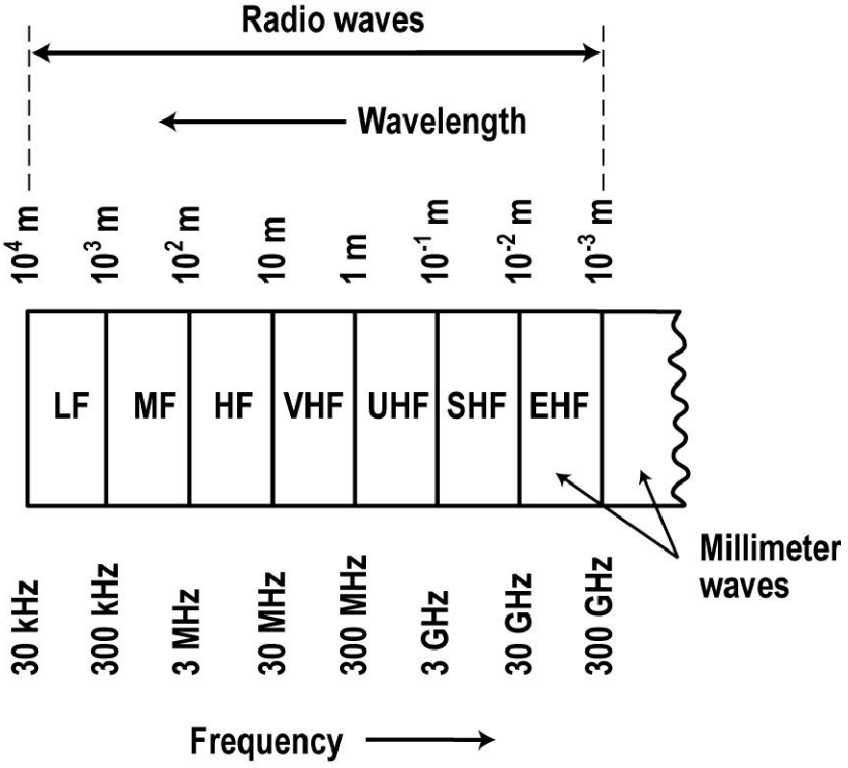
Electromagnetic Spectrum

Frequency Spectrum

A sine wave signal with a frequency from about 30 kHz up to 300 GHz can be radiated as a radio signal. This very wide frequency range is referred to as the frequency spectrum or as the electromagnetic frequency spectrum.

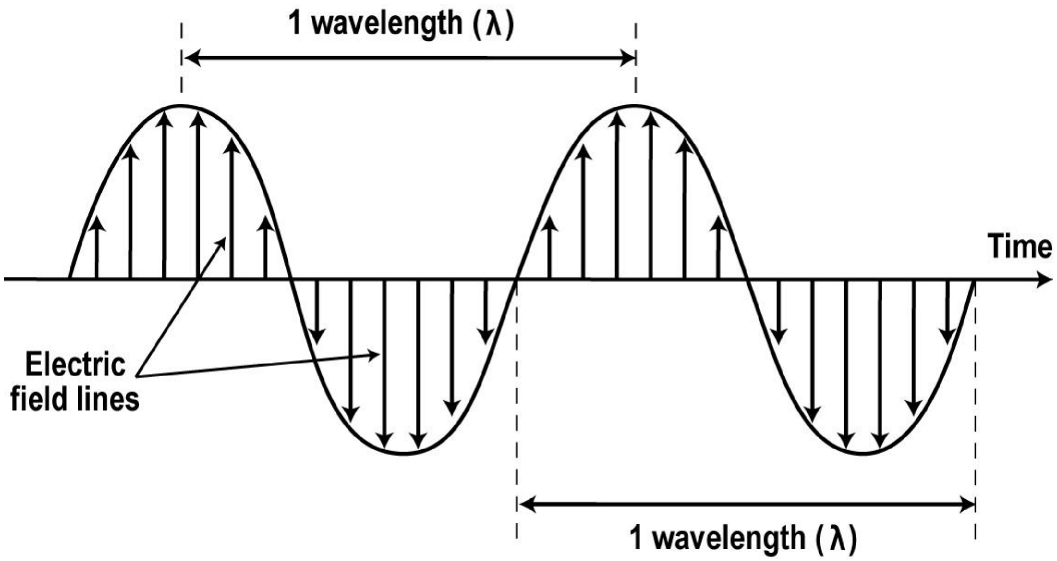
Since the spectrum is free space, it is obviously shared by everyone on earth. It is a precious natural resource and must be regulated internationally by government agencies. In the US, spectrum is allocated and regulated by the Federal Communications Commission (FCC) and the National Telecommunications and Information Agency (NTIA). Spectrum management and allocation is necessary to prevent different radio services from interfering with one another.

