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

Short Title: SAR Handsets Multi Xmiter and Ant

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

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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

648474 D04 SAR Handsets Multi Xmiter and Ant v01 replaces previous attachements:

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

Attachment List:

648474 D04 SAR Handsets Multi Xmiter and Ant v01

Attachment 648474 D04 SAR Handsets Multi Xmiter and Ant v01

SAR Evaluation Considerations for Handsets with Multiple Transmitters and Antennas

I. Introduction

This document describes the SAR evaluation requirements for consumer cellphones operating with multiple transmitters and simultaneous transmitting antennas. The procedures are applicable to phones with built-in licensed and unlicensed transmitters, such as WWAN, WLAN and Bluetooth transmitters. The SAR test reduction and exclusion provisions in KDB 447498 can be applied to streamline both standalone and simultaneous transmission SAR measurements. The *published KDB procedures* must be used to test different wireless technologies, such as 3GPP, 3GPP2, WiMax, 802.11 and Bluetooth.[1] When simultaneous transmission SAR measurement is required, the procedures in KDB 865664 must be considered. SAR test considerations for simultaneous transmission configurations, power reduction implementations, VoIP test requirements, NFC, wireless charging and similar accessories are also discussed for recent generation smart phones.

II. SAR Evaluation Considerations

Cellphones are tested for SAR compliance in both head and body-worn accessory use configurations. Head exposure is limited to next to the ear voice mode operations. Body-worn accessory exposure is typically related to voice mode operations when phones are carried in body-worn accessories. For phones that support hotspot mode operations, with wireless router capabilities and various web browsing functions, the relevant exposure conditions for hand and body are tested according to the hotspot SAR procedures in KDB 941225.

A. Standalone and simultaneous transmission SAR test requirements

Regardless of the simultaneous transmission requirements of a phone, each transmitter must be evaluated independently according to the applicable rules and policies to determine RF exposure compliance.

1. The SAR test reduction and exclusion provisions in KDB 447498 should be applied to determine the tests required for standalone and simultaneous transmission for all transmitters in the phone. For the purpose of determining SAR test exclusion, a separation distance of 5 mm is used. The test exclusions are based on the maximum output power, antenna-to-antenna and antenna-to-user separation distances.

2. The SAR measurement procedures in KDB 865664 are required for test results to be acceptable for TCB approval.

3. Head SAR compliance is tested according to the test positions defined in IEEE Std 1528-2003 using the SAM phantom.

4. The body-worn accessory procedures in KDB 447498 are applied to test for body-worn accessory SAR compliance.

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

5. For handsets that support hotspot mode, the procedures in KDB 941225 are applied.

6. A test separation distance of 10 mm is required for all surfaces and edges with a transmitting antenna located within 25 mm from that surface or edge.

7. A separation distance of 5 mm is required for phones with a form factor smaller than 9 cm x 5 cm.

8. When the separation distance required for body-worn accessory testing is greater than or equal to that required for the same surface of a phone and in the same wireless mode for hotspot use, the hotspot SAR data may be used to support body-worn accessory SAR compliance for that particular configuration.

9. The simultaneous voice and data transmission configurations and combinations for all applicable wireless operating modes, frequency bands and exposure conditions must be identified in the SAR report.

10. Simultaneous transmission SAR tests are considered separately for head (touch and tilt positions) and body-worn accessory exposure conditions, antenna diversity configurations, handset flip or slide cover positions, modulations, channel bandwidths and resource allocations, such as data rate, zone type, symbol ratio/duty factor, data block size etc.

11. For example, the highest SAR measured with the slide 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 or SAR to peak location separation ratio.

12. 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 for SAR test exclusion and reduction, to minimize the number of required simultaneous transmission SAR measurements.

13. When simultaneous transmission SAR measurements are necessary, the enlarged zoom scan measurement and volume scan post-processing procedures in KDB 865664 are required.

14. The RF exposure reporting procedures in KDB 865664 are applied to document compliance.

B. Simultaneous voice and data transmission

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 multiple antennas for standalone and simultaneous transmission operations. Some technologies may require voice and high speed data to be transmitted separately; for example, 1xRTT and EvDo. Other technologies may allow voice and data to occur within the same physical channel, such as WCDMA and HSPA. Smart phones with 3G and 4G/LTE can support voice and data transmission on separate transmitters concurrently. The 3G transmitter(s) is used for 1xRTT, EvDo, WCDMA/HSPA, GSM/GPRS/EDGE and capable of transmitting in only one of these modes at a time, and an independent 4G LTE transmitter is used for 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 refer to other 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.

C. Transmitter and antenna operating configurations

In a typical phone, 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 2.45 GHz band only, while others may support both 2.45 GHz and multiple 5 GHz bands. Depending on the implementation, most phones use a single antenna to cover all WLAN operations. Other phones may use a single transmitter module for both WLAN and Bluetooth, with varying antenna and simultaneous transmission requirements. When hotspot mode applies, a phone may restrict its operations to certain 3G/4G transmitter and transmission mode combinations for wireless routing and, in addition, the WLAN modes may also be limited to 2.45 GHz or only include some 5 GHz bands.

Among all the possible transmitter, antenna and operating mode combinations, some phones may apply additional restrictions in the firmware to limit certain combinations of simultaneous transmission configurations due to 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 be explained clearly in the SAR report in order 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.

