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| **Part I Power electronics (60H)** |

**1- *Objectives:***

This course is an introduction of the industrial electronics. It treats the semiconductor electronic devices which are used in the power circuits, the command circuits, the converters and their applications.

At the end of this course, the student will be able to:

•Define the properties of a P-N junction.

•Describe the operation of the following electronic devices: Diode, Diode zener, Thyristor, Diac,Triac, UJT, and PUT.

•Identify the structures and characteristics of these devices.

•Explain the operation of the command circuits of thyristor, triac and diac.

•Analyze the different application circuits using these devices.

• Explain the operation of the converter circuits AC/DC (rectifiers) and DC/AC and study their applications.

**2- *Teaching method*:**

The Analog electronics I course is a prerequisite for the power electronics and sensors course.

After a brief review of the basic concepts of semiconductors the instructor explains the course of power electronics and sensors in such a way as to bring about coherence and continuity between the various parts, as follows:

1. Explain the principle of operation of the diode and zener diode, give their characteristics.
2. Show the composition of the electronic power components (thyristor, diac and triac) and present their principle of operation and characteristic curves I = f (V).
3. Show the composition of the unijunction transistor (UJT) and programmable unijunction transistor (PUT) and present their principle of operation, characteristic curves I = f (V) and application circuits.
4. Show the command circuits of the thyristor , explain the principle of operation of each one and draw the waveforms at each interested point on the circuit.
5. Define the role of AC/DC converter, state their types, draw the circuits, explain the principle of operation of each one and show the waveforms at the input and output of each circuit.
6. Define the role of DC/DC converter, state their types, draw the circuits and explain the principle of operation of each one, and show the waveforms of the current and voltage at the output of each circuit.
7. Define the role of DC/AC converter, state their types, draw the circuits and explain the principle of operation of each one, and show the waveforms of the current and voltage at the output of each circuit.

**3- *Teaching aids***

* Overhead projector or power point on white board or active board with accessories.
* A notebook.
* A technical manual.
* A multi-media computer (if possible).
* Technical information documentaries (movies).
* Library access (guided if possible).

**4**- ***Content***

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|  | **Hours** |
| 1. Semiconductor junctions | **2** |
| 1. The diode and zener diode | **4** |
| 1. The thyristor | **4** |
| 1. The triac | **4** |
| 1. The diac | **2** |
| 1. The unijunction transistor | **4** |
| 1. The programmable unijunction transistor | **4** |
| 1. Command circuits of the thyristor | **10** |
| 1. The AC/DC converters or rectifiers | **10** |
| 1. The DC/DC converters | **8** |
| 1. The DC/AC converters | **8** |
| **T O T A L** | **60** |

***Skills:***

At the end of this section, the student will be able to:

1. Describe the basic operation of a thyristor, diac and triac.

2- Describe the basic operation of a UJT and PUT.

3- Knowledge the command methods of thyristors and triacs.

4- Describe the application circuits of these devices: Rectifiers, DC/DC converters and DC/AC converters.

***Evaluation***

1. Define and give the symbol and the construction of a thyristor, diac and triac.
2. Represent the characteristic curves of a thyristor, diac and triac.
3. Define and give the symbol and the construction of a UJT and PUT.
4. Represent the characteristic curves of the UJT and PUT.
5. Analyze the thyristor command circuits by using a UJT or PUT relaxation oscillator, and study their principle of operation.
6. Analyze the triac command circuit by using a diac, and study its principle of operation.
7. Analyze the applications on the power devices as rectifiers, DC/DC converters and DC/AC converters.

***Chapter 1*: Semiconductor Junctions (2h)**

1.1- Definition of the semiconductor.

1.2- Intrinsec semiconductor.

1.3- N and P Doped Semiconductor.

1.4- PN junction; structure potential barrier.

1.5- Courant-voltage characteristic I = f (v)

1.6- Applications of the PN junctions.

***Chapter 2:* The diode and zener diode (4h)**

2.1- The diode:

2.1.1- Definition, structure, symbol, and equivalent circuit.

2.1.2- Principle of operation in forward and reverse bias.

2.1.3- Characteristic curves I= f (V) in forward and reverse bias.

2.2- The zener diode:

2.1.1- Definition, structure, symbol, and equivalent circuit as battery and battery in series

with its internal resistance.

2.1.2- Principle of operation in forward and reverse bias.

