NVLAP Lab Code 200087-0

ROGERS LABS, INC.
4405 West 259th Terrace
Louisburg, KS 66053
Phone / Fax (913) 837-3214

47CFR, Part 15E, Paragraph 15.407
Unlicensed National Information Infrastructure (U-NII) and
Industry Canada RSS-247 Issue 2
License-Exempt Local Area Network (LE-LAN) Devices
(U-NII) Point-to-Point Operation Device

Application For Grant of Certification

PMN: CFL Sprint MXM Repeater Mk2S
FCC ID: W9Z-58F2DMXMR2S
IC: 8855A-58F2DMXMR2S
5739-5836 MHz

SAF Tehnika AS

24a, Ganibu dambis
Riga Latvia LV-1005

FCC Site Registration: US5305
IC Test Site Registration: 3041A-1

Test Report Number: 200911

Test Date: September 11,2020

Authorized Signatory: Scot D Rogers
Scot D. Rogers

Table of Contents

Revisions

Revision 1 Issued January 15, 2021

Executive Summary

The following information is submitted for consideration in obtaining Grants of Certification for License Exempt, Unlicensed National Information Infrastructure (U-NII) Intentional Radiator operating under 47CFR Paragraph 15E (15.407), U-NII-3, 5745-5825 MHz band and Innovation, Science and Economic Development (ISED) RSS-247 Issue 2, LE-LAN point-to-point transmitter and RSS-GEN Issue 5.

Name of Applicant: SAF Tehnika AS FRN: 0018662312
24a, Ganibu dambis
Riga Latvia LV-1005

PMN: CFL Sprint MXM Repeater Mk2S

HVIN: V06S2118LU000S; V06S2118HU000S; V06S1218LU000S; V06S1218HU000S; V06M2118LU000S; V06M2118HU000S; V06M1218LU000S; V06M1218HU000S

FCC ID: W9Z-58F2DMXMR2S **IC**: 8855A-58F2DMXMR2S

Frequency Range: 5739-5836 MHz (U-NII-3 under new rules 15.407), power is manufacturer or installer adjustable from 10-30 dBm

Maximum Power: U-NII-3 Band, 28 MHz mode, 1.00-Watt
U-NII-3 Band, 30 MHz mode, 1.00-Watt

Channel Width Mode	Output Power (Watts)	99% OBW (kHz)	6-dB OBW (kHz)
U-NII, 28 MHz	1.00-0.010	26,731	25,962
U-NII, 30 MHz	1.00-0.010	26,683	25,881

Opinion / Interpretation of Results

Test Number	Measurement	FCC Rule	Pass/Fail
#1	Maximum Conducted Output Power	15.407(a)(3)	Pass
#2	Maximum power spectral density	15.407(a)(3)	Pass
#3	Undesirable emission limits	15.407(b)(4)	Pass
#4	Minimum 6 dB bandwidth	15.407(e)	Pass
#5	Frequency stability	15.407(g)	Pass
#6	Antenna Requirement	15.203	Pass
#7	Radiated emission in restricted Bands	15.205, 15.407(b)(7)	Pass
#8	AC Line Conducted Emissions	15.207, 15.407(b)(6)	Pass
#9	General Radiated Emission	15.209, 15.407(b)(6)	Pass

Tests Performed	Margin (dB)	Results
Restricted Frequency Bands 15.205, RSS-GEN 8.10	-1.4	Complies
AC Line Conducted 15.207, RSS-GEN 7.2.4	-2.9	Complies
Radiated Emissions 15.209, RSS-GEN 7.2.5	-2.0	Complies
Harmonic Emissions per 15.407, RSS-247	-11.9	Complies
Power Spectral Density per 15.407, RS-247	-4.5	Complies

Tests performed include
47CFR
§15.407 General technical requirements.
(a) *Power limits:*

(3) For the band 5.725-5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. In addition, the maximum power spectral density shall not exceed 30 dBm in any 500-kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. However, fixed point-to-point U-NII devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

NOTE TO PARAGRAPH (a)(3): The Commission strongly recommends that parties employing U-NII devices to provide critical communications services should determine if there are any nearby Government radar systems that could affect their operation.

(4) The maximum conducted output power must be measured over any interval of continuous transmission using instrumentation calibrated in terms of an rms-equivalent voltage.

(5) The maximum power spectral density is measured as a conducted emission by direct connection of a calibrated test instrument to the equipment under test. If the device cannot be connected directly, alternative techniques acceptable to the Commission may be used. Measurements in the 5.725-5.85 GHz band are made over a reference bandwidth of 500 kHz or the 26 dB emission bandwidth of the device, whichever is less. Measurements in the 5.15-5.25 GHz, 5.25-5.35 GHz, and the 5.47-5.725 GHz bands are made over a bandwidth of 1 MHz or the 26 dB emission bandwidth of the device, whichever is less. A narrower resolution bandwidth can be used, provided that the measured power is integrated over the full reference bandwidth.

(b) *Undesirable emission limits.* Except as shown in paragraph (b)(7) of this section, the maximum emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:

(4) For transmitters operating in the 5.725-5.85 GHz band:

(i) All emissions shall be limited to a level of −27 dBm/MHz at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.

(ii) Devices certified before March 2, 2017 with antenna gain greater than 10 dBi may demonstrate compliance with the emission limits in §15.247(d), but manufacturing, marketing, and importing of devices certified under this alternative must cease by March 2, 2018. Devices certified before March 2, 2018 with antenna gain of 10 dBi or less may demonstrate compliance with the emission limits in §15.247(d), but manufacturing, marketing, and importing of devices certified under this alternative must cease before March 2, 2020.

(5) The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz.

(6) Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in §15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in §15.207.

(7) The provisions of §15.205 apply to intentional radiators operating under this section.

(8) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the upper and lower frequency band edges as the design of the equipment permits.

(c) The device shall automatically discontinue transmission in case of either absence of information to transmit or operational failure. These provisions are not intended to preclude the transmission of control or signaling information, or the use of repetitive codes used by certain digital technologies to

complete frame or burst intervals. Applicants shall include in their application for equipment authorization a description of how this requirement is met.
(d) [Reserved]
(e) Within the 5.725-5.85 GHz band, the minimum 6 dB bandwidth of U-NII devices shall be at least 500 kHz.
(f) U-NII devices are subject to the radio frequency radiation exposure requirements specified in §1.1307(b), §2.1091 and §2.1093 of this chapter, as appropriate. All equipment shall be considered to operate in a "general population/uncontrolled" environment. Applications for equipment authorization of devices operating under this section must contain a statement confirming compliance with these requirements for both fundamental emissions and unwanted emissions. Technical information showing the basis for this statement must be submitted to the Commission upon request.
(g) Manufacturers of U-NII devices are responsible for ensuring frequency stability such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the user's manual.
(i) *Device Security.* All U-NII devices must contain security features to protect against modification of software by unauthorized parties.
(1) Manufacturers must implement security features in any digitally modulated devices capable of operating in any of the U-NII bands, so that third parties are not able to reprogram the device to operate outside the parameters for which the device was certified. The software must prevent the user from operating the transmitter with operating frequencies, output power, modulation types or other radio frequency parameters outside those that were approved for the device. Manufacturers may use means including, but not limited to the use of a private network that allows only authenticated users to download software, electronic signatures in software or coding in hardware that is decoded by software to verify that new software can be legally loaded into a device to meet these requirements and must describe the methods in their application for equipment authorization.
(2) Manufacturers must take steps to ensure that DFS functionality cannot be disabled by the operator of the U-NII device.
(j) *Operator Filing Requirement:* Before deploying an aggregate total of more than one thousand outdoor access points within the 5.15-5.25 GHz band, parties must submit a letter to the Commission acknowledging that, should harmful interference to licensed services in this band occur, they will be required to take corrective action. Corrective actions may include reducing power, turning off devices, changing frequency bands, and/or further reducing power radiated in the vertical direction. This material shall be submitted to Laboratory Division, Office of Engineering and Technology, Federal Communications Commission, 7435 Oakland Mills Road, Columbia, MD 21046. Attn: U-NII Coordination, or via Web site at *https://www.fcc.gov/labhelp* with the SUBJECT LINE: "U-NII-1 Filing".

RSS-247 Issue 2

6. Technical requirements for licence-exempt local area network devices and digital transmission systems operating in the 5 GHz band

This section provides standards for License-Exempt Local Area Network (LE-LAN) devices operating in the bands 5150-5250 MHz, 5250-5350 MHz, 5470-5600 MHz, 5650-5725 MHz and 5725-5850 MHz and for DTSs operating in the band 5725-5850 MHz that employ digital modulation technology, but are not designed for LE-LAN operation.
Devices with occupied bandwidths which overlap different bands shall comply with all operational requirements for each band.

6.1 Types of modulation

Equipment shall employ digital modulation.

6.2 Power and unwanted emissions limits

The output power and e.i.r.p. of the equipment wanted emission shall be measured in terms of average value.
The power and e.i.r.p. of the equipment unwanted emission shall be measured in peak value.
However, the equipment is required to comply with the provisions in RSS-Gen with respect to emissions falling within restricted frequency bands which are listed in the same standard.
If the transmission is in bursts, the provisions of RSS-Gen for pulsed operation shall apply.
The outermost carrier frequencies or channels shall be used when measuring unwanted emissions.
Such carrier or channel centre frequencies are to be indicated in the test report.

6.2.4 Frequency band 5725-5850 MHz

6.2.4.1 Power limits

For equipment operating in the band 5725-5850 MHz, the minimum 6 dB bandwidth shall be at least 500 kHz.
The maximum conducted output power shall not exceed 1 W. The output power spectral density shall not exceed 30 dBm in any 500 kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the output power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. However, fixed point-to-point devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed point-to-point operations exclude the use of point-to-multipoint[3] systems, omnidirectional applications and multiple collocated transmitters transmitting the same information.

6.2.4.2 Unwanted emission limits

Devices operating in the band 5725-5850 MHz with antenna gain greater than 10 dBi can have unwanted emissions that comply with either the limits in this section or in section 5.5 until six (6) months after the publication date of this standard for certification. Certified devices that do not comply with emission limits in this section shall not be manufactured, imported, distributed, leased, offered for sale, or sold after April 1, 2018.
Devices operating in the band 5725-5850 MHz with antenna gain of 10 dBi or less can have unwanted emissions that comply with either the limits in this section or in section 5.5 until April 1, 2018 for certification. Certified devices that do not comply with emission limits in this section shall not be manufactured, imported, distributed, leased, offered for sale, or sold after April 1, 2020.
Devices operating in the band 5725-5850 MHz shall have e.i.r.p. of unwanted emissions comply with the following:
a) 27 dBm/MHz at frequencies from the band edges decreasing linearly to 15.6 dBm/MHz at 5 MHz above or below the band edges;
b) 15.6 dBm/MHz at 5 MHz above or below the band edges decreasing linearly to 10 dBm/MHz at 25 MHz above or below the band edges;
c) 10 dBm/MHz at 25 MHz above or below the band edges decreasing linearly to -27 dBm/MHz at 75 MHz above or below the band edges; and
d) -27 dBm/MHz at frequencies more than 75 MHz above or below the band edges.

Equipment Tested

Equipment	Model / PMN	Serial Number
EUT (Low)	CFL Sprint MXM Repeater Mk2S	331670100442
EUT (High)	CFL Sprint MXM Repeater Mk2S	331680100443
IDU (In Door Unit)	PhoeniX G2 IDU	358390100405
MSU (In Door Unit)	CFL Sprint MSU Mk1	3476601001216
AC Adapter	CFIP-AC-PS	323870132283
AC Adapter	CFIP-AC-PS	323870130616
AC Adapter	CFIP-AC-PS	323870130619
Computer	Dell Latitude E6520	6CB35Q1

Test results in this report relate only to the items tested.

Firmware Version: 3.18.9

Abbreviations:
Monitoring and Switching Unit (MSU)
Indoor Unit (IDU)
Outdoor Unit (ODU)

HVIN

V06S2118LU000S; V06S2118HU000S; V06S1218LU000S; V06S1218HU000S,
V06M2118LU000S; V06M2118HU000S; V06M1218LU000S; V06M1218HU000S

Antenna options

5 GHz antenna

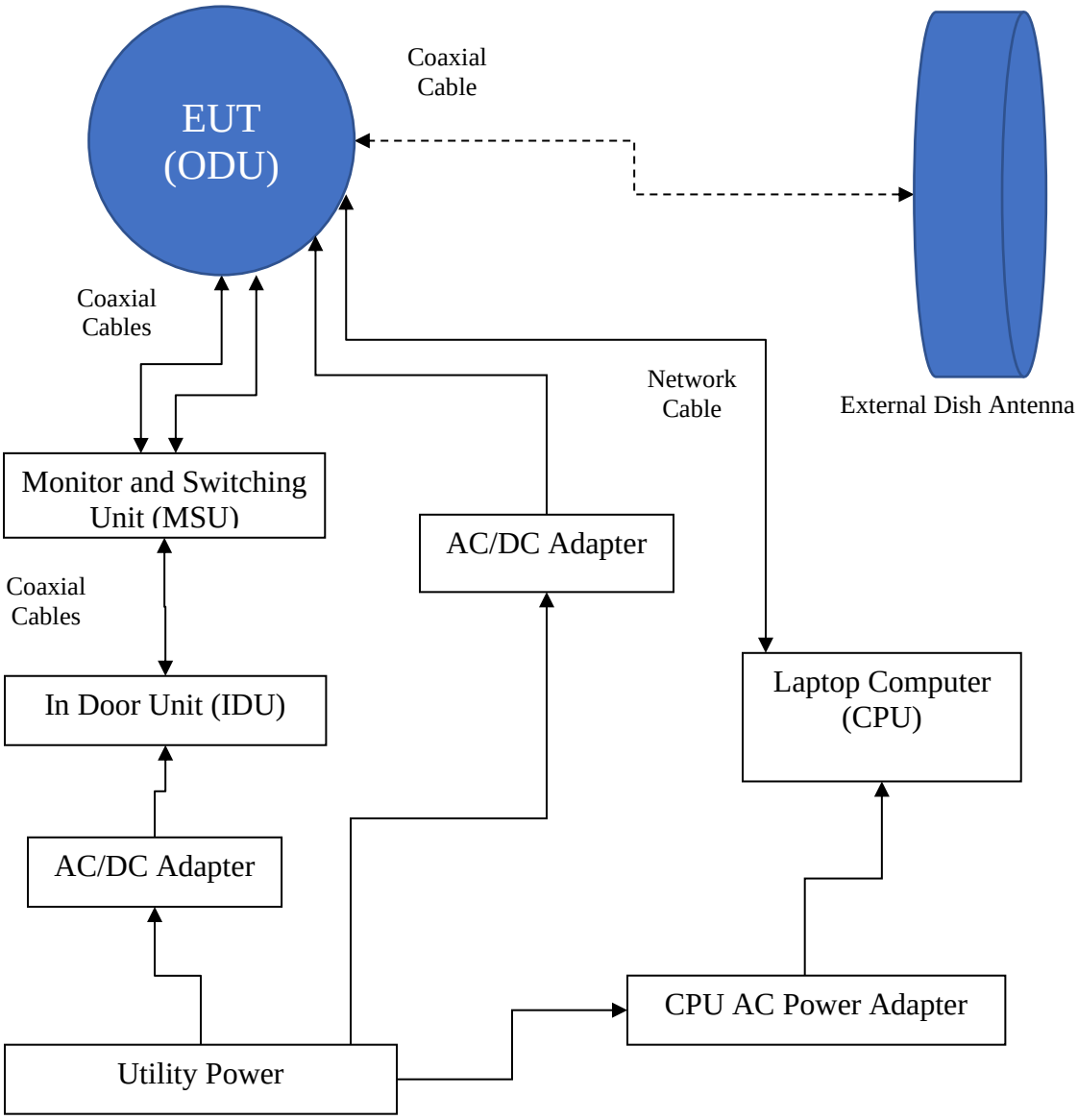
Dish Antenna manufactured by radiowaves model: HPD8-5.2 41.2 dBi gain High Performance Parabolic Reflector Antenna. Note, antennas of same style and lower gain than 41.2 dBi may also be used with the product.

Equipment Function and Configuration

The EUT is a 5 GHz Digital Point-to-Point Transmission System. The design provides operational capabilities in the U-NII-3 band across the frequency band of 5739-5836 MHz. The model CFL Sprint MXM Repeater Mk2S is designed as Outdoor Unit (ODU) providing for long distance Point-to-Point, high data rate, digital communication transmissions. The design provides modulation options including 4QAM, 16QAM, 32QAM, 64QAM, and 128QAM, to maintain quality communications link. The design may auto-select modulation or it may be set during installation to allow for longer distance link. The product offers two options for channel width, either 28 MHz or 30 MHz channel providing high data rates and full duplex operation for point-to-point communications. While the design operates in the U-NII-3 frequency band, it does not communicate with typical U-NII-3 equipment. The EUT requires direct current power supplied from an AC/DC power supply. A typical installation would use a low side transmitter at one location and high side transmitter at the next providing full duplex communications. All up and down conversions are processed in the EUT supplying the MSU and IDU digital data. The MSU provides switching and monitoring of data and supplies the data to the IDU for distribution. Software was provided internal to the EUT which provided the ability to set test channel, operational mode, and modulation scheme. The system provides single wave guide port for use with authorized antennas or wave guide as documented in this report. The EUT provides three n-connection ports for transmit/receive communications to the Monitoring and Switching Unit (MSU) or IDU, network port for installation use which provides installer to monitor the RSSI, DC power port, proprietary four pin connection port for service, and proprietary laser port. The coaxial cable ports provide duplex communications path to the MSU, the network port is provided for setup, the wave guide allows connection to antenna and the power port provides connection to direct current power source. For testing purposes, the EUT transceiver was connected to a laptop computer at the network port, the manufacturer supplied MSU, IDU and AC/DC power supply. A laptop computer provided communications and control to the EUT for testing purposes. This configuration provided operational control of the EUT and communications over the network interface between the EUT, MSU, IDU, and supporting computer system. The EUT provides no other interfacing options than those presented in this

report. For testing purposes, the CFL Sprint MXM Repeater Mk2S test samples were configured to transmit in available data modes receiving power from the AC/DC power adapter. As requested by the manufacturer and required by regulations, the equipment was tested for emissions compliance using the available configurations with the worst-case data presented. Test results in this report relate only to the products described in this report.

Equipment Use Configuration



Applicant Company information

Applicants Company	SAF Tehnika AS
Applicants Address	24a, Ganibu dambis, Riga Latvia LV-1005
FCC ID:	W9Z-58F2DMXMR2S
Industry Canada Identifier	8855A-58F2DMXMR2S
Manufacturer Company	SAF Tehnika AS
Manufacturer Address	24a, Ganibu dambis, Riga Latvia LV-1005

Equipment information

Product Marketing Name (PMN): The PMN is the name or model number under which the product will be marketed/offered for sale in Canada. If the product has PMN, it must be provided.	CFL Sprint MXM Repeater Mk2S Labeled 06-MXM Mk2S
Unique Product Number (UPN): The applicant, made up of a maximum of 11 alphanumeric characters (A-Z, 0-9), assigns the UPN.	58F2DMXMR2S
Hardware Version Identification Number (HVIN): The HVIN identifies hardware specifications of a product version. The HVIN replaces the ISED Model Number in the legacy E-filing System. An HVIN is required for all products for certification applications.	V06S2118LU000S; V06S2118HU000S; V06S1218LU000S; V06S1218HU000S; V06M2118LU000S; V06M2118HU000S; V06M1218LU000S; V06M1218HU000S
Host Marketing Name (HMN) (if applicable): The HMN is the name or model number of a final product, which contains a certified radio module.	
Brand Name	
Test Rule Part(s)	47CFR 15E, 15.407, RSS-247
Test Frequency Range	5.725-5.85 GHz
Project Number	200911
Submission Type	Certification

Application for Certification

(1) Manufacturer: SAF Tehnika AS
24a, Ganibu dambis
Riga Latvia LV-1005

(2) Identification: model (PMN): CFL Sprint MXM Repeater Mk2S

FCC I.D.: W9Z-58F2DMXMR2S IC: 8855A-58F2DMXMR2S

(3) Instruction Book:

Refer to Exhibit for Instruction Manual.

(4) Description of Circuit Functions:

Refer to Exhibit of Operational Description.

(5) Block Diagram with Frequencies:

Refer to Exhibit of Operational Description.

(6) Report of Measurements:

Report of measurements follows in this Report.

(7) Photographs: Construction, Component Placement, etc.:

Refer to Exhibit for photographs of equipment.

(8) List of Peripheral Equipment Necessary for operation. The equipment operates from direct current power received from AC/DC power adapter. The EUT provides three Coaxial cable ports for communications with MSU/IDU, 4-pin connector, network port for installation and monitoring, DC connection port, and single wave guide port for antenna connection. During testing, the EUT was powered from AC/DC power adapter and connected to CPU through the network port.

(9) Transition Provisions of 47CFR 15.37 are not requested

(10) Not Applicable. The unit is not a scanning receiver.

(11) Not Applicable. The EUT does not operate in the 59 – 64 GHz frequency band.

(12) The equipment is not software defined and this section is not applicable.

(13) Applications for certification of U-NII devices in the 5.15-5.35 GHz and the 5.47-5.85 GHz bands must include a high-level operational description of the security procedures that control the radio frequency operating parameters and ensure that unauthorized modifications cannot be made. The required information has been provided in Operational Description Exhibit filed with the application.

(14) Contain at least one drawing or photograph showing the test set-up for each of the required types of tests applicable to the device for which certification is requested. These drawings or photographs must show enough detail to confirm other information contained in the test report. Any photographs used must be focused originals without

glare or dark spots and must clearly show the test configuration used. This information is provided in this report and Test Setup Exhibits provided with the application filing.

Applicable Standards & Test Procedures

The following information is submitted in accordance with e-CFR dated September 10, 2020, Part 2, Subpart J, Part 15, Subpart 15E, Industry Canada RSS-GEN Issue 5, and RSS 247 Issue 2. Test procedures used are the established Methods of Measurement of Radio-Noise Emissions as described in ANSI C63.10-2013, KDB 789033 D02 General UNII Test Procedures New Rules v02r01, KDB 926956 v02, RSS-247 Issue 2, and RSS-GEN Issue 5.

- 47CFR Part 15, Subpart 15E, paragraph 15.407
- KDB 789033 D02 General U-NII Test Procedures New Rules v02r01
- 926956 D01 U-NII Transition Plan v02
- ANSI C63.10-2013

Equipment Testing Procedures

AC Line Conducted Emission Test Procedure

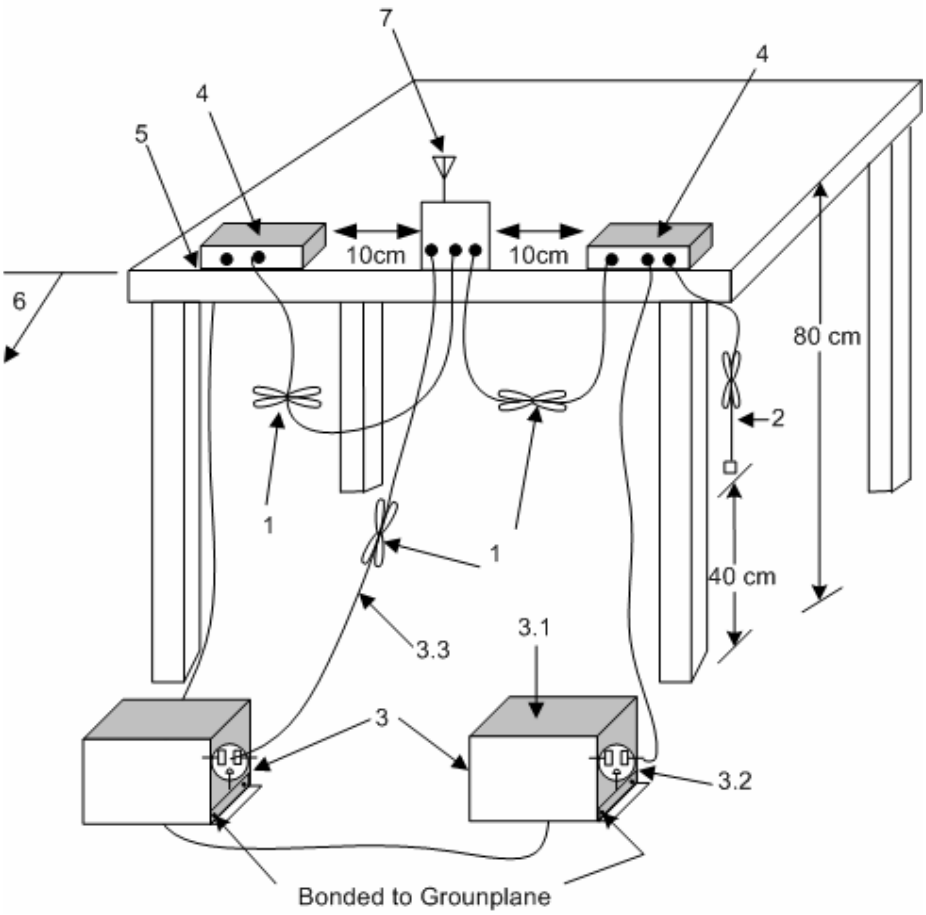
Testing for the AC line-conducted emissions was performed as defined in ANSI C63.10-2013. The test setup, including the EUT, was arranged in the test configurations as presented during testing. The test configuration was placed on a 1 x 1.5-meter wooden bench, 0.8 meters high located in a screen room. The power lines of the system were isolated from the power source using a standard LISN with a 50-µHy choke. EMI was coupled to the spectrum analyzer through a 0.1 µF capacitor internal to the LISN. The LISN was positioned on the floor beneath the wooden bench supporting the EUT. The power lines and cables were draped over the back edge of the table. Refer to diagram one showing typical test arrangement and photographs in exhibits for EUT placement used during testing.

Radiated Emission Test Procedure

Radiated emission testing was performed as required on a CISPR 16-1-4 compliant OATS and as specified in ANSI C63.10-2013 and applicable KDB documents. The EUT was placed on a rotating 0.9 x 1.2-meter platform, elevated as required above the ground plane at a distance of 3 meters from the FSM antenna. The table permitted orientation of the EUT in each of three orthogonal axis positions if necessary. EMI energy was maximized by equipment placement, raising, and lowering the FSM antenna, changing the antenna polarization, and by rotating the turntable. Each emission was maximized before data was taken using a spectrum analyzer. The frequency spectrum from 9 kHz to 60,000 MHz was searched for during preliminary investigation. Refer to diagrams two and three showing typical test arrangement and photographs in the test setup exhibits for specific EUT placement during testing.

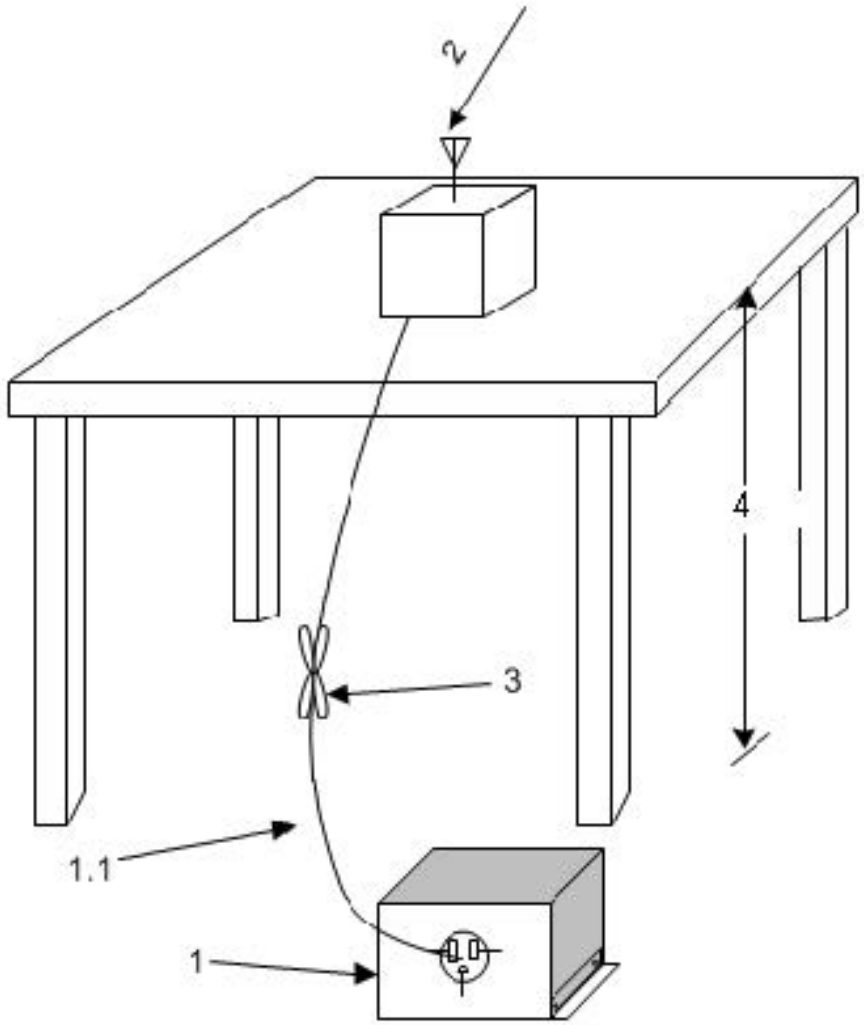
Antenna Port Conducted Emission Test Procedure

The EUT test sample #2 was assembled as required for operation and placed on a benchtop located in a screen room. This configuration provided the ability to connect test equipment to the manufacturer provided antenna ports. Antenna Port conducted emissions testing was performed as required in the regulations and specified in ANSI C63.10-2013. Testing was completed on a laboratory bench in a shielded room. The active antenna port of the unlicensed wireless device was connected to appropriate attenuation and the spectrum analyzer or power meter. Refer to diagram four showing typical test arrangement and photographs in the test setup exhibits for specific EUT placement during testing.



