EE 5220 - Lecture 18 Friday Feb 16, 2024

Topics for Today:

- Course Info:
  - Web page: http://www.ee.mtu.edu/faculty/bamork/ee5220/
  - Software - Matlab. ATP/EMTP [License - www.emtp.org] ATP tutorials posted on our course web page
  - EE5220-L@mtu.edu (participation = min half letter grade)

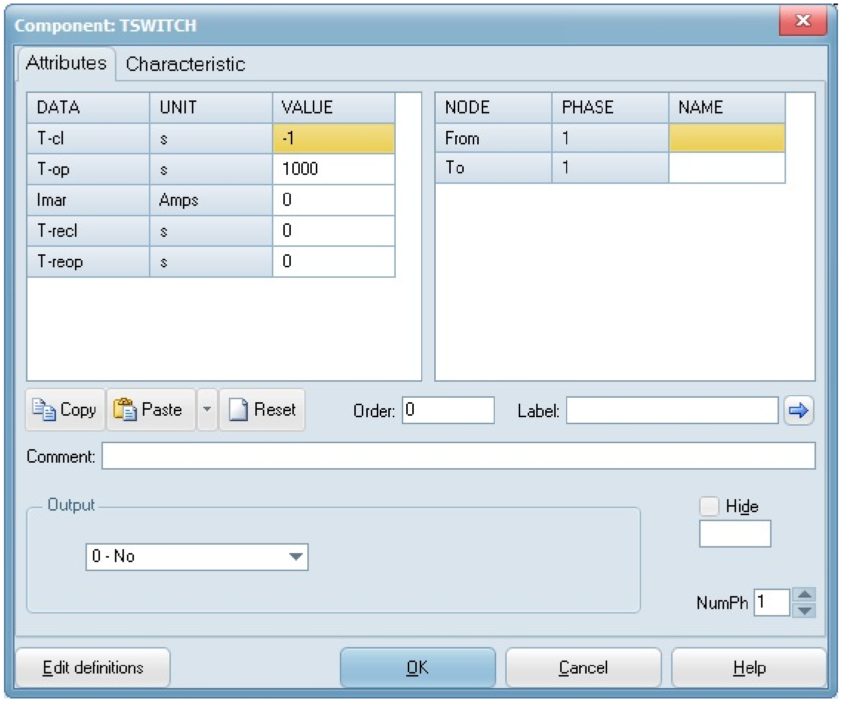
- HW#6 - due latest Tues Mar 5th 9am.
- Term Project - list of proposed topics via e-mail to Dr. Mork for discussion. Formal submission to Canvas by next Monday 5pm.
- ATP Simulation pointers
- Transmission Line Models available in ATP (more detail on these later)
  - Lumped Pi
  - Bergeron
  - Marti
  - Semlyen
  - Noda
- Use of ATPDraw's Line Constants to obtain parameters, build line models.
- Use of Line Constants .lis output file to obtain detailed matrices, line parameters, propagation constants.

ATP Simulation Pointers for the day:

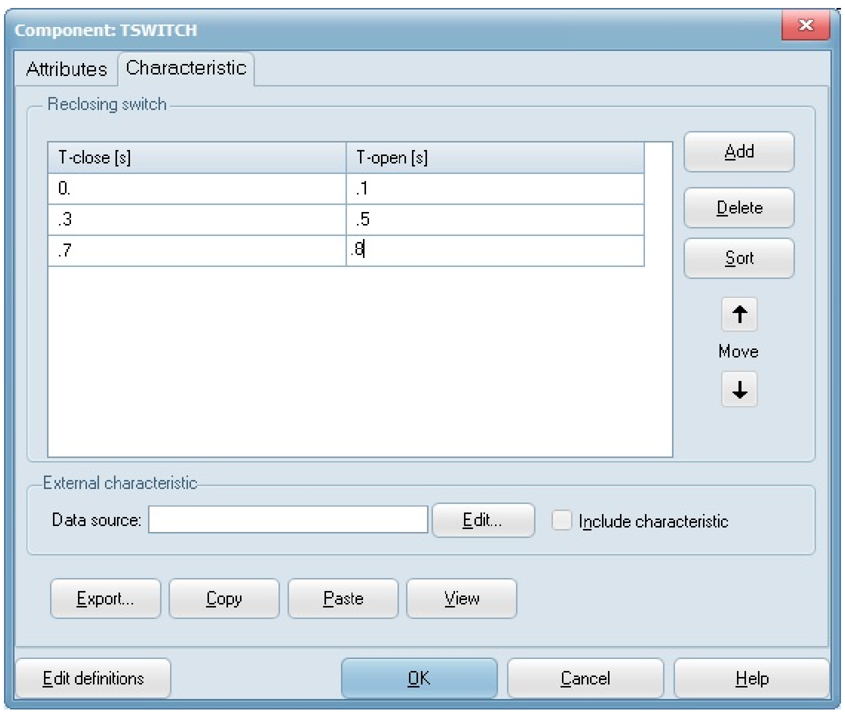
Switching operations cause a step response in the system you're simulating. If numerical oscillations should occur upon a switching operation, it may very likely be due to a very small source inductance. This is typical in very small Ls or very large Cs. In this case, first add numerical damping to the small L. This usually solves the problem.

The new time-controlled switch in ATPDraw allows many on-off cycles of switch. If you are paralleling the older/simpler switches (which only allow one on-off cycle) for complex operations, then a small R can be inserted in series with the second and later switches.

Insert a current probe (internal to ATP this is called a "measuring switch" or "metering switch") in series with other elements if you want to measure the current flowing into a particular node in your system.



