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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

Reason: Revision to replace

- 648474 D01 SAR Handsets Multi Xmiter and Ant v01r05
- 648474 D02 SAR Polcy Handsts Multi Xmiter Ant v01r01

Publication: 648474

Keyword/Subject: 2.1093, SAR Evaluation for Handsets that Contain Multiple Transmitters and Antennas, and 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: See the attached documents:

- 648474 D04 SAR Handsets Multi Xmiter and Ant v01 describes the SAR evaluation requirements for consumer cellphones operating with multiple transmitters and simultaneous transmitting antennas.
- 648474 D03 Handset Wireless Battery Chargers v01r01 provides test and approval considerations for certain handsets with wireless charging capabilities (not modified)

648474 D04 SAR Handsets Multi Xmiter and Ant v01 will replace the following current attachments:

- 648474 D01 SAR Handsets Multi Xmiter and Ant v01r05
- 648474 D02 SAR Policy Handsets Multi Xmiter Ant v01r01

Notes:

(1) This draft (648474 SAR Handsets Multi Xmiter and Ant DR02-41164, posted on 09/12/2012 that expires on 10/16/2012) is a revision of an earlier draft (648474 SAR Handsets Multi Xmiter and Ant

DR01), posted 04/23/2012 which expired on 06/30/2012). Draft documents are only posted for comment and are not in effect.

(2) This draft is expected to take effect by October 2012 when it will be included in the Knowledge Data Base (KDB 648474) as an updated attachment [1] 648474 D04 SAR Handsets Multi Xmiter and Ant v01 along with other current attachments: [2] 648474 D01 SAR Handsets Multi Xmiter and Ant v01r05, [3] 648474 D02 SAR Policy Handsets Multi Xmiter Ant v01r01 and [4] 648474 D03 Handset Wireless Battery Chargers v01r01 for a transition period until January 1, 2013. During the transition period either the updated attachment [1] or the two current attachments, [2] and [3] must be used in their entirety to demonstrate compliance. After January 1, 2013 only the new attachment [1] and current attachment [4] can be used.

Attachment List:

648474 D04 SAR Handsets Multi Xmiter and Ant v01

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Attachment 648474 D04 SAR Handsets Multi Xmiter and Ant v01

SAR Evaluation Considerations for Wireless Handsets

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. SAR test considerations for recent generation smart phones which support simultaneous transmission configurations, power reduction implementations, VoIP transmission, NFC, wireless charging and other 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. For phones with other near body use configurations that cannot be restricted from use through acceptable user disclosure, the test procedures in 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.

2.3. Body-worn accessory exposure conditions

Body-worn accessory exposure is typically related to voice mode operations when handsets are carried in body-worn accessories. 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 results for such configuration to be compatible with that required for 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.[2]

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

[2] *Reported* SAR is the measured SAR adjusted for maximum tune-up tolerance.

2.4. Hotspot mode exposure conditions

For cellphones that support hotspot mode operations, with wireless router capabilities and various web browsing functions, the relevant hand and body exposure conditions are tested according to the hotspot SAR 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 the 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, in the same wireless mode 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).

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 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. For example, the highest SAR measured with the 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.[3] 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.[4]

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

[3] Only slide 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.

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

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 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. 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 is typically illustrated in diagrams along with supporting descriptions. When it is unclear, a KDB inquiry should be submitted to determine 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 the firmware to restrict certain combinations of simultaneous transmission configurations to satisfy internal interference, SAR or other infrastructure requirements. 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. Power Reduction Considerations for Simultaneous Transmission

When multiple transmitters operate simultaneously at relatively high maximum output power at close proximity to users and as the device form factor becomes smaller bringing the antenna and radiating structures closer, 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 during simultaneous transmission to maintain voice call quality and SAR compliance. There are also situations where the output power for 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 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 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.[5]

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.

If the 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, the highest

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

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 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.

In addition to built-in VoIP support through wireless carriers, users of smart phones can typically download apps 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 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 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. While it has been known for some time that there are SAR measurement difficulties in these regions of the SAM phantom, 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 tight areas, such as 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 measurement location requires a probe to be tilted at steep angles, 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 additional SAM phantoms that are specifically constructed to enable rotation. Under these circumstances, 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 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 or along steep curved surfaces of the SAM

phantom, the measured SAR distribution is often truncated. Under such circumstances, 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, the low (bottom) edge of the phone is lowered from the phantom to establish the same separation distance between 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 peak location with the smallest distance between the phone and the phantom is applied to all enlarged zoom scan measurements using the flat phantom.