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Antenna & Propagation

Antenna Fundamental

by

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Chapter Synopsis

In this chapter, the student will be exposed to the basic of communication systems. The regular term that regarding to communication and in specifically in antenna.

Teaching Outcome

At the end of this chapter student should be able to:

- ❑ Understand the fundamentals of antenna operation.

- ❑ Know the basic regular term in antenna communications.

Introduction

- Our 'operational' life today depends on wireless network such as:
  - Cellular Telephony
  - Global Positioning Systems (GPS)
  - Wireless Fidelity (Wi-Fi)
  - Television / Radio Broadcast
- Wireless technologies use radio waves to communicate.

Radio Waves

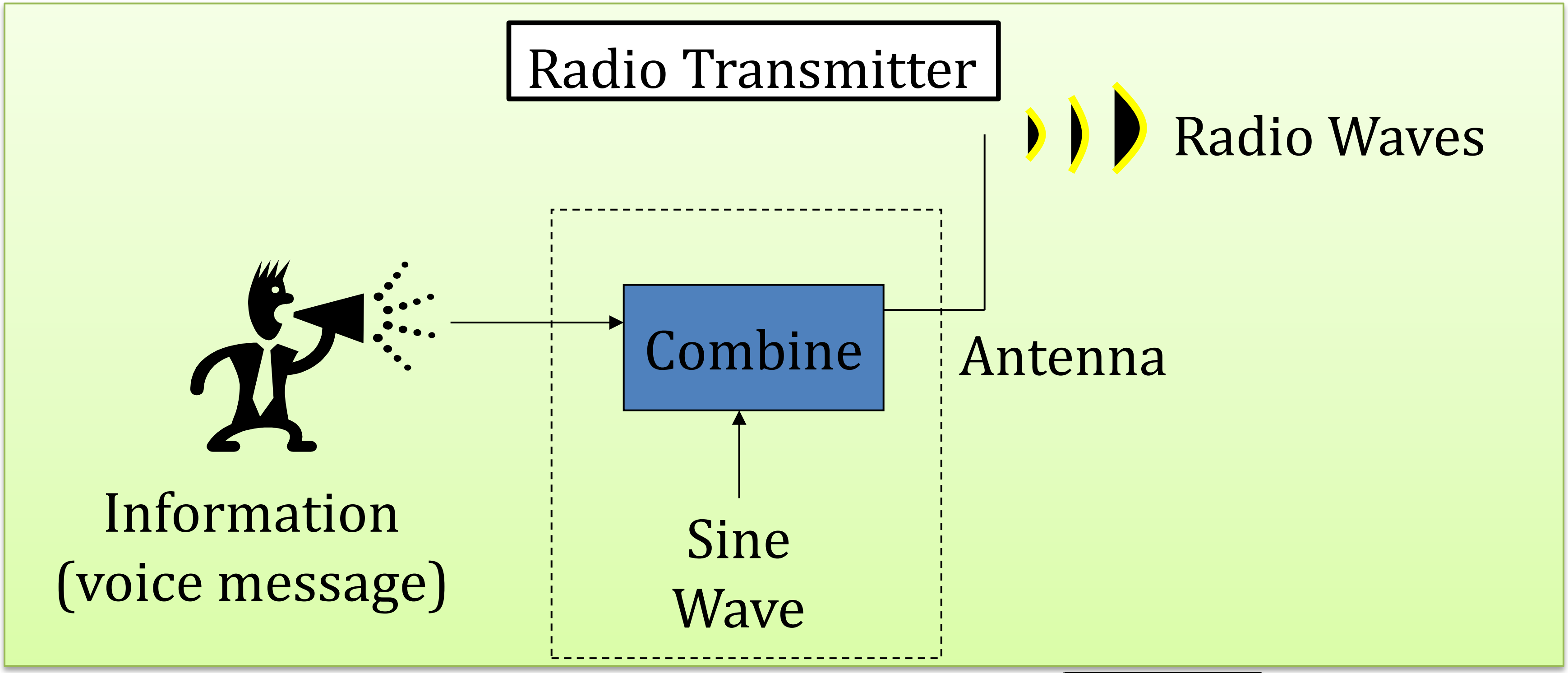
- Radio waves carry information invisibly through the air over millions of miles.
- Radios can transmit and/or receive radio waves.

Radio Basic

- Any radio setup has two parts: **Transmitter** and **Receiver**
- **Transmitter:** takes some form of message (someone's voice, pictures for TV set, etc.) encodes it into a sine wave and transmits it with radio waves.
- Combination of encoded message on a radio wave is commonly referred to as a **signal**.
- **Receiver:** receives radio waves and decodes messages from the sine waves.
- Both transmitter and receiver use antennas to radiate and capture radio waves.

