KDB 558074

Revision to Compliance Measurement Guidance for 15.247 Digital Transmission Systems

TCB Workshop

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Scope of the Revision

- Applicable only to systems defined in 15.247(a)(2)
  - Limited to systems using digital modulation techniques and operating in the 902-928, 2400-2483.5 or 5725-5850 MHz bands
  - Not applicable to frequency-hopping spread spectrum (FHSS) systems defined in 15.247(a)(1)

DTS Test Configurations

- The output power limits provided in 15.247(b) are specified in terms of RF "conducted" power
  - Both the previous and the revised guidance assume conducted measurements to demonstrate compliance to the limit
  - In those cases where antenna-port conducted tests cannot be performed (*e.g.*, integrated transmit antenna), radiated measurements will be required
- The emission limits specified in 15.247(d) are based on either RF conducted or radiated measurements
- When radiated measurements are made, they must be performed on a test site that conforms to C63.4 requirements and shall utilize the applicable procedures and requirements described in C63.10
  - The measurement procedures and instrument settings provided in this guidance document are applicable to either conducted or radiated measurements
  - If radiated power is measured it must be converted to an equivalent conducted output power level for comparison to the limit
    - Refer to KDB 412172 for further guidance

Required Test Suites

- Number of channel measurements required:
  - Specified by 15.31(m)
  - Typically 3 for DTS devices: lower, middle, and upper
- Variable data rates, bandwidths, modulations and multiple data streams becoming common
  - Combination that produces “worst-case” results for all technical requirements (bandwidth, fundamental power, PSD and OOBE) must be included in the final test suite
  - FCC does not recommend a specific “worst-case” combination
    - Manufacturers and test labs should review the capabilities of the EUT, including specific operational characteristics and implementation, to determine the appropriate modes to be tested
  - If test reduction is applied, a detailed justification is required to be submitted with the application

Maximum Peak vs. Maximum Conducted Power

- §15.247(b)(3) permits either the maximum peak conducted output power or the maximum (*aka* "average") conducted output power to be used to demonstrate compliance to the 1 watt limit.
- The maximum conducted output power does not include transmitter off time or times when the EUT is transmitting at reduced power levels
- Ideally, compliance measurements should be made with the EUT transmitting continuously (duty cycle ≥ 98%); however, in practice this may not always be achievable

Transmission Duration and Duty Cycle

- When measuring the maximum conducted output power one of the following conditions must be satisfied:
  - EUT configured to transmit continuously during the measurement duration (duty cycle ≥ 98%)
  - Sweep triggering or signal gating is used to perform measurement only during EUT transmission periods (at maximum power control level)
- If neither of the above conditions can be realized then it will be necessary to measure the duty cycle in order to adjust the power measured over transmitter on/off times
- Guidance is provided for determining the transmission duration (*T*) and the transmitter duty cycle

Transmit Antenna Considerations

- The conducted output power limits in §15.247(b)(3) assume the use of transmit antennae with directional gains that do not exceed 6 dBi
- If the DTS transmit antennae gain exceeds 6 dBi, a correction must be applied to the conducted output power limit to compensate for the additional gain as defined in 15.247(c)
- Guidance is provided on how to determine the appropriate correction
- Guidance for determining the antenna gain for multiple antennae is provided in a separate KDB (Publication 662911)

Required Measurements

- The measurement procedures presented in the following slides are acceptable to the FCC for demonstrating compliance to the requirements specified in §15.247(a)-(d)
- The procedures designated as “Option” represent the preferred methodologies
- The procedures designated as “Alternative” represent acceptable methodologies
- This document is intended to provide guidance for TCB filings. Alternative procedures that are not specifically included in this guidance will be considered but will require filing directly with the Commission

DTS Bandwidth Measurement

- DTS (6-dB) Bandwidth
  - Measurement used to demonstrate compliance to the minimum bandwidth requirement of 500 kHz
  - This is the only bandwidth measurement required to be reported
    - However, maximum (average) conducted output power measurements utilize the -26 dB emission bandwidth
  - Option 1 – traditional method (see C63.10 Clause 6.9.1)
    - Legacy procedure specified RBW = 100 kHz
    - New guidance specifies RBW = 1-5% of fundamental bandwidth
    - Comments received suggests that this change will result in a more difficult measurement and may be problematic for DTS EUT's with bandwidths near the minimum limit
    - We agree and will modify to restore specified RBW setting to 100 kHz
  - Option 2 – use of automatic bandwidth function
    - RBW specification will also be changed to 100 kHz

