FCC PART 15, SUBPART F
ISEDC RSS-220, ISSUE 1, JULY 2018

TEST REPORT

For

Tesla Motors, Inc.

3500 Deer Creek Road, Palo Alto, CA 94304, USA

FCC ID: 2AEIM-1614285
IC: 20098-1614285

Report Type:	**Product Type:**
Original Report	Automotive Part

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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	R2009186-519	Original Report	2021-04-26

1 General Description

1.1 Product Description for Equipment Under Test (EUT)

This test report was prepared on behalf of *Tesla Motors, Inc.,* and their product model: 1614285*, FCC ID: 2AEIM-1614285; IC: 20098-1614285* or the "EUT" as referred to in this report. The EUT is a Key Fob with Ultra Wide-band (UWB) operating in 6489.6-7987.2 MHz, Bluetooth Low Energy, and passive NFC.

UWB Subclass as specified by RSS-220 §3.2: Hand-held Communication Devices.

The radio terminal has data port.

1.2 Mechanical Description of EUT

1614285 measures approximately 6.35 cm (Length), 2.54 cm (Width), and 1.27 cm (Height).

The data gathered is from production sample provided by Tesla Motors, Inc. with BACL assigned serial number: R2009186-1.

1.3 Objective

This report was prepared on behalf of *Tesla Motors, Inc.,* in accordance with Part 2, Subpart J, and Part 15, Subpart and F of the Federal Communication Commission's rules and ISEDC RSS-220 Issue 1, July 2018.

The objective was to determine compliance with FCC Part 15.519 and ISEDC RSS-220 rules for Peak Fundamental Emission, Antenna Requirements, UWB Bandwidth, Average Radiated Emissions, Radiated Spurious Emissions and Ceasing Transmission requirements.

1.4 Related Submittal(s)/Grant(s)

FCC Part 15, Subpart C, Equipment Class: DTS with FCC ID: 2AEIM-1614285; IC: 20098-1614285

1.5 Test Methodology

All measurements contained in this report were conducted in accordance with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices and FCC KDB 393761 D01 UWB FAQ v02: Ultra-Wideband (UWB) Devices Frequently Asked Questions.

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
Power Spectral Density, conducted	±1.48dB
Unwanted Emissions, conducted	±1.57dB
All emissions, radiated	±4.0 dB
AC power line Conducted Emission	±2.0 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 3297.01)*****,** 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 3297.02)*** 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 3297.03)*** 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 C63.10-2013.

The EUT was tested in a testing mode to represent worst-case results during the final qualification test.

2.2 EUT Exercise Software

Python scripts were provided by Tesla Motors, Inc., and was verified to be compliant with the standard requirements being tested against. The following channel frequencies were selected for testing. All the modes were measured for fundamental field strength, and the corresponding power settings used are listed below.

Radio	Frequency (MHz)	Mode	Power Setting
UWB	6489.6 MHz (Channel 5)	0	3
		4	2
		5	1
		9	3.25
		10	2.25
		14	3.25
	6988.8 MHz (Channel 6)	0	3
		4	1.5
		5	0.75
		9	3
		10	1.75
		14	3
	7987.2 MHz (Channel 9)	0	3
		4	1
		5	1.25
		9	2.5
		10	1.75
		14	2.5

Please refer to the Operational Description for detailed description of the test modes.

2.3 Equipment Modifications

None

2.4 Remote Support Equipment

Manufacturer	Description	Model	S/N
HP	Laptop	Zbook Studio G3	00329-00000-00003-AA284

2.5 Local Support Equipment

Manufacturer	Description	Model	S/N
Volteq	DC Power Supply	HY5003D	160402343

2.6 Interface Ports and Cabling

Cable Descriptions	Length (m)	From	To
USB Type A to Micro USB Type B	< 1 m	Microcontroller	Laptop
Power cables	< 1 m	EUT	Power Supply

3 Summary of Test Results

Results reported relate only to the product tested.

FCC and ISEDC Rules	Description of Test	Results
FCC §15.203 ISEDC RSS-220 §5.1(b), ISEDC RSS-Gen §6.8	Antenna Requirement	Compliant
FCC §15.207 ISEDC RSS-Gen §8.8	AC Line Conducted Emissions	N/A[1]
FCC §2.1093, §1.1310(d) (3) ISEDC RSS-102	RF Exposure	Compliant
FCC §2.1053, §15.205, §15.209, §15.519(c) ISEDC RSS-220 §3.4, 5.3.1(c) ISEDC RSS-Gen §8.9 & §8.10	Radiated Emissions	Compliant
FCC §15.503(d),§15.519(b) ISEDC RSS-220 §5.1(a) ISEDC RSS-Gen§6.7	Emission Bandwidth	Compliant
FCC §15.519(e) ISEDC RSS-220 §5.3.1(g)	Peak Fundamental Emission	Compliant
FCC §15.519(c), §15.519(d) ISEDC RSS-220 §5.3.1(d), §5.3.1(e)	Average Radiated Emissions	Compliant
FCC §15.519(a)(1) ISEDC RSS-220 §5.3.1(b)	Cease Transmission	Compliant

Note[1]: Device is powered by battery.

4 FCC §15.203 & ISEDC RSS-220 §5.1(b), RSS-Gen §6.8 - Antenna Requirements

4.1 Applicable Standards

According to FCC §15.203:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

According to ISEDC RSS-Gen §6.8: Transmitter Antenna

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report (and in the notice to be included in the user manual, provided below).

When measurements at the antenna port are used to determine the RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer.

The test report shall state the RF power, output power setting and spurious emission measurements with each antenna type that is used with the transmitter being tested.

For licence-exempt equipment with detachable antennas, the user manual shall also contain the following notice in a conspicuous location:

This radio transmitter [enter the device's ISED certification number] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Immediately following the above notice, the manufacturer shall provide a list of all antenna types which can be used with the transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna type.

4.2 Antenna Description

External/Internal/Integral	Maximum Antenna Gain (dBi)	Antenna Type
Integral	4.4	Chip

The antenna is factory-installed and is not modifiable by users.
The antenna gain is information provided by the customer.

5 FCC §2.1093, §1.1310(d) (3) & ISEDC RSS-102 - RF Exposure

5.1 Applicable Standards

As per FCC §1.1310(d) (3), At operating frequencies above 6 GHz, the MPE limits listed in Table 1 in paragraph (e)(1) of this section shall be used in all cases to evaluate the environmental impact of human exposure to RF radiation as specified in §1.1307(b) of this part.

TABLE 1 TO §1.1310(E)(1)—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(i) 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
(ii) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	<30
1.34-30	824/f	2.19/f	*($180/f^2$)	<30
30-300	27.5	0.073	0.2	<30
300-1,500			f/1500	<30
1,500-100,000			1.0	<30

f = frequency in MHz. * = Plane-wave equivalent power density.

According to ISED RSS-102 Issue 5 Section 3, devices operating above 6 GHz regardless of the separation distance shall undergo an RF exposure evaluation.

Table 4: RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)				
Frequency Range (MHz)	**Electric Field (V/m rms)**	**Magnetic Field (A/m rms)**	**Power Density (W/m^2)**	**Reference Period (minutes)**
0.003-10	83	90	-	Instantaneous*
0.1-10	-	$0.73/f$	-	6**
1.1-10	$87/f^{0.5}$	-	-	6**
10-20	27.46	0.0728	-2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142 f^{0.3417}$	$0.008335 f^{0.3417}$	$0.02619 f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158 f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000/f^{1.2}$

Note: f is frequency in MHz.
* Based on nerve stimulation (NS).
** Based on specific absorption rate (SAR).

5.2 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

5.3 MPE Results

UWB Standalone

Maximum output power at antenna input terminal (dBm):	-46.058
Maximum output power at antenna input terminal (mW):	0.0000248
Prediction distance (cm):	0.5
Prediction frequency (MHz):	7987.2
Maximum Antenna Gain, typical (dBi):	4.4
Maximum Antenna Gain (numeric):	2.75
Power density of prediction frequency at 0.5 cm (mW/cm^2):	0.000022
FCC MPE limit for uncontrolled exposure at prediction frequency (mW/cm^2):	1.0
Power density of prediction frequency at 0.5 cm (W/m^2):	0.00022
IC MPE limit for uncontrolled exposure at prediction frequency (W/m^2):	10

The device is compliant with the FCC requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 0.5 cm is 0.000022 mW/cm^2. Limit is 1.0 mW/cm^2.

The device is compliant with the IC requirement MPE limit for uncontrolled exposure. The maximum power density at the distance of 0.5 cm is 0.00022 W/m^2. Limit is 10 W/m^2.

Worst Case Colocation MPE Calculation: BLE and UWB:

	Radio	Max Conducted Power (dBm)	Evaluated Distance (cm)	Worst-Case Exposure Level	Limit	Worst-Case Ratios	Sum of Ratios	Limit
Worst Case								
FCC	BLE	3.98	0.5	0.1033 W/kg	1.6 W/kg	6.46%	6.46%	100%
	UWB	-46.058	0.5	0.000022mW/cm^2	1.0 mW/cm^2	0.00002%		
IC	BLE	3.98	0.5	0.1033 W/kg	1.6 W/kg	6.46%	6.46%	100%
	UWB	-46.058	0.5	0.00022W/m^2	10 W/m^2	0.00002%		

Note: The BLE calculation for Colocation evaluation was determined using the standalone SAR value estimation defined in section 4.3.2.b.1 of KDB 447498 D01 General RF Exposure Guidance v06.

6 FCC §15.209, §15.519(c), (d) & ISEDC RSS-220 §3.4, §5.3.1(d), (e), RSS-Gen §8.9, §8.10 - Radiated Emissions

6.1 Applicable Standards

As per FCC §15.519(c), the radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in §15.209

As per FCC §15.35(b): Unless otherwise specified, on any frequency or frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. Unless otherwise specified, measurements above 1000 MHz shall be performed using a minimum resolution bandwidth of 1 MHz.

As Per FCC §15.205(a) and RSS-Gen except as show in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 – 0.110	16.42 – 16.423	960 – 1240	4. 5 – 5. 15
0.495 – 0.505	16.69475 – 16.69525	1300 – 1427	5. 35 – 5. 46
2.1735 – 2.1905	25.5 – 25.67	1435 – 1626.5	7.25 – 7.75
4.125 – 4.128	37.5 – 38.25	1645.5 – 1646.5	8.025 – 8.5
4.17725 – 4.17775	73 – 74.6	1660 – 1710	9.0 – 9.2
4.20725 – 4.20775	74.8 – 75.2	1718.8 – 1722.2	9.3 – 9.5
6.215 – 6.218	108 – 121.94	2200 – 2300	10.6 – 12.7
6.26775 – 6.26825	123 – 138	2310 – 2390	13.25 – 13.4
6.31175 – 6.31225	149.9 – 150.05	2483.5 – 2500	14.47 – 14.5
8.291 – 8.294	156.52475 – 156.52525	2690 – 2900	15.35 – 16.2
8.362 – 8.366	156.7 – 156.9	3260 – 3267	17.7 – 21.4
8.37625 – 8.38675	162.0125 –167.17	3332 – 3339	22.01 – 23.12
8.41425 – 8.41475	167.72 – 173.2	3345.8 – 3358	23.6 – 24.0
12.29 – 12.293	240 – 285	3600 – 4400	31.2 – 31.8
12.51975 – 12.52025	322 – 335.4		36.43 – 36.5
12.57675 – 12.57725	399.9 – 410		Above 38.6
13.36 – 13.41	608 – 614		

As per FCC §15.209(a): Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table

Frequency (MHz)	Field Strength (micro volts/meter)	Measurement Distance (meters)
0.009 - 0.490	2400/F(kHz)	300
0.490 - 1.705	24000/F(kHz)	30
1.705 - 30.0	30	30
30 - 88	100**	3
88 - 216	150**	3
216 - 960	200**	3
Above 960	500	3

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz.

However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

As per ISEDC RSS-Gen §8.9, except where otherwise indicated in the applicable RSS, radiated emissions shall comply with the field strength limits shown in the table below. Additionally, the level of any transmitter unwanted emission shall not exceed the level of the transmitter's fundamental emission.

General Field Strength Limits at Frequencies above 30 MHz

Frequency (MHz)	Field Strength (µv/m at 3 meters)
30-88	100
88-216	150
216-960	200
Above 960	500

As per ISEDC RSS-220 §5.3.1(c), Radiated emissions at or below 960 MHz from a device shall not exceed the limits in section 3.4

As per ISEDC RSS-220 §3.4, Radiated emissions at or below 960 MHz for all subclasses of UWB device shall not exceed the following limits. Measurements of radiated emissions at and below 960 MHz are to be made using a CISPR quasi-peak detector. CISPR measurement bandwidth specifications are to be used

Radiated Emissions at or below 960 MHz

Frequency (MHz)	Field Strength (Microvolts/m)	Measurement Distance (Metres)	E.i.r.p. (dBmW)
0.009-0.490	2,400/F (F in kHz)	300	10 log (17.28 / F^2) (F in kHz)
0.490-1.705	24,000/F (F in kHz)	30	10 log (17.28 / F^2) (F in kHz)
1.705-30	30	30	-45.7
30-88	100	3	-55.2
88-216	150	3	-51.7
216-960	200	3	-49.2

According to FCC §15.519(c): (c) The radiated emissions at or below 960 MHz from a device operating under the provisions of this section shall not exceed the emission levels in §15.209. The radiated emissions above 960 MHz from a device operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz:

Frequency in MHz	EIRP in dBm
960-1610	-75.3
1610-1990	-63.3
1990-3100	-61.3
3100-10600	-41.3
Above 10600	-61.3

According to ISEDC RSS-220 §5.3.1(d): Radiated emissions above 960 MHz from a device shall not exceed the following average limits when measured using a resolution bandwidth of 1 MHz.

Frequency	EIRP
960-1610 MHz	-75.3 dBm
1.61-4.75 GHz	-70.0 dBm
4.75-10.6 GHz	-41.3 dBm
Above 10.6 GHz	-61.3 dBm

According to FCC §15.519(c): (d) In addition to the radiated emission limits specified in the table in paragraph (c) of this section, UWB transmitters operating under the provisions of this section shall not exceed the following average limits when measured using a resolution bandwidth of no less than 1 kHz:

Frequency in MHz	EIRP in dBm
1164-1240	-85.3
1559-1610	-85.3

According to ISEDC RSS-220 §5.3.1(e): In addition to the limits specified in paragraph (d) of this section, radiated emissions shall not exceed the following average limits when measured using a resolution bandwidth greater than or equal to 1 kHz. The measurements shall demonstrate compliance with the stated limits at whatever resolution bandwidth is used.

Frequency	e.i.r.p. in a Resolution Bandwidth of no less than 1 kHz
1164-1240 MHz	-85.3 dBm
1559-1610 MHz	-85.3 dBm

6.2 Test Setup

The radiated emissions tests were performed in the 5-meter Chamber, using the setup in accordance with ANSI C63.10-2013. The specification used was the FCC 15 Subpart F and ISEDC RSS-220 limits.

The spacing between the peripherals was 10 centimeters.

External I/O cables were draped along the edge of the test table and bundle when necessary.

6.3 Measurement Procedure

The EUT host, and all support equipment power cords were connected to the AC floor outlet.

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

For radiated testing the EUT was set 1 meter away from the testing antenna, which was varied from 1-4 meter, and the EUT was placed on a turntable, which was 0.8 meter and 1.5 meter above the ground plane for below and above 960 MHz measurements, the table shall be rotated for 360 degrees to find out the highest emission. The receiving antenna's polarity should be changed between horizontal and vertical.

The spectrum analyzer or receiver was set as:

Below 960 MHz:

RBW = 100 kHz / VBW = 300 kHz / Sweep = Auto

Above 960 MHz:

The measurements were based on ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices section 10.3: Radiated measurement procedure above 960MHz.

6.4 Corrected Amplitude and Margin Calculation

For emissions below 1 GHz,

The Corrected Amplitude (CA) is calculated by adding the Correction Factor to the S.A. Reading. The basic equation is as follows:

CA = S.A. Reading + Correction Factor

For example, a corrected amplitude of 40.3 dBuV/m = S.A. Reading (32.5 dBuV) + Correction Factor (7.8 dB/m)

The Correction Factor is calculated by adding the Antenna Factor (AF), the Cable Loss (CL), the Attenuator Factor (Atten) and subtracting the Amplifier Gain (Ga) together. This calculation is done in the measurement software, and reported in the test result section. The basic equation is as follows:

Correction Factor = AF + CL + Atten – Ga

For emission above 1 GHz,

The Corrected Amplitude (CA) is calculated by adding the Antenna Factor (AF), the Cable Loss (CL), the Attenuator Factor (Atten) and subtracting the Amplifier Gain (Ga) to indicated Amplitude (Ai) reading. The basic equation is as follows:

$$CA = Ai + AF + CL + Atten - Ga$$

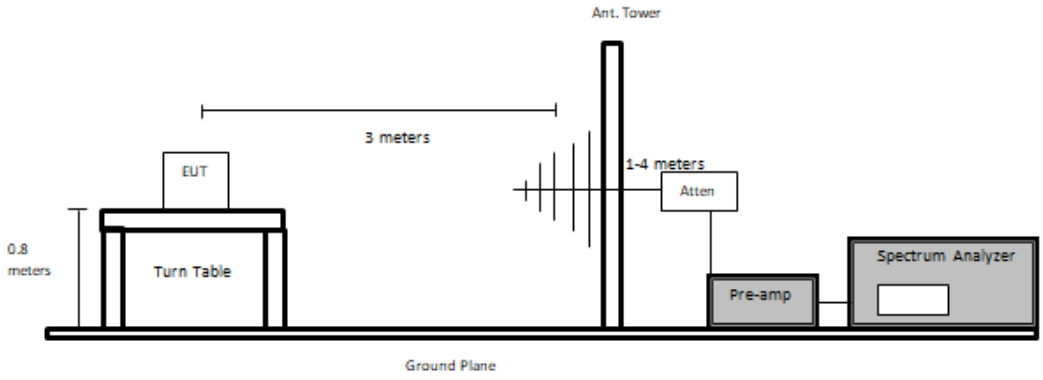
For example, a corrected amplitude of 40.3 dBuV/m = Indicated Reading (32.5 dBuV) + Antenna Factor (+23.5dB) + Cable Loss (3.7 dB) + Attenuator (10 dB) - Amplifier Gain (29.4 dB)

The "**Margin**" column of the following data tables indicates the degree of compliance within the applicable limit. For example, a margin of -7 dB means the emission is 7 dB below the maximum limit. The equation for margin calculation is as follows:

$$Margin = Corrected\ Amplitude - Limit$$

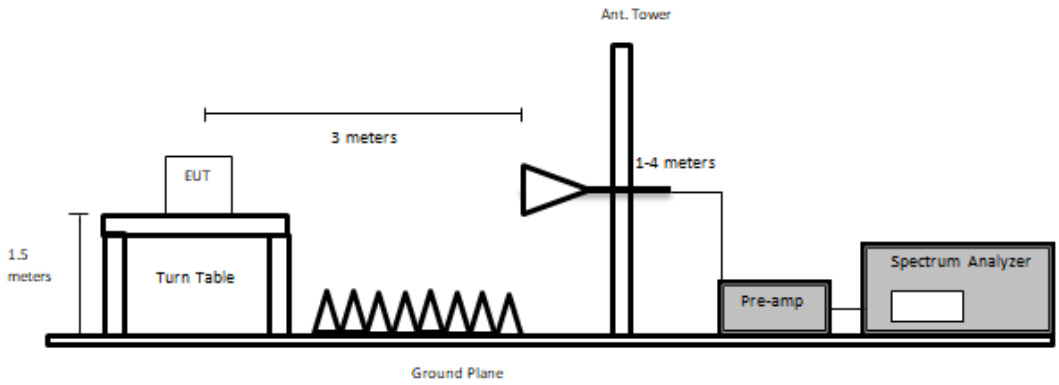
6.5 Test Setup Block Diagram

Below 1GHz:

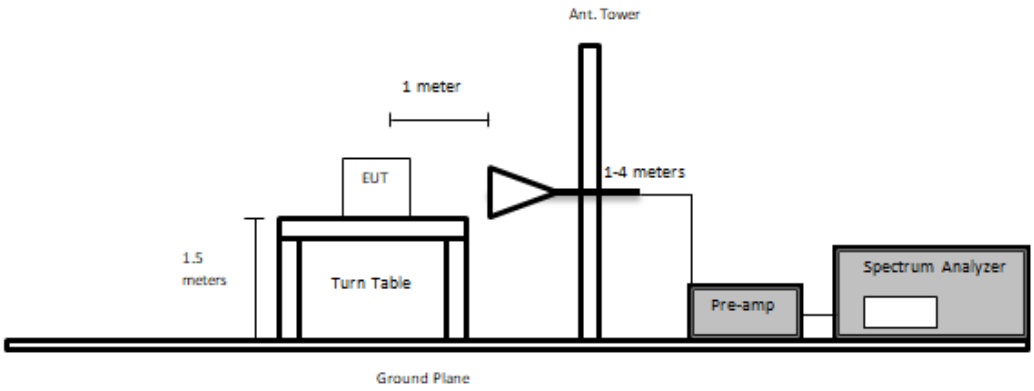


Above 1GHz:

At 3 meters:



At 1 meter:


Ant. Tower
1 meter
EUT
1-4 meters
1.5
meters
Turn Table
Pre-amp
Spectrum Analyzer
Ground Plane

6.6 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Rohde & Schwarz	Spectrum Analyzer	FSQ26	200749	2019-11-07	2 years
Rohde & Schwarz	EMI Test Receiver	ESCI 1166.5950K03	100337	2021-03-09	2 years
Agilent	Spectrum Analyzer	E4446A	MY48250238	2021-02-12	18 months
Rohde & Schwarz	Signal Analyzer	FSV40	101203	2019-08-06	2 years
Sunol Sciences Corp	System Controller	SC110V	122303-1	N/R	N/A
Agilent	Preamplifier	8449B	3147A00400	2021-03-02	1 year
HP	Preamplifier	8447D	2443A04374	2020-08-17	1 year
AH Systems	Preamplifier	PAM 1840 VH	170	2020-11-09	1 year
IW Incorporated	157 Series 2.92 SM (x2) Armored 33 ft. Cable	KPS-1571AN-3960-KPS	DC 1917	2021-03-03	1 year
IW Incorporated	157 Series Cable Armored with 2.92mm Male Plugs on Both Sides	KPS-1571AN-2400	DC 1922	2020-06-06	1 year
MDP Digital	Times Microwave LMR 400 UltraFex Coaxial Cable 35'	LMR400UF	BACL1904161	2020-05-20	1 year
Sunol Sciences Corp	Biconilog Antenna	JB3	A020106-2	2019-11-20	2 years
ETS Lindgren	Horn Antenna	3117	00218973	2019-02-13	2.5 years
ETS Lindgren	Horn Antenna w/built-in Preamplifier	3117 PA	203557	2020-06-20	2 years
Wisewave	Horn Antenna	ARH-4223-02	10555-02	2020-02-05	2 years
Wisewave	Horn Antenna	ARH-2823-02	10555-02	2020-02-27	2 years
-	RF cable	-	-	Each time[1]	N/A
Vasona	Test software	V6.0 build 11	10400213	N/R	N/R

Note[1]: cables included in the test set-up will be checked each time before testing.

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 the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

6.7 Test Environmental Conditions

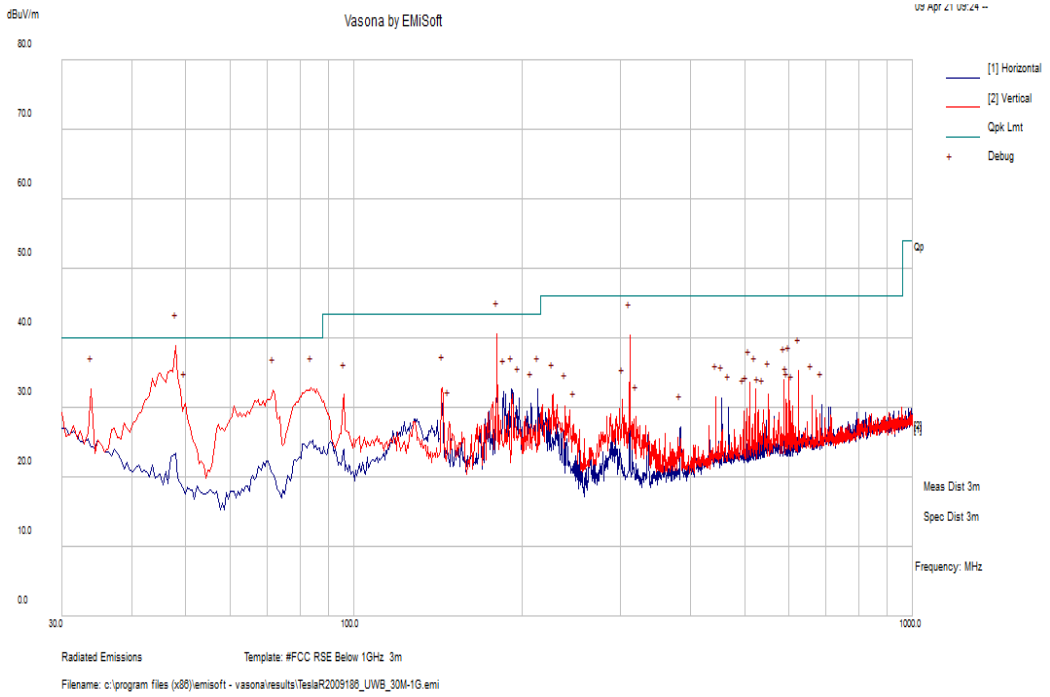
Temperature:	20-22 ºC
Relative Humidity:	42-50 %
ATM Pressure:	102.7 kPa

The testing was performed by Allen Huang from 2021-03-25 to 2021-04-26 in 5 meter chamber 3.

6.8 Test Results below 960 MHz

Worst case configuration: middle channel 6988.8 MHz, Mode 0

30 MHz – 960 MHz Worst case measured at 3 meters



Freq. (MHz)	S.A. Reading (dBµV)	Corr. Factor (dB/m)	Corrected Amp. (dBµV/m)	Antenna Height (cm)	Antenna Polarity (H/V)	Turntable Azimuth (degrees)	Limit (dBµV/m)	Margin (dB)	Comment
47.9825	41.67	-10.03	31.64	186	V	323	40	-8.36	QP
180.716	28.03	-6.93	21.11	161	H	88	43.5	-22.39	QP
311.98925	45.92	-4.21	41.71	102	V	64	46	-4.29	QP
83.407	38.29	-11.08	27.2	188	V	52	40	-12.8	QP
33.8985	19.82	-0.64	19.19	144	V	169	40	-20.81	QP
71.98175	38.07	-10.3	27.77	167	V	184	40	-12.23	QP

6.9 Test Results above 960 MHz

Note: Measurements were performed at 3m distance.

