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Microprocessor VS Microcontroller

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***Abstract*:** Microprocessor and Microcontroller are the heart of computer and embedded respectively. This paper is written especially for the undergraduate students of almost all departments of Engineering and Technology. This paper mainly consists of difference and comparison study of microprocessor(8086) and microcontroller(8051). The features and architecture of both are described elaborately. Even the pin diagram of 8086 and 8051 are explained briefly. This paper consists of working and various advantages of microprocessor and microcontroller.

***Index Terms* - Microprocessor(8086), Microcontroller(8051), specification, comparative study, research methodology.**

I. INTRODUCTION

A)Microprocessor- A microprocessor is a computer processor that incorporates the functions of a central processing unit on a single integrated circuit (IC),or sometimes up to 8 integrated circuits. The microprocessor is a multipurpose, clock driven, register based, digital integrated circuit that accepts binary data as input, processes it according to instructions stored in its memory and provides results (also in binary form) as output. In short, it is a controlling unit of micro-computer, fabricated on a small chip capable of performing ALU operation and communicating with the other devices connected to it.[10][11]Microprocessor consists of an ALU , register array ,and a control unit. ALU performs arithmetical and logical operations on the data received from the memory or an input device. Register array consists of registers identified by letter like B,C,D,E,H,L and accumulator. The control unit controls the flow of data and instructions within the computer.[1]

B)Microcontroller- A Microcontroller is a compact tiny computer that is fabricated inside a chip and is used in automatic control systems including security systems, office machines, power tools, alarming system, traffic light control, washing machine, and much more. It is economical programmable logic control that can be interfaced with external devices in order to control the devices from a distance.[4] The microcontroller includes a CPU,ROM,RAM,I/O ports. Timer like a standard computer but because they are designed to execute only a single specific task to control a single system they are much smaller and simplified so that they can include all the function required on a single chip. Microcontrollers are sometimes called embedded microcontrollers, which just means that they are part of an embedded system that is, one part of a larger device or system.[3]

II. ARCHITECTURE

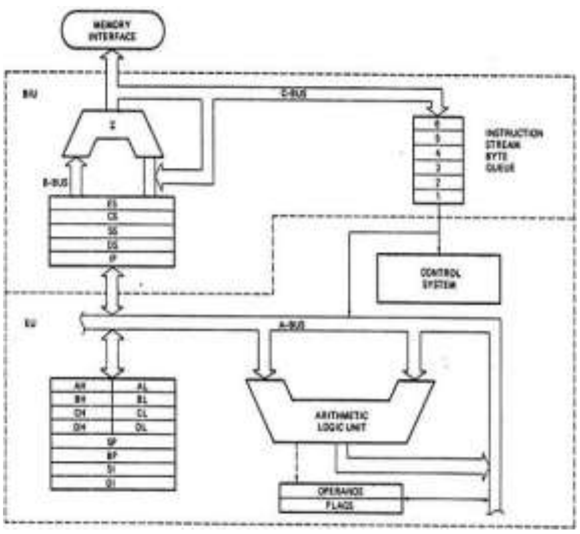

Fig 1. Architecture of Microprocessor

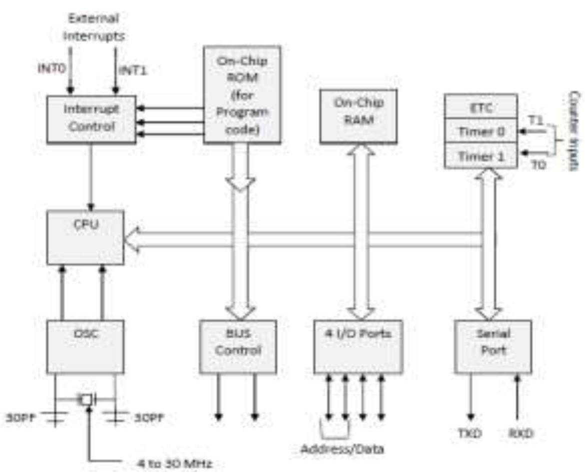

Fig 2. Architecture of Microcontroller

A) Microprocessor

The above diagram depicts the architecture of 8086 microprocessor. 8086 Microprocessor is divided into two functional units, i.e., EU(Execution Unit) and BIU(Bus Interface Unit).Execution unit gives instructions to BIU stating from where to fetch the data and then decode and execute those instructions. The Execution Unit (EU) has Control unit, Instruction decoder, Arithmetic and Logical Unit(ALU), General registers, Flag register, Pointers, Index registers. [5] Let us now discuss the functional parts of 8086 microprocessors.

