



FCC PART 22G


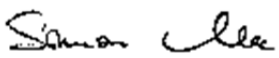
TEST REPORT

For

Ondas Networks Inc.

165 Gibraltar Court, Sunnyvale, CA 94089, USA

FCC ID: X27-VNF22G-1

| | |
|--|--|
| Report Type: Original Report | Product Type: Remote Station |
| Prepared By: Christian McCaig Test Engineer |  |
| Report Number: R2003094 | |
| Report Date: 2020-07-27 | |
| Reviewed By: Simon Ma RF Supervisor |  |
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Note: This test report is prepared for the customer shown above and for the device described herein. It may not be duplicated or used in part without prior written consent from Bay Area Compliance Laboratories Corp. This report **must not** be used by the customer to claim product certification, approval, or endorsement by A2LA* or any agency of the Federal Government.

* This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk "*" (Rev.3)

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DOCUMENT REVISION HISTORY

| Revision Number | Report Number | Description of Revision | Date of Revision |
|------------------------|----------------------|--------------------------------|-------------------------|
| 0 | R2003094 | Original | 2020-07-27 |

1 General Information

1.1 Product Description for Equipment under Test (EUT)

This test report was prepared on behalf of *Ondas Networks Inc.* and their product model: VE-200F-2, FCC ID: X27-VNF22G-1, which will henceforth be referred to as the EUT (Equipment under Test). The EUT is a remote station and operates in the frequency range of 459.675-459.975 MHz.

1.2 Mechanical Description

The EUT measured approximately 21.6 cm (L) x 12.1 cm (W) x 8.6 cm (H)

The test data gathered are from typical production sample, assigned serial number: 0050020120288

1.3 Objective

This report was prepared on behalf of *Ondas Networks*. in accordance with Part 22 Subpart G and Part 2 Subpart J of the Federal Communication Commission's rules.

The objective was to determine compliance with FCC rules for RF output power, occupied bandwidth, frequency tolerance, emission limitations at band edges, spurious emissions at antenna terminal and field strength of spurious radiation.

1.4 Related Submittal(s)/Grant(s)

None

1.5 Test Methodology

All tests and measurements indicated in this document were performed in accordance with the Code of Federal Regulations Title 47 Part 22 Subpart G and Part 2, Subpart J.

All radiated and conducted emissions measurement was performed at Bay Area Compliance Laboratory, Corp. The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

1.6 Measurement Uncertainty

All measurements involve certain levels of uncertainties, especially in the field of EMC. The factors contributing to uncertainties are spectrum analyzer, cable loss, antenna factor calibration, antenna directivity, antenna factor variation with height, antenna phase center variation, antenna factor frequency interpolation, measurement distance variation, site imperfections, mismatch (average), and system repeatability.

| Parameter | Measurement uncertainty |
|-------------------------------|-------------------------|
| Occupied Channel Bandwidth | ±5 % |
| RF output power, conducted | ±0.57 dB |
| Unwanted Emissions, conducted | ±1.57dB |
| All emissions, radiated | ±4.0 dB |
| Temperature | ±2 ° C |
| Humidity | ±5 % |
| DC and low frequency voltages | ±1.0 % |
| Time | ±2 % |
| Duty Cycle | ±3 % |

1.7 Test Facility Registrations

BACL's test facilities that are used to perform Radiated and Conducted Emissions tests are currently recognized by the Federal Communications Commission as Accredited with NIST Designation Number US1129.

BACL's test facilities that are used to perform Radiated and Conducted Emissions tests are currently registered with Industry Canada under Registration Numbers: 3062A-1, 3062A-2, and 3062A-3.

BACL is a Chinese Taipei Bureau of Standards Metrology and Inspection (BSMI) validated Conformity Assessment Body (CAB), under Appendix B, Phase I Procedures of the APEC Mutual Recognition Arrangement (MRA). BACL's BSMI Lab Code Number is: SL2-IN-E-1002R

BACL's test facilities that are used to perform AC Line Conducted Emissions, Telecommunications Line Conducted Emissions, Radiated Emissions from 30 MHz to 1 GHz, and Radiated Emissions from 1 GHz to 6 GHz are currently recognized as Accredited in accordance with the Voluntary Control Council for Interference [VCCI] Article 15 procedures under Registration Number A-0027.

1.8 Test Facility Accreditations

Bay Area Compliance Laboratories Corp. (BACL) is:

A- An independent, 3rd-Party, Commercial Test Laboratory accredited to ISO/IEC 17025:2005 by A2LA (Test Laboratory Accreditation Certificate Number 3297.02), in the fields of: Electromagnetic Compatibility and Telecommunications. Unless noted by an Asterisk (*) in the Compliance Matrix (See Section 3 of this Test Report), BACL's ISO/IEC 17025:2005 Scope of Accreditation includes all of the Test Method Standards and/or the Product Family Standards detailed in this Test Report..

BACL's ISO/IEC 17025:2005 Scope of Accreditation includes a comprehensive suite of EMC Emissions, EMC Immunity, Radio, RF Exposure, Safety and wireline Telecommunications test methods applicable to a wide range of product categories. These product categories include Central Office Telecommunications Equipment [including NEBS - Network Equipment Building Systems], Unlicensed and Licensed Wireless and RF devices, Information Technology Equipment (ITE); Telecommunications Terminal Equipment (TTE); Medical Electrical Equipment; Industrial, Scientific and Medical Test Equipment; Professional Audio and Video Equipment; Industrial and Scientific Instruments and Laboratory Apparatus; Cable Distribution Systems, and Energy Efficient Lighting.

B- A Product Certification Body accredited to ISO/IEC 17065:2012 by A2LA (Product Certification Body Accreditation Certificate Number 3297.03) to certify

- For the USA (Federal Communications Commission):

- 1- All Unlicensed radio frequency devices within FCC Scopes A1, A2, A3, and A4;
- 2- All Licensed radio frequency devices within FCC Scopes B1, B2, B3, and B4;
- 3- All Telephone Terminal Equipment within FCC Scope C.

- For the Canada (Industry Canada):

- 1 All Scope 1-Licence-Exempt Radio Frequency Devices;
- 2 All Scope 2-Licensed Personal Mobile Radio Services;
- 3 All Scope 3-Licensed General Mobile & Fixed Radio Services;
- 4 All Scope 4-Licensed Maritime & Aviation Radio Services;
- 5 All Scope 5-Licensed Fixed Microwave Radio Services
- 6 All Broadcasting Technical Standards (BETS) in the Category I Equipment Standards List.

- For Singapore (Info-Communications Development Authority (IDA)):

- 1 All Line Terminal Equipment: All Technical Specifications for Line Terminal Equipment – Table 1 of IDA MRA Recognition Scheme: 2011, Annex 2
2. All Radio-Communication Equipment: All Technical Specifications for Radio-Communication Equipment – Table 2 of IDA MRA Recognition Scheme: 2011, Annex 2

- For the Hong Kong Special Administrative Region:

- 1 All Radio Equipment, per KHCA 10XX-series Specifications;
- 2 All GMDSS Marine Radio Equipment, per HKCA 12XX-series Specifications;
- 3 All Fixed Network Equipment, per HKCA 20XX-series Specifications.

- For Japan:

- 1 MIC Telecommunication Business Law (Terminal Equipment):
 - All Scope A1 - Terminal Equipment for the Purpose of Calls;
 - All Scope A2 - Other Terminal Equipment
- 2 Radio Law (Radio Equipment):
 - All Scope B1 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 1 of the Radio Law
 - All Scope B2 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 2 of the Radio Law
 - All Scope B3 - Specified Radio Equipment specified in Article 38-2-2, paragraph 1, item 3 of the Radio Law

C- A Product Certification Body accredited to ISO/IEC 17065:2012 by A2LA (Product Certification Body Accreditation Certificate Number 3297.01) to certify Products to USA's Environmental Protection Agency (EPA) ENERGY STAR Product Specifications for:

- 1 Electronics and Office Equipment:
 - for Telephony (ver. 3.0)
 - for Audio/Video (ver. 3.0)
 - for Battery Charging Systems (ver. 1.1)
 - for Set-top Boxes & Cable Boxes (ver. 4.1)
 - for Televisions (ver. 6.1)
 - for Computers (ver. 6.0)
 - for Displays (ver. 6.0)
 - for Imaging Equipment (ver. 2.0)
 - for Computer Servers (ver. 2.0)
- 2 Commercial Food Service Equipment
 - for Commercial Dishwashers (ver. 2.0)
 - for Commercial Ice Machines (ver. 2.0)
 - for Commercial Ovens (ver. 2.1)
 - for Commercial Refrigerators and Freezers
- 3 Lighting Products
 - For Decorative Light Strings (ver. 1.5)
 - For Luminaires (including sub-components) and Lamps (ver. 1.2)
 - For Compact Fluorescent Lamps (CFLs) (ver. 4.3)
 - For Integral LED Lamps (ver. 1.4)
- 4 Heating, Ventilation, and AC Products
 - for Residential Ceiling Fans (ver. 3.0)
 - for Residential Ventilating Fans (ver. 3.2)
- 5 Other
 - For Water Coolers (ver. 3.0)

D- A NIST Designated Phase-I and Phase-II Conformity Assessment Body (CAB) for the following economies and regulatory authorities under the terms of the stated MRAs/Treaties:

- Australia: ACMA (Australian Communication and Media Authority) – APEC Tel MRA -Phase I;
- Canada: (Innovation, Science and Economic development Canada - ISEDC) Foreign Certification Body – FCB – APEC Tel MRA -Phase I & Phase II;
- Chinese Taipei (Republic of China – Taiwan):
 - o BSMI (Bureau of Standards, Metrology and Inspection) APEC Tel MRA -Phase I;
 - o NCC (National Communications Commission) APEC Tel MRA -Phase I;
- European Union:
 - o EMC Directive 2014/30/EU US-EU EMC & Telecom MRA CAB (NB)
 - o Radio Equipment (RE) Directive 2014/53/EU US-EU EMC & Telecom MRA CAB (NB)
 - o Low Voltage Directive (LVD) 2014/35/EU
- Hong Kong Special Administrative Region: (Office of the Telecommunications Authority – OFTA) APEC Tel MRA -Phase I & Phase II
- Israel – US-Israel MRA Phase I
- Republic of Korea (Ministry of Communications - Radio Research Laboratory) APEC Tel MRA -Phase I
- Singapore: (Infocomm Media Development Authority - IMDA) APEC Tel MRA -Phase I & Phase II;
- Japan: VCCI - Voluntary Control Council for Interference US-Japan Telecom Treaty VCCI Side Letter-USA:
- USA:
 - o ENERGY STAR Recognized Test Laboratory – US EPA
 - o Telecommunications Certification Body (TCB) – US FCC;
 - o Nationally Recognized Test Laboratory (NRTL) – US OSHA
- Vietnam: APEC Tel MRA -Phase I;

2 System Test Configuration

2.1 Justification

The EUT was configured for testing according to ANSI C63.26-2015.

2.2 EUT Exercise Software

The test firmware used was Putty, provided by *Ondas Networks*, the software is compliant with the standard requirements being tested against.

2.3 Equipment Modifications

No modifications were made to the EUT.

2.4 Remote Support Equipment List and Details

| Manufacturer | Descriptions | Models | Serial Numbers |
|--------------|--------------|----------|----------------|
| Lenovo | Laptop | Thinkpad | - |

2.5 Power Supply and Line Filters

| Manufacturer | Descriptions | Models | Serial Numbers |
|--------------|--------------|-----------|----------------|
| Meanwell | Power Supply | RS-150-24 | - |

2.6 Interface Ports and Cabling

| Cable Description | Length (m) | From | To |
|---------------------|------------|-------------------|-------------------|
| RF cable | < 1 | EUT Output | Attenuator Input |
| RF cable | < 1 | Attenuator Output | Spectrum Analyzer |
| USB A to RJ45 Cable | 1 | Support Equipment | EUT Input |

3 Summary of Test Results

| FCC Rules | Description of Tests | Results |
|------------------|---|-----------|
| §1.1307, §2.1091 | RF Exposure | Compliant |
| §2.1046, §22.809 | RF Output Power | Compliant |
| §2.1049, §22.805 | Occupied Bandwidth | Compliant |
| §2.1053, §22.861 | Spurious Radiated Emissions | Compliant |
| §2.1051, §22.861 | Spurious Emissions at Antenna Terminals | Compliant |
| §2.1055, §22.863 | Frequency Stability | Compliant |

4 FCC §1.1307(b) (1) & §2.1091 - RF Exposure

4.1 Applicable Standards

FCC §2.1091, (a) Requirements of this section are a consequence of Commission responsibilities under the National Environmental Policy Act to evaluate the environmental significance of its actions. See subpart I of part 1 of this chapter, in particular §1.1307(b).

According to §1.1310 and §2.1091 RF exposure is calculated.

Limits for General Population/Uncontrolled Exposure

| Frequency Range (MHz) | Electric Field Strength (V/m) | Magnetic Field Strength (A/m) | Power Density (mW/cm ²) | Averaging Time (minute) |
|--|-------------------------------|-------------------------------|-------------------------------------|-------------------------|
| Limits for General Population/Uncontrolled Exposure | | | | |
| 0.3-1.34 | 614 | 1.63 | *(100) | 30 |
| 1.34-30 | 824/f | 2.19/f | *(180/f ²) | 30 |
| 30-300 | 27.5 | 0.073 | 0.2 | 30 |
| 300-1500 | / | / | f/1500 | 30 |
| 1500-100,000 | / | / | 1.0 | 30 |

Note: f = frequency in MHz

* = Plane-wave equivalent power density

4.2 MPE Prediction

Predication of MPE limit at a given distance, Equation from OET Bulletin 65, Edition 97-01

$$S = PG/4\pi R^2$$

Where: S = power density

P = power input to antenna

G = power gain of the antenna in the direction of interest relative to an isotropic radiator

R = distance to the center of radiation of the antenna

4.3 Test Results

| | |
|--|----------------|
| <u>Maximum average output power at antenna input terminal (dBm):</u> | <u>33.357</u> |
| <u>Maximum average output power at antenna input terminal (mW):</u> | <u>2167.70</u> |
| <u>Prediction frequency (MHz):</u> | <u>459.675</u> |
| <u>Antenna Gain, typical (dBi):</u> | <u>-1.49</u> |
| <u>Maximum Antenna Gain (numeric):</u> | <u>0.71</u> |
| <u>Prediction distance (cm):</u> | <u>20</u> |
| <u>Power density of prediction frequency at 20 cm (mW/cm²):</u> | <u>0.3062</u> |
| <u>MPE limit for uncontrolled exposure at predication frequency (mW/cm²):</u> | <u>0.3065</u> |

The average output power was derived from the maximum peak power (36.645 dBm) and duty cycle (46.9%).
The average output power = peak output power – 10*log(1/duty cycle)=36.645-3.288=33.357 dBm.

Results

In order to pass the uncontrolled exposure limit of 0.307 mW/cm² with the Output Power being 36.645 dBm, 46.9% duty cycle, and prediction distance of 20cm, the EUT can have a maximum antenna gain of -1.49dBi.

5 FCC §2.1046 & §22.809 - RF Output Power

5.1 Applicable Standards

According to FCC §22.809 (b), the transmitter power output of airborne mobile transmitters must not exceed 25 Watts and must not be less than 4 Watts.

5.2 Test Procedure

Span > 5 times the 26 dB bandwidth, centered on transmitting channel

RBW > the 26 dB bandwidth of the emission being measured

VBW ≥ RBW

Sweep = auto

Detector function = peak

Trace = max hold

5.3 Test Equipment List and Details

| Manufacturers | Descriptions | Models | Serial Numbers | Calibration Dates | Calibration Interval |
|---------------|---------------------|--------|----------------|------------------------|----------------------|
| Agilent | EXA Signal Analyzer | N9010A | MY48030852 | 2020-02-12 | 1 year |
| - | RF Cable | - | - | Each time ¹ | N/A |
| - | 30dB Attenuator | - | - | Each time ¹ | N/A |

Note¹: Equipment was calibrated for each test.

Statement of Traceability: BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 9 June 2016) “A2LA Policy on Metrological Traceability”.

5.4 Test Environmental Conditions

| | |
|---------------------------|---------------|
| Temperature: | 23° C |
| Relative Humidity: | 32 % |
| ATM Pressure: | 101.4-102 kPa |

The testing was performed by Christian McCaig on 2020-07-10 in the RF Site.

5.5 Test Results

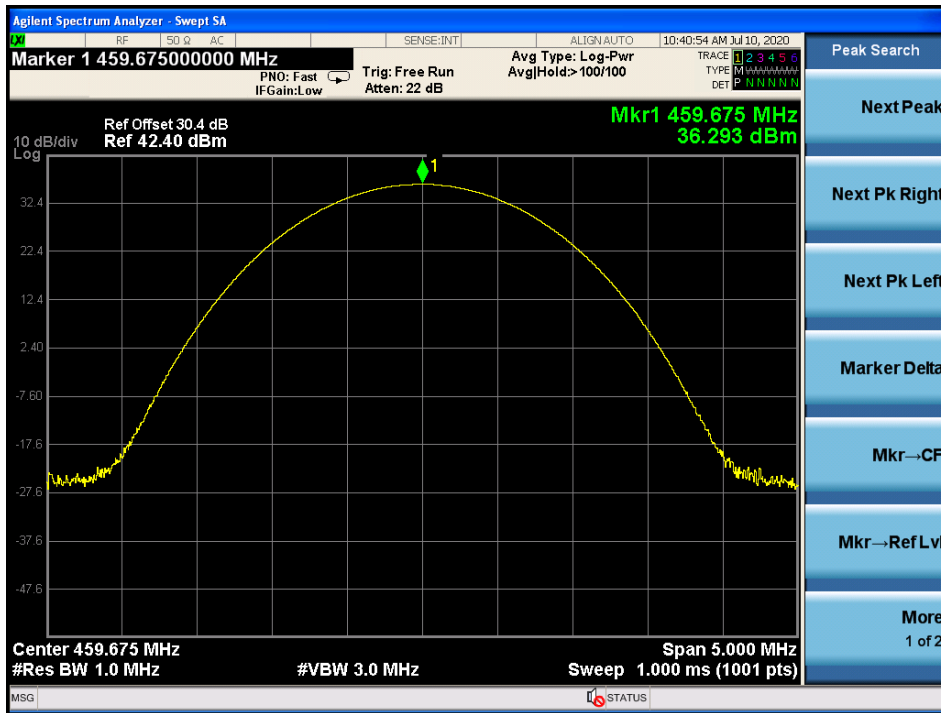
| Modulation | Frequency (MHz) | Output Power (dBm) | Lower Limit (dBm) | Upper Limit (dBm) |
|------------|-----------------|--------------------|-------------------|-------------------|
| QPSK | 459.675 | 36.293 | 36 | 44 |
| | 459.825 | 36.267 | 36 | 44 |
| | 459.975 | 36.285 | 36 | 44 |
| 16QAM | 459.675 | 36.288 | 36 | 44 |
| | 459.825 | 36.329 | 36 | 44 |
| | 459.975 | 36.332 | 36 | 44 |
| 64QAM | 459.675 | 36.645 | 36 | 44 |
| | 459.825 | 36.608 | 36 | 44 |
| | 459.975 | 36.565 | 36 | 44 |

Note: Lower Limit: 4 W, 36 dBm
Upper Limit: 25 W, 44 dBm

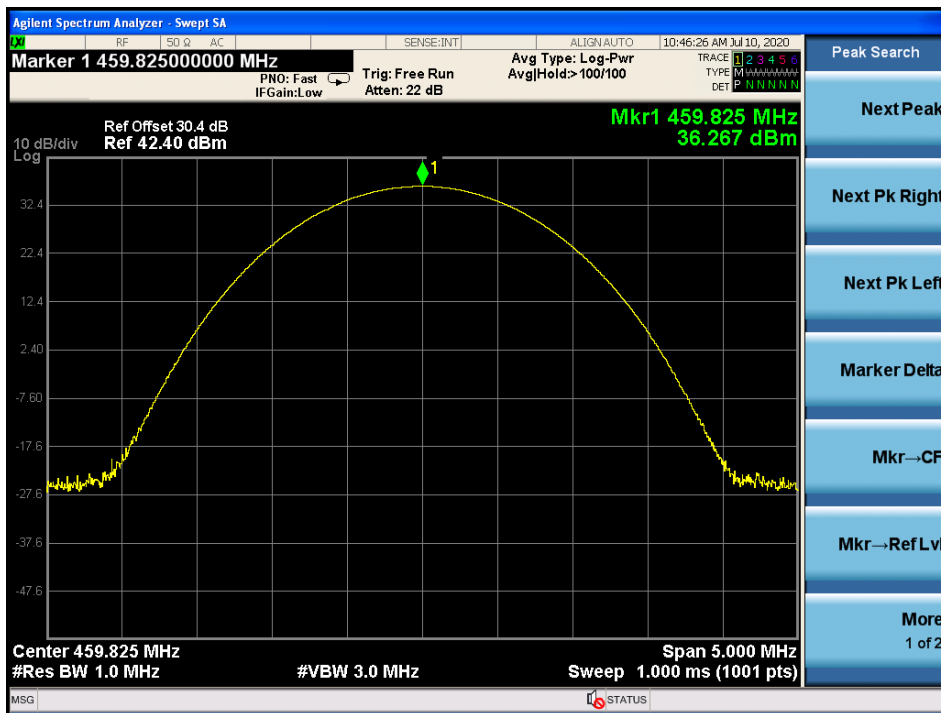
Please refer to the following plots.

