US Amateur Radio Bands

US AMATEUR POWER LIMITS

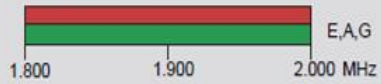
FCC 97.313 An amateur station must use the minimum transmitter power necessary to carry out the desired communications. (b) No station may transmit with a transmitter power exceeding 1.5 kW PEP.

Effective Date March 5, 2012

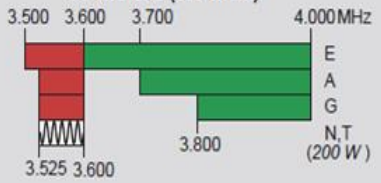
Published by:
ARRL The national association for AMATEUR RADIO®
www.arrl.org
225 Main Street, Newington, CT USA 06111-1494

160 Meters (1.8 MHz)

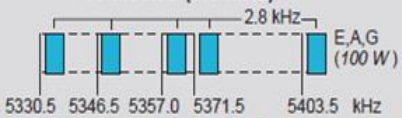
Avoid interference to radiolocation operations from 1.900 to 2.000 MHz



80 Meters (3.5 MHz)

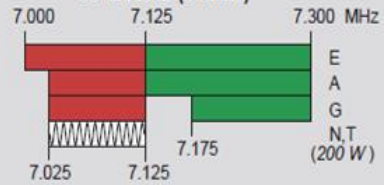


60 Meters (5.3 MHz)



General, Advanced, and Amateur Extra licensees may operate on these five channels on a secondary basis with a maximum effective radiated output of 100 W PEP. Permitted operating modes include upper sideband voice (USB), CW, RTTY, PSK31 and other digital modes such as PACTOR III as defined by the FCC Report and Order of November 18, 2011. USB is limited to 2.8 kHz centered on 5332, 5348, 5358.5, 5373 and 5405 kHz. CW and digital emissions must be centered 1.5 kHz above the channel frequencies indicated above. Only one signal at a time is permitted on any channel.

40 Meters (7 MHz)



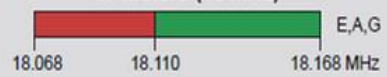
Phone and Image modes are permitted between 7.075 and 7.100 MHz for FCC licensed stations in ITU Regions 1 and 3 and by FCC licensed stations in ITU Region 2 West of 130 degrees West longitude or South of 20 degrees North latitude. See Sections 97.305(c) and 97.307(f)(11).
Novice and Technician licensees outside ITU Region 2 may use CW only between 7.025 and 7.075 MHz and between 7.100 and 7.125 MHz. 7.200 to 7.300 MHz is not available outside ITU Region 2. See Section 97.301(e). These exemptions do not apply to stations in the continental US.

30 Meters (10.1 MHz)

Avoid interference to fixed services outside the US.

20 Meters (14 MHz)

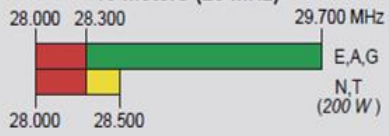
17 Meters (18 MHz)



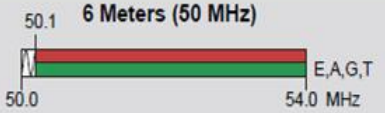
15 Meters (21 MHz)

12 Meters (24 MHz)

10 Meters (28 MHz)



6 Meters (50 MHz)

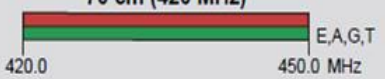


2 Meters (144 MHz)

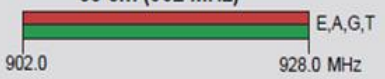
1.25 Meters (222 MHz)

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

70 cm (420 MHz)*



33 cm (902 MHz)*



23 cm (1240 MHz)*

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

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

* No pulse emissions

KEY

Note:
CW operation is permitted throughout all amateur bands.

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

Test transmissions are authorized above 51 MHz, except for 219-220 MHz

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

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

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

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email: newham@arrl.org

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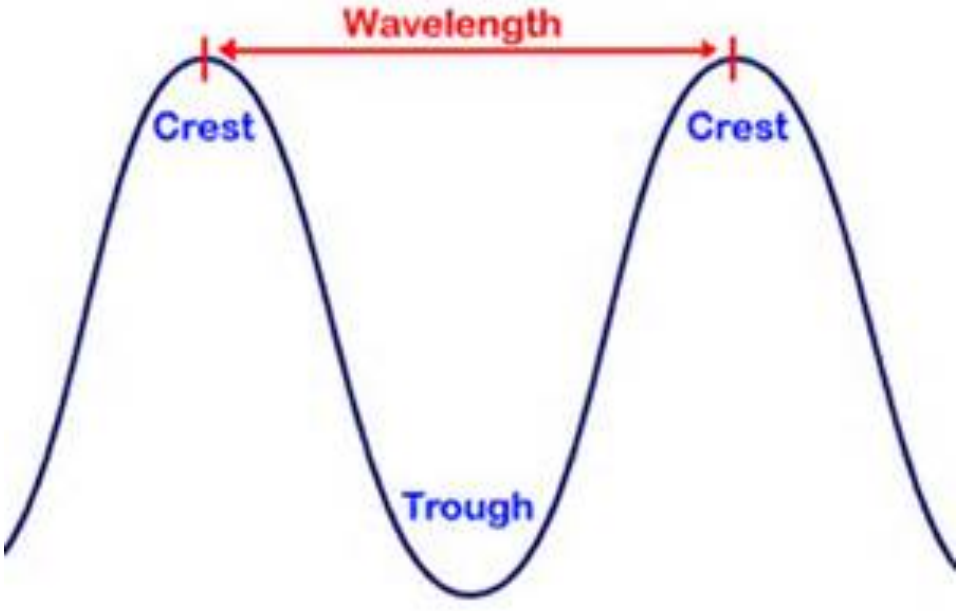
 rev. 4/12/2012

