and technology specific configurations are described in the KDB publications identified in KDB Publication 447498.[4] These other requirements are necessary to apply the Wi-Fi SAR procedures. This document covers the most common types of SAR test configurations; a KDB inquiry is required to determine alternative SAR measurement procedures for additional configurations or special implementations. In the following sections, the general SAR measurement considerations and frequency band specific test requirements are first discussed and then followed by the power and SAR measurement procedures.

2. GENERAL SAR MEASUREMENT CONSIDERATIONS

A brief summary of the 802.11 PHY and typical peer-to-peer Wi-Fi configurations, such as TDLS, Mesh Services and Wi-Fi Direct, is included in Appendix A to identify applicable wireless configurations, modulations and data rates etc. that need consideration to apply the SAR measurement procedures. Transmit diversity, MIMO and TxBF configurations typically used in Wi-Fi transmitters are also summarized in Appendix A. The 5 GHz 802.11 channel configurations are illustrated in Appendix B. Provided the Wi-Fi transmission is not coordinated with other transmitters; for example, 3G/4G devices to support additional exposure conditions, SAR measurement is generally not necessary for standalone peer-to-peer operations. When simultaneous transmission is supported for Wi-Fi in multiple frequency bands or in conjunction with other wireless technologies, SAR compliance must be determined according to the applicable exposure conditions and SAR test positions for each simultaneous transmission configuration. For OFDM transmission modes, the SAR system validation procedures in KDB Publication 865664 are required to address high peak to average power ratio SAR probe calibration and measurement concerns.

2.1. SAR Measurement and Test Reduction Configurations

Kaitlin O'Keefe 11/9/2014 1:29 PM

Comment [1]: We would like to request that somewhere in this document the thresholds in the various procedures are addressed for 10g extremity SAR tests. Since 5 GHz modes often do not support WIFI hotspot, extremity SAR for phablets is a very common test configuration. We assume all the thresholds in this document are for 1g exposure conditions.

The SAR measurement and test reduction procedures are structured according to the transmission modes in each frequency band and aggregated band according to either DSSS or OFDM configurations. For devices that operate in exposure configurations with multiple test positions, additional SAR test reduction may be considered. When the maximum output power specified for production units are used to determine SAR test requirements, tune-up tolerance must be taken into consideration. The general test configurations are defined in the following:

1) An "initial test configuration" is first determined for 2.4 GHz and 5 GHz OFDM transmission configurations in each frequency band and aggregated band according to the maximum output power and tune-up tolerance specified for production units. When the same maximum power is specified for multiple transmission modes, channel bandwidth, modulation, data rate and other operating parameters are used to select a test configuration. SAR is measured using the initial test configuration procedures and applicable frequency band specific requirements (section 5.4).
   a) Initial test configuration does not apply to DSSS. The 802.11b DSSS procedures (section 5.3.1) and 2.4 GHz band SAR test requirements (section 3.1) are used to establish the transmission configurations.
2) An "initial test position" is applied to further reduce the number of SAR tests for devices that operate in next to the ear, UMPC mini-tablet and hotspot mode exposure configurations requiring multiple test positions (section 5.2). SAR is measured using the exposure condition established by the initial

[4] See Introduction section of KDB Publication 447498.

5.7 GHz) wide between the channel center frequencies of the bandedge channels and 220 MHz (5.49 – 5.71 GHz) after accounting for channel bandwidth. Therefore, when a bandedge channel is tested, the tissue dielectric parameters must be within 5% of the required targets at the test frequency and the SAR error compensation provisions described in KDB Publication 865664 for allowing up to 10% tissue parameter tolerance should not be applied.

Table 1

Probe Calibration Frequency (GHz)	Wi-Fi Bands	Frequency Range	
		Channels	Calibration
		GHz	MHz
5.25	U-NII-1, U-NII-2A	5.17 – 5.33	± 80
5.60	U-NII-2C (standalone)	5.49 – 5.71	± 110
	U-NII-2C (< 5.65 GHz)*	5.49 – 5.65	-110/+50
5.75	U-NII-3, §15.247 (standalone)	5.735 – 5.835	-15/+85
	U-NII-2C (> 5.65 GHz) + U-NII- 3 or §15.247 across band gap	5.65 – 5.835	-100/+85

* The portion above 5.65 GHz in U-NII-2C band is tested using the 5.75 GHz probe calibration point, when the band gap channels are supported (See Section 3.3).
Test labs may continue to use existing SAR probe calibrations with more than two calibration points or until the probe is due for recalibration.

Kaitlin O'Keefe 11/12/2014 10:39 AM
Comment [2]: For clarity, we suggest including a comment and reference to when U-NII-2C is treated in as a standalone condition and when < 5.65 GHz is considered.
Kaitlin O'Keefe 11/12/2014 10:39 AM

3. FREQUENCY BAND AND TEST CHANNEL CONFIGURATIONS

SAR test requirements may vary according to Wi-Fi protocols and FCC rule requirements. The test configurations are organized according to transmission modes, as either DSSS or OFDM. The procedures are applied to each frequency band and aggregated band according to channel bandwidths and exposure conditions (i.e., operating configurations and exposure test positions). For purpose of SAR evaluation, simultaneously transmitting two non-contiguous channels or contiguous but independent and non-aggregated channels, regardless of using the same or different channel bandwidth, is not equivalent to transmitting a single contiguous channel. Two non-contiguous 80 MHz channels in 802.11ac VHT is not equivalent to a 160 MHz channel; these must be considered separately for SAR compliance. The procedures also support measurements across selected adjacent frequency bands that are within the frequency range covered by one or more SAR probe calibration points to streamline the SAR measurement. The frequency band specific SAR test configurations are described in this section.

