

BITS,Pilani-Dubai

International Academic City

IV year EEE/2nd Semester/2012-13/Comprehensive Exam./Date-04/06/2013

Course Title—Advanced Power Systems(Course No.—EEE C462)

Max. Marks—80/ Weightage—40% / Duration—3 hours.

(1)A three phase transmission line has $Z=300 e^{j75} \Omega/\text{phase}$ and $Y= j0.0025 \text{ mho}$ per phase, where the phase angle is given in “degree”unit. The power at the generating station is 40 MVA at a power factor of 0.85(lag) at a voltage of 120 KV(L-L). There is a load of 10 MW at unity power factor at the mid-point of the line. Calculate the load (in Megawatts) at the distant end of the line. Use nominal T-circuit of the line.----[12 marks]

(2)With reference to a long transmission line, develop the differential equation in voltage or current and find the solution using “Laplace Transform”, starting from fundamentals, along with necessary labeled diagrams. ----[10 marks]

(3) A three phase star connected Synchronous Generator has positive and negative sequence impedances as $j0.09 \text{ p.u}$ and $j0.075 \text{ p.u}$, respectively. The neutral is solidly grounded. A line – to- line fault occurs on the terminals of the generator phase “b”and phase “c” windings , with $Z^f =0$. Assume: $E_a =1.0+j 0.0 \text{ p.u}$ and $I_a=0$. Starting from fundamentals (with necessary diagrams), derive the expression for I_{a1} and hence calculate V_b and I_b . ----[6+5 marks]
Phase Sequence : a - b - c ($e^{-j\omega t}$)

(4) Derive the expression for the sequence impedance matrix of a transmission line(using the Theory of Symmetrical Components) where X_s and X_m are known. Draw the necessary labeled diagram and state the assumptions (if any) . ---[8 marks]

(5) Draw the labeled diagram of a Modified Impedance Relay and develop the Relay Locus in R-X plane after necessary derivations in detail. ----[12 marks]

(6) Draw the complete circuit diagram (labeled) for percentage differential protection of a star-delta transformer. Also explain the function of different parts/components/elements of that diagram. ----[6+3 marks]

(7) Explain the operation of a Vacuum Circuit Breaker with a neat labeled diagram. --[9 marks] ----[P.T.O]

(8) A synchronous generator is feeding 250 MW to a large 50 Hz. Network over a double circuit transmission line. The maximum steady state power that can be transmitted under different conditions are as follows:--

Prefault—500 MW--- During fault—175 MW--- Post fault---350 MW.

Estimate the critical clearing angle in which the circuit breakers must trip so that the synchronism is not lost. Consider that the maximum load angle(δ_{max}) is the angle at the point of intersection of the 250 MW- load line with the post-fault P- δ curve. Apply "Equal Area Criterion". ----[9 marks]

#-----#-----#-----

Q. 1) $Z = 300 \angle 75^\circ = 77.65 + j 28.78 \text{ } \mu\Omega/\text{ph}$

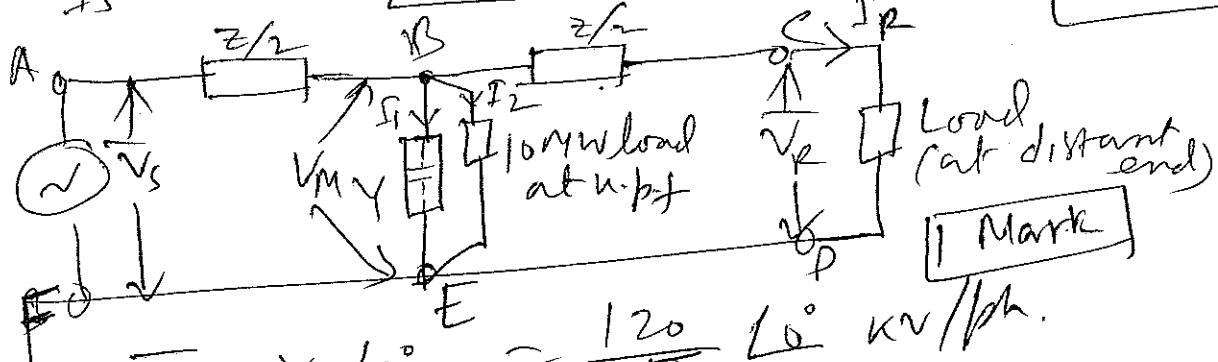
$Y = j 0.0025 \text{ } \mu\Omega/\text{ph}$

I_s = Sending end current

Power at the generating station = 40 MVA

$$|I_s| = I_s = \frac{10^6 \times 40}{\sqrt{3} \times 120 \times 10^3} = 0.192 \text{ kA/ph}$$

$$I_s = 0.192 \angle -\cos^{-1} 0.85 = 0.192 \angle -31.75^\circ \text{ kA/ph}$$



$$\bar{V} = V_S \angle 0^\circ = \frac{120}{\sqrt{3}} \angle 0^\circ \text{ kV/ph.}$$

$$\begin{aligned} \bar{V}_M &= \frac{120}{\sqrt{3}} \angle 0^\circ - (0.192 \angle -31.75^\circ) (120 \angle 75^\circ) \\ &= 69.284 - 21 - j 19.72 \\ &= 52.155 \angle -22.195^\circ \text{ kV/ph.} \end{aligned}$$

$$\begin{aligned} \bar{I}_1 &= (j 0.0025) \bar{V}_M = 0.130 \angle 67.805^\circ \text{ kA/ph} \\ &= 0.049 + j 0.120 \text{ kA/ph} \end{aligned}$$

$$|\bar{I}_2| = \frac{10 \times 10^6}{3 \times 52.155 \times 10^3 \times \cos \phi}$$

It is given that, $\cos \phi = 1$

$$|\bar{I}_2| = I_2 = \frac{(10)^4}{3 \times 52.155} = 0.0639 \text{ kA/ph.}$$

As \bar{I}_2 & \bar{V}_M are in phase,

$$\bar{I}_2 = 0.0639 \angle -22.195^\circ \text{ kA/ph.}$$

1 M

$$\bar{I}_S = 0.192 \angle -31.75^\circ = 0.1632 - j 0.1012$$

$$\begin{aligned}\bar{I}_P &= \bar{I}_S - (\bar{I}_1 + \bar{I}_2) \\ &= (0.1632 - j 0.1012) - (0.1081 + j 0.096) \\ &= 0.205 \angle -74.38^\circ \quad \boxed{2 \text{ Marks}}\end{aligned}$$

$$\begin{aligned}\bar{V}_P &= V_m - \bar{I}_R \left(\frac{Z}{2} \right) \\ &= (48.284 - j 19.72) - (\bar{I}_R) \left(\frac{Z}{2} \right) \\ &= (48.284 - j 19.72) - (0.205 \angle -74.38^\circ \times 150 \angle 75^\circ) \\ &= 26.64 \angle -48.82^\circ \quad \text{KV/ph.} \\ \bar{I}_R &= 0.205 \angle -74.38^\circ \quad \text{KA/ph.} \quad \boxed{1 \text{ M}}\end{aligned}$$

