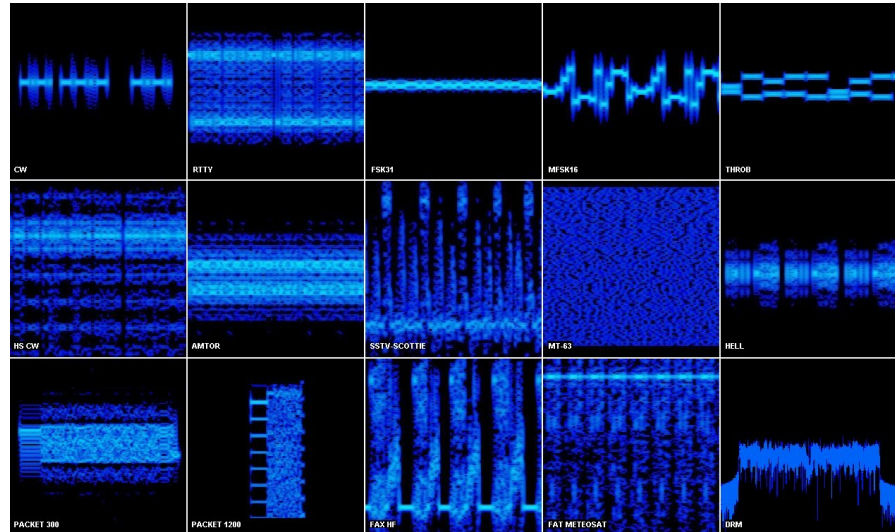
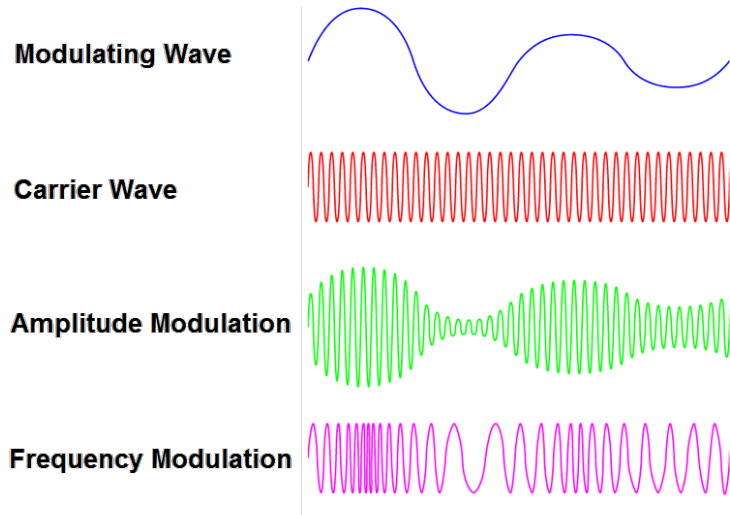


Modulation Modes; Amateur Satellite Operation; Operating Activities; Non-voice and Digital Communications T8: ABCD

KI7TPD Fred Govedich



Modulation

Modulation: Adding information (voice, cw, digital, etc.) to a signal (carrier wave)

Demodulation: Recovering information (voice, cw, digital, etc.) from a modulated signal

What can be modulated/demodulated?

Amplitude (strength or wave height)

Frequency

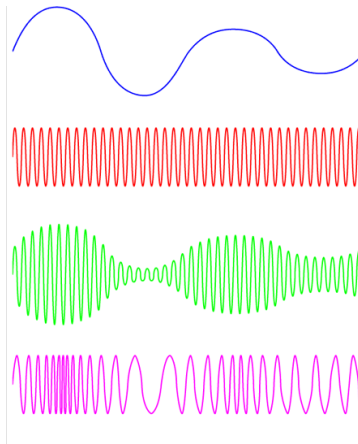
Phase

Modulating Wave

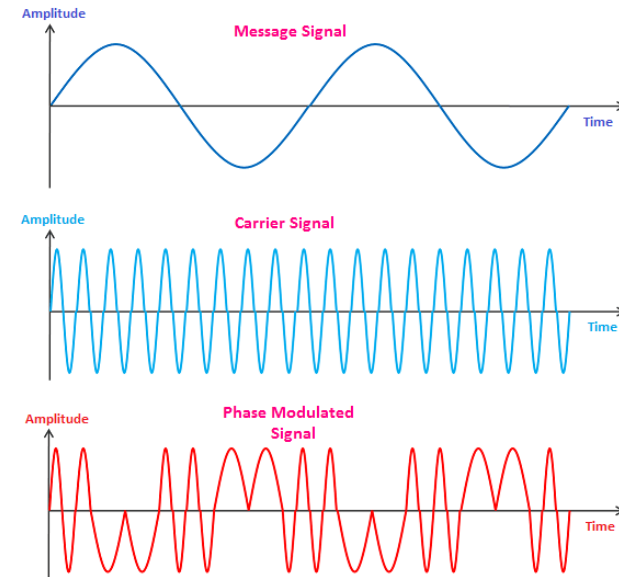
Carrier Wave

Amplitude Modulation

Frequency Modulation



Phase Modulation



Continuous Wave (CW) and Amplitude Modulation (AM)

Continuous Wave (CW*): A continuous wave is turned on and off (Morse Code)

Amplitude Modulation (AM): The amplitude (wave height) of a signal is varied

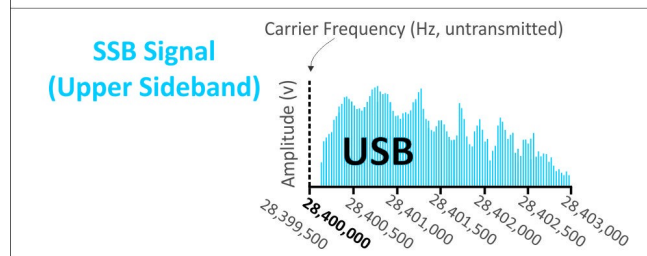
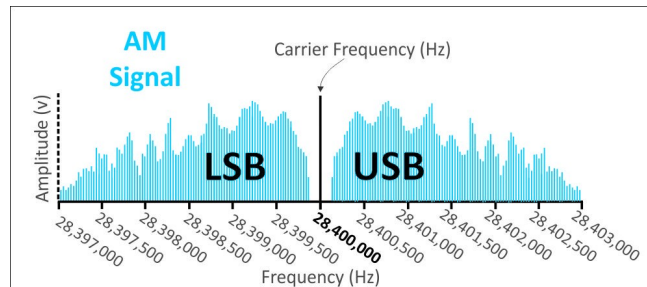
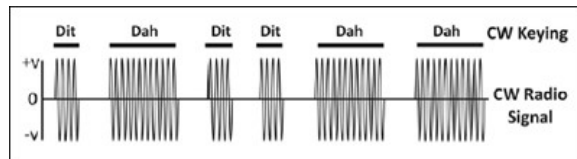
Single Sideband (SSB*): Form of AM where the carrier and one half of the signal are suppressed (filtered)

Carrier does not contain information and Each sideband has the same information (mirrored)

All of the power in SSB is concentrated in one sideband
Allows for long range communication

LSB or USB use depends on frequency/Band
Below 10 MHz use LSB
(except 60 meters uses USB)
Above 10 MHz use USB

*** Weak Signal modes**



US Amateur Radio Bands

US AMATEUR POWER LIMITS — FCC 97.313 An amateur station must use the minimum transmitter power necessary to carry out the desired communications. (b) No station may transmit with a transmitter power exceeding 1.5 kW PEP.



