Radio Merit Badge

Mike Parks

Why get involved with radio?

JOTA

Fox Hunts

Internet and Software Defined Radio (EchoLink)

D-STAR

DX'ing
"Meet" folks around the world

Learn Electronics

IRLP

QRP (Low Power)

Talk to the International Space Station

IT'S FUN!

Weather Reporting

Emergency Communications (RACES)

Digital Modes

OSCAR: Amateur Satellites

Make your own gear

Field Day

Public Service

Bounce signals off the moon

Be Prepared when iPhones don't work

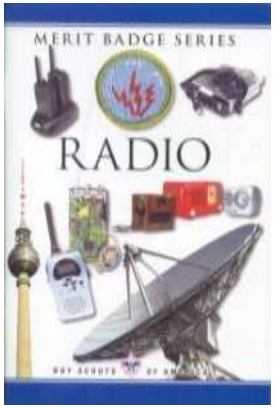
Competitions

APRS

Meteor Scatter

It's not just Morse Code anymore!

Radio Merit Badge Requirements



1. Explain what radio is. Then discuss the following:
   a. The differences between broadcast radio and hobby radio.
   b. The differences between broadcasting and two-way communications.
   c. Radio call signs and how they are used in broadcast radio and amateur radio
   d. The phonetic alphabet and how it is used to communicate clearly.

2. Do the following:
   a. Sketch a diagram showing how radio waves travel locally and around the world. Explain how the broadcast radio stations, WWV and WWVH can be used to help determine what you will hear when you listen to a shortwave radio?
   b. Explain the difference between a DX and a local station. Discuss what the Federal Communication Commission (FCC) does and how it is different from the International Telecommunication Union.

3. Do the following:
   a. Draw a chart of the electromagnetic spectrum covering 100 kilohertz (kHz) to 1000 megahertz (MHz).
   b. Label the MF, HF, VHF, UHF, and microwave portions of the spectrum on your diagram.
   c. Locate on your chart at least eight radio services such as AM and FM commercial broadcast, citizens band (CB), television, amateur radio (at least four amateur radio bands), and public service (police and fire).

Radio Merit Badge Requirements

4. Explain how radio waves carry information. Include in your explanation: transceiver, transmitter, amplifier, and antenna.
5. Do the following:
   a. Explain the differences between a block diagram and a schematic diagram.
   b. Draw a block diagram for a radio station that includes a transceiver, amplifier, microphone, antenna, and feed line.
   c. Explain the differences between an open circuit a closed circuit, and a short circuit.
   d. Draw eight schematic symbols. Explain what three of the represented parts do. Find three electrical components to match to three of these symbols.

6. Explain the safety precautions for working with radio gear, including the concept of grounding for direct current circuits, power outlets, and antenna systems.

7. Visit a radio installation (an amateur radio station, broadcast station, or public communications center, for example) approved in advance by your counselor. Discuss what types of equipment you saw in use, how it was used, what types of licenses are required to operate and maintain the equipment, and the purpose of the station.

8. Find out about three career opportunities in radio. Pick one and find out the education, training, and experience required for this profession. Discuss this with your counselor, and explain why this profession might interest you.

Radio Merit Badge Requirements

9. Do ONE of the following: (a OR b OR c)
    a. AMATEUR RADIO
        1. Tell why the FCC has an amateur radio service. Describe some of the activities that amateur radio operators can do on the air, once they have earned an amateur radio license.
        2. Using proper call signs, Q signals, and abbreviations, carry on a 10 minute real or simulated radio contact using voice, Morse Code, or digital mode. (Licensed amateur radio operators may substitute five QSL cards as evidence of contacts with amateur radio operators from at least three different call districts.) Properly log the real or simulated ham radio contact and record the signal report.
        3. Explain at least five Q signals or amateur radio terms you hear while listening.
        4. Explain some of the differences between the Technician, General, and Extra Class license requirements and privileges. Explain who administers amateur radio exams.
        5. Explain how you would make an emergency call on voice or Morse code.
        6. Explain the differences between handheld transceivers and home "base" transceivers. Explain the uses of mobile amateur radio transceivers and amateur radio repeaters.

Requirement 1a

1. Explain what radio is. Then discuss the following:
    a. The differences between broadcast radio and hobby radio.

Radio is a way to electronically communicate without wires. Radio sends information from one location to another using electromagnetic waves. The information could be Morse code, your voice, music, or data. Electromagnetic waves are created when we get an electrical circuit to vibrate electrons back and forth thousands or millions a time per second.

You probably already know broadcast radio, but radar, wireless networks, remote car locks, cell phones, microwave ovens, communications satellites, television, satellite navigation systems, EZ-Pass toll systems and those security tags in stores are all radio too!

Broadcasting uses radio to send information to many people at the same time. High power levels, paid advertising, play music, different licenses, really big towers. **One-way transmissions to** the public. Could be **commercial** (music, news, sports with advertisements) or **non-commercial** (National Public Radio, school radio stations, Voice of America)

Hobby radio is the use of radio by ordinary people such as ham radio operators to communicate with each other or to control models or home automation.

Requirement 1b

1. Explain what radio is. Then discuss the following:
    b. The differences between broadcasting and two-way communications

Broadcasting is a one way transmission to many receivers at the same time such as a local music station or television station.

Two way communications are a back and forth conversation between two stations. Both stations then take turns transmitting and receiving. Two way radio is used by police, fire, ambulances, planes, trains, ships, astronauts, and folks like you every day!

SIMPLEX: One-way
HALF-DUPLEX: Two-way, one at a time
FULL-DUPLEX: Two-way, both at the same time

Requirement 1c

1. Explain what radio is. Then discuss the following:
    c. Radio call signs and how they are used in broadcast radio and amateur radio

WKIK (Broadcast) and N1HNP (amateur)
A, K, N, W are assigned to the USA.

All radio transmitters must use call signs to prove that they have been licensed. Also for station identification, unique identifier assigned to a single individual, group or event.

Broadcasters: Identify once per hour.
Amateurs: Identify every ten minutes and at end of a conversation.

Ham radio clubs can have a club callsign for repeaters, special events can have temporary short callsign. Type of callsign (1x2, 2x1, 1x3, 2x3) depends on license class.

Vanity callsigns

Some broadcast call signs are WABC or KYW.
Amateur Radio Call signs are like K2GW or KC2PNP, with a number in them.

Enforce licensing:
QRZ.com or FCC ULS to lookup and verify
Prevent pirate radio or harmful interference

Requirement 1d

1. Explain what radio is. Then discuss the following:
   d. The phonetic alphabet and how it is used to communicate clearly.

Because some letters such as "C" and "E" might sound alike when transmissions are noisy, standard

Phonetic Alphabet words are often used to make things understood.
These standard "phonetics" are:

International Phonetic Alphabet

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

Requirement 2a

Sketch a diagram showing how radio waves travel locally and around the world. Explain how the broadcast radio stations, WWV and WWVH can be used to help determine what you will hear when you listen to a shortwave radio?

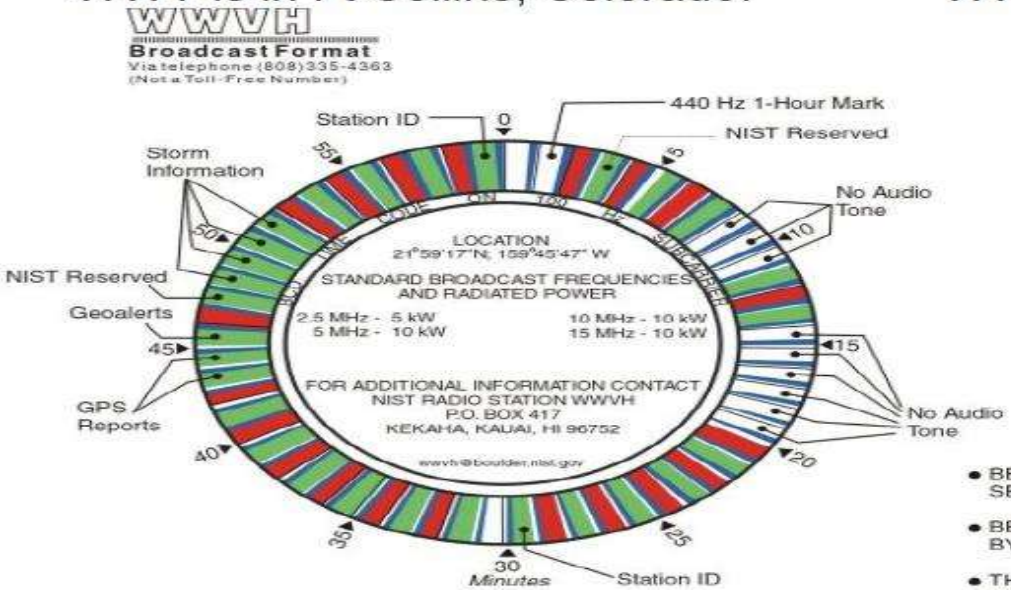
- Radio Waves below 3 MHz can hug the earth's surface to travel hundreds of miles using **ground waves**.
- Radio **sky waves** between 3 and 30 MHz can also reflect off the electrically charged upper atmosphere, which is called the **Ionosphere,** to then bounce thousands of miles around the earth.
- The most common way for radio waves to travel is in a straight **line of sight** from one antenna to another. This is most common for radio waves using frequencies of 30 Megahertz (30 MHz or 30 million changes of direction per second) or higher.

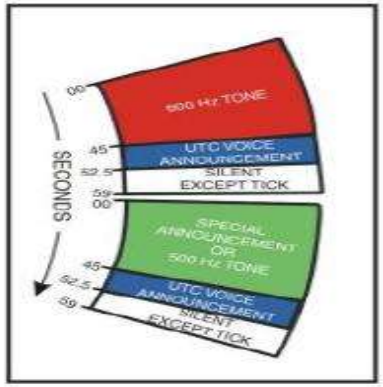
- Radio station WWV is located in Fort Collins Colorado and WWVH is located in Hawaii. Both provide **precise time** signals and transmit exactly on the frequencies of 5, 10, 15 and 25 MHz. They also provide information on how well the Ionosphere is bouncing radio signals today.

- They can be used to **set your clock**, to **calibrate your receiver and transmitter**, and to **see how well radio signals can travel** to and from Colorado and Hawaii.

WWV

- Provides accurate frequencies, time, and HF propagation forecasts.
- WWV & WWVH transmit on 5,10,15 and 20 MHz
- WWV is in Ft Collins, Colorado. WWVH is in Kauai, Hawaii





- BEGINNING OF EACH HOUR IS IDENTIFIED BY 0.8 SECOND LONG, 1500 Hz TONE.
- BEGINNING OF EACH MINUTE IDENTIFIED BY 0.8 SECOND LONG, 1200 Hz TONE.
- THE 29TH AND 59TH SECOND PULSES OF EACH MINUTE ARE OMITTED.
- 440 Hz TONE IS OMITTED DURING FIRST HOUR OF EACH DAY.

How High Frequency (HF) Radio Waves Travel (Propagation)

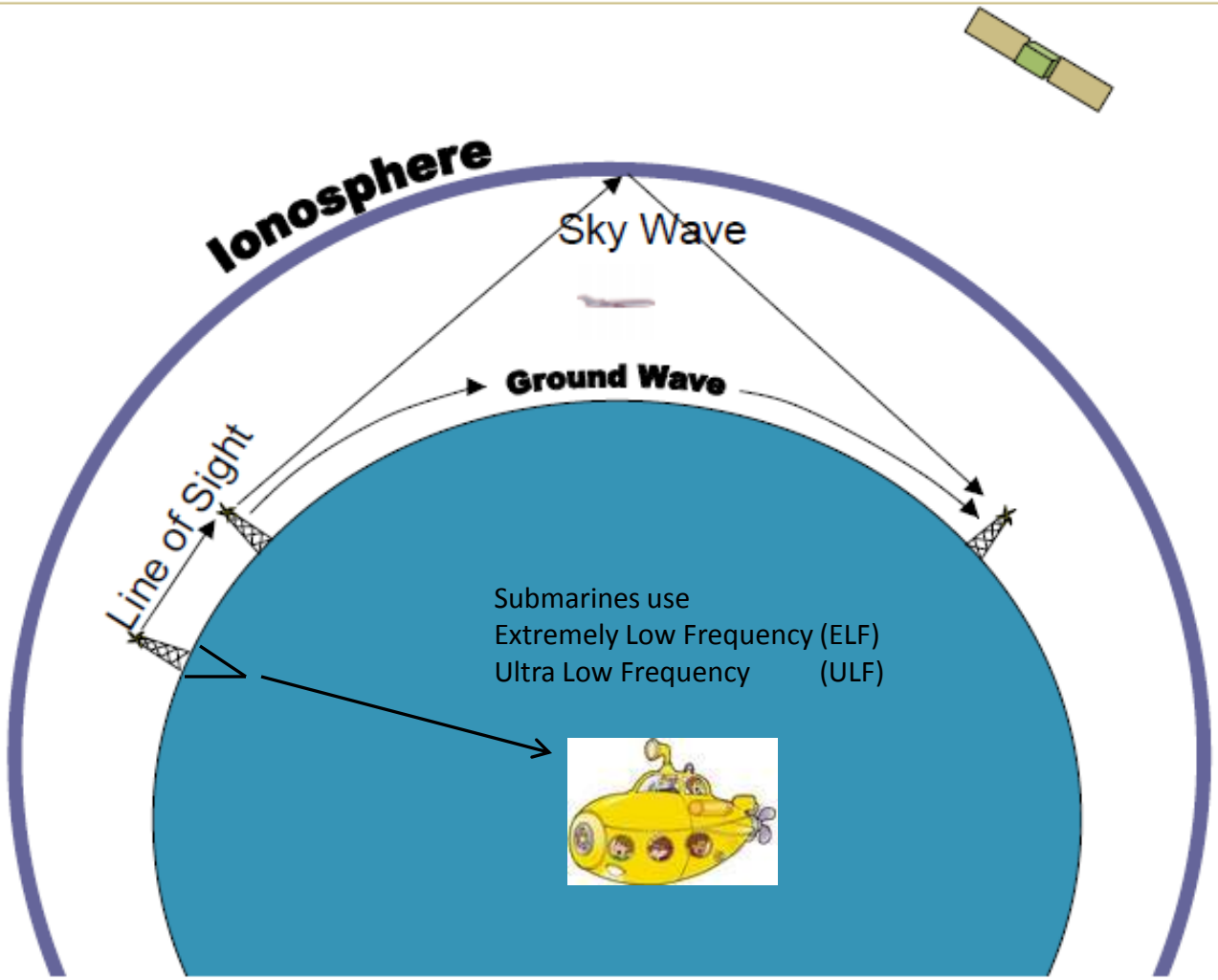
HF radio propagation is affected by radiation from the sun, so different frequencies work better at different times of the day.

Tropospheric Ducting

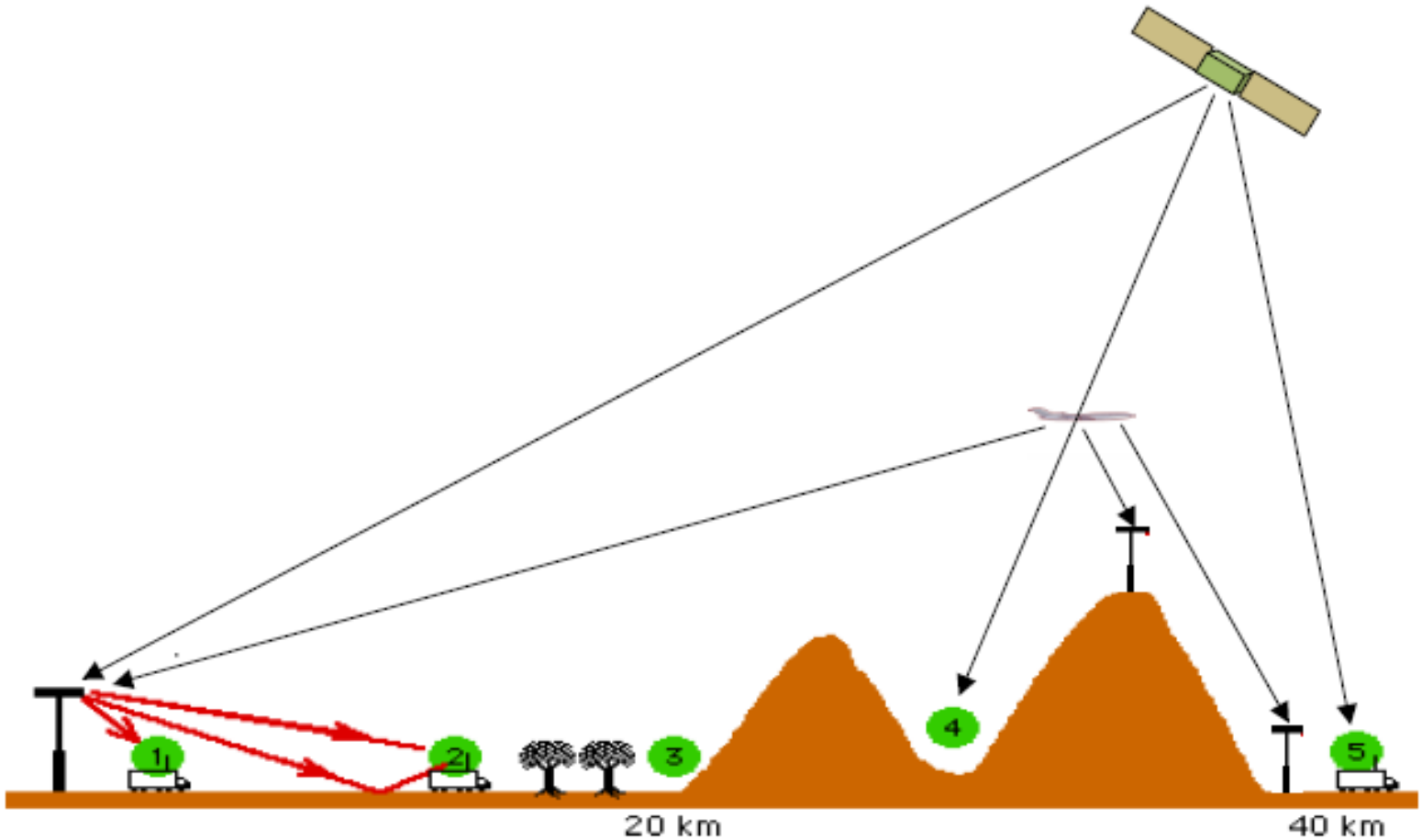
Sunspots, 11 year cycle.

