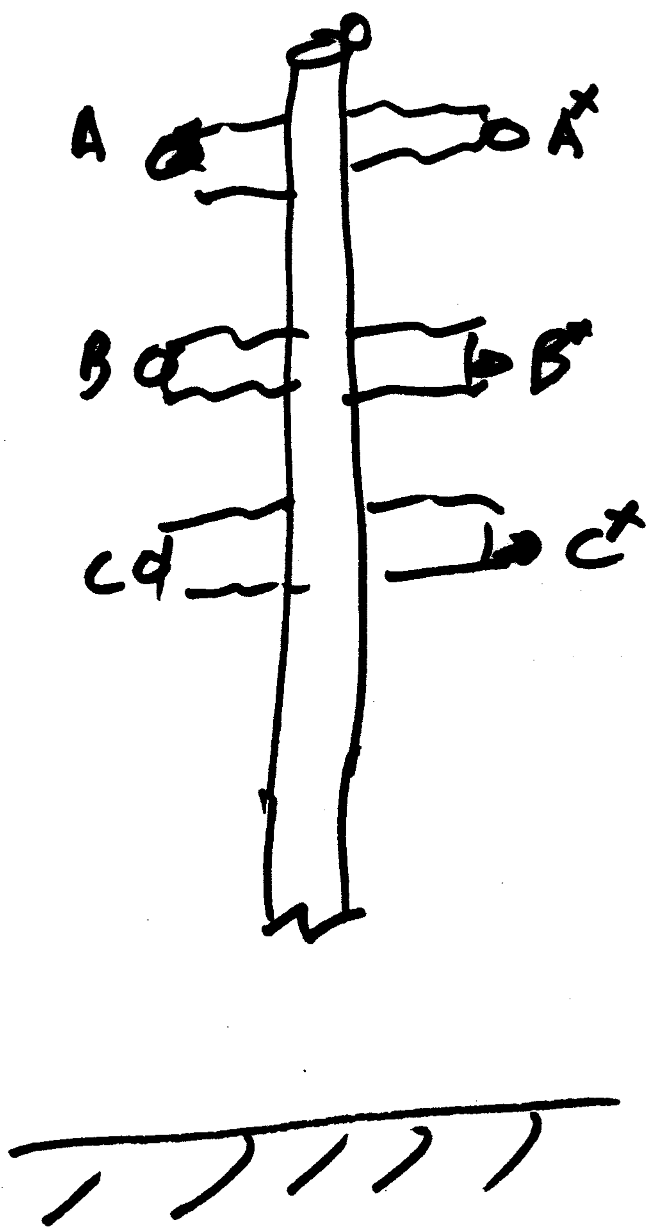
EE 5220 - Lecture 22 Monday Feb 28, 2022

Topics for Today:

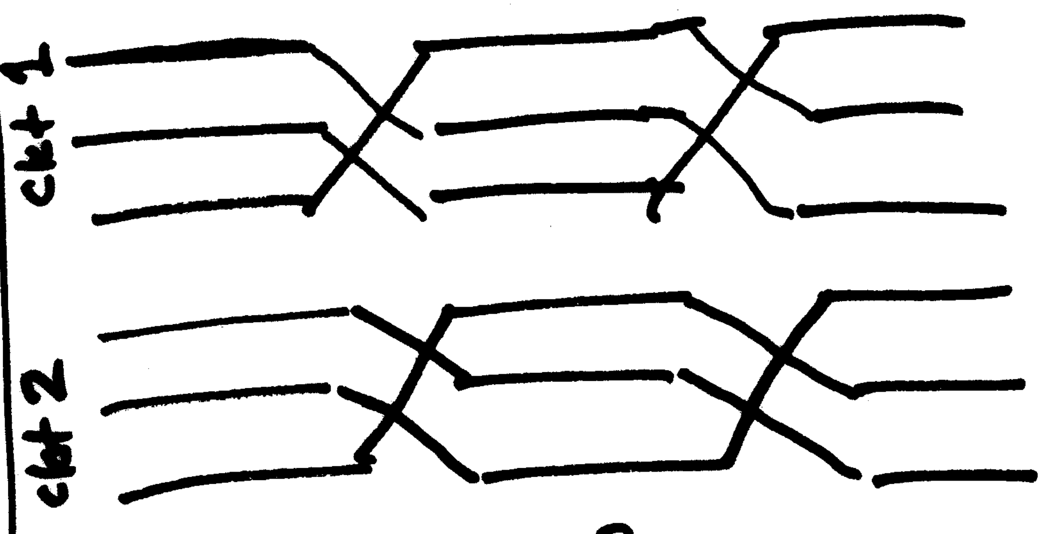
- Course Info:
    - Web page: https://pages.mtu.edu/~bamork/ee5220/
    - Software - Matlab. ATP/EMTP [License - www.emtp.org] ATP tutorials posted on our course web page
    - EE5220-L@mtu.edu (participation = min half letter grade)
    - See ATP_draw_V7_UM.pdf for user's manual and many examples.

