**Computer Organization and Architecture: A Pedagogical Aspect**

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**Fundamentals of Digital Computer**
**Lecture - 05**
**Storage and I/O Interface**

Hello everybody, welcome back to the online course on computer organization and architecture. We are in the module fundamentals of digital computers and this is unit number 5 and in unit number 5 we are going to discuss about storage and I O interface.
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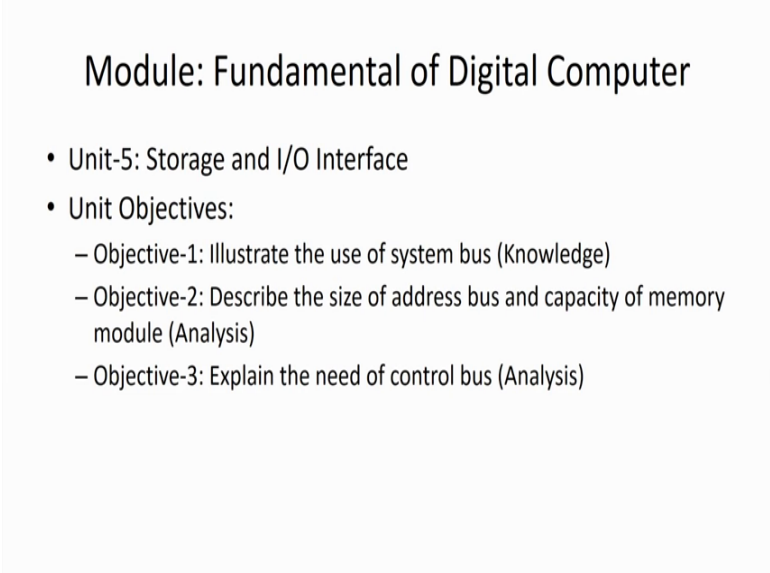


So, like earlier unit also for this particular unit we are going to mention the objective here we have started few Objective-1: Illustrate the use of system bus, again we will be dealing this objective in knowledge. level Objective-2: Describe the size of address bus and capacity of memory module, so this is basically on analysis level so we will able to analyse once get some memory module and you can find out what is the capacity of that particular memory module and what are the other requirements. Objective-3: Explain the need of control bus this is also an analysis level we are going to see.
Why we need a control bus? So, we are discussing about the von Neumann store program architecture and our computer works on this particular model already I have shown this particular model, we are having the central processing unit that I O equipment and memory module and whatever we are going to work everything must be present in a main memory and processor is going to in interact with a main memory and is going to fetch the information from main memory.

And in the top level view of our computer system can be visualise in this particular way here we are having 3 main components; one is your C P U or central processing unit this is the main processing element inside a computer.

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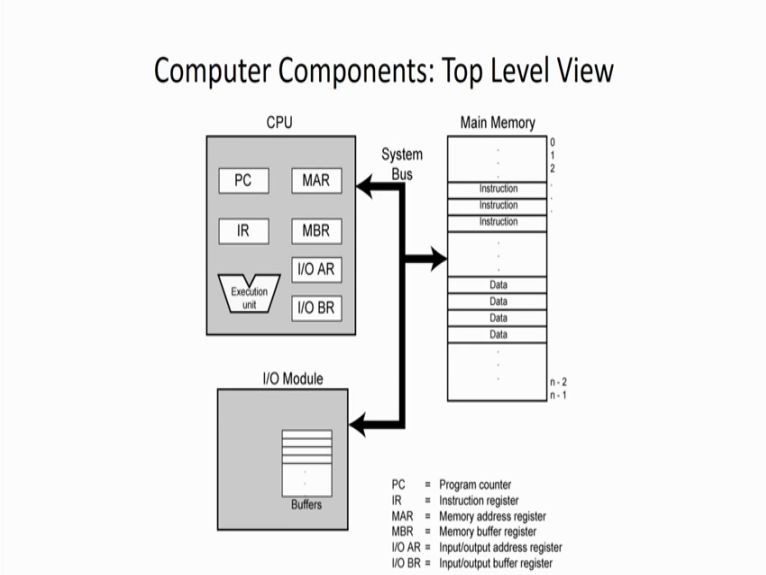


And this C P U is connected to main memory, which is the storage unit primary storage unit and along with that we are having I O module, through I O module we have going to connect all the input output devices like; keyboard, mouse, printer, monitor, those will be connected through this particular I O modules and everything will be integrated through this particular system bus. So, we are talking about a bus; now, what is a bus actually? So, in this particular case this bus is nothing but a Connecting ways, so you are going to connect different devices with the help of bus.

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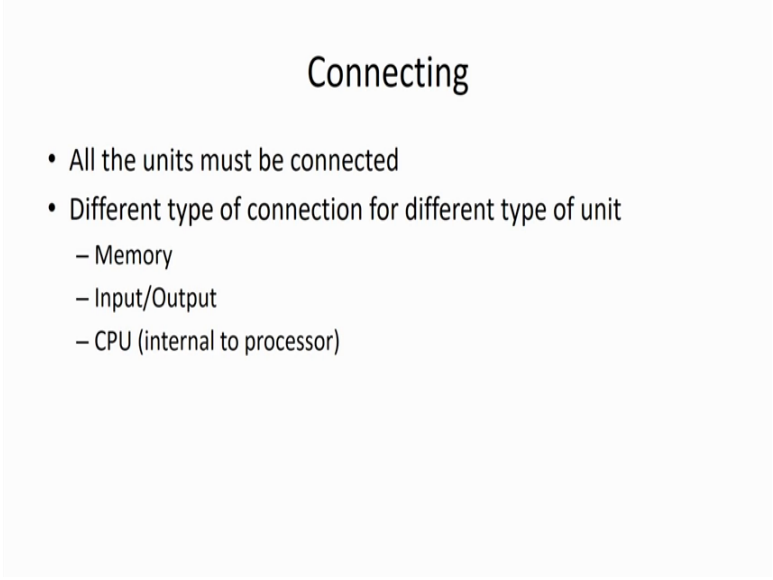

So, we are having different types of connection in a computer; so there may be one connection between processor and memory, so this is for a memory interface. We are having another connection between your processor and input output devices.

