SREENIVASAINSTITUTEOFTECHNOLOGYANDMANAGEMENTSTUDIES
(Autonomous)

Minor -MICRO GRID TECHNOLOGY - Offered by EEE Department

S.No	Course Code	Course Title	Scheme of Instructions Hours per Week				Scheme of Examination Maximum Marks		
			L	T	P	C	I	E	Total
1	23MRMGT1	Futuristic Power Systems	3	-	-	3	30	70	100
2	23MRMGT2	Power Electronic Converters for	3	-	-	3	30	70	100
3	23MRMGT3	Micro Grid Power and Control	3	-	-	3	30	70	100
4	23MRMGT4	Micro grid System Design	3	-	-	3	30	70	100
5	23MRMGT5	Analysis of Smart Grid Systems	3	-	-	3	30	70	100
6	23MRMGT6	Project in Micro Grid Technology	-	-	3	1.5	30	70	100

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EEE Department

Minor- MICRO GRID TECHNOLOGY

23MRMGT1	FUTURISTIC POWER SYSTEMS	L	T	P	C
		3	0	0	3

PRE-REQUISITES:

COURSE EDUCATIONAL OBJECTIVES:

- To explore the state of the art and future trends in power systems.
- To understand the technical, economic and social challenges in power system evolution.
- To realize the role and importance of Micro grid siffuturistic power systems.

UNIT –1: Introduction: (9)

Present status of worldwide scenario of electricity generation, transmission and distribution; Energy infrastructure-Resilience and Security; Social, Technical and economic challenges; Major trends driving power system evolution; State of the art technologies in power system.

UNIT –2: Renewable Energy Integration: (9)

Review of renewable energy (RE) resources and systems: Solar- PV, Solar Thermal, Wind, Biomass, Micro-hydro and Fuel Cell, comparison of various RE resources; Renewable Energy Policies and present status of integration with existing grid; Large scale integration of renewable energy-Technical challenges, enabling technologies, International requirements; Renewable energy for ecasting

UNIT –3: Energy Storage Systems(ESS): (9)

Review of energy storage components: Battery, VRB, Ultra-capacitor, Fuel Cells, Pumped Hydro-Storage and flywheels, comparison of ESS technologies; Importance of ESS infuturistic power systems; Aggregated ESS, Distributed ESS; Applications of ESS: Energy Management (Load Leveling and Peak Shifting), Fluctuation Suppression (Intermittency Mitigation), Uninterruptible Power System Low-Voltage Ride Through; Placement of the ESS to Improve
Power Quality, Voltage Regulation Using ESS, ESS as Spinning Reserve.

UNIT –4: Micro-gridandSmart-grid: (9)

Micro-grid evolution: Micro-grid concept, importance in futuristic power system, basic architectures and control, objectives and state of the art technologies; Micro grid as a building block of Smart-grid; Smart-grid concept, Smart Grid versus conventional electrical networks, Smart-grid infrastructure, Smart Grid communication system and its cyber security, International standard IEC 61850 and its application to Smart-grid; Micro grids /smart grid and Electric Vehicles integration. Technical, Economic, Environmental and Social Benefits of Micro grid Operation. Micro grids for Rural Electrification, Review of Micro grid Best Practices through Case Studies: Strategic Planning, Operations: Commercial and Financial Considerations; Technical and Social Context.

UNIT –5: Communication and IT infrastructure: (9)

Requirements of Communication and IT infrastructure in futuristic power systems: various communication protocols, comparison of performance; IEEE standard: IEEE 802.11 Mesh Networking, IEEE 802.15.4-Wireless Sensor Networks; Communications Technologies for Smart metering; Cyber security issues and mitigation techniques.

