FCC PART 22G

TEST REPORT

For

Ondas Networks Inc.

165 Gibraltar Court, Sunnyvale, CA 94089, USA

FCC ID: X27-VNB22G-1

Report Type:	Product Type:
Original Report	Base Station

Prepared By:	Christian McCaig Test Engineer
Report Number:	R2003093
Report Date:	2020-07-27
Reviewed By:	Simon Ma RF Supervisor

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ACCREDITED
CERTIFICATE #3297.02

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	R2003093	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-5000-2, FCC ID: X27-VNB22G-1, which will henceforth be referred to as the EUT (Equipment under Test). The EUT is a base station and operates in the frequency range of 454.675-454.975 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 Inc.* 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 º 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 - ISEDC) Foreign Certification Body – FCB – APEC Tel MRA -Phase I & Phase II;
- Chinese Taipei (Republic of China – Taiwan):
  - BSMI (Bureau of Standards, Metrology and Inspection) APEC Tel MRA -Phase I;
  - NCC (National Communications Commission) APEC Tel MRA -Phase I;
- European Union:
  - EMC Directive 2014/30/EU US-EU EMC & Telecom MRA CAB (NB)
  - Radio Equipment (RE) Directive 2014/53/EU US-EU EMC & Telecom MRA CAB (NB)
  - 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:
  - ENERGY STAR Recognized Test Laboratory – US EPA
  - Telecommunications Certification Body (TCB) – US FCC;
  - 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

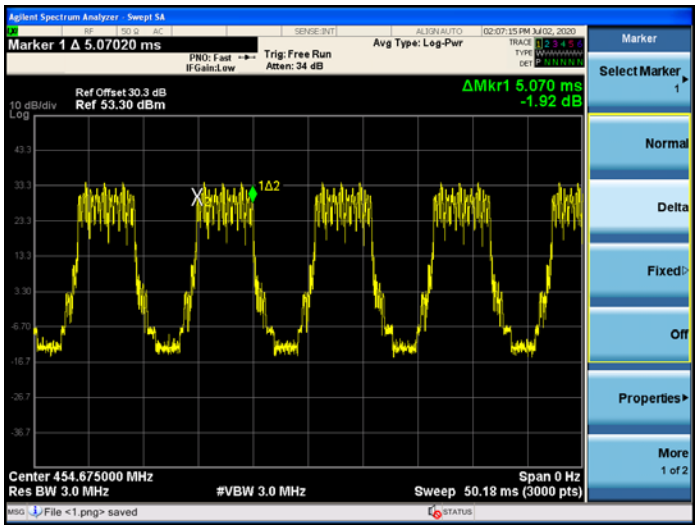
2.7 Duty Cycle

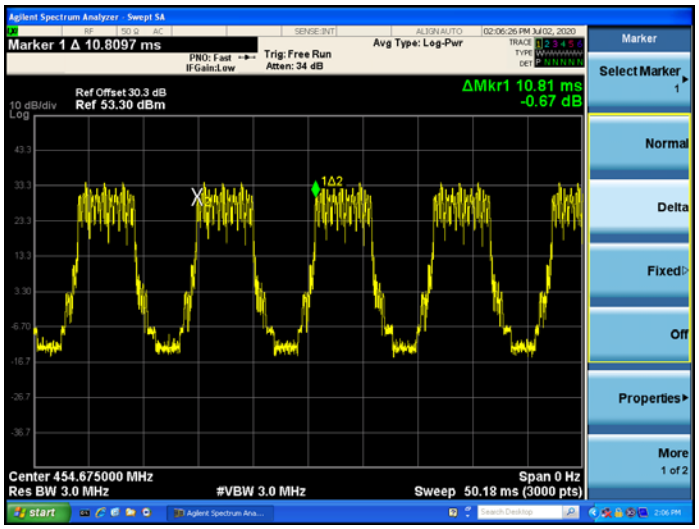
According to KDB 558074 D01 DTS Meas Guidance v05r02 section 6.0:

Preferably, all measurements of maximum conducted (average) output power will be performed with the EUT transmitting continuously (i.e., with a duty cycle of greater than or equal to 98%). When continuous operation cannot be realized, then the use of sweep triggering/signal gating techniques can be utilized to ensure that measurements are made only during transmissions at the maximum power control level. Such sweep triggering/signal gating techniques will require knowledge of the minimum transmission duration (T) over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation. Sweep triggering/signal gating techniques can then be used if the measurement/sweep time of the analyzer can be set such that it does not exceed T at any time that data is being acquired (i.e., no transmitter off-time is to be considered).

On Time (ms)	Period (ms)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)
5.07	10.81	46.9	3.29

Please refer to the following plots





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
§22.861	Band Edge	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 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				
0.3-3.0	614	1.63	*(100)	≤6
3.0-30	1842/f	4.89/f	*($900/f^2$)	<6
30-300	61.4	0.163	1.0	<6
300-1,500			f/300	<6
1,500-100,000			5	<6

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

Maximum average output power at antenna input terminal (dBm):	32.712
Maximum average output power at antenna input terminal (mW):	1867.2
Prediction frequency (MHz):	454.825
Antenna Gain, maximum (dBi):	16.661
Maximum Antenna Gain (numeric):	46.355
Prediction distance (cm):	3048
Power density of prediction frequency at 3048 cm (mW/cm^2):	0.0007
FCC MPE limit for controlled exposure at prediction frequency (mW/cm^2):	1.52

The average output power was derived from the maximum tune up power (36 dBm) and duty cycle (46.9%). The average output power = peak output power – 10*log(1/duty cycle)=36-3.288=32.712 dBm..

Results

The device is compliant with the requirement MPE limit for controlled exposure. The maximum power density at the distance of 3048 cm (100 ft) is 0.0007 mW/cm^2. Limit is 1.52mW/cm^2.

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

Note[1]: 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 2020-07-02 in the RF Site.

5.5 Test Results

Lower Limit =50 Watts, 47 dBm

Modulation	Frequency (MHz)	Output Power (dBm)	Gain (dBi) [1]	ERP (dBm)	≥ Limit (dBm)	Margin (dB)
QPSK	454.675	35.426	13.993	47.269	47	-0.269
	454.825	35.489	13.993	47.332	47	-0.332
	454.975	35.469	13.993	47.312	47	-0.312
16QAM	454.675	35.157	13.993	47	47	0
	454.825	35.440	13.993	47.283	47	-0.283
	454.975	35.272	13.993	47.115	47	-0.115
64QAM	454.675	35.245	13.993	47.088	47	-0.088
	454.825	35.284	13.993	47.127	47	-0.127
	454.975	35.288	13.993	47.131	47	-0.131

Note[1]: Gain determined from minimum gain possible to be used in order to pass ERP Limit.

Upper Limit =100 Watts, 50 dBm

Modulation	Frequency (MHz)	Output Power (dBm)	Gain (dBi) [2]	ERP (dBm)	≤ Limit (dBm)	Margin (dB)
QPSK	454.675	35.426	16.661	49.937	50	-0.063
	454.825	35.489	16.661	50	50	0
	454.975	35.469	16.661	49.98	50	-0.02
16QAM	454.675	35.157	16.661	49.668	50	-0.332
	454.825	35.440	16.661	49.951	50	-0.049
	454.975	35.272	16.661	49.783	50	-0.217
64QAM	454.675	35.245	16.661	49.756	50	-0.244
	454.825	35.284	16.661	49.795	50	-0.205
	454.975	35.288	16.661	49.799	50	-0.201

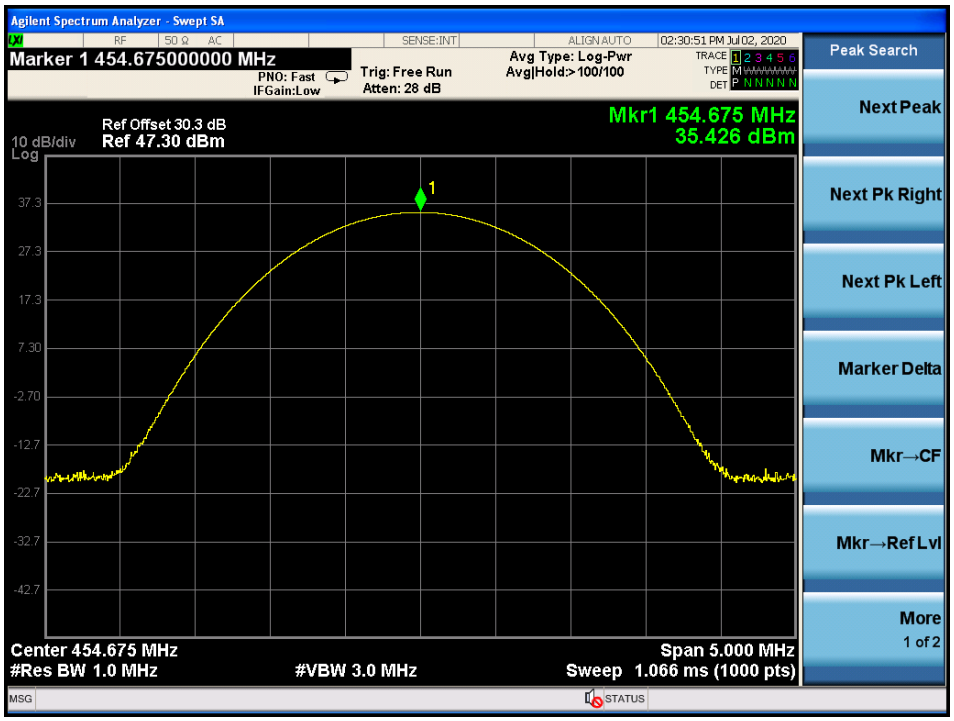
Note[2]: Gain determined from max gain possible to be used in order to pass ERP Limit.

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

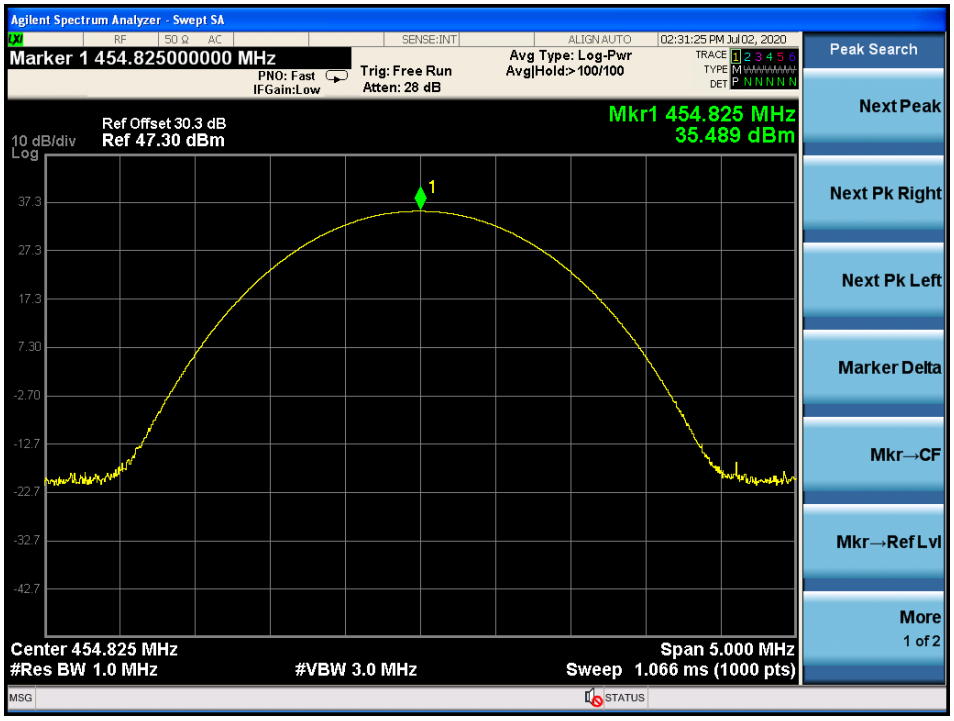
Please refer to the following plots.

