EE 5220 - Lecture 38 Wed Apr 13, 2022

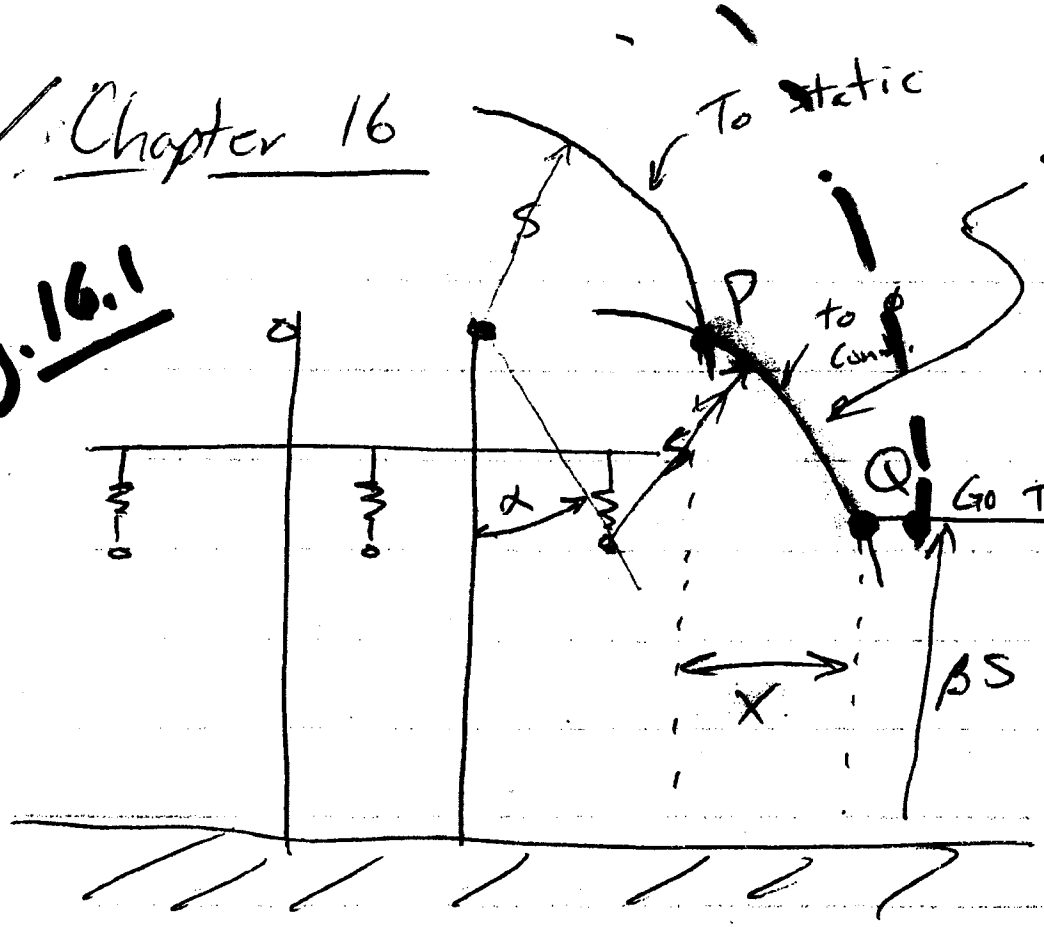
Topics for Today:

- Course Info:
  - Web page: https://pages.mtu.edu/~bamork/ee5200/
  - 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 = min half letter grade)

- Hmwk 10 (Probs. 5.7 & 14.5) due Tues Apr 19th 9am.
- Term Project - Final Report - completed by Mon April 25th 9am
- Term Project - On-campus teams present on Monday Apr 25th 3pm
- Insulation design and coordination - Chapter 16
  - Shielding design for overhead lines
  - CB ratings in general
  - NESC tables for conductor separation, corona discharge
  - BIL and BSL levels vs. nominal voltage ratings
  - Comments on L-G vs. L-L overvoltages
  - Corona characteristic - nonlinear capacitance.

