



Carrier Aggregation and Simultaneous Transmissions

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Contents

- 1. Summary**
- 2. Carrier Aggregation Definition**
- 3. Compliance Relevance**
- 4. Carrier Aggregation and RF Exposure**
- 5. SAR Frequency Dependence**
- 6. Conclusions**



Summary

- This effort reflects the recent update to the PAG list regarding the **removal** of the **AGGREG** item.
- While the use of carrier aggregation in RF devices does **no longer** trigger a **PAG**, specific guidance is provided to support compliance of Equipment Authorization applications.



Carrier Aggregation Definition

3GPP Language

- “**Carrier Aggregation**” introduced in 3GPP-release 10: “*A terminal receives or transmits on multiple component carriers (frequency blocks assigned to the same user)*”, definition from [[Merias, 2022](#)]
- The general concept refers to the situation where the transmission of a signal with a given bandwidth is split into **different spectrum segments**, and it can be applied to both TDD and FDD modes of operation.
- Each of these spectrum segments is identified through a frequency named “**Components Carrier**”, CC.



Compliance Relevance (I)

Carrier Aggregation and FCC Compliance

- From the FCC compliance perspective, the use of Carrier Aggregation (CA, hereafter) requires ensuring that the **applicable rules are met** in each portion of the spectrum that is used by each component carrier.
- *Example*: CA using FR1 and FR2:
 - CA_n2A-n260A(NR). n2A is at ~1.9GHz and n260 is at ~39GHz, both used in the US.
- In general, CA can be applied to both transmission, or **uplink** (UL) from the Device Under Test (DUT) perspective, and reception, or downlink (DL)
- From FCC compliance, **only UL operations** are relevant (in this context, FCC compliance is presently not concerned about receivers)



Compliance Relevance (II)

CA-DL Test Reductions

- The **uplink (UL)** is the only aspect of concern; the downlink (DL) pertains to receiver functionality, thus it is not related to EMC or RF exposure compliance limits related to cumulative effects of different transmitters.
- The various UL configurations permitted by design need to be identified. It is possible that in **some cases the DL impacts** the available options for UL, but ultimately, compliance is to be referred to mapping all possible UL cases.
- Equipment authorization applications shall refer to the **worst-case UL power** as resulting from all the possible modes of operations. Accordingly, CA-DL cases do not need to be analyzed separately, unless pertinent to establishing UL power setting.
- This guidance **supplements**, where applicable, previous guidance in KDB 941225-D05A.



Compliance Relevance (III)

EMC and CA Concerns

- From a simultaneous transmission perspective, compliance verification of transmitters employing CA techniques considers
 - Total **Power** or Power Density Requirements (Conducted or Radiated)
 - If CCs are subject to one or more **rule parts**, they need to be investigated
 - Any other **power adjustments** that may need to be implemented as a result of carrier aggregation
 - Bandwidth of Operation
 - Contiguous or non-contiguous transmissions may impact how operating BW needs to be defined
 - **Out of Band and Spurious** Emission
- KDB publications and standards have addressed the points above for **both licensed and unlicensed** operations subject to the FCC's rules
 - KDB Publication 789033 for unlicensed U-NII operation
 - ANSI C63.26 for licensed operation



Carrier Aggregation and RF Exposure (I)

RF Exposure and CA Concerns

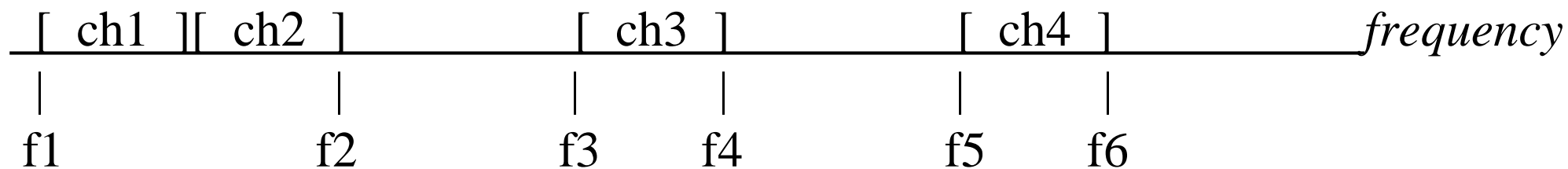
- Recent “AGGREG” PAG item focused on ensuring the proper choice of **frequencies** to use in **RF exposure testing**.
- This aspect is maintained in the **present guidance**: all RF exposure tests (both SAR and MPE) must **frequency sampling in each portion** of the spectrum that is being used (and not frequencies in between CA bands).
- The **frequencies** selected for the RF exposure evaluation shall be **selected** according to the provisions in KDB 447498-D04 (Sect. 3.1.6 on “Determination of the Frequencies for SAR Testing”), in each **noncontiguous** frequency interval that contains contiguous channels (regardless of being formally defined as “band”).



Carrier Aggregation and RF Exposure (II)

Example - Sketch of a carrier aggregation scheme

- Two contiguous channels, “ch1” and “ch2,” in the frequency range $f1 - f2$, plus two non-contiguous channels, “ch3” and “ch4”, in a higher frequency range, the first from frequency $f3$ to $f4$, and the second from frequency $f5$ to $f6$.



