General License Course

Chapter 5.5
HF Station Installation

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Mobile Installations

- Mobile 100 W HF rigs require 20 A or more current at 12 V minimum
- Power connections go directly to the battery using heavy gauge wire with fuses in both the positive and negative leads*

Do not use a cigarette lighter socket! Wiring not rated for the may be damaged

- Do not assume that the vehicle's metal chassis is a suitable dc ground connection

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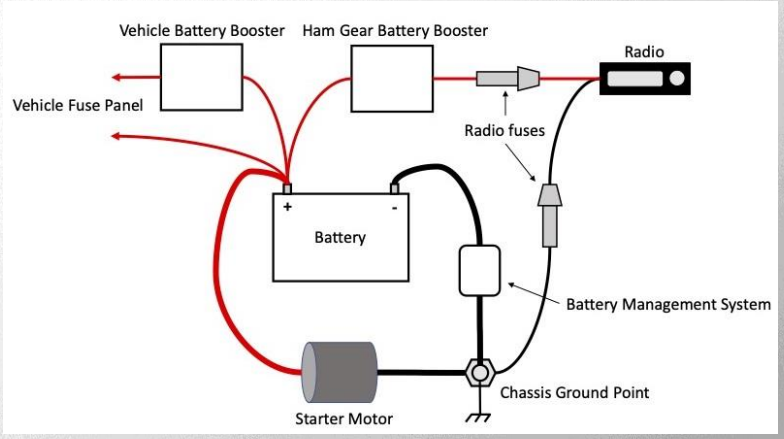
* see next slide...

Mobile Installations

Connect the radio power ground (negative) either directly to the battery or where the battery ground strap attaches to the engine block or vehicle chassis. This is where the battery management system negative connection is made in modern vehicles. This connection must not be bypassed (by your antenna ground connection). Connecting the radio negative lead directly to the battery may also interfere with the operation of any special installation practices used by the manufacturer with respect to galvanic corrosion in aluminum-bodied vehicles, thus voiding the warranty.



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Mobile HF Antennas

- The most significant limitation of mobile HF operating is the antenna system

Electrically short, very inefficient

The 40, 60, 80/75, 160 meter bands are particularly challenging because of electrically short antennas

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Mobile HF Antennas

- The entire vehicle is part of the antenna system
- Use the most efficient antenna you can
- Make sure RF ground connections to the vehicle are solid
- Mount the antenna where it is as clear as possible of metal surfaces

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Mobile Interference - Sources

- Ignition noise from arcs at the spark plugs
- Vehicle's onboard control computers
- Electric fuel pumps and windows
- Battery charging systems
- *All three are correct!*
- Manufacturer service bulletins can help deal with interference and noise problems without voiding warranties

Home Station Grounding

- AC safety ground wiring can act more like an antenna than a ground - Separate RF bonding is intended to keep all equipment grounds at the same RF voltage
- Bond all equipment enclosures/grounds together!
- Minimizes “hot spots” (high RF voltage)
- Prevents hazardous voltages from appearing on the chassis
- Reduces RF current flowing between pieces of equipment which can cause audio distortion or improper operation

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Grounding & Bonding

- During digital operation, RF being picked up on an audio cable (between the computer and transceiver) can cause:
  - Audio distortion resulting in transmitted signal distortion or erratic operation of computer interfaces
  - The transmitter to Key/Un-key improperly (when using VOX)
  - Garbled signals causing data loss or connection timeout

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(demo later)

Grounding & Bonding

- External ground connections – make the connection as short as possible with heavy wire or strap

