



## 6. DIGITAL MODES – AI6JB

# Chapter 6 Digital Modes

ARRL General Class

Sections 6.3 Packet-Based Modes





## Section 6.3

# Packet-Based Modes & Systems

Packet-based or structured modes are derived from early teletype-over-radio modes (TOR) and computer-to-computer network protocols

Hams have adapted these protocols, creating packet radio, PACTOR, WINMOR, and other communication systems

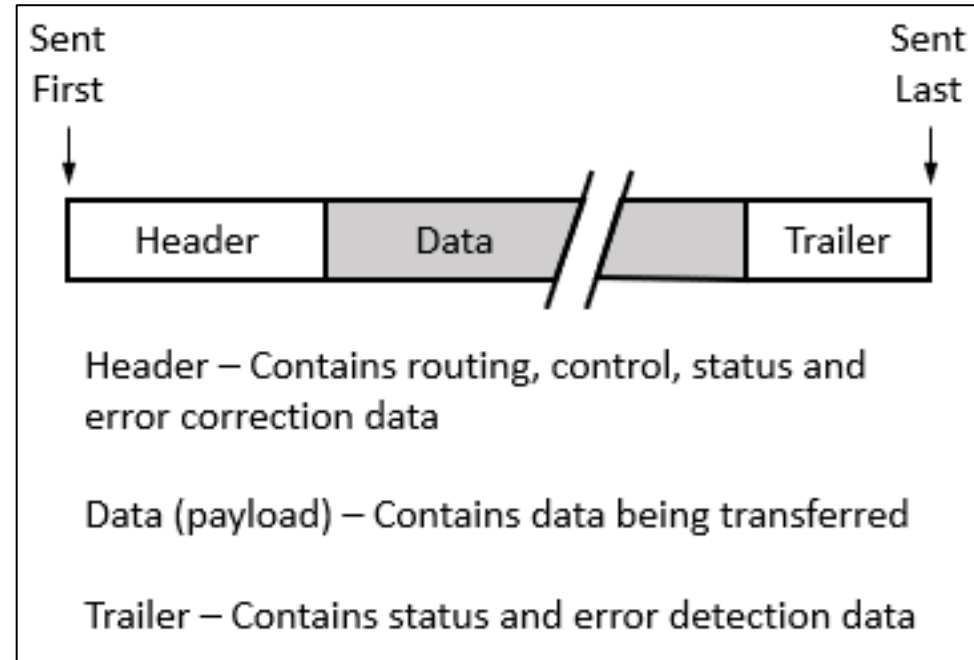
Some packet modes (JT65 & FT8) require precisely-defined transmission periods ... utility software is available to keep your computer synchronized to within 1 second of standard time



# Packet Basics

Packet refers to the transmission of data in structured groups (frames)

Packet communication systems package data with control and routing information and add error detection information. Each package of header, data, and trailer is called a frame. Different packet protocols use different sets of information and methods of creating the frame.





## Packet Basics (cont.) ... see Fig 6.2

Header – Contains bit patterns that allow receiver to synch with the packet's structure, control, and routing information, and for some protocols, error detection/correction information.

Data – Data to be exchanged between the systems. Usually ASCII characters. Usually compressed for efficiency.

Trailer – Additional info used for error detection.

- Forward error correction (FEC) goes beyond simply detecting errors. By including redundant encoded info with the data, it's possible for receiver to CORRECT certain types of data errors.
- Most common error detection mechanism is a cyclic redundancy check or CRC



# Automatic Repeat reQuest (ARQ) Systems

If mismatch is detected, receiving system responds with NAK (not acknowledged) and protocol requests retransmission

Transmitting system will continue to send packet until received without errors or retransmission limit is exceeded

ARQ used in modes: PACTOR, packet radio, WINMOR, etc.

ARQ protocols were designed for wired network connections, and the transmission can only be received from one receiving station during the connection. This means you can't break in to an ongoing contact between two stations using an ARQ mode.



