RF Exposure Procedures Update

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Overview

- discussions on product related KDB procedures
  - KDB 616217 (laptop), 648474 (handset)
  - 447498 (mobile & portable devices in general)
- test requirement issues
  - KDB 248227 (802.11 & MIMO), 865664 (5 GHz SAR) etc.
  - simultaneous transmission SAR
  - proximity sensing and power reduction
  - transmitters and accessories in handsets
- RF exposure review and approval concerns for
  - wireless chargers and other devices
  - general SAR test and setup issues
  - SAR system calibration and verification
  - documentation and review issues
- moving forward with new products and technologies
- status for some of the KDB procedures

Product Related KDB Procedures

RF Exposure KDB Publications

- for RF exposure purpose there are 3 general types of KDB publications that provide test guidance relating to
  - products, technologies and SAR measurement methodologies
- product KDB:
  - 616217 (laptop), 648474 (handset & wireless charging battery cover)
  - 447498 (mobile & portable devices in general, tablets, USB dongles)
  - 643646 (occupational PTT), 941225 (UMPC mini-tablets)
- technology KDB:
  - 248227 (802.11), 615223 (WiMax)
  - 941225 (3G, LTE, GSM-GPRS, DTM, hotspot mode, HSPA)
  - 680106 (wireless charging applications)
- SAR measurement methodology KDB:
  - 450824 (SAR probe and dipole calibration), 865664 (3 – 6 GHz SAR)
- there are also a few policy KDBs that are RF exposure related
  - 628591 (exclusion list), 388624 (PBA), 996369 (modular transmitters)
  - 178919 (permissive change), 690783 (SAR listing)
  - 616217 (laptop policies), 648474 (handset policies)

Laptops: KDB 616217

- the original KDB has been in use since Dec 2007
  - it has not been keeping pace with the most recent products & technologies
  - it is becoming insufficient for testing the latest generation products
- subsequently introduced supplemental procedures in Nov 2009
  - with plans to retire/replace original KDB for moving forward
  - but continue to lack manufacturer & test lab feedback
- applying the earlier procedures generally have certain unintended consequences; therefore, issues continue to arise; for example
  - mobile grants with numerous class II changes for portable hosts
    - instead of applying conservative SAR test configurations to a platform
    - multiple class II changes are used to add dedicated hosts
  - many simultaneous transmission issues can occur in hosts & platforms
    - due to mix and match of different modules, transmitters & antenna configurations
- it is time to analyze the situation
  - to alleviate further bottlenecks
  - to facilitate moving forward

KDB 616217: Original

- intended to provide SAR test reduction for multiple antennas built-in around edges of laptop displays ≥ 12” diagonal
  - to reduce SAR tests for both standalone and simultaneous transmission configurations in such laptops (2007 products)
    - when antenna gain ≤ 6 dBi
  - also to allow some flexibility to facilitate OEM integration and to minimize unnecessary class II permissive changes
- the test reduction and exclusion thresholds are based on
  - sum of 1-g SAR for all simultaneous transmitting antennas
  - power and distance thresholds determined according to
    - multiples of $60/f_{(GHz)}$ mW when antenna to user separation ≥ 5 cm
    - and antenna to antenna separation ≥ 5 cm
- class II permissive change is required when
  - material changes are within 5 cm of an antenna
  - an antenna is installed closer to the user or another antenna than approved
  - when the original SAR > 1.2 W/kg and testing is required to shift (install) an antennas further away from the user or other antennas

KDB 616217: Supplement

- added supplement to overcome netbook, notebook & tablet issues (2009 product trends)
  - also expanded the procedures to cover an entire laptop or tablet
- to concentrate on mixed mobile & portable simultaneous transmission issues and to minimize volume SAR scans
  - outlined procedures to document the simultaneous configurations
  - adapted & expanded SAR test exclusion concepts in KDB 648474
    - applying 1-g sum and MPE ratios
    - using modified SAR to peak location ratios
- outlined OEM integration & documentation requirements
  - class I vs. class II based on conservativeness of test conditions
- included test setup examples to encourage moving forward
  - alternative procedures in supplement have been mostly not utilized
  - many of the earlier and other related issues continue to be problematic when conservative testing is not applied

