



FCC PART 22G

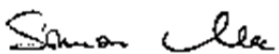
TEST REPORT

For

Ondas Networks Inc.

165 Gibraltar Court, Sunnyvale, CA 94089, USA

FCC ID: X27-MA22G-1

Report Type: Original Report	Product Type: Base Station
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Report Number: R2004231	
Report Date: 2020-07-24	
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* This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk "*" (Rev.3)

TABLE OF CONTENTS

1	GENERAL INFORMATION	5
1.1	PRODUCT DESCRIPTION FOR EQUIPMENT UNDER TEST (EUT).....	5
1.2	MECHANICAL DESCRIPTION	5
1.3	OBJECTIVE.....	5
1.4	RELATED SUBMITTAL(S)/GRANT(S).....	5
1.5	TEST METHODOLOGY	5
1.6	MEASUREMENT UNCERTAINTY.....	6
1.7	TEST FACILITY REGISTRATIONS	6
1.8	TEST FACILITY ACCREDITATIONS.....	7
2	SYSTEM TEST CONFIGURATION	9
2.1	JUSTIFICATION	9
2.2	EUT EXERCISE SOFTWARE.....	9
2.3	EQUIPMENT MODIFICATIONS	9
2.4	REMOTE SUPPORT EQUIPMENT LIST AND DETAILS.....	9
2.5	POWER SUPPLY AND LINE FILTERS.....	9
2.6	INTERFACE PORTS AND CABLING	9
3	SUMMARY OF TEST RESULTS.....	10
4	FCC §1.1307(B) (1) & §2.1091 - RF EXPOSURE	11
4.1	APPLICABLE STANDARDS	11
4.2	MPE PREDICTION	11
4.3	TEST RESULTS	12
5	FCC §2.1046 & §22.809 - RF OUTPUT POWER	13
5.1	APPLICABLE STANDARDS	13
5.2	TEST PROCEDURE	13
5.3	TEST EQUIPMENT LIST AND DETAILS	13
5.4	TEST ENVIRONMENTAL CONDITIONS.....	13
5.5	TEST RESULTS	14
6	FCC §2.1049, §22.805 - OCCUPIED BANDWIDTH.....	20
6.1	APPLICABLE STANDARDS	20
6.2	TEST PROCEDURE	20
6.3	TEST EQUIPMENT LIST AND DETAILS	20
6.4	TEST ENVIRONMENTAL CONDITIONS.....	20
6.5	TEST RESULTS	21
7	FCC §2.1053 & §22.861 - SPURIOUS RADIATED EMISSIONS.....	27
7.1	APPLICABLE STANDARDS	27
7.2	TEST PROCEDURE	27
7.3	TEST EQUIPMENT LIST AND DETAILS	28
7.4	TEST ENVIRONMENTAL CONDITIONS.....	28
7.5	TEST RESULTS	29
8	FCC §2.1051 & §22.861 - SPURIOUS EMISSIONS AT ANTENNA TERMINALS.....	31
8.1	APPLICABLE STANDARDS	31
8.2	TEST PROCEDURE	31
8.3	TEST EQUIPMENT LIST AND DETAILS	31
8.4	TEST ENVIRONMENTAL CONDITIONS.....	32
8.5	TEST RESULTS	32
9	FCC §2.1055 & §22.863 - FREQUENCY STABILITY	39
9.1	APPLICABLE STANDARD	39

9.2 TEST PROCEDURE39

9.3 TEST EQUIPMENT LIST AND DETAILS40

9.4 TEST ENVIRONMENTAL CONDITIONS.....40

9.5 TEST RESULTS41

10 ANNEX A (NORMATIVE) - EUT SETUP PHOTOGRAPHS.....74

11 ANNEX B (NORMATIVE) - EUT EXTERNAL PHOTOGRAPHS.....75

12 ANNEX C (NORMATIVE) - EUT INTERNAL PHOTOGRAPHS.....76

13 ANNEX D (NORMATIVE) - A2LA ELECTRICAL TESTING CERTIFICATE.....77

DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R2004231	Original	2020-06-29
1	R2004231	Updated TCB comments	2020-07-24

1 General Information

1.1 Product Description for Equipment under Test (EUT)

This test and measurement report was prepared on behalf of *Ondas Networks*, and their product model: Mars, FCC ID: X27-MA22G-1, which will henceforth be referred to as the EUT (Equipment under Test). The EUT is a ground station transmitter and operates in the frequency range of 454.675-454.975 MHz.

1.2 Mechanical Description

The EUT measured approximately 34 cm (L) x 45 cm (W) x 9 cm (H) and weighs 7.5kg

The test data gathered are from typical production sample, BACL assigned serial number: R2004231-1

1.3 Objective

This type approval report was prepared on behalf of *Ondas Networks*. in accordance with FCC 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

BACLs 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 - ISED) 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:
 - 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	DC Power Supply	RSP-500-48	-

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
§2.1091	RF Exposure	Compliant
§2.1046, §22.809	Effective Radiated 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	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 Occupational/Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm ²)	Averaging Time (minute)
Limits for Occupational/Controlled Exposure				
0.3-1.34	614	1.63	*100	30
1.34-30	1842/f	4.89/f	*900/f ²	30
30-300	61.4	0.163	1.0	30
300-1500			f/300	30
1500-100,000			5	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>47</u>
<u>Maximum average output power at antenna input terminal (mW):</u>	<u>50118.7</u>
<u>Prediction frequency (MHz):</u>	<u>454.675</u>
<u>Antenna Gain, typical (dBi):</u>	<u>0</u>
<u>Maximum Antenna Gain (numeric):</u>	<u>1</u>
<u>Prediction distance (cm):</u>	<u>51.22</u>

The average output power was derived from the maximum peak turn-up power (50 dBm) and duty cycle (50%).
The average output power = peak output power – 10*log(1/duty cycle).

Results

In order to pass the controlled exposure limit of 1.52 mW/cm² with the maximum turn-up power being 50 dBm, 50% duty cycle, and antenna gain of 0 dBi, the EUT must have a separation distance of at least 51.22 cm.

5 FCC §2.1046 & §22.809 - RF Output Power

5.1 Applicable Standards

According to FCC §22.809 (a), the effective radiated power of ground stations must not exceed 100 Watts and must not be less than 50 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 02 October 2018) "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 2020-07-17 in the RF Site.

5.5 Test Results

Modulation	Frequency (MHz)	Output Power (dBm)	Gain (dBi)	ERP (dBm)	Limit (dBm)	Margin (dB)
QPSK	454.675	49.608	0	47.458	50	-2.542
	454.825	49.641	0	47.491	50	-2.509
	454.975	49.596	0	47.446	50	-2.554
16QAM	454.675	49.475	0	47.325	50	-2.675
	454.825	49.648	0	47.498	50	-2.502
	454.975	49.626	0	47.476	50	-2.524
64QAM	454.675	49.749	0	47.599	50	-2.401
	454.825	49.507	0	47.357	50	-2.643
	454.975	49.646	0	47.496	50	-2.504

ERP (dBm) = Output Power (dBm) + Antenna Gain (dBi) – 2.15 (dB)

Please refer to the following plots.

QPSK

454.675 MHz



454.825 MHz



454.975 MHz

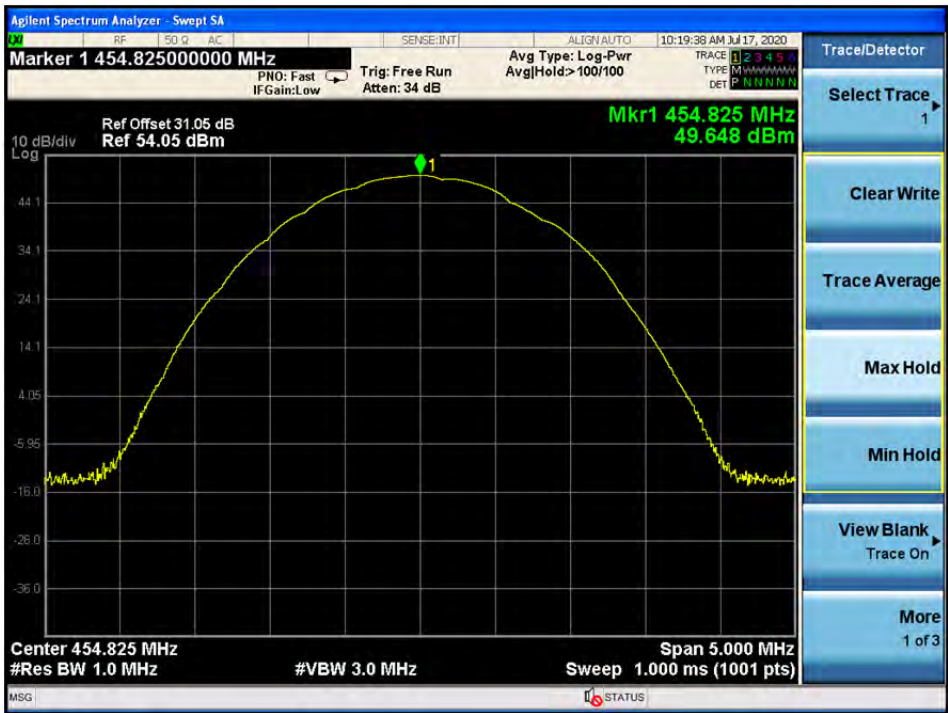


16QAM

454.675 MHz



454.825 MHz



454.975 MHz



64QAM

454.675 MHz



454.825 MHz



454.975 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 02 October 2018) "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 2020-05-26 in the RF Site.

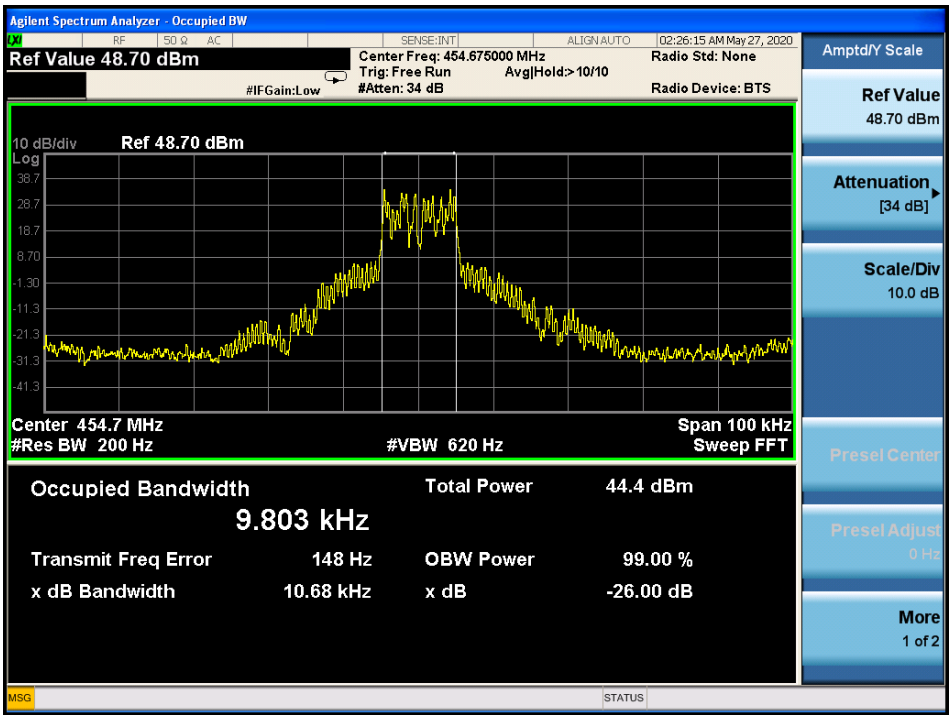
6.5 Test Results

Modulation	Channel Frequency (MHz)	99% OBW (kHz)	26dB Bandwidth (kHz)	26dB Bandwidth Limit (kHz)
QPSK	454.675	9.803	10.68	< 20
	454.825	9.796	10.68	< 20
	454.975	9.798	10.67	< 20
16QAM	454.675	9.600	10.52	< 20
	454.825	9.579	10.49	< 20
	454.975	9.593	10.51	< 20
64QAM	454.675	9.888	13.57	< 20
	454.825	9.874	13.58	< 20
	454.975	9.894	12.15	< 20

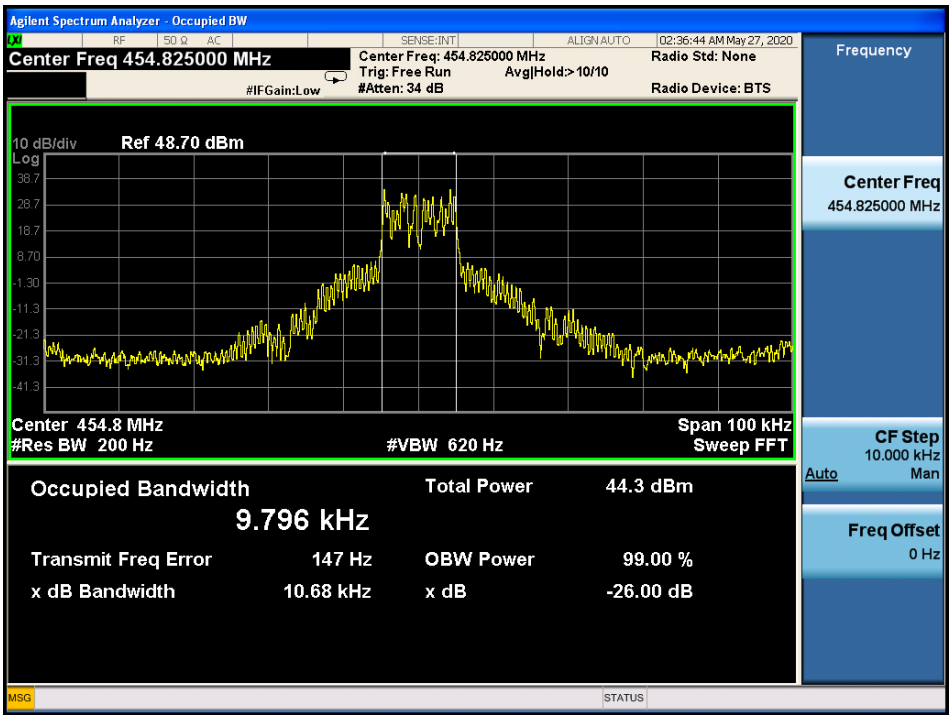
Please refer to the following plots.

