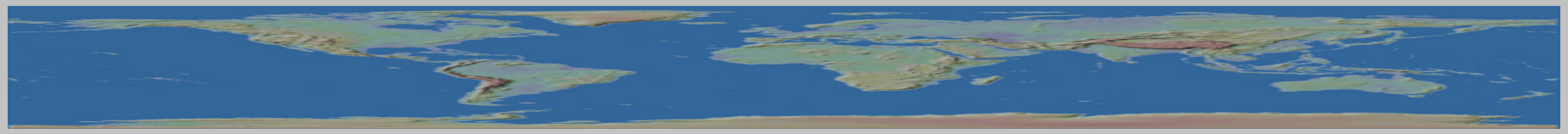
# *Technician Licensing Class*

# Lesson 4

presented by the

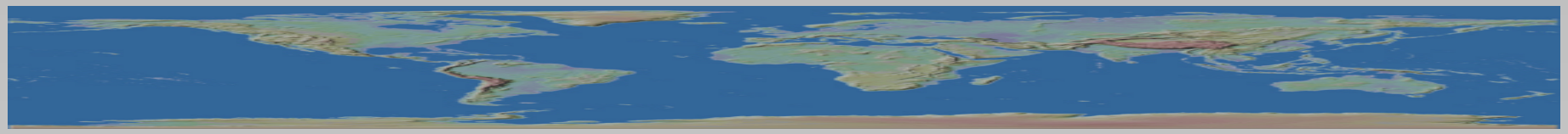
Arlington Radio Public Service Club

Arlington County, Virginia



# *Quiz*

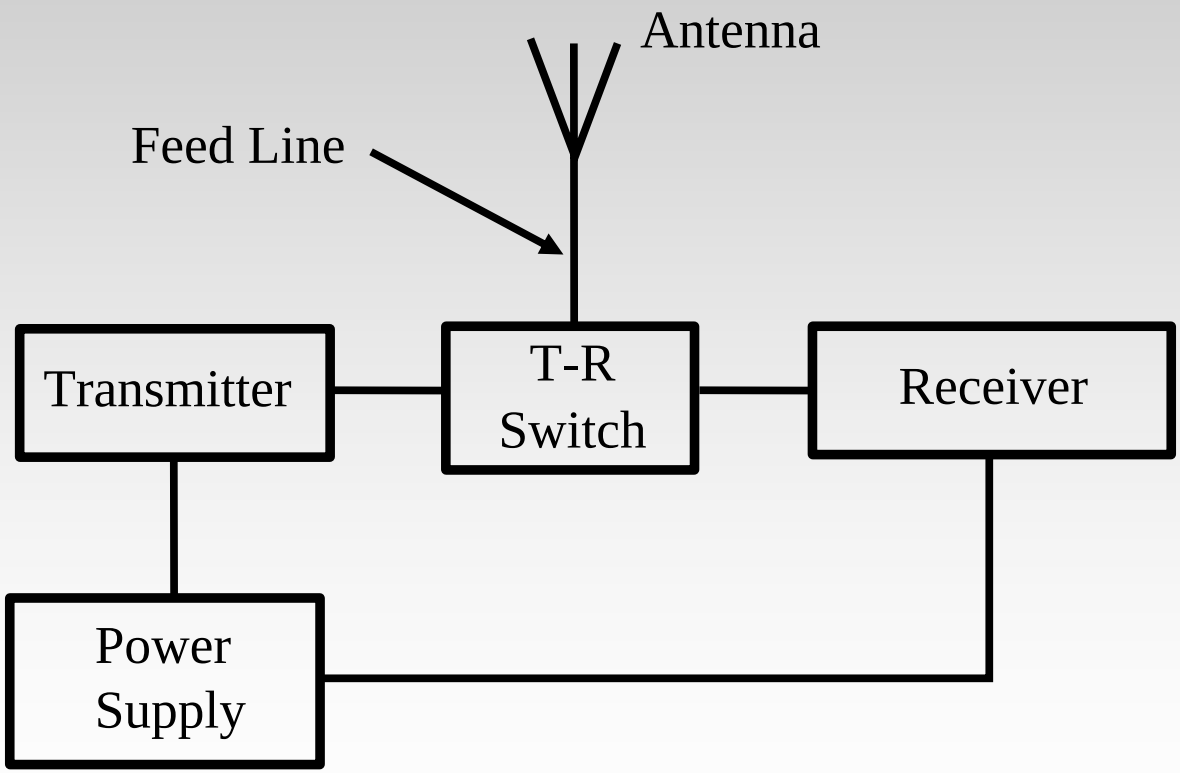
## *Sub elements T6 & T7*



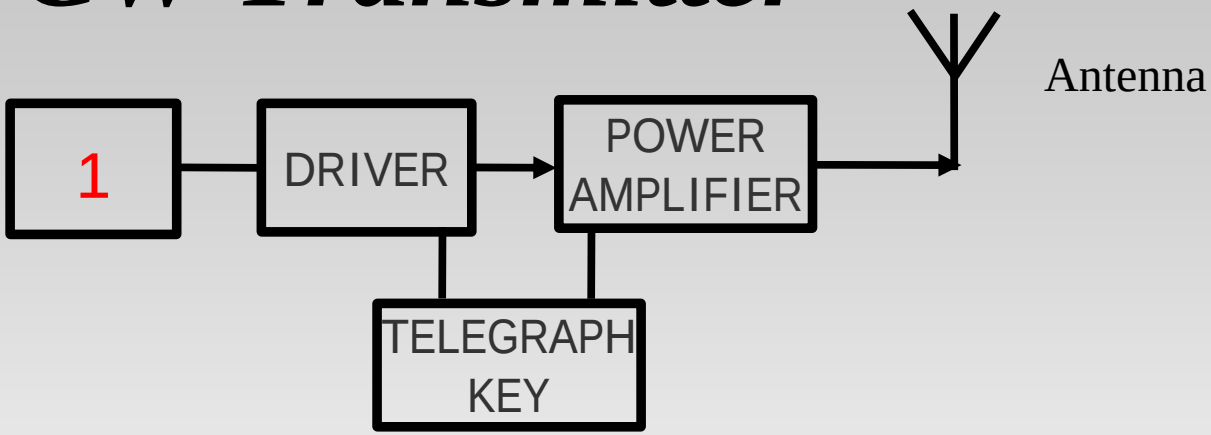
# *Good Engineering Practice*

## *Sub element T8*

# *A Basic Station*

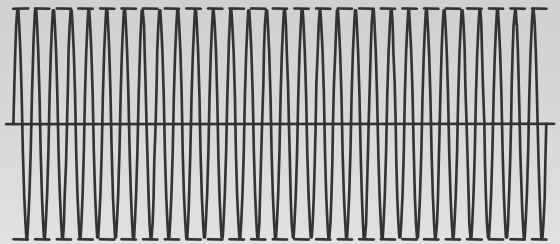


# *Simple CW Transmitter*



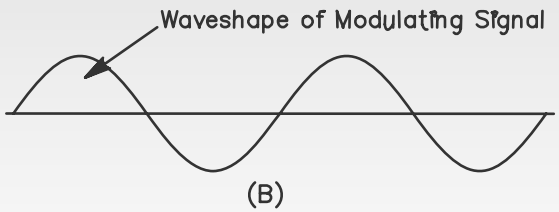

- Block 1 controls the frequency of the transmitter
  - If Block 1 is a crystal it is referred to as a “crystal controlled transmitter”
  - If Block 1 is a variable-frequency oscillator it is referred to as a “VFO controlled transmitter”
- CW is transmitted by on/off keying of the RF signal with the telegraph key.

# *Frequency Modulation (FM)*



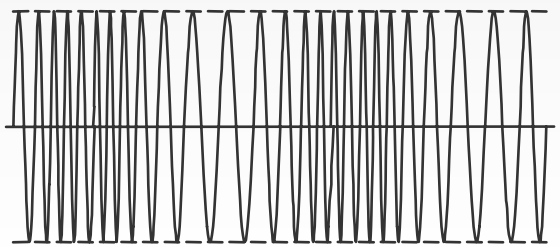
(A)

Un-modulated carrier, full power at all times




(B)

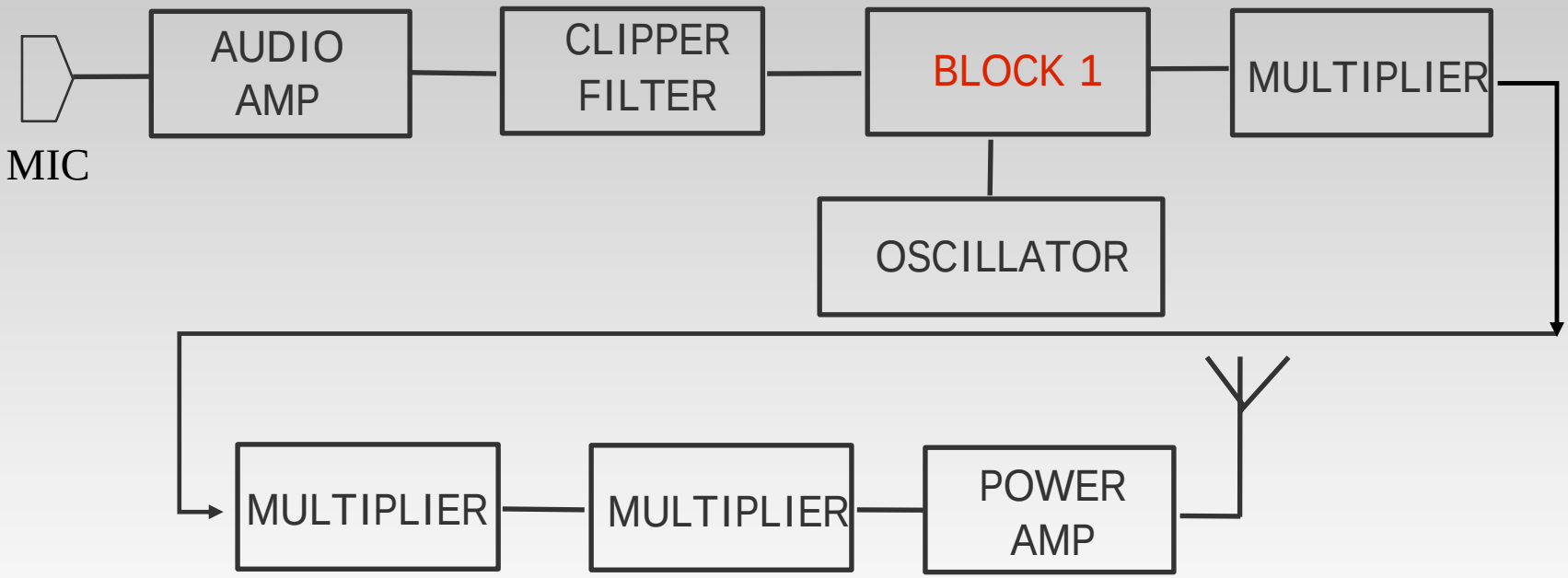
Waveform of modulating signal



(C)

