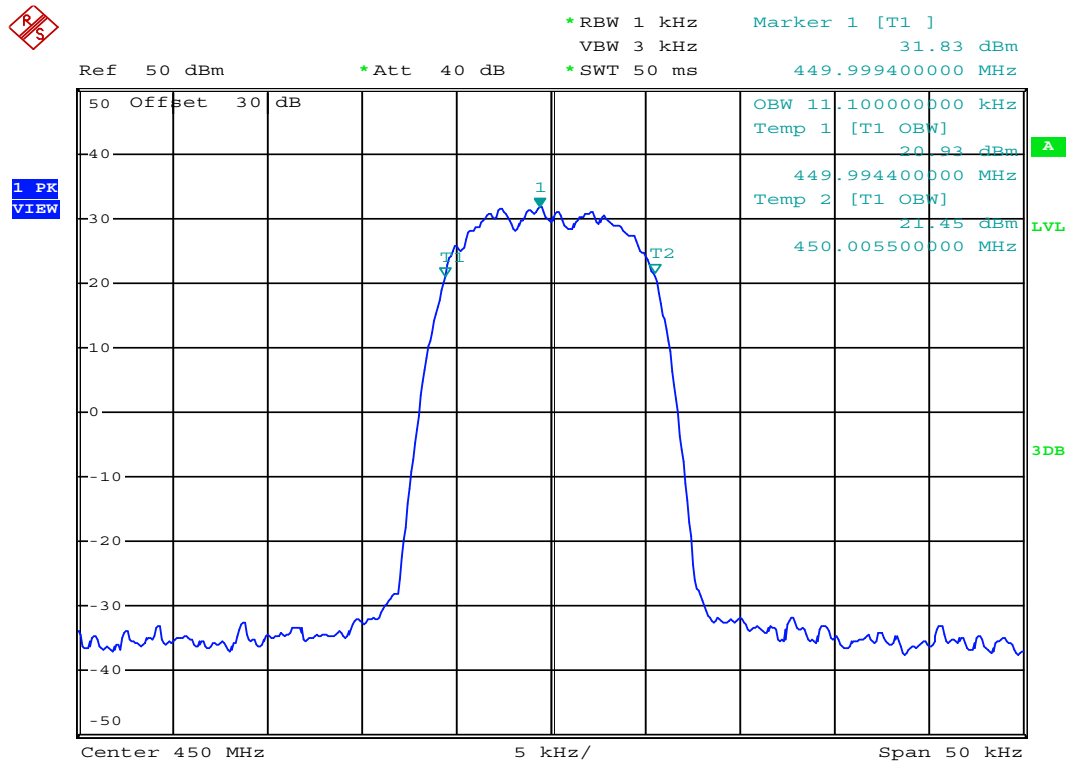


Date: 23.JUL.2021 13:17:58

Channel BW *(kHz)*	Channel Frequency *(MHz)*	DUT Modulation	Occupied Bandwidth *(kHz)*
12.5	512	16QAM	11.0

Plot 8.7 – Occupied Bandwidth, 12.5kHz BW, 450MHz, 64QAM

Occupied Bandwidth:

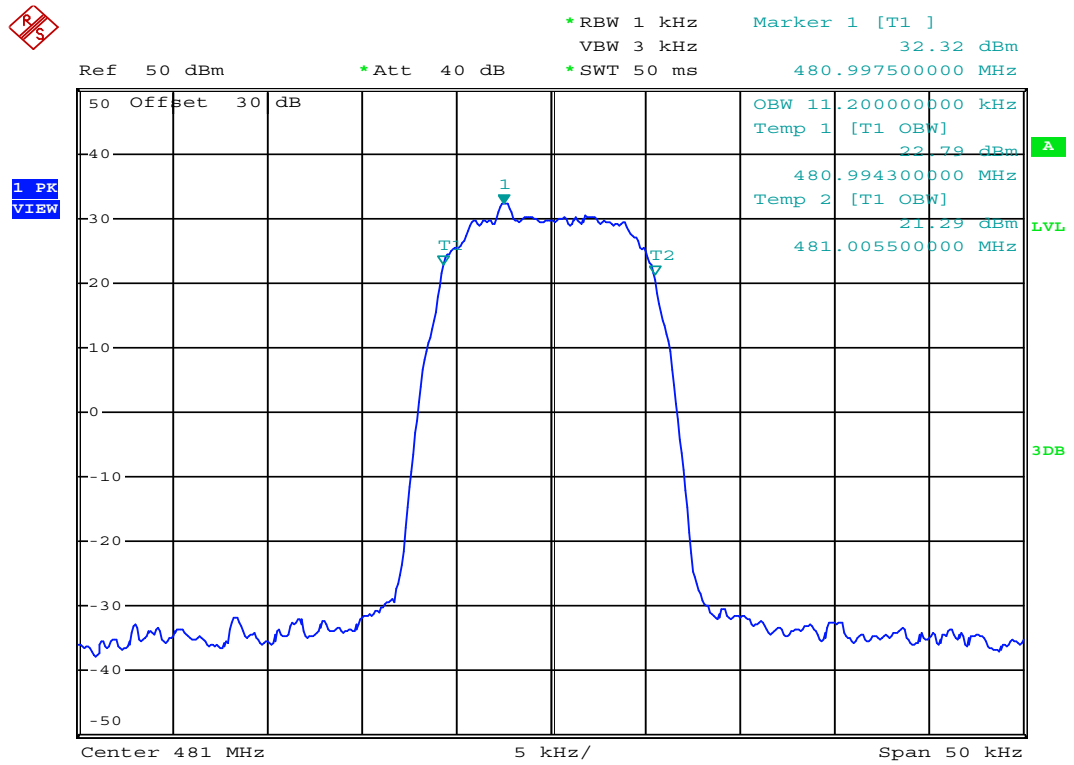


Date: 23.JUL.2021 13:21:17

Channel BW (kHz)	Channel Frequency (MHz)	DUT Modulation	Occupied Bandwidth (kHz)
12.5	450	64QAM	11.1

Plot 8.8 – Occupied Bandwidth, 12.5kHz BW, 481MHz, 64QAM

Occupied Bandwidth:

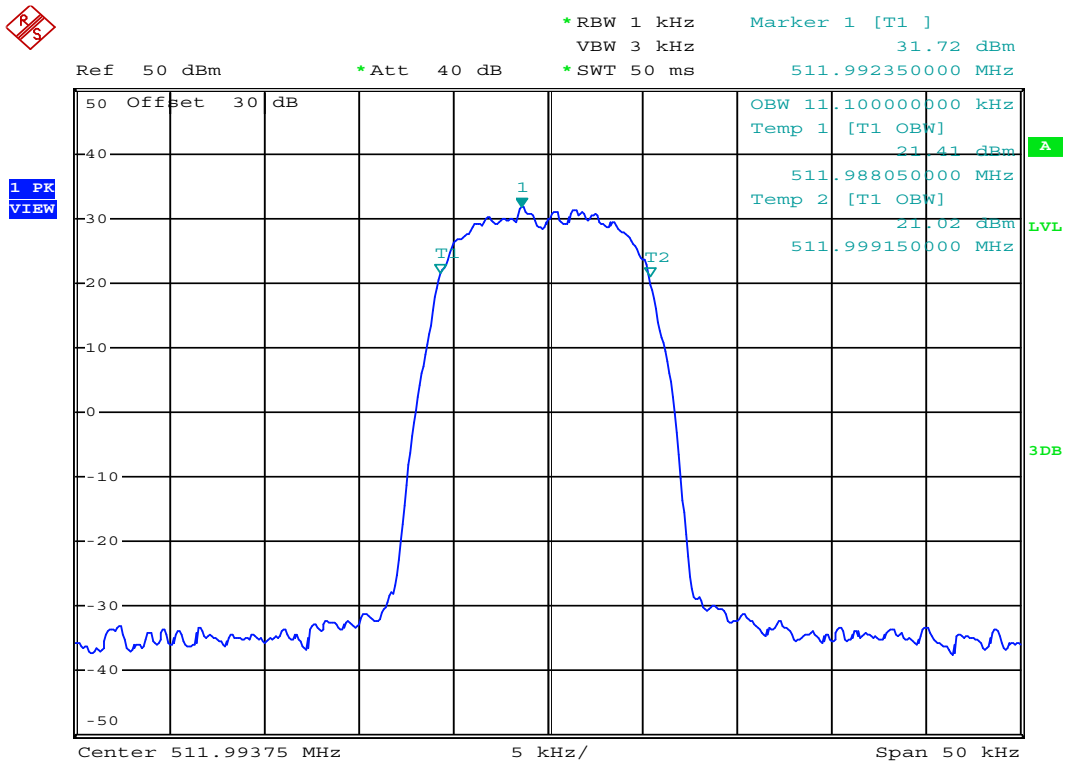


Date: 23.JUL.2021 13:20:20

Channel BW (kHz)	Channel Frequency (MHz)	DUT Modulation	Occupied Bandwidth (kHz)
12.5	481	64QAM	11.2

Plot 8.9 – Occupied Bandwidth, 12.5kHz BW, 520MHz, 64QAM

Occupied Bandwidth:

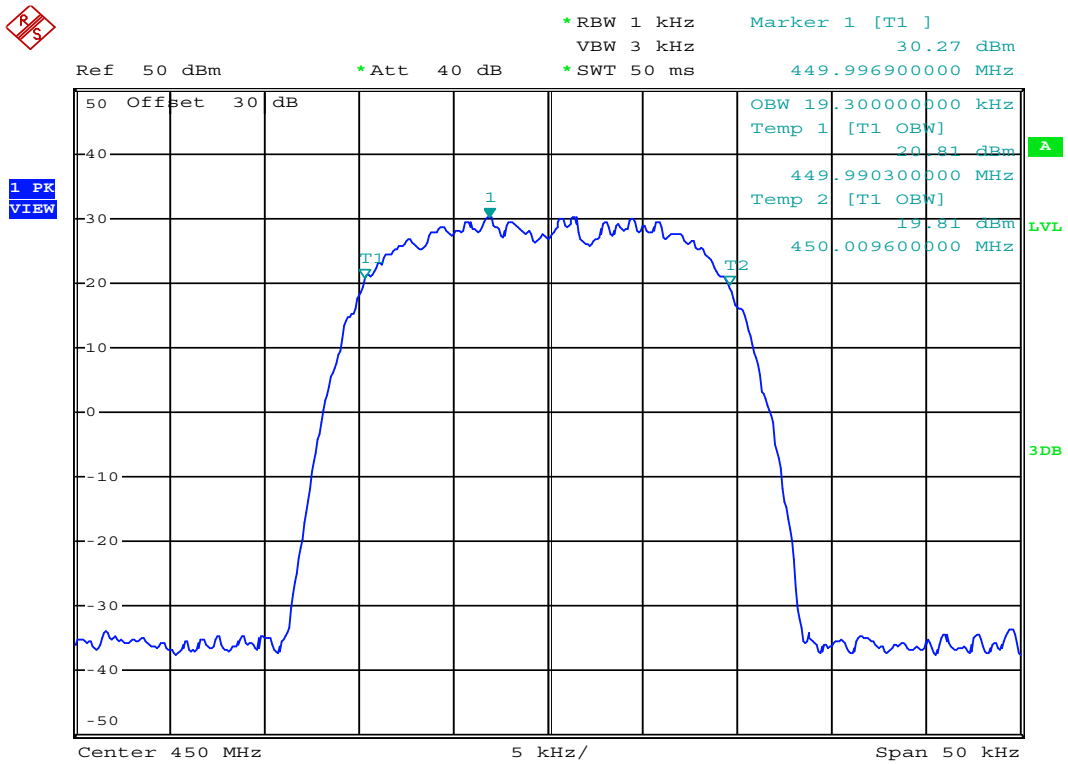


Date: 23.JUL.2021 13:19:26

Channel BW (kHz)	Channel Frequency (MHz)	DUT Modulation	Occupied Bandwidth (kHz)
12.5	512	64QAM	11.1

