Microprocessors and Microcontrollers

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Lecture – 28
8051 Microcontroller (Contd.)

So, other addressing that we have is the absolute at absolute jump type of instruction. So, the absolute jump instruction so, the jump address is specified explicitly the problem with relative addressing is that this jump address has to be within 256 bytes from the current location. So, that may not be always possible.

So, what we can do is that we can take a small relative jump and from there we may have to take a long jump. So, that is by means of absolute addressing.

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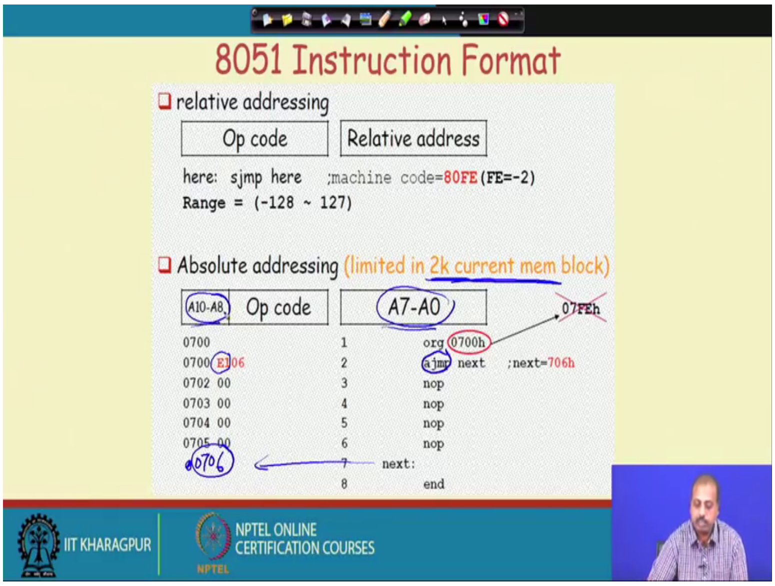

So, you cannot always deny the use of absolute addressing. So, in case of absolute jump instruction in 8 0 of 5 1 so, the we have got different version 1 inversion is the AJMP instruction. So, this AJMP so, is the is an absolute jump, but here this it is limited to 2 kilobyte from the in the that is the current memory block so, limited in 2 kilobyte. So, you cannot go beyond to kilobyte.

So, this why because this address that is mentioned is this a 0 to a 7 and this a 8 to a 10. So, total 11 bits are devoted for keeping the offset and by 11 bits. So, you can mention the numbers in the range of total range of numbers that you can have is 2 kilobyte.

So, as a result so, it cannot be more than 2 kilobyte. So, we can have this this AJMP next instruction. So, this next value is 0 7 this next value is here. So, that is this instruction ends as 0 7 0 5. So, next instruction this one is at address 0 7 0 6 this is the 0 7 0 6 so, this 0 7 0 6. So, this is it will be. So, u one is the u one is the code that we have for AJMP. So, actually these bits are actually mixed. So, you cannot really differentiate very easily so, you have to distribute it and then only it will come. So, this is not 0 7. So, this will be based on if you if you just look into the code then it will be like this.

So, here this 0 7 0 6 is put directly it is distributed in these bits and these bits.

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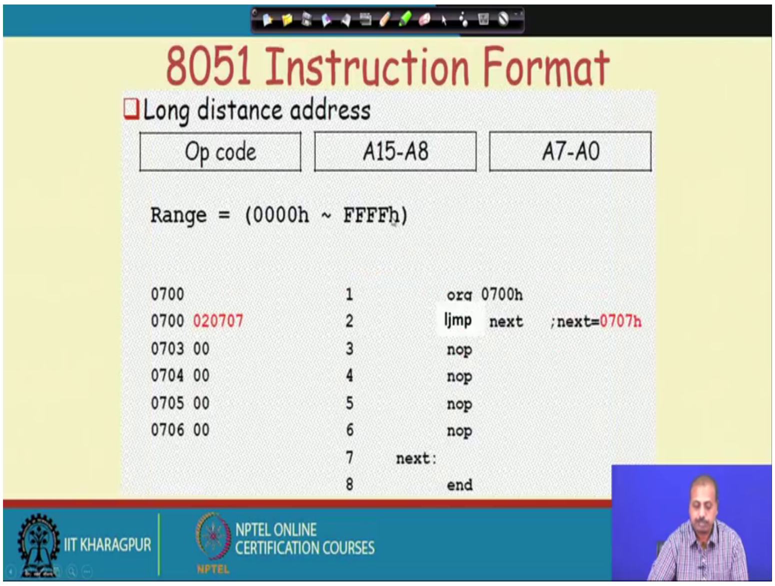

So, this is actually this this this is the other version of this jump instruction, which is ljmp. So, this is ljmp instruction.

