



RF Exposure Procedures

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Overview

- Product Platform and Technology Specific Updates
- WiGig RF Exposure Platform & Technology
- SAR Measurement System and Methodology
- General Issues and Miscellaneous Updates



Product Platform and Technology Specific Procedures Updates



HDMI Dongles

- The USB dongle procedures in KDB 447498 D02 may not apply to certain types of HDMI dongles that do not support portable exposure conditions
- Recent generation HDMI output dongles are mostly designed to plug into host devices such as a TV with HDMI input ports
 - a handheld remote control or an app on a smartphone or tablet is typically used to configure and control the HDMI dongle
 - this usually limits the types of host products the HDMI output dongles can support
- Other than a few exceptions, HDMI interface on typical laptop computers are generally implemented as output ports for connecting to a TV or projector
 - such configurations require a HDMI input dongle; HDMI output dongles cannot be used
- Most of the existing HDMI dongles require an AC adapter or a USB connection to the host device for DC power supply (+5V on HDMI interface appears limited)
 - this type of use conditions can generally satisfy mobile exposure conditions or provide at least 5 cm separation from users to support portable exposure conditions
 - Wi-Fi, Bluetooth or certain WWAN transmitters incorporated in this type of HDMI dongles can usually qualify for SAR or MPE test exclusion



HDMI Dongles - continued

- There have been a few cases where test labs incorrectly applied the USB dongle procedures to test HDMI dongles and overlooked by TCBs during equipment approval
- The input/output configurations and host devices that support portable exposure conditions need consideration to determine HDMI dongle SAR test requirements
- When HDMI dongles are not restricted to applicable host device types by nature of its design or use configurations
 - a KDB inquiry should be submitted to determine if the USB dongle procedures in KDB 447498 D02 are suitable for testing the HDMI dongle
 - SAR evaluation should be based on the operating configurations of the wireless technologies incorporated in the HDMI dongle and exposure conditions associated with applicable host devices and dongle configurations
- As HDMI dongle implementations continue to evolve, additional considerations may be necessary to determine SAR testing concerns



Wrist-Worn Wearables

- General SAR guidance for wrist watch is available in KDB 447498
 - the typical SAR measurement procedures can be applied when
 - the device & wrist bands can conform to a flat phantom or the measureable neck region of SAM phantom
 - typical SAR measurement procedures do not apply when
 - device or wrist bands cannot conform to a flat phantom or at the neck of SAM
 - wrist band straps must be closed for circuit continuity
 - test distances or gaps to the phantom are inconsistent with normal use conditions
 - when unclear, these should be confirmed through a KDB inquiry
- Generic limb phantoms are under consideration by IEC 62209 and SAR system manufacturers; but not yet available
- A KDB inquiry is required to address SAR measurement difficulties
 - when non-standard phantom or test setups are used
 - immersing device in liquid for SAR measurement should be the last resort
- Low duty factor SAR test exclusion may apply to
 - devices that transmit sporadically in data mode only, with no voice functions
 - for example, location trackers, telemetry or health monitoring devices etc.



Head-Worn Wearables

- The availability of head-worn transmitting devices are on the rise
 - eyeglasses, visors, head-bands, helmets etc. mostly using Wi-Fi
 - the antennas are usually located at the front or on the side(s) of the head
- Flat phantom is often not be suitable for head-worn SAR measurement
 - due to issues relating to device form factor, curvature and antenna locations
 - when unacceptable modification is required for device to support testing
- Antennas located near the ear may need to address pinna SAR
- Existing face down head phantoms may not fully support SAR measurements in certain regions of the head
- A generic face down head phantom is under consideration by IEC 62209 and SAR system manufacturers for head-worn wearables
- When flat phantom cannot be used, case-by-case KDB inquiry is required to address SAR measurement difficulties
 - UMPC mini-tablet procedures are not applicable but have been adapted incorrectly by some labs to perform SAR for head-worn devices



