

Syllabus: Introduction to Microcontroller, 8051 Microcontroller Architecture and an example of Microcontroller based Stepper motor control system (Only Block diagram approach)

* Introduction:

- In 1981, Intel Corporation introduced an 8-bit Microcontroller, called the 8051.
- Some of the companies producing a member of the 8051 family: Intel, Atmel, Philips/Signetics, Infineon, Dallas Semi/Maxim, Motorola etc
- A Microcontroller has a CPU (a microprocessor) in addition to a fixed amount of RAM, ROM, I/O ports, & a timer all on a single chip.

The Processor, RAM, ROM, I/O ports, & timer are all embedded together on a single chip is a Microcontroller.

→ Advantages of microcontroller (MC)

- ① No need of any external memory, I/O & timer.
- ② Higher Performance
- ③ Lower Power Consumption
- ④ Compact Size

→ Criteria for choosing a microcontroller

- | | |
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| <ol style="list-style-type: none"> ① Speed ② Packaging ③ Power consumption ④ Cost/unit | <ol style="list-style-type: none"> ⑤ Amount of RAM & ROM on chip ⑥ Number of I/O pins & the timer on the chip ⑦ Ease of upgrading to higher-performance. ⑧ Lower Power Consumption versions. |
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→ Applications of Microcontroller

Home Appliances

- ① Intercom
- ② Telephones
- ③ Security Systems
- ④ Fax Machines
- ⑤ Computers
- ⑥ Camcorder
- ⑦ Remote Controls
- ⑧ VCR
- ⑨ Video games
- ⑩ Camera
- ⑪ Paging
- ⑫ Sewing Machines
- ⑬ Musical Instruments
- ⑭ Cellular phones
- ⑮ Cable TV tuner
- ⑯ TVs
- ⑰ Washing machines

Office

- ① Telephones
- ② Computers
- ③ Copiers
- ④ Laser Printer
- ⑤ Color Printer
- ⑥ Network Server
- ⑦ Internet terminal
- ⑧ Mouse
- ⑨ CD-ROM drives
- ⑩ Elevators
- ⑪ Modem

Others

- ① Engine control
- ② Air bag
- ③ Climate control
- ④ Keyless entry
- ⑤ Instrumentation
- ⑥ Cars
- ⑦ Traffic signals
- ⑧ Aerospace
- ⑨ Diagnostics
- ⑩ Water level controller.

→ Features of 8051 microcontroller

- ① 8-bit CPU
- ② 128 bytes of RAM.
- ③ 4K bytes of on-chip ROM. (8051 can have a maximum of 64K bytes of on-chip ROM)
- ④ Two 16 bit timers/counters
- ⑤ One Serial Port
- ⑥ Four I/O Ports (each 8-bits wide) (provides 32 I/O pins)

- ⑦ 8-bit Program Status Word (PSW)
- ⑧ 16-bit Program Counter (PC) and data pointer (DPTR)
- ⑨ 8-bit Stack Pointer (SP)
- ⑩ Two external & three internal interrupts
- ⑪ Four register banks, each containing 8 registers.
- ⑫ 8-bit data bus
- ⑬ 16-bit address bus.
- ⑭ Full duplex Serial data transmitter/receiver
- ⑮ Oscillator & clock circuits (operate at a clock frequency of 12MHz)

