

- i) Only one channel fits in the aggregated band: channel 50
  - ii) Maximum output power is limited by the band with lower allowed or specified maximum output
    - (1) When all reported standalone SAR for both bands are  $\leq 1.2$  W/kg and the maximum output power of the aggregated band is at least 1 dB lower than the individual bands
      - (a) SAR is not required for the aggregated band
        - (i) when SAR test exclusion applies to a band, the reported SAR is assumed to be  $\leq 1.2$  W/kg
        - (b) otherwise, SAR is required for 160 MHz channel in the aggregated band
- 3) 5.47 – 5.725 GHz and 5.725 – 5.85 GHz UNII 2C, UNII 3 and §15.247 (referred to as 5.6 and 5.8 GHz bands)
- a) Different maximum allowed output power
    - i) 5.6 GHz UNII 2C: 250 mW / 30 dBm EIRP
    - ii) 5.8 GHz UNII 3 & §15.247: 1 W / 36 dBm EIRP
    - iii) Lower maximum output power may apply due to emission bandwidth restriction
    - iv) Frequency range for the three bands is too wide to easily facilitate SAR test reduction, 380 MHz
      - (1) requires multiple SAR probe calibration points
      - (2) difference in tissue-equivalent media conductivity is about 8%
  - b) 5.60 – 5.65 GHz in UNII 2C is restricted for master devices until further notice due to TDWR
    - i) A client device must be considered for SAR, except when it is specifically disabled to operate in this frequency range through acceptable mechanisms<sup>1</sup>
  - c) When the same transmitter and antenna configuration(s) are used for both 5.6 and 5.8 GHz bands
    - i) The additional 20, 40 and 80 MHz channels that span across these bands, unless permanently disabled, must also be considered for SAR testing
    - ii) The maximum output for these channels is limited by UNII 2C requirement (250 mW)
    - iii) Channels above 5.65 GHz in UNII band 2C are grouped with 5.8 GHz band channels in UNII 3 and §15.247 for SAR measurement, with respect to the maximum output power levels allowed for each band and specified for the transmitter, to facilitate test reduction
  - d) Band aggregation for 160 MHz channel BW across UNII 2C and 3 bands is not defined in the 802.11ac standard, most likely due to channel number misalignment. Client devices that do not disable operation in 5.60 – 5.65 GHz may fit a single 160 MHz channel in UNII 2C
    - i) SAR testing must be considered for products that implement 160 MHz channel(s) in UNII 2C or across the 5.6 and 5.8 GHz bands on an ad hoc basis
- 4) Simultaneously transmitting in two channels is not equivalent to transmitting in a single channel with twice the BW; i.e., two non-contiguous 80 MHz channels (80 + 80) is not equivalent to a 160 MHz channel. These are considered separately for SAR compliance
- a) **Issues relating to channel and band aggregation with respect to product implementations need investigation**

**Comment [1]:** Please clarify – reported SAR for 20 MHz BW? 40? 80? 802.11a/n/ac.?

#### SAR probes calibration and measurement considerations

- 1) SAR probes should be calibrated with at least +/- 100 MHz coverage at the following frequencies and according to the tissue dielectric parameter requirements of KDB 865664 to cover the 5 GHz frequency bands
  - a) 5.25 GHz for UNII 1 and 2A: 5.15 - 5.35 GHz
  - b) 5.60 GHz for UNII 2C: 5.475 – 5.725 GHz (250 MHz)
    - i) Probe calibration is expected to become marginal for the band edge channels
      - (1) Span of actual channel frequencies is 220 MHz (5.49 – 5.71 GHz)
      - (2) Span of channel center frequencies is 200 MHz (5.5 – 5.7 GHz)
    - ii) When band edge channels are tested, the tissue dielectric parameters must be within 5% of the required targets
  - c) 5.75 GHz for UNII 3, §15.247, or upper UNII 2C (above 5.65 GHz) with UNII 3 or §15.247: 5.65 – 5.85 GHz
  - d) SAR system validation dipoles must be calibrated within the frequency range covered by the probe calibration points required for device testing, according to KDB 865664 requirements
- 2) Other SAR measurement concerns that need consideration

<sup>1</sup> This supersedes the slide presented in October 2013 TCB workshop; also see explanation in 05/28/2013 TCB conference call minutes.

