Sub Code: 18BIT46S

Skill Based Subject – II: MICRO PROCESSOR & ASSEMBLY LANGUAGE PROGRAMMING

UNIT I: Introduction to Microprocessors – Evolution of Microprocessors- Buses -Microprocessor Architecture: Intel 8085 – ALU - Timing and control unit – Registers - Pin configuration - Instruction cycle: Fetch and Execute operation - Machine cycle and state.

UNIT II: Instruction set of INTEL 8085: Introduction – Instruction and Data formats - Addressing Modes - Status Flags - Intel 8085 Instructions: Data transfer group – Arithmetic group- Logical group - Branch group - Stack, I/O machine control group - Assembly language: stacks – subroutines – MACRO.

UNIT III: Assembly language programming - Addition of two 8-bit numbers - 8-bit subtraction - Decimal addition of two 8-bit numbers - Addition of two 16-bit numbers - 8-bit decimal subtraction - finding square from look-up table - Finding largest number in a data array - Arrange a data array in ascending and descending order - Sum of series of 8-bit numbers - 8-bit multiplication - 8-bit division.

UNIT IV: Peripheral devices and their interfacing: Address space partitioning - Memory and I/O interfacing -Data Transfer schemes- Interrupts of Intel 8085.

UNIT V: I/O ports- Programmable Peripheral interface - Architecture of Intel 8255-Programmable DMA controller - Programmable interrupt controller 8259 - Programmable communication interface 8251.

TEXT BOOK

1. B.RAM, “Fundamentals of Microprocessors and Microcontrollers”, Dhanpat Rai Publications, 7thEdition, 2010.

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UNIT I: Introduction to Microprocessors – Evolution of Microprocessors- Buses -Microprocessor Architecture: Intel 8085 – ALU - Timing and control unit – Registers - Pin configuration - Instruction cycle: Fetch and Execute operation - Machine cycle and state.

What is a Microprocessor

The microprocessor is nothing but the CPU and it is an essential component of the computer. It is a silicon chip that comprises millions of transistors and other electronic components that process millions of instructions per second. It accepts digital data as input and processes it according to the instructions stored in the memory. The microprocessor has many functions like functions of data storage, interact with various other devices and other time related functions. But the main function is to send and receive the data to make the function of the computer well.

How does a Microprocessor work?

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.

So basically, a microprocessor takes input from input devices, process it as per instructions given in the memory and produces output.

Evolution of Microprocessor

The microprocessor has become more essential part of many gadgets. The evolution of microprocessors was divided into five generations such as first, second, third, fourth and fifth generation and the characteristics of these generations are discussed below.

First Generation Microprocessors

The first-generation microprocessors were introduced in the year 1971-1972. The instructions of these microprocessors were processed serially, they fetched the instruction, decoded and then executed it.

Intel started marketing its first microprocessor in the name of Intel 4004 in 1971. This was a4-bit microprocessor having 16-pins in a single chip of PMOS technology. This was called the first-generation microprocessor. The Intel 4004 along with few other devices was used for making calculators. The 4004-instruction set contained only 45 instructions. Later in 1971, INTEL Corporation released the 8008 – an extended 8-bit version of the 4004 microprocessors. The 8008 addressed an expanded memory size (16KB) and 48 instructions.

Limitations of first-generation microprocessors is small memory size, slow speed and instruction set limited its usefulness.

Second Generation Microprocessors

In the year 1970, small number of transistors were available on the integrated circuit in the second generation microprocessors. Examples of the second generation microprocessors are 16-bit arithmetic 7 pipelined instruction processing, MC68000 Motorola microprocessor. These processors are introduced in the year 1979, and Intel 8080 processor is another example of the microprocessor.

The difference between the first generation microprocessor and second generation microprocessors was mainly the use of new semiconductor technologies to manufacture the chips. The advantages of second generation microprocessors were

- Large chip size (170x200 mil) with 40-pins
- Ability to address large memory space (64-K Byte) and I/O ports (256).
- More powerful instruction sets.
- Better interrupt handling facilities.
- Used Single Power Supply

Third Generation Microprocessors

The third generation microprocessors were introduced in the year 1978, as denoted by Intel's 8086 and the Zilog Z8000. These were 16-bit processors with a performance like mini computers. These types of microprocessors were different from the previous generations of microprocessors in that all main workstation industrialists began evolving their own ISC based microprocessor architectures.

Fourth Generation Microprocessors

As many industries converted from commercial microprocessors to in house designs, the fourth-generation microprocessors are entered with outstanding design with a million transistors. Leading edge microprocessors like Motorola's 88100 and Intel's 80960CA could issue & retire more than one instruction per clock cycle.

Fifth Generation Microprocessors

Fifth generation microprocessors employed decoupled super scalar processing, and their design soon exceeded 10 million transistors. In fifth generation, PCs are a low-margin, high volume business conquered by a single microprocessor.