Average Radiated Fundamental Field Strength

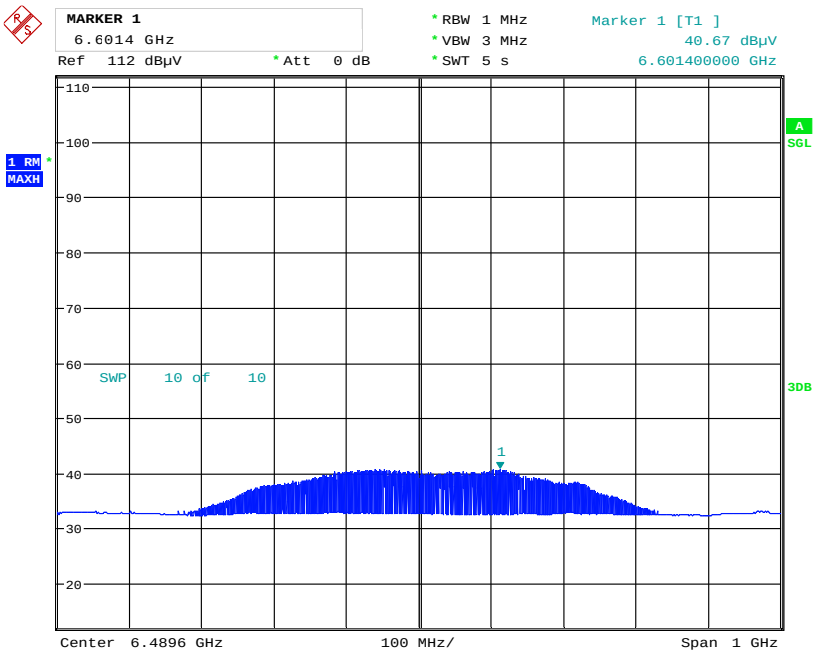
Channel Number	Channel Frequency (MHz)	Mode	PSA Reading (dBµV)	Antenna Factor (dB/m)	Cable Loss (dB)	Pre Amp Gain (dB)	Corrected Field Strength (dBµV/m at 3m)	EIRP (dBm)[1]	Limit (dBm)	Margin (dB)
5	6489.6	0	40.67	36	11.938	35.892	52.716	-42.484	-41.3	-1.184
		4	41.35	36	11.738	35.892	53.196	-42.004	-41.3	-0.704
		5	41.35	36	11.938	35.892	53.396	-41.804	-41.3	-0.504
		9	41.3	36	11.938	35.892	53.346	-41.854	-41.3	-0.554
		10	41.16	36	11.938	35.892	53.206	-41.994	-41.3	-0.694
		14	41.18	36	11.738	35.892	53.026	-42.174	-41.3	-0.874
6	6988.8	0	40.85	36.1	12.311	36.308	52.953	-42.247	-41.3	-0.947
		4	41.54	36.1	12.081	36.308	53.413	-41.787	-41.3	-0.487
		5	41.23	36.1	12.311	36.308	53.333	-41.867	-41.3	-0.567
		9	41.37	36.1	12.311	36.308	53.473	-41.727	-41.3	-0.427
		10	41.4	36.1	12.311	36.308	53.503	-41.697	-41.3	-0.397
		14	41	36.1	12.081	36.308	52.873	-42.327	-41.3	-1.027
9	7987.2	0	39.56	36.3	14.028	36.646	53.242	-41.958	-41.3	-0.658
		4	40.2	36.3	13.638	36.646	53.492	-41.708	-41.3	-0.408
		5	40.25	36.3	13.638	36.646	53.542	-41.658	-41.3	-0.358
		9	39.61	36.3	14.028	36.646	53.292	-41.908	-41.3	-0.608
		10	40.16	36.3	13.638	36.646	53.452	-41.748	-41.3	-0.448
		14	39.82	36.3	13.638	36.646	53.112	-42.088	-41.3	-0.788

Note[1]: EIRP [dBm] = Field Strength [dBµV/m at 3 meters] – 95.2.

Please refer to the following plots.

Channel 5 (6489.6 MHz), Fundamental Average Measurements

Mode 0



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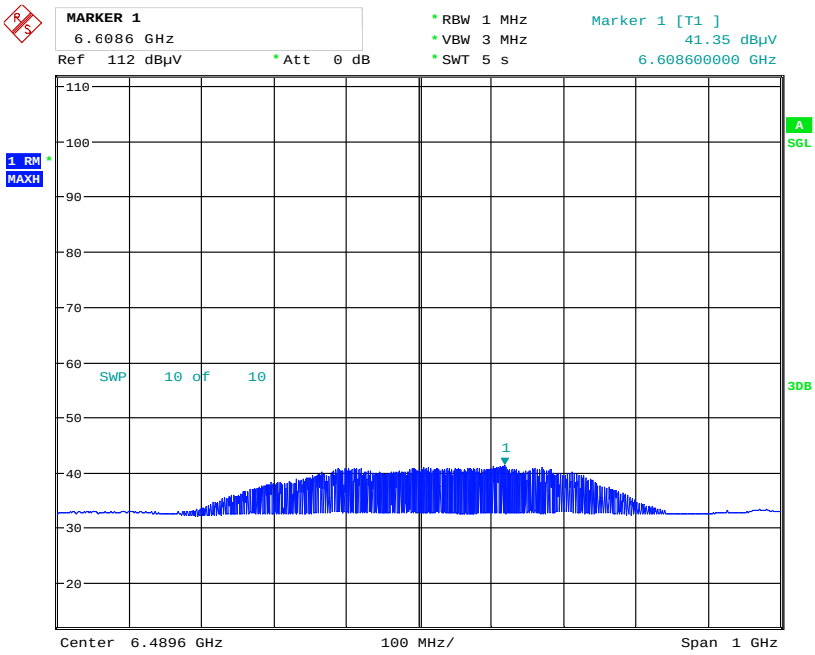
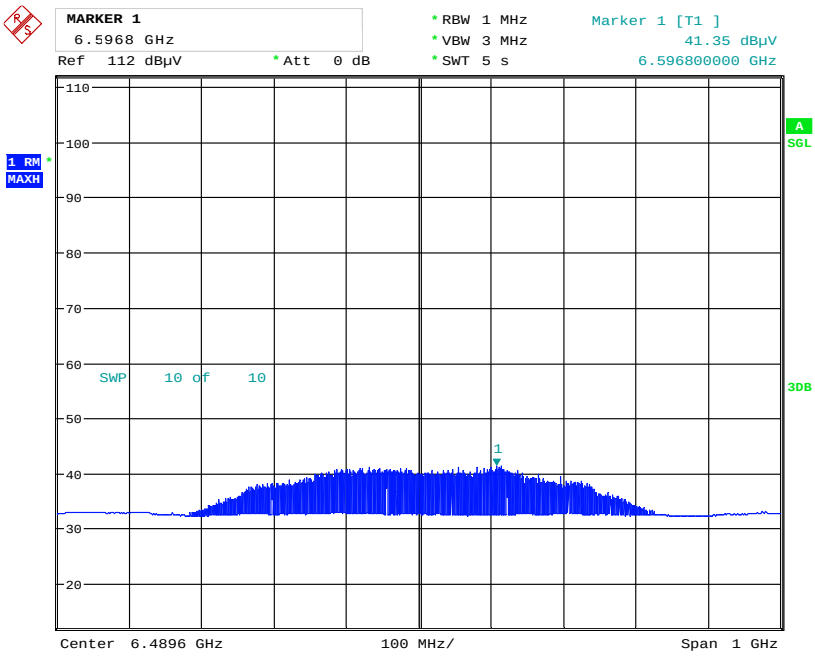
Mode 4



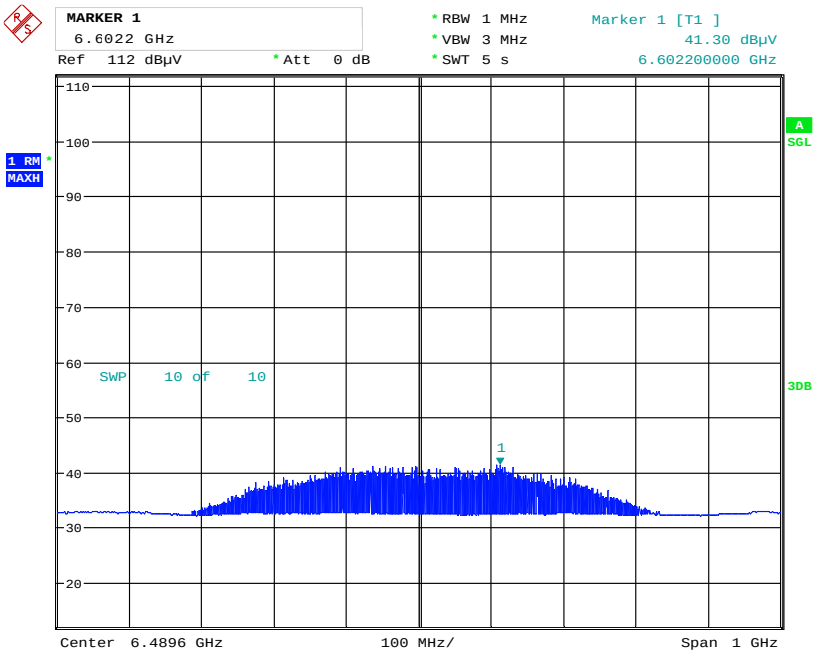
Date: 5.APR.2021 10:13:15

Mode 5



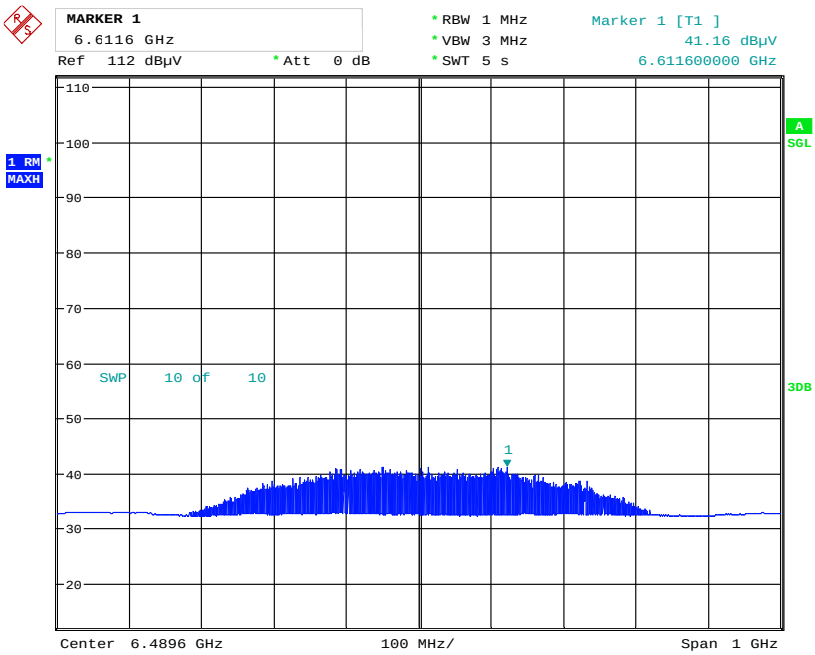
Date: 1.APR.2021 14:53:27

Mode 9



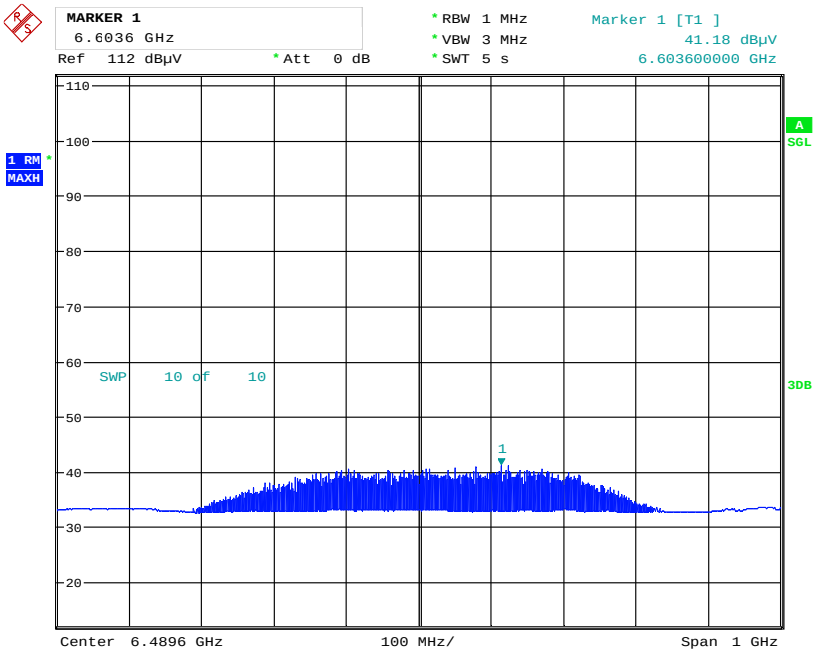
Date: 1.APR.2021 15:02:26

Mode 10



Date: 1.APR.2021 15:08:06

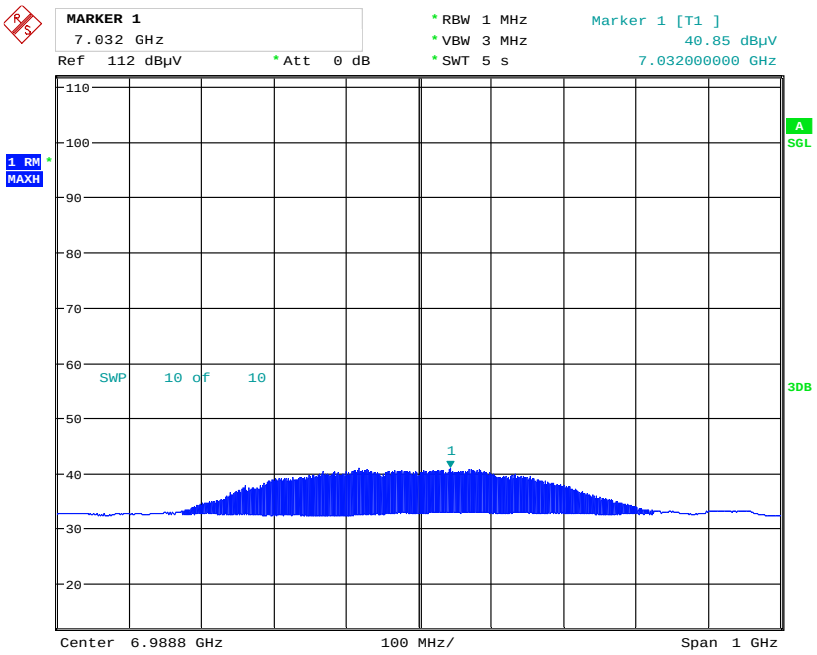
Mode 14



Date: 5.APR.2021 10:47:14

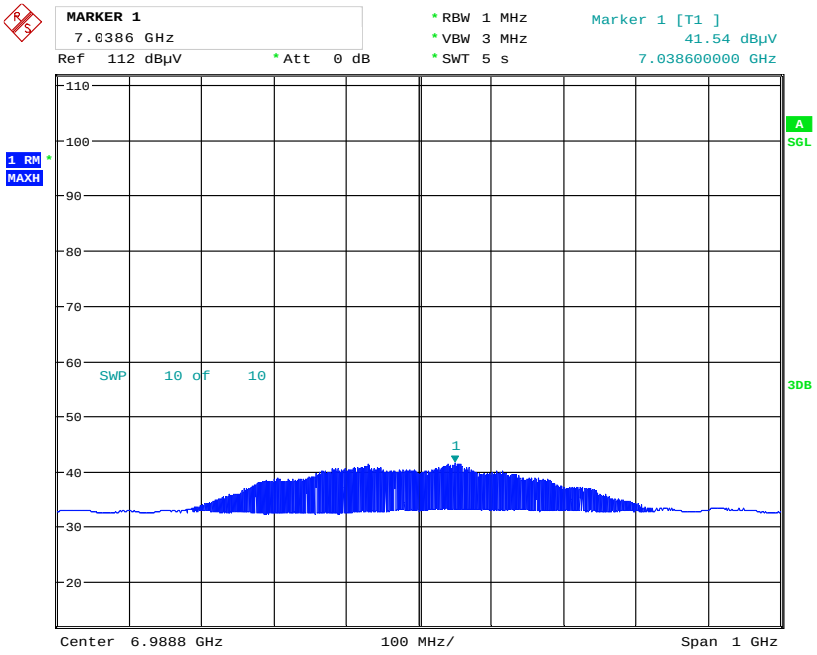
Channel 6 (6988.8MHz), Fundamental Average Measurements

Mode 0



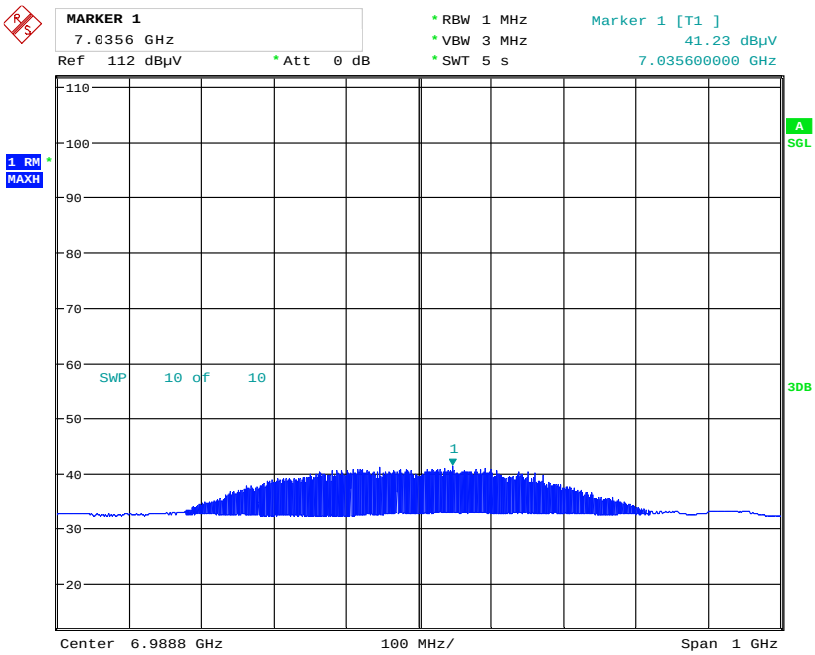
Date: 1.APR.2021 15:29:01

Mode 4



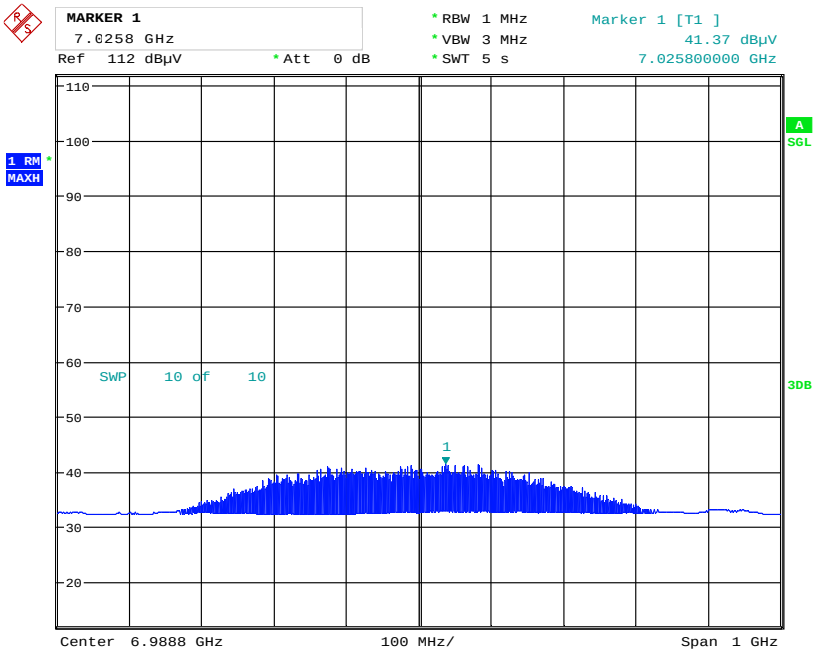
Date: 5.APR.2021 11:07:56

Mode 5



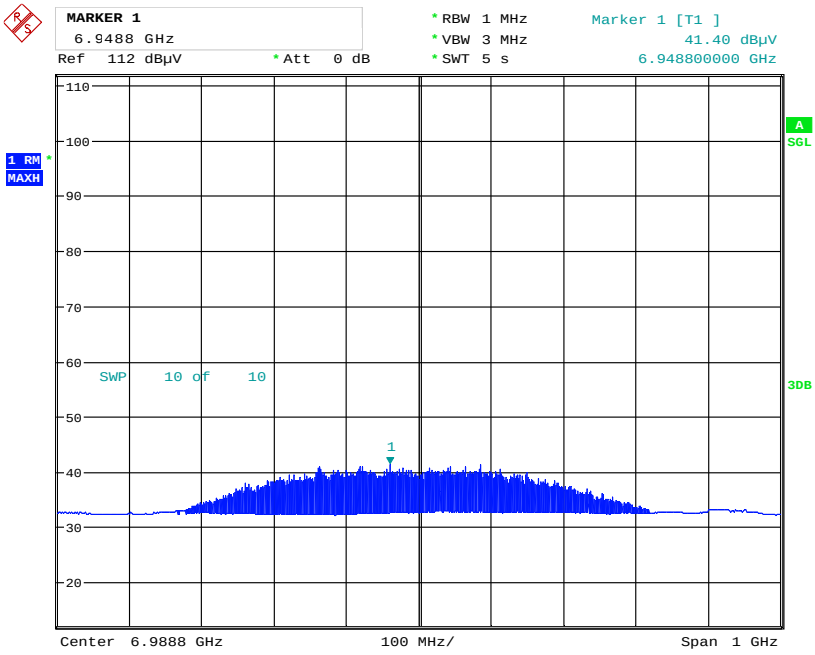
Date: 1.APR.2021 15:36:49

Mode 9



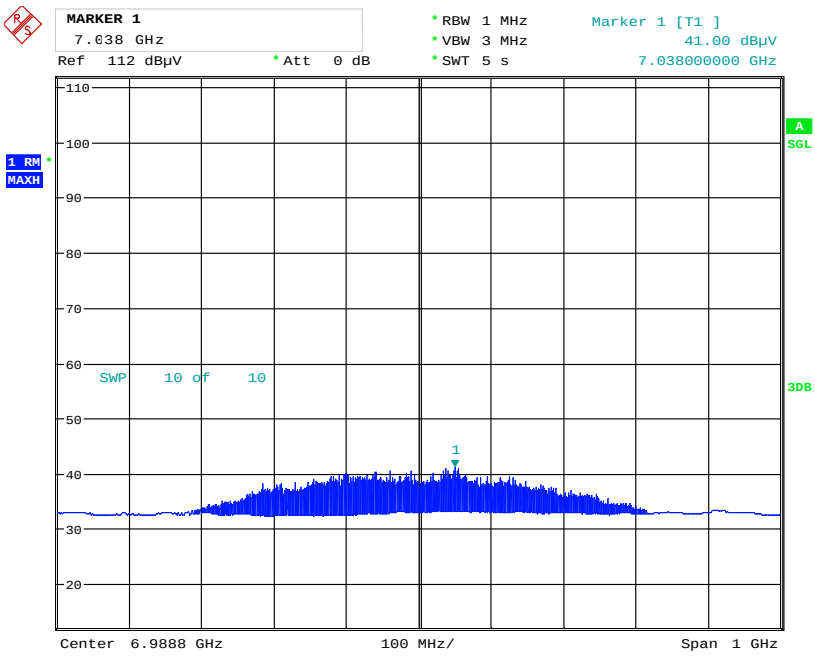
Date: 1.APR.2021 15:40:58

Mode 10



Date: 1.APR.2021 15:47:20

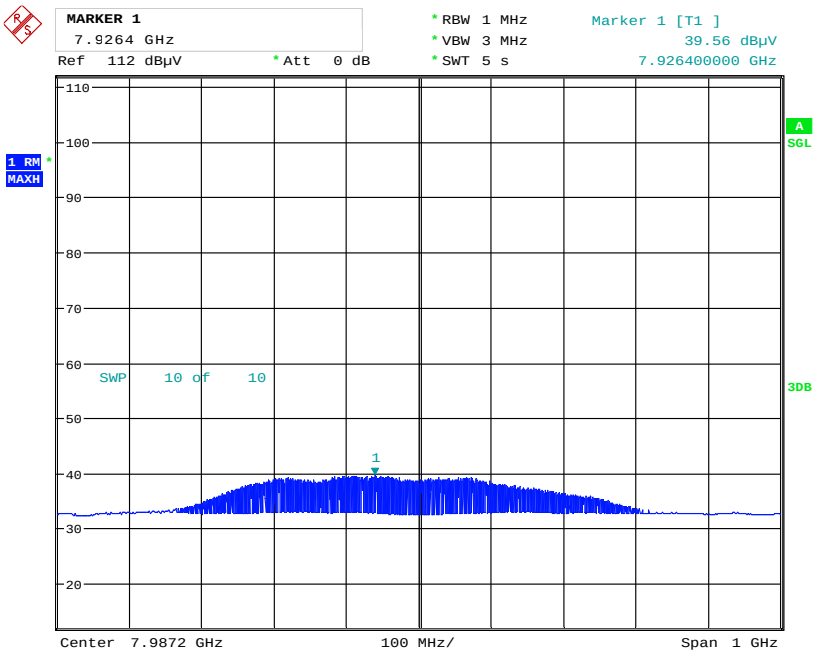
Mode 14



Date: 5.APR.2021 11:16:50

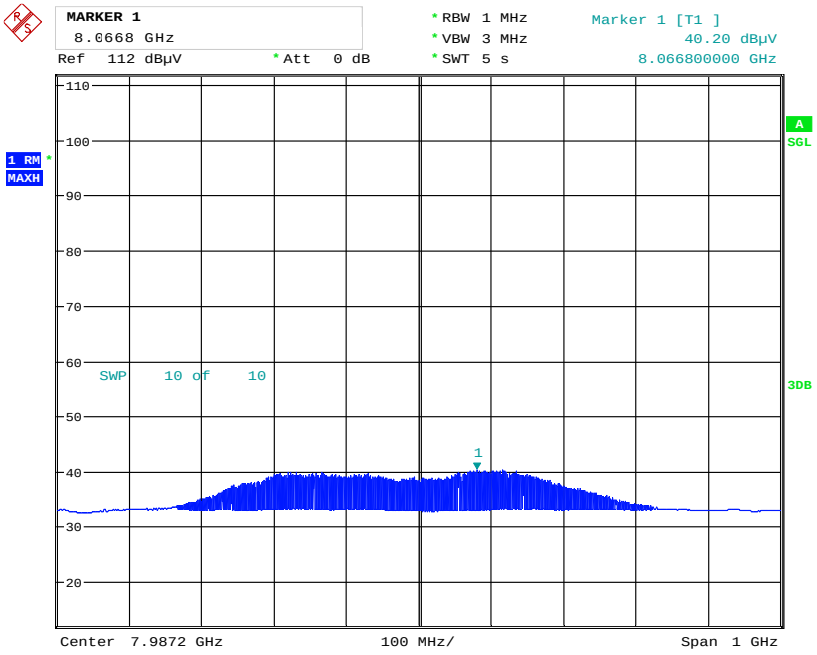
Channel 9 (7987.2MHz), Fundamental Average Measurements

