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ANTENNAS

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Abstract: *To explain the design of antenna both in software and hardware*

I. INTRODUCTION

An **antenna** is an electrical device which converts electric power into radio waves, and vice versa.[1] It is usually used with a radio transmitter or radio receiver. In transmission, a radio transmitter supplies an electric current oscillating at radio frequency (i.e. a high frequency alternating current (AC)) to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminals, that is applied to a receiver to be amplified.

Antennas are essential components of all equipment that uses radio. They are used in systems such as radio broadcasting, broadcast television, two-way radio, communications receivers, radar, cell phones, and satellite communications, as well as other devices such as garage door openers, wireless microphones, Bluetooth-enabled devices, wireless computer networks, baby monitors, and RFID tags on merchandise.

The first antennas were built in 1888 by German physicist Heinrich Hertz in his pioneering experiments to prove the existence of electromagnetic waves predicted by the theory of James Clerk Maxwell. Hertz placed dipole antennas at the focal point of parabolic reflectors for both transmitting and receiving.

II. Headings

1. Wire antennas:

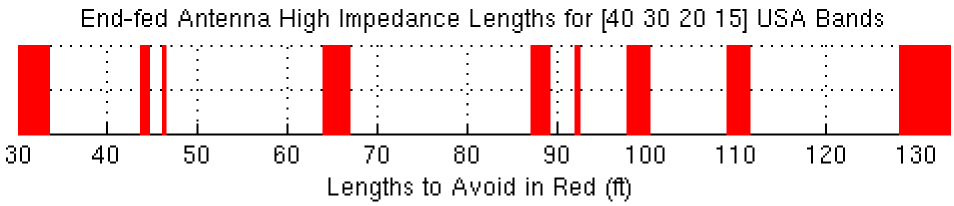
Wire antenna is a radio antenna consisting of a long wire suspended above the ground, whose length does not bear a relation to the wavelength of the radio waves used, but is typically chosen more for convenience. The wire may be straight or it may be strung back and forth between trees or walls just to get enough wire into the air; this type of antenna sometimes is called a zig-zag antenna. Such antennas are usually not as effective as antennas whose length is adjusted to resonate at the wavelength to be used. Random wire antennas are a type of monopole antenna and the other side of the receiver or transmitter antenna terminal must be connected to an earth ground.

They are widely used as receiving antennas on the long wave, medium wave, and short wave bands, as well as transmitting antennas on these bands for small outdoor, temporary or emergency transmitting stations, as well as in situations where more permanent antennas cannot be installed.

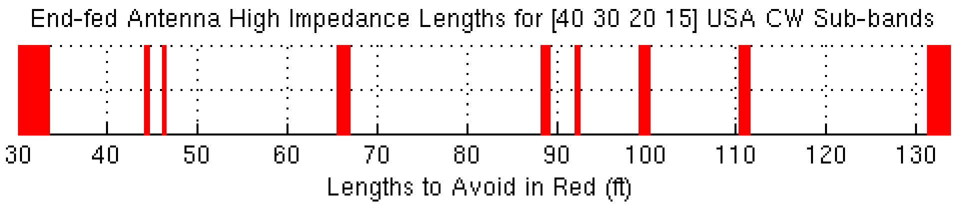
A so-called random wire antenna is an end fed antenna. As typically installed, it is a compromise antenna but great for portable use because it is easy to pack and easy to install. One end goes straight into the rig, often with no feedline, and the other end in the air attached to something as high as you can find. It is important to use a counterpoise. A standard recommendation (see QST, March 1936, p. 32, "An Unorthodox Antenna") is an 84' long end fed and a 17' long counterpoise (6.5' for 20m). While these lengths have been shown to work well on many bands, which is helpful if you're in a hurry to get on the air, read up on the topic and experiment.

