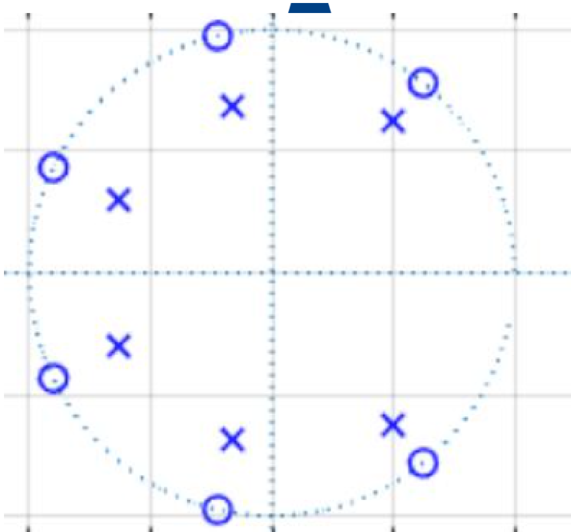
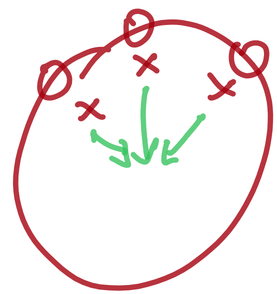
UNITED STATES AIR FORCE ACADEMY

ECE 434
Digital Signal Processing

CPX2
x8



Lesson 32



- made FIR
many poles to origin

ES AIR FORCE ACADEMY

Dr George York
Room 2E46E
333-4210
719-484-9608

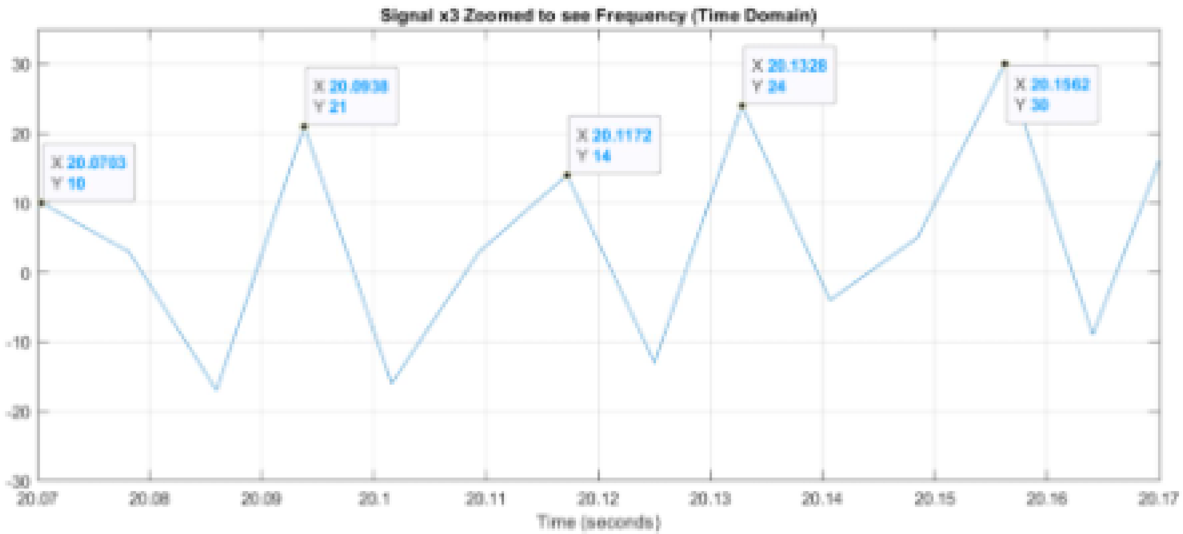
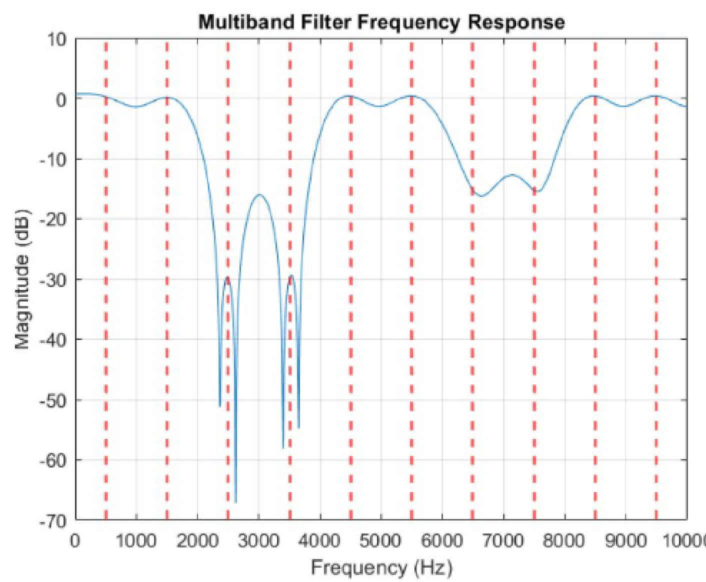
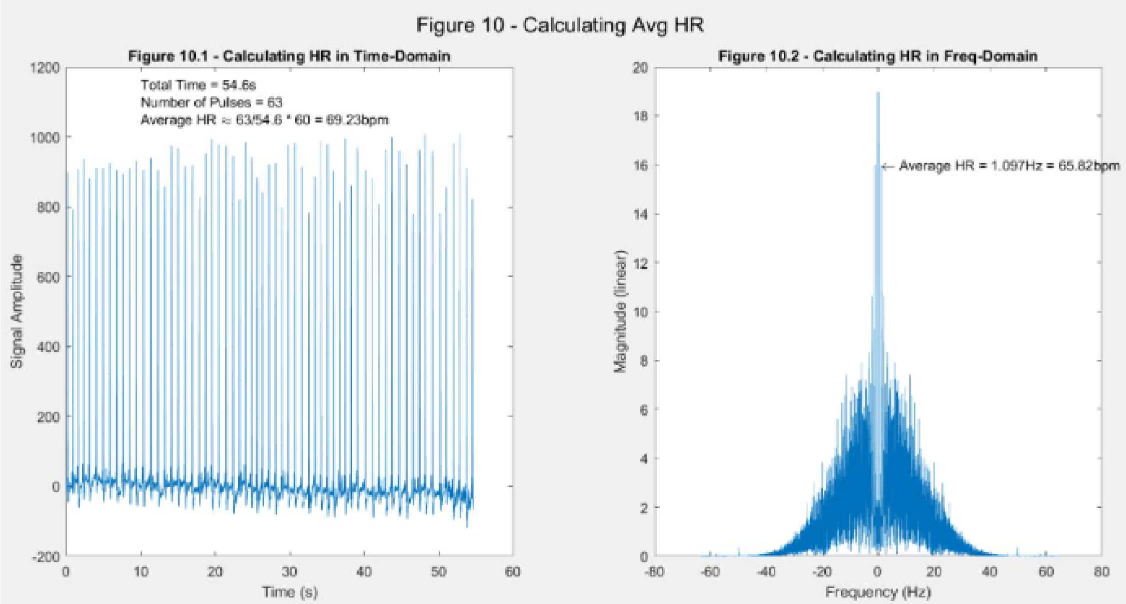