Mode 0



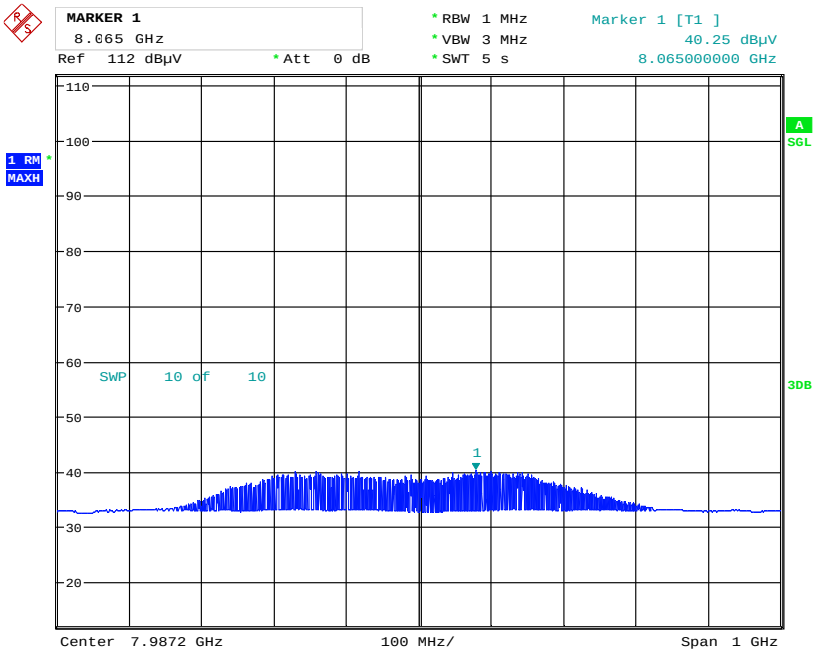
Date: 1.APR.2021 16:13:38

Mode 4



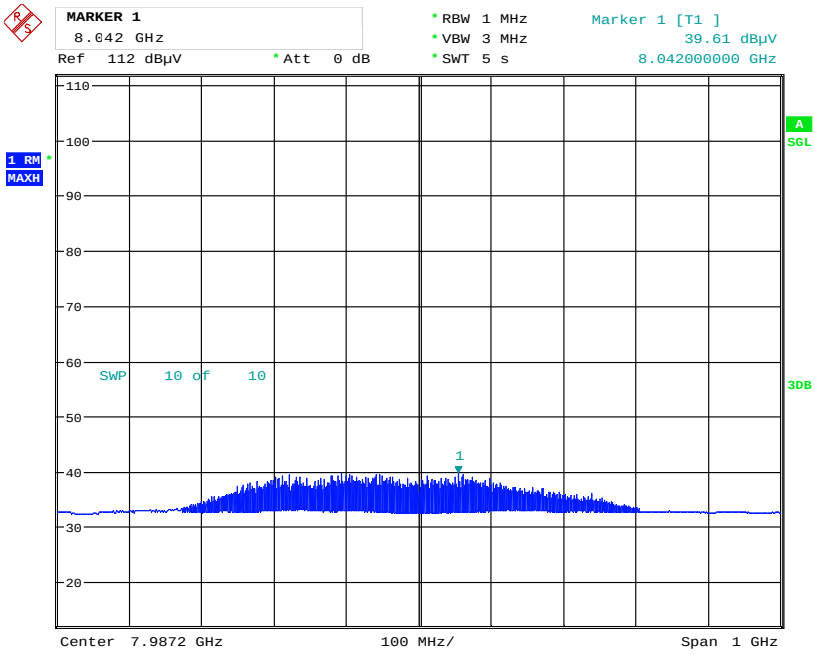
Date: 5.APR.2021 11:47:34

Mode 5



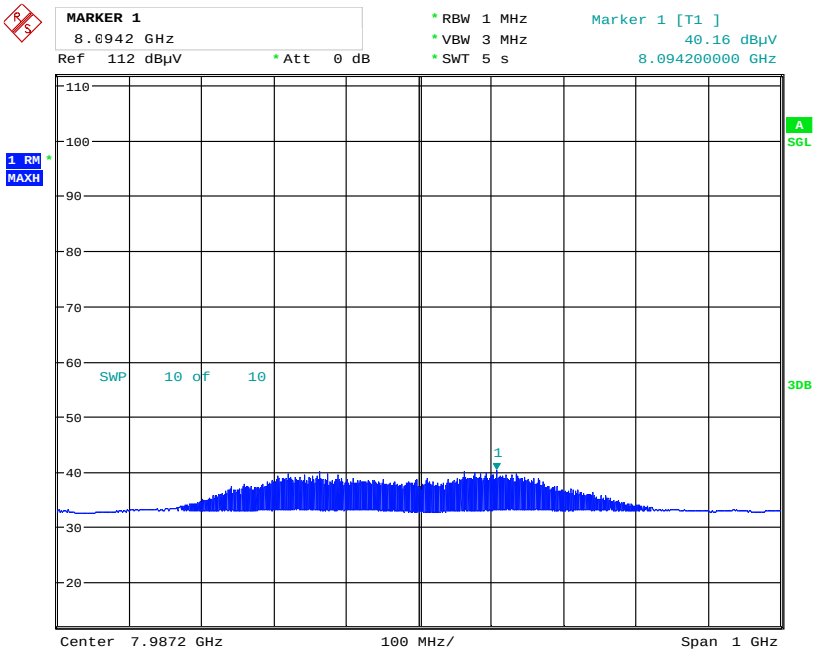
Date: 5.APR.2021 11:53:39

Mode 9



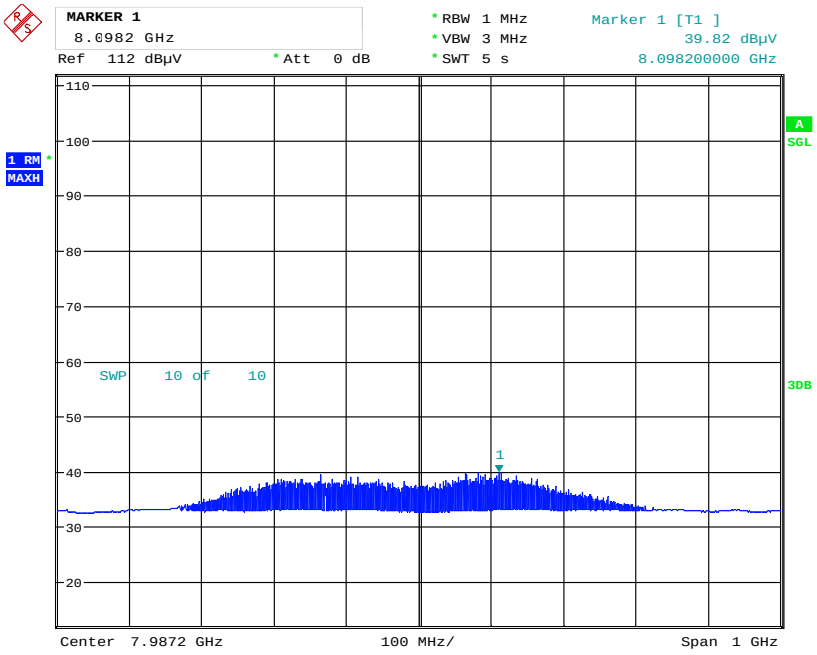
Date: 1.APR.2021 16:25:52

Mode 10



Date: 5.APR.2021 12:01:14

Mode 14



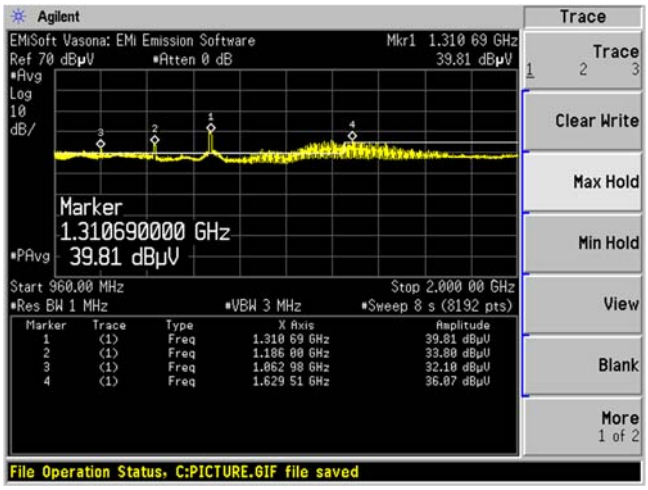
Date: 5.APR.2021 12:06:29

Average Radiated Spurious Emissions: 960 MHz-26.5 GHz

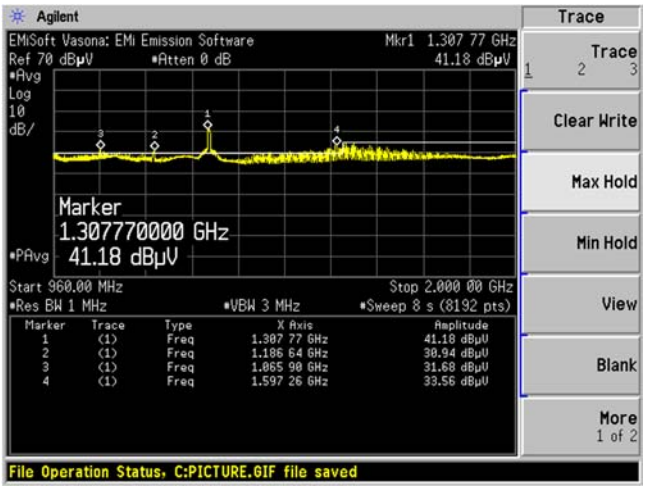
Note: Measurement was performed at 1m distance. The stricter IC limit was used to demonstrate compliance.
Note: For Spurious Emissions testing, pre-scan was performed for all modes, and Mode 0 was selected to demonstrate compliance as the worst case configuration.
Note: For Spurious Emissions in 960MHz to 2GHz range, "Baseline" scans were performed to show that displayed "failing" emissions in screenshots are from the support equipment, i.e., laptop, Teensy, and the connection in between, but not from the EUT. "Baseline" scans were performed with the laptop on and Teensy plugged in, EUT was powered off.
Note: In radiated measurement screenshots from 960MHz to 26.5GHz, shown emissions account for equipment factors to show corrected values compared to applicable limits.
Note: According to ANSI C63.10 Section 10.3.9, measured field strength in dBµV/m was converted to EIRP in dBm to compare with the limit. The equation below was used,

$$EIRP\ (dBm) = E\ (dB\mu V/m) - 95.3$$

960 MHz-2 GHz H-Pol Baseline



960 MHz-2 GHz V-Pol Baseline

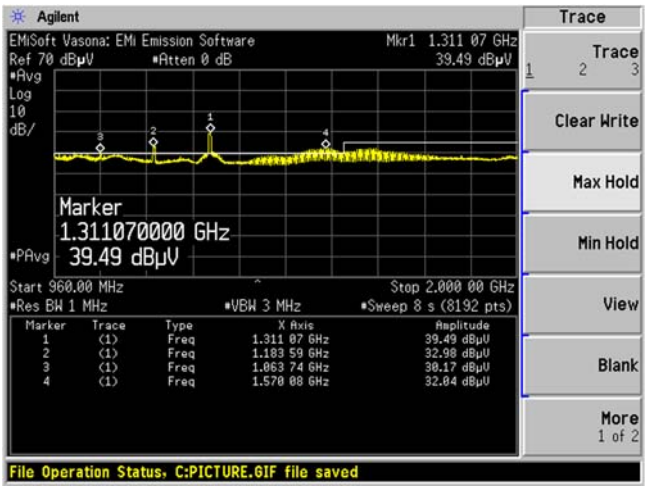


Channel 5 (6489.6 MHz), Mode 0

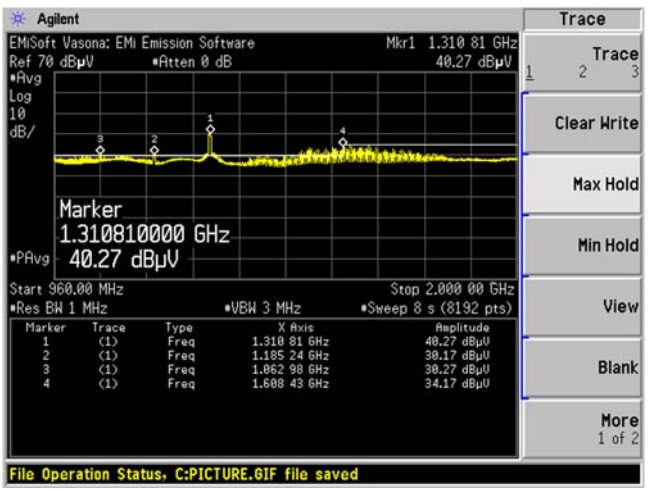
Measured Emission Frequency (GHz)	Antenna Pol (H/V)	Field Strength (dBµV/m at 1m)	Corrected Average Field Strength (dBµV/m at 3m)	EIRP (dBm)	Limit (dBm)	Margin (dB)
2.1297	H	30.92	21.38	-73.92	-61.3	-12.62
2.1265	V	33.50	23.96	-71.34	-61.3	-10.04
25.6619	H	30.77	21.23	-74.07	-61.3	-12.77
25.6806	V	30.93	21.39	-73.91	-61.3	-12.61

Please refer to the following plots.

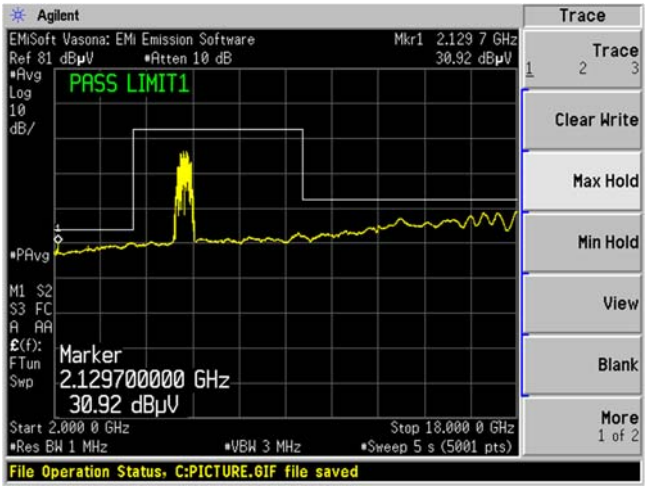
960 MHz-2 GHz H-Pol



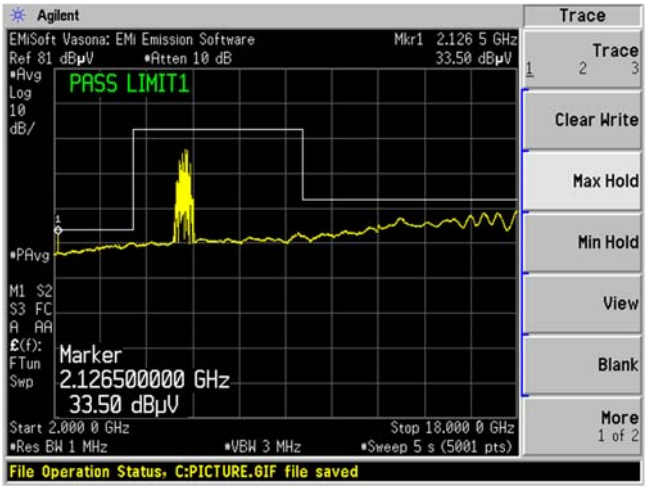
960 MHz-2 GHz V-Pol



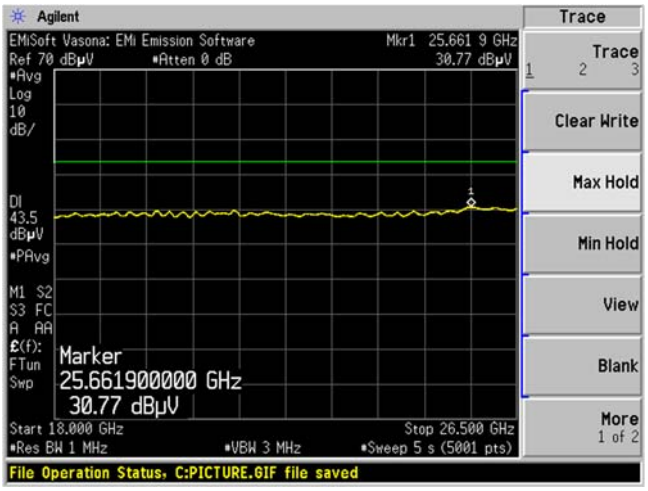
2 GHz-18 GHz H-Pol



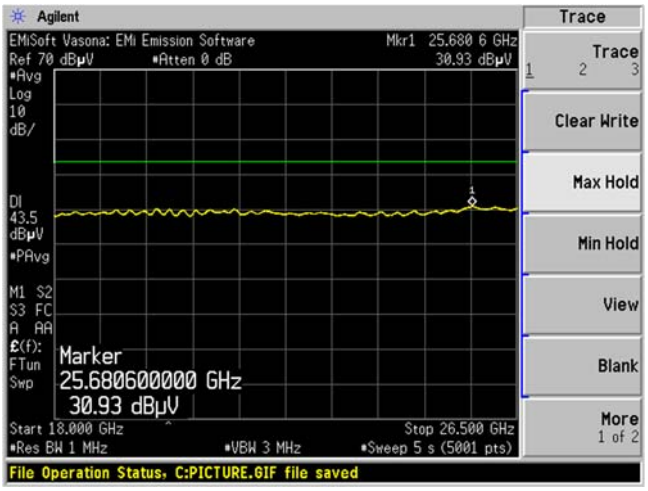
2 GHz-18 GHz V-Pol



18 GHz-26.5 GHz H-Pol



18 GHz-26.5 GHz V-Pol

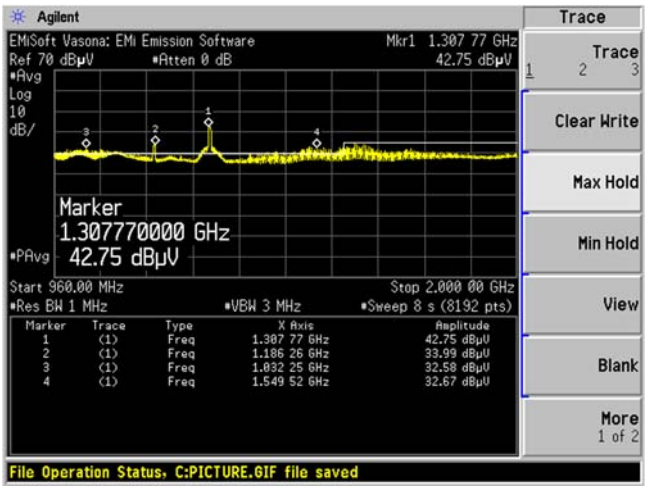


Channel 6 (6988.8 MHz), Mode 0

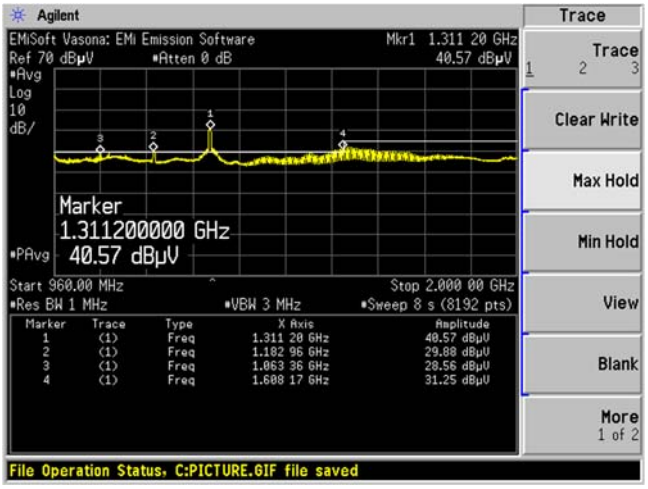
Measured Emission Frequency (GHz)	Antenna Pol (H/V)	Field Strength (dBµV/m at 1m)	Corrected Average Field Strength (dBµV/m at 3m)	EIRP (dBm)	Limit (dBm)	Margin (dB)
2.1297	H	33.68	24.14	-71.16	-61.3	-9.86
2.1233	V	33.09	23.55	-71.75	-61.3	-10.45
25.7078	H	30.78	21.24	-74.06	-61.3	-12.76
25.667	V	30.87	21.33	-73.97	-61.3	-12.67

Please refer to the following plots.

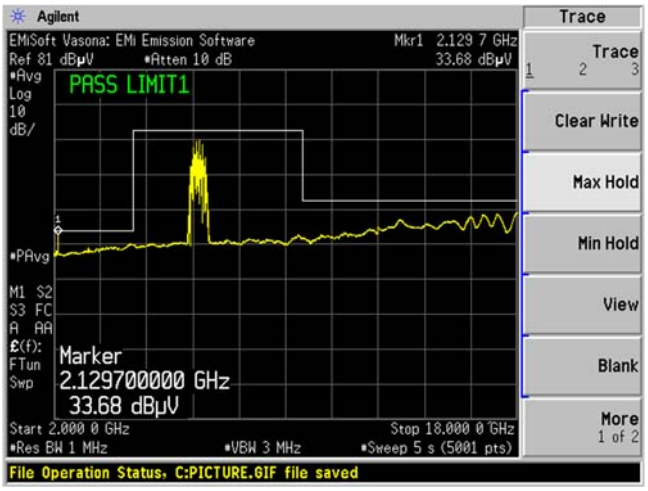
960 MHz-2 GHz H-Pol



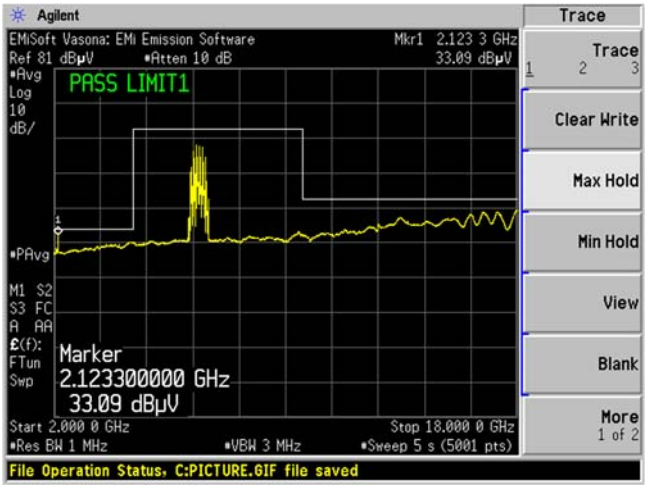
960 MHz-2 GHz V-Pol



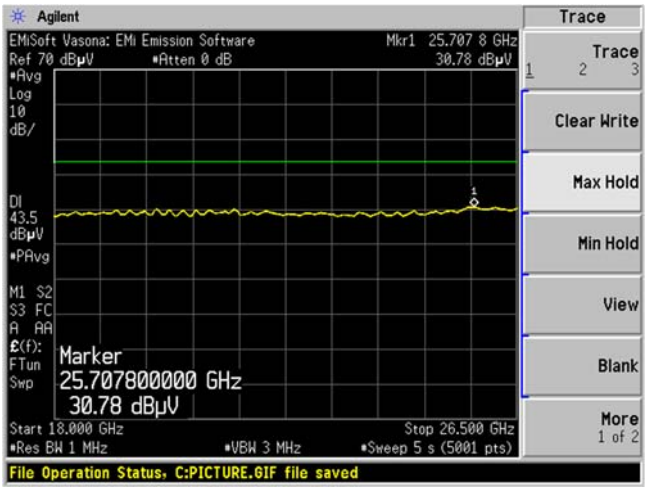
2 GHz-18 GHz H-Pol



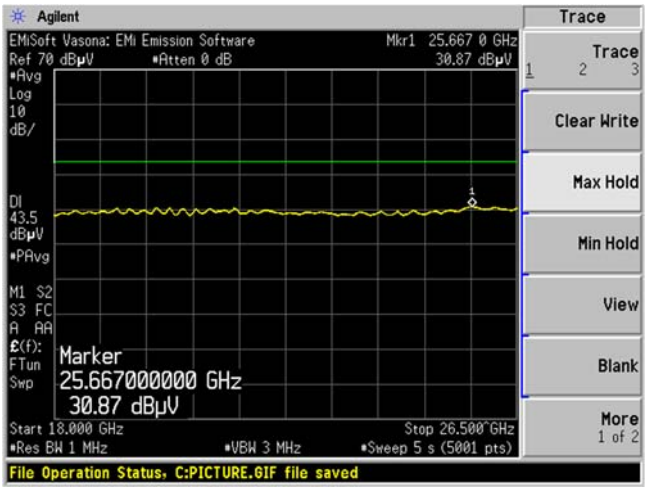
2 GHz-18 GHz V-Pol



18 GHz-26.5 GHz H-Pol



18 GHz-26.5 GHz V-Pol

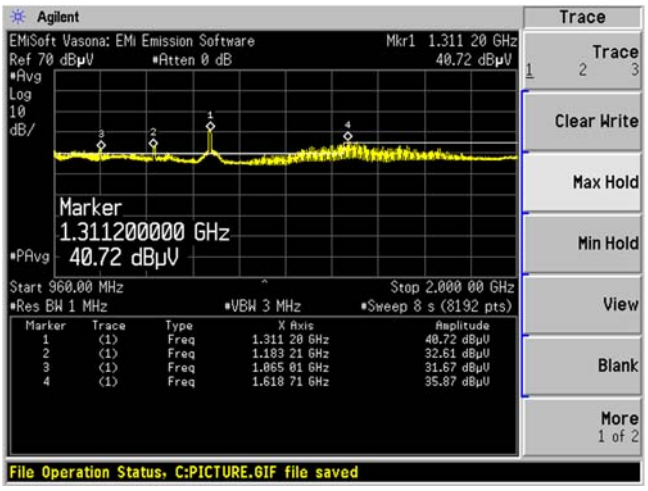


Channel 9 (7987.2 MHz), Mode 0

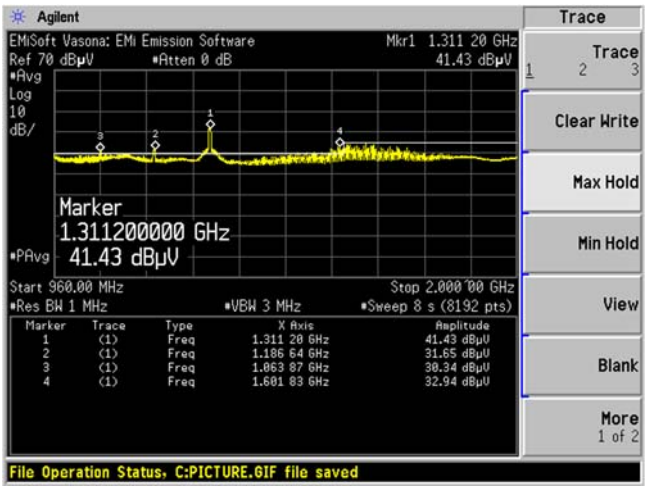
Measured Emission Frequency (GHz)	Antenna Pol (H/V)	Field Strength (dBµV/m at 1m)	Corrected Average Field Strength (dBµV/m at 3m)	EIRP (dBm)	Limit (dBm)	Margin (dB)
2.1237	H	32.23	22.69	-72.61	-61.3	-11.31
2.1265	V	32.20	22.66	-72.64	-61.3	-11.34
25.6636	H	30.72	21.18	-74.12	-61.3	-12.82
25.6925	V	30.77	21.23	-74.07	-61.3	-12.77

Please refer to the following plots.