Chapter 16

Fig. 16.1



Strike Distance $S = 10 I^{0.6}$

$I = kA$

S = meters

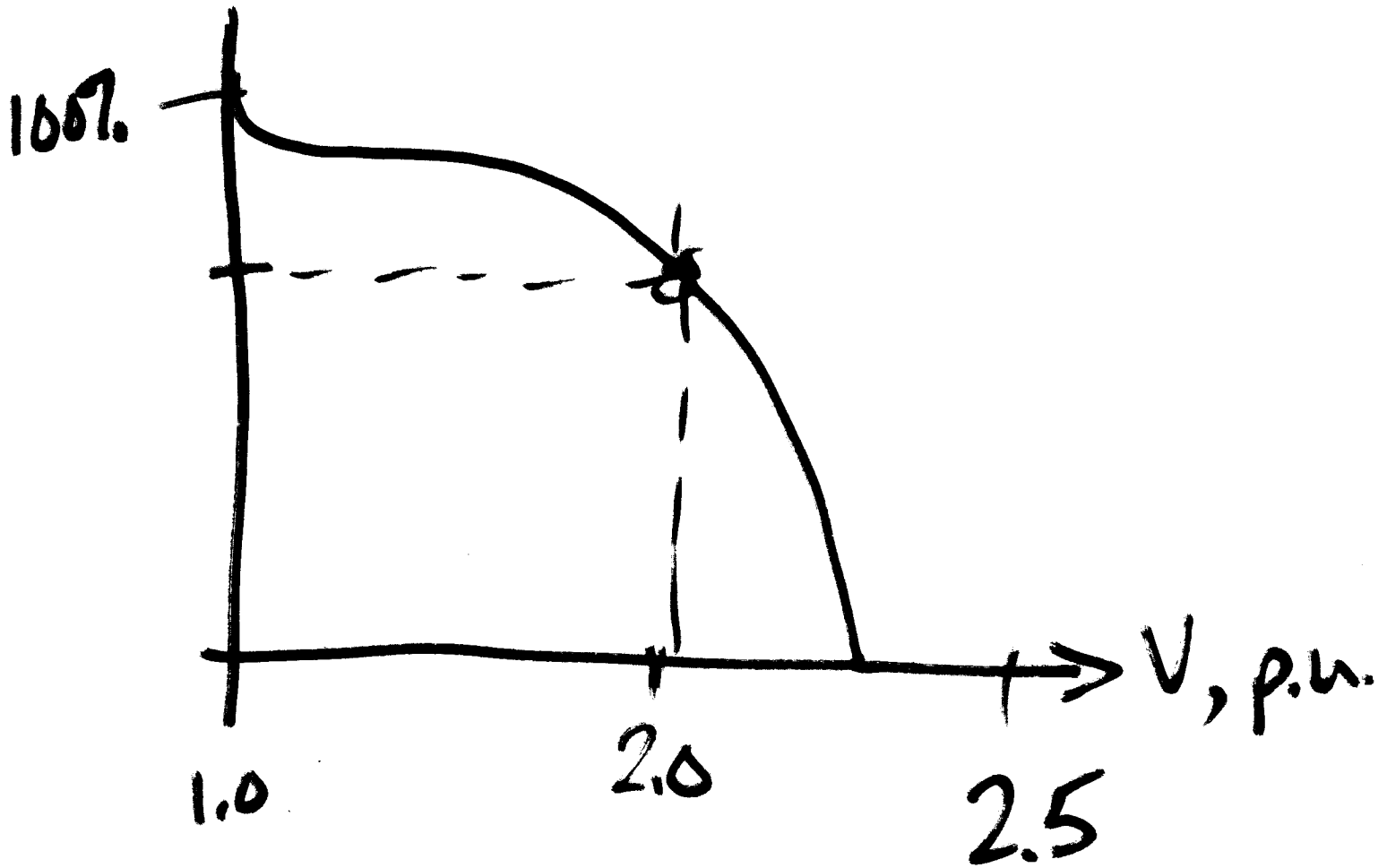
Quite likely to hit if it gets within S meters of conductor.

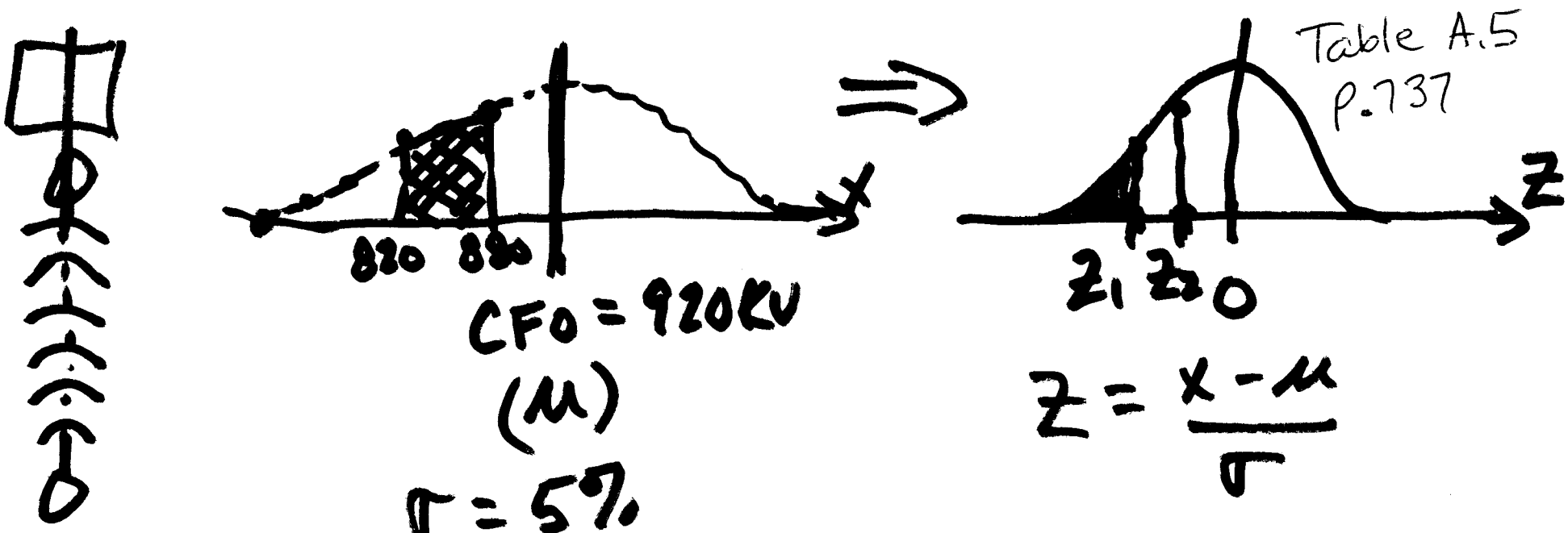
$\beta \cong 0.8$ - EHV

0.67 - UHV

Shielding Failure Occurs over arc P-Q.

At some current value I_{max}, P & Q will coincide.
No shielding failure above I_{max}.


100%
V, p.u.
1.0
2.0
2.5



Often need to know P of V_T falling within a range of values.