Diversity Antenna KDB

- When sensor array system or Motorola fast SAR is used according to October 2015 TCB RF exposure presentation for diversity antennas
 - TCB is required to submit a KDB inquiry with the FCC ID and TC number
 - FCC requires info to identify test results and make appropriate considerations to develop KDB guidance
 - subject of the KDB inquiry should indicate diversity antenna SAR procedures using sensor array/Motorola fast SAR
- All equipment approved by TCB using the diversity antenna procedures since October 2015 should submit a follow-up KDB inquiry
- In addition to the normally required SAR reporting procedures
 - the SAR results table should include a column to identify the test methods used for each measured SAR
 - test descriptions section of SAR report also need appropriate update
- The term “fast SAR” can be interpreted differently in various contexts
 - sensor array system and Motorola fast SAR expedite the actual measurement
 - IEEE/IEC “fast SAR” procedures reduce/eliminate measurements
 - depending on the context, “fast SAR” can have different meanings



Simultaneous Transmission MPE

- When incorporating multiple transmitter assemblies in host devices; for example, Wi-Fi modules supporting 2.4 GHz and multiple U-NII bands, where
 - an individual assemble may contain multiple antennas to support MIMO chains
 - the transmissions can be coordinated among different assemblies for selective spatial coverage (e.g. multiple sectors) using multiple combinations of frequency bands
 - maximum output power for the different antenna chains, frequency bands/channels and transmitter assembly combinations can be different
 - the sustained transmission duty factor may vary due to implementation requirements for the different combinations of configurations
- Aggregate power may require routine evaluation in host configurations
- MPE estimates may result in distances that are unrealistic for the use conditions
- When MPE measurement or similar evaluation is required, additional considerations are necessary for this type of configurations; for example,
 - exposure contribution due to front-to-back ratio of antenna & assembly combinations
 - variations in maximum output power and duty factor for the different combinations
 - calibration offsets of the probe or equipment across the frequency bands of interest
- A KDB inquiry with sufficient implementation and operating details is required to determine MPE measurement configuration requirements



PTT SAR Measurement Drifts

- Battery capacity and other design limitations for PTT radios can introduce continuous power droop during SAR measurement
 - radios can be overdriven and cause overheating issues during testing
 - the invalid results cannot be used or scaled to compensate for power droop
- Some devices may have lower power setting available in test modes
 - to alleviate overheating concerns and enable SAR results to be scaled up
- Hardware modifications or removal of components to enable testing at lower power is generally unacceptable for equipment certification
- Preliminary tests are often necessary to determine the cause of SAR drift
 - battery capacity and design limitations may require different test solutions
 - support from radio manufacturers is typically required to address issues
- The procedures applied to one radio may not necessarily work for others
 - tests labs must coordinate with device manufacturers
 - test requirements are addressed through KDB inquiries



6.78 MHz A4WP SAR Measurements

- Certain SAR probe(s) can be calibrated for SAR measurement at 6.78 MHz
 - for tissue-equivalent liquid with $\epsilon_r = 55.5$ and $\sigma = 0.75$ S/m (IEC 30 MHz values)
- The desired average muscle dielectric parameters are
 - $\epsilon_r = 211$ and $\sigma = 0.63$ S/m (average of parallel and transverse muscle fibers)
 - numerical simulation results indicate SAR is not sensitive to ϵ_r at 6.78 MHz
 - for $\epsilon_r = 50 \sim 300$ and $\sigma = 0.63$ S/m
- A current-loop device is currently under development by a SAR system manufacturer to support system validation and verification
- A KDB inquiry should be submitted to confirm details before proceeding with SAR measurements
- SAR measurement is preferred over numerical simulation to expedite equipment approval
 - IEC draft 62704-1 does not cover SAR simulation below 30 MHz
 - additional considerations are necessary for non-FDTD codes
 - code validation, canonical benchmarking, device model validation and uncertainty analysis (computational and modeling) also need to be addressed



