SAR Evaluation Considerations for Handsets with Multiple Transmitters & Antennas

FCC / OET
Laboratory Division
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TCB Workshop
Issues

current TCB requirements:
  – non-dominant transmitters in handsets that transmit simultaneously cannot be approved by TCB when output is > 5 mW
  – these have to be submitted to the FCC for approval

SAR procedures for simultaneous transmission have not been standardized among SAR systems
  – the high level recommendations in draft standards are insufficient and testing is very time consuming at multiple frequencies
  – procedures on how to determine 1-g SAR for simultaneous transmission are unclear
  – simultaneous SAR tests are often problematic and done incorrectly

measurement issues in tight regions of the SAM phantom
Procedures Overview

the procedures in KDB 648474 will allow:

– manufacturers to minimize or avoid complex tests when satisfying certain SAR and antenna separation requirements while products are developed

TCB can approve these when simultaneous SAR tests are not required

– consumer cellphones with multiple transmitters & antennas
  • Part 22H, 24E, 27L (AWS) & 90 SMR
    – with 802.11 a/b/g and Bluetooth

stand-alone SAR tests

– routine evaluation applies to licensed transmitters
– test reduction applies to unlicensed devices

simultaneous transmission test exclusion applies when

– the sum of stand-alone 1-g SAR is within SAR limit
– SAR to antenna separation ratio of antenna pair is low

when simultaneous transmission test is required

– test only highest SAR configuration in stand-alone evaluation
Stand-alone Test Requirements

**licensed transmitters:** IEEE-1528, Supplement C, 3G procedures
- routine SAR required

**unlicensed transmitters:** Supp. C, 802.11 & 3-6 GHz procedures
- output \( \leq 60/f_{(GHz)}\) mW – SAR evaluation is generally not required
  (see flowchart)
- output \( > 60/f_{(GHz)}\) mW – test according to multiples of \( P_{\text{Ref}}\)
  - SAR not required for certain antenna separation & power
  - test highest output channel only if SAR is \( \leq 0.8 \) W/kg
  - test all required channels if SAR is \( > 0.8 \) W/kg (50% of limit)

<table>
<thead>
<tr>
<th>( P_{\text{Ref}} )</th>
<th>2.45</th>
<th>5.15 – 5.35</th>
<th>5.47 – 5.85</th>
<th>GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>mW</td>
<td>12</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Values for \( P_{\text{Ref}} \) are derived from \( \frac{1}{2} \cdot 60/f_{(GHz)} \)
Device output power should be rounded to the nearest mW to compare with values specified in this table.
Simultaneous Transmission SAR - General

**simultaneous transmission**: overlapping transmissions
- except when maximum network handoff time is < 30s

**unlicensed transmitters**: SAR is not required when
- antenna is ≥ 5 cm from other antennas and stand-alone SAR is not required (i.e. \( \leq 2 \cdot P_{\text{Ref}} \), see flow charts)

**all transmitters in a cellphone:**
- SAR is not required when
  - sum of 1-g SAR is < 1.6 W/kg (SAR limit) or
  - SAR to antenna separation ratio for antenna pair is < 0.3
- SAR is required when
  - SAR to antenna separation ratio for antenna pair is ≥ 0.3
    - test only highest SAR configuration in stand-alone mode

**simultaneous transmission SAR requirements for head and body can be different; especially for clam-shell phones**
Licensed Transmitters

- Licensed
  - Routine SAR Evaluation Required
    - IEEE 1528 Supplement C
      - 3G FCC SAR Procedures (for stand-alone)
        - Simultaneous Transmission
          - Yes
            - Simultaneous Transmission Procedures
          - No
            - No Simultaneous Transmission SAR
Unlicensed Transmitters

- **Unlicensed**
- **Simultaneous Transmission**
  - yes
  - ≥ 2.5 cm < 5.0 cm
    - ≤ $P_{Ref}$
      - No Stand-alone SAR
      - Simultaneous Transmission Procedures
    - > $P_{Ref}$
  - < 2.5 cm
    - Other antennas < 2.5 cm are ≤ $P_{Ref}$ or < 1.2 W/kg
      - yes
        - No Simultaneous Transmission SAR
      - no
        - No Stand-alone SAR
  - ≥ 5 cm
    - yes
      - No Stand-alone SAR
    - no
      - No Simultaneous Transmission SAR

- no
  - Output ≤ 60/f

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1. Antenna separation is determined by the closest distance between antennas
2. When simultaneous transmission applies, reduced antenna separations may require SAR at ≤ 60/f

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Unlicensed Stand-alone Procedures

