Mechatronics
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Lecture - 23
Microprocessor

I welcome you all to today's NPTEL online certification course on Mechatronics. Today we are going to talk about Microprocessors. Here if you look at this chart on the different mechatronic system components, the microprocessor falls into this category that is under the digital control architecture.

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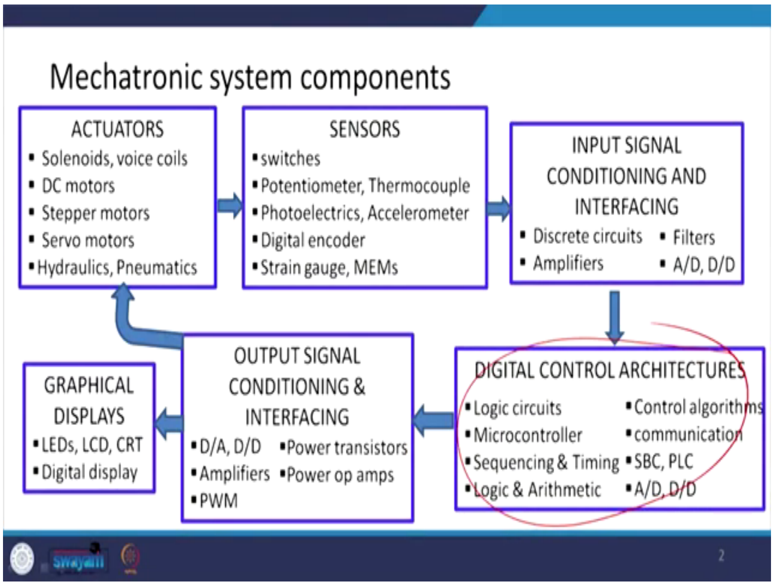

So, in this lecture and next lecture, I am going to talk about microprocessors and microcontrollers. So, as we have seen in the last class, that is on combinational and sequential logic IC's. So, if you have a simple control problem, then that can be solved using combinational and sequential logic IC's, that is, integrated circuits.

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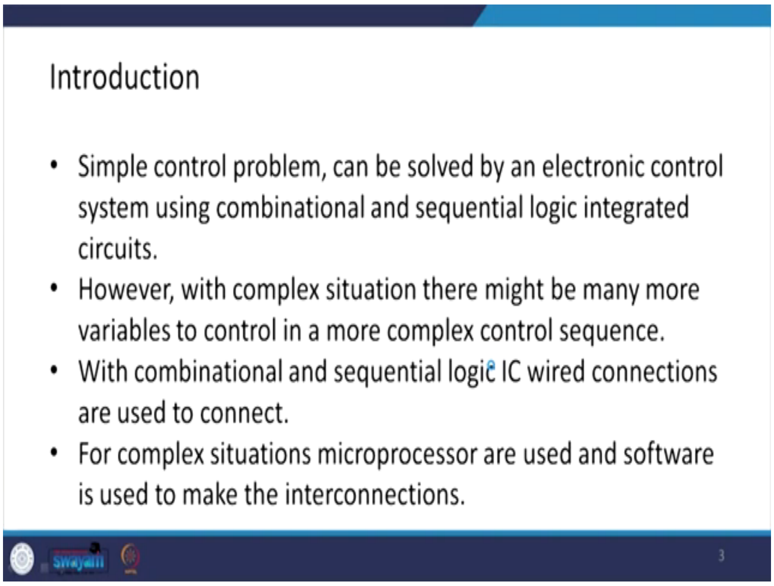

But if you have a complex problem where we are going to have many more variables to control, and there is a more complex control sequence in such type of situation, combinational and sequential logic IC wired connections might not be very useful. So, for such complex situations, microprocessors are used, and software is used to make the interconnections.

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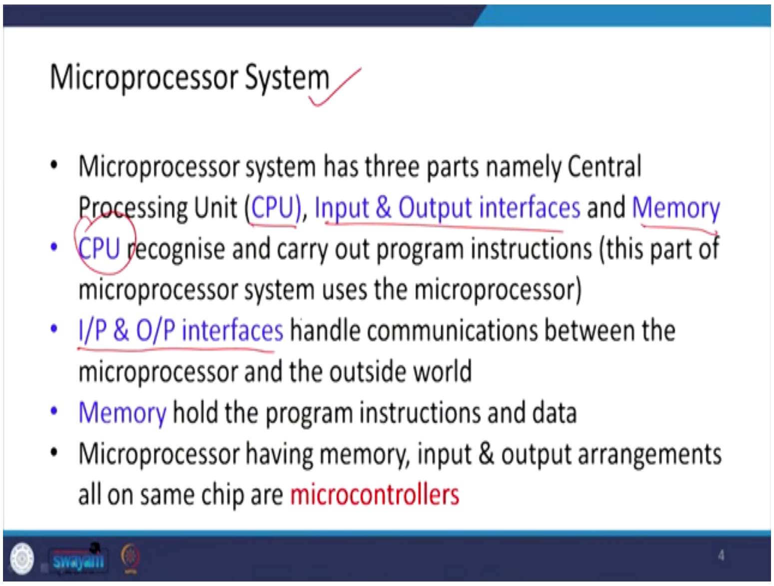

Let us look at the microprocessor system. A microprocessor system has essentially got three main parts. These are the central processing unit, which we call in short CPU, input and output interfaces for interacting with the microprocessor, and a memory. So, these three are the principal components of a microprocessor system.

