Universidad Carlos III de Madrid www.uc3m.es	COURSE: POWER ELECTRONICS IN ENERGETICS SYSTEMS 19/20		
	DEGREE: DEGREE IN ENERGY ENGINEERING	YEAR: 3	TERM: 1

WEEKLY PLANNING

WEEK	SESSION	DESCRIPTION	GROUPS		SPECIAL ROOM FOR SESSION (Computer classroom, audio-visual classroom)	Indicate YES/NO If the session needs 2 teachers	WEEKLY PROGRAMMING FOR STUDENT		
			LECTURES	SECTIONS			DESCRIPTION	CLASS HOURS	HOMEWORK HOURS (Max. 7h week)
1	1	**Course introduction.** **Power Electronics applications in Energetic Systems** 1. Micro-Grids 2. Power Electronics Loads 3. Power Quality Solutions 4. Transmission and Distribution (T&D) Applications		G		NO	Study of topics developed. Obtaining course materials	1,66	4,0
1	2	**Revision of basic electrical concepts and mathematical tools (I)** 1. Instant value, average value, RMS values 2. Instant and average power 3. Periodic waveforms. Fourier Series and harmonics Quality factors for electrical transformations: Power factor, THD, Ripple factor	M			NO	Study of topics developed	1,66	
2	3	**Revision of basic electrical concepts and mathematical tools (II)** 1. Resistors 2. Inductors Transformers 3. Capacitors 4. Power balance. Steady–state operation. Transient operation 5. Filtering		G		NO	Study of topics developed	1,66	4,0
2	4	**More exercises on basic electrical concepts and mathematical tools** 1. Calculation of the waveform, slope, peak, valley, peak to peak and average values of the inductor current in a switching circuit. 2. Use of Fourier Series to calculate the RMS, THD and delivered power to and R-L load fed by quasi-square waveform (Phase shift modulation)	M			NO	Study of topics developed	1,66	
3	5	**DC-DC Converters (I)** 1. Introduction to DC-DC converters 2. Buck Converter. Exercise. a. Blocks diagram of a converter: chopper, LC filter, and free-wheeling diode b. Equivalent circuits		G		NO	Study of topics developed	1,66	4,0

		c. Waveforms d. Obtaining the voltage and current DC conversion rations using Steady –State conditions.							
3	6	**DC-DC Converters (II)** 1. Boost Converter. a. Waveforms b. Obtaining the voltage and current DC conversion rations using Steady –State conditions. 2. Exercise.	M			NO	Study of topics developed	1,66	
4	7	**DC-DC Converters (III)** 1. Full Bridge Converter. a. Waveforms b. Obtaining the voltage and current DC conversion rations using Steady –State conditions.		G		NO	Study of topics developed	1,66	4,0
4	8	**DC-DC Converters (IV)** 1. Bidirectional Converter: Four-switch Buck-Boost Converter a. Waveforms b. Obtaining the voltage and current DC conversion rations using Steady –State conditions. 2. Exercise.	M			NO	Study of topics developed	1,66	
5	9	**Exercises of DC-DC converters** Four-switch Buck-Boost Converter Simulation 1. Introduction to PSIM simulator 2. PWM modulator operation 3. Theoretical and simulated waveforms 4. Theoretical calculation and measurements on the simulated waveforms of the average and RMS values and current ripple.		G	Computer room	YES	Study of topics developed	1,66	7,0
5	10	**DC-AC Inverters (I)** 1. Introduction to DC-AC Inverters. Full-Bridge converter with R load. Four quadrants operation 2. Square waveform modulation. Free Wheeling diodes 3. Pros and cons of Square waveform modulation 4. 3-Ph bridge square waveform operation 5. Exercise: 1-Ph inverter with square waveform modulation and a RL load 6. Exercise: 3-Ph inverter with square waveform operation and a RL load	M			NO	Study of topics developed	1,66	
6	11	**DC-AC Inverters (II)** 1. PWM modulation concept. Relationship between the pulse width (duty cycle) and the average value. Moving average concept. 2. Modulating and carrier signals 3. Relationship between the moving average of the output voltage and the modulating signal 4. Unipolar sinusoidal PWM modulation. Definitions of the amplitude modulation index, m_a, and the frequency modulation index, m_f		G		NO	Study of topics developed	1,66	4,0