QPSK

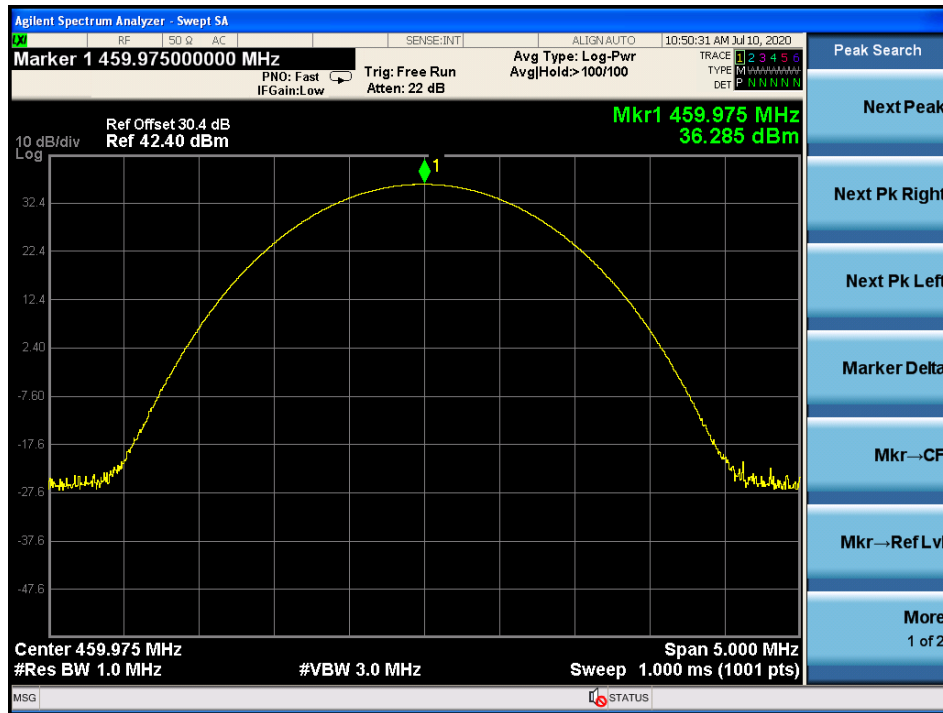
459.675 MHz



459.825 MHz

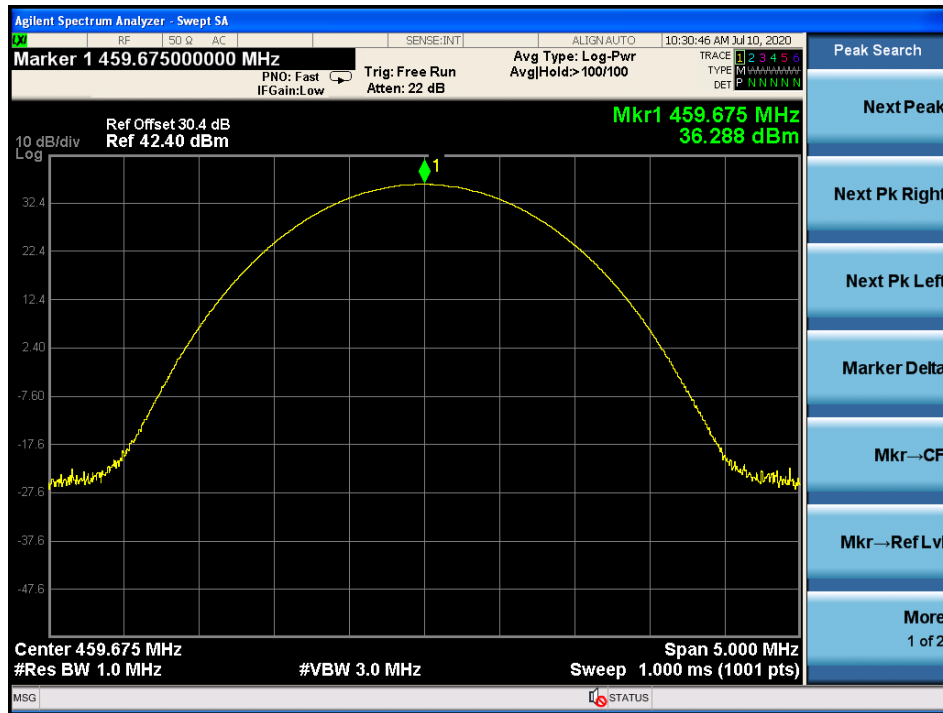


459.975 MHz

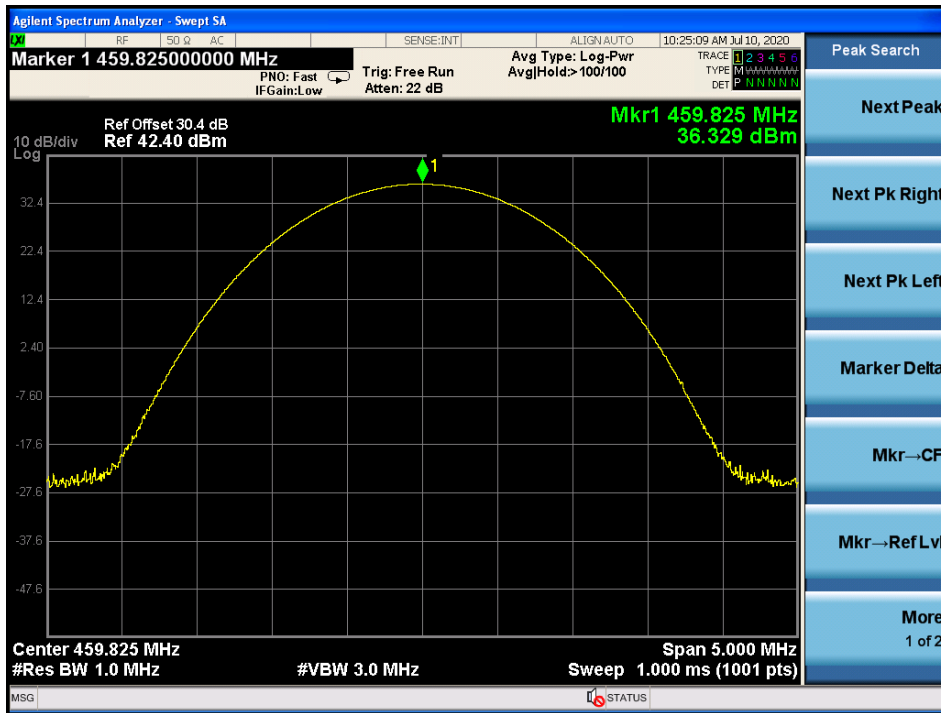


16QAM

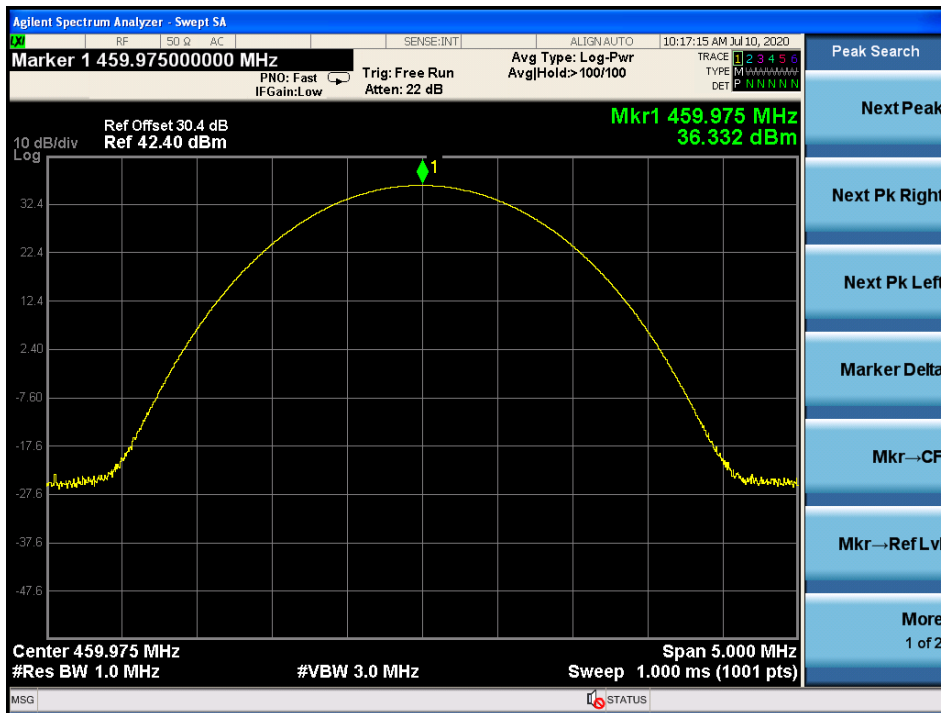
459.675 MHz



459.825 MHz

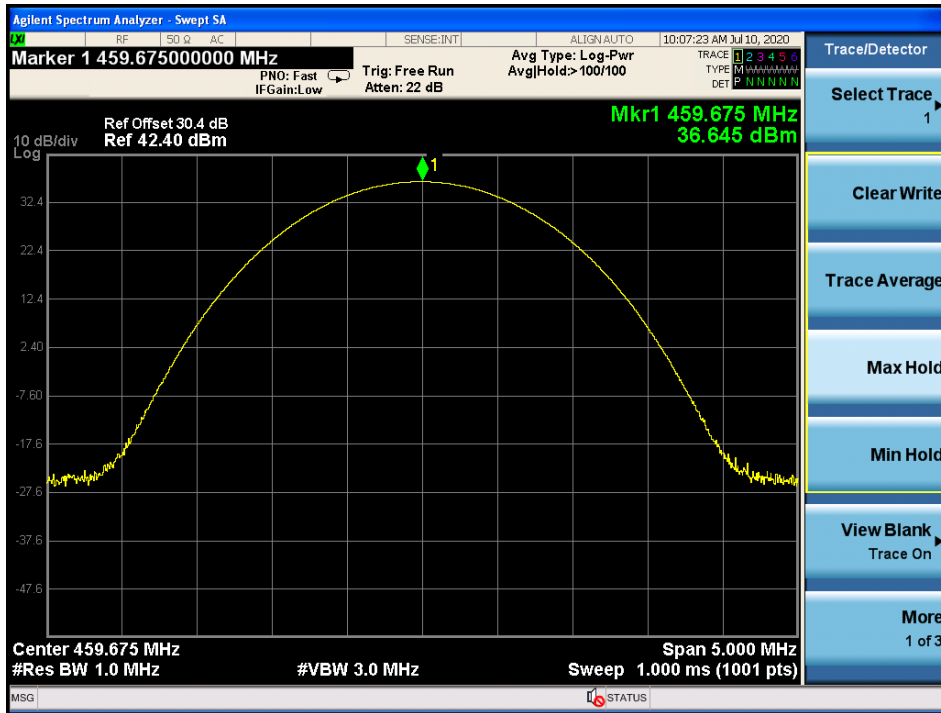


459.975 MHz

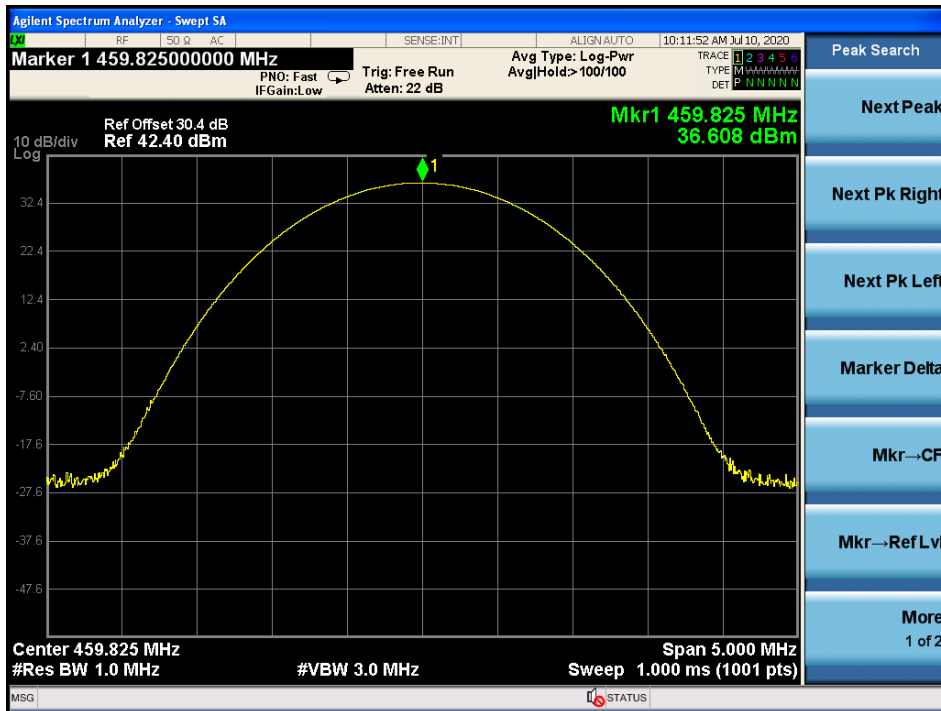


64QAM

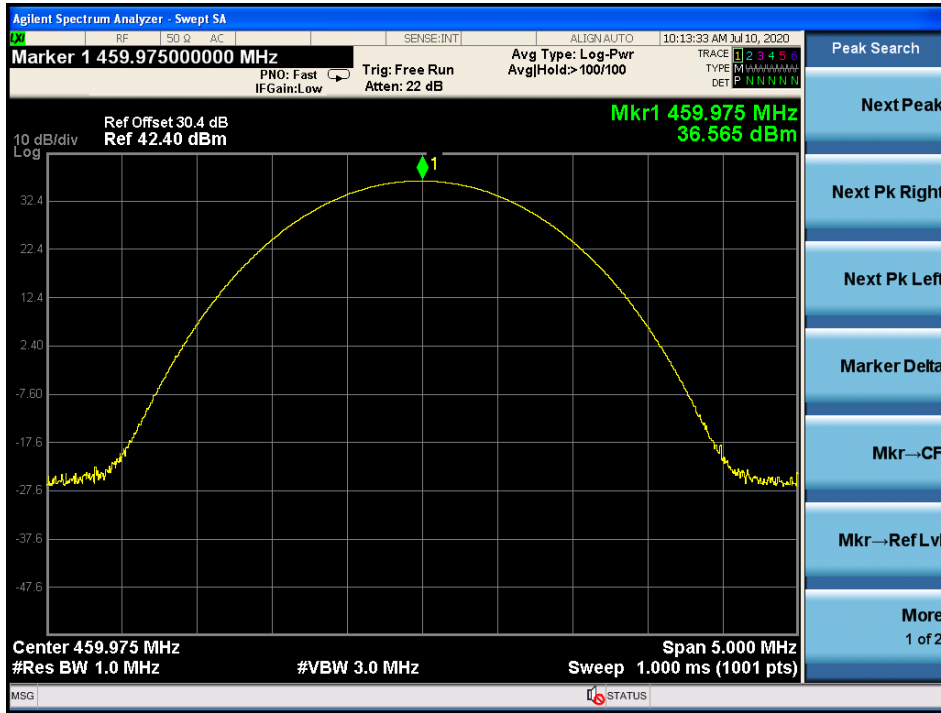
459.675 MHz



459.825 MHz



459.975 MHz



6 FCC §2.1049 & §22.805 - Occupied Bandwidth

6.1 Applicable Standards

According to FCC §22.805, These channels have a bandwidth of 20 kHz and are designated by their center frequencies in MegaHertz.

6.2 Test Procedure

Span = approximately 2 to 5 times the occupied bandwidth, centered on the transmitting channel

RBW = 1% to 5 % of the occupied bandwidth

VBW = 3RBW

Sweep = auto

Detector function = peak

Trace = max hold

6.3 Test Equipment List and Details

| Manufacturers | Descriptions | Models | Serial Numbers | Calibration Dates | Calibration Interval |
|---------------|---------------------|--------|----------------|------------------------|----------------------|
| Agilent | EXA Signal Analyzer | N9010A | MY48030852 | 2020-02-12 | 1 year |
| - | RF Cable | - | - | Each time ¹ | N/A |
| - | 30dB Attenuator | - | - | Each time ¹ | N/A |

Note¹: Equipment was calibrated for each test.

Statement of Traceability: BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 9 June 2016) "A2LA Policy on Metrological Traceability".

6.4 Test Environmental Conditions

| | |
|---------------------------|---------------|
| Temperature: | 23° C |
| Relative Humidity: | 32 % |
| ATM Pressure: | 101.4-102 kPa |

The testing was performed by Christian McCaig on 2020-06-22 in the RF Site.

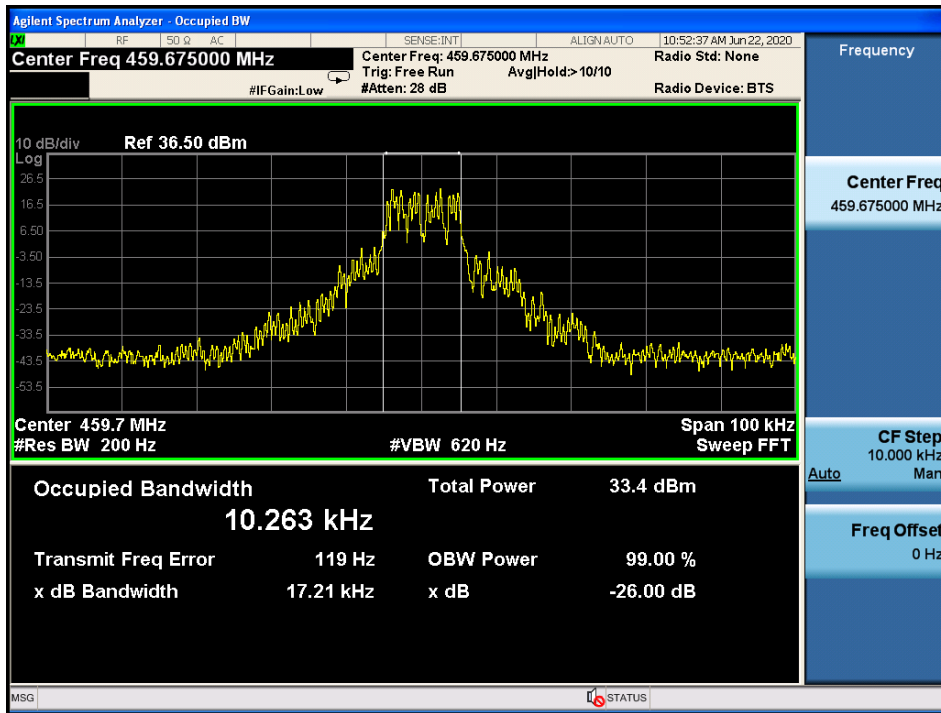
6.5 Test Results

| Modulation | Frequency (MHz) | 99% OBW (kHz) | 26 dB OBW (kHz) | OBW Limit (kHz) |
|------------|-----------------|---------------|-----------------|-----------------|
| QPSK | 459.675 | 10.263 | 17.21 | < 20 |
| | 459.825 | 10.243 | 17.2 | < 20 |
| | 459.975 | 10.244 | 17.21 | < 20 |
| 16QAM | 459.675 | 9.659 | 17.76 | < 20 |
| | 459.825 | 9.663 | 17.76 | < 20 |
| | 459.975 | 9.66 | 17.78 | < 20 |
| 64QAM | 459.675 | 10.262 | 17.2 | < 20 |
| | 459.825 | 10.229 | 17.2 | < 20 |
| | 459.975 | 10.243 | 17.19 | < 20 |

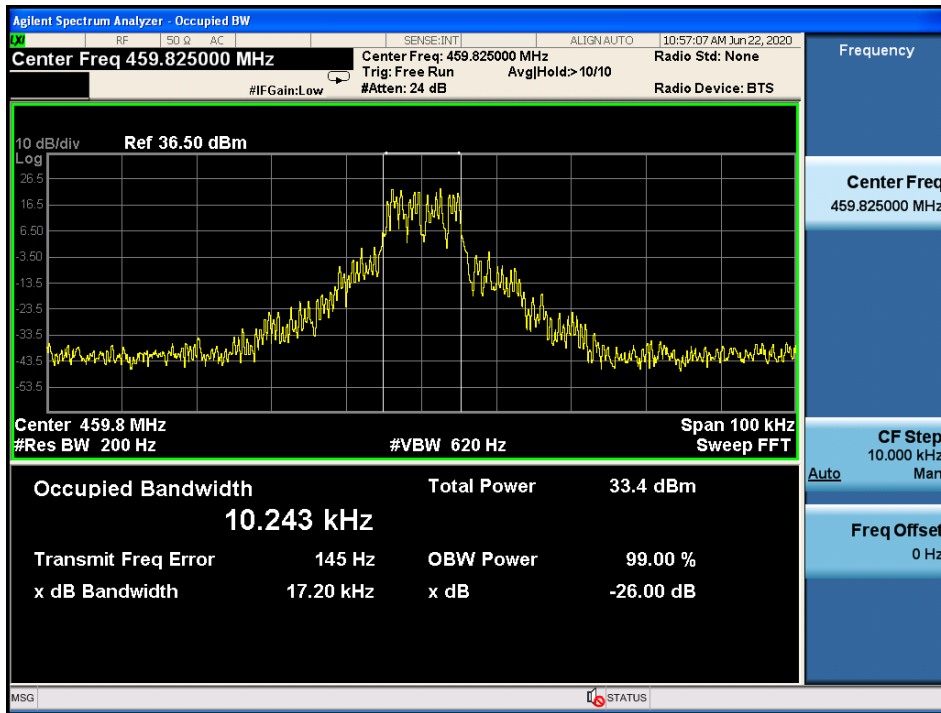
Please refer to the following plots.

