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GUIDANCE FOR COMPLIANCE MEASUREMENTS ON DIGITAL TRANSMISSION SYSTEM, FREQUENCY HOPPING SPREAD SPECTRUM SYSTEM, AND HYBRID SYSTEM DEVICES OPERATING UNDER SECTION 15.247 OF THE FCC RULES

1. INTRODUCTION

This document provides general information on certification application filings and measurement procedures for devices operating under Section 15.247 of the FCC rules. The guidance in this document is in addition to and shall be used in conjunction with other information and measurement procedures provided in ANSI C63.10.[1,2] Examples of equipment types certified under Section 15.247 of the FCC rules include devices used for wireless internet, wireless access points, and Bluetooth transceivers. Many devices can operate under multiple rules or bands (*e.g.*, Sections 15.247 and 15.407); the overall device must be shown to be in compliance with the individual rule requirements.

Equipment certified under Section 15.247 can operate as either a Digital Transmission System (DTS),[3] a Frequency Hopping Spread Spectrum (FHSS) system or a Hybrid system, as long as the appropriate requirements for each classification are met. For instance, for a device using digital modulation and frequency hopping, compliance demonstration for both the FHSS requirements and the DTS requirements is not needed. Instead, such a device could be certified by complying with either all the FHSS requirements, or all of the DTS requirements, or all of the hybrid system requirements.

For systems that employ two mutually exclusive operational modes, such as an acquisition mode and a data mode that are separate and distinct (*e.g.*, one operates after the other), one mode can show compliance for example with the DTS requirements, and the other mode can show compliance as an FHSS system. Such a device would need to be certified as a composite system under one FCC ID (in this example, two Form 731 applications with two different equipment classes). This example (DTS and FHSS composite system) is not considered to be a hybrid system. Hybrid systems use both digital

[1] ANSI C63.10-2013, *American National Standard for Testing Unlicensed Wireless Devices*, Institute for Electrical and Electronic Engineers (IEEE). Throughout this document the general description “ANSI C63.10” is used, however all clause and subclause cross-references are per ANSI C63.10-2013.

[2] As part of the rule changes adopted by the *Report and Order* FCC 14-208 (docket no. 13-44), Section 15.31(a)(3) was amended to include ANSI C63.10-2013 as an acceptable measurement procedure for various types of unintentional radiators. See also KDB Publications 300643 and 414788, concerning measurements procedures for Part 15 equipment overall and for associated test site requirements, respectively.

[3] Effective March 2, 2016, applications for new DTS devices or for already approved devices to add digital operation in the 5725-5850 MHz band cannot be approved under the Section 15.247 rules and instead are subject to the revised § 15.407 rules and requirements (see § 15.37(h), FCC 15-61, and FCC 15-163). This guidance must be used if the device is being approved under Section 15.407(b)(4)(ii) rules. For further information on permissive changes and marketing restrictions see KDB Publications 789033 and 926956.

(continued....)

modulation and frequency hopping techniques at the same time on the same carrier. A hybrid system must use digital modulation and must also meet the definition for frequency hopping systems in Section 2.1(c).[4]

While these devices must comply with the general rules and requirements for all transmitters in Part 15 Subpart A and C, and the specific requirements listed in Section 15.247, this guidance document only provides additional filing and measurement guidelines for DTS, FHSS, and hybrid system equipment. An FAQ section for devices operating under Section 15.247 is also provided in Section 11 of this document.

2. POWER LIMITS, DEFINITIONS AND DEVICE CONFIGURATION

2.1 DTS equipment

The maximum output power limit for DTS devices is specified as 1 W and is expressed in terms of either maximum peak conducted output power or maximum conducted output power.[5]

The maximum peak conducted output power is defined as the maximum power level measured with a peak detector using a filter with width and shape of which is sufficient to accept the full signal bandwidth.

The maximum conducted output power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level.