Load at distant end

$$\begin{aligned}&= (1 \text{ } \textcircled{O}) \times 3 \times 26.64 \times 0.205 \angle (74.38 - 48.82)^\circ \text{ Watts} \\ &= 16.38 \times 10^6 \times \cos 25.56^\circ \\ &= 14.74 \times 10^6 \text{ Watts} = 14.74 \text{ MW}\end{aligned}$$

→ Answer 2 Marks

2 See Chapter 5 (TIR) and class notes

Archives

(3.)

Derivation for $I_{a_1} = \frac{E_a}{z_1 + z_2 + z^f}$
and necessary diagrams

→ Refer Text Book (Chapter 11)

→ Diagrams - [2 Marks]

→ Derivation - [4 Marks]

Numerical Problem Part :-

$$z^f = 0 ; I_{a_1} = \frac{E_a}{z_1 + z_2 + z^f} = \frac{1.0 \angle 0^\circ}{j(0.09 + 0.075)} \\ = -j 6.06 \text{ p.u.} \quad \boxed{1M}$$

$$V_{a_1} = E_a - I_{a_1} z_1 = 1 - (-j 6.06)(j 0.09) \\ = 0.455 \text{ p.u.} \quad \boxed{1M}$$

Now, $V_{a_1} = V_{a_2} \rightarrow \text{Known}$

$$\bar{V}_b = \alpha^v V_{a_1} + \alpha V_{a_2} = \bar{V}_c \quad \boxed{1M}$$

$$V_b = (\alpha^v + \alpha) V_{a_1} = -V_{a_1} = -0.455 \text{ p.u.}$$

$$\bar{I}_b = -\bar{I}_c = \frac{-j\sqrt{3} E_a}{z_1 + z_2 + z^f} = (-\sqrt{3}) 6.06 \\ = -10.495 \text{ p.u.} \quad \boxed{2 Marks}$$

(4)

Derivation → See Chapter-10 of T.B.
(Art 10.4)

(5)

Modified Impedance Relay

→ Diagram / Derivation - Art 15.5 (Ch - 15)

of Text Book + Class Notes.

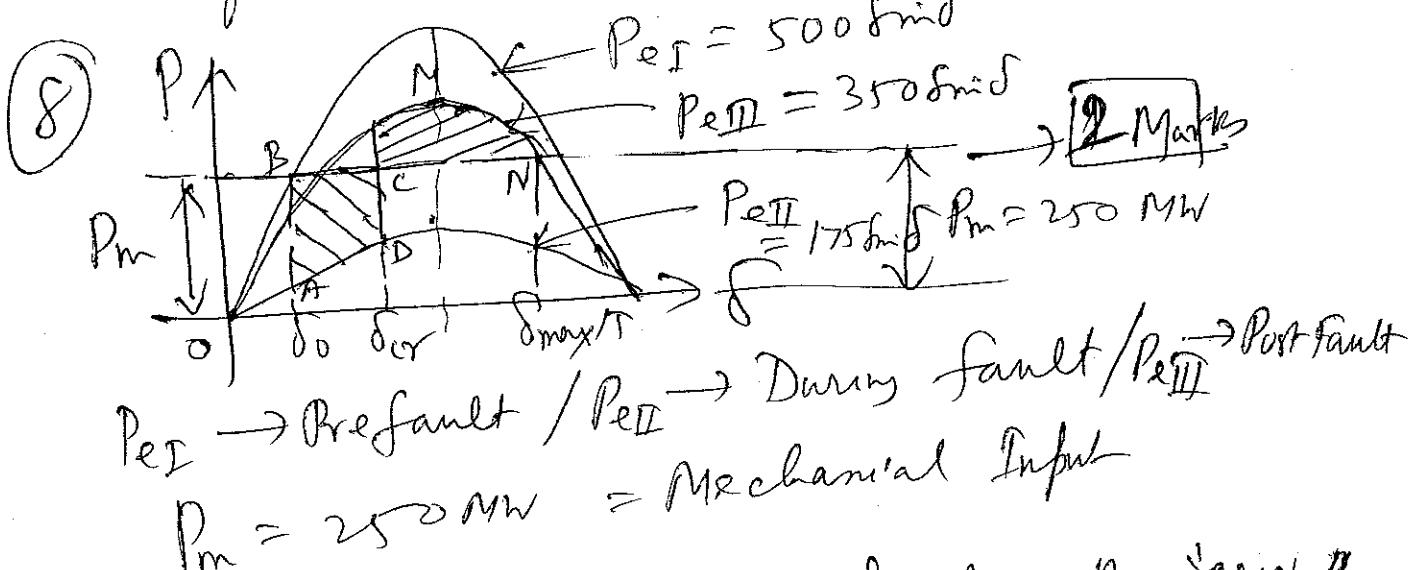
~~with diagram~~

BITS, Pilani - Dubai
Answering Scheme / COMPRE Exam / 2012-13 / 1st Sem. (4)

Course Title - Advanced Power Systems (EEE 462)
IV yr (EEE) / F.M = 80 (Weightage = 40%)
Date of Exam. - 04/06/2013

- (6) Art 15.10 (Chapters 15) of Text Book
Complete Diagram — 6 Marks + Explanation
of function of different elements — 3 marks

- (7) V.C.B → explanation and
Diagram → Art 14.4 (Chapter - 14)
of Text Book + Class Notes



$A_1 = \text{Area } "ABCD A"$ and $A_2 = \text{Area } "EMNC"$

$$\delta_0 = \sin^{-1} \left(\frac{250}{350} \right) = 30^\circ \rightarrow [1M]$$

$$\delta_{\max} = \pi - \sin^{-1} \left(\frac{250}{350} \right) = 134.42^\circ \rightarrow [1M]$$

$$\delta_{\max} - \delta_0 = 104.42^\circ = 1.82 \text{ radian} = \left(\frac{\pi}{180} \right) \times 104.42$$

Equal Area Criterion :- $A_1 = A_2$

Answers

BITS Pilani - Dubai

Comprehensive Exam / Answering Scheme / 2012-13
 (EEE) / Course Title - Advanced Power Systems (EEE 463)
 F. M = 80 (Weightage = 40%) / Date of Exam - 04/06/2013

