RF Exposure Procedures Update

TCB Workshop
October 2014

(Page 37 revised, Dec. 10, 2014)

Laboratory Division
Office of Engineering and Technology
Federal Communications Commission
Overview

- KDB 248227 – 802.11 SAR draft update
- KDB publications update
- SAR measurement methodology and test systems
- Other miscellaneous updates
KDB 248227 Draft Update
Draft Revision Overview

KDB 248227 introduced in 2006; updated in 2007
- based on 802.11 a/b/g; does not address 802.11n or 802.11ac
- procedures are based on 802.11 a/b/g transmission mode configurations

Revised draft has been re-organized and procedures consider
- 802.11 transmission modes and configurations collectively for each frequency band and aggregated band to apply SAR measurement procedures and SAR test reduction
- test reduction for multiple exposure test positions
- frequency band specific SAR test consideration
- additional simultaneous transmission SAR considerations
- clarified transmission duty factor and SAR probe calibration conditions

Information on 802.11 & Wi-Fi mode configurations included in appendix
- basic 802.11 modes (802.11a/b/g/n/ac), MIMO, STBC, TxBF
- TDLS, Wi-Fi Direct, Mesh Services
5 GHz Channel Configurations

- **802.11ac**: 160 MHz BW
- **802.11a**: 80 MHz BW
- **802.11a/n**: 40 MHz BW
- **20 MHz BW**

- **Existing 802.11a/n**
- **New Channels**
- **TDWR Channel Restriction**

- U-NII-1: 5.15 GHz to 5.25 GHz
- U-NII-2A: 5.25 GHz to 5.35 GHz
- U-NII-2C: 5.41 GHz to 5.50 GHz
- U-NII-3: 5.725 GHz to 5.85 GHz

- TDWR Channel
Test Procedures Overview

- Maximum output power is considered according to
  - product specification and tune-up tolerance for initial testing
  - default power measurement procedures for core 802.11 configurations
  - additional power measurements as necessary for further test reduction

- SAR procedures are structured according to 802.11 transmission modes for each frequency band and aggregated band, with respect to DSSS or OFDM configurations and specific test requirements
  - initial test configuration
  - initial test position
  - subsequent test configurations
  - frequency band related test configurations
  - SAR probe calibration conditions
General SAR Requirements

SAR measurement test mode setup
- Wi-Fi networks are not suitable
- chipset or firmware based test mode is required
- must use unmodified production unit settings for SAR testing

SAR measurement transmission duty factor requirements
- must be periodic and at least 85%
- *reported* SAR procedure is applied after adjusted to 100% duty factor
- if hardware limited, must be within 15% of maximum duty factor device is capable
- adjust to 100% or max. duty factor then apply *reported* SAR procedure

SAR probe calibration requirements
- at least ±100 MHz coverage for 5 GHz bands
- SAR may be measured using 2 probe calibration points
  - 5.60 and 5.75 GHz
  - for U-NII-2C or U-NII-2C with U-NII-3 or 5.8 GHz §15.247
  - tighter tissue dielectric tolerance required for U-NII-2C bandedge channels
SAR Test Reduction Considerations

Separate procedures apply to DSSS and OFDM transmission modes
  – to keep 2.4 GHz 802.11b DSSS requirements simple
  – to streamline 802.11a/g/n/ac OFDM configurations more effectively

Next to ear, UMPC mini-tablet and hotspot mode exposure configurations require multiple SAR test positions
  – an initial test position is applied to DSSS & OFDM configurations for SAR test reduction

2.4 & 5 GHz 802.11 OFDM modes includes multiple configurations
  – different channel bandwidths, modulations, data rates
  – different power and operating requirements in different frequency bands
  – different SAR probe calibration & tissue dielectric parameter requirements
  – initial test configuration & subsequent test configuration procedures are applied to each frequency band and aggregated band for test reduction
Power Measurement & Channel Selection Requirements

Default power measurement procedure is applied to highest specified max. output configuration in each frequency band and aggregated band

– according to 802.11 modes, channel BW, modulation, data rate etc.

