Amateur Radio Technician Class Training

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(based on the No-Nonsense, Technician Class Study Guide by Dan Romanchik KB6NU

Updated to the 2022-2026 Question Pool

Instructors

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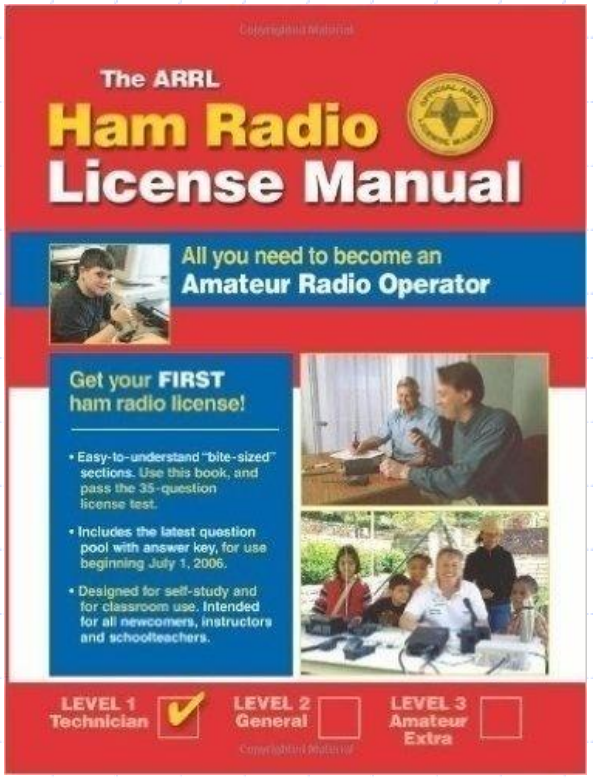
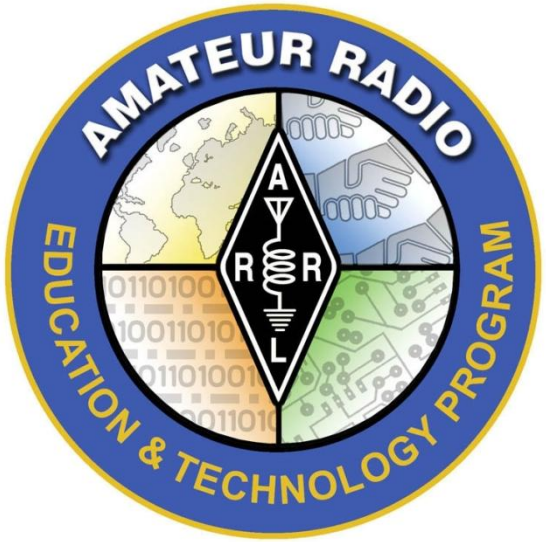
Agenda

- Introduction
- Electrical Principles
- Electronic and Electrical Components
- Radio Wave Propagation
- HF Propagation
- Antennas & Feedlines
- Amateur Radio Signals and Emissions
- Safety Concepts
- Station Setup & Operation
- Operating Procedures
- Rules & Regulations



What is Amateur Radio

- A Hobby – yes!
- A Service – yes!
- Fun – yes!



- It's what you make of it!

Communicate, Experiment, Serve, Interact, Compete

- Regulated, but non-commercial
- Experimentation is allowed/encouraged
- Community Service
- Technical learning and discovery
- Ways to "compete"
- *Something for everyone!*

Cool things to do…

Electrical Principles

Voltage

Current

Resistance

Amps

AC

DC

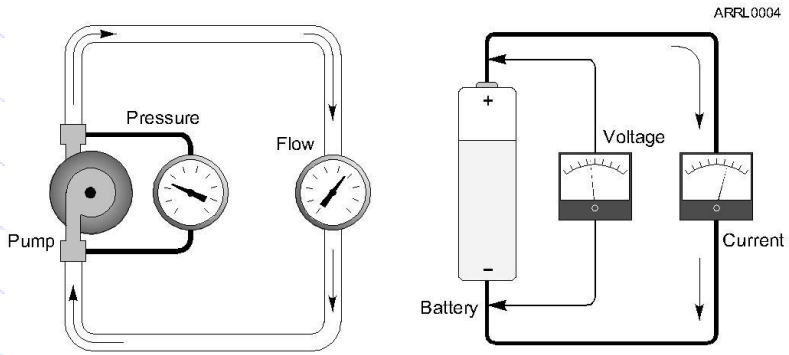
Volts

Insulator

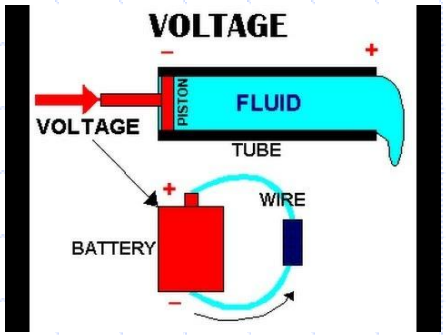
Ohms

Watts

Conductor

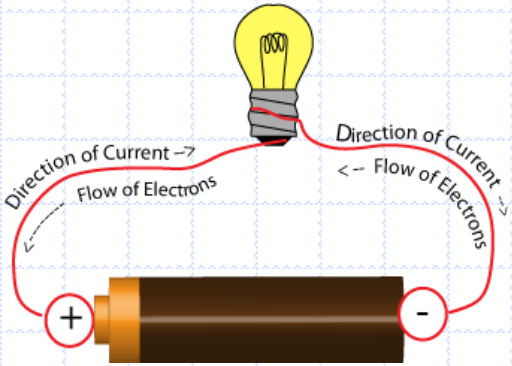


Voltage



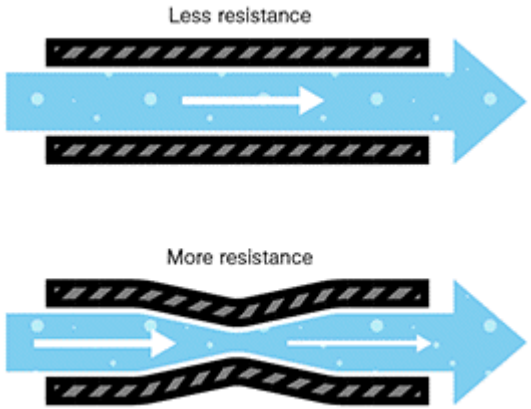
- The **force** that pushes electrons around
- Also called Electro-motive force: **EMF**
- Measured in units called **VOLTS**
- Measured with a **Voltmeter**
- Symbol is **E**, unit symbol is **V**

Current



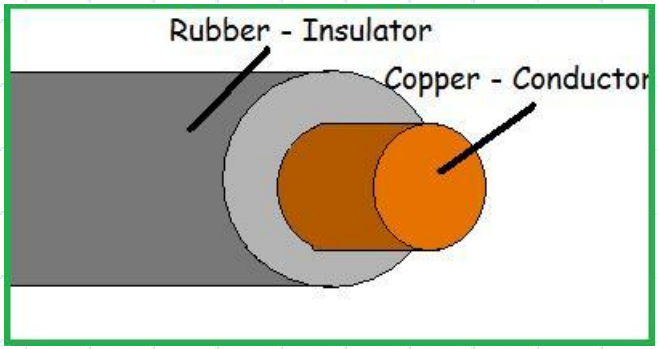
- The flow of electrons in a circuit
- Measured in units of **Amperes** (amps)
- Symbol is **I**, units symbol is **A**
- Measured with an **Ammeter**
- **DC**: Direct Current flows in one direction
- **AC**: Alternating Current alternates between positive and negative directions

Resistance



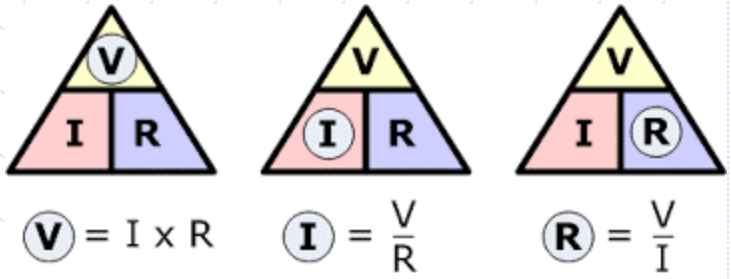
- Opposes the flow of electrons
- Measured in ***Ohms***
- Symbol is ***R***, unit symbol is **Ω**
- Measured with an ***Ohmmeter***
- DC, AC, and RF current flow is opposed by resistance

Conductors & Insulators

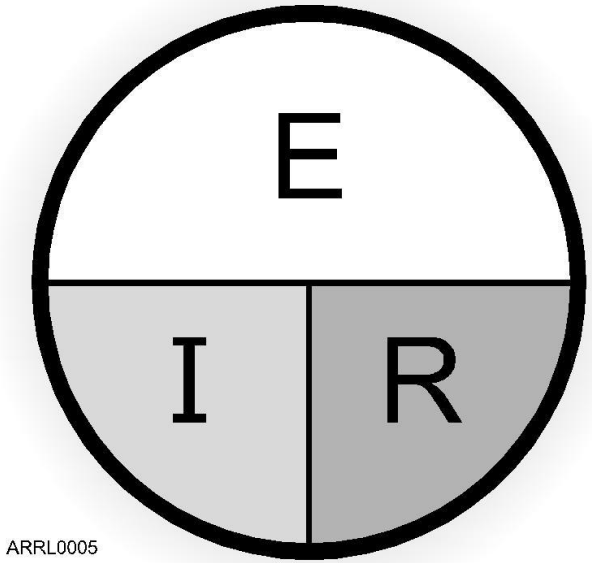


- **Conductors**
  - Low resistance, allow current to flow
  - Copper, aluminum, gold, silver, etc.
  - Metals have many free electrons
- **Insulators**
  - High resistance, little/no current flow
  - Plastic, wood, glass, mica, paper, etc.

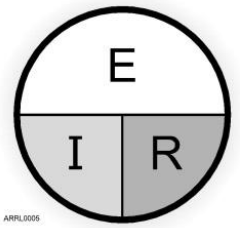
Ohm's Law



- Relationship between:
  - Voltage
  - Current
  - Resistance
- E = I * R
- I = E / R
- R = E / I



Ohm's Law Examples



- 90 volts is applied across a resistor resulting in 3 amperes of current. What's the resistance?
  - R=E/I 90V/3A = **30Ω**
- 120 volts applied to a circuit with 80 ohms of resistance – how much current flows?
  - I=E/R 120V/80Ω = **1.5 amperes**

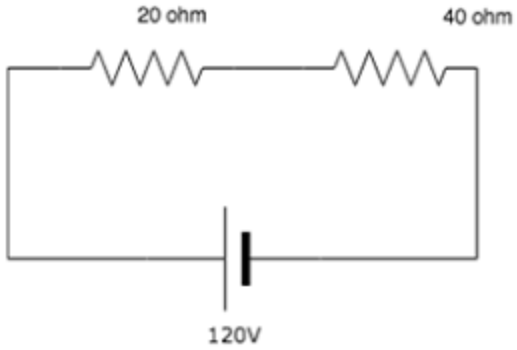
Ohm's Law Examples (continued)

- What is the voltage across a 2-ohm resistor if a current of 0.5 amperes flows through it?
  - $E=I \times R = 0.5A \times 2\ \Omega = 1\ V$

Series and Parallel Circuits

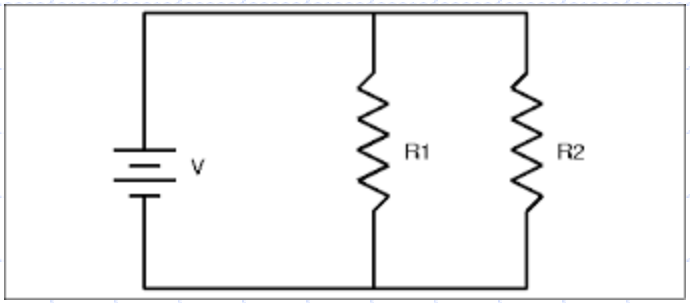
- Consider a circuit with two resistors. They can be connected in two ways.

Series Circuit



There is only one path for the current to flow so the same current must flow through both resistors.
The sum of the voltages across both resistors must equal the source voltage of 120V. The voltage across each resistor depends on the resistance value of the component.

Parallel Circuit



In a parallel circuit, both resistors are connected to the voltage source. Thus the voltage across each of them will be the same.

The current must divide itself between the two resistors depending on the value of the components.

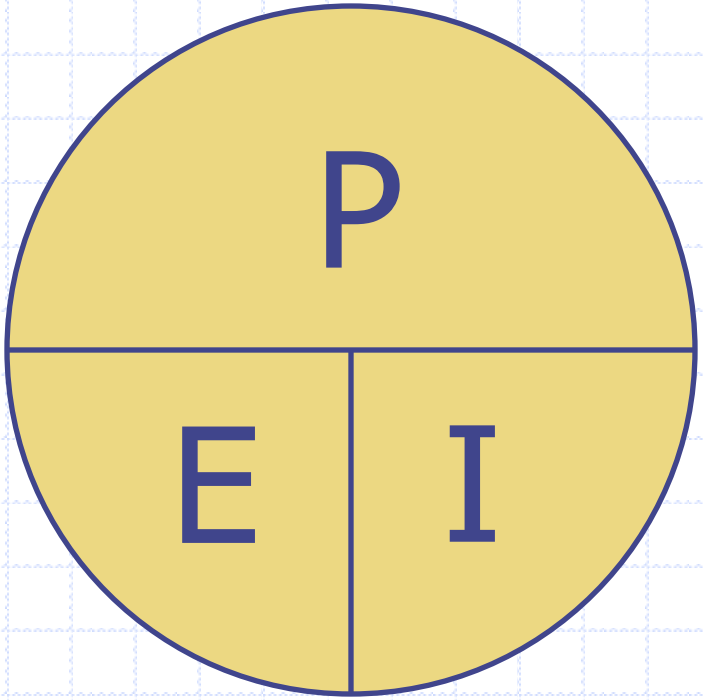
Power

- Rate at which electrical energy is used
- Measured in **Watts**
- Symbol is **P**, unit symbol is **W**

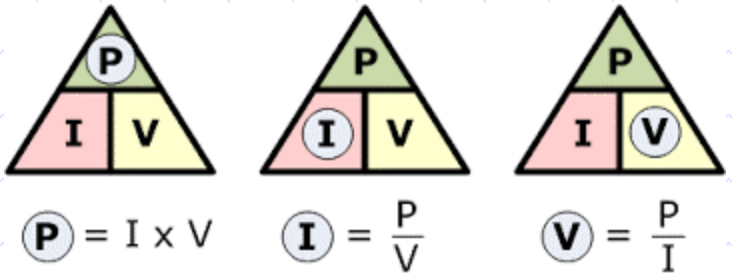
- Often not measured directly, but calculated – *more on this shortly…*

Calculating Power

- Power is Voltage * Current
  - P = E * I
  - E = P / I
  - I = P / E



Power Examples



- How much power is being used by a circuit that draws 10A from a 13.8V source?
  - P=E*I 13.8V * 10A = **138 Watts**
- Applied voltage is 12V and current is 2.5A, what is the power?
  - 12V * 2.5A = **30W**
- Applied voltage is 12 V DC and the load is 120W, how much current is flowing
  - I=P/V = 120W/12V = **10 A**

Math for Electronics: Prefixes

- Used with electrical quantities
  - **milli** = 1/1000th, such as 1**mA** is 1/1000th of an ampere, or 0.001A
  - **micro** = 1/1,000,000th (one millionth), such as 3**µV** which is 0.000003V
  - **pico** = 1 trillionth (millionth of a millionth) such as 5**pA** = 0.000005µA

Prefixes continued

- **kilo** = 1000x, such as 1**kV** = 1000V
- **mega** = 1 million times (1,000,000x) such as 1**MΩ** = 1,000,000Ω
- **giga** = 1 billion times, such as **2.4GHz**

- Prefixes are often used on many different electrical quantities

Prefix examples

- 1.5 amperes (1.5 A) = ? Milliamperes
  - 1500 milliamperes (ma)
- 1 kilovolt (1kV)= ? Volts
  - 1000 Volts (V)
- 1 microvolt (1μV) = ? Volts
  - One millionth of a volt (.000001 V)
- 1,000,000 picofarads = ? Microfarad
  - 1 microfarad (1 μF)

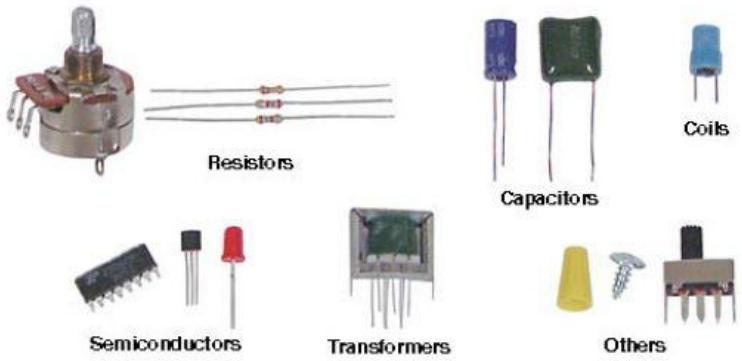
Decibels, or dB

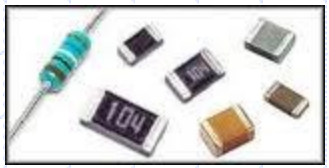
- When dealing with ratios, especially power ratios, we use decibels
- Easy to express large ratios with small numbers
- +dB represents an “increase”
  -dB represents a “decrease”

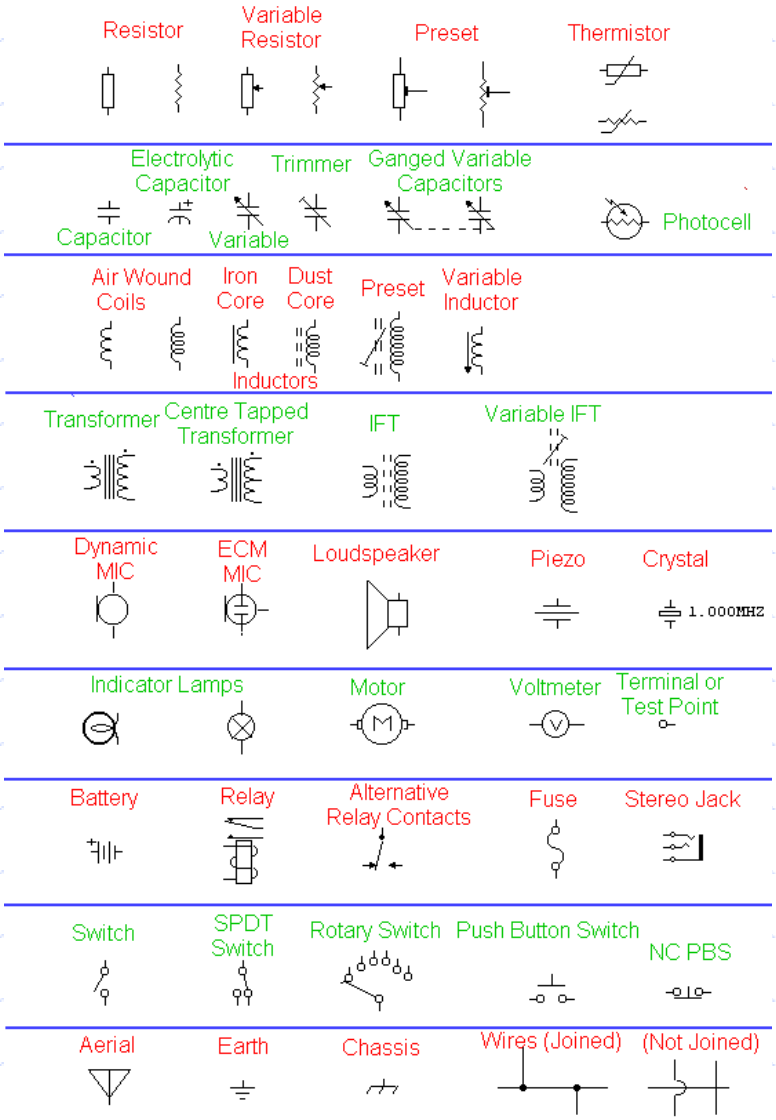
Ratios to remember

- 3dB is a factor of 2x
  - A change from 5W to 10W is a 3dB increase, a ratio of 2 to 1
- 6dB is a factor of 4x
  - A change from 12W to 3W is a 6dB decrease (-6dB change), ratio of 4 to 1
- 10dB is a factor of 10x
  - 20W to 200W is a 10dB increase, ratio of 10 to 1

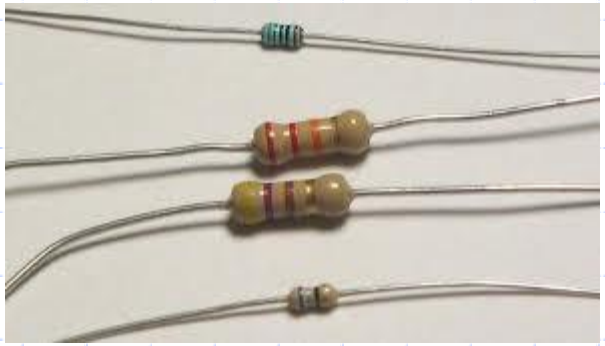
Electronic Principles & Components



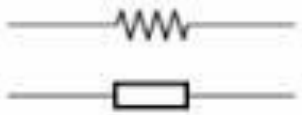


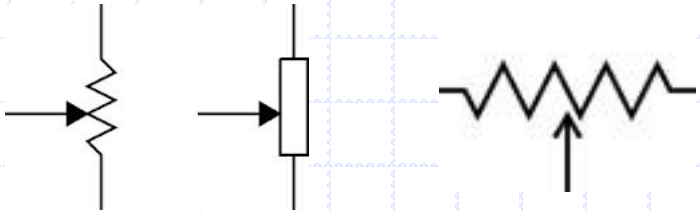


Resistors



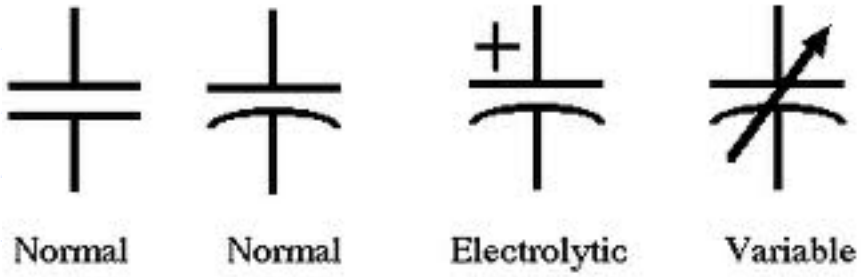
- **Resistors** oppose the flow of current
- Variable resistors are called **Potentiometers** (or **Rheostats**)
- Resistor value expressed in **ohms**



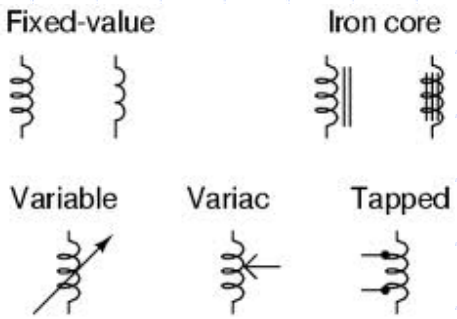


Capacitors

- Two conductors separated by an insulator is a **Capacitor**
- Stores energy in an *electric* field
- Capacitance is the ability to store energy in an electric field
- The unit of measure is the **Farad**



Inductors



- An **inductor** stores energy in a *magnetic* field
- Often just a coil of wire!
- The ability to store energy in a magnetic field is called **Inductance**
- Unit of measure is **Henry**

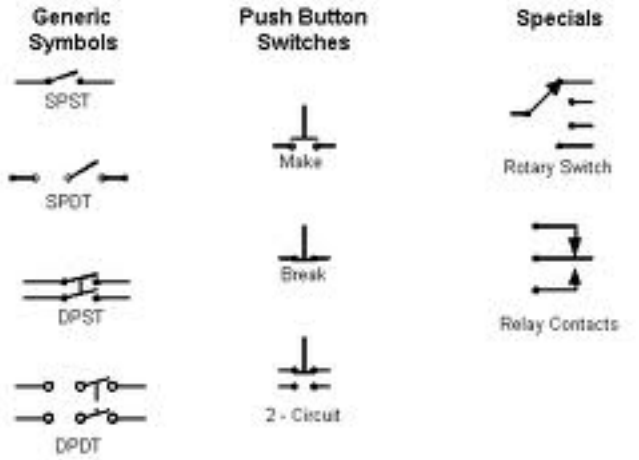
Impedance

- In a DC circuit, only resistance matters
  - A capacitor acts as an open circuit
  - An inductor acts as a short circuit
- In an AC circuit, capacitors and inductors both provide some opposition to current flow
- The combined opposition to current flow (resistance, capacitance, and inductance) in an AC circuit is called impedance and is measured in ohms.

