Federal Communications Commission
Office of Engineering and Technology
Laboratory Division Public Draft Review

Draft Laboratory Division Publications Report

Title: Proposed Certification Test Procedures for TV Band (White Space) Devices Authorized Under Subpart H of the Part 15 Rules

Short Title: White Space Test Procedures

Reason: New Publication

Publication: 416721

Keyword/Subject: Part 15 Subpart H, White Space, White Space Certification Test Procedures

First Category: Administrative Requirements

Second Category: Measurement Procedures

Third Category:

Question:

What are the test procedures for certifying equipment to operate under the Part 15 Subpart H, White Space rules?

Answer:
Test procedures for White Space devices are contained in the attached document 416721 D01 White Space Test Procedures v01 below.

Attachment List:
416721 D01 White Space Test Procedures v01

Attachment

Proposed Certification Test Procedures for TV Band (White Space) Devices Authorized Under Subpart H of the Part 15 Rules

INTRODUCTION

Background

The Commission recently adopted rules to permit a category of unlicensed devices access to television (TV) broadcast frequency bands in order to provide wireless broadband services on those TV channels that are not occupied by licensed incumbent services (also known as TV white spaces).[1] The rules governing the operation of such Television Band Devices (TVBDs) are codified in Subpart H of the Part 15 rules depicted in Title 47 of the Code of Federal Regulations (CFR).

Objective

This paper is intended to specify and document recommended measurement and validation procedures applicable to TVBDs that will provide sufficient data to demonstrate compliance to the applicable rules specified in Part 15; Subpart H – Television Band Devices.

Approach

The TVBDs currently envisioned will access one or more TV band databases which will in turn provide the device with a list of TV white space channels available for operation. [2]

At the time of this writing, the details associated with the operation of the TV bands database(s) are under development. As a result, there is little specificity available with respect to those final tests that will be required to demonstrate compliance to the interference avoidance and protection requirements established in the rules *(i.e.*, §15.711 and §15.712). Therefore, the effort to document required TVBD certification tests will be separated into two distinct parts.

Part 1 will specify verification tests and recommended measurement procedures that can be performed on TVBDs without the need to access a TV bands database and thus will include guidance primarily intended for demonstrating compliance to the specific radio frequency (RF) requirements and limits.

Part 2 will be a follow-on effort intended to specify verification tests and recommended procedures for testing the rules requirements that will necessitate a connection between the TVBD and one or more TV

[1] *See Second Report and Order and Memorandum Opinion and Order (Second Report and Order)* in ET Docket No. 04-186, 23 FCC Rcd 16807 (2008) and *Second Memorandum Opinion and Order (Second Memorandum Opinion and Order)* in ET Docket No. 04-186, FCC 10-174, adopted September 23, 2010.

[2] Measurement procedures associated with database access are not addressed in herein. Rather, such procedures will be included in a subsequent edition of the document.

band databases. The Part 2 effort will define requisite bench tests as well as field tests and will be made available once the database development effort more fully matures.

PART 1: RADIO FREQUENCY (RF) CERTIFICATION TESTS

The compliance tests described herein can be performed on a stand-alone TVBD *(i.e.*, without requiring access to a TV bands database).

Test Mode Requirements

In order to perform many of the certification compliance tests described herein, a test mode accessible by test personnel (but not end-use customers) must be incorporated into a TVBD submitted for testing. This test mode must at a minimum provide:

- The ability to compel the device-under-test (DUT) to operate on a TV channel selectable by the test personnel.
- The ability to vary the output power from the minimum to the maximum realizable levels and set it to a desired level.
- The ability to continuously transmit a modulated signal (*i.e.*, with no time bursting or signal gating applied).

Rules Requirements

§15.706 Information to the user

- Visually verify adherence to labeling requirements specified in §15.19.
- Visually verify that the required statement, pursuant to §15.706(a), is included in the TVBD user's manual.

§15.707 Permissible channels of operation

Verify that the DUT cannot be tuned to operate on unauthorized TV channels or outside of the authorized frequency band(s).

Fixed TVBDs:

Check that Fixed TVBDs are limited to using TV channels 2, 5 through 35 and 39 through 51. Verify that the DUT cannot tune to TV channels 3, 4, 36, 37, and 38. Also verify that the DUT cannot tune to frequencies below 54 MHz (TV channel 2) or above 698 MHz (TV channel 51).

