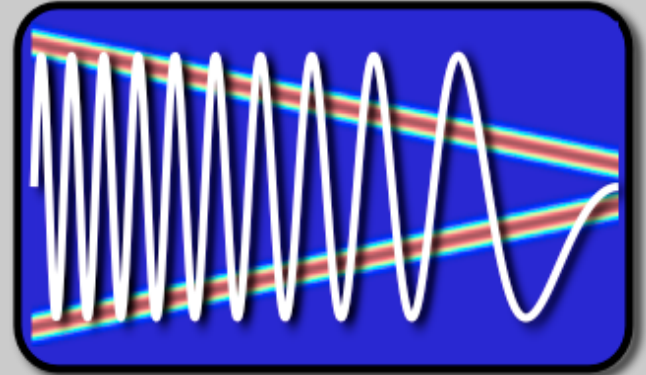


EE123



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

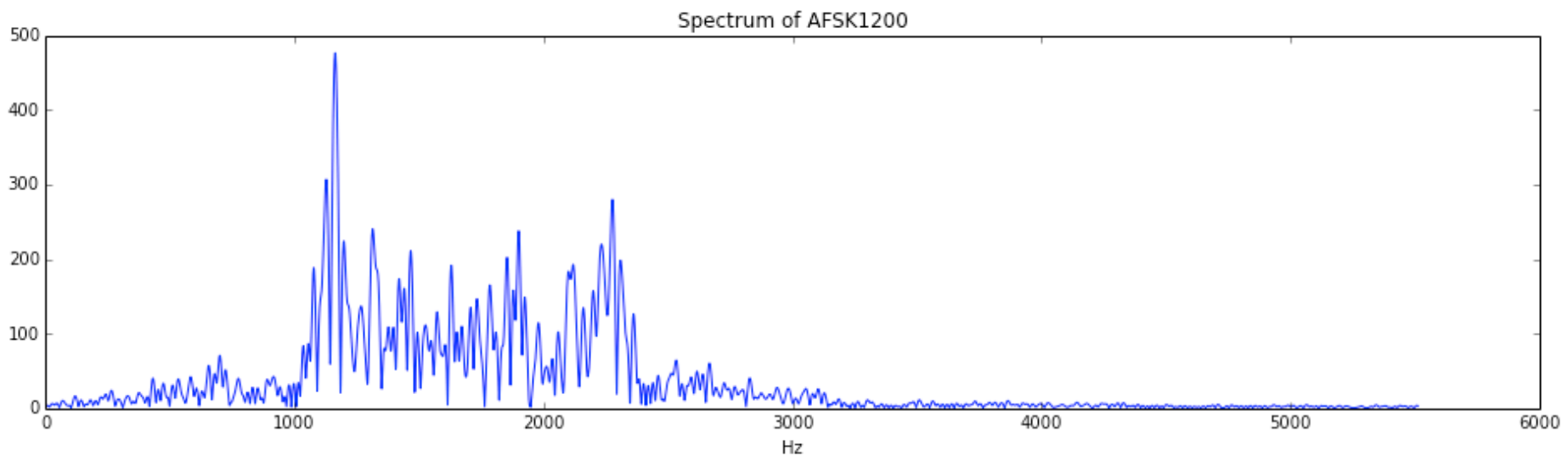
- Encodes digital data at 1200b/s
- Use audio frequencies 1200/2200Hz
- Within the bandwidth of the audio input BP filter of your radios
- Still(!) popular for ham packet networks

