MICROPROCESSOR 8085

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MICROPROCESSOR

What is a Microprocessor?

- The word comes from the combination micro and processor.
- Processor means a device that processes whatever.
  - In this context, processor means a device that processes numbers (specifically binary numbers, 0's and 1's).
  - To process means to manipulate.
  - It is a general term that describes all manipulation.
  - It means to perform certain operations on the numbers that depend on the microprocessor's design.

MICROPROCESSOR

- Micro is a new addition.
- In the late 1960's,
  - processors were built using discrete elements.
  - These devices performed the required operation, but were too large & slow.
- In the early 1970's
  - the microchip was invented. All of the components that made up the processor were now placed on a single piece of silicon.
  - The size became several thousand times smaller and the speed became several hundred times faster.
  - The "Micro" Processor was born.

MICROPROCESSOR

- A Microprocessor (μP) is a multipurpose, programmable, clock-driven, register based integrated device (IC) that
  - has computing (when used as data processing unit) and decision making (when used to control process) capabilities.
  - reads binary instructions (program) from a storage device called memory, accepts binary data as input and processes data (arithmetic or logical operations) according to those instructions and provides results as output.

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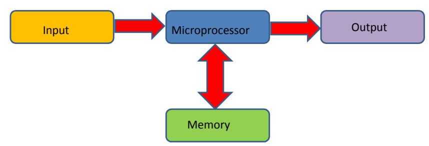
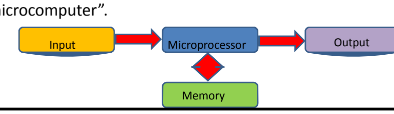
- From the above description, we can draw the following block diagram to represent a microprocessor-based system:



MICROPROCESSOR

- A programmable machine can be represented with four components; microprocessor, memory, input and output.
- These four components work together or interact with each other to perform a given task.
- A computer with a microprocessor (μP)as its CPU is known as "microcomputer".



MICROPROCESSOR ARCHITECTURE

- The internal logic design of the microprocessor called its architecture, determine how and what operations are performed by the microprocessor (μP).
- All the various functions performed by the 8085/8080A μP can be classified in three general categories.
  - Microprocessor initiated operations.
  - Internal data operation.
  - Peripheral (External) initiated operation.

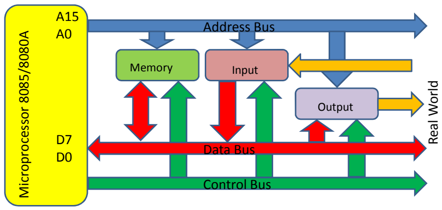
Microprocessor Initiated Operations

- The 8085/8080A microprocessor unit performs primarily four operations;
  1. Memory Read — Reads data from memory
  2. Memory Write — Writes data into memory
  3. I/O Read — Accept data from input devices
  4. I/O Write — Sends data to output devices
- All these operations are part of the communication process between the μP unit and peripheral devices including memory.

Microprocessor Initiated Operations

- The 8085 μP unit performs these functions using three sets of communication lines called buses. They are;
  - Address Bus
  - Data Bus
  - Control Bus

Microprocessor Initiated Operations



Microprocessor Initiated Operations

ADDRESS BUS

- A group of 16 lines; A0 to A15.
- Unidirectional, i.e., bits flow from the μP to memory/peripheral devices.
- Function: Identifying peripheral/memory location.
- Capable of addressing 2^{16} bits = 65536 bits = 64 kb memory location.

Microprocessor Initiated Operations

DATA BUS

- A group of 8 lines; D0 to D7
- Bidirectional, i.e., data flow in both directions between the μP and peripheral devices/memory.
- Function: Transferring data.
- Manipulate 8 bit data (2^8 = 256 no's) ranging from 00_H to FF_H.

Microprocessor Initiated Operations

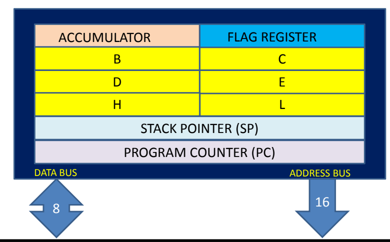
CONTROL BUS

- comprised of various single lines
- carry Synchronization signal
- Function: provides Timing Signal used to identify a device type.
- Control Signal

Internal Data Operation

- To perform various operations the microprocessor requires the following units -
  - Registers
  - Accumulator
  - Flags
  - Program Counter (PC)
  - Stack Pointer (SP)

Internal Data Operation



Internal Data Operation

- **REGISTERS**
  - General Purpose Registers to store 8 bit data.
  - B, C, D, E, H & L (8 bit registers)
  - Can be used singly
  - or can be used as 16 bit register pairs
  - BC, DE, HL
  - H & L can be used as a data pointer (holds memory address).
  - Registers are programmable.