Personal/portable TVBDs:

Check that Mode I and Mode II TVBDs are limited to using TV channels 21-35 and 39-51 only. Verify that the DUT cannot tune to TV channels 2-20, 36, 37, and 38. Also verify that

the DUT cannot tune to frequencies below 512 MHz (TV channel 21) or above 698 MHz (TV channel 51).

Note that the lockout of unauthorized channels may not be totally implemented in the DUT but rather, may be reliant upon limitations provided to the DUT by the database (*e.g.*, channels 36 and 38).

§15.709 General technical requirements

Power Limits for Fixed TVBDs:

The maximum power delivered to the transmitting antenna shall not exceed one watt (30 dBm) in any 6-MHz TV channel.[3]

If transmitting antennae of directional gain greater than 6 dBi are used, the maximum conducted output power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

The power spectral density (PSD) conducted from the TVBD to the antenna shall not be greater than 12.2 dBm in any 100-kHz band during any time interval of continuous transmission.

Recommended Measurement Procedure:

The power limits for fixed TVBDs are specified in terms of conducted PSD; therefore, the recommended compliance verification measurement should utilize a conducted test configuration. The following paragraphs provide recommended settings and procedures for using a spectrum analyzer (with signal-processing capability) to perform the measurement:

- Connect a patch cable of known attenuation (at the specific frequencies under consideration) between the antenna port of the DUT and a spectrum analyzer. For a fixed TVBD, it may be necessary to insert an external attenuator in the signal path to prevent overload damage to the analyzer.

- Select the analyzers power averaging (RMS) detector, a span of 10- MHz, a resolution bandwidth (RBW) of 100-kHz, a video bandwidth of 300-kHz and a sweep speed that provides one millisecond per trace point integration time.

- Activate the DUT test mode that provides continuous transmission of the output signal (no time bursting or signal gating) on the operating channel under investigation (low, middle, and high channels within tuning range must be examined).

[3] Transmitters utilizing multiple RF chains to transmit on more than one TV channel simultaneously are subject to the power limits within each and every 6-MHz TV channel used. Additionally, such composite devices must adhere to the requirements specified in §15.31.

- Employ the trace averaging analyzer function over a minimum of 10 traces.
- Use the integrated band/channel power analyzer function to determine the average power within the 6-MHz channel bandwidth.
- Use the peak marker function to determine the maximum power in any 100-kHz band segment.
- Make the necessary corrections to the measured amplitude levels to account for externalities inserted into the signal path (*e.g.*, signal attenuation in patch cable and/or external attenuator). Record the adjusted amplitude levels as the power levels measured in 6-MHz and 100-kHz, respectively.
- Check that reported DUT transmit antenna gain is in compliance with §15.709(a)(1). If necessary, reduce the PSD limit by the amount in dB that the transmit antenna gain exceeds 6 dBi.
- Compare the recorded power levels to the applicable PSD limits to assess compliance.
- Repeat until data is accumulated for the low, middle and high channels in the DUT tuning range.

Power Limits for Personal/Portable TVBDs:

The maximum EIRP shall not exceed 100 milliwatts (20 dBm) within the 6-MHz channel bandwidth of operation.

Mode I and Mode II personal/portable TVBDs that do not meet the adjacent channel separation requirements of §15.712(a) are limited to a maximum EIRP of 40 milliwatts (16 dBm) within the 6-MHz channel bandwidth of operation.

The power conducted from a personal/portable TVBD to the antenna, when measured in any 100-kHz band segment during any time interval of continuous transmission is 2.2 dBm when not operating on a channel that is adjacent to an occupied TV channel and -1.8 dBm when operating on a channel that is adjacent to an occupied TV channel.

Applicants for equipment certification shall include a description of the DUT transmit power control mechanism pursuant to §15.709(a)(3).

Recommended Measurement Procedure:

The power limits specified for personal/portable TVBDs are mixed in that the limit within the 6-MHz channel is specified as an EIRP whereas, the limit in any 100-kHz band segment is specified in terms of conducted power provided to the transmit antenna.

The antenna requirements subsection (§15.709(a)) specifies that the transmit/receive antennae of personal/portable devices shall be permanently attached to the DUT, potentially making conducted measurements difficult.

Although the 100-kHz PSD limits are specified in the rules in terms of conducted power, they were established under the assumption that these were the maximum levels that could be applied to an ideal isotropic radiating antenna. Therefore, the conducted limits can reasonably be interpreted to also represent the maximum permissible EIRP levels under the presumption that the antenna gain of an ideal isotropic radiating antenna is 0 dBi.