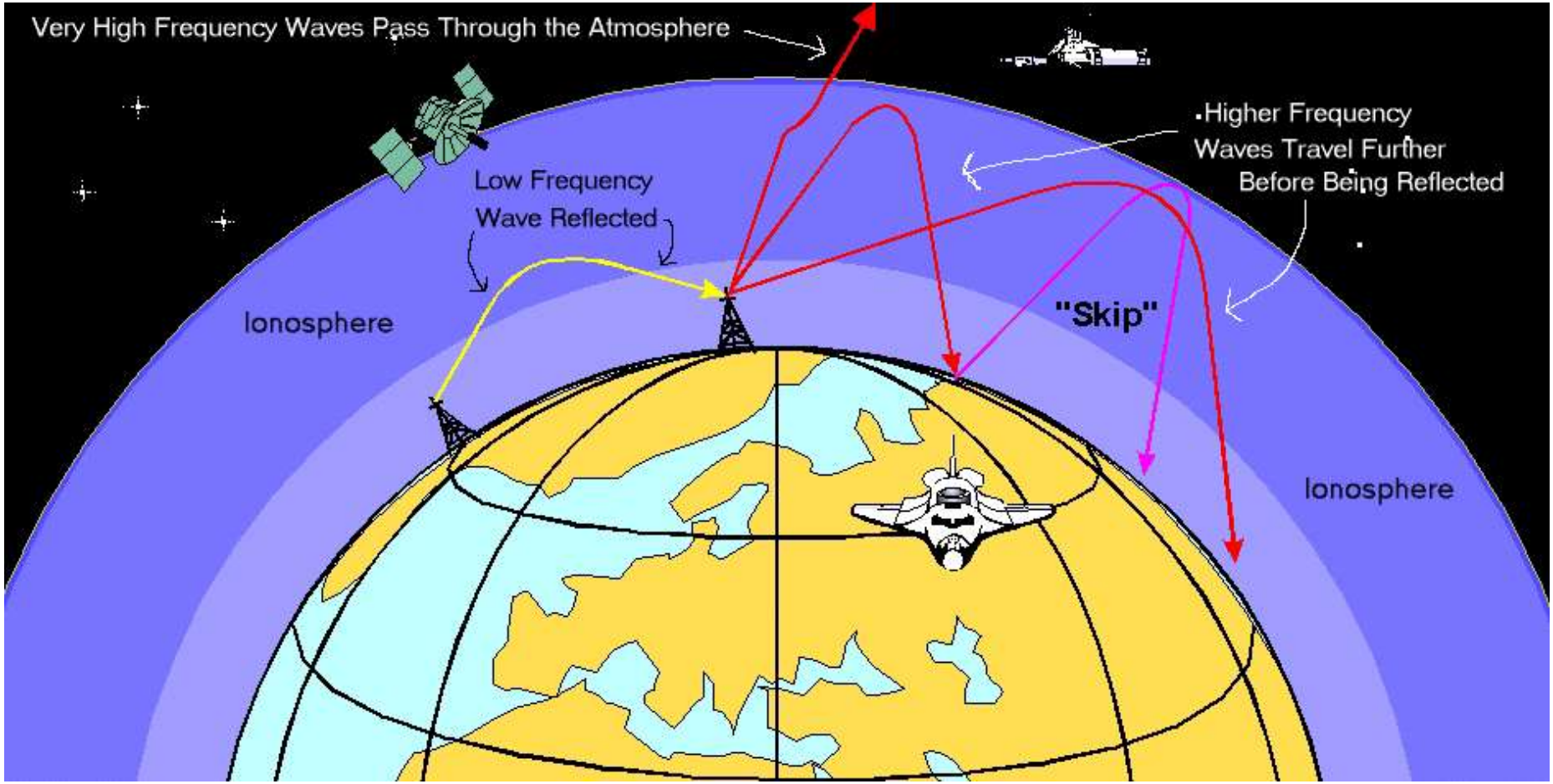
Ionosphere Layers
D, E, F1, F2

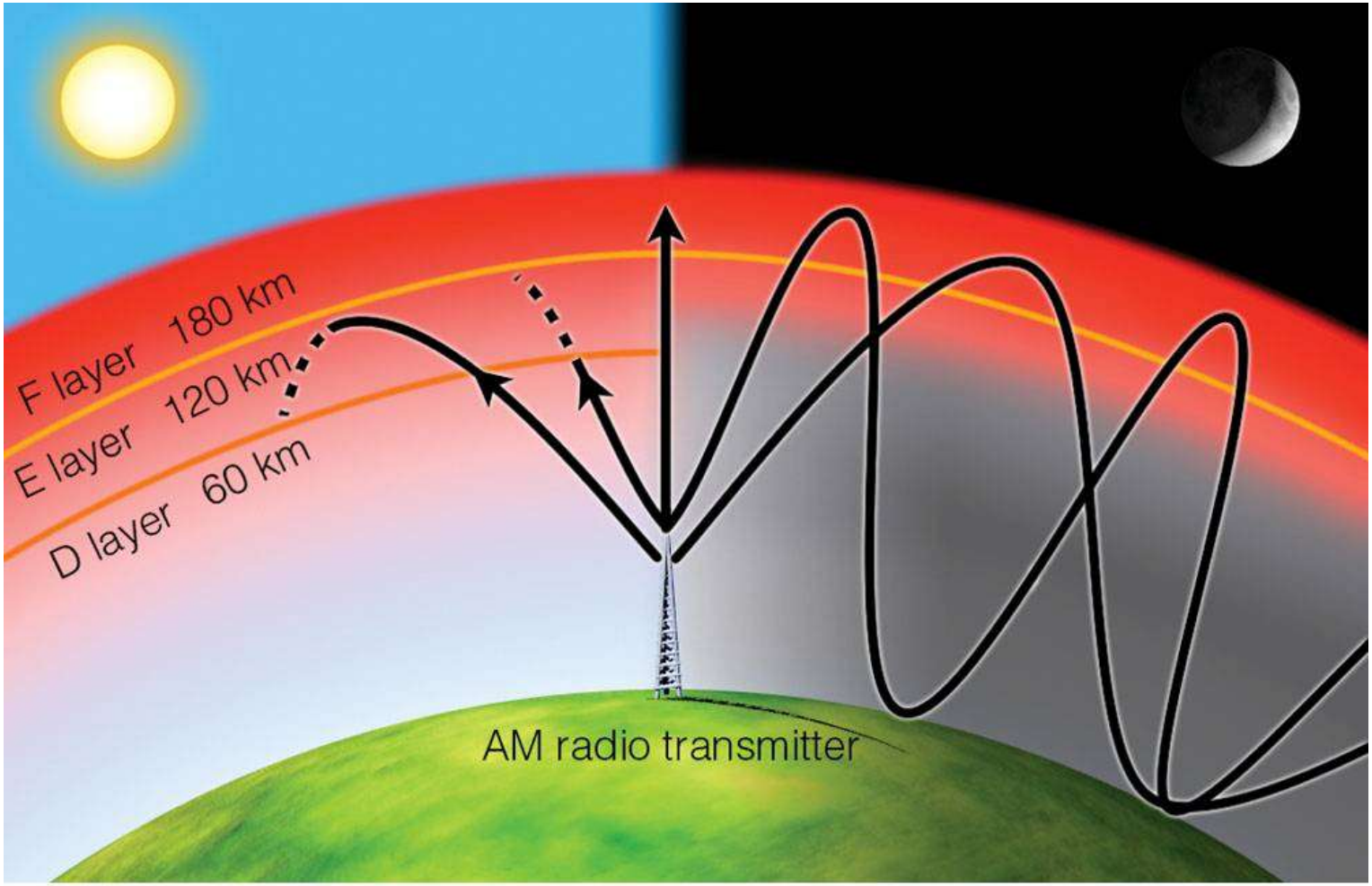
Higher at night as planet cools



How VHF & UHF Radio Waves Travel




Very High Frequency Waves Pass Through the Atmosphere
Higher Frequency
Waves Travel Further
Before Being Reflected
Low Frequency
Wave Reflected
Ionosphere
"Skip"
Ionosphere



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The ionosphere is important for radio wave (AM only) propagation....
ionosphere is composed of the D, E, and F layers
the D layer is good at absorbing AM radio waves
D layer dissapears at night.... the E and F layers bounce the waves back to the earth
this explains why radio stations adjust their power output at sunset and sunrise

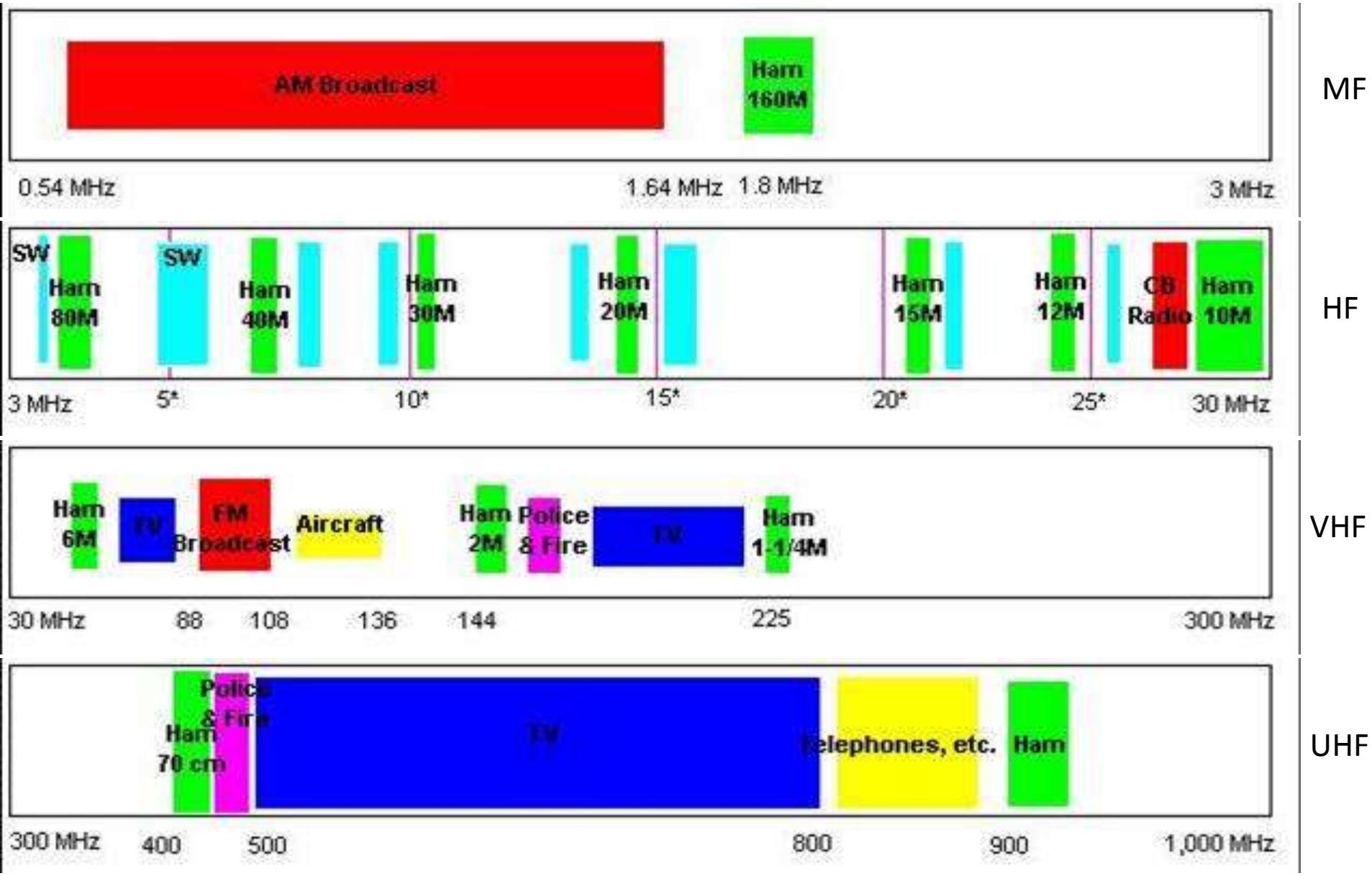
Requirement 2b

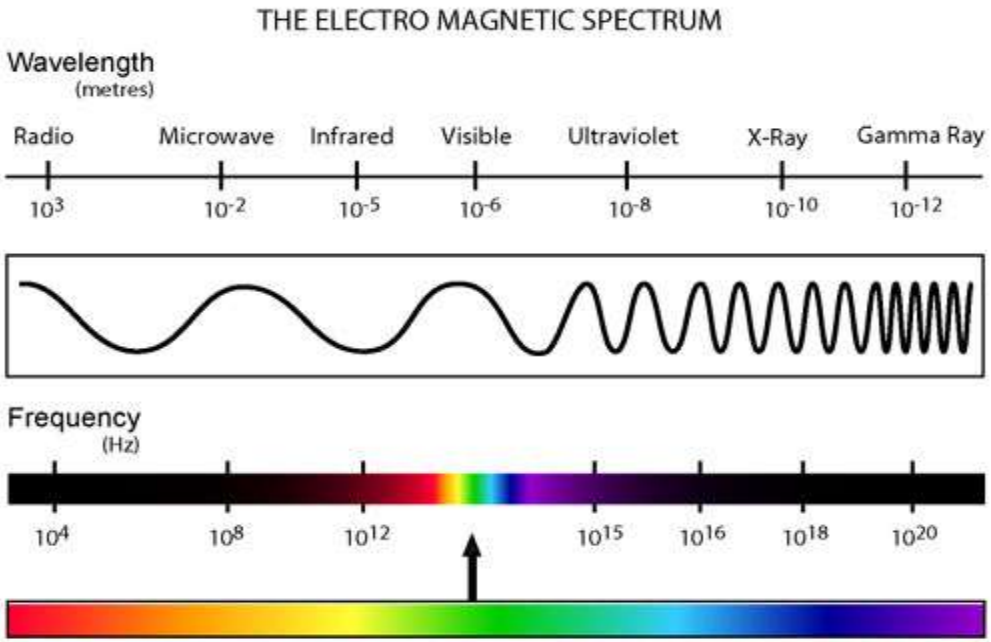
Explain the difference between a DX and a local station. Discuss what the Federal Communication Commission (FCC) does and how it is different from the International Telecommunication Union.

