Dire Wolf Software TNC

John Langner, WB2OSZ

ATGP, December 14, 2021

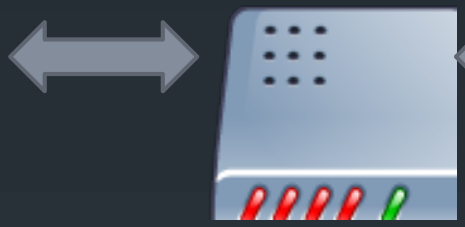
Topics

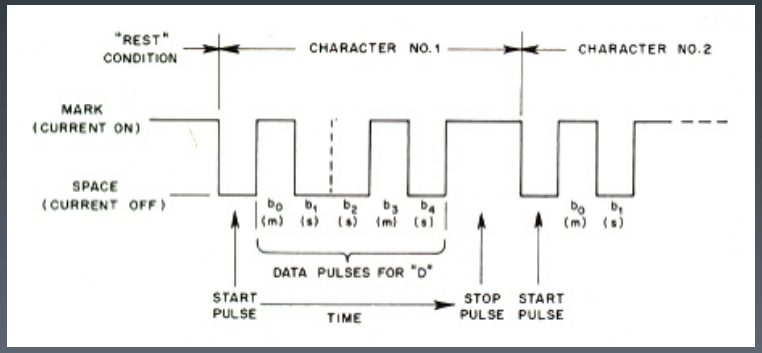
- History: Packet Radio. What is a TNC?
- Main Theme: Replace old hardware TNC with only software.
- Building a better demodulator.

Radio + Teletype = RTTY

Simple Modem

Audio & PTT





Modem was called a “terminal unit”.

170 Hz AFSK

AFSK → SSB → RF FSK

Packet Radio - 1978

- Radical new concept.

- Montreal Amateur Radio Club.
- Vancouver Area Digital Communications Group.

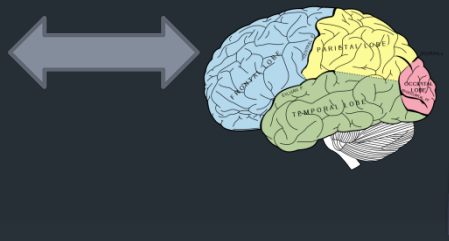
- Each transmission was a short burst (“packet” or “frame”) containing:

Flag	Address	Control	Info	FCS
01111110	112/224 Bits	8/16 Bits	N*8 Bits	16 Bit

Packet Radio

Modem &
packet protocol

RS-232



Audio &
PTT

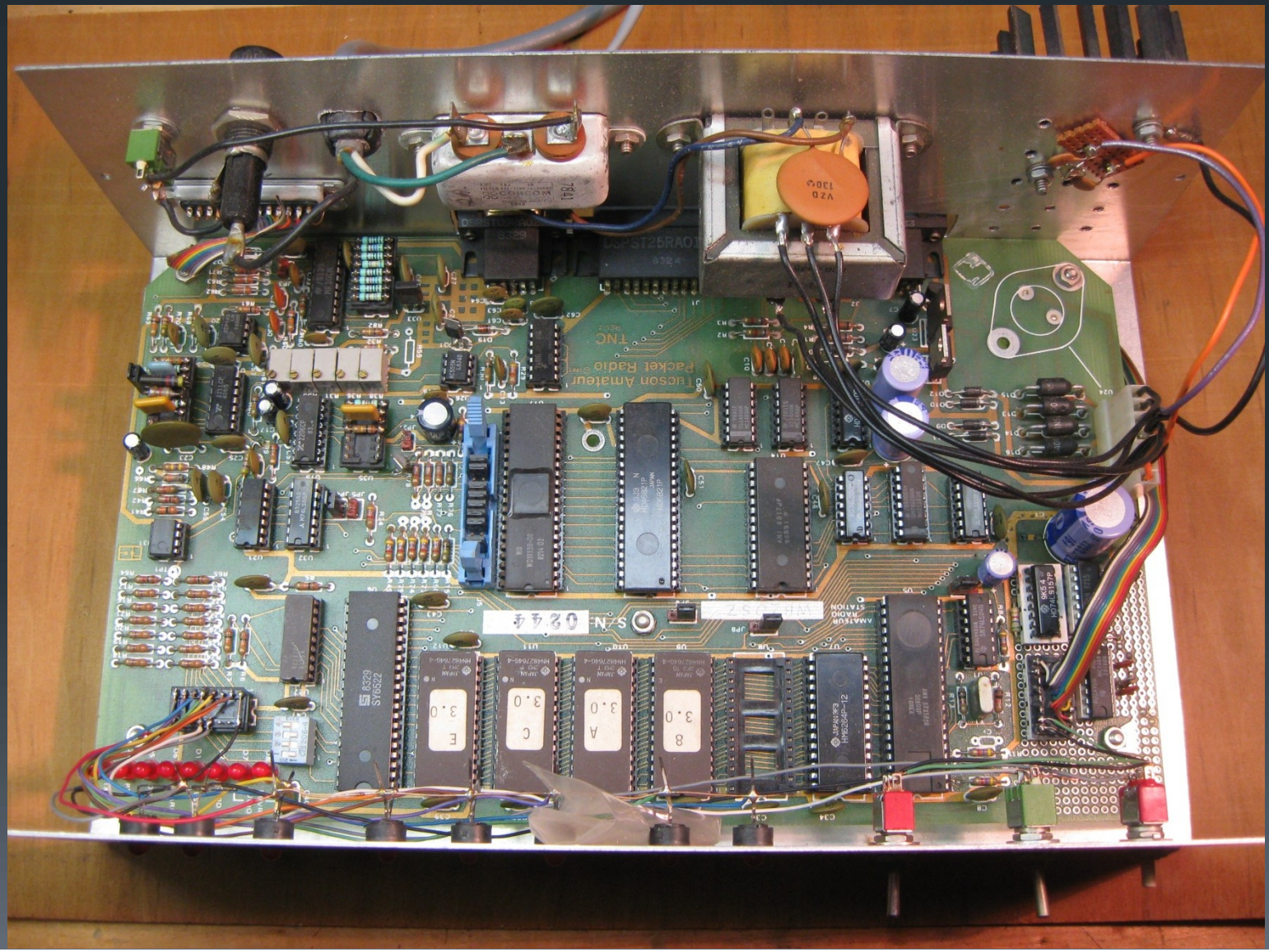
Terminal Node Controller (TNC).

Modem + brains.

Advantages of Packet Radio

- Short bursts.
- Addresses.
- Shared channel.
- Error detection.
- ACK & retry – for “connected” mode.
- Repeaters.
- “Transparent” for “binary” data.

TAPR TNC-1 kit - 1983



Dumb Terminal to Human Interface

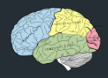
```
K1OJH>ALL,W0RLI*:NEPRA meeting tonight at 7:00

cmd> c k7ve
*** CONNECTED to K7VE
I will bring the cable that you need tonight.
Great!  See you there.
(ctrl-C)
cmd> d
*** DISCONNECTED from K7VE
```

Not good for computer control.

K.I.S.S. Protocol - 1986

RS-232

Very simple
(KISS) TNC



Address	Control	
112/224 Bits	8/16 Bits	N*

Flag	Address	Control	Info	FCS
01111110	112/224 Bits	8/16 Bits	N*8 Bits	16 Bit

Smaller brain needed for TNC.

- Transmit: TNC adds CRC and HDLC flags.
- Receive: TNC checks for correct CRC and removes it.

APRS – Data Types

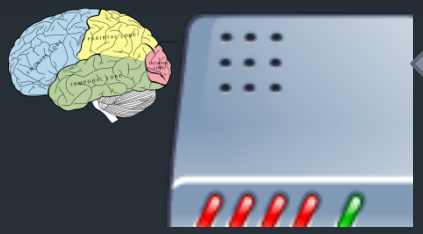
"APRS is not a vehicle tracking system. …"

- Positions (usually transmitting station.)
- Objects (usually on behalf of other entity.)
- Weather Reports.
- Telemetry.
- "Messages" to an individual or bulletins to groups.
- Queries and Responses.
- APRS of Things. (like Internet of Things)

Packet / APRS – late 20th Century

Hardware TNC
from 1980's

RS-232



TNC replaced by software

Audio &
PTT

Cheaper.

Better Results.

More Flexibility

APRSDroid,
APRSISCE,
YAAC,
Xastir, UISS,
APRS-TW,
WinLink
Express,
Outpost PM,
etc.

APRS-IS

Raspberry Pi
TNC software.

What is Dire Wolf ?

Free Open source software replacement for the traditional TNC.

- Windows, 32 or 64 bit.
- Linux - x86, x86_64 PC, ARM, Raspberry Pi.
- Mac OSX, BSD.

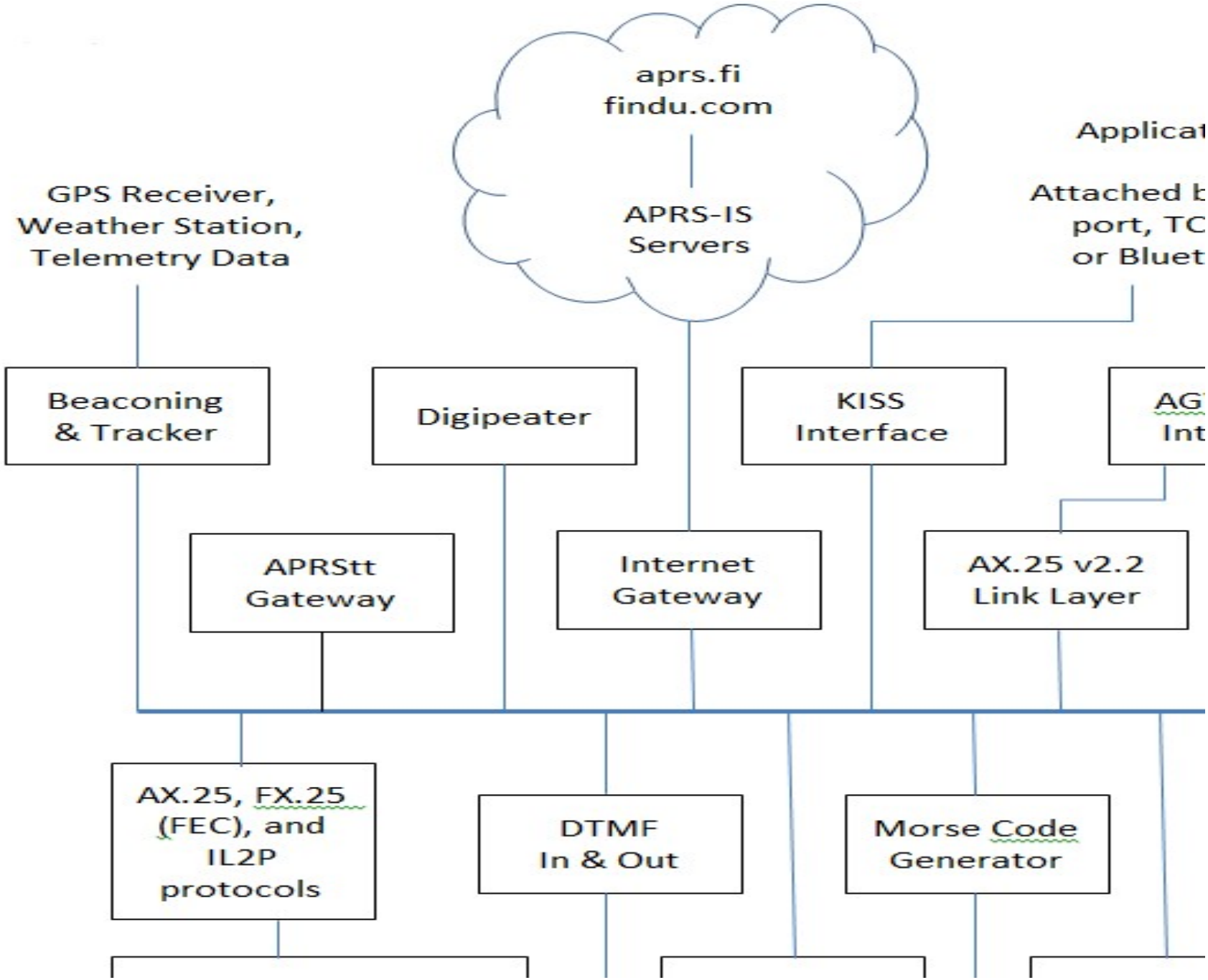
- GPS Tracker.
- Digipeater.
- Internet Gateway (IGate).
- APRStt gateway.