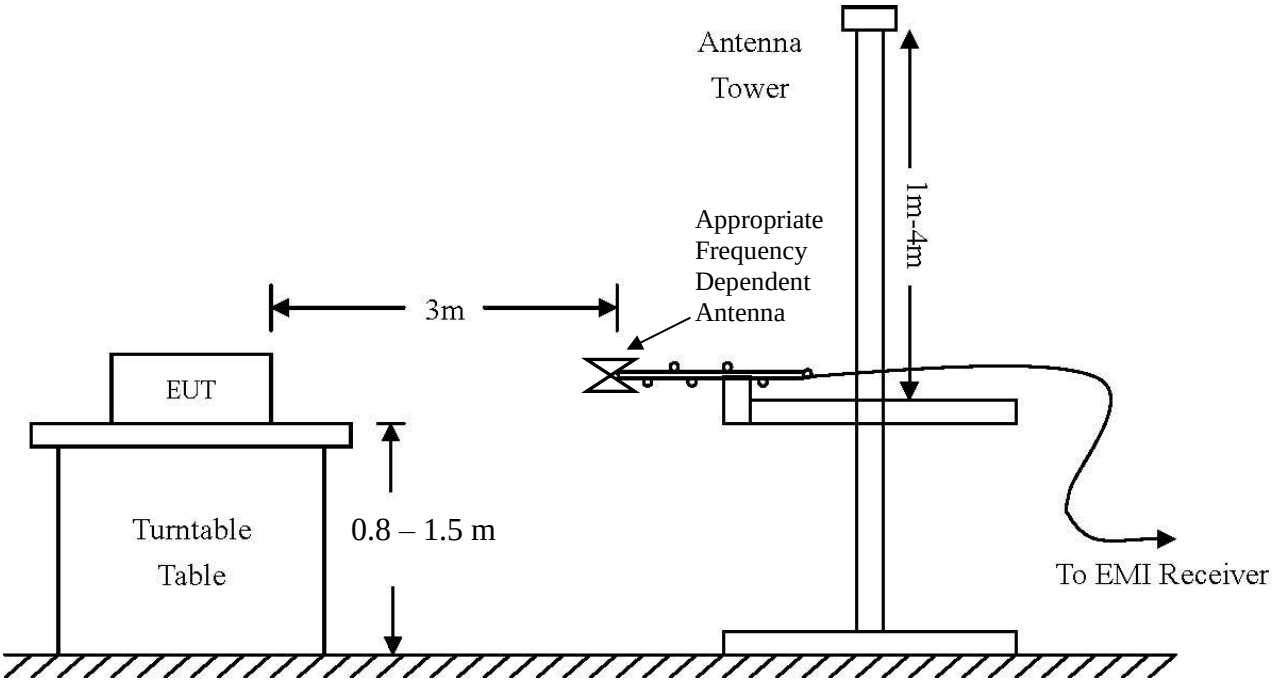
1. Interconnecting cables that hang closer than 40 cm to the ground plane shall be folded back and forth in the center forming a bundle 30 cm to 40 cm long see (see 6.2.3.2).
2. The I/O cables that are not connected to an accessory shall be bundled in the center. The end of the cable may be terminated, if required, using the correct terminating impedance. The overall length shall not exceed 1 m (see 6.2.2).
3. EUT connected to one LISN. Unused LISN measuring port connectors shall be terminated in 50 Ω loads. LISN may be placed on top of, or immediately beneath, reference ground plane (see 6.2.2 and 6.2.3).
   3.1 All other equipment powered from additional LISN(s).
   3.2 Multiple-outlet strip can be used for multiple power cords of non-EUT equipment.
   3.3 LISN at least 80 cm from nearest part of EUT chassis
4. Non-EUT components of EUT system being tested
5. Rear of EUT, including peripherals, shall all be aligned and flush with edge of tabletop (see 6.2.3.2).
6. Edge of tabletop shall be 40 cm removed from a vertical conducting plane that is bonded to the ground plane (see 6.2.2 for options).
7. Antenna may be integral or detachable. If detachable, the antenna shall be attached for this test.

Diagram 1 Test arrangement for Conducted emissions



1. A LISN is optional for radiated measurements between 30 MHz and 1000 MHz but not allowed for measurements below 30 MHz and above 1000 MHz (see 6.3.1). If used, then connect EUT to one LISN. Unused LISN measuring port connectors shall be terminated in 50 Ω loads. The LISN may be placed on top of, or immediately beneath, the reference ground plane (see 6.2.2 and 6.2.3.2).
   1.1 LISN spaced at least 80 cm from nearest part of EUT chassis.
2. Antenna can be integral or detachable, depending on the EUT (see 6.3.1).
3. Interconnecting cables that hang closer than 40 cm to the ground plane shall be folded back and forth in the center forming a bundle 30 cm to 40 cm long (see 6.3.1).
4. For emission measurements at or below 1 GHz, the table height shall be 80 cm. For emission measurements above 1 GHz, the table height shall be 1.5 m for measurements, except as otherwise specified (see 6.3.1 and 6.6.3.1).

Diagram 2 Test arrangement for radiated emissions of tabletop equipment



Frequency: 9 kHz-30 MHz	Frequency: 30 MHz- 1 GHZ	Frequency: Above 1 GHz
Loop Antenna	Broadband Biconilog	Horn
RBW = 9 kHz	RBW = 120 kHz	RBW = 1 MHz
VBW = 30 kHz	VBW = 120 kHz	VBW = 1 MHz
Sweep time = Auto	Sweep time = Auto	Sweep time = Auto
Detector = PK, QP	Detector = PK, QP	Detector = PK, AV
Antenna Height 1m	Antenna Height 1-4m	Antenna Height 1-4m

Diagram 3 Test arrangement for radiated emissions tested on Open Area Test Site (OATS)

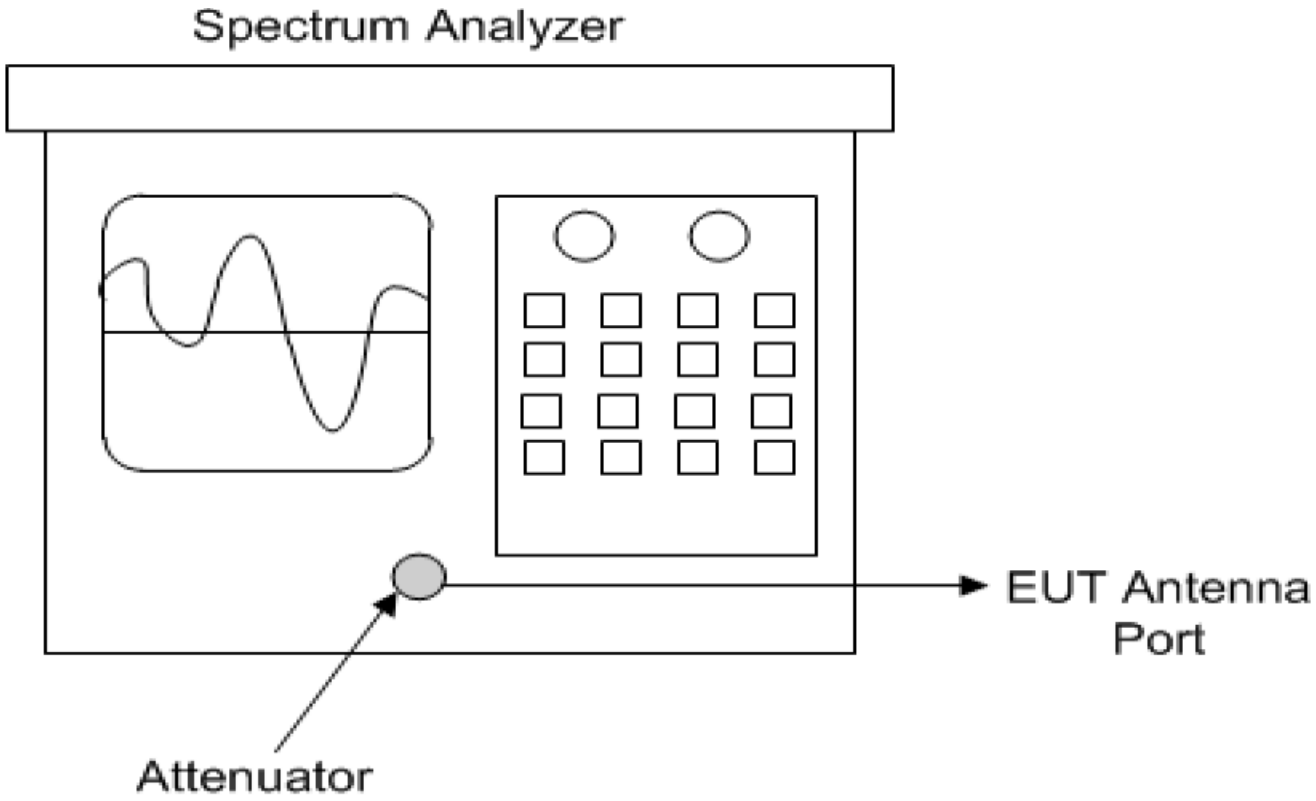


Diagram 4 Test arrangement for Antenna Port Conducted emissions

Test Site Locations

Conducted EMI	AC line conducted emissions testing performed in a shielded screen room located at Rogers Labs, Inc., 4405 West 259th Terrace, Louisburg, KS
Antenna port	Antenna port conducted emissions testing was performed in a shielded screen room located at Rogers Labs, Inc., 4405 West 259th Terrace, Louisburg, KS
Radiated EMI	The radiated emissions tests were performed at the 3 meters, Open Area Test Site (OATS) located at Rogers Labs, Inc., 4405 West 259th Terrace, Louisburg, KS
Registered Site information:	FCC Site: US5305, ISED: 3041A, CAB Identifier: US0096
NVLAP Accreditation	Lab code 200087-0

Conducted EMI Data presented in dBµV; dB referenced to one microvolt

Antenna port Conducted Data is in dBm; dB referenced to one milliwatt

Radiated EMI Data presented in dBµV/m; dB referenced to one microvolt per meter

Note: The limit is expressed for a measurement in dBµV/m when the measurement is taken at a distance of 3 or 10 meters. Data taken for this report was taken at distance of 3 meters. Sample calculation demonstrates corrected field strength reading for Open Area Test Site using the measurement reading and correcting for receive antenna factor, cable losses, and amplifier gains.

Sample Calculation:

RFS = Radiated Field Strength, FSM = Field Strength Measured
A.F. = Receive antenna factor, Losses = attenuators/cable losses, Gain = amplification gains
RFS (dBµV/m @ 3m) = FSM (dBµV) + A.F. (dB/m) + Losses (dB) - Gain (dB)

Environmental Conditions

Ambient Temperature 20.2° C

Relative Humidity 36 %

Atmospheric Pressure 1017.1 mb

Intentional Radiators

As per 47CFR part 15 subpart E 15.407 and Industry Canada RSS-247 Issue 2, the following information is submitted for consideration and demonstration of compliance with regulations and standards.

Operation in the 5725-5850 MHz Frequency U-NII-3 Bands

Testing followed FCC KDB 789033 D02 General U-NII Test Procedures New Rules v02r01. The test sample was provided with a wave guide to N-connector allowing for direct connection to the antenna port. This port was monitored using both the ESU/ESW receiver/spectrum analyzer or a power meter to measure transmitter power. A spectrum analyzer / receiver was used to produce plots and make other antenna port conducted measurements for compliance testing. The antenna port was connected to 50-ohm attenuator, coaxial cable and receiver, spectrum analyzer, or power meter during testing. Antenna port conducted testing was performed in a screen room with the EUT placed on a wooden table. The design provides multiple modulations which provide different data rates and transmitter output powers. All modulations were investigated and found the change in modulation did not impact the spectral signature of the transmitter. Radiated emissions testing was performed with the EUT placed on the rotating table elevated as required above the ground plane as required at a distance of 3 meters from the FSM antenna located on the OATS (Open Area Test Site). The peak and quasi-peak amplitude of the frequencies below 1000 MHz were measured using a spectrum analyzer. The peak and average amplitude of emissions above 1000 MHz were measured using a spectrum analyzer. Emissions data was recorded from the measurement results. Data presented reflects measurement result corrected to account for measurement system gains and losses. Plots were made of transmitter performance for reference and demonstration of compliance. In addition, all Manufacturers of U-NII devices are responsible for ensuring frequency stability such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the user's manual. The manufacturer has attested the equipment operates within the required frequency spectrum under normal operational conditions. This report documents emissions governed under the U-NII-3 band operating in the 5739-5836 MHz frequency band.

TEST #1 Maximum Conducted Output Power 15.407(a)(3)

The maximum conducted output power measured over any interval of continuous transmission using instrumentation calibrated in terms of an rms-equivalent voltage. Testing was performed as directed in KDB 789033 D02 General U-NII Test Procedures New Rules v02r01 using both the spectrum analyzer and Power meter. Transmitter output power was measured and recorded. Plots were produced of EUT operation across the authorized band. The device transmits on single channel only as determined by channel selection in software. Plots present lowest, near middle and highest channels of operation across the band for each channel width and mode.

§15.407(a)(3) General technical requirements

(a) *Power limits:*

(3) For the band 5.725-5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. In addition, the maximum power spectral density shall not exceed 30 dBm in any 500-kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. However, fixed point-to-point U-NII devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

Methods of Measurement Conducted Output Power

789033 D02 General UNII Test Procedures New Rules v02r01

E. Maximum Conducted Output Power

Maximum conducted output power may be measured using a spectrum analyzer/EMI receiver or an RF power meter.

1. Device Configuration

If possible, configure or modify the operation of the EUT so that it transmits continuously at its maximum power control level (see II.B.).

a) The intent is to test at 100% duty cycle; however, a small reduction in duty cycle (to no lower than 98%) is permitted if required by the EUT for amplitude control purposes. Manufacturers are expected to provide software to the test lab to permit such continuous operation.

b) If continuous transmission (or at least 98% duty cycle) cannot be achieved due to hardware limitations (e.g., overheating), the EUT shall be operated at its maximum power control level with the transmit duration as long as possible and the duty cycle as high as possible.

2. Measurement using a Spectrum Analyzer or EMI Receiver (SA)

Measurement of maximum conducted output power using a spectrum analyzer requires integrating the spectrum across a frequency span that encompasses, at a minimum, either the EBW or the 99% occupied bandwidth of the signal.[1] However, the EBW must be used to determine bandwidth dependent limits on maximum conducted output power in accordance with Section 15.407(a).

a) The test method shall be selected as follows:

(i) Method SA-1 or SA-1 Alternative (averaging with the EUT transmitting at full power throughout each sweep) shall be applied if either of the following conditions can be satisfied:

- The EUT transmits continuously (or with a duty cycle ≥ 98%).
- Sweep triggering or gating can be implemented in a way that the device transmits at the maximum power control level throughout the duration of each of the instrument sweeps to be averaged. This condition can generally be achieved by triggering the instrument's sweep if the duration of the sweep (with the analyzer configured as in Method SA-1, below) is equal to or shorter than the duration *T* of each transmission from the EUT and if those transmissions exhibit full power throughout their durations.

b) **Method SA-1** (trace averaging with the EUT transmitting at full power throughout each sweep):

(i) Set span to encompass the entire emission bandwidth (EBW) (or, alternatively, the entire 99% occupied bandwidth) of the signal.

(ii) Set RBW = 1 MHz.

(iii) Set VBW ≥ 3 MHz.

(iv) Number of points in sweep ≥ 2 × span / RBW. (This ensures that bin-to-bin spacing is ≤ RBW/2, so that narrowband signals are not lost between frequency bins.)

(v) Sweep time = auto.

(vi) Detector = power averaging (rms), if available. Otherwise, use sample detector mode.

(vii) If transmit duty cycle < 98%, use a video trigger with the trigger level set to enable triggering only on full power pulses. Transmitter must operate at maximum power control level for the entire duration of every sweep. If the EUT transmits continuously (i.e., with no off intervals) or at duty cycle ≥ 98%, and if each transmission is entirely at the maximum power control level, then the trigger shall be set to "free run."

(viii) Trace average at least 100 traces in power averaging (rms) mode.

(ix) Compute power by integrating the spectrum across the EBW (or, alternatively, the entire 99% occupied bandwidth) of the signal using the instrument's band power measurement function with band limits set equal to the EBW (or occupied bandwidth) band edges. If the instrument does not have a band power function, sum the spectrum levels (in power units) at 1 MHz intervals extending across the EBW (or, alternatively, the entire 99% occupied bandwidth) of the spectrum.

3. Measurement using a Power Meter (PM)

a) **Method PM** (Measurement using an RF average power meter):

(i) Measurements may be performed using a wideband RF power meter with a thermocouple detector or equivalent if all of the conditions listed below are satisfied.

- The EUT is configured to transmit continuously or to transmit with a constant duty cycle.
- At all times when the EUT is transmitting, it must be transmitting at its maximum power control level.

- The integration period of the power meter exceeds the repetition period of the transmitted signal by at least a factor of five.

(ii) If the transmitter does not transmit continuously, measure the duty cycle, x, of the transmitter output signal as described in II.B.

(iii) Measure the average power of the transmitter. This measurement is an average over both the on and off periods of the transmitter.

(iv) Adjust the measurement in dBm by adding 10 log (1/x) where x is the duty cycle (e.g., 10 log (1/0.25) if the duty cycle is 25%).

Test Arrangement Conducted Output Power

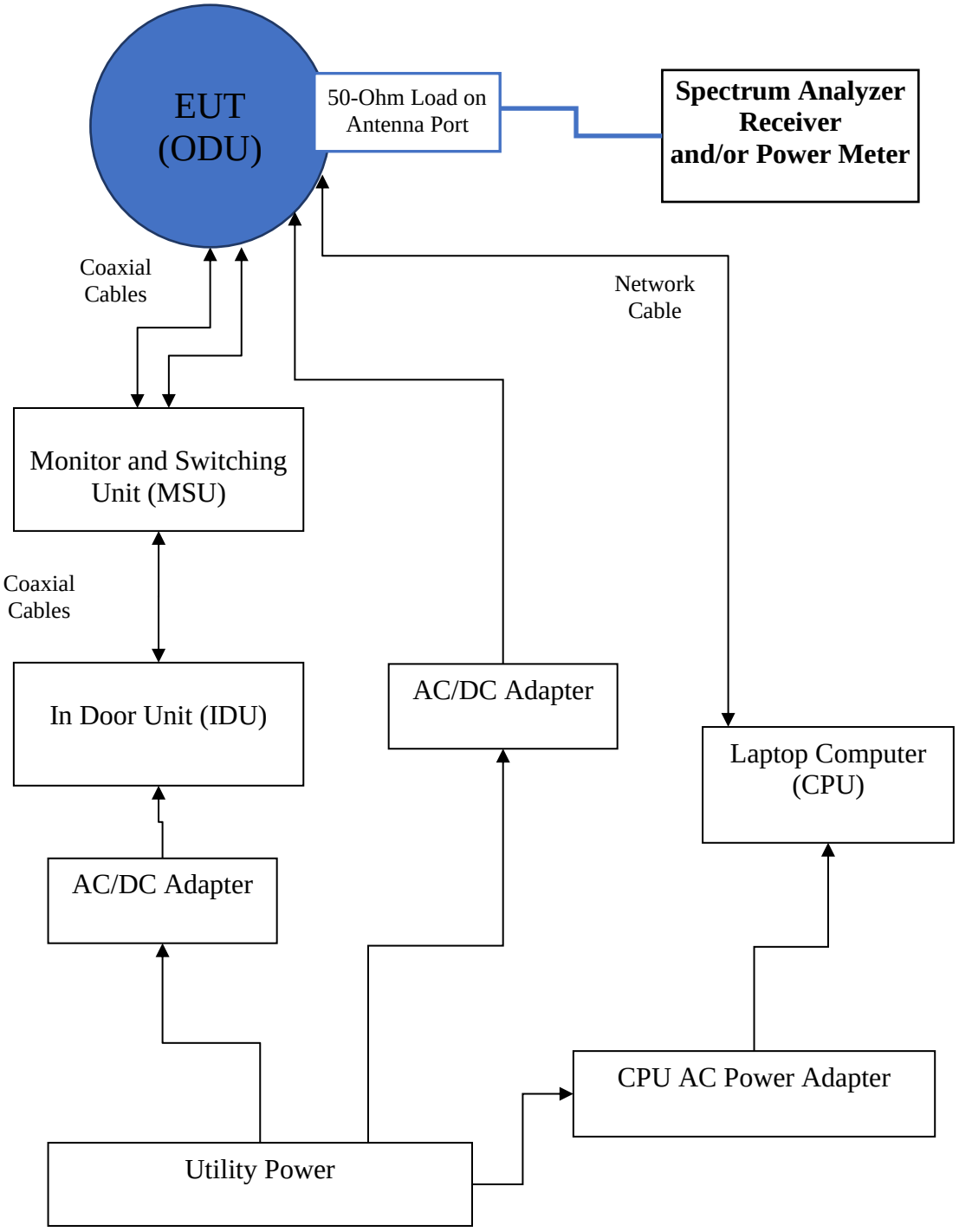


Table 1 Maximum Conducted Output Power Data

Frequency MHz	Conducted Antenna Port Output Power (Watts)
28 MHz Channel (4QAM)	
5739.0	0.997
5834.0	0.946
5836.0	0.942
28 MHz Channel (16QAM)	
5739.0	0.953
5834.0	0.942
5836.0	0.920
28 MHz Channel (32QAM)	
5739.0	0.871
5834.0	0.832
5836.0	0.778
28 MHz Channel (64QAM)	
5739.0	0.525
5834.0	0.518
5836.0	0.504
28 MHz Channel (128QAM)	
5739.0	0.446
5834.0	0.452
5836.0	0.445
30 MHz Channel (4QAM)	
5740.0	0.997
5835.0	0.955
30 MHz Channel (16QAM)	
5740.0	0.964
5835.0	0.935
30 MHz Channel (32QAM)	
5740.0	0.638
5835.0	0.729
30 MHz Channel (64QAM)	
5740.0	0.530
5835.0	0.520
30 MHz Channel (128QAM)	
5740.0	0.419
5835.0	0.471

Plots were produced for graphical presentation of operation and demonstration of compliance. Plots were produced using traces for each channel observed addressing the requirement for presenting lowest channel, middle of band, and highest operational channels in the band.

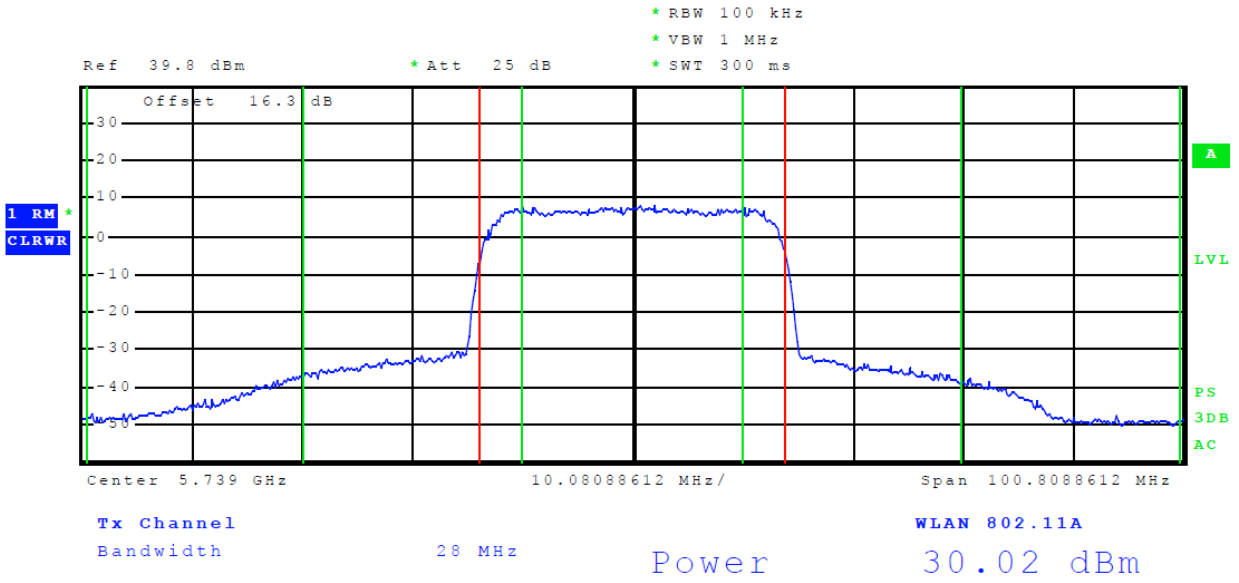


Figure 1 Plot of Antenna Port Power (28 MHz Channel, 4QAM)

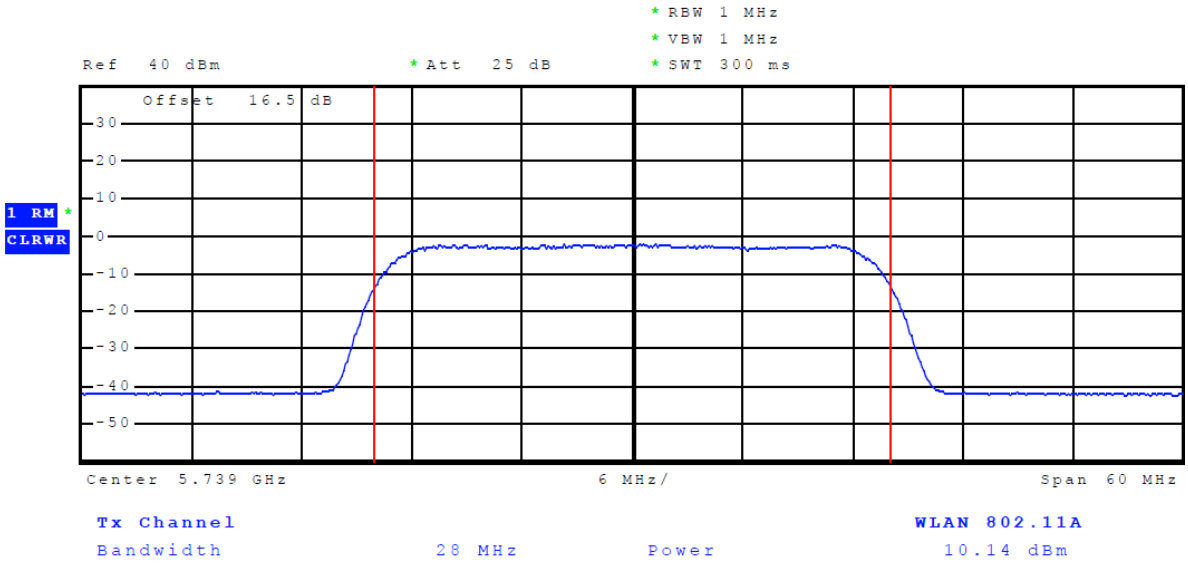


Figure 2 Plot of Antenna Port Low Power (28 MHz Channel, 4QAM)

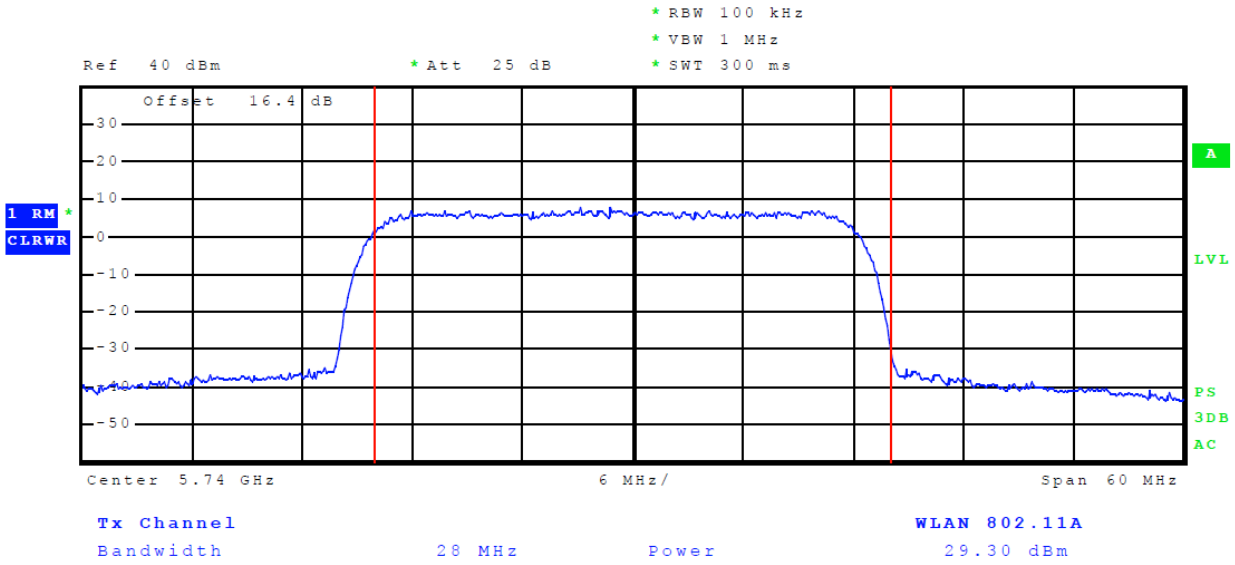


Figure 3 Plot of Antenna Port Power (28 MHz Channel, 16QAM)

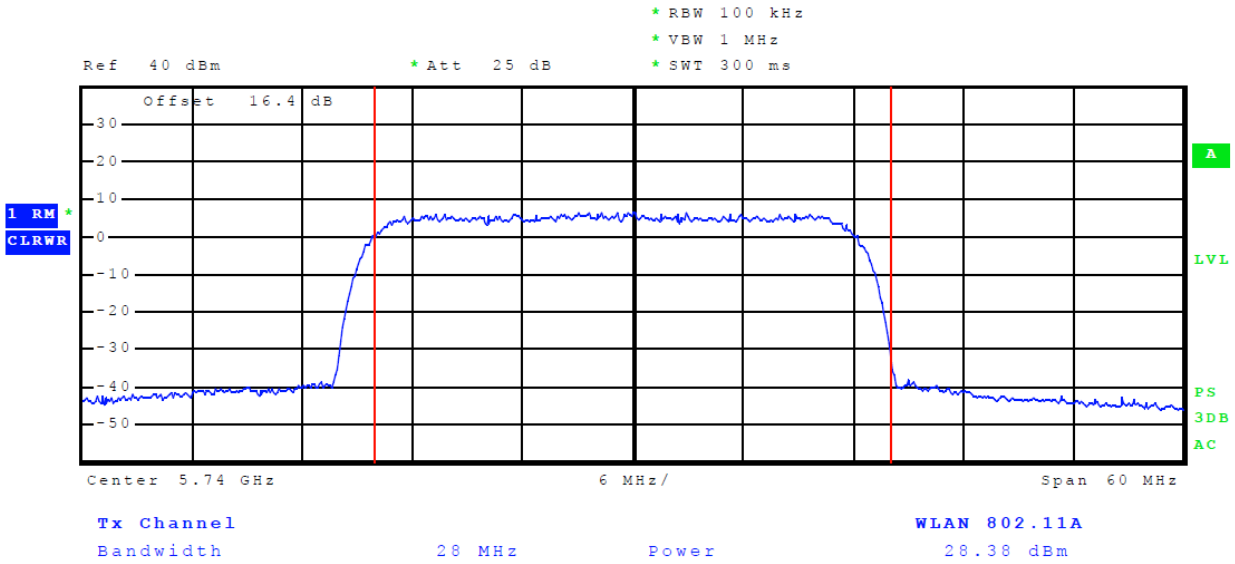


Figure 4 Plot of Antenna Port Power (28 MHz Channel, 32QAM)

