RF Exposure Guidance Updates

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Note: The views expressed in this presentation are those of the authors and may not necessarily represent the views of the Federal Communications Commission.

Contents

Take-Home Message

- Following up on the directions outlined in the Oct 2023 Workshop, new KDB 447498 is still in progress, to better support rulemaking efforts, enhancing our test-based approach so to develop stronger technical foundations for our guidance.
- Changes being considered to provide uniform guidance on RF eXposure (RFX) testing for evolving wireless communication devices.
- Welcoming informal comments on the proposals in this presentation, poised for introduction in the new 447498 draft.

Reducing Required Data in RFX Test Exhibits

New Lab Testing and Analysis to Reduce Size of Compliance Test Datasets

- Effort in progress towards reduction of required test cases for RFX compliance reports.
- One key point is to identify SAR and PD variations vs. frequency.
- Identification of worst case among modulation schemes and resource block parameters, accounting for potential issues from specific device nonlinearities.
- Consider possible *ad hoc* setup (could be RF–technology dependent, not necessarily "all bits up") to conservatively represent all the DUT use cases.
- Include analysis for simplifying (possibly eliminating) AGGREG PAG item, by looking into device functionality details, such as adherence to 3GPP standards.

Accessories and Peripherals to RF Devices

- Revision on RF Exposure guidance for "accessories and peripherals" to be connected to other RF devices
- Guiding principle already considered in KDB 680106v04-Section 4 "OPERATIONS OF WPT DEVICES CO-LOCATED WITH OTHER RF DEVICES"
- In summary, for Equipment Authorization purposes:
  - Emissions due to other independently authorized transmitters (e.g., "accessories") do not need to be considered to account for possible cumulative effects with the emissions from the device under test DUT. [See KDB 680106, Section 4].
  - However, testing in all "typical" operating conditions for establishing compliance of the DUT, include accounting for the presence of passive structures external to the DUT that may alter the emission patterns.

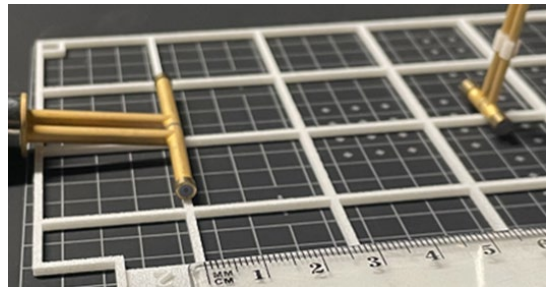
"*Form Factor*"-Independent RFX Testing

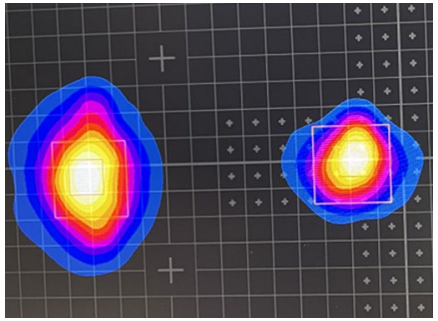
Lab Testing Towards New, "*Form-Factor*"-*Independent* Guidance

- Uniform guidance for RF devices to avoid issues such as "9 x 5" limits for Hotspot, 20 cm diagonal threshold for "laptops" vs. "UMPC", etc.
- Guidance to focus on RF exposure evaluations, and not on commercial, unspecified, and ever-evolving nomenclature.
- Analysis to identify uniform and consistent guidance for minimum test separation distance among use cases for 2.1093-*Portable* devices.
- Lab testing in progress to analyze non-monotonic patterns for SAR vs. distance in the 0 to 10 mm range.
- Special cases can be dealt with via ECR per KDB Pub. 951290.

Extension of SPLSR Formula (I)

- SAR to Peak Location Separation Ratio (SPLSR, KDB 447498) recap:
  - SAR $\propto |\mathbf{E}|^2 = E^2$, $\quad \mathbf{E} = \mathbf{E}_A + \mathbf{E}_B$, $\quad |\mathbf{E}|^2 = |\mathbf{E}_A + \mathbf{E}_B|^2 = E_A^2 + E_B^2 + 2\,\mathbf{E}_A \cdot \mathbf{E}_B$
  - The SPLSR formula identifies cases where $|\mathbf{E}_A + \mathbf{E}_B|^2 \approx E_A^2 + E_B^2$
- Validation was performed with exact, analytic, near-field expressions for thin dipoles, placed at different distances.
- Preliminary recent lab testing confirmed expected behavior, and justification for SPLSR extension based on SAR compliance being a conservative estimate of PD compliance.
- As applicable, account for differences between correlated vs. uncorrelated transmissions, to identify worst-case scenarios.