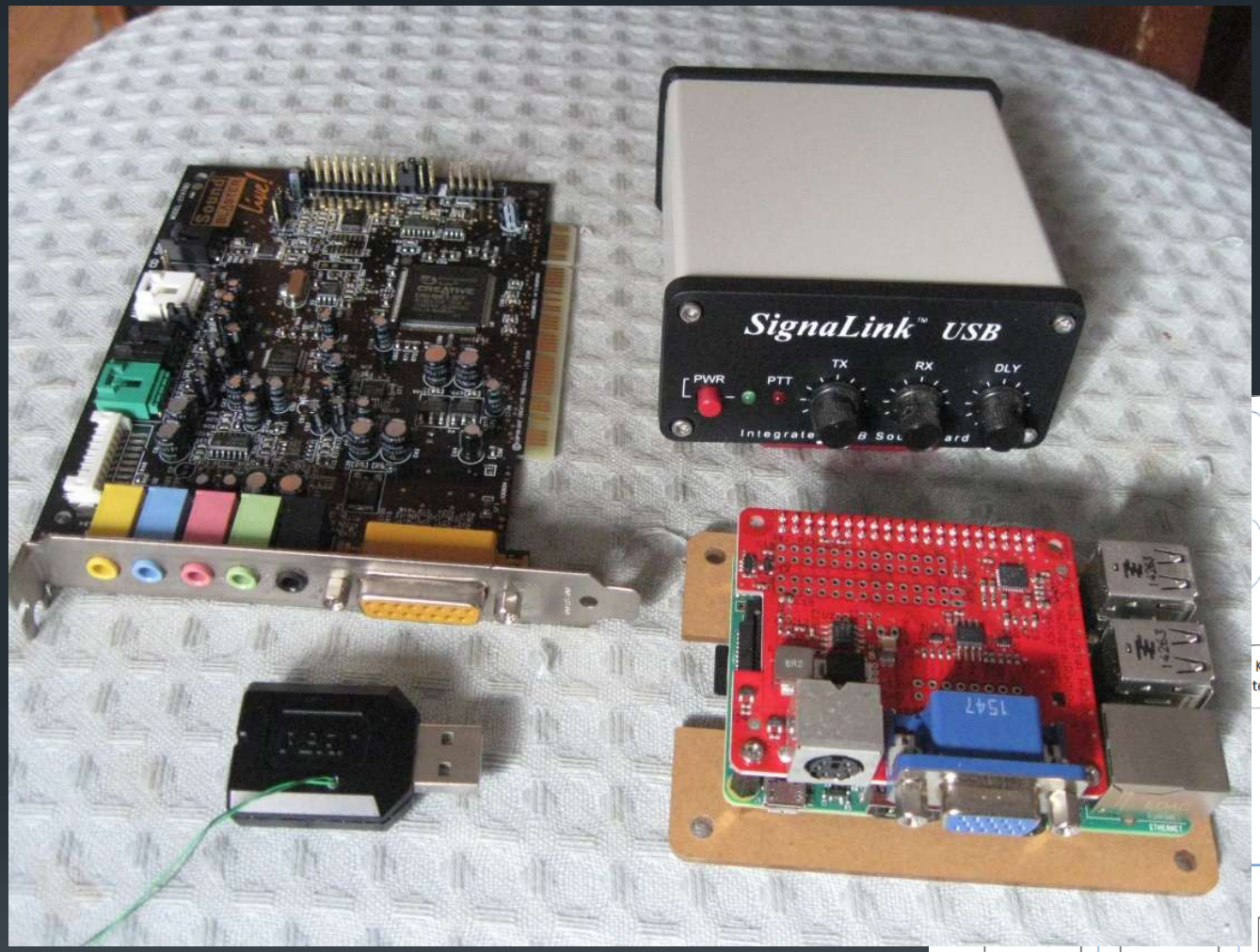
- Virtual TNC for applications such as APRSIS32, YAAC, Xastir, SARTrack, PinPoint, APRS, APRS-TW, UISS, Linux AX25, WinLink Express (RMS Express), Outpost PM, Linpac, and many others.

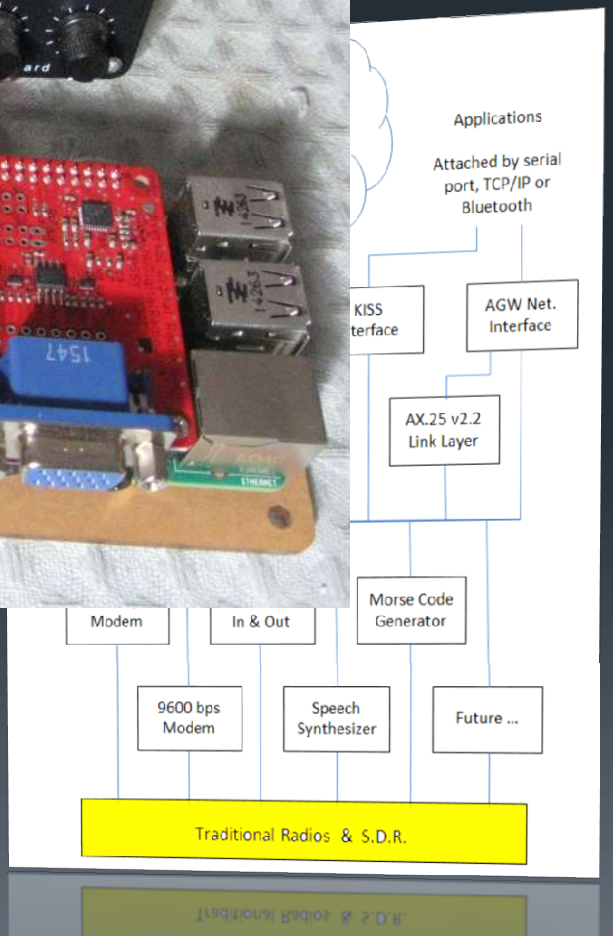
Where did the name come from?

Decoded
Information from
Radio
Emissions for

Windows
Or
Linux
Fans


aprs.fi
findu.com
APRS-IS
Servers
GPS Receiver,
Weather Station,
Telemetry Data
Beaconing
& Tracker
Digipeater
KISS
Interface
APRStt
Gateway
Internet
Gateway
AX.25 v2.2
Link Layer
AX.25, FX.25
(FEC), and
IL2P
protocols
DTMF
In & Out
Morse Code
Generator





Receiver audio → computer.

Computer audio → transmitter.

Software Defined Radio (SDR) Interface

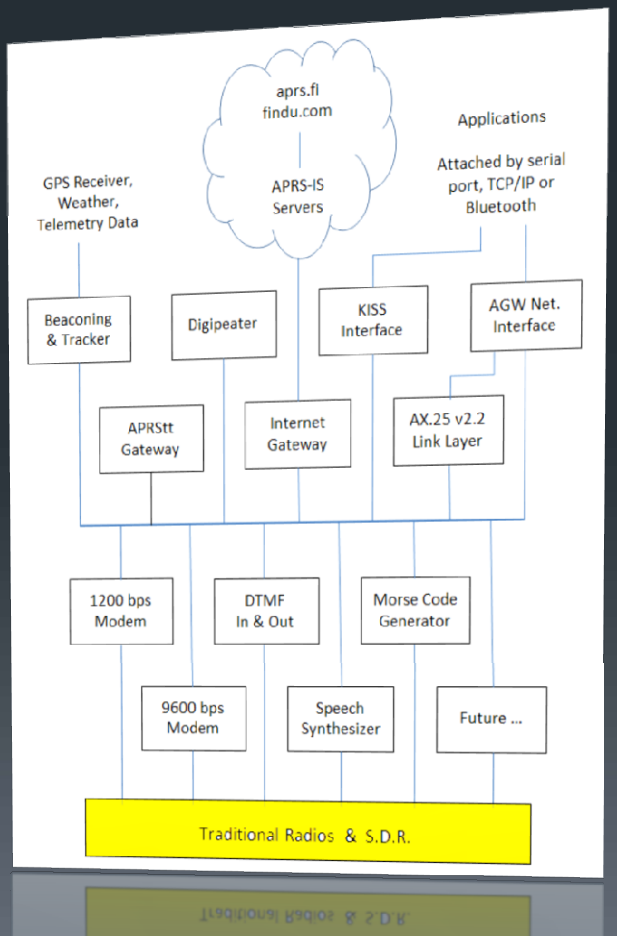
- Pipe into stdin

```
rtl_fm -f 144.39M | direwolf  -
```

- Listen for audio on a UDP port.

  (e.g. gqrx v2.3 and later)

- Virtual audio cable. SDR#.



Modems

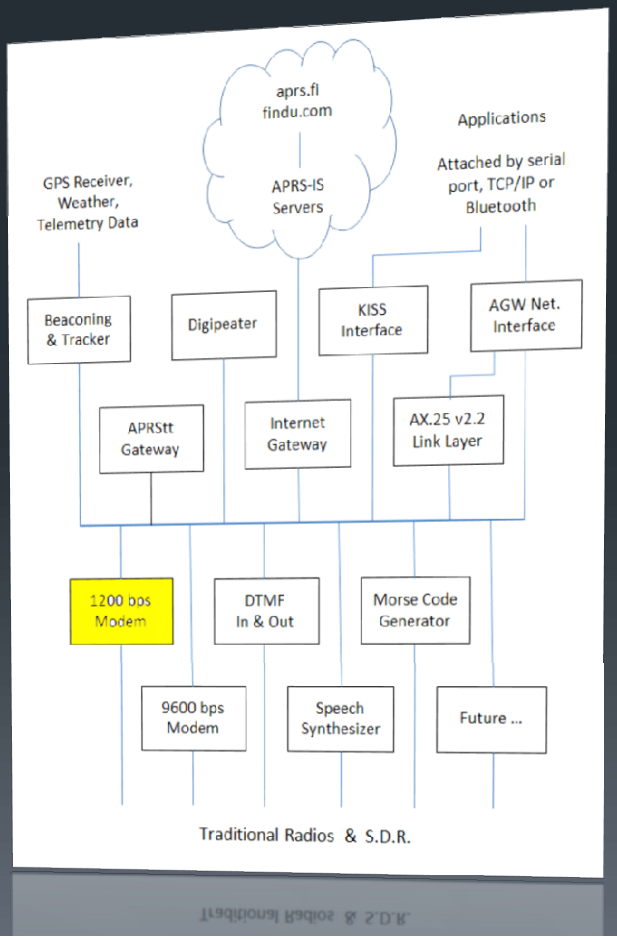
- 300 bps AFSK for HF SSB

- **1200 bps Bell 202 AFSK VHF**
- 2400 bps QPSK (MFJ-2400, etc.)