3.1. 2.4 GHz Band (§15.247)

The maximum output power permitted for devices authorized under §15.247 is 1 W conducted and 36 dBm EIRP.[5] Within the frequency range of 2400 – 2483.5 MHz, a total of 13 channels may be used in the U.S. However, non-overlapping frequency channels are necessary to minimize interference degradation; therefore, channels 1, 6 and 11 are used most often. Channels 12 and 13, in general, require reduced output power to satisfy bandedge radiated field strength requirements at 2483.5 MHz. Provided higher maximum output power is not specified for the other channels, channel 1, 6 and 11 should be used to configure 22 MHz DSSS and 20 MHz OFDM channels for SAR measurements; otherwise, the closest adjacent channel with the highest maximum output power specified for production units should be tested

[5] As described in KDB Publication 447498, EIRP may not be relevant for evaluating the SAR of small portable transmitters designed to operate next to persons.

instead of channels 1, 6 or 11.[6] When 40 MHz channels are supported, and provided higher maximum output power is not specified for other applicable 40 MHz channels, channel 6 should be used to measure SAR; otherwise, the channel with highest specified maximum output power should be tested instead. In addition, the SAR test reduction provisions in section 4.3.3 of KDB Publication 447498 should also be applied.

3.2. U-NII-1 and U-NII-2A Bands (§15.407)

The maximum output power permitted for devices authorized under §15.407 U-NII-1 band (5.15 – 5.25 GHz), with respect to interim provisions (for old rules) in ET Docket No. 13-49, (FCC 14-30), is 50 mW conducted and 23 dBm EIRP. The maximum output power permitted by the new rules in FCC 14-30 is 250 - 1000 mW conducted and 21 – 36 dBm EIRP, depending on transmitter configurations and antenna operating requirements.[7] For U-NII-2A band (5.25 – 5.35 GHz), the maximum output power is 250 mW conducted and 30 dBm EIRP. When applicable, a lower maximum output power may be required to satisfy emission bandwidth restrictions for these bands. When both bands apply to a device, SAR test reduction may be considered according to procedures in section 5.4.1.

3.3. U-NII-2C, U-NII-3 Bands (§15.407) and 5.8 GHz Band (§15.247)

The maximum output power permitted for devices authorized under §15.407 U-NII-2C band (5.470 – 5.725) is 250 mW conducted and 30 dBm EIRP. For U-NII-3 band (5.725 – 5.825 GHz) and §15.247 5.8 GHz band (5.725 – 5.850 GHz) the maximum output power permitted is 1 W conducted and 36 dBm EIRP.[8] When applicable, a lower maximum output power may be required due to emission bandwidth restrictions for these bands. The frequency range covered by these bands is 380 MHz (5.47 – 5.85 GHz), which requires a minimum of at least two SAR probe calibration frequency points to support SAR measurements. The typical SAR probe calibration point in this frequency range should cover at least ± 100 MHz. The difference in tissue-equivalent media conductivity among the bands is about 8%, which is larger than the 5% tissue dielectric tolerance required for SAR probe calibration. In addition, when Terminal Doppler Weather Radar (TDWR) restriction applies, the channels at 5.60 – 5.65 GHz in U-NII-2C band must be disabled with acceptable mechanisms and documented in the equipment certification to avoid SAR requirements.[9] TDWR restriction does not apply under the new rules; all channels at 5.60 – 5.65 GHz must be included to apply the SAR test reduction and measurement procedures, when supported by the manufacturer.

When the same transmitter and antenna(s) are used for U-NII-2C band and U-NII-3 band or §15.247 5.8 GHz band, the bands may be aggregated to enable additional channels with 20, 40 or 80 MHz bandwidth

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[6] Channels 1, 6 and 11 should each be considered separately to determine the closest adjacent channel with higher output power.

[7] Interim provisions for U-NII-1 band expire 12 months after the effective date of FCC 14-30. See KDB Publication 926956 for U-NII Transition Plan. For point-to-point operations, antenna gain up to 23 dBi at 1.0 W conducted maximum power is permitted; however, SAR and portable exposure conditions typically do not apply to point-to-point configurations. To satisfy SAR limit, it may be necessary for some devices to operate at maximum output power levels less than that permitted by the rules.

[8] Interim provisions for approval of 5.8 GHz §15.247 expire 12 months after the effective date of FCC 14-30. For point-to-point operations, up to 23 dBi antenna gain at 1.0 W conducted maximum power is permitted for U-NII-3 band; however, SAR and portable exposure conditions typically do not apply to point-to-point configurations. For some devices, lower than permitted maximum output power may be necessary to meet SAR limit.

