EE123
Digital Signal Processing

Lecture 32
Lab 6B
Lab 6 Part B - AX.25 and APRS

• The lab implements a packet based transceiver
• You will be able to send/receive packet to other classmates
• You will be able to send/receive APRS packets that users and stations with APRS equipped radios can decode.
AFSK1200 / Bell 202 modem

- Audio FSK
  - Encodes digital data at 1200b/s
  - Use audio frequencies 1200/2200Hz
  - Within the bandwidth of the audio input BP filter of your radios
  - Still(!) popular for ham packet networks

\[ s(t) = \cos\left(2\pi f_c t + 2\pi \Delta f \int_{-\infty}^{t} m(\tau) d\tau \right) \]

- \( f_c = 1700, \Delta f = 500, m(t) = \pm 1 \)

- Phase is not the same for each bit -- must use non coherent detection.
AFSK1200

• Write a function to generate AFSK1200
  – Take care: sampling rate (44.1KHz) does not divide with bit-rate
  – Look at Spectrum
Non-Coherent Demodulator

- Complex BP filters around frequencies
FM Demodulator

- Complex bandpass filter
- Compute Phase derivative to get frequency
- Low-pass filter again with a BW of 1200hz corresponding to bit rate
Bit Error Rate

• When adding noise, things are not so nice

• Compute % or bits incorrectly decoded with respect to total bit sent.

• 'BER of non-coherent:', 0.0021 in this case
AX.25

- Link Layer packet based protocol
- Used by ham radio, based on X.25

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<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>7</td>
<td>56</td>
<td>1</td>
<td>1</td>
<td>256</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

- NRZI: 0 is encoded in change, 1 is no change
  11011000 is converted to 11000101
- Bit stuffing: include a ‘0’ every 5 ‘1’s to guarantee signal change -- help synchronization
- Flag: 01111110 at beginning and end. The only sequence with 6 ‘1’s.
- FCS field for checksum error detection
Automatic Positioning and Reporting System

• Ham packet system for real-time tactical digital communication
• Based on AX.25
• Many commercial products implementing APRS
• National frequency 144.39MHz (ch-117)
• ISS packet: 145.825 (ch-50)
• Internet aggregation and services
  – Email, SMS, geo-location
APRS Packet

- Dest address: APDSP (software version)
- Source address: Your call sign
- Digipeter addresses - Wide1-1, Wide2-1
- Control field (UI X.25 packet) : \x03
- ID: \xF0
APRS Information Field

• 256 Bytes
• Messages:
  – :ALL------:Everyone will capture this 64 byte message text
  – :KK6MRI----:This message will only show on Miki’s APRS enabled Yaezu VX-8dr radio screen
  – :EMAIL----:mlustig@eecs.berkeley.edu I sent you an email Miki through an OpenAPRS node!
  – :SMSGTE---:@5551231234 I’m sending this number and SMS message
  – :CQSRVR---:CQ EE123 Starting an EE123 chat group

• Position:

<table>
<thead>
<tr>
<th>I or = symbols</th>
<th>Latitude 8 chars / Longitude 9 chars</th>
<th>icon 1 char</th>
<th>Comment max 43 chars</th>
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</thead>
<tbody>
<tr>
<td>=</td>
<td>3752.50N / 12215.43W</td>
<td>K</td>
<td>Shows a school symbol on Cory Hall position</td>
</tr>
<tr>
<td>=</td>
<td>3752.45N / 12215.98W</td>
<td>[</td>
<td>Shows a person walking on Oxford and Hearst</td>
</tr>
<tr>
<td>=</td>
<td>2759.16N / 08655.30E</td>
<td>[</td>
<td>I’m on the top of the world! (Mt. Everest)</td>
</tr>
</tbody>
</table>

  – =3752.50N/12215.43WKShows a school symbol on Cory Hall position

• Status  (starts with a ‘>’)  
  – ->I like radios
Generate APRS packet

- import ax25
- callsign = "KK6MRI"
- Digi = b'WIDE1-1, WIDE2-1'
- dest = "APDSP"

# Uncomment to Send Email
- info = ":EMAIL :mlustig@eecs.berkeley.edu What a great lab!"

# uncomment to report position
- info = "=3752.50N/12215.43W This is Cory Hall!"

# uncomment to send a status message
# info = ">I like radios"

- packet = ax25.UI(
  destination=dest,
  source=callsign,
  info=info,
  digipeaters=Digi.split(b','),
)
- print(packet.unparse())
APRS packet

- bitarray('0111111001000001000001010001000101100101000
  00101000000100000011001101001011010010010011011001011
  001001001010100100100000110011101010101001001001000100
  010101000101000110000000100100011001101010101001001001
  000100010101000100100110000000100010110001101100000000
  00111110011110011001100111011001010110001001100111
  0100101011000000110001110010111101001000110001001000111
  00010001100011001011000110011001011011001110001001001000
  001000110001100110011001110000101100011011000000000
  111010011110000001000001001000100011000110110001101
  101000010010100110001000100010001111110')
Decode APRS packets

- From: Sivan Toledo, 4X6IZ
- Look at zero-crossing
Packet from ISS

* Dest: CQ 0 | Source: RS0ISS | Digis: | >ARISS - International Space Station |
Implement Stream Processing

• Data comes in
• Process in chunks
• Make sure overlaps are taken care of

• Write an application:
  – Decode in real time
  – Interactive text messaging
Demo
Tips for Debugging

• Check audio device volume on computer and radio
• Turn Squelch off
• Create an audio look without the radio