## ARQ (cont.)

So that a station can advertise its presence, ARQ protocols provide a broadcast mode to transmit without another station having established a contact

A MON mode is also provided so that other stations can listen to the conversation without error correction

Using the MON (monitoring) mode allows you to determine if a frequency is occupied by 2 stations having an ARQ mode contact

- Designed to transfer data between only two stations ... meaning you can't break in to an ongoing contact



# Packet Radio

TOR systems developed to compensate for transmission errors in RTTY (e.g., MTOR, G-TOR, etc.)

Used almost exclusively on UHF bands

Sends short bursts of characters with error detection and correction data

Based on computer network protocol X.25

- One of the oldest packet-switching communication protocols
- Popular during the late 1970s and 1980s (computer industry)

Packets exchanged using VHF FM voice at 1200 or 9600 baud

Does not work well with HF because data are easily disrupted by noise and fading (even at 300 baud allowed on HF)



# PACTOR and WINMOR

Original TOR protocols (AMTOR, G-TOR) are reliable, but slow

PACTOR (Packet-based TOR) and WINMOR (Windows TOR) addresses reliability AND speed ... extends TOR capability

PACTOR 1 uses FSK (frequency shift key) modulation; PACTOR 1 thru 4 use advanced PSK modulation (PACTOR 4 not yet legal for US amateurs)

PACTOR and VARA modes overcome some of the issues with HF (e.g., garbled text over fading signal paths)

