EE5240 - Lecture 17 (EE5220 L12, 2/3/12) Wed Feb 15, 2023

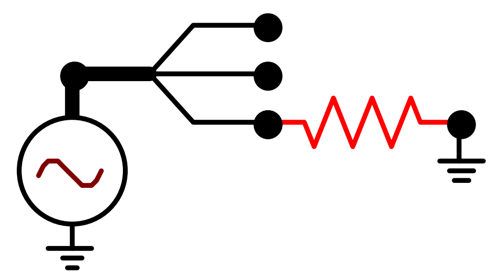
Topics for Today:

- Computer methods for time-domain transient simulation
  - ATP Simulation pointers 3-phase connections
  - Cap Bank Switching
  - ***ATP - how it works internally***
    - ***History of program development, versions available***
    - ***Rs, Ls, Cs***
    - ***Transmission lines***
    - ***System description as conductance matrix [G]***
    - ***Solution of [G] [V] = [I] when V's and I's are a mixture of knowns and unknowns.***

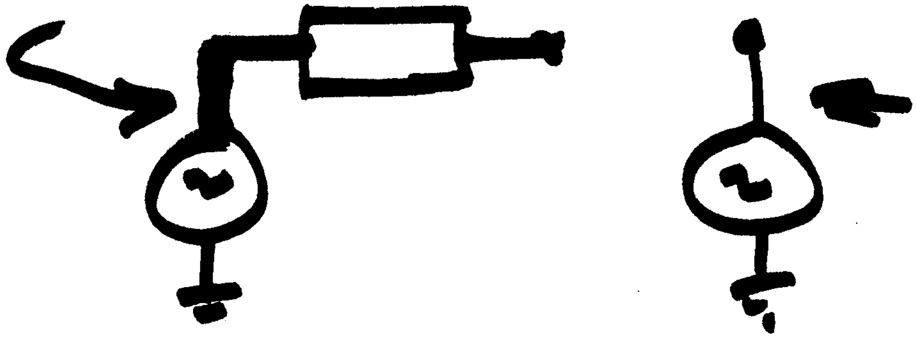
ATP Simulation Pointer for the day:

When building 3-phase circuits, you are actually drawing a one-line which represents the L-G per-phase equivalent of the system. Node names have a base name 5 characters long, with the 6^{th} character A, B, C automatically added. Click on the 3-phase end of the splitter if you want to define the base node name.

If you need to make single-phase connection(s) to individual phases, use the splitter. When drawing a connecting line to a splitter, start at the node of the single-phase element and connect ***to*** the splitter. If you need to ground one phase, you can do that at the single phase element, but not at the splitter.