Resonance

- The opposition that capacitors and inductors exhibit against an AC current depends on its frequency (Reactance)
  - Capacitive reactance decreases with increasing frequency
  - Inductive reactance increases with increasing frequency
- There will be one frequency where the capacitive reactance equals the inductive reactance. The circuit is said to be in resonance.
- Resonant circuits can be used for filtering or tuning

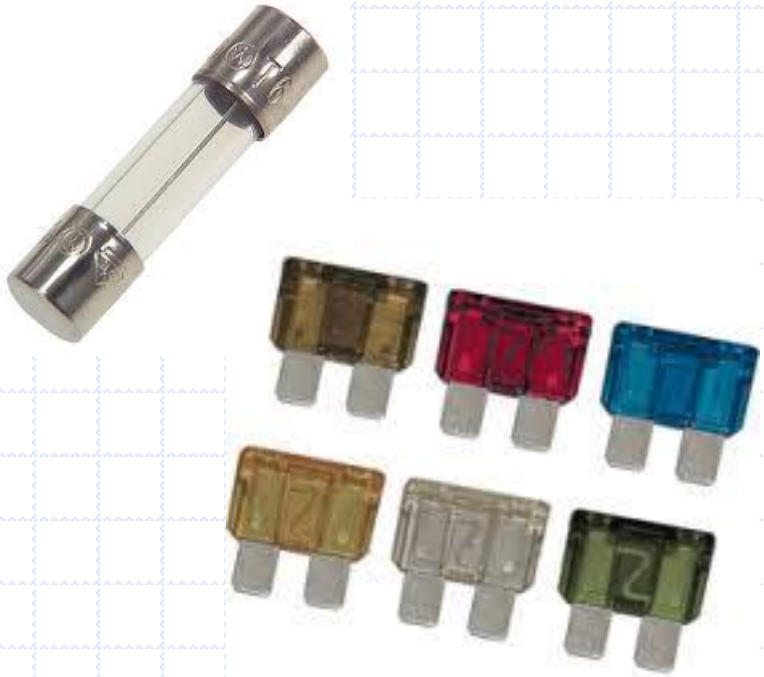
Switches



- Used to connect and disconnect electrical circuits
- Pole: "movable part"
- Throw: the places the pole can go
- SPST: single-pole, single-throw
- SPDT: single-pole, double-throw
  - Single circuit switched between one of two other circuits

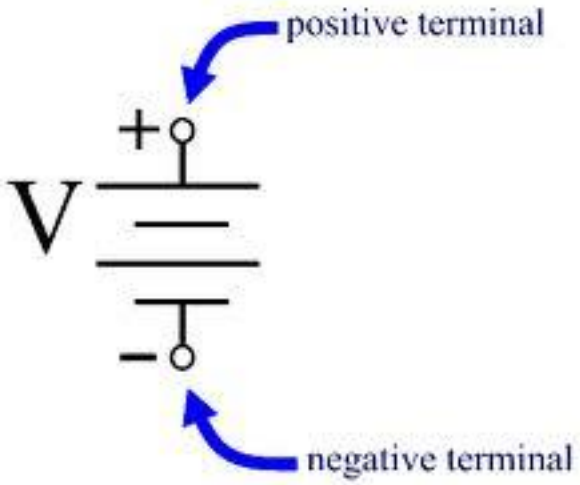
Fuses

- Protects circuits from overload (excessive current)
- Rated in **Amps**



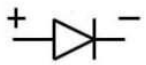
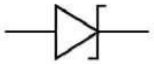
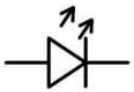
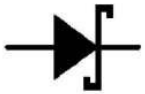
Batteries

- Primary batteries are not rechargeable
  - Carbon Zinc, Alkaline
- Secondary batteries are rechargeable
  - Lead-acid gel-cell, NiMH, Lithium
- Different types have different voltages
  - NiCad typically 1.2V



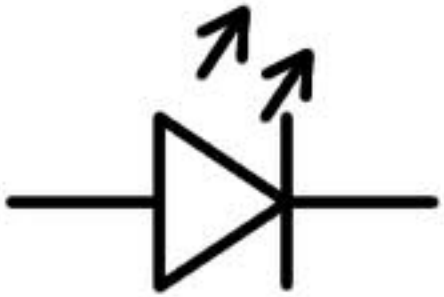
Diodes

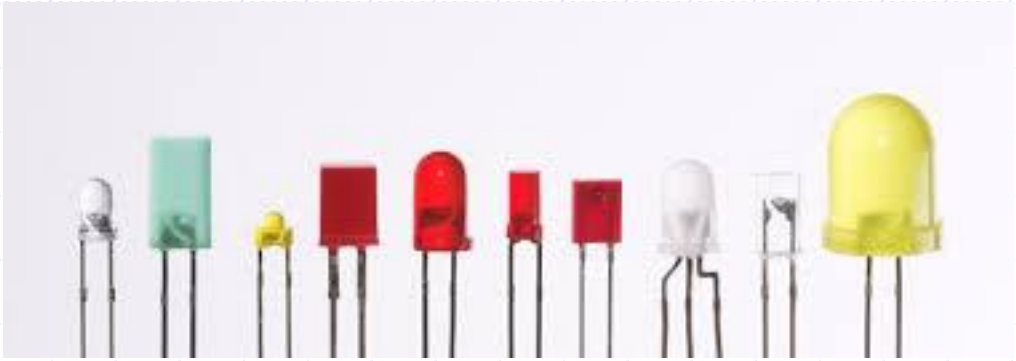
- Allows current to flow in only one direction
- Terminals are:
  - *Anode (+)*
  - *Cathode (-)*
- Cathode has the *stripe*
- Often called **Rectifier**
- Forward current is lower in some diode types than in others

Name	Symbol	Image
Diode		
Zener Diode		
LED (Light Emitting Diode)		
Schottky Diode		

LEDs / Light Emitting Diodes

- A diode that creates light when a forward current passes through it
- Commonly used as a visual indicator



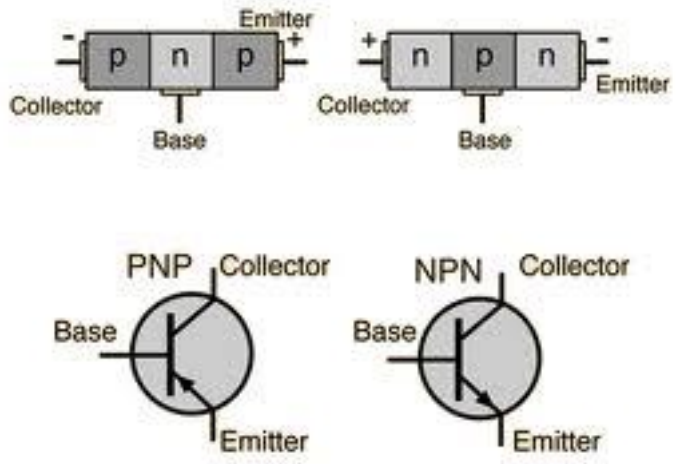


Transistors

- Component where current flow is controlled by another current or voltage
- Used as a *switch* or *amplifier*
- **Gain** is a measure of the ability to amplify

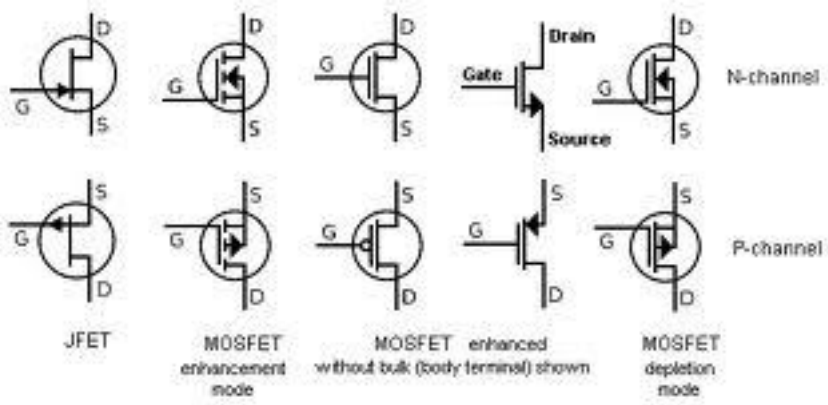
Some transistor types

- **Bipolar transistors** are made of three layers of semiconductor
  - NPN or PNP
- Terminals are:
  - Base, Collector, Emitter



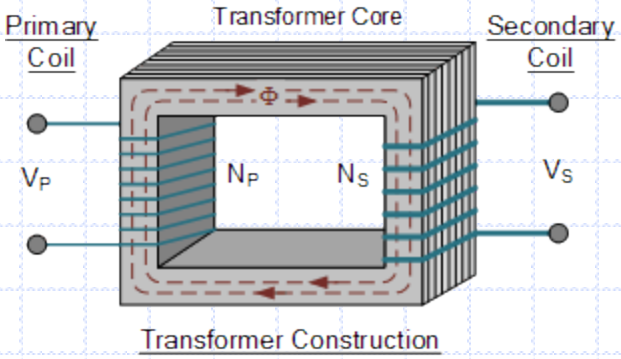
Some transistor types

- **Field Effect Transistor** is abbreviated as *FET*
- Terminals are:
  - *Gate*, Drain, Source

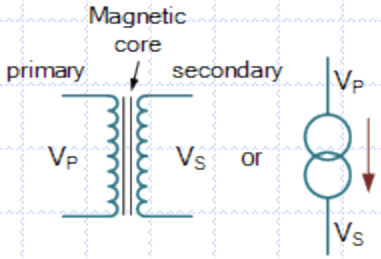


Transformer

A transformer is used to increase (step-up) or decrease (step-down) the voltage of an alternating current. It works by linking two electrical circuits (coils) with a common alternating magnetic field.



Transformer Construction



Transformer Symbols

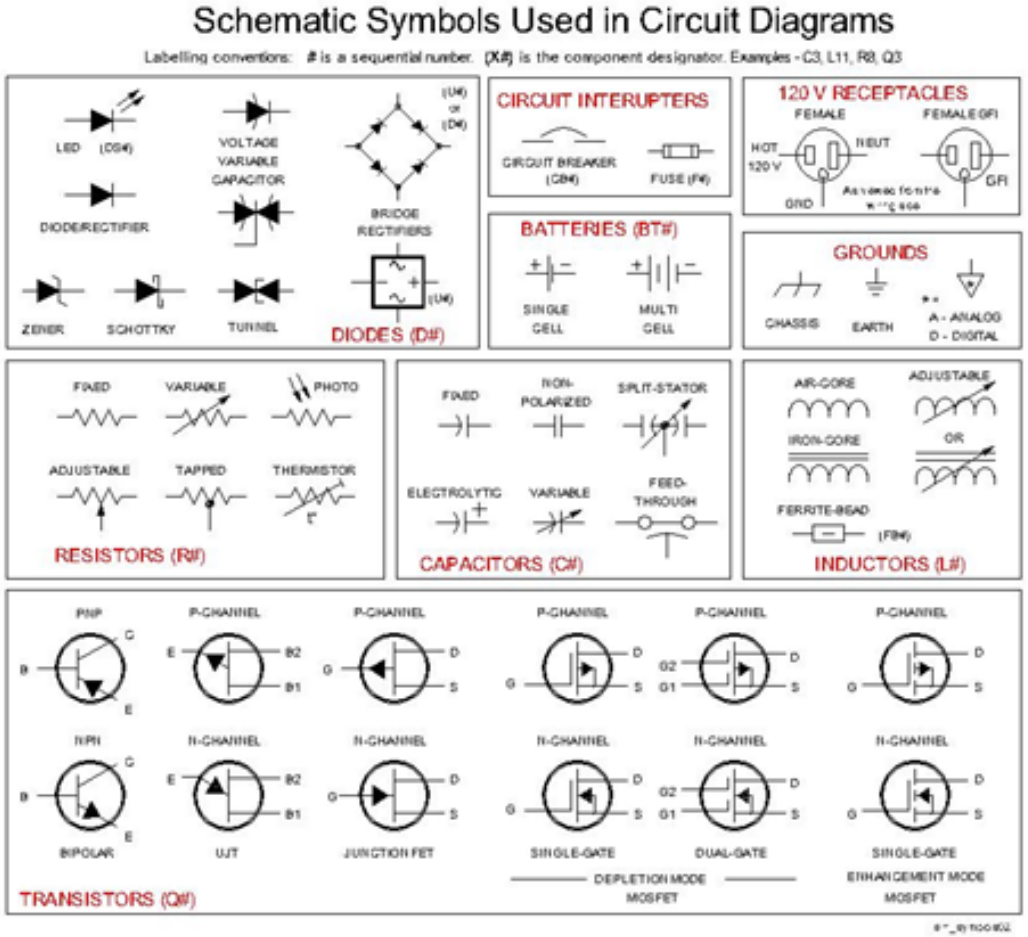
Other Components

- **Relay**: a switch controlled by an electromagnet
- **Meter**: used to display a signal strength on a numeric scale
- **Regulator**: controls the amount of voltage from a power supply
- **Integrated Circuit**: combines many parts in one package, perform analog and/or digital functions

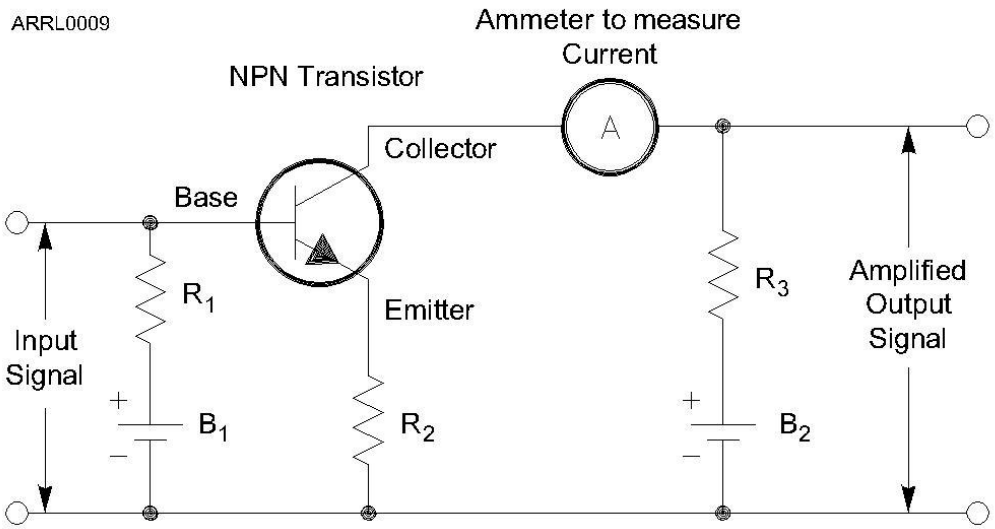
Schematic Symbols

- Schematic **symbols** are standardized representations for *components*
- Schematic **diagram** depicts the *interconnections* between components that make up a circuit

Schematic Symbols



Schematic Diagram



Schematic Diagram examples

- 1:
  - **Resistor**, used to limit input current
- 2:
  - **Transistor**, used to control current
- 3:
  - **Lamp**
- 4:
  - **Battery**, to supply current to light the lamp
- 5:
  - **Chassis Ground**

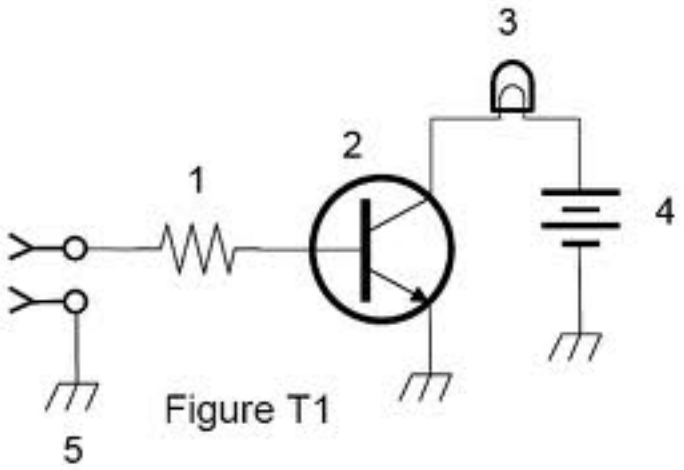


Figure T1

Turns on a light when a positive voltage is applied to the input

Schematic Diagram examples

- 2:
  - **Fuse**
- 3:
  - **Single Pole, Single Throw switch** (SPST) to turn the power supply on/off
- 4:
  - **Transformer**, used to change 120VAC to lower AC voltage
- 5:
  - **Rectifier diode** to change AC to a varying DC signal
- 6:
  - **Capacitor** helps to remove the 60Hz variation in the signal (filter)
- 8:
  - **LED** – pilot light to show it is on
- 9:
  - **Variable Resistor** to vary the output current

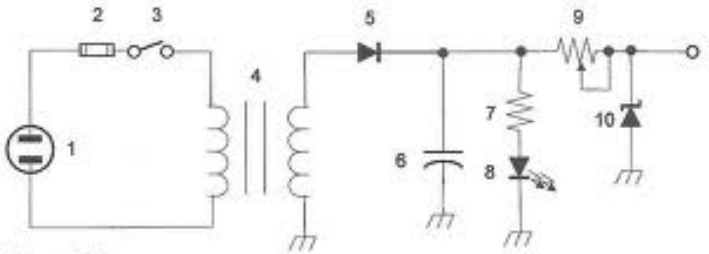


Figure T2

Simple AC – DC Power Supply

Schematic Diagram examples

- 3:
  - **Variable Inductor**
- 2:
  - The **variable capacitors** together with the variable inductor together used as a *tuned circuit*
- 4:
  - **Antenna**

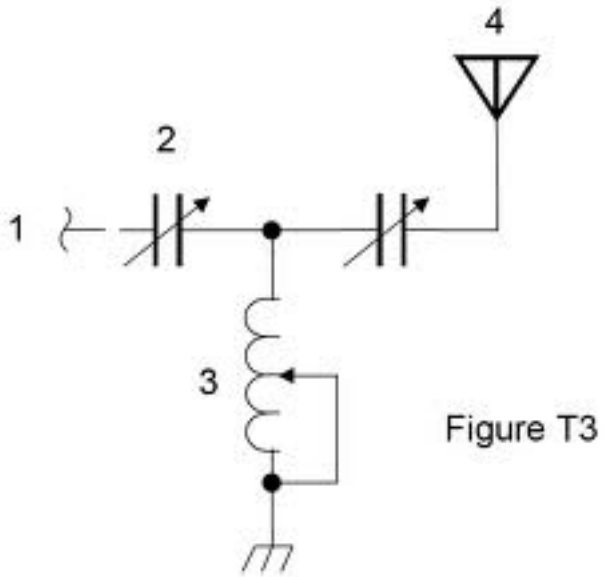
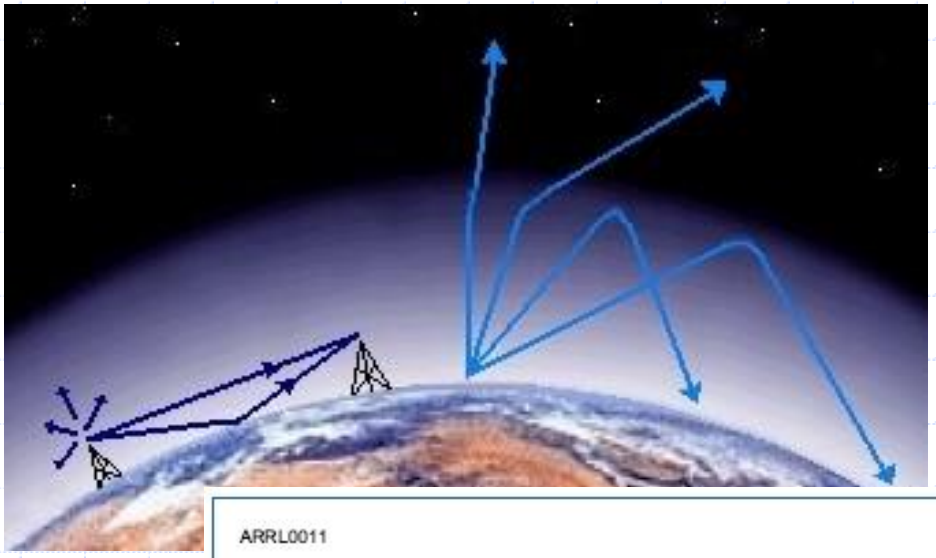