ARRL The national association for AMATEUR RADIO

KEY

Note: CW operation is permitted throughout all amateur bands.

MCW is authorized above 50.1 MHz, except for 144.0-144.1 and 219-220 MHz. Test transmissions are authorized above 51 MHz, except for 219-220 MHz.

- = RTTY and data
- = phone and image
- = CW only
- = SSB phone
- = USB phone, CW, RTTY, and data
- = Fixed digital message forwarding systems only

E = Amateur Extra
A = Advanced
G = General
T = Technician
N = Novice

See **ARRLWeb** at www.arrl.org for detailed band plans.

ARRL We're At Your Service

ARRL Headquarters:
860-594-0200 (Fax 860-594-0259)
email: hq@arrl.org

Publication Orders:
www.arrl.org/shop
Toll-Free 1-888-277-5289 (860-594-0355)
email: orders@arrl.org

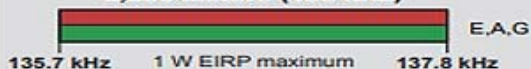
Membership/Circulation Desk:
www.arrl.org/membership
Toll-Free 1-888-277-5289 (860-594-0338)
email: membership@arrl.org

Getting Started in Amateur Radio:
Toll-Free 1-800-326-3942 (860-594-0355)
email: newham@arrl.org

Exams: 860-594-0300 email: vec@arrl.org

Amateurs wishing to operate on either 2,200 or 630 meters must first register with the Utilities Technology Council online at <https://utc.org/plc-database-amateur-notification-process/>. You need only register once for each band.

2,200 Meters (135 kHz)



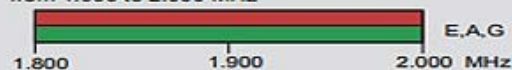
630 Meters (472 kHz)

5 W EIRP maximum, except in Alaska within 496 miles of Russia where the power limit is 1 W EIRP.

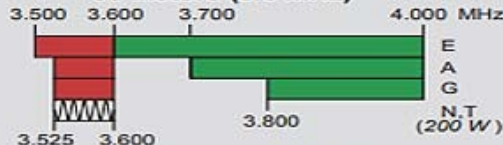


160 Meters (1.8 MHz)

Avoid interference to radiolocation operations from 1.900 to 2.000 MHz



80 Meters (3.5 MHz)

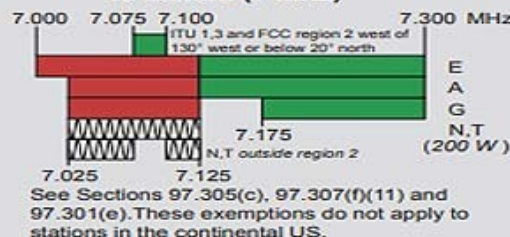


60 Meters (5.3 MHz)



General, Advanced, and Amateur Extra licensees may operate on these five channels on a secondary basis with a maximum effective radiated power (ERP) of 100 W PEP relative to a half-wave dipole. Permitted operating modes include upper sideband voice (USB), CW, RTTY, PSK31 and other digital modes such as PACTOR III. Only one signal at a time is permitted on any channel.

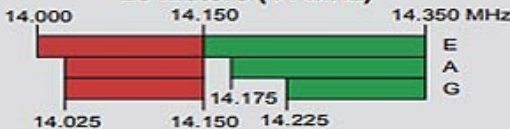
40 Meters (7 MHz)



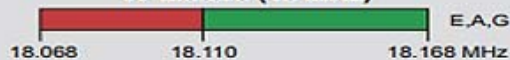
30 Meters (10.1 MHz)



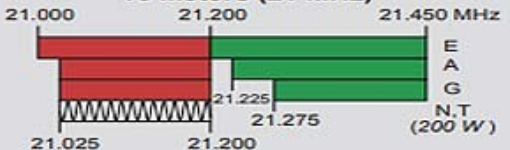
20 Meters (14 MHz)



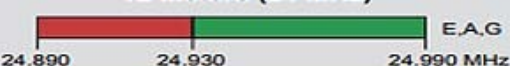
17 Meters (18 MHz)



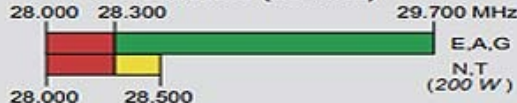
15 Meters (21 MHz)



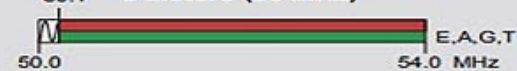
12 Meters (24 MHz)



10 Meters (28 MHz)



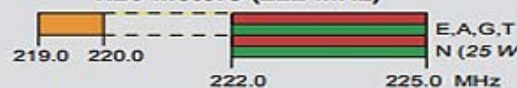
6 Meters (50 MHz)



2 Meters (144 MHz)

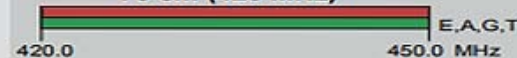


1.25 Meters (222 MHz)

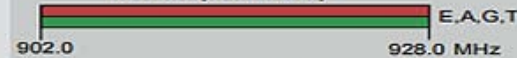


*Geographical and power restrictions may apply to all bands above 420 MHz. See *The ARRL Operating Manual* for information about your area.