Classification of Microprocessor

The microprocessor is identified with the word size of data. For E.g. The ALU can perform a 4-bit data operation at a time these microprocessors is called as 4-bit microprocessor.

4-Bit Processors	:	INTEL 404 4040
8-Bit Processors	:	8008 8080 8085 MOTOROLA 6800 (M6800)
16-Bit Processors	:	8086 8088 Zilog Z800 80186 80286
32-Bit Processors	:	Intel 80386 80387 80486 PENTIUM PENTIUM PRO

Applications of the microprocessors

A microprocessor makes daily life easier because of its low cost, low power, small weight, and vast application in every field. There are several applications of microprocessors. Some of the important applications are:

Household Devices

- The programmable thermostat allows the control of temperature at homes. In this system, a microprocessor works with the temperature sensor to determine and adjust the temperature accordingly.
- High-end coffee makers, Washing machines, and radio clocks contain microprocessor technology.
- Some other home items that contain microprocessors are: microwaves, toasters, televisions, VCRs, DVD players, ovens, stoves, clothes washers, stereo systems, home computers, alarm clocks, hand-held game devices, thermostats, video game systems, bread machines, dishwashers, home lighting systems and even some refrigerators with digital temperature control.

Industrial Applications of Microprocessors

- Some industrial items which use microprocessors technology include: cars, boats, planes, trucks, heavy machinery, elevators, gasoline pumps, credit-card processing units, traffic control devices, computer servers, most high tech medical devices, surveillance systems, security systems, and even some doors with automatic entry.

Transportation Industry

- Automobiles, trains and planes also use microprocessor technology.
- Consumer vehicles-buses, cars, trucks -integrate microprocessors to communicate important information throughout the vehicle. E.g., navigation systems provide information using microprocessors and global positioning system (GPS) technology.

Computers and Electronics

- Microprocessor-drives technology is the brain of the computer. They are used in all type of computers ranging from microcomputers to supercomputers.
- A cell phone or mobile device executes game instructions by way of the microprocessor.
- VCRs, televisions and gaming platforms also contain microprocessors for executing complex instructions and tasks.

In Medicals

- Many medical devices, like an insulin pump, are typically controlled by a microprocessor. The microprocessors perform various functions, such as processing data from bio-sensors, storing measurements, and analyzing results.

Instrumentation

- Microprocessor is also very useful in the field of instrumentation. Function generators, frequency counters, frequency synthesizers, spectrum analyses and many other instruments are available, when microprocessors are used as controller.

Entertainment

- The use of microprocessor in entertainment equipment, toys and home entertaining applications is making them more useful and full of features.

Buses

Bus is a group of conducting wires which carries information, all the peripherals are connected to microprocessor through Bus.
There are three types of buses.

1. Address bus – It is a group of conducting wires which carries address only. Address bus is unidirectional because data flow in one direction, from microprocessor to memory or from microprocessor to Input/output devices.
Length of Address Bus of 8085 microprocessors is 16 Bit. The microprocessor 8085 can transfer maximum 16-bit address.
The Length of the address bus determines the amount of memory a system can address. Such as a system with a 32-bit address bus can address 2^32 memory locations. If each memory location holds one byte, the addressable memory space is 4 GB. However, the actual amount of memory that can be accessed is usually much less than this theoretical limit due to chipset and motherboard limitations.

2. Data bus – It is a group of conducting wires which carries Data only. Data bus is bidirectional because data flow in both directions, from microprocessor to memory or Input/Output devices and from memory or Input/Output devices to microprocessor.
Length of Data Bus of 8085 microprocessors is 8 Bit.
When it is write operation, the processor will put the data on the data bus, when it is read operation, the memory controller will get the data from specific memory block and put it into the data bus.
The width of the data bus is directly related to the largest number that the bus can carry, such as an 8-bit bus can represent 2 to the power of 8 unique values, this equates to the number 0 to 255.A 16-bit bus can carry 0 to 65535.

3. Control bus – It is a group of conducting wires, which is used to generate timing and control signals to control all the associated peripherals, microprocessor uses control bus to process data, that is what to do with selected memory location. Some control signals are:

- Memory read
- Memory write
- I/O read
- I/O Write
- Opcode fetch

If one line of control bus may be the read/write line. If the wire is low, then the memory is read, if the wire is high then the memory is written.
Diagram to represent bus organization system of 8085 Microprocessor.

Microprocessor Architecture: Intel 8085

The microprocessor is the central processing unit (CPU) of a micro computer. It is the heart of the computer.

