Federal Communications Commission  
Office of Engineering and Technology  
Laboratory Division  

Alternative Guidance for IEEE 802.11ac and Pre-ac Device Emissions Testing

This document provides an alternative to the guidance presented in 644545 D01 Guidance for IEEE 802.11ac and Pre-ac Device Emissions Testing for demonstrating compliance of 802.11 devices with sections 15.247 and 15 subpart E (15.401 through 15.407) of the FCC rules. The alternative guidance permits all emissions testing for operation between 5.725 and 5.850 GHz to be performed using test procedures for Unlicensed National Information Infrastructure (U-NII) devices and emission limits based on the U-NII rules even though operations may extend above the 5.825 GHz upper bound of the highest U-NII band. Testing of 802.11 devices using the alternative procedures will ensure that the requirements of both digital transmission systems (DTS) in 15.247 and U-NII in Part 15, subpart E of the FCC rules are satisfied. Procedures are provided to identify a device tested using this procedure as operating under rules for both DTS and U-NII.

This alternative guidance applies only to 802.11 devices. Anyone wishing to apply similar techniques to non-802.11 devices will be required to submit a KDB inquiry providing specific information about the device being tested.

BACKGROUND AND JUSTIFICATION

Devices operating in the U.S. under various versions of the IEEE 802.11 standard in frequency bands between 5 and 6 GHz often require testing and authorization under two separate FCC rule sections. All operations between 5.15 and 5.725 GHz must comply with part 15, subpart E (U-NII) rules. However, operations above 5.725 GHz can occur under two rule sections: the U-NII rules permit operations in the band 5.725-5.825 GHz, and the DTS rules in section 15.247 permit operation in the band 5.725-5.850 GHz, which extends 25 MHz higher in frequency than the corresponding U-NII band.

One of the channels defined in the IEEE 802.11 standard (channel 165—the highest 20 MHz channel) extends above the upper U-NII band and thus requires use of the DTS rules. In the past, manufacturers have been free to choose either rule section for all other channels operating between 5.725 GHz and 5.825 GHz. However, the addition of channels that straddle 5.725 GHz by version ac of the 802.11 standard (the channels shown in red in Figure 1) has resulted in more a complex allocation of channels in that frequency region among the two rule sections. The complexities are necessary to ensure that any single channel operates under a single rule section (either 15.247 or 15.407), that all emissions during transmission under a single rule section comply with the limits for that rule section, and that composite emissions in multiple channels do not violate the composite system requirements in section 15.31(k) of the rules, i.e., that composite emissions cannot exceed the highest level permitted for a single component under either of the rule sections.

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1 Section 15.407(b)(4) of the rules specifies an undesirable emission limit of -17 dBm/MHz peak EIRP in the 10 MHz from the upper U-NII band edge (5825 MHz) to a frequency 10 MHz above the upper band edge (i.e., 5835 MHz), and a limit of -27 dBm/MHz peak EIRP above 5735 MHz. In applying the U-NII measurement procedures to operations in the extended band (to 5850 MHz), we do not extend the applicability of the -17 dBm/MHz limit upward in frequency. The emission limit above the extended band (i.e., above 5850 MHz) is -27 dBm/MHz peak EIRP.
Table 1 compares the DTS and U-NII emission limits and shows that, for 802.11 devices, the FCC emission limits for operation in the 5.725-5.825 GHz U-NII band are generally equivalent to—or more stringent than—the emission limits for operation in the 5.725-5.850 GHz DTS band. Thus, compliance with DTS, U-NII, and composite system rules can be ensured by testing 5-6 GHz operations of IEEE 802.11™ devices using U-NII test procedures and U-NII-based emission limits as described in this document.

![Operating Channels in 5-6 GHz Bands for IEEE 802.11ac™ Devices Operating in the U.S.](image)
### Table 1. Comparison of DTS and UNII Emission Limits for 5725+ MHz Bands