QPSK

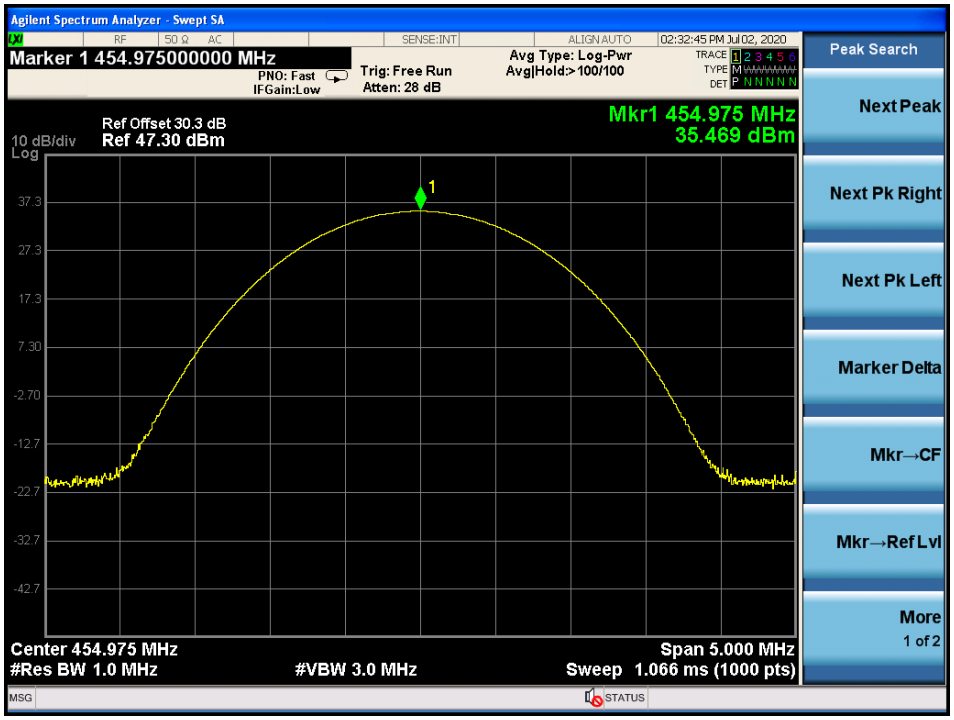
454.675MHz



454.825MHz

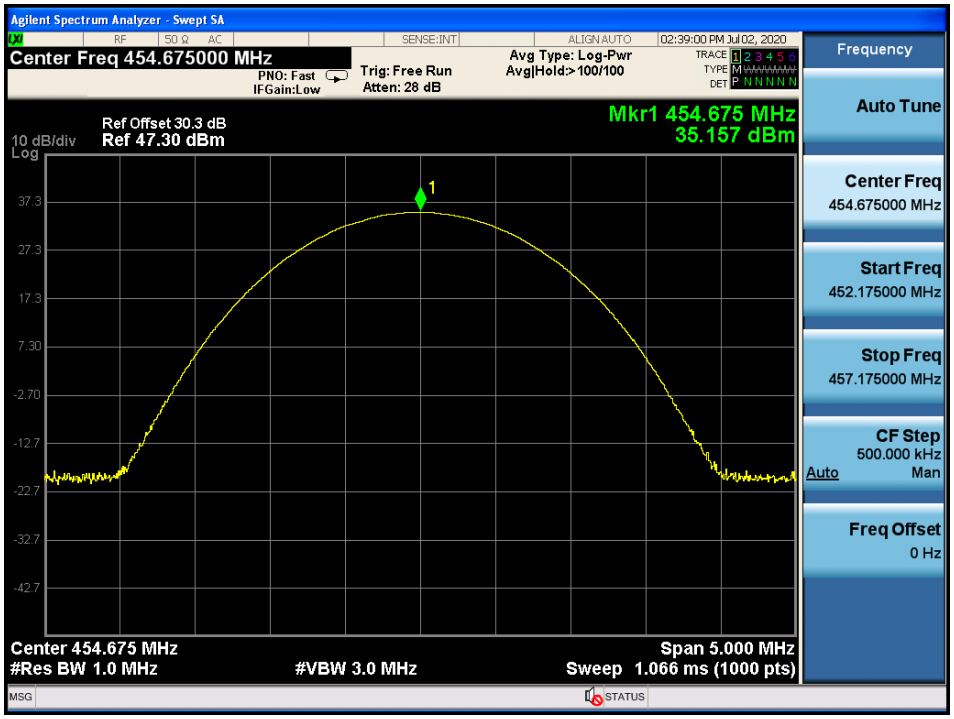


454.975MHz

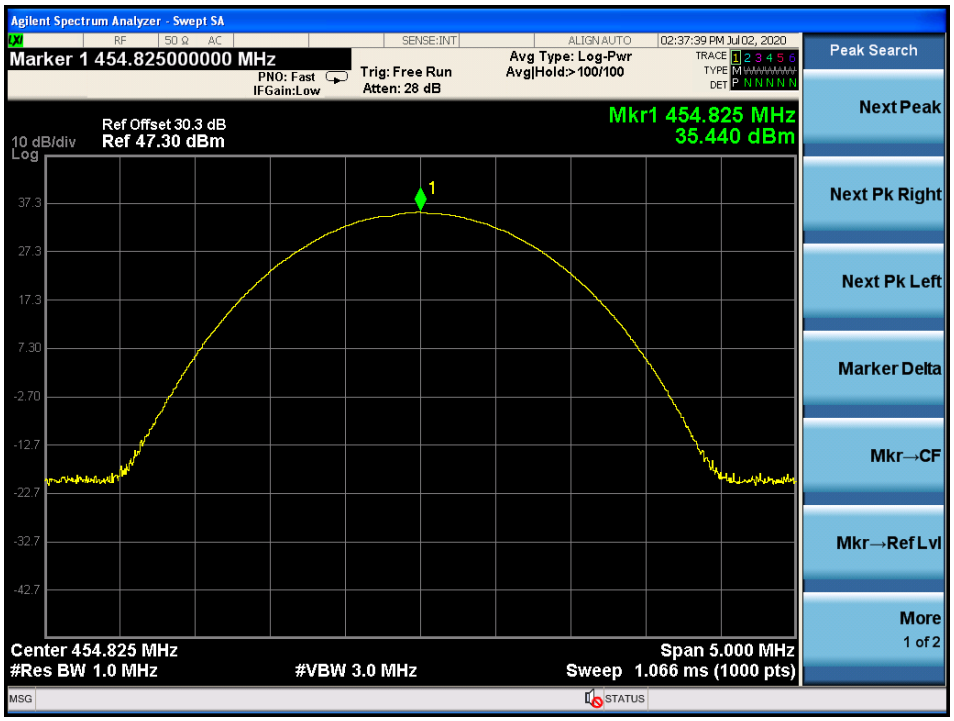


16QAM

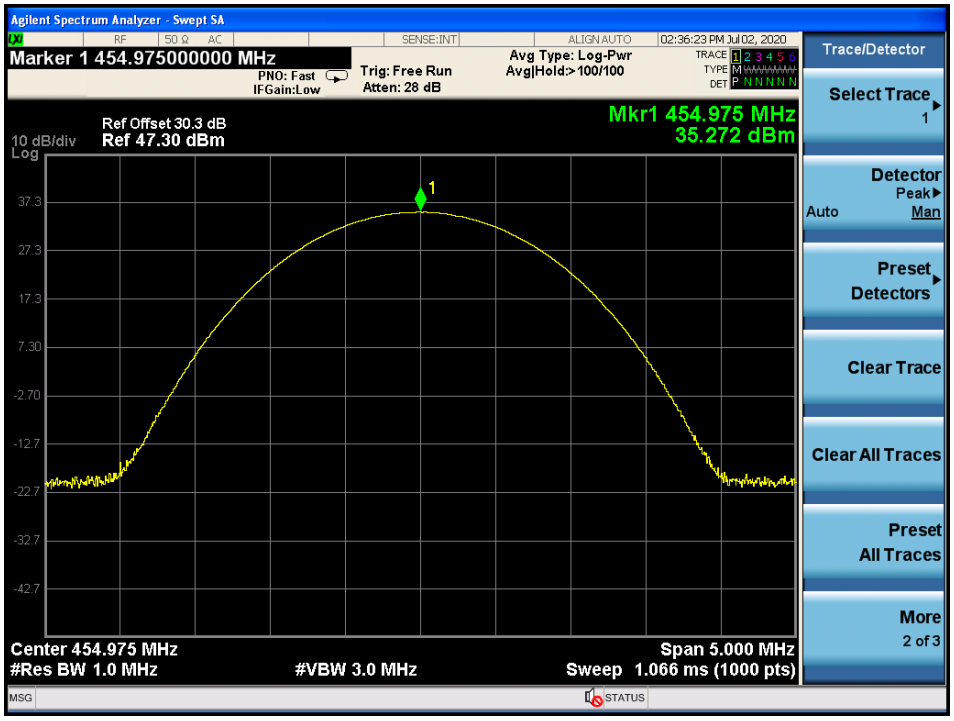
454.675MHz



454.825MHz

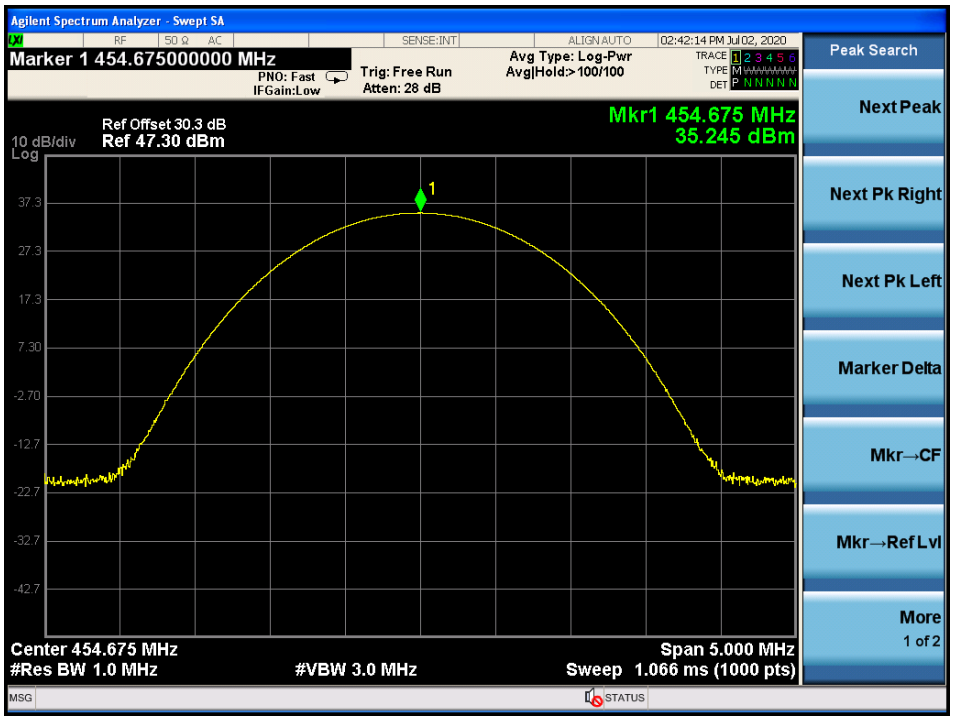


454.975MHz

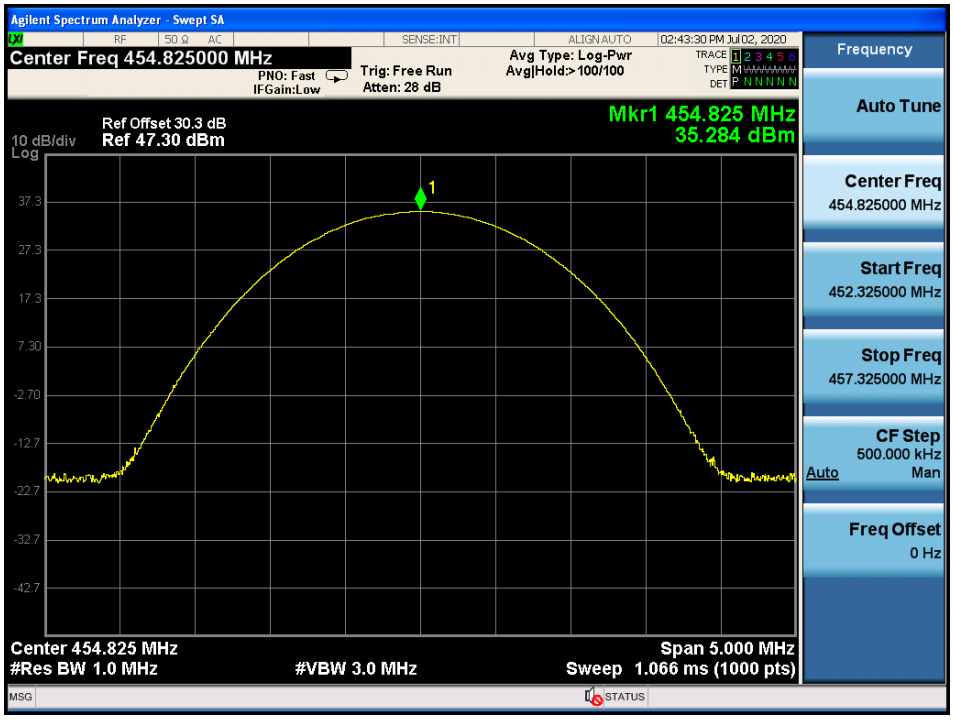


64QAM

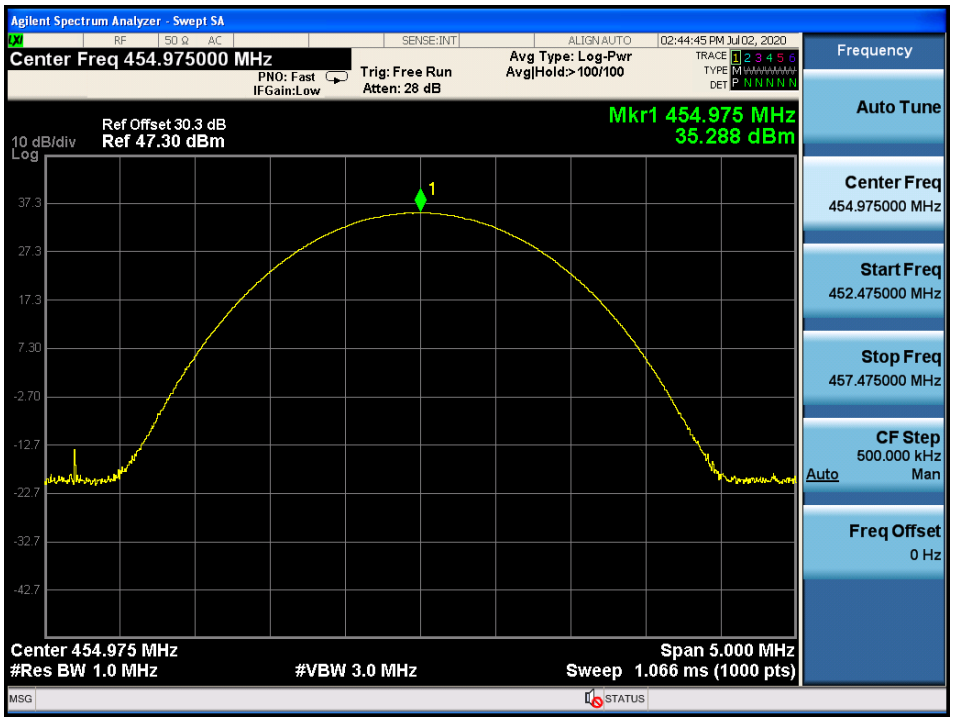
454.675MHz



454.825MHz



454.975MHz


Agilent Spectrum Analyzer - Swept SA
Center Freq 454.975000 MHz
PNO: Fast
IFGain:Low
Trig: Free Run
Atten: 28 dB
Avg Type: Log-Pwr
Avg|Hold:>100/100
02:44:45 PM Jul 02, 2020
Ref Offset 30.3 dB
10 dB/div
Log
Ref 47.30 dBm
Mkr1 454.975 MHz
35.288 dBm
37.3
27.3
17.3
7.30
-2.70
-12.7
-22.7
-32.7
-42.7
Center 454.975 MHz
#Res BW 1.0 MHz
#VBW 3.0 MHz
Span 5.000 MHz
Sweep 1.066 ms (1000 pts)
Frequency
Auto Tune
Center Freq
454.975000 MHz
Start Freq
452.475000 MHz
Stop Freq
457.475000 MHz
CF Step
500.000 kHz
Auto
Man
Freq Offset
0 Hz
MSG
STATUS

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

Note[1]: 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.

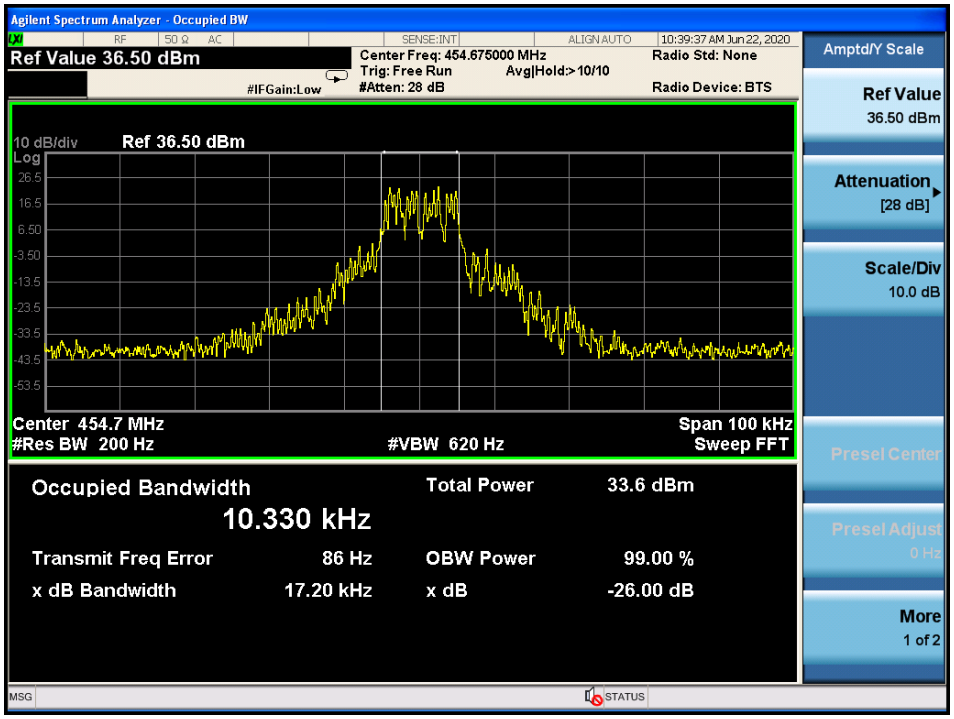
6.5 Test Results

Modulation	Frequency (MHz)	99% OBW (kHz)	26 dB OBW (kHz)	OBW Limit (kHz)
QPSK	454.675	10.33	17.2	< 20
	454.825	10.34	17.2	< 20
	454.975	10.253	17.2	< 20
16QAM	454.675	9.694	17.77	< 20
	454.825	9.701	17.77	< 20
	454.975	9.732	17.79	< 20
64QAM	454.675	10.253	17.21	< 20
	454.825	10.314	17.21	< 20
	454.975	10.345	17.22	< 20

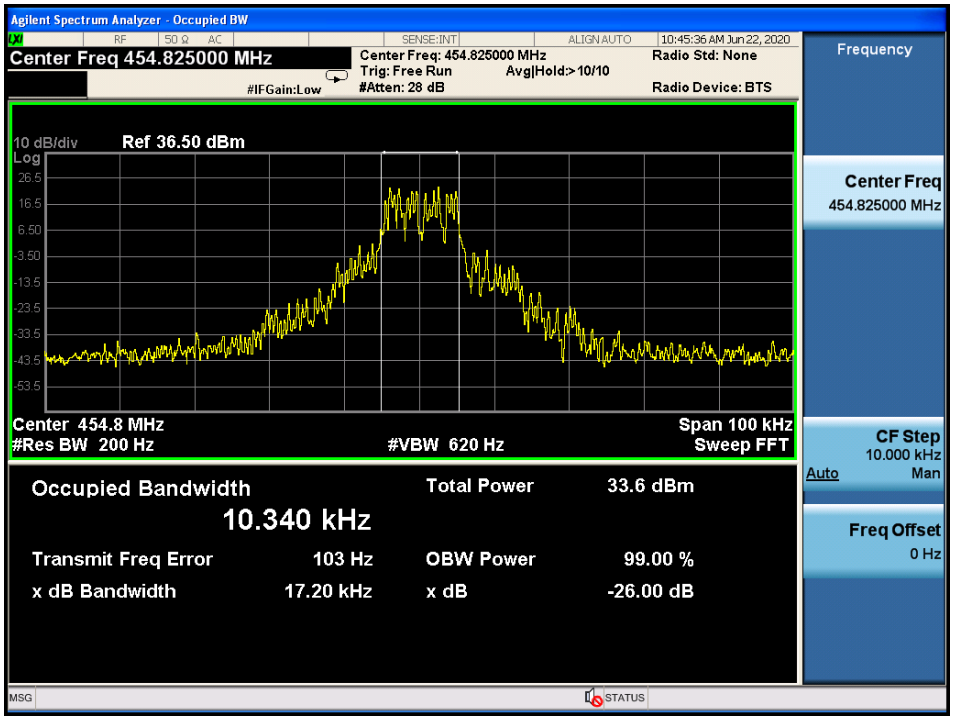
Please refer to the following plots.