Figure 19. The signal x3 zoomed in to analyze the 50 Hz frequency.

zoomed powerline 50Hz noise





Admin

- T33: Radar/Sonar Intro
- T34: CPX3 stages 1-5 Intro — CPH14a due
- T35 Quiz, then lab time — CPH14b due
- T36 CPX3 lab time — CPX3 Stages 1-5 Due COB Taps?
- T37 CPX3 stages 6-11 Intro — CPH16a due
- T38 CPX3 lab time — CPH16b due
- T39 Quiz, then lab time 2x points
  - CPX3 Stages 6-11 Due BOC
- T40: Team Presentations — Peer Eval Due

CPX3 Teams

- Teams

M4				
Team MSG	Sam	Tia	Grant	
Team NoName	Zoe	Mateo	Zach	
Team NoName	Joel	MC	Jake	
M5				
Team The Three Js	Joshua	Jake	Simon	
Team NoName	Noah	Sam	Jack	Chris
Team NoName	Parker	Brock	Dustin	Ridge

- Company Goal? Fastest, most efficient, best quality?
- Grading? Part team grade; part individual grade

Lots of good reading…

- Final_Project_Assignment_v6.pdf
- sonar_processing_v7.pdf
- radar.pdf ← 315/215?

Radar?
Sonar?
Ultrasound?

- And Code
  - cpx3_sonar_v4.zip
  - cpx3_sonar_Matlab_Headers_v4.zip

pcode?