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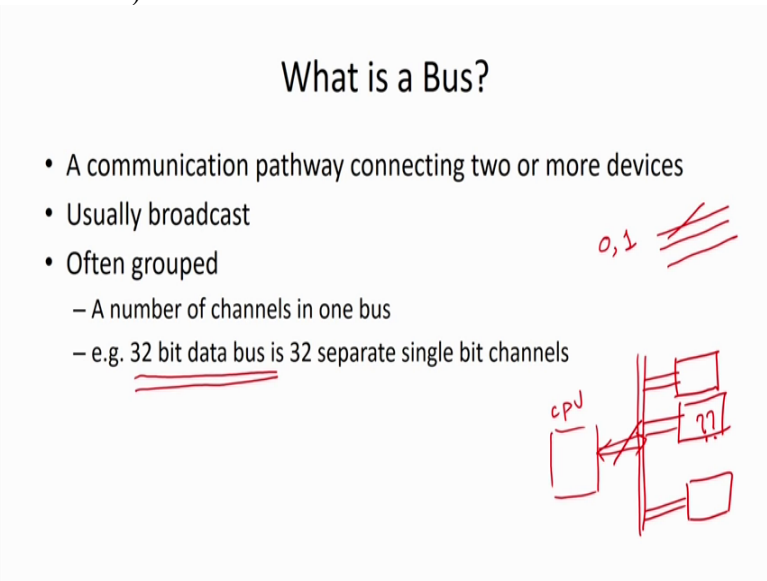


And another kind of connection we are having C P U interconnection this is basically internal to the C P U, already have mentioned in our last lecture that; all the components of processor will be connected to each other through an internal C P U bus. So, the bus is nothing but a collection of words through which we are going to transfer information and basically it is broadcast methodology, basically what happened you can see that if I am having a device say; in this particular case, device you are going to talk about say C P U and say through this particular system bus, it is connected to different devices or different unit. So, in that particular case whatever information we are transferring to this particular bus, this is in the broadcast mode and it will be available for all the connecting devices, but according to the need; one particular connecting device going to use this particular information.

Secondly, that collection of words are basically grouped together and we can say this is basically channels, so number of words that you having one particular bus is basically known as the number of channel and this is basically depends on the number of information that we are going to transfer.

So as for example; if I talk about a 32 bit data bus, in that particular case we are having 32 bit separate signals bit channel, so we having 32 different channel; in every channel, we can transfer 1 bit of information, that information may be [vocalised-noise] either 0 or 1. So, collecting all those particular channels or words basically we say this is a bus.

So, what is a bus? Bus, is nothing but a connecting words through which you can transfer information from one point to the other point in the particular bus.
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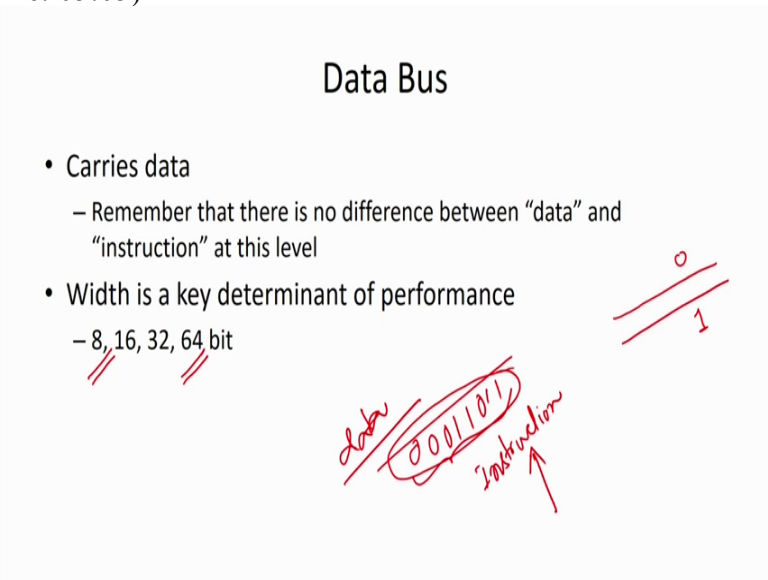


Now, there are categories of bus; one we are talking about a data bus, through this data bus we are going to transfer data from one point to the other point, maybe you are transferring data from memory to the processor or maybe from processor to the memory, so but when we are going to talk about data or when you are going to talk about transfer of data through a bus, in that particular case or in this particular level device level there is no difference between data and instruction all will be treated as a binary bit.
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So, as for example; if I am going to consider about 8 bit numbers, so if this is an instruction then what will happen? It is going to interpret as an instruction inside the processor, but this can be treated as a data also that may be a data for a particular instruction. So, when you are transferring information from one point to the other point or one device to another device at that point in the signal level you do not have any distinction between data and instruction all are in the beat level either it is 0 or 1, in some signal line you are transferring 0 or in some signal line you are transferring 1. But when we are going to interpret it, at that time you have going to see whether we have to treat this particular information as an instruction or we have to treat this particular information as a data or an instruction.
And width is a key determinant factor for the performance, so if we having an 8 bit data bus then what will happen? We can transfer 8 bit at a time. If we are having 64 bit data bus, we can transfer 64 bit of information at a time. So, in one go you can transfer 64 bit, so if we having more width basically you said that you are going to achieve more performance, because in one go we can transfer a complete information do which

another was you call this is the address bus this address bus usually identify the source or destination of a data so basically what will happen I am saying that we are keeping our information in main memory.

So this is a memory location and already have mentioned that to go to a particular memory location, we must identify that particular memory location. And how you are going to identify it? It is with the help of an address, but what is the addressing format when we are going to work with our digital computer, just consider small example; just say that in this particular memory module itself, we are having total 8 memory location, so I can numbered them as; a 0, 1, 2, 3, 4, 5, 6, 7, so we are having 8 different memory location and we are going to take information from say one particular memory location.

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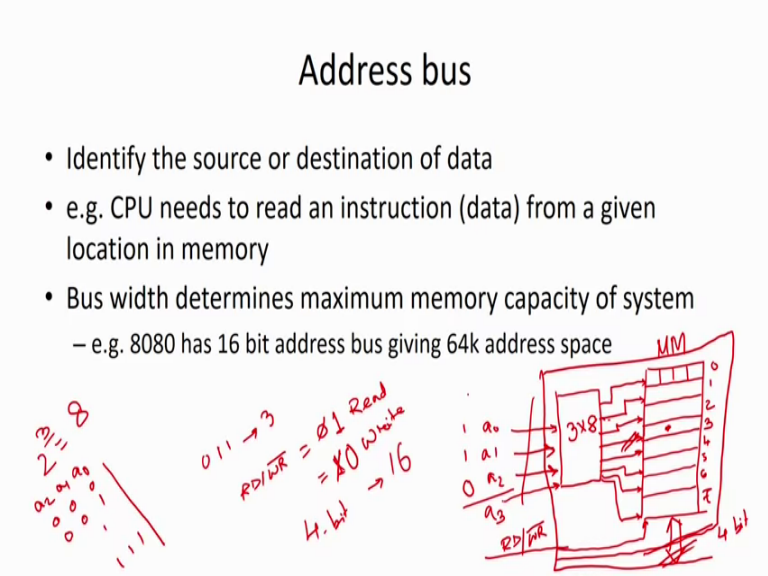


Now, how we are going to identify that particular memory location. So, we are going to do it with the help of address. Now what is the addressing format? Now you just see that, if we are having 8 different combination to identify any one of this combination we need 3 bit of information, because you know that 2 to the power 3 equal to 8 and this particular 3 bit I can say that a 0, a 1, a 2 that 3 information that may go have all 0 0 0 0 0 0 0 1 like that 1 1 1 1, so these are 8 possible combination of this particular 3 bit a 0, a 1 and a 2. So, since these are the unique combination, so we can use those particular combinations to identify one of the memory locations.