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

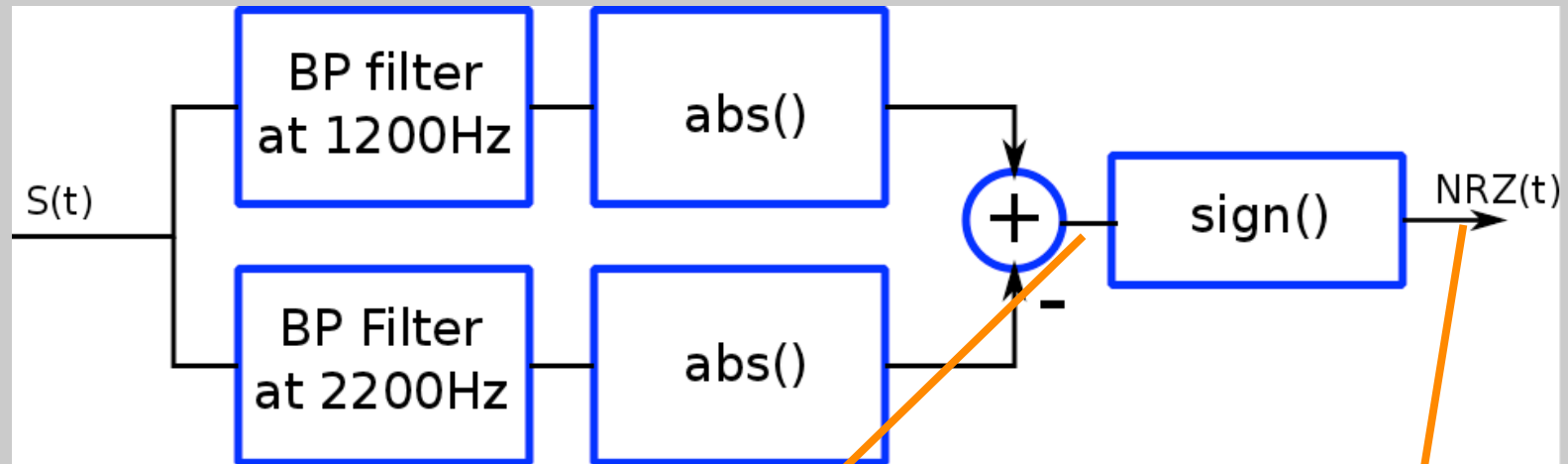
- $f_c = 1700$, $\Delta f = 500$, $m(t) = \pm 1$
- Phase is not the same for each bit -- must use non coherent detection.

AFSK1200

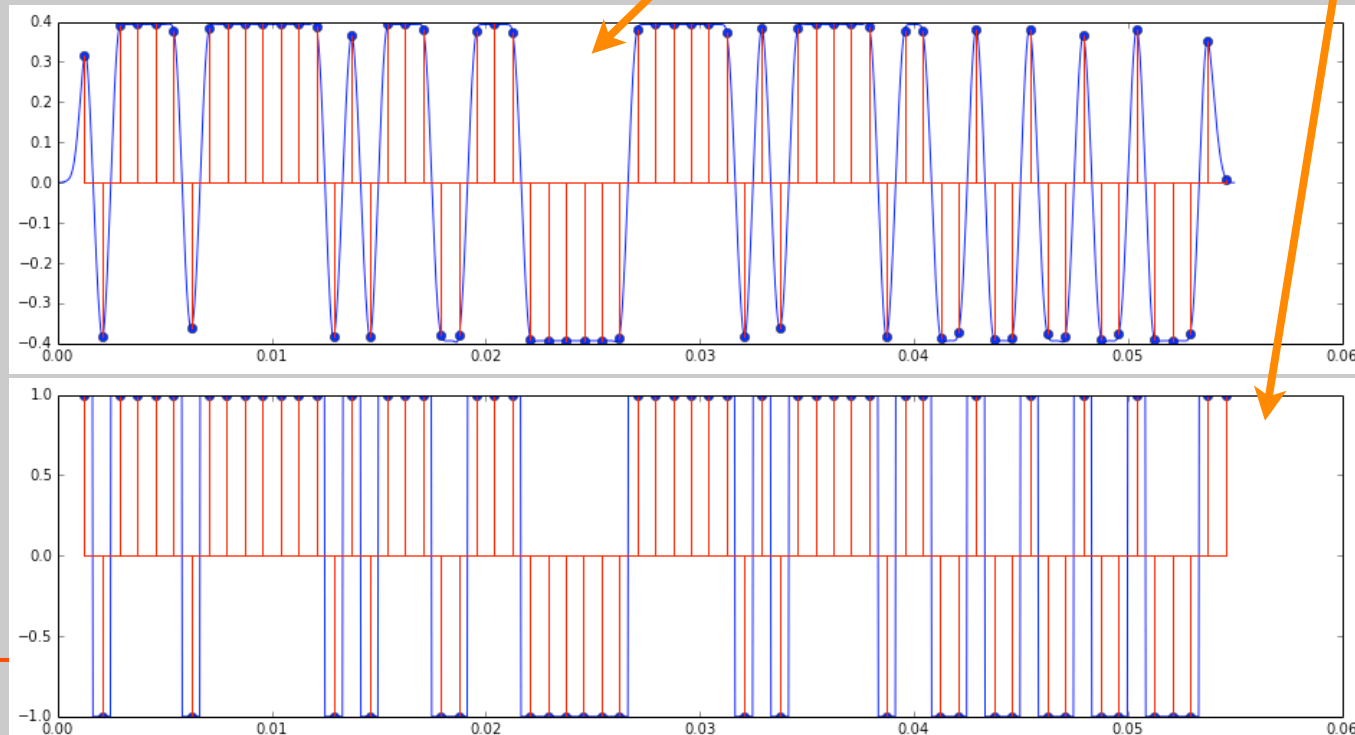
- Write a function to generate AFSK1200
 - Take care: sampling rate (44.1KHz) does not divide with bit-rate
 - Look at Spectrum



