15 A TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Bhadra

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Advanced Power System Analysis *(Elective II) (EE76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

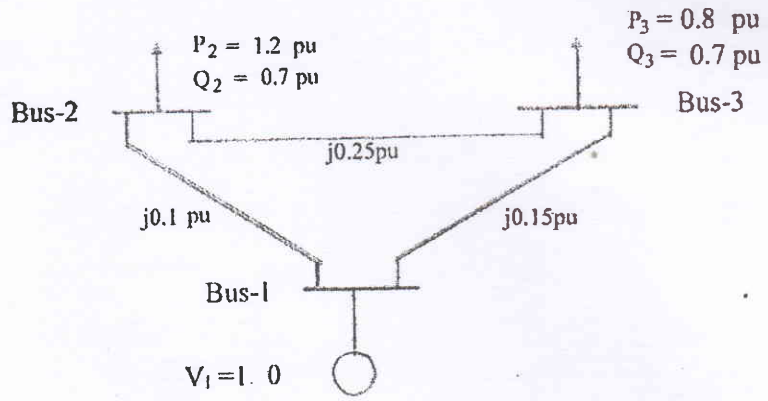
1. a) Describe the basic concept of shunt and series compensation of a transmission line. Explain how these compensations improve the transient stability of the system. [8]

   b) A 250 km long, 132 kV (Line to Line), 50 Hz transmission line has line inductance of 1.2 mH per km. The above line is transmitting the power with sending end and receiving end voltage constant at 132 kV with a phase angle of 30° between them. Calculate the value of series capacitor to be added in the line so that the active power flow through the line increases by 20%. [8]

2. Explain the operation of the Fixed Capacitor Thyristor Controlled Reactor (FCTCR) scheme with necessary diagram and waveforms. Elaborate its advantage and disadvantage with compare to discrete Thyrirstor Switched Capacitor scheme. [8]

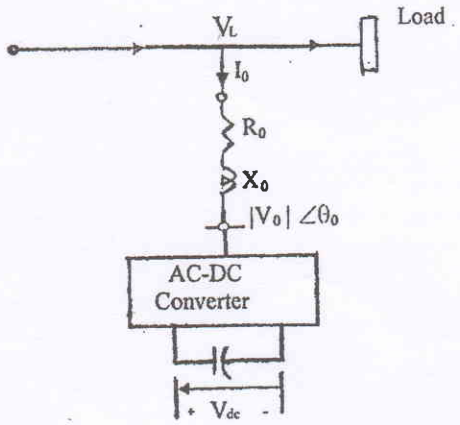
   If the Capacitor used in the scheme has a value of 120μF and the inductor of the scheme has an inductance of 125mH. Calculate the Effective series reactance of the scheme at a firing angle $\alpha = \frac{3\pi}{4}$ (i.e. $\delta = \frac{\pi}{4}$) and state whether Effective reactance is capacitive or inductive. [8]

3. For the 3-bus network shown below, perform one iteration of Load flow analysis with Fast Decoupled Load Flow method. [16]



4. a) Explain the operation Static Synchronous Compensator (STATCOM) with basic circuit diagram and phasor diagram. [8]

b) The following figure shows a basic arrangement of STATCOM used as reactive power compensator.



The inverter branch of the STATCOM has $R_0 = 0.06$ ohm and $X_0 = 0.12$ ohm
The system load is $P_L = 24$ kW per phase at 230 V with pf = 0.85 lag
Calculate the magnitude and phase of the inverter output voltage ($V_0\angle\theta_0$) required for unity power factor operation. Also calculate the magnitude and phase of the current through the inverter branch. Take load voltage as reference phasor. [8]

5. Why d-q equivalent circuit is necessary to analyze the salient pole synchronous machine? The current drawn by a three phase load is given by the following equations:

$i_a = 10\ \text{Cos}(\omega t - \phi)$
$i_b = 10\ \text{Cos}(\omega t - 120° - \phi)$
$i_c = 10\ \text{Cos}(\omega t - 240° - \phi)$

Calculate the magnitude of d-q component of the three phase current. [8+8]

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Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Advanced Power System Analysis *(Elective II) (EE76501)*

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
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1. What do mean by un-compensated symmetrical transmission line? Prove that the mid-point voltage, active power and reactive power through such line are given by: [8+8]

$$V_m = V\,Cos\frac{\delta}{2},\quad P = \frac{V^2}{X}Sin\delta \quad \text{and} \quad Q = \frac{V^2}{X}(1-Cos\delta)$$

Where, V = magnitude of receiving end voltage per phase

δ = Phase angle between sending end voltage and receiving end voltage

X = Reactance of the line per phase

If shunt, series and phase angle compensators are installed on above un-compensated symmetrical transmission line. Explain their effects on transient stability.

2. a) Explain the operation of GTO controlled series capacitor scheme. If the Capacitor used in the GTO controlled Series Capacitor scheme has a value of 100 μF and the inductor of the scheme has an inductance of 100 mH. Calculate the effective series reactance of the scheme for turnoff angle $\gamma = 45°+\pi/2$ and state whether effective reactance is capacitive or inductive. [10]

b) The three phase stator current of synchronous generator are: [6]

$i_a = 50\cos(\omega t-\theta)$, $i_b = 50\cos(\omega t-120°-\theta)$

and $i_c = 50\cos(\omega t-240°-\theta)$. Calculate d – q components.