The minimum 6 dB bandwidth of a DTS transmission shall be at least 500 kHz.[6] Within this document, for DTS devices this bandwidth is referred to as the *DTS bandwidth*. The procedures for measuring the maximum peak conducted output power assume the use of the *DTS bandwidth*.

The procedures provided herein for measuring the maximum conducted (average) output power assume the use of the occupied bandwidth (OBW) as the reference for power integration. See ANSI C63.10 for guidance pertaining to measuring the OBW. Either of the two methods specified in ANSI C63.10 are acceptable, but the methodology for measuring the 99 % OBW is the most accurate for noise-like emissions and thus is the preferred method.

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[4] 47 CFR § 2.1(c), *Frequency Hopping Systems.* A spread spectrum system in which the carrier is modulated with the coded information in a conventional manner causing a conventional spreading of the RF energy about the frequency carrier. The frequency of the carrier is not fixed but changes at fixed intervals under the direction of a coded sequence. The wide RF bandwidth needed by such a system is not required by spreading of the RF energy about the carrier but rather to accommodate the range of frequencies to which the carrier frequency can hop. The test of a frequency hopping system is that the near-term distribution of hops appears random, the long term distribution appears evenly distributed over the hop set, and sequential hops are randomly distributed in both direction and magnitude of change in the hop set.

[5] See 47 CFR § 15.247(b)(3).

[6] See 47 CFR § 15.247(a)(2).

2.2 FHSS equipment

The following table provides a shorthand summary of the FHSS power limits and other basic requirements, per Sections 15.247(a), 15.247(b)(1), and 15.247(b)(2).

902-928 MHz	$P_{max\text{-}pk} \leq 1$ W $N_{ch} \geq 50$ $\Delta f \geq$ MAX { 25 kHz, BW_{20dB} } $BW_{20dB} \leq 250$ kHz $t_{ch} \leq 0.4$ s for $T = 20$ s	$P_{max\text{-}pk} \leq 0.25$ W $25 \leq N_{ch} < 50$ $\Delta f \geq$ MAX { 25 kHz, BW_{20dB} } 250 kHz < $BW_{20dB} \leq 500$ kHz $t_{ch} \leq 0.4$ s for $T = 10$ s
2400-2483.5 MHz	$P_{max\text{-}pk} \leq 1$ W $N_{ch} \geq 75$ $\Delta f \geq$ MAX { 25 kHz, BW_{20dB} } max. BW_{20dB} not specified $t_{ch} \leq 0.4$ s for $T = 0.4 \cdot N_{ch}$	$P_{max\text{-}pk} \leq 0.125$ W $15 \leq N_{ch} < 75$ $\Delta f \geq$ MAX { 25 kHz, $0.67 \cdot BW_{20dB}$ } max. BW_{20dB} not specified $t_{ch} \leq 0.4$ s for $T = 0.4 \cdot N_{ch}$
5725-5850 MHz	$P_{max\text{-}pk} \leq 1$ W $N_{ch} \geq 75$ $\Delta f \geq$ MAX { 25 kHz, BW_{20dB} } $BW_{20dB} \leq 1$ MHz $t_{ch} \leq 0.4$ s for $T = 30$ s	

t_{ch} = average time of occupancy; T = period; N_{ch} = # hopping frequencies;
BW = bandwidth; Δf = hopping channel carrier frequency separation

3. ACCEPTABLE MEASUREMENT CONFIGURATIONS[7]

The measurement procedures are based on the use of an antenna-port conducted test configuration. However, if antenna-port conducted tests cannot be performed on an EUT (*e.g.*, portable or handheld devices with integral antenna), then radiated tests are acceptable for demonstrating compliance to the conducted emission requirements. The guidance is applicable to either antenna-port conducted or radiated compliance measurements.