1) ALU: It handles all arithmetic and logical operations, like +, −, ×, /, OR, AND, NOT operations.

2) Flag Register: It is a 16-bit register that behaves like a flip-flop, i.e. it changes its status according to the result stored in the accumulator. It has 9 flags and they are divided into 2 groups − Conditional Flags and Control Flags.

3) Conditional Flags: It represents the result of the last arithmetic or logical instruction executed. Following are the conditional flags Carry flag, Auxiliary flag, Parity flag, Zero flag, Sign flag, Overflow flag.

4) Control Flags: Control flags controls the operations of the execution unit. Following are the control flags –Trap flag, Interrupt flag, Directional flag.

5) General purpose register: There are 8 general purpose registers, i.e., AH, AL, BH, BL, CH, CL, DH, and DL. These registers can be used individually to store 8-bit data and can be used in pairs to store 16bit data.

6) Stack pointer register: It is a 16-bit register, which holds the address from the start of the segment to the memory location, where a word was most recently stored on the stack.[11]

BIU takes care of all data and addresses transfers on the buses for the EU like sending addresses, fetching instructions from the memory, reading data from the ports and the memory as well as writing data to the ports and the memory. EU and BIU are connected with the Internal Bus. BIU contains instruction queue, segment register and instruction pointer.[6]

- Instruction queue − BIU gets up to 6 bytes of next instructions and stores them in the instruction queue. When EU executes instructions and is ready for its next instruction, then it simply reads the instruction from this instruction queue resulting in increased execution speed.
- Segment register − BIU has 4 segment buses, i.e. CS, DS, SS& ES. It holds the addresses of instructions and data in memory, which are used by the processor to access memory locations.
- Instruction pointer − It is a 16-bit register used to hold the address of the next instruction to be executed.[9]

B) Microcontroller

The above diagram depicts the architecture of 8051 microcontroller. Central Processor Unit (CPU): It monitors and controls all operations that are performed on the Microcontroller units. The User has no control over the work of the CPU directly . It reads program written in ROM memory and executes them and do the expected task of that application.[1]

i)Interrupts: Interrupt is a subroutine call that interrupts of the microcontrollers main operations or work and causes it to execute any other program, which is more important at the time of operation. An Interrupts gives us a mechanism to put on hold the on going operations, execute a subroutine and then again resumes to another type of operations.[8]

ii)Memory: Microcontroller requires a program which is a collection of instructions. This program tells microcontroller to do specific tasks. These programs require a memory on which these can be saved and read by Microcontroller to perform specific operations of a particular task.[1]

iii)Bus: Basically Bus is a collection of wires which work as a communication channel or medium for transfer of Data. These buses consists of 8, 16 or more wires of the microcontroller.

a) Address Bus: Microcontroller 8051 has a 16 bit address bus for transferring the data

b)Data Bus: Microcontroller 8051 has 8 bits of the data bus, which is used to carry data of particular applications.[3]

iv)Oscillator: Microcontroller 8051 has an on-chip oscillator which works as a clock source for Central Processing Unit of the microcontroller. The output pulses of oscillator are stable. Therefore, it enables synchronized work of all parts of the 8051 Microcontroller.[3]

v)Input/ Output Port: Normally microcontroller is used in embedded systems to control the operation of machines in the microcontroller. Therefore, to connect it to other machines, devices or peripherals we require I/O interfacing ports in the microcontroller interface. For this purpose microcontroller 8051 has 4 input, output ports to connect it to the other peripherals.[3]

vi)Timers/Counters: 8051 microcontroller has two 16 bit timers and counters. These counters are again divided into a 8 bit register. The timers are used for measurement of intervals to determine the pulse width of pulses.[1]