Matlab code is here.
Again, the bands are USA, so change them for your country and favorite modes of operation. Even easier than the C code, in Matlab or Octave get a plot by simply putting the bands you're interested in a vector like the example below, by typing

```
>> rw([40 30 20 15])
```




```
>> rw([40 30 20 15], 'cw')
```



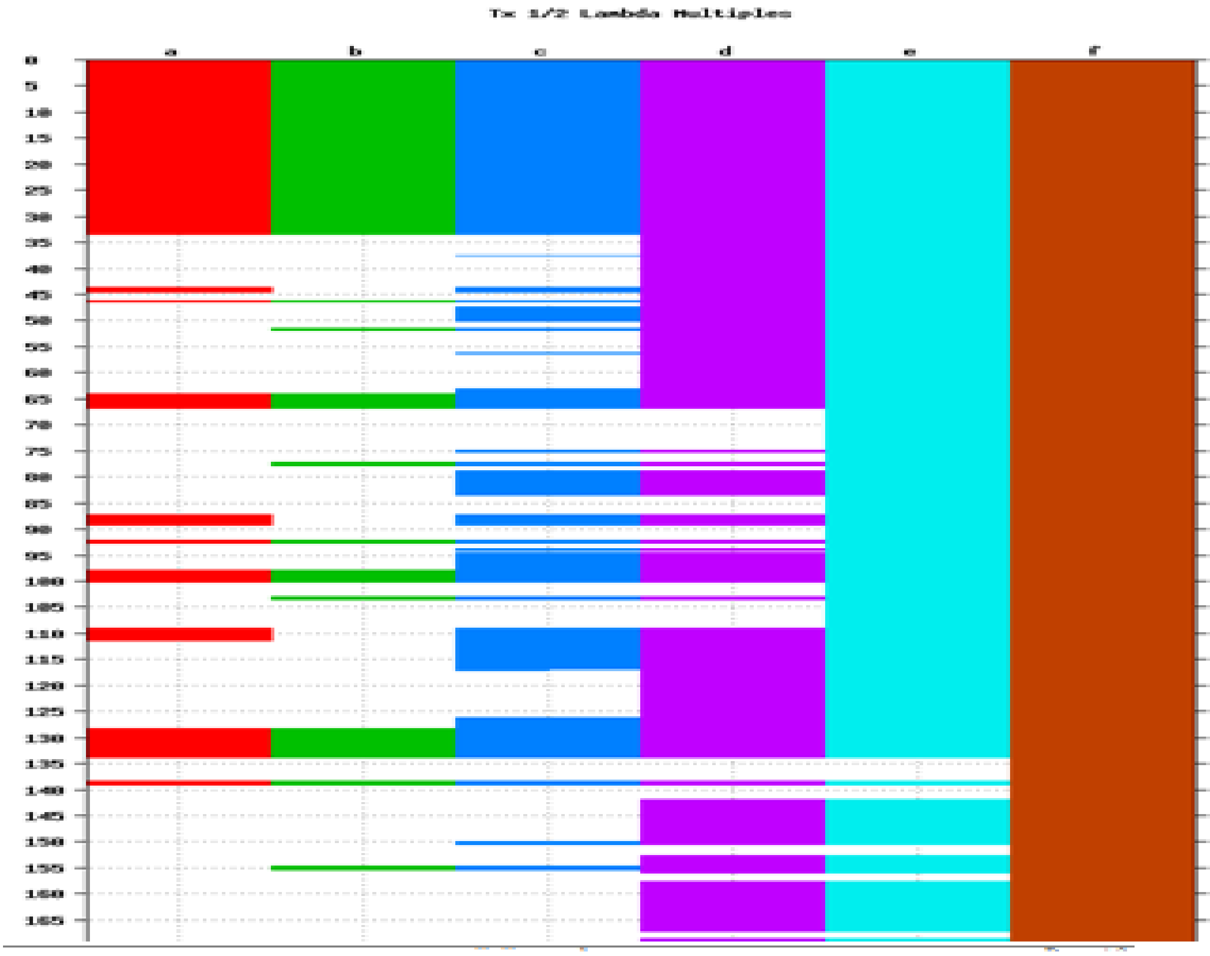
- Use a slide rule! It's an efficient way to get all the multiples doing the initial 468/f on C and D scales. Multiples are on C and answers on D - one setting.