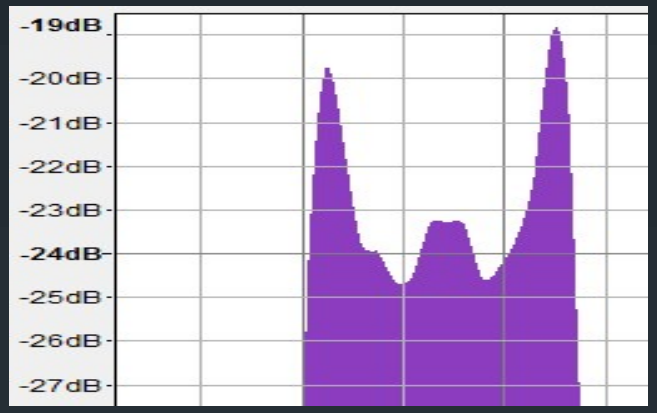
- 4800 bps 8PSK
- **9600 bps G3RUH**

Receive only:

- AIS – for tracking ships
- Emergency Alert System (EAS) Specific Area Message Encoding (SAME)

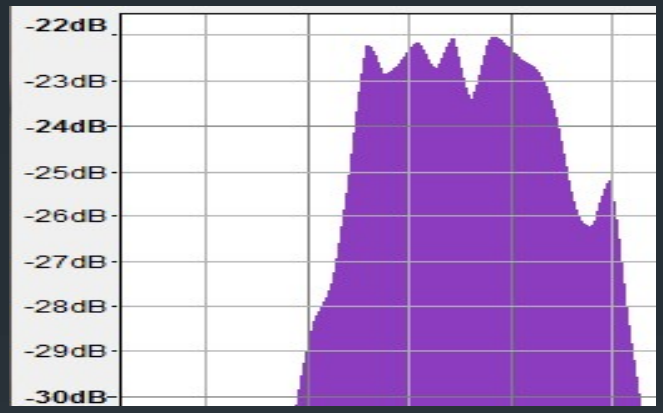


| ← Voice → |



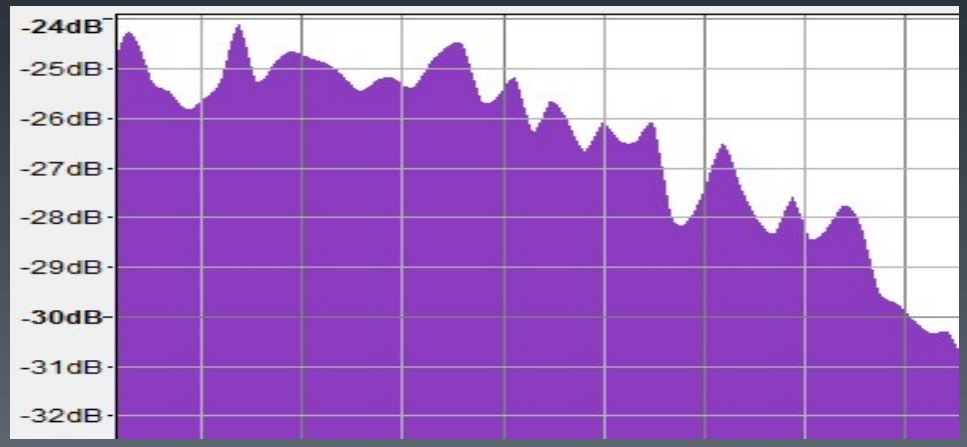
Modem Audio Spectrum

1200 bps AFSK (Bell 202)



2400 bps PSK (V.26 / Bell 201)

MFJ-2400, AEA PK232-2400,
Kantronics KPC-2400



9600 bps (“G3RUH”)
Very low out to about 5 kHz.

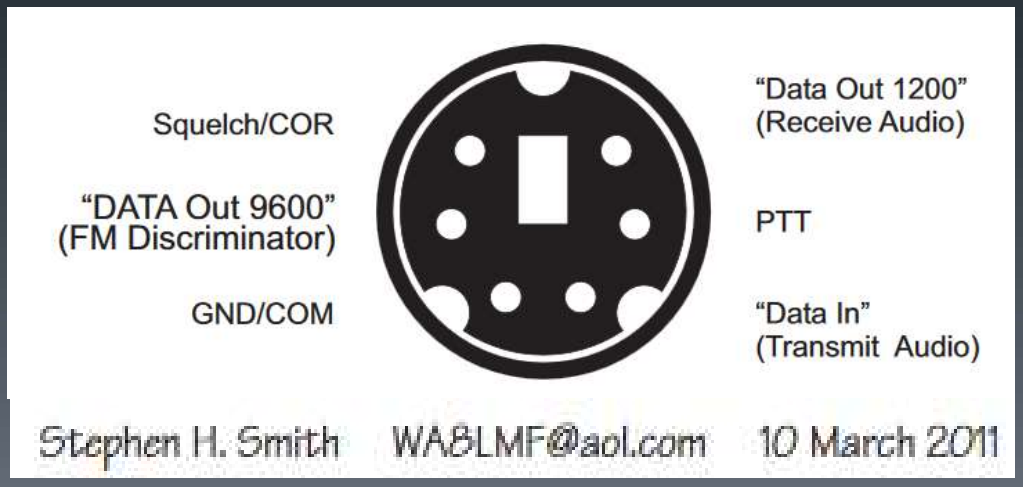
Speaker cuts off below about 300 Hz to eliminate CTCSS.

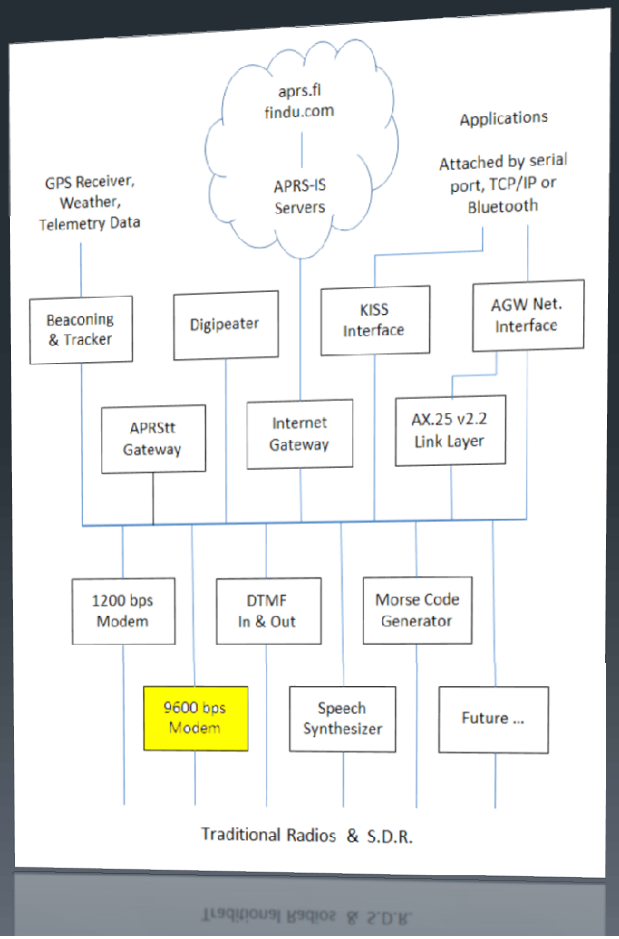
9600 bps

K9NG G3RUH et al – around 1988

About 5 kHz of audio bandwidth.

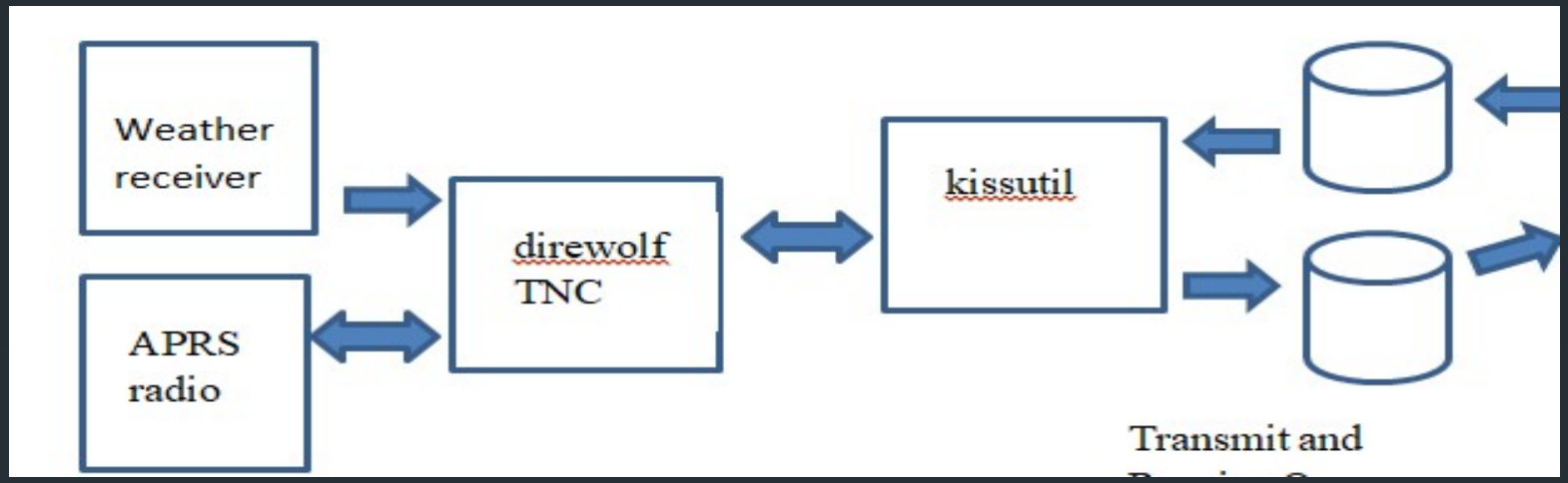
Will not work with microphone and speaker connections.





Emergency Alert System

National Weather Service - more than 1000 stations - around 162 MHz.



Encoded:

ZCZC-WXR-RWT-020103-020209-020091-020121-029047-029165-029095-029037+0030-1051700-KEAX/NWS

Translated:

The National Weather Service in Kansas City/Pleasant Hill, MO has issued a Required Weekly Test valid until 01:30 PM for the following counties in Kansas: Johnson, Leavenworth, Miami, Wyandotte, and for the following counties in Missouri: Cass, Clay, Jackson, Platte. (KEAX/NWS)

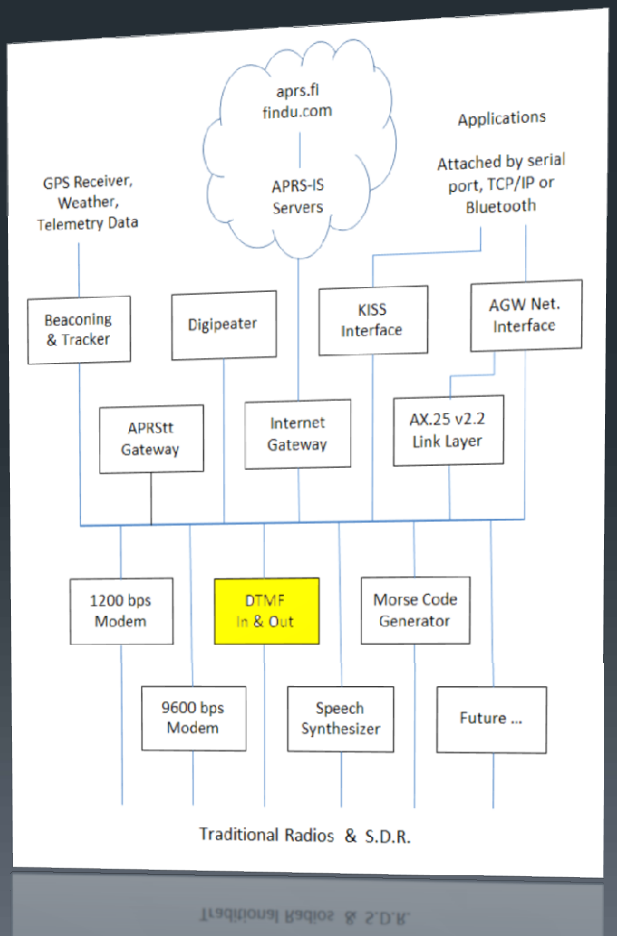
DTMF decode / encode

Received tone sequences are converted to packet like:

```
DTMF>APDW15:t12345#
```

