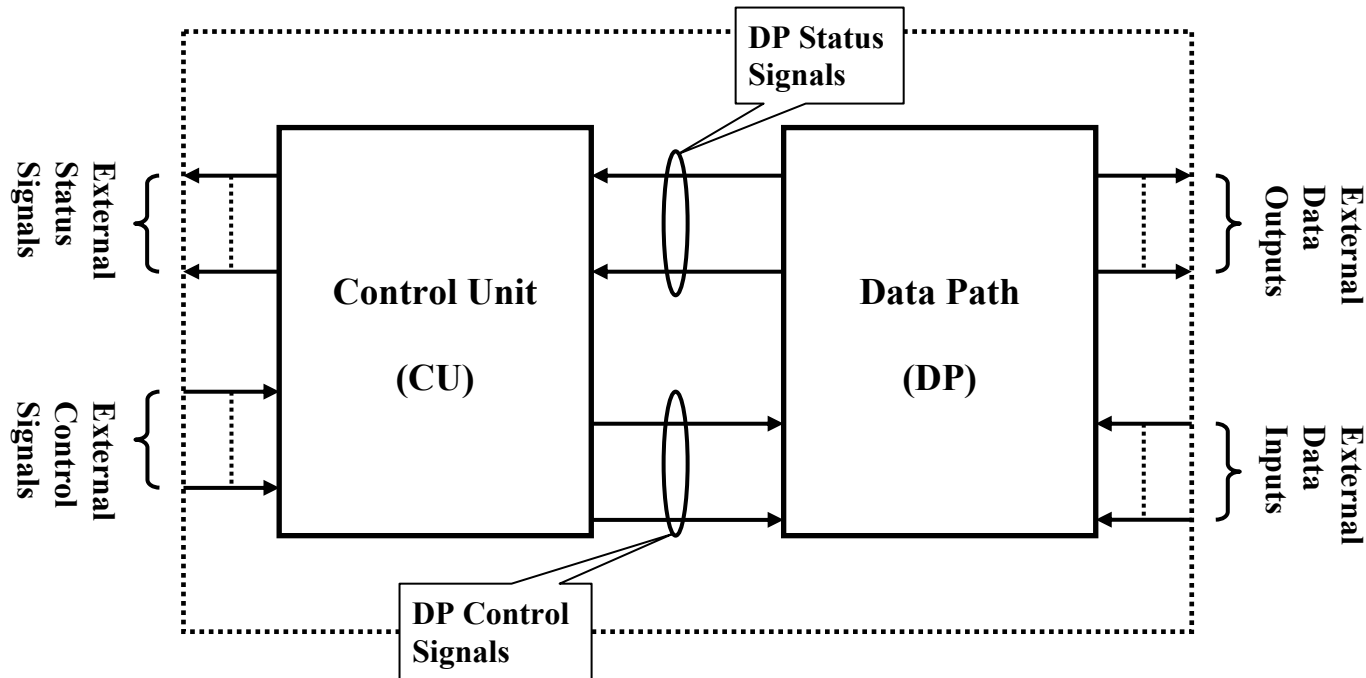# Digital System Design Using Data path (DP) and Control Unit (CU)

The general structure of a digital system that performs a specific task(s) is as follows:

- **External Control Signals: Specifies the task required from the whole circuit (e.g. calculate the average of some integers)**

- **External Status Signals: Indicate the status of the whole circuit (e.g. finished processing, error or overflow ...etc.)**

- **External Data Inputs/Outputs: Data going into the circuit or out of it (e.g. the integers to be averaged and their average)**

- **DP Control Signals: Signals generated by the CU to control different blocks in the DP (e.g. Shift Registers, Counters, MUXs ...etc.)**

- **DP Status Signals: Signals that indicate the status of some blocks in the DP (e.g. when a counter reaches 7 or when an adder produces a carry or an overflow, or when the sign bit of the result is negative ...etc.)**

Data Path Design:

- **The data path contains blocks that only deal with data; they do not provide control to any other blocks and them selves need to be controlled (by the CU).**

- **Data Path blocks can be viewed as the workers that perform certain tasks (on the data) who need to be managed by someone (in this case the CU is the manager that tells every 'worker' in the Data Path what to do).**

- **Examples of Data Path blocks:**

    - **Registers:**

        - **Parallel load registers to read data in parallel**

        - **Shift Registers to read data serially one bit at a time**

        - **Digit serial registers that reads data serially one digit at a time, where the digit size could be anything (e.g. 4-bits, 8-bits, 16-bits …etc.)**

    - **Arithmetic Circuits:**

        - **Adders, Subtractors, Multipliers, Square root, etc.**

    - **Multiplexers: To rout 1 of many data to a single destination**

    - **DeMultiplexers: To rout a single data to one of many destinations**

    - **Counters: As timers and counters (i.e. to count the occurrence of a certain event, e.g. how many data was read)**

    - **Comparators, Logic Circuits (AND, OR, etc)**

Design Steps:

1. **Identify all inputs and outputs for the whole circuit. Identify, separately data inputs/outputs and control inputs/outputs (external status).**

2. **Identify the required Data Path blocks (as per above) and design them**

3. **Identify the input and output signals to the Data Path and Control unit**

4. **Design the control Unit (start by obtaining the state diagram, then the next state and output equations and finaly the logic implementation) and connect it to the DP.**