Technician License Course

KE6HEC February 11, 2021

Chapter 5 Part 1

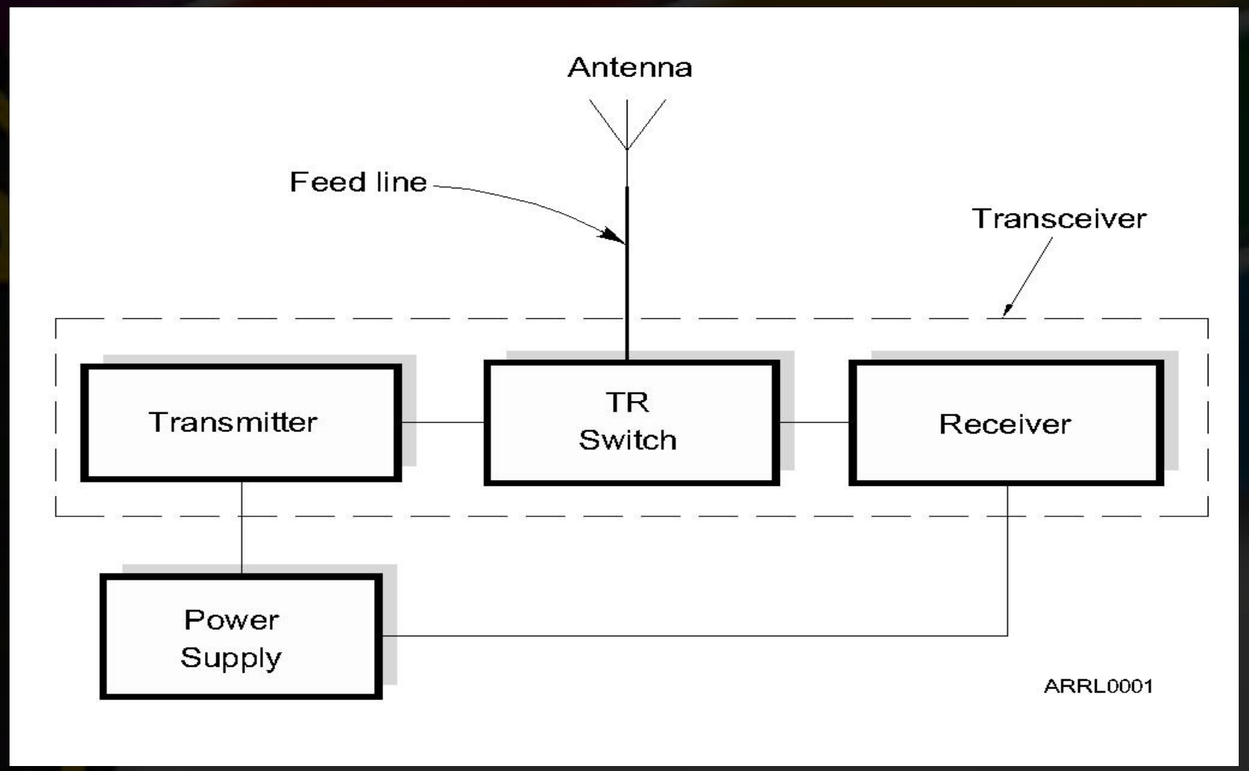
Technician License Course

Chapter 2

Lesson Plan Module - 3

Modulation & Bandwidth

The Basic Radio Station

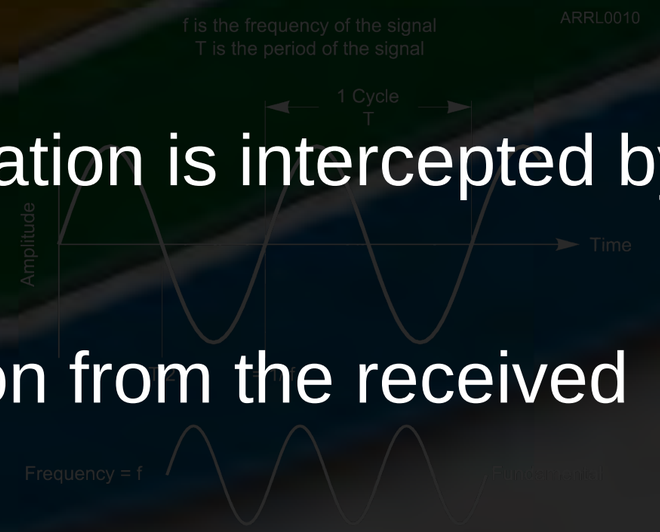


What Happens During Radio Communication?

- Transmitting (sending a signal):
  - –Information (voice, data, video, commands, etc.) is converted to electronic form.
  - –The information in electronic form is added to a radio wave.
  - –The radio wave carrying the information is sent from the station antenna into space.

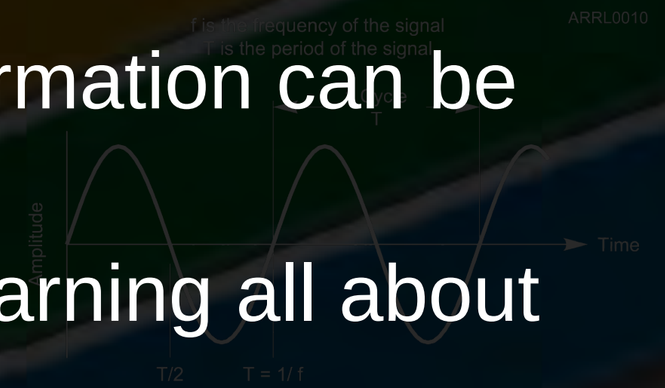
What Happens During Radio Communication?

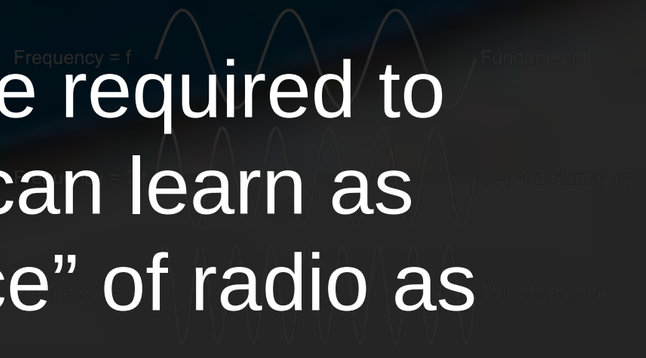
- Receiving:
  - The radio wave carrying the information is intercepted by the receiving station's antenna.
  - The receiver extracts the information from the received wave.
  - The information is then presented to the user in a format that can be understood (sound, picture, words on a computer screen, response to a command, etc.).



