Appendix 1

Equivalent resistance of a conductor with non-uniform current distribution

The current on antenna conductors will usually be non-uniform, i.e. the current amplitude will vary from one point to another. Conductors are typically either wire or metal tubing, using either copper or aluminum. When the antenna is large enough to approach self-resonance the current distribution is usually very close to sinusoidal as shown in figure 1A. For small LF-MF antennas however, the current will approximately linear as indicated in figure 1B.

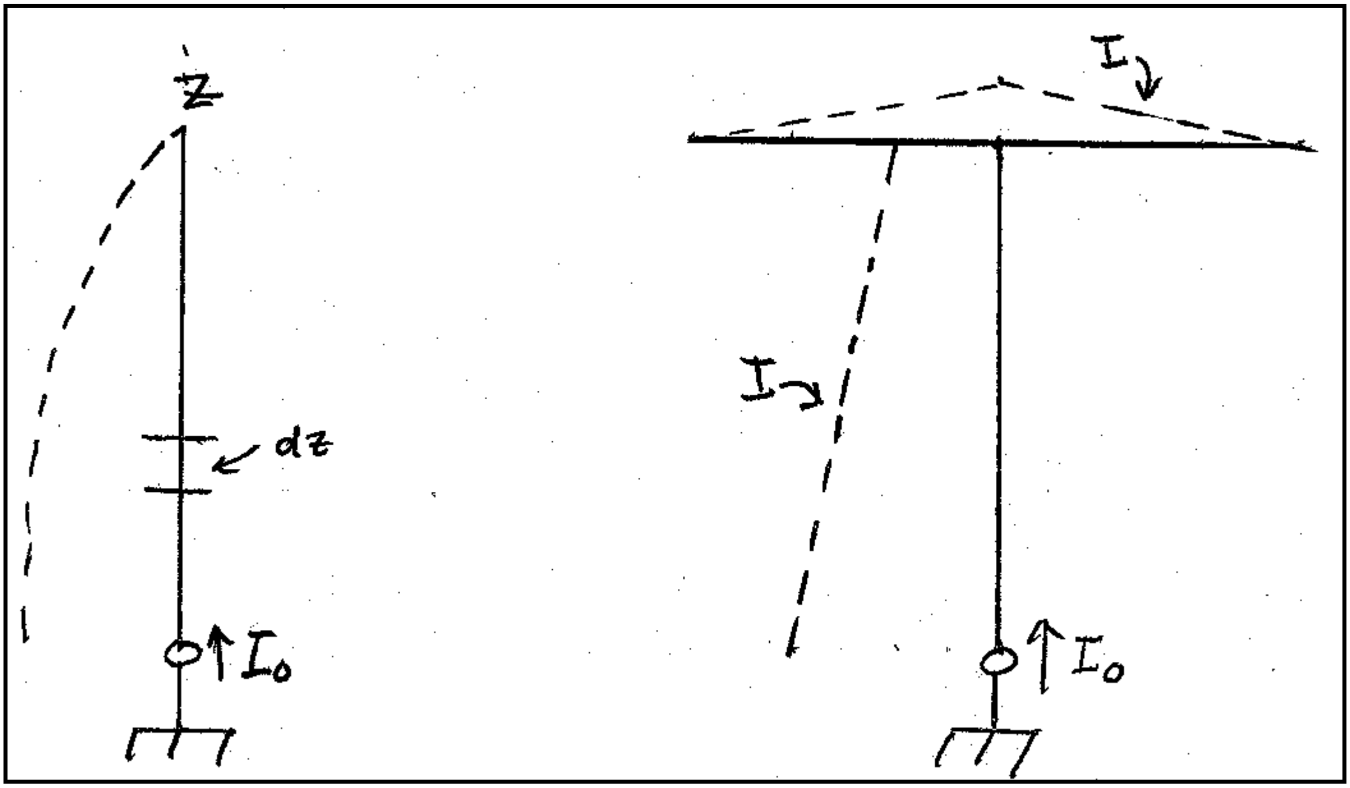

Figure 1 - Antenna current examples.

The following definitions apply:

Rdc= DC resistance of the wire.

Rac= AC resistance of the wire at the operating frequency taking into account skin effect, i.e. Rac=RdcKs, where Ks is the skin effect factor (see chapter 6).

Io= rms current at one end of the wire. The base of a vertical for example.

Re= effective resistance of the wire which results in the same power dissipation for a given Io as the actual power dissipation on the wire.