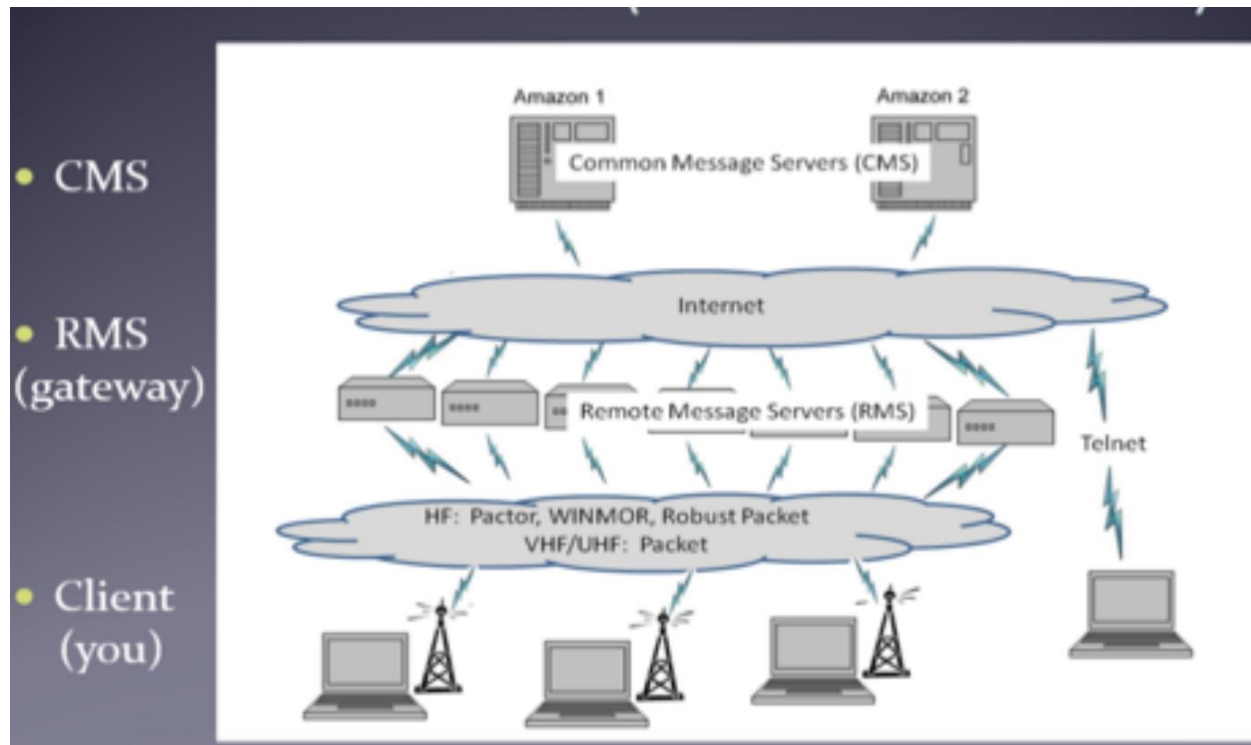




# WINLINK ([www.winlink.org](http://www.winlink.org))

Enables transferring of email messages & digital files via radio

Winlink isn't a mode ... it's a gateway communication system





# WINLINK ([www.winlink.org](http://www.winlink.org))

Uses internet to connect its email servers with gateway and mailbox stations around the world on HF, VHF and UHF

- Winlink stations do not connect directly with the internet, but provide a means for stations out of local internet connection range
- Even without internet connectivity, Winlink Express can act as standalone mailbox stations or communicate directly with each other
- On HF, WINLINK uses PACTOR and VARA modes (VARA is the more popular)
  - VARA is a TOR software developed by EA5HVK Software



# FT8 & WSPR (WS = Weak Signal)

Supported by the WSJT software suite (and JT65, MSK144, etc.)

- <https://wsjt.sourceforge.io/wsjt.html>
- Uses 8-tone frequency shift keying modulation and error decoding/correction to enable successful decoding at very low signal-to-noise ratios (SNR)

FT8 sends 75-bit messages ... limits messages to call signs, grid locators, signal reports, etc.

- FT8 signal reports are on the signal-to-noise ratio, so a report of +3 means the signal is 3dB above the noise floor

Most common FT8 transmission range is 14.074 and 14.077 MHz

- Be sure to locate a clear frequency and select the time slot that doesn't interfere with the calling station. Specifically, when responding, select a clear frequency in the alternate time slot to that used by the calling station.

WSPR (“whisper”) experiments with HF propagation paths at very low signal-to-noise ratios ... does not support 2-way QSOs

Low power WSPR transmitters generate coded packets; stations that receive these report success on [www.wsprnet.org](http://www.wsprnet.org)



# Amateur Wireless Networks

Certain wireless networking frequencies overlap with amateur bands (see Table 6.2)

Amateurs are able to use them for many of the same purposes that unlicensed users are able to (text messages, Voice Over IP, email, etc.)

If you operate a wireless network on FCC Part 97 frequencies, you must comply with the prohibitions on encryption

Hams use two basic network topologies; mesh and star configurations

An advantage of the mesh networking topology is that if one node fails, a packet may be able to find its destination by routing through another available node



# Wireless Networking Frequencies

<i>airMAX</i>	<i>Ubiquiti</i>	<i>ISM</i>	<i>Amateur</i>
M900 900MHz	902 – 928	902 – 928	902 – 928
M2 2.4 GHz	2402 – 2462	2400 – 2500	2390 – 2459
M3 3 GHz <sup>1</sup>	3370 – 3730		3300 – 3500 <sup>3</sup>
M5 5GHz	5725 – 5850	5725 – 5875 <sup>2</sup>	5650 – 5925

<sup>1</sup>For export from USA

<sup>2</sup>U-NII: 5150 – 5350, 5470 – 5825 MHz

<sup>3</sup>ARRL Band Plan



# AREDN (AMATEUR RADIO EMERGENCY DATA NETWORK)

A mesh network

Uses commercially available routers in the 900 MHz, 2.4, 3.4, and 5.8 GHz amateur bands

Supported device list at:

- <https://www.arednmesh.org/content/supported-platform-matrix>

Generally used during emergencies or to support community events like road races, parades, and other large gatherings



# QUESTIONS?

ONLINE EXAM REVIEW AND PRACTICE QUESTIONS:

<http://www.arrl.org/examreview>