



# **RF Exposure: Order/NPRM Issues**

## **TCB Workshop**

Technical Analysis Branch  
Office of Engineering and Technology  
Federal Communications Commission



# Overview

- 2013 Rulemaking Proposals
- Technological Development
- Possible Future FCC Actions
- Interim KDB Guidance



# 2013 Rulemaking Proposals

- Key topics proposed in 2013:
  - Exclusion → exemption
    - 1 mW exemption
    - SAR-based exemption
    - MPE-based exemption
    - Exemption summation
      - each can be applied to all exposure conditions (i.e., fixed, mobile and portable)
  - Evaluation



# 2013 1 mW Exemption Proposal

- A device is exempt from testing if available maximum time-averaged power is  $\leq 1$  mW
- May not be used in combination with any other exemption criteria
- Medical implant devices may use only 1 mW exemption if seeking to be exempt from testing
- Multiple 1 mW exemptions permitted within a device if each antenna is separated by at least 2 centimeters



# 2013 SAR-Based Exemption

- Available maximum time-averaged power or effective radiated power (ERP), whichever is greater, only used at separation distances from 0.5 to 40 centimeters and at frequencies from 0.3 to 6 GHz.

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

- Where

$$x = -\log_{10} \left( \frac{60}{ERP_{20\text{ cm}} \sqrt{f}} \right) \text{ and } f \text{ is in GHz;}$$

$$ERP_{20\text{ cm}} \text{ (mW)} = \begin{cases} 2040f & 0.3\text{ GHz} \leq f < 1.5\text{ GHz} \\ 3060 & 1.5\text{ GHz} \leq f \leq 6\text{ GHz} \end{cases}$$

$d$  = the separation distance (cm)



# 2013 SAR-Based Exemption

		Example Power Thresholds (mW)												
		Distance (cm)												
		0.5	1	1.5	2	2.5	5	7	10	12.5	15	17.5	20	40
Frequency (GHz)	0.3	39	65	88	110	130	220	280	360	430	490	550	610	610
	0.45	22	44	67	89	110	230	320	460	570	690	800	920	920
	0.835	9.2	25	44	66	90	240	390	640	880	1100	1400	1700	1700
	0.9	8.3	23	42	63	88	240	400	670	920	1200	1500	1800	1800
	1.45	4.3	15	30	50	74	250	460	870	1300	1800	2300	3000	3000
	1.8	3.5	13	26	45	67	240	450	860	1300	1800	2400	3060	3060
	1.9	3.4	12	26	44	66	240	440	850	1300	1800	2400	3060	3060
	2.45	2.7	10	22	38	59	220	420	820	1300	1800	2400	3060	3060
	3	2.3	9.0	20	35	53	210	400	790	1200	1700	2400	3060	3060
	5.2	1.5	6.3	15	26	42	170	350	730	1200	1700	2300	3060	3060
	5.8	1.4	5.9	14	25	40	170	340	720	1100	1700	2300	3060	3060





# 2013 MPE-Based Exemption

Table 1—Single RF Sources Subject to Routine Environmental Evaluation

RF Source Frequency (MHz)	Threshold ERP (watts)
0.3 – 1.34	1,920 R <sup>2</sup>
1.34 – 30	3,450 R <sup>2</sup> /f <sup>2</sup>
30 – 300	3.83 R <sup>2</sup>
300 – 1,500	0.0128 R <sup>2</sup> f
1,500 – 100,000	19.2R <sup>2</sup>

- Available maximum time-averaged power if the physical dimensions of the radiating structure(s) do not exceed the electrical length of  $\lambda/4$  or if the antenna gain is less than that of a half-wave dipole.



$$\sum_{i=1}^a \frac{P_i}{P_{th,i}} + \sum_{j=1}^b \frac{ERP_j}{ERP_{th,j}} + \sum_{k=1}^c \frac{Evaluated_k}{Exposure Limit_k} \leq 1$$

