SAR Measurement Procedures

FCC / OET

Laboratory Division

October 2009

TCB Workshop

Overview

- SAR evaluation procedures / requirements
  - notebook/netbook computers
  - WiMax
  - HSPA & HSPA+
  - LTE
  - USB dongles & similar external peripheral transmitters
  - wireless wrist watch
  - wireless power charging/transfer applications
  - transmitters with low transmission duty factor
  - test reduction considerations
  - simultaneous transmission SAR evaluation
- SAR measurement system verification
  - SAR dipole calibration requirements
  - tissue equivalent media considerations – head or body

Supplemental SAR Procedures for Notebook / Netbook Computers

Adding Supplemental Attachment to KDB 616217

May Need Changes to Exclusion List KDB 628591

Scope & Purpose

- Scope
  - covers notebooks, netbooks & laptops (not intended for UMPC devices)
    - including displays < 12” diagonal
    - for antennas in display & keyboard
    - for stand-alone & simultaneous transmission
    - including mixed mobile & portable exposure conditions
  - excludes user plug-in external transmitters & antennas
    - follow KDB 447498, section 2 for USB dongles, CardBus, ExpressCard etc.
- Purpose
  - to supplement the earlier SAR procedures in
    - KDB 616217 that enable SAR test reduction
      - for antennas in laptop displays
    - KDB 447498 that provide flexibility to integrate transmitters and modules into host platforms
      - Section 2 & 3 (b) (ii): for generic transmission conditions
  - to streamline test and permissive change requirements
    - for the latest netbook/notebook type of host configurations

Individual Transmitters

- when SAR tests in initial approvals are based on the most conservative exposure configurations
  - required by the intended hosts & platforms
    - with respect to section 2 & 4 of KDB 447498
  - incorporating the approved configurations into qualified hosts
    - **normally do not require additional tests & certifications**
- when initial approvals are based on less or the least conservative exposure configurations; such as mobile exposure conditions
  - OEM integration options can become quite limited & restrictive
    - additional tests & certifications are usually necessary to incorporate new hosts or configurations
  - this option is highly undesirable and should be discouraged
    - it has been intended for early-on larger laptops; however, it is often applied to more recent complex hosts and has introduced many unnecessary permissive change and other filing issues

Individual Considerations

- to maintain continuity, the procedures in KDB 616217 continue to apply (to be phased out gradually or merged with other procedures later)
  - SAR tests not required when maximum average power ≤ $60/f_{(GHz)}$ mW
  - SAR test reduction applies for antennas ≥ (5+½·n) cm from users
    - antennas must satisfy minimum user separation distance requirements
    - require further tests & approval for unqualified host configurations
- these notebook/netbook procedures should be applied
  - to supplement KDB 616217
  - for used in conjunction with section 2 of KDB 447498
  - to overcome issues for smaller notebooks/netbooks
- need to shift focus to the initial approval of individual transmitters
  - to emphasize tradeoffs between test conservativeness & OEM integration flexibility
  - to keep up with recent generation wireless products & technologies
  - in order to streamline test & certification requirements
    - to enable OEM integration and implementation flexibility

Simultaneous Considerations

- procedures and conditions in KDB 616217 or KDB 447498 section 3 & 8 (draft) may continue to apply (to be phased out or merged later)
  - to antennas on displays that meet the required minimum antenna-antenna and antenna-user separation distance requirements
  - these cannot be mixed with the new netbook/notebook procedures
- focuses of new notebook/netbook procedures are
  - to consider the entire notebook/netbook or laptop computer
    - including antennas in both display and keyboard
    - including SAR exclusion criteria for mixed mobile & portable exposure conditions (displays < 10" do not meet mobile conditions)
  - to enable OEM flexibility to integrate simultaneous transmitting antenna configurations in the smaller netbook/notebook hosts
    - using the SAR/MPE of individual transmitters and test conditions
    - to streamline test & certification requirements for simultaneous transmission conditions

Simultaneous Configurations

- need to identify all possible combinations of simultaneous transmission conditions for intended host configurations
  - for antennas in both display and keyboard
    - transmitters operating through connectors & external card slots must be ≥ 5 cm from any simultaneous transmitting antennas
- document the details for each identified simultaneous transmission combinations
  - antenna types, transmission modes, operating configurations, maximum average output power etc.
  - antenna locations, antenna-antenna & antenna-user separations
  - restrictions required by the individual transmitter grants etc.
- specify the applicable antenna and host configurations
  - range of physical, mechanical and electrical variations supported by existing and new test results
- all these should be properly documented
  - in the original filing & permissive changes (Class I & II)

Simultaneous SAR Exclusion

- each simultaneous transmitting transmitter/antenna must
  - be certified with stand-alone SAR or with average power ≤ $60/f_{(GHz)}$ mW
  - be installed with user separations at no closer than tested for certification
    - applies to SAR and MPE
- considering all simultaneous transmitting antennas in each host
  - if the Σ(highest SAR/1.6) + Σ(highest MPE/MPE limit) < 1; or
  - if the distances between the antennas that require SAR evaluation
    - considered a pair at a time, are > $5\cdot[(SAR_1+SAR_2)/1.6]^{1.5}$ cm
      - round to the nearest cm
    - and the Σ (highest MPE/MPE limit) < 1
  - simultaneous transmission SAR/MPE exclusion applies, where
    - ∑ requires highest SAR or MPE for each antenna
    - MPE does not apply to displays < 10” diagonal
    - Σ excludes antennas that do not require SAR evaluation
  - otherwise, submit KDB inquiry
    - to determine simultaneous transmission evaluation procedures and whether PBA or FCC filing applies
      - while awaiting more practical procedures from measurement standards

Documentation

- all combinations of simultaneous transmission and intended host configurations must be fully documented in the SAR report or Class I documentation, according to required procedures, to qualify for SAR exclusion
- grantees of individual transmitters must provide OEM integrators and distributors with specific instructions for qualified configurations to meet both stand-alone and simultaneous transmission RF exposure requirements
- OEM integrators and other third-parties must be able to adhere to the operating & installation requirements of all transmitters/antennas configured in each host
- with the required documentation, transmitter/antenna and host configurations that satisfy the new/supplemental notebook/netbook procedures and do not require additional SAR evaluation can be considered for Class I permissive change
- initial equipment certifications should focus on the flexibility to integrate transmitters/antennas into entire host platform or product line instead of focusing narrowly on individual hosts