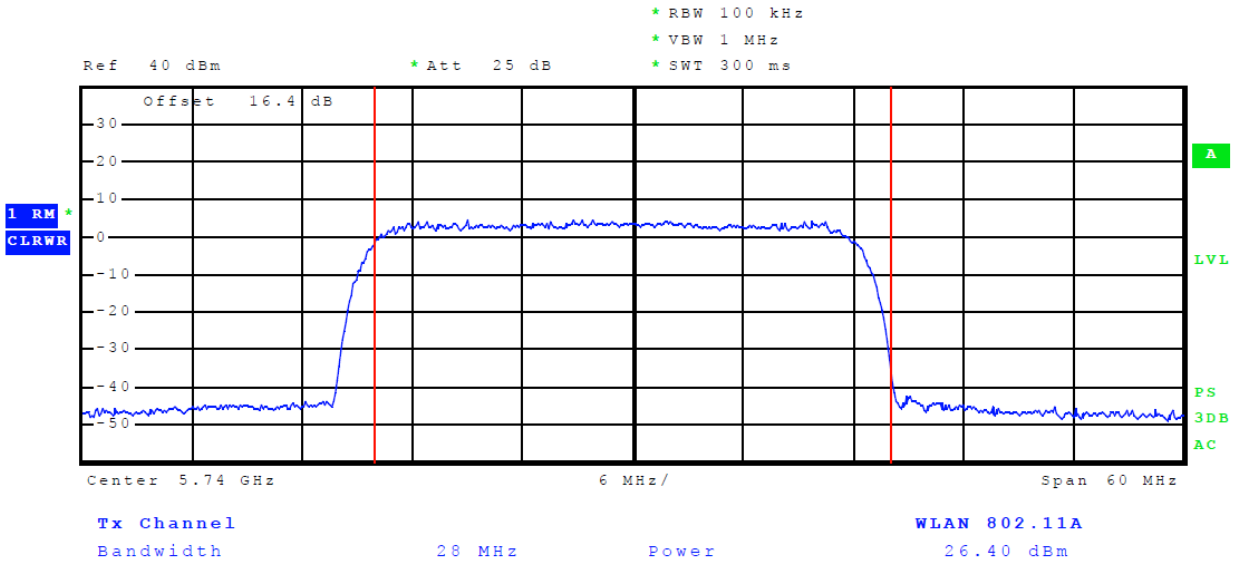


Figure 5 Plot of Antenna Port Power (28 MHz Channel, 64QAM)

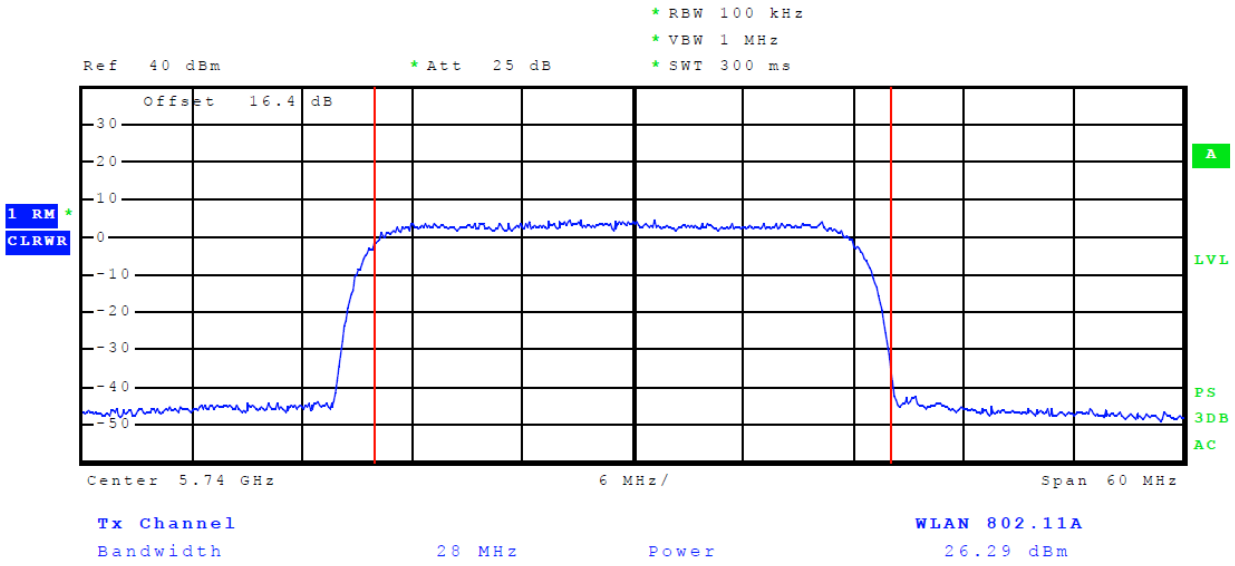


Figure 6 Plot of Antenna Port Power (28 MHz Channel, 128QAM)

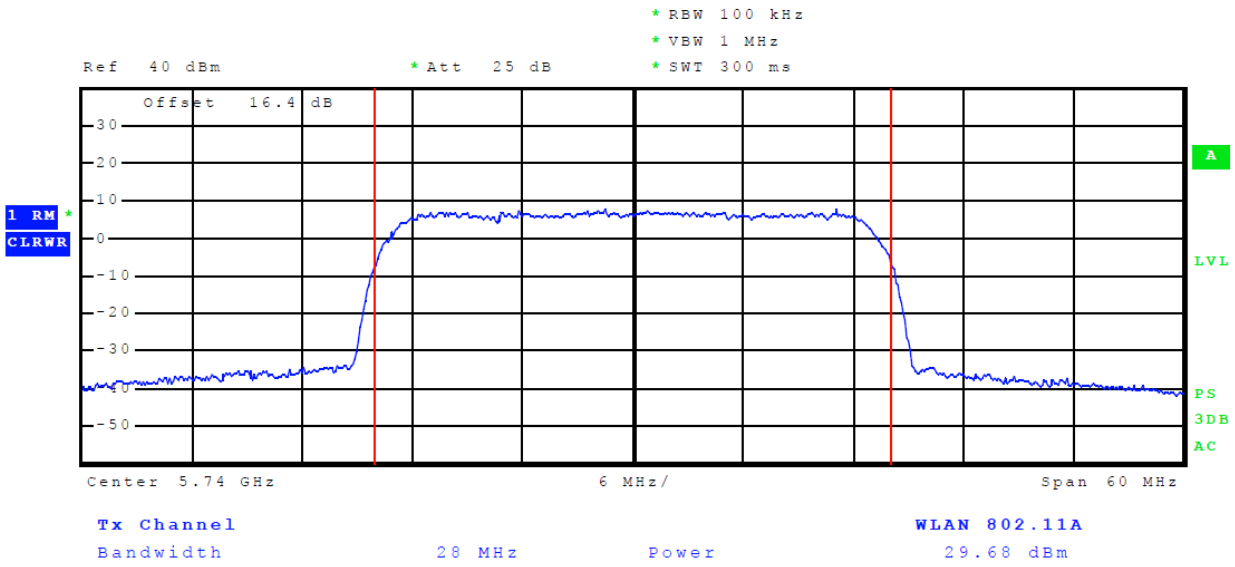


Figure 7 Plot of Antenna Port Power (30 MHz Channel, 4QAM)

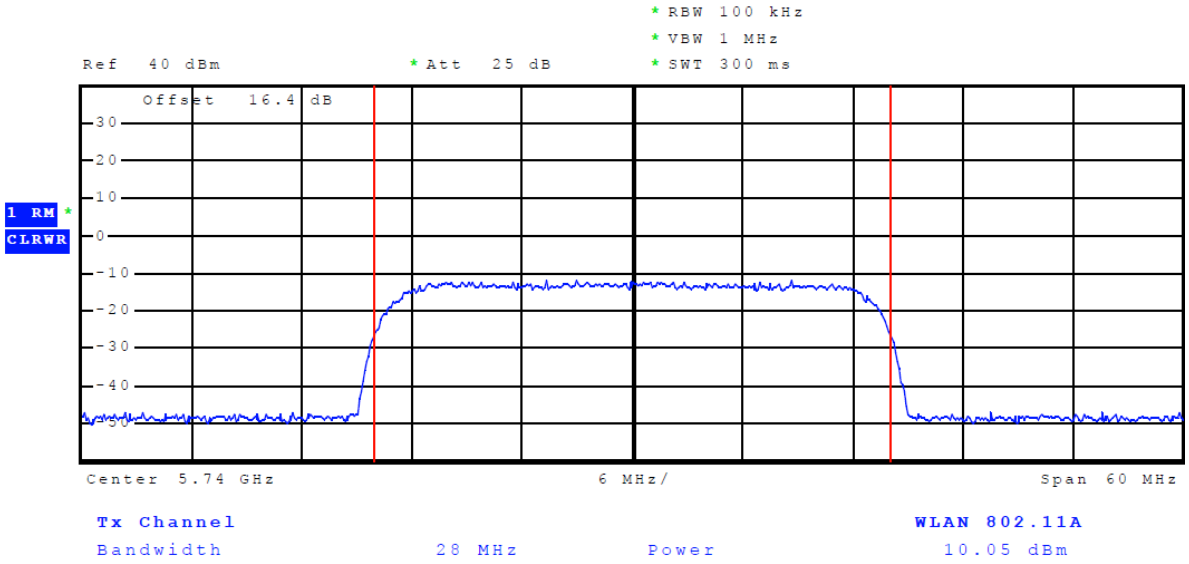


Figure 8 Plot of Antenna Port Low Power (30 MHz Channel, 4QAM)

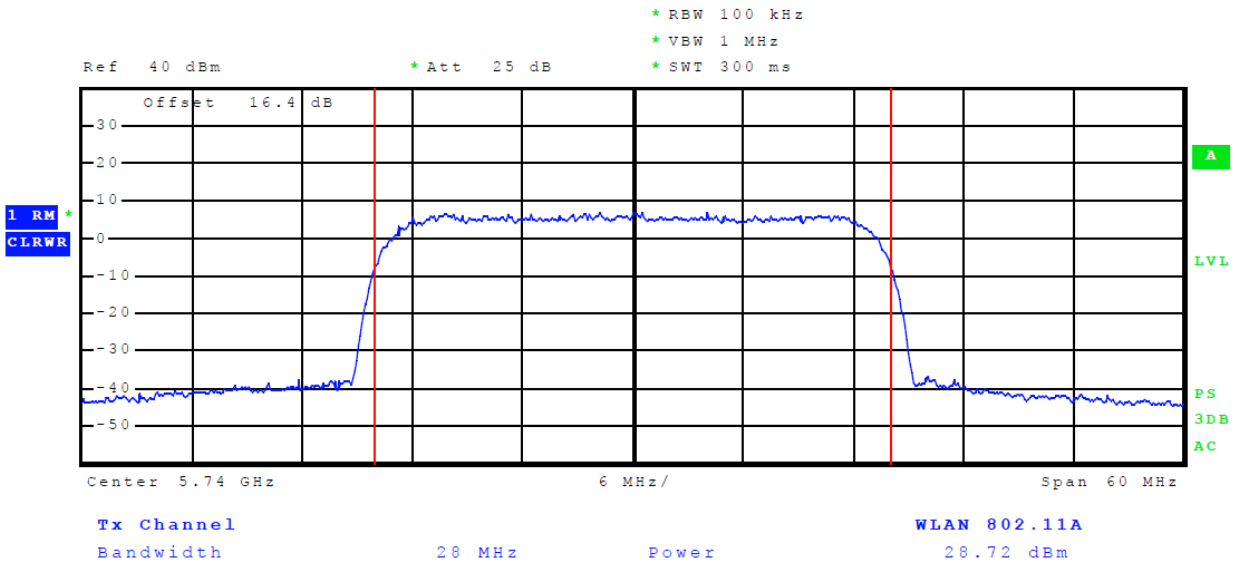


Figure 9 Plot of Antenna Port Power (30 MHz Channel, 16QAM)

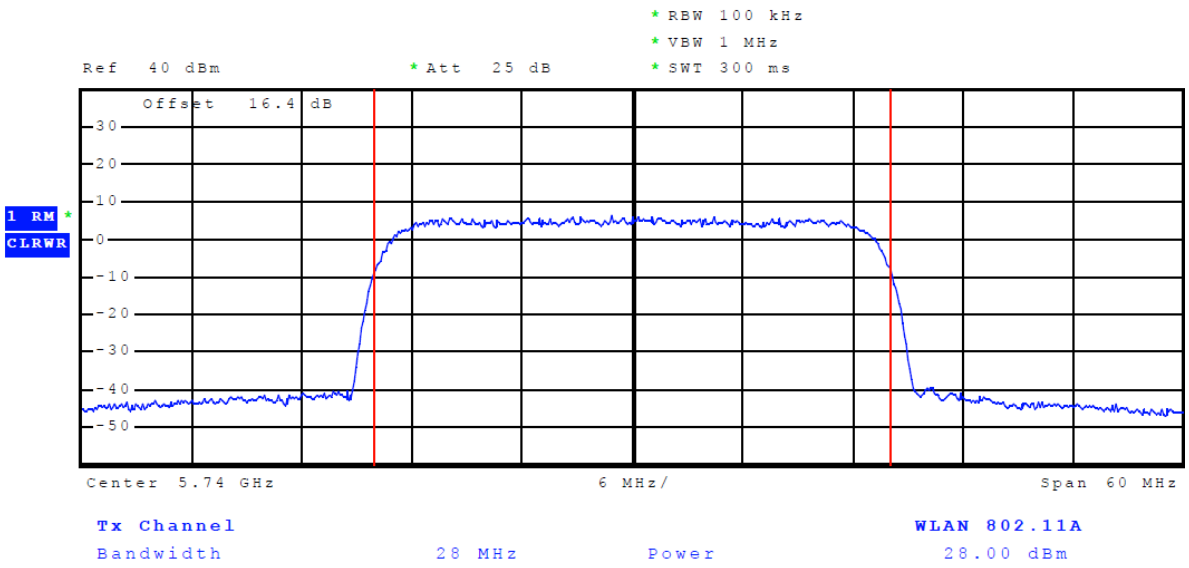


Figure 10 Plot of Antenna Port Power (30 MHz Channel, 32QAM)

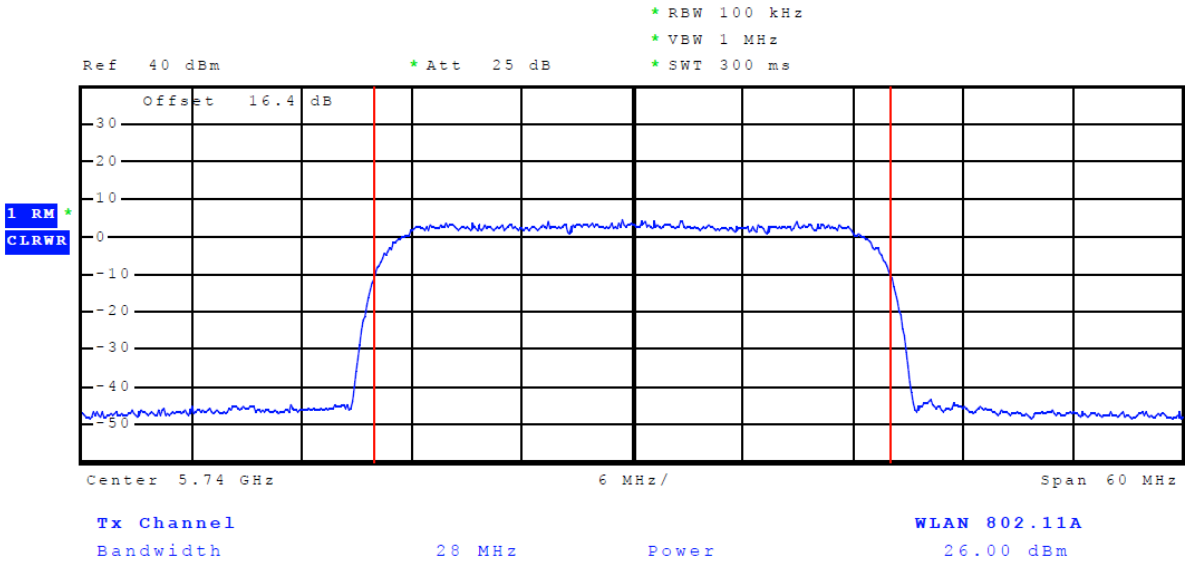


Figure 11 Plot of Antenna Port Power (30 MHz Channel, 64QAM)

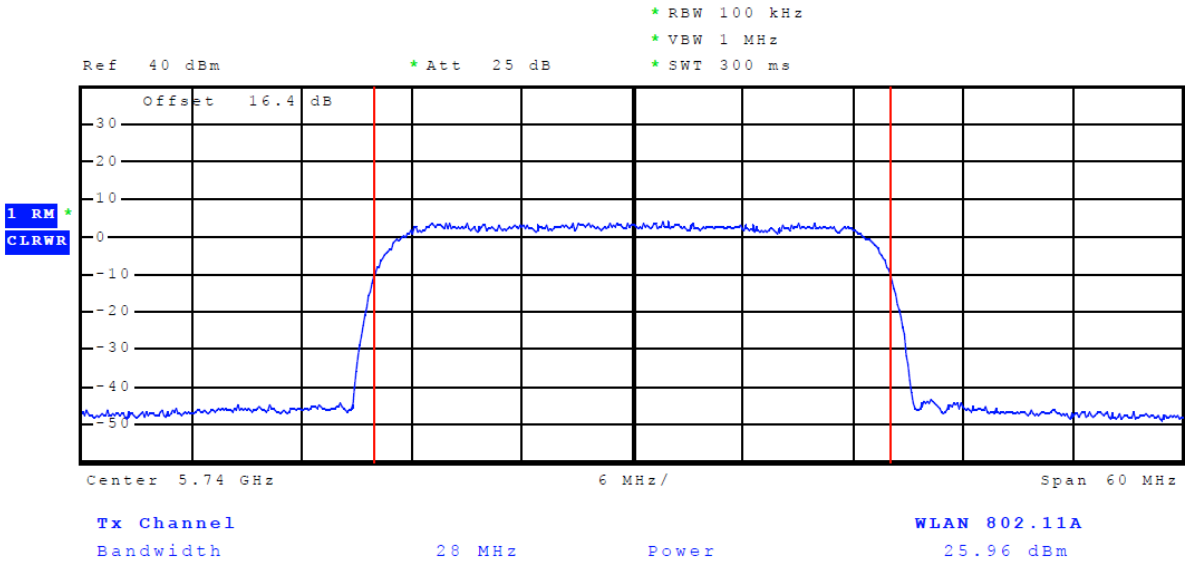


Figure 12 Plot of Antenna Port Power (30 MHz Channel, 128QAM)

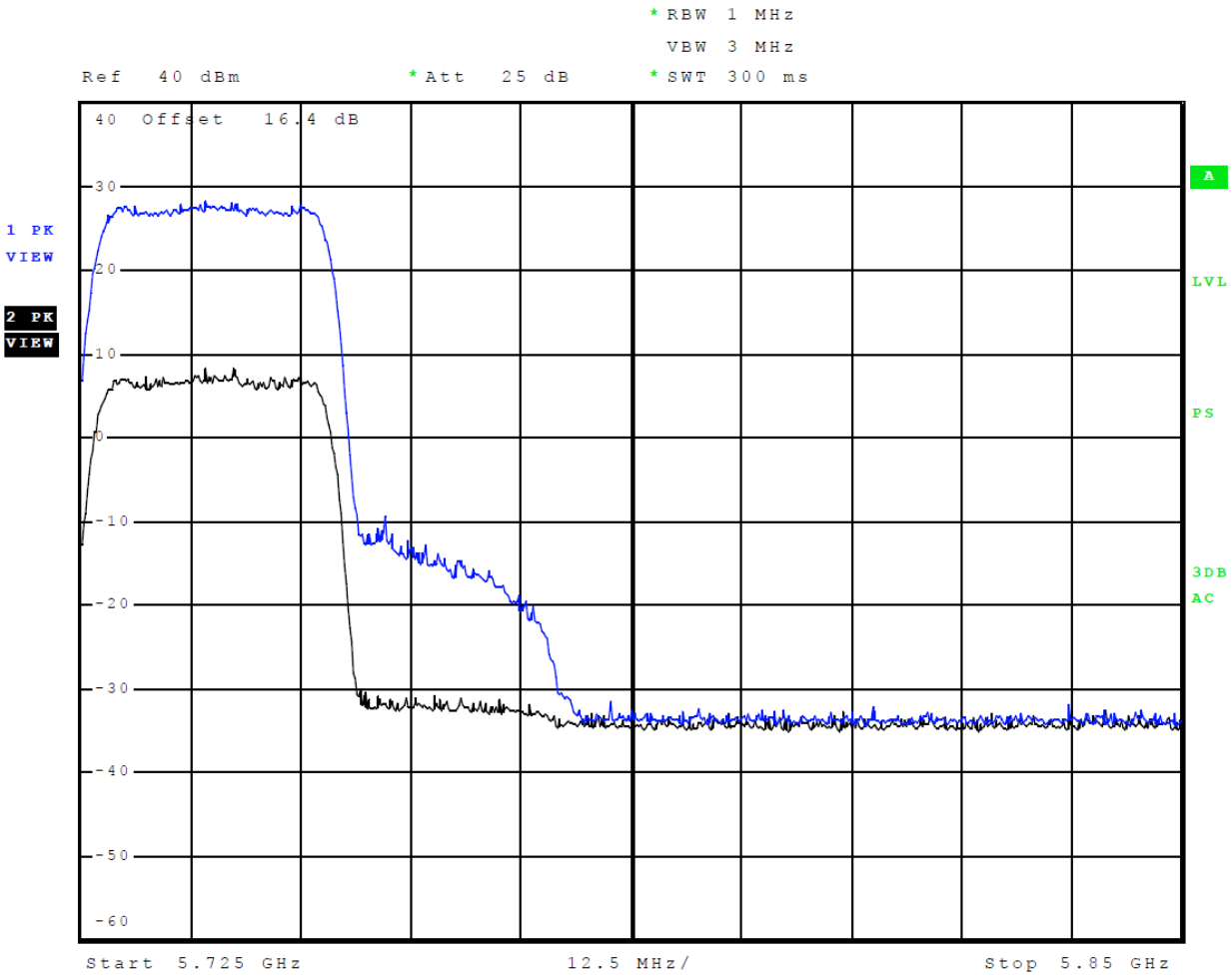


Figure 13 Plot of Transmitter Operation in Band (28 MHz Channel) power levels

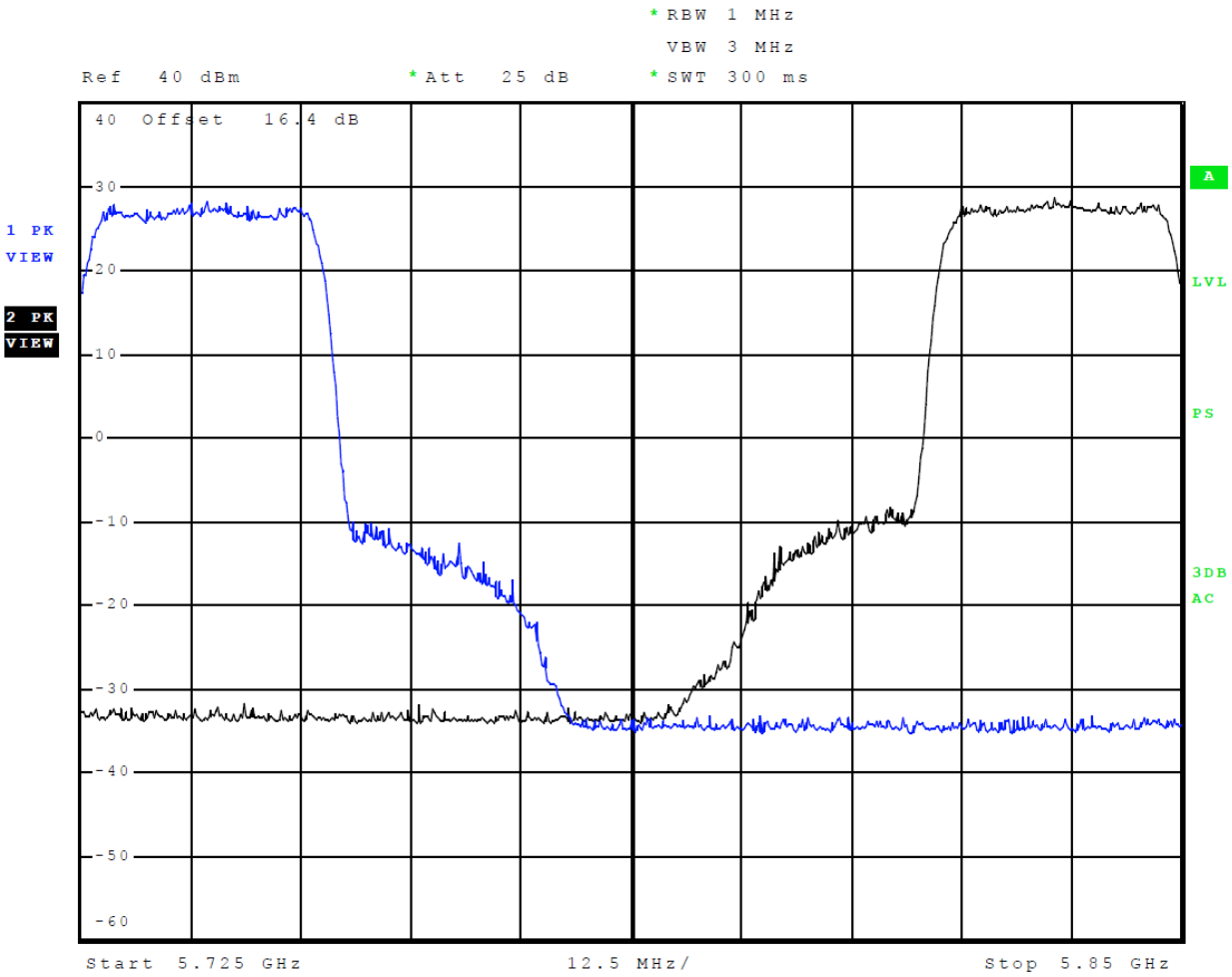


Figure 14 Plot of Transmitter Operation Across 5725-5850 MHz Band (28 MHz Channel)

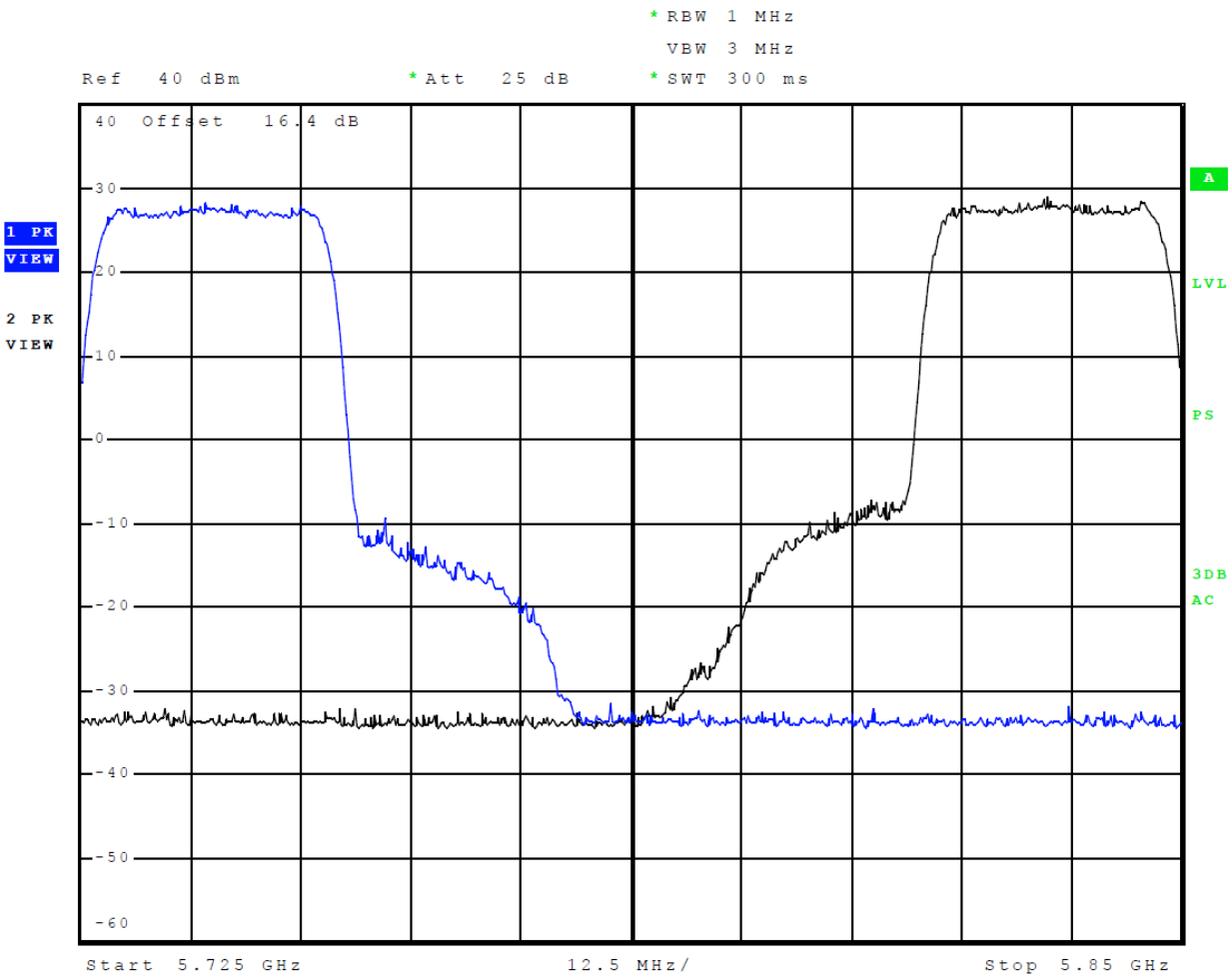


Figure 15 Plot of Transmitter Operation Across 5725-5850 MHz Band (30 MHz Channel)

TEST #2 Maximum power spectral density 15.407(a)(3)

Measurement of maximum power spectral density in any 500-kHz band. Testing was performed as directed in KDB 789033 D02 General UNII Test Procedures New Rules v02r01for peak power spectral density.

§15.407(a)(3) General technical requirements

(a) *Power limits:*
(3) For the band 5.725-5.85 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. In addition, the maximum power spectral density shall not exceed 30 dBm in any 500-kHz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. However, fixed point-to-point U-NII devices operating in this band may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted power. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

Methods of Measurement power spectral density

789033 D02 General UNII Test Procedures New Rules v02r01

F. Maximum Power Spectral Density (PSD)

The rules require "maximum power spectral density" measurements where the intent is to measure the maximum value of the time average of the power spectral density measured during a period of continuous transmission.

1. Create an average power spectrum for the EUT operating mode being tested by following the instructions in II.E.2. for measuring maximum conducted output power using a spectrum analyzer or EMI receiver: select the appropriate test method (SA-1, SA-2, SA-3, or alternatives to each) and apply it up to, but not including, the step labeled, "Compute power…." (This procedure is required even if the maximum conducted output power measurement was performed using a power meter, method PM.)

