

Amateur Radio Technician License Training

Welcome to 2023 Amateur
Radio Technician Class License
Training

Amateur Radio Technician License Training

These presentations are sponsored by:

**Mendocino Auxiliary Communications Service (MACS)
Office of Emergency Services**

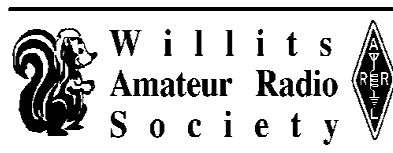
Mendocino County Amateur Radio Communications Service (McARCS)

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Topics on Exam

Section	Contents	Questions on Exam	Questions in Pool	Covered in Session
T1	FCC Rules and Regulations	6	67	Session 5
T2	Operating Procedures	3	36	Session 4
T3	Radio Wave Propagation	3	34	Session 2
T4	Amateur Radio Practices	2	24	Session 4
T5	Electrical Principles	4	52	Session 1
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T9	<i>Antennas and Feedlines</i>	2	24	Session 3
T0	Safety	3	36	Session 2

Signals and Emissions

Topics in the lesson:

- **Modulation – adding information to radio signals**
 - Modulation techniques
 - Basic characteristics of voice transmissions
- **Amateur satellite operation**
 - Basic orbit concepts, terminology, operating protocols
 - Telemetry
- **Operating activities**
 - Radio direction finding, contests, grid locators
- **Non-voice and digital communications**
 - Image transmission
 - Digital/data modes

Review questions:

What is the term that describes a device's ability to amplify a signal?

- A. On resistance
- B. Forward voltage drop
- C. Forward resistance
- D. Gain

Review questions:

What is the purpose of a fuse in an electrical circuit?

- A. To prevent power supply ripple from damaging a circuit
- B. To remove power in case of overload
- C. To limit current to prevent shocks
- D. All of these choices are correct

Review questions:

What formula is used to calculate voltage in a circuit?

- A. $E = I - R$
- B. $E = I \times R$
- C. $E = I / R$
- D. $E = I + R$

Review questions:

Which is equal to one microvolt?

- A. One one-millionth of a volt
- B. One million volts
- C. One thousand kilovolts
- D. One one-thousandth of a volt

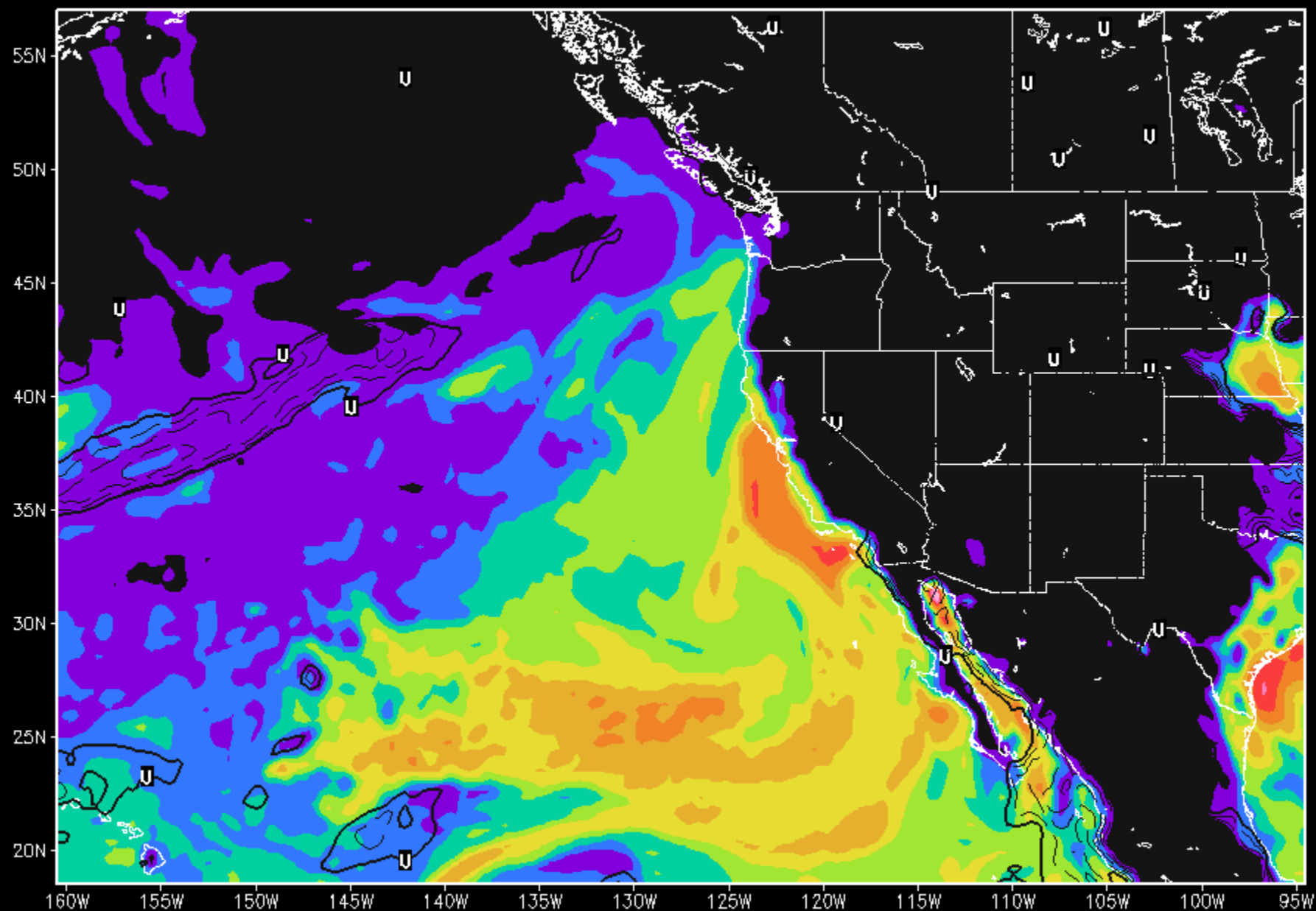
Review questions:

What mode is responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis?

- A. Tropospheric ducting
- B. D layer refraction
- C. F2 layer refraction
- D. Faraday rotation

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Review questions:

What are the frequency limits of the VHF spectrum?

- A. 30 to 300 kHz
- B. 30 to 300 MHz
- C. 300 to 3000 kHz
- D. 300 to 3000 MHz

Review questions:

What is the name of an electrical wiring diagram that uses standard component symbols?

- A. Schematic
- B. Connector pinout
- C. Bill of materials
- D. Flow chart

Review questions:

Under what circumstances is it safe to climb a tower without a helper or observer?

- A. When no electrical work is being performed
- B. When no mechanical work is being performed
- C. When the work being done is not more than 20 feet above the ground
- D. Never

Signals and Emissions

Radio Communications

Universe is full of electromagnetic energy, including RF

- Most is random, from variety of sources
- The energy simply exists, carries no information
- To use RF to communicate, information must be added/extracted

Signals and Emissions

What Happens During Radio Communication?

Transmitting:

- 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 radiates from the station antenna

Receiving:

- The radio wave carrying information is intercepted by the receiving antenna
- The receiver extracts the information from the received wave
- The information is converted to a format that can be understood (sound, image, written words, response to a command)

Modulation Techniques

Adding Information - Modulation

Adding information to a radio wave (carrier) = modulation

- Simplest - turn wave on and off (Morse code)
- Encode speech or music
- Digital data

Different modulation techniques alter different properties of the wave to add information