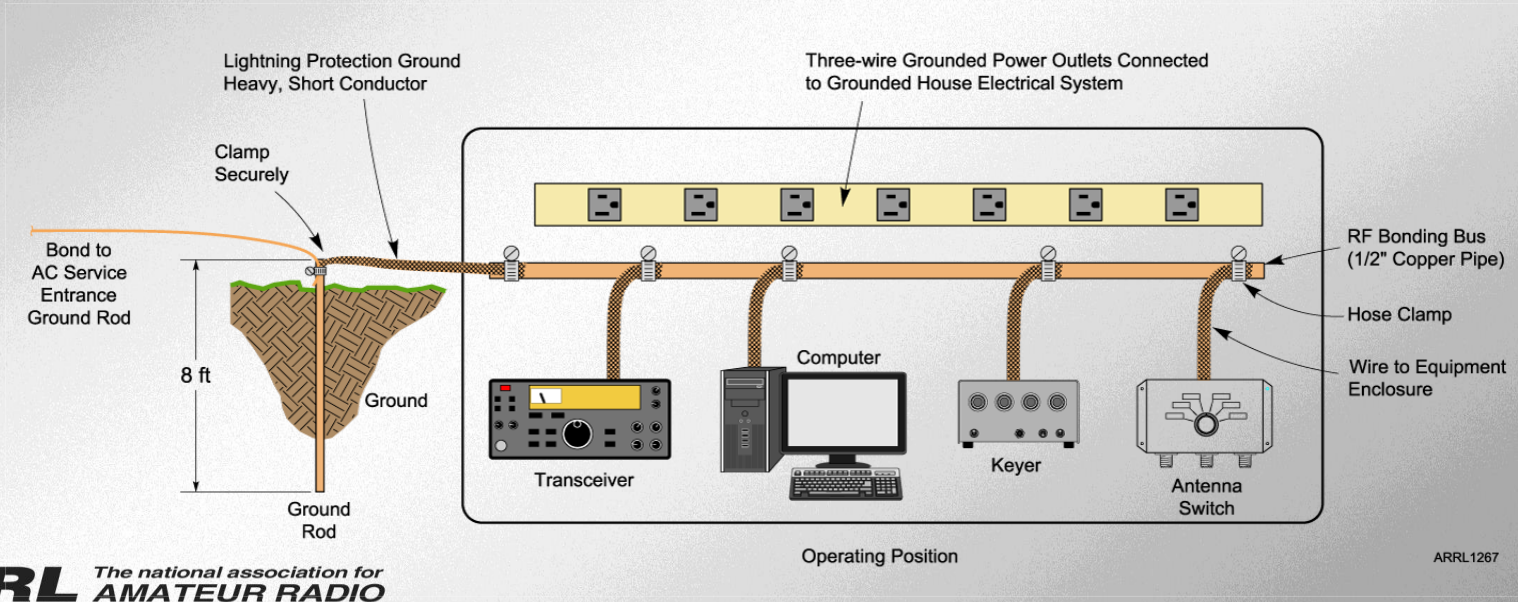
- As ground wire length approaches an odd number of ¼-wavelengths, it presents a high impedance at that frequency (it is resonant) which allows RF voltages on equipment enclosures and connecting cables - beware of RF burns!

Grounding & Bonding

- Ground loops are created when a continuous current path exists through enclosures and cables. Loops are nearly impossible to avoid.
- The loops act as single-turn inductors picking up voltages from magnetic fields. The result can be a “hum” or “buzz” on your transmitted signal, on audio signals, or interference with control or data signals
- Minimize the effect of ground loops by minimizing loop area and connecting all equipment grounds together at a single point.

Grounding & Bonding

- Good practice is to provide good bonding and make earth connections short



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RF Interference

- *Fundamental overload* – radio or TV receivers unable to reject a strong signal. This causes distortion or inability to receive the desired signal.
- Cure – prevent the offending signal from entering the equipment by using filters in the path of the signal.

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RF Interference

- Two types: *Common-mode* *and direct pickup* (or *direct detection)* – The signal is picked up as *common-mode current* on the outside of cable shields or on all conductors of an unshielded connection
- Power cords, speaker leads, telephone cable
- Conducted into the equipment where it causes erratic operation or audio noise
- Cure – block current with RF chokes (Ferrite beads) to increase the impedance of the common-mode noise path

RF chokes made from ferrite cores and beads block common-mode RF current

C:\Users\ai2n\Videos\General Course - Videos\Ferrite_Noise_Reduction.wmv

Ferrites (SDR-Spectrum Analyzer)
(note the “waterfall” display)

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RF Interference

- Distorted speech is heard from an audio device or telephone if there is interference from a nearby single-sideband phone transmitter
- On-and-off humming or clicking is one effect that a nearby CW transmitter may have on an audio device or telephone system