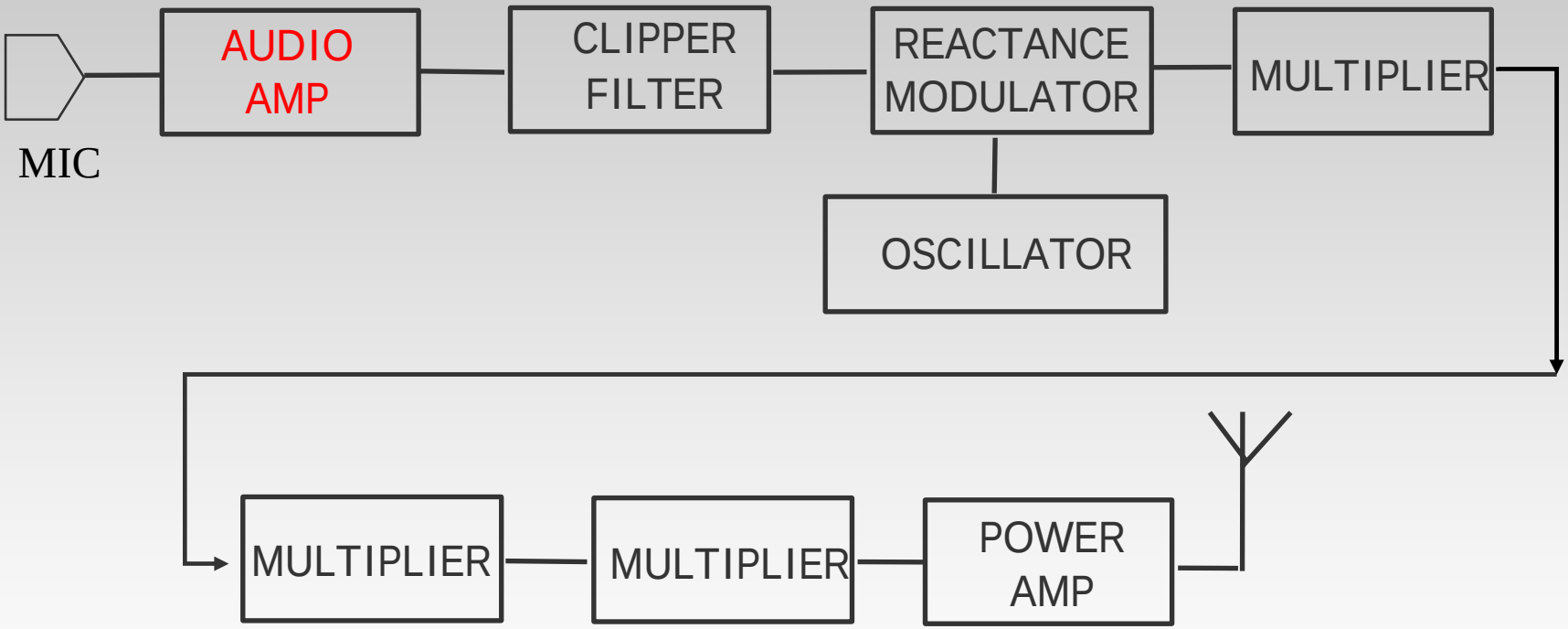
Modulated carrier with frequency deviation and constant amplitude

# *FM Transmitter*




- In an FM transmitter, Block 1 represents a Reactance Modulator.
- The Reactance Modulator changes the phase or frequency of the oscillator in response to the audio input.

# *FM Transmitter*

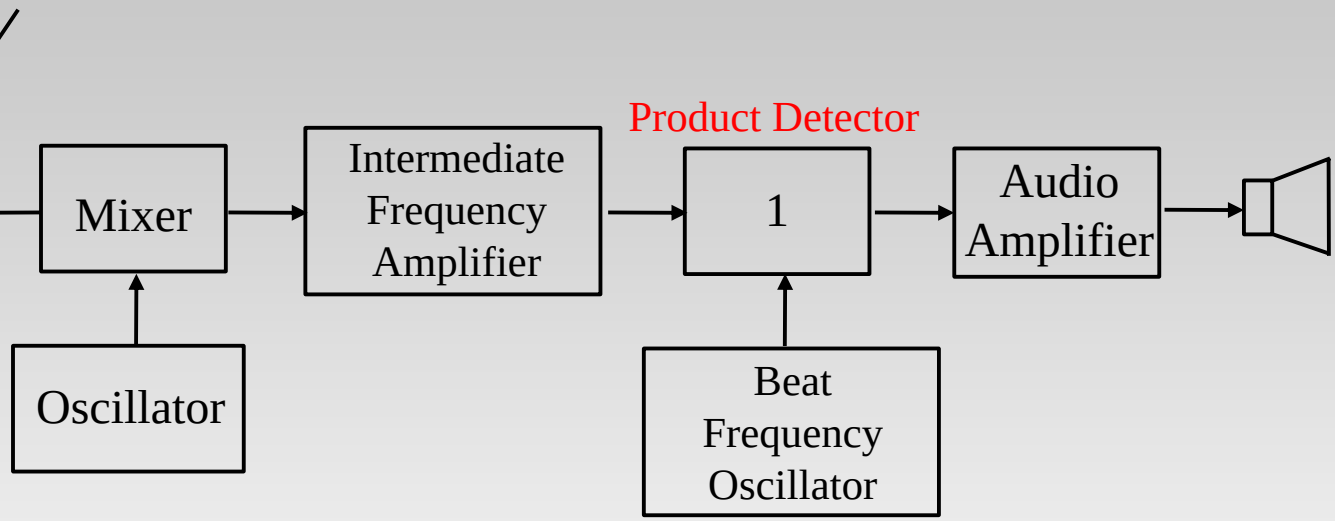



If the Audio Amplifier in this FM transmitter failed the output would be an un-modulated carrier.

# *Frequency Modulation*

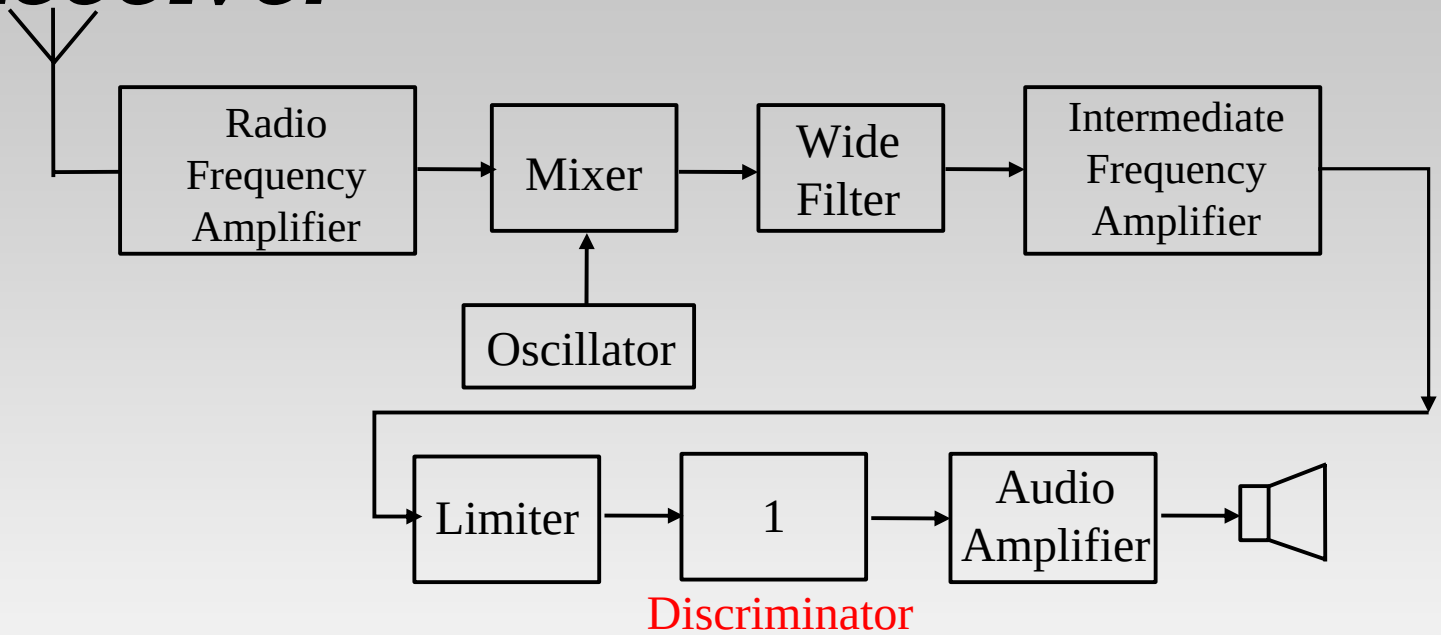
- FM transmitters operate at full power at all times, even with no audio input.
- When an FM transmitter over-modulates, the transmitted signal becomes so wide (bandwidth) it may cause out-of-channel emissions and interfere with adjacent channels.  This is called over-deviation.
- If you are told you are over deviating you can talk farther away from the microphone.
- FM is effective for local VHF/UHF communications because the audio is less affected by static-type electrical noise.