Power measurement is also required for all configurations that require SAR measurement to determine reported SAR

Additional power measurements may be needed to determine SAR test reduction across the test channels

channel selection criteria for SAR measurements

– channels with same power – test channel closest to mid-band frequency

– when there are 2 mid-band channels due to an even number of test channels, test channel with higher frequency or channel number
Multiple Position Test Reduction

- Next to ear (head), UMPC mini-tablet and hotspot mode exposure conditions have multiple test positions
  - left, right, touch & tilt combinations of SAM phantom for head
  - applicable surfaces & edges for UMPC mini-tablet & hotspot mode

An initial test position is determined according to

- area scans to establish conservativeness of the test positions
  - using DSSS procedure for 802.11b or initial test configuration procedures for OFDM
  - with respect to extrapolated or 1-g estimated SAR
  - when available, antenna implementation details from device manufacturer to compare test positions based on
    - test separation distance at antenna location
    - RF coupling conditions between device and phantom
Initial Test Position Procedure

- SAR is measured in the initial test position using either the 802.11b DSSS procedure or initial test configuration for OFDM
  - apply initial test configuration setup, but not the SAR procedures

When *reported* SAR of the initial test position is

- ≤ 0.4 W/kg – SAR is not required for other test positions in that exposure configuration, within the frequency band or aggregated band
- > 0.4 W/kg – SAR is required for subsequent next conservative test positions until *reported* SAR is ≤ 0.8 W/kg or all positions are tested

If the *reported* SAR of any test position is > 0.8 W/kg

- SAR is measured on subsequent next highest measured output power channel(s) for that test position(s) until the *reported* SAR is ≤ 1.2 W/kg or all channels are tested
- additional power measurement may be required to determine subsequent highest output power channels
2.4 GHz SAR Requirements

802.11b DSSS and 802.11g/n OFDM are considered separately
- Channels 1, 6 & 11 or closest higher power channels apply to 20 MHz BW
- Channel 6 or closest higher power channel applies to 40 MHz BW

802.11b DSSS
- if applicable, the initial test position procedure is applied
- start SAR measurement on highest output power channel
  - if reported SAR is ≤ 0.8 W/kg; SAR is not required for other channels
  - otherwise, SAR is measured on next highest output channel(s) until reported SAR is ≤ 1.2 W/kg or all channels are tested

802.11g/n OFDM
- when KDB 447498 SAR test exclusion applies, SAR is not required
- when the highest reported SAR for DSSS is adjusted and ≤ 1.2 W/kg; SAR is not required for OFDM
  - SAR is adjusted by ratio of OFDM to DSSS specified maximum output & tolerance
  - 0.4 W/kg is used when SAR test exclusion applies to DSSS
- otherwise, apply the SAR procedures required for OFDM configurations
5 GHz Band Specific Procedures

- U-NII-1 and U-NII-2A bands using same transmitter and antenna(s)
  - for bands with the same specified maximum output and tolerance
    - measure SAR in U-NII-2A band first
    - if highest reported SAR is \( \leq 1.2 \) W/kg, U-NII-1 band does not require SAR
  - for bands with different specified maximum output or tolerance
    - SAR is first measured for the band with higher output power
    - if highest reported SAR is \( \leq 1.2 \) W/kg, other band does not require SAR
  - when the U-NII-1 or U-NII-2A band reported SAR is \( > 1.2 \) W/kg
    - SAR is required for 160 MHz channel; excepted when power reduction and SAR exclusion are both applicable

- U-NII-2C band only or U-NII-2C with U-NII-3 or 5.8 GHz §15.247
  - unless TDWR restriction applies, channels at 5.60 – 5.65 GHz and 160 MHz channel require consideration
  - when multiple bands apply or band gap channels are used, SAR is measured separately for channels above and below 5.65 GHz
OFDM Mode Test Reduction