[9] Interim provisions for excluding TDWR channels in U-NII-2C expire 12 months after the effective date of FCC 14-30. Compliance with the new rules is required upon expiration.

to span across the band gap, as illustrated in Appendix B. The maximum output power for the additional band gap channels is limited to the lower of those certified for the bands. Unless band gap channels are permanently disabled, SAR must be considered. To maintain SAR measurement accuracy and to facilitate test reduction, the channels in U-NII-2C band above 5.65 GHz are grouped with the 5.8 GHz channels in U-NII-3 band or §15.247 5.8 GHz band to enable two SAR probe calibration frequency points to cover the bands, including the band gap channels.[10] When band gap channels are disabled, each band must be tested independently according to the normally required OFDM SAR measurement and probe calibration frequency points requirements.

A single 160 MHz channel may be supported by U-NII-2C band for client devices that are certified to operate at 5.60 – 5.65 GHz without TDWR restriction. Band aggregation for 160 MHz channel across U-NII-2C and U-NII-3 bands is not defined in IEEE Std 802.11ac-2013 for VHT; however, transmitters may operate with proprietary implementations to transmit across the bands. When applicable, these types of implementations and configurations must be taken into consideration to determine SAR compliance. A KDB inquiry is necessary to determine the test configurations.

Kaitlin O'Keefe 11/12/2014 10:46 AM

Comment [3]: Would it be possible to consider not aggregating part of U-NII-2C with U-NII-3 (or 15.247)? We believe this will be confusing to manufacturers and consumers who will expect the U-NII-2C /U-NII-3 results from the SAR report to correspond to those in the EMC test reports. Additional confusion may arise when manufacturers consider different target powers across the U-NII bands.

4. POWER MEASUREMENT REQUIREMENTS

The maximum output power of typical 802.11 transmitters may vary with transmission modes, frequency bands, antenna implementation and operating conditions. The peak to average output power ratio of signals in different transmission modes is typically a function of the channel bandwidth and transmission scheme. While different modulations may be applied to the raw data bits in DSSS and OFDM, for example, BPSK, CCK, PBCC, ERP, QPSK, 16- to 256-QAM, etc., these are generally not expected to have significant influence to the DSSS or OFDM output characteristics and SAR. The choice of modulation and data rate used in SAR measurements is mostly for maintaining test configuration consistency.

Maximum output power must be measured according to the default power measurement procedures in this section. When SAR measurement is required, power measurement is also required to confirm output power settings and to determine *reported* SAR according to procedures in KDB Publication 447498. Additional power measurements may be necessary to apply SAR test reduction for the test channels in a transmission mode. When different maximum output power is specified across the channels in a Wi-Fi transmission mode, a KDB inquiry is required to determine the test requirements. If the required power measurement is not included in the default configurations, it is typically measured immediately before and/or after the SAR measurement. Otherwise, when power measurement is not required for a transmission mode, the maximum output power and tune-up tolerance specified by production units can generally be used to determine SAR test exclusion and reduction.

Kaitlin O'Keefe 11/20/2014 6:03 PM

Comment [4]: Procedures in this document already outline steps to ensure that SAR is measured on channels operating at the maximum specified power level of the device. Therefore perhaps "may be required" would be appropriate

The default power measurement procedures are described in the following:

1) Power must be measured at each transmit antenna port according to the DSSS and OFDM transmission configurations in each standalone and aggregated frequency band.

[10] Test labs may continue to use existing SAR probe calibrations with more than two calibration points or until the probe is due for recalibration.

2) Power measurement is required for the transmission mode configuration with the highest maximum output power specified for production units.[11]

3) For transmission modes with the same maximum output power specification, the lowest order modulation and lowest data rate is measured for the largest channel bandwidth.

4) For transmission modes with identical maximum specified output power, channel bandwidth, modulation and data rate requirements, power measurement is required for all identical configurations.

5) For each transmission mode configuration, power must be measured for the highest and lowest channels; and at the mid-band channel(s) when there are at least 3 channels.[12] For configurations with multiple mid-band channels, due to an even number of channels, both channels should be measured.

Kaitlin O'Keefe 11/20/2014 6:04 PM
Comment [5]: This step could be difficult to interpret since the larger channel bandwidth transmission modes will always have a higher lowest data rate than modes with a lower bandwidth. We suggest the revised text for clarity.

Kaitlin O'Keefe 11/9/2014 2:11 PM
Deleted: , lowest order modulation and lowest data rate is measured.

Kaitlin O'Keefe 11/9/2014 1:42 PM
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5. SAR TEST PROCEDURES

SAR test reduction is determined according to 802.11 transmission mode configurations and certain exposure conditions with multiple test positions. In the 2.4 GHz band, separate SAR procedures are applied to DSSS and OFDM configurations to simplify DSSS test requirements. For OFDM, in both 2.4 and 5 GHz bands, an initial test configuration must be determined for each frequency band and aggregated band, according to the transmission mode configuration with the highest maximum output power specified for production units to perform SAR measurements. When applicable, an initial test position may be applied to reduce the number of SAR measurements required in next to the ear, UMPC mini-tablet and hotspot mode configurations with multiple test positions. For 2.4 GHz 802.11b DSSS, either the initial test position procedure for multiple exposure test positions or the DSSS procedure for fixed exposure position is applied; these are mutually exclusive. For 2.4 GHz and 5 GHz OFDM configurations, the initial test configuration is applied to measure SAR with either the initial test position procedure for multiple exposure test position configurations or the initial test configuration procedures for fixed exposure test conditions. Based on the *reported* SAR of the measured configurations and maximum output power of the transmission mode configurations that are not included in the initial test configuration, the subsequent test configuration and initial test position procedures are applied to determine if SAR measurements are required for the remaining OFDM transmission configurations. In general, the maximum output power measured for test sample(s) are used to minimize the number of test channels require SAR measurements. For OFDM configurations with the same maximum output power, channel bandwidths, modulations and data rates, additional procedures are applied to determine which test configuration to use for SAR measurement.