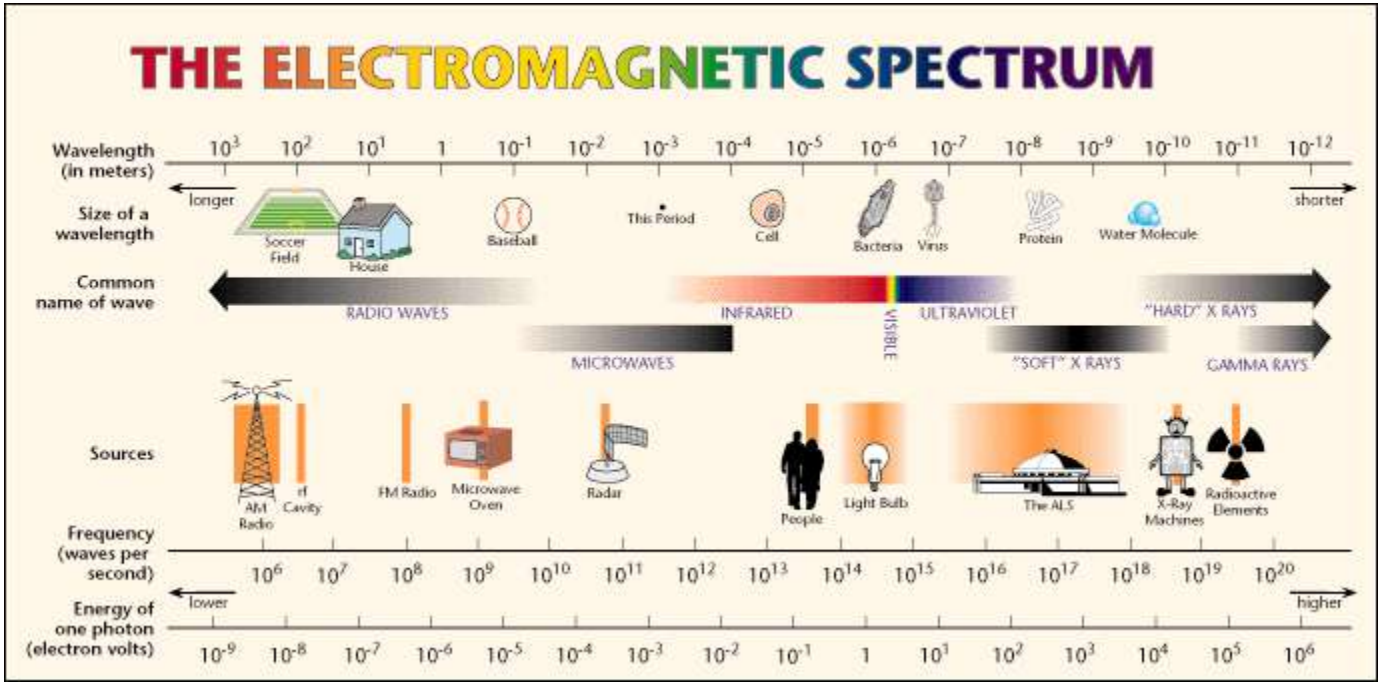
- **Local vs DX -** Signals from nearby stations are called local, while those from **far away places are called "DX**". "DX" is the old Morse Code abbreviation for "distance".
  The **FCC** is the **Federal Communications Commission**. It regulates **and issues radio licenses in the United States**.
  - Regulates the spectrum allocations, technical and operational characteristics inside U.S. (Spectrum is vital national resource with national, private, business uses)
  - Issues licenses to practice with U.S.A.
  - Sets U.S. licensing standards
  - Coordinate with FEMA the Radio Amateur Civil Emergency Service (RACES)
  - The rules for U.S. amateur radio written and enforced by, the FCC
  - While FCC regulation preempts state and local regulation of radio with respect to radio frequency interference and radio frequency exposure safety, state and local authorities may still enforce "reasonable" regulations on antenna structures for the purpose of electrical and mechanical safety and other "legitimate" purposes.
  - Mostly a self-policed hobby.
  - Set Frequency. Assignments in US. Issues Licenses & Call Signs. Enforces Radio Laws.
- The **ITU** is the **International Telecommunications Union** and the agency of the United Nations that **establishes international standards for radio.**
  - ITU **coordinates** the shared global use of the radio spectrum,
  - Promotes international cooperation in assigning satellite orbits,
  - Works to improve telecommunication infrastructure in the developing world and
  - Establishes worldwide standards.
  - Meets every few years. Sets International Frequency assignments. Assigns prefixes to countries.

Requirement 3a

Draw a chart of the electromagnetic spectrum covering 100 kilohertz (kHz) to 1000 megahertz (MHz).




THE ELECTRO MAGNETIC SPECTRUM
Wavelength
(metres)
Radio
Microwave
Infrared
Visible
Ultraviolet
X-Ray
Gamma Ray
10^{3}
10^{-2}
10^{-5}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
Frequency
(Hz)
10^{4}
10^{8}
10^{12}
10^{15}
10^{16}
10^{18}
10^{20}


THE ELECTROMAGNETIC SPECTRUM
Wavelength (in meters)
10^{3} 10^{2} 10^{1} 1 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} 10^{-7} 10^{-8} 10^{-9} 10^{-10} 10^{-11} 10^{-12}
Size of a wavelength
longer
shorter
Soccer Field
House
Baseball
This Period
Cell
Bacteria
Virus
Protein
Water Molecule
Common name of wave
RADIO WAVES
INFRARED
VISIBLE
ULTRAVIOLET
"HARD" X RAYS
MICROWAVES
"SOFT" X RAYS
GAMMA RAYS
Sources
AM Radio
rf Cavity
FM Radio
Microwave Oven
Radar
People
Light Bulb
The ALS
X-Ray Machines
Radioactive Elements
Frequency (waves per second)
10^{6} 10^{7} 10^{8} 10^{9} 10^{10} 10^{11} 10^{12} 10^{13} 10^{14} 10^{15} 10^{16} 10^{17} 10^{18} 10^{19} 10^{20}
Energy of one photon (electron volts)
lower
higher
10^{-9} 10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10^{1} 10^{2} 10^{3} 10^{4} 10^{5} 10^{6}

EM Spectrum by Frequency

- DC Power 0 Hertz (goes in one direction only)
- AC Power 60Hertz(Hz)
- Audio (Sound) 100 Hz to 20 KHz (100 - 20,000 Hz)
- LF 30-300 kHz (30,000-300,000)
- MF .3-3 MHz (300,000-3,000,000)
- HF or Shortwave 3-30 MHz (3,000,000-30,000,000)
- VHF 30-300 MHz (30,000,000-300,000,000)
- UHF 300-3,000 MHz (well, you get the idea)
- Microwave Frequencies above 500 MHz
- Visible Light 400-800 THz (400,000,000- 800,000,000 MHz)

• AM Broadcast Radio	540 - 1600 kHz
• FM Broadcast Radio	88-108MHz
• Short Wave Broadcast	5-22MHz
• Television Broadcast	Channel 2 = 54-60 MHz
• CB Radio	27MHz
• Police Radio	450-470 MHz
• Amateur Radio	3.5, 7.5, 10, 15, 20, 30, 50, 150 MHz
	80, 40, 30, 20, 15, 10, 6, 2 meters

Freq=C/meters
C=300,000,000 or
Freq (MHz)= 300/meters

Requirement 3b

Label the MF, HF, VHF, UHF, and microwave portions of the spectrum on your diagram.

Different frequencies in the Electromagnetic spectrum are used for different purposes and travel a bit differently.

Medium Frequencies - The frequencies from 300 KHz to 3 MHz are called the Medium Frequencies. The usually follow the earth's surface using "Ground Waves" and can reach hundreds of miles. AM broadcasters are found here

High Frequencies - The frequencies from 3 MHz to 30 MHz are called the High Frequencies or "HF" The usually bounce off the Ionosphere using "Sky Waves" and can reach thousands of miles. Shortwave broadcasters and many Ham bands are found here

Very High Frequencies - The frequencies from 30 MHz to 300 MHz are called the Very High Frequencies or "VHF" The usually go right through the Ionosphere and so are mostly used for line of sight communications on earth. They also can be used to talk to spacecraft. FM Radio and TV broadcasters as well as many Police, Fire and Aircraft radios operate here. The popular 6 meter and 2 meter Ham bands are found here.

Ultra High Frequencies - The frequencies from 300 MHz to 3000 MHz are called the Ultra High Frequencies or "UHF" The usually go right through the Ionosphere and so are used for line of sight communications on earth. They also can be used to talk to spacecraft. UHF TV broadcasters as well as some Police, Fire radios and cell phones operate here. The 440 MHz Ham band is found here.

Requirement 3c

Locate on your chart at least eight radio services such as AM and FM commercial broadcast, citizens band (CB), television, amateur radio (at least four amateur radio bands), and public service (police and fire).

See previous slide.

Requirement 4

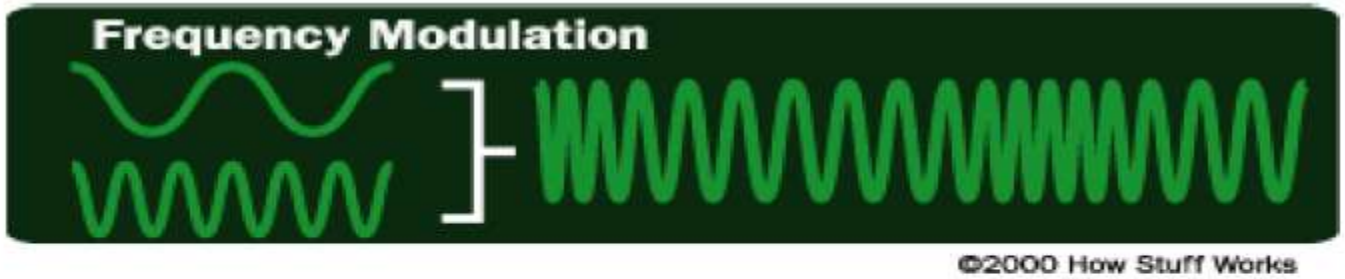
Explain how radio waves carry information. Include in your explanation: transceiver, transmitter, amplifier, and antenna.

We vary the Frequency, Amplitude, or Phase (or some combination thereof) of a radio wave to carry information.

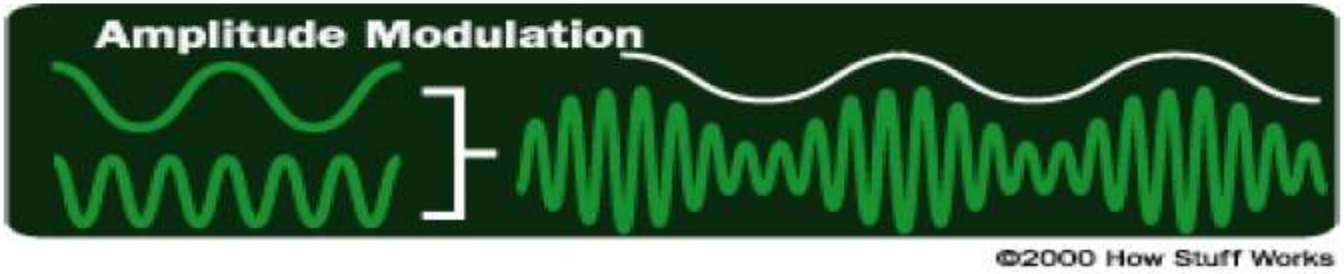
Frequency Modulation
Amplitude Modulation
Phase Modulation (Phase Shift Keying)

The RF transmitted is a sum of a Carrier Signal (RF) and Modulating Signal (Data)

FM



AM



A	• —	N	— •	1	• — — — —
B	— • • •	O	— — —	2	• • — — —
C	— • — •	P	• — — •	3	• • • — —
D	— • •	Q	— — • —	4	• • • • —
E	•	R	• — •	5	• • • • •
F	• • — •	S	• • •	6	— • • • •
G	— — •	T	—	7	— — • • •
H	• • • •	U	• • —	8	— — — • •
I	• •	V	• • • —	9	— — — — •
J	• — — —	W	• — —	Ø	— — — — —
K	— • —	X	— • • —		
L	• — • •	Y	— • — —		
M	— —	Z	— — • •		

Ø MEANS ZERO, AND IS WRITTEN IN THIS WAY TO DISTINGUISH IT FROM THE LETTER "O" IT OFTEN IS TRANSMITTED INSTEAD AS ONE LONG DASH (EQUIVALENT TO 5 DOTS)

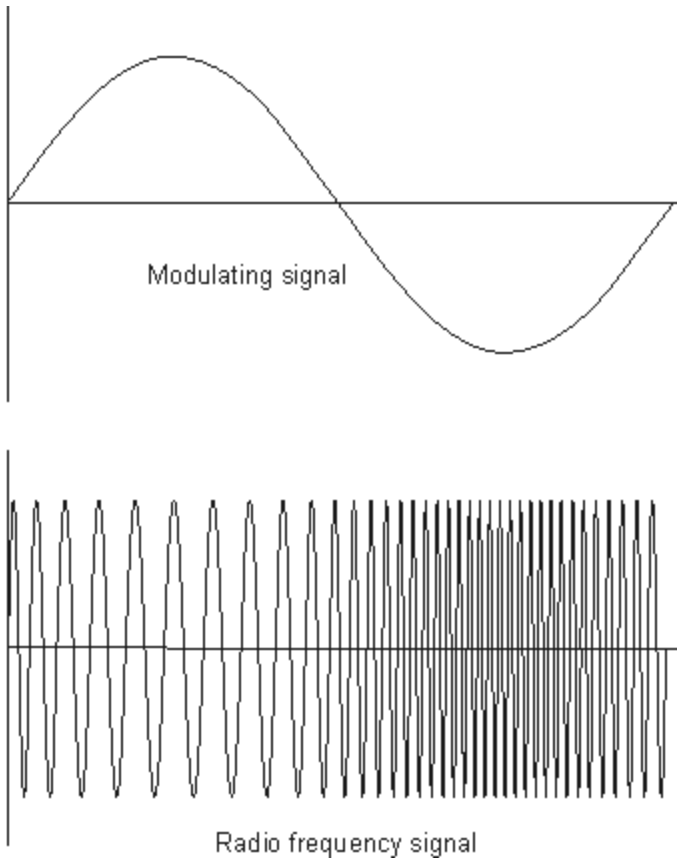
PERIOD (.)	• — • — • —	WAIT SIGN (AS)	• — • • •
COMMA (,)	— — • • — —	DOUBLE DASH (BREAK)	— • • • —
INTERROGATION (?)	• • — — • •	ERROR (ERASE SIGN)	• • • • • • • •
QUOTATION MARK (")	• — • • — •	FRACTION BAR (/)	— • • — •
COLON (:)	— — — • • •	END OF MESSAGE (AR)	• — • — •
SEMICOLON (;)	— • — • — •	END OF TRANSMISSION (SK)	• • • — • —
PARENTHESIS ( )	— • — — • —	INTERNAT. DISTRESS SIG. (SOS)	• • • — — — • • •

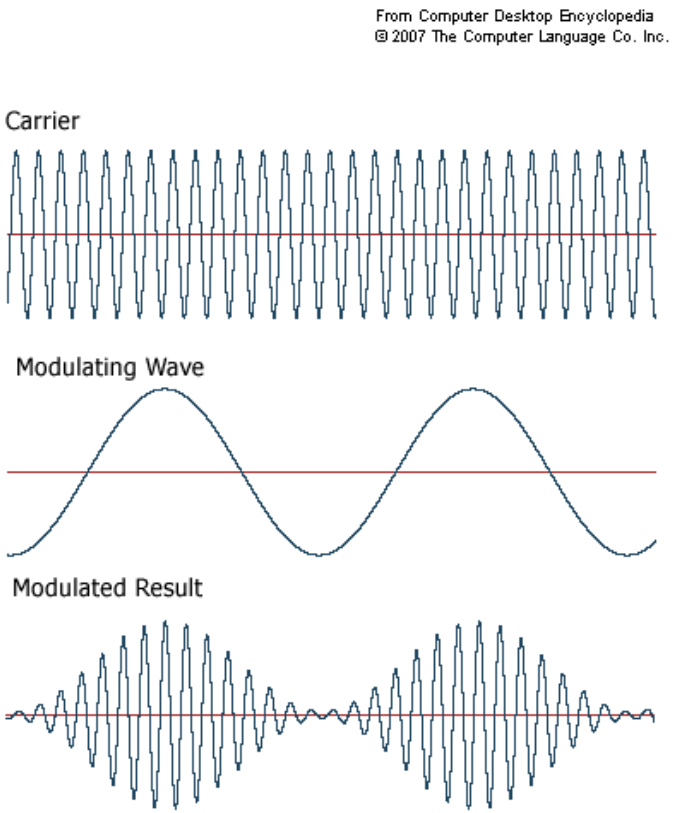
Figure 1

The Continental (or International Morse) Code is used for substantially all non-automatic radio communication. DO NOT memorize from the printed page; code is a language of SOUND, and must not be learned visually; learn by listening as explained in the text.

Requirement 4

Explain how radio waves carry information. Include in your explanation: transceiver, transmitter, amplifier, and antenna.



