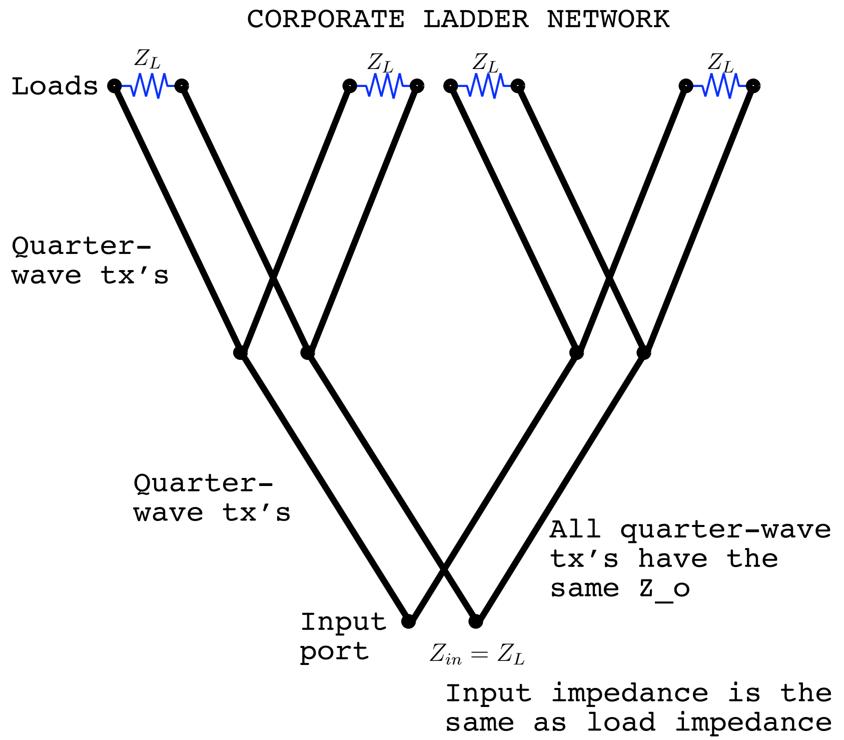
38 Distribution networks

- A **corporate ladder** network that combines 4 identical loads Z_L into a single equivalent input impedance Z_L is shown in the margin.

- In this network 6 different quarter-wave transformers with arbitrary but identical characteristic impedances Z_o are utilized.

  You should be able to compute the load voltages V_L in the network in terms of input voltage V_{in} applied across the input port by using the current-forcing formula for the quarter-wave transformer introduced earlier on.

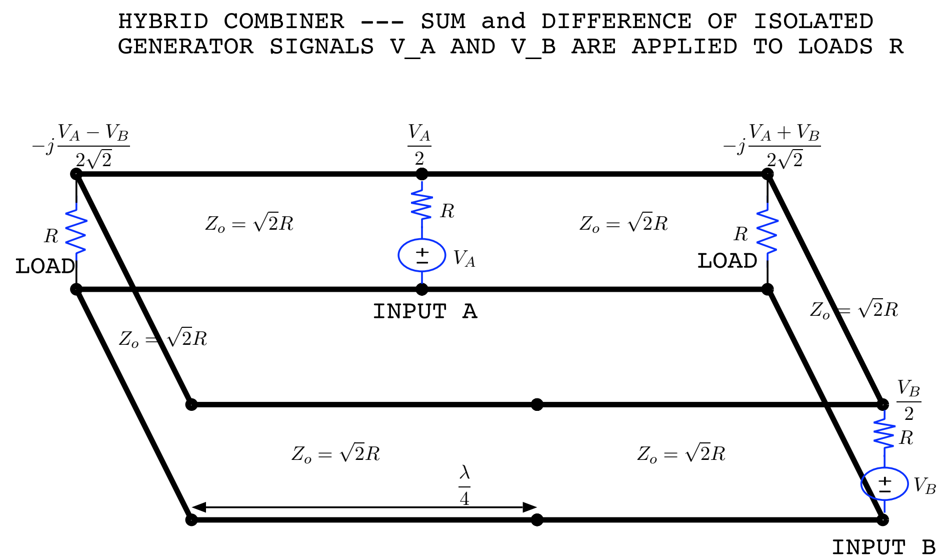


By symmetry, the loads absorb equal avg power,
a quarter of the input power each.

- If, in a **corporate ladder** network, $Z_L = Z_o$, then TL segment lengths connected to each Z_L can be varied at will without affecting the input impedance $Z_L = Z_o$ (why?).

- Allowing variable length TL's connected to each Z_L makes it possible to adjust and vary the phase of the voltage and current of each Z_L — this is useful, for instance, in feeding phased antenna arrays (Z_L represents an antenna load) to achieve steerable radiation patterns.

- A **hybrid combiner** network shown in the margin can be used to *excite* two identical TL loads R (e.g., antenna arrays impedance matched to have input impedances R) with independent signal generators V_A and V_B having equal internal resistances R matched to the load resistance.



- The hybrid "rat-race" combiner is built with 6 quarter-wave transformers of identical

$$Z_o = \sqrt{2}R,$$

in which case the generators V_A and V_B see impedance-matched loads (at the hybrid inputs where they are connected) and produce load voltages proportional to $V_A \pm V_B$ as shown in the diagram.

  - Generators A and B with open ckt voltages V_A and V_B are *isolated* from one another's influence because of "destructive interference" between the two paths from each generator to the other one (two paths have a $\frac{\lambda}{2}$ length difference).

  - This very special situation allows one to calculate the various terminal voltages on the hybrid due to V_A and V_B one-at-a-time as if loads R were isolated from generator-B and -A (by "virtual shorts" existing across generator terminals when V_B and V_A are suppressed) in turns, and then superpose the results.

- Terminal voltages obtained with that procedure (those shown on the diagram) turn out to be valid when both generators are active as can easily be checked for self-consistency by using the current-forcing equations introduced earlier. For instance, the total current into generator-A terminal (flowing from both sides) is

$$I_A = -\frac{j}{R\sqrt{2}}(-j\frac{V_A - V_B}{2\sqrt{2}}) - \frac{j}{R\sqrt{2}}(-j\frac{V_A + V_B}{2\sqrt{2}}) = -\frac{V_A}{2R},$$

and hence the voltage drop from the same terminal to the ground is

$$I_A R + V_A = -\frac{V_A}{2R}R + V_A = \frac{V_A}{2}$$

as marked explicitly on the diagram. All self-consistency tests that can be applied with the given expressions are passed, and so the results given are valid.

- The input and output ports of a hybrid combiner can be swapped while still maintaining the properties of the hybrid — namely, input impedance R, and output signals the sum and difference of generator voltages.