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Now, how to do it? You having 8 locations and we having 3 bit of information, so already we have talked about the decoder, we know that we are having a decoder where you are having some an input lines then maximum output lines will be 2 to the power n depending on the input combination one of the output line is high. So, in that particular case what we can do? We can use an 3 by 8 decoder, we are having 3 input lines, so this

is a 0, a 1, a 2 and these output lines will be connected to those particular memory location. So, depending on the information that we are putting over here it is going to enable one of the line, so if I give the information say 1 1 0, so this is the most significant bit a 0 is the least significant bit, so 0 1 this is basically going to represent in decimal trees. So, that is means 0, 1, 2, 3 these particular line will be enabled.

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So, when this line is high; that means, you are going to select this particular memory location with the help of this particular line and this is the combination. So, this combination is basically known as my address to my memory location and you just see that in every memory location we are going to store 4 bit of information. So, in that particular case what happened? You can think that you are having a data bus which is the 4 bit wide, now along with that we may have 1 control line or 2 control lines say; if I say that, this is a line which is giving as name as you read write bar, so in read write bar what will happen? If this is 0, then we are going to perform a read operation we are going to take the information from the memory and this signal is 1 then we are going to perform a write operation.

Maybe I can say like that or maybe it is in other way round since it is read no bar. So, 1 is your read and 0 is your write this is the exact definition we say since I am defining a read write bar, so when it is 0 then it is a write operation. So, when we are going to perform read operation we will identify the memory location through address and whatever we have stored in this particular memory location that will be available in the data bus and through data bus we can take it to the another device or another component. And when it is a write operation, so whatever information we are giving in to the data bus that will be stored in this memory location that whatever we have identified over here.

So, in that particular case what will happen? I can see the memory module, this one is a memory module, so we are having input lines call address bus through address bus we are going to give the address to a particular memory location and we are having the data bus, through data bus that they were going to read the information or we are going to write the information and along with that we are having a control line which is going to indicate whether it is a read operation or light write operation. So, in this way we can visualise our memory unit, so in case of memory unit we are having address bus as well as data bus.

Again the size of data bus basically we get how many bits you can transfer in one go and size of address bus basically give the number of memory location, that we have in the particular memory location. So, it is 3 bit we are going to say 8 memory locations, so if I increase it to the 4 bit then we are going to get 16 memory locations; that means, I am going to add one more bit in the address bus. So, in that particular case what will happen? With a 3 is equal to 0 and I am going to get 8 combination and with a is equal to 1 we are going to get another 8 combination, so total 16 combinations.

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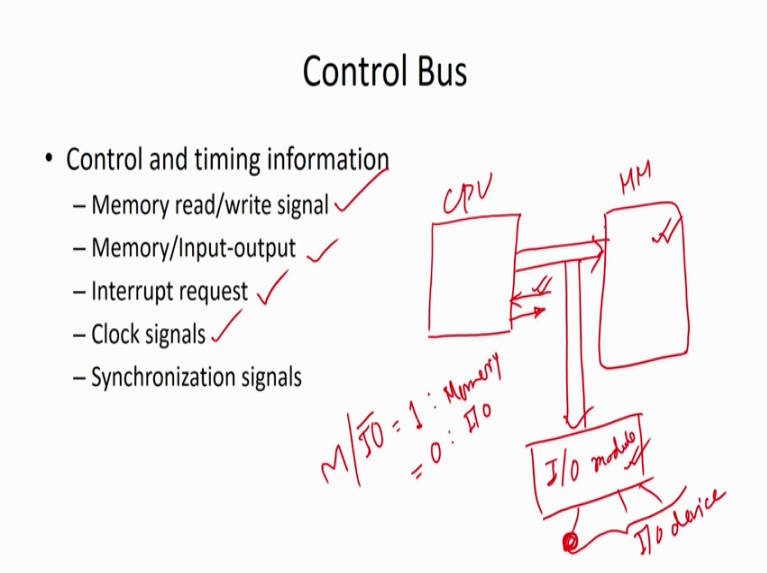


So, address bus is nothing but collection of words through which are going to give information 0's and 1's and that combination is going to identify one of the memory location. So, like that we are having a control bus, already I have said that we may have a control signal call read and write signal that we are going to either read the memory or we are going to write into the memory. We have put another control signal which is known as your memory and input output, so basically just see that this is my processor through this particular address bus we are connecting to the memory location, again through this particular address bus we are connecting to input output module. Now whatever address you are giving over here that may be either address to a memory location or that may be an address to the I O device, so through I O module we are connecting several I O devices, so it may be an address to an I O devices.

Now, how to identify whether it is a memory address or it is an I O address? For that we are going to have one more control signal coming out from the C P U and that control signal is identify whether it is a memory or I O. So, if I am going to say that; memory or I O bar, so in that particular [vocalised-noise] if this signal is your high, then you are

going to said a it is an memory address and if the signal is 0 then you say that this is an I O address, so with the help of this another control signal we can identify whether we are going to access the memory or we are going to access a I O. Another signal this talking about the interrupt request, because again it is related to the I O say some of the I O device is sitting over here and say this I O device onto have to do carry out some work in the processor.

Then since during program execution that processor is interacting with the memory and taking the information from memory to a processor and carrying out it is job and in between this device onto perform some work. So, in that particular case; it will give an indication through another control signal, which is known as your interrupt request. So, those things will be discuss in details while you are going to discuss about the I O devices.

We may have another clock signal call clock signal, because it is in synchronous operation, so everything will be controlled by a continuous clock signals and that signal will also come as in the input or output to that device and we may have some synchronization signal will see what is that synchronization signal? So, finally we are having now 3 components one is a; data bus, address bus and system control bus. So, combining all those 3 buses, Control bus data bus and address bus we are going to say this is the system bus. So, system through the system bus you are going to connect external devices to this particular processor, those external devices basically may be some input output devices.

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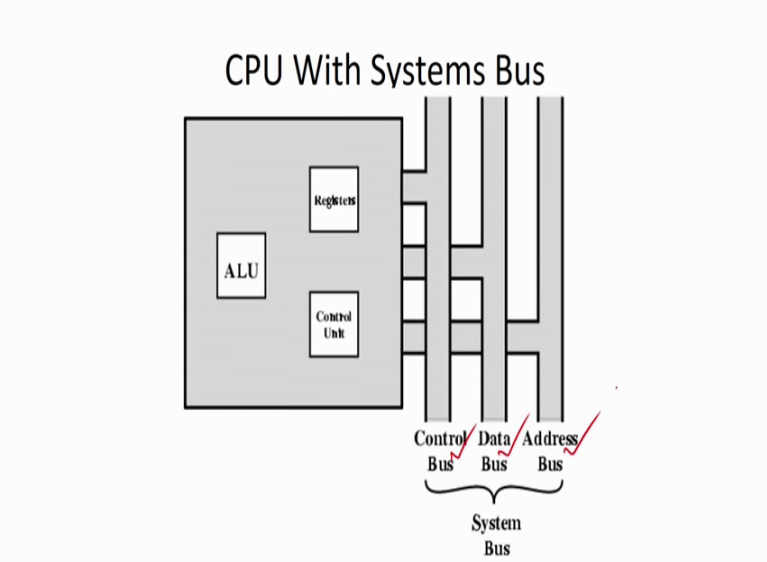


And secondly I can tell that memory can also be treated as an external devices with respective to this particular processor because memory is sitting outside the processor so;

that means, through system bus we are going to connect the other devices on memory to the processor and the system bus is having 3 components control bus, data bus and address bus, now already I have mentioned all those things. So, basically we are having memory connection. So, with the help of memory connection what we are going to do receives and sends data received address or location because we have to identify the location also and receives some control signals.