QPSK

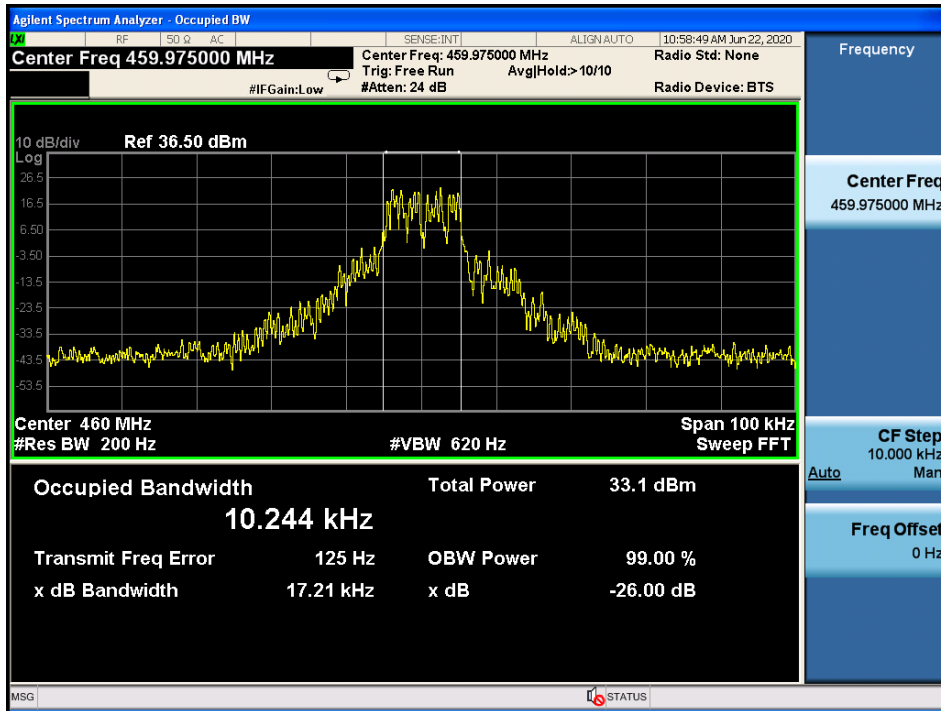
459.675 MHz



459.825 MHz

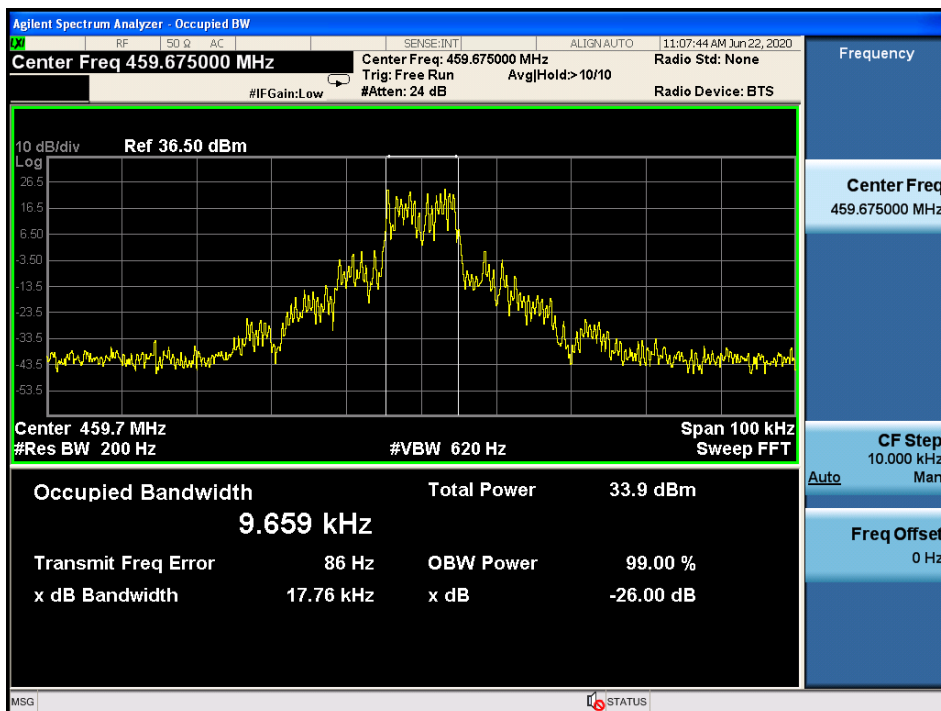


459.975 MHz

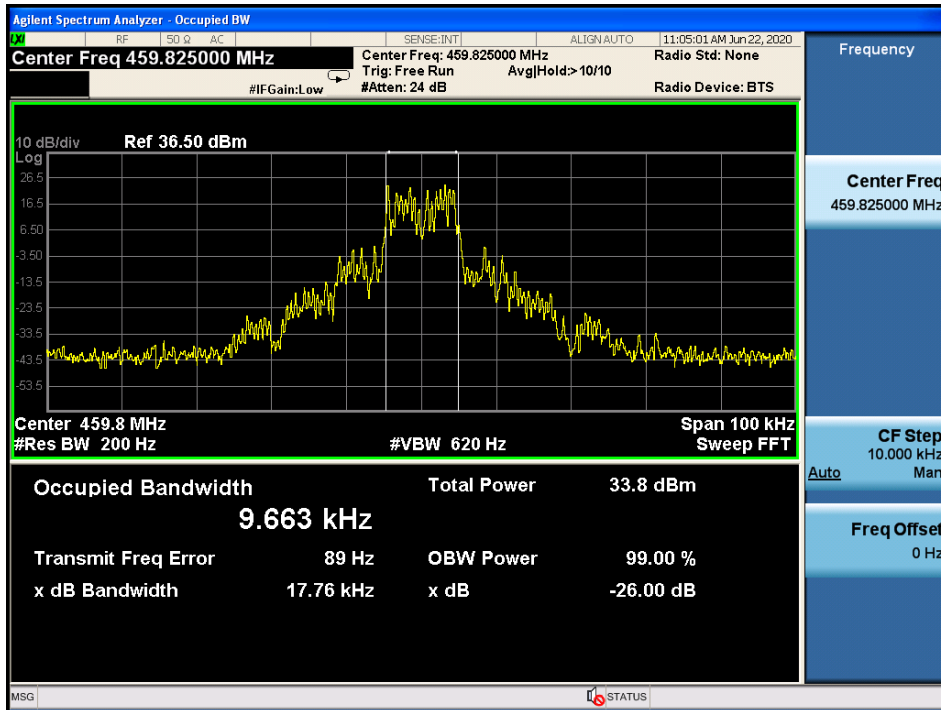


16QAM

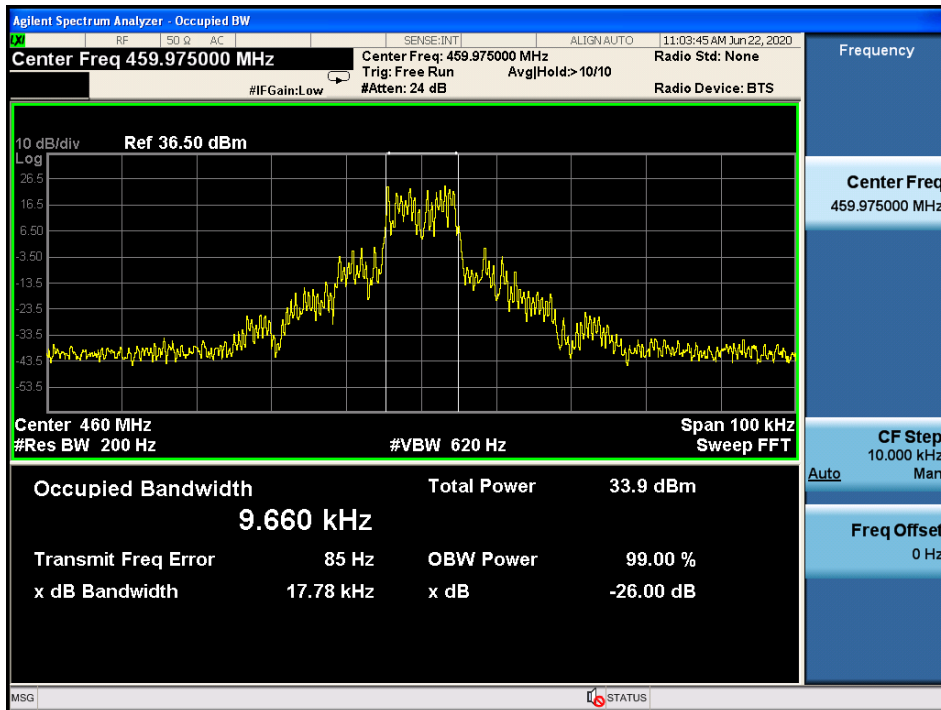
459.675 MHz



459.825 MHz

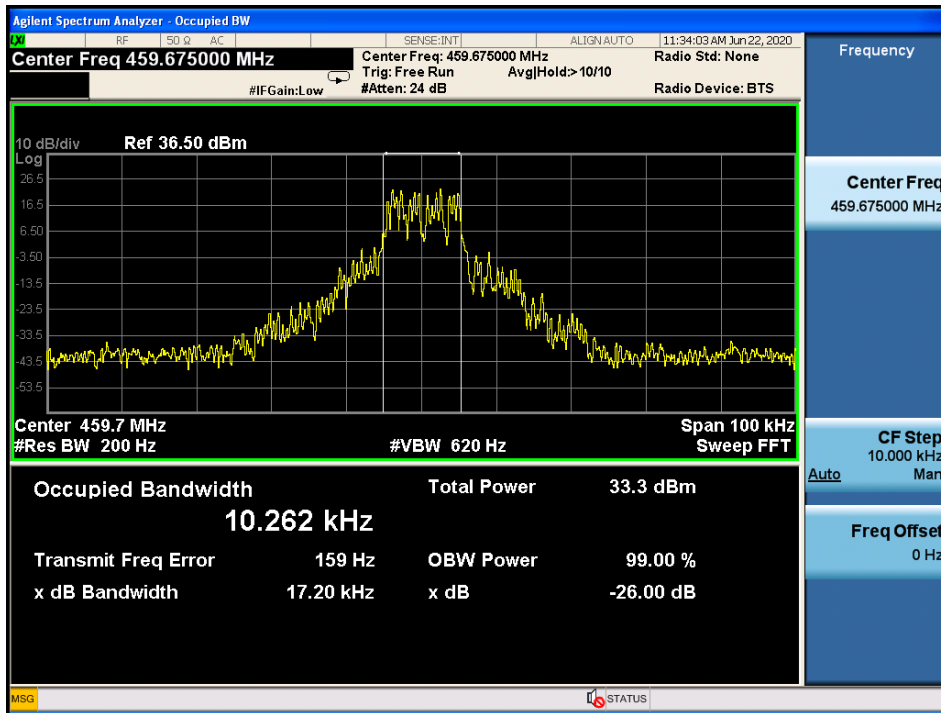


459.975 MHz

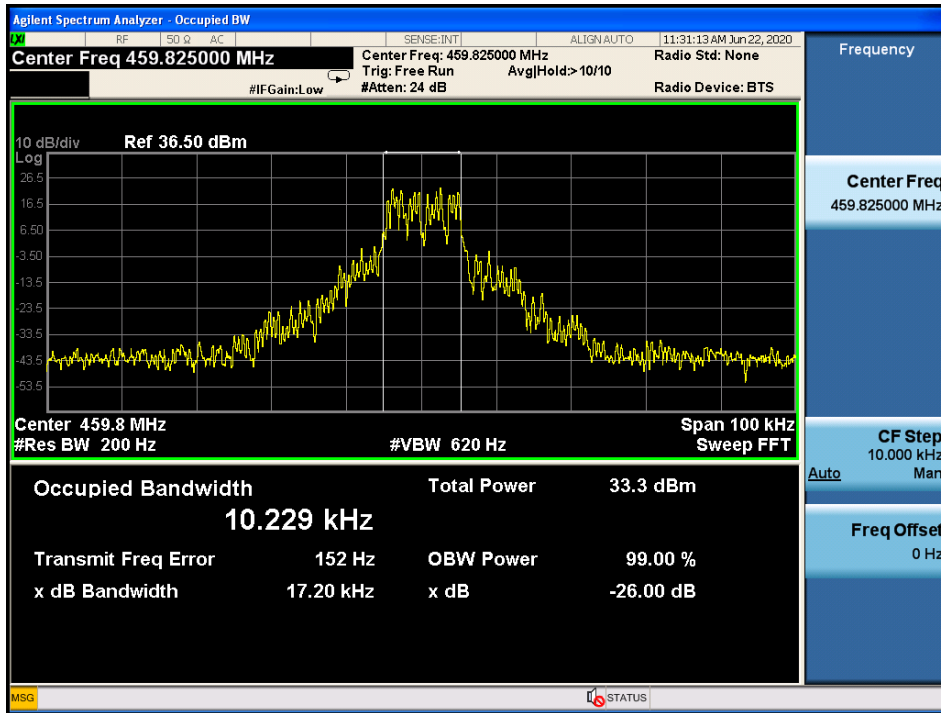


64QAM

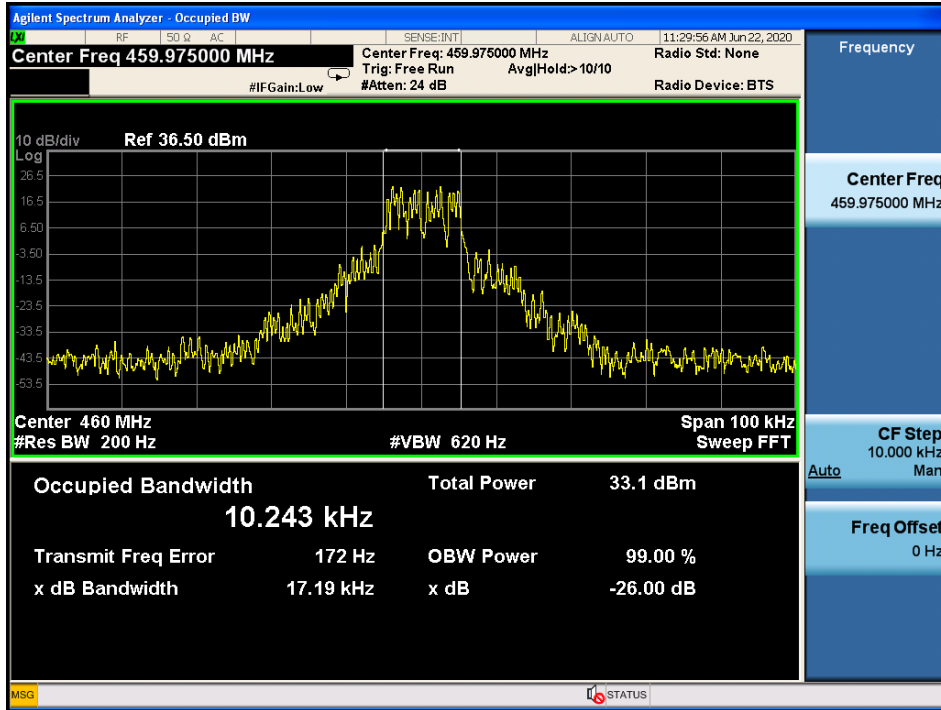
459.675 MHz



459.825 MHz



459.975 MHz



7 FCC §2.1053 & §22.861 - Spurious Radiated Emissions

7.1 Applicable Standards

According to FCC §22.861

The rules in this section govern the spectral characteristics of emissions for commercial aviation systems in the Air-Ground Radiotelephone Service. Commercial aviation air-ground systems may use any type of emission or technology that complies with the technical rules in this subpart.

(a) *Out of band emissions.* The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least $43 + 10 \log (P)$ dB.

7.2 Test Procedure

The transmitter was placed onto a Styrofoam block. The unit was normally transmitting with a 50 ohm terminator connected to the antenna terminal.

The measurement antenna was placed at a distance of 3 meters from the EUT. During the tests, the antenna height and polarization as well as EUT azimuth were varied in order to identify the maximum level of emissions from the EUT.

Emissions were investigated up to the tenth harmonic of the fundamental frequency.

After the emissions were found, the EUT was removed and replaced by a substituting antenna. A signal generator was connected to the substituting antenna by a non-radiating cable. The absolute levels of the spurious emissions were measured by the substitution.

7.3 Test Equipment List and Details

| Manufacturer | Description | Model No. | Serial No. | Calibration Date | Calibration Interval |
|-----------------------|--|--------------------|-----------------|------------------------|------------------------|
| Agilent | Analyzer, Spectrum | E4446A | MY48250238 | 2019-06-26 | 1 year |
| Sunol Science Corp | System Controller | SC99V | 122303-1 | N/R | N/R |
| Sunol Sciences | Antenna, Biconi-Log | JB3 | A020106-2 | 2019-11-20 | 2 years |
| Agilent | Amplifier, Pre | 8447D | 2443A04374 | 2019-08-13 | 1 year |
| HP/ Agilent | Pre Amplifier | 8449B OPT HO2 | 3008A0113 | 2019-09-30 | 1 year |
| ETS Lindgren | Antenna, Horn | 3117 | 00218973 | 2019-02-13 | 2 years |
| Sunol Sciences | Antenna, Horn | DRH-118 | A052704 | 2019-04-02 | 2 years |
| Agilent | Generator, Signal | E4438C | MY45091309 | 2019-11-15 | 1 year |
| Keysight Technologies | Vector Signal Generator | N5182B | MY51350070 | 2020-02-11 | 1 year |
| COM-POWER | Antenna, Dipole | AD-100 DB-4 | 721033DB1/2/3/4 | 2019-03-06 | 2 years |
| IW Microwave | 150 Series 2.92mm Cable | KPS1501AN-3780-KPS | DC 1925 | 2019-09-11 | 1 year |
| MDP Digital | Times Microwave LMR 400 UltraFex Coaxial Cable 35' | LMR400UF | BACL1904161 | 2020-05-21 | 1 year |
| - | SMA cable | - | C0003 | Each Time ¹ | Each Time ¹ |
| - | SMA cable | - | C0006 | Each Time ¹ | Each Time ¹ |

Note¹: This equipment was calibrated for each test.

Statement of Traceability: BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 9 June 2016) "A2LA Policy on Metrological Traceability".

7.4 Test Environmental Conditions

| | |
|---------------------------|-----------------|
| Temperature: | 20-21°C |
| Relative Humidity: | 47-49 % |
| ATM Pressure: | 101.4-101.6 kPa |

The testing was performed by Christian McCaig on 2020-06-23 in 5 Meter Chamber 3.