The idea is that for a given ham band there are min and max frequencies which are easily converted to half wavelengths by the famous 468/f generally used by hams for dipole lengths. (QST, Oct 1926, "The Length of the Hertz Antenna" shows in line 2 of the table that a similarly installed random wire should use 423/f. W3EDP's results in the above referenced 1936 article, however, fall in line with 468/f and so is used here. Change the program to use 423 if desired.) In addition to multiples, wire lengths less than 1/4 wavelength of the lowest desired frequency are blocked out because an antenna should be at least that long.
Lengths to avoid are not always the same as ones recommended on VE3EED's page because I use all halfwave multiples, and of course different band combinations yield differ

Wire Lengths for Various Band Combinations

The graph below shows lengths to avoid for different collections of bands. The fewer bands, the fewer high impedance regions to avoid. You also want the antenna to be at least 1/4 wavelength long for each band you plan to use. For instance, to work 40m be sure the antenna is at least 10m or 33' long. Use only the white gaps for your antenna lengths, and if you're using different ham bands than in these examples, modify and rerun the program as I did, above, for my K1. If you want all the bands from 80m up, W3EDP's 84' antenna, 17' counterpoise is probably the way to go. Notice from column f that there is no length giving low impendance for all US ham bands. You have to give up a band or two, like 60m and 6m, as shown in the column e.
Band combinations in graph:

Group	USA Bands
a	40-30-20-15
b	40-30-20-17
c	40-30-20-17-15-12-10
d	80-40-30-20-17-15-12-10
e	160-80-40-30-20-17-15-12-10
f	160-80-60-40-30-20-17-15-12-10-6



2. Travelling wave antenna:

Traveling-wave antenna is a class of antenna that use a traveling wave on a guiding structure as the main radiating mechanism. Their distinguishing feature is that the radio-frequency current that generates the radio waves travels through the antenna in one direction. This is in contrast to a *resonant antenna*, such as the monopole or dipole, in which the antenna acts as a resonator, with radio currents traveling in both directions, bouncing back and forth between the ends of the antenna. An advantage of traveling wave antennas is that since they are nonresonant they often have a wider bandwidth than resonant antennas. Common types of traveling wave antenna are the Beverage antenna and the rhombic antenna.

3. Log-periodic antennas:

A **log-periodic antenna** (**LP**), also known as a **log-periodic array** or **aerial**, is a multi-element, directional, narrow-beam antenna that operates over a broad band of frequencies. The antenna normally consists of a series of dipoles positioned along the antenna axis, spaced at intervals following a logarithmic function of the frequency. It is normal to drive alternating elements with 180° (π radians) of phase shift from one another. This is normally done by connecting individual elements to alternating wires of a balanced transmission line. LP antennas are widely used with television receivers, especially in the VHF band. The log periodic antenna was invented by Dwight E. Isbell, Raymond DuHamel and variants by Paul Mayes.

4. Aperture Antennas:

Antenna aperture or **effective area** is a measure of how effective an antenna is at receiving the power of radio waves. The aperture is defined as the area, oriented perpendicular to the direction of an incoming radio wave, which would intercept the same amount of power from that wave as is produced by the antenna receiving it. At any point, a beam of radio waves has an *irradiance* or *power flux density (PFD)* which is the amount of radio power passing through a unit area. If an antenna delivers an output power of P_o watts to the load connected to its output terminals when irradiated by a uniform field of power density *PFD* watts per square metre, the antenna's aperture A_{eff} in square metres is given by:

$$A_{eff} = \frac{P_o}{PFD}.$$

5. Reflector Antennas:

An antenna **reflector** is a device that reflects electromagnetic waves. Antenna reflectors can exist as a standalone device for redirecting radio frequency (RF) energy, or can be integrated as part of an antenna assembly.