# *Simple CW & SSB Receiver*



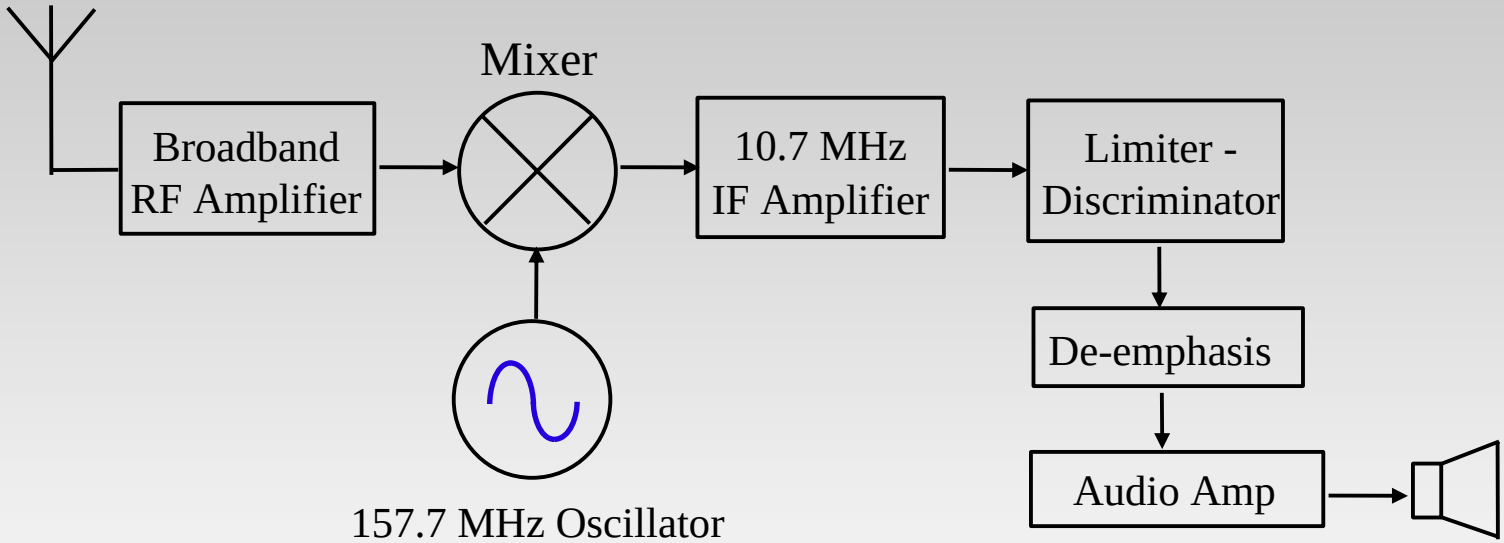

- The Mixer shifts the received signal frequency to an Intermediate Frequency (IF) for processing.
- The IF Amplifier adds gain and filtering.
- Many receivers have several IF filters of different bandwidths because some emission types need a wider bandwidth than others.
- The Product Detector mixes the IF with the Beat Frequency Oscillator (BFO) and restores the carrier and recovers the audio.

# *FM Receiver*




- The IF Amplifier and Limiter remove unwanted amplitude variation.
- The Discriminator recovers the modulation signal from the Frequency Modulated IF signal.
- If a receiver has a DISCRIMINATOR it is an FM receiver.
- If the discriminator FAILS there is no audio output.

# *FM Receiver*

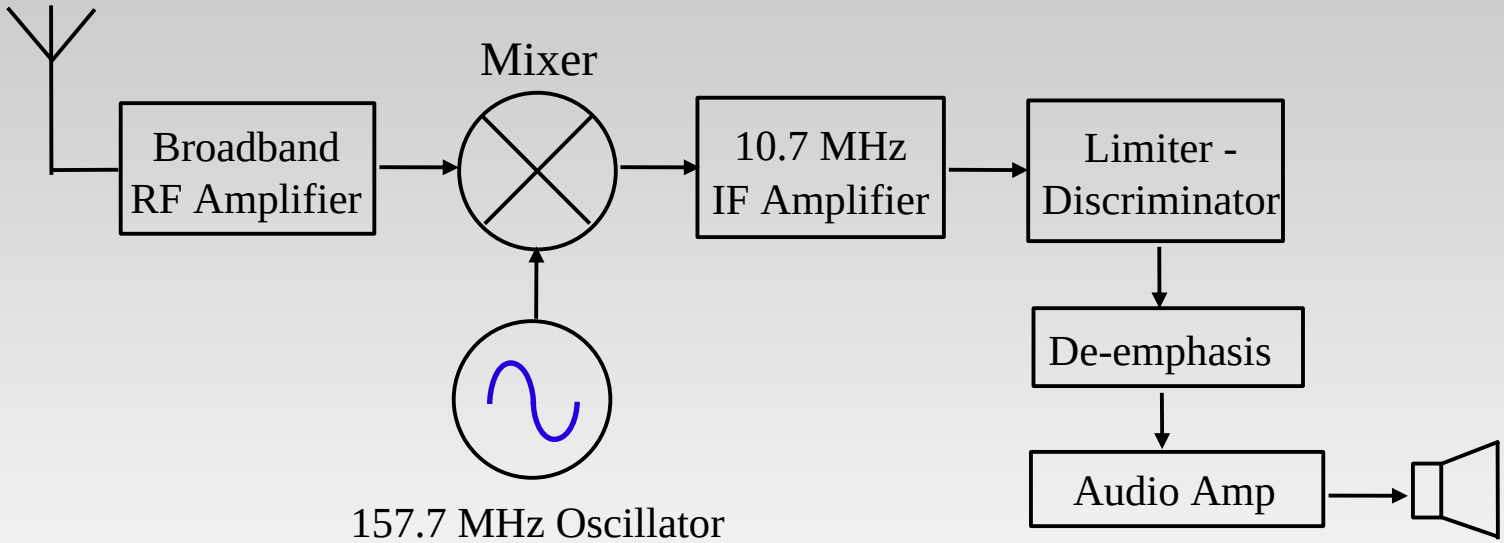



This receiver could receive signals on 147.0 MHz or 168.4 MHz.

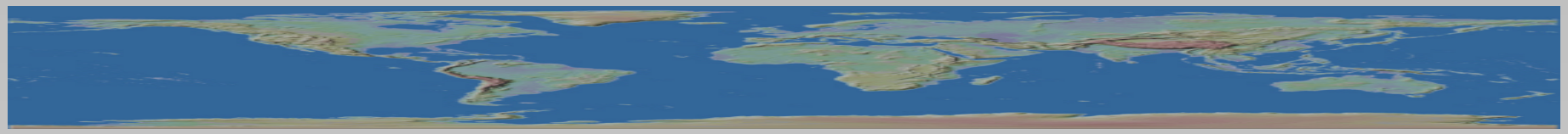
157.7 MHz Oscillator minus 10.7 MHz IF = 147.0 MHz

or 157.7 MHz plus 10.7 MHz = 168.4 MHz

# *FM Receiver*




- This is a single-conversion super-heterodyne receiver because it has only one IF stage.
- This is an FM receiver because it has a DISCRIMINATOR.
- FM receivers have a SQUELCH which should be set at the point that it just silences background noise.



# *Receivers*

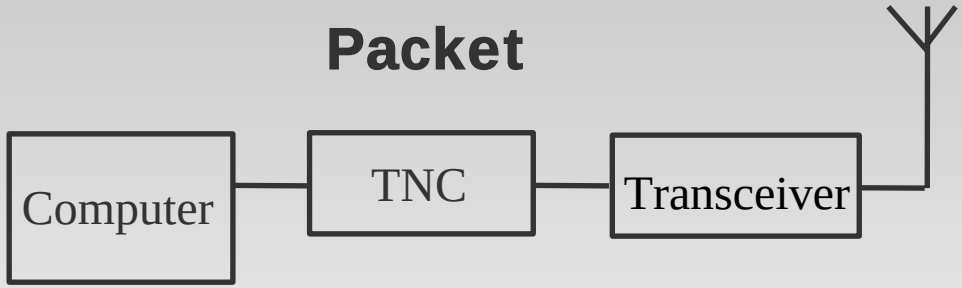
- All receivers have a “detector” circuit function.
  - In a CW/SSB receiver it is called a product detector
  - In an FM receiver it is called a discriminator.
- One way to accurately check a receiver's tuning accuracy is to tune into one of the frequencies of station WWV or WWVH.
  - Transmits the time and other information on exactly 2.5, 5, 10, 15, & 20 MHz.

# *VHF / UHF Multimode Transceiver*

- VHF / UHF transceivers are available which will operate on FM as well as AM, SSB, and CW.
- These transceivers are well suited for “weak-signal” communications work.

