EE 5220 - Lecture 39 Fri Apr 15, 2022

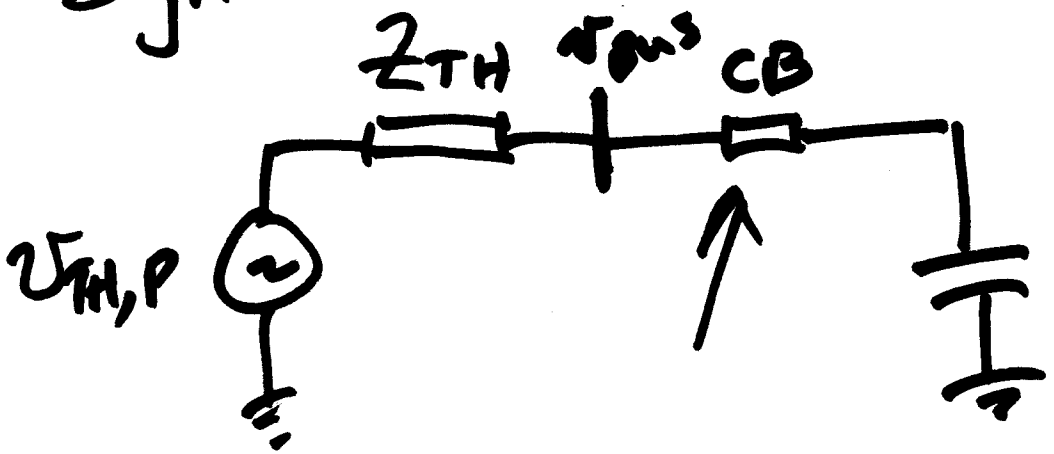
Topics for Today:

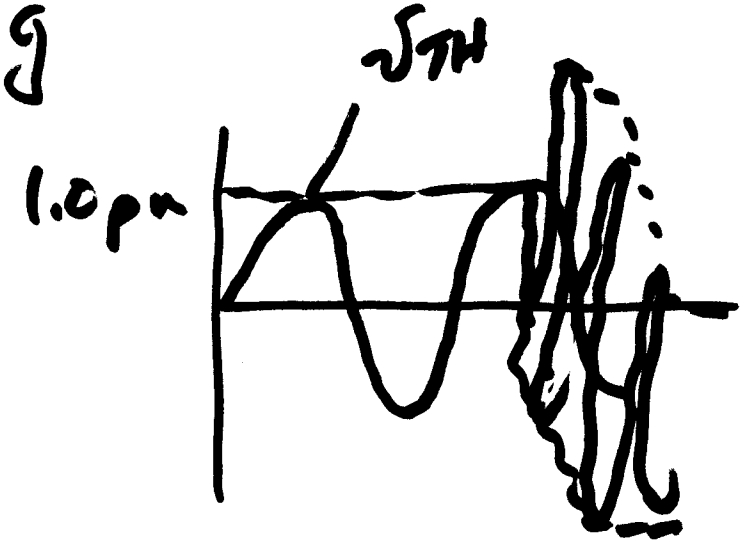
- Course Info:
  - Web page: https://pages.mtu.edu/~bamork/ee5220/
  - Book, references, syllabus, more are on web page.
  - Software - Matlab. ATP/EMTP [License - www.emtp.org] ATP tutorials posted on our course web page
  - EE5220-L@mtu.edu (participation = half letter grade, 5%)

- Term Project - Final Report - completed by Mon April 25th 9am
- Term Project - Present on Mon Apr. 25th, 3:00 -- 5:00pm
- Applications in 3-phase systems - Chapter 5, 6, 17
  - Three-pole switching, CB issues
    - Cap Bank Switching (deenergization)
    - Reactor Switching (deenergization)
  - Synchronized switching for energization
    - Cap banks, Reactors, Transformers
- Next - work thru class demo/simulations of these switching scenarios

