POWER SYSTEM OPERATION AND CONTROL **Course Code : 315336**

Programme Name/s : **Electrical Engineering/ Electrical Power System**
Programme Code : **EE/ EP**
Semester : **Fifth**
Course Title : **POWER SYSTEM OPERATION AND CONTROL**
Course Code : **315336**

I. RATIONALE

Electrical power system operation and control plays a significant role in electric power transfer from generation to consumer's end. The diploma engineers working in power sector have to perform operation and control of power system. He should have understanding about the reactive power control strategies, system stability and role of load dispatch center. This course aims to develop the basic knowledge and required skills to maintain the proper functioning of the power system.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Maintain the effective functioning and operation of electrical power transfer from generation to the consumer's end.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Represent power system by reactance diagram using per unit method
- CO2 - Manage real and reactive power balance within a power system network.
- CO3 - Ensure the effective operation of an automatic generation control system.
- CO4 - Apply various techniques to maintain power system stability.
- CO5 - Operate and manage a load dispatch center.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315336	POWER SYSTEM OPERATION AND CONTROL	PSO	DSE	4	-	2	-	6	2	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the basic structure of the given power system network. TLO 1.2 Explain the requirements of the given type of power system. TLO 1.3 Develop power system representation using the given single line diagram. TLO 1.4 Explain the concept of per unit method. TLO 1.5 Draw reactance diagram for the given power system by using per unit method.	**Unit - I Representation of Power System.** 1.1 Structure of power system. 1.2 Requirements of stable power system operation. 1.3 Representation of power system by single line diagram, impedance diagram and reactance diagram. 1.4 Concept of per unit method and its advantages. 1.5 Per unit method for representing power system parameters.	Lecture Using Chalk-Board, Model Demonstration Video Demonstrations Flipped Classroom
2	TLO 2.1 Explain the impact of real and reactive power imbalance for the given power flow data. TLO 2.2 Explain the relation between real power balance and frequency on the system. TLO 2.3 Explain the effect of the given condition of the frequency on the power system. TLO 2.4 Explain the relation between reactive power balance and voltage of the system. TLO 2.5 Explain the effect of the given condition of the voltage on the power system. TLO 2.6 Explain the significance of FACT controllers TLO 2.7 Explain different methods of second-generation FACT devices used for Reactive power injection.	**Unit - II Real And Reactive Power Flow** 2.1 Power flow: real power balance and reactive power balance, impact. 2.2 Relation between real power balance and frequency of the system. 2.3 Impact of variation in frequency on consumers and supply agencies (generation plants). 2.4 Relation between reactive power balance and voltage of the system 2.5 Impact of variation in voltage on consumers and supply agencies (generation plants). 2.6 FACT controllers in reactive power compensation: Need. 2.7 Reactive power injection methods by various second-generation FACT devices 2.7.1. Static synchronous series compensator (SSSC) 2.7.2. Static synchronous shunt compensator (STATCOM) 2.7.3. Unified power flow controller (UPFC) 2.7.4. Interline power flow controller (IPFC) (Introduction Only)	Lecture Using Chalk-Board Video Demonstrations Flipped Classroom Presentations Site/Industry Visit
3	TLO 3.1 Describe the functioning of the automatic load frequency control using the block diagram for the given type of generator. TLO 3.2 Suggest suitable governor controller system for the given type of turbine. TLO 3.3 Explain the automatic voltage control (AVC) system. TLO 3.4 Describe the block diagram of automatic generation control (AGC) for the specified generating system.	**Unit - III Automatic Generation Control** 3.1 Automatic load frequency control (ALFC): Schematic diagram and working. 3.2 Governor controller system- electro hydraulic governor (Digital Governor), Restricted governing mode of operation (RGMO), Free governing mode of operation (FGMO) (Introduction Only) 3.3 Automatic voltage control (AVC): Schematic diagram and working. 3.4 Automatic generation control (AGC): Schematic diagram and working.	Lecture Using Chalk-Board Model Demonstration Video Demonstrations Flipped Classroom Site/Industry Visit