If a radiated test configuration is used, then the measured power or field strength levels shall be converted to equivalent conducted power levels for comparison to the applicable output power limit. This may be accomplished by first measuring the radiated field strength or power levels using a methodology for maximum peak conducted power or maximum conducted (average) power as applicable and peak or average power spectral density as applicable. The radiated field strength or power level can then be converted to EIRP (see ANSI C63.10 for guidance). The equivalent conducted output power or power spectral density is then determined by subtracting the EUT transmit antenna gain (guidance applicable to devices utilizing multiple antenna technologies is provided in KDB Publication 662911) from the EIRP (assuming logarithmic representation). All calculations and parameter assumptions shall be provided in the test report.

Antenna-port conducted measurements shall be performed using test equipment that matches the nominal impedance of the antenna assembly to be used with the EUT. Additional attenuation may be required in the conducted RF path to prevent overloading of the measurement instrument. The measured power

[7] Note that Sections 3 through 7 of this document are mostly the same as in 11.3 through 11.7 of ANSI C63.10-2013, except for various wording adjustments and cross-reference section number changes mainly due to the different overall arrangements and contents of the two documents. This August 2018 revision retains this material for continuity and better readability purposes.

levels shall be adjusted to account for all losses or gains introduced into the conducted RF path, including cable loss, external attenuation or amplification. These adjustments shall be recorded in the test report.

Radiated measurements shall utilize the procedures specified in ANSI C63.10, as applicable.

Averaging over the symbol alphabet is permitted when measuring the maximum conducted (average) output power; however, time intervals when the transmitter is off or transmitting at reduced power levels are not to be considered. Thus, whenever possible the EUT shall be configured to transmit continuously (*i.e.*, with a duty cycle of greater than or equal to 98 %) at the maximum power control level over a random symbol set. Alternatively, sweep triggering/signal gating may be employed within the measurement instrumentation so that all measurements are performed while the EUT is transmitting at its maximum power control level.

The Section 15.247 emission limits apply to the total of the emissions from all outputs of the transmitter. Thus, emissions from the transmitter outputs must be summed before comparing the measured emissions to the emission limit. See KDB Publication 662911 for additional guidance.

4. TEST SUITE CONSIDERATIONS

Depending on the operational frequency range utilized by a particular EUT, compliance measurements can be required on multiple frequencies or channels. Section 15.31(m) specifies the number of frequencies/channels that shall be tested as a function of the frequency range over which the EUT operates.

Many EUTs utilize wireless protocols that provide for operation in multiple transmission modes, where the data rate, bandwidth, modulation, coding rate, and number of data streams are often variable. When such multiple modes of operation are possible, then compliance to the applicable technical requirements shall be confirmed for any and all realizable operational modes.

In some cases, it might be possible to identify one or more specific operational modes that produce the “worst-case” test results with respect to all of the required technical limits (*e.g.*, output power, power spectral density, unwanted emission power at the band edge and in all spurious emissions, and for each possible output data stream), and then reduce the testing to just these modes on each of the frequencies/channels required per Section 15.31(m). Whenever this type of test reduction is utilized, a complete and detailed technical justification shall be provided in the test report, to include measurement data where applicable.

5. REFERENCE LEVEL/ATTENUATION/HEADROOM

5.1 General

For measurements where the bandwidth of the emission is greater than the resolution bandwidth of the measuring instrument care must be taken to ensure that the input mixer of the instrument is operating in its linear region and is not saturating or clipping the signal.

For measurements where the bandwidth of the emission is less than or equal to the resolution bandwidth of the measuring instrument it is generally sufficient that the peak of the displayed signal be less than the reference level, as long as the instrument attenuation is set to AUTO.

5.2 Setting the proper reference level and input attenuation

Set attenuation to auto. If finer control of attenuation is required to achieve a sufficiently low noise floor for out-of-band measurements, manual setting of attenuation is permitted provided that the power level corresponding to the reference level setting specified below falls within the mixer level range recommended by the instrument manufacturer.