- HW#7 - due Tues 9am after break
- Term Project - Week 9 (Fri Mar 18th) - complete reference list and fully-detailed table of contents, submit pdf via Canvas Assignments to grader and Dr. Mork.
- Use of Line Constants .lis output
    - Double-circuit lines: Phase matrices; Sequence matrices; B; Z
    - Zero sequence coupling
- Basics for lines vs. cables; traveling wave model (See video/ATP)
    - HW#7
- Multi-conductor line models for transient and traveling wave behaviors
    - Traveling wave equations for multi-conductor system
    - Modal transformations
        - Symmetrical components, Park's, Clarke, Karrenbauer

Double- Circuit Lines

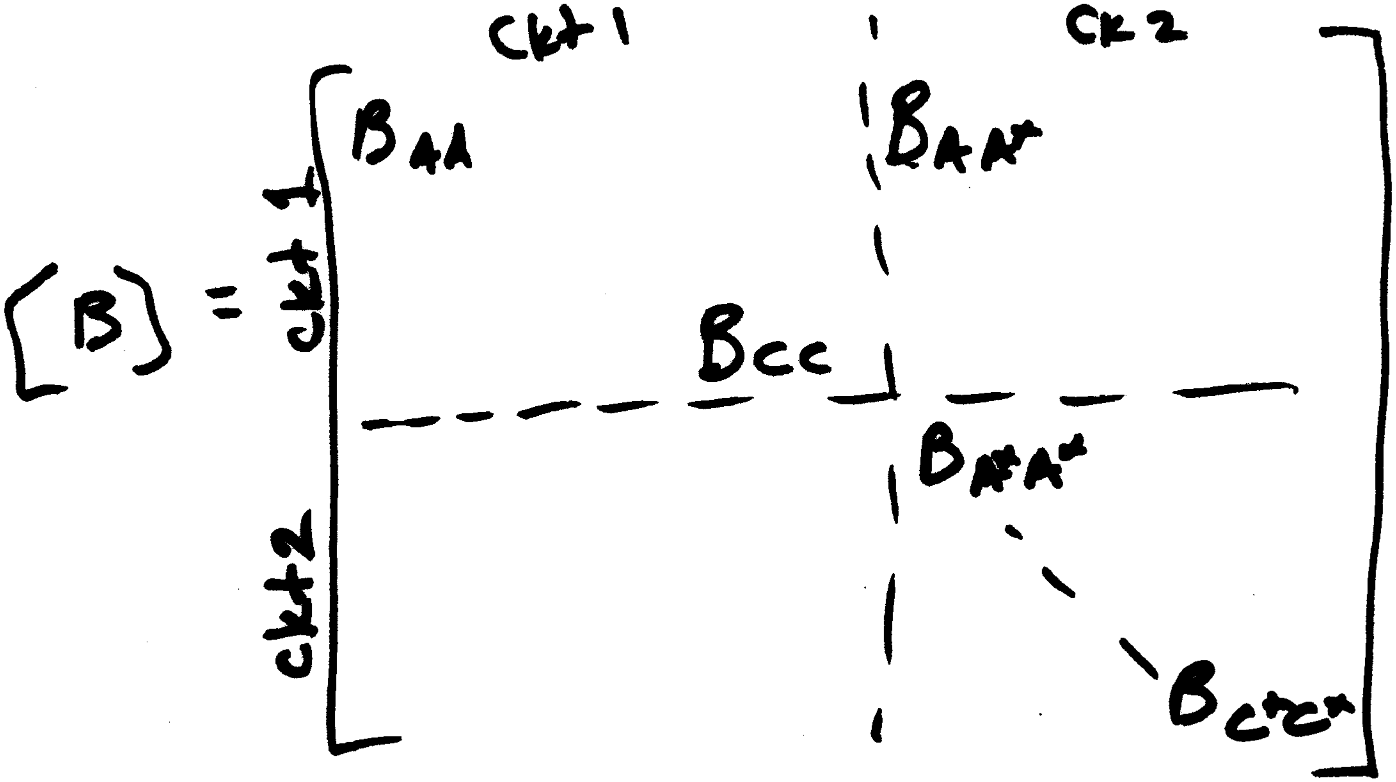


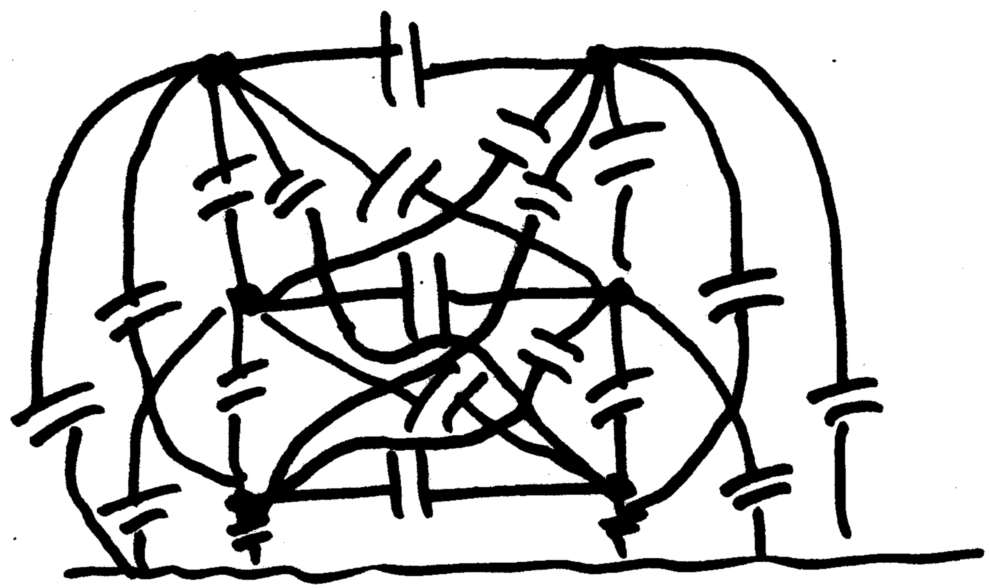
Transposition

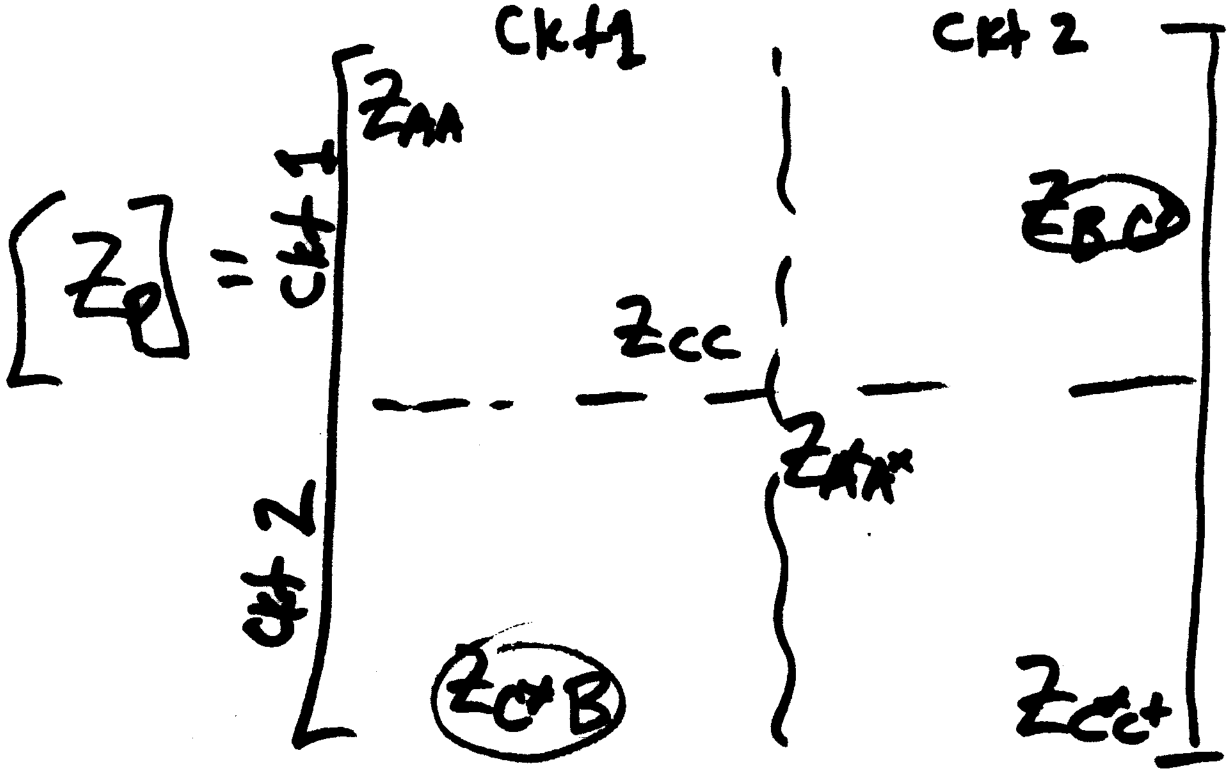


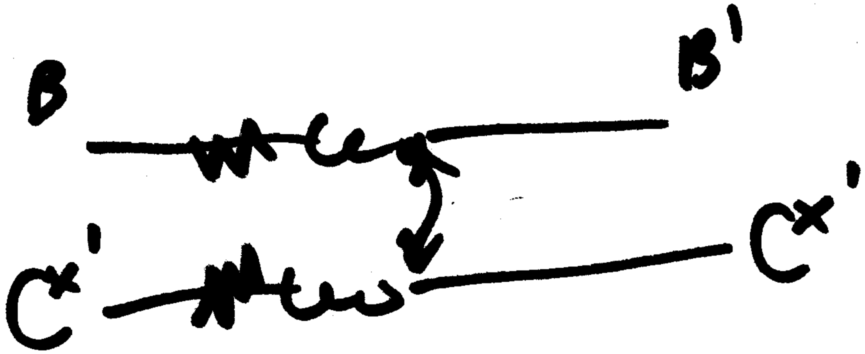
?