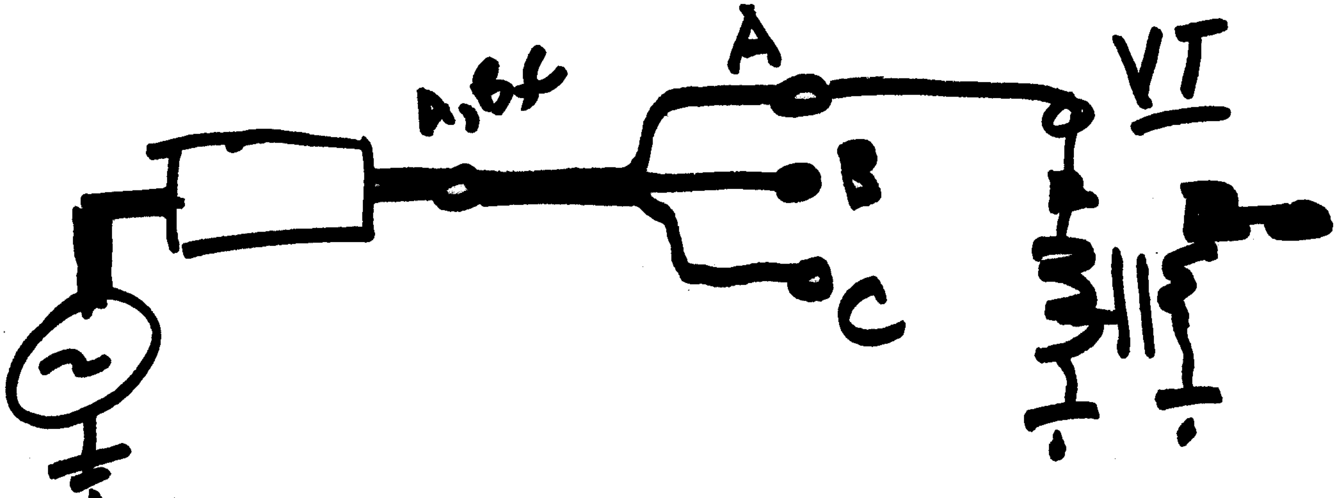


3-PHASE ELEMENTS

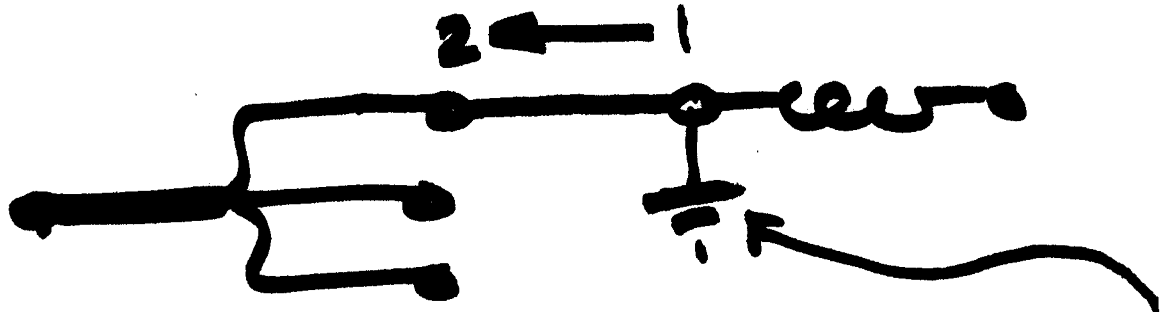


Single PHASE

SPLITTER · 3ph → 1ph



CONNECTING: Draw from 1→2



Ground - Connect at 1ϕ element

R's, L's & C's in EMTP

Notes

EMTP - BPA, 1970 → '85