2. Use the peak search function on the instrument to find the peak of the spectrum and record its value.

3. Make the following adjustments to the peak value of the spectrum, if applicable:
a) If Method SA-2 or SA-2 Alternative was used, add 10 log (1/x), where x is the duty cycle, to the peak of the spectrum.

b) If Method SA-3 Alternative was used and the linear mode was used in step II.E.2.g)(viii), add 1 dB to the final result to compensate for the difference between linear averaging and power averaging.
4. The result is the Maximum PSD over 1 MHz reference bandwidth.

5. For devices operating in the bands 5.15-5.25 GHz, 5.25-5.35 GHz, and 5.47-5.725 GHz, the above procedures make use of 1 MHz RBW to satisfy directly the 1 MHz reference bandwidth specified in Section 15.407(a)(5). For devices operating in the band 5.725-5.85 GHz, the rules specify a measurement bandwidth of 500 kHz. Many spectrum analyzers do not have 500 kHz RBW, thus a narrower RBW may need to be used. The rules permit the use of a RBWs less than 1 MHz, or 500 kHz, "provided that the measured power is integrated over the full reference bandwidth" to show the total power over the specified measurement bandwidth (i.e., 1 MHz, or 500 kHz). If measurements are performed using a reduced resolution bandwidth (< 1 MHz, or 500 kHz) and integrated over 1 MHz, or 500 kHz bandwidth, the following adjustments to the procedures apply:

a) Set RBW ≥ 1/*T*, where *T* is defined in II.B.l.a).

b) Set VBW ≥ 3 RBW.

c) If measurement bandwidth of Maximum PSD is specified in 500 kHz, add 10 log (500 kHz/RBW) to the measured result, whereas RBW (<500 kHz) is the reduced resolution bandwidth of the spectrum analyzer set during measurement.

d) If measurement bandwidth of Maximum PSD is specified in 1 MHz, add 10 log (1MHz/RBW) to the measured result, whereas RBW (< 1 MHz) is the reduced resolution bandwidth of spectrum analyzer set during measurement.

e) Care must be taken to ensure that the measurements are performed during a period of continuous transmission or are corrected upward for duty cycle.
Note: As a practical matter, it is recommended to use reduced RBW of 100 kHz for steps 5.c) and 5.d) above, since RBW=100 KHZ is available on nearly all spectrum analyzers.

Test Arrangement power spectral density

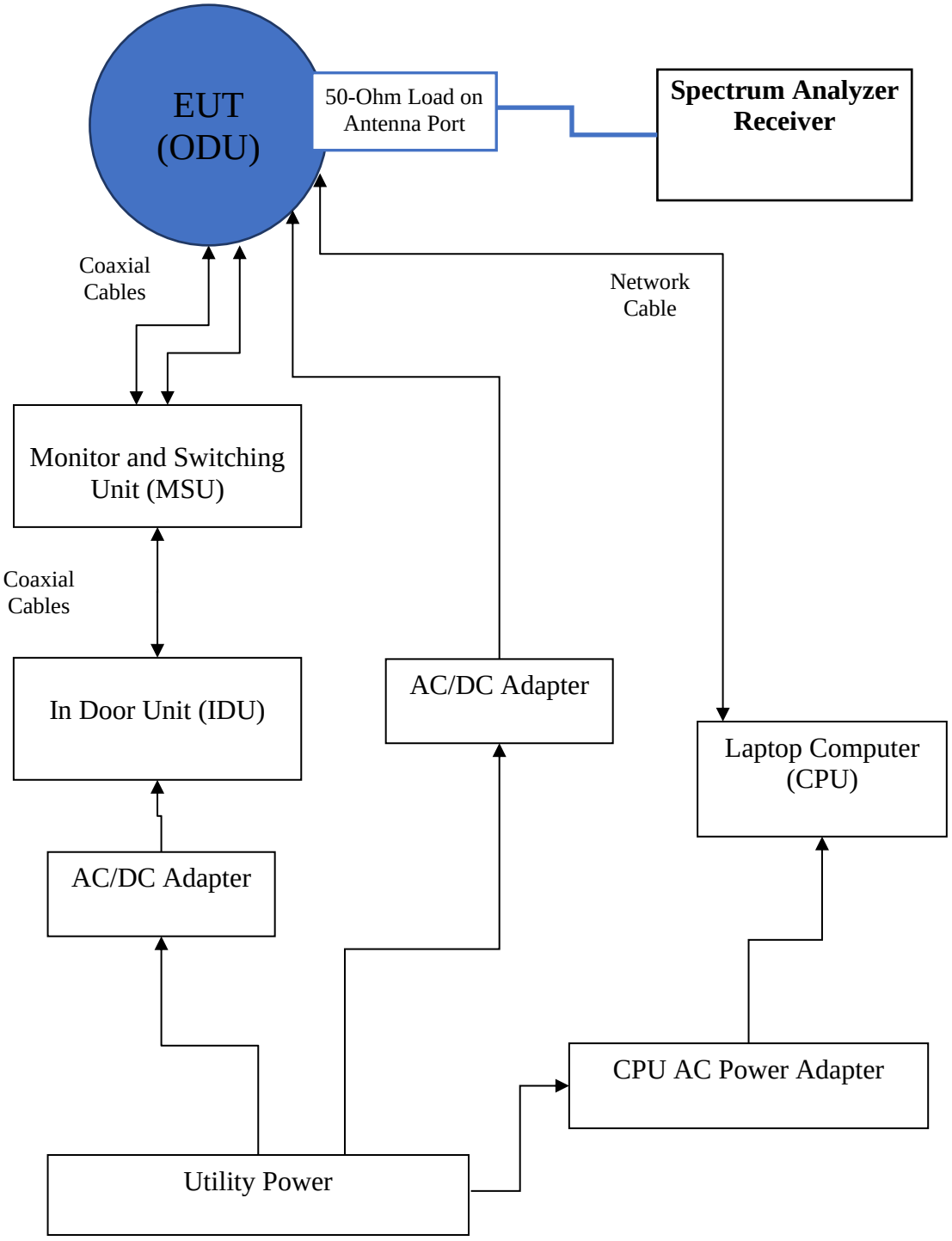


Table 2 Maximum power spectral density data

Frequency MHz	Peak Power Spectral Density (dBm/500kHz)
28 MHz Channel (4QAM)	
5739.0	25.52
5834.0	25.29
5836.0	25.33
28 MHz Channel (16QAM)	
5739.0	25.08
5834.0	25.33
5836.0	25.31
28 MHz Channel (32QAM)	
5739.0	23.95
5834.0	23.99
5836.0	23.92
28 MHz Channel (64QAM)	
5739.0	21.50
5834.0	21.77
5836.0	22.35
28 MHz Channel (128QAM)	
5739.0	21.96
5834.0	21.89
5836.0	22.18
30 MHz Channel (4QAM)	
5740.0	25.31
5835.0	25.26
30 MHz Channel (16QAM)	
5740.0	24.43
5835.0	25.41
30 MHz Channel (32QAM)	
5740.0	23.45
5835.0	24.27
30 MHz Channel (64QAM)	
5740.0	21.28
5835.0	22.12
30 MHz Channel (128QAM)	
5740.0	22.02
5835.0	22.56

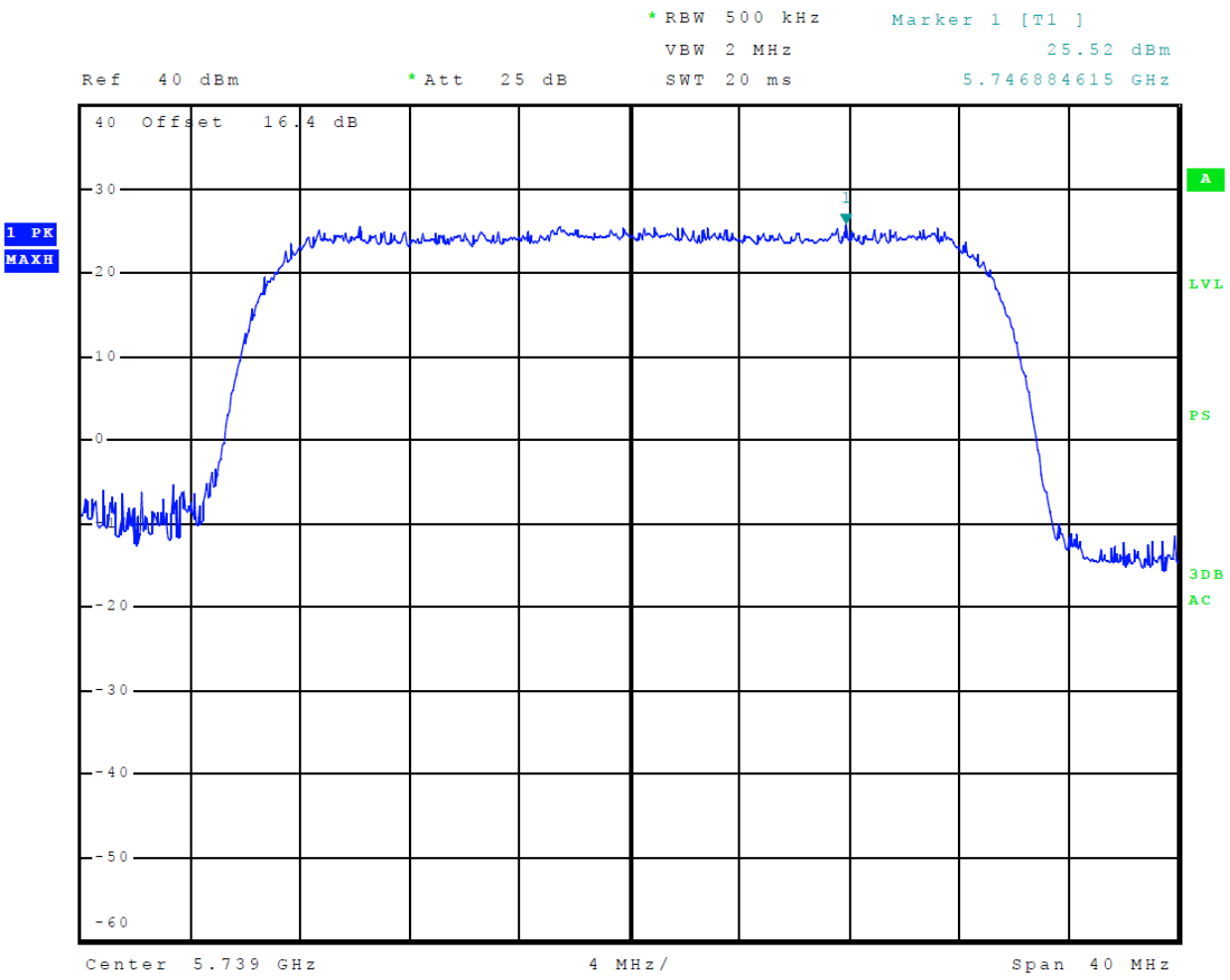


Figure 16 Plot of Power Spectral Density (28 MHz Channel 4QAM)

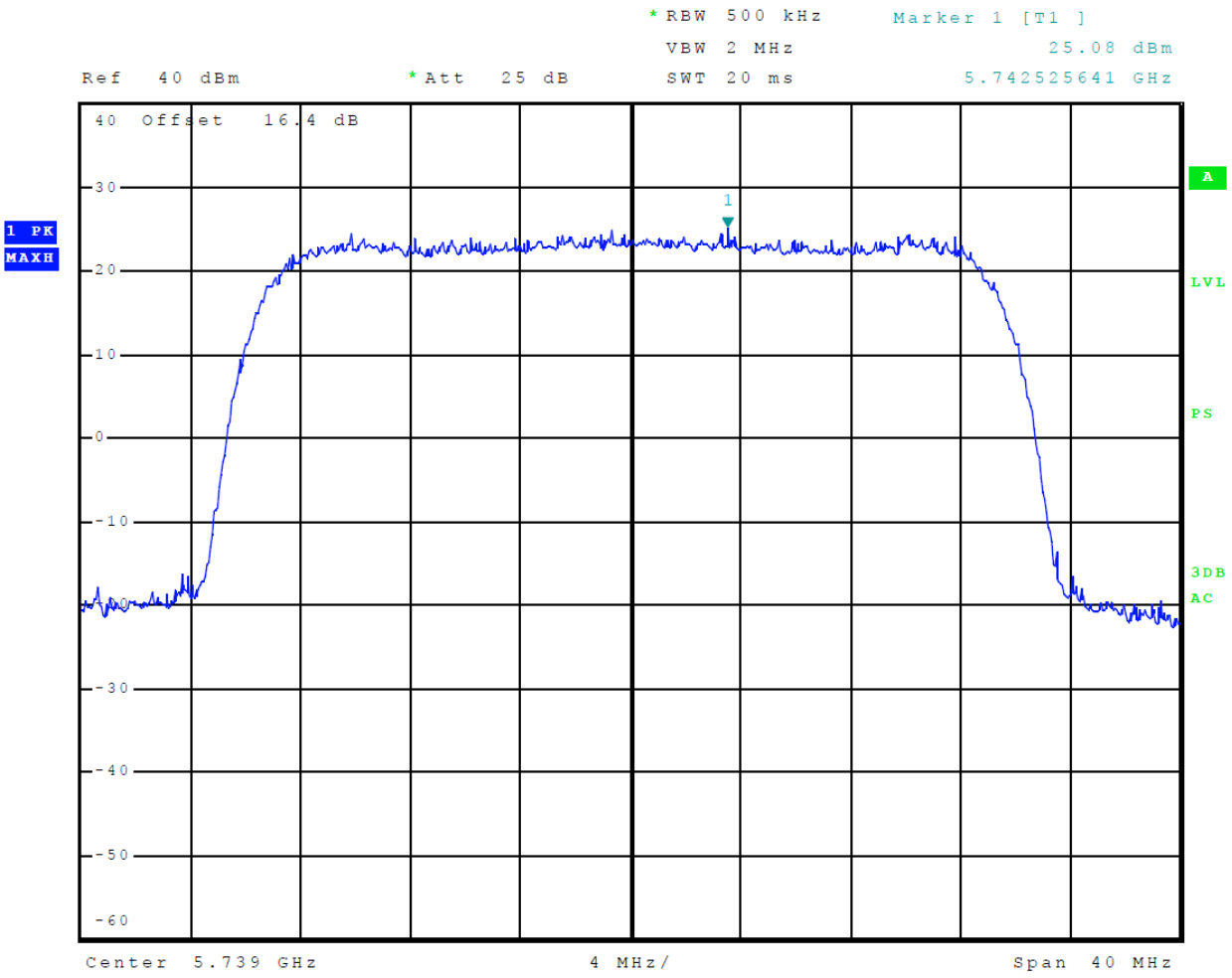


Figure 17 Plot of Power Spectral Density (28 MHz Channel 16QAM)

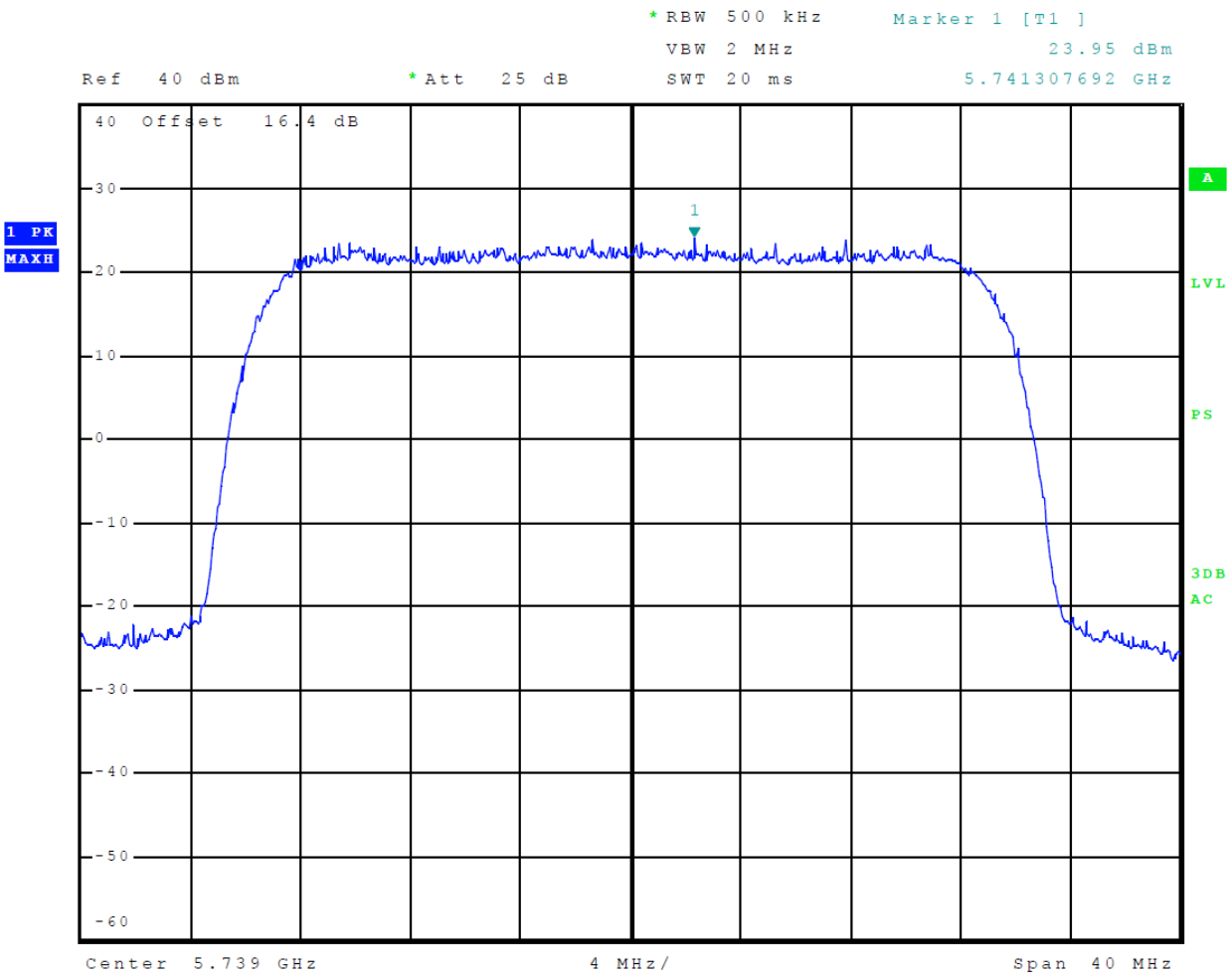


Figure 18 Plot of Power Spectral Density (28 MHz Channel 32QAM)

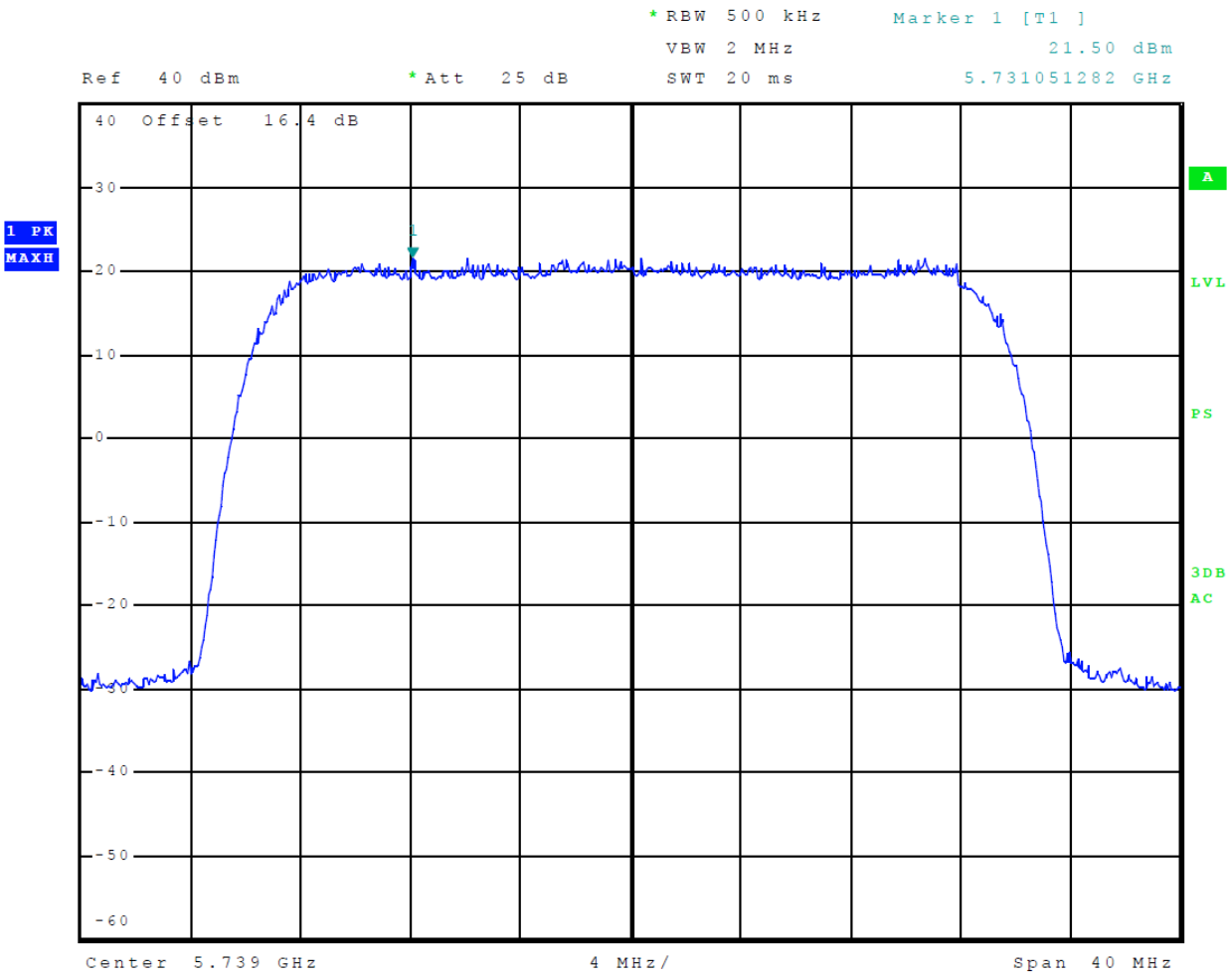


Figure 19 Plot of Power Spectral Density (28 MHz Channel 64QAM)

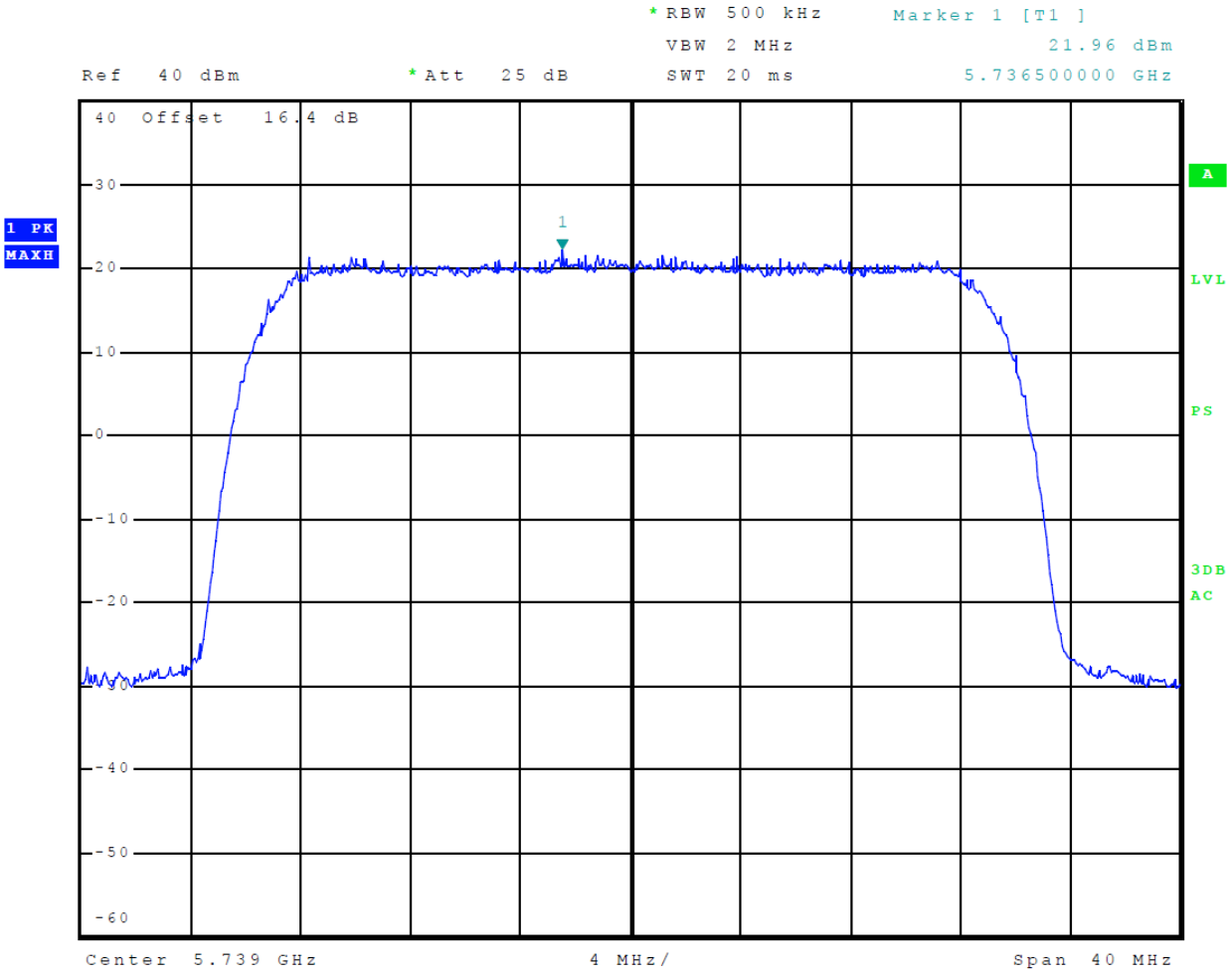


Figure 20 Plot of Power Spectral Density (28 MHz Channel 128QAM)

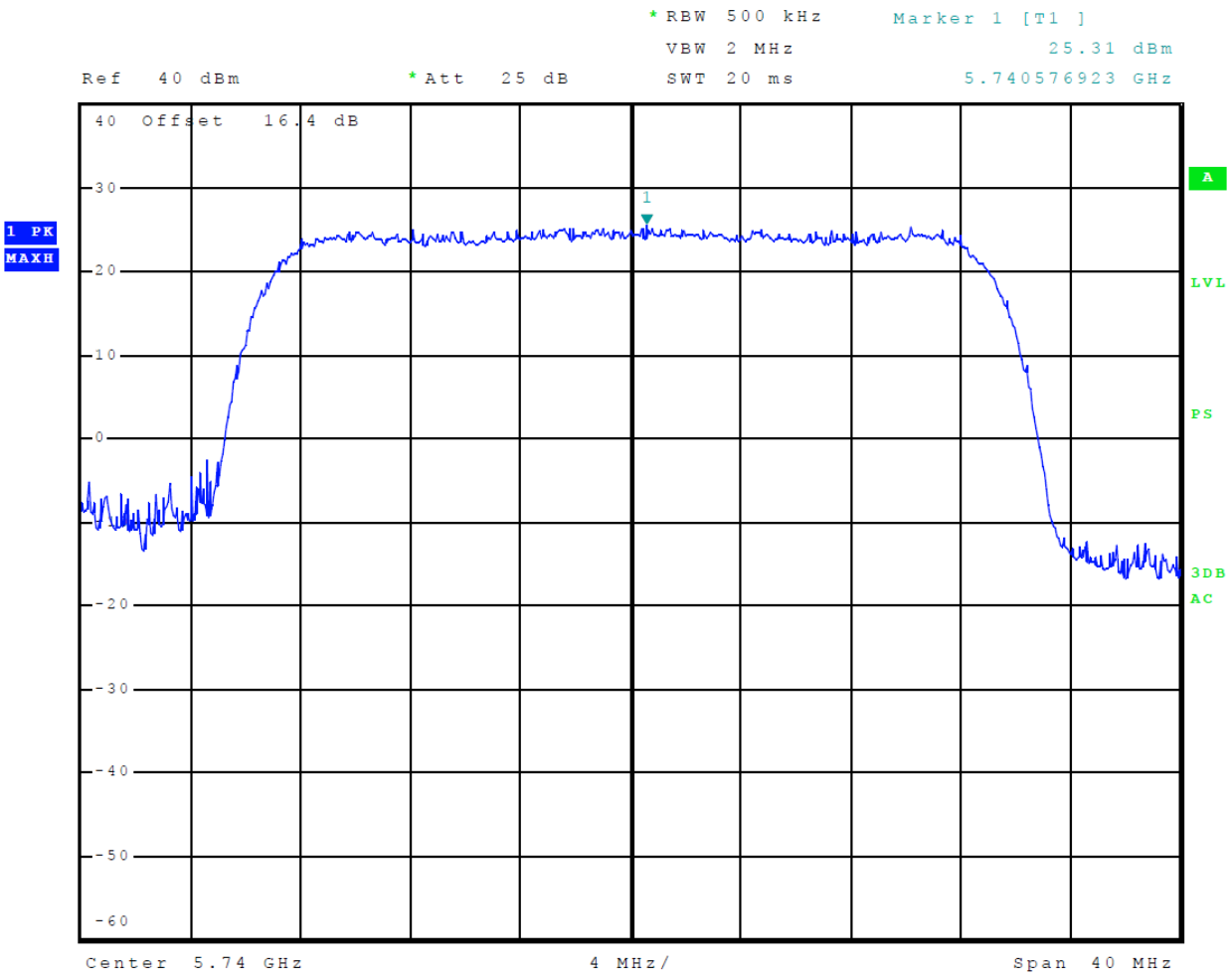


Figure 21 Plot of Power Spectral Density (30 MHz Channel 4QAM)