* Block diagram of 8051 microcontroller ①
Architecture of 8051 microcontroller

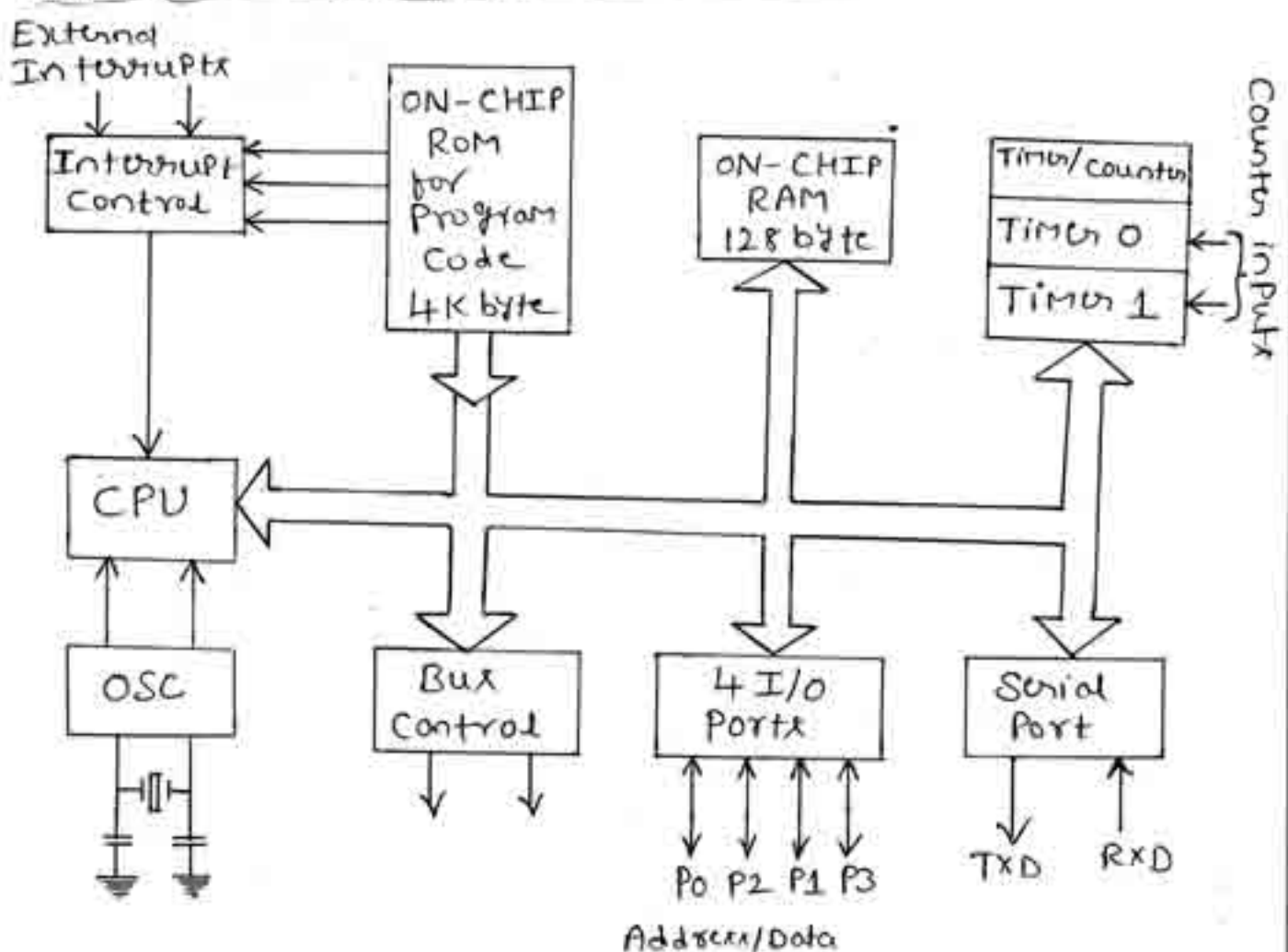


Fig ①: Block diagram of 8051 microcontroller

The block diagram of 8051 microcontroller is shown in fig 1.

8051 microcontroller consists of Registers, memory, I/O Ports, Interrupts, Timer/Counter, UART, Oscillator & clock circuits.

⊛ A register (Accumulator): It is an 8-bit register used for arithmetic & logical operations.

⊛ B register: It is an 8-bit register used for multiplication & division operations.

⊛ Internal memory: Internal memory of 8051 are
ⓐ 128 bytes RAM ⓑ 128 bytes of Special function ROM
ⓒ 4K bytes ROM.