		5. DC voltage gain 6. Harmonic content of the output voltage as a function of m_a and m_f 7. Overmodulation and square waveform operation							
6	12	**DC-AC Inverters (III). 3-Ph inverters with PWM modulation** 1. Three Modulating signals 2. DC voltage gain 3. Harmonic content of the output voltage as a function of m_a and m_f 4. Third-harmonic injection PWM **Advanced topologies: Multilevel and Modular converters** 1. Multilevel converter with clamping diodes. Advantages regarding voltage levels and current THD. 2. Modular converters. Series and parallel connections. Economy of Scale	M			NO	Study of topics developed	1,66	
7	13	**Phasor representation of 3-Ph inverters** 1. Exercise: 3-Ph inverters with PWM modulation		G		NO	Study of topics developed	1,66	4,0
7	14	**AC-DC Converters (I)** 1. Introduction to AC-DC converters. Diode. 2. Basic single-phase topologies: half-wave and full-wave rectifier. 3. Non-controlled single-phase full-wave rectifier with C filter: approximation to calculate the output voltage ripple.	M			NO	Study of topics developed	1,66	
8	15	**AC-DC Converters (II)** 1. Non-controlled full-wave three-phase rectifier. 2. Non-controlled three-phase full-wave rectifier with C filter: approximation to calculate the output voltage ripple. 3. Non-Controlled three-phase rectifier with RL and RLC loads using infinite-L approximation.		G		NO	Study of topics developed	1,66	4,0
8	16	**Exercises of AC-DC Converters** 1. Single-phase and three-phase full wave rectifier with C filter. 2. Single-phase and three-phase full wave rectifier with inductive load.	M			NO	Study of topics developed	1,66	
9	17	**Power Semiconductors and Power Losses** 1. Main features 2. Power Losses 3. Diodes 4. MOSFET 5. IGBT 6. Basic losses calculation for IGBT 7. Basic losses calculation for inductors		G		NO	Study of topics developed	1,66	7,0
9	18	**Exam I: Fundamentals, DC-DC, AD-DC and DC-AC converters** 1. Description of Lab Session 1	M			NO	Study of topics developed	1,66	
10	19	**Lab Session 1: DC-DC Converters** The student will develop the experimental setup of a DC-DC converter. Open and closed loop measurements must be obtained **Note**: Laboratories of the Electronics Technology Department		G	Lab	YES	Study of topics developed	1,66	7,0

10	20	**Thermal management of power converters** 1. Temperature effects in power converters 2. Thermal – electrical equivalence 3. Main conduction thermal models 4. Natural convection and forced convection 5. Heat-sink calculation (natural convection) 6. Heat-sink calculation (forced convection)	M			NO	Study of topics developed	1,66	
11	21	**Fundamentals of dynamic modeling of switched converters** 1. Steady-state operation 2. Transient operation and stability 3. Average model of the power stage 4. Linearization of the average model 5. Modeling of the other blocks of the feedback loop 6. Blocks diagram of the complete loop 7. Audiosusceptibility and Output impedance 8. Positive effects of negative feedback Oscillation problem		G		NO	Study of topics developed	1,66	4,0
11	22	**Control loop design** 1. Basic concepts of control theory 2. Loop Stability 3. Phase margin and crossover frequency 4. Phase Margin and Transient response 5. Requirements of the compensator transfer function 6. Type of regulators (PI, type 2 and type 3). Calculate PI regulator.	M			NO	Study of topics developed	1,66	
12	23	**Exercises: Control loop design of a Buck and Boost DC-DC converter** Modeling and design of the control loop of a DC-DC converter 1. Introduction of SmartCtrl 2. Control loop design using the predefined topologies of SmartCtrl 3. Simulate in PSIM the both converters under input voltage steps and load steps. 4. Use different types of regulator (PI and type 3)		G	Computer room	YES	Study of topics developed	1,66	7,0
12	24	**Power converters for renewable energy applications** **Active and reactive exchange with the grid** 1. Two sinusoidal generator coupled by an inductor 2. Three-Phase Systems. Space Phasors and Bidimensional reference frames	M			NO	Study of topics developed	1,66	
13	25	**Modeling and control of the current loop of a grid-tied three-phase inverter (I)** 1. Average model 2. Small-signal model 3. Feed-forward compensations 4. PI compensator design		G		NO	Study of topics developed	1,66	7,0
13	26	**Exam II: Power semiconductor, power losses, Thermal Management, modeling and control loop design of DC-DC converters** **Functional Blocks of the current loop of a grid-tied three-phase inverter (II)**	M			NO	Study of topics developed	1,66	

		1. Power Stage 2. Current Filtering and abc to dq Transformation 3. Voltage measurement, voltage re-scaling and abc to dq Transformation 4. PLL 5. Current References Generator 6. P and Q references steps 7. PI regulator and Feed-Forward compensations 8. PWM Modulator 9. Parameter File 10. Instant Active and Reactive Power Meters **Note**: This session is connected with Lab Session 2. Models and PSIM blocks will be given to students in order to help them to design the complete PV system considered as Lab Session 2.							
14	27	**Lab Session 2: Grid-tied PV inverter** To complement the contents of session 24, 25 & 26, the complete 3-ph grid-tied inverter will be simulated by means of PSIM.		G	Computer room	YES	Study of topics developed	1,66	7,0
14	28	**Main electrical protections in power converters** 1. Overvoltage protection a. Clamping Snubbers. b. dV/dt Snubbers. c. Diode Snubbers. d. IGBT Snubbers. 2. Overvoltage protection for the complete converter. a. Metal-oxide varistors. b. Gas discharge tubes. c. Other devices. 3. Overcurrent protection. a. Active protection in power-electronics switching devices. b. Fuses and thermal-magnetic circuit breakers.	M			NO	Study of topics developed	1,66	