Callsign Groups

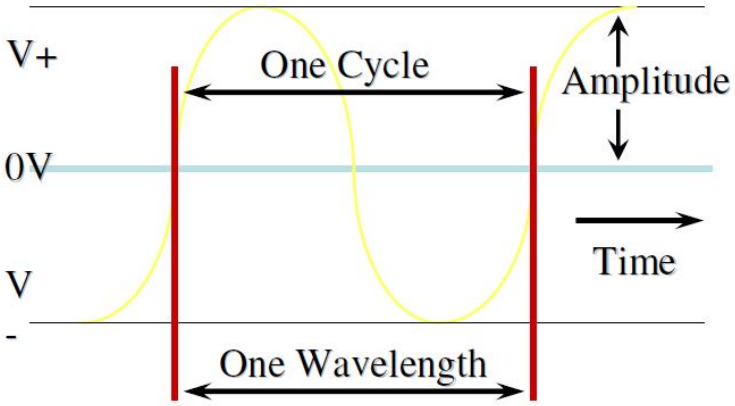
All valid US Callsigns start with A, K, N or W
and contain a digit 0-9

Group A	**1x2, 2x1** **W1AW, KU7M**
Group B	**2x2** **KK7LK**
Group C	**1x3** **N7WSU**
Group D	**2x3** **KB7PJM**



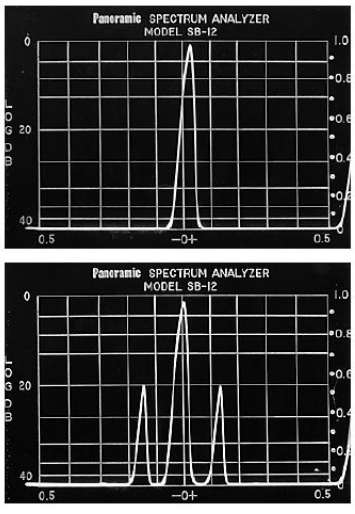
Wavelength vs Frequency

The distance a radio wave travels in one cycle is called wavelength
The number of cycles per second is frequency
The maximum displacement of wave from reference value is amplitude



High Frequency (HF): 3 MHz – 30MHz
Very High Frequency (VHF): 30MHz – 300MHz
Ultra High Frequency: 300MHz – 3000MHz (3GHz)

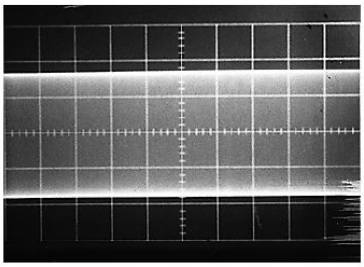
Amplitude Modulation



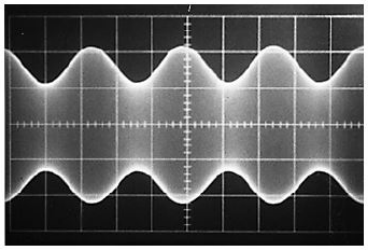
An unmodulated RF carrier requires narrow bandwidth

Modulation of the carrier creates sidebands. This requires more bandwidth. Transmitter power is spread across this bandwidth

