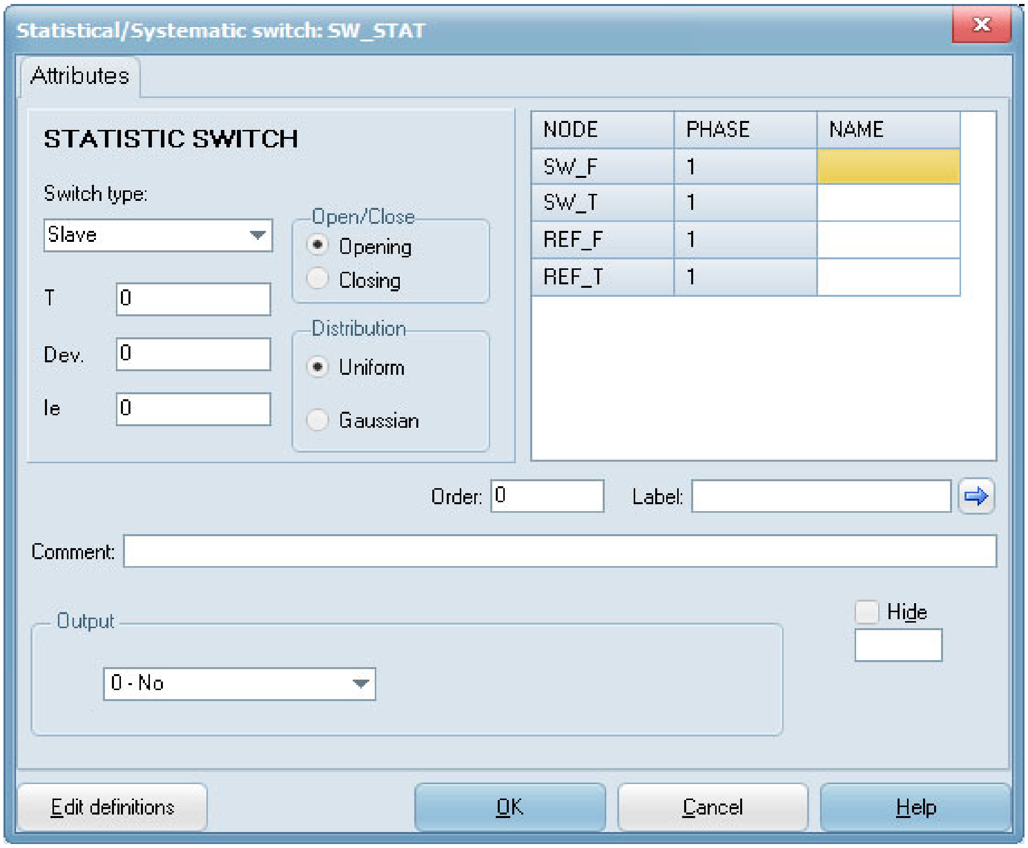
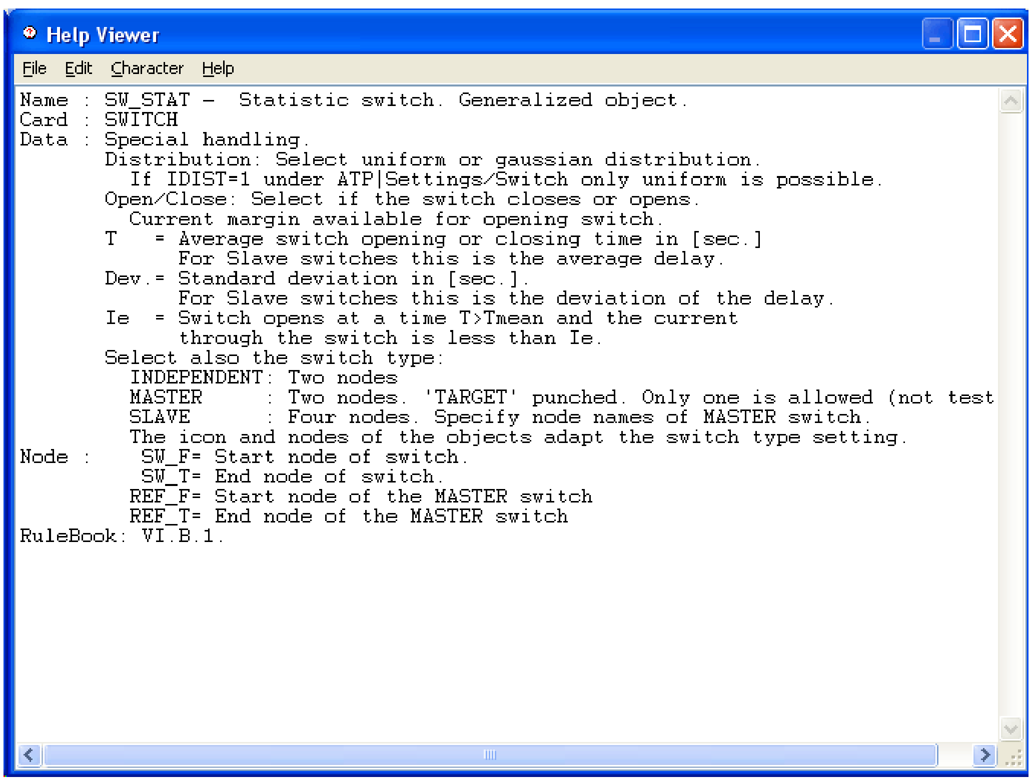
EE 5220 - Lecture 33 Fri Apr 1, 2022