QPSK

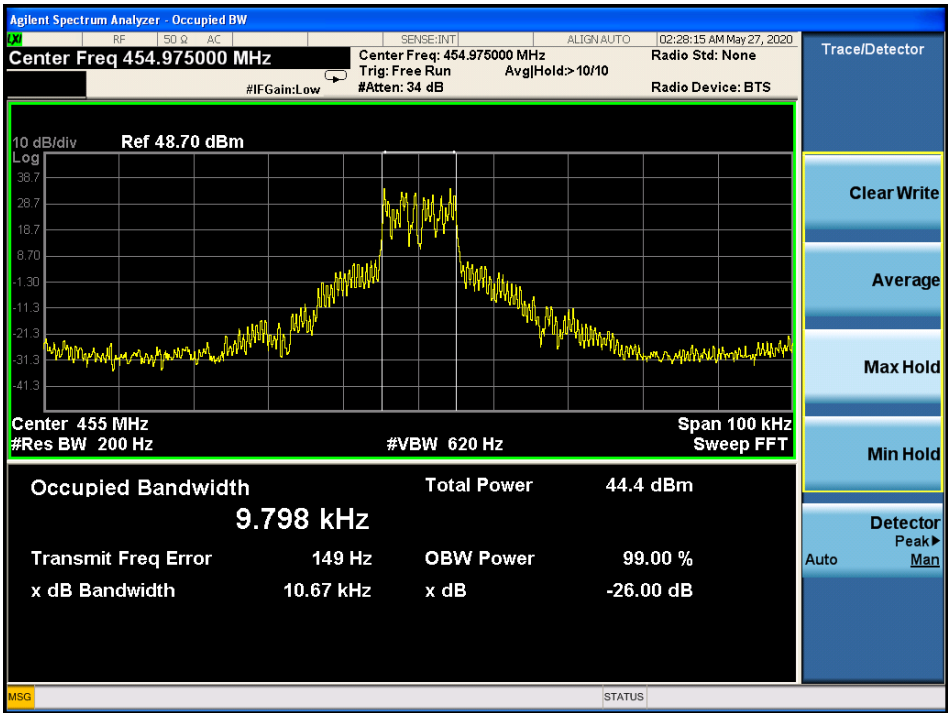
454.675 MHz



454.825 MHz



454.975 MHz

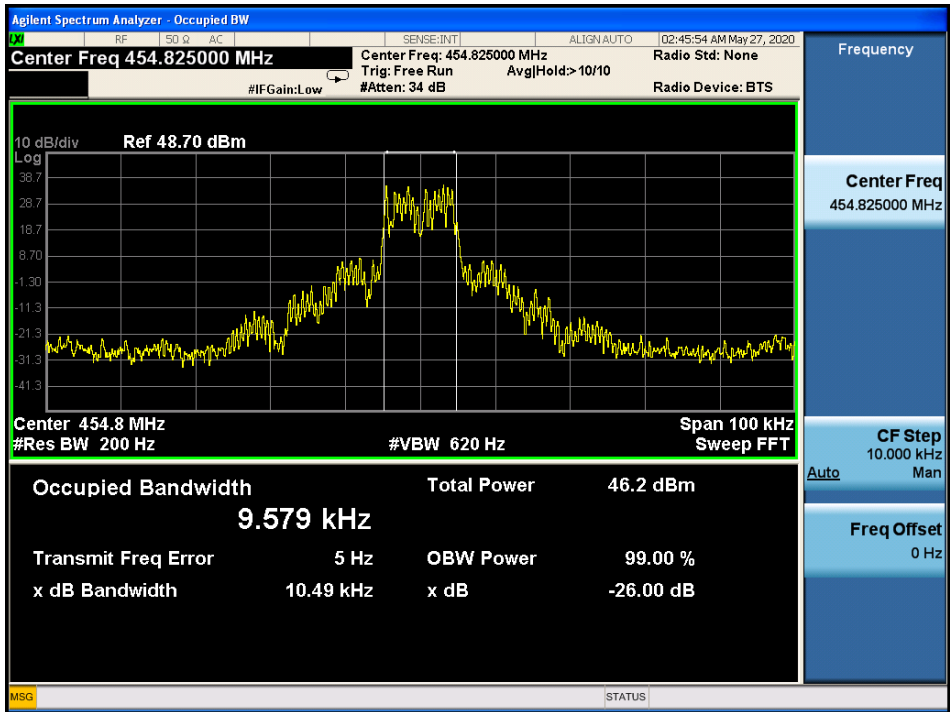


16QAM

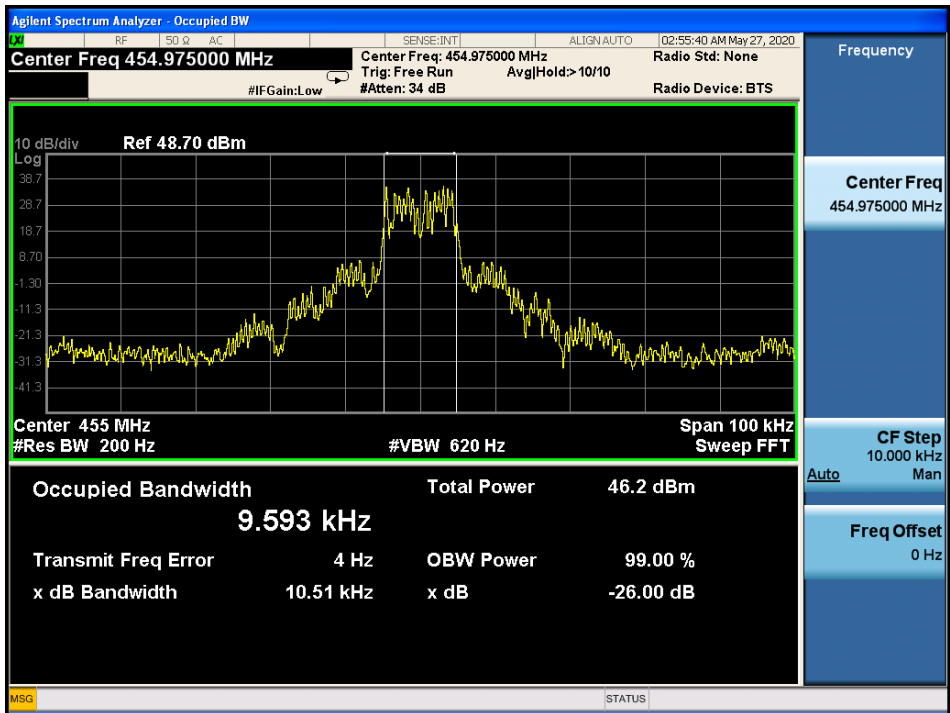
454.675 MHz



454.825 MHz

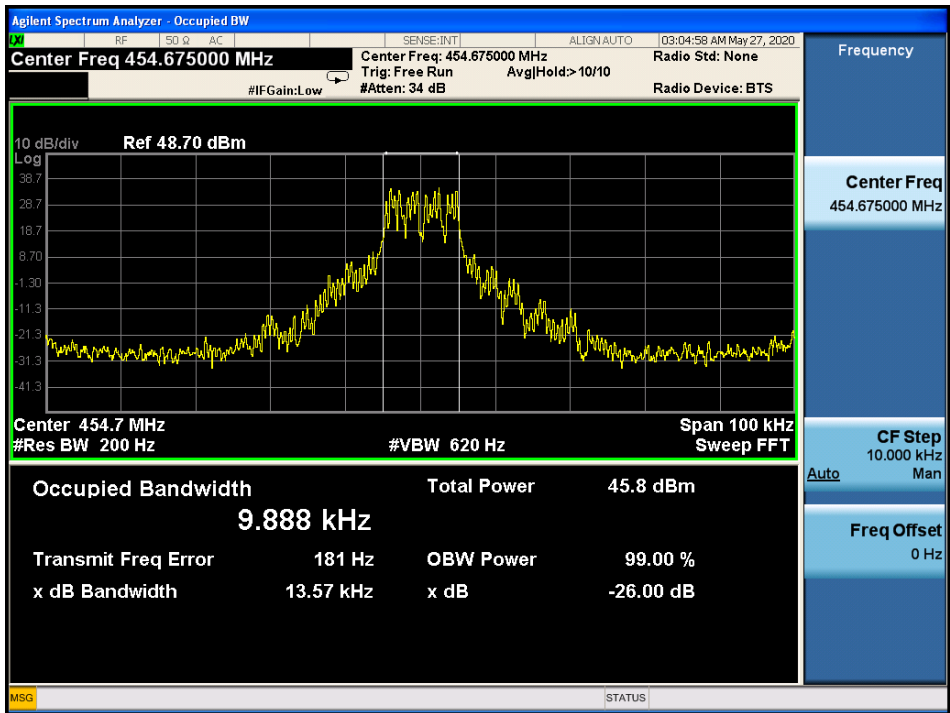


454.975 MHz

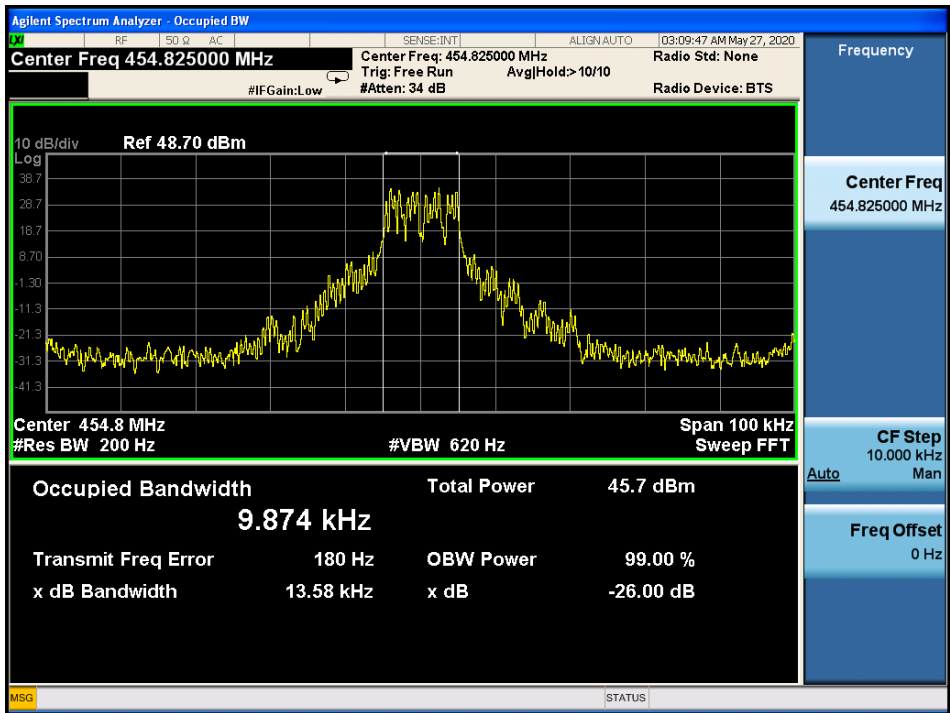


64QAM

454.675 MHz



454.825 MHz



Agilent Spectrum Analyzer - Occupied BW

Center Freq 454.97500 MHz

Trig: Free Run

Avg/Hold: > 10/10

Radio Device: BTS

#IFGain: Low

#Atten: 34 dB

03:03:30 AM May 27, 2020

Trace/Detector

Clear Write

Average

Max Hold

Min Hold

Detector Peak

Auto

MSG

STATUS

10 dB/div

Ref 48.70 dBm

Log

Center 455 MHz

#Res BW 200 Hz

#VBW 620 Hz

Span 100 kHz

Sweep FFT

Occupied Bandwidth

9.894 kHz

Total Power

45.7 dBm

Transmit Freq Error

182 Hz

OBW Power

99.00 %

x dB Bandwidth

12.15 kHz

x dB

-26.00 dB

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 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 UltraFlex Coaxial Cable 35'	LMR400UF	BACL1904161	2020-05-20	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 02 October 2018) "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 2020-05-27 in 5 Meter Chamber 3.

7.5 Test Results

Middle channel (454.825 MHz) was tested

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 (dBd/dBi)	Cable Loss (dB)	Absolute Level (dBm)		
400.3	71.15	120	125	H	400.3	-32.97	1.8	2.2	-33.37	-13	-20.37
400.3	69.41	292	100	V	400.3	-32.51	1.8	2.2	-32.91	-13	-19.91
909.65	57.4	120	102	H	909.65	-34.79	3.6	3.34	-34.53	-13	-21.53
909.65	53.75	346	107	V	909.65	-38.35	3.6	3.34	-38.09	-13	-25.09
1364.5	79.95	130	158	H	1364.5	-29.6	7.992	0.9	-22.508	-13	-9.508
1364.5	79.19	115	100	V	1364.5	-28.6	7.992	0.9	-21.508	-13	-8.508
2401.8	56.5	10	175	H	2401.8	-47.02	8.939	1.96	-40.041	-13	-27.041
2401.8	56.41	100	180	V	2401.8	-42.46	8.939	1.96	-35.481	-13	-22.481

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 (dBd/dBi)	Cable Loss (dB)	Absolute Level (dBm)		
400.3	70.86	122	127	H	400.3	-33.26	1.8	2.2	-33.66	-13	-20.66
400.3	69.38	289	100	V	400.3	-32.54	1.8	2.2	-32.94	-13	-19.94
909.65	57.75	124	106	H	909.65	-34.44	3.6	3.34	-34.18	-13	-21.18
909.65	53.39	354	100	V	909.65	-38.71	3.6	3.34	-38.45	-13	-25.45
1364.5	83.41	149	110	H	1364.5	-26.14	7.992	0.9	-19.048	-13	-6.048
1364.5	77.1	98	100	V	1364.5	-30.69	7.992	0.9	-23.598	-13	-10.598
2401.8	54.32	342	130	H	2401.8	-49.2	8.939	1.96	-42.221	-13	-29.221
2401.8	53.96	107	137	V	2401.8	-44.91	8.939	1.96	-37.931	-13	-24.931

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 (dBd/dBi)	Cable Loss (dB)	Absolute Level (dBm)		
400.3	71.04	124	123	H	400.3	-33.08	1.8	2.2	-33.48	-13	-20.48
400.3	69.97	288	100	V	400.3	-31.95	1.8	2.2	-32.35	-13	-19.35
909.65	58.26	130	100	H	909.65	-33.93	3.6	3.34	-33.67	-13	-20.67
909.65	53.64	348	106	V	909.65	-38.46	3.6	3.34	-38.2	-13	-25.2
1364.5	82.4	215	108	H	1364.5	-27.15	7.992	0.9	-20.058	-13	-7.058
1364.5	79.02	318	144	V	1364.5	-28.77	7.992	0.9	-21.678	-13	-8.678
2401.8	56.21	8	292	H	2401.8	-47.31	8.939	1.96	-40.331	-13	-27.331
2401.8	56.19	157	123	V	2401.8	-42.68	8.939	1.96	-35.701	-13	-22.701

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

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.

According to FCC §22.861 (b), 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 02 October 2018) "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 2020-05-26 in the RF Site.

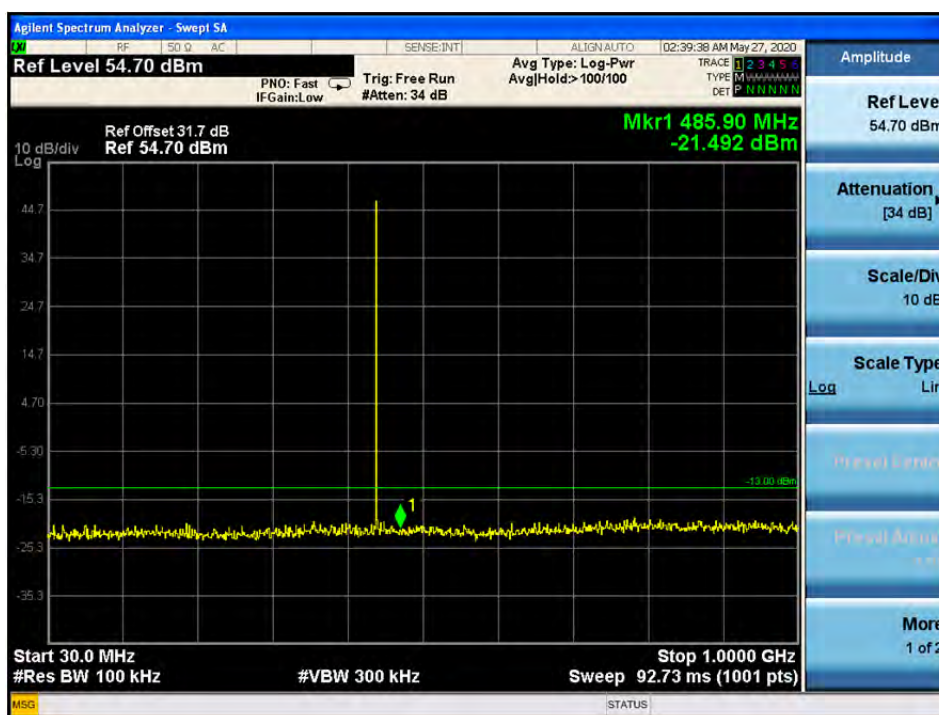
8.5 Test Results

Conducted Spurious Emissions:

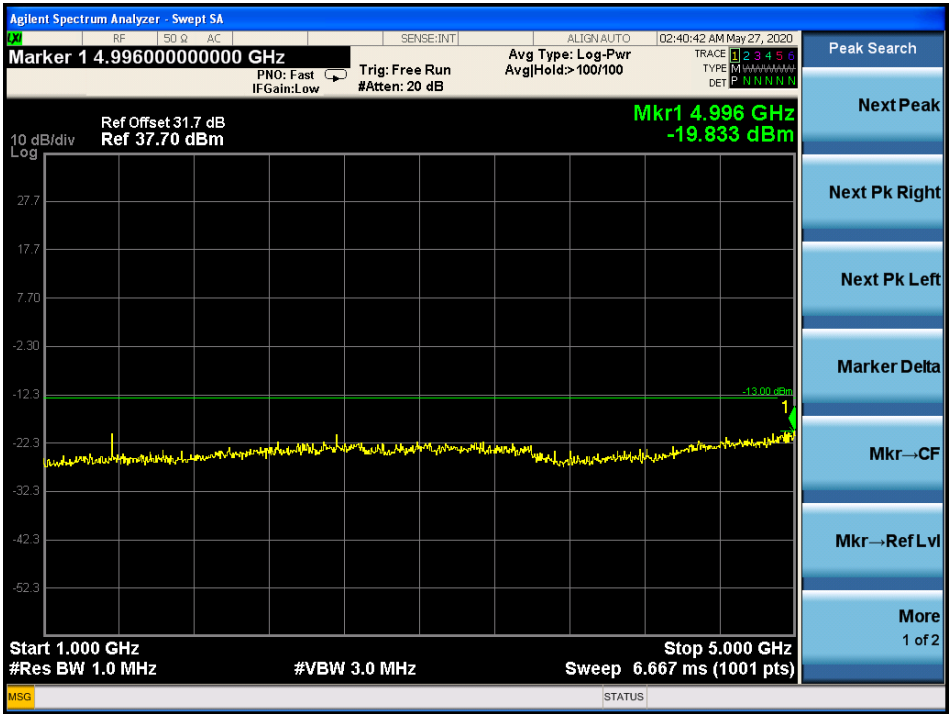
QPSK

454.825 MHz

30 MHz-1GHz



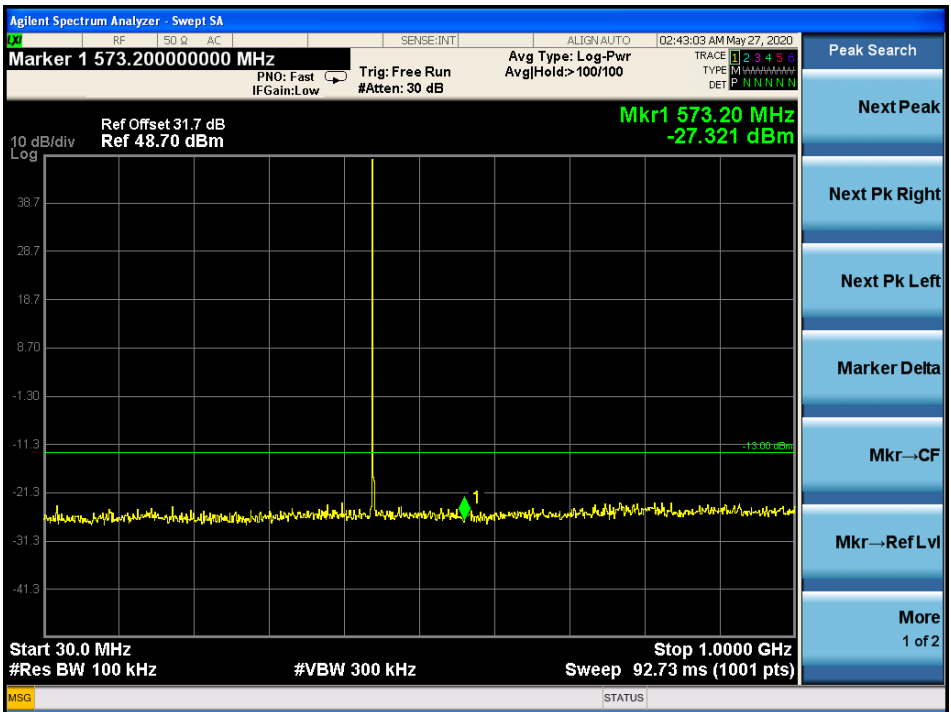
1 GHz-5 GHz



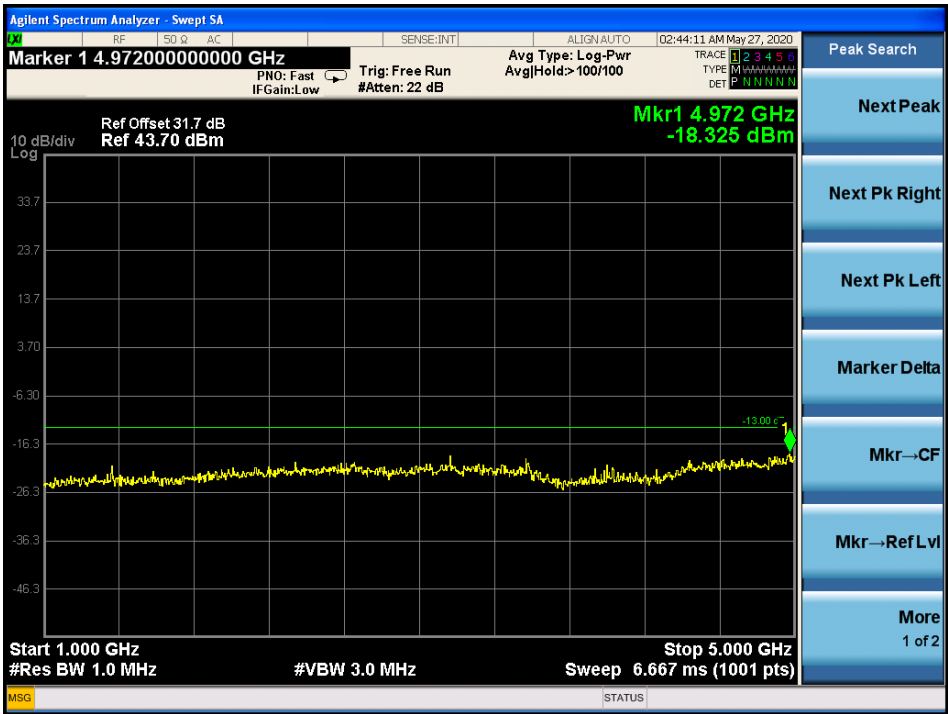
16QAM

454.825 MHz

30 MHz-1 GHz



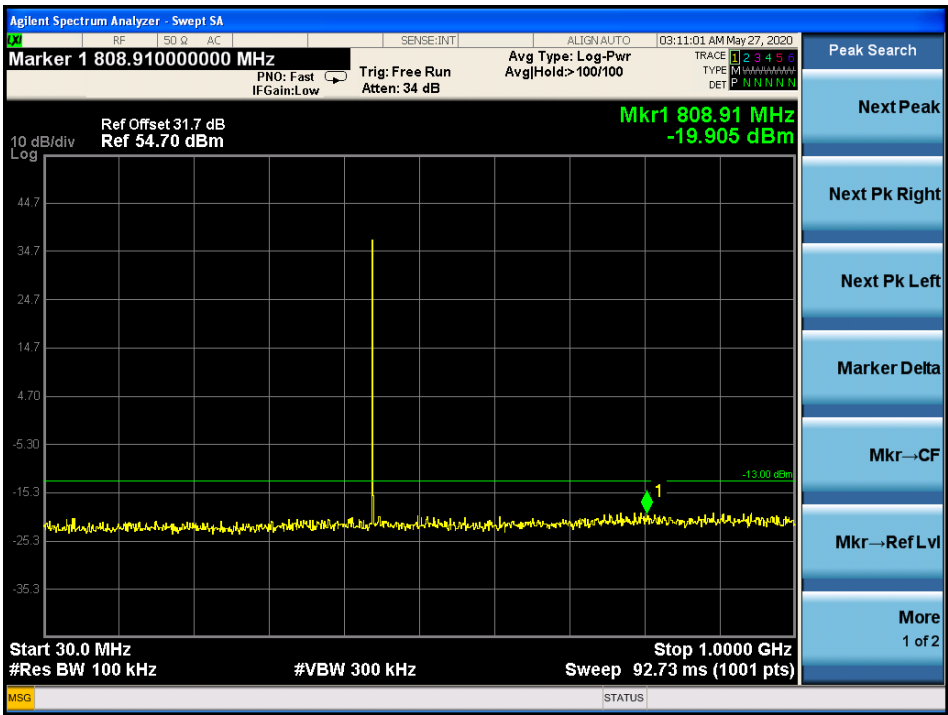
1 GHz-5 GHz



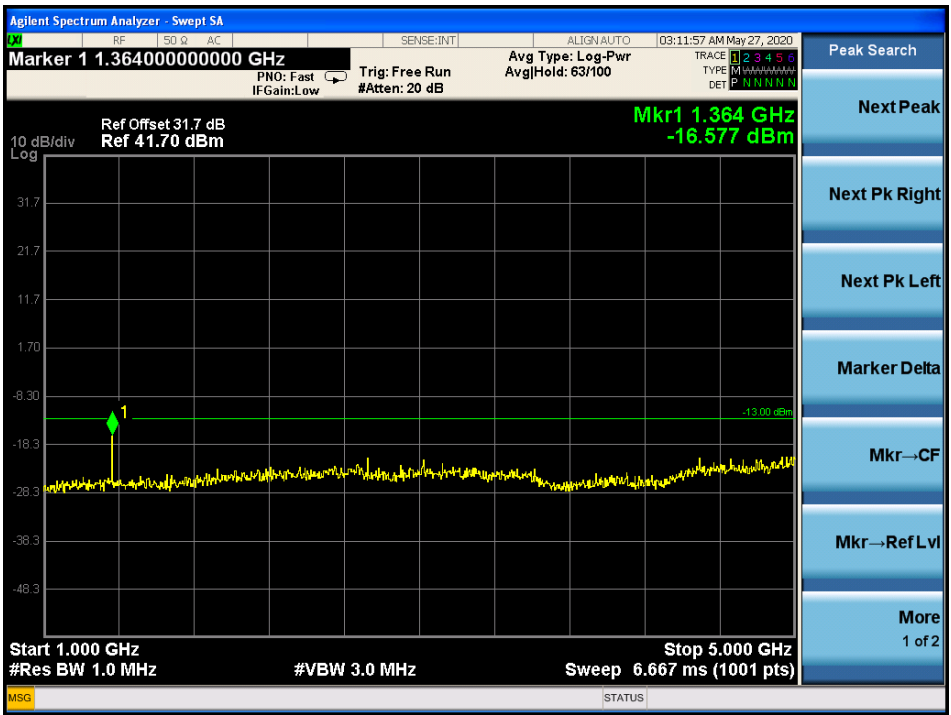
64QAM

454.825 MHz

30 MHz-1GHz



1 GHz-5 GHz



Band-edge

QPSK

454.675 MHz



454.975 MHz



16QAM

454.675 MHz



454.975 MHz



64QAM

454.675 MHz



454.975 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

The 26 dB bandwidth was measured to show the fundamental emissions remain within the authorized frequency bands.