- OFDM transmission configurations apply to 2.4 and 5 GHz bands.
- An initial test configuration is determined for each frequency band and aggregated band according to:
  - the maximum output power and tune-up tolerance specified for production units among the OFDM transmission modes (802.11a/n/ac or 802/11g/n) and configurations (channel bandwidth, modulation, data rate etc.).
- For configurations with the same maximum power, choose:
  - highest channel bandwidth, lowest modulation & lowest data rate
  - lowest order 802.11 modes; 802.11 a/n/ac or 802.11 g/n
- When applicable, the initial test position is measured using the initial test configuration for OFDM configurations.
Initial Test Configuration Procedures

Initial test configuration procedures only apply to exposure configurations with a fixed test position

- SAR is measured for fixed test positions with the initial test configuration using the highest measured output power channel

- the initial test configuration setup (not the procedures) is also used for initial test position SAR measurement according to the initial test position procedure

When *reported* SAR of the initial test configuration, for fixed exposure position, is

- > 0.8 W/kg – SAR is required for subsequent next highest measured output power channel(s), using the initial test configuration until the *reported* SAR is ≤ 1.2 W/kg or all required channels are tested
Subsequent Test Configuration Procedures

Subsequent test configuration procedures are applied to determine if the remaining OFDM configurations in each frequency band and aggregated band that have not been tested in the initial test configuration procedures require SAR measurement.

If KDB 447498 SAR test exclusion applies and SAR is not required for the initial test configuration, SAR is also not required for subsequent test configurations for the frequency band.

When highest reported SAR of the initial test configuration for initial test position or fixed test position is adjusted:

1. by ratio of subsequent test configuration to initial test configuration maximum output and tolerance specified for production units, and
2. if adjusted SAR is ≤ 1.2 W/kg, SAR is not required for that subsequent test configuration.
Subsequent Test Configuration Procedures (… continued)

When the channel bandwidth in a subsequent test configuration is smaller than that tested in the initial test configuration, all smaller channels in smaller bandwidth configuration require consideration

- SAR is first measured on highest measured output power channel
- SAR is required for subsequent next highest output smaller BW channels if reported SAR is > 1.2 W/kg or until all required channels are tested
- for small BW channels with the same measured maximum output, test the channel closest to mid-band of the larger BW (previous) channel

Repeat subsequent test configuration procedures for next subsequent test configurations by replacing

- subsequent test configurations with next subsequent test configuration
- initial test configuration with all tested higher output power configurations
For spatially separated antennas with non-overlapping SAR distributions
- when aggregate SAR at any location is ≤ 1.2 W/kg and also ≤ 0.1 W/kg higher than contribution from each individual antenna
- compliance is determined separately for each antenna

Switch transmit diversity – average the reported SAR for the antennas

Standalone SAR test exclusion in KDB 447498 may be applied using aggregate maximum output power of all applicable antennas
- use most conservative test separation distance among the antennas
- Otherwise, apply KDB 447498 simultaneous transmission SAR test exclusion procedures or perform SAR measurement

All subsets of MIMO combinations must be taken into consideration
- especially when power varies among MIMO chains, or
- there is antenna interactions in integrated antenna structures

Proprietary implementations with coherent signals may need to address near-field SAR evaluation issues
Specified maximum output power at an antenna port

<table>
<thead>
<tr>
<th>802.11 Modes</th>
<th>a</th>
<th>g</th>
<th>n (HT)@</th>
<th>ac (VHT)@</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel Bandwidth (MHz)</td>
<td>20</td>
<td>20</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>§15.247 (2.4 GHz)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>U-NII-1</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>U-NII-2A</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>U-NII-1 + U-NII-2A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U-NII-2C</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X’</td>
</tr>
<tr>
<td>U-NII-3</td>
<td>X</td>
<td>X</td>
<td>X’</td>
<td>X’</td>
</tr>
<tr>
<td>§15.247 (5.8 GHz)</td>
<td>X</td>
<td>X</td>
<td>X’</td>
<td>X’</td>
</tr>
</tbody>
</table>