Set the reference level based on power measurements of the signal or by ensuring that the "head room" between the maximum spectrum level and the reference level is at least 10 log (99 % occupied bandwidth/RBW). The nominal channel bandwidth or the emission bandwidth may be substituted for 99 % occupied bandwidth in this formula if a measurement of occupied bandwidth is not available.

Additional headroom (*i.e.*, higher reference level) equal to 10 log(1/duty cycle) will be needed if the headroom calculation is based on power or spectrum measurements that are averaged across the on/off cycle of the transmission. For example, the reference level should be set 3 dB higher if the settings are based on power or spectrum measurements that are averaged across the on/off cycles of a 50 % duty cycle transmission.

For in-band measurements the reference level is based on in-band power or maximum in-band spectrum level.

The same reference level is also used for out-of-band measurements unless a preselector attenuates the in-band signal sufficiently to justify a lower reference level.

6. DUTY CYCLE, TRANSMISSION DURATION AND MAXIMUM POWER CONTROL LEVEL

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

When continuous transmission cannot be achieved and sweep triggering/signal gating cannot be implemented, alternate procedures are provided that can be used to measure the average power; however, they will require an additional measurement of the transmitter duty cycle. Within this guidance document, the duty cycle refers to the fraction of time over which the transmitter is on and is transmitting at its maximum power control level. The duty cycle is considered to be constant if variations are less than ± 2 %, otherwise the duty cycle is considered to be non-constant.

The term “maximum power control level” is intended to distinguish between operating power levels of the EUT and differences in power levels of individual symbols that occur with some modulation types such as quadrature amplitude modulation (QAM). During testing, the EUT is not required to transmit continuously at its highest possible symbol power level. Rather, it should transmit all of the symbols and should do so at the highest power control level (*i.e.*, highest operating power level) of the EUT.

Measurements of duty cycle and transmission duration shall be performed using one of the following techniques:

a) A diode detector and an oscilloscope that together have sufficiently short response time to permit accurate measurements of the on- and off-times of the transmitted signal.

b) The zero-span mode on a spectrum analyzer or EMI receiver if the response time and spacing between bins on the sweep are sufficient to permit accurate measurements of the on- and off-times of the transmitted signal.

   1) Set the center frequency of the instrument to the center frequency of the transmission.
   2) Set RBW ≥ OBW if possible; otherwise, set RBW to the largest available value.
   3) Set detector = peak or average.
   4) The zero-span measurement method shall not be used unless both RBW and VBW are > 50/T and the number of sweep points across duration T exceeds 100.

      (For example, if VBW and/or RBW are limited to 3 MHz, then the zero-span method of measuring duty cycle shall not be used if T ≤ 16.7 microseconds.)

7. TRANSMIT ANTENNA PERFORMANCE CONSIDERATIONS

The conducted output power limits for Section 15.247 EUTs are based on the use of transmit antennas with directional gains that do not exceed 6 dBi. If transmit antennas with an effective directional gain greater than 6 dBi are used, then the conducted output power from the EUT shall be reduced, as specified in the applicable Section 15.247 requirements.[8]

For those cases where the rule specifies that the conducted output power be reduced by the amount in dB that the directional gain of the transmitting antenna exceeds 6 dBi, the applicable output power limit shall be calculated as follows:

$$P_{Out} = P_{Limit} - \left(G_{Tx} - 6\right) \qquad (1)$$

where:

P_{Out} is the maximum conducted output power in dBm,
P_{Limit} is the output power limit in dBm,
G_{Tx} is the maximum transmitting antenna directional gain in dBi.

For those cases where the rule specifies that the conducted output power be reduced by 1 dB for every 3 dB that the directional gain of the transmitting antenna exceeds 6 dBi, the applicable output power limit shall be calculated as follows:

$$P_{Out} = P_{Limit} - \text{Floor}\left[\left(G_{Tx} - 6\right)/3\right] \qquad (2)$$

[8] See 47 CFR §§ 15.247(b) and 15.247(c).

where:

P_{Out} is the maximum conducted output power in dBm,
P_{Limit} is the output power limit in dBm,
Floor[x] is the largest integer not greater than *x* (*i.e.*, drop all fractional portions of the real number retaining only the least integer value of the operation),
G_{Tx} is the maximum transmitting antenna directional gain in dBi.