The central processing unit recognizes and carries out the program instructions, and this part of the microprocessor system uses the microprocessor. So, in a microprocessor system, the CPU is the component that uses the microprocessor, and here it carries out the program instructions. Then next is the input and output interfaces, and these handle communication between the microprocessor and the outside world. They receive inputs as well as they give the output. The microprocessor receives input and gives the output through with the help of these interfaces. The memory, as the name indicates, holds the program instructions as well as data. So, it will store the program instructions and the data. Microprocessors have memory input-output arrangement, all on the same chip that is what is called the microcontrollers, and this I am going to discuss in detail in my next lecture.

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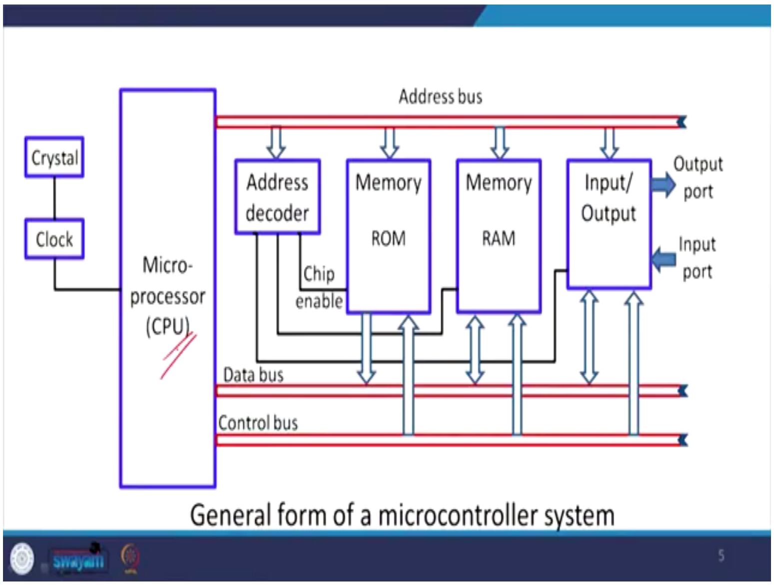

So, let us look at the general form of a microcontroller system or the microprocessor system, where we have a microprocessor or what is we call a CPU that is a CPU that uses a microprocessor. We have crystal and clock, and then as I was telling you, we have the input and output. So, we have an input-output unit is there. So, you have an input port, output port, and then these are the memories. So, memory is there. I am going to talk about these memories a little later in this lecture. And then, there are different buses; address bus, data bus, and control bus. And what do you mean by this bus, again I am going to discuss this in the next slide.

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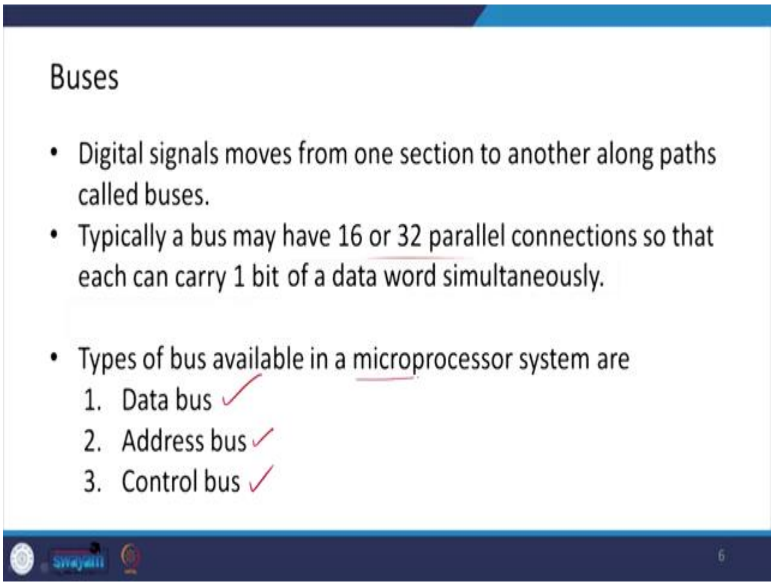

The digital signal moves from one section to another along paths, and these paths we are calling as a bus. Typically a bus may have 16 or 32 parallel connections so that each can carry 1 bit. So, you can have the 16 bit or 32 bit like that. So, they can carry 1 bit of data word simultaneously. The type of bus, as we have seen here, is the address bus, data bus, and control bus. So, these are the types of the bus that are available in a microprocessor system.

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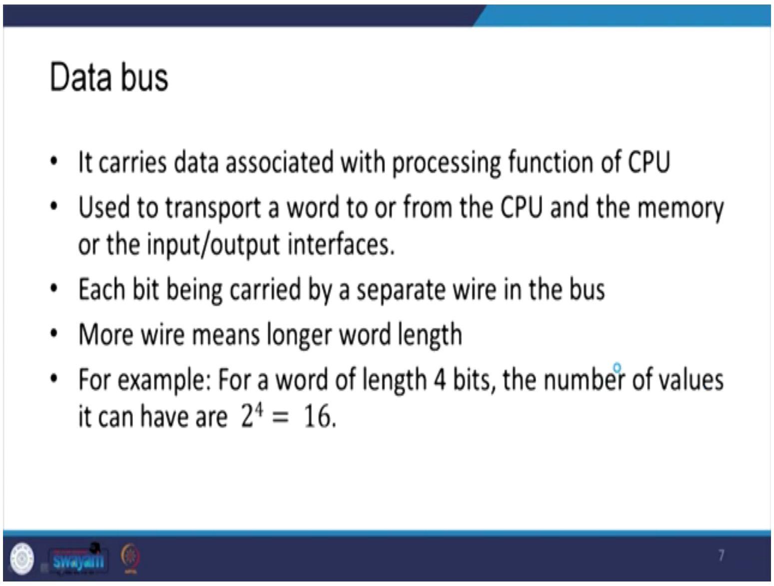

Let us look at what do these buses do. The data bus carries data associated with the processing function of a CPU. It is used to transport a word to and from CPU and memory or the input-output interfaces. Each bit is carried by a separate wire in the bus, and more wire means longer is the word length, so as it indicates. So, for example, for a word of length 4 bit, the number of values it can have is 2^4 that is 16.