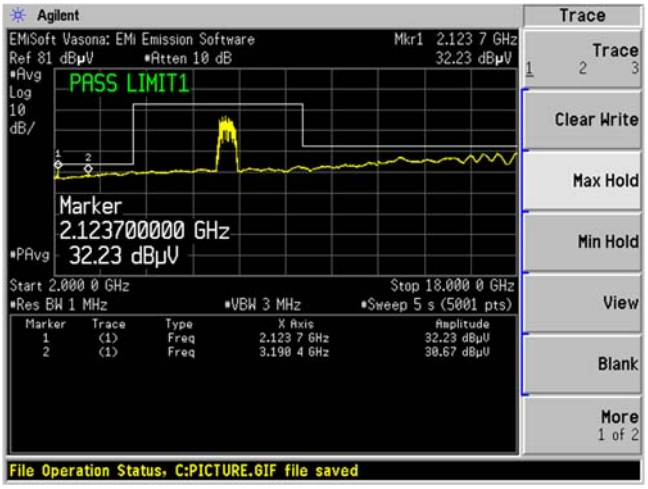
960 MHz-2 GHz H-Pol



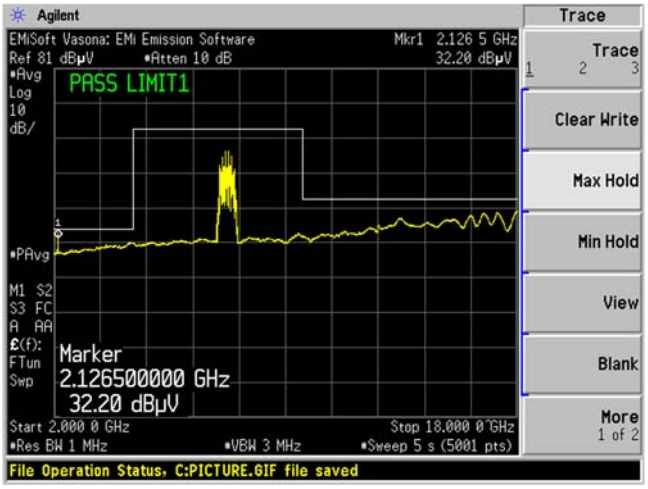
960 MHz-2 GHz V-Pol



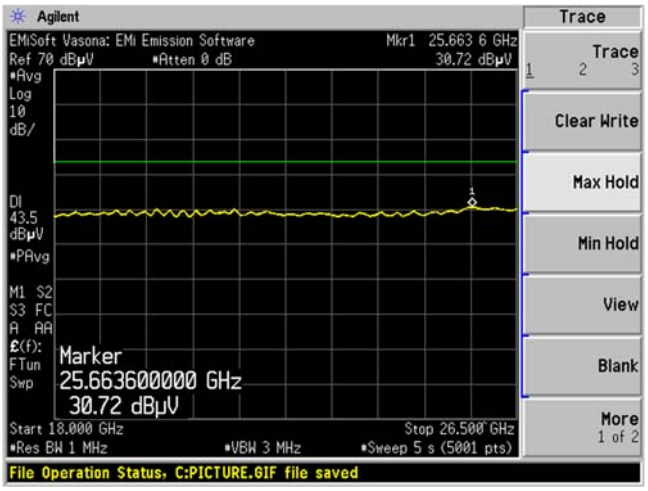
2 GHz-18 GHz H-Pol



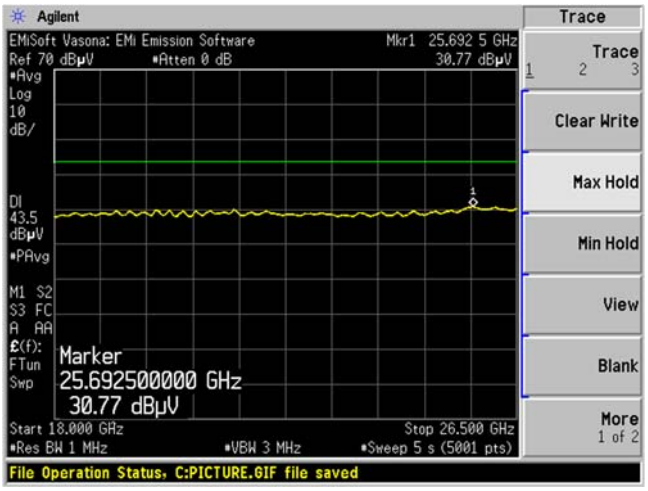
2 GHz-18 GHz V-Pol



18GHz-26.5GHz H-Pol



18GHz-26.5GHz V-Pol



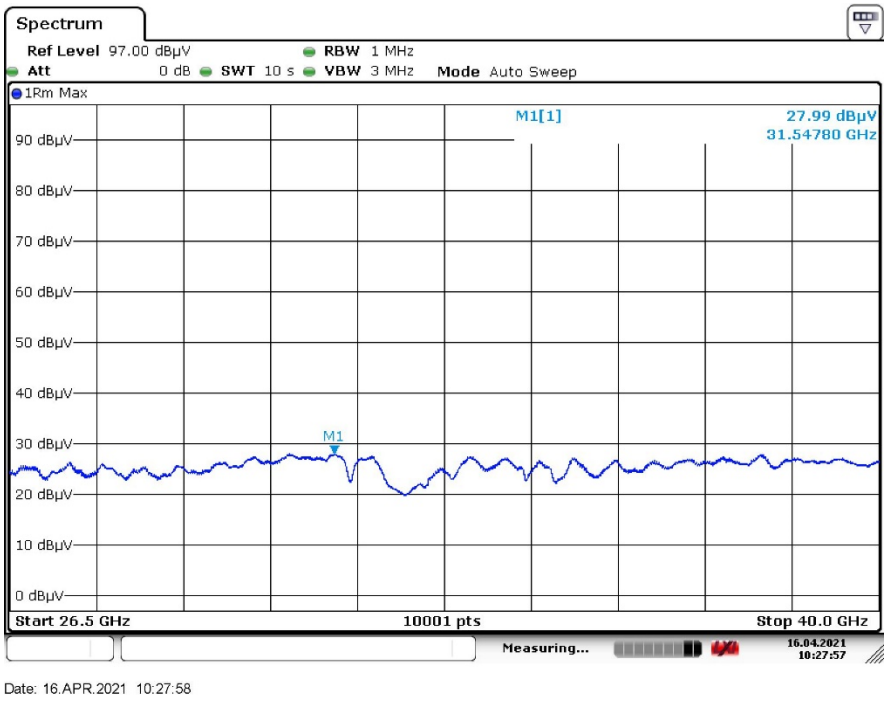
Average Radiated Spurious Emissions: 26.5-40 GHz

Note: Measurement was performed at 1m distance. The stricter IC limit was used to demonstrate compliance.
Note: For Spurious Emissions testing, pre-scan was performed for all modes, and Mode 0 was selected to demonstrate compliance as the worst case configuration.
Note: In radiated measurement screenshots from 26.5GHz to 40GHz, shown emissions do not account for equipment factors. In this case, highest emission was chosen and corrected value was calculated given equipment factors in order to compare to limit.

Channel 5 (6489.6 MHz), Mode 0

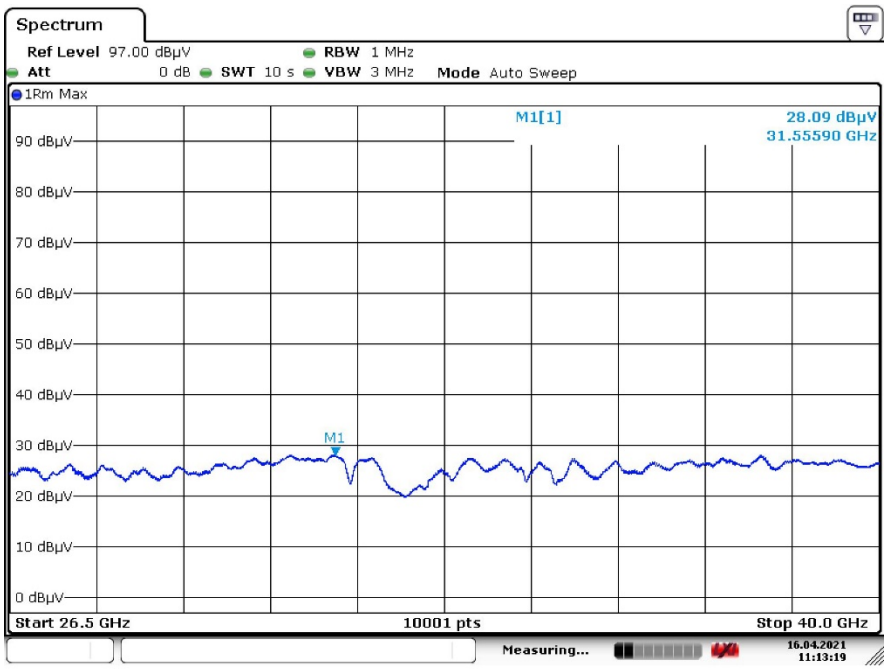
Measured Emission Frequency (GHz)	PSA Reading (dBµV)	Antenna Pol (H/V)	Antenna Factor (dB)	Cable Loss (dB)	Pre Amp Gain (dB)	Field Strength (dBµV/m at 1m)	Corrected Average Field Strength (dBµV/m at 3m)	EIRP (dBm)	Limit (dBm)	Margin (dB)
31.5478	27.99	H	39.793	8.08	40.272	35.591	26.051	-69.249	-61.3	-7.949
31.5559	28.09	V	39.793	8.08	40.272	35.691	26.151	-69.149	-61.3	-7.849

26.5-40 GHz H-Pol



Date: 16.APR.2021 10:27:58

26.5-40 GHz V-Pol

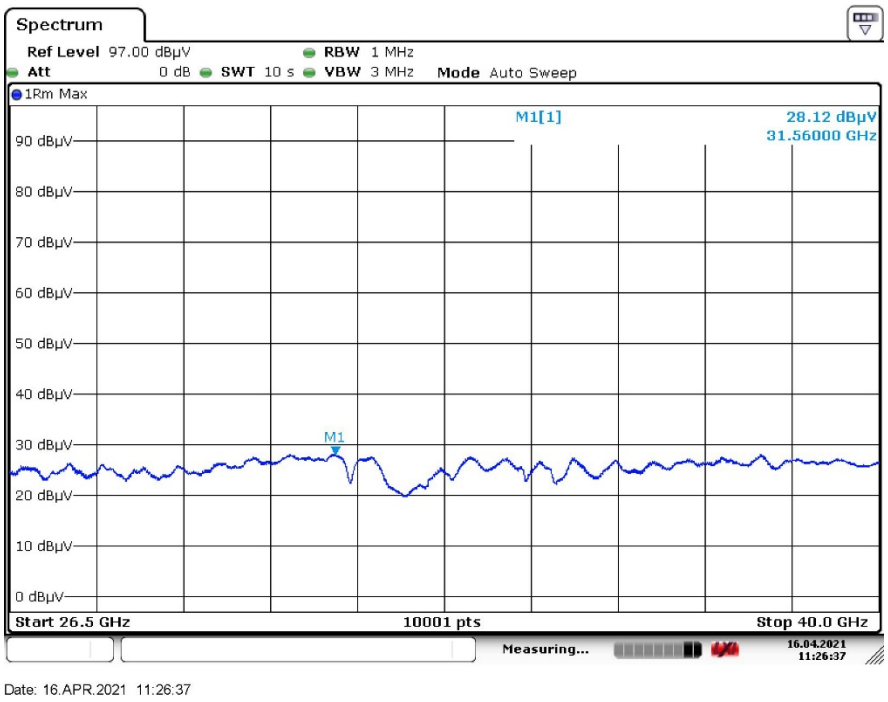


Date: 16.APR.2021 11:13:20

Channel 6 (6988.8 MHz), Mode 0

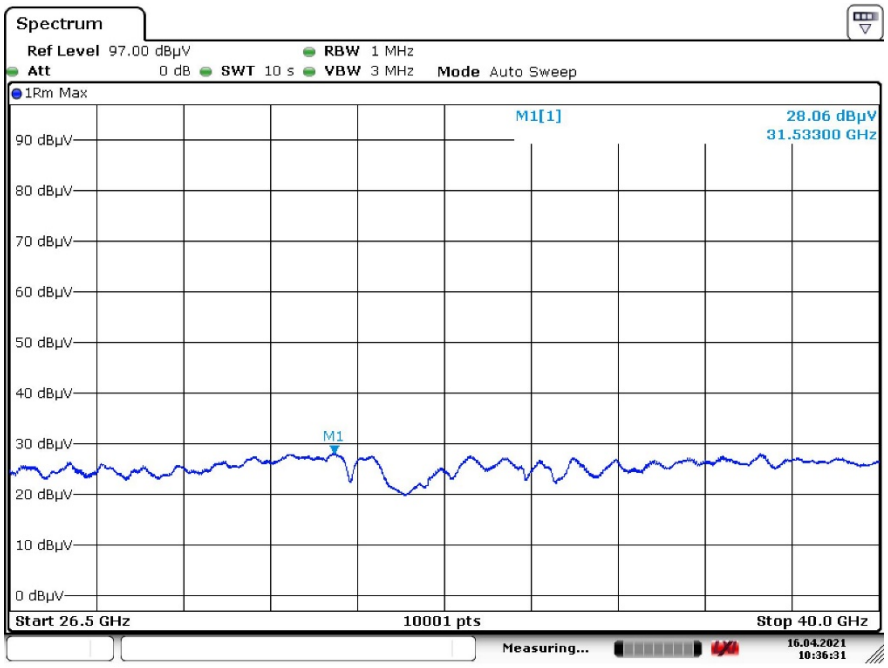
Measured Emission Frequency (GHz)	PSA Reading (dBµV)	Antenna Pol (H/V)	Antenna Factor (dB)	Cable Loss (dB)	Pre Amp Gain (dB)	Field Strength (dBµV/m at 1m)	Corrected Average Field Strength (dBµV/m at 3m)	EIRP (dBm)	Limit (dBm)	Margin (dB)
31.56	28.12	H	39.793	8.08	40.272	35.721	26.181	-69.119	-61.3	-7.819
31.533	28.06	V	39.793	8.08	40.272	35.661	26.121	-69.179	-61.3	-7.879

26.5-40 GHz H-Pol



Date: 16.APR.2021 11:26:37

26.5-40 GHz V-Pol

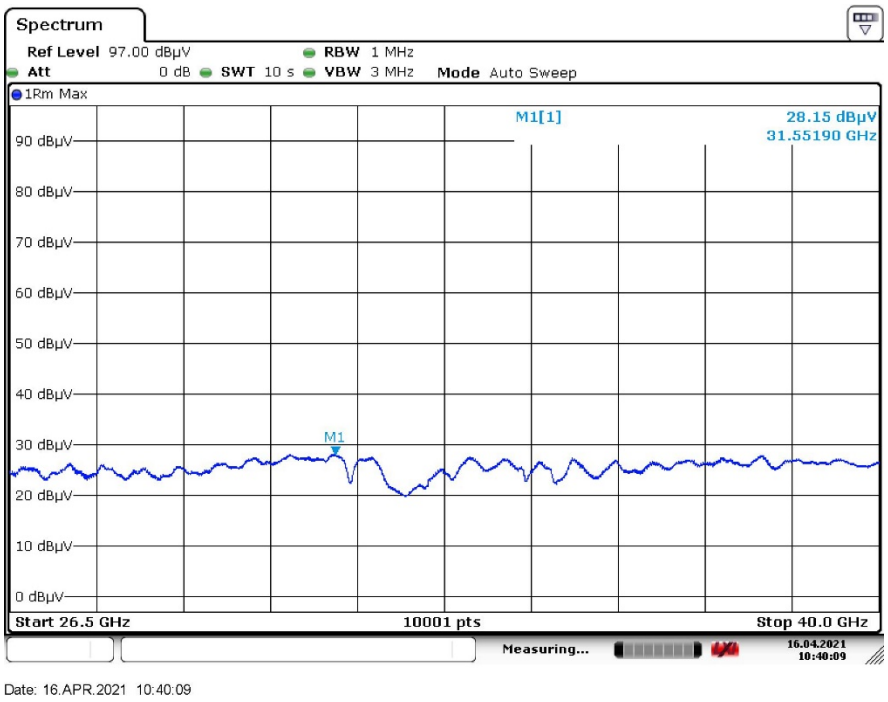


Date: 16.APR.2021 10:36:31

Channel 9 (7987.2 MHz), Mode 0

Measured Emission Frequency (GHz)	PSA Reading (dBµV)	Antenna Pol (H/V)	Antenna Factor (dB)	Cable Loss (dB)	Pre Amp Gain (dB)	Field Strength (dBµV/m at 1m)	Corrected Average Field Strength (dBµV/m at 3m)	EIRP (dBm)	Limit (dBm)	Margin (dB)
31.5519	28.15	H	39.793	8.08	40.272	35.751	26.211	-69.089	-61.3	-7.789
31.5316	28.06	V	39.793	8.08	40.272	35.661	26.121	-69.179	-61.3	-7.879

26.5-40 GHz H-Pol



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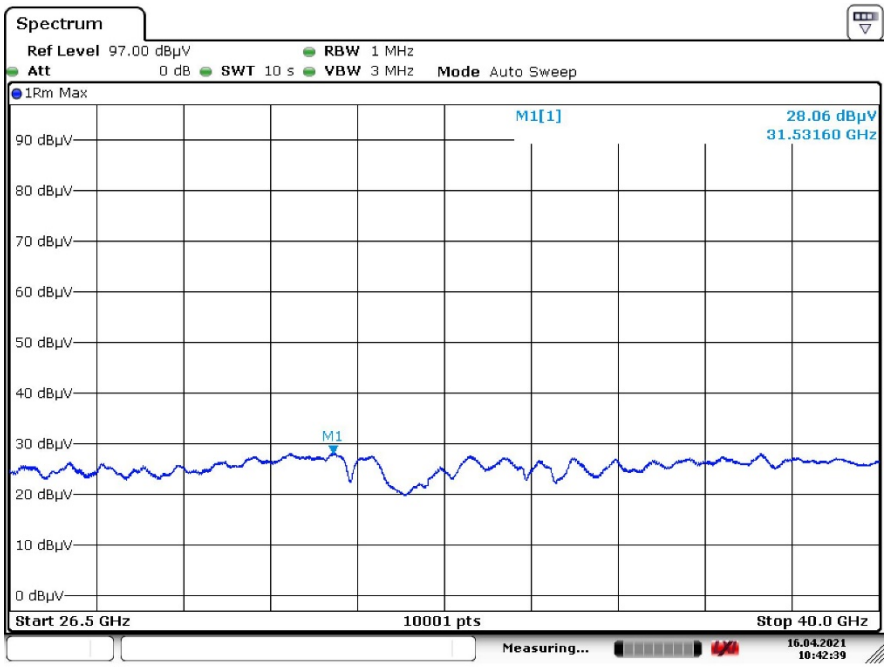
26.5-40 GHz V-Pol



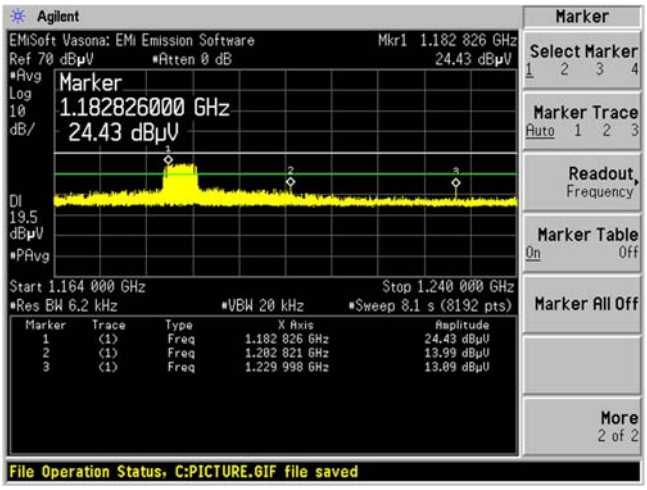
Date: 16.APR.2021 10:42:39

Additional Radiated Average Spurious Emissions with RBW of 1 kHz

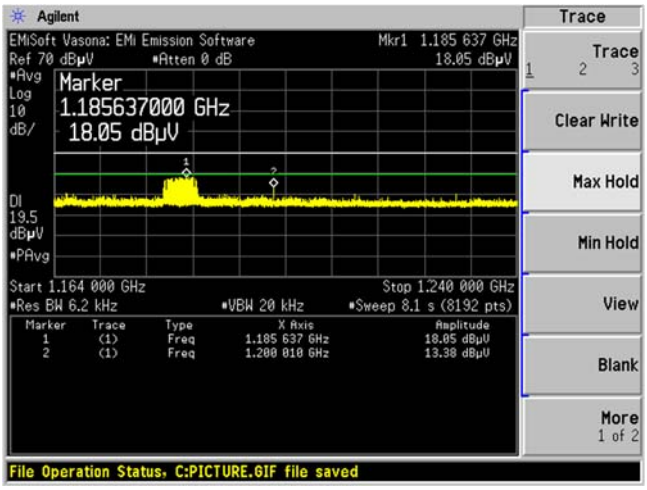
Note: For Spurious Emissions testing, pre-scan was performed for all modes, and Mode 0 was selected to demonstrate compliance as the worst case configuration.
Note: "Baseline" scans were performed for the 1164 MHz to 1240 MHz frequency span, to show that displayed "failing" emissions in screenshots are from the support equipment, i.e., laptop, Teensy, and the connection in between, but not from the EUT. "Baseline" scans were performed with the laptop on and Teensy plugged in, EUT was in standby mode.
Note: In radiated measurement screenshots from 1164 MHz to 1240 MHz and 1559 MHz to 1610 MHz, shown emissions account for equipment factors to show corrected values compared to applicable limits.
Note: According to ANSI C63.10 Section 10.3.9, measured field strength in dBµV/m was converted to EIRP in dBm to compare with the limit. The equation below was used,