Figure T3

Output circuit of a transmitter

Radio Wave Properties

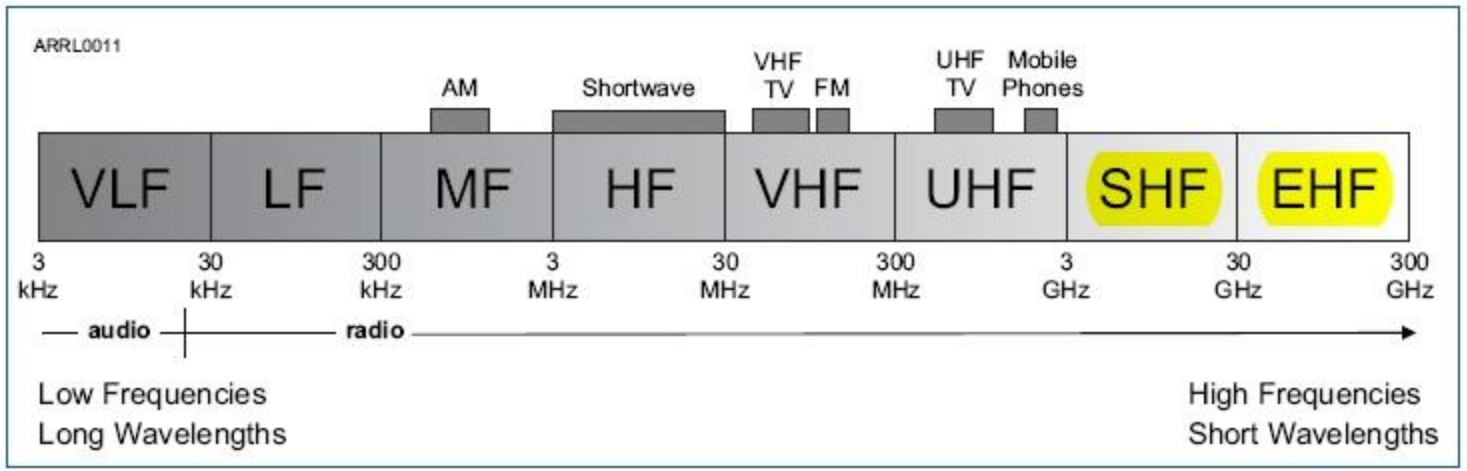


Frequency

Wavelength

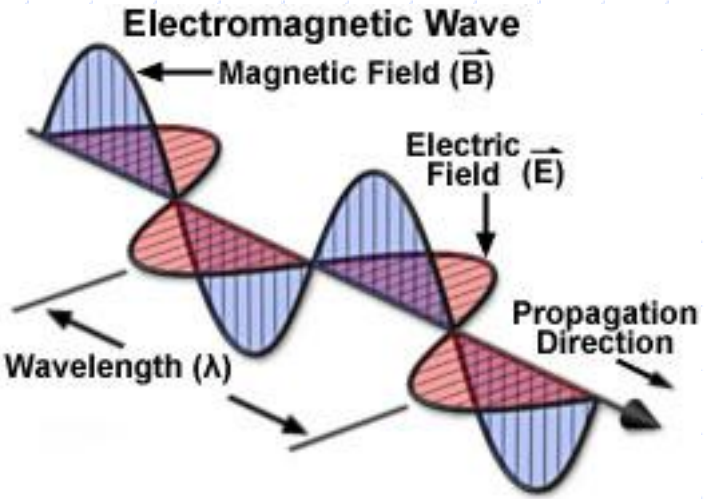
Spectrum

Propagation

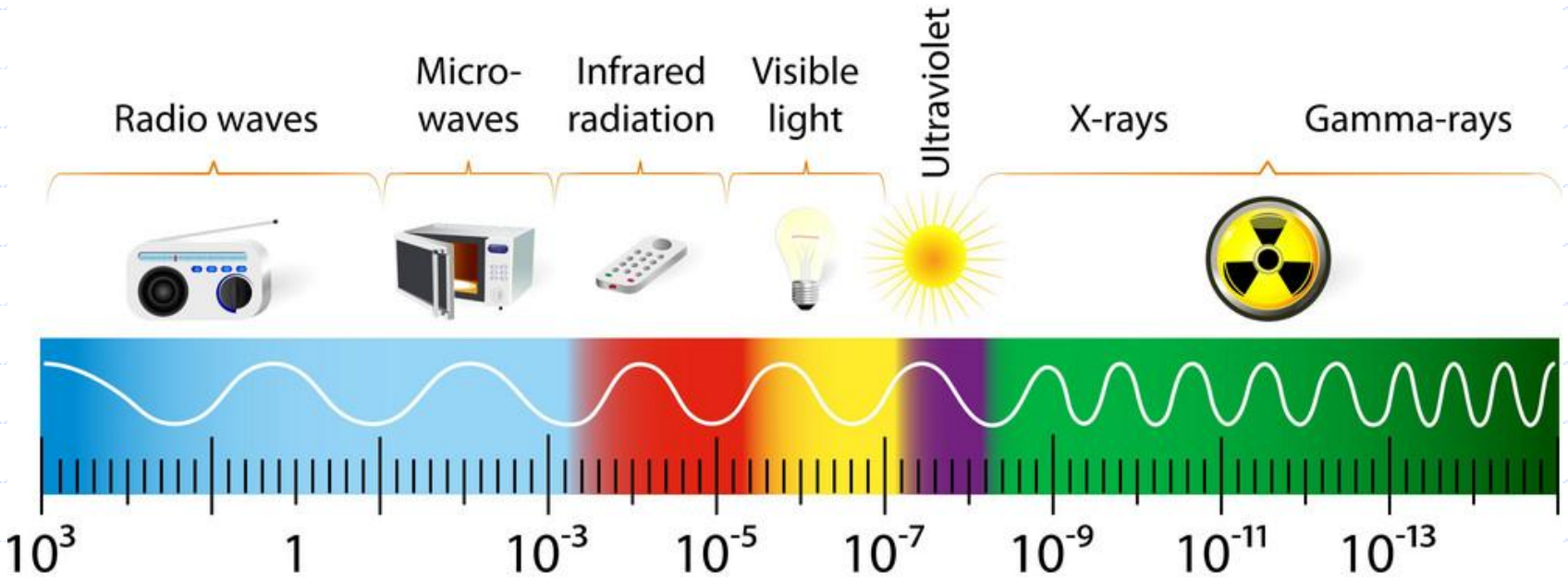


Radio Waves

- Radio waves are **Electromagnetic**
- Have an *electric* and *magnetic* field components that are at right angles to each other
- *Radio waves* travel through space and they carry signals from transmitter to receiver

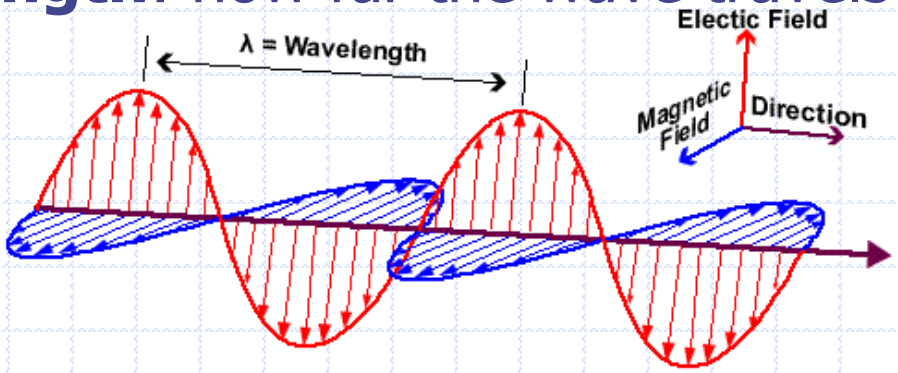


THE ELECTROMAGNETIC SPECTRUM



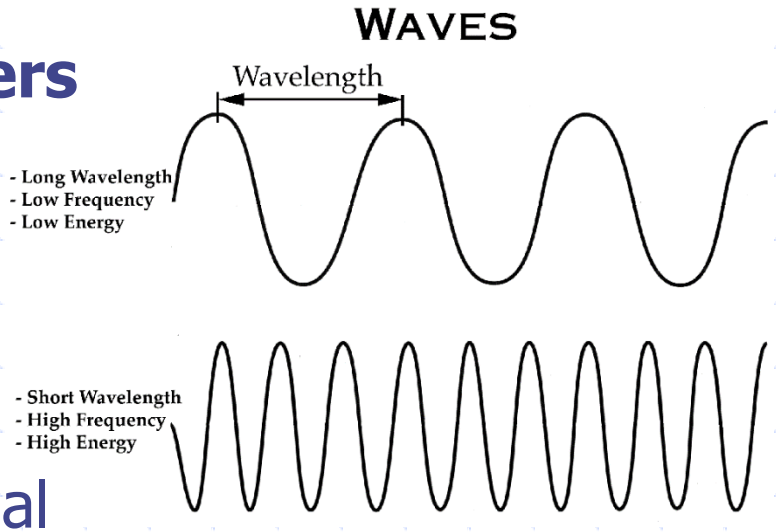
Frequency and Wavelength

- **Frequency**: number of times per second the signal repeats (cycles) {exam may say reverses…}
- Frequency measured in **Hertz** (cycles/second) **Hz**
  - **1,000 Hz = 1 kilohertz or 1 kHz**
  - **1,000,000 Hz = 1 megahertz or 1 MHz**
- **Wavelength**: how far the wave travels during one cycle



Radio Wave facts

- Travels at *speed of light* in free space
- …about **300,000,000 meters per second**!
- …regardless of frequency
- Wavelength is shorter as frequency increases
- Wavelength in meters is equal to 300 / frequency (MHz)

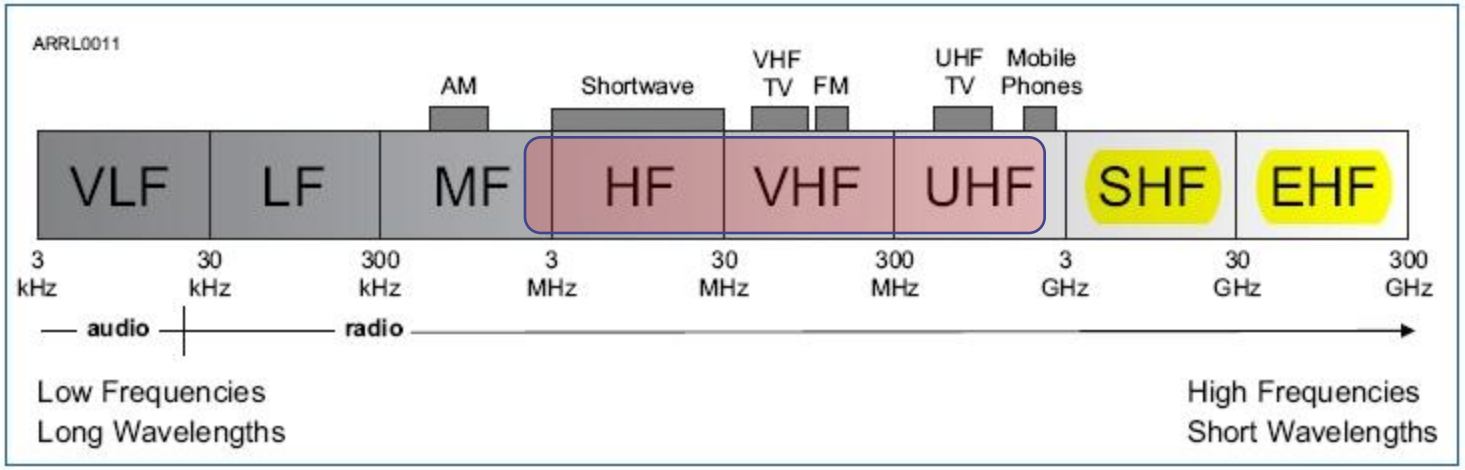


Radio Frequency Bands

- The **approximate wavelength** of radio waves is used to identify different bands
- Examples:
  - The 2m band spans 144 - 148MHz
  - The 40m band spans 7.000 – 7.300MHz
- It's not always "exact"…

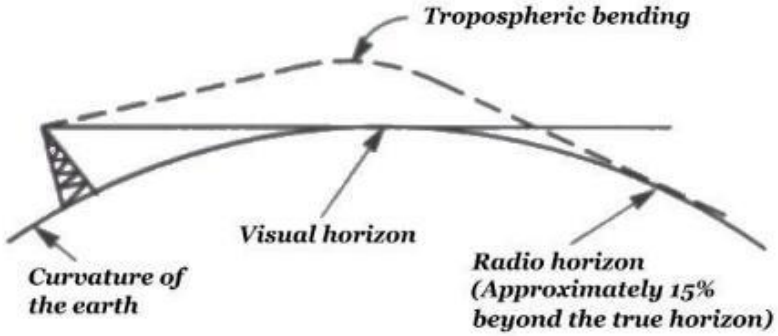
The RF Spectrum

- **RF = Radio Frequency**
- The full range of frequencies are divided into sub-ranges for convenience
- Most common for Amateur Radio: **HF**, **VHF** & **UHF**
  - *HF 3-30MHz* *VHF 30-300MHz* *UHF 300-3000MHz*



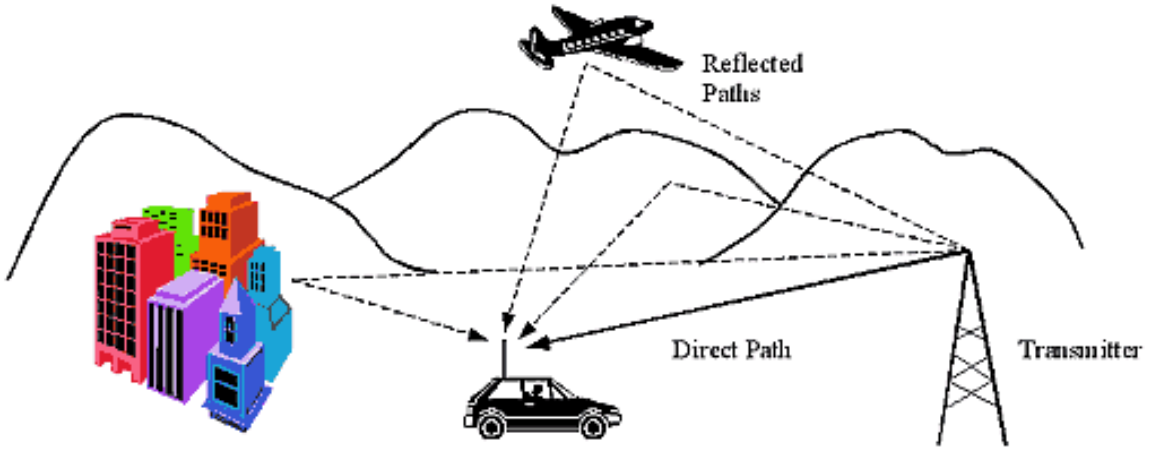
Frequency Band Properties

- Different bands have different propagation properties – thus different use cases
- **VHF & UHF** are typically **line-of-sight**
  - *Not reflected off of the ionosphere*
- *Radio horizon* is where the radio signals are blocked by the curvature of the earth
  - The radio horizon is usually a little greater than the visual horizon because the atmosphere refracts radio waves slightly



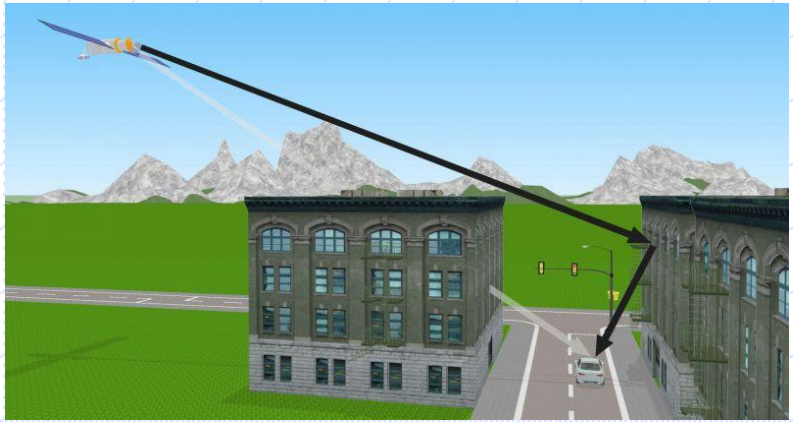
Multipath

- VHF & UHF often affected by **Multipath**
- Signals from different paths may be in phase or out
  - They can add to each other, or cancel each other out
- If you're affected by *multipath*, *try moving a few feet!*
- Multipath can affect digital signal *error rates*



Signal Reflections…

- If you can't reach a VHF / UHF station, try directing your antenna to a reflecting path if the direct path is blocked

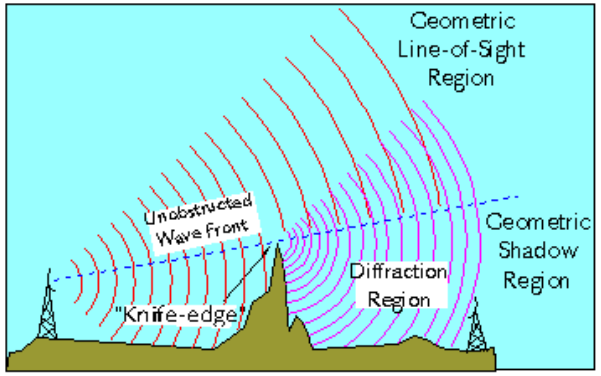


- Multiple / changing reflections due to being in a moving vehicle can often cause rapid fading or fluttering known as **"Picket Fencing".**

More VHF/UHF…

- **UHF** is better at penetrating building structures than VHF – so is better suited for use inside or around buildings

- *Knife Edge* diffraction helps radio waves "bend" around "sharp" objects



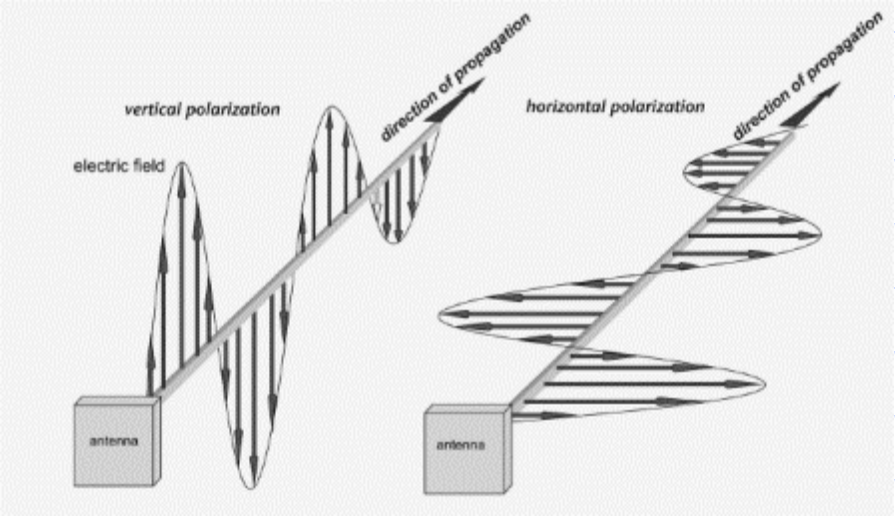
knife-edge effect

- VHF and UHF signals may have a greate range in winter because of less absorption by vegetation

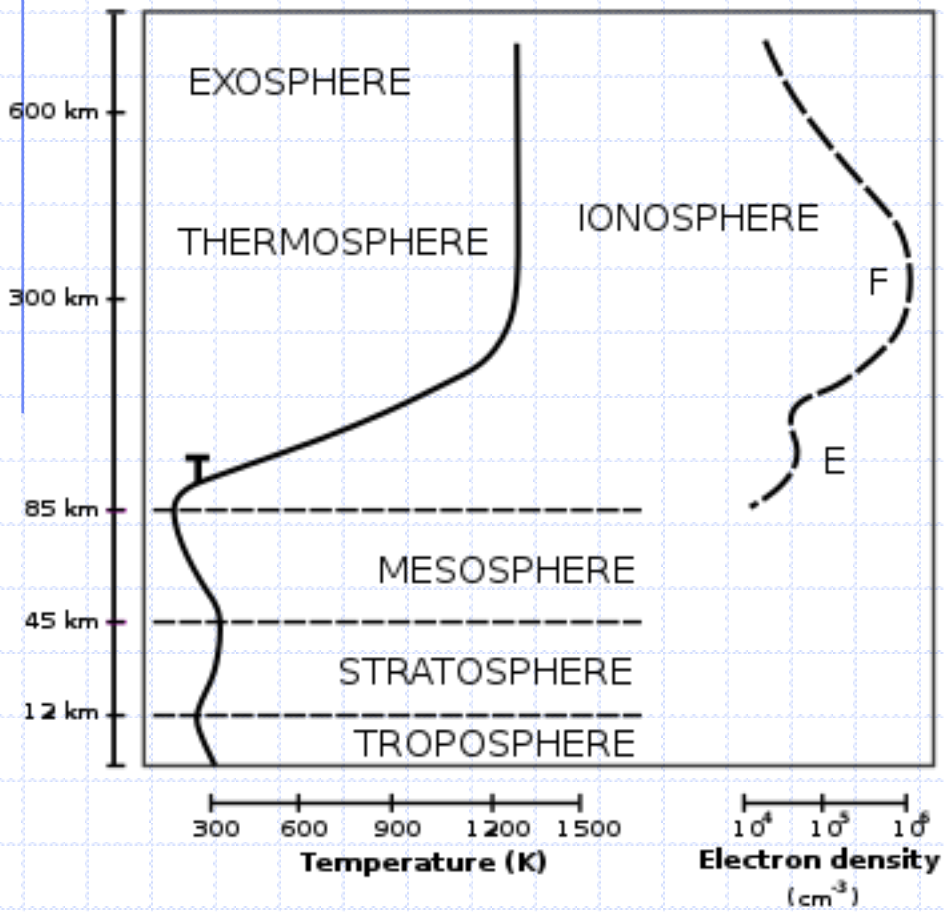
- Precipitation can decrease range of microwave frequencies

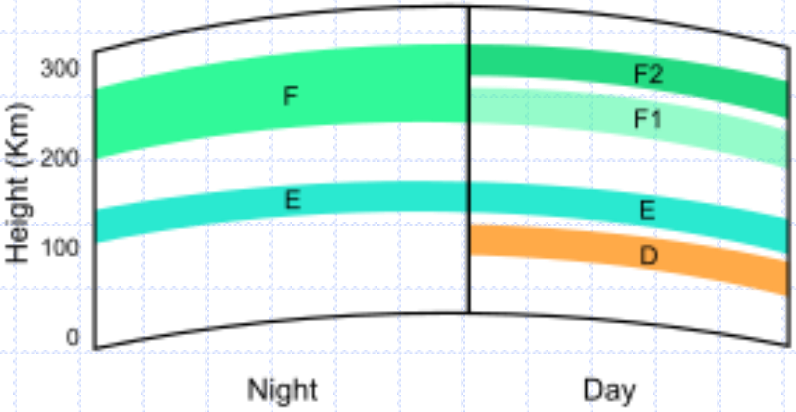
Signal Polarization

- **Polarization** is defined as the orientation of the electric field and is important for VHF / UHF
  - *Vertical* polarization often used for repeaters
  - *Horizontal* often used for weak-signal operation



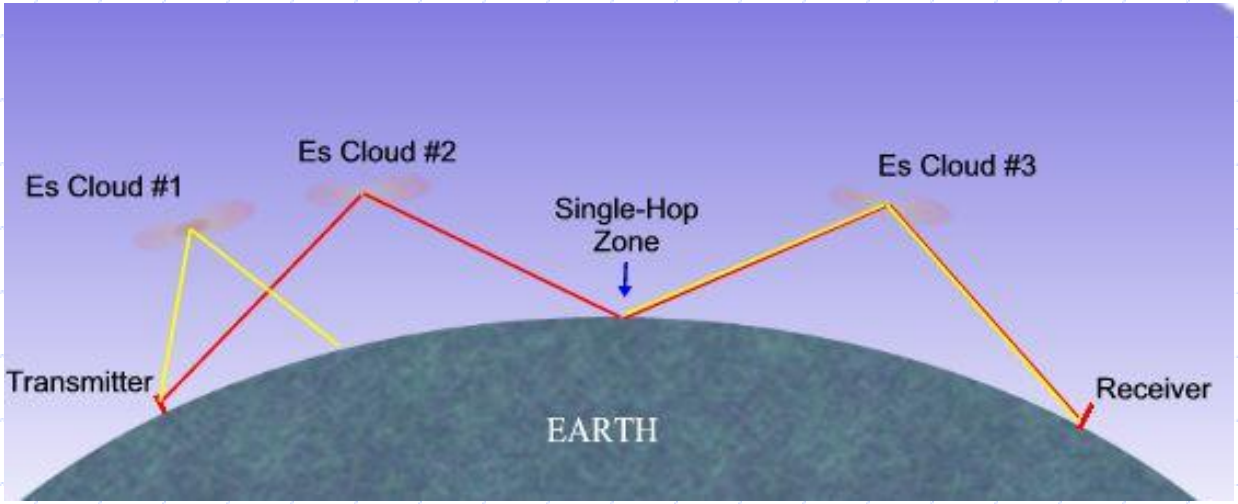
The Ionosphere





Long Distance VHF: Sporadic-E

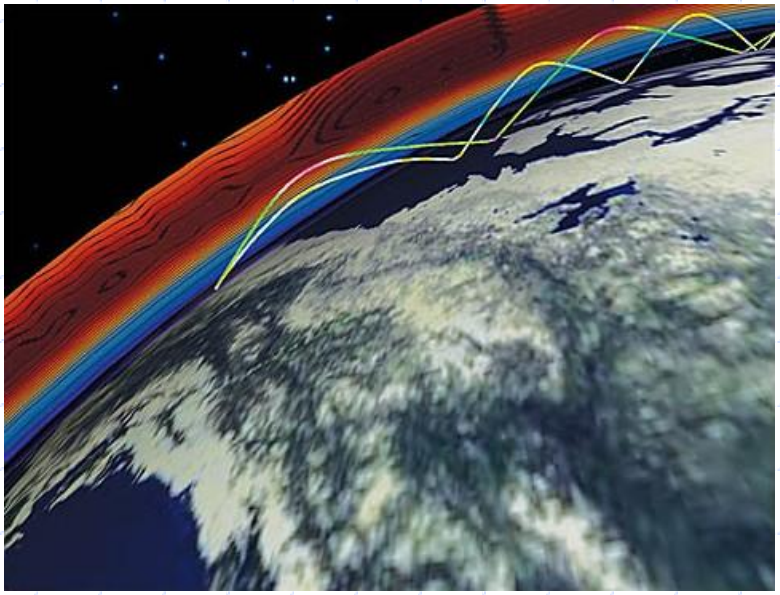
- Sometimes signals are refracted by the E-Layer - called **Sporadic-E**
- Results in strong over-the-horizon signals on 10m, 6m and 2m



