Amateur Radio Service
Technician Class

Exam Preparation Class

September — October 2018

Session 1

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These slides will be uploaded to my website

https://k7ojl.com/technician-class-materials/

just before class each week.

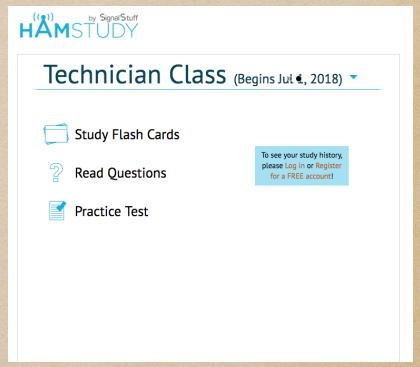
Depending on how the class goes, they may get updated after the class.

Class Overview

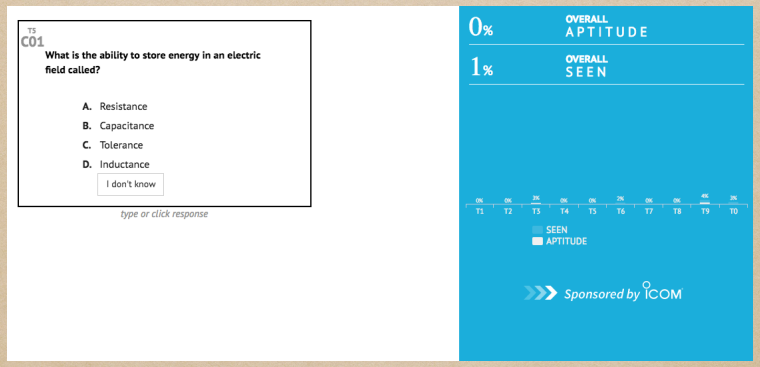
- Getting Started With This Class
- What is the Amateur Radio Service
- Operating Practices
- Call Signs
- The Technician Exam
- Frequencies and Band Plans
- Your Radio and Repeaters
- Emergency Operations
- Nets and Net Operations
- Propagation
- Antennas and Feed Lines

Getting Started

- This class will teach the fundamentals and information that the Amateur Radio Operator needs to know.
  - It doesn't "teach the test".
- www.hamstudy.org is where you'll study the actual test questions and take practice tests.
  - If you will spend three hours/ week in class and 2-3 hours/ week on hamstudy.org, you will pass the test.



hamstudy.org Demonstration



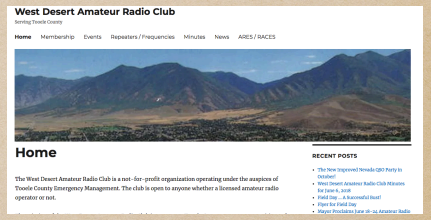
This time will be spent helping class members
sign up for hamstudy.org

Other Resources

- Gordon West's Technician Class Manual
  - A few copies are available, others can be ordered. $30 each.
- Dan Romanchik's "No Nonsense" Technician Class Study Guide (https://www.kb6nu.com/study-guides/)
  - PDF is free from his website
  - I've printed a few copies, $5 each
- YouTube Video Series
  - AmateurLogic.TV
  - David Casler KE0OG "Technician Ham Radio License"

Get The Most Out of Your License!

- Join a club
  - The local club is the West Desert Amateur Radio Club which meets on the 1st Wednesday of each month at the EOC
- Participate in weekly nets
  - WDARC every Thursday at 7pm
  - Various Church nets (talk to your stake emergency preparedness person)



The Amateur Radio Service

What Is the Amateur Radio Service?

Amateur radio (also known as "ham radio") services are regulated under Part 97 of the FCC rules. Amateur radio operators are licensed users who operate radio communications as a hobby or a voluntary service running within amateur radio frequencies allocated by the FCC.

Amateur, in this case, means "non-professional", or in other words, unpaid.

There are more than 800,000 ham radio operators in the US.

As a licensed amateur radio operator
- We can experiment
- We can design and/build our own equipment
- We can play with different antenna designs
- We can experiment with high power (up to 1,500 watts) or very low power
- We can test various frequencies and modulation schemes

In order to do all that, we need to be licensed
- Take a test to demonstrate some basic understanding of radio principles and the rules and regulations

What Is the Amateur Service?

The amateur service is for qualified persons of all ages who are interested in radio technique solely with a personal aim and without pecuniary interest (fcc.gov).

License Classes

- Currently being issued:
  - Technician Class
  - General Class
  - Amateur Extra Class
- Previously issued, some still operating
  - Novice class
  - Advanced class

Operating Practices

Operating Practices

- As a station licensee, you are the Control Operator
  - You can designate another licensed operator as a control operator
- You must identify every ten minutes and at the end of a communication
- Phonetic alphabet is encouraged (but not required)

Tactical callsigns … end the communication with the control operator's FCC callsign

Phonetic Alphabet

A - Alpha	J - Juliet	S - Sierra
B - Bravo	K - Kilo	T - Tango
C - Charlie	L - Lima	U - Uniform
D - Delta	M - Mike	V - Victor
E - Echo	N - November	W - Whiskey
F - Foxtrot	O - Oscar	X - X-ray
G - Golf	O - Papa	Y -Yankee
H - Hotel	Q - Quebec	Z - Zulu
I - India	R - Romeo	

Operator Practices (continued)

- You may communicate with any other country EXCEPT where that country has notified the US Government that communication is prohibited.
- You may communicate about amateur radio or personal characteristics. No Business!

3rd-Party Communications

A third-party communication is a message from a control operator to another station's control operator on behalf of another person.

Specifically, it is a communication by amateur radio on behalf of a non-licensed person.

- Permitted between countries ONLY where a 3rd-part agreement is in place between those two countries.