$$EIRP\ (dBm) = E\ (dB\mu V/m) - 95.3$$

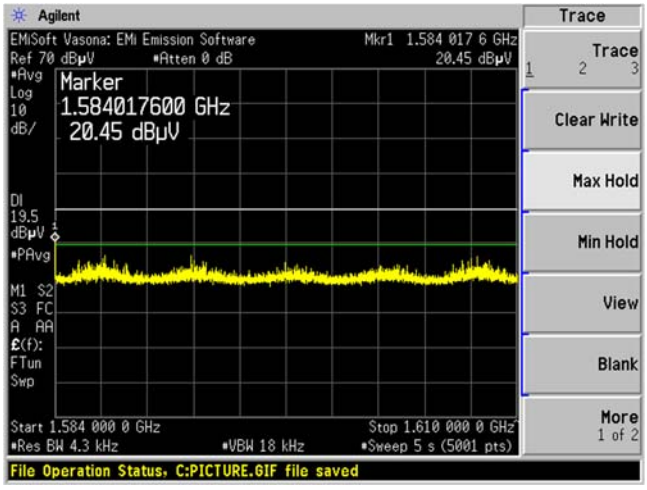
1164 MHz-1240 MHz H-Pol Baseline



1164 MHz-1240 MHz V-Pol Baseline



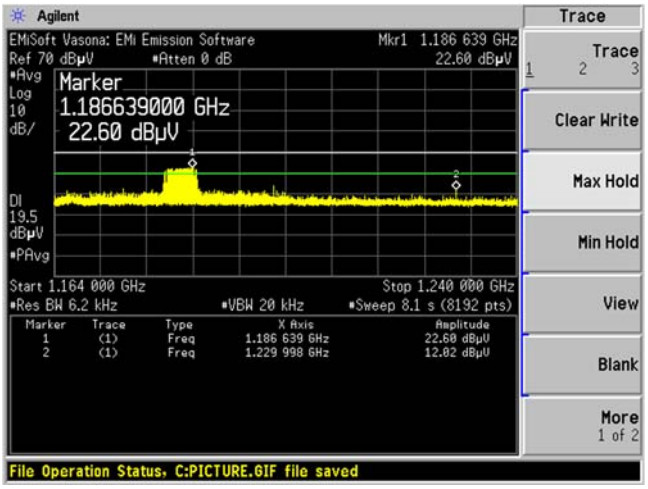
1584 MHz – 1610 MHz H-Pol Baseline



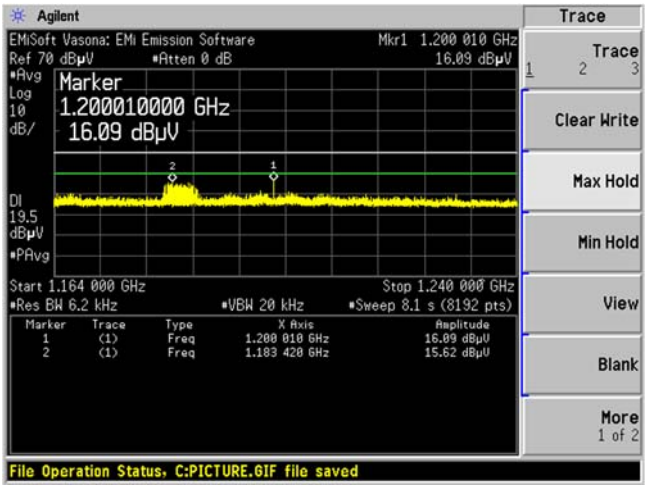
Channel 5

1164 MHz-1240 MHz

Transmitting Scan H-Pol

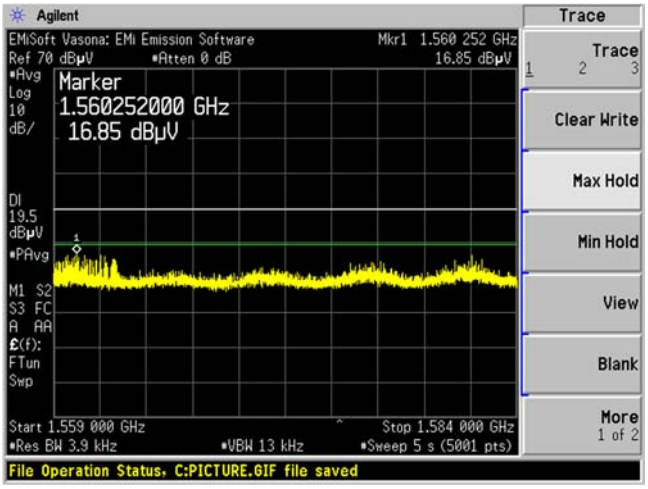


Transmitting Scan V-Pol

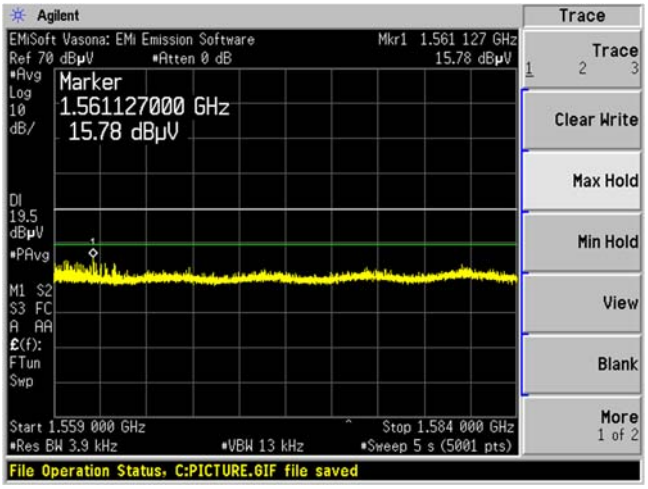


1559 MHz-1584 MHz

Transmitting Scan H-Pol



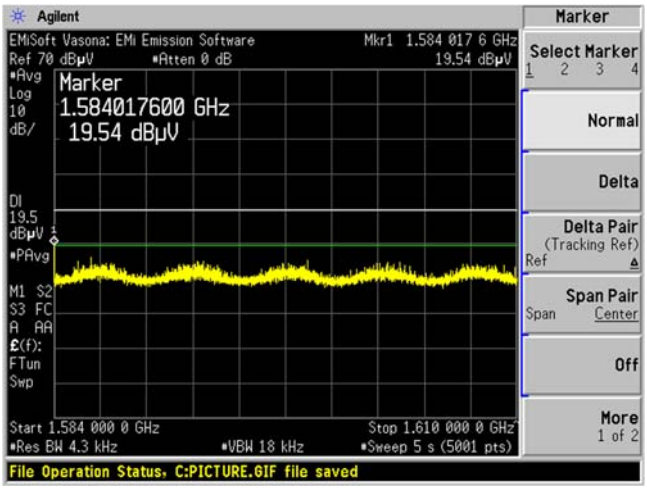
Transmitting Scan V-Pol



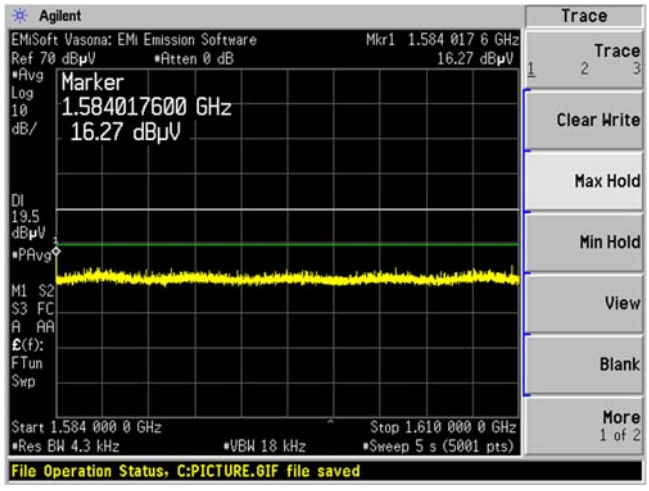
Channel 5

1584 MHz-1610 MHz

Transmitting Scan H-Pol



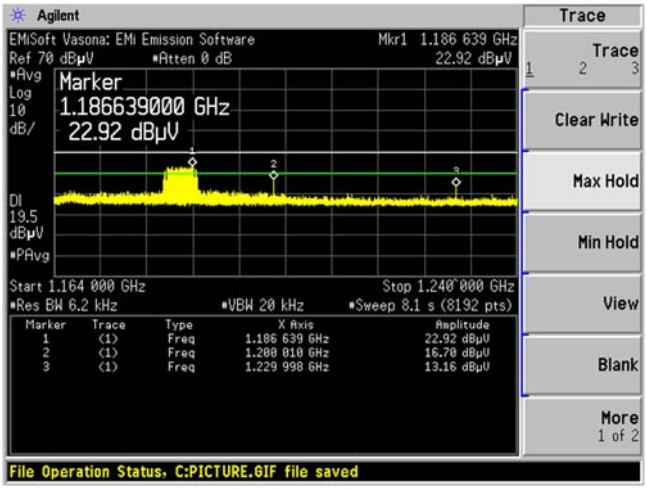
Transmitting Scan V-Pol



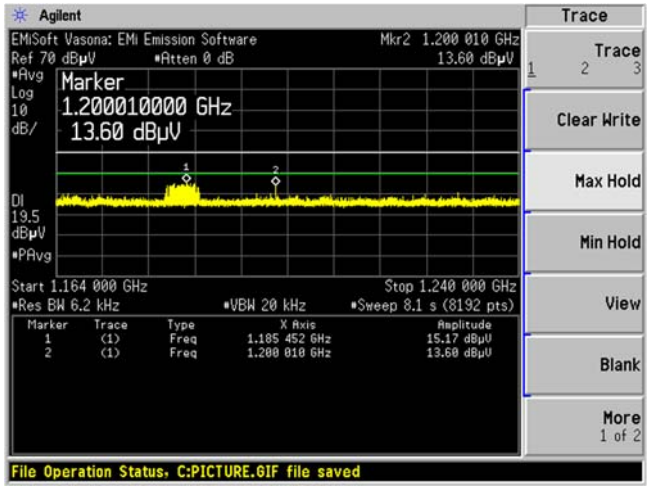
Channel 6

1164 MHz-1240 MHz

Transmitting Scan H-Pol



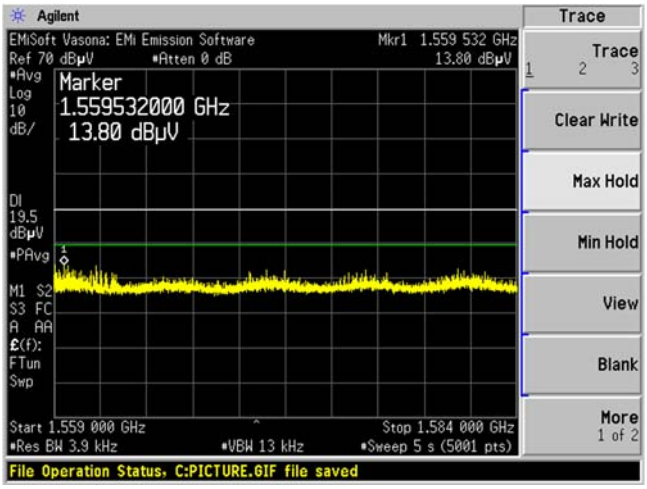
Transmitting Scan V-Pol



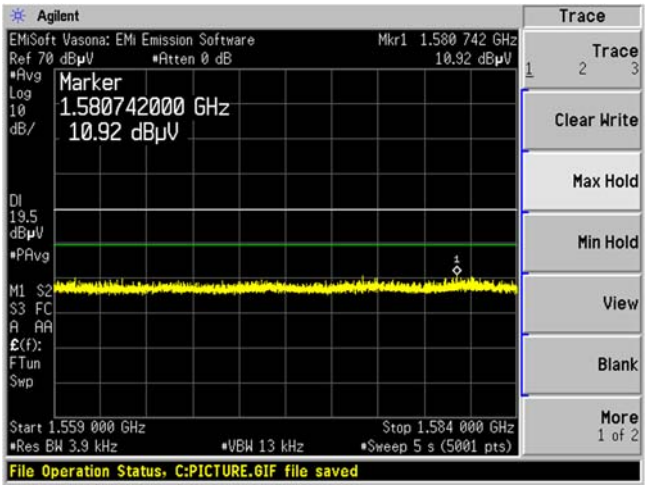
Channel 6

1559 MHz-1584 MHz

Transmitting Scan H-Pol

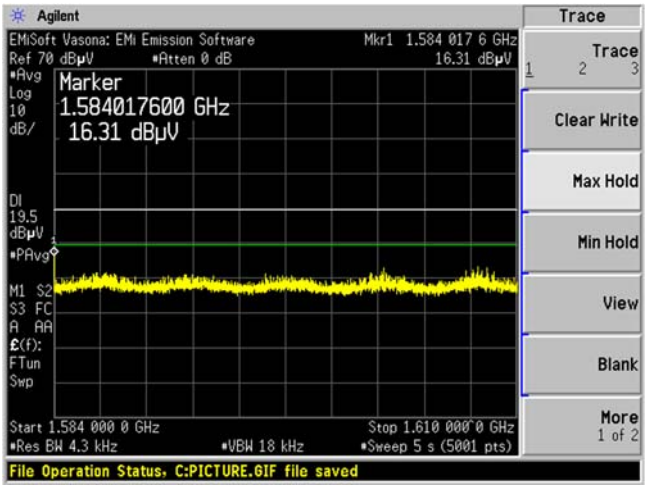


Transmitting Scan V-Pol

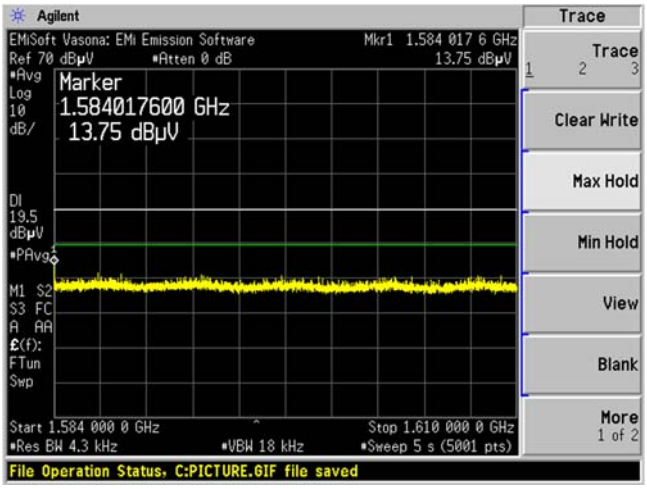


1584 MHz-1610 MHz

Transmitting Scan H-Pol



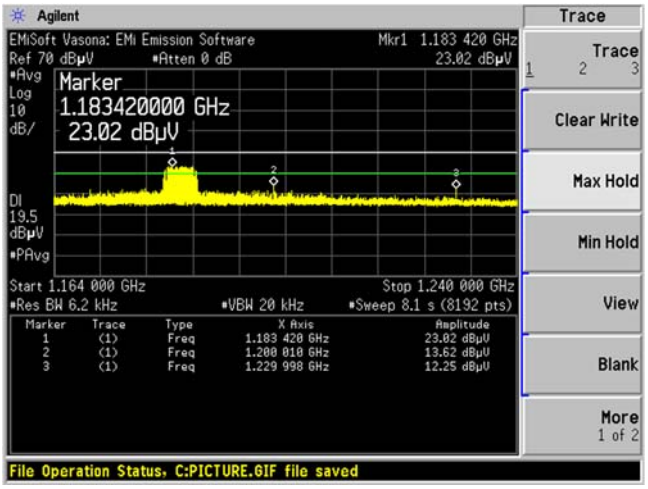
Transmitting Scan V-Pol



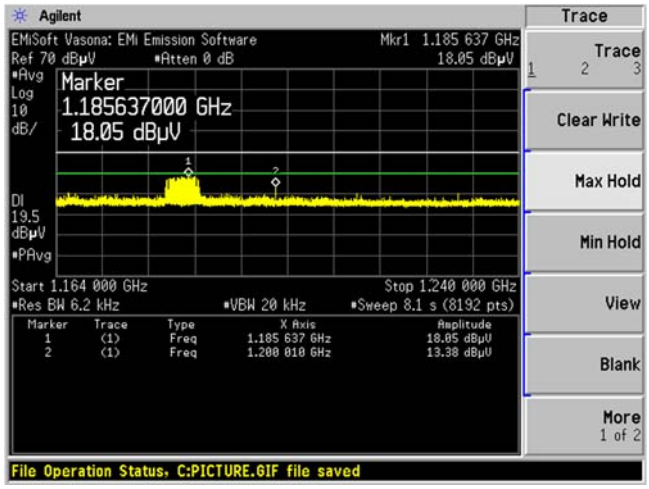
Channel 9

1164 MHz-1240 MHz

Transmitting Scan H-Pol

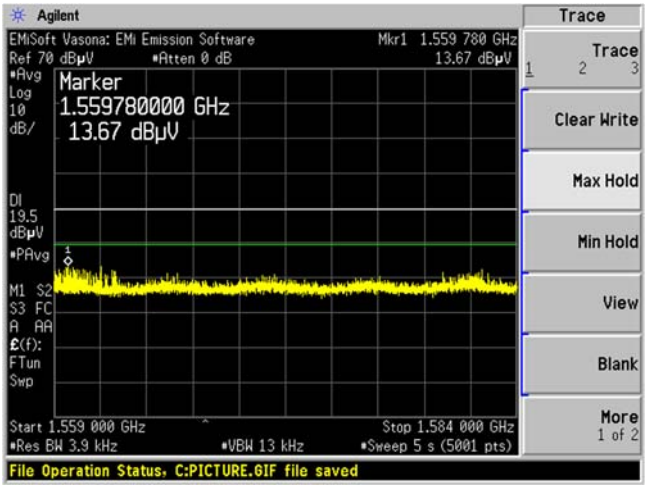


Transmitting Scan V-Pol

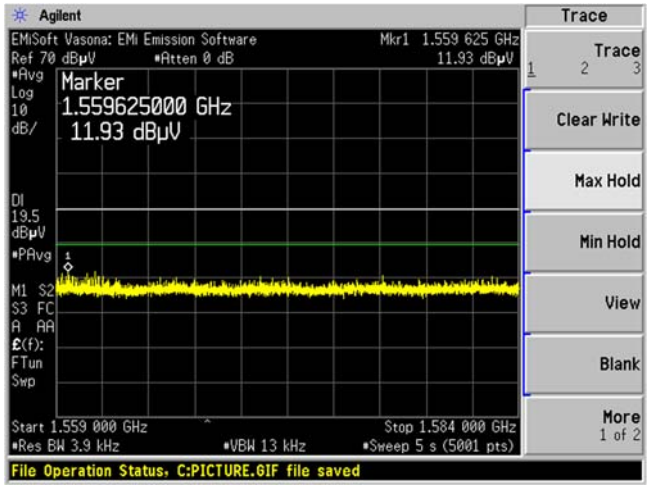


1559 MHz-1584 MHz

Transmitting Scan H-Pol



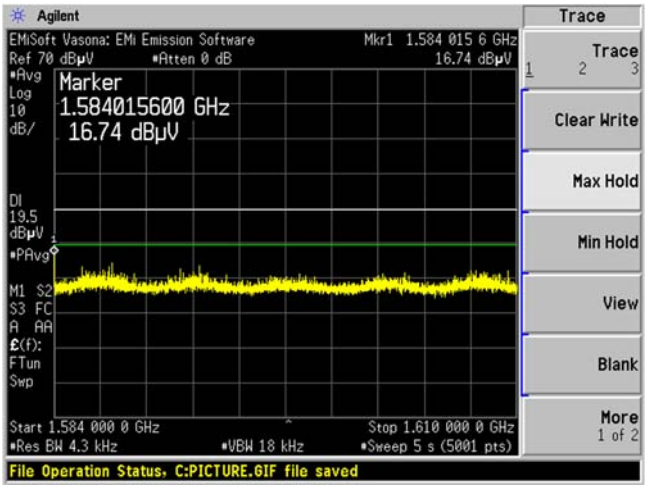
Transmitting Scan V-Pol



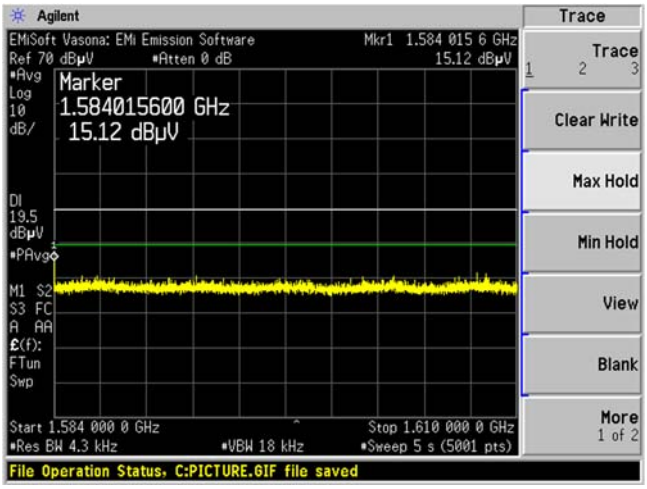
Channel 9

1584 MHz-1610 MHz

Transmitting Scan H-Pol



Transmitting Scan V-Pol



7 FCC §15.519(e), §15.521(e) & ISEDC RSS-220 §5.3.1(g) - Peak Fundamental Emission

7.1 Applicable Standards

According to FCC §15.519(e): There is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on the frequency at which the highest radiated emission occurs, f_M. That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth, and a correspondingly different peak emission limit, following the procedures described in §15.521.

According to FCC §15.521(e): The frequency at which the highest radiated emission occurs, f_M, must be contained within the UWB bandwidth.

According to ISEDC RSS-220 §5.3.1(g): The peak level of the transmissions shall not exceed the peak equivalent of the average limit contained within any 50 MHz bandwidth, as defined in section 4 of the Annex

According to ISEDC RSS-220 Annex 4(c): Peak measurements shall be made in addition to average measurements. Transmissions shall not exceed 0 dBm e.i.r.p. in any 50 MHz bandwidth when the average limit is -41.3 dBm/MHz.

According to FCC §15.521(g): When a peak measurement is required, it is acceptable to use a resolution bandwidth other than the 50 MHz specified in this subpart. This resolution bandwidth shall not be lower than 1 MHz or greater than 50 MHz, and the measurement shall be centered on the frequency at which the highest radiated emission occurs, f_M. If a resolution bandwidth other than 50 MHz is employed, the peak EIRP limit shall be 20 log (RBW/50) dBm where RBW is the resolution bandwidth in megahertz that is employed. This may be converted to a peak field strength level at 3 meters using E(dBuV/m) = P(dBm EIRP) + 95.2. If RBW is greater than 3 MHz, the application for certification filed with the Commission must contain a detailed description of the test procedure, calibration of the test setup, and the instrumentation employed in the testing.

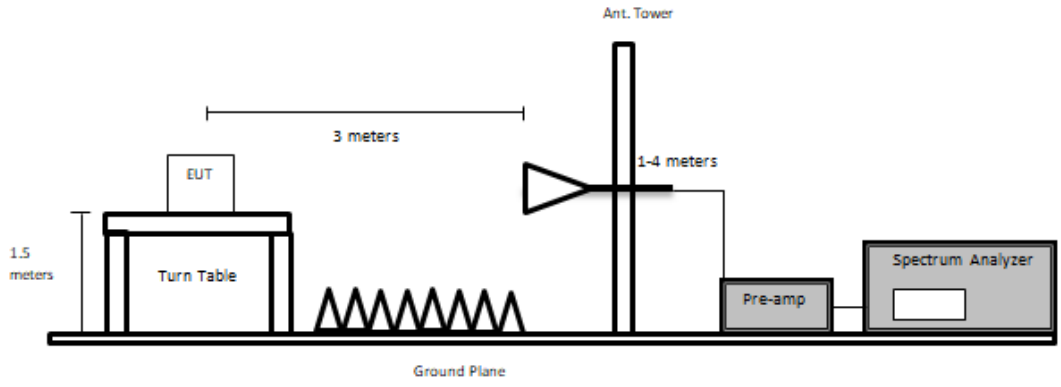
7.2 Measurement Procedure

The measurements were based on ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices section 10.3: Radiated measurement procedure above 960MHz.

7.3 Test Setup Block Diagram

Above 1GHz:

At 3 meters:



7.4 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Rohde & Schwarz	Spectrum Analyzer	FSQ26	200749	2019-11-07	2 years
Sunol Sciences Corp	System Controller	SC110V	122303-1	N/R	N/A
ETS Lindgren	Horn Antenna	3117	00218973	2019-02-13	2.5 years
Agilent	Preamplifier	8449B	3147A00400	2021-03-02	1 year
-	RF cable	-	-	Each time[1]	N/A
IW Incorporated	157 Series 2.92 SM (x2) Armored 33 ft. Cable	KPS-1571AN-3960-KPS	DC 1917	2021-03-03	1 year

Note[1]: cables included in the test set-up will be checked each time before testing.

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 the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

7.5 Test Environmental Conditions

Temperature:	23º C
Relative Humidity:	42 %
ATM Pressure:	102.7 KPa

The testing was performed by Allen Huang on 2021-04-01 and 2021-04-05 in 5 meter chamber 3.

7.6 Test Results

Measurements were taken at 3 meters.

Channel Number	Channel Frequency (MHz)	Mode	PSA Reading (dBµV)	Antenna Factor (dB/m)	Cable Loss (dB)	Pre Amp Gain (dB)	Corrected Field Strength (dBµV/m at 3m)	Limit[1] (dBµV/m at 3m)	Margin (dB)
5	6489.6	0	74.71	36	11.938	35.892	86.756	87.27	-0.514
		4	67.36	36	11.738	35.892	79.206	87.27	-8.064
		5	70.37	36	11.938	35.892	82.416	87.27	-4.854
		9	72.83	36	11.938	35.892	84.876	87.27	-2.394
		10	71.33	36	11.938	35.892	83.376	87.27	-3.894
		14	72.57	36	11.738	35.892	84.416	87.27	-2.854
6	6988.8	0	74.6	36.1	12.311	36.308	86.703	87.27	-0.567
		4	67.4	36.1	12.081	36.308	79.273	87.27	-7.997
		5	70.08	36.1	12.311	36.308	82.183	87.27	-5.087
		9	72.45	36.1	12.311	36.308	84.553	87.27	-2.717
		10	70.92	36.1	12.311	36.308	83.023	87.27	-4.247
		14	72.10	36.1	12.081	36.308	83.973	87.27	-3.297
9	7987.2	0	73.22	36.3	14.028	36.646	86.902	87.27	-0.368
		4	66.12	36.3	13.638	36.646	79.412	87.27	-7.858
		5	69.43	36.3	13.638	36.646	82.722	87.27	-4.548
		9	70.65	36.3	13.148	36.646	83.452	87.27	-3.818
		10	69.36	36.3	14.028	36.646	83.042	87.27	-4.228
		14	70.16	36.3	13.638	36.646	83.452	87.27	-3.818

Note[1]: Radiated Peak limit determined using a 20 MHz measurement BW. (i.e. 20*log(20/50)= -7.96 dB), then adding 95.2 dB for field strength at 3 meters as instructed to in FCC §15.521(g)

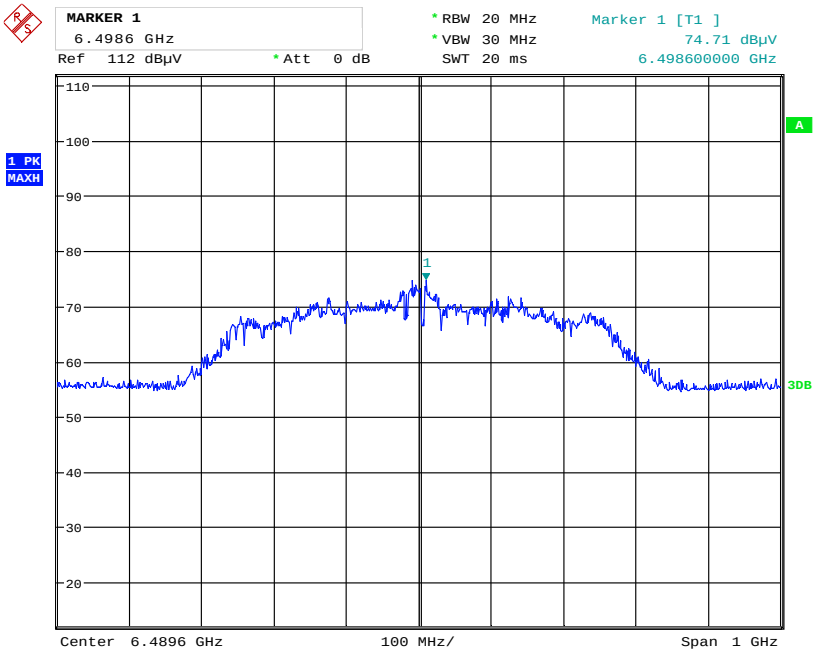
Channel Number	Channel Frequency (MHz)	Mode	f_M (MHz)	Range of UWB BW[2] (MHz)	Result
5	6489.6	0	6498.6	6234.228-6762.972	Pass
		4	6599.6	6322.959-6876.241	Pass
		5	6489.6	6210.285-6768.915	Pass
		9	6482.6	6184.4345-6780.7655	Pass
		10	6614.6	6347.1-6882.1	Pass
		14	6491.6	6224.7395-6758.4605	Pass
6	6988.8	0	6980.8	6713.328-7248.272	Pass
		4	7029.8	6764.5515-7295.0485	Pass
		5	7051.8	6769.828-7333.772	Pass
		9	6985.8	6720.3405-7251.2595	Pass
		10	7052.8	6779.7375-7325.8625	Pass
		14	6985.8	6732.6815-7238.9185	Pass
9	7987.2	0	7979.2	7709.7945-8248.6055	Pass
		4	8094.2	7795.1505-8393.2495	Pass
		5	8113.2	7809.947-8416.453	Pass
		9	7990.2	7704.224-8276.176	Pass
		10	7987.2	7700.0345-8274.3655	Pass
		14	8105.2	7814.215-8396.185	Pass

Note[2]: please refer to Section 8.5 of this report for the UWB bandwidth measurement result.

Please refer to the following plots.