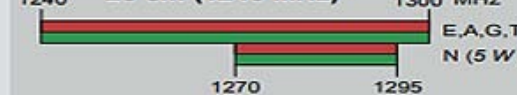
70 cm (420 MHz)*



33 cm (902 MHz)*



23 cm (1240 MHz)*



All licensees except Novices are authorized all modes on the following frequencies:

2300-2310 MHz	10.0-10.5 GHz ±	122.25-123.0 GHz
2390-2450 MHz	24.0-24.25 GHz	134-141 GHz
3300-3500 MHz	47.0-47.2 GHz	241-250 GHz
5650-5925 MHz	76.0-81.0 GHz	All above 275 GHz

± No pulse emissions

Frequency Modulation (FM) and Phase Modulation (PM)

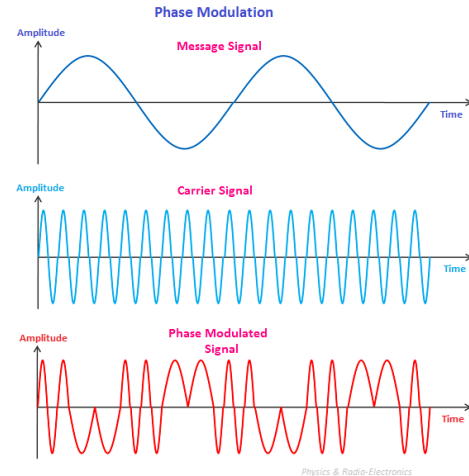
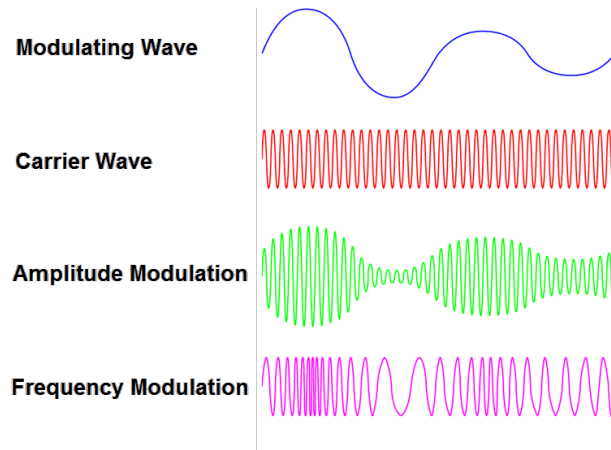
Frequency Modulation (FM): The frequency of the carrier wave is varied

Phase Modulation (PM): The phase of the carrier wave is varied

Both are very similar and the signals are nearly identical

Excellent noise-rejection

Commonly used for repeaters and packet radio on VHF and UHF



Bandwidth of Modulated Signals

Bandwidth: Literally width of the signal on the radio spectrum

Varies with the modulation type

CW is extremely narrow at 150 Hz (0.15 kHz)

SSB Digital: 500-3000 Hz (0.5 – 3 kHz)

SSB Voice: 2-3 kHz

AM Voice: 6 kHz

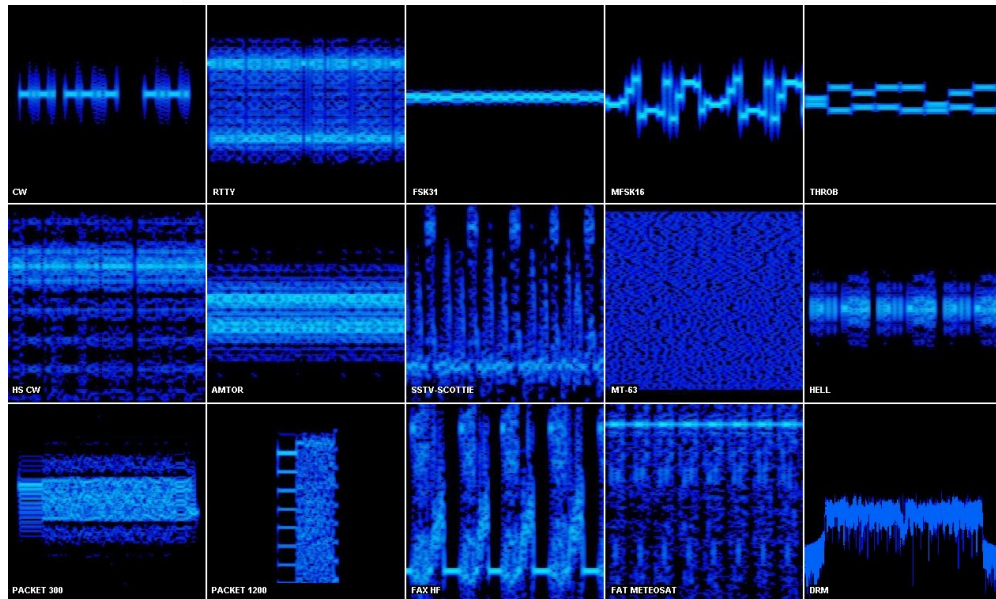
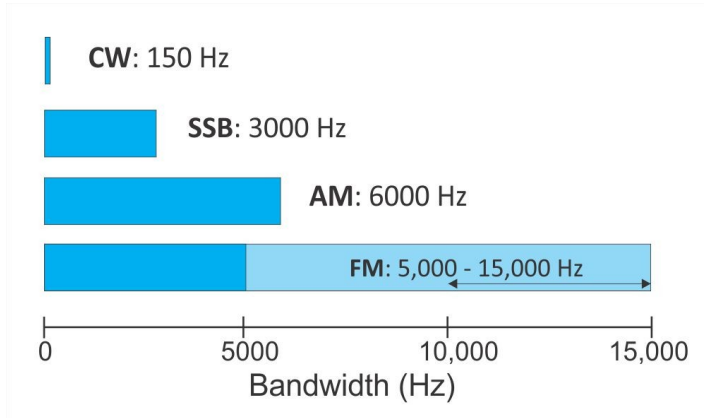
AM broadcast: 10 kHz

FM Voice: 10-15 kHz

FM narrowband: 6kHz (max)

FM broadcast: 150 kHz

Commercial Video broadcast: 6 MHz



Satellite or Space Station Operation

Key Terms for Satellite Operations

OSCAR: Orbiting Satellite Carrying Amateur Radio

Satellites and Space Stations (ISS): Defined by the FCC as an amateur station located more than 50 km above Earth's surface

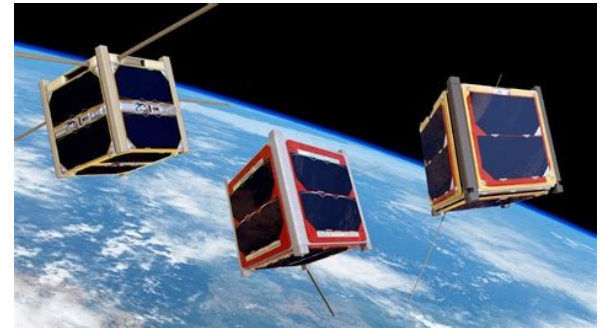
Uplink: Frequency that you can use to transmit to satellite

