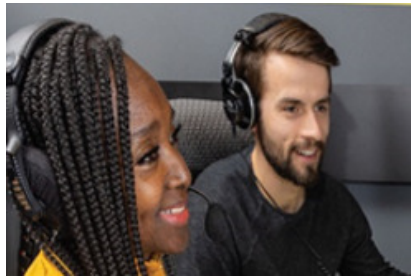
THE ARRL

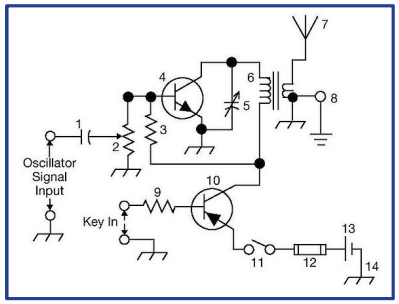
TENTH EDITION

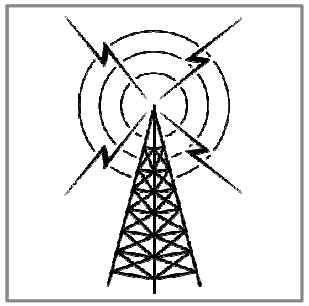
GENERAL

LICENSE COURSE FOR HAM RADIO CLASS

All You Need to Pass Your General Class Exam!

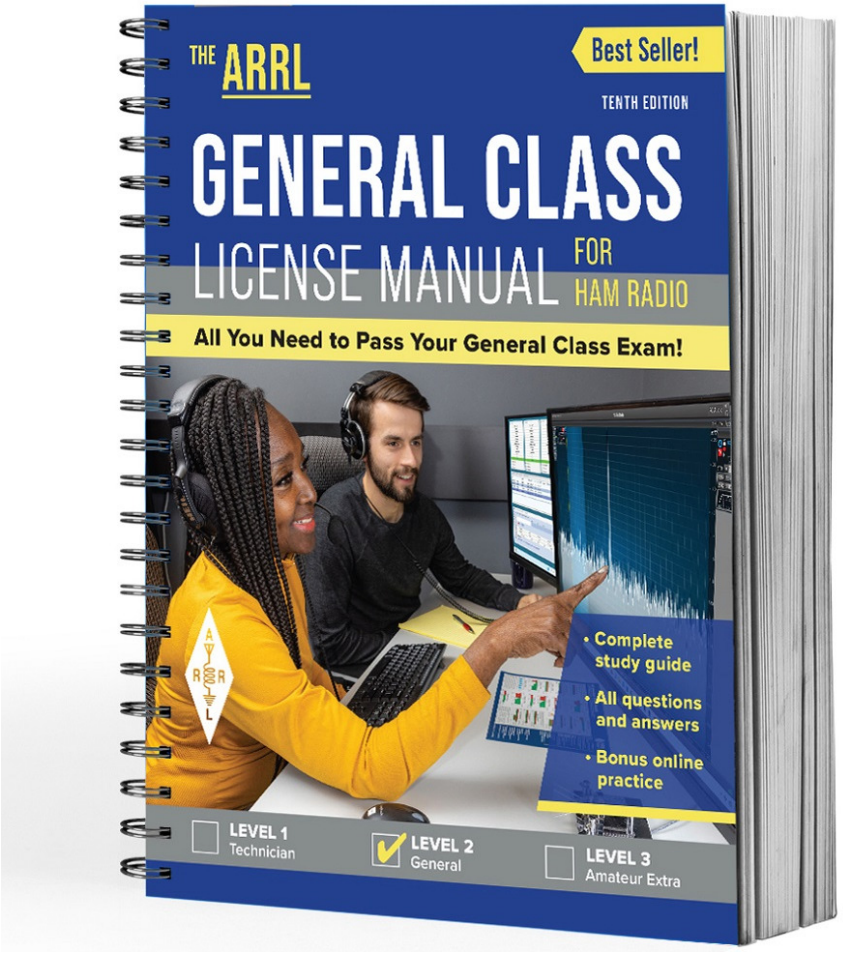






Resource & Reference

www.arrl.org/shop/Licensing-Education-and-Training



Chapter 6 Part 1 of 1

ARRL General Class
Digital Modes
Sections 6.1, 6.2, 6.3, 6.4, 6.5

Basics of Digital Modes, Character-Based Modes, Packet-Based Modes & Systems, Receiving & Transmitting Digital Modes, Digital Operating Procedures

Section 6.1

Basics of Digital Modes: Where to Find Digital Activity

- Communications are digital modes if info is exchanged as individual characters encoded as digital bits … Morse Code (CW), radioteletype, PSK31, FT8, D-STAR, DMR, slow-scan TV, etc.
- Digital modes are restricted to CW/data segments of each HF band *
  - Found near top of CW segment
  - Example: On 20 meters, most PSK signals are near 14.070 MHz. RTTY and other digital modes are found above that between 14.070 and 14.112 MHz. See Table 6.1.