More Long Distance VHF

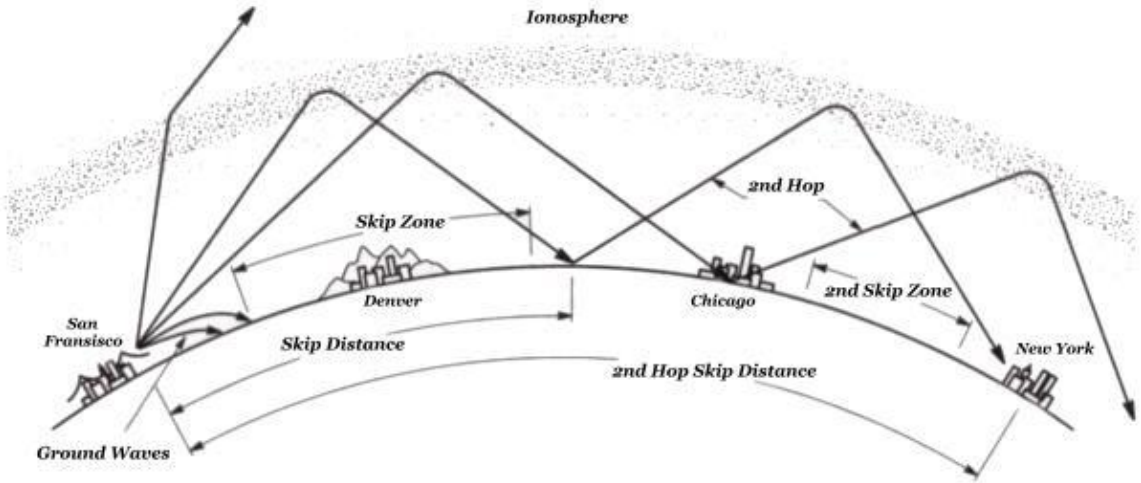
- Other long distance VHF propagation types:
  - Auroral reflection
  - Meteor scatter
  - Tropospheric scatter and ducting (tropo layer 6-10km up)
- ***Auroral*** reflected signals often have a lot of fluctuations in strength and sound distorted
- ***Meteor Scatter*** is popular on 6m
- **Tropospheric scatter** results in VHF/UHF propagation up to 300mi
- *Temperature inversions* result in **Tropospheric Ducting** – VHF propagation for hundreds of miles
- Precipitation can decrease range at microwave frequencies, but has little effect on lower frequencies, such as 10M and 6M.

HF Propagation



- HF signals can be reflected by the ionosphere
- The **ionosphere** is what enables worldwide propagation

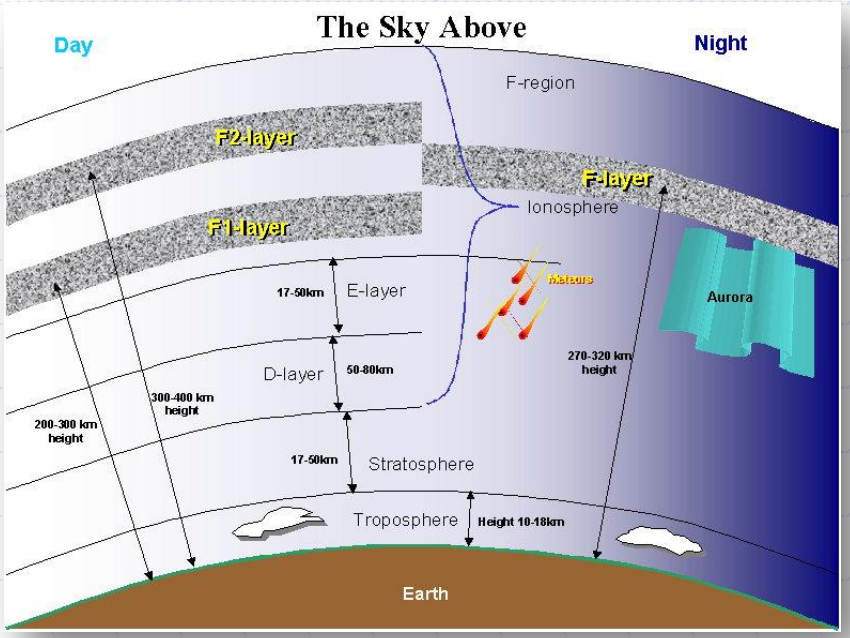
Ionospheric Skip



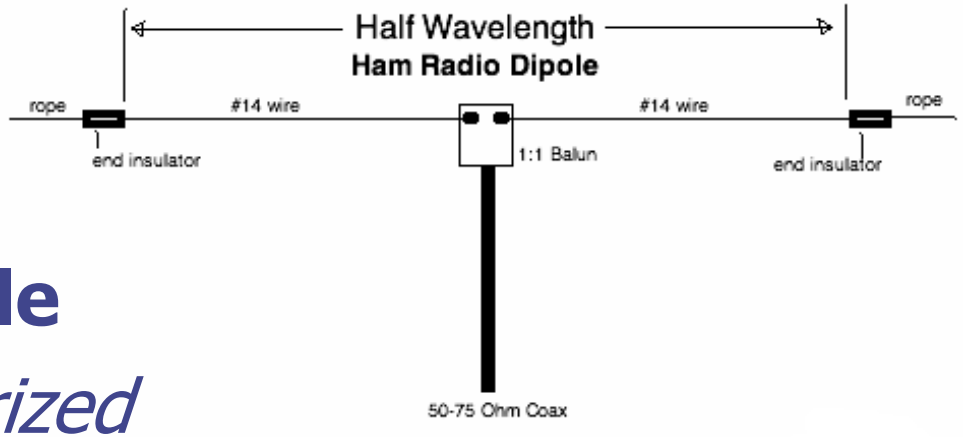
- *Fading* is common, due to random combination of signals arriving from different path lengths
- *Polarization* not so important, gets *randomized* by the reflection

Variations in Ionosphere

- Daily variations:
  - Higher bands like 10m, 15m, and 20m better during day
  - Lower bands like 40m, 80m, 160m better at night
- 11 year sunspot cycle affects ionization – thus propagation
  - The 6 and 10M bands may provide long distance communication during the peak of the sunspot cycle.



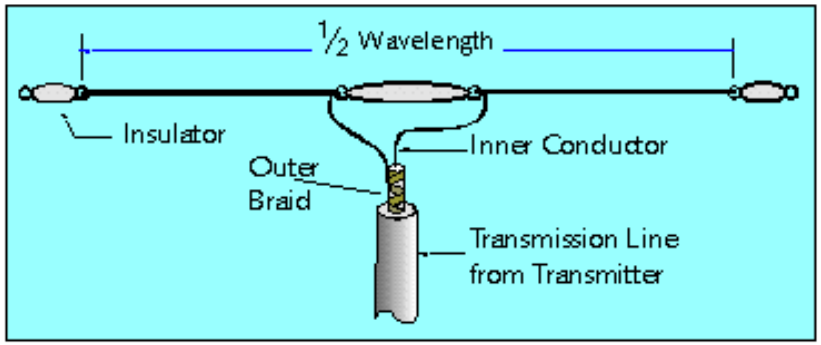
Antennas & Feedlines



- Most Common: **Half-wave dipole**
- Horizontally *polarized* when mounted parallel to earth
- Radiation is broadside to antenna

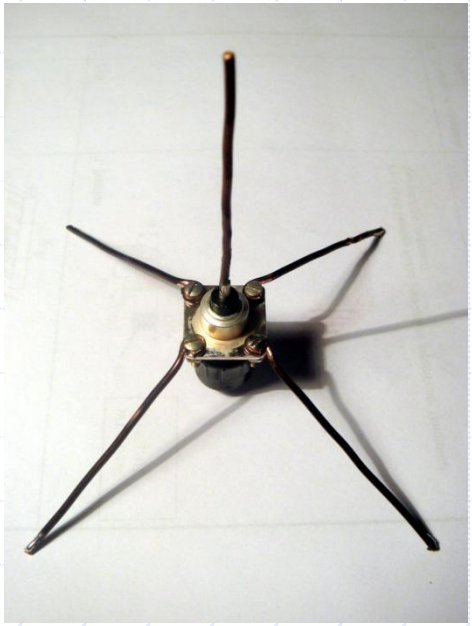
Half-Wave Dipole Details

- About 5% shorter than free-space half-wavelength
- Example: a *6m* dipole is about *112″* long
- To make it resonant on a higher frequency, you would shorten it
- L(ft) = 468 / F(MHz)

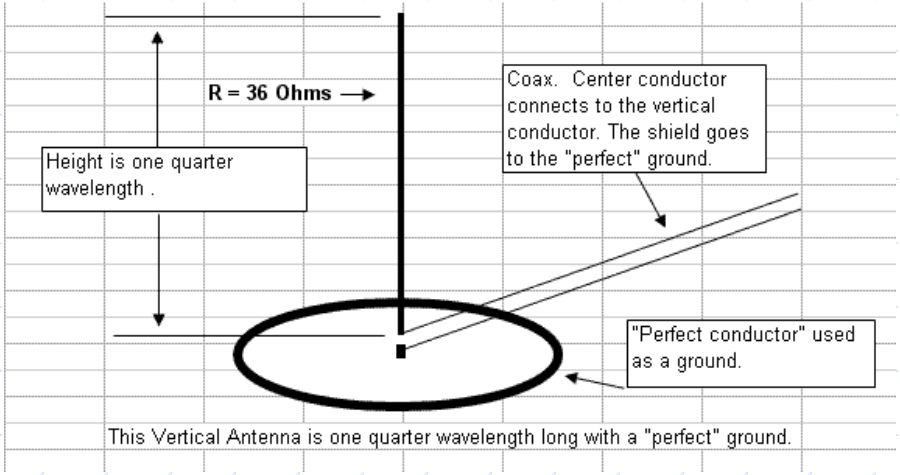


dipole antenna

Vertical Antennas

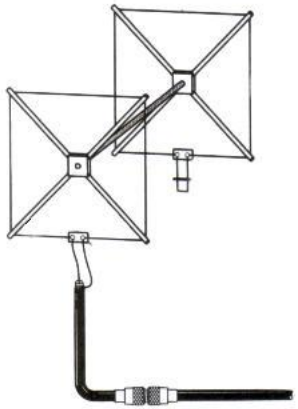


- Typically ¼ wavelength tall
- Vertically polarized, meaning the electric field is perpendicular to the earth
- A *2m* vertical is ~*19"* long
- L(ft) = 234 / F(MHz)



Beam Antennas

- Concentrates energy or gain in *one* direction
- *Quad*, ***Yagi*** and *Dish* are all **directional** antennas
- **Gain** is the increase in signal strength w.r.t. a reference antenna



Antenna Loading

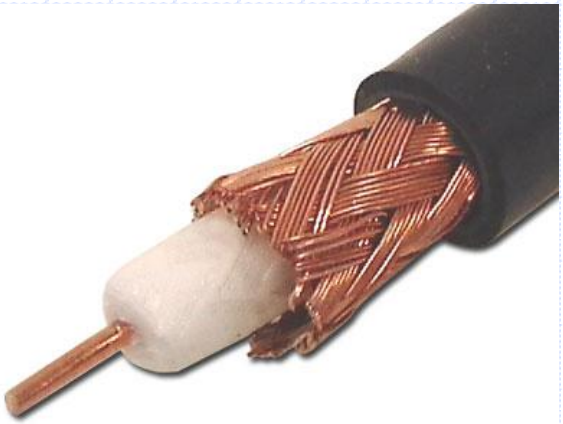
- Adding a capacitor or, more usually, an inductor to an antenna makes the antenna electrically longer and allows one to use a shorter physical antenna.

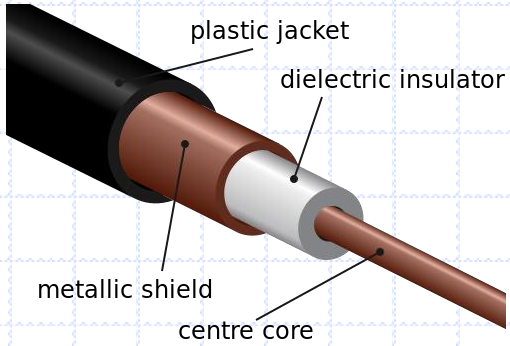
"Rubber Duck" antenna

- Flexible antenna on most handheld transceivers (HTs)
- *Disadvantage*: not as efficient as a full sized antenna
- Good reason **not** to use in a car is that the signals will be much **weaker** as compared to outside the vehicle

Feedlines

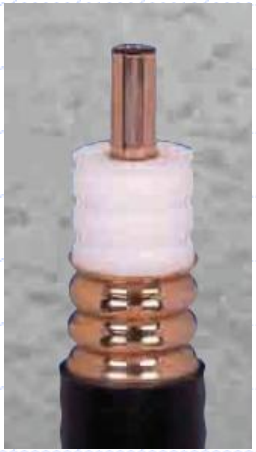
- **Coaxial** cable is used most often because
  - It is easy to use
  - Requires few special installation considerations
- Mainly used to *carry RF* between *radio* and *antenna*
- **Loss** in cable increases as frequency increases
- **Impedance** of feedline ideally matches the impedance of the transmitter and antenna – most common is **50 ohms**

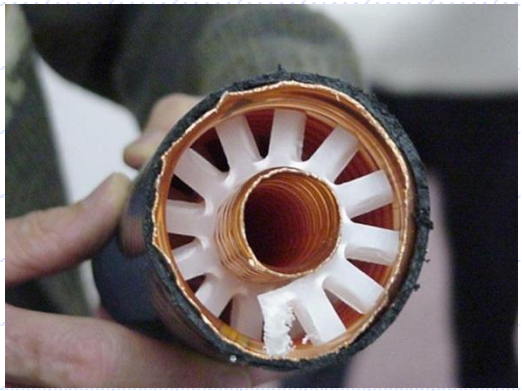




Common Coax types

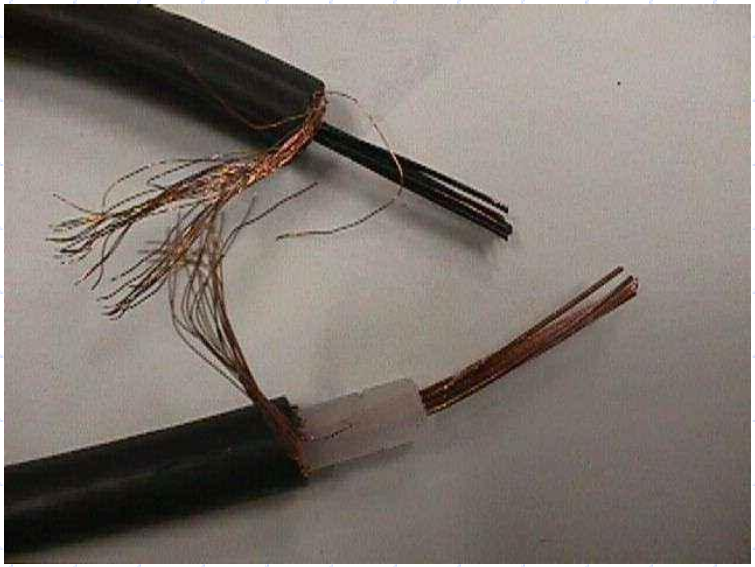
- **RG-58** and **RG-213** are common
- *Both* are 50 ohms
- RG-58 is thinner, but *higher loss* that RG-213
- Coax with lowest loss for **VHF** and **UHF** is *air-insulated hardline*





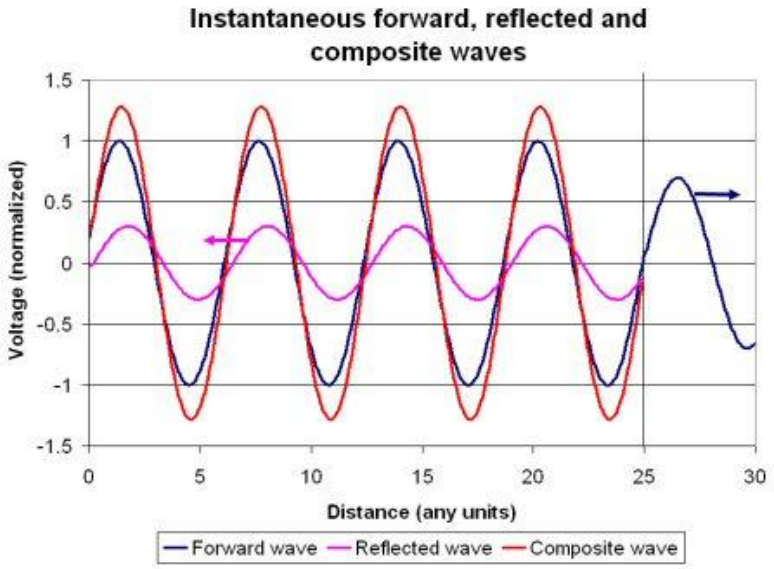
Common Coax Failure modes

- **Moisture contamination**
  - cracks in jacket
  - Around connections
- Jacket needs to be **UV resistant** to prevent cracking
- Air-Core coax requires special techniques to prevent water absorption



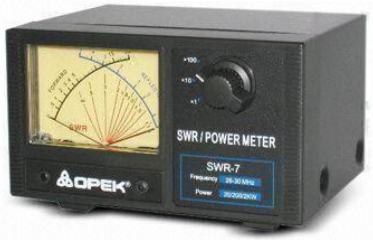
Standing Wave Ratio - SWR

- A measure of how well **matched** a *load* is to the *transmission line*
- *Low SWR needed* with coax feedlines:
  - *Efficient power transfer*
  - *Minimize losses*
- Power *lost* in a feedline is converted to **heat**



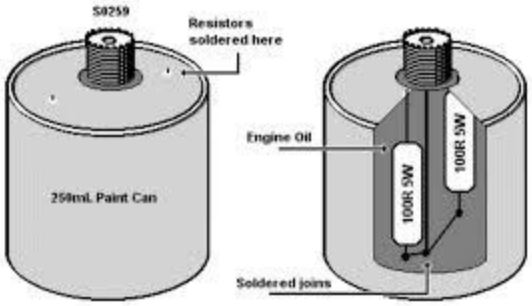
SWR Measurement

- SWR is measured with an **SWR meter**
  - **Frequency and power level should be considered when selecting SWR meter**
- SWR meter is connected between the *transmitter* and *feedline*
- A **Directional Wattmeter** can also be used to determine if a feedline and antenna are matched properly
- **SWR** of 1 to 1, or 1.0:1 is a **perfect match**
- SWR of 2:1 or more is where *protection circuits* in most solid-state transmitters will *reduce power*
- *SWR of 4:1* means there is a large **impedance mismatch**
- An **antenna tuner** is used to match the antenna system impedance to the transmitter



More Measurements

- An **antenna analyzer** is commonly used to measure
  - SWR
  - *Antenna resonant frequency*
  - Capacitance
  - Inductance
- In testing, a **dummy load** is used to prevent transmitting over the air. It consists of a non-inductive resistor and a heat sink
- An **RF Power Meter** should be installed in the feed line between the transmitter and the antenna



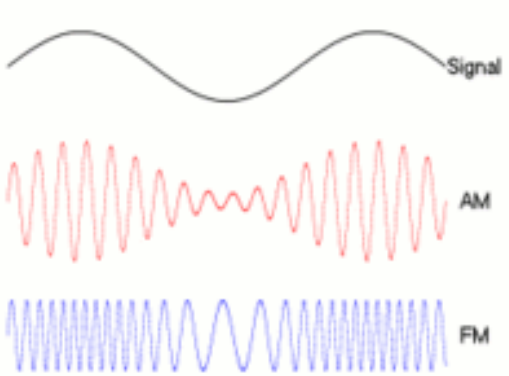
Feedline Connectors

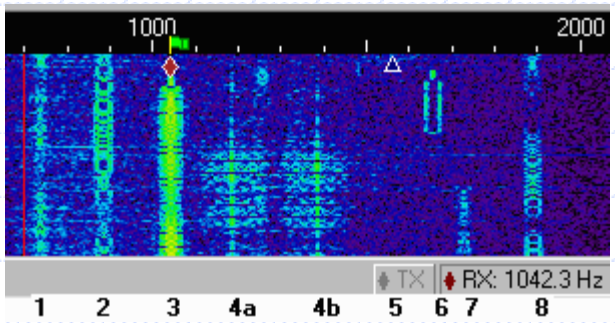
- **PL-259** is most common for **HF frequency** use
- PL-259 is not the most suitable at higher frequencies
- **Type-N** connector is most suitable above 400MHz
- Take care to *seal against water intrusion* to prevent increase in feedline loss
- **Keep 'em tight** – loose connections can cause *erratic SWR* readings

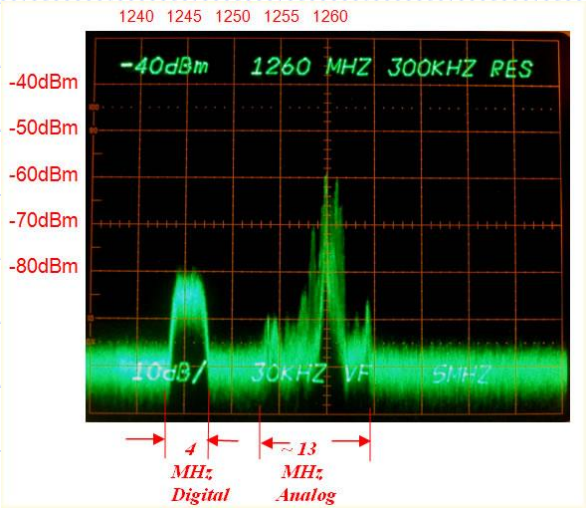
Amateur Radio Signals

Modulation Modes

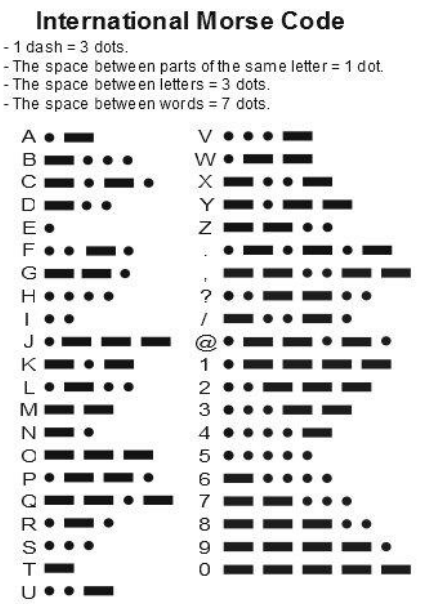
Signal Bandwidth







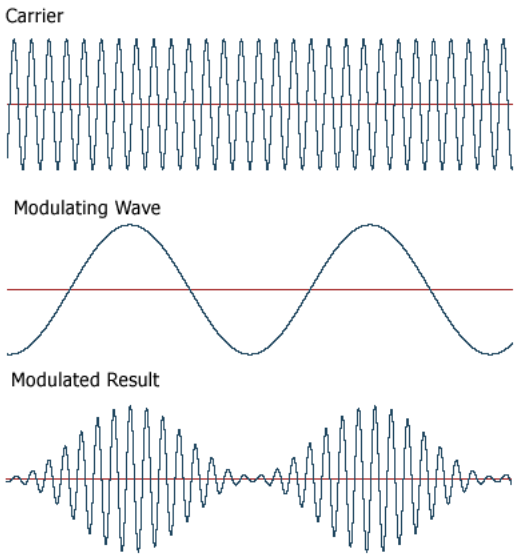
CW mode (Morse Code)