The environmental and supply voltage conditions was applied following the procedures below,

(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 02 October 2018) "A2LA Policy on Metrological Traceability".

9.4 Test Environmental Conditions

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

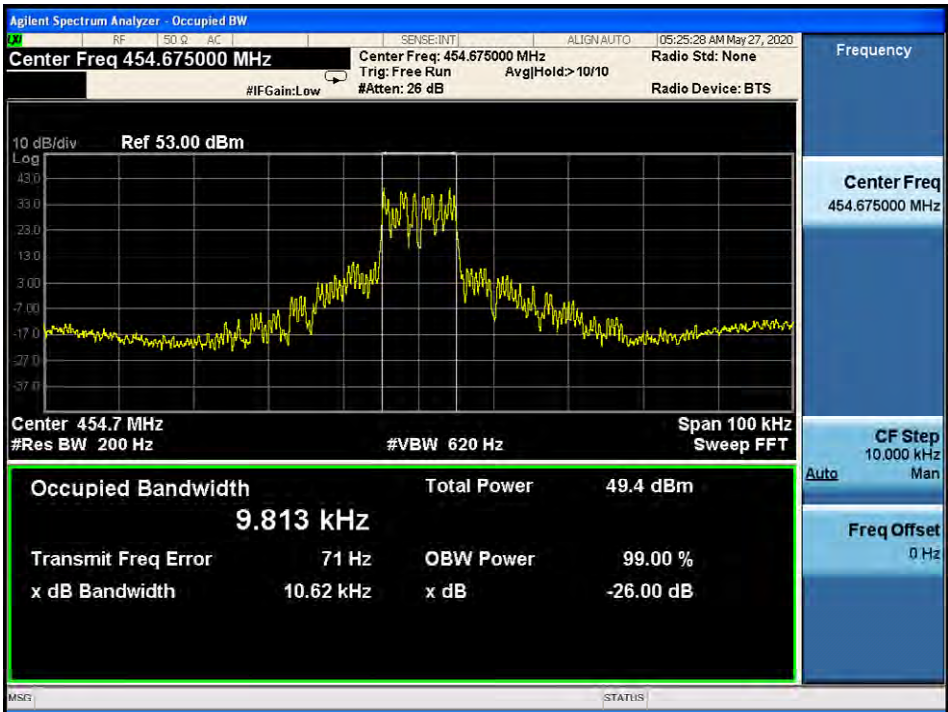
The testing was performed by Christian McCaig from 2020-05-27 to 2020-05-28 in the RF Site.

9.5 Test Results

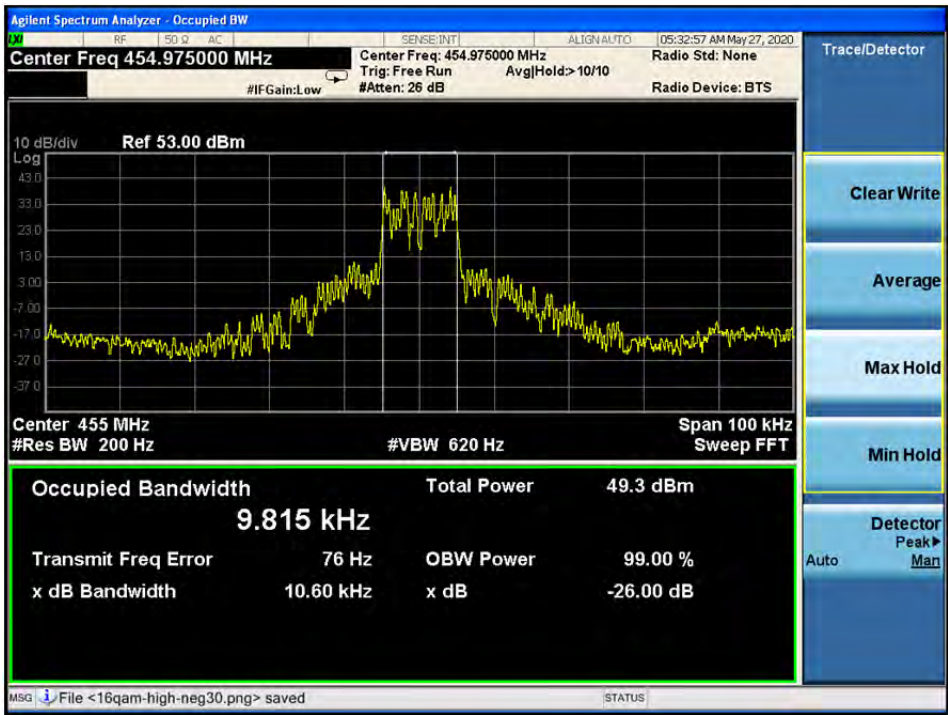
-30 °C

QPSK

454.675 MHz

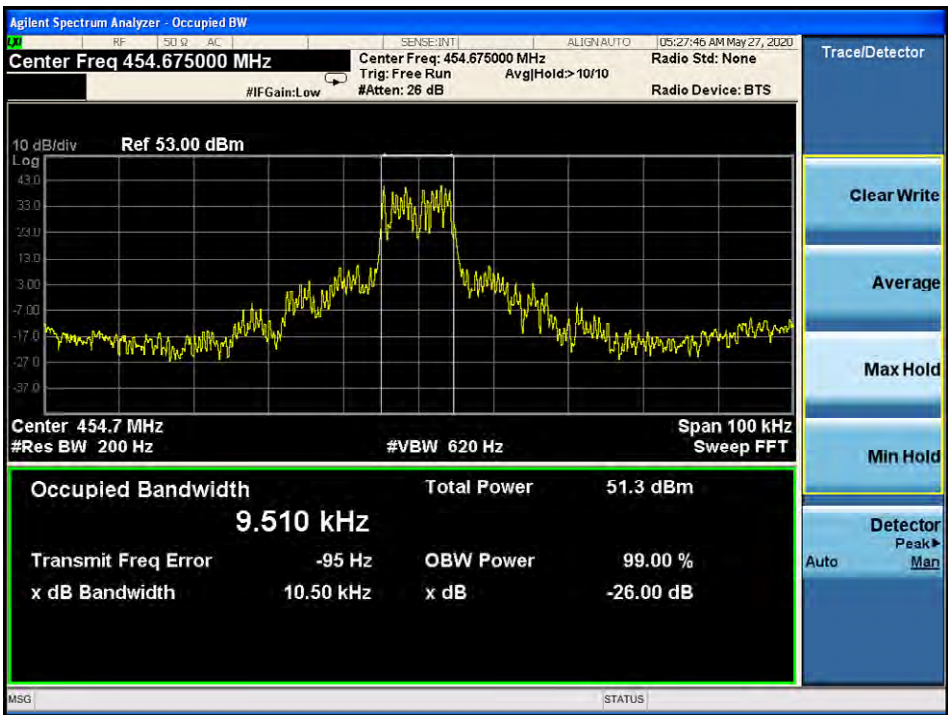


454.975 MHz

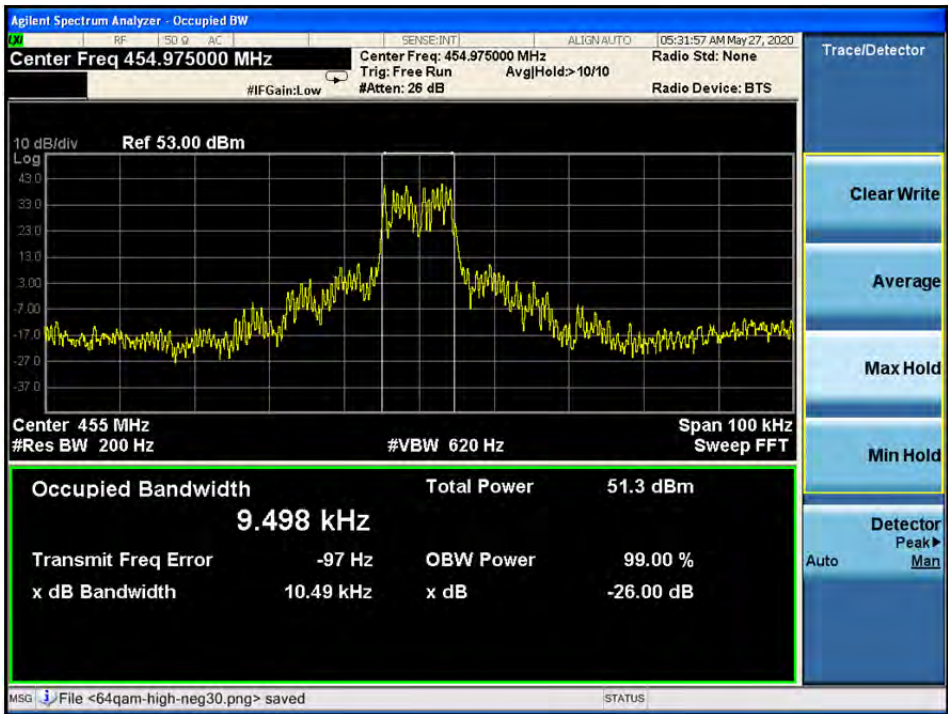


16QAM

454.675 MHz

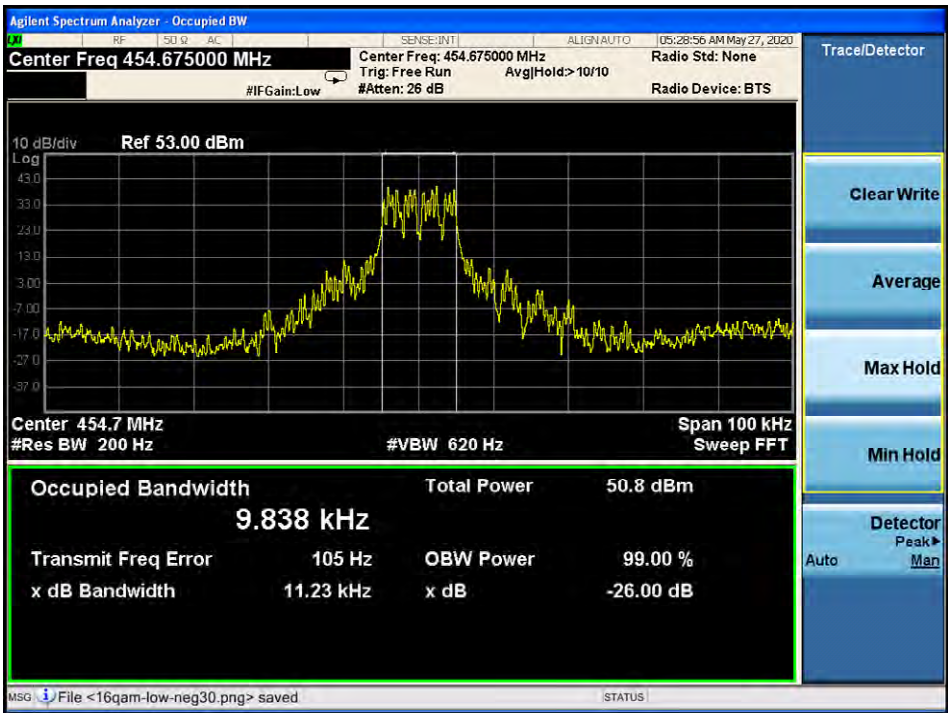


454.975 MHz

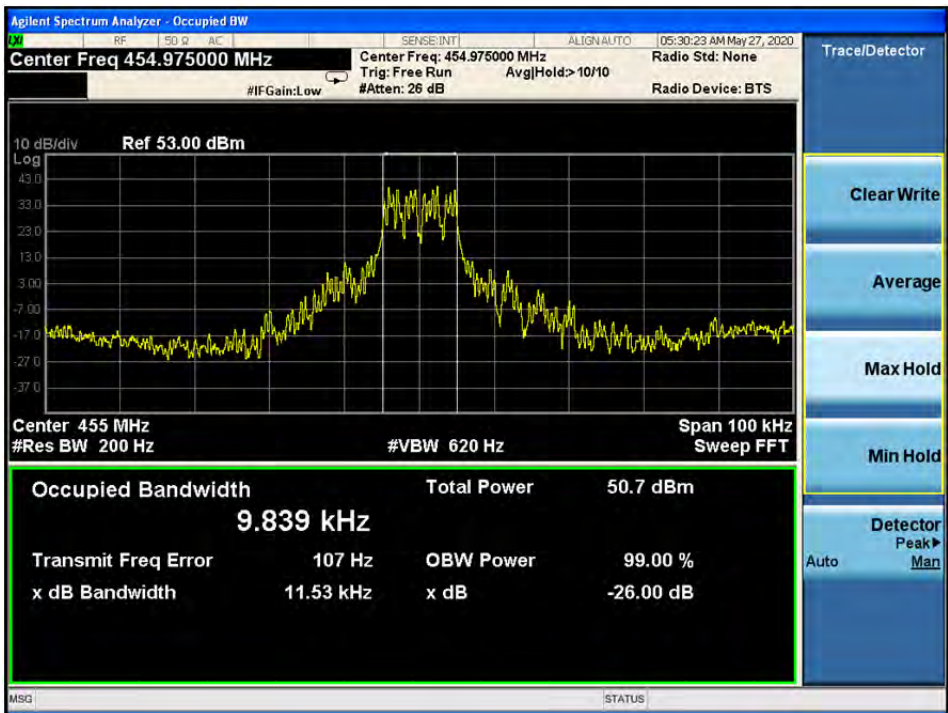


64QAM

454.675 MHz



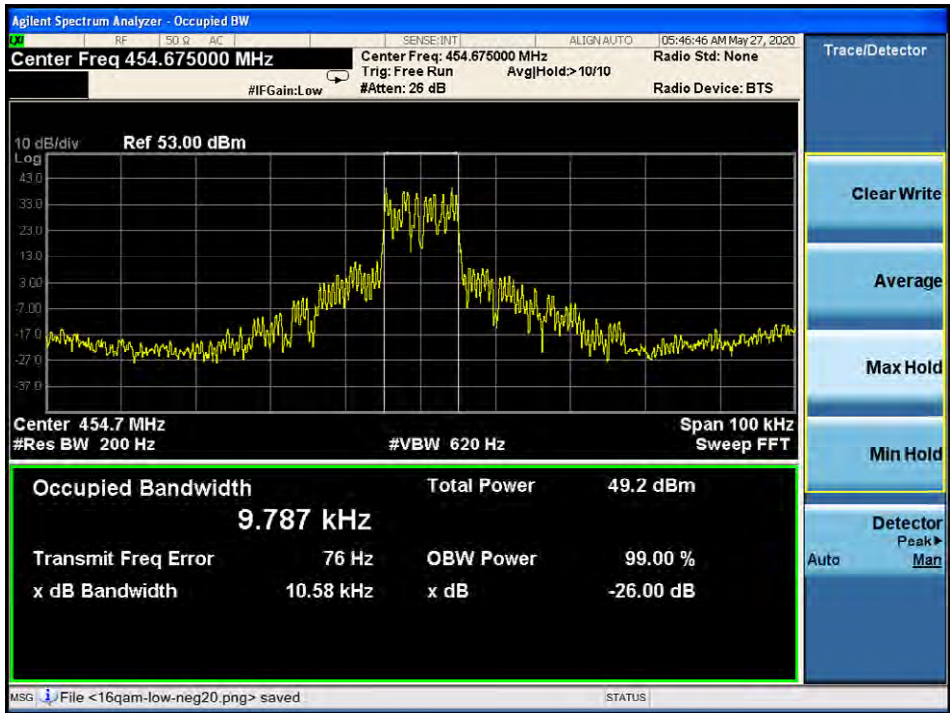
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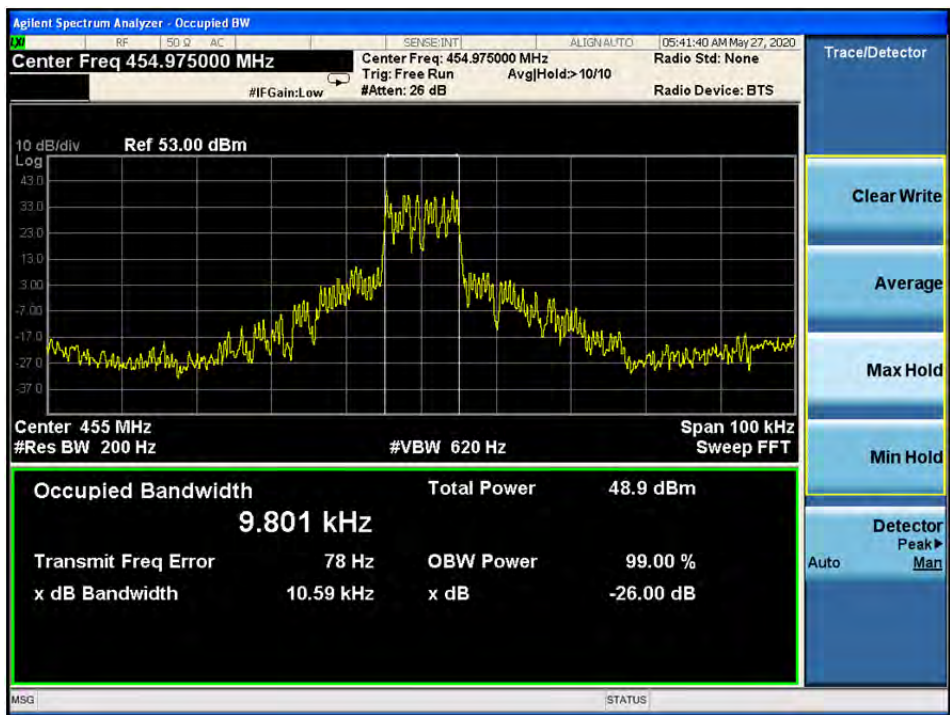
-20 °C

