DDPP 2163 Propagation Systems

Radar System

Introduction

- **Radar – radio detection and ranging**
- **Developed in the early 1900s (pre-World War II)**
  - 1904 Europeans demonstrated use for detecting ships in fog
  - 1922 U.S. Navy Research Laboratory (NRL) detected wooden ship on Potomac River
  - 1930 NRL engineers detected an aircraft with simple radar system
- **World War II accelerated radar's development**
  - Radar had a significant impact militarily
  - Called "The Invention That Changed The World" in two books by Robert Buderi

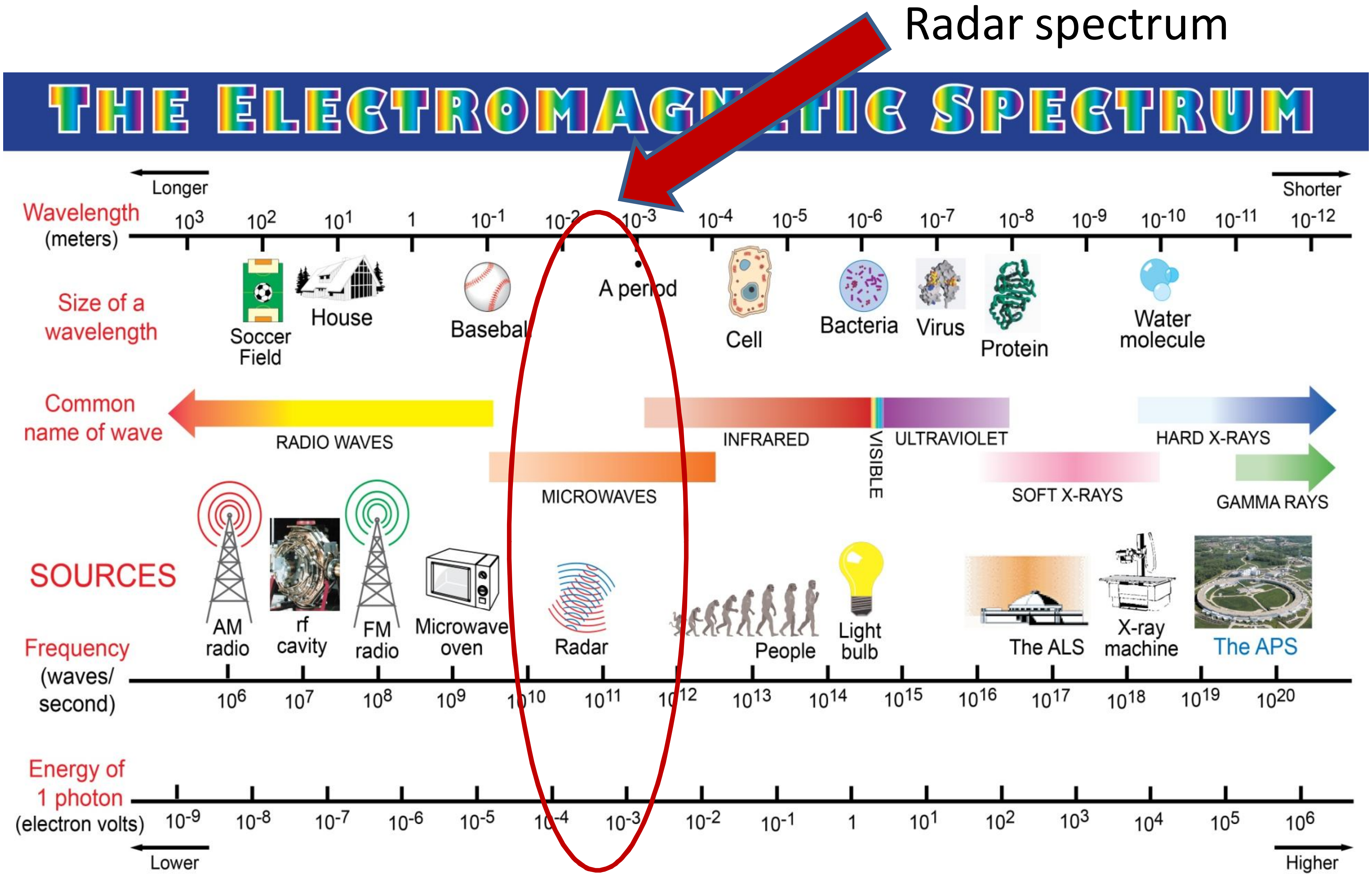
What is radar?

Radar uses radio waves to determine the range, altitude, direction, or speed of objects. It can be used to detect aircraft, ships, spacecraft, guided missiles, motor vehicles, weather formation and terrain.

Radar frequency bands

Frequency Band	Primary Application
HF, VHF	Primarily used for early warning and over-the-horizon
UHF (300 M-1 G)	Used for early warning radars, wind profilers
L-band(1G-2G)	Used for Air Route Surveillance Radars. Used by first civilian remote sensing American satellite carrying SAR (SEASAT) and Japanese JERS-1 satellites (L band SAR) and NASA airborne system.

Electromagnetic Spectrum



Radar frequency bands (cont.)

Frequency Band	Primary Application
S-band	Used on board the Russian ALMAZ satellite, Magellan mapped Venus
C-band	Used on board the Russian ALMAZ satellite, Magellan mapped Venus
X-band	Commonly used on airborne (CCRS Convair-580 and NASA AirSAR) and spaceborne systems (including ERS-1 and 2(SAR & radar altimeter) and RADARSAT.
Ka, K, and Ku	Used in early airborne radar systems but uncommon today.