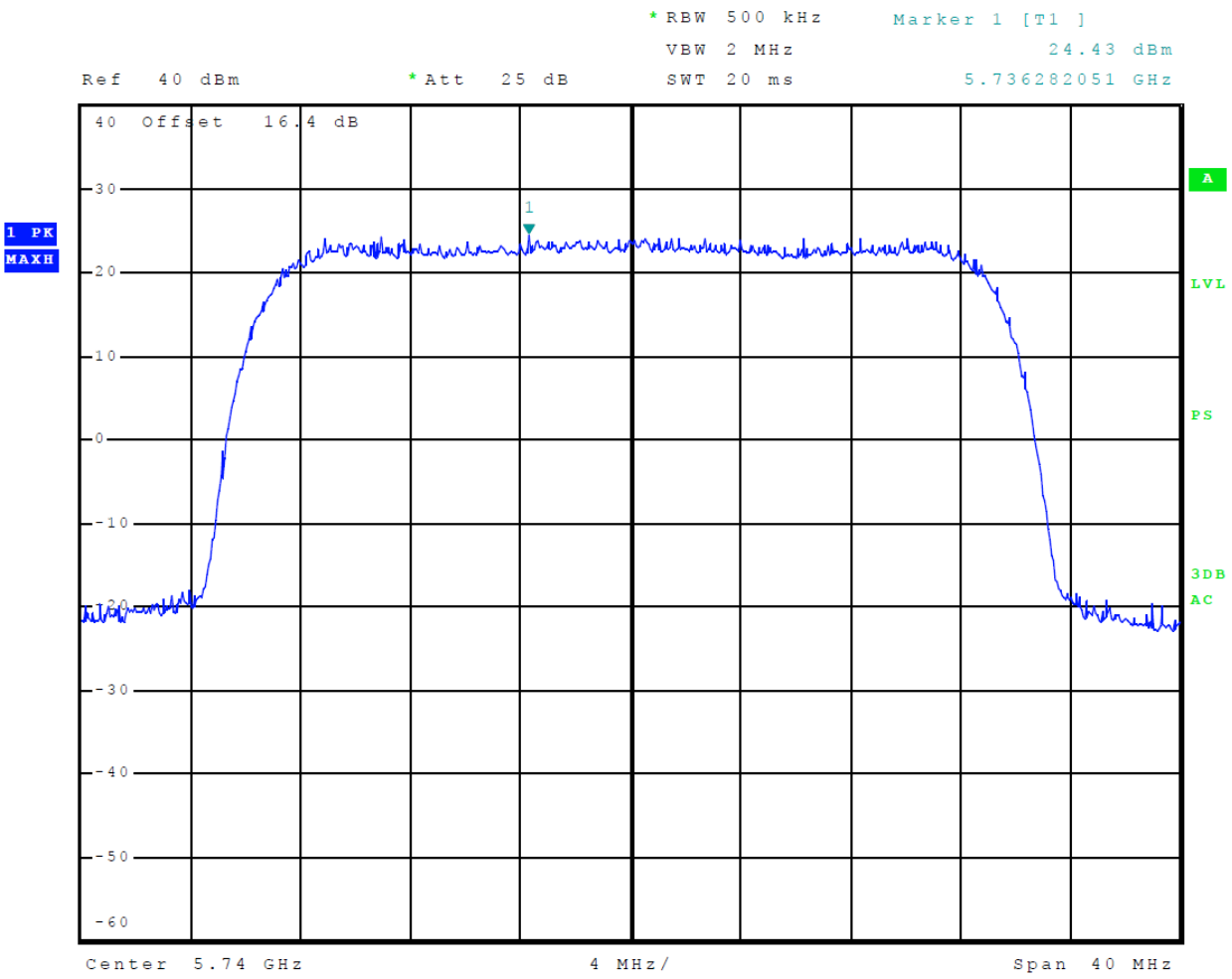


Figure 22 Plot of Power Spectral Density (30 MHz Channel 16QAM)

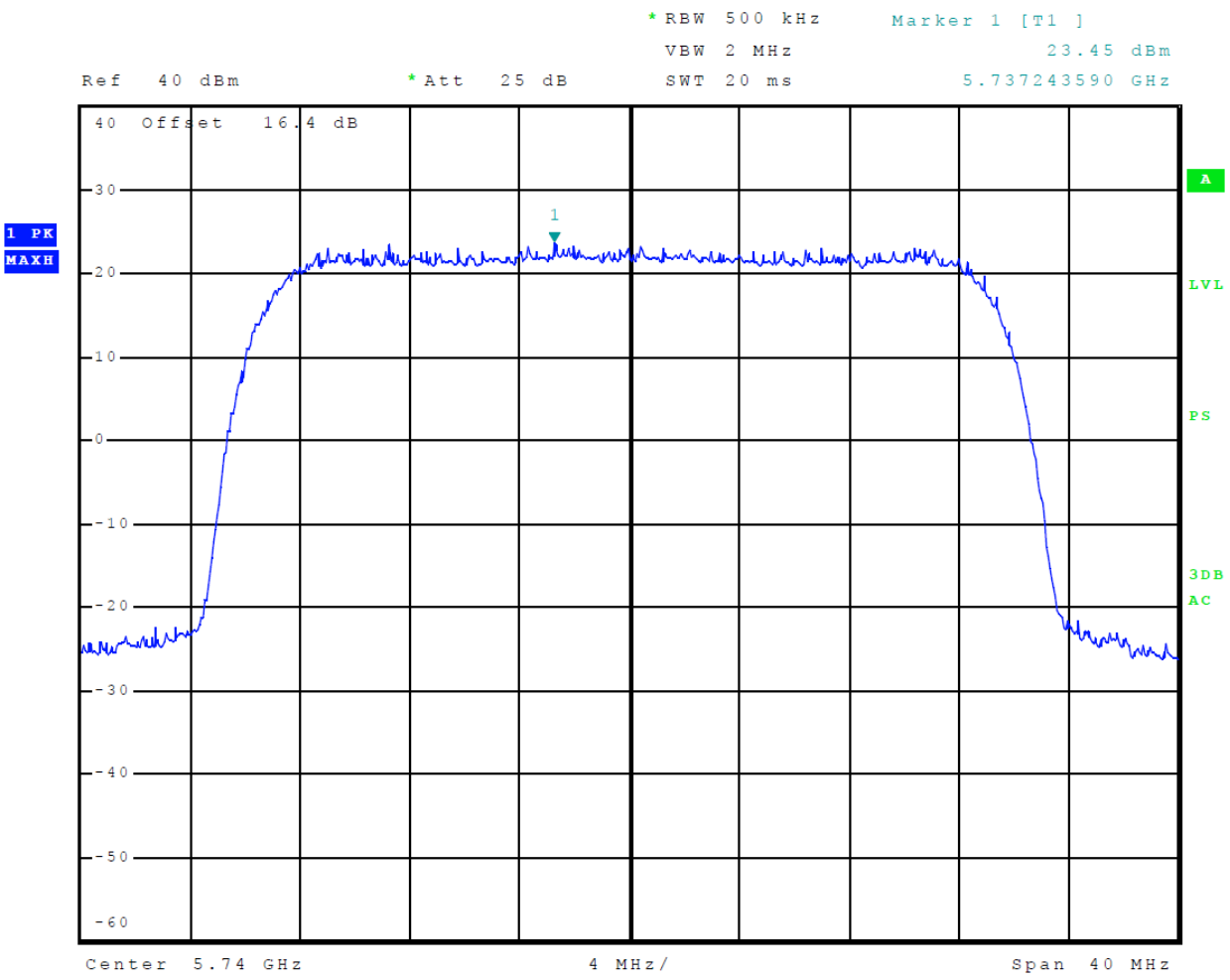


Figure 23 Plot of Power Spectral Density (30 MHz Channel 32QAM)

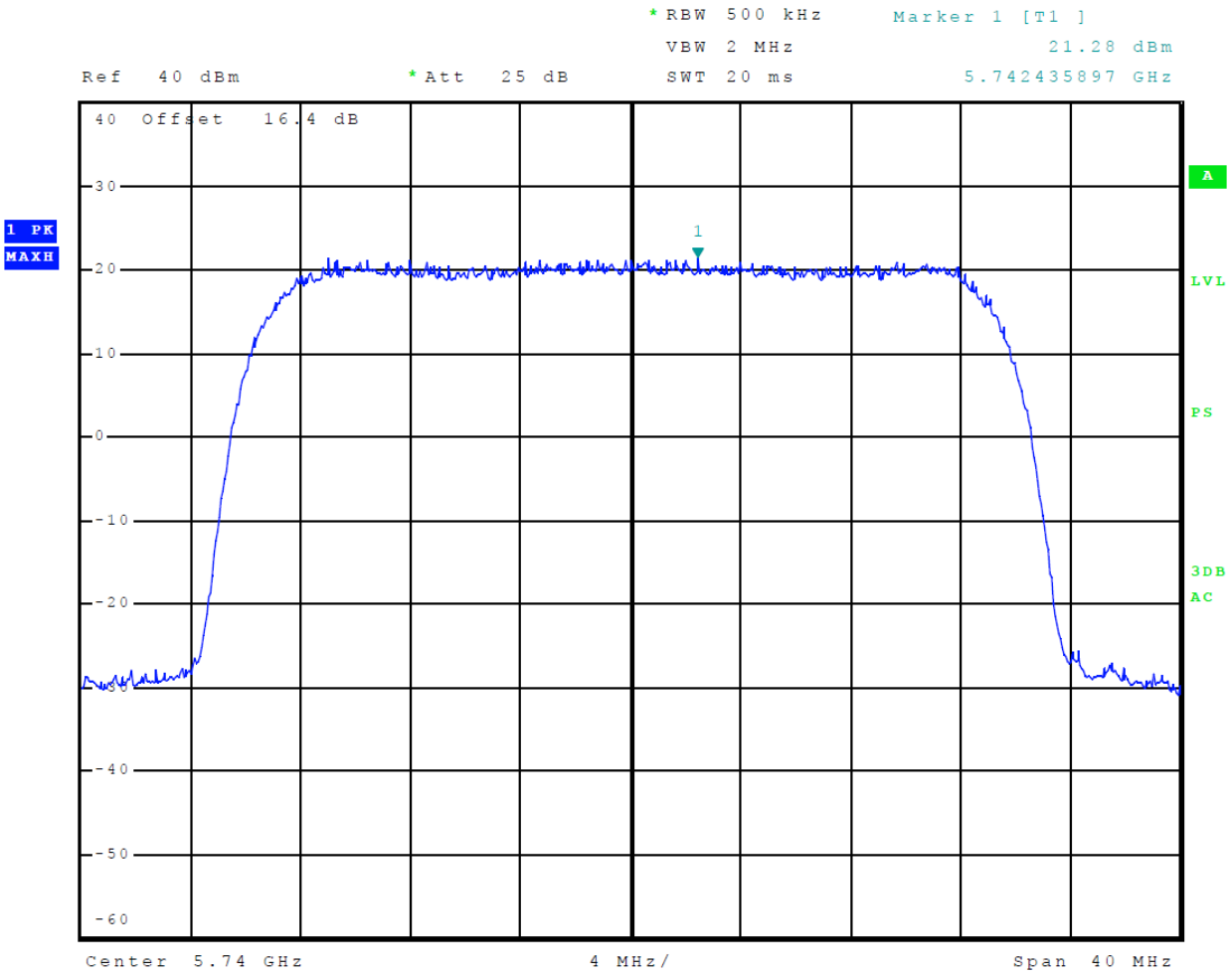


Figure 24 Plot of Power Spectral Density (30 MHz Channel 64QAM)

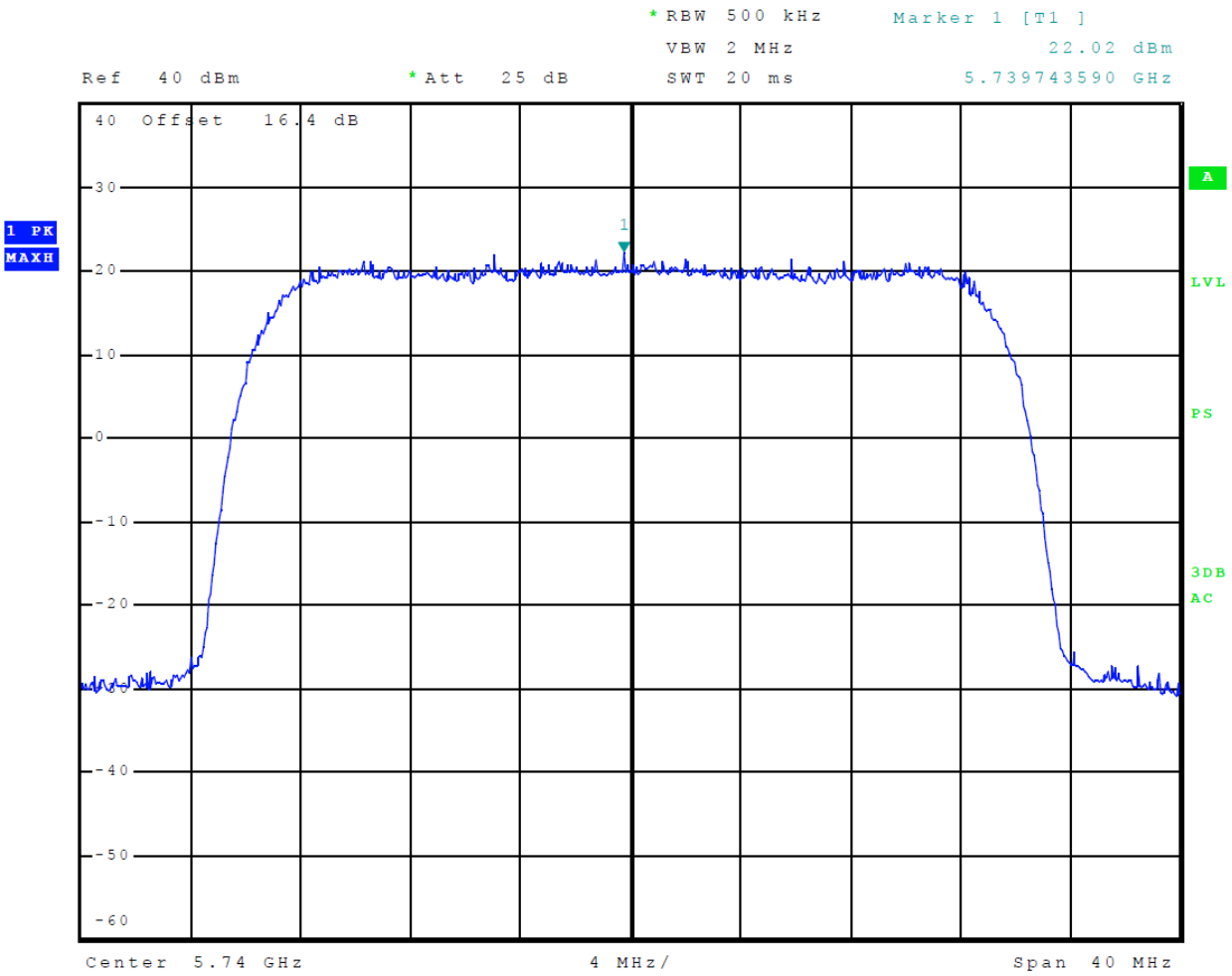


Figure 25 Plot of Power Spectral Density (30 MHz Channel 128QAM)

TEST #3 Undesirable emissions 15.407(b)(4) Conducted

The undesirable emissions from an intentional radiator shall not exceed the field strength levels specified. Emissions testing as performed at the antenna port and investigation made using all available modulations. Change in modulation had no impact on emission spectral profile. Antenna Port Conducted emission testing was performed in a screen room. Conducted emissions testing was performed as directed in 789033 D02 General UNII Test Procedures New Rules v02r01. Worst-case emissions are documented in this report.

§15.407(b)(4) Undesirable emission limits

(b) *Undesirable emission limits.* Except as shown in paragraph (b)(7) of this section, the maximum emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:

(4) For transmitters operating in the 5.725-5.85 GHz band:

(i) All emissions shall be limited to a level of −27 dBm/MHz at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.

(ii) Devices certified before March 2, 2017 with antenna gain greater than 10 dBi may demonstrate compliance with the emission limits in §15.247(d), but manufacturing, marketing, and importing of devices certified under this alternative must cease by March 2, 2018. Devices certified before March 2, 2018 with antenna gain of 10 dBi or less may demonstrate compliance with the emission limits in §15.247(d), but manufacturing, marketing, and importing of devices certified under this alternative must cease before March 2, 2020.

(5) The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz.

(6) Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in §15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in §15.207.

(7) The provisions of §15.205 apply to intentional radiators operating under this section.

(8) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the upper and lower frequency band edges as the design of the equipment permits.

Methods of Measurement Undesirable emissions

G. Unwanted Emission Measurement

Note: Sections 1. and 2. below cover measurements in the restricted and non-restricted bands, respectively. However, those sections are not self-contained. Rather, they reference the general unwanted emissions measurement requirements in Section 3. and the specific measurement procedures in Sections 4., 5., and 6.

2. Unwanted Emissions that fall Outside of the Restricted Bands

a) For all measurements, follow the requirements in II.G.3. *"General Requirements for Unwanted Emissions Measurements."*

b) At frequencies below 1000 MHz, use the procedure described in II.G.4. *"Procedure for Unwanted Emissions Measurements Below 1000 MHz."*

c) At frequencies above 1000 MHz, use the procedure for maximum emissions described in II.G.5., *"Procedure for Unwanted Emissions Measurements Above 1000 MHz."*

(i) Sections 15.407(b)(1) to (b)(3) specify the unwanted emission limits for the U-NII-1 and U-NII-2 bands. As specified, emissions above 1000 MHz that are outside of the restricted bands are subject to a peak emission limit of -27 dBm/MHz.[3]

(ii) Section 15.407(b)(4) specifies the unwanted emission limit for the U-NII-3 band. A band emissions mask is specified in Section 15.407(b)(4)(i). The emission limits are in terms of a Peak detector. An alternative to the band emissions mask is specified in Section 15.407(b)(4)(ii). The alternative limits are based on the highest antenna gain specified in the filing. There are also marketing and importation restrictions for the devices using the alternative limit.[4]

d) If *radiated* measurements are performed, field strength is then converted to EIRP as follows:

(i) EIRP = ((E×d)^2) / 30

where:

- E is the field strength in V/m;
- d is the measurement distance in meters;
- EIRP is the equivalent isotropically radiated power in watts.

(ii) Working in dB units, the above equation is equivalent to:

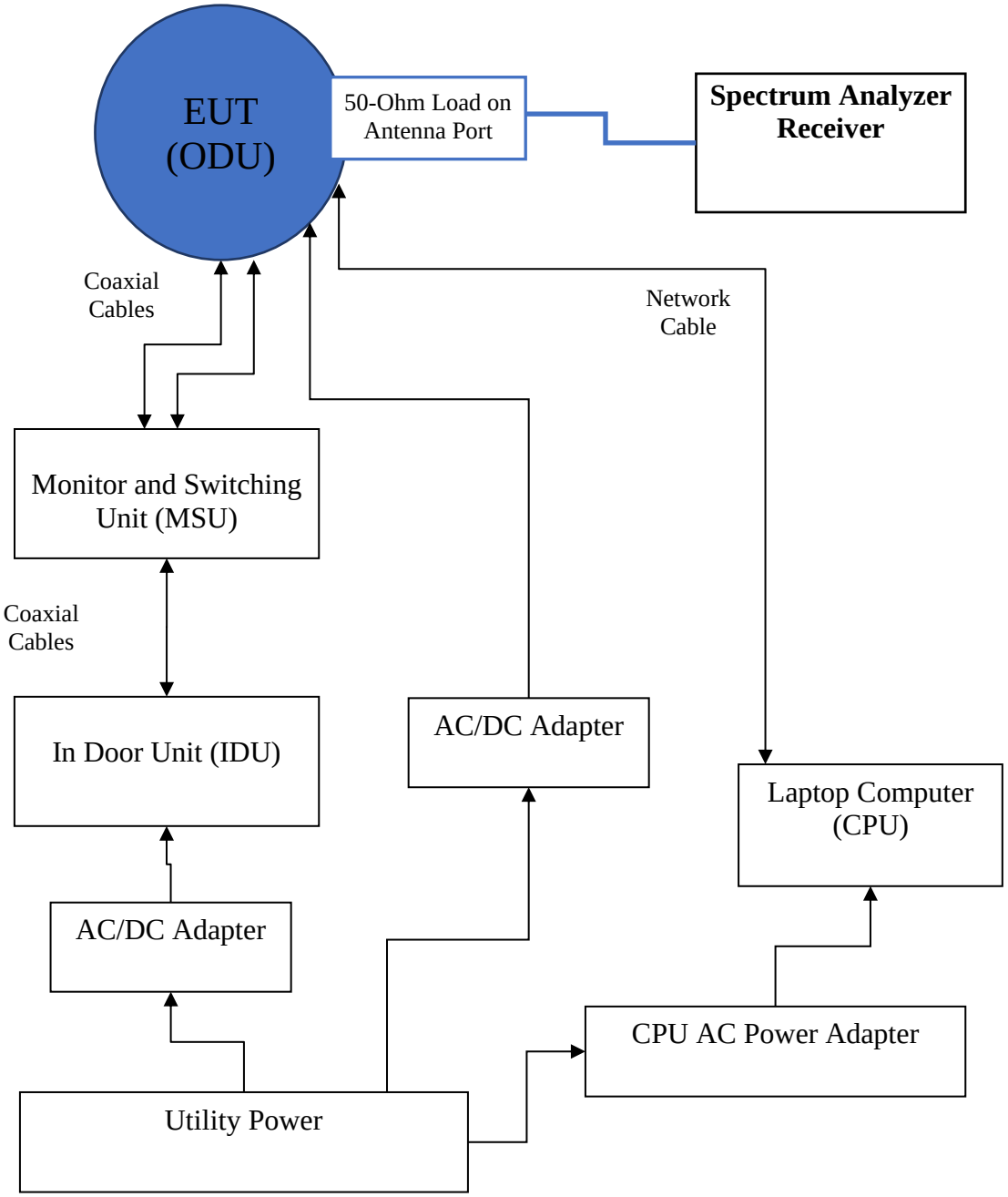
EIRP[dBm] = E[dBµV/m] + 20 log (d[meters]) - 104.77

(iii) Or, if d is 3 meters:

EIRP[dBm] = E[dBµV/m] - 95.2

The EUT was arranged as diagramed below and operated through all available modulation modes with worst-case data recorded. The frequency spectrum from 9 kHz to 60,000 MHz was searched for undesirable emissions.

Test Arrangement antenna port conducted Undesirable emissions



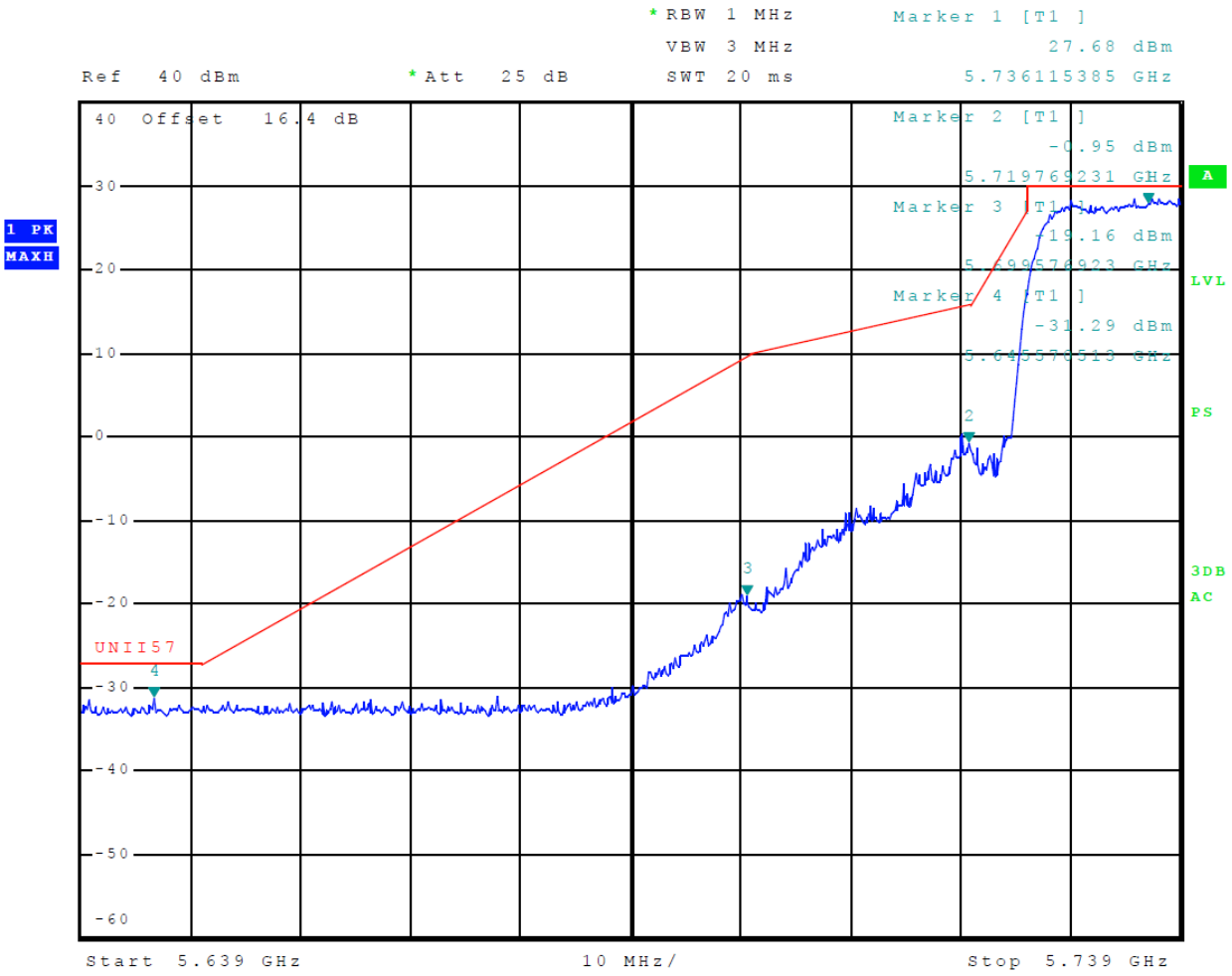


Figure 26 Plot of Undesirable emissions (28 MHz Channel)

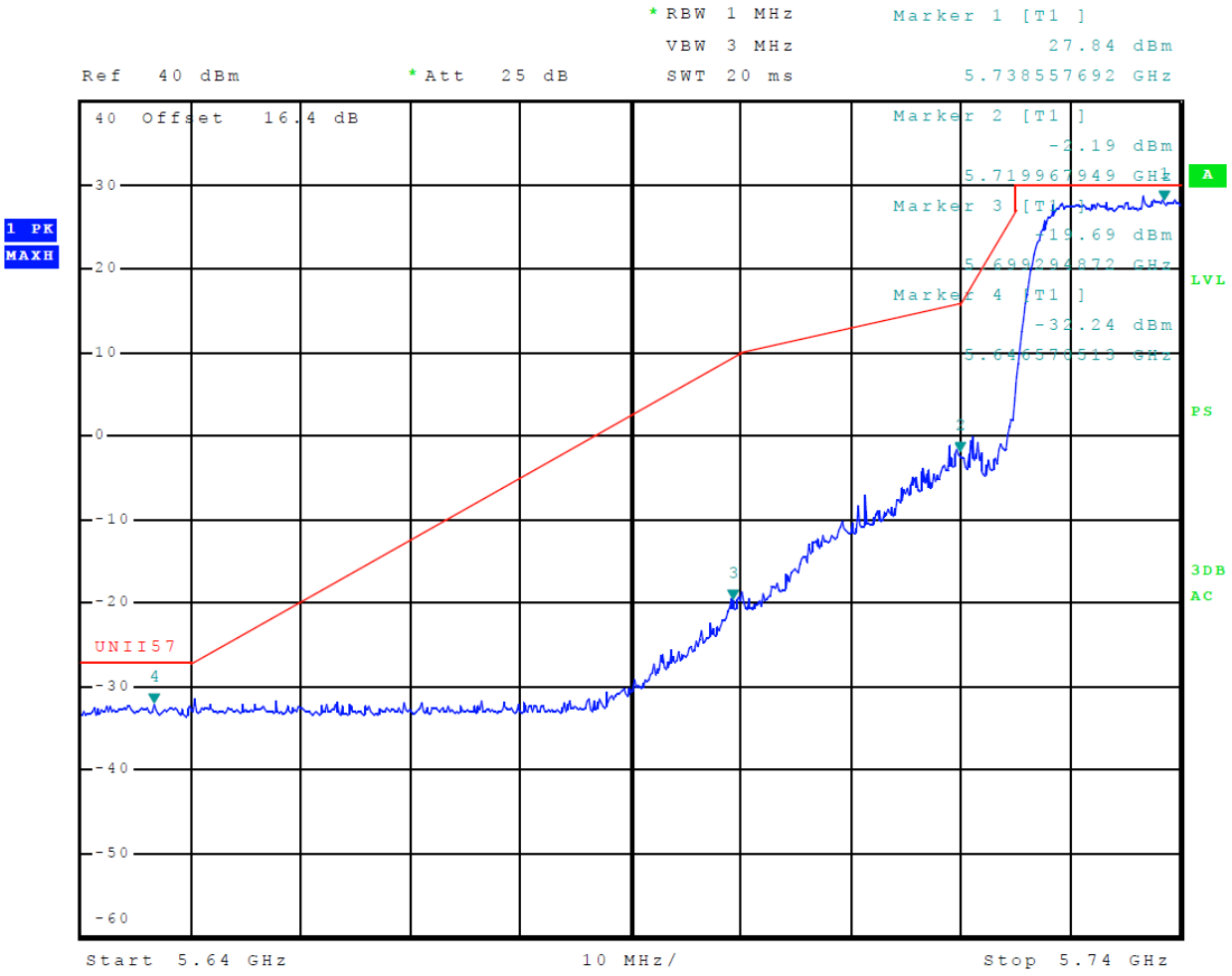


Figure 27 Plot of Undesirable emissions (30 MHz Channel)