RF Interference

- *Harmonics* – spurious emissions from an amateur station may be received by radio or TV equipment
- Cure – use a low-pass filter at the transmitter to remove the spurious emissions (or a hi-pass filter at the device)
- The filter's impedance must closely match the characteristic impedance of the feed line
- RFI to cable TV may be due to bad connectors allowing external signals to get in (or out – also known as *cable leakage*)

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RF Interference

- *Rectification* – Poor contacts between conductors picking up RF signals can create a mixer and mixing products from the signals – Cure: repair the contact or connection
- *Arcing* – arcing at a poor electrical connection creates interference over a wide frequency range, typically from power-line hardware
  - May require the power company to make the necessary repairs

RF Interference Suppression

- Bypass capacitors CAN be useful in reducing RF interference to audio frequency devices **- but -**
- This is not recommended for modern, solid-state audio amplifier outputs – it may cause them to become unstable (oscillate) and damage the amplifier.
  - Use RF chokes first
  - Twisted-pair speaker cable also helps.
  - Only try bypass capacitors as a last resort on device power and non-audio signal connections

RF Interference

- Intermodulation: Poor contact between conductors picking up two RF signals (f1 and f2) can create a non-linear connection that acts as a mixer and produces mixing products which may interfere with reception
- Cure: find and repair the faulty connection
  - Example: Strong, local AM broadcast stations at 830 and 1000 kHz would generate mixing products at 170 kHz (LF band) and 1830 kHz (MF band ***in the 160 meter amateur band***)

Odd-Order Harmonics

Remember that intermodulation refers to mixing products ($f_1 \pm f_2$). The *odd-order* intermodulation refers to a *harmonic* (i.e., a spurious harmonic emission).

Since *odd-order harmonics are closest* to the original (fundamental) frequency, they refer to the second harmonic of F1 (instead of the 3rd, 4th, etc.).

The frequency of this 2nd harmonic is represented by the formula ($2 \times f_1$ or 2F1)

So, the two intermodulation products of F1 and F2, where F1 is really the 2nd harmonic of F1 would be the sum and difference, *2F1 + F2* and *2F1 – F2*.

Which of the following is an odd-order intermodulation product of frequencies F1 and F2? Answer: *2F1 – F2*

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Take Quiz 1

G4C01 - Which of the following might be useful in reducing RF interference to audio frequency circuits?

A. Bypass inductor

B. Bypass capacitor

C. Forward-biased diode

D. Reverse-biased diode

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G4C02 - Which of the following could be a cause of interference covering a wide range of frequencies?

A. Not using a balun or line isolator to feed balanced antennas

B. Lack of rectification of the transmitter's signal in power conductors

C. Arcing at a poor electrical connection

D. Using a balun to feed an unbalanced antenna

G4C02 - Which of the following could be a cause of interference covering a wide range of frequencies?

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G4C03 - What sound is heard from an audio device experiencing RF interference from a single sideband phone transmitter?

A. A steady hum whenever the transmitter is on the air

B. On-and-off humming or clicking

C. Distorted speech

D. Clearly audible speech

G4C03 - What sound is heard from an audio device experiencing RF interference from a single sideband phone transmitter?

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G4C04 - What sound is heard from an audio device experiencing RF interference from a CW transmitter?

A. On-and-off humming or clicking

B. A CW signal at a nearly pure audio frequency

C. A chirpy CW signal

D. Severely distorted audio

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G4C05 - What is a possible cause of high voltages that produce RF burns?

A. Flat braid rather than round wire has been used for the ground wire

B. Insulated wire has been used for the ground wire

C. The ground rod is resonant

D. The ground wire has high impedance on that frequency

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G4C06 - What is a possible effect of a resonant ground connection?

A. Overheating of ground straps

B. Corrosion of the ground rod

C. High RF voltages on the enclosures of station equipment

D. A ground loop

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G4C08 - Which of the following would reduce RF interference caused by common-mode current on an audio cable?

A. Place a ferrite choke on the cable

B. Connect the center conductor to the shield of all cables to short circuit the RFI signal

C. Ground the center conductor of the audio cable causing the interference

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G4C09 - How can the effects of ground loops be minimized?

A. Connect all ground conductors in series

B. Connect the AC neutral conductor to the ground wire

C. Avoid using lock washers and star washers when making ground connections

D. Bond equipment enclosures together

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G4C10 - What could be a symptom caused by a ground loop in your station's audio connections?