Additional guidance for determining the effective antenna gain of EUTs that utilize multiple transmit antennas simultaneously or sequentially is provided in KDB Publication 662911.

8. DIGITAL TRANSMISSION SYSTEM (DTS) EQUIPMENT

8.1 General

The following information is for certification of DTS devices under Section 15.247.

a) Use Form-731 equipment-class code DTS.

b) DTS device must use digital modulation. Digital modulation is defined as: "The process by which the characteristics of a carrier wave are varied among a set of predetermined discrete values in accordance with a digital modulating function as specified in document ANSI C63.17-1998."[9]

c) Test procedures for DTS device EMC and radio parameters, such as power, OBW, radiated and band-edge measurements, are described in the following subclauses, including cross-references to Clause 11 of ANSI C63.10.

   In addition the following clarifications relative to ANSI C63.10 are also applicable.

   1) Concerning 11.13 (Band-edge measurements) of ANSI C63.10:

      The requirement in 11.13.1 that the DTS bandwidth (or EBW) edge falls within 2 MHz of the band edge applies only for use of the marker-delta method; use of the integration method is not subject to the same limitation.

   2) For measuring output power of a device transmitting a wide-band noise-like signal (*i.e.*, digitally-modulated) where the peak power amplitude is a statistical parameter, the preferred methodology is to use integrated average power measurements, as described in 11.9.2 and 11.13.3 of ANSI C63.10. The peak integrated band power methods of 11.9.1.2 and 11.13.3.2 of ANSI C63.10 are not applicable for FCC compliance testing purposes.

   3) Additional measurement procedures and the allowance for duty cycle for DTS device out-of-band measurements in a restricted band for protocol-limited devices is described in FAQ #3 in Section 11 of this document.

[9] See 47 CFR § 15.403(f).

8.2 DTS bandwidth

Subclause 11.8 of ANSI C63.10 is applicable.

8.3 DTS fundamental emission output power

8.3.1 Maximum peak conducted output power

One of the following procedures may be used to determine the maximum peak conducted output power of a DTS EUT.

8.3.1.1 RBW ≥ DTS bandwidth

Subclause 11.9.1.1 of ANSI C63.10 is applicable.

8.3.1.2 Integrated band power method

For measuring the output power of a device transmitting a wide-band noise-like signal where the peak power amplitude is a statistical parameter, the preferred methodology is to use an integrated average power measurement, as described in 8.3.2. The peak integrated band power method of 11.9.1 in ANSI C63.10 is not applicable.

8.3.1.3 PKPM1 Peak-reading power meter method

Subclause 11.9.1.3 of ANSI C63.10 is applicable.

8.3.2 Maximum conducted (average) output power

8.3.2.1 General

Section 15.247 permits the maximum conducted (average) output power to be measured as an alternative to the maximum peak conducted output power for demonstrating compliance to the limit. When this option is exercised, the measured power is to be referenced to the OBW rather than the *DTS bandwidth* (see ANSI C63.10 for measurement guidance).

When using a spectrum analyzer or EMI receiver to perform these measurements, it shall be capable of utilizing a number of measurement points in each sweep that is greater than or equal to twice the span/RBW to set a bin-to-bin spacing of ≤ RBW/2 so that narrowband signals are not lost between frequency bins.

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

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 during which sweep triggering/signal gating techniques may be used to perform the measurement over the transmission duration.

8.3.2.2 Measurement using a spectrum analyzer (SA)

Subclause 11.9.2.2 of ANSI C63.10 is applicable.

8.3.2.3 Measurement using a power meter (PM)

Subclause 11.9.2.3 of ANSI C63.10 is applicable.