- Amplitude
- Frequency or phase

Modulation Techniques

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

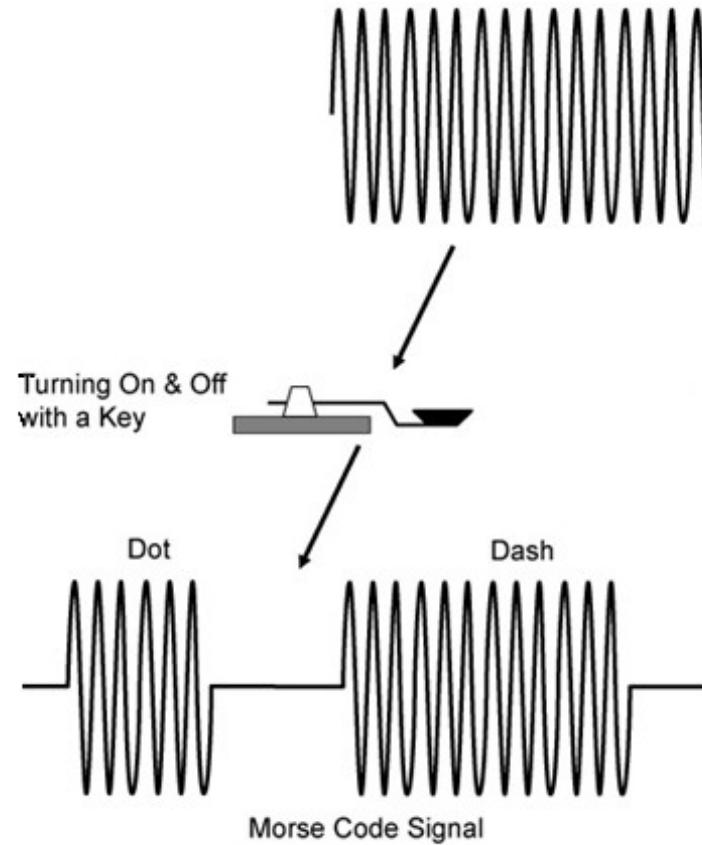
Modulation Techniques

Bandwidth

- Carrier + sidebands occupy a range of spectrum space
- Occupied range of composite signal = bandwidth
- Different types of modulation and information results in different signal bandwidths

Modulation Techniques

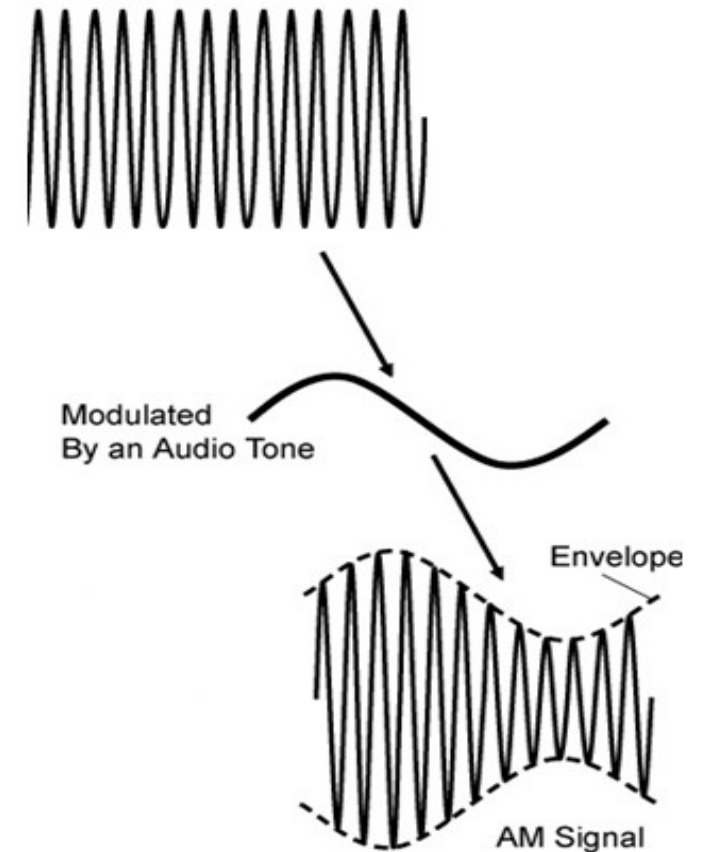
CW (Morse Code) – On or Off



Modulation Techniques

Amplitude Modulation (AM)

