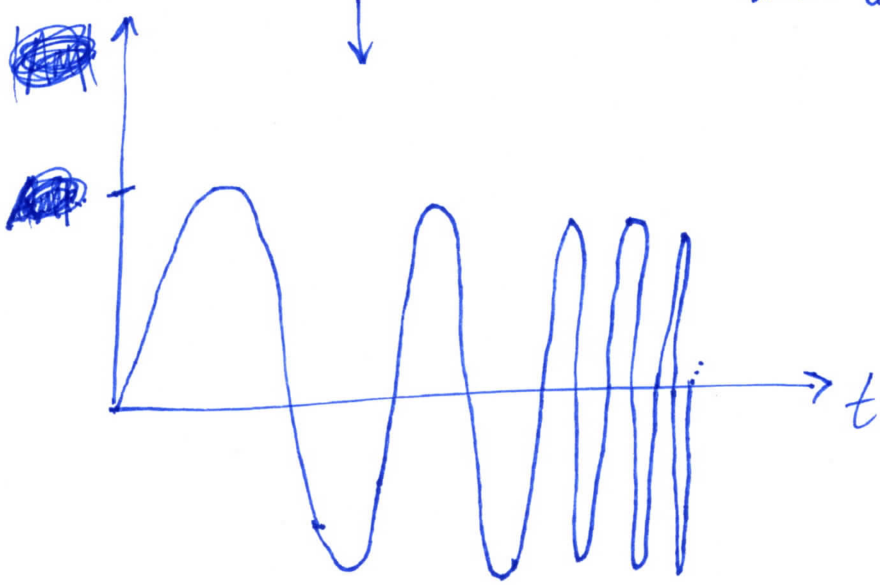
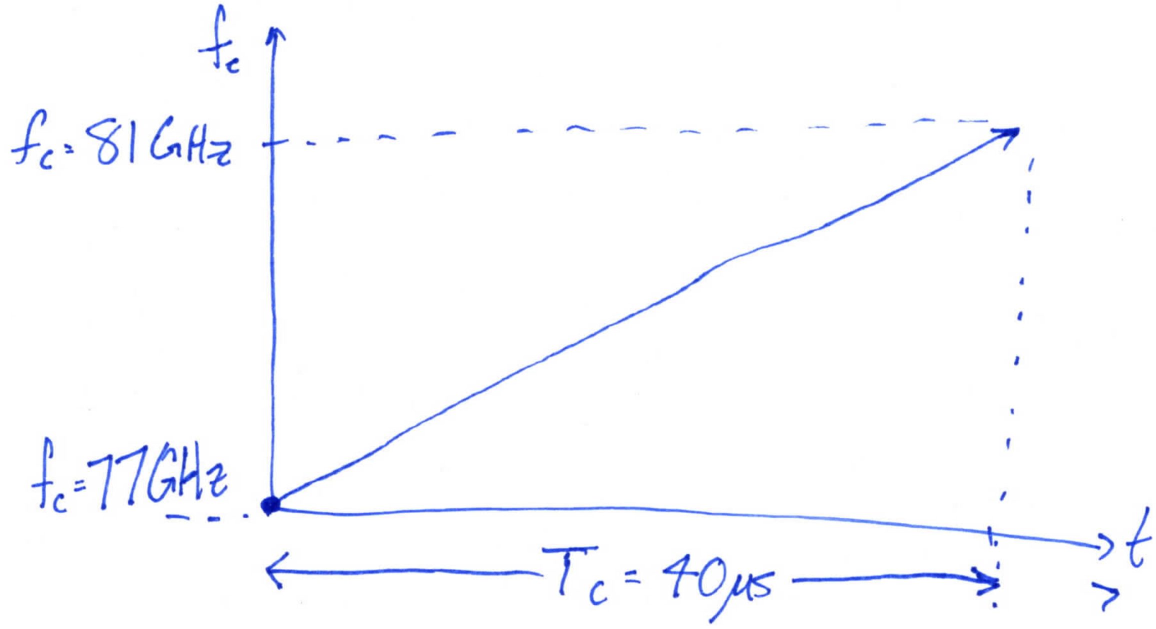
TI-FMCW videos p1

