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CoSC360

Quiz #3

① Doppler effect

f_T = transmitted frequency

f_r = reflected frequency

$$f_d = f_r - f_t$$ to first order in v/c

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

a) Suppose $v \approx 300ms^{-1}$
our radar operates at 1 GHz.
what is f_d?

$$f_d \approx 2(300)\frac{1\times10^9}{3\times10^8} = 2000_{Hz}$$

b) $\frac{1}{T} = \Delta f$ $\quad T = \frac{1}{\Delta f}$

$$\frac{1}{2000} = 0.0005_{sec}$$ half a milli second

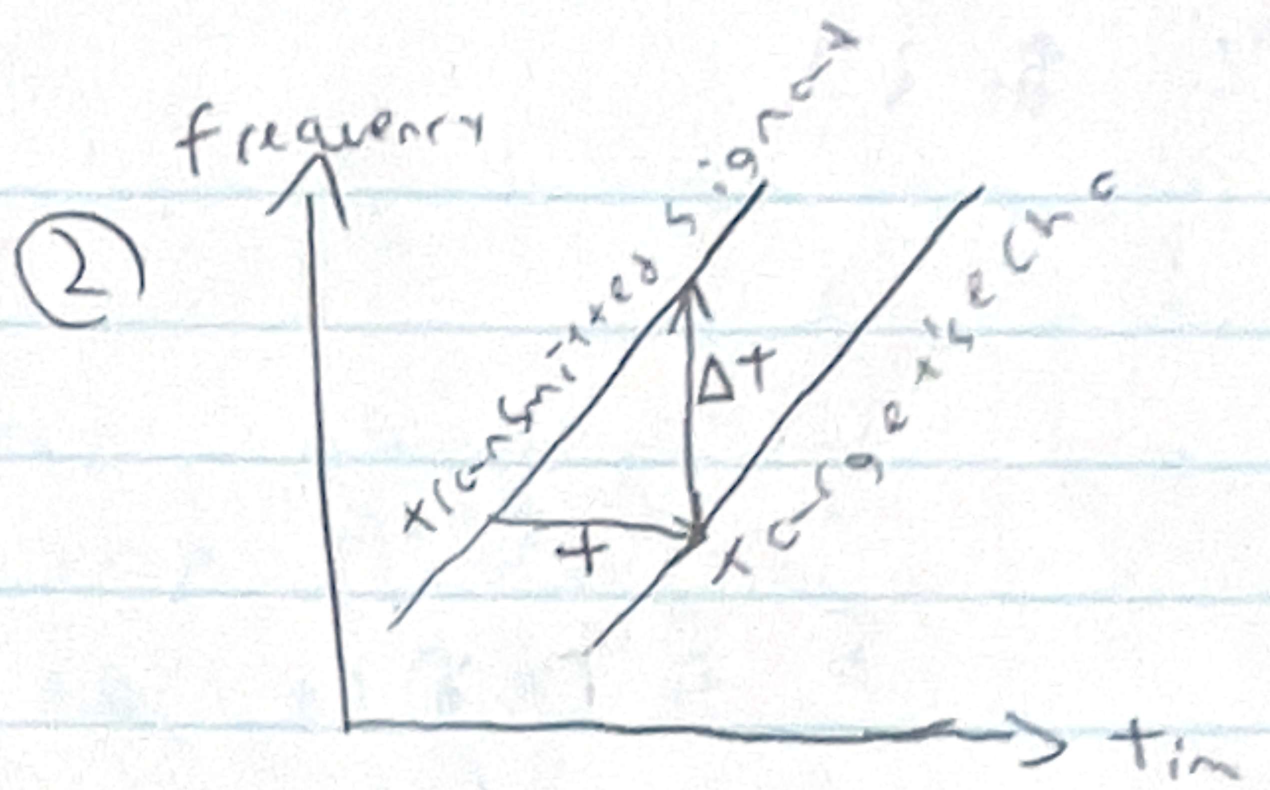
c) if we sample at 2 GHz, how many samples would be in the wave form?

$$\frac{1}{2GHz} = 0.5\times10^{-9}\ sec = \Delta T$$

$$\frac{T}{\Delta T} = \frac{0.0005}{0.5\times10^{-9}} = \boxed{1000000\ \text{samples}}$$

that... is very impractical.
and imagine if it were instead 10 GHz we were sampling at.
That's far too many to be practical.

(2)



$$\Delta f = k t$$

$$t = \frac{1}{k} \Delta f$$

$$R = \frac{c}{2} t$$

our craft produces a chirped pulsed radar transmission that echoes from the enemy craft from a distance R.

our transmitted signal is a linear chirp of slope k, usually in MHz/μs

a) c = speed of light

Δf, Δt = changes in frequency & time respectively

R = range to other craft $\quad k = \left(\frac{\Delta f}{\Delta t}\right)$

Show that $R = \frac{c}{2k} \Delta f$

from the figure, we can see that

$R = \frac{c}{2} t$ let's plug in $t = \frac{1}{k} \Delta f$.

$$R = \frac{c}{2}\left(\frac{1}{k} \Delta f\right) = \frac{c \Delta f}{2k} \checkmark$$

b) This implies that the difference btwn the most powerful frequencies at a fixed time, Δf, can be translated into a target range.

$\frac{m \cdot MHz}{MHz/\mu s}(MHz)$

$= \frac{m\,MHz^2\,\mu s}{MHz}$

Suppose our system detects

$\Delta f = 25\ MHz$ with $k = 1\ MHz/\mu s$ and
$c = 300\ m\ MHz$

what is R in km?

$R = \frac{c}{2k}\Delta f$ $\quad R = \frac{0.3}{2(1)}(25)$

$300\ m\ MHz = 0.3\ km\ MHz$

$\boxed{R = 3.75\ km}$

4) b) the obtained R value was 1473.3 m or 1.4 km.

5) the number appears to be 954.

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Code for Quiz 3

Question 3:

```
clear;
close;
home;

data = load('radar_data.m');
%data = data(1:2:end, 1:2);

n1 = 2048;
n2 = 256;
T = data(end,1) - data(1,1);
dt = data(2,1) - data(1,1);
fs = 1/dt;
[sdata, info] = stft(data(:,2), n1, n2, n1, "hamming");
sdata = sdata(1:end/2,:);
[n_freq, n_time] = size(sdata);
fbins = [0 fs/2];
tbins = [0 T];
sdata = abs(sdata);


figure(1)
image(tbins, fbins, sdata)
xlabel('Time (seconds)')
ylabel('Volts (V)')
h = colorbar();
colormap('ocean')
set(gca(), 'fontsize', 18)
set(h, 'fontsize', 18)
set(gca(), 'YDir', 'normal');


c = sdata(1:400,10);
[pks idx] = max(c);
c2 = sdata(400:2048, 10);
[pks2 idx2] = max(c2);
idx2 = idx2+400;
```

```
freqs = linspace(0,fs/2,n_freq);
df = freqs(idx2) - freqs(idx);

k = (6.7e7-8.2e6)/(4.6e-5-0);
R = (3E8/(2*k))*df;

plot(c2)
```

The obtained R value was 1473.3 meters, or 1.4 km.

Question 5:

```
clear;
close;

data = imread('aircraft.jpg');
data = data(:,:,1);
data = data(1:450,1:450);

kernel = ones(3)/40;
kernel(2,2) = 1.0;
proc = filter2(kernel, data);
proc = uint8(proc);

imshow(proc)
```

The number shown under the cockpit appears to be **054.**