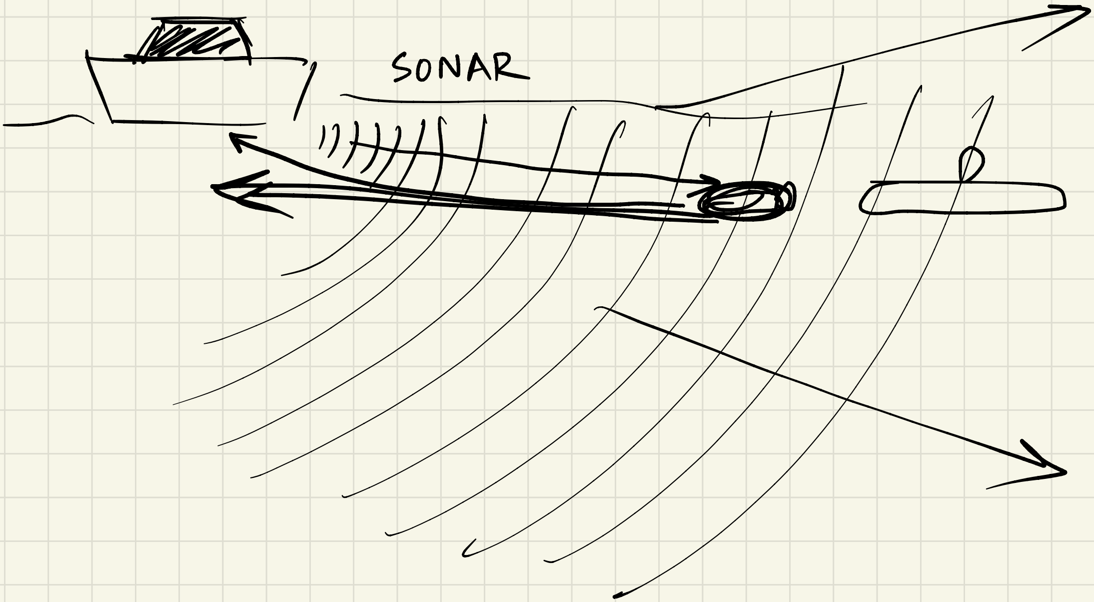
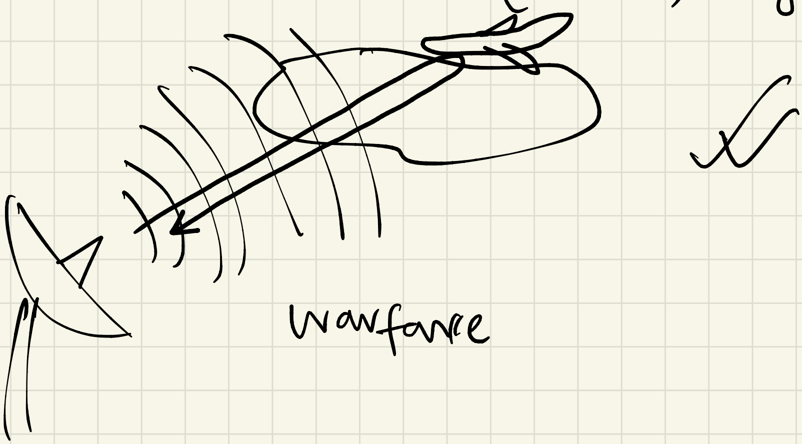
FMCW