** CW isn't formally restricted anywhere in the ham bands*

Digital Modes Overview

- Data rates and bandwidths specified by FCC rules
- Digital codes not specified by the FCC *must be public*
- Radioteletype (RTTY) – originally used mechanical teleprinters but migrated to computer sound cards
- PSK31 – good weak signal mode using low transmitter power and very narrow bandwidth (computer sound card)
- PACTOR – stands for PACket Teletype Over Radio
- WINMOR – stands for WINdows Messaging Over Radio
- Packet Radio – common on the VHF and UHF bands (1200 & 9600 baud)

Table 6.1: Digital Signal Band Plan (HF Bands)

Band (meters)	Frequency Range (MHz)	Notes
160	1.800 – 1.810	FT8 is on 1.840 MHz
80	3.570 – 3.600	
60	5332, 5348, 5358.5, 5373, 5405 kHz	Channel center frequencies
40	7.070 – 7.125	RTTY DX calling frequency 7.040
30	10.130 – 10.150	
20	14.070 – 14.0995 and 14.1005 – 14.112	PSK31 calling frequency 14.070
17	18.100 – 18.110	
15	21.070 – 21.110	
12	24.920 – 24.930	
10	28.070 – 28.189	

Definitions

- Air link: the part of the comm system that involves radio transmission and reception of signals
- Bit: the fundamental unit of data; a 0 or 1 representing all or part of a binary number
- Bit rate: number of digital bits/second sent from one system to another
- Baud(s): number of symbols/second sent from one system to another
- Duty cycle: ratio of time that transmitter is on to total time plus off time
- Protocol: rules that control the method used to exchange data between systems
- Mode: combination of a protocol with a modulation method

CLARIFICATION: *Digital voice modes* are regulated as voice emissions by the FCC. Examples include; Icom's D-STAR, Yaesu's System Fusion, AOR's digital voice system, DMR.

Frequency Shift Keying (FSK)

VFO = variable frequency oscillator

- Individual bits of data encoded as tones
  - As data are transmitted, different tone frequencies are used
- The frequencies in a two-tone FSK signal are called *mark* and *space*
  - Space represents 0, mark represents 1
- In "direct" FSK, the frequency of the transmitter's VFO is controlled by a digital data signal from the computer
- Audio FSK (AFSK) – audio tones modulate an SSB or FM transmitter through the mic input
- Multiple FSK – more than 2 tones are used to create more codes

Phase Shift Keying (PSK)

- Most common type of phase shift is to invert one of the tone waveforms (shifting phase 180°)
- Rapid changes in phase can be heard from human ear as a raspy noise of buzz – the signature of PSK signals on the air received by a CW or SSB receivers (sort of like the sound on an old computer modem)

PRACTICE QUESTIONS

In what segment of the 20-meter band are most digital mode operations commonly found?

A. At the bottom of the slow-scan TV segment, near 14.230 MHz
B. At the top of the SSB phone segment, near 14.325 MHz
C. In the middle of the CW segment, near 14.100 MHz
D. Between 14.070 MHz and 14.100 MHz

How is direct binary FSK modulation generated?

A. By keying an FM transmitter with a sub-audible tone
B. By changing an oscillator's frequency directly with a digital control signal
C. By using a transceiver's computer data interface protocol to change frequencies
D. By reconfiguring the CW keying input to act as a tone generator

How are the two separate frequencies of a Frequency Shift Keyed (FSK) signal identified?

A. Dot and dash
B. On and off
C. High and low
D. Mark and space

Which of the following provide digital voice modes?

A. WSPR, MFSK16, and EasyPAL
B. FT8, FT4, and FST4
C. Winlink, PACTOR II, and PACTOR III
D. DMR, D-STAR, and SystemFusion

