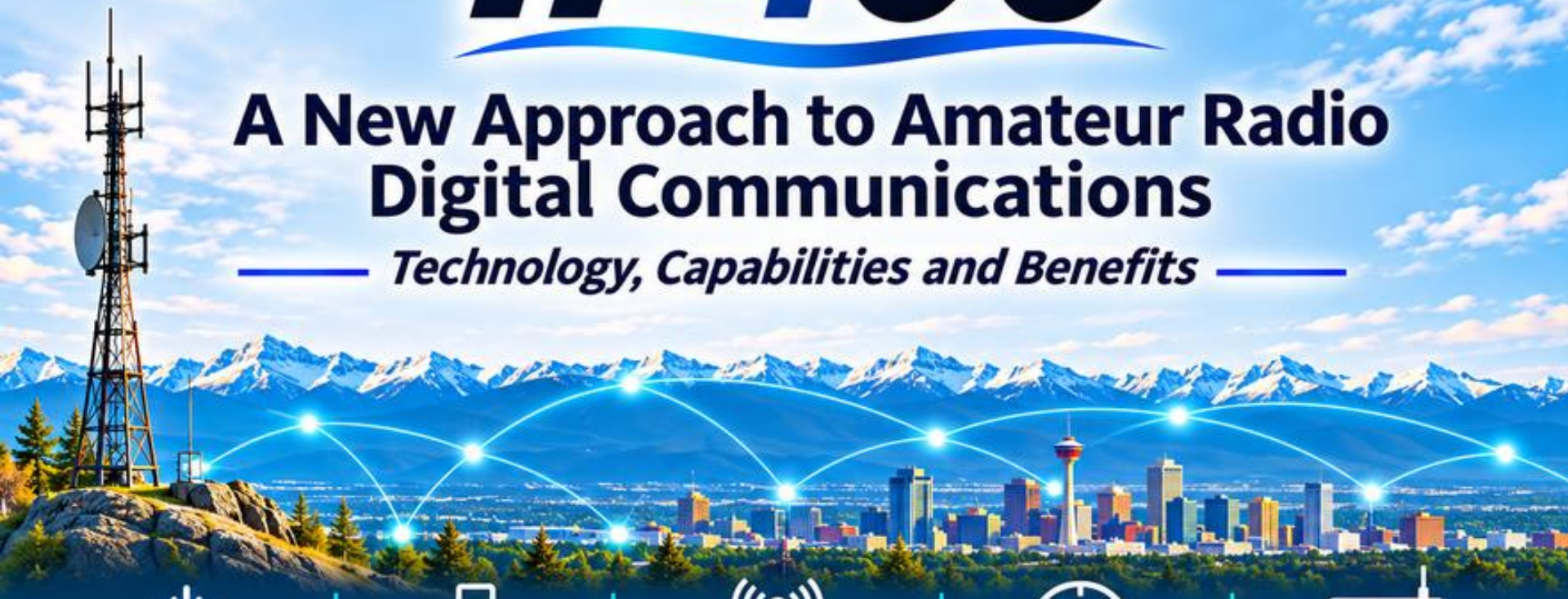
Alberta Digital Radio Communications Society
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Founded 2022

Member Presentation

IP400

A New Approach to Amateur Radio Digital Communications

Technology, Capabilities and Benefits



- OFDM-AB Modem
- Mesh Networking
- Upgrades Existing Repeaters
- Higher Data Speeds (2.6 – 57 kbps)
- Works with Existing FM Radios

Jerry Spring, VE6TL

November 2026

IP400

2. The Beginnings of Amateur Digital Communications

From RTTY to the First Digital Networks

1950s – 1970s

RTTY – Radio Teletype

- Early digital mode for sending text over radio
- Used a 5-bit Baudot code (32 characters)
- Rates such as 45.45 and 75 baud (≈ 45–75 bits/sec)



1980 – 1982

The First Packet Radio

- Amateurs began connecting computers over VHF/UHF
- Early systems used Bell 202 AFSK modulation at 1,200 bits/sec
- Led to the development of AX.25 in 1982



Early 1980s

The First Digital Networks

- Packet repeaters (digipeaters) extended range
- Bulletin Board Systems (BBS) for messages and files
- Early regional and national packet networks began to form

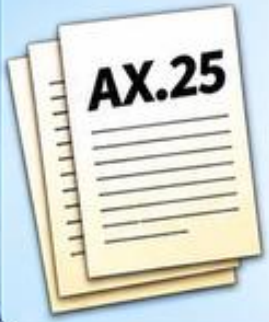


Baud vs. Bits per Second

- **Baud:** the number of signal changes (symbols) per second.
- **Bits per second (bps):** the amount of information carried per second.

Example	Baud	Bits per Second
RTTY (Baudot)	45.45	≈ 45 bps
RTTY (higher rate)	75	≈ 75 bps
Early packet (Bell 103)	300	300 bps

A Key Milestone – AX.25 (1982)



- **AX.25** — Amateur packet protocol.
- Derived from **X.25**, a commercial packet-switching protocol.
- Adapted for amateur radio using callsign addressing.
- Provides packet framing, error detection and digipeating.
- Version 2.0 standardized in **1984.**

These early developments provided that digital communications worked on amateur radio and laid the foundation for the higher-speed systems that followed — and for IP400.

AX.25 – The Amateur Packet Radio Protocol

A Common Standard That Made Amateur Data Networks Possible

What Is AX.25?

- A data communications protocol developed for amateur radio.
- Based on the X.25 packet-switching protocol, adapted for amateur use.
- First developed in 1982 and standardized by the ARRL in 1984 (Version 2.0).

What Does It Do?

- Organizes data into packets ("frames").
- Identifies the sender, receiver and optional digipeaters.
- Detects errors using a 16-bit Frame Check Sequence (FCS).
- Supports both connected (with acknowledgments) and unconnected operation (e.g. APRS).

The AX.25 Frame (HDLC)

HDLC Flag (7E)	Address Field Source, Destination and Digipeaters	Control Frame type and link control	PID Protocol identifier	Information Field The actual data (message, file, etc.)	FCS 16-bit error check	HDLC Flag (7E)

← *AX.25 Frame (HDLC)* →

HDLC Framing & Bit Stuffing

- AX.25 uses HDLC (High-Level Data Link Control) framing.
- The flag value 7E (binary 01111110) marks the beginning and end of a frame.
- A 0 is inserted after five consecutive 1 bits in the frame contents (bit stuffing).
- The receiver removes these inserted zeros.
- This prevents data from being mistaken for the flag sequence and clearly distinguishes data from control codes.