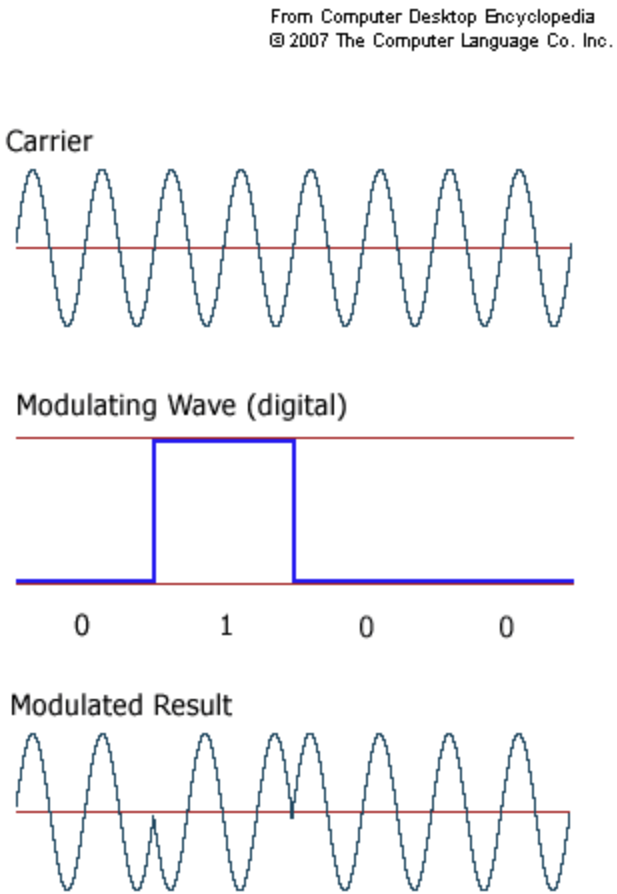


FM

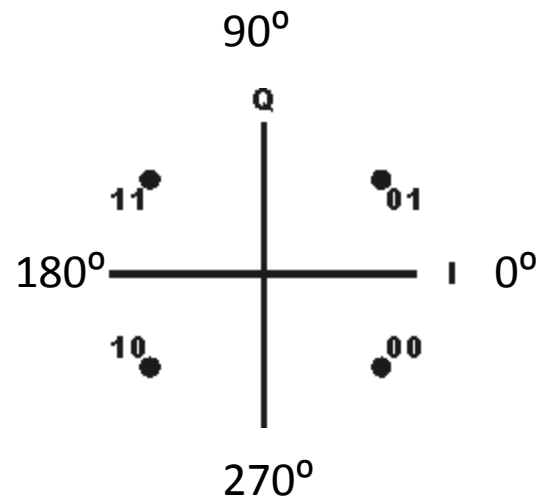
AM

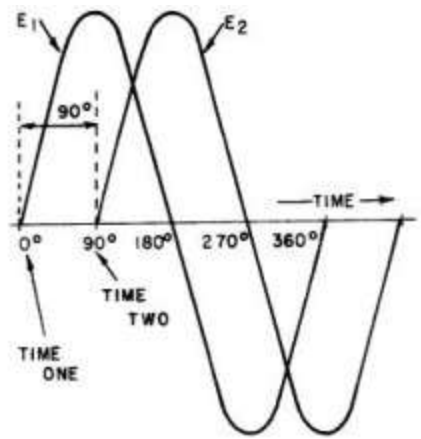
Requirement 4

Explain how radio waves carry information. Include in your explanation: transceiver, transmitter, amplifier, and antenna.



Phase Shift Keying





Phase Shift Keying is typically relative to the previous received cycle, vice synchronizing transmit and receive signals.

If same phase as previous, keep same bit output (1 or 0). If phase shifted 180*, then toggle from 1 to 0 or 0 to 1.

Requirement 4

Explain how radio waves carry information. Include in your explanation: transceiver, transmitter, amplifier, and antenna.

Radio waves are created when an **oscillator** circuit gets electrons to vibrate thousands or millions of times per second. An **amplifier** in the **transmitter** makes these **Radio Frequencies (RF)** more powerful.

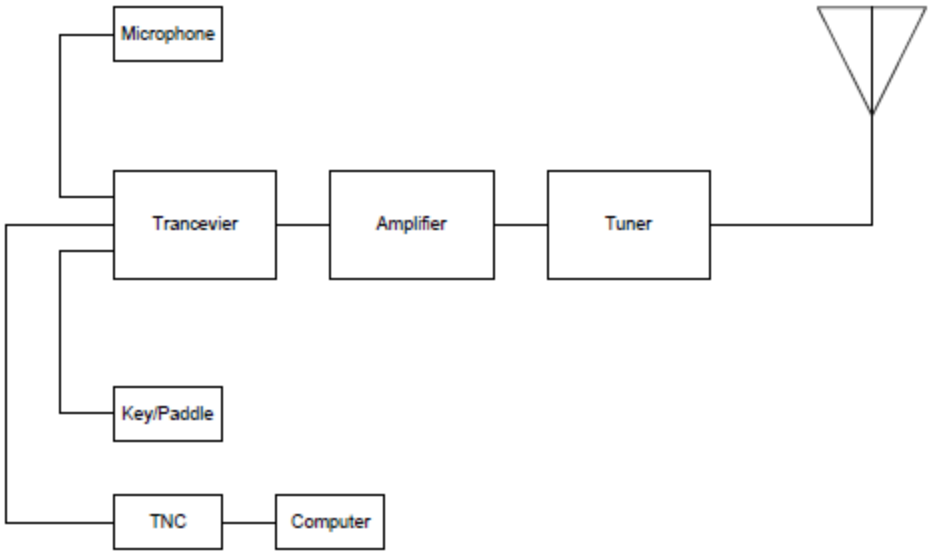
If the circuit is turned on or off in a pattern using a **telegraph key**, information may be sent using **Morse Code**. You can also talk into a **microphone** and have a circuit then **modulate** the radio waves to have them carry your voice signal.

In both cases, these radio waves are then fed to an **antenna** via a **feedline** which lets them travel through space. The impedance of the transmitter, feedline, and antenna must match for maximum transmitted power.

An antenna somewhere else catches the radio waves and feeds them to a **receiver** where they are **demodulated** into **Audio Frequencies (AF)** and played through **headphones** or a **speaker**.

A **transceiver** is a radio that has both a transmitter and receiver in the same case.

- **Microphone**
  - Audio or Digital signal input
- **Transmitter**
  - Creates the RF “carrier”
  - Modulates the carrier
- **Amplifier**
  - Increases RF signal power
- **Tuner**
  - Matches transmitter to antenna
- **Feed line**
  - Provides path to antenna
- **Antenna**
  - Radiates RF signal
- **Key or Paddle**
  - For sending Morse code



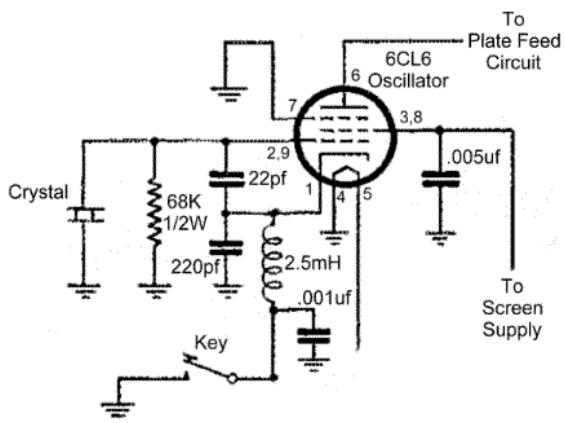
Requirement 5a

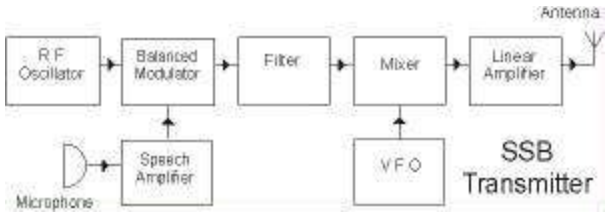
Explain the differences between a block diagram and a schematic diagram.

Abstraction vs. Hierarchy

A **block diagram shows the different sections** of a transmitter or receiver.

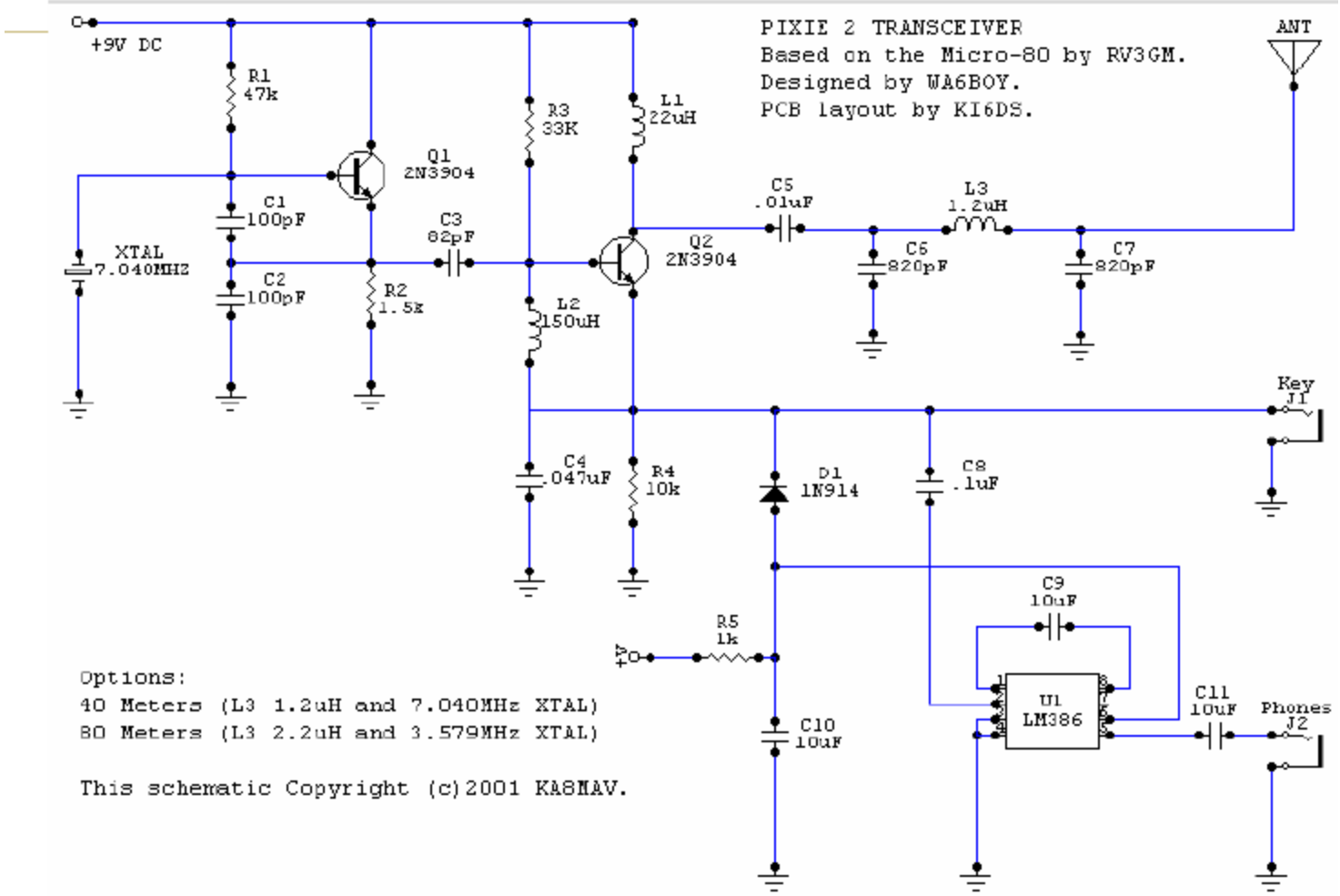
A more detailed **schematic diagram** shows all of the individual electrical components used **to build the radio.**





Schematic Diagram
How components links, how it works in detail

Block Diagram
Big picture, how systems works high level



Shows how to build a radio from components.

Requirement 5b

Draw a block diagram for a radio station that includes a transceiver, amplifier, microphone, antenna, and feed line.

Microphone

Transceiver

Amplifier

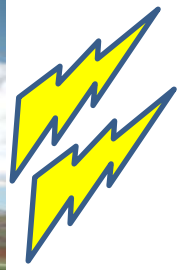
Antenna Tuner

If you can tune antenna to SWR to about 1.5:1 it is better to run “barefoot” without tuner.

Feed Line

Coaxial cable
SO-239
PL-259

Antenna



Radio Wave

Requirement 5b

Draw a block diagram for a radio station that includes a transceiver, amplifier, microphone, antenna, and feed line.

Radio Wave

Antenna

Feed Line

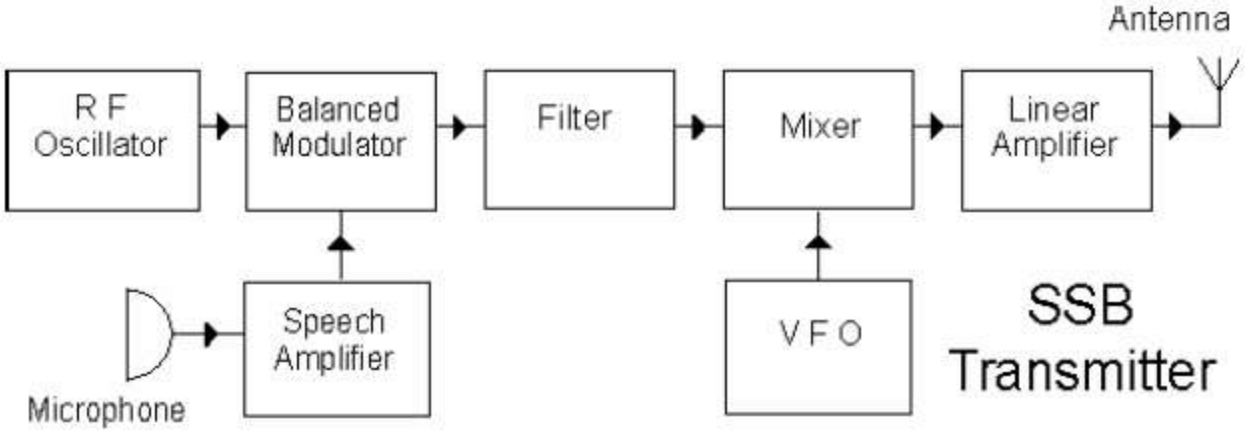
Coaxial cable
SO-239
PL-259

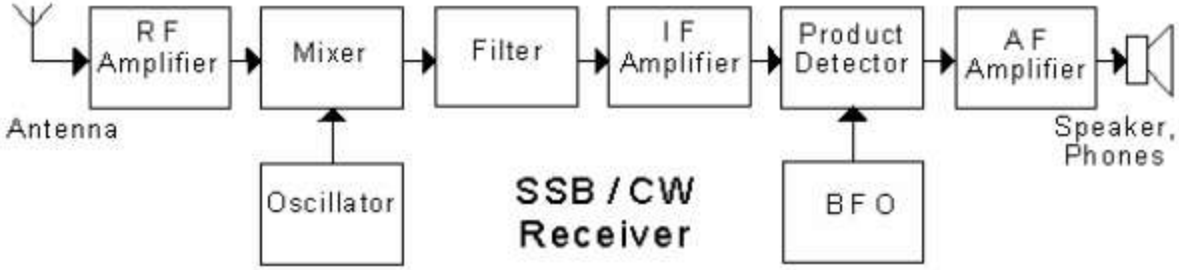
Antenna Tuner

Radios can be set use or not use a tuner on receive

Transceiver

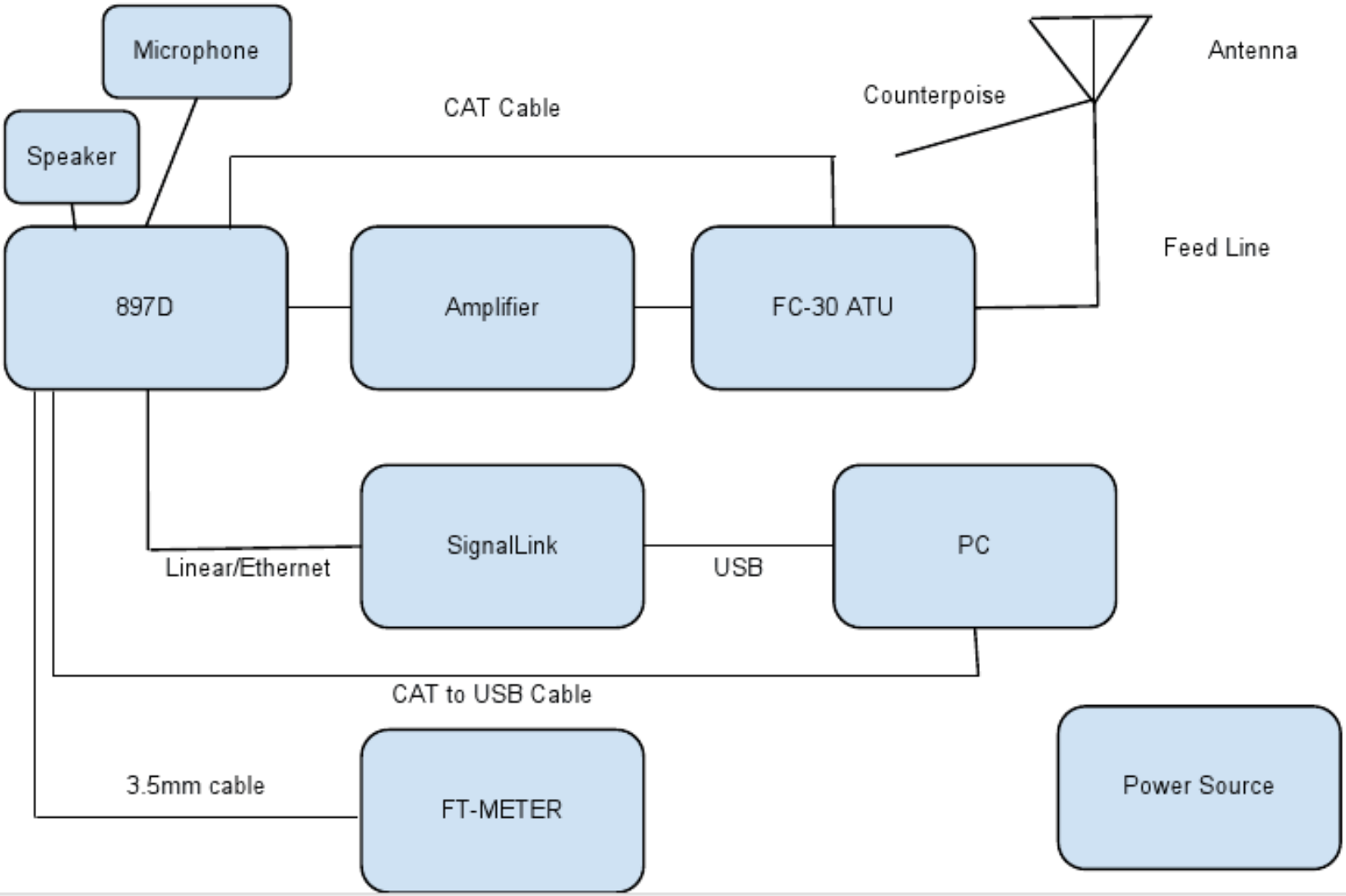
External speaker


Antenna
R F Oscillator
Balanced Modulator
Filter
Mixer
Linear Amplifier
Speech Amplifier
Microphone
V F O
SSB Transmitter


R F Amplifier
Mixer
Filter
I F Amplifier
Product Detector
A F Amplifier
Antenna
Speaker, Phones
Oscillator
SSB / CW Receiver
B F O

Requirement 5b

Draw a block diagram for a radio station that includes a transceiver, amplifier, microphone, antenna, and feed line.