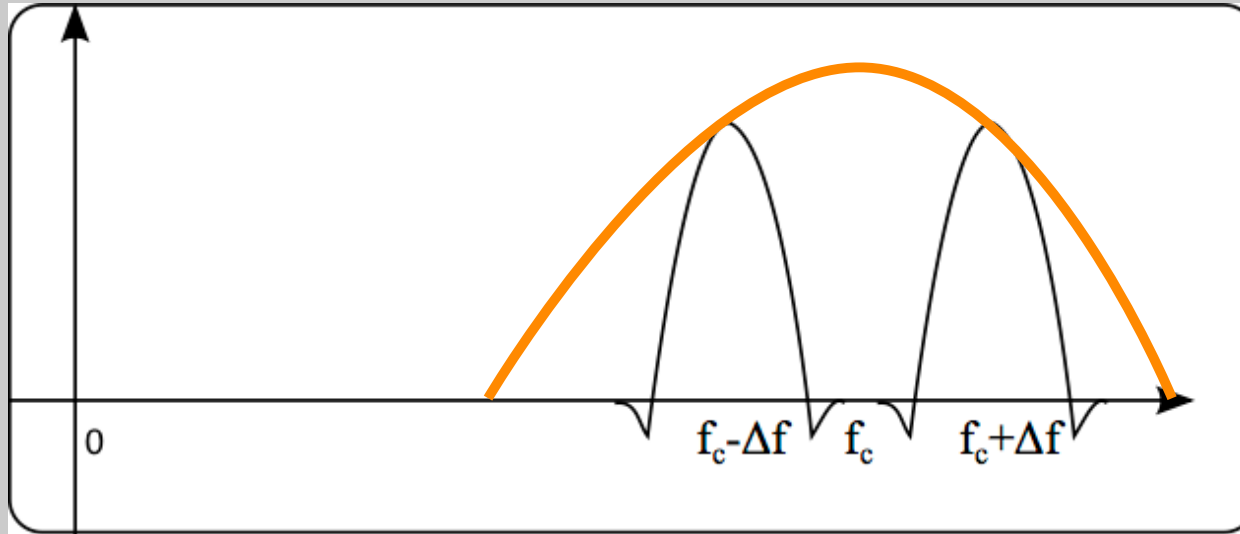
Non-Coherent Demodulator



- Complex BP filters around frequencies



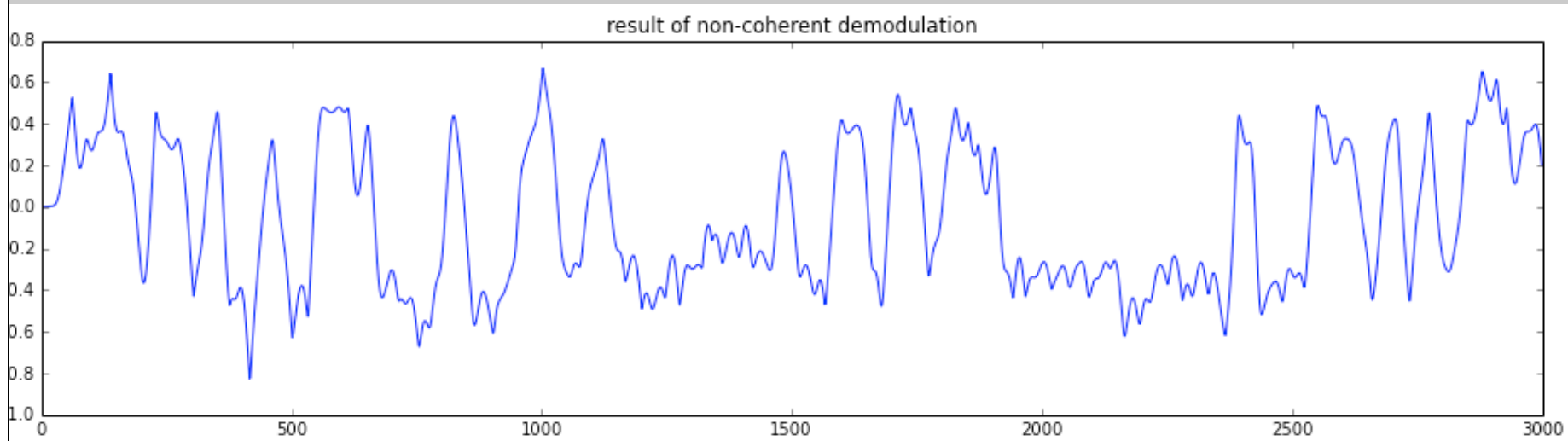
FM Demodulator



- 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

flag	Dest. Addr.	Src. Addr.	Digipeter Addresses	Control field	ID	Information Field	FCS	Flag
1	7	7	56	1	1	256	2	1

- 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

flag	Dest. Addr.	Src. Addr.	Digipeter Addresses	Control field	ID	Information Field	FCS	Flag
1	7	7	56	1	1	256	2	1

- 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 Yaesu VX-8dr radio screen