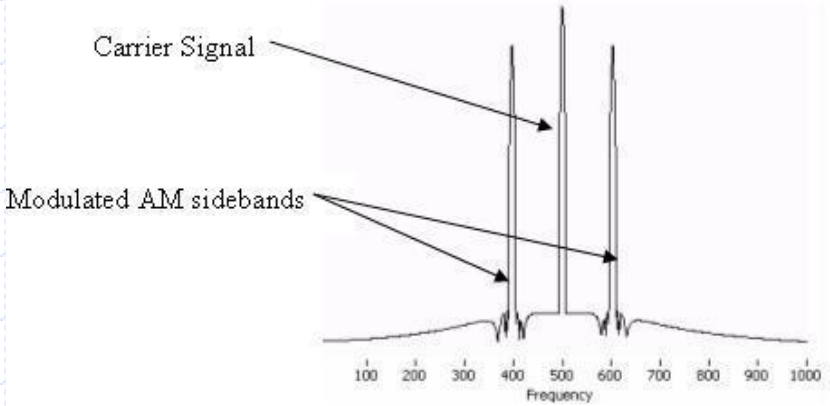


- Narrowest BW (not really) **~150Hz**
- *International Morse* is what we use
- CW can be sent using:
  - Straight Key
  - Electronic Keyer
    - Assists in manual sending
  - Computer Keyboard

Modulation Modes: AM

- AM is one of the simplest modulation modes
- The amplitude (size) of the RF carrier is varied
- Energy is present at the carrier frequency and in sidebands on either side of the carrier



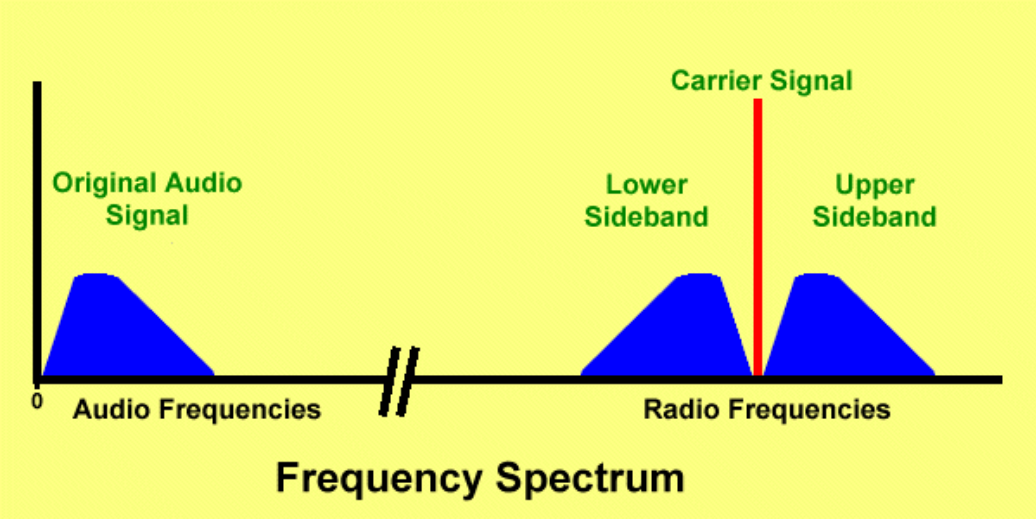


Single Sideband, or SSB

- **SSB** is a form of *Amplitude Modulation*
- Used for *long distance* and *weak-signal* contacts on *VHF & UHF*
- May be Upper or Lower (USB or LSB)
- **USB** used for 10m HF, and *VHF & UHF*

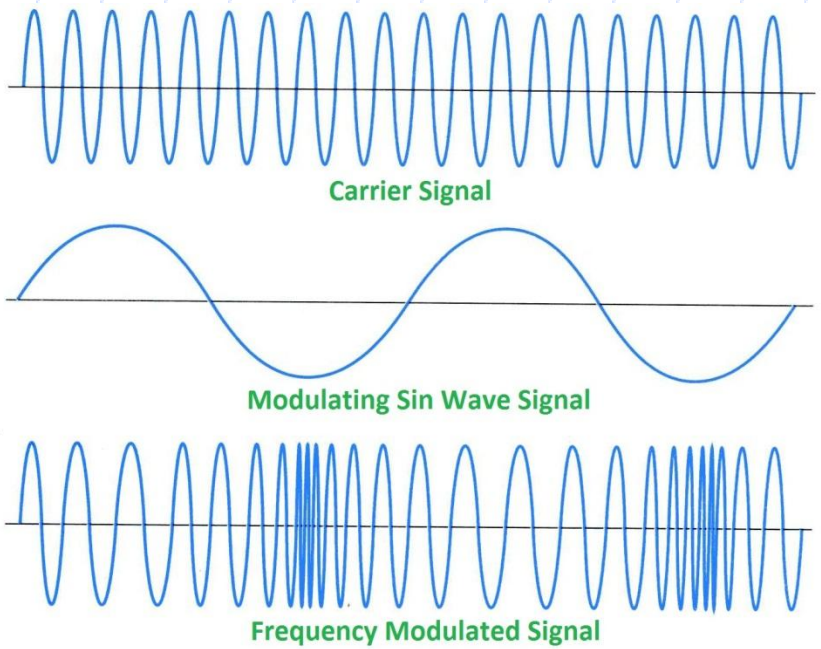
SSB Properties

- Advantage:
  narrower bandwidth vs. FM for voice
- Typically *~3kHz for SSB*
- …vs. 5-15kHz for FM



Modulation Modes: FM

- **FM** is Frequency Modulation
- Most common on *VHF and UHF voice* repeaters
- Also used for *VHF packet radio* transmissions

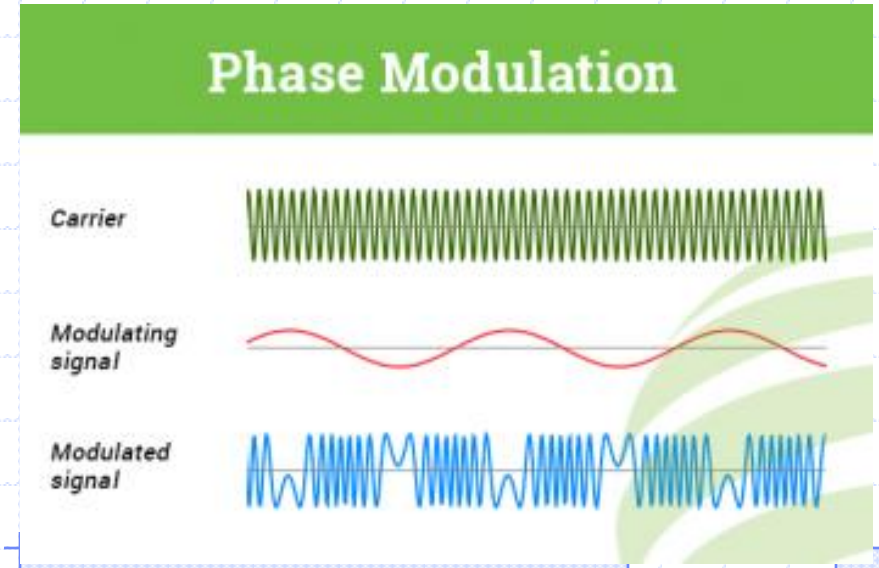


FM Issues

- Capture Effect
  - When two signals of the same frequency reach an FM receiver, only the stronger signal will be heard
  - With AM or SSB, both signals would be heard
- If FM receiver is tuned above or below a signal's frequency, the signal audio will be distorted

Phase Modulation (PM)

- Vary the phase or position of a wave
- Similar to FM
- Both FM and PM are commonly used for VHF packet transmissions and VHF and UHF voice repeaters



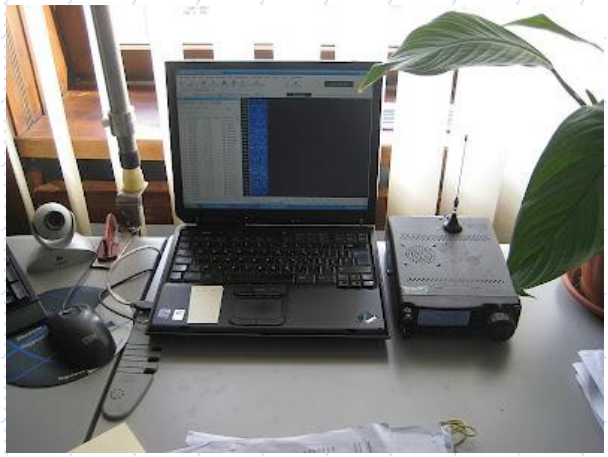
Amateur Television signals

- **Analog fast-scan TV** on 70cm band occupy *6MHz BW*
- **NTSC** refers to analog fast scan color TV signal transmission

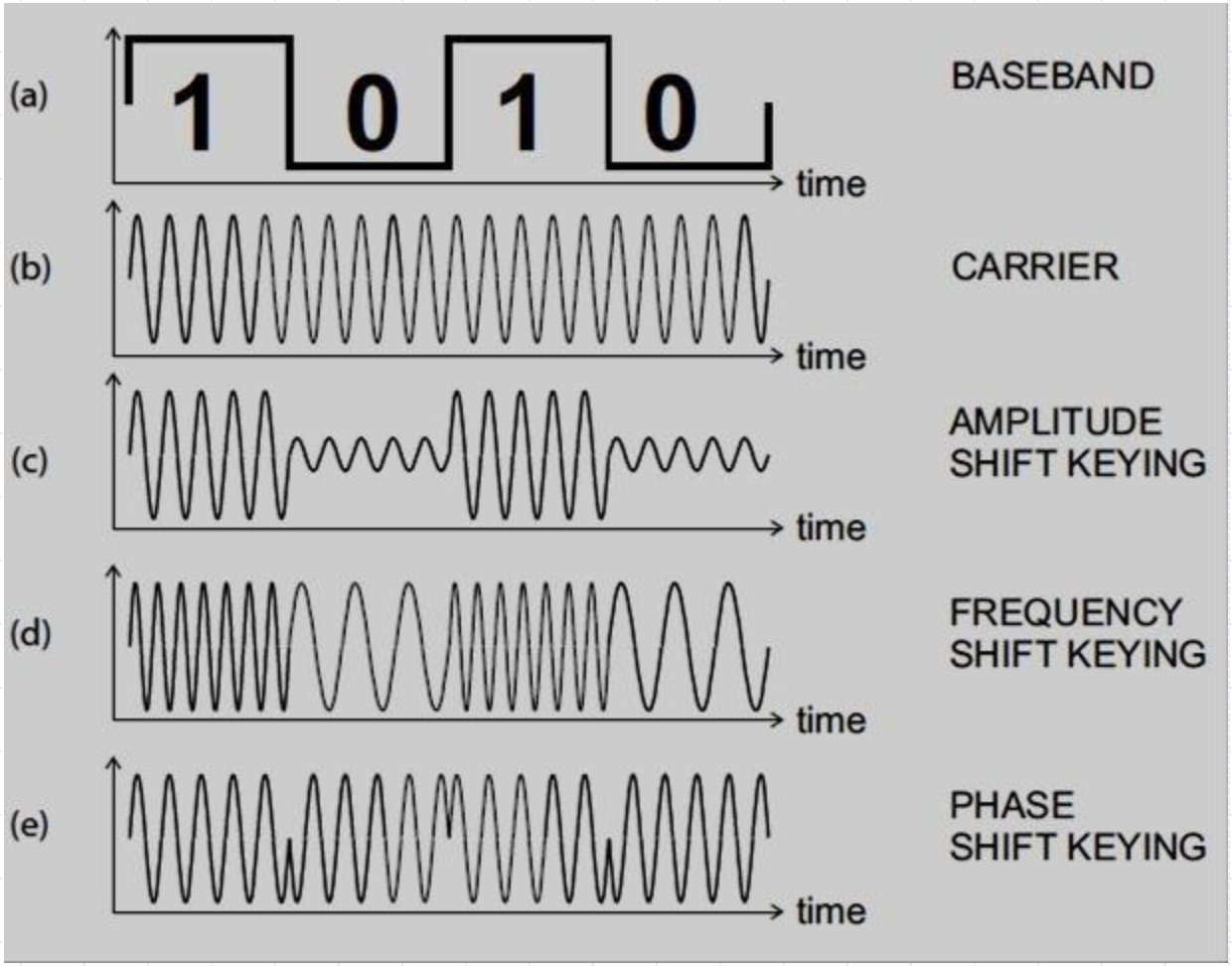
Digital Modes

- Usually using a computer and radio to communicate
- Data (not voice) is sent back and forth
- Receive audio, transmit audio, and transmitter keying are used at the computer-radio interface
- *Technician Class* can use **Data** transmission on **219-220MHz**
- Some digital modes use **ARQ (automatic repeat request)** – *The receiving station detects errors and sends a request to the sending station for retransmission*

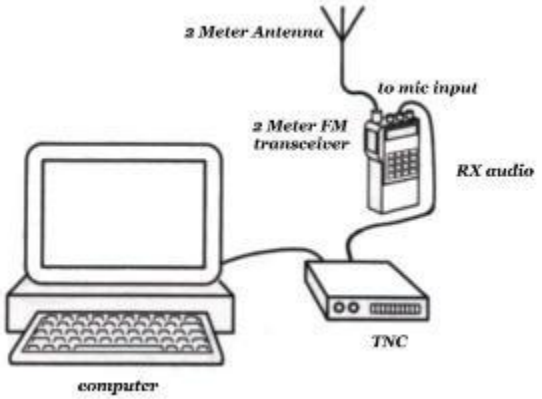
- Examples of Digital Modes:
  - Packet Radio
  - IEEE 802.11
  - JT65



Digital Modulation Modes



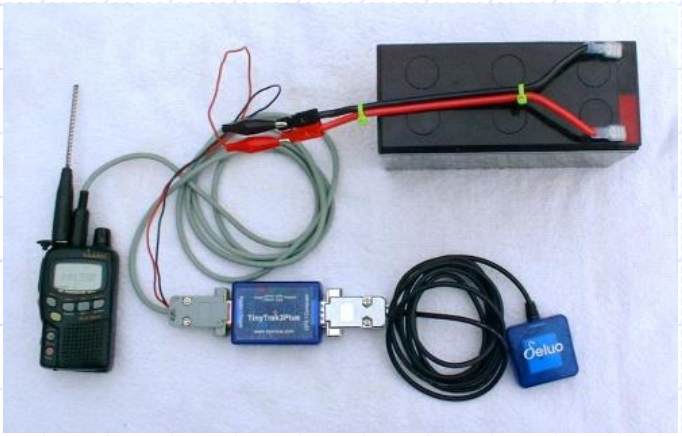
Packet Radio

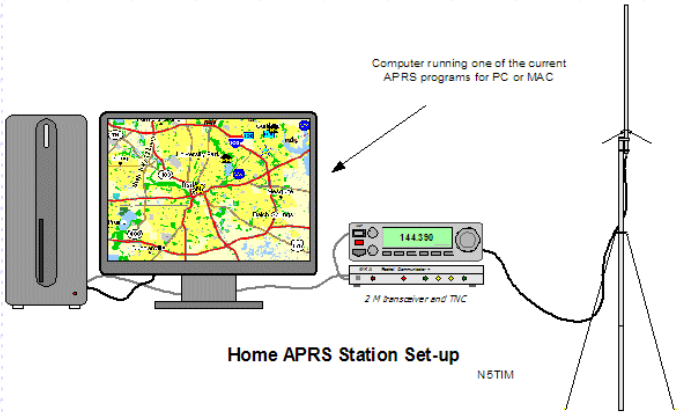


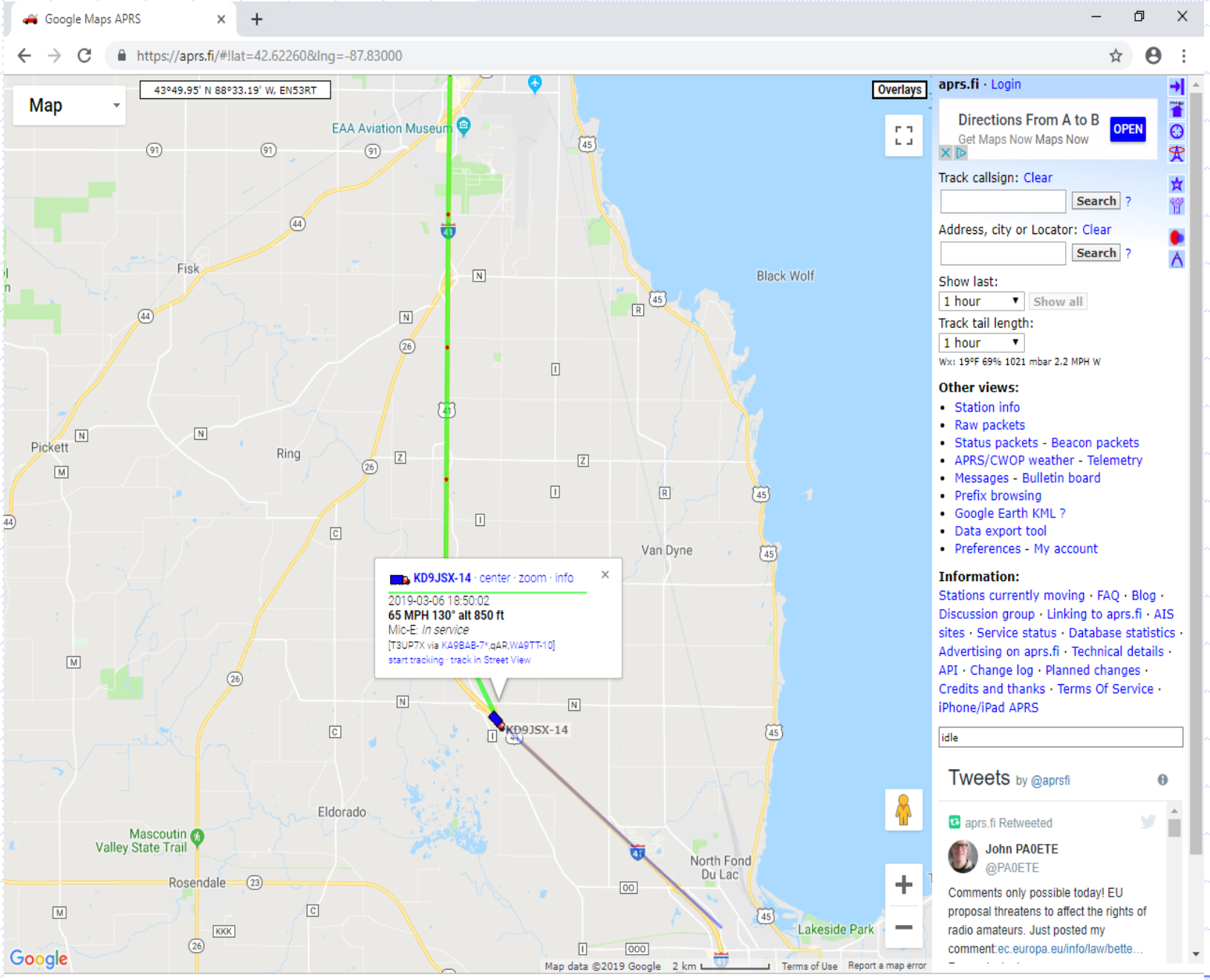
- One of the first digital modes
- Data grouped and sent in "packets"
- Packet radio includes:
  - A check sum which permits error detection
  - A header containing call sign of recipient
  - Automatic repeat request in case of an error
- FM is commonly used for packet radio

APRS

- **Automatic Packet Reporting System**
- Uses Packet radio
- **GPS** *(Global Positioning System)* receiver is used when sending **position reports**
- Also can send **text messages** and **weather reports**



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Overlays
EAA Aviation Museum
Fisk
Black Wolf
Pickett
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Van Dyne
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North Fond Du Lac
Lakeside Park
Rosendale
Mascoutin Valley State Trail
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65 MPH 130° alt 850 ft
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Map data ©2019 Google
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Other views:
Station info
Raw packets
Status packets - Beacon packets
APRS/CWOP weather - Telemetry
Messages - Bulletin board
Prefix browsing
Google Earth KML ?
Data export tool
Preferences - My account
Information:
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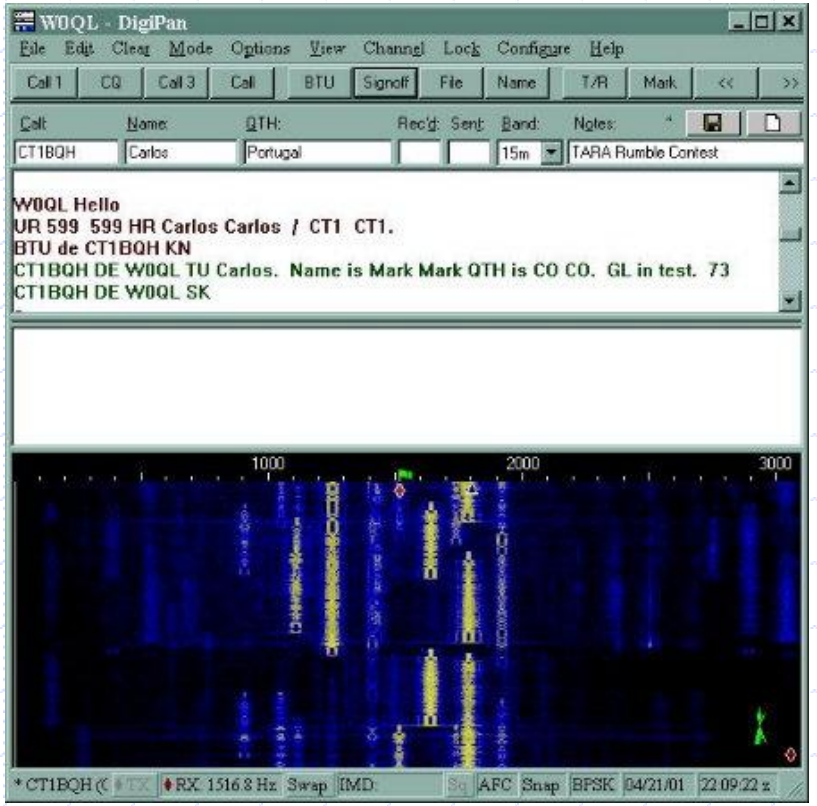
ASK-FSK-PSK.png
Show all

2023

Phase Shift Keying: PSK

- **PSK = Phase Shift Keying**
- A popular HF digital mode
- **PSK31** is a *low-rate data transmission mode*

