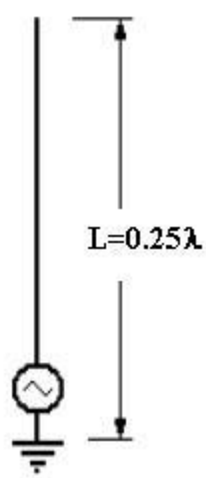
THE VERTICAL (MARCONI) ANTENNA

In the last unit, we discussed the ground wave, and the necessity that the ground wave have vertical polarization. A vertical antenna is used to launch a vertically polarized RF wave. Vertical antennas are most often used in two areas:

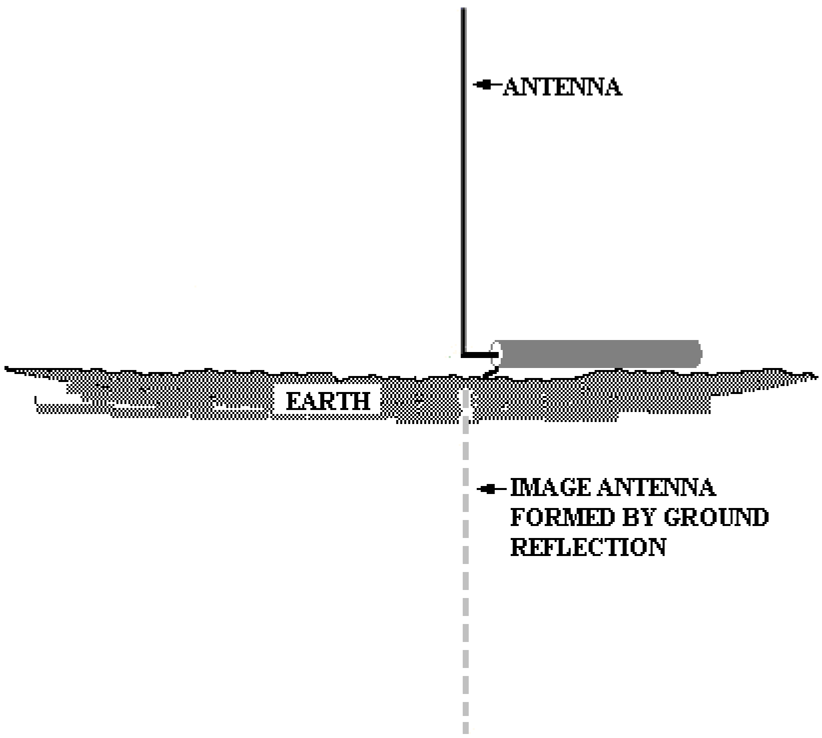
1.Low frequency communications – at frequencies below 2 MHz, it is difficult to use dipole antennas because of their length and the requirement that they be mounted at least a half wavelength above ground. For example: a 2 MHz dipole antenna is approximately 234 ft long and needs to be approximately 234 feet above ground. Also, most communications at frequencies below 2 MHz is via ground wave, which requires vertical polarization.

2.Mobile communications – it is difficult to mount a horizontally polarized dipole on a vehicle. A vertical antenna only has one mounting point and less wind resistance.

The most common vertical antenna is the Marconi antenna. It is a vertical conductor $\lambda/4$ high, fed at the end near ground. It is essentially a vertical dipole, in which one side of the dipole is the RF image of the antenna in the ground. This may sound strange, but remember that ground reflects RF as a mirror reflects light



Simple Marconi Antenna

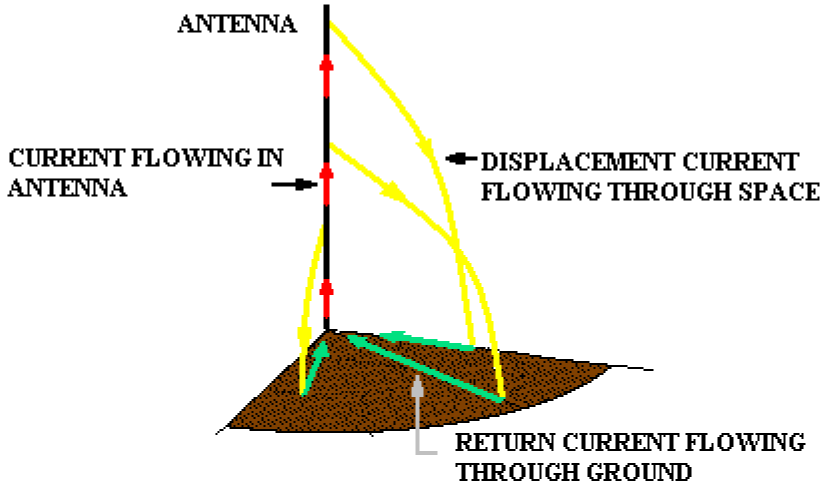


The image antenna formed in the ground under a Marconi antenna

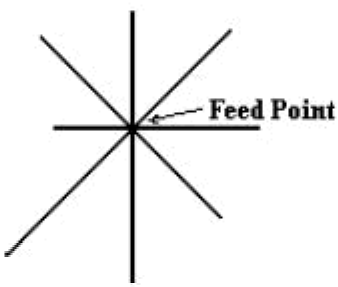
This type of antenna, unlike the dipole, is an unbalanced antenna, and should be fed directly with coaxial cable. The shield of the coax is connected to the ground at the base of the antenna and the center lead of the coax is connected to the vertical radiator.