 - :EMAIL----:mlustig@eecs.berkeley.edu I sent you an email Miki through an OpenAPRS node!
 - :MSGTE---:@5551231234 I'm sending this number and SMS message
 - :CQSRVR---:CQ EE123 Starting an EE123 chat group

- Position:

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

- =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/12215.43WKThis is Cory Hall!"`

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

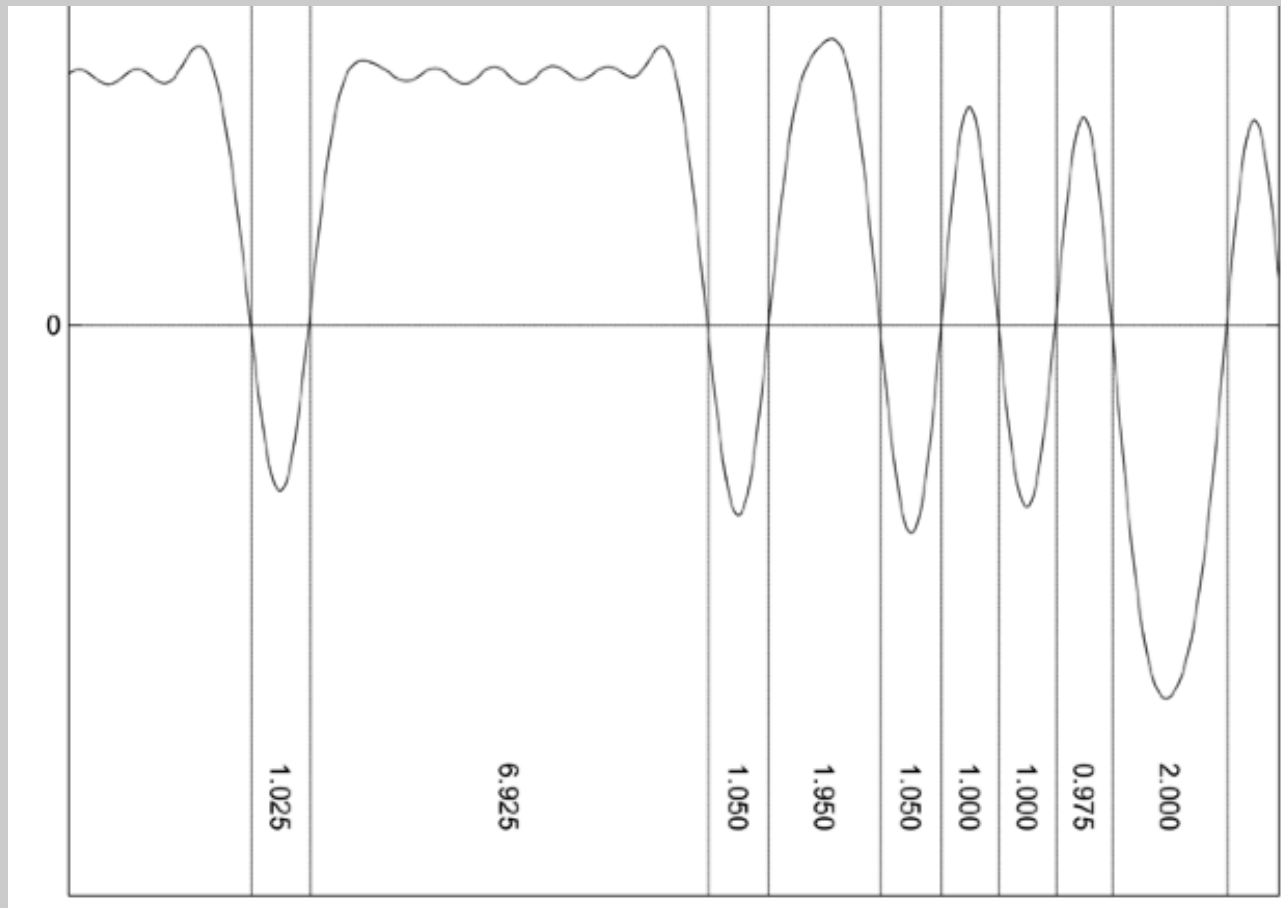
- `packet = ax25.UI(`
- `destination=dest,`
- `source=callsign,`
- `info=info,`
- `digipeaters=Digi.split(b','),`
- `)`
- `print(packet.unparse())`