3-pole Switching

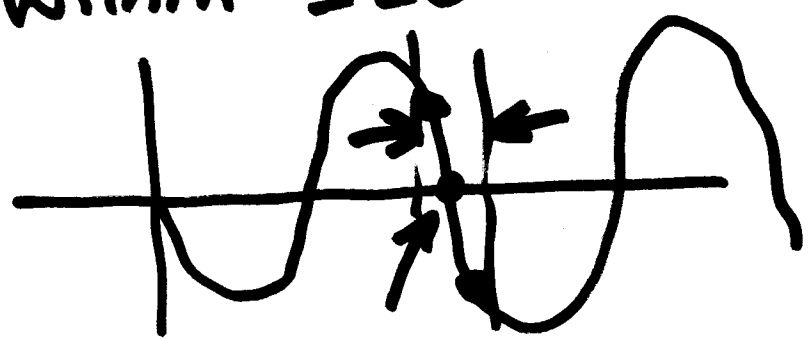
Synchronized Switching



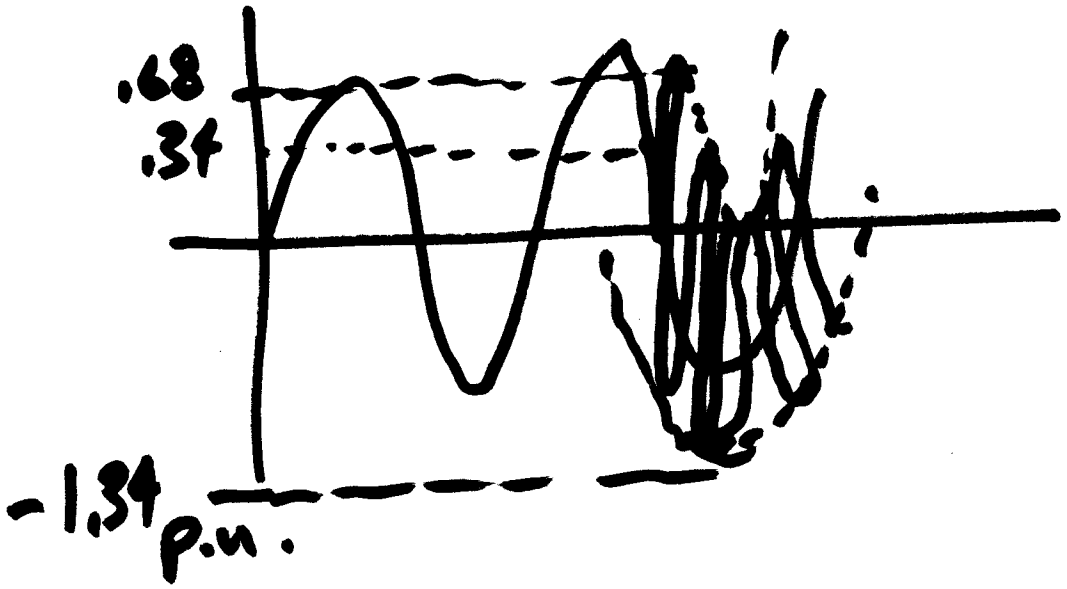


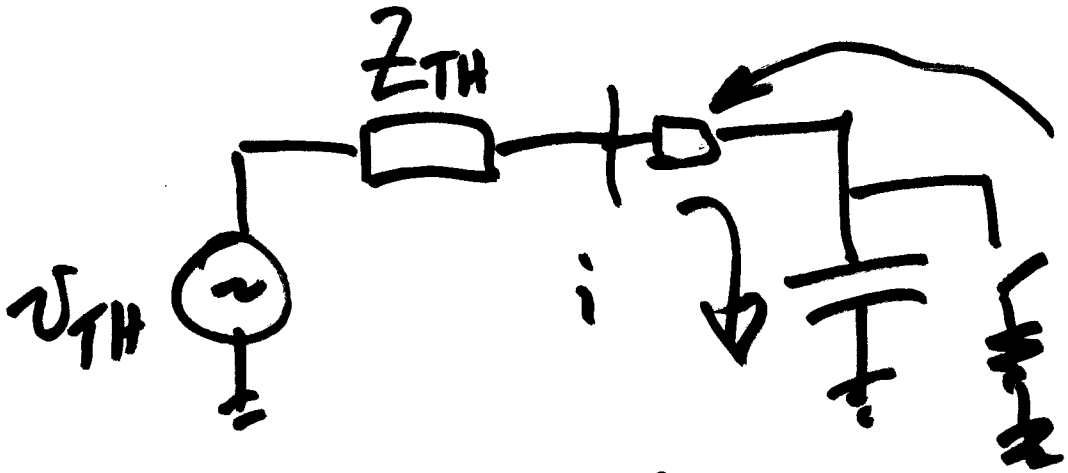
Energizing at voltage zero would eliminate the inrush current.

In practice, it's possible to control CB to within ±20° of desired phase angle.