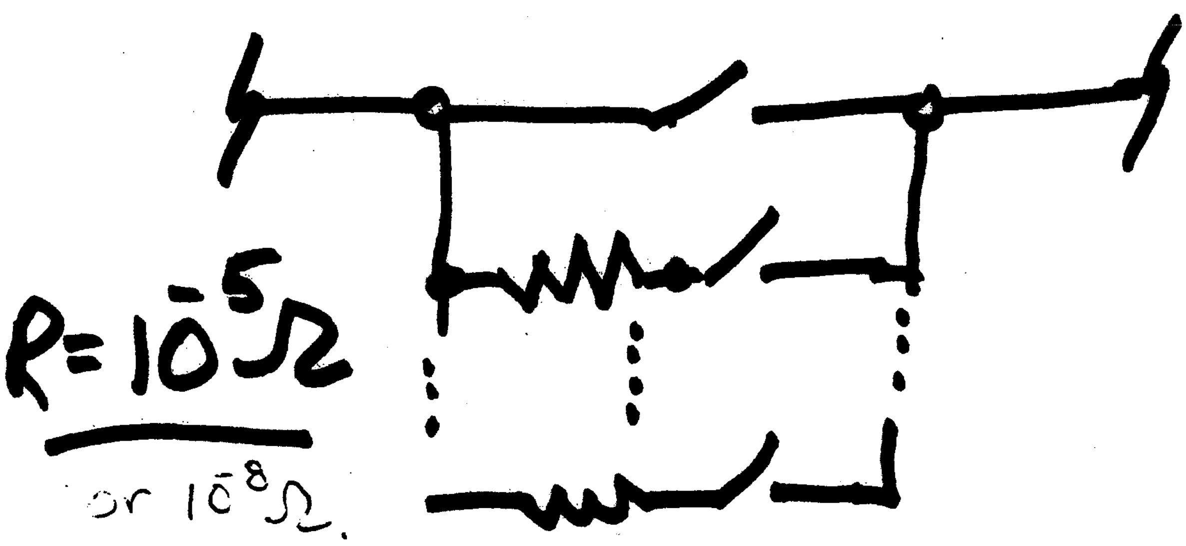
Here you can see the default time-controlled switch. One close time and one open time.



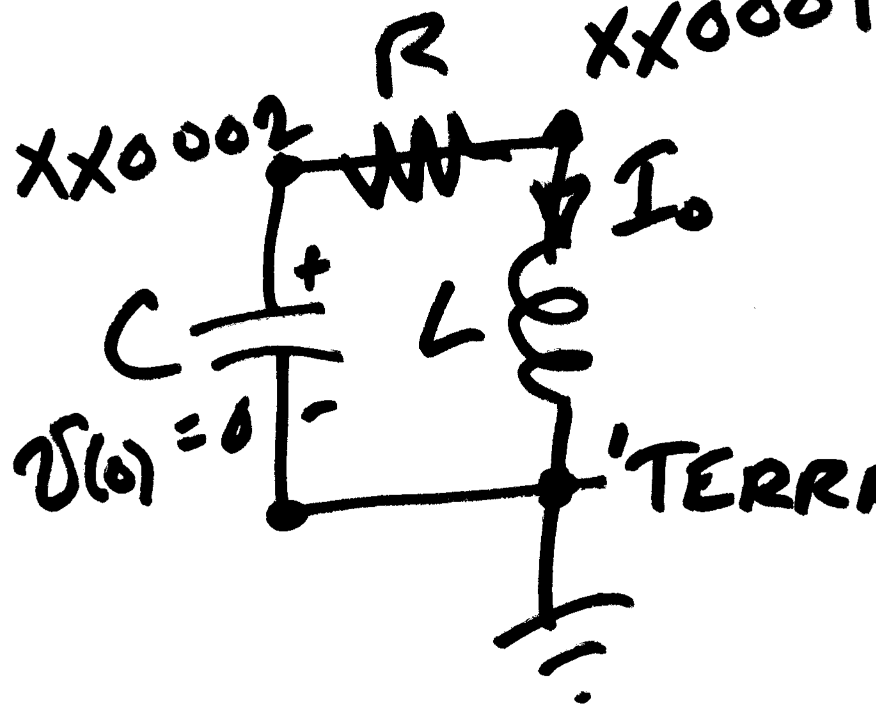
If you need a sequence of on-off switching operations, then you can specify them in the Characteristic, like this. This is particularly useful if you are simulating a trip of a circuit breaker with multi-shot reclose attempts.

ATP Simulation Pointer for the day:

When simulating a multi-step switching operation, switches can be placed in parallel. However, this topology can cause some numerical instabilities, especially with a voltage-controlled switch. To avoid this problem, you can insert very small resistances in series with the additional switches.