As such, although the preferred method for determining the maximum output power is to utilize a conducted measurement set-up, in those cases where there is no accessible antenna port to accommodate conducted measurements, a radiated measurement set-up can be used instead.

Conducted measurements:

The following recommended spectrum analyzer settings and procedures assume access to a 50-Ω RF output port incorporated within the DUT.

- Connect a patch cable of known attenuation (at the specific frequencies under consideration) between the antenna port of the DUT and a spectrum analyzer.
- Select the analyzers power averaging (RMS) detector, a span of 10- MHz, a resolution bandwidth (RBW) of 100-kHz, a video bandwidth of 300-kHz and a sweep speed that provides one millisecond per trace point integration time.
- Activate the DUT test mode that provides continuous transmission of the output signal (no time bursting or signal gating) on the operating channel under investigation (low, middle, and high channels within tuning range must be examined).
- Employ the trace averaging analyzer function over a minimum of 10 traces.
- Use the integrated band/channel power analyzer function to determine the average power within the 6-MHz channel bandwidth.
- Use the peak marker function to determine the maximum amplitude in any 100-kHz band segment.

- Make the necessary corrections to the measured amplitude levels to account for externalities inserted into the signal path (*e.g.*, signal attenuation in patch cable and/or external attenuator or pre-amplifier). Record the adjusted amplitude levels as the power measured in 6-MHz and 100-kHz, respectively.

- Compare the recorded power levels to the applicable PSD limits to assess compliance.

- Repeat until data is accumulated for the low, middle and high channels in the DUT tuning range.

Radiated measurements:

The following recommended measurement procedures assume that the DUT provides no accessible RF output port and thus, radiated measurements must be performed.

Refer to ANSI C63.4-2009 for general guidance on performing radiated measurements on unlicensed devices.

Once the azimuth and elevation associated with the maximum emission has been determined, use the following recommended analyzer settings and procedures for final measurements.

- Connect a patch cable of known attenuation (in the specific frequency range under consideration) between a measurement antenna of known receive gain and a spectrum analyzer.

- Select the analyzers power averaging (RMS) detector, a span of 10- MHz, a resolution bandwidth (RBW) of 100-kHz, a video bandwidth of 300-kHz and a sweep speed that provides one millisecond per trace point integration time.

- Activate the DUT test mode that provides continuous transmission of the output signal (no time bursting or signal gating) on the operating channel under investigation (low, middle, and high channels within tuning range must be examined).

- Employ the trace averaging analyzer function over a minimum of 10 traces.

- Use the integrated band/channel power analyzer function to determine the average amplitude over the 6-MHz channel bandwidth.

- Use the peak marker function to determine the maximum amplitude in any 100-kHz band segment.

- Make the necessary corrections to the measured amplitude levels to account for externalities inserted into the signal path (*e.g.*, signal attenuation in patch cable and the measurement antenna gain). Record the adjusted amplitude levels as the power measured in 6-MHz and 100-kHz, respectively.

- Determine the associated EIRP levels using guidance provided in KDB 412172

- Compare the EIRP levels to the applicable EIRP limits to assess compliance.

- Repeat until data is accumulated for the low, middle and high channels in the DUT tuning range.

Antenna Requirements

The transmit/receive antenna(s) of a personal/portable TVBD shall be examined to verify that they are permanently attached to the DUT.

The maximum gain of the transmitting antenna used with a Fixed TVBD must be declared by the manufacturer in the certification application. If the transmitting antenna gain exceeds 6 dBi, then the maximum conducted output power shall be reduced by the amount in dB by which the gain exceeds 6 dBi.

See KDB 662911 for guidance on testing a TVBD transmitter utilizing multiple antenna outputs.

Emission Limits

Undesired emissions from a TVBD into the channels immediately adjacent to the channel of operation shall be at least 72.8 dB below the highest average power in the operating channel.

Emission measurements in the channel of operation shall be performed over a reference bandwidth of 6-MHz with an average detector.

Emission measurement in the adjacent channels shall be performed using a minimum resolution bandwidth of 100-kHz with an average detector. A narrower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 100-kHz.

At frequencies beyond the television channels immediately adjacent to the channel in which the TVBD is operating, the radiated emissions from TVBDs shall meet the requirements of §15.209.