Plot 8.10 – Occupied Bandwidth, 25kHz BW, 450MHz, QPSK

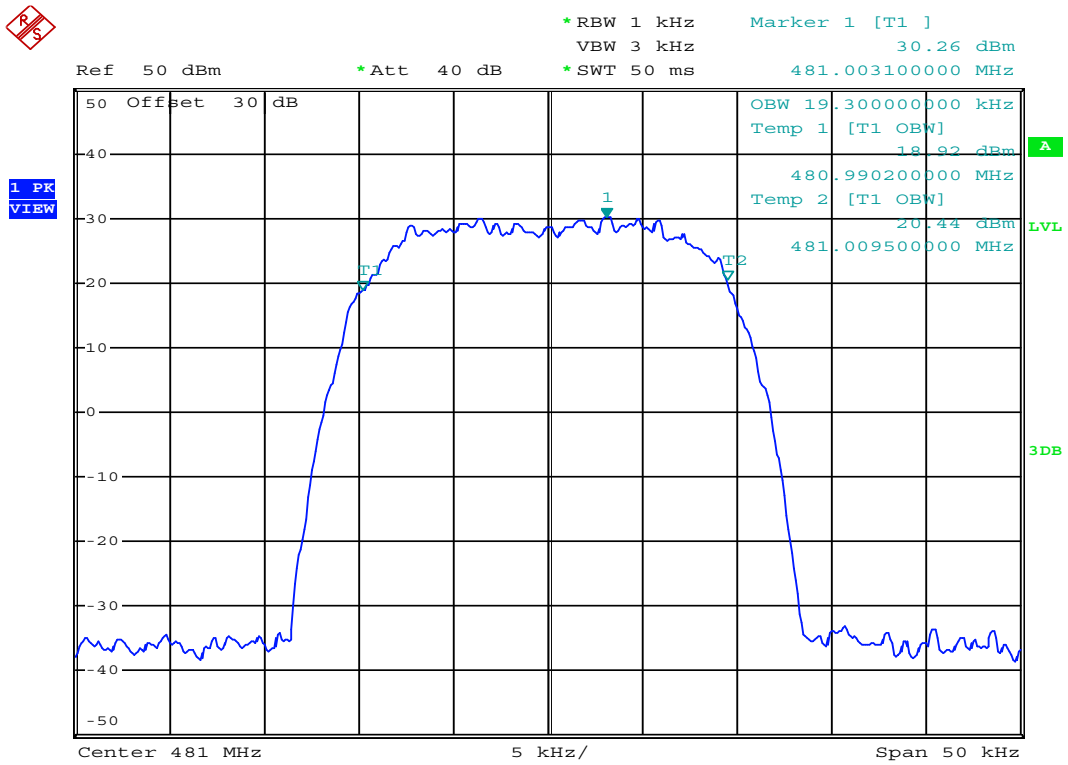
Occupied Bandwidth:



Channel BW (kHz)	Channel Frequency (MHz)	DUT Modulation	Occupied Bandwidth (kHz)
25	450	QPSK	19.3

Plot 8.11 – Occupied Bandwidth, 25kHz BW, 481MHz, QPSK

Occupied Bandwidth:

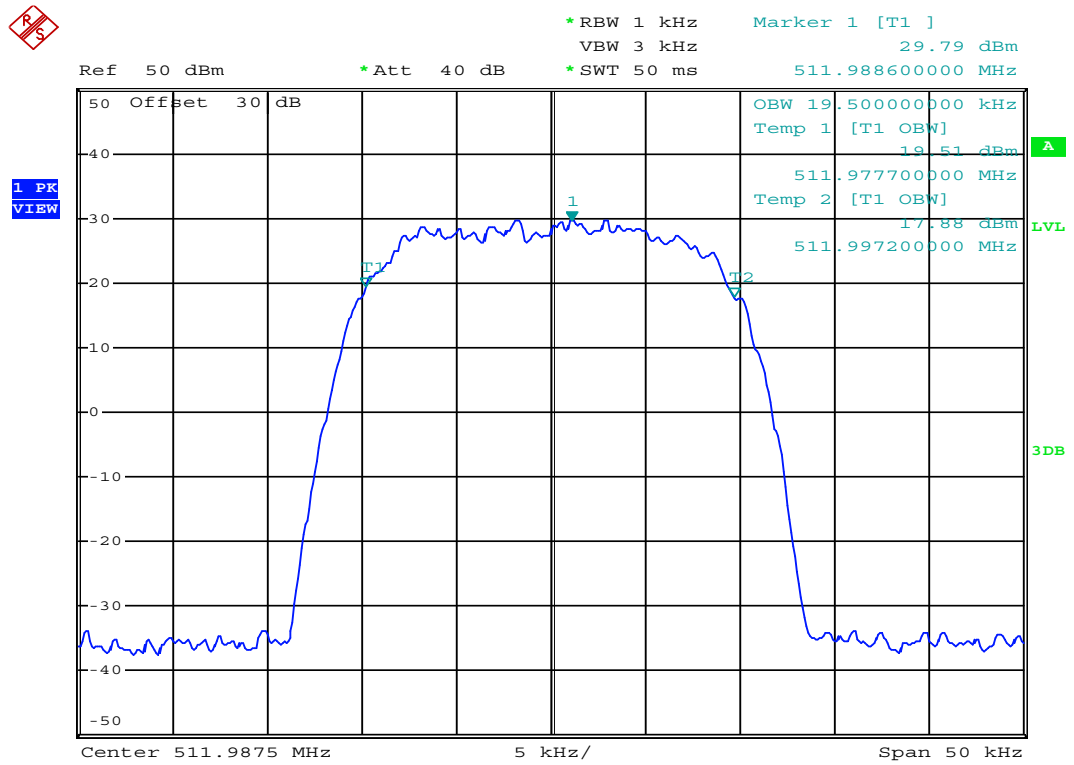


Date: 23.JUL.2021 13:38:42

Channel BW (kHz)	Channel Frequency (MHz)	DUT Modulation	Occupied Bandwidth (kHz)
25	481	QPSK	19.3

Plot 8.12 – Occupied Bandwidth, 25kHz BW, 512MHz, QPSK

Occupied Bandwidth:

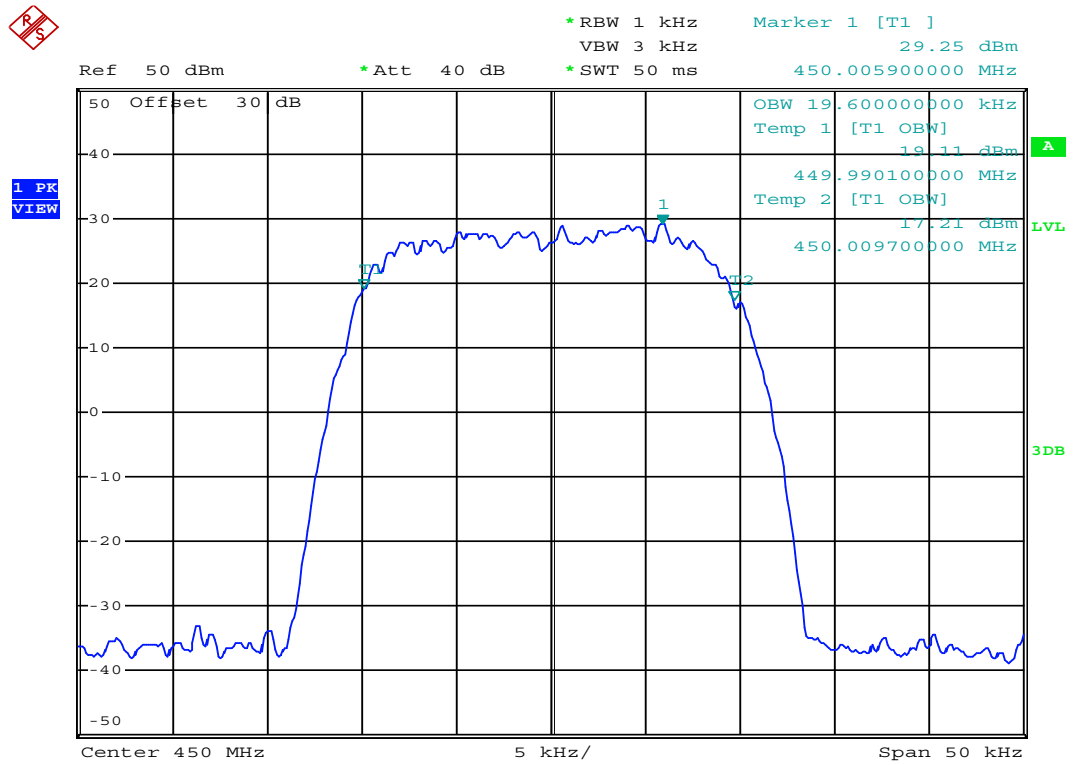


Date: 23.JUL.2021 13:39:48

Channel BW (kHz)	Channel Frequency (MHz)	DUT Modulation	Occupied Bandwidth (kHz)
25	512	QPSK	19.5

Plot 8.13 – Occupied Bandwidth, 25kHz BW, 450MHz, 16QAM

Occupied Bandwidth:

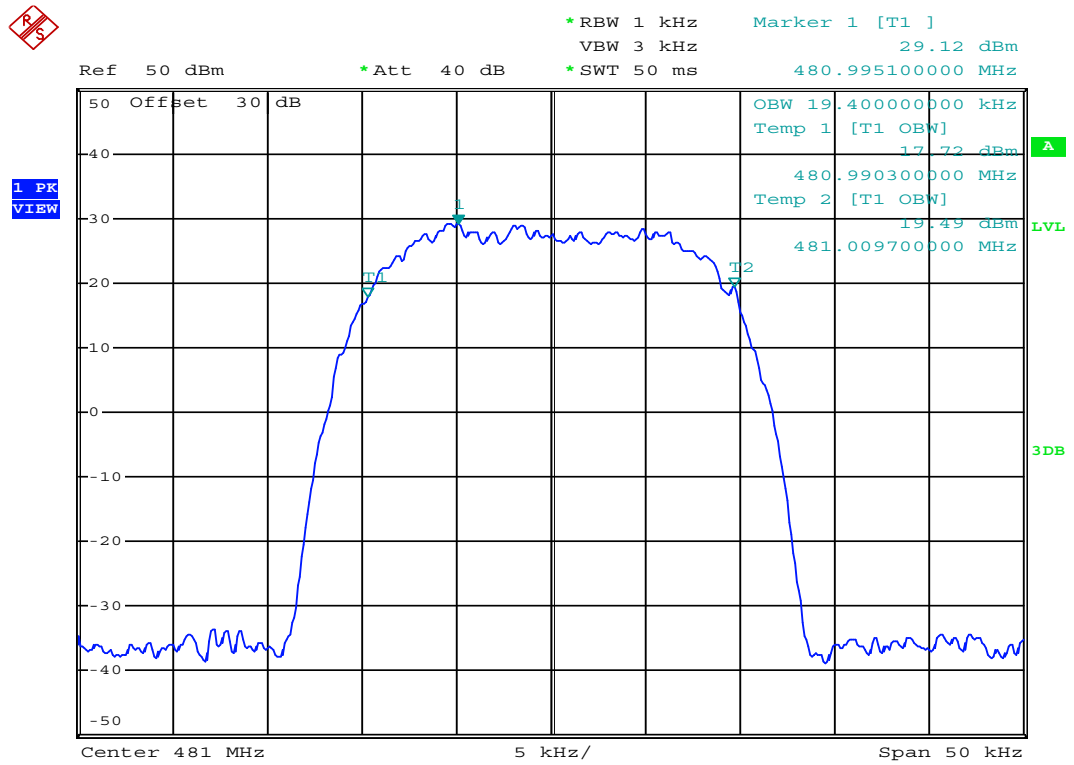


Date: 23.JUL.2021 13:42:38

Channel BW (kHz)	Channel Frequency (MHz)	DUT Modulation	Occupied Bandwidth (kHz)
25	450	16QAM	19.6

