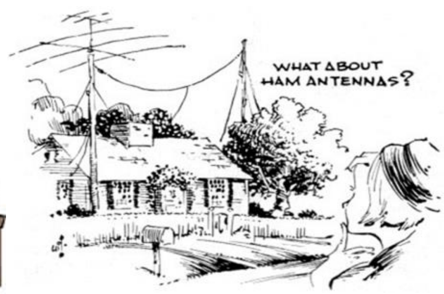
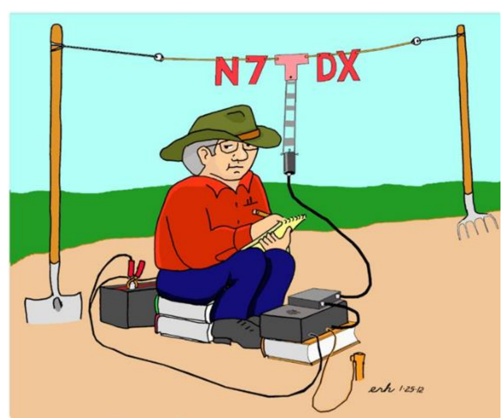
Basic Antenna Fundamentals
By
Michael McGuire
VK5ZC





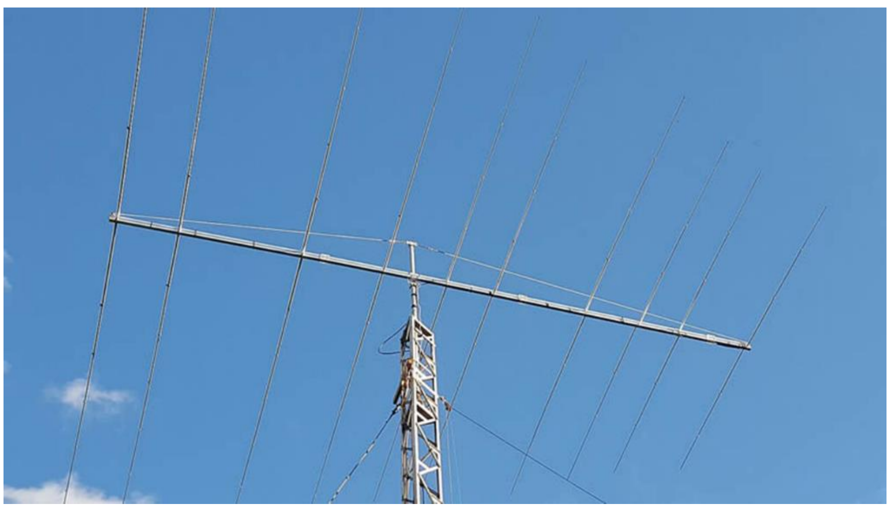
Contents

What is an antenna?



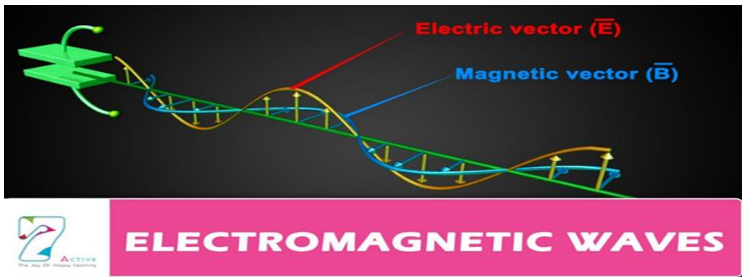
In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce an electric current at its terminals, that is applied to a receiver to be amplified.

Antennas are essential components of radio equipment, and are used in radio broadcasting, broadcast television, two-way radio, communications receivers, radar, mobile phones, satellite communications and other devices.

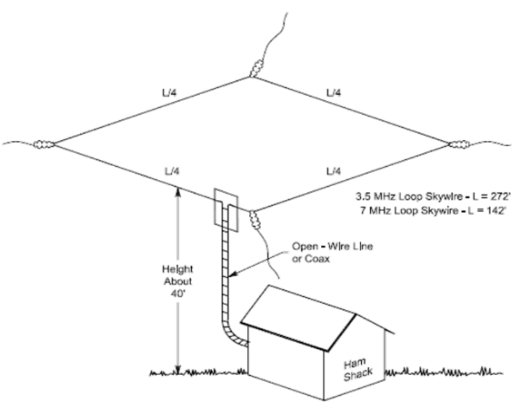


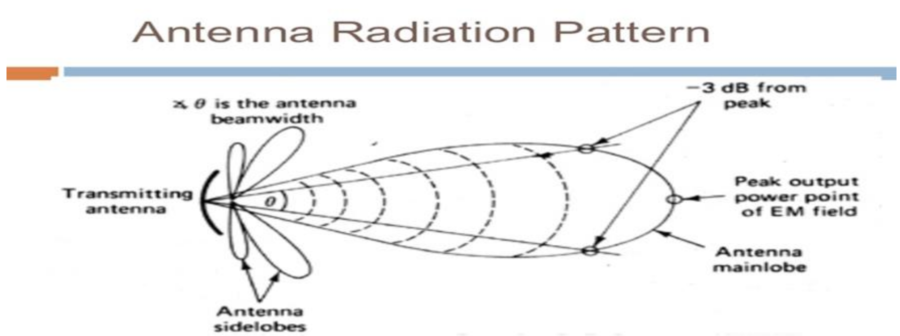
An antenna is an array of conductors (elements), electrically connected to the receiver or transmitter.

During transmission, the oscillating current applied to the antenna by a transmitter creates an oscillating electric field and magnetic field around the antenna elements. These time-varying fields radiate energy away from the antenna into space as a moving transverse electromagnetic field wave. Conversely, during reception, the oscillating electric and magnetic fields of an incoming radio wave exert force on the electrons in the antenna elements, causing them to move back and forth, creating oscillating currents in the antenna.

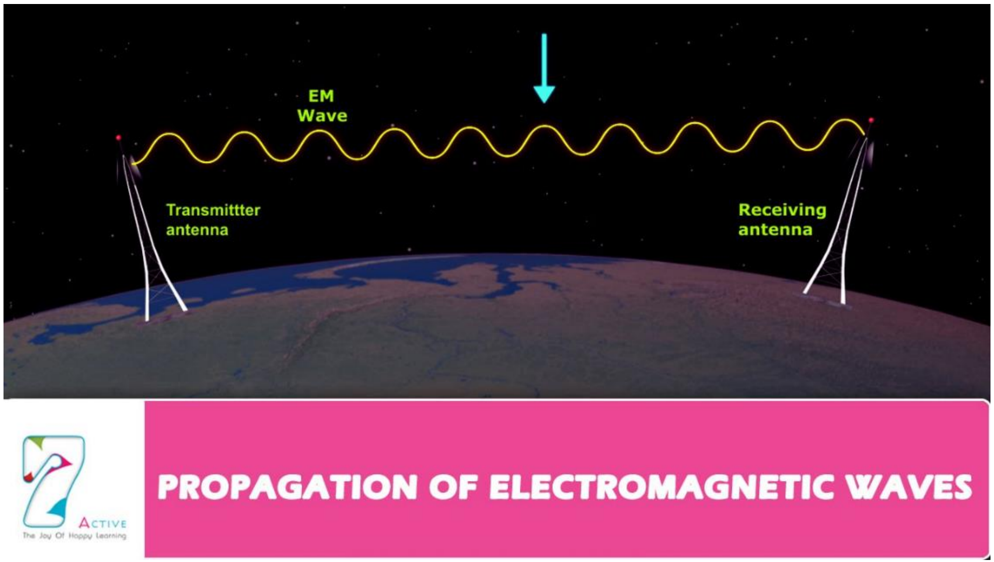


Antennas can be designed to transmit and receive radio waves in all horizontal directions equally (omnidirectional antennas), or preferentially in a particular direction (directional or high gain antennas).
An antenna may include parasitic elements, parabolic reflectors, which serve to direct the radio waves into a beam or other desired radiation pattern.

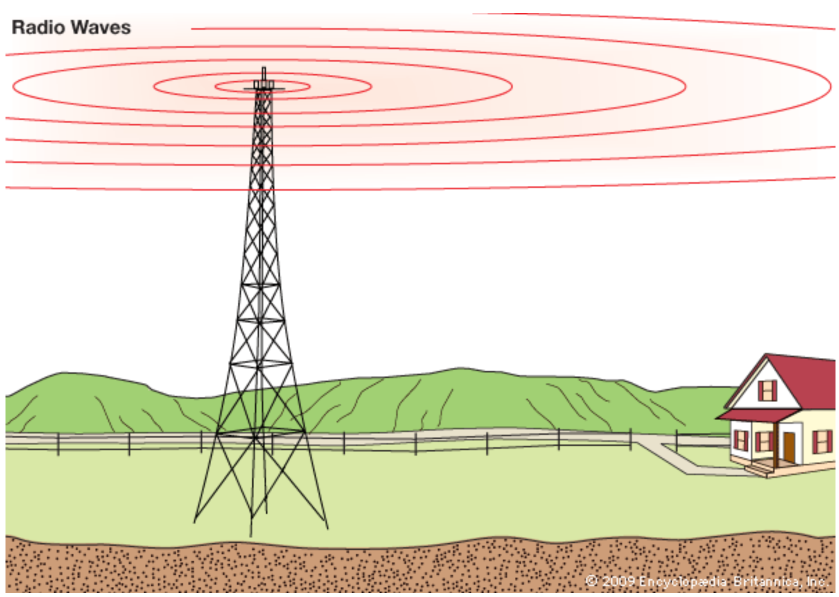




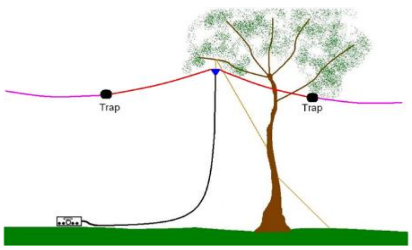
In radio, an antenna is the interface between radio waves propagating through space and, used with a transmitter or receiver.