1TX - 1RX FMCW Radar

FMCW - Freq. Modulated Continuous Wave

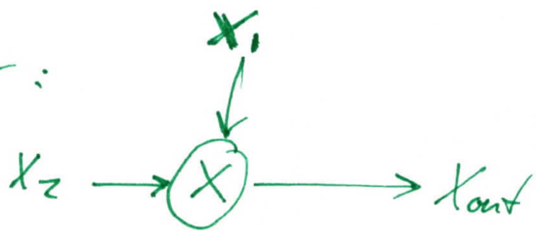
Chirp signal - freq. increases linearly with time





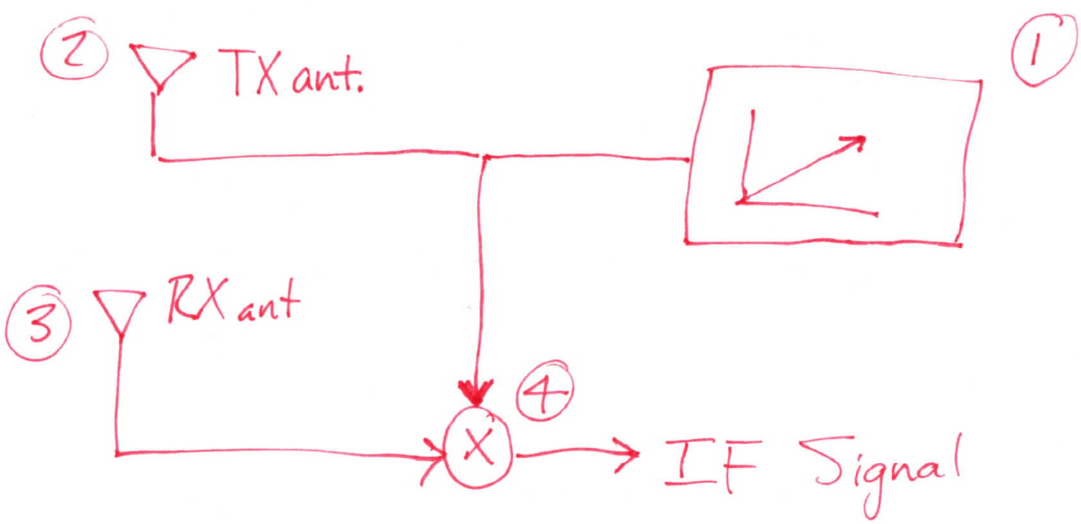
T_c = chirp time

Mixer:

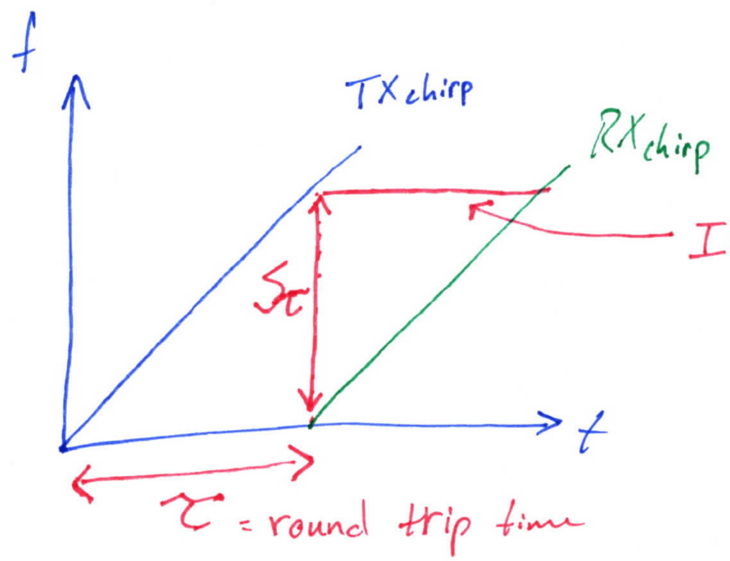


$$x_1 = \sin(\omega_1 t + \phi_1)$$
$$x_2 = \sin(\omega_2 t + \phi_2)$$
$$x_{out} = \sin((\omega_1 - \omega_2)t + (\phi_1 - \phi_2))$$