Plot 8.14 – Occupied Bandwidth, 25kHz BW, 481MHz, 16QAM

Occupied Bandwidth:

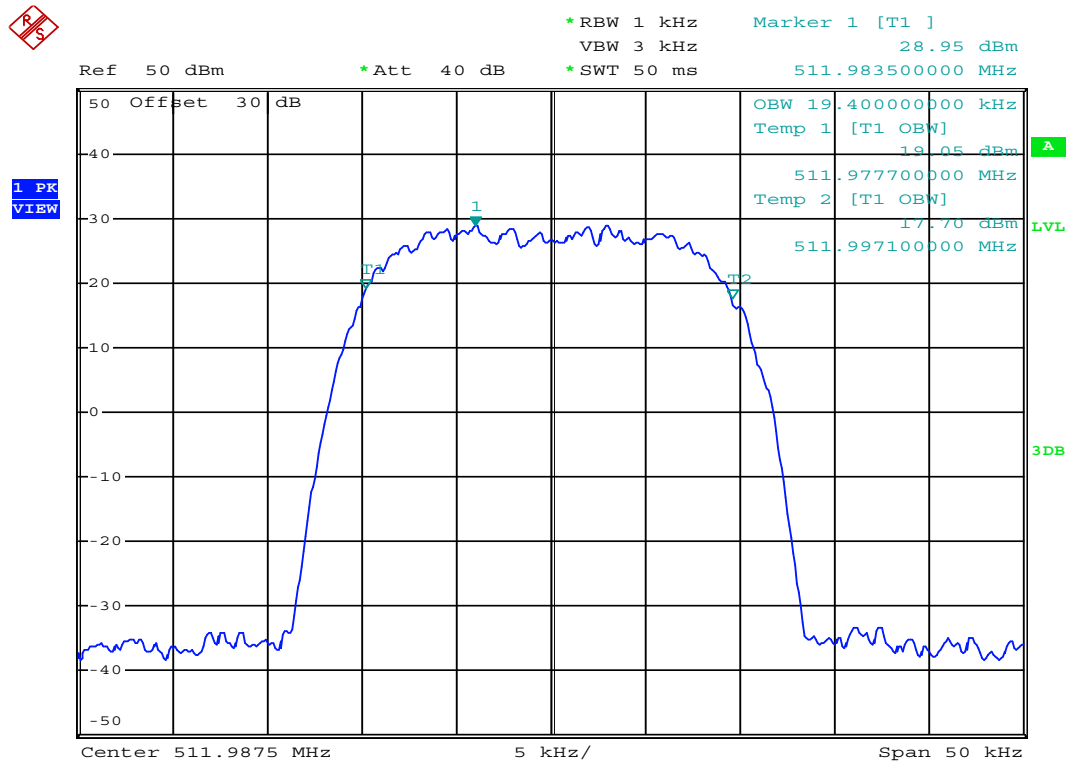


Date: 23.JUL.2021 13:41:47

Channel BW *(kHz)*	Channel Frequency *(MHz)*	DUT Modulation	Occupied Bandwidth *(kHz)*
25	481	16QAM	19.4

Plot 8.15 – Occupied Bandwidth, 25kHz BW, 520MHz, 16QAM

Occupied Bandwidth:

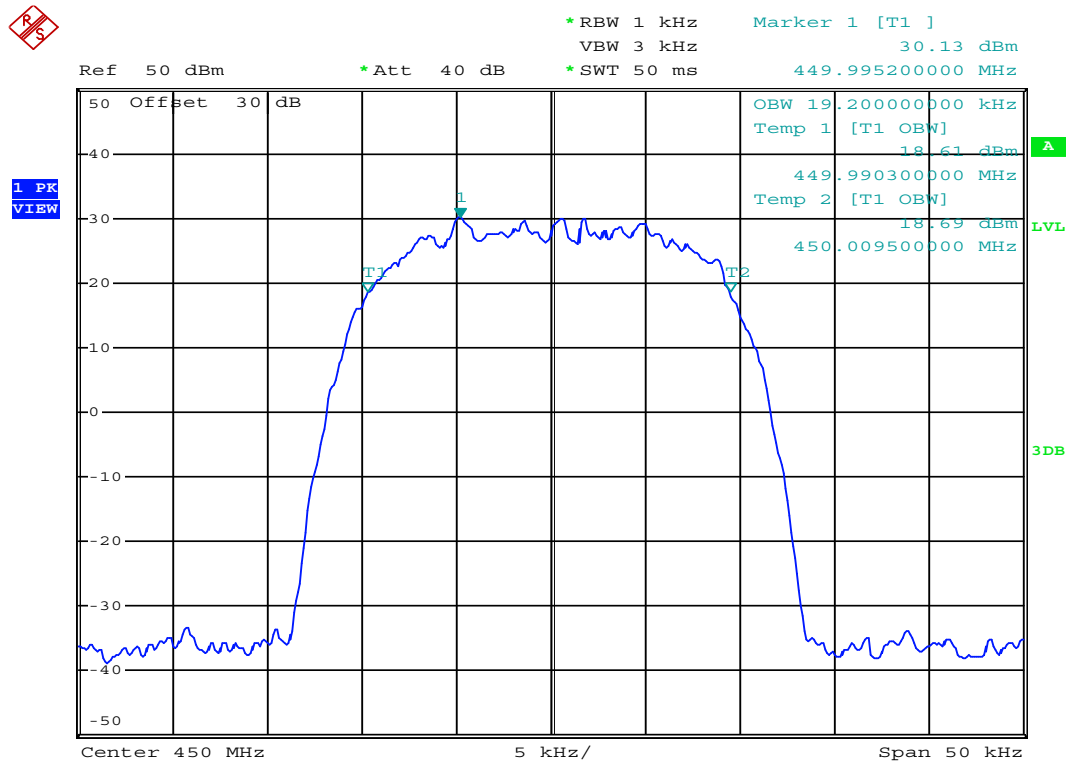


Date: 23.JUL.2021 13:40:57

Channel BW *(kHz)*	Channel Frequency *(MHz)*	DUT Modulation	Occupied Bandwidth *(kHz)*
25	512	16QAM	19.4

Plot 8.16 – Occupied Bandwidth, 25kHz BW, 450MHz, 64QAM

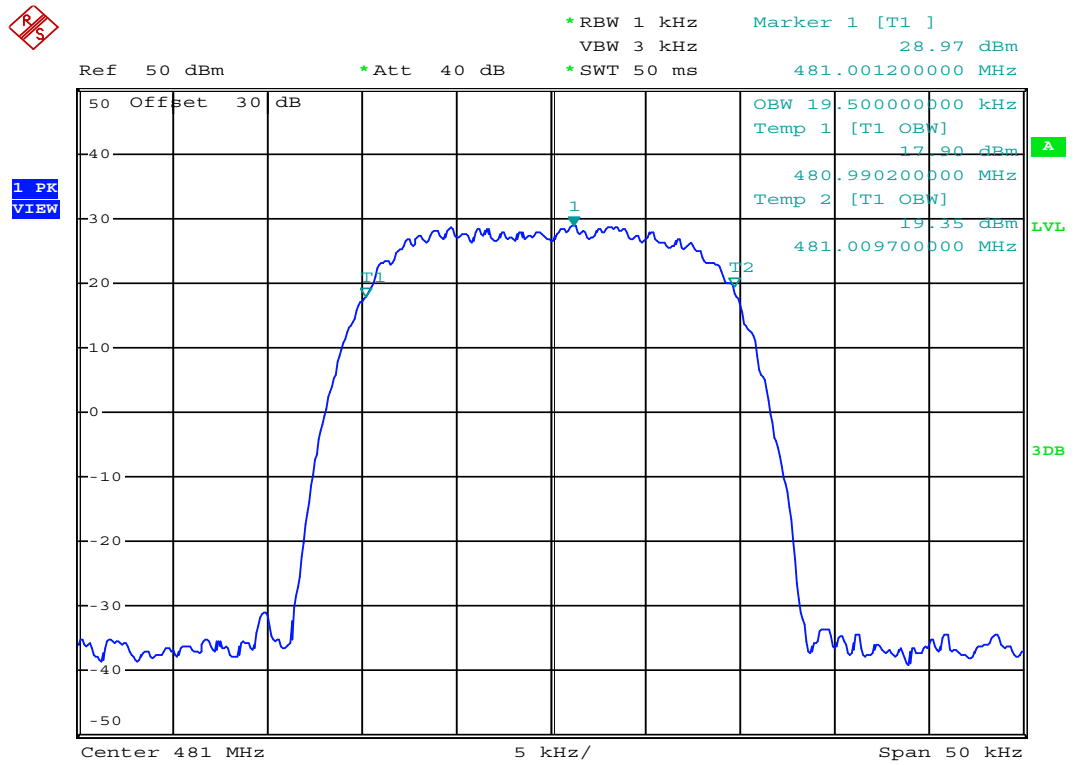
Occupied Bandwidth:



Channel BW (kHz)	Channel Frequency (MHz)	DUT Modulation	Occupied Bandwidth (kHz)
25	450	64QAM	19.2

Plot 8.17 – Occupied Bandwidth, 25kHz BW, 481MHz, 64QAM

Occupied Bandwidth:

