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New FCC RF Exposure Rules

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Presentation

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Topics

Background and Introduction to Changes

New Rules
- Mitigation Methods for Transmitter Sites with Fixed RF Sources
- New Exemptions

Other Rule Revisions
- 47 CFR § 2.1091 (Mobile device RF radiation exposure)
- KDB 447498 D04v01 (Current General RF exposure draft policy)

Possible Future Scenarios and Procedural Changes

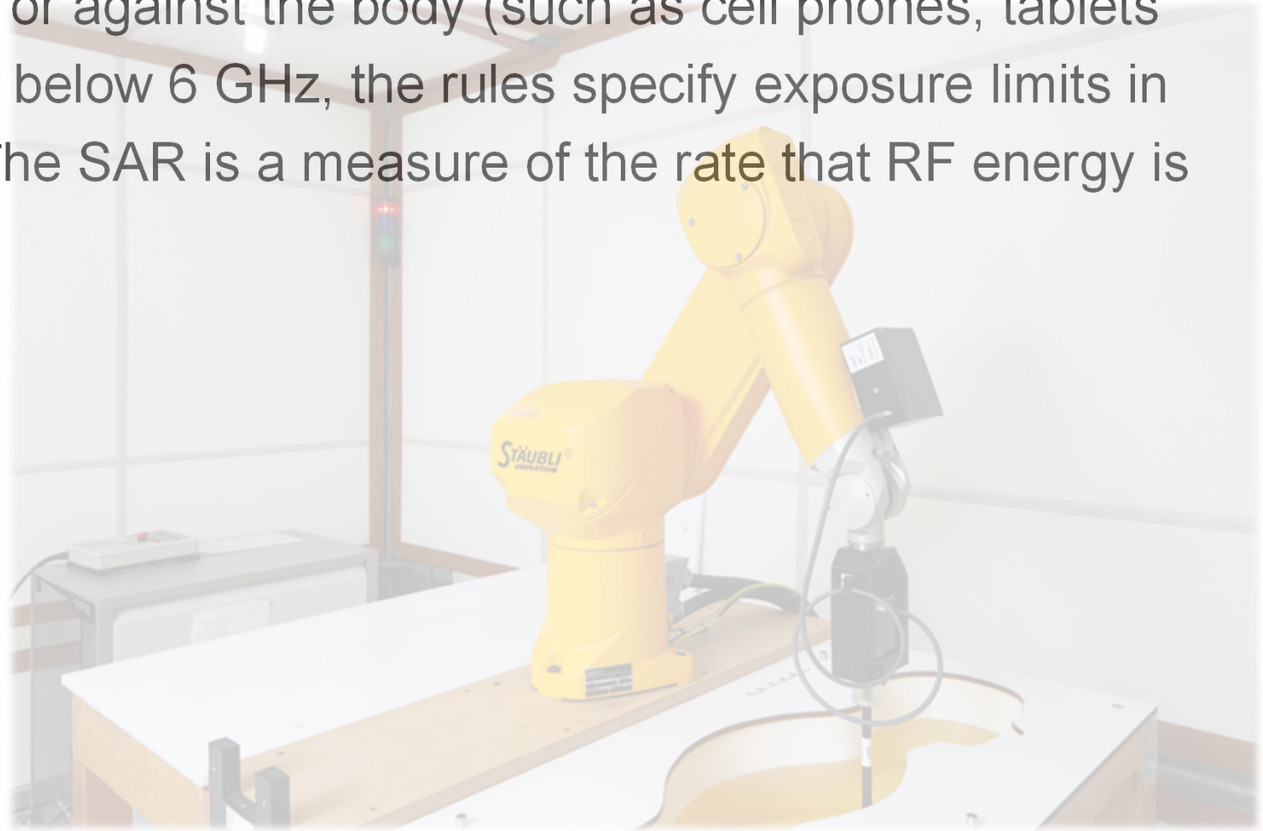
Background

- The FCC is the responsible party for determining safe levels of exposure to radio frequency (RF) energy for wireless communication devices.
- RF Exposure rules and guidelines have been based on standards developed by IEEE and NCRP and input from other federal agencies.
- All wireless device manufacturers and responsible parties must demonstrate compliance with FCC regulations.
- The National Environmental Policy Act of 1969 (NEPA) requires the FCC to evaluate the effects of their actions, including human exposure to RF energy emitted by devices regulated by the FCC.
- In 2013 a review commenced, and based on the proliferation in the number and types of radiofrequency (RF) devices around us and the ways we interact with them the FCC proposed updated rules
- The Notice of Proposed Rulemaking and memorandum opinion and order FCC 19-126 was thereby published in the Federal Register on January 1, 2020

NCRP = National Council on Radiation Protection and Measurements

General Info on Human Exposure to RF Electromagnetic Fields

For wireless devices intended for use near or against the body (such as cell phones, tablets and other portable devices) operating at or below 6 GHz, the rules specify exposure limits in terms of Specific Absorption Rate (SAR). The SAR is a measure of the rate that RF energy is absorbed by the body.