- Stand-alone SAR Procedures
  - 802.11 a//b/g FCC SAR Procedures
  - Test SAR on Highest Output Channel
    - ≥ 0.8 W/kg
      - yes
      - no
        - Test All Channels
          - yes
          - no
            - Simultaneous Transmission Procedures
              - yes
              - no
                - Simultaneous Transmission
                  - no
                    - No Simultaneous Transmission SAR
  - 3 – 6 GHz FCC SAR Procedures
Simultaneous Procedures

Simultaneous Transmission Procedures

\[ \sum 1-g \text{ SAR} < 1.6 \text{ W/kg} \]

- yes

No Simultaneous Transmission SAR

Antenna Pair SAR to Antenna Separation Ratio

- no

\[ < 0.3 \]

- ≥ 0.3

Measure Simultaneous Transmission SAR with Volume Scans for All Required Antennas

Include Antenna Pair for Simultaneous Transmission Testing

Note: Simultaneous transmission exposure conditions for head and body can be different for certain style phones; therefore, different test requirements may apply. For example, clam-shell phones in open and folded operating configurations.
Examples: rectangular phones

- upper center (patch antenna) - 250 mW PCS
  - routine stand-alone SAR
  - simultaneous SAR if $\sum 1-g \geq 1.6$ W/kg and SAR to antenna ratio $\geq 0.3$

- bottom edge – 50 mW 802.11 b/g, simultaneous with PCS only
  - $\geq 5$ cm (PCS only) and $> 2 \cdot P_{\text{Ref}}$ - test stand-alone SAR
    - on highest output channel and test all channels if SAR $\geq 0.8$ W/kg
  - simultaneous SAR if $\sum 1-g \geq 1.6$ W/kg or SAR to antenna ratio $\geq 0.3$

- lower left edge – 5 mW Bluetooth, simultaneous with PCS only
  - $\geq 5$ cm (PCS only) and $\leq 2 \cdot P_{\text{Ref}}$
    - no stand-alone SAR and no simultaneous SAR

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Examples: clam-shell phones

right hinge (stub antenna) – 300 mW PCS
  – routine stand-alone SAR
  – simultaneous SAR if $\sum 1-g \geq 1.6$ W/kg and SAR to antenna ratio $\geq 0.3$

bottom edge – 20 mW 802.11 a/b/g
  – $\geq 5$ cm (PCS & Bluetooth)
    • 802.11 b/g $\leq 2 \cdot P_{Ref}$ – no stand-alone SAR and no simultaneous SAR
    • 802.11a $> 2 \cdot P_{Ref}$ – test stand-alone SAR
      – on highest output channel and test all channels if SAR $\geq 0.8$ W/kg
      – simultaneous SAR if $\sum 1-g \geq 1.6$ W/kg or SAR to antenna ratio $\geq 0.3$

top edge – 25 mW Bluetooth
  – $\geq 5$ cm (PCS & 802.11 a/b/g) and $> 2 \cdot P_{Ref}$ – test stand-alone SAR
    • on highest output channel and test all channels if SAR $\geq 0.8$ W/kg
    – simultaneous SAR if $\sum 1-g \geq 1.6$ W/kg or SAR to antenna ratio $\geq 0.3$

when body-worn exposure conditions apply
  – simultaneous transmission exposure conditions for head and body are different for 802.11 and Bluetooth
Simultaneous Measurements

- simultaneous transmission at different frequencies
  - require different tissue liquids and probe calibrations
  - separate measurements are necessary
- require measured raw data to be summed
  - on identically registered measurement grids
  - with all simultaneous transmitting antennas enclosed in identical measurement volumes for each measurement
  - to enable the extrapolation and interpolation procedures to determine the aggregate 1-g SAR in post-processing
- volume scans are quite time-consuming
  - difficulties and constrains should be expected
SAR in Mouth Region of SAM

- measurement difficulties in tight regions of SAM
  - mouth, jaw, nose and similar partially enclosed regions
  - measurement accuracy & probe accessibility issues
  - SAM configuration issues – horizontal vs. up-right

- measure SAR with flat phantom
  - when measurement is not feasible with SAM or results can be questionable due to probe calibration and orientation issues
  - position phone with lower edge at a fixed distance determined by smallest separation in cheek touching position using SAM
    - rectangular phones with ERP at ½ cm from flat phantom
    - clam-shell phones with hinge against smooth edge of flat phantom and upper half unfolded beyond side wall

- contact FCC for interim guidance on
  - other clam-shell phone positioning issues (variable gap with SAM)
  - simultaneous transmission SAR measurement requirements