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DTS Limit for Operation in 5725-5850 MHz</th>
<th>U-NII Limit for Operation in 5725-5825 MHz</th>
<th>Which Rule is More Stringent?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum 6-dB Bandwidth</td>
<td>500 kHz</td>
<td>No limit</td>
<td>DTS, but all 802.11ac channel bandwidths are ≥ 20 MHz, so all comply</td>
</tr>
<tr>
<td>Highest conducted output power limit</td>
<td>1 watt, peak or average during transmission*</td>
<td>Lesser of 1 watt or 17 dBm + 10 log(EBW), average during transmission*</td>
<td>U-NII for EBW &lt; 20 MHz; Limits are same for EBW ≥ 20 MHz</td>
</tr>
<tr>
<td>Highest in-band power spectral density (PSD) limit</td>
<td>8 dBm in 3 kHz, peak or average during transmission*</td>
<td>17 dBm in 1 MHz, average during transmission</td>
<td>U-NII (8 dBm in 3 kHz is equivalent to 33.2 dBm in 1 MHz for flat spectra)**</td>
</tr>
<tr>
<td>Required reduction in power &amp; PSD limits for directional gain</td>
<td>Amount by which gain exceeds 6 dBi (No reduction for fixed point-to-point)</td>
<td>Amount by which gain exceeds 6 dBi (23 dBi for fixed point-to-point)</td>
<td>U-NII for fixed point-to-point; otherwise, the limits are the same</td>
</tr>
<tr>
<td>Restricted band limits</td>
<td>15.209</td>
<td>15.209</td>
<td>Same</td>
</tr>
<tr>
<td>Non-restricted band undesirable emission limits above 1 GHz</td>
<td>-20 dBr in 100 kHz if total peak power ≤ power limit; otherwise, -30 dBr but no lower than 15.209†</td>
<td>-17 dBr/MHz peak EIRP in 5715-5725 MHz and 5825-5835 MHz for operations in 5725-5825 MHz; -27 dBr/MHz peak EIRP at all other frequencies</td>
<td>U-NII for 802.11 unless device operates below the transmit power limit by ~21 dB or more where the U-NII limit is ~17 dB/MHz or ~31 dB where the U-NII limit is ~27 dB/MHz.‡</td>
</tr>
<tr>
<td>Non-restricted band undesirable emission limits below 1 GHz</td>
<td>-20 dBr in 100 kHz if total peak power ≤ power limit; otherwise, -30 dBr but no lower than 15.209†</td>
<td>15.209 for &lt; 1 GHz</td>
<td>U-NII for 802.11 down to at least 30 MHz unless device operates below the transmit power limit by ~21 dB or more where the U-NII limit is ~17 dB/MHz or ~31 dB where the U-NII limit is ~27 dB/MHz.‡</td>
</tr>
</tbody>
</table>

EBW = Emission Bandwidth in MHz (26 dB bandwidth, per 15.403(i))

* Based on either peak or average measurements.

** DTS PSD limit would be more stringent than the U-NII only for a transmitter that concentrated power into a bandwidth narrow than 24 kHz, which does not happen in 802.11. [3 kHz × 10\(^{(17 \text{ dBm} - 8 \text{ dBm})/10} = 23.8 \text{ kHz}]**

† dBr specifies the highest out-of-band power in 100 kHz bandwidth relative to the highest in-band power in 100 kHz bandwidth.

‡ Out-of-band emission limits above 1 GHz in the U-NII rules are expressed as an absolute peak EIRP in 1 MHz bandwidth. The out-of-band limits in the DTS rules are levels in 100 kHz bandwidth relative to the highest in-band level in 100 kHz bandwidth. As a result, the effective out-of-band emission limit for DTS increases as transmit power increases and as directional gain increases (up to 6 dBi) and as transmit bandwidth decreases for constant transmit power. For OFDM in 802.11 (assumed not to be fixed point-to-point), a 1 watt transmission in a 20 MHz wide channel at 6 dBi gain would result in the highest average EIRP limit for out-of-band emissions under DTS rules—approximately 30 dBm + 6 dBi - 10 log(16 MHz/0.1 MHz) - 30 dB ≈ -16 dBm/100 kHz (based on a non-HT transmission having a carrier span of approximately 16 MHz). Converting to 1 MHz bandwidth and adjusting to an equivalent peak emission level for comparison to the U-NII limits, the highest out-of-band peak EIRP permitted for an 802.11 device under DTS rules would be approximately -16 dBm/100 kHz + 10\(^{10\log(1000 \text{ kHz/100 kHz}) + ~11 \text{ dB peak-to-average ratio} = +5 \text{ dBm/MHz for a broadband emission. Thus for 802.11, the maximum out-of-band limit under DTS rules is higher than the -27 dB/MHz peak EIRP limit for U-NII by approximately 32 dB for broadband emissions and is higher than the -17 dB/MHz peak EIRP for U-NII (which will apply only in 5715-5725 MHz in this guidance document) by approximately 22 dB. The U-NII emission limit will be more stringent than DTS limit above
1 GHz unless the DTS limit is reduced by at least 32 dB (or 22 dB for 5715-5725 MHz emissions) through a combination of increased transmission bandwidth, reduced directional gain, or reduced transmit power. The maximum reduction in the effective DTS limit due to wider transmission bandwidth is 7 dB (for an 80 MHz channel, the 802.11ac maximum channel width in the DTS band), and the maximum expected reduction due to reduced directional gain is 4 dB (assuming a minimum antenna gain of 2 dBi, the gain of a dipole antenna). Even with the maximum 11 dB reduction from the combination of wide bandwidth and reduced gain, transmit power would have to be reduced by at least 21 dB below the limit in order to reduce the DTS out-of-band limit below the general U-NII limit (or 11 dB below the power limit in the case of emissions in 5715-5725 MHz). A reduction of 11 dB or more would place the peak transmit power below 1 watt (at 11 dB peak-to-average ratio), with the result that out-of-band emissions would require only 20 dB attenuation relative to in-band emissions rather than 30 dB under DTS rules [47 CFR 15.247(d)]—thus raising the effective DTS limit by 10 dB. Consequently, for 802.11 transmissions the U-NII limit above 1 GHz will be more stringent than the DTS limit unless the transmit power is reduced by more than approximately 31 dB below the limit, except for emissions in 5715-5725 MHz, where the U-NII limit will be more stringent than the DTS limit unless transmit power is reduced below the limit by more than 21 dB. For fixed point-to-point operation, the DTS rules are even less stringent.