So, basically in system bus we are having 3 component with data bus we are going to receives or sends our data, we are having a address bus through address bus we are going to give the address to a memory location and through control bus we are going to receipts or send some control signal, one is your read signal already said that we are going to read the information write signal, you may said that we are going to write something to the memory and some timing information also has to be sent in that particular connection.

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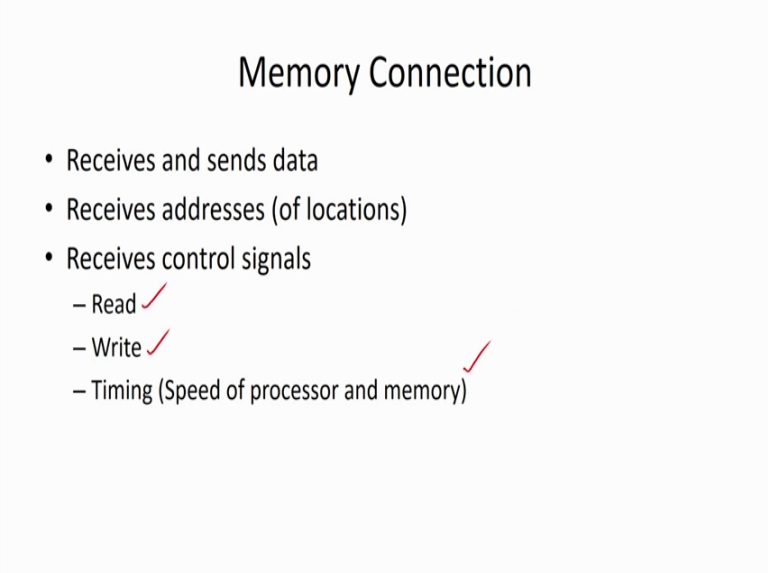


So, here I am to mention that the speed of processor and memory is not same. So, we are having a; processor, C P U and we are having a memory unit and this is connected through this particular system bus.

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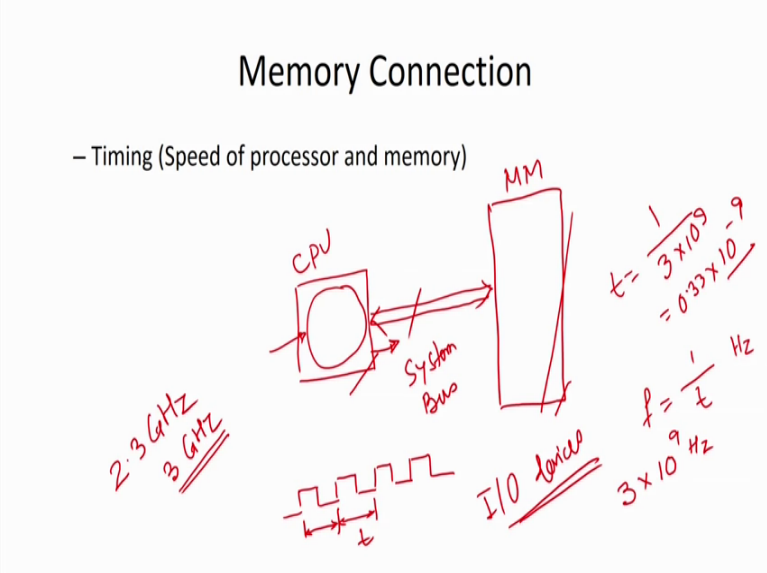


Now most of you are working with a computer and you know that generally used you use to said that, that I am having a computer and it works on say 2.3 Giga hertz or sometimes you may say that, we are having a processor which works in your say 3 Giga hertz.

So, what does it means? Basically this is the frequency of operating frequency of the processor. So, what will happen? We are having a continuous running clock and this is the time period of this particular clock signal. So, this is during this particular clock signal this is clock pulse we are going to perform some job or say some micro operation, then in the next clock cycle we are going to perform some of the clock cycle. So, this is basically call time period of this particular signal and when I am going to talk about the frequency that frequency is nothing, but 1 upon that particular time period and it is basically unit is your hertz.

So; that means, if you are going to said that it works in 3 Giga hertz; that means, 3 gigahertz is equal to; 3 into 10 to the power 9 hertz, kilo hertz is your 10 to the power 3, megahertz is your 10 to the power 6 and kilo hertz is your 10 to the 1 minus. So, it works in this particular frequency 3 into 10 to the power 9 hertz; that means, in 1 second it is going to oscillate that many times 3 into 10 to the 1 minus. So, what is the time period? We can say that this is nothing but t is equal to 1 upon f, so this is nothing but 1 upon 3 into 10 to the power 9, which is I can say that 0.33 into 10 to the power minus 9.

So, this is basically; second, millisecond, microsecond, and nanosecond. So, 10 to the power minus 9 is your Nano seconds, so that many this is the time period. So, in that Nano second 0.33 Nano second I can carry out one small operation inside this processor, so this is the operating speed. So, this is that we are achieved this particular 3 Giga hertz

is due to the advancement of technology and we are going to use the technology over here which is very faster technology, generally it is a silicon technology and generally now a days you are working with the submicron level. So, with the help of advancements of technology we are getting devices which can work in 3 Giga hertz.

So, but when you are looking for the performance the cost is also more over here, so If we are going to use the same technology to make this particular main memory, then what will happen? The cost is going to increase. So, while constructing our main memory generally we used to use a slower technology just to reduce the cost, so this is a slower technology we are a using, so here we are having a faster technology, so somehow we have to synchronize these two operations, so for that we need some synchronization signal or timing signal.

So, some other control signal will come which will say that when the memory has completed these operation or not whether data is ready for the process or not we have to give some indication, so some of the control signal will come for that particular purpose also to synchronize the other unit with the processor. Similarly, when we are connecting some I O devices the speed of those I O devices again still slower, again this slower than the main memory, so again we need the synchronization signal for that, so those all the synchronization signal will coming through this particular control unit bus.