Maximum Peak Conducted Output Power Measurement

- Option 1: Zero Span Method
  - This procedure was intended to be consistent with the legacy procedure in C63.10 Clause 6.10.2.1(a)
  - Comments recently received from C63 Wireless Working Group (WWG) indicates this not to be the case
    - Although previous guidance required RBW ≥ DTS BW, the measurement has previously been performed in the frequency domain, not in the time domain (*i.e.*, not in zero span mode)
  - This procedure will be corrected to maintain consistency and re-titled appropriately

Maximum Peak Conducted Output Power Measurement (continued)

- Option 2: Integrated Band Power Method
  - This procedure was intended to be consistent with the legacy procedure in C63.10 Clause 6.10.2.1(b)
  - However, some minor inconsistencies have been noted
    - No need to restrict RBW to 1 MHz (legacy procedure specifies using widest available RBW)
    - We agree that the when attempting to measure the peak power of a digitally modulated signal, the wider the RBW the better.
    - The procedure will be edited to reflect this (*i.e.*, RBW specification will be changed to maximum available)
  - Title will be changed to “Channel Integration Method” to maintain consistency with legacy procedure in C63.10

Maximum Peak Conducted Output Power Measurement (continued)

- Option 3: Peak Power Meter Method
  - Use of a peak power meter is a legacy procedure that provides a good solution for wide bandwidth signals
  - VBW must equal or exceed DTS BW
- Alternative 1: Bandwidth Correction Method
  - This is a legacy procedure included in C63.10 Clause 6.10.2.1(c)
  - Currently included as an alternative but concerns remain with respect to applicability to randomly distributed peaks associated with modern digital modulations
  - Would like input regarding how necessary it is to retain this procedure

Maximum Conducted Output Power

- In order to utilize the preferred procedures provided, the EUT must be configured to transmit continuously (duty cycle ≥ 98%) or sweep triggering and/or signal gating must be used to ensure measurement only during active, full-power transmission durations
- Additionally, when a spectrum/signal analyzer is used, a minimum of two measurement points per RBW over the span is required [*i.e.*, number of measurement points in the sweep ≥ 2 x (span/RBW)]

Maximum Conducted Output Power (continued)

- Option 1: RMS or sample detection with slow-speed single sweep
  - This is a new procedure in that it is not currently specified in C63.10 or in previous FCC guidance
  - Consistent with new UNII procedure in KDB 789033
- Option 2: RMS or sample detection over multiple traces (spectral trace averaging)
  - This procedure is consistent with the legacy alternate procedure described in C63.10 Clause 6.10.3.1 and in previous FCC guidance
    - Has been slightly modified to include the use of an RMS power averaging detector (preferred over sample detector)
- Option 3: Average power meter method
  - The inclusion of an average power meter is a new addition that is not currently included in C63.10 or in previous FCC guidance
  - Consistent with new UNII procedure in KDB 789033
  - Will produce true average (heating) power consistent with RMS integration of the power envelope
  - Preferred over video averaging for contemporary digital modulations

Maximum Conducted Output Power (continued)

- Alternative 1: Reduced video bandwidth with maximum hold
  - This procedure is a legacy alternative procedure per C63.10 Clause 6.10.3.3
  - Retained as an alternative procedure but concerns remain over accuracy and repeatability when applied to modern digital modulations where the power envelope is often not repetitious with time
  - Would like input with respect to how necessary it is to retain this procedure
    - Even if eliminated from new guidance document, it will still continue to be permitted as long as current version of C63.10 is recognized
- Alternative 2: Zero-span mode with trace averaging
  - This procedure is a legacy alternate procedure per C63.10 Clause 6.10.3.2
  - Retained as an alternate procedure but note that it's the only remaining time-domain procedure
  - Does not appear to be a necessary alternative
  - Would like input with respect to how necessary it is to retain this procedure
    - Even if eliminated from new guidance document, it will still continue to be permitted as long as current version of C63.10 is recognized

Maximum Conducted Output Power (continued)