- X: numerical value (mW) of maximum (conducted) output power specified for production units, including tune-up tolerance, at each antenna port
- @: modify table as necessary for multiple antenna ports or repeat the applicable columns for additional antenna ports used for MIMO or TxBF and split into multiple tables as necessary
- #: this configuration applies only to the new rules in FCC 14-30, without TDWR restriction
- *: when applicable, include the band gap channels
Output Power Example

Maximum output power specified at the antenna port of production units, including tune-up tolerance, for the applicable OFDM configurations of a pretense test sample.

<table>
<thead>
<tr>
<th>802.11 Modes</th>
<th>a</th>
<th>g</th>
<th>n (HT)@</th>
<th>ac (VHT)@</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel Bandwidth (MHz)</td>
<td>20</td>
<td>20</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>§15.247 (2.4 GHz)</td>
<td></td>
<td>50</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>U-NII-1</td>
<td>50</td>
<td></td>
<td>50</td>
<td>45</td>
</tr>
<tr>
<td>U-NII-2A</td>
<td>50</td>
<td></td>
<td>50</td>
<td>45</td>
</tr>
<tr>
<td>U-NII-1 + U-NII-2A</td>
<td>mW</td>
<td>50</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>U-NII-2C</td>
<td>45</td>
<td></td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>U-NII-3</td>
<td>45</td>
<td></td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>§15.247 (5.8 GHz)</td>
<td>50</td>
<td></td>
<td>50</td>
<td>45</td>
</tr>
</tbody>
</table>

- See previous Table for definition of symbols #, @, * etc.
- The maximum output power specified for production units, including tune-up tolerance, is assumed to be the same for all channels, modulations and data rates for each 802.11 mode and channel bandwidth configurations in this example.
- Highlighted cells represent highest output configurations used in subsequent tables to determine the initial test configuration.
- For SAR test reduction in 2.4 GHz band, the maximum output specified for production units, including tune-up tolerance, for 802.11b is assumed to be 50 mW and highest reported SAR for DSSS is assumed to be 0.75 W/kg for this example.
**Initial Test Configuration Example**

Maximum output power measured at the antenna port of a test sample, for the applicable OFDM configurations according to the power measurement test reduction procedures.

<table>
<thead>
<tr>
<th>802.11 Modes</th>
<th>a</th>
<th>g</th>
<th>n (HT)@</th>
<th>ac (VHT)@</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel Bandwidth (MHz)</td>
<td>20</td>
<td>20</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>§15.247 (2.4 GHz)</td>
<td></td>
<td></td>
<td>1/6/11</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>48/46/47</td>
<td>lower power</td>
</tr>
<tr>
<td>U-NII-1</td>
<td>36/40/44/48</td>
<td></td>
<td>36/40/44/48</td>
<td>38/46</td>
</tr>
<tr>
<td></td>
<td>45/46/46/48</td>
<td></td>
<td>46/45/48/47</td>
<td>lower power</td>
</tr>
<tr>
<td>U-NII-2A</td>
<td>52/56/60/64</td>
<td></td>
<td>52/56/60/64</td>
<td>54/62</td>
</tr>
<tr>
<td></td>
<td>46/45/48/47</td>
<td></td>
<td>45/46/46/48</td>
<td>lower power</td>
</tr>
<tr>
<td>U-NII-1 + U-NII-2A</td>
<td>Ch. #</td>
<td>mW</td>
<td>100/112/116/118/128</td>
<td>102/110/118/126</td>
</tr>
<tr>
<td>U-NII-2C</td>
<td>42/44/43/44</td>
<td></td>
<td>43/44/42/43</td>
<td>lower power</td>
</tr>
<tr>
<td>U-NII-3</td>
<td>132/149/165</td>
<td>lower power</td>
<td>lower power</td>
<td>lower power</td>
</tr>
<tr>
<td></td>
<td>48/46/49</td>
<td>49/48/46</td>
<td>lower power</td>
<td>43/47/49*</td>
</tr>
</tbody>
</table>
## Reported SAR