Downlink: Frequency that satellite will transmit on

Sub-bands: restricted uplink and downlink frequencies that satellites use



29.300-29.510 MHz
145.80-146.00 MHz
435.00-438.00 MHz
1260-1270 MHz
2400-2410 and 2430-2438 MHz



Satellite or Space Station Operation

Key Terms for Satellite Operations

Apogee: Point of a satellite's orbit that is furthest from the Earth

Perigee: Point of a satellite's orbit that is closest to the Earth

Beacon: A signal from a satellite containing information about the satellite

Doppler shift: A shift in a signal's frequency due to relative motion between the satellite and the Earth station

Elliptical orbit: An orbit with a large difference between apogee and perigee

LEO: A satellite in Low Earth Orbit

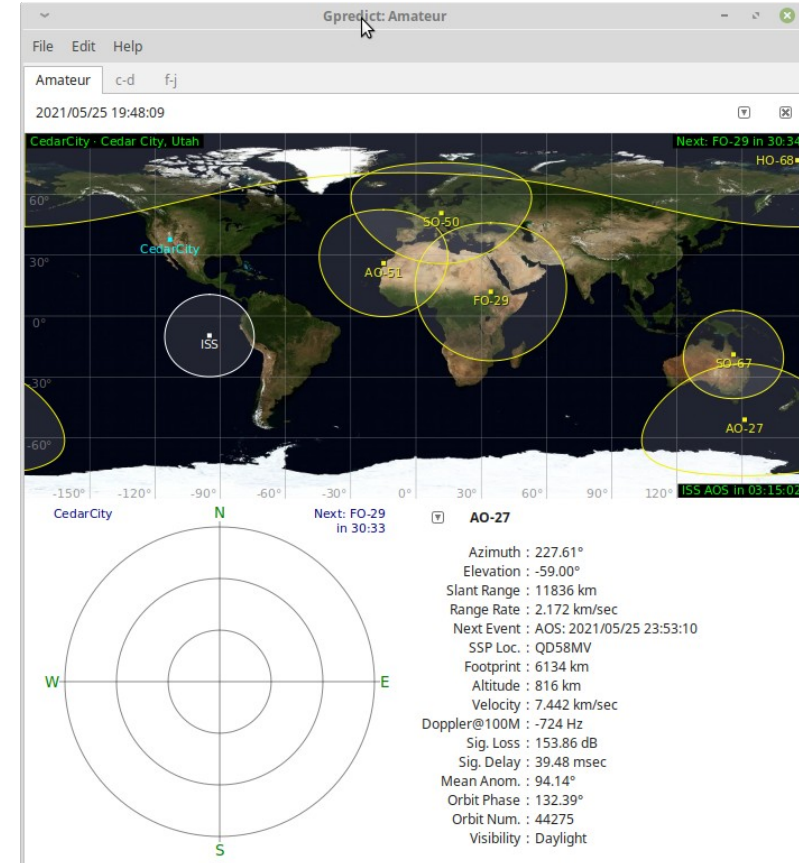
Spin fading: Signal fading caused by rotation of the satellite and its antenna(s)

Tracking Satellites or ISS

Satellite Tracking Programs

Provide information on when a satellite or ISS will pass over your area, the current location of the satellite (map), trajectory, doppler shift, etc.

Need **Keplerian elements** that help define the orbit of the satellite (most software will download this automatically)



Who can Communicate using Satellites?

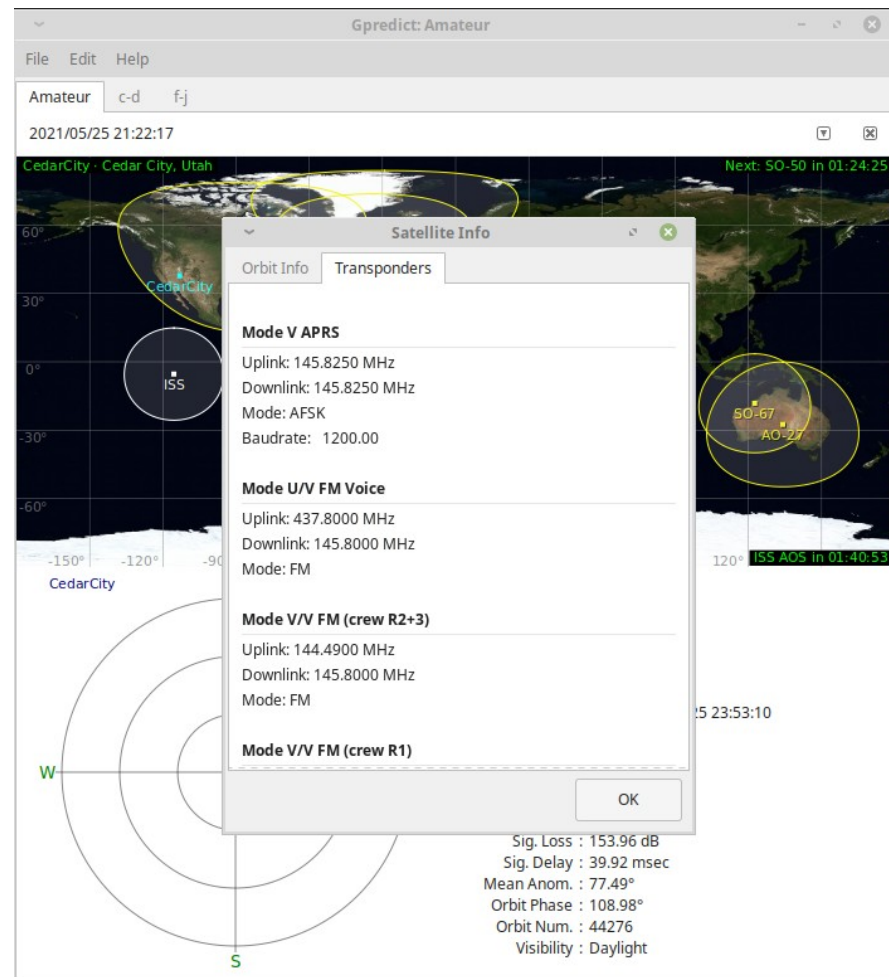
Anyone with a Amateur license that covers the uplink frequency of the satellite!

What you need to know:

Operation mode or bands on which the satellite is transmitting and receiving (uplink/downlink)

The mode is specified as two letters separated by a slash (U/V: uplink is UHF, downlink is VHF)

Satellites can use any amateur mode such as SSB, FM, CW and data



Who can Communicate using Satellites?

