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Draft Laboratory Division Publications Report

Title: SAR Evaluation Considerations for Handsets with Multiple Transmitters and Antennas

Short Title: SAR Handsets Multi Xmiter and Ant

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Keyword/Subject: 2.1093, SAR Evaluation for Handsets that Contain Multiple Transmitters and Antennas, Wireless Charging Battery Covers

First Category: Radio Frequency (RF) Exposure

Second Category: Measurement Procedures

Third Category:

Question: What are the test procedures for SAR evaluation for handsets that contain multiple transmitters and antennas or wireless charging battery covers?

Answer:
The attached documents:
648474 D03 Handset Wireless Battery Chargers v01r02 provides test and approval considerations for certain handsets with wireless charging capabilities

648474 D04 SAR Handsets Multi Xmiter and Ant v01r01 describes the SAR evaluation requirements for consumer cellphones operating with multiple transmitters and simultaneous transmitting antennas. See transition note period below.

Attachment List:
648474 D03 Handset Wireless Battery Chargers v01r02[1]
648474 D04 SAR Handsets Multi Xmiter and Ant v01r01[2]

[1] 648474 D03 Handset Wireless Battery Chargers v01r02 is also available for review (until May 15th 2013), posted as a separate draft publications: 648474 D03 Handset Wireless Battery Chargers v01r02 DR03-41372. Comments to D03 must be filed under that separate draft posting and not under this draft posting.
[2] This draft is for attachment 648474 D04 SAR Handsets Multi Xmiter and Ant v01r01 which will be published by May 20, 2013. Prior to publication, applicants can use this draft guidance during the interim period for compliance testing

April 5, 2013

Attachment: D04 SAR Handsets Multi Xmiter and Ant v01r01

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SAR Evaluation Considerations for Wireless Handsets

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1. Introduction

This document describes the SAR evaluation requirements for consumer wireless handsets such as cellphones, including smart phones and cordless phones that operate next to the ear. Recent generation cellphones generally have multiple transmitters that operate simultaneously. These SAR procedures are applicable to both licensed and unlicensed transmitters that are built-in within handsets to support technologies such as WWAN, WLAN, DECT and Bluetooth. In general, the SAR test reduction and exclusion provisions discussed in KDB 447498 should be applied to streamline both standalone and simultaneous transmission SAR measurements and similarly, the *published RF exposure KDB procedures* must be applied to test the different wireless technologies, such as 3GPP, 3GPP2, WiMax, 802.11 and Bluetooth.[1] When simultaneous transmission SAR measurement is required, the detailed test procedures in KDB 865664 must be used. The SAR test considerations for recent generation smart phones ~~which~~ supporting simultaneous transmission configurations, power reduction implementations, VoIP transmission, NFC, wireless charging and other operating modes are discussed in this guidance.

2. SAR Evaluation Considerations

2.1. General

Handsets are tested for SAR compliance in head, body-worn accessory and other use configurations according to the procedures described in the following subsections. Some of the other use configurations for smart phones may include wireless routing/hotspot mode and UMPC mini-tablet related use conditions. For phones with other near body use configurations that cannot be restricted from use through acceptable user disclosure, the general test procedures described in sections 4.2.2 and 4.2.3 of KDB 447498 should be considered.

2.2. Head exposure conditions

Head exposure is limited to next to the ear voice mode operations. The SAR measurement procedures in KDB 865664 (D01) must be applied for test results to be acceptable for TCB approval. Head SAR compliance should be tested according to the test positions defined in IEEE Std 1528-2003 using the SAM phantom.[2] For handsets that do not operate with a traditional earpiece where the ear reference point (ERP) can become undefined, a KDB inquiry describing the audio transmission technology and use conditions is required to determine acceptable SAR test configurations.