**Reported SAR of initial test configuration with frequency band test reduction taken into consideration**

<table>
<thead>
<tr>
<th>802.11 Modes</th>
<th>a</th>
<th>g</th>
<th>n (HT)@</th>
<th>ac (VHT)@</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel Bandwidth (MHz)</td>
<td>20</td>
<td>20</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>§15.247 (2.4 GHz)</td>
<td>1/6/11</td>
<td>6</td>
<td>1/6/11</td>
<td>6</td>
</tr>
<tr>
<td>U-NII-1</td>
<td>36/40/44/48</td>
<td>36/40/44/48</td>
<td>38/46</td>
<td>36/40/44/48</td>
</tr>
<tr>
<td>U-NII-2A</td>
<td>52/56/60/64</td>
<td>52/56/60/64</td>
<td>54/62</td>
<td>52/56/60/64</td>
</tr>
</tbody>
</table>

SAR not required; 802.11b adjusted SAR ≤ 1.2 W/kg

<table>
<thead>
<tr>
<th>Ch. #</th>
<th>W/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-NII-1</td>
<td>0.85</td>
</tr>
<tr>
<td>+ U-NII-2A</td>
<td>50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>W/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-NII-2C</td>
</tr>
<tr>
<td>U-NII-3</td>
</tr>
</tbody>
</table>

U-NII-1 + U-NII-2A

October 2014 | TCB Workshop
### 802.11 Modes

<table>
<thead>
<tr>
<th>Channel Bandwidth (MHz)</th>
<th>a</th>
<th>g</th>
<th>n (HT)@</th>
<th>ac (VHT)@</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>20</td>
<td>40</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>40</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>80</td>
<td>80</td>
<td>160</td>
<td>80</td>
<td>160</td>
</tr>
<tr>
<td>§15.247 (2.4 GHz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>§15.247 (5.8 GHz)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### U-NII-1

<table>
<thead>
<tr>
<th>Ch. #</th>
<th>W/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>36/40/44/48</td>
<td>36/40/44/48</td>
</tr>
<tr>
<td>38/46</td>
<td>38/46</td>
</tr>
<tr>
<td>42</td>
<td></td>
</tr>
</tbody>
</table>

### U-NII-2A

<table>
<thead>
<tr>
<th>Ch. #</th>
<th>W/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>52/56/60/64</td>
<td>52/56/60/64</td>
</tr>
<tr>
<td>54/62</td>
<td>54/62</td>
</tr>
<tr>
<td>58</td>
<td></td>
</tr>
</tbody>
</table>

### U-NII-1 + U-NII-2A

<table>
<thead>
<tr>
<th>Ch. #</th>
<th>W/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>100/112/116/128</td>
<td>100/112/116/128</td>
</tr>
<tr>
<td>102/110/118/126</td>
<td>102/110/118/126</td>
</tr>
<tr>
<td>106/112</td>
<td>114</td>
</tr>
</tbody>
</table>

### U-NII-2C

<table>
<thead>
<tr>
<th>Ch. #</th>
<th>W/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>132/149/165</td>
<td>132/149/165</td>
</tr>
<tr>
<td>134/142/151/159</td>
<td>134/142/151/159</td>
</tr>
<tr>
<td>138/155</td>
<td></td>
</tr>
</tbody>
</table>

### U-NII-3

<table>
<thead>
<tr>
<th>Ch. #</th>
<th>W/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>132/149/165</td>
<td>132/149/165</td>
</tr>
<tr>
<td>134/142/151/159</td>
<td>134/142/151/159</td>
</tr>
<tr>
<td>138/155</td>
<td></td>
</tr>
</tbody>
</table>