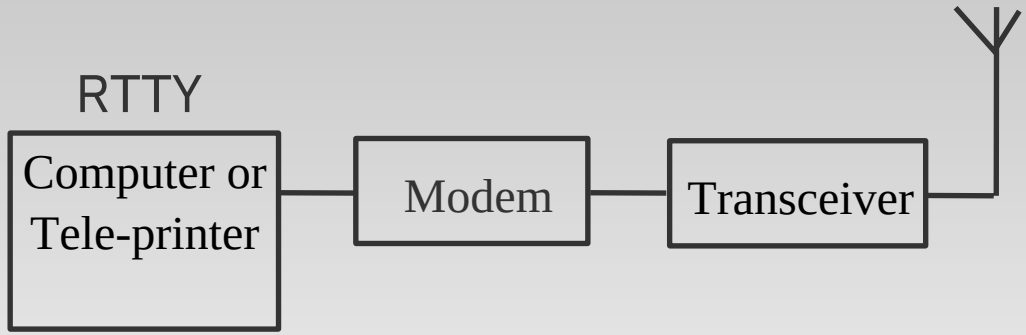
# *Data Communications - Packet*

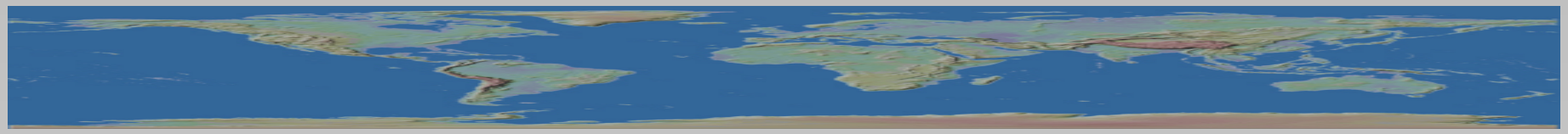
- Packet uses a terminal node controller (TNC) to interface a computer and transceiver.
- A TNC breaks the data to be transmitted into packets which includes error checking information.
- On VHF an FM transceiver may be used for packet.
- Since packet uses data carrier detect the receiver's squelch must be set to quiet the noise or the TNC may falsely detect a data carrier.




# *Data Communications - RTTY*

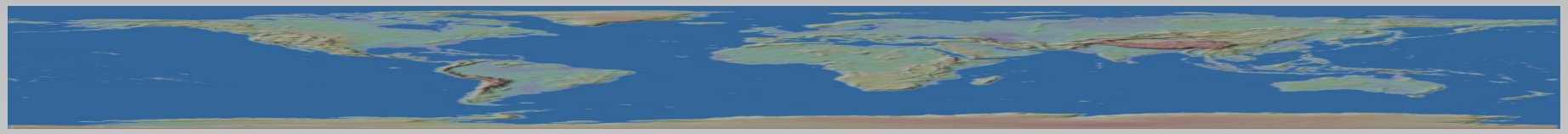
- A modem and Tele-printer or computer are connected to a transceiver for RTTY operation.
- An FM transmitter could be used for RTTY on the VHF / UHF bands.
- RTTY transmits in a continuous stream and has no error checking.



# *Station Accessories*

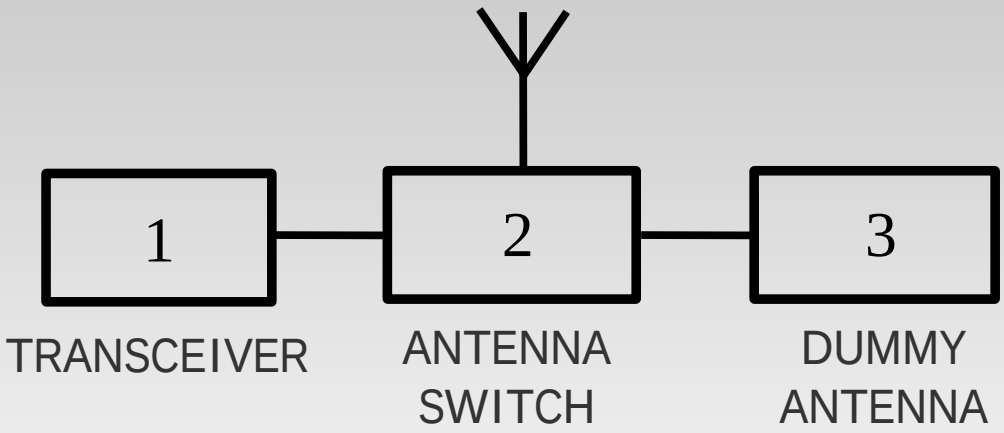
- A power supply converts 120 v AC to 12 v DC and is necessary to run a mobile transceiver in the house.
  - A 12 volt battery may be substituted for a power supply.
- A microphone must be connected to a transceiver for voice operation.
- A telegraph key is needed for CW operation.
  - An electronic-key can be used to help form good Morse code characters.
- A dummy antenna (load) is used to adjust or troubleshoot a transmitter without transmitting a signal.
  - If it is used with a 100-watt, SSB phone transmitter it should have a minimum rating of 100 watts continuous.



# *More Station Accessories*

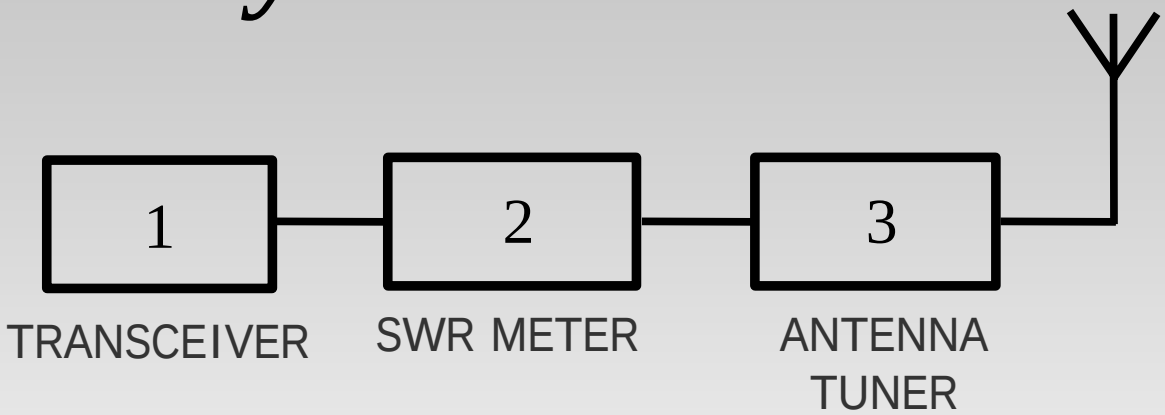
- A duplexer is used to connect a dual-band transceiver with separate VHF & UHF outputs to a dual-band antenna.
  - Most “dual-band” transceivers cover 2 meters and 70 cm.
- A power amplifier may be useful to boost the low-power output from a hand-held transceiver up to 100 watts.
- An SWR meter may be connected between a transceiver and an antenna switch connected to several antennas to check & monitor the match to the antenna.

# *Station Layout*



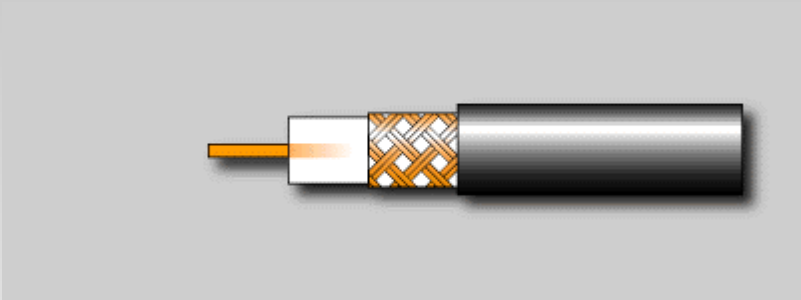

An antenna switch can be used to connect the transceiver to one of several antennas or to a dummy antenna.

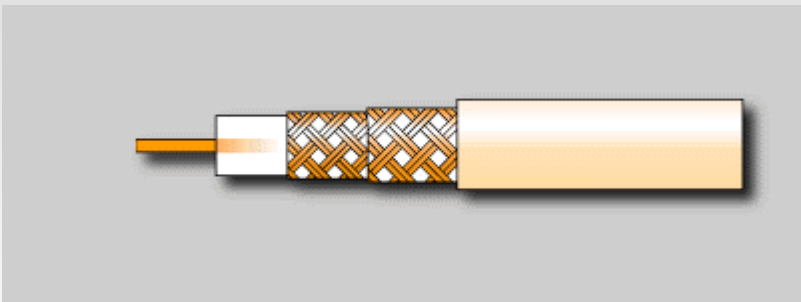
# *Station Layout*

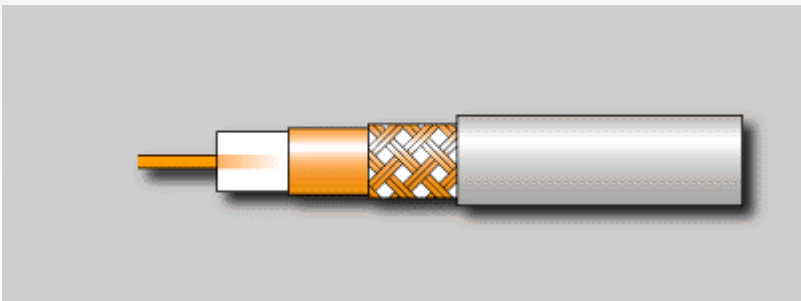



- An Antenna Tuner connects directly to an antenna and allows an antenna to be used on a band it was not designed for.
- An SWR Meter is used to measure the standing wave ratio and can be used to properly adjust an antenna tuner.