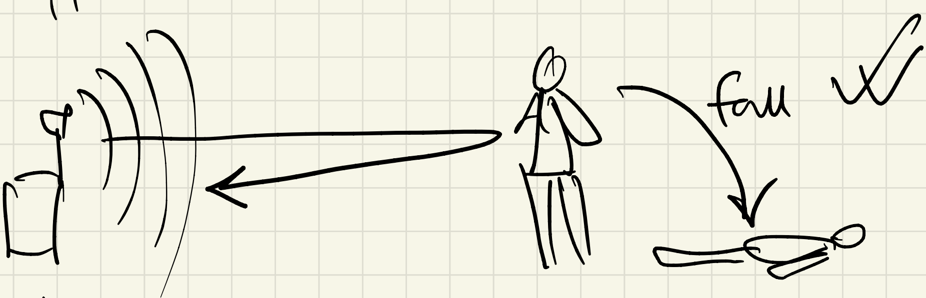
Freq. Modulated Carrier Wave



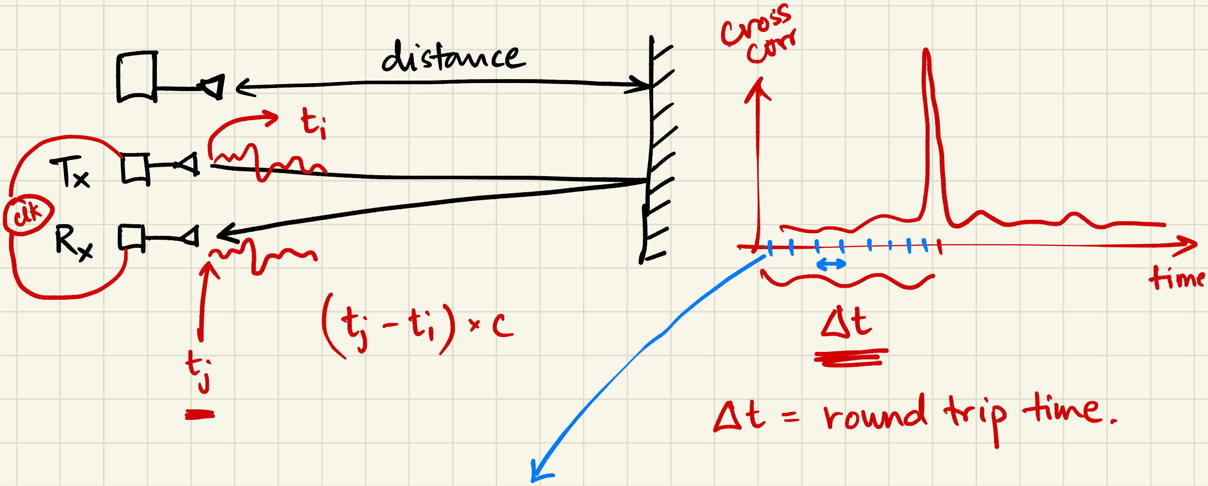
Can we do this with RF (wireless) signals?