What can it measure?

Measurements	Techniques
Range	Using Pulse Delay
Velocity	From Doppler Frequency Shift
Angular Direction	Using Antenna Pointing
Target Size	From magnitude of reflected energy
Target Shape	Analyzing reflected signal as a function of direction
Moving Parts	Analyzing modulation of the reflected signal

Radar Analogy

When you shouted in the well, the time taken for you to hear the echo will tell you the depth of the well.

This is an analogy to radar where in this case the measurement is depth

How radar works?

1. Magnetron
- Generates high-frequency radio waves

2. Duplexer
- switches magnetron through to antenna

3. Antenna
- Acts as a transmitter, generates a signal or radio waves

4. Object
- Radio waves hits the object and reflected

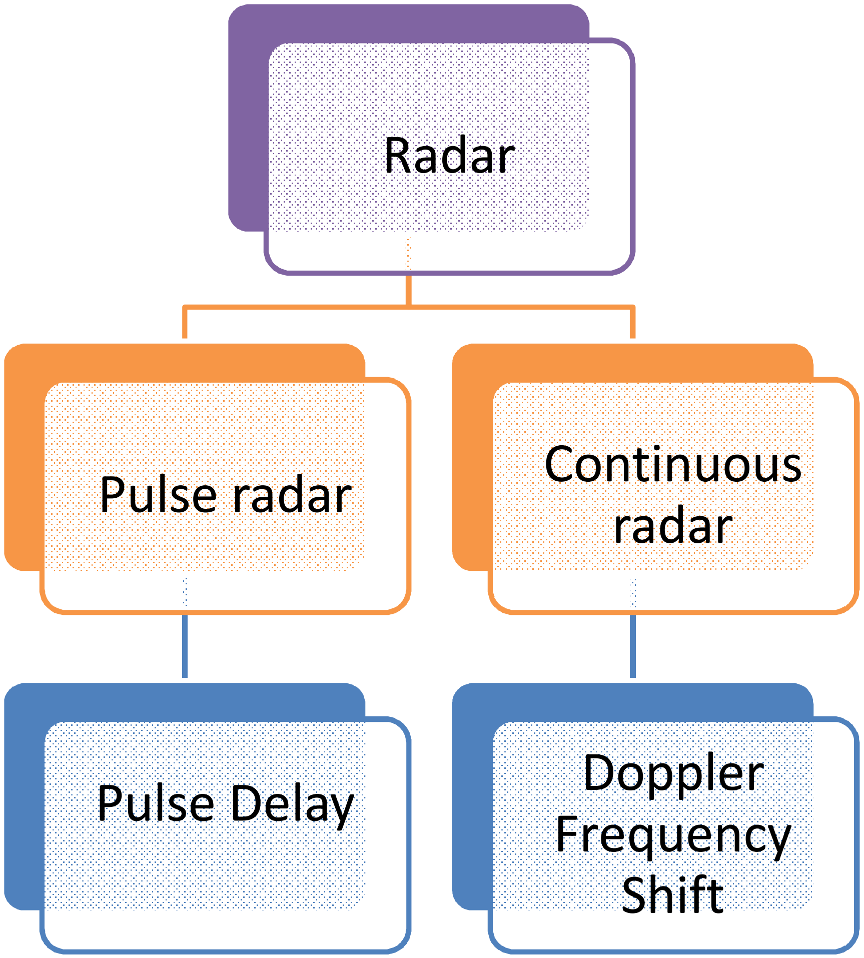
5. Antenna
- Picks up reflected waves during a break between transmissions.

6. Duplexer
- Switches antenna through to receiver unit

7. Computer in receiver
- Processes reflected waves and draws them on a TV

8. TV radar
- Shows the object with any other nearby targets.

Radar Categories



Pulse radar

- A short burst of microwave called burst is transmitted to the object
- A duration between the transmitted time and received time of the pulse is computed for the range of the object

Pulse radar

- Pulse repetition time (PRT)
  - time taken for the pulses to repeat,
- Pulse repetition frequency (PRF)
  - the number of pulses transmitted per second, PRF = 1/PRT
- Pulse Width (PW)
  - the duration of the pulse
- Receiver time
- – the time between pulse

PRT = PW + receiver time

Radar Range Determination

- Range of target ,

$$R = \frac{ct}{2}$$

- Maximum range, $R_{\max}$

$$R_{\max} = \frac{cT}{2}$$

- Minimum range, $R_{\min}$

$$R_{\min} = \frac{cT_p}{2}$$

where R = distance to the target (meters)

c = velocity of light

t = time taken from the echo to return (sec)

T = pulse period

T_p = pulse duration

Continuous Wave Radar

- Transmits radio waves continuously and compares the frequency of the received echo with that of the transmitted signal
- Relative motion between the radar and the object can create Doppler Effect
- Thus, the velocity can be obtained

Doppler Effect

- Doppler shift frequency,

$$f_D = \frac{2 v_r f_i}{c}$$

- relative velocity of object,

$$v_r = \frac{c f_D}{2 f_i}$$

where

f_D = Doppler shift (Hertz)

v_r = relative velocity of the source and target (m/s)

f_i = incident frequency (Hertz)

c = velocity of light (m/s)

END