Universidad Carlos III de Madrid www.uc3m.es	COURSE: POWER ELECTRONICS IN ENERGETICS SYSTEMS 21/22		
	DEGREE: DEGREE IN ENERGY ENGINEERING	YEAR: 3	TERM: 1

WEEKLY PLANNING

DATE	SESSION	DESCRIPTION	PLACE
6-sep	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	7.2.J05
9-sep	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	7.1.H01
13-sep	3	**Revision of basic electrical concepts and mathematical tools (II)** 4. Resistors 5. Inductors Transformers 6. Capacitors 7. Power balance. Steady–state operation. Transient operation 8. Filtering	7.2.J05
16-sep	4	**More exercises on basic electrical concepts and mathematical tools** 9. Calculation of the waveform, slope, peak, valley, peak to peak and average values of the inductor current in a switching circuit. 10. 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)	7.1.H01
20-sep	5	**DC-DC Converters (I)** 1. Introduction to DC-DC converters 2. Buck Converter. Exercise. a. Block diagram of a converter: chopper, LC filter, and free-wheeling diode b. Equivalent circuits c. Waveforms d. Obtaining the voltage and current DC conversion rations using Steady –State conditions.	7.2.J05
23-sep	6	**DC-DC Converters (II)** 1. Boost Converter.	7.1.H01

		a. Waveforms b. Obtaining the voltage and current DC conversion rations using Steady –State conditions. 2. Exercise.	
27-sep	7	**DC-DC Converters (III)** 1. Full Bridge Converter. a. Waveforms b. Obtaining the voltage and current DC conversion rations using Steady –State conditions.	7.2.J05
27-sep	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.	7.2.J05
30-sep	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.	Computer room 11G02
4-oct	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	7.2.J05
7-oct	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 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	7.1.H01
14-oct	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	7.1.H01
18-oct	13	**DC-AC Inverters (IV). Exercise** 1. Exercise: 3-Ph inverters with PWM modulation	7.2.J05

18-oct	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.	7.2.J05
21-oct	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.	7.1.H01
25-oct	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.	7.2.J05
28-oct	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	7.1.H01
4-nov	18	**Computer Session 1: AC-DC Converters** The student will develop the simulation of several AC-DC converters, with and without output filter	Computer room 11G02
8-nov	19	**Exam I: Fundamentals, DC-DC, AD-DC and DC-AC converters** 1. Description of Lab Session 1	7.2.J05
11-nov	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)	7.1.H01
15-nov	21	**Fundamentals of dynamic modeling of switched converters** 1. Steady-state operation, transient operation and small signal 2. Modeling of converters: injected-absorbed-current method 3. Modelling of the other blocks of the feedback loop 4. Block diagram of the complete loop 5. Audiosusceptibility and Output impedance	7.2.J05
18-nov	22	**Control loop design** 1. Brief introduction to control and Bode diagram. 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). Compensator design	7.1.H01

		7. Problem: Design of the control loop of a Buck converter	
22-nov	23	**Power converters for renewable energy applications** 1. Photovoltaic Systems 2. Wind Power Systems 3. Active and reactive power exchange with the grid 4. Three-phase system 5. Space phasors and two-dimensional reference frame	7.2.J05
25-nov	24	**Exercises: Design of the control loop of a DC-DC converter** Modeling and design of the control loop of a DC-DC converter 1. Buck Converter Power Stage and PWM Modulator 2. Simulate in PSIM both converters under input voltage steps and load steps. 3. Use different types of compensator (PI and type 3)	Computer room 11G02
29-nov	25	**Modeling and control of the current loop of a grid-tied three-phase inverter** 1. Average model 2. Small-signal model 3. Feed-forward compensations 4. PI compensator design	7.2.J05
2-dic	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)** 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.	7.1.H01
9-dic	28	**Computer 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.	Computer room 11G02
13-dic	27	**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.	7.2.J05

		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.	