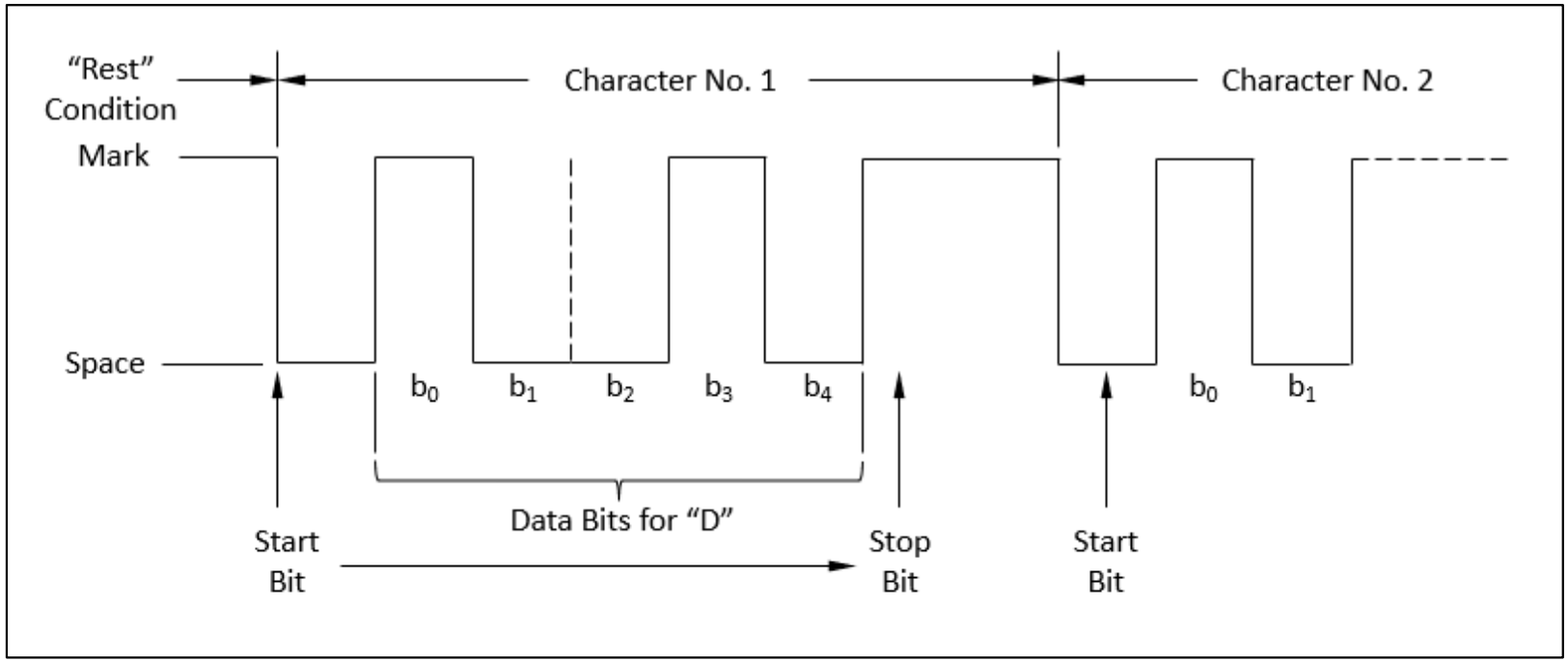
Section 6.2

Character-Based Modes

- Simplest use of digital communications is a mode in which individual characters are entered by an operator, then transmitted to another station where they are read by another operator (e.g., CW)
- Speeds are low, but convenient to use and require little additional equipment other than sound card or modem
- Sometimes referred to as *keyboard-to-keyboard* or *chat*
- Transmit a stream of characters without additional data (referred to as *unstructured*)

RTTY: Oldest form of ham radio digital communications

Fig 6.1: The Baudot timing sequence for the bit pattern that encodes the letter **D**. The start bit is sent first. Start / stop bits are required to allow the receiving and transmitting systems to sync. Mark / space are represented as audio tones in the signal. Baudot is origin of term *baud*.



Referred to in FCC rules as *narrowband, direct-printing telegraphy*

Radioteletype (RTTY)

- RTTY uses Baudot code (represents each character as a 5-bit sequence)
  - 5 bits allow for 32 different characters … not enough for entire English alphabet, numerals, and punctuation
  - 2 special codes (LTRS & FIGS) are used to switch between 2 character sets (doubles number of available characters)
- The difference between the mark and space tones (see Fig 6.1) is called the signal's *shift*
- You should always answer an RTTY station at same speed and shift it's using
  - Most common HF phase shift is 170 Hz

PSK31 (Phase Key Shifting)

- Most popular PSK mode (also called 31 Baud)
- Uses a sound card to generate RTTY signals
- *31* is the symbol rate (actually 31.25 baud)
- Designed for keyboard-to-keyboard communication (typing rates up to 50 wpm)
- Also referred to as BPSK31
- QPSK31 (Quadrature PSK31) sends TWO audio tones, so there are now *four* possible phase shift combinations

PSK31 (cont.)