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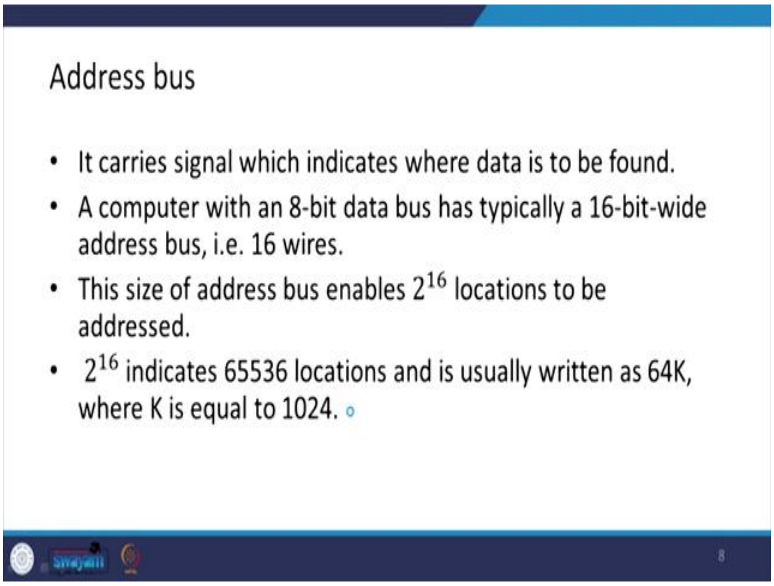

Next, let us look at the address bus. So, as the name indicates, it carries a signal which indicates where data is to be found; so some sort of address of the data. So, a computer with an 8-bit data bus typically has a 16-bit wide address bus that is the 16 wires. The size of the address bus enables 2^{16} locations to be addressed, and it indicates 65536 locations and is usually written as 64 K, where K is equal to 1024.

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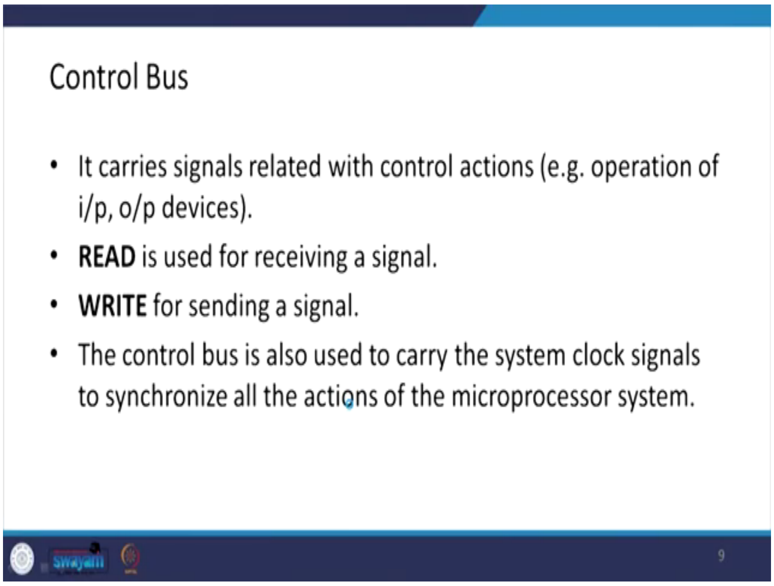

Next is the control bus, which carries a signal related to the control action; that is, the operation of the input-output devices. READ is used for receiving a signal, whereas WRITE is used for sending a signal. The control bus is also used to carry the system clock signals to synchronize all the actions of the microprocessor system.

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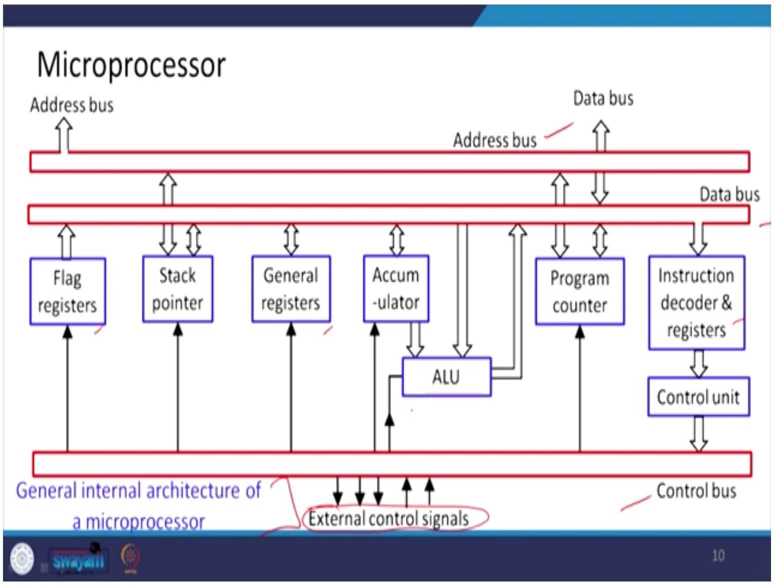

So, if we look at the microprocessor here, so, as I was telling you, we have the address bus, data bus, and the control bus. Also, the three buses are indicated by the red over here. And we have different registers here flag register, general register. I am going to talk about what these are instruction and instruction decoder and register. Then you have an accumulator which is connected to the or which communicates through ALU, that is, arithmetic logic unit. So, this is the general internal architecture of a microprocessor, and from here, they get external control signals; so in come and in as well as out.