QPSK

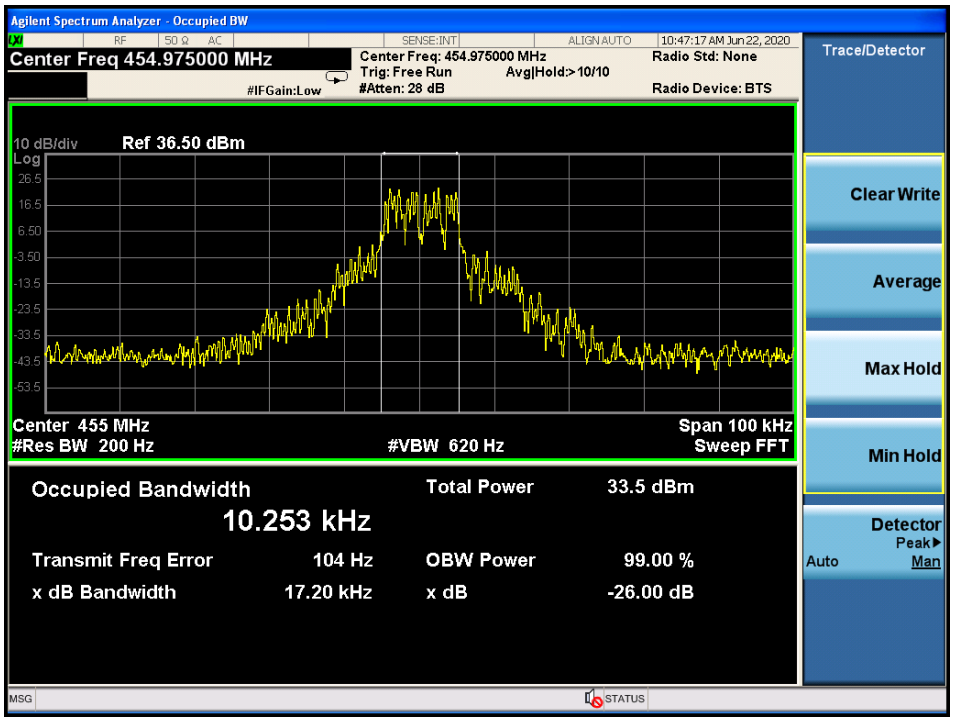
454.675MHz



454.825MHz

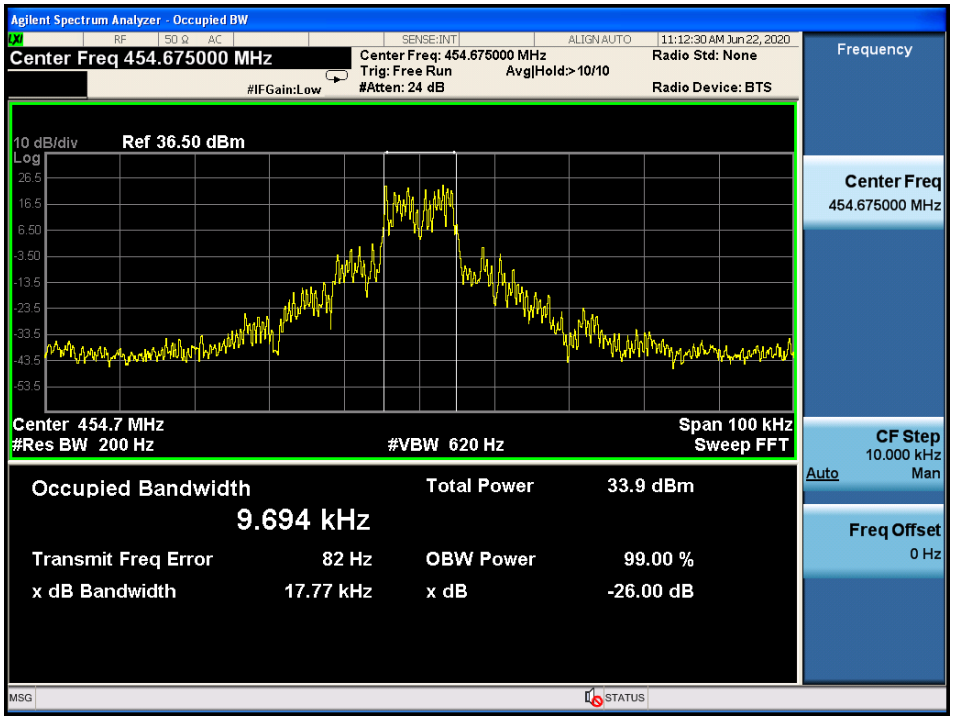


454.975MHz

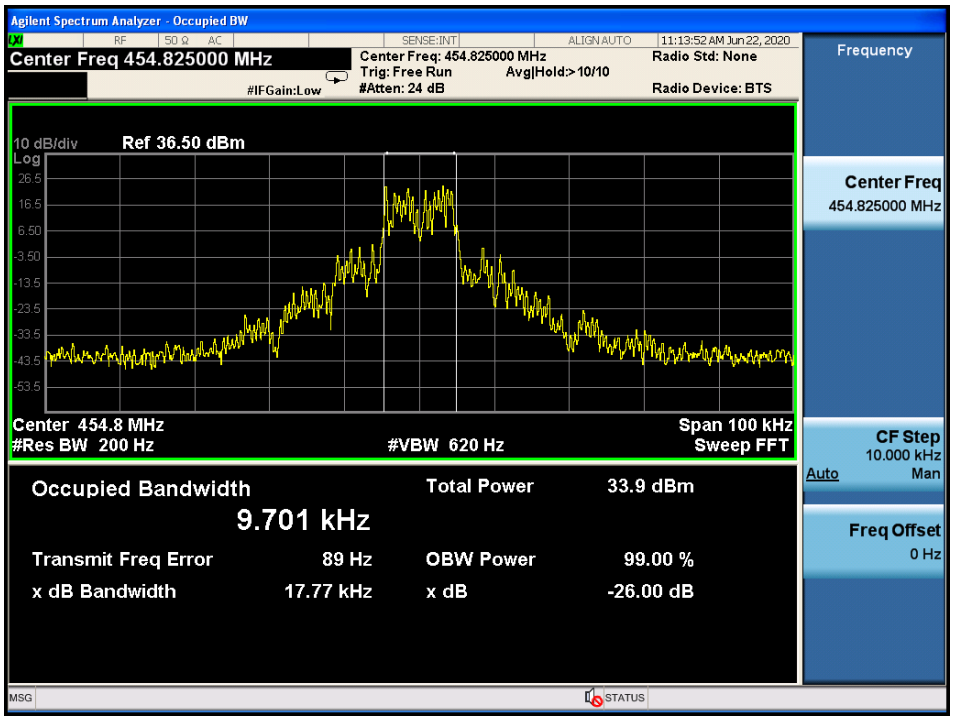


16QAM

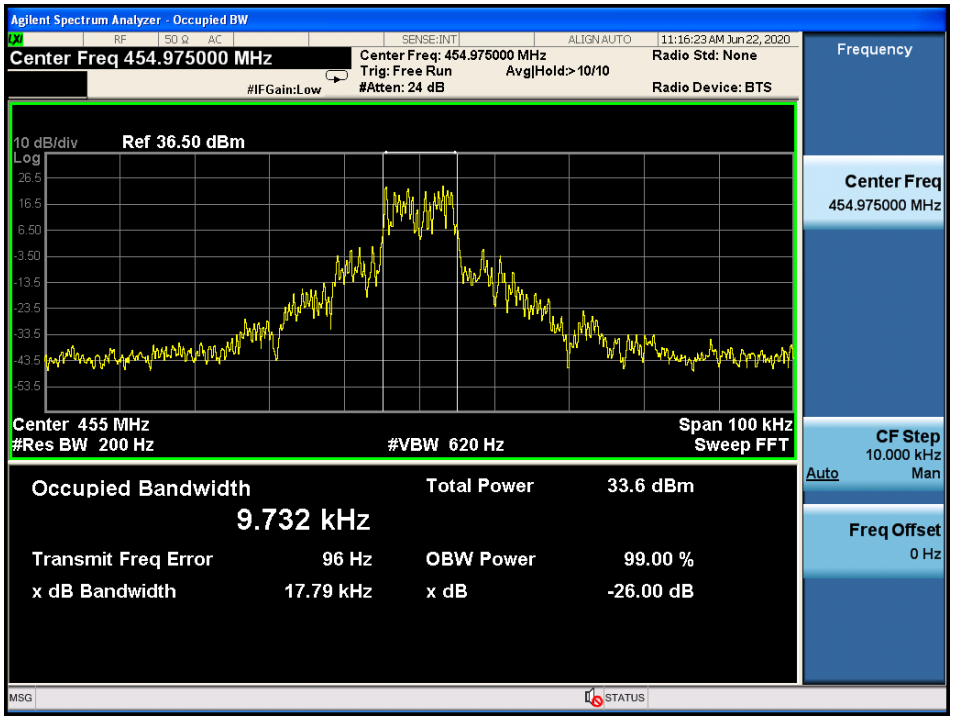
454.675MHz



454.825MHz

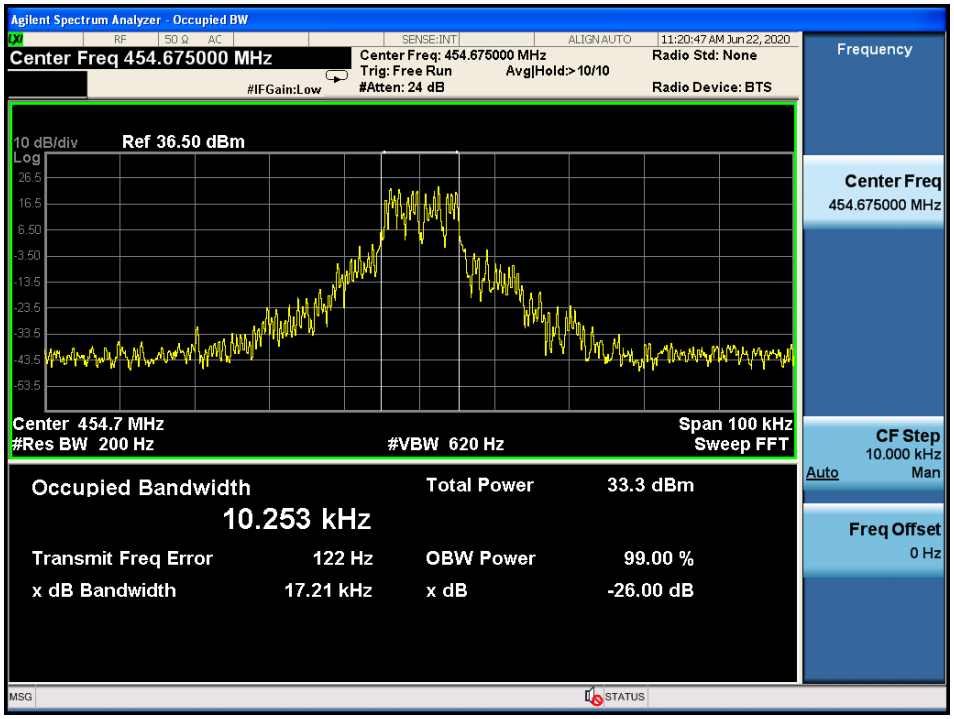


454.975MHz

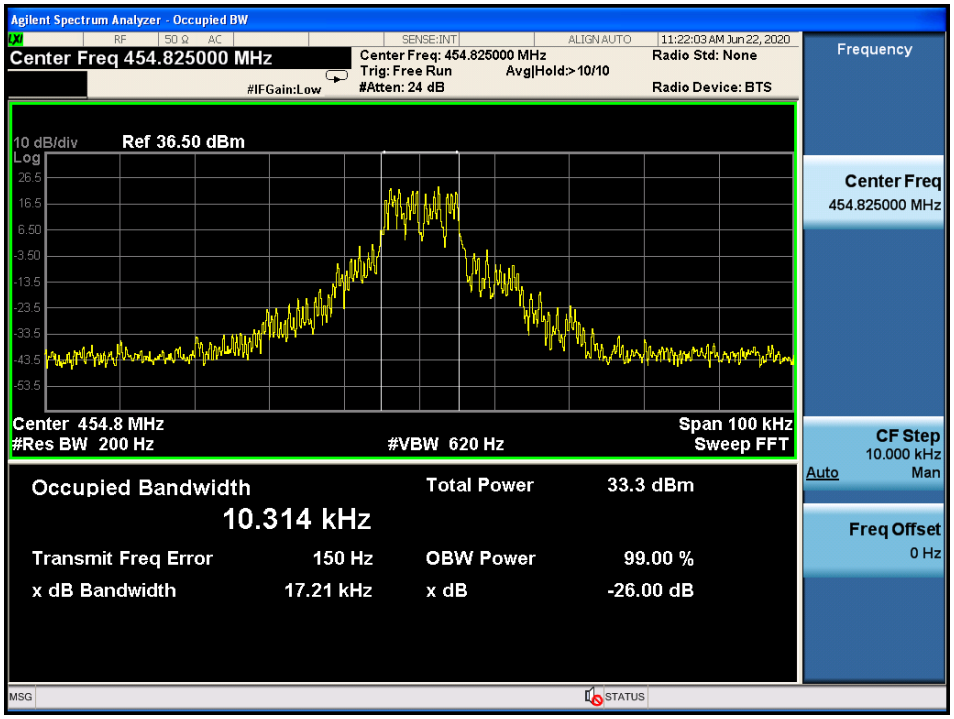


64QAM

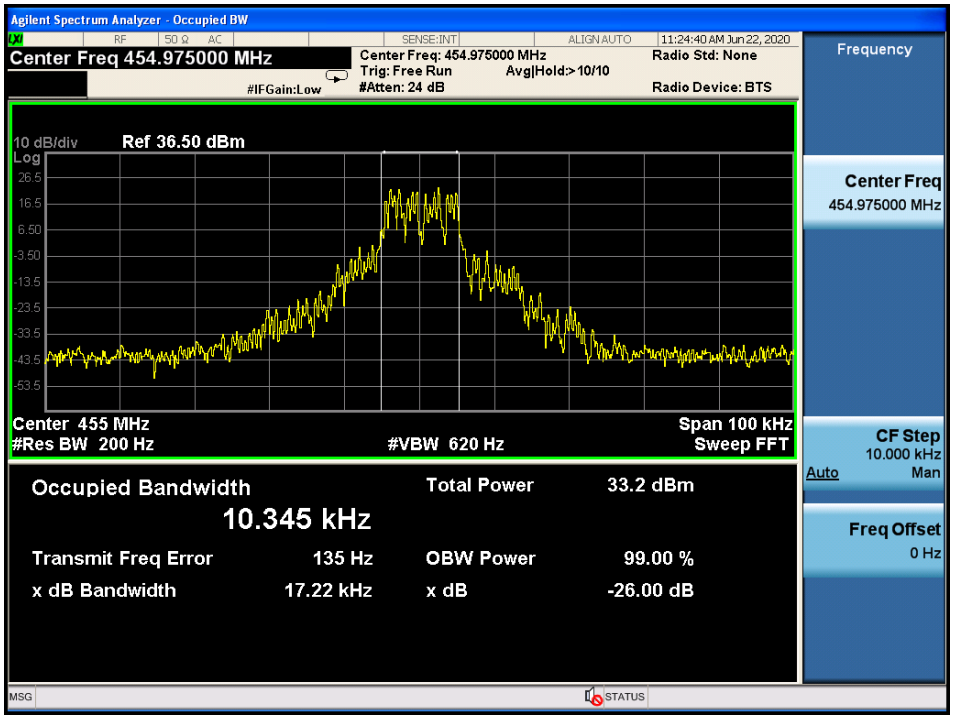
454.675MHz



454.825MHz



454.975MHz


Agilent Spectrum Analyzer - Occupied BW
RF 50 Ω AC
SENSE:INT
ALIGN AUTO
11:24:40 AM Jun 22, 2020
Center Freq 454.975000 MHz
#IFGain:Low
Center Freq: 454.975000 MHz
Trig: Free Run
Avg|Hold:>10/10
#Atten: 24 dB
Radio Std: None
Radio Device: BTS
Frequency
10 dB/div
Log
Ref 36.50 dBm
26.5
16.5
6.50
-3.50
-13.5
-23.5
-33.5
-43.5
-53.5
Center 455 MHz
#Res BW 200 Hz
#VBW 620 Hz
Span 100 kHz
Sweep FFT
Occupied Bandwidth
10.345 kHz
Total Power 33.2 dBm
Transmit Freq Error 135 Hz
OBW Power 99.00 %
x dB Bandwidth 17.22 kHz
x dB -26.00 dB
Center Freq
454.975000 MHz
CF Step
10.000 kHz
Auto
Man
Freq Offset
0 Hz
MSG
STATUS

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 place 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/ Agilant	Pre Amplifier	8449B OPT HO2	3008A0113	2019-09-30	1year
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]

Note[1]: 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 (454.825MHz)

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)		
420	40.95	95	160	H	420	-61.75	1.8	2.1	-62.05	-13	-49.05
420	40.44	280	160	V	420	-60.83	1.8	2.1	-61.13	-13	-48.13
909.65	49.31	110	125	H	909.65	-47.09	3.6	3.2	-46.69	-13	-33.69
909.65	45.77	20	135	V	909.65	-48.4	3.6	3.2	-48	-13	-35
1364.5	82.07	118	110	H	1364.5	-26.61	7.992	1	-19.618	-13	-6.618
1364.5	77	340	150	V	1364.5	-30.2	7.992	1	-23.208	-13	-10.208
2274	68.75	70	130	H	2274	-34.36	8.939	1.85	-27.271	-13	-14.271
2274	68.6	10	165	V	2274	-31.86	8.939	1.85	-24.771	-13	-11.771

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)		
420	40.92	95	160	H	420	-61.78	1.8	2.1	-62.08	-13	-49.08
420	40.51	280	160	V	420	-60.76	1.8	2.1	-61.06	-13	-48.06
909.65	49.11	110	125	H	909.65	-47.29	3.6	3.2	-46.89	-13	-33.89
909.65	45.46	20	135	V	909.65	-48.71	3.6	3.2	-48.31	-13	-35.31
1364.5	81.78	118	110	H	1364.5	-26.9	7.992	1	-19.908	-13	-6.908
1364.5	76.88	340	150	V	1364.5	-30.32	7.992	1	-23.328	-13	-10.328
2274	68.16	70	130	H	2274	-34.95	8.939	1.85	-27.861	-13	-14.861
2274	68.3	10	165	V	2274	-32.16	8.939	1.85	-25.071	-13	-12.071

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	40.85	95	160	H	420	-61.85	1.8	2.1	-62.15	-13	-49.15
420	40.64	280	160	V	420	-60.63	1.8	2.1	-60.93	-13	-47.93
909.65	49.27	110	125	H	909.65	-47.13	3.6	3.2	-46.73	-13	-33.73
909.65	45.79	20	135	V	909.65	-48.38	3.6	3.2	-47.98	-13	-34.98
1364.5	81.85	118	110	H	1364.5	-26.83	7.992	1	-19.838	-13	-6.838
1364.5	76.74	340	150	V	1364.5	-30.46	7.992	1	-23.468	-13	-10.468
2274	68.72	70	130	H	2274	-34.39	8.939	1.85	-27.301	-13	-14.301
2274	68.45	10	165	V	2274	-32.01	8.939	1.85	-24.921	-13	-11.921

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

Note[1]*: 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 2020-07-02in the RF Site.