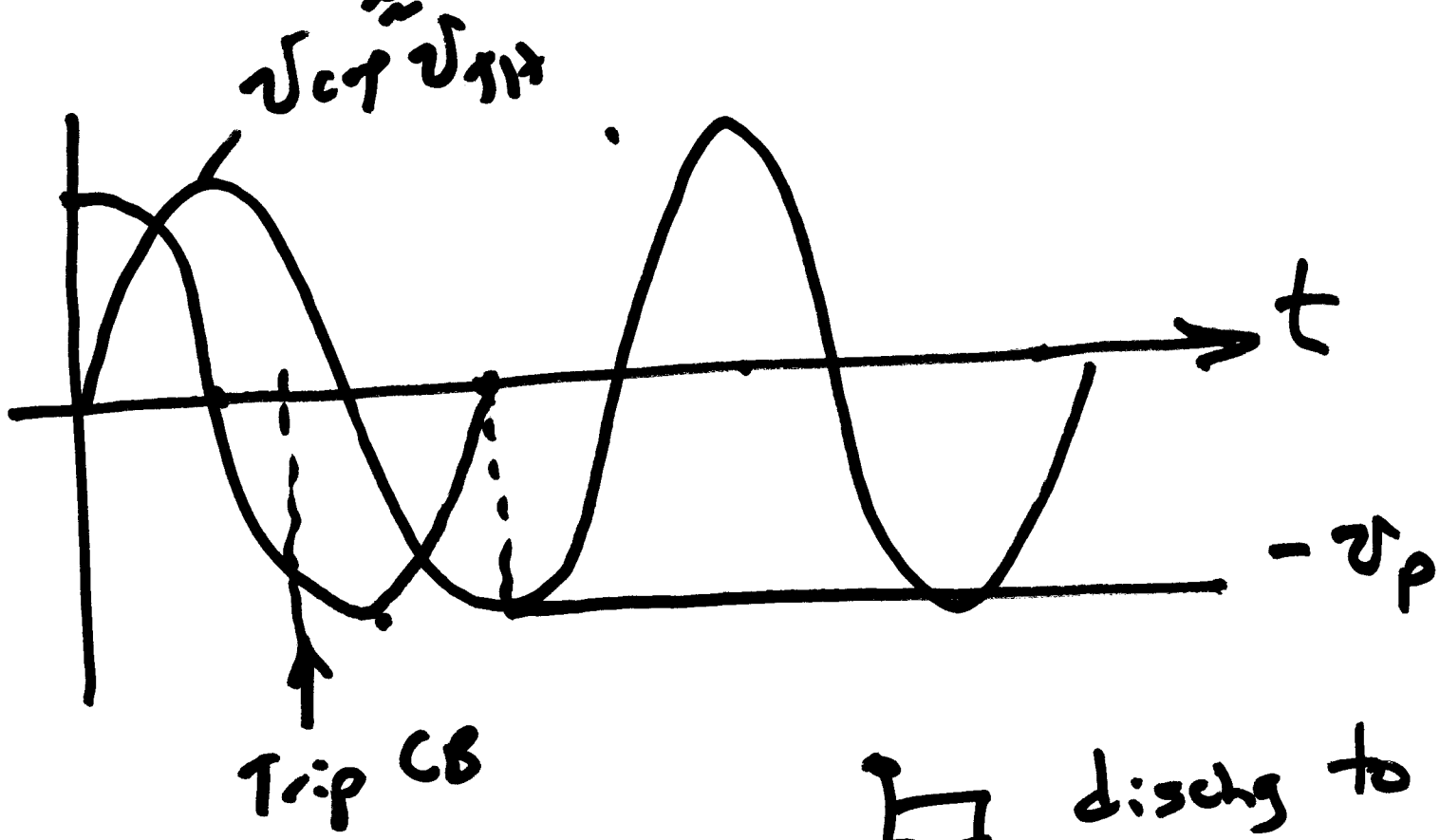


$\Rightarrow$ $\boxed{\pm .34\, V_p}$

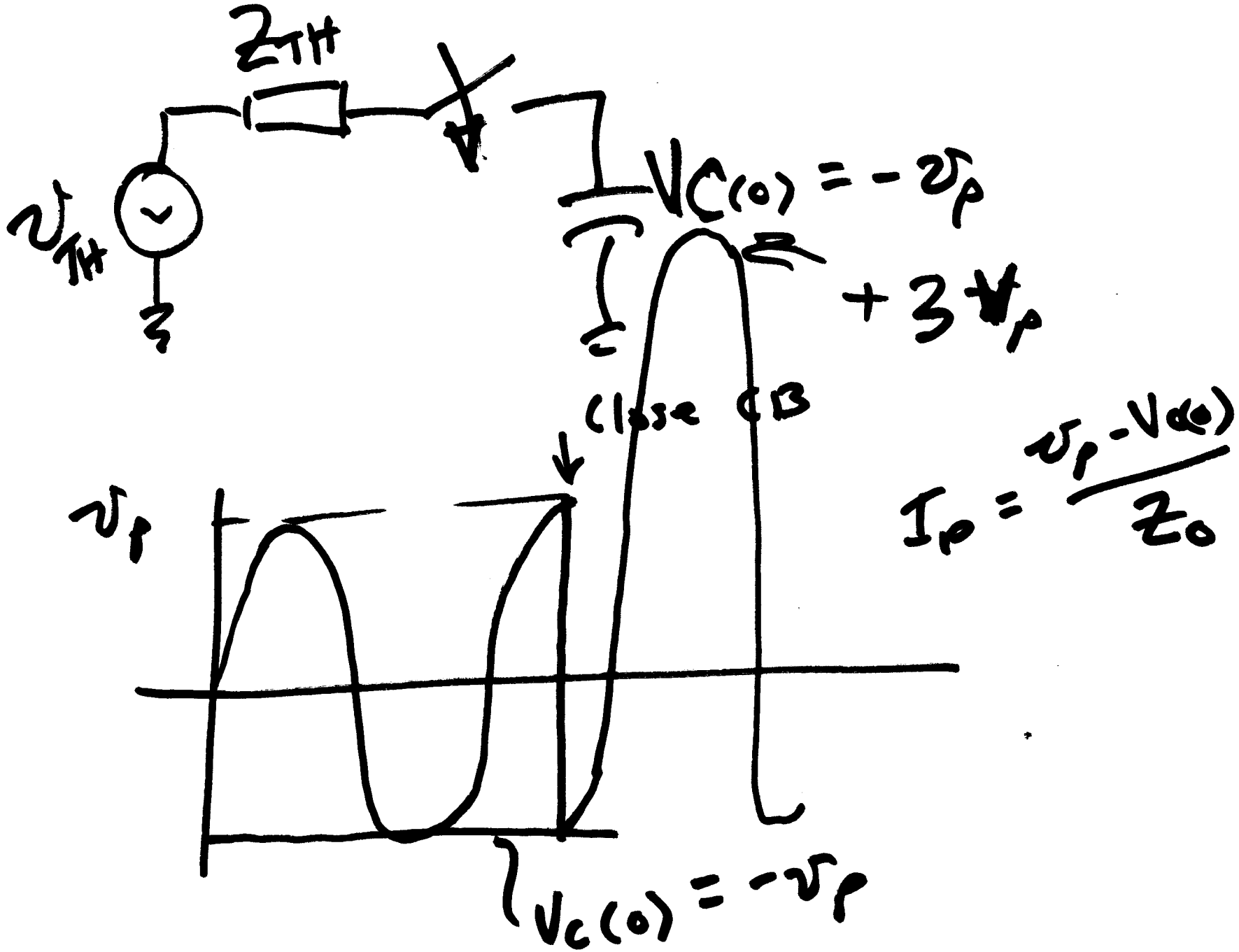