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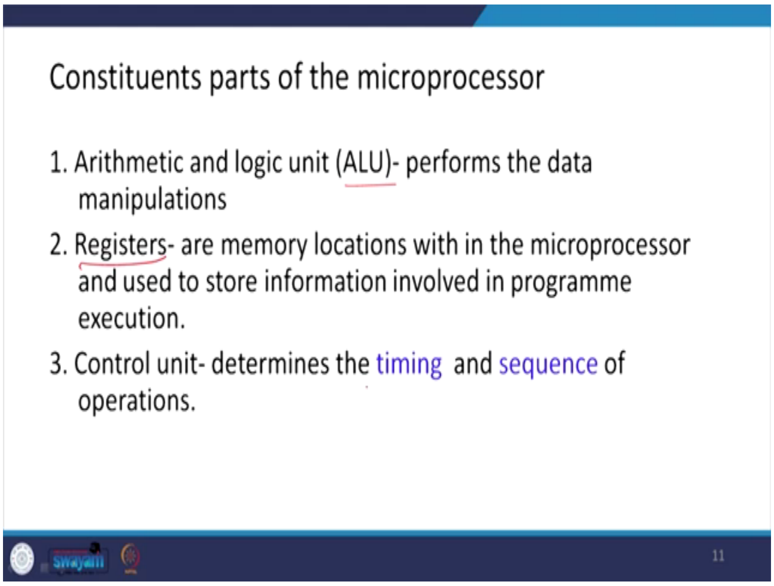

The constituent part of the microprocessor, as I said ALU, that is, arithmetic and logic units perform the data manipulation. The ALU, which performs the data manipulation. Then there are different registers, as I said, and these are memory locations within the microprocessor and used to store information involved in program execution. And the control unit determines the timing and sequence of the operation.

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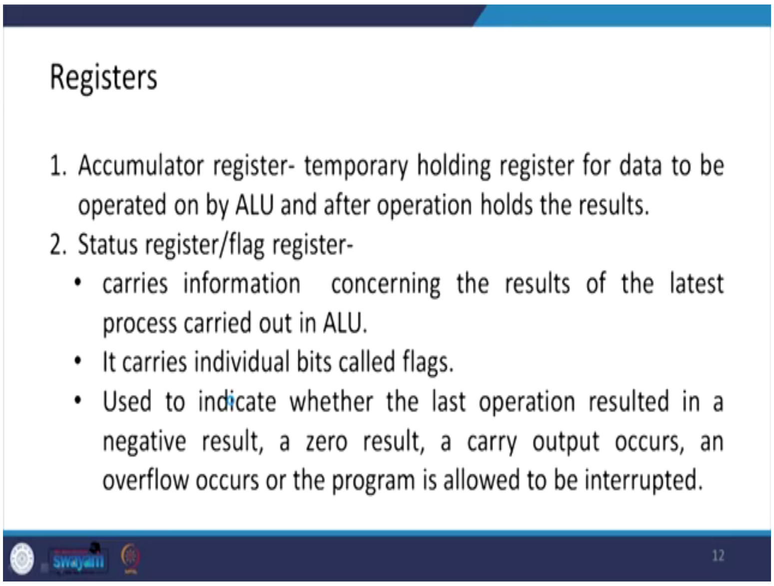

Now, let us look at the different types of registers. So, we have the accumulator register, and this temporary holding register for data to be operated on by ALU and after operation holds the results. Then we have the status or flag register. So, as the name indicates, it carries information concerning the results of the latest process carried out in the ALU. It carries individual bits, which we call flags, and it is used to indicate whether the last operation resulted in a negative result, a zero result, or a carry output occurs, and overflow occurs, or the program is allowed to be interrupted. So, this is all information it has.

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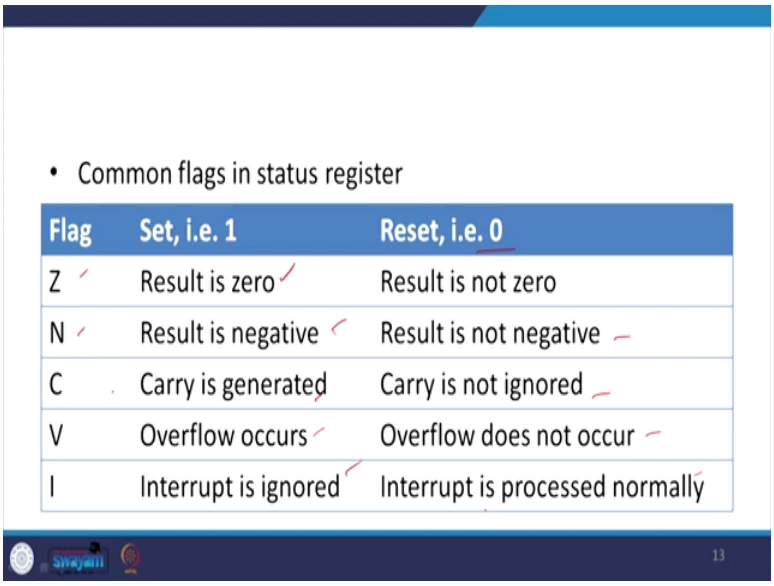

There are common flags in the status register. For example, the flag Z set 1; set that is 1 and reset that is represented by 0. So, Z, if the result is zero, it is represented by 1, and if the result is not zero, it is represented by 0. Similarly, you have N result is negative, the result is non-negative. C carry is generated; here, carry is not generated. And V overflow occurs, overflow does not occur over here and interrupts are ignored, and interrupt is processed normally. So, these are the different flags in the status register.