INTEL 8085

Intel 8085 is pronounced as "eighty-eighty-five" microprocessor. It is an 8-bit microprocessor designed by Intel in 1977 using NMOS technology. It is a forty pin IC (Integrated Circuit) package fabricated on a single LSI (Large scale Integration) chip.
It uses a single +5 Volt d.c. (Direct Current) supply for its operation. Its clock speed is 3 MHz. It consists of 3 main sections.
1-Arithmetic Logic Unit (ALU)
2-Timing and control unit
3-Several Registers

Arithmetic Logic Unit:
It performs various Arithmetic and Logical operations.
Addition, Subtraction, Logical AND, Logical OR, Logical EXCLUSIVE OR, Complement (Logical NOT), Increment, Decrement, Left shift and Clear.

Timing and control unit:
It generates timing and control signals which are necessary for the execution of the instructions. It controls the data flow between CPU and peripheral. It provides status, control and timing signals which are required for the operation of memory and I/O devices. The control unit of the CPU acts as the brain of the computer system.

Registers:
Figure shows the various registers of Intel 8085. It is a collection of flip flops use to store a binary word. they are used by the microprocessor for the temporary storage and manipulation of data and instructions.

Intel 8085 has the following registers:

1-One 8-bit accumulator (ACC) i.e. register A
2-Six 8-bits general purpose registers i.e. B, C, D, E, H, L
3-One 16-bit Stack pointer (SP)
4-One 16-bit Program counter (PC)
5- Instruction Register
6. Status register
7-Temporary register

The register A holds the operands during program execution.
There are six 8-bit general purpose registers B, C, D, E, H, L are to handle 16-bit data. Two 8-bit registers can be combined. this is called register pair. Valid pair of 8085 are B-C, D-E, H-L. The H-L pair is used as address memory location. B-C, D-E are used for access another function.

STACK POINTER:
Stack is a sequence of memory location defined by the programmer in LIFO function. That is last element to be placed on the stack is first one is to removed. The stack pointer (SP) contains the address of the stack top.

PROGRAM COUNTER:
It is the address of the next instructions to be executed.

INSTRUCTION REGISTER:
It holds a copy of the current instruction until it is decoded.

STATUS REGISTER:
It contains the status flags of 8085 microprocessor.

TEMPORARY REGISTER:
It is used to store intermediate results and for intermediate calculations.

STATUS FLAGS:
The Flag register is a Special Purpose Register. Depending upon the value of result after any arithmetic and logical operation, the flag bits become set (1) or reset (0). In 8085 microprocessor, flag register consists of 8 bits and only 5 of them are useful.
It is a set of 5 flip-flops.
i. Carry Flag (CS)
ii. Sign Flag (S)
iii. Zero Flag (Z)
iv. Parity Flag (P)
v. Auxiliary carry flag (AC)

Carry Flag:
It holds carry out of the resulting from the execution of an arithmetic operation. If there is a carry from addition or a borrow from subtraction or comparison, the carry flag is said to 1, otherwise it is 0.

Sign Flag:
It is set to 1 if the MSB of the result of an arithmetic or logical operation is 1, otherwise it is 0.

Zero Flag:
It is said to 1 if the result of an arithmetic or logical operation is zero. For non-zero result, it is 0.

Parity Flag:
It is set to 1 when the result of the operation contains even number of 1s and it is set to 0 if there are odd number of 1s.

Auxiliary Carry Flag:
It holds carry from bit 3 to A resulting from the execution of an arithmetic operation. If there is a carry from bit 3 to 4, the AC flag is set to 1 otherwise it is 0.

Program Status Word (PSW):
It is a combination of 8-bits where five bits indicates the five status flags and three bits are undefined. PSW and the accumulator are treated as a 16-bit unit for stack operation.

Address buffer and address-data buffer
The content stored in the stack pointer and program counter is loaded into the address buffer and address-data buffer to communicate with the CPU. The memory and I/O chips are connected to these buses; the CPU can exchange the desired data with the memory and I/O chips.

Data and Address Bus:

The Intel 8085 is an 8-bit microprocessor. Its data bus is 8-bit wide and hence, 8 bits of data can be transmitted in parallel from or to the microprocessor. The Intel 8085 requires a 16-bits. The 8 most significant bits of the address are transmitted by the address bus, A-bus (Pins A8, to A15). The 8 least significant bits of the address are transmitted by address/data bus, AD-bus (Pins AD0 to AD7). The address/data bus transmits data and address at different moments. At a particular moment it transmits either data or address. Thus the AD-bus operates in time shared mode. This technique is known as multiplexing. First of all 16-bit memory address is transmitted by the microprocessor the 8 MSBs of the address on the A-bus and the 8 LSBs of the address on AD-bus. Thus the effective width of the address is latched so that the complete 16-bit address remains available for further operation. The 8-bit AD-bus now becomes free, and it is available for data transmission. 2^{16}(=65536=64K , where 1 K = 1024) memory locations can be addressed directly by Intel 8085. Each memory location contains 1 byte of data.