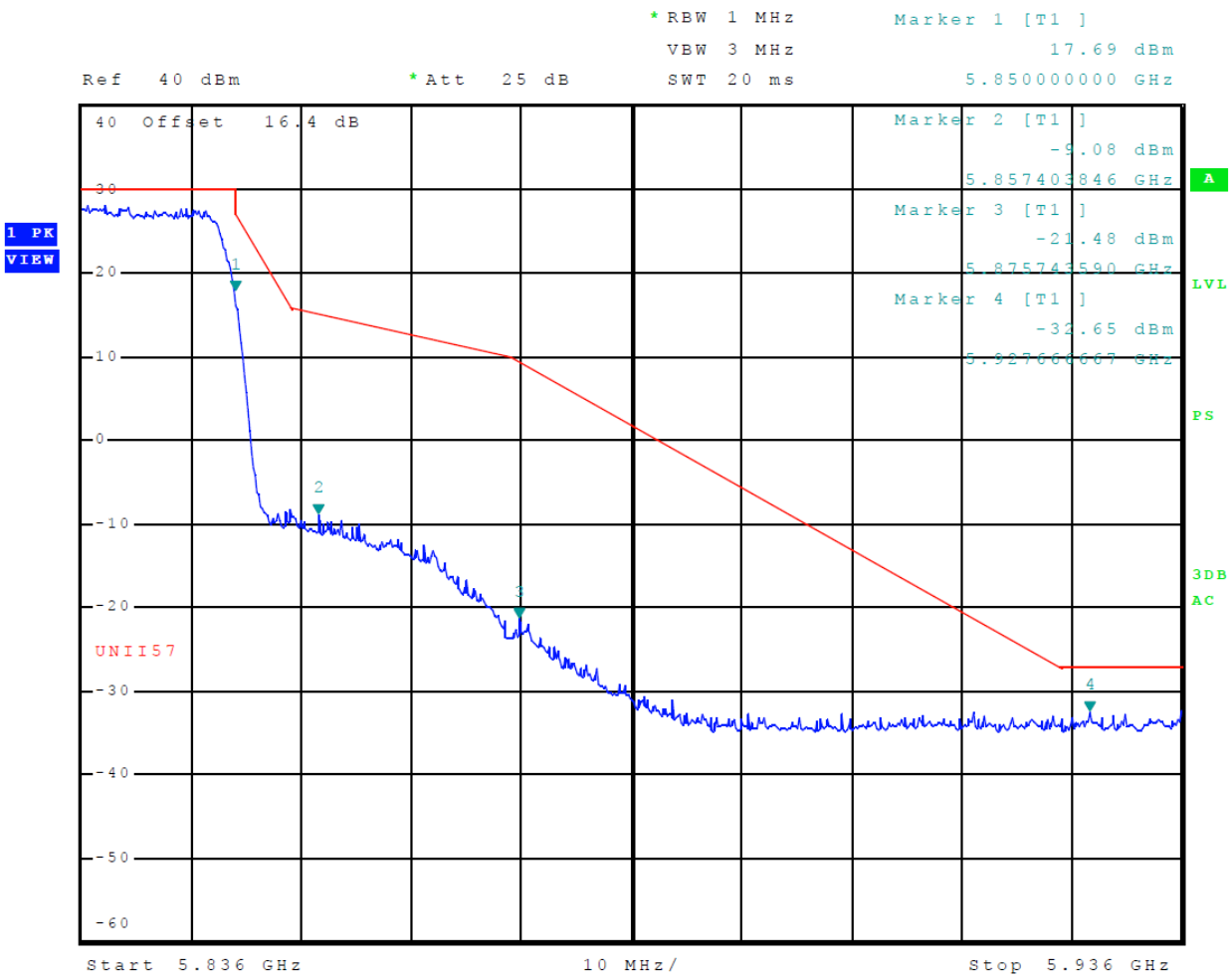


Figure 28 Plot of Undesirable emissions (28 MHz Channel)

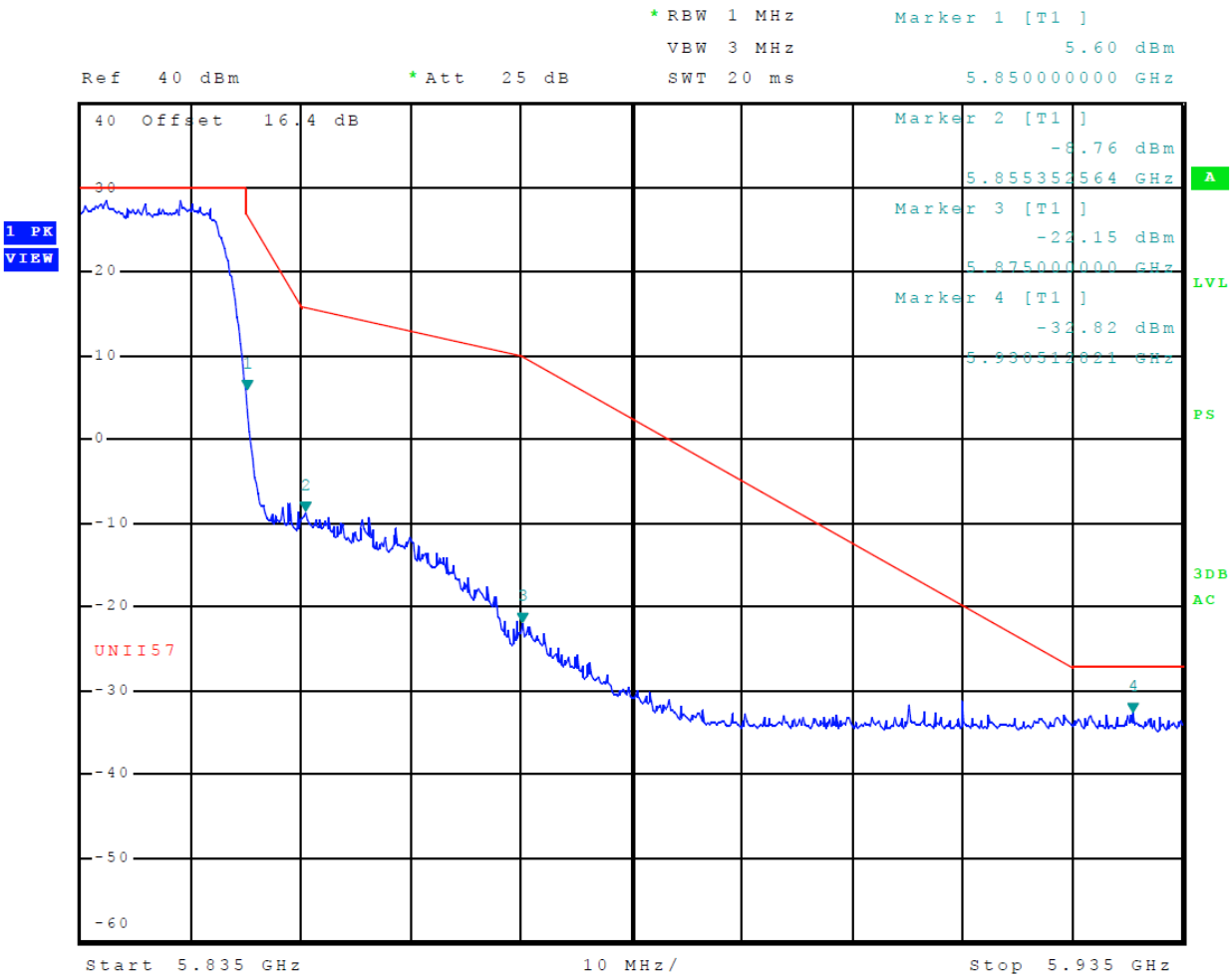


Figure 29 Plot of Undesirable emissions (30 MHz Channel)

TEST #4 Undesirable emissions 15.407(b)(4) Radiated

The undesirable emissions from an intentional radiator shall not exceed the field strength levels specified. Emissions testing as performed at the antenna port and investigation made using all available modulations. Change in modulation had no impact on emission spectral profile. Radiated emission testing was performed on the OATS measuring radiated emissions as required. Radiated emissions testing was performed as directed in 789033 D02 General UNII Test Procedures New Rules v02r01. Worst-case emissions are documented in this report.

§15.407(b)(4) Undesirable emission limits

(b) *Undesirable emission limits.* Except as shown in paragraph (b)(7) of this section, the maximum emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:

(4) For transmitters operating in the 5.725-5.85 GHz band:

(i) All emissions shall be limited to a level of −27 dBm/MHz at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.

(ii) Devices certified before March 2, 2017 with antenna gain greater than 10 dBi may demonstrate compliance with the emission limits in §15.247(d), but manufacturing, marketing, and importing of devices certified under this alternative must cease by March 2, 2018. Devices certified before March 2, 2018 with antenna gain of 10 dBi or less may demonstrate compliance with the emission limits in §15.247(d), but manufacturing, marketing, and importing of devices certified under this alternative must cease before March 2, 2020.

(5) The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz.

(6) Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in §15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in §15.207.

(7) The provisions of §15.205 apply to intentional radiators operating under this section.

(8) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the upper and lower frequency band edges as the design of the equipment permits.

Methods of Measurement Undesirable emissions

G. Unwanted Emission Measurement

Note: Sections 1. and 2. below cover measurements in the restricted and non-restricted bands, respectively. However, those sections are not self-contained. Rather, they reference the general unwanted emissions measurement requirements in Section 3. and the specific measurement procedures in Sections 4., 5., and 6.

2. Unwanted Emissions that fall Outside of the Restricted Bands

a) For all measurements, follow the requirements in II.G.3. *"General Requirements for Unwanted Emissions Measurements."*

b) At frequencies below 1000 MHz, use the procedure described in II.G.4. *"Procedure for Unwanted Emissions Measurements Below 1000 MHz."*

c) At frequencies above 1000 MHz, use the procedure for maximum emissions described in II.G.5., *"Procedure for Unwanted Emissions Measurements Above 1000 MHz."*

(i) Sections 15.407(b)(1) to (b)(3) specify the unwanted emission limits for the U-NII-1 and U-NII-2 bands. As specified, emissions above 1000 MHz that are outside of the restricted bands are subject to a peak emission limit of -27 dBm/MHz.[3]

(ii) Section 15.407(b)(4) specifies the unwanted emission limit for the U-NII-3 band. A band emissions mask is specified in Section 15.407(b)(4)(i). The emission limits are in terms of a Peak detector. An alternative to the band emissions mask is specified in Section 15.407(b)(4)(ii). The alternative limits are based on the highest antenna gain specified in the filing. There are also marketing and importation restrictions for the devices using the alternative limit.[4]

d) If *radiated* measurements are performed, field strength is then converted to EIRP as follows:

(i) EIRP = ((E×d)^2) / 30

where:

- E is the field strength in V/m;
- d is the measurement distance in meters;
- EIRP is the equivalent isotropically radiated power in watts.

(ii) Working in dB units, the above equation is equivalent to:

EIRP[dBm] = E[dBµV/m] + 20 log (d[meters]) - 104.77

(iii) Or, if d is 3 meters:

EIRP[dBm] = E[dBµV/m] - 95.2

Test Arrangement Radiated Undesirable emissions

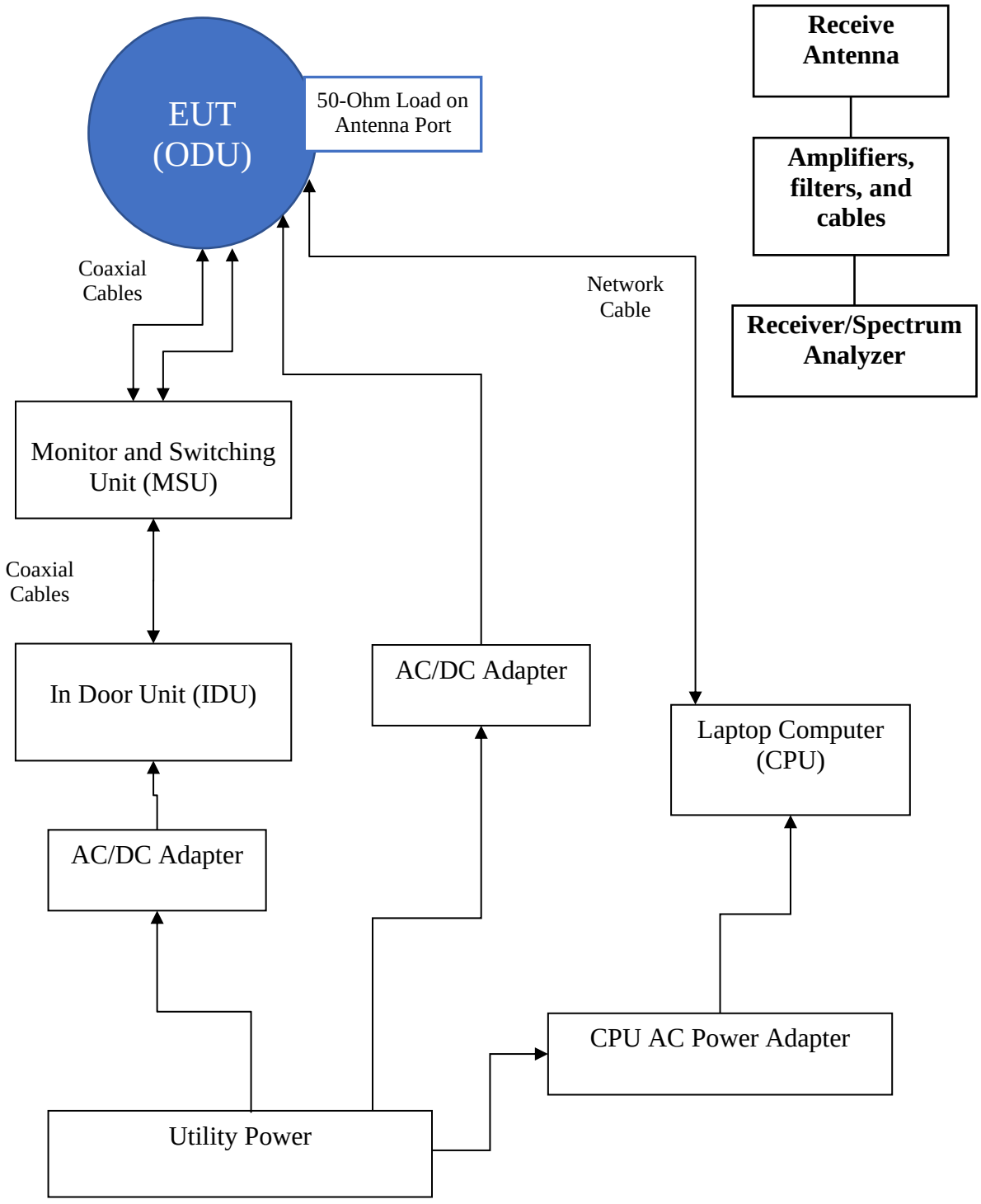


Table 3 Undesirable emissions, Radiated Data

Frequency in MHz	Horizontal Peak (dBµV/m)	Horizontal Average (dBµV/m)	Vertical Peak (dBµV/m)	Vertical Average (dBµV/m)	Limit @ 3m (dBµV/m)
5739.0	--	--	--	--	--
11478.0	57.9	44.5	57.4	44.6	68.3
17217.0	63.7	50.8	63.5	50.7	68.3
22956.0	65.7	52.6	65.7	52.6	68.3
28695.0	68.1	55.2	68.3	55.2	68.3
5835.0	--	--	--	--	--
11670.0	59.1	45.6	58.9	45.2	68.3
17505.0	64.2	51.4	64.4	51.2	68.3
23340.0	65.8	52.7	65.7	52.7	68.3
29175.0	69.1	56.0	68.7	55.9	68.3
5836.0	--	--	--	--	--
11672.0	59.4	46.1	58.7	45.3	68.3
17508.0	65.1	52.0	64.8	51.4	68.3
23344.0	65.9	52.4	66.3	52.5	68.3
29180.0	69.2	56.3	69.8	56.4	68.3
Band Edges					
5725.0	69.1	56.3	62.1	48.4	78.2
5850.0	67.2	54.5	59.1	46.6	78.2

Other emissions present had amplitudes at least 20 dB below the limit. Peak and Quasi-Peak amplitude emissions are recorded above for frequency range of 30-1000 MHz. Peak and Average amplitude emissions are recorded above for frequency range above 1000 MHz.

TEST #5 Minimum 6-dB Bandwidth 15.407(e)

The minimum 6 dB bandwidth of U-NII devices in the 5725-5850 MHz band shall be at least 500 kHz. Testing was performed as directed in KDB 789033 D02 General UNII Test Procedures New Rules v02r01for 6-dB Occupied Bandwidth.

§15.407(e) General technical requirements

(e) Within the 5.725-5.85 GHz band, the minimum 6 dB bandwidth of U-NII devices shall be at least 500 kHz.

Methods of Measurement Minimum 6-dB Bandwidth

789033 D02 General UNII Test Procedures New Rules v02r01

C. Bandwidth Measurement

2. **Minimum Emission Bandwidth for the band 5.725-5.85 GHz**

Section 15.407(e) specifies the minimum 6 dB emission bandwidth of at least 500 kHz for the band 5.725-5.85 GHz. The following procedure shall be used for measuring this bandwidth:

a) Set RBW = 100 kHz.
b) Set the video bandwidth (VBW) ≥ 3 □ RBW.
c) Detector = Peak.
d) Trace mode = max hold.
e) Sweep = auto couple.
f) Allow the trace to stabilize.
g) Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

Note: The automatic bandwidth measurement capability of a spectrum analyzer or EMI receiver may be employed if it implements the functionality described above.

Test Arrangement Minimum 6-dB Bandwidth

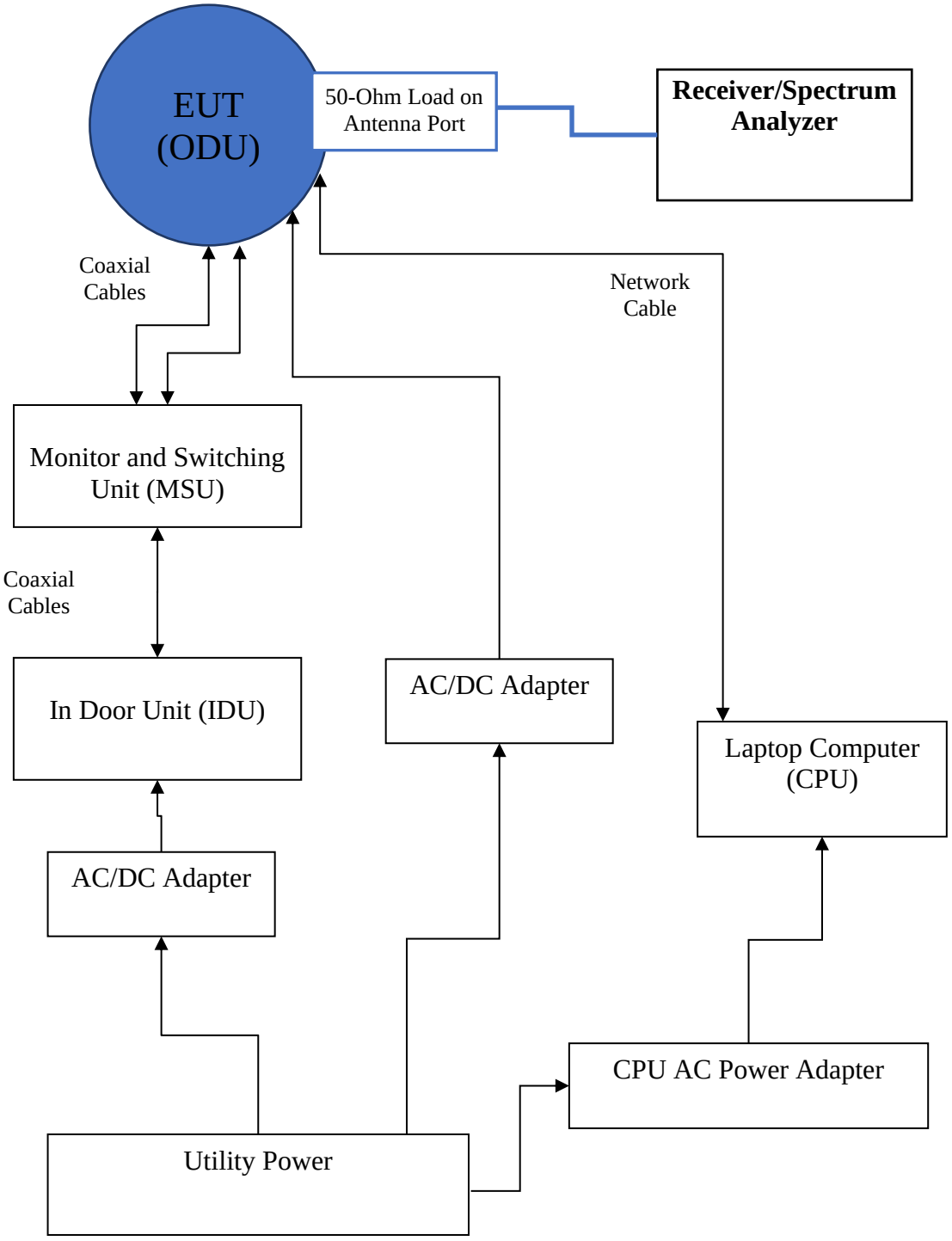


Table 4 Minimum 6-dB Bandwidth data

Frequency MHz	99% Occupied Bandwidth (kHz)	6-dB Bandwidth (kHz)	26-dB Bandwidth (kHz)
28 MHz Channel (4QAM)			
5739.0	26,731	25,385	29,711
5834.0	26,683	25,561	29,728
5836.0	26,683	25,641	29,728
28 MHz Channel (16QAM)			
5739.0	26,635	25,769	29,615
5834.0	26,683	25,561	29,647
5836.0	26,683	25,962	29,647
28 MHz Channel (32QAM)			
5739.0	26,730	25,630	29,711
5834.0	26,683	25,721	29,647
5836.0	26,683	25,801	29,647
28 MHz Channel (64QAM)			
5739.0	26,730	25,673	29,615
5834.0	26,683	25,881	29,647
5836.0	26,683	25,721	29,647
28 MHz Channel (128QAM)			
5739.0	26,635	25,865	29,711
5834.0	26,683	25,641	29,728
5836.0	26,683	25,801	29,647
30 MHz Channel (4QAM)			
5740.0	26,635	25,673	29,615
5835.0	26,683	25,801	29,728
30 MHz Channel 16QAM)			
5740.0	26,635	25,673	29,615
5835.0	26,683	25,881	29,647
30 MHz Channel (32QAM)			
5740.0	26,635	26,154	29,615
5835.0	26,683	26,122	29,728
30 MHz Channel (64QAM)			
5740.0	26,635	25,673	29,615
5835.0	26,683	25,801	29,647
30 MHz Channel (128QAM)			
5740.0	26,635	25,288	29,615
5835.0	26,683	28,551	29,647

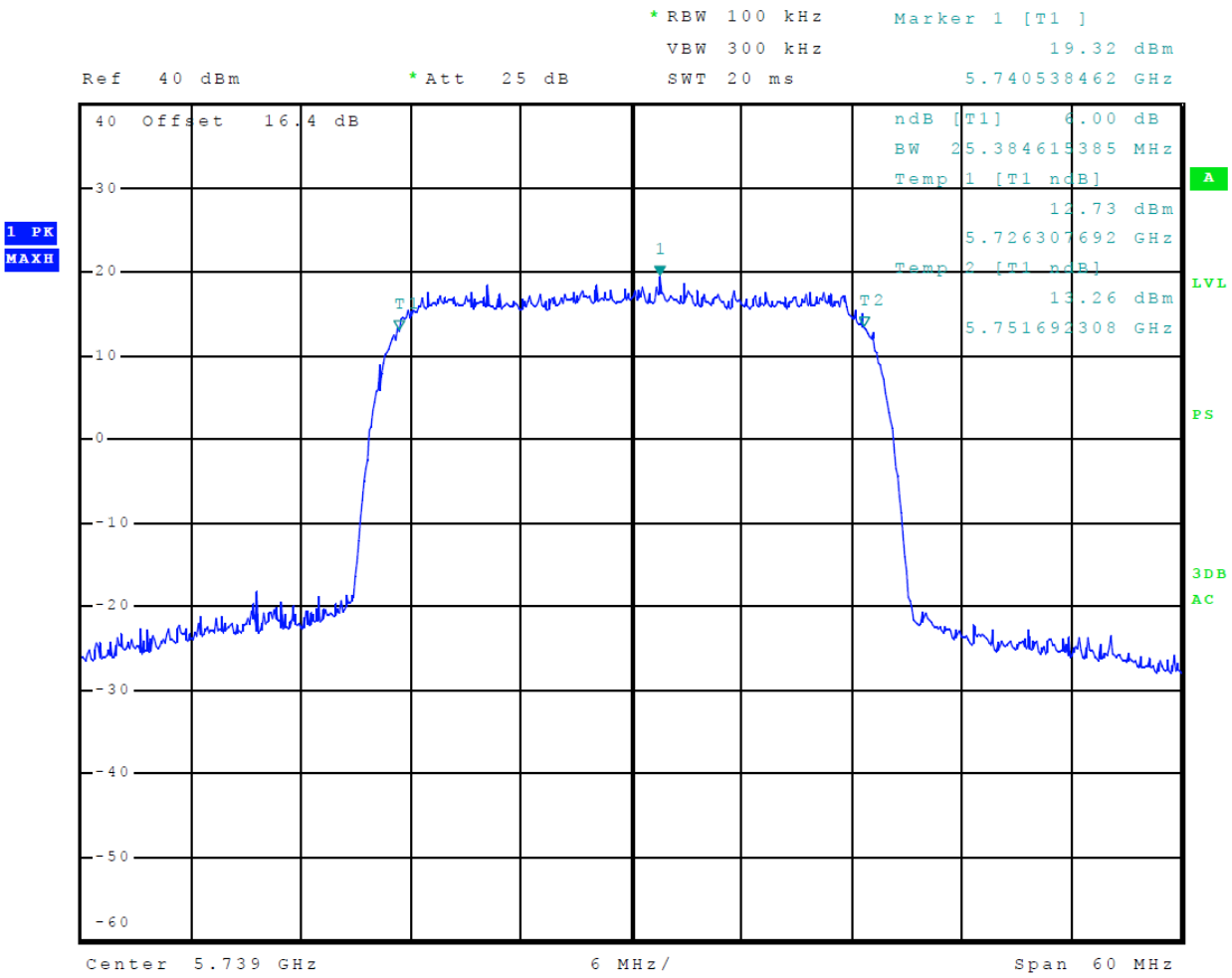


Figure 30 Plot of Minimum 6-dB Bandwidth (28 MHz Channel)

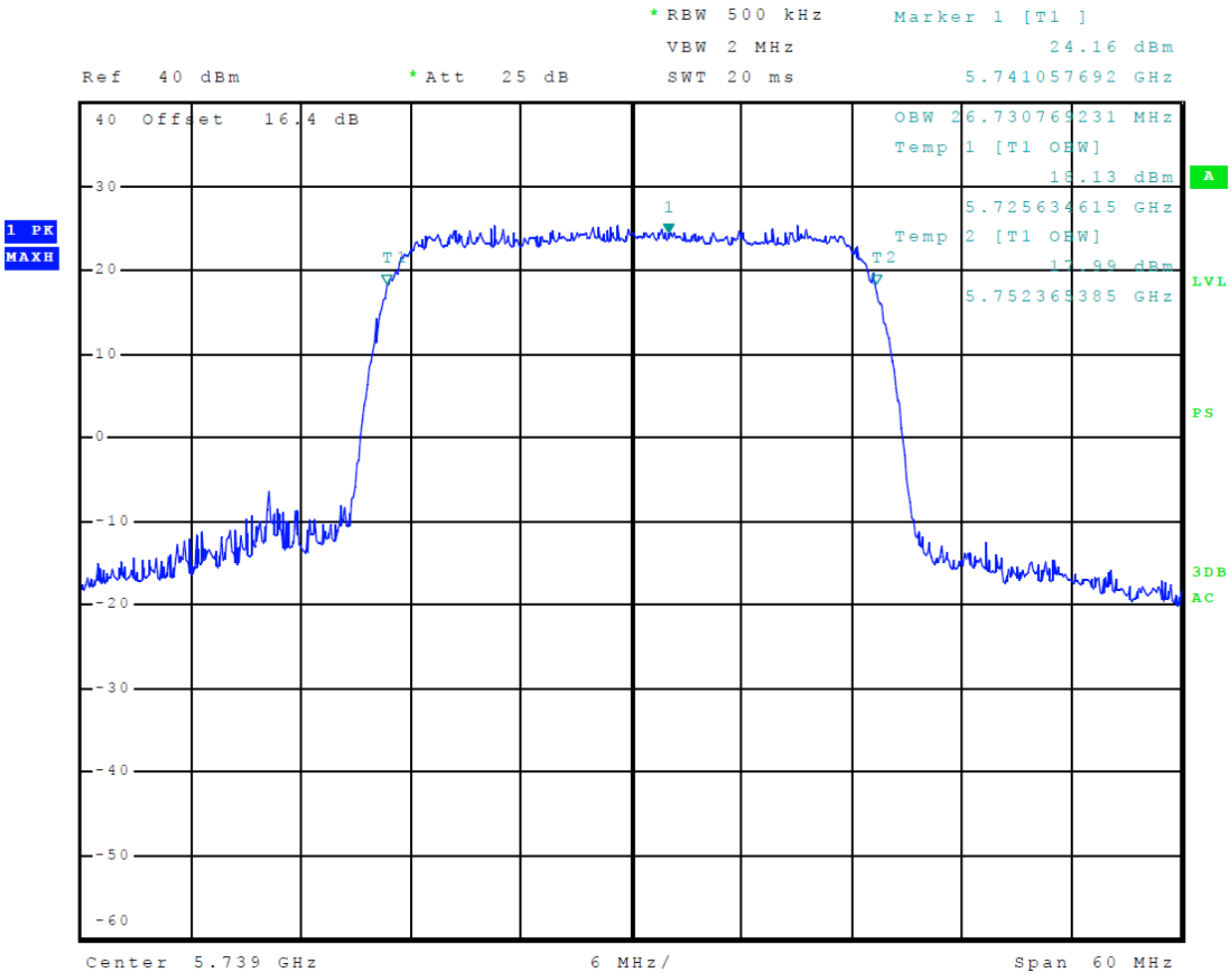


Figure 31 Plot of 99% OBW (28 MHz Channel)

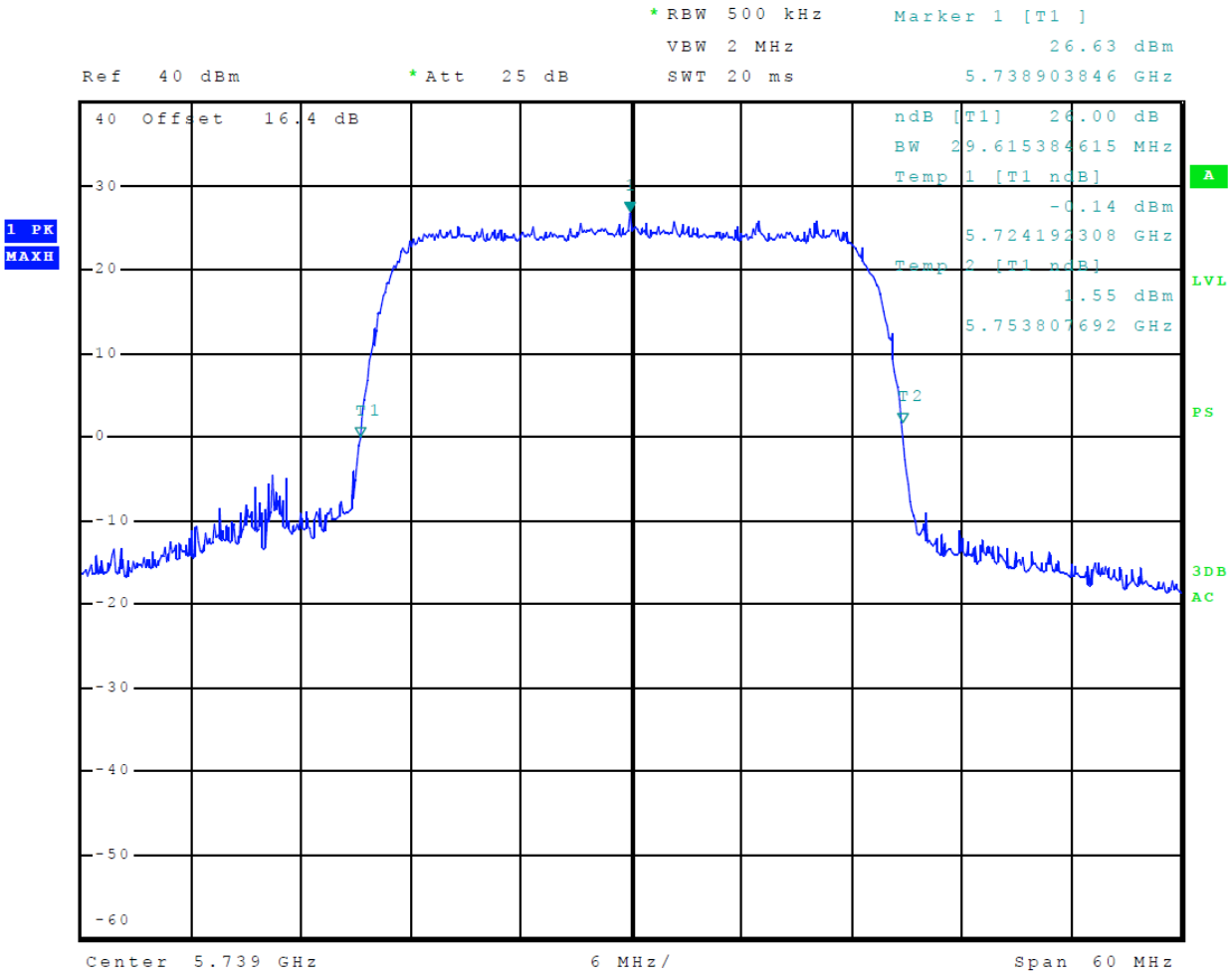


Figure 32 Plot of 26-dB OBW (28 MHz Channel)