A Typical Packet Radio Station



Key Points

- AX.25 is a communications protocol ("language").
- It is independent of the radio modulation (e.g. 1,200-bps AFSK, 9,600-bps FSK, or IP400's OFDM-AB).
- Used by APRS, Winlink, and many applications.

KISS Interface

- KISS = Keep It Simple, Stupid.
- Computer software and TNC/AMNC firmware.
- AX.25 packets over USB or serial cable.

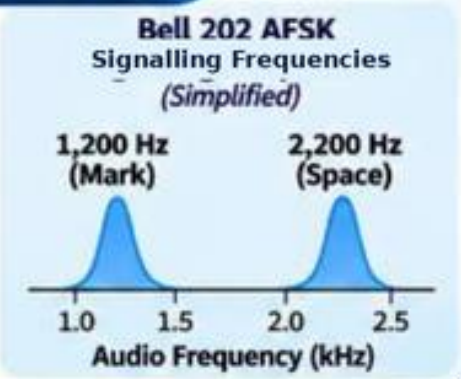
AX.25 uses HDLC framing with bit stuffing, independent of radio modulation.
IP400 can carry AX.25 packets using OFDM-AB.

The Packet Radio Revolution (1980s)

Practical Digital Communications for Amateurs

1200-bps AFSK – The Workhorse

- Standardized on Bell 202 AFSK (Audio Frequency Shift Keying).
- Two audio tones over FM:
  1,200 Hz = Mark.
  2,200 Hz = Space.
- Data rate: 1,200 bits/second (= 1,200 baud).
- Worked with existing FM radios using the microphone and speaker connections.



The Packet Station (TNC)



- **TNC** = Terminal Node Controller.
- Converts computer data to a radio signal (modem).
- Handles AX.25 packet formatting and error checking (e.g. frame check sequence).
- Interfaces a computer to an FM transceiver.

Building a Packet Network

- **Digipeaters:** receive and retransmit packets to extend communications range.
- **Packet Bulletin Board Systems (BBS):** message and file storage.
- Linked local and regional networks began to form.
- Enabled keyboard-to-keyboard communication, file transfer and early e-mail.



Conventional digipeaters extend range but do not automatically find the best route. If the digipeater fails, Station A cannot communicate with Station B.

A New Capability for Amateur Radio



- ✓ Text messaging (keyboard to keyboard)
- ✓ File transfer
- ✓ Bulletin Board Systems (BBS)
- ✓ Local and regional packet networks
- ✓ A growing community of digital operators

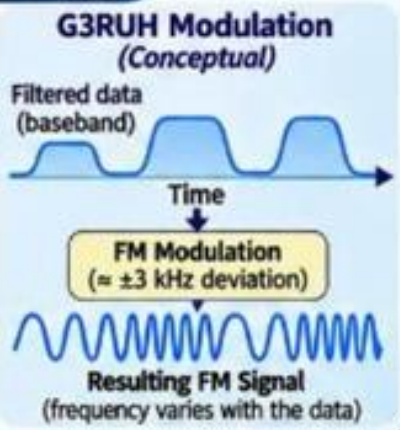
1200-bps packet radio, TNCs and digipeaters created a practical and widely used digital network for amateurs, built on the AX.25 protocol.

Higher Speed Packet Radio: 9600 bps (G3RUH)

A Major Step Forward in Amateur Digital Communications

The G3RUH 9600-bps Modem

- Designed by **James Miller, G3RUH**, in **1988**.
- A higher speed packet modem for amateur FM radio.
- Common rate: **9,600 bits/second (9,600 baud)**.
- Uses filtered binary data (digital pulse shaping) to directly frequency modulate the transmitter (not audio tones).
- Typical FM deviation: **≈ ±3 kHz**.



Why a Different Connection?

- Microphone/speaker (AFSK) paths are limited to about **3 kHz bandwidth** and include filtering, pre-emphasis and limiting, which can distort 9600-bps data.
- 9600-bps packet typically requires direct connections to the radio:
  - **Transmit:** modulation input (direct FM drive)
  - **Receive:** discriminator output (unfiltered receiver audio)
- Many FM transceivers later provided a dedicated **data/packet port** for this use.



1200 bps vs. 9600 bps

Feature	1200-bps (Bell 202)	9600-bps (G3RUH)
Modulation	AFSK (two audio tones)	Filtered data (direct FM)
Deviation	Depends on radio adjustment	≈ ±3 kHz
Radio connection	Mic and speaker (audio)	Data/packet port (direct)
Data rate	1,200 bps	9,600 bps
Relative speed	1×	**≈ 8× faster**

Key Technical Improvements

- ✔ Uses **transmit pulse shaping** (digital filtering) to control the signal spectrum and compensate for the receiver's amplitude and phase response.
- ✔ Higher data rates for faster file transfers (e.g., software, data, images).
- ✔ More capable BBS and early network linking (e.g., gateways to other networks and the Internet).



The G3RUH 9600-bps modem greatly increased the usefulness of amateur packet radio by using transmit pulse shaping and direct FM modulation (≈ ±3 kHz deviation).

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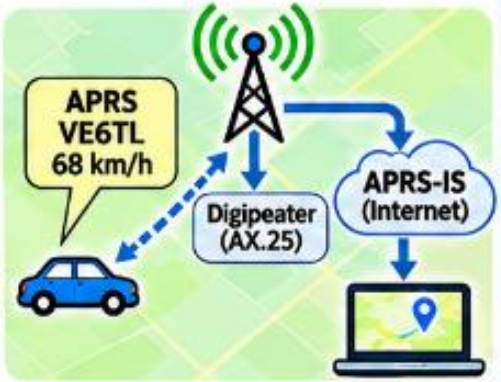
Modern Amateur Digital Networks

IP400

Today's Amateur Data Networks

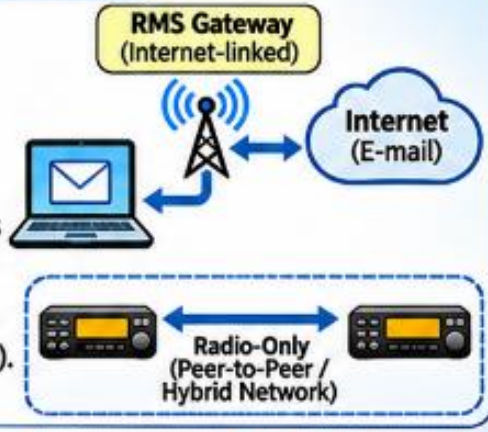
APRS – Automatic Packet Reporting System

- Real-time exchange of position, status and short messages.
- Conventional VHF APRS commonly uses 1200-bps AX.25 packet radio.
- Wide-area coverage via digipeaters and APRS-IS gateways (to the Internet).
- Popular for event support, tracking and situational awareness.



