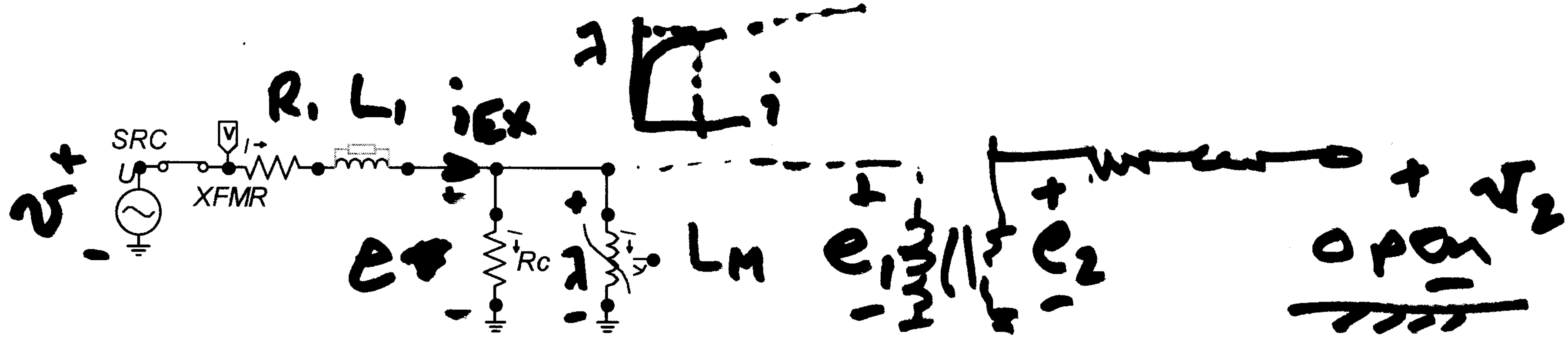
EE 5220 - Lecture 28x (Supplemental, Originally L26 S'08) Mon Mar 22, 2010

Topics for Today:

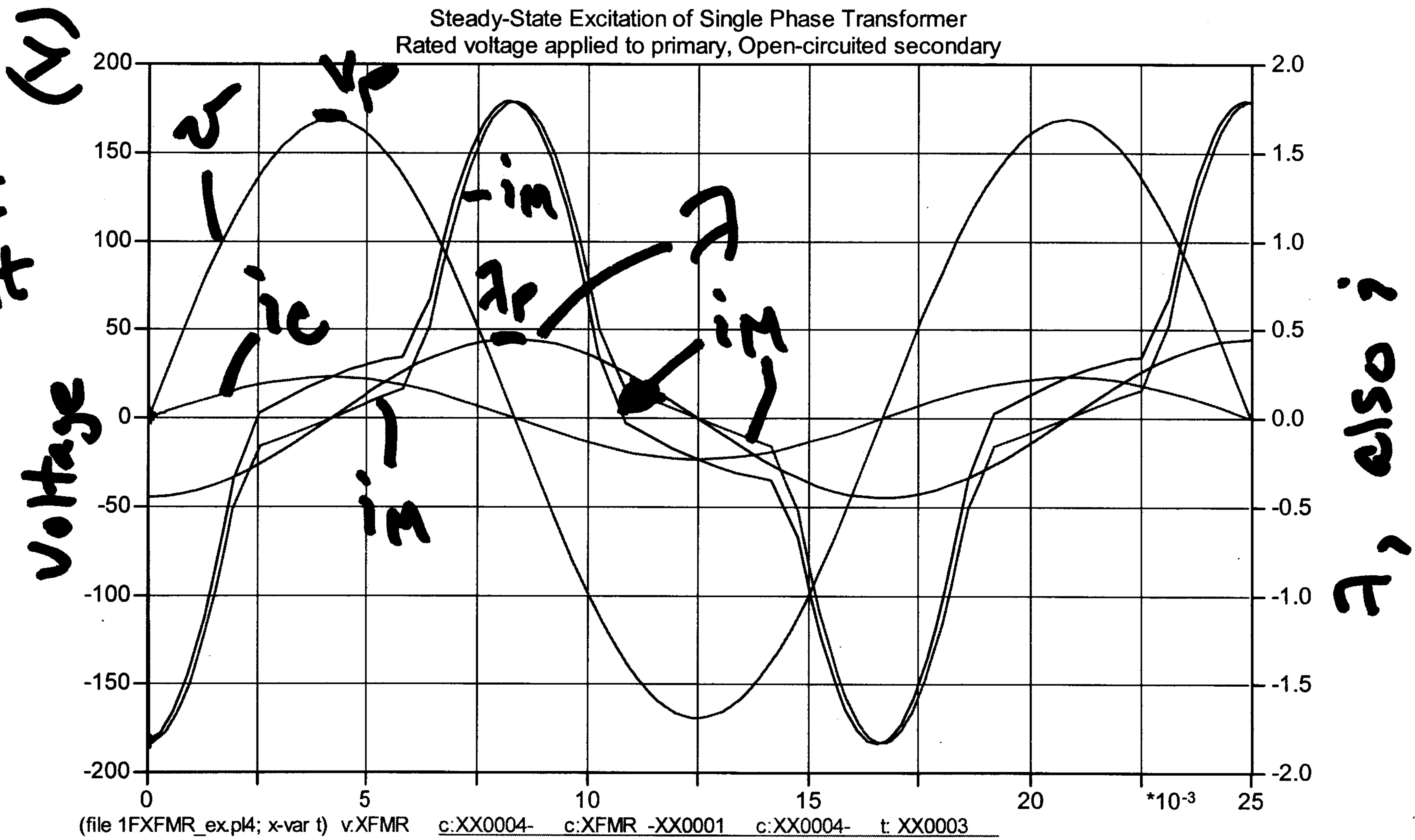
- Course Info:
    - Web page: http://www.ee.mtu.edu/faculty/bamork/ee5220/
    - Book, references, syllabus, more are on web page.
    - Software - Matlab. ATP/EMTP [License - www.emtp.org] ATP tutorials posted on our course web page
    - EE5220-L@mtu.edu (participation = half letter grade, 5%)

- HW#8 - Probs. 9.6, 9.12 due Mon Mar 22^{nd} 5pm.
- HW#9 - Probs. 9.2, 9.3, 9.4 due Mon Mar 29^{th} 5pm.
- Term Project - Mar 19^{th} - a) complete reference list and b) fully-detailed table of contents according to format given in Term Project Guidelines, e-mail Dr. Mork.
- Transformer modeling - Section 11.1 of text, plus lecture notes
    - Example of single-phase transformer, Excitation
        - Waveforms for voltage, I_{EX}, I_R, I_C, λ - demonstrated in Lecture 27
    - Transformer Inrush - initial conditions
        - Energization inrush
        - Recovery inrush
        - Sympathetic inrush
- Next - take stock of available ATP transformer models



$e = \frac{d\lambda}{dt}$

$\lambda = \int e\, dt$



$$v(t) = V_p \sin(\underline{\omega} t)$$

$$\lambda(t) = \int v(t)\,dt$$

$$\lambda(t) = -\frac{V_p}{\omega} \cos(\underline{\omega} t)$$

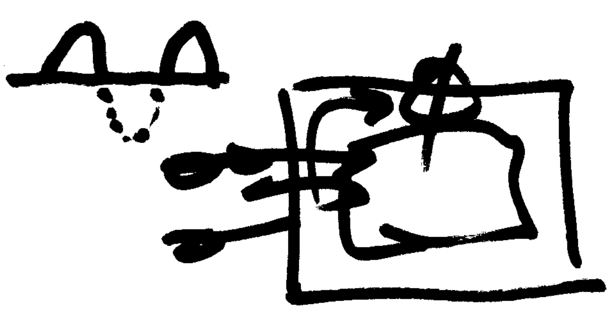
$$v(t) = \frac{d\lambda(t)}{dt} = V_p \sin(\omega t)$$

