



**Federal Communications Commission
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SAR EVALUATION CONSIDERATIONS FOR LTE DEVICES

1. Introduction

This document provides SAR test guidance for devices incorporating Long Term Evolution (LTE) capabilities. The procedures in this revision are intended for Release 8 LTE.¹ For product or manufacturer specific implementations with complex combinations of transmission configurations that are not supported by the procedures, a KDB inquiry is required to determine the SAR test requirements. The procedures apply to both Frequency-Division Duplex (FDD) and Time-Division Duplex (TDD) systems. SAR must be tested using a fixed periodic duty factor according to the highest transmission duty factor implemented for the device and supported by the defined 3GPP LTE TDD configurations. When it is unclear, a KDB inquiry is recommended to determine the SAR test requirements.

2. General Test and Approval Considerations

These LTE procedures are applied in conjunction with the other *published RF exposure KDB procedures* to test specific products; for example, USB dongles (KDB Publication 447498 D02) and wireless handsets (KDB Publication 648474 D04). A properly configured basestation simulator is required to configure the device for SAR testing. A PAG is required when power reduction applies and it is not based on a single fixed level triggered by a specific wireless operating mode and frequency band or single dedicated mode of operation, as defined in KDB Publication 388624 D02.²

3. Power Reduction Considerations

The test configurations required for handsets that implement power reduction to satisfy SAR compliance for various simultaneous voice and data combinations involving LTE and other transmitters, such as Wi-Fi can be quite complex. The similar concerns also apply to tablets that require proximity sensors to activate power reduction. In some cases, power reduction is implemented to address internal interference issues within a handset. For products that require power reduction to manage maximum output power in selected operating modes or configurations to satisfy SAR compliance or other equipment certification and operating requirements, a KDB inquiry detailing the power reduction implementations is typically necessary to determine the SAR test configurations required for the antenna configurations and simultaneous transmission conditions. Unless a single fixed level of power reduction is triggered by a specific wireless operating mode and frequency band or triggered by a single dedicated mode of operation when a simultaneous transmission configuration is activated, the acceptable test requirements for other power reduction implementations and subsequent variations must be determined through KDB inquiries before SAR testing.

¹ Provided there are no SAR testing issues, the procedures may be applied to Release 9 LTE devices. When unclear, a KDB inquiry should be submitted to determine the test requirements.

² A single fixed level of power reduction for all configurations in a wireless operating mode of a frequency band is required to obviate PAG requirements. In addition, the power reduction must be triggered by a single event or operation; for example, hotspot mode, or simultaneous transmission for SVLTE or SVDO, etc.

4. General LTE SAR Test and Reporting Considerations

In addition to the requirements in KDB Publication 865664 (D02) for reporting RF exposure compliance, the following should be documented in SAR test reports to identify the wireless operating parameters and test configurations for LTE devices.

4.1. Frequency range and channel bandwidth

The frequency range and channel bandwidths (1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, and 20 MHz) used in each LTE band must be listed. When multiple channel bandwidths are available in a frequency band and if the channel selection is unclear, a KDB inquiry may be necessary. If a transmission band is > 100 MHz, the channel selection criteria in 4.1 g) of KDB Publication 447498 D01 must be applied; otherwise, the high, middle, and low (H, M, L) channel should be used.³ These are referred to in this document as the *required test channels*. The channel numbers and channel frequencies for each channel bandwidth configuration and frequency band must be clearly identified in the test report.

4.2. LTE transmitter and antenna implementation

The LTE transmitter and antenna implementation must be described to support the SAR test setup. It should be clearly identified if the transmitter operates independently of the other wireless transmitters in the device; *i.e.*, whether the LTE hardware, components and/or antenna(s) are shared with other transmitters, to support the simultaneous transmission configurations. The voice and data transmission requirements for all LTE operating modes and exposure conditions, for standalone and simultaneous transmission, with respect to the required head and body test configurations, antenna locations, device and accessory operations, antenna diversity requirements, etc., must be clearly identified. The LTE test procedures must be applied separately to each device operating configuration and exposure condition, in each frequency band; for example, the different test positions required for head SAR and the various surfaces and edges required by the *published RF exposure KDB procedures*.⁴