What Happens During Radio Communication?

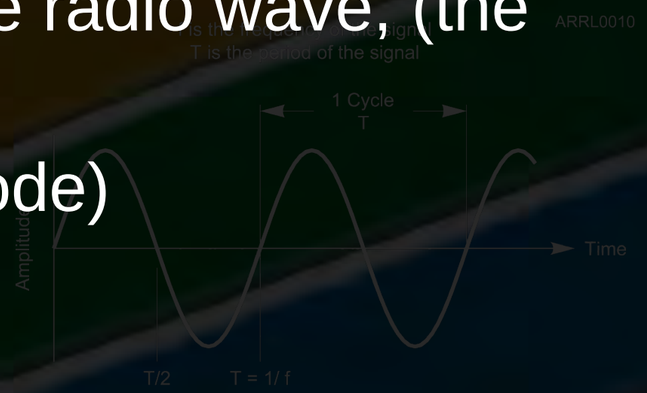
- Adding and extracting the information can be simple or complex.
- This makes ham radio fun…learning all about how radios work.
- Don’t be intimidated. You will be required to only know the basics, but you can learn as much about the “art and science” of radio as you want.





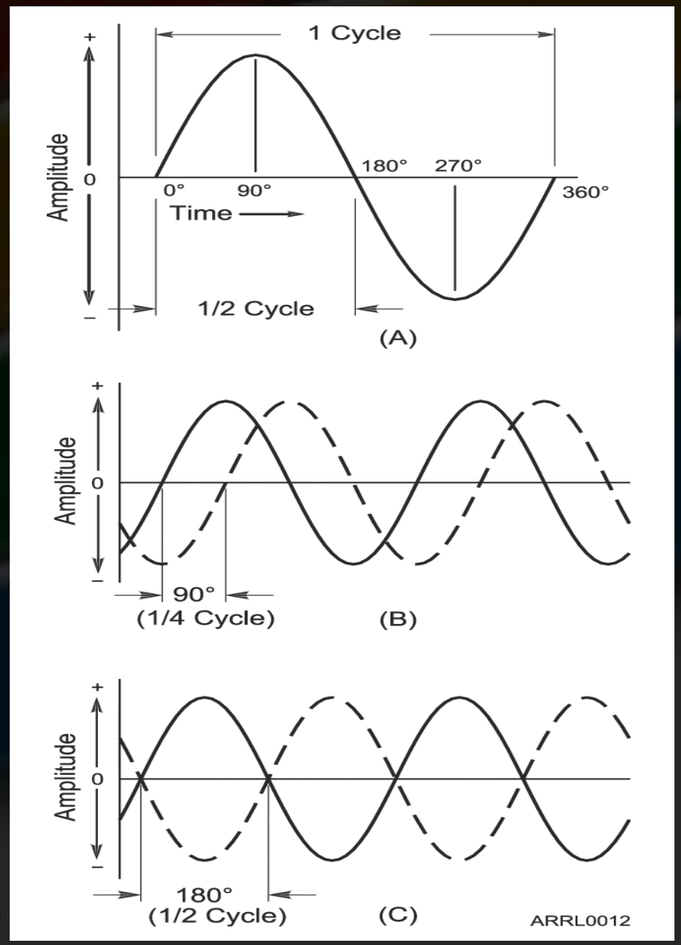
Adding Information – Modulation

- When we add some information to the radio wave, (the *carrier*) we *modulate* the wave.
  - Turn the wave on and off (Morse code)
  - Speech or music
  - Data
- Different modulation techniques vary different properties of the wave to add the information:
  - Amplitude, frequency, or phase

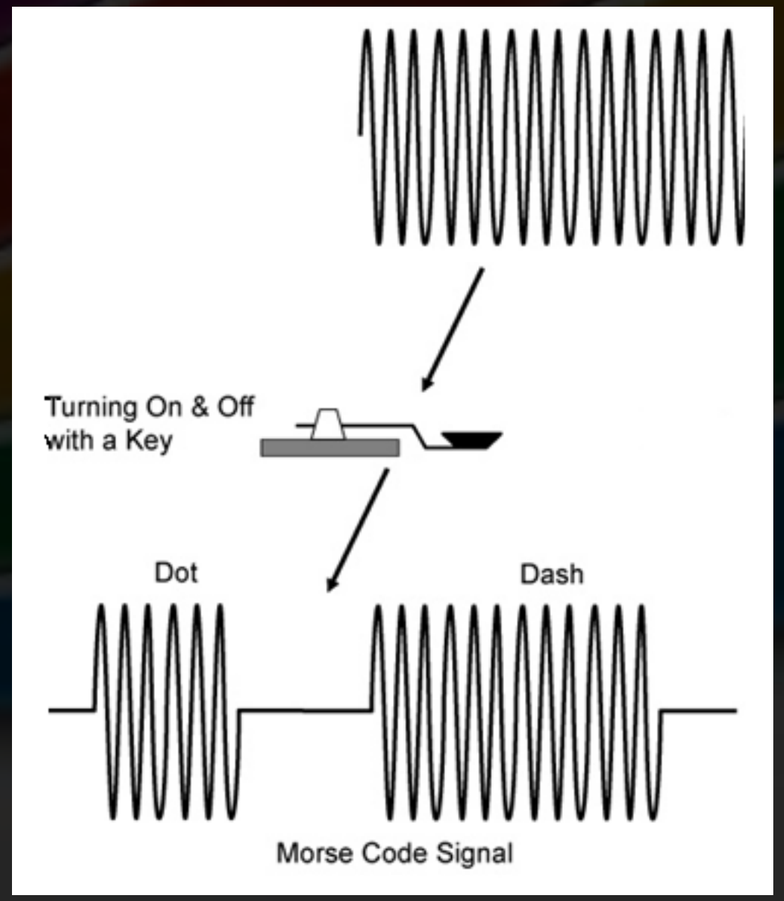


Phase

- Along with frequency and period, another important property of waves is *phase*.
- Phase is a position within a cycle.
- Phase is also a relative position between two waves.