Transmit tones by putting DTMF in the destination address.

```
WB2OSZ>DTMF:123 456
```



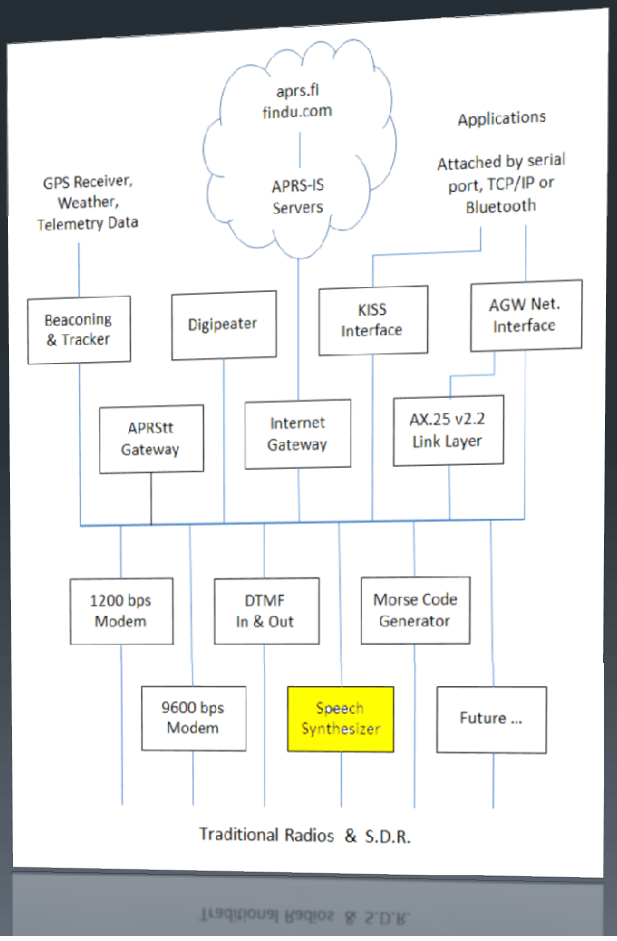
Speech Synthesizer

Any packet with SPEECH is sent to a user-supplied script which can invoke a text-to-speech synthesizer.

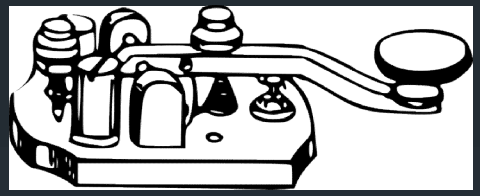
```
WB2OSZ>SPEECH:Hello, World!
```

Configuration file example:

```
CBEACON dest=SPEECH
info="Club meeting tonight
at 7 pm."
```

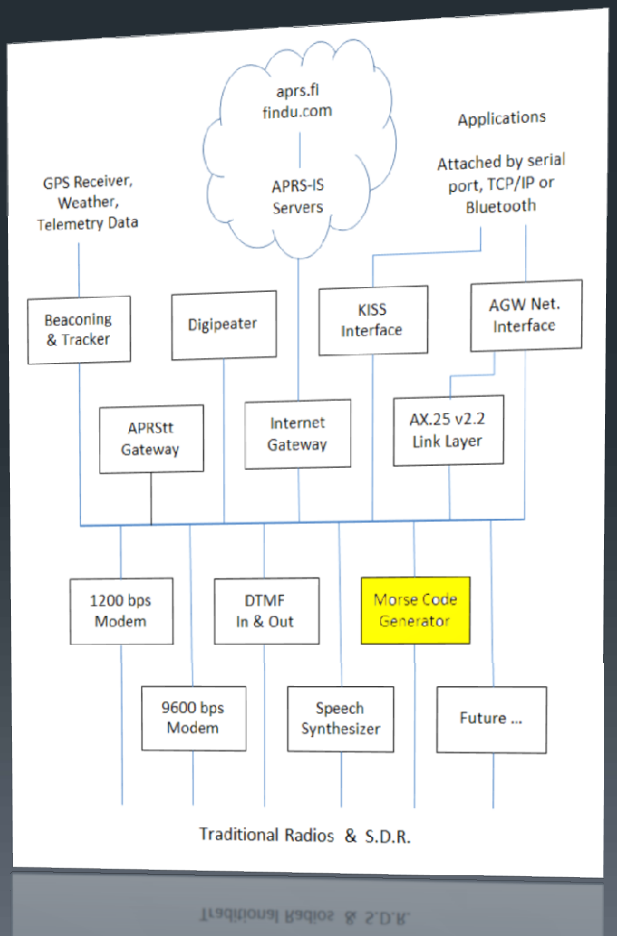


Send Morse Code



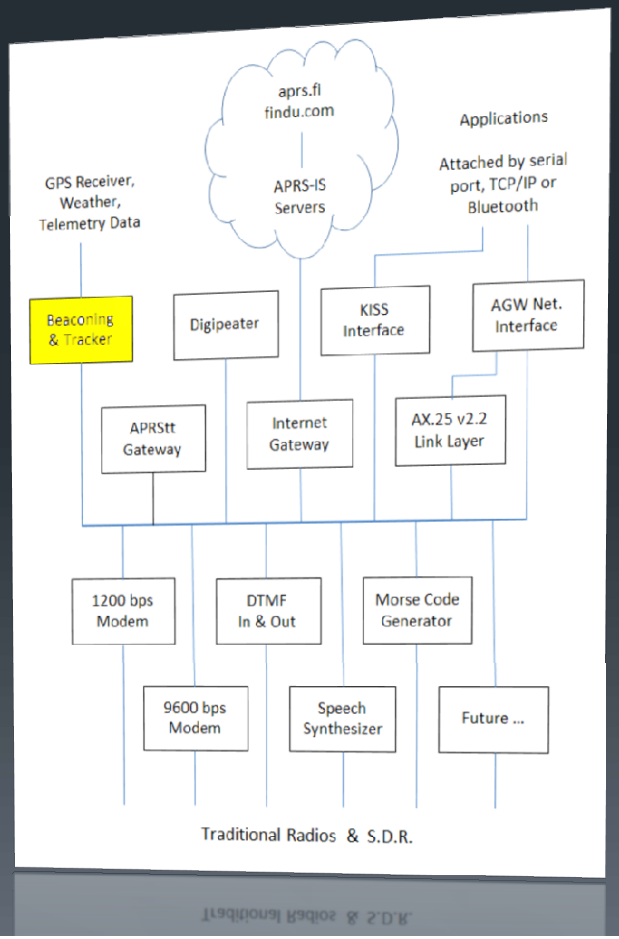
Any packet with MORSE as the destination is sent as Morse Code.

```
WB2OSZ>MORSE:CQ CQ
```



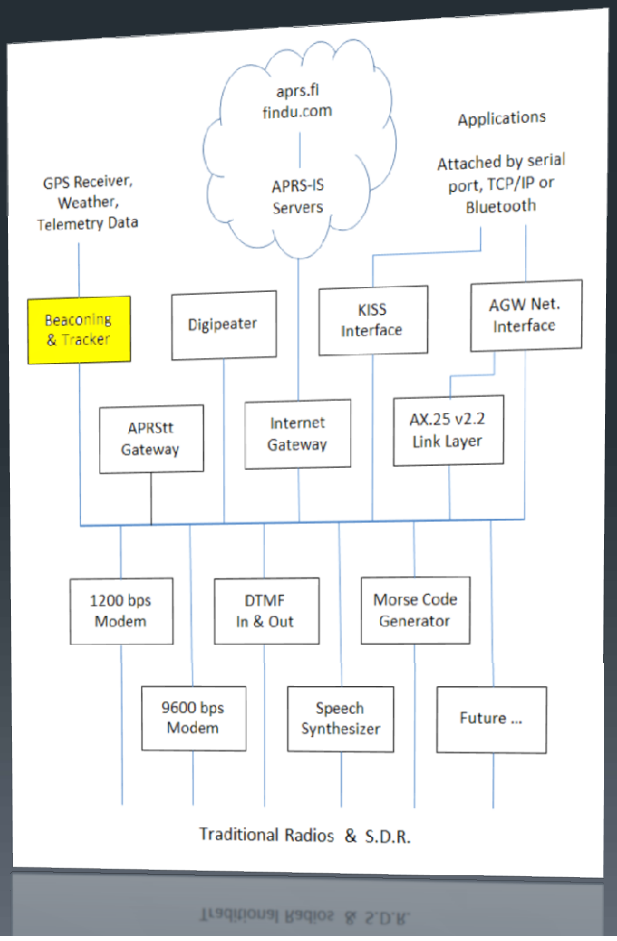
Beacons

- Periodic position or object packets.
- GPS location - tracker.
- “Custom” - invoke user script.
- Weather. wxnow.txt



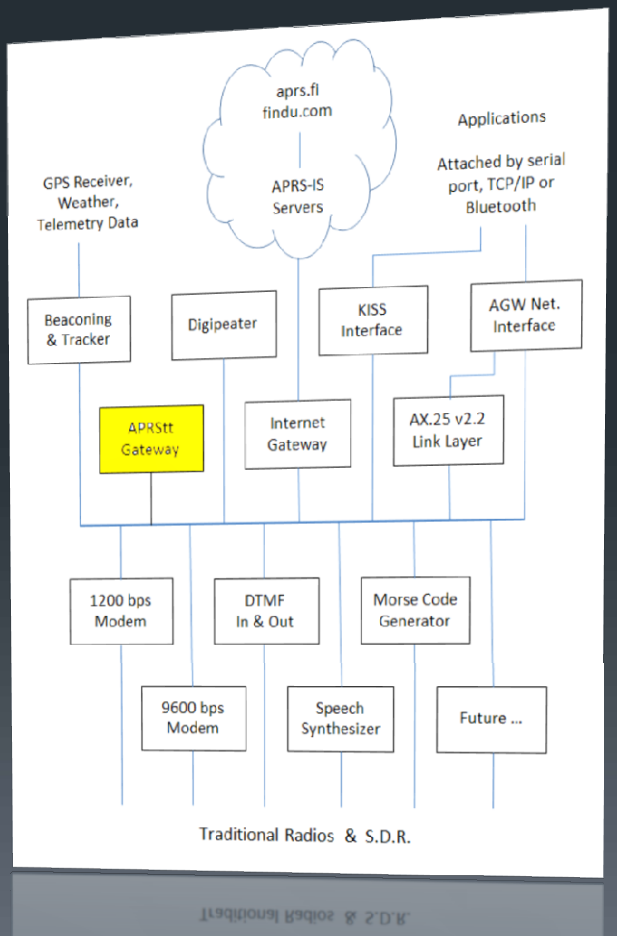
Telemetry Tool Kit

- Building blocks for your own customized solutions.
- User-defined script to generate content.
- Raspberry Pi A/D converter example.

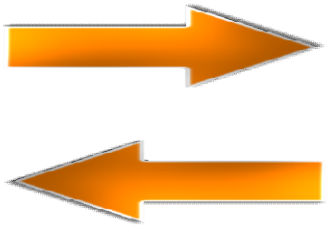


APRStt Gateway

Converts Touch Tone sequences into APRS objects.