Equipment that you need:

VHF/UHF radio

Antenna: Small beam is best (vertical can work)
Need to be able to direct your antenna



Who can Communicate using Satellites?

What you might hear

Telemetry: Typically sent in CW

Status and health of satellite

Anyone can receive telemetry (no license needed)

You can transmit with a license, but use only the minimum amount of power needed to make a contact to conserve the solar charged batteries on the satellite

If your signal strength matches the beacon you are using the correct power



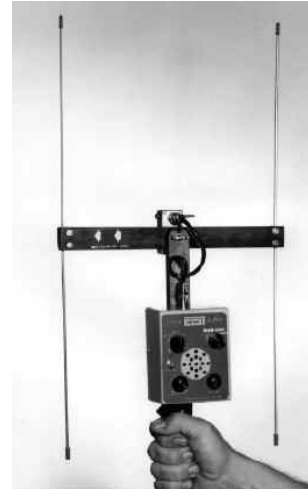
Operating Activities: Radio Direction Finding; Radio Control; Contests; Linking over the Internet; Grid Locators

Radio Direction Finding (RDF): Using radio receivers to find a transmitter

Fox Hunt: contest to locate a hidden transmitter

Practical skills: Locating downed aircraft, lost hikers and interference

Uses a radio receiver with a directional antenna like a small Yagi beam



Radio Contests

Using radio transceivers to make contacts

Special Events: Making as many contacts as you can during a specific period of time
Field Day, Winter Field Day, SOTA, etc.

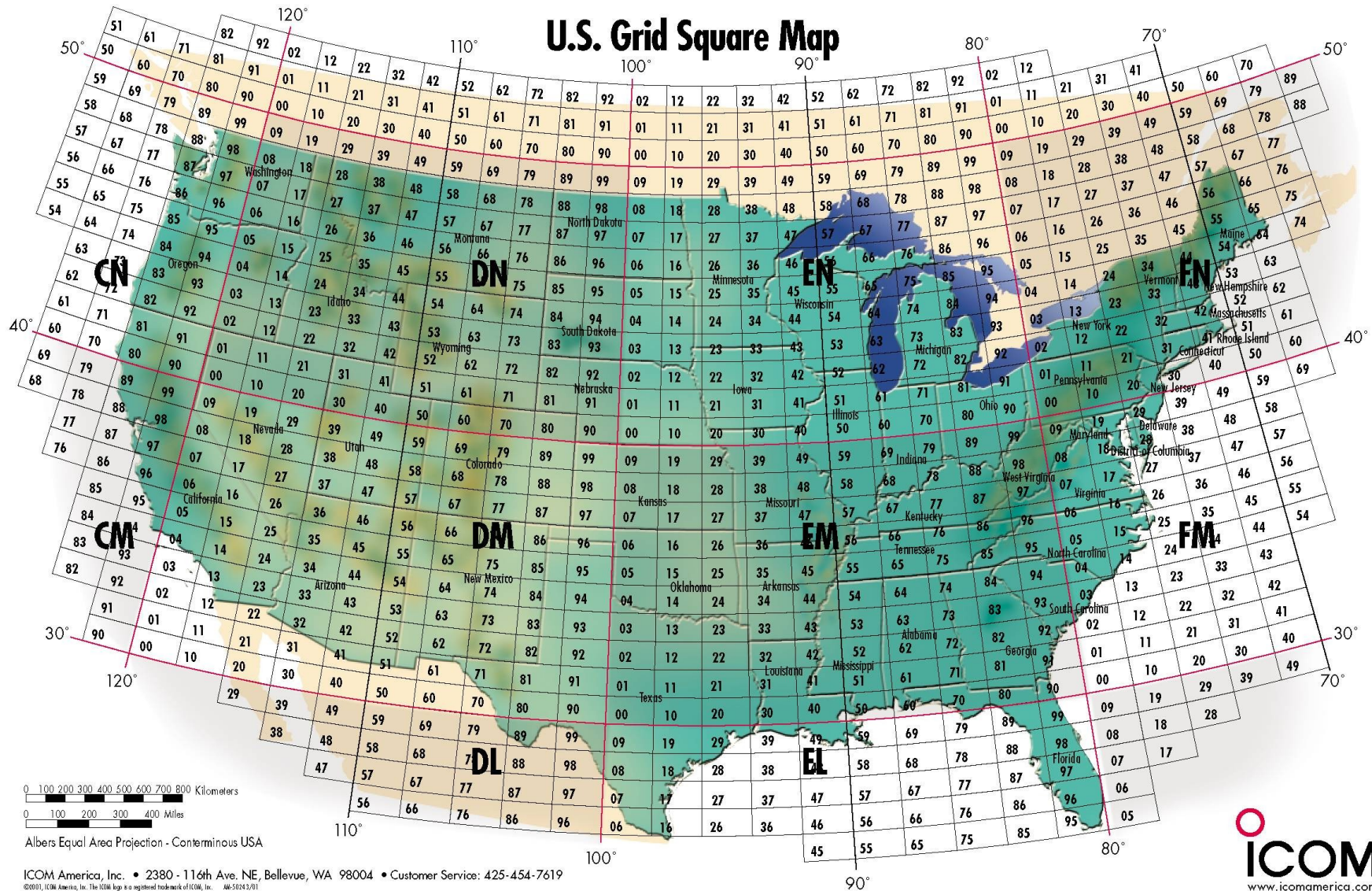
Location/Distance based: Making contacts in as many locations as you can
Worked All states, Worked All Continents, Worked All counties, etc.
DXing: Distant contacts (DX stands for Distant Station)
Typically use SSB or CW

What information do you exchange? Minimum information needed for proper identification and the contest exchange

May include: Callsign, name, location (**Grid locator:** letter and number based geographic designation), signal report, serial number (some contests)



U.S. Grid Square Map



0 100 200 300 400 500 600 700 800 Kilometers

0 100 200 300 400 Miles

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Digital Communications and Linking over the Internet

Ham radio can be linked to the internet using a digital technique known as **VoIP** (Voice Over Internet Protocol).