QPSK

454.675 MHz



454.975 MHz



16QAM

454.675 MHz

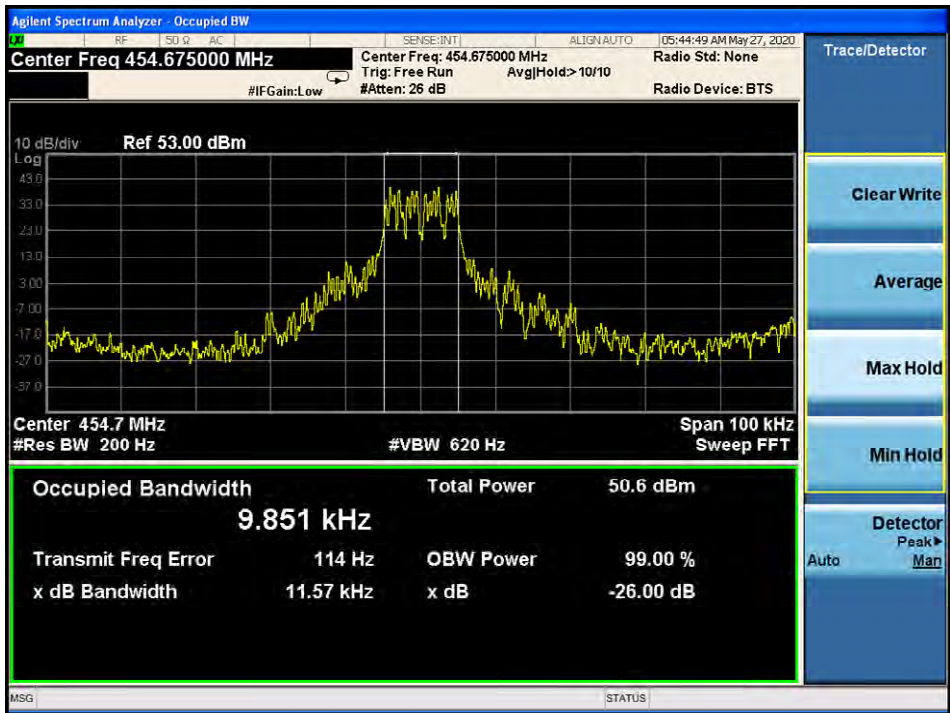


454.975 MHz

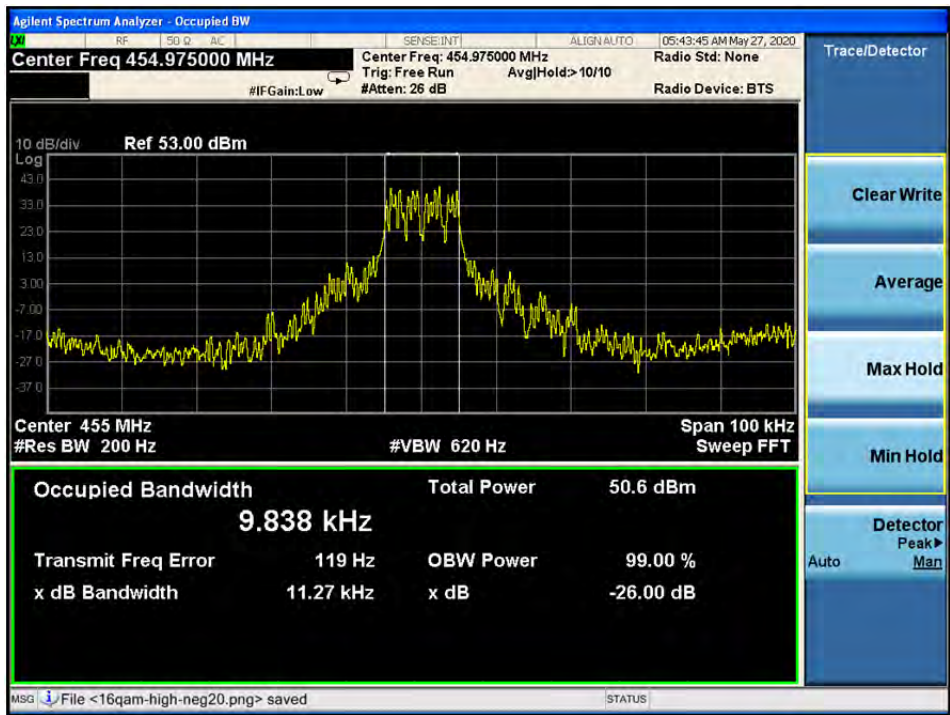


64QAM

454.675 MHz



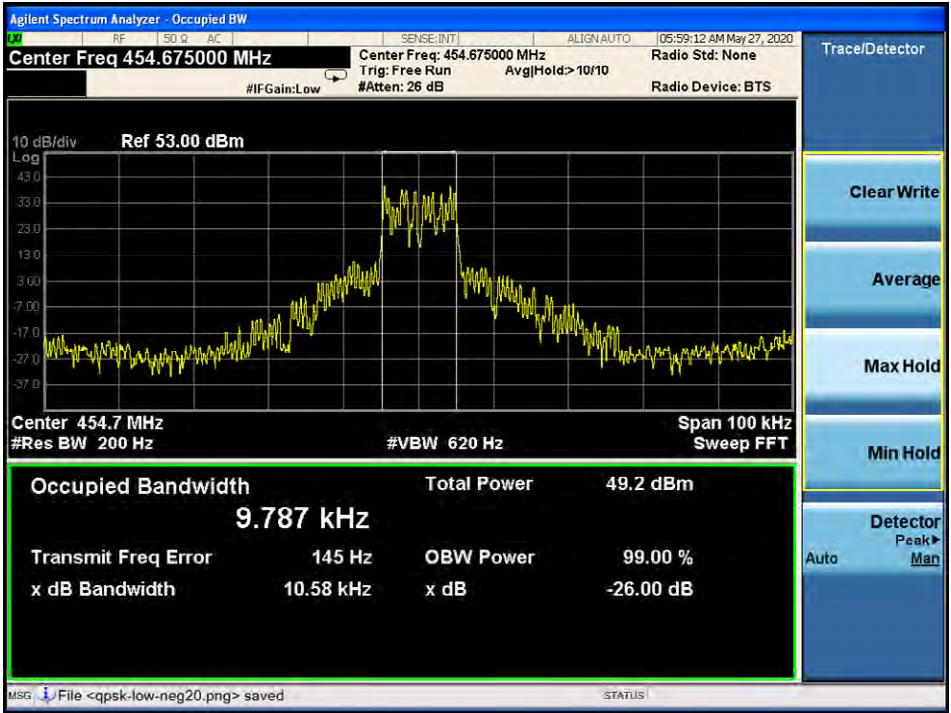
454.975 MHz



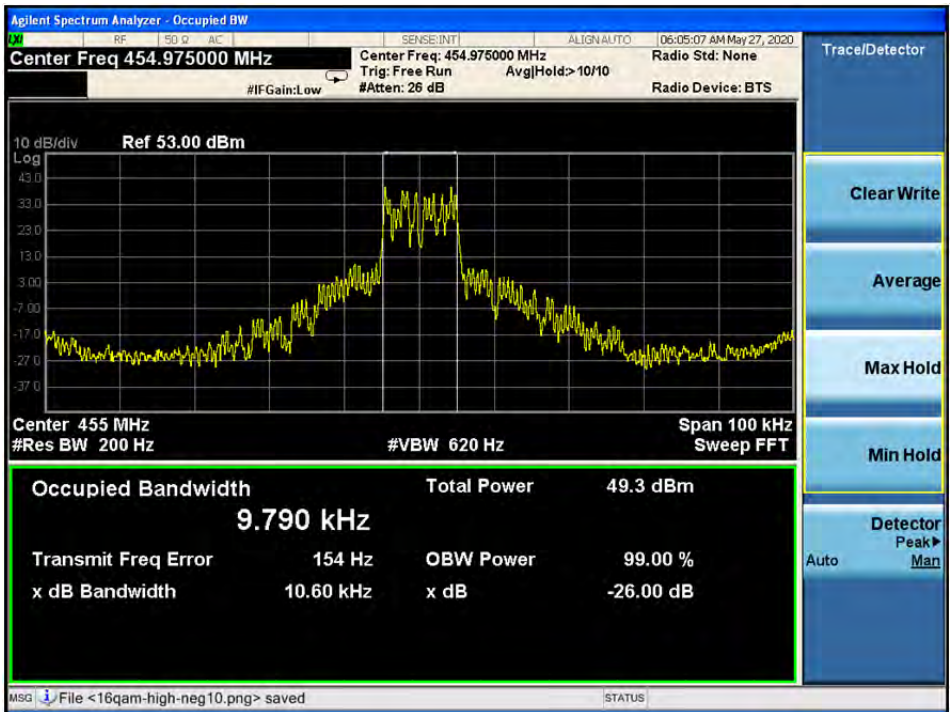
-10 °C

QPSK

454.675 MHz



454.975 MHz



16QAM

454.675 MHz

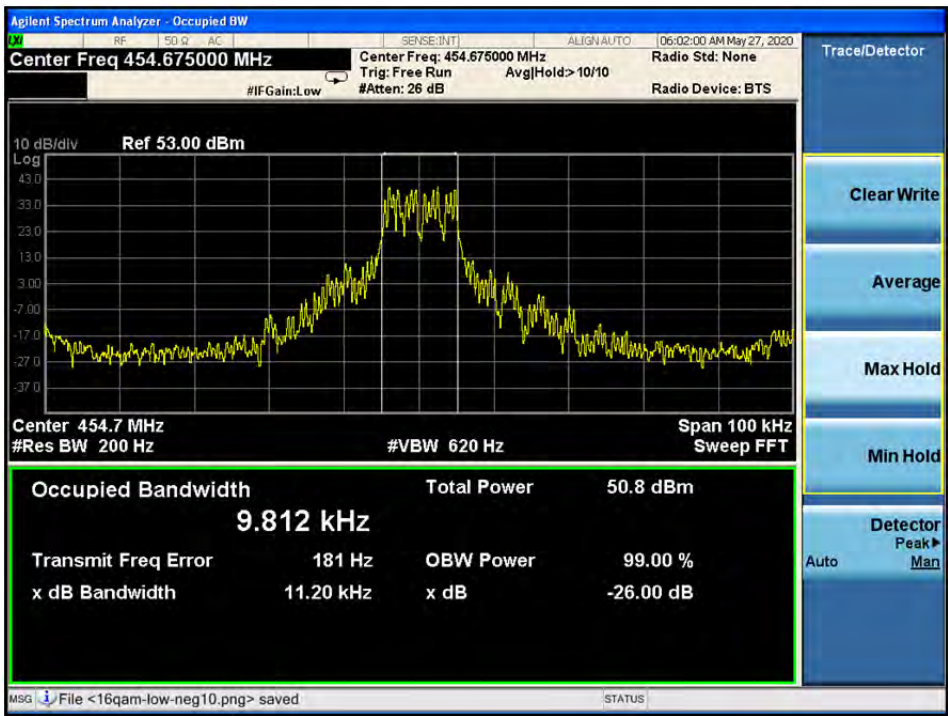


454.975 MHz

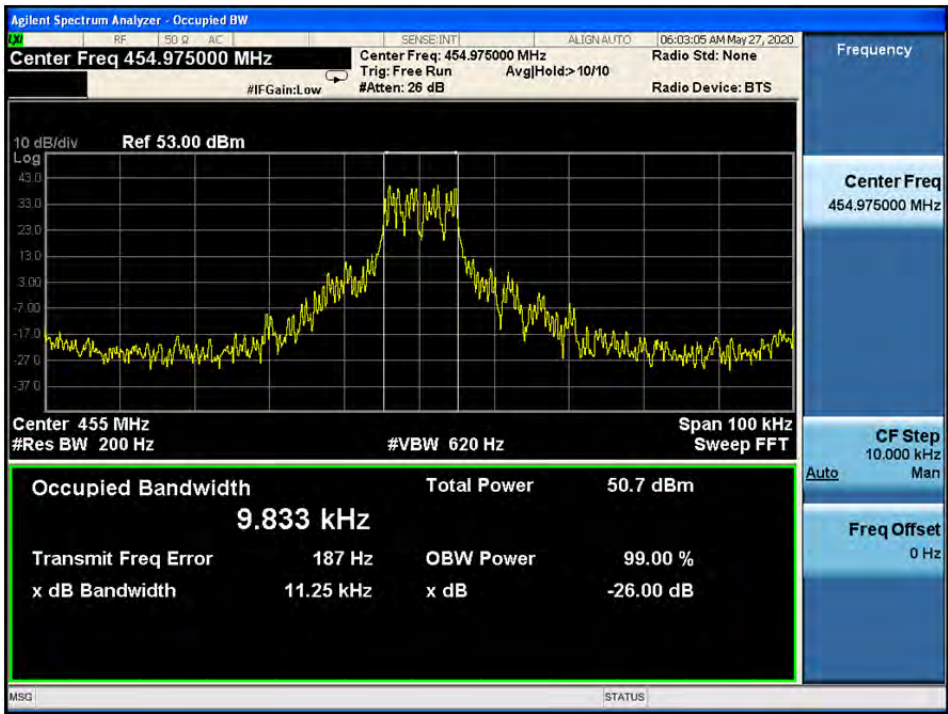


64QAM

454.675 MHz



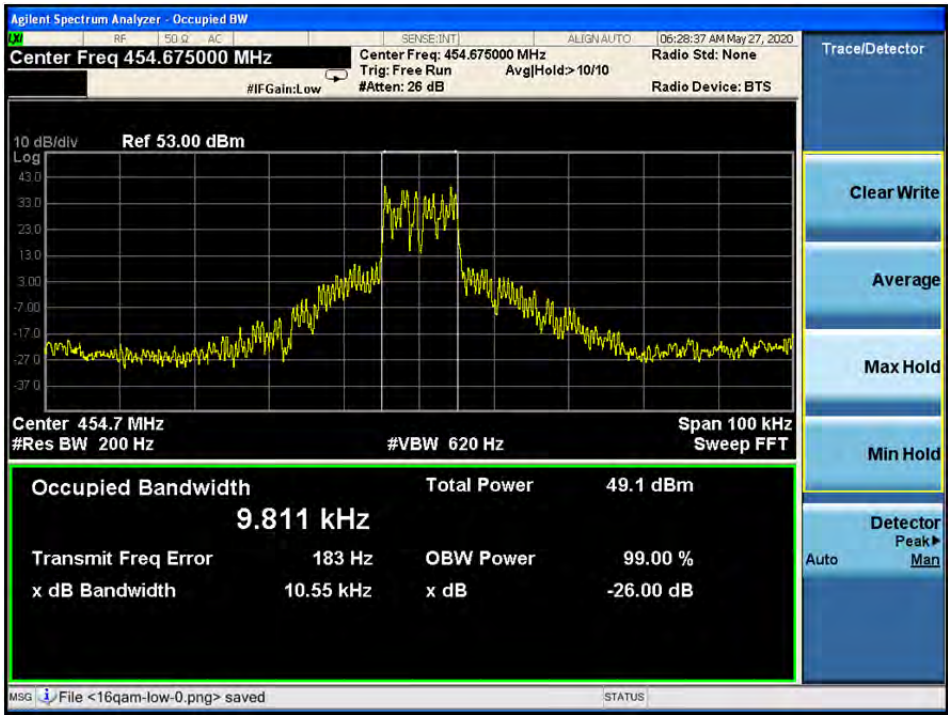
454.975 MHz



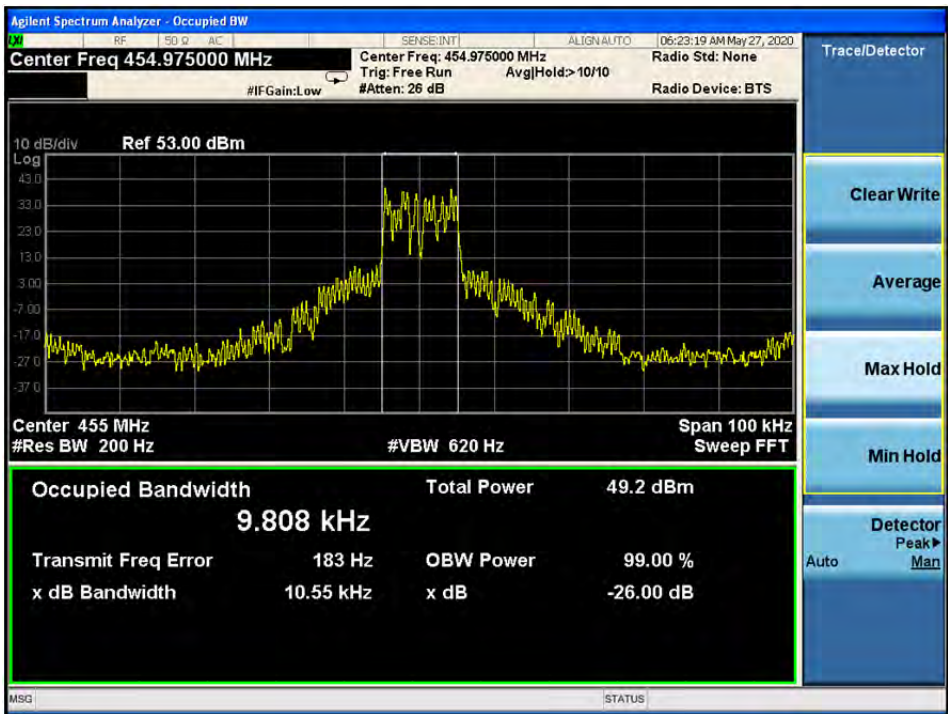
0 °C

QPSK

454.675 MHz



454.975 MHz



16QAM

454.675 MHz

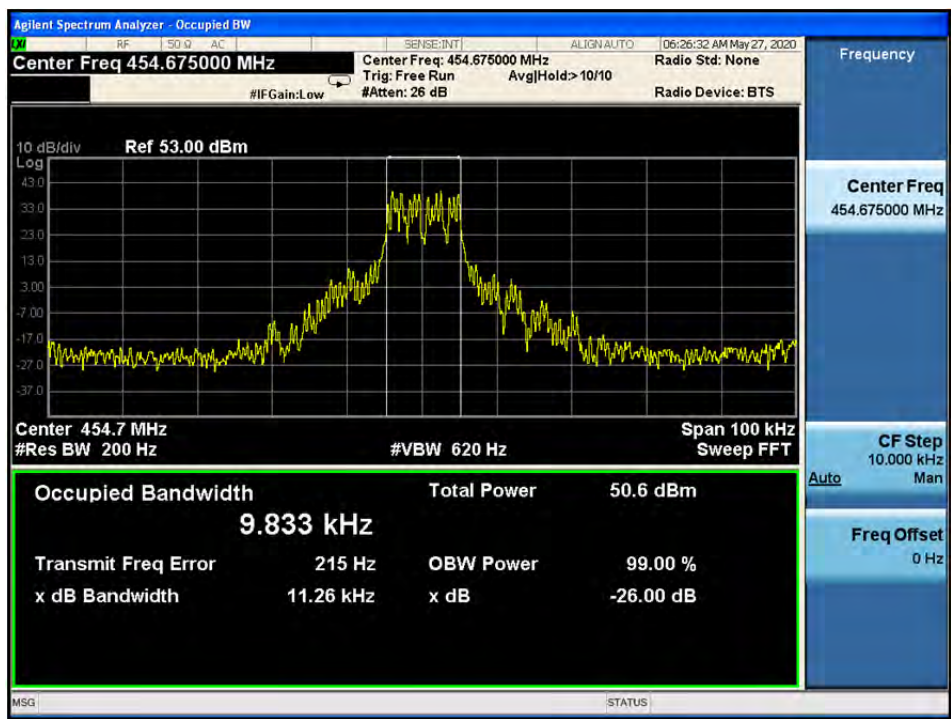


454.975 MHz



64QAM

454.675 MHz



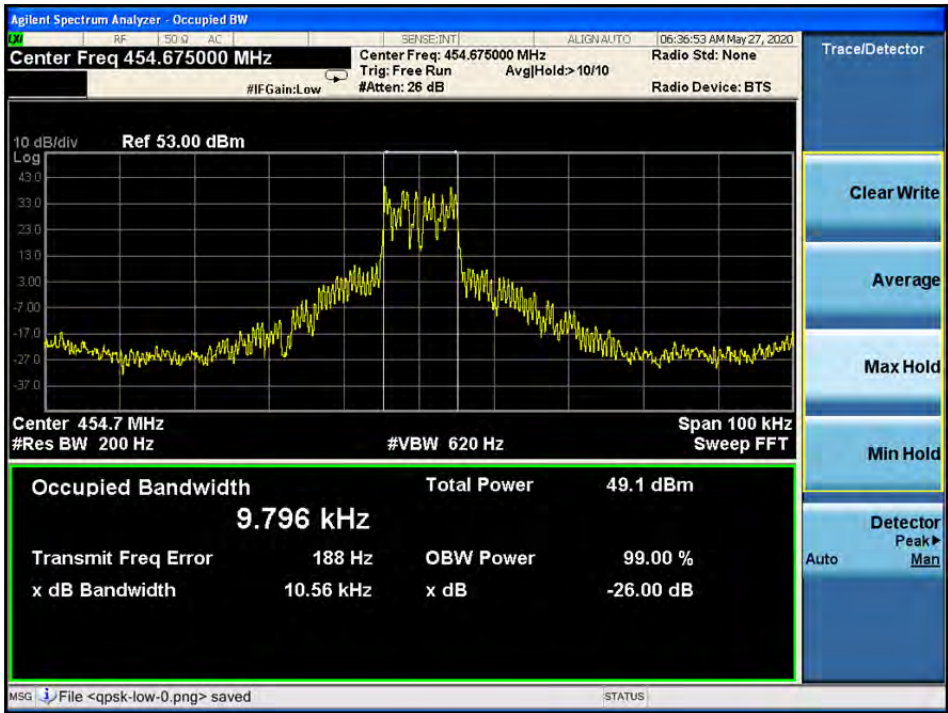
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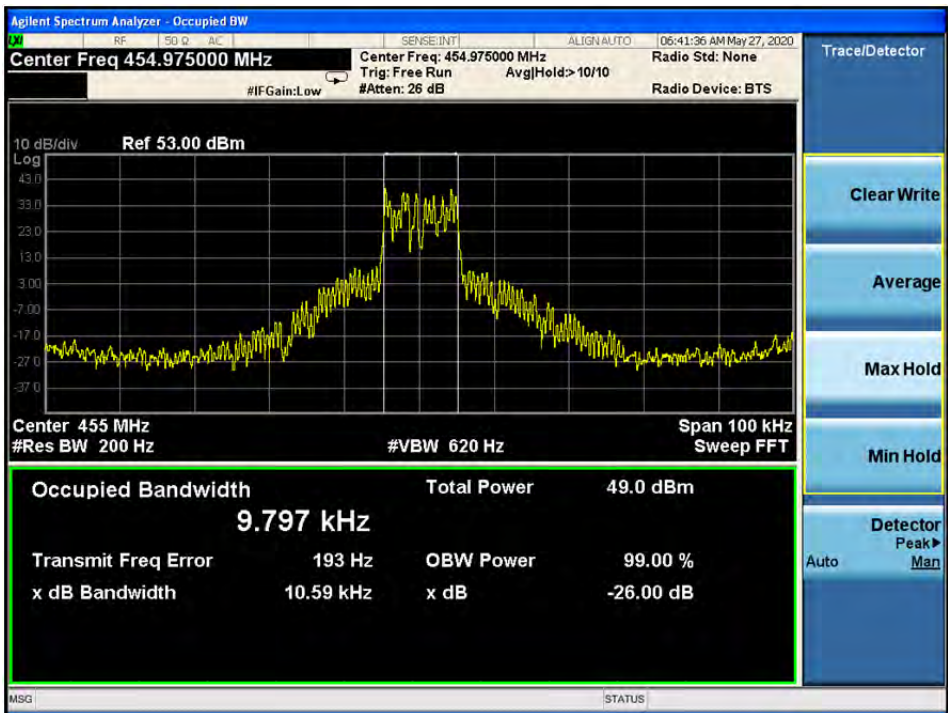
10 °C