# *Coaxial Cable*



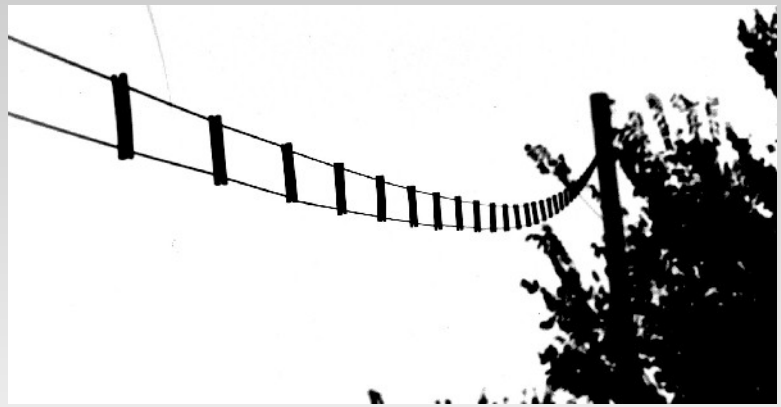




- Coaxial cable has a centred wire inside an insulating material covered by a shield and an insulating cover.
- Good quality coax should be used for a UHF antenna system to keep RF loss low.
- Radio energy is converted to heat in a poor quality coaxial cable.
- Coax is Unbalanced Feed-line in that one conductor is connected to ground.

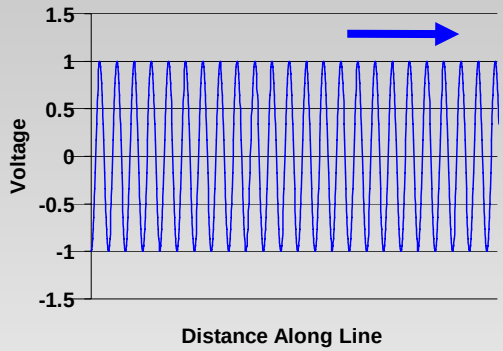
# *Parallel-Conductor Feed Line*

- Consists of two wires held apart by insulating material.
- Parallel-conductor, open wire feed line will operate well even with high SWR and has less loss than coax.
- Parallel-conductor feed-line is balanced.

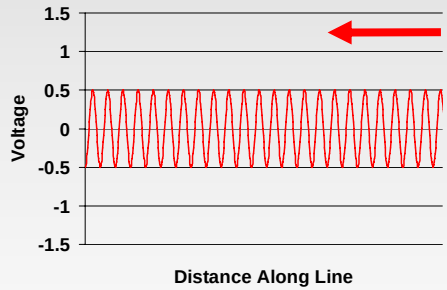


# *Concept of Standing Wave Ratio*

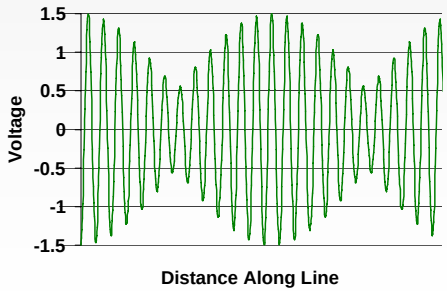
- If an antenna system matches the characteristic impedance of the transmitter all the power is radiated. Power travelling from the transmitter to the antenna is called *Forward Power*.
- If an antenna system does not match the characteristic impedance of the transmitter, some of the power is reflected back to the transmitter. This is called *Reflected Power*.
- At any point along the transmission line, the Forward Power and Reflected Power will add or subtract.
- The Ratio of the Maximum Voltage to Minimum Voltage along the line is called *Standing Wave Ratio* (SWR).




**1 Volt**



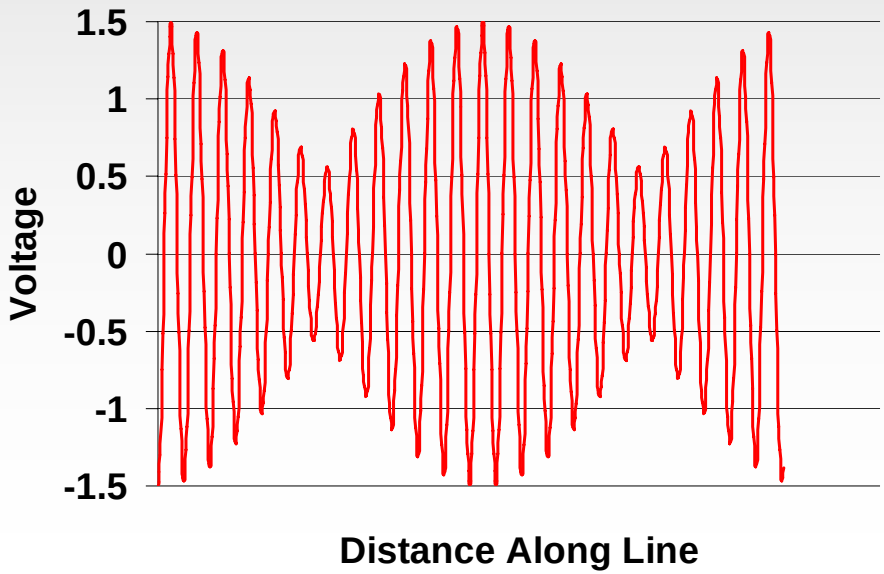

**0.5 Volt**




**R=1.5/0.5 = 3**

# *Calculation of SWR*

- Visualize a coax with a slot in it so that a voltmeter probe can be inserted.
- Slide the probe along the line and record the maximum and minimum voltage.
- Calculate the ratio of maximum to minimum voltage.




V Max = 1.5

V Min = 0.5

SWR = $V_{Max}/V_{Min}$

= 1.5/0.5

= 3

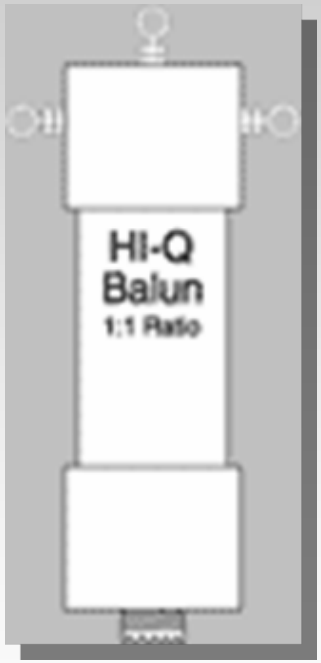
# *SWR Analysis*

- An SWR of 1:1 would indicate the impedance of the antenna and its transmission line are matched.
- An SWR of 4:1 would indicate an impedance mismatch; something may be wrong with the antenna system.
- If a directional RF wattmeter has a forward power reading of 90 watts and a reflected power reading of 10 watts the actual transmitted power would be 80 watts.
- Most RF watt-meters operate with a line impedance of 50 ohms.

# *The Antenna Tuner*

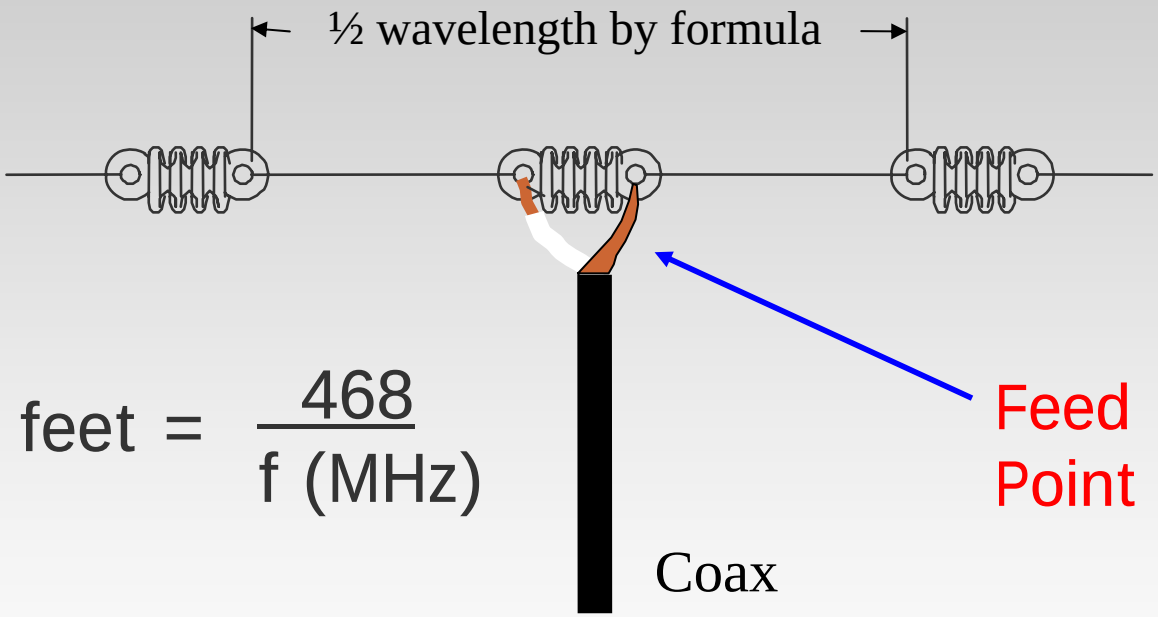

"Antenna Tuners" do not really tune antennas. They provide an impedance match between the transmitter output impedance and the antenna system impedance.