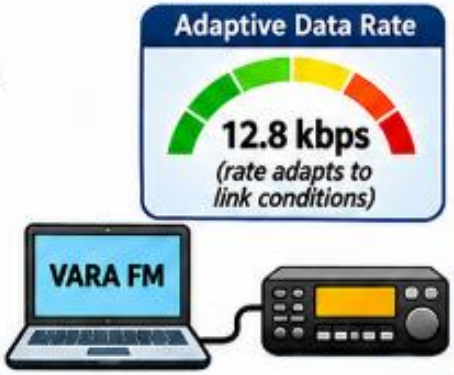
Winlink – E-mail Over Radio

- Reliable e-mail messaging (including attachments) for amateur radio.
- HF/VHF/UHF transports including packet, VARA and PACTOR (as appropriate).
- Internet-linked RMS gateways (to the global e-mail system).
- Also supports peer-to-peer and Hybrid Network radio-only forwarding (no Internet needed).



VARA FM – Adaptive FM Data

- Soundcard modem for VHF/UHF FM.
- Uses advanced modulation, error correction and ARQ (automatic repeat request).
- Automatically adapts the data rate to link conditions.
- Nominal modem rates per developer website):
  - **Narrow:** up to 12,750 bps
  - **Wide:** up to 19,200 bps
  - Actual throughput is lower and varies with signal quality.



AREDN – Amateur Radio Emergency Data Network

- High-speed IP mesh network using commercial-derived microwave radio hardware (e.g., Ubiquiti, MikroTik).
- Frequency choices and channel widths depend on commercial equipment and regulations.
- Links carry voice, video and data between stations without relying on the public Internet.



Modern amateur digital systems use different protocols and technologies. IP400 aims to add flexible digital data and networking to existing FM radios.

Existing Digital Systems — Strengths and Limitations

Why consider another digital radio system?

System	Principal strength	Limitation relative to IP400 goals
APRS	Position reporting, telemetry and short messages	Conventional 1,200-bps APRS is not intended for high-volume data.
Winlink	Reliable email over radio	Not designed as a general-purpose real-time mesh network.
VARA FM	Fast, adaptive data transfer using existing FM radios	Primarily point-to-point sessions; not a complete mesh network.
AREDN	High-speed IP mesh networking	Requires compatible commercial Wi-Fi hardware for microwave bands.

Existing systems serve different needs. IP400 aims to combine higher-speed data and flexible networking.

Why Do We Need Something New?

IP400

The Case for IP400

Extending Digital Communications Using Existing FM Radios

Limitations of Current Solutions

- **APRS:** conventional VHF operation commonly uses 1,200-bps AX.25; ideal for position and short messages.
- **Winlink:** excellent radio e-mail, including peer-to-peer; not intended as a general real-time mesh network.
- **VARA FM:** primarily point-to-point sessions; not a complete mesh network.
- **AREDN:** fast IP mesh networking, but requires compatible commercial Wi-Fi hardware for microwave bands.



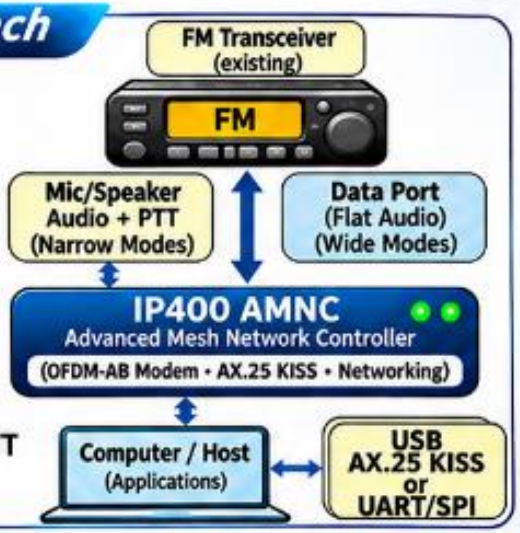
What Is the Opportunity?

- ✓ **Higher data rate than** 1,200 bps over compatible existing FM transceivers.
- ✓ **Flexible** messaging and networking services (e.g., text, file transfer, local IP).
- ✓ **Complement** – not replace – existing amateur digital systems.



The IP400 Approach

- OFDM-AB digital modulation designed for FM radios.
- Uses an AMNC for modem, control and networking.
- Raspberry Pi: UART or SPI; PC: USB (AX.25 KISS).
- Works with compatible FM radios using audio/PTT or a suitable data port.



Potential Benefits / Project Goals

- ✓ Make **better use of existing** FM equipment.
- ✓ Offer **higher data rates** when link conditions permit.
- ✓ Enable **flexible** data, messaging and mesh–network applications.
- ✓ **Reduce** the need for dedicated new radio hardware where compatible.
- ✓ Features, performance and compatibility depend on development and testing.

IP400 is being developed to bring higher-speed digital data and mesh networking to compatible existing FM radios using OFDM-AB.

* Orthogonal Frequency-Division Multiplexing

IP400

Inside the IP400 AMNC

Three Essential Functions Working Together



OFDM-AB Modem
Getting Data Over the Air

- Uses Orthogonal Frequency Division Multiplexing (OFDM) to carry higher speed digital data through an FM radio.
- Converts digital information to an audio signal for transmission and recovers data from received signals.
- Supports multiple IP400 modes (e.g., narrowband and wideband) with different data rates and audio bandwidths.

AX.25 KISS Interface
Connecting Computer Applications

- Implements AX.25 packet radio (at the link layer) for addressing, framing and error detection.
- Uses the KISS (Keep It Simple, Stupid) protocol to exchange AX.25 packets between a computer and the AMNC.
- A standard, widely used interface supported by many amateur radio applications.
- It is an interface, not a modulation method.

Networking
Connecting Stations Together

- Provides IP400 network functions including station discovery, beaconing and maintaining routing information.
- Forwards packets between stations, allowing multi-hop (mesh) operation (e.g., Station A → B → C).
- Supports messaging and other applications via encapsulated data from host network.
- Enables extension to site networks (e.g., AREDN or other IP links) where supported.

The AMNC combines a digital modem, a standard packet interface, and networking functions in a single controller to enable IP400 communications over FM radios.

What Equipment Does an Amateur Need for IP400?