- Alternative 3: Average over on/off transmission periods with a duty cycle correction
  - This is a new procedure that has not been included in C63.10 or previous FCC guidance
  - Consistent with procedure in new UNII procedures in KDB 789033
  - Intended for use when an EUT cannot be configured to transmit continuously and sweep triggering and/or signal gating is not available
  - Requires that the maximum duty cycle be measured in the time domain
  - Measure power envelope over on/off transmitter times and then use the maximum duty cycle to adjust (increase) the measured power commensurate to what would be measured during continuous transmission

DTS Power Spectral Density

- §15.247(e) specifies a conducted PSD limit of 8 dBm/3 kHz
- Complaints have been received over the measurement time associated with the existing PSD procedure, particularly when measurements are required for three channels for multiple modes of operation
- In addition, contemporary wideband technologies are not typically PSD limited when operating under this rule part
  - PSD limit of 8 dBm/3 kHz was derived from the assumption that 1 watt (30 dBm) is spread over a 500 kHz bandwidth (*i.e.*, 30 dBm/500 kHz – 10log(500 kHz/3 kHz) = 8 dBm/3 kHz)
  - However, when 1 watt is spread over a 20 MHz bandwidth (assuming a relatively flat spectrum), the actual PSD is 30 dBm/20 MHz – 10log(20 MHz/3 kHz) = -8 dBm/3 kHz.
  - Thus, the maximum allowable PSD is typically not the limiting factor with respect to wideband applications.
- The PSD procedures in the revised DTS guidance were relaxed to accommodate this situation by permitting the use of a 100 kHz RBW to perform the measurement followed by a mathematical conversion to an equivalent value in 3 kHz for comparison to the limit

DTS Power Spectral Density
(continued)

- Recent comments received from the C63 WWG call attention to the fact that not all technologies operating under the DTS rules utilize such wide channel bandwidths or can be assumed to use modulations that produce relatively flat spectrum (*e.g.*, FSK)
- To address this concern, we propose to retain the legacy procedures from C63.10 Clauses 6.11.2.3 and 6.11.2.4 as Options (currently included in the draft as Alternatives) for channel bandwidths less than 20 MHz
- The new procedures will then be included as Options for use with channel bandwidths that equal or exceed 20 MHz
- Comments on this proposal are encouraged

Unwanted/Spurious Emissions Measurements into Non-Restricted Bands

- §15.247(d) specifies the required attenuation of unwanted/spurious emissions in any 100 kHz bandwidth outside of the authorized frequency band based on either RF conducted or radiated measurements as follows:
  - 20 dB relative to the in-band peak output power in 100 kHz, or
  - 30 dB relative to the in-band maximum (average) output power in 100 kHz
- Procedures are provided to measure the reference in-band power level in 100 kHz and the unwanted/spurious levels outside of the authorized band
- The procedures described can be used in either a conducted or radiated measurement set-up
  - Radiated tests must be performed on a site that meets the requirements specified in C63.4 and utilize procedures consistent with those specified in C63.10

Unwanted/Spurious Emission into Restricted Frequency Bands

- Radiated measurements are the traditional method for demonstrating compliance to the limits specified in §15.209(a) for unwanted/spurious emissions falling into the restricted bands
- DTS draft contains new procedures that allow for the use of conducted measurements to demonstrate compliance to these limits
- Radiated measurements are still permitted
- Comments received thus far from C63 WWG will lead to some editorial changes to this section
  - Some minor revisions to the Option 1 and Option 3 procedures
  - Clearly indicate precedence of the radiated procedure
  - Conducted measurement procedure to be designated as an alternative procedure

Band-Edge Measurements

- New guidance permits the use of a reduced RBW to measure within the first 1 MHz of the edges of a DTS-authorized band to help to reduce the influence of the fundamental emission
- The Marker-Delta method specified in C63.10 Clause 6.9.3 is currently listed as an alternative methodology
- Based on comments received from C63 WWG the reduced RBW method and the current precedence implication will be reconsidered
  - At the least, the Marker-Delta method will be designated as a preferred Option

Potential for Revision of Current Draft

- Most of the comments received via KDB and C63 have been discussed in this presentation along with reconciliation considerations
- Further comments are encouraged through KDB
- Additionally, a special subgroup within C63 WWG has been established to provide further review and comment
- This process may result in some additional revisions and/or modifications
- The intent is to issue final guidance document by mid-May with a target implementation date of June 1st, 2012
- In the interim, the previous guidance (documented in C63.10) shall continue to be used. Any specific concerns should be directed to the FCC through the KDB system

Questions and Answers

Thanks!