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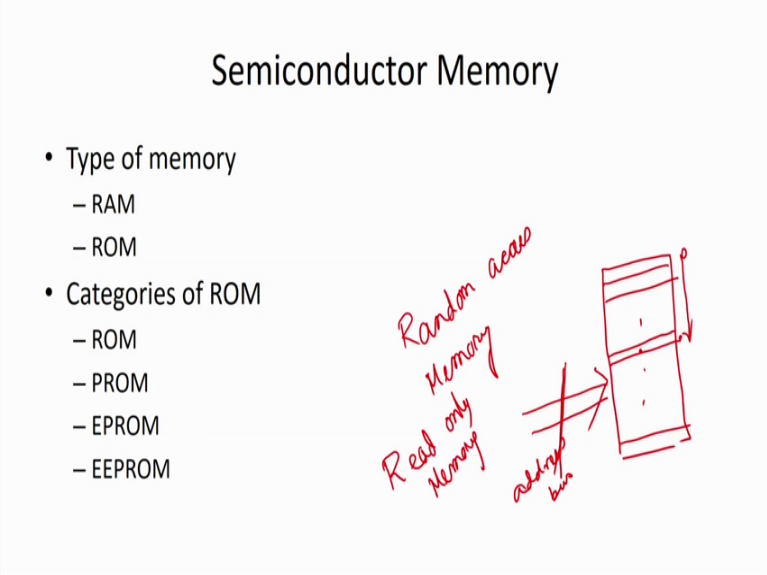

So, if I look into the memory basically that main memory we talked about this particular main memory this is basically nothing but a semiconductor memory. So, in case of semiconductor memory here we can talk about two types of memory; one is your RAM, second one is your ROM. So, RAM is basically is it stands for; random access memory, so RAM is random access memory. So, what is this basically? You can see that we are having a memory module we are having several location and through address bus we can identify any one of this particular memory location.

So, depending on the input of contents of the address bus you can go to any memory location. So, the accessing of memory location random is measured by giving a particular address we can straight away go to that particular memory location. So, it is randomly we can access any memory location.

Since we are talking about the random access there may be some other access also, which is a sequential access? In case of sequential access we have to access the memory in sequence. So, if it is a sequential memory then what will happen? If I want to go to this particular point then I have to go in sequence found a first location to that particular location, but in case of random access that sequence is not required to randomly order any point of time I can access any memory location. So, I have to give the appropriate address to that address bus, so it is talking about the random access memory.

Another one I have mention about ROM; this is read only memory, but again I should mention that ROM read only memory is also random access this is the same nature that we are having, but we can go to a particular location and I can read it. So, what is the difference if I talk about RAM and talk about ROM, what is the similarities over here? Both are random access. And what is the difference? In case of ROM, it is read only we can read the contents from the memory, but in case of RAM; it is read and write, we can read the information that is stored in a memory also you can write some new information in some memory locations. So, both read and write is possible in case of RAM If i say that it is a ram, but if I talk about the ROM then it is only read only we can read the information from that memory. Again here I can say that these RAM and ROM can be categorise into 2 category; one is your volatile second one is your non-volatile or permanent.

So, when we talk about the volatile; it is basic like that, as long as we are working in the system; that means, as long as we are giving the power to the system then we are going to have the content in the memory and we are going to work with those particular contents of the memory, as soon as I switch off the machine if I remove the power then what will happen? The contents of this particular memory will go away, so that is why we have to say it is volatile, so RAM is volatile in nature. So as long as power is there contents is there and we can work with this particular contents, but once you switch off then all the contents will vanish [vocalised-noise] if next time if I will going to switch on the machine again you are not going to get those particular contents, so it is volatile in nature, but rom is read only memory it is a non-volatile memory and it is permanent in nature.

So, during the manufacturing the ammeter we can write the contents in the ROM and while working with the rom we can simply read it we can take the information and you can work with the information. So, it is a permanent in a source, so it is non-volatile memory and when we are going to give the put the information in the ROM? If we say simply ROM, then during the manufacturing time only we are going to keep all information. Again we are having several types of rom and these are basically one is known as ROM that I have already mention this is read only memory. So, during the manufacturing time itself we are going to put the information and that information will be used in our devices, so this is ROM, but we are having the enouncement we are having another type of ROM which is known as your PROM programmable read only memory, so it is a ROM but it is programmable.

So, while manufacturing when it will come from the company, then the contents are null basically it is a null contents or it is a blank memory. Now with the help of programmer we can program this ROM or we can say that we can write some new information in to that particular ROM. So, once I write it then the contents become permanent, we cannot erase it and it is permanent in a nature now we are going to use those particular information, so this is call PROM; programmable ROM, it can program only once you program it once you write a contents it will remain permanent and we can use it, but after programming if you find that there is some mistake then what will happen? I have to use another PROM only I cannot use that one. So, for that we are having next level of ROM which is known as your EPROM is your erasable programmable read only memory; that

means, it is a ROM read only memory it is programmable, but again it is erasable say once you program it we have written a contents into the memory, but if you find a there is some mistake in some data or some information, then what we can do? We can erase it and we can reprogram it.

So, here erasing means? Erasing the contents of the entire memory, there is a mistake in only one bit still you have to erase the entire memory, so erasing can be done by exposing that particular rom chip to ultra violet rays and once it becomes blank again we can reprogram it. So, in that particular case what happen? If there is a mistake in one particular memory locations still you have to erase the entire ROM and reprogram it.

So, for that we are having a next level which is known as your EEPROM electrically erasable programmable read only memory. So, this is programmable it is erasable but erasing is not like that you have to erase the entire chips; here, it is call electrically erasable, so in that particular case what will happen? If you find a there is a mistake in this particular memory location, then we can erase this particular memory location and you can rewrite it and need not to rewrite the entire things over here we need not to rewrite the entire memory, so this is your EEPROM.

So, all are semiconductor memory and those semiconductor memory; we are going to connect to the processor to build our computers, which will worked as a primary memory. So, like memory connection we are having input output connection also, so through input output connection you can connect input output devices. So, basically what will happen? That input output devices will be connected to the processor to I O modules. So, what will happen in case of output? It will receive the data from the computers. So, basically what will happen? I can say that this is the processors, C P U this is the system bus through system bus we have connecting the I O module and I O devices I will be connected to this module.

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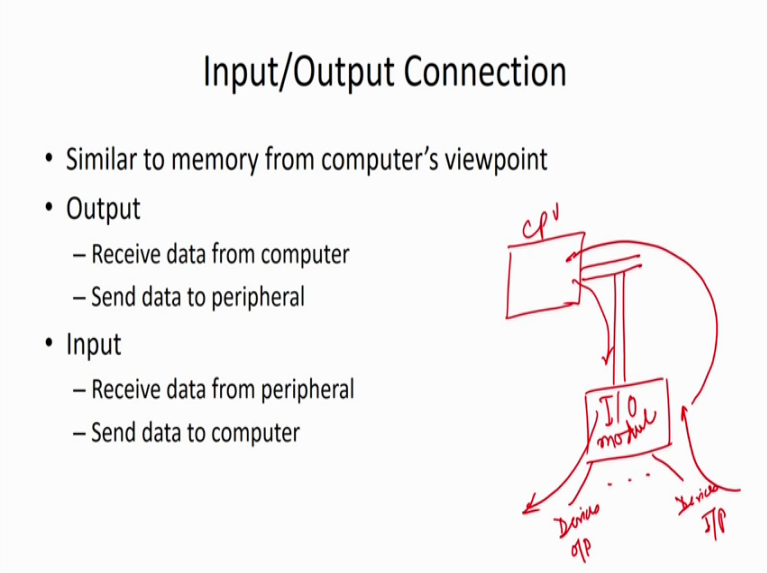


So, what you can do? In case of output, it will receive data from the computer and these module transfers it to the device. So, in case of input it will receive the input from the device and that module will transferred it to the processor. So, this is basically output device and in this is case this is the input device. So, these are the things that we are going to do with the help of input output connection, again those I O modules will be connected to the processor through the system bus.