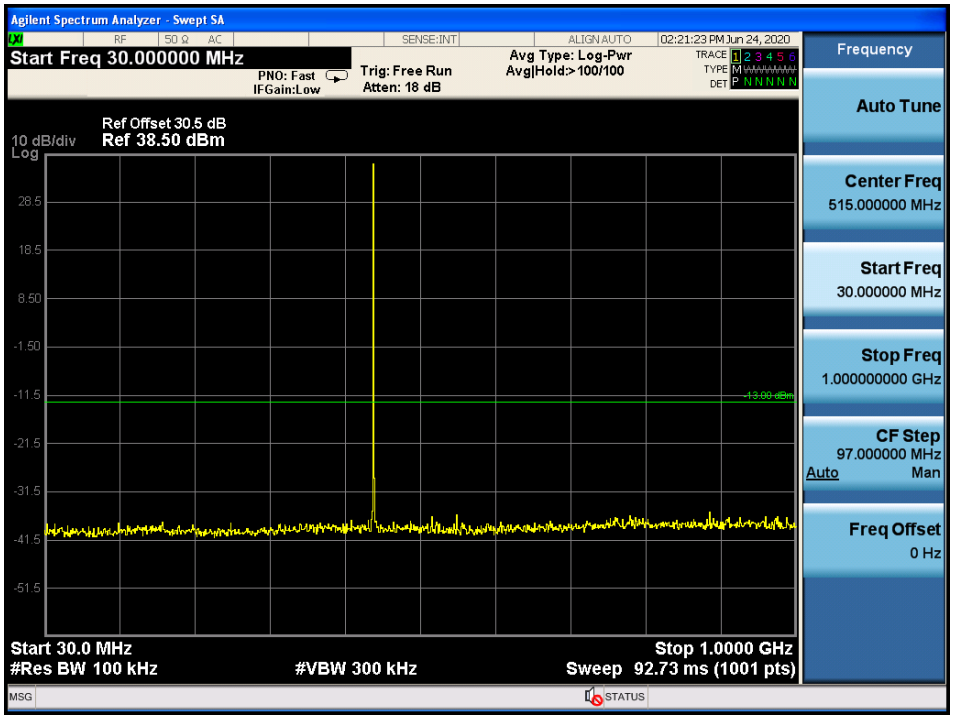
8.5 Test Results

Conducted Spurious Emissions:

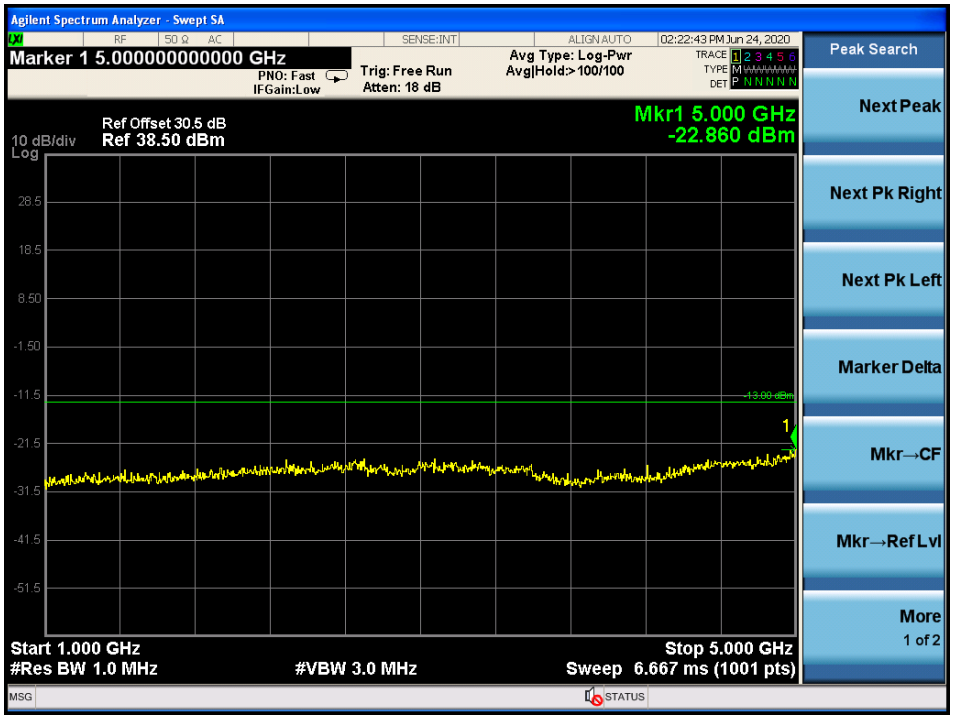
QPSK

454.825MHz

30 MHz-1 GHz



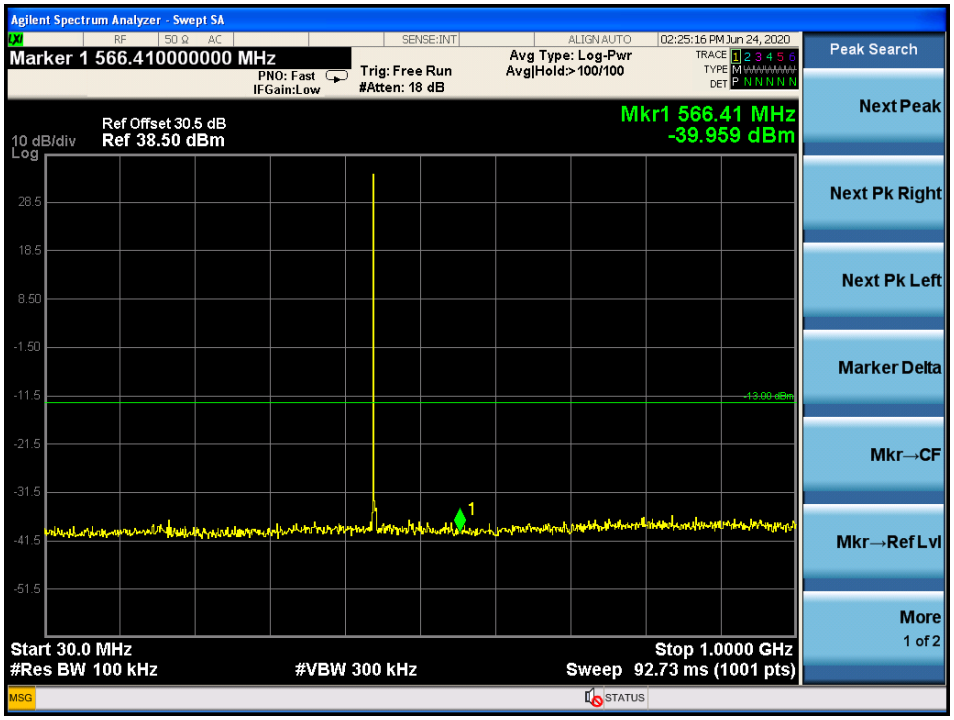
1 GHz-5 GHz



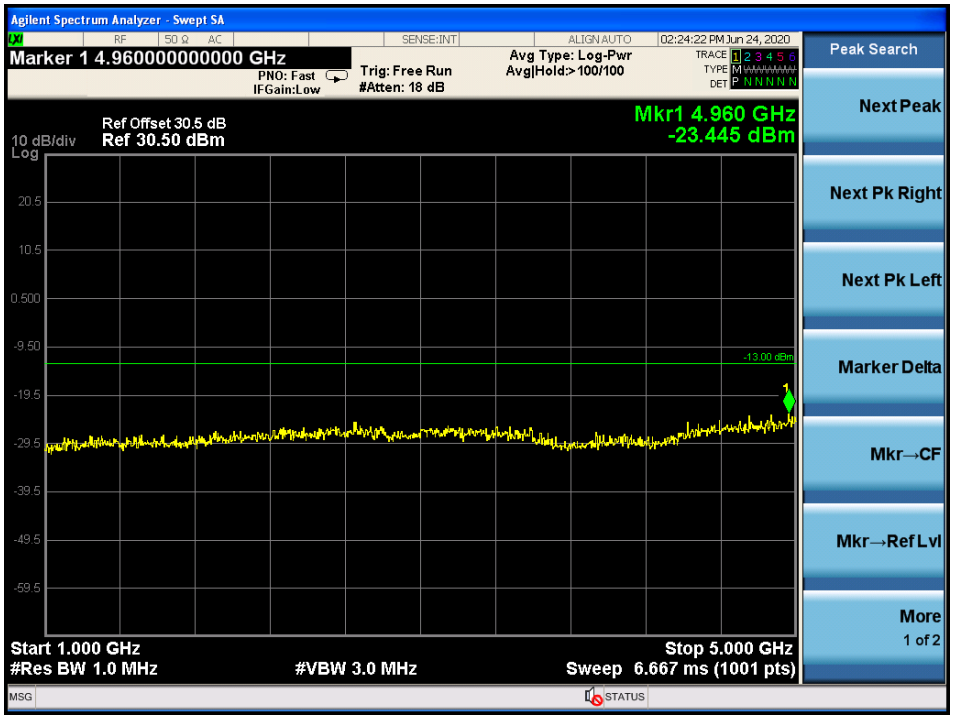
16QAM

454.825 MHz

30 MHz-1 GHz



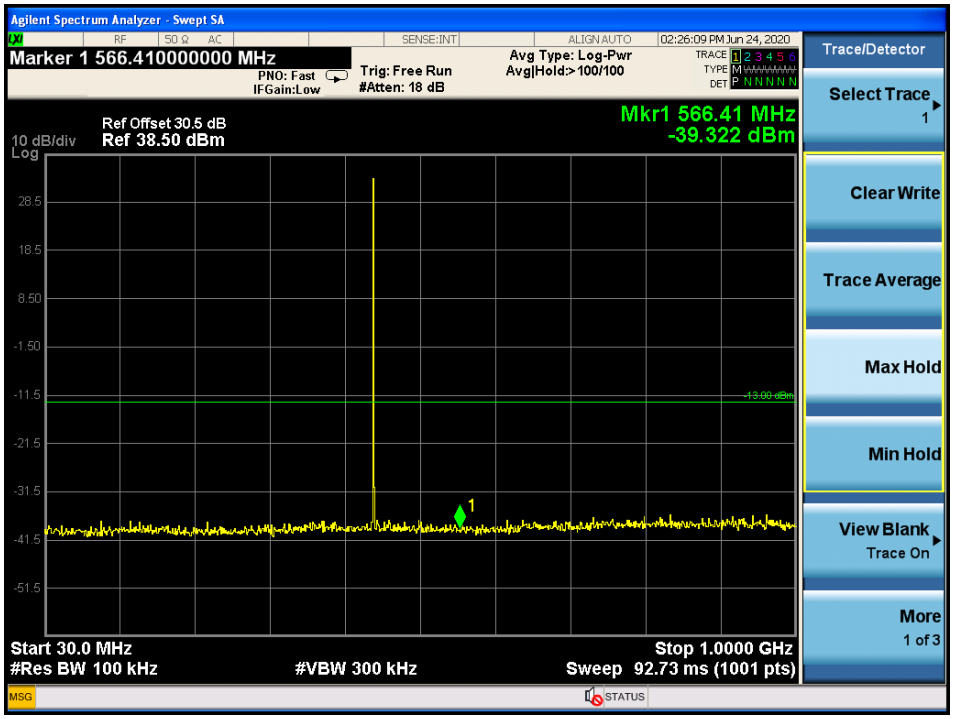
1 GHz-5 GHz



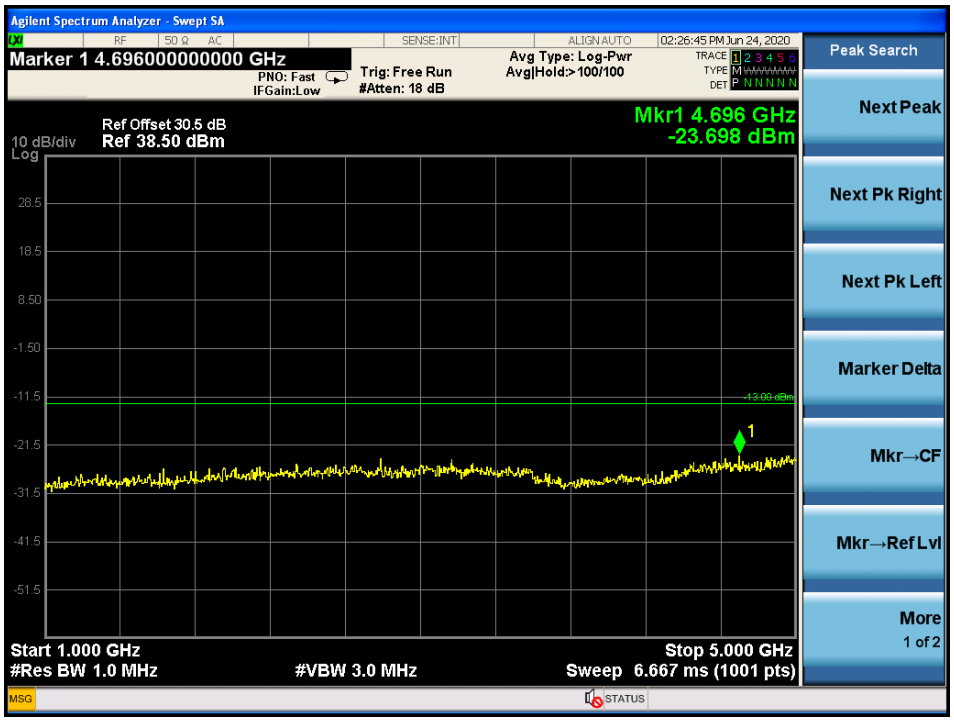
64QAM

454.825 MHz

30 MHz-1 GHz



1 GHz-5 GHz


Agilent Spectrum Analyzer - Swept SA
RF 50 Ω AC
SENSE:INT
ALIGN AUTO
02:26:45 PM Jun 24, 2020
Marker 1 4.696000000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 18 dB
Avg Type: Log-Pwr
Avg|Hold:>100/100
TRACE 1 2 3 4 5 6
TYPE M
DET P N N N N N
Ref Offset 30.5 dB
10 dB/div
Log
Ref 38.50 dBm
Mkr1 4.696 GHz
-23.698 dBm
28.5
18.5
8.50
-1.50
-11.5
-21.5
-31.5
-41.5
-51.5
-13.00 dBm
1
Start 1.000 GHz
#Res BW 1.0 MHz
#VBW 3.0 MHz
Stop 5.000 GHz
Sweep 6.667 ms (1001 pts)
MSG
STATUS
Peak Search
Next Peak
Next Pk Right
Next Pk Left
Marker Delta
Mkr→CF
Mkr→Ref Lvl
More
1 of 2

Band-edge Emissions:

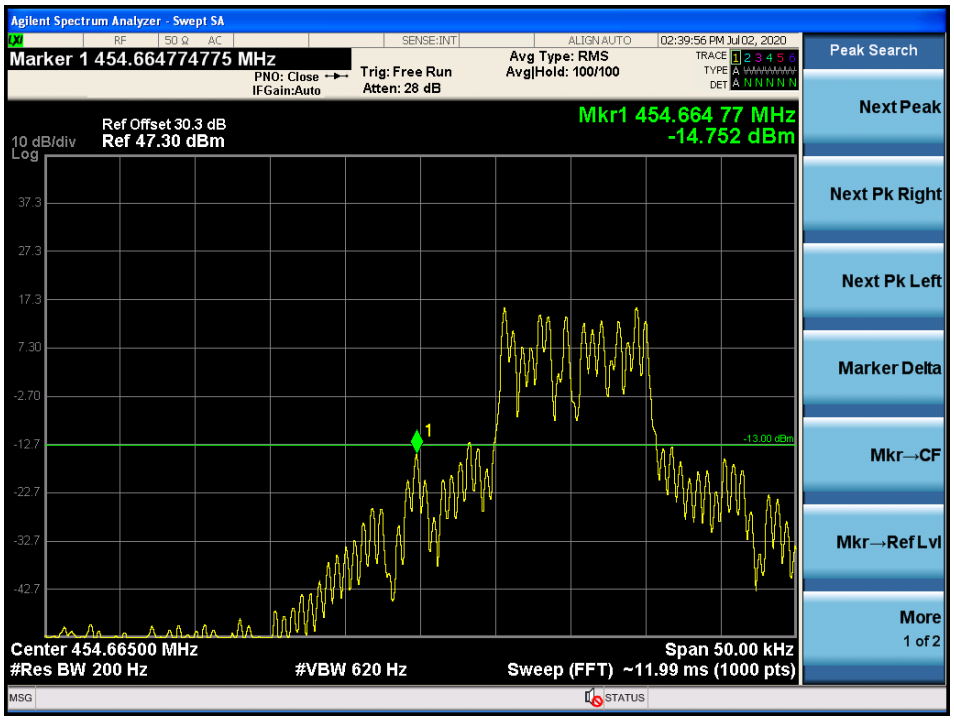
QPSK

454.675 MHz

454.975 MHz

16QAM

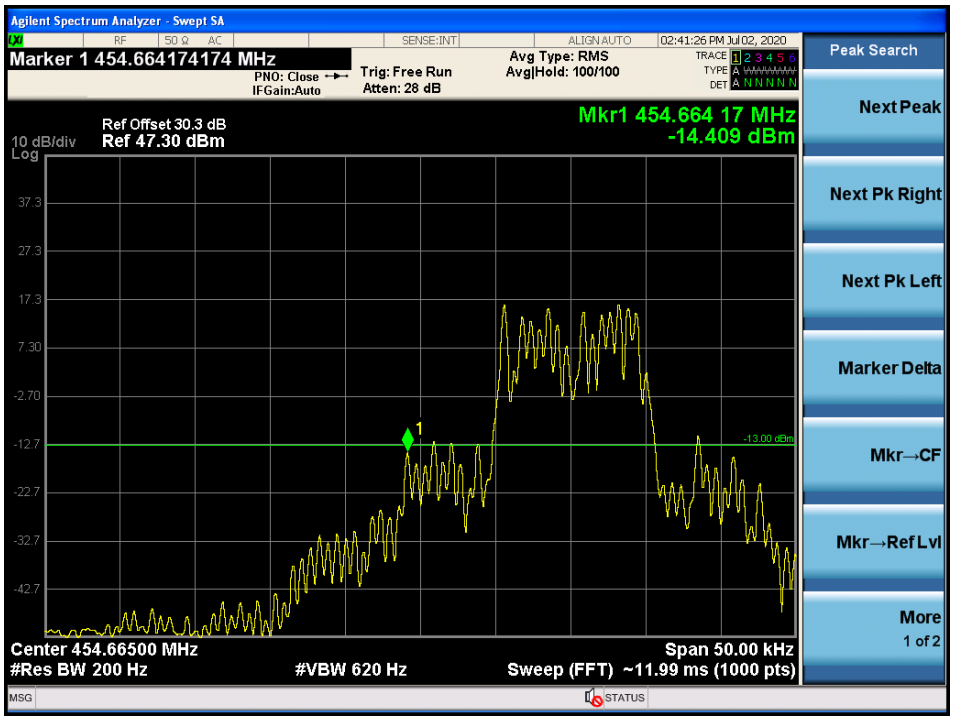
454.675 MHz



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

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

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

(2) From −20° to + 50° 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° 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° 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

Note[1]: 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

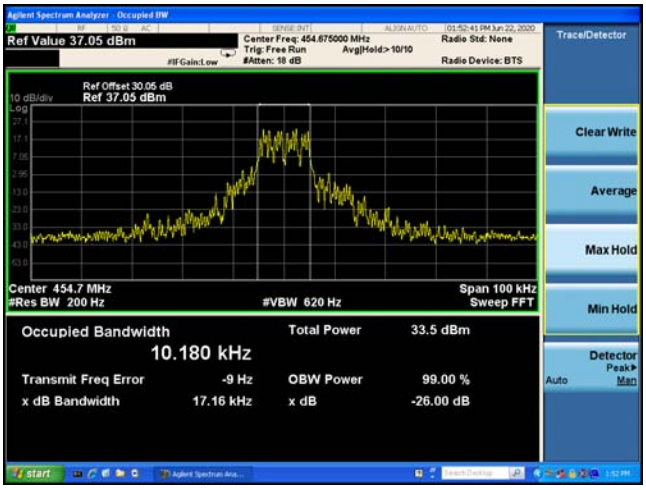
The testing was performed by Christian McCaig from 2020-06-22 to 2020-06-23 in the RF Site.

