RF Exposure Procedures

Presenter: Jake Novicky
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*Slides 6, 17, 18 changed after presentation
Overview

- Power Density Simulation Report Requirements
- Millimeter Wave RF Exposure Evaluation
- 5G New Radio (NR) Sub 6GHz
- Time-Averaging SAR (TAS)
- 802.11ax Transmitters
- Sensor Array Measurement Systems
- Dynamic Antenna Tuning
- Proximity Sensor PAG
- Tissue Simulating Liquids
Millimeter Wave RF Exposure Evaluation

- Recently seen the first grants for handsets utilizing 5G mmWave technology
- There are a few existing grants for mmWave mobile devices
- Combination of numerical simulation and measurements with Total Exposure Ratio Criteria to demonstrate compliance
- Slightly different approaches, but similar measurement methodologies
Power Density Simulation Report Requirements

The following should be considered as minimum reporting requirements for documenting near field power density based on simulations for the purposes of reducing compliance measurement requirements.

- FDTD or other numerical modeling algorithm implementation and validation
- Transmitter model implementation and verification
- Test device positioning
- Steady state termination procedures
- Power density in 4 cm² averaging area
- Test results for determining worst case or justification for reduced measurement configurations
Recommended Millimeter Wave RF Exposure Test Procedure

- Simulate high power beam configurations for antenna arrays
  - For example, all array elements transmitting
- Use beam ID with highest PD as basis for measurement
- Begin by measuring PD with full bandwidth for different polarizations at 1 QPSK, 1 RB, Mid Ch.
- If result > 50% limit, repeat for 2nd, 3rd, and 4th highest beam
- Measure PD for other RB sizes, modulations, bandwidths, component carriers, channels, and device sides, based on max result from previous step
- PD scans need to be of sufficient size to fully capture hotspot
  - Fields at the measurement region boundary should be ~20-30 dB below the peaks
Simulate all beams with all array elements transmitting in Near-Field for selected antenna

Measure Beam ID with highest PD for Selected Side with Full Bandwidth

1) SISO, Vertical Polarization, 1 RB, QPSK, Mid Ch.
2) SISO, Horizontal Polarization, 1 RB, QPSK, Mid Ch.
3) MIMO, 1 RB, QPSK, Mid Ch.

Are Measurement Results (1, 2, 3) above 50% of Lim2?

YES

For the configuration of maximum among 1), 2), 3) select second, third, and fourth highest beams from PD Simulation

4) Second Beam ID, 1 RB, QPSK, Mid Ch., Full BW
5) Third Beam ID, 1 RB, QPSK, Mid Ch., Full BW
6) Forth Beam ID, 1 RB, QPSK, Mid Ch., Full BW

NO

7) For Maximum among 1) – 6) test Half and Full RB
8) For Maximum among 1) – 7) test other modulations
9) For Maximum among 1) – 8) test other bandwidths
10) For Maximum among 1) – 9) test other component carriers
11) For Maximum among 1) – 10) test low and high channel

12) Test other sides for Maximum among 1) – 11) utilizing the Beam ID with highest PD from simulation for that particular side

Legend

Simulation
Power Density Measurement
Decision/Evaluation
Millimeter Wave Additional Considerations

- A sufficiently large measurement region and proper measurement spatial resolution are required to maintain field reconstruction accuracy.
  - Fields at the measurement region boundary should be ~20-30 dB below the peaks.
- "Reported" PD is not directly applicable but uncertainty must be taken into account for final results.
5G New Radio (NR) Sub 6GHz

- Existing FCC KDB Guidance should be applied in relevant situations.
- Test Equipment and call boxes are not readily available
  - Factory Test Mode should be used for testing in interim
  - A KDB Inquiry should be submitted if there are limitations to FTM that do not allow for required testing
- Simultaneous Transmission Scenarios should be evaluated independently
Time Averaging SAR

- Addressed extensively in previous TCB Workshops
- Verification of algorithm is key
  - Need to see multiple test cases: startup, steady state, call drop and reconnect
- Looking for “Moving Average” for all test cases
- Averaging time window depends on frequency

Total exposure ratio: \[ \frac{SAR}{SAR \text{ Limit}} + \frac{PD}{PD \text{ Limit}} < 1 \]
802.11ax SAR Testing

General principles of FCC KDB Publication 248227 D01 can be applied to determine the SAR Initial Test Configurations and test reduction.

