



University of Tehran
School of Electrical and Computer Engineering

Course	Protection, Control and Stability of Microgrids		
Course type, level, credit	Optional	Graduate	3 units
Field, Major	Electrical Engineering	Power	
Co-requisite(s)	-		
Prerequisite(s)	<ul style="list-style-type: none"> - Power System Analysis2 - Relaying and Protection 		
Prerequisite by topic	<ul style="list-style-type: none"> - Coordination of Overcurrent Relays - Load Flow and Short Circuit Studies 		
Goals	<ul style="list-style-type: none"> - Study of characteristics of various renewable energy resources, especially wind turbine and solar cell resources - Study of synchronous generator behavior connected to a combustion engine, which is mostly employed in Iran distribution system - Study of technical issues related to distributed energy resources (DERs) connection to distribution systems including system operation problems, protection, control, and stability 		
Outcome	<p>Students who successfully passed the course would learn the following issues:</p> <ul style="list-style-type: none"> - Specifications of various DER types including combustion engines, wind turbines, and solar cells - Required system studies to connect DERs to distribution systems including load flow, short circuit, grounding, equipment technical specifications, and etc. - Control of DERs including controllers of synchronous generators and inverter-based resources, and microgrid control logic - Protection of generator, point of common coupling, and the distribution system to which DERs are connected 		
Topics	<p>Common technologies of distributed energy resources (DERs)</p> <ul style="list-style-type: none"> - Combustion engine - Wind turbine - Photo voltaic - Microturbine, hydro turbine, and energy storage systems <p>Studies for connection of DERs to distribution system</p> <ul style="list-style-type: none"> - Distribution substation, distribution network, and subtransmission substation 		

	<ul style="list-style-type: none"> - Common structures for DER connection to distribution system - Load flow studies - Short circuit studies - Grounding studies - Power quality studies - Technical specifications of DER equipments <p>Control</p> <ul style="list-style-type: none"> - DER controllers - DER control strategy under grid-connected and islanded conditions - Modeling of small-scale synchronous generator (SSSG) controllers - Modeling of inverter-based DER controller <p>Protection and stability</p> <ul style="list-style-type: none"> - Approaches and issues of conventional distribution system protection - SSSG stability studies - Influence of DER on distribution system protection - Protections required at point of common coupling (PCC) - Protection of microgrid - Protection of DERs
Required software	Phasor-based simulation tool, such as one of the following software: <ul style="list-style-type: none"> - DIgSILENT - ETAP - NEPLAN
Assignments	2 homework
Projects	1 course project
Grading	Homework and influential attendance: 25 % Project: 30 % Midterm exam: 25 % Final exam: 25 %
Textbook(s)	[1] M. Bollen and F. Hassan, "Integration of Distributed Generation in the Power System", John Wiley & Sons Publication, 2011
Further readings	[1] A. Keyhani and M. Marwali, "Smart Power Grids 2011", Springer, 2011 [2] A. Keyhani, M. Marwali, and M. Dai, "Integration of Green and Renewable Energy in Electric Power Systems", John Wiley & Sons Publication, 2010 [3] G. Abad, J. Lopez, M. A. Rodriguez, L. Marroyo, and G. Iwanski, "Doubly Fed Induction Machine Modeling and Control for Wind Energy Generation", IEEE Press, 2011 [4] Various parts of IEEE Std. 1547 [5] Relevant papers from prestigious international journals [6] Technical documents of DER manufacturers and performed projects [7] National regulations regarding DERs