7.5 Test Results

Middle channel tested (459.825MHz)

QPSK

| Indicated | | Azimuth (degree) | Test Antenna | | Substituted | | | | | Limit (dBm) | Margin (dB) |
|--------------------|------------------------|---------------------|----------------|-------------------|--------------------|----------------|--------------------------------------|-----------------------|----------------------------|----------------|----------------|
| Frequency (MHz) | S.A. Amp. (dBuV) | | Height (cm) | Polarity (H/V) | Frequency (MHz) | Level (dBm) | Ant. Gain Correction (dBd/dBi) | Cable Loss (dB) | Absolute Level (dBm) | | |
| 400.3 | 40.8 | 95 | 160 | H | 400.3 | -61.9 | 1.8 | 2.1 | -62.2 | -13 | -49.2 |
| 400.3 | 40.6 | 280 | 160 | V | 400.3 | -60.67 | 1.8 | 2.1 | -60.97 | -13 | -47.97 |
| 919 | 47.5 | 110 | 125 | H | 919 | -48.9 | 3.6 | 3.2 | -48.5 | -13 | -35.5 |
| 919 | 44.86 | 25 | 130 | V | 919 | -49.31 | 3.6 | 3.2 | -48.91 | -13 | -35.91 |
| 1379 | 81.34 | 118 | 110 | H | 1379 | -27.34 | 7.992 | 1 | -20.348 | -13 | -7.348 |
| 1379 | 74.56 | 340 | 150 | V | 1379 | -32.64 | 7.992 | 1 | -25.648 | -13 | -12.648 |
| 2299 | 67.31 | 70 | 130 | H | 2299 | -35.8 | 8.939 | 1.85 | -28.711 | -13 | -15.711 |
| 2299 | 66.34 | 10 | 165 | V | 2299 | -34.12 | 8.939 | 1.85 | -27.031 | -13 | -14.031 |

16QAM

| Indicated | | Azimuth (degree) | Test Antenna | | Substituted | | | | | Limit (dBm) | Margin (dB) |
|--------------------|------------------------|---------------------|----------------|-------------------|--------------------|----------------|--------------------------------------|-----------------------|----------------------------|----------------|----------------|
| Frequency (MHz) | S.A. Amp. (dBuV) | | Height (cm) | Polarity (H/V) | Frequency (MHz) | Level (dBm) | Ant. Gain Correction (dBd/dBi) | Cable Loss (dB) | Absolute Level (dBm) | | |
| 400.3 | 40.91 | 95 | 160 | H | 400.3 | -61.79 | 1.8 | 2.1 | -62.09 | -13 | -49.09 |
| 400.3 | 40.56 | 280 | 160 | V | 400.3 | -60.71 | 1.8 | 2.1 | -61.01 | -13 | -48.01 |
| 919 | 46.88 | 110 | 125 | H | 919 | -49.52 | 3.6 | 3.2 | -49.12 | -13 | -36.12 |
| 919 | 44.52 | 25 | 130 | V | 919 | -49.65 | 3.6 | 3.2 | -49.25 | -13 | -36.25 |
| 1379 | 81.17 | 118 | 110 | H | 1379 | -27.51 | 7.992 | 1 | -20.518 | -13 | -7.518 |
| 1379 | 74.53 | 340 | 150 | V | 1379 | -32.67 | 7.992 | 1 | -25.678 | -13 | -12.678 |
| 2299 | 66.44 | 70 | 130 | H | 2299 | -36.67 | 8.939 | 1.85 | -29.581 | -13 | -16.581 |
| 2299 | 65.93 | 10 | 165 | V | 2299 | -34.53 | 8.939 | 1.85 | -27.441 | -13 | -14.441 |

64QAM

| Indicated | | Azimuth (degree) | Test Antenna | | Substituted | | | | | Limit (dBm) | Margin (dB) |
|--------------------|------------------------|---------------------|----------------|-------------------|--------------------|----------------|--------------------------------------|-----------------------|----------------------------|----------------|----------------|
| Frequency (MHz) | S.A. Amp. (dBuV) | | Height (cm) | Polarity (H/V) | Frequency (MHz) | Level (dBm) | Ant. Gain Correction (dBd/dBi) | Cable Loss (dB) | Absolute Level (dBm) | | |
| 420 | 40.93 | 95 | 160 | H | 420 | -61.77 | 1.8 | 2.1 | -62.07 | -13 | -49.07 |
| 420 | 40.56 | 280 | 160 | V | 420 | -60.71 | 1.8 | 2.1 | -61.01 | -13 | -48.01 |
| 919 | 47.53 | 110 | 125 | H | 919 | -48.87 | 3.6 | 3.2 | -48.47 | -13 | -35.47 |
| 919 | 44.96 | 25 | 130 | V | 919 | -49.21 | 3.6 | 3.2 | -48.81 | -13 | -35.81 |
| 1379 | 81.01 | 118 | 110 | H | 1379 | -27.67 | 7.992 | 1 | -20.678 | -13 | -7.678 |
| 1379 | 74.39 | 340 | 150 | V | 1379 | -32.81 | 7.992 | 1 | -25.818 | -13 | -12.818 |
| 2299 | 66.84 | 70 | 130 | H | 2299 | -36.27 | 8.939 | 1.85 | -29.181 | -13 | -16.181 |
| 2299 | 66.39 | 10 | 165 | V | 2299 | -34.07 | 8.939 | 1.85 | -26.981 | -13 | -13.981 |

8 FCC §2.1051 & §22.861 - Spurious Emissions at Antenna Terminals

8.1 Applicable Standards

According to FCC §22.861

The rules in this section govern the spectral characteristics of emissions for commercial aviation systems in the Air-Ground Radiotelephone Service. Commercial aviation air-ground systems may use any type of emission or technology that complies with the technical rules in this subpart.

(a) *Out of band emissions.* The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least $43 + 10 \log (P)$ dB.

8.2 Test Procedure

Conducted Spurious Emissions:

The RF output of the EUT was connected to a spectrum analyzer through appropriate attenuation. The resolution bandwidth of the spectrum analyzer was set at 100 kHz for measurements up to 1GHz and set to 1 MHz for measurements up to the 10th harmonic.

Band-edge Emissions:

According to FCC §22.861(b):

Measurement procedure. Compliance with these rules is based on the use of measurement instrumentation employing a resolution bandwidth of 100 kHz or greater. In the 1 MHz bands immediately outside and adjacent to the frequency block a resolution bandwidth of at least one percent of the emission bandwidth of the fundamental emission of the transmitter may be employed. A narrower resolution bandwidth is permitted in all cases to improve measurement accuracy provided the measured power is integrated over the full required measurement bandwidth (*i.e.*, 100 kHz or 1 percent of emission bandwidth, as specified). The emission bandwidth is defined as the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.

8.3 Test Equipment List and Details

| Manufacturers | Descriptions | Models | Serial Numbers | Calibration Dates | Calibration Interval |
|---------------|---------------------|--------|----------------|------------------------|----------------------|
| Agilent | EXA Signal Analyzer | N9010A | MY48030852 | 2020-02-12 | 1 year |
| - | RF Cable | - | - | Each time ¹ | N/A |
| - | 30dB Attenuator | - | - | Each time ¹ | N/A |

Note¹: Equipment was calibrated for each test.

Statement of Traceability: BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 9 June 2016) “A2LA Policy on Metrological Traceability”.

8.4 Test Environmental Conditions

| | |
|---------------------------|---------------|
| Temperature: | 23° C |
| Relative Humidity: | 32 % |
| ATM Pressure: | 101.4-102 kPa |

The testing was performed by Christian McCaig on 2020-06-24 and 2020-07-10 in the RF Site.

8.5 Test Results

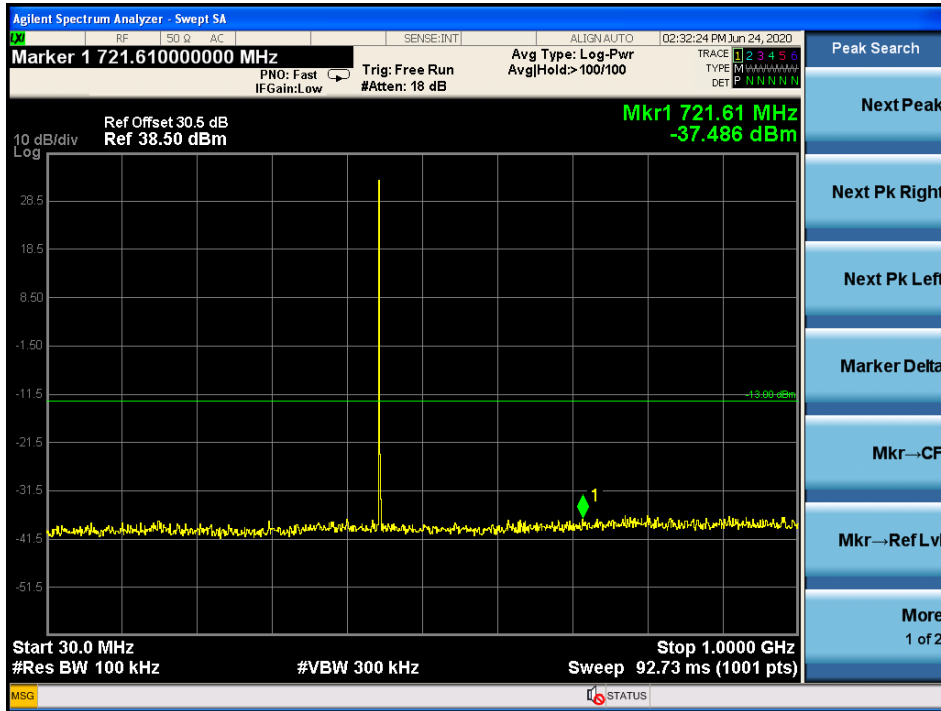
Please refer to the following plots.

Conducted Spurious Emissions:

QPSK

459.825 MHz

30 MHz-1 GHz

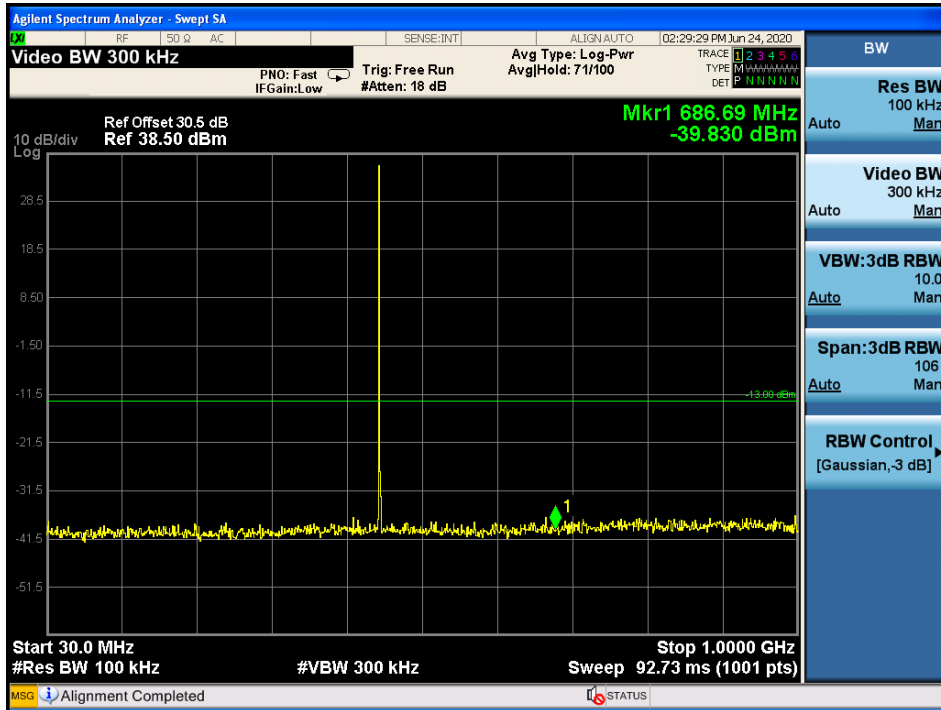


1 GHz-5 GHz

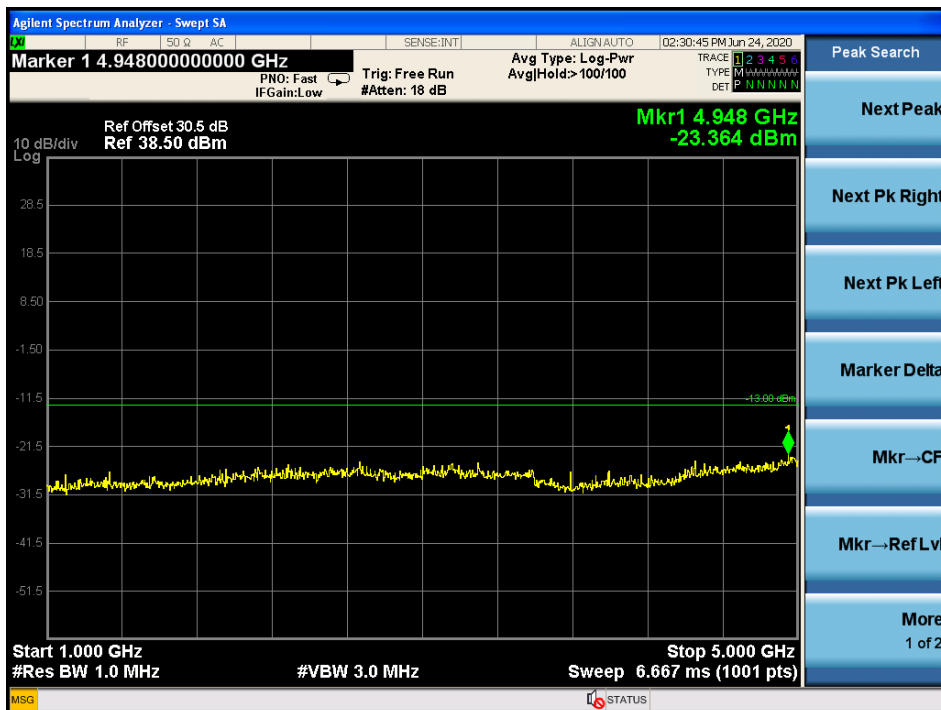


459.825MHz

30 MHz-1 GHz



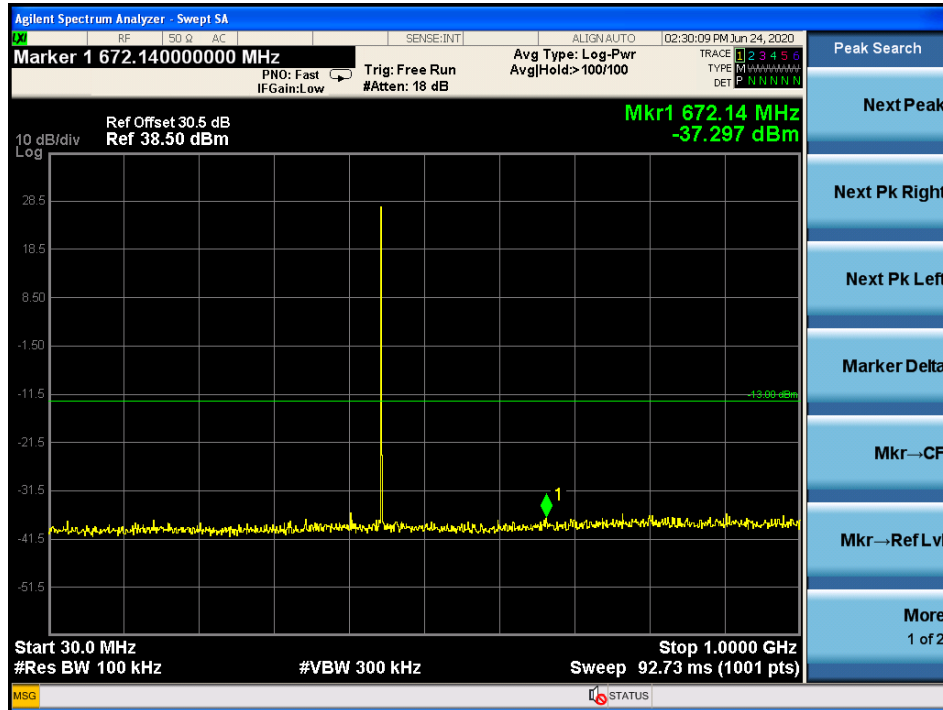
1 GHz-5 GHz



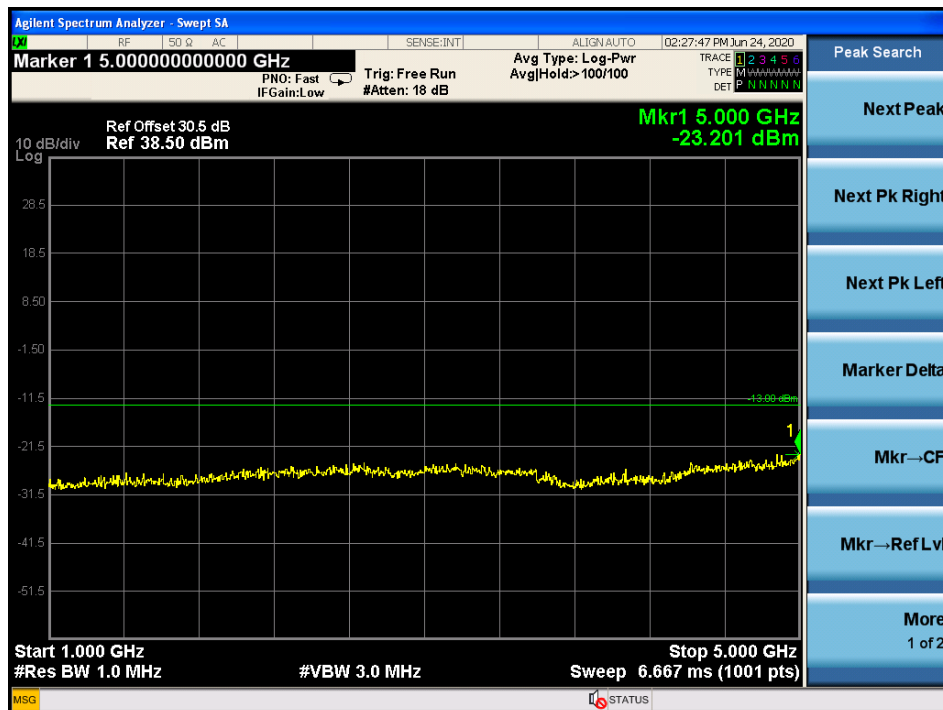
64QAM

459.825MHz

30 MHz-1 GHz



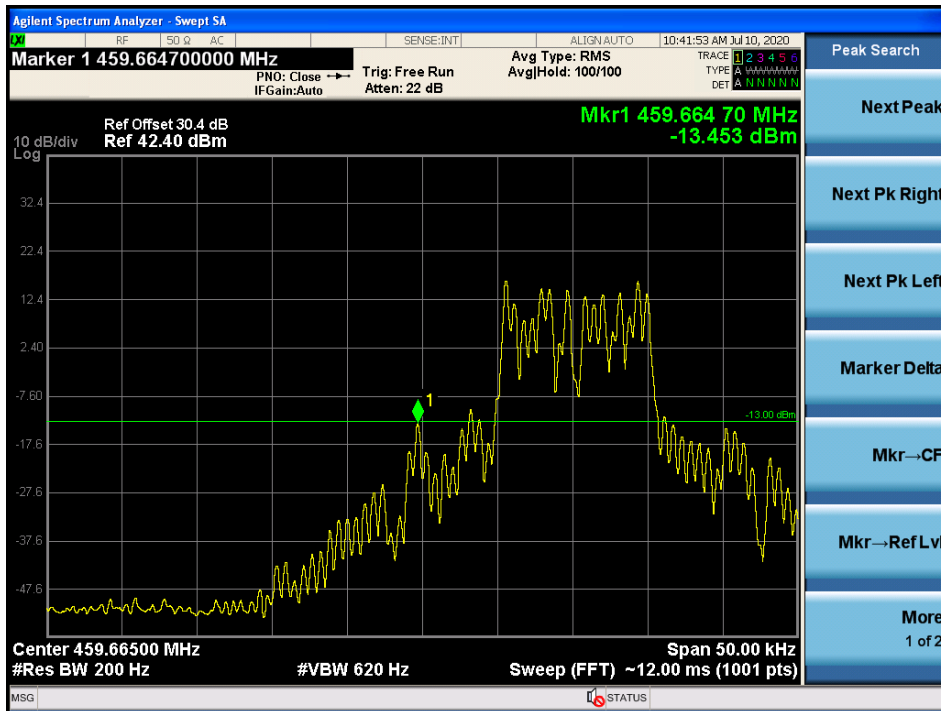
1 GHz-5 GHz



Band-edge Emissions:

