

## Frequency and Wavelength: Conversions among Units, plus Common Sources of EM Fields<sup>1</sup>

Frequency				Wavelength				Common Sources of EM Fields
hertz	kilohertz	megahertz	gigahertz	kilometers	meters	centimeters	millimeters	
Hz	kHz	MHz	GHz	km	m	cm	mm	
100,000,000,000	100,000,000	100,000	100	0.0000030	0.0030	0.30	3.0	
80,000,000,000	80,000,000	80,000	80	0.0000038	0.0038	0.38	3.8	
60,000,000,000	60,000,000	60,000	60	0.0000050	0.0050	0.50	5.0	5G cell phones (contemplated) <sup>2</sup>
40,000,000,000	40,000,000	40,000	40	0.0000075	0.0075	0.75	7.5	
20,000,000,000	20,000,000	20,000	20	0.000015	0.015	1.5	15	
10,000,000,000	10,000,000	10,000	10	0.000030	0.030	3.0	30	
8,000,000,000	8,000,000	8,000	8.0	0.000038	0.038	3.8	38	
6,000,000,000	6,000,000	6,000	6.0	0.000050	0.050	5.0	50	
4,000,000,000	4,000,000	4,000	4.0	0.000075	0.075	7.5	75	Wi-Fi <sup>3</sup> , Bluetooth <sup>4</sup> Smart Meters <sup>5</sup> 2G, 3G, 4G cell phones <sup>6</sup>
2,000,000,000	2,000,000	2,000	2.0	0.00015	0.15	15	150	
1,000,000,000	1,000,000	1,000	1.0	0.00030	0.30	30	300	
800,000,000	800,000	800	0.80	0.00038	0.38	38	380	
600,000,000	600,000	600	0.60	0.00050	0.50	50	500	Television UHF <sup>7</sup> Television VHF <sup>8</sup>
400,000,000	400,000	400	0.40	0.00075	0.75	75	750	
200,000,000	200,000	200	0.20	0.0015	1.5	150	1,500	
100,000,000	100,000	100	0.10	0.0030	3.0	300	3,000	FM radio <sup>9</sup>
80,000,000	80,000	80	0.080	0.0038	3.8	380	3,800	
60,000,000	60,000	60	0.060	0.0050	5.0	500	5,000	
40,000,000	40,000	40	0.040	0.0075	7.5	750	7,500	
20,000,000	20,000	20	0.020	0.015	15	1,500	15,000	
10,000,000	10,000	10	0.010	0.030	30	3,000	30,000	
8,000,000	8,000	8.0	0.0080	0.038	38	3,800	38,000	
6,000,000	6,000	6.0	0.0060	0.050	50	5,000	50,000	
4,000,000	4,000	4.0	0.0040	0.075	75	7,500	75,000	
2,000,000	2,000	2.0	0.0020	0.15	150	15,000	150,000	
1,000,000	1,000	1.0	0.0010	0.30	300	30,000	300,000	AM Radio <sup>10</sup>
800,000	800	0.80	0.00080	0.38	380	38,000	380,000	Switch mode power supply <sup>11</sup>
600,000	600	0.60	0.00060	0.50	500	50,000	500,000	
400,000	400	0.40	0.00040	0.75	750	75,000	750,000	
200,000	200	0.20	0.00020	1.5	1,500	150,000	1,500,000	
100,000	100	0.10	0.00010	3.0	3,000	300,000	3,000,000	
80,000	80	0.080	0.000080	3.8	3,800	380,000	3,800,000	Dirty electricity <sup>12</sup>
60,000	60	0.060	0.000060	5.0	5,000	500,000	5,000,000	
40,000	40	0.040	0.000040	7.5	7,500	750,000	7,500,000	
20,000	20	0.020	0.000020	15	15,000	1,500,000	15,000,000	Solar inverters <sup>13</sup>
10,000	10	0.010	0.000010	30	30,000	3,000,000	30,000,000	Dirty electricity <sup>12</sup>
8,000	8	0.0080	0.0000080	38	37,500	3,750,000	37,500,000	
6,000	6	0.0060	0.0000060	50	50,000	5,000,000	50,000,000	
4,000	4	0.0040	0.0000040	75	75,000	7,500,000	75,000,000	
2,000	2	0.0020	0.0000020	150	150,000	15,000,000	150,000,000	
1,000	1	0.0010	0.0000010	300	300,000	30,000,000	300,000,000	
800	1	0.00080	0.00000080	380	380,000	38,000,000	380,000,000	
600	1	0.00060	0.00000060	500	500,000	50,000,000	500,000,000	
400	0	0.00040	0.00000040	750	750,000	75,000,000	750,000,000	
200	0	0.00020	0.00000020	1,500	1,500,000	150,000,000	1,500,000,000	
100	0	0.00010	0.00000010	3,000	3,000,000	300,000,000	3,000,000,000	
80	0	0.000080	0.000000080	3,800	3,800,000	380,000,000	3,800,000,000	Electrical power <sup>14</sup>
60	0	0.000060	0.000000060	5,000	5,000,000	500,000,000	5,000,000,000	
40	0	0.000040	0.000000040	7,500	7,500,000	750,000,000	7,500,000,000	
20	0	0.000020	0.000000020	15,000	15,000,000	1,500,000,000	15,000,000,000	
10	0	0.000010	0.000000010	30,000	30,000,000	3,000,000,000	30,000,000,000	