Internal Data Operation

- **ACCUMULATOR**
  - Special Purpose Registers – A
  - 8 bit register
  - part of Arithmetic & Logic Unit (ALU)
  - Perform arithmetic & logical operations
  - Store the result of an operation
  - Store 8 bit data during I/O transfer

Internal Data Operation

- **FLAGS**
  - 8 bit register – shows the status of the microprocessor before/after an operation
  - ALU includes five flip flops known as Flags.
  - Used for testing the data conditions in the accumulator and other registers.
  - S (sign flag), Z (zero flag), AC (auxiliary carry flag), P (parity flag) & CY (carry flag)

S	Z	X	AC	X	P	X	CY

Internal Data Operation

- **The Program Counter (PC)**
  - This is a 16-bit register that is used to control the sequencing of the execution of instructions.
  - This is a memory pointer.
  - This register always holds the address of the next instruction.
  - Since it holds an address, it must be 16 bits wide.

Internal Data Operation

- **The Stack Pointer (SP)**
  - The stack pointer is also a 16-bit register
  - That is used to point into memory. The R/W memory this register points to is a special area called the stack.
  - The stack is an area of R/W memory used to hold data that will be retrieved soon.
  - It store the address of last data byte written into the stack
  - The stack is usually accessed in a Last In First Out (LIFO) fashion.

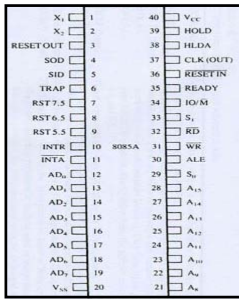
Externally Initiated Operations

- External Devices can initiate the following operations:
  - Reset
    - All internal operations are suspended and the execution begins at zero memory address
  - Interrupt
    - Interrupt normal execution and execute some other instruction called service routine
  - Ready
    - Enters into wait state. Synchronize slower peripherals with the microprocessor.
  - Hold
    - Give up control of buses and allow the external peripheral to use them.

The 8085 Microprocessor

- 8-bit general purpose µP
- Capable of addressing 64 KB of memory
- Has 40 pins
- Requires +5 v power supply
- Can operate with 3 MHz clock
- 8085 upward compatible

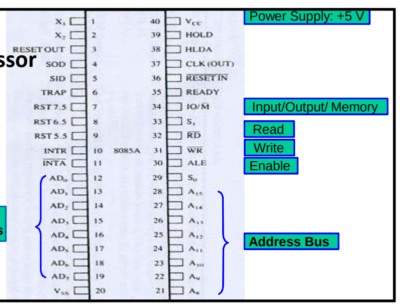
8085 Microprocessor

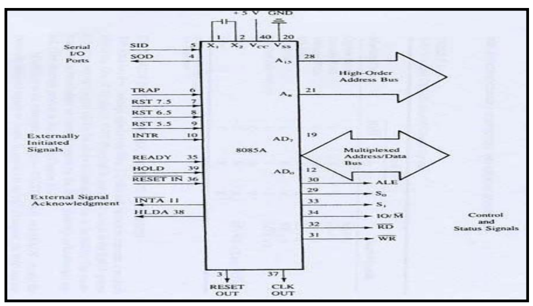


The 8085 Microprocessor and its Buses

- The pins on the chip can be grouped into 6 groups:
- Address Bus.
- Data Bus.
- Control and Status Signals.
- Power supply and frequency.
- Externally Initiated Signals.
- Serial I/O ports.

8085 Microprocessor





The Address and Data Bus Systems

- The address bus has 8 signal lines A8 – A15 which are unidirectional.
- The other 8 address bits are multiplexed (time shared) with the 8 data bits.
  - So, the bits AD0 – AD7 are bi-directional and serve as A0 – A7 and D0 – D7 at the same time.
  - During the execution of the instruction, these lines carry the address bits during the early part, then during the late parts of the execution, they carry the 8 data bits.
  - In order to separate the address from the data, we can use a latch to save the value before the function of the bits changes.