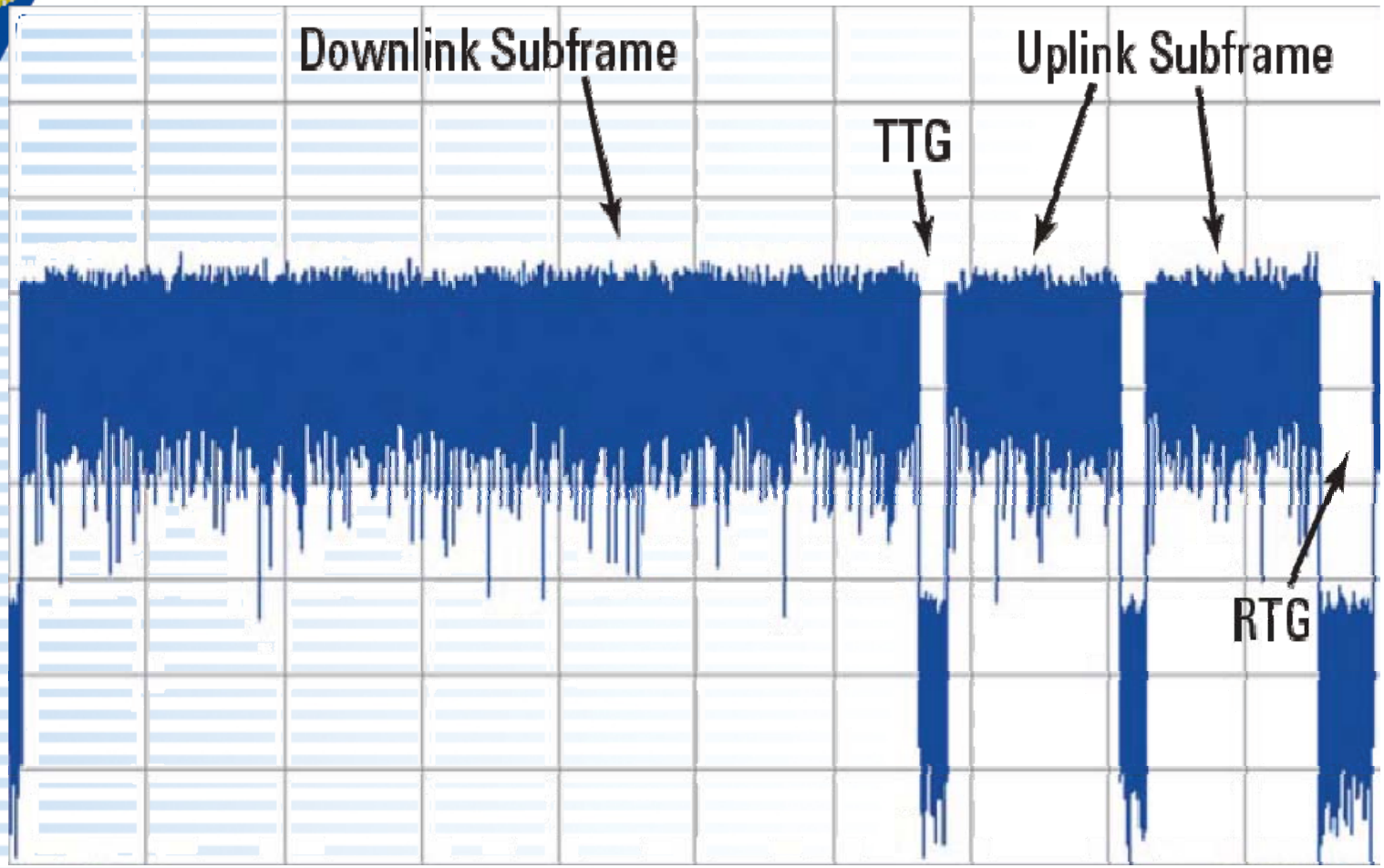
WiMax

Adding New KDB Publication

Overview

- preliminary WiMax SAR procedures have been provided through KDB/PBA inquiries since December 2008
  - received only one inquiry specific to the procedures
- these procedures are often not followed correctly for SAR testing and TCB review
  - issues are mostly related to WiMax implementation, test equipment requirements, device operating configurations and SAR measurement limitations
- need to identify and reiterate these issues
  - to facilitate transitioning the preliminary WiMax procedures to a KDB Publication

TDD Frame Structure



Common Testing Issues

- technology & implementation related considerations
  - DL:UL symbol ratios in TDD configurations
    - identify all combinations to determine highest transmit duty factor
    - also consider any chipset and/or wireless carrier restrictions
  - control symbol configurations
    - testing vs. normal operating requirements
  - test equipment & device operating configurations
    - using combinations of test software & vector signal generator or communication test set / protocol simulator
    - need stable signal at maximum output power suitable for making SAR measurements by existing systems
- SAR measurement limitations
  - SAR probes require test signals with periodic duty factor
  - SAR probes are not calibrated for signals with high peak-to-average power ratios such OFDM/OFDMA