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 = min half letter grade)

- Mid-term equivalent: re-work homeworks, ATP skills demo. Details TBA.
- Term Project - Journal paper analysis + .ppt with embedded audio. Deadline: Week 12 (9am Mon April 11th no further extensions)
- ATP Pointer of the day - Statistical switches
- Lightning - Ch.14
  - Basic characteristics
  - Statistical approach
- Transient overvoltages due to lightning - Chapters 15.
  - Breakdown characteristics
  - Probabilistic approach

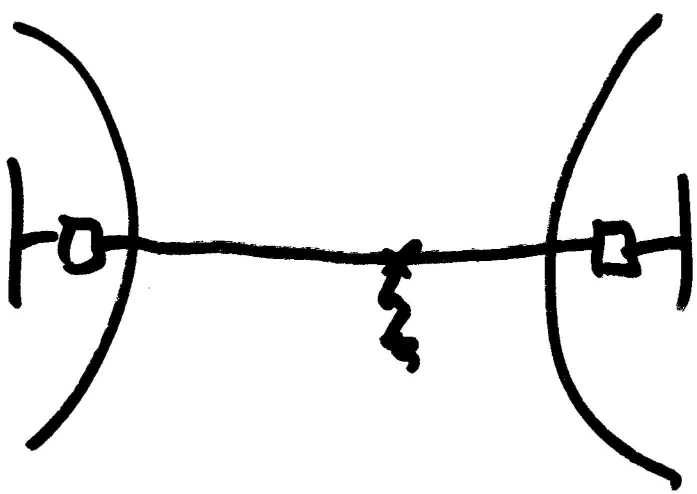

Statistical/Systematic switch: SW_STAT
Attributes
STATISTIC SWITCH
Switch type:
Slave
T
0
Dev.
0
Ie
0
Open/Close
Opening
Closing
Distribution
Uniform
Gaussian
NODE
PHASE
NAME
SW_F
1
SW_T
1
REF_F
1
REF_T
1
Order:
0
Label:
Comment:
Output
0 - No
Hide
Edit definitions
OK
Cancel
Help

