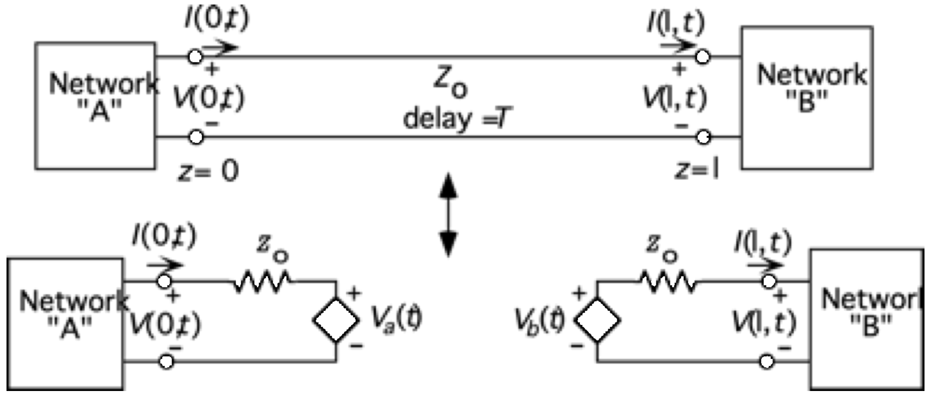
PSpice Model for a Lossless Transmission Line



where: $V_a(t) = V(\ell, t-T) - Z_o I(\ell, t-T)$ and
$V_b(t) = V(0, t-T) + Z_o I(0, t-T)$

To prove that Network "A" sees the equivalent circuit shown, we first note that the total voltage and current at any point of a transmission line can be expressed as the sum of forward and backward travelling components:

$$V = V^+ + V^- \text{ and } I = I^+ + I^- = \frac{1}{Z_0}\left[V^+ - V^-\right] \qquad (1)$$

From these, we find:

$$V^+ = \frac{1}{2}\left[V + Z_0 I\right] \text{ and } V^- = \frac{1}{2}\left[V - Z_0 I\right] \qquad (2)$$

We can use (1) to expand the total voltage $V(0,t)$ at the left side of the line as:

$$V(0,t) = V^+(0,t) + V^-(0,t)$$

Since $V^-(0,t)$ is backward (left) propagating, its value at the left side at time t is the same as its value at the right side at earlier time $t-T$, so we can write:

$$V(0,t) = V^+(0,t) + V^-(\ell, t-T) \quad ,$$

Next, using (2), we can write both $V^+(0,t)$ and $V^-(\ell, t-T)$ in terms of total voltages and currents, yielding

$$V(0,t) = \frac{1}{2}\left[V(0,t) + Z_0 I(0,t)\right] + \frac{1}{2}\left[V(\ell, t-T) - Z_0 I(\ell, t-T)\right]$$

From which we finally obtain:

$$V(0,t) = Z_0 I(0,t) + V(\ell, t-T) - Z_0 I(\ell, t-T) \quad ,$$

Which is exactly what we get by doing KVL around the left equivalent circuit at Network A. A similar development proves that right-hand equivalent circuit is indeed "seen" at Network "B"