Use a compatible existing FM radio — add an AMNC and the proper interface

Typical IP400 Amateur Station



What You May Already Have

- **Compatible FM transceiver** – an existing VHF/UHF (or HF) FM radio that can accept an external audio interface and has adequate audio bandwidth for the desired mode.
- **Antenna** – your current antenna can be used (ensure it is suitable for the operating band).
- **Computer or Raspberry Pi** – to run applications such as messaging, file transfer or network tools.

What You Need to Add

- **IP400 AMNC** – the Advanced Mesh Network Controller, which provides OFDM-AB modulation/demodulation, networking and an AX.25/KISS interface.
- **Radio interface module** – connects the AMNC to your radio (audio in/out, PTT and receiver status (COR), as available).
- **Verify your radio's audio path** – check that the audio bandwidth, filtering and frequency response are suitable for the IP400 mode you plan to use.
- **Computer connection** – USB/serial for a standalone AMNC, or Raspberry Pi HAT via serial or higher-speed SPI.

IP400 OFDM-AB Modes and Radio Requirements

Mode	Audio Bandwidth	Typical Radio Connection
Narrowband	2,625 Hz	Mic/Speaker (most radios)
Enhanced Narrowband	3,656 Hz	Mic/Speaker (if adequate response)
Wideband	5,766 Hz	Suitable data port (wider, flat audio)
Enhanced Wideband	7,781 Hz	Data port (extended, flat audio)

A data connector alone does not guarantee support for wider modes; verify audio passband, filtering and compatibility.

Development Status: IP400 AMNC and OFDM-AB features remain under development/testing; availability varies by firmware.

Many existing FM transceivers may be suitable; highest speeds require a sufficiently wide, flat audio path.

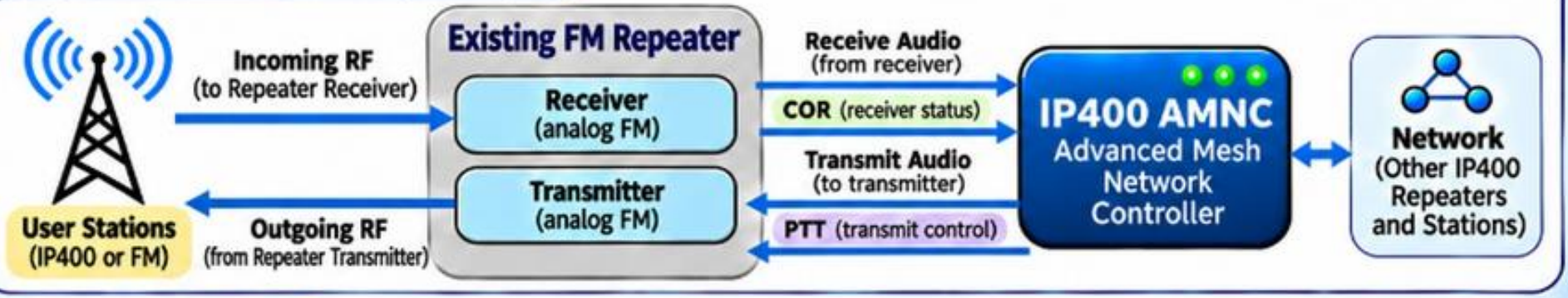
IP400 – Repeater Integration

IP400

Adapting Existing FM Repeaters for IP400

Add an AMNC and Simple Interfaces to Enable IP400 Over FM

Repeater with IP400 Capability



Key Terms (Control Lines)

COR – Carrier Operated Relay
A receiver output that goes active when a valid signal is received (squelch opens). The AMNC uses COR to know when to receive.

PTT – Push To Talk
A control output from the AMNC that turns on the repeater transmitter when the AMNC needs to send an IP400 signal.

What Is Required?

- **IP400 AMNC** – adds OFDM-AB modulation/demodulation and network functions.
- **Audio and control connections** – Receive audio and COR from the repeater to the AMNC, and transmit audio and PTT from the AMNC to the repeater transmitter.
- **Optional network connection** – links to other IP400 repeaters or to an Internet gateway (e.g., AREDN), if desired.

Benefits

- Reuses existing FM repeater equipment.
- Enables higher-speed digital communications (e.g., messaging, file transfer, data services).
- Provides mesh networking between repeaters and IP400 stations.
- A practical and cost-effective upgrade for many existing sites.

Key Considerations

- **Ensure the repeater's and the user's audio bandwidth are suitable for the desired IP400 mode.**

IP400 – OFDM-AB Modulation

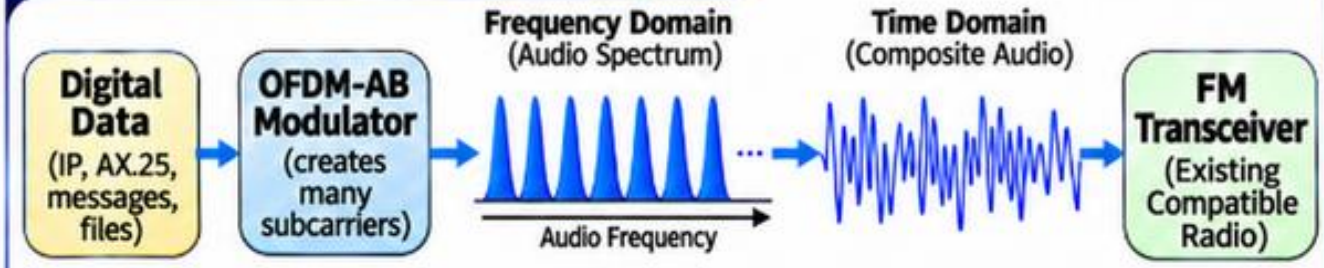
How OFDM-AB Works in IP400

A Modern, Efficient Way to Send Digital Data Over FM

What is OFDM-AB?

- **OFDM** (Orthogonal Frequency Division Multiplexing) is a widely used digital modulation technique that divides data among many closely spaced subcarriers transmitted simultaneously.
- **OFDM-AB** (OFDM for Amateur Bands) is an original OFDM-based implementation developed by ADRCS members for the IP400 project, using the audio passband of compatible amateur FM transceivers.

From Data to an FM Audio Signal



*Multiple orthogonal subcarriers transmitted **simultaneously** within the selected audio bandwidth.*

Where Else Is OFDM Used?

OFDM is an established technology used in many modern communications systems:

- **Wi-Fi** (802.11a/g/n/ac/ax)
- **Cellular** (4G LTE, 5G)
- **Digital television** (DVB-T/T2)
- **Digital radio broadcasting** (DAB, DRM)
- **DSL / broadband** (related DMT) (e.g., ADSL, VDSL)

Key Takeaways

- **OFDM-AB** applies proven OFDM technology to send higher-speed digital data through the audio passband of existing FM radios.
- It divides the data among many closely spaced subcarriers, making efficient use of bandwidth.
- IP400 uses several audio bandwidths (modes) and modulation constellations to provide different data speeds and operating choices *(see next slide)*.

