

A Multimode Reflector for D-Star, DMR, P25, YSF, and NXDN

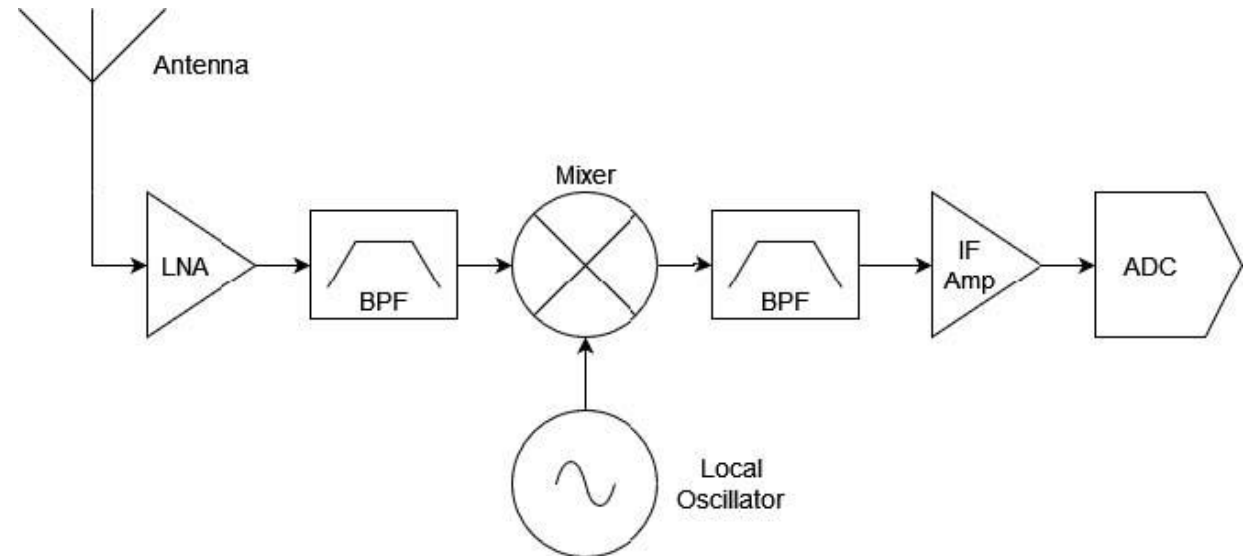
Spencer Ammermon, NG6K

Outline

- Digital communications basics
- Overview of digital voice modes found in amateur radio
- Digital-Utah multi-mode reflector architecture

Digital Data Over Analog RF

- All physical layer RF communications is analog
- Digital data is encoded in an analog waveform
- Amplitude, frequency, and phase modulation schemes are common
 - Modifications can be made for constant envelope, to reduce occupied bandwidth, etc...



An example of the single conversion superheterodyne receiver architecture applied to a digital receiver.

Image Source: Ammermon, Spencer M. "Low Noise Front End Signal Transport Design for L-Band Phased Array Receivers." *BYU ScholarsArchive*, 20 Dec. 2022, scholarsarchive.byu.edu/etd/9779/.

Modulation Schemes in Ham Radio

- C4FM – Continuous 4 Level Frequency Modulation
 - 4-FSK with constant amplitude envelope
- GMSK – Gaussian Mean Shift Keying
 - 2-FSK with specially selected symbol frequencies and a Gaussian pulse shaping filter, also constant amplitude envelope

Why does it have to sound digital?

- A vocoder is used to compress the bandwidth of voice traffic
- DVSI, Inc proprietary vocoder used in all common digital voice modes
 - IMBE for P25 Phase 1, YSF Wide
 - AMBE for D-Star
 - AMBE+2 for DMR, YSF Narrow, NXDN, P25 Phase 2
- Open source Codec 2 used in M17



Parametric Signal Representation

- Send information about the signal and reconstruct it, instead of the whole original signal
- Picture a red rose on a rose bush, with green leaves, grass and trees in the background with clouds in the sky
 - 100 characters, 2 byte per UTF-16 encoding = 200 B
 - Image is 48 KB



Digital Utah Reflectors



TRANSCODE
IMBE

BrandMeister
AMBE+2

NEXEDGE®
NXDN®
AMBE+2

TRANSCODE

AMBE+2

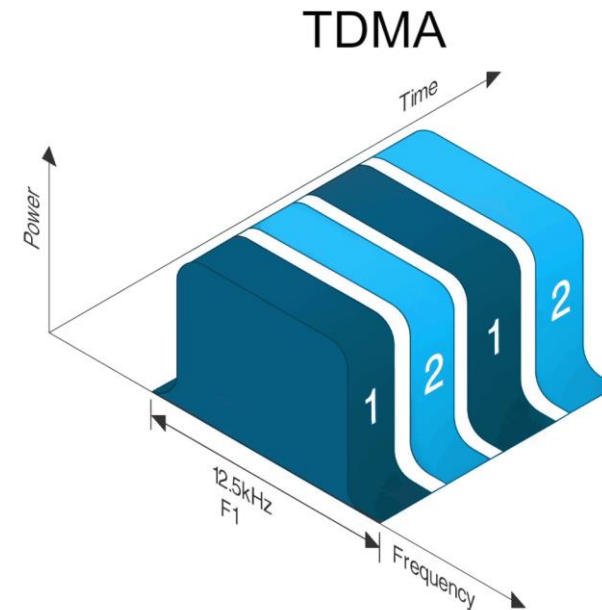


AMBE



DMR – Digital Mobile Radio

- European standard (ETSI)
- Repeaters divide a 12.5 kHz channel into two logical channels in time – TDMA
 - 4800 bps effective bit rate per time slot
- Most popular network is Brandmeister
- Many manufacturers of radios
- Trunking options (DMR Tier 3)