Some Important Rules

- No obscenities
- No interfering with other radio communications
- No broadcasting — communications must be amongst two or more parties
- No "coded" or "encrypted" communications
  - Except when sending control commands to a space station or radio controlled craft
- No music … even background music
- No sales, except incidental sales of amateur radio equipment
- You must let the FCC in to examine your station
- You must keep your address current in the FCC database

Call Signs

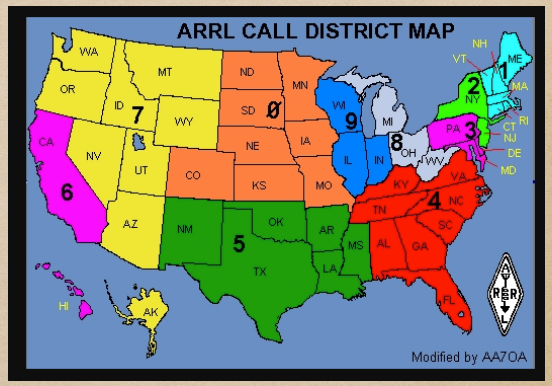
Amateur Radio Call Signs

- Sequentially issued by the FCC
- Will be in the FCC database within 10-12 days of passing the examination
- Format is 1-2 letters followed by a digit followed by 1-3 letters
  - Technicians are limited to 1x3 or 2x3 callsigns
- Valid for 10 years

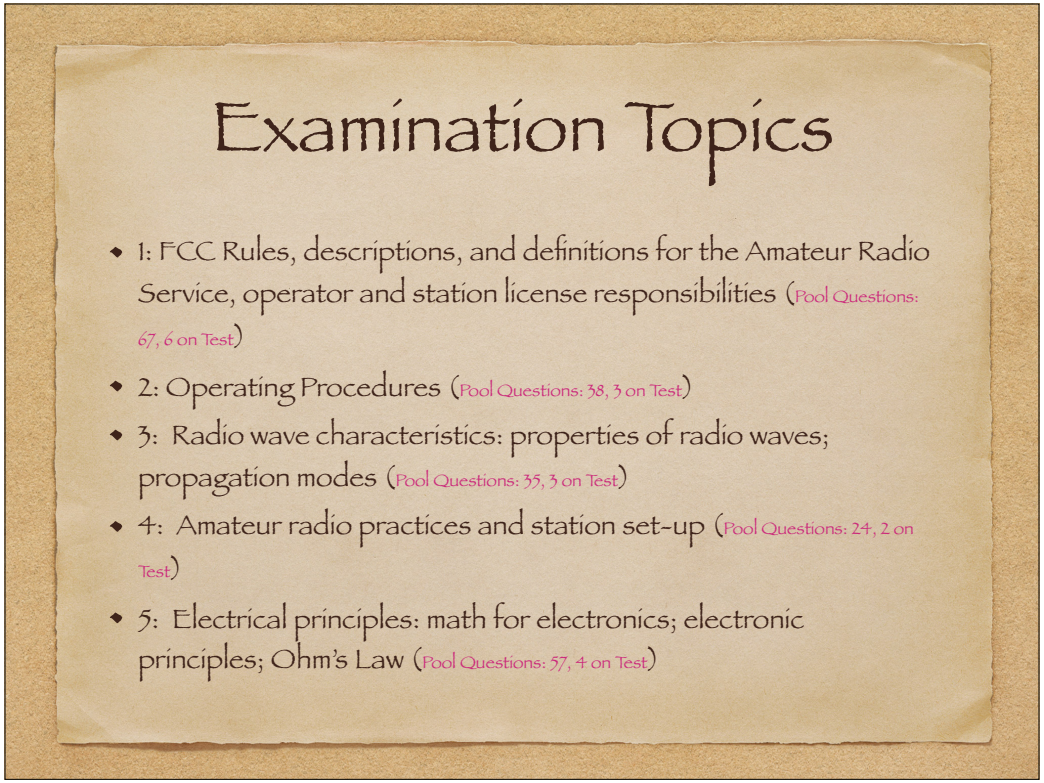
Not a Valid Callsign!

Call Signs

- First character must be A, K, N, or W
  - As allowed by the IARU
- Digit is one of 10 call districts in the US.
  - Set by your permanent mailing address when applying for a license

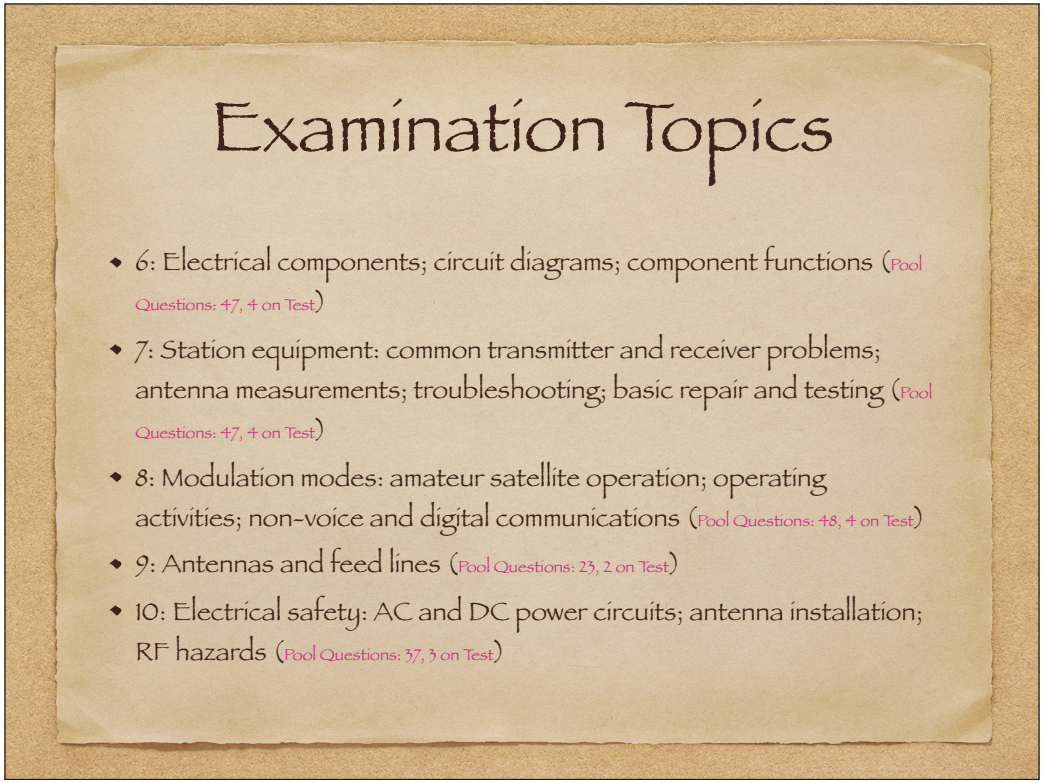


The Technician Exam



The actual test is 35 questions. A 70% or better score is required to pass. Up to 9 questions can be missed.

