Reg No.:_____ Name:_____

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

SIXTH SEMESTER B.TECH DEGREE EXAMINATION, APRIL 2018

**Course Code: EE306**

**Course Name: POWER SYSTEM ANALYSIS (EE)**

Max. Marks: 100 Duration: 3 Hours

**PART A**

***Answer all questions, each carries 5 marks.*** Marks

1 A 120 MVA, 19.5 kV generator has X = 1.5 percent and is connected to a transmission line by a star-delta transformer rated 150 MVA, 230/18 kV with X = 0.1 percent. If the base to be used in the calculations is 100MVA, 230kV for the transmission line, find the per unit values to be used for the transformer and generator reactances. (5)

2 A single line to ground fault occurs at the terminals of a 30 MVA, 11 kV generator. The positive, negative and zero sequence impedances in pu are j0.2, j0.2 and j0.05 respectively. Find the line currents under faulted conditions. Assume that the generator is solidly grounded. (5)

3 What are the main functions of load frequency controller in power system? (5)

4 Classify the various types of buses in a power system for load flow studies. (5)

5 The fuel cost functions for three thermal plants in Rs/hr. are given by, (5)

$C_1 = 500 + 5.3P_1 + 0.004P_1^2$
$C_2 = 400 + 5.5P_2 + 0.006P_2^2$
$C_3 = 200 + 5.8P_3 + 0.009P_3^2$

Find the power generated by each plant if the total demand is 800MW.

6 What do you mean by penalty factor as referred to economic operation of power system? (5)

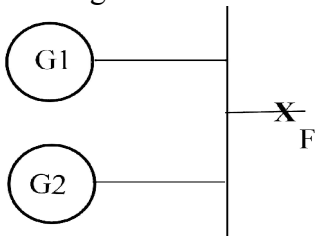
7 What are the factors affecting transient stability in power system? (5)

8 What is swing equation? Derive the expression for swing equation for a synchronous machine connected to an infinite bus. (5)

**PART B**

***Answer any two full questions, each carries10 marks.***

9 (a) Two 11 kV, 3-phase generators rated 10 MVA, 25% and 20 MVA, 40% operate in parallel. Calculate the short circuit kVA if a three phase short circuit occurs on the feeder at point 'F' as shown in the figure. (6)

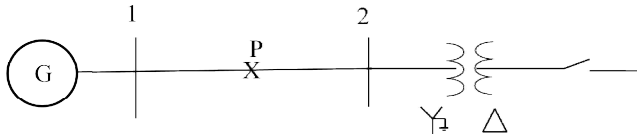



Calculate the reactance value of the feeder reactor to be included so that the short circuit kVA is reduced by 50%.

(b) Find the expression for three phase power in terms of symmetrical components. (4)

10 A synchronous generator and motor are rated 30MVA, 13.2kV and both have sub-transient reactances of 20%. The line connecting them has a reactance of 10% on the base of the machine ratings. The motor is drawing 20,000kW at 0.85 power factor lagging at a terminal voltage of 12.8 kV when a symmetrical three phase fault occurs at the motor terminals. Find the sub-transient current in the generator, motor and fault. (10)

11 (a) A three phase generator is connected to a star-delta transformer as shown in the figure. (6)




The reactance values referred to a common base are :

| | $Z_1$ | $Z_2$ | $Z_0$ |
|---|---|---|---|
| Alternator | j0.1 | j0.1 | j0.05 |
| Transformer | j0.05 | j0.05 | j0.05 |
| Transmission line | j0.4 | j0.4 | j0.8 |

Determine the fault current when a double line to ground fault occurs at point 'P' at the mid-point of the line if the alternator neutral is grounded. Assume that the generator is not loaded.

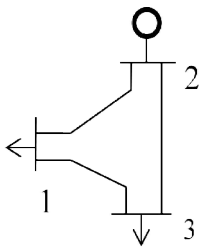
(b) Obtain the symmetrical components of the following set of unbalanced currents (4)
$I_a = 1.6\angle 250^0$, $I_b = 1.0\angle 180^0$, $I_c = 0.9\angle 132^0$.