2.1.3- Characteristic curves I= f (V) in forward and reverse bias.

***Chapter 3*: The thyristor (4h)**

3.1- Definition, structure, symbol, and equivalent circuit.

3.2- Operation: Conduction and blocking laws (thyristors ; GTO).

3.3- Characteristic curves I= f (V) in forward and reverse bias.

3.4- Gate command circuits.

3.5- Applications: controlled rectifiers.

***Chapitre 4 :* The triac (4h)**

4.1- Definition, structure, symbol, and equivalent circuit.

4.2- Operation: Conduction and blocking laws.

4.3- Characteristic curves I= f (V) in forward and reverse bias.

4.4- The modes of operation of the triac.

4.5- Applications: Utilization of the triac as a power regulator or dimmer: Role, circuit, principle of operation and waveforms.

***Chapitre 5:* The diac (2h)**

5.1- Definition, structure, symbol, and equivalent circuit.

5.2- Operation: Conduction and blocking laws, impedance of the diac in the conduction and blocking cases.

5.3- Characteristic curves I= f (V) in forward and reverse bias.

5.4- Applications: Utilization of the diac as a pulse generator: Role, circuit, principle of operation and waveforms.

***Chapitre 6:* The unijunction transistor UJT (4h)**

6.1- Structure, equivalent circuit and symbol.

6.2- Operation of the UJT: The equivalent circuit in both cases when UJT is ON.

6.3- The characteristic curve of the UJT: VE = f (IE).

6.4- Applications:

1- Oscillator circuit with unijunction transistor: Role, principle of operation, waveforms.

2- Relaxation oscillator with unijunction transistor used as pulse generator: Role, circuit, principle of operation, waveforms.

***Chapitre 7:* The programmable unijunction transistor PUT (4h)**

7.1- Structure, equivalent circuit and symbol.

7.2- Principle of operation of the PUT.

7.3- The characteristic curve of the PUT: V = f (I).

7.4- Comparing between UJT and PUT.

7.5- Application: Relaxation oscillator circuit with PUT used as pulse generator: Role, principle of operation, waveforms.

***Chapitre 8:* The command circuits of the thyristor (10h)**

I- Firing circuits: Role and classes:

I.a: Firing by direct voltage on the gate.

I.b: Firing by anode voltage with a resistance and a diode connected between anode and gate.

I.c: Firing by the voltage of the gate obtained through the charge of a capacitor.

I.d: Launching by phase-shifter circuit.

I.e: Launching by saturable transformer.

I.f : Firing by a circuit using UJT or PUT.

I.g: Firing by a circuit using diac.

II- The blocking circuits of the thyristor

II.1: Natural commutation in case of AC supply.

II.2: Blocking of supplied thyristors in direct current.

II.2.a: Blocking by cutoff of the anode circuit.

II.2.b: The forced commutation by short-circuit of the thyristor.

II.2.c: Blocking by reverse discharge of the capacity in parallel.

II.2.d: Blocking by LC oscillation circuit in parallel with the thyristor.

***Chapitre 9:* The AC/DC converters or rectifiers (10h)**

9.1**-** Single phase rectifiers :

9.1.1- Four diodes bridge.

9.1.2- Four thyristors bridge (reversibility).

9.1.3- Combined bridge two diodes and two thyristors (non reversibility).

9.2- Three-phase rectifiers:

9.2.1- Six diodes bridge**.**

9.2.2- Six thyristors bridge (reversibility).

9.2.3- Combined bridge (non reversibility).

***Chapitre 10:* The DC/DC converters (8h)**

10.1- Role, Principle.

10.2- Serial basic converter: Role, circuit, principle of operation, waveforms and utilizations.

10.3- Parallel basic converter: Role, circuit, principle of operation, waveforms and utilizations.

10.4- Practical circuits.

***Chapitre 11:* The DC/AC converters (8)**

11.1- Role, Principle.

11.2- Single phase DC/AC converter with two thyristors and a center tap transformer: Role, circuit, principle of operation, waveforms and utilizations.

11.3- Single phase DC/AC converter with bridge of four thyristors: Role, circuit, principle of operation, waveforms and utilizations.

11.4- Three phase DC/AC converter with three thyristors: Role, circuit, principle of operation,

waveforms and utilizations.  
11.5- Three phase bridge DC/AC converter with six thyristors: Role, circuit, principle of operation,

waveforms and utilizations.