Total Hours: 45

COURSE OUTCOMES:

On successful completion of the course, students will be able to		**Pos**
CO1	To solicit the importance of large scale renewable energy integration with existing grid infrastructure.L1	
CO2	To understand the importance and utility of Energy storage systems in futuristic power systems. L2	
CO3	To explore large scale micro-grid deployment with RES and ESS integration. L3	
CO4	To understand the role of communication and IT Infrastructure in power system and related challenges. L2	
CO5	To explore the potential of Micro grids and its importance in Indian context. L3	

TEXT BOOKS:

1. MicrogridsArchitecturesandControlEditedbyNikosHatziargyriou,IEEEandWiley,2014
2. EnergyStorageforSustainableMicrogridbyDavidWenzhongGao,Elsevier,2015
3. IntroductiontotheSmartGrid-Concepts,TechnologiesandEvolutionbySalmanK.Salman,IET,2017
4. EnergyStorageSystemsandComponentsbyAlfredRufer,CRCPress,2018

REFERENCE BOOKS:

1. Energy Efficiency and Renewable Energy Handbook Edited by D. Yogi Goswami and Frank Kreith, 2nd Edition- 2016, CRC
2. CleanEnergyMicrogrids,EditedbyShin'yaObaraandJorgeMorelIET,2017
3. Hybrid-RenewableEnergySystemsinMicrogrids-Integration,DevelopmentsandControleditedbyHinaFathimaby*et al*., Elsevier WoodHead Publishing, 2018
4. SmartMicrogrids:LessonsfromCampusMicrogridDesignandImplementationeditedbyHassanFarhangi,CRC Press 2017

REFERENCE WEBSITE:

1. NPTELWebCourseon:DCMicrogridAndControlSystemProf.AvikBhattacharya,IITRoorkee
2. NPTELWebCourseonElectronicsandDistributedGenerationDr.VinodJohnDepartmentofElectrical Engineering IISc Bangalore
3. NPTELWeb Courseon Introductionto SmartGrid,PROF. N.P.PADHYDepartment ofElectricalEngineeringIIT Roorkee PROF. PREMALATA JENA Department of Electrical Engineering
4. NPTELWebCourseonElectricvehiclesandRenewableenergy,Prof.AshokJhunjhunwala,Prof.PrabhjotKaur, Prof. Kaushal Kumar Jha and Prof. L Kannan, IIT Madras

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23MRMGT2	Power Electronic Converters for Energy Sources	L	T	P	C
		3	0	0	3

PRE-REQUISITES:

COURSE EDUCATIONAL OBJECTIVES:

1. To illustrate the design philosophies used in the domain of micro grid power converters.
2. To explore the control implementation sin power converters for voltage, current and power Regulation for various DC and AC energy sources.

UNIT –1: SelectionofcomponentsforPowerElectronicsConverters(PEC): (9)
Selection and Sizing of capacitors and magnetic components for PECs, design of Magnetic Components; Selection and sizing of Power Devices, Commonly useds oftware tools for selection and sizing; Heat sink-selection and sizing.

UNIT –2: CAD DesignandControlofDC-DC Converters: (9)
Design of Buck and Boost converters, Design examples; Design of Bidirectional Converters. Designofgatedrivercircuits;ReviewofDC-DCconvertermodelling;ClosedloopPIcontroller design for buck and boost converters; Current control mode and voltage control mode.

UNIT –3: DesignandControlofDC-ACconverters: (9)
Design of Inverter for stand alone applications; Design of grid connected Inverter with different grids yn chronization strategies – ZCD ,PLL; Strategies for Control of voltage, current and power output

UNIT –4: Design of PCU for SPV and Wind Application: (9)
Various topologies of Power Converter Unit (PCU) for SPV and Wind energy systems. Design considerations of PCU for SPV and Wind energy Systems and Design Examples.