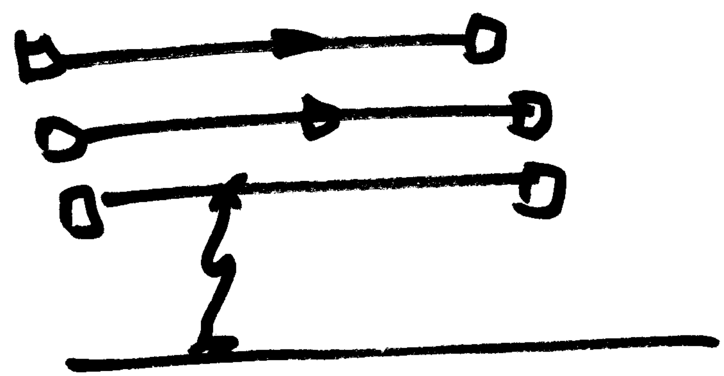

Help Viewer
File
Edit
Character
Help
Name : SW_STAT - Statistic switch. Generalized object.
Card : SWITCH
Data : Special handling.
Distribution: Select uniform or gaussian distribution.
If IDIST=1 under ATP|Settings/Switch only uniform is possible.
Open/Close: Select if the switch closes or opens.
Current margin available for opening switch.
T = Average switch opening or closing time in [sec.]
For Slave switches this is the average delay.
Dev.= Standard deviation in [sec.].
For Slave switches this is the deviation of the delay.
Ie = Switch opens at a time T>Tmean and the current
through the switch is less than Ie.
Select also the switch type:
INDEPENDENT: Two nodes
MASTER : Two nodes. 'TARGET' punched. Only one is allowed (not test
SLAVE : Four nodes. Specify node names of MASTER switch.
The icon and nodes of the objects adapt the switch type setting.
Node : SW_F= Start node of switch.
SW_T= End node of switch.
REF_F= Start node of the MASTER switch
REF_T= End node of the MASTER switch
RuleBook: VI.B.1.

ATP - Simulations - Transformers

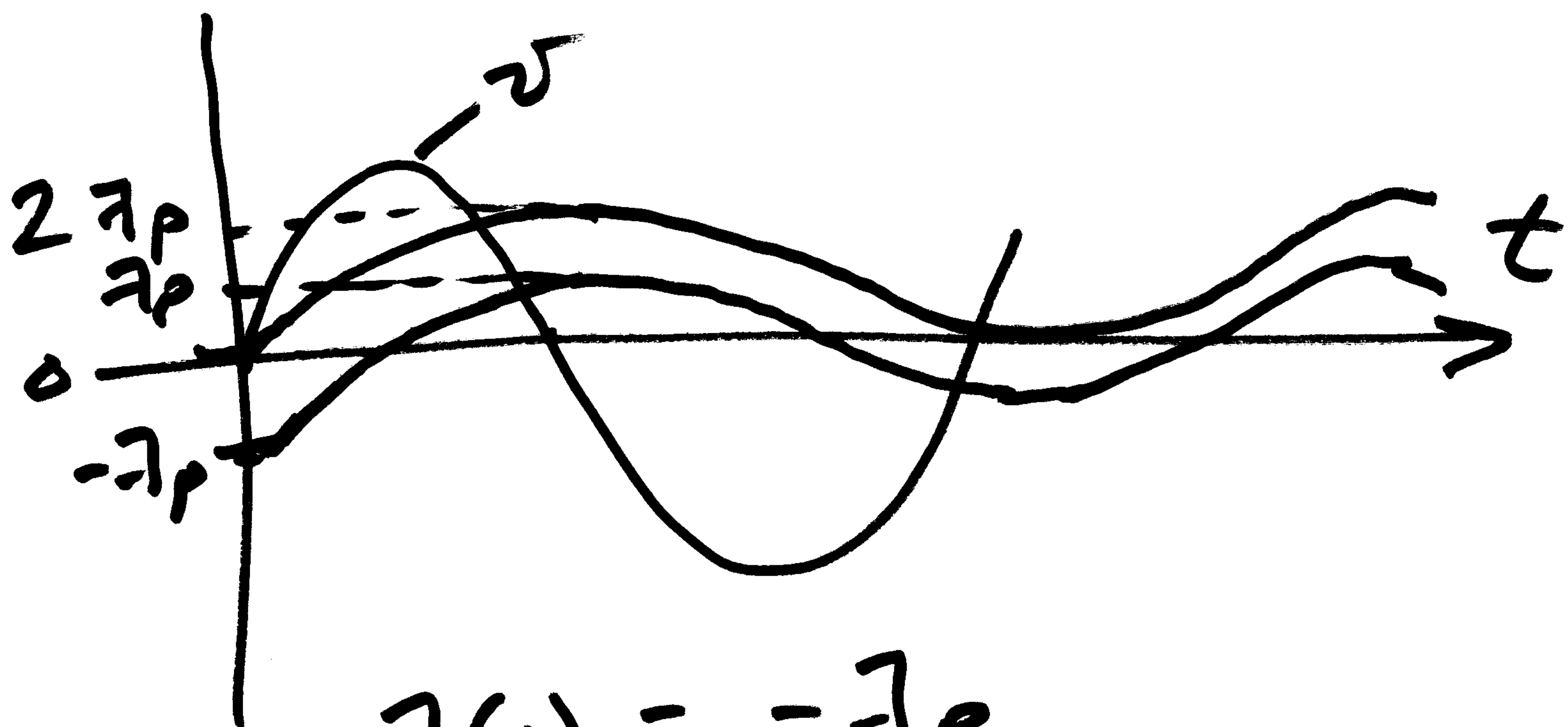
- Prob. 5.7 - ✓
- Inrush ✓
- Ferroresonance ← IEEE
  - April 11th - SWEPCO