$P(820 < V_T < 880KV) = \_\_\_\_?$

$Z_1 = \frac{(820 - 920)}{46} = -2.174$

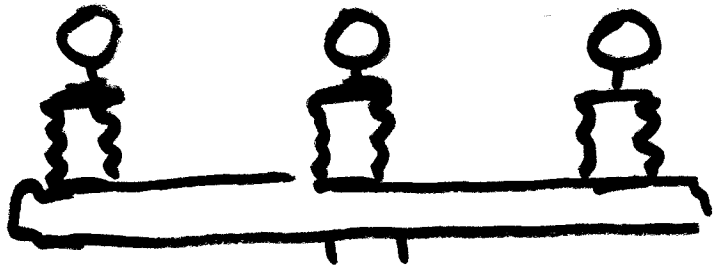
$Z_2 = \frac{(880 - 920)}{46} = -0.8696$

$\Rightarrow P(\leq -.8696) - P(\leq -2.17)$

$\Rightarrow .1922 - .0148$

$= 17.7\%$

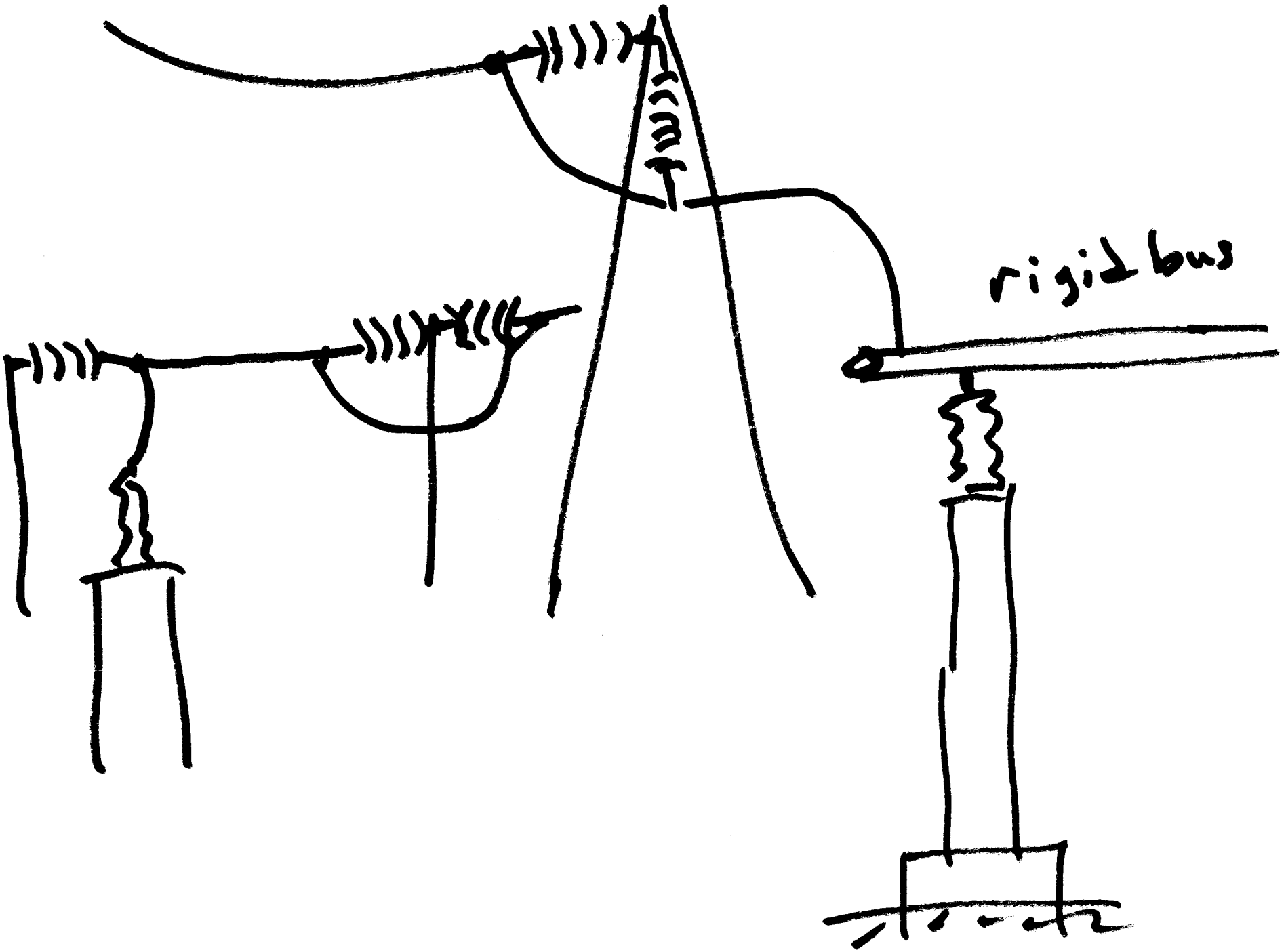
Typical Spacings and Clearances in a Substation



