NTC Amateur Radio Examination Information

Contents

This NTC amateur radio examination information is compiled as an addition to "So You Want To Be A Ham" handbook obtainable from the Philippine Amateur Radio Association (PARA)

In this NTC amateur radio examination information there will be overlaps between the different elements.

The Philippine Amateur Radio Examination.zip folder contains.

1) “NTC Amateur Radio Exam Information”.pdf

2) “Learn Morse Code folder” with information covering Element 1

3) “NTC Amateur Radio Exam Multi Choice” folder has sample questions and answers plus information covering Elements 2 to 10

Class A (Elements 8, 9 and 10) has a total of 310

Class B (Elements 5, 6, and 7) has a total of 270

Class C (Elements 2, 3 and 4) has a total of 390

Element I (1) – Morse Code.

To obtain the NTC Class A amateur radio licence, the Philippine radio amateur has to pass the written examination and at the time this article was written also pass the NTC Element 1 - Morse Code exam.

The following has been reproduced with permission of Anthony Urbano (DU1AU).

The NTC morse code exam gauges your ability to copy and decode Morse code at 5 wpm, letters A-Z only (no numbers, no punctuations, no sending morse code).

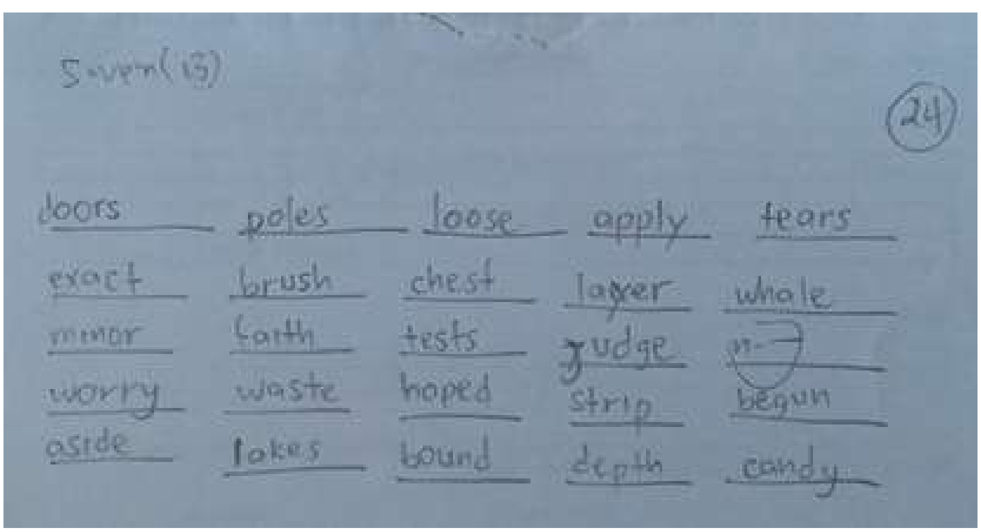
It follows the format:

HR HR HR AA AA word01 word02 word03 word04 word05
AA word06 word07 word08 word09 word10
AA word11 word12 word13 word14 word15
AA word16 word17 word18 word19 word20
AA word21 word22 word23 word24 word25 AR AR SK E E E

HR means "hear"
AA stands for "all after"
AR means "end of transmission" or "end of message"
SK stands for "silent key", which means "end of contact" or "end of work"
E E E indicates "end of message"

The abbreviations used are called procedure signs or prosigns.

Do not write the prosigns on your answer sheet. Prosigns are not part of the message.



To pass the code requirement, you need to satisfy 2 conditions

(1) decode 18/25 words.

(2) decode all 5 words in at least one line.

Even if you get a score of 20, but missed at least one word on all of the five lines, you will not pass the code test.

The speed is 5 wpm, letters A-Z only (no numbers, no punctuations), tone is 1000 Hz, at natural spacing.

Morse code audio file will be played on an audio player (such as a laptop).

If during decoding you miss a word, skip it and use the time to get ready for the next word.

Additional information:

If you miss a letter, leave a space.... you may be able to guess the letter later.

On the test sheet, it is suggested you draw something like this.

________ ________ ________ ________ ________

________ ________ ________ ________ ________

________ ________ ________ ________ ________

________ ________ ________ ________ ________

________ ________ ________ ________ ________

The “Learn Morse Code folder” has more information to help learn and pass the morse code examination.

Also included in the LMC folder are links to two free suitable practice receiving morse code software programs which can be downloaded.

Element II (2) - Rules and Regulations

MEMORANDUM CIRCULAR
NO. 03-08-2012

SUBJECT: Revised Amateur Radio Regulations

https://www.para.org.ph/legacy/NTC%20Memos/MC%2003-08-2012%20Revised%20Amateur%20Regulations.pdf

"NTC Amateur Radio Exam Multi Choice" folder also includes….

Class C Element II (2) - Rules and Regulations which has 130 multi choice questions and information.

1. The Philippines is divided into how many amateur districts?

A. :-) 9

B. ? 10

C. ? 11

D. ? 12

Correct!
Your score is 100%.
Questions completed so far: 1/131.

OK

117. When is music allowed to be broadcast over an amateur radio station?

A. ? During a birthday celebration

B. ? Never

C. ? To celebrate having passed the radio amateur exam

D. ? To celebrate New Year

Element III (3) - Electrical and Electronics Principles

Standard Electrical Units of Measurement

(A) Sample electrical units of measurement which are based on the International (metric) System, also known as the SI System with other commonly used electrical units being derived from SI base units.
The SI system is based on multiples of 10.

Quantity	Symbol	Measuring Unit	Unit Symbol
Capacitance	C	Farad	F
Charge	Q	Coulomb	C
Conductance	G	Siemen	S
Current	I	Ampere	A
Frequency	f	Hertz	Hz
Impedence	Z	Ohm	Ω
Inductance	L	Henry	H
Power	P	Watt	W
Resistance	R	Ohm	R or Ω
Time	t	second	s
Voltage	V (or E)	Volt	V or E
Wavelength	λ	meter	m

Instead of writing out the name of the quantity, each quantity can be written using a symbol example for Current, the symbol I is used.

Each quantity can be measured as a unit instead of writing the measuring unit name, the unit symbol is used, example Current is measured in Ampere for which the unit symbol A is used.

Sometimes when the quantities being measured are very large or very small it is necessary to use multiples or sub-multiples (fractions) of these standard electrical measuring units e.g. Resistance can be lower than 0.001Ω or higher than 1,000,000Ω,

(B)

Prefix	Symbol	Value			
giga-	G	10^9	1,000,000,000	one billion	1 x 1 000 000 000
mega-	M	10^6	1,000,000	one million	1 x 1 000 000
kilo-	k	10^3	1,000	one thousand	1 x 1000
(none)	(none)	10^0	1	one	
deci-	d	10^{-1}	0.1	one-tenth	1/10
centi-	c	10^{-2}	.01	one one-hundredth	1/100
milli-	m	10^{-3}	.001	one one-thousandth	1/1 000
micro-	μ	10^{-6}	.000001	one one-millionth	1/1 000 000
nano-	n	10^{-9}	.000000001	one one-billionth	1/1 000 000 000
pico-	p	10^{-12}	.000000000001	one one-trillionth	1/1 000 000 000 000

(B) Each prefix name has a symbol that is use in combination with the measure unit. The multiplies mega (M) and giga (G) prefix symbols have upper case letters except kilo which has the prefix symbol k.
The sub multiplies have lower case letters except micro (μ)

The prefix symbol precedes that of a basic measure unit to indicate a multiple or submultiple of the unit….The prefix has the same effect as multiplying or dividing the numerical value of the measuring unit by the value of the prefix. Examples:

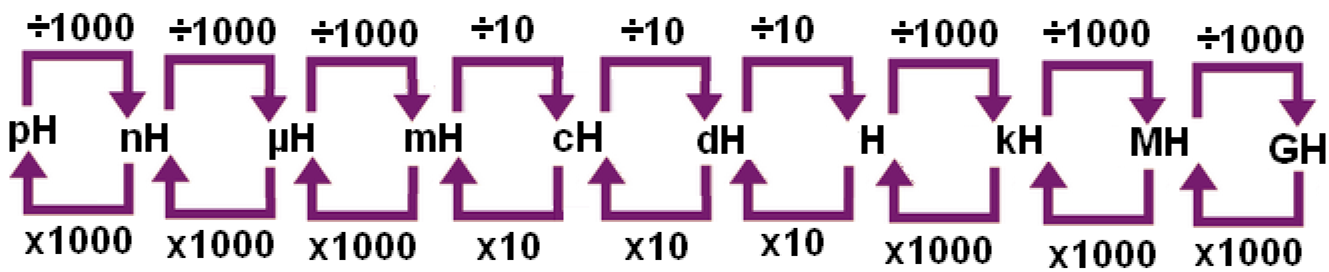
mega- (M) can be used with megamps (MA),megahertz (MHz), megawatts (MW) etc.
micro (µ) can be used with microhenry (µH), microfarad (µF), microamp (µA) etc

Multiples are used to create larger values whereas submultiples are used to create smaller values of the SI units. Using multiples and submultiple's of the measuring unit can avoid having to write too many zero's to define the position of the decimal point. To overcome this SI includes a series of prefixes plus the measuring unit symbol.

By using the prefix symbol for micro (µ), the value of 0.000001H can be written as 1µH. Using the prefix symbol for mega (M), the value of 2,000,000H can be written as 2MH

To convert SI units to another value multiply or divide by 10 (or 1000) sometimes more than once.10^2 = 10x10 = 100….10^3 = 10x10x10 =1000 etc

(C)



(C) This chart example has the Henry (H) as the base value, to use choose the value to be converted, multiply or divide by the number(s) between that value and the target value.

SI values when converting from a larger value to a smaller value multiply x
From a smaller value to a larger value divide ÷ (for divide forward slash / is mostly used)

With some formula it is useful to use the same (base) values. Example Ohms Law uses base values volts, amps and ohms, with 250mA and 10V to find the resistance in ohms ?, to use Ohms Law we could convert 250mA to amps ie 250 ÷1000 = 0.25A

How many millihenries are there in 5 Henries? This means converting from the larger 5 Henries to the smaller millihenries = 5x10 x10x10 (or multiply by 1000) = 5000 mH…
Convert 150 mH (smaller) to H (larger) = 150÷10÷10 ÷10 (or divide by 1000) = 0.15H…
4.7 MΩ to kΩ = 4.7 x 1000 = 4700kΩ…….10mV to µV = 10 x 1000 = 10,000µV
1A to mA = 1 x 1000 = 1000 mA….150µF to F= 150 ÷1000 ÷1000 = 0.00015F

Add 5A + 300mA, convert 300mA to amps = 300 ÷1000 = 0.3A…5 + 0.3 = 5.3A
Subtract 1.4kΩ - 500Ω, convert 1.4kΩ to ohms = 1.4 x 1000= 1400Ω - 500Ω = 900Ω

Atom

Atoms consist of a nucleus made of protons and neutrons orbited by electrons.

It is the electron that is free to move and causes electricity.

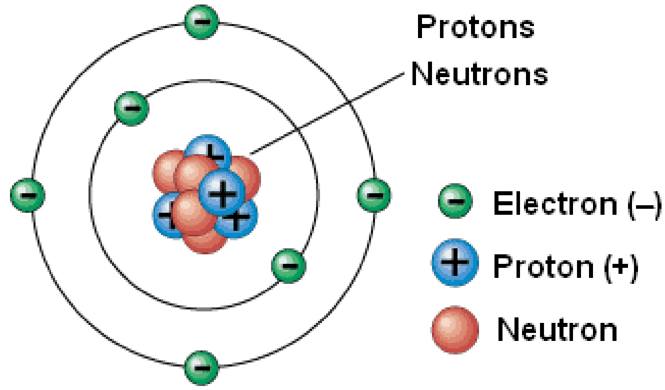
Nucleus (middle)

Protons - Positive

Neutrons - Neutral

Outside

Electrons - Negative



Electric charge is an amount of electricity that is held in or carried by something,
Electric charges can be positive (protons) or negative (electrons).
Like charges repel each other and unlike charges attract each other.

A continuous flow of negative charges (electrons) is what creates an electric current, that is the jump of negatively-charged electrons from atom to atom.

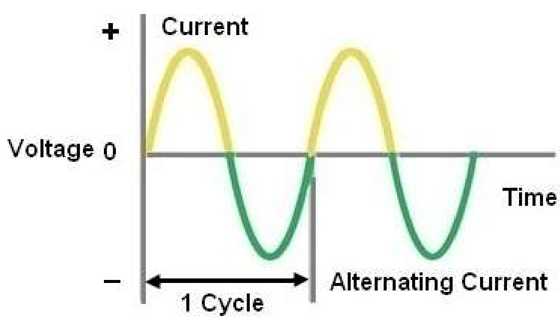
When the charge (current) flows, it carries energy that can be used to do work.
example light a bulb, drive an electric motor, run appliances etc

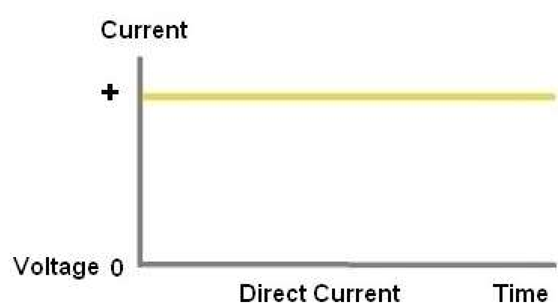
Voltage is the measure of energy available to move electrons. The higher the voltage, the more energy each electron carries.

The pathway taken by an electric current is a circuit; current needs a closed path to flow.

Closed circuits allow the movement of electrical energy. When you turn a switch on you close the circuit, so the electricity can flow through the circuit and back into the wire.

Open circuits prevent the movement of electrical energy. When you turn a switch off, you open the circuit. This means no electricity can flow through the circuit.





AC and DC Voltage : The difference between the AC and DC voltage is that in AC voltage the polarity of the wave changes with the time whereas the polarity of the DC voltage always remains the same.

AC and DC Current : In alternating current (AC) the electric charge changes direction periodically. In direct current (DC), the electric charge (current) only flows in one direction.

Voltage (V): is stored electricity that has the potential for movement, such as a battery or generator. When this potential is activated, the voltage acts as a sort of pressure, pushing current (I) along a circuit. This potential for movement is measured in Volts and symbolized by the letter V (Voltage) or E (Electromotive Force - EMF)

Volt: A potential of one volt appears across a resistance of one ohm when a current of one ampere flows through that resistance.

Resistance (R): is the resistance that electricity encounters by flowing through some physical material, resistance is measured in Ohms (Ω).

One ohm is the resistance that occurs when a current of one ampere (A) passes through a resistor with a one volt (V) drop across its terminals.

Current (I): is a continuous flow of negative charges (electrons) in an electric circuit. When the charge flows, it carries energy that can be used to do work, current is measured in Amperes.

Ampere (A): is a unit of measure of the rate of electron flow or current in an electrical conductor. A flow of one ampere (A) is produced in a resistance (R) of one ohm by a potential difference of one volt (V).

Coulomb (C): is the amount of charge transferred in one second by a steady current of one ampere. One coulomb is equal to 6.24×10^{18} electrons.

One ampere of current represents one coulomb of electrical charge (6.24×10^{18} charge carriers) moving past a specific point in one second.

Decibel (dB): is a relative unit of measurement equal to one tenth of a bel (B). Is a unit for expressing the ratio between two physical quantities, usually amounts of acoustic or electric power, or for measuring the relative loudness of sounds and is often used to express the ratio of output to input signal levels.

Power (P): is associated with a complete electric circuit or a circuit component represents the rate at which energy is converted from the electrical energy of the moving charges to some other form, e.g. heat, mechanical energy, or energy stored in electric fields or magnetic fields and is measured in Watts (W).

Conductance (G): is the opposite or reciprocal of resistance. Conductance is an expression of the ease with which electric current flows through a substance and is measured in Siemens (S)

Ohms Law: The current in a circuit is directly proportional to the electric potential difference (voltage) across its ends and inversely proportional to the total resistance offered by the external circuit. That is I (Current) = V (Voltage) / R (Resistance)

The forward slash / is mostly used instead of the division ÷ sign…Voltage, current, and resistance are all related. If one of the values is changed the other values will change.

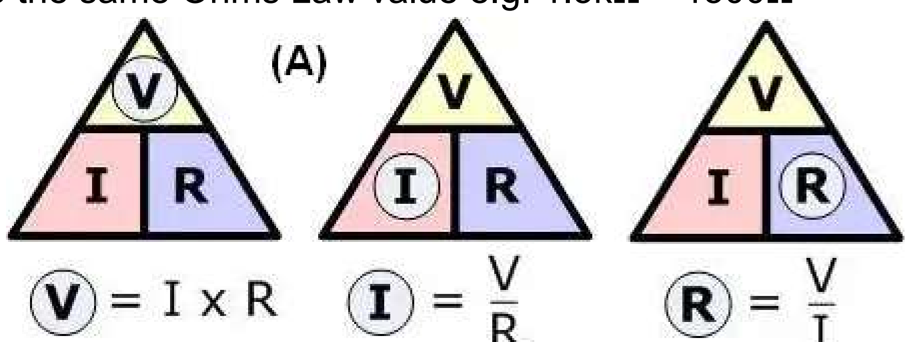
In a circuit with the resistance remaining the same, increase the voltage and more current will flow, decrease the voltage and less current will flow and in a circuit with the voltage remaining the same, an increase (more) resistance less current will flow, with a decrease (less) resistance more current will flow. Vs is Voltage Supply.

Example: Vs = 12V and resistance is 6Ω, the current flow would be 2 amps.
Increase Vs to 24V with the same 6Ω, the current flow would increase to 4 amps.
Decrease Vs to 6V with the same 6Ω resistance and 1 amp would flow.

Example: Resistance is 5Ω with Vs = 20V, the current flow would be 4 amps
Increase resistance to 10Ω with the same Vs = 20V, the current flow would be 2 amps
Decrease resistance to 2Ω with same Vs = 20V, the current flow would be 10 amps

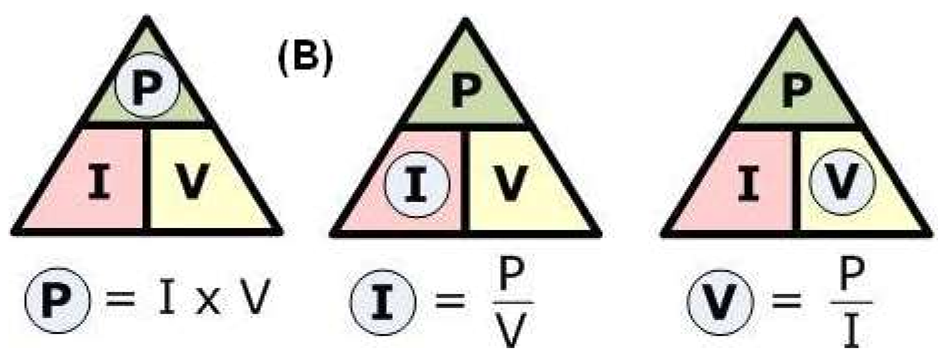
Note : When using Ohms Law all the values should be the same value in ohms, volts, and amps or convert the values to the same Ohms Law value e.g. 1.5kΩ = 1500Ω

Circuit has 6 V and 3 Ω find I?
(1) I = V / R = 6 / 3 = 2 amps
(2) 3 ohms and 2 amps, find V?
V = I x R = 3 x 2 = 6 volts
(3) 6 volts and 2 amps, find R?
R = V / I = 6 / 2 = 3 ohms



(A) Ohms Law triangle shows the relationship between voltage, current and resistance.

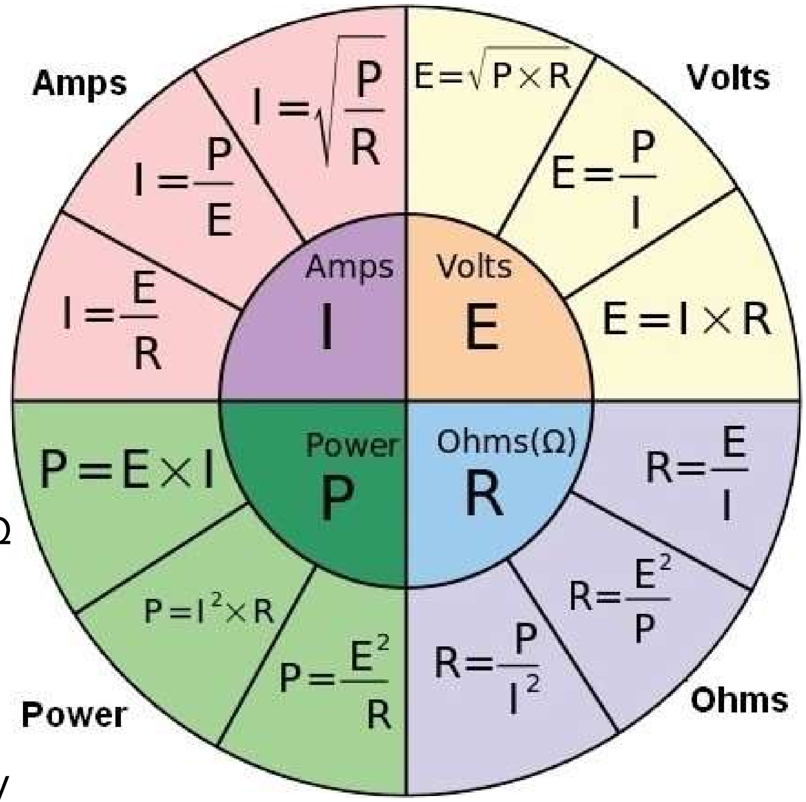
Circuit has 8 volts supply and current of 2 amps, find P?
(1) P = I x V = 2 x 8 = 16 Watts
(2) 16 watts and 8 volts, find I?
I = P / V = 16 / 8 = 2 Amps
(3) 16 watts and 2 Amps, find V?
V = P / I = 16 / 2 = 8 Volts



(B) Power Triangle, shows the relationship between power, current, and voltage

Voltage, Current, Resistance and Power.

Sometimes the letter E (EMF: Electromotive Force) is used in place of the letter V.
Volts (V or E) = 20V: Amps (I) = 5A: Resistance (R) = 4 ohms (Ω): Power (P) = 100 Watts



Power = E x I = 20 x 5 = 100W
Power = I^2 x R = 5 x 5 x 4 = 100W
Power = E^2 / R = 20 x 20 / 4 = 100W

Amps = E / R = 20 / 4 = 5A
Amps = P / E = 100 / 20 = 5A
Amps = √ P/R = √100 / 4 = √25 = 5A

Resistance = E / I = 20 / 5 = 4 Ω
Resistance = E^2 / P = 20 x 20 / 100 = 4Ω
Resistance = P / I^2 = 100 / 5 x 5 = 4Ω

Volts = I x R = 5 x 4 = 20V
Volts = P / I = 100 / 5 = 20V
Volts = √P x R = √ 100 x 4 = √400 = 20V

Useful formula to remember for Power is P = V x I and for Ohms law V = I x R

Having different values when using say Ohms Law, we can convert the different values to Ohms Law values that is to amps, volts and ohms and to watts for the power formula.

Circuit has 2kΩ and 4.0mA what is the voltage? convert 2kΩ to ohms = 2 x 1000 =2000Ω and convert 4.0 mA to amps = 4.0 ÷ 1000 = 0.004A.
Using Ohms Law V = I x R = 2000 x 0.004 = 8V.Check I = V/R = 8/2000 = 0.004A (4.0 mA)

Circuit has 200mV and 5amps, what is the power ? P = V x I. Converting 200mV to volts = 200 ÷ 1000 = 0.2V therefore P = 0.2V x 5A = 1W.
Check V = P / I = 1W / 5A = 0.2V and 0.2V x 1000 = 200mV

Circuit uses 800 mW with a current of 2 amp,find the voltage ? P = V x I therefore V = P / I.
Convert 800 mW to watts = 800 divided by 1000 = 0.8W therefore V = 0.8W/2A = 0.4V

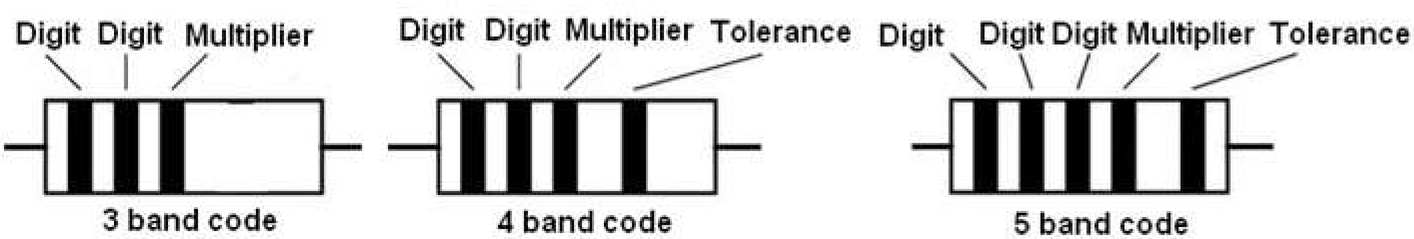
Resistance: Resistor is given the symbol R. It is measured in units called ohms (Ω)

Thinner wires have greater resistance than thick wires.
Longer wires have greater resistance than shorter wires

The value of a resistor (resistance) can be checked using an Ohmmeter (Multimeter)

Resistor Colour Coding uses coloured bands to identify a resistors resistive value and its percentage tolerance.

Color	1st & 2nd Digit	Multiplier	Tolerance
	1st & 2nd Band	3rd Band	4th Band
Black	0	1	-
Brown	1	10	+/- 1%
Red	2	100	+/- 2%
Orange	3	1K	-
Yellow	4	10K	-
Green	5	100K	+/- 0.5%
Blue	6	1M	+/- 0.25%
Violet	7	10M	+/- 0.01%
Gray	8	100M	-
White	9	1000M	-
Gold	-	0.1	+/- 5%
Silver	-	0.01	+/- 10%
None	-	-	

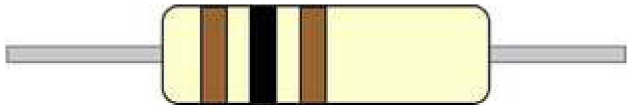


The resistor color code markings are always read one band at a time starting from the left to the right, with the larger width tolerance band oriented to the right side indicating its tolerance. The 3 band resistor has no tolerance band but has a tolerance value of 20%

To help remember the resistor color code.

Bad Boys Race Our Young Girls But Violet Generally Wins

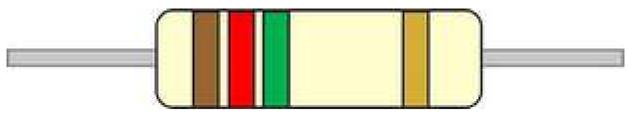
Bad (black 0) : Boys (brown 1) : Race (red 2) : Our (orange 3) : Young (yellow 4) :
Girls (green 5) : But (blue 6) : Violet (violet 7) : Generally (grey 8) : Wins (white 9)



A resistor with 3 coloured bands does not have a tolerance band but has a tolerance value of 20% and is read colour - colour x coloured multiplier.

3 band resistor coloured Brown-Black-Brown value would be 100 Ohms that is 1(Brown) : 0 (Black) x 10 (Brown multiplier) = 100Ω with a tolerance value of 20%

Having Orange-Red-Black value would be 32Ω because the colour black is not a multiplier with a tolerance value of 20%



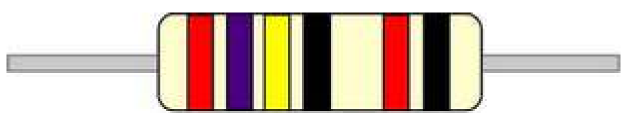
4 band resistor has a tolerance value (colour) and is read colour - colour x coloured multiplier plus the coloured tolerance value.

4 band resistor coloured Brown-Red-Green -Gold would be 1 (Brown) : 2 (Red) x 100k (100,000) (Green multiplier) = 12 x 100,000 = 1.2MΩ with a tolerance value of 5% (Gold)

4 band resistor coloured Yellow-Black-Red -Silver would be 4 (Yellow) : 0 (Black) x 100 (Red multiplier) = 40 x 100 = 4000Ω (4kΩ) with a tolerance value of 10% (Silver)

5 band resistor has colour-colour-colour x coloured multiplier plus the coloured tolerance value.

5 band resistor colored Yellow-Violet-Blue-Black-Brown would be 4 (Yellow) :
7 (Violet) : 6 (Blue) x 0 (Black multiplier) = 476Ω with a tolerance value of 1% (Brown)



6 band resistor colored Red-Violet-Yellow-Black-Red-Black would be 2 (Red) :
7 (Violet) : 4 (Yellow) x 0 (Black multiplier) = 274Ω with a tolerance of value of 2% (Red)

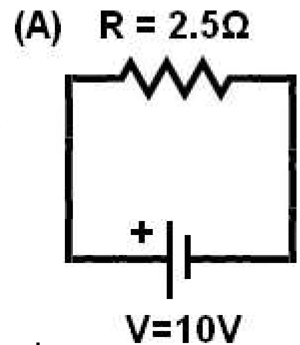
The sixth band (Black) denotes the temperature coefficient 250ppm/K

Resistors in series carry the same current, but the voltage drop across them is not the same, the voltage drops across each resistor is determined by Ohm's Law.

In a series circuit, the voltage drop across each resistor added together equals the voltage supply (Vs). Series circuits are voltage dividers.

When calculating resistor circuits, the values should be the same value or converted to the same value. All ohms or mΩ or kΩ or MΩ etc and the answer will be in that value.

Total resistance in series equals R1 + R2 + R3 + R4 etc …

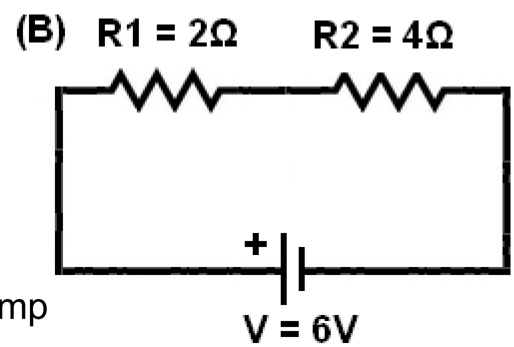


(A) Using Ohms law and the Power formula:
Find current (I) and Power (W). (A) Vs (voltage supply) = 10V

First find the total current (It) using Ohms law
It = V / R = 10V / 2.5Ω (ohms) = 4A (amps).

Power (P) = It x V = 4A x 10V = 40 watts or we could have used….
I^2R = 4 x 4 X 2.5= 40 watts or V^2 / R = 10 x10 / 2.5 = 40 watts

(B) Series circuit : Find total current, total power, voltage drop across each resistor and the power for each resistor.



(B) Vs (voltage supply) = 6V

First find total resistance (Rt) = R1 + R2 = 2Ω + 4Ω = 6Ω
therefore Rt = 6 ohms

Using Rt to find total current (It) = V / Rt = 6V / 6 Ω = 1 amp

To find total power (P) = V x It = 6V x 1(It) = 6 watts or (V^2 / Rt = 6 x 6 / 6) = 6 watts

Voltage (V_1) across R1? V = It x R1 = 1A x 2Ω = 2 volts
Voltage (V_2) across R2 ? V = It x R2 = 1A x 4Ω = 4 volts
Total voltage = It x Rt = 1A x 6Ω = 6 volts = Voltage supply

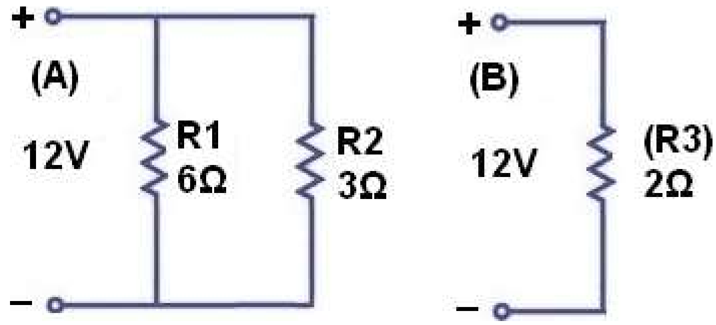
Power drop across R1 ? P = It x V_1 = 1A x 2V = 2 watts
Power drop across R2 ? P= It x V_2 = 1A x 4V = 4 watts
Power P = It x V = 1A x 6V = 6 watts

(C) Table showing the results as calculated for (B)

(C)	R_1	R_2	Total	
V	2V	4V	6V	Volts
I	1A	1A	1A	Amps
R	2Ω	4Ω	6Ω	Ohms
P	2W	4W	6W	Watts

Resistors in Parallel (A) Resistors in parallel share the same voltage on their terminals. Parallel circuits are current dividers.

The total resistance (Rt) of resistors in parallel is the reciprocal of the sum of the reciprocals of the individual resistors.



With 2 or more resistors Rt would be reciprocal of the sum of reciprocals of the individual resistors.

1/Rt = 1/R1 + 1/R2 + 1/R3 etc, the reciprocal of 1/Rt is Rt/1(1/Rt flipped over) = Rt

(A) The reciprocal of 6Ω would be 1/6 and for 3Ω would be 1/3, the sum of reciprocals of the individual resistors would be 1/6 + 1/3 = 3/6 = 1/2, the reciprocal of 1/2 is 2/1 = 2Ω (Rt)

When 2 resistors are in a parallel circuit, Rt can be found by multiplying the two and then dividing the product by the sum.

$$Rt = \frac{R1 \times R2}{R1 + R2}$$

Two resistors in parallel

Rt = R1 x R2 divided by R1+R2
(A) Rt = 6 x 3 divided by 6 + 3 = 18 / 9 = 2 ohms

Note: In a parallel network, the equivalent resistance is always less than the smallest resistor, so Rt will decrease as additional parallel resistors are added.

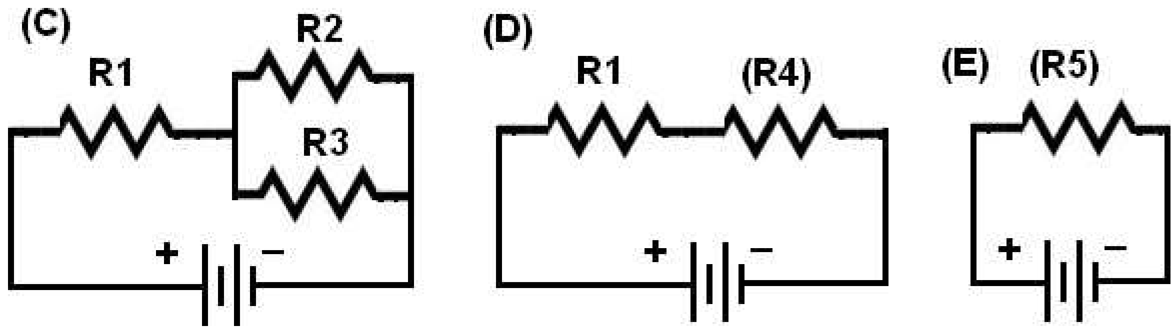
(A) Parallel circuit, find total current ? First find the total circuit resistance and use Ohms Law. In circuit (A) and (B) Vs (voltage supply) = 12V

(A) To find the total circuit resistance (Rt) reduce the circuit to one resistor (R3):
R3 = R1 x R2 divided by R1 + R2 = 6 x 3 / 6 + 3 = 18 / 9 = 2 ohms.

(B) Total current flow (It) = V / (R3) = 12V / 2Ω = 6 amps

(A) To find the current drop across R1 = V/ R1 = 12V / 6Ω = 2 amps (I_1)
Current drop across R2 = V / R2 = 12V / 3Ω = 4 amps (I_2)
Current drop across R1 (2 amps) + R2 (4 amps) = 6 amps (It)
(A) Voltage drop across R1 is I_1 x R = 2 amps x 6 ohms = 12V
Voltage drop across R2 is I_2 x R2 = 4 amps x 3 ohms = 12V
Power drop across R1 = V x I_1 = 12V x 2A = 24 watts
Power drop across R2 = V x I_2 = 12V x 4A = 48 watts
Total Power (P) = It x V = 6 A x 12V = 72 watts.

	R_1	R_2	Total	(C)
V	12V	12V	12V	Volts
I	2A	4A	6A	Amps
R	6Ω	3Ω	2Ω	Ohms
P	24W	48W	72W	Watts



(C) R1 = 8 ohms, R2 = 3 ohms, R3 = 6 ohms and voltage supply (Vs) is 24V.
What is the voltage and current drop across each resistor ?

First find the total resistance (Rt) by reducing the circuit (C) to circuit (E)

Reduce the parallel R2 and R3 to (R4)

(D) R2 + R3 in parallel = 1 / 3 + 1/6 = 3 / 6, reciprocal 6 / 3 = 2 ohms (R4) or
(R4) = R2 x R3 divided by R2 + R3 = 3 x 6 / 3 + 6 = 18 / 9 = 2 ohms.

(D) Rt = R1 + (R4) in series = 8 + 2 = 10 ohms (R5)....(E) Rt = 10 ohms

Next find the total current (It) in the circuit using Rt

Using Ohm's Law I (It) = V / R(t) = 24V / 10Ω (R5) = 2.4 amps

(D) is a series circuit so there will be a voltage drop across R1 and (R4).

(D) Voltage (V_1) drop across R1 : V = I(t) x R1 = 2.4A x 8 Ω= 19.2 Volts.
Voltage (V_2) across (R4) = I(t) x (R4) = 2.4A x 2Ω = 4.8 Volts
Check: V_1 + V_2 = 19.2 + 4.8 = 24V (Vs)

(C) R2 and R3 are in parallel so the voltage across will be same as (R4) that is 4.8 volts and each resistor will have a different current.

Current R2 = V_2 / R2 = 4.8V / 3Ω = 1.6 amps
Current R3 = V_2 / R3 = 4.8V / 6Ω = 0.8 amps
Check: Current R2 + R3 = 1.6A + 0.8A = 2.4 amps (It)

(F) Table showing the results as calculated for (C)

(F)	R_1	R_2	R_3	Total	
V	19.2V	4.8V	4.8V	24V	Volts
I	2.4A	1.6A	0.8A	2.4A	Amps
R	8Ω	3Ω	6Ω	10Ω	Ohms

Reciprocals are used when finding the total resistance in resistance (Rt) and inductance (Lt) parallel circuits and the total capacitance (Ct) in series circuits.

To get the reciprocal of a number, divide 1 by the number (1 / number).
The reciprocal of number 2 is 1/2 and the reciprocal of number 18 is 1/18 etc

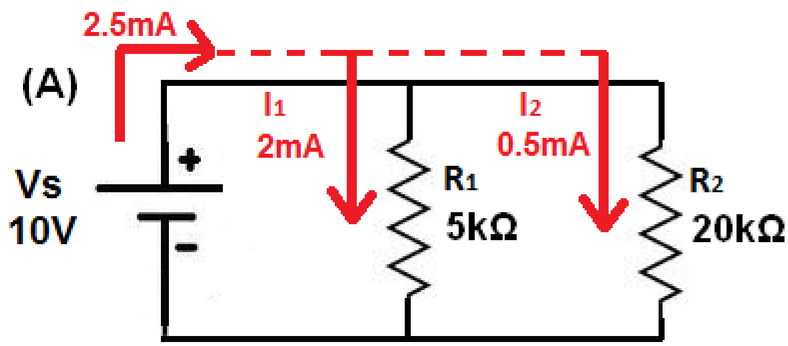
Using resistors in parallel as the example. Rt (resistance total) would be the reciprocal of the sum of reciprocals of the individual resistors added together.

1/Rt = 1/R1 + 1/R2 + 1/R3 + 1/R4 etc…The reciprocal of 1/Rt (flipped over) would Rt. Therefore 1/Rt (flipped over) = Rt

Example : a circuit has 2Ω, 6Ω and 9Ω resistors in parallel, the reciprocals of the individual resistors added together would be 1/2 + 1/6 + 1/9 = 14/18 therefore 1/Rt = 14/18. Rt would be the reciprocal of 14/18 flipped over = 18/14 = 1.28Ω

Current Divider

(A) In a parallel circuit, the voltage across all components is the same.



A current divider circuit is a circuit in which the main current from the power source is divided up in the circuit; thus, different amounts of current are allocated to different parts of the circuit……5kΩ = 5 x 1000 = 5000Ω and 20kΩ = 20 x 1000 = 20000Ω
2mA= 2 ÷1000 = 0.002A… 0.5mA= 0.5 ÷ 1000 = 0.0005A...2.5mA= 2.5÷1000=0.0025A

(A) Parallel circuit. Rt (total resistance) : 1/Rt = 1/R1 + 1/R2 = 1/5 + 1/20 = 5/20, the reciprocal of 5/20 is 20/5 = 4kΩ therefore Rt = 20/5 = 4kΩ,
(A) With 2 resistors in parallel we could have used.
Rt = R1 x R2 divided by R1 + R2….Rt = 5 x 20 / 5 + 20 = 100 / 25 = 4kΩ

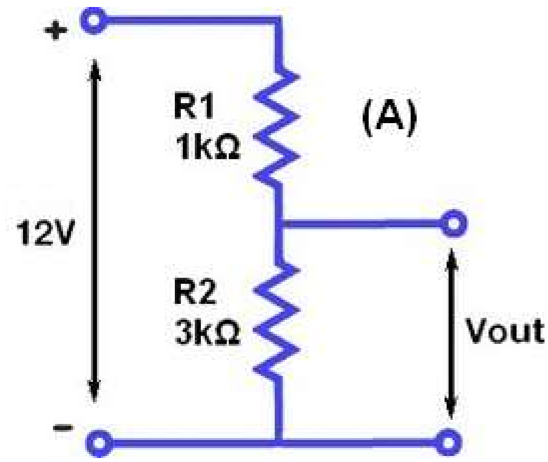
Total current (It) flowing : It = Vs / Rt = 10V / 4kΩ = 2.5mA (0.0025A)

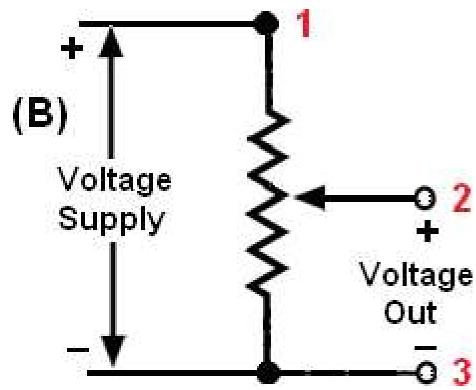
Current R1 : I_1 = V / R = 10V / 5kΩ = 2 mA.
Current R2 : I_2 = V / R = 10V / 20kΩ = 0.5 mA
Check: 1_1 + I_2 = 2.0 mA + 0.5mA = 2.5 mA(It)

(B)	R_1	R_2	Total	
V	10V	10V	10V	Volts
I	2mA	0.5mA	2.5mA	Amps
R	5kΩ	20kΩ	4kΩ	Ohms

Vs = It x Rt = 2.5mA x 4kΩ = 10 Volts
(0.0025A x 4000Ω) = 10 Volts…0.0025A x 1000= 2.5mA

Voltage Divider **Potentiometer**





A voltage divider (also known as a potential divider) is a circuit which turns a larger voltage into a smaller one. Using two or more series resistors, the voltage divider can create an output voltage or output voltages that are smaller than the input.
In a series circuit the amperes flowing in all components is the same.

(A) Supply voltage (Vs) is 12V. Find the Voltage out?
1kΩ = 1 x 1000 = 1000Ω…. 3kΩ = 3 x 1000 = 3000Ω…3mA = 3 ÷1000 = 0.003A

Total resistance (Rt) R1 + R2 = 4kΩ and use Ohms Law to find the total current (It) flowing in the circuit.

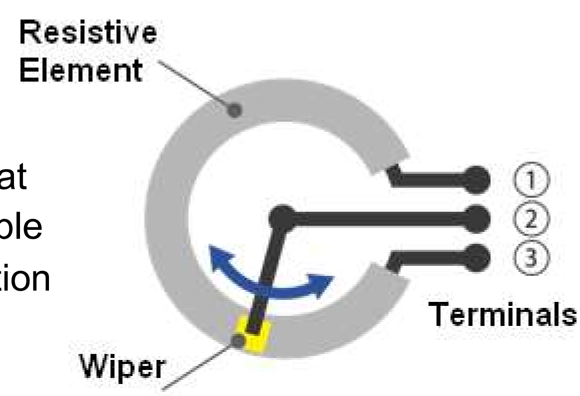
It = Vs / Rt = 12V / 4kΩ = 0.003 amps (3mA)

Voltage drop across R2 = It x R2=
3mA x 3kΩ = 9 volts therefore Vout = 9 Volts

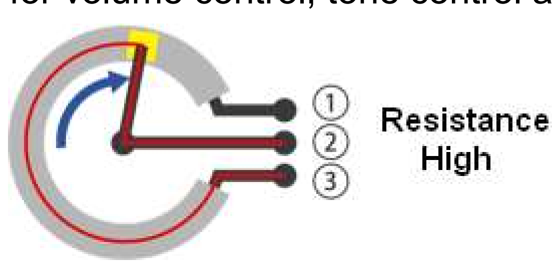
(A1)	R_1	R_2	Total	
V	3 Volts	9 Volts	12 Volts	Volts
I	3mA	3mA	3mA	Amps
R	1kΩ	3kΩ	4kΩ	Ohms

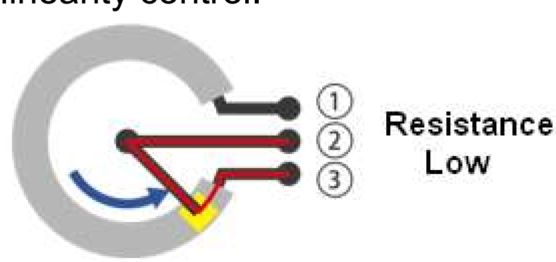
Voltage drop across R1 = It x R1 = 3mA x 1kΩ = 3volts
Check total voltage 3V (R1) + 9V (R2) = 12V (Vs)

(B) The potentiometer is a three-wire resistive device that acts as a voltage divider producing a continuously variable voltage output which is proportional to the physical position of the wiper along the track.
The potentiometer is used in radio and television (TV) receiver for volume control, tone control and linearity control.



Potentionmeter Basic Structure





Capacitance…

	Written as	Value in Farads	Scientific Notation	Fraction of One Farad
Farad	F	1	NA	1
Millifarad	mF	0.001	x 10^{-3}	1/1 000
Microfarad	μF	0.000001	x 10^{-6}	1/ 1 000 000
Nanofarad	nF	0.000000001	x 10^{-9}	1/ 1 000 000 000
Picofarad	pF	0.000000000001	x 10^{-12}	1/1 000 000 000 000

Capacitance is given the symbol C. It is measured in units called the Farads (F). A capacitance of 1 F produces 1 V of potential difference for an electric charge of one coulomb (1 C).

In electronic formulas Farad is a large unit to use, prefixes are used instead with capacitor values given in milli-Farads (mF), micro-Farads (μF), nano-Farads (nF) and the pico-Farads (pF).

When calculating capacitor circuits, the values must be the same value or converted to the same value e.g. all μF, mF or F etc and the answer will be in that value.

Capacitance is the ability of a component or circuit to collect, store and release energy in the form of an electrical charge.

In electrical circuits, capacitors are frequently used to block direct current (dc) while permitting alternating current (ac) to flow.

Capacitors, consists of two conducting plates separated by an electrical insulating material called a dielectric and are designed to store large amounts of electrical energy.

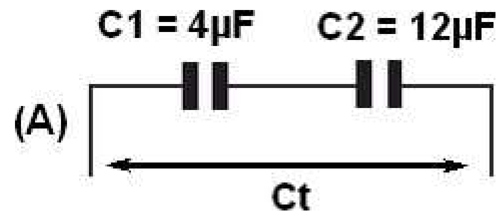
An electrolytic capacitor is a polarized capacitor whose anode or positive (+) plate is made of a metal that forms an insulating oxide layer through anodization.

A capacitor collects energy (voltage) as current flows through an electrical circuit.

Both plates hold equal charges and as the positive plate collects a charge, an equal charge flows off the negative plate.

When the circuit is switched off, a capacitor retains the energy it has gathered, though slight leakage usually occurs.

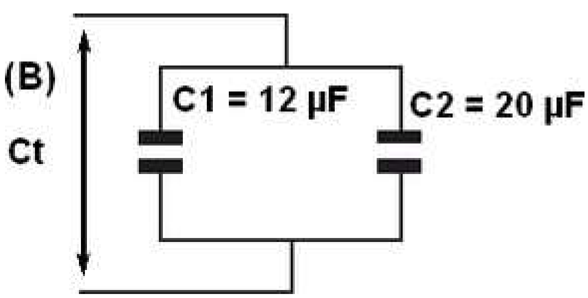
(A) For capacitors in series, the total capacitance (Ct) can be found by adding the reciprocals of the individual capacitances and taking the reciprocal of the sum.



1/Ct = 1/C2 + 1/C2 + 1/C3 + 1/C4 etc : with the reciprocal of 1/Ct (flipped over) = Ct

(A) 1/Ct = 1/4 + 1/12 = 4/12, the reciprocal of 4/12 = 12/4 = 3 therefore Ct = 3.0 µF

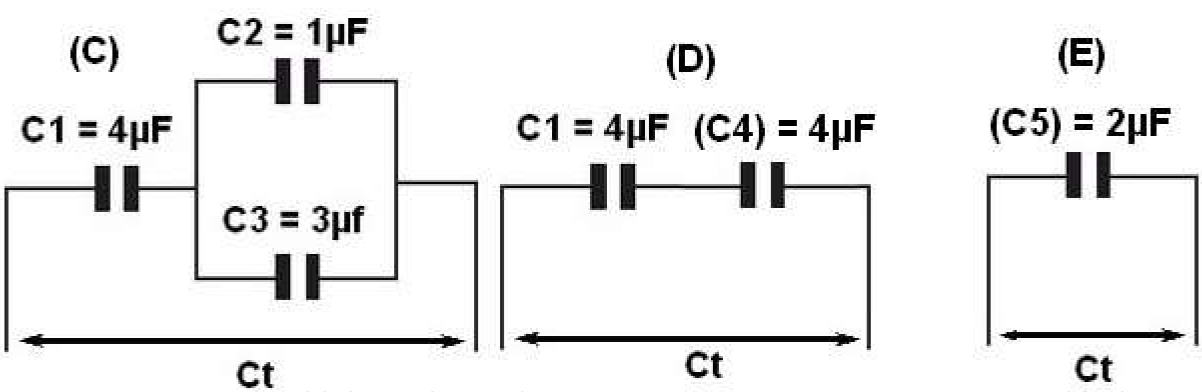
When 2 capacitors are in series. The total capacitance (Ct) can be found by multiplying the two and then dividing the product by the sum. Ct = C1 x C2 divided by C1+ C2
(A) C1 x C2 divided by C1+ C2 = 4 x 12 / 4 + 12 = 48 / 16 = 3 µF



$$Ct = \frac{C1 \times C2}{C1 + C2}$$

Two capacitors in series

(B) When capacitors are connected together in parallel the total or equivalent capacitance (Ct) in the circuit is equal to the sum of all the individual capacitors added together.
Ct = C1 + C2 + C3 + C4 etc
(B) Ct = C1 + C2 = 12µF + 20µF = 32µF



(C) Find total capacitance (Ct)…..C2 + C3 in parallel = 1µF + 3µF = 4µF (C4)
(D) C1 + (C4) in series = 1 / C1+ 1 / (C4) = 1 / 4 + 1 / 4 = 2 / 4 reciprocal = 4 / 2 = 2 µF or
(D) C1 x (C4) divided by C1+ (C4) = 4x4 / 4 + 4 = 16 / 8 = 2 µF
(E) Ct (C5) = 2 µF

Inductance is given the symbol L and measured in units called the Henry (H).

The inductance of a circuit is one henry if the rate of change of current in a circuit is one ampere per second this results in an electromotive force (EMF) of one volt.

Inductance is the tendency of an electrical conductor to oppose a change in the electric current flowing through it.

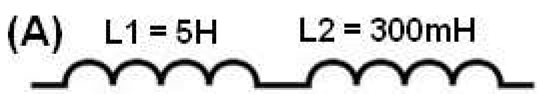
Inductance is the ability of an inductor to store energy and it does this in the magnetic field that is created by the flow of electrical current.

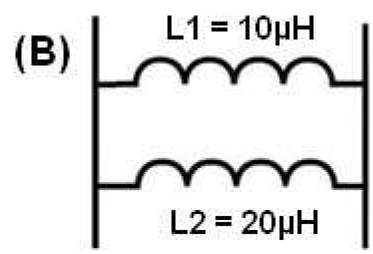
Energy is required to set up the magnetic field and this energy needs to be released when the field falls.

In a DC circuit, an inductor looks like a wire. It has no affect when the current is constant. Inductance only has an effect when the current is changing as in an AC circuit.