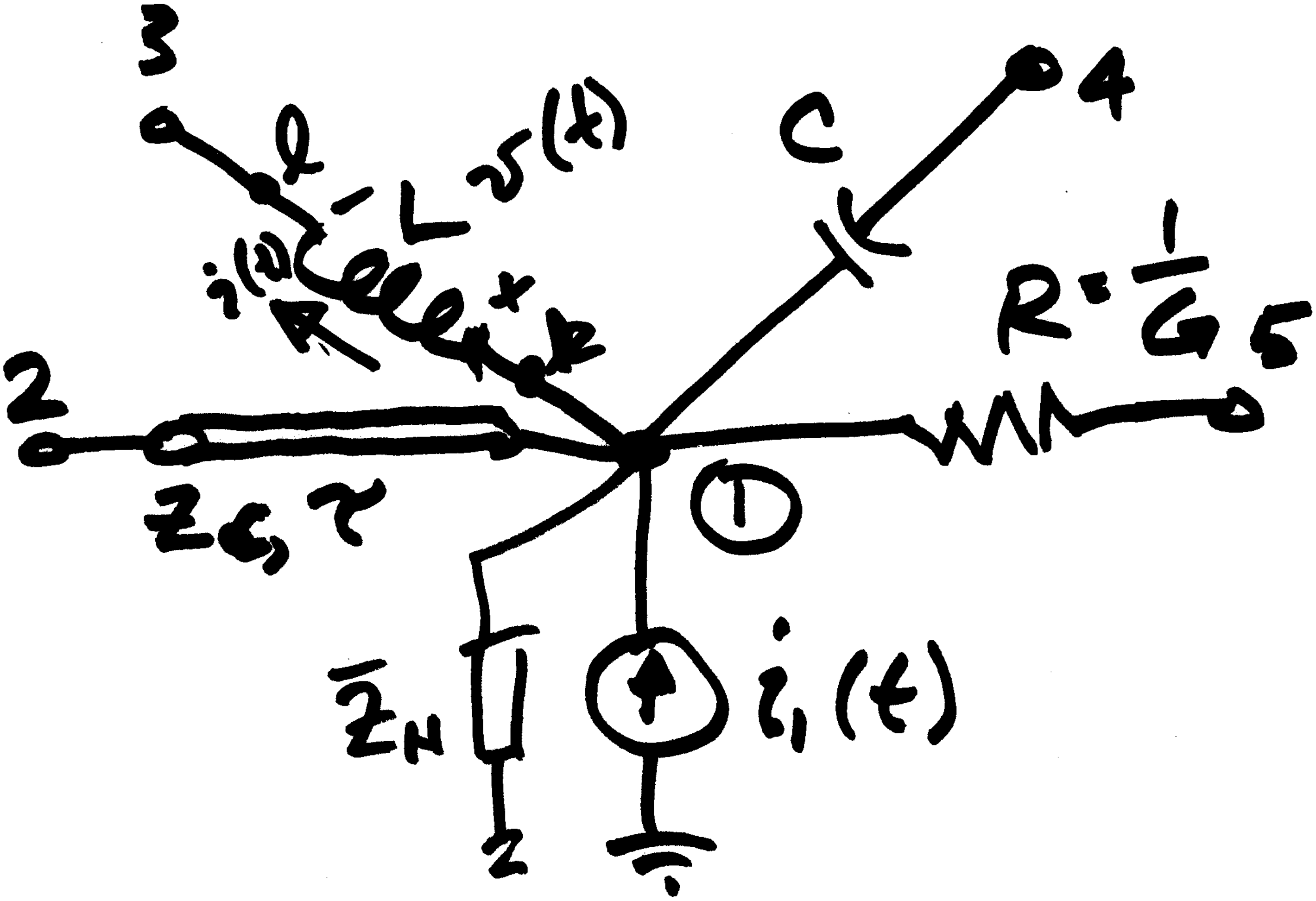
1985 EPRI | DCG ↓

EPRI EMTP
or DCG EMTP
- TACS ↓
EMTP/RV ✓

F.O.I.
1987
↓
ATP ✓

Different:
- TACS
- MODELS
(Controls)

OTHERS:
- EMTDC/Pscad
- Micro-Tran ✓
- ABB/Siemens
- EDF - MORGAT



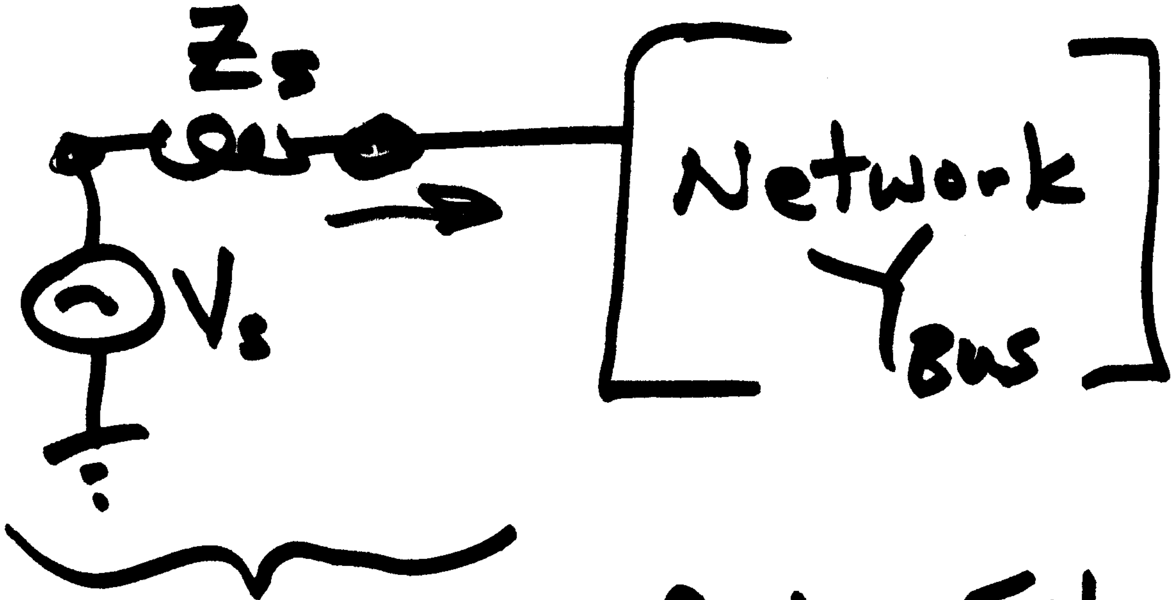
Side Note:

Mathematical Structure is

$$[Y][V] = [I]$$

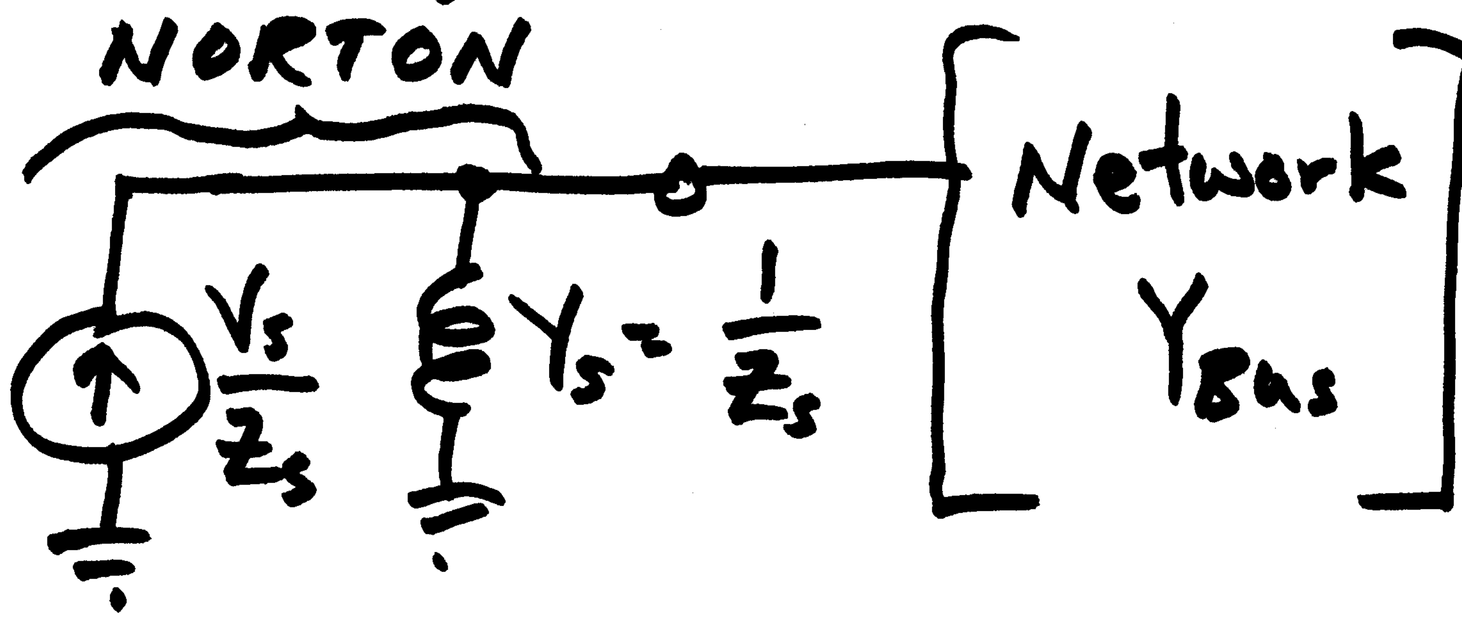
sparse → [Y]; node V's → [V]; injected currents → [I]

Injected Currents!