Warfare



Wifi

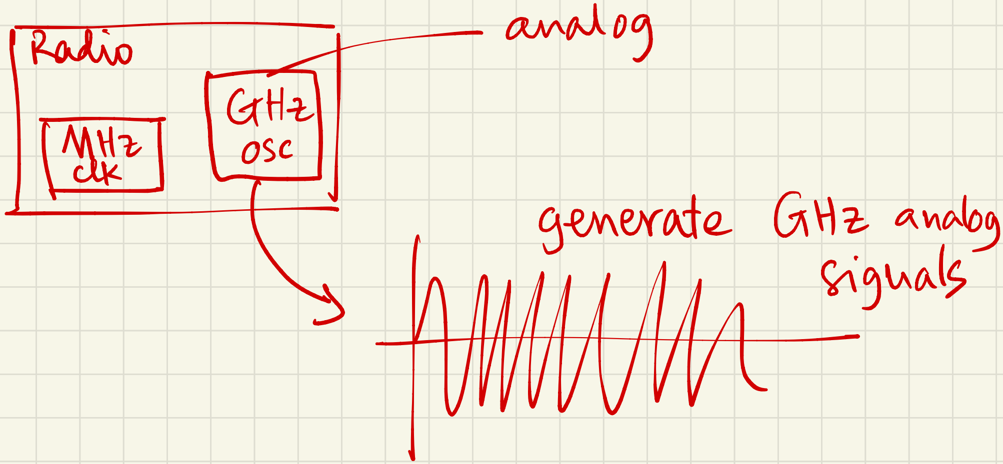


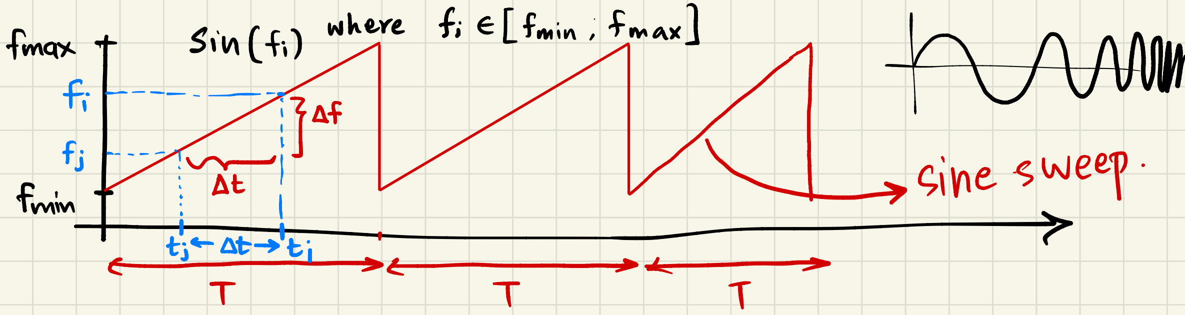
best time granularity of cross-correlation is your clock

- Wireless radios ~ 20 MHz. → 20 MHz clock

  Sampling time $\sim \frac{1}{20 \times 10^6} \cong 10^{-7}$

  RF signal travels 30 m in 10^{-7} seconds.

- 



Rx receives $\sin(f_i) + \sin(f_j)$ at time t_i

FMCW multiplies the transmitted signal $\sin(f_i)$ with the received signal:

$$\sin(f_i)\left(\sin(f_i) + \sin(f_j)\right)$$

$\sin x \sin y = \frac{\cos(x+y) + \cos(x-y)}{2}$

$$= \cos 2f_i + \cos 0 + \cos(f_i+f_j) + \cos(f_i-f_j)$$

$\cos 0$ → DC component

$\cos 2f_i$, $\cos(f_i+f_j)$ → hi freq: can be filtered out

$\cos(f_i-f_j)$ → $\cos(\Delta f)$

$$\frac{\Delta f}{\Delta t} = \frac{F_{max} - F_{min}}{T} = \text{slope of the FMCW signal.}$$

$$\Delta t = \frac{T \cdot \Delta f}{F_{max} - F_{min}} = \frac{\Delta f \cdot T}{B_s}$$

B_s → sweeping bandwidth

$$\Delta t_{min} = ? \equiv \frac{\Delta f_{min} \, T}{B_s}$$

■ FFT foundations :

Sampling rate $= f_s$

You take N point FFT

What is $\Delta f_{min} = ?$ $\quad \frac{f_s}{N}$

Since you know that your signal has max freq. of Δf, you can sample your signal at the R_x at