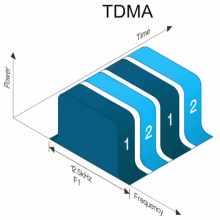


Digital Voice Modes

- Analog Voice – input signal is used to continuously vary or modulate some characteristic of the transmitted radio wave
- Digital Voice – input signal is converted to digital form (0's and 1's) and this digital signal is transmitted
- Some Advantages of Digital
  - More efficient use of radio spectrum
  - Improved audio quality near fringe of coverage range
  - Increased battery life
  - Less background noise

Digital Mobile Ration (DMR)

- FM digital communication system allowing more efficient use of spectrum
- Two signals are multiplexed in a single 12.5kHz channel



- Talk groups are virtual channels that allow groups to share a channel. You join by programming your radio with the group's ID code
- Color Code acts like CTCSS in that you must match the repeater color code to gain access
- Code Plug contains access information for repeaters and talkgroups

Other Digital Protocols

- D-STAR
  - Digital Smart Technology for Amateur Radio
  - You must program your call sign into the D-Star transceiver before transmitting
- System Fusion/C4FM
  - Yaesu's implementation of digital amateur radio
  - Local repeater is Fusion capable

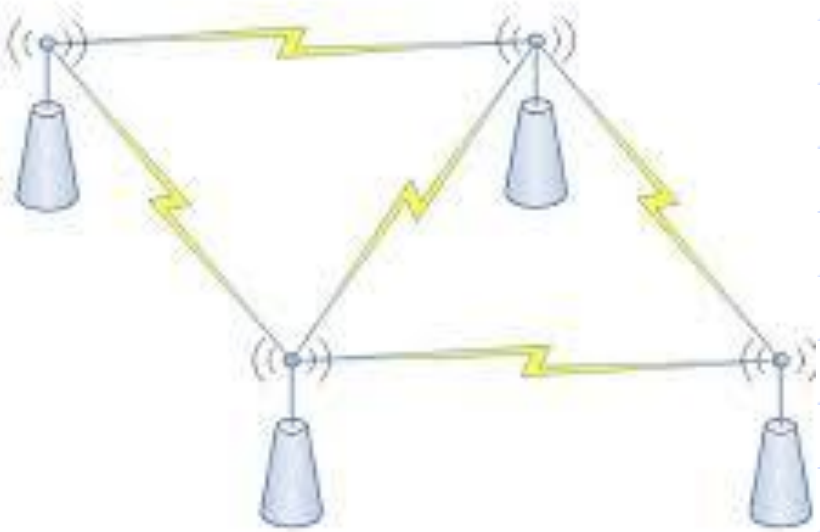
WSJT

- Weak-signal digital communication
  - Moonbounce or Earth-Moon-Earth
  - Weak-signal propagation beacons
  - Meteor Scatter
- FT8 is a popular mode supported by WSJT – 15 second transmission intervals
  - Transceiver audio input and output are connected to the audio input and output of a computer running WSJT-software

Mesh Networking

- Amateur radio used to establish a private, self-contained wireless computer network
- Examples
  - Broadband-Hamnet
  - Amateur Radio Emergency Data Network
    - (AREDN)
- Use Part 97 rules instead of Part 15
  - Often use commercial WiFi gear with modified firmware

Mesh Network Topology



Safety Concepts

- AC Power
- Hazardous Voltages
- Fuses
- Circuit Breakers
- Battery Safety
- Antenna & Tower
- Power Lines
- RF Safety

General Electrical Safety

- Easy to come in contact with dangerous voltages
- **30 Volts** or more can result in dangerous shock
- **100mA** flowing through body can cause death

- **How does current flowing in the body cause harm?**
  - *Heating tissue*
  - *Disrupts electrical function of cells*
  - *Involuntary muscle contractions*

AC Power Safety

- 3-wire outlets and plugs are safer
- 3rd wire is a **Equipment Ground**
- **US 120V Wire Color Codes**
  - **Black – Hot**
  - **White – Neutral**
  - **Green - Ground**

- Good ways to guard against electric shock:
  - *Use 3-wire cords and plugs for all AC equipment*
  - *Connect all AC powered equipment to a common safety ground*
  - *Use a circuit protected by a ground-fault interrupter*
  - *Install mechanical interlocks in high-voltage circuits*

Fuses & Circuit Breakers

- *Interrupts power* in case of an overload
- Always replace fuses with *same type and rating*
- Putting a 20A fuse in place of a 5A fuse can cause a *fire* from excessive current flow
- Always include fuse or circuit breaker in home-made equipment
- **Fuses in 120V AC powered equipment are used in the "hot" lead.**

Working on Equipment

- Disconnect from power
- **Capacitors** in power supplies can *store charge and shock you* – even when disconnected
- Work with one hand

Battery Safety

- 12V Lead-Acid Battery Hazards
  - Explosive gas can collect if not vented
  - If charged/discharged too quickly – can overheat and give off flammable gas or explode
  - Shorting the terminals can cause burns, fire, or an explosion
- If power is out, re-charge 12V battery by connecting to car battery and running the engine
(well ventilated area)
- Battery run time can be estimated by dividing the battery ampere-hour rating by the average current draw of the equipment

Antenna Safety: Installation

- Look for and stay clear of overhead electrical wires
- Keep 10ft of clearance to power lines, even if the antenna should fall
- Never use a utility pole as a support

What's wrong with this picture?

Antenna Placement

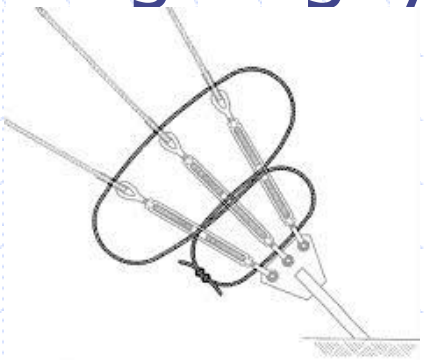
- Position antenna so no one can come in contact when transmitting
- RF burns are painful and dangerous

Tower work

- Have sufficient training on safe tower climbing practices
- Use a **appropriate tie-off to the tower at all times**
- *Everyone* wears **hard hat** and **safety glasses**
- **Wear an approved climbing harness**

Tower Work (continued)

- *Never climb alone*
- Crank-up towers must be fully *retracted* before climbing
- Safety wires are used on turnbuckles to prevent loosening of guy lines

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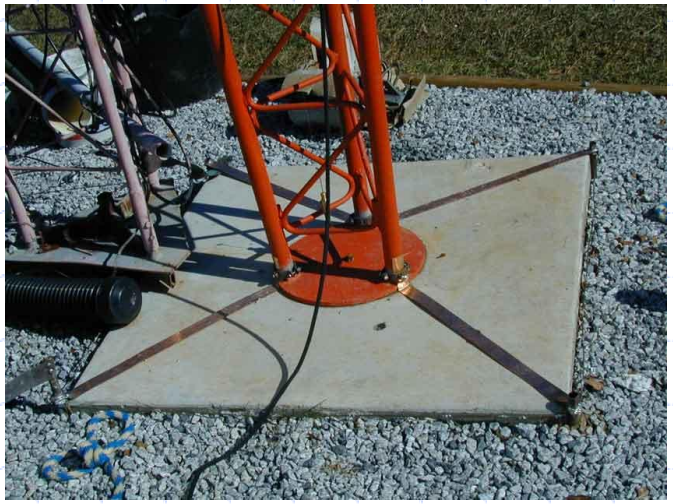
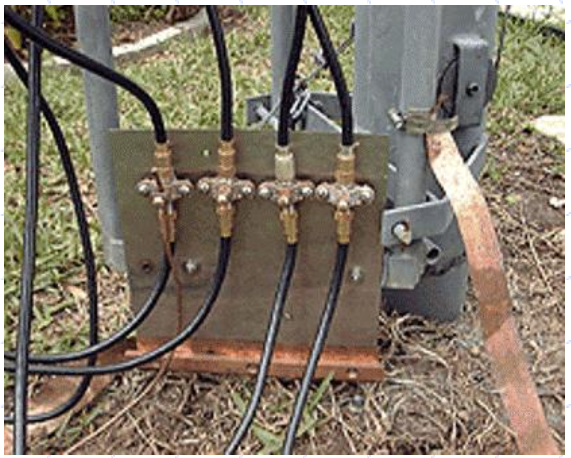
Tower Grounding

- Very important – the tower is a *big lightning rod!*
- **Local electrical codes** should be consulted
- Separate 8’ ground rods per tower leg is good practice
- Bond all legs and rods together
- Ensure connections are short and direct
- Avoid sharp bends
- All feedline lightning protection devices should be mounted to a common plate and connected to an external ground

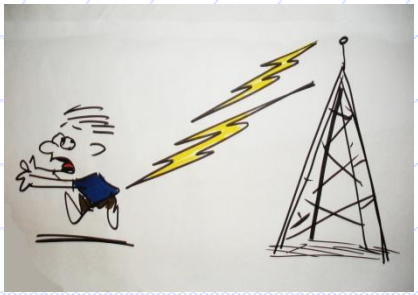




RF Exposure

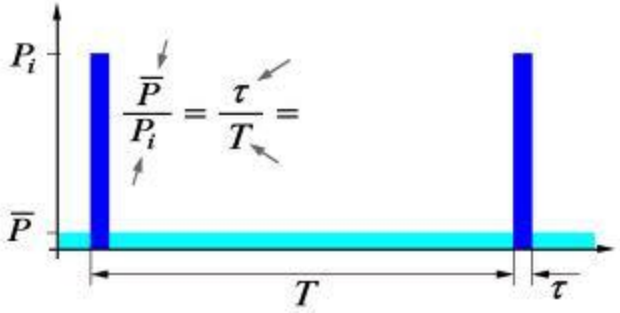
- When using high power
  - you are *required* to perform an **RF Exposure evaluation**
  - even though VHF & UHF are **non-ionizing radiation**
- On *VHF*, you can run up to **50W PEP** at the antenna without performing an exposure evaluation

- RF Exposure Evaluation can be performed:
  - *Calculation based on FCC OET Bulletin 63*
  - *Calculation based on computer modeling*
  - *By measurement of field strength using calibrated equipment*



RF Exposure: Duty Cycle

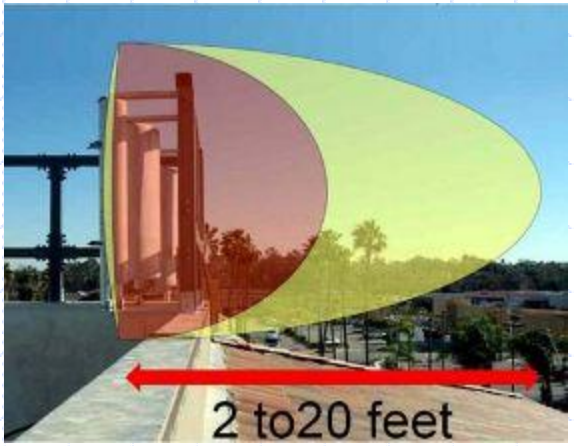
- Ratio of on-air time to total operating time
- **Duty Cycle** is factored into exposure because affects the *average exposure level*
- *Example: The allowable power density increases by a factor of 2 if the duty cycle changes from 100% to 50%*



RF Exposure Limits

- Vary with Frequency
- The human body absorbs more energy at some frequencies than others
- The **50MHz** band has the lowest **Maximum Permissible Exposure Limit**

- Factors that affect Exposure
  - Frequency & Power level of RF Field
  - Distance from antenna to person
  - Radiation pattern of antenna



Keeping Exposure safe

- Relocate antennas
- Lower power levels
- Transmit less

- Re-evaluate if you make any changes in station or antenna setup
- ***The station licensee is responsible for ensuring nobody is exposed to RF energy above FCC limits***

Station Setup and Operation

- Station accessories
- Dealing with Interference
- Grounding
- Operating controls
- Station Equipment
- Troubleshooting
- Repair and Testing

Station Accessories

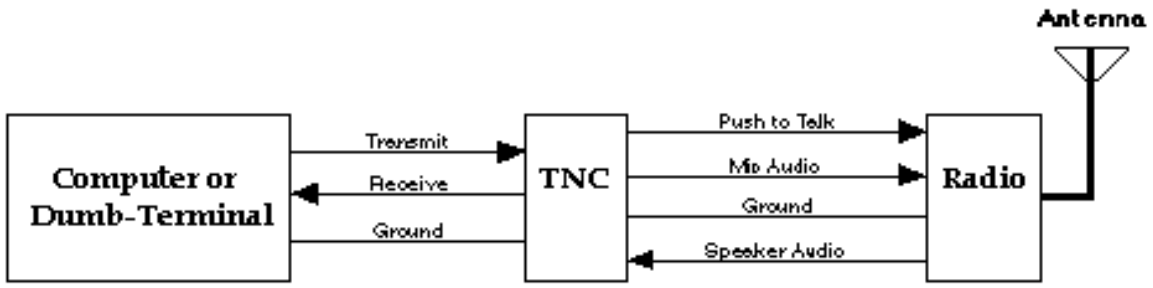
- Power Supply
  - Regulated, *to prevent voltage fluctuations from reaching sensitive circuits*
  - Considerations
    - Efficiency of transmitter at full power output
    - Receiver and control circuit power
    - Power supply regulation and heat dissipation
  - Wiring between radio and power supply should be short and heavy-gauge to prevent excessive voltage drop
- For a typical 50 watt mobile FM transceiver the power supply rating should be 13.8V at 12 A

Station Accessories (continued)

- Headphones
  - Helps copy in *noisy areas*
- Microphone
  - *Rig connector includes push-to-talk (PTT) and sometimes power for microphone*
- Computer
  - *Logging contacts and contact info*
  - *Sending/receiving CW*
  - *Generating/decoding digital signals*
  - *Computer's microphone or line input port connects sound card to transceiver's headphone/speaker output for digital modes*

Digital Mode Accessories

- **Packet**
  - Terminal Node Controller (TNC)
  - Converts 1's and 0's to audio tones
- **RTTY or PSK31**, etc.
  - *Sound card* often performs TNC/modem function
  - Provides audio to microphone input, converts received audio to digital
  - Often an audio interface is used to adjust audio levels and provide some ground isolation



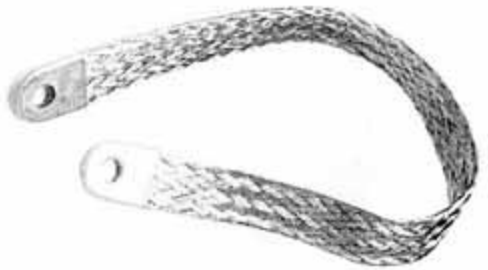
Interference killers

- Ferrite chokes
  - *Help eliminate stray RF from power supply and other cables*
  - *Reduce RF flowing on shield of audio cables*
- Low Pass Filter
  - *Used between the transmitter and antenna to eliminate harmonic emissions*

More Interference killers

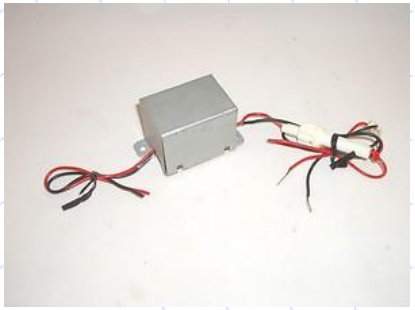
- TV Interference
  - *Band-Reject* filter at TV input
  - Helps prevent overload from nearby transmitter

Grounding helps too…



- Flat strap is best
  - low impedance
- Connect all equipment to a common ground
- Car installations
  - Radio ground connection to chassis or engine block strap
  - Bond all grounds

More Car install tips…



- Positive supply
  - Direct to battery
  - Unused fusebox terminal
- Alternator noise/whine
  - *Varies with RPM*
  - *Filters help*
- Ignition noise
  - *Pulsing/ticking*
  - *Noise Blanker helps*

Operating Controls

RIT: *Receive Incremental Tuning* used to fine tune receive frequency (not transmit frequency). Sometimes called *Clarifier.* Helpful if a SSB signal is high or low pitched.

AF: Audio Frequency gain – just a fancy name for Volume control

AGC: Automatic Gain Control –keep received audio relatively constant

Sets RF power output

Microphone Gain: *excessive gain will result in your transmitted audio being distorted*

Adjusts Receiver gain

Squelch: *mutes the receiver when no signal is being received. To hear weak FM signals, set the squelch so that receiver output audio is on all the time*

Operating Controls

HF Transceivers often have a selection of filters which *permits noise or interference reduction by selecting a filter bandwidth that matches the mode.*
Examples:
2400Hz for SSB
500Hz for CW

Operating Frequency is set by *VFO knob or keypad entry*

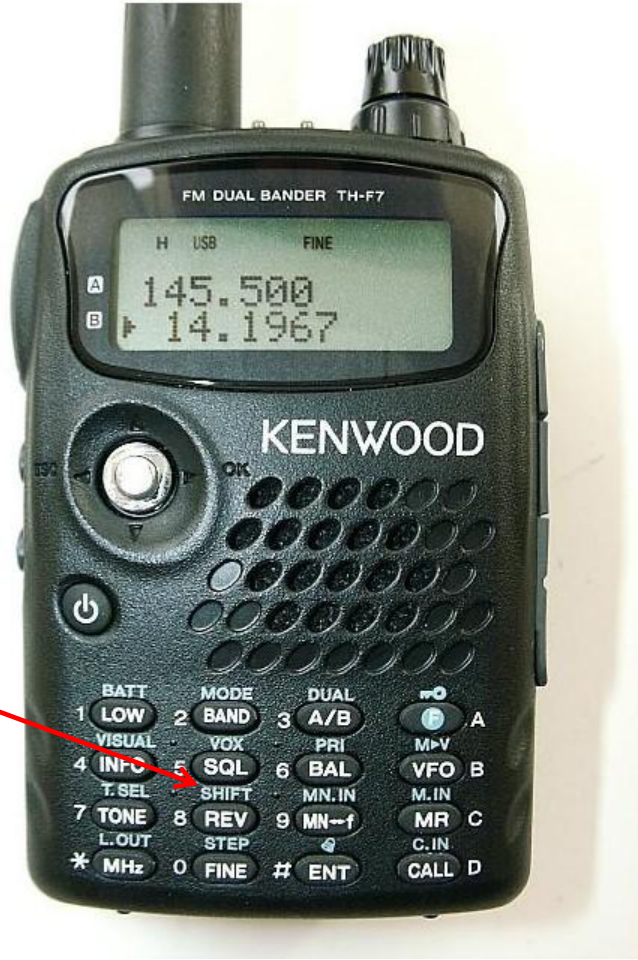
Favorite frequencies can be stored in a memory channel for easy access

Operating Controls

Offset Frequency: *the difference between a repeater's transmit and receive frequencies*

The transceiver's offset is set by an Offset or Shift control.

The REVerse control toggles between transmit and receive frequencies



Station Equipment

- Most basic pieces are **transmitter** & **receiver**
- When in one unit it is called a **transceiver**
- Antenna is switched between transmitter and receiver

Station Equipment

- The figure shows a **transceiver**
  - 1: transmitter portion
  - 3: receiver portion
  - **2: transmit-receive switch**

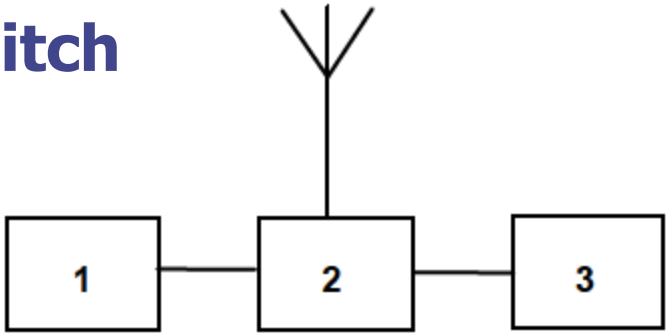


Figure T5

Receiver block diagram

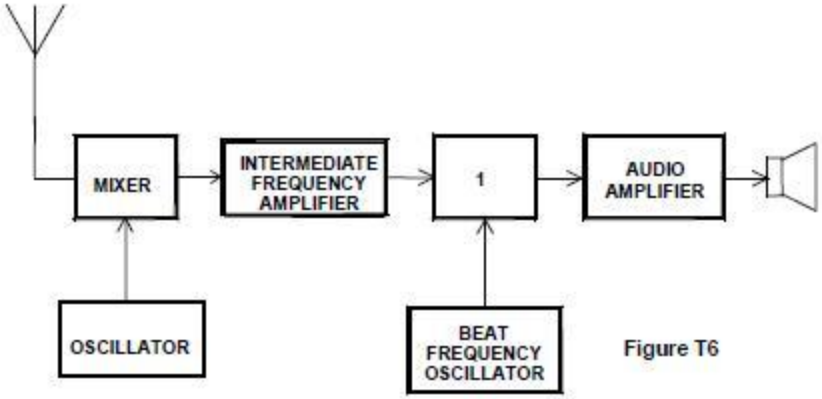


Figure T6

- Figure T6 shows a **single-conversion superheterodyne receiver**
- The **mixer** *shifts the incoming signal to an intermediate frequency*
- **Block 1** is a **Product Detector**, *used to detect CW and SSB signals*

Receiver characteristics

Selectivity

- *The ability of a receiver to discriminate between multiple adjacent signals*
- Receive filters can improve a receiver's selectivity

Sensitivity

- How weak a signal the receiver can detect
- An RF preamplifier can help improve sensitivity
- *An RF preamplifier is installed between the antenna and receiver*

FM Receiver

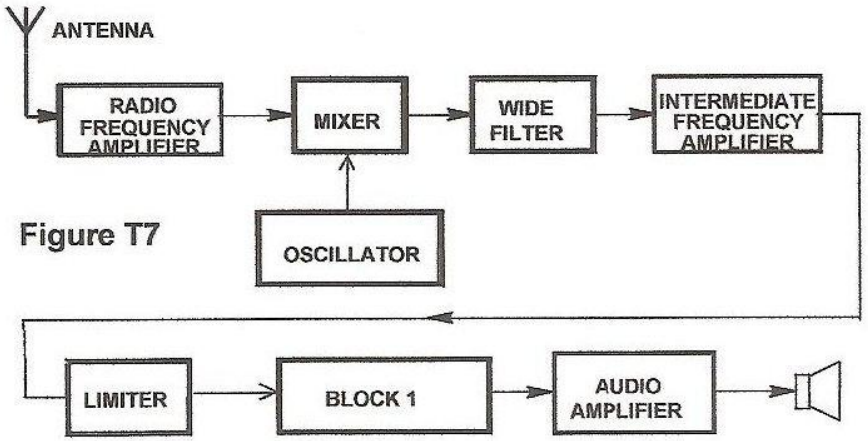


Figure T7

- If **Block 1** is a *frequency discriminator*, then the circuit pictured is an *FM Receiver*
- A **discriminator** is the circuit that *demodulates* FM signals

CW Transmitter

- Simplest transmitter
- **Block 1** is an **oscillator**
- The oscillator generates the frequency that you are going to transmit on