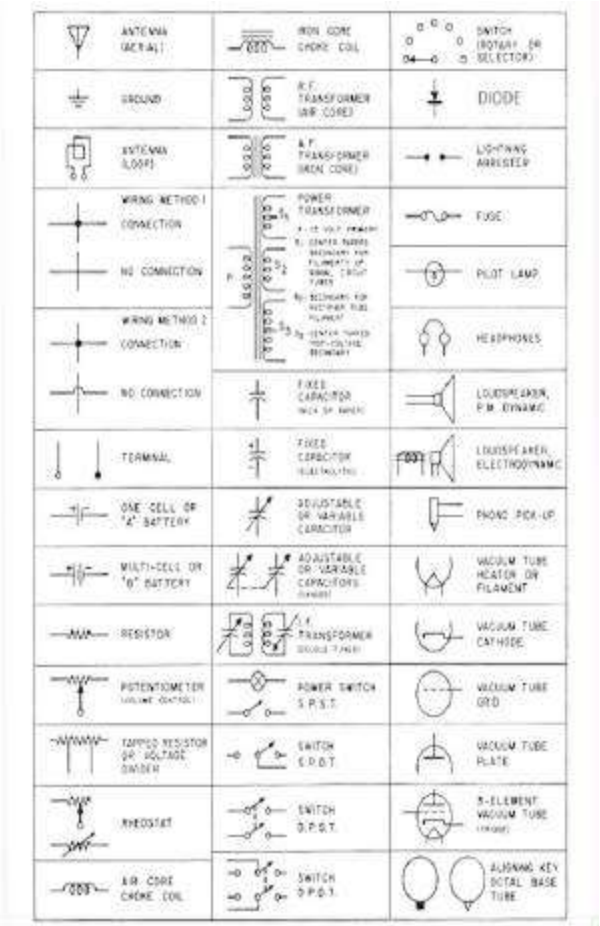
Requirement 5c

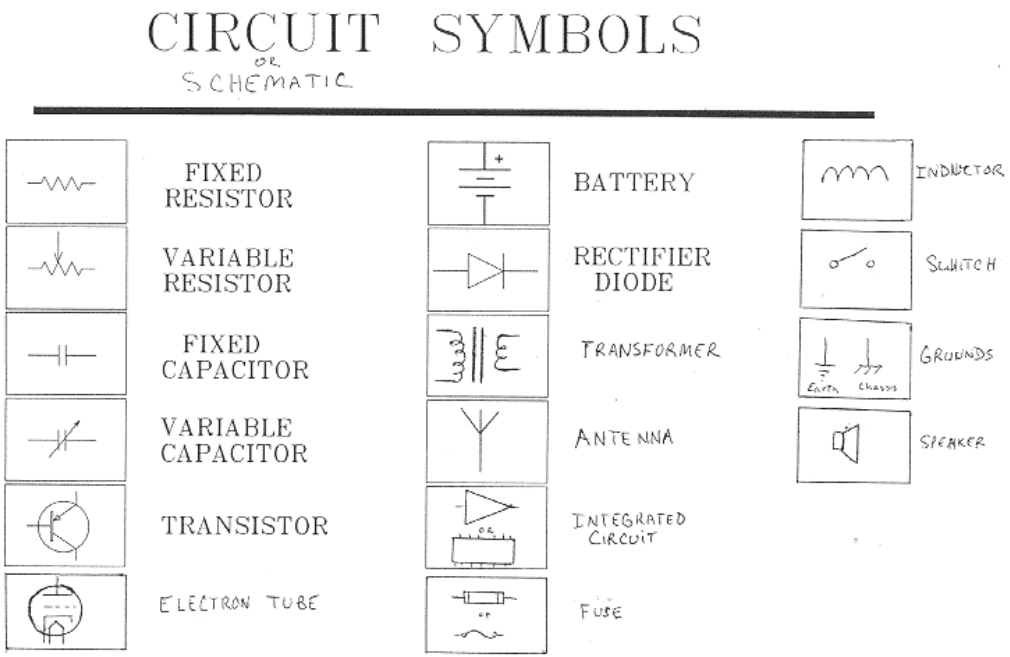
Explain the differences between an open circuit a closed circuit, and a short circuit.

- **Closed Circuit**
  - Circuit is complete.
  - Electricity flows like it should.
- **Open Circuit**
  - Circuit is incomplete.
  - Electricity doesn’t flow.
- **Short Circuit**
  - Circuit is complete through an unplanned shortcut.
  - Electricity flows where it shouldn’t!
  - Dangerous – parts can get hot, start fires or even explode!

Requirement 5d

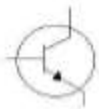
Draw eight schematic symbols. Explain what three of the represented parts do. Find three electrical components to match to three of these symbols.

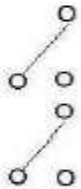




10 core Xeon Westermere Processor has 2.6B transistors. Feature size is channel length in nm.

	Fuse	Contains a thin wire which is made to melt which protects the rest of the circuit from damage if there is too much current from a short circuit.
	Battery	Stores electric energy.
	Resistor	Resists the flow of electric current, reducing its flow.
	Variable resistor	Like a regular resistor, but adjustable. For example, the volume knob on your stereo.
	Earth ground	A connection between the equipment (radio) and the earth, usually through a copper pipe driven into the soil.
	Chassis ground	A connection of the negative side of the electronic circuit to the chassis, or steel frame, of the equipment.

	Capacitor	Gets and stores an electric charge. Lets alternating current (AC - like in your house) flow but stops direct current (DC - like from a battery).
	Variable capacitor	Same as a regular capacitor, but adjustable.
	NPN transistor	Amplifies a current.
	PNP transistor	Amplifies a current.
	Coil	Also called a choke, it works the opposite of a capacitor. It lets DC flow but stops AC.
	Tube	A vacuum tube made of glass with wire filaments inside. Amplifies a current. It has been replaced by transistors in most home equipment, but is still found in some high power radio transmitters.

	Antenna	Sends radio frequency signals into the air.
	SPST switch	Single-pole single-throw switch. Has two positions, on and off. Like most light switches
	DPDT switch	Double-pole double-throw switch. A double-throw switch has three positions. It can switch one input to one of two outputs - sort of like the switch you put on your television to switch between watching TV and playing your video game. The double-pole means it can switch a pair of inputs to either of two pairs of outputs.

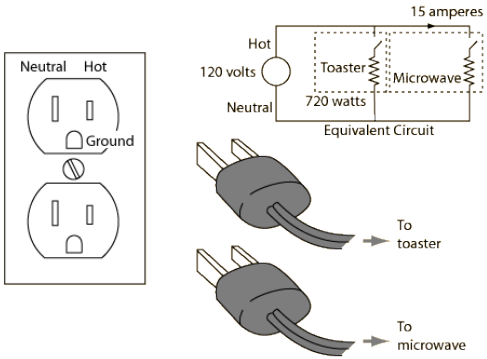
- **Conductors** conduct (carry) electricity.
  - Most Metals (Gold, Silver, Aluminum, Copper)
  - Many Liquids (Water)

- **Insulators** insulate (don't carry) electricity.
  - Air
  - Most Rubbers and Plastics
  - Most Ceramics
  - Wood and cloth (when dry)

Requirement 6

- Explain the safety precautions for working with radio gear, including the concept of grounding for direct current circuits, power outlets, and antenna systems.

- A GROUND is simply a giver or taker of excess electrons. An electric current can either flow to or from GROUND. the earth is a good GROUND with a vast capacity to give up or take electrons. The human body can also be a relatively good GROUND; therefore, if you touch an electrical circuit, an electric current could flow (you could get shocked). Electric current tends to flow along the path of least resistance. If the chassis or a piece of radio equipment is connected to GROUND that offers a much better path for electrons than the human body, the electric current will flow to or from the GROUND rather than you. A cold water pipe that goes into the GROUND can serve as an excellent GROUND. It should be connected to the radio equipment chassis with as short a wire a possible--at least as big as the primary house wiring.
- Need a common ground by tying grounds together. This will prevent voltage difference between the different grounds. Careful to avoid ground loops.
- SAFETY GROUND versus RF GROUND



The high voltage (about 120 volts effective, 60 Hz AC) is supplied to the smaller prong of the standard polarized U.S. receptacle. It is commonly called the "**hot wire**".
If an appliance is plugged into the receptacle, then electric current will flow through the appliance and then back to the wider prong, the **neutral.** The neutral wire carries the current back to the electrical panel and from there to the earth (ground).
The **ground** wire is not a part of the electrical circuit, but is desirable for prevention of electric shock.

Requirement 6

- Genreal Electrical Safety. Although RF, AC, and DC voltages in most amateur radio stations can pose a potentially grave threat to life, common sense and knowledge of safety practices will help to avoid accidents. However, carelessness can lead to severe injury or death.
  - The primary wiring for an amateur radio station should be controlled by one master switch. Other members of the household should know how to turn off the primary power.
  - All wiring carrying power for the station should be of proper size for the current carried and insulated for the voltage level involved. Electrical power outlets should not be overloaded.
  - Bare wire open-chassis construction and open connections are an invitation to accidents.
  - Whenever possible, kill the power and unplug equipment before working on it.
  - Some components retain dangerous charge even if unplugged. Discharge capacitors with an insulated screwdriver. Don't assume the bleeder resisters are 100% reliable.
  - Avoid bodily contact with any grounded object when working on electronics to prevent your body from becoming the return path from a voltage source to ground.
  - Don’t wear watches, bracelets, rings that can conduct electricity.
  - Don’t cut off ground prong to fit cable into two prong outlet or extension cable.
  - Extension cables are temporary solutions. Check all cables for tears in sheathing and replace as necessary.
  - Water and electricity don’t mix
  - Use insulated tools for adjusting circuitry
  - Never work alone. Have someone else present. He or she could kill the power if your are being electrocuted.
  - Static discharge can destroy sensitive electronics, wear static strap attached to ground.

- **Antennas and towers**
  - **Make sure antennas can't touch any power lines** or you could be electrocuted when using the radio.
  - **Lightning can hit your antenna** and travel down your lines to the radio. Make sure your antenna and radio are grounded to a good earth ground.
  - **Be careful working on towers and roofs** so you don't fall or drop something onto someone on the ground
  - Proper **climbing equipment** when working on tower, lower tower first if possible.

Requirement 6

Explain the safety precautions for working with radio gear, including the concept of grounding for direct current circuits, power outlets, and antenna systems.

- Radio Frequency (RF) Energy Safety. The human body can be a very effective ground when exposed to RF energy, either when it is flowing on a conductor or radiating from an antenna. Body tissues subject to large amounts of RF may/will suffer heat damage (burns). Therefore, RF requires some extra safety.
  - Don't work on antennas that have RF power applied. RF can BURN!
  - Confine RF radiation (energy) to antenna radiating elements. Provide a good station ground. It is important that RF sources be grounded.
  - If the radio transmitter is not well grounded, it can tend to become part of the radiating antenna. Thus, the operator can/will become subject to the RF currents and RF burns. Stand no closer than 10-15 feet of a radiating antenna. This is particularly true of vertical monopoles.
  - Don't operate RF power amplifiers, especially VHF/UHF, with the covers removed. (The shorter the wavelength, the more likely the body is to absorb it.) Strong RF radiation can be unhealthy - **Don't use a radio when it is not completely assembled**. The case keeps the RF radiation where it should be.
  - With mobile rigs of 10 watts or more, don't power the antenna when someone is standing next to it.
  - With handheld transceivers with RF output above several watts, maintain at least an inch or so between the forehead and antenna.
  - A microwave oven demonstrates the power of RF energy. A microwave oven uses RF around 2500 MHz to cook food (See where this frequency falls on the chart on page 17 of the pamphlet.). You will note your microwave is enclosed in a metal case and the window has a metal screen to shield you from the RF and the microwave generator turns off when the door is opened to protect you from RF.
  - The amount of energy depends on the transmitter power, type of antenna and the distance from the antenna. Some antennas concentrate energy in one direction.
  - Some frequencies are more dangerous than others. As an example, a wave length of 2.5 cm would find the eyeball a good receiving antenna and could damage it.
  - Typical power, frequencies and distances from antennas do not create RF hazards for Ham operators, their families or their neighbors. Hams receive special RF safety training.

Requirement 7

Visit a radio installation (an amateur radio station, broadcast station, or public communications center, for example) approved in advance by your counselor. Discuss what types of equipment you saw in use, how it was used, what types of licenses are required to operate and maintain the equipment, and the purpose of the station.

- What type transceiver is he using?
  - Yaesu FT-897D
  - Antenna Auto-Tuner
  - SWR Meter / S-Meter
  - External Speaker
  - SignaLink USB for digital mode
  - Laptop
  - Antenna Analyzer
  - SLA Battery
  - Battery Monitory
  - Solar Panel
- What type of antenna is he using?
  - Vertical dipole with counterpoise configure for 20m
- What does he use his station for?
  - DX, Competitions, Repeater Nets, Rag Chewing
- What type of License does he have?
  - Amateur Extra Class

Requirement 8

Find out about three career opportunities in radio. Pick one and find out the education, training, and experience required for this profession. Discuss this with your counselor, and explain why this profession might interest you.

If you're interested in **radio broadcasting** as a career, talk to your high school guidance counselor. You'll need to study communications and public speaking in college. Try to find a local non-profit radio station where you can volunteer and get valuable experience. Many colleges and schools have them.

If you're interested in **radio engineering**, you'll want to take a good college prep curriculum in high school, with a full load of math and sciences. Some colleges well known for electrical engineering include UMBC, MIT, Lehigh University and RPI.

Many community colleges offer electronic technology courses which can lead to career as an electronic technician working in the cellular telephone, computer networking, or radio repair industries.

Additionally, the **US Armed Forces and Coast Guard** all make extensive use of radio and offer many jobs and training courses in using and maintaining radio equipment. Beacons for Aid to Navigation, RADAR, SONAR.

Requirement 9a1

Tell why the FCC has an amateur radio service. Describe some of the activities that amateur radio operators can do on the air, once they have earned an amateur radio license.

Amateur Radio is a hobby where people help others, learn about radio and have fun. It's called Amateur Radio because the frequencies can't be used for commercial (money-making) purposes. It's also called "Ham Radio" No playing MUSIC on ham radio freqs!

The FCC has an Amateur Radio Service for:
Volunteer service - (community service and disaster help). A Scout does a good turn daily - here's another way.
International goodwill - A great way to talk to people in far away lands.
Experimentation - If you want, you can build your own radio equipment, and many hams build their own antennas. Some hams have come up with new inventions, such as FM, SSB, Packet Radio, Automatic Position Reporting Systems.
Communication skills - Because only one person can talk at a time, you learn how to listen!
Self-training - You can learn by doing.