QPSK

459.675 MHz

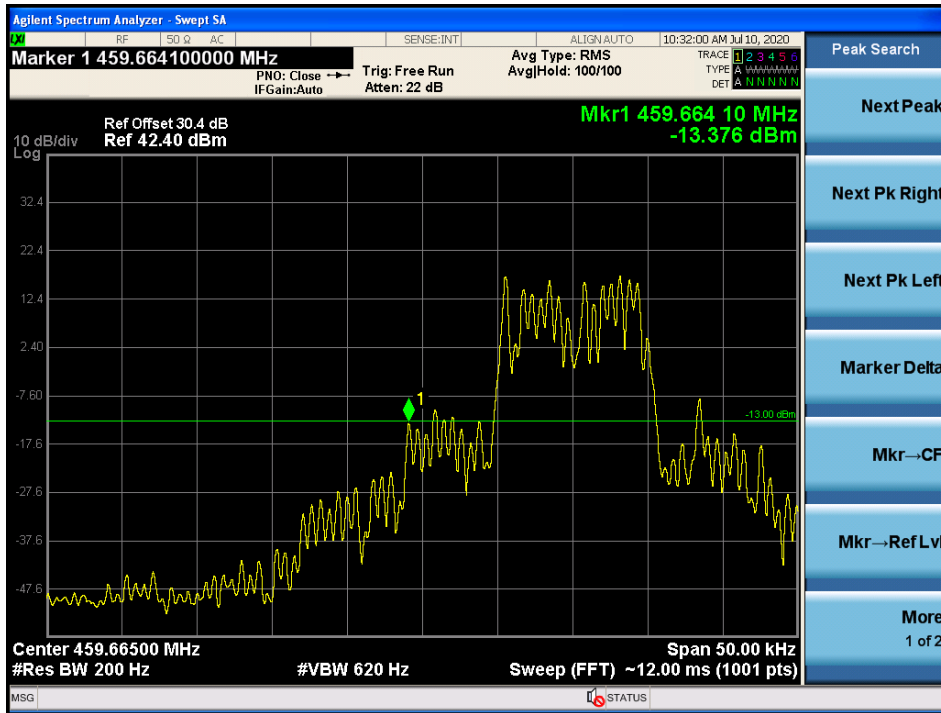


459.975 MHz

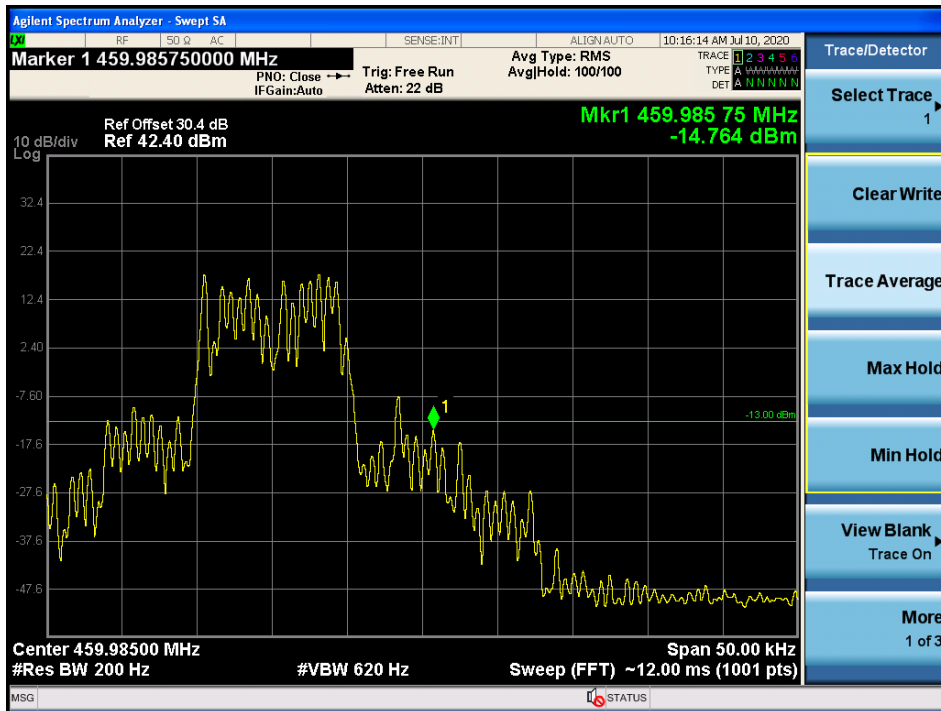


16QAM

459.675 MHz

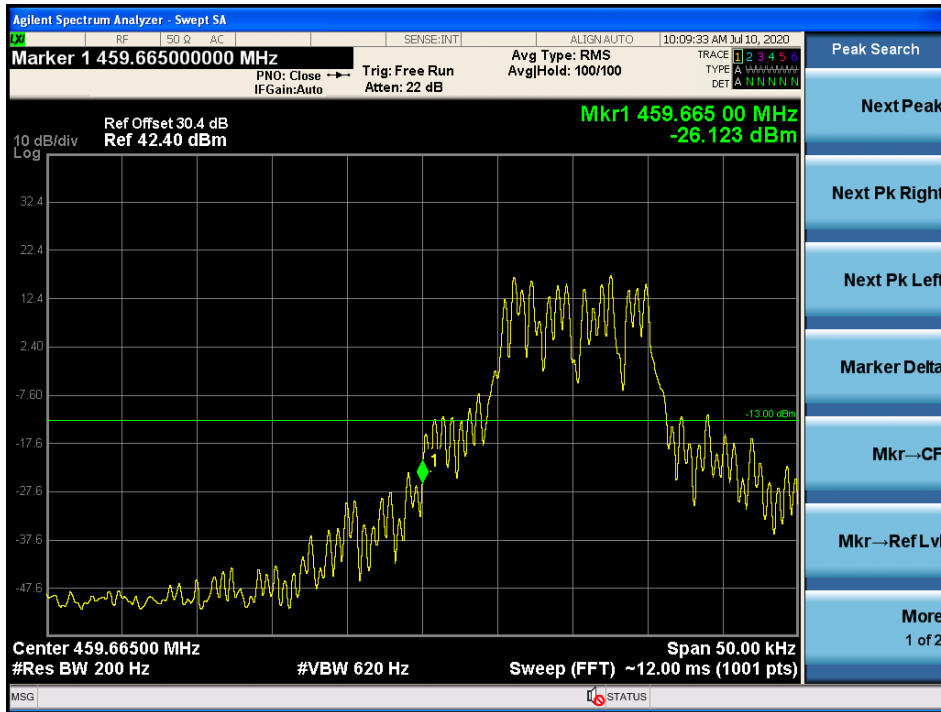


459.975 MHz

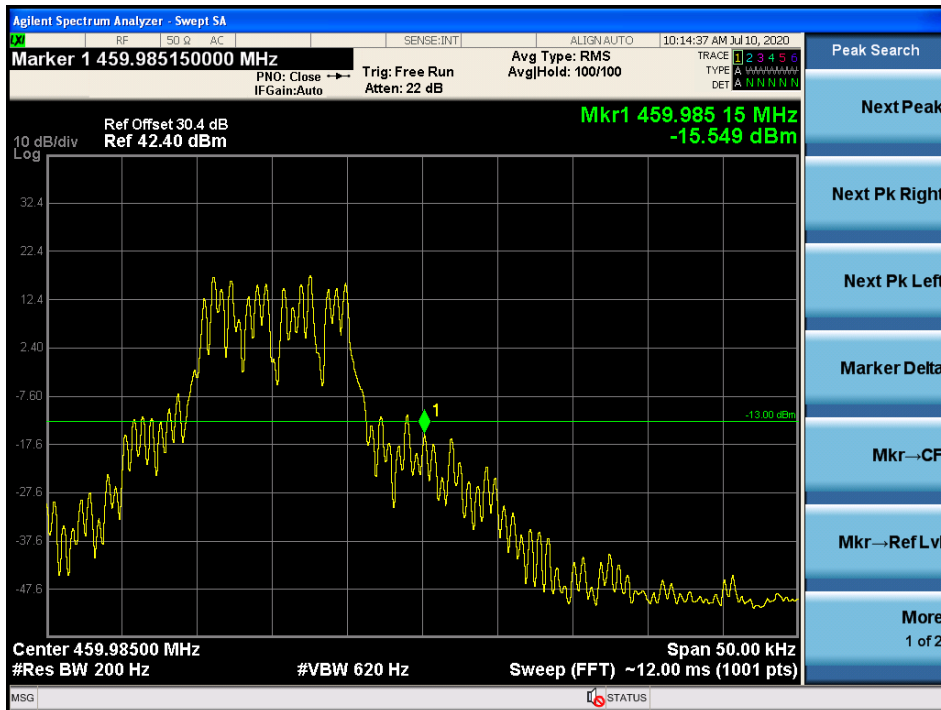


64QAM

459.675 MHz



459.975 MHz



9 FCC §2.1055 & §22.863 - Frequency Stability

9.1 Applicable Standard

According to FCC Part 22.863, The frequency stability of equipment used under this subpart shall be sufficient to ensure that, after accounting for Doppler frequency shifts, the occupied bandwidth of the fundamental emissions remains within the authorized frequency bands of operation.

9.2 Test Procedure

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

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

(2) From -20° to $+50^{\circ}$ centigrade for equipment to be licensed for use in the Maritime Services under part 80 of this chapter, except for Class A, B, and S Emergency Position Indicating Radiobeacons (EPIRBS), and equipment to be licensed for use above 952 MHz at operational fixed stations in all services, stations in the Local Television Transmission Service and Point-to-Point Microwave Radio Service under part 21 of this chapter, equipment licensed for use aboard aircraft in the Aviation Services under part 87 of this chapter, and equipment authorized for use in the Family Radio Service under part 95 of this chapter.

(3) From 0° to $+50^{\circ}$ centigrade for equipment to be licensed for use in the Radio Broadcast Services under part 73 of this chapter.

(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. The short term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stabilizing circuitry need be subjected to the temperature variation test.

(c) In addition to all other requirements of this section, the following information is required for equipment incorporating heater type crystal oscillators to be used in mobile stations, for which type acceptance is first requested after March 25, 1974, except for battery powered, hand carried, portable equipment having less than 3 watts mean output power.

(1) Measurement data showing variation in transmitter output frequency from a cold start and the elapsed time necessary for the frequency to stabilize within the applicable tolerance. Tests shall be made after temperature stabilization at each of the ambient temperature levels; the lower temperature limit, 0° centigrade and $+30^{\circ}$ centigrade with no primary power applied.

(2) Beginning at each temperature level specified in paragraph (c)(1) of this section, the frequency shall be measured within one minute after application of primary power to the transmitter and at intervals of no more than one minute thereafter until ten minutes have elapsed or until sufficient measurements are obtained to indicate clearly that the frequency has stabilized within the applicable tolerance, whichever time period is greater. During each test, the ambient temperature shall not be allowed to rise more than 10° centigrade above the respective beginning ambient temperature level.

(3) The elapsed time necessary for the frequency to stabilize within the applicable tolerance from each beginning ambient temperature level as determined from the tests specified in this paragraph shall be specified in the instruction book for the transmitter furnished to the user.

(4) When it is impracticable to subject the complete transmitter to this test because of its physical dimensions or power rating, only its frequency determining and stabilizing portions need be tested.

(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.

(2) For hand carried, battery powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.

(3) The supply voltage shall be measured at the input to the cable normally provided with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.

(e) When deemed necessary, the Commission may require tests of frequency stability under conditions in addition to those specifically set out in paragraphs (a), (b), (c), and (d) of this section. (For example measurements showing the effect of proximity to large metal objects, or of various types of antennas, may be required for portable equipment.)

9.3 Test Equipment List and Details

| Manufacturer | Descriptions | Models | Serial Numbers | Calibration Dates | Calibration Interval |
|--------------|---------------------|---------------|----------------|------------------------|----------------------|
| Agilent | EXA Signal Analyzer | N9010A | MY48030852 | 2020-02-12 | 1 year |
| - | RF Cable | - | - | Each time ¹ | N/A |
| - | 30dB Attenuator | - | - | Each time ¹ | N/A |
| TCR | DC Power Supply | TCR80S34-2-0V | 92D-6839 | N/A | N/A |
| Espec | Chamber, Humidity | ESL-4CA | 18010 | 2019-04-25 | 14 months |

Note¹: Equipment was calibrated for each test.

Statement of Traceability: BACL Corp. attests that all of the calibrations on the equipment items listed above were traceable to NIST or to another internationally recognized National Metrology Institute (NMI), and were compliant with A2LA Policy P102 (dated 9 June 2016) "A2LA Policy on Metrological Traceability".

9.4 Test Environmental Conditions

| | |
|---------------------------|---------------|
| Temperature: | 23° C |
| Relative Humidity: | 32 % |
| ATM Pressure: | 101.4-102 kPa |

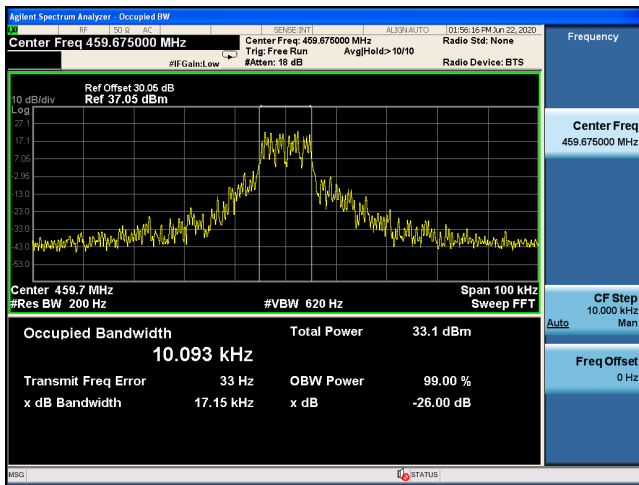
The testing was performed by Christian McCaig from 2020-06-22 to 2020-06-23 in the RF Site.

