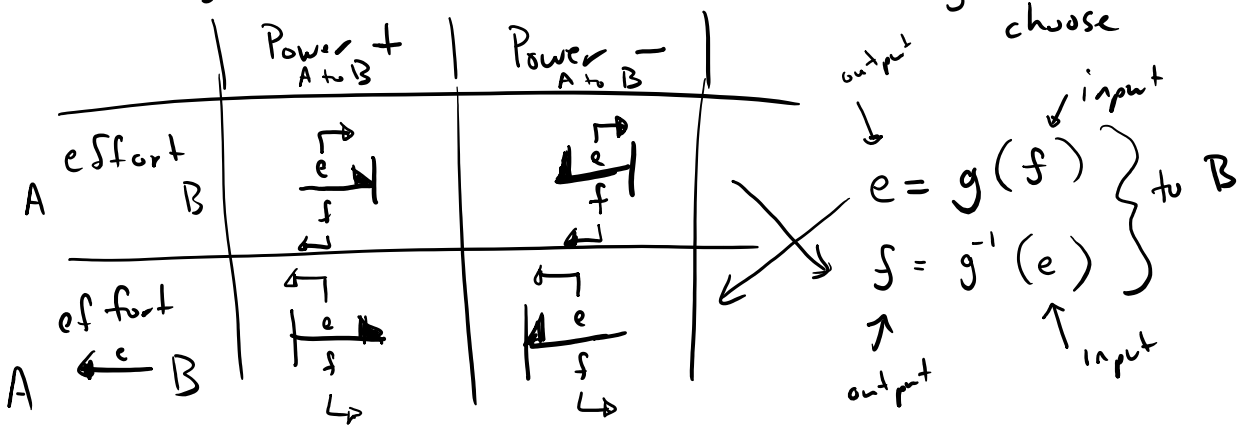
Thursday, January 24, 2019 12:01 PM

Causality is independent of the power sign convention.