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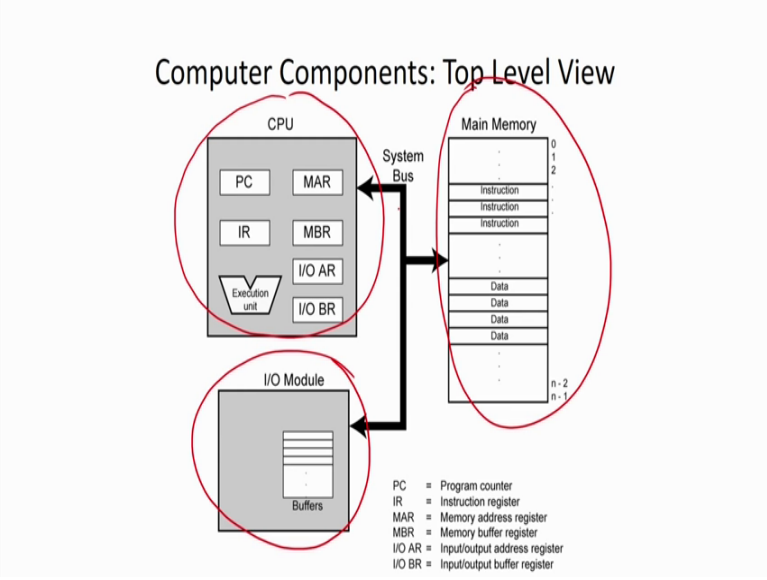

So, this is the top level connection already I have seen this slide you have seen this slide for several times this is the C P U that main memory unit and this is I O module to I O module we are going to connect this particular input output devices and all those things are connected to this particular system bus, again I am I would like to mention that system bus is having 3 component; address bus, data bus and control bus.

Now what is an address bus and data bus? And what we can Store? And what are the limitations? Thus we are going to give one example. So, we are talking about the address bus, already while talking about the memory module what I said that? If I am having 8 memory location then I need 3 bit of address because 2 to the power 3 is equal to 8 and we having 8 different combination.

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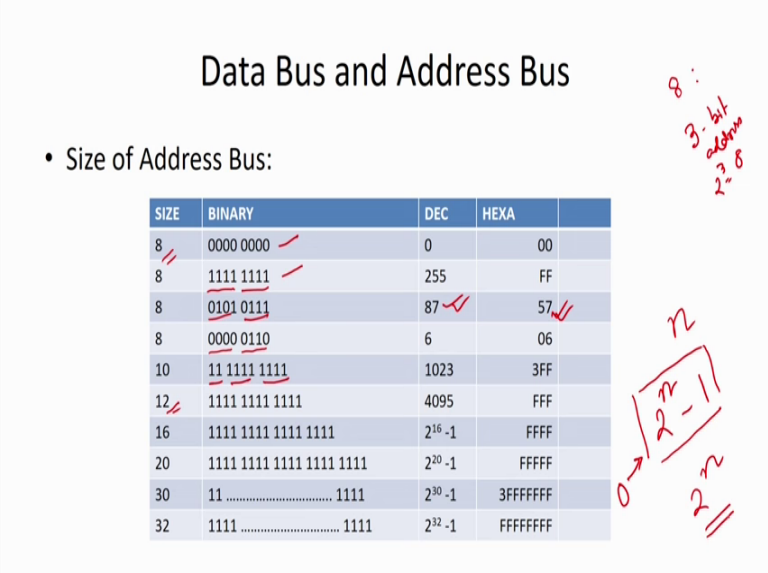


Like that; now I am just elaborating it now if the size of the address bus is 8, then what will happen? This contents will go from all zeros to all one these are the different possible combination and in decimal we are saying that this is 0 or 255 that; that means, we can address 256 memory location if the size of the address bus is your 8 and this is 255 and here I am just writing it in hexadecimal, because I said that you take 4 bit together and thus get the hexadecimal equivalent, so this is your f.

Now, if I am having 8 bit address bus in the contents is something like that 0 1 0 1 0 1 1 1. So, if I will have this particular contents then the decimal equivalent of this one is your 87; that means, we are looking for the 87-th memory location which is starting from 0 8,

so you are going to 87 my location and found a particular memory location we are going to a take the data or we are going to write data. So, that same information that you can write in hexadecimal we can say that 57 hexadecimal, so this is 5 this is 7.

So, if the contents of the address bus is your and 0 0 0 and 0 1 1 0 so; that means this is 6, this is decimal 6 also in hexadecimal also it is 6; that means, we are looking for the 6-th memory location. So, like that we are having total 256 combinations, so we can address 256 memory locations.

Like that if I am going to increase the size of the address bus to 10 then what will happen? It will become now 2 to the power 10 which is your; 1023, or in hexadecimal I am saying that this is 3 F F, so it will go from memory location 0 to memory location 1, 023. If we increase the size of memo address bus to 12 then we can go up to 4095 like that if I am having a 16 bit address bus, then we can go up to 2 to the power 16 minus 1 so; that means, if I am having an n bit address bus then I can go up to 2 to the power n minus 1 memory location. So, total 2 to the power n memory location it will go from 0 to 2 to the power n minus 1, so 2 to the power n memory location we can get this. So, the size of the memory module that we can connect to the processor depends on the size of the address bus.

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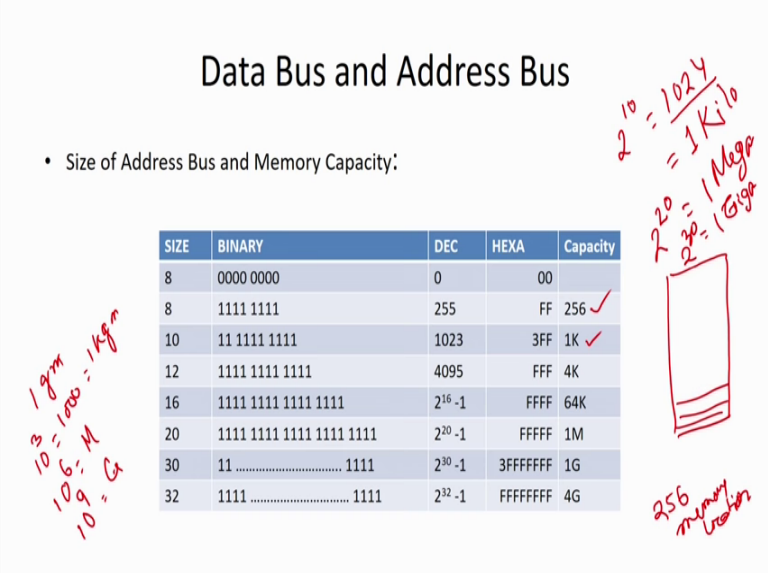

So, now we are talking about address bus this is a same slide, but along with that we are talking about the, what is the capacity? Now if it is size is your 8 bit then total memory capacity is to produce 256; that means, having 256 memory locations. We are talking about these are the location and this is your 256 memory location you are not talking exactly how many bit you are storing over here, but we are storing saying that we having 256 memory location.