Initialization



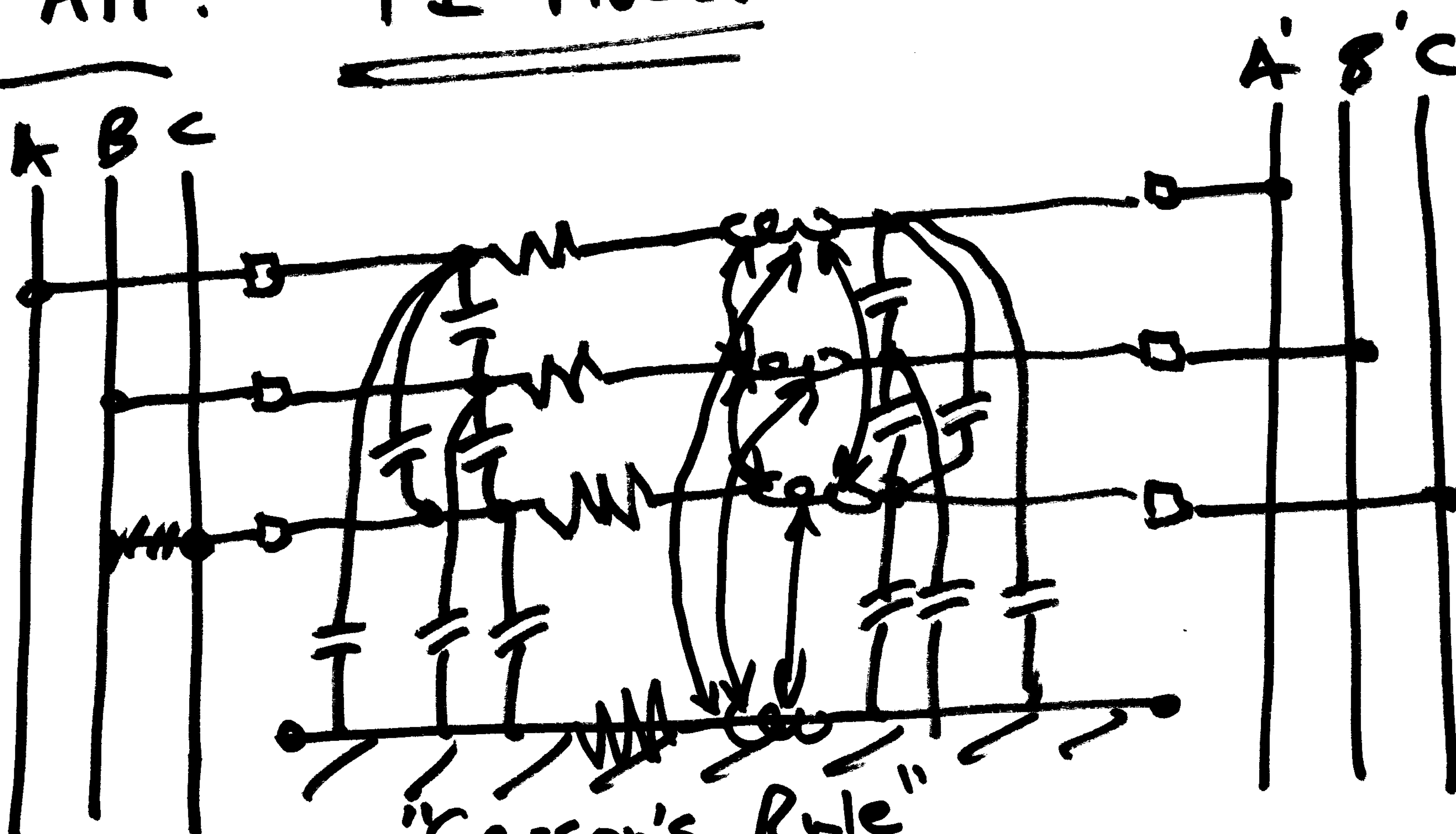
'TERRA' or ' '

Nonlinear Inductors

In ATP "STARTUP" = 1.D-8

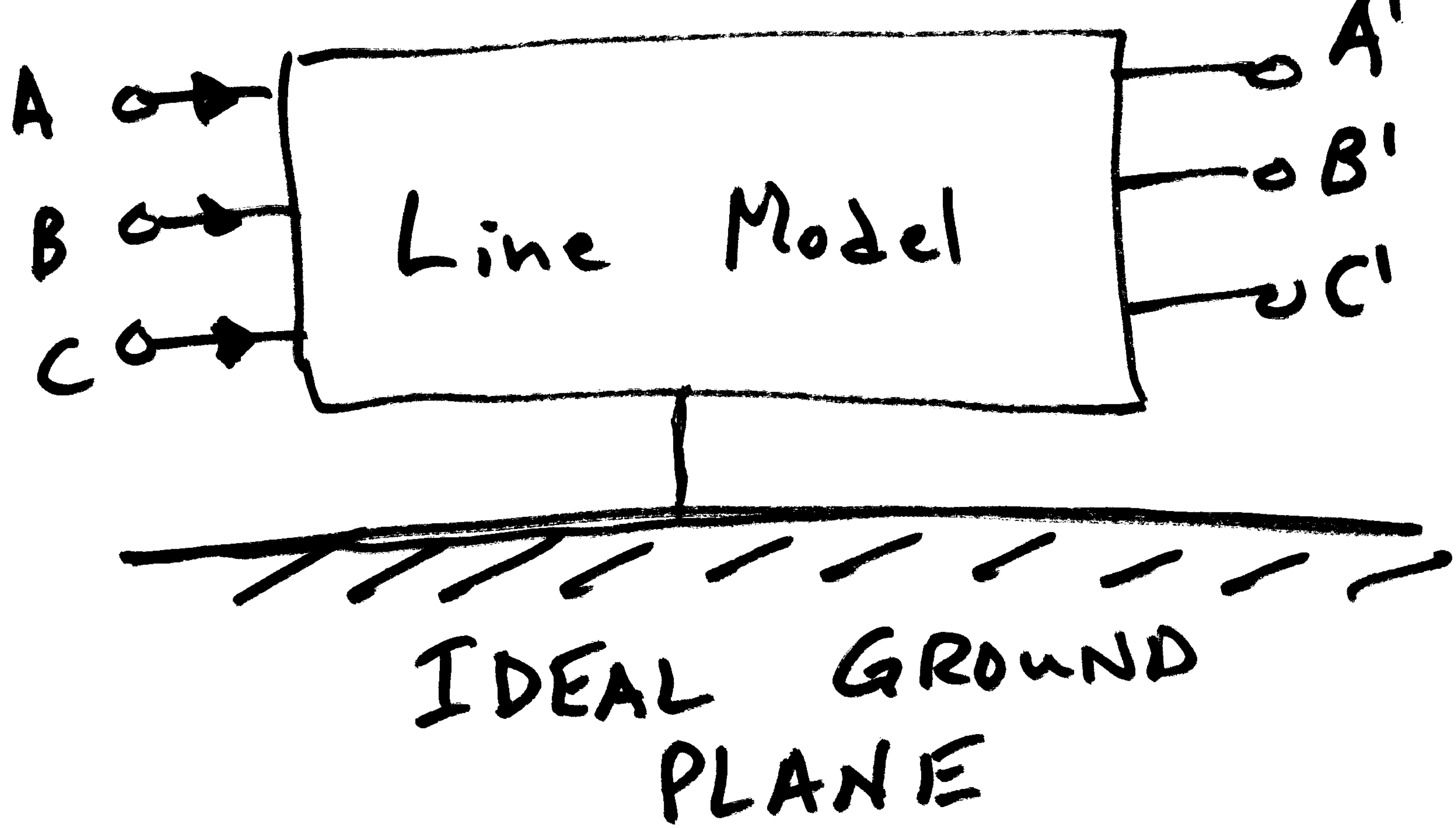
On a one-line:

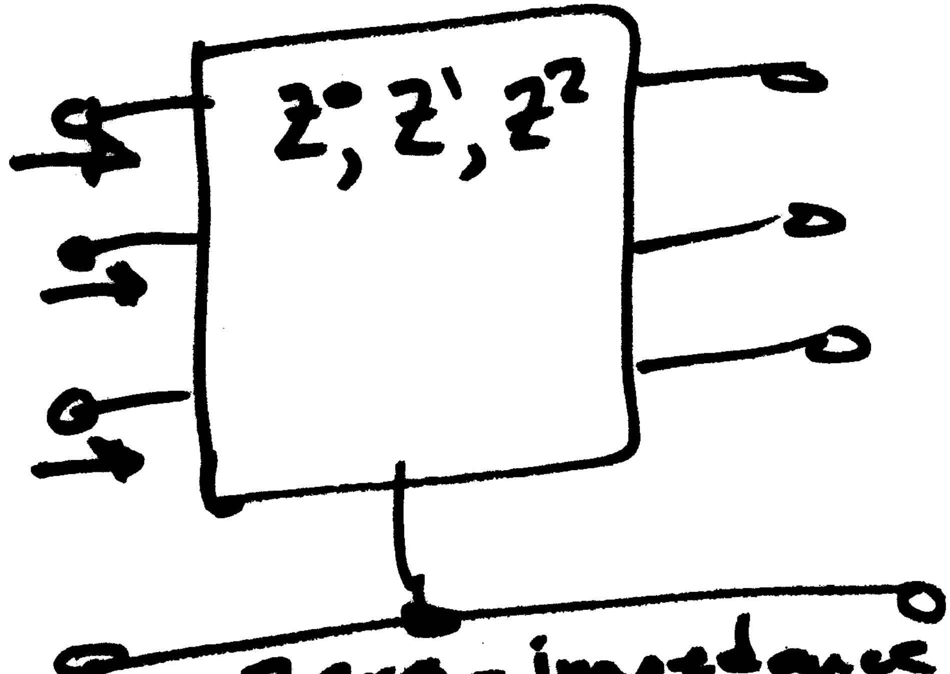
In ATP: "PI Model":



"Carson's Rule"