2.3. Body-worn accessory exposure conditions

Body-worn accessory exposure is typically related to voice mode operations when handsets are carried in body-worn accessories.[3] The body-worn accessory procedures in KDB 447498 should be used to test for body-worn accessory SAR compliance, without a headset connected to it. This enables the ~~test~~ SAR results for ~~such~~ wireless test configurations that are the same for both voice and data to ~~be compatible with that required for~~ support hotspot mode when the body-worn accessory *test separation distance* is greater than or equal to that required for hotspot mode. When the *reported* SAR for a body-worn accessory, measured without a headset connected to the handset, is > 1.2 W/kg, the highest *reported* SAR configuration for that wireless mode and frequency band should be repeated for that body-worn accessory with a headset attached to the handset.[4]

2.4. Hotspot mode exposure conditions

For cellphones that support ~~hotspot mode operations, with~~ wireless routinger capabilities ~~and various web browsing functions~~, the relevant hand and body exposure conditions are tested according to the hotspot mode SAR

[1] See KDB 447498 for *published RF exposure KDB procedures*.

[2] Consideration for rule-making is in the process to address certain RF exposure testing concerns relating to cellphones. Further updates to test and compliance requirements will be determined by the final rules.

[3] See footnote 2.

[4] *Reported* SAR is the measured SAR adjusted for maximum tune-up tolerance; see KDB 447498 for details.

procedures in KDB 941225. A *test separation distance* of 10 mm is required between the phantom and all surfaces and edges with a transmitting antenna located within 25 mm from that surface or edge. When the form factor of a handset is smaller than 9 cm x 5 cm, a test separation distance of 5 mm (instead of 10 mm) is required for testing hotspot mode. When the separation distance required for body-worn accessory testing is larger than or equal to that tested for hotspot mode, using the same wireless mode test configuration for voice and data, such as WCDMA, LTE and Wi-Fi, and for the same surface of the phone, the hotspot mode SAR data may be used to support body-worn accessory SAR compliance for that particular configuration (surface).

2.5. Phablet SAR test considerations

The UMPC mini-tablets SAR procedures are primarily intended for devices with an overall diagonal dimensions ≤ 20 cm that operate like a tablet and mainly support hand-held interactive use next to or near the body of users, with no provision for next to the ear voice mode operations. Early generation mini-tablets are typically designed and optimized for mobile web access and multimedia support; whereas earlier smart phones are primarily intended for voice communication with varying data capabilities. As the use conditions for recent generation UMPC mini-tablets and smart phones are gradually merging; some UMPC mini-tablets are also supporting next to the ear voice mode operations and smart phones are incorporating certain mini-tablet operating characteristics. This new generation of devices has been referred to by industry as "phablets".

For smart phones with a display diagonal dimension > 15.0 cm or an overall diagonal dimension > 16.0 cm that provide similar mobile web access and multimedia support found in mini-tablets or UMPC mini-tablets that support voice calls next to the ear, unless it is confirmed otherwise through KDB inquiries, the following phablets procedures should be applied to evaluate SAR compliance. A device marketed as phablets, regardless of form factors and operating characteristics must be tested as a phablet to determine SAR compliance.

1. The normally required head and body-worn accessory SAR test procedures required for handsets must be applied.
2. The UMPC mini-tablet procedures must also be applied to test the SAR of all surfaces and edges with an antenna closer than 25 mm from that surface or edge, in direct contact with the phantom, for 10-g SAR. The UMPC mini-tablet 1-g SAR at 5 mm is not required. The normal tablet procedures in KDB 616217 are required when the over diagonal dimension of the device is > 20.0 cm.
3. The simultaneous transmission operating configurations applicable to voice and data transmissions for both phone and mini-tablet modes must be taken into consideration to determine the simultaneous transmission SAR test exclusion and measurement requirements for all exposure conditions.

3. Standalone and Simultaneous Transmission SAR Test Requirements

Each transmitter should be evaluated independently for standalone use according to the applicable rules and policies to determine RF exposure compliance regardless of the simultaneous transmission modes of a handset. The SAR test reduction and exclusion provisions in KDB 447498 are applied to the transmitters in a phone to determine standalone and simultaneous transmission test requirements, according to the maximum output power, antenna-to-antenna and antenna-to-user separation distances. When the separation distance is ≤ 5 mm, a *test separation distance* of 5 mm is used to determine SAR test exclusion. When simultaneous transmission SAR measurements are necessary, the enlarged zoom scan measurement and volume scan post-processing procedures in KDB 865664 are required. The RF exposure reporting procedures in KDB 865664 (D02) should be applied to document compliance.