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



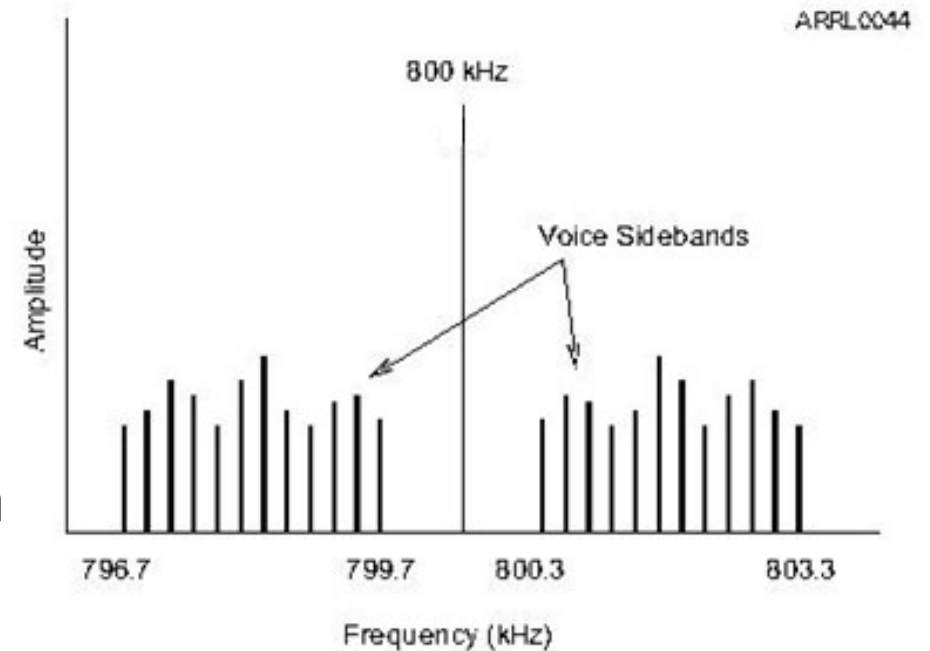
Modulation Techniques

Characteristics of voice AM

AM signals consists of three components

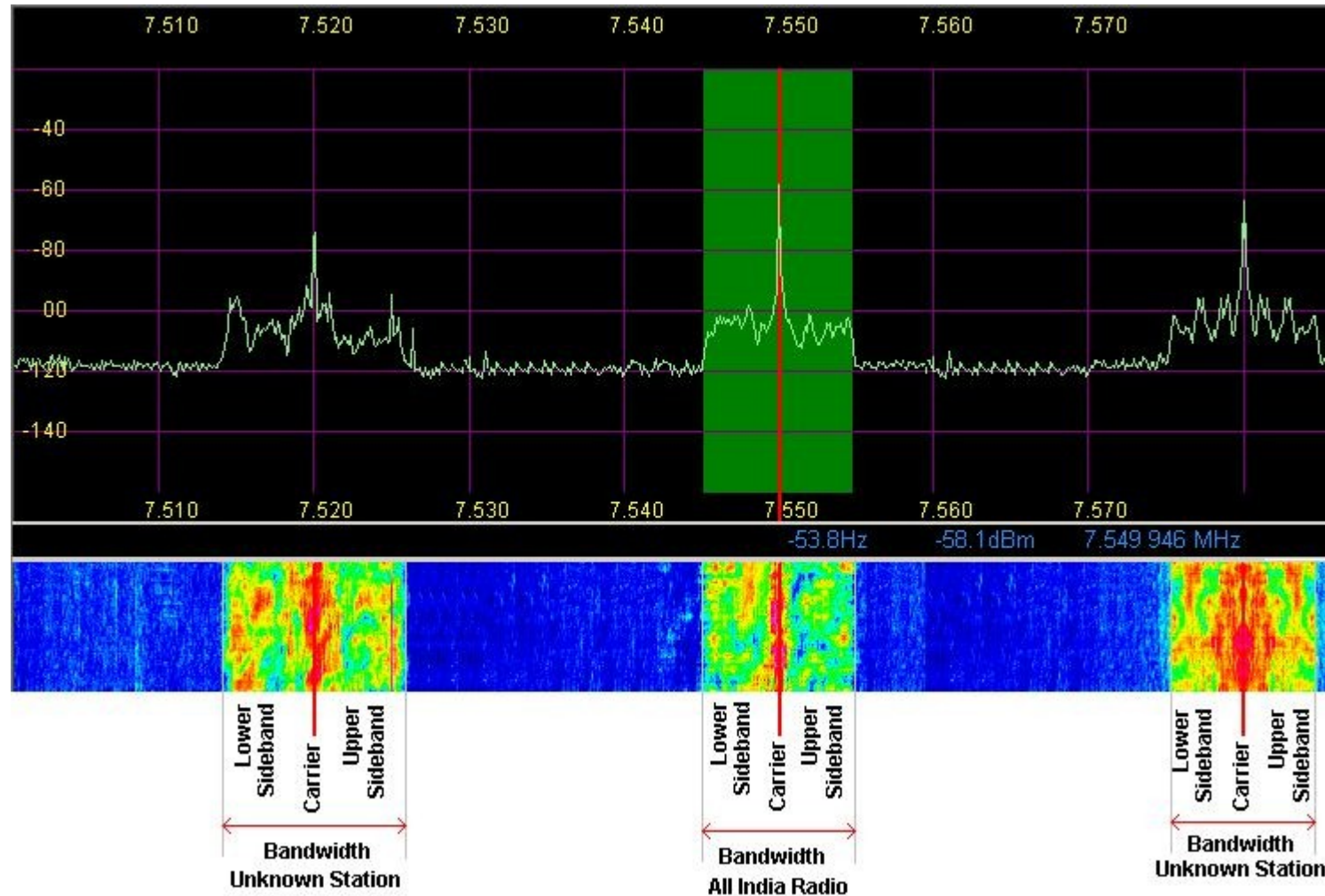
- Carrier
- Lower sideband (LSB)
- Upper sideband (USB)

