RADAR PERFORMANCE

ECE 521E – RADAR & SATELLITE ENGINEERING

Monday, 21 September 2026

MAXIMUM RANGE

The Radar equation (see last lecture notes) is given by

$$P_r = \frac{P_t G_t A_r G_r}{(4\pi)^2 R_1^2 R_2^2} = \frac{P_t G^2 A_r \sigma}{(4\pi)^2 R^4}$$

The maximum range R_{max} is the distance beyond which the target cannot be detected.

If the received signal power P_r is just equal to the minimum detectable signal, S_{min}, then

$$R_{max}^4 = \frac{P_t G \sigma A_e}{(4\pi)^2 S_{min}}$$

$$R_{max} = \sqrt[4]{\frac{P_t G \sigma A_e}{(4\pi)^2 S_{min}}}$$

P_t = Transmitter Power
G = Gain of receiving antenna
σ = Cross section area of the target / scatterer
A_e = Aperture of receiving antenna
S_{min} = Minimum detectable signal
R_{max} = Maximum range of the target

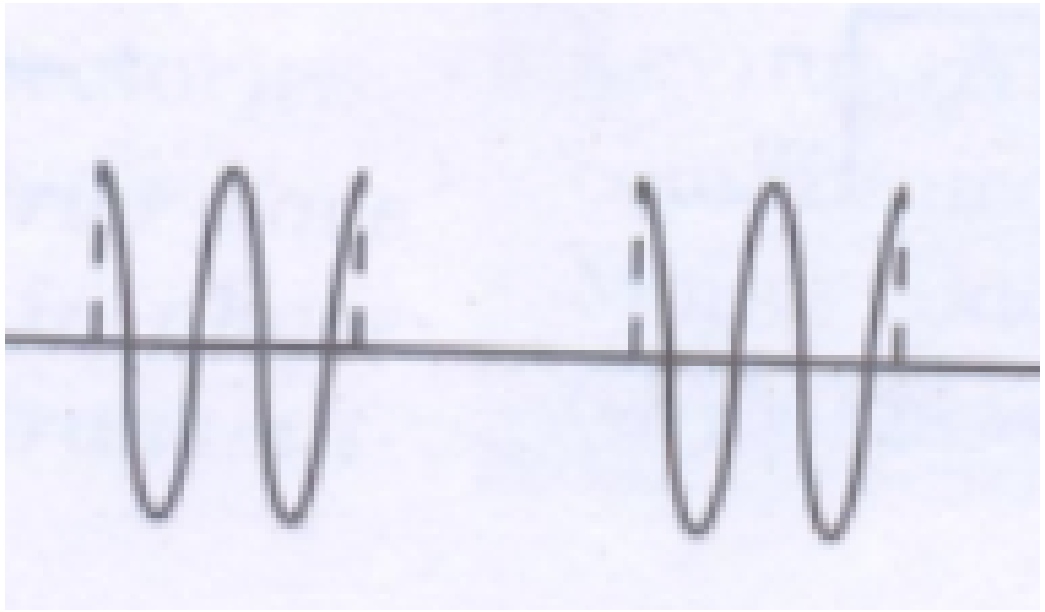
DRAWBACKS OF RADAR EQUATION

There are some drawbacks of the simple form of the radar equation as follows:

1. Fluctuation and uncertainties of the target radar cross-section
2. Nature of minimum detectable signal which is effected by the receiver noise
3. Losses in the radar system
4. Propagation effect of the earth surface and atmosphere

TRANSMITTER POWER, Pt

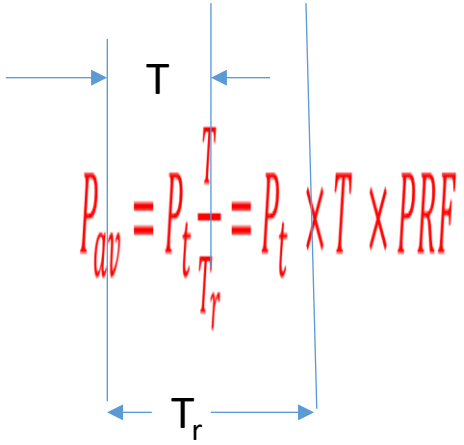
- In radar engineering, P_t is the often referred to as the peak power, which is defined as the power averaged over the carrier frequency cycle and which occurs at the maximum of the pulse power.