III. PINDIAGRAM

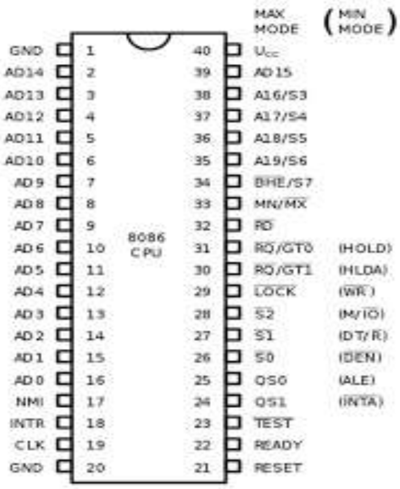

Fig 3. Pin diagram of microprocessor

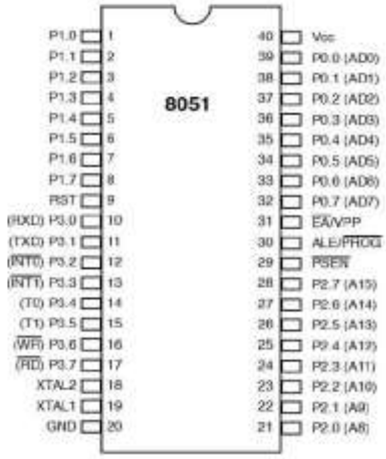

Fig 4. Pin diagram of Microcontroller

A) Microprocessor

1) Address Bus and Data Bus: The address bus is a group of sixteen lines i.e. A0-A15. The address bus is unidirectional, i.e., bits flow in one direction from the microprocessor unit to the peripheral devices and uses the high order address bus.[1]

2) Control and Status Signals:

- ALE: It is an Address Latch Enable signal. It goes high during first T state of a machine cycle and enables the lower 8-bits of the address, if its value is 1 otherwise data bus is activated.
- IO/M’: It is a status signal which determines whether the address is for input-output or memory. When it is high (1) the address on the address bus is for input-output devices. When it is low (0) the address on the address bus is for the memory.
- SO, S1: These are status signals. They distinguish the various types of operations such as halt, reading, instructions fetching or writing.

S1	S2	STATUS
1	1	OPCODE FETCH
1	0	MEMORY READ
0	1	MEMORY WRITE
1	0	I/O READ
0	1	I/O WRITE
1	1	INTERRUPT ACKNOWLEGEMENT
0	0	HALT

Table 1[7]

- RD’: It is a signal to control READ operation. When it is low the selected memory or input-output device is read.
- WR’: It is a signal to control WRITE operation. When it goes low the data on the data bus is written into the selected memory or I/O location.
- READY: It senses whether a peripheral is ready to transfer data or not. If READY is high(1) the peripheral is ready. If it is low(0) the microprocessor waits till it goes high. It is useful for interfacing low speed devices.

3) Power Supply and Clock Frequency:

- Vcc: +5v power supply
- Vss: Ground Reference
- XI, X2: A crystal is connected at these two pins. The frequency is internally divided by two, therefore, to operate a system at 3MHZ the crystal should have frequency of 6MHZ.
- CLK (OUT): This signal can be used as the system clock for other devices.[2]

4) Interrupts and Peripheral Initiated Signals:

The 8085 has five interrupt signals that can be used to interrupt a program execution.

(i) INTR
(ii) RST 7.5
(iii) RST 6.5
(iv) RST 5.5
(v) TRAP

The microprocessor acknowledges Interrupt Request by INTA’ signal. In addition to Interrupts, there are three externally initiated signals namely RESET, HOLD and READY. To respond to HOLD request, it has one signal called HLDA.

- INTR: It is an interrupt request signal.