## PART C

***Answer any two full questions, each carries 10 marks.***

12 Explain the computational procedure for load flow solution using fast decoupled load flow method. (10)

13 Figure shows a three bus power system. The impedance of each line is (0.026 + j0.11) pu. (10)




The bus details are given in the table below

| Bus | $P_G$(pu) | $Q_G$(pu) | $P_L$(pu) | $Q_L$(pu) | \|Vi\|(pu) | Angle | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | - | - | 1.0 | 0.5 | 1.03 | $0^0$ | Slack bus |
| 2 | 1.5 | - | 0 | 0 | 1.03 | - | PV bus |
| 3 | 0 | 0 | 1.2 | 0.5 | - | - | PQ bus |

Assuming a flat voltage start, find the voltages and bus angles at the buses at the end of the first iteration using Gauss-Siedel method.

14 A two area system connected by a tie line has the following parameters on a 1000 MVA common base. (10)

| Area | 1 | 2 |
|---|---|---|
| Speed regulation | 0.05 | 0.0625 |
| Frequency sensitive load co-efficient | 0.6 | 0.9 |
| Inertia constant | 5 | 4 |
| Governor time constant | 0.2 | 0.3 |
| Turbine time constant | 0.5 | 0.6 |

The units are operating in parallel at a nominal frequency of 60 Hz. The synchronizing power co-efficient is given as 2.0 pu. If the load in area1 increases by 187.5 MW, determine the new steady state frequency and the change in tie-line flow.

## PART D

***Answer any two full questions, each carries 10 marks.***

15 Prove that the maximum permissible sudden increase in load is 72.5% of the steady state limit if the machine is initially at no load. (10)

16 (a) Explain Equal Area criterion and state the assumptions made. (5)

(b) Derive the expression for transmission losses as a function of power generation. (5)

17 (a) What is unit commitment problem? What are the constraints and the solution techniques for unit commitment problem involving thermal plants? (5)

(b) Find the energy stored in the rotor of a three phase, 50 Hz. 250 MVA turbo alternator with H=7.5 MJ/MVA. Determine the value of the inertia constant M. The generator is initially supplying a steady power of 150 MW. If the mechanical power input to the turbine is suddenly decreased to 100 MW, evaluate the initial acceleration of the rotor neglecting all losses. Assume 6 poles. Also find the rotor speed after 10 cycles. (5)

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Reg No.:_____ Name:_____

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

SIXTH SEMESTER B.TECH DEGREE EXAMINATION(R&S), MAY 2019

**Course Code: EE306**

**Course Name: POWER SYSTEM ANALYSIS**

Max. Marks: 100 Duration: 3 Hours

**PART A**

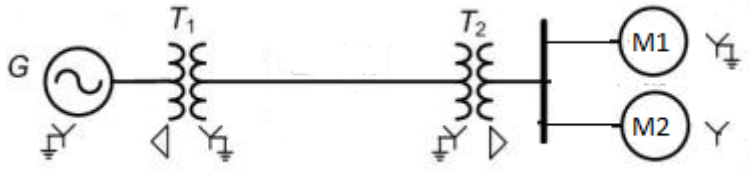
***Answer all questions, each carries5 marks.*** Marks

| | | |
|---|---|---|
| 1 | Define the term per unit quantity. Enumerate Merits and Demerits of P.U | ( 5) |
| 2 | What is the significance of current limiting reactors in power system? Where are they located? Give examples. | (5 ) |
| 3 | How slack bus differs from other buses in a power system? What is the significance of slack bus in load flow analysis? | (5 ) |
| 4 | What is AVR? What are the functions? | ( 5) |
| 5 | Derive condition for economic load dispatch neglecting losses. | ( 5) |
| 6 | Define penalty factors and loss coefficients in economic operation of power system. | (5 ) |
| 7 | Explain the terms 1) steady state stability 2) dynamic stability 3) transient stability | (5 ) |
| 8 | Write all methods to improve steady state stability limit of power system | (5 ) |