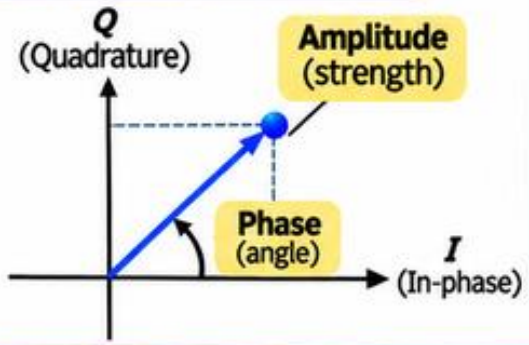
Modulation Constellations
What They Are and How They Work

Understanding how digital information is represented by amplitude and phase

The Basic Idea

- Digital communication sends information by changing the ***amplitude, the phase,*** or ***both,*** of a radio signal.
- Each unique combination represents a ***symbol.***
- A group of symbols, shown on a 2-D plot, is called a ***modulation constellation.***

Amplitude and Phase

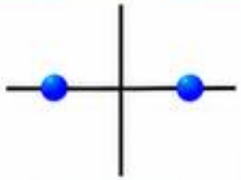


- **Amplitude** = how strong the signal is.
- **Phase** = the signal's position in its cycle (angle).
- **I** (in-phase) and **Q** (quadrature) are two signal components separated by 90° in phase.

Quadrature means 90° apart in phase.
The I and Q components together determine the amplitude and phase of the transmitted symbol.

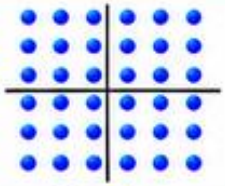
Common Modulation Constellations

BPSK
(Binary Phase Shift Keying)



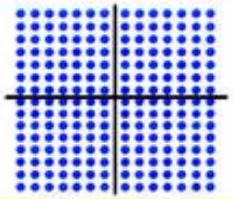
2 points
(1 bit per symbol)

64-QAM
(Quadrature Amplitude Modulation)



64 points
(6 bits per symbol)

256-QAM
(Quadrature Amplitude Modulation)



256 points
(8 bits per symbol)

Comparing the Modulations

Modulation	Bits per Symbol	How It Works and What It Means
BPSK	1	■ Two phase states (0° and 180°). ■ Most robust; works well in weaker or noisier conditions.
64-QAM	6	■ 64 different amplitude/phase combinations. ■ Higher data rate, but needs a cleaner signal with better signal-to-noise ratio (SNR).
256-QAM	8	■ 256 different combinations. ■ Highest data rate, but more sensitive to noise, interference and distortion.

Key Takeaways

- BPSK, 64-QAM and 256-QAM are standard modulation methods used in many digital systems.
- They represent information using different combinations of amplitude and phase.
- Higher-order modulation (more points) carries more bits per symbol, giving higher data rates, but requires a cleaner, stronger signal.
- In ***IP400, OFDM-AB*** uses these modulation techniques on its subcarriers. The selected modulation and audio bandwidth together determine the physical-layer bit rate.

Putting It Together:

How OFDM-AB Achieves Different Data Rates

IP400

Combining Audio Bandwidth and Modulation to Match the Radio Channel

What Is OFDM-AB?

- OFDM-AB stands for ***OFDM for Amateur Bands.***
- An original implementation developed by ADRCS for IP400.
- It uses OFDM with selectable audio bandwidth and modulation to set the physical-layer data rate.

How the Data Rate Is Selected

Operator
Selects one of four audio-bandwidth modes (Narrowband, Enhanced NB, Wideband or Enhanced WB).

→

Firmware
Chooses the modulation (e.g., BPSK, 64-QAM or 256-QAM) based on link quality (signal-to-noise ratio).

→

Result
A physical-layer bit rate for that combination (e.g., 5.3 to 57.2 kb/s).

Bits per Subcarrier Symbol

BPSK	= 1 bit
64-QAM	= 6 bits
256-QAM	= 8 bits

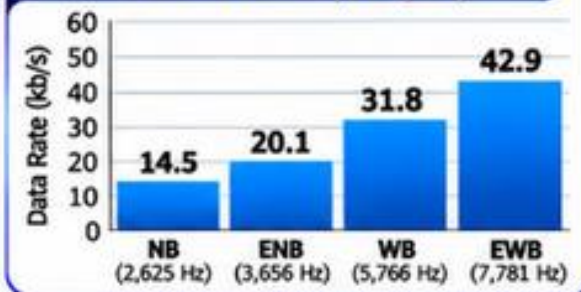
OFDM-AB Audio Bandwidth Modes

Mode	Audio Bandwidth
Narrowband	2,625 Hz
Enhanced Narrowband	3,656 Hz
Wideband	5,766 Hz
Enhanced Wideband	7,781 Hz

Published OFDM-AB Physical-Layer Bit Rates (kb/s)

Mode (Audio Bandwidth)	BPSK (1 bit)	64-QAM (6 bits)	256-QAM (8 bits)
Narrowband (2,625 Hz)	2.4	14.5	19.4
Enhanced Narrowband (3,656 Hz)	3.4	20.1	26.8
Wideband (5,766 Hz)	5.3	31.8	42.4
Enhanced Wideband (7,781 Hz)	7.1	42.9	57.2

Data Rate Increase with Wider Audio Modes (64-QAM)



Comparison with Conventional Packet Radio

System	Nominal Rate (kb/s)
1200-baud packet (AX.25)	1.2
9600-baud packet (AX.25)	9.6
IP400 (NB, 64-QAM)	14.5
IP400 (WB, 64-QAM)	31.8
IP400 (EWB, 64-QAM)	42.9
IP400 (EWB, 256-QAM)	57.2

Key Takeaways

- More audio bandwidth allows more subcarriers, increasing the potential data rate.
- Higher-order constellations carry more bits per symbol (BPSK = 1, 64-QAM = 6, 256-QAM = 8).
- The operator selects the audio-bandwidth mode; the firmware chooses modulation based on signal quality.
- IP400 provides substantially higher data rates than conventional 1200/9600-baud packet, using standard FM radios with a suitable audio path.

Published PHY rates, not guaranteed user throughput. Actual modes and modulation depend on firmware and compatible radio audio paths.

How Long Does It Take to Send a 1 MB File?