- Single-Pole Tripping & Reclosing



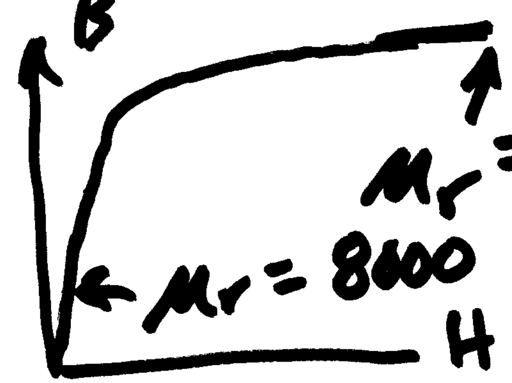


Inrush -

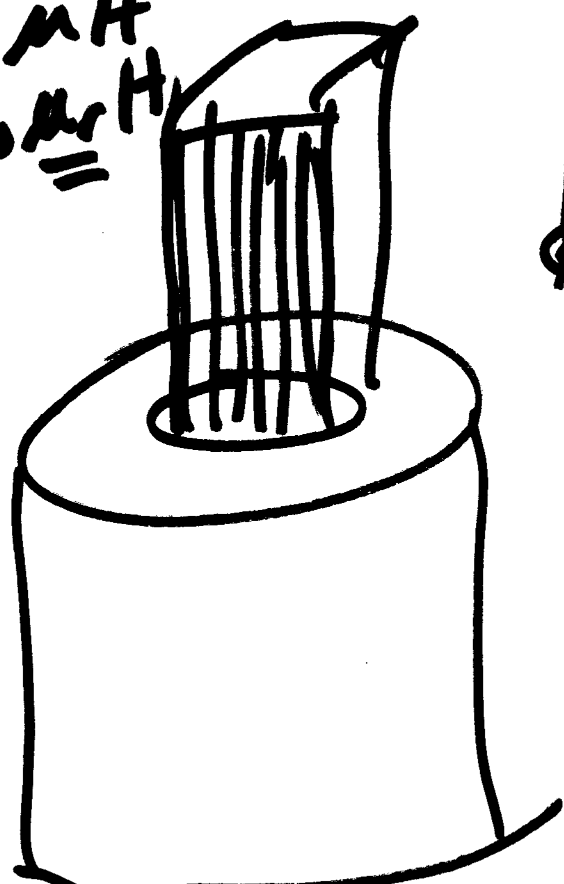


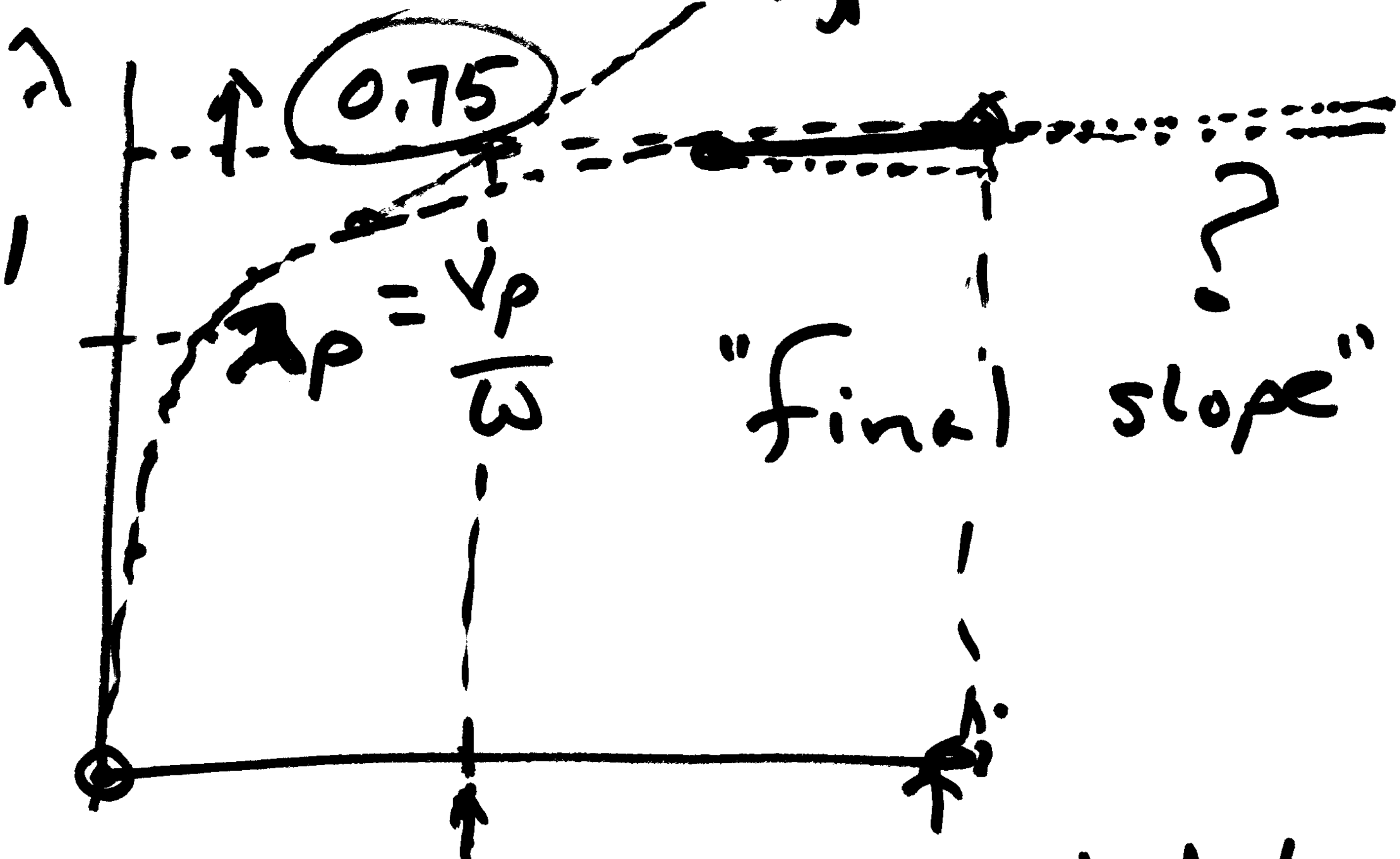
$$\lambda(0) = -\lambda_p$$

Sat Curve



$B = \mu H$
$= \mu_0 \mu_r H$





i incremental L

$L_{inc} = \frac{\Delta \lambda}{\Delta i}$

final slope: $L_{air\ core} = \frac{\Delta \lambda}{\Delta i}$

interrupts the reignition current at the first zero of the high frequency current, trapping energy in L_2.

Compute the peak voltage subsequently appearing across the reactor as a consequence of this trapping of energy.