⊛ External memory: External memory of 8051 are
ⓐ ROM (64K bytes for Program)
ⓑ RAM (64K bytes of data memory)

⊛ Stack: It is a section of internal RAM used to store information temporarily (data @ address)

⊛ Stack Pointer (SP): It is an 8-bit register used to access the stack

⊛ I/O Ports: There are four I/O ports each comprising 8 bits, namely P0, P1, P2 & P3

Three types of buses are used

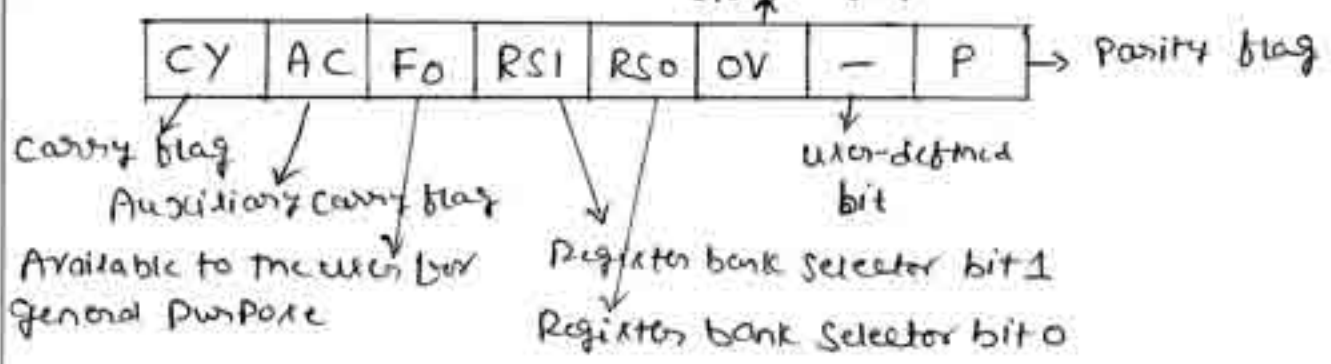
ⓐ Address Bus (16-bit) ⓑ Data Bus (8 bit bi-directional)
ⓒ Control Bus (consists of RD, WR, PSEN, ALE & EA)

⊛ DPTR (Data Pointer): It is a 16-bit register used to hold the address of external data memory @ Program memory. It consists of two 8-bit registers namely DPH (high byte) & DPL (Low byte)

⊛ Program Counter (PC): It is a 16-bit register which holds

the address of the next instruction to be executed

- ⊛ Interrupts: There are six interrupts in the 8051.
- ⊛ Timers/counter: 8051 has two timers/counter:
TIMER0 & TIMER1 (16-bit)
- ⊛ Register bank: There are four register banks each consisting of 8-bit general purpose registers (R0-R7)
- ⊛ Flag register ⊛ Program Status Word (PSW) register:



- ⊛ UART (Universal Asynchronous Receiver & Transmitter): It is used for sending & receiving data bits serially.
- ⊛ Oscillator & clock circuits: Operates at a clock frequency of 12MHz.

⊛ Microcontroller based Stepper motor control system

⊛ 8051 microcontroller connection to the Stepper Motor:

The microcontroller based Stepper motor control system is shown in fig 2.

It consists of 8051 microcontroller, resistors, ULN2003 & a Stepper motor.

8051 microcontroller:

- 8051 MC is low power, high-performance, 8-bit processor.

Resistors:

- If it is required, the external pull up resistors are connected to Pinx depending on the MicroController.

ULN 2003:

- It is a high voltage & high current driving IC.

Stepper motor:

- It is an electromechanical device which converts electrical pulses into mechanical motion.
- This motor divides the complete rotation (360°) into a number of equal steps.
- Stepper motor consists of a rotor @ rotating shaft @ Motor shaft (usually a permanent magnet) & a stator (fixed external winding @ coil)