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Define various terms related with stability. TLO 4.2 Explain the effects of power system instability on consumers or power utility companies. TLO 4.3 Differentiate power system related large disturbance and small disturbance in the given specific case. TLO 4.4 Identify the type of power system stability condition for the given power system. TLO 4.5 Explain stability with the help of power angle diagram. TLO 4.6 List the specified method of improving steady state and transient state stability condition of the given power system.	**Unit - IV Power System Stability** 4.1 Power system stability, overall stability, stability limit and instability. 4.2 Effects of power system instability. 4.3 Large disturbance and small disturbance. 4.4 Classification of stability: i) Steady state stability ii) Transient state stability iii) Dynamic stability 4.5 Stability studies with the help of power angle diagram. 4.6 Methods of improving steady state and transient state stability condition.	Lecture Using Chalk-Board Model Demonstration Video Demonstrations Flipped Classroom
5	TLO 5.1 Describe need of load dispatch center in power system operation and control. TLO 5.2 Explain impact of environmental and social factors on load forecasting. TLO 5.3 State the role of load dispatch center in power system operation for the given situation.	**Unit - V Load Dispatch Centre** 5.1 Load dispatch centre: need and importance. 5.2 Load forecasting: significance, environmental and social factors in load forecasting. 5.3 Types of load dispatch center (NLDC, RLDC, SLDC) and their functions.	Lecture Using Chalk-Board Model Demonstration Video Demonstrations Flipped Classroom Site/Industry Visit

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Calculate per unit values of parameters of power system components for low voltage power system by using MATLAB/ Scilab	1	*Reactance diagram of low voltage Power system by using per unit method	2	CO1
LLO 2.1 Calculate per unit values of parameters of power system components for high voltage power system by using MATLAB/ Scilab	2	Reactance diagram of high voltage power system by using per unit method	2	CO1
LLO 3.1 Use static VAR compensator for the given three phase induction motor. LLO 3.2 Calculate rating of reactive power compensator.	3	*Balancing reactive power at consumers ends.	2	CO2
LLO 4.1 Control bus voltages through onload tap changer by using Virtual Lab	4	*Voltage control through onload tap changer (OLTC)	2	CO2
LLO 5.1 Corelate the relationship between output of alternator and field excitation.	5	*Demonstration of the automatic voltage control system (AVC) in electrical generation by Visit /Animations/ Video programme.	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 6.1 Corelate relationship between the different generators in a generating station.	6	Demonstration of the automatic generation control (AGC) in electrical generation by Visit /Animations/ Video programme.	2	CO3
LLO 7.1 Identify the different parts of electro hydro governor system LLO 7.2 Describe the operation of the electro hydraulic governor (digital governor)	7	Observation of electro hydraulic governor (digital governor) by Visit /Animations/ Video programme of Hydro Power station.	2	CO3
LLO 8.1 Identify the different parts of Restricted Governing Mode of Operation (RGMO) and Free Governing Mode of Operation (FGMO). LLO 8.2 Describe the operation of Restricted Governing Mode of Operation (RGMO) and Free Governing Mode of Operation (FGMO)	8	Observation of Restricted Governing Mode of Operation (RGMO) and Free Governing Mode of Operation (FGMO) by Visit /Animations/ Video programme on Thermal Power station.	2	CO3
LLO 9.1 Identify type of disturbance from the given video clip/ case studies on Blackouts in India LLO 9.2 Prepare report with proper reason behind blackout.	9	*Case study of large disturbance and small disturbance.	2	CO4
LLO 10.1 State the specific function of load dispatch center. LLO 10.2 Prepare report on load dispatch center.	10	*Demonstration of load dispatch center operation by Visit /Animations/ Video programme.	2	CO5
LLO 11.1 Identify specific reasons for load shedding adopted by DISCOM in specific area from given video clip. LLO 11.2 Prepare report on reasons and action taken by DISCOM with proper Justification.	11	Case study of load shedding methodology.	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- Collect the data on Incidents of blackouts happened in India.
- Collect the information on governor used in Hydro Power plant and Thermal Power plant
- Prepare report on role of SCADA in load dispatch center operation.