Look in "EMTP Theory Book"

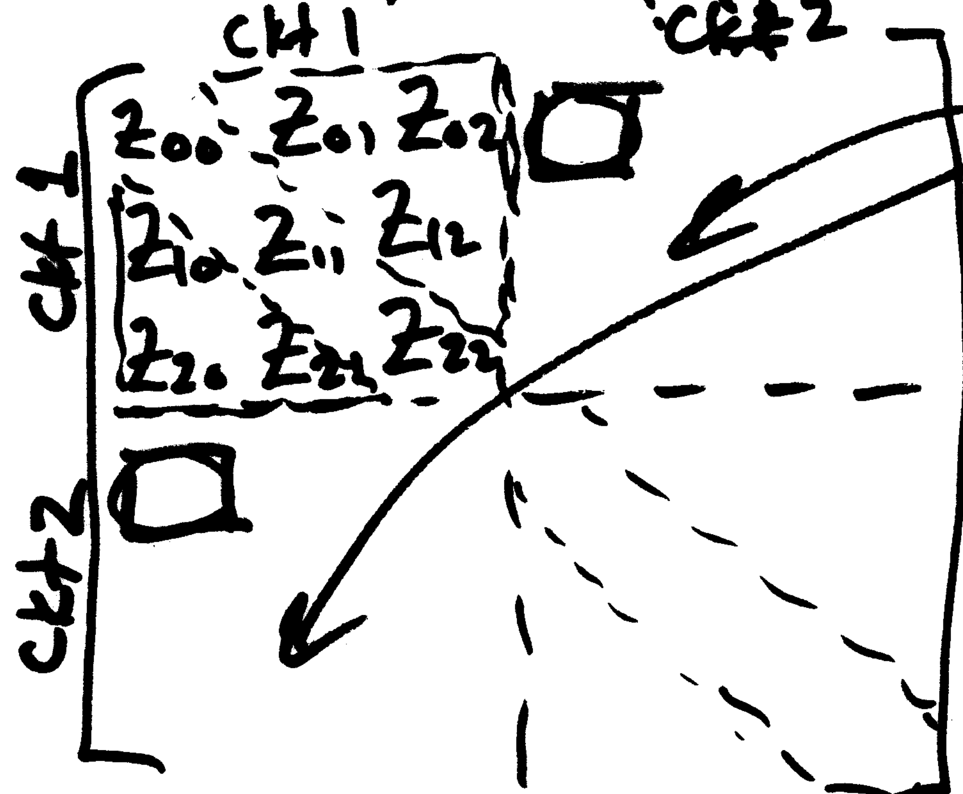

[B] =
ckt 1
ck 2
ckt 1
ckt 2
B_{AA}
B_{AA^*}
B_{CC}
$B_{A^*A^*}$
$B_{C^*C^*}$



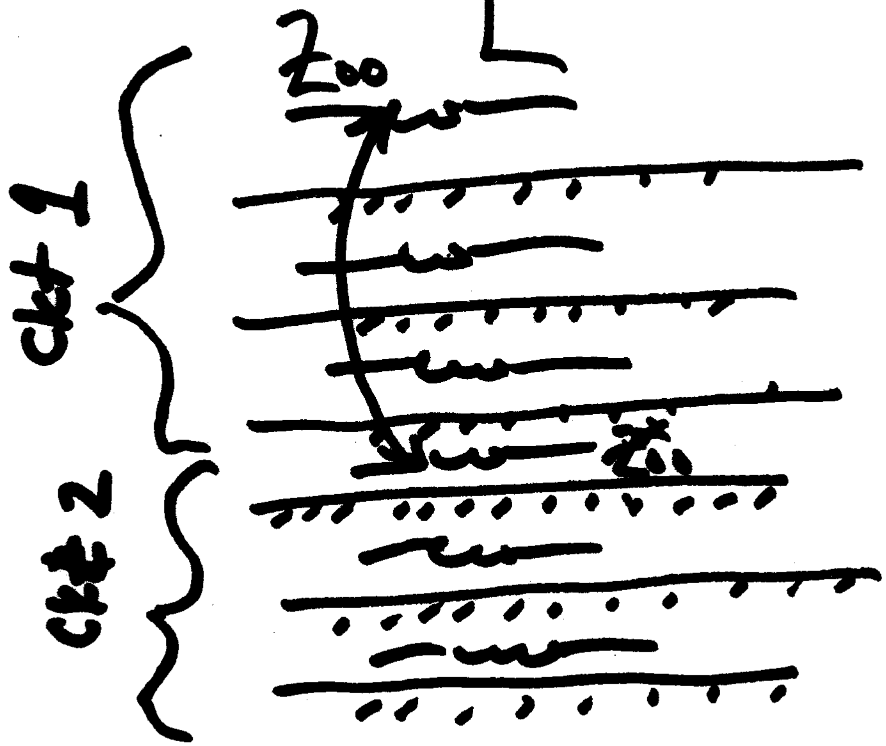

[Zp] =
Ckt 1
Ckt 2
Ckt 1
Ckt 2
ZAA
Zcc
ZBC
ZAA*
ZC*B
ZCC*


B
B'
C*'
C*'