9.5 Test Results

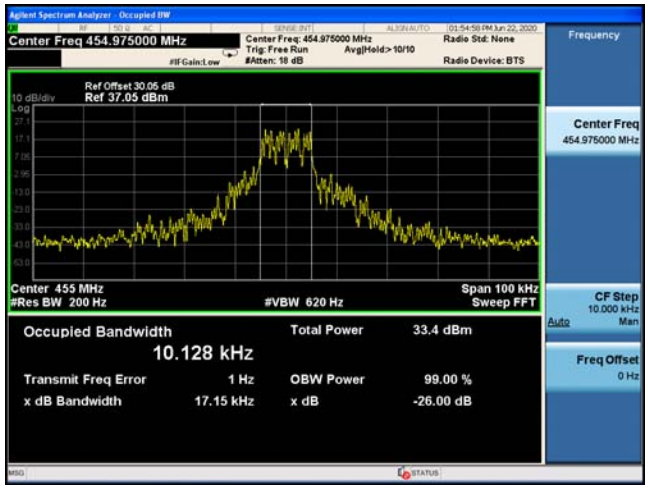
-30 °C

QPSK

454.675MHz

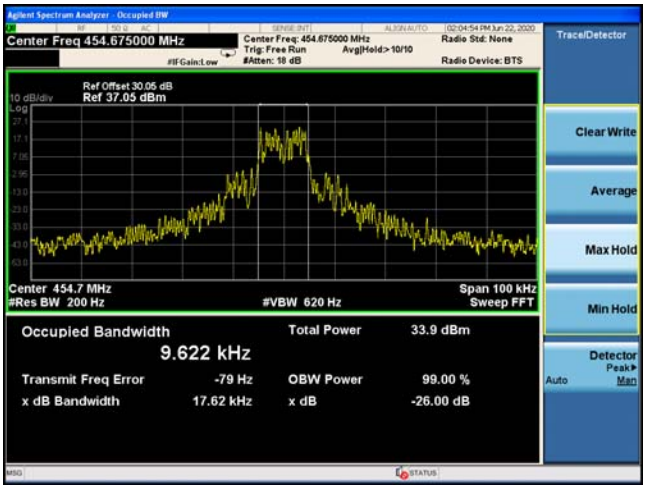


454.975MHz

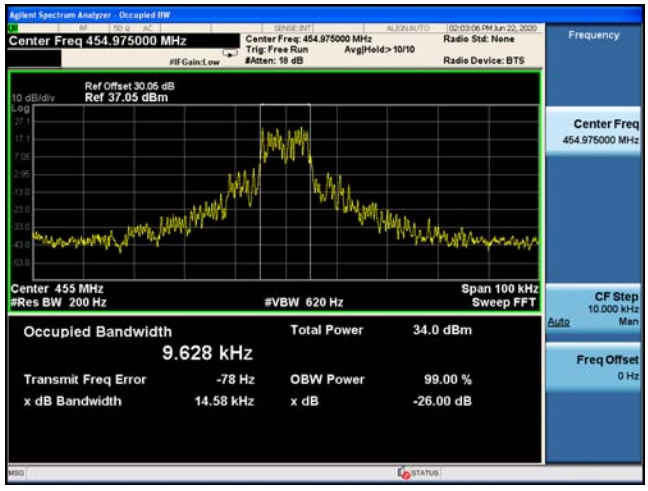


16QAM

454.675MHz

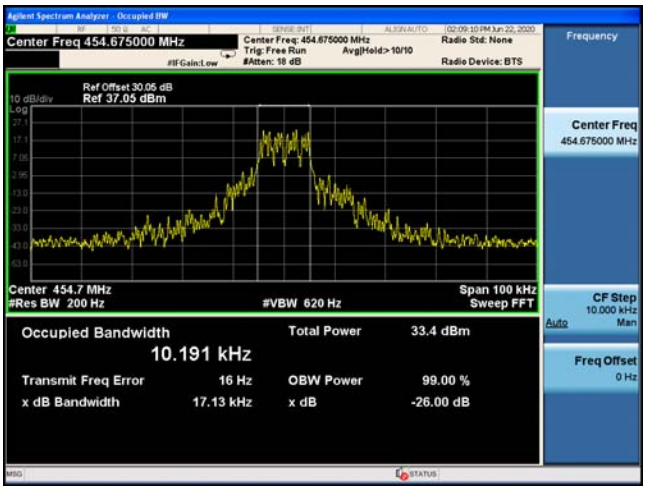


454.975MHz

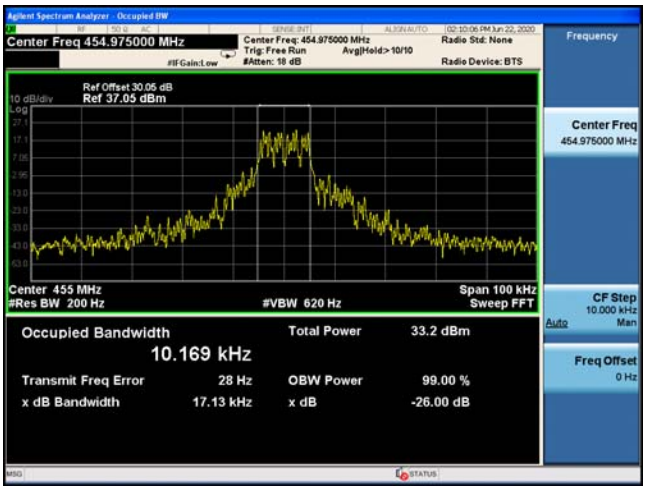


64QAM

454.675MHz



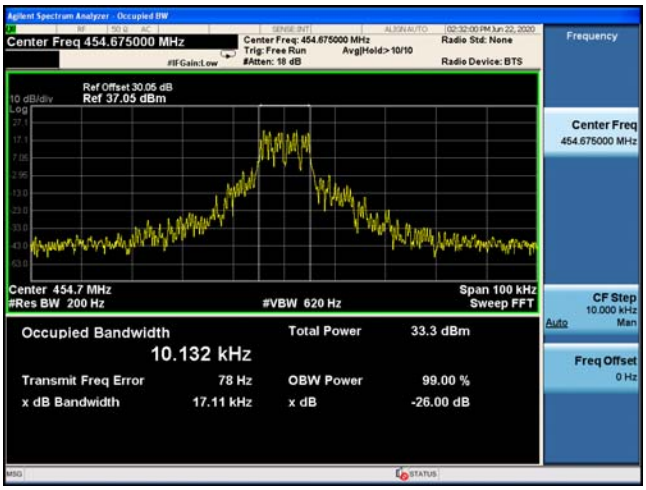
454.975MHz



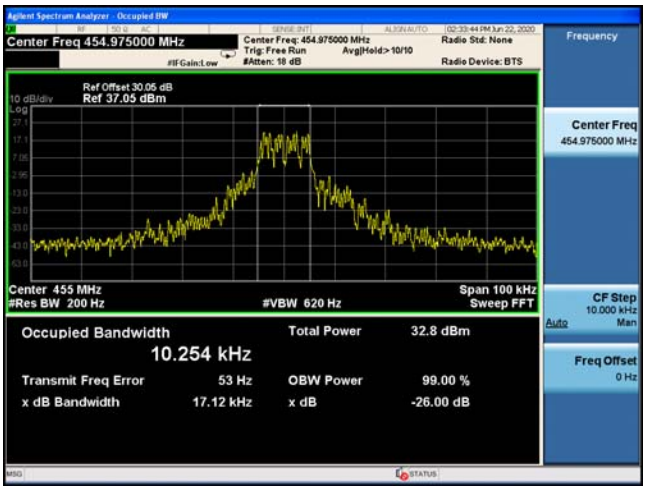
-20 °C

QPSK

454.675MHz

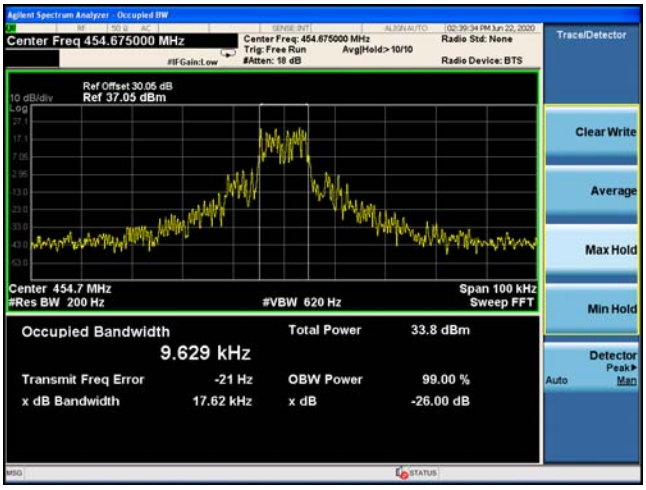


454.975MHz

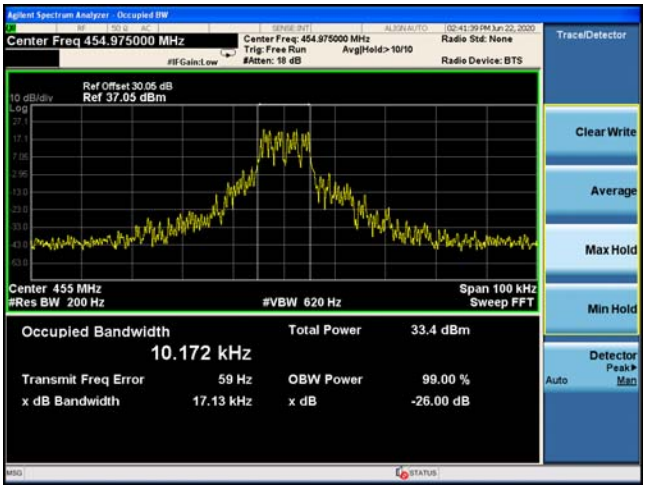


16QAM

454.675MHz

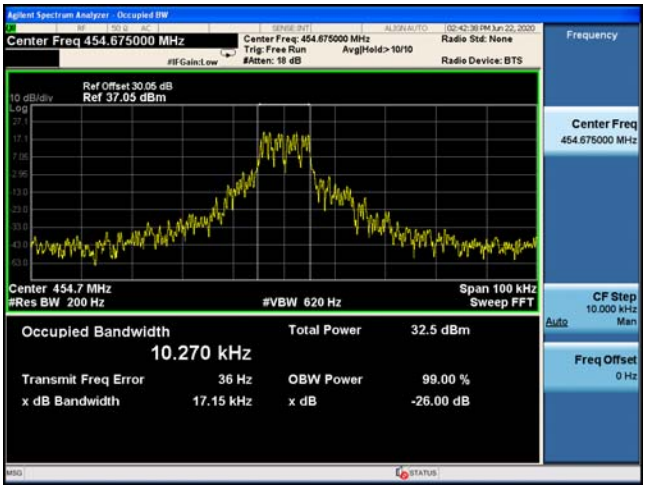


454.975MHz



64QAM

454.675MHz



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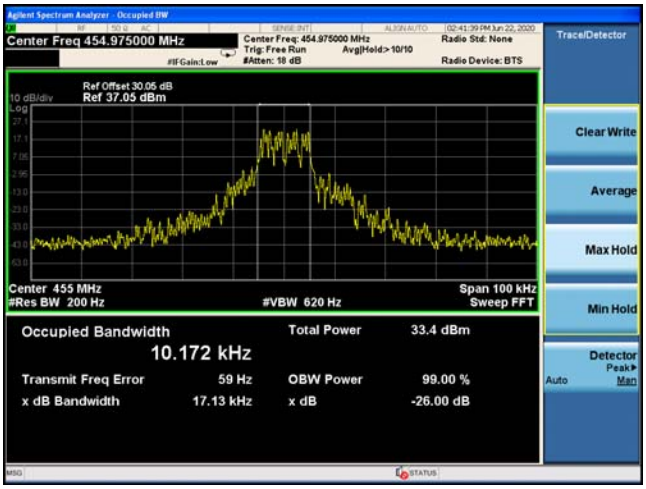

-10 °C

QPSK

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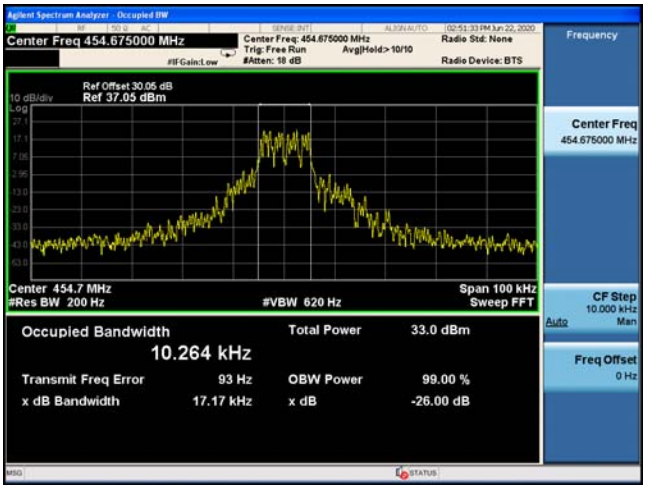

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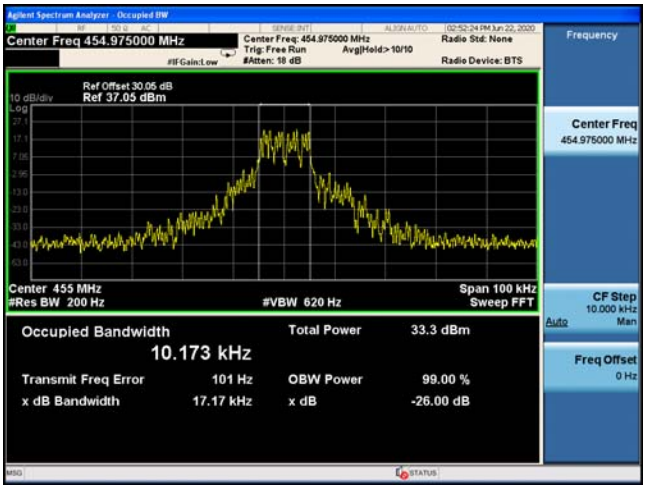

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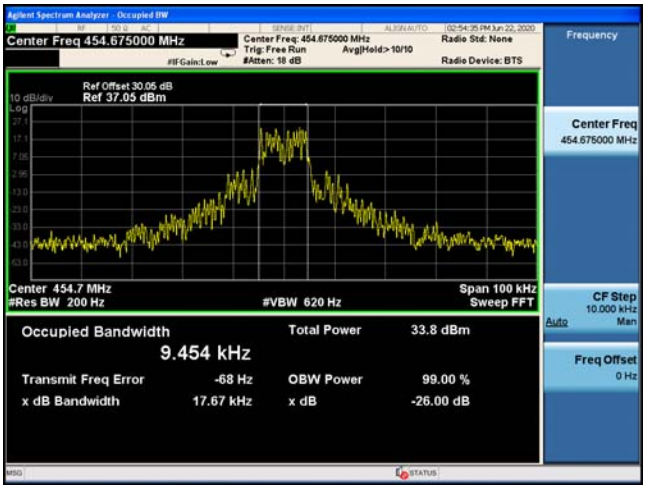