The test each person gets is different than the one his neighbor gets. Some of the questions may be the same, but they'll be in a different order. The software that generates the test randomly selects the required number of questions for each section from the available questions in the pool for that topic.



There is a $15 dollar fee for the exam, half of which is remitted to the Volunteer Examining Coordinator (in this case, W5YI) and half is used by the sponsoring club to cover incidental expenses.

If you pass your Technician exam, you can immediately take the General exam at no extra cost.

The Exam Itself

- Before the exam begins there is paperwork to fill out
  - You must have two forms of ID, one of which must have a picture
- Exam is supervised by a minimum of three authorized examiners
- Each exam is independently scored by three authorized examiners
- You'll be notified immediately of your results

Two pieces of paper, which have to be turned in

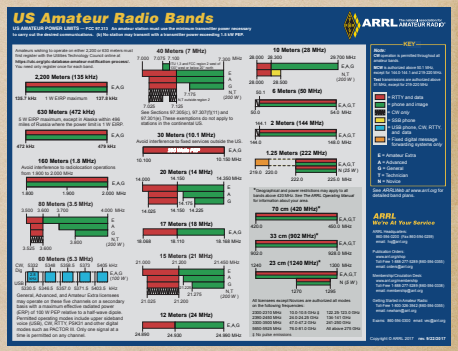
Pencil … answer sheet is best marked with pencil

Calculator (not a smart phone!!)

Frequencies & Band Plans

Technician Privileges

- CW (morse code) in small segments of the high frequency (HF) bands
- Full privileges in the VHF, UHV, and higher
- Satellites, Space Station, moon bounce, meteor scatter, mesh networks, amateur TV, and much more



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.

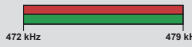
ARRL The national association for AMATEUR RADIO®

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)

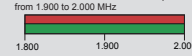
630 Meters (472 kHz)

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

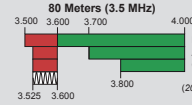


160 Meters (1.8 MHz)

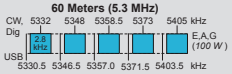
Avoid interference to radiolocation operations from 1.900 to 2.000 MHz



80 Meters (3.5 MHz)

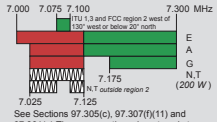


60 Meters (5.3 MHz)



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)

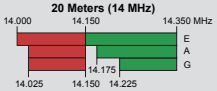


See Sections 97.305(c), 97.307(f)(11) and 97.301(e).These exemptions do not apply to stations in the continental US.

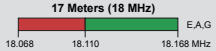
30 Meters (10.1 MHz)

Avoid interference to fixed services outside the US.

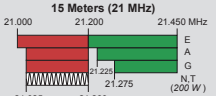
20 Meters (14 MHz)



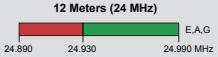
17 Meters (18 MHz)



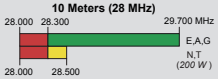
15 Meters (21 MHz)



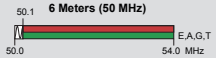
12 Meters (24 MHz)



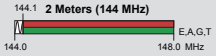
10 Meters (28 MHz)



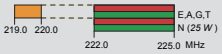
6 Meters (50 MHz)



2 Meters (144 MHz)



1.25 Meters (222 MHz)

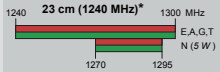


*Geographical and power restrictions may apply to all bands above 420 MHz. See *The ARRL Operating Manual* for information about your area.

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

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:
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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

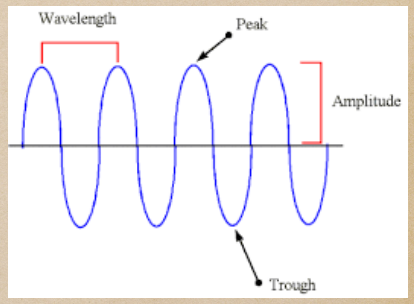
 rev. 9/22/2017

On the "Air"

- Communication is made on radio frequencies
- Electromagnetic waves carry the communication
  - It has both an electrical and a magnetic component
- Radio waves travel at the speed of light or about 300,000,000 meters/ second

Radio Waves

- Measured in cycles per second
- Measurement term is "Hertz" which means, cycles per second
  - The number of cycles per second is the "Frequency"
- Wavelength is measured in "meters"
  - Wavelength and Frequency are inversely related to each other



Frequency vs Wavelength

Wavelength decreases as Frequency increases

Wavelength is depicted by the Greek letter Lambda: λ and is measured in meters

Frequency is depicted by the letter 'f' and is measured in thousands of Hertz (kHz), millions of Hertz (MHz), or billions of Hertz (GHz)

$$\lambda(\text{meters}) = 300 \div f(\text{MHz})$$

$$f(\text{MHz}) = 300 \div \lambda(\text{meters})$$

Frequency Spectrum

High Frequency (HF)	3 to 30 MHz 100 to 10 meters
Very High Frequency (VHF)	30 to 300 MHz 10 to 1 meters
Ultra High Frequency (UHF)	300 to 3000 MHz 1 to 0.1 meters
Super High Frequency (SHF)	Above 3000 MHz Shorter than 0.1 meters