UNIT –5: Design of PCU for ESS Applications and Design of Auxiliary System and Interfaces: (9)
Design consideration for BDC converter based PCU for batteries and Ultra-capacitors. Design of current and voltage sensor interfaces; Design considerations for auxiliary power supplies; Design of protection and snubber components: Introduction to Digital Signal Processors (DSP) and microcontroller interfaces

Total Hours: 45

COURSE OUTCOMES:

On successful completion of the course, students will be able to		Pos
CO1	Select and size various passive and active components for power converters L3	PO1, PO2, P03, PO4
CO2	esignpowerconvertersusedwithDCenergyresourceswiththeircon	PO1, PO2, P03, PO4
CO3	esignpowerconvertersusedwithACenergyresourceswiththeircon	PO1, PO2, P03, PO4
CO4	Understandthedesignconsiderationsofpowerconditioningunitfo	PO1, PO2, P03, PO4
CO5	Understandthe design and selection aspectsofvarious auxiliary systems and components used in PCUs L2	PO1, PO2, P03, PO4

TEXT BOOKS:

1. PowerElectronicConvertersforMicrogridsbySuleimanM.Sharkh,MohammadA.Abusara,Georgios I. Orfanoudakis Babar Hussain, IEEE and Wiley, 2014
2. Control Circuits InPower Electronics Practical Issues InDesign And Implementation Edited by Miguel Castilla, IET, 2016
3. ControlandDynamicsinPowerSystemsandMicrogridsbyLinglingFan,CRCPress,2017
4. IntegratedPowerElectronicConvertersandDigitalControl,byAliEmadi,AlirezaKhaligh,ZhongNie, andYoung Joo, Lee 2009, CRC Press.

REFERENCE BOOKS:

1. Cooperative Synchronization in Distributed Microgrid Control by Ali Bidram, VahidrezaNasirian Ali Davoudi, and Frank L. Lewis, Springer, 2017
2. Hybrid-RenewableEnergySystemsinMicrogrids-Integration,DevelopmentsandControleditedbyHinaFathimaby et al., ElseiverWoodHead Publishing, 2018
3. SmartMicrogrids-LessonsfromCampusMicrogridDesignandImplementationeditedbyHassanFarhangi,CRC Press 2017
4. EnergyStorageSystemsandComponentsbyAlfredRufer,CRCPress,2018
5. MicrogridsDesignandImplementationeditedbyAntonioCarlosZambronideSouzaandMiguelCastilla, Springer, 2019
6. MicrogridsArchitecturesandControlEditedbyNikosHatziargyriou,IEEEandWiley,2014
7. EnergyStorageforSustainableMicrogridbyDavidWenzhongGao,Elsevier,2015

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23MRMGT3	MICRO GRID POWER AND CONTROL ARCHITECTURE	L	T	P	C
	(Common to Branches)	3	0	0	3

PRE-REQUISITES:

COURSE EDUCATIONAL OBJECTIVES:

1. Tostudyvariouspowerandcontrolarchitecturesadoptedin DCandACMicrogrids.
2. Toexplorevariouscontrolstrategiesusedinpowercontrol
3. Totakeinsightintooperationsstabilityandprotectionissuesrelated toMicrogrids

UNIT –1: MicrogridPowerArchitecture: **(9)**

TypesofMicrogridsystem,AC and DC and HybridsMicrogrids, Application based Suitability ofMicrogridtype;ReviewofpowerarchitectureofvariousMicrogridsdeployedworld-wide. Comparison of various Microgrid power architectures.

UNIT –2: ACMicrogridandControlArchitecture: **(9)**

Black-start operation, Grid Synchronisation- various Grid synchronization methods, Grid formingandgridfollowingoperations;PowerControl-RealandreactivepowercontrolinAC Microgrid, simple droop controland other variants of droop control, Unit Power Flow Control, Feeder power flow control and Mixed mode control, source optimization; Centralized, decentralised, distributed and hierarchical control architecture, Local and system / supervisorylevel control strategies, Multi Agent System (MAS) Based Control; Control approaches used in AC Microgrids deployed worldwide. Microgrid standards IEEE
1547series.CommunicationinACMicrogrids

UNIT –3: DCMicrogridandControl Architecture: **(9)**

Power sharing in DC Microgrids, source optimization; Control approaches: Centralized, decentralised,distributedandhierarchicalcontrolarchitecture.Controlapproachesusedin hybrid Microgrids.Communication in DC/Hybrid Microgrids

UNIT –4: OperationalControl inMicrogrids: **(9)**

Energy management in Microgrids, coordinated control, load management, grid synchronisation and islanding, Anti-islanding schemes; Various Architectural and Operational Challenges in Microgrid, Optimal operation of Microgrids.