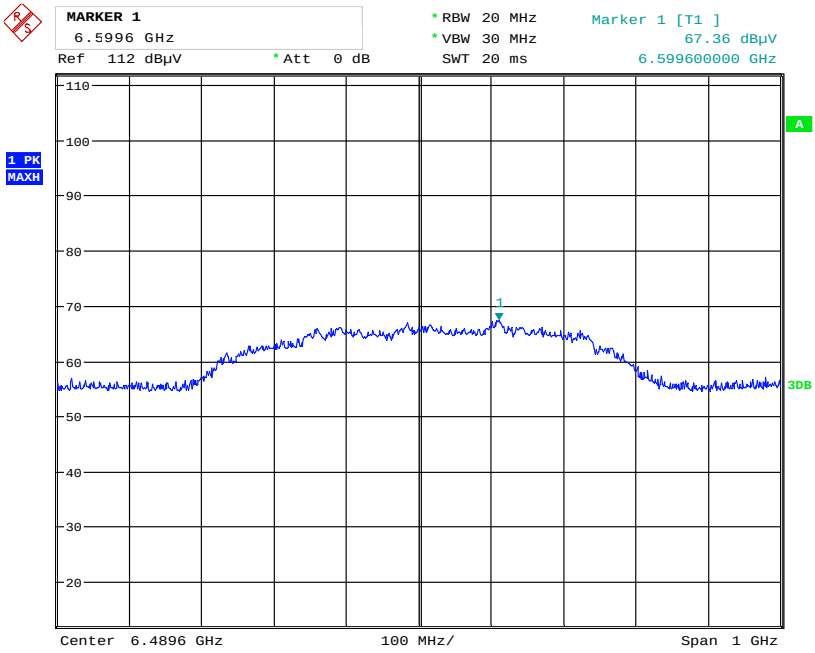
Channel 5 (6489.6 MHz), Fundamental Peak Measurements

Mode 0



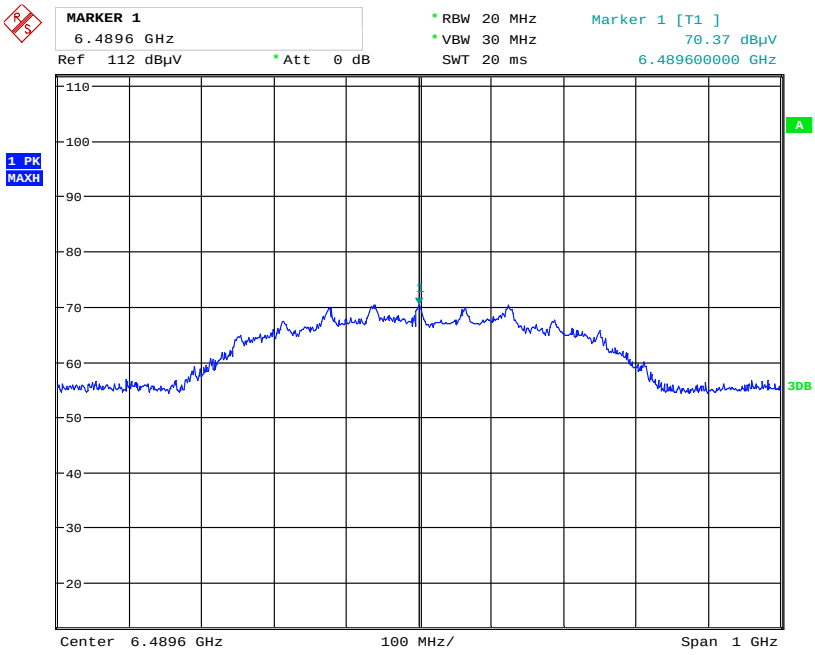
Date: 1.APR.2021 14:40:28

Mode 4



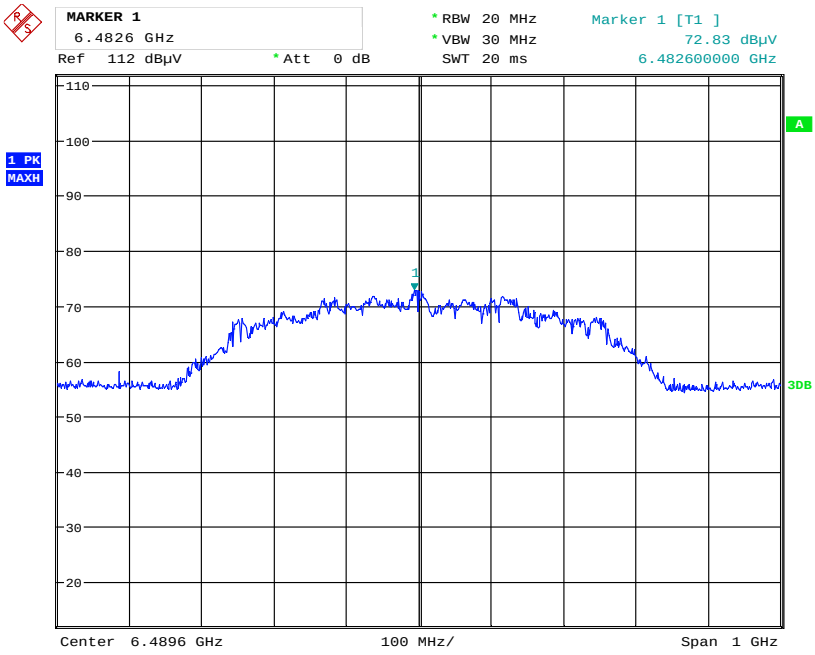
Date: 5.APR.2021 10:22:37

Mode 5



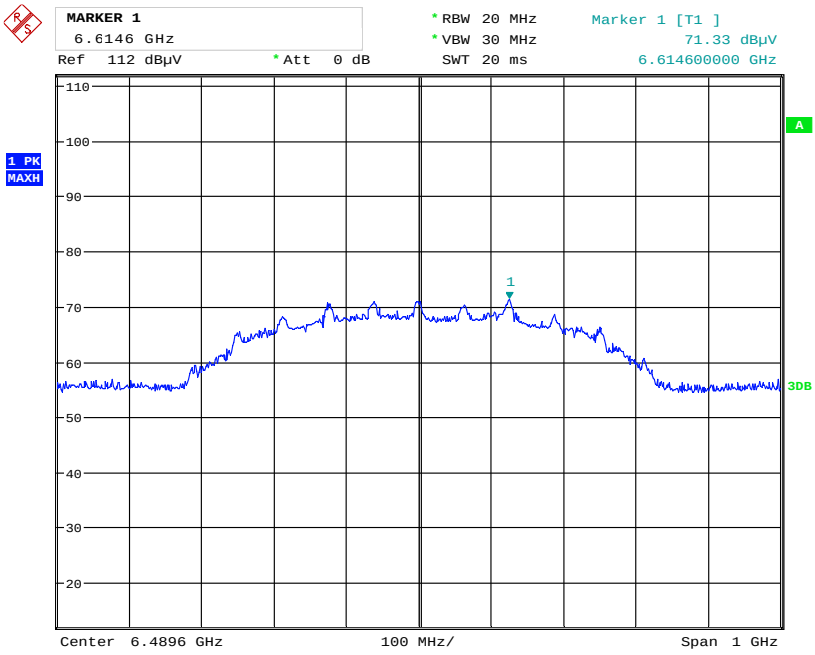
Date: 1.APR.2021 14:55:07

Mode 9



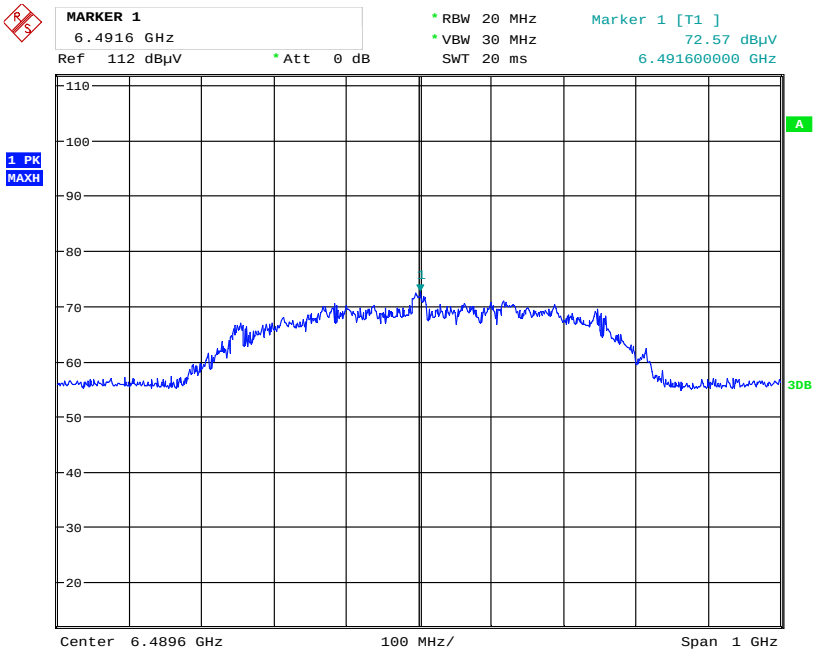
Date: 1.APR.2021 15:04:40

Mode 10



Date: 1.APR.2021 15:09:53

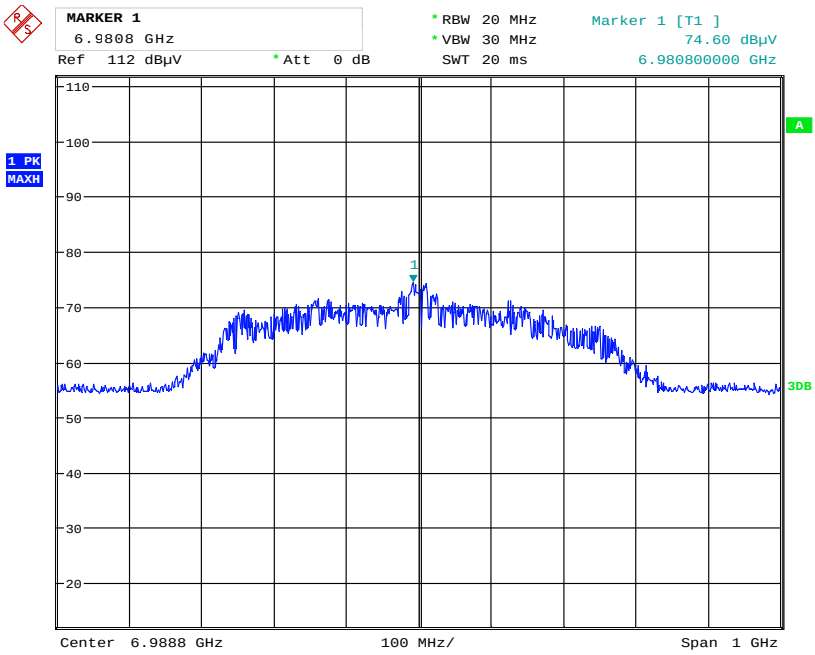
Mode 14



Date: 5.APR.2021 10:51:46

Channel 6 (6988.8MHz), Fundamental Peak Measurements

Mode 0



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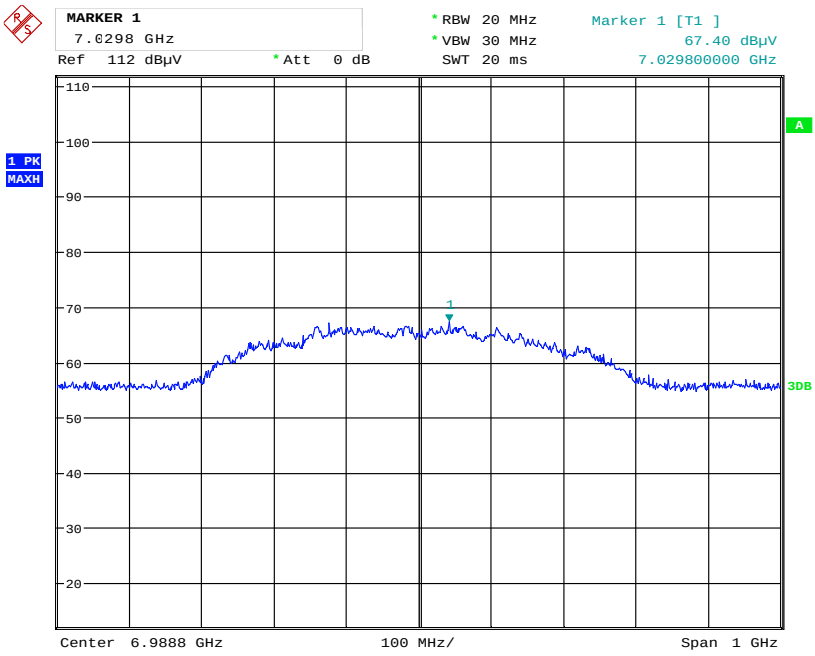
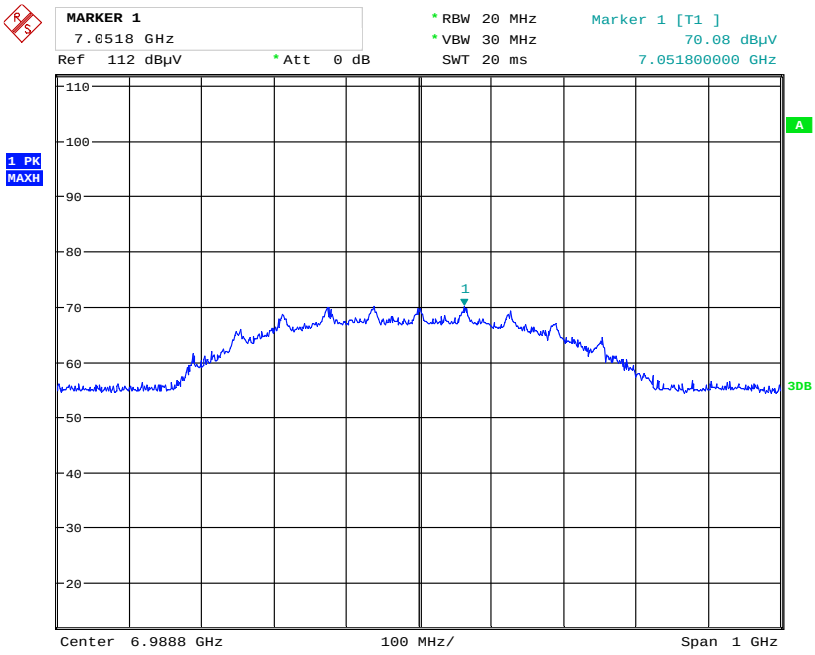
Mode 4



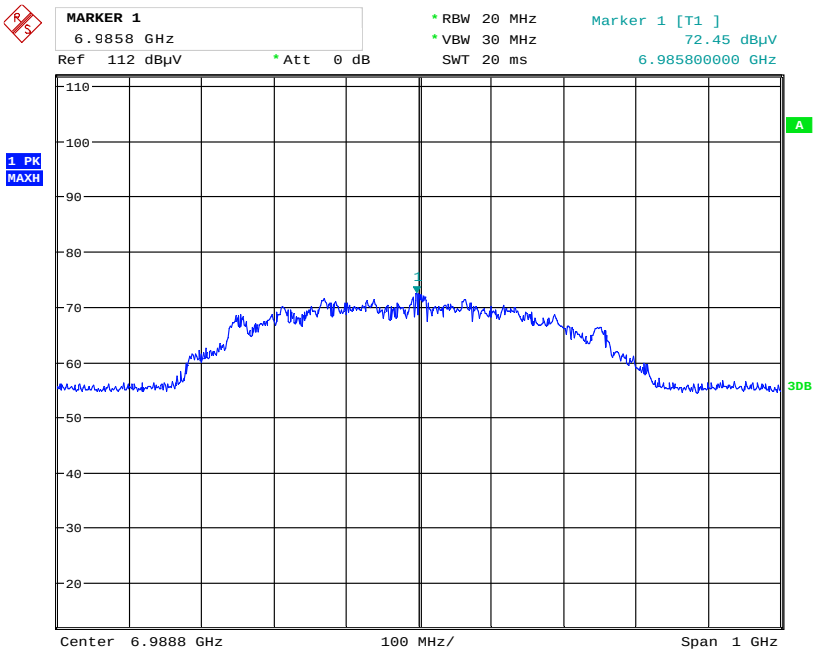
Date: 5.APR.2021 11:10:08

Mode 5



Date: 1.APR.2021 15:38:52

Mode 9



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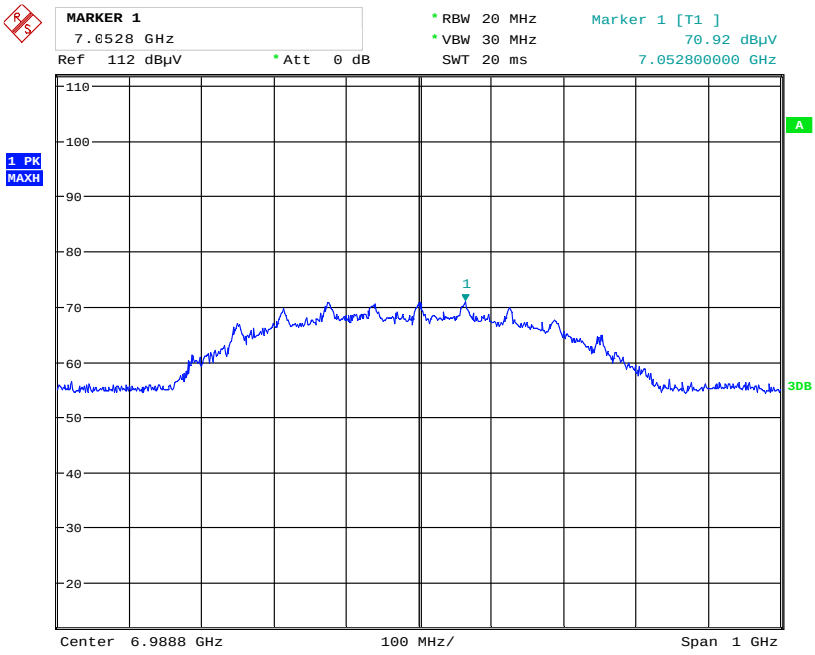
Mode 10



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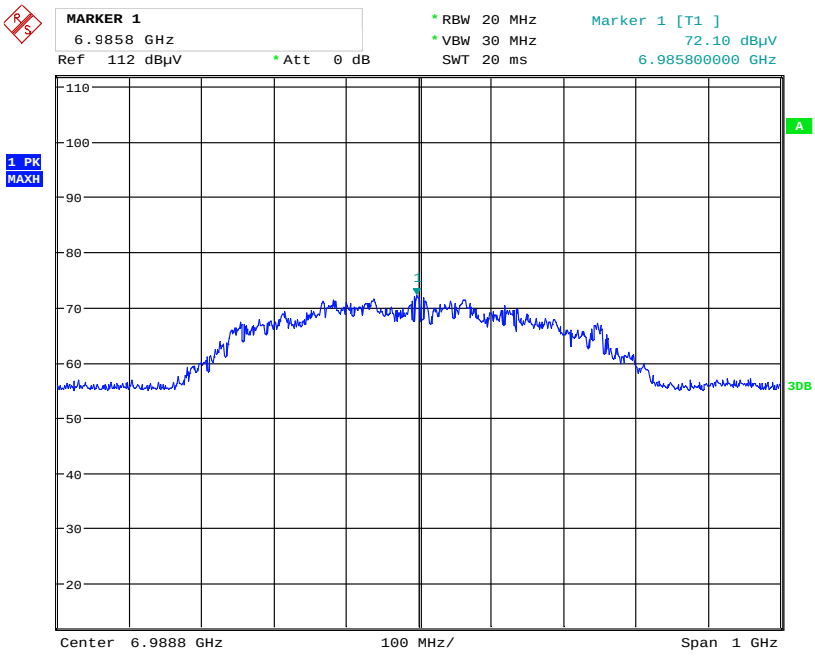
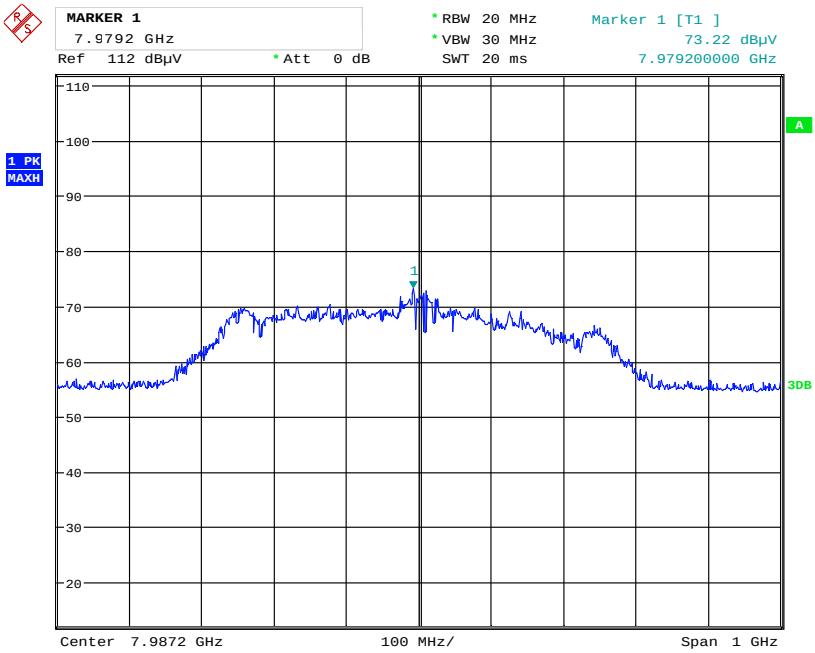
Mode 14



Date: 5.APR.2021 11:24:47

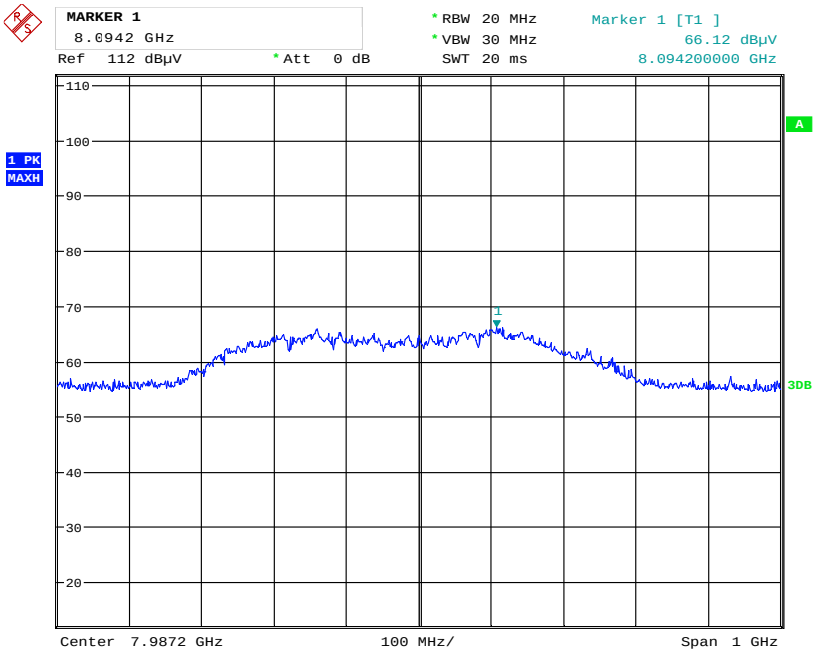
Channel 9 (7987.2 MHz), Fundamental Peak Measurements

Mode 0



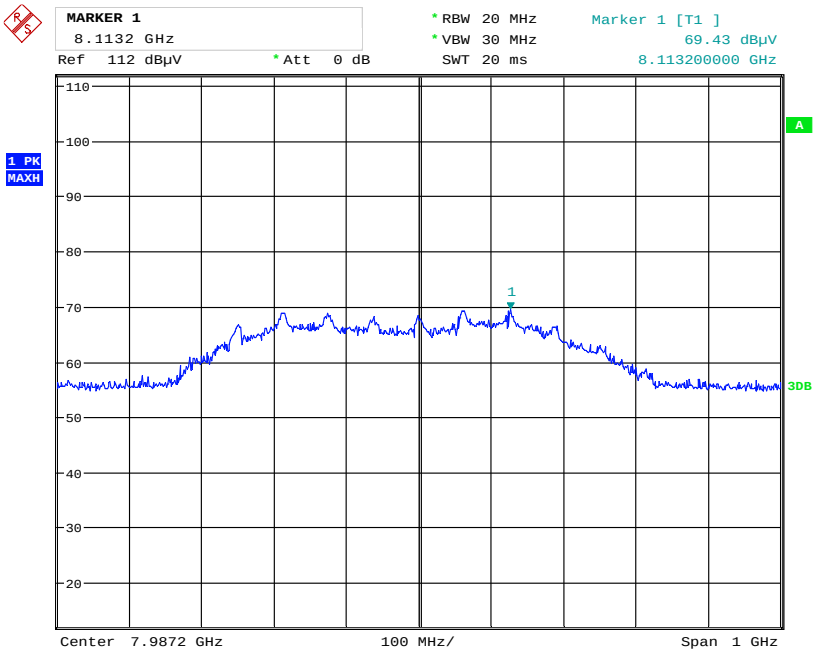
Date: 1.APR.2021 16:11:57

Mode 4



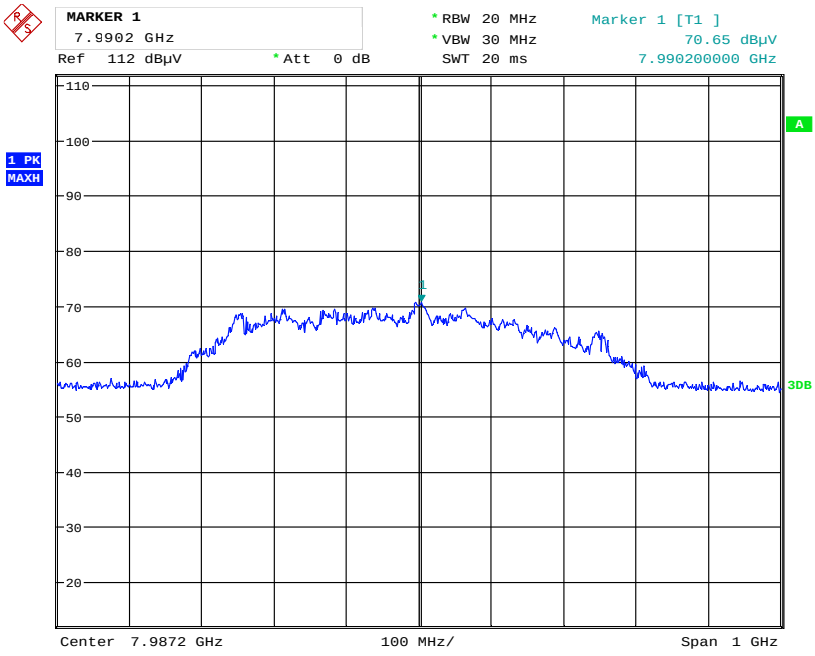
Date: 5.APR.2021 11:48:55

Mode 5



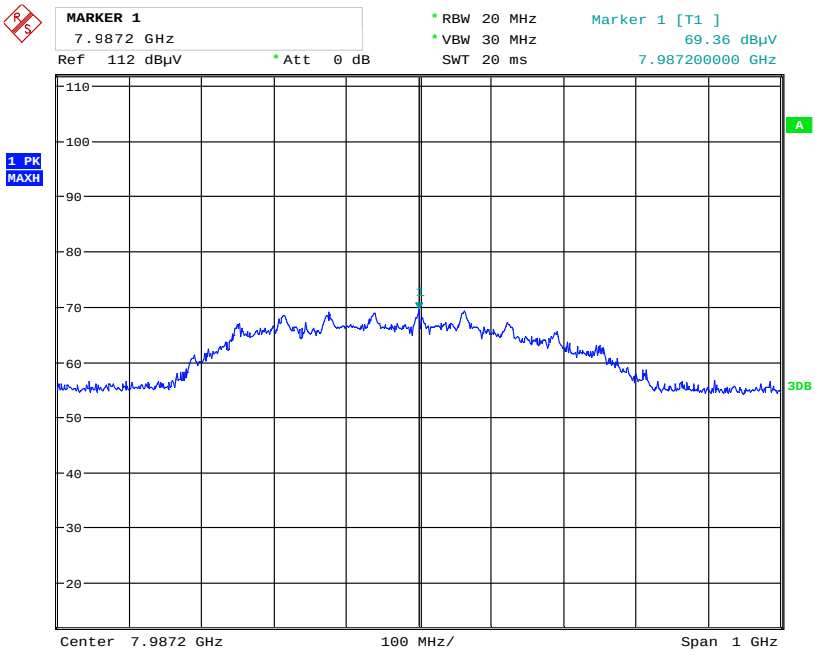
Date: 5.APR.2021 11:56:03

Mode 9



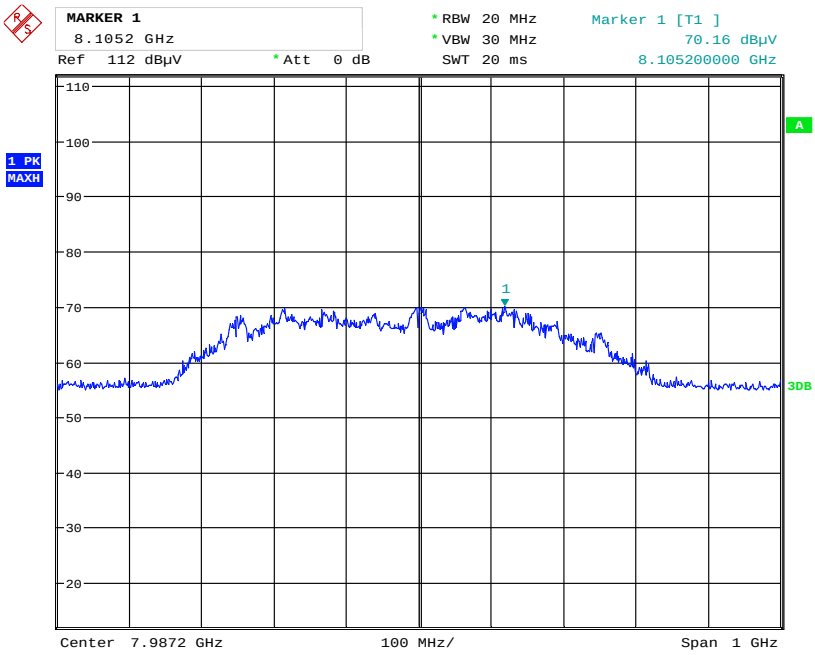
Date: 1.APR.2021 16:28:44

Mode 10



Date: 1.APR.2021 16:33:01

Mode 14



Date: 5.APR.2021 12:08:42

8 FCC §15.503(d), §15.519(b) & ISEDC RSS-220 §5.1(a), RSS-Gen §6.7 -Emission Bandwidth

8.1 Applicable Standards

According to ECFR §15.503(a), For the purpose of this subpart, the UWB bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated emission, as based on the complete transmission system including the antenna.