APRS packet

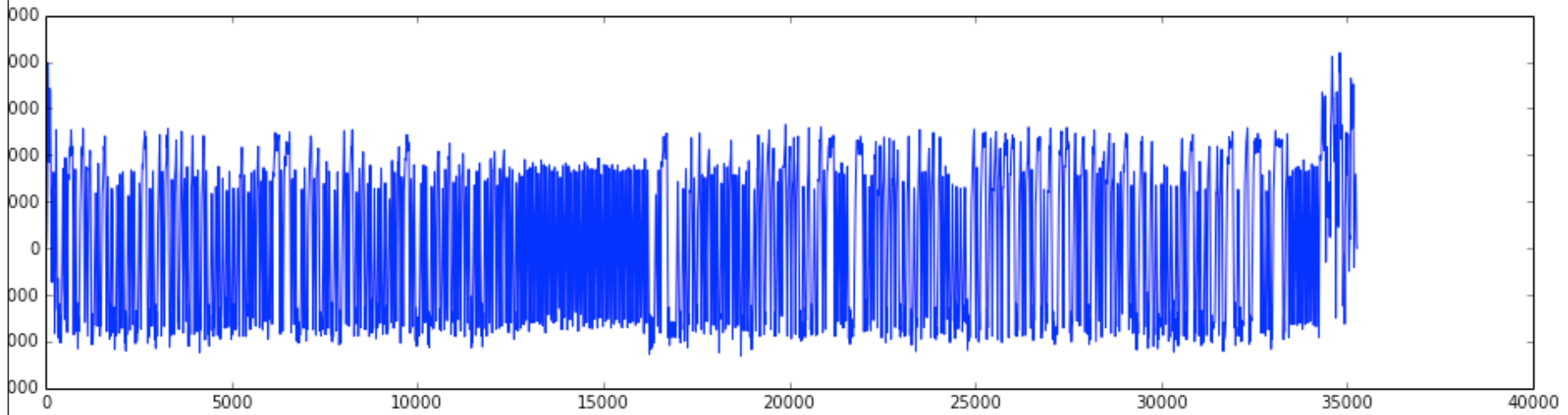
- `bitarray('0111111001000001000001010001000101100101000
00101000000100000011001101001011010010011011001011
0010010010101001001000001100111010101001001000100
01010100010100011000000010010001100111010101001001
00010001010100010010011000000010110001101100000000
001111100111100110011001110110010101100010011000111
01001010110000001100011100101111010010001100010011
00010011001000110010101100011101000010110011001100
11101010110100100010101000010110100101101100111000
00010010010110110011100000010011000010111101100100
11101001111000000100000100101000011000110110001101
1010000100101001100100010001111110')`