- INTA’: It is an interrupt acknowledgment sent by the microprocessor after INTR is received.[4]

5) Reset Signals:

- RESET IN’: When the signal on this pin is low(0), the program-counter is set to zero, the buses are tri-stated and the microprocessor unit is reset.
- RESET OUT: This signal indicates that the MPU is being reset. The signal can be used to reset other devices.[8]

6) DMA Signals:

- HOLD: It indicates that another device is requesting the use of the address and data bus. Having received HOLD request the microprocessor relinquishes the use of the buses as soon as the current machine cycle is completed. Internal processing may continue. After the removal of the HOLD signal the processor regains the bus.
- HLDA: It is a signal which indicates that the hold request has been received after the removal of a HOLD request, the HLDA goes low.

7) Serial I/O Ports:

Serial transmission in 8085 is implemented by the two signals,

- SID and SOD – SID is a data line for serial input whereas SOD is a data line for serial output.[10]

B) Microcontroller

The Pin Description or Pin Configuration of the 8051 Microcontroller will describe the functions of each pins of the 8051 Microcontroller. Let us now see the pin description.

Pins 1 – 8 (PORT 1): Pins 1 to 8 are the PORT 1 Pins of 8051. PORT 1 Pins consists of 8 – bit bidirectional Input / Output Port with internal pull – up resistors. In older 8051 Microcontrollers, PORT 1 doesn’t serve any additional purpose but just 8 – bit I/O PORT.

In some of the newer 8051 Microcontrollers, few PORT 1 Pins have dual functions. P1.0 and P1.1 act as Timer 2 and Timer 2 Trigger Input respectively. P1.5, P1.6 and P1.7 act as In-System Programming Pins i.e. MOSI, MISO and SCK respectively.[1]

Pin 9 (RST): Pin 9 is the Reset Input Pin. It is an active HIGH Pin i.e. if the RST Pin is HIGH for a minimum of two machine cycles, the microcontroller will be reset. During this time, the oscillator must be running.

Pins 10 – 17 (PORT 3): Pins 10 to 17 form the PORT 3 pins of the 8051 Microcontroller. PORT 3 also acts as a bidirectional Input / Output PORT with internal pull-ups. Additionally, all the PORT 3 Pins have special functions. The following table gives the details of the additional functions of PORT 3 Pins.[11]

PORT 3 PIN	FUNCTION	DESCRIPTION
P3.0	RXD	SERIAL INPUT
P3.1	TXD	SEROAL OUTPUT
P3.2	INTO	EXTERNAL INTERRUPT 0
P3.3	INT1	EXTERNAL INTERRUPT 1
P3.4	TO	TIMER 0
P3.5	T1	TIMER 1
P3.6	WR	EXTERNAL MOMORY WRITE
P3.7	RD	EXTERNAL MEMORY READ

Table 2[7]

Pins 18 & 19: Pins 18 and 19 i.e. XTAL 2 and XTAL 1 are the pins for connecting external oscillator. Generally, a Quartz Crystal Oscillator is connected here.

Pin 20 (GND): Pin 20 is the Ground Pin of the 8051 Microcontroller. It represents 0V and is connected to the negative terminal (0V) of the Power Supply.

Pins 21 – 28 (PORT 2): These are the PORT 2 Pins of the 8051 Microcontroller. PORT 2 is also a Bidirectional Port i.e. all the PORT 2 pins act as Input or Output. Additionally, when external memory is interfaced, PORT 2 pins act as the higher order address byte. PORT 2 Pins have internal pull-ups.[11]

Pin 29 (PSEN): Pin 29 is the Program Store Enable Pin (PSEN). Using this pins, external Program Memory can be read. Pin 30 (ALE/PROG): Pin 30 is the Address Latch Enable Pin. Using this Pins, external address can be separated from data (as they are multiplexed by 8051).During Flash Programming, this pin acts as program pulse input (PROG).Pin 31 (EA/VPP): Pin 31 is the External Access Enable Pin i.e. allows external Program Memory. Code from external program memory can be fetched only if this pin is LOW. For normal operations, this pins is pulled HIGH. During Flash Programming, this Pin receives 12V Programming Enable Voltage (VPP).[3]

Pins 32 – 39 (PORT 0): Pins 32 to 39 are PORT 0 Pins. They are also bidirectional Input / Output Pins but without any internal pull-ups. Hence, we need external pull-ups in order to use PORT 0 pins as I/O PORT. In addition to acting as I/O PORT, PORT 0 also acts as lower order address/data bus when external memory is accessed.