A8-A15 (Output)-These are address bus and are used for the most significant bits of the memory address or 8 bits of I/O address.

AD0-AD7 (Input/Output)-these are time multiplexed address /data bus that is they serve dual purpose. they are used for the least significant 8 bits of the memory address or I/O address during the first clock cycle of a machine cycle. Again, they are used for data during second and third clock cycles.

ALE (Output)-it is an address latch enable signal. It goes high during first clock cycle of a machine cycle and enables the lower 8 bits of the address to be latched either into the memory or external latch.

IO/M(Output)-it is a status signal which distinguishes whether the address is for memory or I/O. when it goes high the address on the address bus is for an I/O device. When it goes low the address on the address bus is for a memory location.

S0, S1 (Output)-these are status signal sent by the microprocessor to distinguish the various types of operation.

RD (Output)-it is a signal to control READ operation. when it goes low the selected memory or I/O device is read.

WR (Output)-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 operation.

READY (Input)-it is used by the microprocessor to sense whether a peripheral is ready to transfer data or not. a slow peripheral may be connected to the microprocessor through READY line. if READY is high the peripheral is ready. if it is low the microprocessor waits till it goes high.

HOLD (Input)-it indicates that another device is requesting for the use of the address and data bus. Having received a HOLD request the microprocessor relinquishes the use of the buses as soon as the current machine cycle is completed. Internal processing may continue.

HLDA (Output)-it is a signal for HOLD acknowledgement. It indicates that the HOLD request has been received. after the removal of a HOLD request the HLDA goes low. the CPU takes over the buses half clock cycle after the HLDA goes low.

INTR (Input)-it is an interrupt request signal. Among interrupts it has the lowest priority. An interrupt is used by io devices to transfer data to the microprocessor without wasting its time.

INTA (Output)-it is an interrupt acknowledgement sent by the microprocessor after INTR is received.

RST5.5, RST6.5, RST 7.5(Input)-these are interrupts. Signals are the restart interrupt; they cause an internal restart to be automatically inserted each of them of a programmable mask.

TRAP-TRAP has the highest priority. It is used in emergency situation. it is a non-maskable interrupt.

RESET IN (Input)-it resets the program counter to zero .it also resets interrupts enable that is an HLDA flip-flops.

RESETOUT (Output)-it indicates that the CPU is being reset.

X1, X2 (Input)-these are terminals to be connected to an external crystal oscillator which drives an internal circuitry of the microprocessor to produce a suitable clock for the operation of microprocessor.

CLK (Output)-it is a clock output for user, which can be used for other digital integrated circuits.

SID (Input)-it is data line for serial input. The data on this line is loaded into the 7th bit of the accumulator when rim (read interrupt mask) instruction is executed.

SOD (Output)- it is data line for serial output. The 7th bit of the accumulator is output on sod line when sim instruction is executed.

Vcc- It is +5 volts supply.

Vss- It is the ground reference.

Instruction Cycle

An instruction is a command given to the computer to perform a specified operation on given data. To perform a particular task programmer writes a sequence of instructions, called a program. Program and data are stored in the memory. The CPU fetches one instruction from the memory at a time and executes it. It executes all the instructions of a program one but one to produce the final result.

3.2.1. Fetch operation. The 1st byte of an instruction is its opcode. An instruction may be more than one-byte long. The other bytes are data or operand address. The program counter (PC) keeps the memory address of the next instruction to be executed. In the beginning of a fetch cycle the content of the program counter, which is the address of the memory location where opcode is available, is sent to the memory.

3.2.2 Execute Operation. The opcode fetched from the memory goes to the data register, DR (data/address buffer in Intel 8085) and then to instruction register, IR. From the instruction register it goes to the decoder circuitry which decodes the instruction. The decoder circuitry is within the microprocessor. After the instruction is decoded, execution begins. If the operands are in the general purpose registers, execution is immediately performed. The time taken in decoding and execution is one clock cycle. If an instruction contains data or operand and address which are still in the memory, the CPU has to perform some read operations to get the desired data. After receiving the data, it performs execute operation.

Machine Cycle and State. The necessary steps carried out to perform the operation of accessing either memory or I/O devices, constitute a machine cycle. In other words, necessary steps carried out to perform a fetch, a read or a write operation constitute a machine cycle.

In a machine cycle one basic operation such as opcode fetch, memory read, memory write, I/O read of I/O write is performed. An instruction cycle consists of several machine cycles. The opcode of an instruction is fetched in the first machine cycle of an instruction cycle. Most of the single-byte instructions require only one machine cycle to fetch the opcode and execute the instruction. Two-byte and three-byte instructions require more than one machine cycle. Additional machine cycles are needed to read data from or to write data into the memory or I/O devices. Figure shows instruction cycle for MVI r, data. It has two machine cycles: one for fetching opcode, and the other for reading data from the memory and execution.