Amplitude Modulation

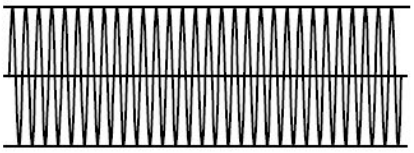


An unmodulated RF carrier wave

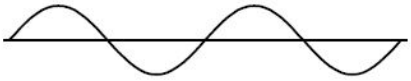


A carrier wave amplitude modulated (AM) with a simple audio tone

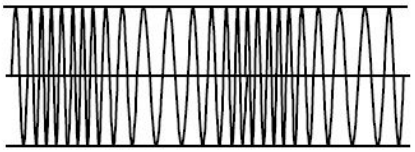
Frequency Modulation



Unmodulated carrier, full power at all times

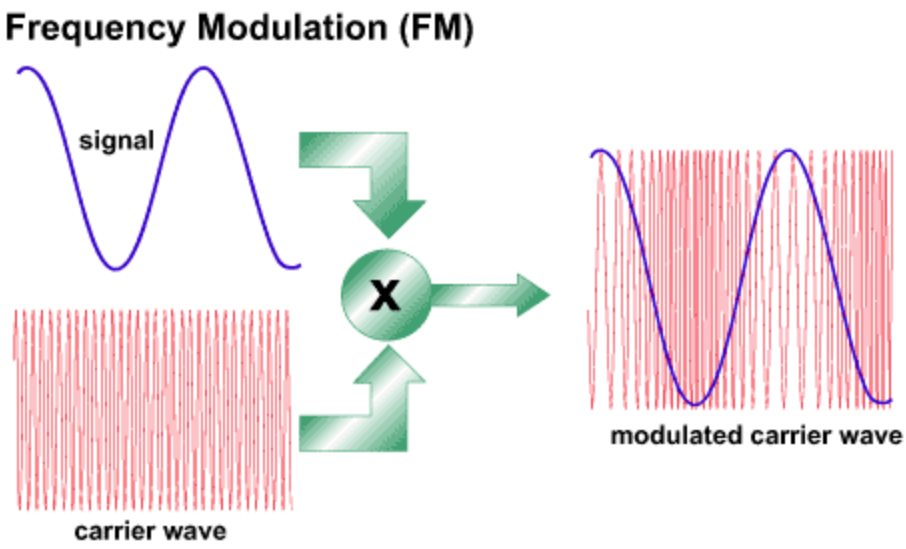


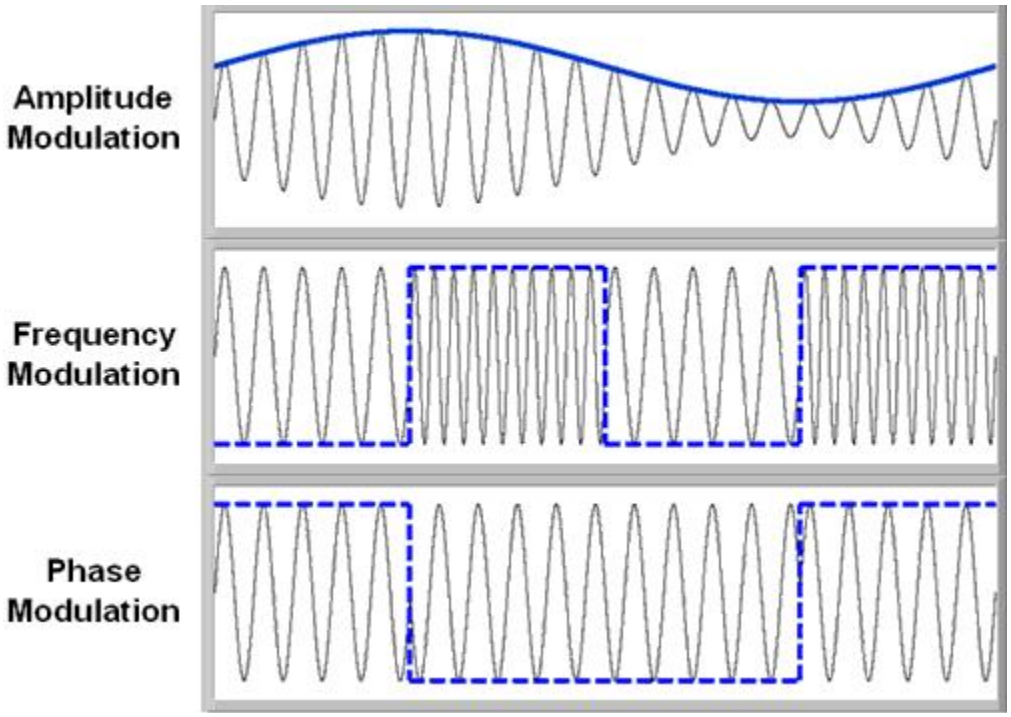
Waveform of modulating signal

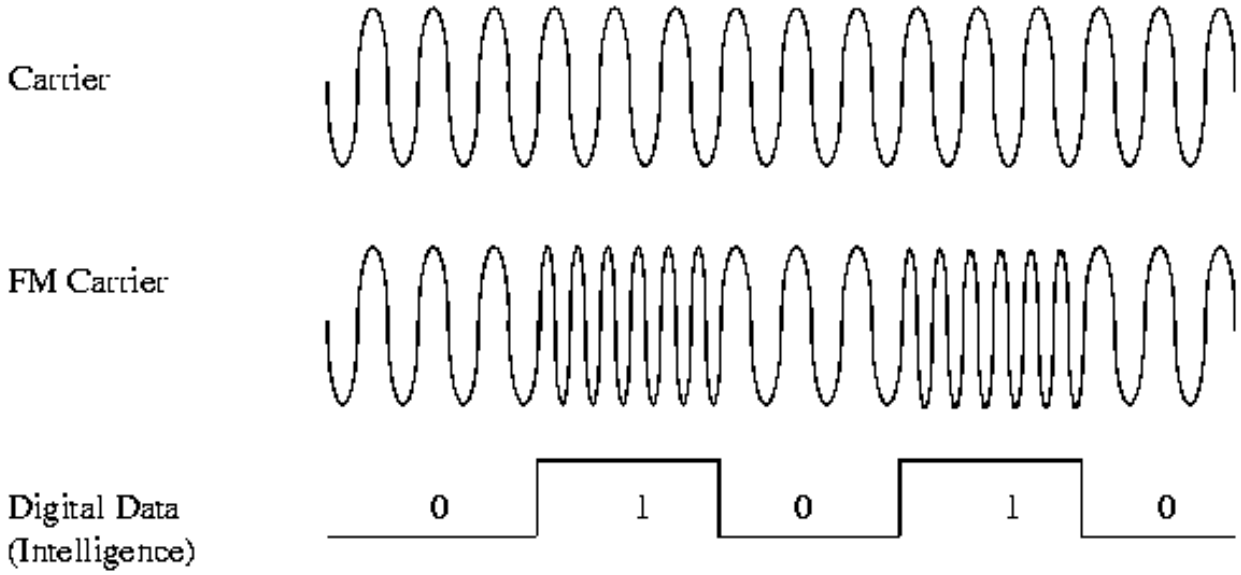


Modulated carrier with frequency deviation and constant amplitude

"Over modulation" called "over deviation" on FM, causes the signal to become wider and potentially cause adjacent channel interference. Phase Modulation (PM) uses a reactance modulator and is similar to FM and can be received with the same equipment.