# *The Balun*




- "Balun" means BALanced to Unbalanced.
- The balun converts from balanced feed line to unbalanced feed lines.
- A balun would be installed between the coax and the antenna to feed a dipole antenna with 50-ohm coax.

# *The 1/2 Wave Dipole*



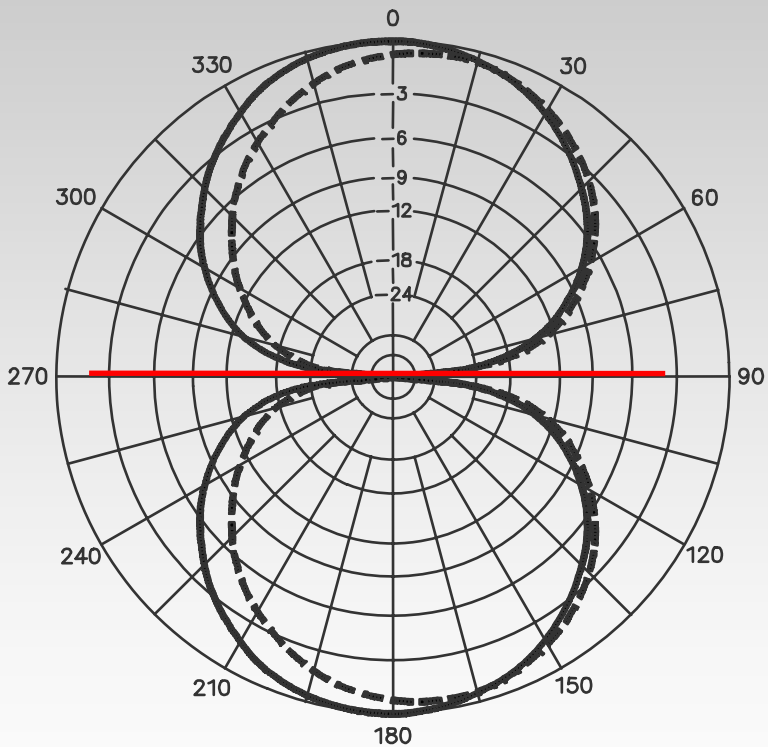

Length of dipole in feet = $\frac{468}{f\ (MHz)}$

The physical length of a dipole and other antennas can be reduced without changing its resonant frequency by adding a loading coil.

# *The 1/2 Wave Dipole*

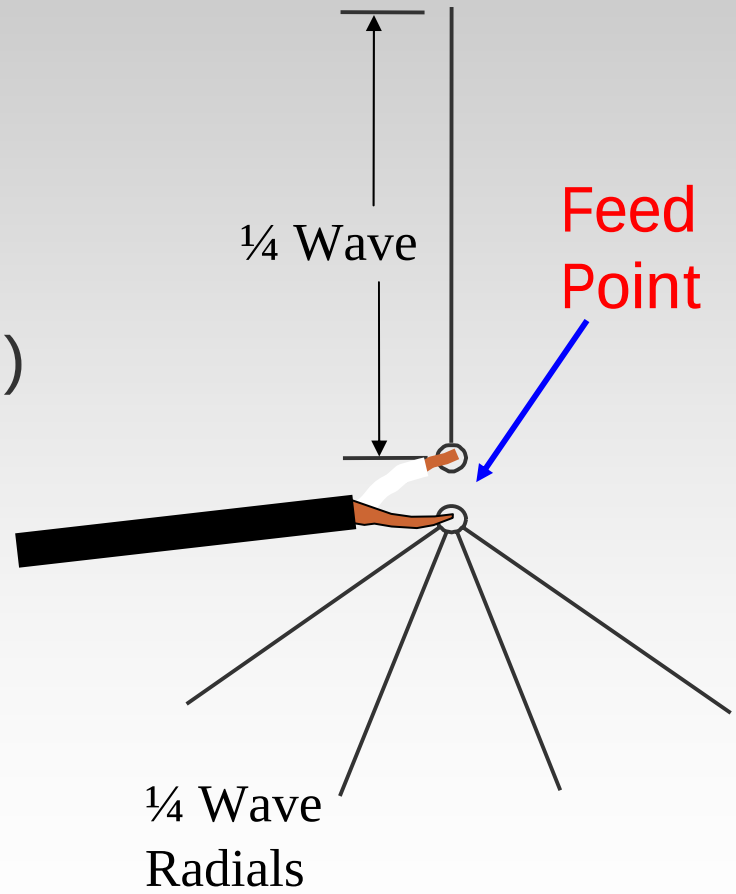
Radiation pattern for a dipole antenna looking down from above the antenna.

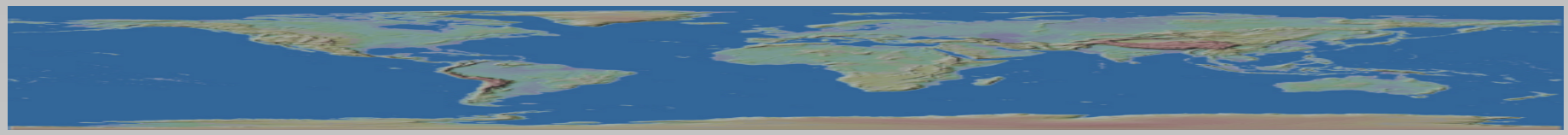
If the ends of a ½ wave dipole antenna point east and west most of the radio energy is radiated north and south.



# *The 1/4 Wave Vertical*

$$\text{Length of vertical in feet} = \frac{234}{f\ (\text{MHz})}$$





# ½ Wave & ¼ Wave Exercise

A half-wave dipole for 147 MHz = 37 inches

A half-wave dipole for 223 MHz = 25 inches

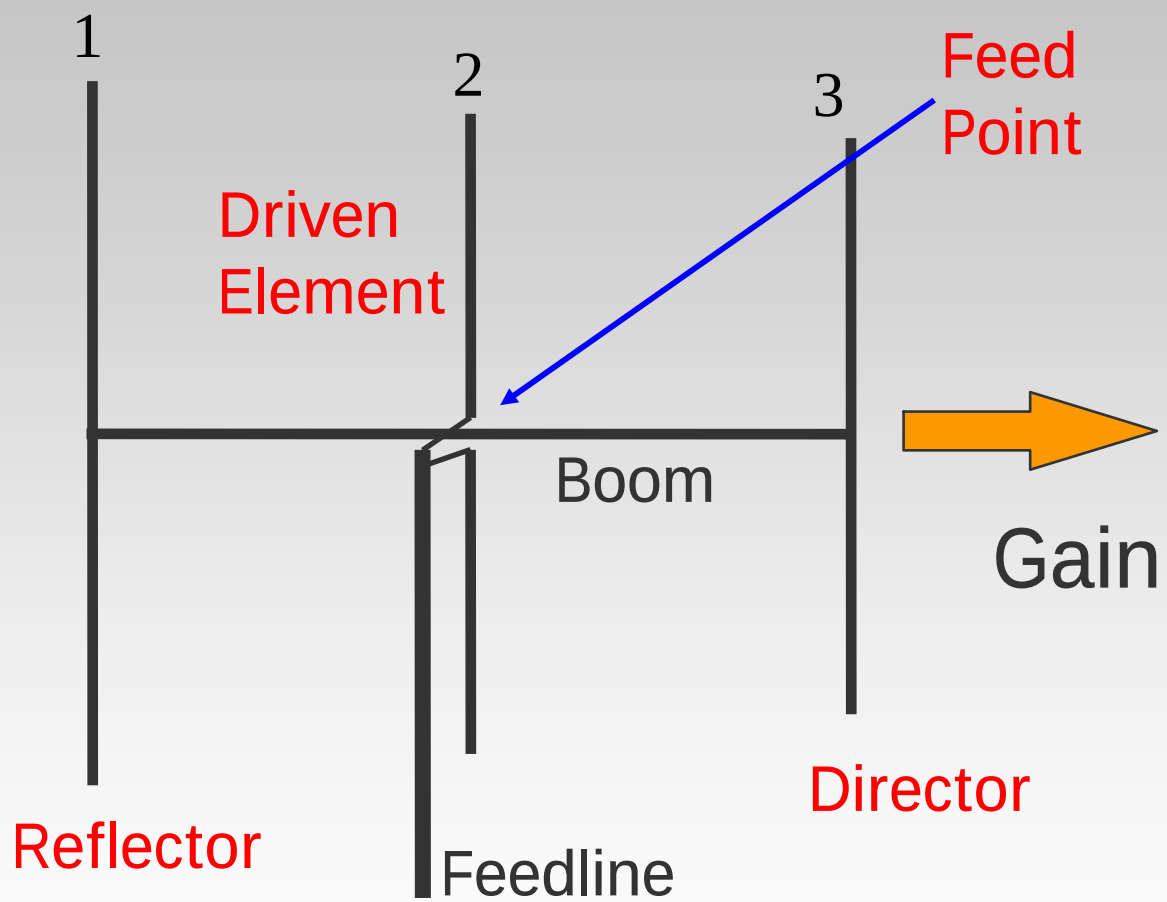
A quarter-wave vertical for 146 MHz = 19 inches

A quarter-wave vertical for 440 MHz = 6 inches

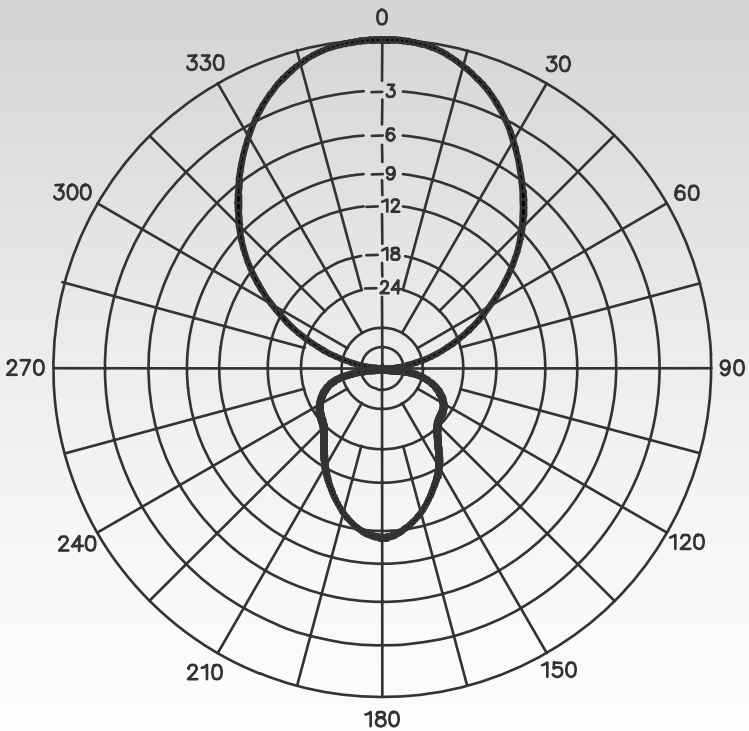
# *The Yagi*

The Driven Element is approximately ½ wavelength long.

