

## **Fifth-Generation (5G) Infrastructure and Related Federal Standards**

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### **Issue**

This report discusses federal limits for maximum permissible exposure to radiofrequency electromagnetic fields as they relate to 5G telecommunications infrastructure. The Office of Legislative Research is not authorized to provide legal opinions and this report should not be considered one.

### **Summary**

Deployment of 5G mobile telecommunications networks will require siting and installation of small cells, which are generally low-powered radio access nodes with ranges of between 10 meters and 2 kilometers. 5G deployment requires small cells because it is anticipated to use higher spectrum bands, requiring providers to place small cells close together to relay signals further distances and around obstacles.

Telecommunications equipment (including small cells) that emits radiofrequency electromagnetic waves is subject to the Federal Communications Commission's (FCC) limits on radiofrequency exposure. Radiofrequency electromagnetic waves have an electric and magnetic component. FCC limits are expressed in terms of electric field strength, magnetic field strength, and power density. They are based on specific absorption rate (SAR) limits based on how the human body absorbs waves at various frequencies.

The FCC established its current limits in 1996 based on recommendations from the National Council on Radiation Protection and Measurements (NCRP), the American National Standards Institute (ANSI), and the Institute of Electrical and Electronics Engineers (IEEE).



While state and local governments have some jurisdiction over siting telecommunications facilities, federal law generally prohibits them from restricting siting based on the effects of radiofrequency emissions. Both the Public Utilities Regulatory Authority (PURA) and the Connecticut Siting Council require applicants to submit reports with their applications that demonstrate compliance with federal standards.

## Federal Regulation

FCC regulations establish limits for maximum permissible exposure (MPE) to radiofrequency electromagnetic fields as shown in Table 1 and Figure 1 (47 CFR § 1.1310). Occupational or controlled limits apply in situations when people are exposed because of their employment and additionally require that employees are fully aware of the potential for exposure and can therefore exercise control over their own exposure. General population or uncontrolled limits are more stringent and apply in situations in which the general public may be exposed, or in which people may be exposed because of their employment but are not aware of the potential exposure or cannot exercise control over their exposure.

The table specifies limits based on the frequency of the waves (the number of electromagnetic waves passing a given point in one second) measured in megahertz (MHz) (one million cycles per second). Because the human body absorbs radiofrequency energy at some frequencies more efficiently than others, MPE limits vary by frequency. As shown in Table 1, some frequency ranges have a constant power density limit, while others are calculated according to a formula that varies by frequency within the range. According to the Congressional Research Service, 5G technology may rely on multiple spectrum bands, including low-band spectrum (below 1,000 MHz), mid-band spectrum (1,000 to 6,000 MHz) and high-band spectrum (over 30,000 MHz).

**Table 1: FCC Limits for Maximum Permissible Exposure (47 CFR § 1.1310)**

<i>Frequency Range (MHz)</i>	<i>Electric Field Strength (V/m)</i>	<i>Magnetic Field Strength (A/m)</i>	<i>Power Density (mW/cm<sup>2</sup>)</i>	<i>Averaging Time (minutes)</i>
<b>Occupational or Controlled Exposure</b>				
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	(900/f <sup>2</sup> )*	6
30-300	61.4	0.163	1.0	6
300-1,500	N/A	N/A	f/300	6
1,500 – 100,000	N/A	N/A	5	6
<b>General Population or Uncontrolled Exposure</b>				
0.3-1.34	614	1.63	(100)*	30

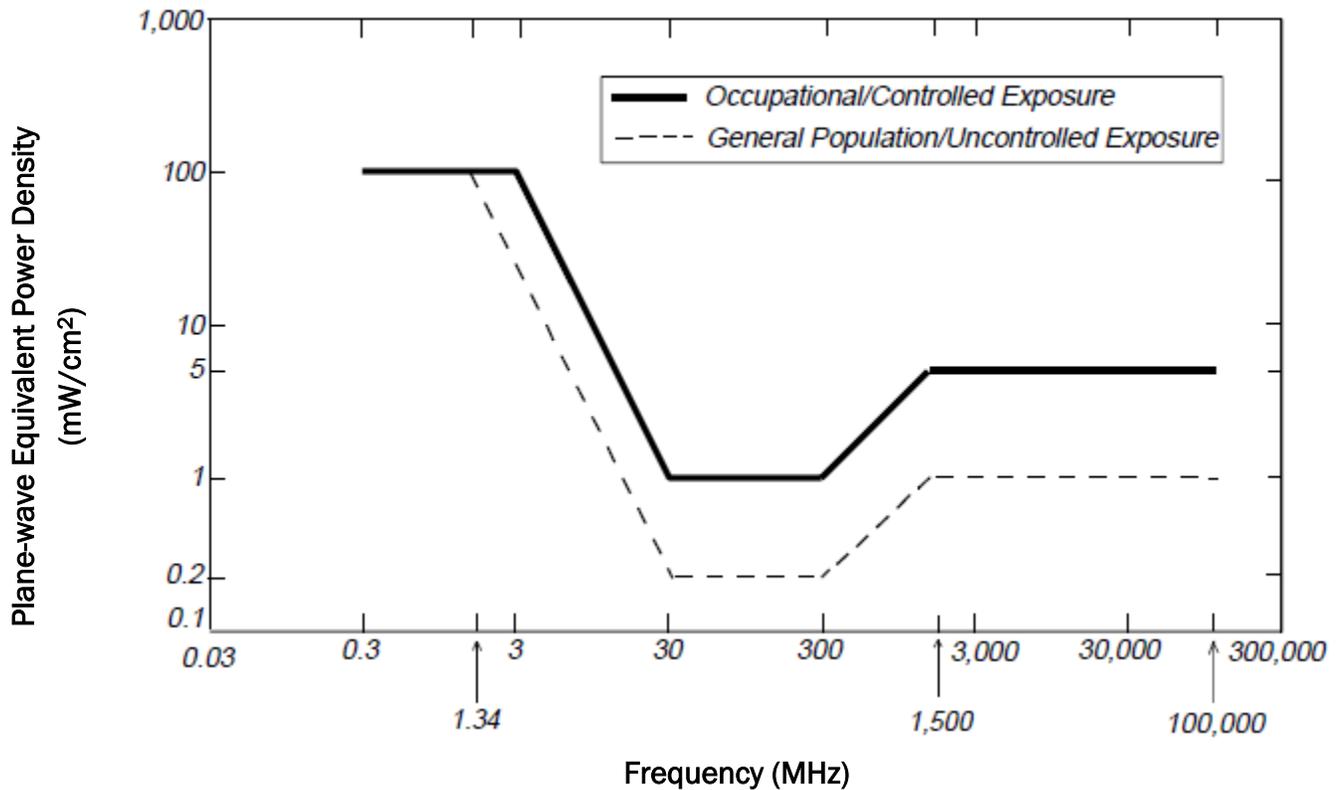
1.34-30	$824/f$	$2.19/f$	$(180/f^2)^*$	30
30-300	27.5	0.073	0.2	30
300-1,500	N/A	N/A	$f/1,500$	30
1,500 – 100,000	N/A	N/A	1.0	30

