Title of the course is Microcontroller Architecture and Programming.

Name of the module is, “Hardware, Output Input Ports and Circuits”

Outline of the module:

1. Introduction
2. 8051 Architecture
3. Hardware
4. I/O ports & Circuits

Learning Outcomes:

At the end of the module, learner will be able to:

- Describe the hardware features of the 8051 microcontrollers.
- List the internal registers of the 8051 microcontroller and their functions.
- State the physical differences between the Port 0, 1, 2, and 3 I/O pins.

In this module we are going to learn about the new computing system i.e. 8051 microcontroller. Therefore, we need to know, the capability of this new machine.

To learn the features, of this microcontroller, let us study its, internal hardware design. i.e. architecture of the device.

8051 Architecture

The unique features of 8051 are represented in the block diagram of Figure 1.

The figure shows:

I. **ALU block** : ALU is an abbreviation for Arithmetic Logic unit: ALU performs, arithmetic functions such as addition, subtraction, multiplication, and division, **AND** logical functions such as AND, OR, and NOT etc. This is the most important "block" of the CPU i.e. (Central Processing Unit). In short ALU is the brain of the computing system.

Now let us discuss about the most widely used registers, those are implemented, for all arithmetic and logic instructions.

- "The **Registers"** are the special electronic circuits, which are used for temporarily storage of information. The information could be a byte of data to be processed, or an address i.e. the location of the data.
- The majority of 8051 register are 8-bit wide; while address is 16 bit wide, and therefore, we treat 8051 microcontroller as 8 bit machine.

II. **Register A:** In the slide, it is displayed just below the ALU. This is the most widely used register. It is used for all arithmetic and logic instructions. It is an 8 bit register and also called as **accumulator**.

III. Next to A is Register B: This is a 8 bit register and used, with A register for multiplication and division operations, and has no other functions other than "as a location" where data may be stored.

IV. **PSW (Program Status Word):** it is 8 bit wide and is also referred to as the flag register. PSW contains the maths flags like Carry flag, Auxiliary carry, Overflow flag , Parity flag etc.

V. **PC:** Program Counter it is 16 bit wide. The PC points to the address, of the next instruction to be executed. As each instruction is executed, the program counter is incremented, to point to the address, of the next instruction to be executed. When 8051 is powered up, the program counter has 0000 and starts to fetch the first, op-code from location 0000 of program ROM. This instruction is executed, and then the program counter is incremented to point to next location of instruction of ROM. And this continues .....

VI. **DPTR:** Data pointer Register. It is 16 bit wide register. This register, temporarily holds the address of the Data. And this

register can be incremented and decremented as per the programmer's wish.

VII. **RAM (**Random Access Memory) is used for temporary storage of intermediate results and data . The data stored in RAM, is lost when system is switched off.

8051 microcontroller has 128 bytes, of location for temporary storage of data.

VIII. **ROM** (Read Only Memory) – contains programs and information required for the operation of the microcontroller. The information cannot be changed by use, and is not lost when power is switched off. i.e. ROM is non volatile memory. 8051 microcontroller has 4 Kilo-bytes of memory, on chip for, storing the instructions OR Programme

IX. **I/O Ports :** these ports, provide a means of communicating with CPU, memory and the external world. There four, 8-bit I/O ports. Each port has addressable D-type latches.

1. Hardware:

The pin diagram of 8051 is shown in the Figure 2.

I. 8051 is a, 40 pin chip.

II. Pin number 40 and 20 are + VCC and Ground (GND) respectively and provides the + 5V, supply voltage, to the chip.

III. Pin number18 & 19 are provided, for connecting a resonant network circuit, to form an oscillator. Typically, a quartz crystal and capacitors are employed as oscillator. This crystal circuitry generates the clock pulses, by which internal operations are synchronised. This clock is referred as the heart of the 8051. This clock determines the speed of the machine.

IV. Pin No. 9 is reset pin.

+5 volts pulse to this pin make the 8051 to start execution of program from 0000 memory location.

V. I/O ports: Total, 32 pins are set aside for FOUR ports. These ports are named as: P0,P1, P2 & P3, where each port takes 8 pins(corresponding to 8 Bits). These Ports and the individual pins are means of CPU to communicate with the outside world/environment.

Apart from Port functions these pins has other functions also, which will be covered in the next module.

VI. Pin No. 29,30 & 31 are used for writing the programme codes on the on-chip ROM of the 8051 using external device like ROM programmer and are also used for accessing the external

RAM/ROM which are added to increase the capacity of the microcontroller.

2. I/O ports & Circuits:

One major feature of a microcontroller, is the versatility built; into the input/output (I/O) circuits that connects the 8051 to the outside world. i.e. these pins are used to interface the additional circuits. (Ex. LCD Display, keyboard, sensors, etc. etc.)

The four 8-bit I/O ports P0, P1, P2 and P3 each uses 8 pins

All the ports, upon RESET are configured as input, ready to be used as input ports. i.e. machine can read the data from the sensor or keyboard.

When the first 0 is written to a port, it becomes an output port. i.e. the CPU will send data, to be displayed on the LCD display, for example.

To reconfigure the port as an input, a 1 must be sent to the port

In other words, to use any of these ports as an input port OR output, it must be programmed.

Also To make the Port P0, as input or output, each pin must be connected externally to a 10K ohm pull-up resistor.

In figure 2, Pin 1 to 8 of 8051 chip are exclusively reserved for I/O operations of port P1. While 24 pins of port P0, P2 & P3 are also used for different functions; yielding a total pin configuration of 64 pins.

The DIP 40 pin (Dual INLINE Package) chip design is widely accepted design in the marketplace, therefore, this design is used to incorporate the flexibility of alternate pin functions.

It is due to this reason, the port P0, P2 & P3, need to be programmed to achieve, its different functions.

For example, Port P0 pins may serve as input / output port OR , as a bidirectional data bus (D0 to D7) and low-order address bus (A0 to A7) for external memory addressing.

Each port has a D type output latch for each pin. The SFR (special function Registers) for each port is made up of these eight latches, which can be addressed at the SFR address for that port.

For example, the eight- latches, of port P0 are addressed at location 80H.

In Port P0, bit 2 of port P0, the SFR (P0.2) is pin 37 of the chip, and has an address 82H; since each port pins has bit addressable latch.

The basic circuitry for port 0, pin configuration is shown in figure 3.

These are the reference/ books I have used for this module.

Thank you very much.