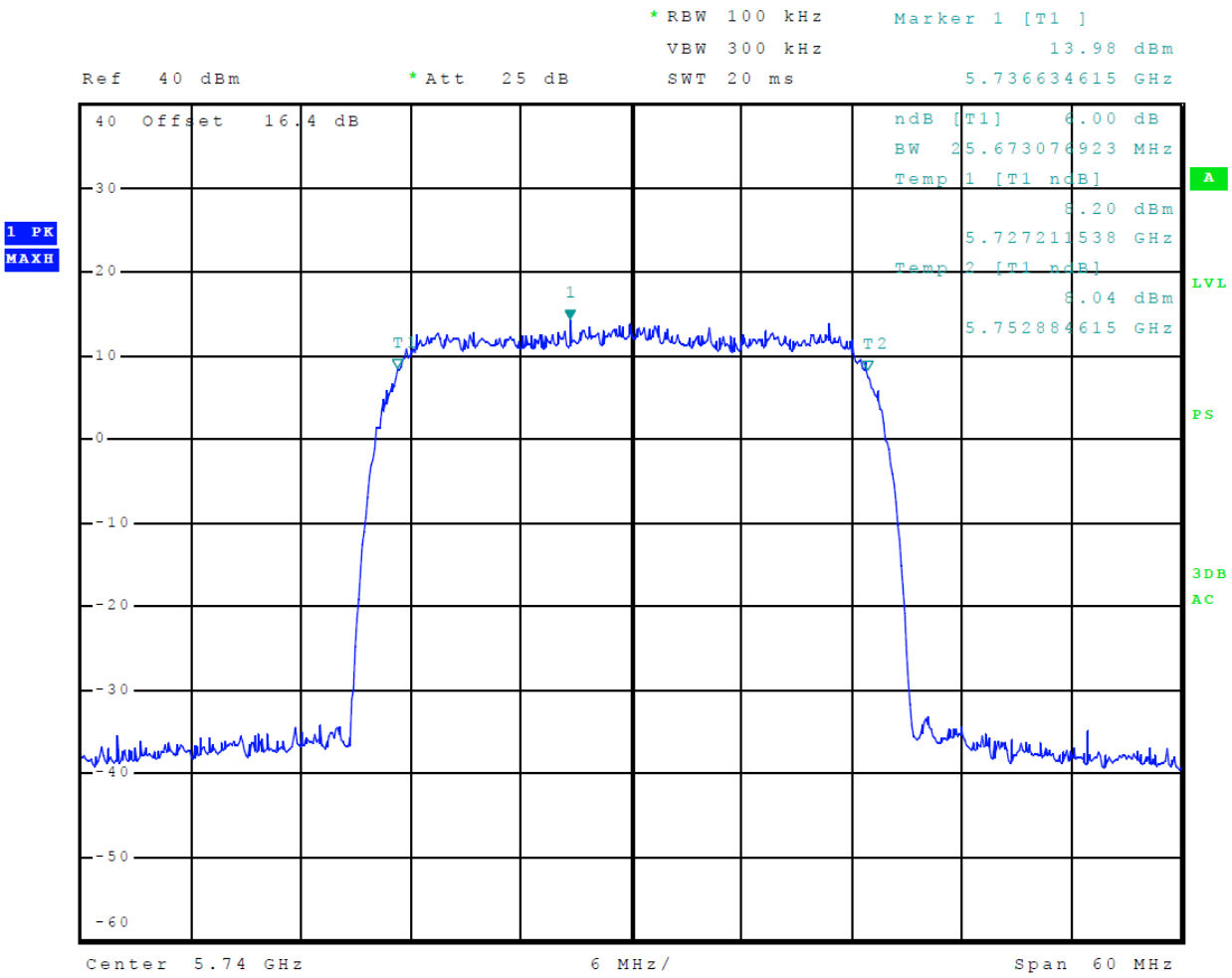


Figure 33 Plot of Minimum 6-dB Bandwidth (30 MHz Channel)

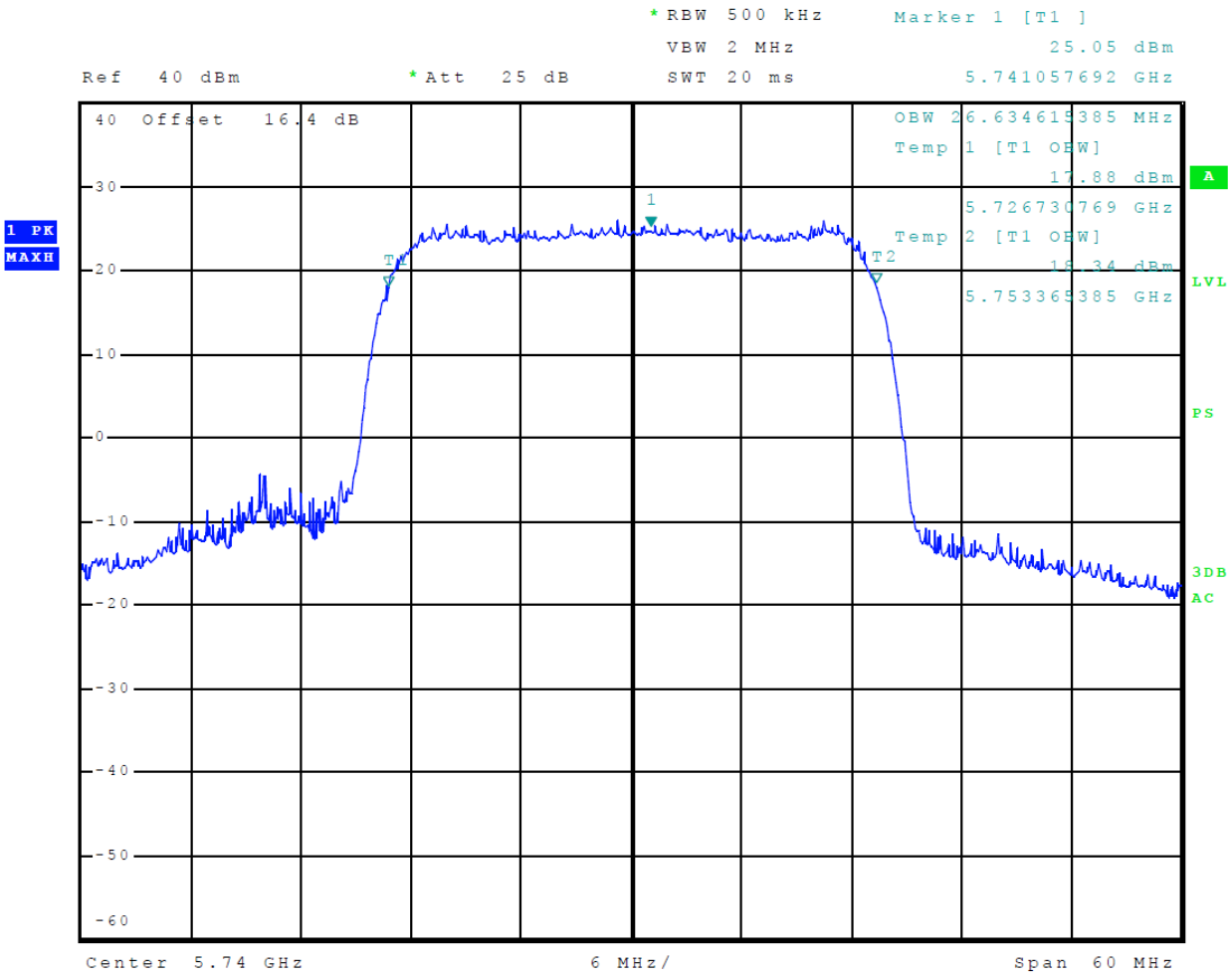


Figure 34 Plot of Transmitter 99% OBW (30 MHz Channel)

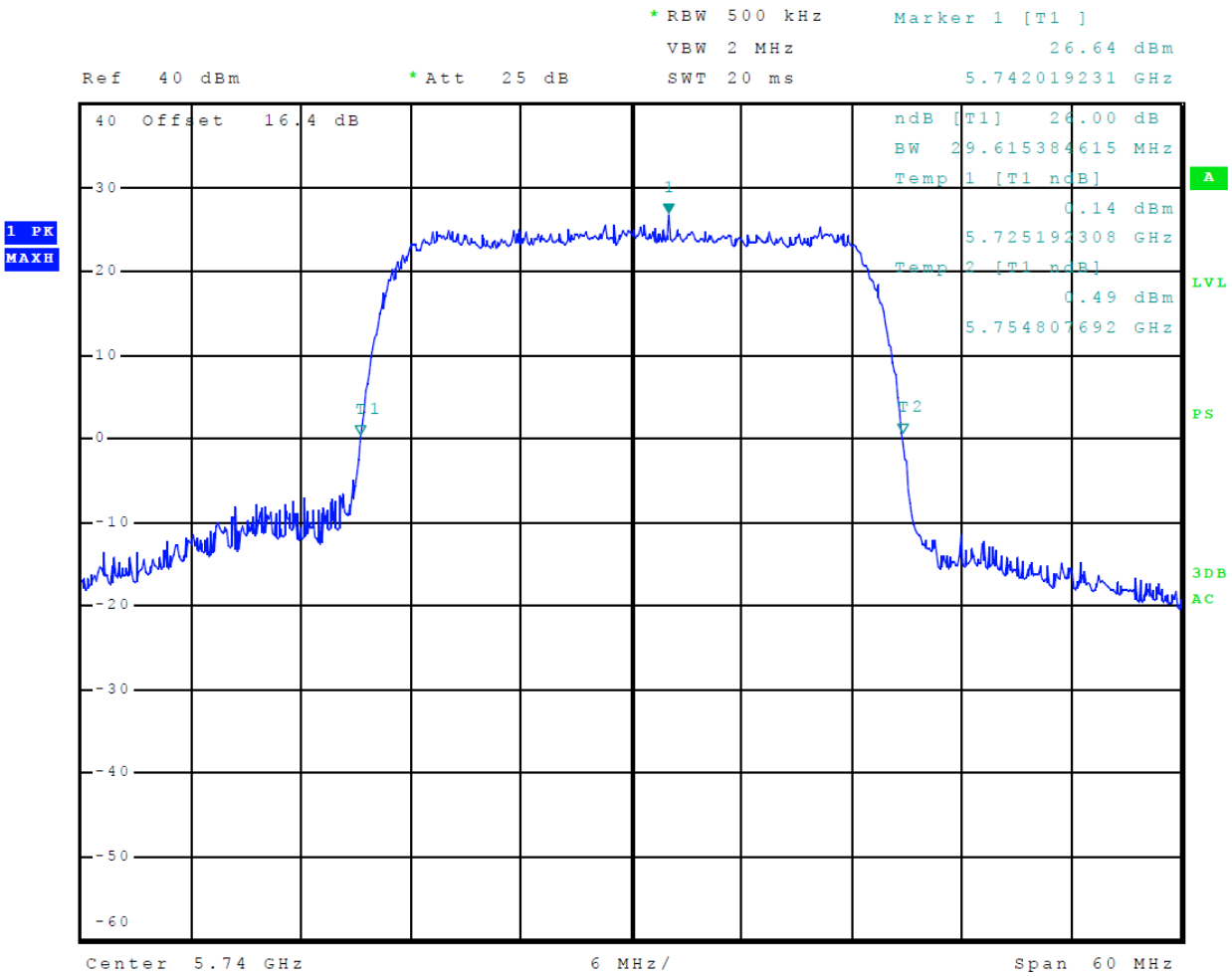


Figure 35 Plot of 26-dB OBW (30 MHz Channel)

TEST #6 Frequency Stability 15.407(g)

U-NII devices are responsible for ensuring frequency stability such that an emission is maintained within the band of operation. The manufacturer has attested the equipment will remain in the frequency band of operation under all normal operational use conditions. Additional temperature stability testing was performed, and stability verified. Testing was performed as defined in ANSI C63.10-2013.

§15.407(g) General technical requirements

(g) Manufacturers of U-NII devices are responsible for ensuring frequency stability such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the user's manual.

Methods of Measurement Frequency Stability

ANSI C63.10-2013

6.8 Frequency stability tests

Some unlicensed wireless device requirements specify frequency stability tests with variation of supply voltage and temperature; the requirements can be found in the regulatory specifications for each type of unlicensed wireless device. The procedures listed in 6.8.1 and 6.8.2 shall be used for frequency stability tests.

6.8.1 Frequency stability with respect to ambient temperature

a) Supply the EUT with a nominal ac voltage or install a new or fully charged battery in the EUT. If possible, a dummy load shall be connected to the EUT because an antenna near the metallic walls of an environmental test chamber could affect the output frequency of the EUT. If the EUT is equipped with a permanently attached, adjustable-length antenna, then the EUT shall be placed in the center of the chamber with the antenna adjusted to the shortest length possible. Turn ON the EUT and tune it to one of the number of frequencies shown in 5.6.

b) Couple the unlicensed wireless device output to the measuring instrument by connecting an antenna to the measuring instrument with a suitable length of coaxial cable and placing the measuring antenna near the EUT (e.g., 15 cm away), or by connecting a dummy load to the measuring instrument, through an attenuator if necessary.

NOTE—An instrument that has an adequate level of accuracy as specified by the procuring or regulatory agency is the recommended measuring instrument.

c) Adjust the location of the measurement antenna and the controls on the measurement instrument to obtain a suitable signal level (i.e., a level that will not overload the measurement instrument but is strong enough to allow measurement of the operating or fundamental frequency of the EUT).

d) Turn the EUT OFF and place it inside the environmental temperature chamber. For devices that have oscillator heaters, energize only the heater circuit.

e) Set the temperature control on the chamber to the highest specified in the regulatory requirements for the type of device and allow the oscillator heater and the chamber temperature to stabilize.

f) While maintaining a constant temperature inside the environmental chamber, turn the EUT ON and record the operating frequency at startup, and at 2 minutes, 5 minutes, and 10 minutes after the EUT is energized. Four measurements in total are made.

g) Measure the frequency at each of frequencies specified in 5.6.

h) Switch OFF the EUT but do not switch OFF the oscillator heater.

i) Lower the chamber temperature by not more that 10 °C, and allow the temperature inside the chamber to stabilize.

j) Repeat step f) through step i) down to the lowest specified temperature.

6.8.2 Frequency stability when varying supply voltage

Unless otherwise specified, these tests shall be made at ambient room temperature (+15 °C to +25 °C). An antenna shall be connected to the antenna output terminals of the EUT if possible. If the EUT is equipped with or uses an adjustable-length antenna, then it shall be fully extended.

a) Supply the EUT with nominal voltage or install a new or fully charged battery in the EUT. Turn ON the EUT and couple its output to a frequency counter or other frequency-measuring instrument.

NOTE—An instrument that has an adequate level of accuracy as specified by the procuring or regulatory agency is the recommended measuring instrument.

b) Tune the EUT to one of the number of frequencies required in 5.6. Adjust the location of the measurement antenna and the controls on the measurement instrument to obtain a suitable signal level (i.e., a level that will not overload the measurement instrument but is strong enough to allow measurement of the operating or fundamental frequency of the EUT).

c) Measure the frequency at each of the frequencies specified in 5.6.

d) Repeat the above procedure at 85% and 115% of the nominal supply voltage as described in 5.13.

The manufacturer attests the equipment operates within the authorized frequency band as required.

TEST #7 Antenna Requirements 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.

§15.203 Antenna requirement.

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. This requirement does not apply to carrier current devices or to devices operated under the provisions of §§15.211, 15.213, 15.217, 15.219, 15.221, or §15.236. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

The design provides single wave guide port for connection with authorized antennas. The design requires professional installation for compliance with unique antenna port connector requirements. The antenna connection provision complies with the unique antenna connection requirements. The requirements of 15.203 are fulfilled there are no deviations or exceptions to the specification.

TEST #8 Radiated Emissions in Restricted Bands of Operation 15.205

Spurious radiated emissions falling in the restricted frequency bands of operation were measured on the OATS. The EUT utilizes frequency, determining circuitry, which generates harmonics falling in restricted bands. Emissions testing as performed at the antenna port and as well as radiated emissions testing using all available modulations. Change in modulation had no impact on emission spectral profile. Radiated emission testing was performed on the OATS measuring radiated emissions as required. Conducted and radiated emissions testing was performed as directed in 789033 D02 General UNII Test Procedures New Rules v02r01. Worst-case emissions are documented in this report.

§15.407 General technical requirements

(b) *Undesirable emission limits.* Except as shown in paragraph (b)(7) of this section, the maximum emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:
(7) The provisions of §15.205 apply to intentional radiators operating under this section.

§ 15.205 Restricted bands of operation.

(a) Except as shown 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	399.9-410	4.5-5.15
[1]0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	([2])
13.36-13.41			

Methods of Measurement Radiated Emissions in Restricted Bands

789033 D02 General UNII Test Procedures New Rules v01r04

G. Unwanted Emission Measurement

Note: Sections 1. and 2. below cover measurements in the restricted and non-restricted bands, respectively. However, those sections are not self-contained. Rather, they reference the general unwanted emissions measurement requirements in Section 3. and the specific measurement procedures in Sections 4., 5., and 6.

1. Unwanted Emissions in the Restricted Bands

a) For all measurements, follow the requirements in II.G.3. *"General Requirements for Unwanted Emissions Measurements."*

b) At frequencies below 1000 MHz, use the procedure described in II.G.4. *"Procedure for Unwanted Emissions Measurements Below 1000 MHz."*

c) At frequencies above 1000 MHz, measurements performed using the peak and average measurement procedures described in II.G.5. and II.G.6, respectively, must satisfy the respective peak and average limits. If all peak measurements satisfy the average limit, then average measurements are not required.

d) For *conducted* measurements above 1000 MHz, EIRP shall be computed as specified in II.G.3.b) and then field strength shall be computed as follows (see KDB Publication 412172):
(i) E[dBµV/m] = EIRP[dBm] - 20 log (d[meters]) + 104.77, where E = field strength and d = distance at which field strength limit is specified in the rules;

(ii) E[dBµV/m] = EIRP[dBm] + 95.2, for d = 3 meters.
e) For *conducted* measurements below 1000 MHz, the field strength shall be computed as specified in d), above, and then an additional 4.7 dB shall be added as an upper bound on the field strength that would be observed on a test range with a ground plane for frequencies between 30 MHz and 1000 MHz, or an additional 6 dB shall be added for frequencies below 30 MHz.[2]

Test Arrangement Radiated Emissions in Restricted Bands

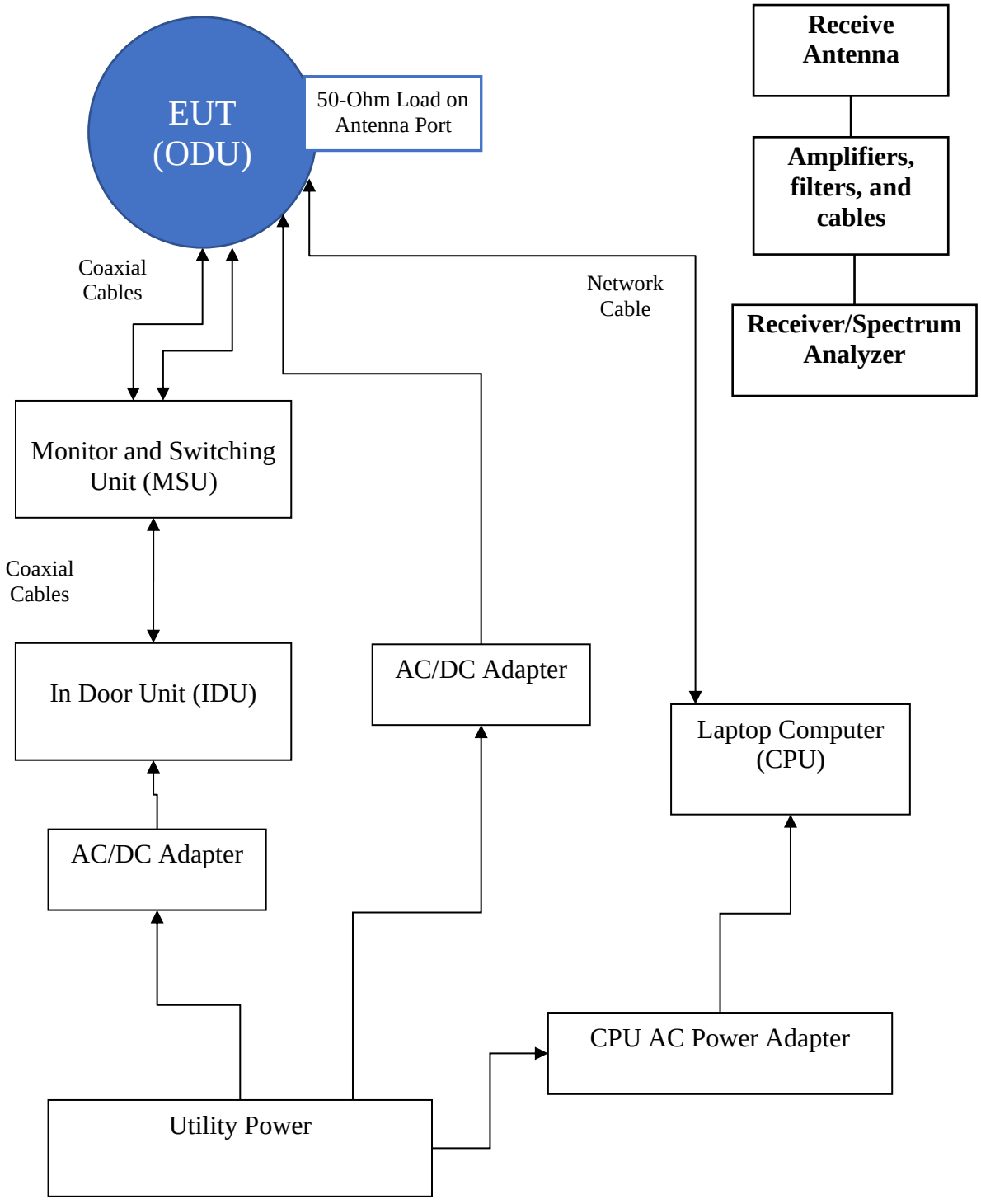


Table 4 Radiated Emissions in Restricted Bands Data

Frequency in MHz	Horizontal Peak (dBµV/m)	Horizontal Average (dBµV/m)	Vertical Peak (dBµV/m)	Vertical Average (dBµV/m)	Limit @ 3m (dBµV/m)	Pass/Fail
11478.0	57.9	44.5	57.4	44.6	54.0	Pass
11670.0	59.1	45.6	58.9	45.2	54.0	Pass
11672.0	59.4	46.1	58.7	45.3	54.0	Pass
22956.0	65.7	52.6	65.7	52.6	54.0	Pass

Other emissions present had amplitudes at least 20 dB below the limit. Peak and Quasi-Peak amplitude emissions are recorded above for frequency range below 1000 MHz. Peak and Average amplitude emissions are recorded above for frequency range above 1000 MHz.

Summary of Results for Radiated Emissions in Restricted Bands

The EUT demonstrated compliance with the emissions requirements of 47CFR 15.205, 15.407, RSS-GEN and RSS-247 Issue 2 Intentional Radiators. The EUT provided a worst-case minimum margin of -1.4 dB below the emissions requirements in restricted frequency bands. Peak, Quasi-peak, and average amplitudes were checked for compliance with the regulations. Worst-case emissions are reported with other emissions found in the restricted frequency bands at least 20 dB below the requirements.

TEST #9 AC Line Conducted Emissions 15.207

Testing for radio frequency voltage conducted back onto the AC power line on frequencies within the band 150 kHz to 30 MHz were performed. AC Line Conducted emissions testing was performed as defined in ANSI C63.10-2013.

§15.407 General technical requirements.

(b) *Undesirable emission limits.* Except as shown in paragraph (b)(7) of this section, the maximum emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:
(6) Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in §15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in §15.207.

§15.207 Conducted limits.

(a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μHy/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of emission (MHz)	Conducted limit (dBμV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	66
5-30	60	50

*Decreases with the logarithm of the frequency.

Methods of Measurement AC Line Conducted Emissions

6.2.5 Final ac powerline conducted emission measurements

Based on the exploratory tests of the EUT performed in 6.2.4, the one EUT cable configuration and arrangement and mode of operation that produced the emission with the highest amplitude relative to the limit is selected for the final measurement, while applying the appropriate modulating signal to the EUT. If the EUT is relocated from an exploratory test site to a final test site, the highest emissions shall be maximized at the final test location before final ac powerline conducted emission measurements are

performed. The final test on all current-carrying conductors of all of the power cords to the equipment that comprises the EUT (but not the cords associated with other non-EUT equipment in the system) is then performed for the full frequency range for which the EUT is being tested for compliance without further variation of the EUT arrangement, cable positions, or EUT mode of operation. If the EUT is composed of equipment units that have their own separate ac power connections (e.g., floor-standing equipment with independent power cords for each shelf that are able to connect directly to the ac power network), then each current-carrying conductor of one unit is measured while the other units are connected to a second (or more) LISN(s). All units shall be measured separately. If a power strip is provided by the manufacturer, to supply all of the units making up the EUT, only the conductors in the power cord of the power strip shall be measured.
If the EUT operates above 30 MHz and uses a detachable antenna, then these measurements shall be made with a representative antenna connected to the antenna output terminals. These tests shall be made with the antenna connected and, if adjustable, fully extended.44
Record the six highest EUT emissions relative to the limit of each of the current-carrying conductors of the power cords of the equipment that comprises the EUT over the frequency range specified by the procuring or regulatory agency.

The EUT was arranged in a typical equipment configuration and placed on a 1 x 1.5-meter wooden bench 80 cm above the conducting ground plane, floor of a screen room. The bench was positioned 40 cm away from the wall of the screen room. The LISN was positioned on the floor of the screen room 80-cm from the rear of the EUT. The manufacturer supplied supporting equipment In Door Unit provided direct current power to the EUT was connected to the LISN for power Line conducted emissions testing. A second LISN was positioned on the floor of the screen room 80-cm from the rear of the supporting equipment of the EUT. All power cords except the EUT were then powered from the second LISN. EMI was coupled to the spectrum analyzer through a 0.1 μf capacitor, internal to the LISN. Power line conducted emissions testing were carried out individually for each current carrying conductor of the EUT. The excess length of lead between the system and the LISN receptacle was folded back and forth to form a bundle not exceeding 40 cm in length. The screen room, conducting ground plane, analyzer, and LISN were bonded together to the protective earth ground. Preliminary testing was performed to identify the frequency of each emission displaying the highest amplitude. The cables were repositioned to obtain maximum amplitude of measured EMI level. Once the worst-case configuration was identified, plots were made of the EMI from 0.15 MHz to 30 MHz then the data was recorded with maximum conducted emissions levels. Refer to figures 33 and 34 for plots of the EUT AC Line Conducted emissions.

Test Arrangement AC Line Conducted Emissions

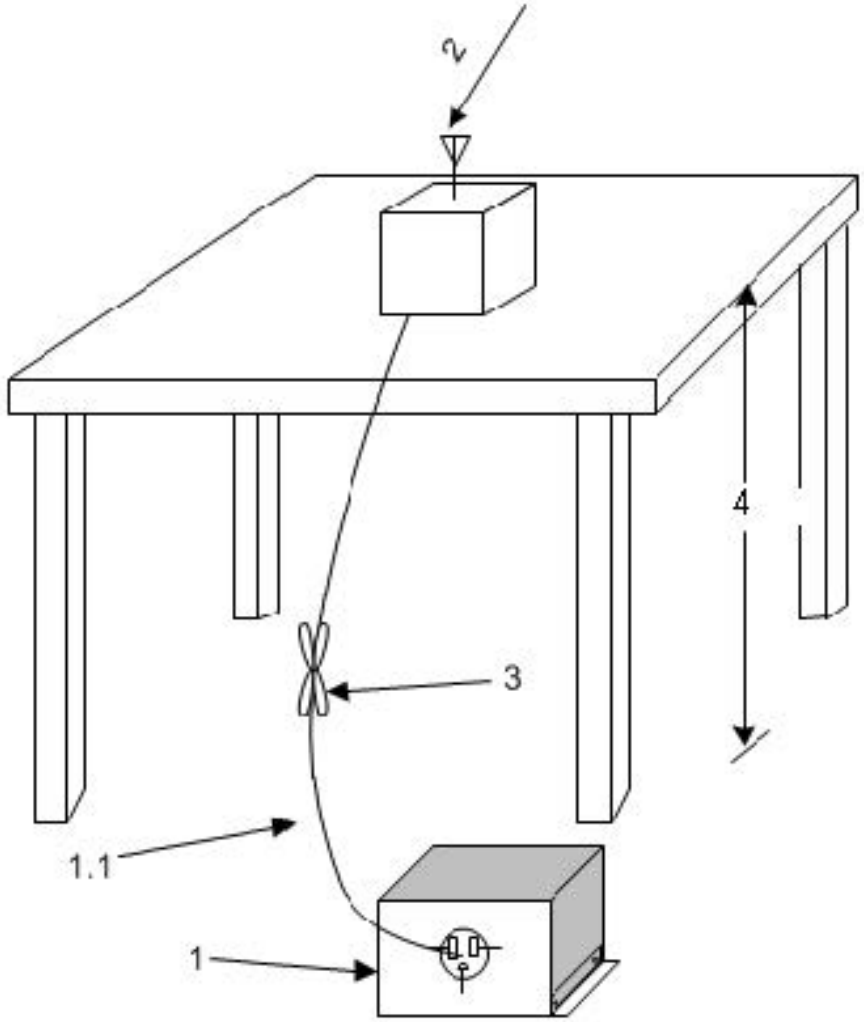


Table 5 AC Line Conducted Emissions Data (Highest Emissions Line L1)

Trace	Frequency	Level (dBµV)	Detector	Delta Limit/dB
2	454.000000000 kHz	38.35	Average	-8.46
1	458.000000000 kHz	42.68	Quasi Peak	-14.05
2	1.198000000 MHz	32.72	Average	-13.28
1	1.202000000 MHz	41.97	Quasi Peak	-14.03
2	1.534000000 MHz	40.33	Average	-5.67
1	1.538000000 MHz	50.83	Quasi Peak	-5.17
2	1.570000000 MHz	38.09	Average	-7.91
1	1.718000000 MHz	40.09	Quasi Peak	-15.91
1	2.746000000 MHz	40.79	Quasi Peak	-15.21
1	2.774000000 MHz	40.88	Quasi Peak	-15.12
2	16.072000000 MHz	37.27	Average	-12.73
2	21.412000000 MHz	35.40	Average	-14.60

Other emissions present had amplitudes at least 20 dB below the limit.