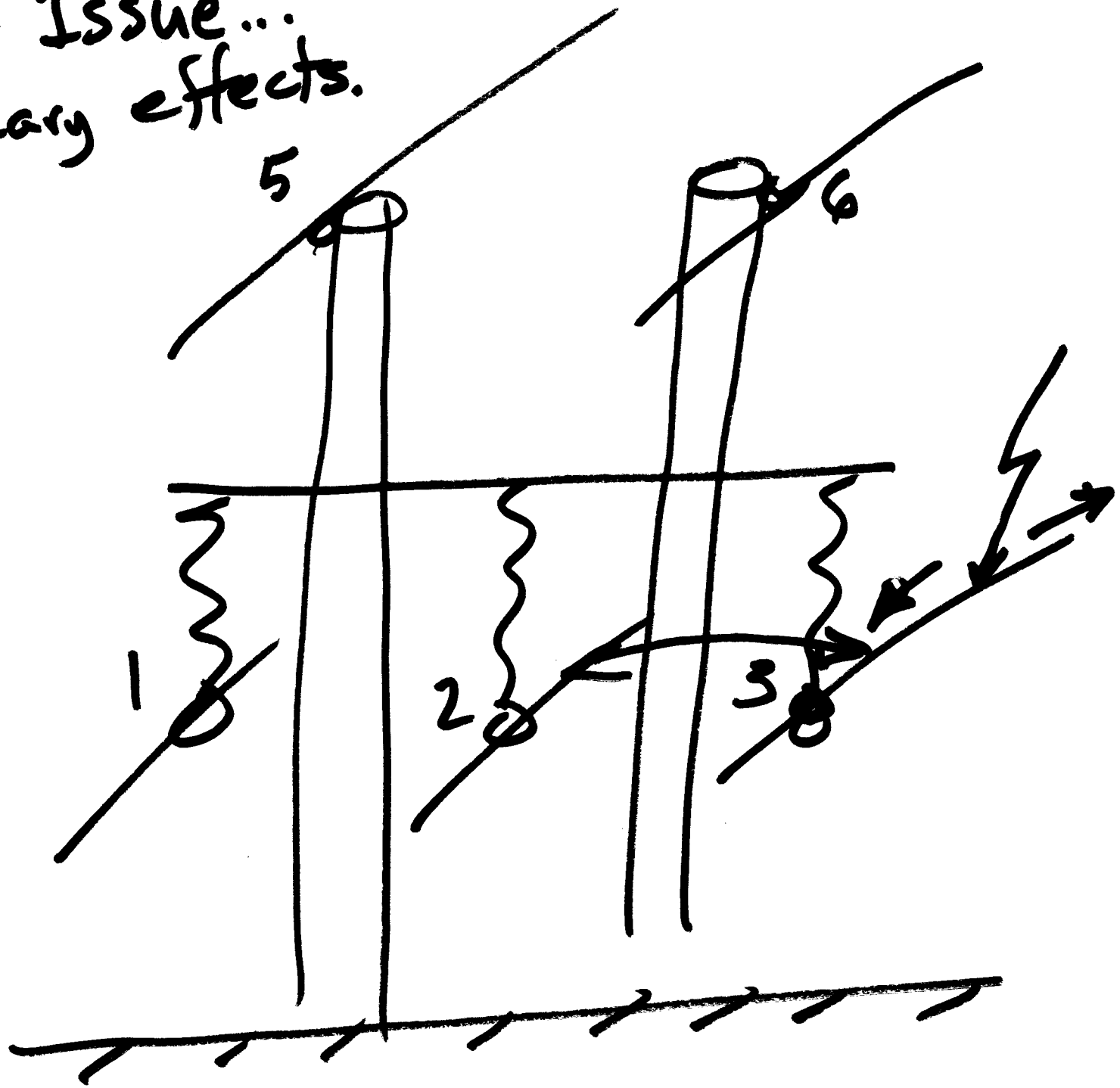
See up-to-date NESC to verify !

Voltage Level		Min Conductor Spacing			Min Switch Spacing Ph-Ph			Min L-L Phase Clearance	Min No. Bells at Deadend	Min Cable Size	Min Bus Size
KV (L-L)	BIL (kV)	Cent-Cent	Ph-Gnd	To Grade	Horngap	V Break	H Break				
7.5	95	1'-6"	7½"	8'	3'	18"	2'-6"	7"	1	#2	½"
15	110	2'	10"	9'	3'	2'	2'-6"	12"	2	#2	½"
23	150	2'-6"	12"	10'	4'	2'-6"	3'	15"	3	#2	½"
34.5	200	3'	15"	10'	5'	3'	4'	18"	4	1/0	½"
46	250	4'	1'-6"	10'	6'	4'	5'	21"	4	1/0	½"
69	350	5'	2'-5"	11'	7'	5'	6'	31"	5	1/0	½"
115	550	7'	3'-7½"	12'	10'	7'	9'	53"	8	4/0	½"
138	650	8'	4'-1"	13'	12'	8'	11'	63"	10	250	½"
161	750	9'	4'-10"	14'	14'	9'	13'	72"	12	350	1"
230	900	11'	6'-½"	15'	16'	11'	16'	89"	14	500	1"
230	1050	13'	7'-3"	16'	18'	13'	18'	105"	16	750	1¼"
345	1300	15'	8'-5½"	18'	20'	15'	---	119"	19	---	2"
500	1800	25'	12'	---	---	25'	---	---	24	---	4"
765											