5.1. OFDM transmission mode and SAR Test Channel Selection Requirements

For the 2.4 GHz and 5 GHz bands, when the same maximum output power is specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration with the largest channel bandwidth, lowest order modulation and lowest data rate. When there are multiple mid-band channels due to an even number of channels, SAR is measured using the higher number channel. When the maximum output power of a channel is the same for equivalent

[11] The Wi-Fi transmission modes include all channel bandwidths, modulations and data rates for the 802.11a/g/n/ac OFDM configurations in a frequency band or aggregated band. For 2.4 GHz, 802.11b DSSS and 802.11g/n OFDM configurations are considered separately.

[12] When only one channel is supported by the 802.11 mode; for example, in 160 MHz channel configurations, high and low channels do not apply.

1) Head Exposure Configuration: The left, right, touch and tilt test positions for next to ear exposure testing using the SAM phantom may be considered collectively as one head exposure configuration to facilitate initial test position SAR test reduction. The initial test position is determined according to area scans or by the side (left or right) of the SAM phantom and test position (touch or tilt) with the smallest test separation distance from the device outer surface, at the Wi-Fi antenna location, to the SAM phantom and maximum antenna to phantom RF coupling conditions.
2) Hotspot mode and UMPC mini-tablets: The surfaces and edges that require SAR measurement in hotspot mode or UMPC mini-tablet configuration may be considered collectively as one exposure configuration to facilitate SAR test reduction. The initial test position is determined according to area scans or by the test position with the smallest test separation distance from the device outer surface, at the Wi-Fi antenna location, to the flat phantom and maximum antenna to phantom RF coupling conditions.

Kaitlin O'Keefe 11/3/2014 4:19 PM
Comment [6]: We suggest that this section include the test positions required for tablets as outlined in KDB 616217

5.2.1. Initial Test Position SAR Test Reduction Procedure

DSSS and OFDM configurations are considered separately according to the required SAR procedures. SAR is measured in the initial test position using the 802.11 transmission mode configuration required by the DSSS procedure or initial test configuration and subsequent test configuration(s) according to the OFDM procedures.[16] The initial test position procedure is described in the following:

1) When the *reported* SAR of the initial test position is ≤ 0.4 W/kg, further SAR measurement is not required for the other (remaining) test positions in that exposure configuration and 802.11 transmission mode combination within the frequency band or aggregated band. SAR is also not required for that exposure configuration in the subsequent test configuration(s).
2) When the *reported* SAR of the initial test position is > 0.4 W/kg, SAR is repeated for the 802.11 transmission mode configuration tested in the initial test position to measure the subsequent highest extrapolated or estimated 1-g SAR condition, according to the area scans or next closest/smallest test separation distance and maximum RF coupling test position, on the highest maximum output power channel until the *reported* SAR is ≤ 0.8 W/kg or all required test positions (left, right, touch, tilt or subsequent surfaces and edges) are tested.[17]
3) For all positions/configurations tested using the initial test position and subsequent test positions, when the *reported* SAR is > 0.8 W/kg, SAR is measured for these test positions/configurations on the subsequent next highest measured output power channel(s) until the *reported* SAR is ≤ 1.2 W/kg or all required channels are tested.
   a) Additional power measurements may be required for this step, which should be limited to those necessary for identifying the subsequent highest output power channels.

[16] For OFDM, the initial test position applies to both the initial test configuration and subsequent test configuration(s).

[17] The subsequent next highest SAR position determined by the initial test position area scans or according to manufacturer details is used. For example, if four area scans are performed to determine the initial test position with 0.8, 0.75, 0.72 and 0.7 W/kg, respectively, as the extrapolated (or 1-g estimated) SAR results; the 0.8 W/kg position would correspond to the initial test position and, when SAR measurement is required, the other positions (in descending SAR) would correspond to the subsequent test positions. The test lab should be able to minimize the number of area scans based on the *reported* SAR obtained from the first few area scans.

Kaitlin O'Keefe 10/30/2014 1:09 PM
Comment [7]: We recommend harmonizing the language in this footnote to position, to distinguish between test position (such as right touch, right tilt, etc) and configuration (802.11 mode)

Kaitlin O'Keefe 10/30/2014 1:08 PM
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Kaitlin O'Keefe 10/30/2014 1:08 PM
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OFDM configurations; for example, 802.11a, 802.11n and 802.11ac or 802.11g and 802.11n with the same channel bandwidth, modulation and data rate etc., the lower order 802.11 mode i.e., 802.11a, then 802.11n and 802.11ac or 802.11g then 802.11n, is used for SAR measurement. When the maximum output power is the same for multiple test channels across the entire band or aggregate band in a test configuration, either according to the default or additional power measurement requirements, SAR is considered using the channel closest to the middle of the frequency band or aggregated band. The channel with the highest measured output power is used for SAR measurements after it is determined if only the mid channel(s) should be considered or if all channels should be initially considered .[13] An example showing how SAR test reduction is determined for channels and transmission mode configurations with the same maximum output power is given in Appendix C; a power measurement template is also included.