.68
.34
-1.34 p.u.



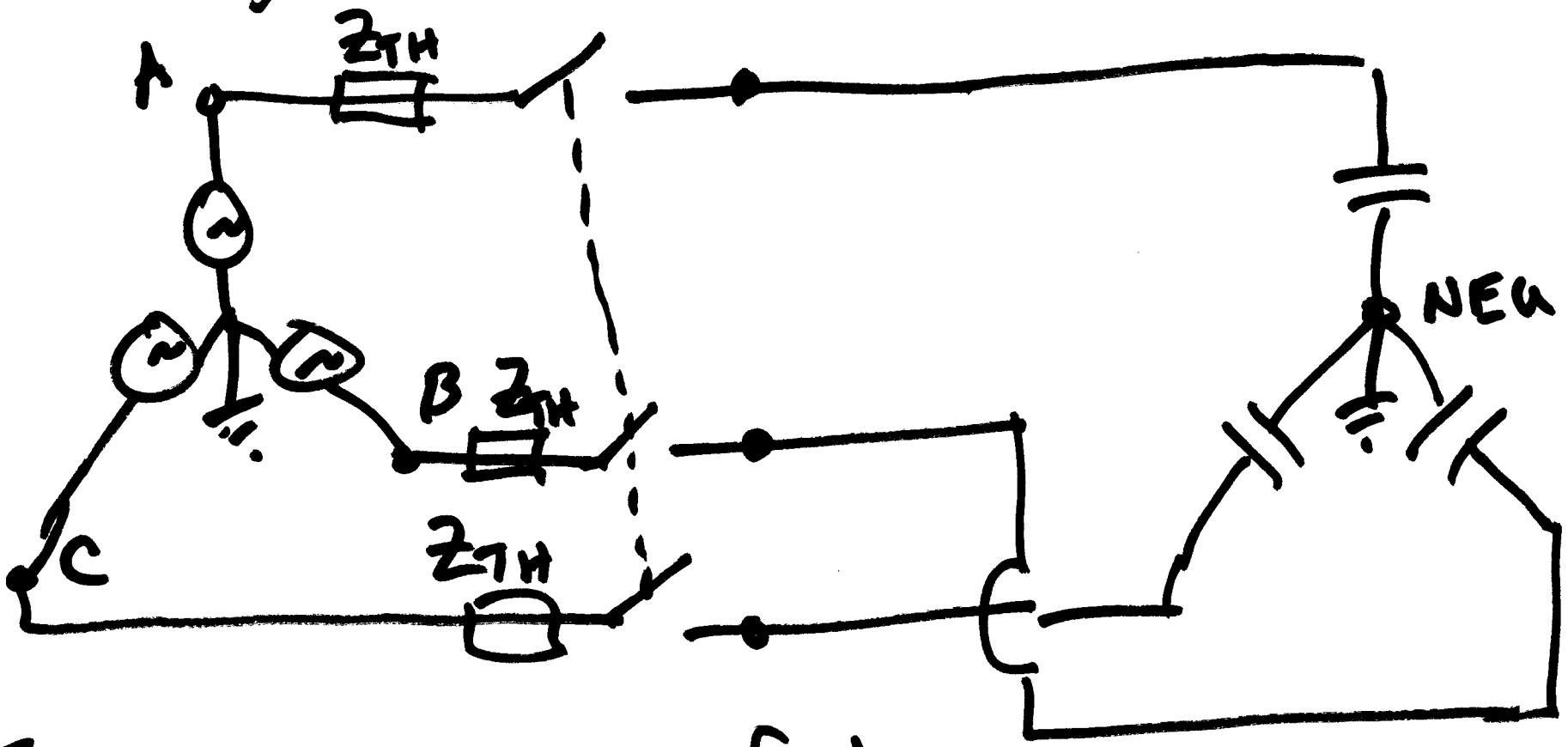
open CB when C_{cp} energized, S.S.