Frequency Modulation (FM)
signal
X
modulated carrier wave
carrier wave


Amplitude Modulation
Frequency Modulation
Phase Modulation



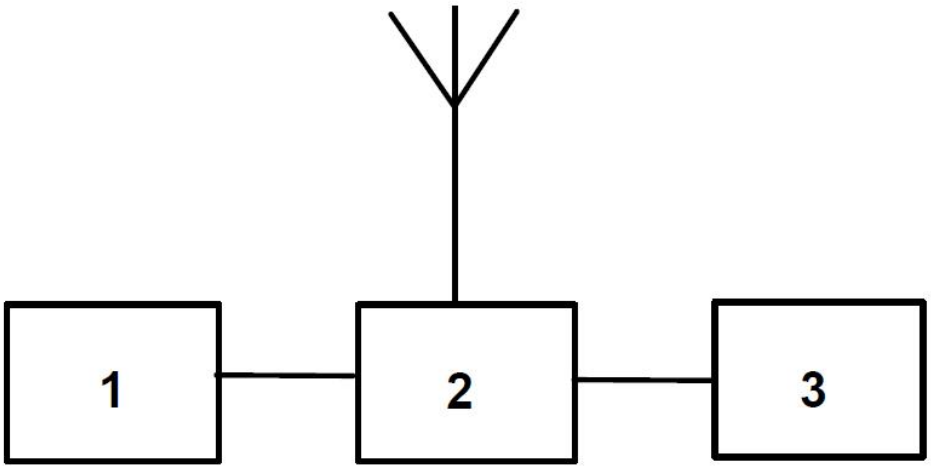


Figure T5

Metric Units of Measure

10^9	10^6	10^3	10^2	10^1	10^0	10^{-1}	10^{-2}	10^{-3}	10^{-6}	10^{-9}
G	M	k	h	da		d	c	m	μ	n
giga	mega	kilo	hecto	deca		deci	centi	milli	micro	nano
Billions	Millions	Thousands	Hundreds	Tens		Tenths	Hundredths	Thousandths	Millionths	Billionths

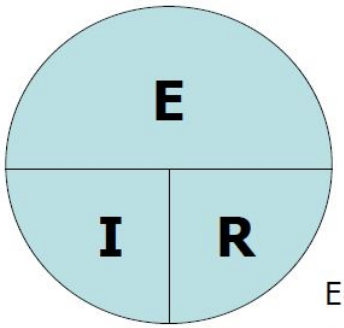
Gigahertz	**1,000,000,000**
Megahertz	**1,000,000**
Kilohertz	**1,000**
Hertz	**1**

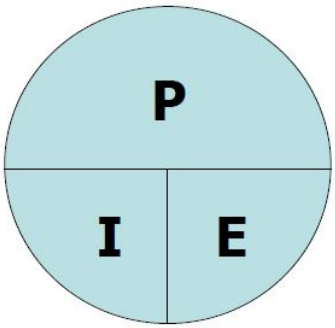
Ampere	**1**
Milliampere	**0.001**
Microampere	**0.000001**
Nanoampere	**0.000000001**

Note the shift in decimal places. This is standard metric notation. 1 Gigahertz is 1 Billion Hertz and a Nanoampere is 1 Billionth of an Ampere.

Ohm's Law and Power Calculations

To solve for a value, cover it with your finger and solve the remaining formula





E=Voltage (Volts)

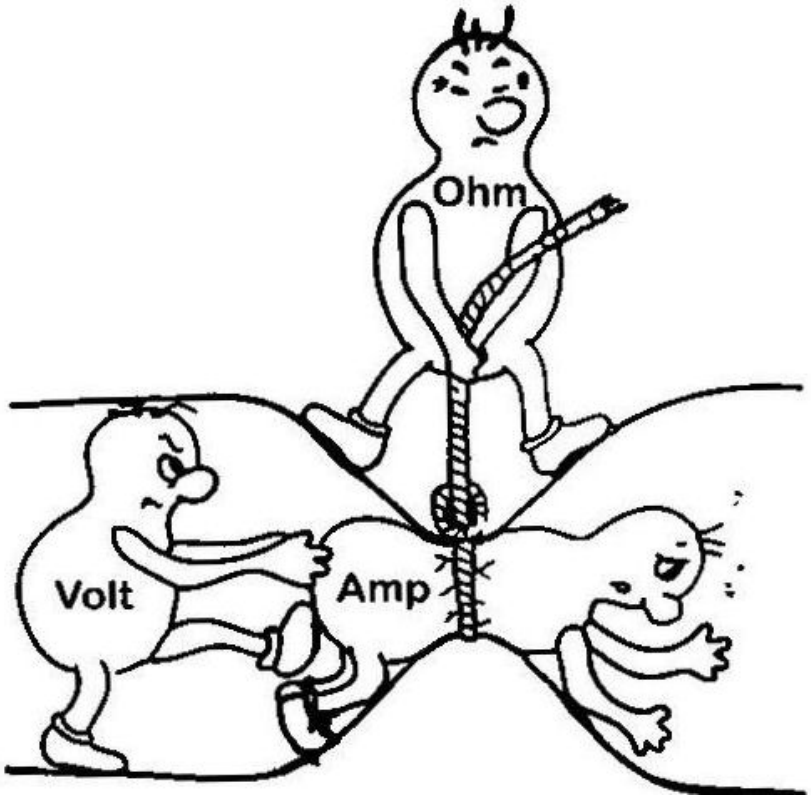
I=Current (Amps)