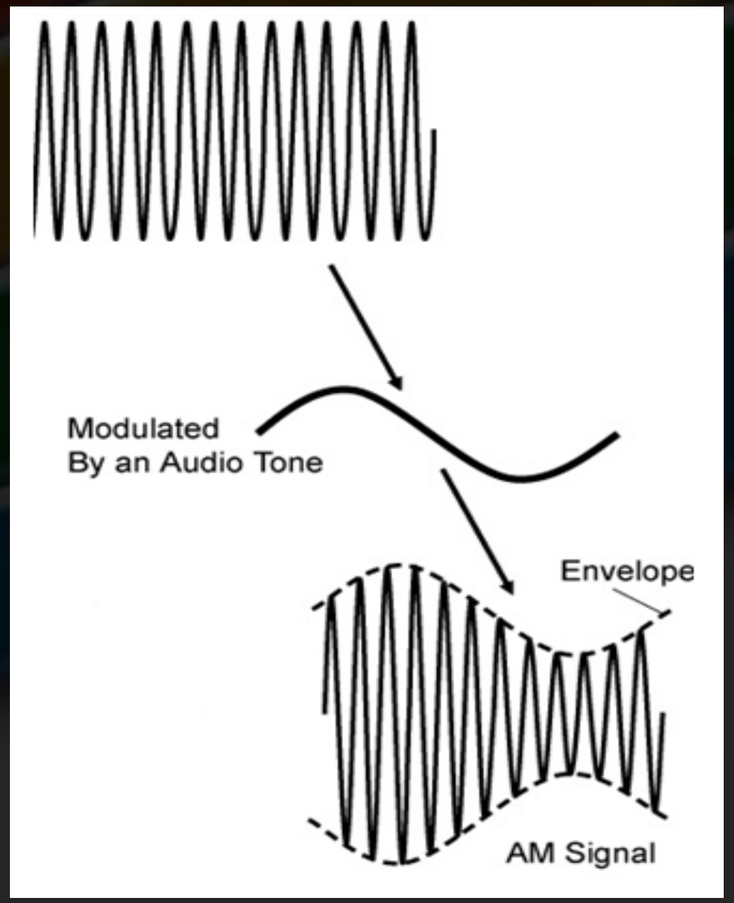


CW - Morse Code – On and Off



Amplitude Modulation (AM)

- In AM, the amplitude of the carrier wave is modified in step with the waveform of the information (the tone shown here).



Composite Signals

- The process of adding information to an unmodulated radio wave creates additional signals called *sidebands*.
- The sidebands and carrier work together to carry the information.
- The combination of carrier and sidebands creates a *composite signal*.

Bandwidth

- The carrier and sidebands have different frequencies, occupying a range of spectrum space.
- The occupied range is the composite signal's *bandwidth.*
- Different types of modulation and information result in different signal bandwidths.

Characteristics of Voice AM

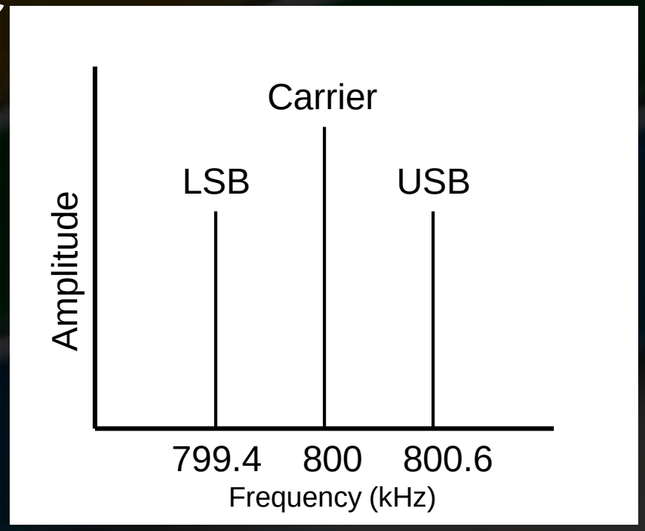
AM signals consist of three components:

–Carrier

–Lower sideband (LSB)

–Upper sideband (USB)

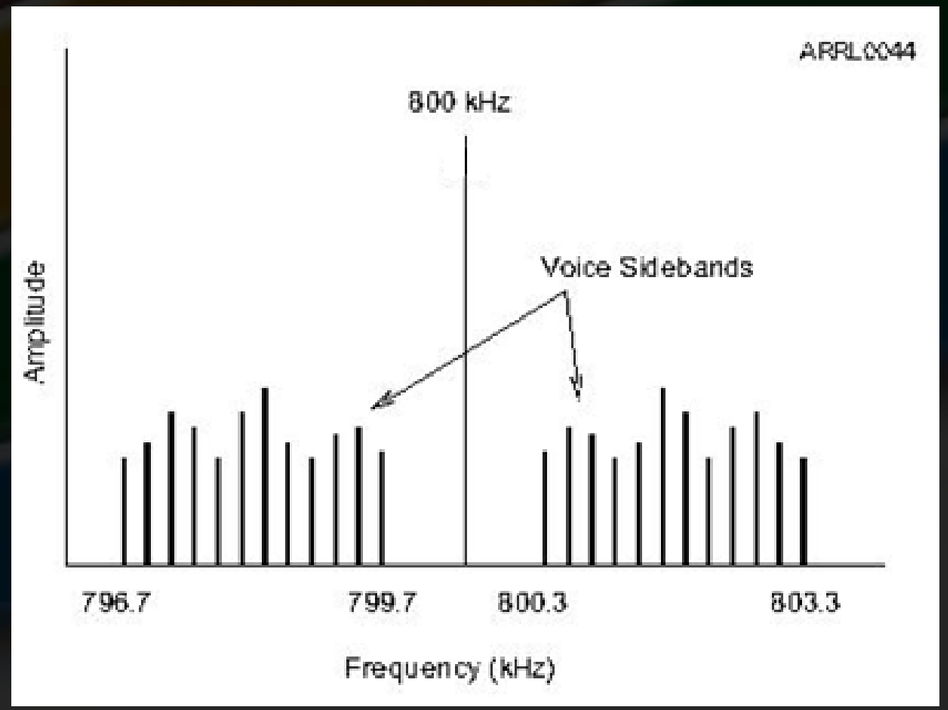
- AM bandwidth is twice the information bandwidth.