Tones 3 1 2 #



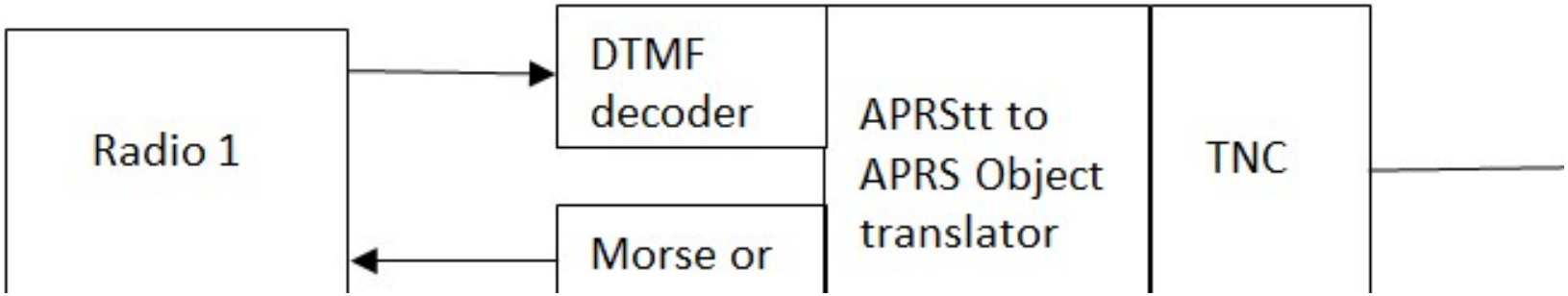
APRS

Object Report

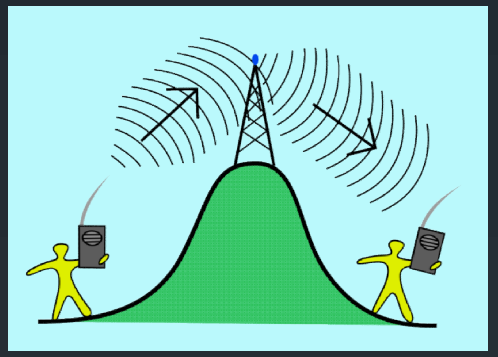
Synthesized Speech

“Canoe 12 is at checkpoint 3.”

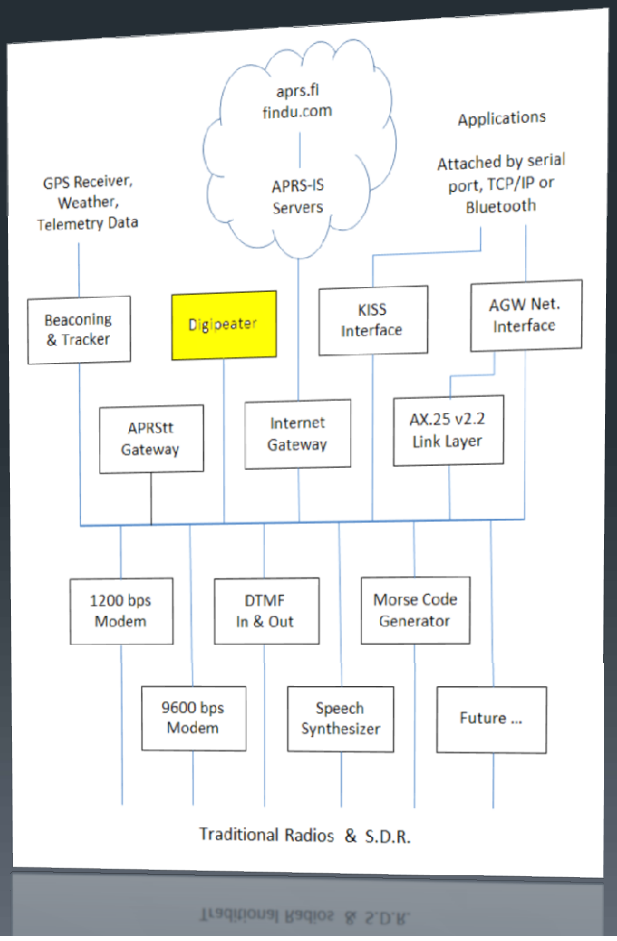
APRStt Gateway



Digital Repeater "digipeater"



- Extends range.
- Usually single frequency.
- Store and Forward.
- Dire Wolf: Multiple radios & routing between radio channels with filtering.



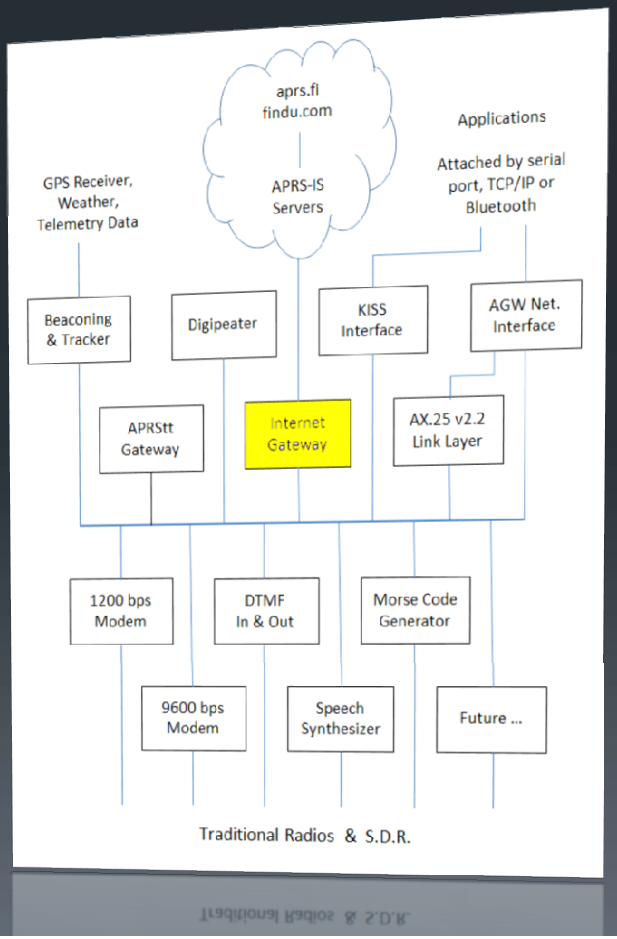
Internet Gateway "IGate"

Connect disjoint radio networks.

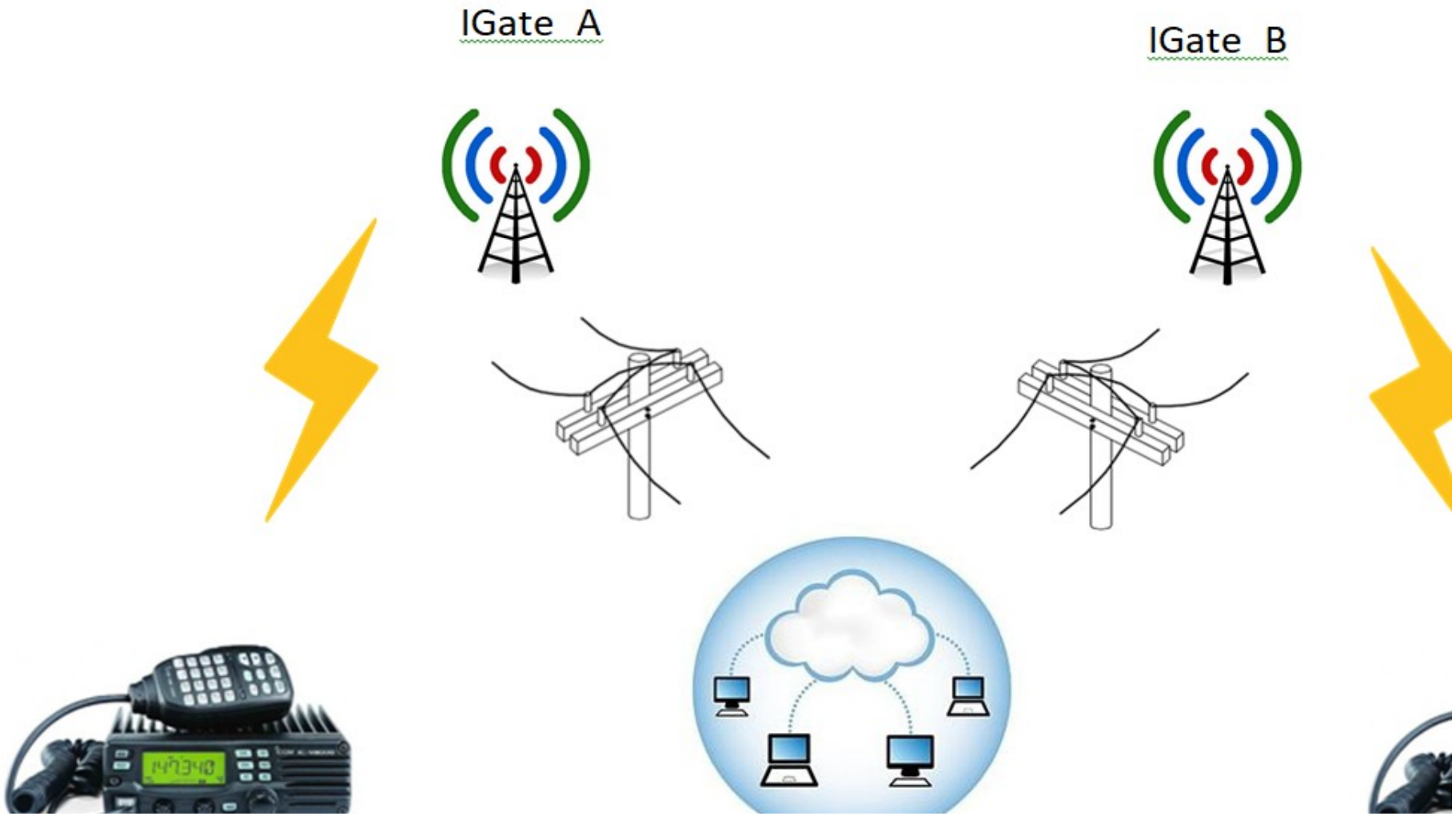
Should be two way.

View APRS activity with web browser at

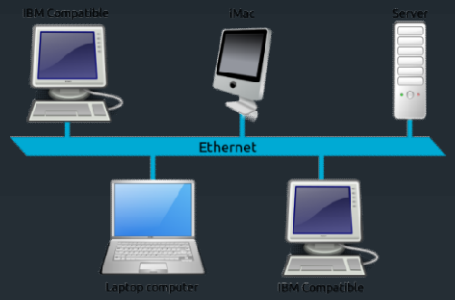
- aprs.fi
- findu.com
- aprsdirect.com



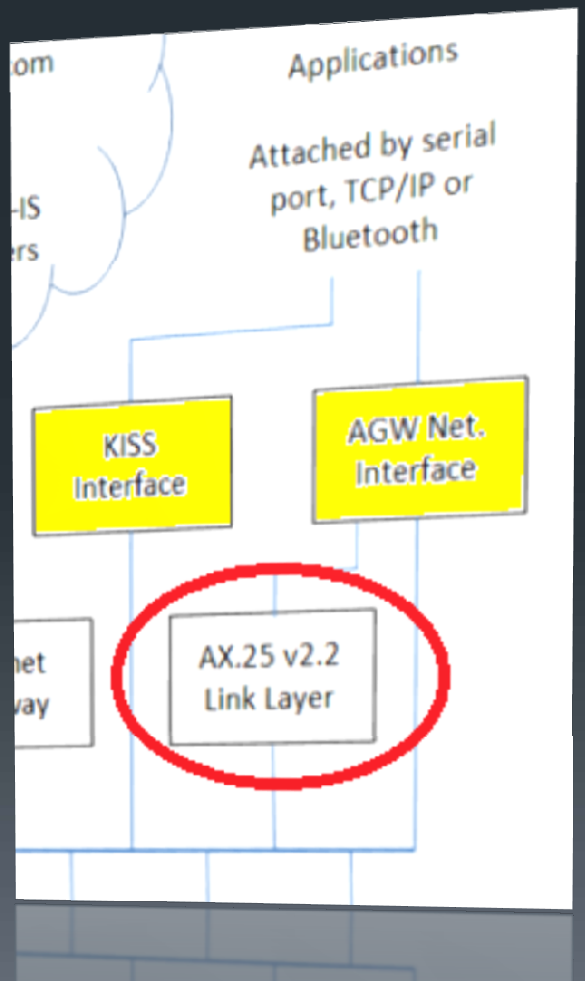
APRS “Messages”
Two way IGate stations required.