The simultaneous voice and data transmission configurations in all applicable combinations of wireless operating modes, frequency bands and exposure conditions must be fully described in the SAR report to identify the required test configurations. Simultaneous transmission SAR test requirements for head and body-worn accessory exposure conditions are considered separately. Antenna diversity configurations, applicable handset sliding cover positions, specific test positions (touch or tilt, etc.), modulations, channel bandwidths and resource allocations, such as data rate, zone type, symbol ratio/duty factor and data block size, etc., when appropriate, may be

considered collectively according to worst case results to determine simultaneous transmission test exclusion according to discussions in KDB 447498. For example, the highest SAR measured with the sliding cover of a handset in the extended and retracted positions for the touch and tilt positions on the left and right side of the head for each transmitter/antenna may be considered collectively to determine simultaneous transmission SAR test exclusion, according to the sum of 1-g SAR.[5] However, these must not be mixed with body-worn accessory SAR test configurations to determine SAR test exclusion. When applying the highest SAR in this manner does not allow SAR test exclusion, the individual device operating configuration and exposure condition should be considered separately to determine SAR test exclusion~~,~~ according to the sum of 1-g SAR or SAR to peak location separation ratio~~,~~ to minimize the number of required simultaneous transmission SAR measurements.[6]

4. Simultaneous Voice and Data Transmission Test Considerations

Recent generation phones transmit both voice and data. Most smart phones with 3G and 4G capabilities can transmit voice and data simultaneously. Depending on the combinations of wireless technologies available in a phone, different transmitters may be used to transmit voice and data through one or more antennas for standalone and simultaneous transmission operations. Some technologies (for example, 1xRTT and EvDo) may require voice and high speed data to be transmitted separately. Other technologies (for example WCDMA and HSPA) may allow voice and data to be transmitted within the same physical (RF) channel. Smart phones with 3G and 4G/LTE may support voice and data transmission on separate transmitters concurrently. The 3G transmitter(s) is used for 1xRTT, EvDo, WCDMA/HSPA, GSM/GPRS/EDGE, each capable of transmitting in only one of these modes at a time; and an independent 4G LTE transmitter is used for the 4G transmissions. Among the possible combinations of transmitter and antenna paths, certain implementations may allow EvDo to operate from the LTE transmitter to support simultaneous 1xRTT and EVDO transmission. These two modes of implementation are typically referred to in industry as SVLTE and SVDO. EvDo Rev. B supports carrier aggregation where recent implementations have allowed up to 3 carriers to transmit simultaneously within the same frequency band, which requires each carrier to be controlled separately in a coordinated manner by a basestation simulator to perform the SAR tests. When EvDo Rev. B transmits simultaneously with voice, combinations of simultaneous voice and multiple carrier data transmissions must be considered for SAR testing. The term SVD is also used to identify various forms of simultaneous voice and data transmission implementations. The SAR test requirements must be determined according to the transmission paths used by the different combinations of transmitters and antennas in a phone. Sufficient details of the transmitter and antenna implementations are required to support the SAR test setup~~:~~, ~~this~~ which is typically illustrated in diagrams along with supporting descriptions. When it is unclear, a KDB inquiry should be submitted to determine the SAR test requirements.

5. Transmitter and Antenna Operating Configurations

In a typical cellphone, the 3G transmitter may operate with one or two antennas to cover the frequency bands for both domestic and international use. The 4G transmitter would generally have one transmit antenna and possibly additional antennas for receive diversity. As phones continue to support more LTE bands; for example, in the 700 MHz, 1700 MHz and 2600 MHz bands, different antenna configurations may be required. In addition to the 3G/4G transmitters and antennas, most phones also support WLAN and Bluetooth operations with additional antenna(s). Some phones may limit the WLAN or 802.11 operations to the 2.4 GHz band only, while others may support both 2.4 GHz and multiple 5 GHz bands. Depending on the implementation, most phones use a single antenna to cover all WLAN operations. Phones may also use a single transmitter module that incorporates both WLAN and Bluetooth, with varying antenna and simultaneous transmission requirements. When hotspot mode applies, a phone may restrict its wireless routing operations to certain 3G/4G transmitter and transmission mode combinations and the WLAN modes could be limited to 2.4 GHz or include only some 5 GHz bands. Among the possible transmitter, antenna and operating mode combinations, some phones may apply additional restrictions in