Sequence [illegible] B, Z



All zeros if ckt 1 is decoupled from ckt 2.



$$"Z_m" = Z_{00'}$$
$$= Z_{0'0}$$

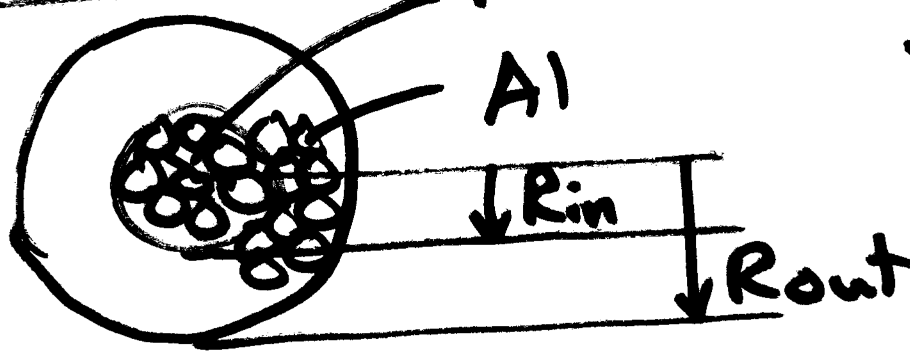
⊙ Transposition

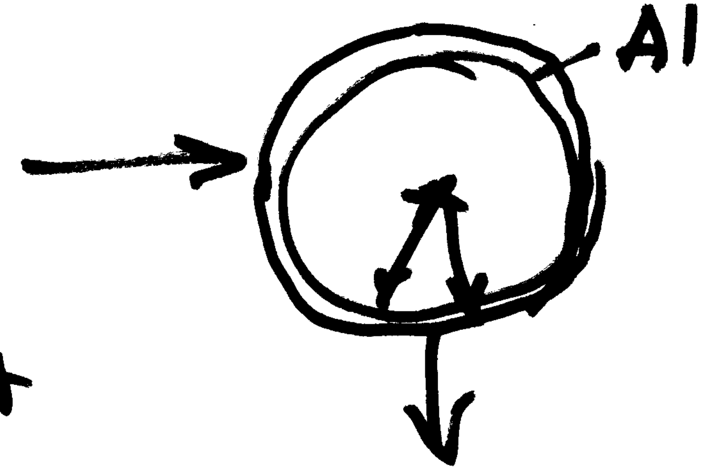
"Continuous Transposition"

$$
Z_s = \left[\begin{array}{ccc|ccc}
Z_{00} & 0 & 0 & Z_{00-00} & 0 & 0 \\
0 & Z_{11} & 0 & 0 & 0 & 0 \\
0 & 0 & Z_{22} & 0 & 0 & 0 \\
\hline
Z_{00-00} & 0 & 0 & Z_{00} & 0 & 0 \\
0 & 0 & 0 & 0 & Z_{11} & 0 \\
0 & 0 & 0 & 0 & 0 & Z_{22}
\end{array}\right]
$$

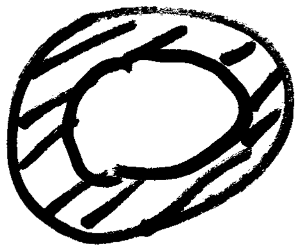
Assumes full transposition.
(or nearly so).