**Reported SAR of Initial test configuration for next highest measured output channel**

SAR not required; 802.11b adjusted SAR ≤ 1.2 W/kg
KDB Publications Update
KDB 447498 – 1.2 W/kg PBA

1.2 W/kg PBA requirement was removed in April 2014
  – procedures needed and not yet available
  – for the interim, submit KDB inquiry to determine
    • if additional user instructions, statements or labels are necessary
  – provide the relevant info and guidance from KDB inquiry to TCB during review and approval

> 1.2 W/kg – may require additional manual instructions to support certain use conditions

between 1.4 and 1.5 W/kg – possible labeling considerations

> 1.5 W/kg – labeling is likely for certain use conditions
KDB 447498 – Fast SAR

- Issues reported previously for 5 GHz dipole using area scan estimated 1-g SAR (Motorola fast SAR) procedures
- KDB updated in April 2014 to limit procedures to below 3 GHz
- Latest findings: discrepancy resulted from using incompatible versions of measurement and post-processing software
  - measurements made with DASY5 when processed by DASY4 can result in fast SAR errors
  - unclear if other version combinations may introduce errors
- 5 GHz restriction is removed; KDB 447498 will be updated (later)
  - existing conditions for using estimated 1-g SAR should reveal this type of discrepancies
  - TCB must review and ensure the conditions for using estimated 1-g SAR are fully satisfied before issuing equipment approval
KDB 941225 – Hotspot Mode

Hotspot mode SAR procedures in KDB 941225 D06 updated

To realign with recent changes in other KDB procedures

– discontinued reference to supplement C
– discontinued use of 60/f SAR exclusion threshold
– removal of TCB exclusion list
– changes in PBA list
– body-worn accessory SAR guidance moved from KDB 865664 to KDB 447498
– simultaneous transmission SAR test exclusion procedures moved from other KDB Publications to KDB 447498

Reorganized document and included editorial changes for clarity

Similar issues for UMPC mini-tablet procedures in KDB 941225 D07 were addressed during update in 2013
Rel. 10 LTE SAR testing guidance updated in August

- included procedures to determine if SAR is required for downlink carrier aggregation
- PBA is required only when SAR is required for downlink carrier aggregation according to the required power measurement procedures
- PBA is not required when it is clearly identified in the SAR report that Rel. 10 implementation involves only network enhancement features and Rel. 8 SAR procedures apply

When VoLTE applies, measure head SAR according to existing data mode configurations until further SAR test guidance is available
3G SAR Procedures

- KDB 941225 D01 – D04 are consolidated into a single document
- 3GPP Rel. 5 – 6, HSPA+, DC-HSDPA, 3GPP2 1xRTT, Ev-Do, 1x Advanced and GSM/GPRS are included in KDB 941225 D01
  - introduced 3G SAR test reduction procedures
    - SAR is estimated according to the ratio of specified maximum output power between two similar modes in same frequency band for test reduction
    - also kept original $\frac{1}{4}$ dB test exclusion provision
  - aligned 3G procedures with recent KDB publication releases (KDB 447498, KDB 865664 etc.)
  - removed the basic 3G tutorial info in previous KDB 941225 D01
- Included Ev-Do Rev. B procedures
  - plan to remove PBA in a few months if there are no additional issues
- 4G LTE and higher 3GPP releases to remain in separate documents
  - KDB 941225 D05 and D05A
¼ dB SAR test exclusion considerations are based on measured output power, according to early-on procedures established in 2006.