Application Interfaces



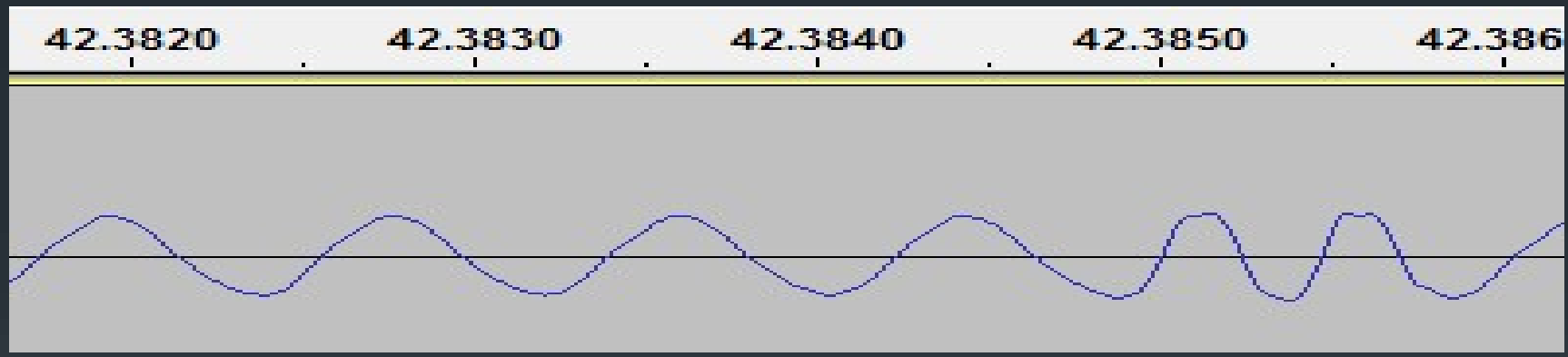
- KISS and AGW network interfaces.
  - AGW interface allows access to more brains in the TNC such as connected mode.
- Applications attached by:
  - RS-232 Serial Port.
  - TCP/IP (Ethernet, WIFI)
  - Bluetooth.
- Many simultaneous applications.



Building a Better Demodulator

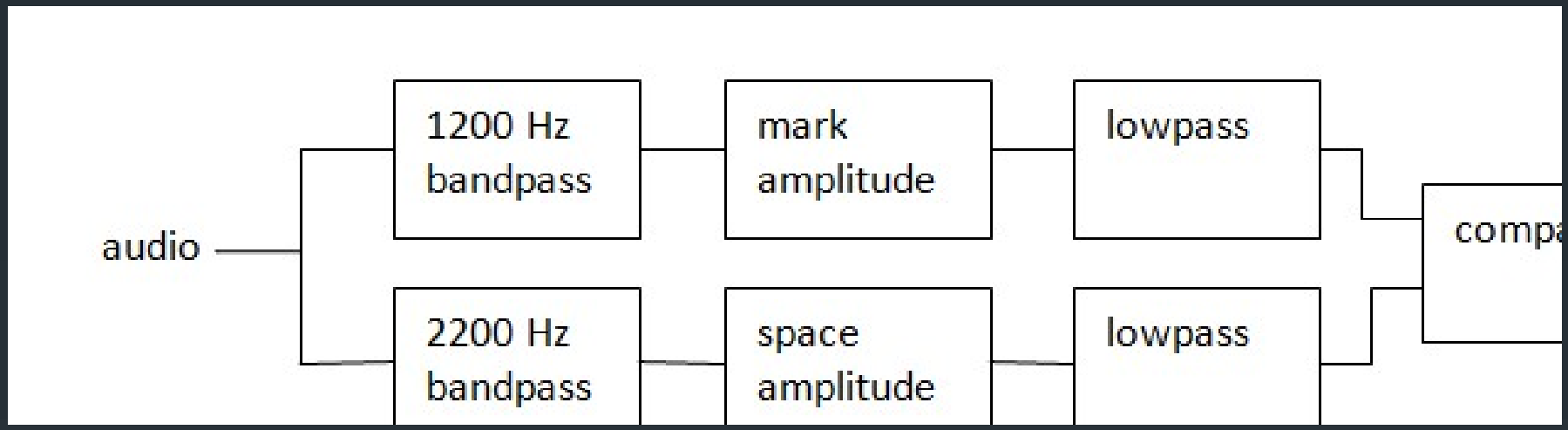
Audio Frequency Shift Keying

- 1200 bits per second, 1200 & 2200 Hz.



- Which of the two tones is present?

How to Demodulate AFSK



After much reading & experimenting

- OK with perfect signals.
- Not so good with real-world signals.
- Why?

WA8LMF TNC Test CD

- Los Angeles, afternoon rush hour, frequency completely saturated.
- Track 1: 25 minutes of flat audio from the discriminator.
- Track 2: De-emphasis to mimic typical receiver. (explained later)
- The de facto standard for measuring demodulator performance.

More details, see: A-Closer-Look-at-the-WA8LMF-TNC-Test-CD.pdf

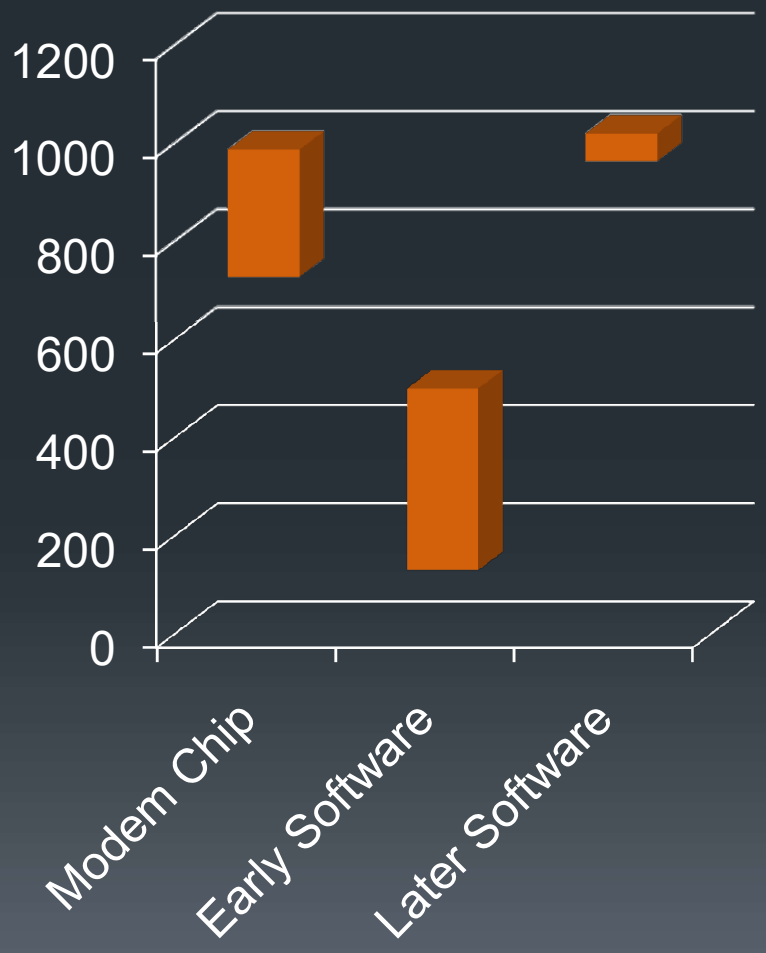
TNC Test CD Results

Do not take too seriously. Collected by different people, at different times, under different conditions. Most don't specify Track 1 / Track 2.

Linux PC multimon	*	130	
Linux PC soundmodem	*	412	
AGWPE	*	500	
AEA PK90		728	
TNC-X		818	
MFJ-1274		883	
AX25 Java Soundcard Modem	*	964	
KPC-3 (non-plus)		967, 986	
SCS Tracker DSP TNC 1.5s		988 / 943	(track 1/2)
Dire Wolf 1.7	*	1014 / 1000	(track 1/2)
UZ7HO Soundmodem 0.83b	*	1021	

* = software on PC

TNC Decoding Comparison

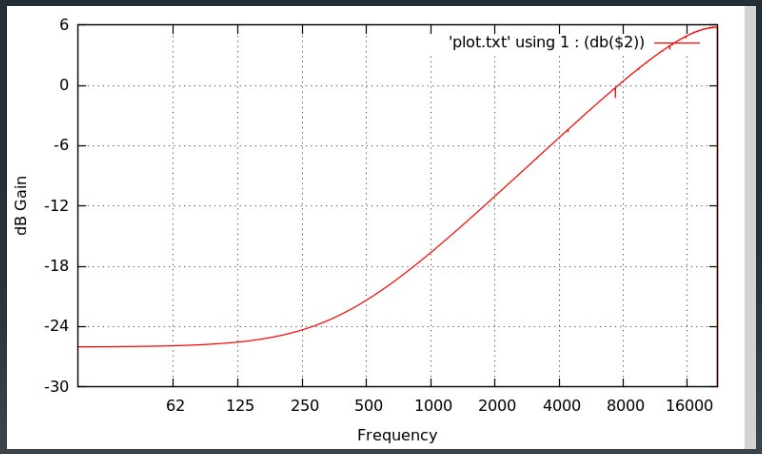


- Poor results from early software modems.
- Bad reputation.
- More recent software better than hardware modems.
- The tarnished reputation endures.

VHF FM voice transceivers.

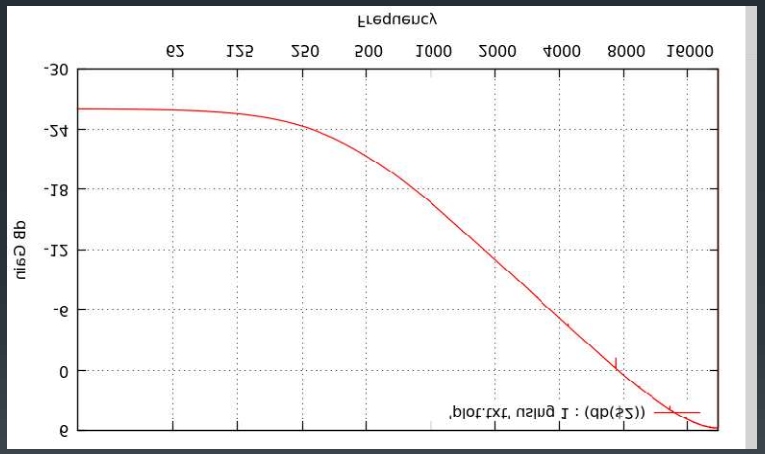
Transmitter pre-emphasis

+ 6 dB per octave.