UNIT –5: MicrogridStability & Protection: **(9)**

Steady-stateanddynamicstabilityinACandDCMicrogrids,Methodstoimprovethestability in Microgrids; introduction to small signal and large signal stability analysis in Microgrids. Fault scenarios in DC and AC Microgrids, Protection in DC and AC Microgrids, adaptive protection,Faultcurrentsource(FCS)basedprotection;Protectionchallengesinislandedand autonomous modes of operation and ways to mitigate.

Total Hours: 45

COURSE OUTCOMES:

On successful completion of the course, students will be able to		**Pos**
CO1	UnderstandvarioustypesMicrogridsbasedonapplications,poweranndcontrolarchitecture. L2	
CO2	IllustratevariouspowercontrolstrategiesadoptedinDC,ACandHybridMicrogrids L3	
CO3	Compareandcontrastvariouscontrolarchitecturesused DC, ACandHybridMicrogrids also various aspects related to stability in Microgrids L4	
CO4	IllustratethevariousoperationalchallengesinMicrogrids L3	
CO5	ComprehendthevariousaspectsrelatedtothestabilityinMicrogrids L4	

TEXT BOOKS:

1. MicrogridsDesignandImplementationeditedbyAntonioCarlosZambroni deSouzaandMiguelCastilla, Springer, 2019
2. MicrogridsArchitecturesandControlEditedbyNikosHatziargyriou,IEEEandWiley,2014
3. CooperativeSynchronizationinDistributedMicrogridControlbyAliBidram,VahidrezaNasirianAli Davoudi, and Frank L. Lewis, Springer, 2017
4. ControlCircuitsInPowerElectronicsPracticalIssuesInDesignAndImplementationEditedbyMiguelCastilla, IET, 2016

REFERENCE BOOKS:

1. ControlandDynamicsinPowerSystemsandMicrogridsbyLinglingFan,CRCPress,2017
2. Hybrid-RenewableEnergySystemsinMicrogrids-Integration,DevelopmentsandControleditedbyHinaFathimaby et al., ElseiverWoodHead Publishing, 2018
3. UrbanDCMicrogridIntelligentControlandPowerFlowOptimizationbyManuelaSechilariuandFabriceLocment, 2016 Elsevier
4. Integrated Power Electronic Converters and Digital Control, by Ali Emadi, AlirezaKhaligh, ZhongNie, andYoung Joo, Lee 2009, CRC Press.
5. IslandPowerSystemsbyLukasSigrist,EnriqueLobato,FranciscoM.EchavarrenIgnacioEgido,and Luis Rouco, CRC Press, 2016

REFERENCE WEBSITE:

1. NPTELWebCourseon:DCMicrogridandControlSystemProf.AvikBhattacharya,IITRoorkee
2. NPTELWebCourseonElectronicsandDistributedGenerationDr.VinodJohnDepartmentofElectrical Engineering IISc Bangalore
3. NPTEL Web Course on Introduction to Smart Grid, PROF. N.P. PADHY Department of Electrical Engineering IIT Roorkee PROF. PREMALATA JENA Department of Electrical Engineering
4. NPTEL Web Course on Electric vehicles and Renewable energy, Prof. Ashok Jhunjhunwala,

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Prof. PrabhjotKaur, Prof. Kaushal Kumar Jha and Prof. L Kannan, IIT Madras

https://nptel.ac.in/courses/113105100

23MRMGT4	MICRO GRID SYSTEM DESIGN	L	T	P	C
	(Common to Branches)	3	0	0	3

PRE-REQUISITES:

COURSE EDUCATIONAL OBJECTIVES:

1. Toillustratethedesignphilosophiesusedinthedomainofmicrogrid.
2. Toexploretheselectionofpowerandcontrolarchitectureofmicrogrids
3. Tostudythedesignaspectsofacmicrogrid,dcmicrogridandtheirauxiliarysystems

UNIT –1: Selection/SizingofMicrogridEnergyResources (9)

Factorsaffectingtheselectionandsizingofenergyresourcesformicrogridapplications, dependency on type of loads connected, Selection/ Sizing: Renewable energy resources, Energy Storage components.Hybrid combination of RES and ESS.