8.4 DTS maximum power spectral density level in the fundamental emission

Subclause 11.10 of ANSI C63.10 is applicable.

8.5 DTS emissions in non-restricted frequency bands

Subclause 11.11 of ANSI C63.10 is applicable.

8.6 DTS emissions in restricted frequency bands

Subclause 11.12 of ANSI C63.10 is applicable [see also 8.1 c) 3)].

8.7 DTS band-edge emission measurements

8.7.1 General

When performing peak or average radiated measurements, emissions within 2 MHz of the authorized band edge may be measured using the marker-delta method described below. The integration method can be used when performing conducted or radiated average measurements.

8.7.2 Marker-delta method

The marker-delta method, as described in ANSI C63.10, can be used to perform measurements of the radiated unwanted emissions level at the band-edges provided that the 99 % OBW of the fundamental emission is within 2 MHz of the authorized band edge.

8.7.3 Integration method

Subclause 11.13.3 of ANSI C63.10 is applicable.

9. FREQUENCY HOPPING SYSTEM (FHSS) EQUIPMENT UNDER SECTION 15.247

The following information is for certification of in FHSS devices under Section 15.247.

a) Use Form-731 equipment-class code DSS.

b) Test procedures for measuring FHSS device EMC and radio parameters, such as power, dwell time, and channel separation, are provided in 7.8 of ANSI C63.10. Note that device power levels are based on the number of channels used, and the BW limits are based on operating frequency.

   The use of a duty cycle correction factor (DCCF) is permitted for calculating average radiated field strength emission levels for an FHSS device in 15.247. This DCCF can be applied when the unwanted emission limit is subject to an average field strength limit (*e.g.*, within a Government Restricted band) and the conditions specified in Section 15.35(c) can be satisfied. The average radiated field strength is calculated by subtracting the DCCF from the maximum radiated field strength level as determined through measurement. The maximum radiated field strength level represents the worst-case (maximum amplitude) RMS measurement of the emission(s) during continuous transmission (*i.e.*, not including any time intervals during which the transmitter is off or is transmitting at a reduced power level). It is also acceptable to apply the DCCF to a measurement performed with a peak detector instead of the specified RMS power averaging detector. Note that Section 15.35(c) specifies that the DCCF shall represent the worst-case (greatest duty cycle) over any 100 msec transmission period. The test report provided with the certification application must provide clear and complete documentation of the justification for use of the procedure as well as the calculations and assumptions that are used. Subclause 7.5 of ANSI C63.10 provides additional measurement guidance applicable to determination of the DCCF.

c) The following items must also be addressed in FHSS device filings.

1) Section 15.247(a)(1):

i) Pseudorandom frequency hopping sequence

Describe how the hopping sequence is generated. Provide an example of the hopping sequence channels, to demonstrate that the sequence meets the requirement specified in the definition of an FHSS system, found in Section 2.1(c). Per the definition in Section 2.1(c), the hop set shall appear as random in the near term, shall appear as evenly distributed in the long term, and sequential hops shall be randomly distributed in both direction and magnitude of change.

ii) Equal hopping frequency use

Describe how each individual EUT meets the requirement that each of its hopping channels is used equally on average (*e.g.*, that each new transmission event begins on the next channel in the hopping sequence after the final channel used in the previous transmission event).

iii) System receiver input bandwidth

Describe how the associated receiver(s) complies with the requirement that the input bandwidth (either RF or IF) matches the bandwidth of the transmitted signal.

iv) System receiver hopping capability

Describe how the associated receiver(s) has the ability to shift frequencies in synchronization with the transmitted signals.

2) Section 15.247(g):

For short burst systems, describe how the EUT complies with the requirement that it be designed to be capable of operating as a true frequency hopping system. Specifically, the device shall comply with the equal frequency use and pseudorandom hopping sequence requirement when transmitting in short bursts, and shall be designed to comply when presented with continuous data (or information) stream.