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General Info on Human Exposure to RF Electromagnetic Fields

For wireless devices operating in the frequency range above 6 GHz, or greater than 20cm from persons the FCC guidelines specify power density as the relevant RF exposure limit. Power density is defined as an amount of RF power per unit area.

$$Power\ Density = \frac{P * G}{4 * \pi * D^2};$$

$$P: Output\ Power; G: Gain; D: Gistance;$$

Main Changes - FCC 19-126

Streamlining of criteria for determining when a manufacturer is exempt from RF exposure evaluation depending on measurement or computational methods, including:

- a set of formulas for situations where risk of excessive RF exposure is minimal, instead of exemptions based on service types
  - All radio services and operations (intentional and unintentional equipment) are subject to routine evaluation for RF Exposure
- more flexibility for manufacturer to establish compliance with RF exposure limits, when they do not qualify for an exemption
- methods that RF equipment operators can use to mitigate the risk of excess exposure, both to members of the public and trained workers (such as training, supervision, and signage)

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Main Changes - FCC 19-126

Targeted proposals on the application of FCC RF emission exposure limits for future uses of wireless technologies

- An additional limit for localized RF exposure and the associated methodology for compliance for portable devices operating at high frequencies (GHz) on top of the already existing limits that apply at these frequencies and propose to extend this to terahertz (THz) frequencies as well.
    - This will address mobile devices (falling into the SAR category) that operate above 6 GHz. With 5G rolling out in waves, this issue has become urgent to address
- Specific exposure limits requirements for wireless power transfer (WPT) equipment under Parts 15 and 18 of the Commission's rules, to support the IoT where technology can operate both locally (within 50cm) and over greater distances simultaneously.

<u>There is no change to the FCC's existing RF emission exposure limits.</u>

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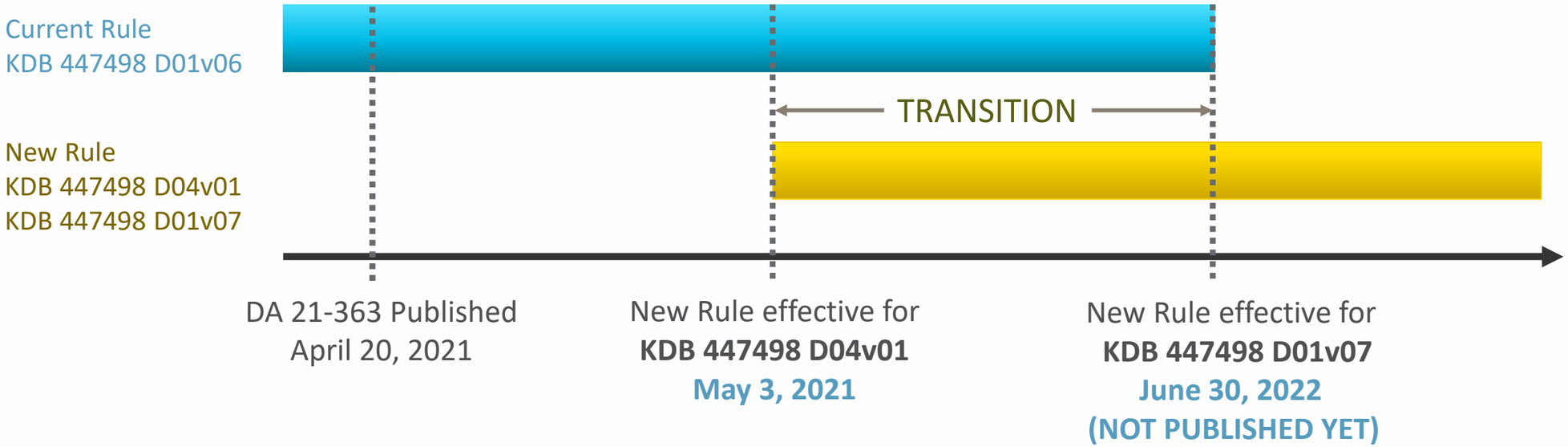
Revised FCC RF Exposure Rules

FCC Rule Part or Knowledge DataBase (KDB)	Title
47 CFR § 1.1307	Actions that may have a significant environmental effect, for which Environmental Assessments (EAs) must be prepared
47 CFR § 2.1091	Radiofrequency radiation exposure evaluation: mobile devices.
47 CFR § 2.1093	Radiofrequency radiation exposure evaluation: portable devices.
KDB 447498 D01v06	General RF Exposure Guidance v06 **(Currently in force)**
KDB 447498 D04v01	Interim General RF Exposure Guidance v01 **(Can be used until Final D01v07 Publication is available)**
KDB 447498 D01v07	General RF Exposure Guidance v07 Final Published version is not yet available (mandatory from June 30, 2022