KDB 648474: Handsets

- introduced in April 2008
  - to address simultaneous transmission SAR test exclusion and test reduction concerns for handsets, due to the smaller form factor
    - for 3G and Wi-Fi/Bluetooth combinations
- to provide SAR test reduction for unlicensed transmitters
  - using power threshold combinations; $60/f_{(GHz)}$ & ½· $60/f_{(GHz)}$ mW
  - according to antenna separation distances & SAR measured for licensed transmitters
- simultaneous transmission SAR test exclusion is based on
  - sum of 1-g SAR
  - SAR to peak location ratio of antenna pairs < 0.3
- also identified the general test requirements for volume SAR scans
- interim options to address SAR measurement difficulties in mouth and jaw regions of the SAM phantom were introduced
  - the issue is often overlooked during testing
  - more permanent solutions are needed

KDB 447498

- KDB 447498 was first released in 2008
  - it was based on an earlier pre-KDB version from 2004
- to provide general guidance for mobile & portable products and test setups that are not covered in other KDB procedures
  - to address test reduction and SAR exclusion needs, such as
    - test channels, mobile & portable exposure conditions, extremities etc.
  - to establish some baseline procedures for testing peripherals & modules
    - in standalone and simultaneous transmission conditions
    - for use in single or multiple product platforms according to the measured SAR
  - to provide SAR test guidance for full-size tablets (2008 products)
  - to provide some general test guidance for PTT radios
  - to clarify occupational use conditions
- subsequent revision has also incorporated KDB 616217 (laptop) and KDB 648474 (handset) SAR test exclusion concepts
  - further revision will require the coordination of multiple KDB documents
    - KDB 616217 (laptops), 648474 (handsets), 941225 (hotspot, mini tablets) etc.

Recent KDB Procedures

- other procedures for new product configurations have also been added as KDB attachments
  - to supplement the procedures in KDB 616217, 648474 and 447498
  - for USB dongle transmitters, UMPC mini-tablets, devices with wireless router functions, wireless charging battery covers etc.
- as products continue to evolve, device functions and categories can overlap; therefore,
  - unclear device operating configurations and exposure conditions may arise and causing confusions in determining test requirements
- many testing issues are often discovered during the final PBA process or post-grant audits
  - these can bring substantial bottlenecks to the approval process
  - making it difficult to provide timely and effective test guidance
    - it usually takes 6 months or more to draft preliminary procedures, getting feedback, modify, finalize and implement as KDB procedures

Next Generation Products

- how can we provide test guidance for next generation products while
  - also maintaining a timely and efficient schedule for everyone
- resources are not unlimited, but various needs have increased substantially due to
  - emerging products and technologies requiring attention for testing
  - receiving multiple or redundant inquiries for the same products
  - questions that have already been addressed in the KDB procedures
  - requests for ad-hoc considerations for equipment approvals
  - case-by-case discretionary considerations to allow deviations from published test procedures, often late in the game during a PBA
- many of these day-by-day and week-by-week short term needs have overwhelmed the long term goals
  - often causing intolerable throughput while system bandwidth may be acceptable

Discussions and Coordination are necessary to streamline the process

Test Requirements

802.11 SAR Issues

- KDB procedures are often NOT followed for SAR tests
  - using 5 GHz zoom scan size smaller than required; see KDB 865664
  - not using the required channels for testing; see KDB 248227
    - especially for the 5 GHz bands
  - often applying ad-hoc SAR test reduction and exclusion criteria
  - lack of explanation for Wi-Fi vendor/chipset based test mode setup
- higher data rate SAR exclusion should apply required KDB procedures
  - certain unexpected or unusual output conditions generally need testing
- 802.11n modes still lack test guidance
  - test labs have been applying 802.11a/g concepts
- MIMO SAR test configuration considerations
  - influences due to MIMO antenna structures
  - output power & performance variations among transmitter/antenna chains
    - test reduction for subsets/combinations of antenna chains may vary
  - antenna design may require single and/or multiple SAR scans
  - acceptable schemes to consolidate test configurations may vary