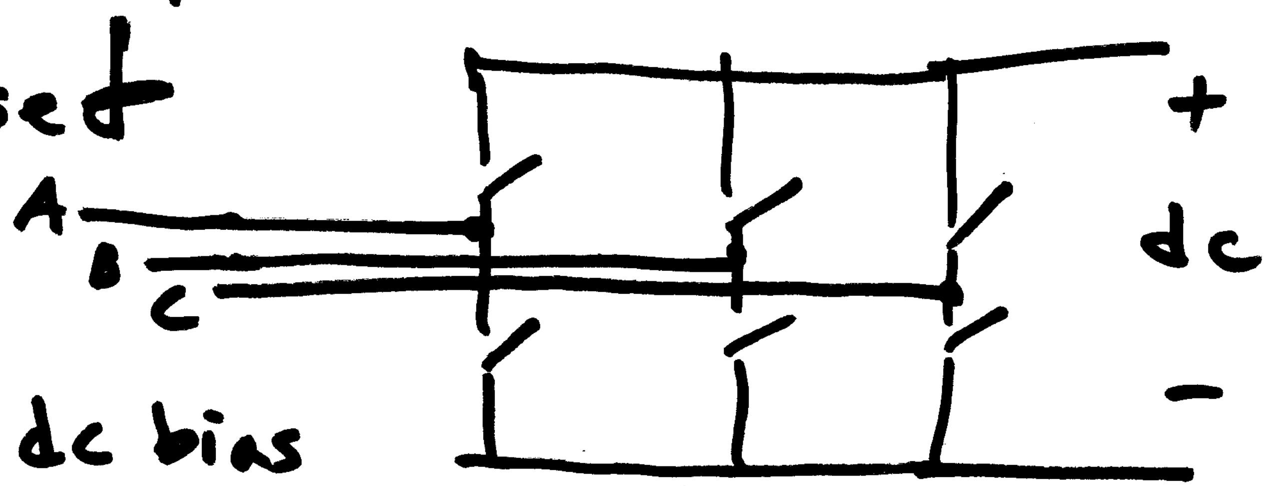
$$\therefore\ V_p = \omega \lambda_p \quad \text{or} \quad \lambda_p = \frac{V_p}{\omega}$$

$$\Rightarrow \frac{V_p}{\omega} = \frac{169\,V}{377\,s^{-1}} = \underline{\underline{0.45\,V\text{-}s}}$$

Transformer Behaviors

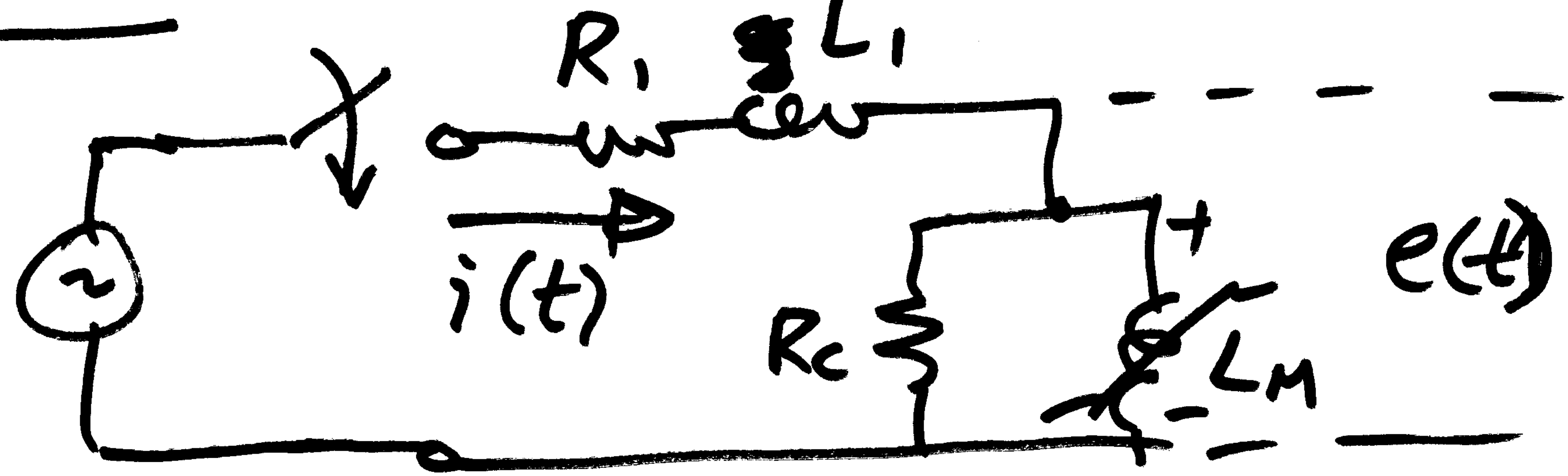
- S.S. Excitation (No-Load)
- Inrush
- Impulse / Lightning Surges — 500 kHz
- Switch Surges (Step response)
- Harmonics / harmonic deration
- dc offset





