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
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
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; $60/f_{(GHz)} \cdot \frac{1}{2} \cdot 60/f_{(GHz)}$ 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 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
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
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
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