[5] Only sliding or flip cover positions that are relevant for the exposure condition should be considered. For example, covers that slide sideways to support texting are generally not relevant for next to the ear or body-worn accessory use.

[6] See KDB 447498 for further discussion on SAR test exclusion considerations.

the firmware to restrict certain combinations of simultaneous transmission configurations to satisfy internal interference, SAR or other infrastructure requirements. For phones with Wi-Fi Direct capabilities, when the optional "cross-connection" feature is available and enabled, the device may provide infrastructure access (AP) to other devices under its control as the group leader. This type of unattended operation is transparent to users, which may require additional simultaneous transmission SAR test or exclusion considerations for exposure conditions that would not require Wi-Fi transmissions if the unattended Wi-Fi Direct features were unavailable. It is essential that all these are clearly identified before performing SAR testing, with respect to the head and body exposure conditions required to support the operating modes of a phone. These must also be explained clearly in the SAR report for the test setup and results to be acceptable for supporting compliance. Without clear explanations, the test results alone are insufficient and unacceptable for demonstrating compliance.

6. Simultaneous Transmission Power Reduction Considerations ~~for Simultaneous Transmission~~

When multiple transmitters operate simultaneously at relatively high maximum output power and at close proximity to users, ~~and~~ as the device form factor becomes smaller ~~bringing~~ the antenna and radiating structures are brought closer to each other, the potential for internal interference and higher SAR increases. Smart phone manufacturers have applied different power reduction implementations to maintain compliance. The maximum output power of the transmitter operating in data mode is often reduced or pulse modulated with a periodic duty factor during simultaneous transmission to maintain voice call quality and SAR compliance. There are also situations where the output power for the data mode is reduced to mitigate interference concerns for the other transmitters and receivers within the phone. In some cases, a fixed level of reduction for the maximum output power is applied to specific frequency bands, wireless modes and simultaneous transmission configurations. For other situations that require more flexibility; the power reduction mechanisms can become quite complex and dynamic. The amount of power reduction and combinations of circumstances that require power reduction are often controlled by specific transmit or receive parameters, selected groups of channels within a frequency band or the types of components or accessories that are actively in use during the transmission, etc. These types of power reduction implementations for simultaneous transmission operations have continued to evolve in the last two years with no established industry standards. Each implementation generally requires case-by-case consideration, in conjunction with the large combinations of transmitter, antenna, operating mode and simultaneous transmission variations, to determine the test configurations needed to support compliance~~, in conjunction with the large combinations of transmitter, antenna, operating mode and simultaneous transmission variations~~. Unless the power reduction is for a fixed level triggered by a specific frequency band or dedicated operation when a simultaneous transmission configuration is enabled for operation, such as hotspot mode or certain SVLTE/SVDO operations, the acceptable test requirements for other power reduction implementations and subsequent variations should generally be determined through KDB inquiries before testing.

7. Optional Batteries, NFC, Wireless Charging and Similar Accessories

Some cellphones may include other functions and capabilities that can influence the SAR characteristics of other transmitters in the handset; for example, optional batteries, NFC and wireless charging operations. The hardware required for this type of additional capabilities can be built-in as an integral part of the phone or available as optional accessories from the original phone manufacturer. When the after-market accessories are provided by third-party suppliers, the test and equipment approval considerations in KDB 447498 must be applied as appropriate.