The Control and Status Signals

- There are 4 main control and status signals. These are:
  - ALE: Address Latch Enable. This signal is a pulse that become 1 when the AD0–AD7 lines have an address on them. It becomes 0 after that. This signal can be used to enable a latch to save the address bits from the AD lines.
  - RD: Read. Active low.
  - WR: Write. Active low.
  - IO/M: This signal specifies whether the operation is a memory operation (IO/M=0) or an I/O operation (IO/M=1).
  - S1 and S0 : Status signals to specify the kind of operation being performed. Usually not used in small systems.

Frequency Control & Power Supply Signals

- There are 3 important pins in the frequency control group.
  - X0 and X1 are the inputs from the crystal or clock generating circuit.
    - The frequency is internally divided by 2.
    - So, to run the microprocessor at 3 MHz, a clock running at 6 MHz should be connected to the X0 and X1 pins.
  - CLK (OUT): An output clock pin to drive the clock of the rest of the system.
- The V_{cc} and V_{ss} are power supply and ground pin, respectively.

Interrupts and Externally Initiated Operations

- Five Interrupt signals which can be used to interrupt execution.
- Interrupt
  - INTR (Interrupt Request) – general purpose interrupt.
    - INTA (Interrupt Acknowledge) – acknowledge an interrupt.
  - RST (Restart Interrupt) – vector interrupt, higher priority than interrupt. Priority order
    - RST 7.5
    - RST 6.5
    - RST 5.5
  - TRAP – Non-maskable interrupt and has highest priority.

Externally Initiated Operations

- RESET signals
  - RESET IN – PC is set to zero and the μP is reset.
    - RESET OUT – indicates that μP is being reset.
- HOLD signals
  - HOLD (Hold Request) – Peripherals is requesting the use of Buses.
    - HLDA (Hold Acknowledge) – acknowledge the HOLD request.
- READY signals
  - READY – delay the μP until a slow peripheral is ready.

Serial Input / Output Ports

- Two signals to implement the serial transmission, i.e., data bits are sent over a single line one bit at a time.
  - SID (Serial Input Data)
  - SOD (Serial Output Data)

Demultiplexing Bus AD7-AD0

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Demultiplexing Bus AD7-AD0

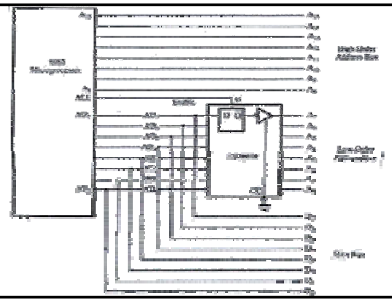
- The AD7– AD0 lines are serving a dual purpose and that they need to be demultiplexed to get all the information.
- The high order bits of the address remain on the bus for three clock periods. However, the low order bits remain for only one clock period and they would be lost if they are not saved externally. Notice that the low order bits of the address disappear when they are needed most.

Demultiplexing Bus AD7-AD0

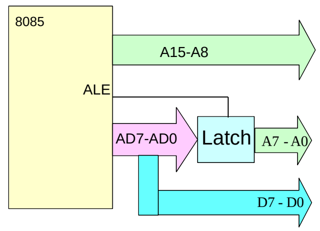
- To make sure we have the entire address for the full three clock cycles, we will use an external latch to save the value of AD7– AD0 when it is carrying the address bits. We use the ALE signal to enable this latch.
- Given that ALE operates as a pulse during T1, we will be able to latch the address. Then when ALE goes low, the address is saved and the AD7– AD0 lines can be used for their purpose as the bi-directional data lines

Demultiplexing Bus AD7-AD0

- The high order address is placed on the address bus and hold for 3 CLK periods.
- The low order address is lost after the first CLK period, this address needs to be hold however we need to use latch.
- The address AD7 – AD0 is connected as inputs to the latch 74LS373.
- The ALE signal is connected to the enable (G) pin of the latch and the OC – Output control – of the latch is grounded



Demultiplexing Bus AD7-AD0

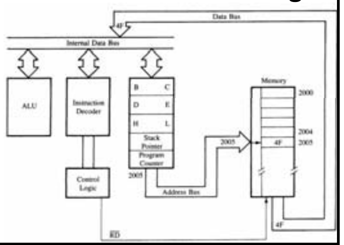


MPU Communication and Bus Timing

- **Example**: Illustrate the steps and the timing of data flow MOV C A when the instruction code 0100 1111 (4FH), stored in location 2005H is being fetched.