Hence, $\int_{\delta_0}^{\delta_{cr}} (P_m - 175 \sin \delta) d\delta = \int_{\delta_{cr}}^{\delta_{max}} (350 \sin \delta - P_m) d\delta$ (5)
 \rightarrow B Marks

Where δ_{cr} = Critical clearing load angle

$$\Rightarrow P_m (\delta_{cr} - \delta_0) + 175 (\cos \delta_{cr} - \cos \delta_0) \\ = -350 (\cos \delta_{max} - \cos \delta_{cr}) \\ - P_m (\delta_{max} - \delta_{cr}) \rightarrow [M]$$

$$\Rightarrow P_m (\delta_{max} - \delta_0) = 175 \cos \delta_{cr} - 350 \cos \delta_{max} \\ + 175 \cos \delta_0$$

$$\Rightarrow 250 \times 1.82 = 175 \cos \delta_{cr} - 350 (-0.699) \\ + 175 (0.866)$$

$$\Rightarrow \cos \delta_{cr} = \frac{58.8}{175} = 0.336$$

$\boxed{\delta_{cr} = \cos^{-1} 0.336 = 70.366^\circ}$ [M]

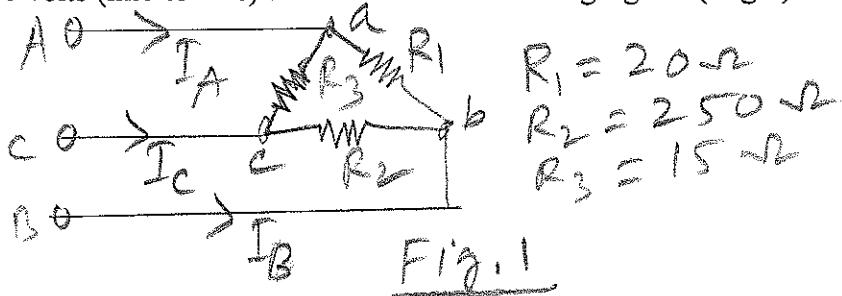
\rightarrow Answer.

Ansawar

BITS, Pilani – Dubai
 International Academic City – Dubai
 IV year EEE, 2nd Semester 2012-13
 Course Title - Advanced Power Systems (EEE C 462)
 Test 2(OPEN BOOK)
 Full Marks – 20 (Weightage 20 %) Duration—50 min
 Date: 28-04-2013

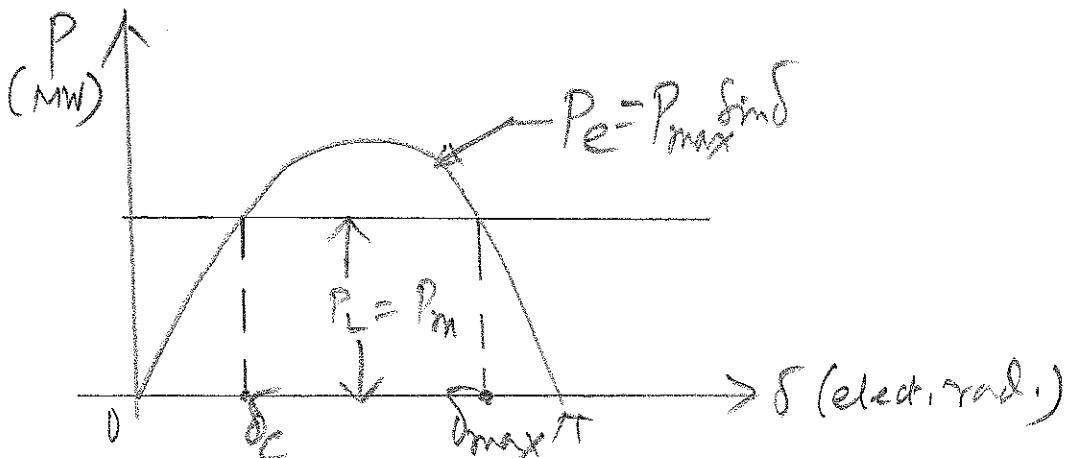
Instruction: Only text book and handwritten class notes are allowed.

- 1) A delta connected resistive load is connected across a balanced three phase supply of 400 volts (line-to-line) as shown in the following figure (Fig.1):



Calculate the positive and negative sequence components of currents, I_{ab1} and I_{ab2} in complex polar forms (Given phase sequence is ph. A-ph. B-ph. C in c.c.w)
[6 Marks]

- 2) With reference to the following figure (Fig.2), suddenly the load P_L ($P_L = P_m$) is put on the synchronous machine. Applying Equal Area Criterion, prove that $\sin(\delta_e/2) = 1/[1 + (\pi - \delta_e)^2]^{0.5}$. Assume that $P_e = P_{max} \sin\delta$. [7 Marks]



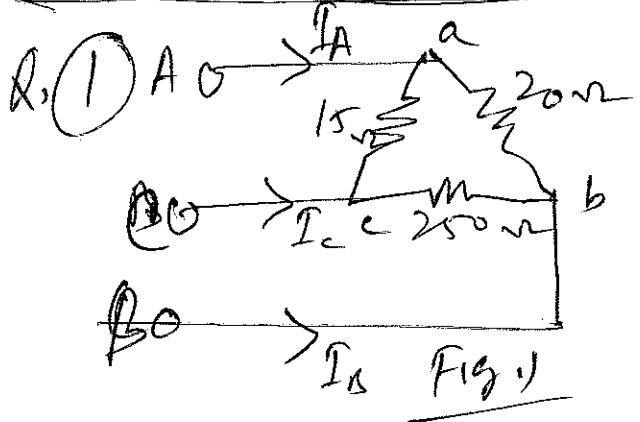
[P.T.O] -- contd to page 2

3) A three phase salient-pole synchronous generator having direct and quadrature axes steady state synchronous reactances (X_d and X_q) of 0.70 p.u and 0.55 p.u, respectively is connected to an infinite bus-bar(magnitude of voltage, $V = 1.0$ p.u) through transformers and a line of total reactance of 0.5 p.u. The generator excitation e.m.f is 1.1 p.u and its inertia constant is $H= 3.5$ MW-s/MVA. The damping power coefficient of the machine is 0.2 p.u/electrical radian/sec. The operating load angle (δ_0) = 20 degree(electrical). The prime mover (mechanical) power input to the generator remains unchanged. The total amount of transformer and line reactance is to be considered in series with X_d for all types of calculations needed. The system frequency is 50 Hz. All reactances are given in per phase .