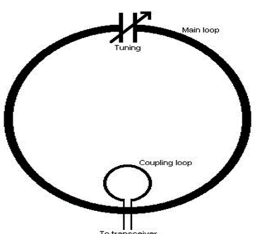


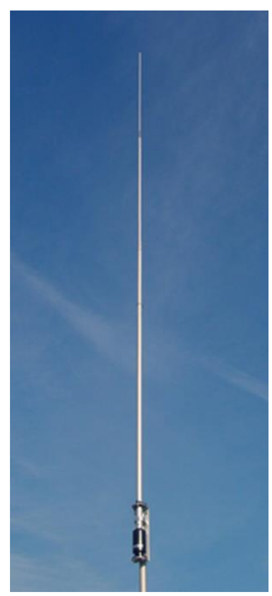
In transmission, a radio transmitter supplies an electric current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves).

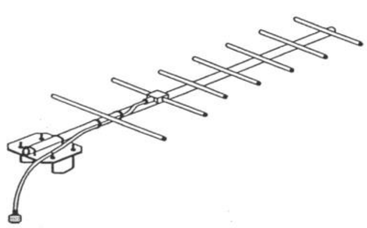


ANTENNA TYPES AND GENERAL USAGE









TYPES OF ANTENNAS

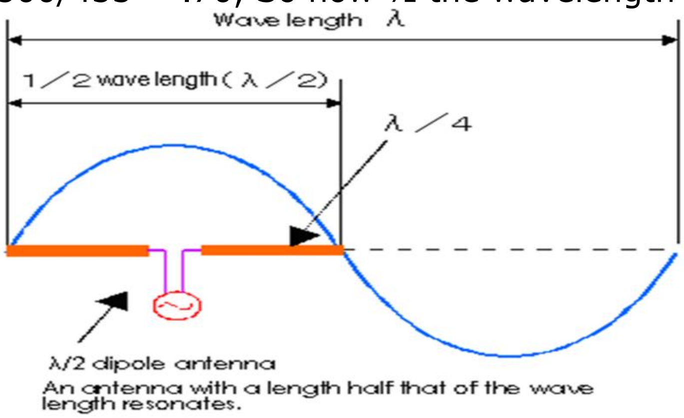
Antenna type	General usage
Whip & Vertical antennas	Antennas used for mobiles and base stations. Non-directional antenna with equal sensitivity in any direction.
Dipole antenna	Bi-directional antenna used for amateur radio and so on.
Yagi	Used as television antennas and so on. They have strong directivity, and must be aligned in the direction of the transmitting station. This is a dipole antenna with director and reflector elements attached to direct and reflect the radio wave.
Parabola antenna	Used for receiving satellite broadcasts. These antennas have very strong directivity and require fine directional adjustment, but they can use the power of the radio waves efficiently.
Loop antenna	Loop antennas capture the changes in the magnetic field of the radio waves. The radio waves propagate in the direction at right angles to the circle of the loop. Similarly, the receiving antenna is placed in such a way as to be perpendicular to the magnetic field of the radio waves.

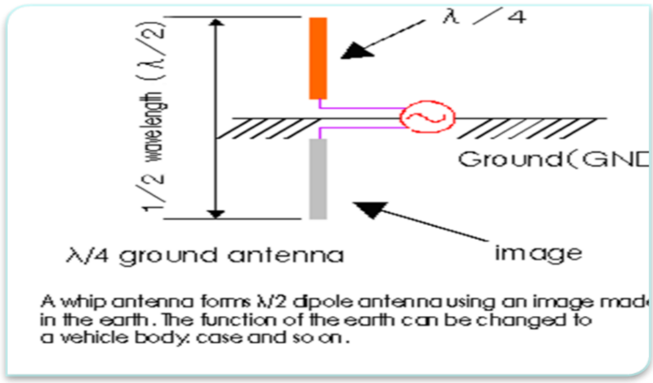
Video of Antenna fundamentals
Youtube
https://www.youtube.com/watch?v=7bDyA5t1ldU

The antenna mechanism.

In this modern era of wireless communication, many engineers are showing interest to do specialization in communication fields, but this requires basic knowledge of fundamental communication concepts such as types of antennas, electromagnetic radiation and various phenomena related to propagation, etc. In case of wireless communication systems, antennas play a prominent role as they convert the electronic signals into electromagnetic waves efficiently.

To calculate the wave length of a radio wave is speed of light 300,000,000 metres/sec ÷ frequency in MHz.
To simplify it we can use 300 / f (MHz) = λ (wavelength in metres).
An antenna which will be most efficient is an antenna with a length half the wave length of the frequency used.
For example, if you are using a frequency of 433 MHz, the wave length is about 70 cm, therefore an antenna with a length of about 35 cm will be most efficient.
300/433 = .70, So now ½ the wavelength would be about 35cm.

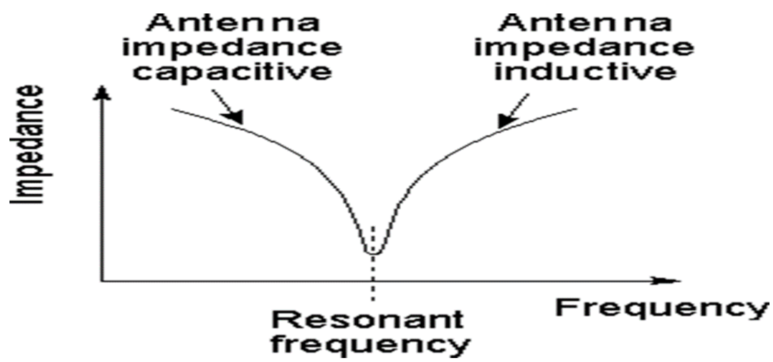




The transmitter must emit radio waves using limited power, and the receiver must capture efficiently the radio waves that are emitted.
With the antenna at this length, the antenna and transmitted radio waves achieve a resonant state and maximum power is emitted.
At the receiver too, the received radio waves and antenna achieve a resonant state, and can capture the maximum power. The antenna should be kept as straight as possible.
Today equipment tends to be compact, and antennas with a length ¼ (λ/4) that of the wave length are frequently used.
The thinking behind λ/4 ground antennas is the same as for λ/2 dipole antennas.
However, as the function of one side is changed to earth, the antenna length is halved making a 1/4 λ antenna.
For this reason, this earth is very important. The whip antennas of radio modules, mobile phones and so on use this mechanism, with the case serving the function of the ground.

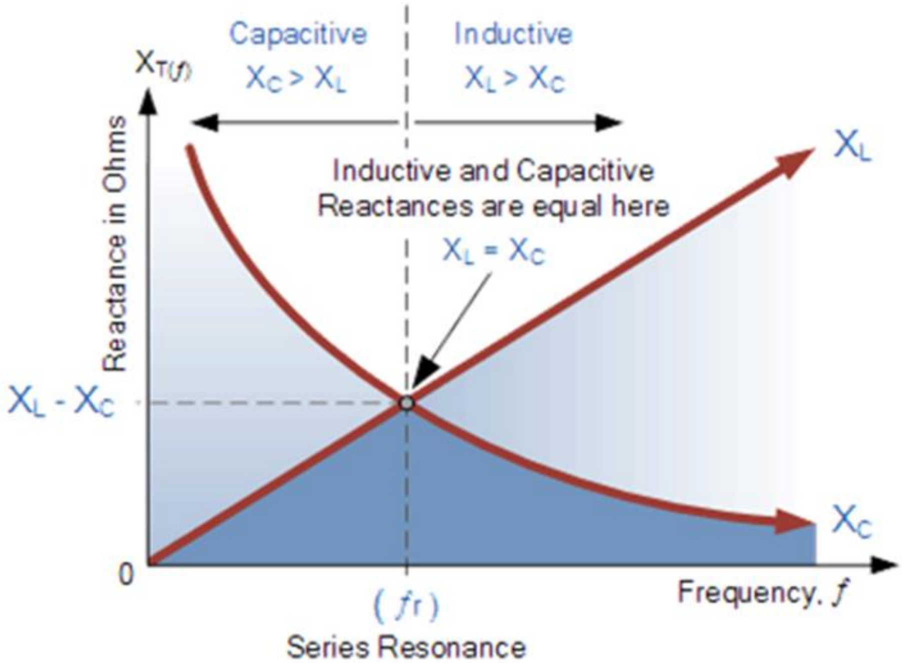
Antenna Resonance & Bandwidth

Two major factors associated with radio antenna design are the antenna resonant point or center operating frequency and the antenna bandwidth or the frequency range over which the antenna design can operate.
Whether the RF antenna is used for broadcasting, or any other application, the performance of the RF antenna is paramount, and the antenna resonant frequency and the antenna bandwidth are of great importance.



Antenna resonance

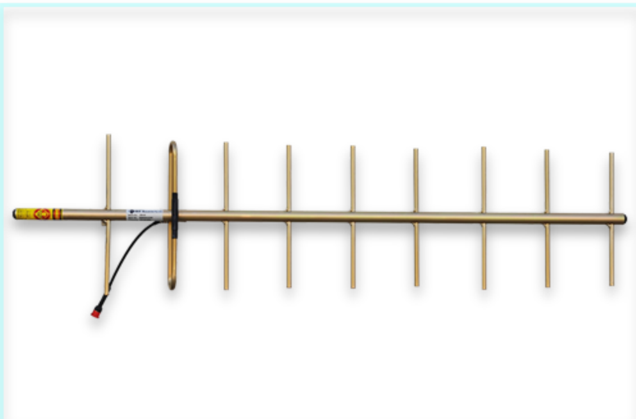
An RF antenna is a form of tuned circuit consisting of inductance and capacitance. As a result, it has a resonant frequency.
This is the frequency where the capacitive and inductive reactance's cancel each other out.
At this point the RF antenna appears purely resistive, the resistance being a combination of the loss resistance and the radiation resistance.