Corona

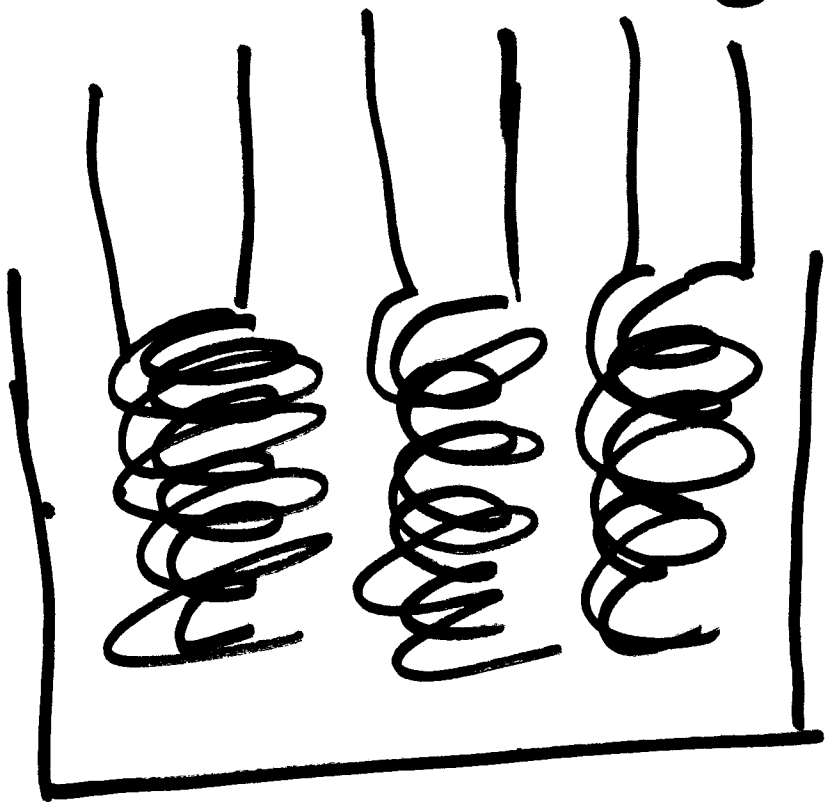

rigid bus

Another Issue...
secondary effects.



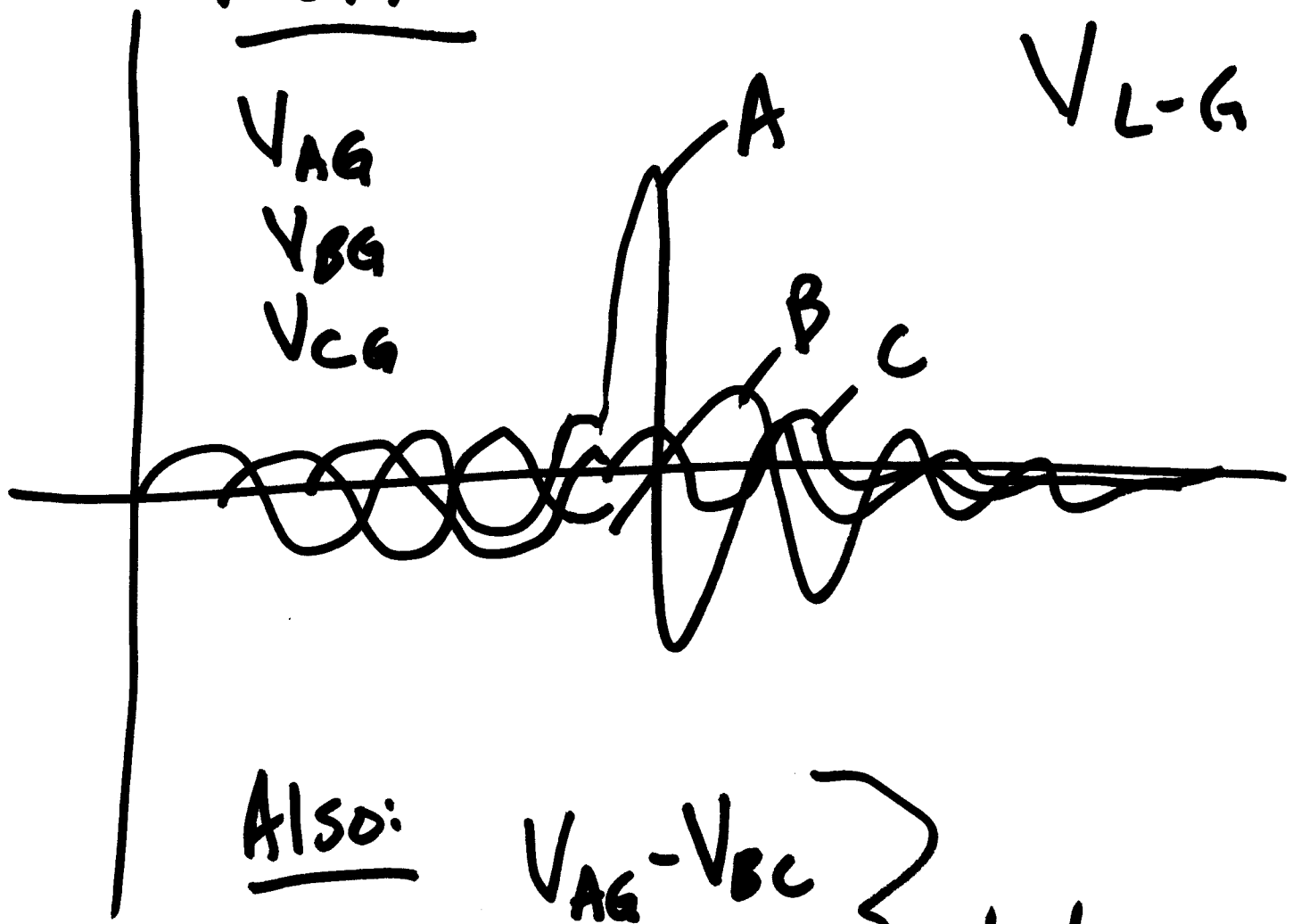
Voltage Levels vs. insulation ratings.