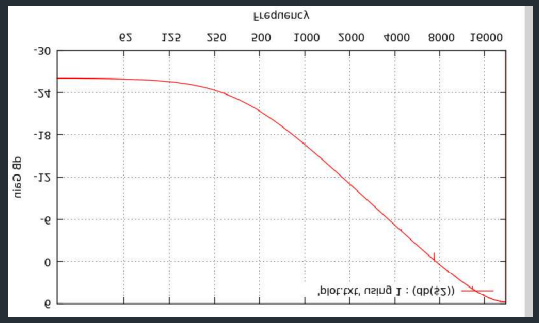
Receiver de-emphasis

- 6 dB per octave

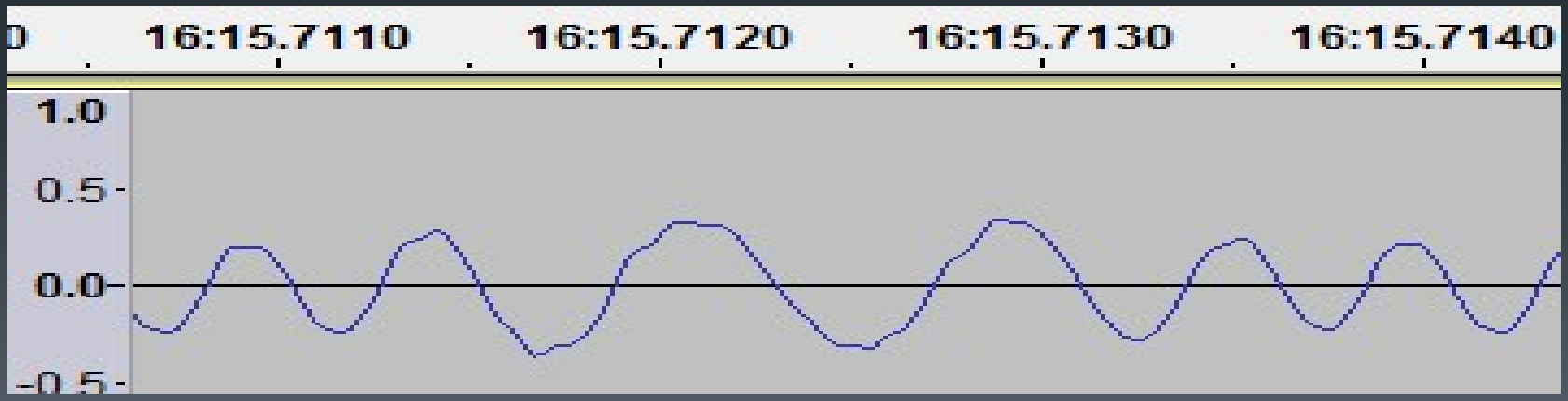


Transmit / Receive mismatch

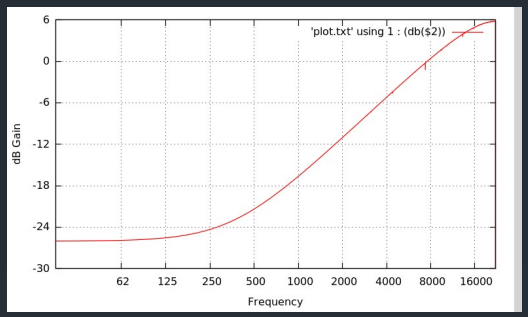
Flat on transmit.



Higher frequency weaker.



Transmit / Receive mismatch

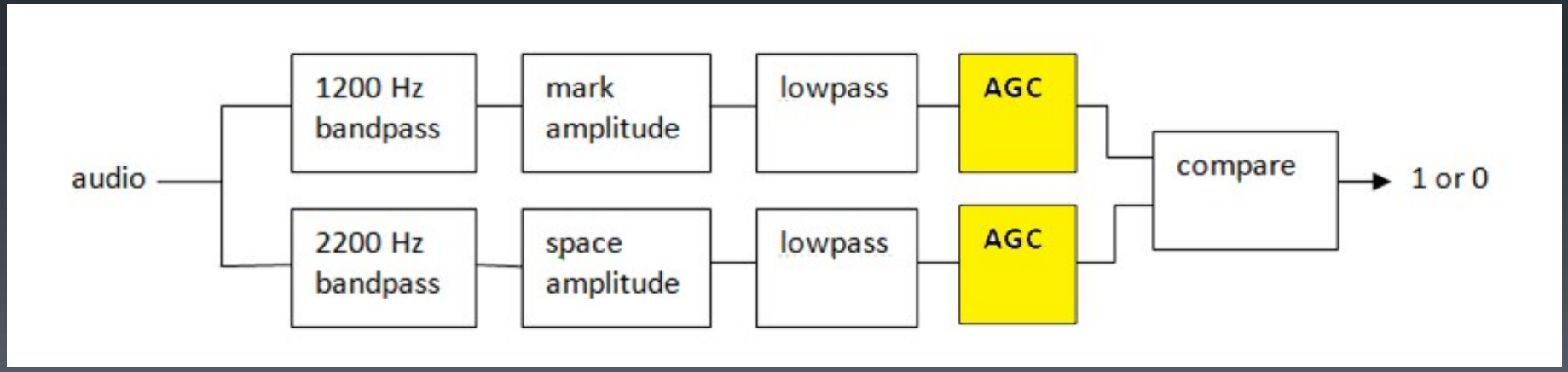


Flat on receive.

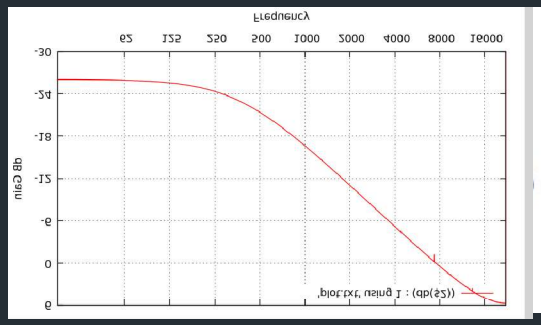
Higher frequency is stronger .

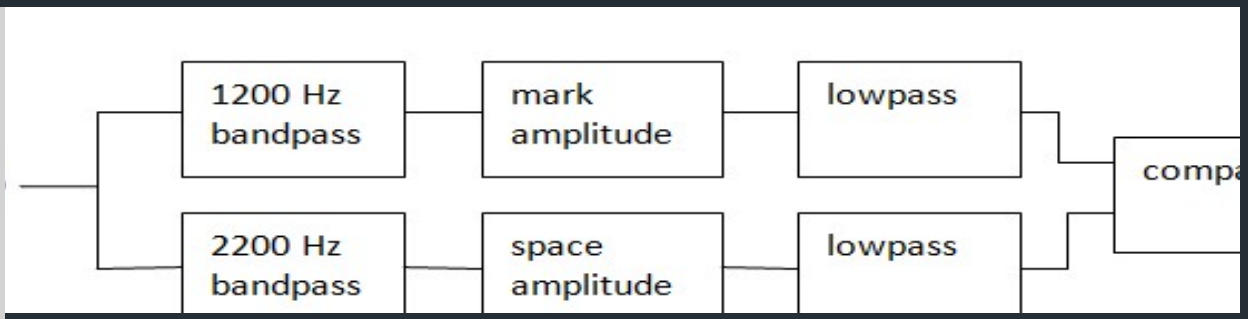
Transmit / Receive mismatch

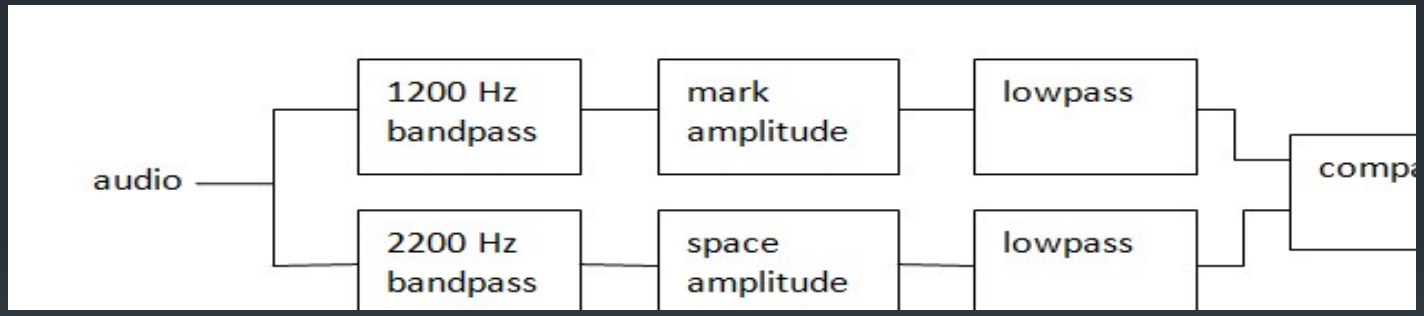
- Less reliable.
- Automatic gain control?
- Better but… AGC time … noise

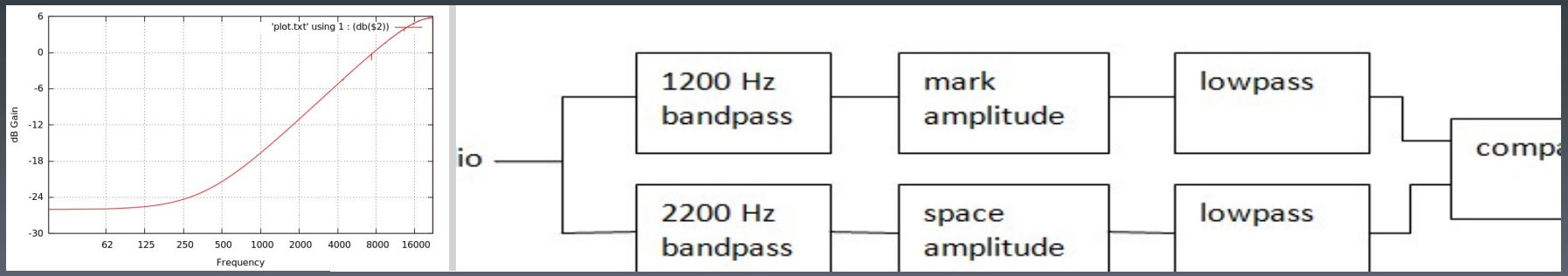


Multiple demodulators.