Pin 40 (VCC): Pin 40 is the power supply pin to which the supply voltage is given (+5V).[11]

IV. WORKING

Fig 5. Microprocessor[7]

Fig 6. Microcontroller[7]

A)Microprocessor

A processor is the brain of a computer which basically consists of Arithmetical and Logical Unit (ALU), Control Unit and Register Array. As the name indicates ALU performs all arithmetic and logical operations on the data received from input devices or memory. Register array consists of a series of registers like accumulator (A), B, C, D etc. which acts as temporary fast access memory locations for processing data. As the name indicates, control unit controls the flow of instructions and data throughout the system.[11]

B)Microcontroller

Microcontrollers are embedded inside devices to control the actions and features of a product. Hence, they can also be referred to as embedded controllers. They run one specific program and are dedicated to a single task. They are low power devices with dedicated input devices and small LED or LCD display outputs. Microcontrollers can take inputs from the device they controlling and retain control by sending the device signals to different parts of the device. A good example is a TV's microcontroller. It takes input from a remote control and delivers its output on the TV screen.[9]

V. COMPARISON

MICROPROCESSOR	MICROCONTROLLER
Microprocessor is heart of Computer system.	Microcontroller is a heart of embedded system.
It is just a processor. Memory and I/O components have to be connected externally.	Microcontroller has external processor along with internal memory and I/O components.
Since memory and I/O has to be connected externally the circuit becomes large.	Since memory and I/O are present internally, the circuit is small.
Cannot be used in compact systems and hence inefficient.	Can be used in compact systems and hence it is and efficient technique.
Cost of entire system increases.	Cost of the entire system is low.
Due to external components, the entire power consumption is high. Hence it is not suitable to used with device running on stored power like batteries.	Since external components are low, total power consumption is less and can be used with devices running on stored power like batteries.
Most of the microprocessor do not have power saving features.	Most of the microcontroller have power saving modes like idle mode and power saving mode. This helps to reduce power consumption even further.
Since memory and I/O components are all external, each instruction will need external operation, hence it is relatively slower.	Since components are internal, most of the operations are internal instruction, hence speed is fast.
Microprocessor have less number of registers, hence more operations are memory based.	Microcontroller have more number of registers, hence the programs are easier to write.
Microprocessors are based on von Nenmann model/architecture where program and data are stored in same memory module.	Microcontrollers are based on Harvard architecture where program memory and data memory are separate.
Mainly used in personal computer.	Used mainly in washing machine, MP3 players.

Table 3[7]

VI. ADVANTAGE

I)Microprocessor

a) Replacement of discrete logic-based circuits.
b) Provide functional upgrades.
c) Provide easy maintenance upgrade.
d) Improve mechanical performance.
e) Protection of intellectual property(IP).
f) Replacement of analog circuits.[11]

II)Microcontroller

a) Low time required for performing operation.
b) The processor chips are very flexibility occurs.
c) Due to their higher integration, cost and size of the system is reduced.
d) The microcontroller is easily to interface additional RAM, ROM and I/O ports.
e) Once microcontrollers are programmed then they cannot be reprogrammed.
f) At the same time many task can be performed so human effect can saved.[9]

VII. CONCLUSION

The basic part of any computer is formed by microprocessor on the other microcontroller forms a key component of an embedded system. A microprocessor can perform operation for various different task whereas microcontroller performs the some task for it's entire life. The undeniable thing is that both of them are different from each other in various aspects, which is often not known by many people.

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