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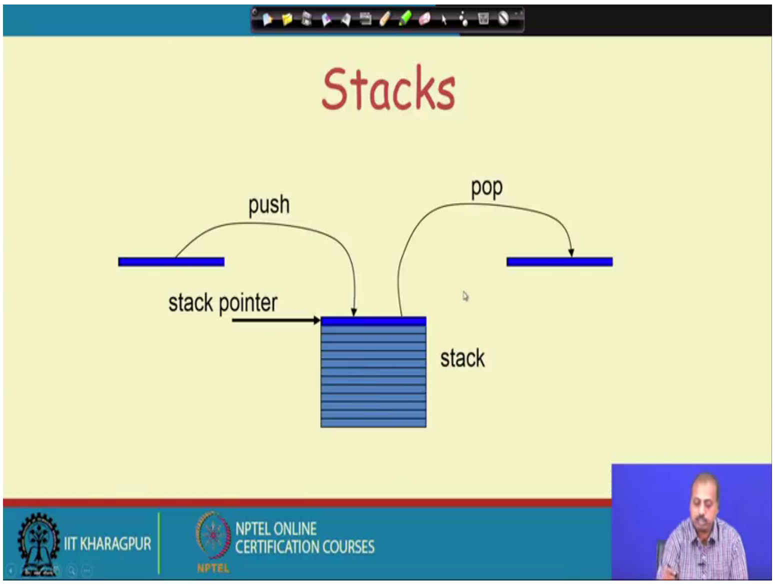

So, this is this is ljmp there is a long jump. So, here we do not have the restriction. So, in the sjmp instruction we had this in the sjmp instruction we had this thing this offset is only 11 bits a 0 to a 10, but in this ljmp instruction. So, offset is total 16 bits. So, you can branch across the total 64 k address space that you have. So, the range is very high all 0 0 0 0 to FFFFh.

So, here when we are saying like ljmp next so, ljmp next so, it is. So, we it the value will be calculated. So, next address is 0 7 0 7 and the off code is 0 2 and then the, whatever be the address. So, that will be coming here. So, that way this long address will be calculated.

So, we have got these 3 variants of jump instruction we have got the relative jumps specified with the relative jump instruction specified as sjmp, we have got this absolute jump instruction specified by ajmp and this absolute jump instruction is is a 2 byte instruction and a relative jump instruction is also a 2 byte instruction, but this ljmp instruction is a 3 byte instruction.

So, that way this ljmp is slightly costly in terms of the area requirement and when this microcontroller is being used you know that this memory space is scarce. So, we would like to we like to save as much memory as possible in the code part. So, if it is not absolutely necessary we should not use ljmp. So, we should restrict us to ajmp instruction because that will require one byte less otherwise there is no difference.

The next important concept that we have is the stack. So, the stack as we have seen that is so, it is a part of memory and the stack pointer it points to the top of the stack.

So, we can have 2 operations push and pop, but the push operation will push the next whatever the value that we want to put into the stack into the location pointed to by stack pointer. And the pop will take out the value from the top of the stack and get into the location that we want.

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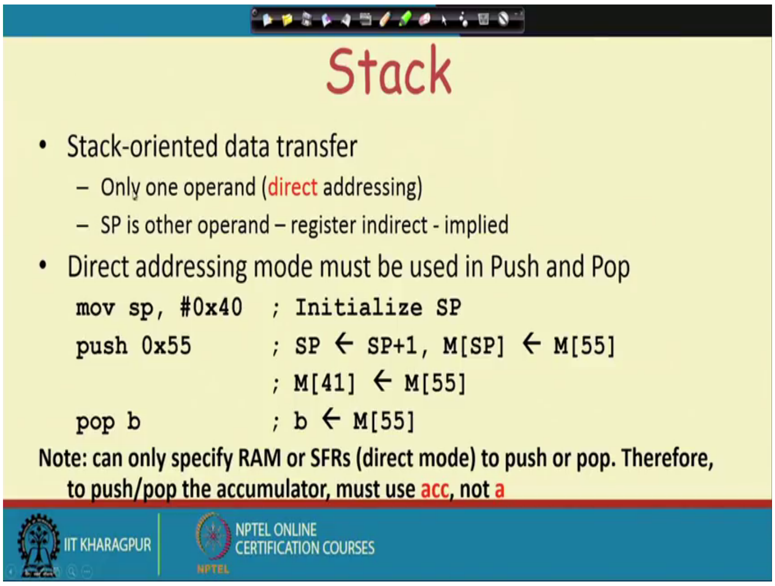