TDD DL:UL Ratios

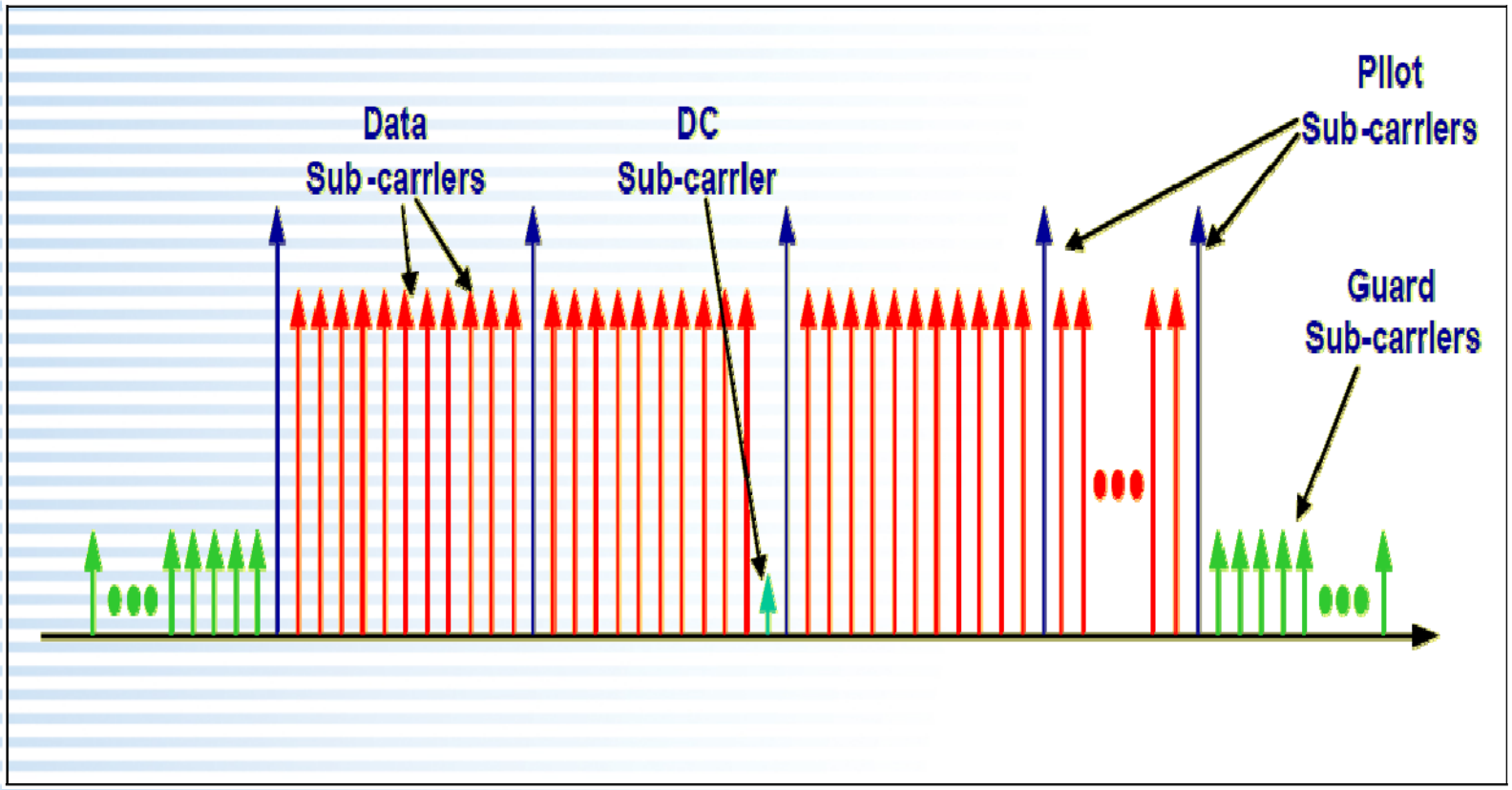
- reported typical U.S. carrier configurations
  - 5 & 10 MHz channel bandwidth in BRS band
    - certain carrier agreement may limit DL:UL ratio to 29:18
      - some chipsets may support higher ratios
    - 48 symbols per 5 ms frame
      - DL + UL + sub-frame gaps = 48 symbols
    - 3 control symbols in UL sub-frame
      - operating at reduced power according to slots used
- before configuring the device for SAR testing
  - identify the highest DL:UL exposure conditions
  - determine how to configure the required test conditions
    - SAR measurement system requires periodic UL bursts
    - test equipment may use 1-way or 2-way communication
      - should control symbols be active or inactive?

Test Setup Issues

- SAR measurement requires signals with periodic duty factor
  - this is the "*cf*" factor typically used in SAR measurement systems to compensate the measured fields with periodic duty factors
  - however, "*cf*" is called crest factor in SAR systems
    - crest factor typically identifies peak-to-average ratios (PAR) in wireless or other applications
  - these terms are often applied incorrectly in SAR measurements
- SAR system and test equipment limitation issues
  - establishing the required periodic test signal using test software & signal generator or communication test set / protocol simulator
  - SAR probe is not calibrated for high PAR signals
    - measurement errors are expected for OFDM/OFDMA signals
- other device configuration considerations
  - zone types, modulations and other WiMax parameters that need to be configured for SAR testing

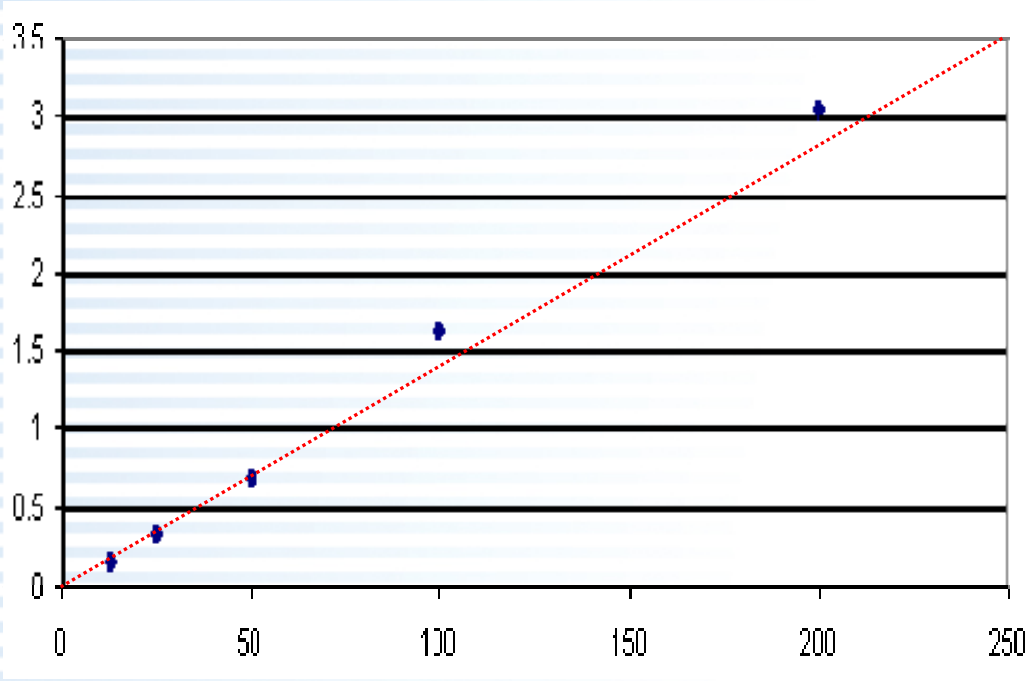
OFDM PAR Issues

- as the number of sub-carriers increases, PAR approaches Gaussian
- SAR probe is calibrated for CW signals, not intended for high PAR