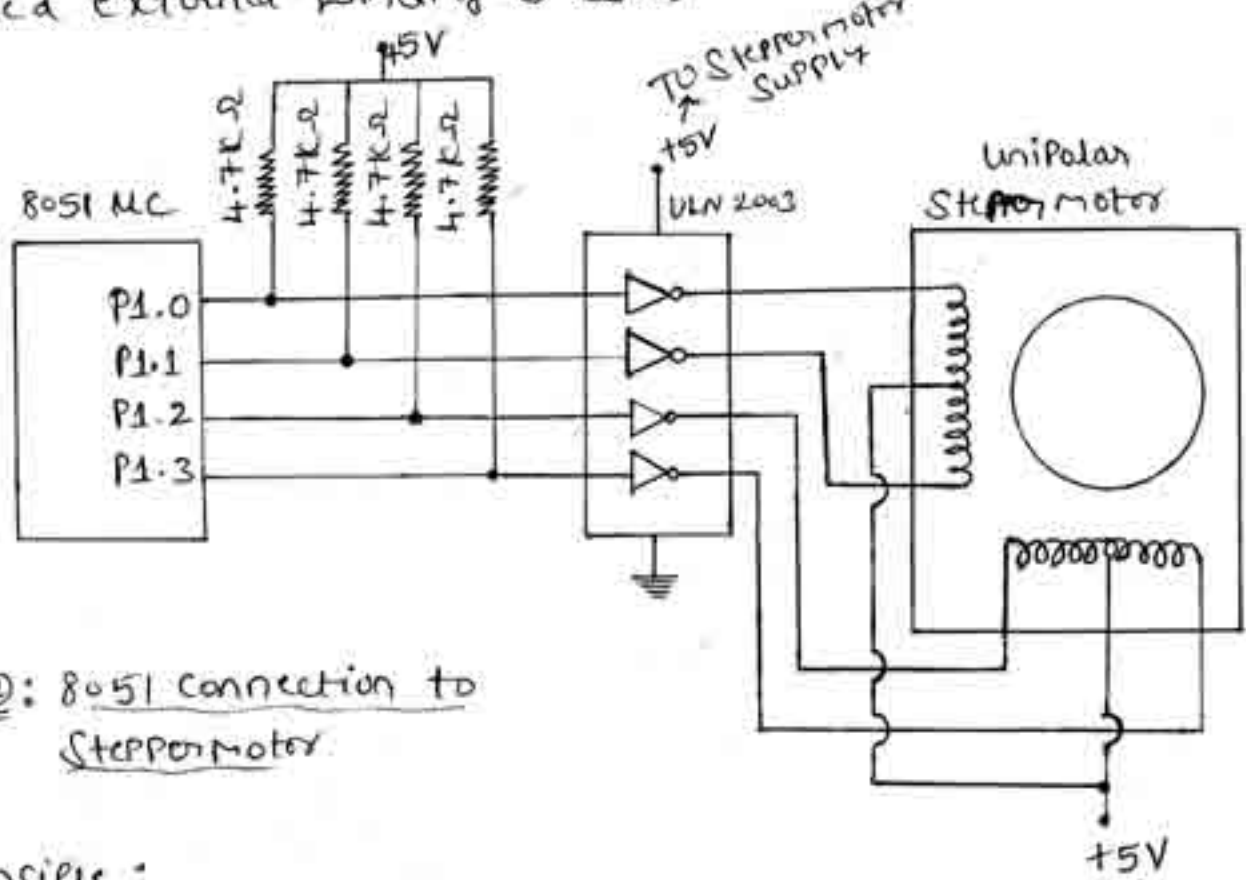


Fig 2: 8051 connection to Stepper motor.

Principle:

- The main principle of the circuit is to rotate the Stepper motor stepwise at a particular step angle.

- ④ The Speed of the motor is determined by the time delay between each incremental movement.
- ④ motor moves each time a pulse is received.
- ④ The stepper motor has 4 coils. These four coils are activated in the cyclic order method.
- ④ Full step drive: Two coils are energized at a time.
- ④ Half step drive: coils are energized alternatively.
- ④ Motor is connected to the Port 1 (P1.0 - P1.3) of the microcontroller through a driver IC.
- ④ The ULN 2003 IC is used to drive the stepper motor as the controller cannot provide current required by the motor (Stepper motor requires more than 60mA).
- ④ Table 3 shows a 2-phase, 4-step stepping sequence.

clock like	STEP #	Winding A	Winding B	Winding C	Winding D	Counter Clockwise
↓	1	1	0	0	1	↑
	2	1	1	0	0	
	3	0	1	1	0	
	4	0	0	1	1	

Table 3: Normal 4-Step Sequence

* Step angle (degrees) $\text{Step angle} = \frac{360}{\text{No of steps per revolution}}$

* Revolutions Per minute (RPM) $\text{RPM} = \frac{60 \times \text{Steps per second}}{\text{Steps per revolution}}$

* Advantages: • High resolution dynamic torque

- Requires low operating voltage
- consumes less power
- cost-effective
- No encoder is required for simple positioning etc

* Applications:

- Facsimile machines • Plotters • Image Scanners
- Copiers • Robotics • Dot matrix printers • Clock
- Card readers • floppy disk • hard disk drives
- tele printers • tele type