- And Data
  - test_data.mat
  - test_data3.mat

>> cpx3_sonar_v4

Old Sonar System

Figure 2. ECE434 CPX3 SONAR STAGES

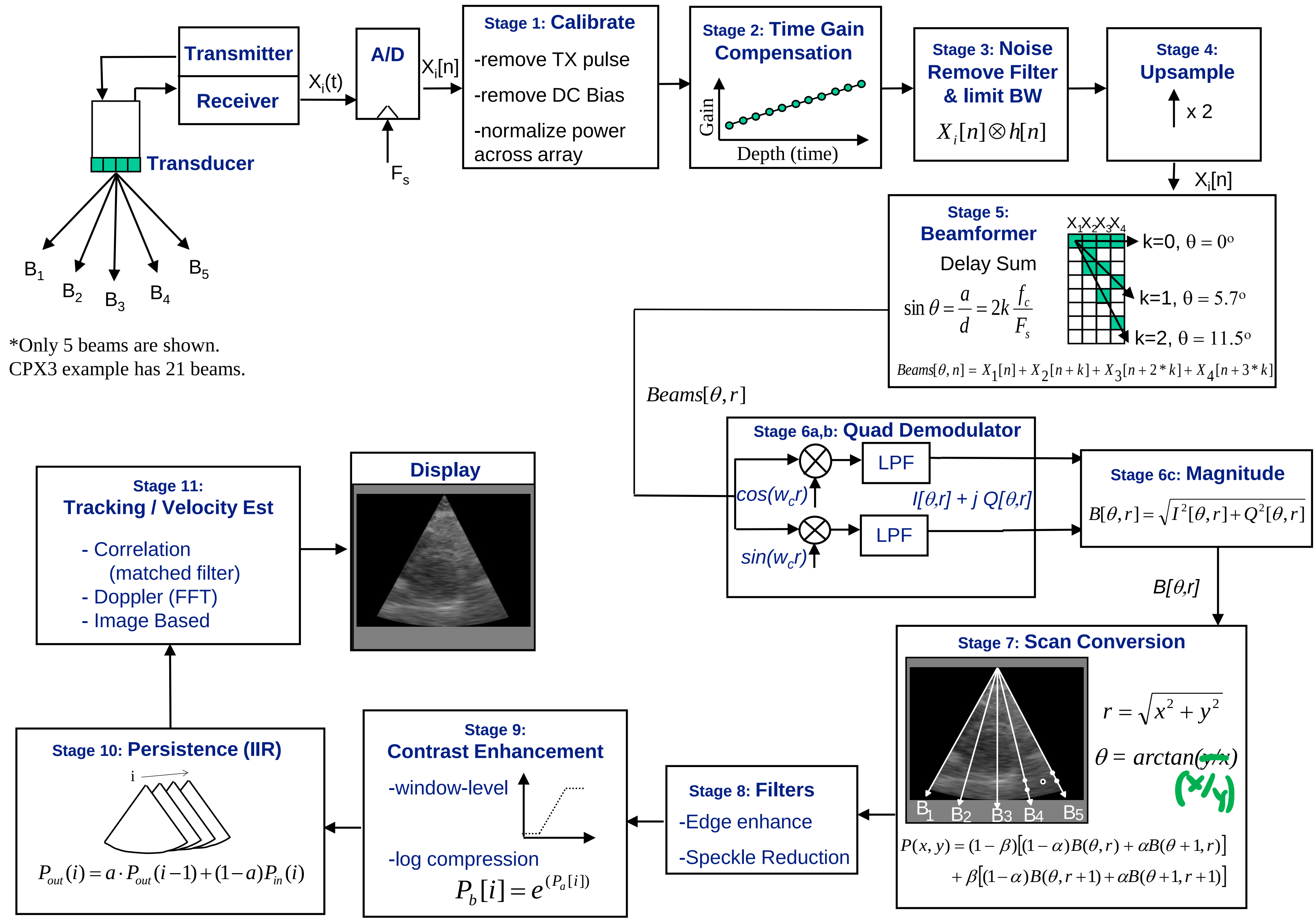
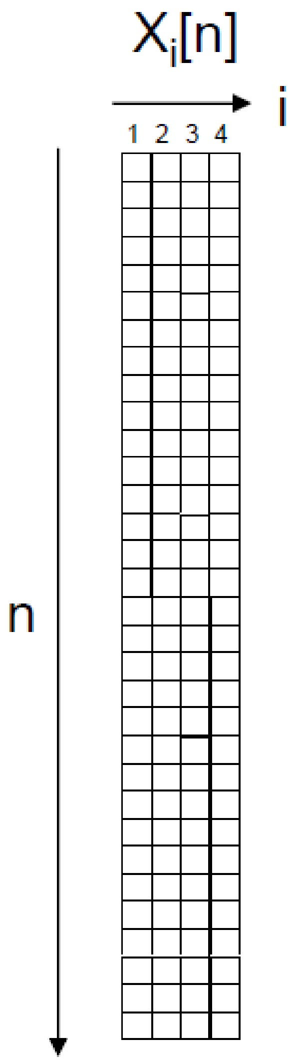
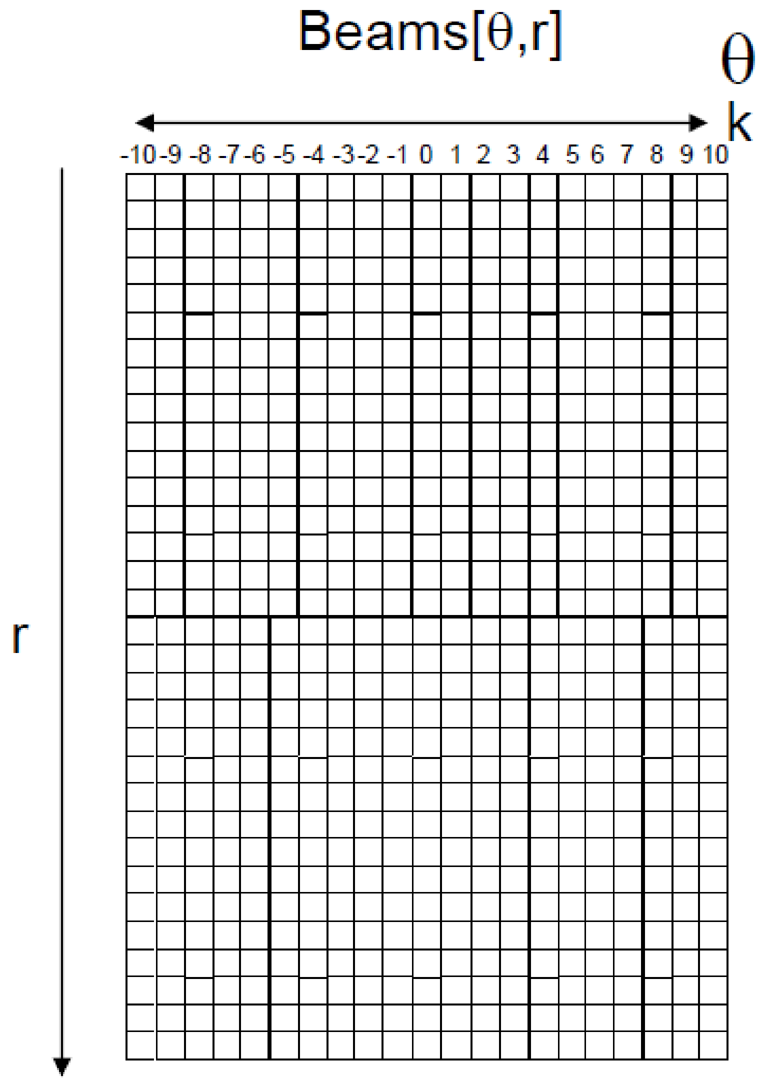
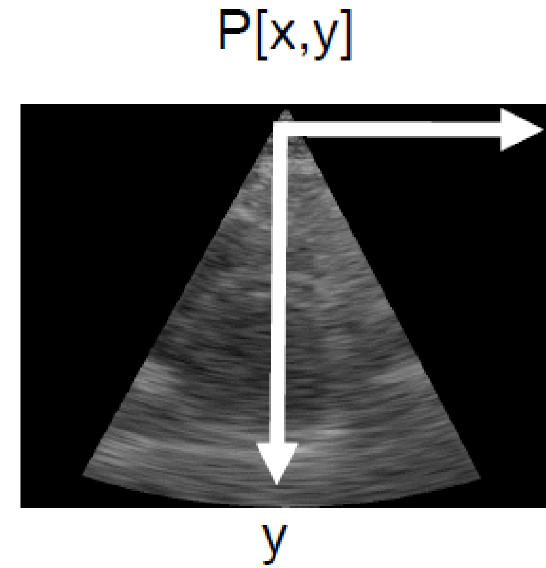
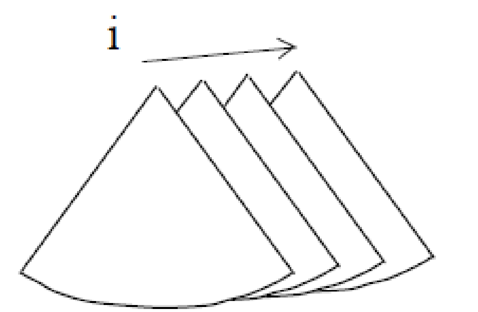


Figure 3. EE434 CPX3 SONAR DATA STRUCTURES









$X_i[n]$ is the sampled arrays from the 4 channels. i is the channel number. n is the sample number.

