Pulse Radar

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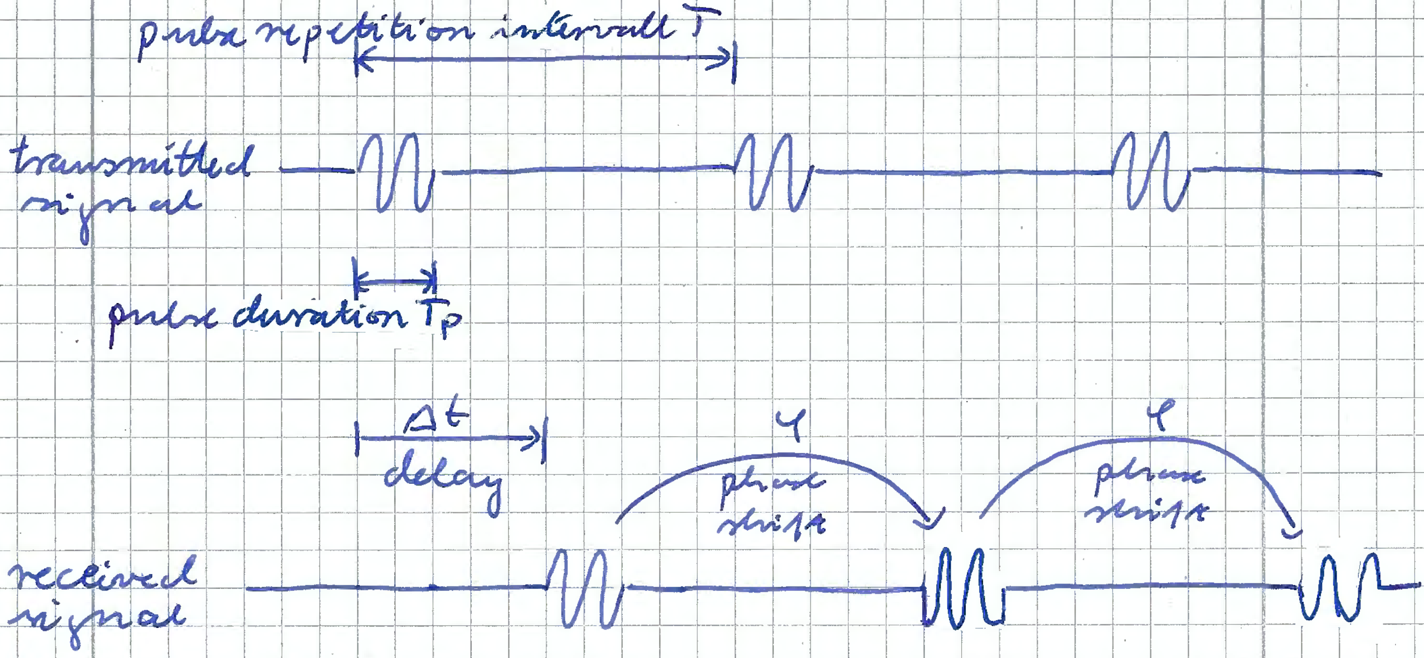
- transmit a coherent train of short bandpass pulses



- pulse repetition frequency

  $$\omega_R = \frac{2\pi}{T}$$

- pulse duration

  $$T_p \ll T, \Delta t$$

- no simultaneous transmission and reception
  $\Rightarrow$ high performance

- high instantaneous transmit powers required
  $\Rightarrow$ high cost

Range

- minimum delay

$$\Delta t > T_p$$

$\Rightarrow$ minimum range

$$r_{min} = \frac{c_0}{2} T_p$$

- maximum unambiguous delay

$$\Delta t < T \quad (\text{more precisely } \Delta t < T - T_p)$$

$\Rightarrow$ maximum range

$$r_{max} = \frac{c_0}{2} T = \frac{c_0 \pi}{\omega_R}$$

$\Rightarrow$ pulse repetition frequency ω_R must not be too high

Velocity

- Doppler frequency negligible within a single short pulse

- Doppler frequency

  $\Delta\omega = -2\beta v$

  causes significant phase shift

  $\varphi = \Delta\omega T = -2\beta v T$

  from pulse to pulse

- phase can only be measured modulo 2π

  $\Rightarrow$ unambiguous phase $|\varphi| < \pi$

- unambiguous velocity

  $$2\beta v_{max} T < \pi$$

  $$v_{max} < \frac{\pi}{2\beta T} = \frac{\omega_R}{4\beta} = \frac{\lambda}{4T}$$

  $\Rightarrow$ pulse repetition frequency ω_R must not be too low

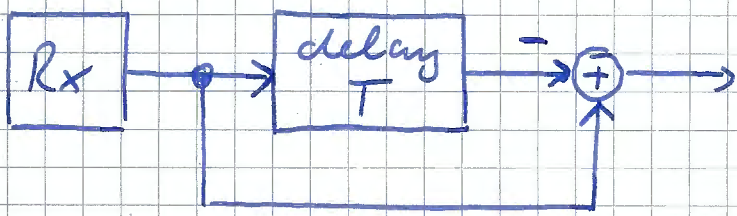
- large unambiguous range r_{max} and large unambiguous velocity v_{max} are contradictory objectives

Moving Target Indication (MTI)

Often moving targets alone are of interest. Unfortunately, they are often masked by clutter (other more or less stationary objects of the natural environment, e.g., land, sea).

