



**Federal Communications Commission
Office of Engineering and Technology
Laboratory Division**

December 22, 2015

**CERTIFICATION TEST PROCEDURES FOR WHITE SPACE DEVICES
AUTHORIZED UNDER SUBPART H OF THE PART 15 RULES**

I. INTRODUCTION

1. Background

The Commission recently modified the rules that permit unlicensed devices to access television (TV) broadcast frequency bands on TV channels that are not occupied by licensed incumbent services (also known as TV white spaces).¹ These changes will allow operation of unlicensed devices in the 600 MHz guard bands, duplex gap and on channel 37 in addition to the TV bands. The rules governing the operation of such White Space Devices (WSDs) are codified in Title 47 of the Code of Federal Regulations (CFR) at Part 15, Subpart H.

2. Objective

This guidance recommends WSD measurement and validation procedures that will demonstrate compliance to the applicable rules in Part 15 Subpart H – White Space Devices.²

In addition to demonstrating compliance with the technical rules governing unlicensed intentional radiators, WSDs are required to demonstrate the capability to access one or more white space databases which provide a list of available channels to the WSD.

To demonstrate compliance to the rules, the requirements and procedures are divided into two parts:

Section II below specifies WSD verification tests and recommended measurement procedures for demonstrating compliance to the specific radio frequency (RF) requirements and limits. These tests can be performed without the WSD accessing a white space database.

Section III below specifies verification tests and recommended procedures for demonstrating compliance with the rules governing the connection between the WSD and one or more white space databases.

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), *Second Memorandum Opinion and Order* in ET Docket No. 04-186, FCC 10-174, adopted September 23, 2010, *Third Memorandum Opinion and Order* in ET Docket No. 04-186, FCC 12-36, adopted April 5, 2012, and *Report and Order* in ET Docket No. 14-165, FCC 15-99 (rel. August 11, 2015).

² WSDs (formerly called TV band devices or TVBDs) are currently on the Pre-Approval Guidance list. A sample must be submitted to the FCC for pre-approval testing prior to approval by a TCB. See KDB Publication 388624 D01 and D02.

II. EMC TESTS

The compliance tests described below can be performed on a stand-alone WSD (*i.e.*, without accessing a white space database).

1. Test Mode Requirements

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

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

2. Rule Requirements

- a) §15.706 Information to the user
 - i. Visually verify adherence to the labeling requirements specified in §15.19.
 - ii. Visually verify that the required statement, specified in §15.706(a), is included in the WSD user's manual.
- b) §15.707 Permissible channels of operation
 - i. Verify that the DUT cannot be tuned to operate on unauthorized channels, based upon device type: fixed or personal/portable, or frequencies outside of the authorized band(s).
 - ii. Note that the lockout of unauthorized channels may not be totally implemented in the DUT but rather, must be reliant upon limitations provided to the DUT by the database.
- c) §15.709 Power Limits
 - i. Fixed WSDs

The basic power limits for fixed WSD are specified in terms of EIRP. Additional limits on conducted power and power spectral density for fixed WSD are specified in § 15.709(b).

The following paragraphs recommend spectrum analyzer (with signal-processing capability) settings and procedures for performing the conducted power measurement:

1. 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 WSD, it may be necessary to insert an external attenuator in the signal path to prevent overload damage to the analyzer.
2. Select the analyzer's 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.
3. 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) as required by § 15.709 (c).
4. Employ trace averaging over a minimum of 10 traces.
5. Use the integrated band/channel power analyzer function to determine the average power within the 6-MHz channel bandwidth.

6. Use the peak marker function to determine the maximum power in any 100-kHz band segment.
7. 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.
8. If the device has multiple antenna ports, power must be summed across all antennas and antenna elements (§ 15.709(c)(2))
9. Compare the total conducted power levels and PSDs to the applicable conducted power and PSD limits to assess compliance.
10. Repeat until data is accumulated for the low, middle and high channels in the DUT tuning range.