Beams[θ,r] is the result of beamforming. k is the delay between samples, representing a fixed phased delay, and in turn the angle of the beam θ. r is the

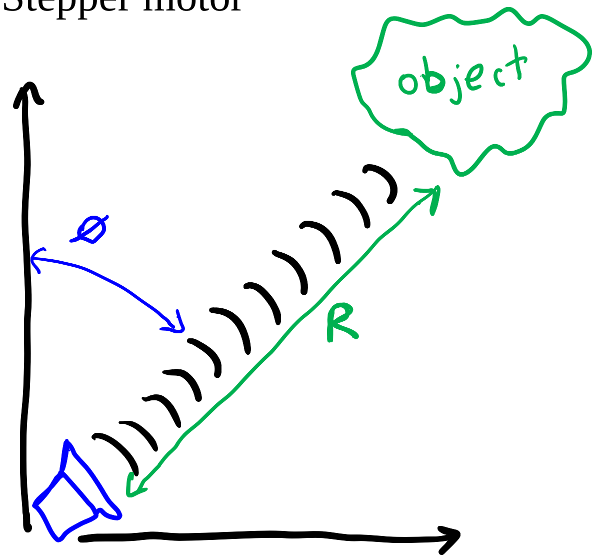
P[x,y] is the echo image after scan conversion. x and y are the spatial coordinates.

P[i] is the final output image after the persistence filter, an IIR filter blending the current image with the previous output image. i is c ?

Sonar/Radar/Ultrasound

Mechanical Scanning

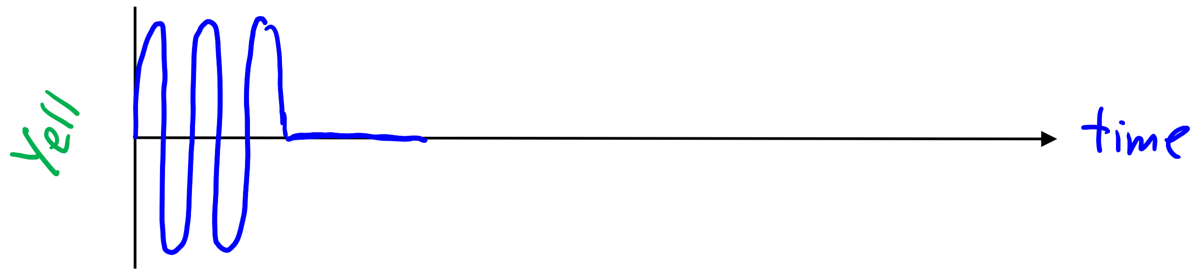
Stepper motor



Beam width?

Transmitted Pulse

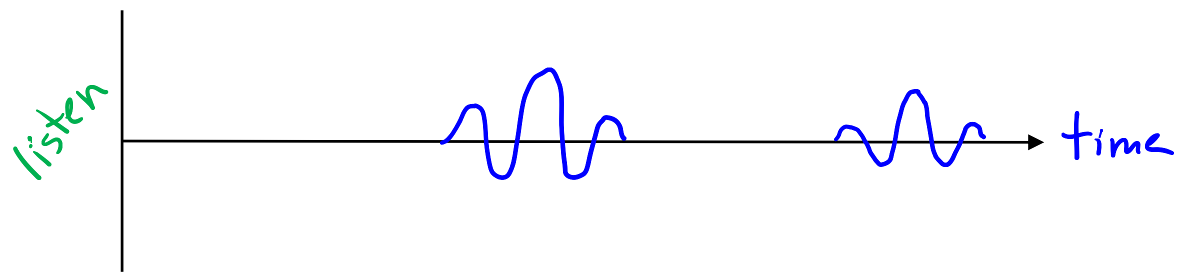
→ space



Like ________________

Returned Echo

← space



Why are returned echoes smaller?

1.
2.
3.

See radar.pdf

How long in time did the pulse travel?

r : range in distance to target

$t =$

c :

$r =$

What is “c”?

PRI =

PRF =

How long does it take to scan an image?

Do we want few cycles or many cycles for our pulse?

lots?

few?

Range Resolution?

$$\Delta R =$$

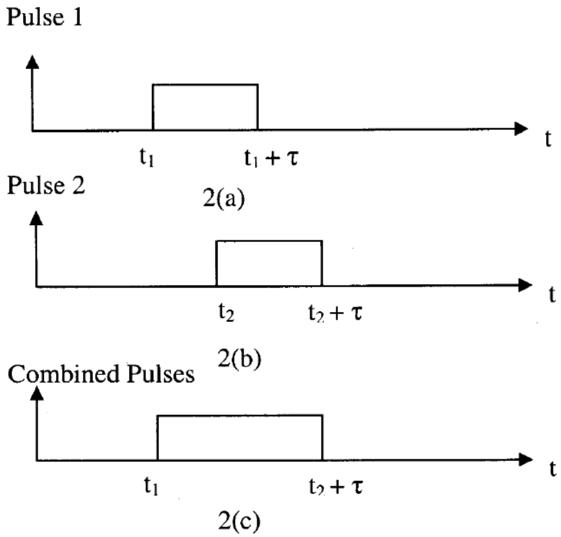


Figure 2 *Two pulses of slightly different ranges merged due to pulse width.*

How much Power do we need to Transmit? __________ Equation

$$P_r =$$

Phase Array

What is the advantage of phased array vs mech steering?