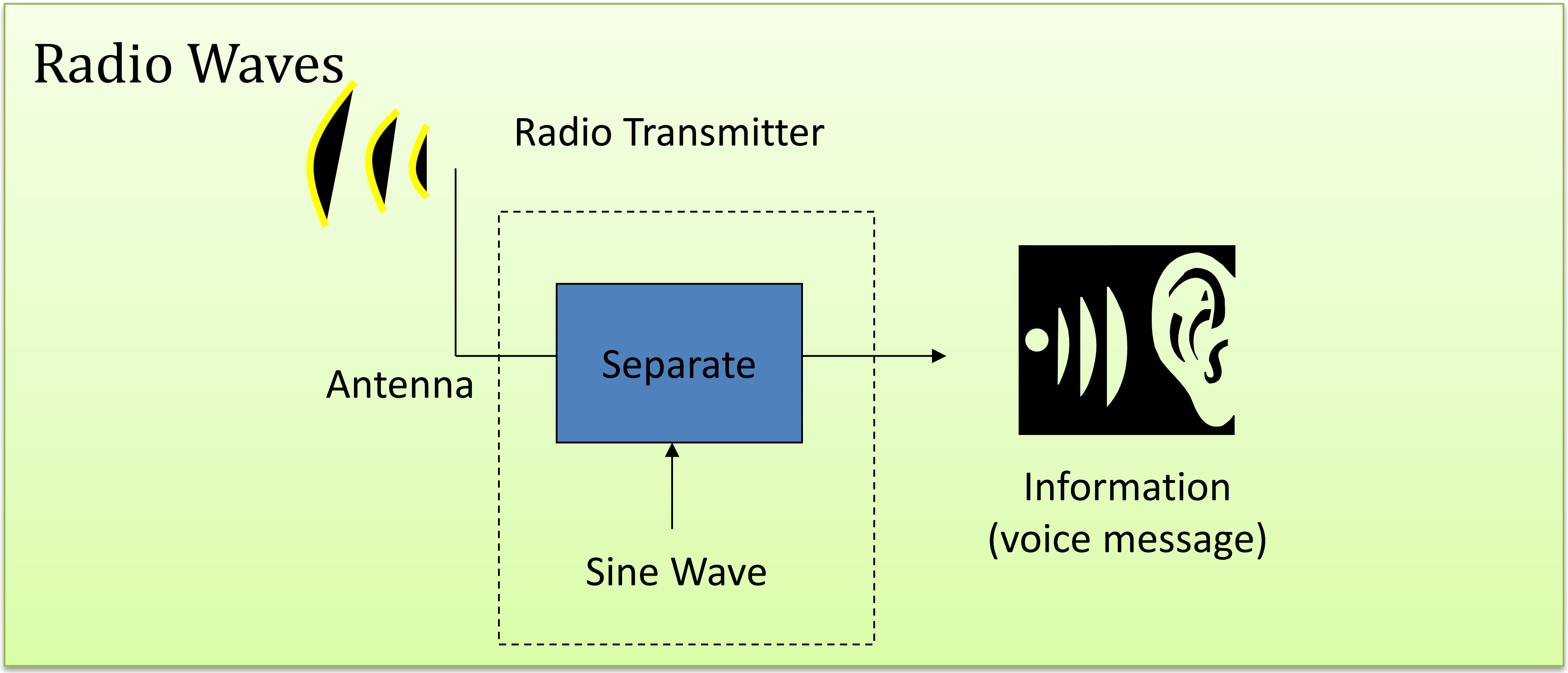
Transmitter Description

Transmitter generates its own sine wave using oscillators.



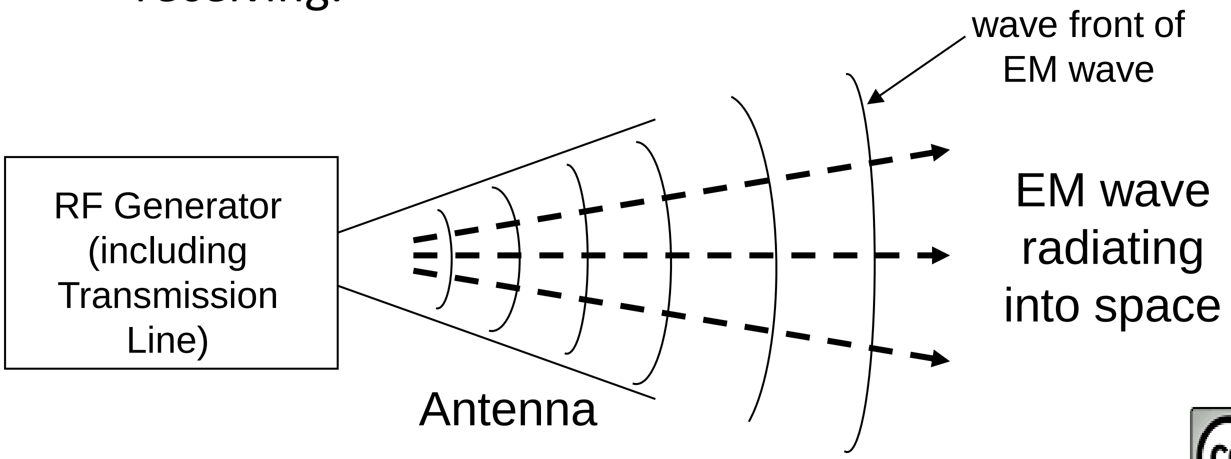
Receiver Description

Receiver decodes messages from the sine waves.