APCO Project 25 (P25)

- A set of standards for interoperable digital radio systems for public safety
- P25 Phase 1 is what hams use, as well as trunking using older IMBE vocoder – patent now expired
 - 9600bps effective bit rate
- P25 Phase 2 – trunking only with TDMA and AMBE+2 vocoder
 - 4800bps effective bit rate per time slot
- MMDVM Reflectors - very simple



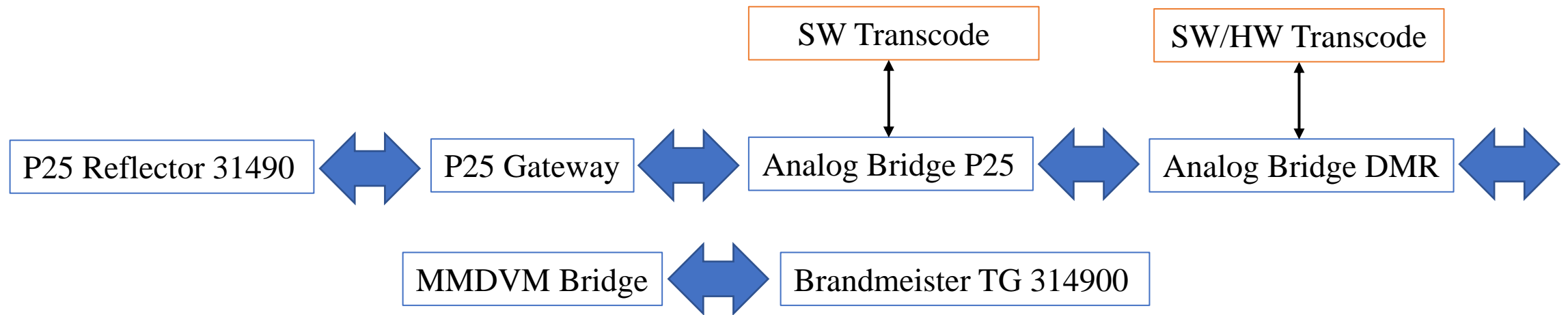
Image Source: UCA/Jeremy Drummond

D-Star

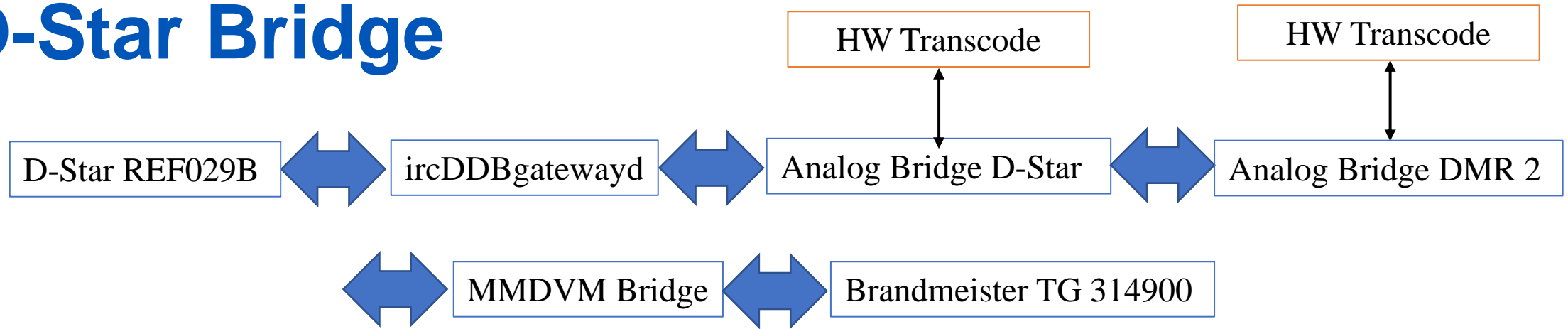
- Open standard developed by the Japan Amateur Radio League
- 4800bps bit rate
- The digital “black sheep”
 - GMSK and AMBE
- Icom was the first major manufacturer to adopt
 - Kenwood now in the game
- Reflector types: REF, XRF, DCS, XLX



P25 Bridge



D-Star Bridge



Yaesu System Fusion

- Two voice modes: Narrow with more data, wide with less data
 - 12.5 kHz channel, 9600bps bit rate
 - Wide uses IMBE like P25 Phase 1, narrow uses AMBE+2 like DMR, NXDN, P25 Phase 2
- Linking Methods
 - Wires-X: Proprietary Yaesu implementation
 - YSF: Open-source implementation of Wires-X on MMDVM with reflectors
 - FCS: Open source servers that host multiple rooms, similar to YSF



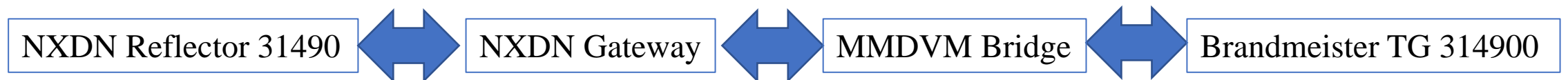
YSF Bridge



No transcoding necessary!

NXDN

- Developed jointly by Kenwood and Icom (Nexedge and iDas respectively)
- Can fit two 6.25 kHz FDMA channels in a 12.5 kHz channel
 - 4800bps bit rate
- Provisions for trunking, like DMR, P25
- Simple reflectors like P25



Digital Utah Reflectors Review