The capacitance and inductance of an RF antenna are determined by its physical properties and the environment where it is located.
The major feature of the RF antenna design is its dimensions.

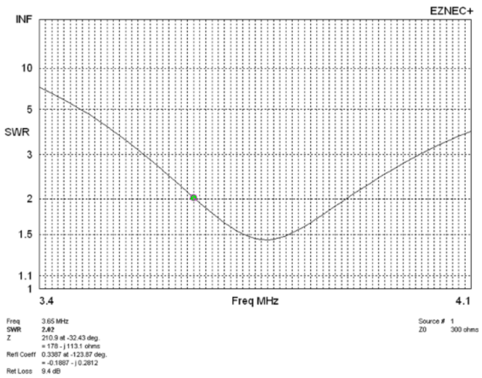
It is found that the larger the antenna or more strictly the antenna elements, the lower the resonant frequency.

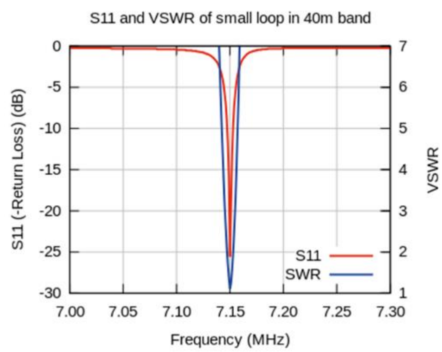
For example, antennas for UHF have relatively small elements, while those for VHF have larger elements indicating a lower frequency.
Antennas for short wave applications the elements are larger still.



Antenna bandwidth

Most RF antenna designs are operated around the resonant point.
This means that there is only a limited bandwidth over which an RF antenna design can operate efficiently. Outside this the levels of reactance rise to levels that may be too high for satisfactory operation. Other characteristics of the antenna may also be impaired away from the center operating frequency.





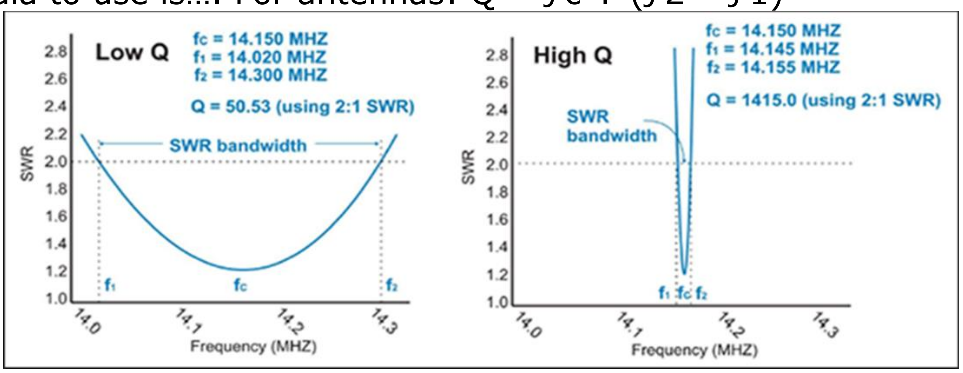
The antenna bandwidth is particularly important where radio transmitters are concerned as damage may occur to the transmitter if the antenna is operated outside its operating range and the radio transmitter is not adequately protected. In addition to this the signal radiated by the RF antenna may be less for a number of reasons.

For receiving purposes, the performance of the antenna is less critical in some respects. It can be operated outside its normal bandwidth without any fear of damage to the set. Even a random length of wire will pick up signals, and it may be possible to receive several distant stations. However, for the best reception it is necessary to ensure that the performance of the RF antenna design is optimum.

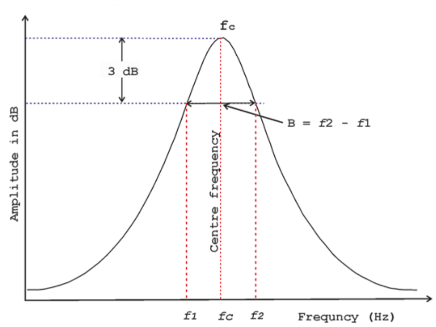
The "Q" Factor

You've probably heard the term "Q factor" tossed around in describing antennas. Maybe you haven't quite yet picked up on exactly what it means from a practical standpoint. Let's see if we can get at Q, or quality factor, as it relates to antenna circuits and amateur radio operations without reviewing any higher-level physics or higher-level math. When we're done, you'll have an intuitive understanding of Q that likely far exceeds that of the average ham!

Q factor has no units – no ohms or henry or amps or anything – just a number. And there's more than one way to calculate Q for an antenna.
The magical mathematical transformations provide us the following more practical definition of Q when applied to oscillators that have relatively high Q values, a simpler formula to use is…. For antennas: $Q = ƒc \div (ƒ2 - ƒ1)$



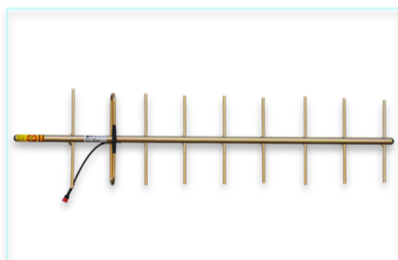
where $ƒc$ is the frequency of resonance (the center frequency to which the antenna is trimmed), and …$ƒ1$ and $ƒ2$ are the frequencies above and below the center frequency to which the antenna will operate, or achieve and acceptable value of SWR. (Properly, this is where the frequency results in 3 dB of power loss compared to the center frequency power transfer, but you can also use the frequencies where SWR increases to 2:1 as a practical comparison measure between antenna systems.)



Directional patterns of antennas

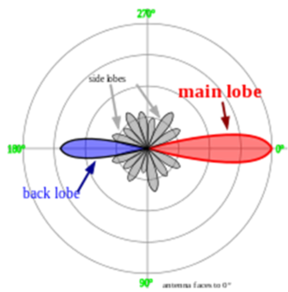
There are both directional antennas and non-directional antennas. Antennas with directivity are used in cases where the direction of the other party in communication is fixed. Directional antennas include Yagi arrays, parabola antennas and the like.

This avoids unwanted radio wave emission in the environment and does not pick up noise from other directions. It is convenient as it allows efficient transmission with low power. Radio waves radiating in a specific direction are called a beam.



Non-directional antennas radiate unwanted radio waves in the environment, and conversely pick up noise from every direction. However, communication is possible wherever the other party in communication goes, so they are suited to mobile applications. Non-directional antennas include vertical whip antennas and base station vertical antennas.

Naturally radio waves radiate in three dimensions, so we should also consider the directivity pattern when seen from the side too. The directional pattern diagrams show the relative intensity of the maximum field strength in any direction, thus indicating electric field directivity. In a radio antenna's radiation pattern, the main lobe, or main beam is the lobe containing the maximum power. This is the lobe that exhibits the greatest field strength. ... The other lobes are called "sidelobes" and usually represent unwanted radiation in undesired directions. The sidelobe in the opposite direction from the main lobe is called the "backlobe".



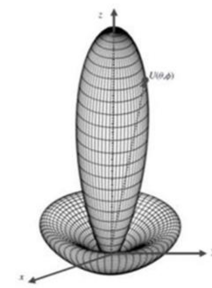
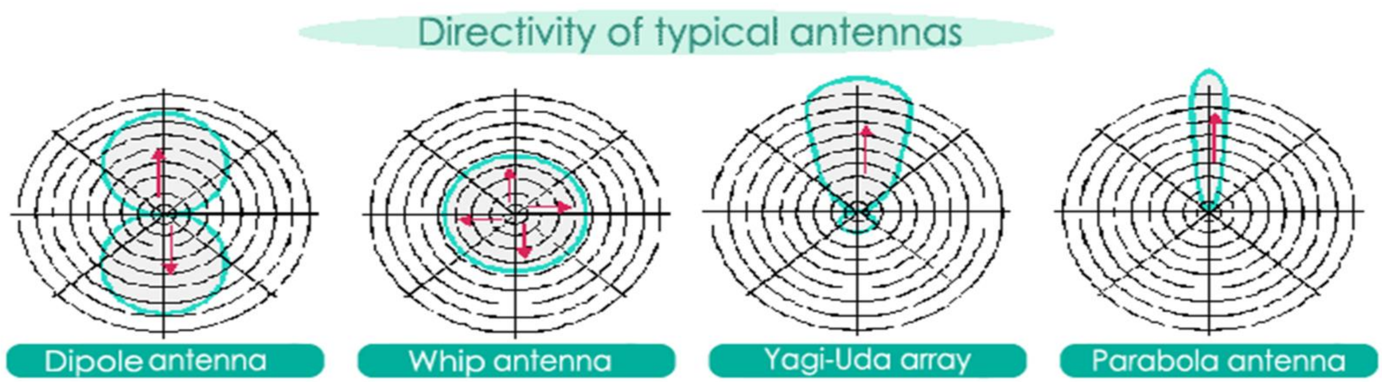


Figure 3 : Graphical representation of a Radiation Pattern

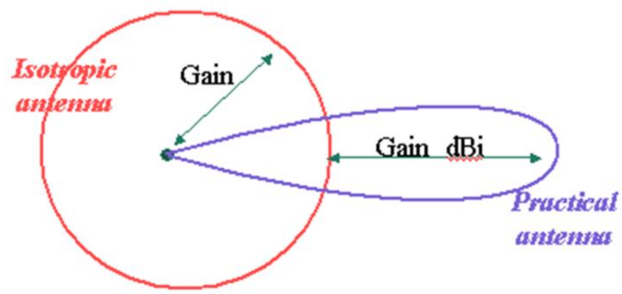
Directional antennas and non-directional antennas. A dipole antenna is called an omni-directional antenna, this radiates in two directions. In the diagram above, with the whip antenna the radio waves are radiating in every direction equally, so it is a non-directional antenna. With the Yagi array and parabola antenna, the radio waves are radiating in a specific direction, so they are said to be directional antennas (beam antennas).



