Variables in System Dynamics

an introduction

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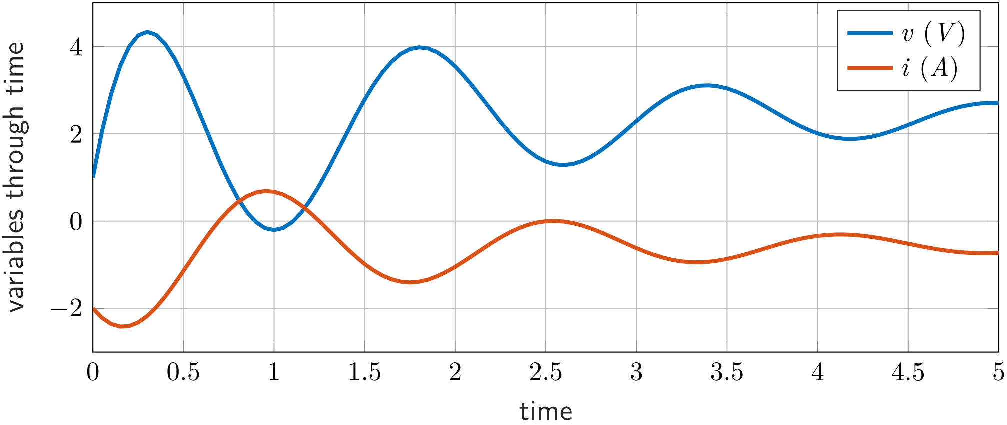
Variables represent quantities

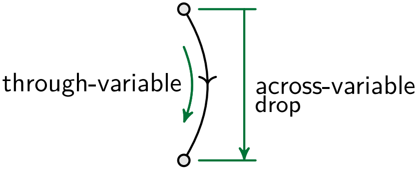


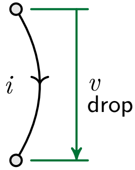
Power flow variables

For instance,

$$\underbrace{\mathcal{P}(t)}_{\text{power}} = \underbrace{i(t)}_{\text{current}} \underbrace{v(t)}_{\text{voltage}} . \tag{1}$$

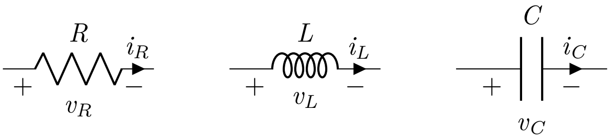
Through- and across-variables





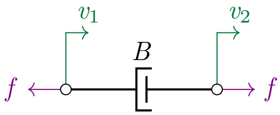
Electronic power flow variables

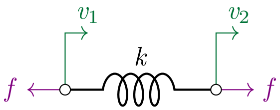
$$\underbrace{\mathcal{P}(t)}_{\text{power}} = \underbrace{i(t)}_{\text{through}} \underbrace{v(t)}_{\text{across}} . \tag{2}$$

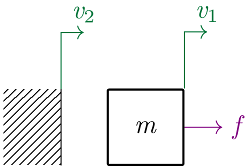


Mechanical translational power flow variables

$$\underbrace{\mathcal{P}(t)}_{\text{power}} = \underbrace{f(t)}_{\text{through}} \underbrace{v(t)}_{\text{across}} . \tag{3}$$

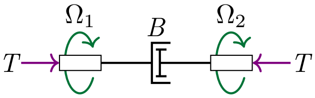


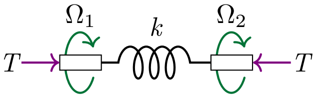


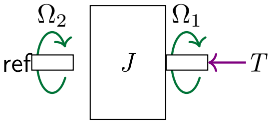


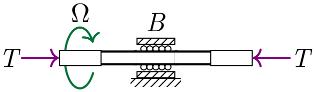
Mechanical rotational power flow variables

$$\underbrace{\mathcal{P}(t)}_{\text{power}} = \underbrace{T(t)}_{\text{through}} \underbrace{\Omega(t)}_{\text{across}} . \qquad (4)$$