P= power dissipation in the wire. $P=Io^2Re$

l = length of the wire

I(z)= current distribution along the wire. I(z)=Iof(z) where f(z)= is a function describing the current distribution along the wire.

$$dP = [f(z)]^2 dRac = \frac{Io^2 Rac}{l}[f(z)]^2 dz$$

$$P = \int_o^l dP dz = \left(\frac{Io^2 Rac}{l}\right)\int_o^l [f(z)]^2 dz$$

$$Re = \frac{P}{Io^2} = \left(\frac{Rac}{l}\right)\int_o^l [f(z)]^2 dz$$

$$\frac{Re}{Rac} = \left(\frac{1}{l}\right)\int_o^l [f(z)]^2 dz$$

Re/Rac is the resistance ratio due to non-uniform current distribution.

For *f(z) = cos(z)* and *l=λ/4* (figure 1A)→ **Re/Rac= 1/2**.

For the linear current distribution shown in figure 1B:

$$f(z) = \frac{l + \left(\frac{It}{Io} - 1\right)z}{l}$$

A graph of Re/Rac for a linear current distribution is given in figure 2. For a vertical with no top-loading It=0 and **Re/Rac=1/3**.

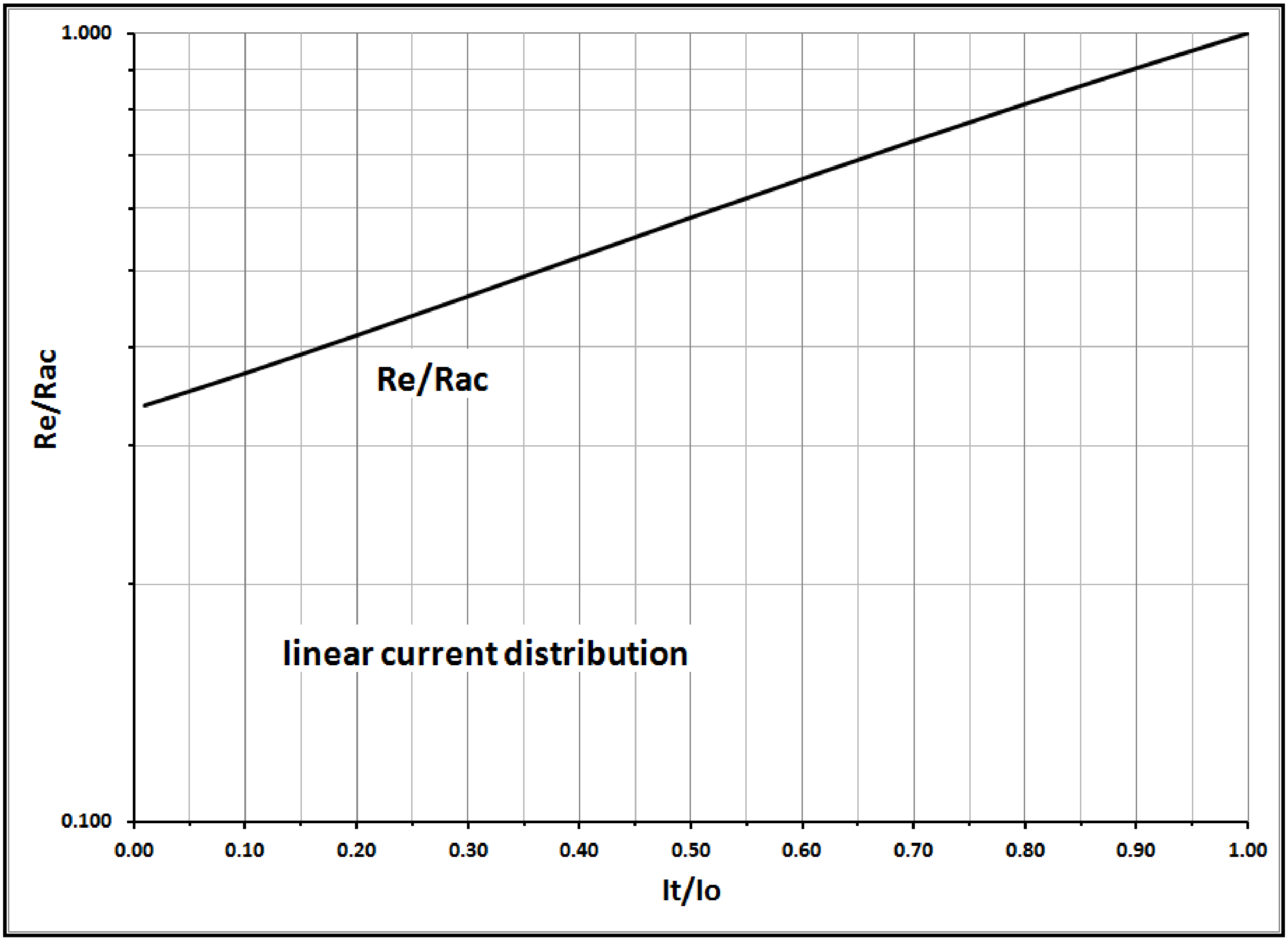

Figure 2 - Re/Rac versus It/Io.