The maximum gain of the transmitting antenna used with a Fixed WSD must be declared by the manufacturer in the certification application. If the transmitting antenna gain exceeds 6 dBi for fixed white space device operating at up to 36 dBm EIRP or exceeds 10 dBi for fixed white space device operating at up to 40 dBm EIRP, the conducted output power, power spectral density, band edge emissions, and adjacent channel emissions limits shall all be reduced by the amount in dB by which the gain exceeds 6 dBi or 10 dBi respectively.³ The documentation filed with certification application must describe how this power level is controlled and compliance with limits ensured. For devices utilizing multiple antennas the appropriate antenna gain should be determined using KDB Publication 662911.

ii. Personal/Portable WSDs:

The power limits for personal/portable WSDs are specified in EIRP. The following paragraphs recommend spectrum analyzer (with signal-processing capability) settings and procedures for performing radiated power measurements.

Refer to the most recent version of ANSI C63.10 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.

1. 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.
2. Select the analyzer's 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.
3. 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).
4. Employ trace averaging over a minimum of 10 traces.
5. Use the integrated band/channel power analyzer function to determine the average amplitude over the 6-MHz channel bandwidth.

³ See §15.709(c)(1) for fixed devices that operate at EIRP levels greater than 36 dBm and §15.709(c)(2) for fixed devices that operate at EIRP levels greater than 40 dBm.

6. Use the peak marker function to determine the maximum amplitude in any 100-kHz band segment.
7. 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.
8. Determine the associated EIRP levels using guidance provided in KDB Publication 412172.
9. Compare the EIRP levels to the applicable EIRP limits to assess compliance.
10. Repeat until data is accumulated for the low, middle and high channels in the DUT tuning range.

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

d) §15.709 Emission Limits

The out-of-band emission limit for fixed and personal /portable WSDs, applicable both at the band-edges and in the adjacent channels (both lower and upper) are provided in the following tables:

Fixed WSD

EIRP (6 MHz)	Conducted power limit (6 MHz)	Conducted PSD limit (100 kHz)⁴	Conducted adjacent channel emission limit (100 kHz)
16 dBm (40 mW)	10 dBm (10 mW)	-7.4 dBm	-62.8 dBm
20 dBm (100 mW)	14 dBm (25 mW)	-3.4 dBm	-58.8 dBm
24 dBm (250 mW)	18 dBm (63 mW)	0.6 dBm	-54.8 dBm
28 dBm (625 mW)	22 dBm (158 mW)	4.6 dBm	-50.8 dBm
32 dBm (1600 mW)	26 dBm (400 mW)	8.6 dBm	-46.8 dBm
36 dBm (4000 mW)	30 dBm (1000 mW)	12.6 dBm	-42.8 dBm
40 dBm (10000 mW)	30 dBm (1000 mW)	12.6 dBm	-42.8 dBm

⁴ See §15.709(b)(1)(ii) for note on fixed WSD operating at 40 mW.

Personal/Portable WSD

EIRP (6 MHz)	Radiated PSD limit EIRP (100 kHz)⁵	Radiated adjacent channel emission limit EIRP (100 kHz)
16 dBm (40 mW)	-1.4 dBm	-56.8 dBm
20 dBm (100 mW)	2.6 dBm	-52.8 dBm

Check that the reported DUT transmit antenna gain complies with §15.709(c). If required, reduce the band-edge and adjacent channel limits by the amount in dB that the transmit antenna gain exceeds 6 dBi.

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 C63.10 for guidance). Out-of-band emission measurements are to be made with the DUT activated in the test mode that provides continuous transmission of the output signal (no time bursting or signal gating) on the operating channel to be investigated. For band-edge, adjacent channel, and beyond adjacent channel measurements the low, middle and high channels of the DUT's tuning range must be tested. The test report must show that the DUT meets the above limits at all power levels. To show compliance with this requirement, include measurements of the worst case at the lowest power level, in addition to other reporting measurements specified herein.

i. Band-edge Measurement:

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

1. Select the power averaging (RMS) detector, a start frequency of fL- 100 kHz and a stop frequency of fL (where fL 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.
2. Employ trace averaging over a minimum of 10 traces.
3. Use the integrated band/channel power function of the analyzer to determine the maximum average power spectral density over the 100-kHz frequency span.
4. 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).
5. Repeat the procedure with the analyzer start frequency set to fU and the stop frequency set to fU + 100 kHz.
6. Repeat the entire procedure until data is accumulated for the lower, middle and upper channels in the DUT tuning range.