Because the ground under a vertical antenna is actually part of the antenna, it is necessary that ground losses be minimized. To minimize the losses, the electrical conductivity of the ground must be made as high as possible, or an artificial low loss ground must be provided.

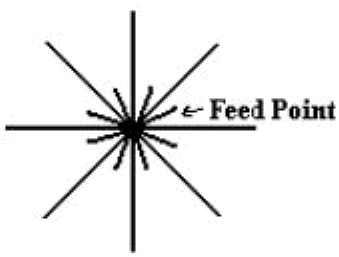
Ground conductivity can be improved by using ground radial wires. These are wires buried just under the earth's surface or laid on the surface that provide a low resistance path for RF currents flowing in the ground. The ground currents are greatest in the vicinity of the feed point of a Marconi antenna, so the radials run out from the feed point, up to a distance of $\lambda/4$ from the antenna, if possible. The ground radials do not have to be any specific length and the general rule is that a large number of short radials is preferable to a few long radials. The diagram below shows how current flows through the ground to the feed point of the Marconi antenna.



The radials should be laid out in a pattern that follows the ground current, that is running radially out from the feed point of the antenna. The diagram below is a bird's eye view of typical ground radial layouts. Note that the radials do not all have to be the same length and that losses may be decreased by adding extra radials near the feed point. These extra radials can be as short as λ/40 and still be effective.

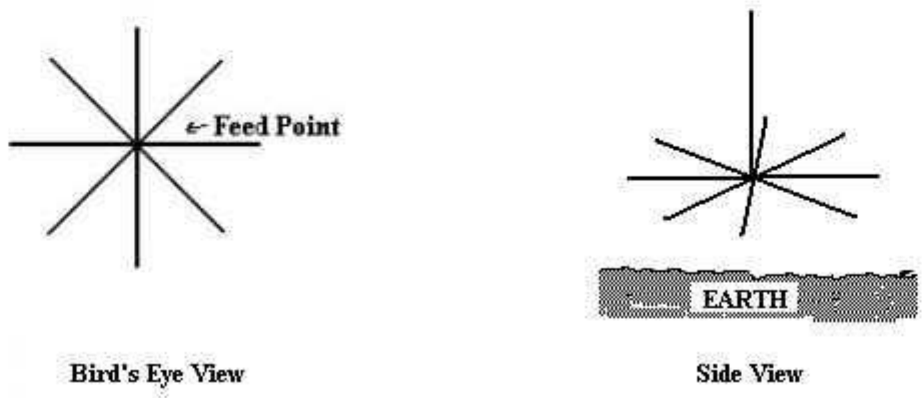


Ground Radial System with random length radials on ground



Ground Radial System with extra short radials in high current region

When a Marconi antenna cannot be mounted on the ground, an artificial ground system, called a counterpoise, is used. The counterpoise consists of λ/4 wires emanating radially from the antenna feed point as shown below. The shield of the coax is connected to the counterpoise at the feed point. The counterpoise is not connected to ground.



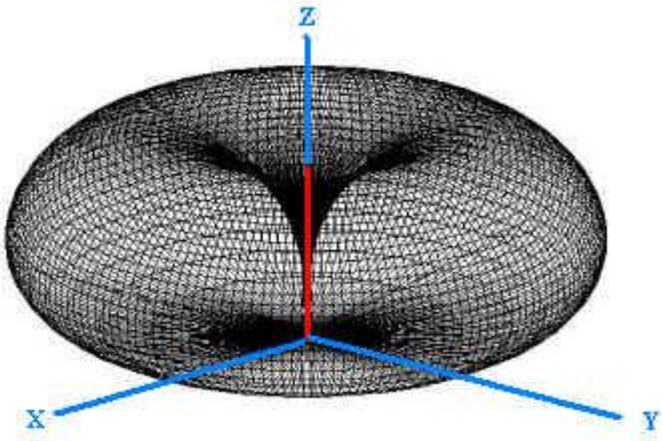
Elevated Counterpoise using λ/4 radials

Ground losses affect the feed point impedance and antenna efficiency. A Marconi antenna mounted on a perfectly conducting ground would have an input impedance that is ½ the impedance of a dipole, or approximately 36 ohms. When mounted on a real ground, the input impedance can range from 38 ohms for a well designed AM broadcast antenna mounted over a specially prepared ground, to over 100 ohms for a Marconi mounted above poor, unprepared ground that has no radials.

Ground loss reduces the antenna's efficiency, because part of the power being delivered to the antenna is being dissipated in the ground rather than being radiated. The efficiency can be computed from the measured value of input resistance by using the following formula:

$$Efficiency = \eta = \frac{36}{R_{INPUT}}$$

The radiation pattern of the Marconi antenna is a half doughnut as shown in the figure below. There is no radiation straight up in the direction of the wire. The bulk of the radiation occurs at a low elevation angle, which is what is needed to launch a ground wave.



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