SUBJECT: POWER ELECTRONICS		
STUDY: Bachelor in Industrial Electronics and Automation Engineering (COMPULSORY, 6 ECTS)	COURSE: 3rd	SEMESTER: 2nd

COURSE CHRONOGRAM

WEEK	SESSION	DESCRIPTION OF THE CONTENT	GROUP (marK X)		Special room for session (computer classroom, audio-visual classroom…)	Indicate YES/NO is two-professor session	WORK TO BE PERFORMED BY STUDENT		
			LARGE	SMALL			DESCRIPTION	HOURS IN ROOM	WEEKLY HOURS (Max. 7h)
1	1	**Subject Introduction. Basic Concepts I.** 1. Subject Presentation: organization, evaluation and planning. 2. Introduction to Power Electronics. 3. Basic electrical concepts. a. Instant value, Mean Value and RMS value on a periodical signal. b. Instant and Mean Power. Energy. c. Calculation examples on typical wave-shapes in Power Electronics.	x					1,66	
1	2	**Basic Concepts II.** 1. Basics on electrical components in Power Electronics (Resistor, Inductor, Capacitor and Transformer): a. Symbol, basic equation and signs convention. b. Steady State Conditions. c. Equivalent Models including actual effects.		x				1,66	3,00

		d. Examples.							
2	3	**DC-DC Converters (I): Introduction to non-isolated DC-DC Converters** 1. Introduction to DC-DC Converters applications. 2. Basic parts in DC-DC Converters on a Buck converter: Chopper, LC filter and free-wheeling diode. 3. Analysis procedure on DC-DC Converters explained on a Buck converter working under Continuous Conduction Mode (CCM). a. Equivalent circuits. b. Wave-shapes on main components. c. Input to Output Voltage and Current Ratio based on steady state conditions. d. Mean value and ripple of the inductor current. 4. Continuous and Discontinuous Conduction Mode concepts (CCM and DCM): a. Wave-shapes of inductor voltage and current under DCM. b. Relationship among load current, inductor current and switching frequency. K non-dimensional factor definition.	x					1,66	
2	4	**Examples of DC-DC Converters (I): computer aided analysis (simulation) of a Buck converter.** **a. <u>Introduction to PSIM simulator (mandatory for the first Lab Session)</u>** b. Main Voltage and Current Wave-shapes. c. CCM-DCM demonstrations changing the values of L and/or R.		x	Computer Classroom			1,66	7,00
3	5	**DC-DC Converters (II): Isolated Converters (I)** 1. Isolation needs. 2. Forward Converter with third winding. a. Buck family. b. Equivalent Circuits and wave-shapes under CCM. c. Obtaining the mean value and ripple of the inductor current. d. Voltages ratio. e. Magnetizing inductor under DCM and tertiary turns designing (N3) in relation with the maximum duty cycle (Dmax).	x					1,66	
3	6	**Examples of DC-DC Converters (II): Solving non-isolated converters.** 1. Problem 1: Boost Converter.		x				1,66	3,00

		2. Problem 2: Buck-Boost Converter. **<u>Particular concepts:</u>** Wave-shapes of the capacitor current and capacitor designing.							
4	7	**DC-DC Converters (III): Isolated Converters (II)** 1. Flyback Converter a. Buck-Boost Family. b. Equivalent Circuits and wave-shapes under CCM. c. Mean value and ripple of the inductor current. d. Voltages ratio. 2. Summary of DC-DC Converters	x					1,66	
4	8	**Examples of DC-DC Converters (II): Solving isolated converters.** 1. Problem 1: Forward Converter 2. Problem 2: Flyback Converter		x				1,66	3,00
5	9	**Inverters (I): Introduction to DC/AC converters: single-phase non-modulated inverters (I)** 1. Inverters applications. 2. Single-phase loaded topologies comparison: a. Half Bridge and Full Bridge. b. Output and switches voltages wave-shapes under a resistor load. 3. Full Bridge topology under an RLC load (sinusoidal load current) a. Voltage and current wave-shapes under an RLC load (sinusoidal load current). 4. Basic parameters definition in DC/AC energy conversion: a. Active and Reactive Power. b. Signal Total Harmonic Distortion (THD) 5. Harmonic concept and Fourier Transform on a signal. Application on a signal through the Superposition Theorem in order to obtain the mean and RMS values, the mean power (Parseval Theorem) and Harmonic Distortion.	x					1,66	
5	10	**Lab Session 1: DC-DC Converter Simulation**		x	Lab	yes		1,66	7,00
6	11	**Exam I: Basic Concepts and DC-DC Converters** **Inverters (II): single-phase non-modulated inverters (II)** 1. Square shape and phase-shift control strategies. 2. Steady State operation of a Full Bridge Inverter with a RL or RLC load.						1,66	7,00

		a. Voltage and current wave-shapes. b. Antiparallel Diodes need. c. Output power regulation capability. Power Balance. d. Harmonic content.							
6	12	**Inverters Exercises (I). Solving single-phase non-modulated inverters problems.** Problem: Full Bridge non-modulated inverter with RL load under square shape and phase-shift respectively. **<u>Particular concepts:</u>** first order transients in order to qualitatively represent the current wave-shape under RL load.						1,66	
7	13	**Inverters (III). Modulated single-phase inverters** 1. Sinusoidal Pulse-Width Modulation (SPWM) a. Bipolar SPWM b. Unipolar SPWM c. Linear zone d. Overmodulation zone e. Square-wave zone 2. Comparison of the harmonic spectrum 3. Description of the table of Fourier series for its use in single-phase PWM inverters	x				To study the topics.	1,66	
7	14	**Exercises of Inverters (II). Solving problems of single-phase SPWM inverters** 1. Problem 1: Bipolar SPWM inverter with RL or RLC load. 2. Problem 2: Unipolar SPWM inverter with RL or RLC load		x			Resolution of problems.	1,66	3,00
8	15	**Inverters (IV). Three-phase inverters** 1. Topology of a three-phase full-bridge 2. Square-wave operation a. 120º-shifted control signals b. Waveform of the line voltage Vab. Null triplen harmonics. c. Calculation and waveform of the neutral-phase voltage Van. Van $\neq$ Va0 and null triplen harmonics. d. Fourier series of Vab and Va0. e. Wye (or star) and Delta (or triangle) load. 3. Three-phase sinusoidal PWM (SPWM) a. 120º-shifted three-phase modulating signals b. Harnessing of the DC voltage: Vab,rms/Vdc	x				To study the topics.	1,66	3,00