R=Resistance (Ohms)

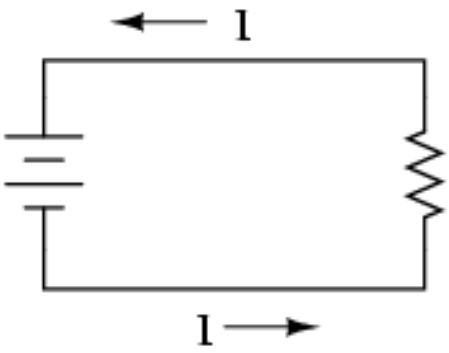
P=Power (Watts)

Units of Measure

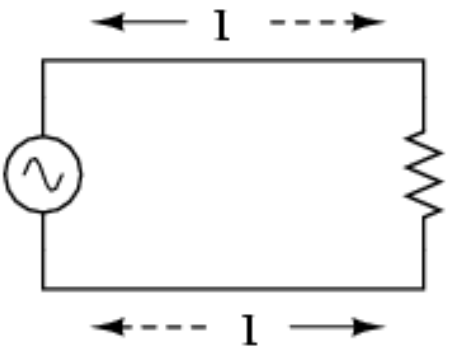
Power	Watt
Resistance	Ohm
Capacitance	Farad
Inductance	Henry
Voltage	Volt
Current	Ampere
Frequency	Hertz



DIRECT CURRENT (DC)

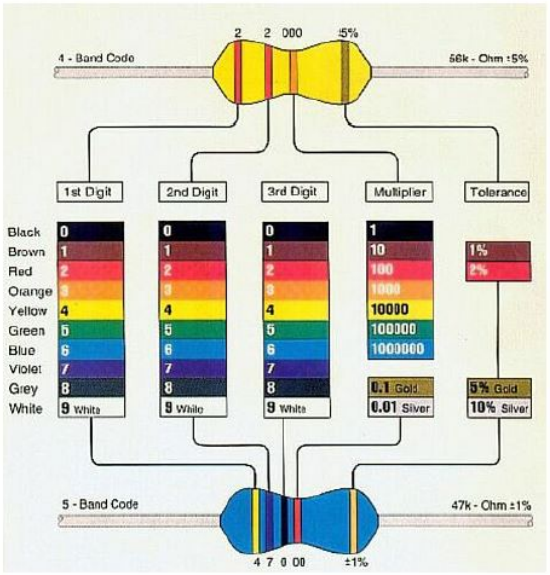


ALTERNATING CURRENT (AC)



Resistors

Resistor



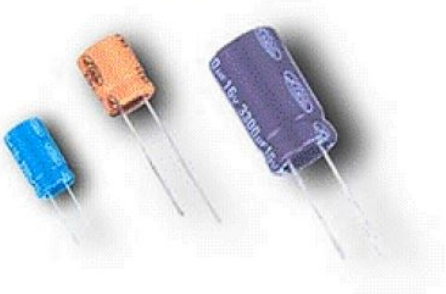
Resistors oppose the flow of current in a DC (or AC) circuit). Their values are represented with the colored strips or numbers and will vary slightly with temperature.

A variable resistor is called a potentiometer and is often used for volume controls

Capacitors

Air
Variable
Capacitor

Ceramic capacitors
(cheap)



Electrolytic capacitors
(polarized, high capacity)

Capacitors are conductive plates separated by an insulator and stores energy in an electric field (electrostatically)

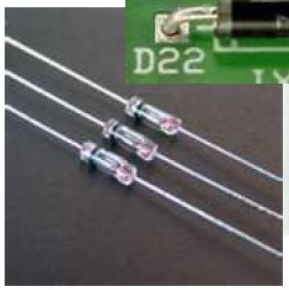
Inductors

Inductors are generally coils of wire that store energy in a magnetic field

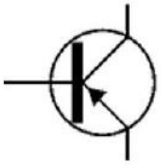
Diode

Electronic one-way “valve”, used e.g. in rectifiers
Mostly made of Si, Ga
Different types: PN diodes, Schottky

Electrodes are called anode and cathode with the cathode indicated by a stripe

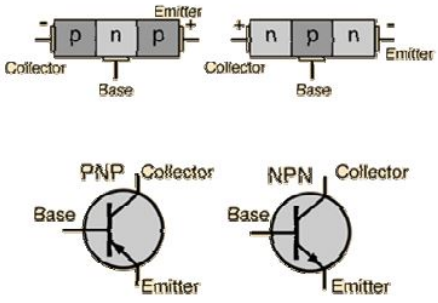


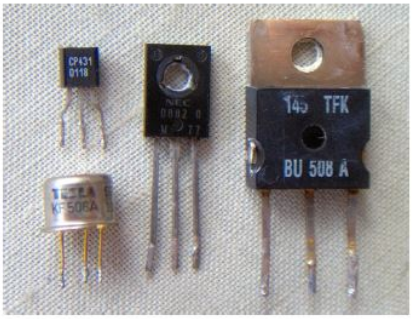
Transistors

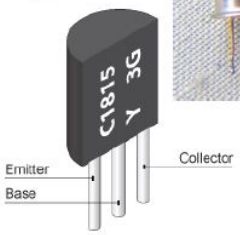


Transistor

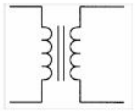
Can be used as an electronic switch or amplifier
Comprised of three layers of semiconductor (PNP, NPN)
Generally have three electrodes (*emitter, base, collector*)
Field Effect Transistors (FET) have *source, drain and gate* instead