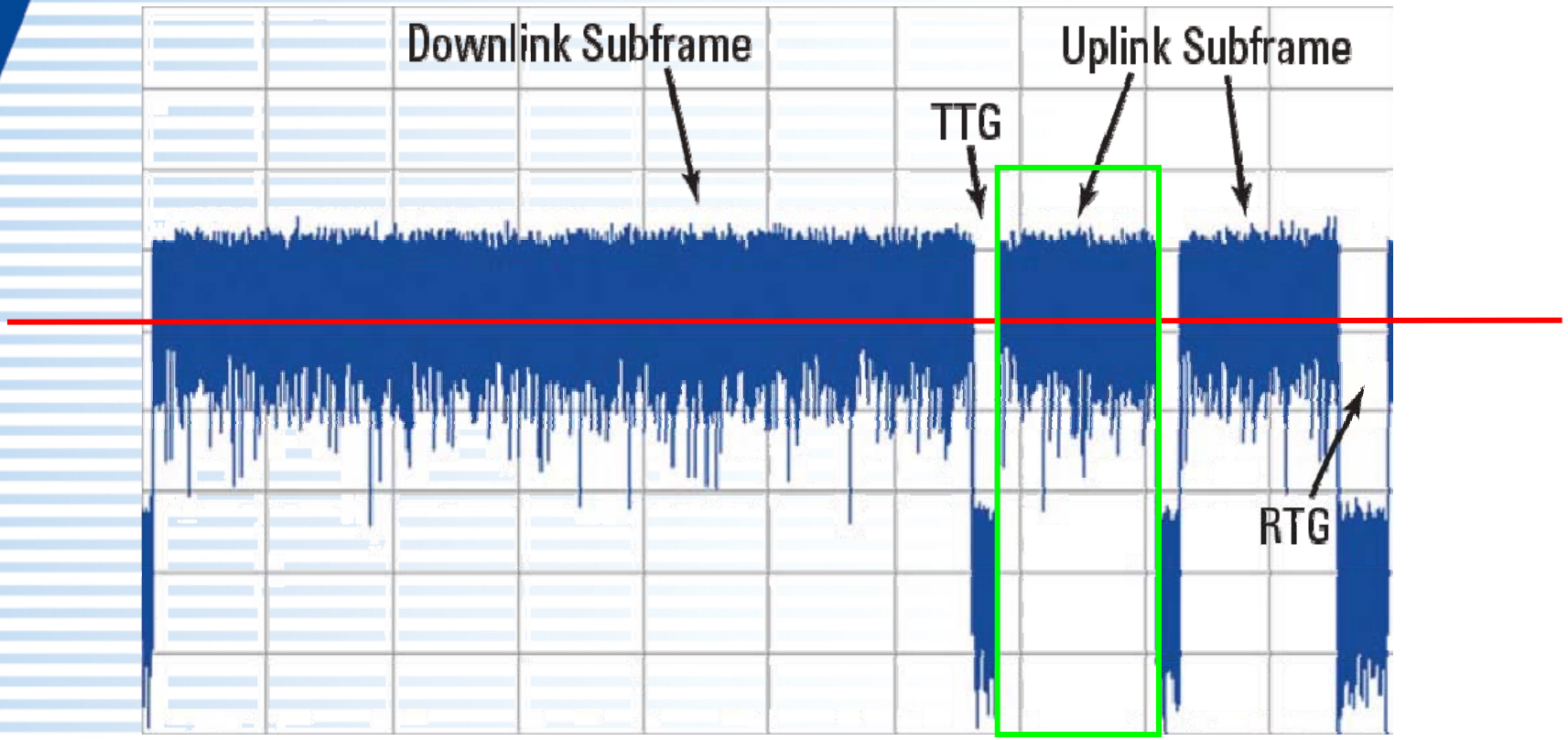
Identifying SAR Errors

- need to measure SAR at various power levels to establish error margin
- at very low power, SAR probe sensors operate in square-law region
  - sensor output is linearly related to power
- at medium to higher power
  - SAR probe sensor output is proportional to E-field



PAR vs. Duty Factor

- PAR & duty factor issues are both SAR probe related
- duty factor issues can be addressed by using periodic test signals
- PAR issues are not easily compensated



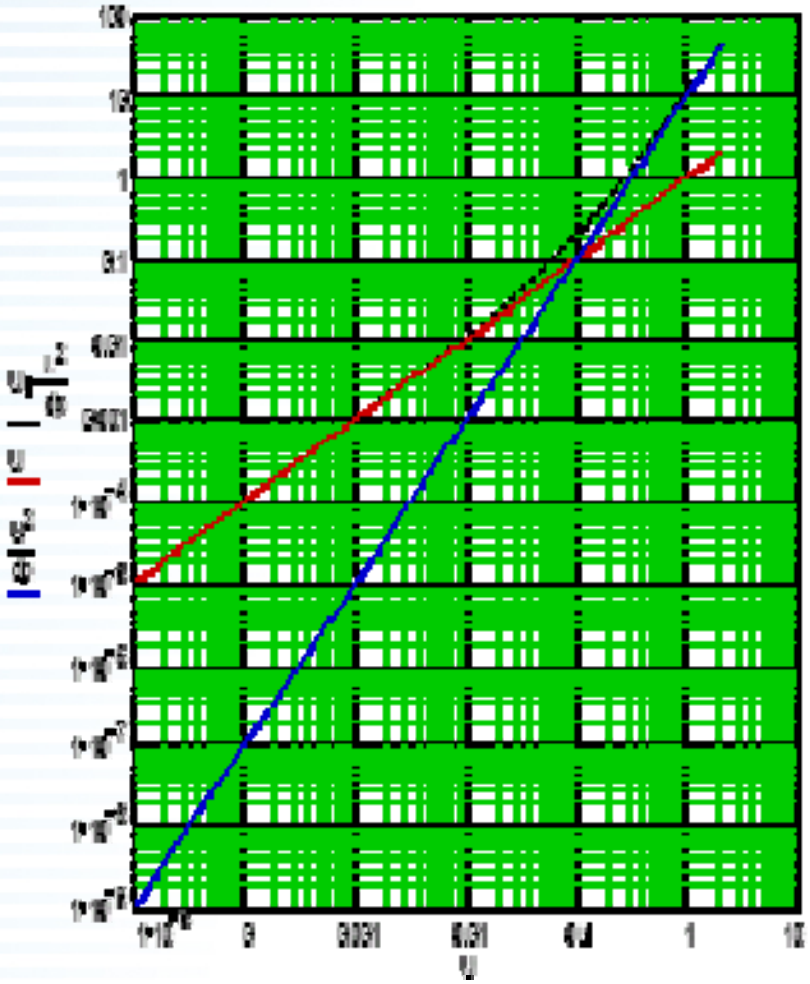
Signal Conversion vs. Duty Factor

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

For Periodic signals

duty factor = t/T

conversion factor (*cf*) =√(T/t)