		c. Harmonic spectrum and table of Fourier series 4. Summary of Inverters							
8	16	**Exercises of Inverters (III). Solving problems of three-phase SPWM inverters** 1. Problem 1: Three-phase non-modulated inverter with RL or RLC 2. Problem 2: Three-phase SPWM inverter with RL or RLC		x			Resolution of problems.	1,66	
9	17	**Rectifiers (I). Single-phase rectifier (I)** 1. Applications of the rectifiers 2. Concepts: ripple factor and power factor. Use of the Fourier series for their calculation. 3. Basic diode-based single-phase topologies: half-wave and full-wave bridges: a. Criteria to determine which diode conducts based on the common anode and the common cathode. 4. Operation and comparison with resistive load	x					1,66	
		PARTIAL EXAM 2					To study the topics. Preparation and resolution of a test of basic questions.		
9	18	**Lab session 2**		x	Lab	Yes	To obtain course materials. To study the related topics. Generation of the results report.	1,66	7,00
10	19	**Rectifiers (II). Single-phase rectifier (II)** 1. Non-controlled single-phase full-waver rectifier with C filter: approximation to calculate the output voltage ripple. 2. Non-controlled single-phase full-wave rectifier with LC filter: a. Solving by using Fourier series b. Continuous and discontinuous conduction modes (CCM and DCM). Current ripple considering only the first harmonic. 3. Thyristor: Ideal behavior. 4. Basic thyristor-based half-wave and full-wave topologies. a. R load b. RL, RLC and RLE load. Infinite L.					To study the topics.	1,66	
10	20	**Exercises of Rectifiers (I). Single-phase rectifiers (I)** 1. Problem 1: diode-based full-wave rectifier with C filter.		x			Resolution of problems.	1,66	3,00

		2. Problem 2: diode-based full-wave rectifier with LC filter.							
11	21	**Rectifiers (III). Single-phase rectifiers (III).** 1. Thyristor-based full-wave rectifier. Steady-state operation. a. Waveforms (output voltage, anode-cathode voltage and input current) varying the firing angle. b. Calculating the average load voltage according to the firing angle. c. Power factor. 2. Free-wheeling diode. Fundamental waveforms and calculation of the average load voltage. 3. Non-autonomous inverter (RLE load). Operating quadrants.	x				To study the topics.	1,66	
11	22	**Exercises of Rectifiers (II). Single-phase rectifiers (II)** 1. Problem 1: thyristor-based full-wave rectifier with RL load. 2. Problem 2: thyristor-based full-wave rectifier with RLC load.		x			Resolution of problems.	1,66	3,00
12	23	**Rectifiers (IV). Three-phase rectifiers** 1. Three-phase topology. Analyzing the conduction of the semiconductor devices (diode and thyristor). Three-phase waveform template. 2. Types of load: a. R load b. RC load c. RL, RLC and RLE loads. Considering infinite L d. Examples of waveforms (output voltage, anode-cathode voltage and input current) for different firing angles. 3. Steady-state operation a. Firing angle (α: 0-90º) with passive RL and RLC loads. b. Firing angle (α: 90º - 180º) with active RLE loads. 4. Calculation of the average load voltage. 5. Calculation of the power factor.	x				To study the topics.	1,66	
12	24	**Lab session 3**		x	Lab	Yes	To obtain course materials. To study the related topics. Generation of the results report.	1,66	7,00
13	25	**Exercises of Rectifiers (III). Three-phase rectifiers**	x				Resolution of problems.	1,66	7,00

		1. Problem 1: three-phase thyristor-based full-wave rectifier with RC load. 2. Problem 2: three-phase thyristor-based full-wave rectifier with RL and RLE load. Infinite L.							
13	26	**Lab session 4**		x	Lab	Yes	To obtain course materials. To study the related topics. Generation of the results report.	1,66	
14	27	**Current applications (I)** 1. Real semiconductor devices: models of the conduction losses (MOSFET, IGBT, diode and thyristor). Calculating the conduction losses. Efficiency. 2. Thermal-electrical analogy. **PARTIAL EXAM 3**	x				To study the topics. Preparation and resolution of a test of basic questions.	1,66	
14	28	**Exercises of Current applications (I)** 1. Problem 1: Losses and efficiency. 2. Problem 2: Scaling the heat sink.		x			Resolution of problems.	1,66	7,00
	29	**Current applications (II).** 1. Advanced specifications. 2. Regulations and standards. 3. Introduction to the modeling and control of power electronics converters	x				To study the topics.	1,66	1,00
							Subtotal 1	**48,14**	**71,00**
		Total Hours 1 *(Weeks 1-14)*						**119,14**	
15		Additional lectures to complete or to review subject contents						7	
16		Final test						3	21
17									
18									
							Subtotal 2	**3**	**28,00**
		Total Hours 2 *(Weeks 15-18)*						**31,00**	
Subject hours *(Total Hours 1 + Total Hours 2. maximum: 180 hours)*								**150,14**	