dischg to
$\leq 50V$ in 5min.

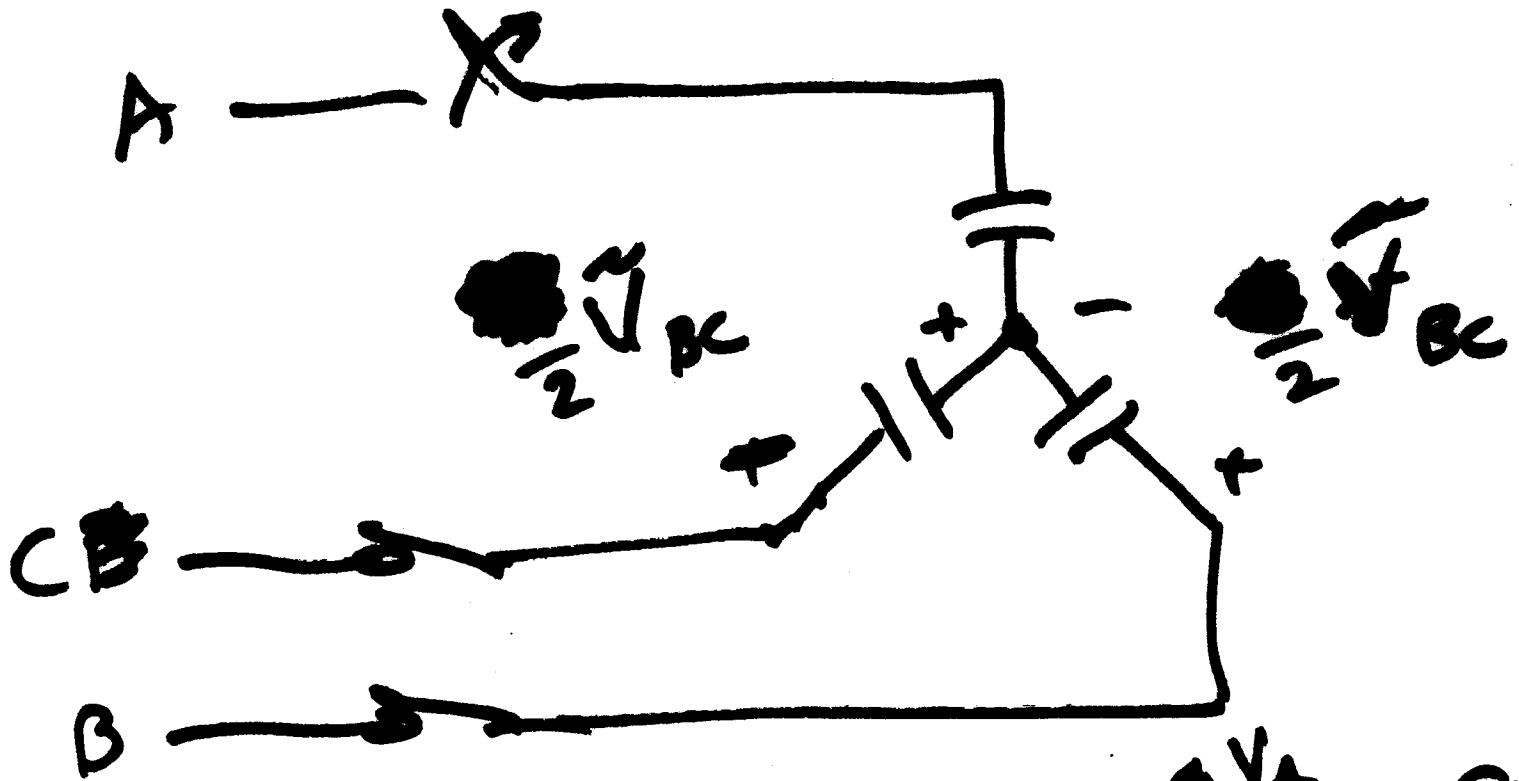

Z_{TH}
v_{TH}
$V_C(0) = -v_p$
$+3V_p$
(lose CB
v_p
$I_p = \frac{v_p - V_C(0)}{Z_0}$
$V_C(0) = -v_p$

De-energize 3-ph Cap Bank

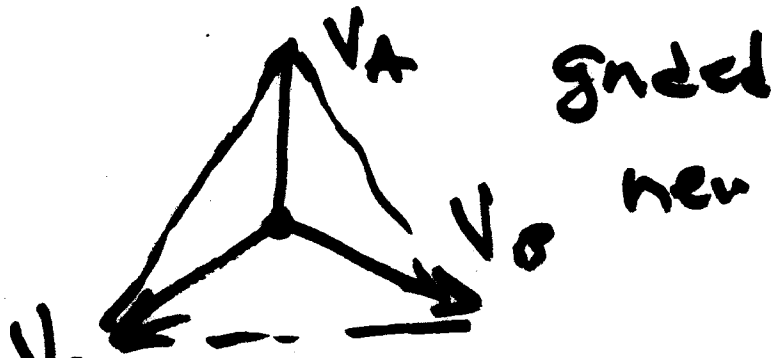


§6.2 - Ex. ΦA opens first.
No problem: both neu grded.