4.3. Maximum power reduction (MPR)

It must be clearly identified if Maximum Power Reduction (MPR) is implemented and whether it is an optional or permanent feature, *i.e.*, built-in by design. MPR may be considered during SAR testing only when the maximum output power is permanently limited by the MPR implemented within the device, according to the RB (resource block) configurations specified in 3GPP/LTE standards. Regardless of network requirements, only those RB configurations allowed by 3GPP for the channel bandwidth and modulation combinations may be tested with MPR active. Configurations with RB allocations less than the RB thresholds required by 3GPP must be tested without MPR. A-MPR (additional MPR) must be disabled during SAR testing, except when there is prior confirmation from the FCC; for example, to implement power reduction according to certain acceptable network signaling (NS) conditions.

4.4. Power reduction

When power reduction is required for one or more LTE modes to satisfy SAR compliance for simultaneous transmission or other equipment certification and operating requirements, maximum average conducted output power measurement results are required for each power reduction mode applicable to the simultaneous voice/data transmission configurations used by such wireless configurations and frequency bands. The sensing or triggering conditions required to activate and

³ For LTE bands that do not support at least three non-overlapping channels in certain channel bandwidths, test the available non-overlapping channels instead. When a device supports overlapping channel assignment in a channel bandwidth configuration, the middle channel of the group of overlapping channels should be selected for testing; therefore, the requirement for H, M, and L channels may not fully apply.

⁴ See KDB Publication 447498 D01 for *published RF exposure KDB procedures*.

deactivate power reduction, such as antenna or transmitter output conditions, user proximity or applicable network conditions, etc., must be explained and verified according to the *published RF exposure KDB procedures* or guidance provided through KDB inquiries. The power measurement setup used in the applicable simultaneous transmission and power reduction modes to demonstrate that maximum power is triggered correctly by the specific event or operation and reduced to the required level must be clearly explained in the SAR report. The power measurement data must confirm that the power reduction mechanism operates reliably and consistently for the SAR results to be acceptable.

- a) When power reduction implementation is based on SAR scaling, acceptable analyses based on SAR and other measurement verifications are required to ensure that a conservative SAR margin is available for each device operating configuration and exposure condition to satisfy compliance. SAR scaling according to device operating power generally only applies to the same operating configuration and exposure condition. Exposure characteristics and SAR distribution are expected to vary from transmitter to transmitter due to design and implementation differences. Even for the same transmitter, SAR cannot be easily scaled across different exposure configurations based on device operating power alone. The power increase allowed by one mode or configuration may not necessarily support an equal amount of power reduction in another mode; especially for different frequency bands and exposure conditions.
- b) For certain dynamic power reduction configurations, if a device is unable to reduce the maximum output power of one transmitter according to the output or other conditions of another transmitter(s) during SAR testing, the power reduction conditions are usually established or simulated manually through test software configurations to enable SAR measurements.⁵ Descriptions of the test equipment, test software, built-in test firmware, etc., used to support device testing when power reduction is applied to one or more transmitters/antennas for simultaneous voice/data transmission are required. A KDB inquiry is recommended to confirm the test setup is acceptable.

4.5. Spectrum plots for RB configurations

When a properly configured basestation simulator is not used for the SAR or power measurements, spectrum plots for each RB allocation and offset configuration should be included in the SAR report to demonstrate that the tested RB allocations have been correctly established at the maximum output power conditions.

5. SAR Test Procedures for LTE Devices

5.1. General

The general test requirements of VoIP support for handsets are described in KDB Publication 648474 D04. The head, body, body-worn accessories and other required test considerations in KDB Publication 447498 D01 and other *published RF exposure KDB procedures* should be applied to configure LTE devices for standalone and simultaneous transmission in voice and data modes for the required exposure conditions.