Simultaneous Transmission

- to qualify for SAR test reduction & exclusion
  - test reports must identify all applicable transmission configurations
    - for head, body-worn accessories, hotspot mode & other use conditions
  - identify the qualified test exclusions according to
    - sum of 1-g SAR for each test configuration
    - SAR to peak location ratio analyzed using measurement coordinates
    - other criteria in KDB procedures for laptops, mini-tablets, hotspot mode etc.
  - otherwise, volume scan measurement is required
    - the procedures can be SAR system dependent
    - scaling of WiMax control symbol requires further consideration
- test results must be listed in SAR reports to document compliance
  - according to the head, body-worn accessories, hotspot mode and other use conditions applicable to a device
  - for configurations that qualify for SAR test exclusion
  - by including the volume scan measurement procedures
  - by showing individual & combined SAR peaks in volume scan plots and SAR to peak ratio analyses

Proximity Sensor

- proximity sensors have been implemented
  - mostly in UMPC-mini tablets and recently in larger tablets
  - to reduce maximum output power for SAR compliance
  - often only active for selected operating modes and use conditions
- demonstration of sensor coverage in all directions and orientations for all applicable use conditions is required to determine SAR test requirements; KDB inquiry is suggested
  - sensor configuration may vary with design & implementation
  - sensor may not necessarily be collocated with the antenna(s)
    - certain assumed test configurations may not cover actual use conditions
  - multiple sensors may be used to cover surface & edge or multiple antennas
    - different triggering distances may apply for each sensing condition
    - different power reduction levels may apply to each triggering condition
  - sensors may trigger in conjunction with other tablet mechanisms
- KDB 447498 procedures may not fully cover tablets with sensors
  - amount of power reduction may affect tests required at touch or backoff
- detailed documentation is required to support the test results
- sensors are host dependent; therefore, may not be extended to modules

Power Reduction

- power reduction is often applied to
  - alleviate SAR or EMC compliance concerns
  - address network or carrier requirements
- reduction of maximum power is often triggered by
  - proximity or other sensing mechanisms, display orientations
  - wireless modes, frequency bands, RF channels, propagation conditions
  - voice or data activities, transmitter & antenna paths or
  - other device operating and use conditions
- test requirements may vary for different implementations
  - power may be reduced to a fixed lower maximum level(s), through fixed step changes, or as functions of other parameters (dynamic)
  - a KDB inquiry is suggested for each new scheme
- control of power reduction must be fully contained within a module
  - approval of split host & module power reduction is currently not supported
- detailed documentation is required
  - for the implementation, test setup and results

Handsets

- support for third-party apps to provide VOIP
  - head SAR is required for operating modes that offer such support
  - manufacturer may choose to block this or limiting such capabilities from user access
  - some data mode test configurations could be unclear for VOIP
    - a KDB inquiry is suggested
- documenting body-worn accessory test separation distance
  - rationale for the test setup and separation distance used must be included in SAR reports for results to support compliance
    - see body-worn accessories in hotspot mode KDB procedures (941225)
  - the test distance must be determined by the handset manufacturer
    - according to the types of accessories that may be acquired by users
    - in conjunction with acceptable user disclosure for proper use
  - a separate attestation letter is generally not necessary
    - unless issues are not fully resolved after FCC consultation

Handsets

- there is a request to reduce 5 GHz Wi-Fi SAR tests for handsets by consolidating the 5 GHz bands; this decision has been deferred
  - it will require further review of the following related issues
    - KDB 248227, 648474, 616217 etc. and impact on other product categories
    - what SAR results are required for standalone vs. simultaneous transmission
    - antenna collocation and separation considerations across products & platforms
- handsets with wireless charging or 13.56 MHz NFC functions
  - the hardware can be fully built-in (internally) within a handset
  - hardware may be incorporated (partially or fully) within removable parts
    - for wireless charging battery cover, see guidance in attachment to KDB 648474
  - other handset configurations should submit KDB inquiry
    - e.g., add-on sleeves for wireless charging
- recent antenna structures/designs for multi-band coverage
  - have shown antenna and peak SAR locations may not be associated
  - simultaneous transmission analysis for SAR to peak location ratio should include SAR distribution plots to document this
  - certain antenna details may be kept confidential in technical descriptions

Review & Approval

Wireless Chargers

- recent wireless chargers are mostly based on WPC specs
  - operating around 110 – 205 kHz with single or multiple coils
    - MPE limits do not extend below 300 kHz
    - SAR procedures are unavailable below 300 MHz
    - these have been handled according to §1.1307 (c) and (d)
      - on a case-by-case basis by applying the MPE limits at 300 kHz
      - with respect to E and H field strengths at 10 – 15 cm from the charger
- the implementation resembles field disturbance sensors
  - RF energy provided by a charger is perturbed by client devices
    - through a specific load modulation scheme that enables the charger to detect client conditions
  - Part 15 C applies to the operating characteristics of the charger
    - however, be aware of restricted band at 90 – 110 kHz (§15.205)
  - Part 15 B applies to the operating characteristics of the clients
    - to address receiver and digital device when no other transmitter is in the device