6. Microstrip Antennas:

This antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Microstrip antennas are relatively inexpensive to manufacture and design because of the simple 2-dimensional physical geometry. They are usually employed at UHF and higher frequencies because the size of the antenna is directly tied to the wavelength at the resonant frequency.

A. Installation Of Antenna For Regular Telivision Purpose:

*A **television antenna**, or **TV aerial**, is an antenna specifically designed for the reception of over-the-air broadcast television signals, which are transmitted at frequencies from about 41 to 250 MHz in the VHF band, and 470 to 960 MHz in the UHF band in different countries. Television antennas are manufactured in two different types: "indoor" antennas, to be located on top of or next to the television set, and "outdoor" antennas, mounted on a mast on top of the owner's house. The most common types of antennas used are the dipole[1] ("rabbit ears") and loop antennas, and for outdoor antennas the yagi and log periodic.*

To cover this range antennas generally consist of multiple conductors of different lengths which correspond to the wavelength range the antenna is intended to receive. The length of the elements of a TV antenna are usually half the wavelength of the signal they are intended to receive. The wavelength of a signal equals the speed of light (c) divided by the frequency. The design of a television broadcast receiving antenna is the same for the older analog transmissions and the digital television (DTV) transmissions which are replacing them. Sellers often claim to supply a special "digital" or "high-definition television" (HDTV) antenna advised as a replacement for an existing analog television antenna, even if satisfactory: this is misinformation to generate sales of unneeded equipmen.

Installation: Antennas are commonly placed on rooftops, and sometimes in attics. Placing an antenna indoors significantly attenuates the level of the available signal. Directional antennas must be pointed at the transmitter they are receiving; in most cases great accuracy is not needed. In a given region it is sometimes arranged that all television transmitters are located in roughly the same direction and use frequencies spaced closely enough that a single antenna suffices for all. A single transmitter location may transmit signals for several channels.

Analog television signals are susceptible to ghosting in the image, multiple closely spaced images giving the impression of blurred and repeated images of edges in the picture. This is due to the signal being reflected from nearby objects (buildings, tree, mountains); several copies of the signal, of different strengths and subject to different delays, are picked up. This is different for different transmissions. Careful positioning of the antenna can produce a compromise position which minimizes the ghosts on different channels. Ghosting is also possible if multiple antennas connected to the same receiver pick up the same station, especially if the lengths of the cables connecting them to the splitter/merger are different lengths or the antennas are too close together. Analog television is being replaced by digital, which is not subject to ghosting.

1) *Rooftop and other outdoor antennas*

Aerials are attached to roofs in various ways, usually on a pole to elevate it above the roof. This is generally sufficient in most areas. In some places, however, such as a deep valley or near taller structures, the antenna may need to be placed significantly higher, using a lattice tower or mast. The wire connecting the antenna to indoors is referred to as the *download* or *drop*, and the longer the download is, the greater the signal degradation in the wire.

The higher the antenna is placed, the better it will perform. An antenna of higher gain will be able to receive weaker signals from its preferred direction. Intervening buildings, topographical features (mountains), and dense forest will weaken the signal; in many cases the signal will be reflected such that a usable signal is still available. There are physical dangers inherent to high or complex antennas, such as the structure falling or being destroyed by weather. There are also varying local ordinances which restrict and limit such things as the height of a structure without obtaining permits. For example, in the USA, the Telecommunications Act of 1996 allows any homeowner to install "An antenna that is designed to receive local television broadcast signals", but that "masts higher than 12 feet above the roof-line may be subject to local permitting requirements.

2) *Indoor antennas*

As discussed previously, antennas may be placed indoors where signals are strong enough to overcome antenna shortcomings. The antenna is simply plugged into the television receiver and placed conveniently, often on the top of the receiver ("set-top"). Sometimes the position needs to be experimented with to get the best picture. Indoor antennas can also benefit from RF amplification, commonly called a TV booster. Indoor antennas will never be an option in weak signal areas.