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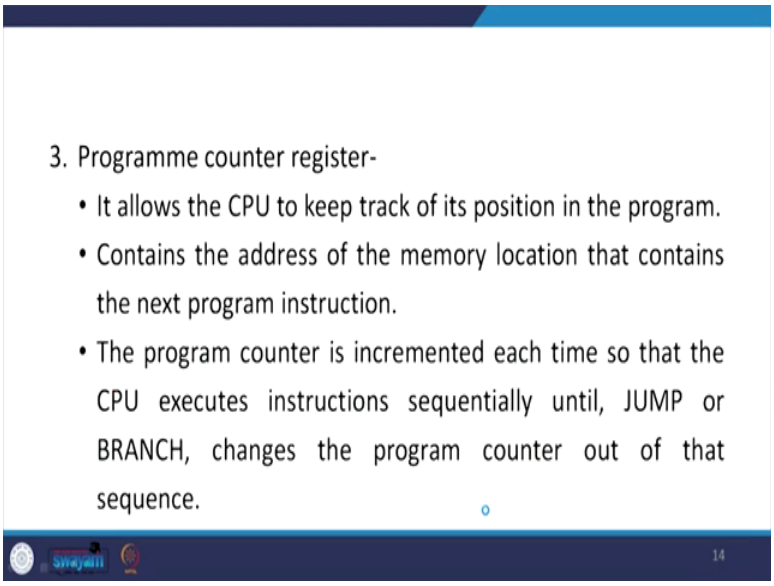

Next is the program counter register. It allows the CPU to keep track of its position in the program. It contains the address of the memory location that contains the next program instruction. The program counter is incremented each time so that the CPU executes instructions sequentially until JUMP or BRANCH changes the program counter out of that particular sequence. Then we have the memory address register, which contains the address of data. We have an instruction register that stores instructions. We have the general-purpose register, and these are temporary storage of data or addresses involved in that transfer between registers.

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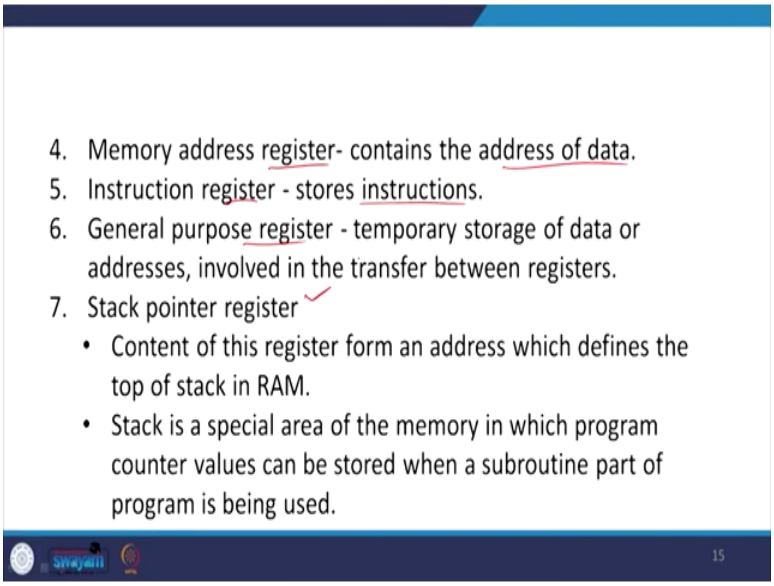

And we have a stack pointer register. The content of this register forms an address that defines the top of the stack in the RAM. And stack is a special area of the memory in which program counter values can be stored when a subroutine part of the program is being used.

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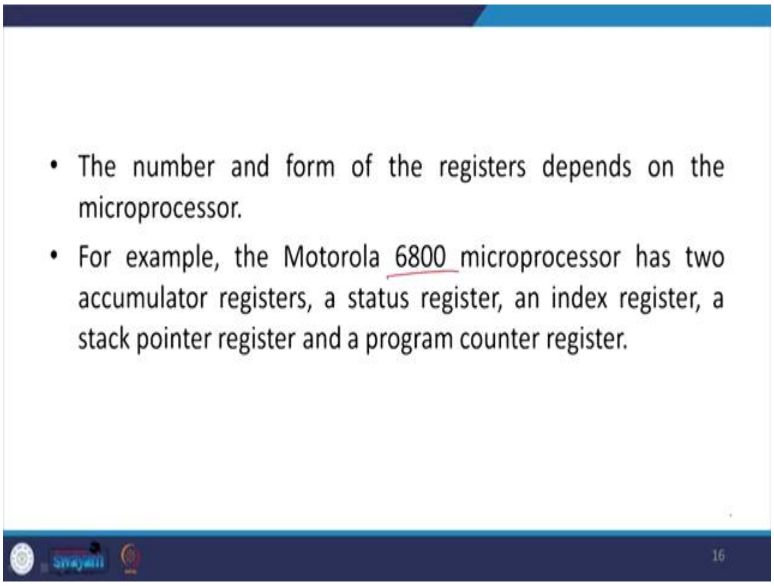

The number and the form of the register depend on the microprocessor. For example, Motorola 6800 microprocessor has two accumulator registers, a status register, an index register, a stack pointer register, and a program counter register.