- Since PSK has two tones, you have to select the right sideband (USB or LSB) to decode the data … *sideband sensitive*
- PSK uses a variable length character code called *Varicode* that assigns shorter codes to common characters and longer codes for uncommon characters (like Morse code)
  - Capital letters & punctuation take longer to send
  - If you're used to RTTY (no lower case), turn off CAPS LOCK!
- QPSK31 / PSK31 have about the same bandwidth (2.5 kHz)
- QPSK31 is sideband sensitive and its encoding provides error detection

PRACTICE QUESTIONS

What is the most common frequency shift for RTTY emissions in the amateur HF bands?

A. 85 Hz
B. 170 Hz
C. 425 Hz
D. 850 Hz

Which of the following is characteristic of QPSK31?

A. It is sideband sensitive
B. Its encoding provides error correction
C. Its bandwidth is approximately the same as BPSK31
D. All these choices are correct

Which of the following describes Baudot code?

A. A 7-bit code with start, stop, and parity bits
B. A code using error detection and correction
C. A 5-bit code with additional start and stop bits
D. A code using SELCAL and LISTEN

Which of the following statements is true about PSK31?

A. Upper case letters are sent with more power

B. Upper case letters use longer Varicode bit sequences and thus slow down transmission

C. Error correction is used to ensure accurate message reception

D. Higher power is needed as compared to RTTY for similar error rates

Which type of code is used for sending characters in a PSK31 signal?

A. Varicode
B. Viterbi
C. Volumetric
D. Binary

G8C12 (A) Page 6-5

Section 6.3

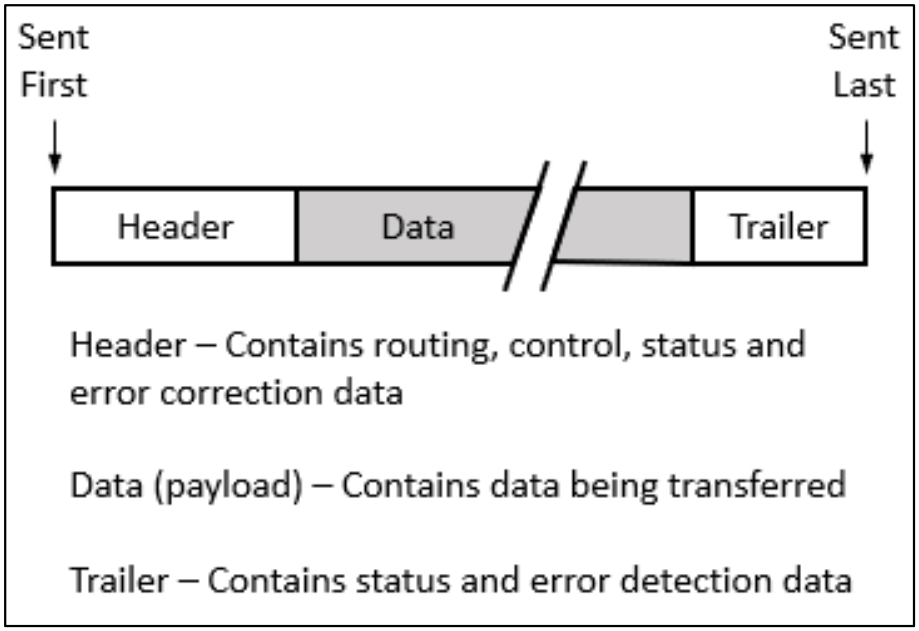
Packet-Based Modes & Systems

- 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*)

Figure 6.2: 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)

- Enables transferring of email messages & digital files on HF bands
- Winlink isn't a *mode* … it's a *gateway* communication system
- 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/wsjtx.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

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

Table 6.2: Wireless Networking Frequencies

airMAX	*Ubiquiti*	*ISM*	*Amateur*
M900 900MHz	902 – 928	902 – 928	902 – 928
M2 2.4 GHz	2402 – 2462	2400 – 2500	2390 – 2459
M3 3 GHz1	3370 – 3730		3300 – 35003
M5 5GHz	5725 – 5850	5725 – 58752	5650 – 5925

[1]For export from USA
[2]U-NII: 5150 – 5350, 5470 – 5825 MHz
[3]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

PRACTICE QUESTIONS

What is VARA?

A. A low signal-to-noise digital mode used for EME (moonbounce)
B. A digital protocol used with Winlink
C. A radio direction finding system used on VHF and UHF
D. DX spotting system using a network of software defined radios

Which of the following is good practice when choosing a transmitting frequency to answer a station calling CQ using FT8?

A. Always call on the station's frequency
B. Call on any frequency in the waterfall except the station's frequency
C. Find a clear frequency during the same time slot as the calling station
D. Find a clear frequency during the alternate time slot to the calling station

Which of the following is required when using FT8?