QPSK

454.675 MHz



454.975 MHz



16QAM

454.675 MHz

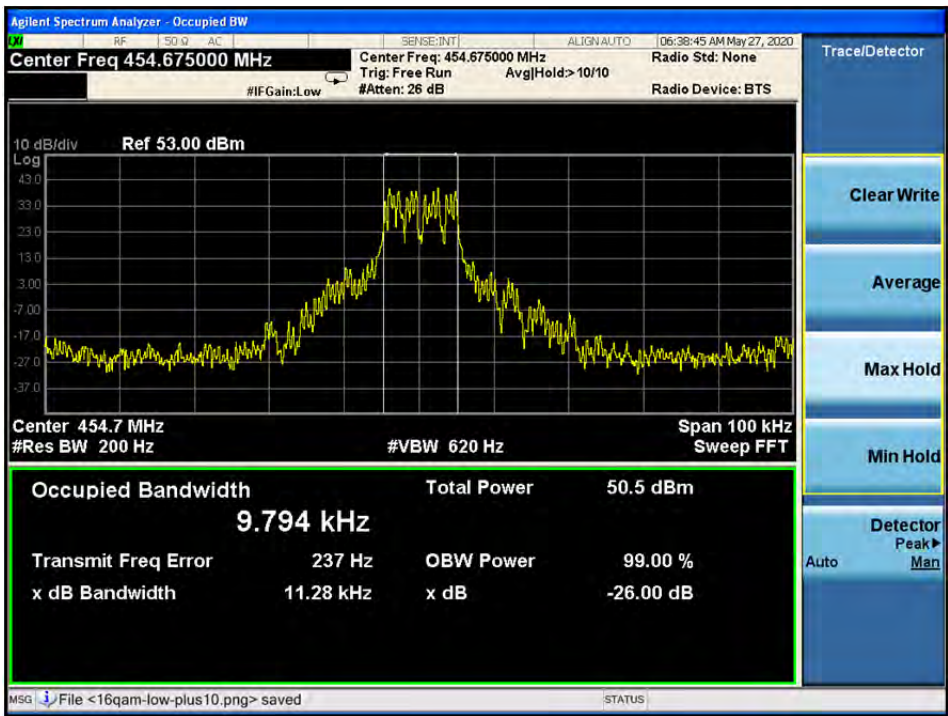


454.975 MHz

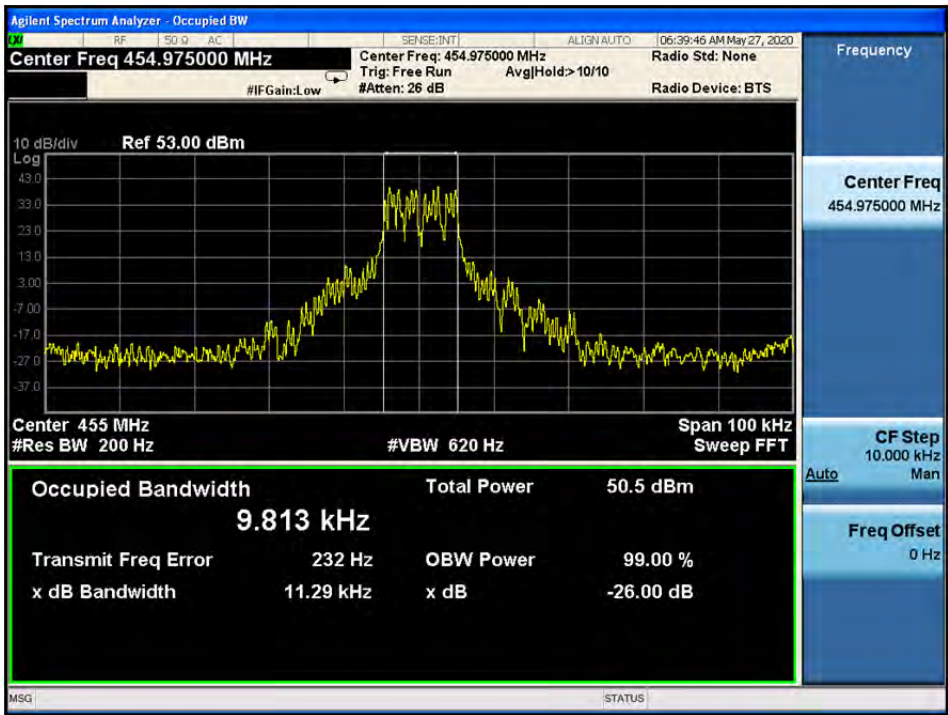


64QAM

454.675 MHz



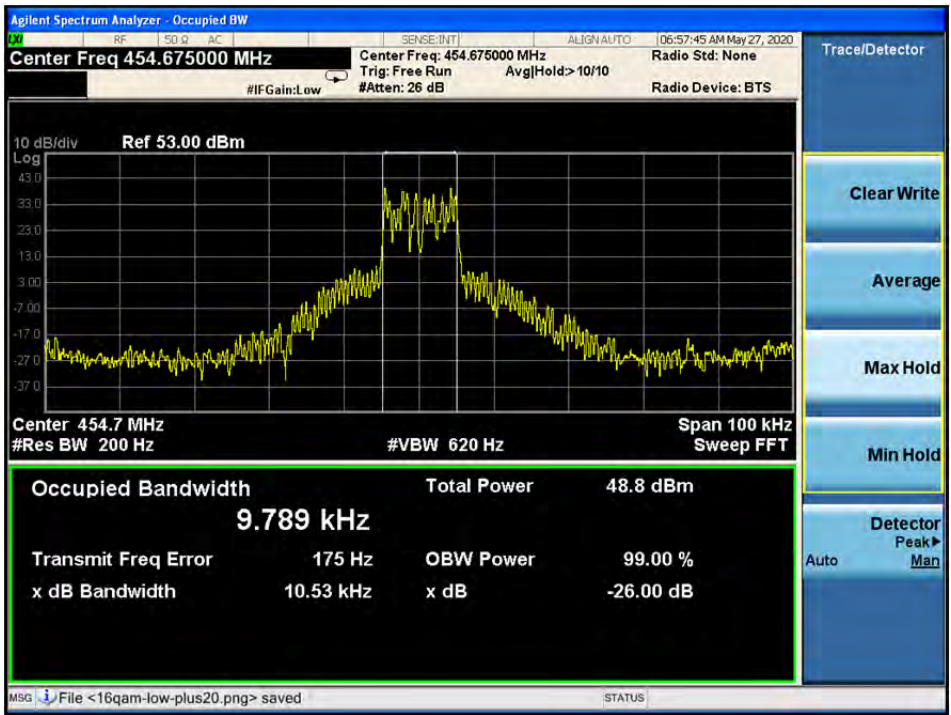
454.975 MHz



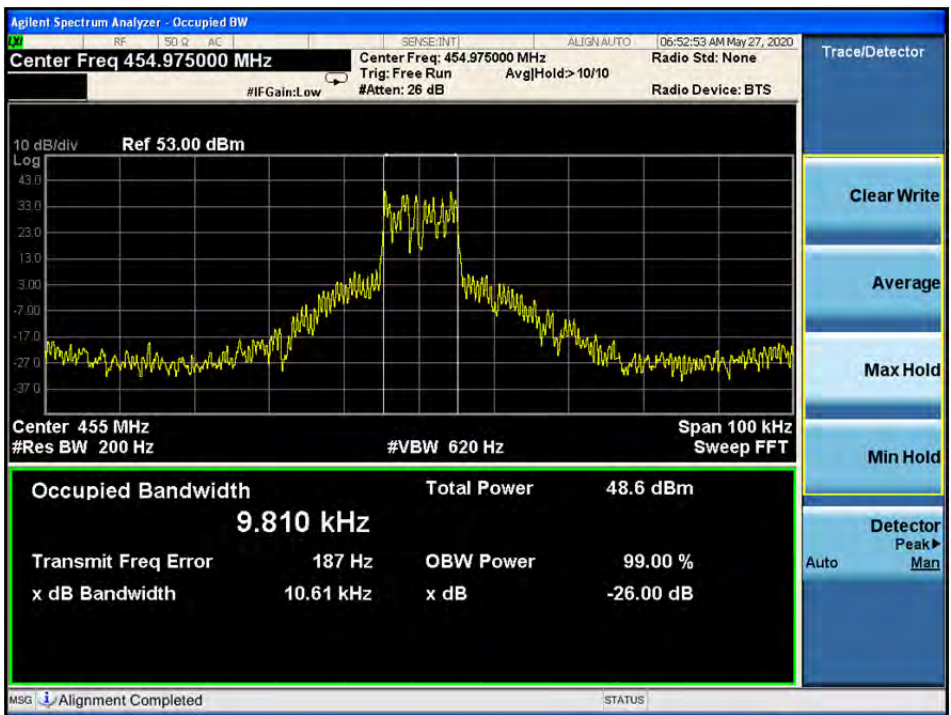
20 °C

QPSK

454.675 MHz



454.975 MHz

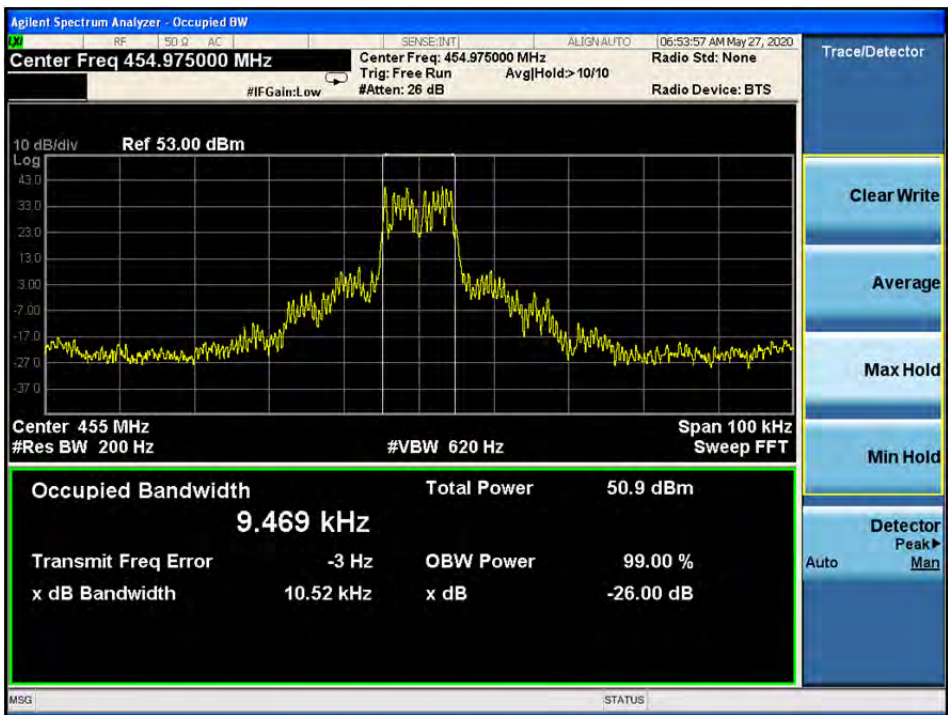


16QAM

454.675 MHz

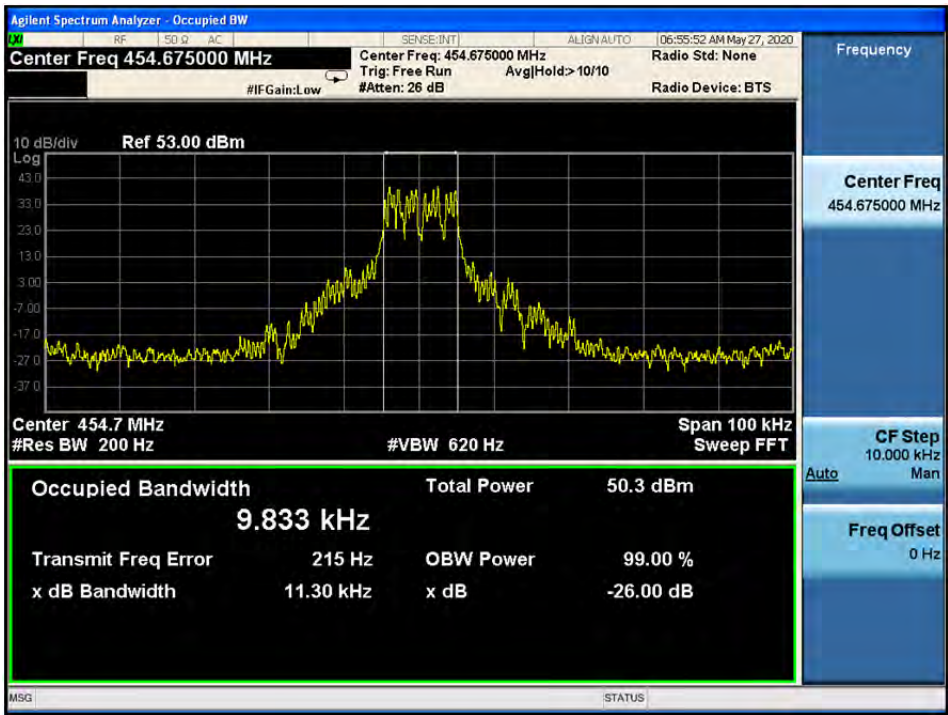


454.975 MHz



64QAM

454.675 MHz



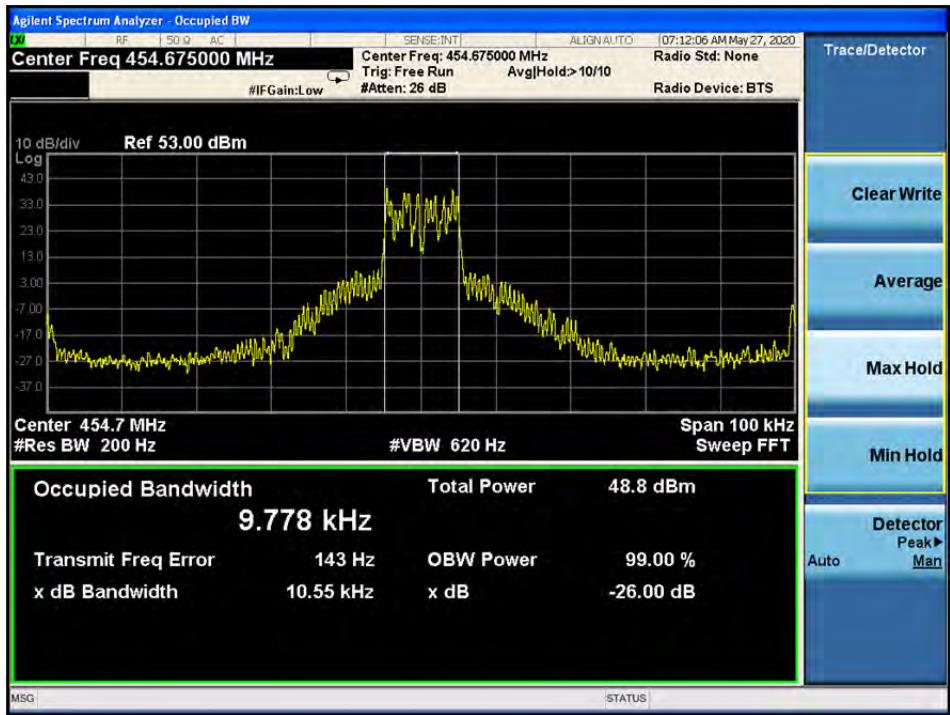
454.975 MHz



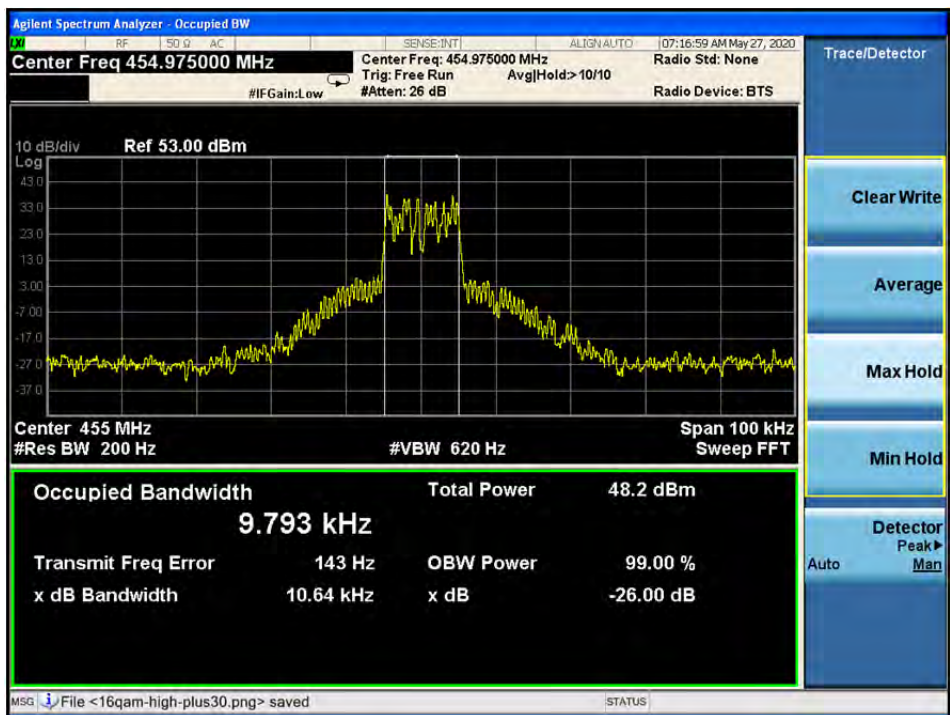
30 °C

QPSK

454.675 MHz