Bluetooth Sleeve Accessories

- The following special evaluation procedure may be used for evaluating Bluetooth Sleeve accessories
- Demonstration of host devices remain compliant is not necessary for certain sleeve accessories meeting these requirements
 - contains a single low power Bluetooth transmitter with maximum conducted output power, including tolerance, ≤ 5 mW
 - sleeve can only be used with specific phone(s) identified by FCC ID
 - sleeve has no major metallic component that can influence the host SAR
 - Bluetooth antenna is ≥ 2 cm from any antenna in the host device
 - highest reported SAR for all applicable host devices for head, body, simultaneous transmission etc. are less than 1.4 W/kg
- RF exposure exhibit for Bluetooth must include proper justification
 - including illustrations for antenna locations and separation margins
 - Identifying the highest reported SAR of all exposure conditions from all equipment approvals for each applicable host device



LTE Carrier Aggregation

- The power measurement test setup and results included in SAR reports for DL CA SAR test exclusion have shown some inconsistencies
 - procedures in KDB 941225 D05A may not have been fully followed
 - these are often overlooked or ignored by TCBs during equipment approval
- Information in the SAR report is insufficient to identify all CA configurations
 - CA bandwidth class combinations; supported inter-band, intra-band, contiguous and non-contiguous configurations are often not identified or using 3GPP definitions
 - the applicable subsets are often not identified for multiple CA bandwidth combinations
- When procedures in KDB 941225 D05A are insufficient; e.g., configurations with more than 2 component carriers (CC), a KDB inquiry is required
- A few generic KDB inquiries for uplink CA has been received, but no details
 - the normal simultaneous transmission SAR procedures should apply to inter-band CA
 - for intra-band contiguous and non-contiguous CA, a KDB inquiry is required
 - details of the CA implementation and configuration are necessary to determine SAR test guidance



WiGig RF Exposure

Platform & Technology



WiGig Host Platforms

- WiGig has been used in host devices operating in
 - mobile exposure conditions for over 2 years
 - portable exposure conditions, such as laptops and tablets, since last year
- There are a few WiGig inquiries for smartphones, but no details
- Different combinations of simulation and measurement approaches have been explored by manufacturers for RF exposure, depending on
 - antenna array complexity, host configurations and exposure conditions
 - numerical simulation tools & measurement techniques used
 - combinations of methodologies applied may enable simulation and measurement to either supplement or complement each other
 - for validating the numerical model or measurement methodology
- These are all work in progress and expected to evolve
 - based on merits of approaches, WiGig host and antenna configurations



WiGig Test Considerations

- Numerical simulation
 - validation of the antenna array model in host device configurations
 - demonstration of confidence in simulated near-field results
- Measurement
 - planar-scanning and plane wave spectrum can be considered
 - the implementation requires validation before deployment
 - verification of test approaches used for individual measurement setup conditions is required
- Both measurement and simulation have inherent difficulties
 - combinations of methodologies used require different levels of user expertise
 - standardized procedures are unavailable for validating these approaches
 - compliance margins may be considered for certain lower power configurations
- Additional difficulties may apply to smartphones & tightly coupled devices
 - IEC 62704-3 is limited to 30 MHz – 6 GHz for investigation and pre-testing only



WiGig in Portable Conditions

- Antenna array characteristics and location in portable host configurations can influence exposure conditions for WiGig devices
 - free-space power density limit applies; mobile MPE exclusion does not
 - directional antenna and beamforming introduce additional concerns
 - tablet or lap held use conditions vs. antenna location and orientation
 - various smartphone use conditions vs. antenna characteristics and simultaneous transmission concerns
- The applicability of measurement and simulation methodologies for specific host and exposure conditions may vary
 - evaluation approaches, implementation and validation can differ
- Until there is sufficient experience to establish standardized test approaches and evaluation requirements, WiGig hosts are currently considered on a case-by-case basis for portable exposure conditions



SAR Measurement System and Methodology



30 MHz – 6 GHz SAR Simulations

When SAR evaluation is required and measurement is not feasible, simulations can be the alternative