Rules & Regulations for Title 47 | FCC.GOV

Effective Dates

- FCC Grants of authorization issued on or after June 30, 2022, must reflect compliance with new rules



- Except where the device has a PAG (pre-approval guidance) application already in process with the FCC via TCB
- Existing equipment authorizations remain valid and do not require specific modifications further to the FCC 19-126 rule changes

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FCC Title 47 CFR Section 1.1307 - Revised

1.1307(b)(2) Definitions:

- Fixed RF source is one that is physically secured at one location, even temporarily, and is not able to be easily moved to another location while radiating;
- Mobile device is as defined in § 2.1091(b) of this chapter; device used more than 20cm away
- Portable device is as defined in § 2.1093(b) of this chapter; device used within 20cm of the user
- Exemption for (an) RF source(s) is solely from the obligation to perform a routine environmental evaluation to demonstrate compliance with the RF exposure limits in § 1.1310 of this chapter; it is not exemption from:
  - the equipment authorization procedures described in part 2 of this chapter
  - general obligations of compliance with the RF exposure limits in § 1.1310 of this chapter
  - determination of whether there is no significant effect on the quality of the human environment under § 1.1306 of this chapter

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FCC Title 47 CFR Section 1.1307 - Revised

Routine evaluation means measurement of power density/field strength or SAR as fitting

- Fixed RF source is one that is physically secured at one location, even temporarily, and is not able to be easily moved to another location while radiating
- For portable / mobile devices and unlicensed fixed installations this must be addressed at time of device certification
- For fixed, licensed installations this can be addressed at time of licensing rather than at time of equipment authorization. Example of grant conditions:
  - The antenna(s) used for this transmitter must be fixed-mounted on outdoor permanent structures. RF exposure compliance is addressed at the time of licensing, as required by the responsible FCC Bureau(s), including antenna co-location requirements of § 1.1307(b)(3).

FCC Title 47 CFR Section 1.1307 – Change Summary

Old Rules

Only specific rule parts were subject to routine evaluation

- Part 18 was out of scope as well as some Part 15 devices

Exemptions for mobile devices base on effective radiated power<1.5W for f<1.5GHz & effective radiated power<3.0W for f>1.5GHz

- Portable device exemptions in KDB 447498 D01

New Rules

All devices are now in scope of RF exposure assessment being required – including unintentional radiators

Exemptions for all devices now codified within the FCC rules

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Mitigation Methods for Transmitter Sites with Fixed RF Sources

- Ensure that individuals are kept out of areas with RF levels that exceed the FCC's exposure limits unless they are specially trained in RF safety
- New methods for RF equipment operators to mitigate the risk of excess exposure to members of the public and trained workers such as training, supervision, and signage
- Licensees shall use warning signs when a location will have RF levels above the limit for the general public.
- Allowance of indicators (chains, railings, paint and diagrams) if other positive access controls (e.g., a locked door to the rooftop) are in place to restrict access to persons who are RF trained.

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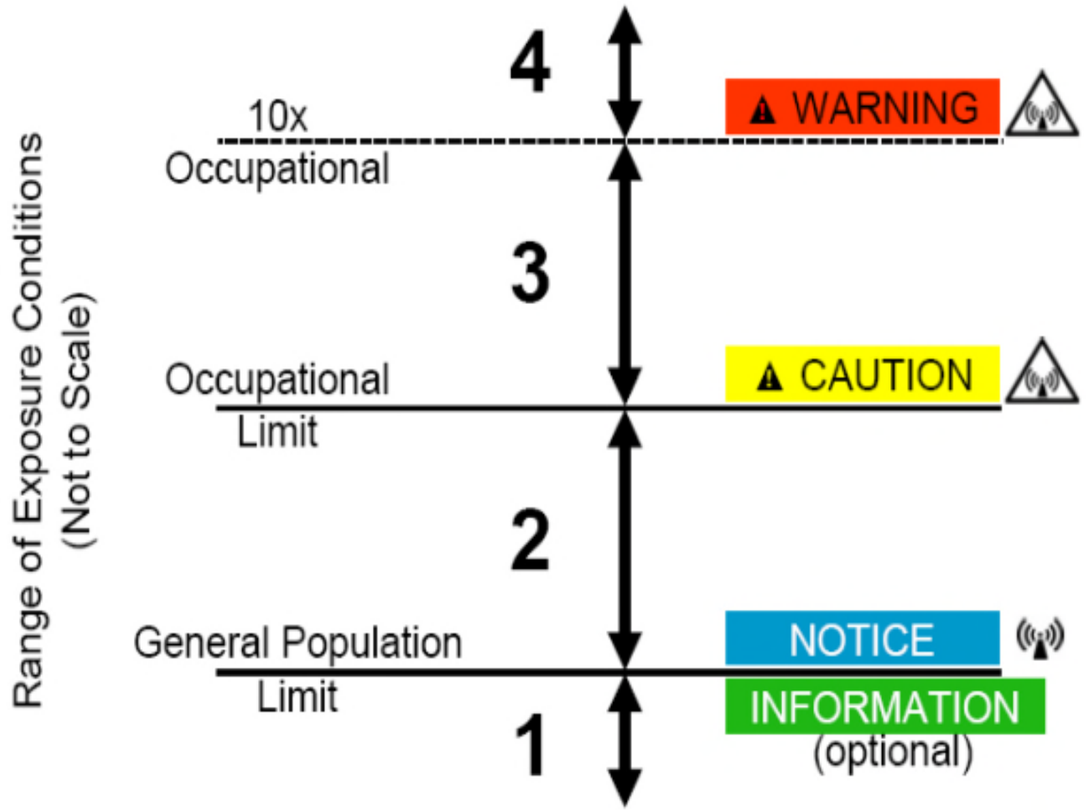
Mitigation Methods for Transmitter Sites with Fixed RF Sources