AM bandwidth is twice the information bandwidth



Modulation Techniques

Bandwidth



Modulation Techniques

Non-voice modes

CW (Morse code)

- Very narrow bandwidth signal
- Approximate bandwidth = 150 Hz

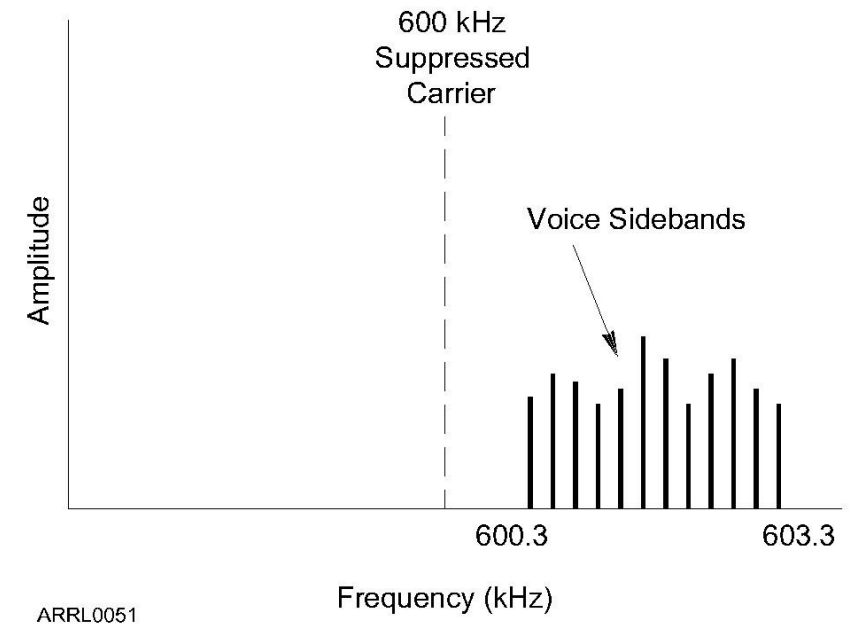
Video

- AM fast-scan TV
- Very wide bandwidth, approximately = 6 MHz
- Utilizes NTSC – analog fast-scan color TV

Modulation Techniques

Single Sideband Modulation (SSB)

- The two voice sidebands carry duplicate information
- Efficiency improved by transmitting only one sideband and recreating missing carrier in the receiver
- SSB bandwidth is only 3000 Hz for voice signals (half of AM voice signal)



Modulation Techniques

Single Sideband Modulation (SSB)