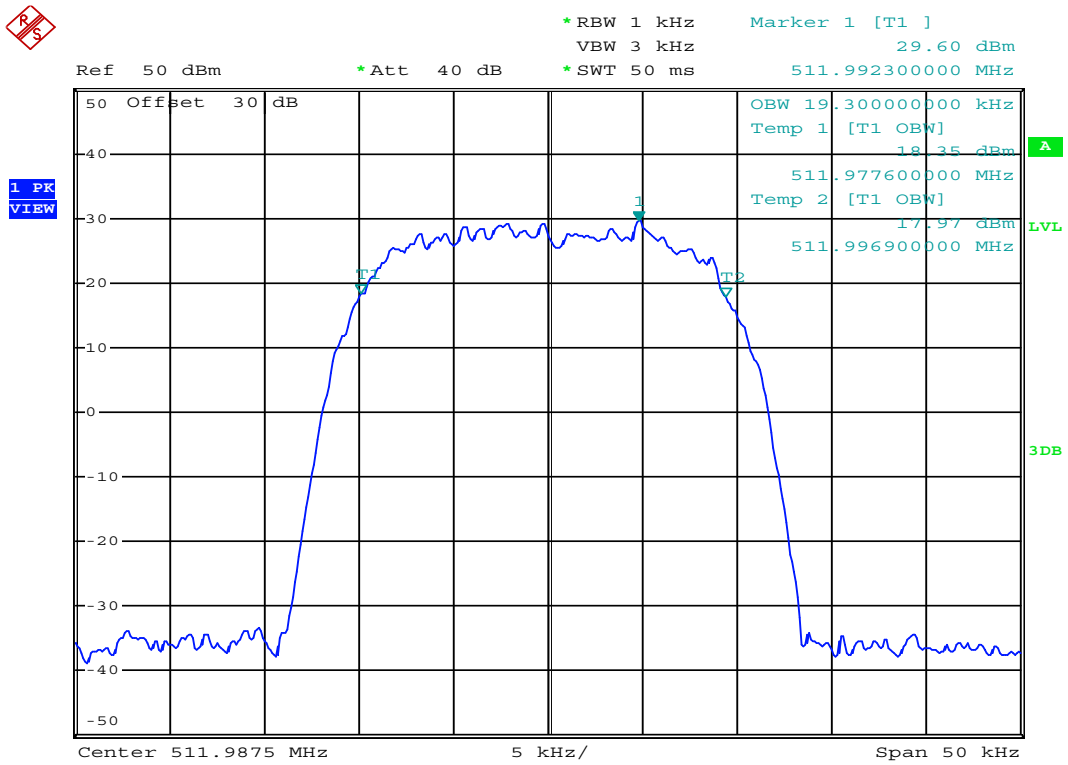


Date: 23.JUL.2021 13:44:37

Channel BW *(kHz)*	Channel Frequency *(MHz)*	DUT Modulation	Occupied Bandwidth *(kHz)*
25	481	64QAM	19.4

Plot 8.18 – Occupied Bandwidth, 25kHz BW, 520MHz, 64QAM

Occupied Bandwidth:



Date: 23.JUL.2021 13:45:50

Channel BW (kHz)	Channel Frequency (MHz)	DUT Modulation	Occupied Bandwidth (kHz)
25	512	64QAM	19.3

Table 8.1 – Summary of Occupied Bandwidth Results

Occupied Bandwidth Results:				
Nominal Channel Bandwidth (kHz)	DUT Modulation	Channel Frequency (MHz)	Measured Occupied Bandwidth (kHz)	Emission Designator
12.5	QPSK	450.0	11.0	11K0G1D
		481.0	11.1	11K1G1D
		512.0	11.1	11K1G1D
	16QAM	450.0	11.1	11K1D1D
		481.0	11.1	11K1D1D
		512.0	11.0	11K0D1D
	64QAM	450.0	11.1	11K1D1D
		481.0	11.2	11K2D1D
		512.0	11.1	11K1D1D
25.0	QPSK	450.0	19.3	19K3G1D
		481.0	19.3	19K3G1D
		512.0	19.5	19K5G1D
	16QAM	450.0	19.6	19K6D1D
		481.0	19.4	19K4D1D
		512.0	19.4	19K4D1D
	64QAM	450.0	19.2	19K2D1D
		481.0	19.4	19K4D1D
		512.0	19.3	19K3D1D
				Complies

9.0 EMISSIONS MASK

Test Procedure	
Normative References	FCC 47 CFR §2.1049, §90.205
	ANSI C63.26 (5.2.3.3)

Requirement / Limits	
47 CFR §90.210	**§90.210 Emission masks.**
	Except as indicated elsewhere in this part, transmitters used in the radio services governed by this part must comply with the emission masks outlined in this section. Unless otherwise stated, per paragraphs (d)(4), (e)(4), and (o) of this section, measurements of emission power can be expressed in either peak or average values provided that emission powers are expressed with the same parameters used to specify the unmodulated transmitter carrier power. For transmitters that do not produce a full power unmodulated carrier, reference to the unmodulated transmitter carrier power refers to the total power contained in the channel bandwidth. Unless indicated elsewhere in this part, the table in this section specifies the
	Frequency Band: 421 - 512 [2 5] Mask for Equipment without audio low pass filter: C, D or E
	[2]Equipment designed to operate with a 25 kHz channel bandwidth must meet the requirements of Emission Mask B or C, as applicable. Equipment designed to operate with a 12.5 kHz channel bandwidth must meet the requirements of Emission Mask D, and equipment designed to operate with a 6.25 kHz channel bandwidth must meet the requirements of mission Mask E.
	[5]Equipment designed to operate on 25 kilohertz bandwidth channels must meet the requirements of either Emission Mask B or G, whichever is applicable, while equipment designed to operate on 12.5 kilohertz bandwidth channels must meet the requirements of Emission Mask D. Equipment designed to operate on 25 kilohertz bandwidth channels may alternatively meet the Adjacent Channel Power limits of §90.221.

Test Procedure	
Normative References	FCC 47 CFR §2.1049, §90.205
	ANSI C63.26 (5.2.3.3)

Requirement / Limits

General Procedure	
47 CFR §90.210	**(o) Instrumentation** The reference level for showing compliance with the emission mask shall be established, except as indicated in §§90.210 (d), (e), and (k), using standard engineering practices for the modulation characteristic used by the equipment under test. When measuring emissions in the 150-174 MHz and 421-512 MHz bands the following procedures will apply. A sufficient number of sweeps must be measured to insure that the emission profile is developed. If video filtering is used, its bandwidth must not be less than the instrument resolution bandwidth. For frequencies more than 50 kHz removed from the edge of the authorized bandwidth a resolution of at least 100 kHz must be used for frequencies below 1000 MHz. Above 1000 MHz the resolution bandwidth of the instrumentation must be at least 1 MHz. If it can be shown that use of the above instrumentation settings do not accurately represent the true interference potential of the equipment under test, then an alternate procedure may be used provided prior Commission approval is obtained.

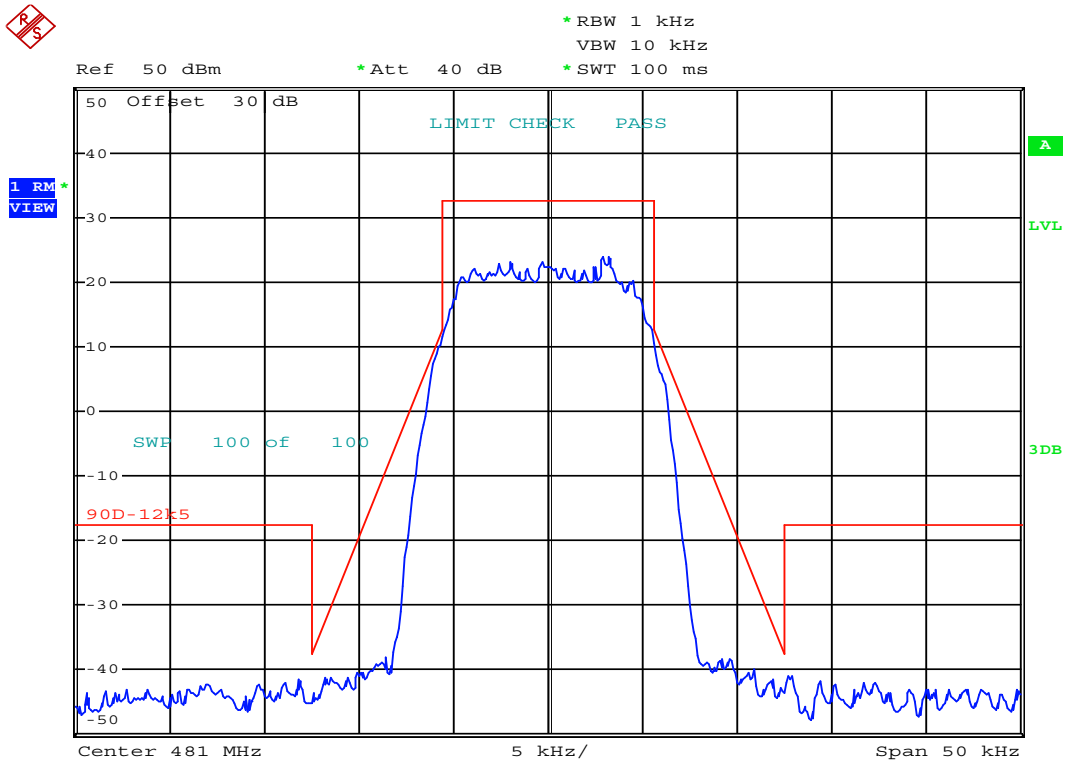
Test Setup	Appendix A - Figure A.1

Measurement Procedure

The DUT was connected to the SA as specified above via a 30dB attenuator. An Emissions Mask was created within the instrument using the instrument's Pass/Fail criteria.

Plot 9.1 – Emissions Mask, 12.5kHz BW, Mask D, QPSK

Emissions Mask:

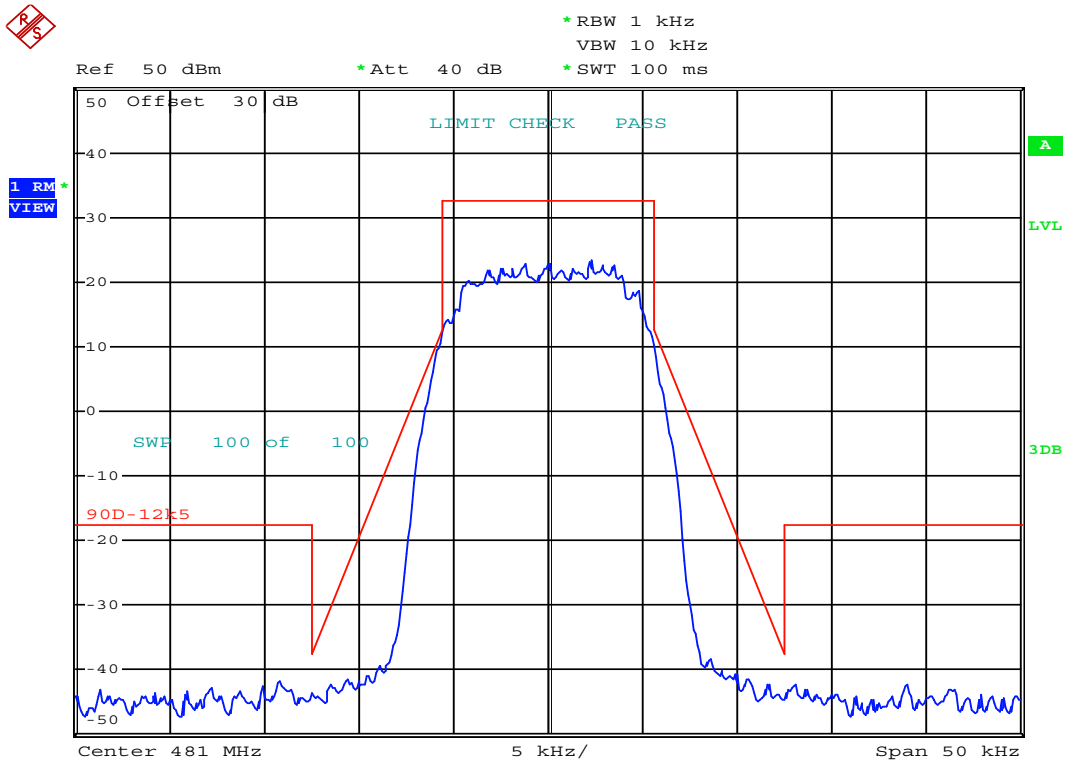


Date: 23.JUL.2021 15:25:00

Channel Mask	Channel BW *(kHz)*	Channel Frequency *(MHz)*	DUT Modulation	Mask Results
D	12.5	481	QPSK	PASS