A. A special hardware modem
B. Computer time accurate to within approximately 1 second
C. Receiver attenuator set to -12 dB
D. A vertically polarized antenna

How do you join a contact between two stations using the PACTOR protocol?

A. Send broadcast packets containing your call sign while in MONITOR mode

B. Transmit a steady carrier until the PACTOR protocol times out and disconnects

C. Joining an existing contact is not possible, PACTOR connections are limited to two stations

D. Send a NAK code

What is the primary purpose of an Amateur Radio Emergency Data Network (AREDN) mesh network?

A. To provide FM repeater coverage in remote areas

B. To provide real time propagation data by monitoring amateur radio transmissions worldwide

C. To provide high-speed data services during an emergency or community event

D. To provide DX spotting reports to aid contesters and DXers

Which of the following describes Winlink?

A. An amateur radio wireless network to send and receive email on the internet
B. A form of Packet Radio
C. A wireless network capable of both VHF and HF band operation
D. All of the above

What is another name for a Winlink Remote Message Server?

A. Terminal Node Controller
B. Gateway
C. RJ-45
D. Printer/Server

G2E13 (B) Page 6-8

Which of the following is a common location for FT8?

A. Anywhere in the voice portion of the band
B. Anywhere in the CW portion of the band
C. Approximately 14.074 MHz to 14.077 MHz
D. Approximately 14.110 MHz to 14.113 MHz

What type of modulation is used by FT8?

A. 8-tone frequency shift keying
B. Vestigial sideband
C. Amplitude compressed AM
D. 8-bit direct sequence spread spectrum

What is QPSK modulation?

A. Modulation using quasi-parallel to serial conversion to reduce bandwidth
B. Modulation using quadra-pole sideband keying to generate spread spectrum signals
C. Modulation using Fast Fourier Transforms to generate frequencies at the first, second, third, and fourth harmonics of the carrier frequency to improve noise immunity
D. Modulation in which digital data is transmitted using 0-, 90-, 180- and 270-degrees phase shift to represent pairs of bits

Which digital mode is used as a low-power beacon for assessing HF propagation?

A. WSPR
B. MFSK16
C. PSK31
D. SSB-SC

G8C02 (A) Page 6-9

What part of a packet radio frame contains the routing and handling information?

A. Directory
B. Preamble
C. Header
D. Trailer

In an ARQ mode, what is meant by a NAK response to a transmitted packet?

A. Request retransmission of the packet
B. Packet was received without error
C. Receiving station connected and ready for transmissions
D. Entire file received correctly

Which of the following narrow-band digital modes can receive signals with very low signal-to-noise ratios?

A. MSK144
B. FT8
C. AMTOR
D. MFSK32

Which is true of mesh network microwave nodes?

A. Having more nodes increases signal strengths

B. If one node fails, a packet may still reach its target station via an alternate node

C. Links between two nodes in a network may have different frequencies and bandwidths

D. More nodes reduce overall microwave out of band interference

How does forward error correction (FEC) allow the receiver to correct data errors?

A. By controlling transmitter output power for optimum signal strength
B. By using the Varicode character set
C. By transmitting redundant information with the data
D. By using a parity bit with each character

What does an FT8 signal report of +3 mean?

A. The signal is 3 times the noise level of an equivalent SSB signal
B. The signal is S3 (weak signals)
C. The signal-to-noise ratio is equivalent to +3dB in a 2.5 kHz bandwidth
D. The signal is 3 dB over S9

Section 6.4

Receiving & Transmitting Digital Modes

- Most digital modes on HF are transmitted as USB signals
  - Exception … RTTY uses LSB
- Modem or software must be configured to correct baud rate and receiving tone frequency to receive data, even if the signal is strong and seems to be tuned correctly
- Since PSK31 uses a single tone, either USB or LSB will work (most use USB)

Bandwidth of Digital Modes

- Like other amateur signals, digital mode bandwidth is defined by the FCC … §97.3(a)(8)
  - Bandwidth of signal changes with the symbol rate
  - As symbol rate increases, so does the bandwidth needed for the signal needed to transmit them … see Table 6.2 for details
- Most common method of generating / transmitting these modes is to connect to audio output from computer sound card to microphone of an SSB transceiver

Table 6.2

Bandwidth Comparison of Digital Modes

Bandwidths are approximate for the highest commonly used symbol rate and are not specifications

MODE	BANDWIDTH (Hz)
PSK31	50
FT8	50
RTTY	200
MFSK16	300
JT65	350
DominoEX	524
Olivia	1000
WINMOR	1600
MT63	2000
PACTOR-III	2300
PACTOR-4	2300

Be careful when operating near the edge of a data signal band. Using LSB for an FSK mode, the sidebands will be *below* the displayed carrier frequency of you radio.