Henry (H)	1
Milli Henry (mH)	1×10^{-3}
Micro Henry (µH)	1×10^{-6}
Nano Henry (nH)	1×10^{-9}
Pico Henry (pH)	1×10^{-12}

When using the Inductor formula all the L values should be the same or converted to be the same L value.
7 millihenry = 0.007 Henrys
100 µH = 0.0001 Henrys etc





(A) Inductors in series : Total inductance : Lt = L1 + L2 + L3 etc :
Lt = 5H + 300mH (0.3H) = 5.3H or Lt = 5000mH + 300mH = 5300mH ÷ 1000 = 5.3H

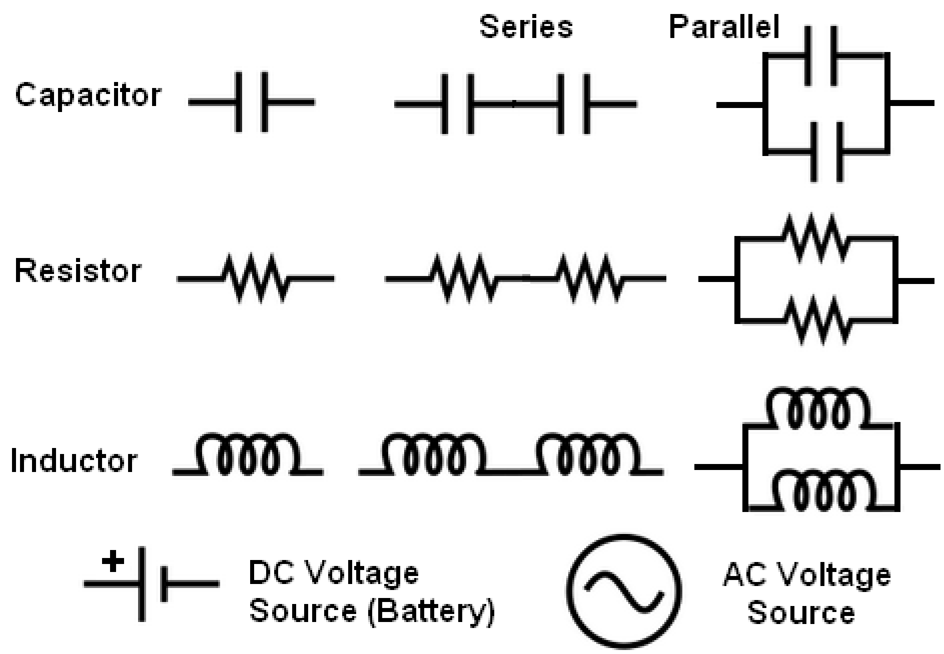
(B) Inductors in parallel: Total inductance : Lt = 1/Lt = 1/L1 + 1/L2 + 1/L3 etc.
Lt = 1/Lt = 1/10 + 1/20 = 2/20 + 1/20 = 3/20, the reciprocal Lt = 20/3 = 6.6µH

For two inductors in parallel Lt = L1 x L2 divided by L1+ L2 .
(B) Lt = 10 x 20 / 10 + 20 = 200 / 30 = 6.6 µH

$$Lt = \frac{L1 \times L2}{L1 + L2}$$

Two Inductors in parallel

Elements Symbol	Resistor	Capacitor	Inductor
Denoted by	R	C	L
Series	$R_T = R_1 + R_2$	$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$	$L_T = L_1 + L_2$
Parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$	$C_T = C_1 + C_2$	$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2}$
Unit	Ohm	Farad	Henry
Symbol	R or Ω	F	H



Decibel: A logarithmic unit, the decibel (dB) is often used to express the ratio of output to input signal levels. When amplifiers and or attenuators are connected in series the overall gain in dB is calculated by adding (or subtracting) the individual dB gains

Gain	Loss
3 db = 2 x power	– 3db = 1/2 power
6db = 4 x power	– 6db = 1/4 power
10 db = 10 x power	– 10db = 1/10 power
20 db = 100x power	– 20 db = 1/100 power
A doubling or halving of power equals a change of approximately 3 dB	3 dB equates to about a 2:1 power ratio 10 dB equates to a 10:1 power ratio

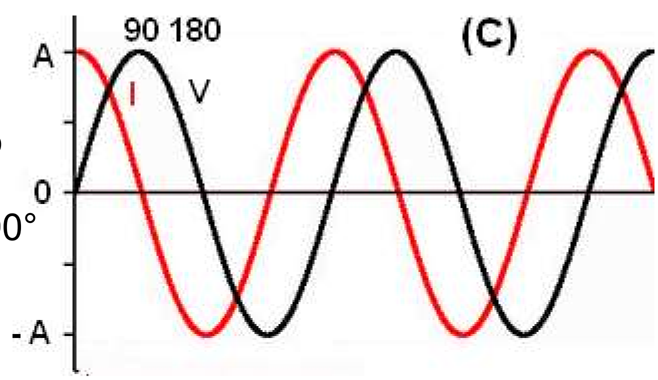
LC Circuits: A LC circuit is also called a tank circuit, tuned circuit or resonant circuit, is an electric circuit built with a capacitor denoted by the letter 'C' and an inductor denoted by the letter 'L' connected together. The circuit is used for giving the required positive feedback for sustaining the oscillations.

These circuits are used for generating signals at a particular frequency or accepting a signal at a particular frequency from a more complex signal.

In a LC circuit resonance occurs when the reactance's of the capacitor and inductor are equal to each other. Because inductive reactance increases with increasing frequency and capacitive reactance decreases with increasing frequency, there will only be one frequency where these two reactance's will be equal.

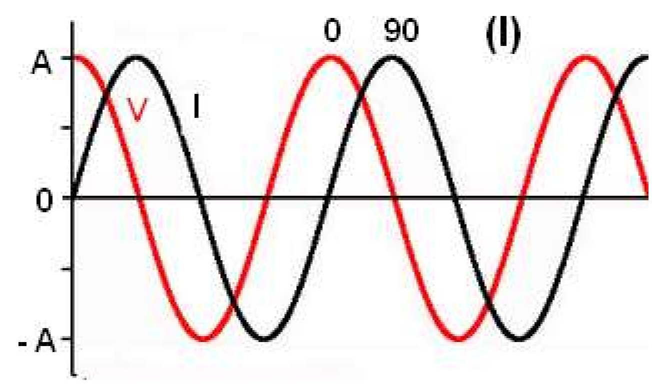
LC circuits are basic electronics components in various electronic devices, especially in radio equipment used in circuits like tuners, filters, frequency mixers and oscillators.

Reactance (symbol X) is a measure of the opposition of capacitance and inductance to current and is measured in Ohms. Because it only affects changing current, reactance is specific to AC power and depends on the frequency of the current.



(C) Capacitive Reactance: When AC is applied to a capacitor it will charge it, first in one direction, then the other. The current leads the voltage by 90°

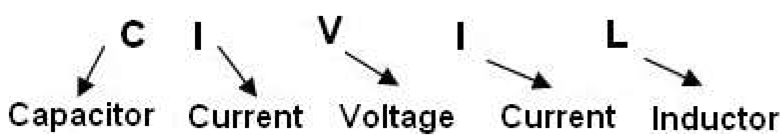
Reactance of the capacitor decreases as the frequency increases

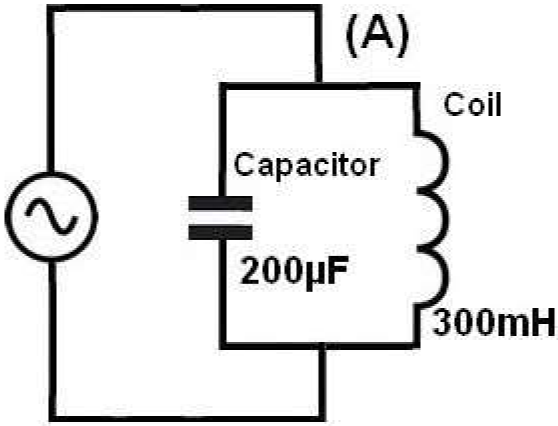


(I) Inductive Reactance: If an AC voltage is applied to an inductor the reverse voltage (back emf) generated causes:
The current to lag the voltage by 90°

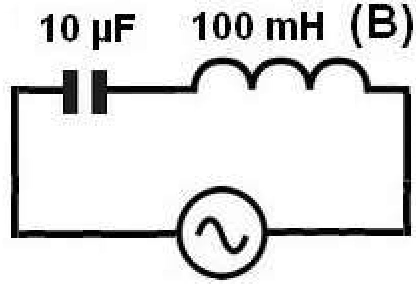
Reactance of the inductor increases as the frequency increases

CIVIL…Capacitor current leads voltage and voltage leads current Inductor.





$$f_{\text{res}} = \frac{1}{2\pi\sqrt{LC}}$$



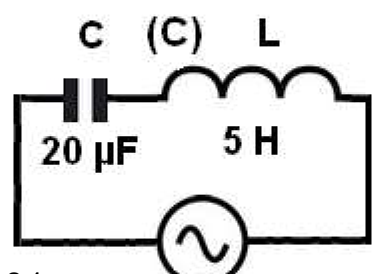
$$f_{\text{res}} = \frac{1}{2\pi\sqrt{LC}}$$

(A) LC parallel circuit and the formula for frequency resonance where L is the inductance in henrys (H), and C is the capacitance in farads (F) and fres (fr) = resonant frequency in Hz .... Note: π = 3.14

(A) Find fr when 200μF (0.0002F) and 300mH (0.3H) are in parallel.
0.3 (L) x 0.0002 (C) = 0.00006 : square root of √0.00006 = 0.0077
6.28 (2 X π) x 0.0077 = 0.48 therefore fr =1 / 0.48 = 20.8Hz

(B) LC series circuit where L is the inductance in henrys (H), and C is the capacitance in farads (F) and f = frequency in Hz.

Find fr when.....100mH (0.1H) and 10μF (0.00001) are in series : f = 0.1(L) x 0.00001 (C) = 0.000001.....square root of √0.000001 = 0.001 x 6.28 = 0.00628 therefore f = 1 / 0.00628 = 159.2 Hz.



(C) Find resonant frequency (F) : 20μF = 0.00002F
using the fr formula

(C): L x C = 5(H) X 0.00002(F) = 0.0001 square root of √0.0001 = 0.01
2π = 6.28 .... 6.28 x 0.01 = 0.0628 : f = 1 / 0.0628 = 15.92 Hz

1) In a series circuit with L = 1H and C = 1Farad what is the resonant frequency?

Using the freq (fr) formula: 1(L) X 1(C) = 1x1 = 1 square root of √1 = 1…
2π = 6.28…6.28 x 1 = 6.28 therefore f = 1 / 6.28 = 0.159 Hz

Reactance (symbol X) is a measure of the opposition of capacitance and inductance to current and is measured in Ohms.

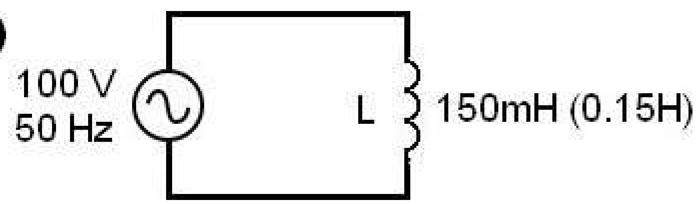
Because it only affects changing current, reactance is specific to AC power and depends on the frequency of the current. Steady electric currents flowing along conductors in one direction undergo opposition called electrical resistance, but no reactance.

There are two types of reactance: capacitive reactance (XC) and inductive reactance (XL).

In electrical and electronic systems, reactance is the opposition of a circuit element to a change in current or voltage, due to that element's inductance or capacitance. Reactance varies with the frequency of the electrical signal. Reactance is measured in ohms

(A)

$$X_L = 2\pi f L$$



When using the Inductance reactance formula (A) : π = 3.14 : f = frequency in Hertz (Hz) : L = inductance in Henrys.....

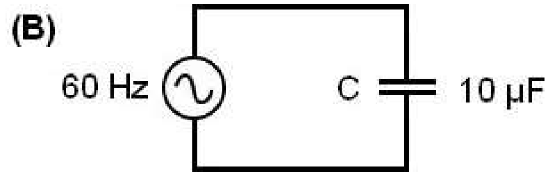
(A) Coil has an inductance of 150mH (0.15H) and zero resistance connected across a 100V, 50Hz supply.

Calculate the inductive reactance (XL) of the coil and the current (Amps) going through it. Using the inductance formula to find XL

XL = 6.28 (2 x 3.14) x 50(Hz) x 0.15(H) = 47.12 ohms.

Current (using Ohms Law) = V / XL = 100 / 47.12 = 2.12 Amps

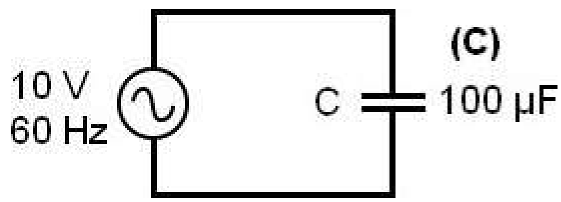
$$X_C = \frac{1}{2\pi f C}$$



When using the Capacitance reactance formula (B): π = 3.14 : f = frequency in Hertz (Hz) C = capacitance in Farads.

(B) Find the capacitance reactance when frequency is 60 Hz and the capacitance is 10µF (0.00001F).

XC = 1 / 6.28 (2 X 3.14) x 60 (Hz) x 0.00001 (F) = 1 / 0.003768 = 265 ohms



(C) Find the current (Amps) when voltage 10v : frequency 60 Hz : Capacitance 100µF (0.0001F):

Using the capacitance reactance formula to find XC

XC = 1 / 6.28 (2 X 3.14) x 60 (Hz) x 0.0001 (F) = 1 / 0.03768 = 26.5Ω :

Current (using Ohms Law) = V / XC = 10V / 26.5 (XC) = 0.377 Amps

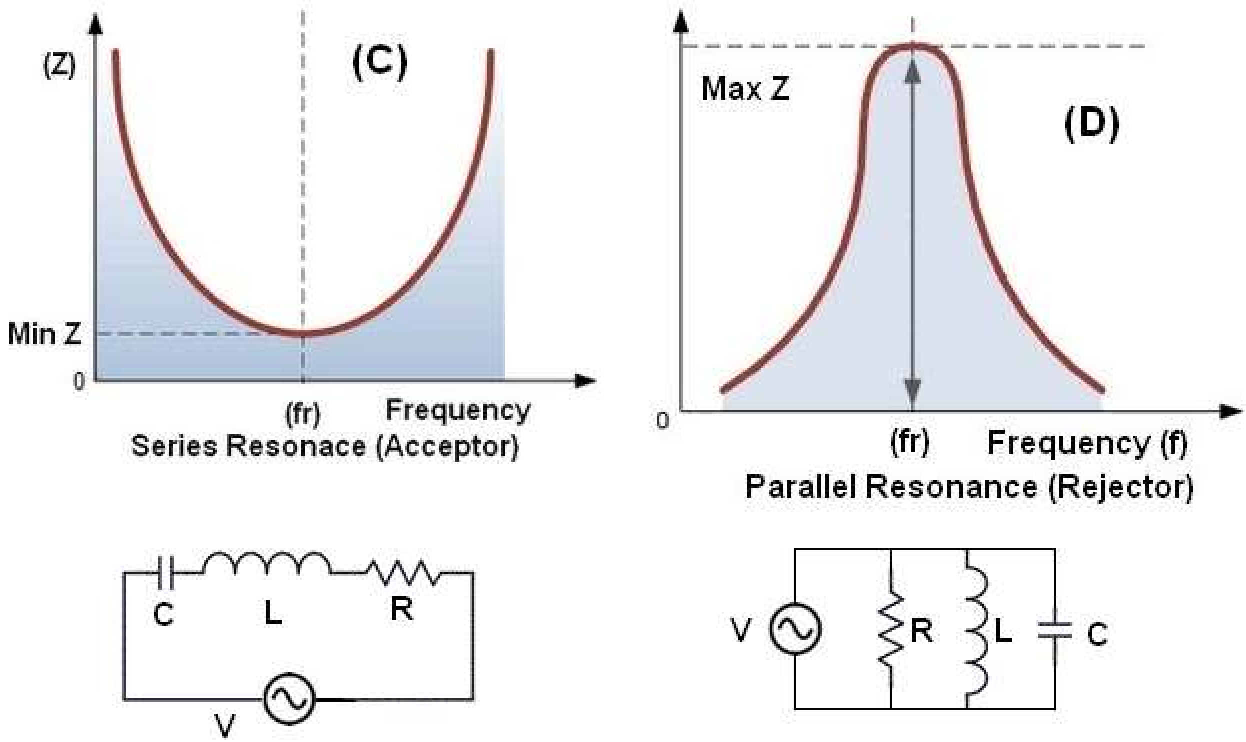
Resonance: Electrical resonance occurs in an electric circuit at a particular resonant frequency when the impedance of the circuit is at a minimum in a series circuit or at maximum in a parallel circuit (usually when the transfer function peaks in absolute value)

Impedance: represented by the symbol Z, is a measure of the opposition to electrical flow.

Electrical resonance occurs in an AC circuit when the two reactance's which are opposite and equal cancel each other out as XL = XC

Series Resonance has minimum impedance at resonant frequency.

Parallel Resonance has maximum impedance at resonant frequency.



(C): A series resonance circuit is also known as an Acceptor Circuit because at resonance (fr), the impedance (Z) of the circuit is at its minimum so easily accepts the current whose frequency is equal to its resonant frequency or we can say that it functions mainly at resonance.
(D): The parallel resonator circuit is also known as a Rejecter Circuit because at resonance (fr), the impedance (Z) of the circuit is at its maximum thereby suppressing or rejecting the current whose frequency is equal to its resonant frequency.

Q Factor: The Q quality factor relates the maximum or peak energy stored in the circuit (the reactance) to the energy dissipated (the resistance) during each cycle of oscillation meaning that it is a ratio of resonant frequency to bandwidth and the higher the circuit Q, the smaller the bandwidth.

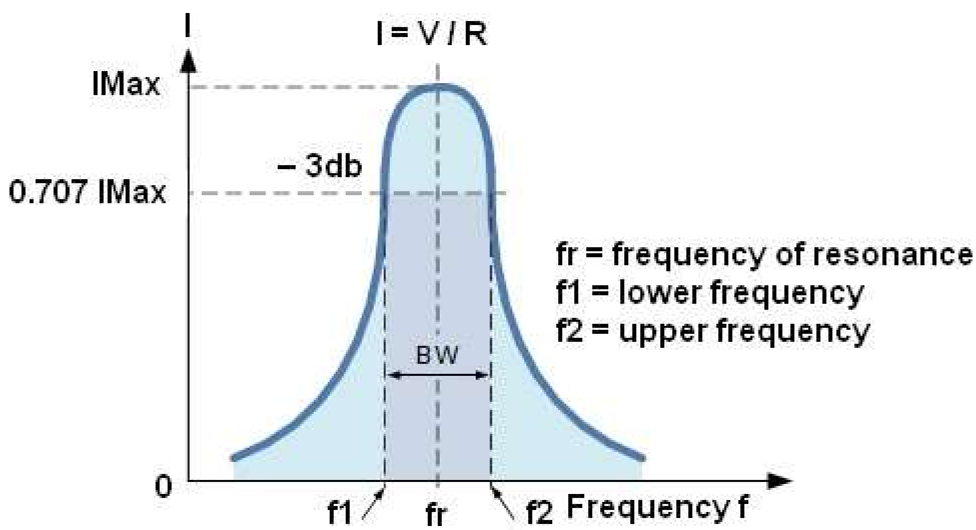
Q = ƒr /BW where ƒr = frequency resonance and BW bandwidth.

Q factor is alternatively defined as the ratio of a resonator's centre frequency to its bandwidth when subject to an oscillating driving force.

Bandwidth. With increasing Q factor or quality factor, so the bandwidth of the tuned circuit filter is reduced. As losses decrease so the tuned circuit becomes sharper as energy is stored better in the circuit.

The bandwidth is measured at the ½ power or 3db point which are where the voltage has fallen 0.707 of its value at resonance.

Bandwidth is defined as the size of frequency range that is passed or rejected by the tuned circuit.



Bandwidth (BW) of a Series Resonance Circuit

As the bandwidth is taken between the two -3dB points, the selectivity of the circuit is a measure of its ability to reject any frequencies either side of these points.

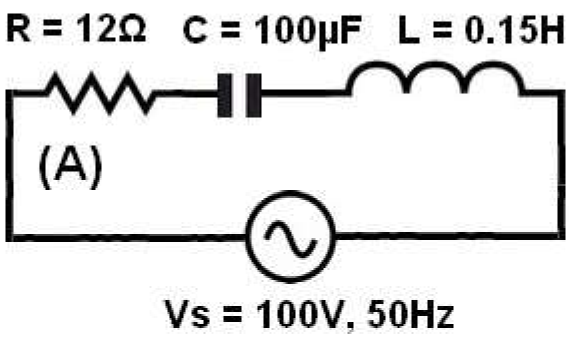
A more selective circuit will have a narrower bandwidth whereas a less selective circuit will have a wider bandwidth. The selectivity of a series resonance circuit can be controlled by adjusting the value of the resistance only, keeping all the other components the same, since Q = (XL or XC)/R.

RLC Circuit: is an electrical circuit consisting of a resistor (R), an inductor (L), and a capacitor (C), connected in series or in parallel.

The RLC circuit forms a harmonic oscillator for current, and resonates in a similar way as an LC circuit. Introducing the resistor increases the decay of these oscillations, which is also known as damping.

When a resistor, inductor and capacitor are connected in series with the voltage supply, the circuit so formed is called series RLC circuit.

Electrical impedance (Z), measures the total opposition that a circuit or a part of a circuit presents to electric current. Impedance includes both resistance and reactance.



$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Impedance (Z) formula where f = Hertz (Hz) : L = Inductance (Henrys) C = Capacitance (Farads) and R = Ohms.

Series RLC circuit (A) : Calculate the total circuit impedance (Z) and the circuit current........

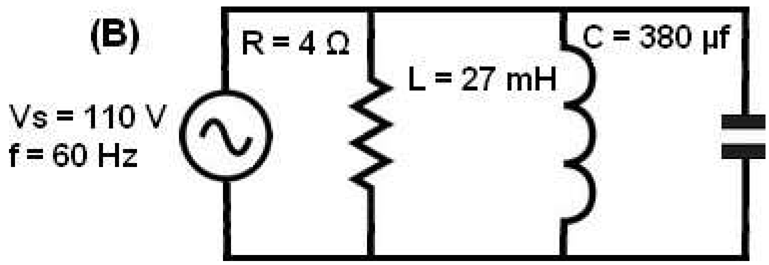
To find the total circuit impedance, first find XL and XC and then use the impedance (Z) formula. : Note 100μF = 100 / 1000 x 1000 = 0.0001F

XL = 2 x π x f x L = 2 x 3.14 x 50 x 0.15 = 47.1Ω.

XC = 1 / 2 x π x f x C = 1 / 6.28 X 50 X 0.0001F = 0.0314 therefore XC = 1 / 0.0314 = 31.83Ω

(A) Impedance (Z) = square root $\sqrt{R^2 + (XL - XC)^2} = 12^2 + 15.27^2 = 144 + 233.17 =$ 377.17 therefore Z = square root of $\sqrt{377.1}$ = 19.4 ohms......

Circuit current (using ohms law) = Vs / Z = 100 / 19.4 = 5.15A



Like series RLC circuit, parallel RLC circuit also resonates at particular frequency called resonance frequency i.e. there occurs a frequency at which inductive reactance becomes equal to capacitive reactance but unlike series RLC circuit, in parallel RLC circuit the impedance becomes maximum and the circuit behaves like purely resistive circuit leading to unity electrical power factor of the circuit.

(B) In the parallel RLC circuit, the supply voltage is common to all components.

To calculate impedance (Z), we should, first calculate the inductive (XL) and capacitive reactance (XC)

(B) Use Ohms, Henrys and Farads in the formula.
4 Ohms: 27 mH = 0.027H and 380μF = 0.00038F

XL = 2 x π x f x L = 2 x 3.14 x 60 x 0.027 = 10.1 ohms

XC = 1 / 2 x π x f x C = 1 / 6.28 X 60 X 0.00038 = 0.143 therefore XC = 1 / 0.143 = 6.99 ohms

To find Z use in the Z formula where XL - XC = 10.1 – 6.99 = 3.11Ω

(Z) Impedance (ohms) = square root $\sqrt{R^2 + (XL – XC)}$ = $4^2 + (10.1 – 6.99) = 4^2 + 3.11^2 = 16 + 9.67 = 25.67$ therefore Z = square root of $\sqrt{25.67}$ = 5 ohms

To find the current = Vs / Z = 110 / 5 = 22A

Impedance: Impedance is the combination of resistance and reactance.

Difference between Resistance and Impedance: Resistance is a concept used for DC (direct current) whereas impedance is the AC (alternating current) equivalent.

In an AC circuit electrical resistance is called “Impedance”. In both cases this voltage-current (V-I) relationship is always linear in a pure resistance.

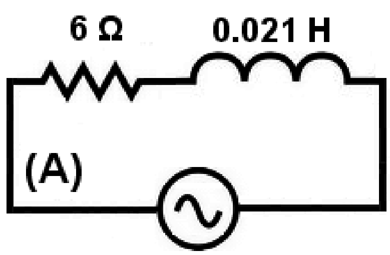
In AC circuits, the term Impedance, symbol Z is the generally used to mean its resistance and is measured in Ohms.

Electrical Impedance (Z), is the amount of opposition that a circuit presents to alternating current. Impedance is measured in ohms and may include resistance (R), inductive reactance (XL), and capacitive reactance (XC)

Impedance (Z), in electrical devices, refers to the amount of opposition faced by direct or alternating current when it passes through a conductor component, circuit or system.

In electronics, impedance matching is the practice of designing the input impedance of an electrical load or the output impedance of its corresponding signal source to maximize the power transfer or minimize signal reflection from the load.

The impedance has a general formula: Z = V / I, this formula is similar to the ohm law, which is applied to resistors, but in this case it is used for AC signals.



110 V AC 60 cycles (Hz)

(1) Find inductive reactance

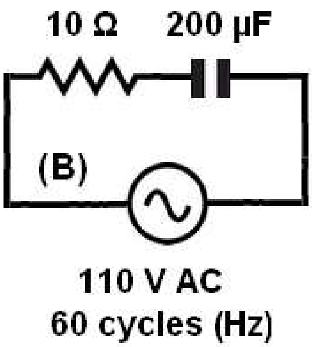
$$X_L = 2\,\pi \times f \times L$$
$$X_L = 6.28 \times 60 \times 0.021$$
$$X_L = 8 \text{ ohms}$$

(2) Total impedance

$$Z = \sqrt{R^2 + X_L{}^2}$$
$$Z = \sqrt{6^2 + 8^2}$$
$$Z = \sqrt{36 + 64}$$
$$Z = \sqrt{100}$$
$$Z = 10 \text{ ohms}$$

(3) Current flow

$$I = \frac{E}{Z}$$
$$I = \frac{110}{10}$$
$$I = 11 \text{ amperes}$$



(1) Find capacitive reactance

200 µf. = 0.000200 farads

$$X_C = \frac{1}{2\,\pi\, f\, C}$$

$$X_C = \frac{1}{6.28 \times 60 \times 0.00200}$$

$$X_C = \frac{1}{0.07536}$$

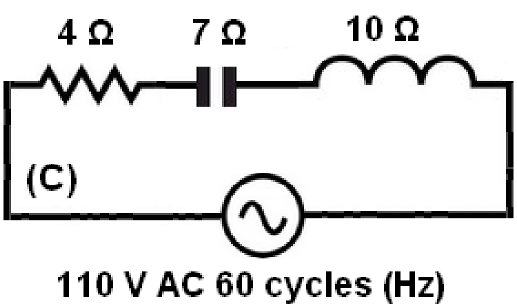
$$X_C = 13 \text{ ohms}$$

(2) Total impedance

$$Z = \sqrt{R^2 + X_C{}^2}$$
$$Z = \sqrt{10^2 + 13^2}$$
$$Z = \sqrt{100 + 169}$$
$$Z = \sqrt{269}$$
$$Z = 16.4 \text{ ohms}$$

(3) Current flow

$$I = \frac{E}{Z}$$
$$I = \frac{110}{16.4}$$
$$I = 6.7 \text{ amperes}$$



(1)
$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$
$$Z = \sqrt{4^2 + (10 - 7)^2}$$
$$Z = \sqrt{4^2 + 3^2}$$
$$Z = \sqrt{25}$$
$$Z = 5 \text{ ohms}$$

(2)
$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$
$$Z = \sqrt{4^2 + (7 - 10)^2}$$
$$Z = \sqrt{4^2 + (-3)^2}$$
$$Z = \sqrt{16 + 9}$$
$$Z = \sqrt{25}$$
$$Z = 5 \text{ ohms}$$

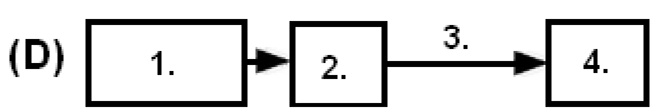
(C) (1) What is the impedance of the circuit when the capacitive reactance (XC) is 7 Ω, inductive reactance (XL) is 10 Ω and resistor resistance is 4 Ω. Z = 5 ohms

(2) Assuming that the capacitive reactance (XC) is 10 Ω and the inductive capacitance (XL) is 7 Ω then XC is greater than XL, the resistor is 4 Ω. Z = 5 ohms

(XL – XC) = (XC – XL) (the small number is always subtracted from the larger) as in (1)

In RF circuits, impedance matching is important for maximum transfer of power.

(D) The ATU (Antenna Tuning Unit) is used to match the output impedance of the transmitter to the antenna impedance which may be different from the transmitter 50Ω output impedance.



1. Transmitter (output impedance 50Ω)
2. Matching Nework (ATU)
3. Transmission Line (coaxial 50Ω)
4. Load (antenna)

Transformer…. A transformer is an electrical device consisting of two or more coils of wire that can be used to transfer the power from one circuit and another circuit without physical contact and without changing its characteristics like frequency by means of a changing magnetic field

Generally: the primary winding of a transformer is connected to the input voltage supply and converts or transforms the electrical power into a magnetic field.
While the job of the secondary winding is to convert this alternating magnetic field into electrical power producing the required output voltage....

Turns Ratio (Tr) : The turns ratio, or the turns-to-turns ratio, is the ratio of the number of turns in the primary to the number of turns in the secondary or the number of turns on the secondary to the number of turns on the primary and is expressed with two numbers, like 2:1 or 1:2. The first number represents the primary's relative number of turns, while the second number represents the secondary's relative number of turns.

This turn's ratio value dictates the operation of the transformer and the corresponding voltage available on the secondary winding.... If there are 2 x number of turns on the secondary of the transformer to that of the primary, the voltage turn ratio of the step-up transformer is 1: 2.

Transformer Ratio (Tr) : A transformers ratio is the relationships between the number of turns in the primary and secondary, the voltage across each winding, and the current through the windings.

(A) We can rearrange the Tr (transformer ratio) equation to find the value of any unknown voltage (V), current (I) or number of turns (N)

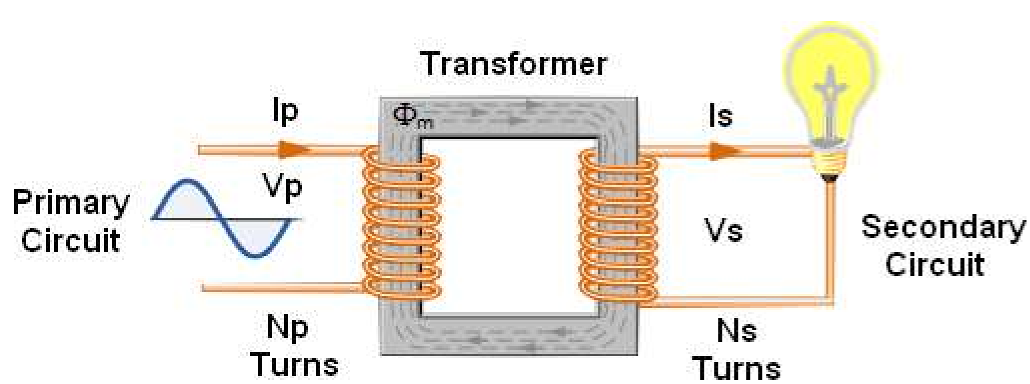
Np turns primary
Ns turns secondary
Vp voltage primary
Vs voltage secondary
Ip current primary
Is current secondary

(A) $$Tr = \frac{Np}{Ns} = \frac{Vp}{Vs} = \frac{Is}{Ip}$$

$$Tr = \frac{Np}{Ns} = \frac{Vp}{Vs} \qquad Tr = \frac{Np}{Ns} = \frac{Is}{Ip} \qquad \frac{Vp}{Vs} = \frac{Is}{Ip}$$

$$Np \times Vs = Ns \times Vp \qquad Np \times Ip = Ns \times Is \qquad Vp \times Ip = Vs \times Is$$

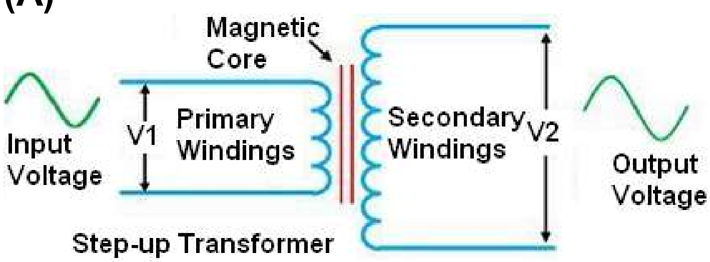
The current in the windings of a transformer is inversely proportional to the voltage in the windings.
Vp / Vs = Is / Ip



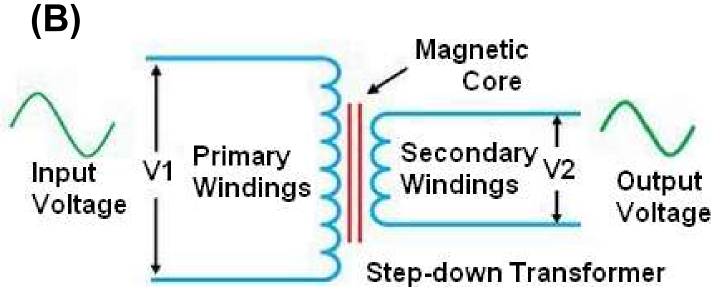
Step up and Step down Transformer. When a transformer is used to “increase” the voltage on its secondary winding with respect to the primary, it is called a Step-up transformer.

When it is used to “decrease” the voltage on the secondary winding with respect to the primary it is called a Step-down transformer….The step-down transformer increases the output current for keeping the input and output power of the system equal.

(A)



(B)



(A) Step-up Transformer		Step up Transformer: Example	
Primary	Secondary	Primary	Secondary
Few Turns	Many turns	3,000 turns	6,000 turns
Low Voltage	High Voltage	25V	50V
High Current	Low current	10A	5A
		250W	250W

Turns ratio Np / Ns = 3000 / 6000 = 1:2

Power Primary = I x V = 10 x 25 = 250 watts : Power Secondary = I x V = 5 x 50 =250W

(B) Step-down Transformer		Step down Transformer; Example	
Primary	Secondary	Primary	Secondary
Many Turns	Few Turns	400 turns	100 turns
High Voltage	Low Voltage	20V	5V
Low Current	High Current	2A	8A
		40W	40W

Turns ratio Np / Ns = 400 / 100 = 4:1
Power Primary = I x V = 2 x 20 = 40 watts : Power Secondary = I x V = 8 x 5 = 40 watts

With both Step-up and Step-down transformers primary power = secondary power or using the power formula P = Vp x Ip = Vs x Is

A 1:1 ratio transformer is primarily used to isolate the primary from the secondary.

“Turns ratio = Voltage ratio”. In (A) turns ratio was 1:2 and the voltage ratio is Vp/Vs = 25/50 = 1:2 and in (B) turns ratio was 4:1 and voltage ratio is Vp/Vs = 20/5 = 4:1

Q1.Step up transformer has ratio of 1:2 with 50 volts (Vp) and 10 amperes (Ip) applied to the primary. With a 1:2 ratio the secondary voltage (Vs) is 2 times (100V) the primary voltage, find the secondary current (Is)?

Having Vp, Ip and Vs, we can use Vp x Ip = Vs x Is therefore Is = Vp x Ip / Vs =
50 x 10 / 100 = 5 amps
To find the power in the primary (Pp) using P = I x V : Pp = Ip x Vp = 10 x 50 = 500 watts

As the power in the primary (Pp) equals the power in the secondary (Ps)
Ps = Is x Vs = 5 x 100 = 500 watts

Q2. What is the turns ratio of a transformer with 500 turns in the primary winding and 2000 turns in the secondary winding? Turns ratio Np / Ns = 500 / 2000 = 1: 4

Q3. The primary winding has 300 turns and the secondary has 15 turns what is the turns ratio. Turns radio Np / Ns = 300 / 15 = 20:1

Q4.When operated at 120 V in the primary of an iron core transformer, the current in the primary is 4 amps. Find the current in the secondary if the voltage is stepped up to 240 V
Vp x Ip = Vs x Is therefore Is = Vp x Ip / Vs = 120 x 4 / 240 = 2 amps
Power: Vp x Ip = Vs x Is…Primary 120 x 4 = 480w and Secondary 240 x 2 = 480w

“turns ratio = voltage ratio. Voltage ratio = Vp / Vs = 120 / 240 = 1:2
Turns ratio 1:2 and voltage ratio1:2 with the current ratio 2:1

Check turns ratio: Vp = 120V and Vs = 240V (1:2) …. Ip = 4A and Is = 2A (2:1)

Q 5. A transformer has a 10:1 turns ratio. That is 1000 turns on the primary (Np) and 100 turns on the secondary (Ns).
If the primary (Ip) has a current of 100 milliamps, how much current flows in the secondary (Is)? 100 milliamps (0.1 amps), Np = 1000 and Ns 100
Using formula Np x Ip = Ns x Is : Is = Np x Ip / Ns = 1000 x 0.1 / 100 = 100 / 100 = 1A
The secondary current would be 1A

Q6. A transformer with a primary voltage of 40 volts has 250 turns in the primary and 500 turns in the secondary. What is is secondary voltage ?
Np x Vs = Ns x Vp therefore Vs = Ns x Vp / Np = 500 x 40 / 250 = 20000 / 250 = 80V
The secondary voltage is 80 volts (turns ratio 1:2)

Q7. If it is needed to change 240 V down to 12 V and the transformer has 2000 turns on its primary coil how many turns should it have on its secondary coil ?
Np x Vs = Ns x Vp therefore Ns = Np x Vs / Vp = 2000 x 12 / 240 = 100 turns (ratio 20:1)

Wavelength (λ): Frequency (f): Speed of Light (c)

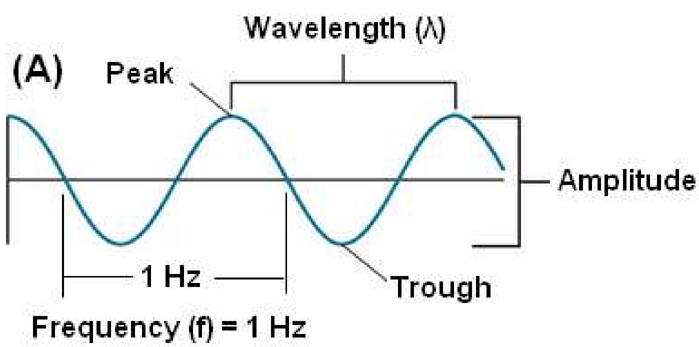
The basic building block of radio communications is a radio wave. A radio wave is generated by a transmitter and then detected by a receiver. An antenna allows a radio transmitter to send energy into space and a receiver to pick up energy from space.

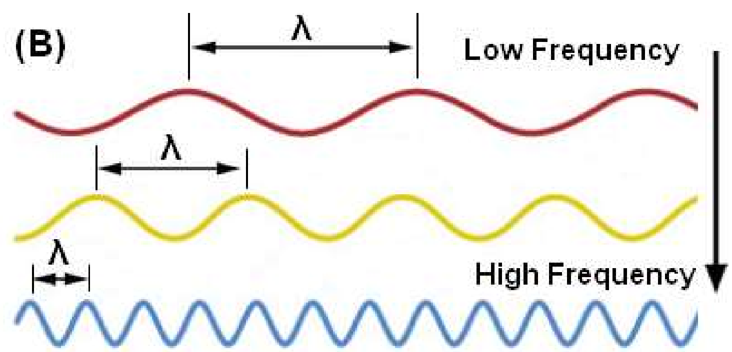
Like waves on a pond, a radio wave is a series of repeating peaks and valleys. The entire pattern of a wave, before it repeats itself, is called a cycle.

The wavelength is the distance a wave takes to complete one cycle. The number of cycles, or times that a wave repeats in a second, is called frequency.

Transmitters and receivers are typically designed to operate over a limited range of frequencies.

Wavelength (λ): Wavelength is usually measured in meters (m) and is the distance between identical points (adjacent peaks or troughs) in the adjacent cycles of a waveform. It is measured in the direction of the wave





(B) λ = wavelength shows that different waves have different wavelengths (distance between peaks) and increasing the frequency reduces the wavelength.

Frequency (f) is measured in the unit hertz (Hz) and is the number of cycles, or times that a wave repeats in a second . One hertz means "one cycle per second"
If a wave repeats 5 times in one second its frequency would be 5 Hz.

One thousand hertz is referred to as a kilohertz (kHz), 1 million hertz as a megahertz (MHz), and 1 billion hertz as a gigahertz (GHz). The range of the radio spectrum is considered to be 3 kilohertz up to 300 gigahertz.

(C) cps = cycles per second

(C) **1 Hz = 1 cps**
1 Khz = 1,000 cps = 10^3
1 MHz = 1,000,000 cps = 1 x 10^6
1 GHz = 1,000,000,000 cps = 1 x 10^9

100 Hz to kHz = 100 / 1000
= 0.1kHz

1 MHz to Hz = 1 x 1,000,000
1,000,000 Hz

(A)

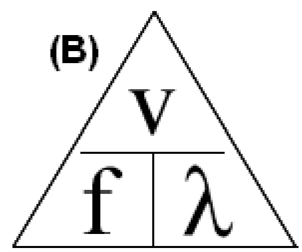
To Convert This to This → ↓	Hz	kHz	MHz	GHz
Hz	1	0.001	1×10^{-6}	1×10^{-9}
kHz	1000	1	0.001	1×10^{-6}
MHz	1×10^{6}	1000	1	0.001
GHz	1×10^{9}	1×10^{6}	1000	1

(A) Convert 75Hz to kilohertz: 1 Hz = 0.001 kHz = 75 x 0.001 = 0.075 kHz
75 kHz to Hz = 75 x 1000 = 75000 Hz : 50MHz = 50 x 1,000,000 = 50,000,000 Hz

Speed of Light (c): speed of light is defined as 299,792,458 meters per second (m/s)
In the wave equation (B) we can use 300,000,000 m/s = 3×10^8 m/s
c = speed of light in a vacuum whereas v = velocity of a radio wave (speed of light)
Speed of light, in some equations the letter c is used instead of the letter v

(B) where v is the velocity (speed m/s), λ is the wavelength in meters and f is the frequency in Hz: $f = v / \lambda$: $\lambda = v / f$ and $v = f \times \lambda$

(B)



As the speed of light is constant, if the frequency is increased, the wavelength must decrease to maintain this equation and vice versa.

10 meters to MHz: f = v / λ = 300,000,000 m/s / 10m = 30,000,000 Hz or 30 MHz
5 MHz to meters: λ = v / f = 300,000,000 m/s / 5,000,000 Hz = 60 meters

When f is the frequency of the signal is measured in megahertz (MHz) and the wavelength is measured in meters we can use: λ = 300 / f and conversely f = 300 / λ

Remembering 10mtrs = 300 /10 = 30 MHz and 30 MHz = 300/ 30 = 10 meters, can serve as a useful reminder when converting MHz to meters and meters to MHz.
6 meters = 300 / 6 = 50MHz and 10MHz = 300/10 = 30 meters etc

1) 145 MHz to meters: λ = v / f = 300,000,000 m/s / 145,000,000 Hz = 2.068 meters
or 300 / f = 300 / 145 = 2.068 mtrs………..2 mtrs = 300/2 = 145MHz
2) Wavelength 80 mtrs to frequency MHz = 300,000,000 / 80 = 3750000Hz (3.75MHz)
or 300 / 80 = 3.75 MHz……...3.75MHz to meters = 300 / 3.75 = 80 meters.

Band	Designation	Frequency limits
VLF	very low frequency	3 kHz - 30 kHz
LF	low frequency	30 kHz - 300 kHz
MF	medium frequency	300 kHz - 3 MHz
HF	high frequency	3 MHz - 30 MHz
VHF	very high frequency	30 MHz - 300 MHz
UHF	ultra high frequency	300 MHz - 3 GHz
SHF	super high frequency	3 GHz - 30 GHz
EHF	extremely high frequency	30 GHz - 300 GHz

Smith Chart: is a chart designed to solve transmission line problems graphically.

The Smith chart coordinate system is comprised of resistance circles and reactance arcs.

In simple terms, a Smith chart is a map from one impedance to another impedance.

In most cases an antenna, filter or amplifier is a load that needs its impedance, noted as ZL, mapped (matched) to a system impedance, noted as Z0.

The impedance Z0 is 50 ohms in most cases, quite often the output of the transceiver.

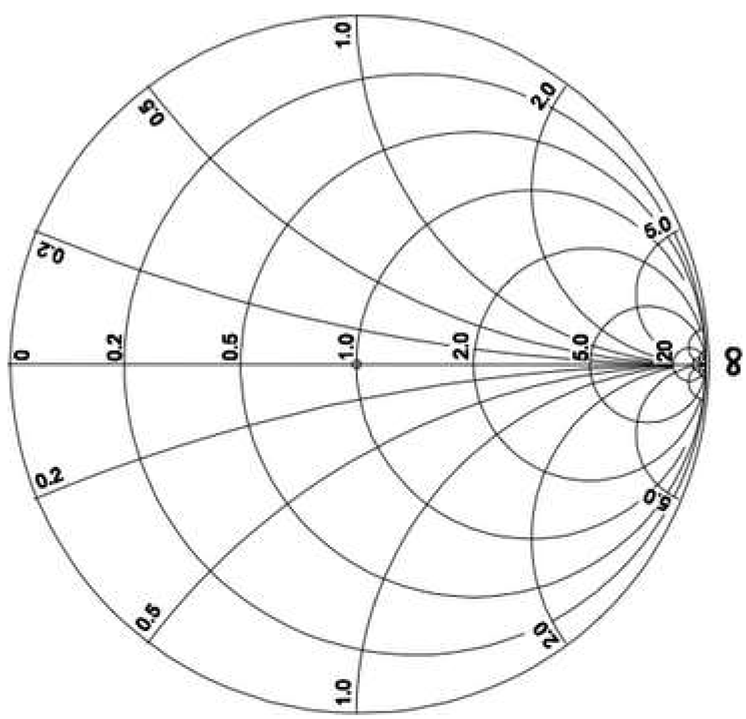
Each component in the matching network between the impedances are represented on the Smith chart by a circular path.

What are the two families of circles and arcs that make up a Smith chart? Resistance and reactance.

What type of coordinate system is used in a Smith chart?
Resistance circles and reactance arcs.

Impedance and SWR values in transmission lines are often determined using a Smith chart

Smith Chart



Element IV (4) - Amateur Radio Practice

“NTC Amateur Radio Exam Multi Choice” includes Element 4 which has 126 multi choice questions and answers and information.

8. Instrument used to measure resistance with value less than one ohm

A. ? multimeter

B. ? ohmmeter

C. ? Wheatstone bridge

D. ? resistance bridge

87. Dummy antenna is used to:

A. ? to reduce standing waves

B. ? to prevent unnecessary radiation that may cause interference

C. ? match the antenna

D. ? reduce power

S-Meter: An S meter (signal strength meter) is an indicator often provided amateur radio transceivers. The scale markings are derived from a system of reporting signal strength from S1 to S9 as part of the R-S-T system. S-points go from S1 to S9 and each S-point is defined as a 6 dB change in signal strength.

Field Strength Meter (FSM): is an electronic device which is used for detecting and measuring the RF radiation generated from any RF transmitter.
It is used to measure the strength of radio signals, for example to determine the directivity and approximate gain of an antenna.

Speech Processor: The primary purpose of a speech processor as used in modern transceivers is to increase the intelligibility of transmitted phone signals during poor conditions. The speech processor brings up the power of low level parts of phone or voice signals while not changing the high level parts of the signal**.**

SWR – VSWR (Reflectometer) Meter: is an electronic test instrument that provides a good indication of the level of SWR (standing wave ratio) present in a feeder, are often left in circuit as a continuous indication of the antenna system performance, including the appearance of any faults which might manifest themselves with a high VSWR level.

Acceptable SWR reading? A SWR reading below 1.5:1 or as close to 1:1 as possible.
If the SWR is 1:1, that means 100% of the power from the radio will be transferred to the antenna. If the SWR is 2:1, that means losing 14% of the output power at the antenna. The SWR reading 3:1 means losing 25% of the power.

Unstable SWR readings are usually an indication of problems such as a loose connection in an antenna or a feedline, incorrectly connecting SWR meter to the radio and antenna.

Antenna Tuning Unit (ATU): is a device that is inserted between a radio transmitter and its antenna; when properly adjusted (tuned) it improves power transfer by matching the impedance of the transceiver to the impedance of the antenna, or the feedline which connects the antenna to the transmitter.

Multimeter: A typical multimeter can measure voltage, resistance, and current.

Monitoring oscilloscope: an oscilloscope can look at the transmitter radio frequency carrier, the carrier envelope, the amplitude demodulated signal, as well as linearity

Wattmeter: In amateur radio also known as a Power Meter is used to measure the transceiver power output in watts.

Electronic T-R (transmit – receive) switch: Allows for rapid and automatic switching of the radio antenna or antenna between the transmitter and receiver.

Grid Dip Oscillator (GDO) or Meter (GDM): is a type of electronic instrument that measures the resonant frequency of nearby unconnected radio frequency tuned circuits**.**

Signal generators: A signal generator is an analog or digital device that can be used to create electronic signals when testing circuit designs.

Radio frequency signal generators are most commonly used by radio amateurs, since they generate signals in the amateur radio bands and allow modulation of the signal to simulate a standard radio transmission.

Signal tracer: is an audio amplifier with high impedance input used to "hear" a signal in a circuit.

Oscilloscope: an oscilloscope displays signals in the time domain. Oscilloscope displays signals that change rapidly. It is useful for measuring RF waveforms, modulation and other operating parameters in a radio station.

Two tone test: to measure of linearity of SSB transceivers and linear amplifiers often requires a standard two-tone (700 and 1900 Hz) audio source.

Spectrum analyzer: A spectrum analyzer measures the magnitude of an input signal versus frequency within the full frequency range of the instrument.
A spectrum analyzer is used to display spurious signals from a radio transmitter and can also be used to display intermodulation distortion products in an SSB transmission.

Logic probe: The logic probe is able to detect lines that are at the logic high or low state.

Logic high state: The logic probe will indicate this typically with an LED which is often coloured red.
Logic low: The logic probe also is able to indicate a logic or digital low. A common indication is with the use of a green coloured LED.

Neutralizing final amplifier: What is the reason for neutralizing the final amplifier stage of a transmitter? To eliminate self-oscillations

In a vacuum tube neutralization is primarily concerned with correcting unwanted feedback that occurs from normal anode-cathode feedback in a grounded.
Neutralization is generally accomplished by adding external capacitance.

Power measurement: Power meters measure the power output of a transmitter.

Harmonics: Interference to consumer electronic products caused by radiated harmonics include television interference and listening to AM or FM radio.

Ground system:
Safety Ground: protect against shock hazards from mains or high powered equipment by providing safe path for current when a fault occurs in wiring or insulation.

Lightning protection: Disconnect all equipment, dissipate the lightning’s charge in the Earth, routing it away from equipment by installing a lightening or surge arrester.

RF Ground: prevent unwanted RF currents and voltages from disrupting the normal functions of equipment (also known as RF interference or RFI).
Create of a single ground point within the operating area.

Antenna installation safety procedure: Do not place an outside antenna system in the vicinity of overhead power lines or other electric light or power circuits, or where it can fall into power lines or circuits. When installing an outside antenna system, take extreme care to avoid touching power lines or circuits, as contact with them could be fatal.

Direction Finding: Direction finding (DF), or radio direction finding (RDF), is finding the direction from where a target signal is transmitted which will help in finding the source and location of the transmitted signal.

For direction finding we can use a receiver, directional antenna, compass and map.
Using one receiver and directional antenna we can plot the direction of signal.
Using two receivers at different locations we can plot from where the signal is transmitted

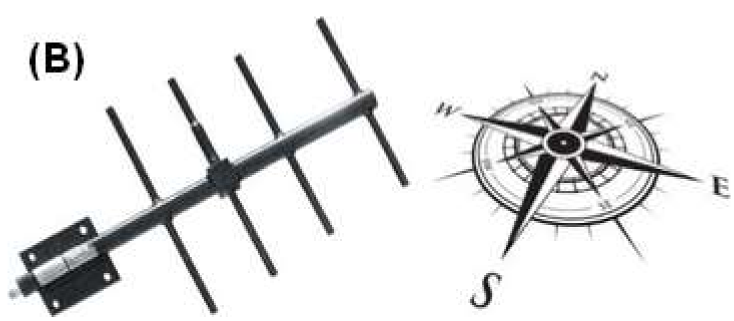
The most common method of direction finding is called Triangulation

What is the triangulation method of direction finding? Three or more receiving sites are distributed at some distance from each other and in different locations around the approximate target area. Each directional receiving antenna is rotated for maximum radio signal strength and the direction azimuths (compass bearings) are then plotted on a map.