In connection with the Steady State Stability Criterion:

- (i) Develop the Differential Equation in $\Delta\delta$ (Small Perturbation Model).
- (ii) Applying Laplace Transform(initial conditions being relaxed) to the D.E in (i), develop the Characteristic Equation and find out the roots.
- (iii) Hence, comment on the steady state stability aspect of the machine. [~~2+5+1~~ Marks]

Test II / Course Title - Advanced Power

IV yr (EEE) / OPEN Book / Date - 28/4/2013
F.M = 20% (20)

$$\bar{I}_{ab} = \frac{400}{20} \angle 0^\circ = 20 \angle 0^\circ$$

$$\bar{I}_{bc} = \frac{400 \angle -120^\circ}{250} = 1.6 \angle -120^\circ$$

$$\bar{I}_{ca} = \frac{400 \angle -240^\circ}{15} = 26.66 \angle -240^\circ$$

[2 Marks]

I_{ab1}
I_{ab2}
I_{ab3}

$$= \frac{1}{3}$$

1	α	α^2
1	α^2	α
1	1	1

I_{ab}
I_{bc}
I_{ca}

[2 Marks]

$$I_{ab1} = \frac{1}{3} [I_{ab} + \alpha I_{bc} + \alpha^2 I_{ca}]$$

$$= \frac{1}{3} [20 \angle 0^\circ + 1.6 \angle -120^\circ \times 1 \angle 120^\circ$$

$$+ 1 \angle 240^\circ \times 26.66 \angle -240^\circ]$$

$$= \frac{1}{3} [20 + 1.6 + 26.66] = 16.1 + j0 \text{ amp}$$

Ans. [1 M]

$$I_{ab2} = \frac{1}{3} [1 \times 20 \angle 0^\circ + 1 \angle 240^\circ \times 1.6 \angle -120^\circ$$

$$+ 1 \angle 120^\circ \times 26.66 \angle -240^\circ]$$

$$= \frac{1}{3} [20 + (1.6 + 26.66) \cos 120^\circ$$

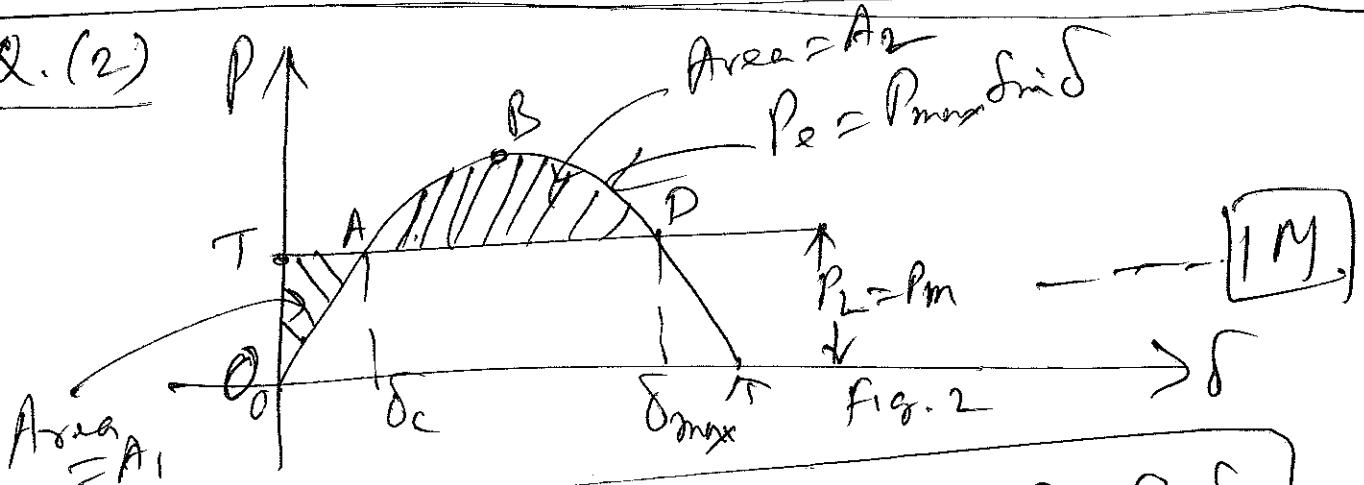
$$+ j \sin 120^\circ (1.6 - 26.66)]$$

$$= \frac{1}{3} [5.87 - j21.8] = 7.53 \angle -74.9^\circ$$

$$= 1.96 - j7.27 \approx 7.53 \angle -75^\circ \rightarrow \text{Ans}$$

[1 M]

Q. (2)



$$\delta_{\max} = \pi - \delta_c \quad \& \quad P_L = P_{\max} \sin \delta_c \quad \boxed{1}$$

From Graph (Fig. 2)

$$A_1 = \int_0^{\delta_c} (P_L - P_{\max} \sin \delta) d\delta \quad \boxed{2 \text{ Marks}}$$

$$A_2 = \int_{\delta_c}^{\delta_{\max}} (P_{\max} \sin \delta - P_L) d\delta \quad \boxed{2}$$

Applying Equal Area Criterion ($A_1 = A_2$), we get:-

$$P_L(\delta_c - \delta) + P_{\max}(\cos \delta_c - 1)$$

$$= -P_{\max} [\cos \delta_{\max} - \cos \delta_c] - P_L(\delta_{\max} - \delta_c) \quad \boxed{2}$$

$$\delta_{\max} = \pi - \delta_c \quad \boxed{3} \quad \boxed{1 M}$$

From equations (2) & (3), we get,

$$P_L \delta_c + P_{\max} (\cos \delta_c - 1)$$

$$= -P_{\max} [\cos(\pi - \delta_c) - \cos \delta_c] - P_L(\pi - 2\delta_c)$$

Orthodox

(3)

BITS, Pislami-Dubai

2012-13 / And Sem / Test II / Answering
(open book) Scheme

Course Title - Advanced Power Systems (EEE462)
Engg (EEE) / Date - 28/4/2013 / FM = 20% (20)

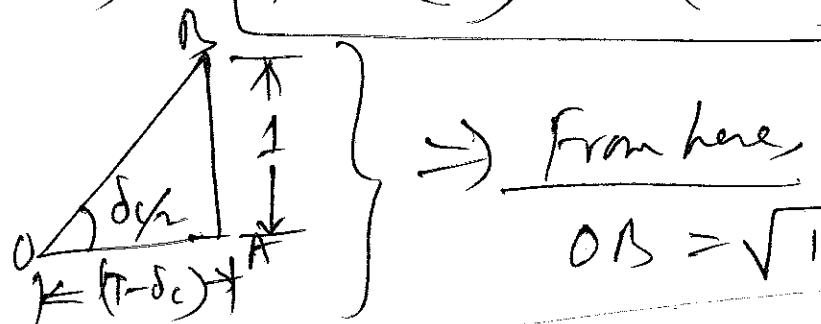
$$\Rightarrow P_L (\pi - \delta_c) = P_{max} [2 \cos \delta_c + 1 - \sin \delta_c]$$