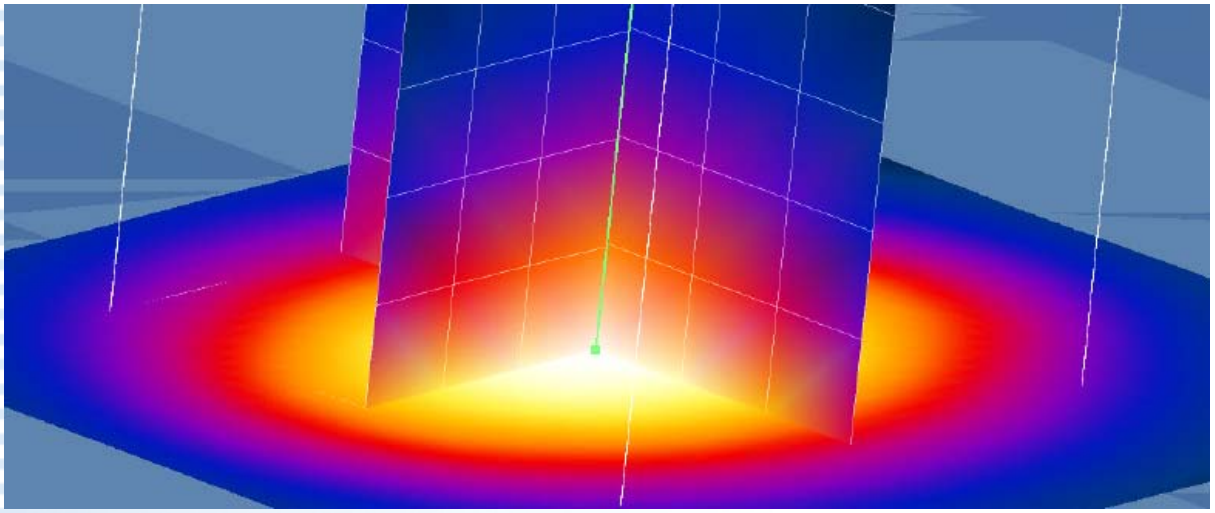


SAR Conversion

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i} \qquad E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2} \qquad SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1'000}$$

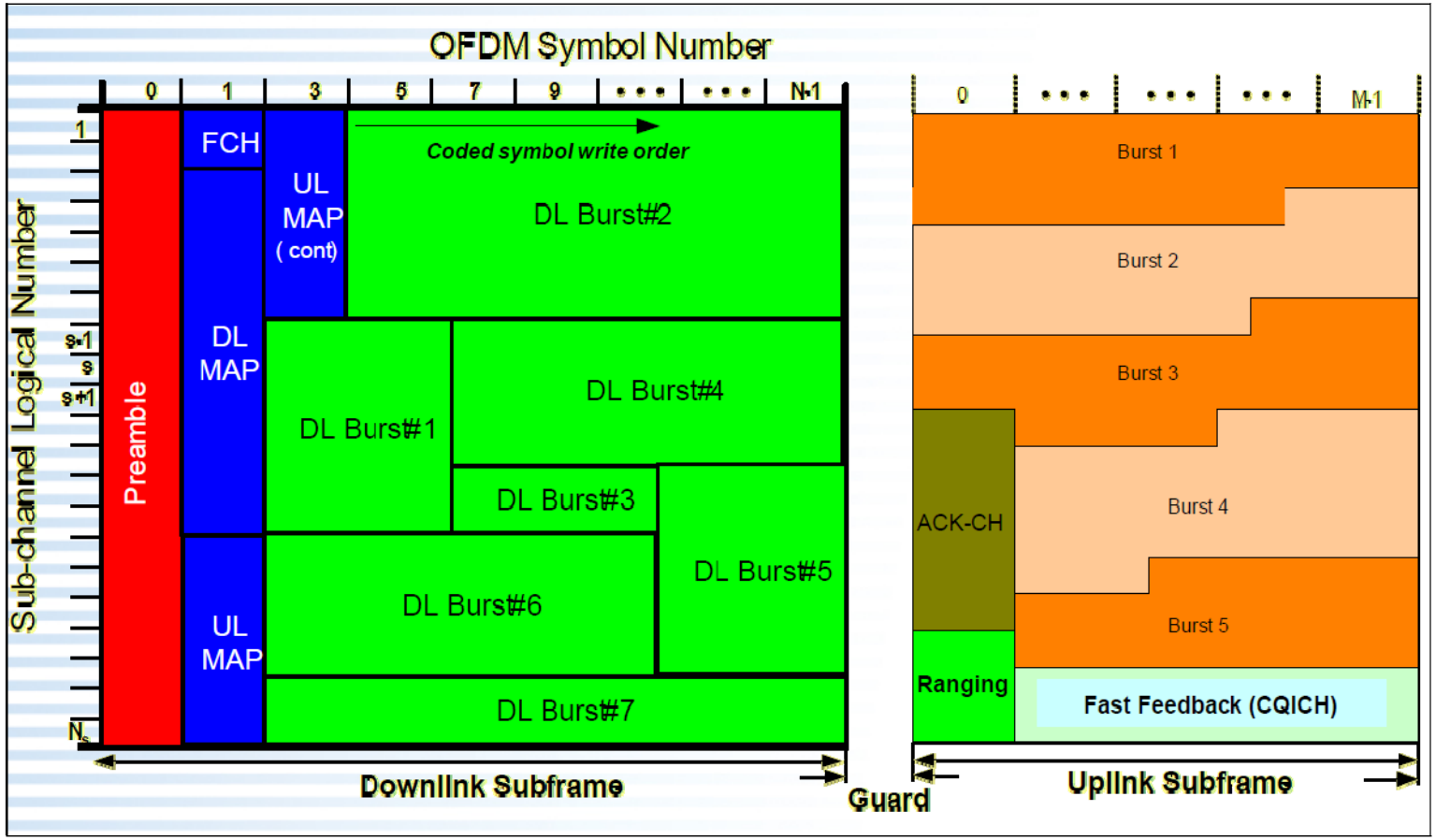
- depending on proximity of measurement points to the peak SAR location
  - measurement points could be at high or low field locations
  - the compensation could be in the square-law or linear region of the probe sensors
- all measured points must be in the square-law region of probe sensors to use probes calibrated with CW to ensure error is insignificant



WiMax Parameters

- frames are divided into UL & DL sub-frames of
  - different zone types (PUSC, FUSC, AMC etc.) & sub-channels
- zones contain bursts
  - a burst is assigned to a dedicated user
    - OFDM bursts are different than conventional power bursts
- smallest logical allocation
  - frequency domain = sub-channel = groups of sub-carriers
  - time domain = symbol time → guard time & carrier spacing
- sub-channels are group into segments
  - a segment can contain 1 – 6 sub-channels
- 1 slot is the minimum data allocation
  - a slot = 1 sub-channel = 1 ~ 3 symbols (3 symbols for UL-PUSC)