So, similarly if I am having a 10 bit then it is 1 k actually 2 to the power 10 is nothing but 1024, so in that particular case that 1024 memory location is basically written as 1 kilo memory location. So, this is use as; 1 k means, 1024 which is your 2 to the power ten, so this is having slight difference without metric system basically what will happen? If I am giving one gram one centimetre and then what will happen? I can say that 10 to the power 3 is equal to 100 1000, so we are going to say this is your 1 kilogram.

Like that we are having 10 to the power 6, 10 to the power 9 which is a kilo mega and here it is your Giga like that megahertz Giga hertz like that. So, in metric system having 10 cube, 10 to the power 6 10 to the power 9, but in a binary system when we talk about the computer than 1 k is your 1024 which slightly more than 1000 slightly more than a metric system, like that 2 to the power 20 is known as a your 1 mega and similarly 2 to the power 30 is known as your 1 Giga, so this is the information or we are having it.

Now how we are going to specify our memory? Whether it is your mega location or Giga location or kilo location, now you just see that sometimes you used to say that, in your memory we are having 4 gigabyte of memory what does it means? To see these things will explain it, so this is the scenario and secondly what about the data bus?

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## Data Bus and Address Bus

- Size of Data Bus/Memory Location:

| SIZE | BINARY | DEC | HEXA |
|---|---|---|---|
| 8 | 0000 0000<br>1111 1111 | 0 - 255 | 00 - FF |
| 12 | 0000 0000 0000<br>1111 1111 1111 | 0 - 4095 | 000 - FFF |
| 16 | 0000 0000 0000 0000<br>1111 1111 1111 1111 | 0 –<br>$(2^{16} - 1)$ | 0000- FFFF |
| 20 | 0000 0000 0000 0000 0000<br>1111 1111 1111 1111 1111 | 0 –<br>$(2^{20} - 1)$ | 00000 - FFFFF |
| 32 | 0000 .....0000<br>1111 .....1111 | 0 –<br>$(2^{32} - 1)$ | 00000000 –<br>FFFFFFFF |

So, this is a something if I am going to have a data bus of a 8 bit then I can go up to 0 to 255 if it is your 16 bit, I can go up to 0 to 2 power 16 minus 1 when you are talking about the number system at that we have discuss all those issues. So, now you just see that. What is the relationship between them?

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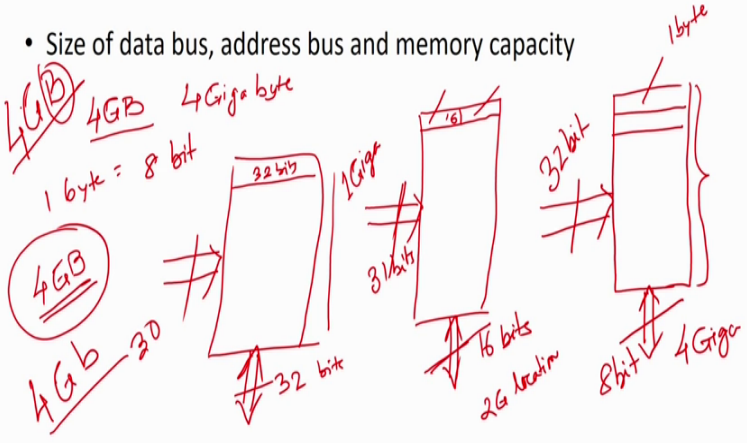
## Capacity of memory module

- Size of data bus, address bus and memory capacity




So, you have mentioned that you are having a computer with 4 Giga g b usually said I am having memory that my computer is having 4 g b memory, so it means it is having 4 Gigabyte. What is byte? I thing somewhere you have mentioned 1 byte is equal to 8 bit,

so it we take 8 bit together generally we will call 1 byte. So, it is having 4 Gigabyte; that means, we can say that in a simple case what I can think that? Which is having 4 Gigabyte and I say that, in every memory location I am going to store 1 byte of information.

Then how many memory location we are having over here? 4 Giga memory location. So, see; we are having 4 Giga memory locations and in every memory location we are storing 1 byte of information. So, for that now if I am going to look into it, what is the size of this data bus over here? Since every memory location we are storing 1 bit of information 1 byte of information; that means, here I am having 8 bit, so data bus size of the data bus is your 8 bit.

Now what is the size of the address bus? So, you just see that I am telling you with 3 bit I can address 8 location, 4 bit we can address 16 location, 5 bit we can address 32 location, like that; if I am having your 10 bit of information 1 kilo, 20 bit of information 1 mega, so 30 bit of information 1 Giga 2 to the power 30 and 4 Giga is your 2 to the power 32; that means, we need 32 bit over here.

So; that means, if I say that I am having computer with the memory capacity is 4 Giga byte basically we can visualize in this particular way, that it is having 32 bit of address bus and 8 bit of data bus and we are having total 4 Giga memory location and 2 in an every memory location I can store 8 bit of information, but again I can consider about the 4 Giga byte of memory location, but depending on the organization what will happen? The size of data bus and size of address bus will vary. So, 4 Giga byte I am talking about that memory capacity is 4 Giga byte, but we are not mentioning our how many memory location is there, now if I am going to look this in that particular way that in every memory location I am going to store 16 bit of information, then data bus is your 16 bits now here in every memory location now I am going to store 2 byte, since every memory location we are going to store 2 byte. So, the number of memory location that we have over here will be reduced by 2, so here I am going to have 2 Giga locations. So, in 2 Giga locations in every location I am using storing 2 byte of information, so finally we are going to get 4 Giga byte of memory.

So, since now I am having only 2 Giga memory locations then size of this address bus is your 31 bit, now again I am going to consider a memory module with 4 Gigabyte

capacity but organisation is different in that particular organisation, what will happen? I can say that; the size of my data bus is your say 32 bits. So, in that particular case; that means, in every memory location I can store 30 bits of information, now since it is 4 Gigabyte and in one memory location I am storing 32 bit; that means, I am storing 4 byte since in one memory location I am saving 4 bit 4 bytes. So, what will be the total number of memory location? Will find this is your 1 Giga locations, 1 Giga into 4 byte will give 4 Gigabyte. Now to address 1 Giga memory location, what will be the size of this particular address bus? Now we can very well find it out this is your 32 to the power 30 is equal to 1 Giga. So, you just see that if I am going to talk about that I am having a computer with memory 4 Gigabyte.

Then we have to see, what is the processor size? Basically, whether it is a 32 bit processor or whether it is a 64 bit processor and depending on that you can find out that addresses and data bus. Again we are having some more concept call this is byte addressable; that means, though I am having 2 byte in one memory location you can address bitwise also I can take 8 bit and 8 bit, if I go into that one and what will happen? Sizes of address bus will be slightly different you have to re calculate it again it will turn up to be with 32 only, so when we are going to discuss about the memory module then at that time we are going to emphasise on that particular issue.