6 meter band is where

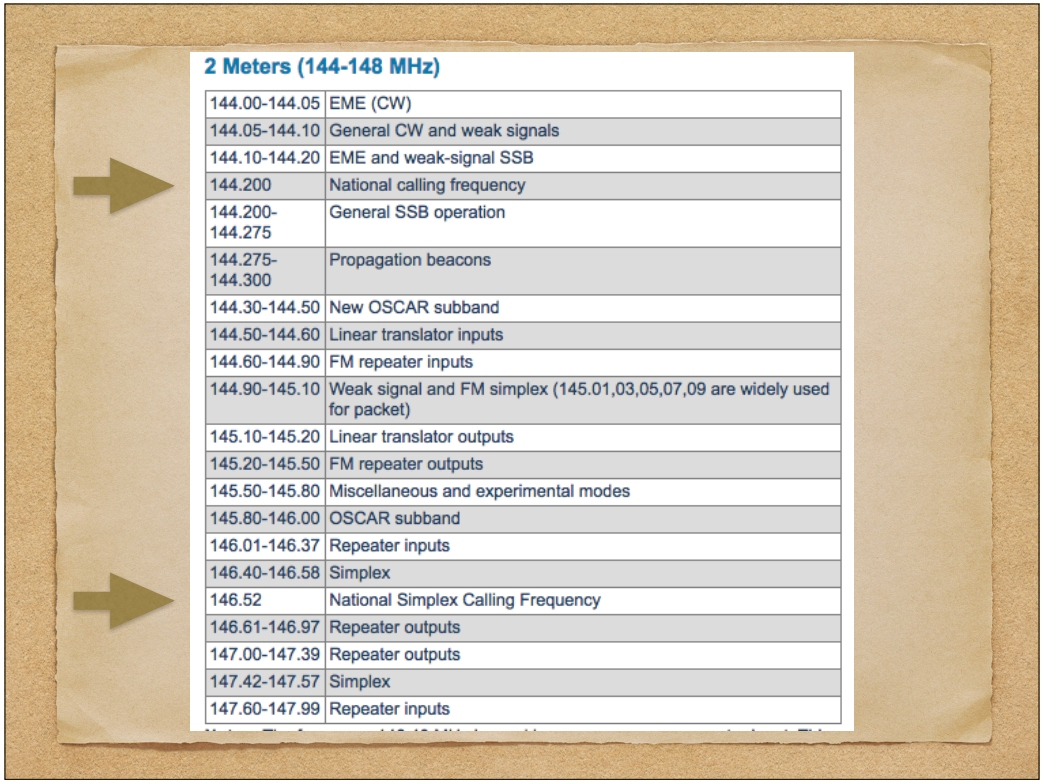
146.52 MHz is where

HF max Technician power is 200 watts

VHF and up max Technician power is 1,500 watts

Band Plans

- Band Plans are the dictated ways in which the authorized spectrum may be used as well as the generally accepted segmentation of the authorized spectrum
- In some cases, Amateur Radio is a secondary user of certain frequency ranges
  - The 70cm band is primary for military radar and secondary for amateur radio
  - We must avoid interfering with the primary user
- Stay away from band edges
  - Emissions have width, so transmitting on a band edge means that some of the emission will be outside of the band



2 Meters (144-148 MHz)

144.00-144.05	EME (CW)
144.05-144.10	General CW and weak signals
144.10-144.20	EME and weak-signal SSB
144.200	National calling frequency
144.200-144.275	General SSB operation
144.275-144.300	Propagation beacons
144.30-144.50	New OSCAR subband
144.50-144.60	Linear translator inputs
144.60-144.90	FM repeater inputs
144.90-145.10	Weak signal and FM simplex (145.01,03,05,07,09 are widely used for packet)
145.10-145.20	Linear translator outputs
145.20-145.50	FM repeater outputs
145.50-145.80	Miscellaneous and experimental modes
145.80-146.00	OSCAR subband
146.01-146.37	Repeater inputs
146.40-146.58	Simplex
146.52	National Simplex Calling Frequency
146.61-146.97	Repeater outputs
147.00-147.39	Repeater outputs
147.42-147.57	Simplex
147.60-147.99	Repeater inputs

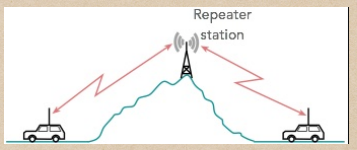
National SSB / CW calling frequency: 144.200 MHz
National FM calling frequency: 146.52 MHz

Your Radio & Repeaters

Radio Characteristics

- A method to switch between transmit and receive: PTT (push to talk)
- A method to store frequently used frequencies and modes (Memory Channels)
- A method to attach an antenna
  - Outside is better
  - Some HT "rubber-duck" antennas are poor performers
- Has at least one mode of operation
  - For VHF/UHF bands, most HT's offer only FM
- May have a method of setting the frequency (VFO or Variable Frequency Oscillator)
- May have squelch settings to mute the receiver when no signal is present
- Usually offer the ability to operate in Simplex or Split mode

What is a Repeater?



- A radio that listens on one frequency and simultaneously transmits on another frequency (generally limited to 10 meters and above)
- The "split" between receive and transmit depends on the band (0.6 MHz in the 2 meter band and (5.0 MHz in the 70cm band is common). The split can be either up (+) or down (-)
- To avoid spurious transmissions, repeaters often require a specific sub-audible tone to be sent with the transmission otherwise the repeater ignores the incoming signal … Specifically called CTCSS (commonly called a PL tone)

CTCSS: Continuous Tone-coded Squelch System

Reverse split means listening on the repeater's input frequency

Repeaters are often linked, either over the air or over the Internet. The Intermountain Intertie is an excellent example

Local volunteers work to coordinate the frequency pairs used by repeaters in the area to avoid conflicts. The FCC is never involved in this coordination work … only when transmissions are being interfered with.

