ECE 514E – RADAR & SATELLITE ENGINEERING

CONTINUOUS WAVE (CW) RADAR – STUDY GUIDE/REVISION

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1. INTRODUCTION

- **Definition**: Radar (Radio Detection and Ranging) uses electromagnetic waves to detect objects' range, velocity, and angle.
- **Categories**:
  - **Pulsed Radar**: Transmits short pulses, measures echo delay.
  - **Continuous Wave (CW) Radar**: Transmits uninterrupted waves, ideal for velocity measurement.

2. CORE PRINCIPLES OF CW RADAR

- **Transmission**: Emits a continuous sinusoidal wave (e.g., 24 GHz).
- **Reception**: Simultaneously receives reflected signals.
- **Key Feature**: No range measurement in *unmodulated* CW radar (only velocity).

6. BLOCK DIAGRAM OF CW RADAR

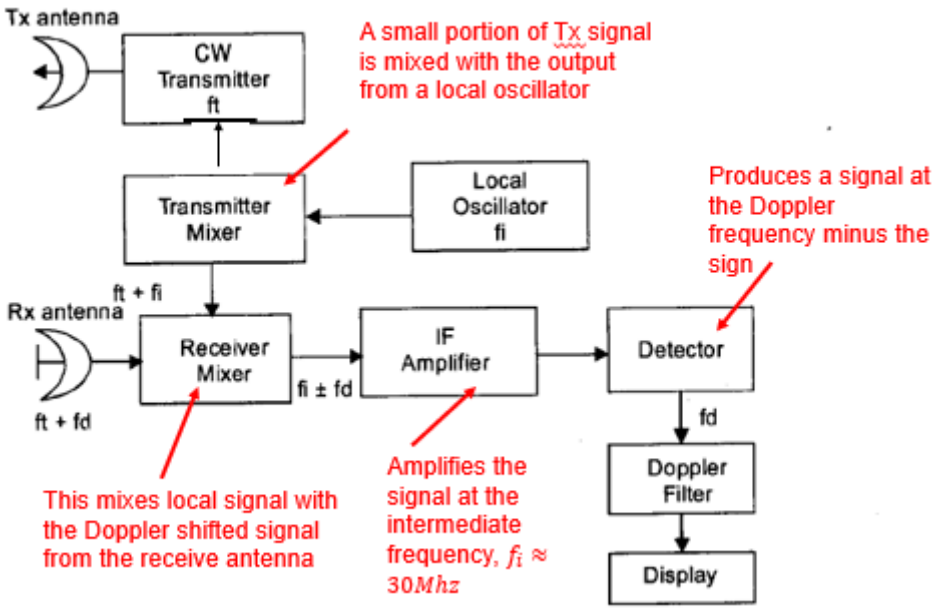

Figure 1. Block diagram of CW-Radar

3. DOPPLER EFFECT & VELOCITY MEASUREMENT

1. **Doppler Principle**

Frequency shift f_d between transmitted f_t and received f_r signals:

$$f_d = f_r - f_d = \frac{2v_r}{\lambda} = \frac{2f_t}{c}$$

where:

v_r is the relative speed of target

C is the speed of light

2. **Velocity Calculation**

$$v_r = \frac{f_d c}{2f_t}$$

3. **Directionality:**

Use **IQ (In-phase/Quadrature) demodulation** to distinguish approaching/receding targets.

4. TYPES OF CW RADAR

Type	**Key Mechanism**	**Applications**
Unmodulated CW	Pure sine wave; measures velocity only.	Speed guns, motion sensors.
FMCW (Frequency-Modulated CW)	Frequency ramps (e.g., linear chirp).	Automotive radar, drone altimeters.
Phased Array CW	Beam steering using phase shifters.	Military tracking, 5G/6G.

5. ADVANTAGES & DISADVANTAGES OF CW RADAR

FEATURE	PULSED RADAR	SIMPLE CW RADAR	FMCW RADAR
Range Measurement	Yes	No	Yes
Velocity Measurement	Yes (via Doppler)	Yes (Simple)	Yes
Hardware	Complex (high-power switch)	Very Simple	Moderately Complex
Average Power	Low (duty cycle <1)	Low	Low
Peak Power	Very High	Very Low	Very Low
Minimum Range	Limited (pulse width)	Excellent (none)	Excellent
Range Resolution	$\Delta R = \frac{c\tau}{2}$	N/A	$\Delta R = \frac{c}{2B}$
"Blind" Speed	Yes (PRF ambiguities)	No	No

6. PRACTICE PROBLEMS

Doppler Calculation:

1. A police radar gun operates at 24.15 GHz. What is the Doppler frequency for a car moving towards the radar at 30 m/s (108 km/h)? What is the beat frequency the radar gun measures? *(Answer: $f_d \approx 4830$ Hz)*