- a) Influences of high peak to average power ratio OFDM signals to SAR probe calibration
- b) Conservativeness of existing tissue-equivalent media dielectric parameters at 2.4 and 5 GHz for certain test separation distances and exposure conditions; according to on-going investigations in SAR measurement standards committees

Power measurement requirement considerations

- 1) For SAR purposes, power must be measured in each frequency band and aggregated band for the highest output power wireless mode specified for production units, including tolerance, according to channel BW, modulation and data rate to confirm the device is operating within specifications
  - a) at the highest and lowest channels in the frequency band, and at the mid-band channel when there are at least 3 channels
  - b) this enables the highest output power channel to be identified for DSSS and OFDM SAR measurements
  - c) when the same maximum output specification applies to multiple channel BW, modulation, guard interval, and data rate combinations in a standalone or aggregated frequency band, select the configuration with the largest channel BW, lowest order modulation and lowest data rate
  - d) these power measurement test reduction provisions are applicable only when the same maximum power and tolerance are specified for production units across all channels in a wireless mode, channel BW and frequency band
- 2) Power measurement is required for all configurations that require SAR measurement to enable *reported* SAR to be determined and to confirm that output power levels are within the test conditions required by KDB 447498
- 3) When power measurement is not required for a specific wireless configuration, the maximum output power specified and supported by production units, including tolerance, is applied to determine SAR test exclusion and reduction

SAR test reduction considerations for specific exposure conditions

- 1) For next to the ear, UMPC mini-tablet and hotspot mode equivalent exposure conditions (need definition for "equivalent") that require multiple test positions, an initial test position may be selected to test the highest output power channel/configuration required by the initial test configuration in the DSSS or OFDM SAR procedures to facilitate test reduction
  - a) Left, right, touch and tilt head exposure test positions for the SAM phantom are considered as one head exposure condition for applying SAR test reduction
    - i) Start on the side (left or right) of the SAM phantom and test position (touch or tilt) with the smallest Wi-Fi antenna to phantom test separation and maximum antenna to phantom coupling condition
      - (1) When the differences in separation distance are indistinguishable, select the position with maximum antenna coupling to the SAM phantom, with respect to antenna orientation and polarization etc.
      - (2) When exposure is dominated by antenna coupling, instead of antenna to phantom separation, antenna to phantom coupling must be considered first to determine the initial test position
      - (3) Certain antenna details that are only available from device manufacturers may be necessary to apply this test reduction
  - b) When hotspot mode or UMPC mini-tablet equivalent SAR configuration applies, start with the configuration that provides the smallest antenna or device (to be determined) to flat phantom separation and maximum antenna to phantom coupling condition
    - i) for example, front or back surface vs. side edges with respect to antenna orientation and polarization
    - ii) **further review is needed to determine if these can be adapted for phablets ("equivalent" conditions)**
  - c) When it is unclear, all equivalent smallest separation and maximum coupling conditions must be considered for initial test position testing; i.e., a single initial test position cannot be established
- 2) When all *reported* SAR for the initial test position(s) measured according to the required DSSS or OFDM SAR measurement procedures for a wireless mode test configurations are
  - a)  $\leq 0.4$  W/kg, further SAR measurement is not required for the DSSS or OFDM configuration in that exposure condition and frequency band
  - b)  $> 0.4$  W/kg
    - i) Repeat the SAR measurement for subsequent next closest/smallest antenna to phantom separation and maximum antenna to phantom coupling test position(s) with the same wireless mode test configuration



**Comment [2]:** Please clarify if this includes body-worn and tablet/laptop devices as described in 648474 and 616217?

**Comment [3]:** Please clarify how test labs should determine this condition and how TCBs will verify these conditions.

**Comment [4]:** When certain test positions are excluded, how should simultaneous SAR be addressed for these configurations?

used for the initial test position until the reported SAR is  $\leq 0.8$  W/kg or all required test positions are considered (left, right, touch, tilt or subsequent surfaces and edges)