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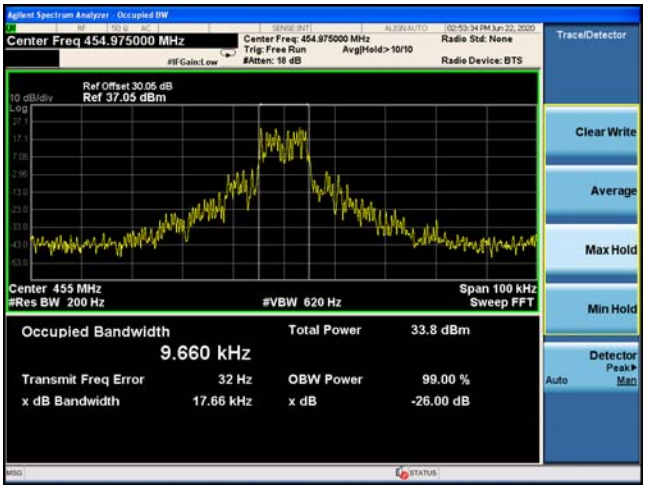

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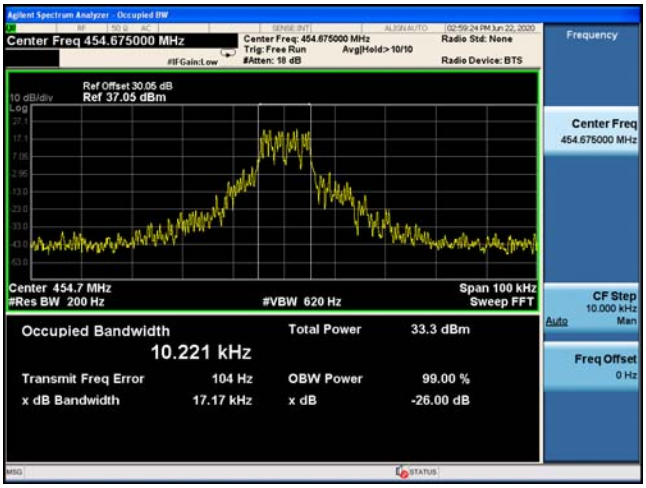

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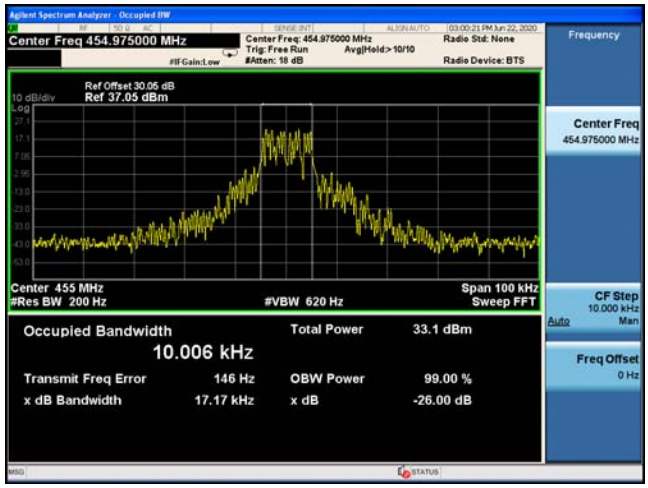

0 °C

QPSK

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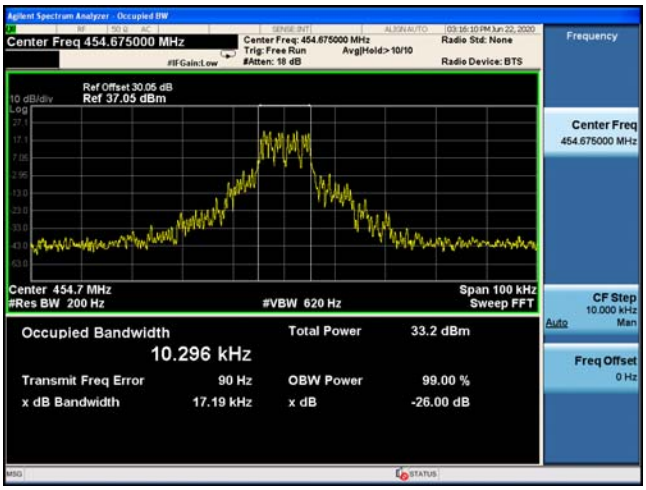

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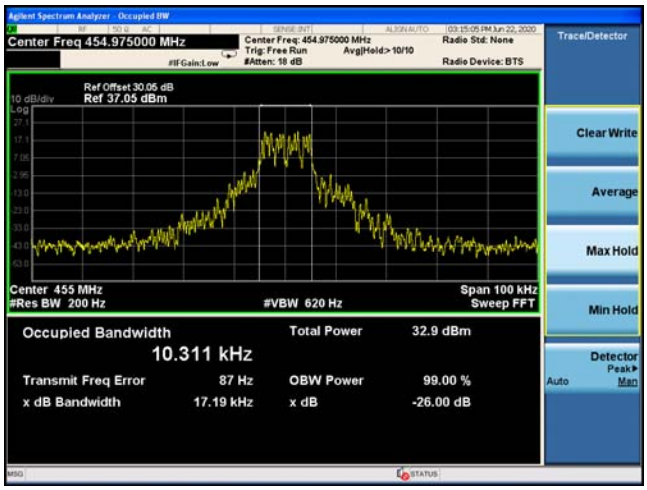

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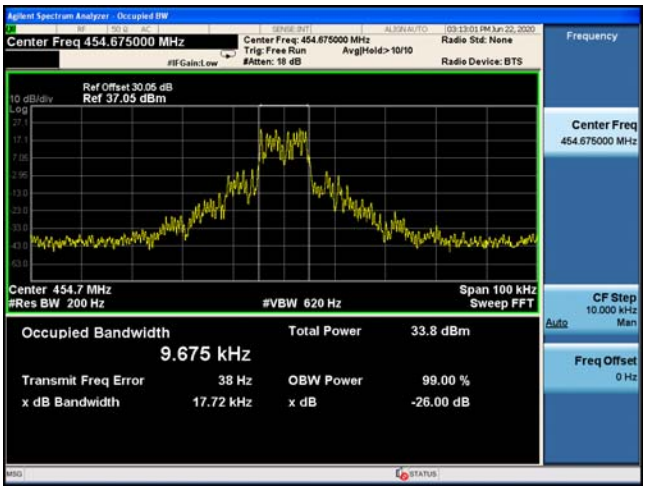

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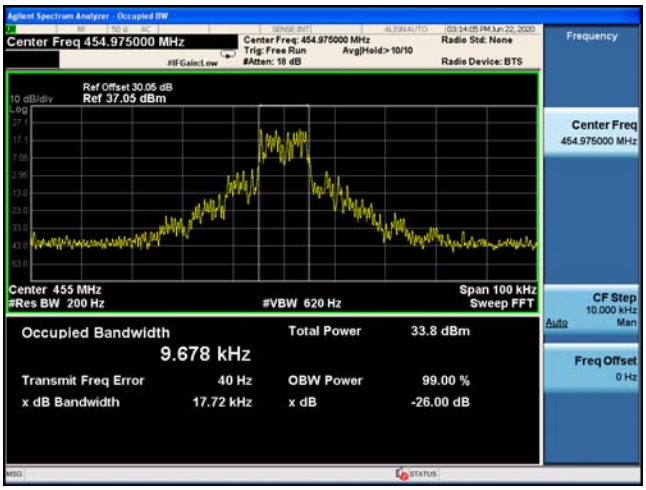

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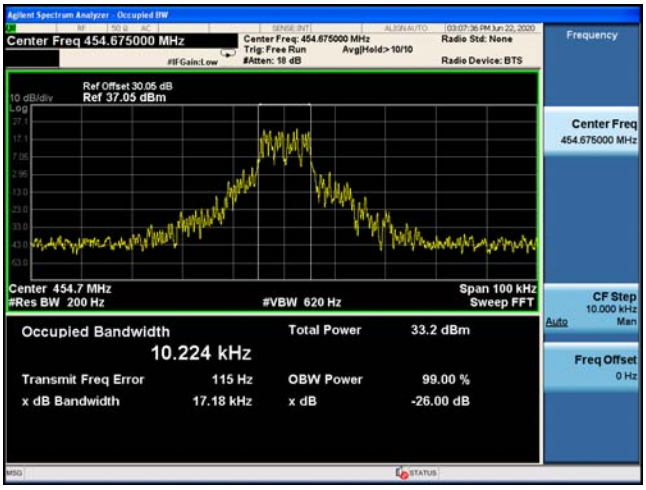

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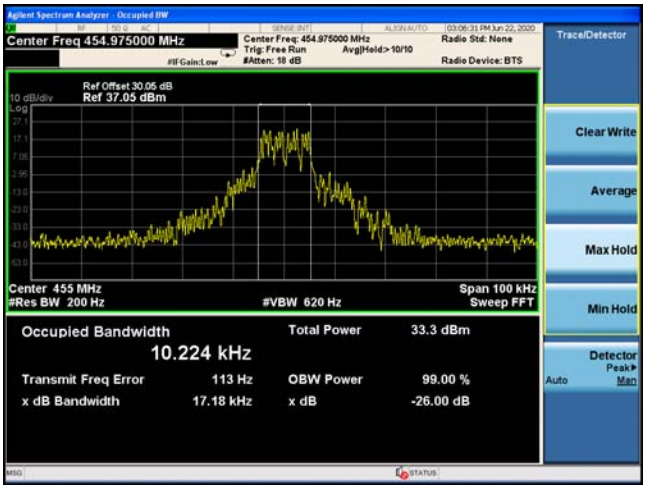

10 °C

QPSK

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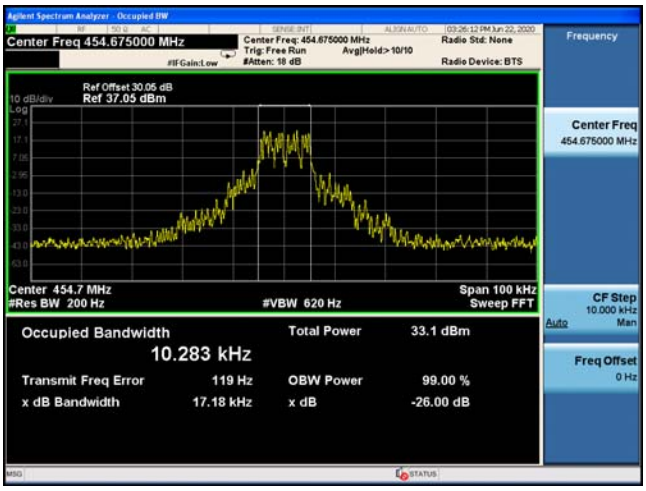

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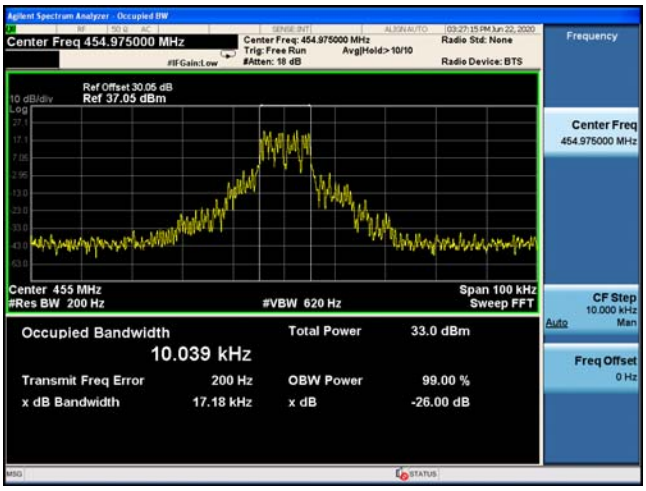

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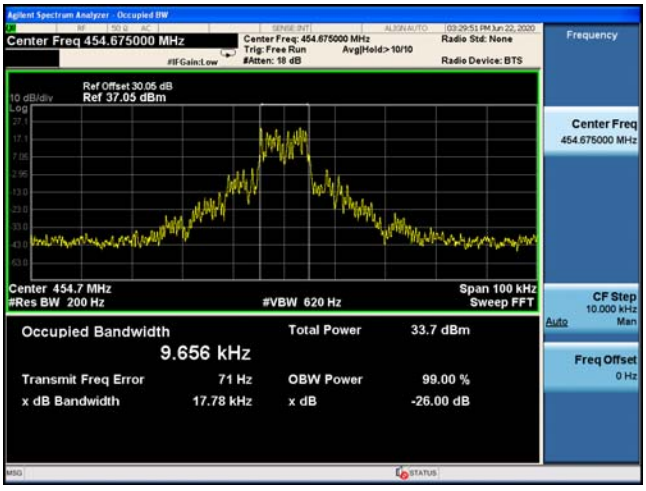

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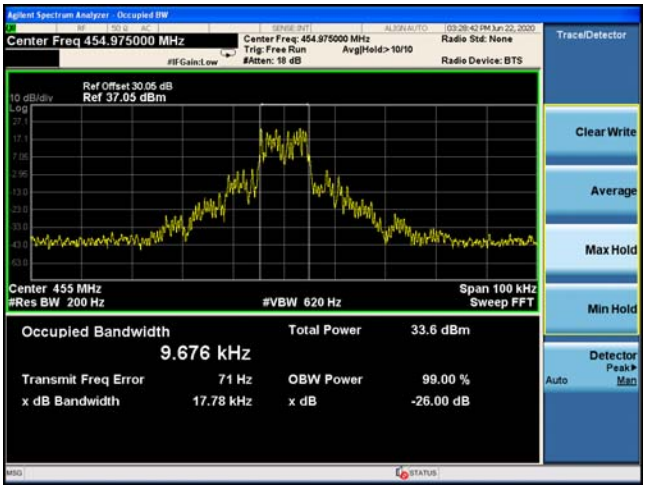

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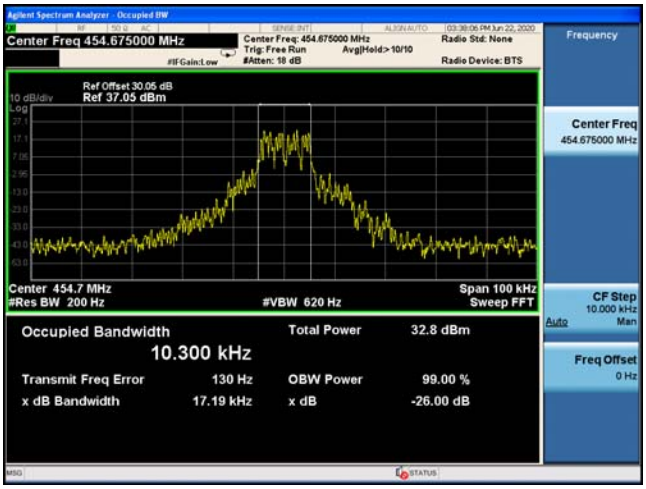

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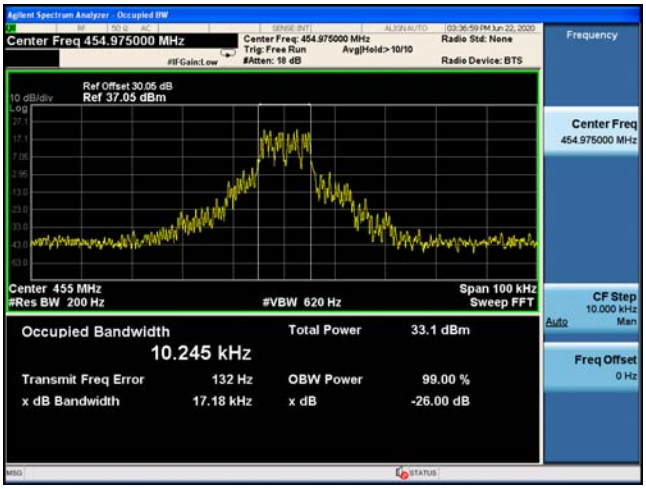

20 °C

QPSK

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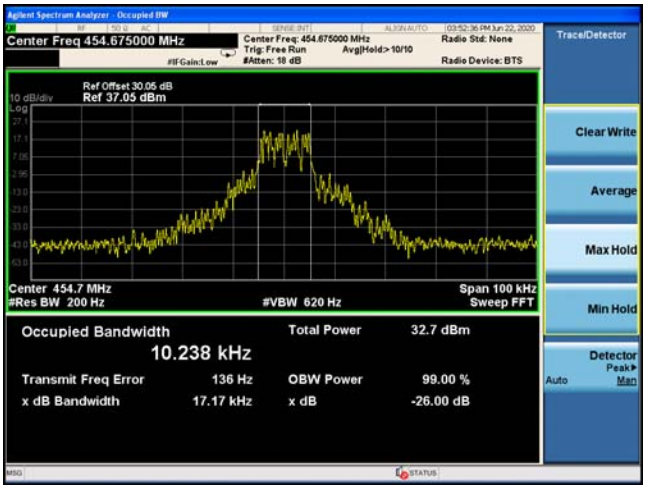
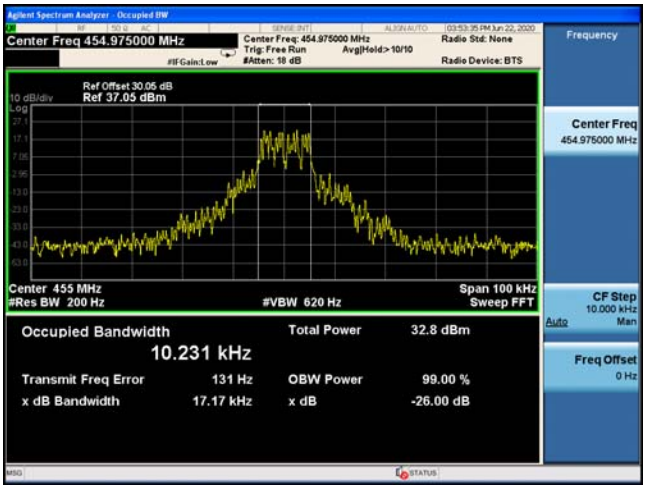