9.5 Test Results

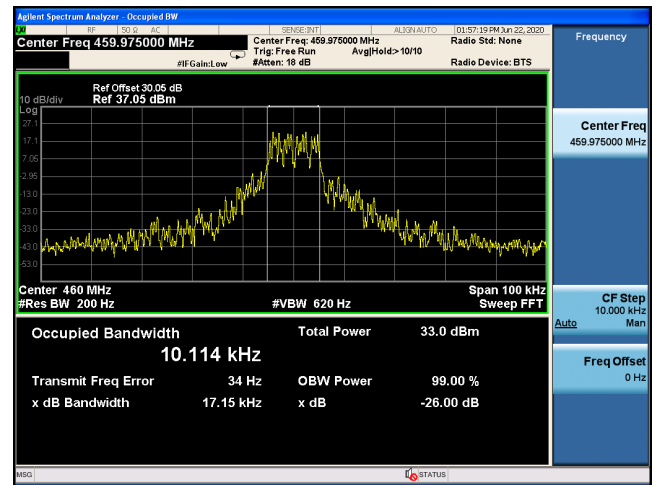
-30 °C

QPSK

459.675MHz

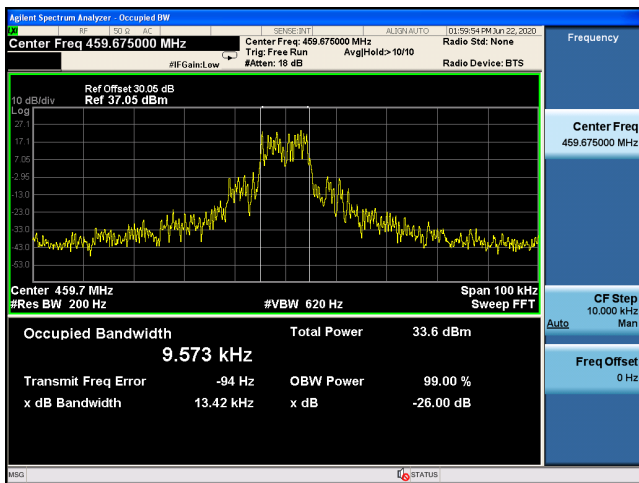


459.975MHz

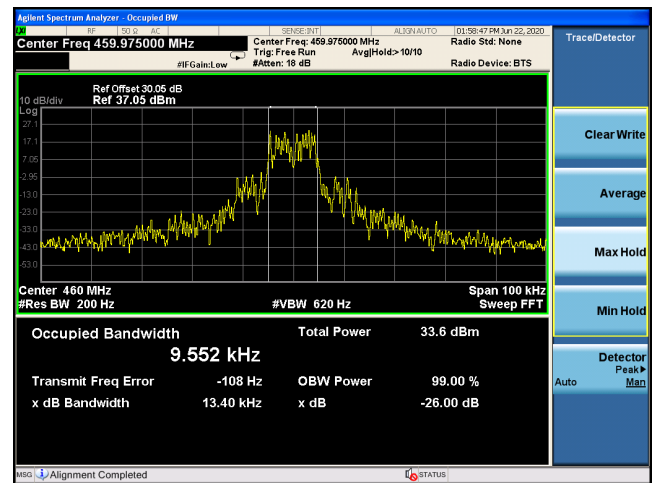


16QAM

459.675MHz

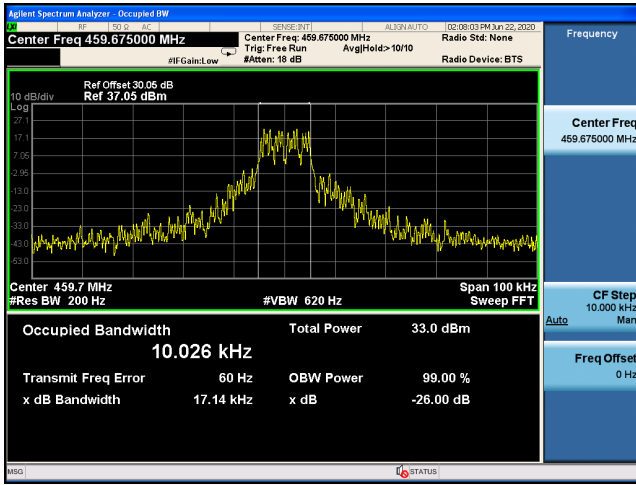


459.975MHz

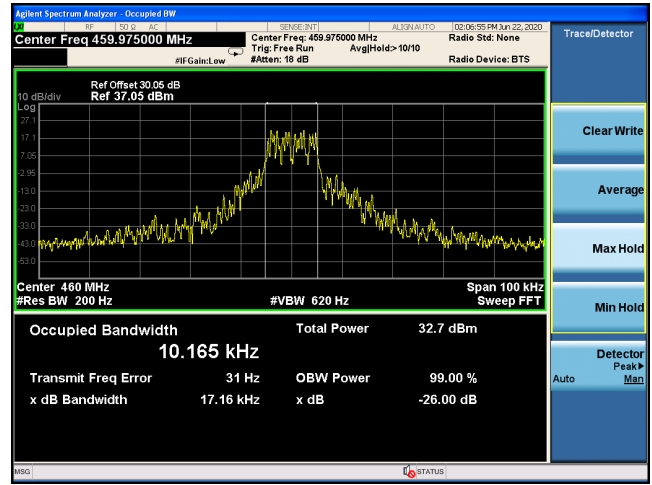


64QAM

459.675MHz



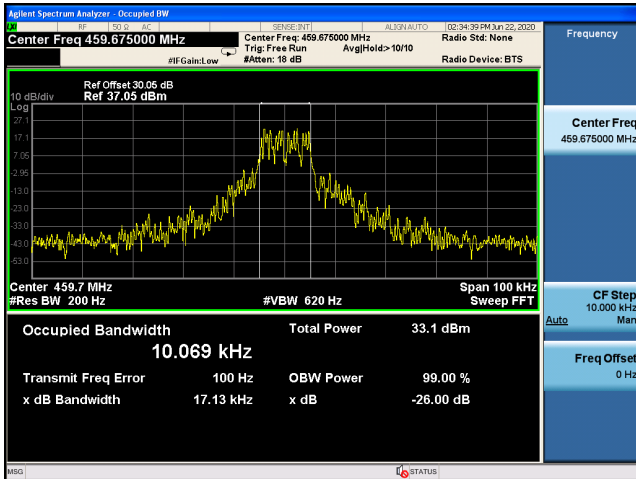
459.975MHz



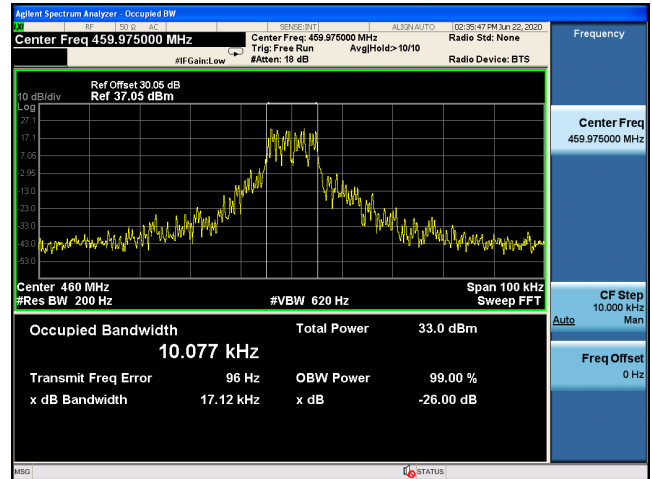
-20 °C

QPSK

459.675MHz

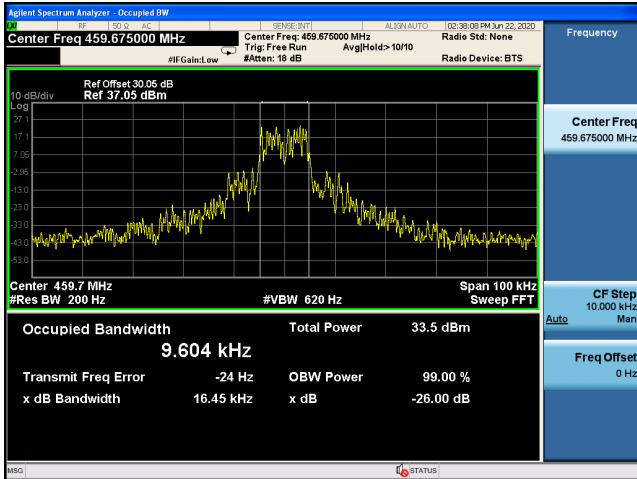


459.975MHz

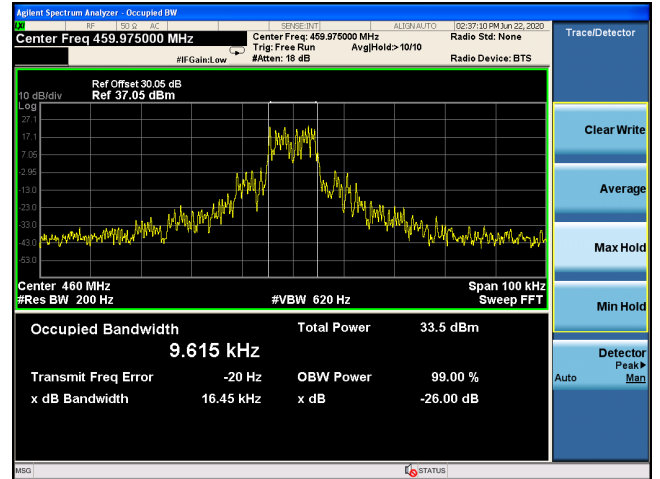


16QAM

459.675MHz

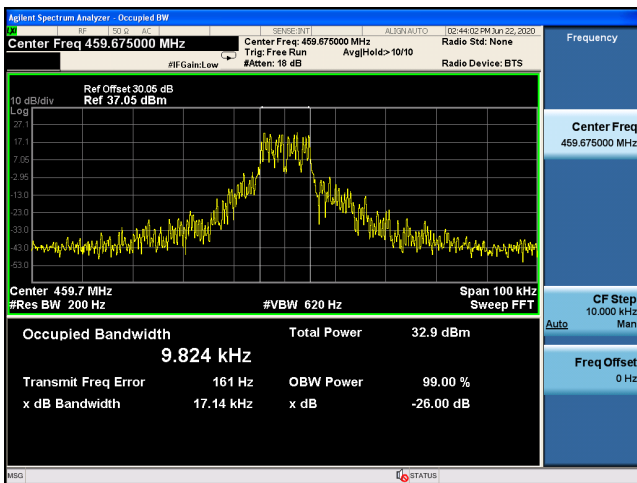


459.975MHz

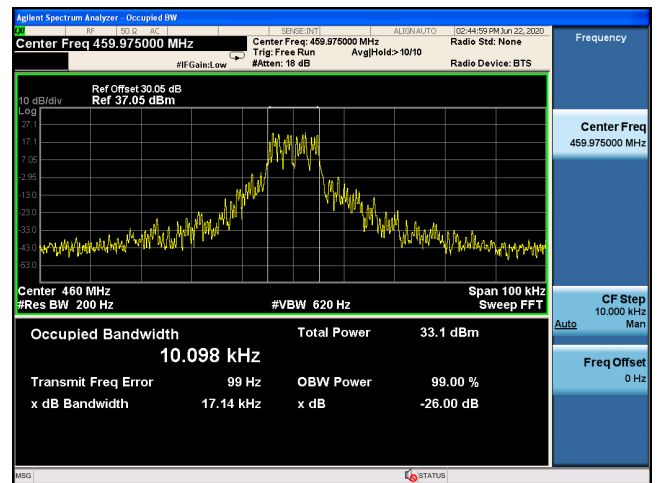


64QAM

459.675MHz



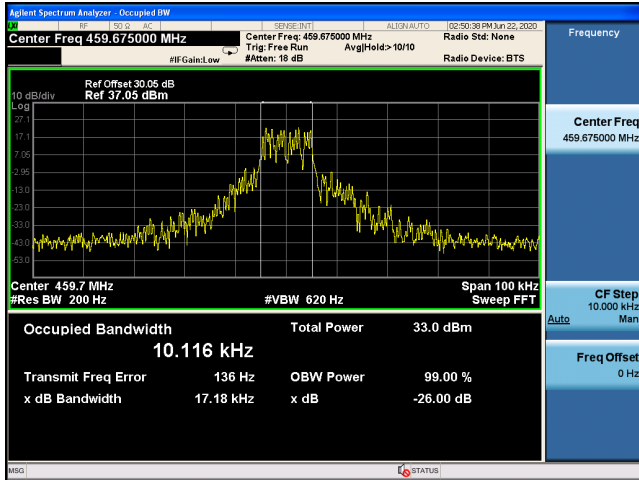
459.975MHz



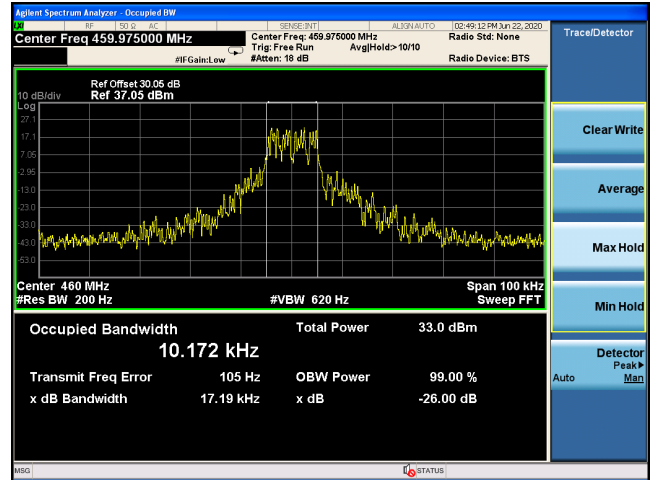
-10 °C

QPSK

459.675MHz

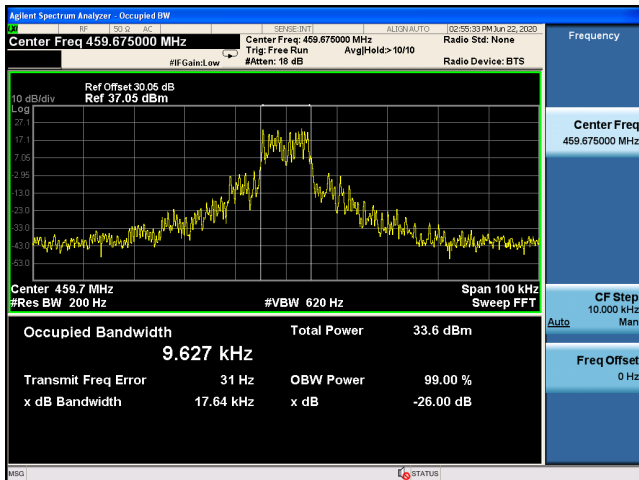


459.975MHz

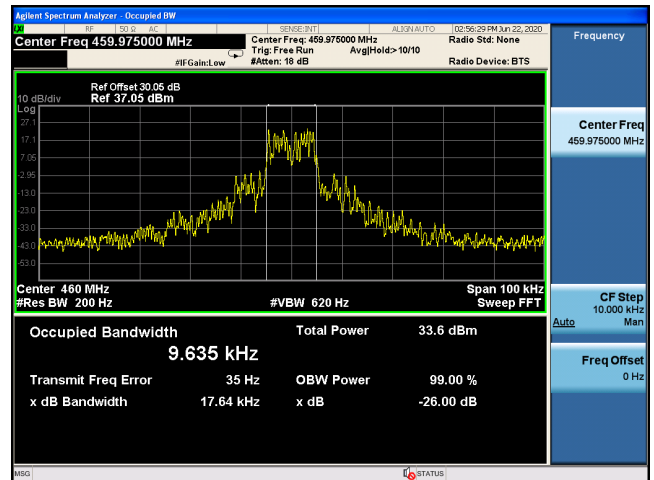


16QAM

459.675MHz

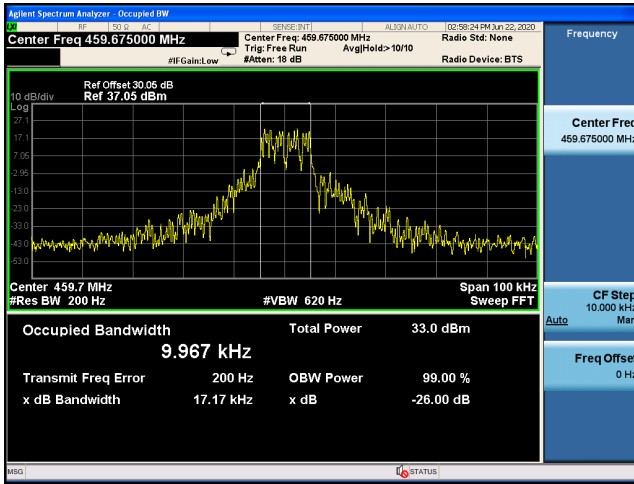


459.975MHz

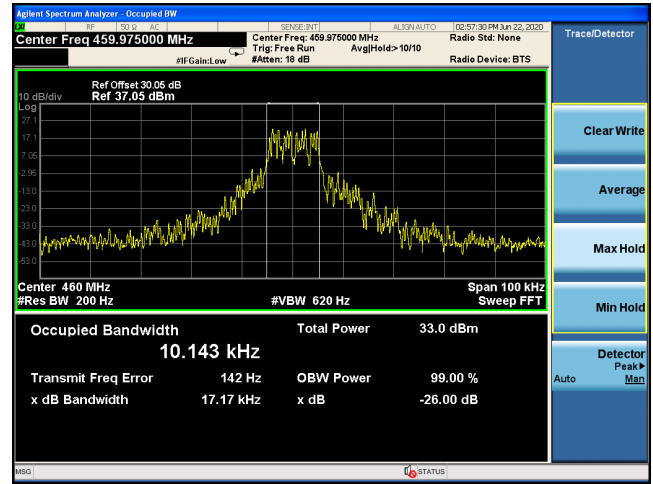


64QAM

459.675MHz



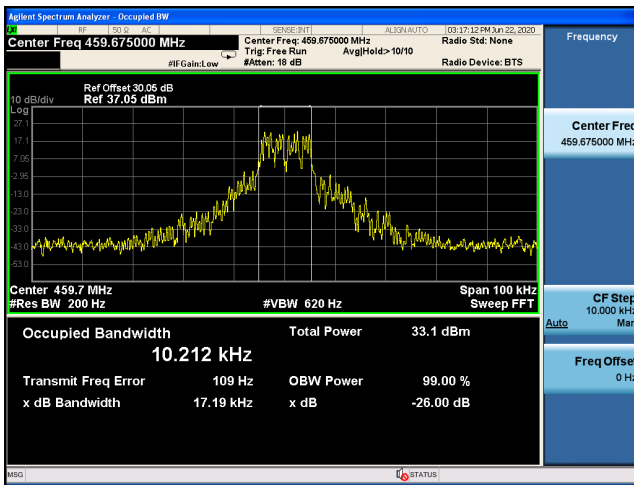
459.975MHz



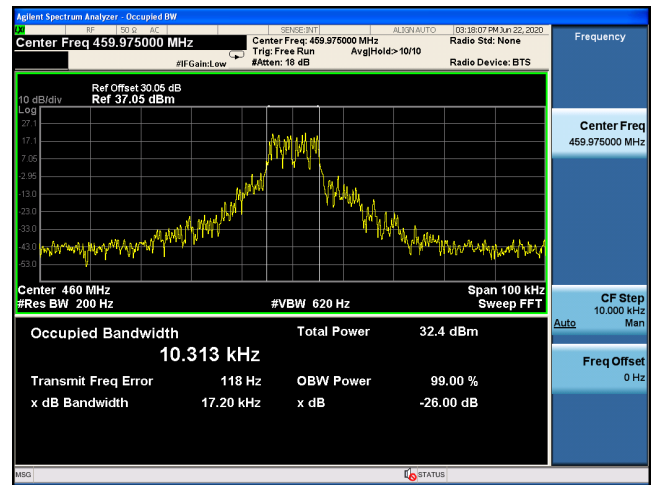
0 °C

QPSK

459.675MHz

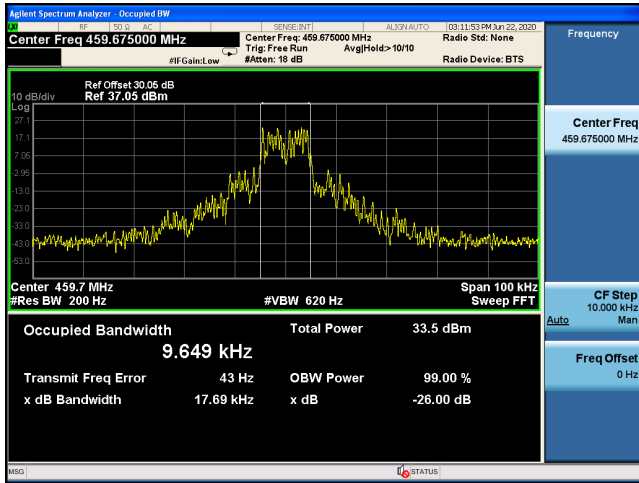


459.975MHz

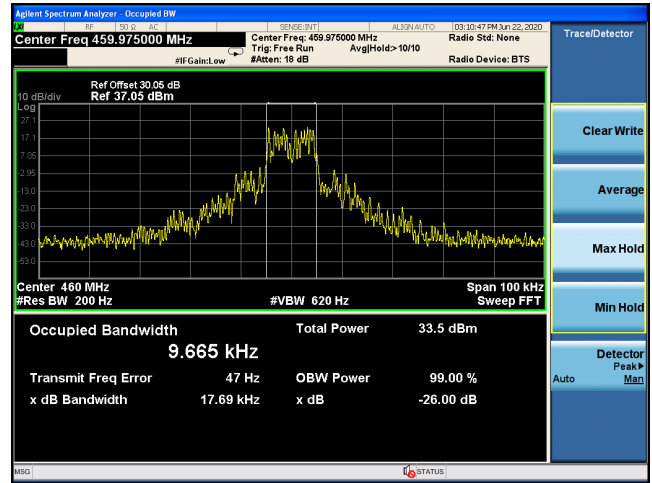


16QAM

459.675MHz

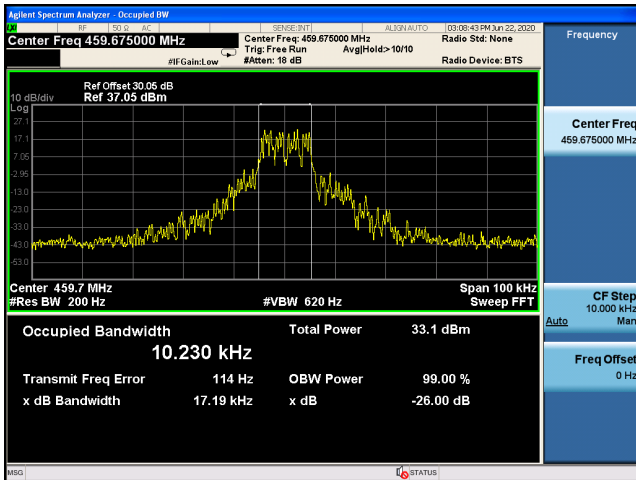


459.975MHz

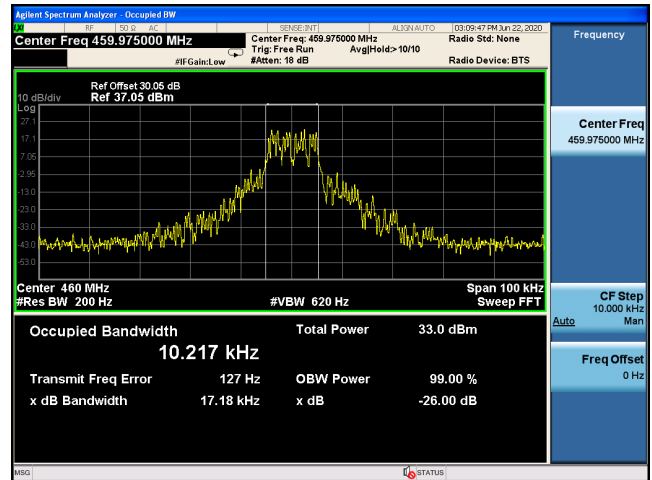


64QAM

459.675MHz



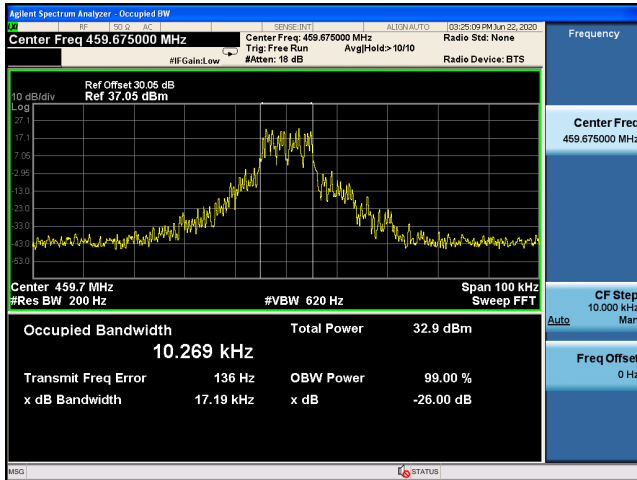
459.975MHz



