Radar sends EM waves. It works by radiating energy (EM waves) into space and detecting the echo signals reflected from target.

Reflected EM wave that is returned to the radar : not only indicates presence of a target but also indicate its location

Location of target can be found out by: comparing the received echo with transmitted radiated energy (from this information the radar tell location and distance of a target)

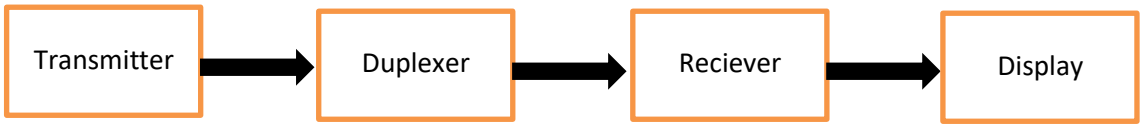
There are no other competitive techniques that can accurately measure long range in both clear and badwhether , as radar can (due to advantages of µW freq. stated before).

Radar is an object-detection system uses EM waves to determine range,altitude(measure of angle height),direction or speed of both moving and fixed objects. Ships,aircraft-space craft,gunded missiles motor vichles information and terrain.

The modern use of radar are:

- Air traffic control
- Radar astronomy
- Air defense system
- Anti-missile system
- Nautical radars used to locate ships

Block diagram of primary rdar with signal flow:



Transmitter → duplexer → antenna → EM wave → aim(target object of detection)

Display ← Reciever ← duplexer ← antenna ← echo signal ← aim

Components of block diagram:

Tx : The transmitter creates EM waves in the range.

Rx : Receiver: is a sensitive receiver which receives the picked-up echo or return by the antenna and provides amplification of this return signal.

Duplexer : is a device that allows bidirectional communication over a single channel.

Duplexer :

1- Is device allows bi-directional (duplex) communication over a single channel
2- Single antenna is used for both transmission and reception
3- Protects receiver from damage caused by high power of transmitter
4- Manage received echo to go to receiver and not to transmitter

Operating principle of primary radar: The radar antenna illuminate the target with μW signal which is then reflected and picked up by a receiving device The electrical signal picked up by the recieveing antenna is called echo or return. The radar signal is generated by a powerful transmitter and received by a highly sensitive receiver

Radar classification

☒ **Based on system:**
- Ground based system
- Air borne based system
- Space brone based system
- Ship based system

☒ **Based on specific characteristics:**
- Frequency band
- Antenna type
- Type of wave form used

☒ **Mission and/or functionality of radar:**
- Weather
- Acquisition tracking and search
- Tracking while scan
- Fire control
- Early warning
- Over the horizon
- Terrain following
- Terrain avoidance radar
- Phased array radars

☒ **Phased array radar:** it uses phased array antenna (formed from 2 or more basic radiator) . This array give more narrow direction beams (high directivity) can be steered :
- Mechanically
- electronically