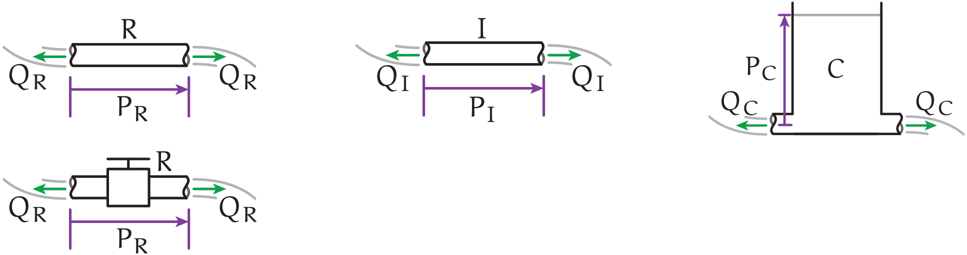






Fluid power flow variables

$$\underbrace{\mathcal{P}(t)}_{\text{power}} = \underbrace{Q(t)}_{\text{through}}\ \underbrace{P(t)}_{\text{across}}\,. \tag{5}$$

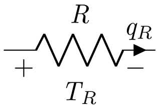


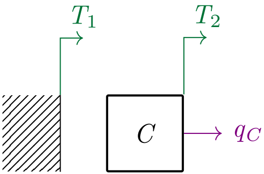
Thermal power flow variables

$$\underbrace{\mathcal{P}(t)}_{\text{power}} = \underbrace{q(t)}_{\text{through}} \, . \tag{6}$$

Also,

$$\underbrace{T(t)}_{\text{across}} . \tag{7}$$





		generalized	mechanical translation	mechanical rotation	electrical	fluid	thermal
variables	*across*	$\mathcal{V}$	velocity v	angular vel. Ω	voltage v	pressure P	temp. T
	through	$\mathcal{F}$	force f	torque T	current i	vol. fr. Q	heat fr. q
A-type	*capacitor*	capacitor	mass	mom. inertia	capacitor	capacitor	capacitor
	capacitance	C	m	J	C	C	C
	elem. eq.	$\frac{d\mathcal{V}_C}{dt} = \frac{1}{C}\mathcal{F}_C$	$\frac{dv_m}{dt} = \frac{1}{m}f_m$	$\frac{d\Omega_J}{dt} = \frac{1}{J}T_J$	$\frac{dv_C}{dt} = \frac{1}{C}i_C$	$\frac{dP_C}{dt} = \frac{1}{C}Q_C$	$\frac{dT_C}{dt} = \frac{1}{C}q_C$
	impedance	$\frac{1}{Cs}$	$\frac{1}{ms}$	$\frac{1}{Js}$	$\frac{1}{Cs}$	$\frac{1}{Cs}$	$\frac{1}{Cs}$
T-type	*inductor*	inductor	spring	rot. spring	inductor	inertance	
	inductance	L	$1/k$	$1/k$	L	I	
	elem. eq.	$\frac{d\mathcal{F}_L}{dt} = \frac{1}{L}\mathcal{V}_L$	$\frac{df_k}{dt} = kv_k$	$\frac{dT_k}{dt} = k\Omega_k$	$\frac{di_L}{dt} = \frac{1}{L}v_L$	$\frac{dQ_I}{dt} = \frac{1}{I}P_I$	
	impedance	Ls	s/k	s/k	Ls	Is	
D-type	*resistor*	resistor	damper	rot. damper	resistor	resistor	resistor
	resistance	R	$1/B$	$1/B$	R	R	R
	elem. eq.	$\mathcal{V}_R = \mathcal{F}_R R$	$v_B = f_B/B$	$\Omega_B = T_B/B$	$v_R = i_R R$	$P_R = Q_R R$	$T_R = q_R R$
	impedance	R	$1/B$	$1/B$	R	R	R