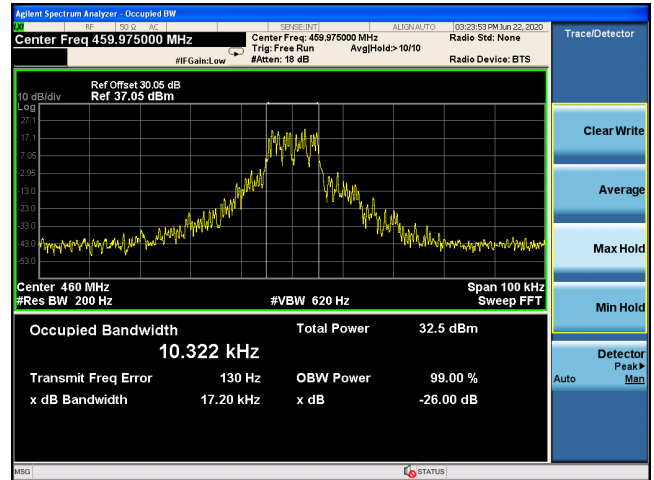
10 °C

QPSK

459.675MHz

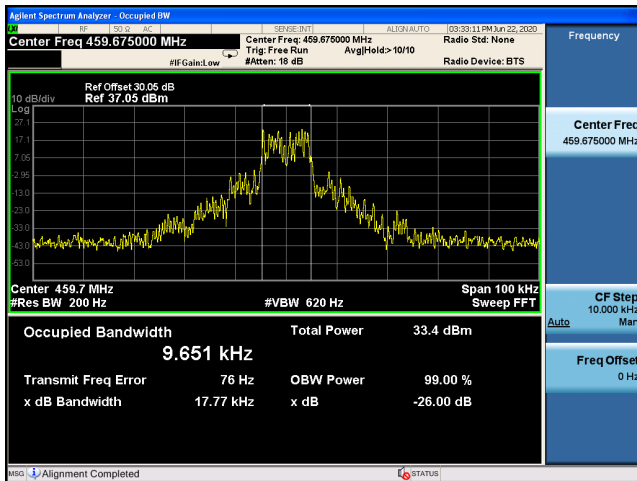


459.975MHz

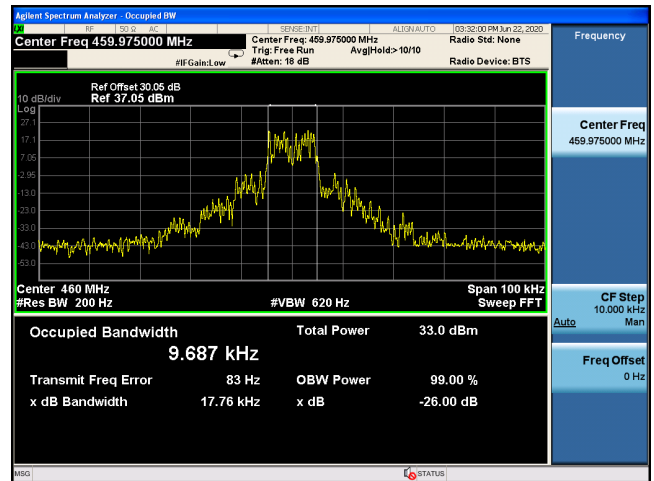


16QAM

459.675MHz

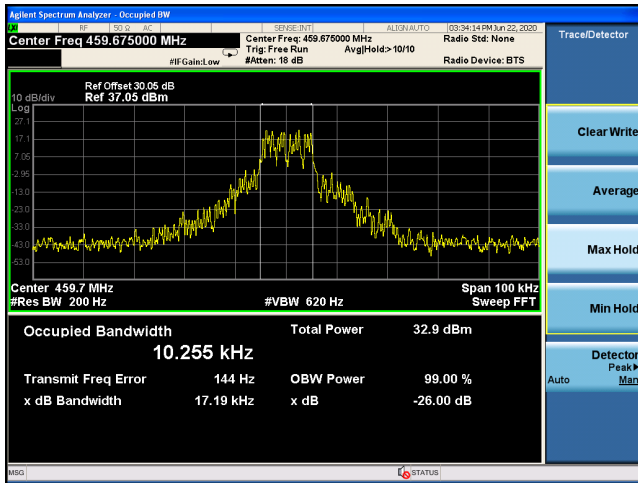


459.975MHz

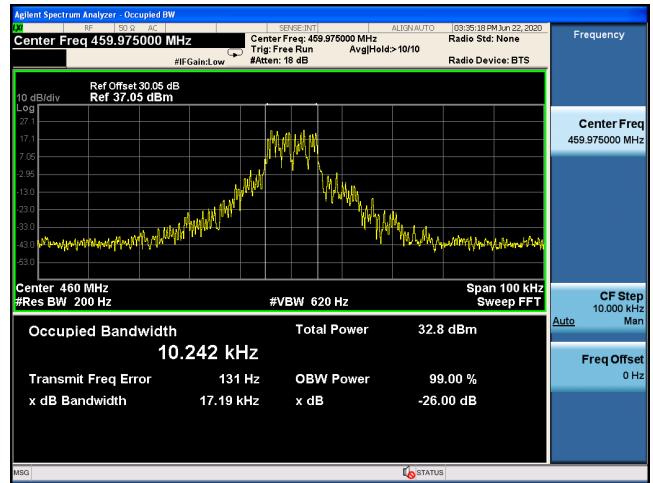


64QAM

459.675MHz



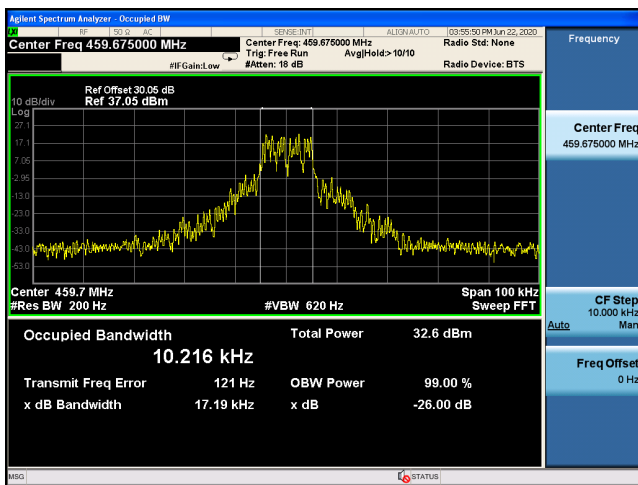
459.975MHz



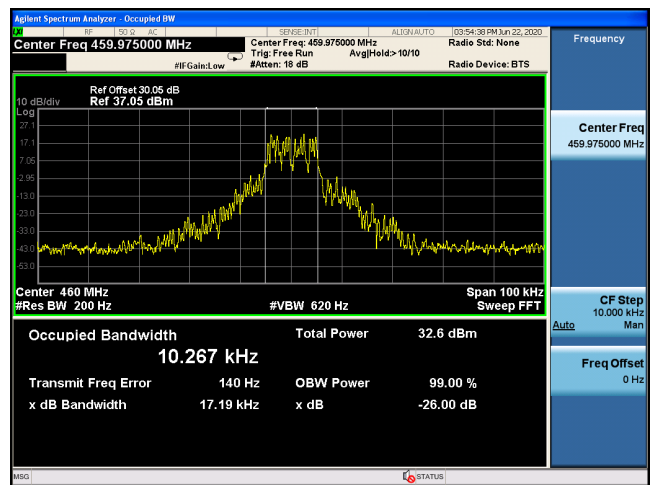
20 °C

QPSK

459.675MHz

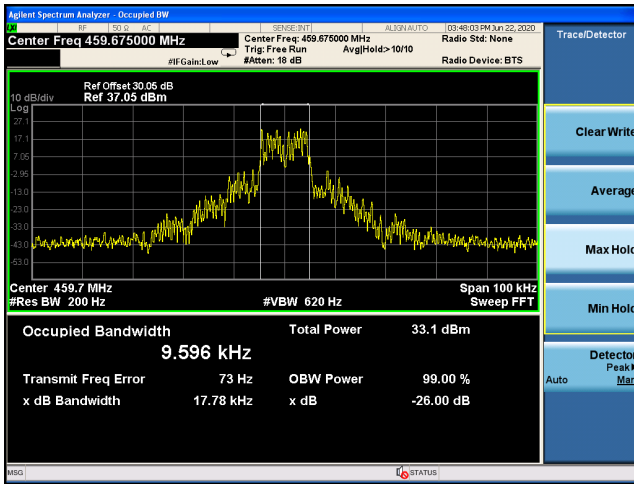


459.975MHz

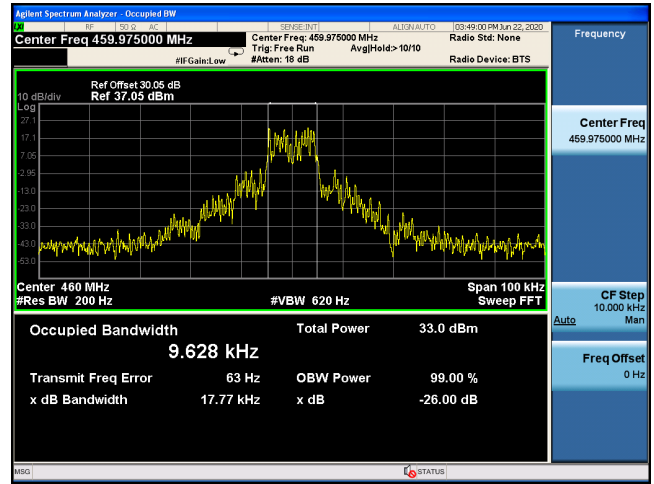


16QAM

459.675MHz

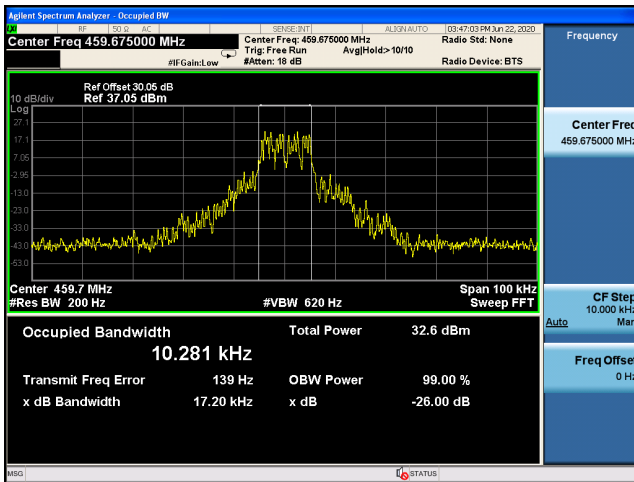


459.975MHz

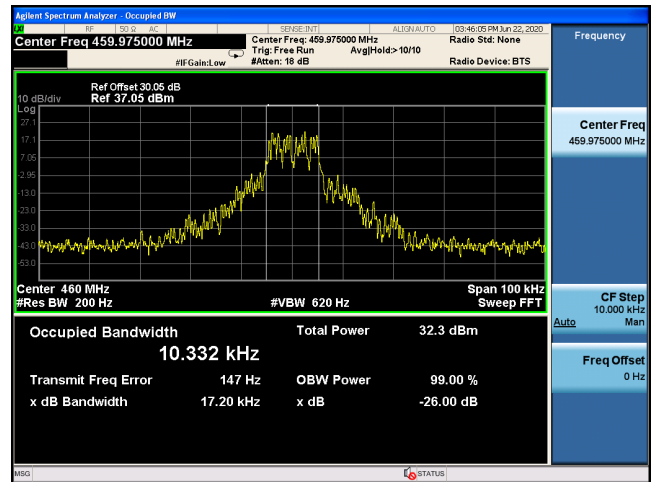


64QAM

459.675MHz



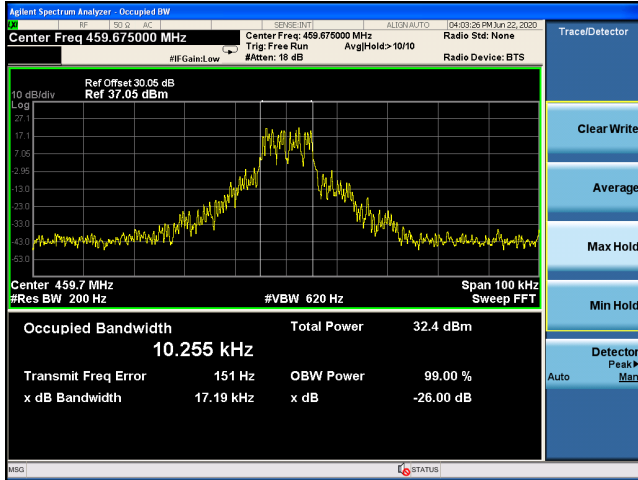
459.975MHz



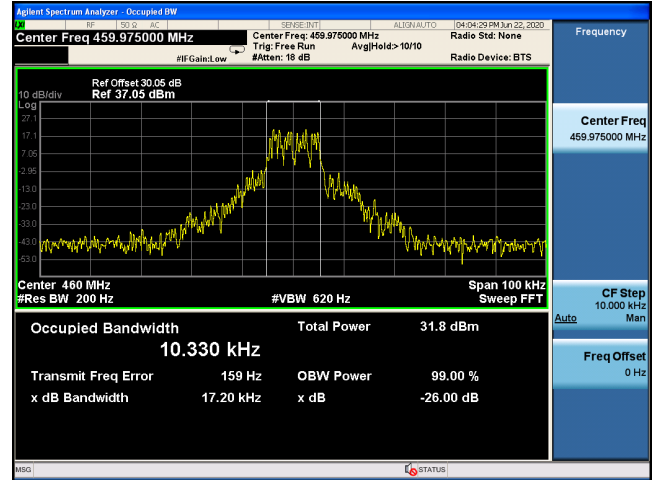
30 °C

QPSK

459.675MHz

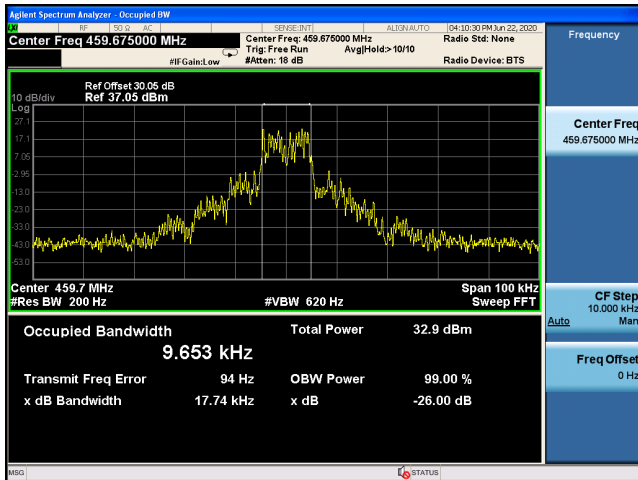


459.975MHz

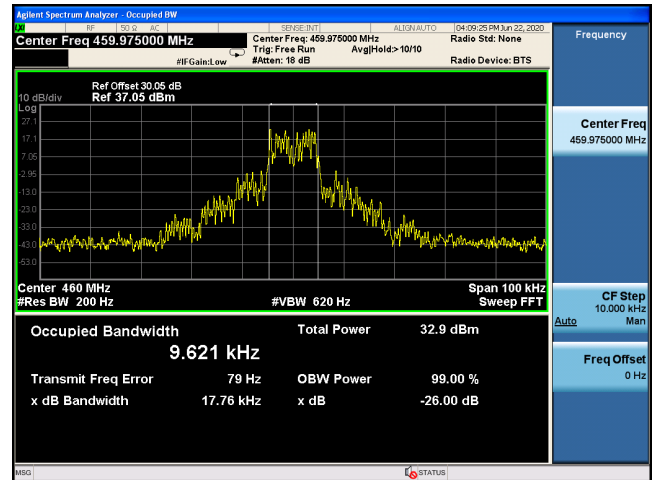


16QAM

459.675MHz



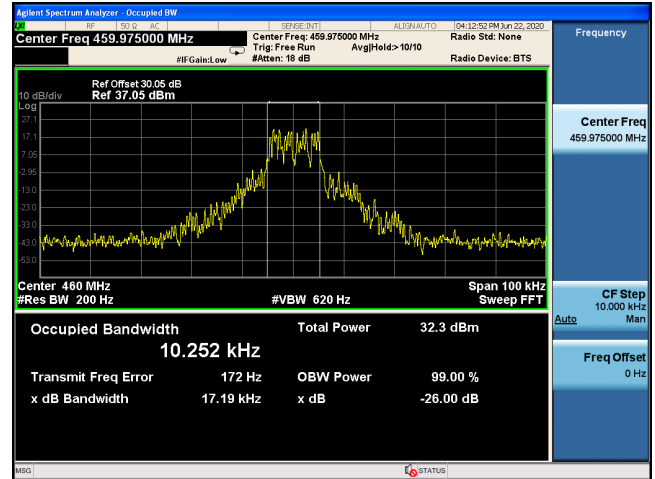
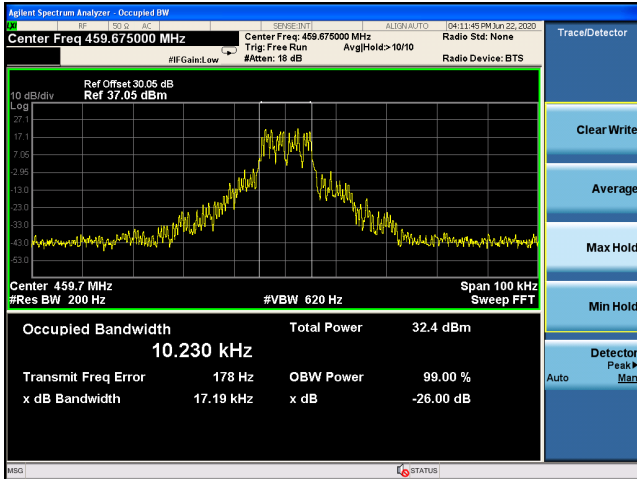
459.975MHz



64QAM

459.675MHz

459.975MHz

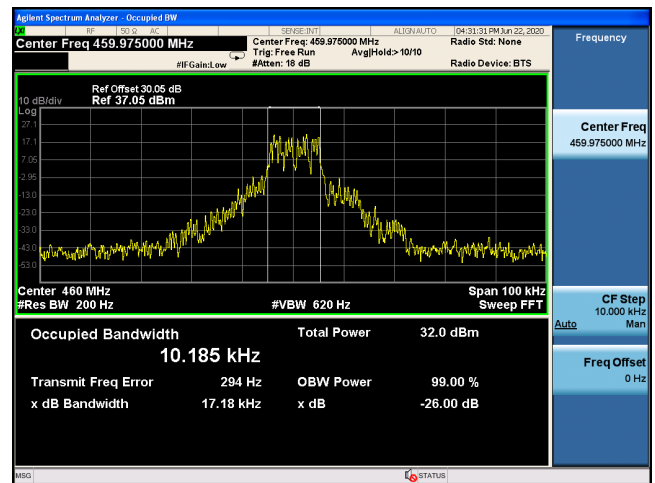
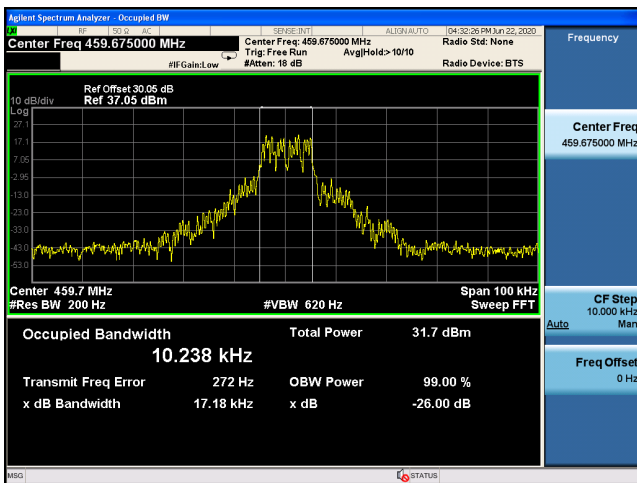


40 °C

QPSK

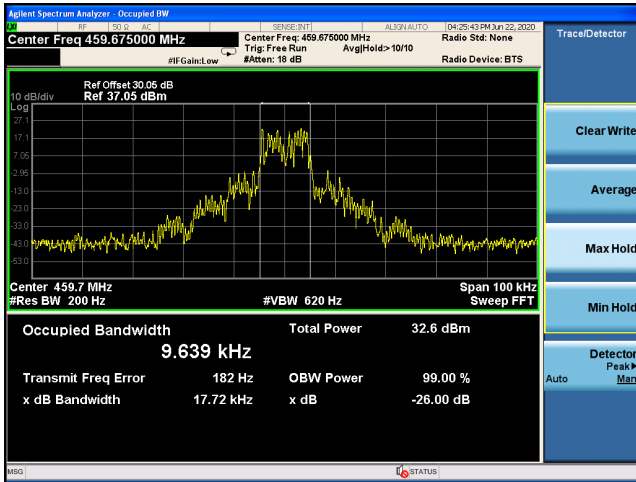
459.675MHz

459.975MHz

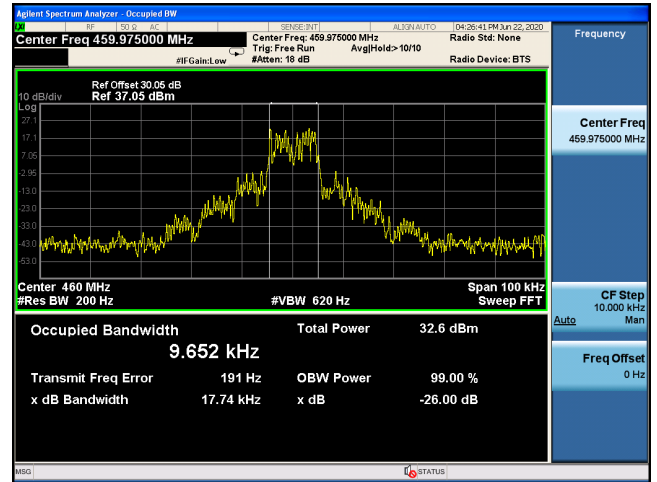


16QAM

459.675MHz

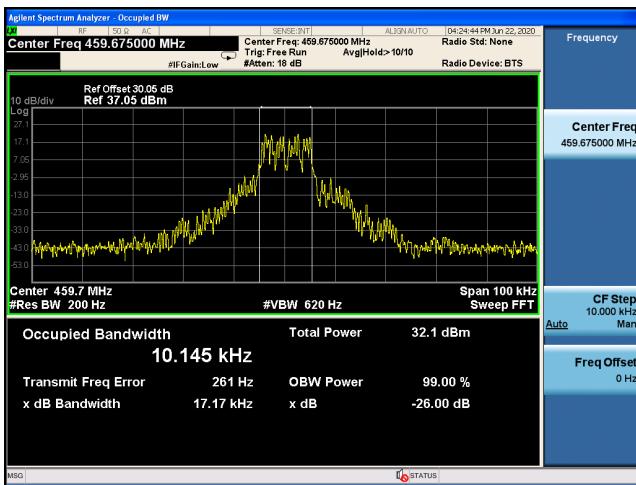


459.975MHz

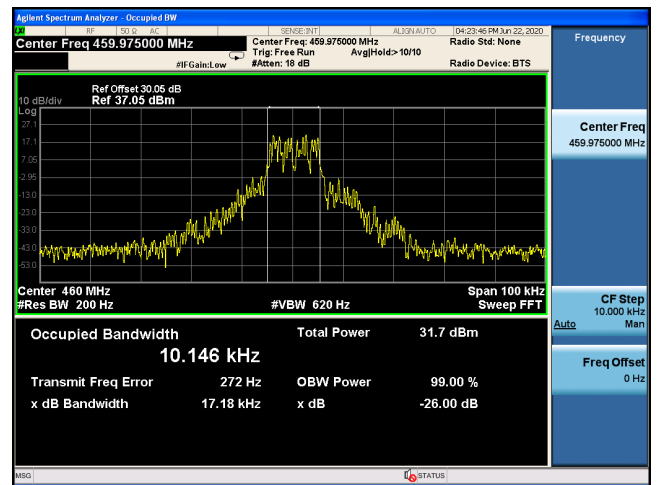


64QAM

459.675MHz



459.975MHz

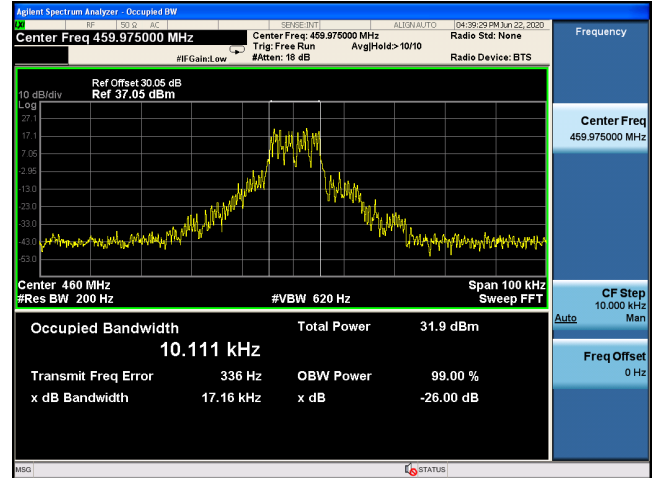
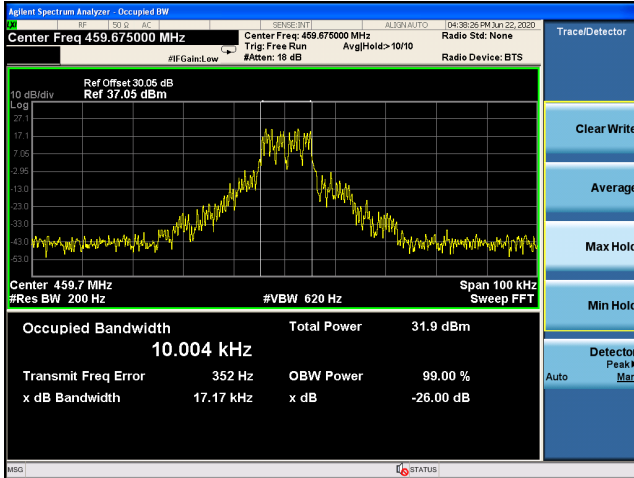