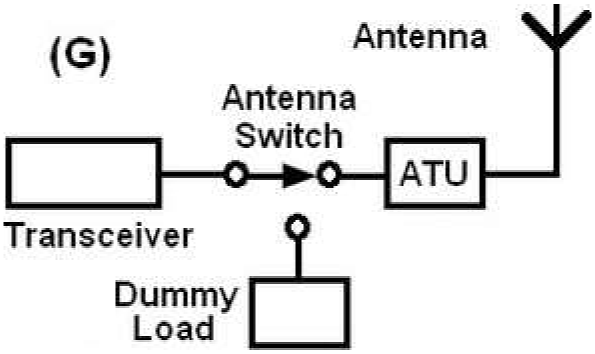
With a receiver, directional antenna, move/rotate the antenna to receive the strongest signal from the target source. With a compass and map we can plot the direction which the directional antenna pointing, this will give the direction of the transmitted signal.

(A) Shows the bearings from each receiver location to give the triangulation source of the signal.

(B) Shows a VHF directional antenna, this can be a handheld portable antenna.



Dummy Load



Small RF Dummy load with a capacity of 1 kW at frequencies up to 459 MHz. It consists of a 50Ω resistor immersed in oil to absorb the heat.

A dummy load is a device used to simulate an electrical load, usually for testing purposes.

In radio a dummy antenna is connected to the output of a radio transmitter and electrically simulates an antenna to allow the transmitter to be adjusted and tested without radiating radio waves.

(G) : Transceiver - (SWR Meter) - Antenna Switch - Dummy Load or ATU - Antenna.

Some dummy loads are 50 ohm resistors immersed in oil to dissipate the heat. Others are a single 50 ohm resistor with sufficient dissipation rating usually having a heat sink with fins to dissipate the heat or multiple resistors with lower dissipation rating, in parallel or series-parallel configuration.

The ideal dummy load provides a standing wave ratio (SWR) of 1:1 at the given impedance.

Frequency range and Power capability:
Dummy loads have a limited frequency band over which they can operate and have power handling capability limitations.

50Ω dummy load suitable for 150W intermittent or 35W continuous 0 - 800MHz

Dummy load can be useful in the case of causing domestic inference when transmitting, transmit using a dummy load to see if the inference goes away.

Element V (5) – Signals and Emissions

The general purpose of a transmitter is to transmit signals. These signals contain information, which can be audio, video, or data etc, a transmitter launches signals into the air via a transmitting antenna. After traveling some distance, the transmitted signal eventually reaches the receiving antenna of a receiver. The receiver then deciphers and processes the information contained in the transmitted signal.

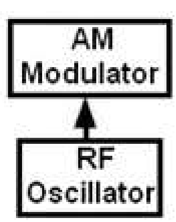
A transmitter's functionality is achieved through a series of steps. First, a carrier signal must be generated. The actual information (modulating) signal such as audio, video, or data then modulates this carrier signal in a modulator. The carrier signal essentially "carries" the modulation information.
Sending Morse code is achieved by switching (or keying) the carrier on and off.

Carrier Wave: is an alternating electromagnetic signal with a steady frequency upon which information is superimposed by some form of modulation.
The carrier wave is modulated in direct proportion to the signal, such as the audio, video, or data that is to be transmitted, the carrier wave usually has a much higher frequency than the input signal.

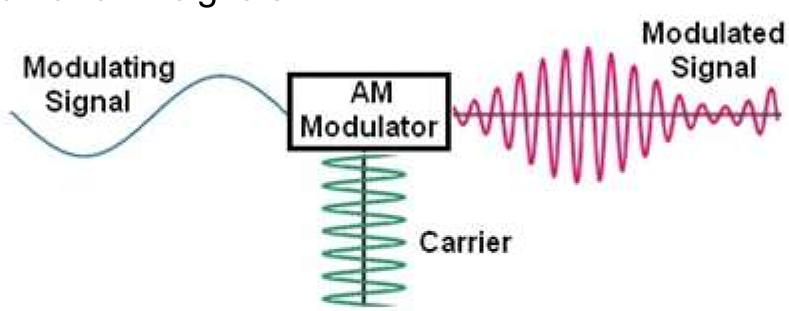
Oscillator: The oscillator creates the alternating current (sine wave). The oscillator can be a fixed frequency or a Variable Frequency Oscillator (VFO) can be used to generate very accurate frequency carrier waves over a predetermined range in radio transmitters.

Carrier frequency is defined as the frequency of a carrier wave, measured in cycles per second, or Hertz, that is modulated to transmit signals.

(G)

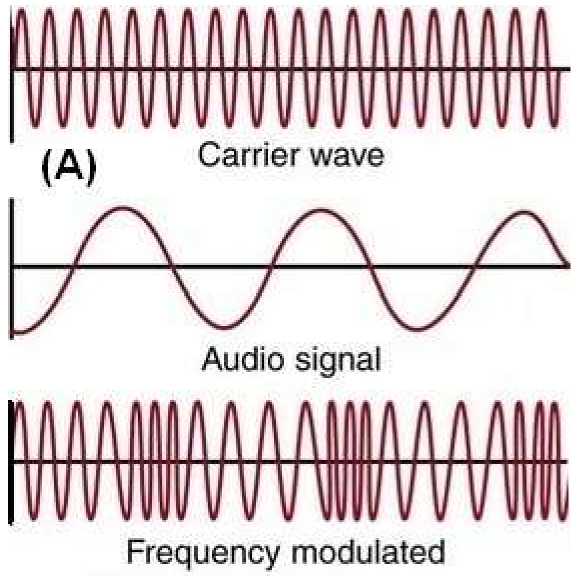


The RF Oscillator generates the carrier



(G) In this example of the modulating signal is being combined in a AM modulator with a RF oscillator (carrier wave) to produce a modulated signal. Once the carrier signal is modulated, it is amplified to a level sufficient power amplifier (PA) for transmission.

Frequency Modulation



(A) Frequency Modulation (FM) (F3E) : The process of changing the frequency of carrier signal according to the amplitude of data signal is termed as Frequency Modulation. The amplitude of the carrier wave remains constant. Digital FM types include Frequency-shift keying (FSK).

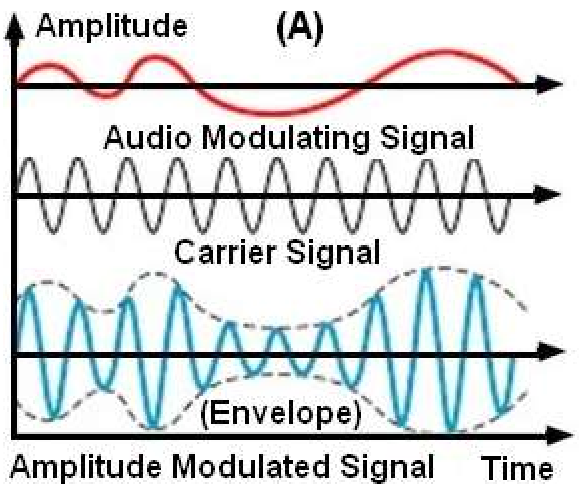
Frequency Modulation (FM) (F3E) is a method of transmitting information using a radio-frequency carrier wave.

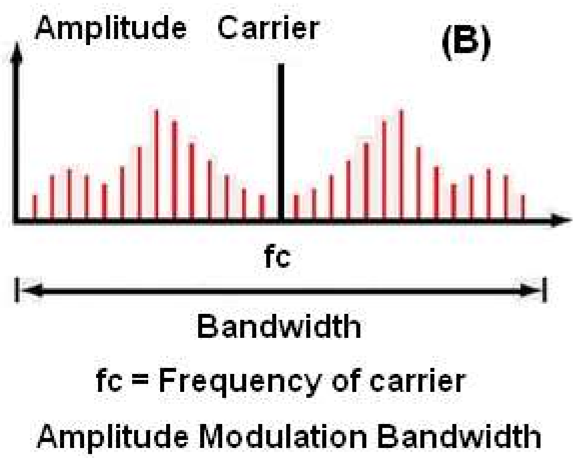
The frequency of the carrier wave is varied in accordance with the amplitude and polarity of the input signal, the amplitude of the carrier remaining unchanged.

Frequency modulation is widely used on frequencies above 30 MHz, and it is particularly well known for its use for VHF FM broadcasting......

Advantage of frequency modulation : Amplitude of frequency modulation signal is remain constant. Less susceptible to noise…..Provides good sound quality.....The typical amateur radio FM signal bandwidth varies from about 10 kHz to 15 kHz...

Amplitude Modulation





(A) Amplitude Modulation (AM) (A3E) : The process of changing the amplitude of carrier signal according to the amplitude of the data signal is termed as Amplitude Modulation.

The frequency of the carrier wave is kept constant.....AM types include DSB-C : SSB : VSB etc.........

AM is mostly used for transmitting information via a radio carrier wave.

In amplitude modulation, the amplitude of the carrier wave is varied in proportion to that of the audio signal being transmitted.

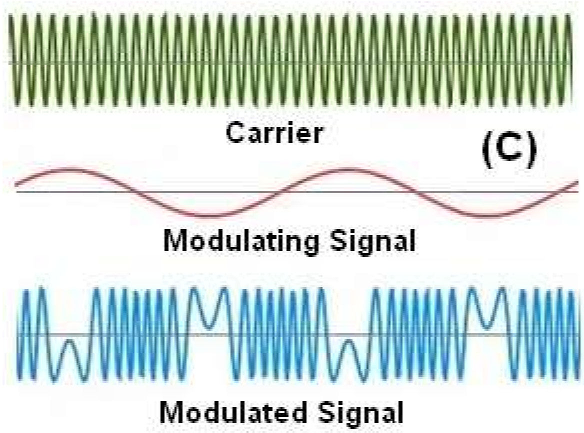
AM voice bandwidth is about 6khz wide.

Amplitude Modulated Signal (Envelope): The audio waveform modifies the amplitude of the carrier wave and determines the envelope of the waveform.

The envelope is an "apparent line" which is formed by the peaks of the signal and follows the contours of the modulating signal....

(B) AM voice transmissions have a fixed bandwidth of about 6 kHz. The AM signal is comprised of two mirror image bands Lower Sideband (LSB) and Upper Sideband (USB), one band either side of the carrier frequency.

Phase Modulation



Phase Modulation

(C) Phase Modulation (PM) : The process of changing the phase of carrier signal according to the amplitude of data signal is termed as phase Modulation.

The amplitude of the carrier wave is kept constant.

Digital PM types include Binary Phase Shift Keying (BPSK) : Quadrature phase shift keying (QPSK).

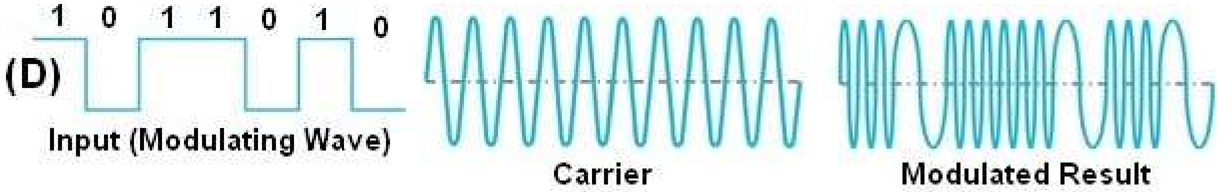
PM encodes a message signal as variations in the instantaneous phase of a carrier wave.

PM is one of the two principal forms of angle modulation, together with Frequency Modulation.

Phase Modulation (PM) can be used for both analogue and digital data, but it is for data & phase shift keying that it is most widely used.

Phase Modulation is the process of varying the phase of the carrier signal linearly with the message signal.

Digital Signals



Digital Modulation

Radio Teletype (RTTY) : Uses the Baudot code at a data rate of either 45.5 or 50 baud using a two tone scheme.

Packet Radio : Sends data out in packets. Once received, the receiving station checks that the data has been received correctly before allowing the next packet to be sent. If errors are detected the packet can be resent....

AMTOR (Amateur Teleprinting Over Radio) : Data is sent out in small groups and when acknowledgements are received the next small group is sent.......

The AmTOR system uses the same basic five-bit code as RTTY, but sent at a data rate of 100 baud. A total of seven bits are sent. The additional two bits are used to ensure that the transmitted data pattern always contains four mark bits and three space bits.

From knowledge of this expected pattern the receiver is able to detect an error and action can be taken to correct it.

Is a digital mode scheme that uses Frequency Shift Keying (FSK) modulation and is used primarily on the HF portion of the radio spectrum.....

Three methods of digital signal modulation

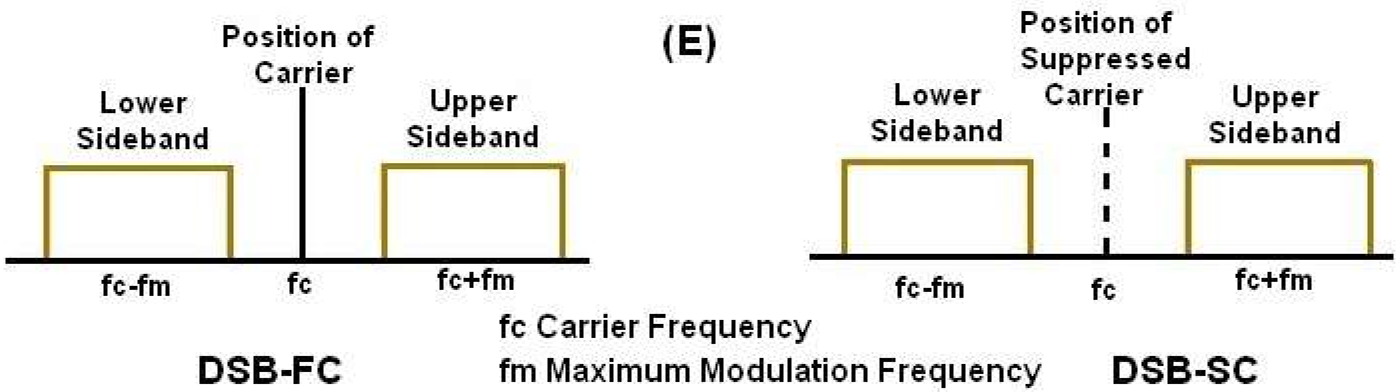
A digital signal, representing the binary digits 0 and 1 by a series of on and off amplitudes, is impressed onto an analog carrier wave of constant amplitude and frequency.

In amplitude-shift keying (ASK), the modulated wave represents the series of bits by shifting abruptly between high and low amplitude.

In frequency-shift keying (FSK), the bit stream is represented by shifts between two frequencies.

In phase-shift keying (PSK), amplitude and frequency remain constant; the bit stream is represented by shifts in the phase of the modulated signal.

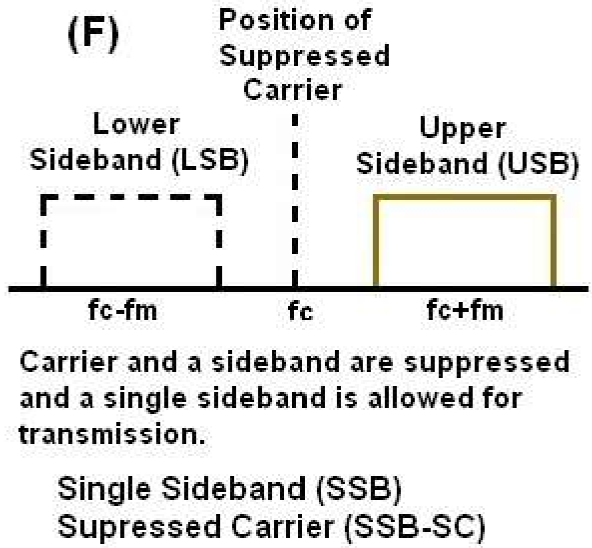
Side Bands



Amplitude Modulation consist of three components
1. Carrier...
2.Upper SideBand (USB) and Lower SideBand (LSB)

(E) DSB-FC (Double Sideband Full Carrier) consists of
1. Carrier
2. USB and LSB, the transmission is inefficient because two-thirds of the power is being wasted in the carrier, which carries no information.....Has maximum efficiency of 33.3%.....

DSB-SC (Double-sideband suppressed-carrier) consists of
1. Suppressed Carrier....
2. USB and LSB.......With DSB-SC the carrier is suppressed and the saved power is distributed to the two sidebands giving DSB-SC a 50% efficiency.



(F) Single Side Band Suppressed Carrier (SSB-SC) (J3E) : Single sideband modulation (SSB) is a method of transmitting information such as audio signal by radio waves in which either the upper or the lower sideband is transmitted, the carrier being either wholly or partially suppressed.

(F) fc is the carrier frequency : fm is the band width of the modulating wave.

A refinement of amplitude modulation, it uses transmitter power and bandwidth more efficiently and improves the signal-to-noise ratio and is 100% efficient.

Compared to AM, SSB requires less than half the bandwidth and it offers much more "talk power", since the unnecessary carrier and second sideband are not transmitted.

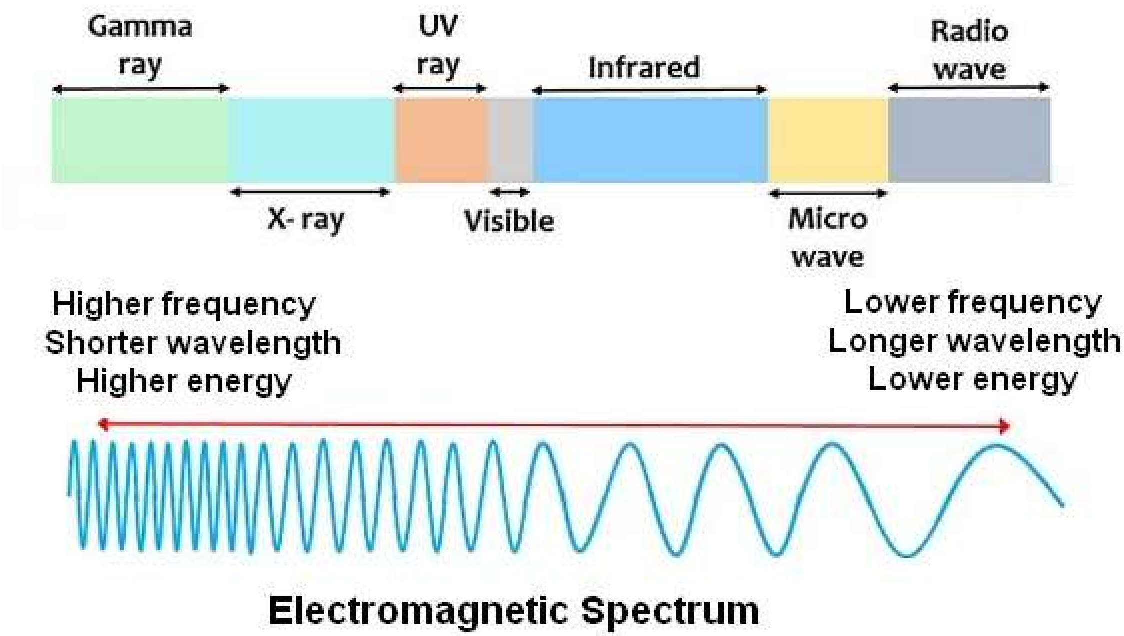
The bandwidth used by a single sideband voice signal varies between 300 and 3400 Hz, or 3 to 3.4 kHz. The approximate bandwidth, therefore, is the rough maximum used, which is approximately 3kHz.

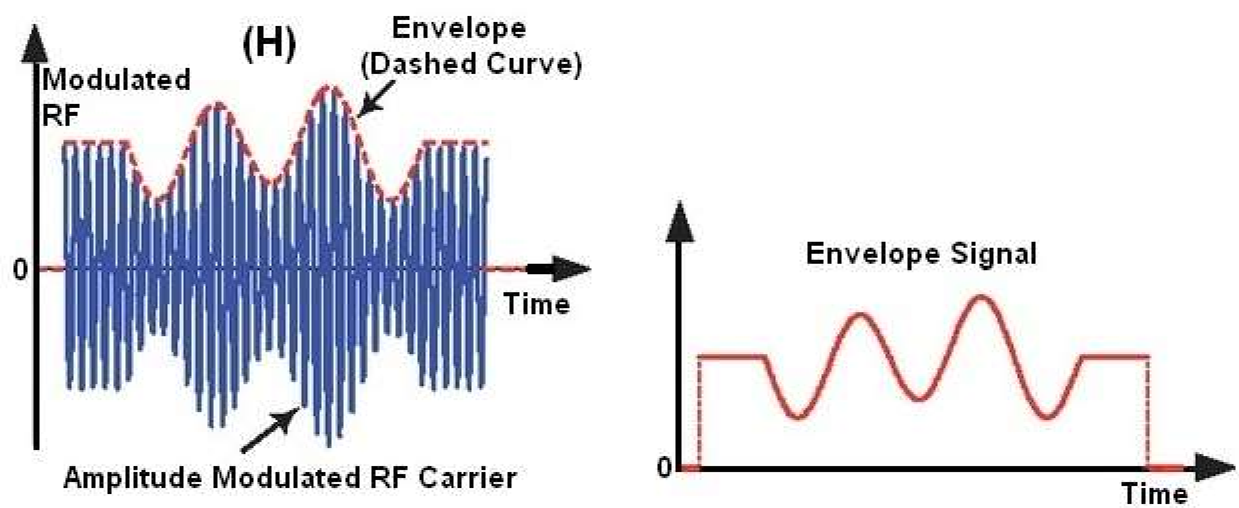
In SSB, the transmitter output is expressed in terms of Peak Envelope Power (PEP) is the maximum average power supplied by the transmitter to the antenna transmission line during one radio frequency cycle taken under normal operating conditions.

One way to measure PEP is to use an oscilloscope, dummy load and a audio 2 tone generator.

It is customary on the amateur radio HF bands above 10 MHz is that voice operation takes place using USB while below 10 MHz on LSB.

The radio spectrum is the part of the electromagnetic spectrum with frequencies from 30 Hertz to 300 GHz



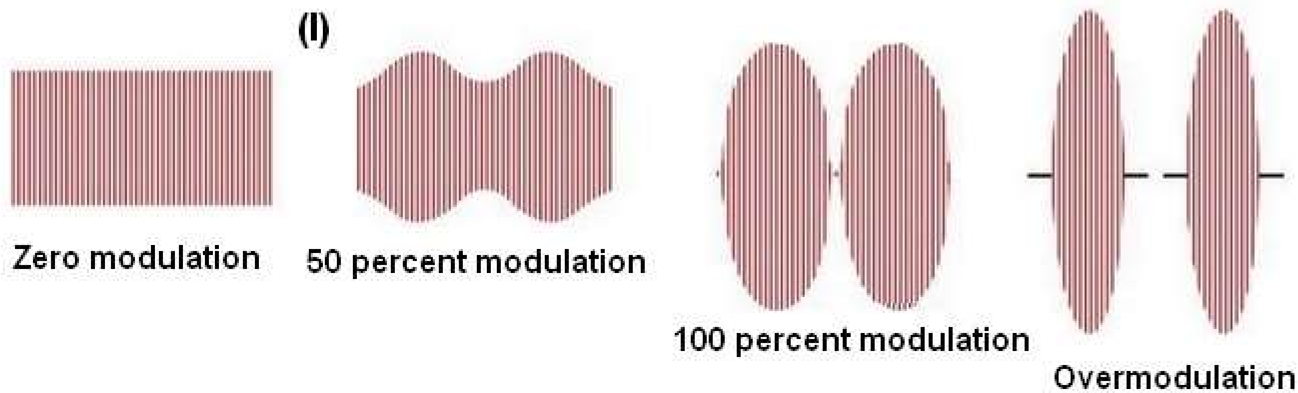


(H) The envelope of an oscillating signal is a smooth curve outlining its extremes…
The envelope thus generalizes the concept of constant amplitude. The envelope is an "apparent line" which is formed by the peaks of the signal and follows the contours of the modulating signal.

Envelope Signal: This shows top half of the envelope with the amplitude modulated RF carrier removed.

Over-modulation (I) is the condition that prevails in telecommunication when the instantaneous level of the modulating signal exceeds the value necessary to produce 100% modulation of the carrier.

(I)



Over-modulation is caused when modulation increases the carrier wave to over two times its peak value. This means that the envelope of the output waveform is distorted.

The over-modulated signal causes splatter (spurious emissions) will have an increased bandwidth and will be rich in unwanted harmonics.... meaning that a transmitter is improperly transmitting outside of the necessary and proper bandwidth for the mode and/or frequency band being used. Transmitter gain set too high can cause over modulation and distortion.

Automatic Level Control (ALC): To help prevent over modulation, ALC is a circuit that reduces output power as the transmitter's output power is reached....ALC is not a foolproof remedy but will keep the signal that is free from spurious emissions.

For a perfect modulation, the value of modulation index should be 1, which means the modulation depth should be 100%.

If this value is less than 1, i.e. the modulation index is 0.5, this is called under-modulation. Such a wave is called as an under-modulated wave.

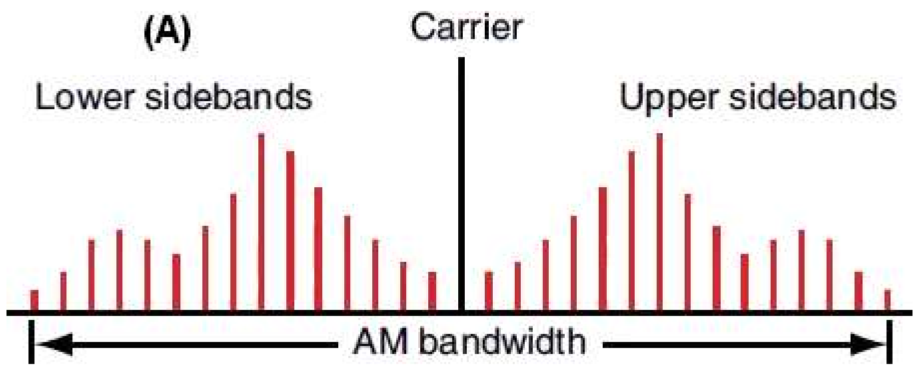
If the value of the modulation index is greater than 1, i.e., 1.5 or so, then the wave will be an over-modulated wave.

Modulation index: m = M ÷ A where A = the carrier amplitude and M = the modulation amplitude and is the peak change in the RF amplitude from its un-modulated value

The amplitude modulation index describes the amount by which the modulated carrier envelope varies about the static level….A modulation index of 0.75 means that the signal will increase by a factor of 0.75 and decrease to 0.25 of its original level.

Bandwidth is defined as a range within a band of frequencies or wavelengths.

1) In radio, the bandwidth is used to measure the difference between the electric signal having highest-frequency and the signal having the lowest-frequency.



The bandwidth of AM (Amplitude Modulation) is the difference between its highest and lowest frequency components and is expressed in Hertz (Hz). Bandwidth deals with only frequencies.

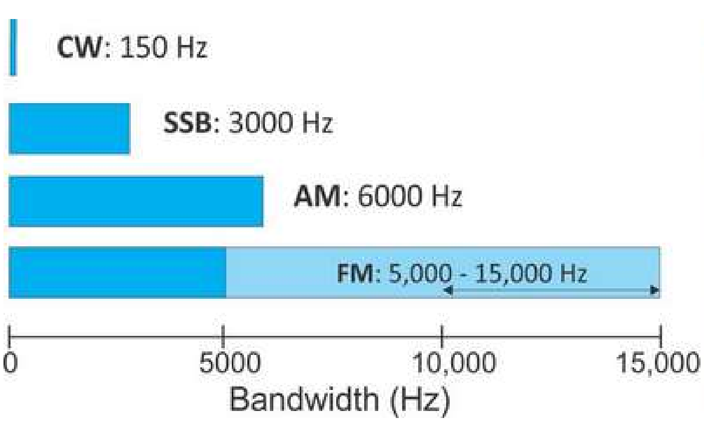
(A) If the fc (Carrier Frequency) is 5.000 MHz and the AM audio is 6 kHz, the total bandwidth occupied would be 4.997 to 5.003 kHz.
The lower sideband bandwidth would be 3 kHz and upper sideband 3 kHz

The bandwidth occupied by LSB (lower sideband) would be 4.997 to 5.000 kHz and USB (upper side band) 5.000 to 5.003 kHz

One of these sidebands will be removed (filtered) by the transmitter and the remaining sideband will be transmitted.

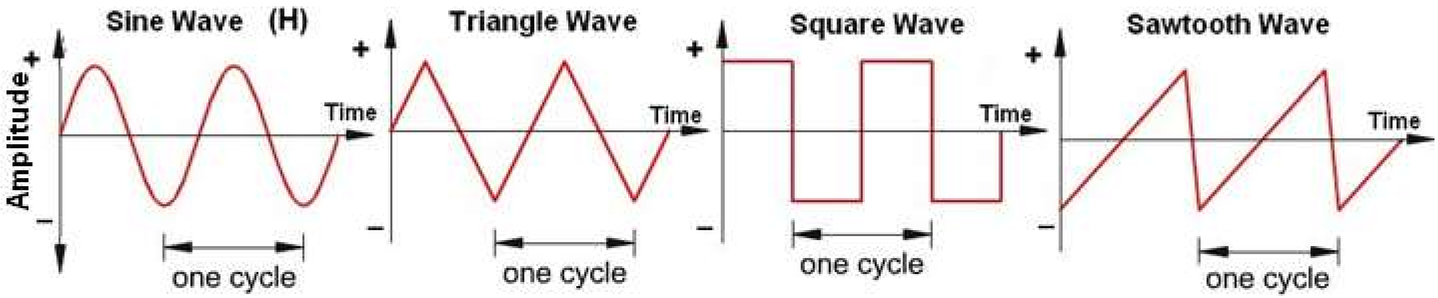
Bandwidth: Sidebands The signal components above the carrier frequency constitute the USB and those below the carrier frequency constitute LSB.

In conventional AM transmission, the carrier and both sidebands are present, sometimes called double sideband amplitude modulation (DSB-AM).



Type of Signal	Typical Bandwidth
AM Voice	6 kHz
Amateur Television	6 MHz
SSB Voice	2 khz to 3 kHz
Digital using SSB	50 Hz to 3 kHz
CW	100 Hz to 300 Hz
FM Voice	10 kHz to 15 kHz

Waveforms



One cycle of a wave is one complete evolution of its shape until the point that it is ready to repeat itself.

(H): Electrical waveforms include the following three common characteristics:

1) Period: – The period of a wave is the amount of time it takes to complete one cycle. This is the length of time in seconds that the waveform takes to repeat itself from start to finish. Period refers to the time it takes something to happen.

The formula for period is T = 1 / f , where "T" is period – the time it takes for one cycle to complete, and "f" is frequency. Time period is the reciprocal of frequency

What is a period of 20Hz?. T=1/f = 1/(20 Hz) = 0.05 secs.
For 100Hz = 1 / 100 (Hz) = 0.01 second.
What is the frequency of a wave with a period of 0.2 seconds? 1/T = f = 1/0.2 = 5Hz

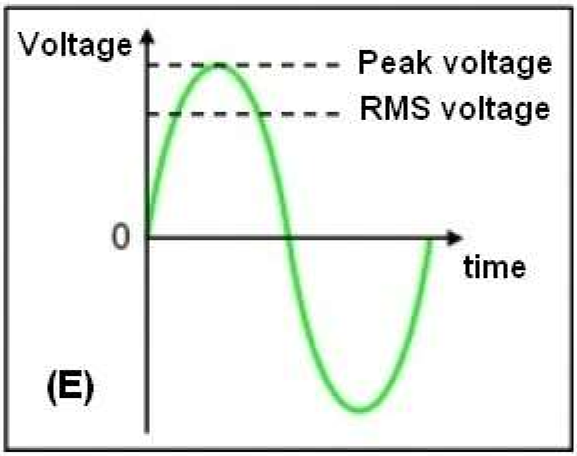
2).Frequency: – The Frequency, (f) is the number of times the waveform repeats itself within a one second time period. Frequency is usually measured in Hertz (Hz), 1 Hz being equal to one complete wave cycle per second. Frequency refers to how often something happens

One Hertz is exactly equal to one cycle per second, but one hertz is a very small unit so prefixes are used that denote the order of magnitude of the waveform such as kHz, MHz and GHz.

3).Amplitude: – This is the magnitude or intensity of the signal waveform can be measured in volts or amps.

Most waveforms found in electronic circuits have a much higher frequency than household alternating current (AC) which is say 50hz or 60Hz, typically in the range of several thousand hertz (kilohertz, or kHz) or millions of hertz (megahertz, or MHz).

RMS



RMS voltage = 0.707 peak voltage

Peak voltage = 1.414 RMS voltage

Average voltage = 0.637 peak voltage

(E) Root-Mean-Square (RMS): Unlike DC voltages which are constant over time, AC (alternating current) voltages are time varying and sinusoidal in shape. The RMS value of an AC signal is equivalent to the DC voltage that would be required to produce the same heating effect (power).

The RMS value is the effective value of a varying voltage or current. It is the equivalent steady DC (constant) value which gives the same effect.

RMS is not an "Average" voltage, and its mathematical relationship to peak voltage varies depending on the type of waveform. The RMS value is the square root of the mean (average) value of the squared function of the instantaneous values.....

Since an AC voltage rises and falls with time, it takes more AC voltage to produce a given RMS voltage than it would for DC.

A lamp connected to a 6V RMS AC supply will light with the same brightness when connected to a steady 6V DC supply, the same lamp will be dimmer if connected to a 6V peak AC supply because the RMS value of the 6V peak AC supply is 4.2V (it is equivalent to a steady 4.2V DC)….6V AC = 0.707 x 6 = 4.2 DC

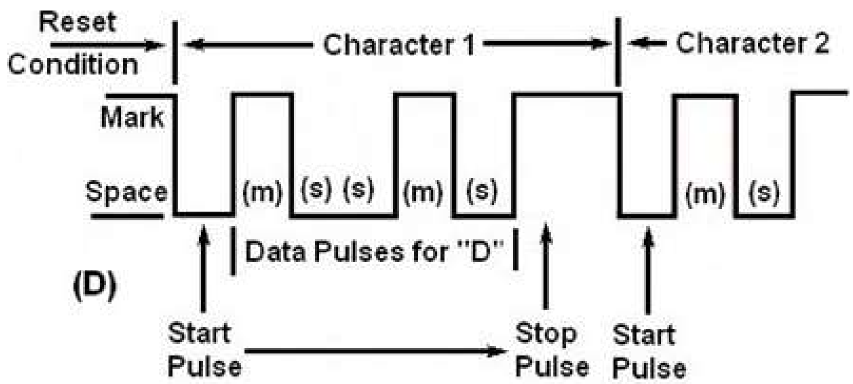
If a 12 volt car battery operated a light bulb of power 36 watts with direct current.
What would be the equivalent AC supply to achieve the same 36 watts output?
12 V x 1.414 = 16.7 AC would be needed to achieve the same 36 W power output.

Q: The voltage on the voltmeter reads 220V what is the peak voltage?
A : 220 x 1.414 = 311.08 peak voltage

Note....Most multi-meters, either voltmeters or ammeters, measure RMS value assuming a pure sinusoidal waveform.

Baudot and RTTY: Baud is a unit of transmission speed equal to the number of times a signal changes state per second. For one baud is equivalent to one bit per second.

RTTY uses the 5-bit Baudot code to encode each character meaning that every character consists of five bits, either mark or space.



A typical Baudot timing Sequence for the letter "D"

More specifically, on the Amateur HF bands, it’s 5 bit Baudot meaning that every character consists of five bits, either mark or space. Actuality Baudot is 8 bits because a start bit and two stop bits are added for synchronization.

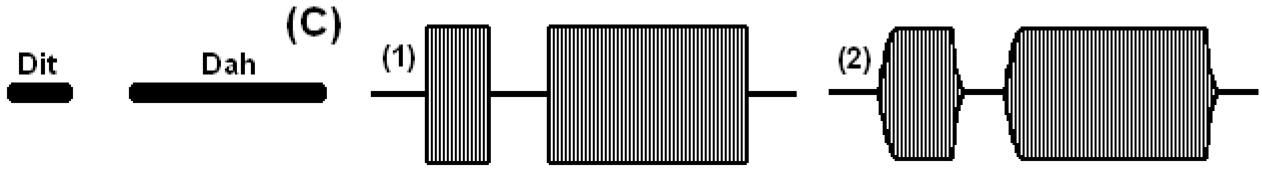
(D) Radio teletype (RTTY) :There are 2 ways to transmit a RTTY signal:
1) Frequency Shift Keying (FSK) by sending a carrier frequency which gets shifted between Mark (current on) and Space (current off) frequencies.

The difference between these two frequencies is called 'Shift'. Common shifts are between a few Hz and about 1 kHz.

2) Or by keying 2 audio tones called Audio Frequency Shift Keying (AFSK) which is a modulation technique by which digital data is represented by changes in the frequency (pitch) of an audio tone, yielding an encoded signal suitable for transmission via radio or telephone.

RTTY audio frequency-shift keying (AFSK) between the two tones is 170Hz difference between the mark and the space bits, the difference is generated using audio frequencies of 1445 Hz to represent a mark condition and 1275 Hz to give a space. This results in a 45-baud connection

Interference



Morse (CW, A1A mode) is usually transmitted by on-off keying of an otherwise continuous wave..

(C) In a cw transmission, the envelope of the keyed RF output maybe shown as (1) a square wave. When analysed this will be found to be composed of a large number of sine waves.

These sine waves may extend over an wide part of the adjacent band and be annoying to the listener.

Methods of keying the transmitter vary but whichever method is used, care must be taken to prevent key-clicks being produced.

Only a relatively narrow bandwidth is needed for morse – less than a few hundred hertz at the most at normal keying speeds.

However, if the keying turns the transmitter on and off instantaneously, a signal with a very wide bandwidth is produced.

To prevent this from happening, the hIgh-frequency components of the waveform must be attenuated.....

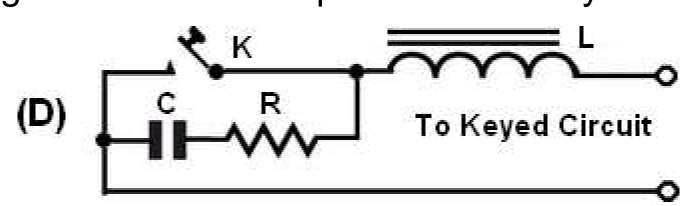
In practice this means preventing any sudden changes to the amplitude of the RF signal.

With suitable shaping it is possible to produce a envelope waveform as (2)

(1) Key clicks occur when the transmitter is being turned on and off by usually a morse key which abruptly switches a carrier on and off.

(2) The solution to the problem for CW is to make the transition between on and off to be more gradual, making the edges of pulses soft, appearing more rounded.

Key-clicks can be suppressed by: inserting a choke and a capacitor at the key.
(D) Example of a key click circuit.



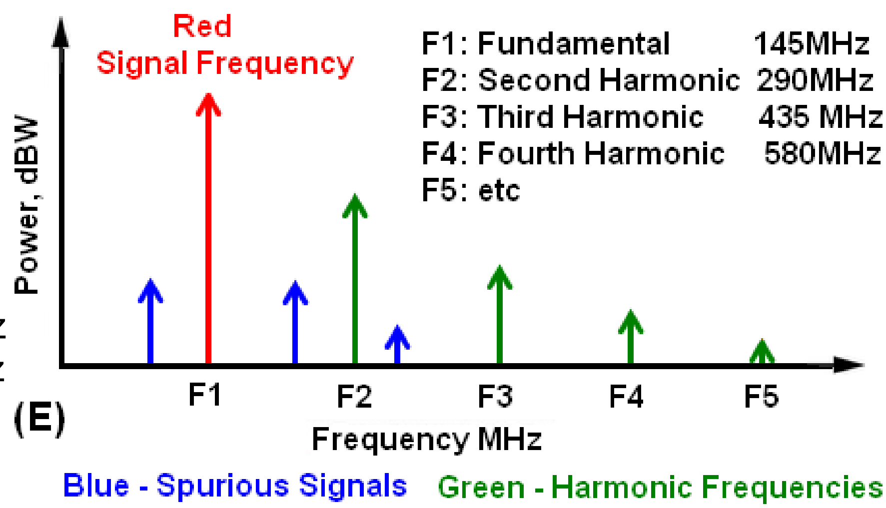
"**Chirp**" is a change in frequency when the transmitter is keyed on (by pressing the Morse key) and keyed off (the release of the Morse key) when the Morse characters are being formed, thus the change in frequency would be heard on a receiver at the start and end of each keying stroke.

There are three main causes of chirp :-
1) Poor design of the transmitter
2) DC Instability caused by poor voltage regulation.
3) Pulling RF Feedback : RF Feedback getting back into the frequency determining stage (oscillators)

Harmonics are undesired transmissions that occur when signals are produced at two or three times the station's fundamental operating frequency in addition to the desired signals.

Harmonics produced by an ill functioning amateur radio transmitter ie overdriven stages of the transmitter (over modulation) may lie well outside of the amateur frequency bands and cause interference to other radio services or electronic devices.

(E) If the fundamental (first) frequency was 7.0 MHz, the second harmonic would be 14.0MHz and the third harmonic 21.0MHz etc
Fundamental = 1 x 7.0 = 7.0 MHz
2nd harmonic = 2 x 7.0 = 14.0 MHz
3rd harmonic = 3 x 7.0 = 21.0 MHz

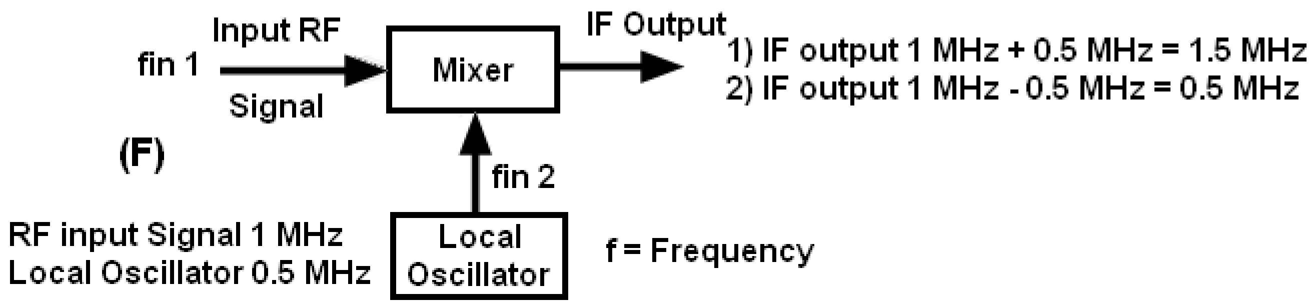


To reduce harmonic output from a transmitter, a low pass filter (LPF) (which blocks all signals above its stated frequency) could be put in the transmission line as close to the transmitter output as possible.

Spurious emissions are a more general term for radio frequency emissions that are not desired or deliberately transmitted, such as harmonics. They occur as a result of over modulation of the transmitter, intermodulation, electromagnetic interference, frequency conversion, or harmonics.

(E) A spurious transmission from a transmitter is an unwanted emission unrelated to the output signal frequency, whereas harmonic emission is related to the output signal frequency.

Frequency Mixer



Frequency translation is the process of moving a signal from one part of the frequency axis, to another part of the axis. Frequency translation is often done in wireless communications systems to move a pass band signal to base band before demodulation.

A Mixer is an analogue device that can add two signals together and also provides the difference of the two signals.

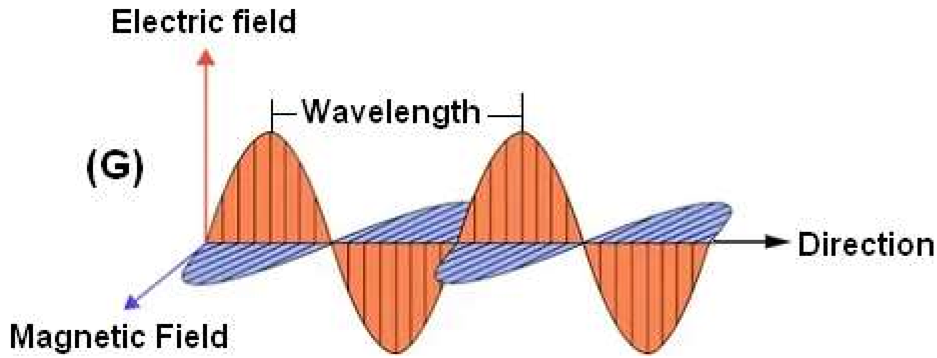
(F) The mixer has two inputs: the RF signal, and a local oscillator (LO).
The LO is at a fixed offset from the desired signal to be tuned and is usually set above the carrier frequency.

Mixers are composed of a non-linear device (a diode or a transistor) and passive couplers devices to inject the input mixing signals into the non-linear device that will perform the mixing.

It is found that if two signals are passed through a non-linear circuit, then additional signals on new frequencies are formed. These appear at frequencies equal to the sum and difference frequencies of the original signals. If signals at frequencies of f1 (RF signal) and f2 (Local Oscillator) enter the mixer, then additional signals at frequencies of (f1+f2) and (f1-f2) will also be seen at the output.

The Intermediate Frequency (IF) is a fixed RF frequency used to simplify the operation of a radio receiver which allows the signal of interest to be efficiently processed, filtered, and demodulated.

Wave Polarization



(G) Shows the magnetic field polarized horizontally and the electric field polarized vertically.

A radio wave is composed of one electric and one magnetic field that oscillate in a repeating pattern.

When we talk of electromagnetic waves we do not generally separate the two and we can say that the antenna is either polarized vertically or horizontally 90 degrees from the orientation of the antenna.

In general we would like the orientation of the receiving equipment to match that of the transmitter.

(G) Wave Polarization : Radiation from an antenna consists of two fields, electric and magnetic which keep each other going and are at right angles to each other moving outward at a constant speed, which is speed of light.

The direction the electric field acts determines the polarization, vertical or horizontal.

The electrical field is the one which generates the signal on the antenna.

"Polarization describes the way the electric field of the radio wave is oriented" A vertical antenna receives and emits vertically polarized waves and a horizontal antenna receives or emits horizontally polarized waves.

An antenna's "polarization" is understood to refer to the direction of the electric field.

Vertical polarization – electric field that lies in a plane perpendicular to the earth's surface

Horizontal polarization – electric field that lies in a plane parallel to the earth's surface

Types of radio emissions

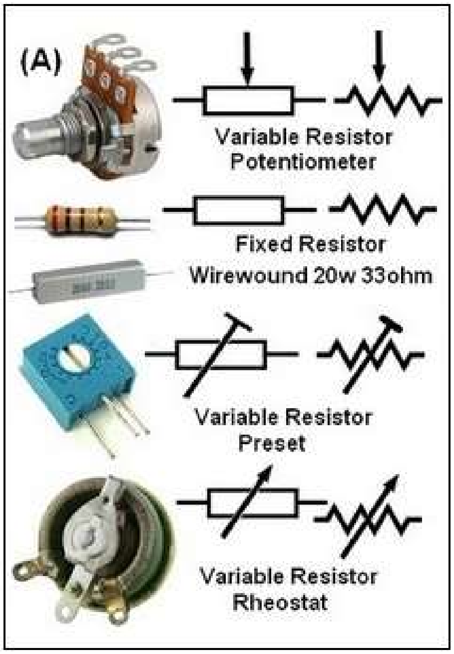
Emission	Old	New
Morse (on / off keying of the carrier)	A1	A1A
Morse (modulated CW)	A2	A2A
AM (amplitude modulation, speech)	A3	A3E
SSB suppressed carrier	A3J	J3E
SSB reduced carrier	A3R	R3E
SSB full carrier	A3H	H3E
RTTY (F.S.K.)	F1	F1B
RTTY (A.F.S.K.)	F2	F2B
FM (frequency modulation, speech)	F3	F3E

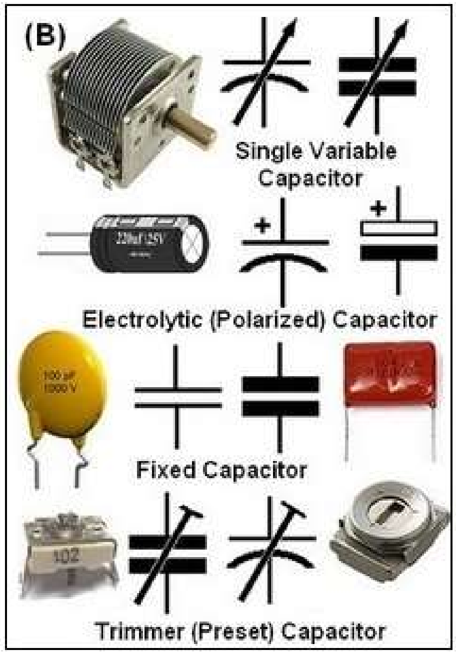
F1B, F2B, J2B = RTTY / AMTOR

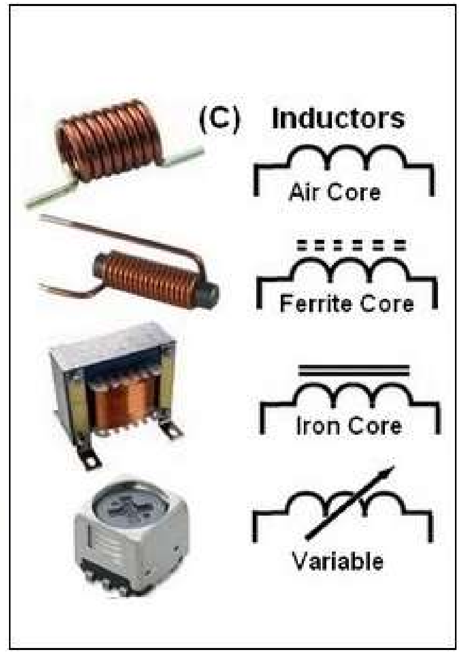
F1D, F2D, J2D = Packet / Data

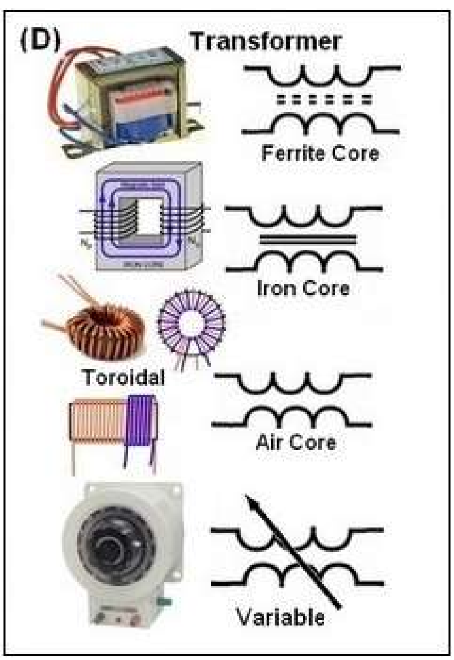
Element VI (6) - Circuit Components

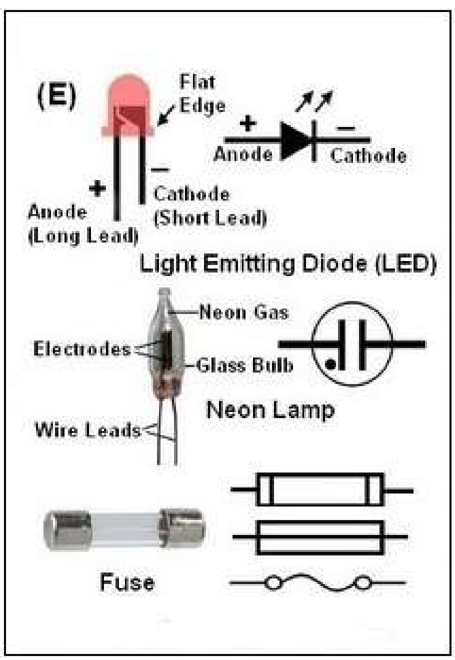
Physical appearance, types, characteristics, applications and schematic symbols.