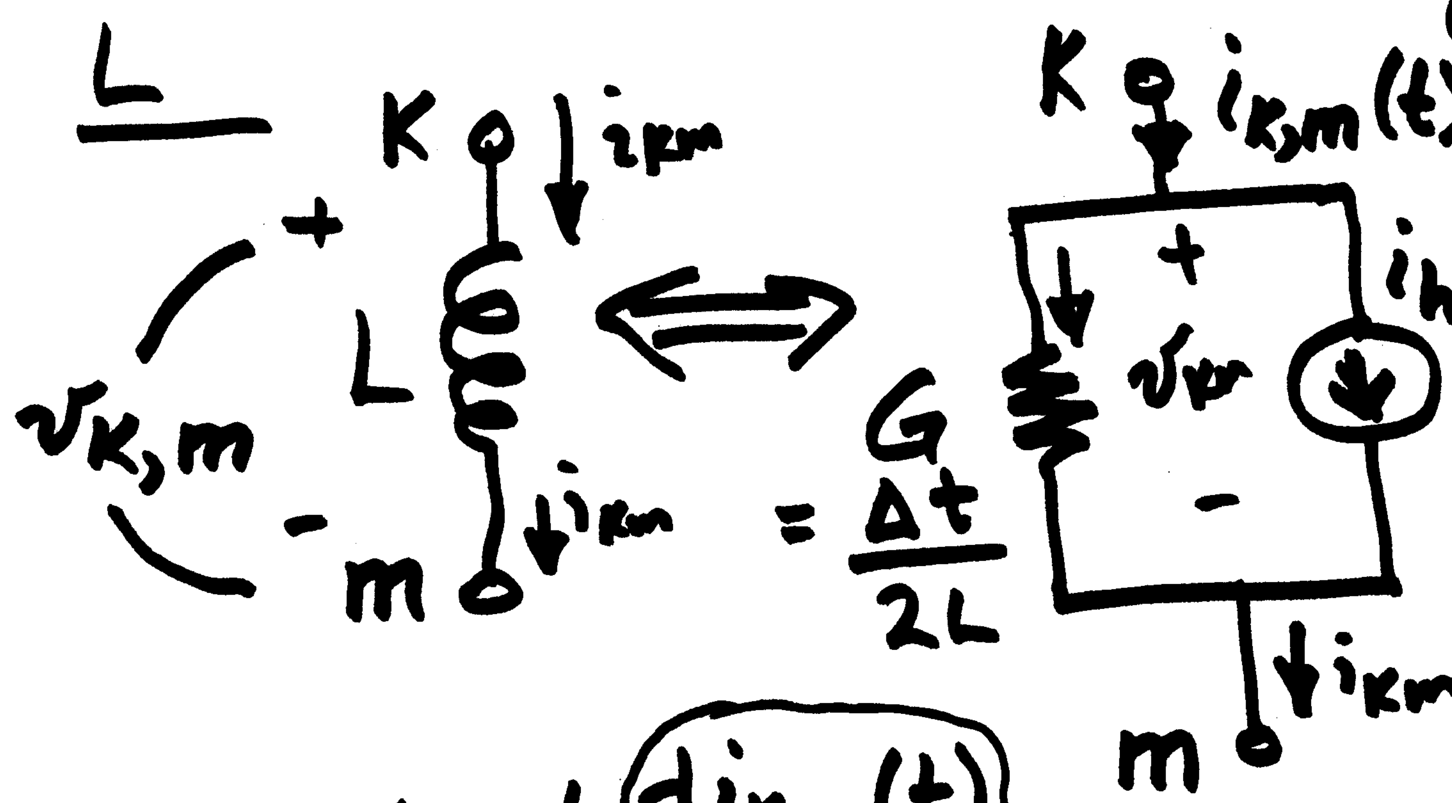


Thevenin = Bad : Extra Node
V = Fixed

Instead, convert to Norton:



L

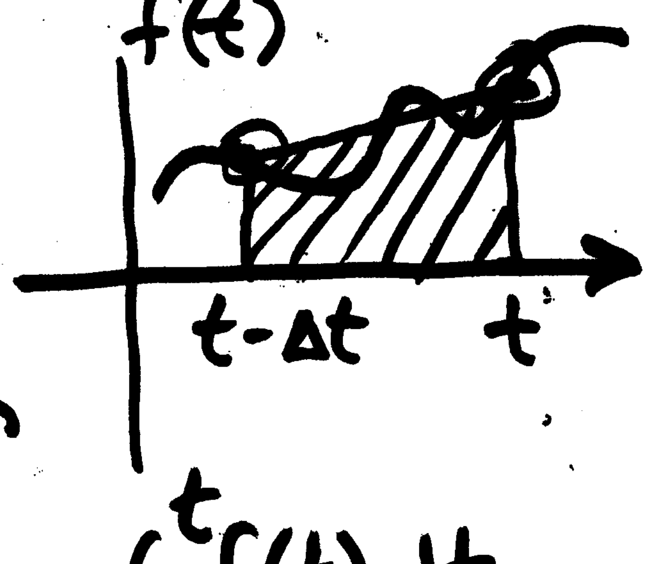


$$v_k - v_m = L \frac{d i_{k,m}(t)}{dt}$$

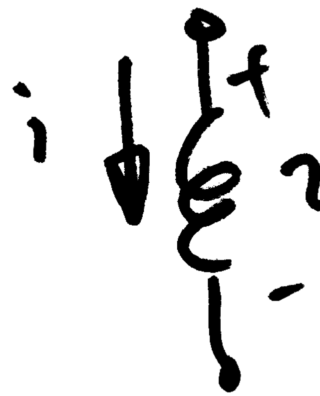
$$d i_{k,m}(t) \cong \overbrace{\{ i_{k,m}(t) - i_{k,m}(t-\Delta t) \}}^{\Delta i}$$

