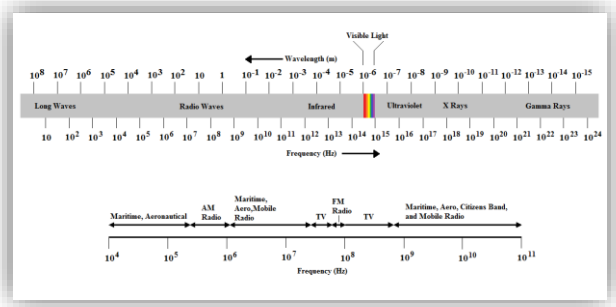
Introduction to Basic Electro-Magnetic Concept



Now that we have introduced the time and frequency domains, let's take a closer look at electro-magnetic radiation and the electro-magnetic spectrum.
Electro-magnetic radiation is a form of energy that is carried by synchronized oscillating electric and magnetic fields. Electro-magnetic radiation is unique in that its actions can be explained by theories that are based on both waves and particles. Electro-magnetic radiation also travels without a medium. Waves on the ocean require water in order to exist. Sound waves require air to propagate. Neither of these waves can travel through a vacuum. But, electromagnetic waves can. In fact, they travel through the vacuum of space at the speed of light.

Recall that a wave can be described by its frequency of oscillation. Electro-magnetic waves are no different and they cover quite a broad range of frequencies. In fact, there are no known physical limits on maximum and minimum frequencies in nature.
Frequencies are grouped into bands based on similarities in their physical traits or specific applications. Some frequency bands travel through the Earth's atmosphere with less loss. Some are more useful for a particular application and are "set aside" for experimentation and some bands contain more than one official user.

Two common frequency bands to note are light and radio. Visible light is defined as electro-magnetic radiation having wavelengths from 400 to 700nm (1nm is 1x10-9m). This is equivalent to frequencies from 5x1014Hz to 1x1015Hz, although wavelengths are traditionally used when discussing light. Electromagnetic radiation having wavelengths (or frequencies) in this band are visible to a human observer.
The Radio Frequency (RF) band of electro-magnetic waves have frequencies from 8.3kHz (104 HZ) to 300GHz (1011HZ).

The full electro-magnetic spectrum and the RF band are shown below:

The RF band is useful for many industries and applications. It is used in direct audio communications (cell phones, mobile radios, FM radio), device communications (wireless keyboard, WiFi hotspot, game controller), as well as interplanetary studies like the giant radio telescope at the Arecibo Observatory in Puerto Rico.

Within the RF band, there are specific frequencies that are dedicated to communication and broadcast that are open to anyone with the ability to transmit. The Citizens band (CB) as well as Industrial, Science, and Medical band (ISM) are examples of unlicensed communications bands.

Others, like FM radio, are licensed channels that are specifically allocated or rented by individuals or corporations for a particular use. Licensed broadcast channels are monitored very closely by the national government and the channel licensee in order to ensure that the broadcasts maintain certain content and physical transmission criteria. In the USA, the RF spectrum is regulated by the Federal Communications Commission (FCC).

Electro-magnetic Interference (EMI) is also an important aspect of the RF story. There are devices that are designed to transmit and receive RF signals. These are classified as intentional radiators. Some examples include FM radios, WiFi routers, and wireless keyboards. But, there are also devices that are not specifically intended to create RF signals. These are classified as unintentional radiators and are the primary source of electromagnetic interference (EMI).

EMI is RF noise. An unintentional radiator creates RF radiation that is not intended to communicate, control, or deliver any relevant information. Therefore, unintentional radiators are RF noise sources. Some designs exhibit less noise than others. But, just imagine if every electronic device emitted a large amount of RF noise?
What if your radio controlled car interfered with the radar at a nearby airport?
In order to control and maintain a safe operating environment, governments regulate the amount of acceptable EMI that a design or product can have. Products outside of the limits set forth by the regulations can bring heavy financial penalties to offending individuals or companies.
When performing experiments and development with RF, it is very important to understand the requirements of working within a specific frequency band. If you are working within a licensed or restricted band, make sure to research how to do that safely and work within the regulations for that band.
Our previous discussions on the time/frequency domains and the electromagnetic spectrum have provided a base for our knowledge of RF. In the following sections, we will introduce basic RF measurement instrumentation and techniques with a focus on typical RF component tests, broadcast/radio monitoring, and EMI.