3) *Attic installation*

Sometimes it is desired not to put an antenna on the roof; in these cases, antennas designed for outdoor use are often mounted in the attic or loft, although antennas designed for attic use are also available. Putting an antenna indoors significantly decreases its performance due to lower elevation above ground level and intervening walls; however, in strong signal areas reception may be satisfactory.[7] One layer of asphalt shingles, roof felt, and a plywood roof deck is considered to attenuate the signal to about half.

It is sometimes desired to receive signals from transmitters which are not in the same direction. This can be achieved, for one station at a time, by using a rotator operated by an electric motor to turn the antenna as desired. Alternatively, two or more antennas, each pointing at a desired transmitter and coupled by appropriate circuitry, can be used. To prevent the antennas interfering with each other, the vertical spacing between the booms must be at least half the wavelength of the lowest frequency to be received (Distance=λ/2).[9] The wavelength of 54 MHz (Channel 2) is 5.5 meters (λ x f = c) so the antennas must be a minimum of 2.25 metres, or about 89 inches apart. It is also important that the cables connecting the antennas to the signal splitter/merger be exactly the same length, to prevent phasing issues, which cause ghosting with analog reception. That is, the antennas might both pick up the same station; the signal from the one with the shorter cable will reach the receiver slightly sooner, supplying the receiver with two pictures slightly offset. There may be phasing issues even with the same length of down-lead cable. Bandpass filters or "signal traps" may help to reduce this problem. For side-by-side placement of multiple antennas, as is common in a space of limited height such as an attic, they should be separated by at least one full wavelength of the lowest frequency to be received at their closest point. Often when multiple antennas are used, one is for a range of co-located stations and the other is for a single transmitter in a different direction.

III. INDENTATIONS AND EQUATIONS

1. The basic formula for determining the length of a center fed, half-wave wire ***Dipole*** or ***Inverted Vee*** antenna is:
468 ÷ freq (mHz) = Length (feet).

2. **The Gain of an antenna with losses is given by:**

$$G = \frac{4\pi\eta A}{\lambda^2}$$

Where η = Efficiency
A = Physical aperture area
λ = wavelength

Another is:

$$G = \frac{X\,\eta}{BW_\phi\, BW_\theta}$$

Where $BW_{\theta and \phi}$ are the elev & az beamwidths in degrees.
For approximating an antenna pattern with:
(1) A rectangle; $X = 41253$, $\eta_{typical} = 0.7$
(2) An ellipsoid; $X = 52525$, $\eta_{typical} = 0.55$

3. The far-field range was the original antenna measurement technique, and consists of placing the AUT a long distance away from the instrumentation antenna. Generally, the far-field distance or Fraunhofer distance, *d*, is considered to be

$$d = \frac{2D^2}{\lambda},$$

4. The formula for electromagnetic radiation dispersion and information is:

$$D^2 = \frac{P}{S} \propto 3dB$$

Where D=Distance, P=Power, and S=Speed

5. $$\tilde{n} = \frac{P_r}{P_r + P_l}$$

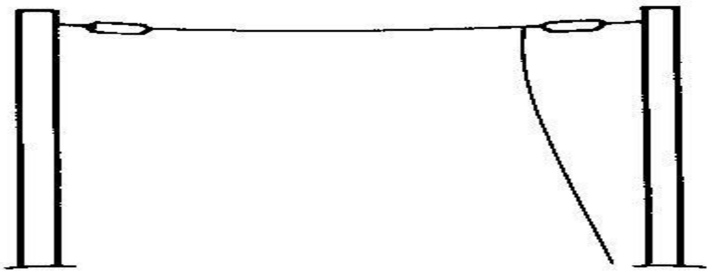
IV. FIGURES AND TABLES

TABLE II — MEASURED RETURN LOSS, SIDE LOBE LEVEL, CROSS-POLAR LEVEL, GAIN AND CALCULATED HPBW WITH RESPECT TO RESONATING FREQUENCIES