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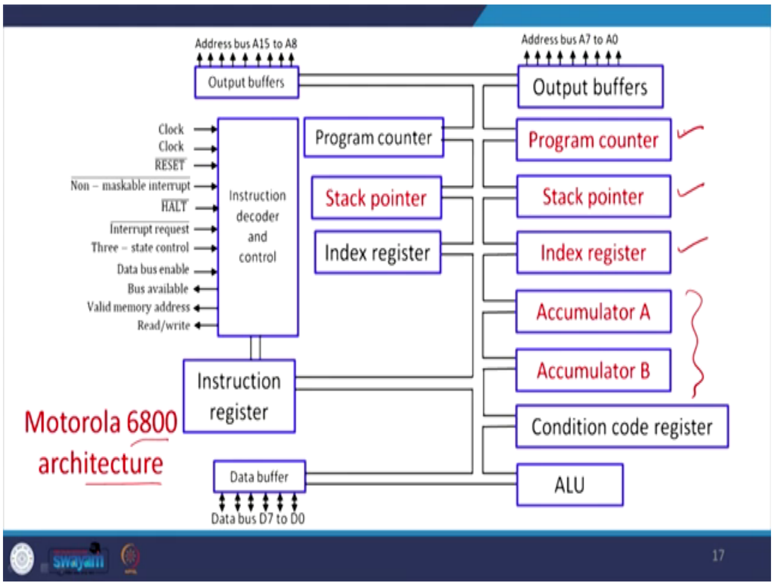

Next slide, I am showing here Motorola 6800 architecture. So, as I said, it has got two accumulators; accumulators A and B. It has an index register, a stack pointer, and a program counter are there. It also has an output buffer, ALU, condition code register, instruction register, instruction decode, and control, and here you have the various pins for the different types of addresses; clock, RESET and all.

Then let us look at the memory. The memory units store binary data, and the size of memory is determined by the number of wires in the address bus; based on that, the size of memory is found.

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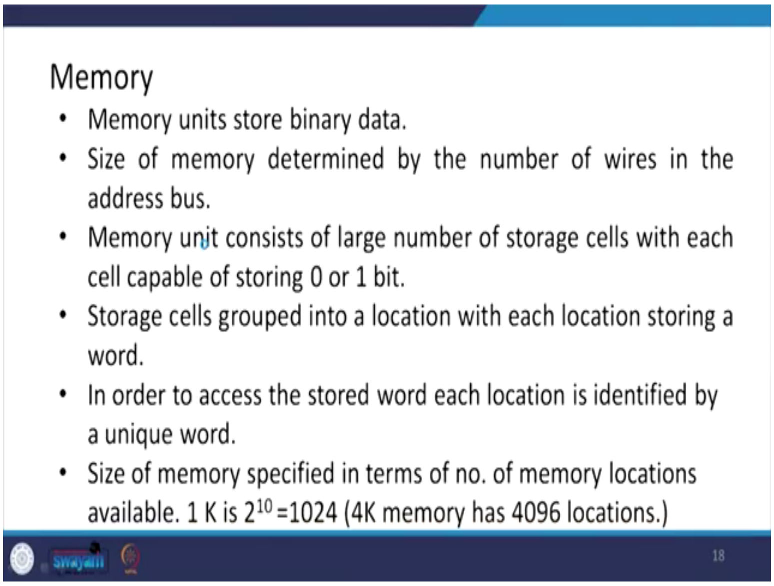

Memory units consist of a large number of storage cells, with each cell capable of storing 0 or 1-bit storage cells grouped into a location, with each location storing a word. And in order to access the stored word, each location is identified by a unique word. And the size of memory is specified in terms of the number of memory locations available. So, 1 K is 2^{10}or 1024. So, and 4 K memory has that is 4096 locations.

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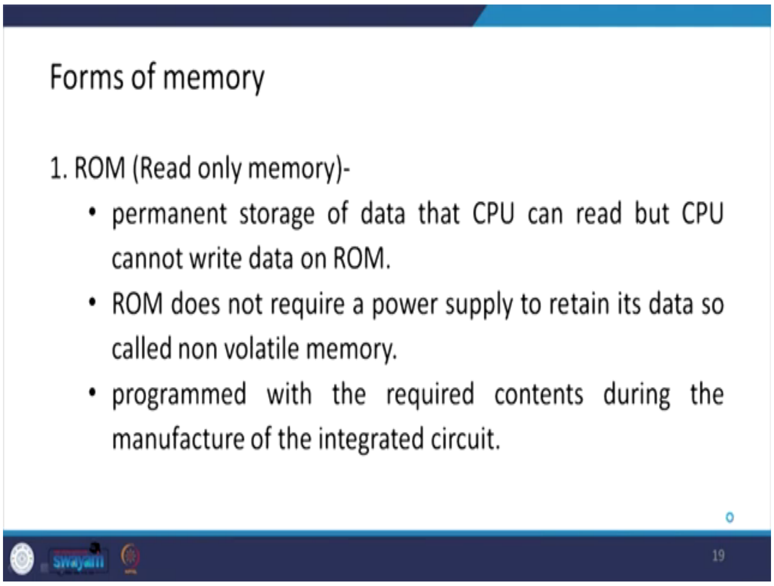

Now, let us look at the forms of memory. First of all, we will see the ROM that is what we call the read-only memory. Now, as the name indicates, it is read-only memory. So, it is permanent storage of data that the CPU can read; but the CPU cannot write data on ROM because it is a read-only memory. It is a read-only memory that does not require a power supply to retain its data, so it is called non-volatile memory. And this is programmed with the required content during the manufacture of the integrated circuit or the IC's.