Repeaters are required to identify themselves periodically. That can be done either with voice or CW

Using a Repeater

Frequency	Offset Direction	Offset Amount	CTCSS
147.300	+	0.6 MHz	100.0
449.425	-	5.0 MHz	100.0

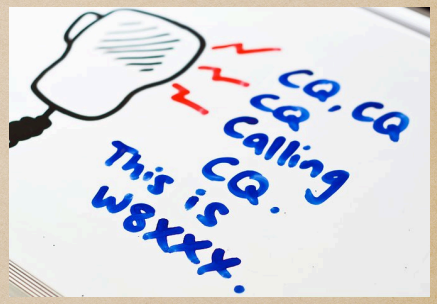
- Need to know
  - Frequency
  - Offset (and offset amount if non-standard)
  - CTCSS
- Utah VHF Society (utahvhfs.org) maintains lists of (most) all repeaters in Utah

The W4VB repeater repeats on 145.330 anything it hears on 144.730 Mhz that has a subduable tone of 131.8 Hz

To us this repeater, I set up my HT:
Set my receive frequency to 145.330 MHz
Set my offset to "minus 0.6 MHz"
Set CTCSS on transmit to 131.8 Hz

Ham Radio Terms

- CQ: Calling any station
- QSO: A conversation over the air (also eyeball QSO)
- QTH: My location
- QRT: Going off the air
- 73: Best wishes
- 88: Hugs and kisses
- QRP: Low power
- QRO: High power
- QRM: Man-made interference
- QRN: Natural interference
- QSY: Changing frequency

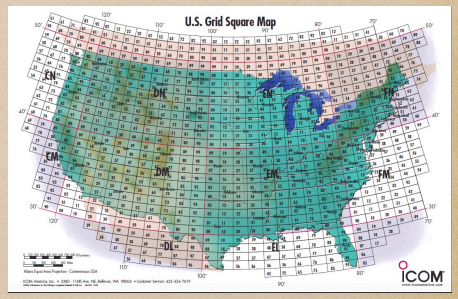


Getting On the Air

- Listen, listen, listen. Is the frequency clear? Are you on an authorized frequency? While no one has "rights" to a specific frequency, be accommodating
- When giving call signs, transmit the other station's call sign first then your call sign
- If the other station reports a weak signal, move a few feet
- Mobile stations sometimes have issues with picket fencing
- Weekends often feature contests where stations try to contact as many other stations as possible over a specific time period

Grid Squares

- A letter / number designator for a specific area.
- Can go up to 10 characters. Most common is 2 letters followed by 2 digits. We're in DN30.
- This year the ARRL is sponsoring an International Grid Square Chase. Contacts will often ask for your grid square



Emergency Operations

ARES and RACES

Amateur Radio Emergency Service

- ARRL Sponsored volunteer service
- Local clubs can register as ARES clubs
- Usually associated with a local governmental or non-governmental agency
- Practices through weekly nets and community service events

Radio Amateur Civil Emergency Service

- Sponsored by a civil defense organization
- Usually requires certification by the sponsoring organization
- Responds only when activated
- Practices through regular nets

Emergency Operations

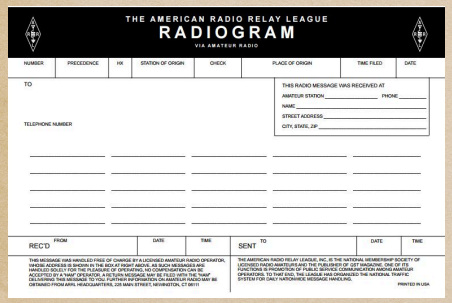
- FCC Rules ALWAYS apply, even during an emergency
  - However, a licensed amateur radio operator may use any mode or frequency in situations involving the immediate safety of human life or the protection of property
- To signal an emergency situation, transmit your callsign followed by the words "Priority Traffic" or "Emergency".

Nets and Net Operations

What Is a Net?

- Most commonly three types of nets:
  - Traffic Net
  - Casual "birds of a feather" net
  - Emergency practice net
- Conducted on the air
  - Usually at a specific time
  - And on a specific repeater or frequency
- Managed by a Net Control Operator (NCS)
  - Stations check in and then only transmit when invited by the NCS

Message Handling



THE AMERICAN RADIO RELAY LEAGUE

RADIOGRAM

VIA AMATEUR RADIO

NUMBER	PRECEDENCE	HX	STATION OF ORIGIN	CHECK	PLACE OF ORIGIN	TIME FILED	DATE

TO

TELEPHONE NUMBER

THIS RADIO MESSAGE WAS RECEIVED AT

AMATEUR STATION _____ PHONE _____

NAME _____

STREET ADDRESS _____

CITY, STATE, ZIP _____

FROM REC'D	DATE	TIME	TO SENT	DATE	TIME

THIS MESSAGE WAS HANDLED FREE OF CHARGE BY A LICENSED AMATEUR RADIO OPERATOR, WHO VOLUNTEERS HIS/HER TIME, EQUIPMENT AND STATION FOR PUBLIC SERVICE. IT WAS HANDLED SOLELY FOR THE PLEASURE OF OPERATING. NO COMPENSATION CAN BE ACCEPTED BY A "HAM" OPERATOR. A RETURN MESSAGE MAY BE FILED WITH THE "HAM" OPERATOR WHO HANDLED THIS, OR WITH ANY OTHER AMATEUR RADIO STATION. INFO MAY BE OBTAINED FROM ARRL HEADQUARTERS, 225 MAIN STREET, NEWINGTON, CT 06111

THE AMERICAN RADIO RELAY LEAGUE, INC. IS THE NATIONAL MEMBERSHIP SOCIETY OF AMATEUR RADIO AMATEUR RADIO. WE ARE THE PUBLISHERS OF QST MAGAZINE. ONE OF ITS FUNCTIONS IS PROMOTION OF PUBLIC SERVICE COMMUNICATION AMONG AMATEUR OPERATORS. TO THAT END, THE LEAGUE HAS ORGANIZED THE NATIONAL TRAFFIC SYSTEM FOR DAILY NATIONWIDE MESSAGE HANDLING.