dc bias on my ckt.

Inrush:



Important to note:

- $R_1, L_1 << R_c, L_M$
- R_1 is main source of damping for inrush.
- R_c no big effect.

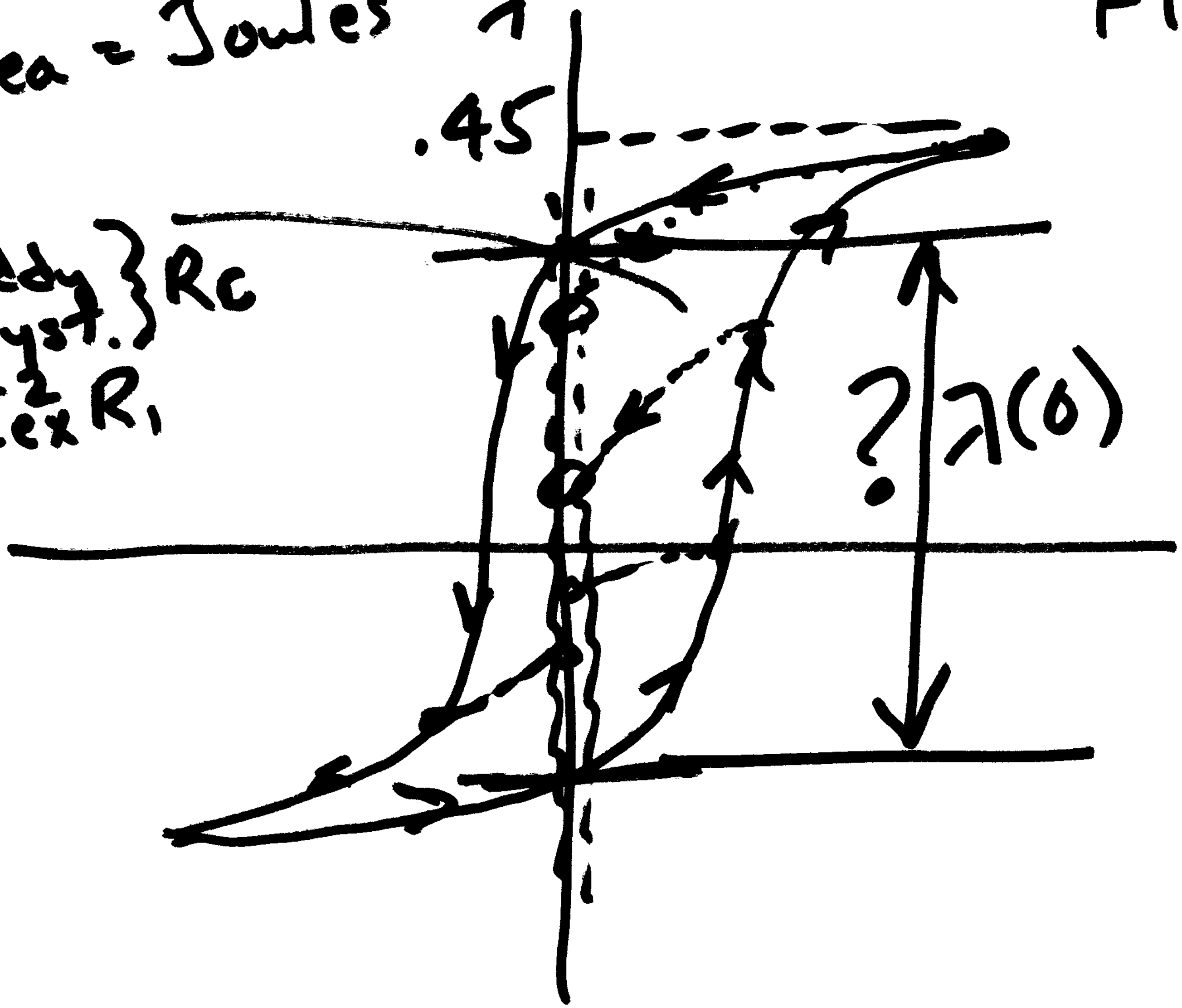
The inrush current $i(t)$ depends on:

- switching time/angle
- Residual flux in L_M

Flux-current Loop ⑥

Area = Joules

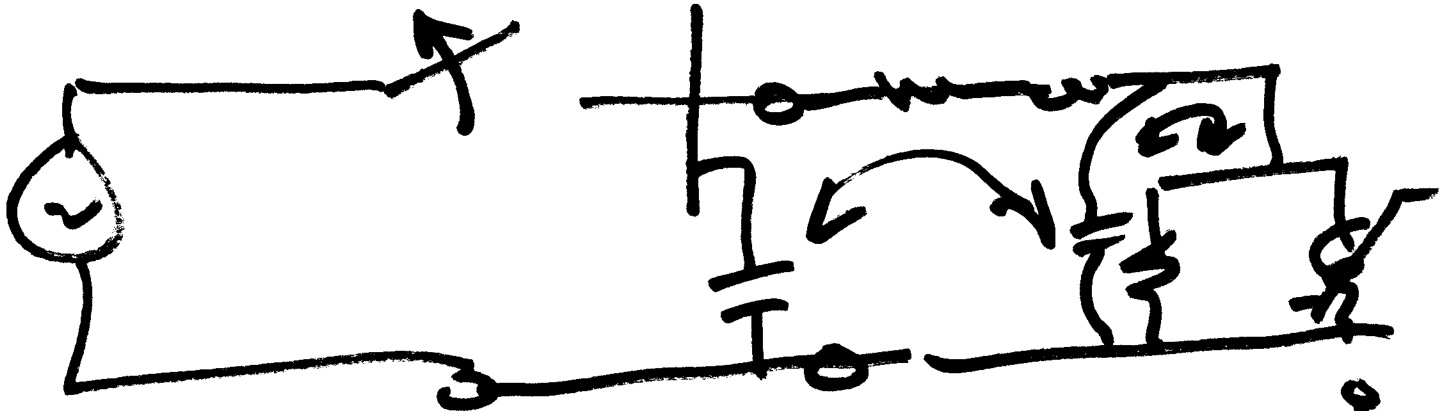
- eddy } R_c
- hyst. } R_c
- $I_{ex}^2 R_1$