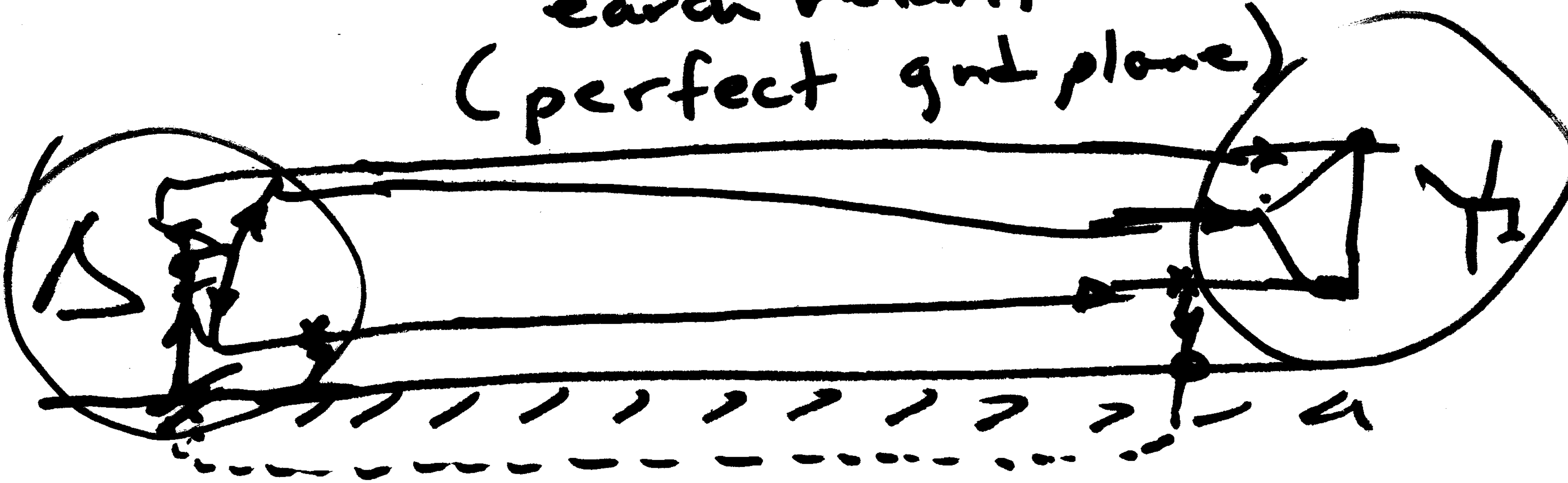
- KRON REDUCTION


A
B
C
Line Model
A'
B'
C'
IDEAL GROUND PLANE

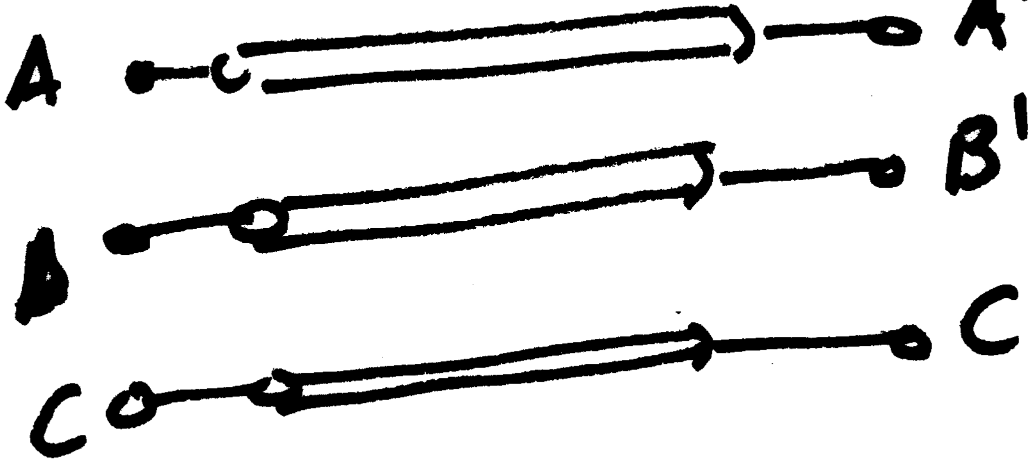


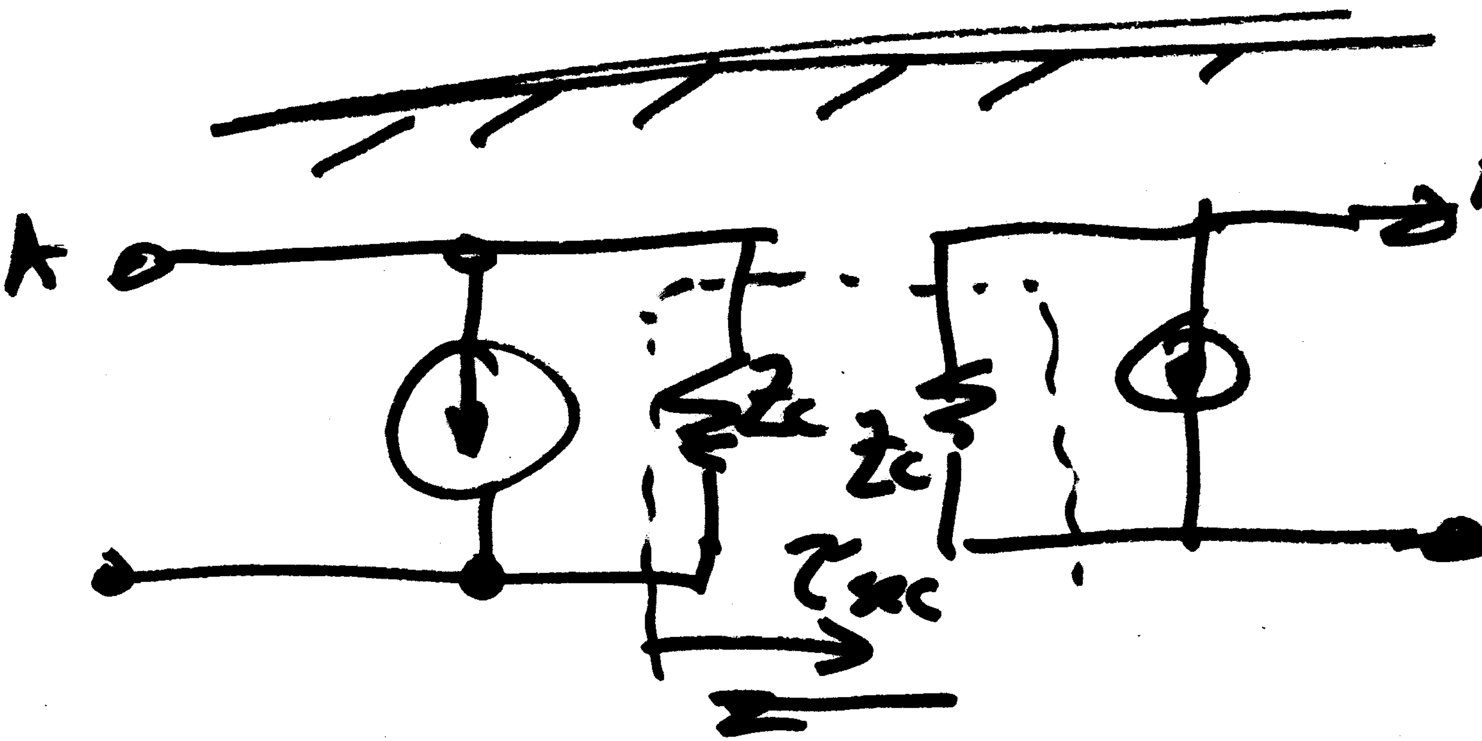
For all line models.

zero-impedance earth return (perfect gnd plane)