Kaitlin O'Keefe 11/20/2014 11:05 PM
Deleted: measured

Kaitlin O'Keefe 11/20/2014 11:22 PM
Comment [6]: It is unclear to us from this text and from the examples in Appendix C how this statement is applied and when/how we should consider the powers that are "the same" across a band.

We suggest adding in the clarifications to clarify that mid channels are only considered primarily when the powers across the entire band/aggregate band are "the same" (<0.25 dB variation).

Additionally, from the examples in appendix C, it appears that we should consider the actual measured power (regardless of <0.25 deviation), once it is determined if all channels or just mid channels should be considered. Please consider clarifying this point in this section.

5.2. Multiple Exposure Test Position SAR Test Reduction

The following procedures are applied to select an initial test position for handsets operating next to the ear, devices with hotspot mode or UMPC mini-tablets to minimize the number of SAR measurements normally required for exposure configurations with multiple test positions.[14] SAR is measured on the highest measured maximum output power channel using the initial test position. The *reported* SAR and power measurement results are used to determine if SAR measurements are required for some of the other exposure positions and test channels.

SAR conservativeness is established by area scan measurements, in the multiple exposure test positions, to determine the initial test position. The area scans must be measured using the same SAR measurement configurations, including test channel, maximum output power, probe tip to phantom distance, scan resolution etc. for the results to be comparable. The SAR is extrapolated to the phantom surface at each peak SAR location. The test position with the highest extrapolated SAR is used as the initial test position. Instead of extrapolated SAR, the 1-g estimated SAR procedures (fast SAR) in KDB Publication 447498 may be used. The interpolated or 1-g estimated SAR must be scaled according to *reported* SAR requirements to compare the area scan results.

As an alternative, when antenna location and implementation details, such as antenna orientation and polarization, are available from device manufacturers the test separation distance between the phantom and outer surface of a device, at the geometric center of a Wi-Fi antenna, and antenna to phantom RF coupling conditions may be used to establish the initial test position.[15] A test lab may consider using such information to assess test separation distance and antenna to phantom RF coupling conditions to determine the initial test position. However, if the required information is unavailable, insufficient or the test separation distance and antenna to phantom RF coupling conditions of multiple test positions are indistinguishable, area scans must be measured to determine the initial test position. Explanations on how the initial test position is established must be clearly described in the SAR report for the results to be acceptable.

[13] Channels with measured maximum output power within ¼ dB of each other are considered to have the same maximum output.

[14] The initial test position test reduction considerations are based on the range of output power, exposure and use configurations for Wi-Fi transmitters used in typical consumer products and host configurations. The SAR margins identified for Wi-Fi are not applicable to WWAN or other transmitters operating at higher output power levels or different conditions.

[15] Instead of the geometric center of a Wi-Fi antenna, locations within the antenna structure that are demonstrated to

Kaitlin O'Keefe 11/20/2014 11:24 PM
Comment [7]: This statement appears to be applied inconsistently across the examples in Appendix C.

5.3. 2.4 GHz SAR Procedures

Separate SAR procedures are applied to DSSS and OFDM configurations in the 2.4 GHz band to simplify DSSS test requirements. For 802.11b DSSS SAR measurements, DSSS SAR procedure is used for fixed exposure test position and initial test position procedure is used for multiple exposure test positions. When SAR measurement is required for an OFDM configuration, the initial test configuration, subsequent test configuration and initial test position procedures are applied. The SAR test exclusion requirements for 802.11g/n OFDM configurations are described in section 5.3.2.

5.3.1. 802.11b DSSS SAR Test Requirements

SAR is measured for 2.4 GHz 802.11b DSSS using either a fixed test position or, when applicable, the initial test position procedure. SAR test reduction is determined according to the following:

1) When the *reported* SAR of the highest measured maximum output power channel for the exposure configuration is ≤ 0.8 W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.
2) When the *reported* SAR is > 0.8 W/kg, SAR is required for that exposure configuration using the next highest measured output power channel. When any *reported* SAR is > 1.2 W/kg, SAR is required for the third channel; i.e., all channels require testing.

5.3.2. 2.4 GHz 802.11g/n OFDM SAR Test Exclusion Requirements

When SAR measurement is required for 2.4 GHz 802.11g/n OFDM configurations, the measurement and test reduction procedures for OFDM are applied. SAR is not required for the following 2.4 GHz OFDM conditions.

1) When KDB Publication 447498 SAR test exclusion applies to the OFDM configuration.
2) When the highest *reported* SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg.
   a) When SAR test exclusion applies to DSSS, a *reported* SAR of 0.4 W/kg is used to determine the adjusted SAR.

Kaitlin O'Keefe 10/22/2014 6:08 PM
Comment [8]: We suggest this statement be removed. If DSSS SAR is excluded just below the threshold power based on KDB 447498 and the output power in OFDM is above the threshold, SAR measurements for OFDM should be performed regardless of the estimated SAR for DSSS mode.

