ECE 587 – FALL 2019

RL TRANSIENT EXAMPLE – 34.5KU SUBSTATION, 60HZ

$$Z = 1 + j3\,\Omega$$

SUBSTATION $t = 0$
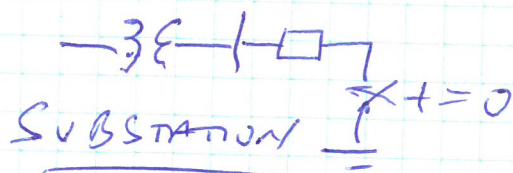
$$\frac{\sqrt{2}}{\sqrt{3}}\,34.5 \times 10^3 \cos(\omega t + \theta)$$

$X = 3.0\,\Omega$

$L = \dfrac{3.0}{2\pi/60}$

$\quad = \dfrac{3.0}{377}$

$\quad = 0.007966$

$$\frac{R}{L} = \frac{1}{0.00796} = 125.6$$

FIND SS $i(t)$

O–P
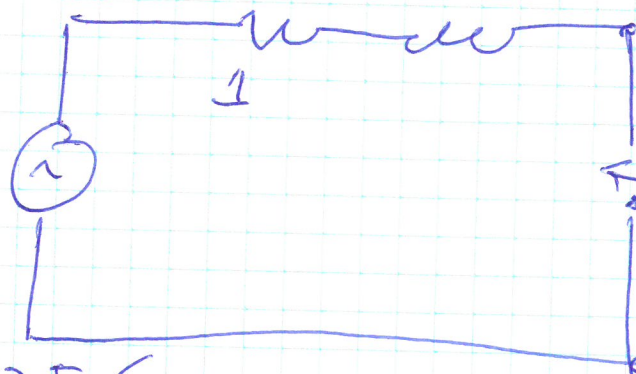
$$\tilde{I}_{SS} = \frac{\hat{V}_S}{Z} = \frac{\hat{V}_S}{\sqrt{R^2 + (\omega L)^2}\;\angle\, \tan^{-1}\left(\frac{\omega L}{R}\right)}$$

$$= \frac{28,169\,\angle\theta}{3.16\,\angle 71.9°} = 8914\,\angle\theta - 71.6°\ A$$

O–PEAK.

$$i_{SS}(t) = 8914 \cos(377t + \theta - 71.6°)\ A$$

FIND TR $i(t)$ $\qquad L\dfrac{di}{dt} + Ri = 0 \implies \left(s + \dfrac{R}{L}\right) = 0$

$$s = -\frac{R}{L}$$

$$i_{TR}(t) = A e^{st} = A e^{-125.6t}$$

$$i(t) = i_{SS}(t) + i_{TR}(t) = 8914\cos(377t + \theta - 71.6°) + A e^{-125.6t}$$

$$t \geq 0$$

$$i(t) = 0 \qquad t < 0$$

$$i(0) = 0 = 8914 \cos(\theta - 71.6°) + A(1)$$

$$A = -8914 \cos(\theta - 71.6°)$$

$$i(t) = 8914 \left[\cos(377t + \theta - 71.6°) - \cos(\theta - 71.6°) e^{-125.6} \right]$$

$$t \geq 0$$

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FIND $i(t)$ FOR FAULT THAT OCCURS WHEN

$V = 10 kV$, WITH VOLTAGE INCREASING

$$V_s(t=0) = 10,000 = 28,169 \cos(\theta)$$

$$\theta = \pm \cos^{-1}\left(\frac{10,000}{28,169} \right) \qquad \theta = \pm 69.2°$$

$$\boxed{\theta = -69.2°}$$

$$i(t) = 8914 \left[\cos(377t - 140.8°) - \cos(-140.8°) e^{-125.6t} \right]$$

$$= 8914 \cos(377t - 140.8°) + 6908 e^{-125.6t} \ A$$

$$t \geq 0$$

$$I_{asym} / I_{sym} \simeq 1.34$$

TO FIND PEAK CURRENT

SOLVE $\frac{di}{dt} = 0 = -8914(377)\sin(377t - 140.8°)$
$$+ 6908(-125.6)e^{-125.6t}$$

FIND t

AS $\qquad$ $\boxed{377t - 140.8° = 0}$ $\begin{cases} \text{WHEN} \\ \text{COSINE TERM} \\ \text{MAXIMIZES} \end{cases}$

APPROXIMATION $\qquad t \cong 0.00652 \text{ sec.}$

$$i_{peak} \cong 12 \text{ kA}$$

SOLVE TRANSCENDENTAL EQUATION