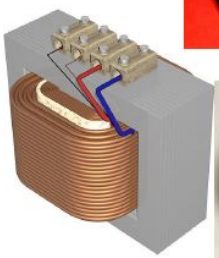




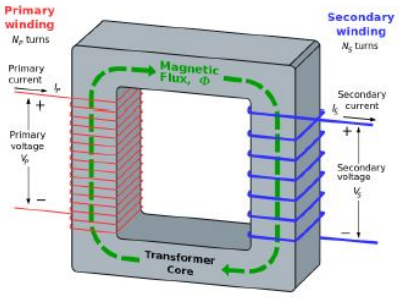
Transformer



Transformers are two coils wound around each other or a common core used to change voltage or impedance.



Voltage applied to a primary winding will induce a voltage in the secondary winding based on the ratio of turns in the two windings.



A 10:1 turns ratio will allow 120v on the primary to be converted to 12v on the secondary windings via mutual inductance.

Schematic Symbols

Resistor		**Capacitor**		**SPST Switch**	
Variable Resistor		**Lamp**		**LED**	
Transistor		**Transformer**		**Antenna**	
Battery		**Variable Inductor**			

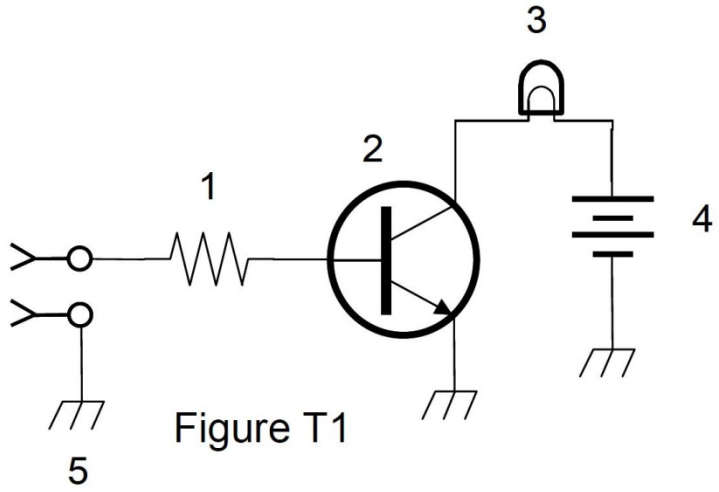


Figure T1

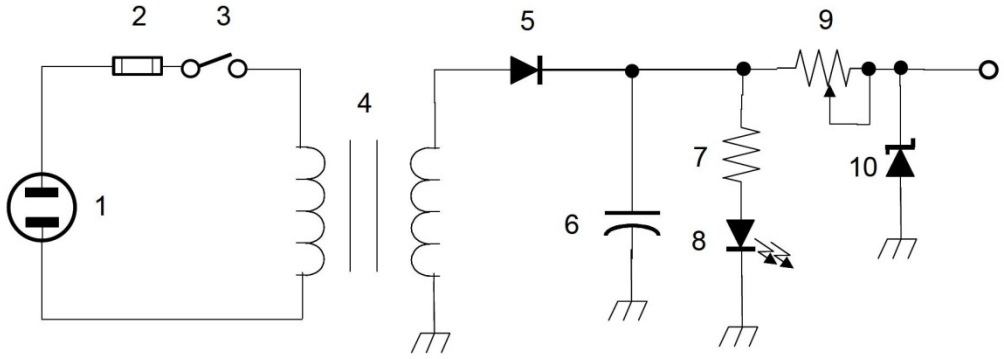


Figure T2

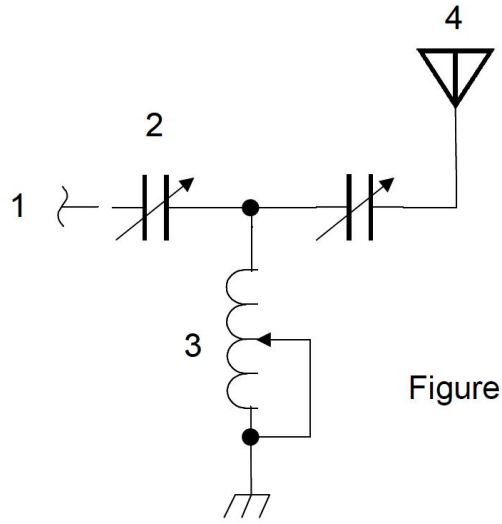


Figure T3

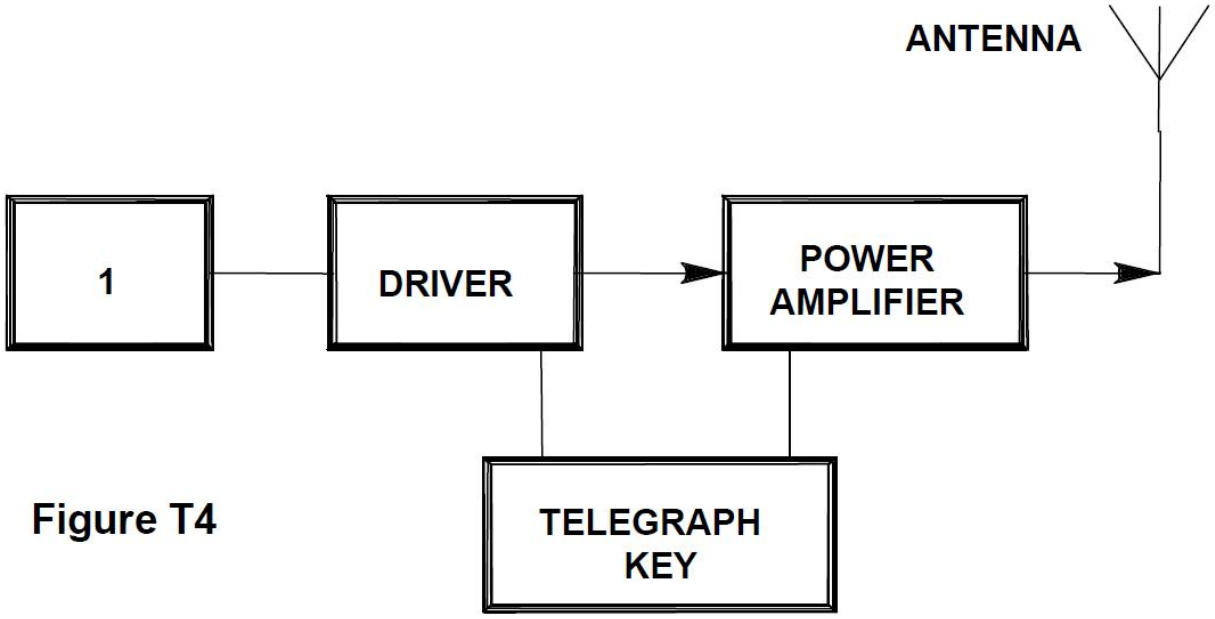
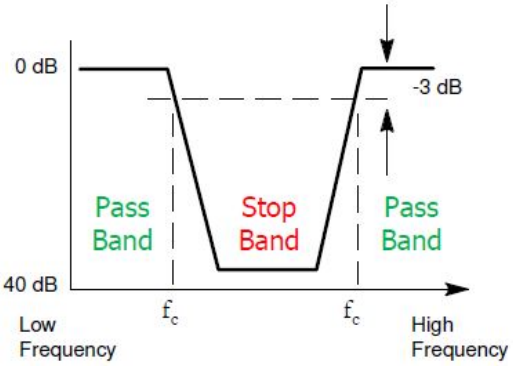


Figure T4

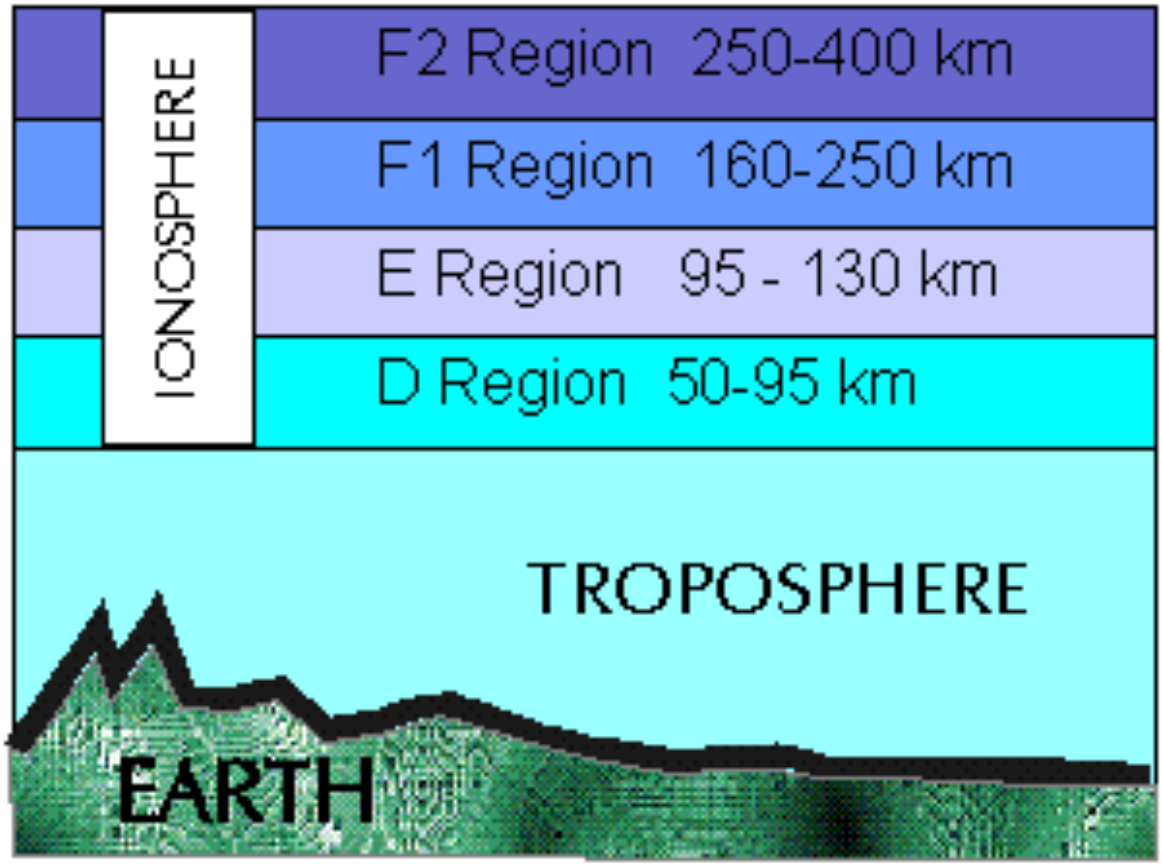
Notch (Band Stop) Filter

There are notch filters built to notch out the powerful pager transmitters located just above the 2m band.