- The **sampling frequencies** for the RF exposure evaluation shall be computed **separately** for the three frequency intervals $[f1, f2]$, $[f3, f4]$ and $[f5, f6]$.



SAR Frequency Dependence (I)

RF Exposure – SAR Variations vs. Frequency

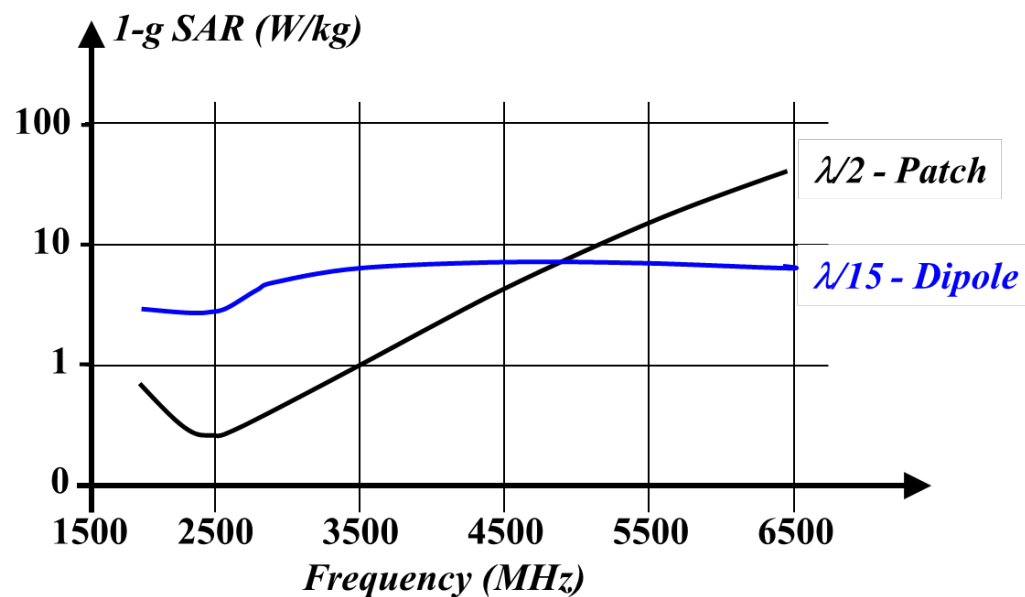
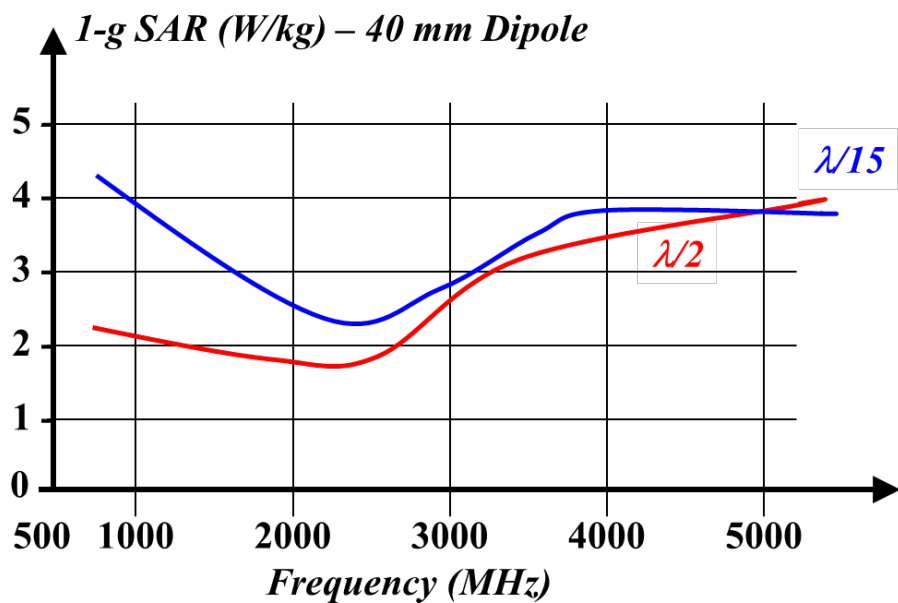
- Variation of **SAR vs. frequency** is expected due to the known frequency dependence of **both conductivity and permittivity** [e.g. [Baker-Jarvis, 2010](#)]; however the exact behavior may be affected by the antenna type and measurement distance.
- Accordingly, the present guidance for RF exposure testing (KDB 447498-D04, Sect. 3.1.6) provides a formula for the **frequency-dependent selection** of the number of channels for a given transmission frequency range (band).
- This selection ensures that a **sufficiently granular sampling** in frequency is provided to account for SAR frequency variations.



SAR Frequency Dependence (II)

(Continued ...) RF Exposure – SAR Variations vs. Frequency

- Example of SAR vs. frequency profiles from measurements and simulations are qualitatively sketched here below (original data in [[Mazady, 2015](#)]).





Conclusions

- The approach in this guidance **simplifies** equipment authorization compliance testing.
- Updated content related to these topics is to be integrated as part of a **revised** RF exposure KDB **Publication**.
- A better understanding of SAR frequency dependence is an important research topic that may impact other RF exposure compliance **test reduction** procedures.
- **Work is in progress** to collect additional data for a more extensive characterization of **SAR and power density vs. frequency**, including spectrum above 6 GHz.