Things To Do Once You Have A License:
Jamboree On The Air (JOTA) is the third weekend every October when Scouts all over the world talk to each other on ham radio. **DX -** Lots of hams like to talk to other hams around the world and collect postcards called QSL cards to prove they did it. It's a great way to have fun and learn about geography.
Contests are held many weekends when you try to contact as many people from a certain place or in a certain way.
Public Service at parades & special events - Ham radio operators are often the best people to help with communication at large community events, from small carnivals all the way up to the Boston and New York City Marathons.
Disasters - Hams are often called on to help during fires, floods, earthquakes, and other disasters. At these times, telephone lines and cell phone sites are often damaged or overloaded, and ham radio is the only reliable communication.
Skywarn - National Weather Service uses Hams to report severe weather.
Digital Communications - Some hams hook their computers to their radios so they can send electronic messages, sort of like wireless e-mail.
Camping communications are easy even in the backcountry when you need to get help or just let the folks back home know how things are going.

Requirement 9a2

Using proper call signs, Q signals, and abbreviations, carry on a 10 minute real or simulated radio contact using voice, Morse Code, or digital mode. (Licensed amateur radio operators may substitute five QSL cards as evidence of contacts with amateur radio operators from at least three different call districts.) Properly log the real or simulated ham radio contact and record the signal report.

When you make a contact on the air, record the following information for your log:

- Date:
- Time:
- Frequency:
- His Callsign:
- His Name:
- His Location:
- His Signal Report (RST/Q):
- My Signal Report (RST/Q):

Readability

1. Unreadable
2. Barely readable, occasional words distinguishable
3. Readable with considerable difficulty
4. Readable with practically no difficulty
5. Perfectly readable

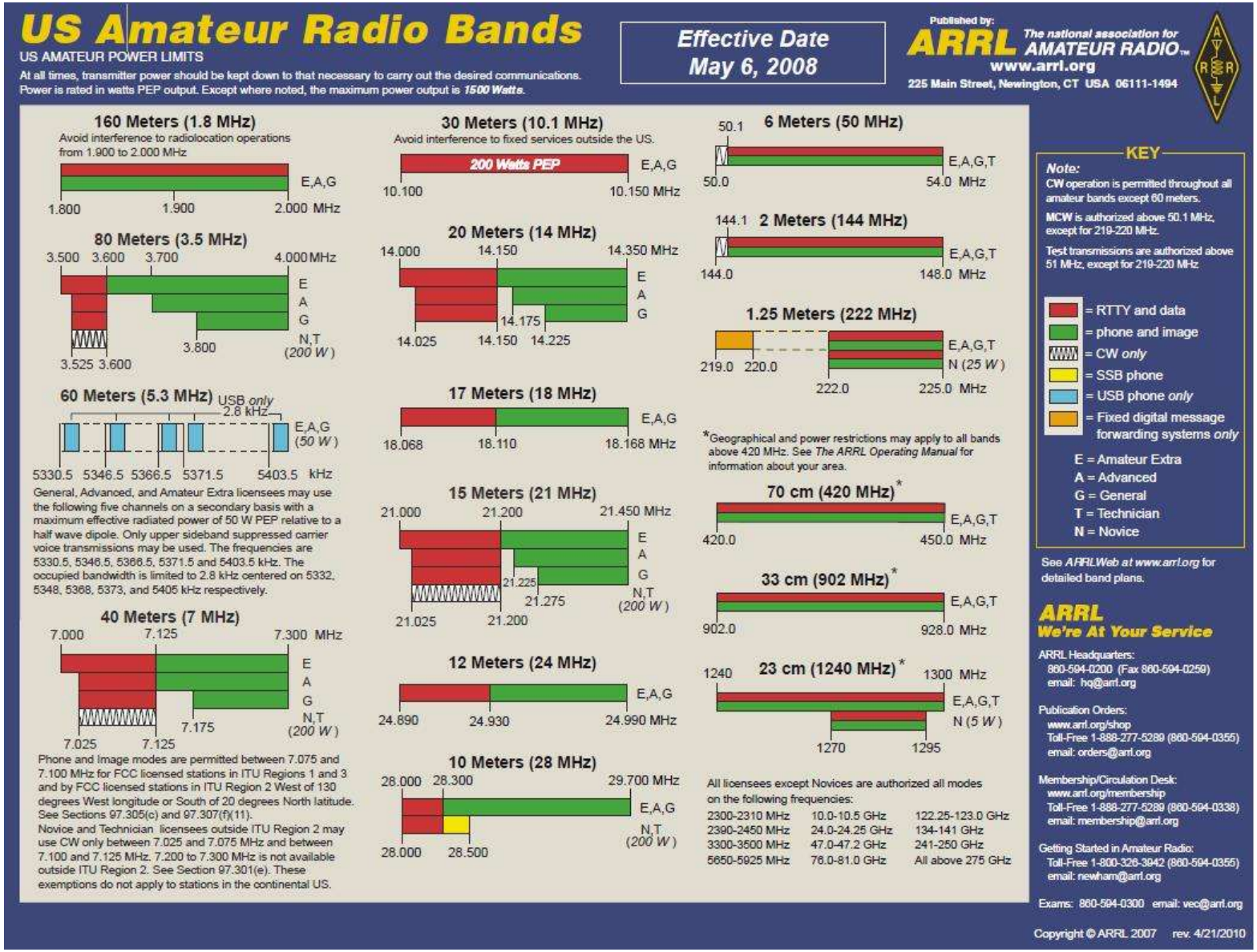
Strength (Read off the radio/meter S-meter)

1. Faint signal, barely perceptible
2. Very weak
3. Weak
4. Fair
5. Fairly good
6. Good
7. Moderately strong
8. Strong
9. Very strong signals

Tone / Quality

1. Splatter over much of the spectrum
3. Multiple visible pairs
5. One easily visible pair
7. One barely visible pair
9. Clean signal - no visible unwanted sidebar pairs

Requirement 9a2 Ham Bands



Requirement 9a2 Script

Frequency: 14.175 MHz Mode: **Upper Sideband (USB)** **Team 1 Callsign: K1BSA** **Team 2 Callsign: N2BSA**

1: This is Kilowatt One Bravo Sierra Alfa. Is this frequency in use?

1: CQ CQ CQ. This is Kilowatt One Bravo Sierra Alfa. Calling CQ CQ on 20 meters. (Repeat 3 times)

2: Kilowatt One Bravo Sierra Alfa this November Two Bravo Sierra Alfa. QSL?

1: November Two Bravo Sierra Alfa, QSL. Name here is _____. QTH is _____.

Your coming in at _____ (RST Report). Back to you N2BSA this is K1BSA.

2: Nice to meet you. Name here is _____. QTH is _____.

Your coming in at _____ (RST Report). Back to you K1BSA this is N2BSA.

1: *Carry on appropriate conversation. End each turn with* "Back to you N2BSA this is K1BSA"

2: *Carry on appropriate conversation. End each turn with* "Back to you K1BSA this is N2BSA"

1: Nice meeting you. I have to get back to camping. 73. N2BSA this is K1BSA, clear.

2: Nice meeting you too. See you on the airwaves. 73. This is N2BSA, frequency clear.

LOGBOOK:

- Date: _____ Time: _____
- Frequency: _____ Mode: _____
- His Callsign: _____
- His Name: _____
- His Location: _____
- His Signal Report (RST/Q): _____ (e.g. 59, 47)
- My Signal Report (RST/Q): _____ (e.g. 59, 47)

Requirement 9a3

Explain at least five Q signals or amateur radio terms you hear while listening.

Q Signals are three letter shortcuts used in Morse Code and useful when radio operators don't speak the same language. Here are the most common:

QTH: location
QSO: a Conversation
QSL: I acknowledge receipt or Do you acknowledge?
QSY: Change frequency
QRM; Manmade Interference
QRN: Noise
QRP: Low Power
QRT: Stopping Transmitting
QRZ: Who is Calling Me?

We use Coordinate Universal Time to record time. For our time zone that is Eastern Time +4 Hours = UTC during daylight savings, and +5 hours during standard time.

Other common terms are

CQ: Wishing to talk with anyone. **CQ DX:** Wishing to talk with anyone outside the U.S.
CW: Morse Code (comes from Continuous Wave)
DX: Long distance
73: Best Regards **HI HI:** Laughing on Morse Code
Ham: An Amateur Radio Operator
Phone: Voice transmissions
RTTY: Radio Teletype
Rig: My radio
Shack: my radio room
K: Over. **KN:** Back to you and only you. **SK:** Out and frequency is now clear.

Another way to put it is that Eastern Time = UTC – 4 or 5 hours depending on time of year.

Signal reports on Morse Code are given as:
RST (**R**eadabilty, **S**trength, **T**one); **599** is the best.

Signal Reports on Voice are given as:
RS (**R**eadability, **S**trength); **59** is the best.

Requirement 9a4

Explain some of the differences between the Technician, General, and Extra Class license requirements and privileges. Explain who administers amateur radio exams.

The Technician Class license is the entry level Amateur Radio license.
There is just **one 35 question multiple choice** test on radio theory, rules, and procedures.
This license gives **full VHF & UHF use** so you can **communicate around town and use repeaters**, but you cannot use some of the HF bands which are used for world-wide contacts.

The General Class license is the mid level Amateur Radio license. **You must pass the Technician Class test** first.
There is just **one 35 question multiple choice** test on HF radio theory, rules, and procedures.
This license adds most **HF band privileges** used for world-wide contacts to the VHF & UHF privileges previously earned.
Also **LIMITS on OUTPUT POWER**

The Extra Class license is the highest level Amateur Radio license. **You must pass the Technician Class test** and the **General Class test** firs.
There is just **one 50 question multiple choice** test on advanced radio theory and modes of operation.
This license adds all **privileges** on all amateur bands.

The FCC has agreement with **Volunteer Examiner Coordinators** to administer exams.
The exams are given by **local Volunteer Examiners**, must have **3** VEs to administer exams.
All tests can be passed same day.
FCC Issues licenses within a week.
Once you show up in FCC ULS database you can get on the air.
Typical fee around $15 so VEs can recoup costs to administer exam
Laurel VEC is free.
Many ham club offer courses to help get you ready. Costs $25 - $40.
QRZ.com for practice tests

Requirement 9a5

Explain how you would make an emergency call on voice or Morse code.

<u>On voice, say</u>
Mayday, Mayday, Mayday
Your callsign
Your location
What help you need
Over

<u>On Morse Code, send</u>
SOS SOS SOS *(. . . - - - . . .)*
Your callsign
Your location
What help you need
AR

Just because you have a radio doesn't mean someone will be able to hear you.

You might have to climb higher up a hill.

This is especially true for FRS radios and cell phones, which don‘t have has much power as ham radios.

Requirement 9a6

Explain the differences between handheld transceivers and home "base" transceivers. Explain the uses of mobile amateur radio transceivers and amateur radio repeaters.

Handheld transceiver (HT): Small, light, portable, but not much power. Some can fit in your pocket. With repeaters they can be quite useful, and they can go on your hike easily.

Base station transceiver: **Permanent station** in a building. More power, easier to use, more features.

Mobile transceiver: Permanent station **in a vehicle**. More power. That HT antenna doesn't work well inside a metal car. Smaller ones can be used hiking for QRP work.

Repeaters: Located on high points (Mountains, tall buildings, satellites) to **automatically relay signals**. Some have connections to the telephone system. Repeaters listen on one frequency and retransmit on another.

Which kind of radio is best? It depends on what you want to do. You wouldn’t backpack with a heavy base radio, but that base radio will let you talk farther when you are at home.

Where To Find Out More

- mbparks@gmail.com
- American Radio Relay League
- Ham Nation (twit.tv/hn)
- Amateur Logic (amateurlogic.tv)

Backup Slides

Setting up Radio for Repeater

147.195MHz (+), PL 156.7Hz

Tune radio to this frequency to receive

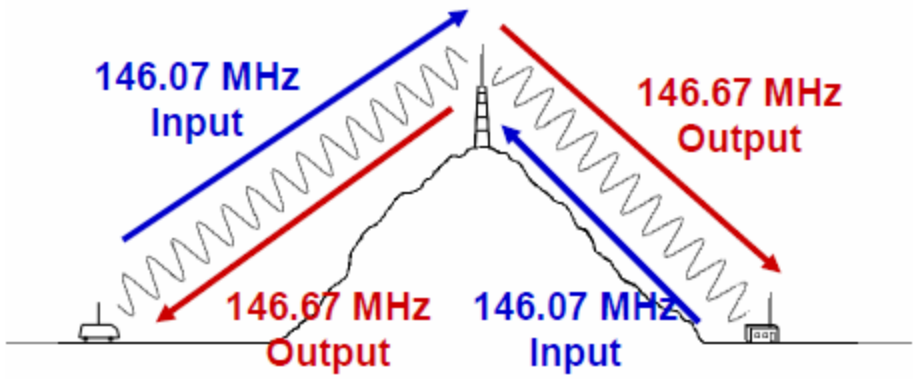
Offset +.6 MHz for Transmit

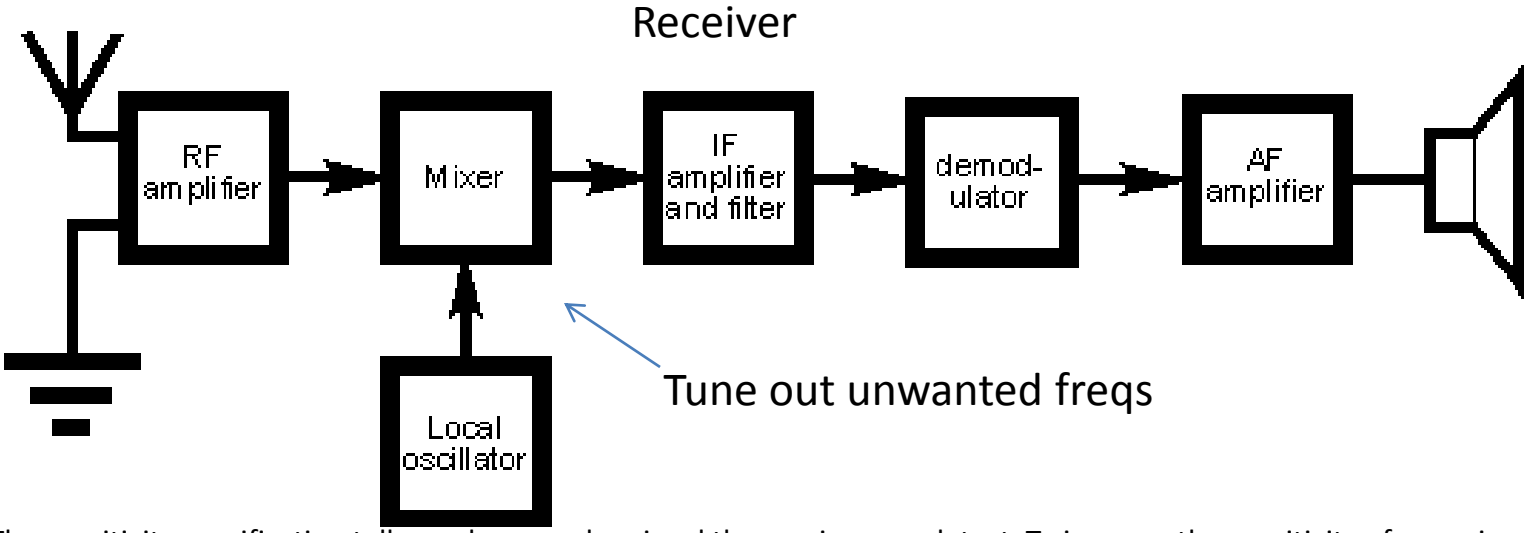
Therefore you actually transmit on 147.795 MHz

Can also be -.6 MHz which case the plus would be a – (minus sign)

Send this sub-audible Private Line (PL) tone to use repeater

- Receive on one frequency and transmit on another.
- Allow much longer range for small radios.
- Located on mountains, towers, buildings and in space.





RF Amp: The sensitivity specification tells you how weak a signal the receiver can detect. To improve the sensitivity of a receiver, you can use an RF preamplifier. An RF preamplifier is installed **between the antenna and receiver.**

The **oscillator** generates a signal at the frequency you want to operate.