According to ECFR §15.519(b) and ISEDC RSS-220 §5.1(a), the UWB bandwidth of a device operating under the provisions of this section must be contained between 3100 MHz and 10,600 MHz.

According to ECFR §15.503(b) and ISEDC RSS-220 §5.1(a), An intentional radiator that, at any point in time, has a fractional bandwidth equal to or greater than 0.20 or has a UWB bandwidth equal to or greater than 500 MHz, regardless of the fractional bandwidth.

According to ISEDC RSS-Gen§6.7, The occupied bandwidth or the "99% emission bandwidth" is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

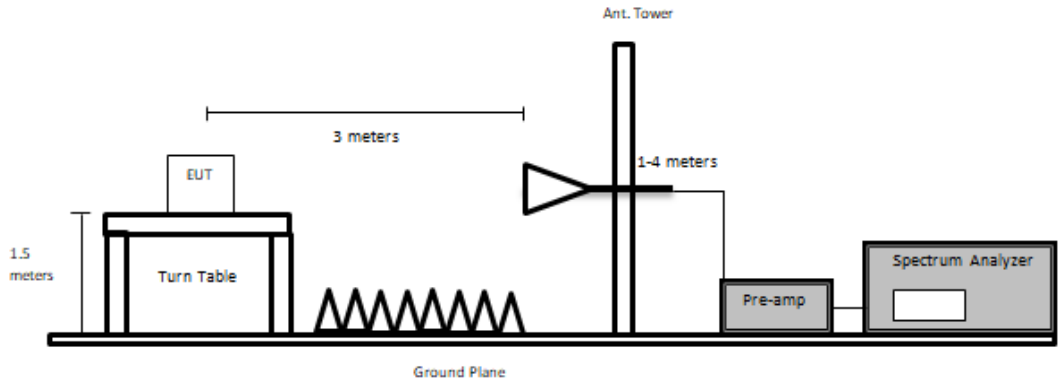
8.2 Measurement Procedure

The UWB bandwidth measurements were based on ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices section 10.1: Evaluation of -10dB bandwidth.

8.3 Test Setup Block Diagram

Above 1GHz:

At 3 meters:



8.4 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer	E4440A	US45303156	2020-04-24	18 months
Sunol Sciences Corp	System Controller	SC110V	122303-1	N/R	N/A
ETS Lindgren	Horn Antenna	3117	00218973	2019-02-13	2.5 years
Agilent	Preamplifier	8449B	3147A00400	2021-03-02	1 year
-	RF cable	-	-	Each time[1]	N/A
IW Incorporated	157 Series 2.92 SM (x2) Armored 33 ft. Cable	KPS-1571AN-3960-KPS	DC 1917	2021-03-03	1 year

Note[1]: cables included in the test set-up will be checked each time before testing.

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 the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

8.5 Test Environmental Conditions

Temperature:	23º C
Relative Humidity:	42 %
ATM Pressure:	102.7 KPa

The testing was performed by Allen Huang on 2021-04-05 at 5 meter chamber 3.

8.6 Test Results

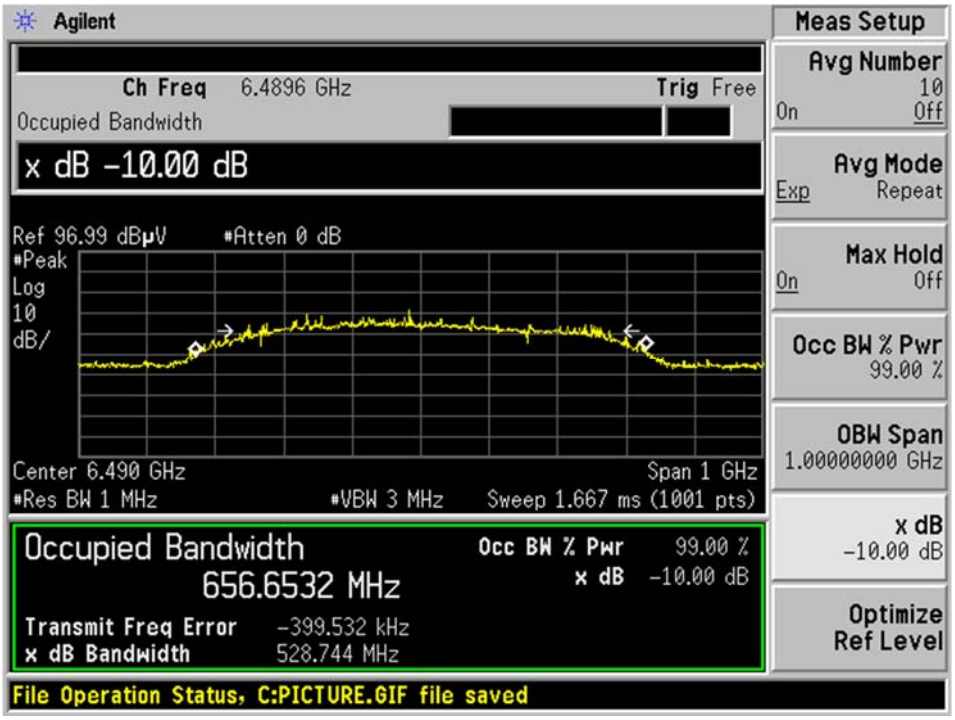
10 dB Bandwidth

Channel	Frequency (MHz)	Mode	10 dB BW (MHz)	10 dB BW limit (MHz)	10 dB BW within 3100MHz-10600MHz
5	6489.6	0	528.744	>500	Pass
		4	553.282	>500	Pass
		5	558.630	>500	Pass
		9	596.331	>500	Pass
		10	535.000	>500	Pass
		14	533.721	>500	Pass
6	6988.8	0	534.944	>500	Pass
		4	530.497	>500	Pass
		5	563.944	>500	Pass
		9	530.919	>500	Pass
		10	546.125	>500	Pass
		14	506.237	>500	Pass
9	7987.2	0	538.811	>500	Pass
		4	598.099	>500	Pass
		5	606.506	>500	Pass
		9	571.952	>500	Pass
		10	574.331	>500	Pass
		14	581.970	>500	Pass

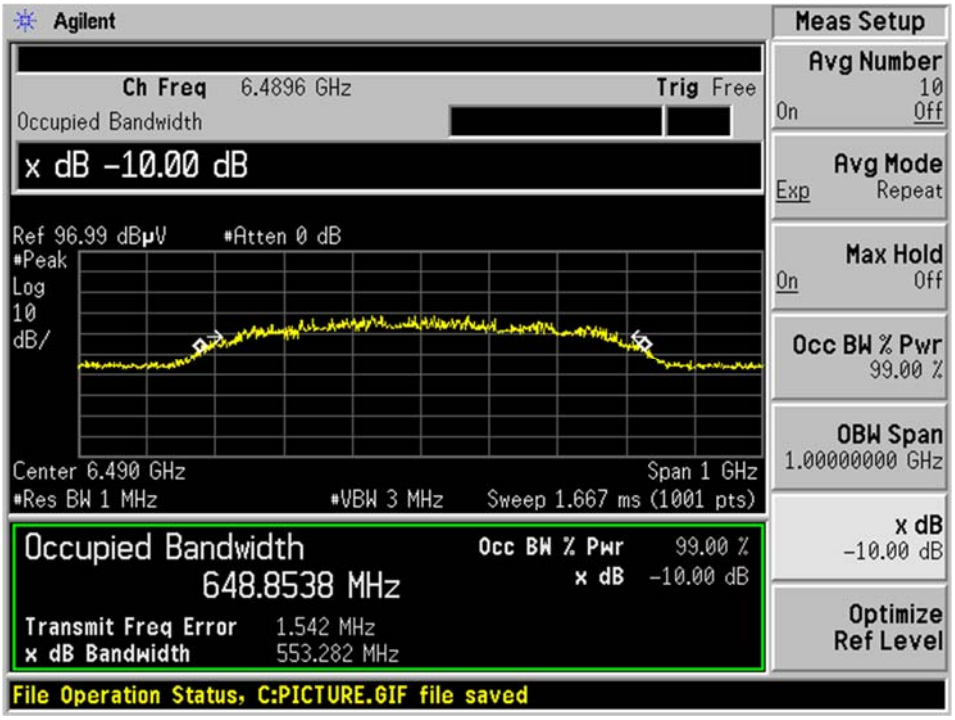
Please refer to the following plots.

Channel 5 (6489.6 MHz), 10dB Bandwidth

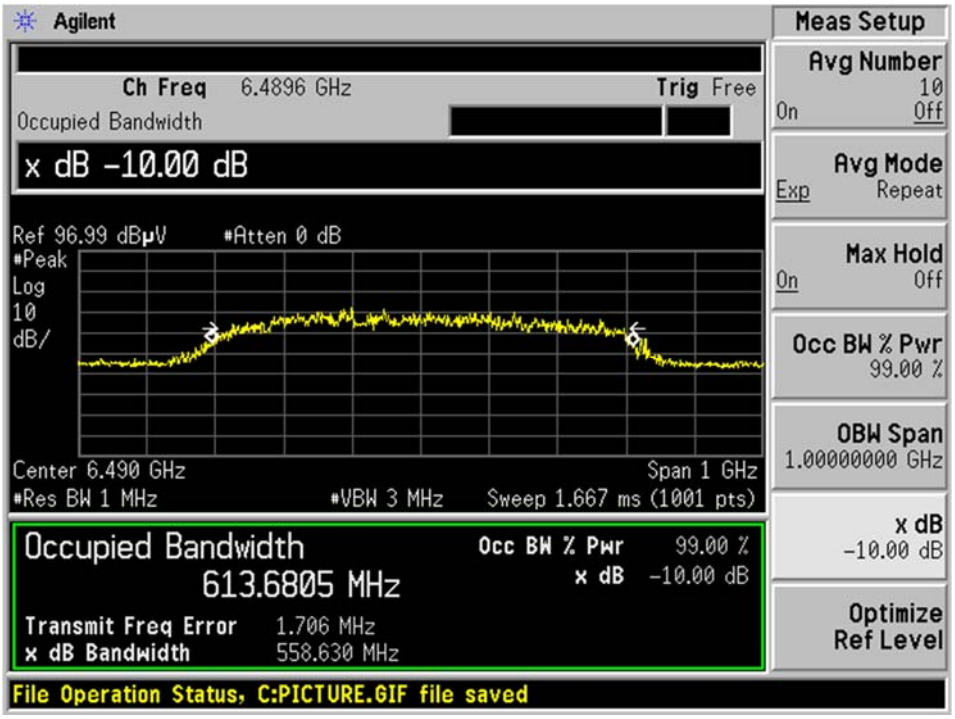
Mode 0



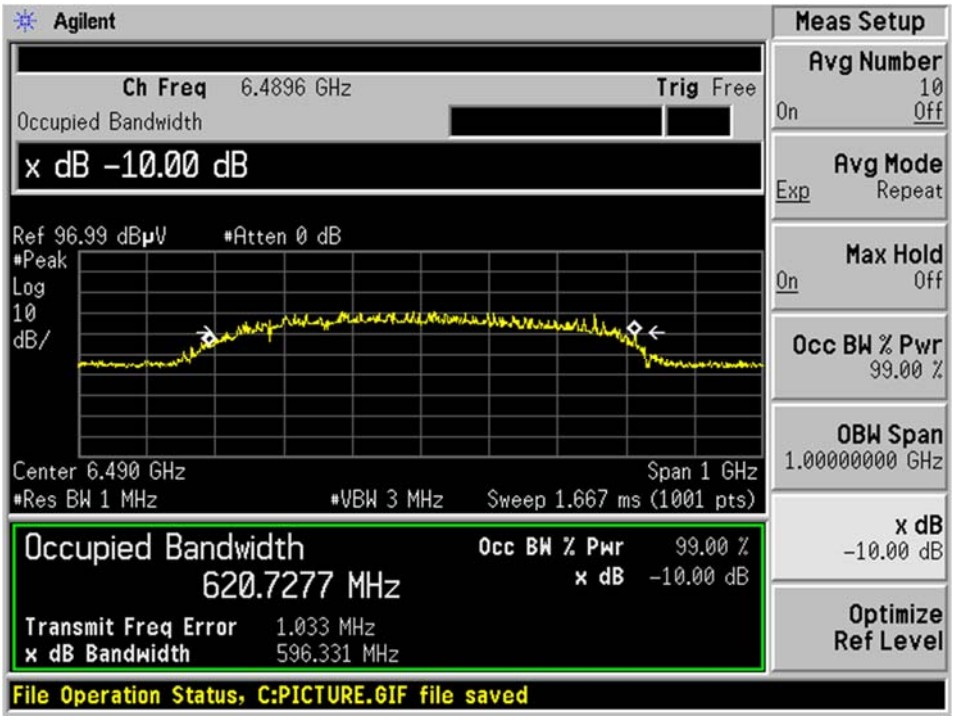
Mode 4



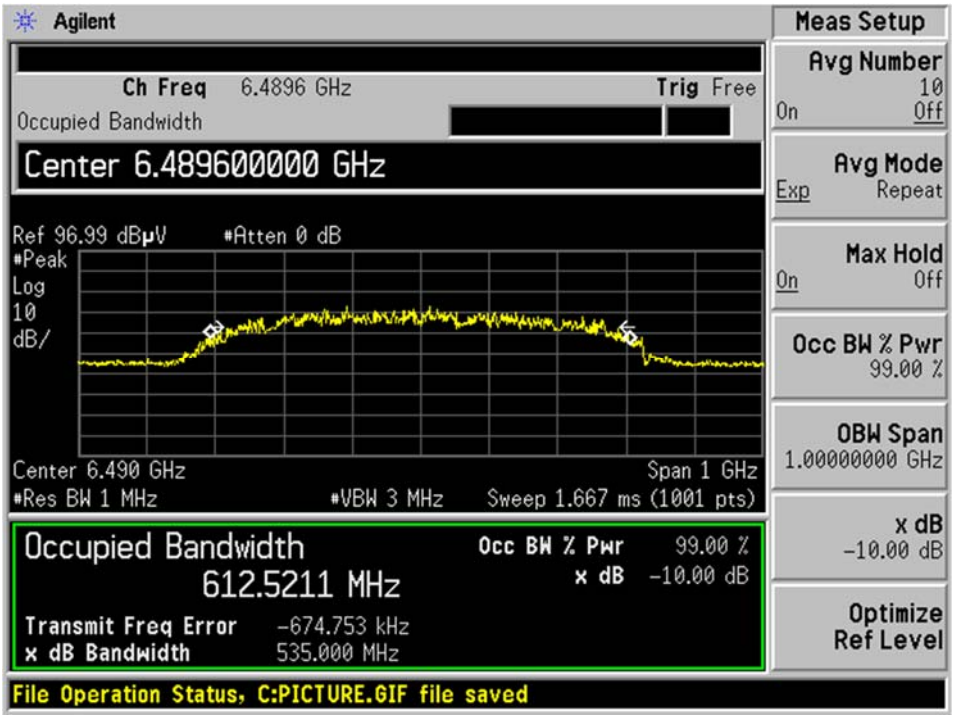
Mode 5


Agilent
Meas Setup
Ch Freq 6.4896 GHz
Trig Free
Occupied Bandwidth
x dB -10.00 dB
Ref 96.99 dBµV
#Atten 0 dB
#Peak
Log
10
dB/
Center 6.490 GHz
Span 1 GHz
#Res BW 1 MHz
#VBW 3 MHz
Sweep 1.667 ms (1001 pts)
Occupied Bandwidth
613.6805 MHz
Occ BW % Pwr 99.00 %
x dB -10.00 dB
Transmit Freq Error 1.706 MHz
x dB Bandwidth 558.630 MHz
Avg Number 10
On Off
Avg Mode Exp Repeat
Max Hold On Off
Occ BW % Pwr 99.00 %
OBW Span 1.00000000 GHz
x dB -10.00 dB
Optimize Ref Level
File Operation Status, C:PICTURE.GIF file saved

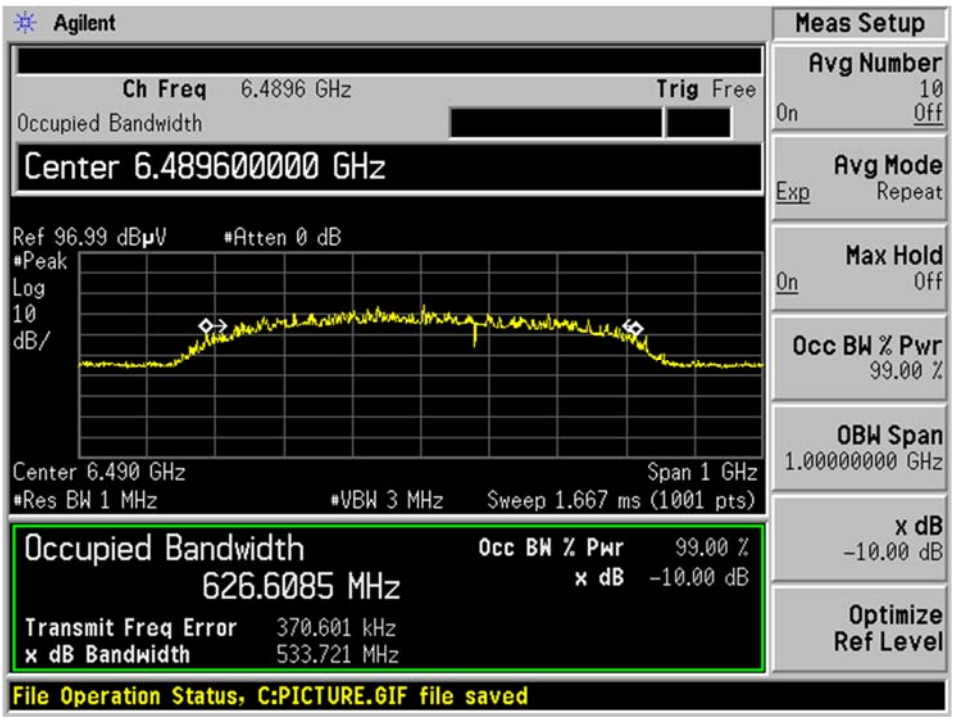
Mode 9


Agilent
Meas Setup
Ch Freq 6.4896 GHz
Trig Free
Occupied Bandwidth
x dB -10.00 dB
Ref 96.99 dBµV
#Atten 0 dB
#Peak
Log
10
dB/
Center 6.490 GHz
Span 1 GHz
#Res BW 1 MHz
#VBW 3 MHz
Sweep 1.667 ms (1001 pts)
Occupied Bandwidth
620.7277 MHz
Occ BW % Pwr 99.00 %
x dB -10.00 dB
Transmit Freq Error 1.033 MHz
x dB Bandwidth 596.331 MHz
Avg Number 10
On Off
Avg Mode Exp Repeat
Max Hold On Off
Occ BW % Pwr 99.00 %
OBW Span 1.00000000 GHz
x dB -10.00 dB
Optimize Ref Level
File Operation Status, C:PICTURE.GIF file saved

Mode 10

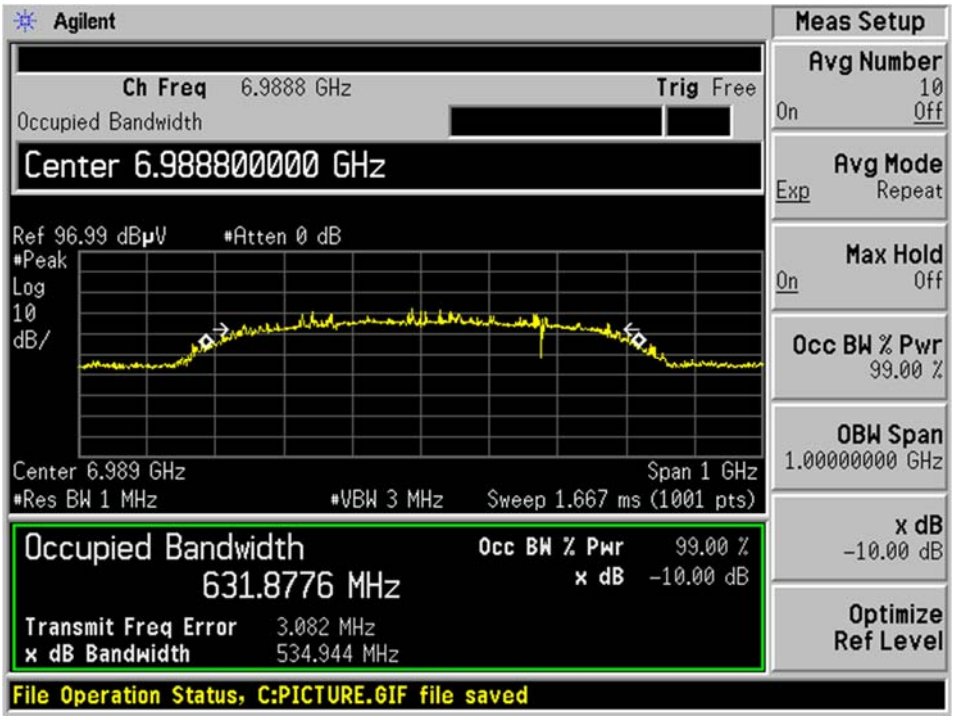


Mode 14

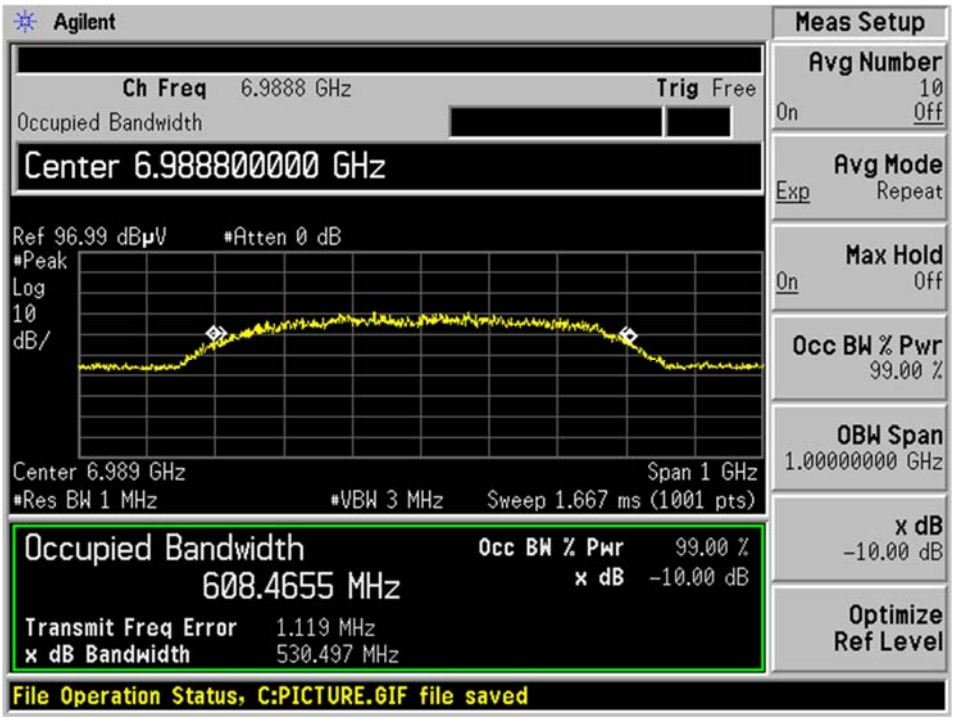


Channel 6 (6988.8 MHz), 10dB Bandwidth

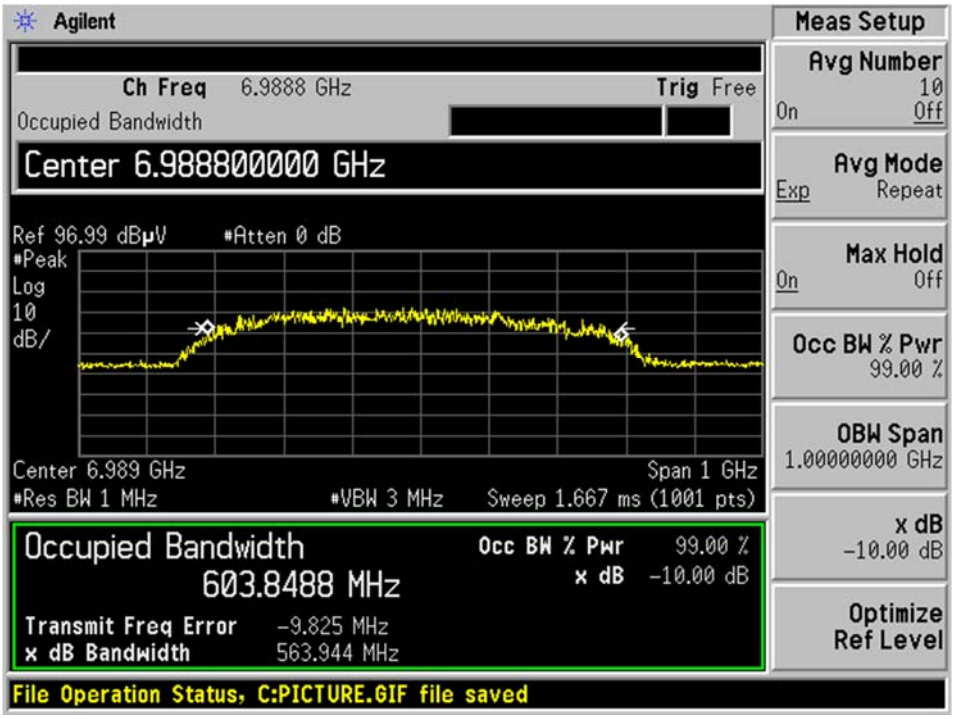
Mode 0



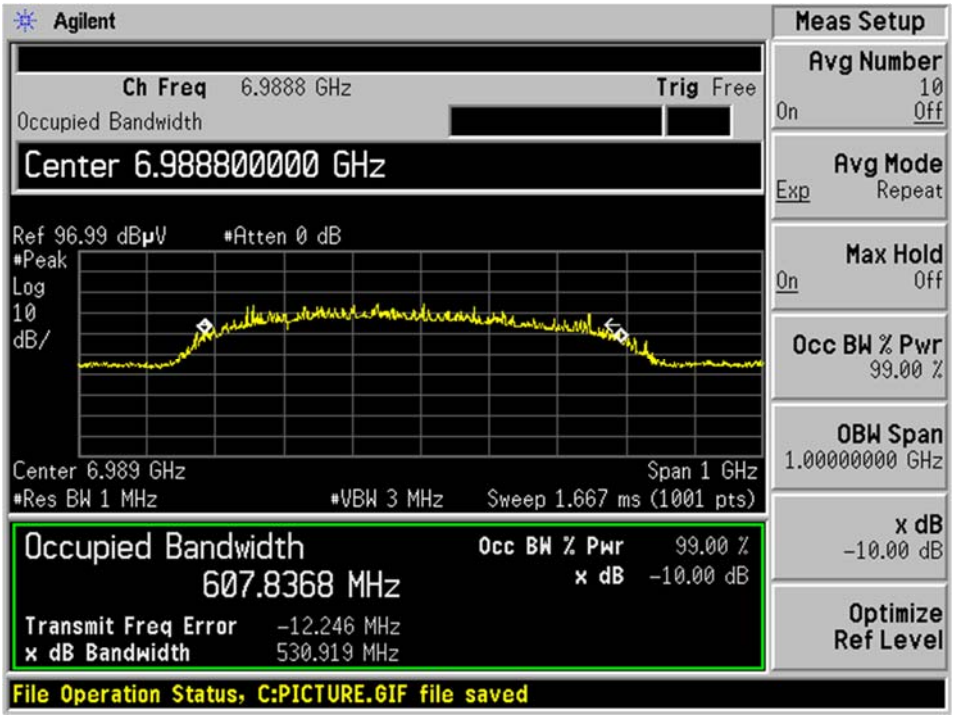
Mode 4



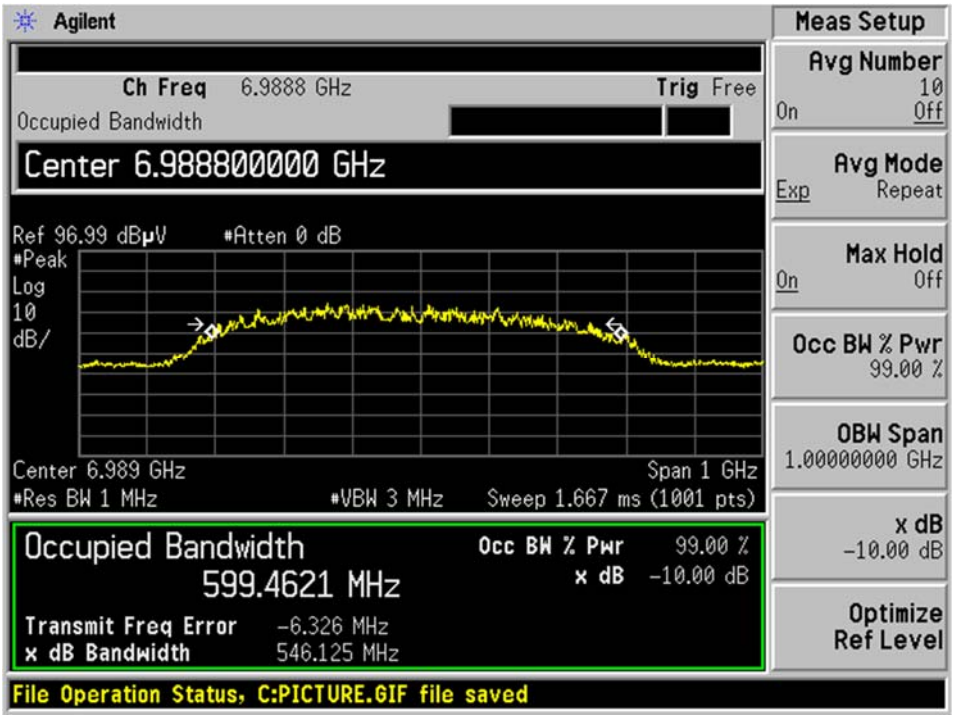
Mode 5


Agilent
Meas Setup
Ch Freq 6.9888 GHz
Trig Free
Occupied Bandwidth
Center 6.988800000 GHz
Avg Number
10
On Off
Avg Mode
Exp Repeat
Max Hold
On Off
Occ BW % Pwr
99.00 %
OBW Span
1.00000000 GHz
x dB
-10.00 dB
Optimize
Ref Level
Ref 96.99 dBµV
#Atten 0 dB
#Peak
Log
10
dB/
Center 6.989 GHz
Span 1 GHz
#Res BW 1 MHz
#VBW 3 MHz
Sweep 1.667 ms (1001 pts)
Occupied Bandwidth
603.8488 MHz
Occ BW % Pwr 99.00 %
x dB -10.00 dB
Transmit Freq Error -9.825 MHz
x dB Bandwidth 563.944 MHz
File Operation Status, C:PICTURE.GIF file saved