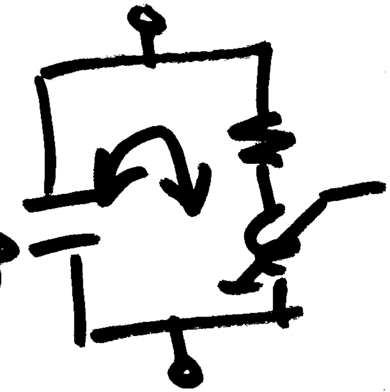


$i_{Ex} = i_c + i_M$

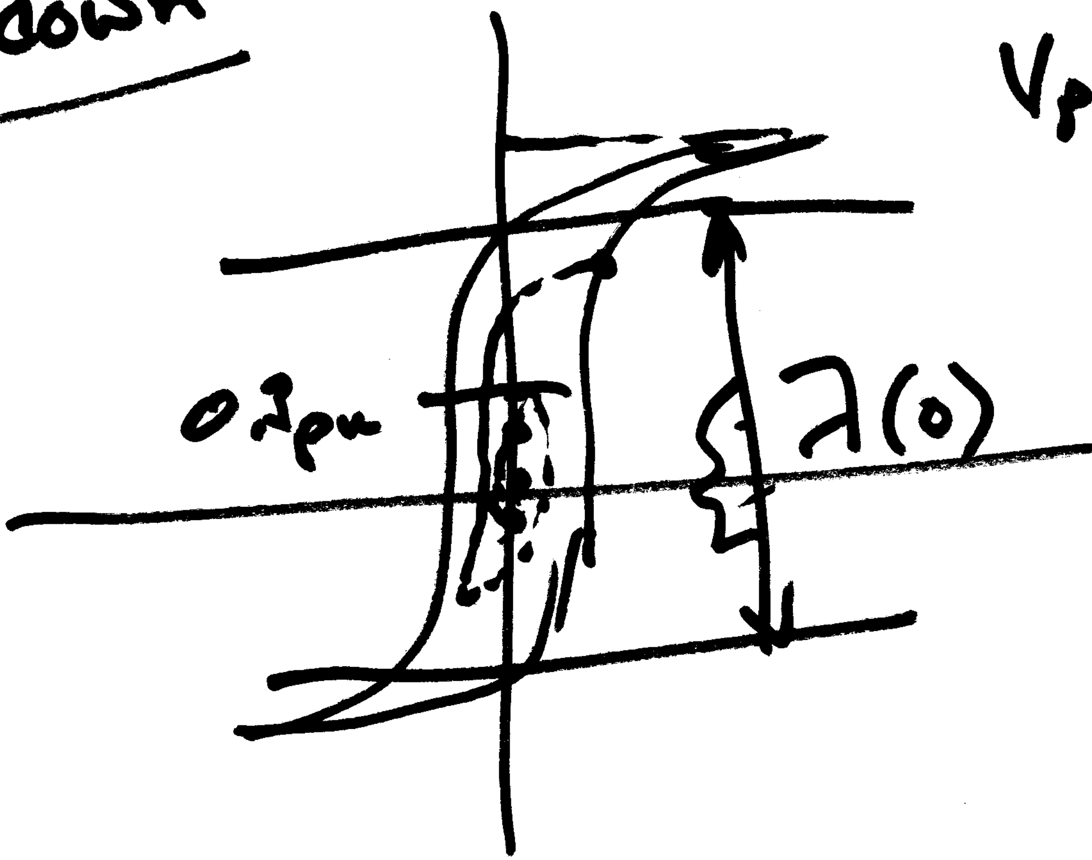
Residual flux in terms of λ.

λ_0 or $\lambda(0)$





Ring-down



$$e(t) = \frac{d\lambda(t)}{dt} \quad \text{or} \quad \lambda(t) = \int_0^t e(t)\,dt + \underline{\underline{\lambda(0)}}$$