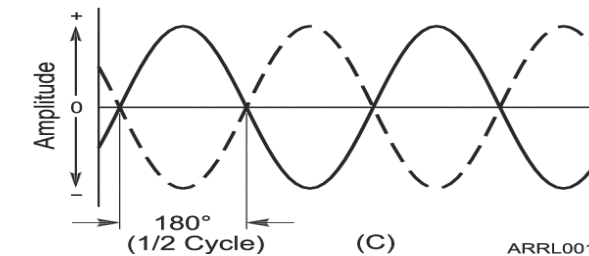
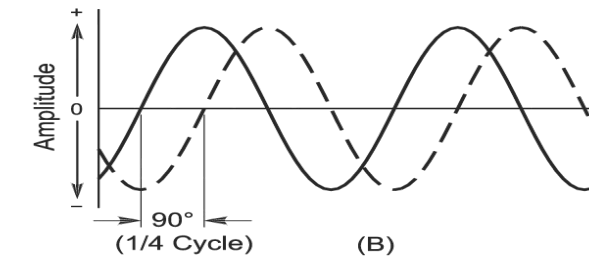
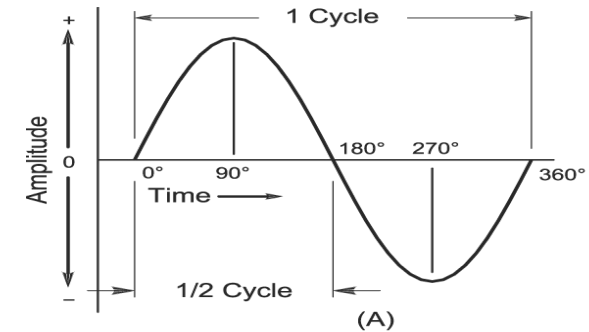
- A form of amplitude modulation
- Popular voice mode for “weak signal” VHF/UHF contacts
- Approximate bandwidth = 3 kHz for voice signals (narrower than FM)
- Upper sideband (USB) used on 10m HF, VHF, UHF

Modulation Techniques

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

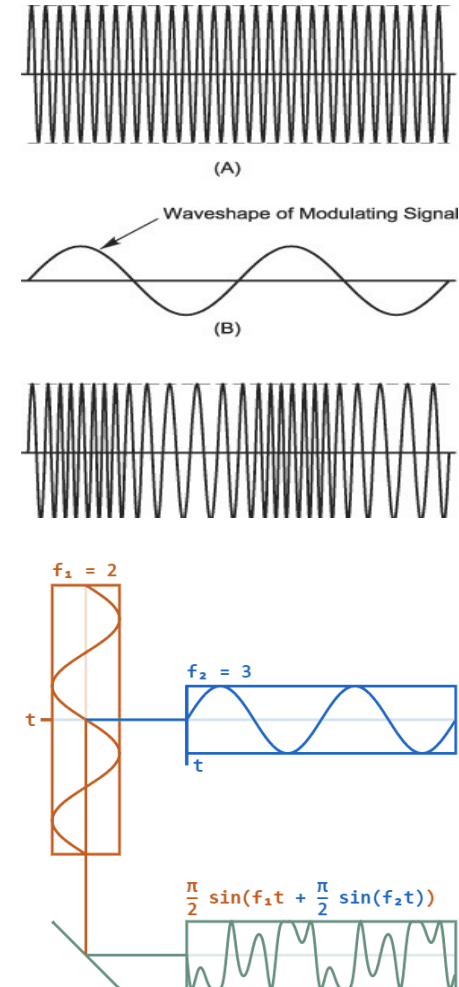


Modulation Techniques

Frequency and Phase Modulation

If information signal used to vary the carrier's frequency (instead of amplitude), frequency modulation (FM) is produced

- FM bandwidth (for voice) is between 5 and 15 kHz
- The phase of the carrier signal may be shifted in response to the information signal, creating phase modulation (PM), very similar to FM



Modulation Techniques

Frequency or Phase Modulation (FM/PM)

- Commonly used on VHF/UHF voice repeaters and VHF packet radio
- Approximate voice bandwidth between 10 and 15 kHz
- Disadvantage vs SSB – only one signal received at a time

Modulation Techniques

Typical Signal Bandwidths

Signal Bandwidths

<i>Type of Signal</i>	<i>Typical Bandwidth</i>
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

Section questions:

Which of the following types of signal has the narrowest bandwidth?