A. You receive reports of "hum" on your station's transmitted signal

B. The SWR reading for one or more antennas is suddenly very high

C. An item of station equipment starts to draw excessive amounts of current

D. You receive reports of harmonic interference from your station

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G4C11 - What technique helps to minimize RF "hot spots" in an amateur station?

A. Building all equipment in a metal enclosure

B. Using surge suppressor power outlets

C. Bonding all equipment enclosures together

D. Placing low-pass filters on all feed lines

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B. To the alternator or generator using heavy-gauge wire

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A. The socket is not wired with an RF-shielded power cable

B. The socket's wiring may be inadequate for the current drawn by the transceiver

C. The DC polarity of the socket is reversed from the polarity of modern HF transceivers

D. Drawing more than 50 watts from this socket could cause the engine to overheat

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B. The wire gauge of the DC power line to the transceiver

C. Efficiency of the electrically short antenna

D. FCC rules limiting mobile output power on the 75-meter band

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G4E07 - Which of the following may cause receive interference to an HF transceiver installed in a vehicle?

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B. The fuel delivery system

C. The control computers

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G6B10 - How does a ferrite bead or core reduce common-mode RF current on the shield of a coaxial cable?

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B. Heterodyning

C. Detection

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A. 5F1-3F2

B. 3F1-F2

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Chapter 6.1 and 6.2
Basics of Digital Modes
and
Character-Based Modes

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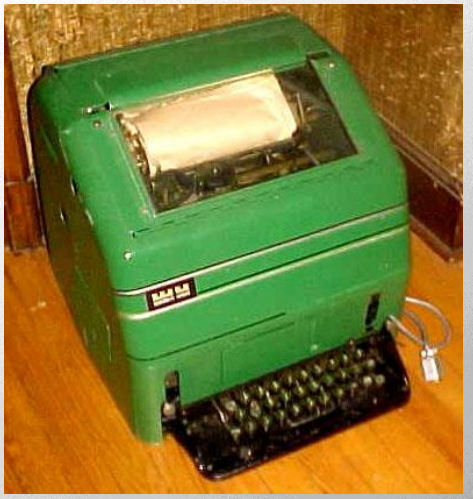
Digital Modes

Radioteletype (RTTY) – invented in the ‘30s, originally used mechanical teleprinters but migrated to computer sound cards



RTTY is popular on all the HF amateur bands (100% duty cycle)

PSK31 and FT8 – good weak signal modes allowing low transmitter power and very narrow bandwidth (computer sound card)

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Digital Modes and Where to Find Them

Band (Meters)	*Notes (MHz)*
160	1.800 – 1.810
80	3.570 - 3.600
60	Data emission not permitted
40	7.080 - 7.125 RTTY DX calling frequency 7.040 MHz
30	10.130 - 10.150
20	14.070 - 14.100 *
→	(PSK31 calling frequency 14.070 MHz, below RTTY seqment)
17	18.100 - 18.110
15	21.070 - 21.110
12	24.920 - 24.930
10	28.070 - 28.150

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* but stay clear of 14.100 Beacon frequency

FSK – AFSK

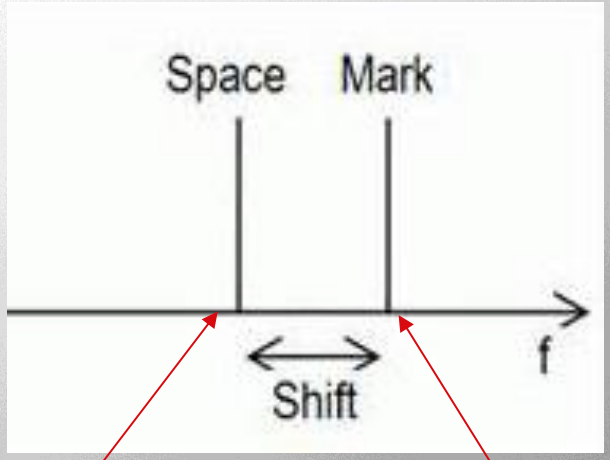
- Frequency Shift Keying (FSK) – the frequency of the transmitter's VFO (oscillator) is controlled directly by a digital control signal from the computer
- *Audio frequency shift keying* (*AFSK*) – audio tones are used to modulate an SSB or FM transmitter through the microphone or other audio input
  - Audio must be kept free of noise
  - ALC and compression must not be used to prevent distortion

Frequency Shift Keying (FSK)

- RTTY signal – two different tones shifting from one frequency to another
- The rapidly changing tones are called *mark* and *space*

Space represents 0
Mark represents 1
170 Hz shift typical

Oldest digital mode – still very popular.