Plot 9.2 – Emissions Mask, 12.5kHz BW, Mask D, 16QAM

Emissions Mask:

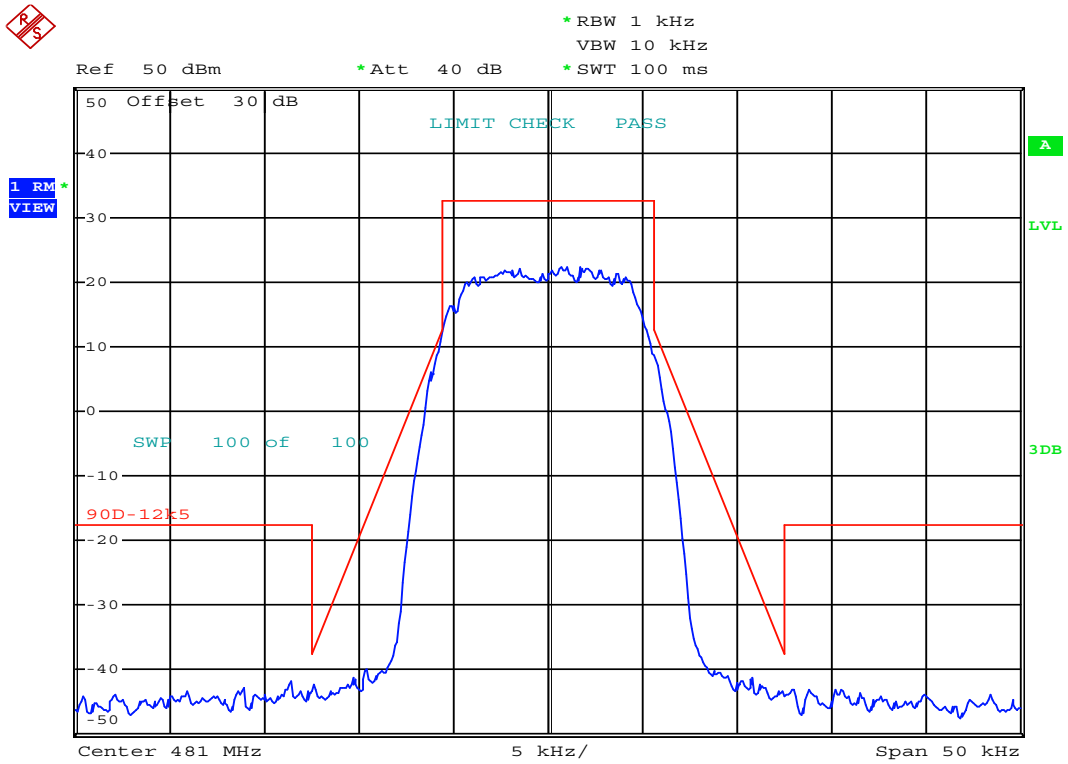


Date: 23.JUL.2021 15:25:55

Channel Mask	Channel BW *(kHz)*	Channel Frequency *(MHz)*	DUT Modulation	Mask Results
D	12.5	481	16QAM	PASS

Plot 9.3 – Emissions Mask, 12.5kHz BW, Mask D, 64QAM

Emissions Mask:

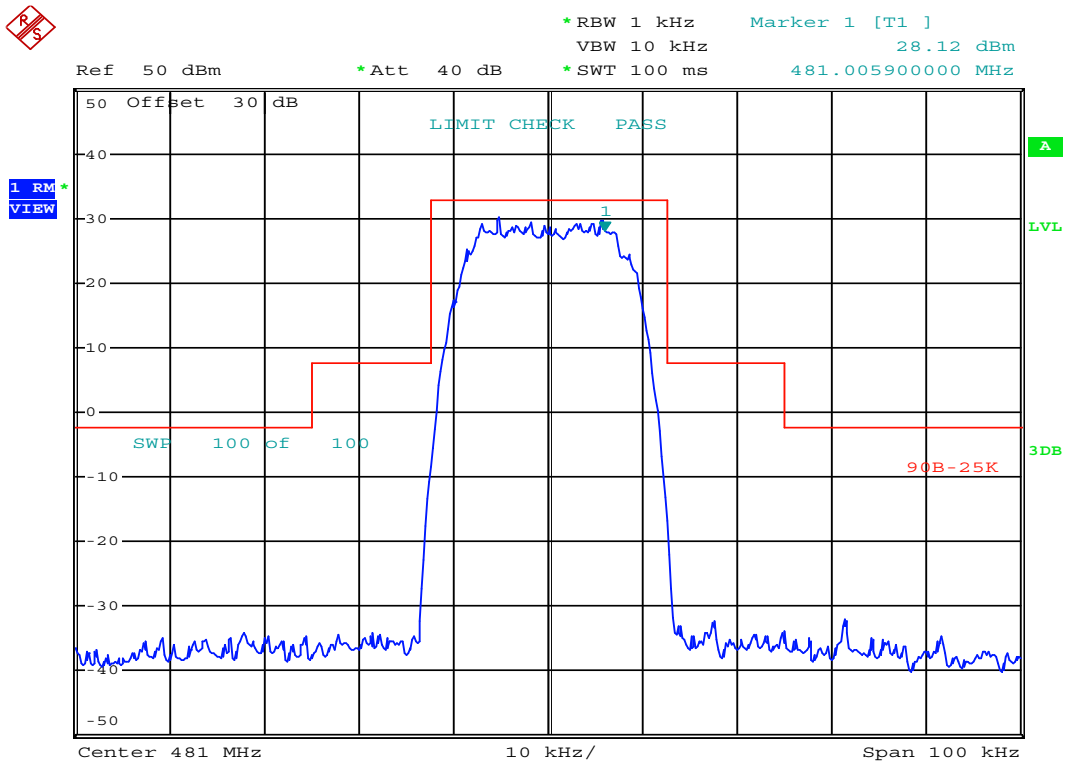


Date: 23.JUL.2021 15:26:49

Channel Mask	Channel BW *(kHz)*	Channel Frequency *(MHz)*	DUT Modulation	Mask Results
D	12.5	481	64QAM	PASS

Plot 9.4 – Emissions Mask, 25kHz BW, Mask B, QPSK

Emissions Mask:

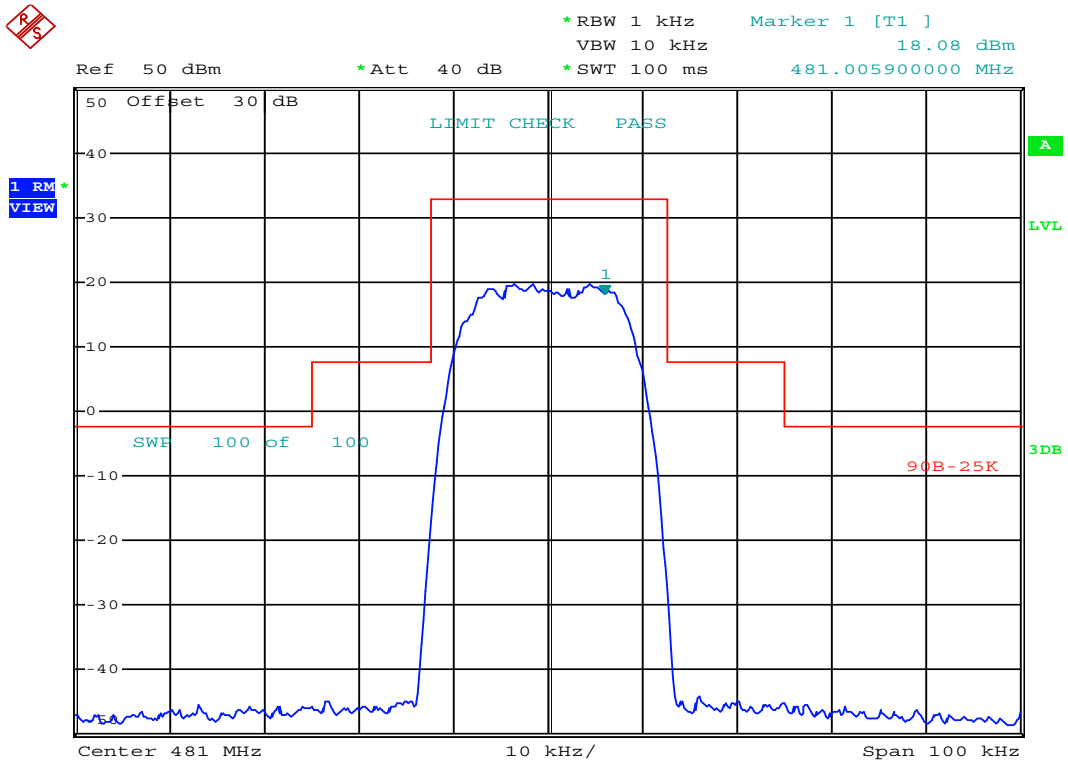


Date: 23.JUL.2021 15:14:12

Channel Mask	Channel BW (kHz)	Channel Frequency (MHz)	DUT Modulation	Mask Results
B	25	481	QPSK	PASS

Plot 9.5 – Emissions Mask, 25kHz BW, Mask B, 16QAM

Emissions Mask:

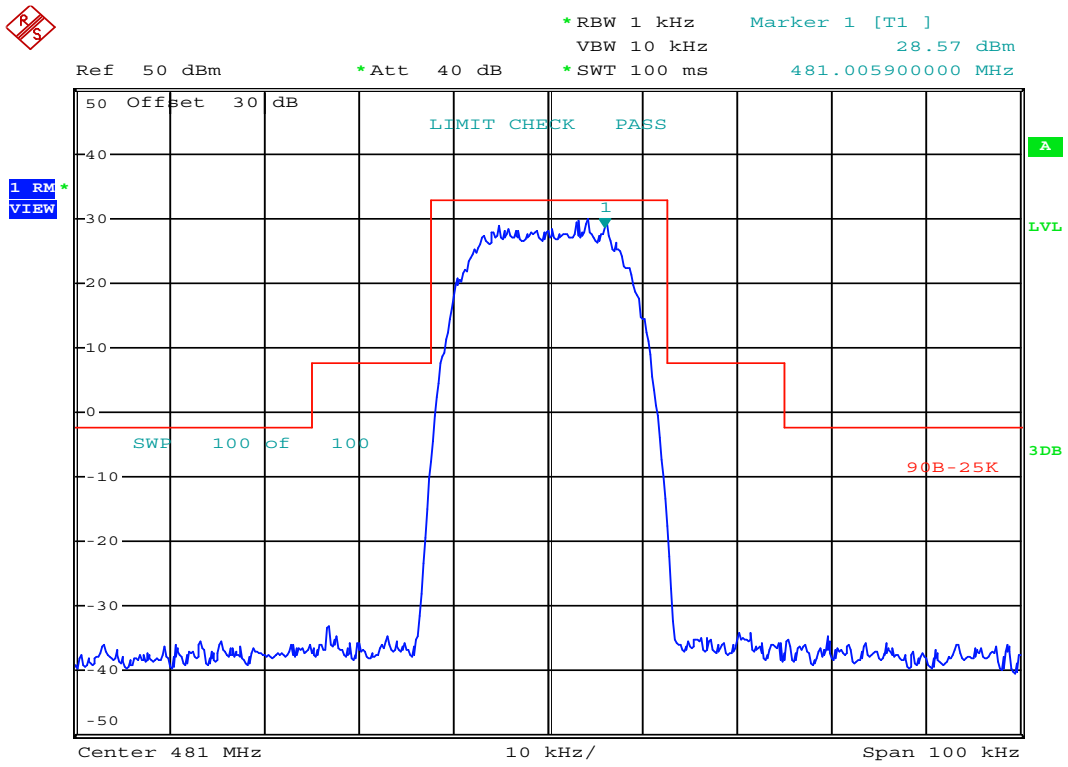


Date: 23.JUL.2021 15:13:21

Channel Mask	Channel BW (kHz)	Channel Frequency (MHz)	DUT Modulation	Mask Results
B	25	481	16QAM	PASS