AM signal being modulated by a 600 Hz tone

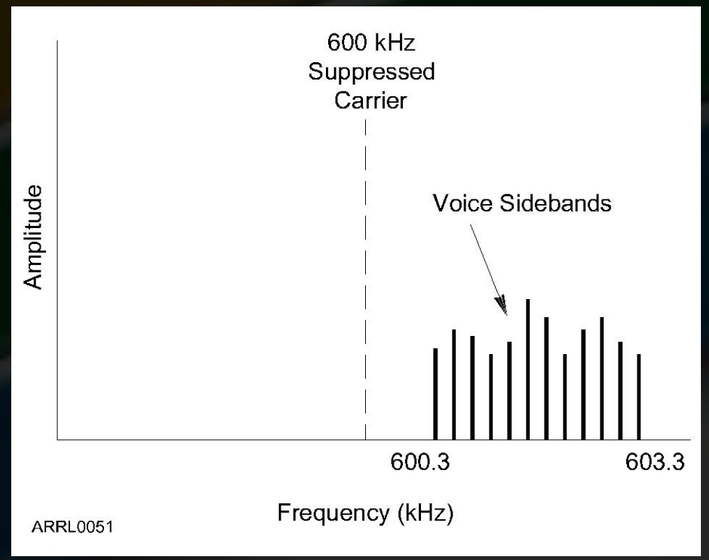
Characteristics of Voice Information

- Sounds that make up voice are a complex mixture of multiple frequencies from 300–3000 Hz
- Two mirror-image sets of sidebands are created, each up to 3000 Hz wide.
- AM voice signal bandwidth 2 x 3000 Hz = 6000 Hz



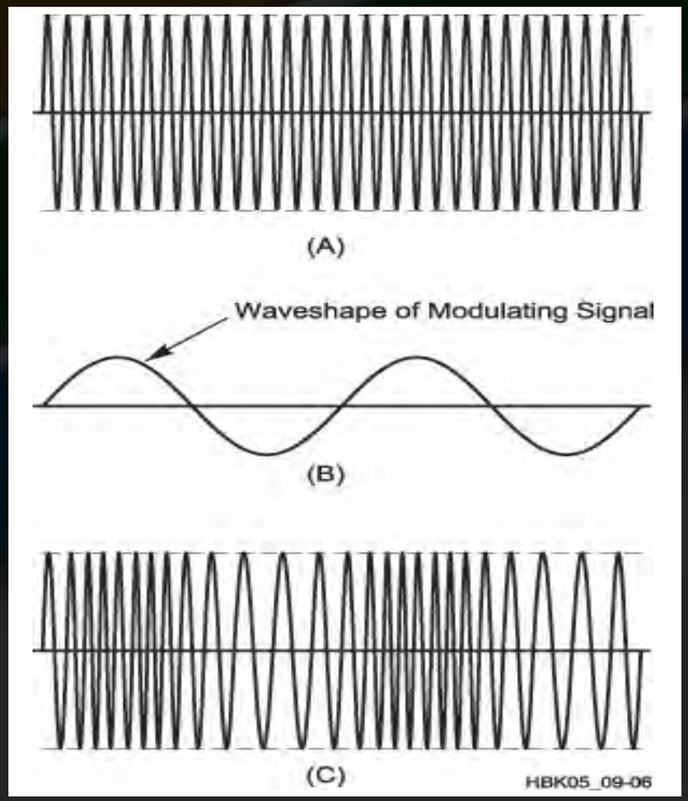
Single Sideband Modulation (SSB)

- The two sets of voice sidebands carry duplicate information.
- We can improve efficiency by transmitting only one sideband and reconstructing the missing carrier in the receiver.
- SSB bandwidth is only 3000 Hz for voice signals.



Frequency and Phase Modulation (FM and PM)

- Instead of varying amplitude, if we use the information to vary the carrier's frequency, *frequency modulation (FM)* is produced.
- FM bandwidth (for voice) is between 5 and 15 kHz.
- We can also shift the signal's phase back and forth, creating *phase modulation (PM)* that is very similar to FM.



Typical Signal Bandwidths

Signal Bandwidths

Type of Signal	*Typical Bandwidth*
AM voice	6 kHz
AM broadcast	10 kHz
Commercial video broadcast	6 MHz
SSB voice	2 to 3 kHz
SSB digital	500 to 3000 Hz (0.5 to 3 kHz)
CW	150 Hz (0.15 kHz)
FM voice	10 to 15 kHz
FM broadcast	150 kHz

Practice Questions

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Why should you not set your transmit frequency to be exactly at the edge of an amateur band or sub-band?

Why should you not set your transmit frequency to be exactly at the edge of an amateur band or sub-band?

To allow for calibration error in the transmitter frequency display
So that modulation sidebands do not extend beyond the band edge
To allow for transmitter frequency drift

What determines the amount of deviation of an FM (as opposed to PM) signal?

What determines the amount of deviation of an FM (as opposed to PM) signal?

The amplitude of the modulating signal

What happens when the deviation of an FM transmitter is increased?

What happens when the deviation of an FM transmitter is increased?

Its signal occupies more bandwidth

Which of the following is a form of amplitude modulation?

Which of the following is a form of amplitude modulation?

Single sideband

What type of modulation is most commonly used for VHF packet radio transmissions?

What type of modulation is most commonly used for VHF packet radio transmissions?

FM

Which type of voice modulation is most often used for long-distance or weak signal contacts on the VHF and UHF bands?

Which type of voice modulation is most often used for long-distance or weak signal contacts on the VHF and UHF bands?

SSB

Which type of modulation is most commonly used for VHF and UHF voice repeaters?

Which type of modulation is most commonly used for VHF and UHF voice repeaters?

FM

Which sideband is normally used for 10 meter HF, VHF and UHF single-sideband communications?

Which sideband is normally used for 10 meter HF, VHF and UHF single-sideband communications?

Upper sideband

What is the primary advantage of single sideband over FM for voice transmissions?

What is the primary advantage of single sideband over FM for voice transmissions?

SSB signals have narrower bandwidth

What is the approximate bandwidth of a VHF repeater FM phone signal?

What is the approximate bandwidth of a VHF repeater FM phone signal?

Between 10 and 15 kHz

What is the typical bandwidth of analog fast-scan TV transmissions on the 70 cm band?