Latest version of KDB 447498 specifies:
- maximum output power requirements for test samples used in SAR measurements
- *reported* SAR procedure is applied to account for tune-up tolerances

Until draft KDB 248227 is finalized, maximum output power and tolerance specified for production units may be applied to determine SAR test exclusion instead of the ¼ dB test exclusion condition:
- must apply straight comparison, without the ¼ dB

Both methods are acceptable until draft KDB 248227 is finalized:
- it must be clearly explained in the SAR report
SAR Measurement Methodology
Recent handsets have used different antenna tuner implementations

- Qualcomm QFE 1520 chipset
- Qualcomm QFE 1550 chipset with external RF switches at input and/or output
- other less common chipsets or proprietary implementations; some with various RF switch configurations

Control algorithms may include

- open loop with static tuner parameters for each wireless technology and frequency band; however, may sub-divide transmit band into several sub-bands
- advanced open loop control based on certain external sensor input conditions to select antenna tuner conditions
- closed loop control using real-time power or impedance related measurements

Combinations of sub-bands, input/sensor conditions, switched and/or chipset internal components and parameters can introduce thousands of tuner states

Small sub-bands and larger LTE channel BW may have SAR testing issues

Variations in implementation require case-by-case KDB inquiry review
Sensor Array SAR Systems

Two different systems have started delivery around mid-summer

- SAR is “estimated” according to near-field transformation calculations
- FCC has limited info or specific implementation details for the systems
  - has not reviewed any validation results for the implementations
  - unaware of the exact system capabilities and limitations/restrictions
  - measurement region vs. sensor coverage in SAM or flat phantom
  - does not have information to consider procedures to verify system calibration, measurement accuracy, validity of results for routine standalone and simultaneous transmission SAR testing etc

Request to use these systems for SAR screening have been proposed

- for dynamic antenna tuner SAR test reduction considerations
- FCC has provided preliminary ad hoc considerations in specific case-by-case situations for use in conjunction with full and estimated 1-g SAR procedures to facilitate SAR test reduction
- however, no actual test data for array systems has been received or reviewed
Miscellaneous Updates
LTE Carrier Aggregation

Recent implementations have considered only downlink carrier aggregation

Aggregation bandwidth class definitions
  - up to 100 MHz with up to 5 component carriers (CC)
  - initially with 2 CC in 40 MHz
    - Class A: aggregated RB \( \leq 100 \) and 1 CC, 20 MHz max. BW
    - Class B: aggregated RB \( \leq 100 \) and up to 2 CC, 20 MHz max. BW
    - Class C: \( 100 < \text{aggregated RB} \leq 200 \); up to 2 CC, 40 MHz max. BW
    - Class D: \( 200 < \text{aggregated RB} \leq 300 \); up to 3 CC, 60 MHz max. BW
    - Class E and F: 80 & 100 MHz max. BW, CC to be determined

Carrier aggregation configurations
  - intra-band contiguous: \( \text{CA}_1C = \text{Band 1 Class C BW} \)
  - intra-band non-contiguous: \( \text{CA}_1A-1A = \text{Band 1 Class A BW} \)
  - inter-band: \( \text{CA}_1A-5B = \text{Band 1 Class A & Band 5 Class B BW} \)

Potential U.S. configurations (up to Rel. 12)
  - 2 DL CC for Rel. 10; 3 DL + 1 UL CC or 2 non-contiguous UL CC for Rel. 12
  - 2A-4A, 2A-12A, 2A-13A, 2A-17A, 4A-12A, 4A-13A, 4A-17A
  - 2A-2A, 4A-4A, 41A-41A, 41A-41C, 41C-41A; 41C
Overlapping LTE Bands

- Multiple frequency band indicator (MFBI) supports roaming between bands
  - Band 17 (704 – 716 MHz) is contained within Band 12 (699 – 716 MHz)
    - where UE may roam between bands under Part 27.5(c)(1) blocks B & C; however, block A is limited to Band 12 only
    - when both bands apply, band 12 SAR also covers Band 17
    - when hardware supports Band 17 only with no block A support, test SAR for blocks B & C
  - Band 7 (2.5 – 2.57 GHz) UL overlaps with Band 41 (2.495 – 2.690 GHz) TDD and Band 38 TDD (2570 – 2620 MHz) also overlaps with Band 41
    - Band 41 SAR covers Band 38, both TDD; provided test configurations match
    - Band 41 or 38 TDD SAR does not cover Band 7 FDD
  - depending on channel BW configurations, submit KDB inquiry to confirm the channels required for SAR measurement
Other LTE Considerations