PRINTED IN USA

A key characteristic of traffic handling is passing the message exactly and precisely

- Traffic nets relay formal messages from an originator to a destination, kind of like a telegram
  - Local nets collect new messages, deliver received messages
  - Regional nets relay messages to and from other regions and local nets
- The preamble (header) of the radiogram is used to track the message from initiation to reception.
- Note that these messages are third-party traffic

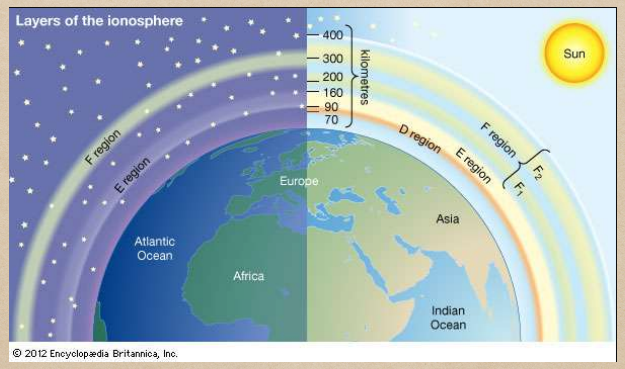
Local WDARC Net

- Held each Thursday evening at 7:00pm on the Tooele South Mountain repeater (147.300- 100.0 Hz)
- Format of the net:
  - A preamble
  - Club officer checkins
  - Club member checkins
  - Any other checkins
  - Traffic handling
  - Postamble

Propagation

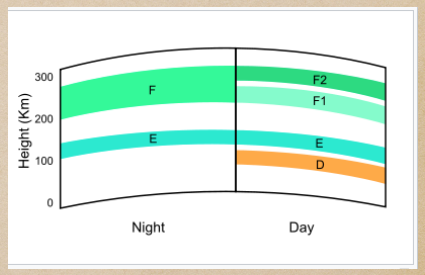
It All Depends on the Sun!

The Ionosphere



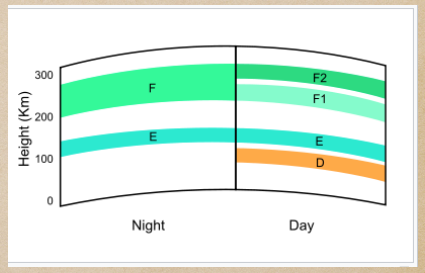
The 'D' Layer

- Appears during daytime
- Closest to the earth (35 to 55 miles above the earth surface)
- Many more neutral molecules rather than ionized molecules
- Significantly attenuates medium frequency and high frequency (below 10 MHz) radio waves



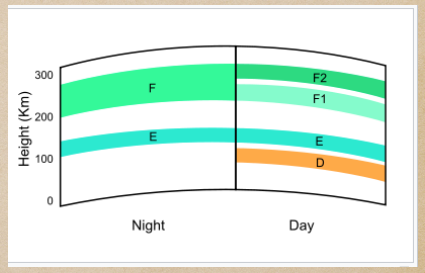
The 'E' Layer

- Appears during daytime
- Middle ionospheric layer (55 to 95 miles
- Significant amounts of ionized oxygen molecules
- Reflects radio frequencies below 10 MHz and may attenuate higher frequencies
- Occasionally sporadic E events occur where frequencies up to 50 MHz are reflected

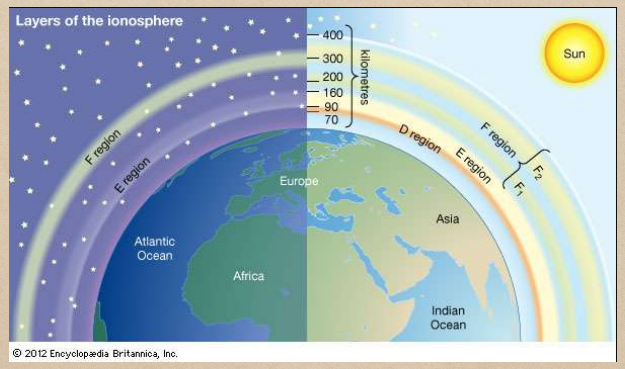


The 'F' Layers

- Splits into the F1 / F2 layers during daytime
- Combines into one F layer during the night
- Highest ionospheric layer (90 to 130 miles
- Responsible for almost all of the high frequency (above 10 MHz) skywave propagation



The Ionosphere Effect

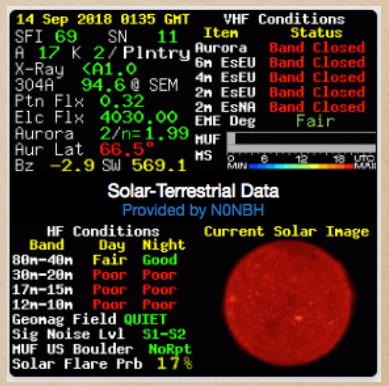


Sunspots Play a Significant Role in Propagation

- Sunspots are dark regions on the face of the sun caused by magnetic field concentrations
- Sunspots emit considerable magnetic and photon activity which is what ionizes the ionosphere
- Sunspots ebb and flow in 11 year cycles. We are currently at a sunspot minimum between cycle 24 and cycle 25
- The Solar Flux Index indicates how ionized the ionosphere is. An index of 70 or less indicates very poor conditions. On the date this slide was prepared, the solar flux was 69

Propagation Forecast

- Propagation forecasts such as the one on the right are commonly available on the Internet
- Notice that on this date there were no sunspots while there was a bright spot sending solar wind which seriously degrades propagation



Propagation Factoids

- VHF and UHF frequencies are generally not affected by the ionosphere, meaning they travel in a straight line forever without being reflected back to the earth
- VHF and UHF radio waves are affected by vegetation — trees and such. In winter these radio waves travel further due to lack of foliage
- VHF radio waves in vertical orientation tend to "bend" over hills or tall buildings. This is called knife-edge diffraction.
- Occasionally (usually in summer) temperature layers may occur opening tropospheric "ducts" which can carry VHF radio waves very long distances of 300 miles or so
- Frequencies below 220 MHz are generally unaffected by fog or rain. Microwave radio waves can be significantly affected by rain and water vapor in the air