- TX and RX omni-directional for each element
- Waves ______________ add along beam line
  - ____________ cancel each other elsewhere
- Time delay → ________ difference →
- Far field assumption

X_1 X_2 X_3 X_4

$\lambda/2$

- **See gilbert_report.pdf about phased arrays**

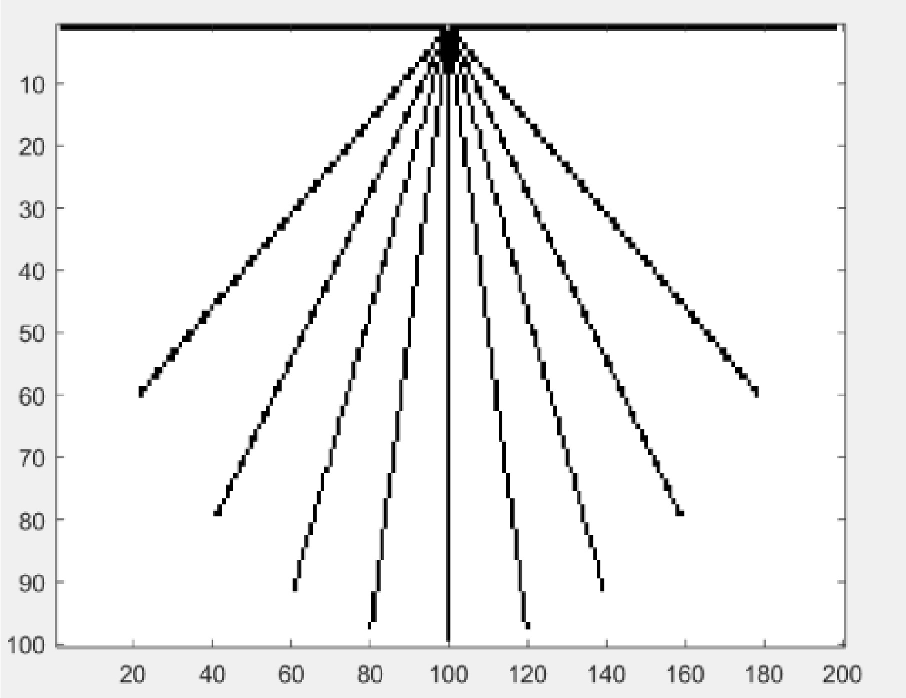
499

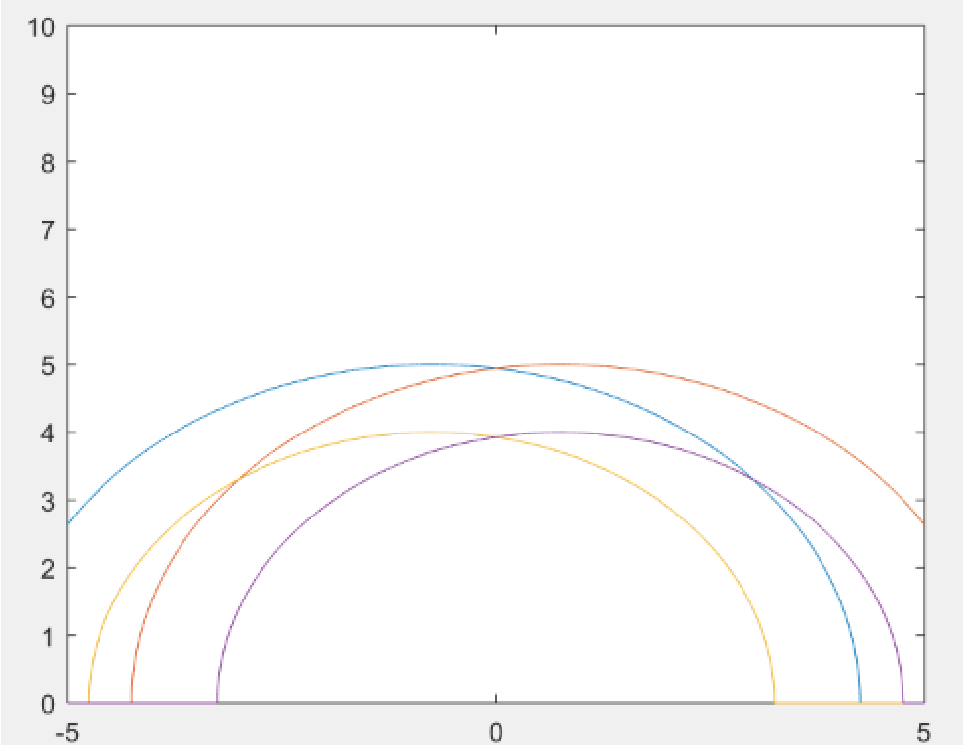
- **Sound demo**
  - http://phet.colorado.edu/en/simulation/sound

>> beamsteer4_halfwave.m

>> beamsteer4_3halfwave.m

>> delay_sum_beams.m





Does the F-15 use a mech steering
Or phased array steering?

Delay-Sum Beamformer

z^{-n} ?