FSK = Frequency shift keying

Transmitter Duty Cycle

- Most amateur transmitters are not designed to operate at full power for an extended period of time
  - CW only operates at full power 40-50% of the time
  - SSB only operates at full power 20-25% of the time
  - *FM modes operate at full power the entire transmission time!*
- Extended transmissions may be enough to exceed a transmitter's average power rating
  - Reduce transmit power to prevent overheating (usually to 50% of max.)

Digital Mode Signal Quality

- Digital modes can generate interference (like phone and CW)
- For digital modes that use an SSB transmitter to transmit *audio frequency shift keying* (AFSK), the most common problem is supplying too much or too little audio from the computer to the radio's microphone input
- On waterfall displays, the vertical lines represent spurious emissions … caused by overmodulation of the transmitter

MFSK16 (another variation of FSK, m = multi) is a method of signal modulation that extends the radio teletype (RTTY) two-tone technique to multiple tones, producing fewer errors

ALC and Digital Modes (automatic level control)

- Used for preventing excessive drive to amplifier inputs
- ALC circuits reduce gain when power levels get too high
  - However, it comes at a price. The signal compression can result in distortion.
  - Resist temptation to turn up gain
- For digital signals, distortion caused by ALC makes the signal harder to decode and creates spurious emissions, similar to overmodulation
- *When in digital mode, your ALC system should be either disabled or the input level and gain turned down to the point where the ALC does not activate.*

PRACTICE QUESTIONS

Which mode is normally used when sending RTTY signals via AFSK with an SSB transmitter?

A. USB
B. DSB
C. CW
D. LSB

What is the standard sideband for JT65, JT9, FT4, or FT8 digital signal when using AFSK?

A. LSB
B. USB
C. DSB
D. SSB

What could be wrong if you cannot decode an RTTY or other FSK signal even though it is apparently tuned in properly?

A. The mark and space frequencies may be reversed
B. You may have selected the wrong baud rate
C. You may be listening on the wrong sideband
D. All these choices are correct

Why should the ALC system be inactive when transmitting AFSK data signals?

A. ALC will invert the modulation of the AFSK mode

B. The ALC action distorts the signal

C. When using digital modes, too much ALC activity can cause the transmitter to overheat

D. All these choices are correct

Why is it important to know the duty cycle of the mode you are using when transmitting?

A. To aid in tuning your transmitter

B. Some modes have high duty cycles that could exceed the transmitter's average power rating

C. To allow time for the other station to break in during a transmission

D. To prevent overmodulation

What is the relationship between transmitted symbol rate and bandwidth?

A. Symbol rate and bandwidth are not related
B. Higher symbol rates require wider bandwidth
C. Lower symbol rates require wider bandwidth
D. Bandwidth is half the symbol rate

What is indicated on a waterfall display by one or more vertical lines on either side of a data mode or RTTY signal?

A. Long path propagation
B. Backscatter propagation
C. Insufficient modulation
D. Overmodulation

Section 6.5

Digital Operating Procedures
Initiating & Terminating Digital Contacts

- Sample CQ from a digital mode (RTTY, PSK31, etc.) … from KØILP
  - CQ CQ CQ DE KØILP KØILP KØILP K
- Sample/typical response … by KX4IU
  - KØILP KØILP KØILP DE KX4IU KX4IU KX4IU K
- Modes such as PACTOR and VARA … the software or modem will have a specific disconnect message … **BYE** or **D**

*The **K** here is not a typo … used at end of transmission to indicate the other station is to transmit as shown.*

Connecting to Gateway and Mailbox Stations

- The exact connection method depends upon equipment and mode, but begin by sending a **CONNECT** message
- If signal is received without errors, a *training sequence* of packets may be exchanged to determine protocol to use
- Because these stations respond without a human control operator present, FCC classifies them as automatically-controlled digital stations … restricted to certain band segments (Table 6.4)
  - Data also permitted on 6-meter and shorter wavelength bands
- Stations under FCC rules must operate under local or remote control (with control operator in charge of all transmissions)