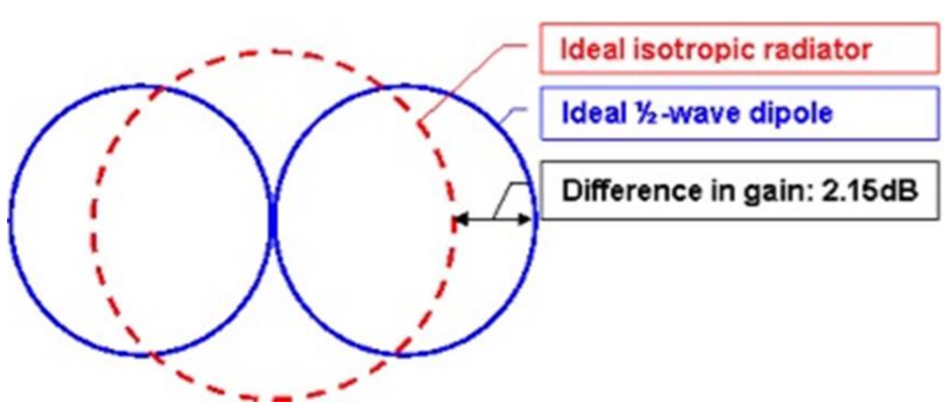
Video on Antenna Directivity
Youtube
https://www.youtube.com/watch?v=md7GjQQ2YA0

Gain of Antennas

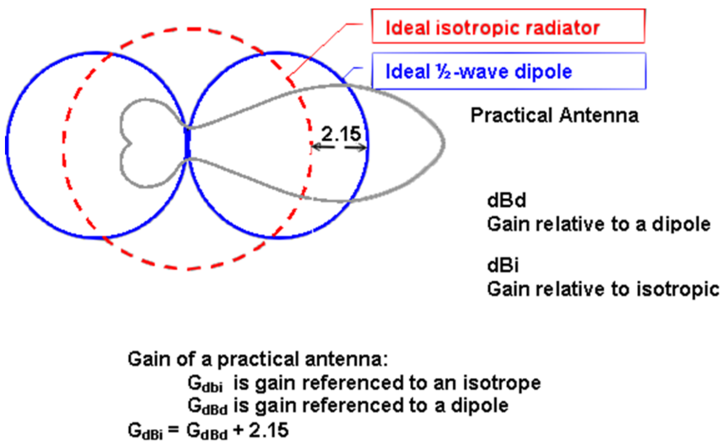
The parameter that measures the degree of directivity of antenna's radial pattern is known as gain. An antenna with a higher gain is more effective in its radiation pattern. Antennas are designed in such a way that power raises in wanted direction and decreases in unwanted directions.
G = (power radiated by an antenna)/ (power radiated by reference antenna)
When choosing an antenna, directivity and gain are concerns. Furthermore, depending on the specification. The unit of gain is expressed variously as dBd, dBi and it is difficult to decide on which to choose. Also, because the antenna is made of metal and there is no circuit for electrical amplification, the fact that there is gain may seem a little strange.



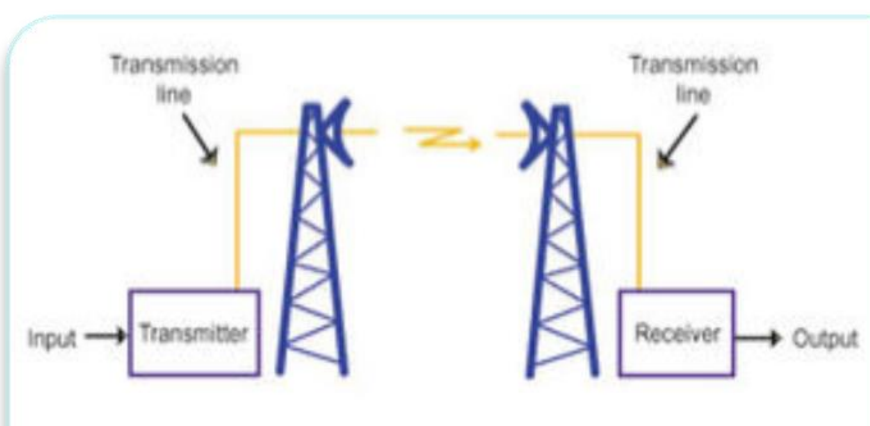
Antennas can concentrate input energy in a certain direction, but there are differences in the method of concentration according to the type and between different antennas. In other words, antennas that spread the input power in directions other than that of the other party in communication, and antennas with directivity that concentrate the power efficiently, show differences in range.
This difference is the difference of gain, and the higher the gain, the more acute directivity becomes, and this means that directional alignment becomes more difficult.
Antenna gain is expressed as the ratio of received power at the maximum electric field direction when the same power is input to an antenna under test and a reference antenna. To express antenna gain, there are two methods, one using an isotropic antenna as reference, the other using another type of antenna (usually a λ/2 half wave length dipole antenna) as reference.



When using an isotropic antenna as reference, the gain is called absolute gain, and the unit used is dBi. When using an ideal half wave length (λ/2) dipole antenna as reference, the gain is called relative gain, and the unit used is dBd.. With relative gain, the ratio of the absolute gain of the antenna used as reference, and the absolute gain of the antenna in question is equivalent. As the absolute gain of the half wave length (λ/2) dipole antenna used as reference is 2.15 dBi, the relative gain Gr dBd of an antenna with absolute gain of Ga dBi is found by relative gain Gr dBd = absolute gain Ga dBi – 2.15 dB.



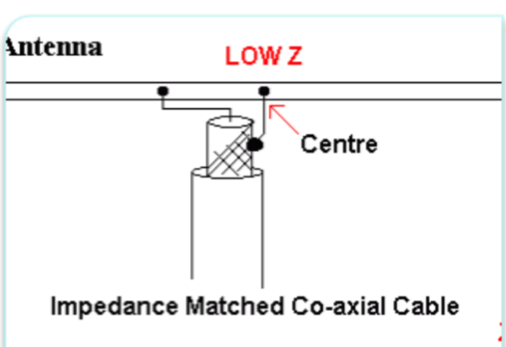
In other words, between dBd and dBi, the relationship 0 dBd = 2.15 dBi obtains. If an antenna specification is 2.15 dBi, it means that it is equivalent to an ideal half wave length dipole antenna. For antenna gain, the expressions dBd and dB mean the same thing, with dBd being the formal designation. Isotropic antennas are theoretic, formulaic, virtual antennas, that radiate radio waves in all directions with equal intensity, and that have spherical directivity



Impedance Matching

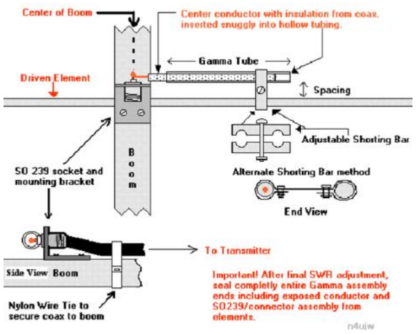
When connecting an antenna from a high frequency circuit it is necessary to transfer power efficiently and ensure that no problems arise with reflection of the radio waves. Reflection occurs when the signal source impedance and the impedance of the antenna do not match, and making them match is called impedance matching. Reflection means the situation in which part of the signal sent in the direction of the antenna returns towards the signal source, and if it combines with the incident signal, adverse effects may arise.

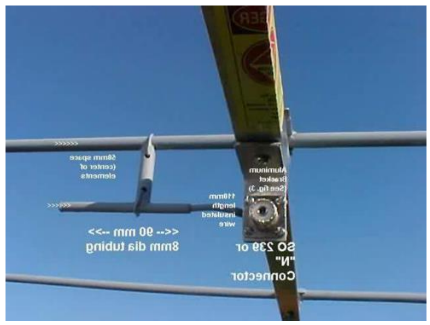
The specification of an antenna will always include “Input impedance: 50 Ω” or the like, so impedance matching should be implemented at the connection circuit to match this value. It is also necessary for the impedance of the cable used to match. The impedance of the cable is decided by the per unit impedance and capacitance, and the impedance of cables on the market will always be indicated.