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Radioteletype (RTTY)

- RTTY uses the Baudot code, which represents (encodes) each text character as a sequence of 5 bits
- An initial bit (the *start bit*) and an inter-character pause (the *stop bit*) are used to synchronize the transmitting and receiving stations - these bits are NOT included in the 5 bit character sequence
- So: Baudot code is a **5**-bit code with additional start and stop bits

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PSK31

- The “31” stands for the symbol rate of the protocol, actually 31.25 baud
- BPSK* uses a variable length code called ***Varicode*** that assigns shorter codes to common characters and longer codes for others (the number of data bits required to transmit a character varies)
- Capital letters and punctuation characters take more bits and thus slow down transmission

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*Note: BPSK31 = Binary PSK31, the most common form of PSK31

QPSK31

- QPSK31 (Quadrature PSK) sends two audio tones, allowing 4 (0, 90, 180, 270 degree) phase shift combinations
  - This encoding allows some error correction
  - It is, however, sideband sensitive
  - It occupies about the same bandwidth as BPSK31

All Three...

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PSK31

C:\Users\ai2n\Videos\General Course - Videos\psk-31 demo.wmv

Digital Voice Modes

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, and DMR.

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Take Quiz 2

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G2E08 - 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

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G8A01 - 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

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G8C11 - 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

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G8C16 - 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

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C. Winlink, PACTOR II, and PACTOR III

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G2E06 - 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

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G8A06 - 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

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G8C04 - 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

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G8C08 - 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

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G8C12 - Which type of code is used for sending characters in a PSK31 signal?

A. Varicode

B. Viterbi

C. Volumetric

D. Binary

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Chapter 6.3
Packet-Based Modes

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Packet Radio Basics

- *Packet* refers to the transmission of data in structured groups
- *Header* – at the start of the packet – contains:
  - Synchronization patterns for the receiver
  - Control, routing and handling information
  - Error detection and correction information

Packet - Error Correction

- *Forward error correction* (*FEC*) –includes additional redundant information with the data being transmitted
- *Automatic Repeat reQuest* (*ARQ*) – the protocol requires that a packet with errors in the data be retransmitted
- Uses ACK (rcvd OK) and NAK (error detected – retransmit previous packet) messages to the sending station

Packet - Error Correction

- ARQ protocols are designed to transfer data between two stations
- An *ACK* or *NAK* response to the sending station can only be received from one receiving station
- You can't "break in" to an ongoing contact between two stations using an ARQ mode (PACTOR or WINMOR)

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Packet - Error Correction

- Monitoring or “MON” mode – stations can listen to the ARQ conversation (without connecting) and receive the data without retransmission of “bad” packets
- Monitoring mode allows you to determine if a frequency is occupied
- PACTOR and WINMOR are ARQ protocols – the preferred method of HF data transmission for the popular Winlink email system

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PACTOR and WINLINK

- PACTOR stands for *PACket Teletype Over Radio*
- WINMOR (WINLINK) stands for *Windows Messaging Over Radio* and can also use the Internet if an RF pathway is not available. It's a form to Packet Radio
- Both modes use advanced modulation techniques, including error correction and automatic communication control

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WINLINK

Enables transferring of email messages & digital files on HF bands

Winlink isn't a *mode* … it's a *gateway* communication system utilizing Winlink Remote Message Servers

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

(via relay) 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 digital protocols

(VARA is the more popular)

VARA is software developed by EA5HVK Software

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Newer Packet Modes

- FT8* and WSPR (from WSJT-X family) use precisely timed 8-tone FSK modulation and sophisticated error correction to permit use at very low signal-to-noise ratios
- This requires computer time accuracy within ~1 second of standard time

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*FT8 = 8-tone

Newer Packet Modes

- An FT8 signal report of “+3” represents a signal-to-noise ratio of +3 dB in a 2.5kHz bandwidth
- FT8 is commonly found between 14.074-14.077 MHz on 20 meters
- When on FT8 observe the waterfall display and select an unused audio frequency on which to transmit. When answering a CQ, be sure to call during the alternate (opposite) time slot to the station being called.