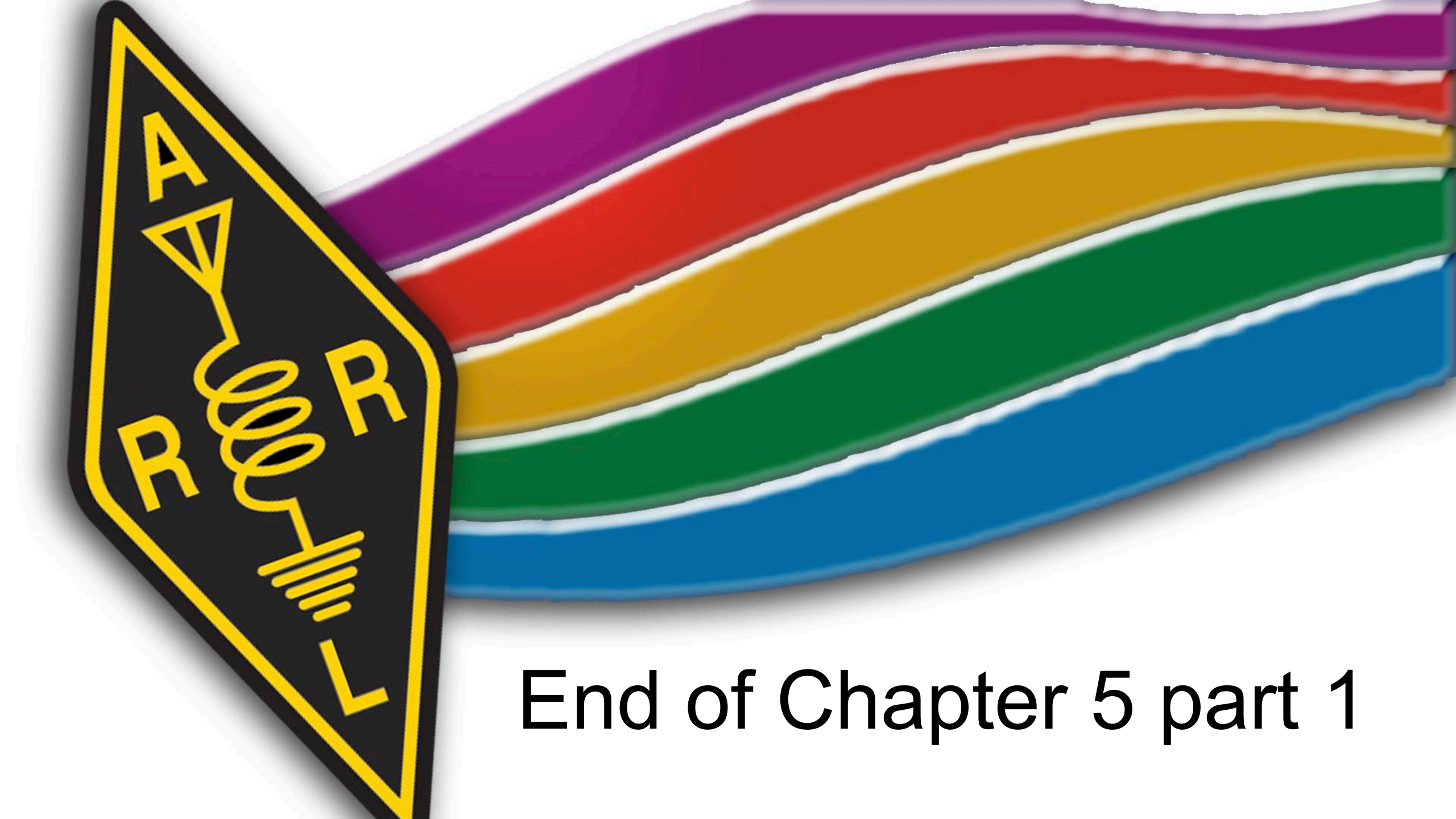
What is the typical bandwidth of analog fast-scan TV transmissions on the 70 cm band?

About 6 MHz

What is the approximate maximum bandwidth required to transmit a CW signal?

What is the approximate maximum bandwidth required to transmit a CW signal?

150 Hz



End of Chapter 5 part 1

End of Module 3

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Chapter 5 Part 2

Technician License Course

Chapter 5

Lesson Plan Module - 11

Transmitters, Receivers and Transceivers

Band and Frequency Selection

- Fundamental to all amateur transceivers
- Can set by VFO (continuously variable) or by keypad “direct” entry
- Memories can generally store:
  - Frequency
  - Mode
  - Filter and similar settings
  - Alphanumeric labels

Transmitter Controls and Functions

- Main tuning display (both TX and RX):
  - –Controls the frequency selection via the variable frequency oscillator (VFO).
  - –Frequency can be set with a knob or keypad or programmed channels.
  - –Variable frequency step size (tuning rate, resolution).
  - –Rigs can usually store the information for two operating frequencies (VFO A and VFO B).

Transmitter Controls and Functions

- Mode selector (both TX and RX for multimode rigs).
  - –AM/FM/SSB (LSB or USB)
  - –CW
  - –Data (RTTY or PSK)
- Could be automatic based on recognized band plan.

Transmitter Controls and Functions

- Microphone controls
  - –Gain
    - Controls transmitter sensitivity to your voice
  - –Speech Compressor or Speech Processor
    - Increases microphone gain at lower sound levels to increase overall signal strength or “punch”

Transmitter Controls and Functions

- Too much gain or compression can cause problems
  - Splatter
  - Over-deviation
  - Over-modulation

Transmitter Controls and Functions

- Automatic Level Control (ALC)
  - –Automatically limits speech modulation, reducing transmitter over-drive
  - –Causes some speech distortion
  - –Do NOT use for data modes like PSK
- Also prevents overdrive to external power amplifier

Microphones and Keys

- Microphones (mic)
  - –Hand mics
  - –Desk mics
    - Preamplified desk mics
  - –Speaker-mics
  - –Headsets or boom-sets
  - –Internal mics
- Speak *across* the mic, not into the mic

Microphones and Keys

- Transmitter ON/OFF or “keying”
  - –Push-to-Talk (PTT)
  - –Voice-Operated Transmission (VOX)
    - •VOX Gain
    - •VOX Delay
    - •Anti-VOX

Microphones and Keys

- –Key jack
- –Manually-Operating Transmission (MOX or SEND - varies with manufacturer)

- Morse code
  - –Straight key
  - –Electronic keyer and paddle
  - –Semi-automatic (Bug)

Receiver Controls and Functions

- AF Gain or Volume
  - Controls the audio level to the speaker or headphones
- RF Gain
  - Controls the gain of the receiver's input amplifiers
- Attenuator
  - Reduces signal at the receiver input

Receiver Controls and Functions

- Automatic Gain Control (AGC)
  - –Automatically limits the incoming signals during signal (voice) peaks to maintain even volume
  - –Keeps strong signals from blasting the listener
  - –Different time response settings:
    - –Fast setting for CW
    - –Slow settings for SSB and AM

Receiver Controls and Functions

- Filters (can be electronic modules or DSP)
  - –IF filter
    - •Used to narrow the width of signal that is passed.
    - •Can attenuate adjacent signals.
  - –Notch filter
    - •Very narrow filter that can be moved over an interfering signal to attenuate it.