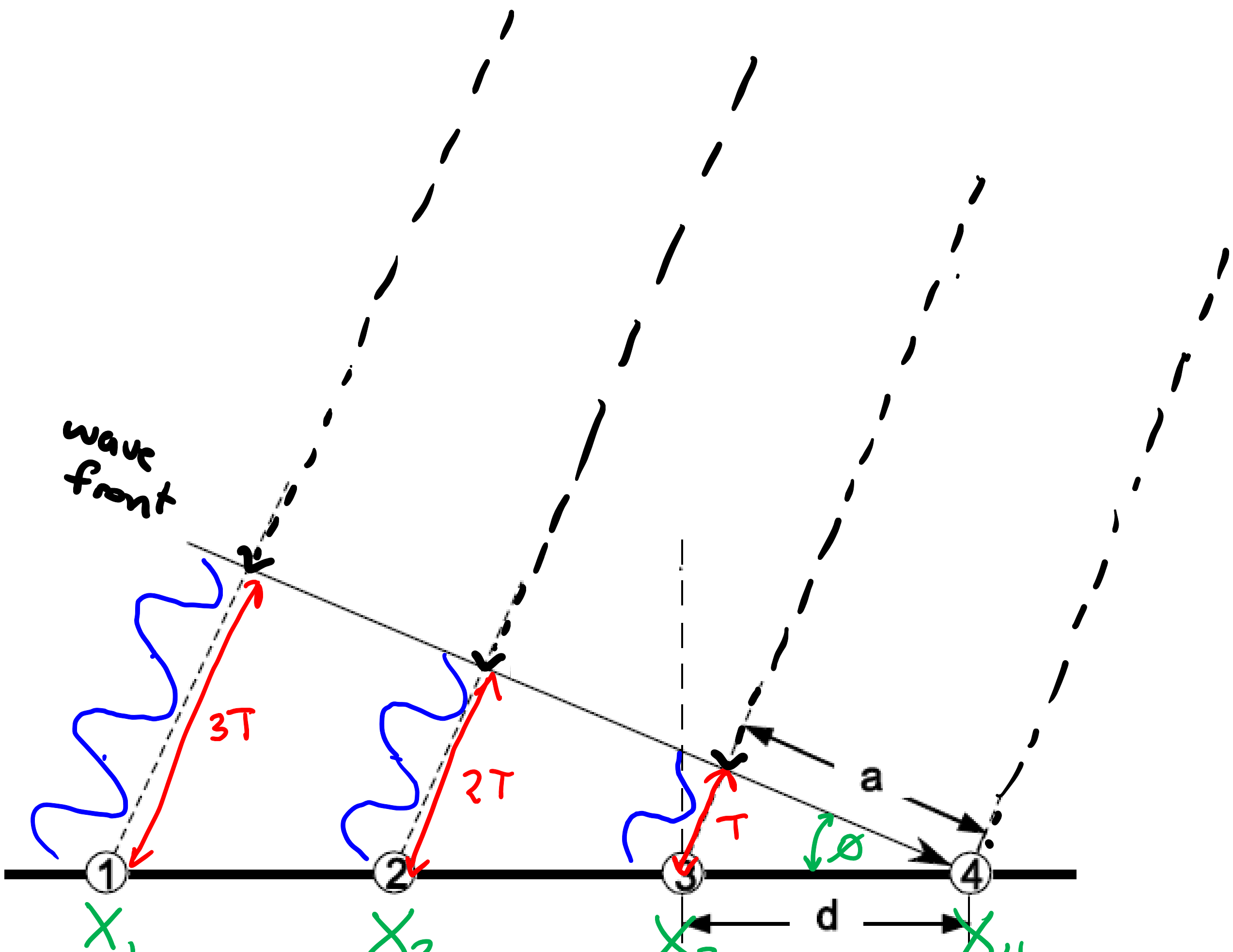
$$Beams[k,n] = X_1[n] + X_2[n+k] + X_3[n+2*k] + X_4[n+3*k]$$