5.4. SAR Test Requirements for 2.4 and 5 GHz OFDM Configurations

When SAR measurement is required for 802.11 a/g/n/ac OFDM configurations, each frequency band and aggregated band is considered separately for SAR test reduction. When the same transmitter and antenna(s) are used U-NII-1 and U-NII-2A bands, additional SAR test reduction applies. When the band gap channels are used between U-NII-2C band and U-NII-3 band or §15.247 5.8 GHz band, the maximum output power may vary across the channels; the highest maximum output power transmission mode configuration and maximum output power channel across the bands must be used to determine SAR test reduction, according to the initial test configuration and subsequent test configuration requirements.[18] In applying the initial test configuration and subsequent test configuration procedures, the 802.11 transmission configuration with the highest specified maximum output power and the channel within a

[18] Band gap channels must satisfy the maximum output power and equipment certification requirements for both adjacent bands.

test configuration with the highest measured maximum output power should be clearly distinguished to apply the procedures.

5.4.1. U-NII-1 and U-NII-2A Bands

For devices that operate in only one of the bands, the normally required SAR procedures for OFDM configurations are applied. For devices that operate in both U-NII bands using the same transmitter and antenna(s), SAR test reduction is determined according to the following, with respect to the highest *reported* SAR and maximum output power specified for production units.

1) When the same maximum output power is specified for both bands, begin SAR measurement in U-NII-2A by applying the OFDM SAR requirements.[19] If the highest *reported* SAR is ≤ 1.2 W/kg, SAR is not required for U-NII-1 band; otherwise, both bands should be tested independently for SAR.
2) When different maximum output power is specified for the bands, begin SAR measurement in the band with higher specified maximum output power. The highest *reported* SAR is adjusted by the ratio of lower to higher specified maximum output power for the two bands. When the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for the band with lower maximum output power; otherwise, both bands should be tested independently for SAR.[20]
3) The two U-NII bands may be aggregated to support a 160 MHz channel on channel number 50. The maximum output power for this is limited to the lower of the maximum output power certified for the two bands. When SAR measurement is required for at least one of the bands and the highest *reported* SAR is > 1.2 W/kg, SAR is required for the 160 MHz channel. This procedure does not apply to an aggregated band with maximum output higher than the standalone band(s) where the aggregated band must be tested independently for SAR. SAR is not required when the 160 MHz channel is operating at a reduced maximum power and also qualifies for SAR test exclusion.

5.4.2. Initial Test Configuration Procedures

An initial test configuration is determined according to the channel bandwidth, modulation and data rate combination(s) with the highest maximum output power specified for production units in each frequency band and aggregated band for SAR measurement using the highest measured maximum output power channel. SAR test reduction for OFDM configurations is partly based on *reported* SAR of the initial test configuration. For next to the ear, hotspot mode and UMC mini-tablet exposure configurations where multiple test positions are required, the initial test position procedure is applied to minimize the number of test positions required for SAR measurement using the initial test configuration transmission mode.[21] For other exposure conditions that do not require multiple SAR test positions, SAR is measured in the transmission mode determined by the initial test configuration. When the *reported* SAR of the initial test configuration is > 0.8 W/kg, SAR measurement is required for the subsequent next highest measured

Kaitlin O'Keefe 11/20/2014 6:07 PM
Comment [9]: This test reduction does not consider that different capabilities may be supported by these NII bands. For example, some devices when certified to the new U-NII rules will support WIFI Hotspot in the U-NII-1 band (and not the U-NII-2A band).

Kaitlin O'Keefe 11/14/2014 11:21 AM
Comment [10]: Please clarify if the reported SAR of measured bands should be adjusted for the power differential before applying this test threshold.

Kaitlin O'Keefe 11/13/2014 6:52 PM
Comment [11]: Based on the example in annex C, the channel selection performed in this procedure is pretty heavily dictated by the guidelines in Section 5.1, but that seems very detached from these procedures. We recommend moving the details in section 5.1 to immediately before or after this section or at least providing a more clear reference to Section 5.1 so readers know to refer there. Without this guidance, the channel selection criteria may be very different.

[19] The applicable procedures for OFDM configurations include the initial test configuration, initial test position and subsequent test configuration procedures.

[20] For example, if the highest *reported* SAR for U-NII-1 band is 1.4 W/kg and the specified maximum output power for U-NII-1 and U-NII-2A bands are 250 mW and 200 mW respectively, the adjusted SAR is 1.4 × 200/250 = 1.12 W/kg. The adjusted SAR is ≤ 1.2 W/kg; therefore, SAR is not required for U-NII-2A band.

[21] When a test lab chooses not to apply the initial test position procedure, the initial test configuration procedures must be applied separately to each exposure test position.

exclusion is determined by the smaller of the estimated SAR or highest *reported* SAR for the 802.11 transmission modes in that frequency band. The SAR peak to location ratio provision in KDB Publication 447498 is intended for peak SAR locations measured in the same (2D) plane within the phantom. When a peak SAR location is estimated because standalone SAR measurement is not required and the antenna is located at > 5 cm from the phantom, there could be substantial overestimation when applying peak SAR to location ratio test exclusion. Under such circumstances, a standalone SAR measurement may be considered to facilitate the SAR test exclusion.