$$dt \cong \Delta t$$

Trapezoidal Integration



$$\int_{t-\Delta t}^{t} f(t)\, dt$$



$$v = L\frac{di}{dt}$$

$i = ?$

$$v\,dt = L\,di$$

$$di = \frac{1}{L} v\,dt$$

$$i = \frac{1}{L}\int_0^t v\,dt$$

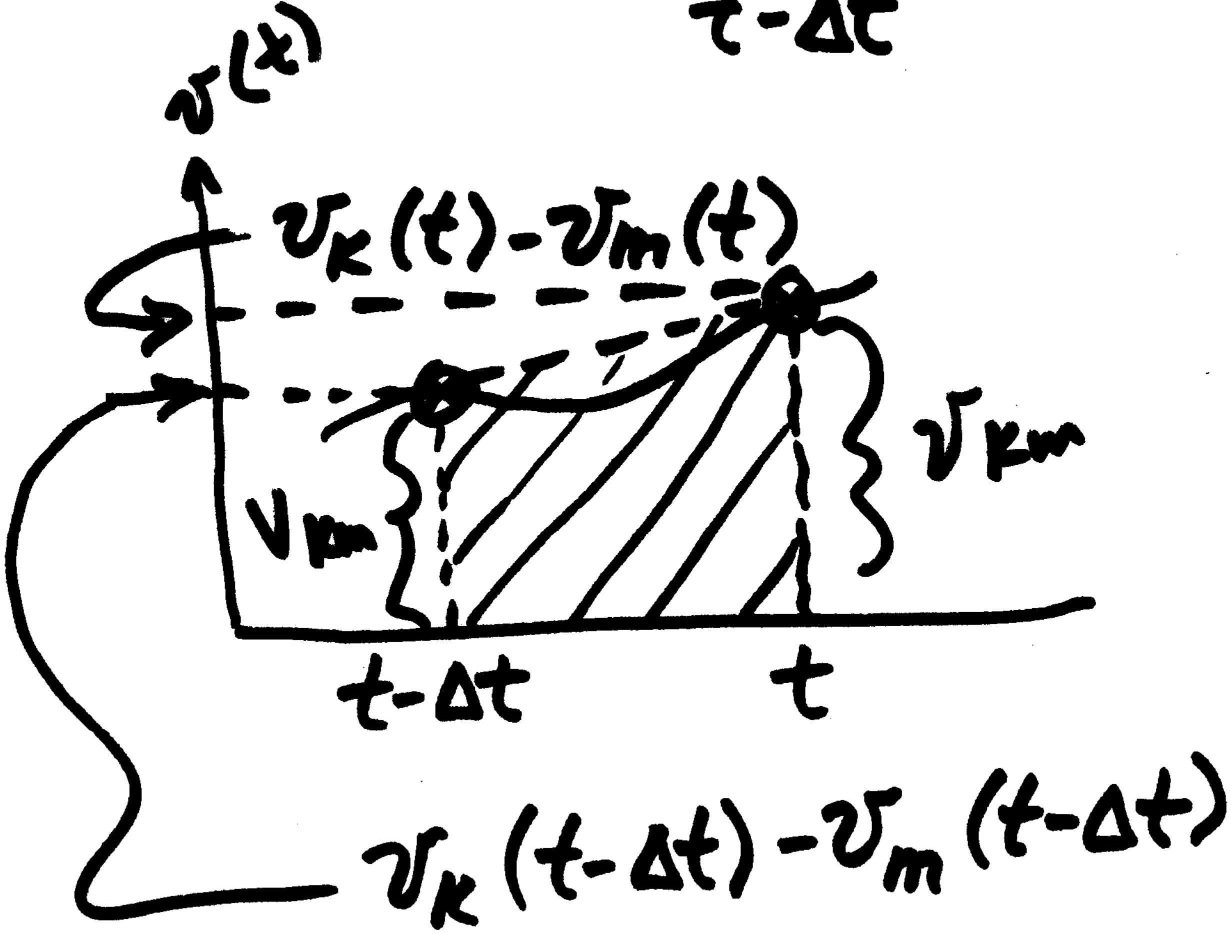
Δt in EMTP
cannot be
as small as dt,
Δt is finite.

6A

Look at Trapezoidal implementation of eqn: 6B

$$v_k(t) - v_m(t) = L \frac{d\, i_{k,m}(t)}{dt}$$

$$d\, i_{k,m}(t) = \frac{1}{L} \int_{t-\Delta t}^{t} \left[v_k(t) - v_m(t) \right] dt$$



The integral can then be approximated as the area of the trapezoid:

$$\frac{1}{L}\int_{t-\Delta t}^{t}\left[v_K(t)-v_m(t)\right]dt$$

$$\cong \frac{\Delta t}{L}\left[\frac{v_K(t)-v_m(t)+v_K(t-\Delta t)-v_m(t-\Delta t)}{2}\right]$$

(i.e. area of trapezoid = Δt x average height of sides)

$$d\,i_{km}(t) = \frac{1}{L}\int_{t-\Delta t}^{t}\left[v_k(t) - v_m(t)\right]dt$$

$$\downarrow$$

$$i_{km}(t) - i_{km}(t-\Delta t)$$

7A

Integral is:

$$\frac{1}{L}\left[v_k(t) - v_m(t) + v_k(t-\Delta t) - v_m(t-\Delta t)\right]\frac{\Delta t}{2}$$

---

putting pieces together,

~~check~~ OK

$$i_{k,m}(t) \cong i_{k,m}(t-\Delta t) + \frac{\Delta t}{2L}\left[v_k(t) - v_m(t) + v_k(t-\Delta t) - v_m(t-\Delta t)\right]$$

Separating (t) & $(t-\Delta t)$ terms, 9

$$i_{m,k}(t) \cong \underbrace{\frac{\Delta t}{2L}}_{G} \underbrace{\left[v_k(t) - v_m(t) \right]}_{\text{Current at time} = t \text{ for present voltage drop}}$$