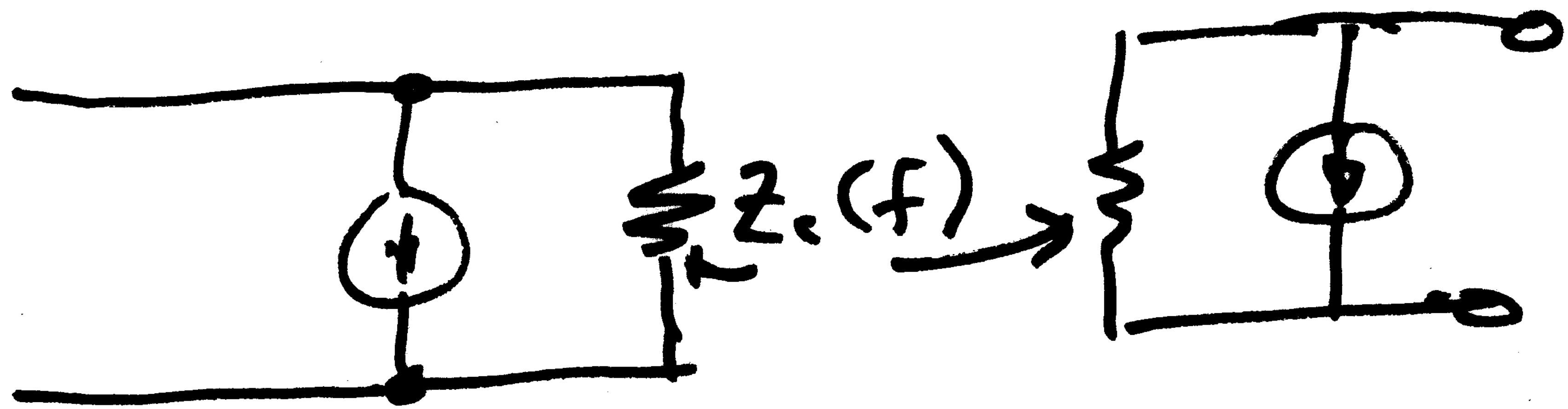


Bergeron - Constant Z_c. (not freq. dep)

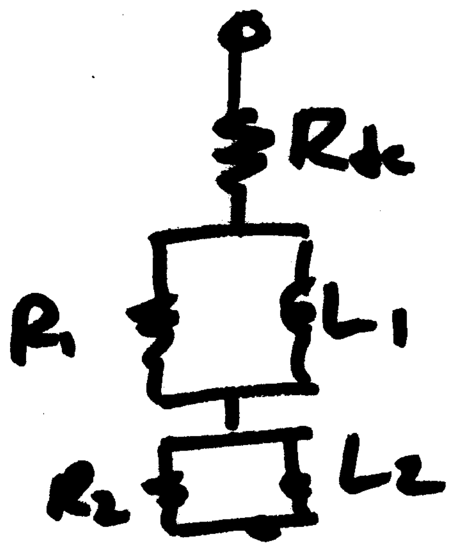


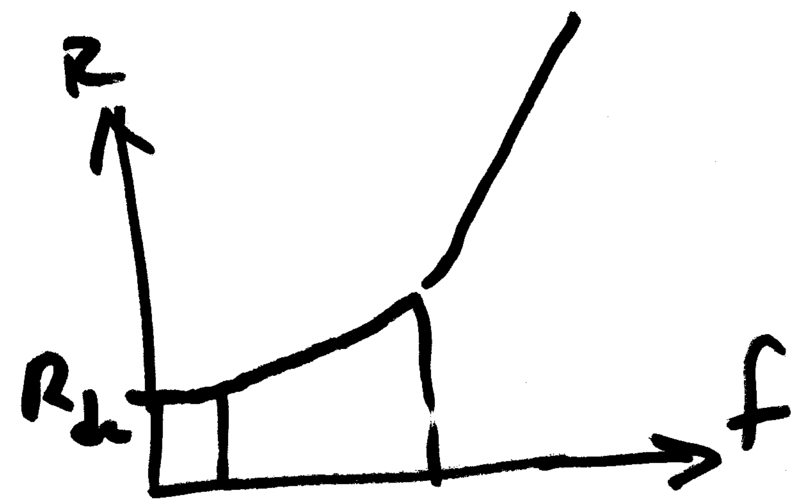


Marti Model - freq-dependent Z_c



Build it for 1 Hz → 1 MHz.

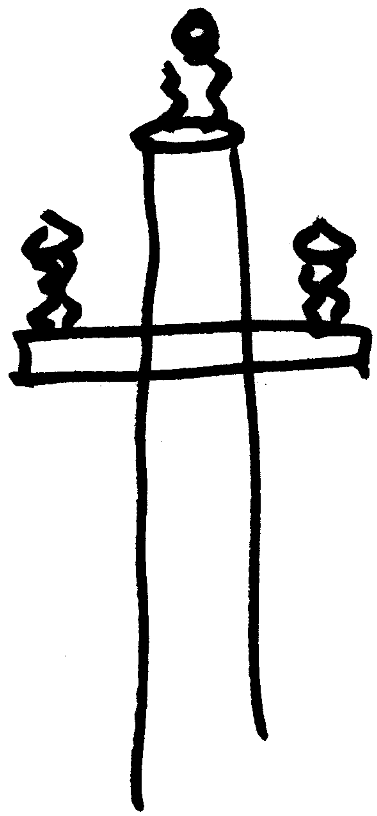




Transposition - Balance phase Z, Y, for lines which are "unsymmetric"

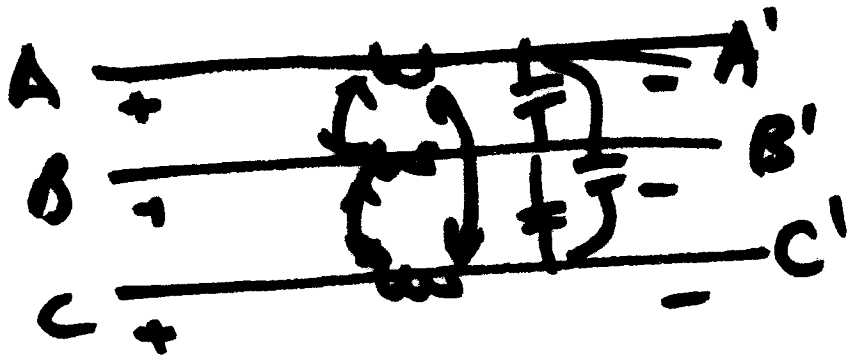
"Horizontal"

non-symm phase spacings



"symm"

