intro.genvars Generalized through– and across–variables

1 We have considered mechanical translational, mechanical rotational, and electronic systems—which we refer to as different energy domains. There are analogies among these systems that allow for generalizations of certain aspects of these systems. These generalizations will allow us to use a single framework for unifying the analysis of these (and other) dynamic systems.

energy domains

2 There are two important classes of variables common to lumped-parameter dynamic systems: across-variables and through-variables.

3 An across-variable is one that makes reference to two nodes of a system element. For instance, the following are across-variables:

across–variable

-
-
-

We denote a generalized across-variable as $\mathcal{V}$.

generalized across–variable

4 A through-variable is one that represents a quantity that passes through a system element. For instance, the following are through-variables:

through–variable

-
-
-

We denote a generalized through-variable as $\mathcal{F}$.

generalized through–variable

5 The generalized integrated across-variable $\mathcal{X}$ is

generalized integrated across–variable

$$\mathcal{X} = \int_0^t \mathcal{V}(\tau)d\tau + \mathcal{X}(0). \quad (1)$$

6 The generalized integrated through-variable

generalized integrated through–variable

$\mathcal{H}$ is

$$\mathcal{H} = \int_0^t \mathcal{F}(\tau) d\tau + \mathcal{H}(0). \tag{2}$$

7 For mechanical and electronic systems, power $\mathcal{P}$ passing through a lumped-parameter element is

$$\mathcal{P}(t) = \mathcal{F}(t)\mathcal{V}(t). \tag{3}$$

8 These generalized across- and through-variables are sometimes used in analysis. However, the key idea here is that there are two classes of power-flow variables: across and through. These two classes allow us to strengthen the sense in which we consider different dynamic systems to be analogous.