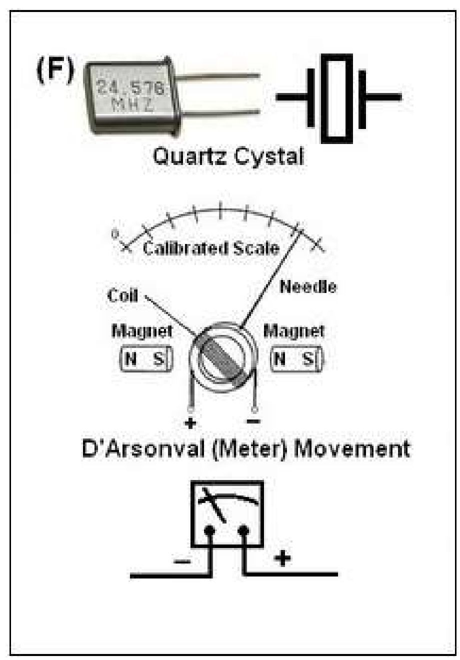


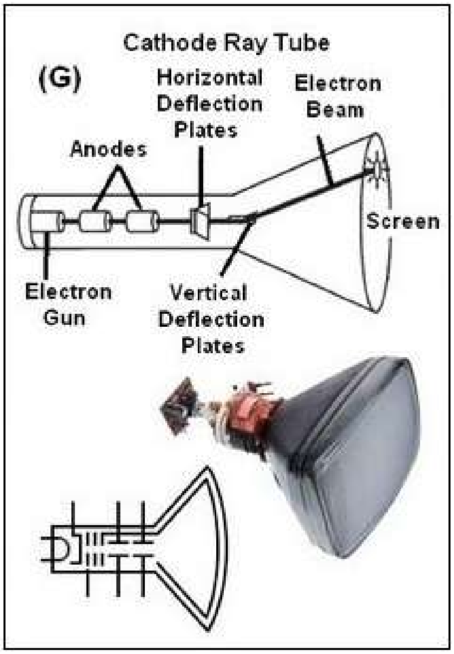


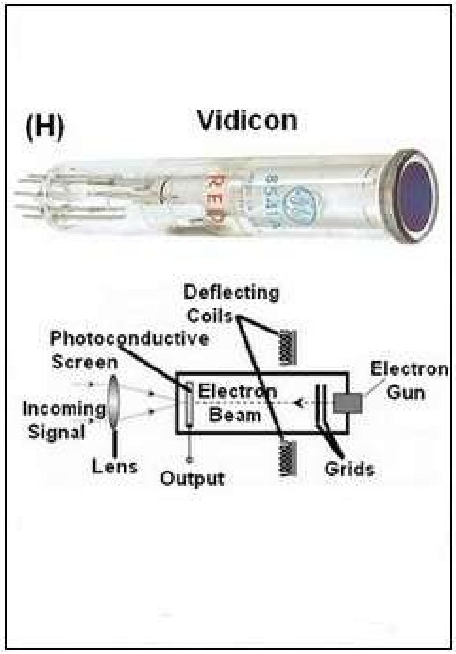


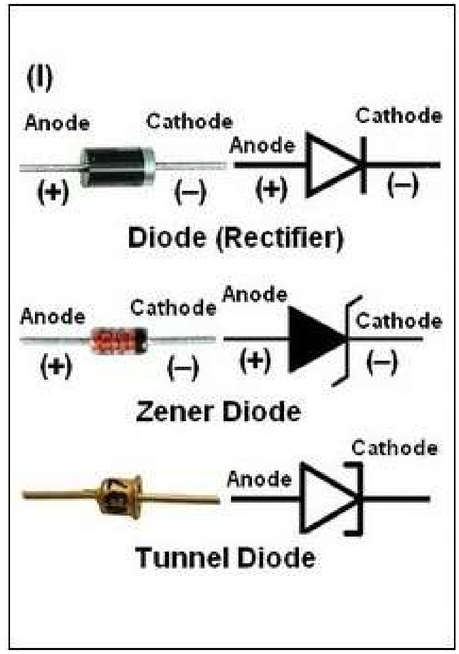


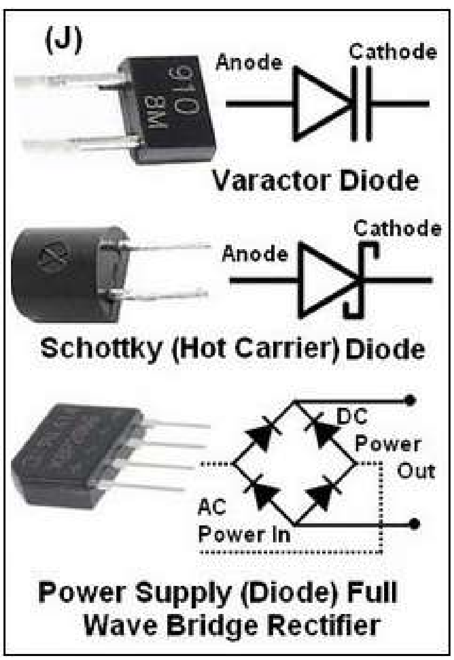


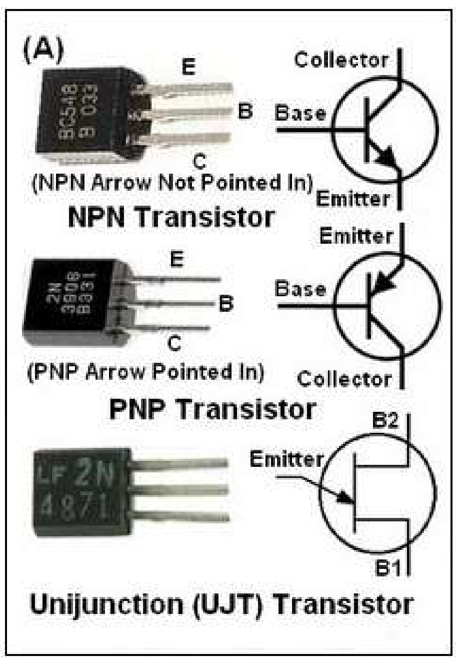


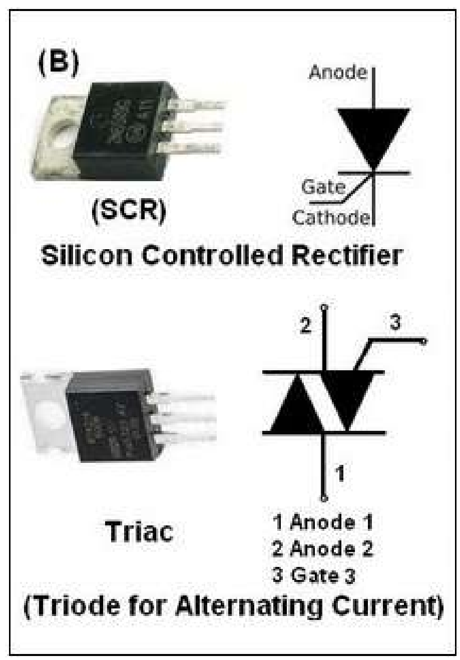

Cathode Ray Tube
(G)
Horizontal Deflection Plates
Electron Beam
Anodes
Screen
Electron Gun
Vertical Deflection Plates

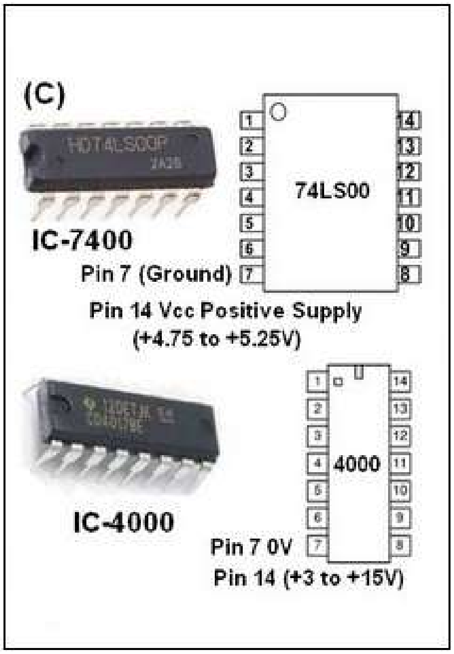

(H)
Vidicon
Deflecting Coils
Photoconductive Screen
Electron Gun
Electron Beam
Incoming Signal
Lens
Output
Grids

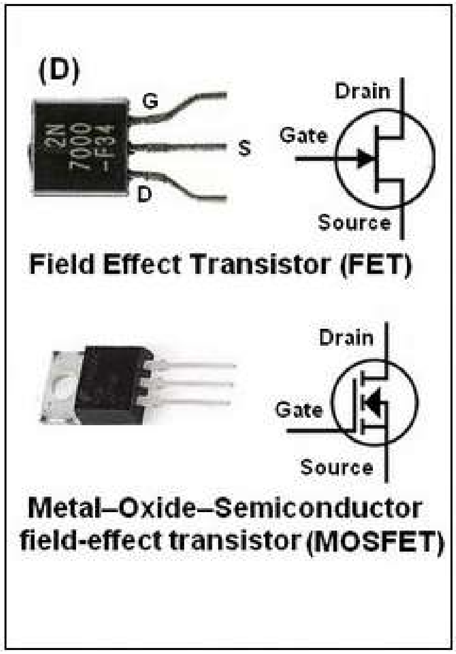

(I)
Anode
Cathode
Anode
Cathode
(+)
(–)
(+)
(–)
Diode (Rectifier)
Anode
Cathode
Anode
Cathode
(+)
(–)
(+)
(–)
Zener Diode
Cathode
Anode
Tunnel Diode

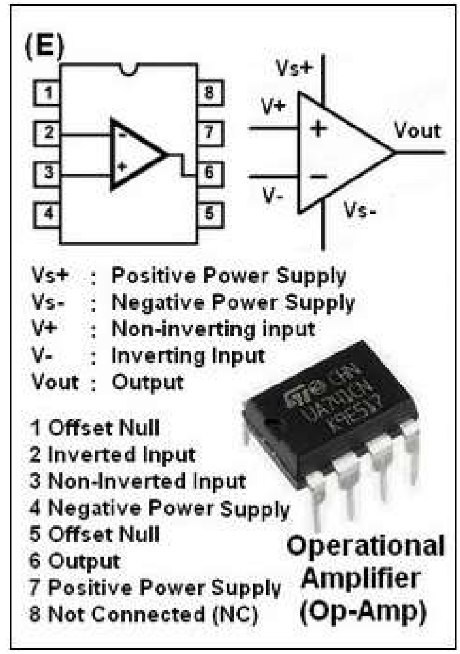

(J)
Anode
Cathode
Varactor Diode
Cathode
Anode
Schottky (Hot Carrier) Diode
DC Power Out
AC Power In
Power Supply (Diode) Full Wave Bridge Rectifier

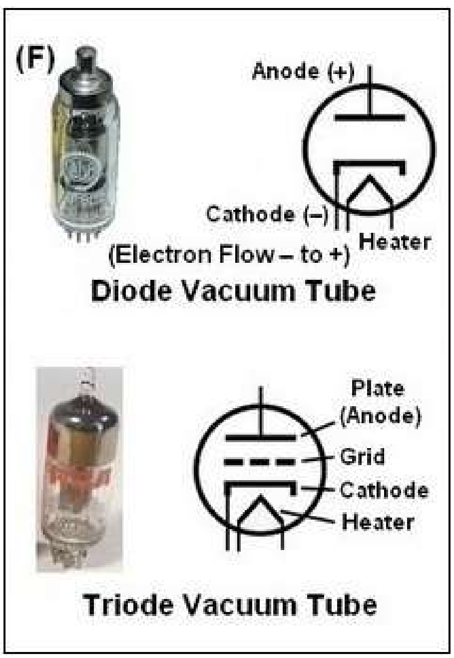

(A)
E
B
C
Collector
Base
Emitter
(NPN Arrow Not Pointed In)
NPN Transistor
E
B
C
Emitter
Base
Collector
(PNP Arrow Pointed In)
PNP Transistor
B2
Emitter
B1
Unijunction (UJT) Transistor

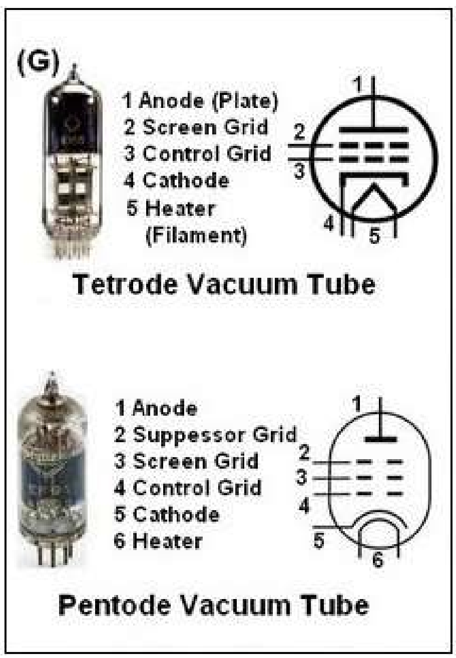

(B)
Anode
Gate
Cathode
(SCR)
Silicon Controlled Rectifier
2
3
1
Triac
1 Anode 1
2 Anode 2
3 Gate 3
(Triode for Alternating Current)

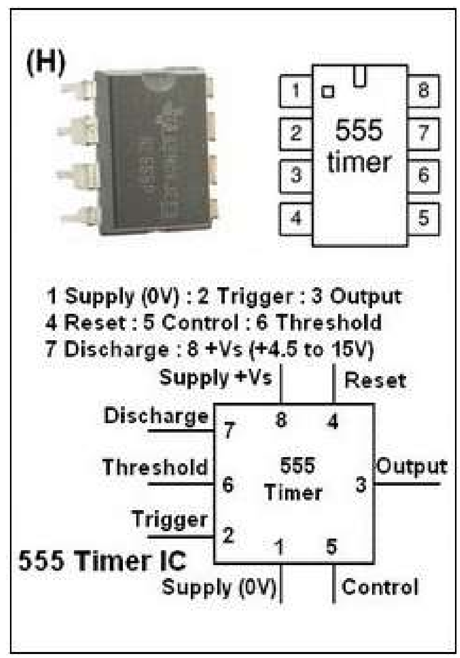




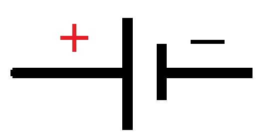








Battery: The longest end line is the positive (+) terminal of the battery and the shortest line is the negative (-) terminal of the battery.



Semiconductors : are materials which have a conductivity between conductors (generally metals) and nonconductors or insulators (such as most ceramics).

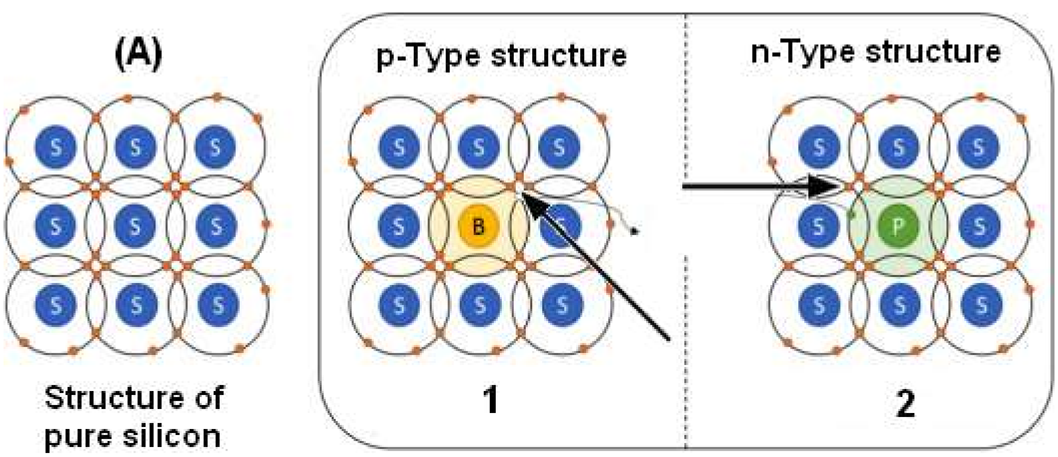
Semiconductors can conduct electricity under some conditions but not others, making it a good medium for the control of electrical current.

Semiconductors can be pure elements, such as silicon (Si) or germanium (Ge), or compounds such as gallium, arsenide or cadmium selenide.

In a process called doping, small amounts of impurities are added to pure semiconductors causing large changes in the conductivity of the material.

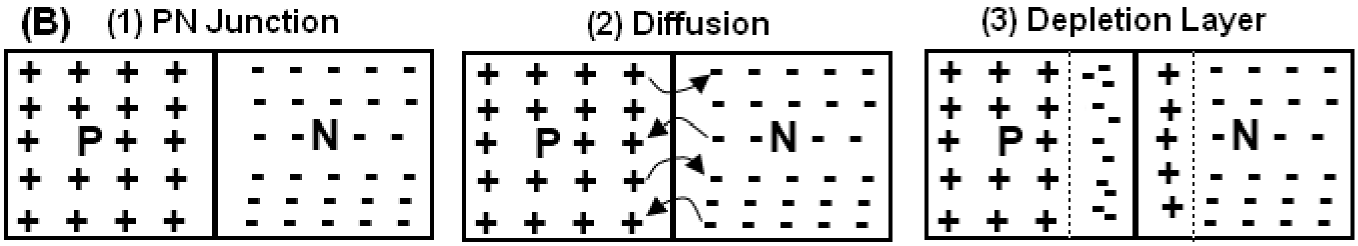
Doping is the process of adding a small amount of impurities to say silicon to alter its property..... Doping changes the electrical properties of the silicon, the silicon becomes more conductive and will conduct when a voltage is applied to it in just the right way. Commonly used are Silicon (Si) and Germanium (Ge) with each having four electrons in its outer orbit.

There are two types of impurities: P-type and N-type.
In P-type semiconductors, holes are the majority carriers and electrons are the minority carriers.
In N-type semiconductors, electrons are the majority carriers and holes are the minority carriers.



(A) 1**.** P-type, silicon doped with a small amount of Boron creates an atom with 3 electrons plus 1 extra space (hole) for an electron.

2. N-type, silicon doped with a small amount of Phosphorus creates an atom with 5 elections (extra electron).



(1) The PN junction is formed when P-type material is fused together with a N-type material.....The region where both p-type and n-type material are joined together is called PN Junction.

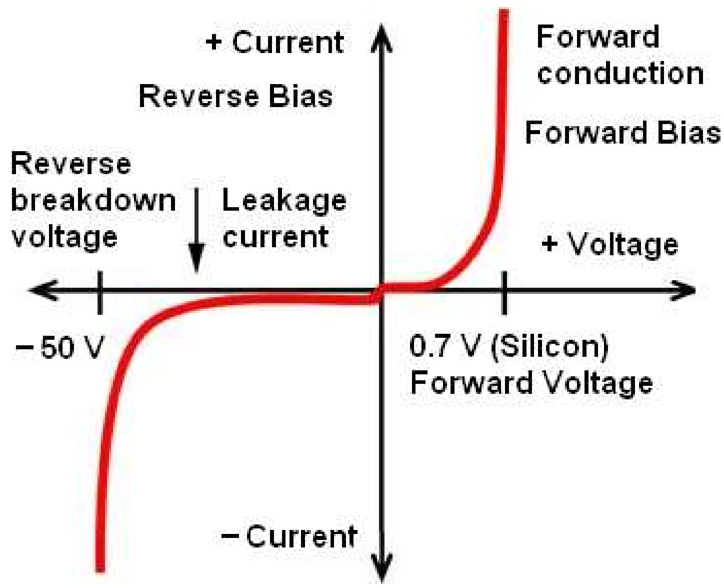
(2) Joining n-type material with p-type material causes excess electrons in the n-type material to diffuse to the p-type side and excess holes from the p-type material to diffuse to the n-type side.......This process continues back and forth until the number of electrons which have crossed the junction have a large enough electrical charge to repel or prevent any more charge carriers from crossing over the junction.....Eventually a state of equilibrium (electrically neutral situation) will occur producing a —potential barrier zone around the area of the junction as the donor atoms repel the holes and the acceptor atoms repel the electrons.

(3) The depletion layer (region) consists of holes that have recombined with free electrons from the n-type semiconductor....

Filling a hole makes a negative ion and leaves behind a positive ion on the n-side. A space charge builds up, creating a depletion region which inhibits any further electron transfer unless it is helped by putting a forward bias on the junction.... The depletion region acts as a barrier and opposes the flow of charge carrier......

At room temp the voltage across the depletion layer for silicon is about 0.6 to 0.7 volts and for germanium is about 0.3 to 0.35 volts. This potential barrier will always exist even if the device is not connected to any external power source

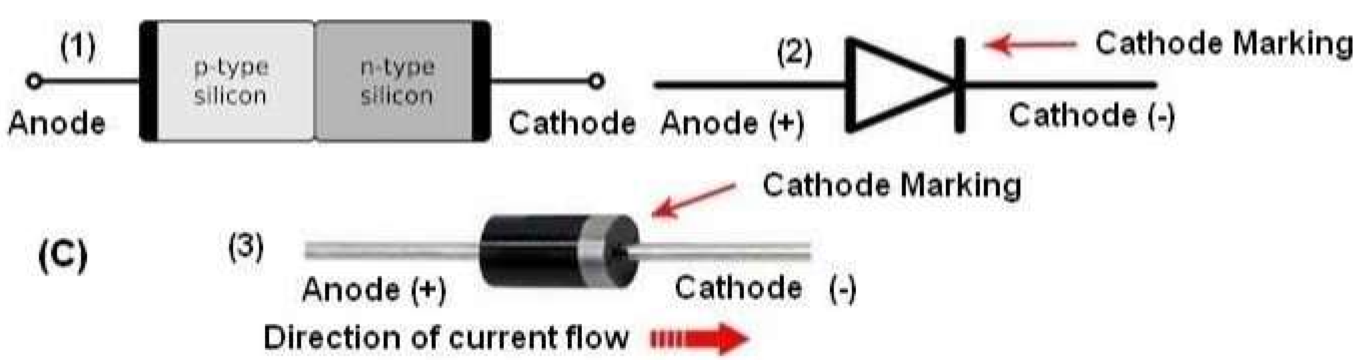
Diode



(B) Shows the I (Current) vs V (Voltage) characteristic curve of a silicon diode. From the curve when the forward bias voltage is increased, it will increase the current flowing through the diode. Forward bias voltage above 0.7 V (Silicon) is required to allow the diode to start conducting.

Under reverse bias condition, a diode will show a different behavior and exhibits no or very little current flowing through the diode. The small current flowing under reverse bias condition is known as leakage current.

When the reverse bias voltage is increased too much, it will break the depletion region, causing the significant amount of current to flow through the diode.

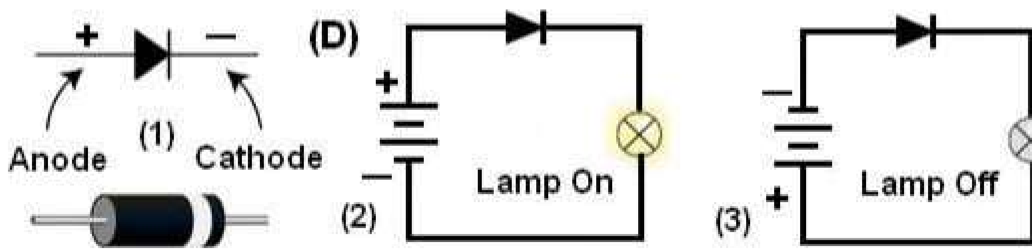


(C) (1) shows the PN junction (2) Diode circuit symbol (3) Diode marking.

The anode side of the symbol has an arrow that indicates the direction of conventional current flow —from positive to negative.

Thus, the diode allows current to flow in the direction of the arrow......The cathode side has marking indicating which side of the diode is negative for forward bias. In some diagrams the anode of a diode may also be indicated by the letter ‘a‘ and the cathode by the letter ‘k‘

Conventional current flows from the positive (anode) terminal to the negative (cathode) terminal although the movement of electrons (electron flow) is in the opposite direction, from cathode to anode.



Diodes are made from semiconductor materials, mainly silicon, with various compounds (combinations of more than one element) and metals added depending on the function of the diode.

A diode is an electrical component acting as a one-way conductor for current....When voltage is applied across a diode in such a way that the diode allows current, the diode is said to be forward-biased ...When voltage is applied across a diode in such a way that the diode prohibits current, the diode is said to be reverse-biased

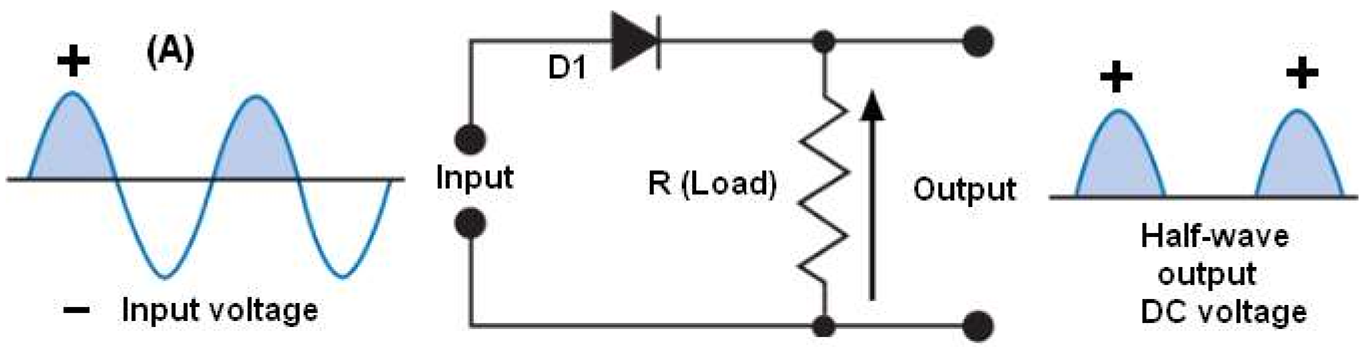
(2) Forward bias weakens the potential barrier (silicon about 0.7volts) current to flow more easily across the junction...In forward biasing; the positive terminal of the voltage supply is connected to the anode and the negative terminal to the cathode

(3) Reverse bias reinforces (increases) the potential barrier and impedes the flow of charge carriers....The depletion zone continues to act as an insulator, preventing any significant electric current flow.... When voltage is applied across a diode in such a way that the diode prohibits current, the diode is said to be reverse-biased......In reverse bias, the positive terminal of the voltage supply is connected to the cathode, and the negative terminal to the anode

Power supply diode rectifier:

A rectifier is an electrical device that is made of one or more diodes that converts the alternating current (AC) into direct current (DC).

A diode allows the current flow in only one direction known as forward bias.



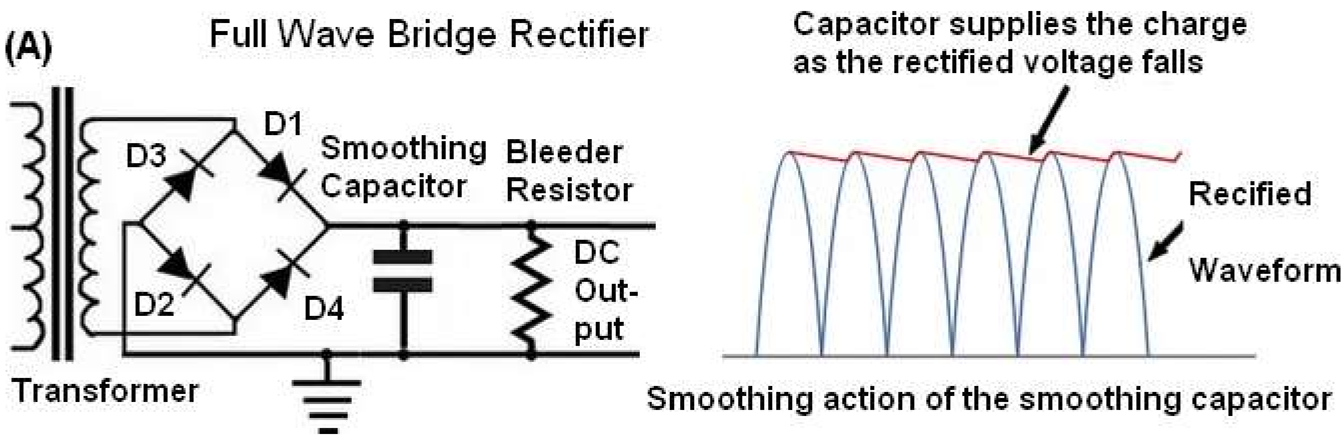
Half Wave Rectifier

(A) When an AC source is connected to the half-wave rectifier, only half cycle will flow through it as shown in (A).

Positive Half Cycle: During the positive half cycle of the input voltage, the D1 diode terminal anode will become positive and the cathode will become negative known as forward bias, it will allow the positive cycle to flow through.

Negative Half Cycle: During the negative half cycle of the input voltage, the D1 diode anode will become negative and the cathode will become positive, which is known as reverse bias so the diode will block the negative cycle.

Full Wave Bridge Rectifier



Rectifier: The rectifier is used to convert the incoming signal (voltage)from an AC format into DC. Example 100 watt transceiver would require a Power Supply Unit (PSU) rated at 13.8 V DC of at least 20 Amps.

Half wave and full wave rectifier: Full-wave rectification rectifies the negative component of the input voltage to a positive voltage, then converts it into DC (pulse current) utilizing a diode bridge configuration (A)

Whereas half-wave rectification removes just the negative voltage component using a single diode before converting to DC.

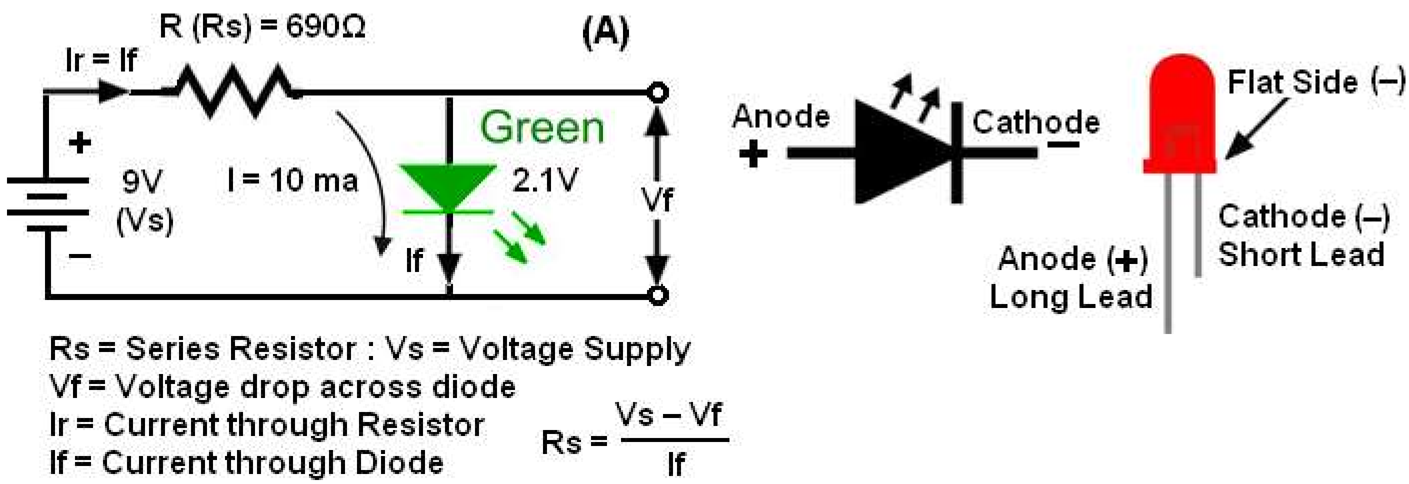
(A) Full Wave Bridge Rectifier: Input transformer: The input (step down) transformer is used to convert the incoming line voltage down to the required level of the power supply. The transformer also isolates the output circuit from the line supply.

Smoothing Capacitor : The pulsated DC from the rectifier is fed to the smoothing capacitor which will remove the unwanted ripples in the pulsated DC.....

Bleeder Resistor : is also known as a power supply drain resistor. It is connected across the filter capacitors to drain their stored charge so that the power system supply is not dangerous.....

Light Emitting Diode: Is a semiconductor device that emits infrared or visible light when an electric current flows through it. There are a few key points to note:

1) There has to be a resistor in the circuit.
2) Resistor can be on either side of the LED.
3) Longer lead on an LED is the positive lead (anode)
4) LED and voltage power supply have to be in the correct direction.
(5) Voltage drop (forward voltage) across the LED is usually between 1.5 - 4V
and is determined by the colour the LED emits with Red1.8V, Green 2.1 V, Blue 3.6V etc .
The characteristic forward voltage must be reached to turn 'on' the LED
6) LED current must be less than the maximum permitted for the LED. For standard 5mm diameter LEDs the maximum current is usually 20Ma



(A) To calculate the current limiting series resistor (Rs) to use with the green LED and the 9V supply voltage, we first need to look in the data for the recommended forward voltage and forward current specifications for the green LED and they are 2.1V (Vf) and 10mA (10mA = 0.01Amps) meaning voltage (Vf) across the green LED diode would be 2.1V and current (If) through the diode would be 10mA

To calculate series resistor (Rs), voltage drop across Rs = Vs – Vf = 9V – 2.1V = 6.9V

To find Rs use Ohms Law, convert 10mA to amps = 10mA divided by 1000 = 0.01A
Rs = 6.9V / 0.01A = 690 ohms

Vacuum tube: is an electronic device that controls the flow of electrons in a vacuum. It is used as a amplifier, display screen (CRT) or used as on/off switches.

The basic working principle of a vacuum tube is a phenomenon called thermionic emission. When a metal is heated the thermal energy knocks some electrons loose.

When the cathode is heated, and a positive voltage is applied to the anode, electrons can flow from the cathode to the anode.

Anode - a positively charged electrode by which electrons leave an electrical device.

Grid - between the cathode and anode controls the flow of electrons

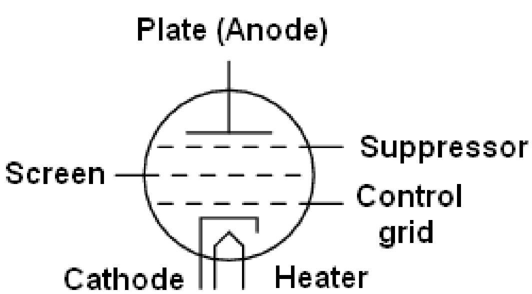
Cathode - is an electrode that emits the free electrons when heated

Diode, thermionic tube having two electrodes; used as a rectifier.

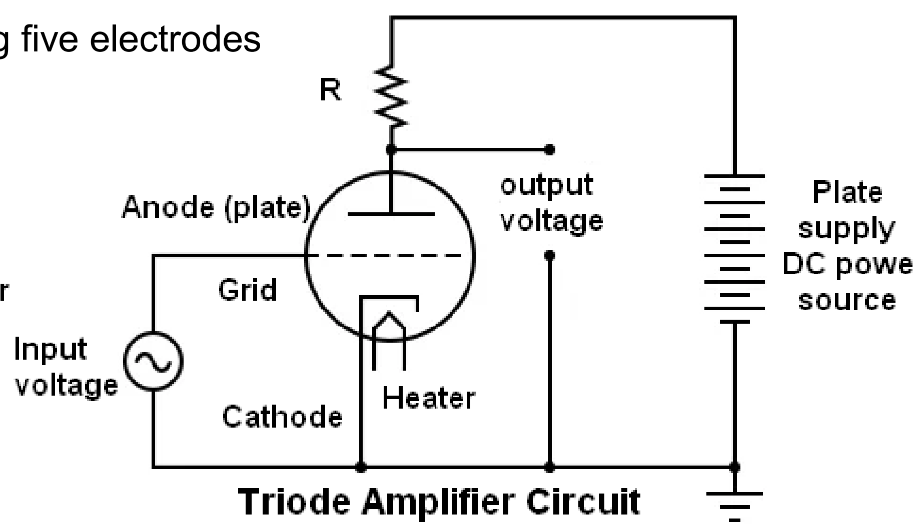
Triode, thermionic vacuum tube having three electrodes; fluctuations of the charge on the grid controls the flow from cathode to anode which makes amplification possible.

Tetrode has four electrodes, cathode, control grid, screen grid, and anode, the screen grid helps to reduce capacitance between the anode and grid in a triode

Pentode, thermionic tube having five electrodes including a suppressor grid.

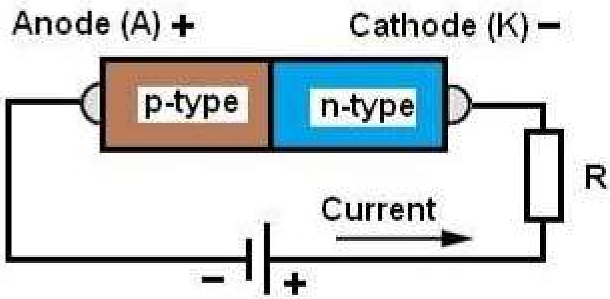


Pentode Vacuum Tube

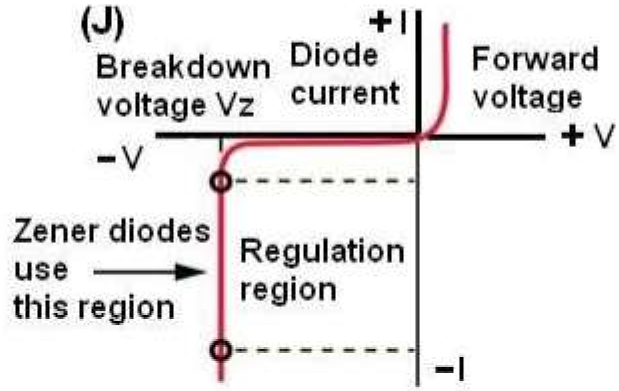


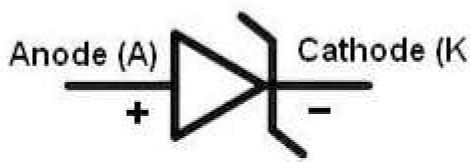
Triode Amplifier Circuit

Zener Diode



Stucture and connection of Zener diode





Symbol of Zener diode

Zener diodes are widely used as voltage references and as shunt regulators to regulate the voltage across small circuits

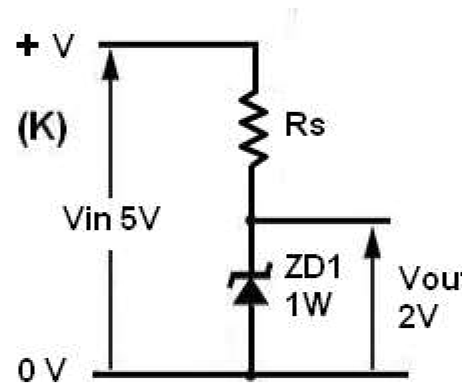
Zener diodes are semiconductor diodes which have been manufactured to have their reverse breakdown occur at a specific, well-defined voltage (Zener voltage), and that are designed such that they can be operated continuously in that breakdown mode.

Commonly available Zener diodes are available with breakdown voltages (Zener voltages) anywhere from 1.8 to 200 V and they can dissipate power ranging from 0.25 to 50 watts or more

(J) The curve shows how steady and constant the voltage across the zener diode is after it reaches the breakdown voltage, despite large changes in current.

This makes the zener diode very useful in circuits where steady voltages need to be supplied.

(K) Resistor (Rs) is connected in series with the zener diode to limit the current flow through the diode with the voltage source Vin (Vs) being connected across both the resistor and zener diode.



The stabilised output voltage Vout is taken from across the zener diode.

The zener diode is connected with its cathode terminal connected to the positive rail of the DC supply so it is reverse biased and will be operating in its breakdown condition. Resistor Rs is selected to limit the maximum current flowing in the circuit.

The voltage In must be greater than the voltage Out and a series resistor must be in place to limit the current into the diode otherwise a large amount of current would flow through zener diode and it could be destroyed.

The value of the resistor in the Zener diode circuit can be calculated to give the required value of current for the supply voltage used. Rs and the zener diode being in series will have the same current (It) flowing through them both.

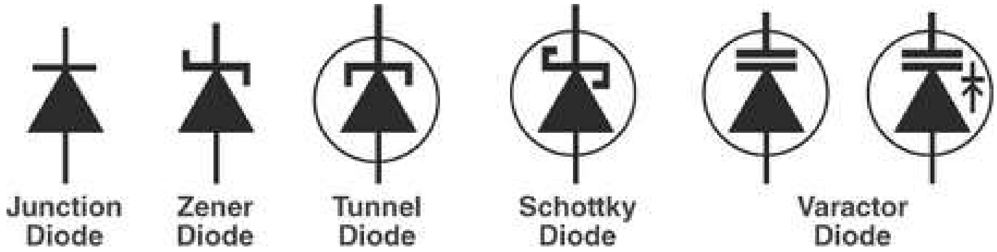
The Zener diode has a voltage and power rating. From this we can calculate the maximum current for the diode and the value of the series resistor (Rs)

(K) If the zener diode has a maximum power rating of 1 W, and a voltage rating of 2 V, the maximum current (It) through the zener diode would be Power (P) = I x V therefore
I = P/ V = 1W / 2V (Vout) = 0.5A (It)…(0.5A x 1000 = 500mA)
The zener diode being in series with Rs, the same current value would also flow through Rs and there will be a different voltage drop across them both.

The voltage drop across Rs would be Vin – Vout = 5V – 2V = 3V
Value of Rs would be= Vin - Vout / It = 3V / 0.5A = 6Ω

Power rating for Rs should be at least
P= I x V = 0.5A (It) x 3V = 1.5 watts.

(L)	Volts	Amps	Pwr	Ohms
Rs	3V	0.5A	1.5 W	6Ω
ZD1	2V	0.5A	1 W	
Total	5V	0.5A	2.5 W	



Junction Diode: The P-N junction diode is also known as rectifier diodes. These diodes are used for the rectification process and are made up of semiconductor material

Zener Diode: can provide a stable reference voltage. Zener diodes are operated in reverse bias and break down on the arrival of a certain voltage.

If current passing through the resistor is limited, a stable voltage is generated. Zener diodes are widely used in power supplies to provide a reference voltage.

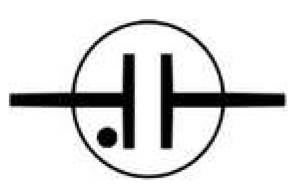
Tunnel diode: Tunnel Diode is the P-N junction device that exhibits negative resistance. When the voltage is increased than the current flowing through it decreases. Tunnel diode can be used as a switch, amplifier, and oscillator.

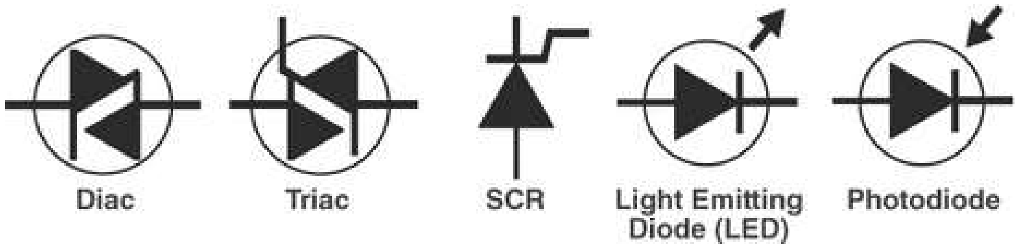
Schottky diodes: Have a lower forward voltage than other silicon PN junction diodes ranging between 0.15 and 0.4 volts and are highly used in rectifier applications**.**

Varactor diode or Varicap diode: is a semiconductor p-n junction diode whose capacitance is varied by varying the reverse voltage and provide a way of having a voltage controlled variable capacitance in a circuit. They are commonly used in voltage-controlled oscillators, parametric amplifiers, and frequency multipliers.

Neon Lamp: A neon light contains a tiny amount of neon gas under low pressure. Electricity provides energy to strip electrons away from neon atoms, ionizing them. Ions are attracted to terminals of the lamp, completing the electric circuit. Light is produced when neon atoms gain enough energy to become excited.

The dot denotes a gas-filled tube





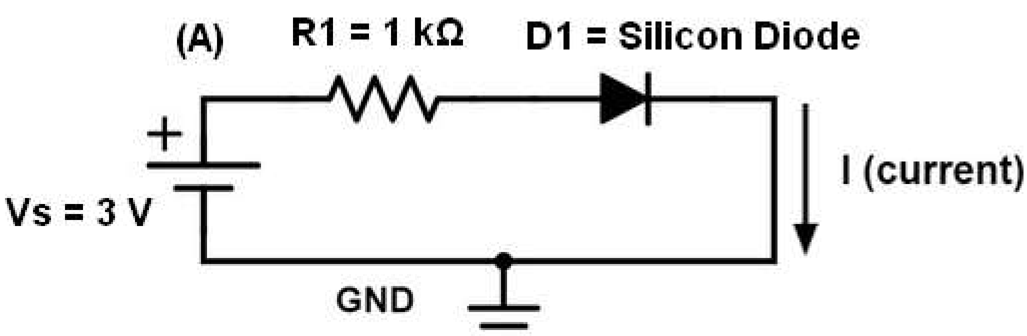
DIAC: (diode for alternating current) is a diode that conducts electrical current only after its break over voltage.

TRIAC: is a three terminal electronic component that conducts current in either direction when triggered.

SCR: A silicon controlled rectifier or semiconductor controlled rectifier is a four-layer solid-state current-controlling device.

Light Emitting Diode (LED): When an electric current between the electrodes passes through this diode, light is produced

Photodiode: can identify even a small amount of current flow resulting from the light.

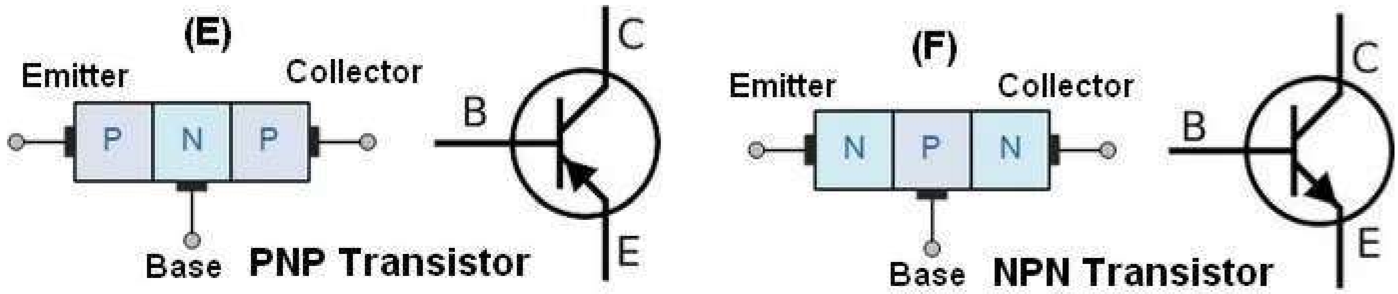


Forward-biased diode silicon diode has a fixed voltage drop across it, which is usually about 0.7V.

(A) Series circuit: Find the voltage drop across R1.The voltage across the diode reduces the voltage drop across R1.

Voltage drop across R1 = Vs – Voltage drop across diode = 3.0 – 0.7 = 2.3V

Transistor : Transistors are three terminal semiconductor devices used for switching or amplifying electrical signals.....There are two types of transistors: NPN and PNP.

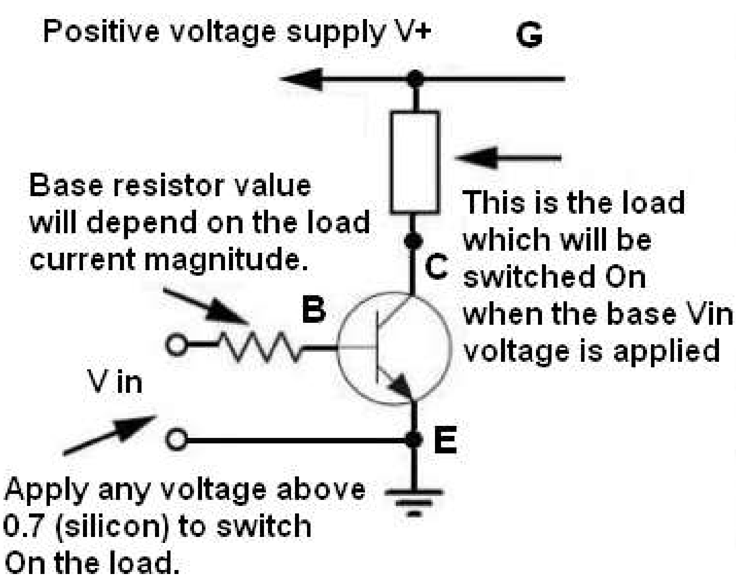


PNP Positive Negative Positive with arrow pointed In.

NPN Negative Positive Negative with arrow pointed Out

The NPN transistor is formed by combination of two junction diodes and is formed of either a thin layer of P-type semiconductor sandwiched between two n-type semiconductors, which is known as n-p-n transistors.

Transistor circuits use one of three transistor configurations: common base, common collector (emitter follower) and common emitter.... The common emitter configuration is frequently used in the applications like an audio amplifier.
A transistor has the ability to use a small signal applied between one pair of its terminals to control a much larger signal at another pair of terminals. This property is called gain...... It can produce a stronger output signal, a voltage or current, which is proportional to a weaker input signal; that is, it can act as an amplifier...... Alternatively, the transistor can be used to turn current on or off in a circuit as an electrically controlled switch.

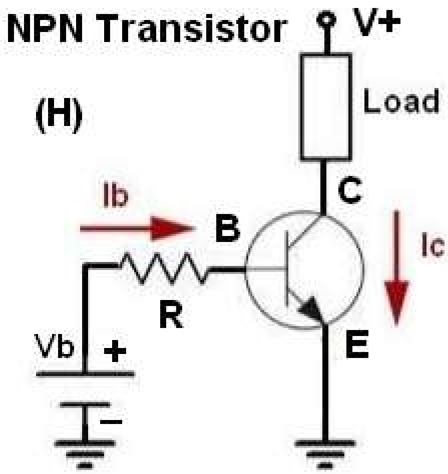


(G) Transistor electronic switch.
The transistor allows the use of a small current (base) to control a larger current (collector).

In a ideal switch, the transistor should be in only one of two states either On or Off

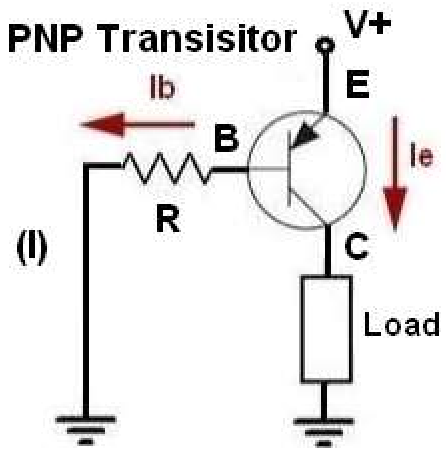
The transistor is Off when there is no bias voltage or when the bias voltage is less than 0.7 V

The transistor is switched On when the base is saturated so that the collector current can flow without restriction.

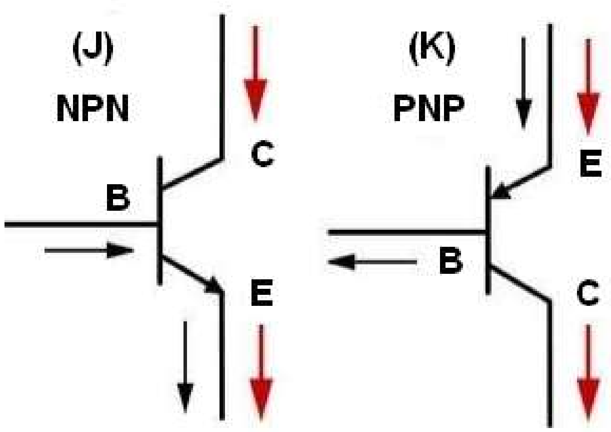


(H) NPN transistor, when a voltage is supplied to the base exceeds the threshold voltage of 0.7 (silicon) as the voltage is increased to the base of the NPN transistor, the transistor conducts more and more current until it conducts fully from collector to emitter.

If the voltage is decreased to the base of the NPN transistor, the transistor conducts less and less current from the collector to the emitter, until the voltage supplied to the base is under the threshold voltage amount of 0.7V at which point the transistor no longer conducts across collector to emitter and shuts off.



(I) PNP transistor receives positive voltage at the emitter terminal. The positive voltage at emitter allows current to flow from emitter to collector providing that there is sufficient negative current to the base (current flowing out of the base to ground)



(J) NPN transistor, current flowing "into" the base leg of the NPN transistor results in a flow proportionally larger current to flow between the collector and emitter.

Operation of NPN transistor...
Base current: Current from base to emitter
Collector current: Current from collector to emitter

(K) PNP transistor, the current flowing "out" of the base to the PNP transistor allows a proportional current to flow between the emitter and collector.

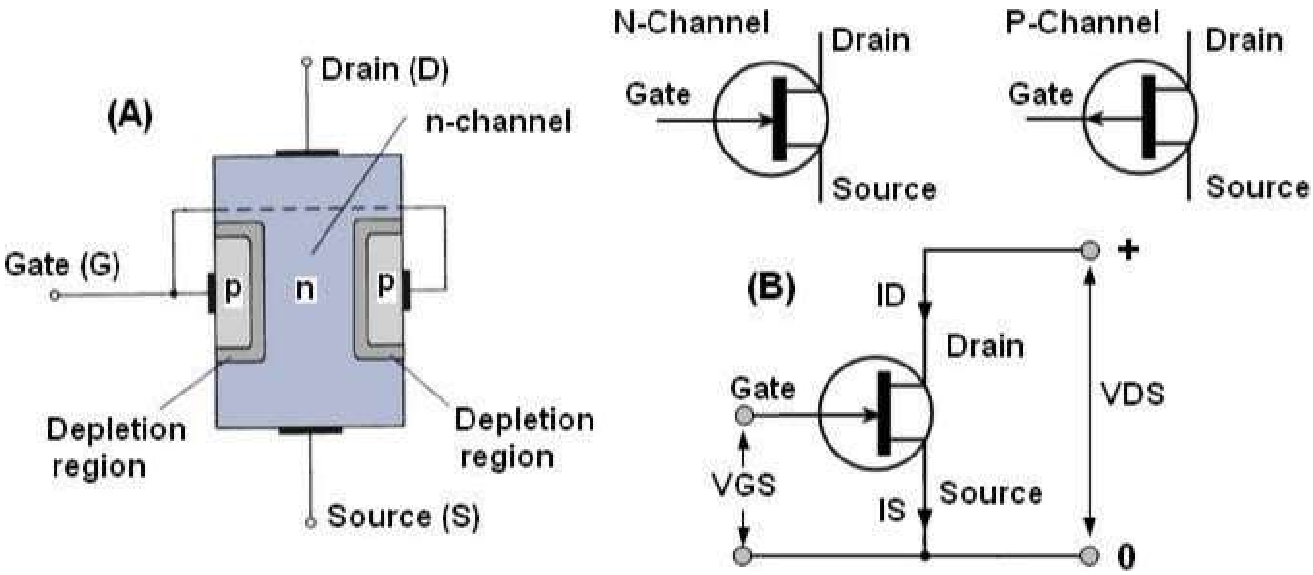
Operation PNP transistor
Base current: Current from emitter to base
Collector current: Current from emitter to collector

The alpha factor (α) of a transistor is the ratio of its collector and emitter currents ($\alpha = Ic/Ie$), and it is always less than 1 (between 0.5 and 1).