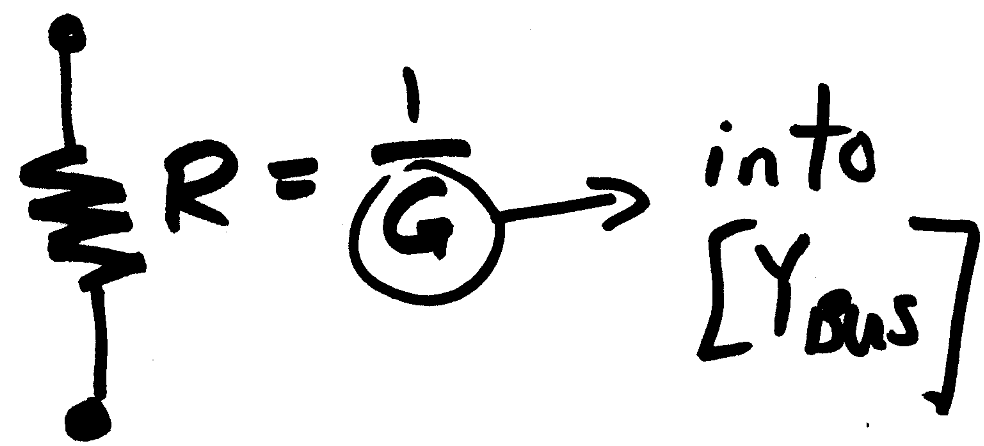
$$+ \underbrace{i_{k,m}(t-\Delta t) + \frac{\Delta t}{2L} \left[v_k(t-\Delta t) - v_m(t-\Delta t) \right]}_{}$$

$I_{hist} = I_{k,m}$ = Summation of all currents at past time steps, i.e. $t-\Delta t$, $t-2\Delta t$, $t-3\Delta t$, ... –

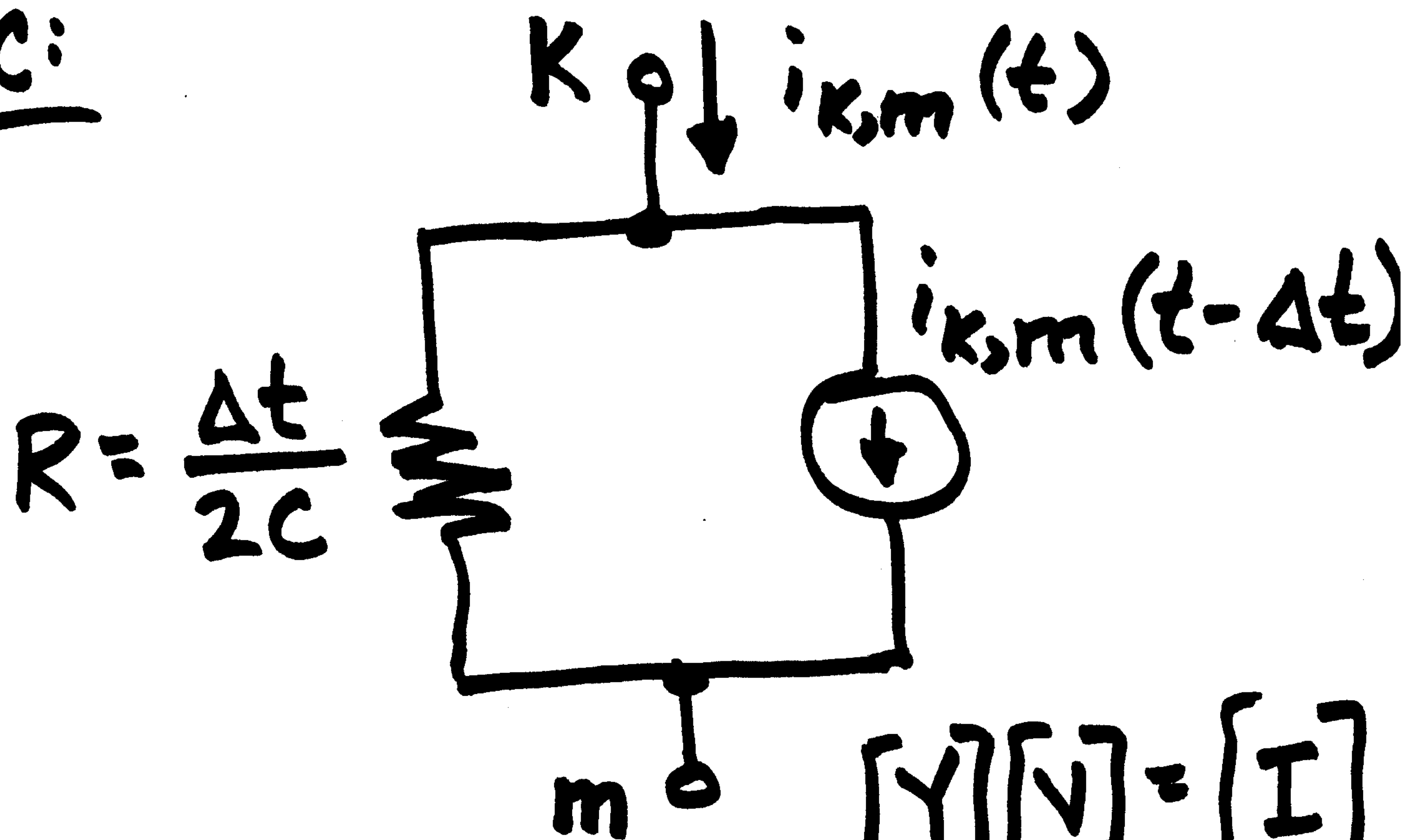
Initial iteration: $\boxed{I_{hist}(0) = i(0)}$.