D. Power reduction

When multiple transmitters operate simultaneously at relatively high maximum output power and at close proximity to users, as the device form factor becomes smaller and the proximity of antenna and radiating structures are closer, the potentials for internal interference and higher SAR are expected to increase. 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 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 be quite dynamic. The amount of power reduction and the 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 have continued to evolve for the last two years with no established industry standards. Each implementation is considered on a case-by-case basis to determine the test configurations needed to support compliance, in conjunction with the large combinations of transmitter, antenna, operating mode and simultaneous transmission variations. Therefore, each new implementation and subsequent variations must be submitted through a KDB inquiry to determine the acceptable test requirements before testing begins.

E. NFC, wireless charging and similar accessories

Some phones may include other functions and capabilities that can influence the SAR characteristics of a device; for example, 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 is provided by third-party suppliers, the test and equipment approval considerations in KDB 447498 must be applied to ensure all intended hosts are compliant while operating in conjunction with such accessories.

Phones with built-in NFC, wireless charging or similar functions that do not require separate SAR testing for these specific capabilities can generally be test according to the normally required SAR measurement procedures. The SAR influence of the additional accessory hardware and functionality to transmitters and antennas that require SAR testing are considered during the required SAR testing; therefore, it is transparent to the testing process. When these capabilities are provided as aftermarket accessories; for example, by incorporating the hardware on a battery cover or carrying case (sleeve), influence of the additional hardware and functionality to the SAR characteristics of a phone must be determined. The SAR test required for the phone must be repeated with the aftermarket accessory to ensure the phone remains compliant. When such accessories are provided by the original phone manufacturer, a Class II permissive change should be applied.[2] When the accessories are provided by a third-party vendor, the procedures in KDB 447498 should be considered to ensure all phones supported by the accessory remain compliant.

A handset must have been tested according to all required SAR test procedures without the after-market accessory (battery cover and sleeve etc.). The highest SAR measured for each wireless technology (1xRTT, EVDO, WCDMA, GSM, Wi-Fi etc.), frequency band, operating mode (different modes/configurations within each wireless technology) and exposure condition (head, body-worn accessory, hotspot mode etc.) must be repeated for the handset with the NFC and wireless charging battery cover or similar accessory (sleeve carrier etc.). 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 NFC and wireless charging battery cover or similar accessory. If there are noticeable changes in SAR distribution when the phone is tested with and without the accessory; for example, shifting of the peak SAR location, explanations for such changes should be included in the SAR report to support the test results.

F. VoIP support

Existing wireless infrastructures are continuing to migrate from 3G to 4G. Wireless carriers are expected to support VoIP as a standard built-in feature for most smart phones. This type of built-in VoIP support for voice mode operations is required to demonstrate SAR compliance in the head and body exposure conditions. The required SAR test procedures and wireless operating configurations required by the *published KDB procedures* for the specific wireless technology to support VoIP operations should be applied for SAR testing. When procedures are unavailable, a KDB inquiry must be submitted to determine the applicable test setup configurations

In addition to built-in VoIP support by wireless carriers, users of smart phones can typically download apps to enable other VoIP support. The operating characteristics for these types of VoIP apps are not

[2] See "Evaluation and Approval Considerations for Handsets with Specific Wireless Charging Battery Covers" in KDB 648474 for additional information.

standardized. These additional features are not supplied as an integral part of the phone by the original equipment manufacturer or the wireless carrier; it may not be feasible to test these types of ad hoc user operating modes. The phone manufacturer may either choose to block such apps or 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 applicable wireless data mode configurations. When these types of operations cannot be blocked, disclosures to users through clear and conspicuous instructions are required. Users must be advised that while these operations cannot be blocked, they are not recommended and have not been tested for RF exposure compliance; therefore must be avoided. When it is unclear which data operating mode or test setup to use for VoIP SAR testing, a KDB inquiry should be submitted to determine the test configurations.

G. SAM phantom limitations

Recent generation phones operating with multiple transmitters and antennas have begun to incorporate antennas near the sides and bottom edges of the phone. Occasionally, a phone with antennas located near the bottom or lower side edges of the phone 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 scattering does not affect probe calibration. When the probe tip is moved into tight regions, such as the mouth and jaw 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 calibration requirements and measurement protocols for maintaining the required measurement uncertainty. In some situations it is just not feasible to tilt the probe or rotate the phantom without acquiring additional SAM phantoms that are constructed specifically to enable rotation. Under these circumstances, the measured SAR distribution is typically clipped, showing only part of the problematic SAR distribution.

To ensure there is sufficient conservativeness for demonstrating compliance until practical solutions are available, other than acquiring multiple phantoms, additional measurement considerations are necessary to address these measurement difficulties. When measurements are required in tight areas of the SAM phantom or the peak SAR is on a curved surface where SAR probe access is not feasible for a horizontally bisected SAM phantom, or the SAR distribution is truncated, 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 phantom shell; if this is not feasible, the top edge of the phone should be touching the phantom. While maintaining this distance at the ERP, the low (bottom) edge of the phone is lowered to establish the same separation distance at the peak SAR location identified by the truncated partial SAR distribution measured with the SAM phantom. When the peak SAR location cannot be identified by 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 in area scans and the position corresponding to the peak location with the smallest distance between the phone and the phantom is used for all enlarged zoom scan measurements with the flat phantom.