Plot 9.6 – Emissions Mask, 25kHz BW, Mask B, 64QAM

Emissions Mask:



Date: 23.JUL.2021 15:15:06

Channel Mask	Channel BW (kHz)	Channel Frequency (MHz)	DUT Modulation	Mask Results
B	25	481	64QAM	PASS

Table 9.2 – Summary of Emissions Mask Results

Emissions Mask Results:				
Nominal Channel Bandwidth (kHz)	**Channel Frequency (MHz)**	**DUT Modulation**	**Measured Occupied Bandwidth (kHz)**	**Mask Results**
12.5	481.0	QPSK	11.1	PASS
		16QAM	11.1	PASS
		64QAM	11.2	PASS
25.0		QPSK	19.3	PASS
		16QAM	19.4	PASS
		64QAM	19.4	PASS
				Complies

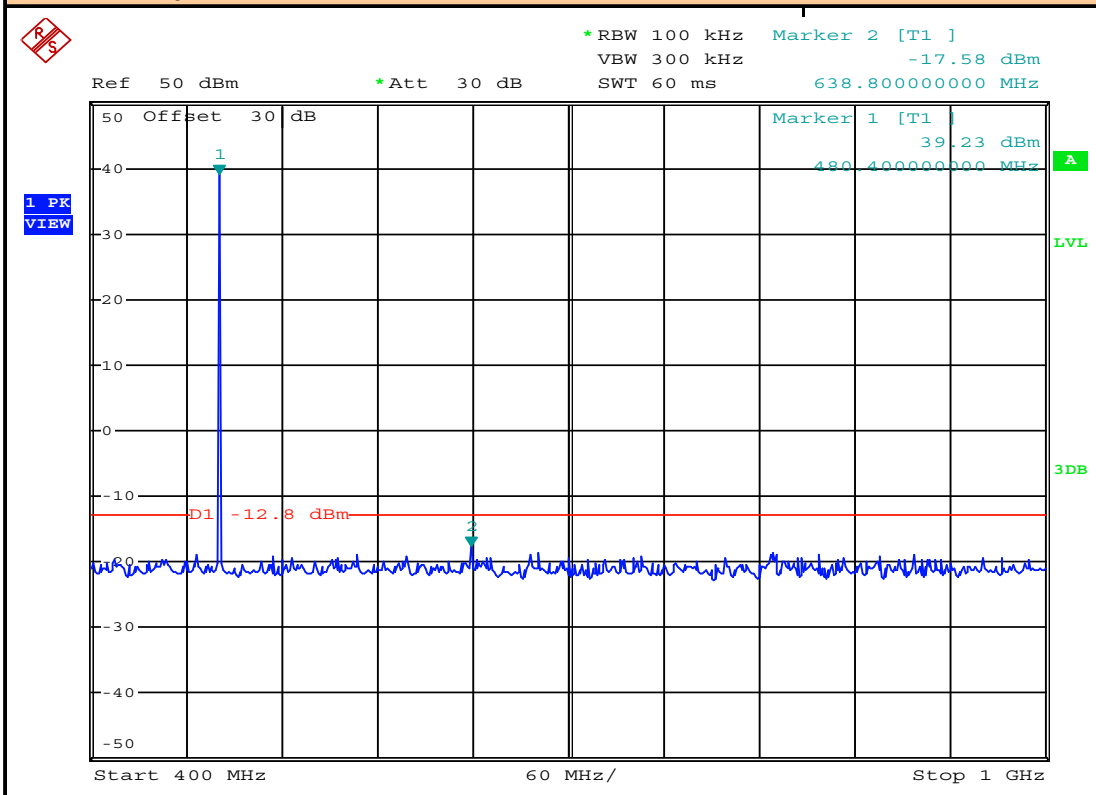
10.0 CONDUCTED SPURIOUS EMISSIONS

Test Procedure	
Normative References	FCC 47 CFR §2.1049, §90.205
	ANSI C63.26 (5.2.3.3)

Requirement / Limits	
47 CFR §90.210	**§90.210 Emission masks.**
	Except as indicated elsewhere in this part, transmitters used in the radio services governed by this part must comply with the emission masks outlined in this section. Unless otherwise stated, per paragraphs (d)(4), (e)(4), and (o) of this section, measurements of emission power can be expressed in either peak or average values provided that emission powers are expressed with the same parameters used to specify the unmodulated transmitter carrier power. For transmitters that do not produce a full power unmodulated carrier, reference to the unmodulated transmitter carrier power refers to the total power contained in the channel bandwidth. Unless indicated elsewhere in this part, the table in this section specifies the
	Frequency Band: 421 - 512 [2 5] Mask for Equipment without audio low pass filter: C, D or E
	[2]Equipment designed to operate with a 25 kHz channel bandwidth must meet the requirements of Emission Mask B or C, as applicable. Equipment designed to operate with a 12.5 kHz channel bandwidth must meet the requirements of Emission Mask D, and equipment designed to operate with a 6.25 kHz channel bandwidth must meet the requirements of mission Mask E.
	[5]Equipment designed to operate on 25 kilohertz bandwidth channels must meet the requirements of either Emission Mask B or G, whichever is applicable, while equipment designed to operate on 12.5 kilohertz bandwidth channels must meet the requirements of Emission Mask D. Equipment designed to operate on 25 kilohertz bandwidth channels may alternatively meet the Adjacent Channel Power limits of §90.221.

Plot 10.1 – Conducted Spurious Emissions, 400 to 1000MHz, 12.5kHz BW

Conducted Spurious Emissions: 400 - 1000MHz



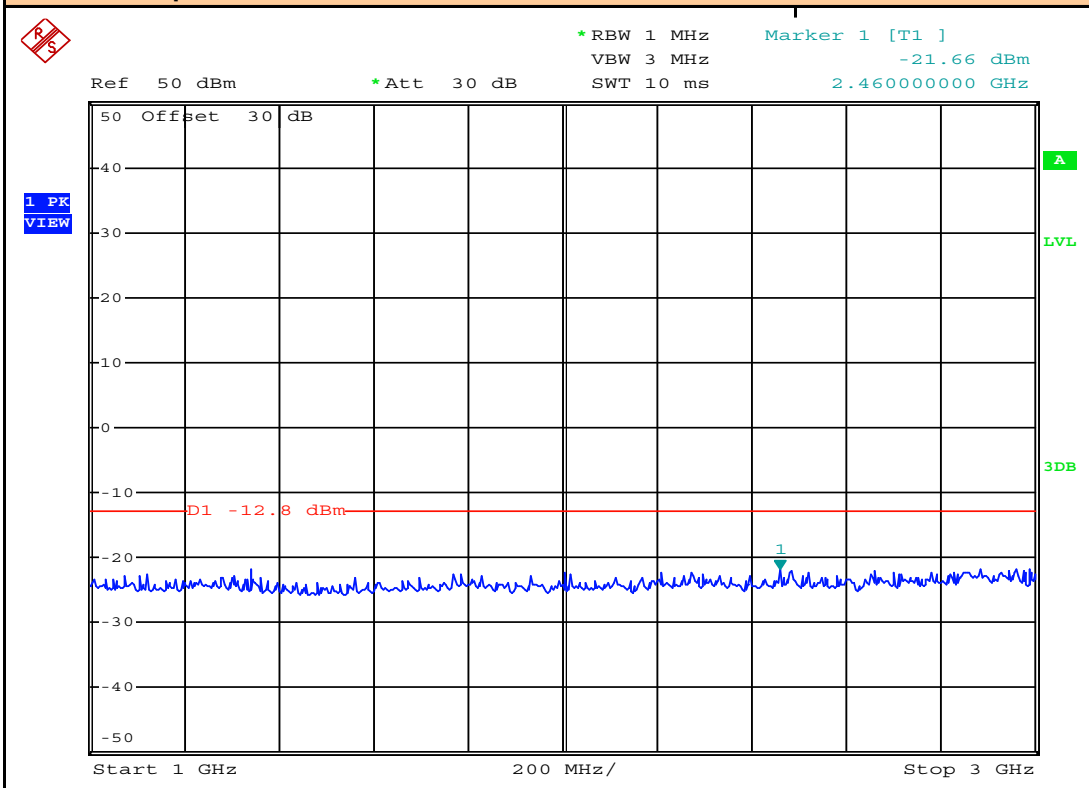
Date: 24.AUG.2021 10:14:50

Channel BW (kHz)	Channel Frequency (MHz)	Modulation	Fund. Power (dBm)	Emission Frequency (MHz)	Measured Emission (dBm)
12.5	481	QPSK	37.2	638.80	-17.58

Marker 1 = Fundamental

Plot 10.2 – Conducted Spurious Emissions, 1 to 3GHz, 12.5kHz BW

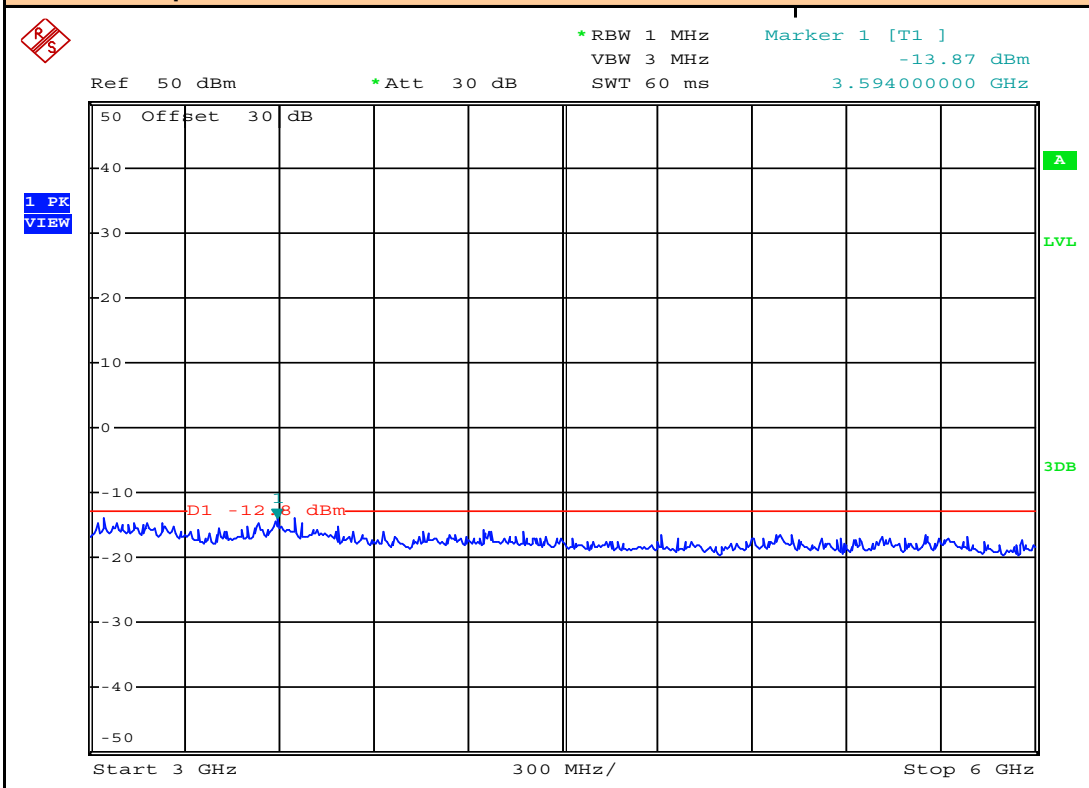
Conducted Spurious Emissions: 1 - 3GHz



Channel BW (kHz)	Channel Frequency (MHz)	Modulation	Fund. Power (dBm)	Emission Frequency (GHz)	Measured Emission (dBm)
12.5	481	QPSK	37.2	2.46	-21.66