Wireless Chargers

- the majority of charging clients are in cellphones, for example, battery covers
  - these are tested as an integral part of the phone and approved as accessories for the specific phone in original or class II permissive change filings
  - additional SAR/HAC/EMC tests with & without the accessory are required (see KDB 648474)
  - the goal is to minimize separate client approval and to avoid compliance issues relating to third-party accessories
- third-party client charging accessory approval
  - must be limited to clients attached to
    - hosts without transmitters, such as music players
    - hosts that only allow the client to be attached during charging
  - otherwise, such approvals are difficult and must be discouraged
    - because host compliance cannot be assured without proper assessment

Wireless Chargers

- other wireless charging implementations
  - should review KDB 680106 & submit a KDB inquiry for guidance
- chargers operating at higher frequencies may need to apply
  - numerical simulation techniques to show RF exposure compliance
    - with respect to mobile or portable exposure limits and use conditions
  - some may need combinations of simulation & field measurements
  - SAR measurements may be applied when procedures are available
- chargers designed for wide coverage or special use conditions may operate at high power or exposure levels
  - there could be testing and compliance concerns
  - the exposure concerns for consumer products vs. restricted use situations may vary
- a KDB inquiry is suggested before evaluation

Other Devices

- e-Reader low duty factor consideration
  - this only applies to e-Readers with the unique black & white display design that imposes device capability restrictions
  - those with color display or browsing functions are treated as tablets
- other low duty factor SAR exclusions may be considered
  - for tracking and personal emergency response devices etc.
  - through duty factor and maximum average output power analyses
- UMPC mini-tablet & hotspot mode
  - PBA is not required when KDB procedures are followed
  - PBA is required only when the required KDB procedures cannot be fully applied due to device form factor or other concerns
    - a KDB inquiry is suggested

Other Devices

- some recent USB dongle considerations have shown
  - hotspot mode and simultaneous transmission concerns
    - the 10 mm hotspot mode requirement in KDB 941225 does not apply to dongles
    - dongles are evaluated for SAR compliance at 5 mm
  - transmit antenna diversity issues need case-by-case consideration
  - dongle look-alikes that do not operate like the typical USB dongles
    - USB dongle procedures may not fully apply
- for full-size tablets
  - hotspot mode KDB procedures are not intended for larger tablets
  - normal tablet testing with KDB 447498 could be insufficient when
    - proximity sensor, G-sensor, display orientation, power reduction mechanisms are used
    - these may require case-by-case consideration

General SAR Test Requirements

- GMSK vs. 8-PSK in GPRS & EDGE modes
  - the specified power levels for most products are usually defined with respect to GMSK and 8-PSK
    - this is often incorrectly indicated in test reports as GPRS and EDGE
  - the maximum output power levels for the different time slot configurations in each mode must be clearly identified
    - especially when further power reduction is required
- 150 MHz VHF
  - is excluded from TCB approval when SAR measurement is required
  - standardized dipole is unavailable for SAR system verification
    - there is no easy or reliable means to verify SAR system measurement accuracy
  - need KDB inquiry for case-by case SAR requirement
- area & zoom scan grids should be
  - appropriate for DUT dimensions and aligned to the DUT axes
- a device should be tested at its maximum output power within the tune-up tolerance specifications to qualify for TCB approval

SAR System Verification

- when multiple SAR probes are used
  - the combinations of probes, frequency bands and liquids used for the measurements must be identified in the SAR report
  - SAR system verification is required for all probe calibration points
    - with respect to DUT transmit frequency bands and tissue-equivalent liquids
- when graded grids are used; typically for 5 GHz measurements
  - SAR system verification should be performed with the same graded grid configurations used for the DUT measurements
  - follow IEEE Std. 1528-2003 procedures to verify area & zoom scan grid resolution requirements
- besides a simple statement to indicate KDB 450824 requirements are satisfied
  - test reports must include info to show the applicable criteria in KDB 450824 are met