Micro project

- Prepare a chart/ Model on automatic load frequency control used in power plant.
- Observe power consumption pattern of your Institute or nearby commercial center and prepare daily load curve.
- Prepare a chart/ Model on automatic generation control used in power plant.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Software – MATLAB / Scilab or any other open sources.	1,2
2	Induction motor (3phase /1 phase,3kW)	3
3	Ammeters MI Type: AC/ DC 0-5-10Amp (03 Nos.)	3
4	Voltmeter MI Type: AC/DC, 0-150/300V, 0-250/500V (01 No.)	3
5	Wattmeter: Single phase, single element 2.5/5Amp, 200/400V, (02 Nos.)	3
6	Dimmer: 3-phase, 5kVA	3
7	Capacitor bank, 3-phase, 5kW, 415V	3
8	MCB :10Amp	3
9	Virtual Lab (V-Lab)	4
10	Chart relevant to practical	5,6,7,8
11	LCD, PA System, Internet facility	5,6,7,8,9,10,11
12	Relevant videos	5,6,7,8,9,10,11

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Representation of Power System.	CO1	8	2	4	6	12
2	II	Real And Reactive Power Flow	CO2	12	4	8	8	20
3	III	Automatic Generation Control	CO3	6	2	4	6	12
4	IV	Power System Stability	CO4	8	4	4	6	14
5	V	Load Dispatch Centre	CO5	6	2	6	4	12
Grand Total				**40**	**14**	**26**	**30**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two unit tests of 30 marks will be conducted and average of two unit tests considered.
- For formative assessment of laboratory learning 25 marks.
- Each practical will be assessed considering appropriate % weightage to process and product and other instructions of assessment.

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks through offline mode of examination.
- End semester summative assessment of 25 marks for laboratory learning.

XI. SUGGESTED COS - POS MATRIX FORM

POWER SYSTEM OPERATION AND CONTROL **Course Code : 315336**

Course Outcomes (COs)	Programme Outcomes (POs)							Programm Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PS 3
CO1	3	3	3	3	1	1	2			
CO2	3	2	2	2	2	2	2			
CO3	3	2	2	3	2	2	2			
CO4	3	2	2	1	2	2	2			
CO5	3	2	3	1	2	2	2			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Nagrath I. J., Kothari D. P.	Modern Power System Analysis	5th Edition, McGraw Hill Education, New Delhi 2003 ISBN-978-9354600968
2	Gangadhar K. A.	Electric Power Systems (Analysis, Stability and Protection)	Khanna Publishers, Delhi. India, 2006. ISBN 9788174090041
3	K.R. Padiyar	Facts Controllers in Power Transmission and Distribution	3rd Edition, New Age International Private Limited, 2006. ISBN 978-9389802047
4	Abhijit Chakrabarty	Power System Analysis, operation and control	PHI Learning, New Delhi, New Delhi, 2010 ISBN: 788120340152
5	Chakrabarti, D P A Kothari, A K Mukhopadhyay, D E Abhinandan	An introduction to Reactive Power Control and Voltage Stability in Power Transmission Systems	PHI Learning, New Delhi, 2015 ISBN: 9788120340503
6	A. J. Wood, B. F. Woolenberg,	Power Generation Operation and Control	John Wiley and Sons, UK ISBN:978-0-471-79055-6
7	Prabha S. Kundur, Om P. Malik	Power System Stability and Control	2nd Edition, 2022 McGraw Hill ISBN: 9781260473544

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://iitr.ac.in/Departments/Hydro%20and%20Renewable%20Energy%20Department/static/Modern_hydroelectric_engg/vol_1/Chapter-6_Hydro-Turbine_Governing_System.pdf	Governor Controller System-ElectroHydraulic Governor (Digital Governor)
2	WRLDC-TP-019-Implementation-of-Free-Governor-Mode-of-Operation-in-Western-Region-of-India-2004.pdf (posoco.in)	Free Governing Mode of Operation (FGMO)
3	https://cercind.gov.in/2017/draft_reg/GC-copy/Power%20System%20Operation%20Corporation%20Limited%20(POSOCO).pdf	Details of Restricted governing mode of operation (RGMO) and free governing mode of operation (FGMO)
4	https://posoco.in/reports/monthly-reports/monthly-reports-2024-25/	Statistics and current scenario of NLDC/RLDC/SLDC
5	https://www.mahatransco.in/information/details/load_despatch	Statistics and current scenario of NLDC/RLDC/SLDC
6	https://sa-nitk.vlabs.ac.in/exp/onload-tap-changes/	Control of Bus Voltages Through Onload Tap Changes

POWER SYSTEM OPERATION AND CONTROL **Course Code : 315336**

Sr.No	Link / Portal	Description
7	https://cercind.gov.in/2016/whatsnew/anx1.pdf	Details of Restricted governing mode of operation (RGMO) and free governing mode of operation (FGMO)

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students