The beta (β) or current gain of a transistor is the ratio of its collector and base currents ($\beta = Ic/Ib$), and it is always more than 1.

Field Effect Transistor : The Field Effect Transistor (FET) is a three terminal active device that uses an electric field to control the current flow, it has a high input impedance and is commonly used for weak-signal amplification (for example, for amplifying wireless signals)...The device can amplify analog or digital signals. It can also switch DC or function as an oscillator.

For a field-effect transistor, the terminals are labeled gate, source, and drain, the current flow along the channel between the source and the drain is controlled by the gate voltage. Small change in the gate voltage causes a large change in the current drain.



(B) The voltage VGS applied to the Gate controls the current flowing between the Drain and the Source terminals...VGS refers to the voltage applied to the Gate and Source while VDS refers to the voltage between the Drain and Source.

(B) With zero gate bias applied, a current flow from drain to source via a conductive ‘channel‘ in the n-type bar is formed....When negative gate bias is applied; a high resistance region is formed within the junction, and reduces the width of the n-type conduction channel and thus reduces the magnitude of the drain-to-source current.

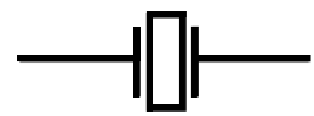
As the gate bias is increased, the depletion region (A) spreads deeper into the n-type channel, until eventually at some pinch-off voltage value, the depletion layer becomes so deep that conduction ceases.

Quartz Crystal: A quartz crystal oscillator is an electronic circuit that uses the mechanical resonance of a vibrating crystal to generate a sinusoidal electronic signal at a very precise frequency. Quartz crystal behaves like an RLC circuit, composed of an inductor, capacitor and resistor, with a precise resonant frequency.

In operation the quartz crystal uses the Piezoelectric Effect. When voltage is applied across a piezoelectric crystal, it vibrates at the frequency of the applied voltage.

Conversely, if we apply a mechanical force to vibrate the crystal, it generates an AC voltage of the same frequency.

In communications equipment, the crystal is used in receiver transmitter oscillators for the purpose of frequency control.



Symbol Quartz Crystal

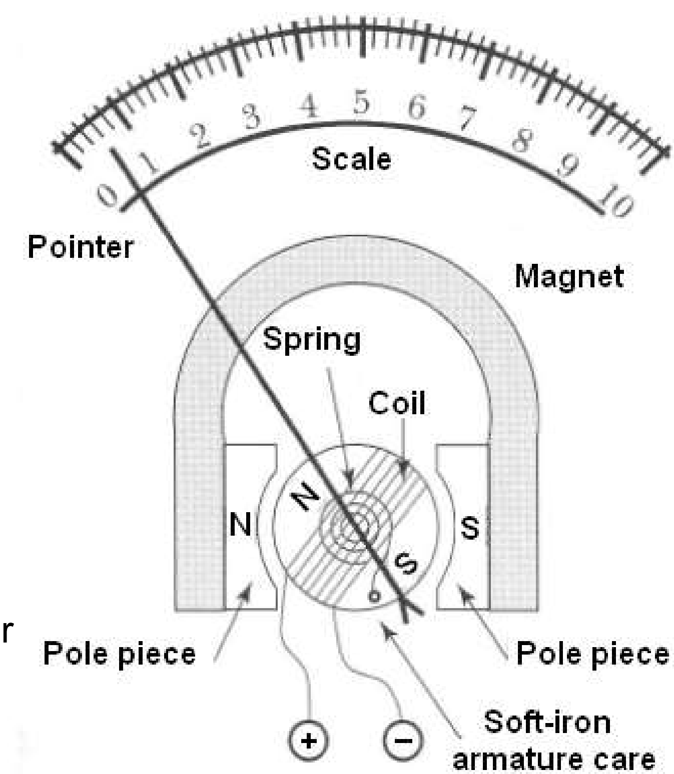
Meter: A Permanent Magnet Moving Coil (PMMC) meter is an instrument for indicating or measuring a small electric current by means of a mechanical motion derived from electromagnetic or electrodynamic forces

The D'Arsonval movement is a current sensing mechanism which is used in DC Ammeter, ohm meter and Voltmeter.

When a current is passed through the coil, it produces a force.

Due to this force, a torque is produced in the spindle which rotates it.

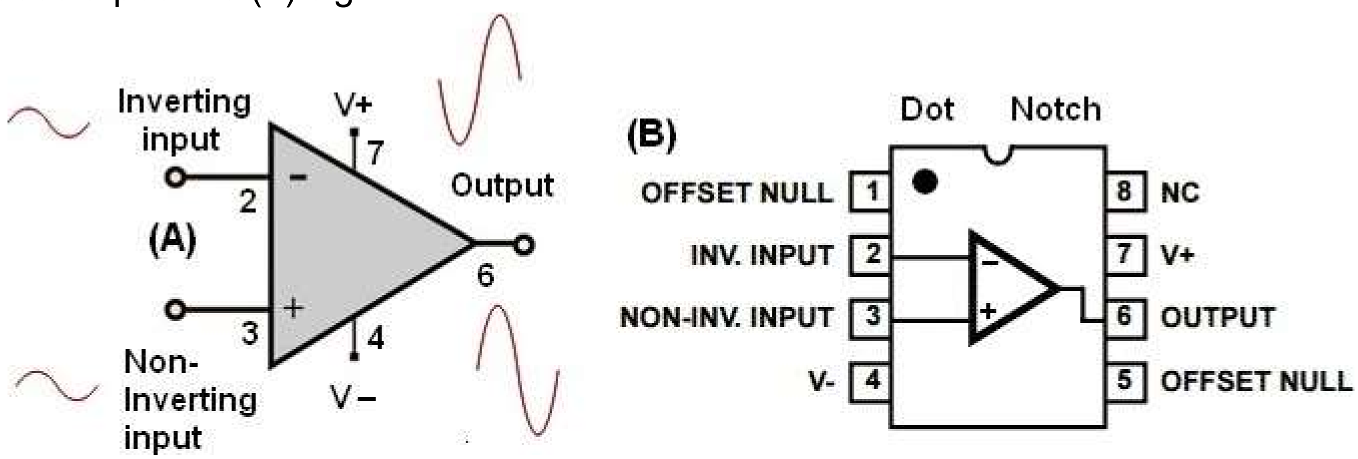
When the spindle rotates, it moves a pointer making it move over the calibrated scale.



Operational Amplifier (Op Amp): An operational amplifier is a high-gain, direct-coupled differential amplifier with very high input and very low output impedance.

Operational amplifiers work to amplify the voltage differential between the inputs, they can be used to build amplifiers, filter circuits, and many other types of circuits that do analog signal processing.

Op amps usually have three terminals: two high-impedance inputs and a low-impedance output port. Its basic role is to amplify and output the voltage difference between the two input pins. The inverting input is denoted with a minus (-) sign, and the non-inverting input uses a positive (+) sign.



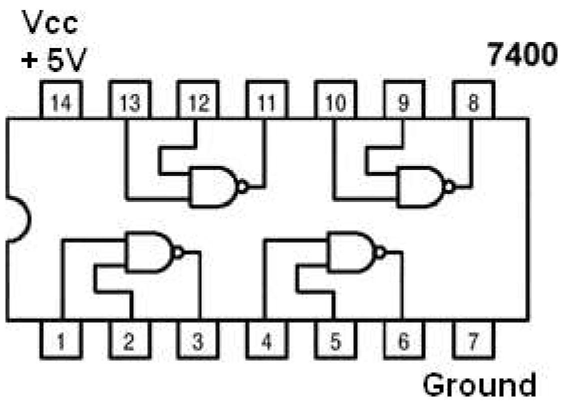
(**A) Inverted amplifier :** is one which the output is 180 degrees out of phase with respect to input.
A positive voltage applied to the inverting input will produce a negative swing at the output.
A sine wave applied to the inverting input, will appear inverted at the output.

(A) Non-inverting amp: is one which has the output in phase with respect to the input.
If a positive voltage applied to the non-inverting input will produce a positive swing at the output and if a changing waveform, such as a sine wave is applied to the non-inverting input, then it will appear in the same sense at the output.

(B) Is a 8 pin IC. Most ICs will use either a notch and or a dot (B) to indicate which pin is the first pin. The pins are numbered (viewed from above) anti-clockwise around the IC (chip) starting near the notch or dot.

7400 TTL and 4000 CMOS Integrated Circuits.

The top of the IC is usually marked with a small notch.
When viewed from above - pin 1 is on the left of the notch - and pin 14 is on the right.
In addition - pin 1 is often identified by a small dot.

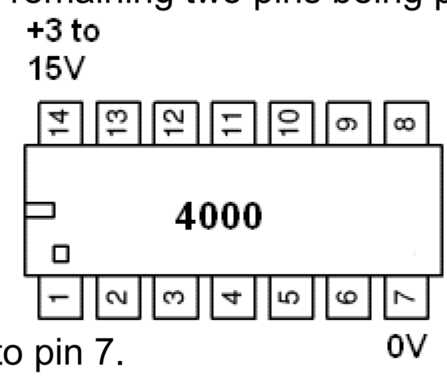


A	B	Out
0	0	1
0	1	1
1	0	1
1	1	0

7400 IC is a 14 pin TTL (Transistor-Transistor Logic) device. It contains four independent two-input NAND gates each of which performs the logic NAND function.

NAND gate, the output is "false" if both inputs are "true”...Page 112...Digital Logic Circuits

Each gate uses two input pins and one output pin, with the remaining two pins being power supply pin 14 (+ 5 V) and ground (0V) pin 7



4000 CMOS
(Complementary Metal Oxide Semiconductor)

4000 power supply can range from +3 V to +15 V
and is connected to pin 14, and ground (0V) is connected to pin 7.

The CMOS circuitry means that 4000 series ICs are static sensitive. Touching a pin while charged with static electricity (from your clothes for example) may damage the IC.

Most ICs in regular use are quite tolerant and earthing your hands by touching a metal water pipe or window frame before handling them will be adequate

ICs should be left in their protective packaging until you are ready to use them.

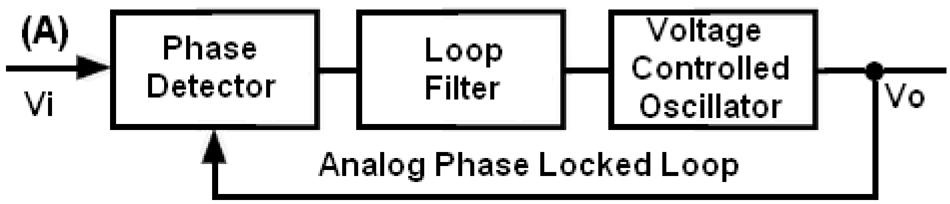
Phase Locked Loop (PLL): Can be used as modulators, demodulators, oscillators, synthesizers, clock signal recovery circuits, recover a signal from a noisy communication channel, generate a stable frequency at multiples of an input frequency (frequency synthesis) etc.

Phase locked loops are closed-loop feedback systems consisting of both analog and digital components including a voltage controlled oscillator (VCO).

PLLs use a negative feedback circuit to match the phase of the frequency of another signal.

PLLs synchronize the phase of the PLL's output to the input signal's frequency by tweaking the output of a voltage-driven oscillator; The PLL adjusts the oscillator to match what it sees at the PLL's input.

A feedback loop, or phase comparator, is used to compare the input signal with the output signal. PLLs are often used to duplicate or track the frequency of another signal.



(A) Simple Analog Phase Locked Loop shows the three main elements of the PLL: phase detector, loop filter and voltage controlled oscillator.

Phase comparator / detector: Compares the phase of two signals and generates a voltage according to the phase difference between the two.

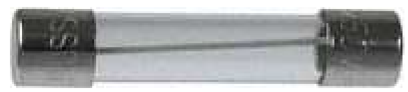
Loop filter: Is used to filter the output from the phase comparator. It is used to remove any components of the signals of which the phase is being compared from the VCO line, i.e. the reference and VCO input. It also governs many of the characteristics of the loop including the loop stability, speed of lock,

The VCO is the circuit block that generates the radio frequency signal that is normally considered as the output of the loop. Its frequency can be controlled over the operational frequency band required for the loop.

Fuse: A fuse is an electrical safety device that breaks the circuit if a fault in an appliance causes too much current to flow. This protects the wiring and the appliance if something goes wrong.

The schematic symbol for a fuse

(A) is called a Cartridge Fuse. It contains a thick conductor that is designed to melt at relatively low temperatures. If the current through the component reaches a specified level, the conductor heats to its melting point.

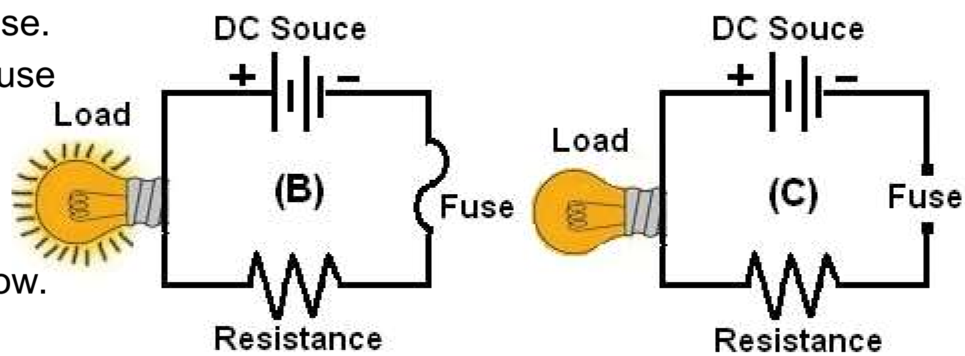


(A)

When it melts, the connection between the ends of the fuse is broken, the fuse is destroyed, and it effectively acts as an open switch.
(A) Example of a fuse with markings on the metal cap. ie voltage and current rating. Example 250VAC and 3A. Fuses are used in both AC and DC circuits.

Fuses are connected in series with the component(s) to be protected from overcurrent, so that when the fuse blows (opens) it will open the entire circuit and stop current through the component(s)

(B) Electrical circuit connected fuse.
(C) Electrical with open (blown) fuse

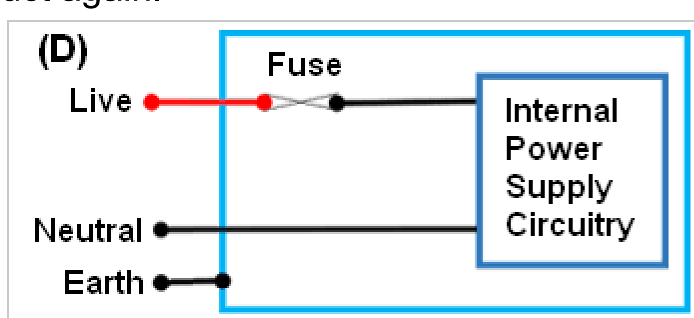


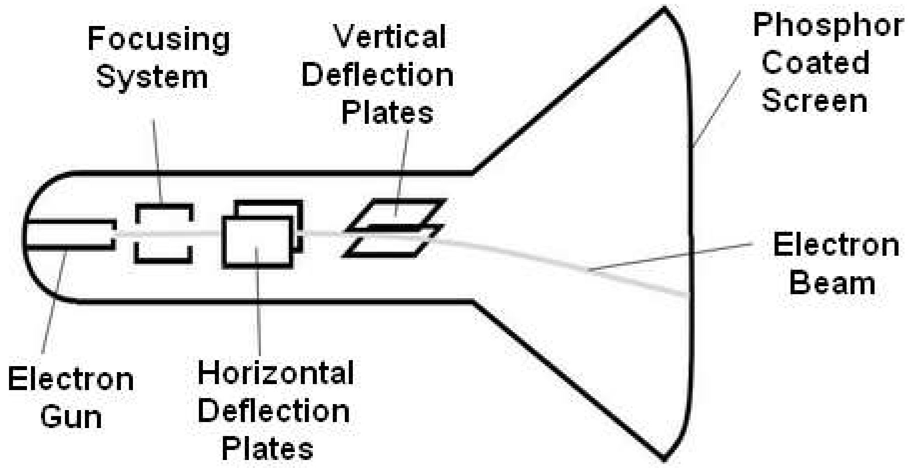
Fuses are rated in terms of their voltage capacity as well as the current level at which they will blow.

The current rating of a fuse is the maximum allowable fuse current and is measured in Amperes. If the current rating of a fuse is exceeded, the fuse will “Blow” (open).

The voltage rating of the fuse is the maximum amount of voltage that an open fuse can block. If the voltage across an open fuse exceeds its voltage rating, the air in the fuse may ionize (charge), causing the open fuse to conduct again.

(D) In mains (AC) wiring the fuse is connected to the live wire

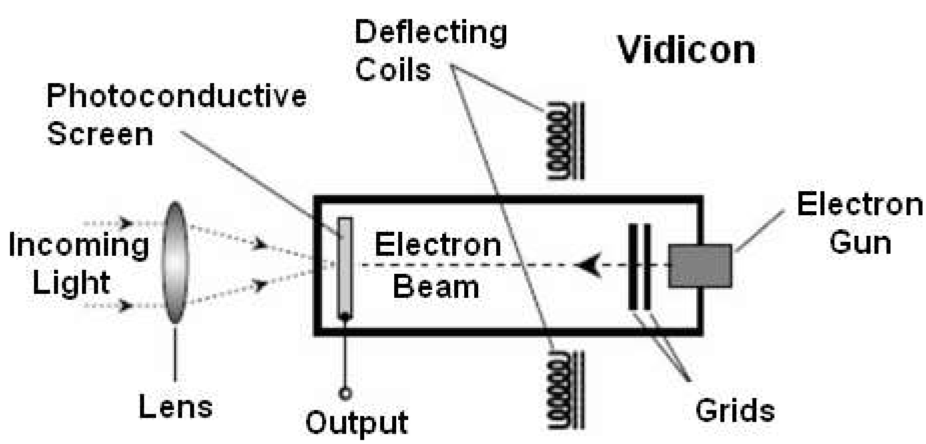




Cathode Ray Tube

The cathode ray tube (CRT) is a vacuum tube containing one or more electron guns (a source of directed electrons) and a fluorescent screen used to view images. It has a means to accelerate and deflect the electron beam onto the fluorescent screen to create the images. The images are generated when electrons strike fluorescent phosphors on the screen, which then emit light (the color varies depending on the phosphor used).

CRTs are widely used in a number of electrical devices such as computer screens, television sets, radar screens and oscilloscopes.

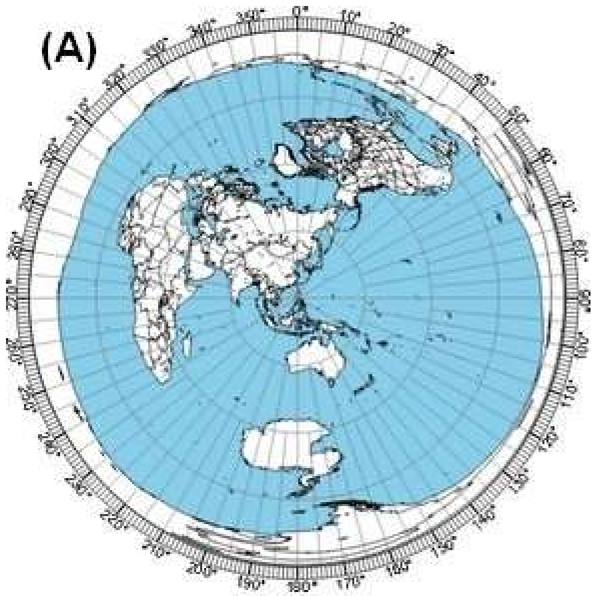


Vidicon: a small television camera tube in which the image is formed on a transparent electrode coated with photoconductive material, the current from which varies as it is scanned by a beam of low-speed electrons.

Element VII (7) - Operating Procedures

"All Elements in one zip folder" NTC Class B Element 7 (VII) has 80 multi choice questions and information.

Azimuth Map:



Reduced in size Azimuth Map

(A) One way to determine the best orientation for an antenna is to use an azimuth map. Using an azimuth map allows the user to see the compass bearing from their location to other locations.

The azimuthal equidistant projection is an azimuthal map projection.

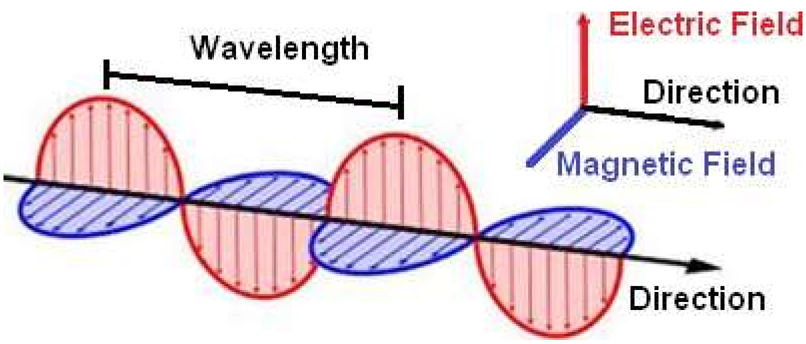
It has the useful properties that all points on the map are at proportionally correct distances from the center point, and that all points on the map are at the correct azimuth (direction) from the center point.

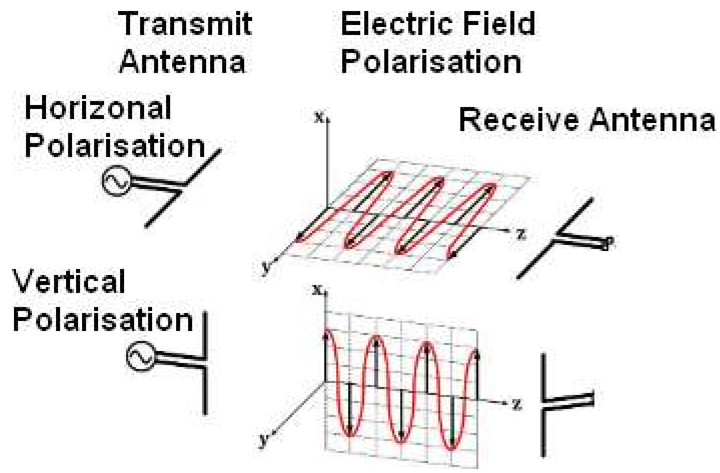
A world map which has been set so that all the directions on that map are real antenna directions from one central point.....

On the internet there are websites on which free azimuth maps maybe generated to suit a particular qth, then downloaded and printed.

A compass or Great Circle Map can also be used as a way to point the antenna in a direction

Antenna Orientation:





The orientation of the antenna is more critical when using VHF and UHF whereas when using HF bands and using a vertical, yagi, dipole etc the antenna orientation is less critical as the operator can communicate with other amateur radio stations using an assortment of the different antennas depending on the propagation and the antenna efficiency.

A radio wave is made up of electrical and magnetic fields it is called an Electromagnetic Wave. The electric field and magnetic field oscillate at the same frequency as the electromagnetic wave. Antenna Polarization refers to the electric field orientation of the electromagnetic wave.

In transmitting antennas, the polarization of an antenna is the direction of the electromagnetic fields produced by the antenna as energy radiates away from it.

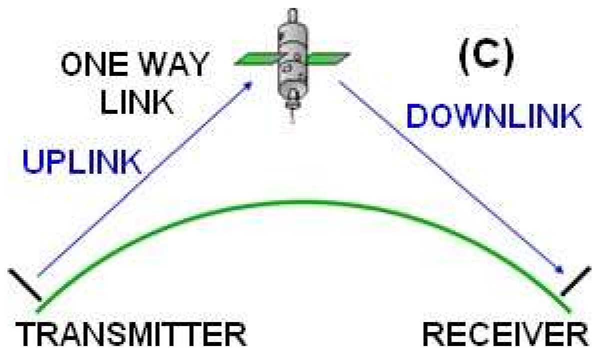
The receiving antenna should have the same polarization as the polarization of the transmitted antenna for optimum reception.

The polarization of an antenna refers to the orientation of the electric field (E-plane) of the radio wave with respect to the Earth's surface and is determined by the physical structure of the antenna and by its orientation.

For a horizontally polarized antenna, the E-Plane usually coincides with the horizontal / azimuth plane, oriented horizontal to the surface of the earth.

For a vertically polarized antenna, the E-plane usually coincides with the vertical / elevation plane. Omni-directional (Vertical) antennas focus their energy equally in all directions. A simple straight wire antenna will have one polarization when mounted vertically, and a different polarization when mounted horizontally.

Satellites



There are four common types of satellites:

(1): Transponder: A transponder listens on a range of frequencies on one band, translates those signals to a different band, and retransmits them in real time.

(2) : Repeater: Just like terrestrial repeaters, repeater satellites listen and receive on a specific pair of channels. Satellite repeaters are crossband, meaning that their input and output frequencies are on different bands

(3) Digital: Digital satellites can act as bulletin boards or as store-and-forward systems. You can access both types of digital satellites by using regular packet radio protocols and equipment.

(4) Telemetry: Many student teams and other noncommercial groups (whose members have licenses, like all other hams) use amateur radio frequencies to build small satellites called CubeSats, which are launched into low Earth orbit as a group when a commercial satellite launch has spare payload capacity.

(C) Amateur Radio Satellites: Most amateur satellites are located in near-circular low Earth orbit, circling the planet several a times each day.
The ionosphere doesn't pass signals reliably at lower frequencies, and satellite antennas need to be small, requiring shorter wavelengths.

Many amateur satellites receive an OSCAR (Orbiting Satellite Carrying Amateur Radio) designation.

Uplink: The satellite receiver listens on this frequency; you need to transmit on this frequency for someone to hear you on the downlink.

Downlink: This is the frequency that the satellite (repeater) uses to transmit, when people talk on this repeater (uplink), this is the frequency you use to hear them.

Example: Uplink FM 145.880 MHz with Downlink FM 435.880 MHz

Slow Scan Television (SSTV): is a picture transmission method for transmitting still images used mainly by amateur radio operators to transmit and receive static pictures via radio in monochrome or color.

SSTV occupies the same amount of bandwidth as a typical SSB signal with approximate bandwidth for SSTV digital transmissions made on the HF amateur bands being 3 KHz.

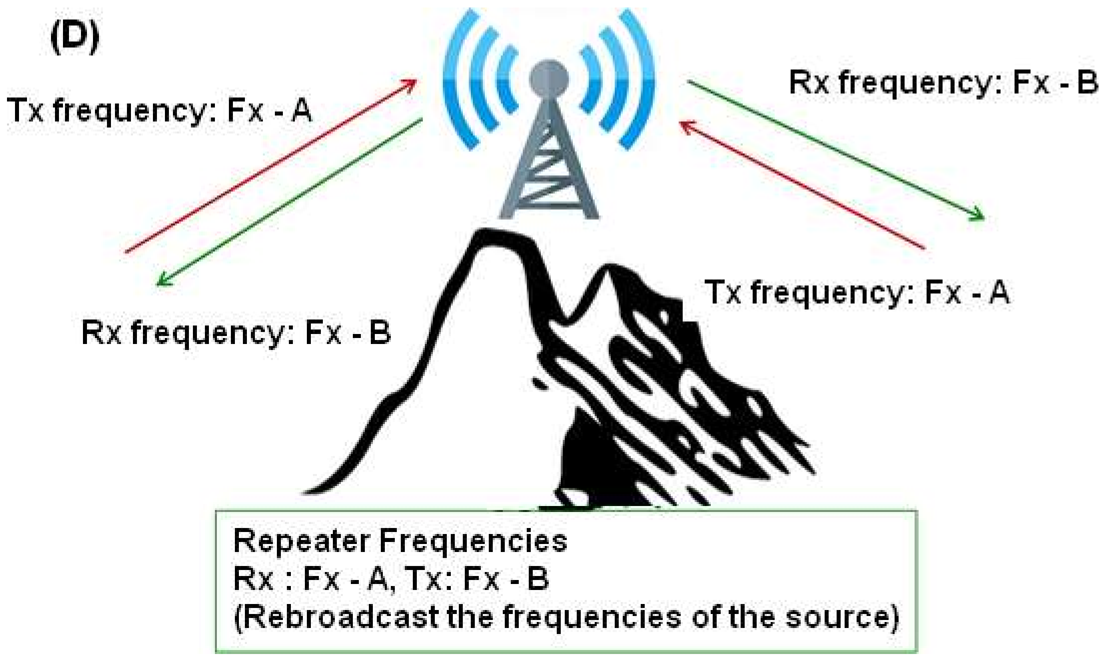
Fast Scan Amateur Television (ATV): A system of sending broadcast quality full motion pictures over shorter distances on the UHF and microwave bands, has a 6 MHz wide signal.

Facsimile transmission: A "fax machine" usually consists of a means of scanning the image, a device to convert that scanned image into an encoded signal that can be transmitted (the modem) a means of transmitting the signal and at the other end, some form of receiver, decoder and printer to reproduce the image.

For the amateur this involves scanning the image and encoding that information. That encoding is transmitted in the form of audio tones which are within the usual voice frequencies and hence can be readily transmitted with either Frequency Modulation (FM) in VHF or UHF bands or Single Sideband for HF bands.

RTTY (Radio Teletype): is a method of using tones to send digital messages between radios in amateur HF bands (and other services).

Repeater:



(D) FM (Frequency Modulation) Repeater: A ham radio FM repeater is essentially a relay station that receives a signal on one frequency and retransmits the audio on another.

The repeater receives a weak or low-level radio signal and retransmits it at a higher level or higher power, so that the signal can cover longer distances without degradation.

In order to listen and transmit at the same time, repeaters use two different frequencies. One for its transmit frequency and another for its receive frequency.

Output Frequency: The frequency that the repeater transmits on, and that you need to tune to in order to hear what's being transmitted

Input Frequency: The frequency that you need to transmit on, so that the repeater can re-transmit it

CTCSS: Continuous Tone Coded Squelch System. This is a tone that you can't hear that is transmitted with voice. Repeaters listen for CTCSS tones and will only 'open' the repeater if the correct CTCSS tone is sent

Offset: A repeater uses different transmit and receive frequencies, which are 'offset' by a fixed value. On the 2 meter amateur band these frequencies are 600 kHz (or 600 kilohertz) apart

For example, a repeater that transmits on 145.725MHz will 'listen' for incoming signals on (145.725 Mhz – 600 kHz) = 145.125MHz – This is known as the Input frequency.

Repeaters are sited in good locations with good coverage enabling stations that can access the repeater to be heard on the output and thereby take advantage of the location of the repeater.......Effectively it gives the low power amateur radio station the same coverage as that of the repeater.

Repeaters make it possible for line-of-sight 2 meter radio signals to reach much further than the usual simplex contact.

In order to "open" the repeater up there must be a signal on its receive or input frequency….There are two methods of achieving this:

1) Use of an audio tone burst at the beginning of each transmission

2) By using a sub-audible tone system known as CTCSS. The CTCSS is the form of repeater access tone.

The different tones are denoted by letter and the correct tone must be used for each repeater. Sometimes repeaters transmit a Morse letter after the end of a transmission to indicate the tone it requires.

Once the repeater has been accessed, the audio from the incoming signal will be re-transmitted on the output frequency of the repeater

Q Codes: Q Codes are standard three-letter codes, developed originally to facilitate commercial Morse transmissions to speed up the sending of messages and to act as a form of ‘international language’ for messages.

Q codes continue to be used extensively in amateur Morse (CW) transmissions and are also commonly used in amateur voice transmissions.

Each Q code can be a question if followed by a question mark or an answer (or statement) if not. On CW, the Q code if sent with a question mark (IMI) following the Q code, then the Q code will represent a question. QRZ IMI

QSL Can you acknowledge receipt? I am acknowledging receipt
QRZ Who is calling me?
QTH My QTH (Location) is…
Sample Q codes:
QRA= Name or call sign
QRG= Exact frequency between stations
QRL= Busy
QRM= Man made interference
QRN= natural interference, static
QRO= Increase power
QRP= Reduce or low power
QRQ= Send faster
QRS= Send slower
QRT= Quit operating, sign off
QRU= Anything for me
QRV= Are you ready
QRX= Standby
QRZ= Who is calling
QSB= Signals are fading
QSL= Acknowledge copy
QSO= Communicate or conversation
QSY= Change frequency to…MHz
QTH= Location or address
QTR= Correct time

Morse Code Abbreviations: Are used in radio communications to speed up the sending of messages, to facilitate conversations between operators and between amateurs who speak different languages. Q codes are also used when using CW. Abbreviations are also used in voice communications. CQ : 73 : DX
Some cw abbreviations are shortened versions of words. Tcvr for Transceiver

Examples.
AGN : Again
AR : End of transmission
AS : Wait
BK : Break, used to interrupt a transmission in progress
BT : Separation (add a space)
CFM : Confirm
CL : Closing down (I am closing my station)
CQ : General call to all stations to have a QSO with the sender.
DE : From, this is…(XS3DXX de AS9GHR)
DX : Distance (sometimes refers to long distance contact)
ES : And
FB : Fine Business
HI : Laugher
HR : Here
K : Invitation to any station to respond to a call (CQ de AS9GHR K)
KN : Only the station named should respond (XS3DXX de AS9GHR KN)
PSE : Please
R : Received as transmitted (QSL)
RST : Signal report format (Readability-Signal Strength-Tone)
WX : Weather
SK : End of contact or end of Sked (Schedule)
RX : Receiver
TX : Transmitter
UR : Your
73 : Best Regards
88 : Love and kisses

Readability, Signal strength and Tone (RST): The RST code consists of three digits, the first one represents the readability, the second one represents the strength and the last one the tone. 599 - means that the morse code cw signal being assessed is Readability 5 (perfectly readable), Strength 9 (extremely strong signal), Tone 9 (perfect tone).
On phone only readability and signal strength is used.
With 59 being perfectly readable and extremely strong signal

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

S Meter
(Signal Strength Meter)

An S meter (signal strength meter) is an indicator often provided on amateur radio transceivers.

The scale markings are derived from a system of signal strength from S1 to S9 as part of the R-S-T system.

The term S unit can be used to refer to the amount of signal strength required to move an S meter indication from one marking to the next.

Signal Strength
1- Faint signals, barely perceptible.
2- Very weak signals.
3- Weak signals.
4- Fair signals.
5- Fairly good signals.
6- Good signals.
7- Moderately strong signals.
8- Strong signals.
9- Extremely strong signals.
Tone
1- Sixty cycle a.c or less, very rough and broad.
2- Very rough a.c., very harsh and broad.
3- Rough a.c. tone, rectified but not filtered.
4- Rough note, some trace of filtering.
5- Filtered rectified a.c. but strongly ripple-modulated.
6- Filtered tone, definite trace of ripple modulation.
7- Near pure tone, trace of ripple modulation.
8- Near perfect tone, slight trace of modulation.
9- Perfect tone, no trace of ripple or modulation of any kind.

Vox transmitter control: VOX stands for "voice-operated exchanged" or “voice operated transmission”

When the VOX is on, the sound of your voice will automatically switch the transceiver into the transmit mode. When you start speaking, the transmitter should activate automatically. When you finish speaking, the transceiver should return to the receive mode (after a short delay). Vox means the user can keep his or her hands free while talking.

Zero beating receive signal: Matching your transmit frequency to the frequency of a received signal.

Transmitter tune up procedure: Sometimes before transmitting it is necessary to tune (adjust) the transmitter. Tuning the transceiver should in the first instance be done on a dummy load afterwards listen to find a clear frequency and ask if the frequency is in use ? Reduce power; fine tuning of the transceiver can be done on that clear frequency by adjusting the ATU (Antenna Tuning Unit) for a matching SWR (Standing Wave Ratio) reading. Adjust power to the required output.

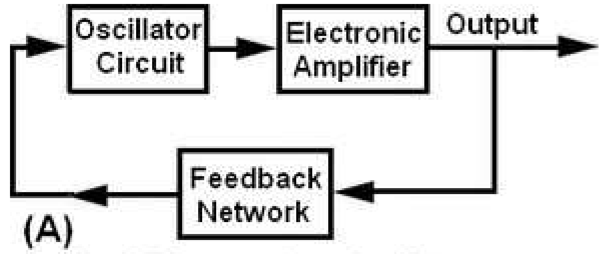
Full break in telegraphy: In CW Morse code operations, QSK or full break-in operation describes an operating mode in which the transmitting station can detect signals from other stations between the elements (dots and dashes) or letters of the Morse transmission.

Receiver Incremental Tuning (RIT): A transceiver control that allows for a slight change in the receiver frequency without changing the transmitter frequency.

Xmitter Incremental Tuning (XIT): is the ability to shift the transmit frequency of a transceiver away from the receive frequency by a small amount.

Operating Courtesy: includes
Do not tune your transmitter (transceiver) on frequencies being used.
Always listen in a few seconds, a minute if necessary, before calling for a “CQ” on frequency…….If using repeater systems, keep the QSO short.
Never use abusive terms, stay polite and courteous.

Element VIII (8) - Practical Circuits



Block Diagram of an Oscillator

An oscillator is an electronic circuit that produces a periodic, oscillating electronic signal, often a sine wave or a square wave. Oscillators convert direct current from a power supply to an alternating current signal.

Requirements for Oscillation
1). Frequency determining device (Oscillator Circuit)
2). Amplification (Electronic Amplifier)
3). Positive feedback (Feedback Network)

Oscillators: An audio oscillator produces frequencies in the audio range, about 16 Hz to 20 kHz. An RF oscillator produces signals in the radio frequency (RF) range of about 100 kHz to 100 GHz.

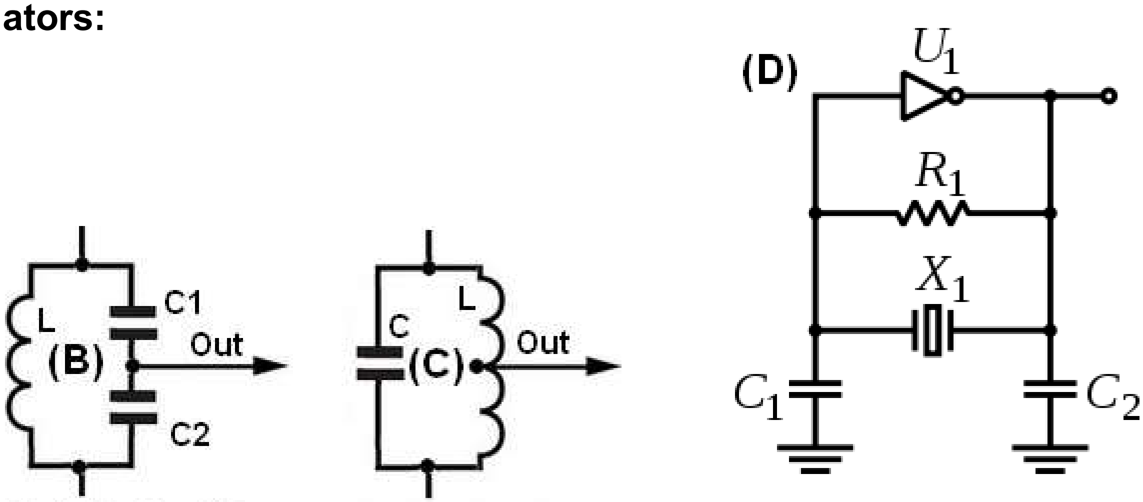
One of the most important features of any oscillator is its frequency stability, or in other words its ability to provide a constant frequency output under varying load conditions.

There are many types of electronic oscillators, but they all operate according to the same basic principle: an oscillator always employs a sensitive amplifier whose output is fed back to the input in phase.

Thus, the signal regenerates and sustains itself, this is known as Positive feedback.......Positive feedback is the condition where a fraction of the amplifier's output signal is fed back to be in phase with the input, and by adding together the feedback and input signals, the amplitude of the input signal is increased.

An oscillator is an amplifier, which uses a positive feedback and without any external input signal, generates an output waveform at a desired frequency.

Oscillators:



Colpitts Oscillator   Hartley Oscillator   Simple Piece Oscillator

Oscillator circuits are not only used to generate the RF signals we transmit........They are also an integral part of receivers, such as the superheterodyne (superhet) receiver.

What condition must exist for a circuit to oscillate?   It must have positive feedback with a gain greater than 1

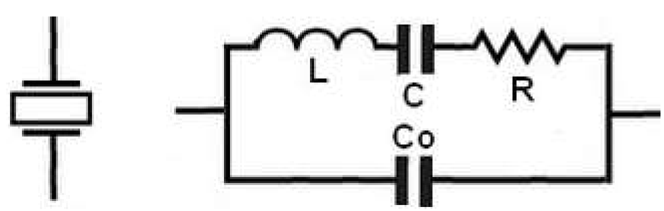
The three oscillator circuits used in Amateur Radio equipment are Colpitts, Hartley and Pierce.

(B) How is positive feedback supplied in a Colpitts oscillator? ......Through a capacitive divider.

(C) How is positive feedback supplied in a Hartley oscillator? Through a tapped coil.

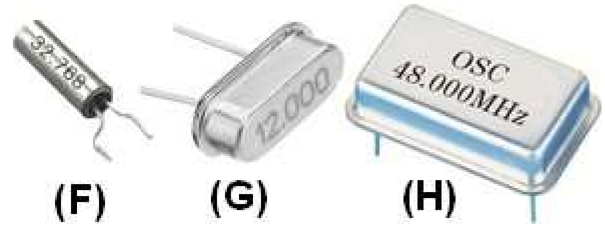
(D) How is positive feedback supplied in a Pierce oscillator?....Through a quartz crystal.

Colpitts and Hartley oscillator circuits are commonly used in Variable Frequency Oscillators (VFOs).



Symbol of a Crystal   Equivalent circuit of a crystal

(F) Clock quartz crystal
(G) Quartz crystal resonator
(H) Quartz crystal oscillator



Crystal Oscillator advantages....

1) They have a high order of frequency stability.....
2) The quality factor (Q) of the crystal is very high...

Disadvantages.
1) They are fragile and can be used in low power circuits....
2) The frequency of oscillations cannot be changed appreciably.

As well as being used to generate very accurate frequency carrier waves in radio transmitters, they also form the basis of the very accurate timing elements in clocks, watches, and computer systems.

At radio frequencies and higher, whenever a fixed frequency with very high degree of frequency stability is needed, the component that determines the frequency of oscillation is usually a quartz crystal.

Crystal oscillators use piezoelectric crystals to generate highly stabilized output signal.

Stability, small size and low cost make them superior over other oscillator circuits.

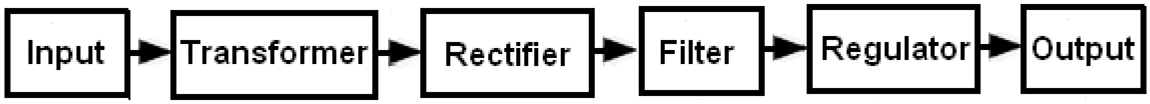
The principle of piezoelectric effect. When voltage is applied across a piezoelectric crystal, it vibrates at the frequency of the applied voltage.

Conversely, if we apply a mechanical force to vibrate the crystal, it generates an AC voltage of the same frequency......

The frequency depends on the physical dimensions of the crystal; therefore once the crystal has been manufactured to specific dimensions, the frequency of oscillation is extremely accurate.....

Crystal oscillator designs can produce either sine wave or square wave signals.

Power Supply (A)



A power supply (sometimes known as a power supply unit or PSU) is a device or system that supplies electrical or other types of energy to an output load or group of loads. The term is most commonly applied to electrical energy supplies.

Converts a.c. to d.c. used in amateur radio to convert say input 220v AC to 13.8-volt DC

Transceivers unless they have a built in power supply typically require13.8 V DC ±15% (negative ground)….A transceiver with a maximum output power of 100 W will require about 25 A of current at 13.8 V

Transformer: A transformer is a device that transfers electrical energy from one circuit to another through a shared magnetic field and is commonly used to change a higher AC voltage to a lower secondary AC voltage for other uses.

In a DC regulated power supply the transformer is usually step down which provides less secondary voltage so the lower secondary AC voltage is easy for conversion in DC voltage as well can be easier to obtain the required level of DC voltage.

Rectifier: A rectifier is an electrical device that converts alternating current to direct current, a process known as rectification**……**A circuit which performs the opposite function (converting DC to AC) is known as an inverter.

Filter: In a PSU a capacitor is commonly used in the output filter of a DC power supply to maintain a constant DC value by removing as much power ripple as possible.

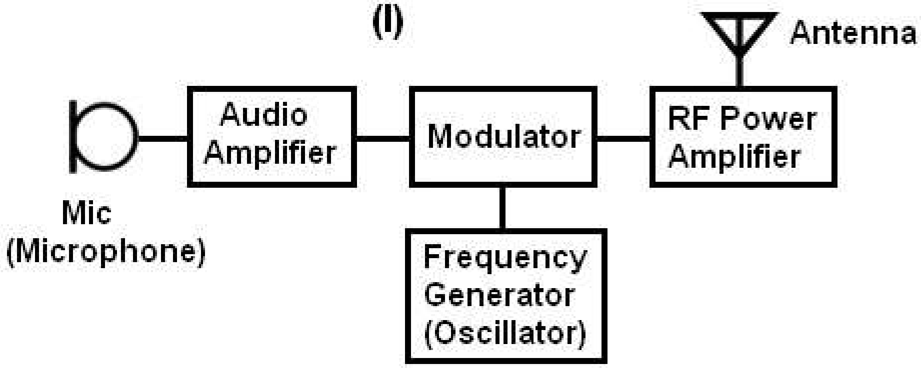
Regulator: A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level.

Output: Well regulated lower output voltage example12v or 13.8v DC etc

A variable power supply is one which includes some means for the user to easily adjust the output voltage and sometimes the current

Simple Transmitter

(I)



The transmitter combines the information signal to be carried with the radio frequency signal which generates the radio waves, which is called the carrier signal.

The radio signal from the transmitter is applied to the antenna, which radiates the energy as radio waves.

(I) Shows a block diagram of a simple transmitter

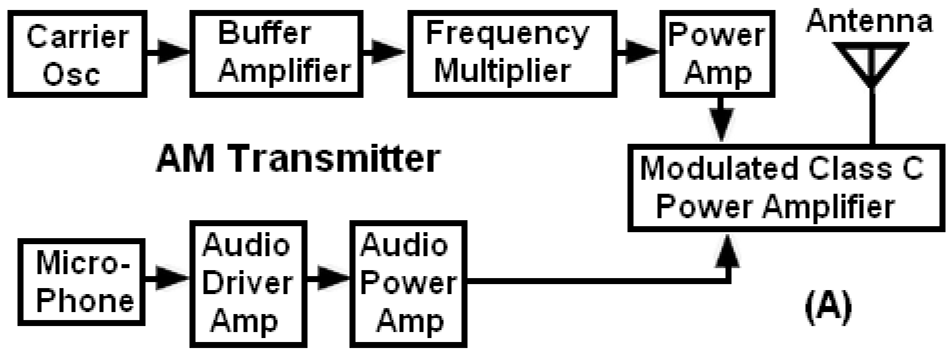
1) The audio amplifier amplifies the low level signal from the microphone (mic) to the required level and then passed onto the modulator

2) Modulator mixes the signal from the audio amplifier with the frequency generator to give a signal to the RF power amplifier

3) Frequency generator generates the radio frequency to be transmitted and is mixed in the modulator with the audio amplifier output before going to the RF power amplifier

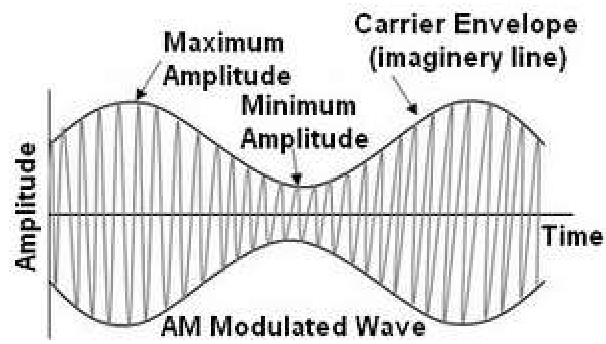
4) RF power amplifier amplifies the small signal from the modulator and sends the resultant signal via the feeder to the antenna.

Amplitude Modulation (AM) Transmitter



AM transmitters vary the amplitude of the carrier wave

The amplitude of the carrier wave is proportional to the amplitude of the signal being modulated. AM Bandwidth about 6KHz.



(A) Amplitude Modulation (AM) Transmitter : The carrier oscillator generates the carrier signal, which lies in the RF range.

Buffer Amplifier : First matches the output impedance of the carrier oscillator with the input impedance of the frequency multiplier; it then isolates the carrier oscillator and frequency multiplier.

Audio signal to be transmitted is obtained from the microphone. Audio driver amplifier amplifies the voltage of this signal. This amplification is necessary to drive the Audio power amp.

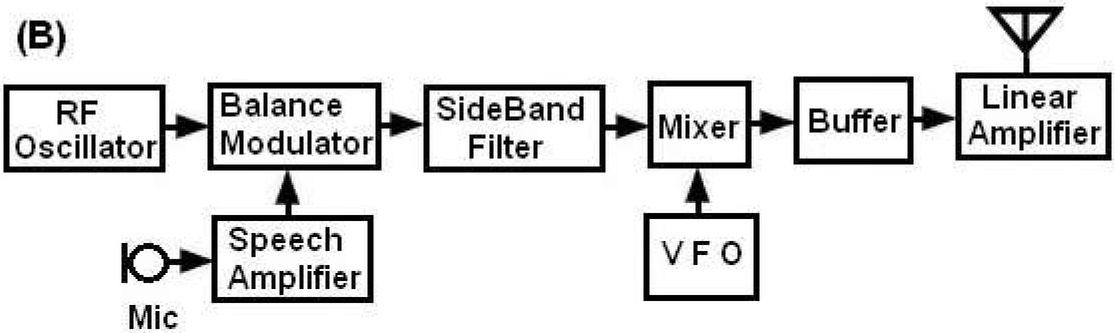
Frequency Multiplier: This stage is also known as harmonic generator and generates higher harmonics of carrier oscillator frequency.

The frequency multiplier is a tuned circuit that can be tuned to the requisite carrier frequency that is to be transmitted.

Modulated Class C Amplifier: Power Amplifier (PA) is the output stage of the transmitter.

The modulating audio signal and the carrier signal, after power amplification, are applied to this modulating stage. The modulation takes place at this stage. The PA also amplifies the power of the AM signal to the required transmitting power. This signal is finally passed to the antenna which radiates the signal into space of transmission.

Single Sideband Transmitter



Single Sideband Transmitter

(B) Single-sideband (SSB) transmitter differs from an AM transmitter in that it only transmits either the upper or lower sideband—not both. Thus, an SSB transmitter uses less bandwidth than an AM transmitter.....

Speech amplifier will process/tailor audio.

RF Oscillator produces a stable carrier frequency.

Balanced modulator “mixes” oscillator and audio to produce identical upper and lower sidebands at a fixed frequency (DSB) and almost entirely suppresses the carrier...

SideBand filter (crystal or mechanical) removes unwanted sideband....

Filter characteristic determines bandwidth of signal.....Typical filters bandwidths between 1.8 kHz and 2.4 kHz.....

When operating an amateur radio station using SSB, there are choices for upper and lower sideband.

It is generally accepted that Upper Sideband (USB) is used on frequencies above 10 MHz and that Lower Sideband (LSB) is used in frequencies below 10 MHz.

The Variable Frequency Oscillator (VFO) is combined in the mixer with the fixed frequency SSB signal to tune to the desired frequency........

Mixer : mixes fixed frequency SSB and VFO signals up to final frequency.

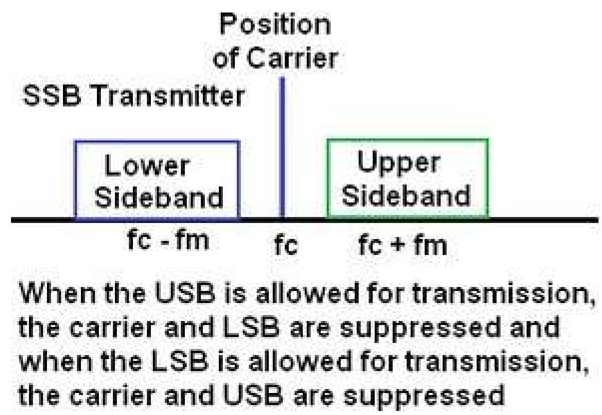
Output of mixer is sum or difference of Oscillator and VFO frequencies (and there harmonics).....Important only the wanted frequency is selected.

Buffer isolates the mixer from PA to prevent “pulling” due to varying load.

Class AB amplifiers are widely used in SSB linear amplifier applications where low-distortion and high power-efficiency tend to both be very important.

Care needed with high duty cycle modes not to exceed power rating.

Must not be over driven as non-linearity and thus splatter will occur.



Note: Speech processor as used in a modern transceiver.

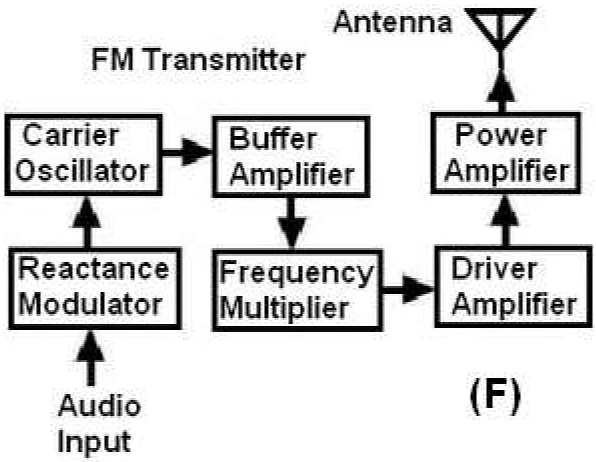
Speech processors can be very useful when operating SSB.