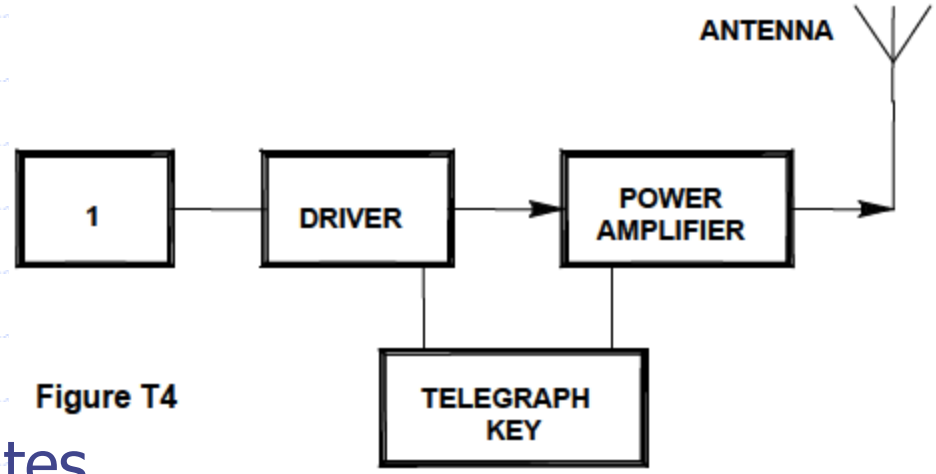
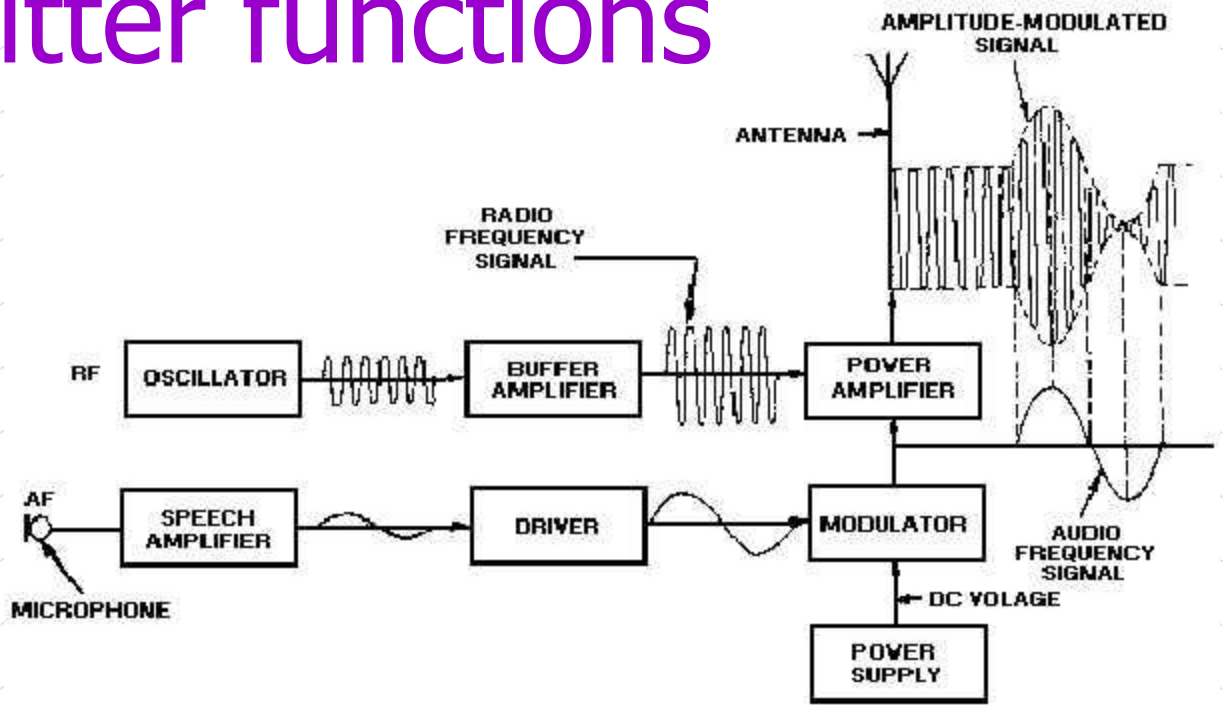


Figure T4

Transmitter functions



- Voice modes like *SSB* and *FM* need a modulator
- A **modulator** *combines the RF carrier and the audio/speech signal*

Transverter

- Used to operate on a frequency which a radio was not designed for
- A **transverter** *is a device that takes the output of a low-powered 28MHz SSB exciter and produces a 222MHz output signal*
- It also converts an incoming 222MHz signal to a 28MHz signal for the receiver

Some VHF & UHF info…

- Most operation is using FM and Repeaters
- CW and SSB are also popular – often weak signals
- *The device most useful for VHF weak signal communications is a **multi-mode VHF transceiver***
- Handheld transceivers (HTs) have low power transmitters (5W or less), which limits range
- *The device that increases the low-power output from a handheld transceiver is an **RF power amplifier***

Sets amplifier for proper operation in selected mode

Troubleshooting Common Problems

- Overload
- Distortion
- Feedback
- Interference

- **What can cause radio frequency interference:**
  - *Fundamental overload*
  - *Harmonics*
  - *Spurious emissions*
- Any of these can cause radio or TV interference

If someone tells you that your transmissions are causing interference, you should first ***make sure that your station is functioning properly and not causing interference to your own TV and radio If so, first be sure all TV feed line coax connectors are installed properly***

Telephone interference

- Telephones often experience interference
- *Most likely cause of interference to a non-cordless phone from a nearby transmitter is that the* ***telephone is acting like a radio receiver***
- Logical first step to cure radio interference on a telephone *is to install an RF filter at the telephone*

Unprotected Telephone

Addressing Interference

- Useful ways to cure RF interference
  - *Snap-on ferrite chokes*

    Can cure distorted audio caused by RF current on the shield of the microphone cable
  - *Low-pass and high-pass filters*
  - *Band-reject and band-pass filters*
- **Fundamental Overload** *is interference caused by very strong signals injected into a receiver*

Part 15 Devices

This device complies with part 15 of FCC Rules. Operation is subject to the following two conditions; (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

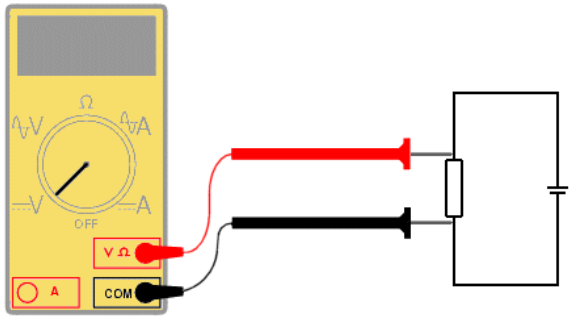
- If a neighbor's device is causing interference:
  - *Work with them to identify offending device*
  - *Politely inform them about the rules that require them to stop using the device if it causes interference*
  - *Check your station to ensure it meets standards of good amateur practice*

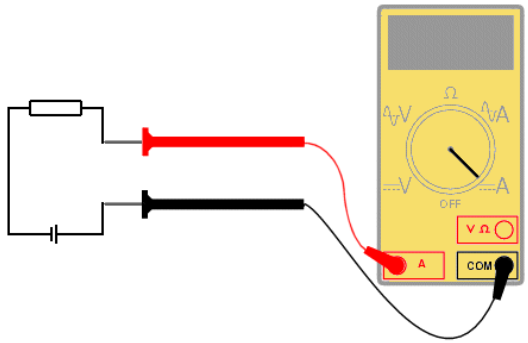
Common Problems

- **Distorted / Noisy Audio**
  - *Transmitter might be slightly off frequency*
  - *Batteries might be running low*
  - *You might be in a bad location*
- **Garbled, Distorted or Unintelligible transmission**
  - *RF Feedback*
  - Over-deviation on FM
    - *Back off the mic*
- **Noise in digital transmissions causes bit errors**
  - **BER**: *Bit error rate, the rate at which errors are occurring*
- **High pitched whine**
  - *Noise from vehicle's electrical system, usually alternator*

Using a Multimeter or DMM

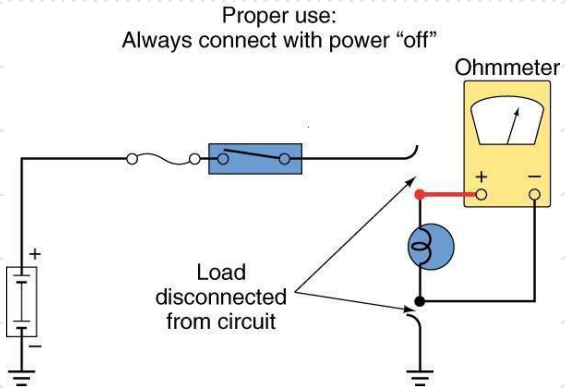
- **Multimeter** = voltmeter, ohmmeter and ammeter
- **DMM** = digital multimeter
- Measuring **voltage** and **resistance** are *common*
- *To measure **voltage**, the voltmeter is placed in parallel with the circuit*
- *To measure **current**, the ammeter is placed in series with the circuit*

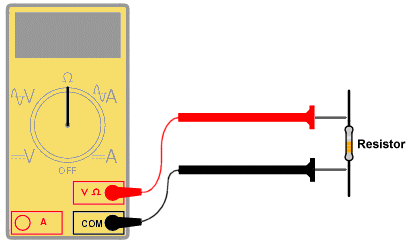




Measuring Resistance

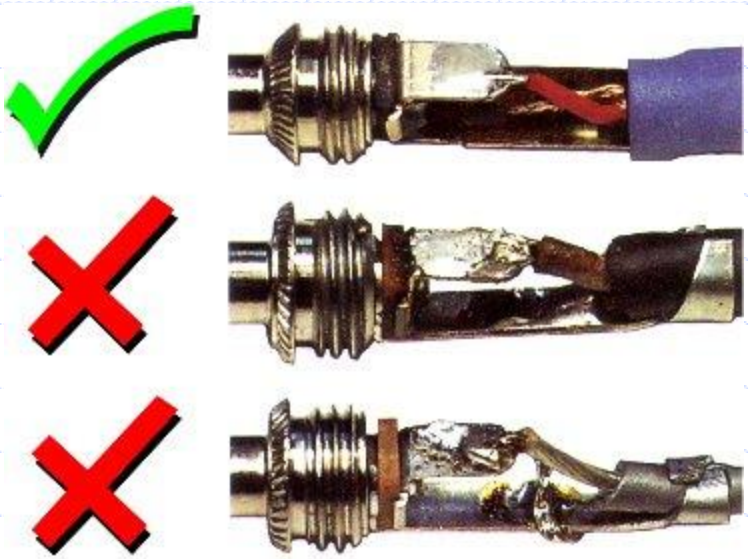
- **Ohmmeter** is used to measure *resistance*
- *Attempting to measure a voltage on the resistance setting might damage the meter*
- *When measuring **resistance**, an initial low reading that **slowing increases** means that the circuit contains a large capacitor*





Soldering

- Good skill to have!
- ***Rosin-core solder*** *is best for radio and electronic use*
- Joints should be smooth and shiny
- ***Dull*** *or* ***grainy*** *surface is characteristic appearance of a "**cold**" solder joint*



Operating Procedures

FM Operation

Most new Technicians start with a VHF/UHF FM transceiver

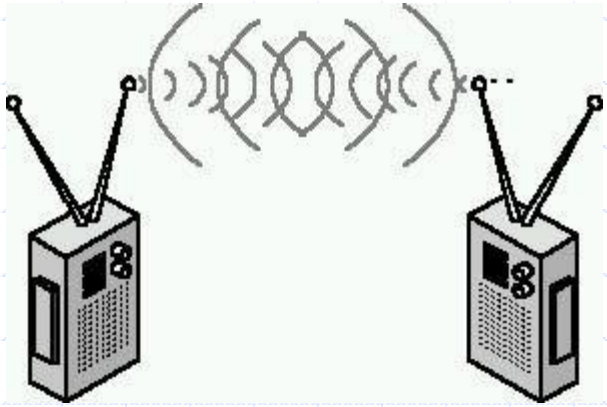
- **Repeaters**
  - Listen to you on one frequency (*Input*)
  - Re-broadcast you on another frequency (*Output*)
- **Your Radio must:**
  - Transmit on the *Input*
  - Receive on the *Output*
- **Difference** between *Input* and *Output* frequencies is called the **Offset**

- **Common Repeater Offsets**
  - **+/- 600kHz** for the **2m** band
  - **+/- 5MHz** for the **70cm** band

Duplex and Simplex

- Duplex Communication
  - Tx & Rx on two different frequencies

- **Simplex Communication**
  - **Tx & Rx on the same frequency**
  - **Used to prevent tying up repeater**



- National simplex frequency
  - 446.000MHz on 70cm
  - **146.520MHz on 2m**

Repeater details

- **CTCSS** tones
  - *Sub-audible tone sent with your voice to open the squelch on repeater*
  - Also called PL (private line) tone
- **Reasons why you can *hear* a repeater, but can't talk on it:**
  - **Improper transceiver offset**
  - **Repeater req's CTCSS for access**
  - **Repeater may require a DCS tone sequence for access**
- **If a station is not strong enough to keep a repeater's receiver squelch open you can use the "reverse split" function on your transceiver to listen on the repeater's input frequency**

Some VHF/UHF Trx Controls

- **Carrier Squelch**
  - Mutes Rx in the absence of an RF signal
- **Microphone Gain**
  - Changes the *amplitude* of the modulating signal
  - Determines the amount of **FM deviation**
  - If **deviation** is **increased**, the signal **occupies more BW**

Repeater Operation

- How to strike up a conversation…
  - CQ isn't really used
  - Say your **call sign** to indicate that you're a listening
- To call someone…
  - Say **their call sign, identify** with **your call sign.**

HF Operation

- **CQ** means *"calling any station"*
  - "CQ, CQ, CQ, this is W2AEW calling CQ"
- **Responding** to a CQ
  - *Transmit the other station's call sign, followed by yours*

Station Identification

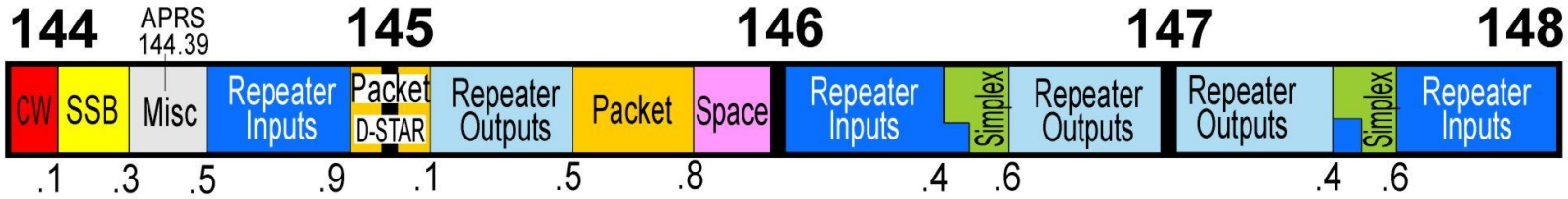
- Always **properly identify when transmitting**, even when testing
- Identify at least **every 10 minutes** of operating, and when you **end** operating

More HF Details

- Techs can operate CW on 80/40/15/10m
- **Q-Signals** used as shorthand
  - **QRM** indicates your getting interference from other stations
  - **QSY** indicates you are changing frequency

General Guidelines

- **Band Plan:** a voluntary guideline for different modes and activities in an amateur band
- Amateurs must use **minimum power necessary** to carry out desired communication
  - Allowed up to 1500W on VHF and above, 500W on HF



- Before calling CQ:
  - Listen to make sure nobody is using the frequency
  - Ask if frequency is in use
  - Make sure you are in the assigned band

More Guidelines

- *Stay Clean*
  - If you get a report you're causing splatter or interference, **check your transmitter for off-frequency operation or spurious emissions**
  - If you unintentionally cause interference, then **properly identify yourself and move to a different frequency**
- Use of **phonetic alphabet** is encouraged by FCC
  - *Learn it, use it!*

A - ALPHA	N - NOVEMBER
B - BRAVO	O - OSCAR
C - CHARLIE	P - PAPA
D - DELTA	Q - QUEBEC
E - ECHO	R - ROME0
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

Public Service
Emergency & non-emergency

- Uniquely qualified to help
- **FCC Rules** still apply when using amateur radio for public service purposes

- ***May use any means necessary for essential communication when there's immediate danger to life, safety and property damage***

RACES & ARES

- RACES: **R**adio **A**mateur **C**ivil **E**mergency **S**ervice
- *FCC Part 97 amateur radio service for civil defense communication during national emergencies*

- ARES: **A**mateur **R**adio **E**mergency **S**ervice
- Both **RACES** & **ARES** *may provide communications during emergencies*

Common for these groups to form a network, or "*net*"

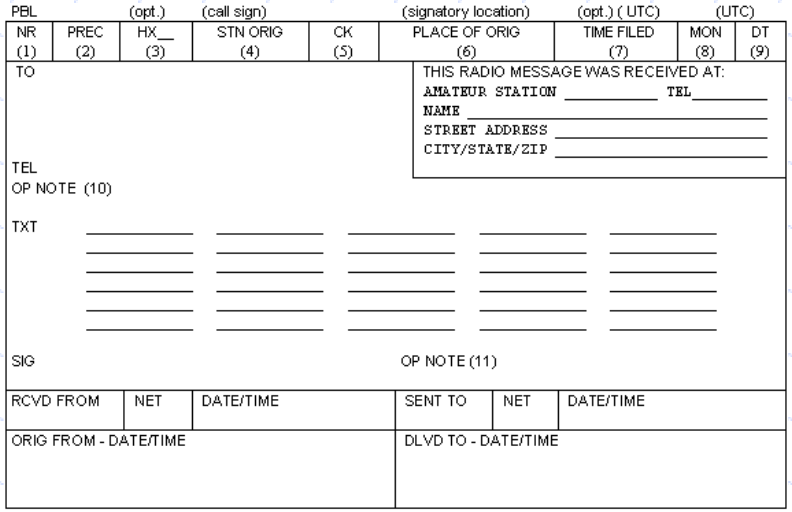
Orchestrated by a "*net control operator*" at the net control station (NCS)

Messages passed during these operations are called "*traffic*"

Message / Traffic handling

- Informal & Formal
- Most important: **pass messages exactly as written, spoken or received**

- Formal Messages
  - Preamble
  - Address
  - Text
  - Signature



PBL (opt.) (call sign) (signatory location) (opt.) (UTC) (UTC)

NR (1)	PREC (2)	HX__ (3)	STN ORIG (4)	CK (5)	PLACE OF ORIG (6)	TIME FILED (7)	MON (8)	DT (9)

TO

THIS RADIO MESSAGE WAS RECEIVED AT:
AMATEUR STATION _____ TEL_____
NAME _____
STREET ADDRESS _____
CITY/STATE/ZIP _____

TEL
OP NOTE (10)

TXT

SIG

OP NOTE (11)

RCVD FROM	NET	DATE/TIME	SENT TO	NET	DATE/TIME

ORIG FROM - DATE/TIME

DLVD TO - DATE/TIME

Formal Traffic Messages

- ***Preamble*** used to **track** the msg as it passes thru the amateur traffic handling system
  - The preamble **check** is the **number of words or word equivalents in the text** of the message
- *Address* is the name/address of the recipient
- *Text* is the body of the message
- *Signature* identifies the originator
- Check is the number of words or word equivalents in the text portion of the message

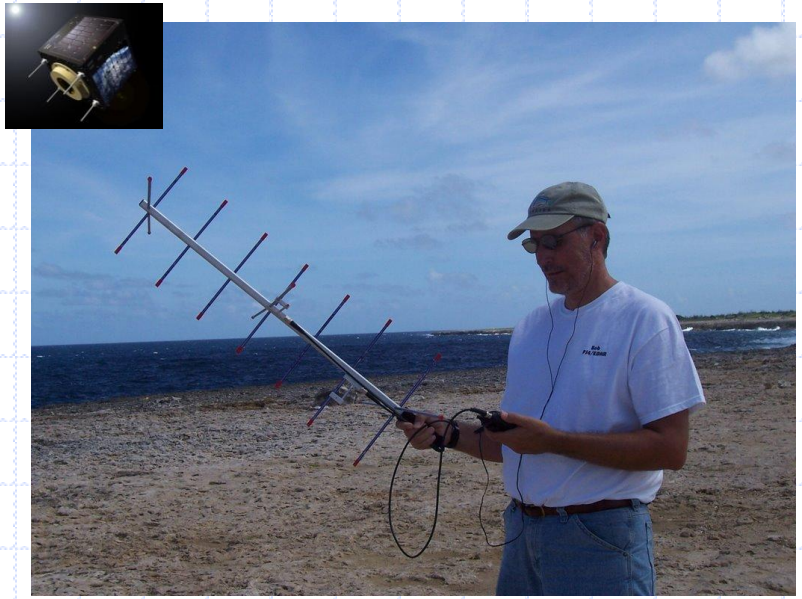
Net Operation / protocol

- Net Control Station (NCS) calls net to order and directs communications between stations checking in
- **Only transmit when directed by the NCS**
- If your emergency can't wait – get **attention** of **NCS** by begin your transmission with "**Priority**" or "**Emergency**" followed by your **call sign**

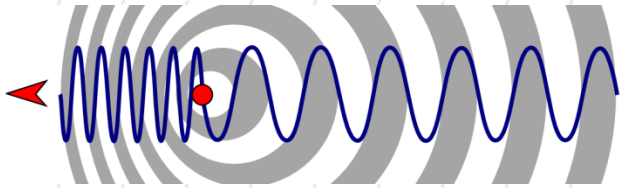
Hams in Space

Amateur Satellites

- Repeater in space
  - Uplink & downlink frequencies
  - Often on different bands
  - **U/V mode**: *uplink* in **70cm** band, *downlink* in **2m** band
- Need license **privileges** to transmit on *uplink frequency*
  - *Technician class license has privileges for 2m and 70cm bands*
  - Use minimum power necessary
- Modes can be SSB, FM, CW, or data
- ***Talk to amateur radio operators in other countries***



More Satellite info



- **Satellite Beacon**:
  - Transmission from a space station/satellite that contains **health and status info** about the satellite
- **FM Packet** is commonly used to send to/from digital satellite
- A **satellite tracking program** is often used to determine when a satellite can be accessed
  - Real-time position of satellite track
  - Time, azimuth and elevation of the start, max altitude, and end of a pass
  - Apparent frequency of satellite transmission, including Doppler shift
  - Inputs are satellite's Keplerian elements

Keplerian Elements

SB KEPS @ AMSAT $ORB19066.N
2Line Orbital Elements 19066.AMSAT

HR AMSAT ORBITAL ELEMENTS FOR AMATEUR SATELLITES IN NASA FORMAT
FROM WA5QGD FORT WORTH,TX March 7, 2019
BID: ORB19066.N

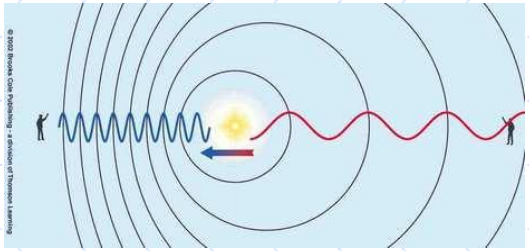
DECODE 2-LINE ELSETS WITH THE FOLLOWING KEY:
1 AAAAAU 00 0 0 BBBBB.BBBBBBBB .CCCCCCCC 00000-0 00000-0 0 DDDZ
2 AAAAA EEE.EEEE FFF.FFFF GGGGGGG HHH.HHHH III.IIII JJ.JJJJJJJJKKKKKZ
KEY: A-CATALOGNUM B-EPOCHTIME C-DECAY D-ELSETNUM E-INCLINATION F-RAAN
G-ECCENTRICITY H-ARGPERIGEE I-MNANOM J-MNMOTION K-ORBITNUM Z-CHECKSUM