⁵ See §15.709(b)(2) for note on personal/portable WSD operating at 40 mW.

ii. 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 ($N \pm 1$, where N represents the channel of operation).

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

1. 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.
2. Employ trace averaging over a minimum of 10 traces.
3. Use the peak marker function of the analyzer to determine the maximum power spectral density in any 100-kHz segment within the frequency span.
4. 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).
5. Repeat the procedure with the analyzer start frequency set to $f_U + 100$ kHz and the stop frequency set to $f_U + 6$ MHz.
6. Repeat the entire procedure until data is accumulated for the lower, middle and upper channels in the DUT tuning range.

iii. 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 C63.10 for guidance on performing these measurements. The DUT must comply with radiated emission limits for a Class B digital device, except that authorization as a Class A device may be considered with appropriate justification for non-residential use.

iv. Channel Bonding or Aggregation

Devices that use multiple contiguous and/or non-contiguous channels must comply with the requirements of § 15.709(d). The test report shall describe how the channel bonding or aggregation is done and must show how it complies with the adjacent channel emission limits in § 15.709(b)(1) and (b)(2). To demonstrate compliance, include the worst case measurements in the test report.

III. DATABASE INTERACTION VERIFICATION

1. Test Mode Requirements

Radio management software must be provided to perform the certification compliance tests described in this document. The software may be the same package as will be available to end users; however administrative privileges must be available. The software must provide the following:

- a) The ability to enter all required registration information.
- b) The ability to view all information provided to the radio by the database.

2. Rule Requirements

a) §15.713(g)(3) Fixed WSD Registration

The Fixed WSD must provide the required information to the database and obtain a successful registration.

The management software must be able to collect the data listed below. Confirm that the DUT will not operate unless a successful registration notification is received from the database.

- i. FCC ID
- ii. Serial Number
- iii. Location Coordinates
- iv. Location uncertainty with 95% accuracy
- v. Antenna Height AGL (must not be > 30 m)
- vi. Contact information (Device owner and device contact)

For a fixed WSD without a direct connection to the internet, confirm that registration through a registered fixed device takes place only on a channel available to that registered device.

b) §15.713(h) Mode II WSD Initialization

Mode II WSDs must be able provide the required information to the database for a successful initialization.

The management software must be able to collect the data listed below. Confirm that the DUT will not operate unless a successful registration notification is received from the database

- i. FCC ID
- ii. Serial Number
- iii. Location Coordinates
- iv. Location uncertainty with 95% accuracy

For a Mode II WSD without a direct connection to the internet, confirm that initialization through another initialized or registered device takes place only on a channel available to that other device.

c) §15.711(e)(1) Mode I WSD Validation

A Mode I WSD must provide its FCC ID to a white space database through a Fixed or Mode II WSD. Confirm that the DUT will not operate unless a successful registration notification is received from the database. Confirm that validation only takes place on a channel available to the Fixed/Mode II device.

d) §15.711(c)(2)(ii) and (d)(3) Fixed and Mode II channels of operation

Confirm that device only operates on channels provided by the database.

e) §15.711(h) Fixed & Mode II TVDB Database Update

To simulate that the device fails to successfully contact the database, block access to the database from the WSD by removing connection to the database. All other radio functions, including internet connectivity should be maintained. Confirm that the WSD ceases operation by 11:59 PM on the following day.

f) §15.711(d) Mode II WSD Position Check

Using the system management software provided with the radio, validate that the WSD executes a position check and database access as required. The WSD must display the position (coordinates) and channel list to allow confirmation.

g) §15.711(d)(1) Mode II WSD Power Loss

Remove power source from operating Mode II WSD. Reconnect power and use the system management software to confirm the device does not operate prior to receiving a new channel list from the database.

f) §15.711(d) Mode I Signal Verification

Use the system management software to confirm that a Mode I WSD receives an available channel verification signal on power-up, and every 60 seconds thereafter.

g) §15.711(d) Mode II to Mode I WSD Channel List Update

Remove the power source and/or relocate a Mode II WSD and confirm that an updated channel list is pushed to a connected Mode I WSDs. WSDs should display the new position (coordinates) and channel list to allow confirmation.

