graphs.connect Element interconnection laws

1 The interconnections among elements constrain across- and through-variable relationships. The first element interconnection law requires the concept of a contour "": a closed path that does not self-intersect superimposed over the linear graph. The first interconnection law is called the continuity law.

contour

continuity law

Definition graphs.2: continuity law

The sum of the through-variables that flow on into a contour on a linear graph is zero, or, in terms of generalized through-variables $\mathcal{F}_i$ for N elements with through variables defined as positive into the contour,

$$\sum_{i=1}^{N} \mathcal{F}_i = 0. \tag{1}$$

2 Contours can enclose any number of nodes and edges, as illustrated in Figure connect.1. Kirchhoff's current law (KCL) is the special case of the continuity law for electronic systems.

KCL

3 The second interconnection law we consider requires the concept of a loop "": a continuous series of edges that begin and end at the same node, not reusing any edges.[2] The second interconnection law is called the compatibility law.

loop

2. Technically, we need not restrict the definition to series that do not reuse edges for purposes of the compatibility law, but these loops are superfluous and we exclude them here.

compatibility law

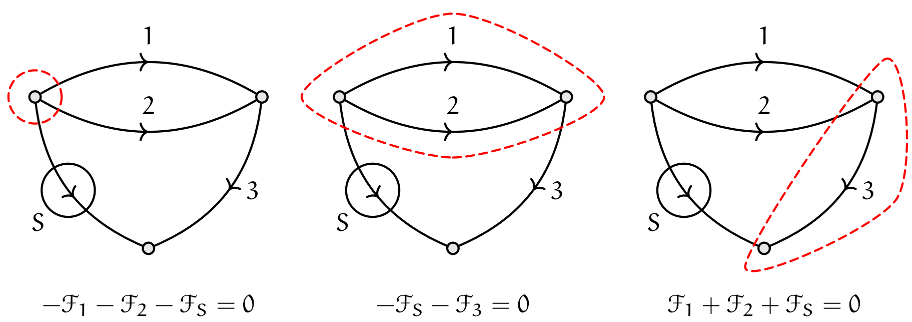

Figure connect.1: illustration of different contours, denoted with red dashed lines ",", contours for which the continuity law applies, as shown below each graph.

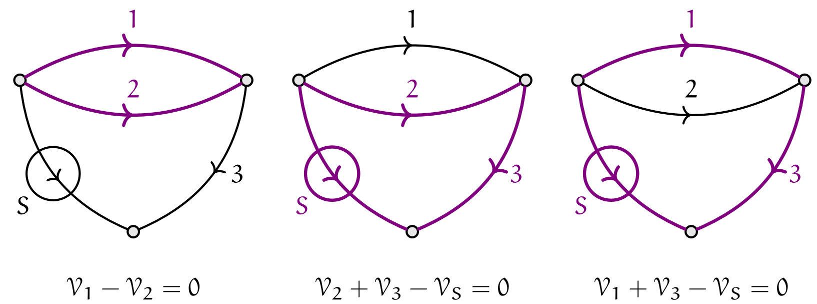

Figure connect.2: illustration of different loops, denoted with violet edges "," loops for which the compatibility law applies.

Definition graphs.3: compatibility law

The sum of the across-variable drops on edges around any closed loop on a linear graph is zero, or, in terms of generalized across variables $\mathcal{V}_i$ for N elements in a loop,

$$\sum_{i=1}^{N} \mathcal{V}_i = 0. \tag{2}$$

A loop can be "inner" or "outer," as shown in Figure connect.2. Kirchhoff's voltage law (KVL) is the special case of the compatibility law for electronic systems.

KVL

Example graphs.connect−1

re: element interconnection laws

For the system shown, (a) write three unique continuity and three unique compatibility equations. Moreover, (b) write a continuity equation solved for $\mathcal{F}_4$ in terms of $\mathcal{F}_S$ and $\mathcal{F}_1$. Finally, (c) write a compatibility equation solved for $\mathcal{V}_5$ in terms of $\mathcal{V}_S$, $\mathcal{V}_3$, and $\mathcal{V}_4$.