5.7 The magnetizing curve of a transformer (refer to Fig. 5.22) is as follows:

Current	= 0	0.5	1.0	3.0	5.0	10.0	14.0	19.0	(A)
Flux density	= 0	0.56	0.8	1.34	1.52	1.64	1.68	1.70	(T)

The normal maximum, flux density is 1.0 tesla. Prior to energization, the flux density is +0.45 tesla. The voltage on energization calls for the flux to increase positively and is 10° before the peak. Determine the peak tansient inrush current.

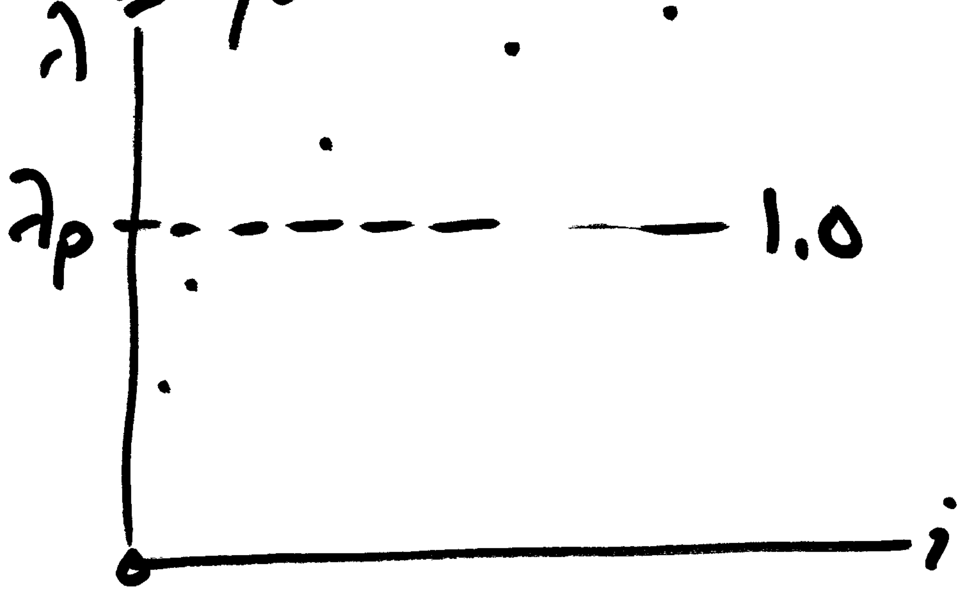
REFERENCES

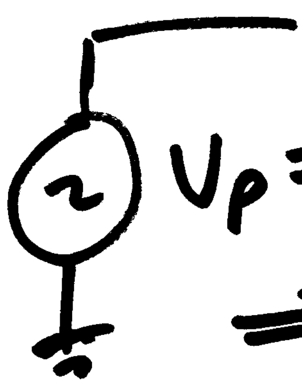
1. A. F. B. Young, "Some Researches in Current Chopping in High Voltage Circuit Breakers," *Proc. IEE* London, Vol. 100, No. 76 (1953), pp. 337.
2. E. J. Tuohy and J. Panek, "Chopping of Transformer Magnetizing Current Part I: Single Phase Transformers," *Trans. IEEE*, Vol. PAS-97 (1978), pp. 1317–1325.
3. CIGRE Working Group 13.02, "Interruption of Small Inductive Currents, Chapters 1, 2, *Electra*, No. 72 (1980), pp. 73–103.
4. J. D. Gibbs, D. Koch, P. Malkin, and K. J. Cornick, "Investigations of Prestriking and Current Chopping in Medium voltage SF_6 Rotating Arc and Vacuum Switchgear," IEEE, PES Winter Meeting, paper No. 88WM221-4 (1988).
5. C. G. Damstra, "Current Chopping and Overvoltages in Relation to System Parameters," CIGRE Report No. 201 (1964).
6. T. H. Lee, "The Effect of Current Chopping in Circuit Breakers on Networks and Transformers, Part I, Theoretical Considerations," *Trans. AIEE*, Vol. 79 (1960), p. 535.
7. A. N. Greenwood, discussion of paper, "Commutation and Destructive Oscillation in Diode Circuits," by I. Somos, *Trans. AIEE*, Vol. 80, Part I (1961).
8. I. B. Johnson et al., "Some Fundamentals of Capacitance Switching," *Trans. AIEE*, Vol. 74, Part III (1955), pp. 727–736.
9. T. M. McCauley et al., "The Impact of Shunt Capacitor Installations on Power Circuit Breaker Applications," *Trans. IEEE*, Vol. PAS-99 (1980), pp. 2210–2222.
10. S. S. Mikhail and M. J. McGranaghan, "Evaluation of Switching Concerns Associated with 345 kV Shunt Capacitor Applications," *Trans. IEEE*, Vol. PWRD-1, No. 2 (1986), pp. 221–230.