**PART B**

***Answer any two full questions, each carries10 marks.***

| | | |
|---|---|---|
| 9 | A 300 MVA, 20kV three phase generator has a subtransient reactance of 20%. The generator supplies two synchronous motors over a 64km transmission line having transformers at both ends as shown on the single line diagram. The ratings of the motors are:M1-200MVA, 13.2kV, X"=20%; M2- 100MVA, 13.2kV, X"=20%. The ratings of transformers are T1-350MVA, 230/20 kV, X=10%; T2- composed of 3 single phase transformers each rated 127/ 13.2kV,100MVA, X=10%. Series reactance of the transmission line is 0.5 ohm/km. Draw the reactance diagram with all reactances marked in p.u. Select the generator ratings as base values. | ( 10) |



10 a) Draw the zero sequence networks of star-delta and delta-delta transformers ( 5)

b) Draw and explain the oscillogram of short circuit current when an unloaded alternator is subjected to a 3-phase fault (5 )

11 Derive the expression for fault current and draw the interconnection of sequence networks for the following faults on the terminals of an unloaded generator. (10)

(a) single Line to Ground fault

(b) Line to Line fault

## PART C

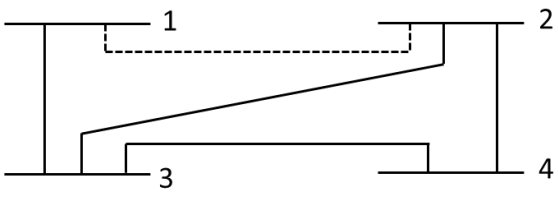
***Answer any two full questions, each carries10 marks.***

12 (10 )

The figure shows the SLD of a simple four bus system. The table gives the line impedance identified by the buses on which these terminate. The shunt admittance at all the buses is assumed to be negligible.

a) Find $Y_{BUS}$, assuming that the line shown dotted is not connected.

b) What modifications need to be carried out in $Y_{BUS}$ if the line shown dotted is connected




| Line, Bus to Bus | R pu | X pu |
|---|---|---|
| 1-2 | 0.05 | 0.15 |
| 1-3 | 0.10 | 0.30 |
| 2-3 | 0.15 | 0.45 |
| 2-4 | 0.10 | 0.30 |
| 3-4 | 0.05 | 0.15 |

13 a) Compare between Gauss-Seidal method and Newton-Raphson method, in load flow studies. (5 )

b) With neat diagram explain the working of a turbine speed governing system. (5)

14 Derive the generator load model and draw the complete block diagram of a single area system (10)

## PART D

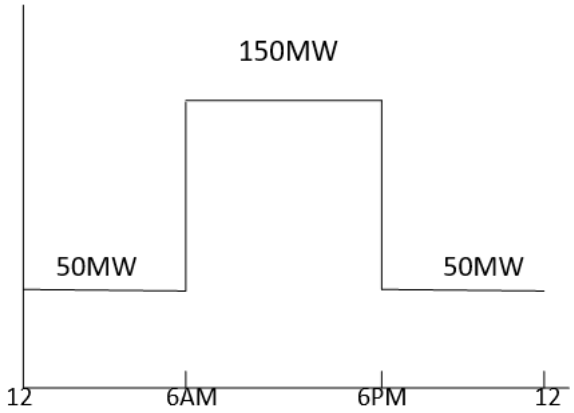
***Answer any two full questions, each carries 10 marks.***

15 Assume that the fuel input Btu/hr for units 1 and 2 are given by ( 10)

$$F_1 = (8P_1 + 0.024P_1^2 + 80)10^6$$

$$F_2 = (6P_2 + 0.04P_2^2 + 120)10^6$$

The maximum and minimum loads on the units are 100MW and 10MW respectively. Determine the minimum cost of generation when the following load is supplied. The cost of fuel is Rs`2/million Btu.