So, for stack oriented data transfer. So, only one operand can be specified. So, we have to just tell the value that we are trying to push or pop. And the stack pointer is the other operand so, because the memory access will be in terms of the stack pointer only. So, in on the only direct addressing it can be used. So, we can so, before doing any per stack operation the most important thing is to initialize the stack pointer.

So, if we do not initialize the stack pointer properly then this stack pointer may be pointing to some garbage location and then this push pop will arbitrarily modify some memory location. So, what is done? So, for so, before doing any push swap operation the program should first set this stack pointer and that may be done at the beginning of the program and later on when it is. So, as it is doing other operate the push pop operation. So, since the program has set it properly it is expected that it will not corrupt any of the important program and data parts.

So, here move SP comma hash 0 x 4 0 hex. So, the value of 40 hex will be put into the stack pointer. So, stack pointer is initialized to that then push 0 x 55. So, what happens is that the memory look first this stack pointer is updated stack pointer is updated by one incremented by 1, then the memory location stack pointer gets the value 55 x. So, what happens actually is the since stack pointer is at 40. So, memory location 41 will get the content of memory location 55. So, this is again you see that one way of transferring data between 2 memory locations.

So, from memory location 55 we are transferring the data to the memory location 41 the other instruction that we have is the pop instruction. So, you can again mention some address or you can mention these special registers. So, pop b. So, b gets the value of memory location 55. So, you see that can only the we can only specify RAM or SFR registers to push or pop. So, we can to push pop accumulates. So, we should use acc and not a. So, a cannot be used because a is treated as a register, but acc is treated as a special function resistance that is why we cannot use a, but we have to use acc in the instruction, but anyway apart from that. So, you can directly specify the memory addresses for those registers.

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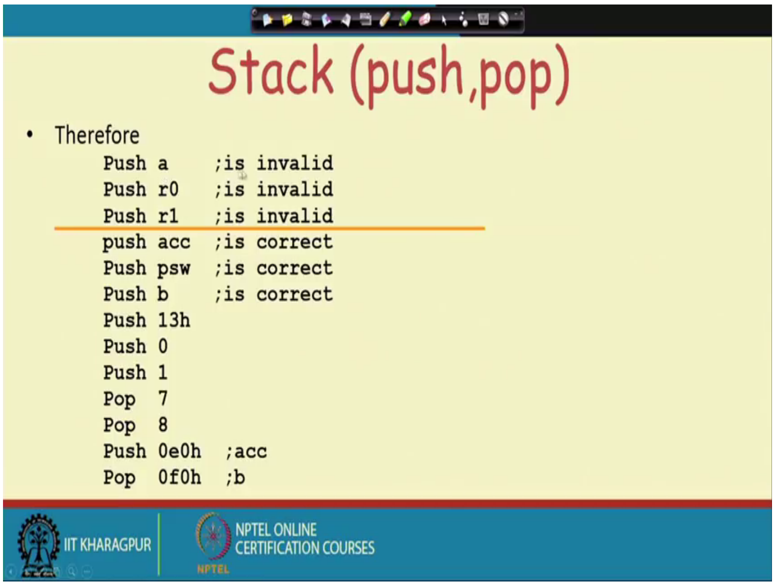

So, push a is invalid push r 0 is invalid, push r 1 is invalid. So, these 3 are invalid because these are not. So, I cannot mention registers like this, we can write like push accumulator push acc, push psw, push b, push 13 x, push 0. So, all these can be done or you can even even write in terms of the special the register numbers like push 0 e 0 hex. So, that is same as this push acc then pop 0 f 0 hex. So, that is same as you know this pop b. So, that way so, these push pop instructions. So, these assembly assemblers so, they will not accept these things they, but they will accept this one.