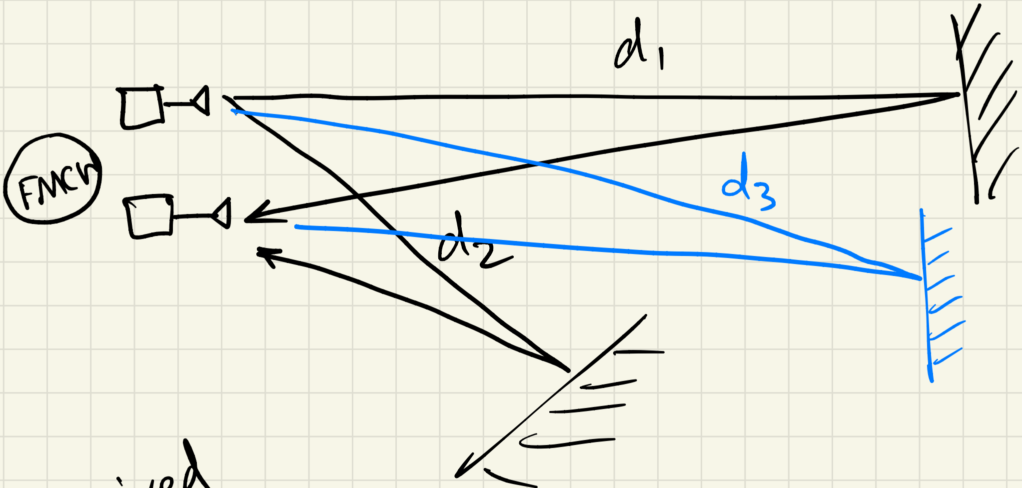
$$f_s = \Delta f$$

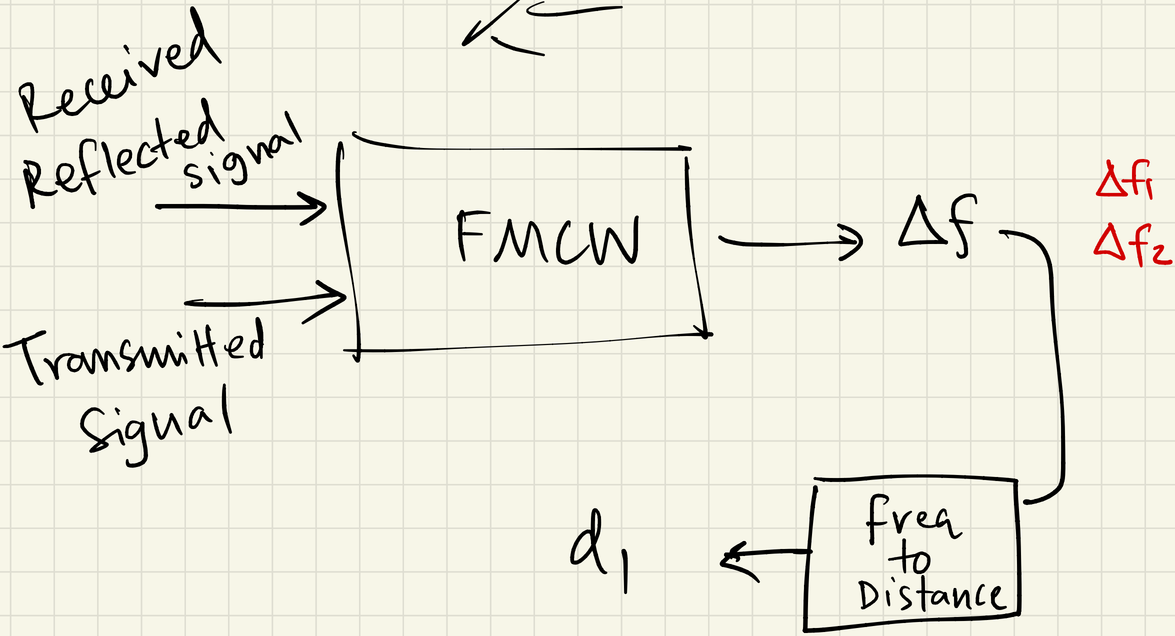
$$\Delta f_{min} = \frac{\Delta f}{N}$$

$$\Delta t_{min} = \frac{\frac{\Delta f}{N} \cdot T}{B_s} = \frac{\frac{\Delta f}{N} \cdot N t_s}{B_s} = \frac{\frac{1}{t_s N} \cdot N t_s}{B_s}$$

$$\boxed{\Delta t_{min} = \frac{1}{B_s}}$$

→ order of GHz



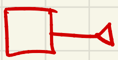


$$\Delta t_{min} = \frac{1}{B_s} \longrightarrow \Delta distance$$

$$\Delta d_{min}$$

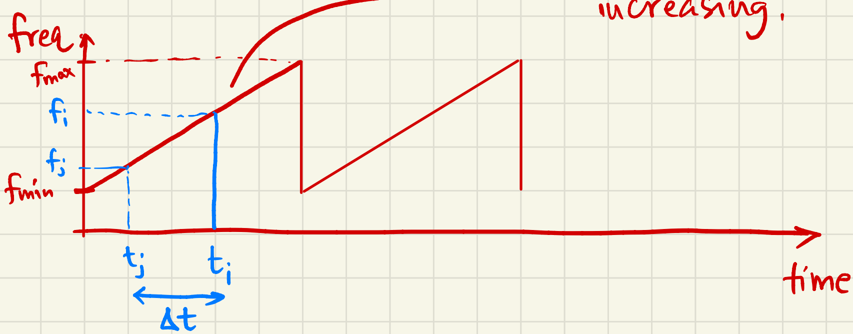
$$\Delta t_{min} = \frac{\Delta f_{min} \cdot T}{B_s} \qquad \Delta t_{min} \times c = \Delta d_{min}$$