So, now you just see that we are going to connect a memory module to our processor that memory module is having some capacity; we can say it is a, 4 Gigabyte or 2 Gigabyte or may be say 4 megabyte, 256 megabyte and depending on the way that we are storing information; that means, size of the memory location with respect to that we can find out what is the size of the data bus? And what is the size of the address bus? So, these are the things that we are discussing over here, so what we are talking about? That processor is the basically connected to memory unit and I O devices through system bus, system bus is are in 3 part; one is your address bus, data bus and control bus and depending on the now by looking into the size of the address bus we can find out what is the maximum size or memory that we can connect to that particular memory processor?

So, if I am having an address bus of 32 bit; that means, you can connect a memory to the processor where we can have 2 to the power 32 which is 4 Giga memory location and depending on size of the data bus we can say how many bit you can store in a particular memory location. So, this is basically connecting the other component with the processor

to build a full computer, so now just see that we have now discuss the all those things now try to work out some work example or test item.

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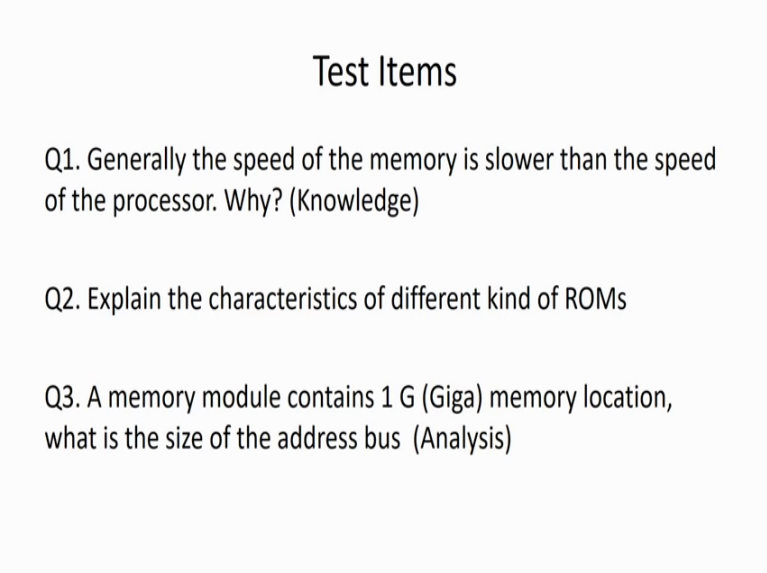


So, first question that I mentioned over here; the generally speed of the memory is slower than the speed of the processor why? So, it is in knowledge level only because you have mentioned this thing in knowledge level, because to reduce the cost on the computers and then what will happen? We use different technologies to build different component and the technology that we used to build a memory module is a slower technology, so that is why the speed is slower. So, basically to balance the cost excel we need the performance as well as we want to reduce the cost, so for that we are coming with the slower device and due to that what will happen? The speed of the memory is slow.

Question number 2: I am saying that explain the characteristics of different kind of ROM's already I have mention that we are having ROM, PROM EPROM, EEPROM, so these are the and you know what are the characteristic one common characteristic all are non-volatile, but they are having some other characteristics also so I think you can note it down and you can write it down.

Question number 3: A memory module contains 1 Giga memory location, what is the size of the address bus? So, it is in analysis level I am talking about memory model

contains 1 Giga memory location; that means, we should have a provision to address 1 Giga memory location.

Here I am not talking about the capacity of the memory module we are not saying that is 1 Gigabyte we are talking about 1 Giga memory location. Now what will be the total size? It depends on the information that we are storing in it is memory location, if we are storing 1 byte then this is your 1 Gigabyte, if your storing only 1 bit of information in your every memory location then capacity of this memory module will be 1 Giga bit. So, if we are storing too much of information in each memory location then the total capacity of memory module will be 2 Gigabyte. So, you are taking out 1 Giga memory location. So, what is the size of the address bus? I think you know it is 2 to the power 30 is equal to 1 Gigabyte, so size of the address bus will be a 30.

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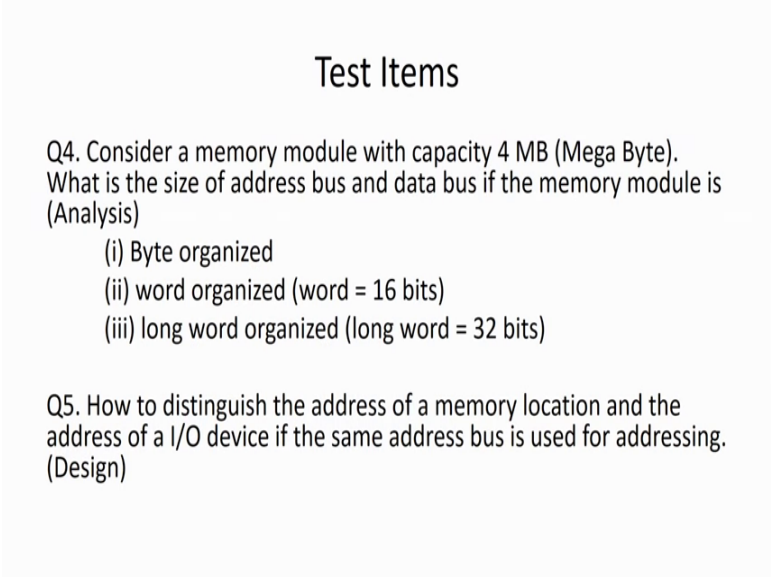


Now consider a memory location with capacity 4 M B, 4 megabyte. So, I should mention one thing if I say; 4 G B it means that 4 Gigabyte, but if I write 4 G and lower case b in that case it is a 4 Giga bit. So, this upper case talk about the byte and this lower case talk about the bit, now this test items said that consider memory module with capacity 4 megabyte what is the size of the address bus and data bus? If the memory module is this in the analysis level, so it is if it is byte organized; that means, in every location we are going to store 1 byte of information then what will be the size of address bus and data

bus? If it is word organized that means one word is equal to 16 bit that we are storing 2 bits of information.

So, depending on the size of the address bus and size of the data bus will same. Third one: I am saying that long word organised; that means, one long word is equal to 32 bits; that means, 4 bytes in one memory location we can fit 32 bit of address, but total memory capacity is 4 megabyte. So, with respect to that you have to identify what is the size of the address bus and what is the size of the data bus?

Question number 5: How to distinguish the address of a memory location and the address of the I O device, if the same address bus is used for addressing, so this is some clean high-level in the design level, so when you are going to design a computer at that time we have to resolve all those particular issue. I think I have mentioned something now you are using the same address bus, but at some point of time you are going to place the address of the memory [vocalised-noise] location at some other point we are going to put address of the a I O devices. So, we have to distinguish this particular address for that so I think we need one additional control signal.

So, with the help of an additional signal we can say, what is the content of this particular address bus? So, this is basically I am just saying that is in the design level, because while you are going to design a processor you have to resolve this at the particular time itself. So, like that you can now try out with some other example also and with this I will wind up this particular unit. So, hope you have you understood the methods over here.

Thank you very much.