As $P_L = P_{max} \sin \delta_c$, we get

$$P_{max} \sin \delta_c (\pi - \delta_c) = P_{max} [1 + \cos \delta_c]$$

$$\Rightarrow 2 \sin \frac{\delta_c}{2} \cos \frac{\delta_c}{2} = \left(\frac{1}{\pi - \delta_c} \right) [2 \cos^2 \frac{\delta_c}{2}]$$

$$\Rightarrow \boxed{\tan \left(\frac{\delta_c}{2} \right) = \left(\frac{1}{\pi - \delta_c} \right)} \quad \text{--- [2 Marks]}$$



From here,

$$OB = \sqrt{1 + (\pi - \delta_c)^2}$$

$$\therefore \sin \left(\frac{\delta_c}{2} \right) = \frac{AB}{OB} = \frac{1}{\sqrt{1 + (\pi - \delta_c)^2}}$$

$$= \frac{1}{\{1 + (\pi - \delta_c)^2\}^{0.5}}$$

Pathway \rightarrow [1M] \rightarrow (Prove)

(3)

$$\begin{aligned}
 & V_F = V \rightarrow \text{Infinite} \\
 P_e &= \frac{V_E}{(X_d + X_T)} \sin \delta + \frac{V^2}{2} \left[\frac{1}{X_d} - \frac{1}{(X_d + X_T)} \right] \sin 2\delta \\
 &= \left(\frac{1.1 X_1}{1.2} \right) \sin \delta + \frac{1}{2} \left[\frac{1}{0.55} - \frac{1}{1.2} \right] \sin 2\delta \\
 &= 0.917 \sin \delta + 0.492 \sin 2\delta \quad [2 \text{ Marks}]
 \end{aligned}$$

$$\begin{aligned}
 \Delta P_e &= \left(\frac{\partial P_e}{\partial \delta} \Big|_{\delta=\delta_0} \right) \Delta \delta \quad \boxed{1 \text{ M}} \\
 &= [0.917 \cos \delta_0 + (2 \times 0.492) \cos 2\delta_0] \Delta \delta
 \end{aligned}$$

$$\delta_0 = 20^\circ \text{ (elect)}$$

$$\begin{aligned}
 \therefore \frac{\partial P_e}{\partial \delta} \Big|_{\delta=\delta_0} &= 0.917 \cos 20^\circ + 0.984 \cos 40^\circ \\
 &= 0.862 + 0.753 = 1.616
 \end{aligned}$$

$$\text{Hence, } \Delta P_e = (1.616) \Delta \delta$$

$$M = \frac{H}{\pi X_T} = \frac{3.5}{\pi X_T} = 0.022 \text{ pu}$$

B = Damping Power Coefficient = 0.2 pu/deg/sec

$$\delta = \delta_0 + \Delta \delta \rightarrow \text{Small Perturbation Model}$$

Dynamics of Syn-M/C (with $\Delta P_m = 0$)

$$\begin{aligned}
 M \frac{d^2 \delta}{dt^2} + B \frac{d\delta}{dt} + P_e = P_m \quad \boxed{1 \text{ M}} \\
 \text{Applying small perturbation concept}
 \end{aligned}$$

Course Title - IV yr (EEE) / Test II (Open Book)
 Course Title - Advanced Power Systems (EEE 462)
 Date - 28/4/2013 / F.M = 20% (20)

(3) → Answer - Contd - -

$$M \frac{d^2(\delta)}{dt^2} + B \frac{d(\delta)}{dt} + K \delta = \Delta P_m = 0 \quad - [1 M]$$

Where $K = \left. \frac{\partial P_e}{\partial \delta} \right|_{\delta=\delta_0} = 1.616$

Applying Laplace Transform (with initial conditions relaxed), we get : -

$$[Ms^2 + Bs + K] \mathcal{L}\{\delta(t)\} = 0$$

$$\text{Where } \delta(t) = \mathcal{L}\{\delta(t)\}$$

Characteristic eqn :-

$$Ms^2 + Bs + K = 0$$

$$\Rightarrow 0.022 s^2 + 0.2 s + 1.616 = 0$$

Roots are :- s_1, s_2

$$s_1, s_2 = \frac{-0.2 \pm \sqrt{(0.2)^2 - 4 \times 0.022 \times 1.616}}{2 \times 0.022}$$

$$= \frac{-0.2 \pm j \sqrt{0.102}}{0.044} = \frac{-0.2 \pm j 0.319}{0.044}$$

Comments:- $= -4.545 \pm j 7.25 \quad - - [1 M]$

Both roots are lying in the Left half S-plane. So, the steady state stability of the system is maintained / assured. - - - [1 M]

BITS, Pilani – Dubai
International Academic City – Dubai
IV year EEE, 2nd Semester 2012-13
Course Title - Advanced Power Systems (EEE C 462)
Test 1
Full Marks – 25 (Weightage 25 %) Duration—50 min
Date: 10---03--2013

(1)Derive the expressions for “A” and “B” in a medium transmission line (Nominal “T” or “π”- representation). The derivation should be presented in detail (with necessary figures/diagrams) [6 Marks]

(2)A three phase 50 Hz. overhead long transmission line has $Z=40+j125$ ohms (per phase) and $Y=j 0.001$ mho(per phase), for the whole length of the line. The load (total, for three phases) at the receiving end is 45 MW at 0.85 power factor(lagging) and at voltage of 220KV(L-L). Calculate the sending end voltage magnitude (per phase value, in Kilo-Volts), using the established expressions for “A” and “B” , in terms of hyperbolic functions. ----[8 marks]

(3) Develop the sequence impedance matrix for transmission line. Derive all equations , in detail with necessary diagrams and assumptions, if any. -----[11 marks]

BITs, Pilani-Dubai
2012-13 / 2nd Semester

(1)

TE87-1 (Advanced Power Systems)

Date of Test-1 - 10/3/2013 / EEE (C482)

IV yr (EEE) Duration = 50 min.