- for example, certain higher output implant devices operating under Part 15
- The size and type of human or tissue-equivalent model may depend on the device or implant type and exposure conditions
- Include electrodes & accessories in model to address exposure enhancement
- The general SAR simulation requirements are described in KDB 447498
 - including code and device modeling validation, canonical benchmarking, and simulation uncertainty
 - equivalent procedures are required for non-FDTD codes
 - the reporting procedures in KDB 865664 D02 are also required
 - expand SAR contour plots to full page, zoom-in to peak and add 1-D profile plots
- Pending approval of IEC 62704-1 and revamping of IEC 62704-4
 - adherence to KDB 447498 and KDB 865664 D02 is expected
- Other frequencies are generally case-by-case, including power density
- TCBs are required to verify these before submitting PAG



Sensor Array SAR Systems

- The FCC has considered using sensor array systems for SAR screening
 - until general SAR measurement procedures are established, this does not imply acceptance or rejection of these systems
 - collaborations between FCC and system manufacturers are in progress
- The current plan is to consider sensor array SAR systems independently
 - as a separate category of SAR measurement methodology with absolute measurement accuracy equivalent to traditional SAR systems, but allowing substantially reduced measurement time
 - to use the normally required SAR procedures in KDB publications
- Fast SAR procedures, as described in IEEE 1528 and IEC 62209 are
 - established according to traditional SAR system measurement methodology
 - to substantially reduce the number of normally required measurements
 - due to continued changes in products and technology, coupled with the complexity of fast SAR procedures, providing simple steps for TCBs and test labs while maintaining sufficient confidence have been difficult
 - the concerns are similar to those in found SAR measurement uncertainty analysis



General Issues and Miscellaneous Updates



Questions from Labs & TCBs

- Tablet proximity sensor triggering procedures may not fully apply to sensors used for triggering in next to ear configurations
 - a KDB inquiry is required to determine applicable triggering test procedures
- Test setup, results and test exclusion supporting info are non-confidential
 - LTE CA configurations are required in SAR report to support SAR test exclusion
 - only qualified design and implementation specific info can be kept confidential
- Phablet procedures use 10-g SAR to support composite use conditions
 - phablet 10-g SAR should not be identified as hand or extremity SAR
 - this should be reported as product specific 10-g SAR in reports and grants
- Band edge conditions for 2.4 GHz vs. 5 GHz U-NII band SAR testing
 - KDB 248227 requires highest power configurations for 5 GHz test reduction
- How to choose SAR exclusion test distance for hand-held remote control?
- Concerns for Bluetooth use conditions in handsets
 - for determining SAR test exclusion, simultaneous transmission or SAR testing of head, body-worn and other use conditions



Coordinating KDB Inquiries

- KDB inquiries for the same product(s) seeking different test guidance should be coordinated to avoid issues and delays
 - common mechanisms used to address different SAR measurement, test reduction or exclusion concerns should be described in all KDBs
 - operating descriptions of common control schemes or overlapping functions and characteristics should be identified in all relevant KDBs
 - an overall summary of the related KDB inquiries should also be included in each KDB inquiry to avoid receiving insufficient or inapplicable test guidance that can lead to issues during PAG or equipment certification
- Specific KDB guidance may not apply to generic use
 - guidance provided for specific devices, FCC IDs, conditions or configurations
 - guidance provided to a specific test lab, manufacturer or TCB
 - guidance limited to specific product or technology implementation



IEC TC106/PT62209 Activities

- Tissue-equivalent parameter conservativeness has been under investigation by the IEC 62209 project team since ~2010
 - results from earlier electromagnetic simulation studies show existing dielectric parameters may not be sufficiently conservative
 - the additional thermal simulation results need review to draw conclusion, with respect to temperature rise and conservativeness
 - an incorrect dielectric parameter was used at one of the simulation frequencies, which will require further consideration
 - the goal is to use one set of conservative parameters for both head and body SAR
- 62209-2 has proposed an amendment to update SAR scan requirements
 - to address reactive and capacitive coupled field conditions
 - in certain device configurations and exposure conditions
 - not sufficiently captured by existing scanning procedures
 - measurement resolution, closest probe to phantom distance etc. are revised
 - when the parameters are finalized, an update to KDB 865664 is expected