Receiver Controls and Functions

- Noise blanker (NB)
  - Removes signal pulses that are frequently associated with random naturally generated noise
  - Can cause problems if strong signals are present
- Noise reduction (NR)
  - DSP function to remove noise from signal
- Noise limiter (NL)

Receiver Controls and Functions

- Preamplifier
  - Increases sensitivity but can cause overload
- Reception and Transmission Meter
  - In transmit, indicates output power or ALC or other functions as selected by switch setting
  - In receive, indicates signal strength
    - In “S” units S1 through S9 – S9 is strongest
    - Above S9, meter is calibrated in dB (i.e S9+10 dB)

Receiver Controls and Functions

- Receivers can be limited to ham bands or can cover other parts of the spectrum.
- General coverage receivers cover a wide area of the spectrum and can be used for shortwave listening (SWL).

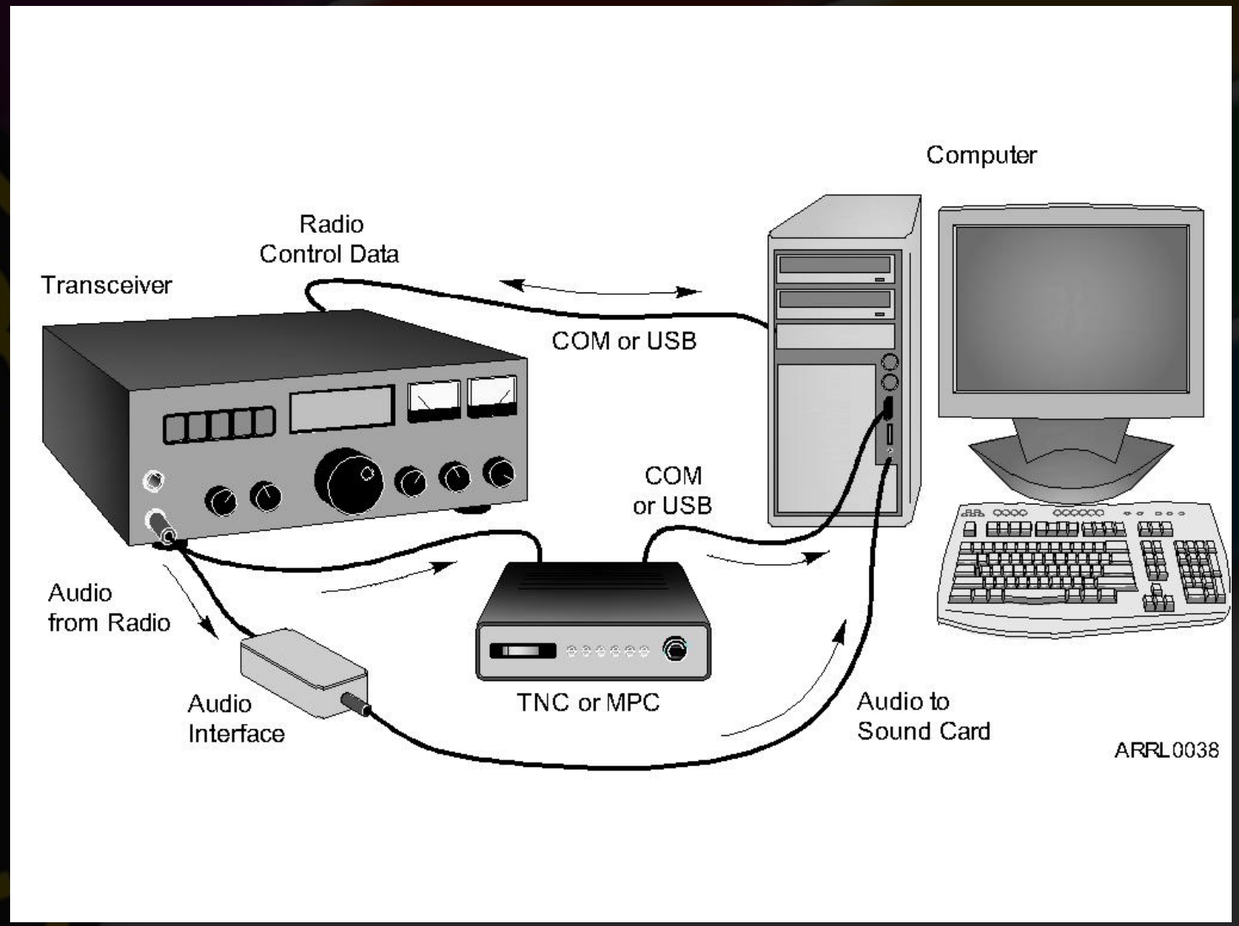
Data Modes

- Computer-to-computer communication
- Specialized modems
  - Terminal Node Controller (TNC)
  - Multiple Protocol Controller (MPC)
- Computer sound card software
  - Requires radio interface

