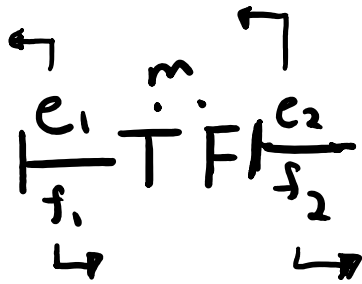


Causality of 2-Ports

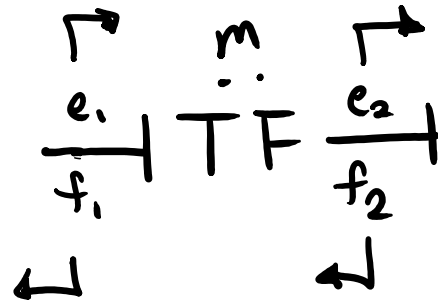
Each has two possibilities.

Transformer



$$\begin{bmatrix} e_1 \\ f_2 \end{bmatrix} = m \begin{bmatrix} e_2 \\ f_1 \end{bmatrix}$$

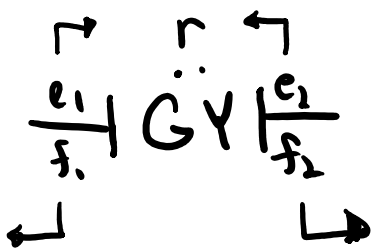
Outputs Inputs



$$\begin{bmatrix} e_2 \\ f_1 \end{bmatrix} = \frac{1}{m} \begin{bmatrix} e_1 \\ f_2 \end{bmatrix}$$

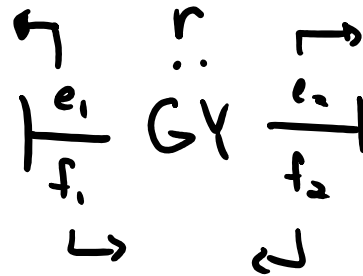
Outputs Inputs

Gyrator



$$\begin{bmatrix} f_1 \\ f_2 \end{bmatrix} = \frac{1}{r} \begin{bmatrix} e_2 \\ e_1 \end{bmatrix}$$

Outputs Inputs

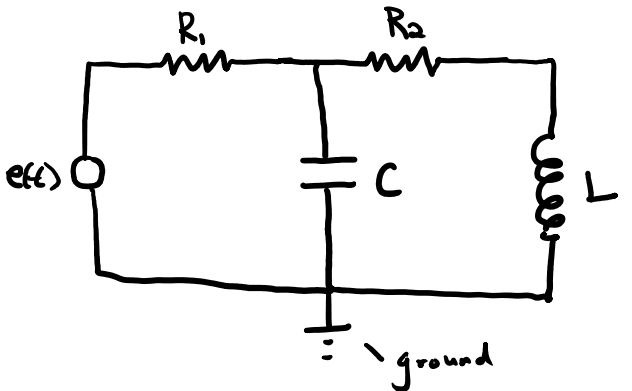


$$\begin{bmatrix} e_1 \\ e_2 \end{bmatrix} = r \begin{bmatrix} f_2 \\ f_1 \end{bmatrix}$$

Outputs Inputs

Chapter 4: System Models

Electrical Networks



R_1, R_2 : linear resistors
 L : linear inductor
 C : linear capacitor
 $e(t)$: voltage source

ground
reference voltage
for determining
voltages at
other nodes

4 step process to making a bond graph of an electrical system.

Step 1: assign a power sign convention

Step 2: add ϕ junctions for each electrical node that have common voltages

Step 3: establish voltage drops across components using 1 junctions

Step 4: choose ground or reference voltage node and remove all zero power nodes

Step 5 (optional): simplify the bond graph

→ ... enforce Kirchoff's laws:

Step 2 (optional): simplifying the circuit

The ϕ and 1 junctions enforce Kirchoff's laws:

Kirchoff's Voltage Law: voltage around a closed loop must be zero

Kirchoff's Current Law: sum of the currents at junctions must be zero