UNIT –2: SelectionofPowerandControlArchitecture (9)

Factors affecting the selection of Microgrid power and control architecture; Design Consideration for control implementation; Sensors: Selectionof sensors and design of sensorInterfaces,designofcontrolInterfaces.DesignconsiderationsforDSP/ Microcontrollerinterfaces

UNIT –3: SelectionandDesignofCommunicationArchitecture (9)

Design considerations for selection of communication network for Microgrid applications; Design and implementation of communication links/ interfaces.
Microg4controllerprogrammingforDatatransferoncommunicationnetwork.Practical designconsiderationsforCommunicationnetworks.

UNIT –4: DesignofDC and AC Microgrid: (9)

Design DC Power Conditioning Units for RES and ESS, Unidirectional and Bidirectional Converter design, implementation of Control loop with DSP; Programming for Power sharingandEnergyManagementalgorithms;DesignofProtectionsystemforDC MicrogridDesign AC Power Conditioning Units for RES and ESS, Unidirectional and Bidirectional Converter design, implementation of Control loop with DSP; Grid Synchronization. ProgrammingforPowersharingandEnergyManagementalgorithms;Designof ProtectionsystemforACMicrogrid.

UNIT –5: IslandinginMicrogrids: (9)

Selectionandimplementationof Islandingdetectionandanti-islandingscheme;Black- start and Autonomousoperations in Microgrids;

Total Hours: 45

COURSE OUTCOMES:

On successful completion of the course, students will be able to		**Pos**
CO1	SelectandsizevariousMicrogridenergy resources L3	
CO2	SelectthepowerandcontrolarchitectureoftheMicrogrid L3	
CO3	SelectanddesigntheMicrogrid'scommunicationarchitecture. L3	
CO4	IllustratethedesignaspectsDC and ACMicrogridswiththeircontrolstrategies. L4	
CO5	IllustratetheimplementationoftheMicrogridislandingdetectionandanti-islandingscheme/ blackstart operation L4	

TEXT BOOKS:

1. MicrogridsDesignandImplementationeditedbyAntonio CarlosZambronideSouzaandMiguelCastilla, Springer, 2019
2. MicrogridsArchitecturesandControlEditedbyNikosHatziargyriou,IEEEandWiley,2014
3. PowerElectronicConvertersForMicrogridsbySuleimanM.Sharkh,MohammadA. Abusara,GeorgiosI. Orfanoudakis Babar Hussain, IEEE and Wiley, 2014

REFERENCE BOOKS:

1. EnergyStorageforSustainableMicrogridbyDavidWenzhongGao,Elsevier,2015
2. CooperativeSynchronizationinDistributedMicrogridControlbyAliBidram,VahidrezaNasirianAli Davoudi, and Frank L. Lewis, Springer, 2017
3. EnergyEfficiencyandRenewableEnergyHandbookEditedbyD.YogiGoswamiandFrankKreith,2nd Edition- 2016, CRC
4. ControlCircuitsInPowerElectronicsPracticalIssuesInDesignAndImplementationEditedbyMiguelCastilla, IET, 2016
5. Hybrid-RenewableEnergySystemsinMicrogrids-Integration,DevelopmentsandControleditedbyHinaFathimaby et al., ElseiverWoodHead Publishing, 2018
6. UrbanDCMicrogridIntelligentControlandPowerFlowOptimizationbyManuelaSechilariuandFabriceLocment, 2016 Elsevier
7. Integrated Power Electronic Converters and Digital Control, by Ali Emadi, AlirezaKhaligh, ZhongNie, andYoung Joo, Lee 2009, CRC Press.