h) §15.711(c)(2)(iii), §15.713(a)(1) 48 Hour Channel Scheduling

After receiving an available channel list, register a low-power auxiliary device on the WSD operating channel to operate on an available channel and in an upcoming time period when the device will be tested. Repeat the available channel request after the update interval and in the time period when the low-power auxiliary device is scheduled to operate, and confirm that the low-power device is accounted for in the schedule. Using the system management software, confirm that the device changes channels at the scheduled time.

j) §15.707, §15.711(c),(d), §15.712 WSD Channel Availability

Confirm that WSD properly identifies itself as fixed or personal/portable to the database by comparing the channel list provided by the database with those allowable to the class of WSD under test. Confirm that the WSD is operating on a channel or channels from the list at the authorized power and cannot be made to operate on an unauthorized channel.

k) §15.715(f), §15.713(l), §15.711(j) Security

The device operations procedures must include documentation with a detailed explanation of the following for each database the device is expected to work with:

- i. What communication protocol is used between the database and the WSD?
- ii. How are communications initiated?
- iii. How does the WSD validate messages from the database?
- iv. How does the device handle failure to communicate or authenticate the database?
- v. How does the database validate messages from a WSD?
- vi. What encryption method is used?
- vii. How does the database ensure secure registration of protected devices?

l) §15.711(i) Push notification to Fixed and Mode II

Confirm that the WSD device changes channels (or cease operation) when it receives ‘push’ notification from the database.

Using system management software, register the device at (specific coordinates) and wait for the database to send a push notification. Confirm that, once the notification is received, the device responds to the new channel availability list provided by the database, which would include ceasing operation on a channel no longer available, or ceases operation.

m) §15.711(b) Location accuracy

For Fixed and Mode II devices, provide details regarding the technologies used by the device to determine its location and how, in case of other than GPS technology, the location uncertainty is calculated with a 95% confidence level.

n) §15.712 Interference protection requirement (Fixed and personal/portable)

Using system management software or database, provide different location (coordinates) so that compliance with operating channel and power level is shown under each of the scenarios outlined in §15.712. Include a sample scan showing the total channel power and adjacent channel emission settings for test coordinates.

o) §15.711(c)(2)(ii), (d)(3), §15.715(e) Fixed and Mode II Power level reduction

Using system management software, make a channel availability request to the database. Using the spectrum analyzer, confirm that the WSD operates at no more than the maximum power level indicated by the database and that the power level cannot be set to a higher level than indicated by the database at that specific location. If the device cannot reduce power, it must cease operation.

CHANGE NOTICE

06/25/2012: 416721 D01 White Space Test Procedures v01 is replaced by 416721 D01 White Space Test Procedures v02 to reflect the rule changes adopted in the *Third Memorandum Opinion and Order* in ET Docket No. 04-186, FCC 12-36, adopted April 5, 2012.

12/22/2015: 416721 D01 White Space Test Procedures v02 is replaced by 416721 D01 White Space Test Procedures v03 to reflect the rule changes adopted in the *Report and Order* in ET Docket No. 14-165, FCC 15-99 (rel. August 11, 2015).

FREQUENTLY ASKED QUESTIONS

Question 1: What are the effective dates for the WSD rules adopted on August 6, 2015 by the Commission in ET Docket No. 14-165 (FCC 15-99)?

Answer 1: Most of the rules will be effective from December 23, 2015. All filings for new devices must comply with the new technical requirements.

Question 2: If a device is already certified, do I need to file a permissive change to comply with the new rules?

Answer 2: If the device is updated to comply with the new rules, a permissive change filing is required. However, with the exception of the 'push' notification, manufacturers of approved devices are not required to incorporate the new rules for emission into already certified equipment (see Questions 3 and 4 for more information).

Question 3: What is the transition period for the 'push' notification?

Answer 3: There are different transition dates:

Certification - All new application for certification filed after June 23, 2016, must comply with the 'push' notification.

Marketing – All WSD imported and marketed after September 23, 2016, must comply with the 'push' notification.

Operation – A device that does not comply with the 'push' notification, must cease operation after December 23, 2016.

Question 4: For already certified devices, what is the deadline to comply with the 'push' notification?

Answer 4: Certified devices can file Class II Permissive Changes up to 1 year after the effective date of the rules, *i.e.*, December 23, 2015. After December 23, 2016 devices which do not comply with this requirement must cease operation.