IRLP: Internet Radio Linking Project, links are made using DTMP tones (like a phone number) and VoIP

EchoLink: Like IRLP uses DTMP tones and VoIP to make a link with a radio. You must register online with proof of your license for this service, but is available as an app on your phone to allow you to connect to a remote radio

Lists of active VoIP nodes are published online, are included in repeater directories, and can be obtained from repeater frequency coordinators

Other services that may be available on your radio:

WIRES II: Proprietary voice-only system developed by Yaesu

D-STAR: Combines both data and voice communications (ICOM)

DMR: (Digital Mobile Radio) Uses time-multiplexing (alternating times for signals) to allow two digital voice signals on a single 12.5 kHz repeater channel

Split into Talk Groups with an ID code

Digital Communications

Amateur Digital Modes:

CW: Uses Morse Code or International Morse Code. These are tone pulses for 'dit' or 'dah'
Electronic keyers that assist in the manual sending of Morse Code are often used

Some Digital modes are used for data:

RTTY (Radioteletype)

PSK31

Weak-signal modes: FT8, JS8Call, WSPR, etc.

PACTOR or WINMOR (Winlink)

Packet radio based on AX.25 protocol

B2F (Winlink)

JT65 for moonbounce and MSK144 for scatter paths

IEEE 802.11 (WiFi)

Some Digital modes are used for voice:

AOR

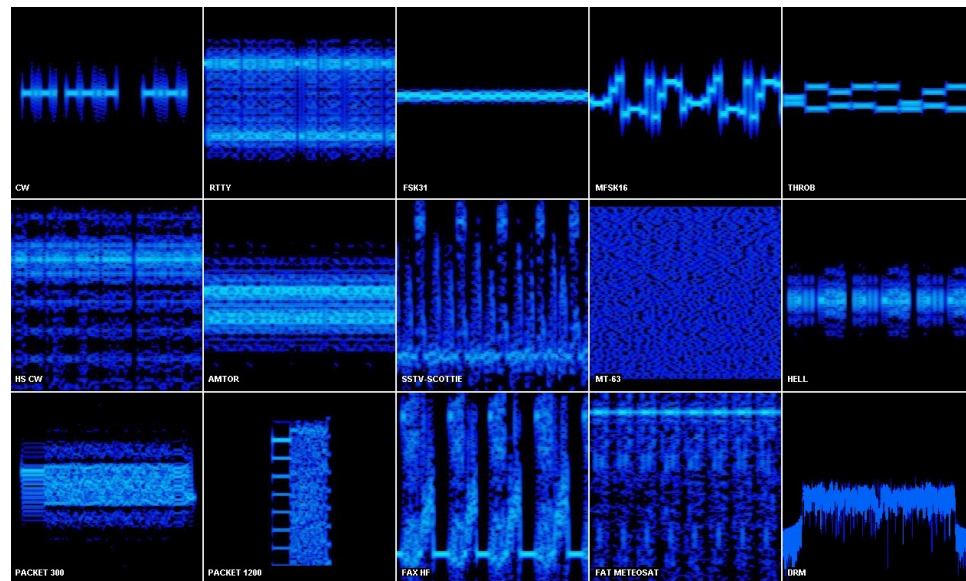
FreeDV

D-STAR

C4FM (System Fusion)

DMR

P25



Digital Communications

Amateur Digital Modes Software

WSJT: Open source software package that has many weak-signal modes including FT8, WSPR, JT65 etc.

FT8 allows for operating in low signal to noise conditions by transmitting special code sequences on 15-second intervals

Some of these modes allow of unique modes of propagation like MSK144 for meteor scatter, bouncing signals off of aircraft, and JT65 for moonbounce or Earth Moon Earth (EME) communications

WSPR is also used for weak-signal propagation beacons

Broadband-Hamnet or high speed multi-media (HSMM) network is the use of modified (firmware) commercial Wi-Fi devices that use the IEEE 802.11 standard on the 5.6 GHz amateur service

These are used to set up data networks that can allow for rapid data exchanges

TV signals can be sent using NTSC (an analog fast scan color TV signal) using some programs

Keyboard to Keyboard

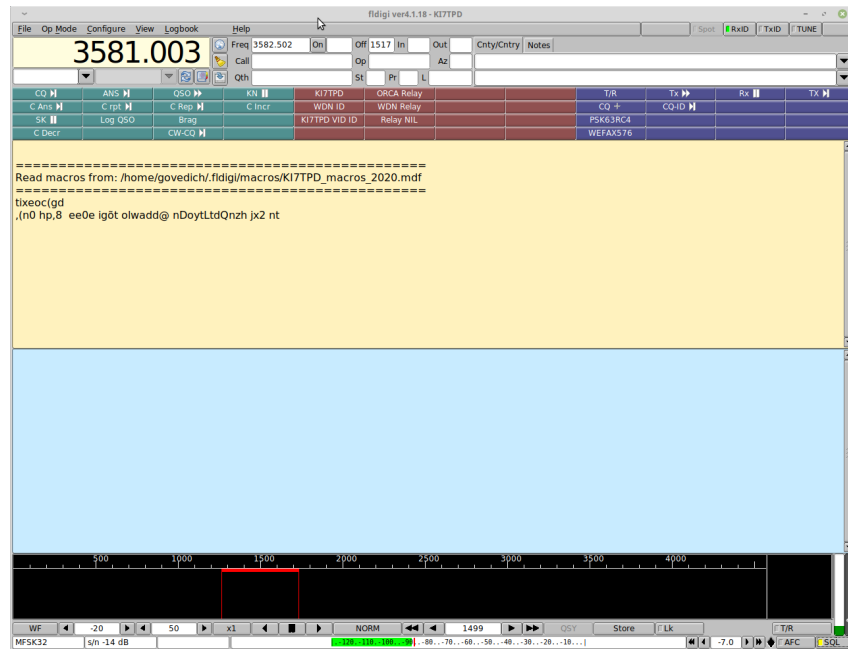
Ham radio digital modes that allow for real-time person to person communication

Most popular on HF bands (commonly using fldigi or other computer programs)

Tones are generated using a computer sound card and are sent to a radio using a special interface (Signalink) connected to the radio

RTTY (Radioteletype): Oldest keyboard to keyboard mode (1930's) and uses the Baudot code to transmit data

PSK or Phase-shift keying uses precise signal timing to recover the signal from noise and interference. PSK31 indicates a 31 baud mode that is commonly used



Packet and Packet Networks

Ham radio modes that transmit groups of data called packets

These are often used on VHF and UHF

FSK or Frequency-shift keying uses a series of rapidly alternating audio tones to transmit the information to a receiving modem and terminal node controller (TNC) where the data is reassembled

On VHF and UHF packets are transmitted at 1200 or 9600 baud with a throughput of 400-3000 bits per second

Each packet consists of a **header**, **data** and a **checksum**. The header contains information about the packet and the callsign of the destination of the station. The data is the message or information and the checksum allows the receiver to detect errors in the transmission