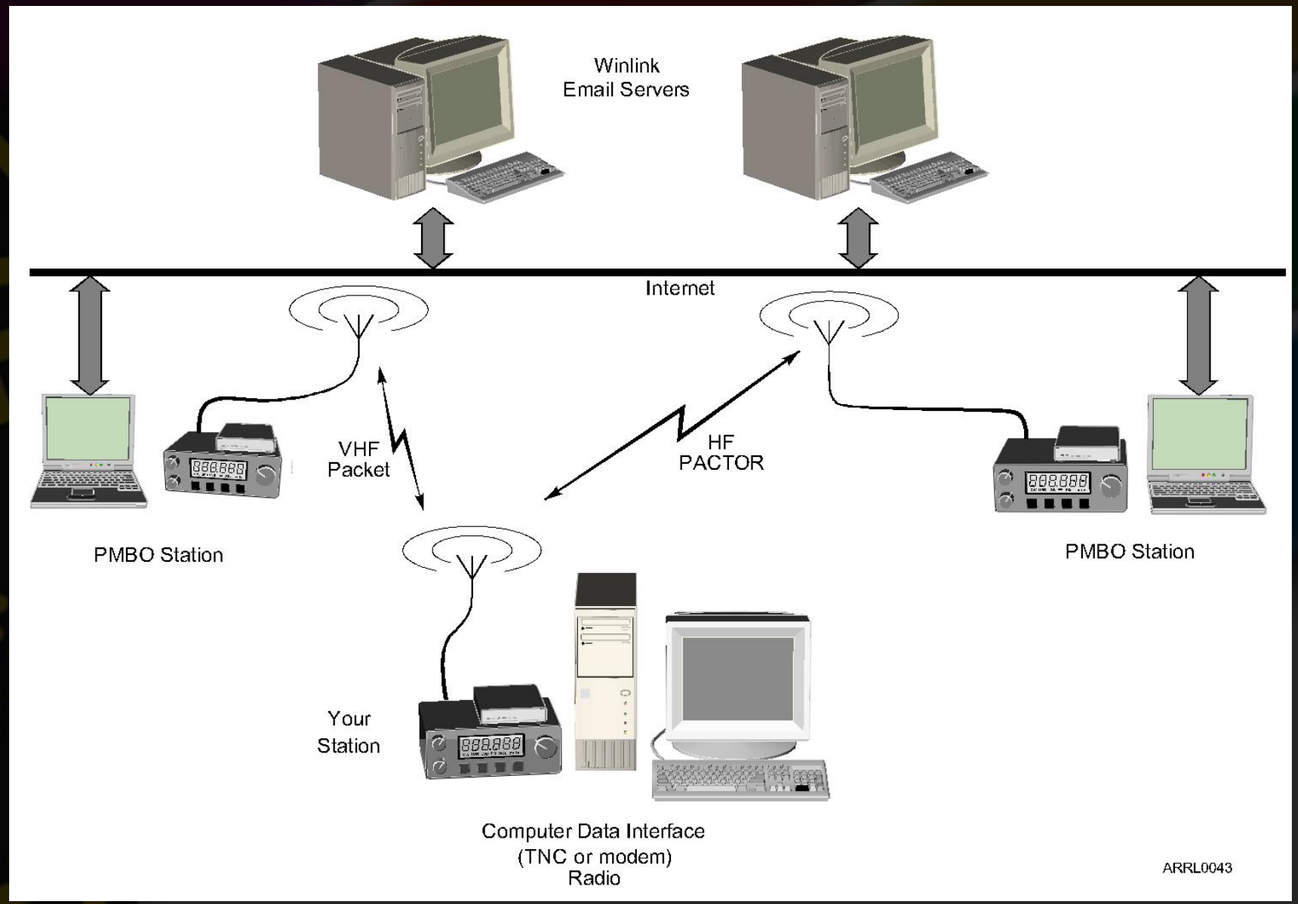
Popular Digital Modes & Systems

- Error detection
  - Yes: Packet radio, MFSK
  - No: RTTY, PSK31
- Error correction
  - MFSK (forward error correction or FEC)
  - Packet radio
    - Checksums and call signs
    - Retransmission or ARQ

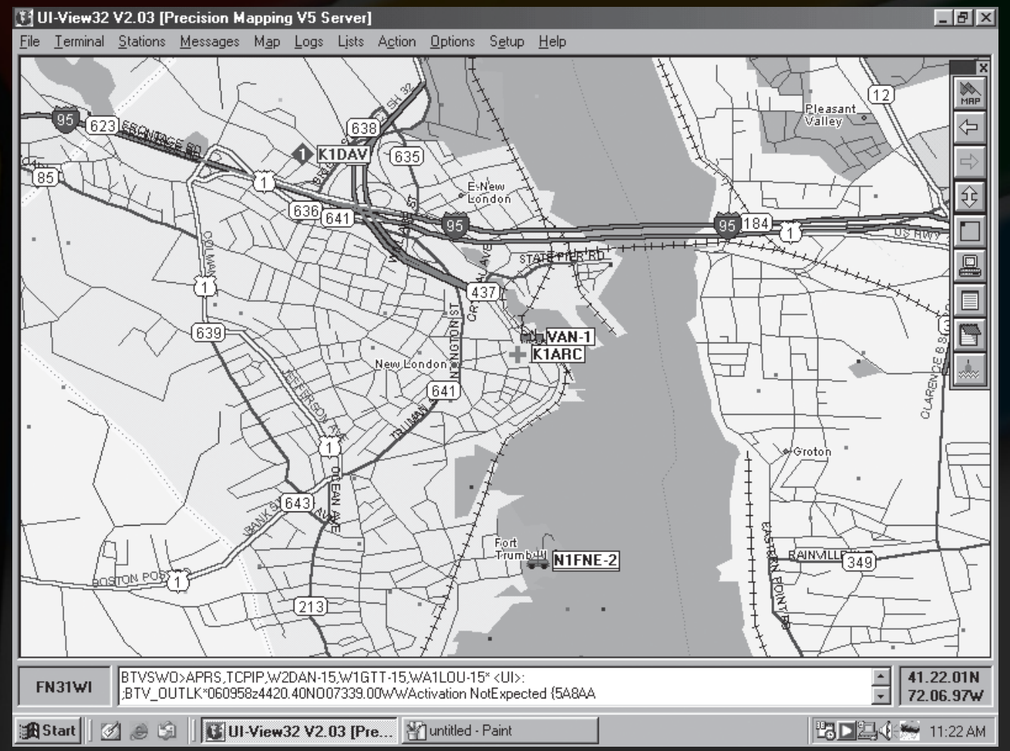
Data Station Setup



Internet Gateway



Automatic Position Reporting System (APRS)



Technician License Course

Chapter 5

Lesson Plan Module – 12

Power Sources and RF Interference (RFI)

Power Supplies

- Most modern radio equipment runs from 12 volts dc.
  - Actual preferred voltage is 13.8 volts.
- Household ac power is 120 volts ac.
- Power supplies convert 120 volts ac to regulated, filtered dc.
  - If you use a lab-type 12 volt power supply, be sure it is adjustable to 13.8 volts.