In applying the test guidance, the IEEE 802.11 mode with the maximum output power (out of all modes) should be considered for testing.

For modes with the same maximum output power, the guidance from section 5.3.2 a) of FCC KDB Publication 248227 D01 should be applied, with 802.11ax being considered as the highest 802.11 mode for the appropriate frequency bands.
When SAR testing for 802.11ax is required:

- If the maximum output power is highest for OFDMA scenarios, choose the tone size with the maximum number of tones and the highest maximum output power.
- Otherwise, consider the fully allocated channel for SAR testing.
- When SAR testing is required on RU sizes less than the fully allocated channel, use the RU number closest to the middle of the channel, choosing the higher RU number when two RUs are equidistant to the middle of the channel.

Maximum output powers for each RU size should be measured.
Sensor Array Measurement
Considerations

Guidance from previous FCC presentations at
TCB Workshop is still applicable
- Allowed for pre-scan test reduction measurements
  for 2G/3G technology
- Final tests to demonstrate compliance should be
done on a traditional SAR measurement system

Still evaluating for pre-scan measurements for
4G and Wi-Fi technologies

Awaiting additional information from IEC
62209-3 standards committee

Draft KDB Publication in development
Dynamic Antenna Tuning

SAR is measured according to required procedures with dynamic tuner active allowing device to automatically tune.

Auto-tune state determined by device during normal SAR measurement verified and listed alongside the reported SAR results.
Dynamic Antenna Tuning

Additional single point SAR measurements to verify other tuner configurations result in equivalent or lower SAR value
- total number tuner states divided evenly among each supported band / air interface and exposure condition combination
- tuner state is established remotely so that the device is not moved for the entire series of single point SAR measurements for the tuner states in each combination
- single point measurements performed at the peak SAR location of the highest measured SAR configuration for each combination. SAR probe remains stationary throughout the entire series of single point measurements for each combination
- if any single point SAR measurement result is > 1.2 W/kg for a band/exposure condition combination set, all supported tuner states are evaluated with single point SAR measurements for the combination.
Dynamic Antenna Tuning

- Applicable only to implementations where tuning hardware is separate from the antenna and does not influence antenna performance (other than impedance matching).

- Future update to KDB Publication 648474 D04 Handset SAR

- PAG is required however TCBs/grantees may use PAG Re-use procedures
  - Notification KDB inquiry should include operational description of dynamic antenna tuning implementation and approved test procedure
  - Only applicable if prior implementation remains the same in new application
Power Reduction Pre-Approval Guidance

- Use of proximity sensors in both mobile and portable devices for the purpose of power reduction has become widespread and commonplace.
- These sensors have been implemented in a wide array of device form factors and sizes.
- Procedures for determining proximity sensor triggering distance, coverage, and tilt angle are outlined in section 6 of FCC KDB Publication 616217 D04.
May utilize various sensing mechanisms, including capacitive, thermal, Hall effect (magnetic), among others.

Due to the well established data and uniformity in implementation the following power reduction mechanisms do not require PAG:

- Power Reduction based on Capacitive Proximity Sensors
- Power reduction based on audio routing to the earpiece of the device
- Power Reduction based on user-enabled hotspot mode via software
Due to the high variability in implementation the following proximity sensor types will still require a PAG:

- Thermal (Infrared)
- Motion
- Hall Effect/Magnetic
- Other mechanisms not listed in previous slide
Tissue Simulating Liquids (TSL)

- Effective February 19, 2019, FCC has permitted the use of single head-tissue simulating liquid specified in IEC 62209-1 for all SAR tests.
- Mix and Match of traditional FCC SAR TSLs and IEC 62209-1 TSL in a single application is not permitted.
- TSL can be changed in a Permissive Change. If SAR increases and original SAR > 1.2 W/kg, additional SAR measurements will be required.
- IEC 62209-1 TSL is an alternative, not mandatory at this time.
- If FCC parameters are used, ±5% tolerance. If IEC parameters, ±10% tolerance.
Questions?

Thank You!