For MIMO configurations, when lower order subsets of the maximum MIMO chains are used; for example, different 2×2 subsets of a 3×3 MIMO configuration, all MIMO combinations must be accounted for to determine compliance, either by SAR test exclusion or measurement; especially when there is a difference in maximum output power among the MIMO chains or when antenna interaction is expected in an integrated MIMO antenna structure.

The simultaneous transmission SAR test exclusion provisions in KDB Publication 447498 can be applied to avoid simultaneous transmission SAR measurement or to reduce the number of tests. For the typical circumstances, the number of simultaneous transmission SAR measurements can usually be kept to less than two to three. To correctly apply simultaneous transmission SAR test exclusion, the *reported* standalone SAR results must be examined according to all combinations of channel bandwidths, maximum output power, 802.11 transmission modes, frequency bands, exposure configurations and test positions to determine if certain combinations may be considered collectively to apply the SAR test exclusion procedures according to the highest *reported* SAR for the group. The decision to consolidate standalone SAR results into meaningful groups according to 802.11 transmission mode configurations, exposure conditions and test positions etc. must be consistent with the actual transmission and use conditions. When the sum of 1-g SAR is used to determine SAR test exclusion for all simultaneous transmission configurations in a group, the highest *reported* standalone SAR in each frequency band, among all transmission modes and exposure configurations, for each antenna must be used to determine if simultaneous transmission SAR measurement is unnecessary. However, if SAR peak to location ratio is also applied to some of the configurations for further SAR test reduction, it is generally inappropriate to consider these transmission and exposure configurations collectively with respect to the highest SAR used for sum of 1-g test exclusion because the SAR peak to location ratio procedure is specific to the simultaneous transmitting antennas and test configuration considered.[25]

To apply the simultaneous transmission SAR test exclusion procedures in KDB Publication 447498, it must be ensured that the maximum output power of each antenna during simultaneous transmission is not greater than that used in standalone transmission. When power reduction is applied to simultaneous transmission, instead of the higher maximum power for standalone transmission, additional standalone SAR measurements at the (reduced) maximum output power or SAR measurements with all antennas transmitting simultaneously may be considered to apply simultaneous transmission SAR test exclusion. The number of additional standalone measurements at the reduced maximum power may be minimized by demonstrating that SAR scaling is applicable; however, a KDB inquiry may be required to address the details for individual circumstances. When simultaneous transmission SAR test exclusion is not satisfied for a transmission mode and exposure configuration, simultaneous transmission SAR measurement is required for the specific configuration. Unless the antennas are spatially separated and SAR distributions do not overlap, when antennas transmit simultaneously in the same frequency band, within the frequency range covered by a single SAR probe

[25] See simultaneous transmission SAR test exclusion section of KDB Publication 447498 for additional explanation.

Table C.3 – Maximum output power measured at the antenna port of a test sample, for the applicable OFDM configurations, according to the default power measurement procedures

802.11 Modes		a	g		n (HT)[@]		ac (VHT)[@]			
Channel Bandwidth (MHz)		20	20	40	20	40	20	40	80	160
§15.247 (2.4 GHz)			*1/6/11*	*6*	*1/6/11*	*6*				
			48/46/47	lower power	47/48/46	lower power				
U-NII-1		*36/40/44/48*			*36/40/44/48*	*38/46*	*36/40/44/48*	*38/46*	*42*	
		45/46/46/48			46/45/48/47	lower power	46/48/47/46	lower power	lower power	
U-NII-2A		*52/56/60/64*			*52/56/60/64*	*54/62*	*52/56/60/64*	*54/62*	*58*	
		46/45/48/47			45/46/46/48	lower power	48/46/49/47	lower power	lower power	
U-NII-1 + U-NII-2A	*Ch. #*									*50*
	mW									lower power
U-NII-2C		*100/112/116/128*			*100/112/116/128*	*102/110/118/126*	*100/112/116/128*	*102/110/118/126*	*106/112*	*114*
		42/44/43/44			43/44/42/43	lower power	42/43/44/43[*]	lower power[*]	lower power[*]	lower power[#]
U-NII-3		*132/149/165*			*132/149/165*	*134/142/151/159*	*132/149/165*	*134/142/151/159*	*138/155*	
		lower power			lower power	lower power	lower power[*]	lower power[*]	lower power[*]	
§15.247 (5.8 GHz)		*132/149/165*			*132/149/165*	*134/142/151/159*	*132/149/165*	*134/142/151/159*	*138/155*	
		48/46/49			49/48/46	lower power	43/47/49[*]	lower power[*]	lower power[*]	

- The example assumes the same modulations and data rates are used for all 802.11 modes.
- When applicable, initial test configuration is chosen according to maximum measured output channel closest to mid-band frequency among all identical configurations. For multiple mid-band channels with the same measured maximum output power, the higher channel number is selected. When the same transmission mode configurations have the same maximum output power on the same channel for the 802.11 a/g/n/ac modes, the channel in the lower order/sequence 802.11 mode (i.e. a, g, n then ac) is selected.
- An entry of "lower power" means power measurement is not required.
- Specified maximum output power is higher for 5.8 GHz §15.247; therefore, power measurement is not required for U-NII-3.
- Channels selected for initial test configuration(s) are highlighted in yellow.
- This example assumes new rules in FCC 14-30 are applied, without TDWR restriction.
- U-NII-2C and U-NII-3 or 5.8 GHz §15.247 band gap channels are enabled. Aggregated band procedures for SAR probe calibration apply.