ARQ or Automatic Repeat Request: If an error is found (using the checksum) the receiver automatically requests that the packet be retransmitted until the data is received properly

Keyboard to Keyboard

Ham radio digital modes that allow for real-time person to person communication

Most popular on HF bands (commonly using fldigi or other computer programs)

Tones are generated using a computer sound card and are sent to a radio using a special interface (Signalink) connected to the radio

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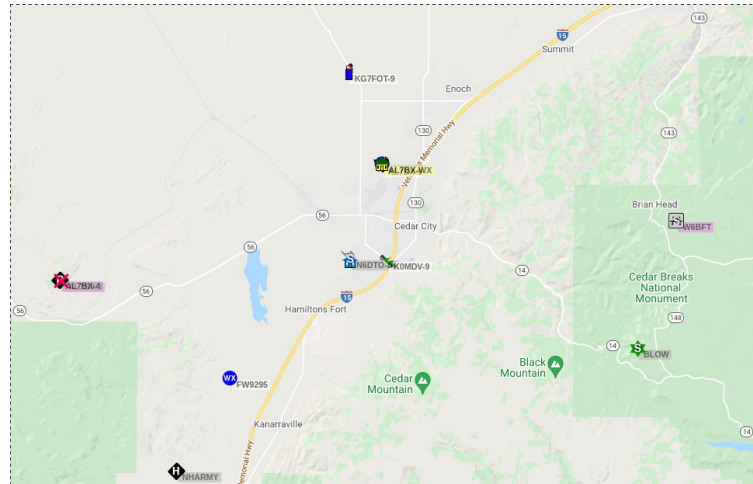
APRS: Automatic Packet Reporting System

Uses packet radio to transmit the position information from a moving or portable station

APRS is a packet radio station combined with a GPS (Global Positioning System) receiver

Digipeaters and gateways (radio stations that provide a connection to the internet via Amateur Radio) forward APRS packets, position information and call sign to a computer system connected to the internet

Data can then be mapped to show the position of the station



QUIZ Time!

QUIZ Time!

T8A01: Which of the following is a form of amplitude modulation?

- a. Spread spectrum
- b. Packet radio
- c. Single sideband
- d. Phase shift keying (PSK)

T8A02: What type of modulation is most commonly used for VHF packet radio transmission?

- a. FM
- b. SSB
- c. AM
- d. PSK

T8A03: Which type of voice mode is most often used for long-distance (weak signal) contacts on the VHF and UHF bands?

- a. FM
- b. DRM
- c. SSB
- d. PM

QUIZ Time!

T8A04: Which type of modulation is most commonly used for VHF and UHF voice repeaters?

- a. AM
- b. SSB
- c. PSK
- d. FM

T8A05: Which of the following types of emission has the narrowest bandwidth?

- a. FM voice
- b. SSB voice
- c. CW
- d. Slow-scan TV

T8A06: Which sideband is normally used for 10 meter HF, VHF, and UHF single-sideband communications?

- a. Upper sideband
- b. Lower sideband
- c. Supressed sideband
- d. Inverted sideband

QUIZ Time!

T8A07: What is an advantage of single sideband (SSB) over FM for voice transmissions?

- a. SSB signals are easier to tune
- b. SSB signals are less susceptible to interference
- c. SSB signals have narrower bandwidth
- d. All of these choice are correct

T8A08: What is the approximate bandwidth of a single sideband (SSB) coice signal)

- a. 1 kHz
- b. 3 kHz
- c. 6 kHz
- d. 15 kHz

T8A09: What is the approximate bandwidth of a VHF repeater FM phone signal?

- a. Less than 500 Hz
- b. About 150 kHz
- c. Between 10 and 15 kHz
- d. Between 50 and 125 kHz

QUIZ Time!

T8A10: What is the typical bandwidth of analog fast-scan TV transmission on the 70 centimeter band?

- a. More than 10 MHz
- b. About 6 MHz
- c. About 3 MHz
- d. About 1 MHz

T8A11: What is the approximate maximum bandwidth required to transmit a CW signal

- a. 2.4 kHz
- b. 150 Hz
- c. 1000 Hz
- d. 15 kHz

QUIZ Time!

T8B01: What telemetry information is typically transmitted by satellite beacons?

- a. The signal strength of received signals
- b. Time of day accurate to plus or minus 1/10 second
- c. Health and status of the satellite
- d. All of these choices are correct

T8B02: What is the impact of using too much effective radiated power on a satellite uplink?

- a. Possibility of commanding the satellite to an improper mode
- b. Blocking access by other users
- c. Overloading the satellite batteries
- d. Possibility of rebooting the satellite control computer

T8B03: Which of the following are provided by satellite tracking programs?

- a. Maps showing the real-time position of the satellite track over the earth
- b. The time, azimuth, and elevation of the start, maximum altitude, and end of a pass
- c. The apparent frequency of the satellite transmission, including effects of Doppler shift
- d. All of these choices are correct

QUIZ Time!

T8B04: What mode of transmission is commonly used by amateur radio satellites?

- a. SSB
- b. FM
- c. CW/data
- d. All of these choices are correct

T8B05: 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

T8B06: Which of the following are inputs to a satellite tracking program?

- a. The weight of the satellite
- b. The Keplerian elements
- c. The last observed time of zero Doppler shift
- d. All of these choices are correct

QUIZ Time!

T8B07: With regard to satellite communications, what is Doppler shift?

- 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 the earth station
- d. A special digital communications mode for some satellites

T8B08: What is meant by the statement that a satellite is operating in mode U/V?

- a. The satellite uplink is in the 15 meter band and the downlink is in the 10 meter band
- b. The satellite uplink is in the 70 centimeter band and the downlink is in the 2 meter band
- c. The satellite operates using ultraviolet frequencies
- d. The satellite frequencies are usually variable

T8B09: What causes spin fading of satellite signals?

- a. Circular polarized noise interference radiated from the sun
- b. Rotation of the satellite and its antennas
- c. Doppler shift of the received signal
- d. Interfering signals within the satellite uplink band

QUIZ Time!

T8B10: What do the initial LEO tell you about an amateur satellite?

- a. The satellite battery is in Low Energy Operation mode
- b. The satellite is performing a Lunar Ejection Orbit maneuver
- c. The satellite is in a Low Earth Orbit
- d. The satellite uses Light Emitting Optics

T8B11: Who may receive telemetry from a space station?

- a. Anyone who can receive the telemetry signal
- b. A licensed radio amateur with a transmitter equipped for interrogating the the satellite
- c. A licensed radio amateur who has been certified by the protocol developer
- d. A licensed radio amateur who has registered for an access code from AMSAT

T8B12: Which of the following is a good way to judge whether your uplink power is neither too low nor too high?

