EE123
Digital Signal Processing

Lecture 11
Time-Freq
and Lab I + II
Announcements

• Lab 1
  – Deadline extended to Sunday night
• Lab 2
  – Out Friday, due next Friday (SDR)
• Midterm
  – Friday 3-5pm. Be on time, open everything
  – Conflicts make sure send an email to ALL of us
Lab 1

- Generate a chirp
Lab1

- Play and record chirp
Lab 1

- Auto-correlation of a chirp - pulse compression
Lab I part II - Sonar

- Generate a pulse - analytic
- Use real part for pulse train
- Transmit and record

Sent and recorded:
Lab I part II - Sonar

• Extract a pulse

sent:

received:
Lab I part II - Sonar

• Matched Filtering

Received:

Filter:

Envelope Matched Filtered
Lab I part II - Sonar

• Display echos vs distance

Matched Filter:

\[ d = \frac{\text{samp}}{\text{fs}} \times v_s \]

\[ t = \frac{\text{samp}}{\text{fs}} \]
Lab I part II - Sonar

- def sonar(Npulse, f0, f1, fs, Nseg, Nrep, T=20, maxDist=400, vmax=0.2):

- Play with different parameters: f0-f1 10,000 - 19000 Npulse = 300
  – change range of frequencies, change pulse length
SDR Stuff

• Samples you measure from the SDR are COMPLEX! **WHY?**

• Aren’t physical signals real???????
SDR Stuff

• Samples you measure from the SDR are COMPLEX! WHY?
• Aren’t physical signals real???????
With the SDR we look at part of the spectrum.

Example:
```
>> rtl_sdr -f 94e6 -s 5e5
```

Samples represent this freq. band.
• How is it implemented?

\[ e^{-i2\pi f_0 t} \]

SDR Stuff
How is it physically implemented?

\[ e^{-i2\pi f_0 t} = \cos(2\pi f_0 t) - i \sin(2\pi f_0 t) \]
How is it physically implemented?

\[ e^{-i 2\pi f_0 t} = \cos(2\pi f_0 t) - i \sin(2\pi f_0 t) \]
SDR Stuff
Lab I part III - SDR

• Get samples around 162Mhz
  – Compute DFT 8000

  – Compute average DFT of many windows size 800
Lab I part III - SDR

• Compute spectrum of FM radio around 88.3MHz

![Average Power Spectrum](image)

- NPR radio
- HD radio
ADS-B

1030MHz interrogation

1090MHz reply

1090MHz ADS-B squitter

ADS-B In
ADS-B

**ADS-B mode S Packet**

- Preamble: 8.0 us
- Data: 56/112 us

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**rtl-sdr measured ADS-B mode S packet**

Preamble: 0 1 0 1 1 1 0

Data: 1 0 1 0 1 0 0

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ADS-B

- Acquire 1 seconds

- Extract 1 packet
Detect Preamble

• Energy:
  – Median and MAD to estimate noise
  – Set threshold based on noise

• Using cross correlation

\[ \hat{R}_{xy}[n] = \frac{\sum_{k=0}^{15}(x[n+k] - \hat{x}_n)(y[k] - \hat{y})}{||x[n] - \hat{x}_n|| \cdot ||y - \hat{y}||} \]

• Using Logic
  1’s bigger than 0’s
See airplane position