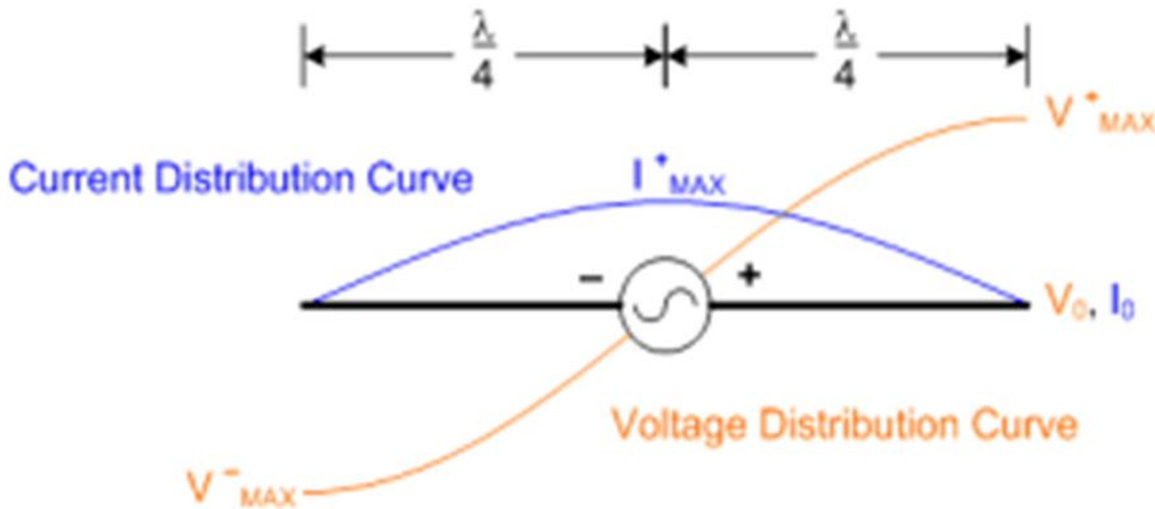
Gamma Matching

What is a gamma match, how does it work, and what is its purpose?
It's an adjustable device used for feeding and matching an antenna, usually the driven element of a beam, and usually to 50 Ohm coaxial cable. Its advantage over some other matching systems is that it may be used with the driven element of a beam antenna when the center of that driven element is directly grounded to the antenna boom. Most other feed systems require that the driven element be isolated from the boom. Using a gamma match eliminates the need for a balun, as it provides an unbalanced feed to the radiator, so the system that results is unbalanced-to-unbalanced (unbalanced coaxial cable to unbalanced driven element).
On the HF bands, the gamma match works very well because its component losses can be maintained very low. On the VHF bands, gamma matches can often be lossy as component Qs are lower, and on the UHF bands, they usually don't work well at all -- too much loss in the components. There are better, less lossy matching systems for the "very short" wave bands.



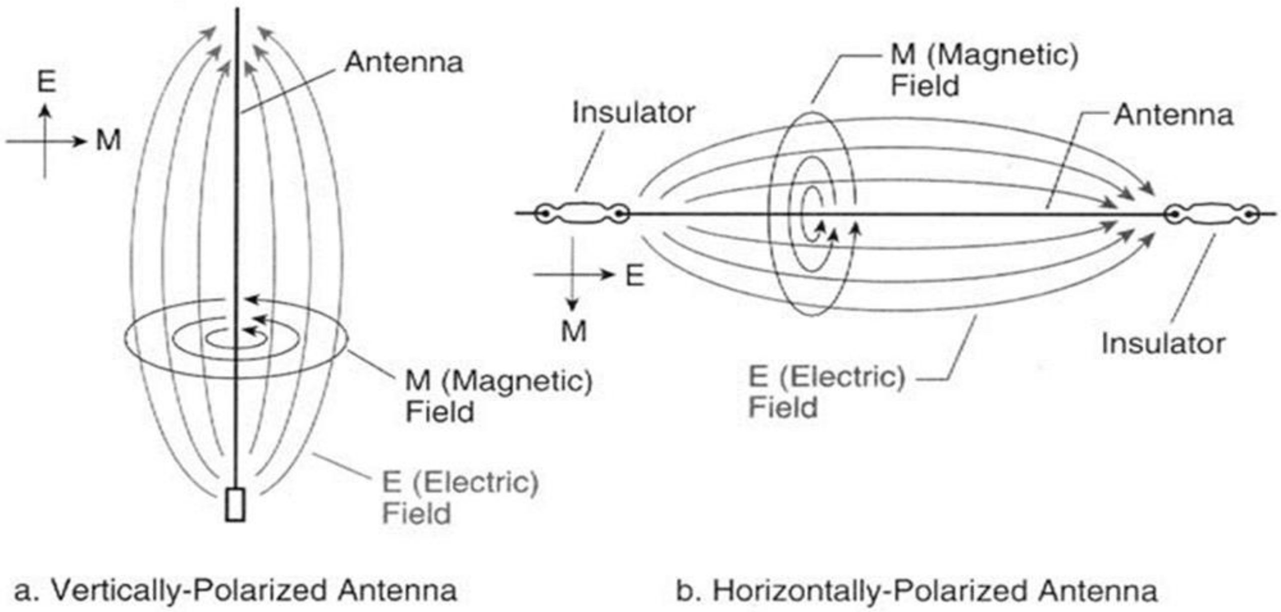



There are various methods of impedance matching. However, as it is a very involved subject, we would refer you to a specialist textbook.
We are looking for high voltage and low current high on the antenna.



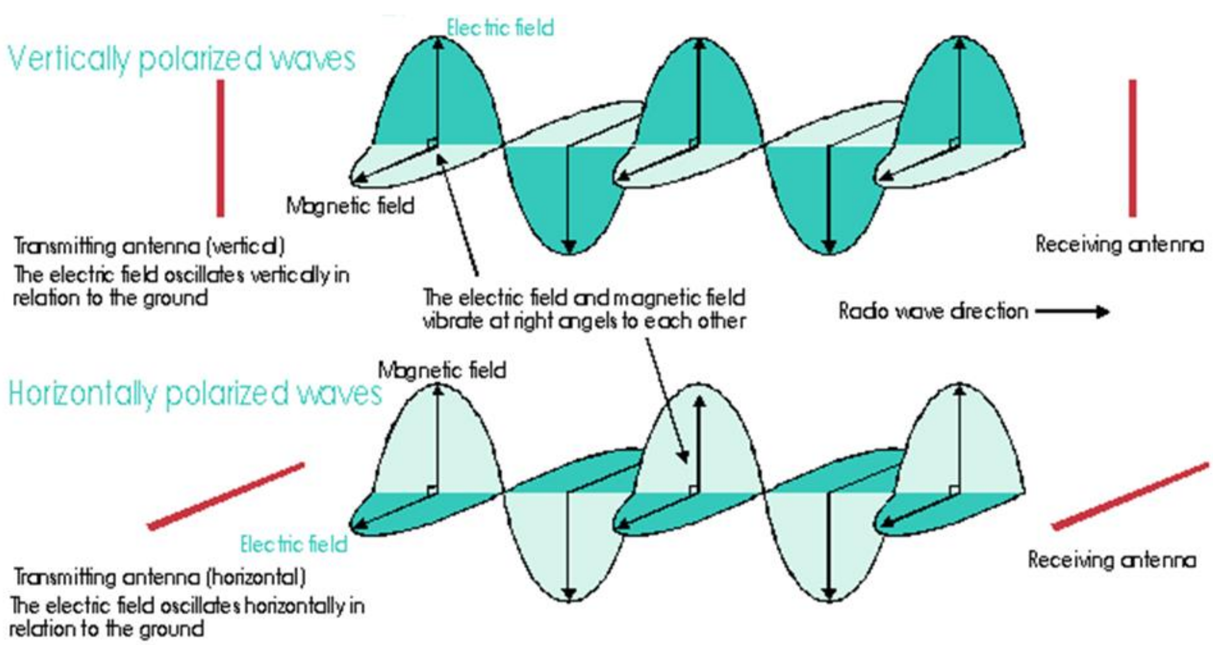
Horizontally and Vertically Polarized Waves

Polarization is an important factor for RF antennas and radio communications in general. Both RF antennas and electromagnetic waves are said to have a polarization.



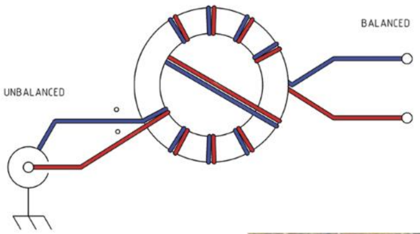
For the electromagnetic wave the polarization is effectively the plane in which the electric wave vibrates. This is important when looking at antennas because they are sensitive to polarization, and generally only receive or transmit a signal with a particular polarization.

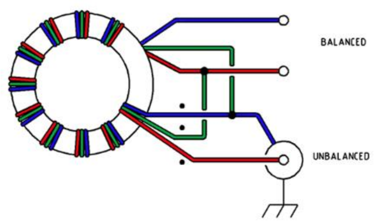
For most antennas it is very easy to determine the polarization. So, a vertical antenna (i.e. one with vertical elements) will receive vertically polarized signals best and similarly a horizontal antenna will receive horizontally polarized signals.

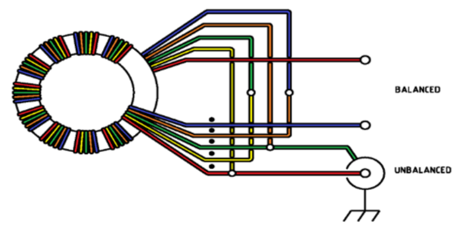


Balun Basics

Baluns are still a mystery to some radio amateurs and the only way to understand them is to learn what they are and how to use them.
The word balun means balanced-unbalanced.
It's used to adapt a balanced device to an unbalanced one and vice versa. In a balanced device (as most type of dipoles) we have the same voltage on both terminals in relation to common ground and if it's not the same, then it is an unbalanced device. A dipole with direct feed is balanced, whereas coaxial cable is unbalanced. For example, an antenna with a 200Ω impedance connected to a coaxial cable impedance of 50Ω we have a ratio 200:50 or 4:1.





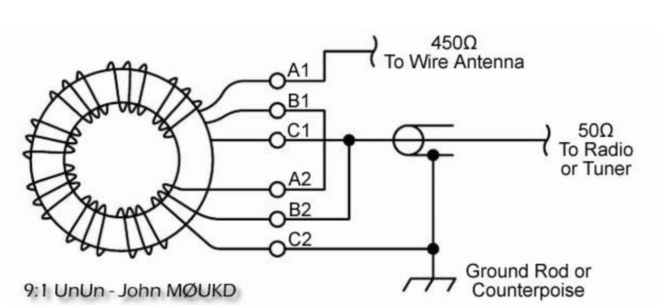


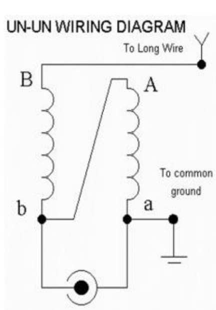


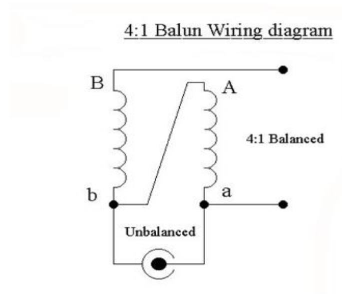


When is a Balun not a balun?
When it is an UNUN!