Recommended Measurement Procedures

The limit on out-of-band emissions (at the band-edge and in the adjacent channels) is specified as the power in 100-kHz obtained from subtracting 72.8 dB from the average power measured in the 6-MHz operating channel. This value has been previously determined. Thus, the out-of-

band emission limit for all TVBDs, applicable both at the band-edges and in the adjacent channels (both lower and upper) is determined from:

Power/100 kHz = Power/6 MHz – 72.8.

As with the power measurements, the preferred methodology for determining the maximum band-edge and adjacent-channel emission power is to utilize a conducted measurement procedure; however, in those cases where there is no accessible antenna port for accommodating conducted measurements, a radiated measurement procedure can be utilized (see C63.4-2009 for guidance).

If the fundamental emission power was measured using a conducted test set-up, then the band-edge and adjacent-channel measurement should also be performed using a conducted test set-up. Similarly, if the fundamental emission power was measured using a radiated test set-up, then the band-edge and adjacent-channel measurement should also be performed using a radiated test set-up.

Band-edge Measurement:

The band-edge measurements must be performed relative to both the lower (f_L) and upper (f_U) channel edge frequencies. The PSD is to be measured within a100-kHz band segment relative to the channel edge (*i.e.*, f_L- 100 kHz and f_U + 100 kHz). The following spectrum analyzer settings and procedures are recommended for this measurement:

- Select the power averaging (RMS) detector, a start frequency of f_L- 100 kHz and a stop frequency of f_L (where f_L is the lower edge frequency of the operating channel), a resolution bandwidth (RBW) of 10 kHz, a minimum video bandwidth of 30 kHz and a sweep speed that provides one millisecond per trace point integration time.

- Activate the DUT test mode that provides continuous transmission of the output signal (no time bursting or signal gating) on the operating channel to be investigated (low, middle and high channels of tuning range must be tested).

- Employ the trace averaging feature of the analyzer over a minimum of 10 traces.

- Use the integrated band/channel power function of the analyzer to determine the maximum average power spectral density over the 100- kHz frequency span.

- Adjust the measured amplitude level to account for externalities in the signal path (*e.g.*, attenuation in the patch cable for conducted measurements; to include measurement antenna gain for radiated tests).

- Repeat procedure with the analyzer start frequency set to f_U and the stop frequency set to f_U + 100 kHz.

- Repeat the entire procedure until data is accumulated for the lower, middle and upper channels in the DUT tuning range.

Adjacent-Channel Measurement

The adjacent channel emission limit applies in any 100-kHz band segment within either the lower- or upper-adjacent 6-MHz channels relative to the operating channel (N±1, where N represents the channel of operation).

The following spectrum analyzer settings and procedures are recommended for this measurement:

- Select the power averaging (RMS) detector, a start frequency of f_L- 6 MHz and a stop frequency of f_L- 100 kHz (where f_L is the lower edge frequency of the operating channel), a resolution bandwidth (RBW) of 100-kHz, a minimum video bandwidth of 300-kHz and a sweep speed that provides one millisecond per trace point integration time.

- Activate the DUT test mode that provides continuous transmission of the output signal (no time bursting or signal gating) on the operating channel to be investigated (low, middle and high channels of tuning range must be tested).

- Employ the trace averaging feature of the analyzer over a minimum of 10 traces.

- Use the peak marker function of the analyzer to determine the maximum power spectral density in any 100-kHz segment within the frequency span.

- Adjust the measured amplitude level to account for externalities in the signal path (*e.g.*, attenuation in the patch cable for conducted measurements and the measurement antenna gain for radiated tests).

- Repeat procedure with the analyzer start frequency set to f_U + 100 kHz and the stop frequency set to f_U + 6 MHz.

- Repeat the entire procedure until data is accumulated for the lower, middle and upper channels in the DUT tuning range.

Beyond Adjacent-Channel Measurements

Beyond the immediately adjacent channels to the operating channel, the general emission limits of §15.209 apply. See §15.31, §15.33, §15.35, and ANSI C63.4-2009 for guidance on performing these measurements.

Measurements in the 602-620 MHz band (TV Channels 36-38)

§15.709(c)(4) provides a table of field strength limits applicable to emissions from TVBDs that fall within the frequency spectrum representing channels 36-38 (602-620 MHz). The emission levels within these channels should be measured on a radiated basis following the guidance provided in ANSI C63.4-2009.