$[Y_{Bus}]$ is augmented according to system elements needed.

<u>R:</u>

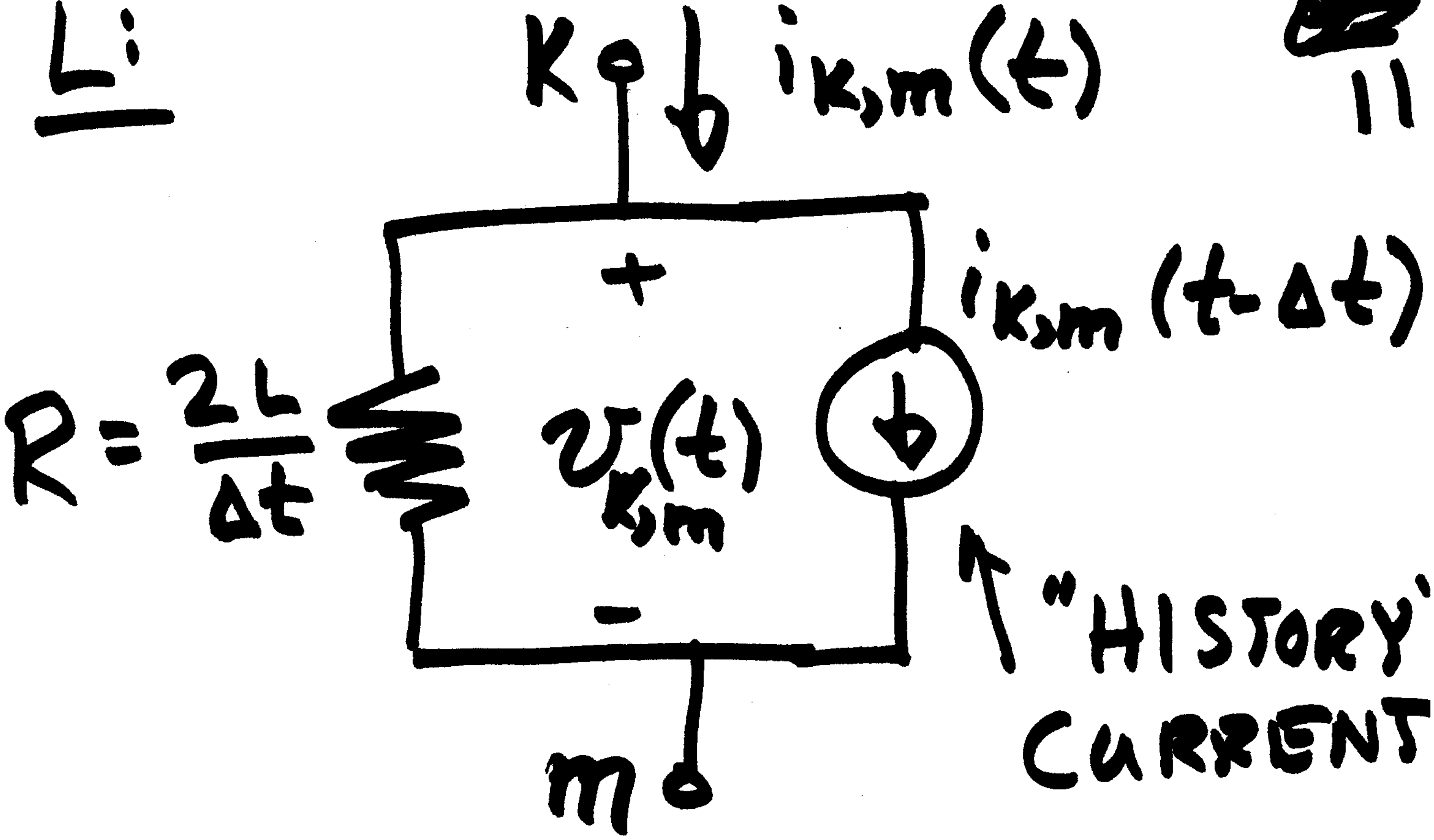


<u>C:</u>



$[Y][V] = [I]$

L:



11