- Part 27 and Part 90 include 3 W ERP configurations
- 700 MHz band higher power UE - Band 12, 13, 14 & 17
  - concerns include
    - occupational vs. general population exposure limits requirements can be unclear
    - public vs. private networks issues
- KDB 447498 requires 5 SAR test channels for Band 41
  - test channels 39750, 40185, 40620, 41055, 41490 for all channel bandwidths*

*Channel numbers updated on Dec. 10, 2014 after initial publication
HSPA Carrier Aggregation

- Rel. 5 – HSDPA
- Rel. 6 – HSUPA
- Rel. 7 – HSPA+
- Rel. 8 – DC-HSDPA, intra-band, contiguous CA, 64 QAM
- Rel. 9 – DC-HSUPA, intra-band, contiguous CA, 16 QAM
- Rel. 9 – DB-DC-HSDPA, inter-band, non-contiguous, MIMO, 1 UL
- Rel. 10 – 4C-HSDPA, inter-band, non-contiguous (protocol), contiguous (deployment), 64 QAM, 2x2 MIMO
- Rel. 11 – 8C-HSDPA, inter-band, non-contiguous, 1 UL

Submit KDB inquiry for DC-HSUPA or higher configurations and implementations during product development
  - to allow time to address SAR testing issues
  - do not wait until testing to avoid expected delays
Ev-Do Updates

Ev-Do Rev. B multi-carrier
- see updated KDB 941225 D01, 3G SAR Measurement Procedures
- see 3GPP – C.S0024-B; TIA/EIA/IS-865B Rev. B for details
- allows contiguous and non-contiguous intra-band aggregation
- aggregated maximum output ≤ single carrier; 3.3 dB back-off
- supports 64 QAM; each carrier is individually power controlled
- up to 3 carriers, all within 10 MHz, in existing deployments
- test with RMCTAP = 4096 bits; FMCTAP = 2 slots 307.2 kbps
- use sub-type 3; test 2 with 2 carriers at maximum separation and test 3 with N adjacent carriers

Ev-Do Advanced – mostly network related to enhance load balancing; do not foresee SAR concerns
Proximity Movement Detection

- Capacitive proximity movement sensors for selective movement and motion detection may be available in some products
  - sensor implementation and detection algorithms are host configuration dependent
    - may include multiple sensors on device to provide distributed sensing
    - may apply multiple stage algorithms to fine tune movement detection with respect to nearby objects (human vs. furniture etc.) for selective sensing
    - sensor may timeout during SAR measurement due to lack of motion
  - could be used in conjunction with G-sensors or other hybrid configurations

- Existing KDB 616217 proximity sensor procedures are insufficient for this type of proximity and movement detection implementations
  - submit KDB inquiry with implementation details to determine SAR test requirements for distributed sensing and/or selective proximity/motion detection
Modules in Small Hosts

Transmitters and antennas in small host devices such as handsets, mini-tablets etc. can have RF energy coupling concerns due to close proximity in a host and to users; therefore, cannot be approved for use as modules in such product platforms through modular approval.

- see section 5.1 of KDB Publication 447498

Complex influences among transmitters and antennas etc. must be taking into consideration by testing the entire host device for SAR compliance.

When SAR test exclusion applies to a low power or low exposure module inside a host, the influence is taken into consideration through normal SAR testing of the other transmitters in the host.

- the module is considered as a component, not an approved module

Similar concerns also apply to certain approved modules with high SAR where influences among transmitters in a host can be unclear.

- SAR testing of the host may be necessary to ensure compliance