Category 4	Locations where the exposure limit for RF-trained personnel would be exceeded by more than a factor of 10 or where there is a possibility for serious contact injury. “WARNING” signs in orange color are required, and “DANGER” signs in red color are required where immediate and serious injury will occur on contact, in addition to positive access control.
Category 3	Locations where the exposure limit for occupational (RF-trained) personnel would be exceeded by no more than a factor of ten. The FCC will require signs with the word “CAUTION” in yellow color, and controls or indicators (chains, railings, contrasting paint, diagrams, etc.) in addition to positive access control.
Category 2	Locations where the continuous exposure limit for the general population is exceeded but not for RF-trained personnel. These locations must have positive access controls and signs with the word “NOTICE” in blue color.
Category 1	Locations where RF energy is not in excess of the general population limit. Signage is not required but if used must show a green “INFORMATION” heading.



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3 New Exemption Criteria - 47 CFR Section 1.1307(b)(3)

A. 1-mW blanket exemption (maximum time averaged power) [1.1307(b)(3)(i)(A)]

- Independent of separation distance and frequency
- Available maximum time-averaged power is no more than 1 mW, regardless of separation distance.
- This exemption may not be used in conjunction with other exemption criteria other than those for multiple RF sources in paragraph §1.1307(b)(3)(ii)(A).

B. SAR-based exemption formulas (using distance and 'ERP') Separation distances from 0.5 cm to 40 cm

- Frequencies from 300 MHz to 6 GHz

C. MPE-based exemption formulas [1.1307(b)(3)(i)(C)]

- Separation distance at least $\lambda/2\pi$
  - Examples: 2 cm at 2.4 GHz; 20 cm at 240 MHz; 2 m at 24 MHz
- Frequencies from 300 kHz to 100 GHz
- ERP is below a threshold calculated based on the distance between the person and the antenna / radiating structure, where $R > \lambda / 2\pi$

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Option 1: 1-mW blanket exemption

- RF source is exempt if the conducted **maximum time averaged power does not exceed 1mW**
- Rule: 47 CFR § 1.1307 (b)(3)(i)(A)

$$P \leq 1mW$$

Simultaneously Transmitting radio sources:

- §1.1307(b)(3)(ii)(A) **End product** is exempt if
  - A. each source is 1 mW or less, and any portions of radiating structures of each are 2 cm or more apart, **or**
  - B. sum of power of the multiple sources is less than 1 mW (separation is not required)

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Option 2: SAR-Based Exemption

- RF source is exempt if the greater of available max. time averaged power or ERP does not exceed Pth
- Formulas are published in amended 47 CFR 1.1307(b)(3)(i)(B), 2.1091 and 2.1093

$$P_{th}(\text{mW}) = \begin{cases} ERP_{20\text{cm}}(d/20\text{ cm})^x & 0.5\text{ cm} \le d \le 20\text{ cm} \\ ERP_{20\text{cm}} & 20\text{ cm} < d \le 40\text{ cm} \end{cases}$$

$$\textit{where} \quad x = -\log_{10}\left(\frac{60}{ERP_{20\text{cm}}\sqrt{f}}\right)$$

$$ERP_{20\text{cm}}(\text{mW}) = \begin{cases} 2040f & 0.3\text{ GHz} \le f \le 1.5\text{ GHz} \\ 3060 & 1.5\text{ GHz} < f \le 6.0\text{ GHz} \end{cases}$$

$$d = \text{separation distance (cm)}$$

- Formula is based on calculation of P_{th} based on separation distance from transmitter to the person and the frequencies supported