Extension of SPLSR Formula (II)

- Work in progress to devise a "Generalized" SPLSR formula:
  - Recast the formula in terms of TER quantities, i.e., based on normalized SAR and for field and power density MPEs.
  - Include power density contributions and contributions of MPE below 4 MHz in place of SAR (the latter already allowed for non-SPLSR evaluations per TCB Workshop Apr. 2022-4.1 procedure and now in KDB 680106v04).
- Lab testing for representative configurations to validate the generalized approach.
- Generalized SPLSR to include SAR or PD from validated numerical simulations.
  - Example: SAR_A and SAR_B are used for evaluating SPLSR between two transmitters "A" and "B". SAR_A can be from lab testing while SAR_B is from a numerical simulation (properly validated and deemed acceptable). NUMSIM PAG will apply.

Module Integration in "Crowded" Products (I)

Main Challenge for *Module* Integration in Host Products

- Integration of transmitters with modular grant ("*Modules*") needs to account for the host device form factor: in an excessively "crowded environment" near-field emissions patterns may add up and be re-shaped, leading to noncompliance.
- Work in progress on *Module* uniform integration procedures for all *§2.1093-Portable* host devices to prevent incorrect RF exposure evaluations.
- Important: in many cases, the entire host certification may represent a better/easier overall route vs. integration of *Modules* that require permissive changes.

Module Integration in "Crowded" Products (II)

Ensuring Consistency for *Modules* Integration Procedures

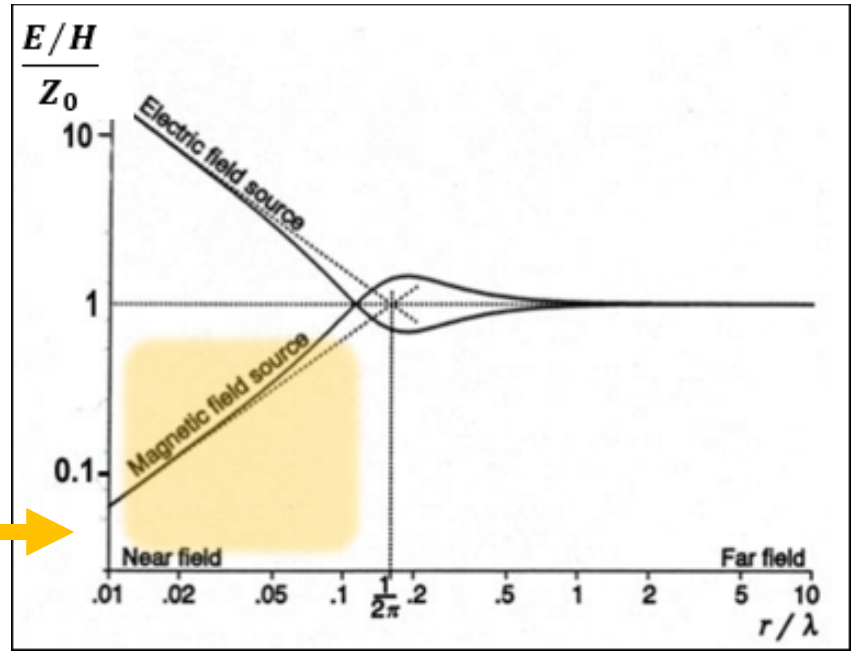
- Working towards improved *Module* integration guidance, regardless of the host outer enclosure form factor.
- RF Exposure integration constraints to be based on actual position of radiating structures in the host and SAR/PD data from Stand-alone *Module* certifications.
- The SPLSR criterion automatically constrains the minimum distance between *Modules* thus implicitly proving restrictions for "small form factors".
- Test and analysis in progress to extend the SPLSR approach for module integration to all devices.
- Considering extension of Host Environment Simulator (HES) provisions of KDB 996369 D05 "Split Module v01" to other *Module* integration cases.

RF Exposure Test Exemption Below 300 MHz

- Compliance Test exemption criteria for Equipment Authorization parallels the Section 1.1307 test exemptions from the need for performing an Environmental Assessment between 300 MHz and 3 THz.
- For the purpose of Equipment Authorization, RFX test exemptions below 300 MHz will be reaffirmed, maintaining present provisions from 447498-v06.
- Test exemptions criteria previously outlined in KDB 447498 draft will be presented with an enhanced format to simplify its application to the full frequency range for equipment authorization (9 kHz to 3 THz).
- Lab tests and modeling for representative hardware is underway for validation of the test exemption formulas for 2.1093-Portable devices.

Unintentional Radiator Sources Compliance (I)

- URS presently covered by interim Note in KDB 447498 Main Page
- Devising "test compliance friendly" procedure based on Part 15 B test data for equipment authorization of RF devices that include Unintentional Radiator Sources (URS)
- Only special cases will be required to account for URS contribution to the RFx evaluation, when a Part 15 B testing cannot provide a good measure of the total radiated power.
- This occurs when the Part 15 B measurement is done in the near field and for a "predominantly magnetic" source.