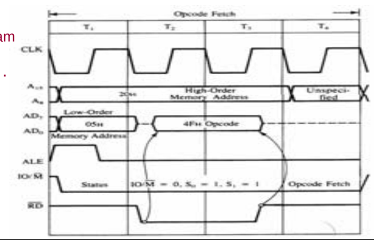
MPU Communication and Bus Timing

Moving data form memory to MPU using instruction **MOV C, A** (code machine 4FH = 0100 1111)



MPU Communication and Bus Timing

8085 timing diagram for Opcode fetch cycle for **MOV C, A** .



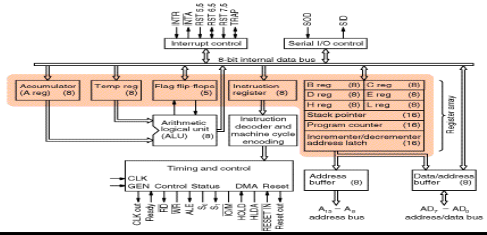
MPU Communication and Bus Timing

- The Fetch Execute Sequence :
  1. The μP placed a 16 bit memory address from PC (program counter) to address bus.
  2. At T1:
     - The high order address, 20H, is placed at A15 – A8.
     - the low order address, 05H, is placed at AD7 - AD0 and ALE is active high.
     - Synchronously the IO/M is in active low condition to show it is a memory operation.
  3. At T2:
     - the active low control signal, RD, is activated so as to activate read operation; it is to indicate that the MPU is in fetch mode operation.

MPU Communication and Bus Timing

4. At T3:
   - The active low RD signal enabled the byte instruction, 4FH, to be placed on AD7 – AD0 and transferred to the MPU. While RD high, the data bus will be in high impedance mode.
5. At T4:
   - The machine code, 4FH, will then be decoded in instruction decoder. The content of accumulator (A) will then copied into C register at time state, T4.

Architecture of Intel 8085 μP



The Flags Register

- Flag register whose bits are affected by the ALU operations.
  - S-sign flag: The sign flag is set if bit D7 of the accumulator is set after an arithmetic or logic operation.
  - Z-zero flag: Set if the result of the ALU operation is 0. Otherwise is reset. This flag is affected by operations on the accumulator as well as other registers. (DCR B).
  - AC-Auxiliary Carry: This flag is set when a carry is generated from bit D3 and passed to D4 . This flag is used only internally for BCD operations.
  - P-Parity flag :After an ALU operation, if the result has an even # of 1s, the p-flag is set. Otherwise it is cleared. So, the flag can be used to indicate even parity.
  - CY-carry flag: This flag is set when a carry is generated from bit D7 after an unsigned operation.

MICROPROCESSOR 8085

ENDS

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Programmable device:

- The microprocessor can perform different sets of operations on the data it receives depending on the sequence of instructions supplied in the given program.
- By changing the program, the microprocessor manipulates the data in different ways.

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Instructions:

- Each microprocessor is designed to execute a specific group of operations. This group of operations is called an instruction set. This instruction set defines what the microprocessor can and cannot do.

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Takes in data: The data that the microprocessor manipulates must come from somewhere.

- It comes from what is called “input devices”.
- These are devices that bring data into the system from the outside world.
- These represent devices such as a keyboard, a mouse, switches, and the like.

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Numbers:

- The microprocessor has a very narrow view on life. It only understands binary numbers.
- A binary digit is called a bit. The Microprocessor recognizes and processes a group of bits together. This group of bits is called a “word”.
- The number of bits in a Microprocessor’s word, is a measure of its “abilities”.

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Arithmetic and Logic Operations:

- Every microprocessor has arithmetic operations such as add and subtract as part of its instruction set.
- Most microprocessors will have operations such as multiply and divide.
- Some of the newer ones will have complex operations such as square root.
- In addition, microprocessors have logic operations as well. Such as AND, OR, XOR, shift left, shift right, etc.

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Stored in memory:

- When a program is entered into a computer, it is stored in memory. Then as the microprocessor starts to execute the instructions, it brings the instructions from memory one at a time.
- Memory is also used to hold the data.
- The microprocessor reads (brings in) the data from memory when it needs it and writes (stores) the results into memory when it is done.

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Produces:

- For the user to see the result of the execution of the program, the results must be presented in a human readable form.
- The results must be presented on an output device.
- This can be the monitor, a paper from the printer, a simple LED or many other forms.