- (1) For subsequent test positions with equivalent antenna to phantom separation or when antenna to phantom coupling dominates the exposure, select the position with maximum antenna to phantom coupling condition
  - (2) When it is unclear, all equivalent conditions must be tested; i.e., a single subsequent test position cannot be established
- c) For all positions/configurations from the initial test position and subsequent test configurations (SAR  $> 0.4$  W/kg) with reported SAR  $> 0.8$  W/kg, repeat these test positions/configurations on the subsequent next highest measured output channel(s) until the reported SAR is  $\leq 1.2$  W/kg or all required test channels are considered

**Comment [5]:** Please clarify – until the reported SAR of the subsequent test positions is  $\leq 0.8$  W/kg? If SAR of the initial test position is  $> 0.4$  but  $< 0.8$ , is an additional evaluation required at the subsequent test position?

#### SAR test considerations for 802.11b DSSS

- 1) When SAR test exclusion does not apply, 2.4 GHz 802.11b DSSS SAR is measured on the highest output power channel
  - a) An initial test position may be applied to next to the ear, UMPC mini-tablet and hotspot mode equivalent exposure conditions for test reduction
  - b) For other exposure conditions (not next to the ear, UMPC mini-tablet or hotspot mode), when the reported SAR on the highest output channel for the exposure condition is
    - i)  $\leq 0.8$  W/kg, no further testing is required for 802.11b DSSS in that exposure condition
    - ii)  $> 0.8$  W/kg, measure SAR on the next highest measured output channel, and
      - (1) when any reported SAR is  $> 1.2$  W/kg, measure SAR on the 3<sup>rd</sup> channel; i.e., all channels require testing

**Comment [6]:** Please clarify what data rate(s) should be evaluated

**Comment [7]:** Please clarify – from here, are the procedures outlined above for “SAR test reduction considerations for specific exposure conditions” followed to determine test positions and configurations?

**Comment [8]:** Please clarify what is meant by “other exposure condition?”

#### SAR test exclusion and test reduction for 2.4 GHz OFDM (802.11g/n)

- 1) SAR is not required for an OFDM mode (802.11g or n) when the specified maximum output power for production units, including tolerance, is
  - a) at least 1 dB lower than DSSS and the highest reported SAR for DSSS is  $\leq 1.2$  W/kg
  - b)  $\leq 1/4$  dB higher than DSSS and
    - i) highest reported SAR for DSSS is  $\leq 0.8$  W/kg or SAR test exclusion applies to DSSS

**Comment [9]:** Please clarify what SAR tests would be required if these conditions are not met.

#### OFDM SAR measurement procedures for 2.4, (4.9) and 5 GHz bands

- 1) When SAR measurement is required, an initial test configuration is determined for each frequency band and aggregated band to facilitate SAR test reduction for 802.11 a/g/n/ac OFDM modes
  - a) Start with the channel BW, modulation and data rate combination(s) with the highest maximum output power specified for production units, including tolerances
    - i) The highest measured output channel according to power measurement results should be tested
      - (1) for channels with the same measured maximum output power, measure SAR on the channel closest to mid-band
    - ii) When the same maximum output specification applies to multiple channel BW, modulation and data rate combinations, select the configuration with the largest channel BW, lowest order modulation and lowest data rate
    - iii) Modulation and data rate selection is mainly intended for test setup consistency
      - (1) 802.11 data rates are associated with modulations
      - (2) For SAR purposes, the modulations associated with sub-carriers are generally not expected to have significant impact to the OFDM channel output
- 2) Support for 4.94 – 4.99 GHz (part of existing KDB 247227), with respect to §§90.1213 and 90.1215, or other 802.11 related frequency bands such as §90.377 (5.85 – 5.925 GHz, OBU/RSU) etc., remain to be determined
- 3) Initial test configuration SAR measurement
  - a) An initial test position may be applied to the initial test configuration for next to the ear, UMPC mini-tablet and hotspot mode equivalent exposure conditions to determine SAR test reduction
  - b) For other exposure conditions (not next to the ear, UMPC mini-tablet or hotspot mode equivalent)

**Comment [10]:** Please clarify – from here, are the procedures outlined above for “SAR test reduction considerations for specific exposure conditions” followed to determine test positions and configurations?