Wi-Max Frame Structures



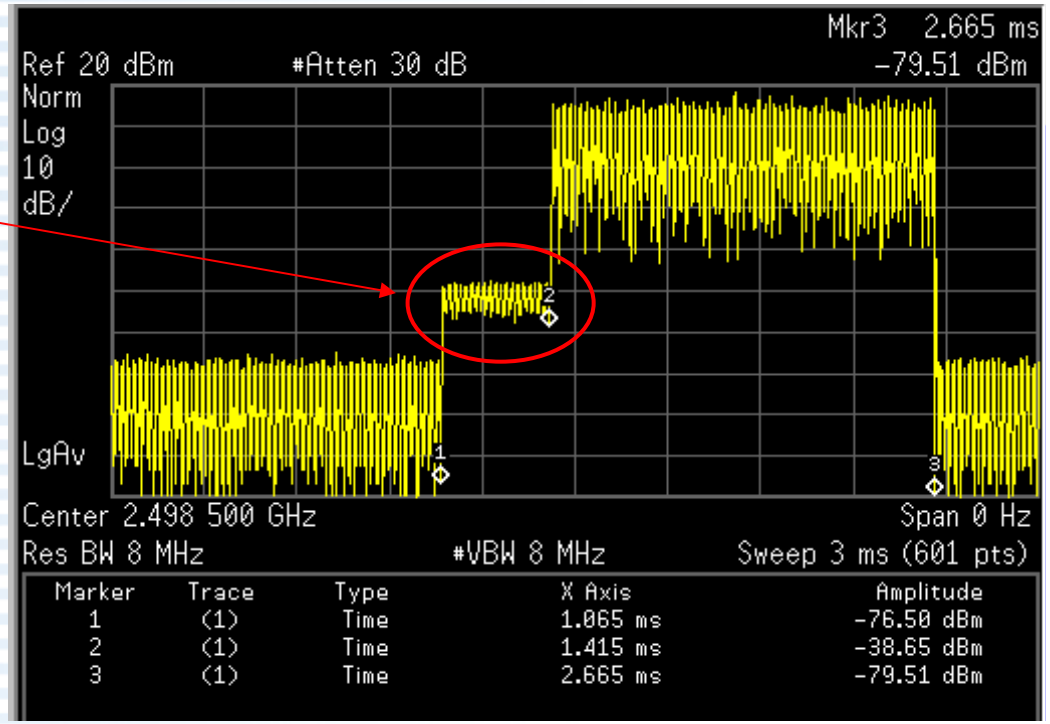
PUSC Zone Example

Parameter	Downlink	Uplink	Downlink	Uplink
System Bandwidth	5 MHz		10 MHz	
FFT Size	512		1024	
Null Sub-Carriers	92	104	184	184
Pilot Sub-Carriers	60	136	120	280
Data Sub-Carriers	360	272	720	560
Sub-Channels	15	17	30	35
Symbol Period, T_S	102.9 microseconds			
Frame Duration	5 milliseconds			
OFDM Symbols/Frame	48			
Data OFDM Symbols	44			

Control Symbol Example

- using DL:UL symbol ratio = 31:15 for SAR evaluation
  - with 12 traffic and 3 inactive control symbols in UL
  - the measured SAR needs scaling to account for control symbols
- duty factor = 12 x 102.857µs/5 ms = 24.69% (or 25% if using 12/48 symbols)
- "*cf* " factor for SAR measurement = 1 / 0.2469 = 4.05 (or 4 if 25%)
- If highest DL:UL symbol ratio is 29:18; additional SAR scaling is necessary

control is inactive, 40 dB down



SAR Scaling

- control channels may occupy up to 5 slots
  - a slot is a sub-channel with 3 symbol duration
- total slot = 35 for 10 MHz and 17 for 5 MHz channel configuration
  - CQICH – up to 2 slots & HARQ – up to 3 slots
    - control = 5/35 or 5/17 slots
  - control symbol max. power = traffic symbol max. power x 5/35 (or 5/17)
- when the control symbols are inactive during SAR measurement
  - SAR is scaled by
    - [(control symbol max. power) x 3 + traffic symbol max. power x max. UL traffic symbols] / [measured max. traffic symbol power x traffic symbols used in SAR measurement]; (i.e. desired/measured)
    - for 200 mW maximum average power with highest DL:UL = 29:18 and SAR is measured using DL:UL = 31:15 with inactive control symbols
      - 10 MHz = (200 x 5/35 x 3 +200 x 15) / (measured max. power x 12)
      - 5 MHz = (200 x 5/17 x 3 + 200 x 15) / (measured max. power x 12)
- "*cf*" factor of 4 is used in the SAR system to compensate the results

Equipment/Test Software Issues

- combinations of test software and signal generator have been typically used to setup WiMax devices for SAR testing
  - maximum output power is controlled by the test software
  - FCH, UL-MAP and DL-MAP are transmitted by the signal generator to configure the device on a frame by frame basis
    - transmitted info includes, DL:UL ratio, modulation, zone type, sub-channel configuration and other operating parameters
    - control symbols are not transmitted by the UL for this type of 1-way communication configuration
- basestation or protocol simulator setup
  - need to establish static conditions similar to those used with test software and signal generator
  - SAR measurements do not tolerate dynamic configurations

HSPA & HSPA+

Revising HSPA Attachment to KDB 941225

Revising PBA List in KDB 388624 for HSPA and add HSPA+

Typical Issues & Update

- when incorporating an approved (HSPA) transmitter module without modification into a host
  - HSPA power measurements should be quite similar to the original module, within the specified tune-up tolerance specifications
- when the same or similar support chipsets are used in different transmitters or modules
  - differences in RF components, design and layout can result in different output performance and SAR
  - power measurements of transmitters & modules using similar chipsets often been compared inappropriately, in attempts to resolve power measurement discrepancies
- Release 6 – HSPA
  - to be taken off PBA list
    - (also see PBA for ≥ 1.2 W/kg in KDB 447498)
- Release 7 - HSPA+
  - submit PBA with conducted power results if 16 QAM applies to UL
    - see TS 34.121-1 Table C.11.1.4 for operating parameters

LTE
- Preliminary Considerations -

Revised PBA List in KDB 388624 to include LTE

preliminary, not adding KDB procedures

LTE PBA Considerations

- LTE requires PBA for SAR
- include details on device characteristics and capabilities in inquiry
  - UE category, power class, modulation, channel BW, frequency band, voice & data modes etc.
- include test plan, test equipment requirements and device configuration setup details
  - submit KDB inquiry on test requirements before testing
- set up device for SAR testing according to
  - TS 36.101 Annex A.2.2, full RB allocation for the RMC configurations in QPSK and 16 QAM
    - ensure that MPR and A-MPR are disabled and cannot be triggered
  - include details of how the device can be configured and put into the RMC test operating modes with the test equipment (and test software)
  - include time and frequency domain plots to demonstrate the device is transmitting full RB allocation at maximum average output power