V_{L-N} (L-G)



V_{L-L}

PlotXY



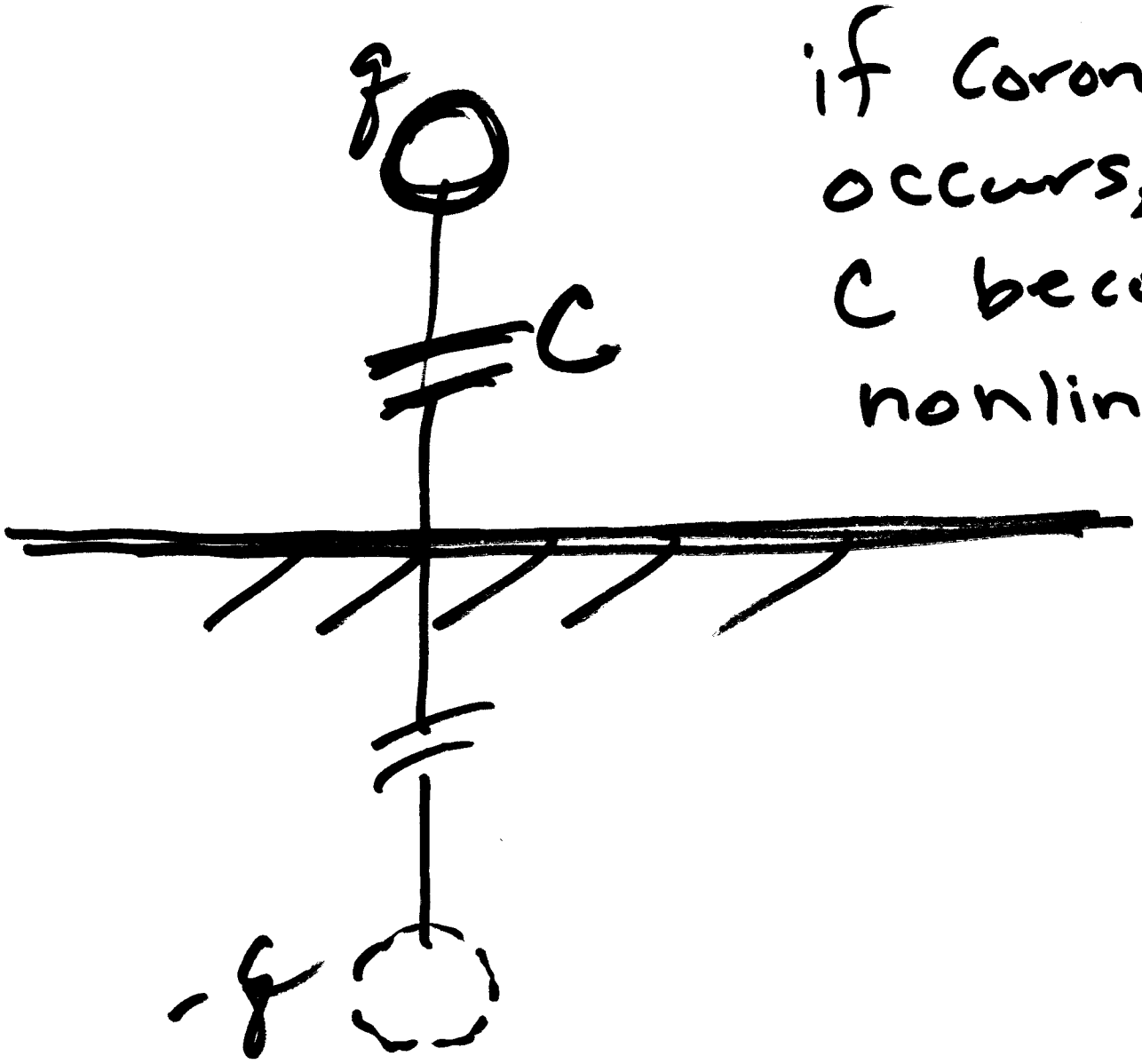
Also:

$V_{AG} - V_{BC}$

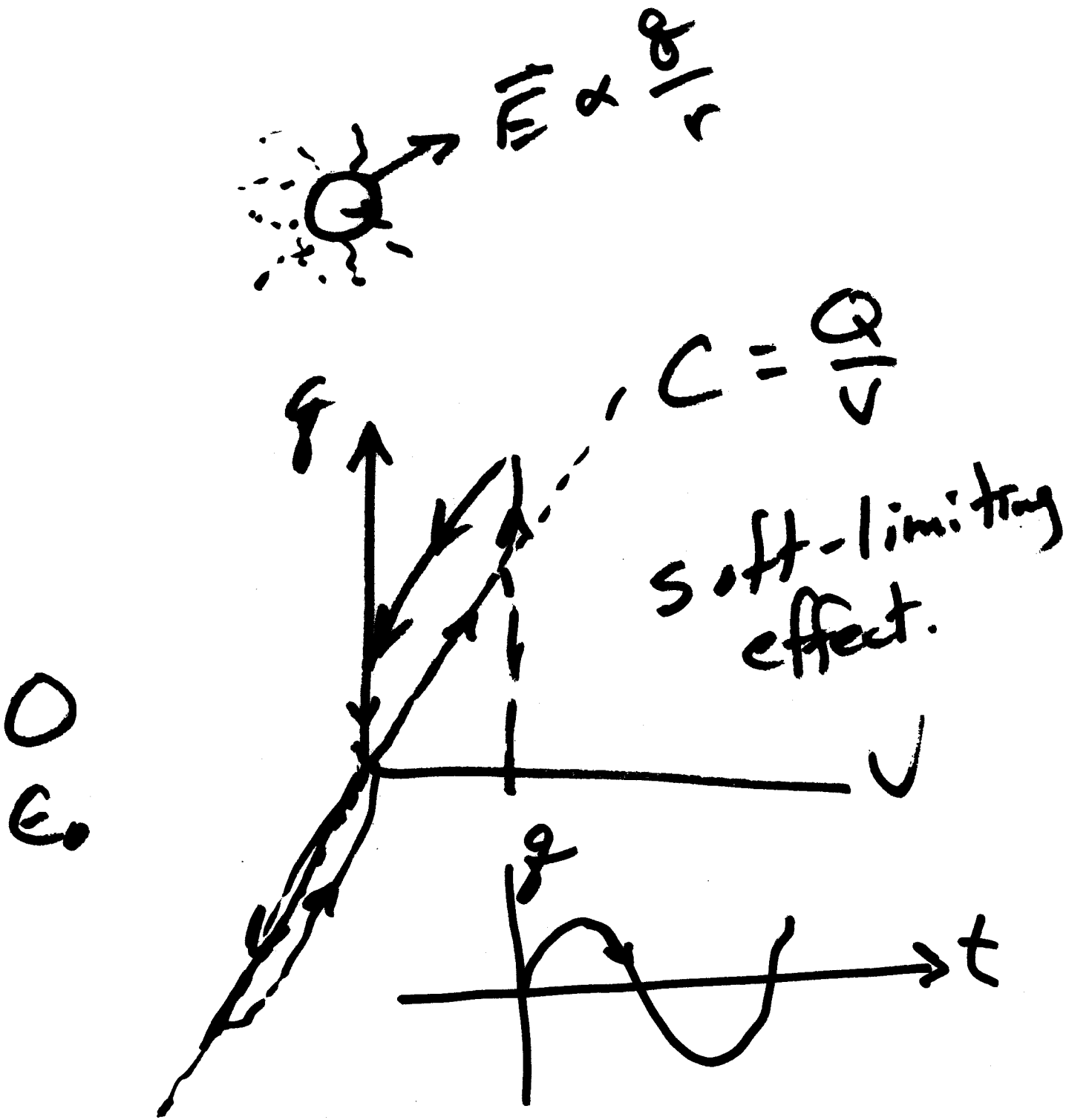
$V_{BG} - V_{CG}$

$V_{CG} - V_{AG}$

} L-L

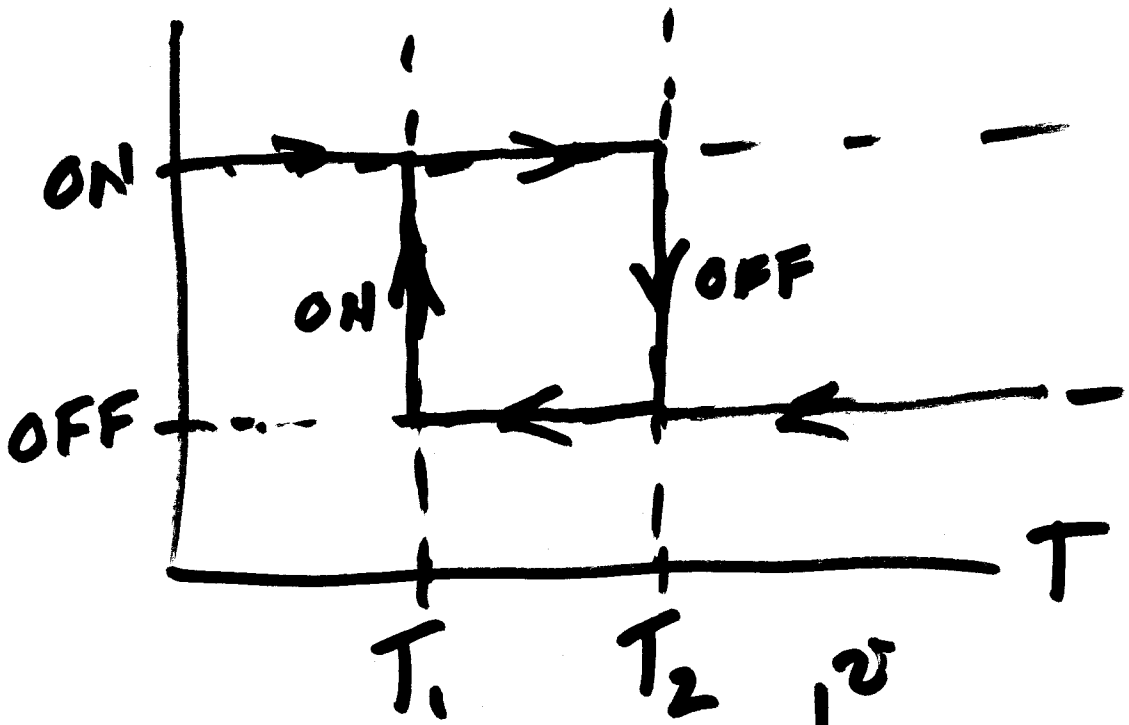


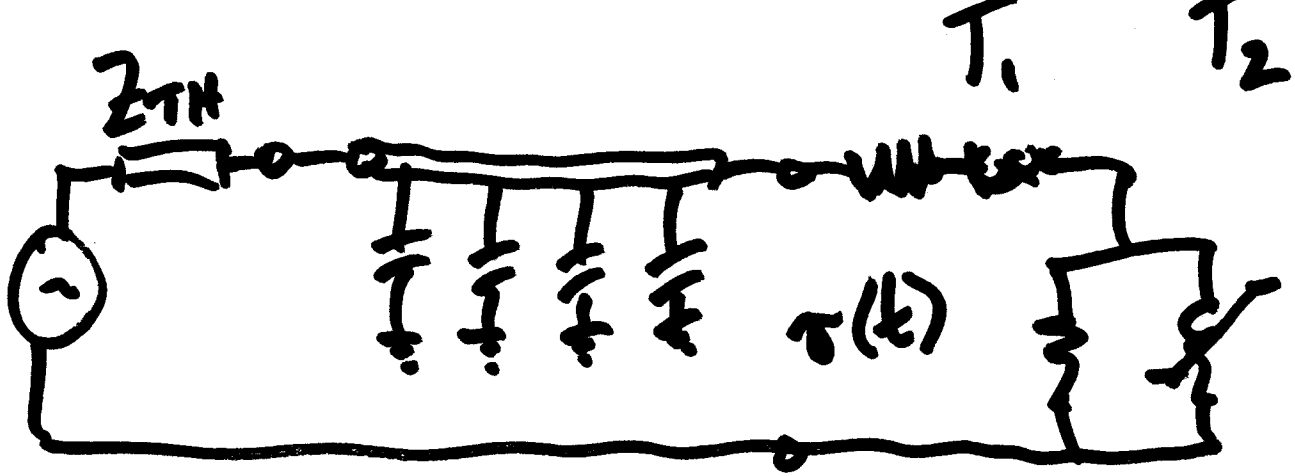
if Corona occurs, C becomes nonlinear.