Antenna as an Interface

- Antennas are dielectric structures that allow radiating of electromagnetic (EM) waves into space.
- Theoretically, any structure can radiate EM waves but not all structures can do it efficiently.
- An antenna can be viewed as a transducer between a transmission and the surrounding medium. It can be used for either transmitting or receiving.



Antenna

- Often radio stations use extremely tall antenna towers to transmit their signals.
- Antenna at radio **transmitter**: launch radio signals into space.
- Antenna at radio **receiver**: pick up as much of the transmitter’s power as possible and feed it to the tuner.

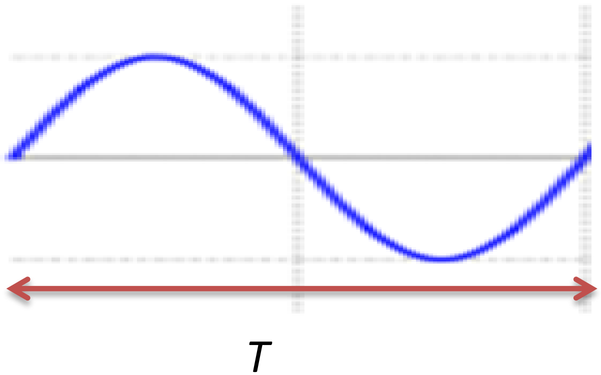
Sine Waves

- By sending sine wave electric current to antenna, you can transmit sine wave into space.

- All radios today, however, transmit continuous sine waves to transmit information (audio, video, data).

Period vs Frequency

- One cycle (period) of a sine wave is:



- Sine wave can be written as $\sin(\frac{2\pi t}{T})$
- When one cycle of a sine wave lasts *T* seconds, the sine wave as frequency 1/*T* Hertz (Hz).
- 1 Hz = 1 cycle/second.

Frequency

- When you listen to Analog Modulation (AM) broadcast, your radio is tuning into sine waves oscillating at a frequency around 1,000,000 cycles per second.

- For example, 880 on the AM dial corresponds to listening to a radio (sine) wave that has frequency 880,000 Hz = 880 KHz.

- Frequency Modulation (FM) signals operate in range of 10,000,000 Hz. So, 90.9 on FM dial corresponds to 90,900,000 Hz = 90.9 MHz.

Frequency – Wavelength (λ) Relationship

The **wavelength** (λ) **in unit meter** of an electromagnetic wave is related to its **frequency** (f) by:

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

where ;
$c = 3x10^8\ m/s$ (speed of light in vacuum)

Decibel (dB)

- In the electronic communication field, decibel is normally used to define the power ratios between two (2) signals.
- To express relative gain and lose of the electronic device/circuit.
- Describing relationship between signal and noise
- It also used to express the ratios of voltage and current
- If two (2) powers are expressed in the same units (e.g. watt, miliwatt), their ratio is a **dimensionless** quantity that can be expressed in decibel form as follow:

$$dB = 10\log_{10}\left(\frac{P_1}{P_2}\right)$$

Power Gain

To measure the power gain or loss of any electronic circuit or device, the equation can be written as follow:

$$A_{p(dB)} = 10 \log_{10}\left(\frac{P_{out}}{P_{in}}\right)$$

where; $A_{p(dB)}$: power gain (unit in dB) of P_{out} with respect to P_{in}

P_{out} : output power level (watts)

P_{in} : input power level (watts)

P_{out}/P_{in} : absolute power gain (unitless)

Indication of +ve or –ve dB

- Positive (+) dB value indicates the output power is greater than the input power, which indicates **power gain** or **amplification**.

- Negative (-) dB value indicates the output power is less that the input power which indicates **power loss** or **attenuation**.

- If $P_{out} = P_{in}$, the absolute power gain is **1**, which means dB power gain is **0** (referred as **unity** power gain).

Power Gain

Expressing power gain in term of voltage ratio,

From: $P \alpha V^2$

i.e, $$\mathrm{dB} = 10\log_{10}\left(\frac{V_{out}^2}{V_{in}^2}\right)$$

Then, $$A_{v(dB)} = 20\log_{10}\left(\frac{V_{out}}{V_{in}}\right)$$

References

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[3] T. A. Milligan, "Modern Antenna Design" John Wiley, 2nd edition, 2005.

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