f = frequency in MHz

\* = plane-wave equivalent power density

Radiofrequency electromagnetic waves have an electric and magnetic component. The FCC limits are expressed in terms of electric field strength (measured in volts per meter (V/m)) and magnetic field strength (measured in amperes per meter (A/m)). The limits are also expressed in terms of power density, which is power flow per unit area, measured in microwatts per square centimeter (mW/cm<sup>2</sup>). “Plane-wave equivalent” generally means a far-field equivalent measurement, i.e., calculating a power density with measurements obtained in the near-field (near the antenna or other emitting structure) as though they were obtained in the far-field (where the distribution of magnetic field strength and electric field strength is locally uniform or with a “plane-wave” character).

Figure 1: FCC Limits for Maximum Permissible Exposure



Source: [FCC Office of Engineering and Technology \(OET\) Bulletin 65 p. 68](#)

The regulations state that the maximum permissible exposure limits described above are based on whole-body specific absorption rate (SAR) limits that are also defined in regulation. Like the MPE limits, the SAR limits have separate thresholds for occupational or controlled exposure versus general population or uncontrolled exposure. SAR limits are also expressed as a whole-body average limit and peak spatial average limits, as shown in Table 2. SAR is a measure of the rate of energy absorption by the body.

**Table 2: SAR Limits (47 C.F.R. § 1.1310)**

	<i>Occupational or Controlled Exposure (averaged over 6 minutes)</i>	<i>General Population or Uncontrolled Exposure (averaged over 30 minutes)</i>
Whole body	0.4 W/kg averaged over the whole body	0.08 W/kg averaged over the whole body
Peak spatial average (general)	8 W/kg averaged over 1 gram of tissue	1.6 W/kg averaged over 1 gram of tissue
Peak spatial average (extremities)	20 W/kg averaged over 10 grams of tissue	4 W/kg averaged over 10 grams of tissue

While the MPE limits are based on the whole body SAR limits, applicants for facilities with operating frequencies of 6,000 MHz or lower may use either type of limit to prove compliance, with an exception for certain portable devices. Applicants for projects with operating frequencies greater than 6,000 MHz must use MPE limits (47 CFR § 1.1310).

## **Basis for Federal Limits**

The FCC generally established the limits described above in 1996. According to FCC, it generally adopted MPE limits recommended by [the National Council on Radiation Protection and Measurements](#) (NCRP), a nongovernmental nonprofit organization incorporated under federal law (P.L. 88-376) to, among other things, formulate and widely disseminate information, guidance, and recommendations on radiation protection and measurements. The commission’s limits were also based, in part, on guidelines recommended by the American National Standards Institute (ANSI) and the Institute of Electrical and Electronics Engineers (IEEE). Relevant recommendations include:

1. NCRP’s “Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields” (1986) and
2. ANSI’s and IEEE’s “Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 Ghz” (1992).

In 2013, FCC voted to review various rules related to radiofrequency emissions from radio transmitters. As part of that review, FCC opened a Notice of Inquiry ([ET Docket No. 13-84](#)) to

discuss its radiofrequency exposure limits and possible policy approaches, including relaxing or tightening current rules and policies. It appears [the docket](#) remains open.

## State and Local Jurisdiction

Depending on the proposed locations of small cells, PURA, the Connecticut Siting Council, or the municipality may have jurisdiction over siting. However, section 704 of the Telecommunications Act of 1996 prohibits states and municipalities from regulating facilities based on environmental effects of radiofrequency emissions as long as the facility complies with FCC regulations (47 U.S.C. § 332(c)(7)(B)(iv)).

According to Connecticut Siting Council staff, when telecommunications carriers submit requests to install small cells to the council, they must also submit a radio frequency report specific to the proposed equipment and a cumulative report (if the small cell is to be located on a shared tower or structure) to show that emissions comply with FCC's MPE limit. Council staff analyzes the report while the request is pending. PURA's process is similar. Applicants provide PURA with a report from a radiofrequency emissions expert to certify that FCC standards are being met. PURA reviews that information while reviewing the application.

## Resources

Congressional Research Service: [Fifth-Generation \(5G\) Telecommunications Technologies: Issues for Congress](#). January 30, 2019.

OLR Report 1998-R-0038: [Federal Law Regarding Siting Telecommunications Towers](#). January 16, 1998.

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