- A. FM voice
- B. SSB voice
- C. CW
- D. Slow-scan TV

Section questions:

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

- A. Upper sideband
- B. Lower sideband
- C. Suppressed sideband
- D. Inverted sideband

Section questions:

Which of the following is a disadvantage of FM compared with single sideband?

- A. Voice quality is poorer
- B. Only one signal can be received at a time
- C. FM signals are harder to tune
- D. All these choices are correct

Amateur satellite operation

Amateur Satellites

OSCAR

- Orbiting Satellites Carrying Amateur Radio

Modes

- FM
- Analog (SSB and CW)
- Digital

International Space Station

Amateur satellite operation

Satellite Terms

- **Uplink** – Earth stations transmission to satellite
- **Downlink** – Satellite transmission to stations on Earth
- **Beacon** – Transmission (telemetry) from satellite that contains status information (health/status), anyone can receive telemetry
- **Doppler Shift** – Observed change in signal frequency due to relative motion between satellite and Earth station
- **LEO** – Low Earth Orbit

Amateur satellite operation

Satellite Terms

Spin fading – caused by rotation of satellite/antennas

Tracking software – uses Keplerian elements to provide orbital details

- Real-time maps of track
- Time, azimuth, and elevation of start/maximum altitude/end of pass
- Apparent frequency, adjusted for Doppler shift

Mode – bands satellite is using for uplink and downlink (Mode U/V = 70 cm uplink, 2 meters downlink)

Amateur satellite operation

Satellite operation

Regardless of Mode

- Use minimum uplink power
- Excessive uplink ERP blocks access by other users
- Adjust uplink power so downlink signal = beacon signal

Section questions:

What is a satellite beacon?

- A. The primary transmit antenna on the satellite
- B. An indicator light that shows where to point your antenna
- C. A reflective surface on the satellite
- D. A transmission from a satellite that contains status information

Section questions:

What is Doppler shift in reference to satellite communications?

- A. A change in the satellite orbit
- B. A mode where the satellite receives signals on one band and transmits on another
- C. An observed change in signal frequency caused by relative motion between the satellite and Earth station
- D. A special digital communications mode for some satellites

Section questions:

What is a LEO satellite?

- A. A sun synchronous satellite
- B. A highly elliptical orbit satellite
- C. A satellite in low energy operation mode
- D. A satellite in low earth orbit

Operating activities

Operating Activities

Radio Direction Finding (RDF)