Plot 10.3 – Conducted Spurious Emissions, 3 to 6GHz, 12.5kHz BW

Conducted Spurious Emissions: 3 - 10GHz

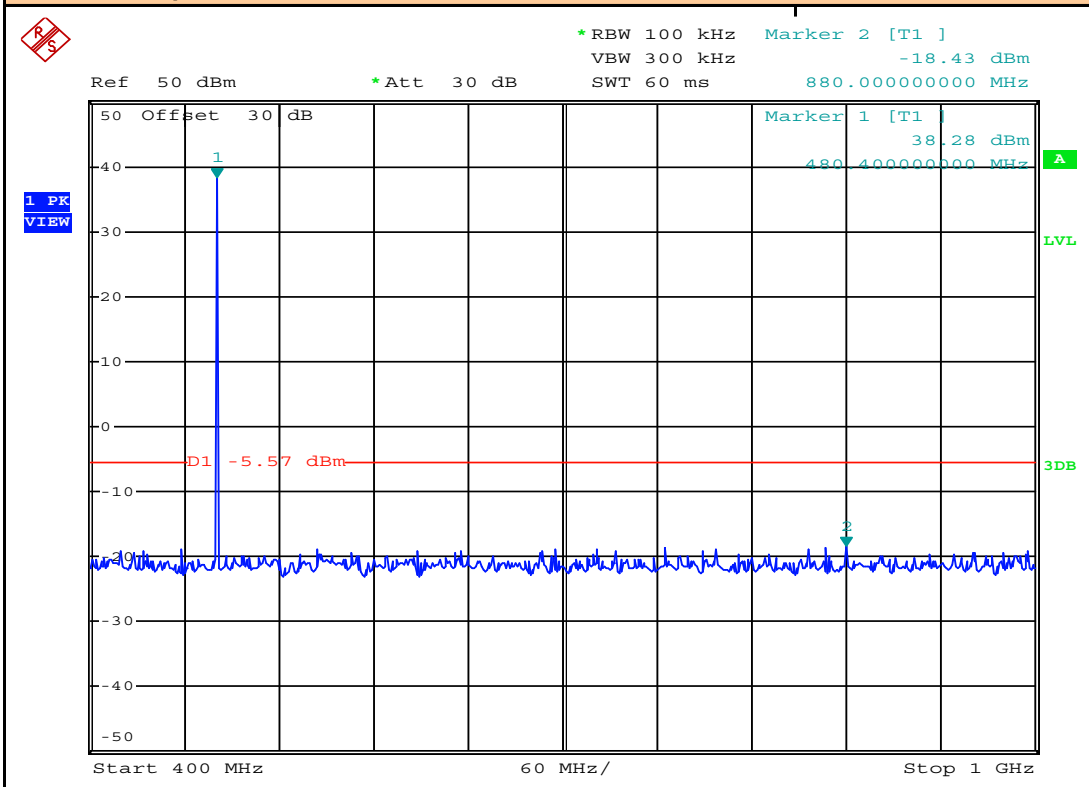


Date: 24.AUG.2021 10:11:57

Channel BW (kHz)	Channel Frequency (MHz)	Modulation	Fund. Power (dBm)	Emission Frequency (GHz)	Measured Emission (dBm)
12.5	481	QPSK	37.2	3.59	-13.87

Plot 10.4 – Conducted Spurious Emissions, 400 to 1000MHz, 25kHz BW

Conducted Spurious Emissions: 400 - 1000MHz



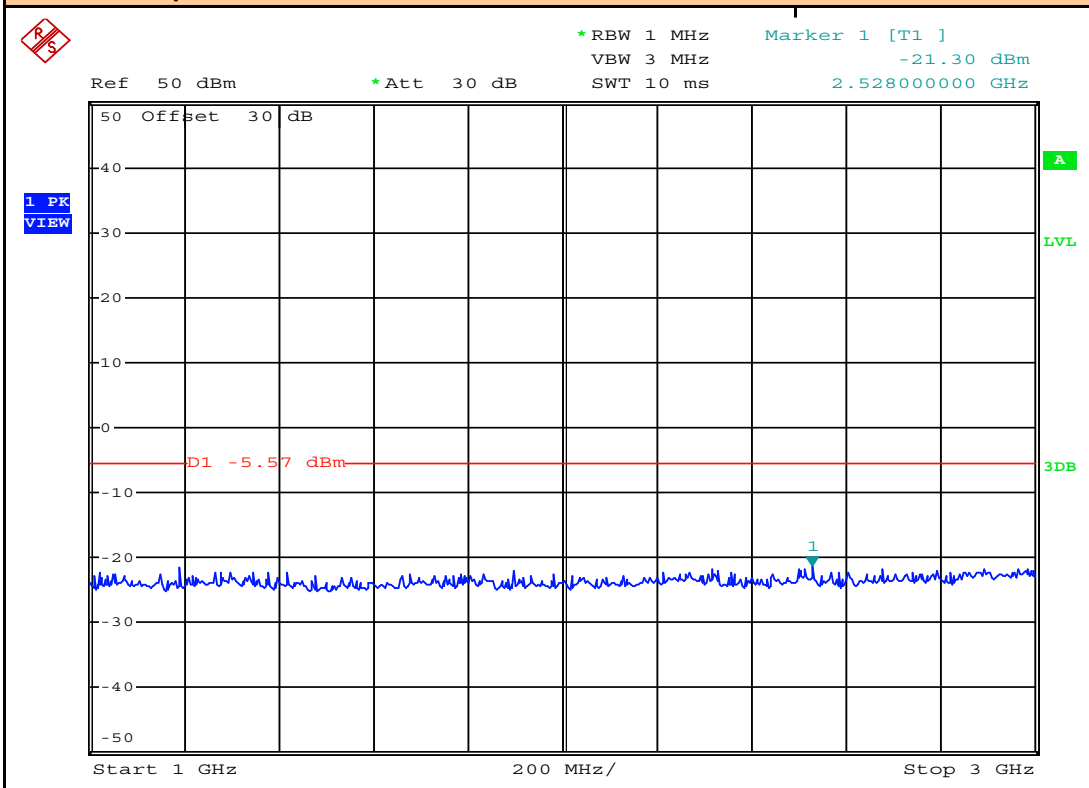
Date: 24.AUG.2021 10:17:20

Channel BW (kHz)	Channel Frequency (MHz)	Modulation	Fund. Power (dBm)	Emission Frequency (MHz)	Measured Emission (dBm)
25	481	QPSK	37.43	880.00	-18.43

Marker 1 = Fundamental

Plot 10.5 – Conducted Spurious Emissions, 1 to 3GHz, 25kHz BW

Conducted Spurious Emissions: 1 - 3GHz

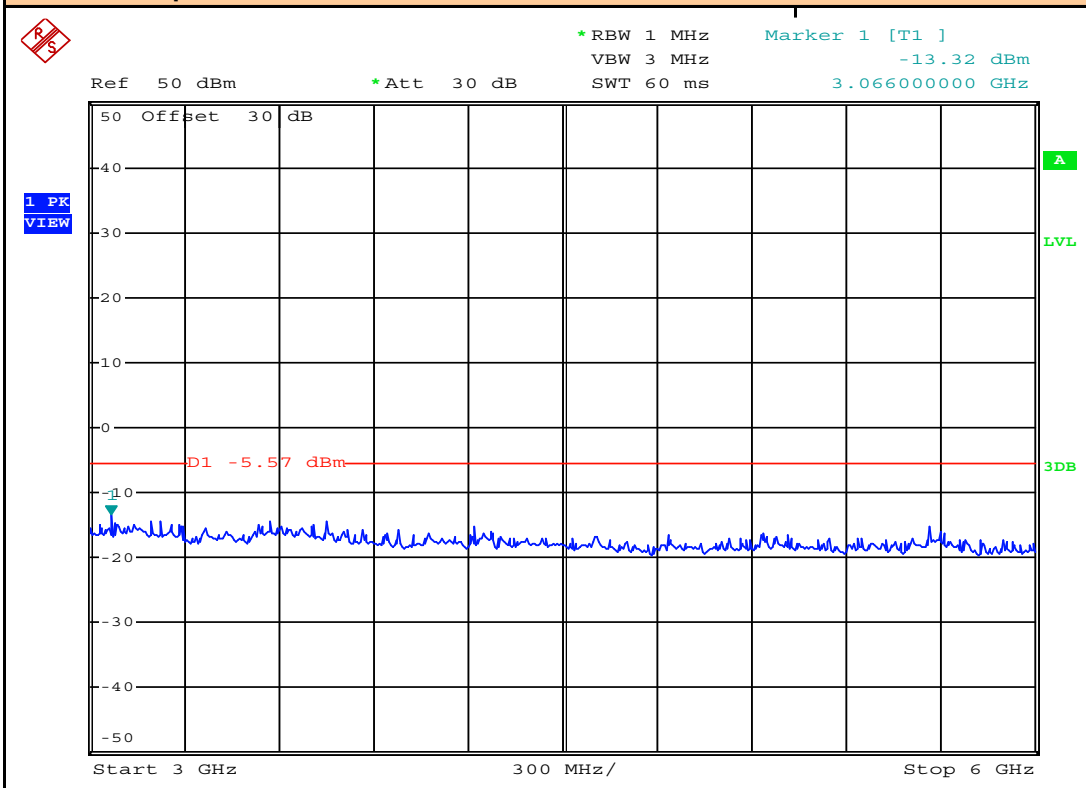


Date: 24.AUG.2021 10:17:59

Channel BW (kHz)	Channel Frequency (MHz)	Modulation	Fund. Power (dBm)	Emission Frequency (GHz)	Measured Emission (dBm)
25	481	QPSK	37.43	2.53	-21.30

Plot 10.6 – Conducted Spurious Emissions, 3 to 6GHz, 25kHz BW

Conducted Spurious Emissions: 3 - 10GHz



Channel BW (kHz)	Channel Frequency (MHz)	Modulation	Fund. Power (dBm)	Emission Frequency (GHz)	Measured Emission (dBm)
25	481	QPSK	37.43	3.07	-13.32

Table 10.1 – Summary of Conducted Spurious Emissions

Conducted Spurious Emissons Measurement Results:								
Frequency (MHz)	Modulation	Channel Bandwidth (kHz)	Fundamental Power [P_{Fund}] (dBm)	Emission Frequency (MHz)	Measured Emission [P_{Meas}] (dBm)	Attenuation [Att] (dBm)	Limit (dB)	Margin (dB)
481.0	QPSK	12.5	37.20	638.0	-17.58	54.78	50.0	4.8
			37.20	2460.0	-21.66	58.86		8.9
			37.20	3590.0	-13.87	51.07		1.1
		50.0	37.43	880.0	-18.43	55.86	43.0	12.9
			37.43	2530.0	-21.30	58.73		15.7
			37.43	3070.0	-13.32	50.75		7.8
							Result:	Complies

Attenuation [Att] = Fundamental Power [Pf_{und}] - Measured Emission [P_{meas}]
Margin = [Att] - Limit

11.0 FREQUENCY STABILITY

Test Conditions	
Normative Reference	**FCC 47 CFR §2.1055, §90.213**

Limits	
47 CFR §90.213	[7]In the 421-512 MHz band, fixed and base stations with a 12.5 kHz channel bandwidth must have a frequency stability of 1.5 ppm. Fixed and base stations with a 6.25 kHz channel bandwidth must have a frequency stability of 0.5 ppm.

