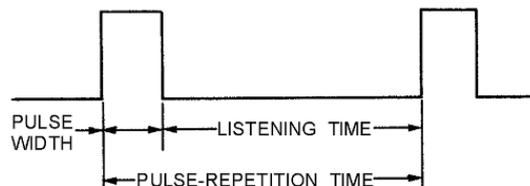




WEEK 9

RANGE AMBIGUITY

Radar systems radiate each pulse at the carrier frequency during transmit time, wait for returning echoes during listening or rest time, and then radiate a second pulse, as shown in figure below. The number of pulses radiated in one second is called the pulse-repetition frequency (prf), pulse repetition time $p_{rt} = 1/prf$.



The radar timing system must be reset to zero each time a pulse is radiated. This is to ensure that the range detected is measured from time zero each time. The prt of the radar becomes important in maximum range determination because target return times that exceed the prt of the radar system appear at incorrect locations (ranges) on the radar screen. Returns that appear at these incorrect ranges are referred to as AMBIGUOUS RETURNS or SECOND-SWEEP ECHOES.

The maximum unambiguous range R_{unamb} is:

$$R_{unamb} = \frac{c}{2} * p_{rt}$$

Example:

A radar system with a 1 millisecond prt, scanning two targets A & B.

For target A, the pulse travels round trip in 0.5 millisecond, which equals to a target range of 75,000 meter.

Since 0.5 millisecond is less than 1 millisecond, displaying a correct range is no problem. However, target B is 180,000 meter distant from the radar system. In this case, total pulse travel time is 1.2 milliseconds and exceeds the prt limitation of 1 millisecond for this radar. While the first transmitted pulse is traveling to and returning from target B, a second pulse is transmitted and the radar system is reset to 0 again. The first pulse from target B continues its journey back to the radar system, but arrives during the timing period for the second pulse. This results in an inaccurate reading. In this case, the first return pulse from target B arrives 0.2 millisecond into the second timing period. This results in a range of 30,000 meter instead of the actual 180,000 meter.



RADAR TYPES

Radar systems are often divided into operational categories based on energy transmission methods to continuous wave (cw) and pulse modulation (pm).

The CONTINUOUS WAVE (cw) : transmits a constant frequency and detects moving targets by detecting the change in frequency caused by electromagnetic energy reflecting from a moving target. This change in frequency is called the DOPPLER SHIFT or DOPPLER EFFECT.

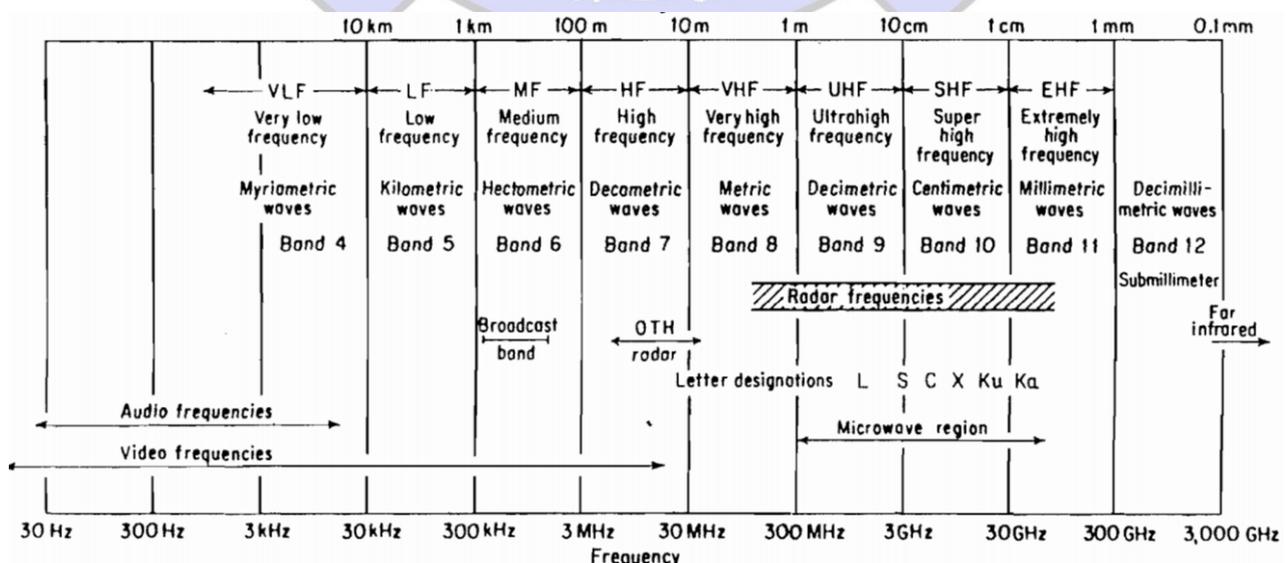
The PULSE-MODULATION (pm) : uses short pulses of energy and relatively long listening times to accurately determine target range. Since this method does not depend on signal frequency or target motion, it has an advantage over cw radar. It is the most common type of radar.

Radar systems are also classified by function. SEARCH RADAR continuously scans a volume of space and provides initial detection of all targets. TRACK RADAR provides continuous range, bearing, and elevation data on one or more specific targets. Most radar systems are variations of these two types.

RADAR FREQUENCIES

Conventional radars generally have been operated at frequencies extending from about 220 MHz to 35 GHz, a spread of more than seven octaves. These are not necessarily the limits, since radars can be, and have been operated at frequencies outside either end of this range.

Skywave HF over-the-horizon (OTH) radar might be at frequencies as low as 4 or 5 MHz, and groundwave HF radars as low as 2 MHz. At the other end of the spectrum, millimeter radars have operated at 94 GHz. Laser radars operate at even higher frequencies.





Q1/ A monostatic radar is employed to detect a target of a typical RCS of 4 m^2 . Its operational frequency is 10 GHz, the transmitted power is 1000 W. If its antenna gain is 30 dBi, find the operational range of this radar.

Q2/ Consider a radar system with the following parameters:

- $f = 2 \text{ GHz}$ Transmitter frequency
- $P_T = 1 \text{ W}$ Peak transmitter power ($P_T = 0 \text{ dBW}$)
- $G_T = G_R = 18 \text{ dB}$ Antenna gains
- $R = 2 \text{ km}$ Range to target
- $B = 50 \text{ kHz}$ Receiver bandwidth
- $F = 5 \text{ dB}$ Receiver noise figure
- $\sigma_t = 1 \text{ m}^2$ Target radar cross section

What is the SNR at the receiver?

Q3/ Consider a radar system with

- $P_T = 1,000,000 \text{ W}$
- $G_{ANT} = 28 \text{ dB}$
- $\tau = 100 \mu\text{s}$
- $T_{eff} = 200 \text{ K}$
- $f = 10 \text{ GHz}$

What is the Noise figure of the system & SNR of the return from a 1-m^2 target at 20 km?

Q4 / Consider a radar system with the following parameters:

- Transmit power $P_t = 10.0 \text{ kW}$
- Antenna gain $G = 25 \text{ dB}$
- Frequency $f = 10 \text{ GHz}$

What is the received signal level from a 13-dBsm target at 10 km?