Also, what makes SF6 so different that it will only attempt to open at natural current zero & not at the high freq. current zeros? Is that because of the dielectric strength of SF6?

$\lambda = BAN$

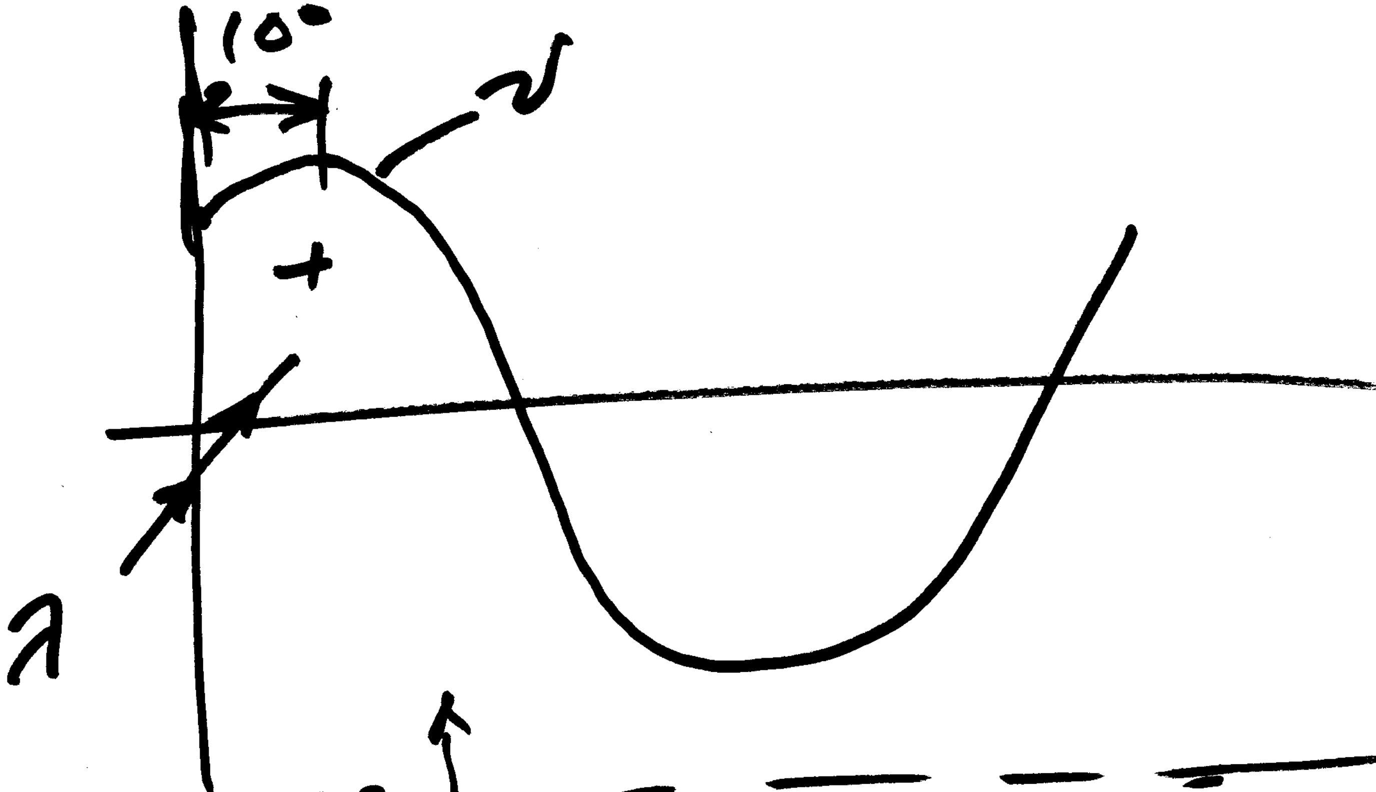
$\lambda = V_p / \omega$

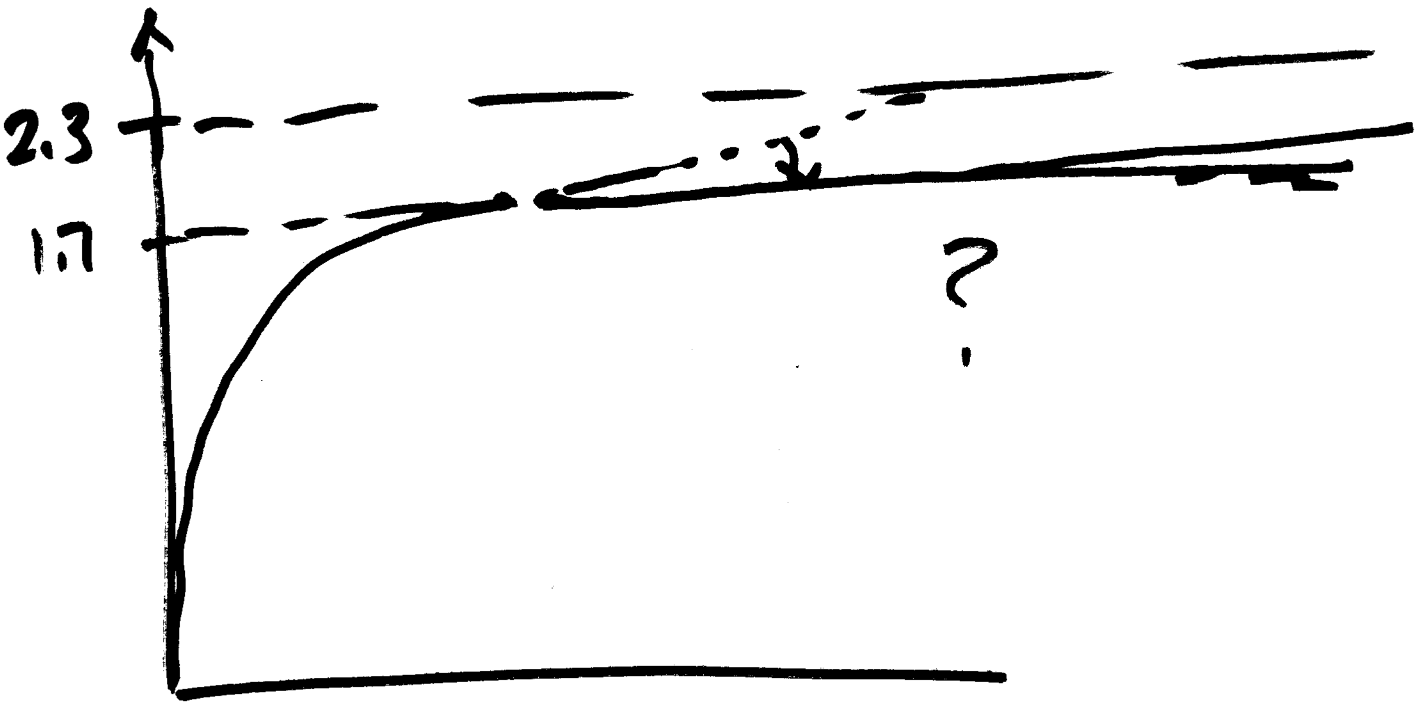




$V_p = \omega \lambda_p$

$\Rightarrow V_p = 377$


10°
ν
+
λ


2.3
1.7
?