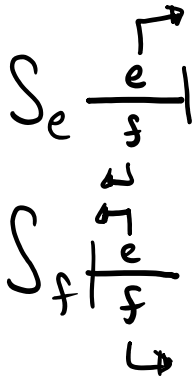
system defined

you can choose



Causality of Ports

Sources



always have this causality by definition

Compliance/Capacitor

causality indicates whether we use the function or its inverse

$e = \Phi_c^{-1}(q)$

$q = \Phi_c(e)$

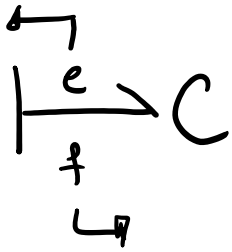
$q = \int f\,dt$

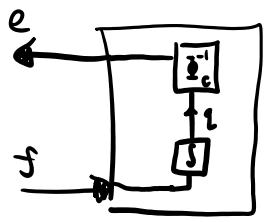
or

$\frac{dq}{dt} = f$

integral

dt





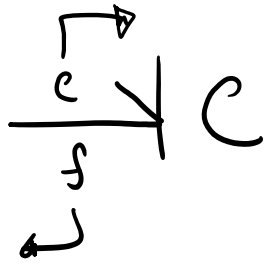
integral causality

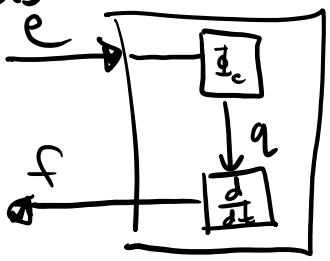
$e = \Phi_C^{-1}(\int f dt)$ non-linear

$e = \frac{1}{C}\int f dt$ linear

$e = \frac{1}{C} q$

Derivative causality





non-linear

$f = \frac{d}{dt}\left(\Phi_C(e)\right)$

linear

$f = C\frac{d}{dt}e$

Similarly for the inertia port

$f = \Phi_I^{-1}(p)$

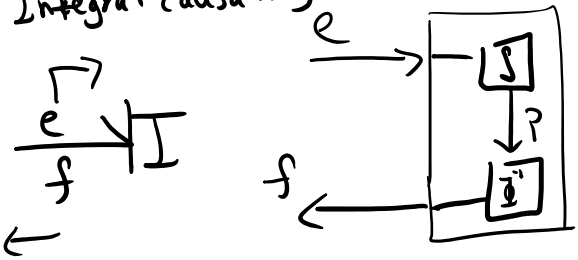
$p = \Phi_I(f)$

$\dot{p} = \frac{d}{dt}\Phi_I(f)$

$\dot{p} = e$

$p = \int e\,dt$

Integral causality

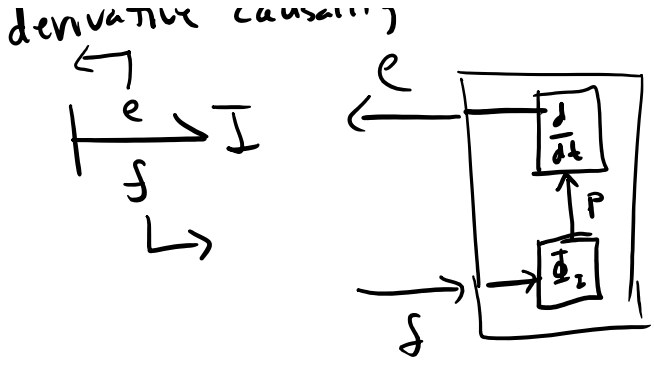


derivative causality

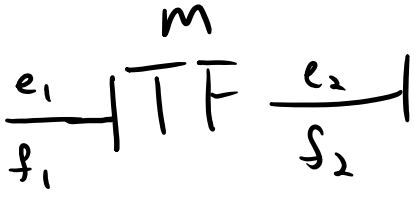
$e = \frac{d}{dt}\Phi_I(f)$

$$e = \frac{d}{dt}\Phi_I(f)$$

derivative causality



Transformer: two possibilities



$e_2 = \frac{1}{m} e_1$ ← input

$f_1 = \frac{1}{m} f_2$

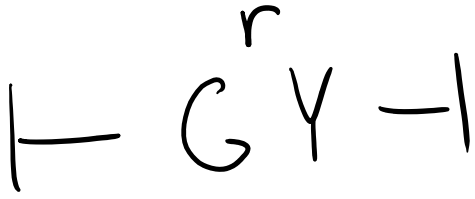