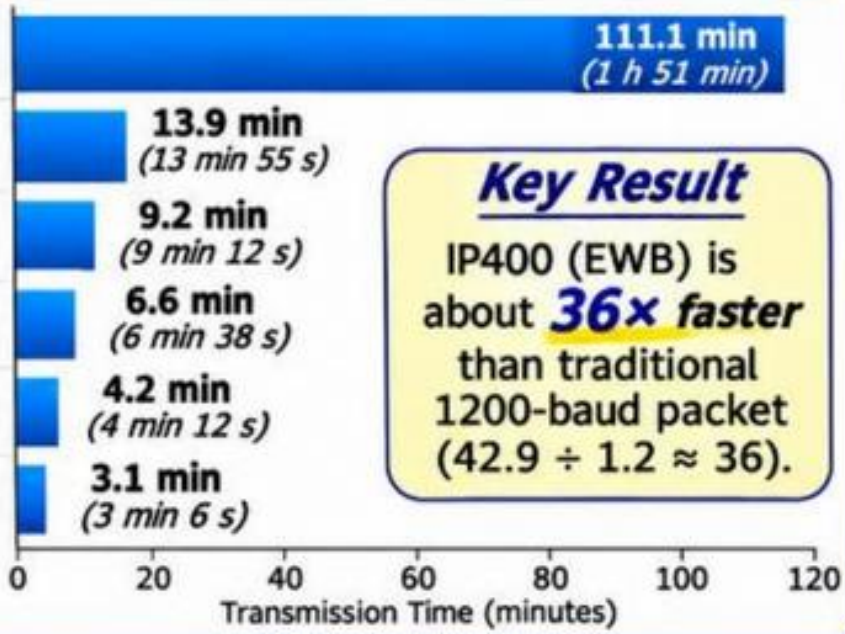
A Practical Comparison of Traditional Packet Radio and IP400

Assumptions

- File size: 1 MB (1,000,000 bytes = 8,000,000 bits).
- Using nominal (physical-layer) data rates from published IP400 specifications.
- Uninterrupted transmission (no errors or retries).
- Actual transfer times will be longer due to protocol overhead, framing, error correction, and acknowledgements (ARQ), and channel sharing.

Estimated Minimum Time to Transmit a 1 MB File

System / Mode (64-QAM where applicable)	Nominal Rate	Time for 1 MB File (*theoretical minimum*)
1200-baud packet (AX.25)	1.2 kb/s	**111.1 min** *(1 h 51 min)*
9600-baud packet (AX.25)	9.6 kb/s	**13.9 min** *(13 min 55 s)*
IP400 Narrowband (NB, 2,625 Hz)	14.5 kb/s	**9.2 min** *(9 min 12 s)*
IP400 Enhanced NB (ENB, 3,656 Hz)	20.1 kb/s	**6.6 min** *(6 min 38 s)*
IP400 Wideband (WB, 5,766 Hz)	31.8 kb/s	**4.2 min** *(4 min 12 s)*
IP400 Enhanced WB (EWB, 7,781 Hz)	42.9 kb/s	**3.1 min** *(3 min 6 s)*



Key Result

IP400 (EWB) is about ***36× faster*** than traditional 1200-baud packet (42.9 ÷ 1.2 ≈ 36).

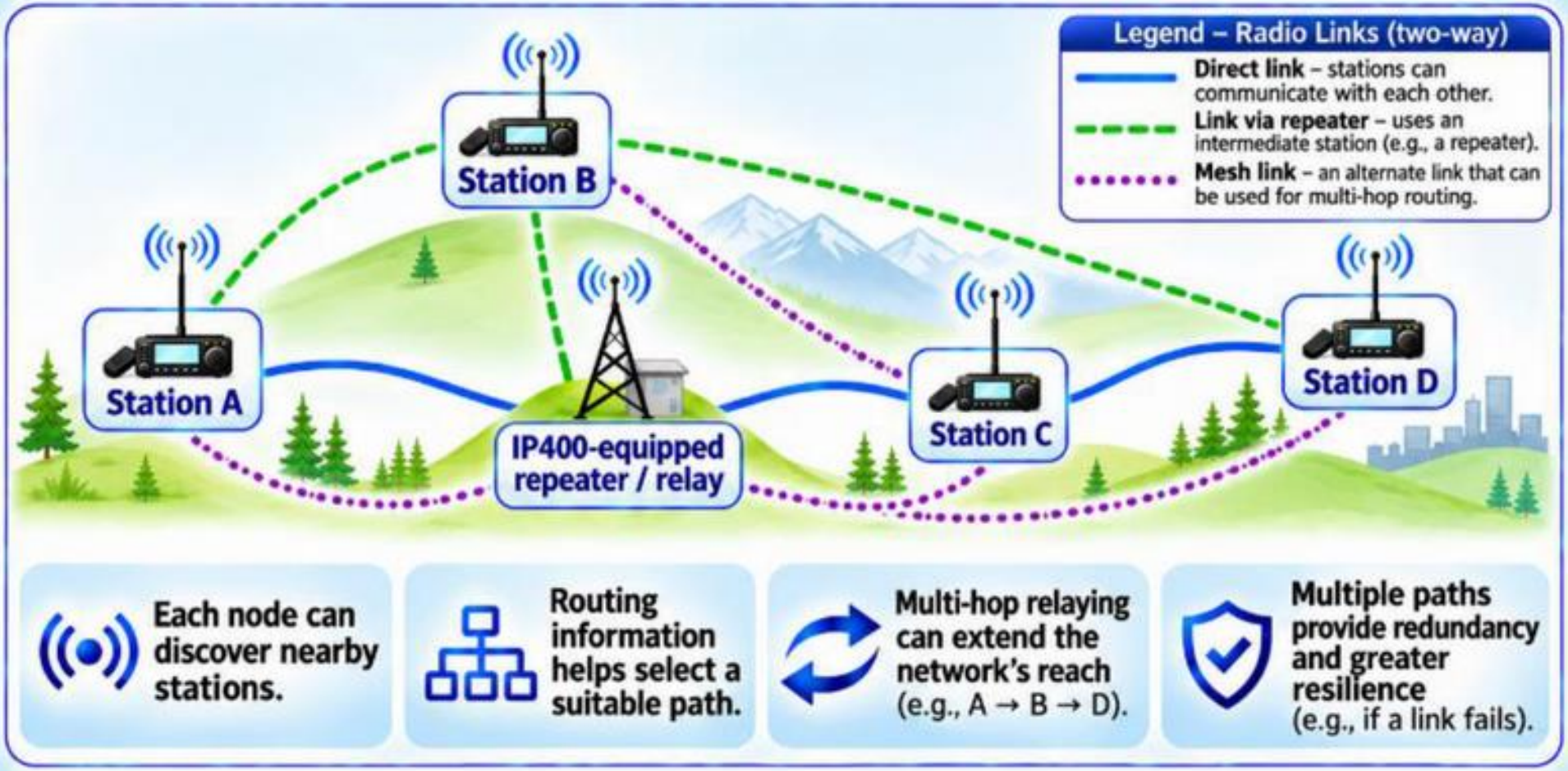
Key Takeaways

- ***A file that takes almost two hours with traditional 1200-baud packet could theoretically be transmitted in about three minutes using IP400.***
- IP400 (EWB) is about 36× faster than 1200-baud packet.
- The wider the audio bandwidth, the higher the potential data rate (and shorter time).