16 a) What is the significance of spinning reserve constraint in unit commitment problem? Explain with example. (5 )

b) Explain the equal area criterion to determine the stability of a power system ( 5)

17 a) Derive the swing equation. (5 )

b) A 2 pole 50 Hz, 11kV turbo generator has a rating of 60 MW at 0.85 p.f lagging. Its rotor has a moment of inertia of 8800 kg-$m^2$. Calculate its inertia constant in MJ/MVA and its angular momentum in MJ-s/elect. Degree. ( 5)

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Reg No.:_____ Name:_____

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

SIXTH SEMESTER B.TECH DEGREE EXAMINATION(S), DECEMBER 2019

**Course Code: EE306**

**Course Name: POWER SYSTEM ANALYSIS**

Max. Marks: 100 Duration: 3 Hours

**PART A**

***Answer all questions, each carries5 marks.*** Marks

| | | | |
|---|---|---|---|
| 1 | | Prove that symmetrical components transformation is power invariant. | (5 ) |
| 2 | | Explain different types of current limiting reactors | (5 ) |
| 3 | | Starting from the first principles, obtain the equations of real power and reactive power used in load flow problem. | ( 5) |
| 4 | | Derive the block diagram representation of a generator-load model. | ( 5) |
| 5 | | How loads are distributed between units within a plant? | ( 5) |
| 6 | | What is the significance of thermal unit constraint in unit commitment problem? | (5 ) |
| 7 | | Derive the swing equation of a synchronous machine? | (5 ) |
| 8 | | Draw and explain power angle curve of a synchronous machine? | ( 5) |

**PART B**

***Answer any two full questions, each carries10 marks.***

| | | | |
|---|---|---|---|
| 9 | a) | How will you draw a reactance diagram when the single line diagram of a power system is given? | (6) |
| | b) | A three phase delta-star transformer with a rating of 1000 kVA, 11kV/400V has its primary and secondary leakage reactance as 12Ω/ph and 0.05Ω/ph respectively. Calculate the p.u reactance of transformer | (4) |
| 10 | a) | The symmetrical components of phase a voltages in a 3-phase unbalanced system are $V_{a0=}10\angle 180^0$ V, $V_{a1=}50\angle 0^0$ V and $V_{a2=}20\angle 90^0$ V. Determine the phase voltages $V_a$, $V_{b,}$ and $V_c$ | ( 6) |
| | b) | What are the effects of faults in power system? Explain symmetrical fault and why its calculation is necessary? | ( 4) |
| 11 | | Derive the expression for fault current and draw the interconnection of sequence networks for double line to ground fault on the terminals of an unloaded generator. | (10 ) |

***Answer any two full questions, each carries10 marks.***

| | | | |
|---|---|---|---|
| 12 | | Explain the algorithm for load flow analysis using Newton-Raphson Method. | (10 ) |
| 13 | a) | Give reasons for : | (5 ) |

i) Direct solution of load flow problem is not possible.

ii) Bus admittance matrix is sparse matrix.

b) A 100MVA synchronous generator operates on full load at frequency of 50 Hz. The load is suddenly reduced by 50 MW. Due to time lag in governor system, the steam valve begins to close after 0.4 s. Determine the change in frequency that occurs in this time. Given H= 5kW-s/kVA. (5)

14 Draw the block diagram representation of Load Frequency Control (LFC) of a single area system & explain the steady state stability for free governor operation ( $\Delta P_C = 0$) (10)

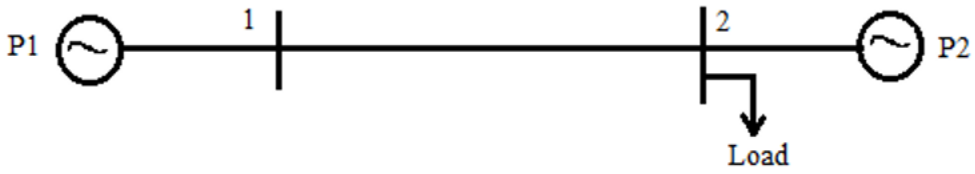
## PART D

***Answer any two full questions, each carries 10 marks.***

15 A two bus system is shown in figure below. If a load of 125MW is transmitted from plant 1 to the load, a loss of 15.625MW is incurred. Determine the generation schedule and the load demand if the cost of received power is Rs.24/MWhr. Solve the problem using coordination equations and the penalty factor method. The incremental production costs of the plants are: (10 )