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

GUI

APRS123

2015-04-19 22:11>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:Hello from CM87, qsl?
2015-04-19 22:11>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:Hello from CM87, qsl?
2015-04-19 22:12>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:ack02
2015-04-19 22:12>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:ack02
2015-04-19 22:12>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:Thanks for QSO from CM87, 73!
2015-04-19 22:12>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:Thanks for QSO from CM87, 73!
2015-04-19 22:12>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:Thanks for QSO from CM87, 73!
2015-04-19 22:12>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:ack04
2015-04-19 22:12>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:ack04
2015-04-19 22:12>	APP:CQ	0	FRM:RS0ISS	MSG:>ARISS - International Space Station	
2015-04-19 22:13>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:ack05
2015-04-19 22:13>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:ack05
2015-04-19 22:13>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:Yes, almost too easy! :-)
2015-04-19 22:13>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:Yes, almost too easy! :-)
2015-04-19 22:14>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:ack07
2015-04-19 22:14>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:ack07
2015-04-19 22:14>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:Seems to be working great !
2015-04-19 22:14>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:Seems to be working great !
2015-04-19 22:14>	APP:CQ	0	FRM:KG6NUB	MSG::KK6MRI	:Using my Arrow here .

hi sawson!
hi sawson!
qso!qso!
my first through iss
Very cool, thanks for the contact
this is my ee123 python appthis is my ee123 python app
It is. csn we reschedule for tomorrow 2:40pm?csn we reschedule for tomorrow 2:40pm?
?
Using a measure tape antennaUsing a measure tape antenna
Using a measure tape antenna

MSG:

Your Callsign:

KK6MRI

Digi Path:

ARISS

Dest:

APDSP

To Callsign:

KG6NUB

USB In:

AirPlay

Built-in Microph

Built-in Output

C-Media USB Headphone Set

Soundflower (2ch)

Soundflower (16ch)

ProcasterAudioredirector

USB Out:

AirPlay

Built-in Microph

Built-in Output

C-Media USB Headphone Set

Soundflower (2ch)

Soundflower (16ch)

ProcasterAudioredirector

Speaker:

AirPlay

Built-in Microph

Built-in Output

C-Media USB Headphone Set

Soundflower (2ch)

Soundflower (16ch)

ProcasterAudioredirector

PTT Serial Port:

/dev/tty.SLAB_USBtoU

☐ Beacon

Lat/Lon

3752.50N

12215.43W

Symb/Comnt

K

EE123 Rocks!

Quit

00:00:05:15 : KG6NUB]CQ,RS0ISS*,qAS,KG6HSQ-2::KK6MRI :Wow, impressive!
00:00:05:48 : KK6MRI]APDSP,RS0ISS*,qAS,KG6HSQ-2::KG6NUB :Using a measure tape antenna{10
00:00:06:03 : KK6MRI]APDSP,RS0ISS*,qAS,KG6HSQ-2::KG6NUB :csn we reschedule for tomorrow 2:40pm?{09
00:00:06:44 : KG6NUB]CQ,RS0ISS*,qAS,KG6HSQ-2::KK6MRI :Seems to be working great !
00:00:06:53 : KG6NUB]CQ,RS0ISS*,qAS,KG6HSQ-2::KK6MRI :ack07
00:00:06:55 : KK6MRI]APDSP,RS0ISS*,qAS,KG6HSQ-2::KG6NUB :this is my ee123 python app{07
00:00:07:23 : KG6NUB]CQ,RS0ISS*,qAR,N6VUD-2::KK6MRI :Yes, almost too easy! :-)
00:00:07:36 : KG6NUB]CQ,RS0ISS*,qAR,N6VUD-2::KK6MRI :ack05
00:00:08:10 : RS0ISS]CQ,qAR,N6VUD-2:]ARISS - International Space Station
00:00:08:37 : KG6NUB]CQ,RS0ISS*,qAR,N6VUD-2::KK6MRI :Thanks for QSO from CM87, 73!
00:00:08:43 : KK6MRI]APDSP,RS0ISS*,qAR,KJ6VCP-2::KG6NUB :qso!{03
00:00:08:52 : KG6NUB]CQ,RS0ISS*,qAR,N6VUD-2::KK6MRI :ack02
00:00:08:55 : KK6MRI]APDSP,RS0ISS*,qAR,N6VUD-2::KG6NUB :hi sawson!
00:00:08:59 : KK6MRI]APDSP,RS0ISS*,qAR,N6VUD-2:=3752.50N/12215.43WKEE123 Rocks!
00:00:09:10 : KG6NUB]CQ,RS0ISS*,qAR,N6VUD-2::KK6MRI :Hello from CM87, qsl?
00:00:10:10 : RS0ISS]CQ,qAR,N6VUD-2:]ARISS - International Space Station

Demo

Tips for Debugging

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