1. Microwave Frequency Bands:

The field of radio frequency (RF) and microwave engineering generally covers the behaviour of alternating current signals with frequencies in the range of 100 MHz. RF frequencies range from very high frequency (VHF) (30–300 MHz) to ultra-high frequency (UHF) (300–3000 MHz), while the term microwave is typically used for frequencies between 3 and 300 GHz, with a corresponding electrical wavelength between $\lambda = c/ f = 10$ cm and $\lambda = 1$ mm, respectively.

Signals with wavelengths on the order of millimeters are often referred to as millimeter waves. Because of the high frequencies (and short wavelengths), standard circuit theory often cannot be used directly to solve microwave network problems. In a sense, standard circuit theory is an approximation, or special case, of the broader theory of electromagnetics as described by Maxwell's equations. This is due to the fact that, in general, the lumped circuit element approximations of circuit theory may not be valid at high RF and microwave frequencies. Microwave components often act as distributed elements, where the phase of the voltage or current changes significantly over the physical extent of the device because the device dimensions are on the order of the electrical wavelength. At much lower frequencies the wavelength is large enough that there is insignificant phase variation across the dimensions of a component. The other extreme of frequency can be identified as optical engineering, in which the wavelength is much shorter than the dimensions of the component. In this case Maxwell's equations can be simplified to the geometrical optics regime, and optical systems can be designed with the theory of geometrical optics.
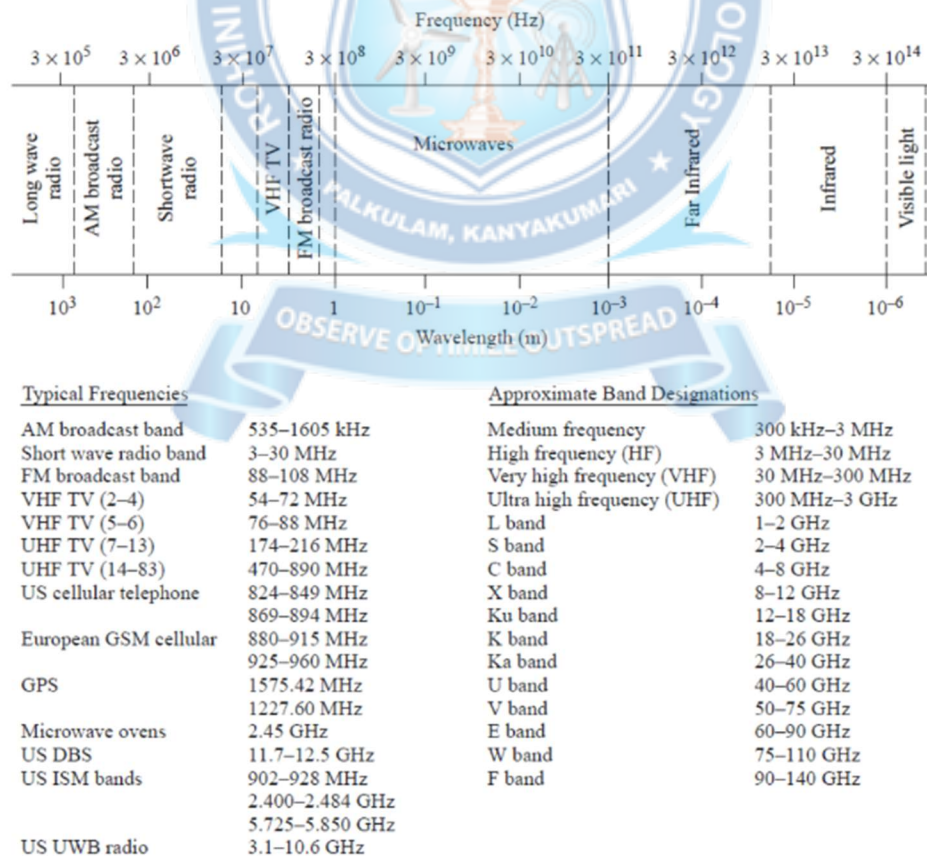

Typical Frequencies		Approximate Band Designations	
AM broadcast band	535–1605 kHz	Medium frequency	300 kHz–3 MHz
Short wave radio band	3–30 MHz	High frequency (HF)	3 MHz–30 MHz
FM broadcast band	88–108 MHz	Very high frequency (VHF)	30 MHz–300 MHz
VHF TV (2–4)	54–72 MHz	Ultra high frequency (UHF)	300 MHz–3 GHz
VHF TV (5–6)	76–88 MHz	L band	1–2 GHz
UHF TV (7–13)	174–216 MHz	S band	2–4 GHz
UHF TV (14–83)	470–890 MHz	C band	4–8 GHz
US cellular telephone	824–849 MHz	X band	8–12 GHz
	869–894 MHz	Ku band	12–18 GHz
European GSM cellular	880–915 MHz	K band	18–26 GHz
	925–960 MHz	Ka band	26–40 GHz
GPS	1575.42 MHz	U band	40–60 GHz
	1227.60 MHz	V band	50–75 GHz
Microwave ovens	2.45 GHz	E band	60–90 GHz
US DBS	11.7–12.5 GHz	W band	75–110 GHz
US ISM bands	902–928 MHz	F band	90–140 GHz
	2.400–2.484 GHz		
	5.725–5.850 GHz		
US UWB radio	3.1–10.6 GHz		

Figure 1.1 The electromagnetic spectrum.

1.1 Applications of Microwave Engineering

• Antenna gain is proportional to the electrical size of the antenna. At higher frequencies, more antenna gain can be obtained for a given physical antenna size, and this has important consequences when implementing microwave systems.

• More bandwidth (directly related to data rate) can be realized at higher frequencies. A 1% bandwidth at 600 MHz is 6 MHz, which (with binary phase shift keying modulation) can provide a data rate of about 6 Mbps (megabits per second), while at 60 GHz a 1% bandwidth is 600 MHz, allowing a 600 Mbps data rate.

• Microwave signals travel by line of sight and are not bent by the ionosphere as are lower frequency signals. Satellite and terrestrial communication links with very high capacities are therefore possible, with frequency reuse at minimally distant locations.

• The effective reflection area (radar cross section) of a radar target is usually proportional to the target's electrical size. This fact, coupled with the frequency characteristics of antenna gain, generally makes microwave frequencies preferred for radar systems.

• Various molecular, atomic, and nuclear resonances occur at microwave frequencies, creating a variety of unique applications in the areas of basic science, remote sensing, medical diagnostics and treatment, and heating methods.