Measurement Procedure

47 CFR §2.1055 Frequency Stability

(a) The frequency stability shall be measured with variation of ambient temperature as follows:

(1) From -30° to +50° centigrade for all equipment except that specified in paragraphs (a) (2) and (3) of this section.

(b) Frequency measurements shall be made at the extremes of the specified temperature range and at intervals of not more than 10° centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement.

(d) The frequency stability shall be measured with variation of primary supply voltage as follows:

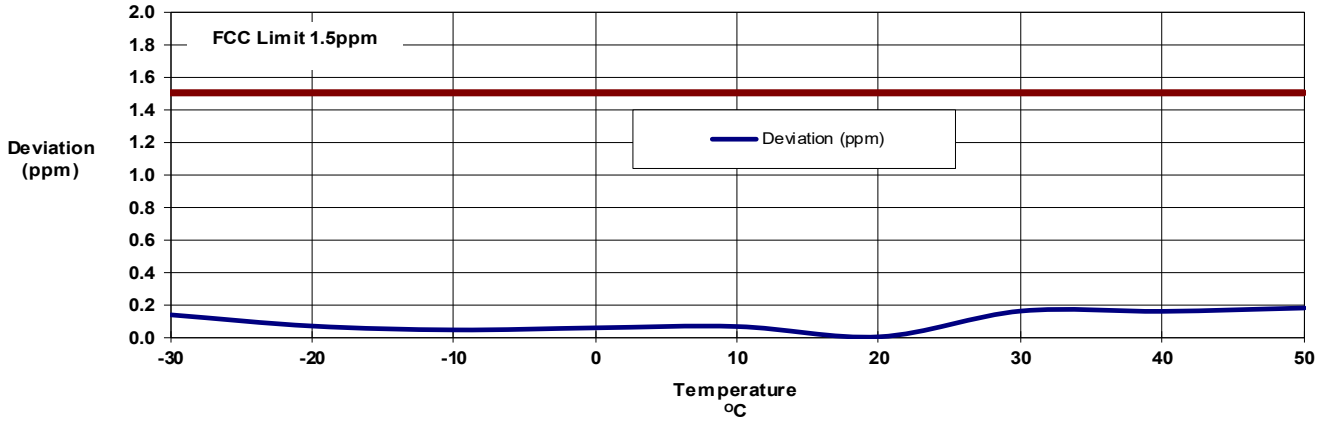
(1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.

Test Setup	Appendix A Figure A.4

Table 11.1 – Summary of Frequency Stability Results

Frequency Stability

Nominal Frequency (MHz):	481.0
Nominal Channel BW (KHz):	CW
Nominal Voltage (VDC):	20
Nominal Temperature (°C):	20



Frequency Stability Measurements (Temperature)

Temp (°C)	Assigned Frequency (MHz)	Measured Frequency (MHz)	Deviation (Hz)	Deviation [Absolute] (ppm)
-30	481.000690	481.000754	64	0.13
-20		481.000659	-31	0.06
-10		481.000710	20	0.04
0		481.000716	26	0.05
10		481.000720	30	0.06
20		481.000690	0	0.00
30		481.000615	-75	0.16
40		481.000616	-74	0.15
50		481.000606	-84	0.17
			Maximum Deviation:	0.17
			Maximum Limit:	1.50
			Result:	Complies

Frequency Stability Measurements (Voltage)

Voltage (VDC)	Assigned Frequency (MHz)	Measured Frequency (MHz)	Deviation (Hz)	Deviation [Absolute] (ppm)
34.5 (115%)	481.000690	481.000695	5	0.01
20 (100%)		481.000690	0	0.00
10 (50%)		481.000672	-18	0.04
		Maximum Deviation:		0.04
		Maximum Limit:		1.50
		Result:		Complies

NOTE: The DUT does not operate below 9.5VDC

APPENDIX A – TEST SETUP DRAWINGS

Table A.1 – Conducted Measurement Setup

Equipment List				
Asset Number	**Manufacturer**	**Model Number**	**Serial Number**	**Description**
00241	R&S	FSU40	100500	Spectrum Analyzer
00263	Koaxis	KP10-1.00M-TD	263	1m Armoured Cable

Figure A.1 – Test Setup – Conducted Measurements

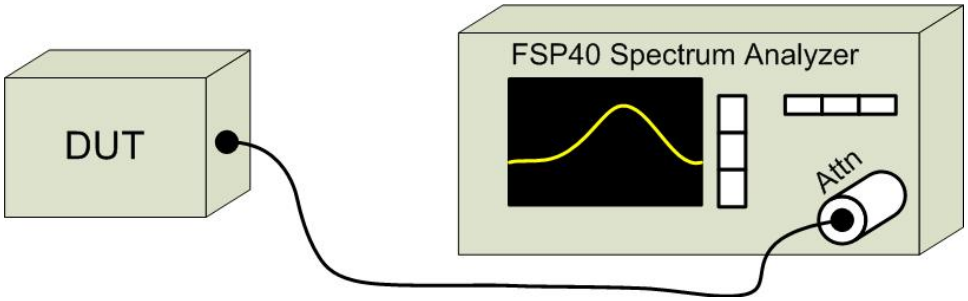
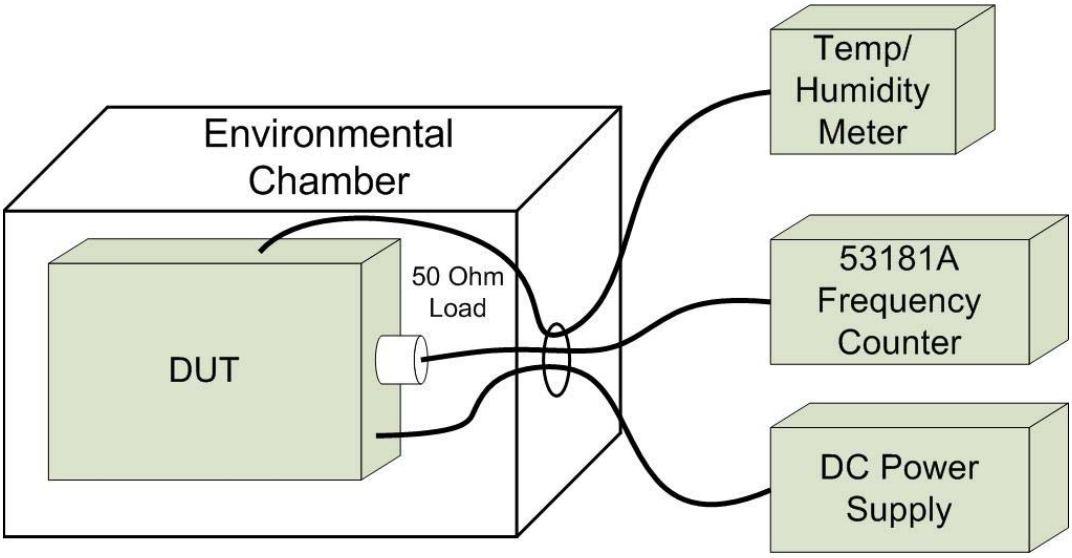


Table A.2 – Frequency Stability Setup

Equipment List				
Asset Number	**Manufacturer**	**Model Number**	**Serial Number**	**Description**
00241	R&S	FSU40	100500	Spectrum Analyzer
00081	ESPEC	ECT-2	0510154-B	Environmental Chamber
00234	VWR	61161-378	140320430	Temp/Humidity Meter

Figure A.2 – Test Setup – Frequency Stability



APPENDIX B – EQUIPMENT LIST AND CALIBRATION

Equipment List							
Asset Number	Manufacturer	Model Number	Serial Number	Description	Last Calibrated	Calibration Interval	Calibration Due
00241	R&S	FSU40	100500	Spectrum Analyzer	10 Aug 2021	Triennial	10 Aug 2024
00003	HP	53181A	3736A05175	Frequency Counter	23 Jun 2020	Triennial	23 Jun 2023
00081	ESPEC	ECT-2	0510154-B	Environmental Chamber	NCR	n/a	CNR
00234	VWR	61161-378	140320430	Temp/Humidity Meter	New	Triennial	New
00201	HP	E3611A	KR83015294	DC Power Supply	COU	n/a	COU
00275	TMS	LMR400	n/a	25m Cable	COU	n/a	COU
00276	TMS	LMR400	n/a	4m Cable	COU	n/a	COU
00277	TMS	LMR400	n/a	4m Cable	COU	n/a	COU
00278	TILE	34G3	n/a	TILE Test Software	NCR	n/a	NCR

NCR: No Calibration Required
COU: Calibrate On Use

APPENDIX C – MEASUREMENT INSTRUMENT UNCERTAINTY

CISPR 16-4 Measurement Uncertainty (U_{LAB})	
This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence interval using a coverage factor of k=2	
Radiated Emissions 30MHz - 200MHz	
U_{LAB} = 5.14dB U_{CISPR} = 6.3dB	
Radiated Emissions 200MHz - 1000MHz	
U_{LAB} = 5.90dB U_{CISPR} = 6.3dB	
Radiated Emissions 1GHz - 6GHz	
U_{LAB} = 4.80dB U_{CISPR} = 5.2dB	
Radiated Emissions 6GHz - 18GHz	
U_{LAB} = 5.1dB U_{CISPR} = 5.5dB	
Power Line Conducted Emissions 9kHz to 150kHz	
U_{LAB} = 2.96dB U_{CISPR} = 3.8dB	
Power Line Conducted Emissions 150kHz to 30MHz	
U_{LAB} = 3.12dB U_{CISPR} = 3.4dB	
If the calculated uncertainty U_{lab} is **less** than U_{CISPR} then:	
1	Compliance is deemed to occur if **NO** measured disturbance exceeds the disturbance limit
2	Non-Compliance is deemed to occur if **ANY** measured disturbance **EXCEEDS** the disturbance limit
If the calculated uncertainty U_{lab} is **greater** than U_{CISPR} then:	
3	Compliance is deemed to occur if **NO** measured disturbance, increased by (U_{lab} - U_{CISPR}), exceeds the disturbance limit
4	Non-Compliance is deemed to occur if **ANY** measured disturbance, increased by (U_{lab} - U_{CISPR}), **EXCEEDS** the disturbance limit

Other Measurement Uncertainties (U_{LAB})
RF Conducted Emissions 9kHz - 40GHz
U_{LAB} = 1.0dB U_{CISPR} = n/a
Frequency/Bandwidth 9kHz - 40GHz
U_{LAB} = 0.1ppm U_{CISPR} = n/a
Temperature
U_{LAB} = 1^{O}C U_{CISPR} = n/a

END OF REPORT