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23MRMGT5	ANALYSIS OF SMART GRID SYSTEMS	L	T	P	C
	(Common to Branches)	3	0	0	3

PRE-REQUISITES:

COURSE EDUCATIONAL OBJECTIVES:

UNIT –1: Introduction: (9)

Conventional power systems and Smart grid, definition of smart grid, need for smart grid, Smart grid architecture, smart grid domains, enablers of smart grid, Communication architecture and protocols for smart grid, smart grid priority standards and regulation, smart-grid activities in India.

UNIT –2: Systems of non linear equations: (9)

Fixed point iteration, Newton Raphson Iteration, Continuation methods, Power system application: power flow, regulating transformer, Fast decoupled load flow, PV curves and continuation power flow, three phase power flow

UNIT –3: Smart Grid Security analysis: (9)

Concept of security, Security analysis and monitoring, factors affecting power system security, detection of network problems, an overview of security analysis. Contingency analysis for generator and line outages by Interactive Linear Power Flow (ILPF) method, Fast decoupled inverse Lemma based approach, network sensitivity factors, Contingency selection, concentric relaxation and bounding.

UNIT –4: Smart Grid Operation and Planning: (9)

Economic Dispatch, Optimal Power Flow, Load forecasting, Operation of smart grid system, Load Dispatch Centre functions, preventive, Emergency and Restorative, control objectives of a smart distribution system, Operational bottlenecks in smart grid. Planning Aspects of smart grid, Planning and operation Standards.

UNIT –5: Distributed Generation in Smart Grid: (9)

Renewable-based Distributed generations, Energy Storage Technologies, Modeling, Control of energy storage system, Short- mid -long term application of energy storage system in smart grids..

Total Hours: 45

COURSE OUTCOMES:

On successful completion of the course, students will be able to		Pos
CO1	Understand the analysis and planning of smart grids L2	PO1, PO2, P03, PO4
CO2	Evaluate the tools for modeling and analysis of smart grid L3	PO1, PO2, P03, PO4
CO3	Analyze and synthesize the smart grid operation L4	PO1, PO2, P03, PO4
CO4	Assess the influence of distributed generation in smart grid on power systems L4	PO1, PO2, P03, PO4
CO5		PO1, PO2, P03, PO4

TEXT BOOKS:

1. Mikell P. Groover- Emory W. Zimmers - CAD/CAM- 5/e- Pearson Prentice Hall of India- Delhi- 2008.
2. Ibrahim Zeid- R.Siva Subramanian- CAD/CAM: Theory and Practice- 2/e- Tata McGraw-Hill- Delhi- 2009

REFERENCE BOOKS:

1. P. N. Rao- CAD/CAM: Principles and applications- 3/e- Tata McGraw-Hill- Delhi- 2017.
2. P. Radhakrishnan- S. Subramanyan& V. Raju- CAD/CAM/CIM- 3/e- New Age International Publishers- 2008.
3. Computer Aided Manufacturing- 3/e- TienChien Chang- Pearson- 2008.

REFERENCE WEBSITE:

- https://onlinecourses.nptel.ac.in/noc20_me44/preview
- https://www.youtube.com/watch?v=EgKc9L7cbKc
- https://www.youtube.com/watch?v=KXFpTb9cBpY
- https://web.iitd.ac.in/~hegde/cad/lecture/L01_Introduction.pdf
- https://www.vssut.ac.in/lecture_notes/lecture1530947994.pdf
- https://www.iare.ac.in/sites/default/files/lecture_notes/CAD_CAM_LECTURE_NOTES.pdf

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23MRMGT6	PROJECT IN MICRO GRID TECHNOLOGY	L	T	P	C
		-	-	3	1.5

PRE-REQUISITES: Nil.