USB Dongle
&
External Peripheral Transmitters

- Update -

Revising USB Dongle Attachment to KDB 447498

Revising PBA List in KDB 388624 to include KDB 447498 Section 2 devices > 1.2 W/kg

USB Dongle Update

- existing procedures are intended for simple dongles with internally integrated antenna(s)
- if unclear, submit KDB inquiry before testing non-simple dongles
  - dongles with swivel/rotating connectors and/or antennas need additional considerations
  - certain spacers or contours/tapering added to a dongle housing may not enable the 5 mm test separation requirement to be relaxed
    - the 5 mm test separation distance for simple dongles is based on overall host, device and user operating configurations and exposure conditions
  - other evolving dongle configurations and variations
- also identify if swivel antennas may transmit in stowed position
- for dongles & external peripheral cards under section 2 of KDB 447498
  - PBA is required when SAR is above 1.2 W/kg
    - to be removed from TCB Exclusion List
  - FCC filing is optional

Wireless Wrist Watch

Interim Policies & Recommendations, not adding KDB procedures

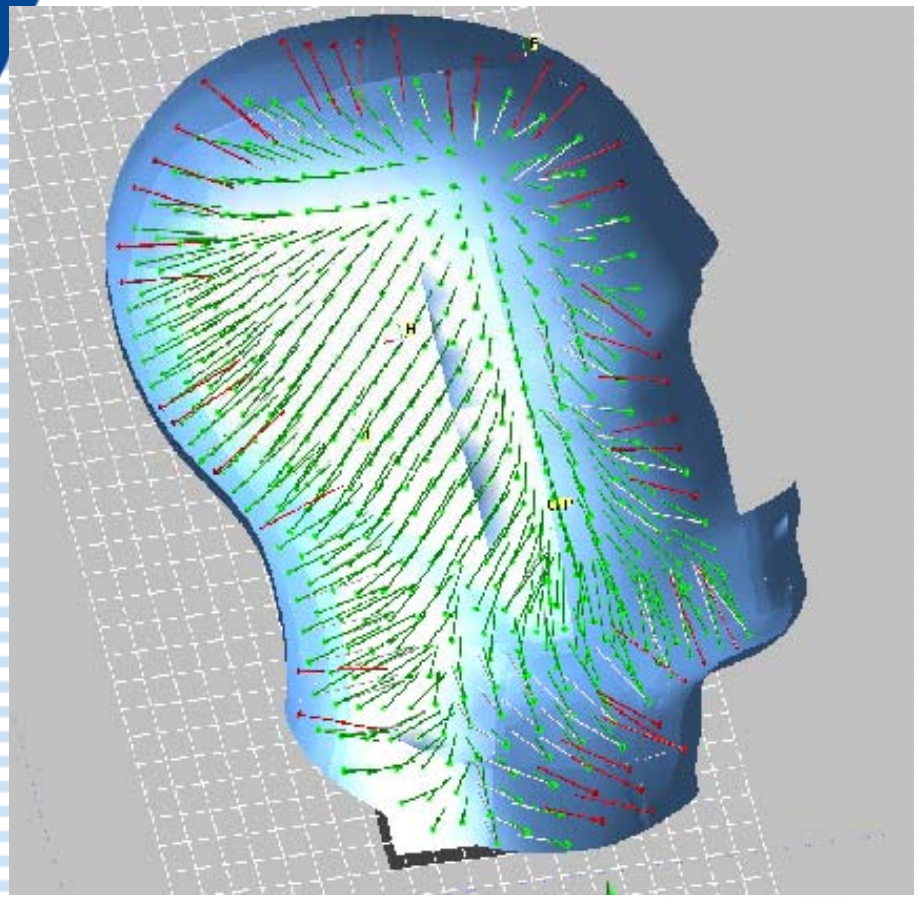
Design Related Issues

- operating configurations & exposure conditions
  - wrist-worn wireless watch supports voice and/or data
    - may support Bluetooth and held next to mouth operations
  - can support different wireless technologies and modes
  - may also support simultaneous transmission
- material and construction
  - one piece watch with wrist bands
    - back of some watches may not conform to flat phantom
  - watch & band may have plastic, metal or other materials
  - other electronics could be integrated or embedded in the wrist band

Testing Issues

- submit KDB inquiry to determine test requirements
  - identify antenna location & distances to various surfaces of watch
  - wrist SAR considerations
    - curvature of wrist band and housing often result in large gap between the back of the watch and flat phantom
      - requiring ad-hoc test considerations
- other exposure conditions
  - front of watch at 1 cm from flat phantom to cover other typical use conditions
- when non-standard phantom or test considerations are necessary
  - PBA is required
- user instruction considerations
  - device is limited to wrist-worn and next-to-mouth operations
  - if applicable, also identify simultaneous transmission requirements

Phantom Issues



- SAR measurement phantoms are not available for wrist watch
- watch designs vary and may not conform to a flat phantom or curvature around the head or neck of SAM phantom
- some regions of SAM cannot be reached by SAR probes
- phantom setup requires case-by-case consideration
- if less suitable phantoms must be used, ad-hoc procedures may be necessary to scale the measured SAR

Wireless Power Charging/Transfer Applications

Interim Policies & Recommendations, not adding KDB procedures

RF Exposure & Testing Issues

- wireless power charging devices may operate at various frequencies
  - low kHz to 1 GHz or higher
  - with substantially different operating power requirements
    - according to frequency, design and implementation
- depending on device operating configurations & exposure conditions
  - 1.1307(c) & (d) are considered on a case-by-case basis
    - according to exposure potential and likelihood of non-compliance
- wireless power could be used to charge
  - consumer electronics, medical or other devices
- exposure evaluation considerations
  - SAR measurements are quite difficult at low frequencies
  - SAR modeling at low frequencies may also require special techniques
  - MPE limits are quite restrictive at lower frequencies
- submit KDB inquiry with design & implementation details to determine RF exposure requirements
  - excluded from TCB approval when RF exposure evaluation is necessary
    - as a result of 1.1307 (c) or (d)
  - otherwise, PBA may be considered on a case-by-case basis

Low Transmission Duty Factor not Source-Based

Interim Policies & Recommendations, not adding KDB procedures

Device Characteristics

- devices with built-in transmitter and antenna for low duty factor data transactions and/or location-based services
  - no voice capabilities
  - sporadic or intermittent transmissions
  - transmitting only short messages (<< 1 sec) for
    - credit card & other purchase transactions/requests
    - transmitting user location to request consumer service information
  - transmission is not typically source-based
    - a minimum transmission turn-around time may be determined to estimate the worst case transmission duty factor
      - for SAR test reduction or exclusion considerations
- these types of devices may include certain
  - point-of-sales devices: hand-held, body-worn and next to body
  - location-based service devices: hand-held and next to body
  - location tracker: ankle or body-worn