454.975MHz



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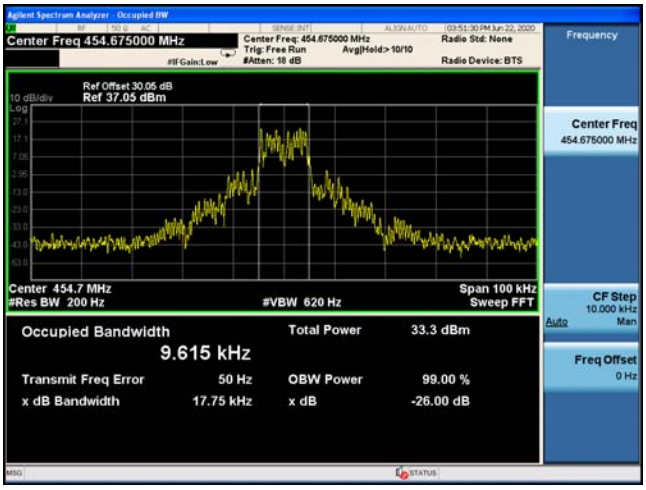

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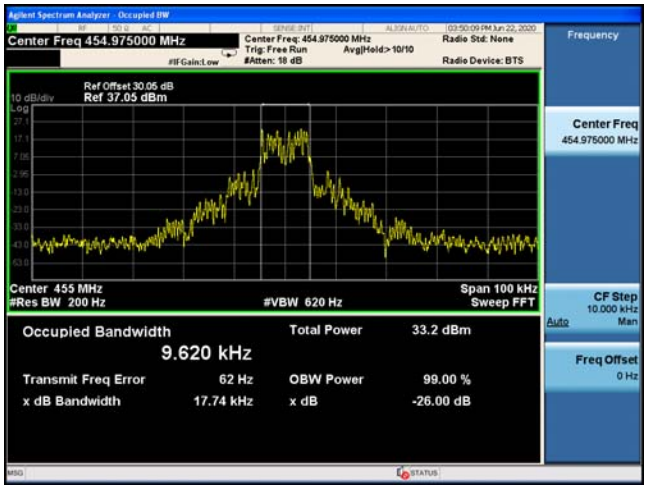
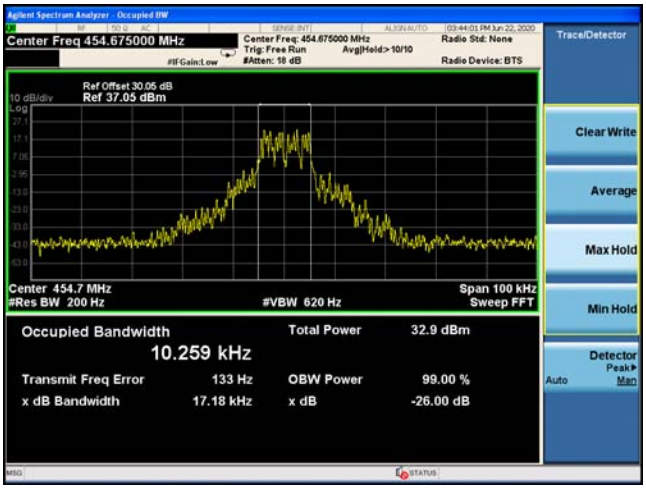


64QAM

454.675MHz



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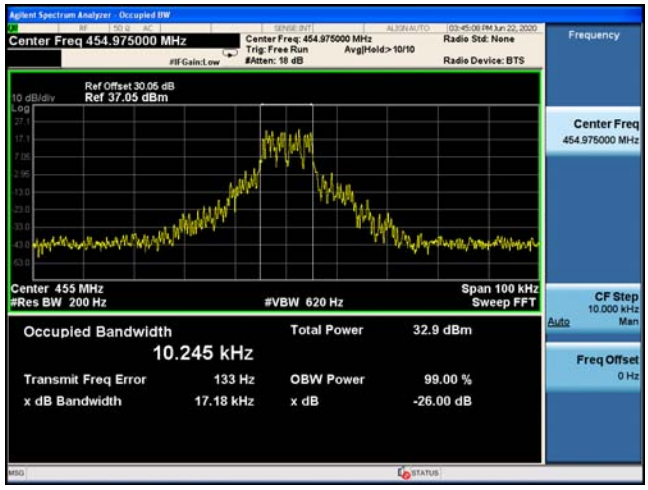

30 °C

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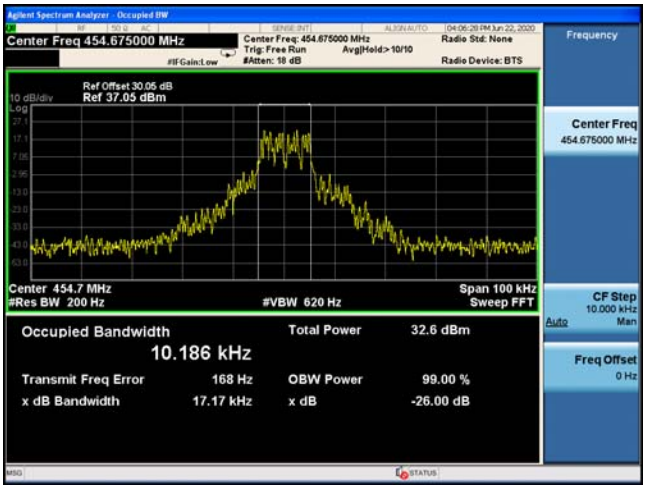

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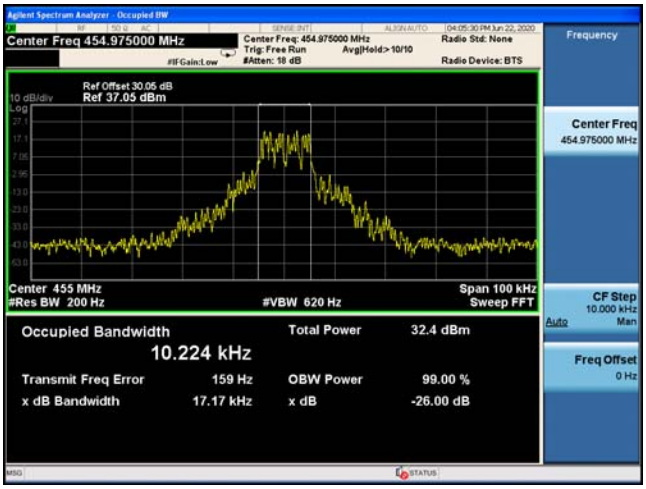

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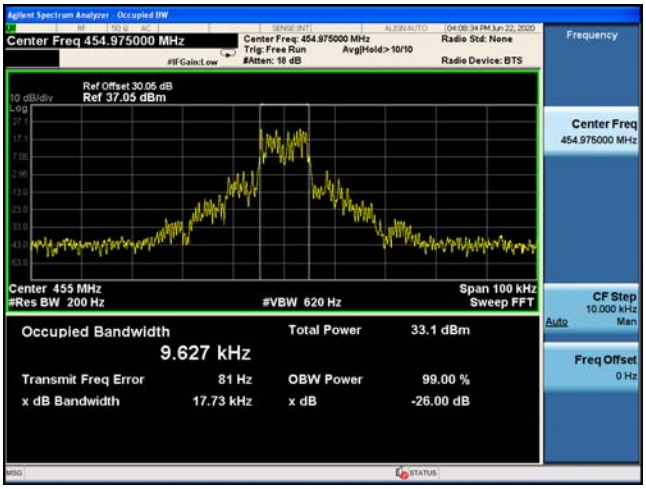
454.675MHz

454.975MHz



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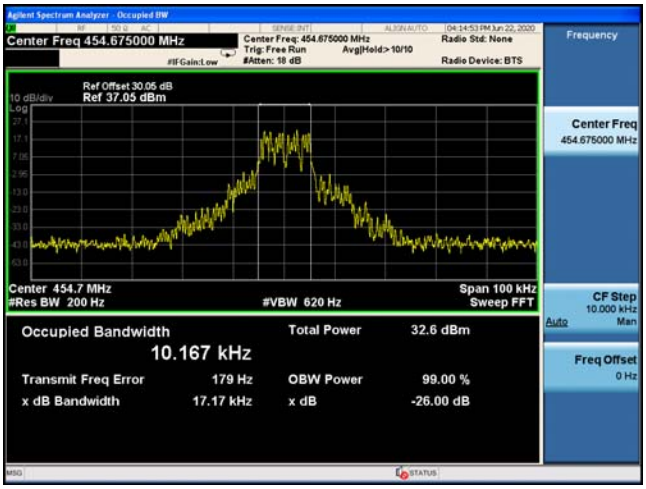

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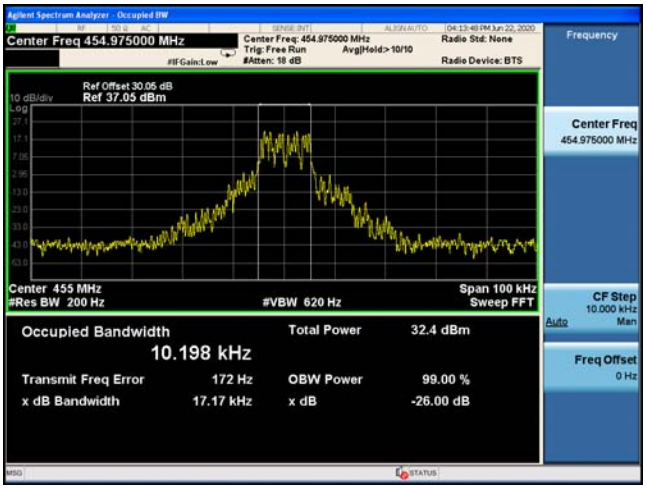

40 °C

QPSK

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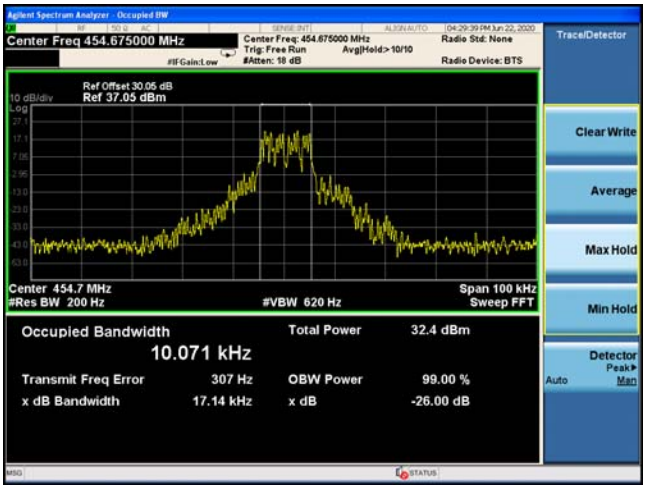

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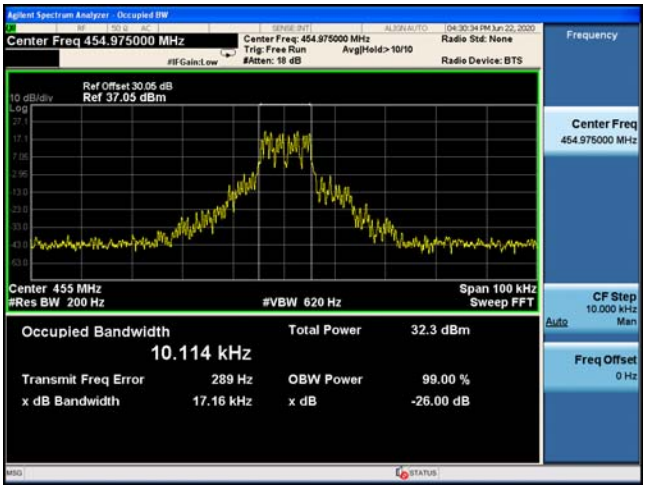

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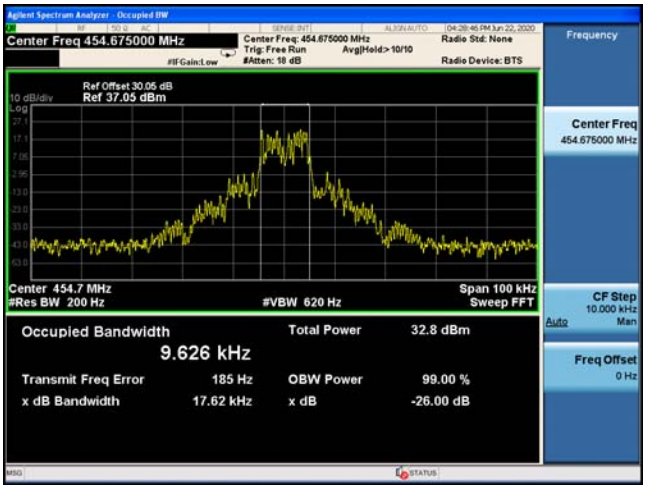
454.675MHz



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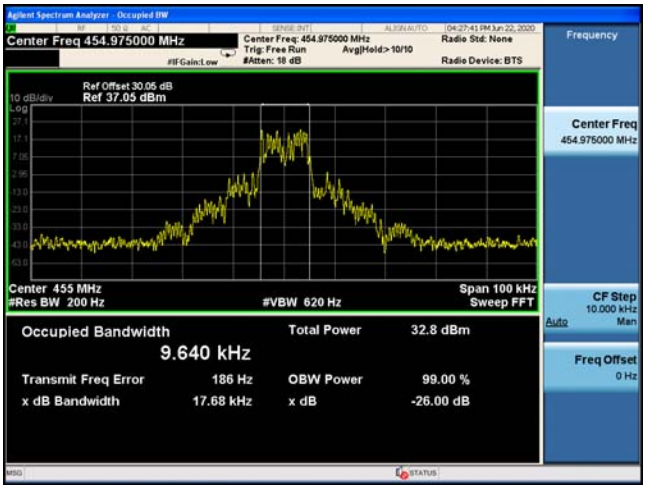

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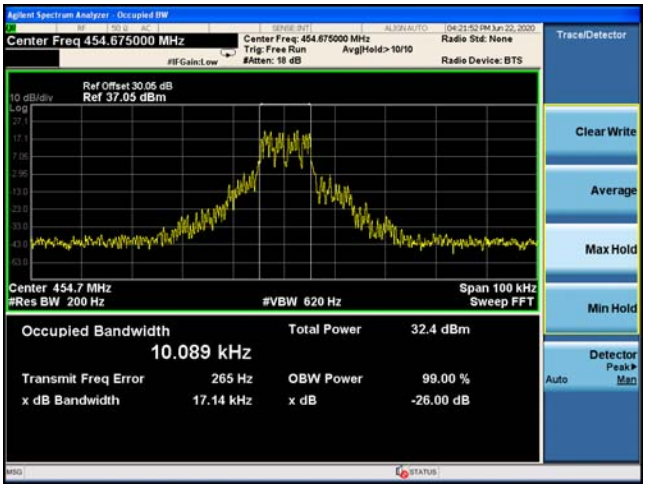

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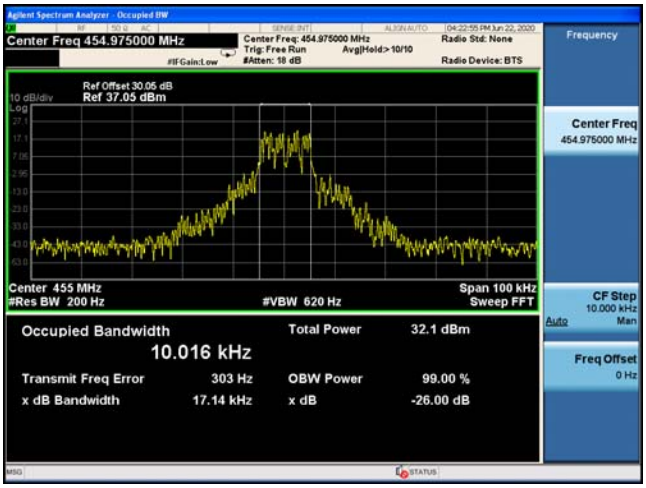
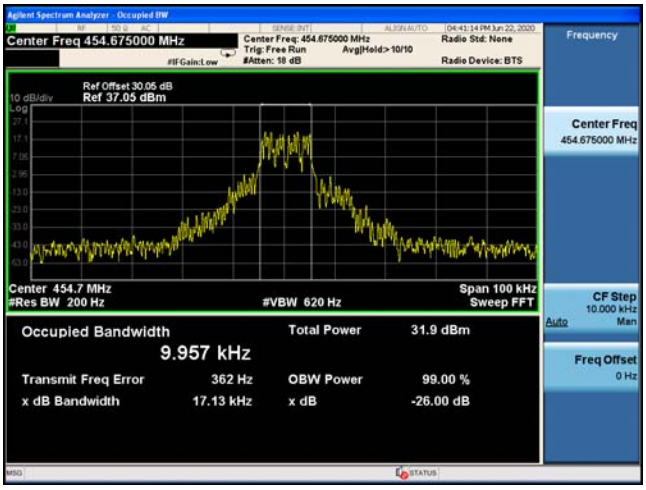


