Ground Screen Grid Dimensions

When laying down a ground screen it is necessary to know what spacing to use between the wires, i.e. the size of the grid. Normally we want to use as large a spacing as possible to minimize the amount of wire required. One way to go about determining the grid spacing is to treat the ground screen and the soil under it as parallel impedances. The idea is make the screen impedance lower than the soil impedance so the antenna current flows in the low loss screen rather than in the soil. There are of course practical limits to how far we can go in reducing the ground current, so we have to decide what fraction of the total current we are willing to allow to continue flowing in the soil.

Ground loss is I^2R in nature, so if we reduce the ground current by a factor of 10, then the ground loss will drop to 1% of what it would have been if there were no screen at all. This is usually a reasonable compromise but of course any other ratio could be chosen.

Figure 1 illustrates the concept.

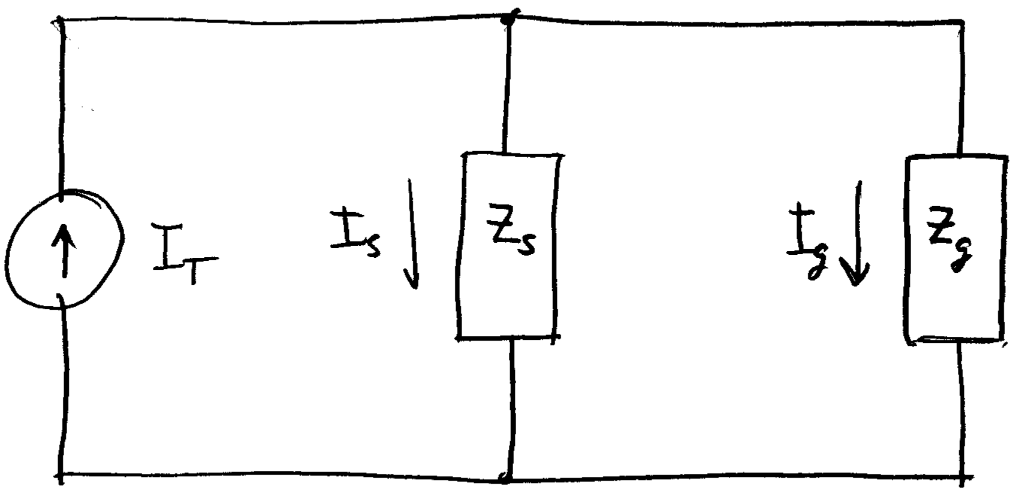

Figure 1

Where:

Z_s = impedance of the soil

Z_g = impedance of the grid or ground screen

I_T = total current returning to the antenna

I_s = current in the soil

I_g = current in the ground screen

What do we mean by the soil impedance? We know that the impedance of free space is the ratio of the H-field to the E-field components in an E-M wave and is given by:

$$Z_{space} = \sqrt{\frac{\mu_o}{\varepsilon_o}} = 376.7\ \text{Ohm} \qquad (1)$$

Where:

μ_o = permeability of free space = $4\pi\ 10^{-7}$

ε_o = permittivity of free space = 8.854×10^{-12}

We can extend this concept to soil by taking into account the conductivity and permittivity:

$$Z_s = \sqrt{\frac{\mu_o}{\varepsilon_o}}\left[\frac{1}{\sqrt{\varepsilon_r - j\left(\frac{\sigma}{\omega\varepsilon_o}\right)}}\right] = \frac{376.7}{\sqrt{\varepsilon_r - j\left(\frac{\sigma}{\omega\varepsilon_o}\right)}} \qquad (2)$$

Where:

ε_r = relative permeability

σ = soil conductivity in S/m

$\omega = 2\pi f$, where f is the frequency in Hz.

Note that Z_s can be complex.

We can also state the equivalent impedance for the grid:

$$Z_g = jf\mu_o d \ln\left(\frac{d}{2\pi a}\right) \qquad (3)$$

Where:

d = spacing of grid wires in meters

a = radius of grid wires in meters

Note, for the d/a term it is only necessary that d and a have the same units, they can be in inches for example, however, the multiplying d must be in meters. Also notice that the form for equation 3 is very similar to the expression for the surge impedance of a two-wire open transmission line.

Now let's see what Z_s is for average ground at 1.83 MHz. Plugging $\varepsilon_r = 15$ and $\sigma = 0.005$ S/m into equation 2 we will get: $Z_s = 42.2+j31.28$ Ohms, $|Z_s| = 52.6$ Ohms. If the ground screen is made up from #12 wire spaced 24", we will find that $Z_g = j6.41$ Ohms and $|Z_g| = 6.41$ Ohms.

$$|I_s| = \frac{|Z_g|}{|Z_g + Z_s|}|I_T| = 0.113|I_T| \qquad (4)$$

We see that for this ground characteristic and frequency, 24" spacing in the grid reduces the ground loss to about 1% of what it would have been without the screen.

Using the above equations, this procedure can be applied for any soil, frequency, wire size, residual percentage of current in soil, etc.

Above equations can be found in many sources. I used:

Frank Abbott, Design of Optimum Buried-Conductor RF Ground System, IRE proceedings, July 1952, pp. 846-852.

You don't have to restrict these equations to rectangular grid ground systems. If you have a conventional radial ground system and a single vertical, the H-field take the form of concentric circles intersecting the radials at right angles. This is the optimum angle to induce the maximum current in the radial so you have no need to put in cross-wires to form a grid. The cross-wires buy you nothing in this case. If you have a 60 radial system, the angle between radials is 6°. At a radius of 19.1' the spacing between the wires will be 2' and the ground loss within that radius will be <1.3% as calculated earlier. At a radius of 130', the spacing between the wires is 13.6' and Z_g = j62 Ohm. Redoing the earlier calculation with Z_g = j62 we get that the $|I_s|$ = 0.606 $|I_T|$ and the loss <u>at that radius</u> is about 37% of what it would be without the radial system. The radial system is still doing its job.

In the case where the H-field is not at 90° to the wire, then the current induced in the wire will be reduced by the cosine of the angle between the field and the wire. If you are using a rectilinear grid then you can always reduce the field to two components, each one of which is perpendicular to a wire. This situation can arise in multi-element arrays where the field at any given point is the vector sum of the fields from the individual elements.