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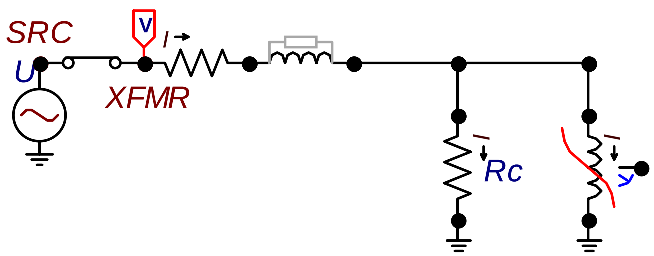
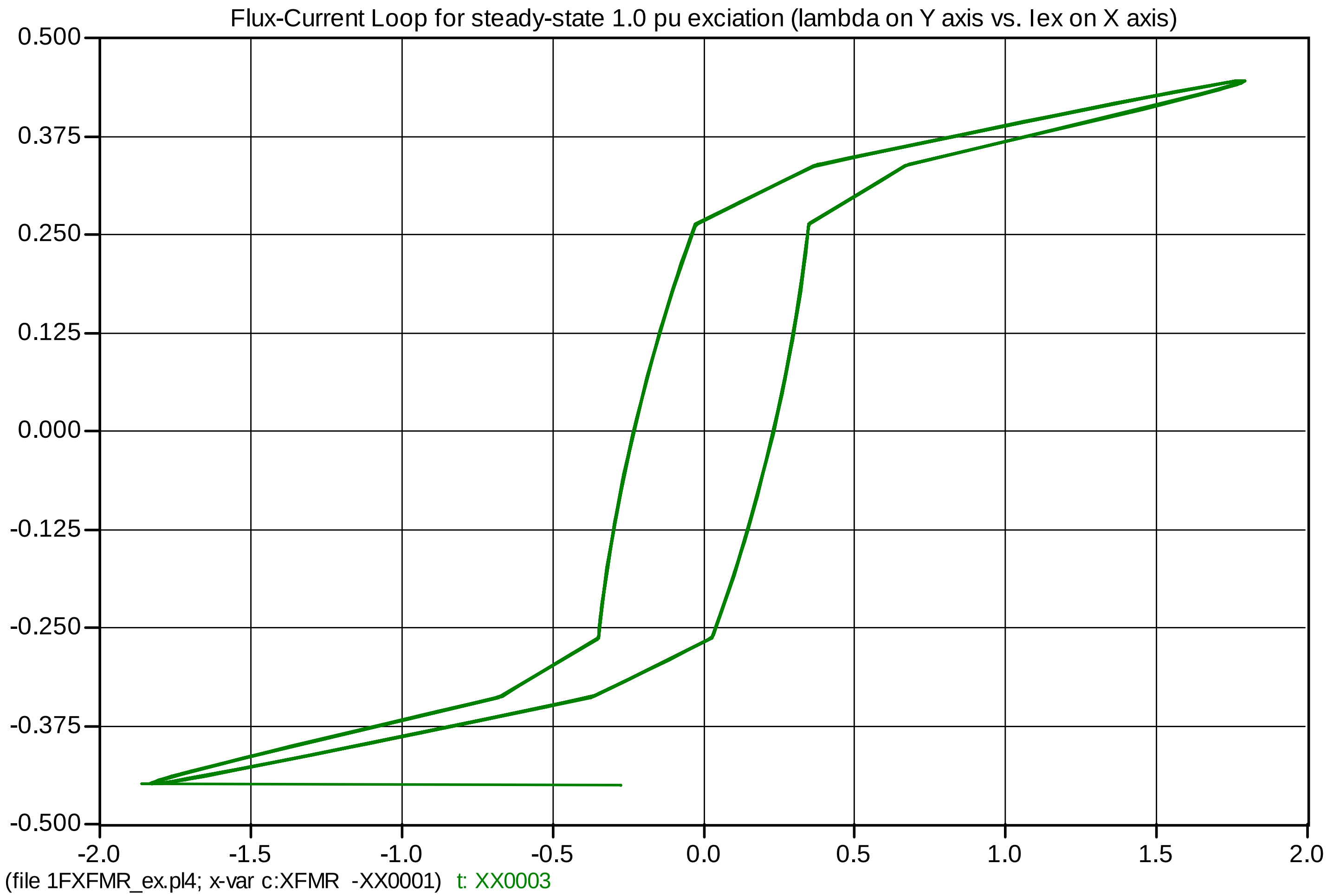
inst. swith is closed!


SRC
U
V
I
XFMR
I
Rc
I
λ


Flux-Current Loop for steady-state 1.0 pu exciation (lambda on Y axis vs. Iex on X axis)
0.500
0.375
0.250
0.125
0.000
-0.125
-0.250
-0.375
-0.500
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
2.0
(file 1FXFMR_ex.pl4; x-var c:XFMR -XX0001)
t: XX0003