FT8 Video – coming soon!

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Newer Packet Modes

- Because of time and bandwidth considerations, FT8 can exchange a limited amount of information, generally call signs, grid locators and signal reports. It is an open-source mode, so variations other than WSJT may behave differently
- WSPR (Whisper) is designed to assess HF propagation at very low signal-to-noise ratios. It does not support two-way communication and acts as a beacon. Successful reception can be reported on websites such as wsprnet.org

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Amateur Radio 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

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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

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AREDN (AMATEUR RADIO EMERGENCY DATA NETWORK)

A mesh network providing high-speed data services

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

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Take Quiz 3

G2E02 - 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. A DX spotting system using a network of software defined radios

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C. A radio direction finding system used on VHF and UHF

D. A DX spotting system using a network of software defined radios

G2E04 - 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

G2E04 - Which of the following is good practice when choosing a transmitting frequency to answer a station calling CQ using FT8?

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G2E07 - 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

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A. A special hardware modem

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D. A vertically polarized antenna

G2E09 - 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

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G2E11 - 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

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G2E12 - 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 these choices are correct

G2E12 - 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

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G2E13 - What is another name for a Winlink Remote Message Server?

A. Terminal Node Controller

B. Gateway

C. RJ-45

D. Printer/Server

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G2E15 - 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

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G8A09 - 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

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G8A12 - 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

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G8C02 - Which digital mode is used as a low-power beacon for assessing HF propagation?

A. WSPR

B. MFSK16

C. PSK31

D. SSB-SC

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A. WSPR

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G8C03 - What part of a packet radio frame contains the routing and handling information?

A. Directory

B. Preamble

C. Header

D. Trailer

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A. Directory

B. Preamble

C. Header

D. Trailer

G8C05 - 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

G8C05 - 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

G8C07 - 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

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C. AMTOR

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G8C09 - 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

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G8C10 - 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

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G8C15 - 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

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Chapter 6.4
Receiving and Transmitting Digital Modes

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Receiving and Transmitting Digital Modes

- AFSK RTTY is transmitted as a LSB signal. Make sure audio levels are adequate (most common problem)
- JT65, JT9, FT4, and FT8 use USB.
- USB/LSB selected by *convention* for each mode.
- Digital signals of the wrong baud rate, on the wrong sideband or with the mark and space frequencies reversed will not decode correctly because the relationship of the tones and the digital data will be inverted. ***(ALL THREE)***

Know where your sidebands are with respect to the displayed frequency – stay in the band!

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Bandwidth of Digital Modes

- The FCC rules define the bandwidth of a digital mode signal in the same way as any other signal
- As the symbol rate of a digital signal increases, so does the bandwidth required to transmit that signal

Bandwidth of Digital Modes

Bandwidth Comparison of Digital Modes

Mode	*Bandwidth (Hz)*
FT8	50
PSK31	50
RTTY	200
MFSK16	300
JT65	350
DominoEX	524
Olivia	1000
WINMOR	1600
MT63	2000
PACTOR-III, -IV	2300

Bandwidths are approximate for the highest commonly used symbol rate and are not specifications. Stay away from band/sub-band edges!

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Transmitter Duty Cycle

- Most amateur transmitters are not designed to operate at full power output for an extended time
- RTTY, PSK31 – nearly 100% duty cycle
- ARQ modes – less than 100% but still high
- Reduce your transmitter power to about 50% of maximum output power for most digital modes

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Digital Mode Signal Quality

- Excess audio levels causes distortion and splatter just as for voice modes
- On a waterfall display, vertical lines to each side of the main signal represents a spurious emission (overmodulation) (more later…)
- Distortion makes a signal harder to copy
- Spurious emissions cause interference
- Keep your data audio levels set correctly

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ALC and Digital Modes

- *Automatic Level Control* (*ALC*) is used to prevent excessive drive to amplifier inputs
- As it changes power levels, ALC can cause distortion of the original signal.
- Distortion caused by ALC makes the signal harder to decode (distorts the signal) and creates spurious emissions
  - Mild distortion caused by ALC is acceptable on voice modes

ALC and Digital Modes

- When using a digital mode, your ALC system should be either disabled or the microphone input level and gain turned down to the point where the ALC system does not activate
- Monitor ALC during digital transmission (usually a meter function selection)

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Take Quiz 4

G2E01 - Which mode is normally used when sending RTTY signals via AFSK with an SSB transmitter?