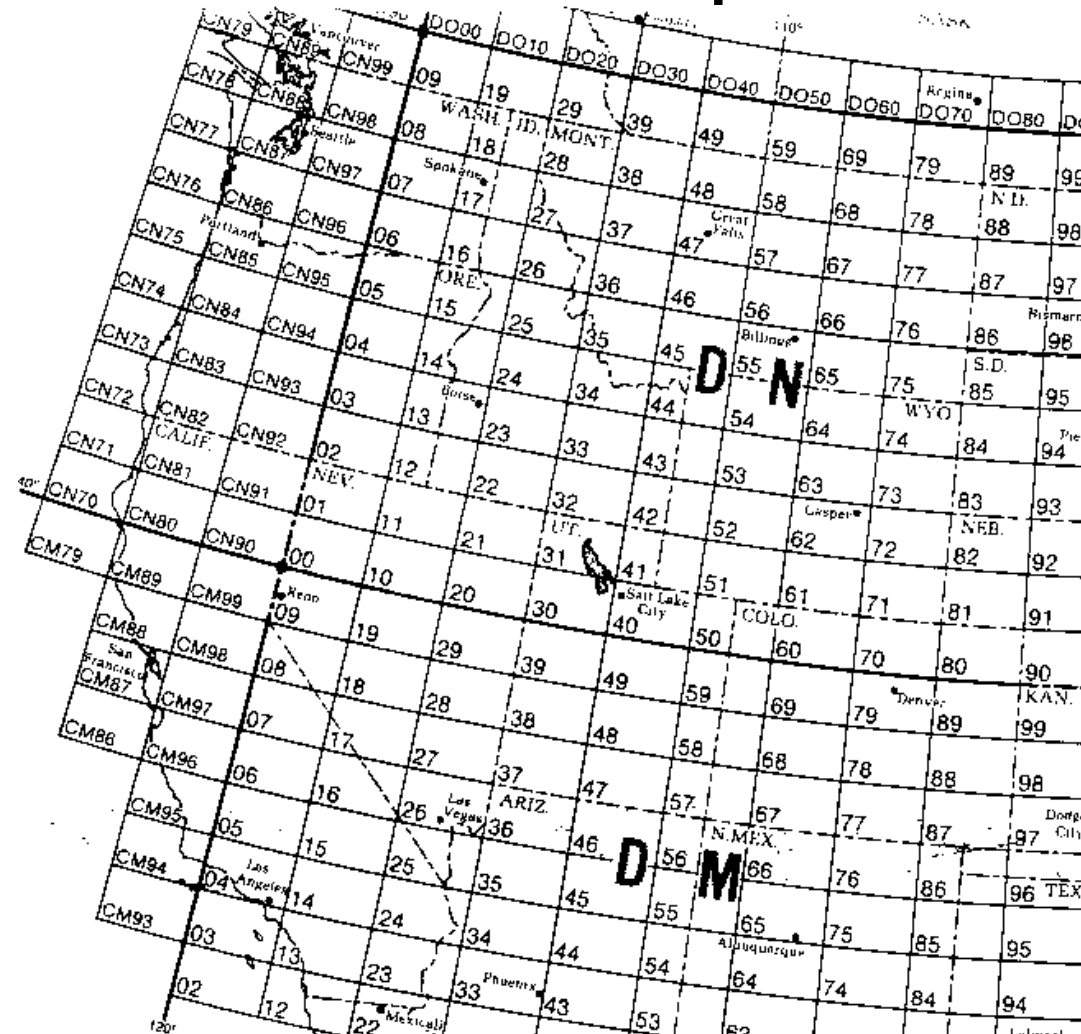
- Directional Antenna
- Locate interference/jamming
- Hidden transmitter hunt (foxhunt)

Contesting

- Contact as many stations as possible in specified period
- Minimum information for contest exchange (call and grid locator)
- Maidenhead grid, 1° x 2°, two letter two digits
- Mendocino county is grid CM89

Operating activities

Grid map



Digital modes

Digital Communications

Voice over Internet Protocol (VoIP)

- Delivers voice communications over internet (digital)

Internet Radio Linking Project (IRLP)

- Connects amateur radio systems/repeaters via the internet with VoIP
- Access nodes using DTMF (touch tone) signals

Echolink – allows transmission via repeater without using radio

- Requires call registration/license verification

Gateway – Amateur station that connects other amateur stations to internet

Digital modes

Digital Communications

Digital Modes – Packet Radio, IEE 802.11, FT8

- FT8 = digital mode capable of low signal-to-noise
- WSJT-X for EME, weak signal beacons, meteor scatter
- PSK = Phase Shift Keying (modulation technique)

Automatic Packet Reporting System (APRS) – GPS/mapping, text, weather

Packet Transmissions – error correction

- Check sum, header with call, auto repeat request
- ARQ – receiving station detects error, request re-transmission

Digital modes

Digital Communications

Digital Mobile Radio (DMR)

- Time multiplexing two digital voice signals on 12.5 kHz repeater channel
- DMR repeater talkgroup allow users to share channel without hearing others

Amateur radio mesh network

- Uses commercial Wi-Fi equipment with modified firmware
- Unlicensed Wi-Fi band overlaps with amateur frequencies

Section questions:

What is a grid locator?

- A. A letter-number designator assigned to a geographic location
- B. A letter-number designator assigned to an azimuth and elevation
- C. An instrument for neutralizing a final amplifier
- D. An instrument for radio direction finding satellite

Section questions:

How is over the air access to IRLP nodes accomplished?

- A. By obtaining a password that is sent via voice to the node
- B. By using DTMF signals
- C. By entering the proper internet password
- D. By using CTCSS tone codes

Section questions:

What kind of data can be transmitted by APRS?

- A. GPS position data
- B. Text messages
- C. Weather data
- D. All these choices are correct

Signals and Emissions

Questions?

Signals and Emissions

End of SUB ELEMENT 8
Signals and Emissions

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