Adapted from [*K. McDonald, 2004*]

Unintentional Radiator Sources Compliance (II)

- An RF device that includes an URS exempted from authorization (per §§ 15.23, 15.103, and 15.113) will be exempted from including the URS contributions in the total RF Exposure evaluation budget.
- For non-exempt URS, leveraging Part 15 B EMC compliance test data can be used for addressing RFX compliance.
- For Part 15-B compliant URS, in almost all cases, the radiated power estimate based on near-field components is far below the 1-*mW* RFX test exemption level.
  - Exceptions may be found for emissions in the tens of kHz from magnetic-type sources (i.e., E/H= $Z_w << Z_0 \approx 377\ \Omega$).
  - These are cases where Part 15-B test data collected in the near-field, may lead to a power estimate that is less than the actual power radiated by the device [TCBC Workshop Apr. 2023].

Unintentional Radiator Sources Compliance (III)

- General procedure under consideration for identifying the URS special cases:
  - If URS is Part 15 B compliant based on test distance in the far field, no further RF Exposure contribution needs to be reported/filed.
  - Compute the near field transition boundary based on the URS frequency and size.
  - Check if Part 15 B test distance is the near field, provide additional H field measurement: if $E/H \geq 377\ \Omega$, no further RF Exposure contribution needs to be reported/filed.
- URS special cases evaluation, supported by formula/table to be introduced in the next KDB 447498 draft along with example and actual test data.

Devices Certifications Require an RFX Exhibit (I)

- RFX exhibits required per Interim Note in current 447498 Main Page :
  - These exhibits must provide a full discussion of how RF exposure compliance was established, including numeric data.
  - These exhibits are useful for proper evaluation of applications for certification, especially when test exemption conditions are leveraged.
  - The reviewer will then have all the essential elements, while reference to the actual measurement details are provided by referencing the EAS Report files and location therein.
- Requirement waived for special cases (URS, etc.) per 447498 Main Page Note.
- A template-guidance example follows, to illustrate what is expected in the RFX compliance exhibits.

Devices Certifications Require an RFX Exhibit (II)

Example: Template for a RF Exposure compliance exhibit

XYZ Test Laboratories Inc.

RF Exposure Exhibit - FCC ID ABC01-0001

This exhibit is provided to demonstrate RF exposure compliance for FCC ID ABC01-0001 (hereafter referred to as the Device Under Test, or DUT), in accordance with FCC KDB 447498.

The DUT is certified as a *2.1093-Portable* device under Parts … for general population exposure.

The DUT is equipped with … independent transmitters, TX1, TX2, … TXn. TX1 and TX2 can operate simultaneously, while TX3 can only operate by itself, as constrained by design.

Devices Certifications Require an RFX Exhibit (III)

Example (continued): Template for a RF Exposure compliance exhibit

Transmitter TX1

Conducted Power= … mW Frequency Range= … to … MHz

Requires SAR body testing, test separation distance is 5 mm as allowed in KDB Pub. 447498

Applicable c

Maximum 1-

Details for th
SAR_Evalua

Transmitter TX2

Conducted Power= … mW Frequency Range= … to … MHz

Requires SAR body testing, test separation distance is 5 mm as allowed in KDB Pub. 447498

Applicable compliance limit is 1-g S

Maximum 1-g SAR was evaluated a

Details for this evaluation are provi
SAR_Evaluation", page … and Tabl

Transmitter TXn

Conducted Power= … mW Frequency Range= … to … MHz

Requires SAR head-front face testing, test separation distance is 50 mm as allowed per ECR-RFXd inquiry … .

Applicable compliance limit is 1-g SAR average=1.6 W/kg

Maximum 1-g SAR was evaluated at 0.2 W/kg, thus TXn is compliant.

Details for this evaluation are provided in are provided the EAS exhibit file "ACB01-0001-SAR_Evaluation", page … and Table … .

Devices Certifications Require an RFX Exhibit (IV)

Example (continued): Template for a RF Exposure compliance exhibit

Simultaneous Transmissions

Since only TX1 and TX2 can operate simultaneously, while TX3 can only operate by itself, as constrained by design, the only applicable simultaneous transmission case is TX1 + TX2

TX1 + TX2

The sum of the maximum SAR values for TX1 and TX2 during simultaneous operations is: 1.2 + 0.5 = 1.7 > 1.6.

The closest distance between the antennas of TX1 and TX2 is … mm. Thus, applying the SPLSR formula (from KDB Pub. 447498) it is found SPLSR=(…) = 0.03

Thus, the SPLSR formula condition SPLSR< 0.04 is met, and the simultaneous RF exposure compliance can be determined based on the individual transmitter compliance. Since both TX1 and TX2 are compliant, then in this case also the TX1 + TX2 simultaneous transmission is complaint.

Conclusions

- New RF Exposure guidance built from Lab testing and simulations on specific RF Devices and configurations
- This approach strengthen the ability to provide uniform and consistent procedures for equipment authorization across different use cases and rule parts.
- Forthcoming publications will document technical foundations for the guidance provided, so to facilitate extensions and changes that can keep equipment authorization abreast of evolving technologies