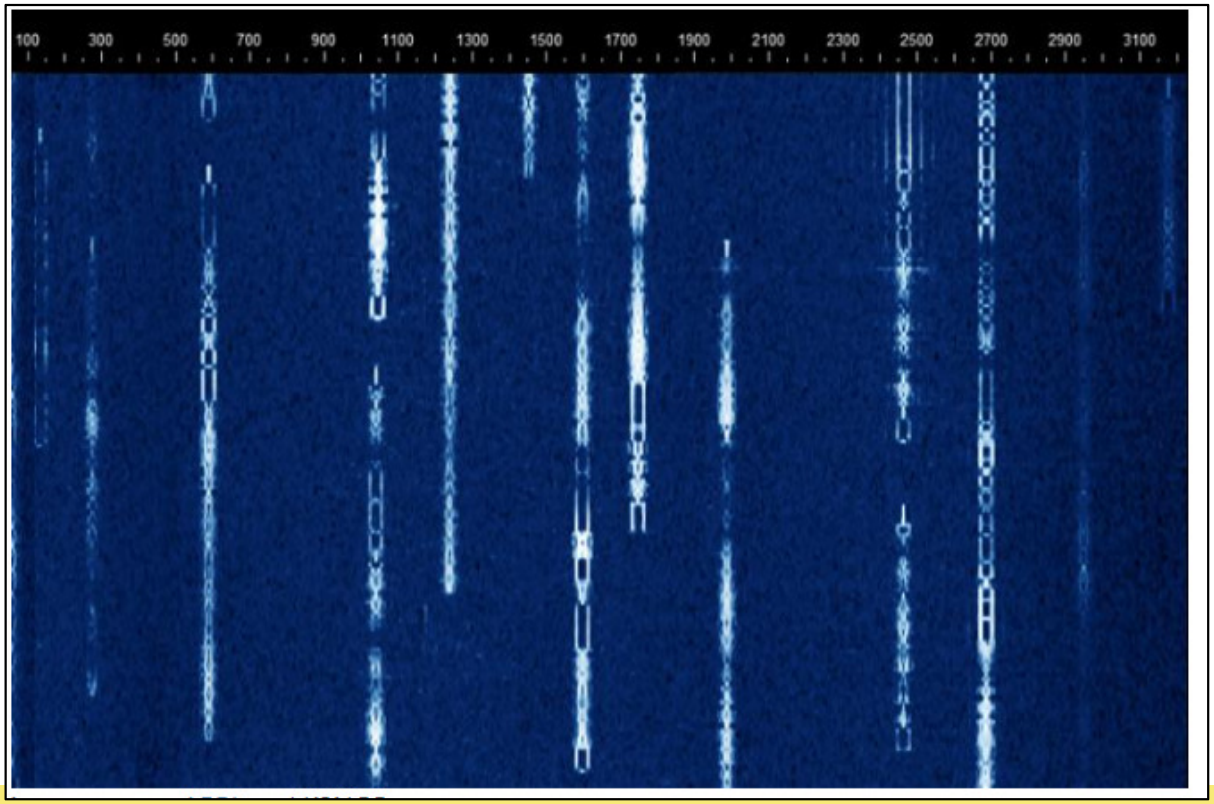
Table 6.4

Automatic Control Band Segments for RTTY & Data

BAND (Meters)	FREQUENCY RANGE (MHz)
160	Not permitted
80	3.585 – 3.600
60	Not permitted
40	7.100 – 7.105
30	10.140 – 10.150
20	14.095 – 14.0995 & 14.1005 – 14.112
17	18.105 – 18.110
15	21.090 – 21.100
12	24.925 – 24.930
10	28.120 – 28.189
6	50.1 – 54.0
2	144.1 – 148

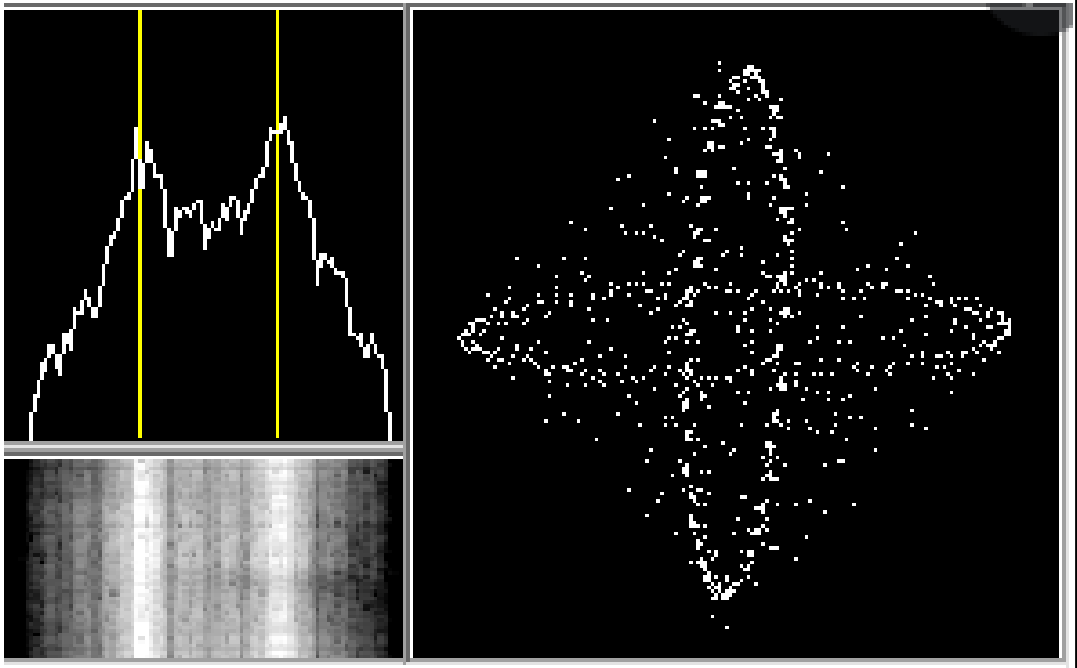
During the Contact (*Operating Displays*) – See Fig 6.5 in text