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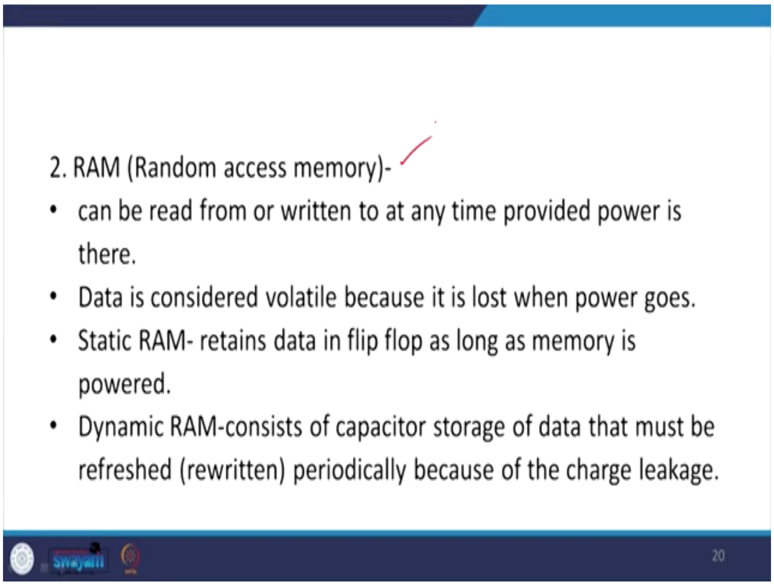

Next is the RAM, which is called random access memory. This can be read from or written to at any time provided power is there, and data is considered volatile because it is lost when the power goes. So, again the RAM is of 2 types; that is static RAM and dynamic RAM. The static RAM retains data in a flip flop as long as memory is powered, and the dynamic RAM consists of capacitor storage of data that must be refreshed or rewritten periodically because of the charge leakage.

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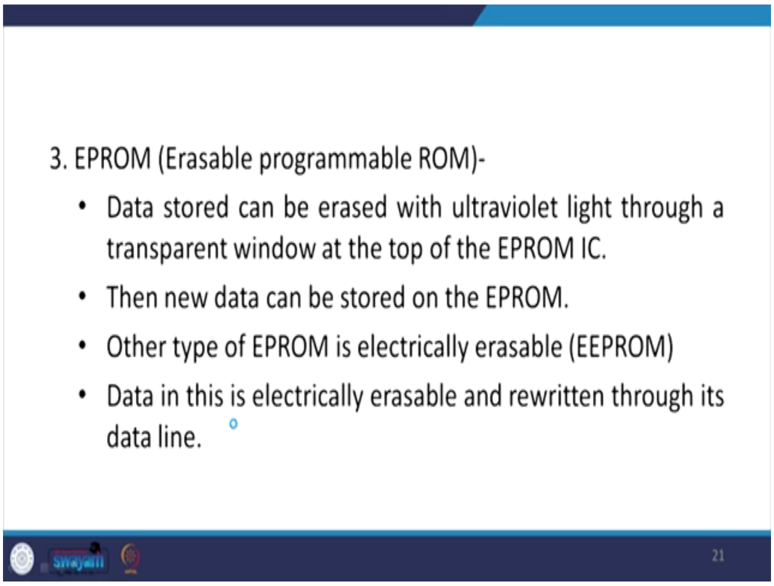

Next is the EPROM. This is an erasable programmable read-only memory, which is called EPROM. In this, the stored data can be erased with ultraviolet light through a transparent window at the top of the EPROM IC. The new data can be stored on the EPROM. Another type of EPROM is electrically erasable; that is what we call EEPROM. And data in this is electrically erasable and rewritten through it is the data line.

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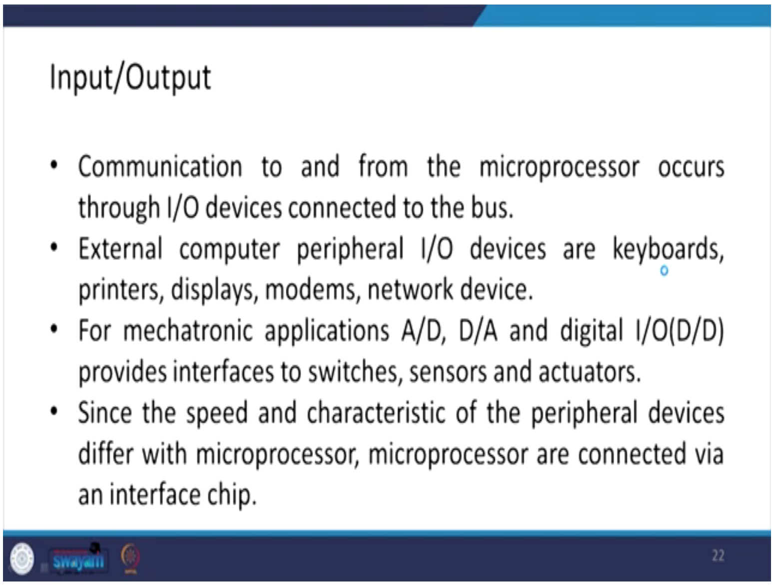

Now, let us look at the input-output. So, the communication to and from the microprocessor occurs through the input-output devices connected to the bus. External computer peripherals input-output devices are keyboard, printer, displays, modems, network devices, and for mechatronic applications analog to digital converter, or digital to analog converter, and digital input-output. For example, digital to digital converter provides interfaces to switches, sensors, and actuators. Since the speed and characteristics of the peripheral devices differ with the microprocessor, microprocessors are connected via an interface chip.

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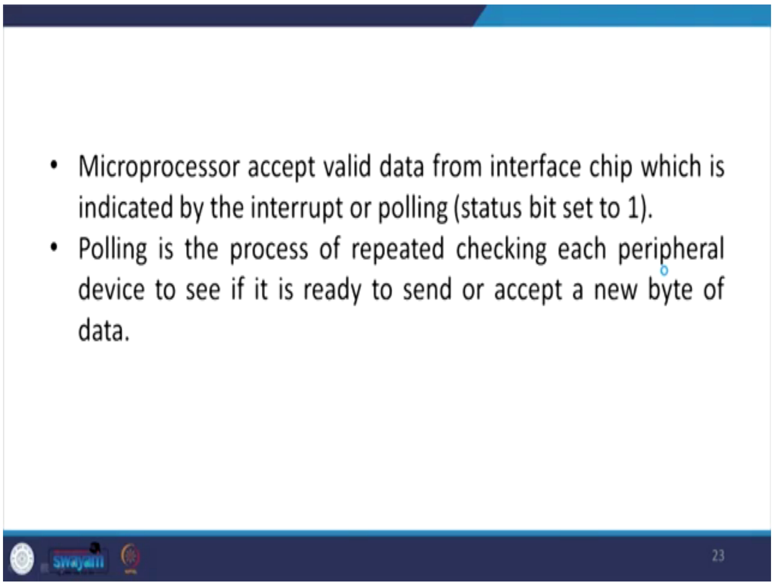

Microprocessor accepts valid data from interface chip which is indicated by the interrupt or polling the that is a status bit set to 1. Now, polling is the process of repeated checking each peripheral device to see if it is ready to send or accept a new byte of data.