The Boom length has the greatest effect on the gain of a Yagi.



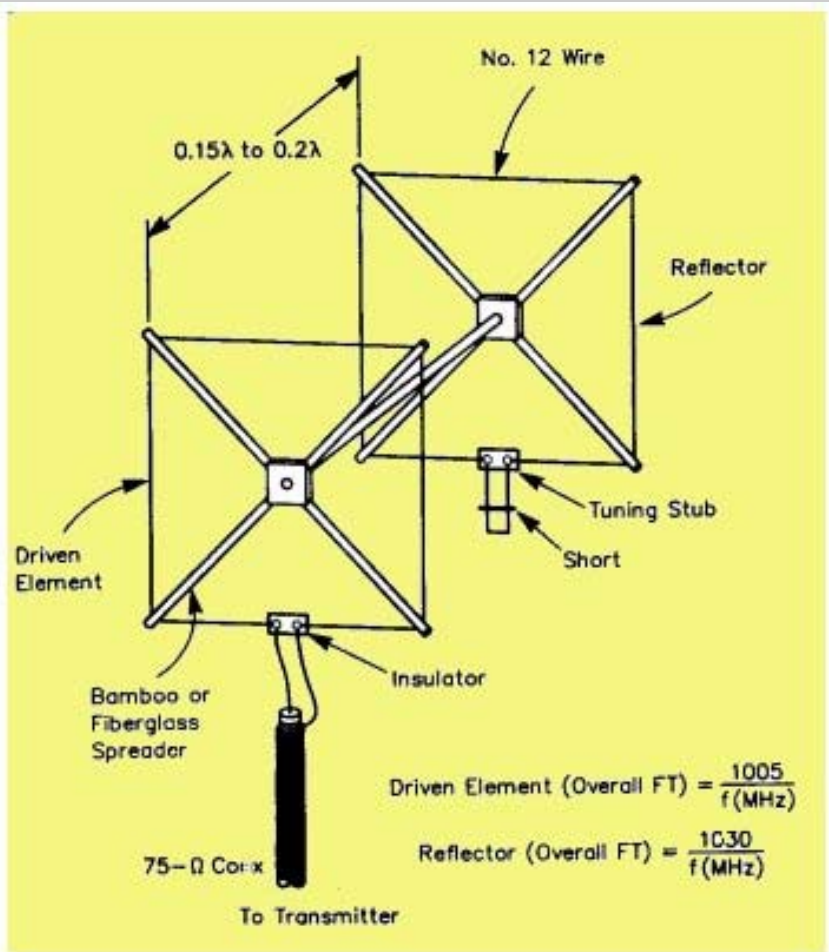
# *The Yagi*

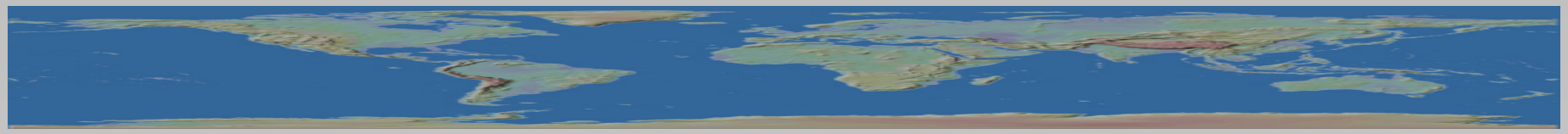



- The yagi antenna focuses RF energy in one direction, giving the appearance of getting “free power.”
- This free power is called Antenna Gain.
- If an antenna has a gain of 3 dB the effective radiated power will double.
- Many yagis are multi-band antennas allowing them to operate on several bands with a single feed line.

# *Cubical Quad Antenna*

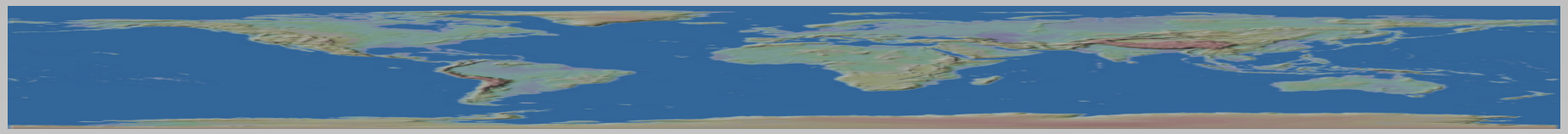
A cubical quad has two or more parallel four-sided wire loops, each approximately one-electrical wavelength long.





# *Radio Wave Polarization*

- With *horizontal* polarization the electric lines of force of a radio wave are parallel to the Earth's surface. Horizontal antennas produce horizontal polarization.
- With *vertical* polarization the electric lines of force of a radio wave are perpendicular to the Earth's surface. Vertical antennas produce vertical polarization.
- Most VHF and UHF repeater antennas use vertical polarization.
- Most weak signal VHF / UHF SSB operation is done with horizontal polarization.
- Most satellite operation uses circular polarization.

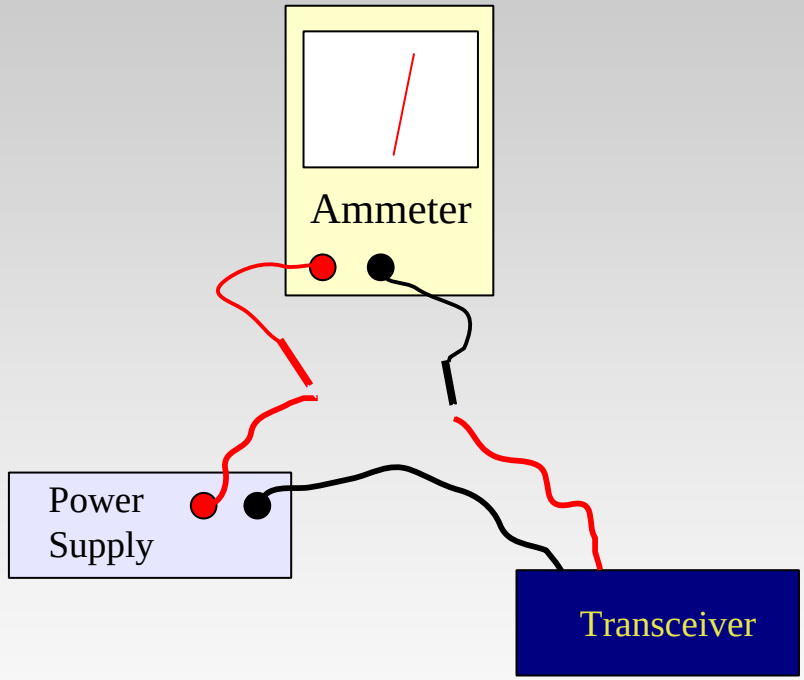


# *VHF / UHF Antenna Considerations*

- Most hand-held transceivers come with a “rubber duck” antenna which is much less efficient than a quarter-wavelength telescopic antenna.
- The operation of a hand-held transceiver in a vehicle will be greatly improved by using an external antenna on the vehicle roof.

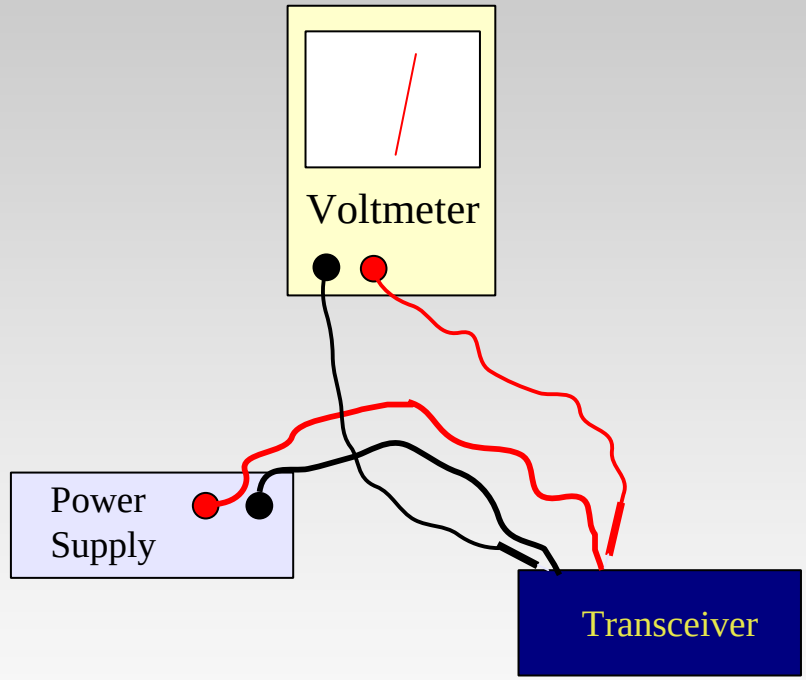
# *Ammeter*

- An ammeter measures current.
- An ammeter is connected in series with the circuit under test.