More Factoids

- While VHF and higher frequencies are not reflected by the ionosphere, they can be reflected by meteors, aurora, airplanes, and the moon
  - Six and two meter waves reflect off auroras giving a fluttery distorted signal, a characteristic of aurora scatter
  - Six meters frequencies work best with meteor scatter
- The ten meter band is an amazing band during periods of high sunspot activity with very long distance propagation possible from just before sunrise until shortly after sunset. Note that Technicians have phone (SSB) privileges on portions of the ten meter band!
- Sporadic E propagation, mentioned earlier, occasionally occurs during late spring and summer on the 10, 6, and 2 meter bands where propagation of thousands of miles is possible

Space Weather Woman

- Dr. Tamitha Skov
- Produces a weekly propagation forecast published on YouTube
- https://www.youtube.com/channel/UCkXjdDQ-db0xz8f4PKgKsag

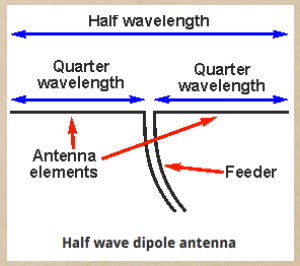
Antennas and Feed Lines

Antenna Polarization

- Antenna polarization is important at VHF and higher frequencies.
  - The position of the antenna determines the electrical polarization: vertical, horizontal, or circular
  - A signal from a horizontally polarized antenna will be significantly attenuated by a vertical receiving antenna
  - VHF and UHF FM radios are standardized around vertical polarization (including repeaters), so how you hold your HT makes a difference
  - VHF and higher SSB and Digital modes are generally horizontally polarized
- HF frequencies are usually unaffected by polarization and the ionosphere often reverses the polarization anyway

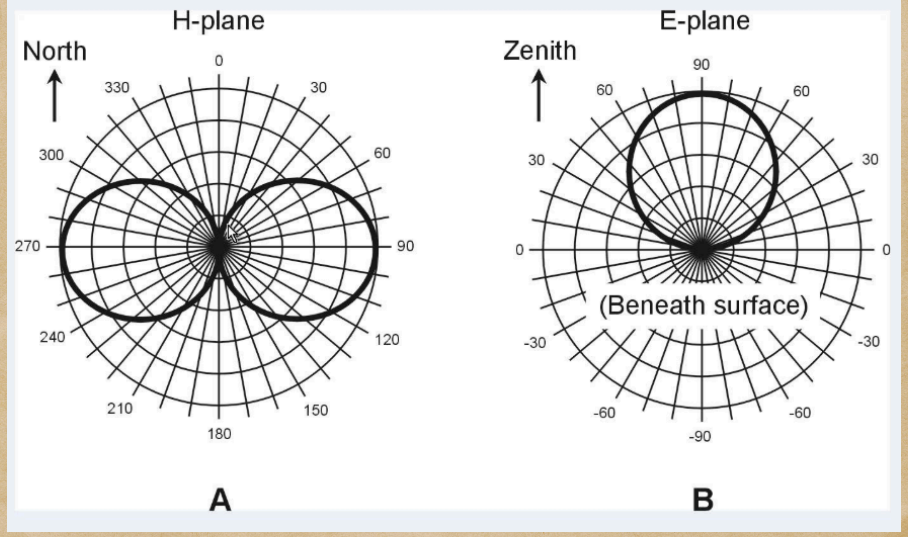
Dipole Antennas

- Most common type of antenna
- Radiates well broadside to the antenna
- Length of the antenna wire determines the resonant frequency
  - Shorten to go higher
  - Lengthen to go lower
- Height above ground affects the radiation angle
  - Works best 1/2 wavelength or more above ground



Takeoff angle

Dipole Radiation Pattern

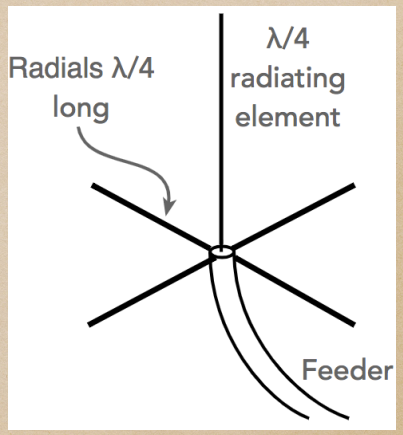


How Long Should A Dipole Be?

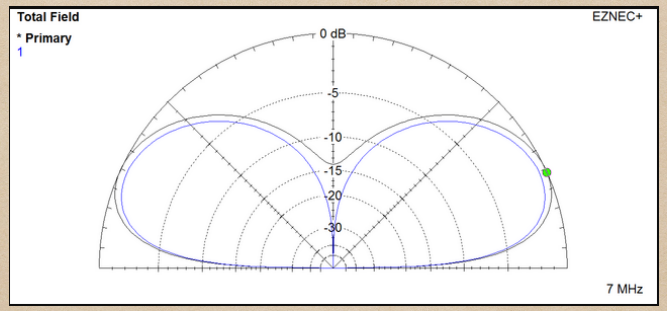
- Length in feet = 468 / frequency in MHz
  - Remember the formula to convert wavelength into frequency
- A 6 meter half-wave dipole?
  - 6 meters = 50 MHz (300/6)
  - length = 468 / 50 = 9.36 feet = 112.3 inches

Vertical Antennas

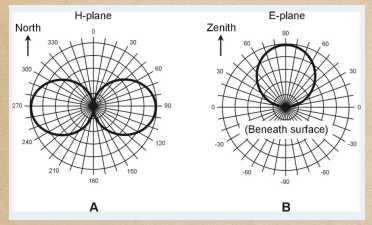
- Vertical antennas have a vertical element (1/4 wavelength) and several radials, also 1/4 wavelength, along the ground
- They have a very low takeoff angle (good for distant contacts)
- More susceptible to noise that horizontal dipoles