ANSWERING Scheme:-

Q. (1) See Art 5.4 (Text Book) -
Derivation for A & B $\rightarrow 2 \times 3$ marks.

Q. (2) $Z = 40 + j120 = 131.2 \angle 72.3^\circ \text{ ohm}$
 $Y = j0.001 \text{ siemens}$
 $I_R = \left(\frac{45}{\sqrt{3} \times 220 \times 0.85} \right) \angle -\cos^{-1} 0.85 \text{ kA/ph}$
 $= 0.139 \angle -31.79^\circ \text{ kA/ph.} \rightarrow [1M]$

$$V_R = \frac{220}{\sqrt{3}} \angle 0^\circ = 127 \angle 0^\circ \text{ kV/ph.}$$

$$Yl = \sqrt{YZ} = \sqrt{10^{-3} \angle 90^\circ \times 131.2 \angle 72.3^\circ}$$
 $= 0.362 \angle 81.2^\circ = 0.0554 + j0.3577 \rightarrow [1M]$

$$Yl = \alpha l + j\beta l = 0.0554 + j0.3577 \rightarrow \text{in radians}$$

$$\cos \theta Yl = \frac{e^{\alpha l + j\beta l} + e^{-(\alpha l + j\beta l)}}{2}$$

$$= \frac{1}{2} [e^{\alpha l} (\cos \beta l + j \sin \beta l)]$$

$$+ e^{-\alpha l} (\cos \beta l - j \sin \beta l)$$

$$= \cos \beta l \cosh \alpha l + j \sin \beta l \sinh \alpha l$$

$$\rightarrow \text{becomes, } \cosh \alpha l = \frac{e^{\alpha l} + e^{-\alpha l}}{2} \text{ and } \sinh \alpha l = \frac{e^{\alpha l} - e^{-\alpha l}}{2}$$

(2)

BITS, Pilani-Dubai

2012-13/IInd Sem./Test-1

Course Title (EEE C462) — Advanced Power Systems
 Date - 10/3/2013 / F.M = 25 (25%)

Answering SchemeQ. (a) -- Contd :-

$$\begin{aligned} \text{Hence, } \cos \delta_{yl} &= \cos(0.3577) \cosh(0.0554) \\ &\quad + j \sin(0.3577) \sinh(0.0554) \\ &= 0.938 + j0.02 = 0.938 \angle 1.2^\circ \end{aligned}$$

$$\begin{aligned} \text{Similarly, } \sin \delta_{yl} &= \sinh \delta_{yl} \cos \beta_l + j \sin \beta_l \cosh \delta_{yl} \\ &= 0.052 + j0.35 = 0.354 \angle 81.5^\circ \end{aligned}$$

$$\begin{aligned} \text{Characteristic Impedance } Z_c &= \sqrt{\frac{Z}{Y}} \rightarrow [2 \text{ marks}] \\ &= \sqrt{\frac{131.2 \angle 72.3^\circ}{10^{-3} \angle 90^\circ}} \\ &= 362.21 \angle -8.85 \rightarrow [1M] \end{aligned}$$

$$A = \cos \delta_{yl} = 0.938 \angle 1.2^\circ$$

$$\begin{aligned} B = Z_c \sin \delta_{yl} &= 362.21 \angle -8.85 \times 0.354 \angle 81.5^\circ \\ &= 128.2 \angle 72.65^\circ \rightarrow [2 M] \end{aligned}$$

In per phase

$$\begin{aligned} V_s &\approx A V_R + B I_R \\ &= \{(0.938 \angle 1.2^\circ) \times (127 \angle 0^\circ)\} \\ &\quad + \{128.2 \angle 72.65^\circ \times 0.139 \angle -31.79^\circ\} \\ &= 119.13 \angle 1.2^\circ + 17.819 \angle 40.86^\circ \text{ kV}_\text{ph} \\ &= 133.33 \angle 6.093 \text{ kV/phase} \end{aligned}$$

BITS, Pilani - Dubai

2012-13 / Ind Sem. / Test - I

Course Title: (EEE CU62) - Advanced Power Systems
Date - 10/3/2013 / Marks - 25 (25%)

(3)

ANSWERING SCHEME

Q. (2) Contd -

Magnitude of V_S (Supply end voltage)
= 133.33 kV/phm

→ [2 marks]

→ Answer.

Q. (3) See Art 10.4 (Text Book)

i) Bus Diagram - [1 Mark]

ii) $[Y_s] = [A]^{-1} [Z_p] [A]$ → This derivation
--- [3 Marks]

iii) Simplification of both matrices
→ [2 + 2 marks]

iv) Final arrangement for answer
→ [3 marks]

Followup?

BITS, Pilani – Dubai

International Academic City – Dubai-----Name of the student-----

IV year EEE, IIInd Semester 2012-13-----Id No.of the student-----

Course Title - Advanced Power Systems (EEE C 462)/ Quiz-1

Full Marks – 16 (Weightage 8 %) Duration—20 min

Date: 27—02—2013

(Page-1/2)

(1) Write the Differential Equation (in voltage or current) for a long transmission line, with the meanings of the concerned symbols. [2 Marks]

(2) A medium line has $Z = 45 + j125 \text{ ohm}$ and $Y = j10^{-3} \text{ mho}$. Calculate the value of the parameter A (considering either T-model or π -model of the line). -----[2 Marks]

(3) Write the solution for current or voltage (as a function of “x”) on the basis of the answer of question(1) -----[2 Marks]

(4) Derive the expressions for “C” and “D” in a nominal π -model of a medium transmission line ,using any method . -----[4 Marks]

BITS, Pilani – Dubai

International Academic City – Dubai-----Name of the student-----

IV year EEE, IIInd Semester 2012-13-----Id No.of the student-----

Course Title - Advanced Power Systems (EEE C 462)/ Quiz-1

Full Marks – 16 (Weightage 8 %) Duration—20 min

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(5) Prove that $AD - BC = 1$ ---- for a long transmission line having a length = l and having sending end and receiving end voltage and currents being V_s, I_s, V_r, I_r ----- [3 Marks]

(6) “Mathematical analysis of a long transmission line is performed on the basis of LUMPED PARAMETER system.” -----True/False? -----[1 Mark]

(7) Prove that $Z_c \approx \sqrt{\frac{z}{y}}$, where the symbols have their usual meanings. -----[2 Marks]

ANSWERING SCHEME

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- (1) Write the Differential Equation (in voltage or current) for a long transmission line, with the meanings of the concerned symbols. [2 Marks]

$$\frac{d^2 V_x}{dx^2} = Y^2 V_x \rightarrow \text{Where } \begin{array}{l} \text{i) } Y = \sqrt{Y_0}, \text{ ii) } Y \rightarrow \text{short admittance} \\ \text{iii) } Z \rightarrow \text{series impedance} \\ \text{iv) } V_x \rightarrow \text{Voltage at any position (x)} \end{array}$$