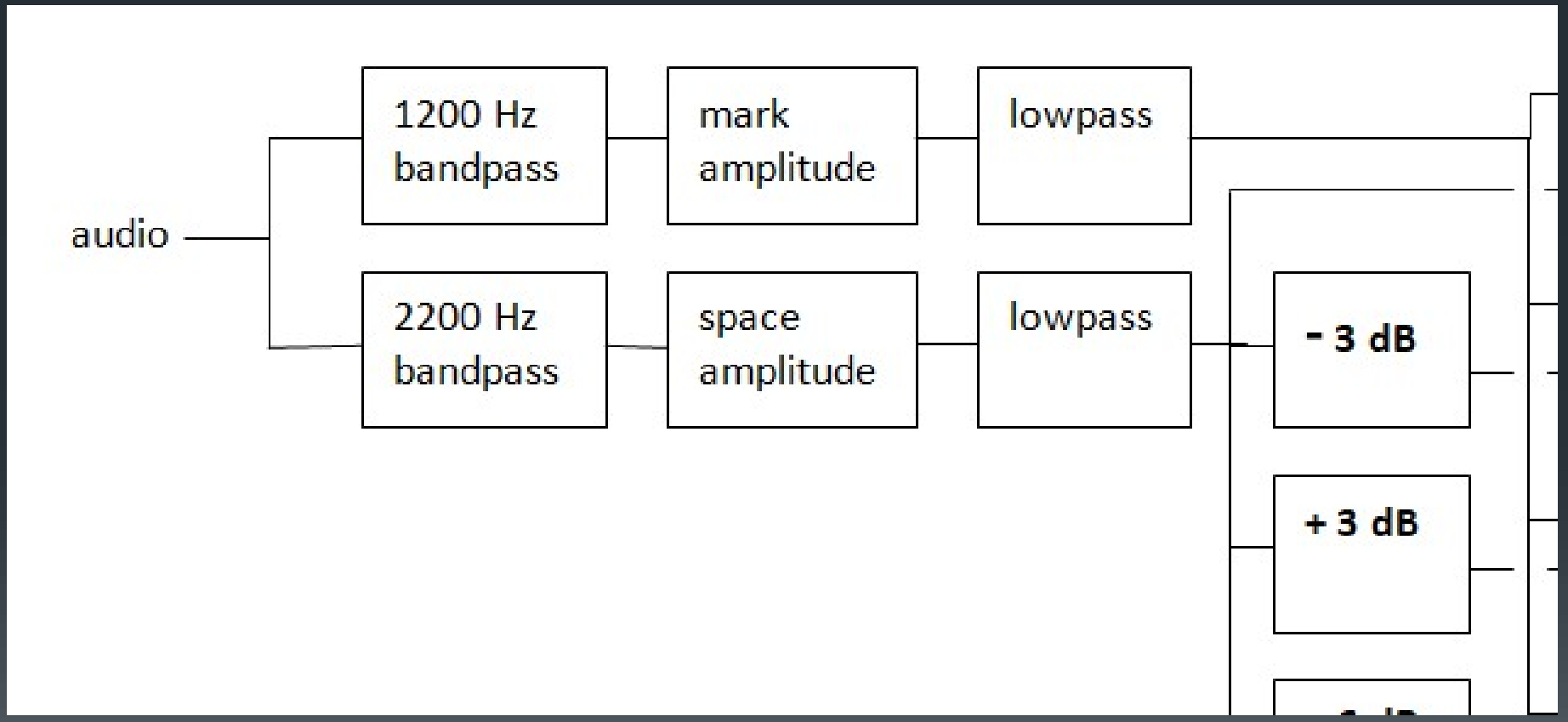






Multiple Gains for One Tone.

- Multiple fixed gains.



Less compute power needed.

AX.25 + FEC = FX.25

2006 – Stensat Group – Satellites

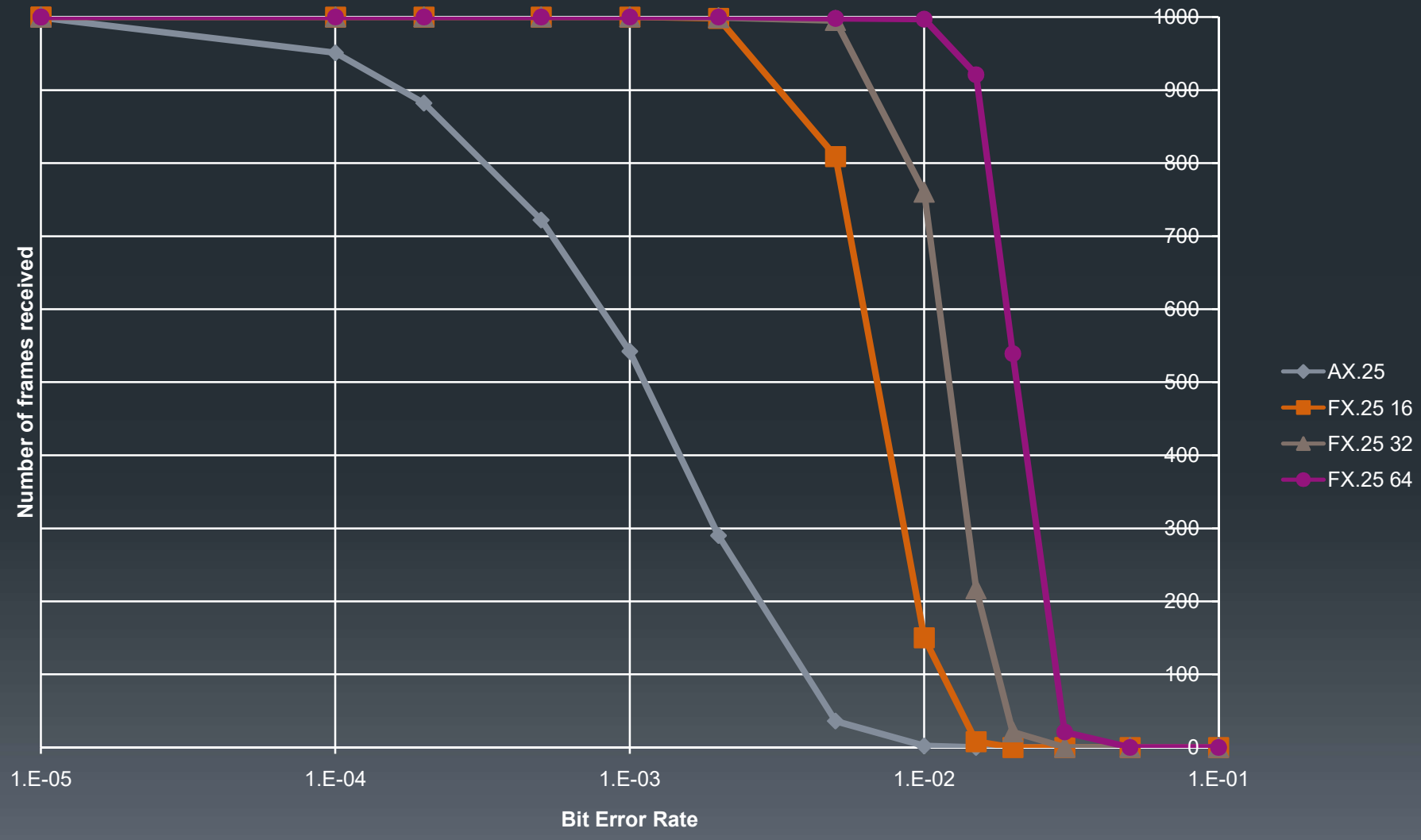
- 64 bit pattern to identify the format of the data to follow.
- The normal AX.25 frame, including the FCS, and surrounding "flag" patterns.
- Parity check bytes.

8 bytes	32 To 239 bytes	16, 32, or 64 bytes
Correlation Tag	**Data (Normal AX.25 Frame)**	**Parity Check**

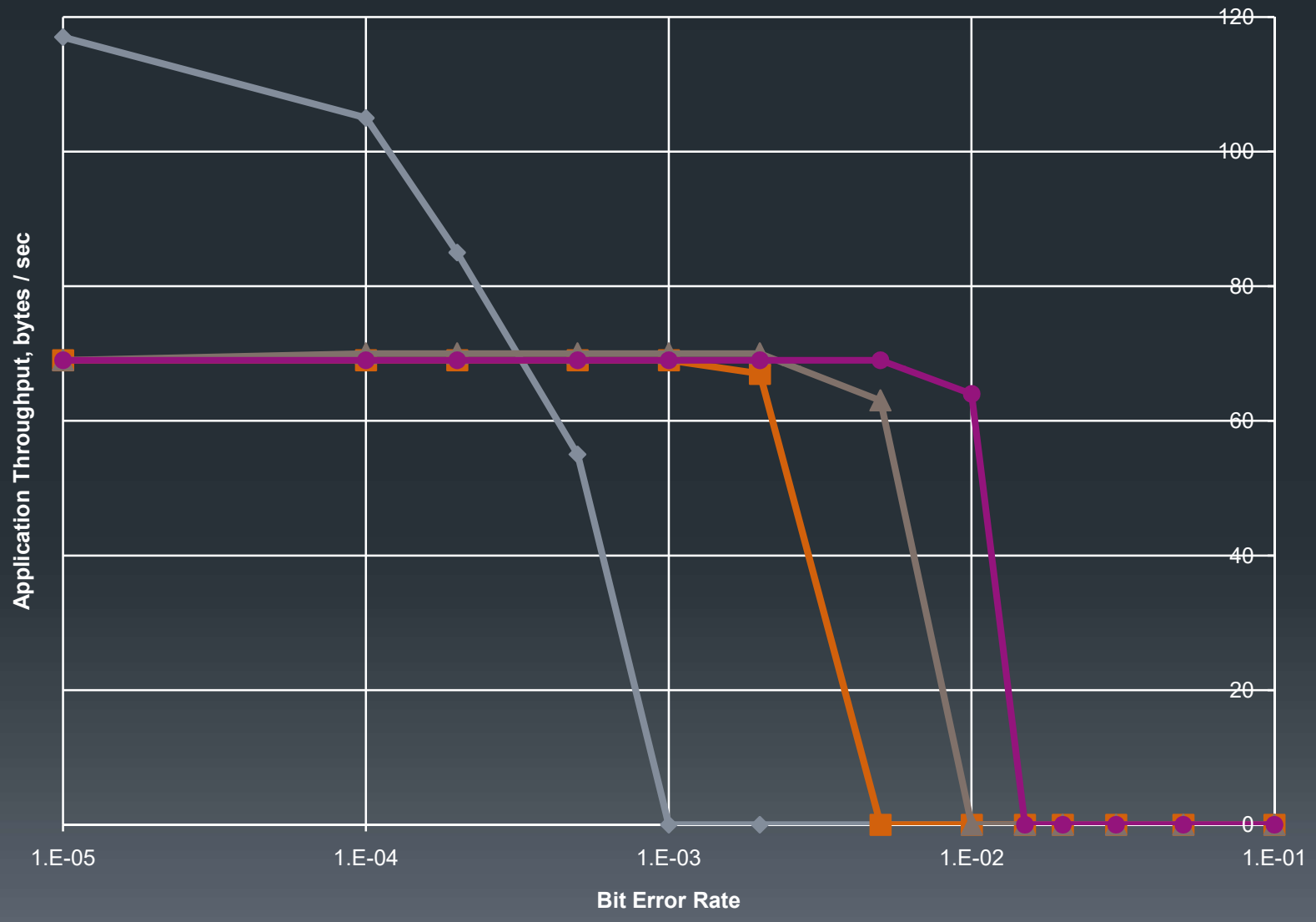
AX.25 + FEC = FX.25

Tag Number	Correlation Tag Value	Data Bytes	Check Bytes	Number of Defective Bytes that can be repaired.
0x01	0xB74DB7DF8A532F3E	239	16	8
0x02	0x26FF60A600CC8FDE	128	16	8
0x03	0xC7DC0508F3D9B09E	64	16	8
0x04	0x8F056EB4369660EE	32	16	8
0x05	0x6E260B1AC5835FAE	223	32	16
0x06	0xFF94DC634F1CFF4E	128	32	16
0x07	0x1EB7B9CDBC09C00E	64	32	16
0x08	0xDBF869BD2DBB1776	32	32	16
0x09	0x3ADB0C13DEAE2836	191	64	32
0x0A	0xAB69DB6A543188D6	128	64	32
0x0B	0x4A4ABEC4A724B796	64	64	32

FX.25 Improvement for APRS



FX.25 Improvement for traditional Packet Radio



Summary

- Ignore the advice from around the turn of the Century
- You don’t need to spend $200 on a box from the 1980’s to get started with APRS / Packet Radio.
- Free Open Source Software:
  - Better Performance
  - More Features
  - Lower Cost

Questions?

For more information:

https://github.com/wb2osz/direwolf

https://groups.io/g/direwolf

wb2osz @ arrl . net

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