Quiz 3: Digital Signal Processing

Prof. Jordan C. Hanson

April 23, 2025

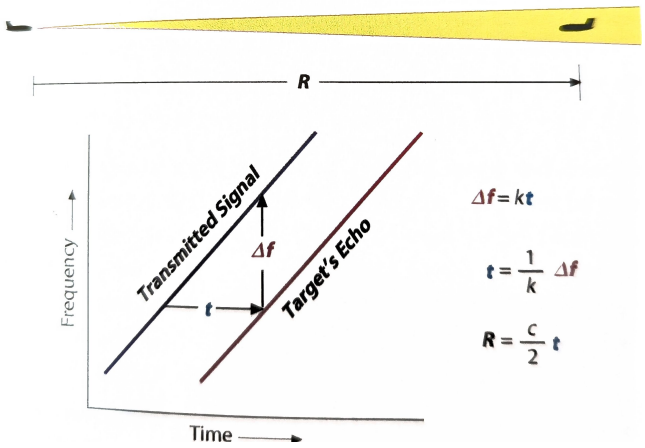

Figure 1: In a basic chirping RF signal scheme used to detect enemy aircraft, a transmitted RF signal is linearly chirped. Information in the radar echo can be used to find the range, R.

1. According to the **Doppler effect**, the frequency of electromagnetic waves reflecting from a moving target will shift in proportion to the velocity of the target. Let f_t represent the transmitted frequency, f_r represent the reflected frequency, and $f_d = f_r - f_t$. To first order in v/c,

$$f_d \approx 2v\frac{f_t}{c} \tag{1}$$

(a) Suppose the relative velocity v between our craft and the enemy fighter is $v \approx 300$ m s^{-1}, and our radar operates at 1 GHz. What is the Doppler shift, f_d? (b) Given that our receiver has to resolve the difference between $f_t = 1$ GHz and f_d, for how long do we have to record the reflected waveform? That is, how do we achieve the required frequency resolution? (c) If we sample at 2 GHz, how many samples would be in the waveform? Is this practical?