Phones with built-in NFC, wireless charging or similar functions that do not require separate SAR testing for these specific capabilities can generally be tested according to the SAR measurement procedures normally required for the phone. Influences of the hardware introduced by these built-in accessories and functions are inherently considered through testing of the other transmitters that require SAR evaluation. When these capabilities are provided as aftermarket accessories by the grantee; for example, by providing optional batteries or incorporating the hardware on a battery cover or carrying case (sleeve), influences of the additional hardware and functionality to the SAR characteristics of the phone must be determined separately. The SAR tests normally required for the

phone must be repeated with the accessory to ensure the phone remains compliant. A Class II permissive change may need to be applied.[7]

A handset must be tested according to all required SAR test procedures, without the after-market accessory (additional batteries, battery cover and sleeve, etc.), to demonstrate compliance. For handsets with additional batteries, NFC and wireless charging battery covers or similar accessory (sleeve carrier, etc.), the highest SAR *reported* for each wireless technology (1xRTT, EVDO, WCDMA, GSM, Wi-Fi, etc.), frequency band, operating mode (different modes/configurations within each wireless technology) and applicable exposure condition (head, body-worn accessory, hotspot mode, etc.) without the accessory must be repeated with the specific accessory attached. In addition, for test cases where the measured SAR for a handset without the accessory is greater than 1.2 W/kg, these tests should be repeated with the additional batteries, NFC and wireless charging battery covers or similar accessory. When there are noticeable changes in the SAR distributions for tests with and without the accessory; for example, shifting of the peak SAR location, a KDB inquiry should be submitted to determine if additional SAR tests may be required.

For third-party accessories, such as sleeves, it is necessary to verify the maximum output power and SAR distribution of the handset test sample without the accessory attached, for each wireless mode and exposure condition in each frequency band, to ensure the test sample is acceptable before testing with the accessory. For phones that require proprietary test mode, software or other setup requirements to perform the necessary tests, at the discretion of the phone manufacturer, specific licensing and support agreement is typically necessary for third-party accessory manufacturers to have access to such options to perform the tests. For Wi-Fi SAR measurements, publically available apps (application software) that support sustained file transfer with a transmission duty factor ≥ 80% and remain stable for the duration of the measurement should be used. All SAR results tested without the accessory attached, when adjusted to 100% duty factor at maximum tune-up tolerance, must be within 15% of those reported in the original equipment certification of the phone before testing with the accessory. The test setup and all relevant information must be clearly explained in the SAR report for the results to be acceptable.

~~If the~~ When test reduction guidance is used to evaluate additional batteries and accessories, the standalone SAR results may not be sufficient for determining simultaneous transmission SAR test exclusion for all configurations. ~~t~~The highest *reported* SAR for the same test configuration among those measured with and without the accessory should be used to determine simultaneous transmission SAR test exclusion. When power reduction applies, the test configurations required for additional accessories can become quite complex and must be clearly explained in the SAR report.

8. VoIP Support

Existing wireless infrastructures are continuing to migrate from 3G to 4G. Wireless carriers are expected to support VoIP and requiring it as a standard built-in feature for most smart phones. When a phone supports VoIP through carrier networks, SAR evaluation for head and body-worn accessory exposure conditions is required. The required SAR test procedures and wireless operating configurations required by the *published RF exposure KDB procedures* for the specific wireless technology to support VoIP operations should be applied for SAR testing. When it is unclear, a KDB inquiry should be submitted to determine the test configurations.

In addition to built-in VoIP support through wireless carriers, users of smart phones can typically download apps (application software) to enable other VoIP functionalities. When third-party apps are provided or endorsed by the handset manufacturer or wireless carriers to support VoIP operations, the exposure conditions for these features should also be considered for SAR testing. The operating characteristics of other third-party VoIP apps ~~(application software)~~ are not standardized. When the additional features are not supplied as an integral part of the phone or supported by the original equipment manufacturer or the wireless carrier; it is generally difficult to test this type user acquired ad hoc features consistently. For some phones, the manufacturer may be able to block

[7] See KDB 648474 (D02) for additional information on evaluation and approval considerations for handsets with wireless charging battery covers.

certain incompatible apps or choose to test the wireless modes that have the potential to support VoIP apps for head, next to the ear, and body-worn accessory exposure conditions using the most appropriate wireless data mode configurations. When there is no SAR result to demonstrate compliance for user acquired third-party ad hoc VoIP apps, user disclosure through clear and conspicuous instructions are required. Users must be advised that while these features cannot be blocked or disabled without impacting the normal functions of the phone, such operations have not been tested for RF exposure compliance and are not recommended; therefore must be avoided.