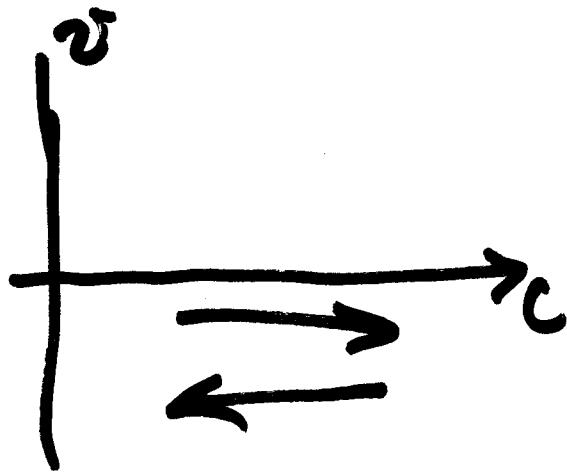

$E \propto \frac{q}{r}$
$C = \frac{Q}{V}$
q
soft-limiting effect.
O
ϵ_0
V
q
t

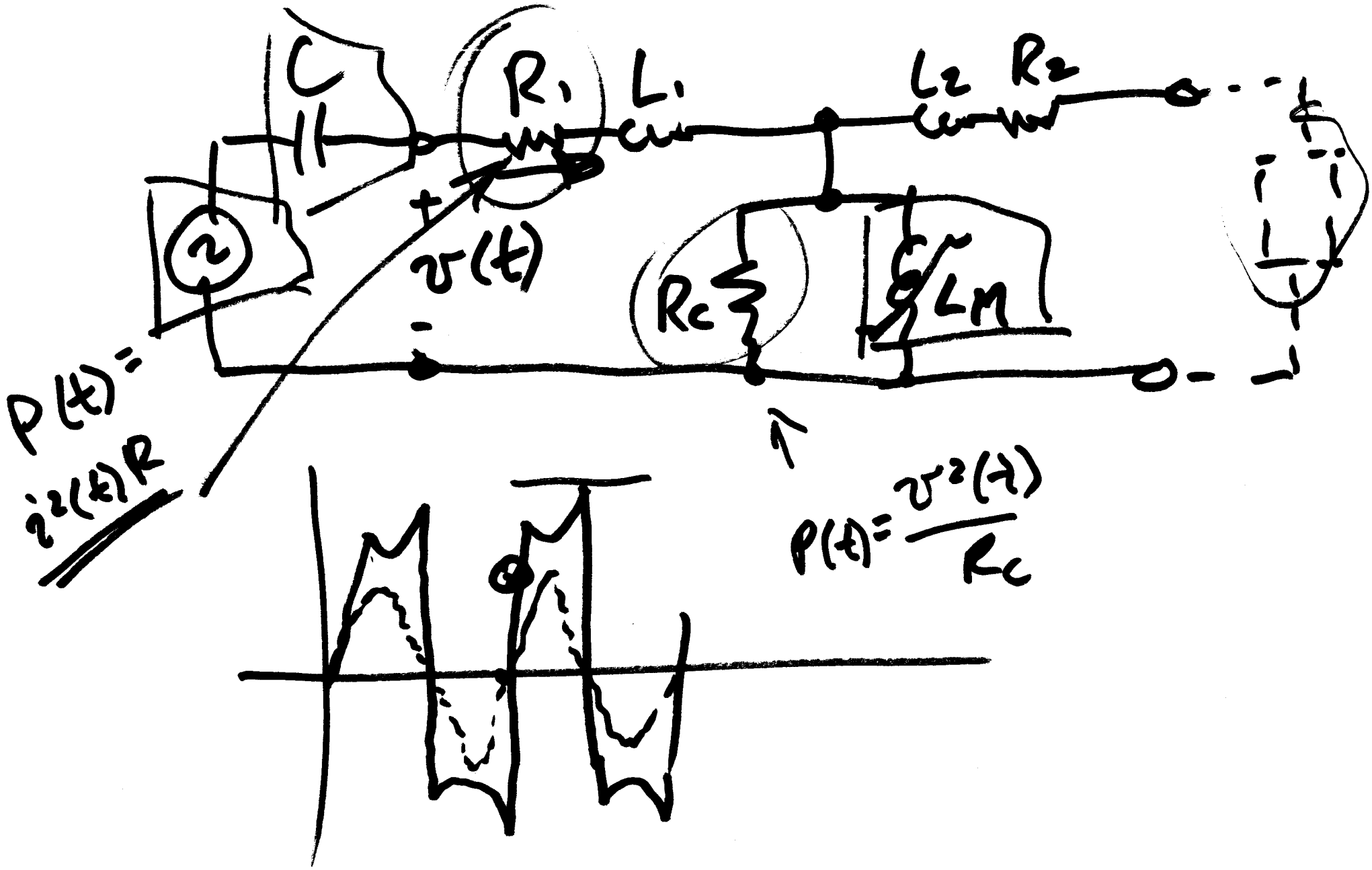
* Tues 1pm

- Bifurcation








C
R1
L1
L2
R2
2
+
v(t)
-
Rc
Lm
P(t) = i²(t)R
P(t) = v²(t) / Rc