A. USB

B. DSB

C. CW

D. LSB

G2E01 - Which mode is normally used when sending RTTY signals via AFSK with an SSB transmitter?

A. USB

B. DSB

C. CW

D. LSB

G2E05 - What is the standard sideband for JT65, JT9, FT4, or FT8 digital signal when using AFSK?

A. LSB

B. USB

C. DSB

D. SSB

G2E05 - What is the standard sideband for JT65, JT9, FT4, or FT8 digital signal when using AFSK?

A. LSB

B. USB

C. DSB

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G2E14 - 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

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G4A11 - 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

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D. All these choices are correct

G8B08 - 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

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G8B10 - 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

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B. Higher symbol rates require wider bandwidth

C. Lower symbol rates require wider bandwidth

D. Bandwidth is half the symbol rate

G8C13 - 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

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C. Insufficient modulation

D. Overmodulation

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Chapter 6.5
Digital Operating Procedures

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Listening First

- To avoid causing interference, the control operator:
  - *Must* listen to the received audio or watch a waterfall-style display *before* transmitting
  - It's not enough to just check a BUSY light on a modem
  - Follow good amateur practice and listen, listen, listen!

Automatically Controlled Stations

"Automatically controlled digital station" is the FCC term for an unattended digital messaging system gateway station that transfers messages to and from the Internet.

Unmanned *gateway* and *mailbox* stations (connected to the Internet) monitor a published frequency awaiting stations to connect to them

They respond without requiring a human control operator

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Automatically Controlled Stations

- Establishing a connection will vary with the equipment and mode being used
- The contact starts with sending a CONNECT message (on the station's published frequency) to the station with which you want to connect
- A training sequence then determines the best rate and modulation to use based on conditions
- Once training is completed, a message can then be transferred

Automatically Controlled Stations

- Automatically controlled stations transmitting RTTY or data emissions may communicate with *other* automatically controlled digital stations anywhere where data is permitted in the 6 meter or shorter wavelength bands, and in specified segments of the 80 meter through 10 meter bands. (next slide)

- To conduct communications with a digital station operating under automatic control *outside* the automatic control band segments the station initiating the contact must be under local or remote control.

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Automatically Controlled Stations

Automatic Control Band Segments for RTTY and Data

Band (Meters)	*Frequency range (MHz)*
80	3.585-3.600
40	7.100-7.105
30	10.140-10.150
20	14.095-14.0995 and 14.1005-14.112
17	18.105-18.110
15	21.090-21.100
12	24.925-24.930
10	28.120-28.189

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Digital Contact Display

- The waterfall displays the presence of signals as a series of lines, each representing a scan across the frequency range (horizontal) vs. time (vertical)
- The strength of the signals is represented as the brightness, intensity, or color of the line at each frequency on the display
- The display gives the impression of a “waterfall” as the data flows across the screen in successive scans