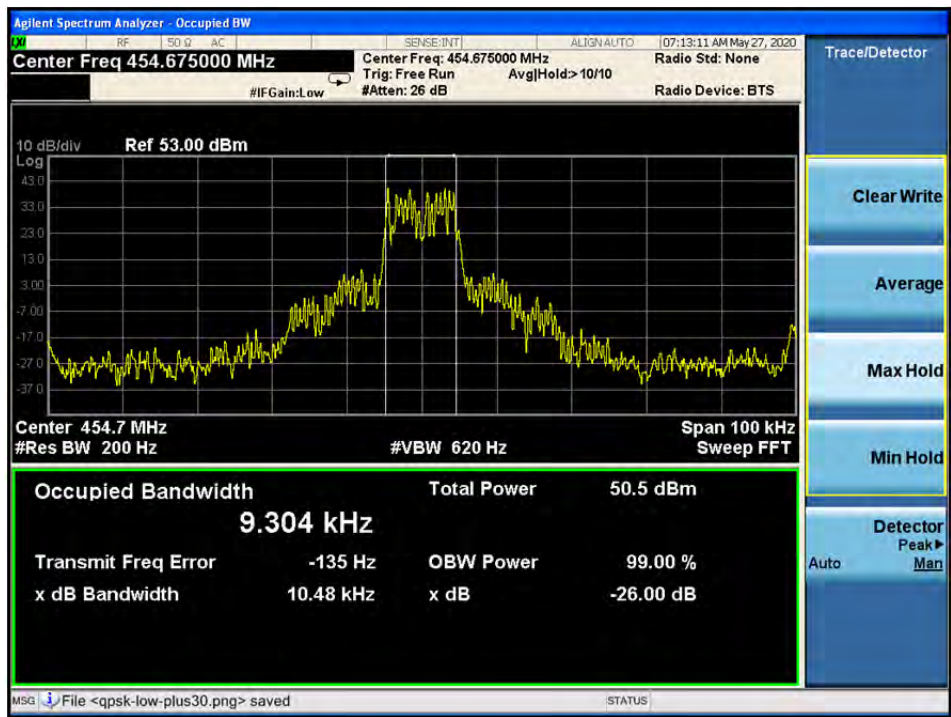


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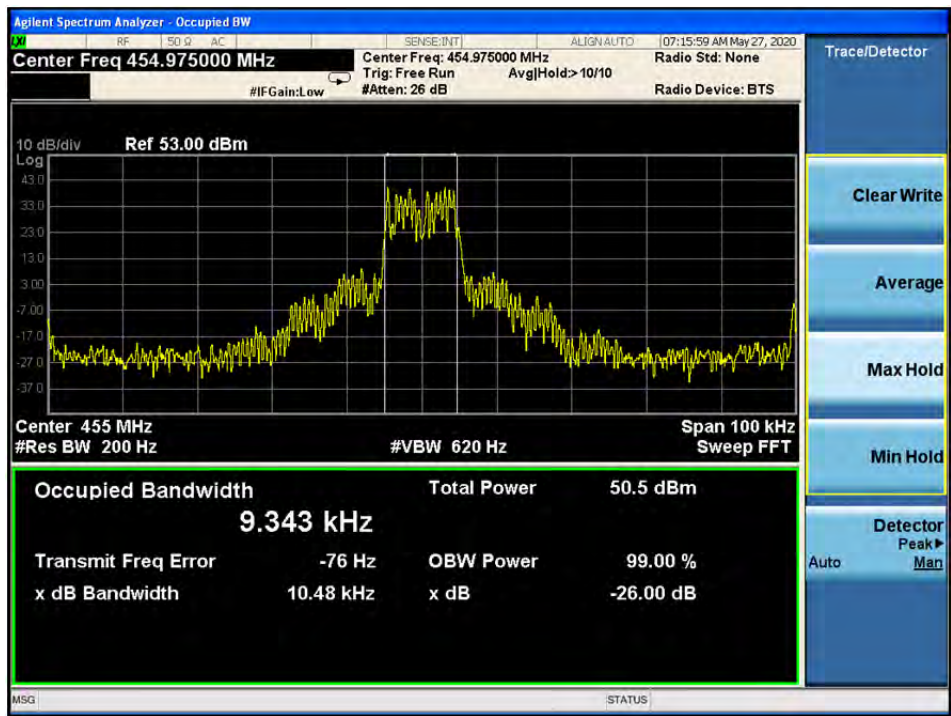


16QAM

454.675 MHz

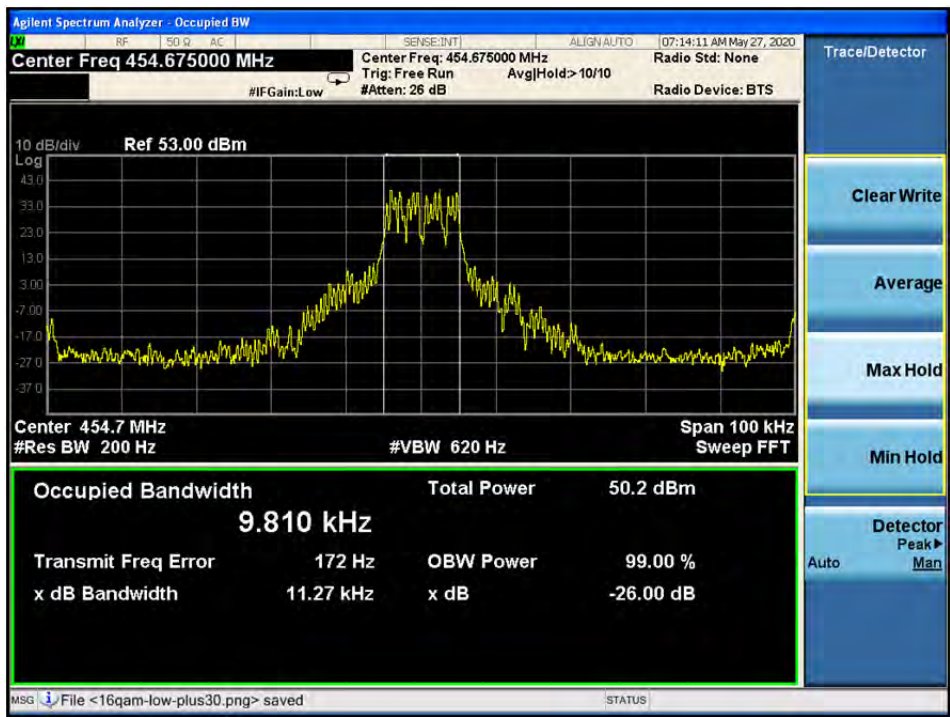


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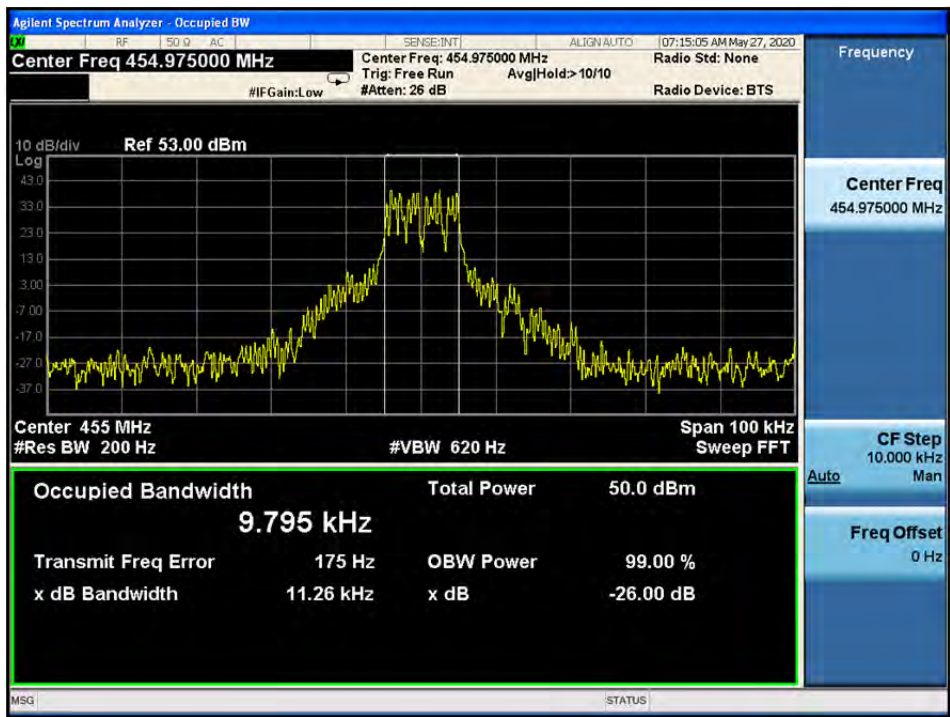


64QAM

454.675 MHz



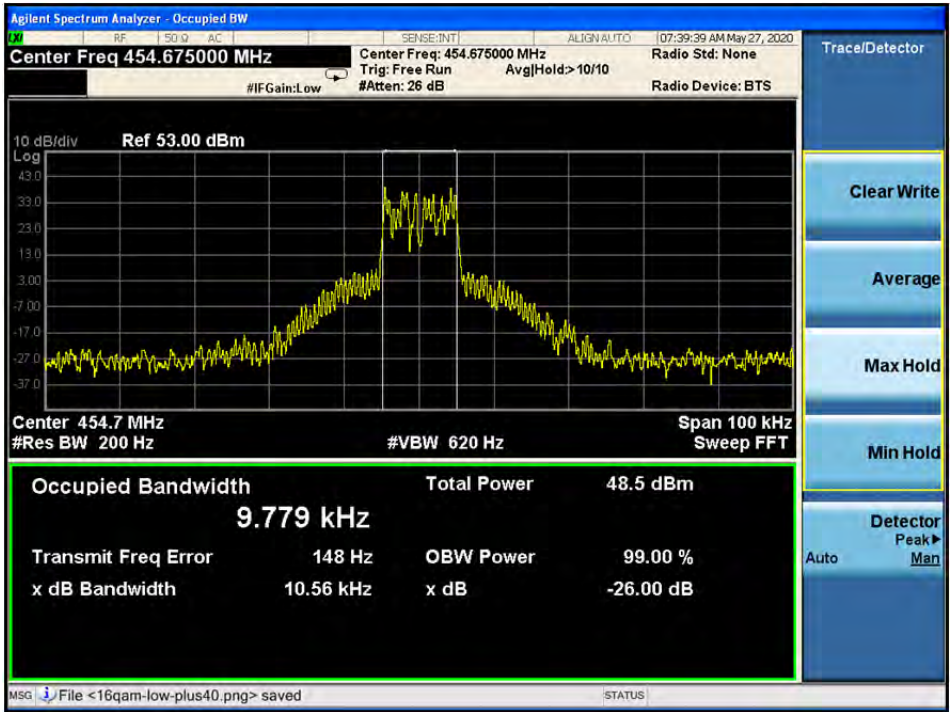
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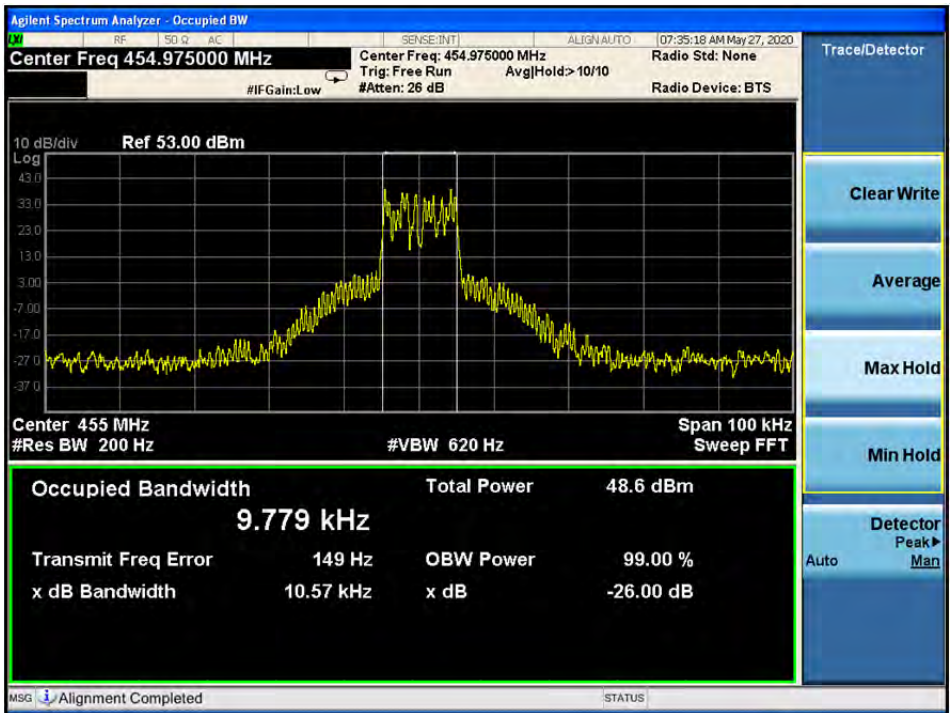
40°C

QPSK

454.675 MHz

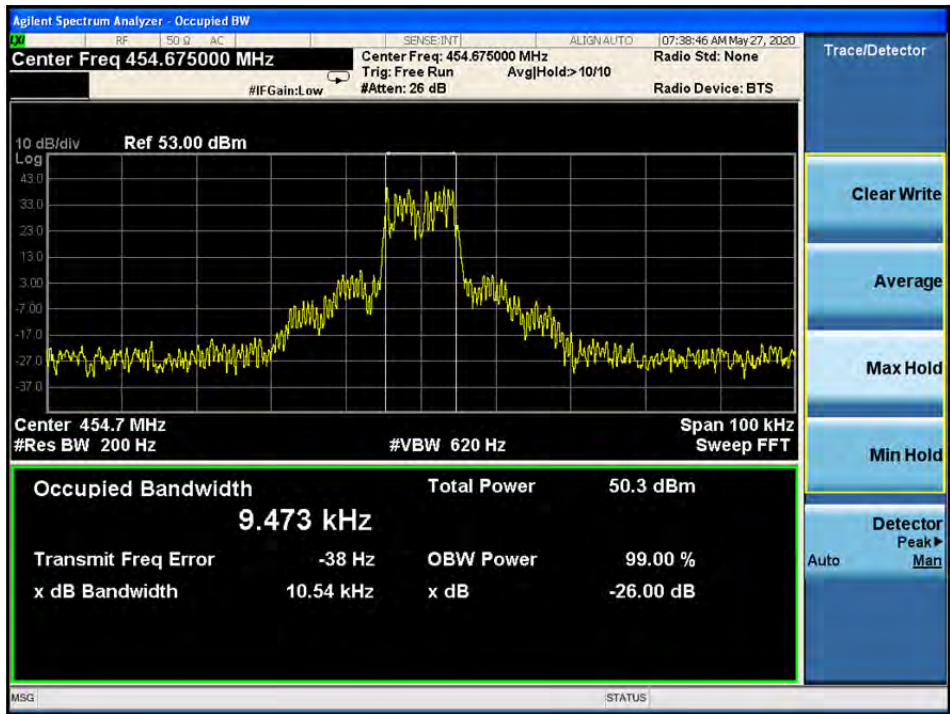


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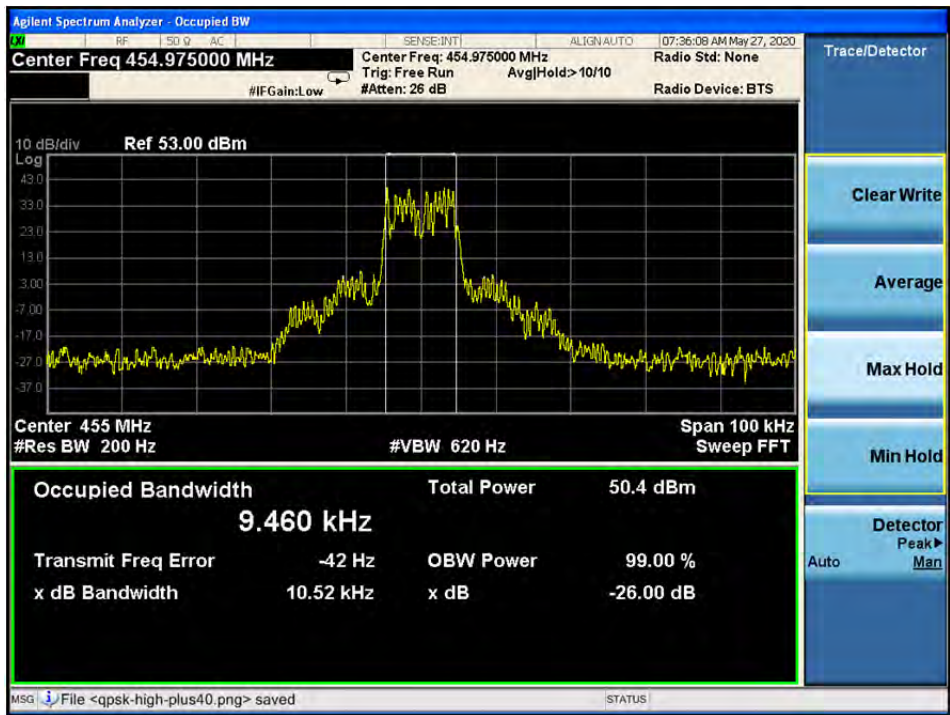