Test Considerations

- transmission may include source-based & other duty factor
  - source-based: GSM/TDMA or periodic transmission timers
  - other transmission based duty factor
    - very short transmissions per transaction (<< 1 sec) followed by a fixed minimal turn-around time identified by the smallest receiving data block to establish a worst case duty factor (assuming this repeats continuously)
  - do not consider duty factors according to message/packet size, data speed, irregular data gaps
- must submit KDB inquiry to qualify for test reduction or exclusion
- if SAR evaluation is necessary, test according to the operating configurations & exposure conditions expected by the users
  - any accessories that may influence SAR must be tested accordingly, supplied with the device and cannot be easily disregarded by users
  - SAR tested at arbitrary separation distances is unacceptable
  - acceptable user operating instructions are necessary
  - if non-standard SAR procedures are used for testing
    - PBA is required; also submit KDB inquiry before testing

Test Reduction Considerations

- accessories & test frequencies -

Revising KDB 447498

Accessory Test Reduction

- passive accessories
  - may include batteries, body-worn and other audio accessories that are not primary radiating elements, but can introduce SAR changes
  - test reduction should be based on the SAR impact of each accessory
    - material, construction, separation, similarities etc.
    - test reduction must be confirmed by KDB inquiry before testing
      - PBA is required, may be waived on a case-by-case basis
- devices operating with optional antennas
  - antennas are primary radiating elements; therefore, they do not qualify for the same test reductions as passive accessories
  - each antenna must be tested independently to determine the highest exposure conditions
    - the highest exposure test configuration for each antenna is used to determine possible test reduction for accessories used with that antenna

Test Frequency Reduction

- 10% of mid-band frequency used in IEEE 1528-2003 has been mostly intended for cellphone frequencies
- when the number of test frequencies (channels) is not specified in the FCC procedures or KDB Publications, use the following equation
  - to ensure sufficient channels are tested for the frequency range and transmission bandwidth used by the transmitter
- confirm with KDB inquiry before testing using less frequency channels
  - PBA is required, may be waived on a case-by-case basis, for reduced test channels

$$N_c = Round\left[100\left(f_{high} - f_{low}\right)/f_c\right]^{0.5} \times \left[f_c/100\right]^{0.2}$$

f(bw)	30	80	150	350	450	650	750	837	915	1390	1450	1730	1880	2450	2600	3650	5200	5300	5600	5800
1.00%	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2
3.00%	1	2	2	2	2	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4
5.00%	2	2	2	3	3	3	3	3	3	4	4	4	4	4	4	5	5	5	5	5
10.00%	2	3	3	4	4	5	5	5	5	5	5	6	6	6	6	6	7	7	7	7
15.00%	3	4	4	5	5	6	6	6	6	7	7	7	7	7	7	8	9	9	9	9
20.00%	4	4	5	6	6	7	7	7	7	8	8	8	8	8	9	9	10	10	10	10
25.00%	4	5	5	6	7	7	7	8	8	8	9	9	9	9	10	10	11	11	11	11
30.00%	4	5	6	7	7	8	8	8	9	9	9	10	10	10	11	11	12	12	12	12

Simultaneous Transmission SAR Evaluation

Adding Supplemental Attachment to KDB 450824

Simultaneous Transmission SAR Evaluation

- to be moved from Exclusion List to PBA List
  - when simultaneous transmission SAR evaluation is required
    - PBA is required for TCB approval
    - consider submitting KDB inquiry before testing
- SAR test reduction and exclusion procedures
  - KDB 616217 and its supplement
    - notebook/netbook/laptop computers
  - KDB 648474 for handsets

SAR System Verification

- Dipole Calibration -

Adding Supplemental Attachment to KDB 450824

Dipole Characteristics

- SAR dipoles are optimized in the test configurations required by SAR measurement standards
  - for measurement repeatability
  - lab-to-lab reproducibility
- specific design parameters are specified in SAR standards
  - at selected frequencies only (mostly for popular wireless bands)
  - to ensure acceptable electrical and mechanical tolerances
  - to achieve consistent SAR results
- the target SAR values for these specific dipoles are derived by standards committees in specific test configurations
  - using numerical simulation and experimental validation
- SAR standards recommend regular calibration (annual)
  - to verify electrical specifications and target SAR of the dipoles

Performance Validation

- when dipoles are constructed according to the parameters and tolerances required by measurement standards (both electrical & mechanical)
  - additional numerical validation is not necessary
  - experimental validation is required to verify the target SAR value
    - the dipole validation requires an already validated SAR system
- dipoles may also be optimized individually for impedance matching & return loss requirements (50 Ω and ≤ 20 dB) for specific phantom conditions
  - the actual target SAR values may deviate from those in SAR standards, typically within a small range
  - therefore, experimental validation is important
- at frequencies where dipole parameters are not specified in SAR standards
  - the same procedures used by standards committees are necessary
    - using both numerical and experimental validation

Calibration Requirements

- SAR dipoles must be calibrated (verified) with a SAR system that has been fully validated according to measurement standards protocol
  - a calibrated dipole is required to validate the SAR system
  - calibrating a dipole on a system that needs the dipole to validate it is unacceptable
- the dipole must be calibrated according to the phantom configuration, tissue dielectric parameters and dipole spacing used by individual labs
- immediate re-calibration is required if
  - a dipole is damaged and properly repaired to meet requirements
  - the measured SAR deviates by more than 10% from the last calibrated value
  - compared to the most recent measurements made within 12 months
    - return loss changes by more than 3 dB or not meeting the -20 dB minimum requirement
    - real or imaginary part of impedance changes by more than 2.5 Ω
- with proper documentation, 3 year calibration cycle is acceptable when immediate re-calibration is not required

SAR System Verification

- Head or Body Liquid -

Included as Part of Supplemental Attachment to KDB 450824 for Dipole Calibration

Head or Body Liquid

- when head and body liquids are required for testing a device
  - SAR system verification should be performed using the tissue liquid required to test the primary operating & exposure conditions of the device
    - for example; head for cellphones and body for data cards
- when the dominant exposure configuration cannot be identified
  - either head or body liquid may be used for SAR system verification
  - the selection must be clearly explained in SAR report
- regardless of head or body liquid is used for system verification
  - the SAR probe must be calibrated for both head and body
  - the same probe must be used for dipole and device measurements
- if the measured dipole SAR is more than 8% from the calibrated target SAR
  - separate system verifications are required for head and body