Stationary clutter can be suppressed by cancellers which exploit the different Doppler frequency of moving targets and clutter.

Single Canceller



- impulse response

$$h_1(t) = \delta(t) - \delta(t-T)$$

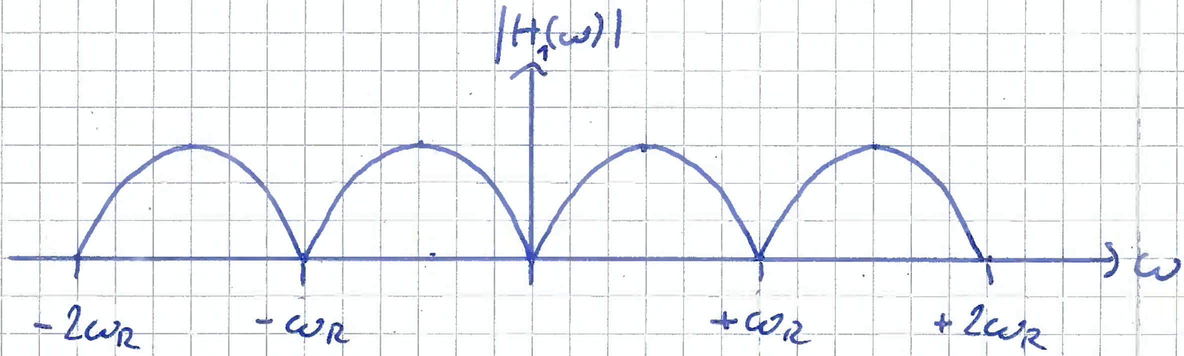
- periodic transfer function

$$\underline{H}_1(\omega) = \int_{-\infty}^{+\infty} h_1(t)\, e^{-j\omega t}\, dt$$

$$= \int_{-\infty}^{+\infty} \left(\delta(t) - \delta(t-T)\right) e^{-j\omega t}\, dt$$

$$= 1 - e^{-j\omega T} = e^{-j\cdot\frac{\omega T}{2}}\left(e^{+j\cdot\frac{\omega T}{2}} - e^{-j\cdot\frac{\omega T}{2}}\right)$$

$$= 2j\, e^{-j\cdot\frac{\omega T}{2}} \sin\left(\frac{\omega T}{2}\right)$$



- blind velocities

$$\Delta\omega = -2\beta v = n\frac{2\pi}{T}$$

$$\Rightarrow v = -\frac{n\pi}{\beta T} = -\frac{n\lambda}{2T}, \quad n = \dots -1, 0, +1, \dots$$

Double Canceller

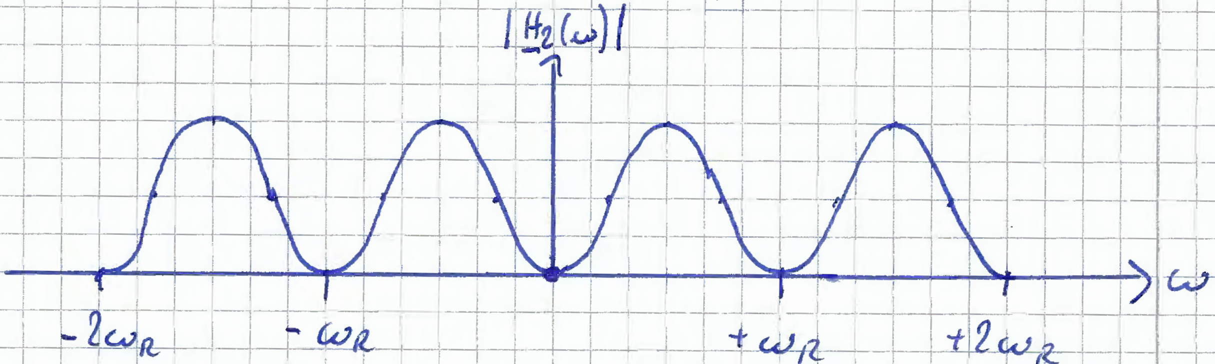
- two single cancellers in series

$$h_2(t) = h_1(t) * h_1(t)$$
$$= \delta(t) - 2\,\delta(t-T) + \delta(t-2T)$$

- periodic transfer function

$$\underline{H}_2(\omega) = \underline{H}_1(\omega) \cdot \underline{H}_1(\omega)$$
$$= -4\, e^{-\omega T} \sin^2\left(\frac{\omega T}{2}\right)$$

$$\Rightarrow |\underline{H}_2(\omega)| = 4 \sin^2\left(\frac{\omega T}{2}\right)$$
$$= 2\,(1 - \cos(\omega T))$$



$\Rightarrow$ better suppression of slow clutter