16QAM

454.675 MHz

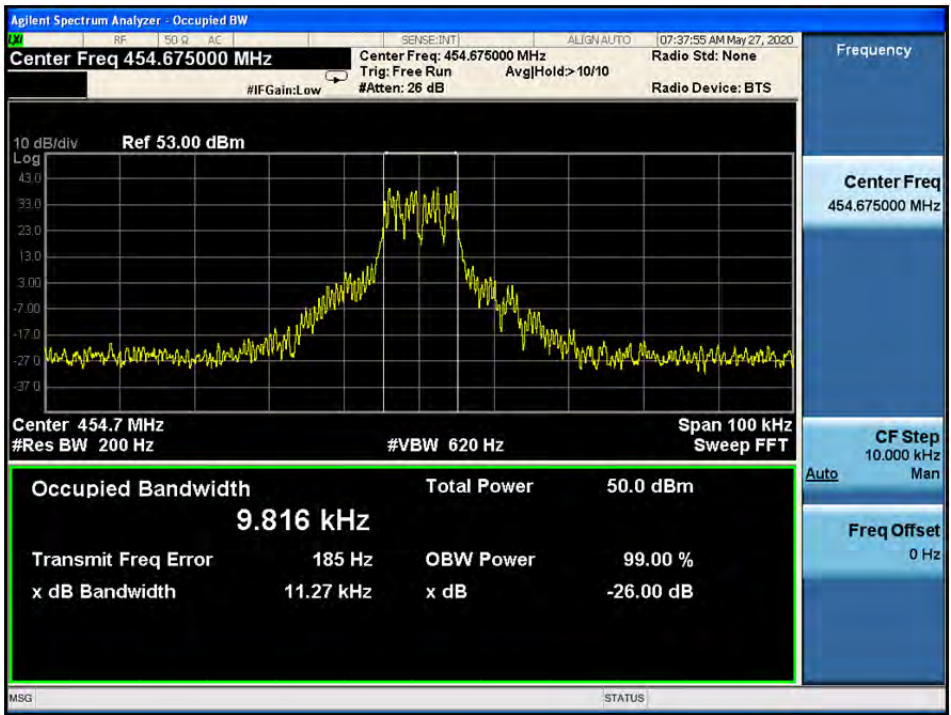


454.975 MHz

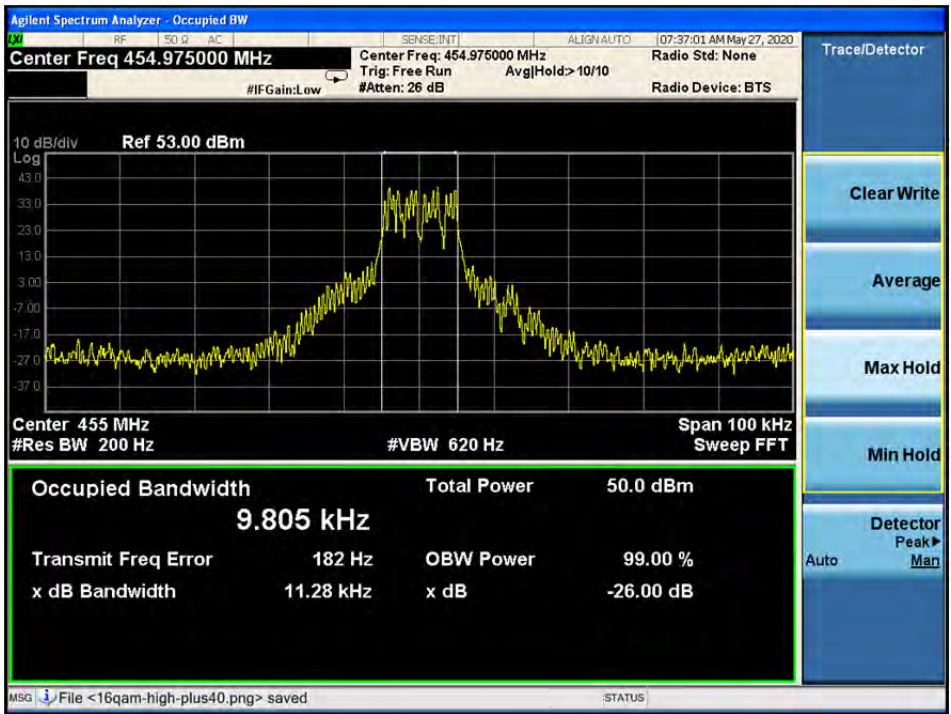


64QAM

454.675 MHz



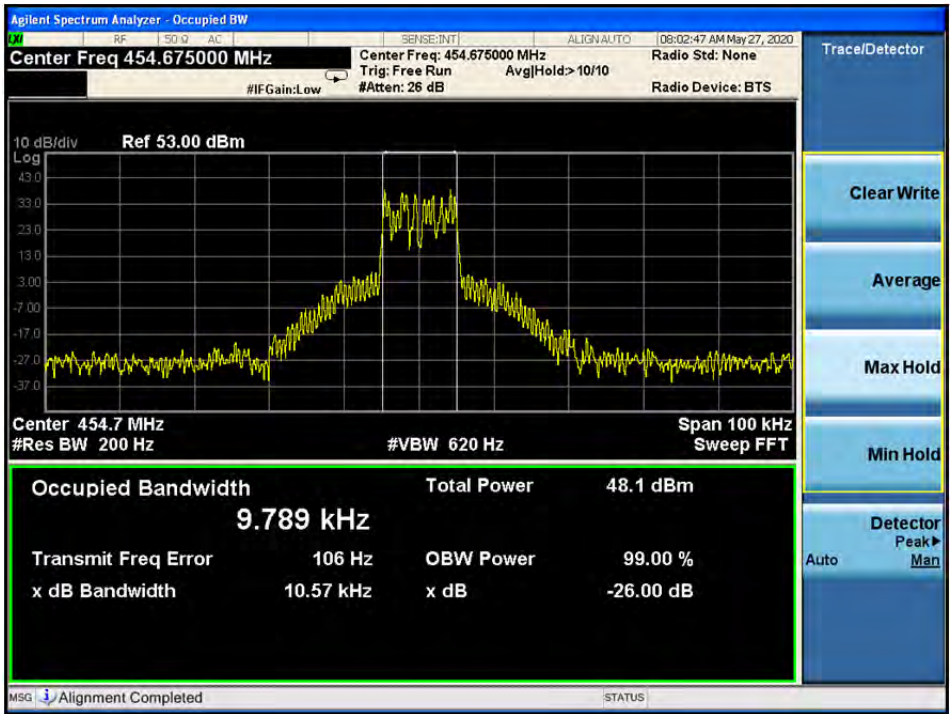
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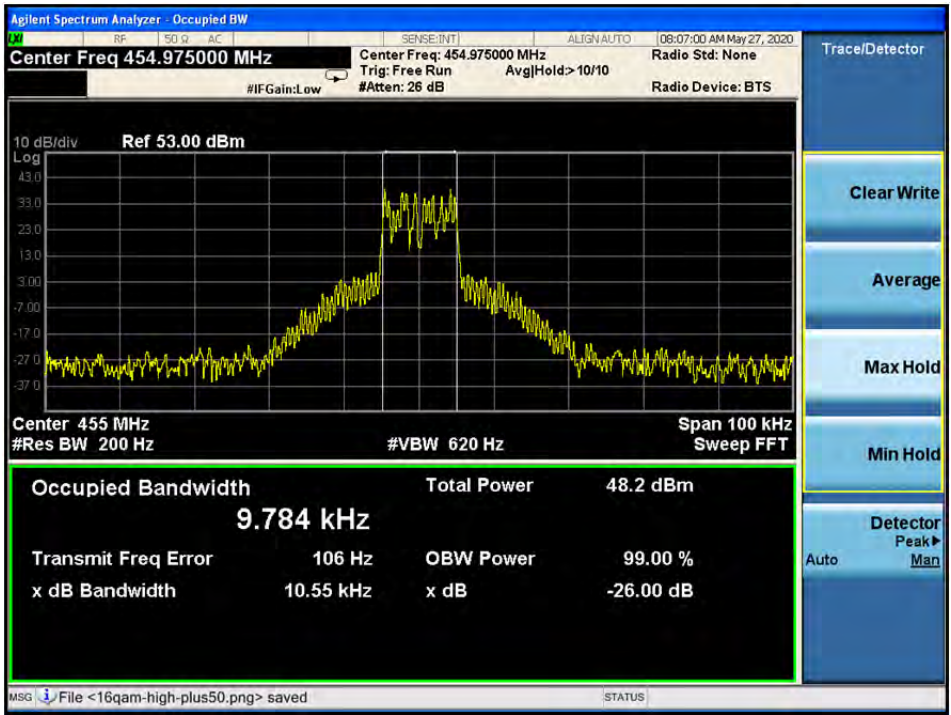
50 °C

QPSK

454.675 MHz

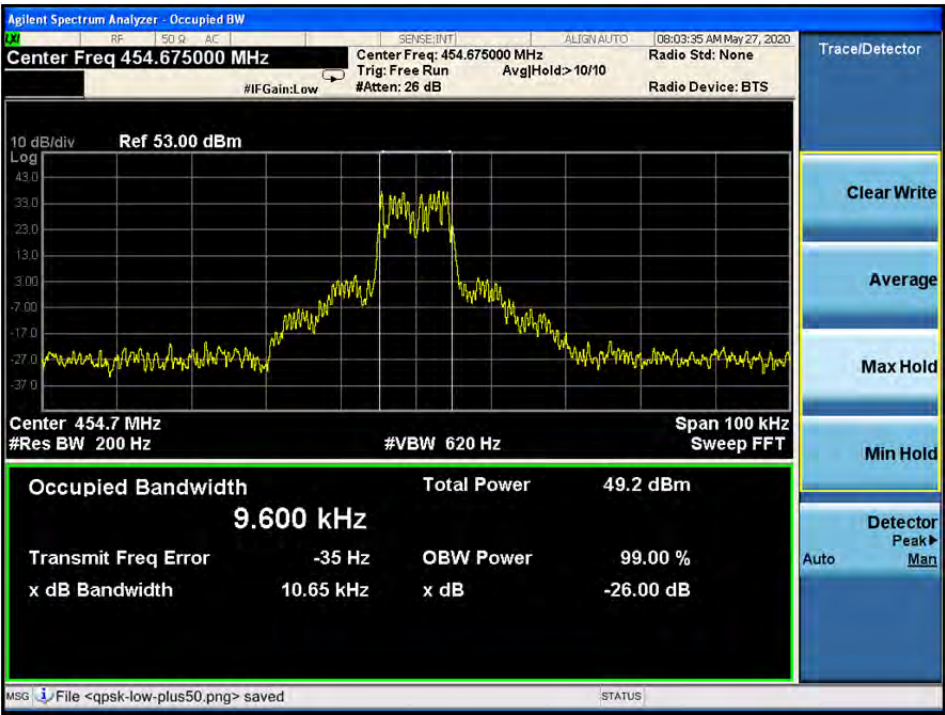


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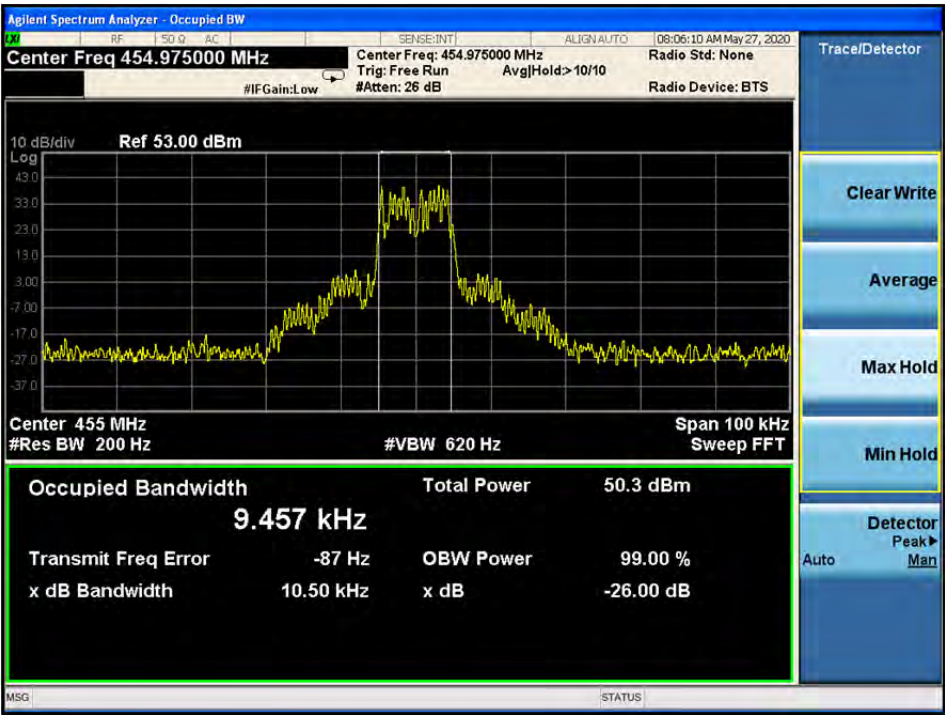


16QAM

454.675 MHz

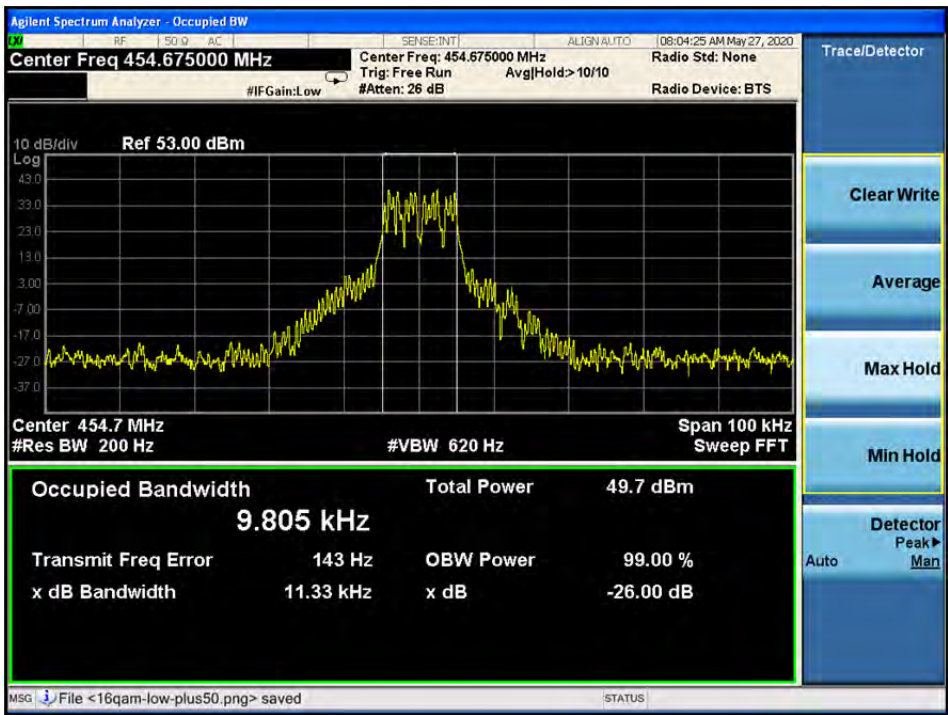


454.975 MHz

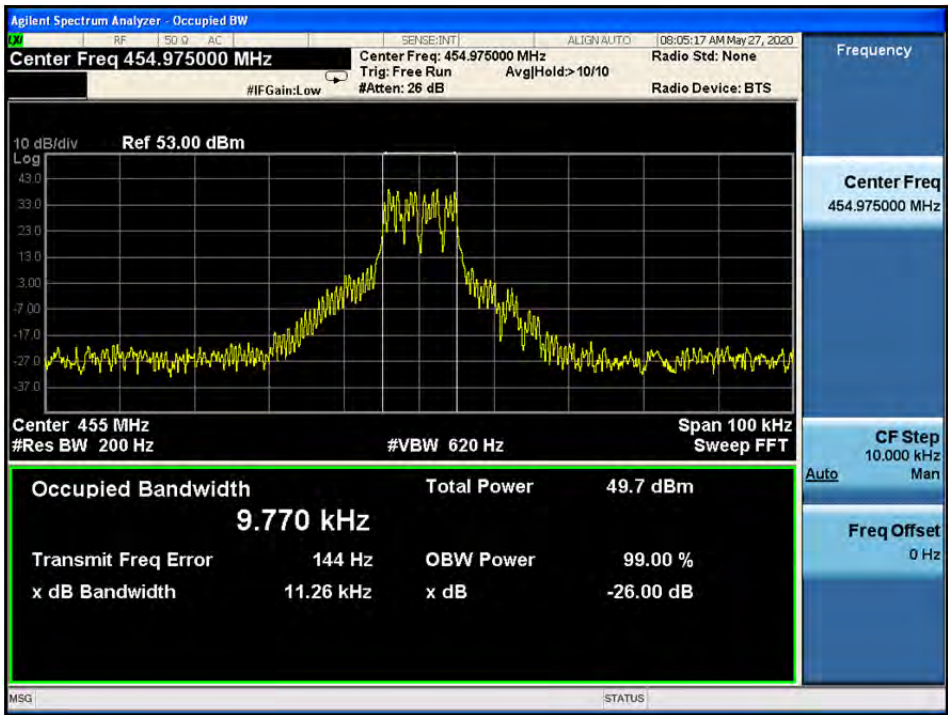


64QAM

454.675 MHz



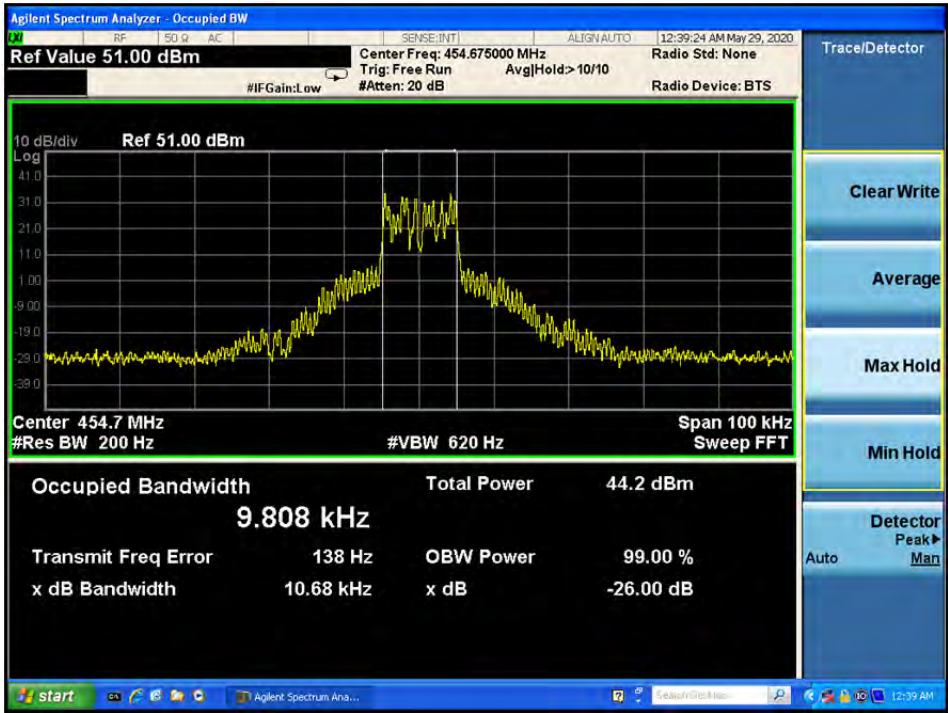
454.975 MHz



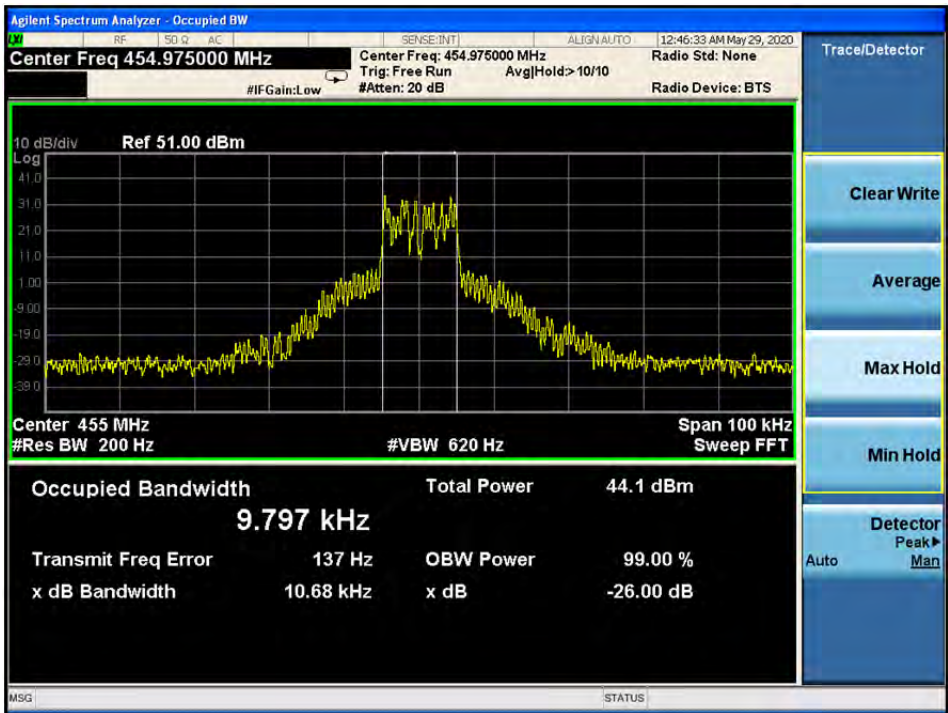
Low Voltage (40.8 V)