Types of Power Supplies

- Linear:
  - –Use iron transformers
  - –Heavy (physically)
  - –Do not emit RF, generally immune to strong RF
- Switching:
  - –Electronics instead of transformers
  - –Lightweight and small
  - –Can emit RF if not properly filtered
    - –Check product reviews

Power Supply Ratings - Voltage and Current

- Continuous duty – how much current can be supplied continuously.
- Intermittent duty – how much current can be supplied for short surges, such as on voice peaks.
- Regulation – how well the power supply maintains a constant output voltage.

Mobile Power Wiring Safety

- Car batteries hold lots of energy – shorting a battery could cause a fire.
- Special requirements for safe car wiring:
  - –Use grommets or protective sleeves to protect wires.
  - –Don’t assume all metal in the car is grounded; modern cars are as much plastic as metal.

Batteries

- Create current through a chemical reaction
  - –Individual cells connected in series or parallel
  - –Cell chemistry determines voltage per cell
- Battery types
  - –Disposable (primary batteries)
  - –Rechargeable (secondary batteries)
  - –Storage

Batteries

- Energy capabilities rated in Ampere-hours
  - –Amps X time (at a constant voltage)

Battery Charging

- Some batteries can be recharged, some cannot.
- Use the proper charger for the battery being charged.
- Batteries will lose capacity with each cycle.
- Best if batteries are maintained fully charged.
  - –Over-charging will cause heating and could damage the battery.

Battery Charging

- Lead-acid batteries release explosive hydrogen during charging or rapid discharge so adequate ventilation is required.
- Automobiles can be a good emergency power source by recharging batteries
- A 12-volt lead-acid station battery can be recharged by connecting it to an automobile’s electrical system

Battery Charging

- Monitor battery temperature
- Make sure battery is well-ventilated

Practice Questions

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What describes the muting of receiver audio controlled solely by the presence or absence of an RF signal?

What describes the muting of receiver audio controlled solely by the presence or absence of an RF signal?

Carrier squelch

What is true concerning the microphone connectors on amateur transceivers?

What is true concerning the microphone connectors on amateur transceivers?

Some connectors include push-to-talk and voltages for powering the microphone

How might a computer be used as part of an amateur radio station?

How might a computer be used as part of an amateur radio station?

For logging contacts and contact information
For sending and/or receiving CW
For generating and decoding digital signals

What would be connected between a transceiver and computer in a packet radio station?

What would be connected between a transceiver and computer in a packet radio station?

Terminal node controller

How is a computer’s sound card used when conducting digital communications using a computer?

How is a computer’s sound card used when conducting digital communications using a computer?

The sound card provides audio to the microphone input and converts received audio to digital form

What may happen if a transmitter is operated with the microphone gain set too high?

What may happen if a transmitter is operated with the microphone gain set too high?

The output signal might become distorted

What can be used to enter the operating frequency on a modern transceiver?

What can be used to enter the operating frequency on a modern transceiver?

The keypad or VFO knob

What is the purpose of the squelch control on a transceiver?

What is the purpose of the squelch control on a transceiver?

To mute receiver output noise when no signal is being received

What is a way to enable quick access to a favorite frequency on your transceiver?

What is a way to enable quick access to a favorite frequency on your transceiver?

Store the frequency in a memory channel

What would reduce ignition interference to a receiver?

What would reduce ignition interference to a receiver?

Turn on the noise blanker

What control could be used if the voice pitch of a single-sideband signal seems too high or low?

What control could be used if the voice pitch of a single-sideband signal seems too high or low?

The receiver RIT or clarifier

What does the term "RIT" mean?

What does the term "RIT" mean?

Receiver Incremental Tuning

What is the advantage of having multiple receive bandwidth choices on a multimode transceiver?

What is the advantage of having multiple receive bandwidth choices on a multimode transceiver?

Permits noise or interference reduction by selecting a bandwidth matching the mode

What is an appropriate receive filter bandwidth to select in order to minimize noise and interference for SSB reception?

What is an appropriate receive filter bandwidth to select in order to minimize noise and interference for SSB reception?

2400 Hz

What is an appropriate receive filter bandwidth to select in order to minimize noise and interference for CW reception?

What is an appropriate receive filter bandwidth to select in order to minimize noise and interference for CW reception?

500 Hz

What is the function of automatic gain control or AGC?

What is the function of automatic gain control or AGC?

To keep received audio relatively constant

What is meant by the term "PTT"?

What is meant by the term "PTT"?

The push to talk function which switches between receive and transmit

What device is most useful for VHF weak-signal communication?

What device is most useful for VHF weak-signal communication?

A multi-mode VHF transceiver

What device increases the low-power output from a handheld transceiver?

What device increases the low-power output from a handheld transceiver?

An RF power amplifier

What can you do if you are told your FM handheld or mobile transceiver is over-deviating?

What can you do if you are told your FM handheld or mobile transceiver is over-deviating?

Talk farther away from the microphone

What name is given to an amateur radio station that is used to connect other amateur stations to the Internet?

What name is given to an amateur radio station that is used to connect other amateur stations to the Internet?

A gateway

Which of the following is an example of a digital communications method?

Which of the following is an example of a digital communications method?

Packet
PSK31
MFSK

What does the term APRS mean?

What does the term APRS mean?

Automatic Packet Reporting System

What device provides data to the transmitter when sending automatic position reports from a mobile amateur radio station?

What device provides data to the transmitter when sending automatic position reports from a mobile amateur radio station?

A Global Positioning System receiver

What is an application of APRS (Automatic Packet Reporting System)?

What is an application of APRS (Automatic Packet Reporting System)?

Providing real time tactical digital communications in conjunction with a map showing the locations of stations

What does the abbreviation PSK mean?

What does the abbreviation PSK mean?

Phase Shift Keying

What is PSK31?

What is PSK31?

A low-rate data transmission mode

What may be included in packet transmissions?

What may be included in packet transmissions?

A check sum which permits error detection
A header which contains the call sign of the station to which the information is being sent
Automatic repeat request in case of error

What code is used when sending CW in the amateur bands?

What code is used when sending CW in the amateur bands?

International Morse

What can be used to transmit CW in the amateur bands?

What can be used to transmit CW in the amateur bands?

Straight Key
Electronic Keyer
Computer
Keyboard

What is an ARQ transmission system?

What is an ARQ transmission system?

A digital scheme whereby the receiving station detects errors and sends a request to the sending station to retransmit the information

End of Chapter 5 Part 2

End of Module 11