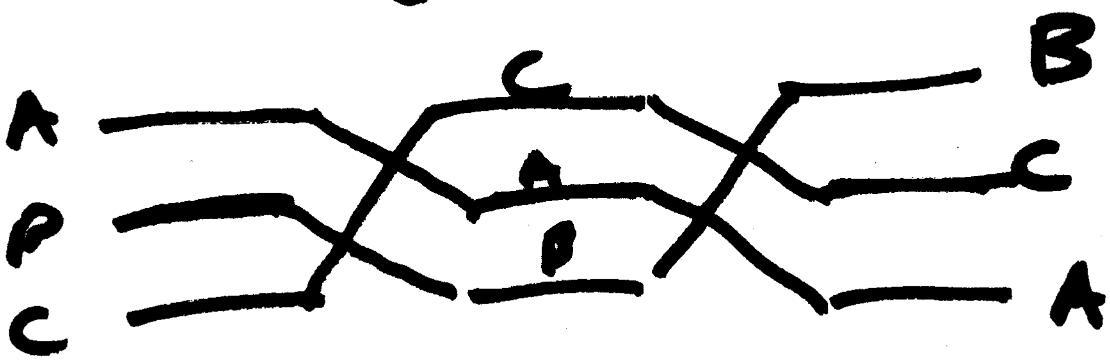
$\Longrightarrow$ Transposition.



Unbalanced V-drops, hence unbalanced phase voltages at Receiving end of line

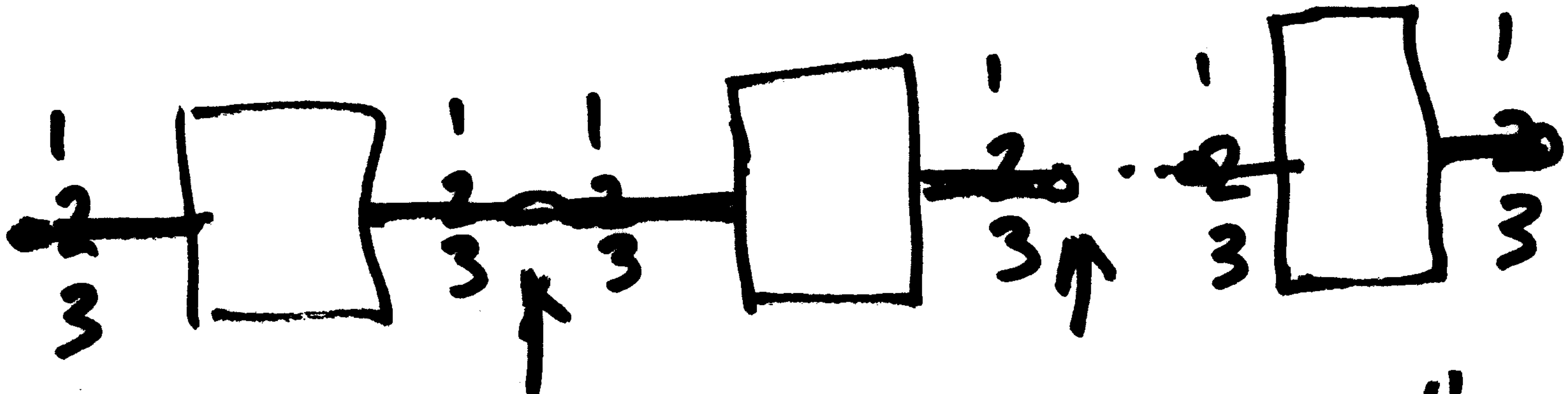
Fix

⇓

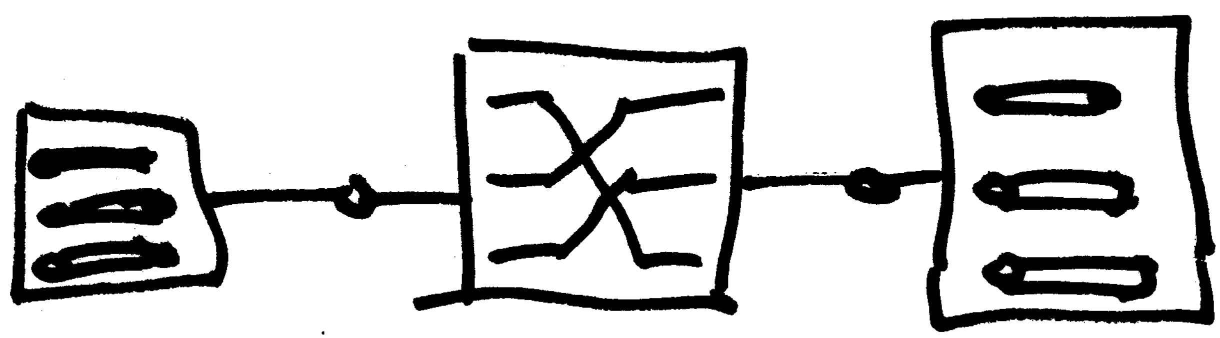


□ Transposed (= Continuously transposed)

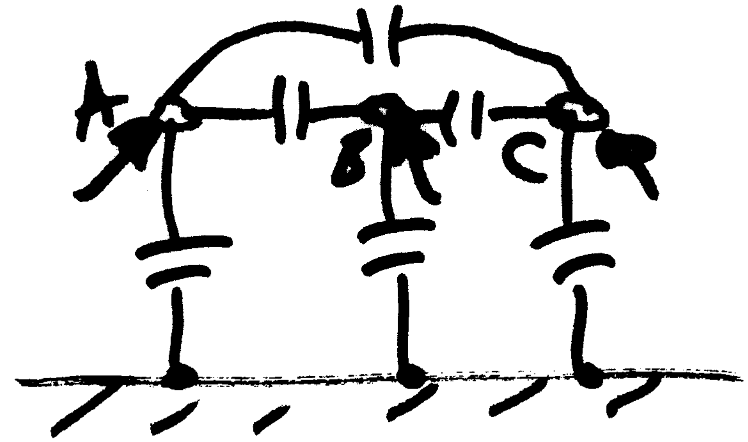
For actual lines, model each line section separately.