R_{in} vs. R_{out}



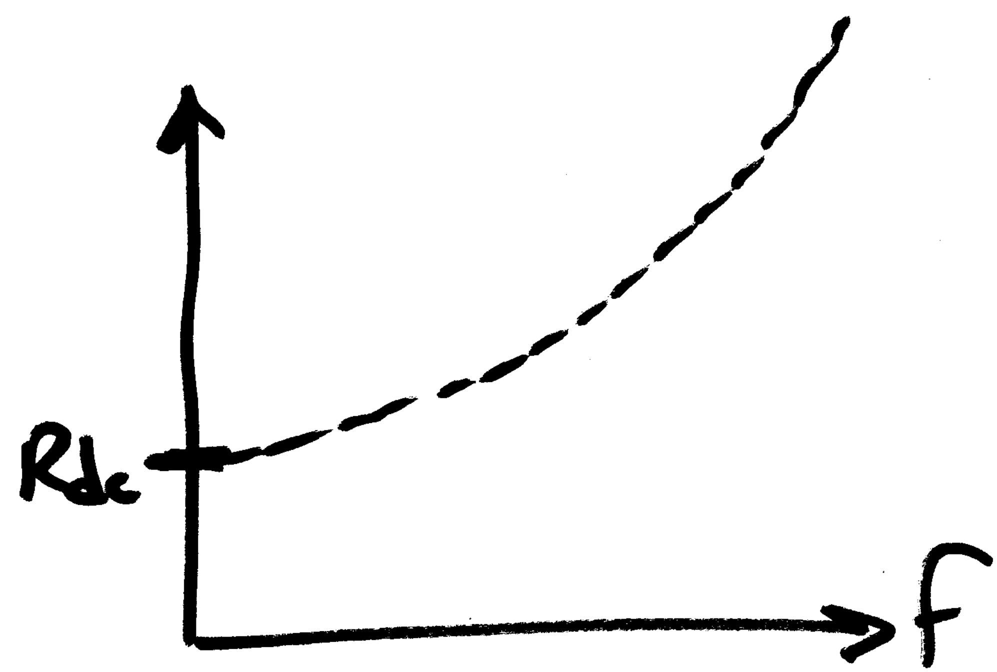


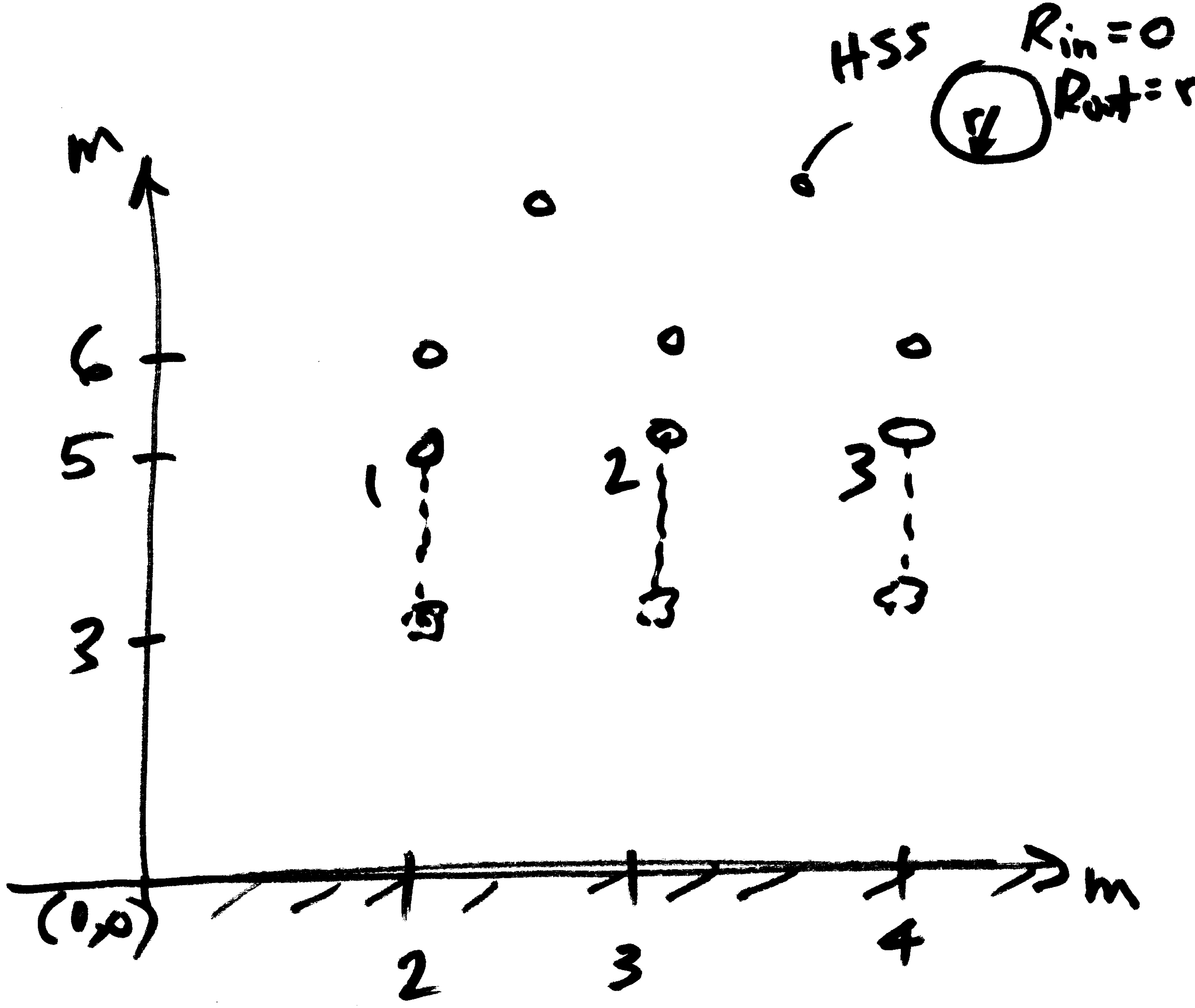
Skin Effect



R_{dc}

Skin Depth "δ"