- $a$  = number of fixed, mobile, or portable RF sources claiming exemption using the SAR-based formula for  $P_{th}$ , including existing exempt transmitters and those being added.
- $b$  = number of fixed, mobile, or portable RF sources claiming exemption using the applicable MPE-based formula for Threshold ERP, including existing exempt transmitters and those being added.
- $c$  = number of existing fixed, mobile, or portable RF sources with known evaluation for the specified minimum distance.
- $P_i$  = the available maximum time-averaged power or the ERP, whichever is greater, for fixed, mobile, or portable RF source  $i$  at a distance between 0.5 cm and 40 cm (inclusive).
- $P_{th,i}$  = the exemption threshold power ( $P_{th}$ ) according to the SAR-based formula for fixed, mobile, or portable RF source  $i$ .
- $ERP_j$  = the available maximum time-averaged power or the ERP, whichever is greater, of fixed, mobile, or portable RF source  $j$ .
- $ERP_{th,j}$  = exemption threshold ERP for fixed, mobile, or portable RF source  $j$ , at a distance of at least  $\lambda/2\pi$ , according to the applicable MPE-based formula at the location in question.
- $Evaluated_k$  = the maximum reported SAR or MPE of fixed, mobile, or portable RF source  $k$  either in the device or at the transmitter site from an existing evaluation.





## 2013: 5 cm distance > 6 GHz

- Proposed removing from the rules the requirement that measurements and calculations to demonstrate compliance for devices operating above 6 GHz be made at a minimum distance of 5 cm from the radiating source
- This was a limitation of probe measurement accuracy, but currently available probes do not have such limitation
- At the same time, handheld portable devices motivate measurements at closer distances to accurately reflect anticipated typical exposure conditions



# Technological Development

- Handsets at millimeter wave frequencies
- Active time averaging technology for SAR and power density
- Wireless power transfer (WPT) systems
- Standards are still evolving...



## Possible Future Actions

- Preliminary guidance to facilitate the approval of new technologies
- 2013 Further Proposals are still pending
- Commission may issue new rulemaking in the future that could affect this guidance
- Stay tuned...



## Localized Exposure Limit > 6 GHz

- In future NPRM, possibly considering limiting localized power density to  $4 \text{ mW/cm}^2$  to achieve continuity with the local SAR limit of  $1.6 \text{ W/kg}$  at 6 GHz
  - Consistent with ANSI/IEEE C95.1-1991 standard at 6 GHz
- Uniform application of localized  $4 \text{ mW/cm}^2$  limit up to at least 100 GHz would also prevent perception of warmth from continuous exposure through millimeter wave frequencies
  - Presently no specified numeric local power density limit in our rules for portable exposure above 6 GHz
  - Existing whole-body exposure limit is  $1 \text{ mW/cm}^2$  from 1.5 to 100 GHz for the general public



# Time Averaging

- Devices are capable of actively monitoring and adjusting power output over time to comply with exposure limits, which are based on average exposure over a time period
- What is the appropriate time averaging period?
- Source-based time-averaging (typically 10's-100's of microseconds) is too short, 30 minutes (general public limit) may be too long depending on technology
- Assuming energy deposited during a brief impulse, possibly considering proposing in future NPRM:
  - 100 seconds for localized SAR limits up to 3 GHz
  - Superficial absorption of energy at higher frequencies require shorter periods down to 1 second above 95 GHz





# Averaging Time Derivation

- Justification of NPRM proposal based on analysis:
- $\Delta T = \text{SAR} \cdot \Delta t / c$
- Where  $\Delta T$  is the temperature rise for a brief impulse without sufficient time for heat conduction, SAR is the spatial-peak but continuous or time-averaged SAR value,  $\Delta t$  is the averaging time, and  $c$  is the specific heat
- As frequency increases, the depth of penetration decreases, spatial-peak SAR increases at the skin surface, and the averaging time necessarily decreases
- Limit spatial-peak SAR based on temperature rise





## Interim Guidance for > 6 GHz

- To facilitate new technologies, considering aspects of averaging area in light of our rationale for future NPRM and consistency with the ANSI/IEEE standard referenced in our rules
- Rather than continuing guidance to allow the 1 mW/cm<sup>2</sup> limit to be averaged over 1 cm<sup>2</sup>, KDB guidance will allow averaging over 4 cm<sup>2</sup> for portable devices while retaining 1 mW/cm<sup>2</sup> interpreted as both whole-body and local exposure limit (1 cm<sup>2</sup> will remain for whole-body)
- Will revert to 1 cm<sup>2</sup> averaging area for portable if 4 mW/cm<sup>2</sup> is adopted as localized limit by the Commission



# Interim Guidance for Time Averaging

Interim Guidance	Frequency (GHz)	Maximum Averaging Time (sec)
SAR	< 3	100
	3 – 6	60
MPE	6 - 10	30
	10 - 16	14
	16 – 24	8
	24 – 42	4
	42 – 95	2



# Questions?