Based on the design specifications and other information available from the device manufacturer, typically through measurement and analysis during product development, when the maximum output power specifications for the different RB allocations and RB offset conditions within a channel bandwidth, modulation, or across the channels in a frequency band varies by more than 1 dB, a KDB inquiry is required to determine whether the *required test channels* are acceptable for SAR testing or if a different set of *required test channels* should be used. The maximum average conducted output power measured according to the following configurations, for the *required test channels*, channel bandwidths

⁵ When a properly configured basestation simulator is not used or manual test mode or software is required, the non-standard test conditions require a PAG.

and uplink modulations, in each frequency band, are used to support the SAR test reduction and exclusion.

- a) 100% RB allocation
- b) 1 RB, and also 50% RB allocation, offset to the upper edge, middle, and lower edge of the channel bandwidth of each *required test channel*

Based on the power measurements, the SAR test reduction and exclusion provisions in KDB Publication 447498 D01 should be applied to determine SAR measurement requirements. SAR is evaluated separately according to the following procedures for the different test positions in each exposure condition – head, body, body-worn accessories, and other use conditions. The configurations and conditions that qualify for SAR test exclusion or require testing must be clearly explained in the SAR report. The procedures in the following subsections are applied separately to test each LTE frequency band. SAR must be measured with the maximum TTI (transmit time interval) supported by the device in each LTE configuration. The TTI configurations supported and tested must be described in the SAR report.

5.2. Largest channel bandwidth standalone SAR test requirements

5.2.1. QPSK with 1 RB allocation

Start with the largest channel bandwidth then measure SAR for QPSK with 1 RB allocation, using the RB offset and *required test channel* combination with the highest maximum output power among RB offsets at the upper edge, middle, and lower edge of each *required test channel*. When the reported SAR is ≤ 0.8 W/kg, testing of the remaining RB offset configurations and *required test channels* is not required for 1 RB allocation; otherwise, SAR is required for the remaining *required test channels* and only for the RB offset configuration with the highest output power for that channel.⁶ When the reported SAR of a *required test channel* is > 1.45 W/kg, SAR is required for all three RB offset configurations for that *required test channel*.

5.2.2. QPSK with 50% RB allocation

The procedures required for 1 RB allocation in 5.2.1 are applied to measure the SAR for QPSK with 50% RB allocation.⁷

5.2.3. QPSK with 100% RB allocation

For QPSK with 100% RB allocation, SAR is not required when the highest maximum output power for 100 % RB allocation is less than the highest maximum output power in 50% and 1 RB allocations, and the highest reported SAR for 1 RB and 50% RB allocation in 5.2.1 and 5.2.2 are ≤ 0.8 W/kg. Otherwise, SAR is measured for the highest output power channel; and if the reported SAR is > 1.45 W/kg, the remaining *required test channels* must also be tested.

5.2.4. Higher order modulations

For each modulation besides QPSK; *e.g.*, 16-QAM, 64-QAM, apply the QPSK procedures in 5.2.1, 5.2.2, and 5.2.3 to determine the QAM configurations that may need SAR measurement. For each configuration identified as required for testing, SAR is required only when the highest maximum output power for the configuration in the higher order modulation is $> \frac{1}{2}$ dB higher than the same configuration in QPSK or when the reported SAR for the QPSK configuration is > 1.45 W/kg.

⁶ Reported SAR is the measured SAR adjusted for maximum tune-up tolerance.

⁷ Use 3, 8, 12, 25, 36, and 50 RB allocations, respectively, for 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, and 20 MHz channel bandwidths for 50% RB allocation at the upper edge, middle, and lower edge of each *required test channel*.

5.3. Other channel bandwidth standalone SAR test requirements

For the other channel bandwidths used by the device in a frequency band, apply all the procedures required for the largest channel bandwidth in 5.2 to determine the channels and RB configurations that need SAR testing, then only measure SAR when the highest maximum output power of a configuration requiring testing in the smaller channel bandwidth is $> \frac{1}{2}$ dB higher than the equivalent channel configurations in the largest channel bandwidth configuration, or the *reported* SAR of a configuration for the largest channel bandwidth is > 1.45 W/kg. The equivalent channel configuration for the RB allocation, RB offset and modulation, etc., is determined for the smaller channel bandwidth according to the same number of RB allocated in the largest channel bandwidth. For example, 50 RB in 10 MHz channel bandwidth does not apply to 5 MHz channel bandwidth; therefore, this cannot be tested in the smaller channel bandwidth. However, 50% RB allocation in 10 MHz channel bandwidth is equivalent to 100% RB allocation in 5 MHz channel bandwidth; therefore, these are the equivalent configurations to be compared to determine the specific channel and configuration in the smaller channel bandwidth that need SAR testing.