$e_1 = m e_2$

$f_2 = m f_1$ ← input

Gyrator

$f_1 = \frac{1}{r} e_2$ ← input

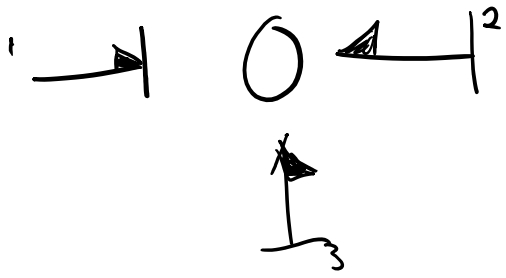
$f_2 = \frac{1}{r} e_1$ ← input



$e_1 = r f_2$ ← input

$e_2 = r f_1$ ← input

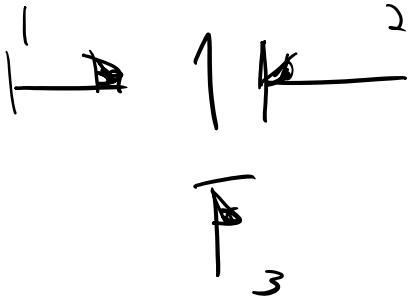
3 ports



$e_2 = e_3 = e_1$ ← input

$f_1 = -(f_2 + f_3)$

↑ output



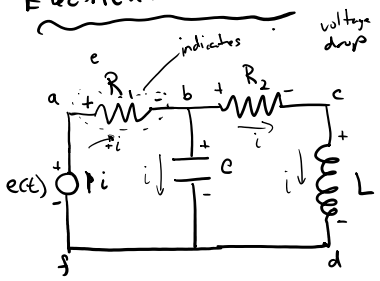
$f_2 = f_3 = f_1$ ← input

$e_1 = -(e_2 + e_3)$

↑ output

System Models

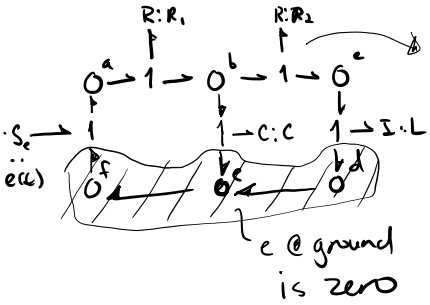
Electrical Networks



Step1: assign power sign convention

Step2: Create a 0 junction for each node where there is a different voltage

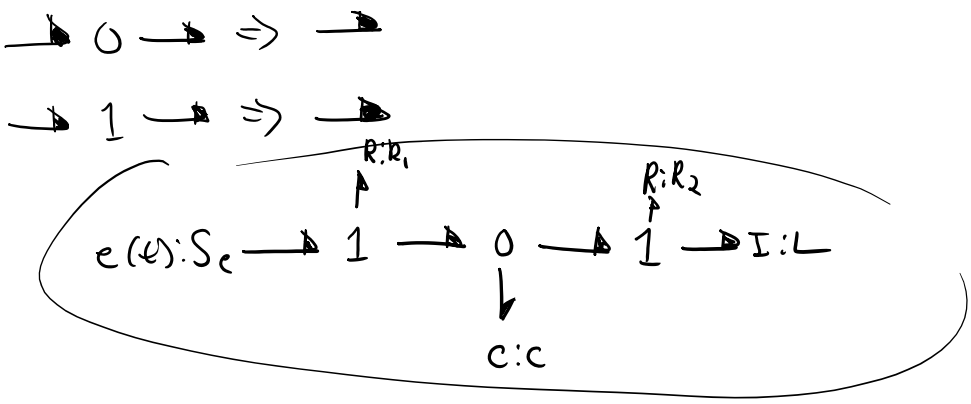
Establish voltage drops with 1 junctions



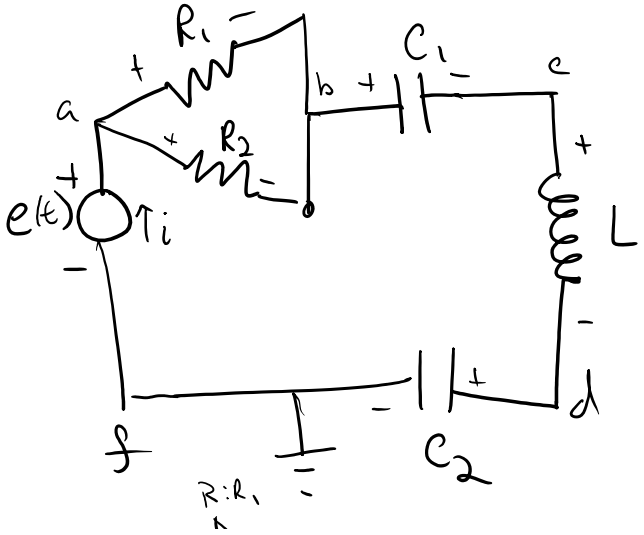
Sign convention ensures power flow to ports when power is positive

Step4: Choose ground or reference voltage node and remove zero power nodes

Step 5: simplify



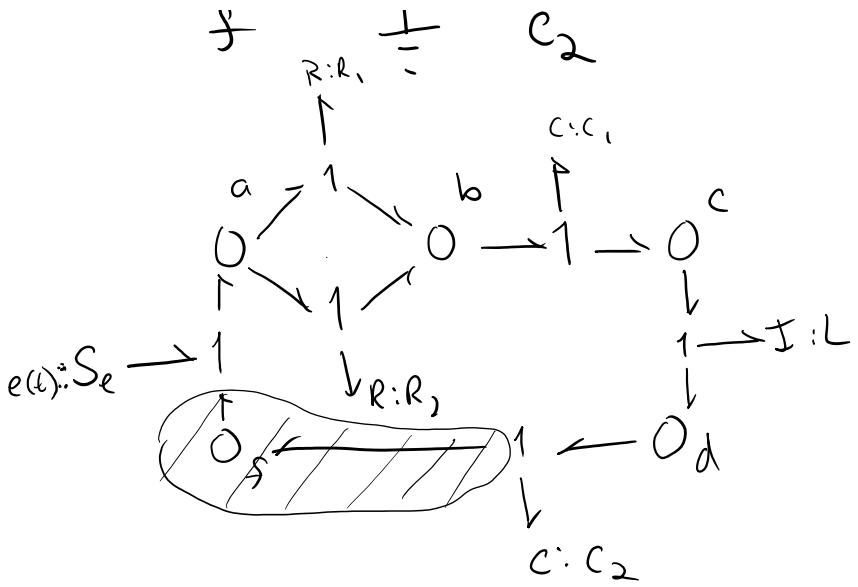
Exercise



Step1: Assign power sign convention

Step2: Create 0 junction for each node with common voltage

Step3: Create 1 junction to establish voltage



to establish voltage drops

Step 4: Choose ground/ref voltage, set to zero, eliminate bonds of zero power

Step 5: Simplify