for all n and all k

k is ______________

$T = \frac{1}{F_s}$

Let k=1

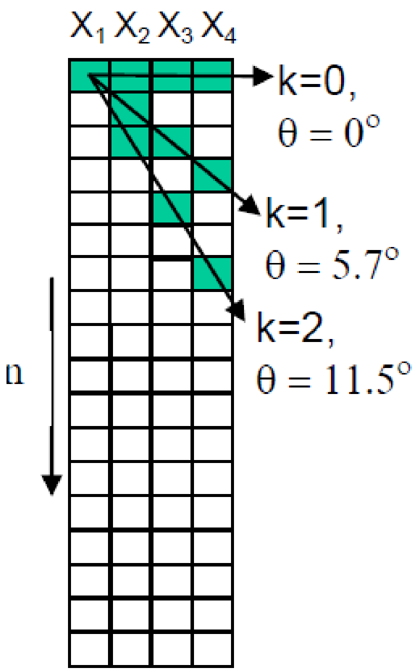


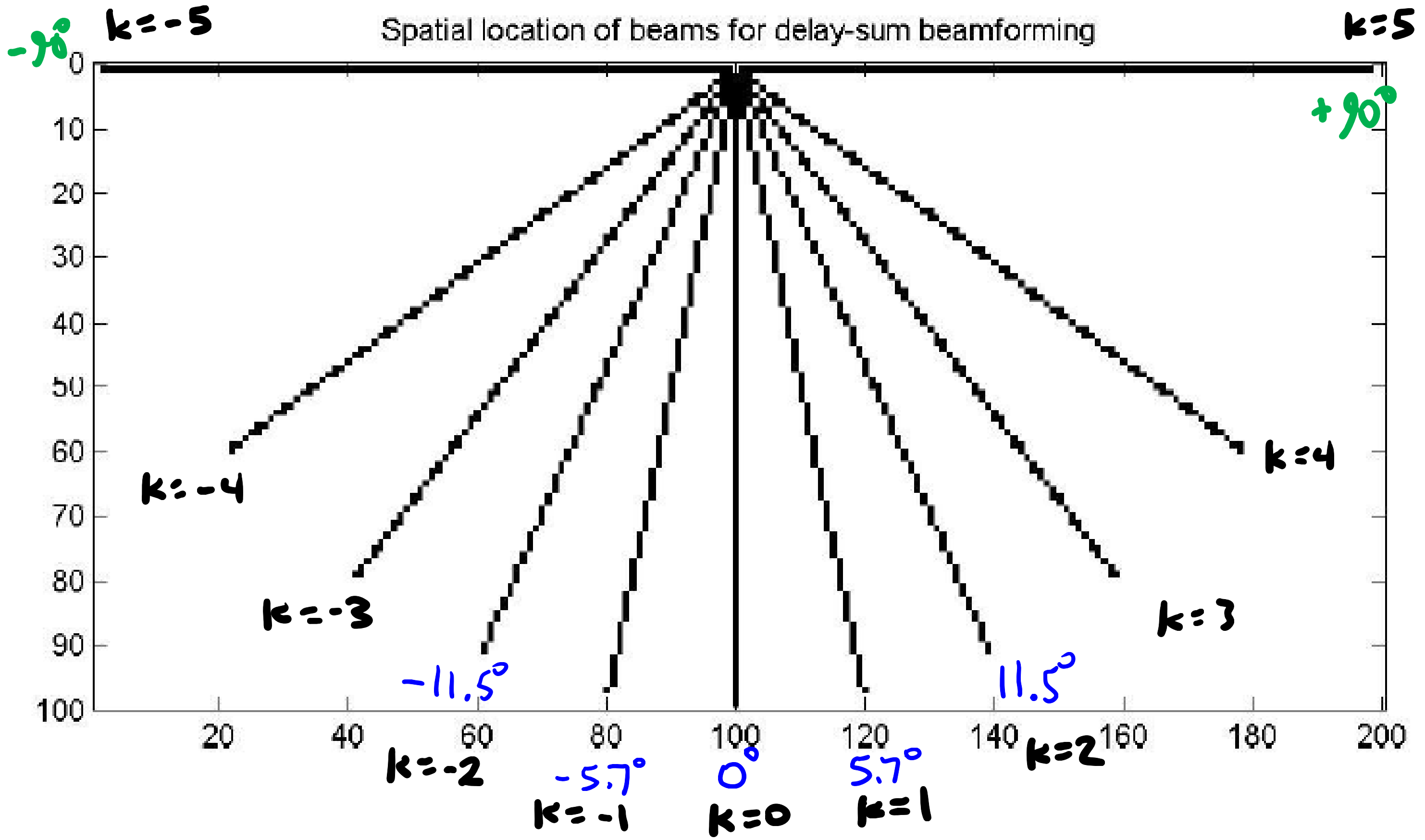
$d = \frac{\lambda}{2}$

Figure 18. A linear sensor array consisting of four omni-directional microphones, labeled 1-4. $\boxed{d = ½}$

Beam Location

$$\sin\theta = \frac{a}{d} = 2k\frac{f_c}{F_s}$$



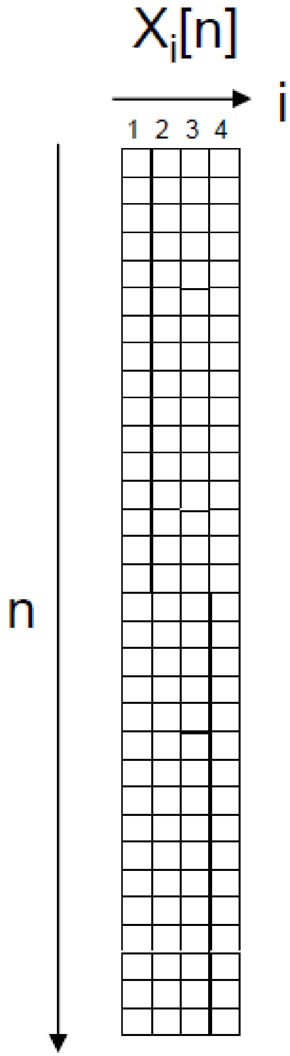


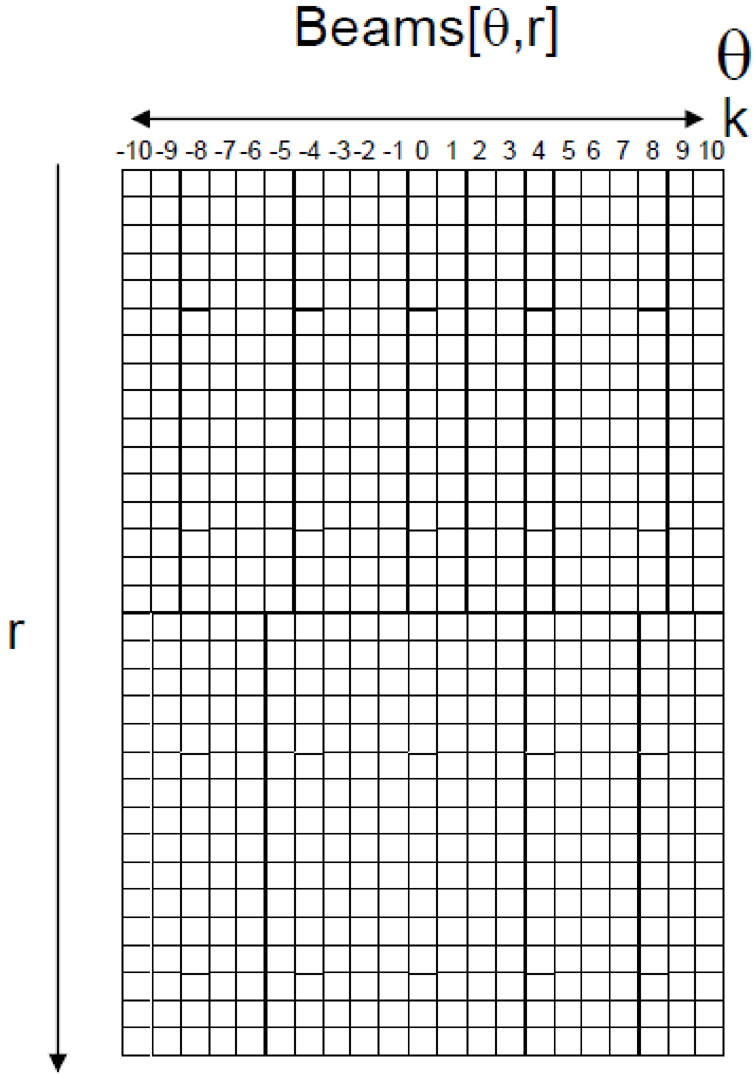
If $\frac{f_c}{F_s} = \frac{10kHz}{100kHz} = — \rightarrow$ *beams*

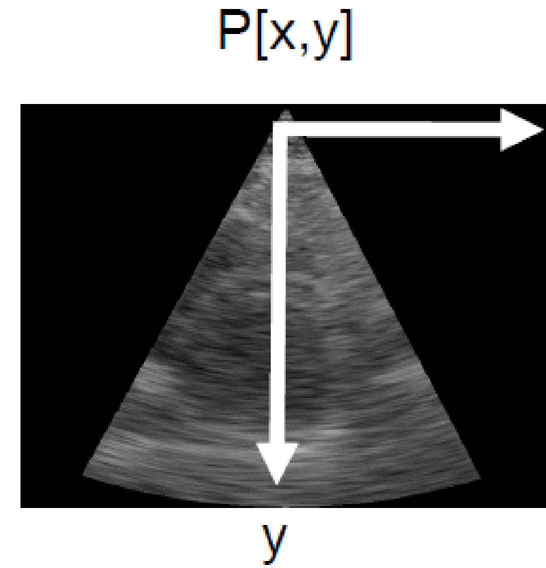
If $\frac{f_c}{F_s} = \frac{10kHz}{200kHz} = — \rightarrow$ *beams*