} Electronic steering

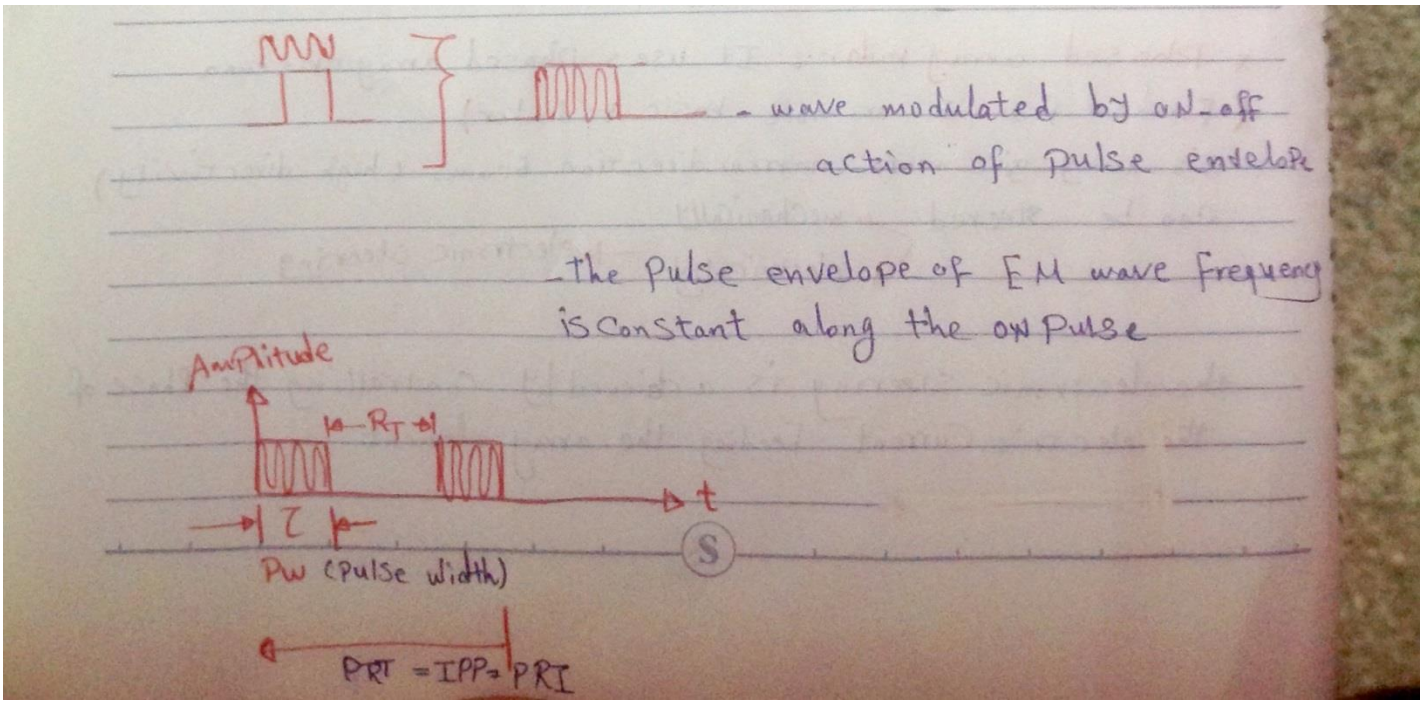
The electronic steering is achieved by controlling the phase of the electric current feeding the array element

☒ **The wave form used in radar:**

- CW " continuous wave"
- PR " pulse radar"

- **CW :**
  - CW → radar continuously emit EM energy and use separate transmit and receive antennas (two's antenna)
  - CW are un-modulated
  - CW radar required relative motion of either the radar or the target to indicate target position (frequency shift)
  - CW radar relieson the "Doppler effect"
  - CW application : target velocity search and track in missile guidance

- **Pulse radar:**
  - Pulse radar transmits a series of pulses separated by non-transmission intervals during – which the radar "listens" for a return echo"
  - Used to determine target range



☒ **Common parameters of radar pulse:**

- Pulse width Ƭ [msec] = duration of the pulse
- Rest time (RT) ≡ listening time :
  Interval of non-transmission of pulse during which the radar listen for a return of (echo)
- PRT ≡ pulse repetition time
- PRI ≡ pulse repetition time
- IPP ≡ inter pulse period

Is the time between the beginning of one pulse and the start of the next pulse and is equal to the reciprocal of pulse repetition frequency (PRF)

$$PRF = \frac{1}{PRT} = \frac{1}{PRI} = \frac{1}{IPP} = F_r$$

- The pulse repetition frequency of the radar system is the number of pulses that are transmitted per second.
- PRI = Ƭ + RT
- RF ≡ Radio frequency [GHz or MHz]: is the frequency of the carrier which is modulated by the pulse train
- PT ≡ peak power (peak transmitted power)
- P_{av} ≡ average power : is the transmitted power over the pulse repetition time.

$$P_{av} = P_t * \frac{\tau}{PRT} = P_t * \tau * PRF$$

Average power = peak power * (pulse width / pulse repetition time)
= peak power * pulse width * pulse repetition frequency

- Duty cycle : is the ratio of average power to peak power of pulse width or pulse width to be PRT or pulse width by PRF

Duty cycle = Ƭ * PRF

$$= \frac{\tau}{PRT} = \frac{P_{av}}{P_t}$$