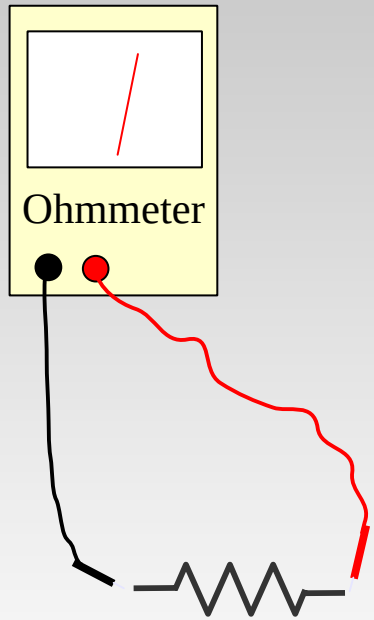
# *Voltmeter*

- A voltmeter is used to measure electromotive force.
- A voltmeter is connected in parallel with the circuit under test.
- When you switch a voltmeter to a higher range resistance is added in series with the meter.



# *Ohmmeter*

An ohmmeter is used to measure DC resistance.



# *Multi-meter*

Multi-meters will measure Voltage, Current and Resistance.

Be sure it is set properly to read what is being measured.

If it is set to the ohms setting and voltage is measured the meter could be damaged!

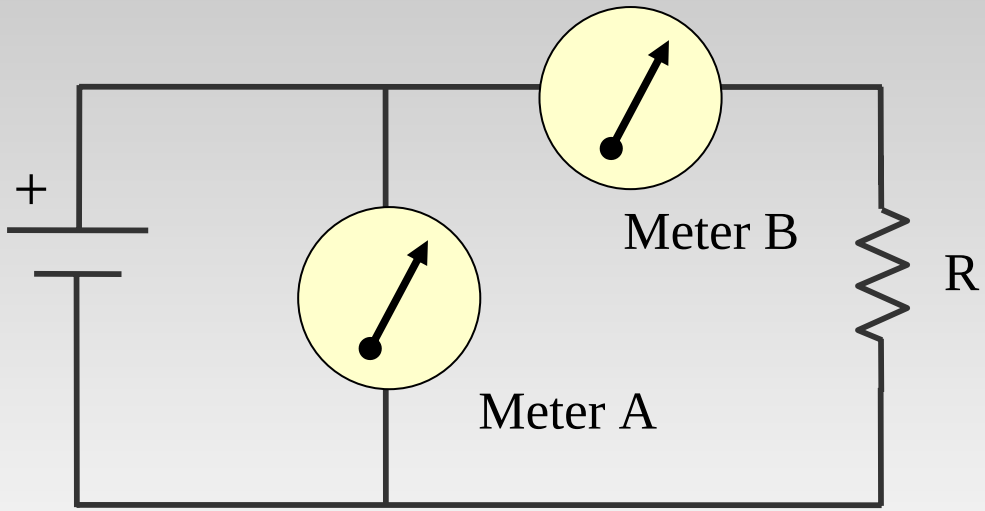
# *Meter Exercise*

What circuit quantity would meter A indicate?

Battery voltage

What circuit quantity would meter B indicate?

The current flowing through the resistor

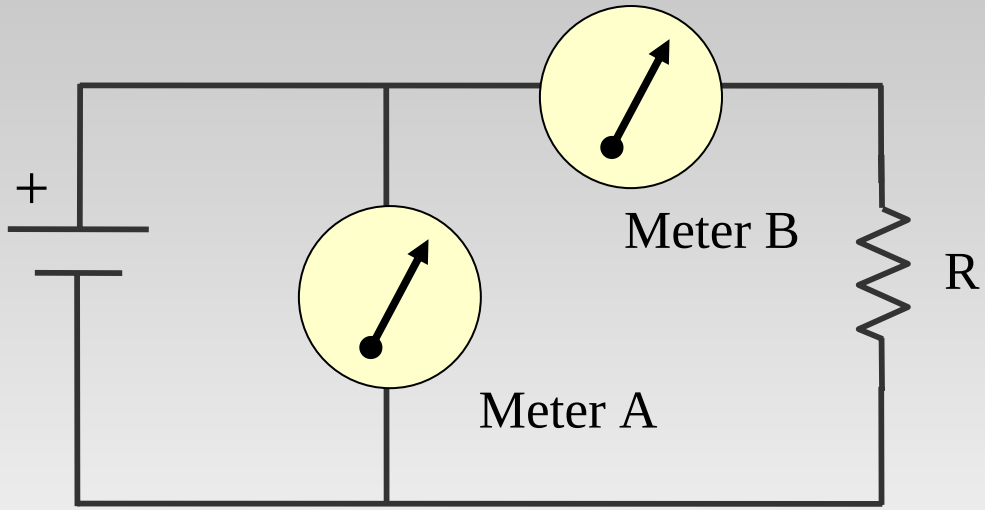


# *Power*

Power is measured in Watts

$W = E \times I$

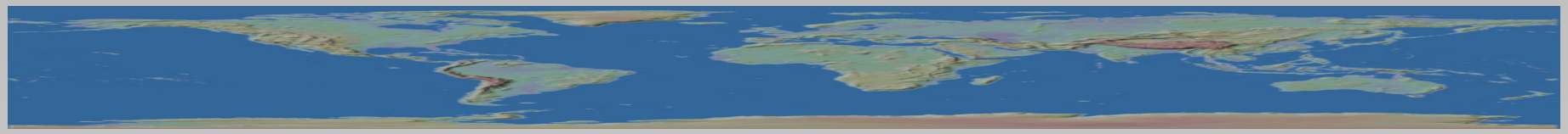
Ohms law states $E = I \times R$




Substituting I x R for E in the power equation gives:

$W = I \times R \times I = R \times 2 \times I = R \times I^2$

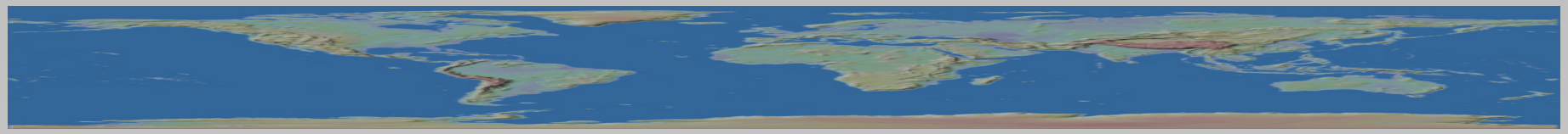
So, for this circuit, the power consumed in the resistor can be calculated by multiplying the value of the resistor times the square of the reading of Meter B.



# *Soldering Safety*

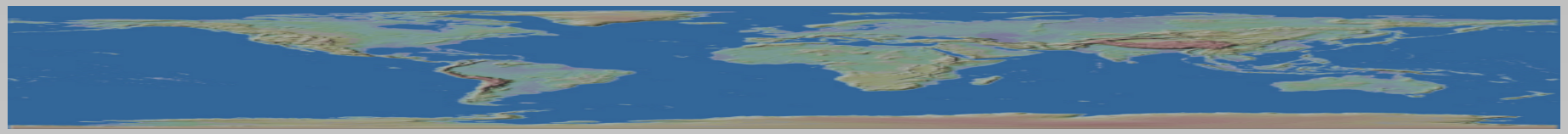
When using a soldering iron or gun keep in mind the following safety considerations:

- A soldering iron gets very hot, make sure no one touches it for at least 10 min after turning it off.
- Wear safety glasses, occasionally molten solder will splash.
- Solder in a well ventilated area.  The fumes can be hazardous.



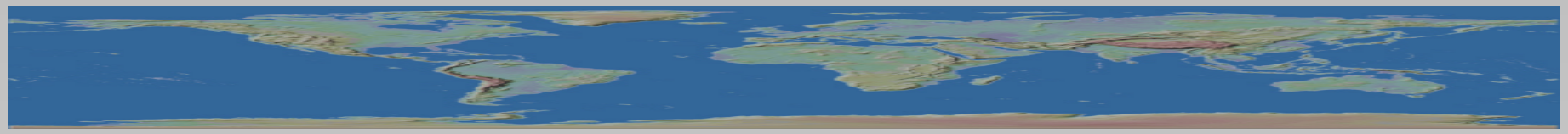
# *Basic Troubleshooting*

- If a rig works in the car but not in the house the first thing to check is the power supply.
- If a mobile transceiver does not power up check the 12 volt fuses.
- If it is suspected the supply voltage to a rig is low, check the voltage with a voltmeter at the 12 volt plug on the rig rather than at the power supply or battery.



# *More Basic Troubleshooting*

- If AC hum is reported on a CW transmitter's RF signal additional filtering of the power supply may be required.
- Stray noise and RF pick-up may be reduced by providing adequate DC source supply filtering for a mobile transceiver.
- A signal generator produces a stable, low-level signal that can be set to a specific frequency and may be useful for checking a receiver.



# *Homework*

- Study Sub element T8 of the question pool.
  - **Read the *Question* and the *Answer* Three Times.**
- Read Chapter 8 in “Now You're Talking”.