QPSK

454.675 MHz

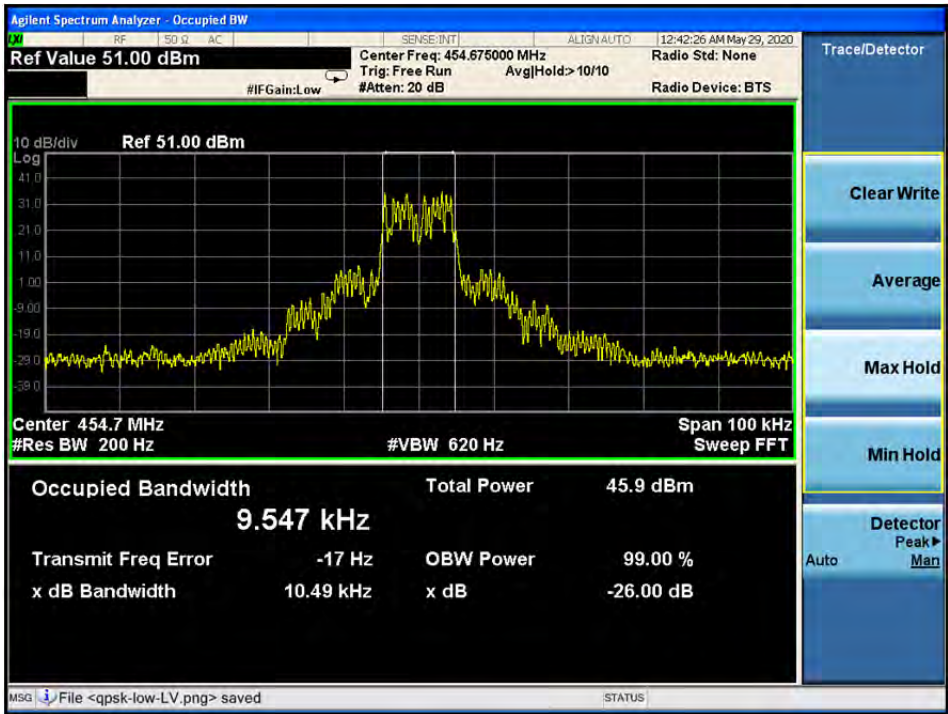


454.975 MHz

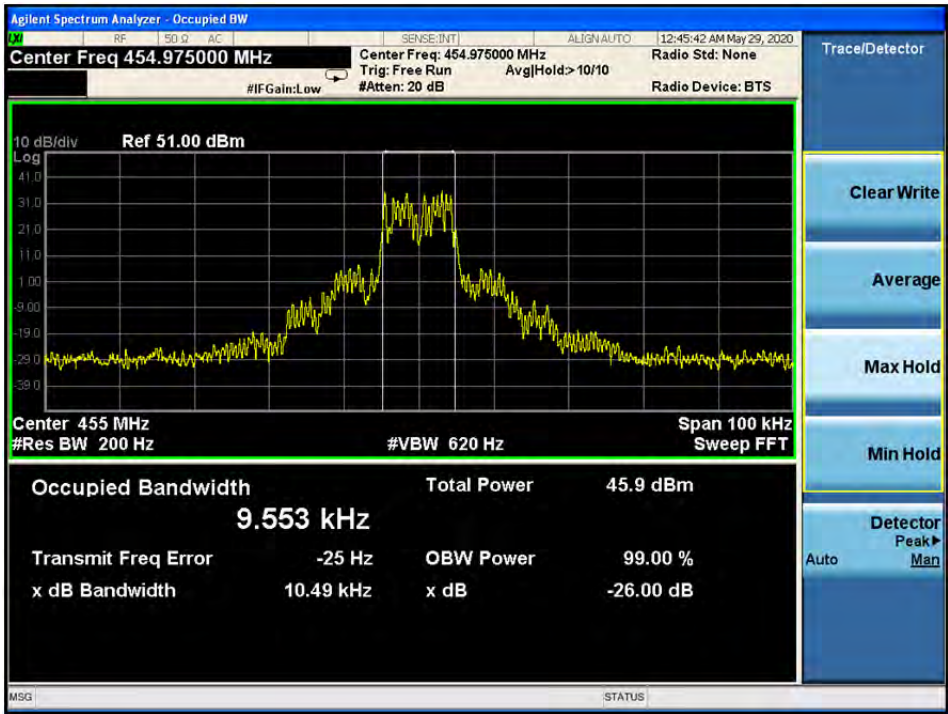


16QAM

454.675 MHz

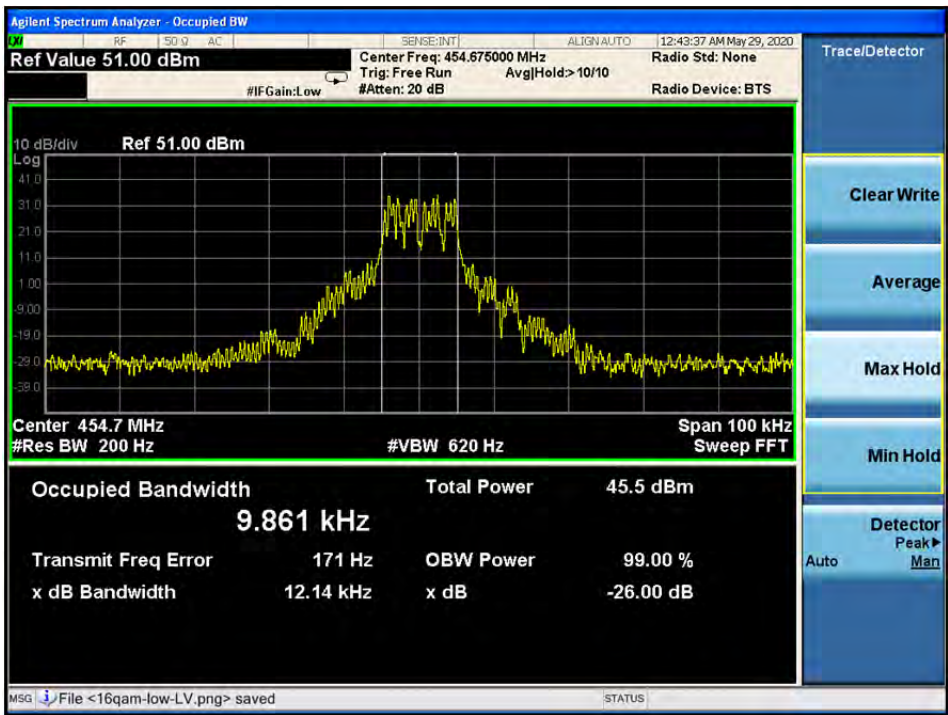


454.975 MHz

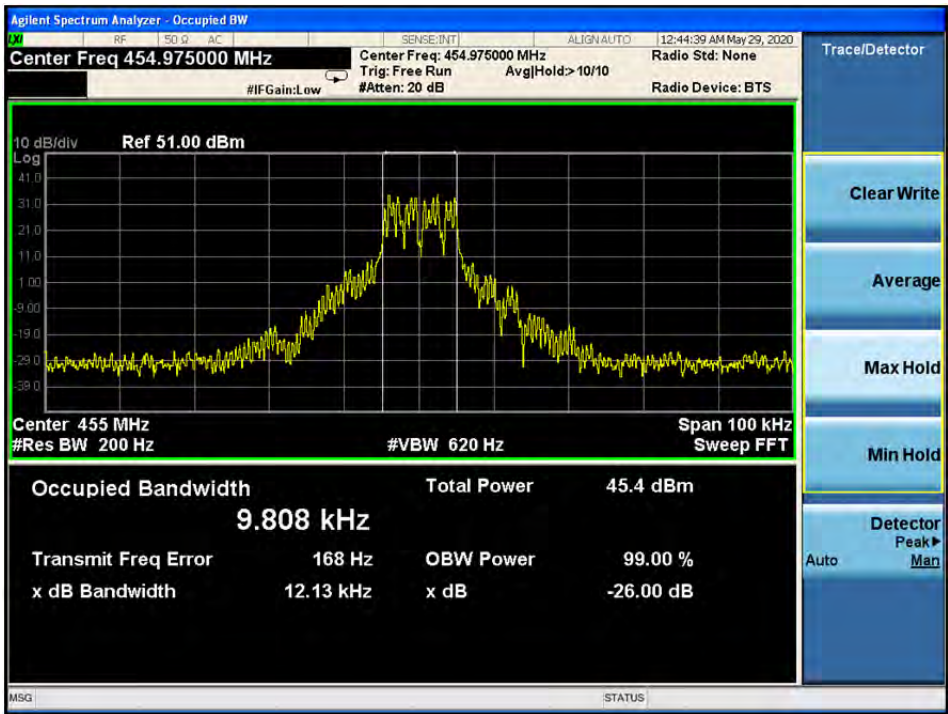


64QAM

454.675 MHz



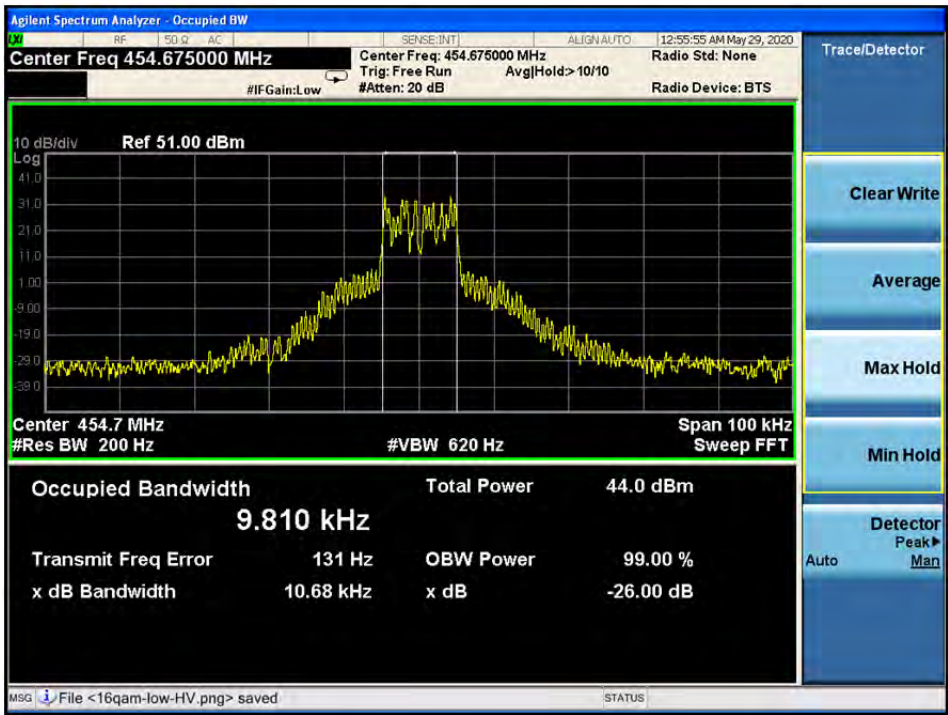
454.975 MHz



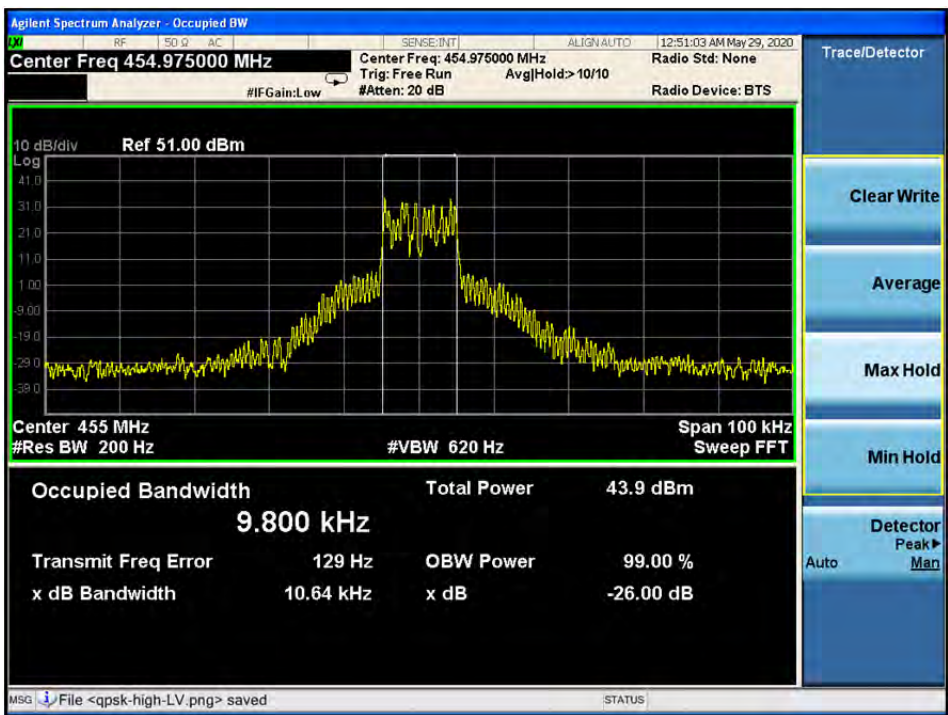
High Voltage (55.2 V)

QPSK

454.675 MHz

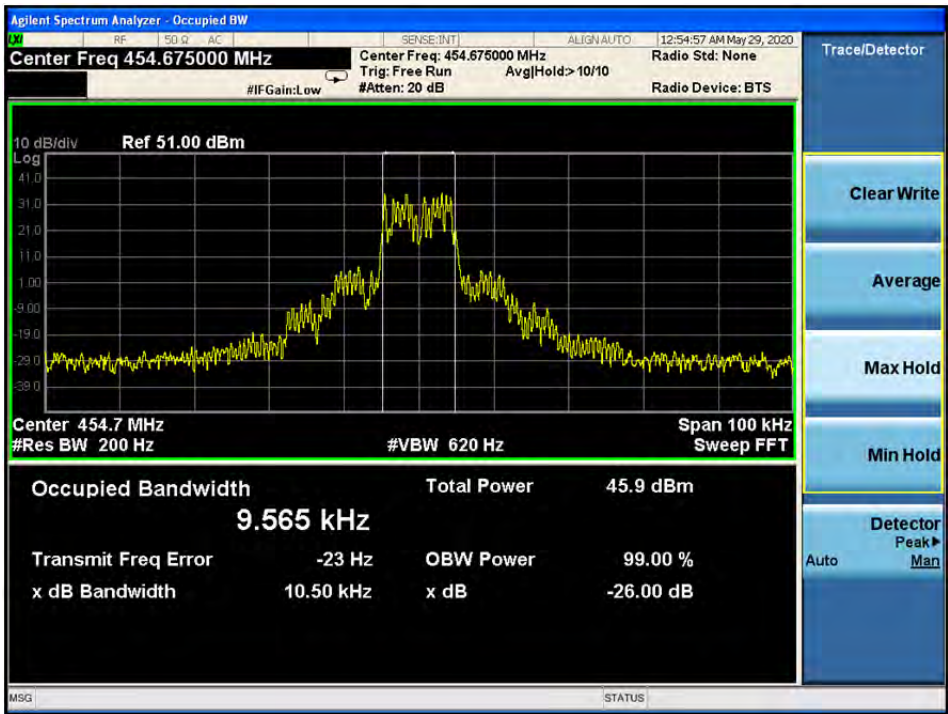


454.975 MHz



16QAM

454.675 MHz

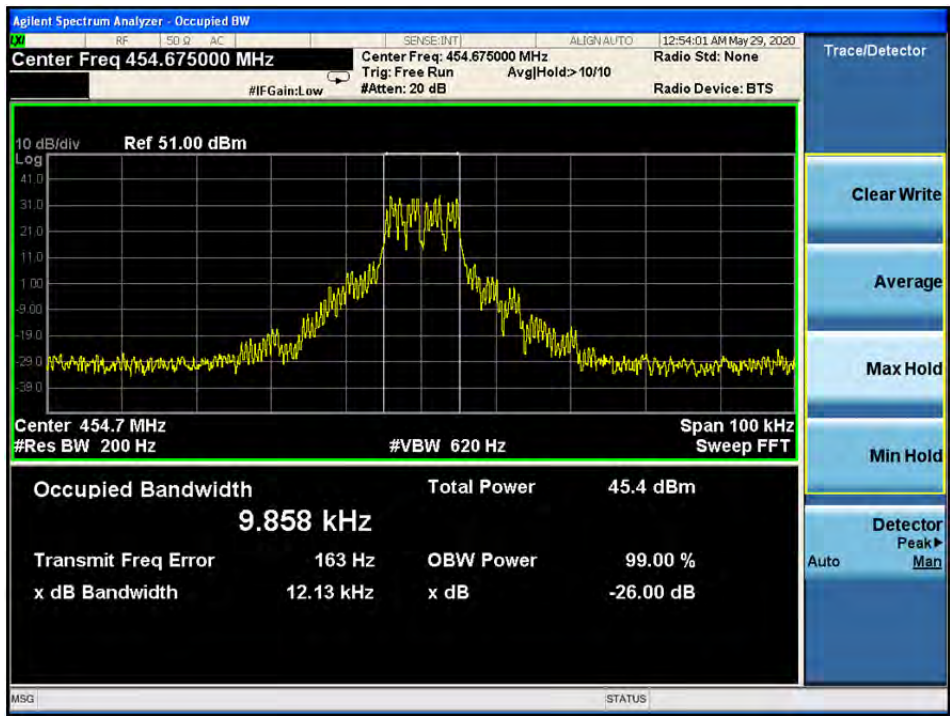


454.975 MHz

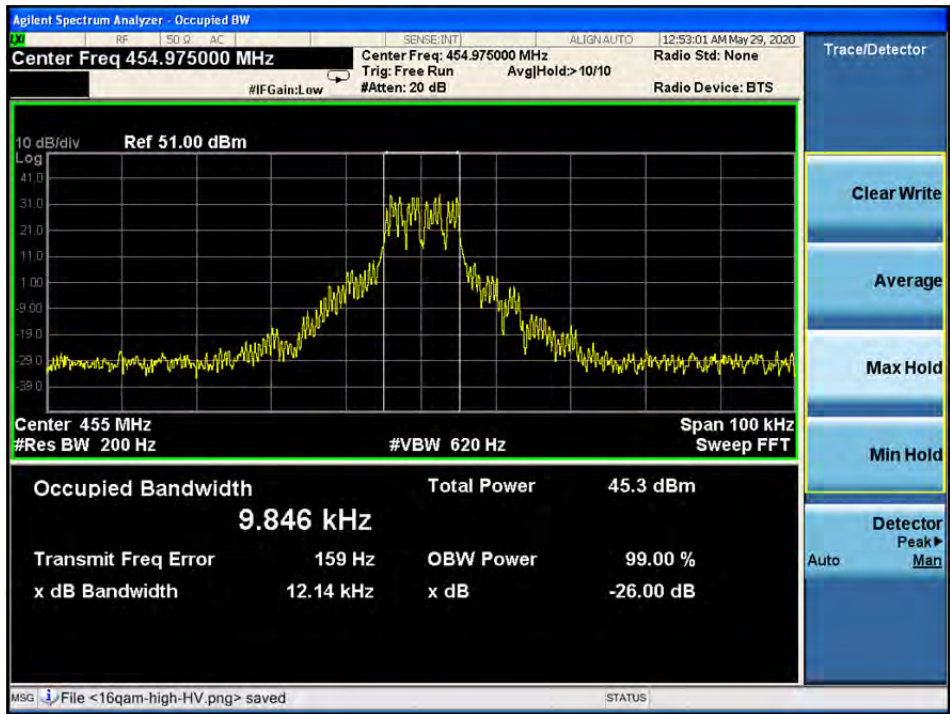


64QAM

454.675 MHz



454.975 MHz



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



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

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

--- END OF REPORT ---