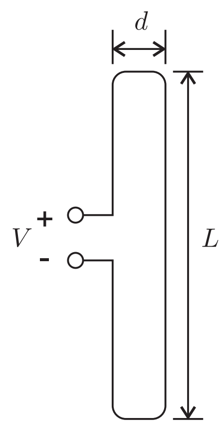
Folded Dipole

The *folded dipole* is a very popular wire antenna, for a number of reasons:

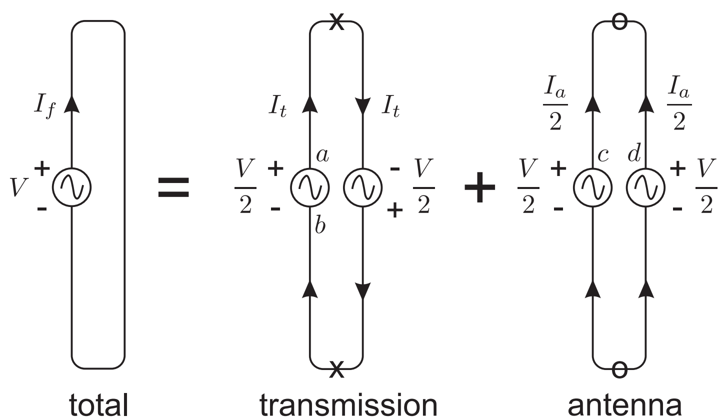
- Impedance properties (easy to match, as we will see);
- Ease of construction;
- Structural rigidity;
- Wider bandwidth than $\lambda/2$ dipole (not proved here).

The structure of a folded dipole is shown below. In general, the dimension $d \ll L$, $d \ll \lambda$.



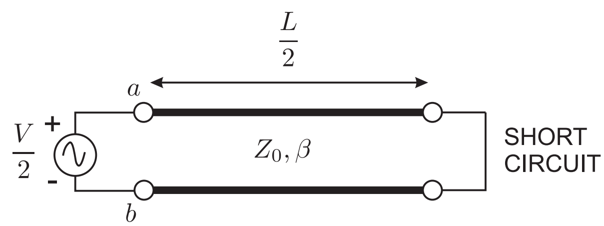
How do we analyze this antenna? On the one hand it looks like a shorted transmission line; on the other, it looks like two parallel dipoles? Which is it?

It turns out that it is both: the currents on the folded dipole can be decomposed into *transmission line* currents and *antenna currents* by superposition. In fact, we can analyze each mode separately and analyze the following structures:



Transmission Line Mode

The transmission line currents do not radiate since we have two closely-spaced and equal currents travelling in opposite directions. Therefore, they cancel in the far field. This is the same phenomenon we have in a transmission line (two oppositely-directed currents). Because of the arrangement of the voltage sources in this mode, virtual short-circuits exist at the points labelled "x", yielding the following circuit for one of the voltage sources:



From transmission line theory, the impedance seen by the source is

$$Z_t = Z_0 \frac{Z_L + jZ_0 \tan \beta L/2}{Z_0 + jZ_L \tan \beta L/2} = jZ_0 \tan \beta L/2. \tag{1}$$

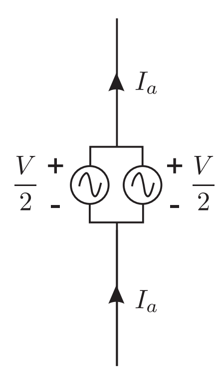
Therefore,

$$I_t = \frac{V/2}{Z_t} = \frac{V/2}{jZ_0 \tan \beta L/2}. \tag{2}$$

Antenna Mode

Since the points c and d are at the same potential, we can connect them together as well as the two line currents. There is no crossover current between the two halves of the folded dipole; we can think of open circuits being located at point "o". We now have a dipole with current I_a, driven by a $V/2$ voltage source. We know how to calculate the input impedance of a dipole. Let's call that impedance Z_d. Then,

$$I_a = \frac{V/2}{Z_d} \tag{3}$$



Impedance Characteristics

We now know the total current leaving the voltage source feeding the folded dipole, $I_f = I_t + I_a/2$. We can then write the input impedance of a folded dipole as

$$Z_f = \frac{V}{I_t + I_a/2} = \frac{V}{\frac{V/2}{Z_t} + \frac{V/2}{2Z_d}} = \frac{4Z_t Z_d}{2Z_d + Z_t} \tag{4}$$

A common folded dipole as $L = \lambda/2$. In this case,

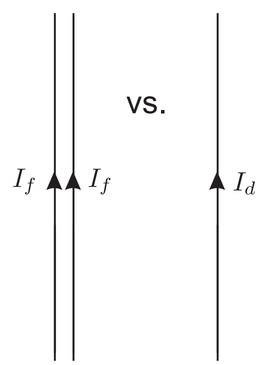
- $Z_t = \infty$ (open circuit) $\rightarrow$ no transmission line currents
- $Z_d =$ input impedance of a $\lambda/2$ dipole ($70\ \Omega$)

The input impedance to the folded dipole is then

$$Z_f = \lim_{Z_t \to \infty} \frac{4Z_t Z_d}{2Z_d + Z_t} = \frac{4Z_t Z_d}{Z_t} = 4Z_d = 280\ \Omega. \tag{5}$$

This is very close to the characteristic impedance of a commonly used transmission line called "twin lead", which has $Z_0 = 300\ \Omega$, yielding a good impedance match (what is Γ?).

An alternative interpretation of impedance behaviour of a folded dipole can be presented as follows. We know that a folded dipole has two closely spaced equal currents, I_f, flowing along the conductors, while a standard dipole has a current I_d flowing on a single conductor.



We know that

$$I_f = \frac{I_d}{2} \tag{6}$$

therefore,

$$W_f = \frac{1}{2} Z_f |I_f|^2 = \frac{1}{8} Z_f |I_d|^2 \tag{7}$$
$$W_d = \frac{1}{2} Z_d |I_d|^2. \tag{8}$$

If we compare a folded dipole and regular dipole radiating the same power,

$$W_f = W_d \Rightarrow Z_f = 4Z_d. \tag{9}$$

Radiation Characteristics

The common folded dipole has the same radiation pattern as a standard $\lambda/2$ dipole, since the two "arms" of the folded dipole carry identical, half-wave sinusoidal current distributions. The currents are so close that we can treat them as a single $\lambda/2$ length of wire. Hence, the directivity of the folded dipole is identical to that of the half-wave dipole.