Kaitlin O'Keefe 11/9/2014 1:39 PM

Comment [12]: We would like to request clarification if this is an assumption we should typically make for 802.11a/n/ac 20 MHz Bandwidth. For 802.11a, the lowest data rate is 6 Mbps, but for 802.11n/ac 20 MHz, it is 6.5 Mbps. However given the same output power across all three modes, it appears that we should consider them as the same test configuration.

Kaitlin O'Keefe 11/3/2014 4:26 PM

Comment [13]: We suggest clarifying here that mid channel is only considered here across all first if the measured output power between the channels is >1/4 dB different.

Table C.4 – *Reported* SAR of initial test configuration with frequency band test reduction taken into consideration

802.11 Modes		a	g		n (HT)@		ac (VHT)@			
Channel Bandwidth (MHz)		20	20	40	20	40	20	40	80	160
§15.247 (2.4 GHz)			1/6/11	6	1/6/11	6				
			SAR not required; 802.11b adjusted SAR ≤ 1.2 W/kg							
U-NII-1		36/40/44/48			36/40/44/48	38/46	36/40/44/48	38/46	42	
					not required					
U-NII-2A		52/56/60/64			52/56/60/64	54/62	52/56/60/64	54/62	58	
							0.85			
U-NII-1 + U-NII-2A	Ch. #									50
	W/kg									
U-NII-2C		100/112/116/128			100/112/116/128	102/110/118/126	100/112/116/128	102/110/118/126	106/112	114
							0.95			
U-NII-3		132/149/165			132/149/165	134/142/151/159	132/149/165	134/142/151/159	138/155	
§15.247 (5.8 GHz)		132/149/165			132/149/165	134/142/151/159	132/149/165	134/142/151/159	138/155	
		1.08								

- This example assumes the device has a fixed exposure test position; therefore, initial test position SAR test reduction does not apply.
- It is also assumed that the test separation distance and measured power (illustrated in Table C.3) do not qualify for standalone SAR test exclusion in KDB Publication 447498.
- SAR probe(s) are assumed to have valid calibrations at 5.25, 5.60 and 5.75 GHz.
- SAR values illustrated in the table have been scaled to 100% transmission duty factor with *reported* SAR procedure applied.
- U-NII-1 and U-NII-2A bands have same specified maximum output and tolerance; SAR is measured for U-NII-2A band first. Adjusted SAR of U-NII-2A band is ≤ 1.2 W/kg, SAR is not required for U-NII-1 band.

Table C.5 – *Reported* SAR of Initial test configuration for next highest measured output channel

802.11 Modes		a	g		n (HT)[@]		ac (VHT)[@]			
Channel Bandwidth (MHz)		20	20	40	20	40	20	40	80	160
§15.247 (2.4 GHz)			*1/6/11*	*6*	*1/6/11*	*6*				
			SAR not required; 802.11b adjusted SAR ≤ 1.2 W/kg							
U-NII-1		*36/40/44/48*			*36/40/44/48*	*38/46*	*36/40/44/48*	*38/46*	*42*	
					not required					
U-NII-2A		*52/56/60/64*			*52/56/60/64*	*54/62*	*52/56/60/64*	*54/62*	*58*	
		channel 60 already tested			0.92		0.85			
U-NII-1 + U-NII-2A	*Ch. #*									*50*
	W/kg									
U-NII-2C		*100/112/116/128*			*100/112/116/128*	*102/110/118/126*	*100/112/116/128*	*102/110/118/126*	*106/112*	*114*
		0.98					0.95			
U-NII-3		*132/149/165*			*132/149/165*	*134/142/151/159*	*132/149/165*	*134/142/151/159*	*138/155*	
§15.247 (5.8 GHz)		*132/149/165*			*132/149/165*	*134/142/151/159*	*132/149/165*	*134/142/151/159*	*138/155*	
		1.08			0.97		channel 165 already tested			

- The yellow highlighted channels are next highest measured output channel that require SAR testing.
- Initial test configuration SAR for U-NII-2A band is > 0.8 W/kg, SAR is required for next highest output channel. Lowest order 802.11 mode applied to next highest output channel selection. Next highest output channel SAR is ≤ 1.2 W/kg, SAR is not required for subsequent next highest output channel. Similar circumstances apply to 5.8 GHz band in §15.247.
- When a next highest output channel has already been tested in an earlier configuration, apply the procedures to next subsequent highest output channel; see entries for U-NII-2A and §15.247 5.8 GHz in above table.
- Note: If *reported* SAR of next highest output channel for 5.8 GHz band in §15.247 is > 1.2 W/kg (does not apply to this example), subsequent next highest output power channels would also need testing until *reported* SAR is ≤ 1.2 W/kg or all channels are tested.

Kaitlin O'Keefe 11/20/2014 11:33 AM
Comment [14]: We believe the "subsequent" channel here should be 132 and not 149, since the powers across the initial test configuration are >0.25 dB. Therefore, the highest output power should be considered not just the mid channels.

Kaitlin O'Keefe 10/27/2014 9:04 AM
Comment [15]: For clarity, it might help to include this clarification additionally in section 5.4.2