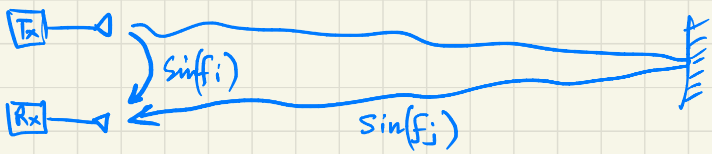
After Class Discussion



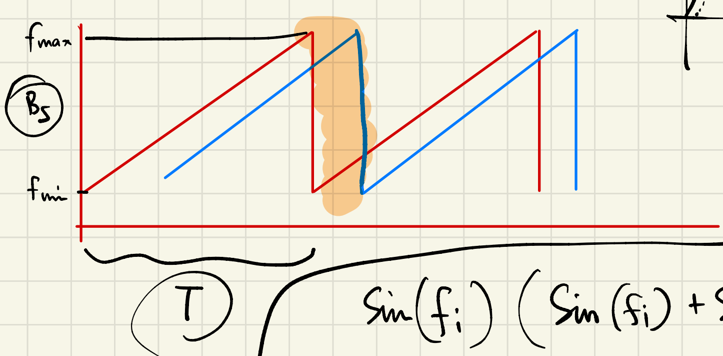
Transmitted signal is called a Sine sweep.

The freq. of this Sin(·) signal is increasing.



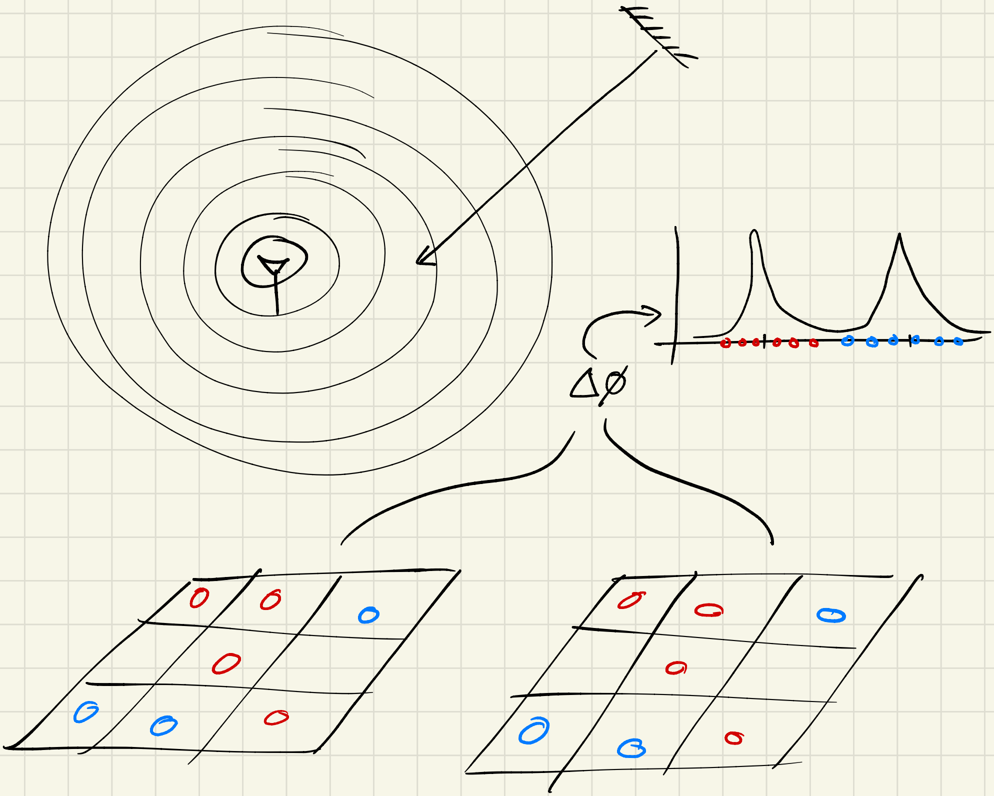


Received signal $= \sin(f_i) + \sin(f_j)$



$$\sin(f_i)\left(\sin(f_i) + \sin(f_j)\right)$$

$$= \sin f_i \sin f_i + \sin f_i \sin f_j$$



t_1		t_2
~~Δf_1~~	−	~~Δf_1~~
Δf_2		Δf_3