- a. Check your signal strength report in the telemetry data
- b. Listen for distortion on your downlink signal
- c. Your signal strength on the downlink should be about the same as the beacon
- d. All of these choices are correct

QUIZ Time!

T8C01: Which of the following methods is used to locate sources of noise interference or jamming?

- a. Echolocation
- b. Doppler radar
- c. Radio direction finding
- d. Phase locking

T8C02: Which of these items would be useful for a hidden transmitter hunt?

- a. Calibrated SWR meter
- b. A directional antenna
- c. A calibrated noise bridge
- d. All of these choices are correct

T8C03: What operating activity involves contacting as many stations as possible during a specified period?

- a. Contesting
- b. Net operations
- c. Public service events
- d. Simulated emergency exercises

QUIZ Time!

- T8C04: Which of the following is good procedure when contacting another station in a radio contest?
- a. Sign only the last two letters of your call if there are many other stations calling
 - b. Contact the station twice to be sure that you are in his log
 - c. Send only the minimum information needed for proper identification and the contest exchange
 - d. All of these choices are correct
- T8C05: 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
- T8C06: How is access to some IRLP nodes accomplished?
- a. By obtaining a password that is sent via voice to the node
 - b. By using DTMP signals
 - c. By entering the proper internet password
 - d. By using CTCSS tone codes

QUIZ Time!

T8C07: What is meant by Voice Over Internet Protocol (VoIP) as used in amateur radio?

- a. A set of rules specifying how to identify your station when linked over the internet to another station
- b. A set of guidelines for contacting DX stations during contests using internet access
- c. A technique for measuring the modulation quality of a transmitter using remote sites monitored via the internet
- d. A method of delivering voice communications over the internet using digital techniques

T8C08: What is the Internet Radio Linking Project (IRLP)?

- a. A technique to connect amateur radio systems, such as repeaters, via the internet using Voice Over Internet Protocol (VoIP)
- b. A system for providing access to websites via amateur radio
- c. A system for informing amateurs in real time of the frequency of active DX stations
- d. A technique for measuring signal strength of an amateur transmitter via the internet

T8C09: How might you obtain a list of active nodes that use VoIP?

- a. By subscribing to an on line service
- b. From on line repeater lists maintained by the local repeater frequency coordinator
- c. From a repeater directory
- d. All of these choices are correct

QUIZ Time!

T8C10: What must be done before you may use the EchoLink system to communicate using a repeater?

- a. You must complete the required EchoLink training
- b. You must have purchased a license to use the EchoLink software
- c. You must be sponsored by a current EchoLink user
- d. You must register your call sign and provide proof of license

T8C11: What name is given to an amateur radio station that is used to connect other amateur stations to the internet?

- a. A gateway
- b. A repeater
- c. A digipeater
- d. A beacon

QUIZ Time!

T8D01: Which of the following is a digital communication mode?

- a. Packet radio
- b. IEEE 802.11
- c. JT65
- d. All of these choices are correct

T8D02: What does “APRS” mean?

- a. Automatic Packet Reporting System
- b. Associated Public Radio Station
- c. Auto Planning Radio Set-up
- d. Advanced Polar Radio System

T8D03: Which of the following devices is used to provide data to the transmitter when sending automatic position reports from a mobile amateur radio station?

- a. The vehicle speedometer
- b. A WWV receiver
- c. A connection to a broadcast FM sub-carrier receiver
- d. A Global Positioning System receiver

QUIZ Time!

T8D04: What type of transmission is indicated by the term “NTSC?”

- a. A Normal Transmission mode in Static Circuit
- b. A special mode for earth satellite uplink
- c. An analog fast scan color TV signal
- d. A frame compression scheme for TV signals

T8D05: Which of the following is an application of APRS (Automatic Packet Reporting System)?

- a. Providing real-time tactical digital communications in conjunction with a map showing the locations of stations
- b. Showing automatically the number of packets transmitted via PACTOR during a specific time interval
- c. Providing voice over internet connection between repeaters
- d. Providing information on the number of stations signed into a repeater

T8D06: What does the abbreviation “PSK” mean?

- a. Pulse Shift Keying
- b. Phase Shift Keying
- c. Packet Short Keying
- d. Phased Slide Keying

QUIZ Time!

T8D07: Which of the following best describes DMR (Digital Mobile Radio)?

- a. A technique for time-multiplexing two digital voice signals on a single 12.5 kHz repeater channel
- b. An automatic position tracking mode for FM mobiles communication through repeaters
- c. An automatic computer logging technique for hands-off logging when communication while operating a vehicle
- d. A digital technique for transmitting on two repeater inputs simultaneously for automatic error correction

T8D08: Which of the following may be included in packet transmissions?

- a. A check sum that permits error detection
- b. A header that contains the call sign of the station to which the information is being sent
- c. Automatic repeat request in case of error
- d. All of these choices are correct

T8D09: What code is used when sending CW in the amateur bands?

- a. Baudot
- b. Hamming
- c. International Morse
- d. All of these choices are correct

QUIZ Time!

T8D10: Which of the following operating activities is supported by digital mode software in the WSJT suite?

- a. Moonbounce or Earth-Moon-Earth
- b. Weak-signal propagation beacons
- c. Meteor scatter
- d. All of these choices are correct

T8D11: What is an ARQ transmission system?

- a. A special transmission format limited to video signals
- b. A system used to encrypt command signals to an amateur radio satellite
- c. A digital scheme whereby the receiving station detects errors and sends a request to the sending station to retransmit the information
- d. A method of compressing the data in a message so more information can be sent in a short time

T8D12: Which of the following best describes Broadband-Hamnet™, also referred to as a high-speed multi-media network?

- a. An amateur-radio-based data network using commercial Wi-Fi gear with modified firmware
- b. A wide-bandwidth digital voice mode employing DRM protocols
- c. A satellite communications network using modified commercial satellite TV hardware
- d. An internet linking protocol used to network repeaters

QUIZ Time!

T8D13: What is FT8?

- a. A wideband FM voice mode
- b. A digital mode capable of operating in low signal-to-noise conditions that transmits on a 15-second intervals
- c. An eight channel multiplex mode for FM repeaters
- d. A digital slow scan TV mode with forward error correction and automatic color compensation

T8D14: What is an electronic keyer?

- a. A device for switching antennas from transmit to receive
- b. A device for voice activated switching from receive to transmit
- c. A device that assists in manual sending of Morse code
- d. An interlock to prevent unauthorized use of a radio