Balun = “BALanced-to-Unbalanced”, Unun = “UNbalanced-to-Unbalanced”
When we say a Balun or UNUN is a 4 to 1 device it will work just as well backwards. A 4 to1 balun can also match 50 Ohm to 12 Ohms, and a 9 to 1 can match 50 Ohm to 5 ohms. Working in the forward direction a 1Ω to 1Ω is 50Ω in 50Ω out. A '4 to 1' will convert the 50 ohms of your coax to 200 ohms ' ie 4 times’. A '9 to 1' will convert the 50 ohms of your coax to 450 ohms ' ie 9 times’.







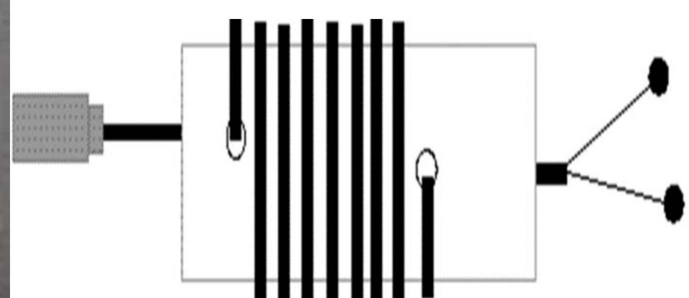
Looking at the two diagrams above you will see the common terminal for the Balun goes to the HOT terminal of the unbalanced side. whereas the common terminal in the UNUN goes to the COLD side of both the input and the output.

The Ugly Balun

However, if the two electrical circuit elements (antenna and coaxial cable) are coupled using a balun, balance will be maintained. Enter.....The Ugly Balun!..... When the connection is to a coaxial cable, WITHOUT A BALUN, this cannot occur because currents flowing inside the cable from the connection to the inner conductor are separated from those flowing on the outside from the connection to the shield, and the result is unbalance causing feeder radiation.

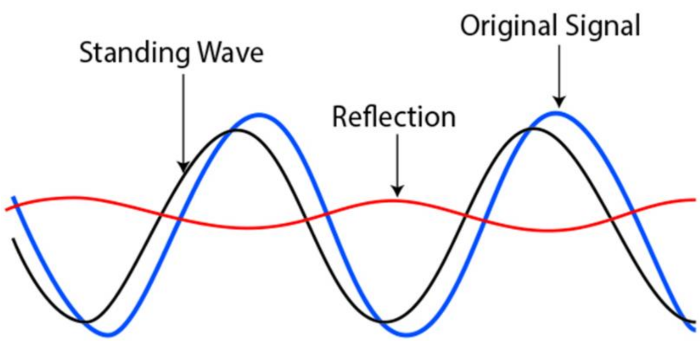
The Ugly Balun for VHF & UHF.
At 2 Metre VHF an Ugly Balun is construct with seven or eight turns of (RG58) coax cable close wound on a piece of 55 mm plastic pipe. The choke prevents radiation from the feed coax by presenting a high impedance to which tend to upset the radiation pattern. There are other methods (such as Ferrite materials) which have their own advantages. UHF will require fewer turns, low-band VHF will require more. It is important that the adjacent turns touch. Fix the ends with cable ties and seal with heat shrink or self-amalgamating tape.

Keep the “ugly little thing” away from metal supports or antenna elements.
The Ugly Balun for HF – 160 to 10 Metres. For the HF bands the Ugly Balun is made from six or seven metres of coaxial cable.
Close would on a piece of 75 or 90mm storm water drain pipe.



S.W.R.
Standing Wave Ratio

Standing-wave ratio (SWR) is a mathematical expression of the non-uniformity of an electromagnetic field (EM field) on a transmission line such as coaxial cable. Usually, SWR is defined as the ratio of the maximum radio-frequency (RF) voltage to the minimum RF voltage along the line. This is also known as the voltage standing-wave ratio (VSWR).



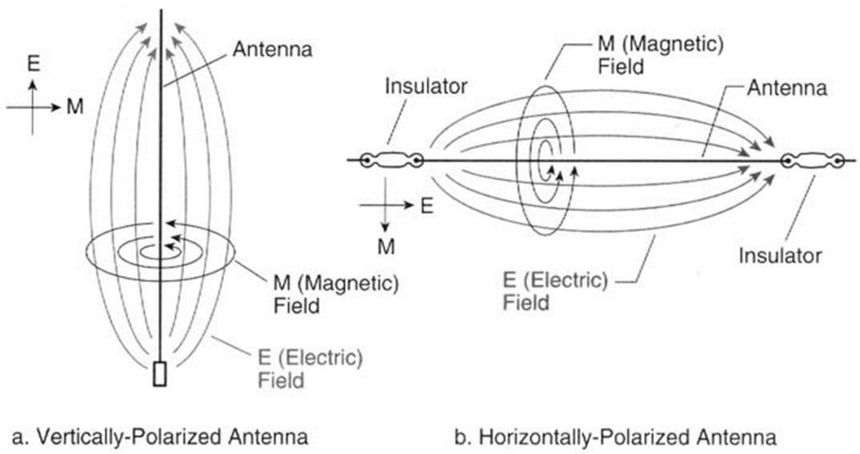
The SWR can also be defined as the ratio of the maximum RF current to the minimum RF current on the line current standing-wave ratio (ISWR). Under ideal conditions, the RF voltage on a signal transmission line is the same at all points on the line, neglecting power losses caused by electrical resistance in the line wires and imperfections in the dielectric material separating the line conductors.

The ideal VSWR is therefore 1:1.
When the Voltage SWR is 1, the Current SWR is also 1. This optimum condition can exist only when the load (such as an antenna or a wireless receiver), into which RF power is delivered, has an impedance identical to the impedance of the transmission line. This means that the load resistance must be the same as the characteristic impedance of the transmission line, and the load must contain no reactance (that is, the load must be free of inductance or capacitance). Various types of SWR meters.

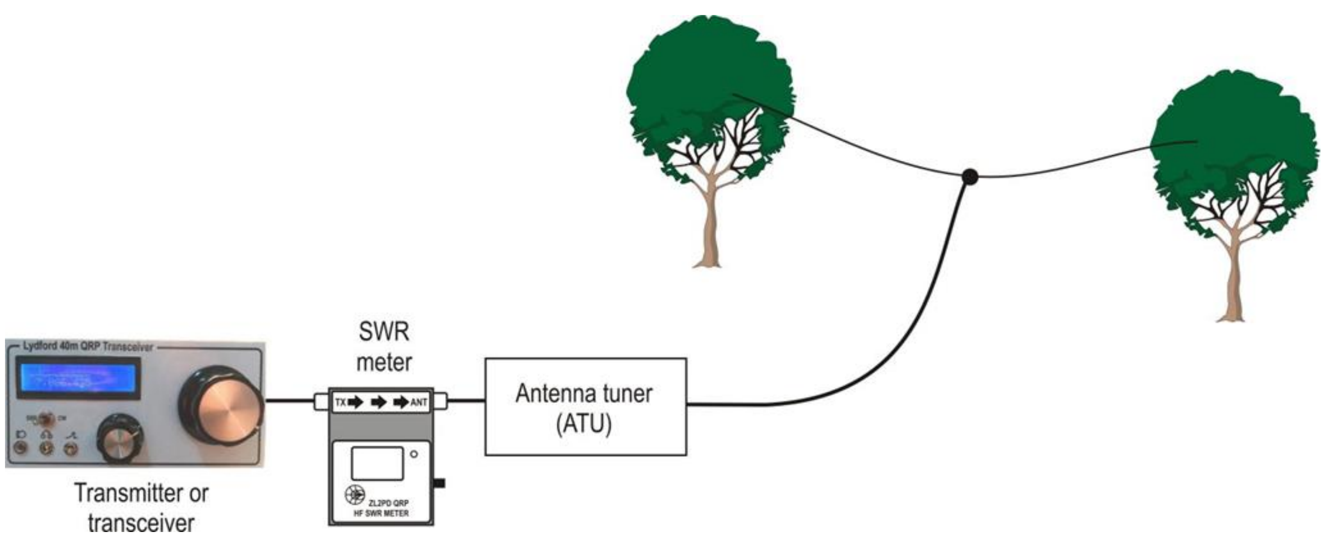
Video on SWR
Youtube

https://www.youtube.com/watch?v=w1eE13UXAKs&t=482s

In any other situation, the voltage and current fluctuate at various points along the line, and the SWR is not 1. When the line and load impedances are identical and the SWR is 1, all of the RF power that reaches a load from a transmission line is utilized by that load. When the load is an antenna, the utilization takes the form of EM-field radiation.