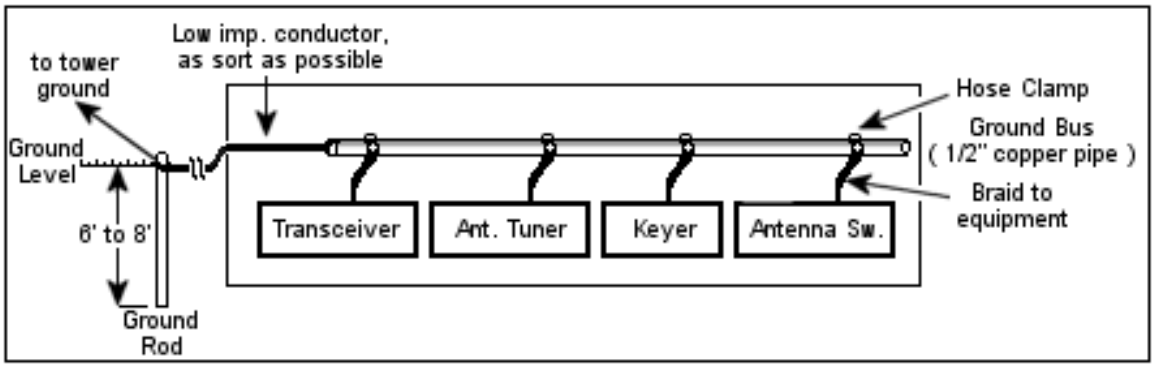
Very effective notch filters can be made with a 1/2 wavelength piece of coax shorted on one end connected to a coaxial "T" connector on the other. These are often called "stubs".



Repeaters use cavity notch filters that have very sharp skirts to keep the transmitter from interfering with the receiver, since they're both active at the same time on very close frequencies.


IONOSPHERE
F2 Region 250-400 km
F1 Region 160-250 km
E Region 95 - 130 km
D Region 50-95 km
TROPOSPHERE
EARTH

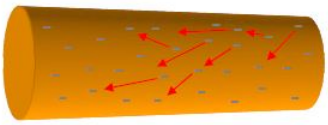
ionosphere


Low imp. conductor,
as sort as possible
to tower
ground
Hose Clamp
Ground Bus
(1/2" copper pipe)
Braid to
equipment
Ground
Level
6' to 8'
Transceiver
Ant. Tuner
Keyer
Antenna Sw.
Ground
Rod

Conductors and Insulators

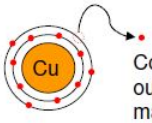
In a conductor, electric current can flow freely, in an insulator it cannot. Simply stated, most metals are good electrical conductors, most nonmetals are not. Metals are also generally good heat conductors while nonmetals are not.

Cross-section of copper wire



Neighboring electrons are repulsed by the motion of electrons, creating a chain reaction that propagates through the material at nearly the speed of light.

Copper's valence electrons move freely throughout the solid copper metal



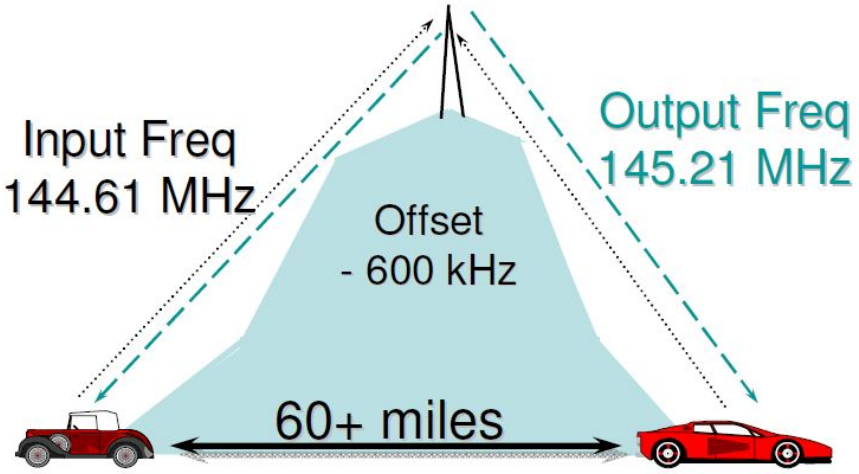
Copper and other metals have a weak hold on their outer or "valence" electrons. Atoms of insulating materials have a tight grip on their outer electrons.

Conductors – Copper, Silver, Gold, Aluminum, Platinum, Steel, …

Insulators – Glass, Wood, Rubber, Air, Plastic …

Note: Salt water is a conductor, and so are you!

Repeater Operation



Repeaters can extend range significantly. Everyone listens on the output frequency and transmits on the input frequency.

RACES / ARES

RACES – Radio Amateur Civil Emergency Service

- Work with local, state and federal government only
- When activated, you work for the government (Restricted)
- When activated, mission participants are covered by government insurance

ARES - Amateur Radio Emergency Service

- Health and welfare
- Work with government and NGO (Red Cross, Salvation Army) and support services
- When activated, you still are a civilian

Note – both groups do good work, and many hams belong to both groups, also both groups are often combined.