The Frequency Spectrum



The electromagnetic spectrum is divided up into different frequency ranges for reference. The signals can also be referred to by their wavelength.

Wavelength



The wavelength of a signal is the distance between the maximum or minimum intensities of the magnetic or electric fields as the signal travels through space. The figure shown here shows a sinusoidal variation of the electric field portion of a radio wave indicating the periodic field reversals and one wavelength.

Wavelength Distance

This distance of one wavelength is designated by the lower case Greek lambda (λ) and is related to frequency by the expression λ = 300,000,000/f.

300,000,000 is the speed of light in meters per second and f is the frequency in Hz. A simpler version is $\lambda = 300/f_{MHz}$. For example, a signal has a frequency of 72 MHz. Its wavelength is 300/72 = 4.167 meters.

Wavelength is also the distance traveled by a wave in the time of one cycle (the period t = 1/f).

Notes About the Spectrum

The range from 30 kHz to 30 GHz is allocated and used more than the others. In fact, there is a spectrum crisis because there is not enough to go around to all those wanting or needing it.

The frequency spectrum is sometimes sold to the highest bidder.

Frequencies above 1 GHz are referred to as microwaves.

Frequencies above 30 GHz are sometimes referred to as millimeter waves since their wavelength is so short it is best expressed in millimeters (mm).

The spectrum above 300 MHz is essentially not used except as it reaches a frequency of about one millionth of a meter (called a micron). At that point the optical spectrum begins.

The table on next slide shows the different ranges of the frequency spectrum and applications.

The Electromagnetic Spectrum

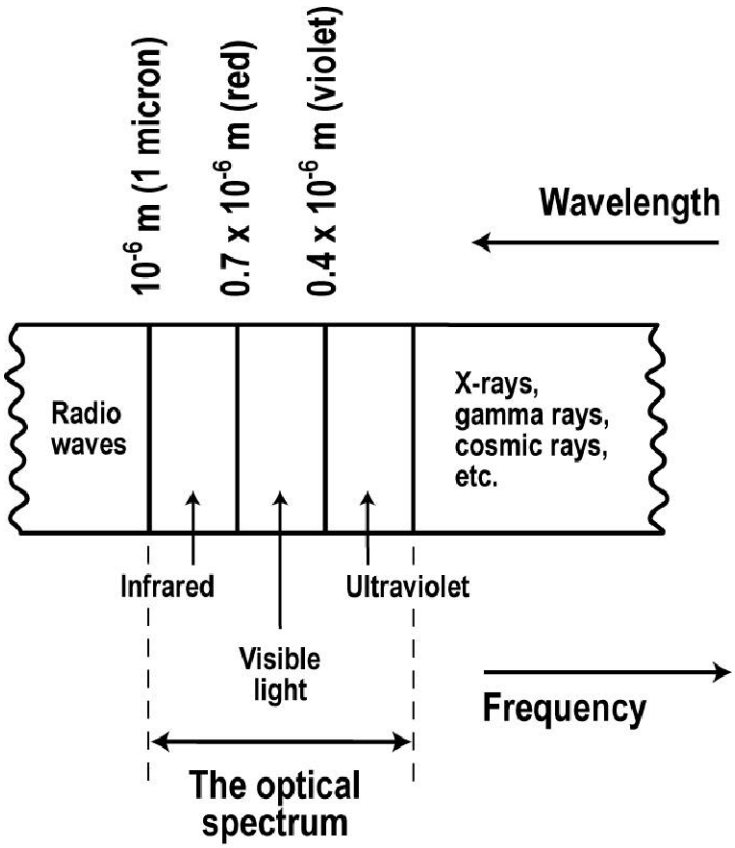
Low Frequency (LF)	30 kHz to 300 kHz	Aeronautical & marine navigation
Medium Frequency (MF)	300 kHz to 3 MHz	AM broadcast radio, marine, amateur radio
High Frequency (HF)	3 to 30 MHz	CB, shortwave broadcast and amateur radio
Very High Frequency (VHF)	30 to 300 MHz	FM radio, TV, mobile, marine and aircraft radio
Ultra High Frequency (UHF)	300 MHz to 3 GHz	TV, satellites, cell phones, WLANs
Super High Frequency (SHF)	3 to 30 GHz	Satellites, radar, microwave relay, wireless networks
Extremely High Frequency (EHF)	30 to 300 GHz	Satellites, radar. (Virtually unused)

Optical Spectrum

The optical spectrum is the spectrum of light. Light is also a form of electromagnetic wave.