What if Load neu is open?



new voltage shifts.

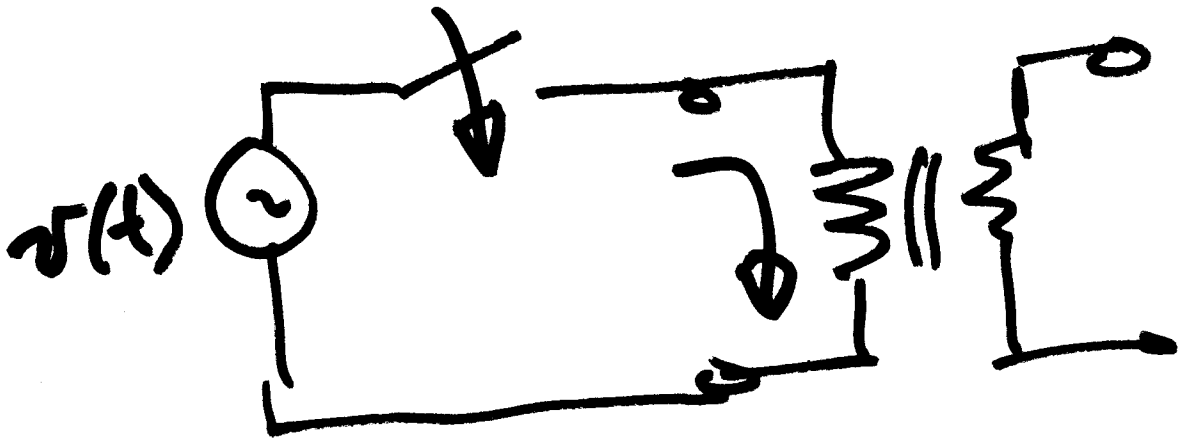


Tripped Voltages:

ϕA: $\sqrt{2}\, V_{LN} = V_P$

ϕB: $\sqrt{2} V_{LL}/2$

ϕC: $\sqrt{2} V_{LL}/2$



Synch Sw. for XFMRS. Close at Vmax.

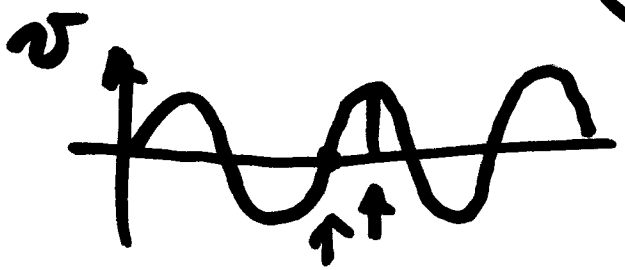
Synch Switching - Minimize Inrush.