$\#beams = \frac{F_s}{f_c} + 1$

Figure 3. EE434 CPX3 SONAR DATA STRUCTURES







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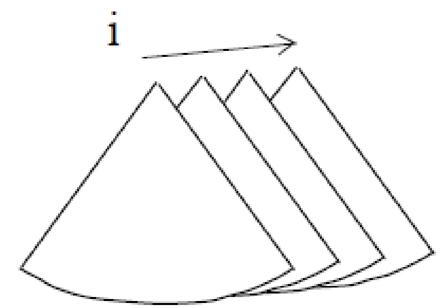

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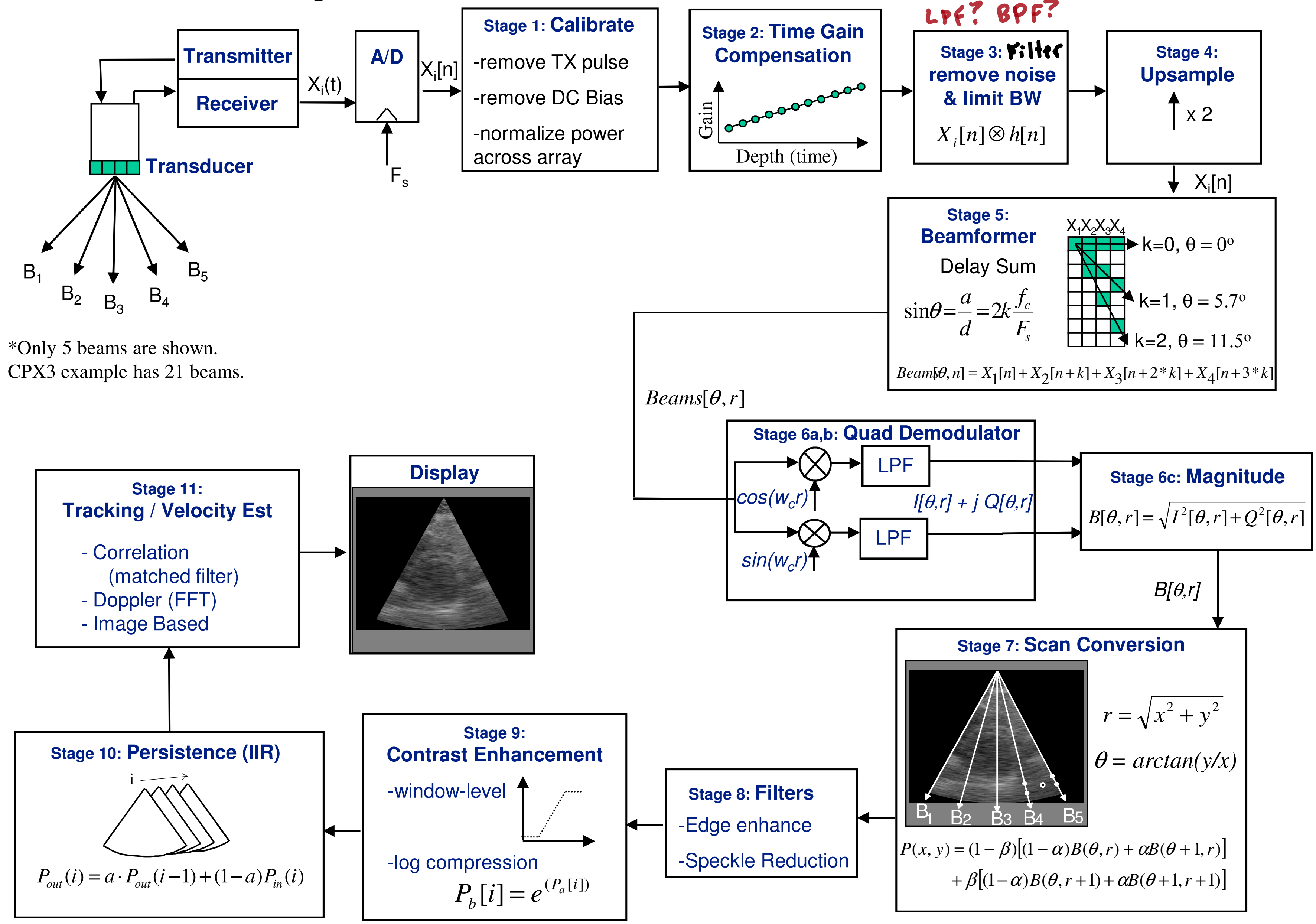

sonar_processing_v4.pdf

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- Stages 1-5

  Taps?

  - By **COB Lesson** 36, stages 1 to 5 (from Calibration to Beamformer) are due. The Beamformer and the Noise Removal Filter are mandatory stages that must be implemented by the team. If the Noise Removal Filter is done inside another stage, then this meets the requirement, however, person doing filter now needs to find another function to do.

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Walk thru the code…

- cpx3_sonar_v4.m
- Pcode vs header

- all stages run from
- should you plot images inside your code?
- where do you put Look up Tables?
- should you load files inside your function?

Appendix A: MATLAB functions you may use inside your Subroutines
Contact your instructor for permission to use other MATLAB functions.

Standard Loops (For, While), If/Then/Else, standard math operators * / + -
Vectorized math operations.

For any filter's designed, you must use the filterDesigner tool, showing the specs from the design window [unless doing a multiband filter with *remez* or *firpm*]

Filter(): for filter's you must export your filters such that the *filter*() or *conv*() can be used as:

y = filter(num, den, x) or y = conv(num, x)

FFT(), *IFFT*()
Plot()
Length(), *Size*()
Sqrt(), *Mean*(), *Abs*(), *RMS*(), *Max*(), *Min*()
Log(), *Log10*(), *Exp*()
Window()
Zeros()
Sin(), *cos*(), *tan*(), *Asin*(), *acos*(), *atan*(), *atan2*()
Load()
Find(), *any*(), *circshift*()
Real(), *imag*(), *conj*()
Floor(), *round*(), *ceil*()