02.3 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**.

Definition 02 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.

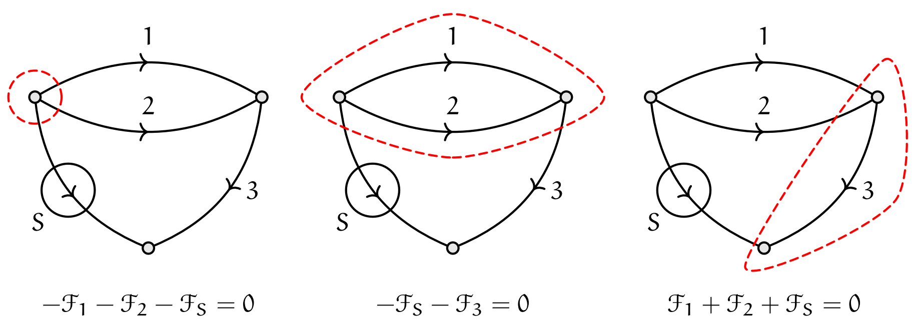

Figure connect.1: illustration of different contours, denoted with red dashed lines ",” contours for which the continuity law applies, as shown below each graph.

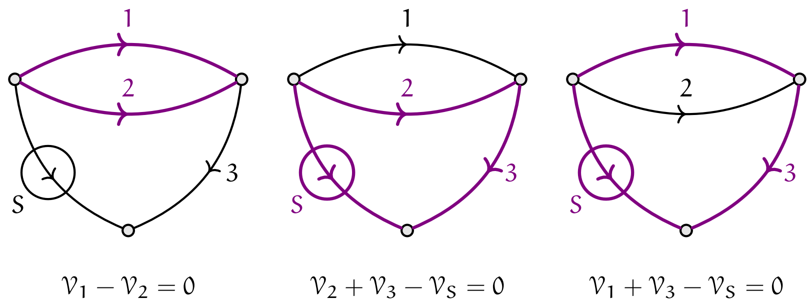

Figure connect.2: illustration of different loops, denoted with violet edges "⟶," loops for which the compatibility law applies.

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**.

Definition 02 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.

Example 02.3 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

[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.

solved for $\mathcal{V}_5$ in terms of $\mathcal{V}_S$, $\mathcal{V}_3$, and $\mathcal{V}_4$.