The purpose of a speech processor is to increase the intelligibility of transmitted phone signals during poor conditions. It increases average power of a transmitted single sideband phone signal.

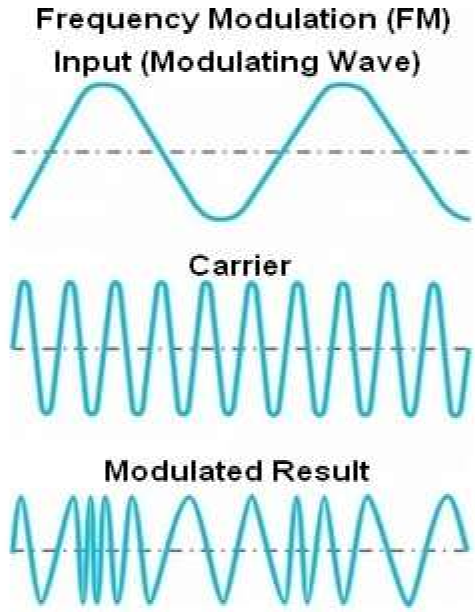
An incorrectly adjusted speech processor will result in:

Distorted speech
Splatter
Excessive background pickup

Frequency Modulation Transmitter



(F)



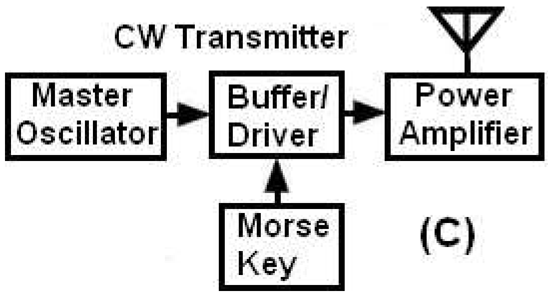
(F): A method of transmitting information using a radio-frequency carrier wave..... The frequency of the carrier wave is varied in accordance with the amplitude and polarity of the input signal with the amplitude of the carrier remaining unchanged.

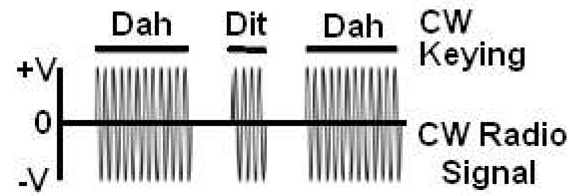
(F) The Reactance Modulator acts to change the carrier oscillator frequency by application of the message signal.....The function of the Carrier Oscillator is to generate a stable sine wave signal at the rest frequency, when no modulation is applied...
The Buffer Amplifier acts as a constant high-impedance load on the oscillator to help stabilize the oscillator frequency.....

Frequency Multiplier. Frequency multipliers are tuned-input, tuned-output RF amplifiers in which the output resonant circuit is tuned to a multiple of the input frequency. Common frequency multipliers are 2x, 3x and 4x multiplication.

Power Output (Amplifier) : The final power section develops the carrier power, to be transmitted and often has a low-power amplifier driven the final power amplifier. The impedance matching network is the same as for the AM transmitter and matches the antenna impedance to the correct load on the final over amplifier.

CW Transmitter





Continuous wave (CW) transmitters are transmitters that generated a CW signal for communication purposes. The transmission of short or long pulses of RF energy to form the dots and dashes of the Morse code characters are referred to as interrupted continuous wave.

Continuous Wave (CW) : On-Off keying of transmitter output by Morse Key
Has about 40% transmission duty cycle
Has constant amplitude when keyed.
Narrow Bandwidth about 50–100 Hz.

The buffer / driver stage: is a voltage amplifier that increases the amplitude of the oscillator signal to a level that drives the power amplifier (linear amplifier).

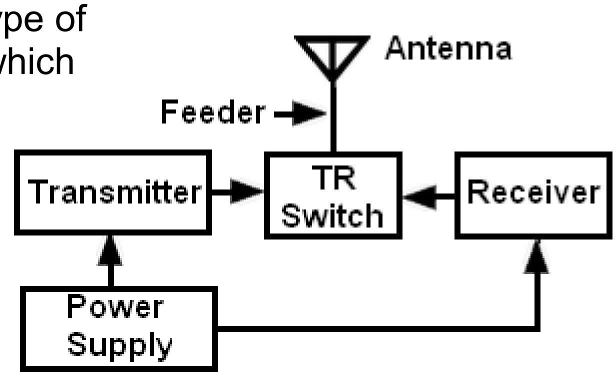
The buffer /driver stage is also used to isolate the oscillator from the amplifier stages. Without a buffer, changes in the amplifier caused by keying or variations in source voltage would vary the load of the oscillator and cause it to change frequency/

(C) Morse key: is used to turn the buffer on and off. When the key is closed, the RF carrier passes through the buffer stage; when the key is open (buffer is turned off), the RF carrier is prevented from getting through.

Power amplifier: is an electronic circuit whose output is proportional to its input, but capable of delivering more power into a load (antenna)

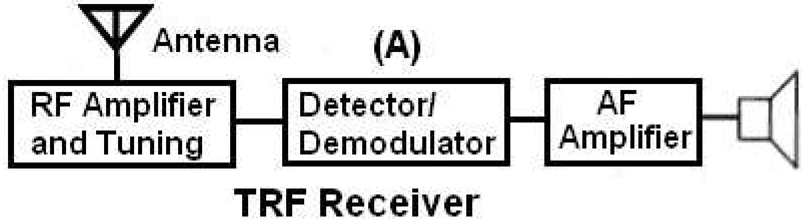
Linear amplifier : The term usually refers to a type of radio-frequency (RF) power amplifier, some of which have output power measured in kilowatts.

(D) Shows the switching arrangement between a separate transmitter and receiver.



(D) Transmit / Receive (TR) can be RF sensing or manual switch

Tuned Radio Frequency Receiver



The tuned radio frequency receiver is one in which the tuning or selectivity is provided at the radio frequency stages.

The TRF receiver: is a type of radio receiver that is composed of one or more tuned radio frequency (RF) amplifier stages followed by a detector (demodulator) circuit to extract the audio signal and usually an audio frequency amplifier.

Typically a TRF receiver would consist of three main sections:

RF Amplifier and Tuning : This consisted of one of more amplifying and tuning stages.

The detector (also call the demodulator) : The detector recovers the AM signal, the recovered audio is passed to the Audio Amplifier stage

Audio Amplifier: The Audio Amplifier stage makes the recovered audio signal louder so that it is sufficient to hear in a loudspeaker.

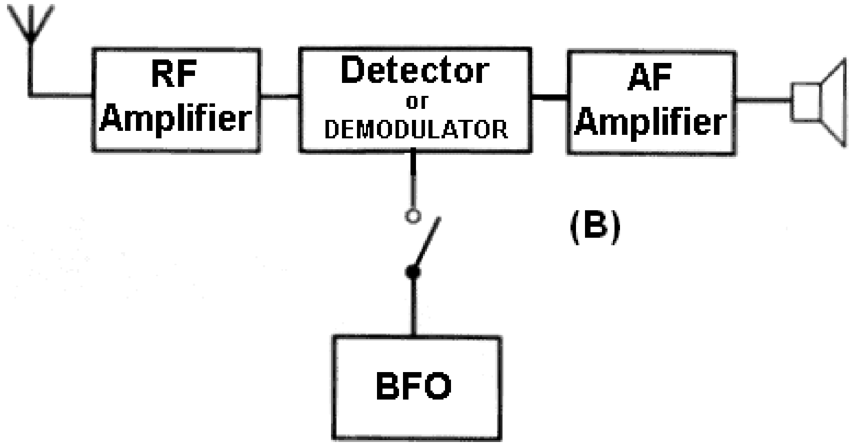
(B) TRF receiver with a switchable in / out Beat Frequency Oscillator (BFO)

The detector mixing with the BFO recovers the CW signal

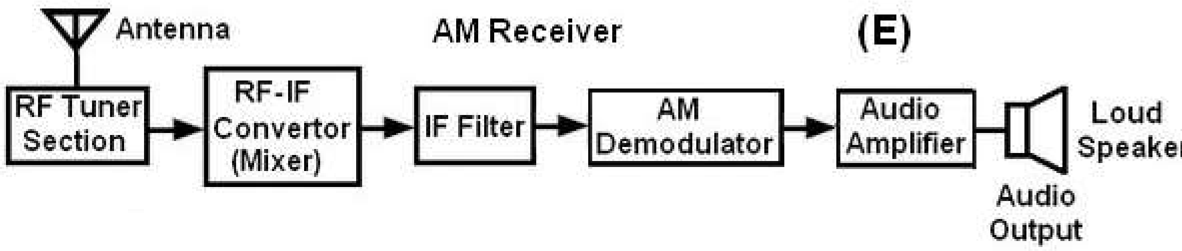
As mentioned above the detector recovers the AM signal and with the BFO switched in a CW signal can be resolved.

Then the recovered audio is passed to the Audio Amplifier stage.

The BFO can be used to receive Morse and SSB.



Amplitude Modulation (AM) Receiver



(E) Amplitude Modulation (AM) Receiver....RF Tuner Section: The amplitude modulated wave received by the antenna is first passed to the tuner circuit.

The tuner selects the frequency, desired by the AM receiver. It also tunes the local oscillator and the RF filter at the same time.

The signal from the tuner output is sent to the RF-IF converter, which acts as a mixer.... It has a local oscillator, which produces a constant frequency.

The mixing process is done here, having the received signal as one input and the local oscillator frequency as the other input. The resultant output is a mixture of two frequencies (f1+f2),(f1−f2) produced by the mixer, which is called as the Intermediate Frequency (IF)

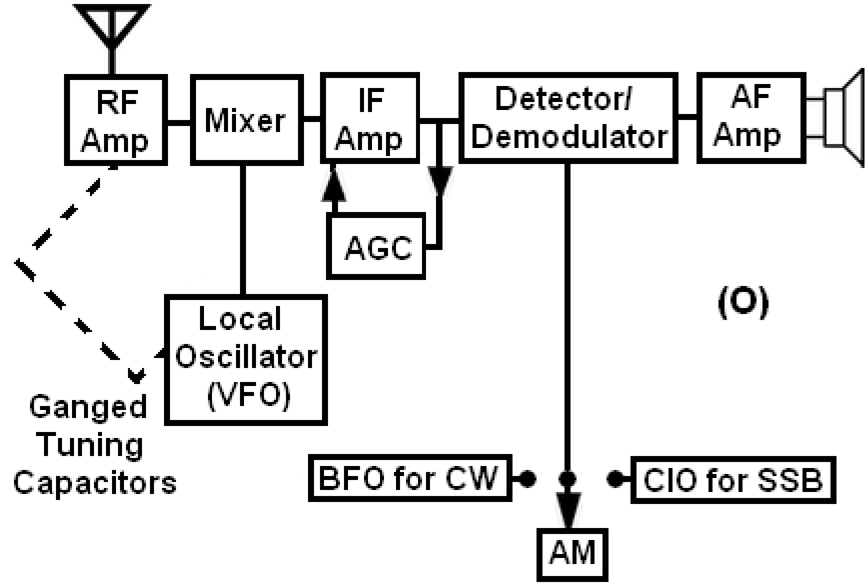
IF Filter: Intermediate frequency filter is a band pass filter, which passes the desired frequency. It eliminates all other unwanted frequency components present in it.

The use of an IF simplifies the design of tunable receivers and reduces the number of components that must be compatible with high frequencies.

AM Demodulator: The received AM wave is now demodulated using AM demodulator. This demodulator uses the envelope detection process to receive the modulating signal.

Audio Amplifier: This is the power amplifier stage, which is used to amplify the detected audio signal. The processed signal is strengthened to be effective. This signal is passed on to the loudspeaker to get the original sound sign

Superhetrodyne Receiver



(O) Superheterodyne receivers basically translate an RF input signal to a lower-frequency intermediate-frequency (IF) signal. The IF signal is then demodulated to allow the modulation data to be processed.

A superhetrodyne receiver works on the principle the receiver has a Local Oscillator (LO) called a variable frequency oscillator (VFO) which maintains a constant difference between itself and the received frequency resulting in a constant intermediate frequency (IF)

A VFO in electronics is an oscillator whose frequency can be tuned (varied) over some range. It is a necessary component in any tunable radio receiver or transmitter that works by the superheterodyne principle, and controls the frequency to which the apparatus is tuned.

A VFO is a device for generating radio frequency oscillations. This frequency is variable within a certain, adjustable, range. In a radio frequency (RF) transmitter, VFOs are often used to tune the frequency of the output signal.

(O) The frequency (intermediate frequency) is the difference between the LO frequency and the radio frequency carrier wave frequency is used during the remaining processing

RF Amplifier (RF Amp) : Amplifies the wanted weak signal from the antenna while largely ignoring signals outside of the required range by the use of tuned circuits.

Mixer : The mixer combines the wanted amplified RF signal with the VFO signal (or as it to produce sum and difference frequencies of the RF signal and the LO signal which in fact are modulated identically to the incoming signal.

Local Oscillator (LO) : The LO is the VFO which generates a RF signal for use by the mixer.

The Intermediate Frequency (IF) is a fixed RF frequency used to simplify the operation of a radio receiver which allows the signal of interest to be efficiently processed, filtered, and demodulated.

The Intermediate Frequency Amplifier (IF Amp) is a linear fixed-frequency tuned amplifier provides the main amplification and includes filters, which removes adjacent signals and wrong mixing products.

AGC: Automatic gain control (AGC), is a closed-loop feedback regulating circuit in an amplifier. The AGC is used stop variations in signals causing large variations in the received volume. The AGC is often called an automatic volume control or AVC.

Detector / demodulator stage: Once the signals have passed through the IF stages of the superheterodyne receiver, they need to be demodulated to recover the modulating audio signal.

Different demodulators are required for different types of transmission, and as a result some receivers may have a variety of demodulators that can be switched in to accommodate the different types of transmission that are to be encountered.

Audio Amplifier (AF amp) : Amplifies the signal to drive a loudspeaker.

Note:……Mixer....The RF and local oscillator tuning capacitors (O) are mechanically coupled on the same shaft and have the same capacitance/rotation law. As the shaft is rotated both circuits increase and decrease together in frequency.

The local oscillator is set such that its difference from the signal frequency is equal to the intermediate frequency.

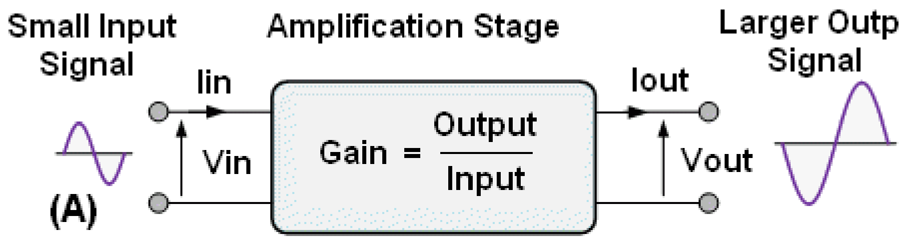
The perfect situation occurs when the RF amplifier and mixer tuned circuits are exactly together and the LO is above these two by an amount exactly equal to the IF frequency.

When used with the BFO (beat frequency oscillator) can recover CW signals.

When used with a CIO (Carrier insertion oscillator) can recover SSB signals.

Ganged Tuning Capacitors -To maintain a constant difference between the local oscillator and RF signal frequency, gang capacitors are used.

Amplifier



What is the purpose of an amplifier? An amplifier is an electronic device that increases the voltage, current, or power of a signal. Amplifiers are used in wireless communications and broadcasting, and in audio equipment of all kinds. They can be categorized as either weak-signal amplifiers or power amplifiers.

Amateur radio linear amplifiers are used where it is necessary to increase the output power from a transmitter or more usually a transceiver.

Gain, the gain of an amplifier is defined as measure of the ability to amplify the power of a signal, voltage or current.

Voltage gain is the ratio of output voltage to the input voltage. Voltage gain = V out / Vin

Current gain is the ratio of output current to the input current. Current gain = I out / I in

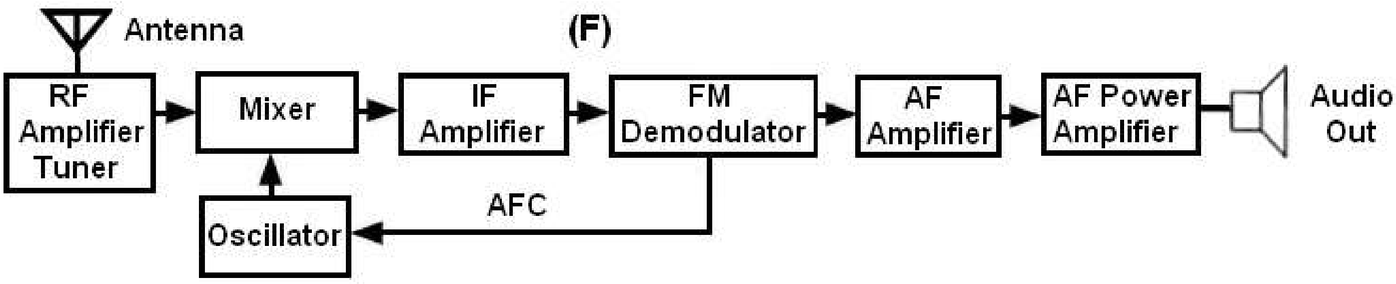
Power gain is the ratio of output power to the input power. Power gain = Pout / Pin

Power gain: If an amplifier has a signal input of 40 milliwatts (mW) and a signal output of 18.4 watts(W), the power gain would be….
Gain = Pout / Pin = 18.4 W / 40 mW = 460

Voltage gain: If an amplifier takes in an AC voltage signal measuring 2 volts RMS and outputs an AC voltage of 30 volts RMS, the gain will be….
Gain = V output / V input = 30 V RMS / 2 V RMS = 15

Current gain: If an amplifier with an AC current is given an AC input signal of 28 mA RMS and the output is 98 Ma RMS, the output gain would be…
Gain = I out / I in = 98 mA / 28 Ma = 3.5

Frequency Modulation (FM) Receiver



Frequency Modulation Receiver

The rf amplifier / tuner selects and amplifies the desired station…It is adjustable so that the selection frequency can be altered…This is called tuning.

The selected frequency is applied to the mixer.

The output of an oscillator is also applied to the mixer.

The mixer and oscillator form a frequency changer circuit.

The output from the mixer is the intermediate frequency (i.f.)

The i.f. is a fixed frequency of say 10.7 MHz.

No matter what the frequency of the selected radio station is, the i.f. will be 10.7 MHz.

The i.f. signal is fed into the i.f. amplifier.

The advantage of the i.f. amplifier is that its frequency and bandwidth are fixed, no matter what the frequency of the incoming signal is.

This makes the design and operation of the amplifier much simpler.

The amplified i.f. signal is fed to the demodulator…This circuit recovers the audio signal and discards the r.f. carrier.

Some of the audio is fed back to the oscillator as an automatic frequency control (AFC) voltage…This ensures that the oscillator frequency is stable in spite of temperature changes.

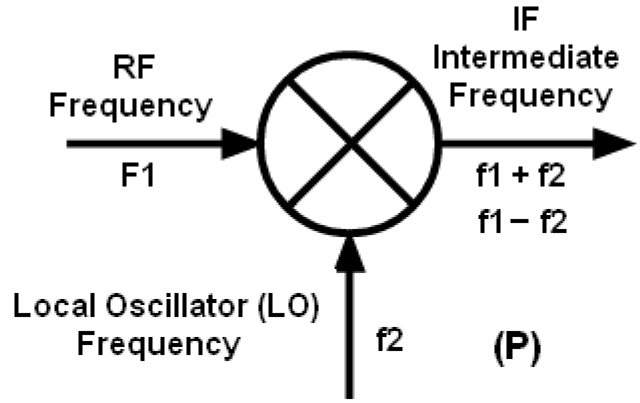
The audio signal voltage is increased in amplitude by a voltage amplifier. The power level is increased sufficiently to drive the loudspeaker by the AF power amplifier.

Mixer: Heterodyning is the generation of new frequencies by mixing two or more signals in a nonlinear device such as a vacuum tube, transistor, diode mixer.

The mixing of each two frequencies results in the creation of two new frequencies, one at the sum of the two frequencies mixed, and the other at their difference.

(P) : Mixer.... The mixer converts the RF signal to a lower-frequency IF signal.

Both the RF signal and an LO signal enter the mixer, thereby generating the IF signal that appears at the mixer's output.



If you have an RF frequency coming into the mixer of 1MHz (f1) and LO frequency is 1.5MHz. (f2)

The output from the Mixer would be (f1 + f2) = 2.5 MHz and (f1-f2) = 0.5mhz

Following frequency conversion, band pass filtering is implemented in the IF stage to remove any unwanted signals.

This way, the IF amplifiers can be fine tuned permanently for maximum image rejection and IF amplification.

Next, an IF amplifier provides a significant amount of gain to the IF signal.

The amplified IF signal is then demodulated, allowing the information to be processed.

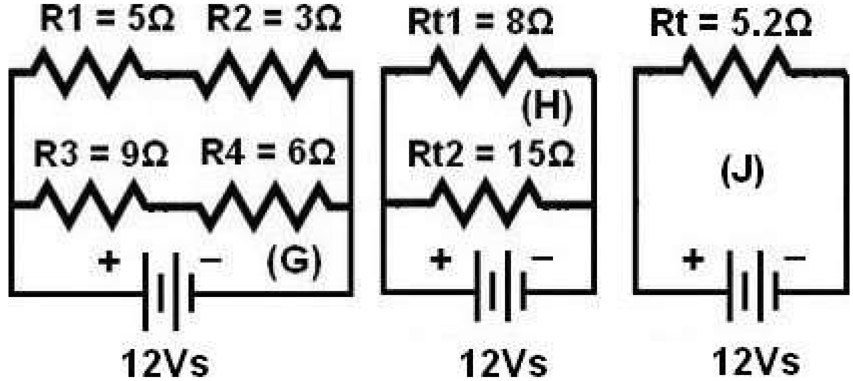
Today most AM radios use 455kHz and most FM radios use 10.7mHz as the IF frequency

If you have an RF frequency coming into the mixer of 1MHz, to give a IF out of 0.5MHz, the LO (tracking) frequency out would be 1.5MHz.

If the RF frequency is increased to 3.5mhz to produce the same IF out of 0.5MHz , the LO (tracking) frequency out would be 4.0MHz.

RF and local oscillator tuning capacitors are mechanically coupled on the same shaft. As the shaft is rotated both circuits increase and decrease together to maintain the IF frequency difference. The output from the mixer will remain the same frequency (IF) difference between RF and LO.

Resistor Circuit
Find (1) Total resistance:
(2) Total Current:
(3) Total power:
(4) Current though R1:
(5) Voltage drop across R4:
Vs = Voltage supply.



First find the circuit total resistance (Rt) by reducing circuit (G) to the equivalent one resistor circuit (J) and then use Ohms Law I = V / R(t) to find the total current

To reduce (G) to an equivalent single resistor (J) make (G) into parallel circuit (H)
(H) Rt1 (R1 + R2 in series) = 5Ω + 3Ω = 8Ω and Rt2 (R3 + R4) = 9 Ω + 6 Ω = 15 ohms

(H) Rt1 and Rt2 are in parallel, to find Rt we can use 1/Rt =1/R1 + 1/Rt2 = 1/8 + 1/15 = 23/120 reciprocal 120/23 therefore **(1)** Rt = 5.2 Ω (J)

Circuit (G) total amps (It) = Voltage supply / Rt = 12V / 5.2Ω therefore **(2)** = 2.3 amps
Total power = It x Voltage supply = 2.3A x12V = 27.6w there therefore (**3)** = 27.6 Watts

(H) Rt1 and Rt2 are in parallel so the voltage across each with be the same as the voltage supply (12V) but the total circuit current will be divided between each.

The current through Rt1 = 12V / 8Ω = 1.5 amps (I_1) and current through
Rt2 = 12V / 15Ω = 0.8A (I_2). Checking I_1 + I_2 = 1.5A + 0.8A = 2.3A = total current (It).

(G) R1 and R2 are in series so the current will be the same as Rt1 = 1.5A
therefore **(4)** will be 1.5A and there will be a voltage drop across each resistor. See (K)
R3 and R4 are in series so the current will be the same as Rt2 = 0.8A and there will be a voltage drop across each resistor. See (K)

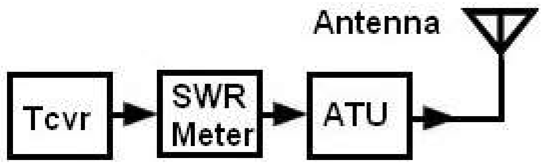
The voltage drop across R1 would be I_1 x R1 = 1.5A x 5Ω = 7.5V with voltage drop across R2 = 1.5A x 3Ω = 4.5V….Voltage drop across R3 would be I_2 x R3 = 0.8A x 9Ω = 7.2V with R4 = 0.8A x 6Ω = 4.8V…The voltage drop **(5)** across R4 would be 4.8V
Note: Voltage across R1 + R2 = 7.5V + 4.5v = 12Vs and R3 + R4 = 7.2V + 4.8V =12Vs

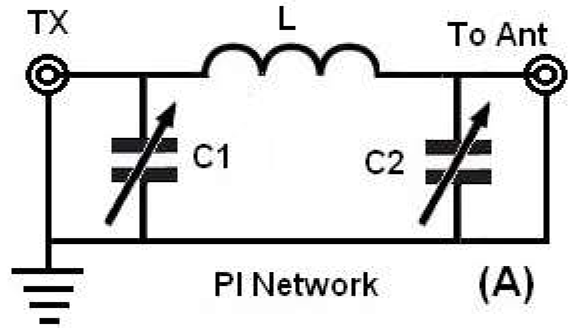
(K) Using Ohms Law and the Power formula to check:
R1 (5Ω) power = I x V = 1.5A X 7.5V=11.25 watts
R2 (3Ω) current = V / R = 4.5V / 3Ω = 1.5A
R3 (9Ω) resistance = V / I = 7.2V / 0.8A = 9 ohms
R4 (6Ω) voltage = I x R = 0.8A x 6Ω = 4.8 Volts

(K)	R1	R2	R3	R4
Voltage (V)	7.5	4.5	7.2	4.8
Current (A)	1.5	1.5	0.8	0.8
Power (W)	11.25	6.75	5.76	3.84

Total 12V : 2.3A : 5.2Ω : 27.6W

Antenna Impedance Matching





Antenna Tuning Unit (ATU) matches a transceiver to a mismatched antenna system.

The ATU doesn't make the antenna work any better: it just takes some load off the transmitter (transceiver).

We can use a Impedance Matching Unit (Antenna Tuning Unit) to match two different impedances ie matching the 50 ohm transceiver output impedance to the antenna impedance so that the ATU transfers almost all power to the load (antenna).

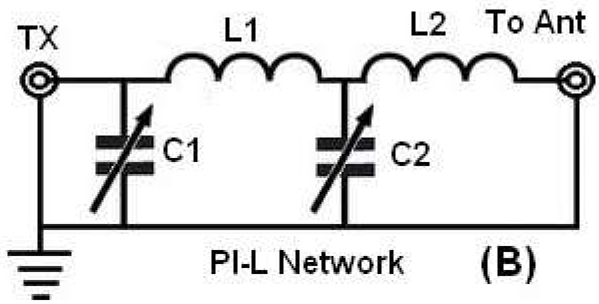
(A): Impedance Matching: Transmitters are designed to feed power into a resistive load of typically 50 ohms but the impedance of an antenna can vary according to its physical characteristics as well as the characteristics of the surrounding materials and feedline impedance can vary depending on frequency and other factors.

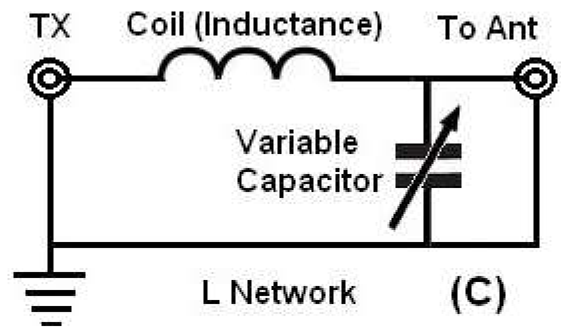
If the impedance seen by the transmitter departs from the 50Ω, the output power of the transmitter can be reduced due to the failure to obtain a match.

In addition to reducing the power radiated by the antenna, this can cause distortion of the signal and may overheat the transmitter causing a output failure.

(A) : Is a PI (π) network (coupler) where (L) can be a fixed value or a variable inductor or a tapped coil to change the inductance value (L) in the tuner circuit....C1 and C2 are adjusted to obtain a low SWR

Standing Wave Radio (ATU) Meter





(B) A Pi-L network has an additional series inductor on the output and greater harmonic suppression.

(C) L-Network : Attenuates harmonics, noise, and other undesired signals and works well for matching values of impedance that aren't too different.

This is called an L network because the two components are at right angles to each other.

One of the bad effects of SWR is heating of the power amplifier inside the radio. This heating occurs because of reflected power.

The result of the presence of standing waves on a transmission line is: reduced transfer of RF energy to the antenna.

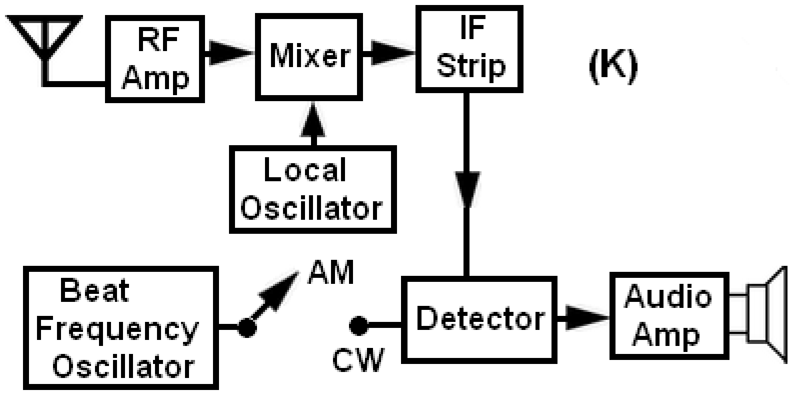
What does standing-wave ratio mean? The ratio of maximum to minimum voltages on a feed line

The ideal SWR reading is 1:1 showing that the best possible match has been obtained. An acceptable SWR reading is 1.0-1.5:

A very high SWR reading would mean the antenna is the wrong length, or there may be an open or shorted connection somewhere in the feed line.

Antenna Tuning Unit (ATU)

Beat Frequency Oscillator (BFO)



(K) In a radio receiver, a beat frequency oscillator or BFO is a dedicated oscillator used to create an audio frequency signal from Morse code radiotelegraphy (CW) transmissions to make them audible.

The signal from the BFO is mixed with the received signal to create a heterodyne or beat frequency which is heard as a tone in the speaker.

The beat-frequency oscillator (BFO) is necessary when you want to receive cw signals, cw signals are not modulated with an audio component so we must provide one.

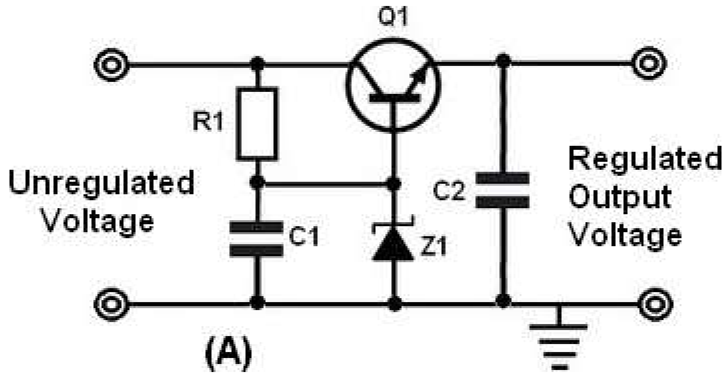
The action of the rf amplifier, mixer, local oscillator, and IF amplifier is the same for both CW and AM; but the cw signal reaches the detector as a single frequency signal with no sideband components.

To produce an AF output, we must heterodyne (beat) any cw signal with an rf signal of the proper frequency. This separate signal is obtained from an oscillator known as a beat-frequency oscillator.

(K) If the intermediate frequency (IF) is 455 kilohertz and the BFO is tuned to 456 kilohertz or 454 kilohertz, the difference frequency of 1 kilohertz is heard in the output.

Generally, we can tune the BFO from the front panel of a receiver. When we vary the BFO control, we are varying the output frequency of the BFO and will hear changes in the tone of the output audio signal

Transistor Zener Diode Voltage Regulator

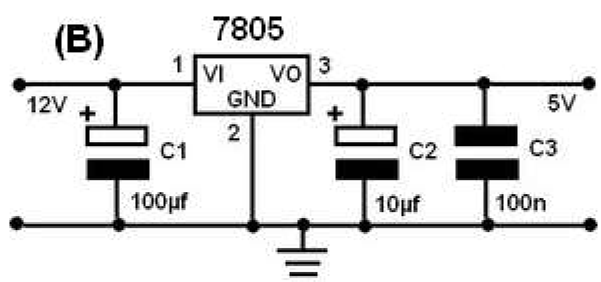


The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. For getting constant and steady output, voltage regulators are used.

(A) Transistor Zener Diode Voltage Regulator.....When the unregulated voltage goes up, the zener diode current will also goes up. The voltage across the zener diode has no or very little variation, so that the output voltage of the voltage regulator is stable…

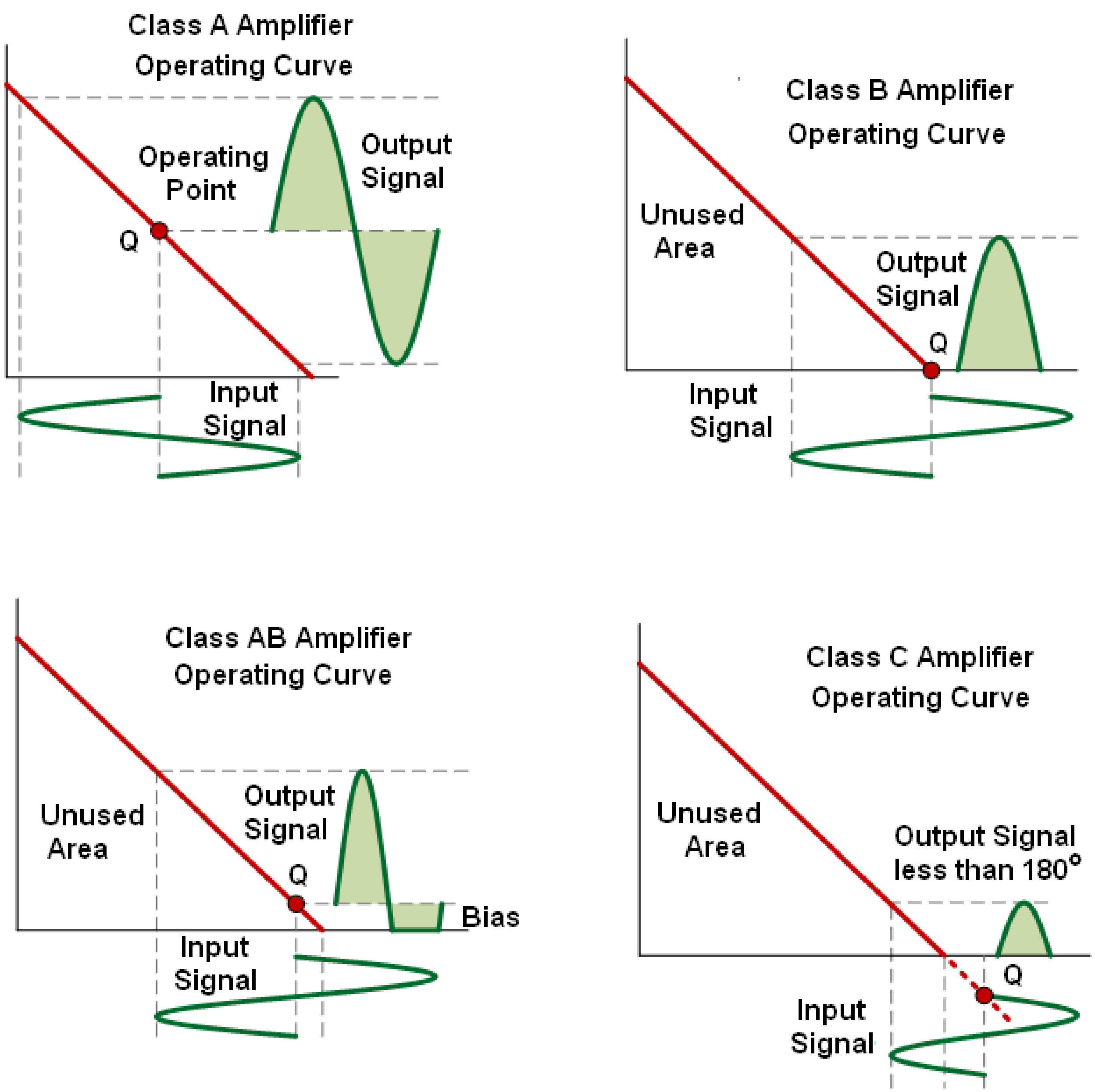
When the unregulated voltage goes down, the zener diode current will also goes down. The voltage across the zener diode has no or very little variation, so that the output voltage of the voltage regulator is stable.

The regulated output voltage do not change if RL (the load) changes. Changes in the load current is not a problem, since it pass through the transistor



(B) This rectifier circuit uses voltage regulator 7805, the 7805 has input 7V-35V and regulated output 5V (4.8V-5.2V) with a current rating of 1 amp.
Pin 1-Input, the function of this pin is to give the input voltage and for the 7085 it should be in the range of 7V to 35V.......Pin2-Ground is connect the ground for output and input, this pin is equally neutral (0V). Pin3-Output is used to take the regulated output for the 7805 it will be 5V.

Amplifiers - Class A, Class B, Class AB and Class C



Based on the choice of Q point on the transfer characteristics Power Amplifiers are classified Class A, Class B, Class AB and Class C

Class	Ideal Efficiency	Linearity	Practical Efficiency
A	50%	Excellent	35%
B	78.5%	Medium	49%
AB	50%-78.5%	Good	45%
C	78.5%-100%	Poor	55%

Class	Practical Efficiency	Power Capability	Gain
A	35%	Low	High
B	49%	High	Med/Hi
AB	45%	Med/High	High
C	55%	High	Low

Uses :

Class A - Amplifiers have excellent linearity, high gain and low signal distortion levels. For these advantages, they are used in high-fidelity audio amplifier designs. They are seldom used in high power amplifier applications due to thermal power supply considerations. They are most commonly used in small-signal applications where linearity is more important than power efficiency

Class AB - The class AB amplifiers are used in hi-fi systems and Class AB amplifiers are widely used in SSB linear amplifier applications where low-distortion and high power-efficiency tend to both be very important.

Class B - Output power amplifiers.

Class C - They are generally used in radio frequency (RF) applications, such as oscillators that have a constant output amplitude, and modulators, where a high-frequency signal is controlled by a low-frequency signal cannot be used as audio amplifiers due to high distortion.

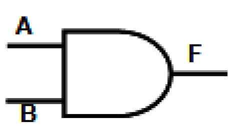
Digital Logic Circuits: In a circuit, logic gates will make decisions based on a combination of digital signals coming from its inputs. Most logic gates have two inputs and one output.

Logic gates process signals which represent true or false. Normally the positive supply voltage +Vs represent true and 0V represents false. Other terms used for the true and false are 1 and 0 : High and Low.
Symbols 0 (false) and 1 (true) are usually used in truth tables.

Depending on the type of logic gate being used and the combination of inputs, the binary output will differ.

A flip flop is an electronic circuit with two stable states that can be used to store binary data. The stored data can be changed by applying varying inputs. At any given moment, every terminal is in one of the two binary conditions, false or true.

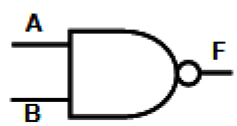
Flip flop truth tables: These truth tables describe how the outputs of a given flip flop will be determined by a combination of inputs.



AND

Inputs		Output
A	B	F
0	0	0
1	0	0
0	1	0
1	1	1

AND gate, the output is "true" when both inputs are "true."



NAND

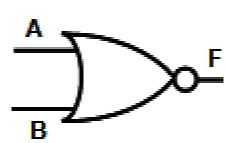
Inputs		Output
A	B	F
0	0	1
1	0	1
0	1	1
1	1	0

NAND gate the output is "false" if both inputs are "true"

OR

Inputs		Output
A	B	F
0	0	0
1	0	1
0	1	1
1	1	1

OR gate, the output is "true" if either or both of the inputs are "true."

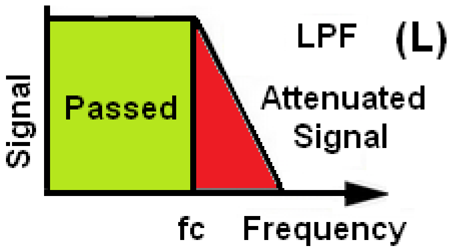


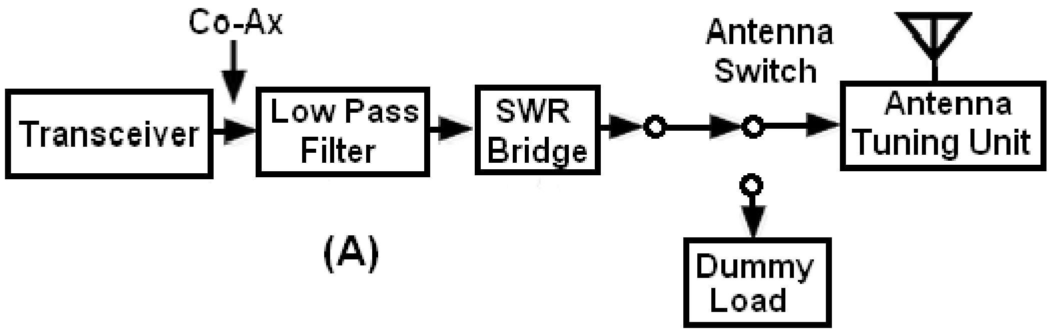
NOR

Inputs		Output
A	B	F
0	0	1
1	0	0
0	1	0
1	1	0

NOR gate the output is "true" if both inputs are "false."

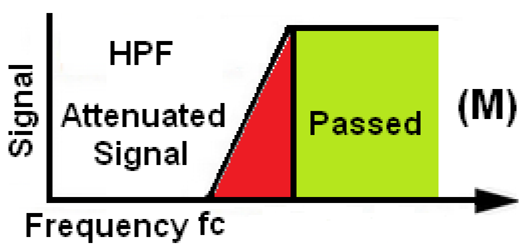
Low, High and Band Pass Filters : (fc is the cut off frequency or frequencies)

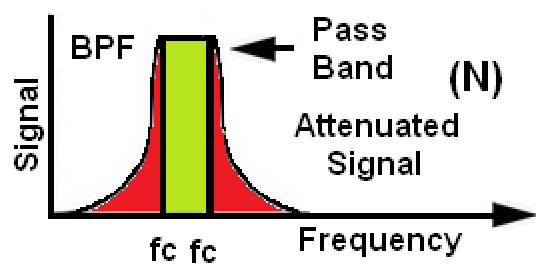




L : Low-pass filter (LPF): A low-pass filter is one that will permit all frequencies below a specified frequency called the cut-off frequency (fc) to be transmitted with little or no loss, but that will attenuate all frequencies above the cut-off frequency.

(A) In amateur radio, the LPF is typically used to block VHF harmonics of HF transmissions that interfere with TV reception. The LPF is placed after the transceiver (transmitter) output amplifier.





M : A high-pass filter (HPF) has a fc above which there is little or no loss in transmission, but below which there is considerable attenuation. High-pass filters can be used to remove low-frequency (unwanted sounds) content from an audio signal below a defined cut-off point. HPF behavior is the opposite of that of the LPF.

N : Band Pass Filter (BPF) is a device that allows signals of a certain frequency range (between fc and fc) to pass through the filter but will reject (attenuate) all frequencies either higher or lower than the desired pass band.

In a transmitter, a BPF can be used to limit the output signals bandwidth toward the minimum necessary level & transmitting data at the preferred speed & form.

In a receiver, the BPF filter lets the signals in a favored frequency range to be decoded by attenuating signals at unnecessary frequencies.

Receiver characteristics:

Noise figure: Noise figure is a number by which the noise performance of a radio receiver, amplifier, mixer or other circuit block can be specified. The lower the value of the noise figure, the better the performance and is measured in decibels (Db).

Q: What is the noise figure of a receiver?
A : The ratio in dB of the noise generated by the receiver to the theoretical minimum noise

Sensitivity: The ability of the receiver to “hear” very weak signals. Sensitivity can be expressed in terms of the voltage (in µV) or power (in dBm) to produce a specific SNR. Signal-to-noise ratio is a measure of a receiver’s sensitivity.

Q: Which term describes the ability of a receiver to detect the presence of a signal?
A: Sensitivity

Selectivity: Is the ability of the receiver to separate the required signal from unwanted or interfering ones. The selectivity is mostly determined by bandwidth, specified in Hz

Q: Which term describes the ability of a receiver to discriminate between multiple signals
A: Selectivity

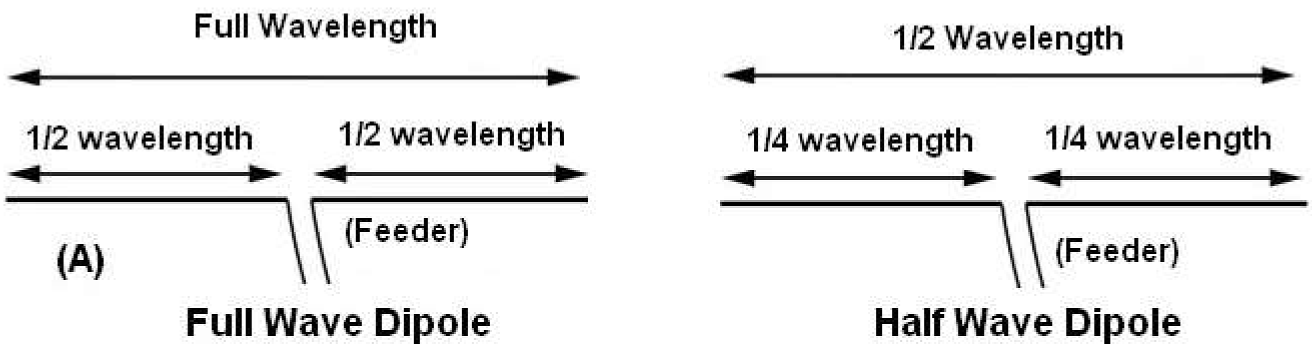
Dynamic range: The dynamic range of a radio receiver is essentially the range of signal levels over which it can operate. The low end of the range is governed by its sensitivity whilst at the high end it is governed by its overload or strong signal handling performance Typical range 90dB to 110dB

Automatic Gain Control (ACG) :
Automatically controls receiver gain to maintain constant output level
Gain of RF and IF amplifiers reduced proportionate to signal strength
Prevents overload of amplifier stages

Element IX (9) - Antenna and Transmission Lines

Antennas – Dipole

An antenna is a metallic structure which captures and / or transmits electromagnetic waves. The antenna transmits and receives the modulated carrier signal at radio frequency in the electromagnetic spectrum.
Dipole means "two poles."



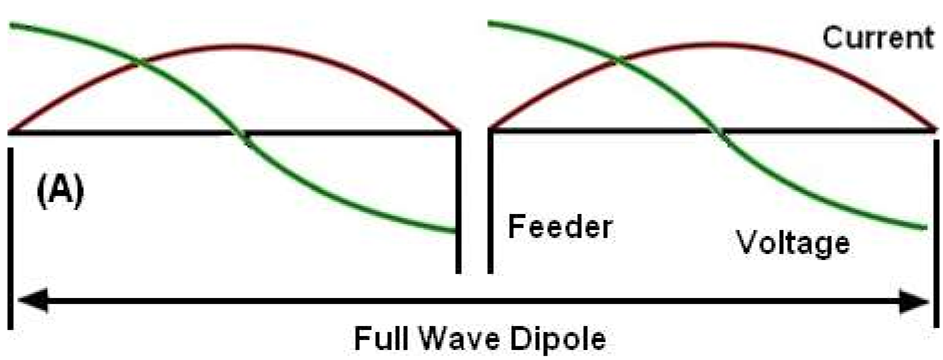
(A) When radio amateurs talk about a dipole, they are usually talking about a 1/2 wavelength dipole.

A balanced antenna has symmetry about the feed point, for example a dipole.

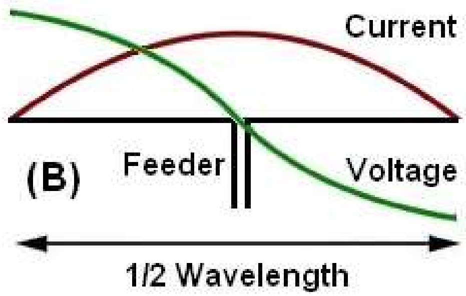
The length of a dipole is the main consideration for determining its operating frequency.

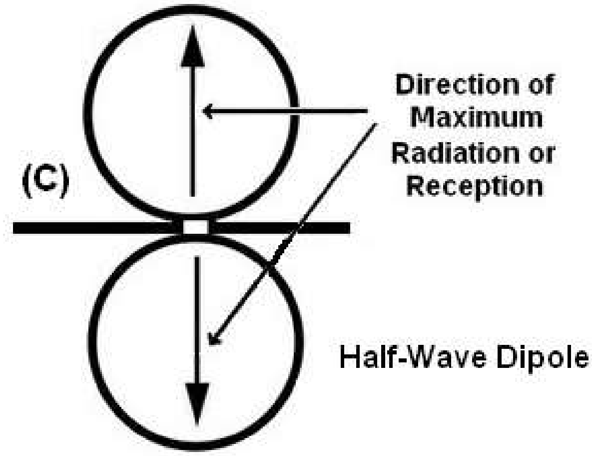
The formulas given here are for the length in feet.

If the length of the dipole, i.e. the total wire, equals the full wavelength it is called a full wave dipole. Full wave dipole overall length (feet) in free space 984/ f (Mhz) and allowing for the end effect (0.95) = 935 feet



Half wave dipole





The term half wave means that the length of this dipole length is equal to a half wave length at the frequency of operation.

(B) shows the voltage and current distribution across a half wave dipole.

(B) Half wave dipole : The feed point on a resonant center-fed half-wave dipole occurs at the point of minimum voltage and maximum current, which enables the most efficient power transfer from the transmitter….The minimum current and maximum voltage occurs at the ends of the antenna.

(C) Shows the radiation pattern for a half wave dipole.

The gain of an antenna is a measure of how the antenna concentrates its radiated power in a given direction.

A 1/2 wave dipole has a power gain of 1.64 (or 2.15 dB) over an isotropic source.

(B) : Half-Wave Dipole length (in free space) feet = 492 / f (Mhz) or meters = 150 / f (Mhz)

For practical purposes taking into account the end effects (0.95) we can use the total length in feet for a half wave dipole 492 x 0.95 = 468 / f (MHz).

This is about 5 percent shorter than the actual theoretical half wavelength and takes into consideration and compensates for “end effects” caused by the supporting insulators and masts, proximity to ground and other structures, Using the standard formula of 468 / Frequency in Mhz = total length in feet.

The overall top length (feet) for a 1/2 wave dipole on 21 MHz = 468/21 = 22.2 feet or 11.1 feet per leg.

The 1/2 wave dipole is a balanced antenna......The well-known value for the radiation resistance of a thin, half- wavelength dipole is 72 ohms.

The half wave dipole antenna often presents a good match to 50Ω feeder because the proximity of other objects, like the earth, antenna mounting, etc. means that the impedance is lowered below the 73Ω it presents in free space.

In practice a half wave dipole made from wire will have impedance at the center of resonance of around 65 ohms and depending on the construction materials used a lower value of around between 55 to 60 ohms.

The impedance value also depends on the antenna height above the ground, presence of nearby buildings, trees, metal objects and the conductivity of the ground below etc

Balanced antennas can be fed with open wire transmission line or a ladder feeder using a balance ATU (antenna tuning unit) or with coax using a balun.

On many modern transceivers, one side of the transmitter output is at the chassis-ground potential. This is said to make the output "unbalanced."

Some amateurs connect the antenna 50Ω coax feeder direct to the ATU.

Using the frequency of 14 Mhz and allowing for end effects (0.95), the total overall length of the dipole would be….