50 °C

QPSK

454.675MHz



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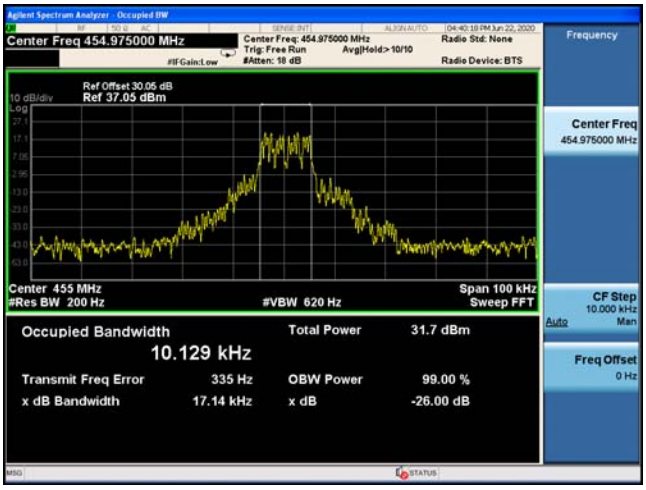

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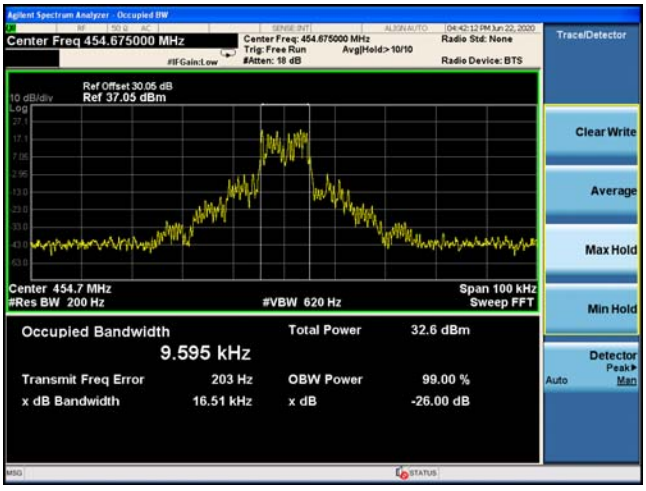

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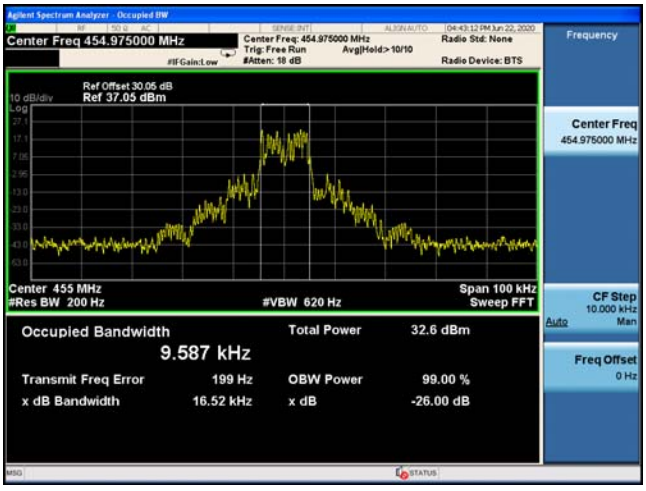

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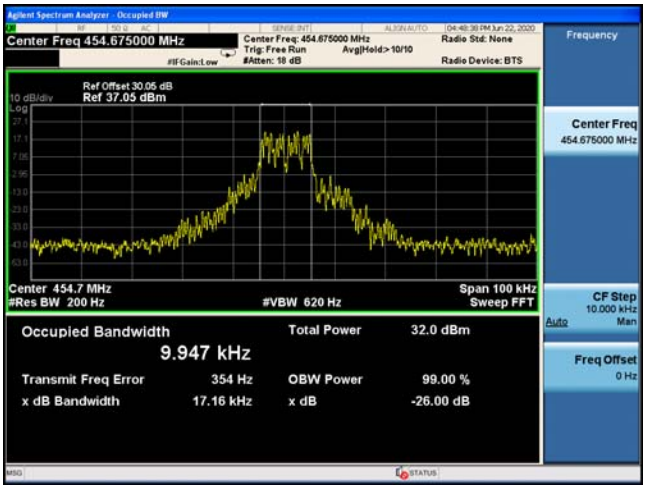

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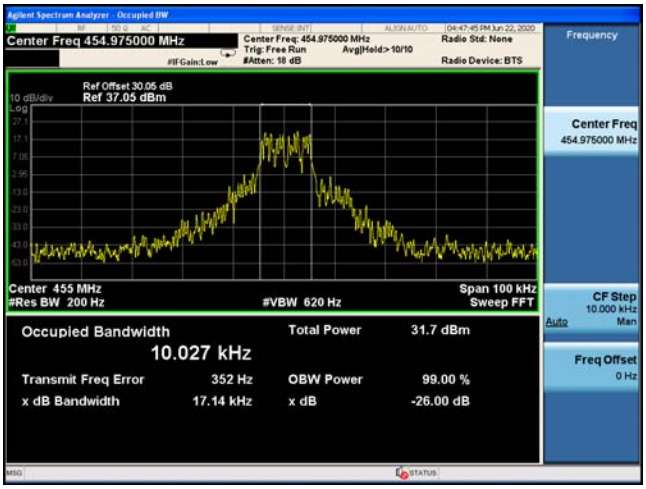
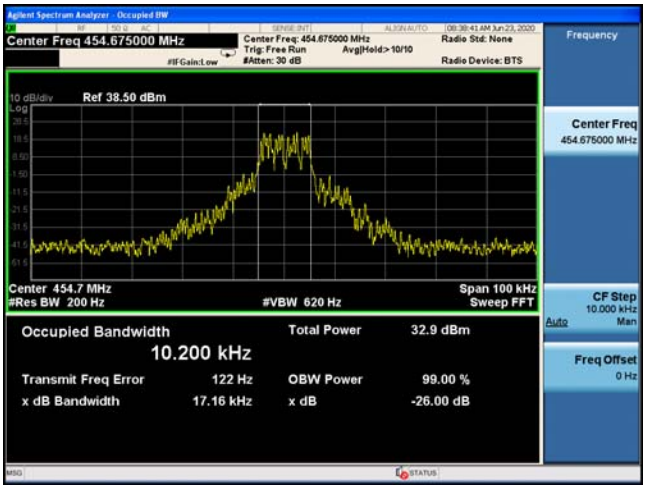


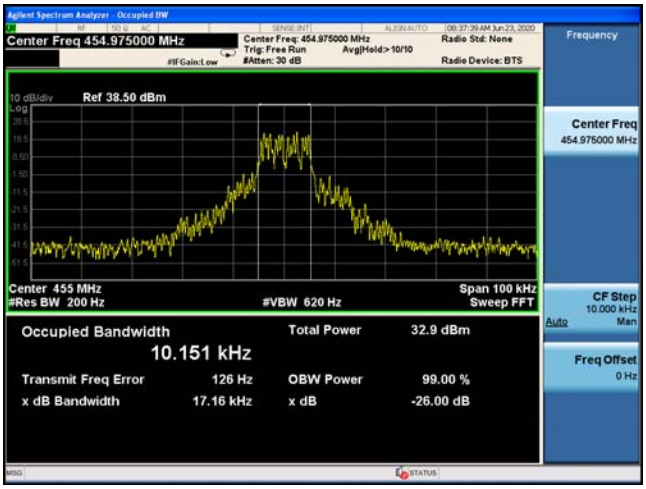
Low Voltage (20.4 V)

QPSK

454.675MHz



454.975MHz



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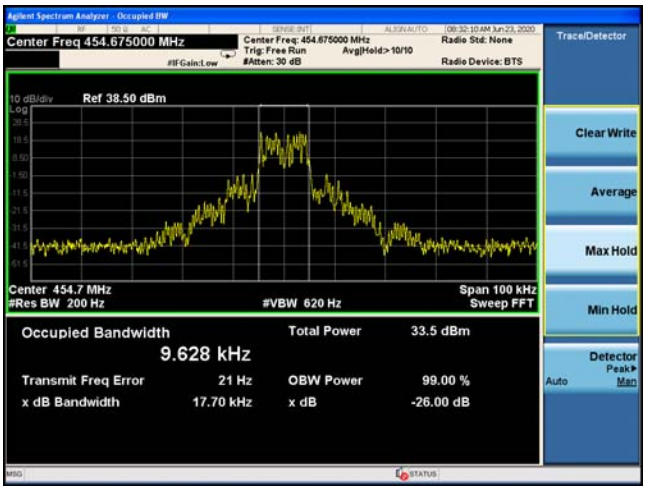
454.675MHz



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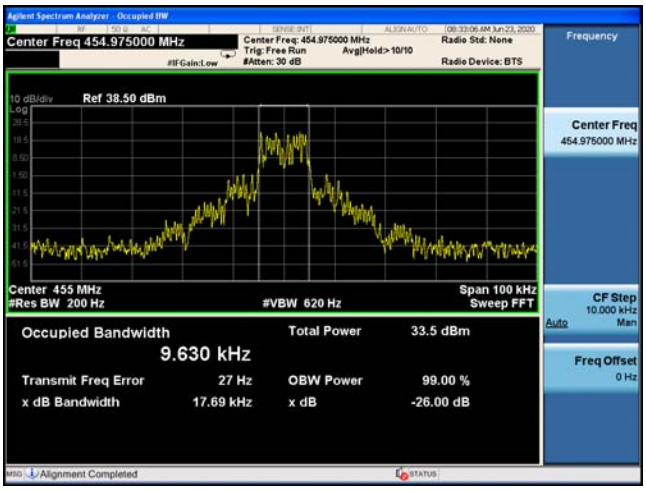

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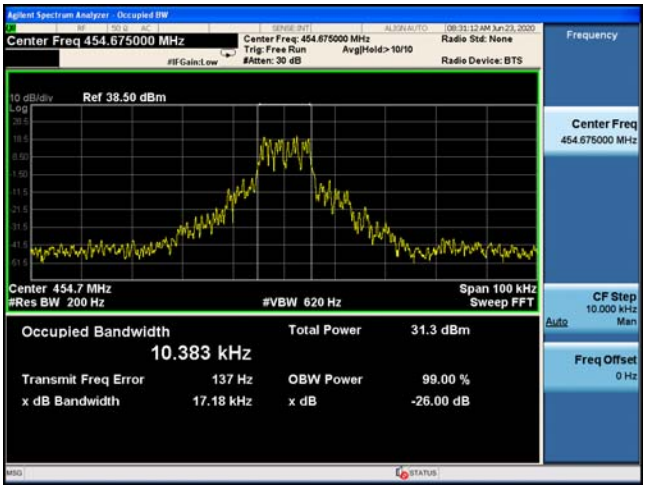

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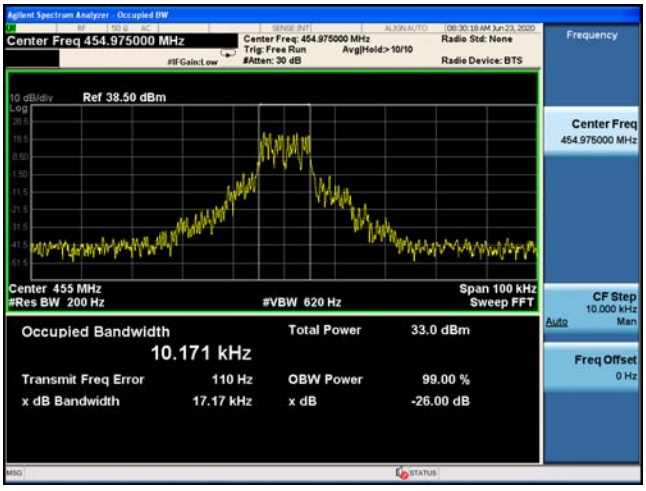
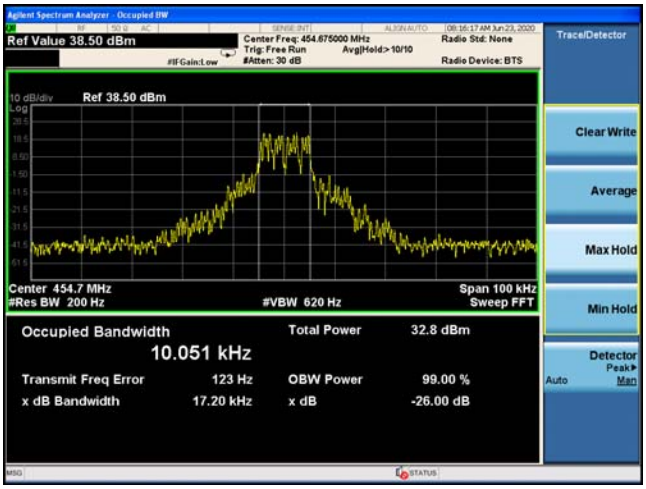


High Voltage (27.6 V)

QPSK

454.675MHz



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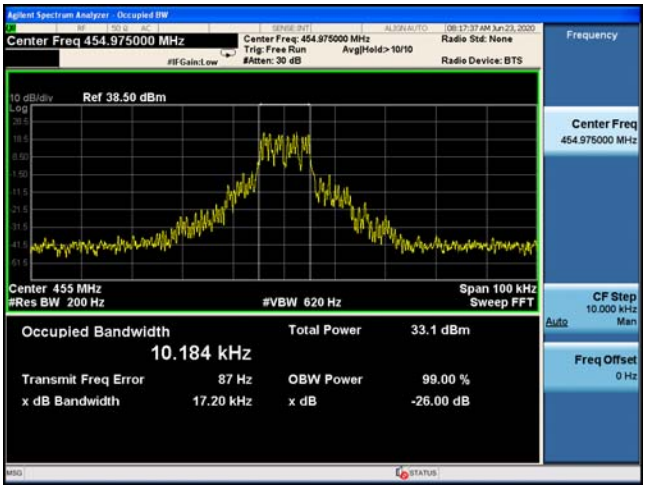

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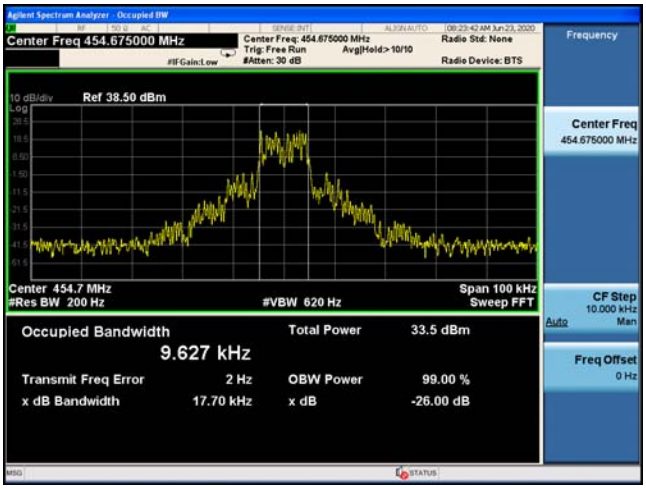

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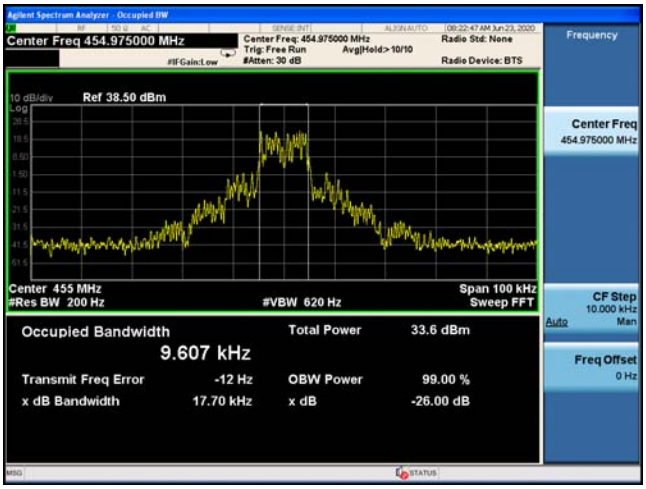

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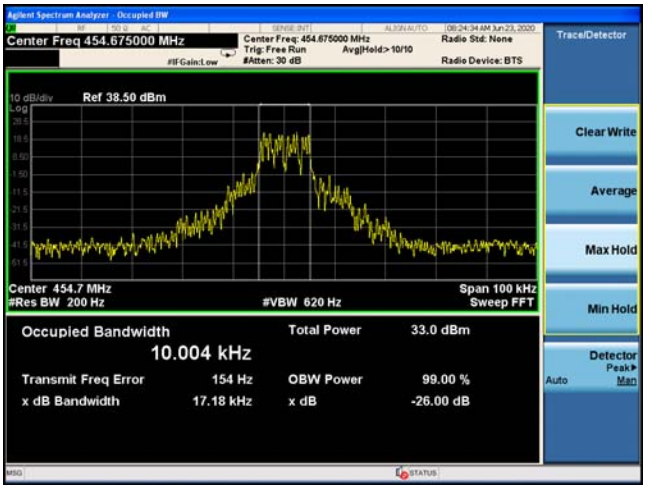

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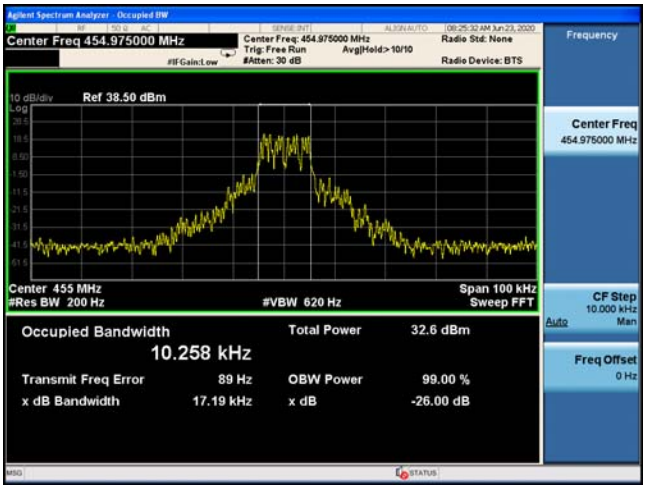

10 Annex A (Normative) - EUT Setup Photographs

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.

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 ---