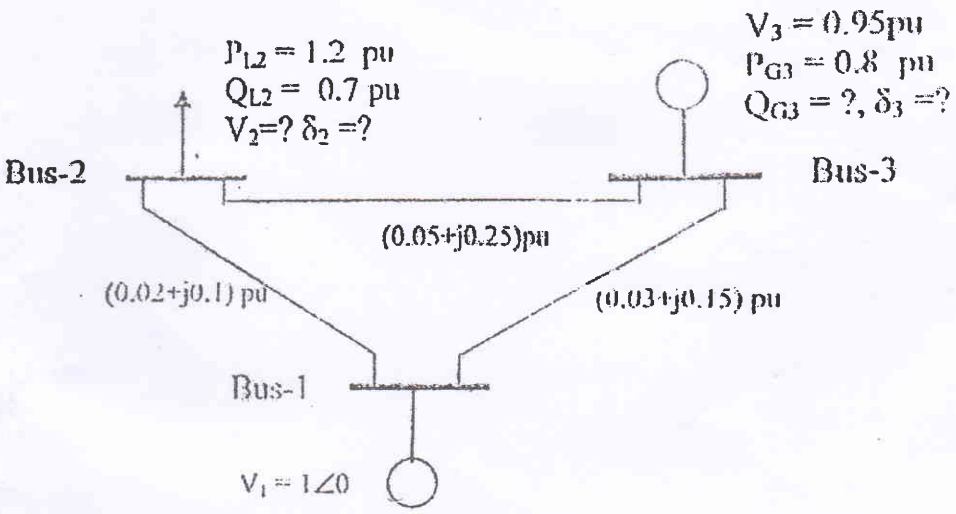
3. a) Explain the operation of Static Synchronous Series Compensator (SSSC) with basic circuit diagram and phasor diagram. Derive the expression for additional active power flow through the line with SSSC. What are the advantages of SSSC with compare to conventional series capacitor compensation? [10]

b) Why d-q model is preferable to analysis synchromous machine with salient polerotor? Explain briefly. [6]

4. a) Explain the operation of STATCOM with help of corresponding figures and phasor diagram. [8]

b) The inverter branch of the STATCOM has R_0 = 0.06 ohm and X_0 = 0.12 ohm. The system load is P_L = 25 kW per phase at 230 V and pf = 0.8 log. Calculate the magnitude and phase of the inverter output voltage required for the unity power factor operation. Also calculate the magnitude and phase of the current through the inverter branch. [8]

5. For the given 3-bus system shown below, perform one iteration of Load Flow analysis with Fast Decoupled Load Flow method. [16]



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Subject: - Advanced Power System Analysis *(Elective II) (EE76501)*

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1. a) A 200 km long, 132KV, 50Hz, symmetrical transmission line has an inductance of 1 mH/km per phase. The phase angle between sending end voltage and receiving end voltage is 30°. Neglecting the resistance and shunt capacitance of the line, calculate:

   (i) Active and reactive power flow through the line
   (ii) Value of series capacitive compensation required to increase the active power flow by 15% [4+4]

   b) Why d-q equivalent circuit is necessary to analyze the salient pole synchronous machine? The current drawn by a three phase load is given by the following equations:

   $i_a = 50 \cos(wt-\theta)$
   $i_b = 50 \cos(wt-120°-\theta)$
   $i_c = 50 \cos(wt-240°-\theta)$
   Calculate the magnitude of d-q component of the three phase current. [3+5]

2. a) What is transient stability? Explain effects of shunt and series compensation on transient stability. [6]

   b) Explain the operating principle of Thyristor Controlled Reactor (TCR) with a pure inductive reactor with necessary waveforms. For a system of 33KV, if an inductor of 2H per phase is used in TCR scheme, calculate effective reactance and reactive power consumed by TCR branch for delay angle $\delta = 45°$. [10]

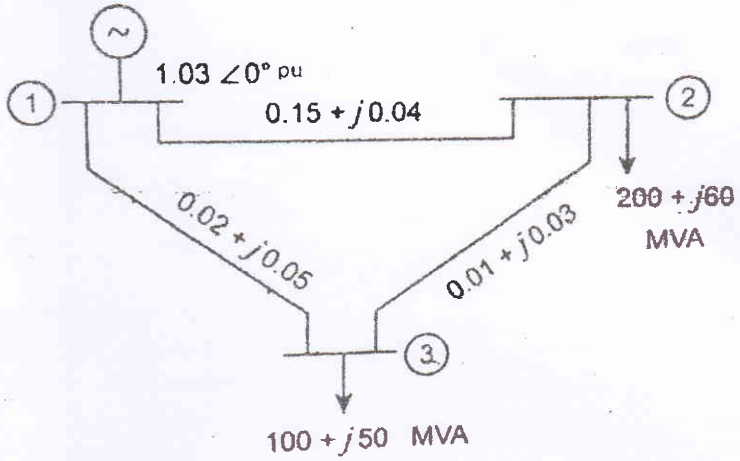
3. Explain the operation of Unified Power Flow Controller (UPFC) with basic circuit diagram and phasor diagram and describe how it can perform all the three actions of voltage regulation, series compensation and phase angle control. Perform a mathematical analysis to show that the extra active power and reactive power through the transmission line due to UPFC are:

$$P_{extra} = \frac{v.vpq.\sin(\delta+\rho)}{x} \text{ and } Q_{extra} = \frac{v.vpq.\cos(\delta+\rho)}{x}$$ [16]

4. a) Explain the operating principle of STATCOM with neat circuit diagram and phasor diagram. [8]

   b) A 400V, 50Hz 3-phase voltage source is supplying a complex power of (25+j20) KVAR per phase. A STATCOM is connected in parallel with load for reactive power compensation. The STATCom branch has coupling inductor having reactance of 2 ohm and resistance of 0.5 ohm per phase. Calculate magnitude and phase of inverter output voltage for unity power factor operation. [8]

5. Calculate the voltages and phase angles of bus2 and bus 3 after one iteration by using fast decoupled load flow for the system as shown in figure below. The line parameters are given in per unit. [16]



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