graphs.intro Introduction to linear graphs

1 Engineers often use graphical techniques to aid in analysis and design. We will use linear graphs to represent the topology or structure of a system modeled as interconnected lumped elements.

linear graphs

topology

2 This represents to us the essential structure of the system in a minimalist form. In this way,

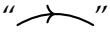
Figure intro.1: a modern New York subway map in the style of Vignelli (Jake Berman).

it is like Massimo Vignelli's famous 1972 New York subway system "map," which inspired widespread adoption of his style (see Figure intro.1).[1] Besides minimalism, the key idea in Vignelli subway maps is that the details of the tunnels' paths are irrelevant and, in fact, distracting to the person attempting to get from one station to another.

1. Vignelli was a brilliant Minimalist designer of many prodcucts, from dishes to clothing, but he was most known for his graphic design. Great places to start studying Vignelli are the documentary Design is One (2012) and The Vignelli Canon.

3 In a similar way, a linear graph represents the system in a minimalist style, with only two types of objects:

edges

1. A set of edges, each of which represents an energy port associated with a system element. Each edge is drawn as an oriented line segment "  ".

nodes

2. A set of nodes, each of which represents a point of interconnction among system elements. Each node is drawn as a dot "o".

4 All edges begin and end at nodes. The nodes represent locations in the system where distinct across-variable values may be measured. For example, wires that connect elements are actually nodes at which voltage may be measured. Putting an edge together with nodes, we have Figure intro.2.

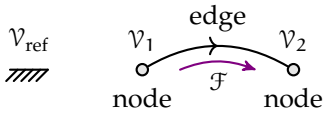


Figure intro.2: an edge with nodes. The across variable is $\mathcal{V} = \mathcal{V}_1 - \mathcal{V}_2$.

5 It is important to note that linear graphs can represent nonlinear system elements—the name is a reference to the lines used.

nonlinearity

6 It is common to choose a node of the graph as the reference node, to which all across-variables are referenced. Due to its similarity to the electronic ground, we often use these terms interchangeably.

reference node

ground

7 Figure intro.3 shows how a linear graph can be constructed for a simple RC-circuit. Note that the wires become nodes, the elements become edges, and the reference node represents the circuit ground. In a similar manner, we will construct linear graphs of circuits, mechanical

translational systems, and mechanical rotational systems.

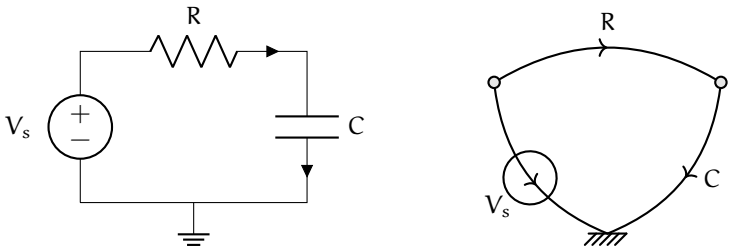


Figure intro.3: an example of a linear graph representation of an RC-circuit.