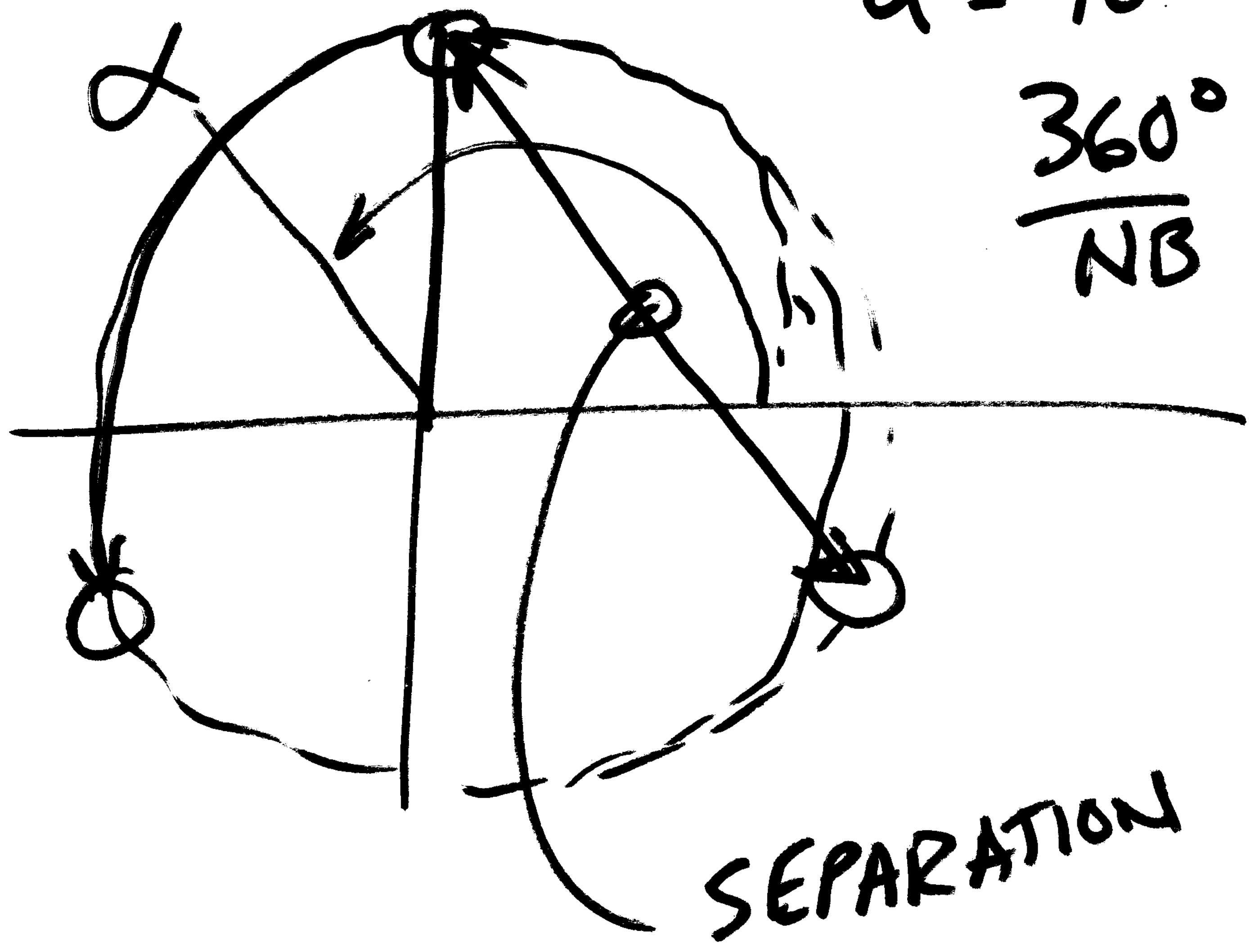

HSS
$R_{in}=0$
$R_{out}=$
m
6
5
3
1
2
3
(0,0)
2
3
4
m

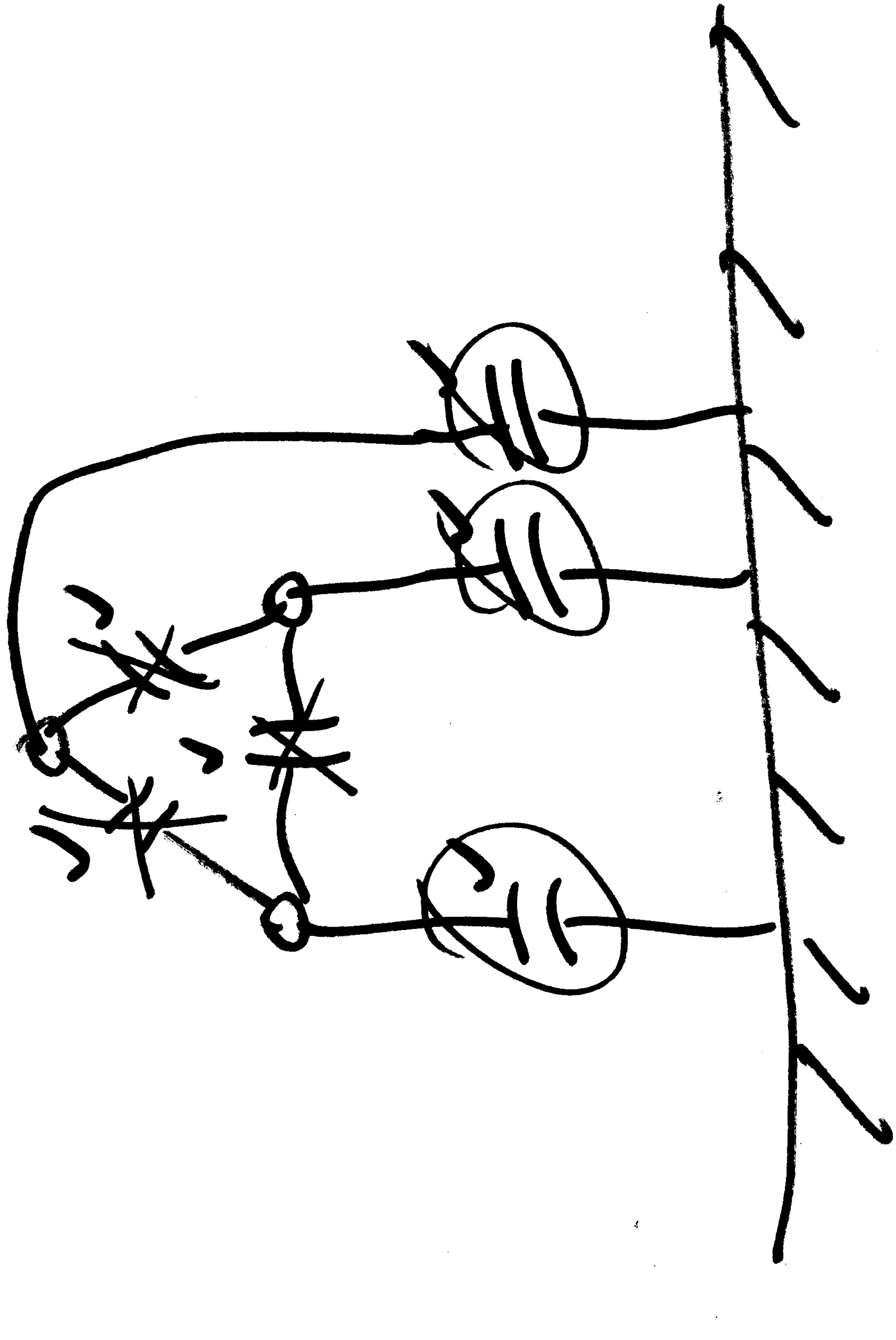
Bundled Cond