3) Section 15.247(h):

   Describe how the EUT complies with the requirement that it not have the ability to be coordinated with other FHSS systems in an effort to avoid the simultaneous occupancy of individual hopping frequencies by multiple transmitters.

10. HYBRID SYSTEM EQUIPMENT UNDER SECTION 15.247

The following information is for certification of hybrid spread-spectrum devices under Section 15.247.

a) Use Form-731 equipment-class code DSS.

b) Hybrid system device measurement guidelines are as follows.

   1) As specified in Section 15.247(f), a hybrid system must comply with the power density standard of 8 dBm in any 3 kHz band when the frequency hopping function is turned off.

   2) The transmission must comply with a 0.4 second/channel maximum dwell time when the hopping function is turned on.

   3) There is no requirement for this type of hybrid system to comply with the 500 kHz minimum bandwidth normally associated with a DTS device.

   4) There is no minimum number of hopping channels associated with this type of hybrid system. While there is not a specific minimum limit, the hop sequence is required to appear as pseudorandom per Section 15.247(a)(1) (see Section 3 of this document).

   5) The hopping function must be a true frequency hopping system, as described in Section 15.247(a)(1). The specific requirements in Section 15.247(a)(1) are:

      i) a minimum channel separation;

      ii) pseudo-random hop sequence;

      iii) equal use of each frequency; and

      iv) receiver matching bandwidth and synchronization.

   6) Generally, use the test procedures for DTS and FHSS devices in Clause 11 and 7.8 of ANSI C63.10, respectively.

      i) Output power: use 11.9 of ANSI C63.10;

      ii) Peak Power Density: use 11.10 of ANSI C63.10;

      iii) Carrier channel separation: use 7.8.2 of ANSI C63.10;

      iv) Dwell time: use 7.8.4 of ANSI C63.10.

11. FREQUENTLY ASKED QUESTIONS

Question 1: Can a device capable of transmitting to multiple users but only one at a time via different beams, via CDMA coding or sequentially via TDMA, be considered as point-to-point?

Answer 1: No. These systems are considered to be transmitting to multiple users and are point-to-multipoint systems.

Question 2: Can fixed remote users that transmit to a single fixed access point (uplink) be considered point-to-point even though the access point is a point-to-multipoint system (downlink) transmitting to multiple remote users?

Answer 2: Yes. The uplink can transmit under point-to-point requirements even when the downlink is point-to-multipoint.

Question 3: What measurement methods are available for making average measurements on devices with protocol-limited duty cycles such as ZigBee devices (DTS devices certified under Section 15.247)?

Answer 3: Several measurement methods are available for making average measurements for radiated and antenna-port conducted spurious emissions provided that: (i) the spurious emissions fall in restricted bands, (ii) emission are temporally related to the fundamental, (iii) the maximum duty cycle used in determining the reduction factor is hardwired such that under no condition can it be changed or modified by either the device or end user, (iv) a documented justification for use of Section 15.35(c) including the measurements used to determine the worst-case duty cycle must be included in the test report, and (v) the duty cycle correction factor is the worst case operational duty cycle based on the maximum transmission time in any 100 msec period. If the above criteria are satisfied, one of the following measurement techniques may be used:

a) Applying a duty cycle correction to the Peak measurement – First, a Peak measurement is made using the Peak detector function of a spectrum analyzer. The spectrum analyzer settings should be such that it meets the requirements of 11.12.2.4 in ANSI C63.10 for making a Peak measurement. Then the operational duty cycle of the EUT may be subtracted from the Peak reading to derive the RMS average value. If the EUT supports more than one operational duty cycle the worst-case value should be used, *i.e.*, the highest operational duty cycle.