So, that is just for can say some sort of convenience.

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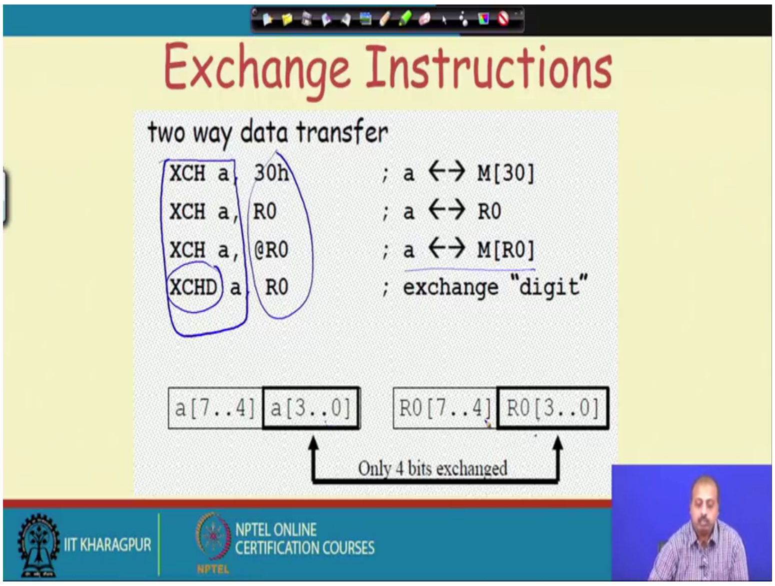

So, there is another type of data transfer instruction which which is known as the exchange. So, exchange. So, this exchanges the values of 2 bytes so, XCH a comma 30 hex. So, the content of memory location a will be exchanged with memory location sorry content of register a will be exchanged with memory location 30. And again the same thing that all this instruction this a part is fixed. So, XCH a so, this part is fixed. So, only the second thing can be specified.

So, you can say like XCH a comma at the rate r 0. So, call so, a will be exchanged with memory location r 0.8 2 by r 0 and there is a special version XCHD. So, it is the exchange digit. So, only 4 bits are exchanged. So, this lower order 4 bits will be exchanged, like between a and r 0 this lower order 3 4 bits will get exchanged ok.

So, this is useful in many cases like particularly for operating system design. So, this type of exchange instructions are useful, particularly when we are going to implement say semaphore type of synchronization primitives then this type of exchange of data will be useful.

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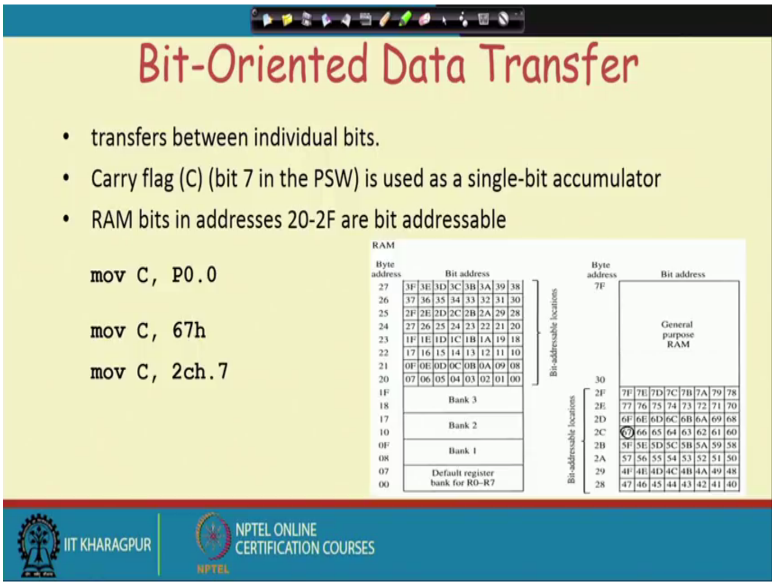

Next, we will look into bit oriented data transfer. So, this is a very powerful feature that this 8 0 5 1 microcontroller has and for that matter most of the microcontrollers, we will see that it has got this bit addressability and this makes it powerful, because many times we do we have to set the different bits in a different fashion.