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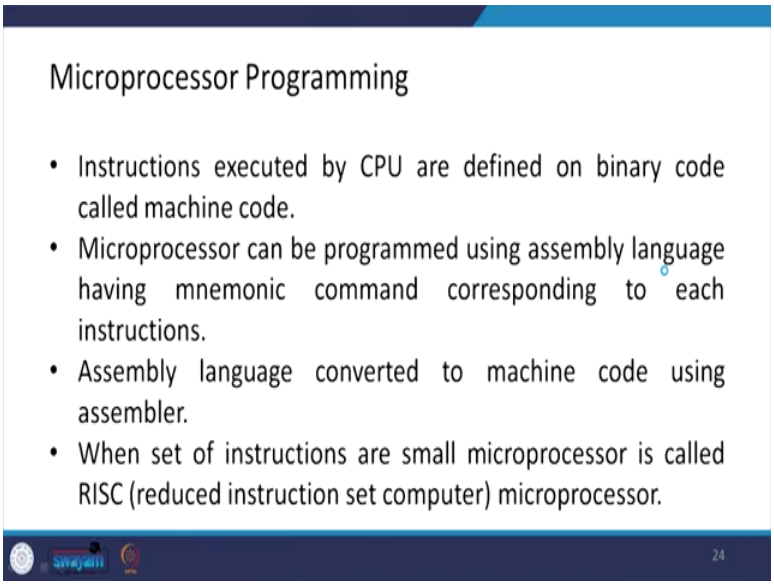

Now, let us look at the programming of the microprocessor. Instructions executed by the CPU are defined on binary code called machine code. Microprocessors can be programmed using assembly language having mnemonic commands corresponding to each instruction. Assembly language converted to machine code using the assembler. And when the set of instructions is small, the microprocessor is called RISC; that is the reduced instruction set computer microprocessor.

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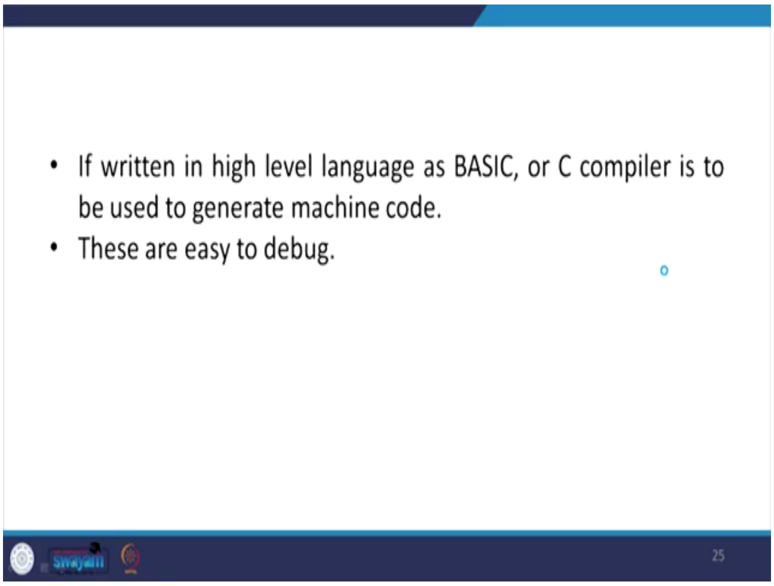

If written in a high-level language, as BASIC or C compiler is to be used to generate the machine code, and these are easy to debug.

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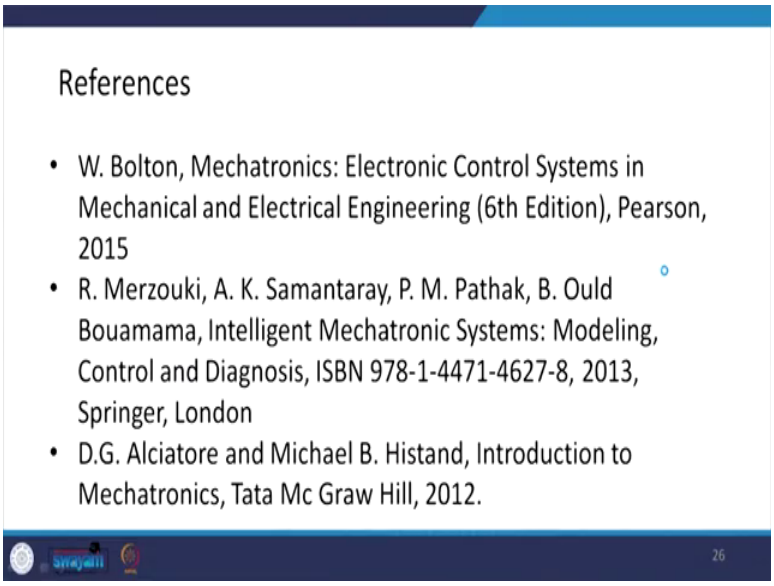

So, these are the references. If you want to read further about this, then you can read either Mechatronics by Bolton or Mechatronics by Alciatore and Histand.

Thank you.