Note: Times are calculated from published PHY bit rates. IP400 64-QAM is a beta target (Q4 2026) and not yet generally available. Actual file-transfer times will be longer due to protocol overhead, error correction, and channel conditions.

How Does IP400 Build a Network?

Direct links, multi-hop relaying and alternative paths



Each node can discover nearby stations.

Routing information helps select a suitable path.

Multi-hop relaying can extend the network's reach (e.g., A → B → D).

Multiple paths provide redundancy and greater resilience (e.g., if a link fails).

Note: *Conceptual network diagram. All radio links are bidirectional (two-way), Routing, digipeating and automatic path selection are IP400 firmware capabilities; actual performance depends on radio range, interference and network configuration.*

IP400 vs. Meshtastic

A Comparison of Two Amateur Radio Data Networking Approaches



Key Takeaways

Band Flexibility

IP400 works on multiple amateur bands (HF, VHF, UHF, etc.); Meshtastic is limited to a single LoRa band.

No Infrastructure Required

Both can form an on-air mesh network directly between stations (ad hoc) without the Internet or existing repeaters.

Higher Power & Coverage

IP400 can use the higher power levels permitted in amateur radio, providing greater range and fewer nodes than Meshtastic (low power per node).

Greater Data Flexibility

IP400 is a data transport system (not an app suite) and can carry many types of information and applications from the network (e.g., files, forms, maps, telemetry), making it more flexible and robust, especially in emergencies.

IP400 vs. Meshtastic – Feature Comparison

Feature	IP400	Meshtastic
Operating Bands	✓ Multiple amateur bands (HF/VHF/UHF+)	✓ Single LoRa band (e.g. 915 MHz in NA)
Network Infrastructure	✓ Not required (ad hoc mesh on-air). Repeaters can extend coverage.	✓ Not required (also ad hoc mesh).
Typical Data Rates (OFDM-AB)	✓ 6.8, 13.6, 27.2, **57.2 kb/s** (256-QAM)	✓ ~0.3 – 50 kb/s (LoRa, depending on settings)
Applications	✓ Provides messaging (chat) and transports other applications and data (e.g., files, forms, maps, telemetry) from the network.	✓ Built-in apps: chat, position (GPS), telemetry, and simple messaging (limited feature set).
Transmit Power (per node)	✓ Higher power levels (amateur radio limits, e.g., 100+ W on HF, 50 W on VHF/UHF) for longer range and larger coverage.	✓ Low power by design (typically ≤ 1 W, often mW) requiring more nodes to cover the same area.
Robustness / Emergency Use	✓ More robust for emergencies due to higher power, longer range, and ability to carry a wide variety of critical information.	✓ Useful for local and portable use, but limited by low power, range, and application scope.

Both can create on-air mesh networks, but IP400 offers greater band and power flexibility, broader data capability, and higher robustness for emergency and large-area operations.

IP400 in Practice — Connecting an Existing Radio

PC or Raspberry Pi



USB-C (serial) or Raspberry Pi (UART or SPI)

IP400 AMNC
(Advanced Mesh Network Controller)



IP400 Advanced Mesh Network Controller (courtesy Mike VA3TEC)

Radio audio / data, PTT and COR (DB-15 interface)

Existing FM Radio



Radio Connection and Modes

OFDM-AB Mode	Audio Bandwidth	Radio Connection
NB (Narrowband)	2,625 Hz	Mic / Speaker
ENB (Enhanced NB)	3,656 Hz	Mic / Speaker (suitable radio)
WB (Wideband)	5,766 Hz	Data Port (flat audio)
EWB (Enhanced WB)	7,781 Hz	Data Port (extended passband)

What It Enables

- **Keyboard-to-keyboard messaging** (chat)
- **AX.25 / KISS** compatible operation (e.g., packet, Winlink integration)
- **File transfer** and data exchange
- **IP networking** (e.g., sensors, status, regional data)
- **Mesh networking** (linking multiple IP400 nodes)

Key Takeaway: *The IP400 AMNC lets you use existing FM radios for digital data, with narrower modes using standard radio audio and higher-speed modes using a suitable data port.*

IP400 at Home or in the Field

Using an Ordinary Handheld

A practical example: a basic 2 m / 70 cm dual-band handheld connected to an IP400 station for messaging, email, file transfer and other data, operating either simplex or through an IP400-enabled repeater.

Typical Portable Station Setup

Host Computer (choose one)



or



Raspberry Pi (with keyboard and monitor)

USB-C (data & control)



IP400 AMNC
(Advanced Mesh Network Controller)

OFDM-AB modem, packet handling, mesh routing and application interface

Mic audio
Speaker audio
PTT



2 m / 70 cm FM Handheld

Standard accessory speaker/microphone jack and antenna

Simplex Operation



Direct IP400 link to another station (within RF range)

Through an IP400 Repeater



Extended coverage and potential access to a wider IP400 mesh network

Setup Steps

1. **Choose the host computer:** Use a PC (Windows, Linux or macOS) connected to the AMNC by USB-C, or a Raspberry Pi with keyboard and monitor (USB) connected to the AMNC.
2. **Download and install software:** From the ADRCS IP400 website (ip400.adrcs.org), get the UFP/IP400 host software and the applications you want (e.g. IP400 Chat, MeshMail, file transfer tools, KISS/AX.25).
3. **Connect the hardware:** Attach the AMNC to the handheld's speaker/microphone jack (audio in/out and PTT).
4. **Configure the station:** Set frequency (2 m or 70 cm), IP400 mode, callsign and node (mesh) settings.
5. **Select and run applications:** e.g. IP400 Chat (text messaging), MeshMail (email), file transfer, or other supported tools.
6. **Operate:** Send and receive messages, email and files, simplex or via a IP400-enabled repeater.