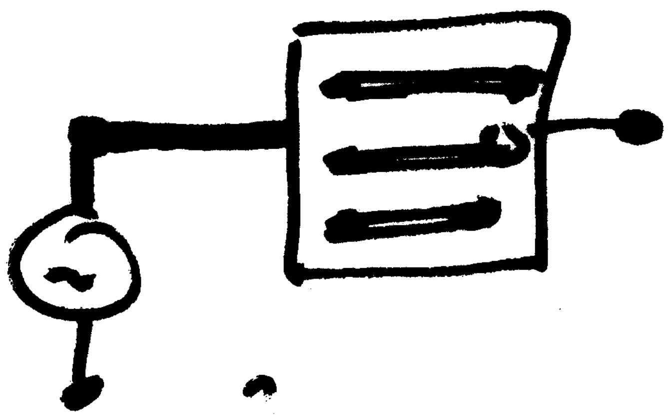
Transpose by "rolling" the phase connections btwn sections.



$$\omega \begin{bmatrix} \underline{C_{AA}} & C_{AB} & C_{AC} \\ C_{BA} & C_{BB} & C_{BC} \\ C_{CA} & C_{CB} & C_{CC} \end{bmatrix}$$



$C_{NN} = +\sum$ connected C's.



$\hat{i}_A =$

$i_B =$

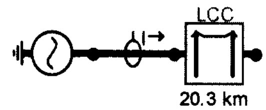
$i_C =$

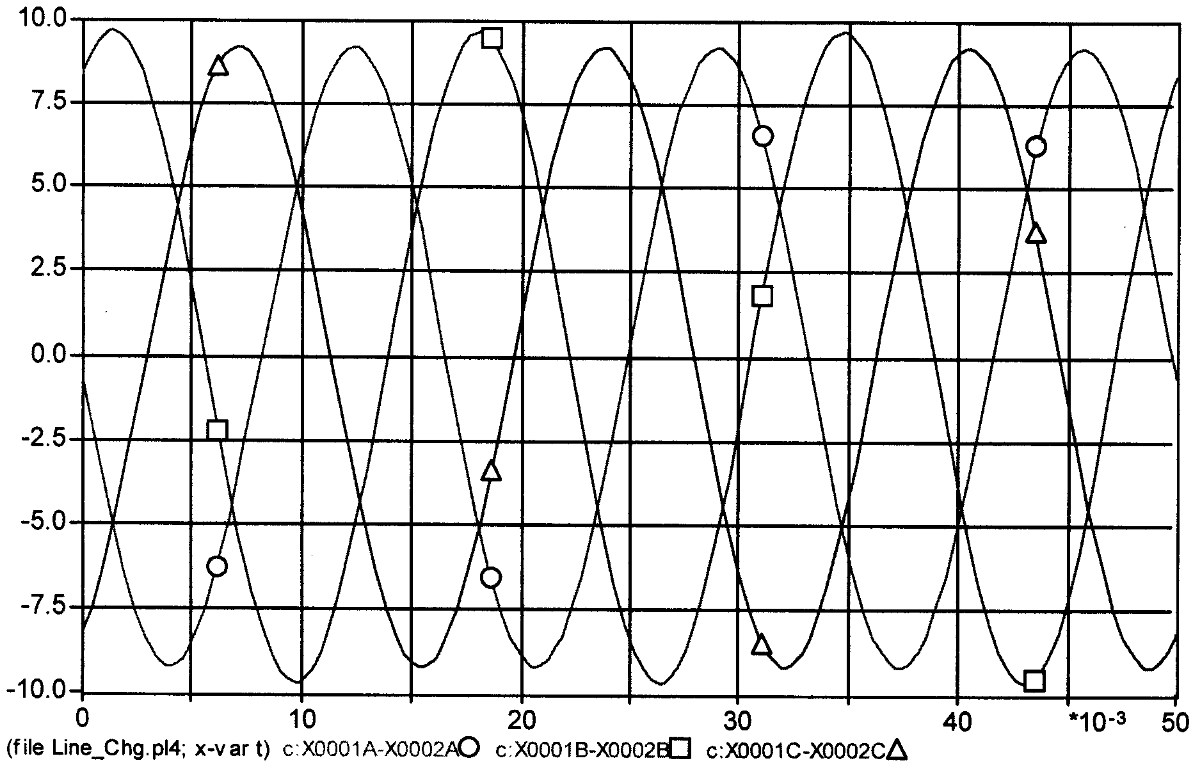
$Y = G + j\underline{\underline{B}}$

$\underline{\underline{Y}} = G + j\omega \underline{\underline{C}}$

Line Charging Example: LCC_3b.alc (Coupled-PI, 60 Hz model).

Simulation file: Line_Chg.acp





As predicted, phase B line current is larger than A or C, due to larger capacitive coupling to phase B. Larger capacitive effect ==> smaller input impedance ==> higher current...

See Line Constants output log file, LCC_3b.lis, on following pages. Be sure to print these with fixed-pitch font so that columnar data is aligned. This file is created in atp\atpdraw\atp\ folder when you "build" the line model (from within Line Constants parameter/dialog box, click on Run ATP).