Table 6 AC Line Conducted Emissions Data (Highest Emissions Line L2)

Trace	Frequency	Level (dBµV)	Detector	Delta Limit/dB
1	454.000000000 kHz	45.27	Quasi Peak	-11.54
2	454.000000000 kHz	40.41	Average	-6.39
2	1.198000000 MHz	35.10	Average	-10.90
1	1.202000000 MHz	44.61	Quasi Peak	-11.39
2	1.478000000 MHz	36.12	Average	-9.88
2	1.534000000 MHz	42.63	Average	-3.37
1	1.542000000 MHz	53.08	Quasi Peak	-2.92
2	1.570000000 MHz	40.35	Average	-5.65
1	1.634000000 MHz	41.72	Quasi Peak	-14.28
1	2.734000000 MHz	42.42	Quasi Peak	-13.58
1	15.644000000 MHz	46.46	Quasi Peak	-13.54
2	15.980000000 MHz	40.42	Average	-9.58

Other emissions present had amplitudes at least 20 dB below the limit.

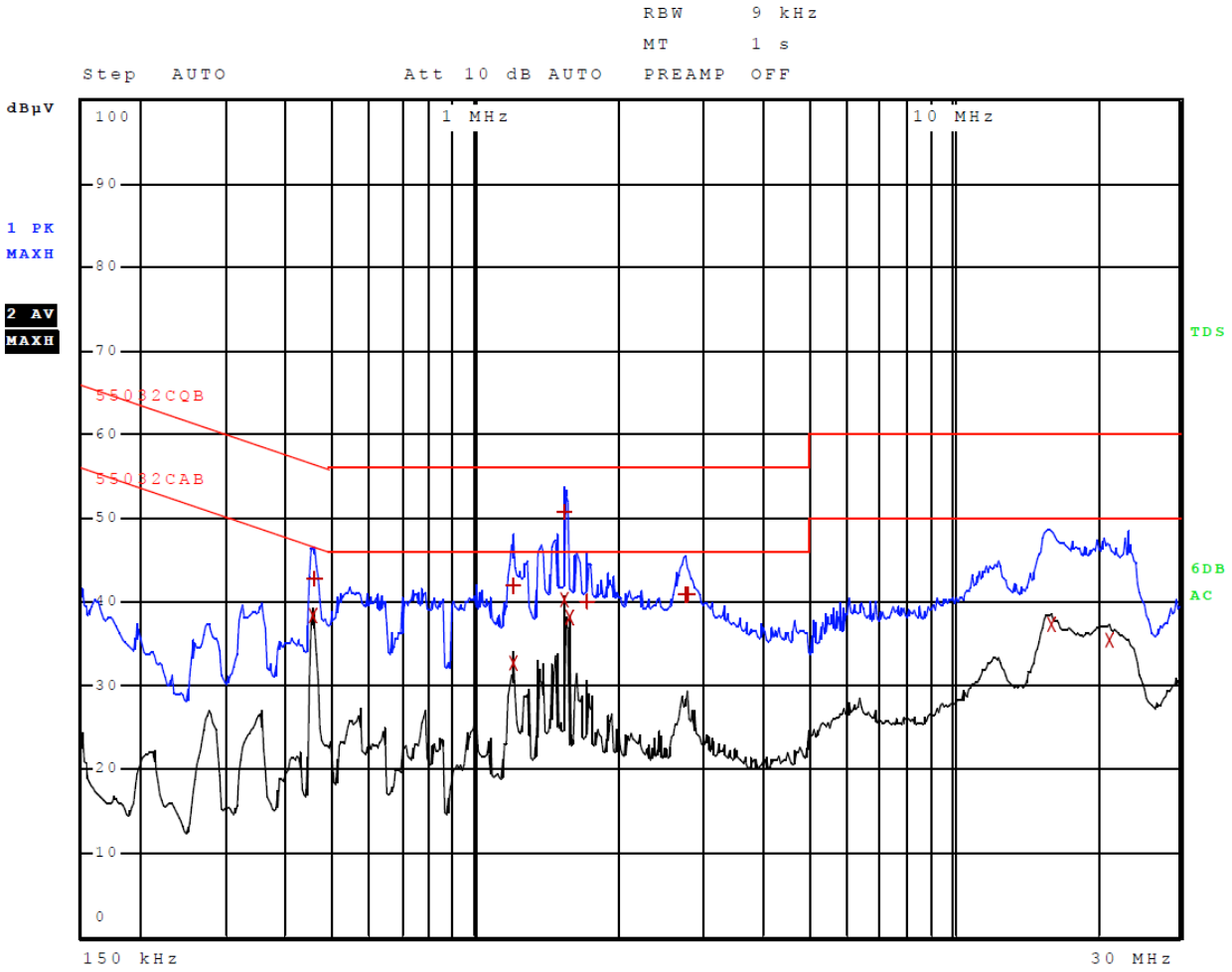


Figure 36 Plot of AC Line Conducted Emissions Line 1

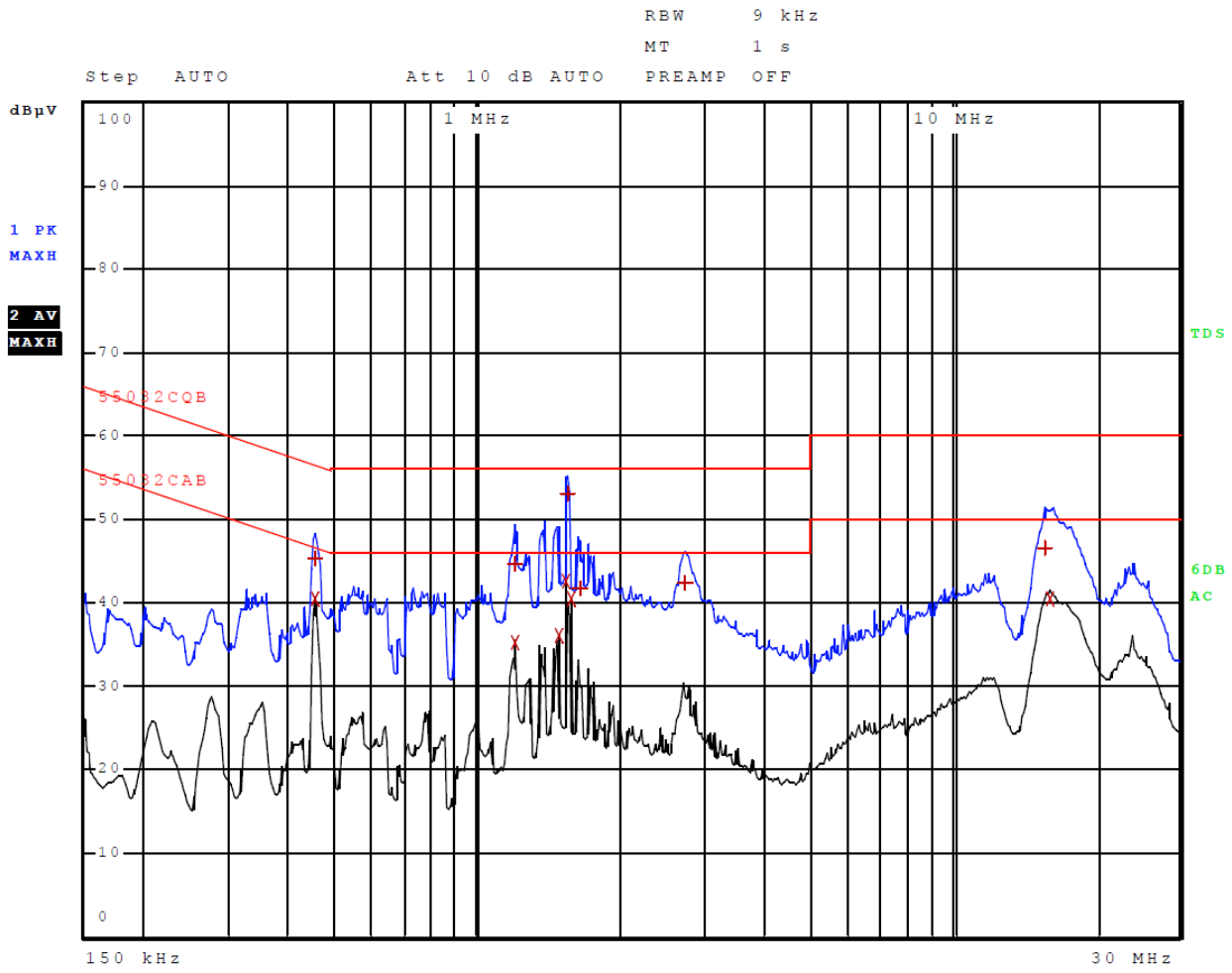


Figure 37 Plot of AC Line Conducted Emissions Line 2

Summary of Results for AC Line Conducted Emissions

Pass - The EUT test system demonstrated compliance to the conducted emissions requirements of 47CFR 15.207, RSS-247 Issue 2 and RSS-GEN. The EUT demonstrated minimum margin of –2.9 dB below the limit. Measurements were taken using the peak, quasi peak, and average, measurement function for each emissions amplitude and were below the limits stated in the specification. Other emissions were present with recorded data representing worst-case amplitudes.

TEST #10 Radiated Emissions, General requirements 15.209

The emissions from an intentional radiator shall not exceed the field strength levels specified. Radiated emission testing was performed on the OATS measuring radiated emissions as required. Radiated emissions testing was performed as directed in ANSI C63-10-2013. Worst-case emissions are documented in this report.

§15.407 General technical requirements.

(b) *Undesirable emission limits.* Except as shown in paragraph (b)(7) of this section, the maximum emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:
(6) Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in §15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in §15.207.

§15.209 Radiated emission limits; general requirements.

(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 (microvolts/meter) / dBµV/m	Measurement distance (meters)
0.009-0.490	2400/F(kHz) / 67.6/F(kHz)	300
0.490-1.705	24000/F(kHz) / 87.6/ F(kHz)	30
1.705-30.0	30 / 29.5	30
30-88	100** / 40.0	3
88-216	150** / 43.5	3
216-960	200** / 46.0	3
Above 960	500 / 54.0	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., §§15.231 and 15.241.

Methods of Measurement Radiated Emissions, General requirements

ANSI C63.10-2013

6.4 Radiated emissions from unlicensed wireless devices below 30 MHz

6.4.1 General

This subclause contains procedures for compliance testing below 30 MHz. Unlicensed wireless devices that are too large for a test site shall be tested for compliance at the manufacturer's facility or in situ; see the procedures in 6.11.

6.5 Radiated emissions from unlicensed wireless devices in the frequency range

of 30 MHz to 1000 MHz

This subclause specifies conditions for compliance testing in the frequency range above 30 MHz and below 1 GHz. The following subclauses describe the procedures that shall be used for making exploratory and final radiated emission tests for frequencies between 30 MHz and 1000 MHz. Measurements may be performed at a distance closer than that specified in the requirements, provided the measuring antenna is beyond its near-field range as determined by the Rayleigh criteria.

6.6 Radiated emissions from unlicensed wireless devices above 1 GHz

6.6.1 General requirements

This subclause specifies procedures for testing unlicensed wireless devices for radiated emissions for frequencies above 1 GHz. These procedures are in addition to the procedures in 6.3. General guidance for instrumentation and measurement issues above 1 GHz is contained in Annex E.

The EUT was arranged in a typical equipment configuration and operated through all available modes with worst-case data recorded. Preliminary testing was performed in a screen room with the EUT positioned 1 meter from the FSM. Radiated emissions measurements were performed to identify the frequencies, which produced the highest emissions. Each radiated emission was then maximized at the OATS location before final radiated emissions measurements were performed. Final data was taken with the EUT located at the OATS at a distance of 3 meters between the EUT and the receiving antenna. The frequency spectrum from 9 kHz to 60,000 MHz was searched for general radiated emissions. Measured emission levels were maximized by EUT placement on the table, rotating the turntable through 360 degrees, varying the antenna height between 1 and 4 meters above the ground plane and changing antenna position between horizontal and vertical polarization. Antennas used were Loop from 9 kHz to 30 MHz, Broadband, Biconilog from 30 to 1000 MHz, and Double Ridge or pyramidal horns and mixers above 1 GHz, notch filters, and appropriate amplifiers and external mixers were utilized. Peak and average amplitudes of frequencies above 1000 MHz were compared to the required limits with worst-case data presented below. Test procedures of ANSI C63.10-2013 were used during testing. No other significant emission was observed which fell into the restricted bands of operation. Computed radiated emission values consider the measured radiated field strength, receive antenna correction factor, amplifier gain stage, and test system cable losses. The spectrum analyzer was used to observe the radio frequency spectrum with the transmitter operated in all normal modes.

Test Arrangement Radiated Emissions

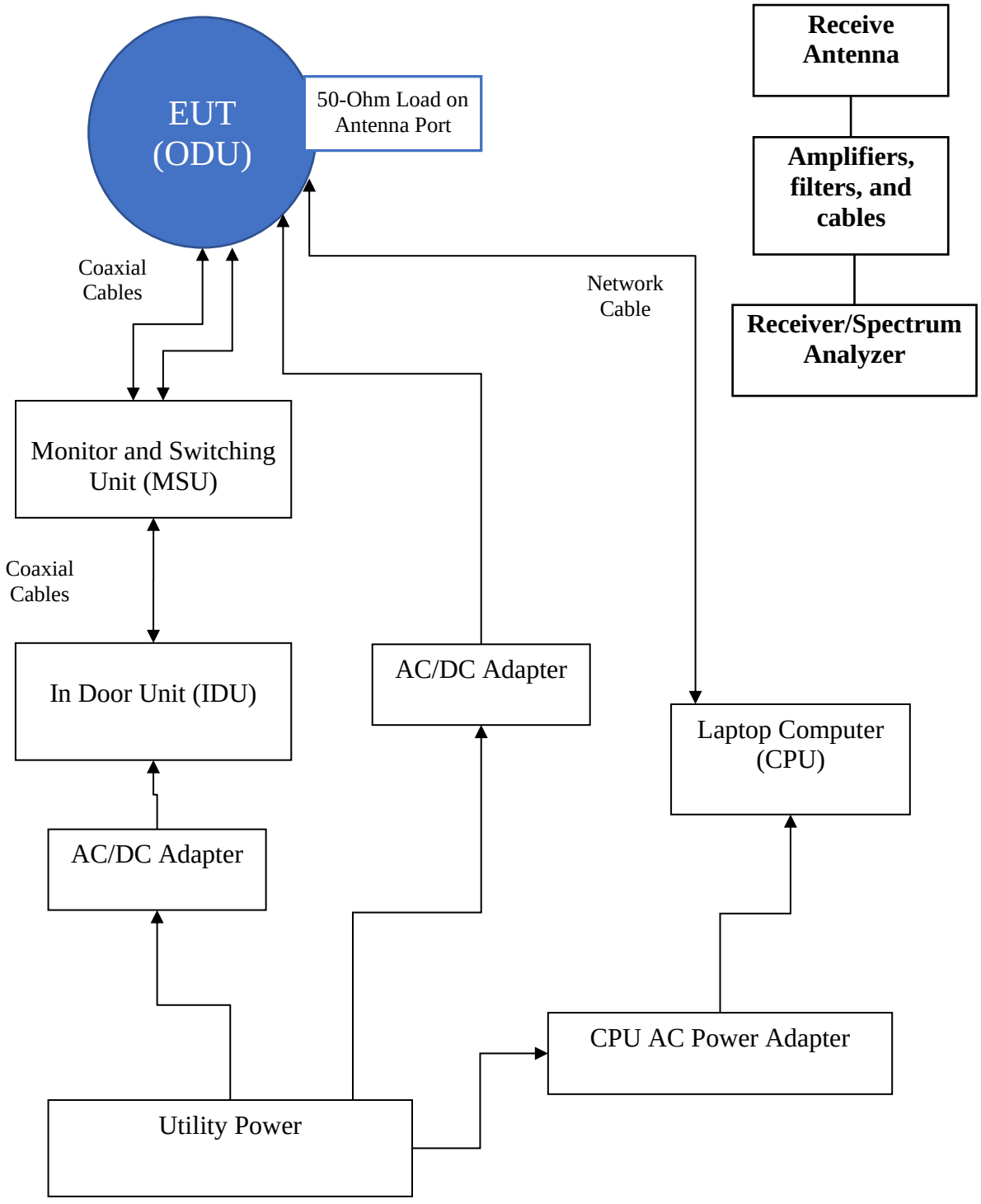


Table 7 General Radiated Emissions from EUT Data (Highest Emissions)

Frequency in MHz	Horizontal Peak (dBµV/m)	Horizontal Quasi-Peak (dBµV/m)	Horizontal Average (dBµV/m)	Vertical Peak (dBµV/m)	Vertical Quasi-Peak (dBµV/m)	Vertical Average (dBµV/m)	Limit @ 3m (dBµV/m)	Pass/Fail
72.0	34.1	26.7	N/A	35.6	30.3	N/A	40.0	Pass
84.9	33.2	28.9	N/A	34.1	29.7	N/A	40.0	Pass
111.4	37.3	23.4	N/A	37.1	33.2	N/A	40.0	Pass
164.4	34.5	31.4	N/A	35.0	32.0	N/A	40.0	Pass
168.1	36.3	32.4	N/A	34.3	31.3	N/A	40.0	Pass
375.0	45.8	44.3	N/A	42.3	41.0	N/A	47.0	Pass
448.0	41.7	40.5	N/A	37.1	35.4	N/A	47.0	Pass
625.0	46.9	45.0	N/A	46.4	43.2	N/A	47.0	Pass
875.0	46.4	44.8	N/A	46.6	43.7	N/A	47.0	Pass
1125.0	39.3	N/A	27.8	43.1	N/A	28.9	54.0	Pass
1343.9	44.4	N/A	37.4	43.8	N/A	36.6	54.0	Pass
1375.0	43.3	N/A	34.0	45.1	N/A	36.8	54.0	Pass

Other emissions present had amplitudes at least 20 dB below the limit. Peak and Quasi-Peak amplitude emissions are recorded above for frequency range below 1000 MHz. Peak and Average amplitude emissions are recorded above for frequency range above 1000 MHz.

Summary of Results for General Radiated Emissions

Pass- The EUT demonstrated compliance with the radiated emissions requirements of 47CFR part 15 and Industry Canada RSS-247 Issue 2 Intentional Radiators. The EUT demonstrated a minimum margin of –2.0 dB below the requirements. Other emissions were present with amplitudes at least 20 dB below the Limits.

Summary of Results for Transmitter Radiated Emissions of Intentional Radiator

The EUT demonstrated compliance with the radiated emissions requirements of 47CFR Part 15.407 and Industry Canada RSS-247 Issue 2. The output power is manufacturer adjustable from 13 dBm to 30 dBm and installers may adjust during installation. The adjustments are available to manufacturer and installers. End users are denied access to the power settings as attested by manufacturer. The maximum measured output power delivered into the antenna port was 1.00-Watts. The minimum harmonic radiated emission margin provided -11.9 dB margin below requirements. General radiated emissions of EUT and supporting equipment provided -2.0 dB margin. There were no other significantly measurable emissions in the restricted bands other than those recorded in this report. Other emissions were present with amplitudes at least 20 dB below the requirements. There were no other deviations or exceptions to the requirements.

Statement of Modifications and Deviations

No modifications to the EUT were required for the unit to demonstrate compliance with the 47CFR Part 15E paragraph 15.407 and Industry Canada RSS-247 Issue 2 emissions requirements. There were no deviations or modifications to the specifications.

Annex

- Annex A Measurement Uncertainty Calculations
- Annex B Rogers Labs Test Equipment List
- Annex C Rogers Qualifications
- Annex D Rogers Labs Certificate of Accreditation

Annex A Measurement Uncertainty Calculations

The measurement uncertainty was calculated for all measurements listed in this test report according To CISPR 16–4. Result of measurement uncertainty calculations are recorded below. Component and process variability of production devices similar to those tested may result in additional deviations. The manufacturer has the sole responsibility of continued compliance.

Measurement	Expanded Measurement Uncertainty $U_{(lab)}$
3 Meter Horizontal 0.009-1000 MHz Measurements	4.16
3 Meter Vertical 0.009-1000 MHz Measurements	4.33
3 Meter Measurements 1-18 GHz	5.14
3 Meter Measurements 18-40 GHz	5.16
10 Meter Horizontal Measurements 0.009-1000 MHz	4.15
10 Meter Vertical Measurements 0.009-1000 MHz	4.32
AC Line Conducted	1.75
Antenna Port Conducted power	1.17
Frequency Stability	1.00E-11
Temperature	1.6˚C
Humidity	3%

Annex B Test Equipment List

Equipment	Manufacturer	Model (SN)	Band	Cal Date(m/d/y)	Due
☒ LISN	FCC	FCC-LISN-50-25-10(1PA) (160611)	.15-30MHz	4/21/2020	4/21/2021
☒ LISN	Compliance Design	FCC-LISN-2.Mod.cd,(126)	.15-30MHz	10/14/2019	10/14/2020
☒ Cable	Huber & Suhner Inc.	Sucoflex102ea(L10M)(303073)	9kHz-40 GHz	10/14/2019	10/14/2020
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(1.5M)(303069)	9kHz-40 GHz	10/14/2019	10/14/2020
☒ Cable	Huber & Suhner Inc.	Sucoflex102ea(1.5M)(303070)	9kHz-40 GHz	10/14/2019	10/14/2020
☒ Cable	Belden	RG-58 (L1-CAT3-11509)	9kHz-30 MHz	10/14/2019	10/14/2020
☒ Cable	Belden	RG-58 (L2-CAT3-11509)	9kHz-30 MHz	10/14/2019	10/14/2020
☒ Antenna	Com Power	AL-130 (121055)	.001-30 MHz	10/14/2019	10/14/2020
☐ Antenna:	EMCO	6509	.001-30 MHz	10/16/2018	10/16/2020
☐ Antenna	ARA	BCD-235-B (169)	20-350MHz	10/14/2019	10/14/2020
☐ Antenna:	Schwarzbeck Model:	BBA 9106/VHBB 9124 (9124-627)		4/21/2020	4/21/2021
☒ Antenna	Sunol	JB-6 (A100709)	30-1000 MHz	10/14/2019	10/14/2020
☐ Antenna	ETS-Lindgren	3147 (40582)	200-1000MHz	10/14/2019	10/14/2020
☐ Antenna:	Schwarzbeck Model:	VULP 9118 A (VULP 9118 A-534)		4/21/2020	4/21/2021
☒ Antenna	ETS-Lindgren	3117 (200389)	1-18 GHz	4/21/2020	4/23/2022
☐ Antenna	Com Power	AH-118 (10110)	1-18 GHz	10/14/2019	10/14/2020
☒ Antenna	Com Power	AH-840 (101046)	18-40 GHz	4/21/2020	4/21/2021
☒ Analyzer	Rohde & Schwarz	ESU40 (100108)	20Hz-40GHz	5/15/2020	5/15/2021
☒ Analyzer	Rohde & Schwarz	ESW44 (101534)	20Hz-44GHz	1/27/2020	1/27/2021
☐ Analyzer	Rohde & Schwarz	FS-Z60, 90, 140, and 220	40GHz-220GHz	12/22/2017	12/22/2027
☒ Amplifier	Com-Power	PA-010 (171003)	100Hz-30MHz	10/14/2019	10/14/2020
☒ Amplifier	Com-Power	CPPA-102 (01254)	1-1000 MHz	10/14/2019	10/14/2020
☒ Amplifier	Com-Power	PAM-118A (551014)	0.5-18 GHz	10/14/2019	10/14/2020
☒ Amplifier	Com-Power	PAM-840A (461328)	18-40 GHz	10/14/2019	10/14/2020
☒ Power Meter	Agilent	N1911A with N1921A	0.05-40 GHz	4/21/2020	4/21/2021
☐ Generator	Rohde & Schwarz	SMB100A6 (100150)	20Hz-6 GHz	4/21/2020	4/21/2021
☐ Generator	Rohde & Schwarz	SMBV100A6 (260771)	20Hz-6 GHz	4/21/2020	4/21/2021
☐ RF Filter	Micro-Tronics	BRC50722 (009).9G notch	30-18000 MHz	4/21/2020	4/21/2021
☐ RF Filter	Micro-Tronics	HPM50114 (017)1.5G HPF	30-18000 MHz	4/21/2020	4/21/2021
☐ RF Filter	Micro-Tronics	HPM50117 (063) 3G HPF	30-18000 MHz	4/21/2020	4/21/2021
☐ RF Filter	Micro-Tronics	HPM50105 (059) 6G HPF	30-18000 MHz	4/21/2020	4/21/2021
☐ RF Filter	Micro-Tronics	BRM50702 (172) 2G notch	30-18000 MHz	4/21/2020	4/21/2021
☒ RF Filter	Micro-Tronics	BRC50703 (G102) 5G notch	30-18000 MHz	4/21/2020	4/21/2021
☐ RF Filter	Micro-Tronics	BRC50705 (024) 5G notch	30-18000 MHz	4/21/2020	4/21/2021
☐ Attenuator	Fairview	SA6NFNF100W-40 (1625)	30-18000 MHz	4/21/2020	4/18/2021
☒ Attenuator	Mini-Circuits	VAT-3W2+ (1436)	30-6000 MHz	4/21/2020	4/21/2021
☐ Attenuator	Mini-Circuits	VAT-3W2+ (1445)	30-6000 MHz	4/21/2020	4/21/2021
☐ Attenuator	Mini-Circuits	VAT-3W2+ (1735)	30-6000 MHz	4/21/2020	4/21/2021
☒ Attenuator	Mini-Circuits	VAT-6W2+ (1438)	30-6000 MHz	4/21/2020	4/21/2021
☒ Attenuator	Mini-Circuits	VAT-6W2+ (1736)	30-6000 MHz	4/21/2020	4/21/2021
☒ Weather station	Davis	6312 (A81120N075)		11/4/2019	11/4/2020

NVLAP Lab Code 200087-0

List of Test Equipment				Calibration	Date (m/d/y)	Due
☐ Frequency Counter: Leader LDC-825 (8060153					4/21/2020	4/21/2021
☐ LISN: Com-Power Model LI-220A					10/14/2019	10/14/2020
☐ LISN: Com-Power Model LI-550C					10/14/2019	10/14/2020
☐ ISN: Com-Power Model ISN T-8					4/21/2020	4/21/2021
☐ LISN: Fischer Custom Communications Model: FCC-LISN-50-16-2-08					4/21/2020	4/21/2021
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(1.5M)(303070)	9kHz-40 GHz		10/14/2019	10/14/2020
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(1.5M)(303072)	9kHz-40 GHz		10/14/2019	10/14/2020
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(L4M)(281184)	9kHz-40 GHz		10/14/2019	10/14/2020
☐ Cable	Huber & Suhner Inc.	Sucoflex102ea(L10M)(317546)	9kHz-40 GHz		10/14/2019	10/14/2020
☐ Cable	Time Microwave	4M-750HF290-750 (4M)	9kHz-24 GHz		10/14/2019	10/14/2020
☐ RF Filter	Micro-Tronics	BRC17663 (001) 9.3-9.5 notch	30-1800 MHz		4/21/2020	4/21/2021
☐ RF Filter	Micro-Tronics	BRC19565 (001) 9.2-9.6 notch	30-1800 MHz		10/16/2018	4/21/2021
☐ Analyzer	HP	8562A (3051A05950)	9kHz-125GHz		4/21/2020	4/21/2021
☐ Analyzer	HP External Mixers	11571, 11970	25GHz-110GHz		4/18/2015	4/18/2025
☐ Analyzer	HP	8591EM (3628A00871)			4/21/2020	4/21/2021
☐ Antenna: Solar 9229-1 & 9230-1					2/22/2020	2/22/2021
☐ CDN: Com-Power Model CDN325E					10/14/2019	10/14/2020
☐ Injection Clamp Luthi Model EM101					10/14/2019	10/14/2020
☐ Oscilloscope Scope: Tektronix MDO 4104					2/22/2020	2/22/2021
☐ EMC Transient Generator HVT TR 3000					2/22/2020	2/22/2021
☐ AC Power Source (Ametech, California Instruments)					2/22/2020	2/22/2021
☐ Field Intensity Meter: EFM-018					2/22/2020	2/22/2021
☐ ESD Simulator: MZ-15					2/22/2020	2/22/2021
☐ R.F. Power Amp ACS 230-50W					not required	
☐ R.F. Power Amp EIN Model: A301					not required	
☐ R.F. Power Amp A.R. Model: 10W 1010M7					not required	
☐ R.F. Power Amp A.R. Model: 50U1000					not required	
☒ Shielded Room					not required	

Annex C Rogers Qualifications

Scot D. Rogers, Engineer

Rogers Labs, Inc.

Mr. Rogers has approximately 35 years' experience in the field of electronics. Working experience includes six years working in the automated controls industry and 6 years working with the design, development and testing of radio communications and electronic equipment.

Positions Held:

Systems Engineer:	A/C Controls Mfg. Co., Inc.	6 Years
Electrical Engineer:	Rogers Consulting Labs, Inc.	5 Years
Electrical Engineer:	Rogers Labs, Inc.	Current

Educational Background:

Bachelor of Science Degree in Electrical Engineering from Kansas State University

Bachelor of Science Degree in Business Administration Kansas State University

Several Specialized Training courses and seminars pertaining to Microprocessors and Software programming

NVLAP Lab Code 200087-0

Annex D Rogers Labs Certificate of Accreditation

United States Department of Commerce
National Institute of Standards and Technology

Certificate of Accreditation to ISO/IEC 17025:2017

NVLAP LAB CODE: 200087-0

Rogers Labs, Inc.
Louisburg, KS

is accredited by the National Voluntary Laboratory Accreditation Program for specific services, listed on the Scope of Accreditation, for:

Electromagnetic Compatibility & Telecommunications

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communique dated January 2009).

2020-02-25 through 2021-03-31
Effective Dates

For the National Voluntary Laboratory Accreditation Program