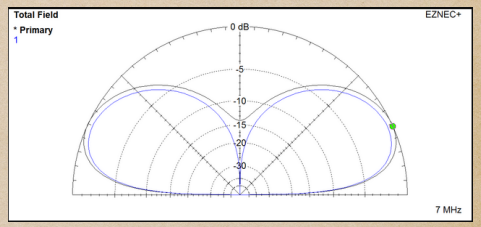


Vertical Antenna Radiation Pattern



Horizontal vs Vertical Antennas





Vertical antenna has a lower take-off angle

Vertical antenna has no “lobes”

Vertical antenna has less radiation on the broadside (evenly distributed)

Directional Antennas

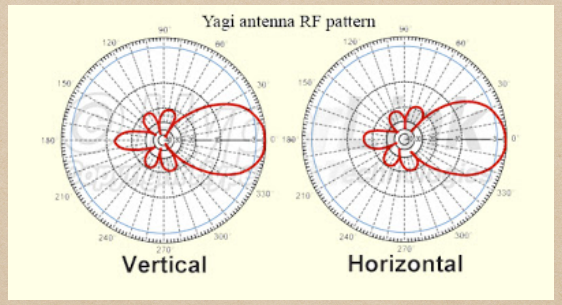
- Yagi, Quad, and Dish are all types of directional antennas
  - Directional means that the radiation pattern is more focused than a dipole or a vertical antenna
- Directional antennas have more "gain" and a higher "front to back ratio"

Gain: a process of taking RF energy and focusing it in an intended direction

Front to Back Ratio: The relative signal strength at the front of the antenna vs the relative signal strength at the back of the antenna

Directional antennas a very useful for radio direction finding

Yagi Antenna Radiation Patten

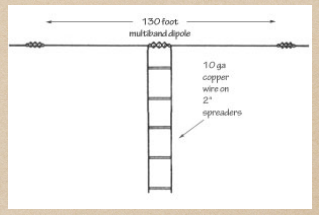


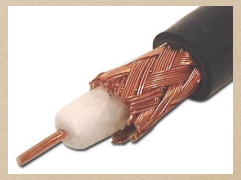
To focus the beam in the vertical: add elements to the beam

To focus the beam in the horizontal: stack another yogi

Feed Lines

- Two main types: ladder line (aka window line) and coax
  - Coax is used most often because of ease of use and no stand-off need
  - Ladder line has the lowest loss
- Each type of feed line has differing characteristic impedance

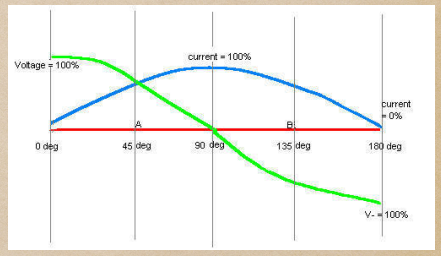




The antenna connector on the back of the transmitter / receiver expects to see an impedance (resistance) of 50 ohms
Coax generally has either 50 ohms or 75 ohms of impedance (50 ohms … amateur; 75 ohms … TV)

Antenna Impedance

- The impedance at the feed point varies across the length of the antenna
- If the impedance of the antenna at the feed point varies much from the impedance of the feed line, some of the energy is reflected back towards the transmitter rather than going into the antenna
- If the mismatch is greater than 3:1 (150 ohms at the feed point from 50 ohm coax), then the transmitter may "fold back" the power to reduce chance of damage to the final amplifier



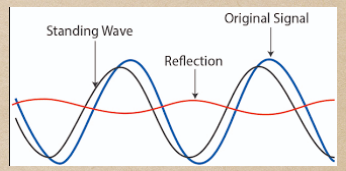
The method to address the mismatch is to insert a "transmatch" (short for transformer match) between the feed line and the antenna

Alternatively, a transmatch is often inserted between the transmitter and the feed line to be sure that the transmitter always sees 50 ohms regardless of the mismatch

Another name for the trans match is an "antenna tuner" … which doesn't tune anything

Standing Waves

- The amount of power reflected back to the transmitter varies with the mismatch
- The returning wave combines with the transmitted wave to cause a "standing wave" on the feed line. The ratio between the transmitted wave and the reflected wave is called the "Standing Wave Ratio"
- Eventually the energy not getting into the antenna goes up in heat in the coax. The greater the SWR, the more heat



Antenna / Feed Line Factoids

- A 5/8 wave vertical antenna has higher gain and a "squashed" signal pattern vs a 1/4 wave antenna
  - Often used for mobile antennas
- Inductance coils are used to electrically lengthen shorter antennas. These coils are often located in the center of the vertical antenna
- All feed lines have loss. The longer the feed line, the more loss. Coax has significantly more loss than window line but is easier to use
  - The difference between RG-8 and RG-58 is the latter has more loss than the former
- Coax must be protected against moisture incursion. The copper braid will disintegrate
- Air-insulated hardline: lowest loss, hardest to use, install, and maintain

Coax Cable Loss per 100 Feet

Coax Type	Size	Loss at HF 100 MHz	Loss at UHF 400 MHz
RG-58U	Small	4.3 dB	9.4 dB
RG-8X	Medium	3.7 dB	8.0 dB
RG-8U	Large	1.9 dB	4.1 dB
RG-213	Large	1.9 dB	4.5 dB
Hardline	Large, Rigid	0.5 dB	1.5 dB

3 dB loss is half the power (100 watts becomes 50 watts at the end)

A Few More Factoids

- An antenna analyzer can be used to measure the SWR of an antenna system
- A perfect impedance match (1:1) is achievable (??). A match of 1.5:1 and lower is considered a good match. Higher than 3:1 is a problematic match and likely will cause the transmitter to "fold back"
- Loose connections (at the transmitter, the trans match, or the feed point) will cause erratic SWR readings
  - Deteriorating coax due to water damage will also exhibit strange SWR readings
- A "dummy load" is very useful when testing a radio but don't want anything to be transmitted
  - A dummy load is simply a set of resistors giving an impedance of 50 ohms to the transmitter but sized large enough to handle the heat produced as the resistors use up the transmitted energy


Questions? Comments?