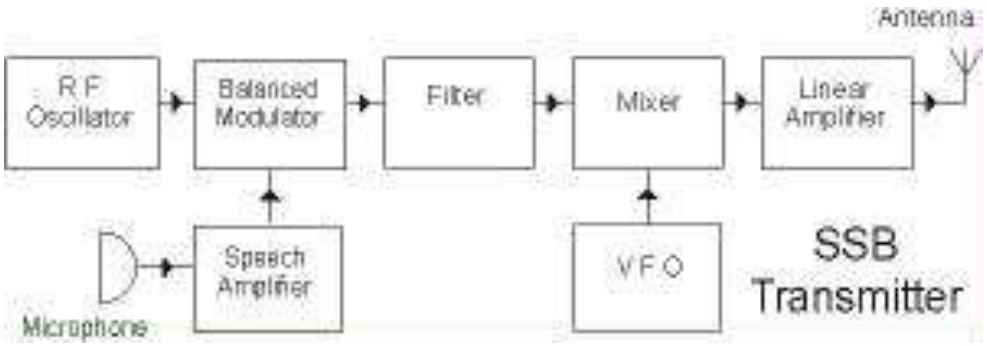
A product detector is a **mixer** used to down convert an input signal to baseband. The term, product detector, is normally used when referring to single sideband (SSB), or double sideband (DSB) demodulation, or continuous wave (CW). Essentially, it is a detector whose output is approximately equal to the product of the beat-frequency oscillator (BFO) and the RF signals applied to it. Output from the product detector is at audio frequency. Some **IF amplifier** and **RF filtering** may be necessary at the detector output to prevent unwanted IF or BFO voltage from reaching the audio amplifier which follows the detector In communications and electronic engineering, an **intermediate frequency** (**IF**) is a frequency to which a carrier frequency is shifted as an intermediate step in transmission or reception. The intermediate frequency is created by mixing the carrier signal with a local oscillator signal in a process called heterodyning, resulting in a signal at the difference or beat frequency. Intermediate frequencies are used in superheterodyne radio receivers, in which an incoming signal is shifted to an IF for amplification before final detection is done. There may be several such stages of intermediate frequency in a superheterodyne, which is called *double* (or *triple*) *conversion*.

DEMODULATION, also called DETECTION, is the process of re-creating original modulating frequencies (intelligence) from radio frequencies. The **DEMODULATOR**

Audio Frequency Amplifier: Avoid distorting audio signal while amplifying so it can be heard.

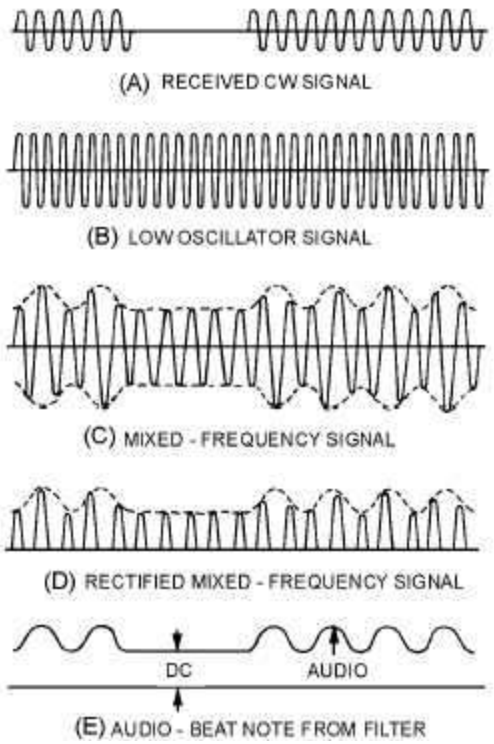
Speaker: Produce soundwave

Transmitter



Balanced modulator to generate an AM signal that has both sidebands and no carrier. This type of AM is known as double sideband suppressed carrier, or DSB. Then the DSB signal is passed through a filter that removes the unnecessary sideband.

In a radio frequency (RF) transmitter, **VFOs** are often used to tune the frequency of the output signal, often indirectly through a hetrodyning process similar to that described above


(A) RECEIVED CW SIGNAL
(B) LOW OSCILLATOR SIGNAL
(C) MIXED - FREQUENCY SIGNAL
(D) RECTIFIED MIXED - FREQUENCY SIGNAL
DC
AUDIO
(E) AUDIO - BEAT NOTE FROM FILTER

NOAA Weather Radio

- Continuous Weather Forecasts & Warnings
- 162.55, 162.475, 162.40, 162.45, 162.50 MHz
- Essential for boating, hiking and camping.
- Most Ham radios can also receive this.
- Special SAME (Specific Area Alert Encoding) receivers actually turn themselves on when a warning is sent for your county!

Antenna Loading Coil

- A (mobile) radio antenna, shorter than a quarter wavelength for practical reasons, presents capacitive reactance to a transmission line. This can be canceled by inserting an equal and opposite (inductive) reactance in series, by means of a loading coil typically at the base or center of the antenna. Consequently the antenna presents a resistance (desirable) to the transmission line.
- The inductive reactance of the loading coil, cancels out the capacitive reactance a shortened (less than 1/4 wave length) antenna has (see chart, courtesy of the ARRL). Although it adds physical length to the antenna, it does not increase the electrical length except in very special cases (long, skinny, linear loading is an example). The current flow within the coil is always uniform, except in the special case noted.
- If a shortened version was required, an inductor was inserted to replace the "missing length." Further, if an antenna's physical length has been significantly reduced, one must accept degraded performance i.e. less than 100% efficiency and in most instances much less than 100%.
- The electrical lengthening allows the construction of shorter aerials. It is applied in particular for aerials for VLF, longwave and medium-wave transmitters, because mast radiators of the necessary height cannot be realized economically.
- Disadvantages: The electrical lengthening reduces the bandwidth of the antenna if other phase control measures are not undertaken. An electrically extended aerial is less efficient than a non-extended antenna.
- There are two possibilities for the realisation of the electric lengthening.
  - Switching in inductive coils in series with the aerial.
  - Switching in metal surfaces, known as roof capacitance, at the aerial ends which form capacitors to earth.

- http://astrosurf.com/luxorion/qsl-antennas-basics.htm

Antenna Theory

- How do we make a small antenna as efficient as possible?
  - We make current as uniform as possible over the length of the antenna by using as much capacitance as possible at the antenna ends.
  - We use low-loss loading such as optimum form factor (size, length, and diameter) loading coils.
  - We make the antenna as large and as straight in a line as possible. We don't fold, bend, zigzag, or curve the antenna..... especially in the high current areas!
  - We keep the high voltage points (the open ends) away from lossy things (such as lossy earth or wet foliage).
  - We keep the high current areas away from other large lossy conductors.
- Moving the coil would have little or no effect on efficiency.
  - A six-foot antenna with a large hat would be electrically equal to a 12-foot antenna without a hat.
- Basically the idea of a capacitance hat is to make up the length needed for resonance while limiting the vertical height. It can be a disc or wires, mesh etc anything that will add capacitance to the antenna.
  - To reduce Q in an antenna system, we can either improve the ground properties or add a capacitance hat above the coil. It will act like a big capacitor in lowering the resonant frequency of the antenna
  - Starting simple - a vertical antenna is in reality a simple series R-L-C resonant circuit. The vertical wire, rod, or tube is the inductor, L. The same vertical mast, in combination with the radials, forms the capacitor, C. Completing the circuit is the antenna radiation resistance Ra. Antenna radiation resistance varies with the length of the antenna. It shrinks as antenna length shrinks.
- Inductors are said to consume reactive power and capacitors are said to supply it

Antenna Theory

- There MUST be good conductive contact between the capacitance hat and the top of the antenna.
- Capacitance hats can use spokes, a single wire, and/or a metal disc. I prefer a metal disc, as this provides more capacitance for a given amount of space.
- The capacitance hat MUST be at the top of the antenna. Mounting the capacitance hat lower makes the portion of the antenna above inactive and has the same effect as chopping off the part of the antenna above the capacitance hat. SO PLEASE KEEP THE HAT AT THE TOP!
- Inductive Loading
  - Adding inductance will compensate for the high capacitive reactance of a shortened vertical antenna. Inductance is usually added in the form of a loading coil. It should be noted that the more inductance you need, the greater the resistive losses in the inductor. This diminishes your antenna's efficiency. Inductance losses can be minimized by using a loading coil with a high Q value. In general, increasing the coil diameter and the thickness of the wires increases the Q value.
- Capacitive Loading
  - Adding capacitance to the antenna will raise the antenna's overall capacitance value, reduce the capacitive reactance, reduce the inductance loading needed for resonance, and thus raise the efficiency of your antenna. Although a capacitance loaded antenna is not as efficient as a full-size antenna, it is more efficient than an antenna of the same size that uses only inductance loading. As you might imagine, operating the lower bands will require the use of BOTH inductive and capacitive loading. Capacitance is added by simply by attaching a capacitance hat (conductor) to the top of the antenna.
- A vertical antenna much shorter than 1/4 wavelength long has capacitance. The shorter the antenna is relative to the wavelength of the RF, the lower the capacitance value and the higher the capacitive (negative) reactance.
- Unless your antenna is at least 1/2 wavelength above the ground, it will transmit most of the RF straight up instead of at low angles above the ground. While this may work well for local contacts, this will handicap your DX capability.
  - If your dipole is made of wire, it must be 1/2 wavelength long. Unless you make a dipole out of Hamstick mobile antennas (there is an adapter you can buy to do this), a shortened dipole may be difficult to find or make.
  - Pros: Dipole antennas require no ground plane. This makes them more efficient than 1/4 wavelength monopole antennas.
- Use balun choke or loop coax if using a very long coax to reduce effects of the feed line acting as an antenna.

ASCII: American Standard Code for Information Interchange

Dec	Hx	Oct	Char		Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr
0	0	000	NUL	(null)	32	20	040		Space	64	40	100	@	@	96	60	140	`	`
1	1	001	SOH	(start of heading)	33	21	041	!	!	65	41	101	A	A	97	61	141	a	a
2	2	002	STX	(start of text)	34	22	042	"	"	66	42	102	B	B	98	62	142	b	b
3	3	003	ETX	(end of text)	35	23	043	#	#	67	43	103	C	C	99	63	143	c	c
4	4	004	EOT	(end of transmission)	36	24	044	$	$	68	44	104	D	D	100	64	144	d	d
5	5	005	ENQ	(enquiry)	37	25	045	%	%	69	45	105	E	E	101	65	145	e	e
6	6	006	ACK	(acknowledge)	38	26	046	&	&	70	46	106	F	F	102	66	146	f	f
7	7	007	BEL	(bell)	39	27	047	'	'	71	47	107	G	G	103	67	147	g	g
8	8	010	BS	(backspace)	40	28	050	(	(	72	48	110	H	H	104	68	150	h	h
9	9	011	TAB	(horizontal tab)	41	29	051	)	)	73	49	111	I	I	105	69	151	i	i
10	A	012	LF	(NL line feed, new line)	42	2A	052	*	*	74	4A	112	J	J	106	6A	152	j	j
11	B	013	VT	(vertical tab)	43	2B	053	+	+	75	4B	113	K	K	107	6B	153	k	k
12	C	014	FF	(NP form feed, new page)	44	2C	054	,	,	76	4C	114	L	L	108	6C	154	l	l
13	D	015	CR	(carriage return)	45	2D	055	-	-	77	4D	115	M	M	109	6D	155	m	m
14	E	016	SO	(shift out)	46	2E	056	.	.	78	4E	116	N	N	110	6E	156	n	n
15	F	017	SI	(shift in)	47	2F	057	/	/	79	4F	117	O	O	111	6F	157	o	o
16	10	020	DLE	(data link escape)	48	30	060	0	0	80	50	120	P	P	112	70	160	p	p
17	11	021	DC1	(device control 1)	49	31	061	1	1	81	51	121	Q	Q	113	71	161	q	q
18	12	022	DC2	(device control 2)	50	32	062	2	2	82	52	122	R	R	114	72	162	r	r
19	13	023	DC3	(device control 3)	51	33	063	3	3	83	53	123	S	S	115	73	163	s	s
20	14	024	DC4	(device control 4)	52	34	064	4	4	84	54	124	T	T	116	74	164	t	t
21	15	025	NAK	(negative acknowledge)	53	35	065	5	5	85	55	125	U	U	117	75	165	u	u
22	16	026	SYN	(synchronous idle)	54	36	066	6	6	86	56	126	V	V	118	76	166	v	v
23	17	027	ETB	(end of trans. block)	55	37	067	7	7	87	57	127	W	W	119	77	167	w	w
24	18	030	CAN	(cancel)	56	38	070	8	8	88	58	130	X	X	120	78	170	x	x
25	19	031	EM	(end of medium)	57	39	071	9	9	89	59	131	Y	Y	121	79	171	y	y
26	1A	032	SUB	(substitute)	58	3A	072	:	:	90	5A	132	Z	Z	122	7A	172	z	z
27	1B	033	ESC	(escape)	59	3B	073	;	;	91	5B	133	[	[	123	7B	173	{	{
28	1C	034	FS	(file separator)	60	3C	074	<	<	92	5C	134	\	\	124	7C	174			|
29	1D	035	GS	(group separator)	61	3D	075	=	=	93	5D	135	]	]	125	7D	175	}	}
30	1E	036	RS	(record separator)	62	3E	076	>	>	94	5E	136	^	^	126	7E	176	~	~
31	1F	037	US	(unit separator)	63	3F	077	?	?	95	5F	137	_	_	127	7F	177	&#127;	DEL

Source: www.LookupTables.com

Wave/Particle Duality

- The problem is commonly known as wave-particle duality. Initially high energy electromagnetic radiation such as Gamma rays and X rays were thought to show more particle like behavior while low energy electromagnetic radiation such as Radio waves & microwaves were thought to show more wave like behavior. Light being in the middle of the spectrum shows a good mixture of both.
- This was a hot topic of debate in the 1600s and wasn't really explained until Quantum Mechanics introduced probability waves in the 20th Century.

- **Tradition: For a long time no one realized that they were all the same thing, and the term \"wave\" came about when it was thought that there was a medium (aether) to be waved. It's all photons - except that photons are only a concept too.**
- Quantum theory states that a photon "carries" a certain energy, but realize that a photon's rest mass is zero - therefore it's only a concept. OR the photon IS the energy.
  The terms are interchangeable, and they're both bogus in reality.

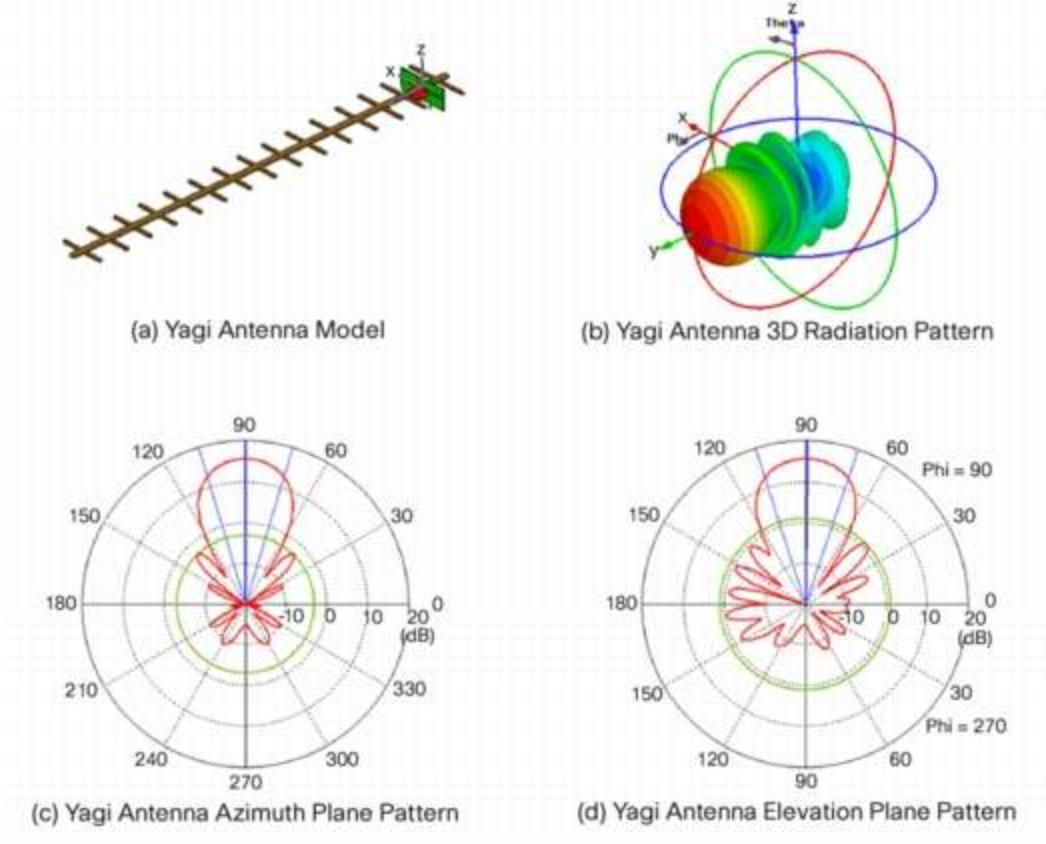
- **Photon versus Wave**
- All electromagnetic waves can have a photon assigned to them . A photon for an electromagnetic waves is frequency dependent, therefore a photon for electromagnetic waves with low frequency such as radiowaves is rather low in energy as compared to a photon of electromagnetic waves of higher frequency such cosmic ray.