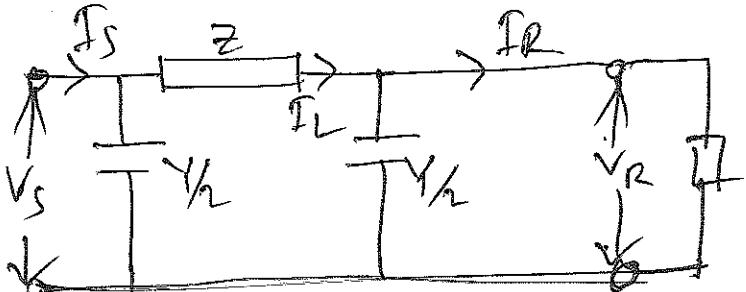
- (2) A medium line has $Z = 45 + j125 \text{ ohm}$ and $Y = j10^{-3} \text{ mho}$. Calculate the value of the parameter A (considering either T-model or π -model of the line). -----[2 Marks]

$$A = 1 + \frac{YZ}{2} \quad \frac{YZ}{2} = \frac{1}{2} \{j \cdot 0.45 - 0.125\} = -0.0625 + j 0.0225 \\ A = 0.9375 + j 0.0225 = 0.937 \angle 1.375^\circ$$

- (3) Write the solution for current or voltage (as a function of "x") on the basis of the answer of question(1) -----[2 Marks]

$$V_x = V_R \cos h y x + I_R Z_c \sinh y x$$

- (4) Derive the expressions for "C" and "D" in a nominal π -model of a medium transmission line using any method. -----[4 Marks]



$$I_s = I_R + \frac{1}{2} V_R Y + \frac{1}{2} V_s Y$$

$$V_s = V_R + I_L Z = V_R + \frac{1}{2} \{I_R + \frac{1}{2} V_R Y\}$$

$$= V_R \left(1 + \frac{YZ}{2}\right) + Z I_R$$

Hence,

$$I_s = \left(\frac{1}{2}\right) V_R + I_R + \frac{1}{2} \left[V_R \left(1 + \frac{YZ}{2}\right) + Z I_R\right]$$

$$= V_R \left[2 + \frac{YZ}{2}\right] \left(\frac{1}{2}\right) + I_R \left(1 + \frac{YZ}{2}\right)$$

Now, $I_s = C V_R + D I_R \rightarrow \text{assumed.}$

Hence,

$$C = Y \left(1 + \frac{YZ}{4}\right) \text{ and } D = 1 + \frac{YZ}{2}$$

() Answer

ANSWERING Scheme

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(5) Prove that $AD-BC=1$ ----for a long transmission line having a length=l and having sending end and receiving end voltage and currents being V_s, I_s, V_r, I_r -----[3 Marks]

$$A = \coshyl, \quad B = Z_c \sinhyl$$

$$C = \frac{1}{Z_c} \sinhyl, \quad D = \coshyl$$

$$\begin{aligned} AD - BC &= \frac{\coshy^2 - \sinhy^2}{Z_c} \xrightarrow{\text{where } \delta = yl} \\ &= \frac{(e^\delta + e^{-\delta})^2 - (e^\delta - e^{-\delta})^2}{2} = \frac{1}{4} e^{2\delta} + \frac{1}{4} e^{-2\delta} + \frac{1}{4} \times 2(1) \\ &\quad - \frac{1}{4} e^{2\delta} - \frac{1}{4} e^{-2\delta} - \left\{ -\frac{1}{4} \times 2(1) \right\} = 1 \xrightarrow{\text{Prove}} \end{aligned}$$

(6) "Mathematical analysis of a long transmission line is performed on the basis of LUMPED PARAMETER system."-----True/False? -----[1 Mark]

(7) Prove that $Z_c \approx \sqrt{\frac{Z}{Y}}$, where the symbols have their usual meanings. -----[2 Marks]

$$\left. \begin{array}{c} \text{Diagram of a transmission line section} \\ \text{with voltage } V \text{ and current } I } \end{array} \right\} \Rightarrow \frac{1}{2} L i^2 = \frac{1}{2} C v^2 \quad (\text{by equality of stored energy})$$

$$\Rightarrow \left(\frac{V}{I} \right)^2 = \frac{L}{C}$$

$\Rightarrow Z_c = \text{characteristic impedance}$

$$= \frac{V}{I} = \sqrt{\frac{L}{C}} \approx \sqrt{\frac{R+j\omega L}{j\omega C}}$$

\rightarrow because "R" is very small generally in long transmission line

$$\text{Hence, } Z \approx \sqrt{\frac{Z}{Y}} \approx \sqrt{\frac{3}{Y}}$$

where $Z = (Z)d$ } $\rightarrow d = \text{length of transmission line.}$
 $Y = (Y)d$ }

BITS, Pilani – Dubai
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IV year EEE, II Semester 2012-13
Course Title - Advanced Power Systems (EEE C 462)
Quiz 2
Maximum Marks – 14 (Weightage 7 %) Duration—20 min.
Date: 19–05—2013

Name-----

Id No.-----

[Marks: Questions (1)to(6) --each 2 marks and questions (7)&(8) --each 1 mark]

(1) Write the general relay equation and substitute (in this equation) the particular conditions to achieve the logic of a Directional Relay.

(2) Derive the expression for “Pick Up Current”of the Over-current Relay.

(3) Draw the circuit diagram of a Modified Impedance Relay with proper labeling.

(4) Draw the circuit diagram of a “ Capacitor coupled potential transformer (Voltage transformer) with tuning inductance, with proper labeling and also explain why the tuning inductance is used.

[P.T.O]

(5) Draw typical characteristics for IDM TL relays for two values of TMS, with necessary labeling.

(6) Why is not the secondary winding of a C.T kept open-circuited?--- Explain

(7) $(R-R_s)^2 + (X-X_s)^2 = |Z_{rs}|^2$ --- This equation refers to:

- (a) Percentage Differential relay
- (b) Reactance relay
- (c) Over current relay
- (d) Modified Impedance relay.

(8) " It is not necessary that Relaying equipment must clearly discriminate between normal and abnormal system conditions" --- TRUE and FALSE ?