TO ALL RADIO AMATEURS BT

AO-07
1 07530U 74089B   19065.87282270 -.00000051 00000-0 -38356-4 0 9997
2 07530 101.7308 34.6540 0012032 186.1476 188.7441 12.53636981 27512
UO-11
1 14781U 84021B   19066.06810873 .00000062 00000-0 13819-4 0 9995
2 14781 97.6220 95.6266 0007200 306.0959 53.9589 14.83067555883400

Common Satellite Problems

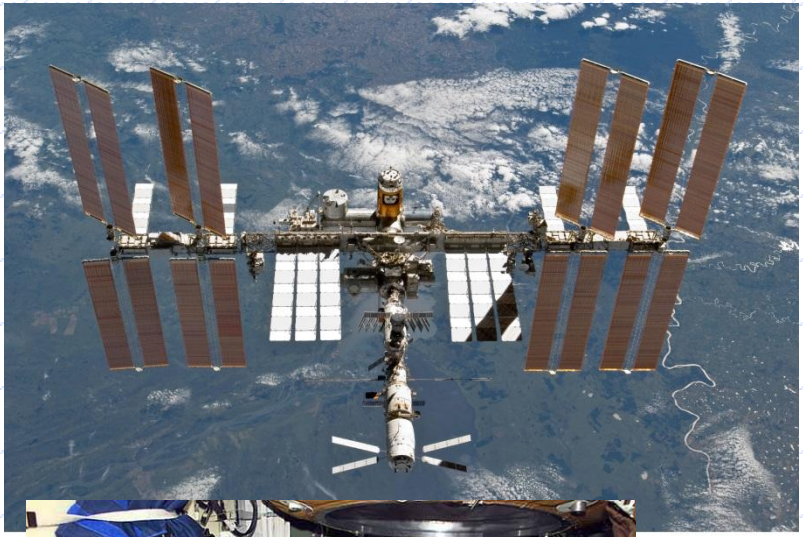
- **Doppler Shift**
  - Observed *change in frequency* due to relative motion between satellite and earth station



- **Spin Fading**
  - Caused by *rotation* of the satellite and its antenna
- **Uplink Power**
  - If you use too much power you can block access by other users
  - Make your signal strength on the downlink similar to that of the satellite's beacon

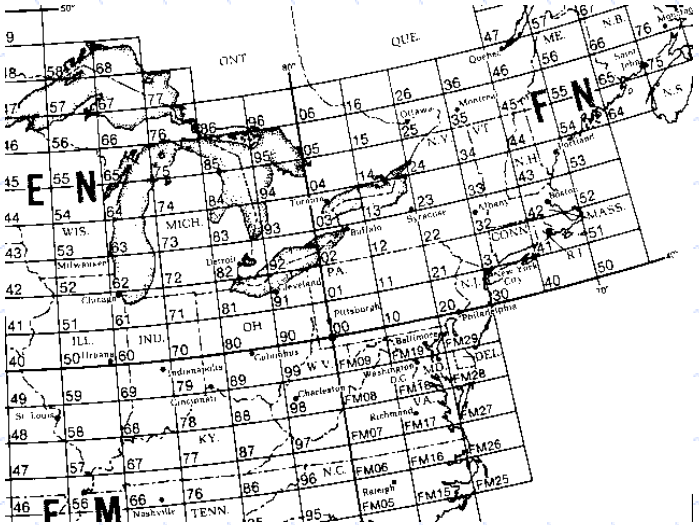
International Space Station

- Any **Technician** class can make contact to the ISS on **70cm** and **2m**
- ISS is a **L**ow **E**arth **O**rbit (**LEO**) satellite



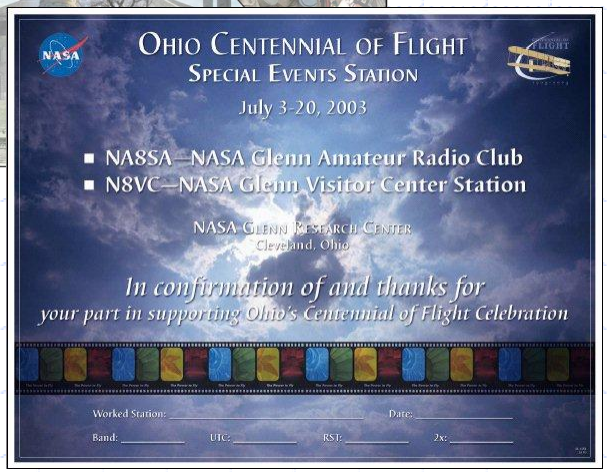
Fun activities

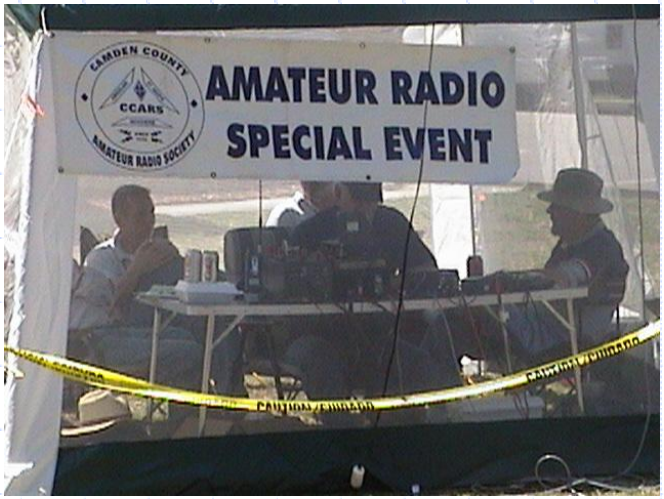
- **Contesting**
  - Make many contacts in a *specific time period*
  - Good practice: send only **minimum amount of info req'd** for ID and contest exchange
  - Be mindful of others on the band
- **VHF/UHF Contests**
  - Often use grid locators: **letter-number designation** for geographic location



More Fun Activities

- **Special Event Stations**
  - 1x1 call signs
  - Often for events of **special significance** to amateur community





Even more fun…

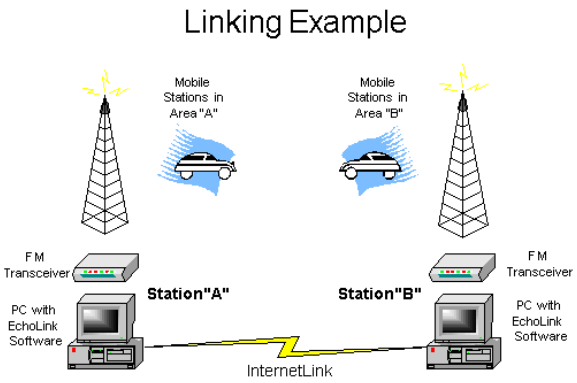
- **Radio Direction Finding** (Fox Hunting)
  - Fun contest
  - Good skill for **interference** and **jammer** hunting
  - Uses a **directional** antenna to hunt for a hidden transmitter

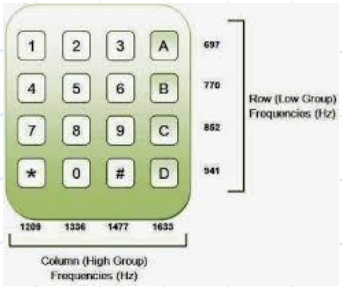
Still more fun activities

- Remote Control (**RC**) Models
  - Planes, Boats, Cars
  - **1 Watt** maximum
- Identification
  - via **label** or **flag** attached to the RC transmitter antenna
  - **Name, call, address**

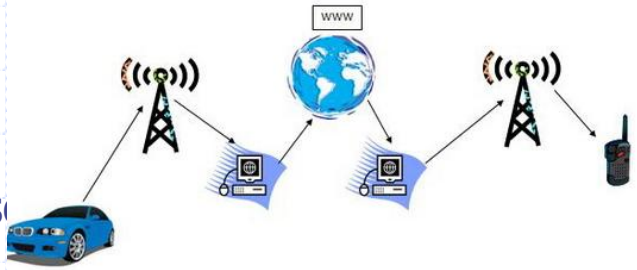
Add a scoop of Internet…

- **IRLP**: **I**nternet **R**epeater **L**inking **P**roject
  - Uses **VoIP** – voice over internet protocol
  - Repeater **directory** will list active nodes
  - **Keypad** on radio used to dial up a node
  - **DTMF signals (pairs of audio tones)**
  - used to access some IRLP nodes





- **Echolink**
  - Radio ***or Computer*** links
  - You must register and provide proof of licens

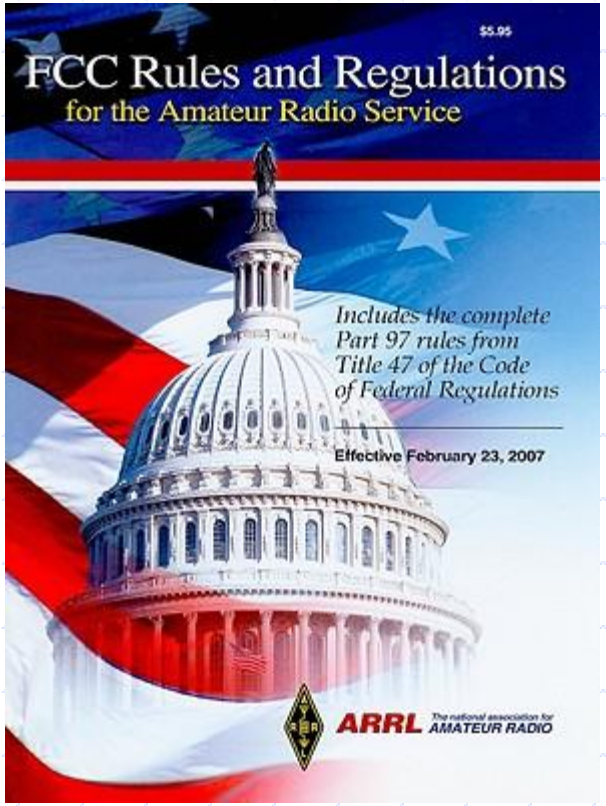


- A **Gateway** is the name of a station that links to other stations via Internet
- A **Digital Mode Hot Spot** allows your transceiver to communicate using digital voice or data via the internet

Rules & Regulations

- **Amateur Radio Service** – for persons who are interested in radio technique solely with a **personal aim** and **without pecuniary interest**
- **One purpose is advancing skills in the radio aret**
- Regulated and enforced by **FCC**
- **Part 97** applies to Amateur Radio

Part 97 defines an amateur radio station as a station in an Amateur Radio Service consisting of the apparatus necessary for carrying on radio communications



More FCC Part 97 Definitions

- **Space Station**
  - an amateur station located **>50km** above earth
- **Telecommand**
  - 1-way transmission to **initiate**, **modify** or **terminate** functions of a device at a distance
- **Telemetry**
  - 1-way transmission of **measurements** at a distance from the measuring instrument
- **Beacon**
  - An amateur station transmitting communications for the purposes of observing propagation or related experimental activities

Repeaters…

- **Repeater**
  - Amateur station that simultaneously retransmits the signal of another amateur station on a different channel(s)
- **Auxiliary Station**
  - A station that transmits signals over the air from a remote receive site to a repeater for retransmission
- **Frequency Coordinator**
  - Entity that recommends transmit/receive frequencies for repeaters and auxiliary stations
  - Serves eligible amateurs in a local/regional area

Interference

- **Harmful Interference**
  - …that which seriously degrades, obstructs, or repeatedly interrupts a radio communication service operating in accordance with the Radio Regulations
- Intentionally causing interference is grounds for:
  - Revocation of license
  - Fines
  - Prison
- Willfull interference is permitted at no time

The ITU (International Telecommunications Union)

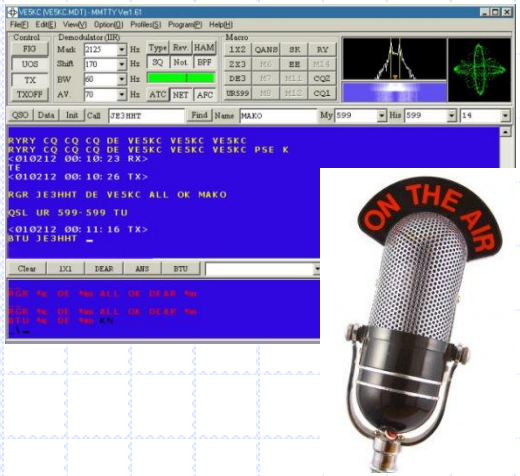
- ***ITU is a United Nations agency for information and communication technology issues***
- Three **ITU Regions**
  - North American radio stations are in **region 2**

- ITU deals with worldwide amateur radio issues
- FCC deals with US only, within ITU framework

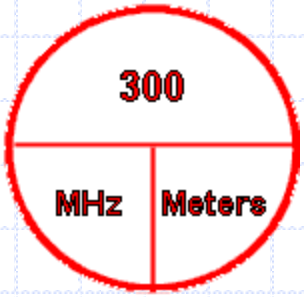
Frequency / Mode Allocations

Band	Frequencies (In MHz)	Modes You Can Use
80 meters	3.525 – 3.600	CW
40 meters	7.025 – 7.125	CW
15 meters	21.025 – 21.200	CW
10 meters	28.000 – 28.300 28.300 – 28.500	CW, RTTY/data, 200 watts PEP maximum power CW, phone, 200 watts PEP maximum power
Above 50 MHz	All amateur privileges	

CW = Morse code; PEP = peak envelope power; RTTY = radioteletype.



Qs on Frequencies/Bands



- **52.525 MHz** is within the 6 meter band
- The **2 meter band** is what you're using when your station is transmitting on 146.52 MHz
- **443.350 MHz** is in the 70 cm band, authorized for use by Technicians in ITU Region 2
- **219 to 220 MHz** is reserved for fixed digital message forwarding
- On the **10M band**, a technician has phone, RTTY, and data privileges
- The maximum peak envelope power output for technicians is 200 watts for their HF assigned portion and 1500 watts above 30MHz

Primary and Secondary users

- Amateur radio shares some bands with other radio services
  - Sometimes we're the primary users, like 70 cm band
  - Sometimes we're the secondary users, like 23 cm band
- When we're secondary users of a band…
  - **…must not cause harmful interference to primary users**
  - Example: *If you learn that your 23 cm operation is interfering with a radiolocation service outside the US, you must **stop operating** or **take actions** to eliminate the interference*

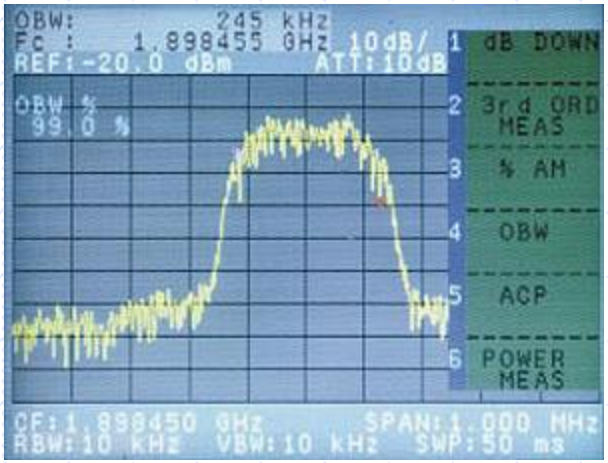
Sub-bands

- **FCC** defines sub-bands for specific operating modes
  - **CW only** is allowed in these mode-restricted sub-bands:
    - **50.0 to 50.1 MHz**
    - **144.0 to 144.1 MHz**
- **Mode-restricted** sub-bands for the Technician are found on…
  - **6 meters**
  - **2 meters**
  - **1.25 meters**
- **SSB phone may be used in at least some segment of bands above 50MHz**

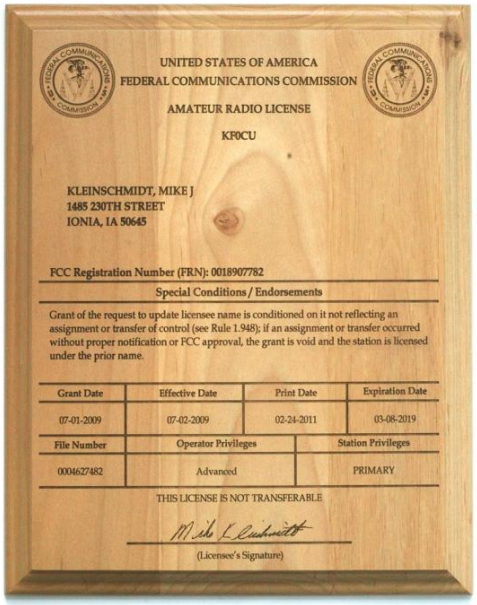
Frequency selection

- Don’t operate right at the band or sub-band edge!

- **Reasons why**:
  - To allow for calibration error of the transmitter frequency display
  - So that modulation sidebands do not extend beyond the band edge
  - To allow for transmitter frequency drift



Licenses and Operating



UNITED STATES OF AMERICA
FEDERAL COMMUNICATIONS COMMISSION

AMATEUR RADIO LICENSE

KF0CU

KLEINSCHMIDT, MIKE J
1485 230TH STREET
IONIA, IA 50645

FCC Registration Number (FRN): 0018907782

Special Conditions / Endorsements

Grant of the request to update licensee name is conditioned on it not reflecting an assignment or transfer of control (see Rule 1.948); if an assignment or transfer occurred without proper notification or FCC approval, the grant is void and the station is licensed under the prior name.

Grant Date	Effective Date	Print Date	Expiration Date
07-01-2009	07-02-2009	02-24-2011	03-08-2019

File Number	Operator Privileges	Station Privileges
0004627482	Advanced	PRIMARY

THIS LICENSE IS NOT TRANSFERABLE

(Licensee's Signature)

- Three license classes
  - Technician
  - General
  - Amateur Extra
- You can transmit once your operator/station license grant appears in the FCC database
- License terms are normally 10 years
  - There is a 2 year grace period to renew, but you cannot transmit until the FCC database shows that your license has been renewed

Call Signs in the US

- Consist of one or two letters…
  …followed by a single number…
  …followed by one, two or three letters
  - 1x2, 2x1, 1x3, 2x3
- **K1XXX** is an example of a valid technician call sign
- Any licensed amateur may apply for a **vanity call sign**
- **Special event** call signs are typically **1x1**
  - W8C is an example of a special event call sign
- **Clubs** can apply for a call sign
  - *must have **at least four members***

Records and Operating

- Logging is no longer required
- You **must** keep your mailing and ***email*** addresses current
  - *Failure to do so can result in suspension or revocation!*
  - *FCC will take action if correspondence is returned due to incorrect address*

Operating outside the US

- You can operate in a foreign country, **when the foreign country authorizes it**
  - Sometimes with reciprocal licensing agreements
  - Example: I can operate in Germany as DL/W2AEW
  - Different countries have different restrictions
- Shipboard in international waters – OK **provided the ship is documented or registered in the United States**, as well as places where FCC regulates communications

When can I operate???

- Operate **as soon as your name and call sign appear in FCC's ULS database**
- License good for **10 years**
- Renewal grace period is **2 years**
- **Can't transmit until renewal** shows in the database

Operating outside of the US

- Allowed **if the foreign country allows it**
  - *Some countries have reciprocal agreements*
  - *Ex: Germany, operate as DL/W2AEW*
  - *Check local restrictions*
- International waters
  - Any vessel **documented or registered in US**

Authorized & Prohibited

- Prohibited Transmissions
  - **Obscene** or **indecent** words or language
  - **Music**
    - *Except when incidental to an authorized retransmission of manned spaceflight communications*
  - Unpublished **codes** or **ciphers**
    - *Except when transmitting control commands to space stations or radio controlled crafts*
- Permitted only with other Amateurs, except:
  - Emergencies
  - Armed Forces Day Communications Test

More Prohibited

- No communications with **any country whose administration has notified the ITU that it objects to such communications**
- Can not use station to make money or be compensated, except
  - Operation in **incidental to classroom** instruction
  - Occasional notification of **equipment for sale**
- **No broadcasting**
  - *Defined as transmissions intended for reception by general public*
  - *Exception:* **only where such communications directly relate to the immediate safety of human life or protection of property**
- **One-way transmissions** only for code practice, information bulletins, or emergency communications

What is allowed?

- Communications incidental to the purposes of the amateur service and remarks of a personal character
- Brief transmissions for the purposes of making adjustments

Control Operator & Types

- Who can be a Control Operator?
  - Only a person for whom an amateur operator/primary station license grant appears in the FCC database or who is authorized for alien reciprocal operation
  - Usually the **station licensee**
- License class of Control Operator determines transmitting privileges
  - Ex: Technician can't be control operator in Extra class portion of band

Control Operator / Point

- Required **only** for **transmitting**
- **Designated** by Station Licensee
- **BOTH** are equally responsible
- Operator or originating station responsible when using repeater

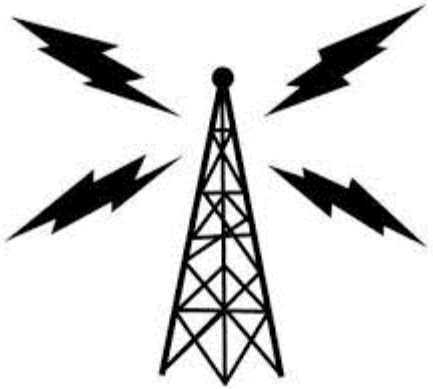
- **Control Point**: location at which the control operator function is performed

Control Type

- **Local Control**
  - Such as transmitting using a handheld radio
- **Remote Control**
  - Control operator is not at the station location but can indirectly manipulate the operating adjustments of a station (e.g. operating over the internet)
- **Automatic Control**
  - Repeater when the control operator is not present at a control point
  - Only type permissible for the control operator to be at a location other than the control point

Station Identification

- Every 10 minutes & at end of contact
- Using English
- Voice (phone) or CW (Morse) emission



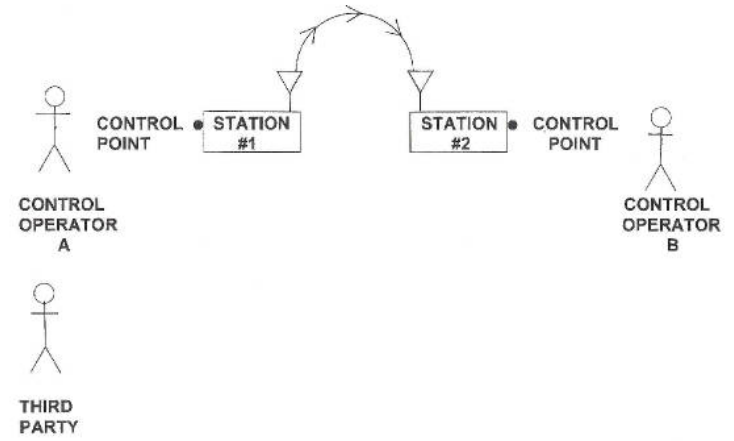
- Tactical call, like "Race Operator" OK
  - *But must still ID with call sign every 10 minutes*

More Station Identification

- Self-assigned Identifiers
  - Examples: “/3”, “mobile”, “QRP”
  - All of these are correct
    - W2AEW stroke W3
    - W2AEW slant W3
    - W2AEW slash W3
  - Must not conflict with other FCC identifiers or foreign country call sign prefixes

Third Party Communications

- On behalf of someone other than licensee
  - For example – a friend using your station
- Legal in US
  - May have restrictions communicating outside of US
  - Authorized by FCC with any station whose government permits such communications



Station Records

- Station records must be made available for inspection by FCC representative at any time

Are you ready???

- Questions?
- What topics are fuzzy to you?

- Practice Exams…

Marinette - Menominee
Amateur Radio Club
w8pif.com

Open to anyone interested in amateur radio!

Great way to learn new things!

Enjoy the camaraderie and many fun events!

ARRL Field Day

After Xmas Party

Club Picnic

Annual Membership - $20 Single/$30 Family

We hope you will join us!!