1/4 wave : 234 / 14 = 16.71 feet

3/8 wave : 350 / 14 = 25 feet

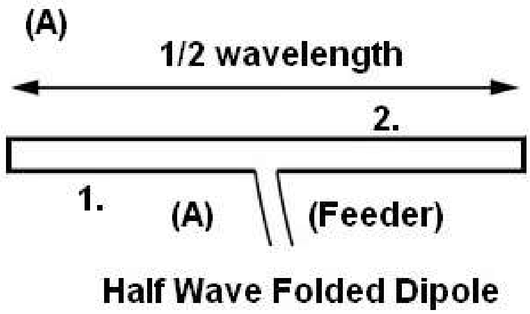
1/2 wave : 468 / 14 = 33.4 feet

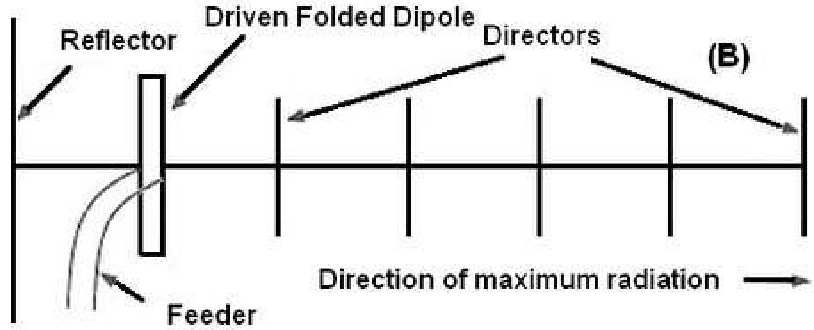
5/8 wave = 585 / 14 = 41.7 feet

Full wave = 935 / 14 = 66.78 feet

Half Wave Folded Dipole

A folded dipole (FD) is a balanced antenna with the ends folded back around and connected to each other, forming a loop. (A)





(A)1. Initial half wave dipole element…2. Additional element (length). More elements can be added in parallel which will increase the impedance.

For the folded dipole 1/2 wavelength we can use the formula for the half wave dipole that is 468/F (Mhz).

Used on the HF bands spacers may need to be employed to keep the wires apart.

In free space the half wave folded dipole has an increase in impedance from 73 ohms to around 300 ohms and has an increase in bandwidth.

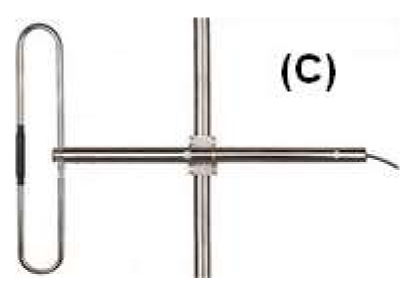
A balanced type Antenna Tuner (ATU) would be needed to transform the 300 Ω impedance to 50 ohms or a balun when used with 50 or 70 Ω coax.

FD antennas are sometimes used on their own to give greater bandwidth but they must be fed with a high impedance feeder typically 300 Ω

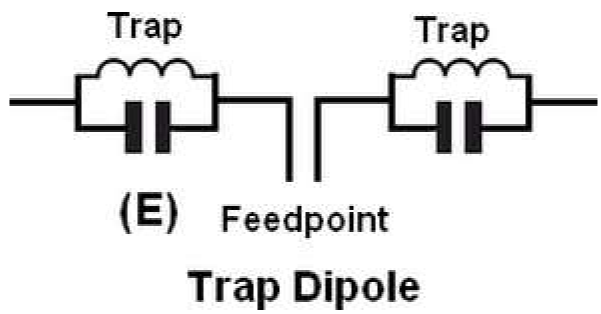
(A): Half Wave Folded Dipole : Advantages has wide bandwidth: The folded dipole antenna has a flatter frequency response, impedance is higher.

(B) The FD can be incorporated as part of another RF antenna design as a driven element in other antennas such as Yagi beam antenna and is widely used with television receivers and VHF FM broadcast transmitters where a wide bandwidth antenna is needed.

(C) Folded Dipole: Frequency Range: 136 -174 MHz



Trap Antenna



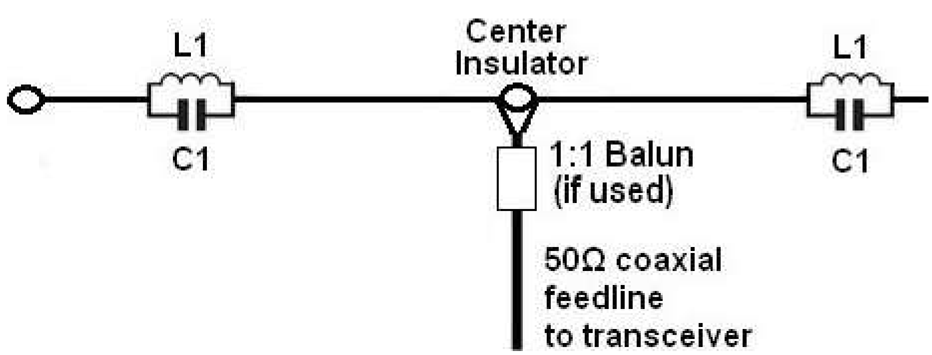
(E) The trap dipole uses tuned circuits (“traps”) to enable a single dipole to operate on multiple bands. A way of multibanding antennas is to install parallel tuned circuits, or traps.
A trapped dipole relies on parallel (L & C) tuned traps to ‘disconnect’ the additional wire when used on the specified band.

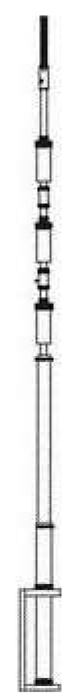
Trap dipoles are usually a little bit shorter than full size dipoles and offer multi-band operation at places, where space does not permit to install larger antennas.

The trap dipole....uses tuned circuits (“traps”) to enable a single dipole to operate on multiple bands. The dipole length is determined by the lowest frequency band and the traps are used to electrically shorten the dipole for higher bands.

Trap antennas can usually be designed to work well with two or three different HF bands, and designs combining fan and trap dipole features can provide more, with some trade-offs in efficiency and performance.

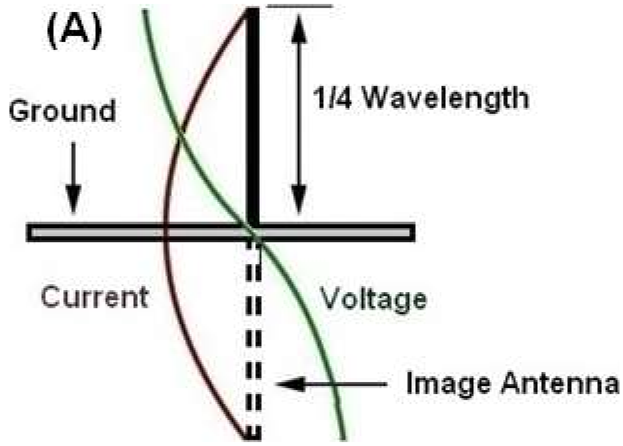
Traps can also be used with vertical antennas.

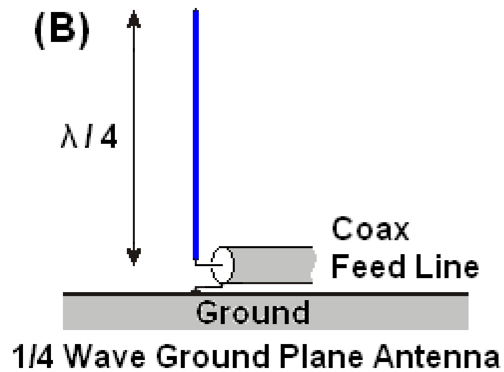




Vertical using
3 traps

Ground Plane (Vertical) Antenna





The basic quarter-wave vertical antenna is essentially half of a dipole with the other half of the antenna composed of a good ground or counterpoise (radials) underneath the vertical antenna either at or above ground to function well.

Vertical antennas are omnidirectional and have low angle radiation patterns, even when they are mounted close to the ground. This makes them well suited for working long distance. The term monopole is also used to describe this antenna.

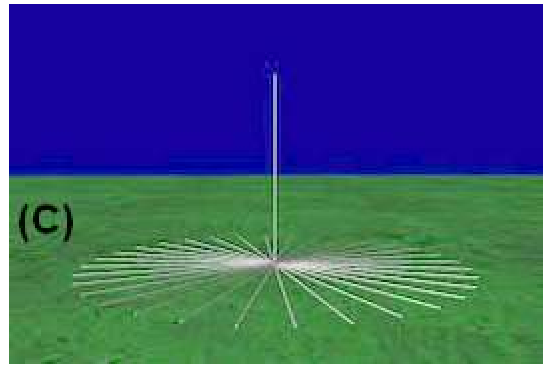
It is “unbalanced” having one connection to the vertical element and uses an earth connection or simulated earth connection to provide an image for the other connection.

Vertical antennas can be 1/4 wave, 3/8 wave, 5/8 wave, 3/4 wave or 1/2 wave tall, or even a random height…..They can also use traps to cover more than one band…..
The vertical length can be shortened by using a loading coil or traps…..The vertical can be used at all frequency bands including LF, MF, HF, VHF and beyond.

(A) : Radiation is reflected back from the ground like a mirror image to supply that part of radiated energy that normally would be supplied by the lower half of an ungrounded half wave dipole antenna. Some of this radiation will be lost in attenuation, how much will depend on the nature of the ground itself.

(B) Vertical Ground Plane Antenna also known as a Marconi Antenna:
The ground underneath the antenna acts as a plane to reflect the radio waves so that an image of the top half of the antenna is seen in the Earth.

It is possible to simulate this function by replacing the real earth with a conducting plane. To function as an antenna ground plane, the conducting surface must extend for least a quarter wavelength from the base of the antenna or a pattern of λ/4 conductors (radials) can be used.



(C) Radial wires either may run above the surface of the earth, on the surface, or buried a centimeter or so under the earth.

The ends of the wires nearest the antenna base are connected to the antenna system electrical ground and the far ends are either unconnected, or connected into the earth.

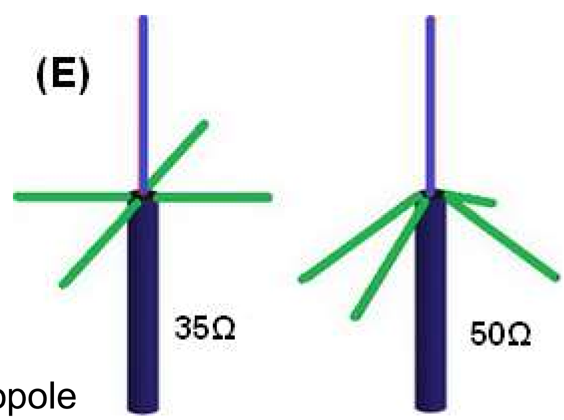
Counterpoise (radials) : Sometimes connecting a vertical antenna to the ground is not feasible….. If the antenna is on a high building or if wanting to raise the vertical antenna in the clear a counterpoise (radials) may be considered.

A counterpoise is a flat structure of wire or screen that forms an artificial reflecting surface (usually radials) for the vertical antenna if the actual earth cannot be used. Most commercially-made VHF ground plane antennas have four radials.

(D) Example. 144 -148 MHz quarter wave vertical antenna has 4 radials.

Radials can be either horizontal or bent at a downward slope from the vertical.

(E) With a vertical 1/4 wavelength element and four horizontal 1/4 wavelength radials, the feed-point impedance is about 35 Ω.
The actual figure depends upon height above the ground.



Radials on a quarter wave ground-plane antenna bent downwards at about 45 degrees will bring the feed-point impedance closer to 50 ohms impendence

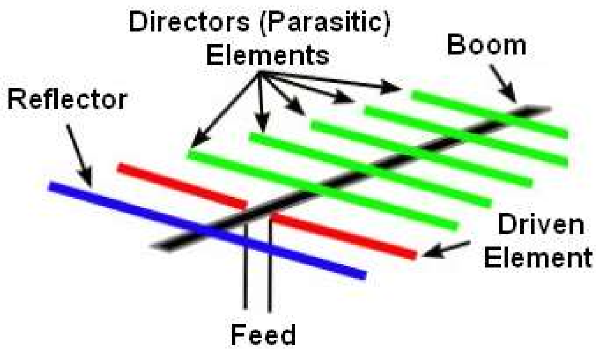
The most common transmission line is 50Ω coax.

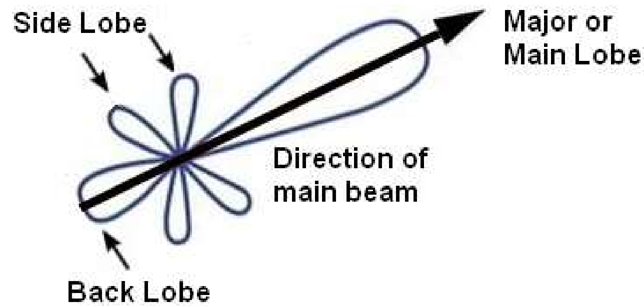
Quarter wave length: For practical purposes taking into account the end effects we can use: 234 / f (MHz).

Note : The VHF 5/8-wavelength (144 Mhz) vertical monopole has long held the reputation of providing about a 3-dB gain advantage over the 1/4-wavelength vertical monopole.

Marconi antennas operate with one end grounded and are mounted perpendicular to the earth or a surface acting as a ground. On vehicles, the earth connection is the metal chassis with capacity coupling to ground.

Yagi – Directional Antenna





Radiation Pattern of Yagi - Uda Antenna

The Yagi – Uda or more usually called a Yagi antenna is a directional or beam antenna which improves the transmission or reception of the radio signal, an advantage for using a Yagi antenna are the gain and directivity. The Yagi can be used vertically or horizontally.

A directional antenna such as the Yagi sacrifices radiated power in most directions to emit more powerfully in a single direction. The greater radiated power in the singular direction is called the main lobe of the antenna's radiation pattern.

Driven element of a Yagi is the feed point where the feed line is attached from the transmitter to the Yagi to perform the transfer of power from the transmitter to the antenna.

The driven element is normally has a half wave dipole or often a folded dipole as the main radiating or driven element to which power is applied directly from a feeder

Reflector is usually located behind the driven element are made electrically long, 5% longer than the driven element. Reverses the direction of energy emitted from rear of antenna…The reflector usually adds 4 dB to 5 dB of forward gain.

Directors are made electrically short, 5% shorter than the driven element. Reinforces and focuses energy from the front of the antenna… If any extra directors are added to the antenna, the antenna gets an average 1 dB of gain.

Parasitic elements of the Yagi antenna operate by re-radiating their signals in a slightly different phase to that of the driven element. In this way the signal is reinforced in some directions and cancelled out in others…More parasitic elements means more gain and the narrower the beam angle…Most Yagi antennas have 1 reflector and up to 1-20 directors….The power in these additional parasitic elements is not directly energized by the transmitter but pick up power from the driven element.

Gain : When a comparison is made between the directional antenna's main lobe signal strength and a reference antenna such as the ideal isotropic radiator, the ratio resulting from the comparison is the directional antenna's gain, usually expressed in decibels (dB)…..The dB is a logarithmic way of describing a ratio.

For high gain level, the antenna will need to be very long. And even then, gain is limited to around 6-9 dB unless you have more than one yagi antenna assembled in an array.

The front-to-back ratio (F/B ratio) is the ratio of the power radiated in the forward direction to the power radiated in the backward direction, normally expressed in dB.

Bandwidth or frequency range…..Most Yagi antennas have a 50° to 70° beam width.

Because they focus all their input in one direction, they put out high gain relative to omnidirectional antennas.

The bandwidth of a Yagi antenna, the frequency range over which it has high gain, is narrow, a few percent of the center frequency, and decreases with increasing gain

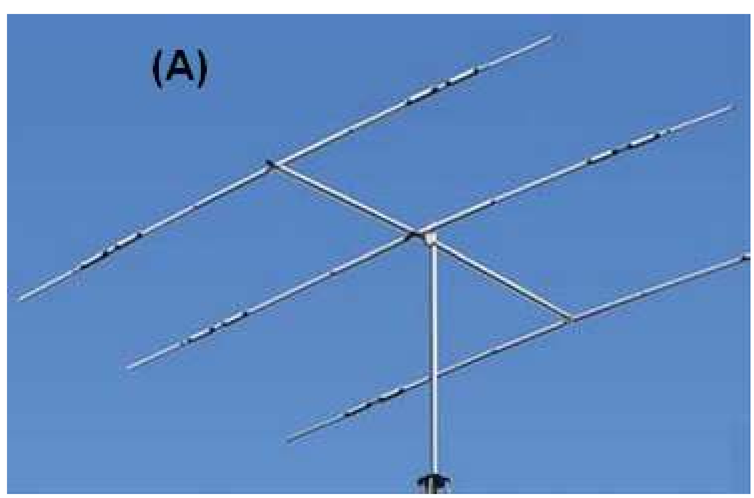
The bandwidth of an antenna is, by one definition, the width of the band of frequencies having a gain within 3 dB (one-half the power) of its maximum gain. The Yagi array in its basic form has very narrow bandwidth, 2–3 percent of the center frequency.

Yagi antennas are designed to be balanced but can be unbalanced if a balun is placed at the feed joint line where it connects to the drive element.

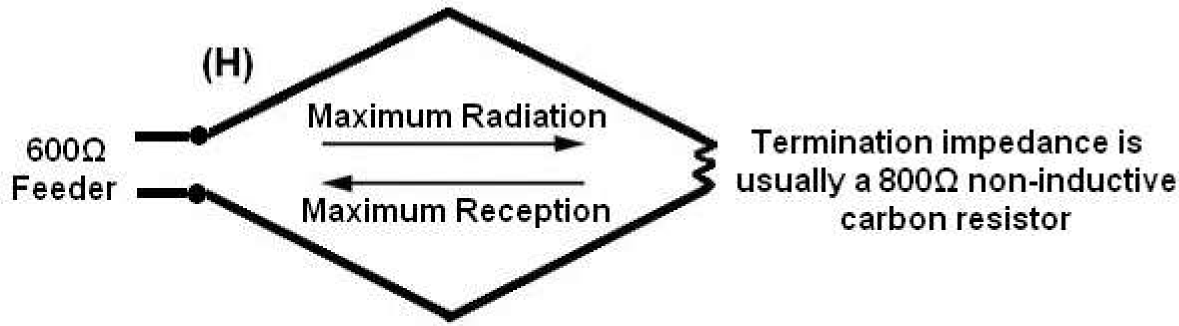
Depending on the design of the driven element, they can be balanced or unbalanced.

Yagi antennas used for amateur radio are sometimes designed to operate on multiple bands using traps whose designs create electrical breaks along each element (both sides) and has the effect of shortening the element at the higher frequency band, making it approximately a half wavelength in length.

(A) Antenna, Beam, HF, Tri-Band,
Yagi, 3 Elements, 1,500 W,
20, 15, 10 meters,
14.0 ft. Boom Length.



Rhombic Antenna



Rhombic Antenna - Top View

Rhombic antenna is a broadband, highly direction antenna and is used for various applications which include HF communications, point to point communication, long distance sky wave propagation and so on.

It is arranged in the form of a rhombus or diamond shape and suspended horizontally above the surface of the earth.

(H) : The frequency range of operation of a Rhombic antenna is around 3MHz to 300MHz. This antenna works in HF, VHF and UHF ranges.

Baluns are available for 50 or 75 ohm coaxial feeders.

Advantages of Rhombic antenna…
Operates over a wide frequency range
Input impedance and radiation pattern are relatively constant
Rhombic antenna is a highly directional broad-band antenna
Simple construction

Disadvantages of Rhombic antenna…
Requires a large space
Wastage of power in terminating resistor
Low transmission efficiency with typical radiation efficiency is in the order of 40–50%.
Each leg is made at least 1 or 2 wavelengths long at the lowest operating frequency.

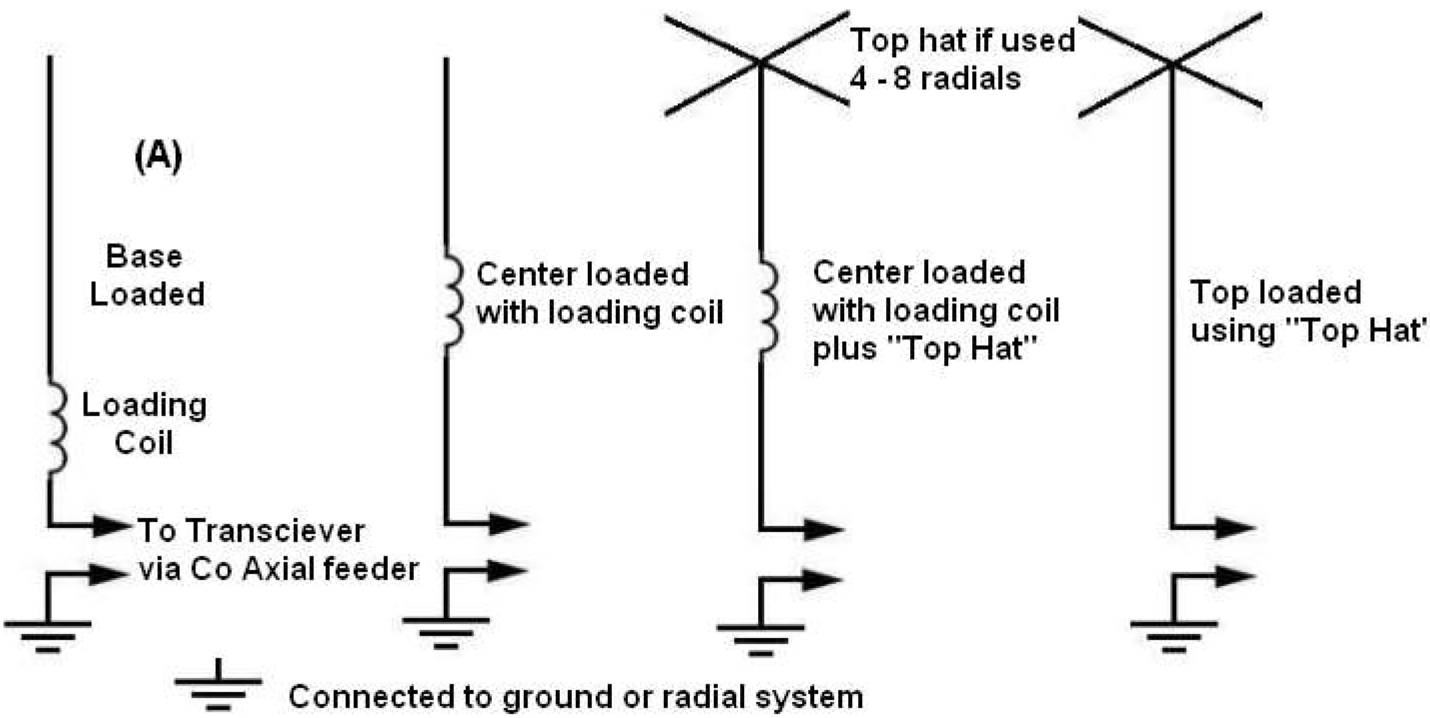
Loading Coil (Vertical): For many applications such as base, mobile or portable, it is not possible to make a full quarter wave antenna.

Example: A 1/4 vertical antenna on 80 mtrs would be approx 67ft high**.**

To overcome this problem, shortened antennas are used and electrical components are added to compensate for the shortening**.**

To make an electrically short antenna resonant, a loading coil is inserted in series with the antenna. The coil is built to have an inductive reactance equal and opposite to the capacitive reactance of the short antenna, so the combination of reactance's cancels.

Mobile antennas are inherently limited by the amount of available space, reducing the length increases its resonant frequency, using a loading coal restores the vertical antenna to the resonant frequency with a reduced bandwidth.



The practical effect of shortening is the vertical antenna no longer resonates at the desired frequency but at a higher frequency.

To compensate for this, a series inductor called a loading coil is connected in series with the vertical radiator; the loading coil brings back the vertical antenna to the desired resonant frequency.

A physically small loading coil inserts a series inductive reactance that cancels capacitive antenna reactance.

The higher the loading coil is placed the higher the efficiency but the operating band width will be narrower.

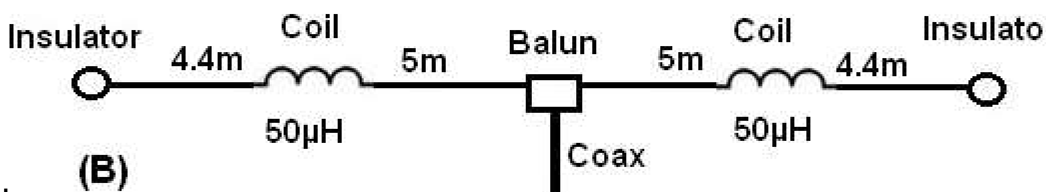
(A) Base loading: the loading coil is often placed at the base of the antenna, between vertical part and the transmission line.

Center loading: For better efficiency, the loading coil is sometimes inserted in the center of the antenna element itself

Top loading : loading coil may be used, on its own or in conjunction with a capacity (top) hat, to tune the antenna to resonance at a lower frequency.

When a horizontal top hat is added to a vertical antenna, the top hat itself doesn't radiate, but it increases the effective height of the vertical portion. Without a top hat, the current in the antenna decreases toward zero at the top end, and the upper part of the antenna contributes very little to the total radiation.

Loading Coil (Dipole)



A standard dipole antenna is resonant if constructed with a length of one-half wavelength.

Sometimes it not always possible due to the limited space available to erect a ½ wave dipole for example on 40mtrs, the ½ wave overall length could be 66ft and on 80mtrs it could be 132 ft. Using loading coils is a way to reduce the overall length of the dipole.

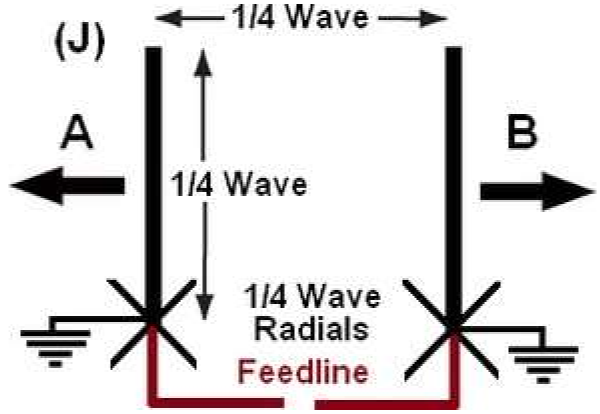
By replacing part of the normal dipole length "electrically" with inductance in the form of loading coils we can make a shorter half-wave dipole become the "electrical" equivalent of a full size half wavelength dipole.

(B) The loading coil is an inductor placed in series with an antenna element in order to lower the antenna’s resonant frequency and reduce the physical length of the antenna.

Example (B) a ½ wave dipole for 80mtrs (3.680MHz) length would be say 39 meters (128 ft) long, with two loading coils (inductor) of approx. 50 microhenries each, the total overall length can be reduced to18.8 meters (62ft).

Using a "loaded" dipole, is a compromise by trading some performance for the capability of being able to install a dipole in less space than normal, loaded antennas are narrow banded.

Log Periodic Antenna (LPA)



(I) A Log-Periodic Dipole Antenna (LPDA) also known as a log-periodic array is a multi-element, directional antenna that provides gain and directivity combined over a wide band of frequencies.

The LPDA consists of a number of dipole elements. These progressively reduce in size from the back to the front – the direction of maximum radiation is from the smaller front.

They have very wide bandwidths. Log periodic antennas have much broader frequency bandwidths than Yagi antennas. Example HF bandwidth 12 – 30 MHz

HF communications: A single log periodic antenna will give access to a sufficient number of frequencies over the HF bands to enable communications to be made despite the variations in the ionosphere changing optimum working frequencies.

UHF: The log periodic antenna is sometimes used for UHF terrestrial television reception. As television channels may be located over a wide portion of the UHF spectrum, the log periodic enables a sufficient bandwidth to be covered.
Example: 470–890 MHz in the UHF as well as 174–216 MHz in the VHF.

EMC (Electromagnetic Compatibility) measurements, when it is necessary to scan a wide band of frequencies. Example 80MHz–4GHz

(J) Phased Vertical Antenna:

A 2 element vertical array (λ / 4 spacing) can be fed in phase to cover the broadside directions.

One quarter wavelength spacing results in low SWR in either end fire direction and slightly higher SWR in the broadside directions.

Two element phased vertical array can achieve 3db of gain with the ability to reverse direction instantly and gives about 20 dB front to back ratio.

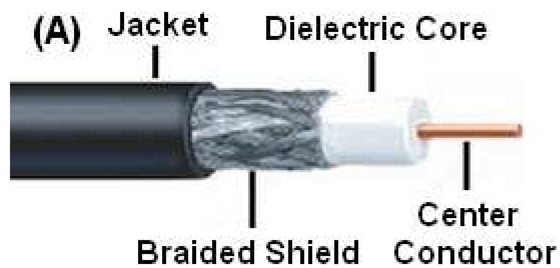
Feeder…..

Properties of open and short Feed-Line Sections		
Length	Termination	Impedance
1/8 wave length	shorted	inductive
1/8 wave length	open	capacitive
1/4 wave length	shorted	very high impedance
1/4 wave length	open	very low impedance
1/2 wave length	shorted	very low impedance
1/2 wave length	open	very high impedance

Power Gain	Power Loss
3 db = 2 x power	– 3db = 1/2 power
6db = 4 x power	– 6db = 1/4 power
10 db = 10 x power	– 10db = 1/10 power
20 db = 100x power	– 20 db = 1/100 power

A doubling or halving of power equals
a change of approximately 3 dB

3 dB equates to about a 2:1 power ratio
10 dB equates to a 10:1 power ratio



(A): Coax or coaxial cable : Coaxial cables are the most popular form of transmission line for getting signals to and from antennas....

Most coaxial cables used in amateur installations have impedance of either 50 ohms or 75 ohms.

Coax is unbalanced, that is the inner conductor carries the signal (positive) while the outer screen or braid (negative) is usually connected to ground.

1) Loss in coax is directly proportional to its length.
2) Loss in coax increases as frequency increases......

Example : RG-58 coax has an attenuation (loss) of 2db per 100 feet at 21 MHz and a loss of about 2.6db per 100 feet at 30 MHz.
RG stands for "Radio Guide"

The velocity factor (VF) of coax cable is the speed an electromagnetic wave travels along a feeder relative to the speed in a vacuum and is determined by dielectric ie (foam) polyethylene or solid (air spaced) PTFE or air spaced polythene etc of the cable...

The velocity factor of a radio wave in a vacuum is unity (1.0) or 100%

Balanced Feeder

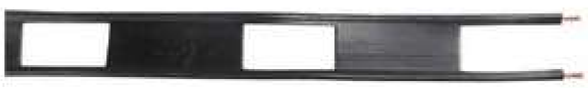
Left is a 300 to 75 ohm balun
Right 75 ohm twin lead

(C)

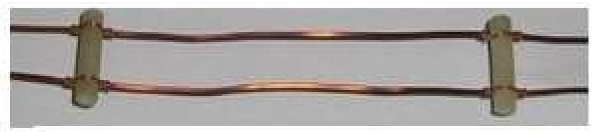
75 ohm twin lead

300 ohm ladder line

300 ohm twin lead



450 ohm ladder line



open wire feeder (600 ohm)

(C) Twin lead cable and ladder line have two parallel wires at constant, fixed distance apart and used as a balanced transmission line to carry radio frequency (RF) signals.

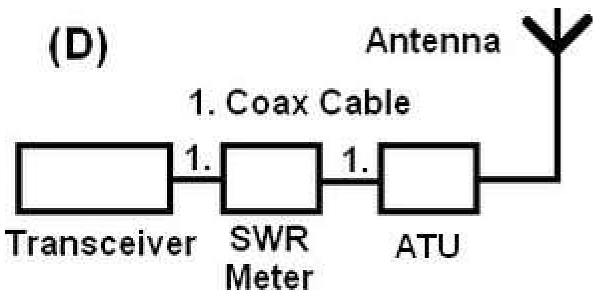
As the currents that flow in the two wires are equal and opposite, in theory no signal should be radiated from them. In practice it is found that they are affected by nearby objects and water.

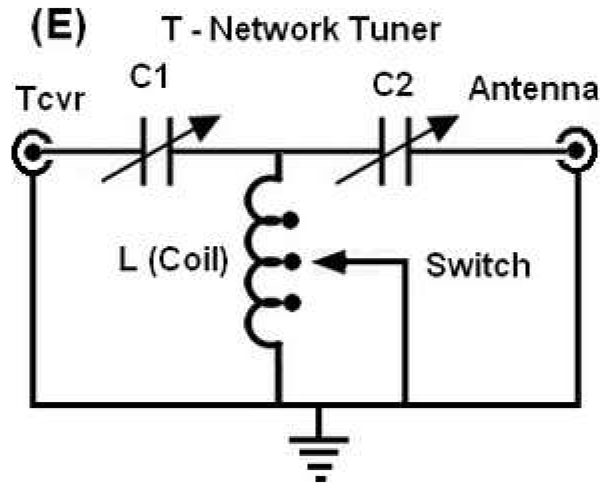
To match balanced (open line) transmission lines to the transceiver having 50 ohm impedance requires a tuner (ATU) that has two "hot" output terminals, rather than a transceiver which has one hot terminal and ground (unbalanced).

Sometimes a Balun (balanced to unbalance) electrical transformer can be used.

Balanced feeders have extremely low loss, much lower than coax cable even at high VSWR so can be used for very long feeder runs.

Antenna Matching (ATU)





Antenna systems may have a wide range of impedance. Example: the antenna impedance can be different at different frequencies.

Antenna Tuning Unit (ATU): The ATU is an impedance matching device.

Amateur Radio transceivers are designed to work with an impedance of 50 ohms.

This will happen when there is a match between the source impedance (transceiver), the characteristic impedance of the transmission line (feeder) and the load's impedance (antenna), if the transceiver "sees" anything other than 50 ohms, it will reduce its output to protect itself from the possible damage.

A mismatch of impedances can cause some of the power to be reflected back toward the source, these reflections lead to peaks and valleys in the voltage at various times and distances along the line meaning less power being transmitted.

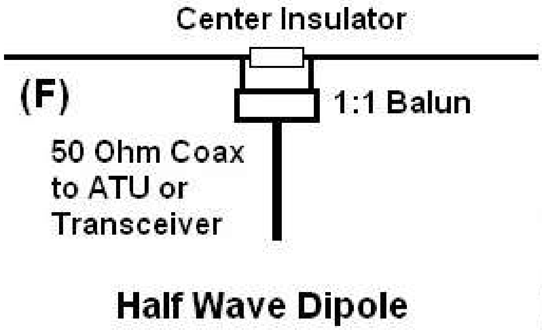
The SWR (Standing Wave Ratio) and VSWR (Voltage Standing Wave Ratio) meter measures these reflections as Standing Waves

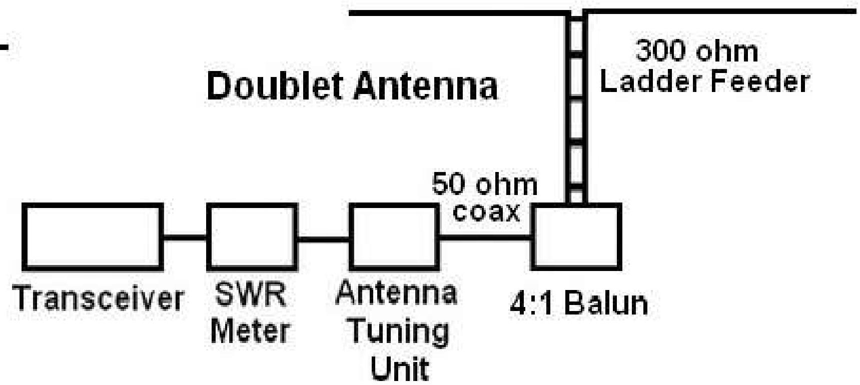
VSWR is measured as a ratio, i.e. 1:1 for no reflected power, 1.6:1, 2.0:1 and so forth. An open or a short circuit will be ∞:1.

There are various ATU designs, (E) shows the circuit of one such design.

The ATU does not change the SWR what an antenna tuner (transmatch) does is to transform the impedance at the feed line input to a value that the transceiver can handle (50 ohms).

Balun





(F) : Balun comes from combining Balanced and Unbalanced.......

Basically, a balun is a RF transformer used to match unbalanced and balanced transmission lines.....Antennas can be balanced or unbalanced.

Dipoles and yagis are balanced antenna whereas vertical antennas are unbalanced.

Likewise feeders can be balanced (e.g. open wire line or ladder feeder etc) or unbalanced (e.g. co-axial cable).

On many modern transceivers, one side of the transmitter output is at the chassis-ground potential. This is said to make the output "unbalanced."

Many amateurs connect the transceiver co-axial cable direct to a center-fed balanced antenna without using a balun.

When a balanced antenna is to be fed with co-axial cable, a balun is often used at the antenna feed-point to provide a balanced to unbalanced transformation (F)

The balun's ratio is normally stated from balanced to unbalanced .....

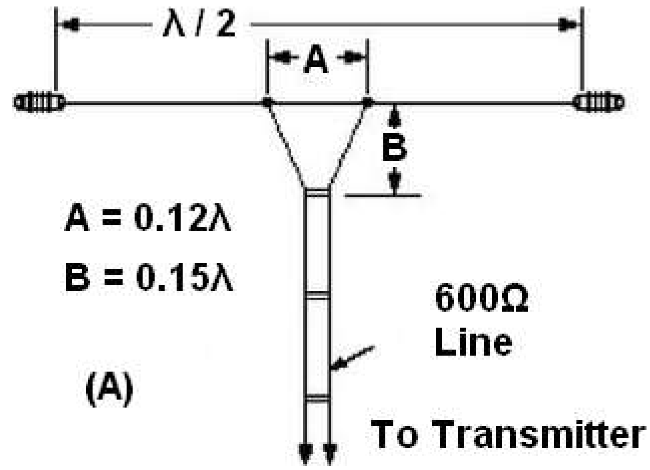
A 4:1 balun has four times the balanced impedance as the unbalanced impedance.

Normally a balun has a 1:1 impedance ratio between its input and output sides.
By modifying the design of the balun, it is possible to have other impedance ratios.
Examples: 4:1, 6:1, 9:1, etc

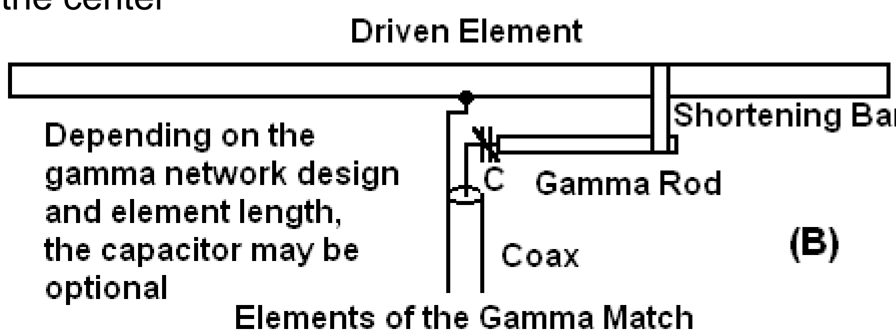
1) Helps elimination of radiation from the feeder cable.
2) Reduces QRM, reduces TVI…. 3) Helps to keep RF out of the shack.
4) Baluns have power handling limits…..5) Will not improve the SWR.
6) Baluns are not Lightning arresters. ..7) They do not make antennas broadband.

Delta, Gamma and Stub Matching.

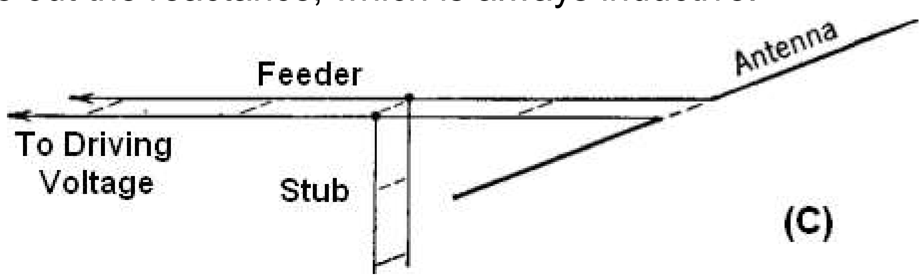
(A) The Delta matching system matches a higher impedance transmission line to a lower impedance antenna by connecting the line to the driven element in two places spaced a fraction of a wavelength each side of element center.



(B) The Gamma matching system matches an unbalanced feed line to an antenna by feeding the driven element both at the center of the element



Common matching method for beams. A gamma match can be used to allow coax able to coupled to the driven element of a Yagi beam antenna.
The series capacitor is used to tune out the reactance, which is always inductive.



(C) Stubs can be used to match a load impedance to the transmission line characteristic impedance. The stub is positioned a distance from the load.

This distance is chosen so that at that point the resistive part of the load impedance is made equal to the resistive part of the characteristic impedance by impedance transformer action of the length of the main line.

Single stub will only achieve a perfect match at one specific frequency.

Can match highly reactive loads. Can be made from pieces of coax.

Isotropic antenna (radiator): An isotropic antenna is a theoretical antenna that radiates equally in all directions - horizontally and vertically with the same intensity and is defined as a hypothetical lossless antenna having the same radiation in all directions (i.e. uniform radiation) and is used as a reference to describe real antennas

All real antennas have a gain; this gain is a measure for the directivity of a given antenna.

The isotropic antenna or radiator is used as reference antenna to evaluate antenna gain.

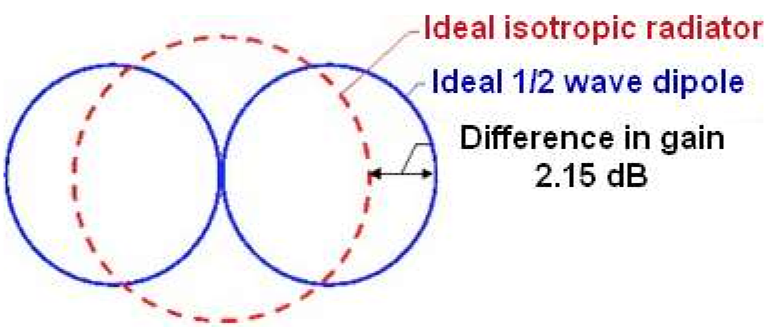
A directional antenna is one that radiates or receives electromagnetic waves in some directions better than others.

It is assumed that the power gain of an isotropic antenna is 1.0

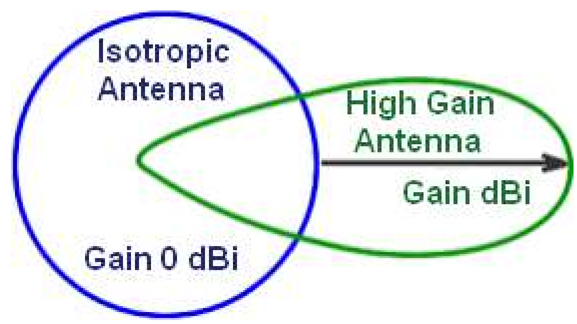
Gain: The isotropic radiator has unity gain, which means having a gain factor of 1 in all directions. In terms of dB, it can be called as 0dB gain (zero loss).

Gain referenced to an isotropic radiator expressed as dBi.

The term antenna gain describes how much power is being transmitted in the direction of peak radiation compared to that of an isotropic source.

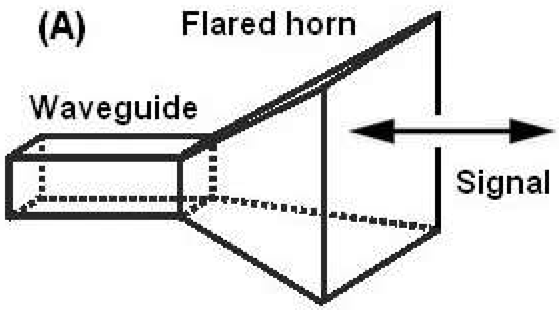


Half Wave dipole vs isotropic anntenna



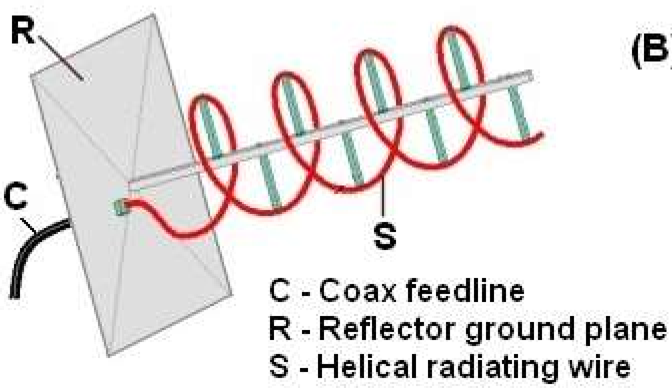
Antenna with a gain of 3dB would mean that the power received from the antenna would be 3dB higher (twice as much) than what would be received from a lossless isotropic antenna with the same input power. A half-wave dipole antenna has a power gain of 1.64. (or 2.15 dB) over an isotropic source.

VHF and UHF Antennas (Examples).

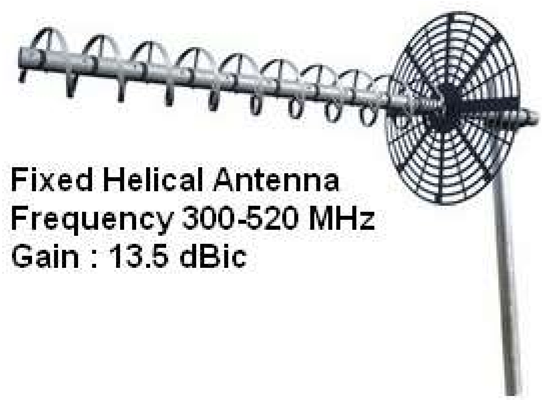


(A) Horn antenna: They are widely used at UHF and microwave frequencies, above 300 MHz to 40 GHz. The input impedance is slowly varying over this wide frequency range, allowing low voltage standing wave ratio (VSWR) over the wide bandwidth.

The horn antenna is used for the transmission and reception of microwave signals and has a gain between 10 - 25 dBi.



(B)

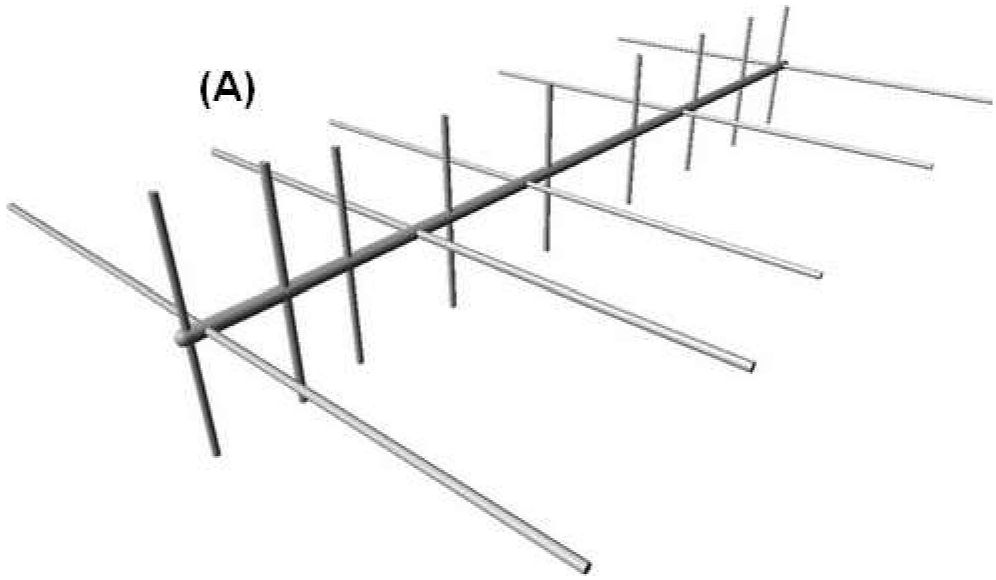


(B) Helical (Helix) antenna, the conducting wire is wound in helical shape and connected to the ground plate with a feeder line.
The frequency range of operation of helical antenna is around 30MHz to 3GHz.

This antenna is commonly used to include transmission/reception of the VHF up to microwave signals through the ionosphere, radiometry or satellite applications.

(B) A reflector R is almost always used to increase the sensitivity, or gain, in one direction (away from the reflector). Helical antennas can receive signals with any type of linear polarization, such as horizontal or vertical polarization.

(A) Antenna for communication via amateur satellites. On the same boom are situated two antennas. First the 144 MHz band and the second the 430 MHz band in opposite polarity. Example: Uplink FM 145.880 MHz with Downlink FM 435.880 MHz



(B) Earth-Moon-Earth (EME) Communication Antenna.
1256 MHz Amateur Radio EME antenna 3 meter dish

Parabolic (or dish) is an antenna that uses a parabolic reflector, a curved surface with the cross-sectional shape of a parabola, to direct the radio waves.

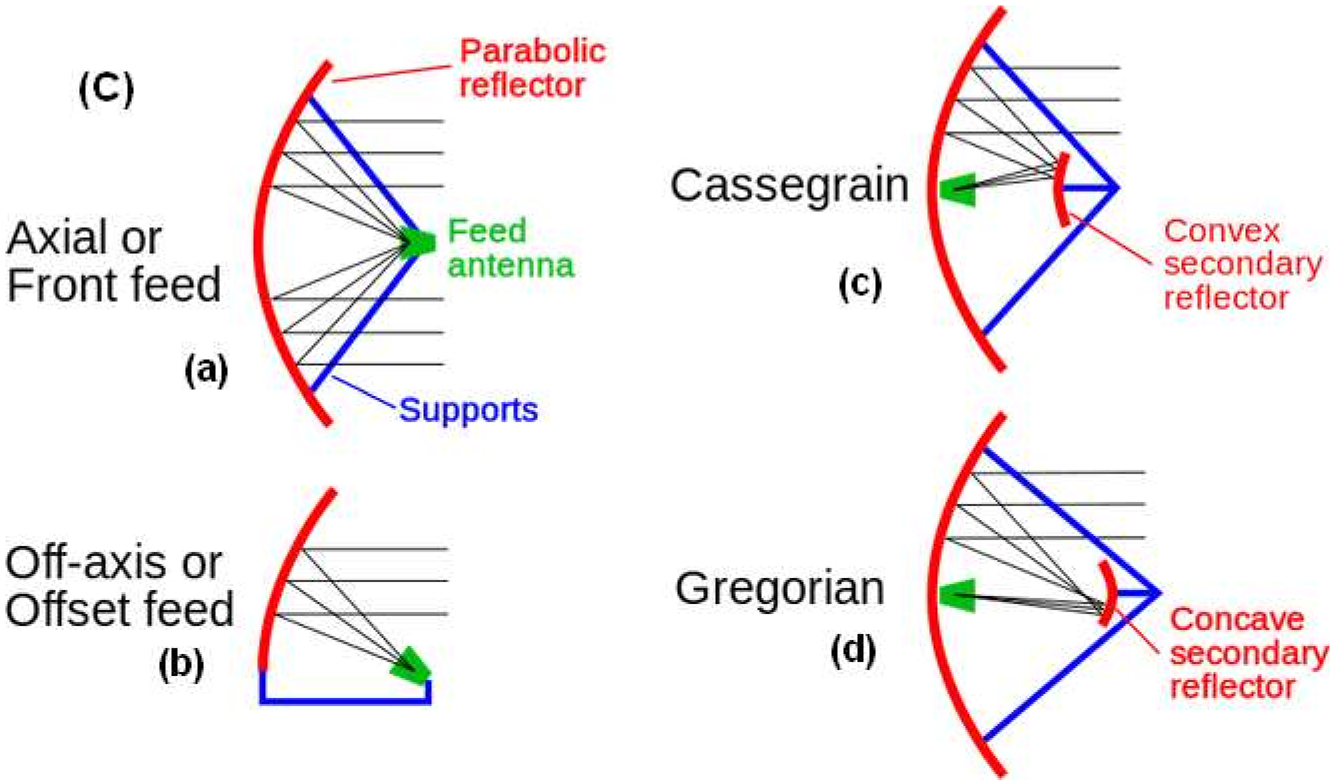
Parabolic antennas have a high level of gain and high levels of directivity.
Receives and radiates signals in one direction only. Sharp and narrow beamwidth.

Parabolic reflectors antenna gain can be as high as 30 to 40 dB…. Parabolic antennas have a narrow beamwidth, usually not exceeding 25 degrees.

Parabolic antenna is used for sending or receiving radio signals that uses the principle of a parabolic mirror to focus incoming signals onto one reception point or direct the emissions of signals from a focal source point into a directed beam.

Uses in radio communication include microwave links, satellite communications, radio astronomy, wireless links for data communications.

Parabolic Reflector Antenna Feed Systems



(C) Parabolic Reflector Antenna Feed Systems

(a) Front feed (or Axial feed): This type of feed always locates at the center of the dish, which is on the beam axis and at the focal. The major disadvantage is that the feed and its supports block some of the beam.

(b) This type of feed is located at one side of the reflector as it is outside the beam area, it can avoid obstructions to the beam.

(c) The Cassegrain feed system, although requiring a second reflecting surface has the advantage that the overall length of the dish antenna between the two reflectors is shorter than the length between the radiating element and the parabolic reflector.

(d) The Gregorian parabolic reflector feed…The major difference between this and the Cassegrain design is the secondary reflector is concave.

Element X (10) - Radio Wave Propagation

Propagation is the process by which radio waves get from the antenna of the transmitter to the antenna of a distant receiver.