- A *waterfall* display displays the presence of signals as a series of lines representing a scan across the frequency range
- Signal strength is represented as brightness, intensity, or color
- As new lines are captured, older lines are moved down or to one side, giving the impression of a waterfall



Tuning Aids for RTTY Signal Display

- The left side is a spectrum of the filtered received audio. The vertical lines are at the *mark* and *space* frequencies, and help tune in the signal so the peaks are on the lines (indicating the right tone frequencies)
- The crossed-ellipses on the right are used for fine tuning … ellipses at right angles and the same size indicate correct tuning



Third-Party Traffic in Digital Modes

- All FCC rules about 3rd party messages apply to digital transmissions
  - Includes info in email, digital images, or web pages transmitted via amateur radio
- Commercial messages may not be transmitted via amateur radio

Interfering Signals in Digital Modes

- "Hidden transmitter" problems occur in all modes
  - If you're in a skip zone for one of the stations involved in a contact or that is trying to connect to the same digital station, you won't hear the hidden transmitter, but the receiving station might hear both of you (hidden to YOU)
  - The resulting interference is unintentional but prevents both you and the hidden transmitter from completing a contact
- Packet modes (PACTOR, WINMOR) don't recover from reception difficulties as well as keyboard-to-keyboard modes (RTTY, PSK31), resulting in … failure to connect, frequent retries, transmission delays, timeouts, and dropped connections

PRACTICE QUESTIONS

What is required to conduct communications with a digital station operating under automatic control outside the automatic control band segments?

A. The station initiating the contact must be under local or remote control
B. The interrogating transmission must be made by another automatically controlled station
C. No third-party traffic may be transmitted
D. The control operator of the interrogating station must hold an Amateur Extra class license

G1E03 (A) [97.221] Page 6-15

Under what circumstances are messages that are sent via digital modes exempt from Part 97 third-party rules that apply to other modes of communication?

A. Under no circumstances
B. When messages are encrypted
C. When messages are not encrypted
D. When under automatic control

On what bands may automatically controlled stations transmitting RTTY or data emissions communicate with other automatically controlled digital stations?

A. On any band segment where digital operation is permitted
B. Anywhere in the non-phone segments of the 10-meter or shorter wavelength bands
C. Only in the non-phone Extra Class segments of the bands
D. Anywhere in the 6-meter or shorter wavelength bands, and in limited segments of some of the HF bands

What symptoms may result from other signals interfering with a PACTOR or VARA transmission?

A. Frequent retries or timeouts
B. Long pauses in message transmission
C. Failure to establish a connection between stations
D. All these choices are correct

Which of the following is a way to establish contact with a digital messaging system gateway station?

A. Send an email to the system control operator
B. Send QRL in Morse code
C. Respond when the station broadcasts its SSID
D. Transmit a connect message on the station's published frequency

What action results from a failure to exchange information due to excessive transmission attempts when using an ARQ mode?

A. The checksum overflows
B. The connection is dropped
C. Packets will be routed incorrectly
D. Encoding reverts to the default character set

Which of the following describes a waterfall display?

A. Frequency is horizontal, signal strength is vertical, time is intensity
B. Frequency is vertical, signal strength is intensity, time is horizontal
C. Frequency is horizontal, signal strength is intensity, time is vertical
D. Frequency is vertical, signal strength is horizontal, time is intensity

G8C14 (C) Page 6-16

END OF CHAPTER 6 PART 1 OF 1

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Feel free to contact me if you find errors or have suggestions for improvement.