The three main segments of the optical spectrum are infrared (IR), visible, and ultra violet (UV).

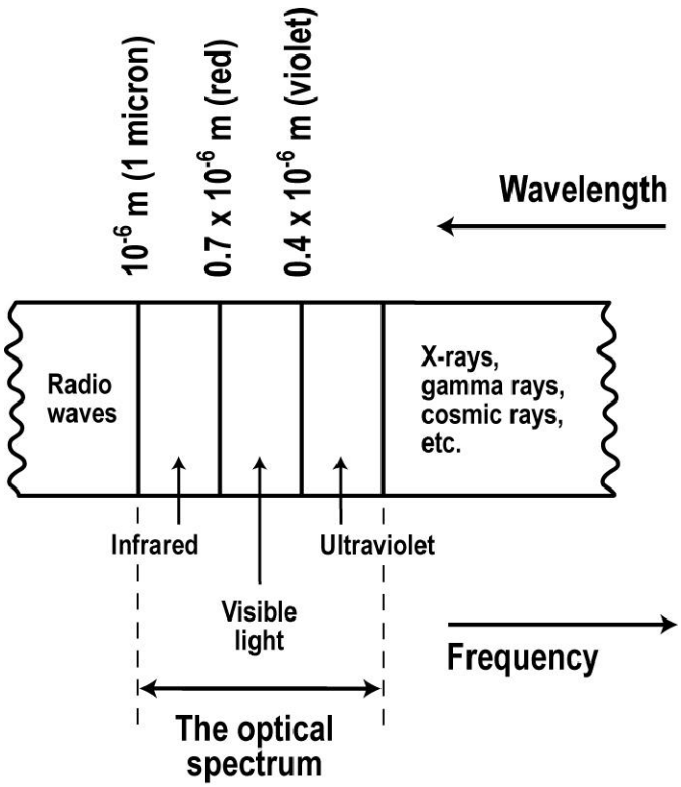
The optical spectrum is usually referred to by its wavelength instead of its frequency.



Optical Spectrum: IR

IR extends from below about 1 x 10^{-6} to 0.7 x 10^{-6} meters. 0.7 x 10^{-6} meters is the same as 700 x 10^{-9} or 700 nanometers (nm).

IR is widely used in communications and wireless. TV and other remote controls are IR. IR is used to transmit signals in various types of networks. IR signals are also those transmitted over fiber optical cable. IR waves come from heat. Heat-seeking missiles detect IR. IR can also be generated by light emitting diodes (LEDs) or lasers.

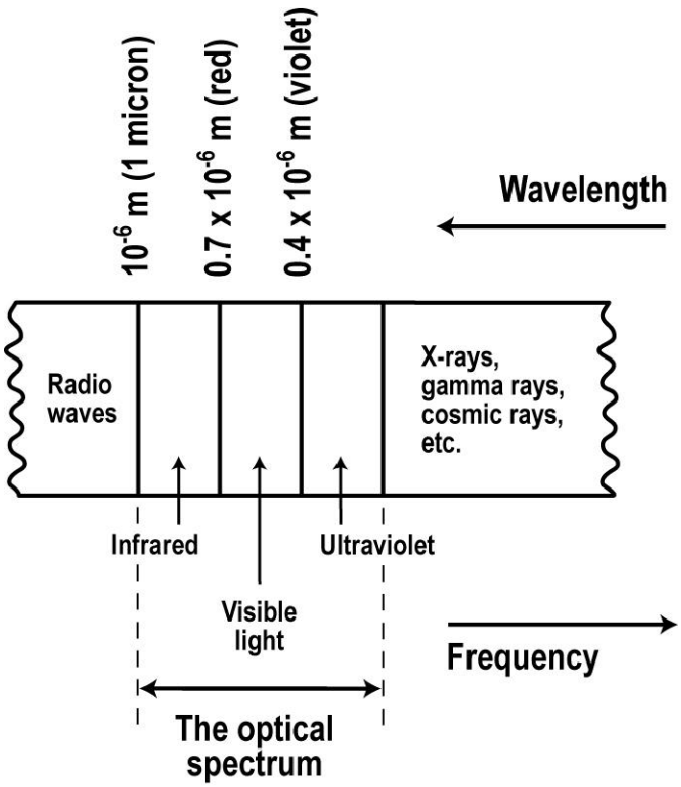


Optical Spectrum: Visible and Ultraviolet

Visible light extends from about 700 nm (red) up to about 400 nm (violet). The eye has a peak color response in the 500 to 600 nm (yellow-green) range.

Visible light is not used in wireless communications.

Ultraviolet (UV) has an even higher frequency or shorter wavelength. It is not used in communications. UV is well known for the sunburn it causes.



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