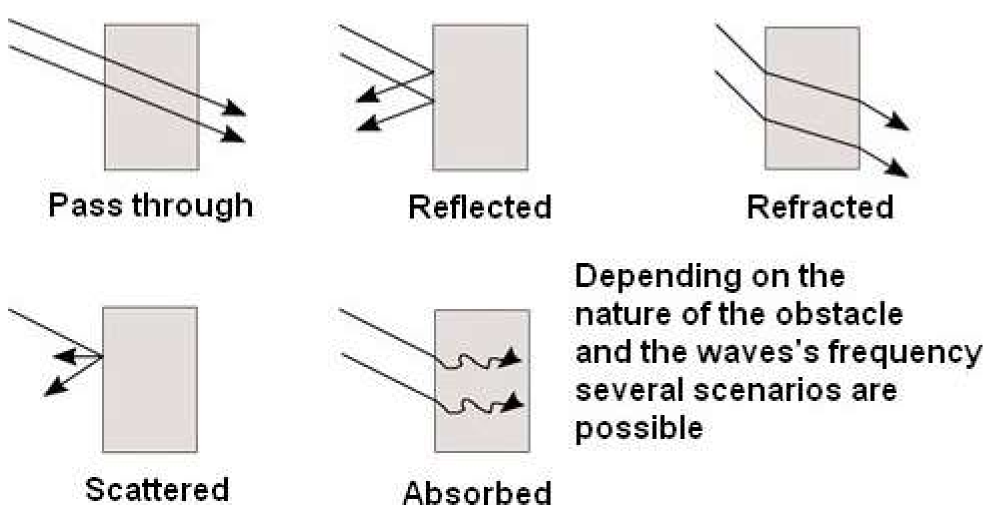
1) Skywave propagation (skip). It is either the reflected or refracted back radio waves to the earth from the ionosphere which is made up of one or more ionized layers in the upper atmosphere. The radio signal may effectively "bounce" or "skip" single hop or multi hops between the earth and ionosphere.

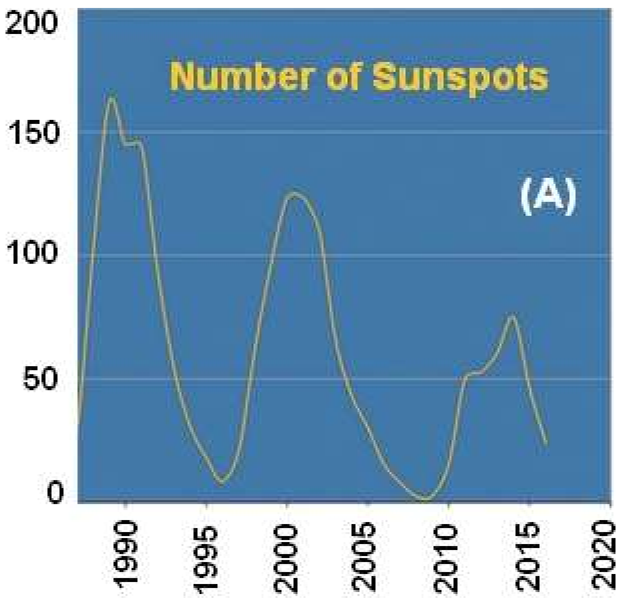
The ionosphere is responsible for long-distance communication in the high-frequency (HF) bands between 3 and 30 MHz.

2) Ground wave propagation is where radio waves follow the surface of the earth. Ground wave propagation is dominant at frequencies below 3 MHz. Ground waves are attenuated rapidly as they follow the earth's surface.

3) Line-of-Sight (LoS) or Space Waves. These radio waves (signals) are used mostly in very high frequency (VHF), ultra high frequency (UHF) and microwave ranges.
The space waves can travel through the atmosphere from transmitter to receiver antenna either directly or after reflection from ground in the earth's stratosphere region.

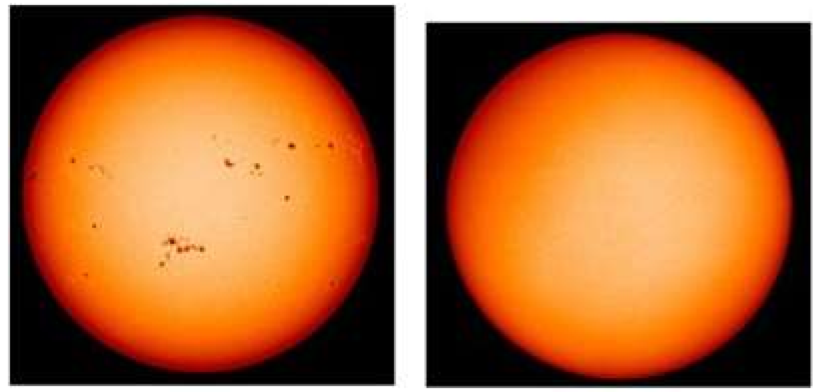
Radio waves travel in a straight line until they encounter an obstacle.





The duration of the sunspot cycle
is on average around eleven years

Sun Spots



Solar Maximum 2000 Solar Minimum 2009

Sunspots are temporary phenomena on the Sun's photosphere that appear as spots darker than the surrounding areas.

(A) The solar cycle or solar magnetic activity cycle is a nearly periodic 11-year change in the Sun's activity measured in terms of variations in the number of observed sunspots on the solar surface.

This increased radiation level from around the sunspots causes the ionosphere to become ionised to a greater extent.

Charged particles from the sun streaming by Earth affect the ability of the ionosphere to refract or reflect radio signals back to Earth. This means that higher frequencies can be reflected from the ionosphere. HF propagation occurs by way of the ionosphere.

The periodic peak of sunspot activity is called the "solar maximum" (solar max), and a period when few sunspots appear is called the "solar minimum" (solar min).

Sunspot cycles are given a number…Cycle 24 started late 2008 and will approximately span the years 2008 to late 2019, next will be cycle 25 etc.

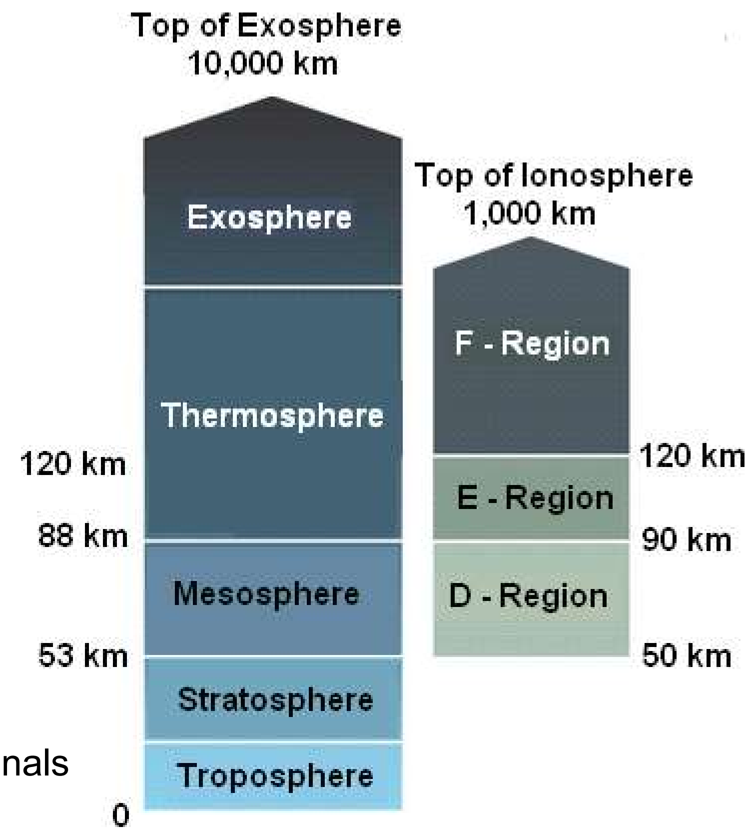
Ionosphere: The ionosphere is the ionized part of Earth's upper atmosphere from about 50 km to 1,000 km altitude in a region that includes the thermosphere and parts of the mesosphere and exosphere. The regions of the ionosphere are not considered separate layers, such as the more familiar troposphere and stratosphere.
Instead, they are ionized regions embedded within the standard atmospheric layers.

Within the ionosphere there are several different ionospheric regions (layers) which make long distance radio communication possible by reflecting the radio waves back to Earth.

The D region usually forms in the upper part of the mesosphere, while the E region typically appears in the lower thermosphere and the F region is found in the upper reaches of the thermosphere.

For frequencies below about 30 MHz, the ionosphere can act as a reflector, and this property permits very long distance radio communications around the world.

At higher frequencies, above 30 MHz, radio signals usually pass through the ionosphere.

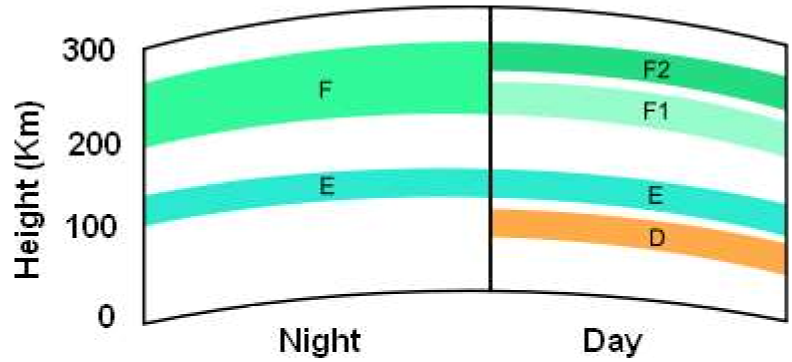


The ionosphere is a very active part of the atmosphere, and it grows and shrinks depending on the energy it absorbs from the Sun.

When using HF propagation via the ionosphere, the radio signals leave the transmitting radio antenna on Earth's surface and travel towards the ionosphere where some of the signals are bent (or refracted) back to Earth’s surface by the ionosphere which enables signals to travel over much greater distances than would otherwise be possible.

The ionosphere is a continually changing area. It is affected by radiation from the Sun which results in the frequencies that can be used for HF communications to vary depending on the time of day, season, year and the on average 11-year solar cycle.

There are three main regions of the ionosphere, called the D layer, the E layer, and the F layer.



These regions do not have sharp boundaries, and the altitudes at which they occur vary during the course of a day and from season to season.

D Region - This is the closest region to the Earth and only exists during daylight hours. It does not have the capability to bend an HF radio signal back to Earth, but it does play an important role in HF communications.

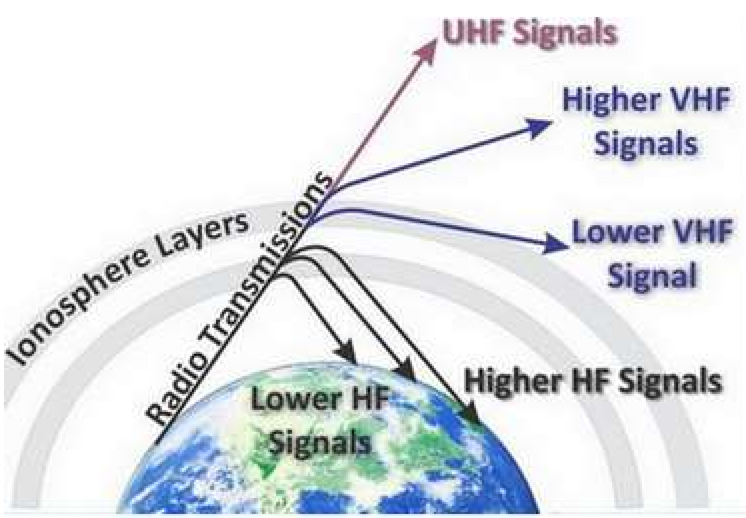
The D region absorbs energy from the radio signal passing through it, thereby, reducing the strength of received signals.

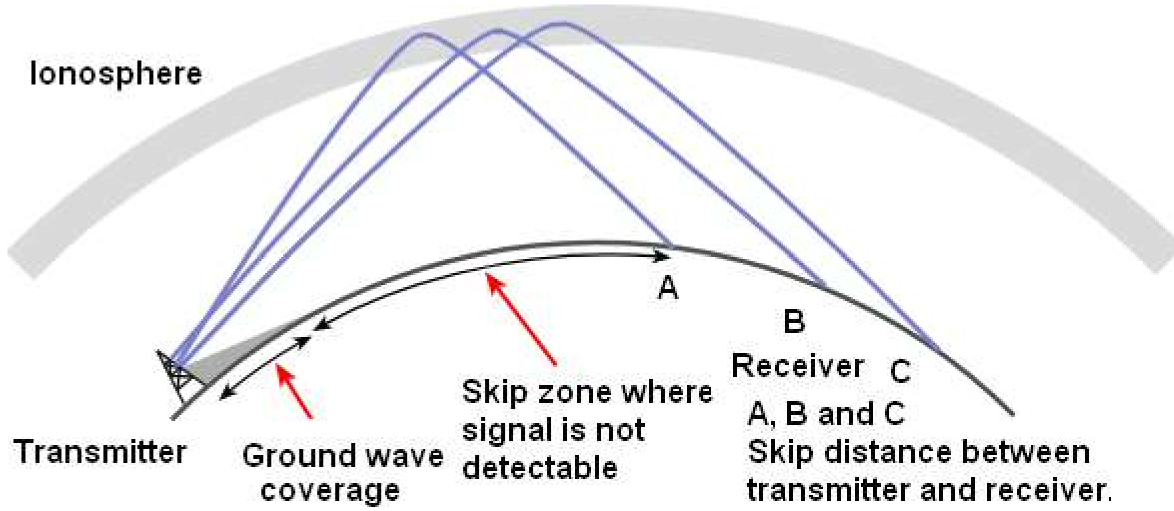
E Region - the E region is present 24 hours a day, although during night hours it is much weaker than during the day. The E region is the first region with enough charge to bend HF radio signals.

At times, parts of the E region become highly charged and can either help or block out HF communications. These highly charged areas are called Sporadic E and occur most often during the summer.

F1/F2 - The most important regions for HF communications are the F1 and F2 regions.

The majority of HF Skywave communications depend on these regions with the F2 region being used the most for long-range daytime communications. During the night, these regions combine to form a single F region.





Ground wave These waves propagate over the earth's surface in low and medium frequencies. The loss in power of ground waves increases with the increase in frequency.

Skywave refers to the signal that travels away from the Earth's surface towards the ionosphere from which it is reflected or refracted back towards Earth. Unlike a ground wave, the skywave does not follow the contour of the ground, but instead it is directed towards the ionosphere.

Skip Distance is a distance on the Earth's surface between the two points where radio waves from a transmitter, refracted downwards by different layers of the ionosphere fall. The skip distance is dependent upon including.

Skip Zone is the region between the point where the ground wave signals can no longer be heard and the point where the skywave first returns to Earth.

1) Frequency: Typically as the frequency increases a lower angle of radiation is needed to return the signals to Earth in a shorter distance.

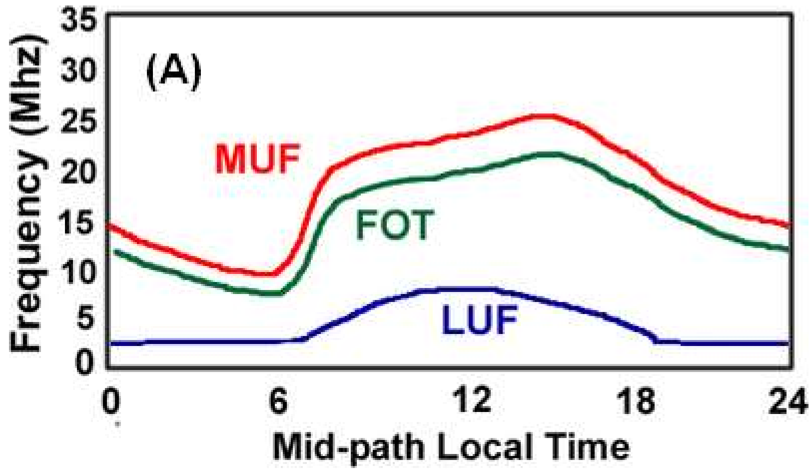
Also higher frequencies tend to be reflected or refracted by higher layers or regions in the ionosphere. This will mean that higher frequencies tend to lead to longer skip distances.

2) Ionospheric conditions play a major role in governing the skip distance. Under some circumstances when ionization levels are high it may be possible for signals to achieve very short skip distances.

3) Angle of radiation: The angle of radiation from the transmitting antenna also has an impact on the skip distance. A lower angle of radiation will lead to longer skip distances.

Maximum Usable Frequency (MUF) is the highest radio frequency that can be used for transmission between two points via reflection from the ionosphere (skywave or "skip" propagation) at a specified time, independent of transmitter power.

Signals whose frequencies are higher than the MUF will not be refracted by the ionosphere, but will instead penetrate the ionosphere and continue to propagate into space without being returned to Earth. Generally speaking, the MUF increases with increasing ionization.



(A) (Example) :The Maximum Useable Frequency (MUF) is the highest frequency (at any time) at which radio waves bounce off the ionosphere. If the signal frequency is higher than the MUF it will pass straight through the ionosphere

Frequency of optimum transmission (FOT) in the transmission of radio waves via ionospheric reflection and is the highest effective (i.e. working) frequency that is predicted to be usable for a specified path and time for 90% of the days of the month.

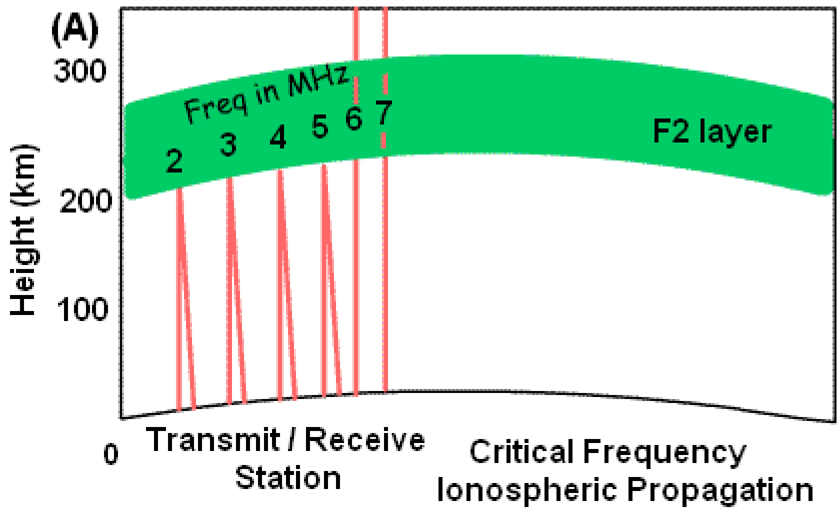
The FOT is normally just below the value of the maximum usable frequency (MUF). In the prediction of usable frequencies, the FOT is commonly taken as 15 - 20% below the monthly median value of the MUF for the specified time and path.

Lowest Usable Frequency (LUF) when the signal frequency is at or below the LUF, communication becomes difficult or impossible due to signal loss or attenuation.

MUF and LUF, these two values define the maximum user spectrum range in which propagation is open allowing HF communications.

There are also other factors which effect the propagation of skywaves between two stations such as emission power, antenna gain, takeoff angle, qrm, qsb, S/N ratio etc.

Critical Frequency



The Critical Frequency (fc). It is obtained by sending a radio wave signal pulses directly upwards towards the ionosphere (vertical incidence), the radio wave will be returned to earth at all frequencies below the critical frequency (fc) this is reflected back radio wave can be received by a receiver on the same site as the transmitter.

The radio wave will be returned to earth at all frequencies below the critical frequency.

The critical frequency depends on the degree of ionization of the ionosphere.

The frequency at which a signal sent vertically will pass right through the ionosphere is called the critical frequency.

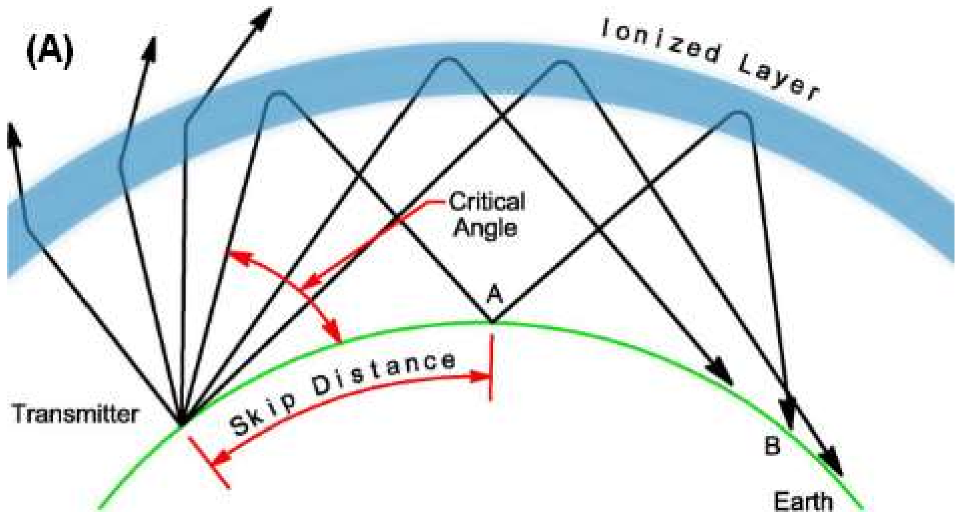
(A) Vertical waves of 2, 3, 4 and 5 MHz are reflected back to the receiving station but not those 6 Mhz and above. The critical frequency is 5 MHz

The critical frequency gives an indication of the state of the ionosphere and the resulting HF propagation.

The frequency at which communication just starts to fail is known as the Maximum Usable Frequency (MUF). It is generally three to five times the critical frequency, dependent upon the layer being used and the angle of incidence.

Critical frequency is different for different layers of the ionosphere.

Critical Angle



(A) Radio waves entering the ionized region at angles above the critical angle are not bent enough to return to Earth and are lost in space...

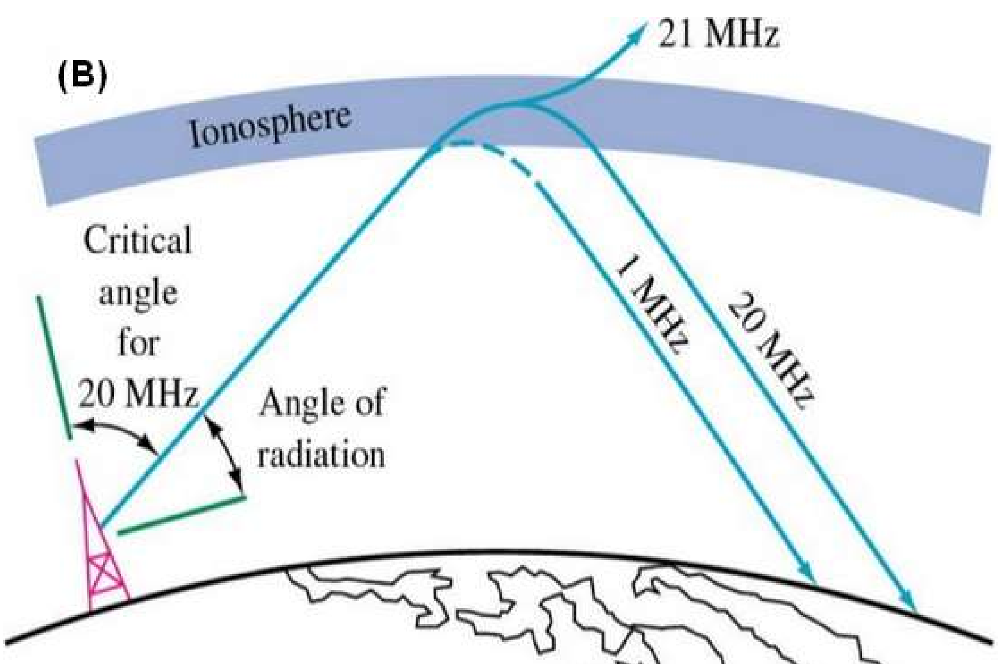
Waves entering at angles below the critical angle reach the Earth at increasingly greater distances as the angle approaches the horizon.

The critical angle of a given frequency is the highest angle at which you can send a radio wave into the ionosphere and have it return to earth.

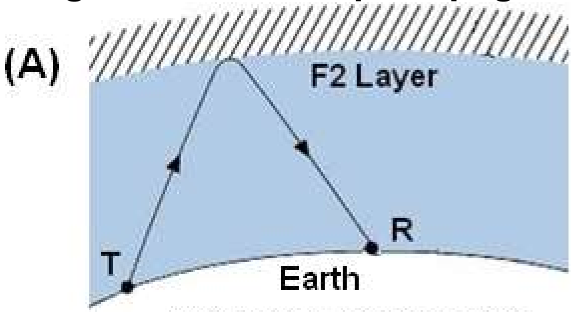
Unlike the critical frequency, the critical angle is not applicable to any single ionospheric layer.

The critical angle applies to the refraction of a single frequency from any part of the ionosphere.

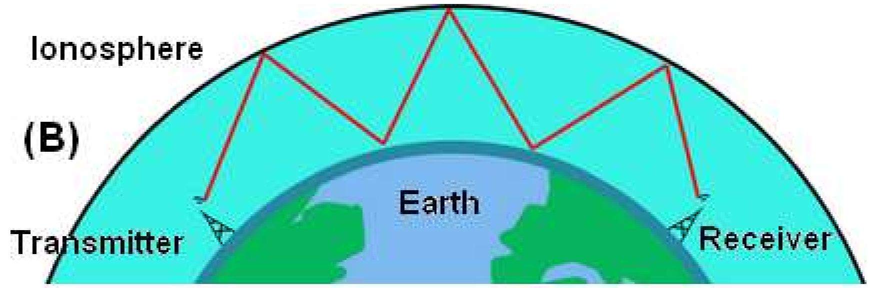
A lower angle of entry generally means the signal will travel farther.



Single and Multi-Hop Propagation



Single-Hop Propagation



Multi-Hop Propagation

HF Radio waves can be reflected by the ionosphere and propagate long distance from the transmitter to the receiver by a single-hop by several multi-hops.

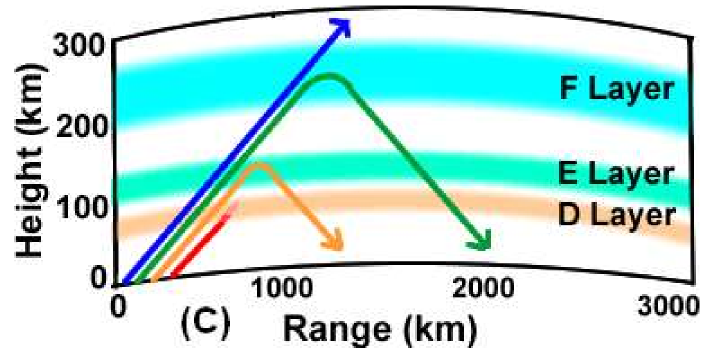
(A) With a single "hop" path distances up to 3500 km maybe reached. Greater distances maybe covered with two or more hops.

Example: The maximum distance that is normally covered in one hop using the F2 region is 4,500 Km (2500 miles) and the maximum distance normally covered in one hop using the E region is 2,160 Km (1200 miles).

(B): The earth itself can reflect/refract signals from the ionosphere back up resulting in multi-hop propagation and worldwide communication is possible with two or more skips (multi-hops) when conditions are right.

There are significant losses with each bounce, so signals get progressively weaker as they skip along. A radio wave will bounce (skip, hop) off the ionosphere at roughly the same angle that it strikes the ionosphere.

(C) Showing the effect of using different frequencies at the same transmission angle.



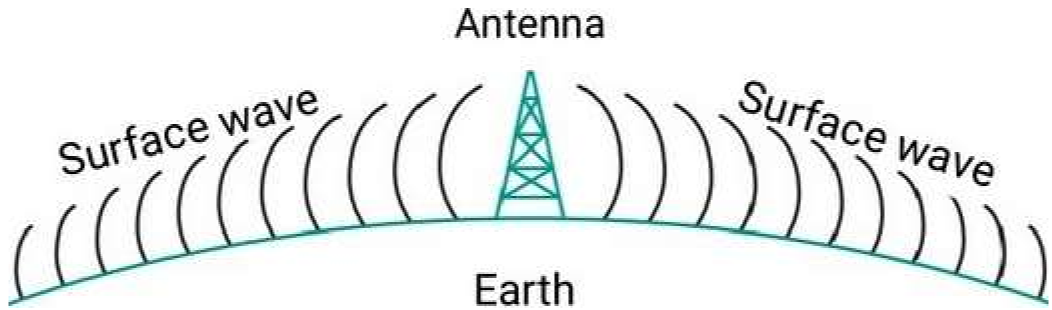
1) Blue wavelength frequency is greater than the MUF and passes into space.

2) Green wavelength frequency is less than the MUF but greater than the E layer MUF. This is usually the best frequency region to use for long range communications and is usually where the FOT (equal to 0.85 x MUF) exists.

3) Orange wavelength frequency is less than the E layer MUF and greater than the LUF. This is best for medium range (around 500 to 1500 km) transmissions.

4) Red wavelength frequency is less than the LUF and is absorbed in the D layer.

Ground Wave:



Lower frequency (between 30 and 3,000 kHz) vertically polarized radio waves can travel as surface waves following the contour of the Earth; this is called ground wave propagation.

Ground wave propagation which is also known as a surface wave is a type of radio propagation that uses the area between the surface of the earth and the ionosphere for transmission; it is used to provide regional coverage on the long and medium wave bands.

Ground waves have the tendency to bend around the corners or obstructions during propagation which makes them more efficient and also these are not affected by the change in atmospheric conditions.

In ground wave propagation, a large portion of wave energy is in space near the surface of the Earth.

This loss in power of ground waves increases with the increase in frequency.

Ground wave communication is not suited for high frequency.

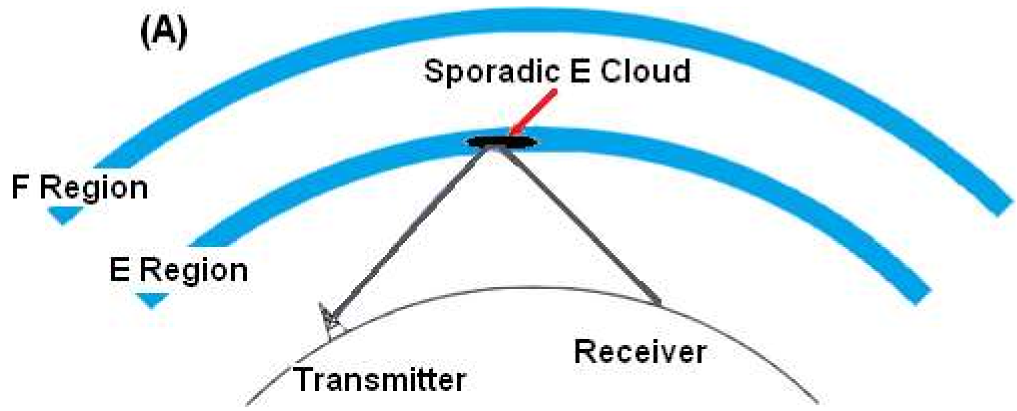
In the VLF, LF and MF bands the ground wave propagation follows the curvature of the earth. The range of ground wave propagation is up to 1,600 km (1,000 Miles)

Depending on the transmission power, the maximum transmission ranges of these waves are of the order of a few hundred kilometers

Medium wave broadcast stations generally use vertical polarization because ground wave propagation over the earth is considerably better using vertical polarization.

Very Low Frequency (VLF) 3 kHz – 30 kHz
Low Frequency (LF) 30 kHz – 300 kHz
Medium Wave (MW) 300 kHz – 3 MHz

Sporadic E

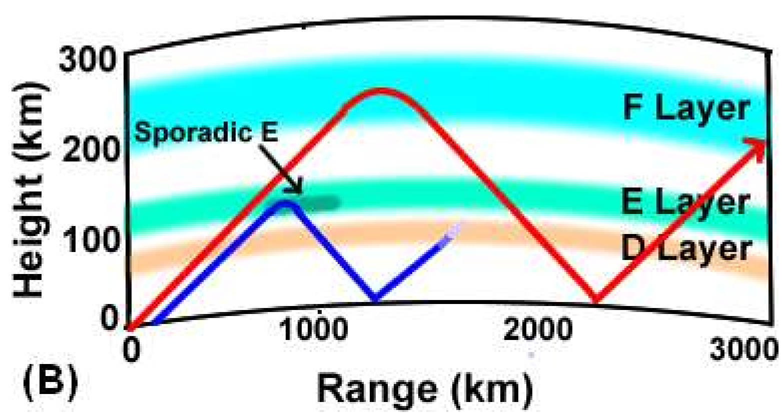


Sporadic E, also known as Es is a form of E layer ionisation that occurs randomly in the ionosphere.

It can affect frequencies normally affected by ionospheric propagation, but as the levels of ionisation can rise very high, it can affect frequencies much higher than would be expected by normal E region ionisation.

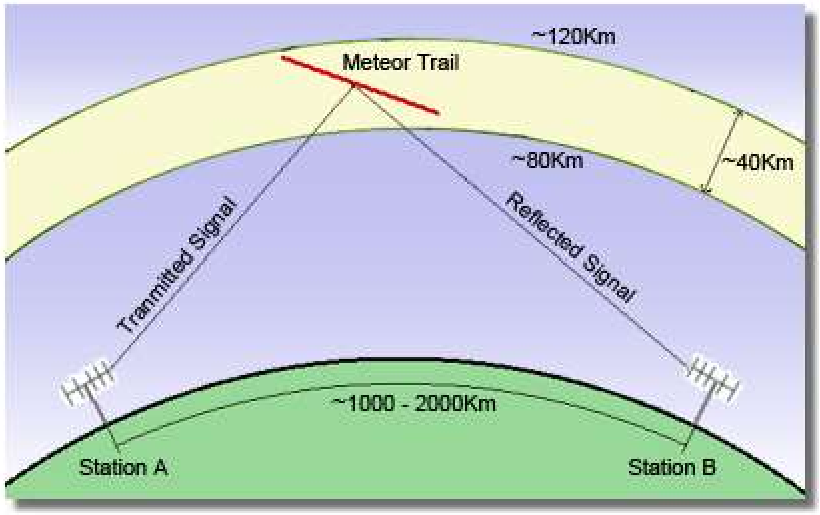
Sporadic E is used by radio amateurs on bands from about 24 or 28MHz up to 144 MHz and very occasionally 225 MHz.

It is widely used on 28 and 50 MHz to yield long distance contact when no other forms of ionospheric propagation are available.



(B) HF radio transmissions above the normal E layer MUF (red) pass through the E layer. During a sporadic E event, signals (blue) will either be refracted or partially refracted in the E layer, resulting in decreased long distance transmission, but better reception within the normal first skip zone.

Meteor Scatter (Meteor Burst)



Meteor Scatter (MS) also referred to as Meteor Burst Communications (MBC) is a radio propagation mode that exploits the ionized trails of meteors during atmospheric entry to establish brief communications paths between radio stations up to 2,250 kilometers apart.

When meteors travel through the ionosphere, they leave behind ionized trails which can be used to reflect radio signals.

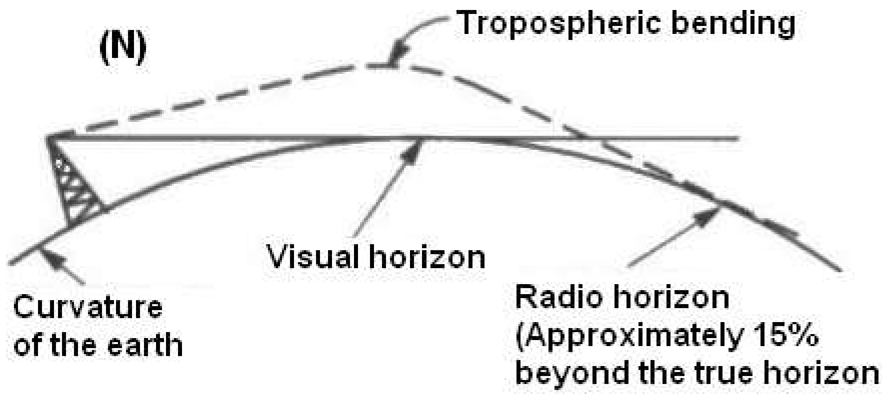
Leonids, Geminids and Perseid showers amongst others provide these conditions.

28 MHz through 432 MHz can be used for this type of propagation.

Any form of communications mode can be used for meteor-scatter communications.

Meteor shower. A number of meteors that appear to radiate from one point in the sky at a particular date each year, due to the earth regularly passing through them at that position in its orbit.

Troposphere:



(N) Tropospheric propagation is radio propagation that occurs in the lowest layer of the Earth's atmosphere - the troposphere. It is weather-related.

The troposphere is the lowest layer of Earth's atmosphere.

The troposphere starts at Earth's surface and goes up to a height of 7 to 20 km above sea level.

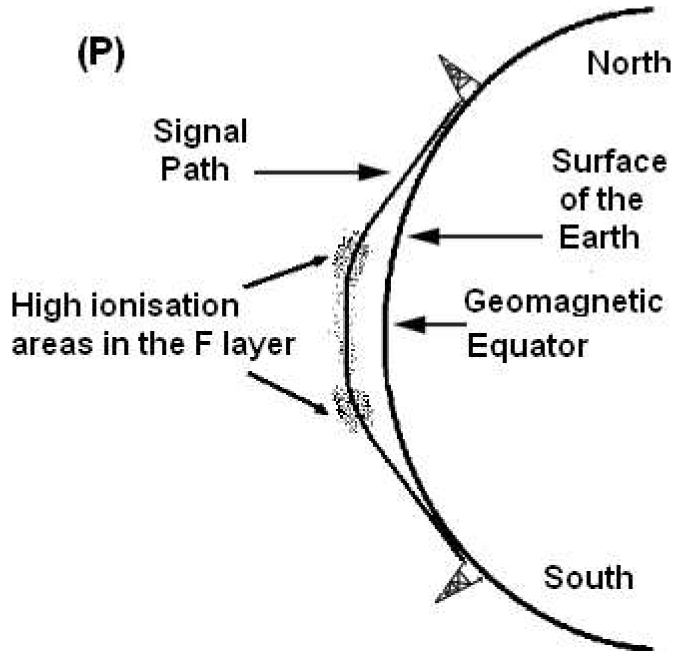
Tropospheric bending on VHF, UHF and/or microwave signals allows the operator to contact stations farther away. Tropospheric ducting of radio waves is due to temperature inversion.

Within the troposphere, bending of radio waves by refraction makes the distance to the radio horizon exceed the distance to the visual (optical) horizon.

Refraction increases the radio horizon approximately 15% beyond the true horizon.

The radio horizon extends beyond the geometric and visible horizons in conditions of normal atmospheric refraction.

Transequatorial propagation:



(P) Transequatorial propagation (TEP) is propagation between two mid-latitude points at approximately the same distance north and south of the magnetic equator.

These paths occur across the equator in a north south or south north direction.

The best time of day for transequatorial propagation is afternoon or early evening.

The communications of the distances between 2500 to 5000 kilometers are all supported by the Trans equatorial propagations.

TEP supports communications usually over maximum distances of around 8000km

The transequitorial propagation (TEP) mode can provide contact from 28 - 432 MHz.

It is thought to be due to irregularities in the F-Layer above the equator bending and reflecting the signals.

Aurora:

(Q) Aurora Propagation… An Aurora is caused by interaction between the Earth's magnetic field and the solar wind (a mix of charged particles blowing away from the sun).

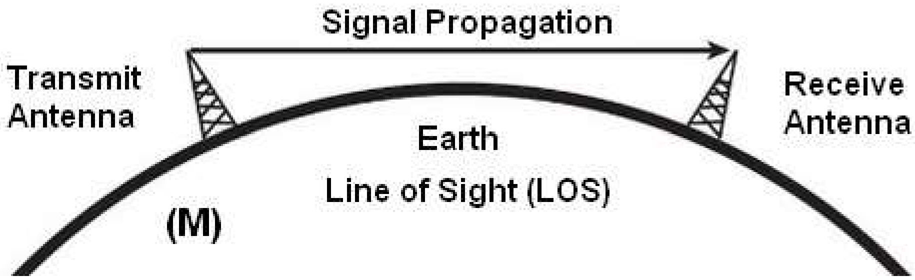
An aurora is usually observed as a glow coming from the upper atmosphere in the north and south polar latitudes. Aurora only appears around the polar regions.

Visible auroras are a sign of a disturbance occurring in the upper reaches of the Earth's atmosphere. This can result in significant changes to radio propagation conditions. ...

With an auroral event, the ionisation is concentrated around the poles communication is only possible at certain latitudes…..Aurora activity occurs in the E region.

Aurora - Abisko National Park, Sweden

Line-of-sight:



(M) : Line-of-sight (LOS) propagation occurs when signals travel in a straight-line form the transmitting antenna to the receiving antenna.

These signals, also known as direct waves, are used mostly in very high frequency (VHF), ultra high frequency (UHF) and microwave ranges.

At these frequencies, the antennas are relatively smaller and can be placed at heights of many wavelengths above the ground.

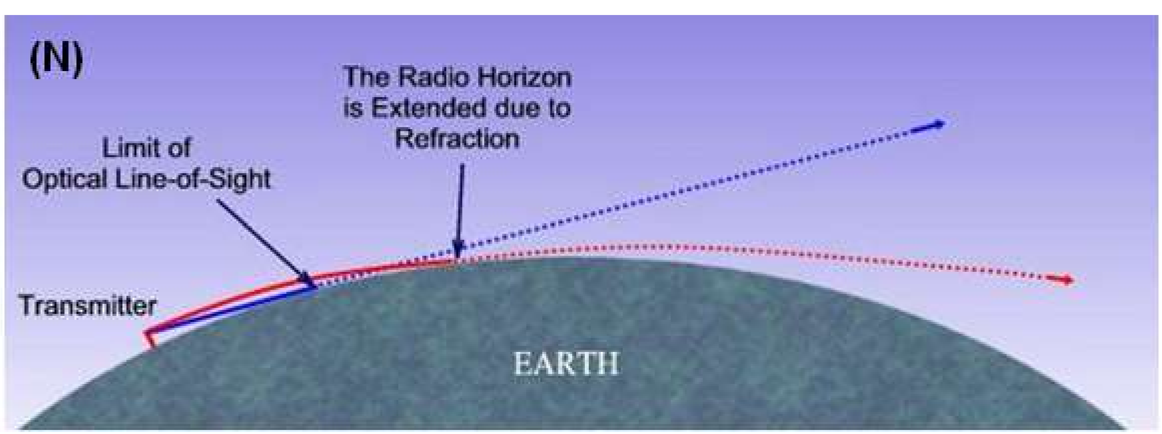
(M) In line-of-sight propagation, space waves are very powerful, the signals are very clear, the bandwidth is very large and a huge amount of information can be transmitted.

Because of line-of-sight nature of propagation, direct waves get blocked at some point by the curvature of the earth.

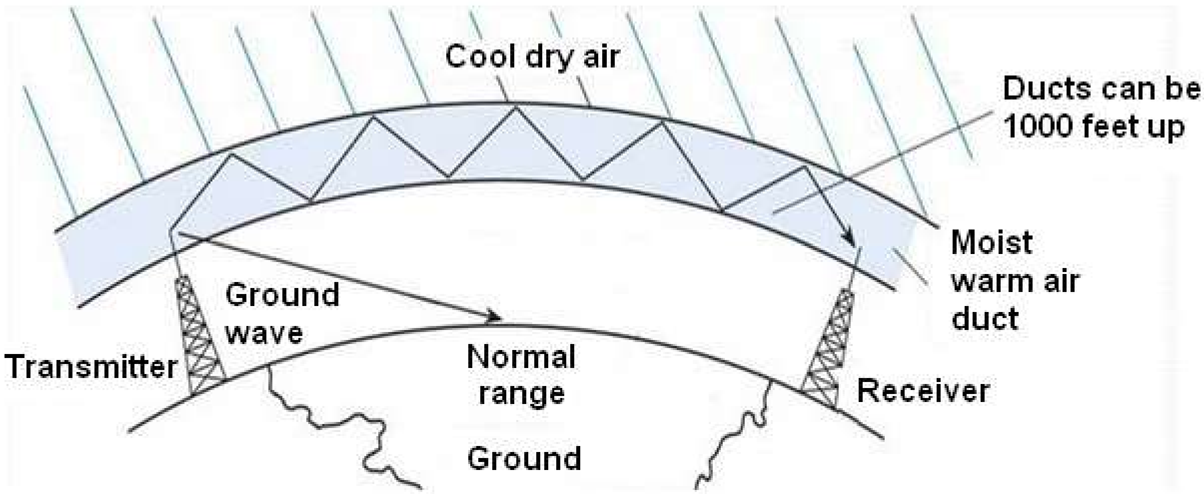
If the signal is to be received beyond the horizon then the receiving antenna must be high enough to intercept the line-of-sight waves.

(N) Optical (line of sight) horizon differs from the radio horizon.

Radio horizon due to refraction is extended beyond the optical horizon by say 15%



Tropospheric Ducting



In the spring and during certain climatic events, radio waves can travel long distances due to an atmospheric phenomenon called Tropospheric Ducting.

Tropospheric propagation occurs when signals are reflected scattered or refracted in the troposphere and continues on a path that allows the signal to travel much farther than it normally would.

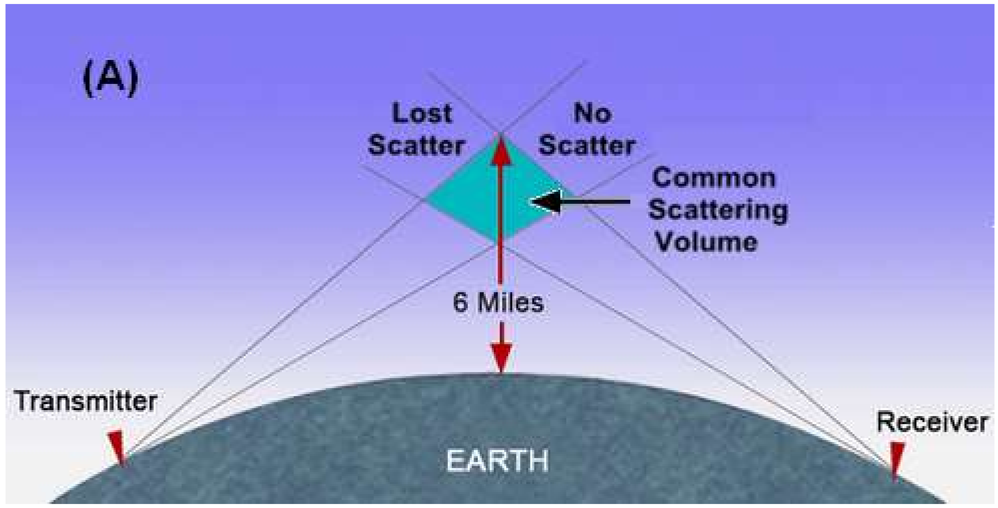
How tropospheric ducts are formed? This is where a layer of air in the troposphere will be at a higher temperature than the layer below it. Some of the radio signals from a transmitter bounce back towards the ground and potentially up again. The inversion effectively creates a duct for signals to travel along. When ducting occurs, signals travel along and within the inversion layer, reflecting off its boundaries.

When a temperature inversion occurs, radio waves that would normally continue into space beyond the Earth’s atmosphere are instead reflected and continue to follow the curvature of the planet.

Radio waves have been able to travel in excess of 1,000 miles (about 1,600 km) because of tropospheric ducting. Temperature inversions are usually layers rather than sharp lines separating regions of different temperature.

On frequencies above 30 MHz, it is found that the troposphere has an increasing effect on radio signals and radio communications systems.

Tropospheric Scatter



In troposcatter propagation, when a signal is aimed towards the troposphere, some part of the radio signal is scattered back to the Earth due to forward scattering in the troposphere, only a small portion of the signal is scattered forward and reaches the receiver, a major part of the signal is either lost in space or reflects in other directions.

This mode of propagation allows over-the-horizon communications at vhf, uhf and microwave frequencies to be transmitted far beyond the normal line-of-sight. Scattering can take place at low altitudes, but mostly it is at about 10 miles.

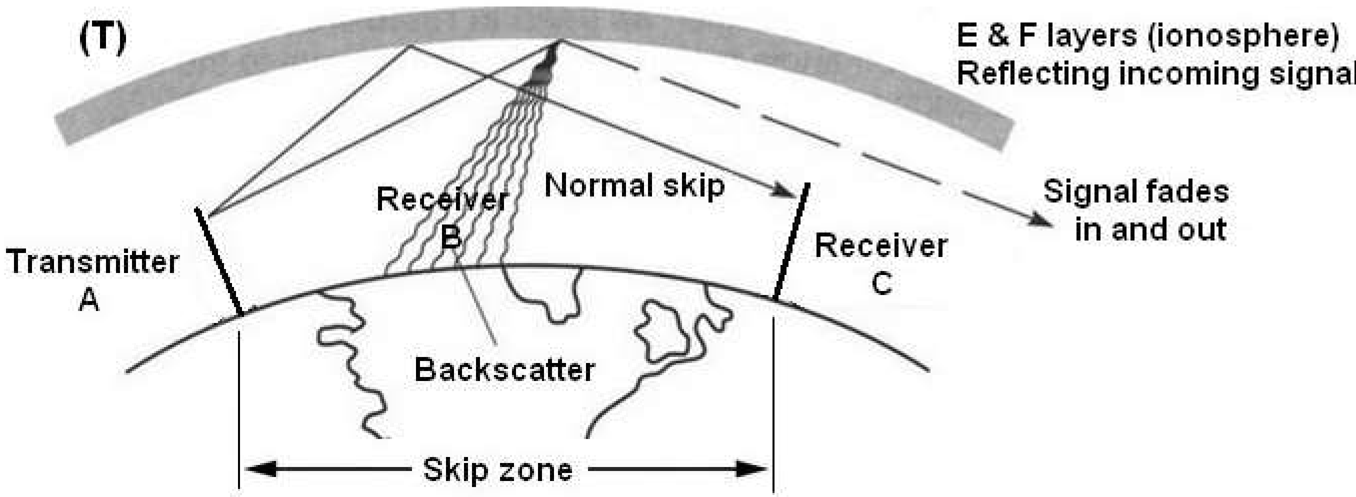
Troposcatter Communications are used for beyond line of sight (over the horizon) point to point communications between remote geographic areas where cable links are not feasible.

A troposcatter system has an antenna at both ends, capable of both transmitting and receiving signals, aimed at a fixed point in the troposphere slightly above the horizon.

To realize communication via troposcatter, over long distances, high-gain antenna, high-power transmitters, and sensitive receivers are a must as path loss is high.

(A) The antennas of the two stations at the ends of the path cannot "see" each other, but they can each "see" a common volume of the atmosphere, labeled in figure (A) as the “Common Scattering Volume” this is where the antenna beams intersect and is the area where the forward scattering phenomenon takes place.

BackScatter



Backscatter (or backscattering) is the reflection of waves, particles, or signals back to the direction from which they came.

Backscatter is a mode of propagation that allows a signal to be heard that would be inaudible when propagated via ‘normal’ methods.

The skip zone is the region between the point where the ground wave signals can no longer be heard and the point where the sky wave first returns to Earth.

(T) Backscatter allows communication within the skip zone.

Normally, station (B) is within skip zone and cannot hear transmitting station (A) by normal ionospheric propagation…

When backscatter is strong enough station B can hear station A, even though C is within the skip zone.

Backscatter is a typical F2-layer propagation mode but is also observed with E-layer propagation. Most of the time backscatter signals are not very strong.

1) Selective Fading: Is caused by partial cancellation of a radio signal by itself when the signal arrives at the receiver by two different paths, and at least one of the paths is changing (lengthening or shortening). Partial cancellation of some frequencies within the receiver passband.

2*)* Sudden ionospheric disturbance (SID): are often experienced on the HF or short wave bands where they may also be called blackouts…They can last from a few minutes to several hours.. Only effects the sunlit side of earth

A sudden ionospheric disturbance usually occurs in association with a solar flare and is seen only on the sunlit side of the earth….UV-rays and X-rays from a solar flare travel to earth at the speed of light (186,000 mi/sec) and greatly increase ionization level of the D-region with the lower frequencies more greatly effected

3) **Absorption:** Most radio waves pass freely through Earth's atmosphere.
However, some frequencies can be reflected or absorbed by the charged particles in the ionosphere.

Depending on the hour, the ionosphere either absorbs a signal or reflects it over the horizon.

Lower frequencies are absorbed the most so it is always advisable to use the highest frequency possible, particularly during the day when absorption is greatest.

D layer when ionized during daylight absorbs RF energy, the longer the wave the more the absorption, resulting in no sky wave on 80 and 160 meters during daylight hours.

4) Geomagnetic disturbances and solar flares increase absorption.
Noise level increase as signals decrease.
More pronounced for paths over the polar regions.

5) Ground conductivity refers to the electrical conductivity of the subsurface of the earth and it is measured in millisiemens per meter (mS/m).

Ground conductivity is an important factor in determining the field strength and propagation of surface wave (ground wave) radio transmissions.

Low frequency (30–300 kHz) and medium frequency (300–3000 kHz) radio transmissions are particularly reliant on good ground conductivity as their primary propagation is by surface wave. It also affects the radiation pattern of high frequency (3-30 MHz) antennas, as the so called "takeoff angle" is not an inherent property of the antenna but a result of a ground reflection.

The history behind this project ? The project started in 2018 when I met a member of Wing Command (Baliwag) Amateur Radio Club who after two or three attempts had not passed the NTC Class C amateur radio exam.

This got me thinking how could I help the club member and other Philippine radio amateurs pass the NTC amateur radio exams?

I first made multi choice questions for the Class C examination, the project was then expanded to include what is now contained in the PARE zip folder

Between 2004 – 2006, I sat and passed the NTC Class C (DW3EWA), Class B (DV3EWA) and Class A (4F3EW) amateur radio exams.

The information could contain errors and now for my get out of this clause.
"No responsibility can be taken for the content or any errors"

73 de John (age 80) - GM4DKO (Scotland) - 4F3EW (Philippines) – Dec 19 2022

An enjoyable project to help Philippine radio amateurs enjoy the hobby.