FT8 and Waterfall Demo

C:\Users\ai2n\Videos\General Course - Videos\FT8 and Waterfall Demo.MOV

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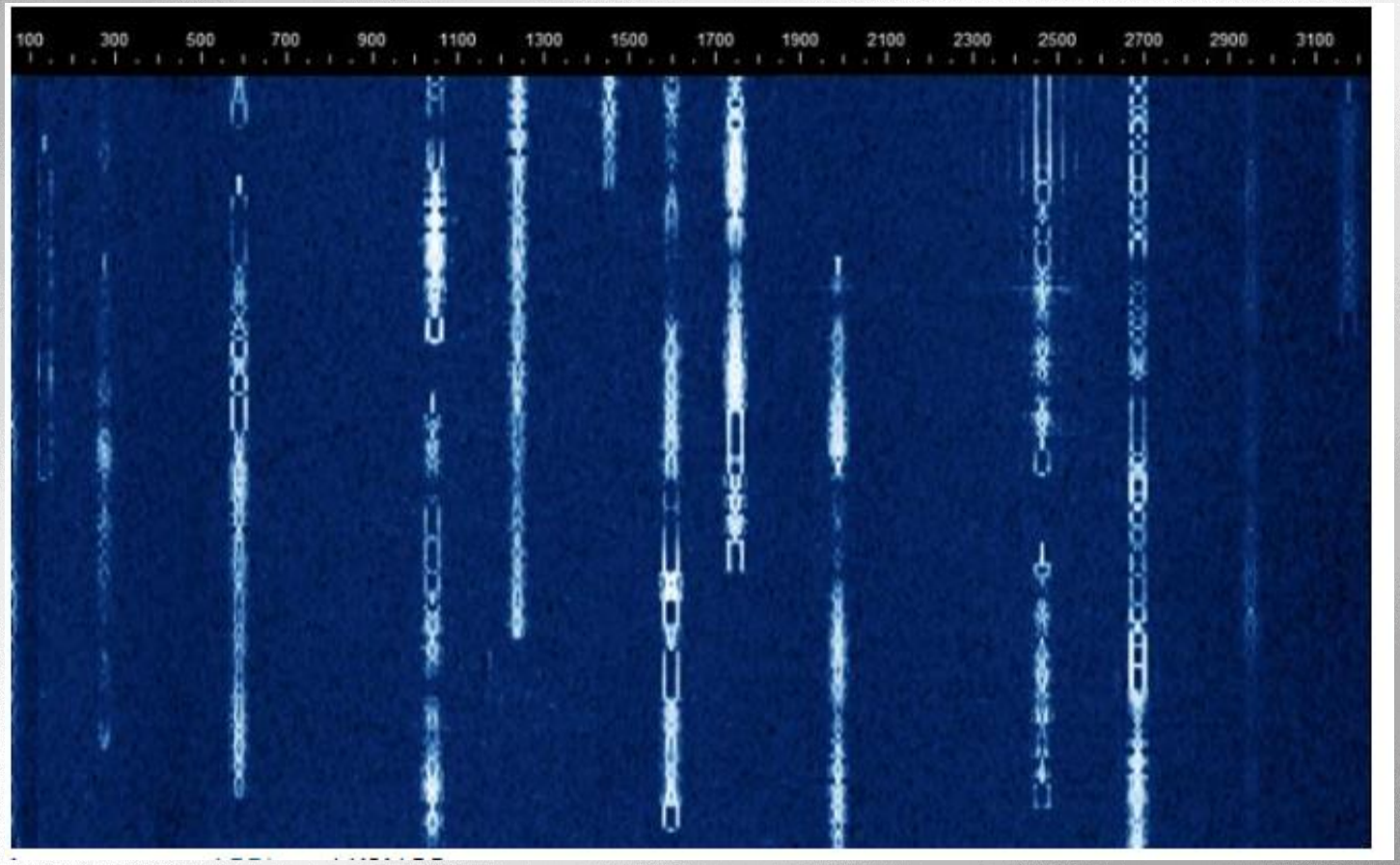
PSK31 Waterfall



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Third Party Traffic

- All FCC rules about third-party messages apply to digital transmissions – NO exemptions ever, anywhere, any mode
- This includes all information included in email, digital images, or web pages transmitted via Amateur Radio
- As always, commercial messages such as advertisements or pertaining to your business may not be transmitted via Amateur Radio

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Interfering Signals

- PACTOR/VARA (Winlink) Symptoms of Interference:
  - Failure to connect to target station
  - Frequent retries or timeouts during data transfer
  - Long pauses in message transmission

- ***ALL THREE...***

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Interfering Signals

- If requested ARQ mode retransmissions exceed a preset limit the connection will be dropped
- Remember, the interference may be accidental; the other station may not hear your signal at all
  - Use a different frequency
  - Aim directional antennas in another direction

Take Quiz 5

G1E03 - 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

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C. No third-party traffic may be transmitted

D. The control operator of the interrogating station must hold an Amateur Extra class license

G1E09 - 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

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A. Under no circumstances

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G1E11 - 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

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G2E03 - 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

G2E03 - What symptoms may result from other signals interfering with a PACTOR or VARA transmission?

A. Frequent retries or timeouts

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D. All these choices are correct

G2E10 - 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

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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

G8C06 - 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

G8C06 - 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

G8C14 - 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 - 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

Next Week
Chapter 7.1-7.4

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