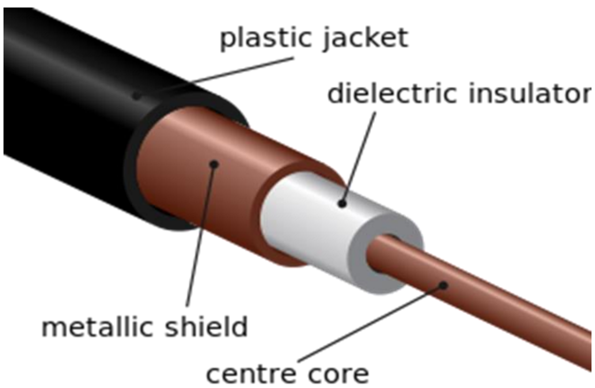


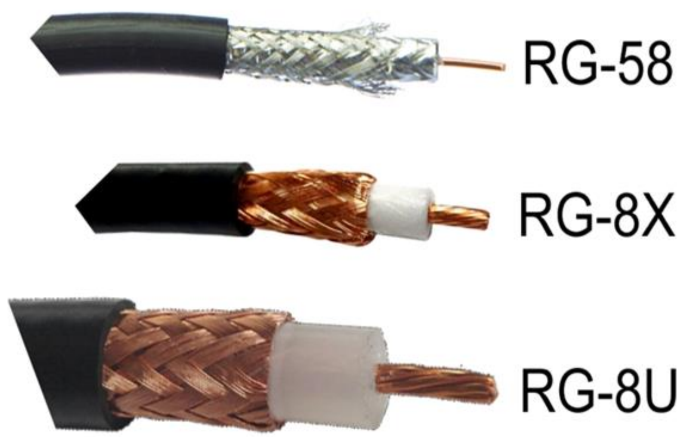
If the impedance of the load is not identical to the impedance of the transmission line, the load does not absorb all the RF power (called forward power) that reaches it. Instead, some of the RF power is sent back toward the signal source when the signal reaches the point where the line is connected to the load.
This is known as reflected power or reverse power.



Coaxial Cable & Feed Lines

Regardless of whether you are operating at HF, VHF or UHF, the quality of your feed line is critical to your station. The feed line (also called the transmission line) is the RF power conduit between your radio and your antenna. All the energy you generate travels to the antenna through the feed line. By the same token, all the signals picked up by your antenna must reach your radio through the same feed line.





The problem with any feed line is that it isn't perfect, it always loses a certain amount of the energy. To complicate matters, all feed lines are not created equal. The amount of loss at any frequency will vary considerably from one type of feed line to another.

Coax Loss Chart dB per 100 Feet

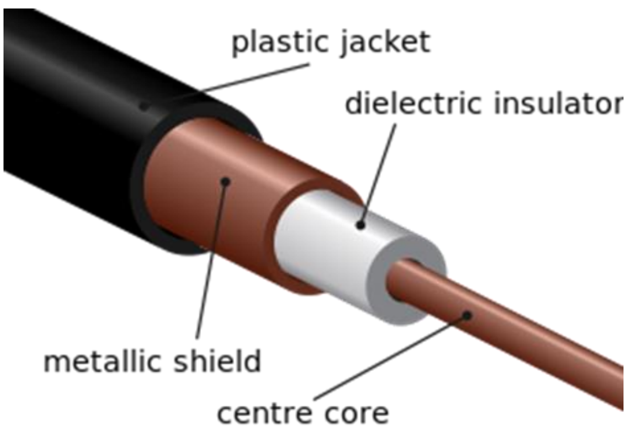
	RG-316	RG-58	RG-8X	LMR-240	RG-213	9913	LMR-400	Bury-Flex
3.5 MHz	1.5	.8	.65	.45	.3	.23	.2	.26
7 MHz	2.1	1.2	.85	.64	.5	.32	.3	.37
14 MHz	3.0	1.7	1.21	.91	.7	.46	.5	.53
28 MHz	4.2	2.4	1.74	1.29	1.00	.65	.7	.75
50 MHz	5.6	3.2	2.36	1.73	1.40	.88	.9	1.00
144 MHz	9.6	5.5	4.20	2.95	2.40	1.54	1.44	1.73
440 MHz	17	9.9	7.92	5.23	4.40	2.818	2.7	3.08
2400	41.4	24.8	22.80	12.65	12	7.48	6.6	7.63

www.qsradio.com

The most common type of feed line is coaxial cable, or simply coax.
It is called coaxial because there are two circular conductors positioned "co-axially" (on the same axis), one inside the other.

The inner conductor is usually called the "center conductor." It is surrounded by a solid or multistranded outer conductor commonly called a "shield." The shield is usually surrounded by an insulating plastic jacket. There is also insulating material between the center conductor and the shield. This material can be hard plastic, foam plastic or even air.

A popular type of feed line for HF use is ladder line. In fact, at HF frequencies it is the most common feed line for random-length dipoles and other antenna designs. Ladder line consists of nothing more than two wires in parallel separated by insulating material.



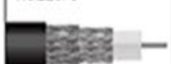
Feed lines also have a characteristic impedance value measured in ohms. Coaxial cable commonly used for Amateur Radio has an impedance of 50Ω while ladder line impedances can vary from 300Ω to 600Ω. One important factor of a coax cable in some applications is the wavelength of the signals travelling in it.

In the same way that the wavelength of a signal is the speed of light divided by the frequency for free space, the same is also true in any other medium. As the speed of the wave has been reduced, so too is the wavelength reduced by the same factor. Thus, if the velocity factor of the coax cable is 0.66, then the wavelength is 0.66 times the wavelength in free space.

In some instances, lengths of coax cable are cut to a specific length to act as an impedance transformed or a resonant circuit, then this needs to be taken into consideration when determining the required length of coax cable.

When rating feed lines for loss, we use "decibels (dB) per 100 feet." If you're not familiar with the decibel, don't worry. Just remember that the higher the decibel number, the greater the loss.

RG Coax Cable Applications

Cable Type	Impedance	Typical Application	Best feature	Trade Off
RG174/U 	50 Ohm	Transmission of data signals in applications such as LAN/WAN or GPS	Small diameter, flexible	Higher signal loss than larger diameter cable such as RG58
RG188A/U 	50 Ohm	Transmission of data signals in applications such as LAN/WAN or GPS in situations where high temperature performance is needed	Small diameter, flexible. High temperature rating of taped TFE outer jacket	Higher signal loss than larger diameter cable such as RG58 and higher cost than standard RG174
RG316/U 	50 Ohm	Transmission of data signals in applications such as LAN/WAN or GPS in situations where high temperature performance is needed	Small diameter, flexible. High temperature rating of extruded FEP outer jacket	Higher signal loss than larger diameter cable such as RG58 and higher cost than standard RG174
RG58C/U 	50 Ohm	Transmission of data signals in applications such as antenna feed cables or Ethernet backbones	Lower signal loss than smaller diameter cable such as RG174	Less flexible than smaller diameter cable such as RG174
RG142B/U 	50 Ohm	Transmission of data signals in applications such as antenna feed cables or Ethernet backbones in situations where high temperature performance is needed	Lower signal loss than smaller diameter cable such as RG174. High temperature rating of extruded FEP jacket	Less flexible than smaller diameter cable such as RG174 and higher cost than RG58C cable.
RG59A/U 	75 Ohm	Transmission of a video or audio signal in applications such as security systems or CATV	Lower signal loss than smaller diameter cable such as RG179. Flexibility of stranded center conductor cable	Higher signal loss than solid center conductor RG59B/U cable
RG59B/U 	75 Ohm	Transmission of a video or audio signal in applications such as security systems or CATV	Lower signal loss than smaller diameter cable such as RG179 and RG59A/U stranded center conductor cable	Less flexible than smaller diameter cable such as RG179 or stranded center conductor RG59A/U
RG6/U 	75 Ohm	Transmission of a video or audio signal in applications such as security systems or CATV	Lower signal loss than smaller diameter cable such as RG179 and both RG59A/U or RG59B/U cable	Less flexible than smaller diameter cable such as RG179 and both RG59A/U or RG59B/U
RG223/U 	50 Ohm	Transmission of data signals in applications such as LAN/WAN or GPS in situations where low signal loss and high shielding performance is needed	Lower signal loss and better shielding than smaller diameter cable such as RG174 or RG58C/U cables	Less flexible than smaller diameter cable such as RG174 and higher cost than single shielded RG58C cable
RG213/U 	50 Ohm	Transmission of data signals in applications such as antenna feed cables in situations where low signal loss and high operating voltage performance is needed	Lower signal loss and higher operating voltage than RG58C/U cable	Larger diameter and less flexible than RG58C/U cable
RG179B/U 	75 Ohm	Transmission of a video signal in applications such as security systems where high temperature performance is needed	Small diameter, flexible. High temperature rating of extruded FEP outer jacket	Higher signal loss and cost than larger diameter cable such as RG59
RG187/U 	75 Ohm	Transmission of a video signal in applications such as security systems where high temperature performance is needed	Small diameter, flexible. High temperature rating of TFE taped outer jacket	Higher signal loss and cost than larger diameter cable such as RG59

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The Velocity Factor

The velocity factor also called wave propagation speed or velocity of propagation of a transmission medium. It is the ratio of the speed at which a wave front or an electromagnetic signal, a radio signal, a light pulse in an optical fibre or a change of the electrical voltage on a copper wire passes through the medium, to the speed of light in a vacuum. The speed of radio signals in a vacuum, for example, is the speed of light, and so the velocity factor of a radio wave in a vacuum is unity, or 100%. In electrical cables, the velocity factor mainly depends on the insulating material.
The use of the terms velocity of propagation and wave propagation speed to mean a ratio of speeds is confined to the computer networking and cable industries. In a general science and engineering context, these terms would be understood to mean a true speed or velocity in units of distance per time, while velocity factor is used for the ratio.