50 °C

QPSK

459.675MHz

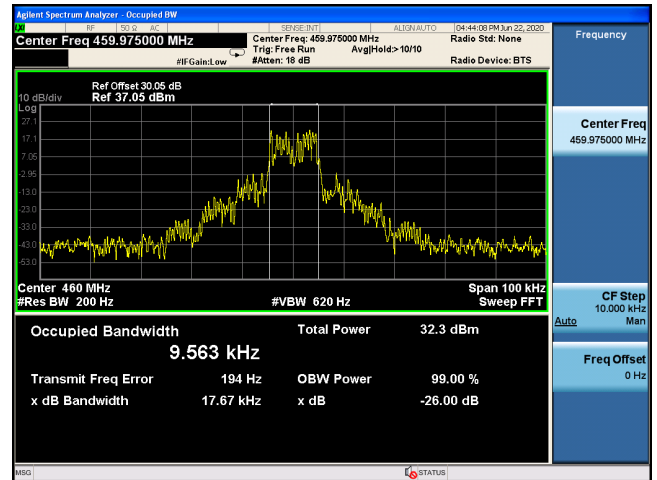
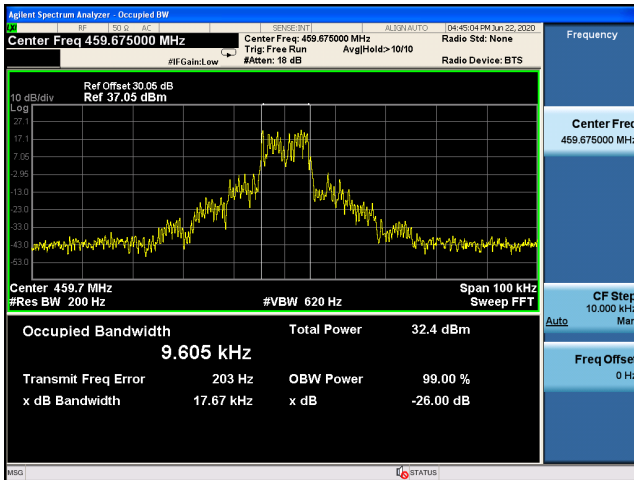
459.975MHz



16QAM

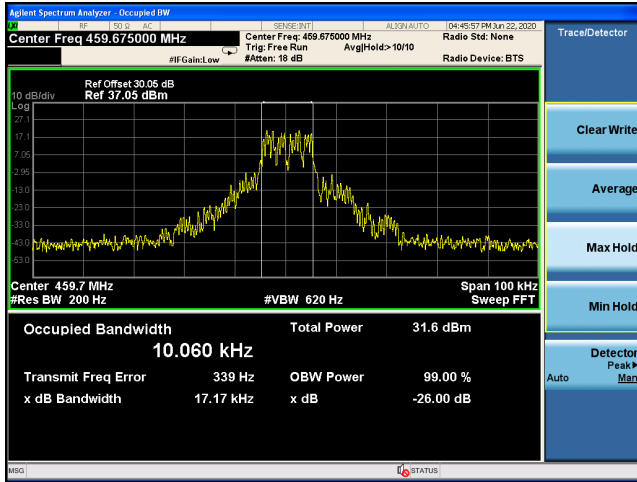
459.675MHz

459.975MHz

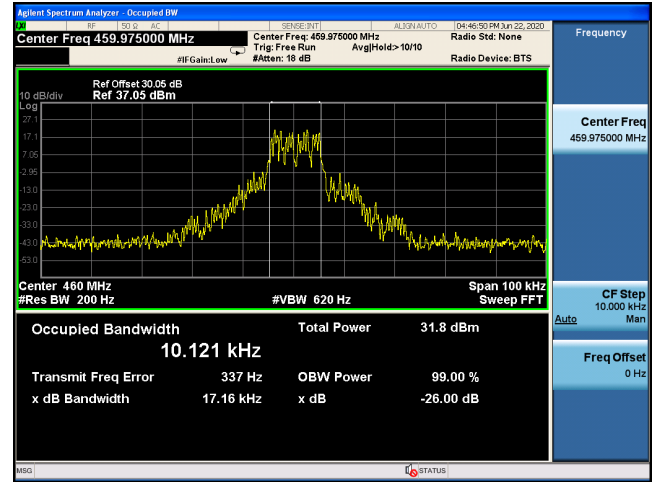


64QAM

459.675MHz



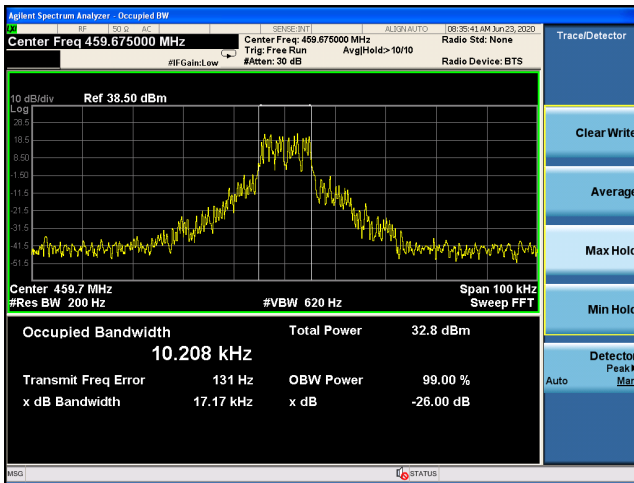
459.975MHz



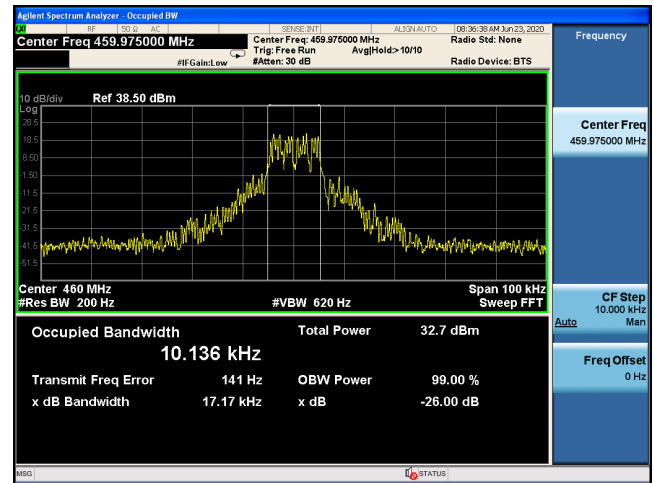
Low Voltage (20.4 V)

QPSK

459.675MHz

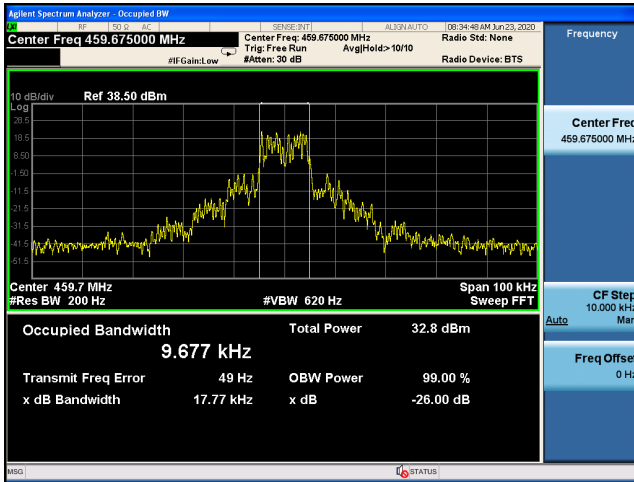


459.975MHz

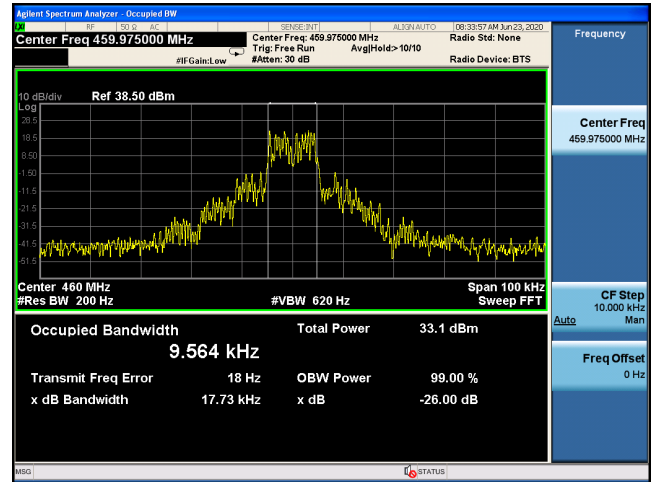


16QAM

459.675MHz

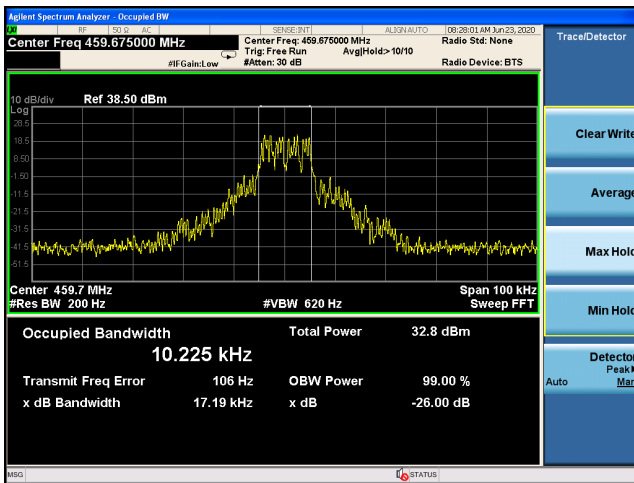


459.975MHz

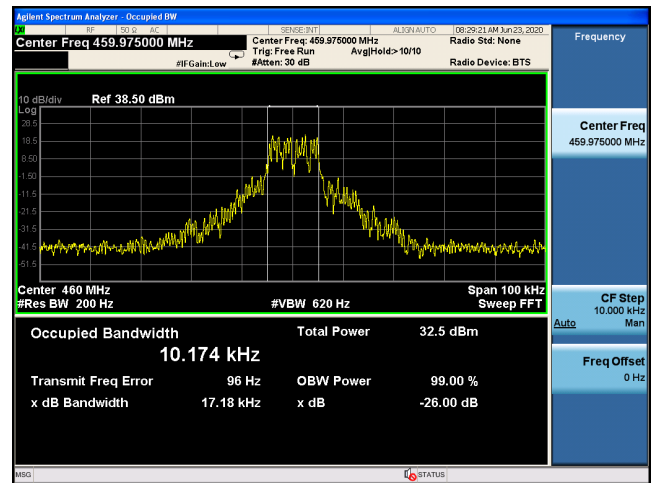


64QAM

459.675MHz



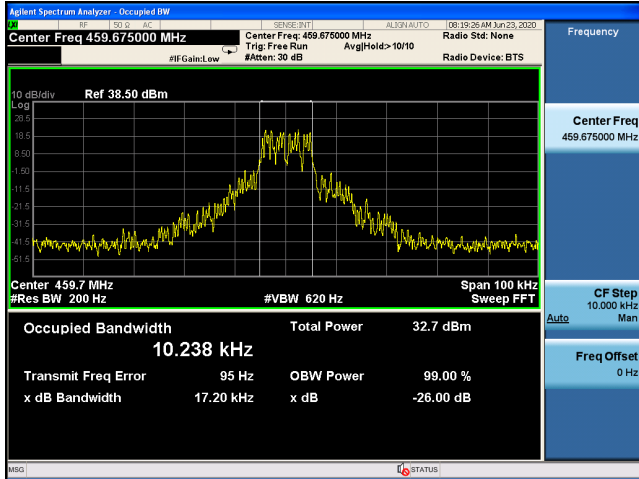
459.975MHz



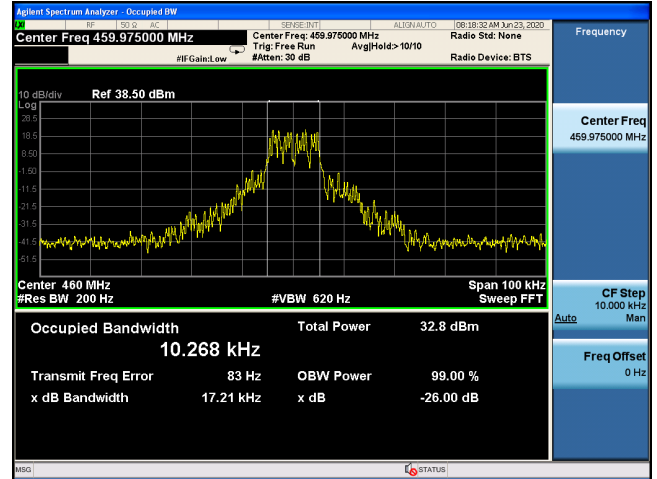
High Voltage (27.6 V)

QPSK

459.675MHz

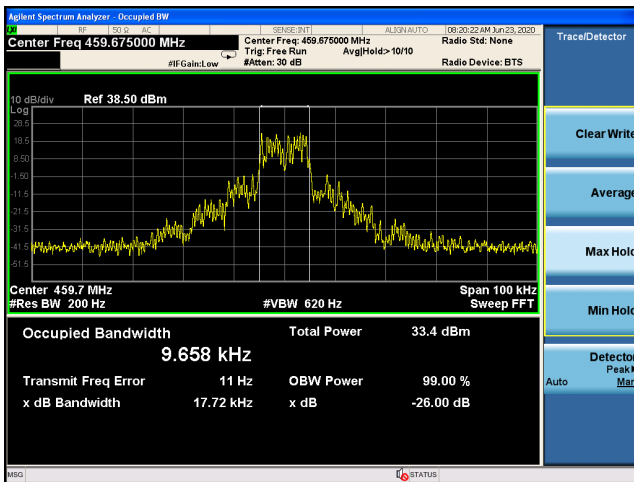


459.975MHz

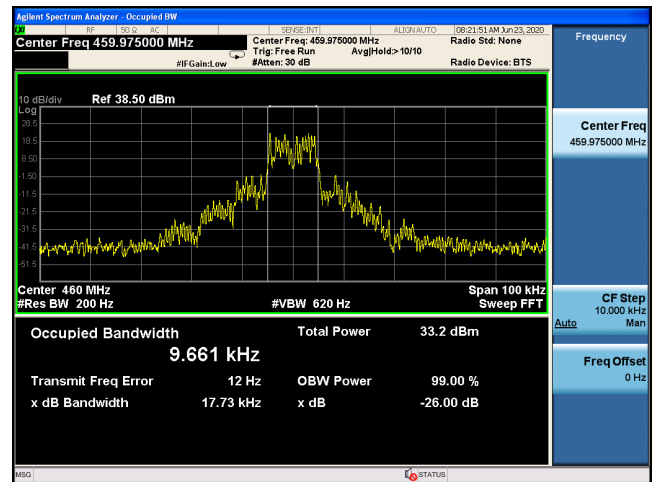


16QAM

459.675MHz

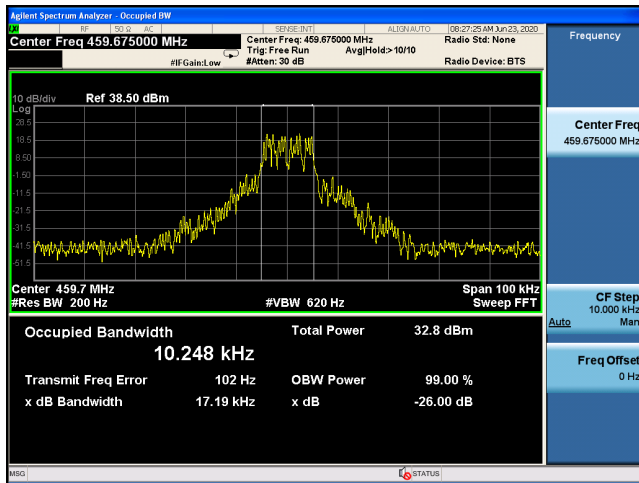


459.975MHz

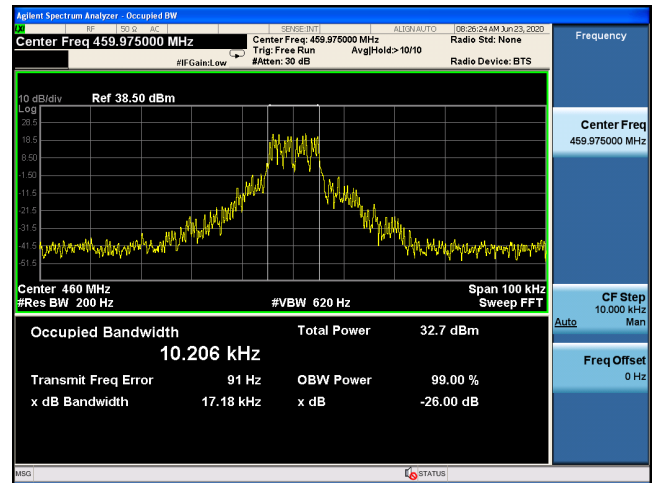


64QAM

459.675MHz



459.975MHz



10 Annex A (Normative) - EUT Setup Photographs

Please refer to the attachment

11 Annex B (Normative) – EUT External Photographs

Please refer to the attachment

12 Annex C (Normative) – EUT Internal Photographs

Please refer to the attachment

13 Annex D (Normative) – A2LA Electrical Testing Certificate



Accredited Laboratory

A2LA has accredited

BAY AREA COMPLIANCE LABORATORIES CORP.

Sunnyvale, CA

for technical competence in the field of

Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 General requirements for the competence of testing and calibration laboratories. This laboratory also meets A2LA R222 - Specific Requirements EPA ENERGY STAR Accreditation Program. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).



Presented this 2nd day of October 2018.

A handwritten signature in blue ink, appearing to be 'A. ...', written over a horizontal line.

Vice President, Accreditation Services
 For the Accreditation Council
 Certificate Number 3297.02
 Valid to September 30, 2020
 Revised June 5, 2019

For the tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.

Please follow the web link below for a full ISO 17025 scope

<https://www.a2la.org/scopepdf/3297-02.pdf>

--- END OF REPORT ---