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Option 2: SAR-Based Exemption

Comparison of example Power exemption threshold levels (in mW) for portable devices at distances ≤ 50 mm calculated per old KDB 447498 D01 v06 / per amended 1.1307(b)(3)(i)(B) - KDB 47498 D04 v01

MHz \ mm	5	10	15	20	25	50
300	27 / 39	55 / 65	82 / 88	110 / 110	137 / 129	274 / 217
450	22 / 22	45 / 44	67 / 67	89 / 89	112 / 112	224 / 226
835	16 / 9	33 / 25	49 / 44	66 / 66	82 / 90	164 / 240
900	16 / 8	32 / 23	47 / 42	63 / 63	79 / 88	158 / 242
1500	12 / 4	24 / 14	37 / 29	49 / 49	61 / 73	122 / 254
1900	11 / 3	22 / 12	33 / 26	44 / 44	54 / 66	109 / 236
2450	10 / 3	19 / 10	29 / 22	38 / 38	48 / 59	96 / 219
3600	8 / 2	16 / 8	24 / 18	32 / 32	40 / 49	79 / 195
5200	7 / 2	13 / 6	20 / 15	26 / 26	33 / 42	66 / 175
5400	6 / 1	13 / 6	19 / 14	26 / 26	32 / 41	65 / 173
5800	6 / 1	12 / 6	19 / 14	25 / 25	31 / 40	62 / 169

- Power thresholds shown in are for head or body exposure
- For Extremity/Limb exposure the power thresholds should be scaled by a factor of 2.5

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Option 3: MPE-Based Exemption

- Exempt if ERP does not exceed the specified threshold
- Separation distance (R, in meters) must be at least $\lambda/2\pi$

$R \geq \lambda/2\pi$ (Note: $\lambda = v/f$)

λ = wavelength of transmitted signal
V = speed of light = 3×10^8 m/s
f = frequency (Hz)

2 cm at 2.4 GHz; 20 cm at 240 MHz; 2 m at 24 MHz

Transmitter Frequency (MHz)	Threshold ERP (W)
0.3 – 1.34	$1{,}920\ R^2$
1.34 – 30	$3{,}450\ R^2/f^2$
30 – 300	$3.83\ R^2$
300 – 1,500	$0.0128\ R^2f$
1,500 – 100,000	$19.2\ R^2$

- Aligns with existing MPE limits under conservative exposure assumptions
- While threshold is provided in ERP, the rules allow use of maximum conducted power when antenna is < $\lambda/4$
- Formulas are published in amended 47 CFR 1.1307(b)(3)(i)(C)

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Option 3: MPE-Based Exemption

- Formulas are published in amended 47 CFR 1.1307(b)(3)(i)(C)

f (MHz)	R > λ / 2π (m)	R > λ / 2π (mm)
0.125	382	381,972
13.56	3.52	3,521
300	0.159	159
918	0.052	52
2400	0.020	19.9
5250	0.009	9.09
5600	0.009	8.53
5825	0.008	8.20
6000	0.008	7.96
7000	0.007	6.82
10000	0.005	4.77

Transmitter Frequency (MHz)	Threshold ERP (W)
0.3 – 1.34	**1,920 R^2**
1.34 – 30	**3,450 R^2/f^2**
30 – 300	**3.83 R^2**
300 – 1,500	**0.0128 R^2f**
1,500 – 100,000	**19.2 R^2**