Example Applications

- **IP400 Chat** – real-time text messaging
- **MeshMail** – store-and-forward email
- **File Transfer** – send and receive files (e.g. documents, images)
- **KISS / AX.25** – connect to traditional packet networks
- **Mesh Networking** – multi-hop routing between stations

Key Points

- ✓ Uses a standard handheld – no internal radio changes.
- ✓ PC or Raspberry Pi, connected to the AMNC by USB-C.
- ✓ Run one or more IP400 applications (chat, email, file transfer, etc.).
- ✓ Operates with OFDM-AB (narrowband, ~2.6 kHz).
- ✓ Works simplex or through an IP400-enabled repeater.
- ✓ Repeater integration and additional features are still in development.

Upgrading an Existing FM Repeater for IP400

What's Needed?



IP400 AMNC
OFDM-AB modem and mesh networking (two radio ports)



Radio interface cable
Audio, PTT and COR (DB-15)

Repeater controller integration
Coordinates normal FM repeater functions and IP400 operation

Suitable audio connections
Mic/speaker (NB, ENB) or flat discriminator/modulator audio (WB, EWB)

Optional Raspberry Pi
Host applications (e.g., AX.25, messaging, network services)

Configuration & testing
Verify operation and that voice and data integration meets site requirements

Conceptual Integration

Existing FM Repeater
Receiver • Transmitter • Duplexer • Antenna

Existing Voice Controller
Analog FM voice, identification and normal repeater functions

IP400 AMNC
Digital modem (OFDM-AB) and mesh networking

Operating Considerations

1. **Normal FM voice**
   Existing repeater functions can be retained, subject to integration and configuration.
2. **IP400 data**
   The AMNC adds digital capability (OFDM-AB) for data, messaging and mesh networking.
3. **Coexistence**
   Sharing one repeater requires coordinated audio/PTT control (e.g., access, timing and priority). Audio signals will be accompanied by a PL tone while data will not.

Key Points

- ✓ Adds IP400 digital networking to existing FM repeater infrastructure.
- ✓ Uses existing repeater hardware (receiver, transmitter, duplexer and antenna).
- ✓ Requires appropriate controller integration for voice/data sharing.
- ✓ Higher-speed modes (WB, EWB) need suitable flat audio connections.
- ✓ AllStarLink integration is a planned feature (targeted for Q1 2027).

Key Takeaway: *IP400 is designed to add high-speed digital networking to existing FM repeater infrastructure. Preserving normal voice operation requires suitable hardware connections and a verified control scheme.*

IP400 Development Status & Roadmap

As of October 2026

Demonstrated / Completed

- **Early IP400 mini-nodes** proved mesh networking in the field.
- **Unified Firmware Platform (UFP) v2.0** released (for mini-nodes) with KISS, SPI and 4FSK.
- **OFDM-AB functional** on prototype **AMNC** (Advanced Mesh Network Controller).
- **Sept. 25, 2026:** ADRCS press release announced AMNC pre-production verification complete, ready for production.

Q4 2026 — Beta Target

- **UFP v2.1** with AMNC support.
- **OFDM-AB** up to 64-QAM.
- **CRC and/or** Reed Solomon FEC

Q1 2027 — Planned

- **v2.1a AllStarLink support** (integration).
- **Ethernet subsystems** (network interface).
- **AMNC retail availability** expected in **Q1 2027.**

(According to October conference report; timing subject to change.)

Q2 2027 — Planned

- **Higher end** modulation schemes.



What is UFP?

UFP (Unified Firmware Platform) is the common, open firmware used by IP400 devices (mini-nodes and the AMNC) that provides the core communications, modem and networking functions.

Key Takeaway: *Working prototypes and released mini-node firmware are available today; advanced AMNC features and repeater integration are still rolling out.*

Sources: *ADRCS IP400 status update (Sept. 11, 2026); ADRCS press release (Sept. 25, 2026); Zero Retries conference report (Oct. 2026).*

How Can Amateurs Participate?

Put IP400 to work — Get involved, learn, and help build the network.

Use the Equipment

- Update compatible radios with the latest firmware.
- Add an AMNC (Advanced Mesh Network Controller) where needed.
- Build and test with UFP (Unified Firmware Platform) devices.
- Explore mini-nodes for portable and mobile use.

Experiment & Develop

- Try different modes and data rates in your area.
- Test messaging, file transfer and network routing.
- Explore applications (e.g. APRS, Winlink, telemetry).
- Share your results and ideas with the community.

Join a Repeater Group

- Work with local repeater owners and user groups.
- Help with installation, configuration and testing.
- Support integration of AMNC with existing FM repeaters.
- Build regional mesh networks (single or multi-site).

Access Resources

- Visit the ADRCS IP400 website (ip400.adrcs.org).
- Read the documentation and user guides.
- Download firmware and software (e.g. UFP, AMNC, tools).
- Join the ADRCS mailing list and forums for updates and support.

Contribute

- Help with documentation, testing and feedback.
- Participate in software development (open source).
- Share your experience at club meetings and conferences.
- Encourage other amateurs to get involved.

Stay Informed

- Watch for project updates and new releases.
- Follow ADRCS on the web and social media.
- Attend webinars and special events (e.g. hamfests, conferences).
- Be part of the conversation as the project evolves.

Together, we can build a stronger, more connected amateur radio community in Alberta and beyond.

Resources & Information

ip400.adrcs.org



Summary — The Future of IP400

A Modern, Open Digital Network for Amateur Radio

What is IP400?

- A new, open digital communications system designed for amateur radio.
- Uses OFDM-AB with narrowband (≈2.6 kHz) and higher-speed options (up to 64-QAM).
- Built on an open, unified firmware platform (UFP) for mesh networking.

Where We Are Now

- **Early mini-nodes** proven in field use.
- **UFP v2.0** released for mini-nodes (KISS, SPI, 4FSK).
- **AMNC** (Advanced Mesh Network Controller) prototype functional.
- **Sept. 25, 2026:** AMNC pre-production verification complete; ready for production.

What's Next

- **Q4 2026** — Beta target (UFP v2.1, OFDM-AB up to 64-QAM, error checking).
- **Q1 2027** — AMNC retail availability (expected).
- **Q2 2027** — higher modulation methods and speeds

Key Takeaways

- **Extends amateur radio beyond voice** — messaging, email, file transfer and more.
- **Uses accessible equipment** — existing FM radios plus the AMNC.
- **Grows through repeaters and mesh networking** for wider coverage and resiliency.
- **Open, community-driven development** with exciting capabilities ahead.

Get Involved, Try It, and Help Build the IP400 Network!

Learn More: ip400.adrcs.org