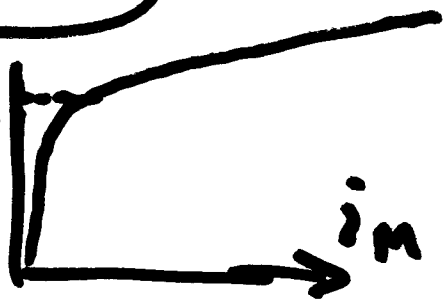
- Depends on: initial λ ($\lambda(0) = ?$)

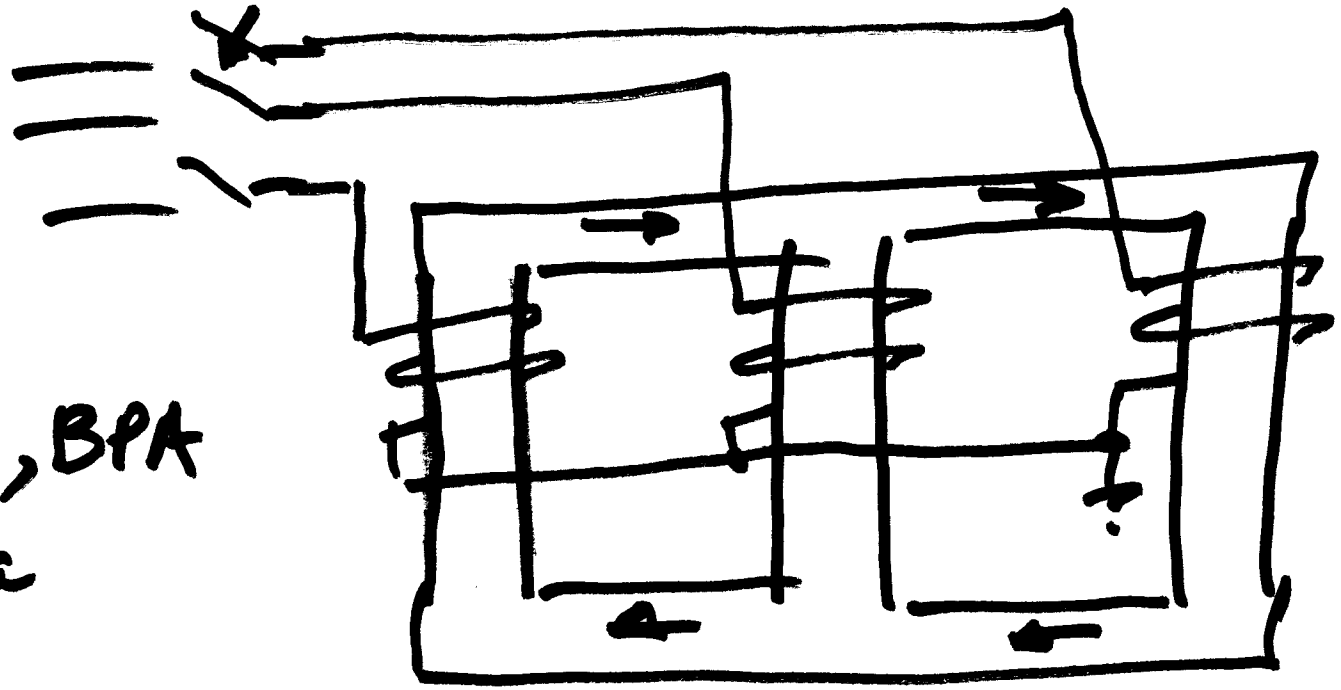
If we knew that $\lambda(0) = 0$, then Close CB at $\pm V_p$.

However... $-0.67\lambda_p < \lambda(0) < +0.6\lambda_p$

worst case. λ_p







- Brunke, BPA
- Chiesa

5 nonlinear L_M's

Close ϕA first

Vind on ϕB & ϕC (Known
- Magnitudes
- Phase Angles)

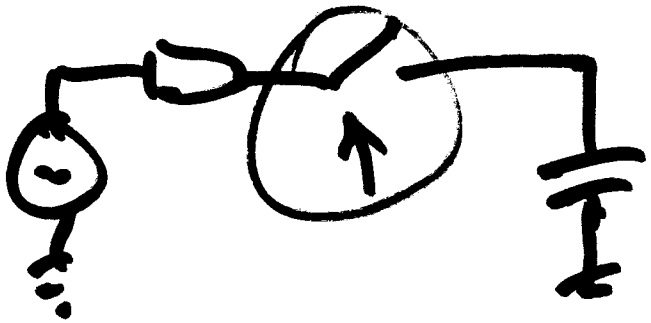
- Close ϕB (synchronized)
- Close ϕC (")

Case 1a - with new.