b) Taking a RMS average measurement while the EUT is transmitting in operational duty cycle – The RMS average detector of a spectrum analyzer can be used for making average measurements with the EUT operating on its operational duty cycle. If the EUT supports more than one operational duty cycle the worst-case value should be used, *i.e.*, the highest operational duty cycle. The measured RMS value using this method is compared against the limits and no other corrections are permitted. The spectrum analyzer settings shall meet the requirements of ANSI C63.10 for making Average measurements. This measurement refers to spectrum analyzer settings in either 11.12.2.5.2 or 11.12.2.5.3 in ANSI C63.10; except when using 11.12.2.5.2, set Trace mode = Max Hold and the measurement correction factor in 11.12.2.5.2 i) is not added.

c) Taking a RMS average measurement while EUT is transmitting continuously, *i.e.*, greater than 98%, and correcting for operational duty cycle – When greater than 98% duty cycle is achieved for testing purposes, applying average measurement techniques (*e.g.*, average detector / reduced VBW) then adjusting for the protocol limited duty factor to determine the average emission is acceptable. If the

EUT supports more than one operational duty cycle the worst-case value should be used, *i.e.*, the highest operational duty cycle. This measurement refers to spectrum analyzer settings 11.12.2.5.1 (Trace averaging with continuous EUT transmission at full power) in ANSI C63.10.

Question 4: What is the 0.4 second/channel maximum dwell time required for FHSS and hybrid system devices?

Answer 4: The dwell time is the time starting from the beginning of the first transmission on a channel and ending at the end of the last transmission in that same channel before the device hops to another channel. The dwell time includes any non-transmissions that may occur between transmissions on the same channel before the device hops to another channel. The dwell time also does not include the non-transmission time between the end of the last transmission on a channel and the start of the next transmission on a new channel.

Question 5: Does the non-coordination requirement of Section 15.247(h) apply to hybrid systems?

Answer 5: No.

Question 6: What is the FCC policy on the use of set-up (or "beacon") channels used in FHSS system devices?

Answer 6: Section 15.247(a)(1) requires that all channels in a FHSS system devices be used equally, on the average, by each transmitter. In certain usage situations such as in, isochronous, or voice, FHSS system devices that tend to have long transmission times relative to the time spent on any single channel, the use of dedicated set up channels, which may or may not be part of the sequence of channels used during normal transmissions, does not violate the intent of the rule.

As such, in the case of isochronous transmissions, FCC has interpreted Section 15.247(a)(1) as allowing the use of dedicated set up channels, as long as the time of occupancy on any such channel does not exceed 0.4 seconds (as required by Sections 15.247(a)(1)(i) and (ii)).

The same cannot be said of asynchronous, or data, transmission systems. In these systems, the average transmission time may not be long relative to the time spent on any single channel. As a result, the use of dedicated set up channels in such a case is not permitted.

Note that a dedicated set up channel which is not part of the sequence of channels used during normal transmissions may not be used to satisfy the minimum number of channels required by Sections 15.247(a)(1)(i) or (ii).

Question 7: Can Bluetooth Low Energy (BLE) mode (V4.0, etc.) devices be approved under the FHSS rules (equipment class DSS)?

Answer 7: Advertising mode operation uses only three channels, and regular connections can drop to only two channels, therefore BLE mode does not meet the FHSS minimum number of channels requirement. Compliance must be addressed under Section 15.247 DTS requirements or using Section 15.249 for qualifying devices.

CHANGE NOTICE

NOTE—this document (KDB Publication 558074 D02) combines information from and expires the former KDB Publication 867751 (FHSS), KDB Publication 453039 (hybrid systems), and FCC Public Notice DA 00-705.

08/24/2018: 558074 D01 DTS Meas Guidance v04 changed to 558074 D01 15.247 Meas Guidance v05. Document restructured including replacing text with cross-references to corresponding text in ANSI C63.10.

02/11/2019: 558074 D01 DTS Meas Guidance v05 changed to 558074 D01 15.247 Meas Guidance v05r01. Clarification on the use duty cycle correction factor added in section 9.