$dF_1/\ dP_1 = 0.025P_1 + 15$

$dF_2\ /dP_2 = 0.05P_2 + 20$




16 a) Distinguish between economic dispatch and unit commitment. (5 )

b) Explain the method of solving swing equation by point-by-point method. (5 )

17 Using equal area criterion, derive an expression for critical clearing angle for a system having a generator feeding an infinite bus through a single circuit line. (10 )

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**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

Sixth semester B.Tech degree examinations (S), September 2020

**Course Code: EE306**

**Course Name: POWER SYSTEM ANALYSIS**

Max. Marks: 100 Duration: 3 Hours

**PART A**

***Answer all questions, each carries 5 marks.***

| | | Marks |
|---|---|---|
| 1 | Define per unit representation of electrical quantities? List out its advantages. | (5) |
| 2 | Explain short circuit MVA and its significance in analysing faults in power system. | (5) |
| 3 | Classify the various types of buses in a power system for load flow studies. | (5) |
| 4 | Explain the basic generator control loops. | (5) |
| 5 | Two units have following cost function<br>$F_1= 120+22P_1+0.05P_1^2$ Rs/hr<br>$F_2= 120+16P_2+0.06P_2^2$ Rs/hr<br>where $P_1$ and $P_2$ in MW. The generator limits are<br>$20 \leq P_1 \leq 100$ MW<br>$20 \leq P_2 \leq 100$ MW<br>Find the economic dispatch for a total demand of 180 MW. | (5) |
| 6 | Explain unit commitment? List out the constraints on unit commitment. | (5) |
| 7 | Explain the three different stabilities of a power system. | (5) |
| 8 | Explain critical clearing angle and its significance with respect to the stability of a power system. | (5) |

**PART B**

***Answer any two full questions, each carries 10 marks.***

| | | |
|---|---|---|
| 9 | A 30 MVA, 13.8 KV, 3-phase generator has a sub transient reactance of 15%. The generator supplies 2 motors through a step-up transformer - transmission line – step-down transformer arrangement. The motors have rated inputs of 20 MVA and 10 MVA at 12.8 KV with 20% sub transient reactance each. The 3-phase transformers are rated at 35 MVA, 13.2 KV -$\Delta$/115 KV-Y with 10 % leakage reactance. The line reactance is 80 ohms. Draw the equivalent per unit reactance diagram by selecting the generator ratings as base values in the generator circuit. | (10) |

10 a) Explain the significance of symmetrical components in power system. (4)

b) Derive the expression for symmetrical components of voltages in terms of phase voltages and hence obtain transformation matrix. (6)

11 Derive the expression for fault current and draw the interconnection of sequence networks for line to line fault on the terminals of an unloaded generator. (10)

## PART C

***Answer any two full questions, each carries 10 marks.***

12 Derive the static load flow equations for a power system. (10)

13 a) Write down the steps involved in solving load flow equation using Guass Siedel method when voltage controlled buses are absent. (7)

b) Enumerate the objectives of AGC. (3)

14 Develop and explain the block diagram of automatic load frequency control of an isolated power system. (10)

## PART D

***Answer any two full questions, each carries 10 marks.***

15 a) Derive the expression for economic operation of a plant having different units neglecting transmission losses. (5)

b) A 2 bus system consist of two power plants connected by a transmission line. The cost curve characteristics of the two plants are (5)

$C_1 = 0.01P_1^2 + 18P_1 + 20$ Rs/hr

$C_2 = 0.03P_2^2 + 33P_2 + 40$ Rs/hr

When a power of 120 MW is transmitted from plant 1 to load (near to plant 2), a loss of 16.425 MW is occurred. Determine the optimal scheduling of plants and load demand, if cost of received power is 36 Rs./MWhr .

16 a) Explain the steady state limit of a power system with the help of power angle diagram. (3)

b) Explain the equal area criterion for assessing the stability of a power system. (4)

c) List the methods for improving transient stability of a power system. (3)

17 a) Derive the equation for penalty factor for optimal system operation. (5)

b) Derive the swing equation representing the rotor dynamics of a synchronous machine. (5)

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