Antenna	Resonating Frequency in GHz	Minimum Return loss in dB	Side lobe level in dB	Cross-polarization level in dB	Gain in dB	HPBW	Input Impedance
Antenna 1	10.63	-27.5	-10	-10	6.26	11^0	$53.61+j1.89$
	12.74	-25	-7	-10	3.14	18^0	$45.45+j2.11$
	14.63	-20	---	-14	---	Split Beam	$43.22+j6.79$
Antenna 2	6.87	-18.42	Mutual Coupling	-5	---	Mutual Coupling	$51.21- j13.97$
	8.44	-24.41	---	-11	---	Split Beam	$63.30-j3.48$
	10.47	-13.01	---	-16	8.76	12^0	$51.56+j176.0$
	12.47	-38.38	---	-14		Split Beam	$46.84+j5.15$
	14.15	-23.41	-8	-10	6.74	23^0	$50.47+j1.42$
	16.56	-18.78	---	-12	---	Split Beam	$46.35- j12.66$
Antenna 3	4.49	-23.96	----	-13	---	Split Beam	$52.59-j6.39$
	7.32	-29.52	----	-7	---	Split Beam	$46.74- j1.28$
	9.49	-21.73	-17	-12	5.84	43^0	$42.52+ j2.31$
Antenna 4	4.35	-31.37	Omni-directional	-15	10.62	115^0	$52.77+ j92.59$
	6.03	-43.06	Omni-directional	-20	15.17	19^0	$52.18+ j2.58$

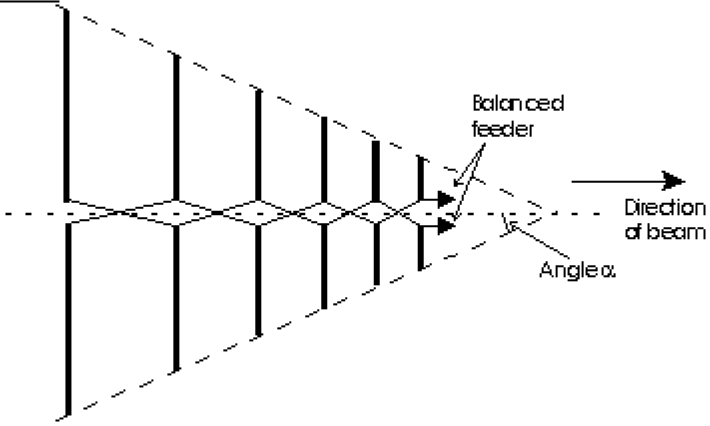
Below Are the List of Figures of Some Antennas