- i) when the *reported* SAR of the initial test configuration is  $> 0.8$  W/kg, repeat the initial test configuration on the subsequent next highest measured output channel(s) until the *reported* SAR is  $\leq 1.2$  W/kg or all required test channels are considered
- 4) Subsequent test configurations are determined for each frequency band and aggregated band to facilitate further test reduction for the applicable exposure conditions
  - a) SAR is measured for the channel BW, modulation and data rate combination with next to highest maximum output power specified for production units, including tolerance
    - i) When the next to highest specified maximum output configuration(s) is within  $\frac{1}{2}$  dB of the highest specified maximum output initial test configuration and the highest *reported* SAR for the initial test configuration(s) according to the initial test position or other exposure conditions is<sup>2</sup>
      - (1)  $\leq 0.8$  W/kg, further SAR testing for the exposure condition in that frequency band is not required
      - (2)  $> 0.8$  and  $\leq 1.2$  W/kg
        - (a) For all test conditions in the initial test configuration(s) with *reported* SAR  $> 0.8$ , test the channel(s) in the next highest specified output configuration that overlap(s) with the channel(s) in the initial test configuration(s) or apply the procedures required for  $> 1.2$  W/kg in (3) below<sup>3</sup>
        - (b) When multiple channels require testing for the next highest specified output configuration, start with the highest measured output channel and continue with subsequent highest measured output channels only when the *reported* SAR of the next highest specified output configuration at the highest measured output channel is  $> 1.2$  W/kg
          - (i) For channels with the same measured maximum output power, measure SAR on the channel closest to the center frequency of the larger channel BW channel
          - (ii) Additional power measurements may be necessary to apply this step for SAR test reduction
      - (3)  $> 1.2$  W/kg, apply the initial test configuration SAR measurement procedures to the next highest output configuration
        - (a) When SAR is required, power measurement is necessary to determine *reported* SAR and to identify the highest measured output channel to apply the initial test configuration
  - b) SAR measurement of subsequent highest specified output configurations, besides the highest and next highest specified output configurations
    - i) Apply the procedures for next highest specified output configuration by replacing
      - (1) “next to highest specified output configuration” with “subsequent highest specified output configuration”
      - (2) “highest specified output configuration” and “initial test configuration” with “all already tested higher output configurations”
- 5) 160 MHz channels must be tested when the *reported* SAR of any channel in a smaller channel BW configuration that overlaps with the 160 MHz channel is  $> 1.2$  W/kg

#### SAR considerations for MIMO configurations

- 1) SAR for MIMO configurations are considered separately for each channel BW and frequency band or aggregated band configurations for the different exposure conditions.
- 2) The following may be applied to determine SAR test exclusion
  - a) The aggregate maximum output power of all simultaneous transmitting antennas in the MIMO chains may be considered to determine SAR test exclusion according to the output power, frequency and distance provisions for standalone SAR in KDB 447498 or other product specific KDB procedures (this need review)
  - b) When the standalone SAR test exclusion of KDB 447498 does not apply, each combination of MIMO chains may be considered separately (e.g., 2x2 as subsets of 3x3) for the MIMO configurations according to the sum of 1-g SAR or SAR to peak location ratio test exclusion described in KDB 447498 to determine simultaneous transmission SAR test exclusion

<sup>2</sup> Specified maximum output is the maximum output power specified for production units, including tolerance, for the applicable 802.11 wireless configuration.

<sup>3</sup> Channels overlap due to differences in channel BW.

**Comment [11]:** When the initial test configuration tested for non-MIMO operations does not overlap with MIMO capabilities, can the SAR of the SISO transmitters still be used for sum of 1g or SPLSR MIMO test exclusion? For example, 802.11b evaluated for SAR as initial test configuration with 802.11n/ac excluded, but MIMO only supported at 802.11n/ac. Could 802.11b SAR be used determine exclusion?