13.6 imp.divide The divider method



Figure divide.1: the two-element across-variable divider.

1 In *Electronics*, we developed the useful voltage divider formula for quickly analyzing how voltage divides among series electronic impedances. This can be considered a special case of a more general **across-variable divider** equation for any elements described by an impedance. After developing the across-variable divider, we also introduce the through-variable divider, which divides an input through-variable among parallel elements.

Across-variable dividers

2 First, we develop the solution for the two-element across-variable divider shown in Figure divide.1. We choose the across-variable across Z_2 as the output. The analysis follows the impedance method of Lecture 13.3 imp.tf, solving for V_2 .

- 1. Derive four independent equations.
 - a) The normal tree is chosen to consist of \mathcal{V}_{in} and Z_2 .
 - b) The elemental equations are
 - c) The continuity equation is
 - d) The compatibility equation is

2. Solve for the output V_2 . From the elemental equation for Z_2 ,

3 A similar analysis can be conducted for n impedance elements.

Equation 1 general across-variable divider

Through-variable dividers

4 By a similar process, we can analyze a network that divides a through-variable into n *parallel* impedance elements.

Equation 2	general through-variable divider

Transfer functions using dividers

5 An excellent shortcut to deriving a transfer function is to use the acrossand through-variable divider rules instead of solving the system of algebraic equations, as in Lec. 13.3 imp.tf. An algorithm for this process is as follows.

- 1. Identify the element associated with an output variable Y_i. Call it the *output element*.
- 2. Identify the source associated with an input variable U_j. Set all other sources to zero.
- 3. Transform the network to be an across- or through-variable divider that includes the "bare" (uncombined) output element's output variable.⁶
 - a) If necessary, form equivalent impedances of portions of the network, being sure to leave the output element's output variable alone.
 - b) If necessary, transform the source *à la* Norton or Thévenin.
- 4. Apply the across- or through-variable divider equation.
- 5. If necessary, use the elemental equation of the output element to trade output across- and through-variables.
- 6. If necessary, use the source transformation equation of the input to trade input across- and through-variables.
- 7. Divide both sides by the input variable.

6 It turns out that, despite its many "if necessary" clauses, very often this "shortcut" is easier than the method of Lecture 13.3 imp.tf for low-order systems if only a few transfer functions are of interest.

Example 13.6 imp.divide-1

Given the circuit shown with voltage source V_s and output v_L ,

- a. what is the transfer function $\frac{V_L}{V_s}$?
- b. Without transforming the source, find the transfer function $\frac{I_L}{V_c}$.
- c. Transforming the source, find $\frac{l_L}{V_s}$.



re: a circuit transfer function using a divider

⁶In other words, if the across-variable of the output element is the output, do not combine it in series; if the through-variable is the output, do not combine it in parallel.

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