## ENDNOTES

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<sup>1</sup> The conversion of frequency to wavelength, in free space, is governed by this equation:

$$\lambda = \frac{c}{f}$$

where

$\lambda$  is the wavelength in meters (m).

$f$  is the frequency in hertz (Hz).

$c$  is the speed of light in free space, about  $3 \times 10^8$  meters per second (m/s).

The speed of light in air is only slightly less than the speed of light in free space, so the wavelength in air is only slightly shorter than the wavelength in free space for a given frequency.

<sup>2</sup> 28 to 71 GHz (with lower frequencies also under consideration). Federal Communications Commission, Fact Sheet: Spectrum Frontiers Rules Identify, Open Up Vast Amounts Of New High-Band Spectrum For Next Generation (5g) Wireless Broadband, June 14, 2016.

(<https://www.fcc.gov/document/rules-facilitate-next-generation-wireless-technologies>)

<sup>3</sup> 2.4 and 5 GHz. Wikipedia, List of WLAN Channels. ([https://en.wikipedia.org/wiki/List\\_of\\_WLAN\\_channels](https://en.wikipedia.org/wiki/List_of_WLAN_channels))

<sup>4</sup> 2.4 GHz. Wikipedia, Bluetooth. (<https://en.wikipedia.org/wiki/Bluetooth>).

<sup>5</sup> 900 MHz and 2.4 GHz in Maryland, USA.

<sup>6</sup> 1G does not appear here because it is now an old and analog technology that has been superseded by the following digital technologies: 2G (800, 850, 1900 MHz); 3G (850, 1700, 1900, 2100 MHz); and 4G (700, 800, 950, 1700, 1900, 2100, 2300, 2500 MHz). Wikipedia, Cellular frequencies in the US. ([https://en.wikipedia.org/wiki/Cellular\\_frequencies\\_in\\_the\\_US](https://en.wikipedia.org/wiki/Cellular_frequencies_in_the_US))

<sup>7</sup> 470-698 MHz. Wikipedia, North American television frequencies.

([https://en.wikipedia.org/wiki/North\\_American\\_television\\_frequencies#Broadcast\\_television](https://en.wikipedia.org/wiki/North_American_television_frequencies#Broadcast_television))

<sup>8</sup> 174-216 MHz. Wikipedia, North American television frequencies.

([https://en.wikipedia.org/wiki/North\\_American\\_television\\_frequencies#Broadcast\\_television](https://en.wikipedia.org/wiki/North_American_television_frequencies#Broadcast_television))

<sup>9</sup> 87.5 to 108 MHz. Wikipedia, FM Broadcasting. ([https://en.wikipedia.org/wiki/FM\\_broadcasting](https://en.wikipedia.org/wiki/FM_broadcasting))

<sup>10</sup> 530 to 1700 kHz. Wikipedia, AM Broadcasting. ([https://en.wikipedia.org/wiki/AM\\_broadcasting](https://en.wikipedia.org/wiki/AM_broadcasting))

<sup>11</sup> 50 kHz to 1 MHz. Wikipedia, Switched-mode power supply. ([https://en.wikipedia.org/wiki/Switched-mode\\_power\\_supply](https://en.wikipedia.org/wiki/Switched-mode_power_supply))

<sup>12</sup> Frequencies unwanted for any particular application.

<sup>13</sup> 20 kHz is one example, but other frequencies are also employed.

<sup>14</sup> 60 Hz.

## Who am I?

I am a retired U.S. Government career scientist (Ph.D. in Applied Physics from Harvard University). During my Government career, I worked for the Executive Office of the President, the National Science Foundation, and the National Institute of Standards and Technology. I currently interact with other scientists, with physicians, and with aware individuals worldwide about the impact of radiofrequency radiation on human health.