ANSWERING Scheme

BITS, Pilani – Dubai
 International Academic City – Dubai
 IV year EEE, II Semester 2012-13
 Course Title - Advanced Power Systems (EEE C 462)

Quiz 2

Maximum Marks – 14 (Weightage 7 %) Duration—20 min.
 Date: 19--05—2013

Name----- Id No.-----

[Marks: Questions (1)to(6) --each 2 marks and questions (7)&(8) --each 1 mark]

(1) Write the general relay equation and substitute (in this equation) the particular conditions to achieve the logic of a Directional Relay.

$$Q = k_1 |I|^2 + k_2 |V|^2 + k_3 |V| |I| \cos(\theta - \phi) - k_4$$

$k_1 > 0, k_2 > 0 \Rightarrow k_4$ is very small

$$\therefore Q = k_3 |V| |I| \cos(\theta - \phi) \rightarrow \text{Directional Relay Logic}$$

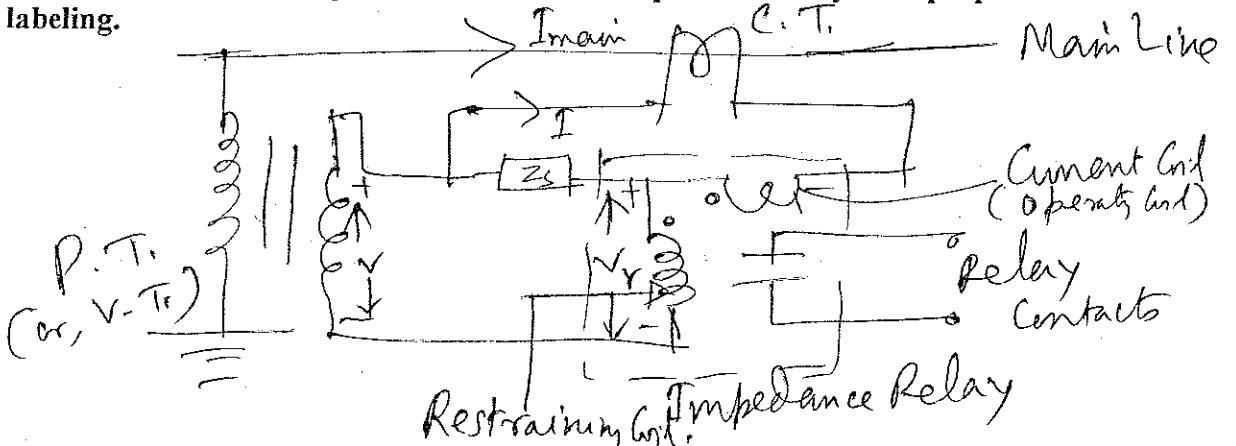
(2) Derive the expression for "Pick Up Current" of the Over-current Relay.

$$Q = k_1 |I|^2 - k_4 \Rightarrow Q \geq 0 \rightarrow \text{for Pick-up}$$

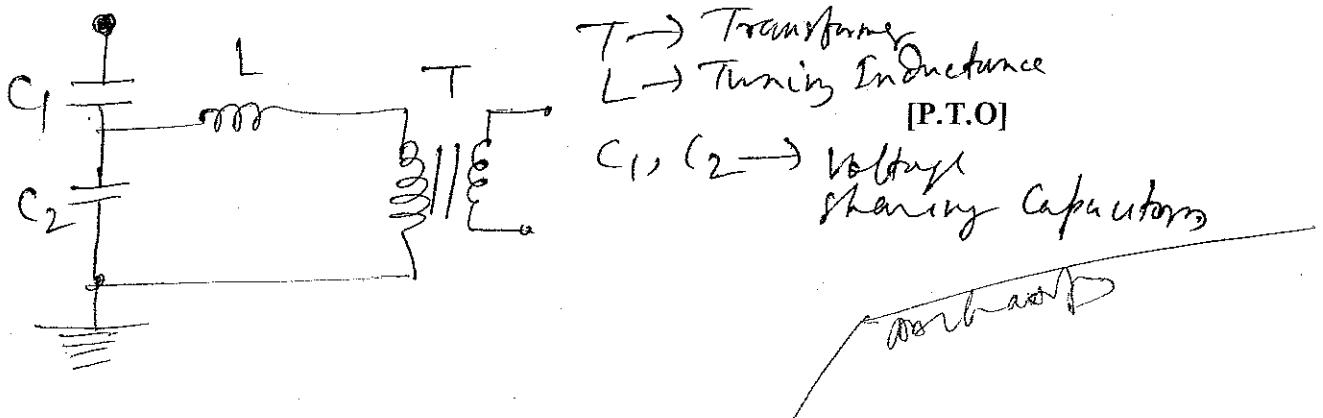
$k_1 |I_p|^2 - k_4 \geq 0 \Rightarrow |I_p| \geq \sqrt{\frac{k_4}{k_1}}$ \rightarrow Expression

$|I_p| = \text{Magnitude of Pickup Current}$

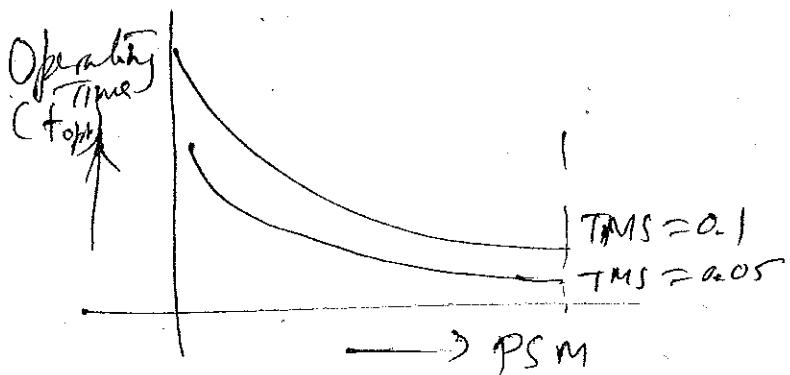
(3) Draw the circuit diagram of a Modified Impedance Relay with proper labeling.



(4) Draw the circuit diagram of a "Capacitor coupled potential transformer (Voltage transformer) with tuning inductance, with proper labeling and also explain why the tuning inductance is used.



(5) Draw typical characteristics for IDMTL relays for two values of TMS, with necessary labeling.



(6) Why is not the secondary winding of a C.T kept open-circuited?---
Explain

For C.T. $\rightarrow N_1 = 1$ and $\frac{N_2}{N_1} = \text{large ratio}$
Hence, open circuit voltage induced in the secondary winding ~~not~~ will be high
this will cause:

- a) Operators unsafe condition
- b) Insulation failure (with advancement of time) in the terminals of secondary winding

(7) $(R - R_s)^2 + (X - X_s)^2 = |Z_{rs}|^2$ --- This equation refers to:
 (a) Percentage Differential relay (b) Reactance relay (c) Over current relay (d) Modified Impedance relay.

(8) "It is not necessary that Relaying equipment must clearly discriminate between normal and abnormal system conditions" --- TRUE and FALSE?

— FALSE:

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