AVERAGE POWER

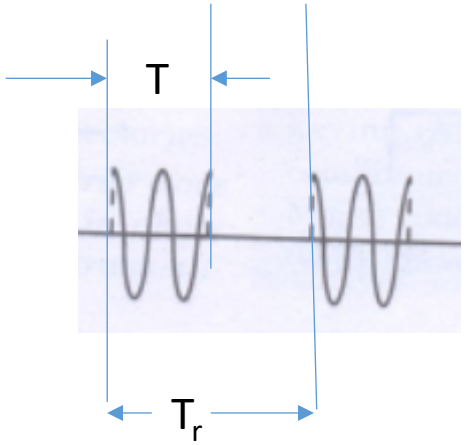
- Average power refers to the average transmitted power over the pulse repetition period.

$$P_{av} = P_t \frac{T}{T_r} = P_t \times T \times PRF$$



RADAR DUTY CYCLE

- The duty cycle is the fraction of time that the radar transmitter is generating pulses

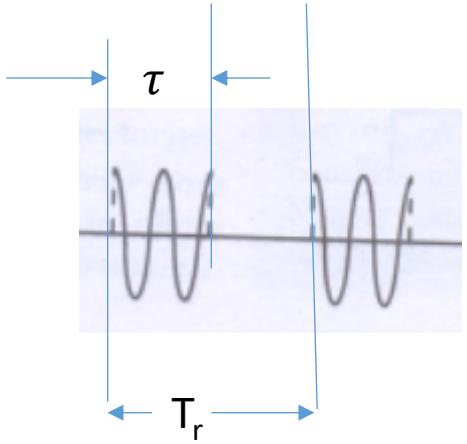


$$Duty\ Cycle = \frac{T}{T_r} = \text{T x PRF}$$

RANGE RESOLUTION

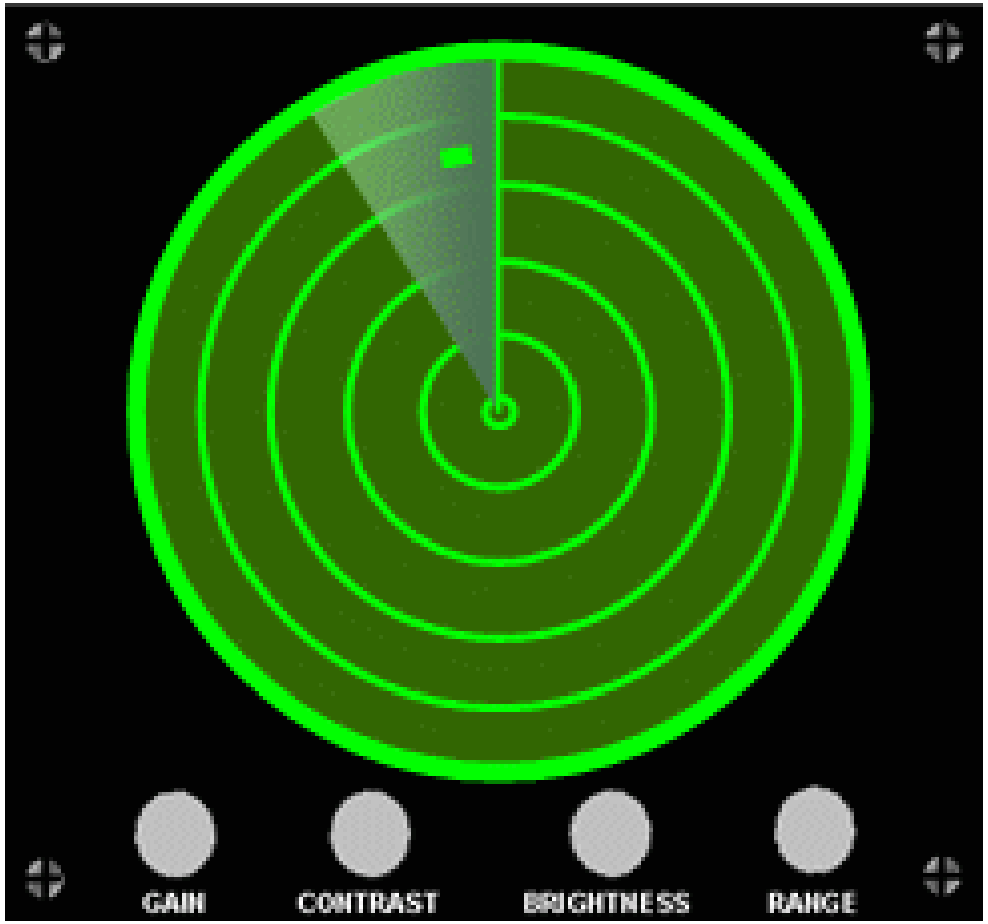
- The duration of the radar pulse and the range of the target determine the duration of the returned pulse.
- The range resolution is given by:

$$R_{Res} = c\frac{\tau}{2}$$





RANGE RESOLUTION



If two targets are closer than the range resolution of the radar, then they will appear as a single object

EXAMPLE 1

- A radar transmits at a peak power of 100KW and its pulse repetition frequency is 1000pps while the pulse width is 1 microsecond. Calculate the average power.

EXAMPLE 1 - SOLUTION

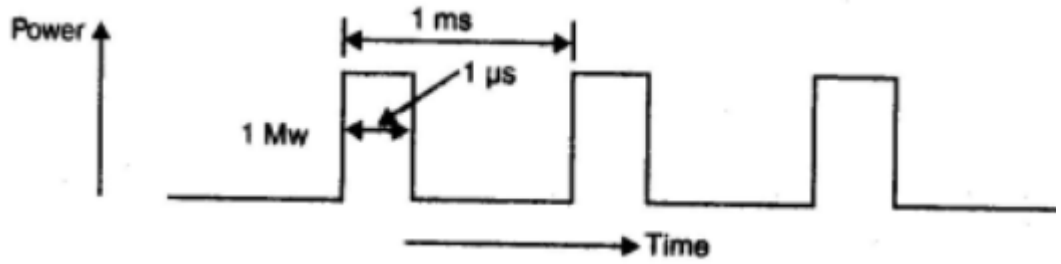
- Given:
  - P_t = 100KW
  - PRF = 1000 pps
  - PW = 1µsec

- Duty cycle = PW X PRF = 10^{-6} x 1000 = 0.001

- Average Power P_{av} = P_t x Duty Cycle = 100 x 10^3 x 0.001 = 100W

EXAMPLE 2

- A radar has a wave form shown below.



Calculate:
(a)The average power
(b)The Duty Cycle
(c)The maximum range of the radar
(d)Range resolution

EXAMPLE 2 SOLUTION

- We are given:
  - P_t = 1 MW
  - Pw = 1µsec
  - T_r = 1 mSec

$$PRF = \frac{1}{T_r} = \frac{1}{1x10^{-3}} = 1000Hz$$

(a) $P_{ave} = P_t \times T \times PRF = 10x10^6 \times 1x10^{-6} \times 1000 = 1$ KW

(b) Duty Cycle = T x PRF = $1x10^{-6}$ x 1,000 = 0.001

(c) $R_{max} = \frac{c}{2xPRF} = \frac{3x10^8}{2x1000} = 150kms$

(d) $R_{Res} = c\frac{T}{2} = \frac{3 \times 10^8 \times 10^{-6}}{2} = 150\ m$