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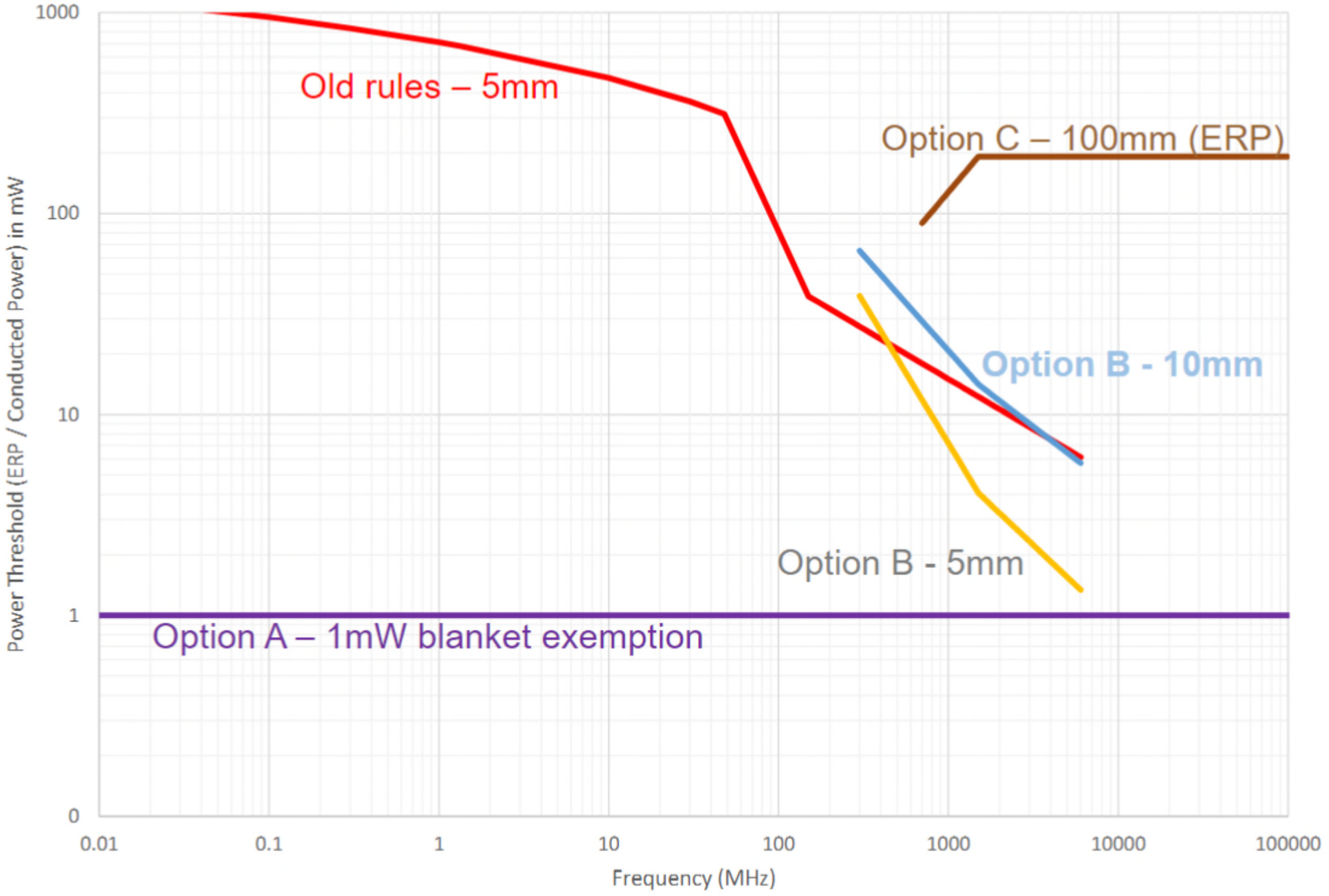
Exemption Threshold Comparison – Portable Devices



- Above 350 MHz the new SAR Exemption calculation at 5mm is tighter than previous
- At 10mm the new rule (Option) is similar to the old rule at 5mm above 1900 MHz
- 1mW blanket exemption not shown

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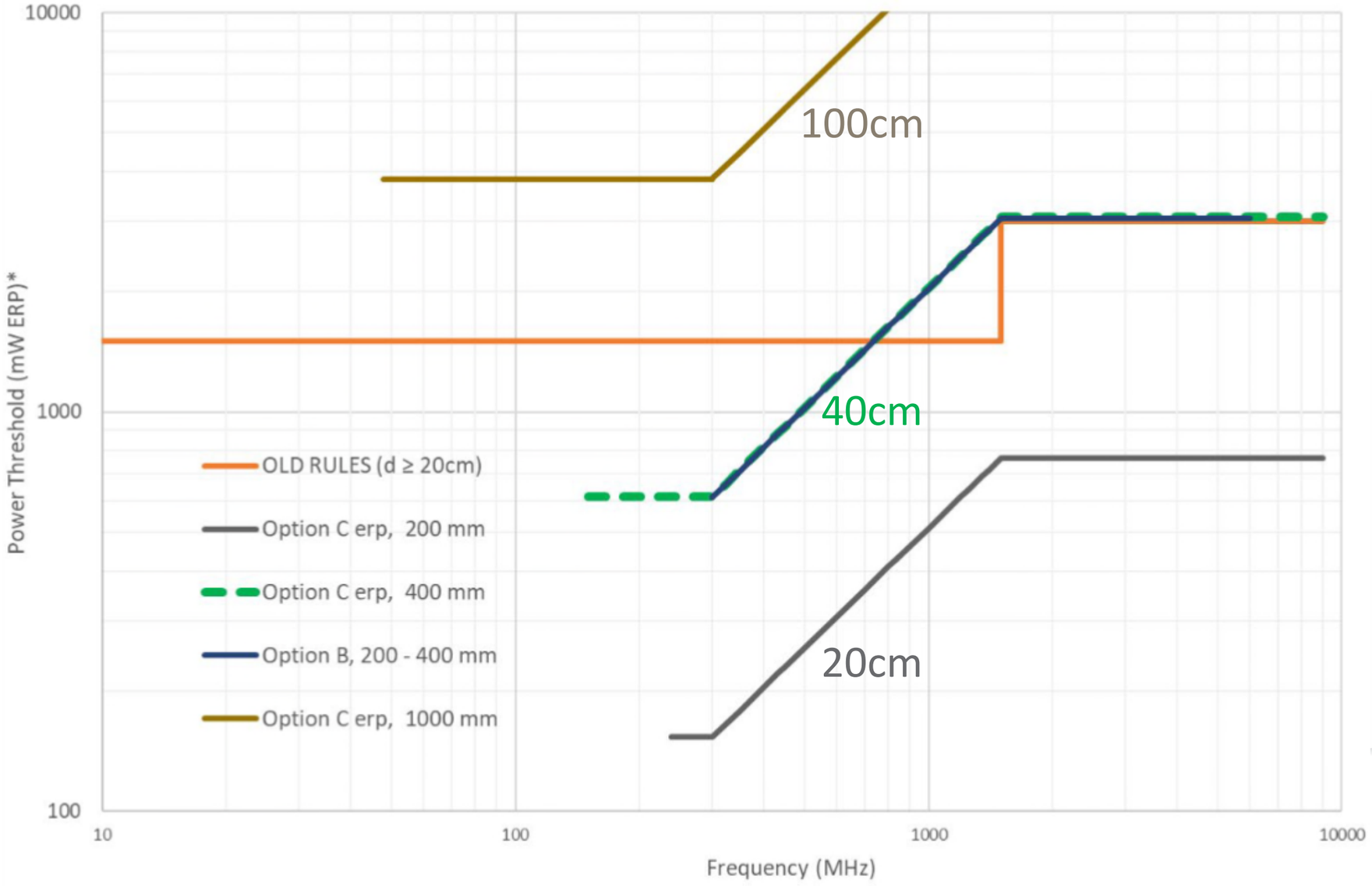
Exemption Threshold Comparison – Mobile & Fixed Devices