  Read more:
  http://wiki.answers.com/Q/Why_are_radio_waves_not_called_radio_photons_but_light_waves_and_X-rays_are_called_X-ray_photons#ixzz1YQFLbMhY

Wave/Particle Duality

- It's a matter of energy. Each kind of matter, such as paper, is made of atoms. Atoms are made of electrons circling about a central nucleus. Furthermore, each electron has many associated discrete energy levels called orbits, shells, probability clouds or probability waves, says Rod Nave, physics professor at Georgia State University. The higher the shell energy level, the farther away the shell is from the nucleus. See Figure 3.
- I'm not being flippant when I term the electron and its energy levels by so many names. We don't know what they are — only how to describe them, mathematically.
- "Things on a very small scale [like electrons] behave like nothing that you have any direct experience about. They do not behave like waves, they do not behave like particles, they do not behave like clouds, or billiard balls, or weights on springs, or like anything that you have ever seen," wrote Nobel prize-winning physicist Richard Feynman in *Six Easy Pieces*.
- Courtesy of NASA, drawing modified by the author A part of the spectrum of electromagnetic waves, indicating the relative wavelengths of gamma, visible light, and radio. Like the atom, an electromagnetic wave has an energy level, but the wave energy relates to wavelength (instead of distance from the atom's nucleus). The shorter the wavelength of a particular wave type, the higher the energy that electromagnetic wave contains. By the way, we can also think of any electromagnetic wave as a particle (called a photon).
- Visible light waves are about half a millionth of a meter in length. Gamma-ray wavelengths are up to a trillion times shorter than visible light and radio waves up to a hundred million times longer. Gamma rays are extremely high-energy electromagnetic waves (the highest known); radio waves are low-energy (the lowest), and visible light sits in the middle of these two extremes. See Figure 4. Incidentally, neutron stars emit some of the highest-energy gamma rays that we have detected.
- Now, what does it take for paper to block a given kind of light? It must trap the light particles (photons) by absorbing or scattering them. That means the energy level of the photon (or wave) must match the energy level of an electron (whatever one is). This takes a pair of just-right energy levels.
- A photon comes zipping along and looks around inside the paper. It sees a likely atom. Aha! It says. There's a low-level electron energy that might work. If I add my energy to that energy, I will raise the electron to an excited state. What's more, that excited state will put the electron in a higher-energy level that already exists. (Only pre-existing authorized-for-that-atom levels will do.) All is well. So the photon nips into this just-right situation and gets absorbed. See Figure 5.
- Courtesy of Wikipedia, drawing modified by the author. A hydrogen atom absorbing a photon of visible light. The electron is shown as green hazy blobs, initially in its lowest energy state (the rest state, ring 1). The incoming photon adds its energy to the lowest-state energy. It works; the added energy of the photon drives the electron to a pre-existing higher energy state (ring 2). It happens that paper is loaded with suitable energy levels that match in this fashion the visible-light energies; so paper absorbs or scatters visible light. But, paper can't block gamma rays because gamma rays have energies that are all much too high to match any electron energy levels that exist in paper. Radio-wave energies are much too low to match. So paper blocks visible light but can't block gamma rays or radio waves.
- Energy levels make the difference

Radiation Pattern



Inverted V = More omnidirectional, less space

Vertical Dipole: Omnidirectional

Flat Top: More directional

Yagi: Highly Directional

Half Wave Length Antenna = 2x ¼ WL halves. 468/MHz

Antenna should be 1/2WL above ground so to not smoosh the pattern, though too high and you lose close in QSOs.

Intermediate Frequency (IF)

- In communications and electronic engineering, an **intermediate frequency** (**IF**) is a frequency to which a carrier frequency is shifted as an intermediate step in transmission or reception. The intermediate frequency is created by mixing the carrier signal with a local oscillator signal in a process called heterodyning, resulting in a signal at the difference or beat frequency. Intermediate frequencies are used in superheterodyne radio receivers, in which an incoming signal is shifted to an IF for amplification before final detection is done. There may be several such stages of intermediate frequency in a superheterodyne, which is called *double* (or *triple*) *conversion*.

- Intermediate frequencies are used for three general reasons. **At very high (gigahertz) frequencies, signal processing circuitry performs poorly**. Active devices such **as transistors cannot deliver much amplification (gain) without becoming unstable. Ordinary circuits using capacitors and inductors must be replaced with cumbersome high frequency techniques such as striplines and waveguides. So a high frequency signal is converted to a lower IF for processin**g.
- A second reason to use an IF, in receivers that can be tuned to different stations, is to convert the various different frequencies of the stations to a common frequency for processing. **It is difficult to build amplifiers, filters, and detectors that can be tuned to different frequencies, but easy to build tunable oscillators**. Superheterodyne receivers tune in different stations simply by adjusting the frequency of the local oscillator on the input stage, **and all processing after that is done at the same frequency, the IF. Without using an IF, all the complicated filters and detectors in a radio or television would have to be tuned in unison each time the station was changed**, as was necessary in the early tuned radio frequency receivers.
- But the main reason for using an intermediate frequency is to **improve frequency selectivity**. In communication circuits, a very **common task is to separate out or extract signals or components of a signal that are close together in frequency. This is called filtering.** Some examples are, picking up a radio station among several that are close in frequency, or extracting the chrominance subcarrier from a TV signal. With all known filtering techniques the filter's bandwidth increases proportionately with the frequency. So a narrower bandwidth and more selectivity can be achieved by converting the signal to a lower IF and performing the filtering at that frequency.
- Perhaps the most commonly **used intermediate frequencies are around 455 kHz for AM receivers and 10.7 MHz for FM receivers**. However, the intermediate frequency can range from 10–100 MHz. Intermediate frequency (IF) are **generated by mixing the RF and LO frequency together to create a lower frequency called IF**. Most of the ADC/DAC operates in low sampling rates, so input RF must be mixed down to IF to be processed. Intermediate frequency tends to be lower frequency range compared to the transmitted RF frequency. However, the choices for the IF are most dependent on the available components such as mixer, filters, amplifiers and others that can operate at lower frequency. There are other factors involved in deciding the IF frequency, because lower IF is susceptible to noise and higher IF can cause clock jitters.

Intermediate Frequency (IF)

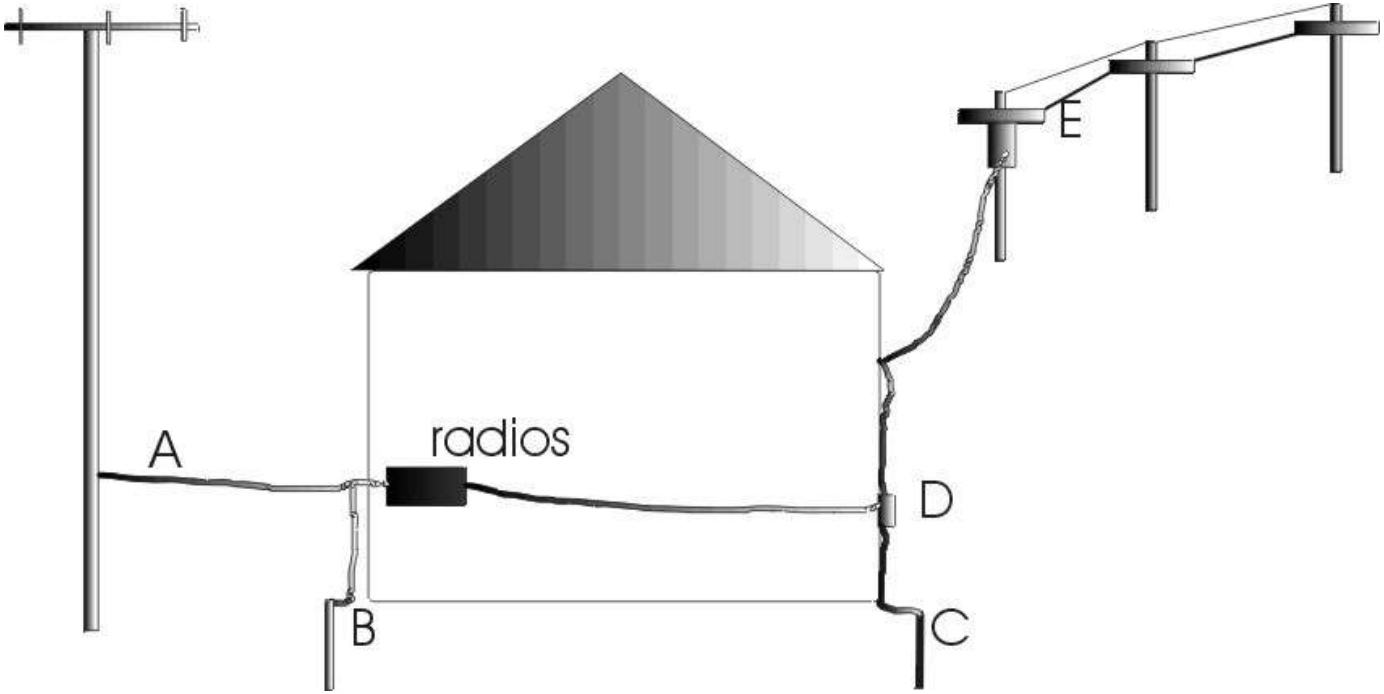
- AN IF allows you to tune over a wide frequency range and yet
  - Keep the same skirt shape
  - Have good selectivity
- Change to/from the IF to that the FILTERING and GAIN can be done on a single, fixed and known frequency.
- Want to keep a linear response

- dB attenuate to knock power down

GROUNDS

- A ground system provides four primary functions:
  - To help disperse or divert energy from lightning strikes
  - To provide safety in case some problem or fault energizes the cabinet or chassis of equipment with dangerous voltages
  - To provide a controlled RF return path for end-fed (single wire feed) or poorly configured or improperly designed transmission-line fed antennas
  - To provide a highly conductive path for induced or directly coupled radio-frequency currents, rather than having them flow in lossy soil
- A ground will ***NOT***.....
  - A ground normally will not help reception. The exception is an antenna system design problem or installation problem causing the antenna system to be sensitive to common mode feedline currents. If adding a station ground helps reception or transmission, there is an antenna system flaw.
  - A ground will not reduce the chances or number of lightning strikes. A properly installed and bonded entrance ground can only reduce or eliminate lightning ***damage*** from hits.
- The lowest impedance connection is provided by a wide smooth surface copper flashing, although very heavy round copper can be used. Round copper has lower RF resistance per unit length for a given surface area, but flat wide copper has less reactance and lower overall impedance. This is because fewer magnetic flux lines encircle any given area of wide strip than enclose the surface area of a compact conductor. In effect the magnetic field is "spread out", reducing inductance.

Grounding



RF GROUND and SAFETY GROUND = GROUND SYSTEM

Skin Effect

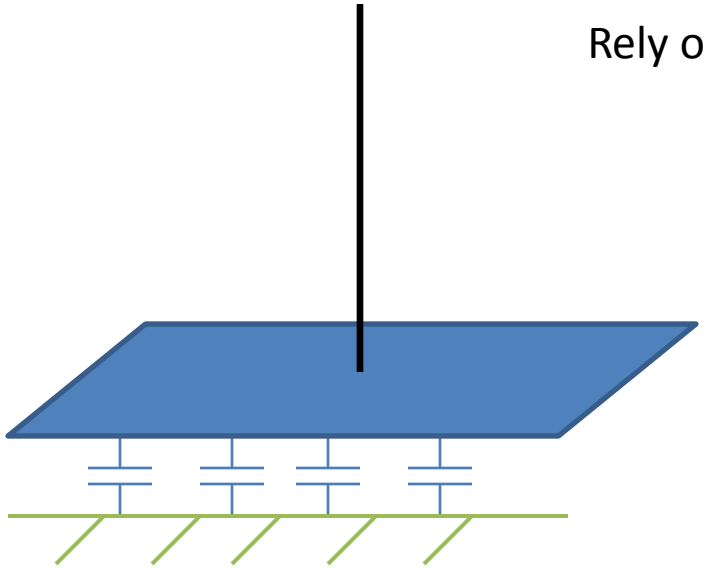
While newer equipment is 12 volt operated, or has three wire grounded plugs, older gear often has internal HV supplies and two wire plugs. This equipment must be grounded to a good earth path for safety, otherwise the case of the equipment could rise to more than the highest voltage.

A ground screen, counterpoise, or ground radial system below the antenna can reduce local noise sensitivity by reducing the antenna's response to local noise.

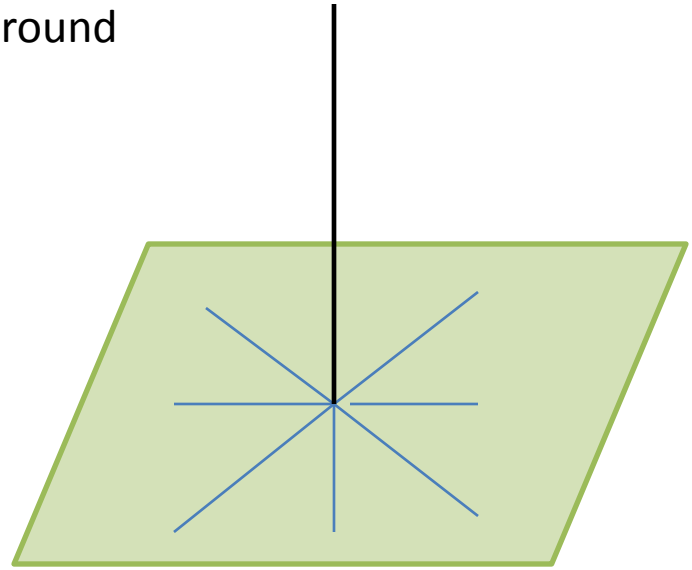
AM vs. FM

- Amplitude Modulation (AM)
  - Can TX farther than FM, especially so at night.
  - Groundwave during day, skywave at night
  - AM has static
  - Cheaper/simpler equipment
  - Narrower bandwidth
  - Prone to interference from electrical storms and other RF sources.
  - 535-1705 kHz
- Frequency Modulation (FM)
  - Better sound quality
  - Less prone to interference
  - Wider bandwidth
  - Can be impacted by physical barrier such as tall building and land mass
  - Can’t transmit as far as AM
  - More complex hardware
  - Line of Sight
  - 88 – 108 MHz

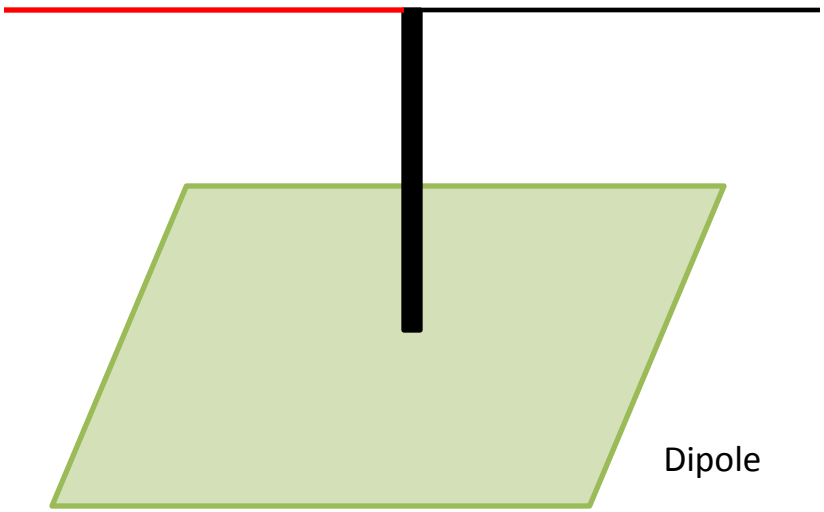
Rely on Earth as Ground



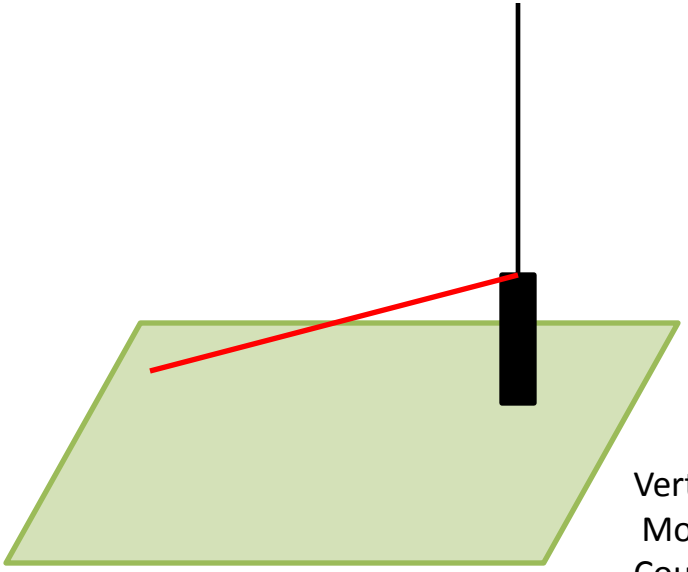
Ground Plane (e.g. car magnetic mounts)



Ground Radials



Dipole



Vertical Dipole or Monopole w/ Counterpoise (artificial ground)

Does NOT Rely on Earth as Ground