1. <u>WIRE ANTENNA</u>

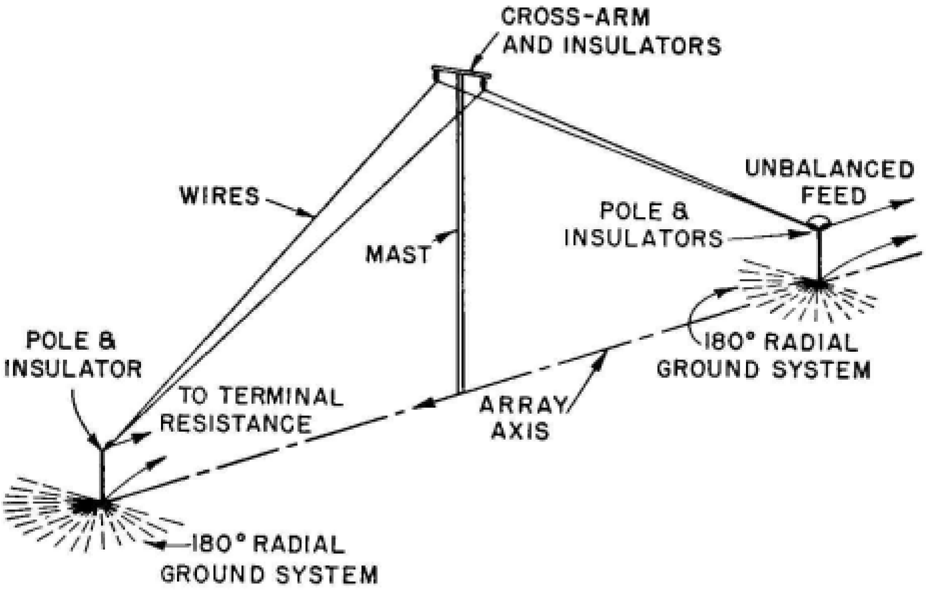


Long Wire Antenna TAA6030_

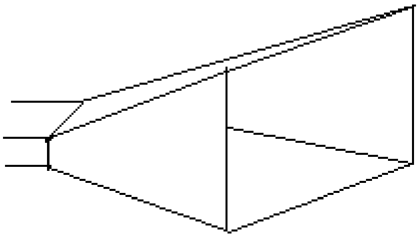
<u>Log-Periodic Antennas</u>



Travelling Wave Antennas



Aperture Antennas

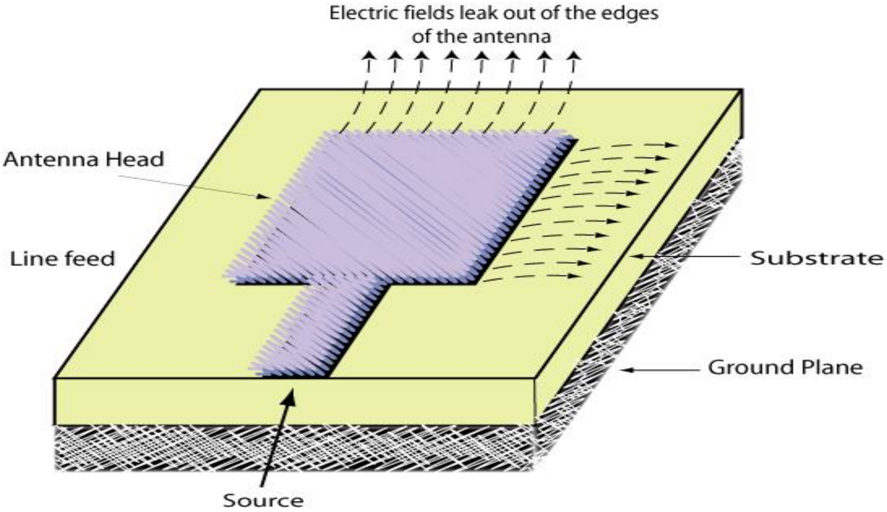


Horn Antenna

www.analyzemath.com

Reflector Antennas

Microstrip Antennas



Antenna Classification

Antenna can be classified on the basis of:
1. Frequency - VLF, LF, HF, VHF, UHF, Microwave, Millimeter wave antenna
2. Aperture - Wire, Parabolic Dish, Micro strip Patch antenna
3. Polarization - Linear (Vertical/Horizontal),Circular polarization antenna
4. Radiation - Isotropic, Omnidirectional, Directional, Hemispherical antenna

V. Conclusion

APPLICATIONS:

1. Increased Range and Users

- The range of a smart antenna is larger than that of a regular antennae because it focuses on specific communication devices. With a high number of frequencies available, the antenna can be used by more users. It takes fewer smart antennas than regular antennas to service the same area.

2. More secure

- Because the signals from smart antennas are specifically focused rather than transmitting in a random way, they offer more security for the user. Anyone wanting to intercept a communication would need to be in the exact location as the antenna

3. Less Interference and more Bandwidth

- As the smart antenna does not emit signals in different, random directions there is less interference. Also, because they have the ability to reuse frequencies, it frees more bandwidth to users.

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