- Larger distances, have higher threshold
- 1mW blanket exemption not shown

Single RF Source Exemptions – Sequence

Generally, the sequence for determining exemption for single RF sources includes:

a) determination of 1 mW blanket exemption under §1.1307(b)(3)(i)(A)

b) determination of exemption under MPE-based section §1.1307(b)(3)(i)(C) if a) is not met

OR

determination of exemption under SAR-based section §1.1307(b)(3)(i)(B) if both a) and b) are not met

a) test reduction procedures for evaluation from FCC Laboratory if a), b) and c) are not met

b) evaluation by SAR measurement or computation if a), b), c), and d) are not met

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Multi-RF Sources Exemption

- §1.1307(b)(3)(ii)(B) Multiple mobile or portable **RF sources within an end product** are exempt from routine evaluation if they meet this requirement:

$$\sum_{i=1}^{a}\left(\frac{P_i}{P_{th\_i}}\right)+\sum_{j=1}^{b}\left(\frac{ERP_j}{ERP_{th\_j}}\right)+\sum_{k=1}^{c}\left(\frac{Evaluated_k}{Exposure\ Limit_k}\right)\leq 1.0$$

- Contribution from all transmitters excluded using Option B
  - Note that P_i is the higher of erp and conducted power
- Contribution from all transmitters excluded using Option C
- Contribution from all transmitters subject to routine evaluation

- $Evaluated_k$ = maximum reported SAR or MPE of source k
- $Exposure\ Limit_k$ = MPE limit or SAR limit for each source

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RF Exposure Limits

Limits §1.1310 are unchanged from previous rules

- SAR limits are defined for 100kHz – 6GHz:
  - Extremities (hands, wrists, ankles, feet, pinnae) 4.0 W/Kg (10-gram averaging)
  - Body/Head: 1.6 W/Kg (1-gram averaging)

RF Exposure Limits

Limits §1.1310 are unchanged from previous rules

Above 6GHz, Maximum Permissible Exposure (MPE) limits are applicable

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(i) Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	*(100)	≤6
3.0-30	1842/f	4.89/f	*($900/f^2$)	<6
30-300	61.4	0.163	1.0	<6
300-1,500			f/300	<6
1,500-100,000			5	<6
(ii) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	<30
1.34-30	824/f	2.19/f	*($180/f^2$)	<30
30-300	27.5	0.073	0.2	<30
300-1,500			f/1500	<30
1,500-100,000			1.0	<30

f = frequency in MHz. * = Plane-wave equivalent power density

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FCC Title 47 CFR Section 2.1091 – Other revisions

§2.1091 contains requirements for mobile devices:

- Mobile device (not fixed devices) used such that a separation distance of at least 20 centimeters is normally maintained between the transmitter's radiating structure(s) and the body of the user or nearby persons
- Fixed device is physically secured at one location and is not able to be easily moved to another location
- Updated to use exclusion equations from new Part 1 rules described previously