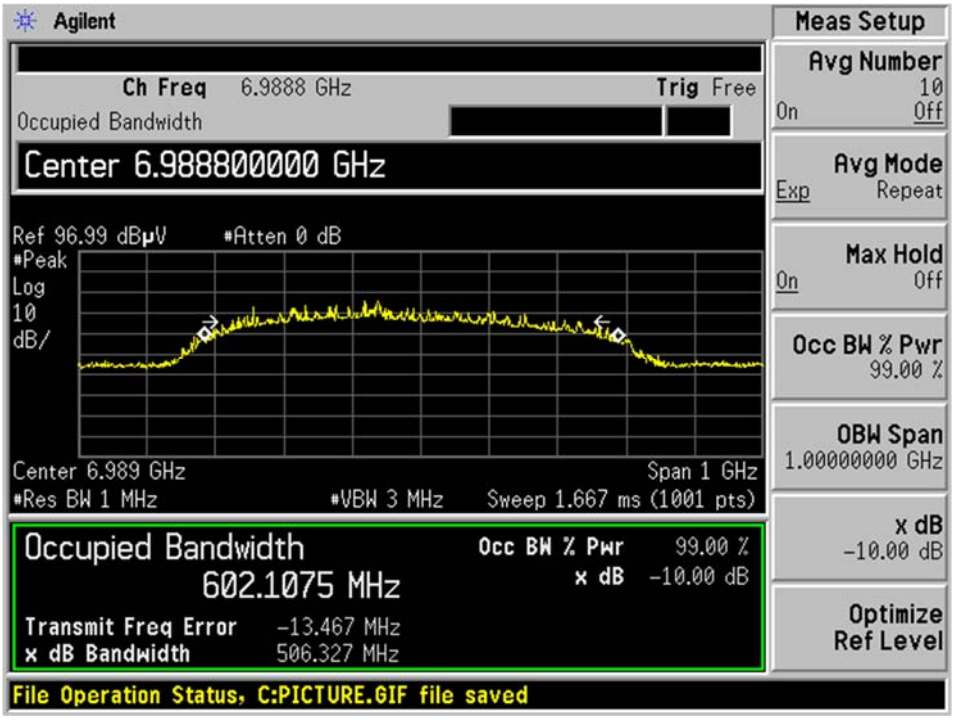
Mode 9


Agilent
Meas Setup
Ch Freq 6.9888 GHz
Trig Free
Occupied Bandwidth
Center 6.988800000 GHz
Avg Number
10
On Off
Avg Mode
Exp Repeat
Max Hold
On Off
Occ BW % Pwr
99.00 %
OBW Span
1.00000000 GHz
x dB
-10.00 dB
Optimize
Ref Level
Ref 96.99 dBµV
#Atten 0 dB
#Peak
Log
10
dB/
Center 6.989 GHz
Span 1 GHz
#Res BW 1 MHz
#VBW 3 MHz
Sweep 1.667 ms (1001 pts)
Occupied Bandwidth
607.8368 MHz
Occ BW % Pwr 99.00 %
x dB -10.00 dB
Transmit Freq Error -12.246 MHz
x dB Bandwidth 530.919 MHz
File Operation Status, C:PICTURE.GIF file saved

Mode 10

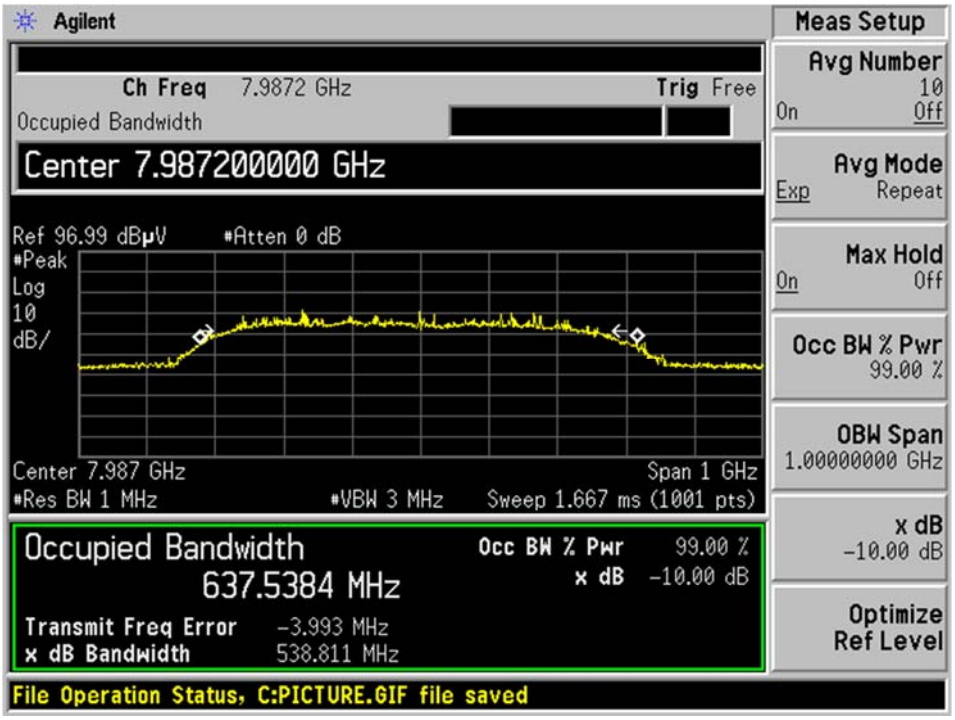


Mode 14

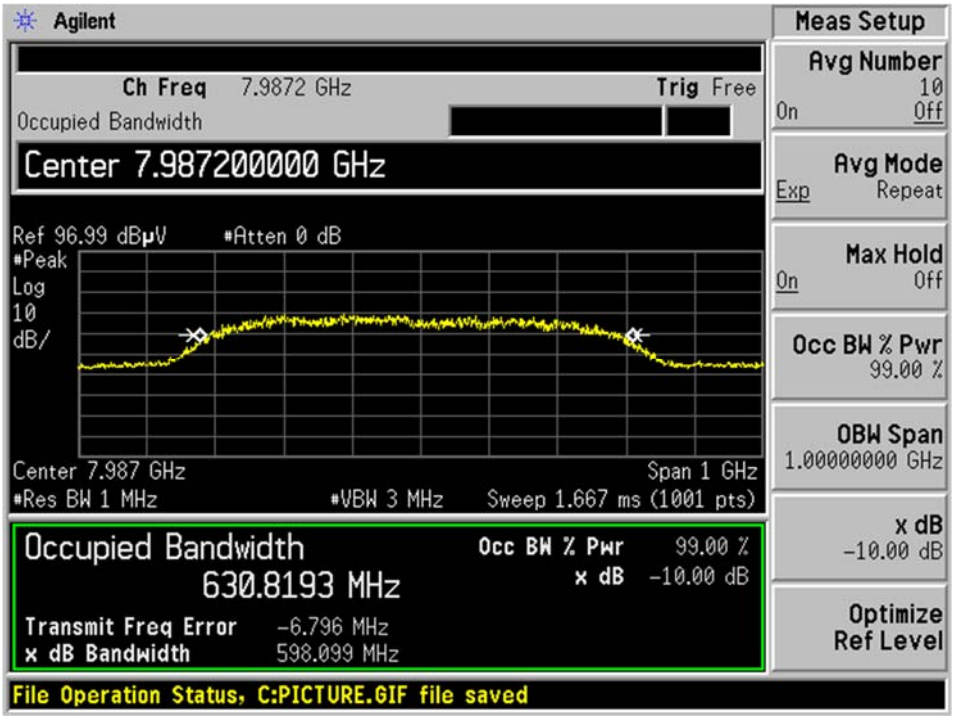


Channel 9 (7987.2 MHz), 10dB Bandwidth

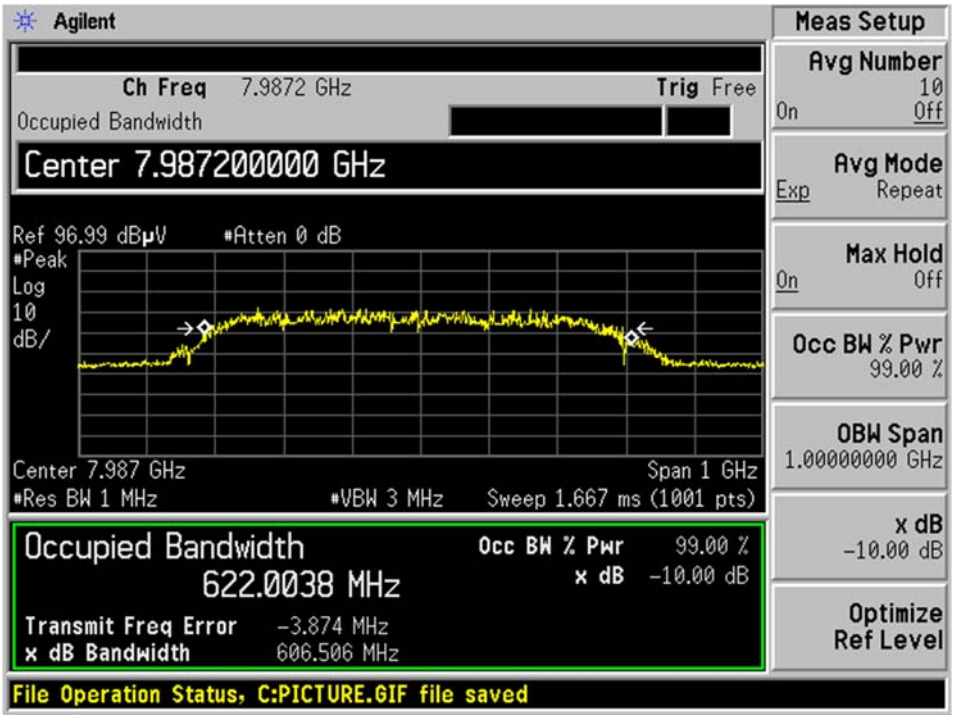
Mode 0



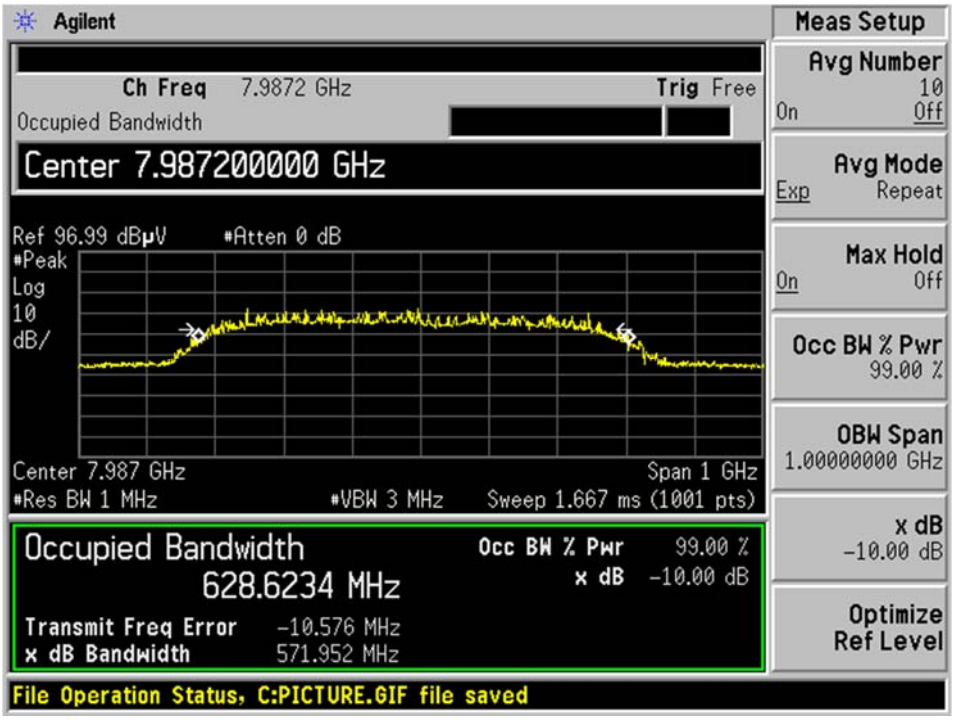
Mode 4



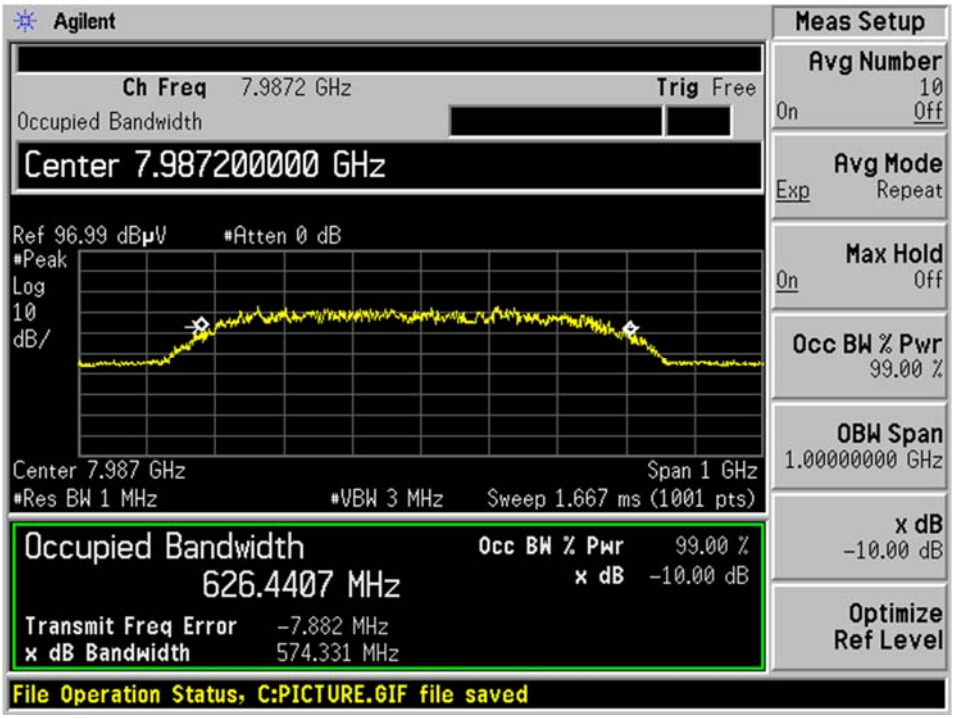
Mode 5


Agilent
Meas Setup
Ch Freq 7.9872 GHz
Trig Free
Occupied Bandwidth
Center 7.987200000 GHz
Avg Number
10
On Off
Avg Mode
Exp Repeat
Max Hold
On Off
Occ BW % Pwr
99.00 %
OBW Span
1.00000000 GHz
x dB
-10.00 dB
Optimize
Ref Level
Ref 96.99 dBµV
#Atten 0 dB
#Peak
Log
10
dB/
Center 7.987 GHz
Span 1 GHz
#Res BW 1 MHz
#VBW 3 MHz
Sweep 1.667 ms (1001 pts)
Occupied Bandwidth
622.0038 MHz
Occ BW % Pwr 99.00 %
x dB -10.00 dB
Transmit Freq Error -3.874 MHz
x dB Bandwidth 606.506 MHz
File Operation Status, C:PICTURE.GIF file saved

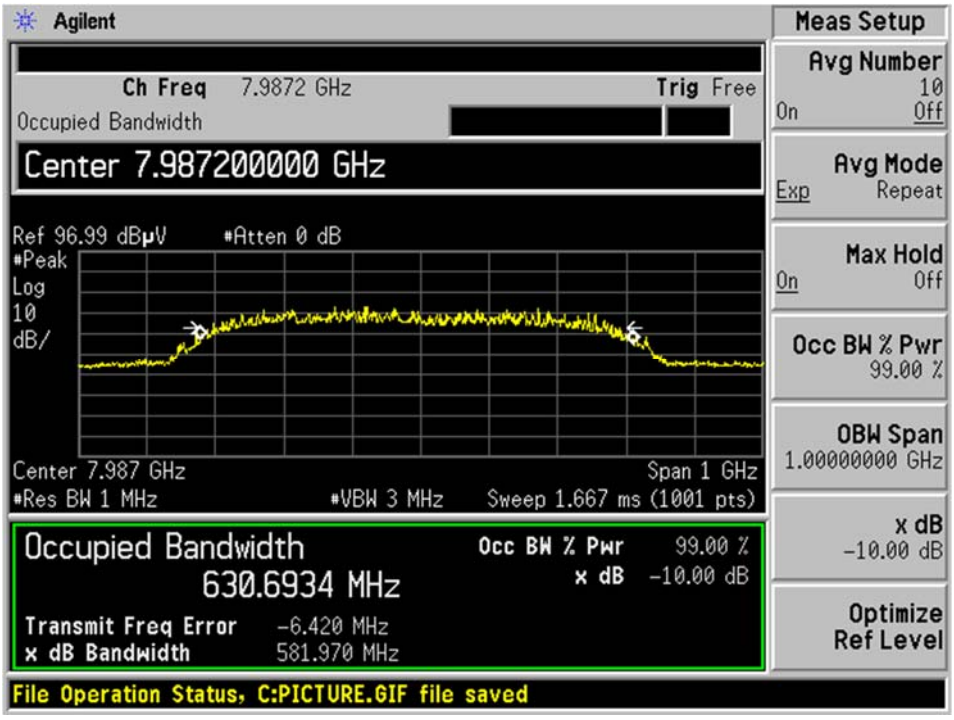
Mode 9


Agilent
Meas Setup
Ch Freq 7.9872 GHz
Trig Free
Occupied Bandwidth
Center 7.987200000 GHz
Avg Number
10
On Off
Avg Mode
Exp Repeat
Max Hold
On Off
Occ BW % Pwr
99.00 %
OBW Span
1.00000000 GHz
x dB
-10.00 dB
Optimize
Ref Level
Ref 96.99 dBµV
#Atten 0 dB
#Peak
Log
10
dB/
Center 7.987 GHz
Span 1 GHz
#Res BW 1 MHz
#VBW 3 MHz
Sweep 1.667 ms (1001 pts)
Occupied Bandwidth
628.6234 MHz
Occ BW % Pwr 99.00 %
x dB -10.00 dB
Transmit Freq Error -10.576 MHz
x dB Bandwidth 571.952 MHz
File Operation Status, C:PICTURE.GIF file saved

Mode 10



Mode 14



9 FCC §15.519(a) (1) & ISEDC RSS-220 §5.3.1(b) - Cease Transmission

9.1 Applicable Standards

According to FCC §15.519(a)(1) and RSS-220 §5.3.1(b): A UWB device operating under the provisions of this section shall transmit only when it is sending information to an associated receiver. The UWB intentional radiator shall cease transmission within 10 seconds unless it receives an acknowledgement from the associated receiver that its transmission is being received. An acknowledgment of reception must continue to be received by the UWB intentional radiator at least every 10 seconds or the UWB device must cease transmitting.

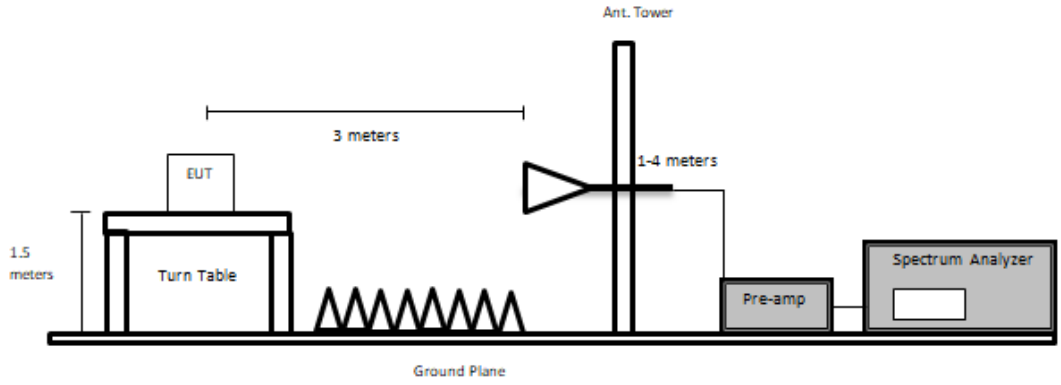
9.2 Measurement Procedure

A support UWB radio device was paired with the EUT for this testing. Transmission was monitored over a 20 second period. Both EUT and support equipment were switched on and paired for UWB ranging from the transmission off state. The support equipment was then powered off, and the transmission time from EUT was monitored and recorded. The first marker marks the time the support equipment was switched off, and the second marker marks the time the EUT stopped transmission.

9.3 Test Setup Block Diagram

Above 1GHz:

At 3 meters:



9.4 Test Equipment List and Details

Manufacturer	Description	Model No.	Serial No.	Calibration Date	Calibration Interval
Agilent	Spectrum Analyzer	E4440A	US45303156	2020-04-24	18 months
-	RF cable	-	-	Each time[1]	N/A
ETS Lindgren	Horn Antenna	3117	00218973	2019-02-13	2.5 years

Note[1]: cables included in the test set-up will be checked each time before testing.
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 the latest version of A2LA policy P102 "A2LA Policy on Metrological Traceability".*

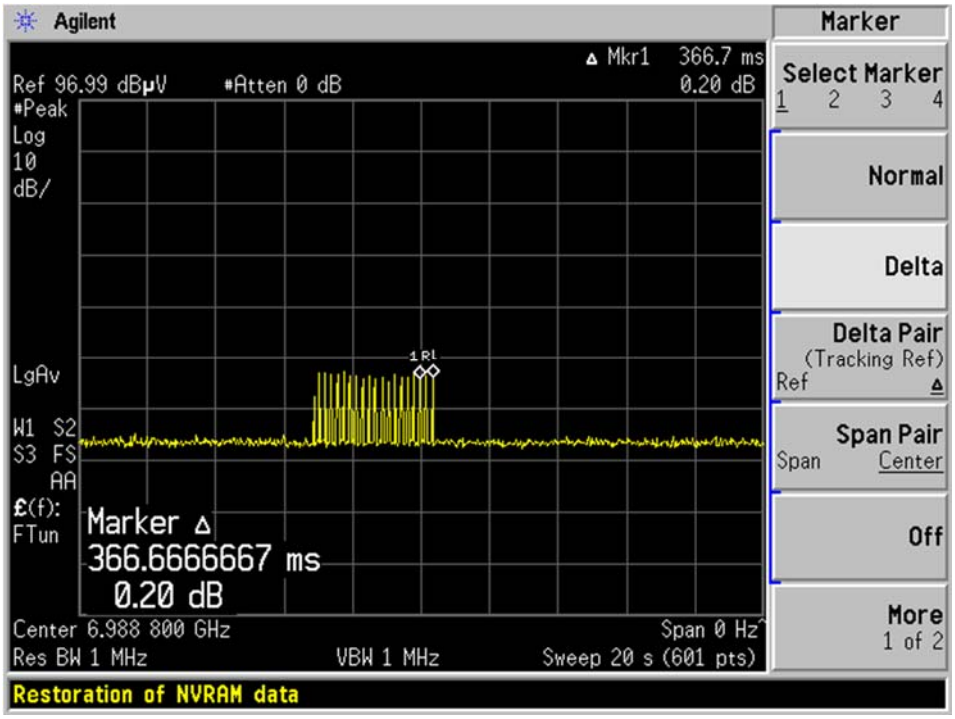
9.5 Test Environmental Conditions

Temperature:	23º C
Relative Humidity:	42 %
ATM Pressure:	102.7 KPa

The testing was performed by Allen Huang on 2021-04-16 at 5 meter chamber 3.

9.6 Test Results

Transmission Time (Seconds)	Limit (Seconds)
0.367	< 10



Note: The cease of transmission function operates the same way on all channels of this device. Therefore, only channel 6 was selected for testing.

10 Annex A (Normative) - Test 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 17025:2017 *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 10th day of March 2021.

Trace McInturff, Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 3297.02
Valid to September 30, 2022

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

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