†† Below 1 GHz, the DTS limits remain the same as above 1 GHz. On the other hand, the U-NII limits from 30 MHz to 1 GHz (-55.2 to -41.2 dBM quasi-peak EIRP in 120 kHz bandwidth, approximately equivalent to -46.0 to -32.0 dBM/MHz for broadband emissions) are more stringent than those above 1 GHz. At frequencies from 1.705 to 30 MHz, where no significant emissions from an 802.11 device are expected, the U-NII limit is only slightly relaxed from the limit above 1 GHz (-45.7 dBM quasi-peak EIRP in 9 kHz bandwidth ~ equivalent to -25.2 dBM/MHz for broadband emissions)

GUIDANCE

A) Applicability
The procedures in this document apply only to 802.11 products that are capable of transmitting in the U-NII 3 band (5.725-5.825 GHz) or in the 5.8 GHz 15.247 band (5.725-5.850 GHz) or both.

B) Use of 644545 D01 “Guidance for IEEE 802.11ac and Pre-ac Device Emissions Testing”
1) Follow the guidance in 644545 D01 “Guidance for IEEE 802.11ac and Pre-ac Device Emissions Testing” except as follows:
   a) Do not use section E) of that publication (“Limitations on simultaneous operation under 15.247 and 15.407 in 5 – 6 GHz bands”);
   b) Do not apply 15.247 (DTS) test procedures or limits for any transmissions between 5 and 6 GHz.

C) In-band measurements for operations above 5.725 GHz
1) Measure maximum conducted output power and power spectral density (PSD) using U-NII procedures and applying the U-NII limits as if the upper U-NII band was extended to 5.850 GHz.
   a) If conducted power in the 5.725-5.850 GHz range (i.e., the upper U-NII band extended to match the upper frequency of the corresponding 15.247 band) satisfies the conducted power limits applicable to the 5.725-5.825 GHz (U-NII 3) band, then the conducted power limits of the U-NII bands and the 5.8 GHz 15.247 band will be judged to have been satisfied.
   b) If maximum PSD in the 5.725-5.850 GHz range (i.e., the upper U-NII band extended to match the upper frequency of the corresponding 15.247 band) satisfies the PSD limits applicable to the 5.725-5.825 GHz (U-NII 3) band, then the PSD limits of the U-NII 4 band and the 5.8 GHz 15.247 band will be judged to have been satisfied.

D) Out-of-band and spurious emissions measurements for operations above 5.725 GHz
Perform out-of-band (restricted and non-restricted band) tests using U-NII procedures and applying the U-NII
limits as if the upper U-NII band was extended to 5.850 GHz and the -27 dBm/MHz peak EIRP limit applies beginning at 5850 MHz, as follows:

1) All restricted band emission limits must be satisfied based on U-NII measurement procedures.
2) All non-restricted-band out-of-band and spurious emission limits specified in 15.407(b) must be satisfied except that, when operating anywhere in the frequency range from 5.725-5.850 GHz, out-of-band emissions requirements are not applied at frequencies from 5.825-5.850 GHz, and the -27 dBm/MHz peak out-of-band EIRP limit shall be applied in non-restricted bands above 5.850 GHz.

E) Application and reporting

1) The test report must specify that U-NII procedures and limits were applied for operations in the frequency band from 5.725-5.850 GHz in accordance with this FCC KDB publication to demonstrate compliance with 15.247 requirements in that band.
2) Filings must be submitted under both DTS and U-NII, but the same test report can be used for both.

CHANGE NOTICE

06/07/2012 644545 D02 Alternative Guidance for 802 11ac v01 was added as a new attachment as alternative guidance for operation above 5.725 GHz