§2.1091(d)(4):

- Use of a device may not allow easy classification as either mobile or portable
- FCC may require SAR evaluation

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FCC KDB 447498 D04 (Draft policy)

Gateway policy for any RF exposure evaluation

Covers SAR and power density (MPE) measurements

Requires evaluation be based on maximum power

- Maximum power after accounting for manufacturing tolerances
- Do not use the highest measured power for sample tested
- Measured values must be scaled for differences between measured and maximum powers (Reported SAR / MPE)
- Calculations for exemption use maximum power

Applications to TCBs must address RF exposure

- Justify exemption if based on power below thresholds in rules
- In accordance with published KDB procedures

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FCC KDB 447498 D04 Draft policy and SAR Exemption

KDB 447498 4.3.1 SAR exclusion thresholds

- May exclude a SAR evaluation based on power level, operating frequency, distance from person to device, tissue type (head/body or extremity)
- Includes exclusions as discussed in previous slides
- Implanted transmitters – only the 1mW exemption threshold is applicable
    - P > 1mW requires FCC guidance to determine the appropriate SAR measurement and / or numerical simulation procedure
- Figure A.1 in the document is a great flowchart showing the approach to apply

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FCC KDB 447498 D04 Draft policy - Numerical Simulation

- IEC/IEEE 62704 series were mostly related to the Finite Difference Time Domain (FDTD) technique, and for the frequency range of 30 MHz – 6 GHz.
- SAR simulations using the Finite Element Method (IEC/IEEE 62704-4), and simulations of power density above 6 GHz and for mm-wave frequencies are available.
- When numerical computation methods other than FDTD are used, the equivalent considerations as required for the FDTD method must be applied, as specified in FDTD reporting guidelines in KDB Pub. 865664 D02 and similar to IEC/IEEE 62704-1.
- When these methods are used, a KDB inquiry is required to determine the applicability the proposed methodology, implementations, and methodologies for specific exposure conditions.

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FCC KDB 447498 D04 Draft policy – Multiple Transmitters

- Multiple transmitters operating at the same time
- Difficult to measure SAR since tissue liquid parameters are different for different transmitter operating frequencies
- FCC offers three approaches to determine compliance:
  - Sum individual SAR values and compare to limit, if less than limit (1.6W/Kg for body SAR) then no further analysis required
  - Determine ratio between the SAR values and distance between the peak SAR locations
  - If (1) or (2) don't work, last alternative is a volume scan
    - SAR measurements for each operating band are overlaid and summed

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FCC SAR KDBs

The following publications may require modifications to address new rules:

- KDB 865664 SAR Measurements and Reporting
- KDB 212821: SAR values in user manuals
- KDB 690783: Guidelines for listing SAR numbers on FCC grants
- Other Technology specific KDB policies:
  - Provides test reductions to streamline the amount of testing performed for common technologies like 802.11, LTE, 3G HSPA, HSPA+
- Other Device specific KDB policies:
  - Provides test methods to define required tests for specific devices or specific functions

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FCC Device Specific KDB Guidance

Device Type	KDB	Exposure Condition
Dongle Transmitters	KDB 447498 D02	Body (5mm)
Portable Hot Spots	KDB 941225 D06	Body (10mm or 5mm)
UMPC	KDB 941225 D07 UMPC Mini Tablet	Body (5mm separation)
Push-to-Talk Radios	KDB 643646 D01 KDB 447498 section 5.1	Body & Head
Handsets	KDB 648474 D04	Body & Head
Wireless Charging Covers	KDB 648474 D03	Body & Head
Wireless Chargers Wireless Power Transfer (WPT)	KDB 680106 D01	Body
Wristwatch / Wrist-worn	KDB 447498 section 5.2	Extremity & head (next to mouth)
Low Duty Factor Transmitters	KDB 447498 section 5.3	Device dependent
OEM accessories with and without transmitters	KDB 447498 section 5.4	Device dependent

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FCC Technology Specific KDB Guidance

Technology	KDB
802.11abgn/ac	KDB 248227 D01
WiMax	KDB 615223 D01
3G, HSPA and 1x Advanced, GSM, GPRS, EDGE, EDGE Dual Transfer Mode (DTM)	KDB 941225 D01
LTE	KDB 941225 D05 and KDB 941225 D05A

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Possible future scenarios

FCC Changes KDB 447498 Policy	Differing from current guidance
Change in deadlines	Compliance deadlines may be extended

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Nemko North America, Inc. Product Certification

FCC Radio and Telephone Terminal Equipment Telecommunications Certification Body (TCB)

EU Radio Equipment Directive

Hong Kong OFCA Radio and Telecom

ISED Canada Radio and Telecom

MIC Japan Radio

Taiwan NCC

UK Radio Equipment Regulations

Thank you for your time!

If you have questions or need support, please reach out to:

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