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DOPPLER RADAR

Preliminary Information:

Doppler etkisi: The Doppler effect is the frequency shift observed between a signal transmitted from a stationary source and the signal that is reflected from a moving target. The signal can be a sound wave or a sinusoidal electromagnetic wave. One of the most well-known applications of the Doppler effect is the radar used to measure vehicle speeds in traffic. In this application, the measured frequency shift is directly proportional to the speed of the vehicle.
To detect the motion of a target, a Doppler radar transmits an unmodulated continuous wave (CW) with an angular frequency of ω, in the form of $\cos(\omega t)$ (Figure 1). The time it takes for the transmitted signal to travel from the transmitter to the target is D/c, where 'c' is the propagation speed of the wave (speed of light) and 'D' is the distance between the target and the source. Since the target is in motion, D changes with time; however, the target's velocity is negligible compared to the speed of light. The signal at the target becomes $\cos[\omega(t-D/c)] = \cos(\omega t-\omega D/c)$. A portion of this signal is then reflected back to the receiver (source). This reflected signal arriving at the receiver can be expressed as $\cos(\omega t-2\omega D/c)$.

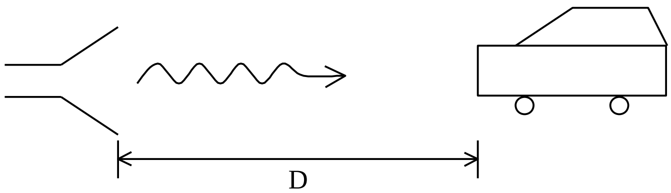

Figure 1: Principle of Doppler Radar

Now, let's assume the target's velocity is constant and the change in distance D over time can be expressed as:

$$D = D_o \mp v_d (t - t_o)$$

Here, D_0 is the distance of the target at time t_0, and v_d is the radial velocity. The (+) sign indicates the target is moving away from the receiver, while the (-) sign indicates it is approaching. If we substitute this expression for D into the reflected signal equation, we get:

$$\cos\left[(\omega \pm \omega_d)t - \left(\frac{2\omega D_o}{c} \pm \omega_d t_o\right)\right]$$

In this term, $\omega_d=2\omega v_d/c$ represents the shift in angular frequency caused by the moving target. Consequently, the Doppler frequency (f_d) is found to be:

$$f_d = \frac{\omega_d}{2\pi} = \frac{2f}{c} v_d$$

Figure 2 shows the block diagram of a simple Doppler radar. A portion of the signal from the transmitter is mixed in a detector with the signal reflected from the target. The resulting difference frequency (the Doppler frequency) is amplified, limited, and the subsequent pulses are counted. The pulse count provides a frequency that is proportional to the measured speed.

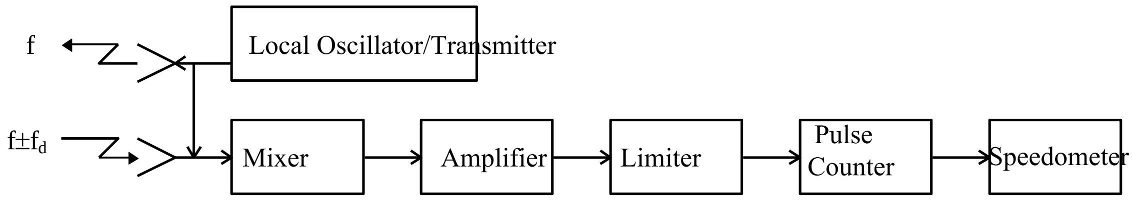

Figure 2: Block diagram of a Doppler Radar

Experimental Procedure:

1. Set up the experimental apparatus as shown in Figure 3.
2. Move various objects at a certain distance from the antenna.
3. For each moving object, record the signal observed on the oscilloscope.
4. Determine the Doppler frequencies from the recorded signals.
5. Calculate the speeds of the objects using the Doppler frequency formula.

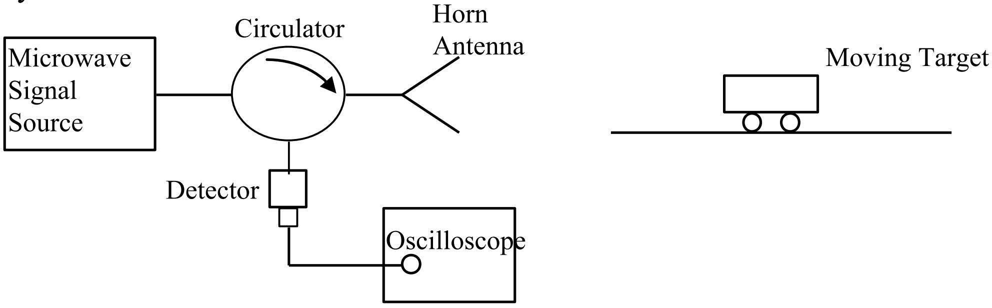

Figure 3: Doppler Radar experimental setup