Construction Specifications RG58A/U Stranded, 50 Ohm (7803)				
Centre Conductor	Tinned Copper, 19 Strand, each 0.18 mm			
Dielectric	Polyethylene (PE)			
Overall Braid	Tinned Copper			
Jacket	Black PVC, 4.95 mm outside diameter.			
Mechanical Specifications				
Minimum Bend Radius	12.7 mm			
Weight	3 kg per 100 metres			
Operating Temperature	-40°C to +85°C			
Electrical Specifications				
Impedance	50 Ohms			
Nominal Capacitance	93.5 pF/m			
Velocity of Propogation	66%			
Attenuation		Per 100 metres	**Maximum Power**	
Frequency	30 MHz	7.60 dB	10 MHz	1,000 Watts
	50 MHz	10.90 dB	50 MHz	425 Watts
	100 MHz	17.48 dB	100 MHz	290 Watts
	400 MHz	33.08 dB	200 MHz	190 Watts
	450 MHz	35.67 dB	400 MHz	105 Watts
	700 MHz	56.20 dB	1,000 MHz	60 Watts
	800 MHz	61.06 dB	3,000 MHz	25 Watts
	900 MHz	65.92 dB	5,000 MHz	20 Watts
	1,000 MHz	70.80 dB		

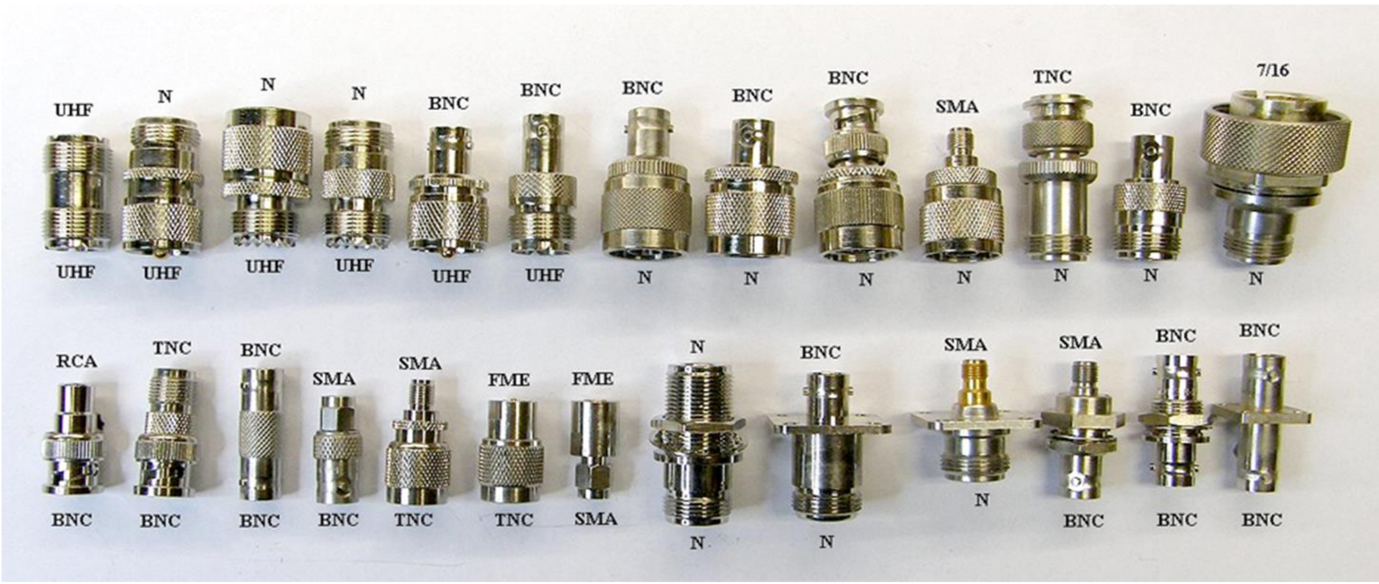
Construction Specifications, RF MAX RG213 Cable (7800)			
Centre Conductor	Bare Copper, 7 Strand x 0.75 mm		
Dielectric	Solid Polyethylene (PE), 7.24 mm diameter		
Outer Conductor	Bare Copper Braid		
Jacket	Black Polyethylene, 10.30 mm outside diameter		
Mechanical Specifications			
Minimum Bend Radius	55.5 mm		
Weight	15.3 kg per 100 metres		
Operating Temperature	-40°C to +85°C		
Electrical Specifications			
Impedance	50 Ohms (± 2 Ohms)		
Maximum Frequency	1 GHz		
Nominal Capacitance	100.7 pF/m		
Velocity of Propogation	66 %		
Attenuation		Per 100 metres	**Maximum Power**
Frequency	50 MHz	4.80 dB	1500 Watts
	100 MHz	6.68 dB	975 Watts
	400 MHz	14.19 dB	450 Watts
	700 MHz	22.00 dB	300 Watts
	900 MHz	26.57 dB	250 Watts
	1000 MHz	27.50 dB	230 Watts

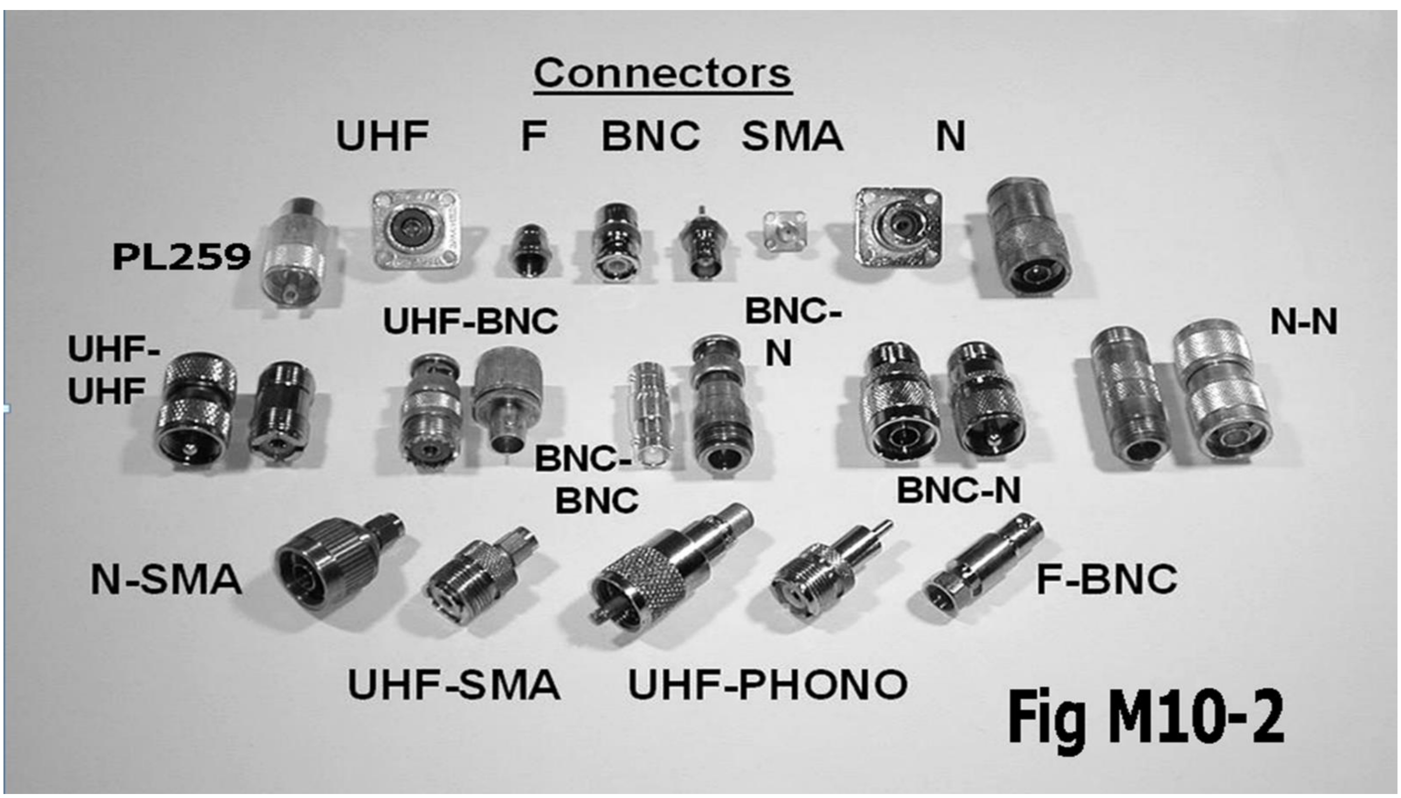
SRC Steel-Flex®		405	402
Center Conductor		Silver Plated Copper Clad Steel	Silver Plated Copper Clad Steel
Dimension	in. (mm)	.020 (.51)	.037 (.91)
Dielectric		PTFE .064	PTFE .117
Jacket		FEP .104	FEP .163
Min. Inside Bend	in. rad	0.5 in.	0.8 in.
Impedance	Ohm	50	50
Capacitance	pF/ft @ 1 GHz	29.4	29.4
Velocity of Propogation		70%	70%
Max Voltage	vrms	2,000	5,000
Frequency Range		.05 to 60GHz	.05 to 34GHz
Temperature range	°C	-65+200	-65+200
Shielding		>110	>110
Max Structural VSWR		1.20:1	1.20:1
Attenuation	(dB/100ft)		
	1GHz	21.7	11.2
	5GHz	47	27
	10GHz	69	41
	18GHz	95	58
	40GHz	165	
	60GHz	191	
Power	(W)		
	1GHz	160	550
	6GHz	50	220
	12GHz	40	150
	18GHz	30	120
	40GHz	10	
	60GHz	10	

Plugs and Connectors

A coaxial RF connector (radio frequency connector) is an electrical connector designed to work at radio frequencies in the multi-megahertz range. RF connectors are typically used with coaxial cables and are designed to maintain the shielding that the coaxial design offers.

Better models also minimize the change in transmission line impedance at the connection. Research activity in the area of radio-frequency (RF) circuit design has surged in the 2000s in direct response to the enormous market demand for inexpensive, high-data-rate wireless transceivers.





This training presentation was put together
By Michael McGuire VK5ZC.
All information in this booklet is available from the internet on various websites.