SAR System Calibration

- third-party calibrations require prior FCC acceptance
  - may include SAR probes, dipoles and other system components
- the organization must demonstrate its qualification
  - personnel expertise
  - facility properly equipped
  - have full support from the original SAR equipment manufacturer(s)
- the identical calibration procedures and quality assurance protocols used by original SAR equipment manufacturer must be applied
- documentation of continued collaboration and support from the SAR equipment manufacturer(s) is necessary
- each specific arrangement could be different
  - therefore, requires independent consideration
- FCC acceptance must be documented through KDB inquiry
  - specific information that identifies such arrangements must be included in the calibration certificates to facilitate TCB review and approval

SAR Plots

- number of SAR plots to include in test reports
  - in general, at least one plot for each exposure condition, in each frequency band and wireless mode
    - when SAR distributions vary, additional plots should be considered
  - additional plots are needed to document the SAR to peak location ratios used to qualify for SAR test exclusion
  - plots for both individual and combined scans should be included in test reports to support the volume scan SAR measurement results
- all plots should be numbered and must include at least the following:
  - SAR probe S/N, probe conversion factors, tissue dielectric parameters, test channel frequency, DUT test configuration, transmit duty factor, measurement grid resolutions, scan dimensions, SAR measurement drift, interpolated peak SAR at the surface and 1-g SAR (10-g for extremities)
  - area scan must cover the projected area of a DUT to capture all peaks
    - plots should zoom in on the SAR distribution & also show the DUT boundary
- multiple peaks may need multiple zoom scan

Other SAR Review Issues

- when measured SAR numbers are in the noise, below the SAR system detection limit
  - but device output power is not low
  - test separation distance is not large
  - test reports must demonstrate the device is operating properly, as required, during the tests with all test equipment setup correctly
- 1.2 W/kg PBA threshold in KDB 447498 section 2c
  - does not apply to all devices
    - it applies to peripheral transmitters that require a host to operate
  - a host can affect the SAR of a peripheral transmitter
  - PBA is required to determine if sufficient margin is available to ensure compliance and if additional user instructions, caution labels or separate packaging inserts may be necessary
  - the threshold is considered after accounting for tune-up tolerances

New Products and Technologies

Emerging Configurations

- multi-carrier in single or multiple frequency bands
  - DC-HSDPA/HSUPA, DC-DB-HSPA, EVDO Rev. B and other 3GPP considerations etc.
    - may have MPE or SAR evaluation issues
- other 3G/4G improvements
  - 1x Advanced
    - new RC configurations required (RC 8 & RC 11)
  - emerging 3GPP uplink MIMO configurations
    - SAR procedures for small devices with MIMO are unavailable
  - TDD configurations do not have SAR test procedures
    - will require time to investigate and provide test guidance

Emerging Configurations

- advanced/smart antenna designs for evolving technologies
  - to the extent that such designs may influence test considerations; there could be different SAR testing issues
    - for example; comparing the old whip vs. printed antennas in the last decade with smart vs. more advanced antenna designs in recent and emerging designs
- other new changes in product designs and implementation
  - form factor changes, different or varying operating configurations, new use conditions or combinations of these that may influence test requirements
- these cannot be dealt with during the PBA process
  - manufacturers and test labs must submit KDB inquiries early on
  - it can take time to investigate before appropriate test guidance can be provided

KDB/PBA Status

KDB/PBA Status

- WiMax, HSPA+ and LTE
  - both WiMax and LTE may need some measurement investigations to revise existing procedures
    - WiMax KDB needs consideration for AMC zone and control symbol issues
    - LTE procedures need additional examination to streamline test requirements
  - apply HSPA procedures for HSPA+
    - identify the 3GPP release versions for the product and use the subtest in Table C.11.1.4 of TS 34.121-1 to measure HSPA+ power to determine SAR exclusion
- 802.11n – will need to be considered along with MIMO issues
  - KDB 248227 needs update, but not as urgent as other KDBs
- SAR procedures for handsets, laptops and modules etc.
  - these need close coordination to streamline further revisions
- SAR measurement
  - volume scan procedures need update as SAR systems continue to improve
  - the SAR measurement related KDB procedures need consolidation
  - there is the need to grow beyond the existing SAR reduction & exclusion criteria to cover recent and future generation products and technologies
- do not embed questions in file attachments of KDB inquiries