5.4. Time-Division Duplex (TDD) test configurations

SAR must be measured with a fixed periodic duty factor corresponding to the highest transmission duty factor implemented for the device according to the UL-DL configurations defined by 3GPP.⁸ The transmission duty factor must take into account UpPTS duration in the special sub-frame.⁹ The applicable cyclic prefix configuration that results in the longest UpPTS duration should be used to determine the transmission duty factor and applied to the SAR measurement setup to ensure the measured SAR is compensated correctly.¹⁰ The parameters used to compute the SAR measurement duty factor must be clearly explained in the SAR report to support the test results. These TDD SAR measurement configurations are applied in conjunction with the FDD test requirements in 5.1 - 5.3.

5.5. Simultaneous transmission SAR test considerations for LTE

Standalone SAR results of the individual transmitters and antennas for the frequency bands, operating modes, device operating configurations and exposure conditions are applied to determine simultaneous transmission SAR test requirements, with respect to the applicable *published RF exposure KDB procedures*; for example, voice and data modes in LTE, 1xRTT, WCDMA, GSM, EvDo, HSPA, GPRS/EDGE, WiMax, Wi-Fi, Bluetooth, etc. The SAR test reduction and exclusion provisions in KDB Publication 447498 D01 should be applied separately for head, body-worn accessory, and other use test conditions according to the channel bandwidths, modulations, RB offsets and allocations in each frequency band.

The conditions and configurations that qualify for test exclusion or reduction must be clearly described in the SAR report. When simultaneous transmission SAR measurement is required, the enlarged zoom scan measurement and volume scan post-processing procedures in KDB Publication 865664 D01 must be applied, in conjunction with the *published RF exposure KDB procedures* required for the product platform and wireless technologies, to each device operating configuration and exposure condition.

Depending on the different combinations of channel bandwidths, modulations, maximum output variations among RB configurations, when LTE devices transmit simultaneously with other wireless modes (for example, Wi-Fi, which can have just as many data rate, modulation, and frequency band combinations), the simultaneous transmission configurations can become very complicated, to the extent

⁸ See 3GPP TS 36.211 Table 4.2-2 for defined uplink-downlink configurations.

⁹ The special sub-frame contains: DwPTS: Downlink Pilot Time Slot; UpPTS: Uplink Pilot Time Slot; and GP: Guard Period.

¹⁰ See 3GPP TS 36.211 Table 4.2-1 for special sub-frame cyclic prefix configurations.

that it would be very difficult to develop test procedures to cover all circumstances. When it is unclear, a KDB inquiry should be considered to clarify the test plan or any test concerns to avoid issues during equipment approval.

Change Notice

05/28/2013: 941225 D05 SAR for LTE Devices v02r02 replaces 941225 D05 SAR for LTE Devices v02r01: For minor editorial changes.

12/05/2013: 941225 D05 SAR for LTE Devices v02r03 replaces 941225 D05 SAR for LTE Devices v02r02: Added to the end of section 4.1 that SAR must be tested with the maximum TTI.

10/23/2015: 941225 D05 SAR for LTE Devices v02r04 replaces 941225 D05 SAR for LTE Devices v02r03: Removed outdated information, added TDD test setup requirements and included other minor clarifications on certain large frequency bands and A-MPR conditions.

12/16/2015: 941225 D05 SAR for LTE Devices v02r05 replaces 941225 D05 SAR for LTE Devices v02r04: Updated an incorrect item list reference to subclause 4.1 of KDB Publication 447498, *i.e.*, changed from “4.1 f)” to “4.1 g)”.