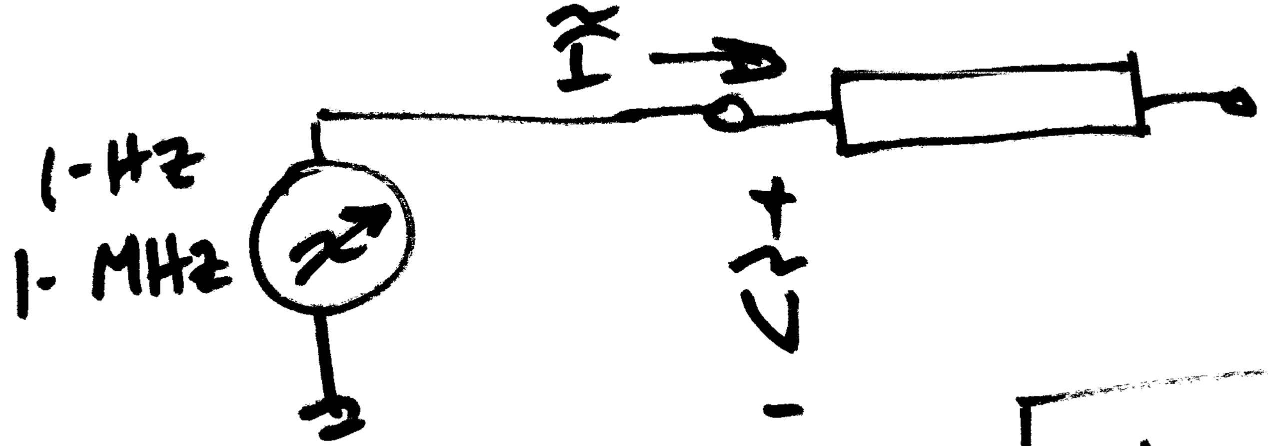
NB = 3

$\alpha = 90°$

$\frac{360°}{NB}$







Verify

$$\overline{Z}_{IN}(f) = \frac{\tilde{V}(f)}{\tilde{I}(f)}$$