9. SAM Phantom Limitations

Recent generation phones operating with multiple transmitters and antennas have begun to incorporate antennas near the sides and along edges of the phone. Occasionally, a phone with antennas located near the bottom or lower side edges may have peak SAR locations near the mouth and jaw regions or along the steep curved surfaces of the SAM phantom where SAR probe access is not feasible with a horizontally configured SAM phantom. While it has been known for some time that there are also other SAR measurement difficulties in ~~these~~ the tight regions of the SAM phantom and~~,~~ there has been no easy solution. SAR probes are calibrated in tissue-equivalent medium with sufficient separation between the probe sensors and nearby physical boundaries to ensure field scattering does not affect the probe calibration. When the probe tip is positioned ~~near~~ in tight areas, such as in the mouth and jaw regions of the SAM phantom, with multiple boundaries surrounding the probe sensors, the probe calibration and measurement accuracy can become questionable. In addition, ~~if the~~ measurements near these locations with steep curvatures may require~~s~~ a probe to be tilted at steep angles that~~,~~ ~~it~~ may no longer comply with the required calibration requirements and measurement protocols for maintaining measurement accuracy and uncertainty. For some situations, it is just not feasible to tilt the probe ~~or rotate the phantom~~ without ~~acquiring~~ using a ~~additional~~ rotated SAM phantom~~s~~ that are specifically constructed to enable ~~rotation~~probe access below the cheek and near the jaw area.[8] ~~Under these circumstances~~When a rotated SAM phantom is not used, the measured SAR distribution is often clipped and showing only part of the SAR distribution under consideration.

To ensure there is sufficient conservativeness for demonstrating compliance and until practical solutions are available, other than acquiring multiple phantoms, additional measurements are necessary to address these difficulties. When measurements are required in ~~tight~~ regions with probe access difficulties or along steep curved surfaces of the SAM phantom, the measured SAR distribution is often truncated. ~~While m~~Measurements with truncated SAR distributions may be repeated using a properly rotated SAM phantom; however, the rotated SAM configuration is generally unacceptable when measurements are required inside the mouth or jaw ~~regions~~where there are probe calibration concerns. Under these circumstances, when rotated SAM phantoms are unavailable or there could be SAR probe calibration concerns, the SAR measurement should be repeated using a flat phantom. The phone should be positioned with a separation distance of 4 mm between the ear reference point (ERP) and the outer surface of the flat phantom shell. While maintaining this distance at the ERP location of the phone, the low (bottom) edge of the phone is lowered from the phantom to establish the same separation distance ~~between~~ at the peak SAR location identified by the truncated partial SAR distribution measured with the SAM phantom. The distance from the peak SAR location to the phone should be determined by the straight line passing perpendicularly through the phantom surface. The coordinates of the peak SAR location can be determined with respect to the ERP location by adapting the SAR peak location separation ratio procedures used for simultaneous transmission SAR test exclusion and other graphical tools available in the SAR measurement system. If it is not feasible to maintain 4 mm separation at the ERP while establishing the required separation at the peak SAR location, the top edge of the phone should be allowed to touch the phantom with a separation < 4 mm at the ERP. If the peak SAR location is not identifiable in the truncated SAR distribution, a KDB inquiry with all relevant information and results should be submitted to determine test requirements. The phone must not be tilted to the left or right while placed in this inclined position to the flat phantom. The same considerations may be extended to the enlarged zoom scan measurements required by the volume scan post-processing procedures provided that the peak SAR locations of individual antennas are identified using area scans and the position corresponding to the

[8] The tissue-equivalent liquid depth requirement for rotated SAM phantom is described in section 2.5 of KDB 865664 D01.

peak location with the smallest distance between the phone and the phantom is applied to all enlarged zoom scan measurements using the flat phantom.

Change Notice:

04/05/2013 As indicated by track changes in the document.