1TX - 1RX FMCW Radar



1) Synthesizer generates a chirp
2) Transmits chirp through TX antenna
3) Receive the reflected (off object) chirp signal thru. RX ant.
4) Mix 2 signals to get $\approx \sin\left[(\omega_{TX} - \omega_{RX})t + (\phi_{TX} - \phi_{RX})\right]$



IF = Intermediate Freq.

$S\tau$ = slope of chirp

(Hz)(sec) = unitless

$S\tau = S\left(\frac{2d}{c}\right)$

d = distance of object

c = speed of light

$\frac{\tau}{T_c} \approx 5\%$ generally

$IF \overset{\text{in}}{(Hz)} = S\tau = \frac{S2d}{c}$

Longer observation period $\Rightarrow$ better resolution

observation of time T separate freq. comp. separated by $\left(\frac{1}{T}\right)$ Hz.
(chirp length)

distance $\propto$ IF $\quad \left(IF = \frac{S 2 d}{c} \right)$

How close can objects be?

$$\Delta f = \frac{S\, 2 \Delta d}{c} \qquad \left(\Delta f > \frac{1}{T_c} \right) \text{ to be resolved}$$

'obviously'

$$\frac{S\, 2\Delta d}{c} > \frac{1}{T_c} \rightarrow \Delta d > \frac{c}{2 S T_c} \rightarrow \boxed{\Delta d > \frac{c}{2B}}$$

$$d_{res.} = \frac{c}{2B}$$

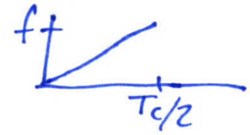
- Trade off IF Bandwidth vs Measurement time.

ADC sampling rate: F_s

$$d_{max} = \frac{F_s\, C}{S}$$

$\therefore$ Same d_{max} : A.)

B.)



- A has ½ IF Bandwidth.
- B has ½ T_c.

½ BW_{IF} means smaller f_s for ADC.

2 chirps spaced T_c apart:

$$V = \frac{\lambda \omega}{4\pi T_c} \quad ; \quad V_{max} = \frac{\lambda}{4T_c}$$

b/c (max. ω) = π

Velocity Resolution:

$$\Delta\omega = \frac{4\pi \Delta V T_c}{\lambda} \rightarrow \Delta\omega > \frac{2\pi}{N} \rightarrow \Delta V > \frac{\lambda}{2NT_c}$$

$$V_{res} = \frac{\lambda}{2T_f}$$

T_f = frame time

* Range FFT resolves objects into range.
* Doppler FFT resolves objects into velocity.

$\boxed{\text{2D FFT}}$

Doppler FFT can only be done once all chirp signals have been ADC'd. System should have enough memory to store all FFTs of a frame.

Recap Equations:

$$d_{res} = \frac{c}{2B}$$

$$V_{res} = \frac{\lambda}{2T_f}$$

$$F_{IF\,max} = \frac{S\,2\,d_{max}}{c}$$

$$V_{max} = \frac{\lambda}{4T_c}$$

Steps in designing:

① Determine T_c by using v_{max}.

$$T_c = \frac{\lambda}{4 V_{max}}$$

② Determine B using d_{res}.

$$B = \frac{c}{2 d_{res.}}$$

③ $S = \frac{B}{T_c}$.

$$S = \frac{B}{T_c}$$

④ Determine T_f by using V_{res}.

$$T_f = \frac{\lambda}{2 V_{res.}}$$

Antenna power P_t. Look @ slides 49-50 for indepth Radar Range Eq.

SNR_{min} typically ~(15-20) dB

$$d_{max} = \left(\frac{\sigma P_t G_{Tx} G_{Rx} \lambda^2 T_{meas}}{(4\pi)^3 SNR_{min} kTF} \right)^{1/4}$$