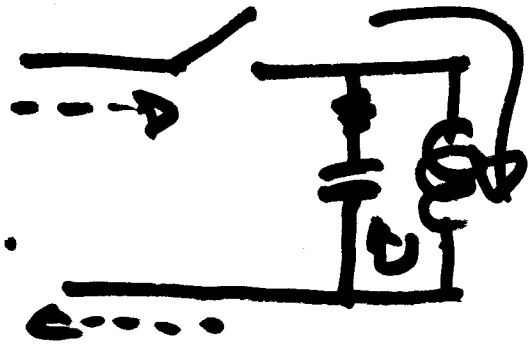
Case 1b - ungrounded.

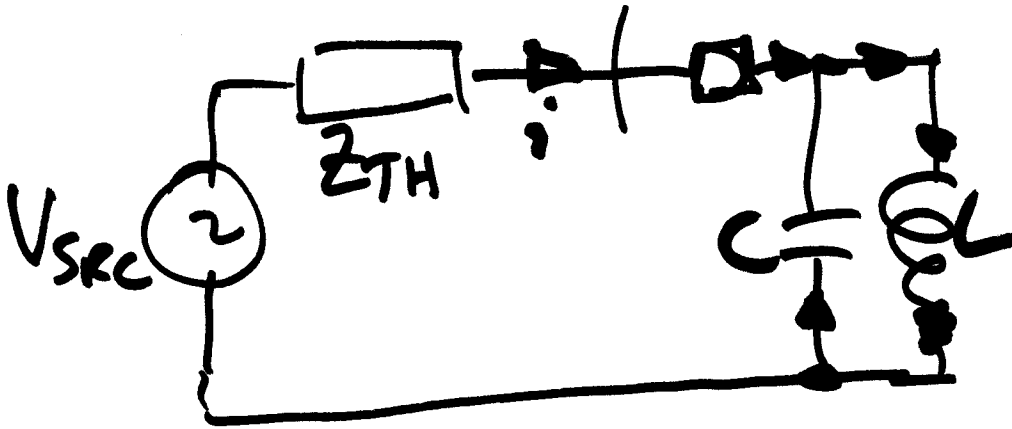
$\Rightarrow$ *.acp

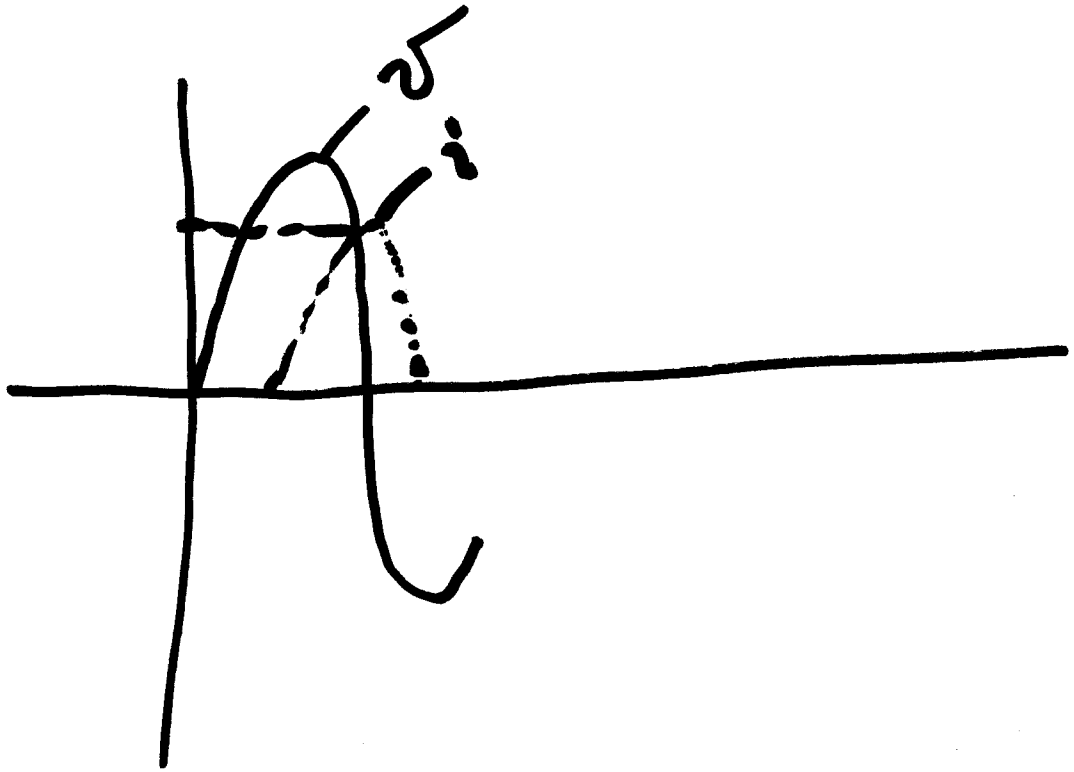
Case 2 - Statistical Sw.
Synch Closing!



Case 3 - Reactor Switching.







$$\omega_0 = \frac{1}{\sqrt{LC}}$$