So, making the mask pattern accordingly and setting the bits that way. So, we it requires a large amount of code and maybe we just put said the number then do left shift or right shift to come to the proper pattern and all that. So, those can be avoided and we can just access individual bits directly to put the values there. So, this bit oriented data transfer. So, it transfers between individual bits. So, this carry flag a carry that is c that is used as single bit it can be used as a single bit accumulator and this ram bit 2 0 to 2 F so, they are all bit addressable.

Like we can have move C comma P0.0. So, this port 0s bit number 0 will come to the carry flag then this 67 hex like say this one. So, this can be moved to the carry flag. So, we can have it like this then this 2 C hex dot 7. So, 2 see hex is this 1 dot 7. So, this is a same this is the same as that bit 67 67 hex. So, that is same as that one. So, it will be sorry yeah. So, bit number 67 x and these 2 C x dot 2 C x dot 7 they are same. So, they will come to the carry flag.

So, they say we can use these bit oriented instructions for data transfer.

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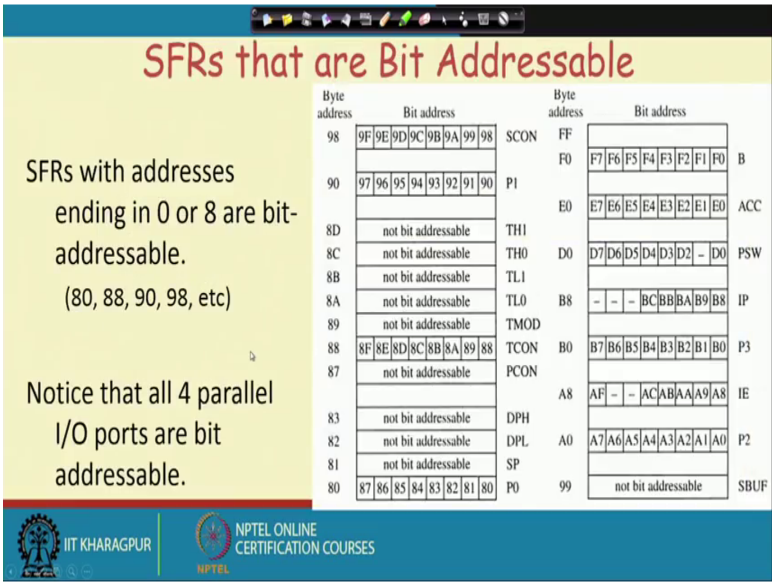

Now, the special function registers that are Bit Addressable so, you see that if you look into the pattern like say this P 0 then this T con. So, they are bit addressable others are not. So, you see that that addresses which end with 0 or 8 are bit addressable like 8 0 8 8 9 0 9 8. So, they are bit addressable and all 4 parallel IO ports. So, they are all bit addressable. So, that is there. So, P 0 P 1 P 2 P 3 they are bit addressable and this registers who end with 8 or 0 that is divisible by 8. So, they are all bit addressable.

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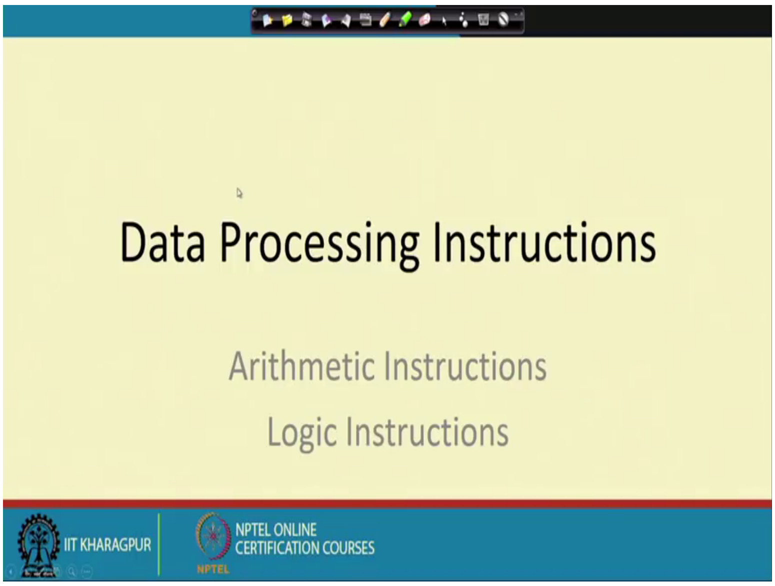

Next we look into data processing instructions there are several data processing instructions.

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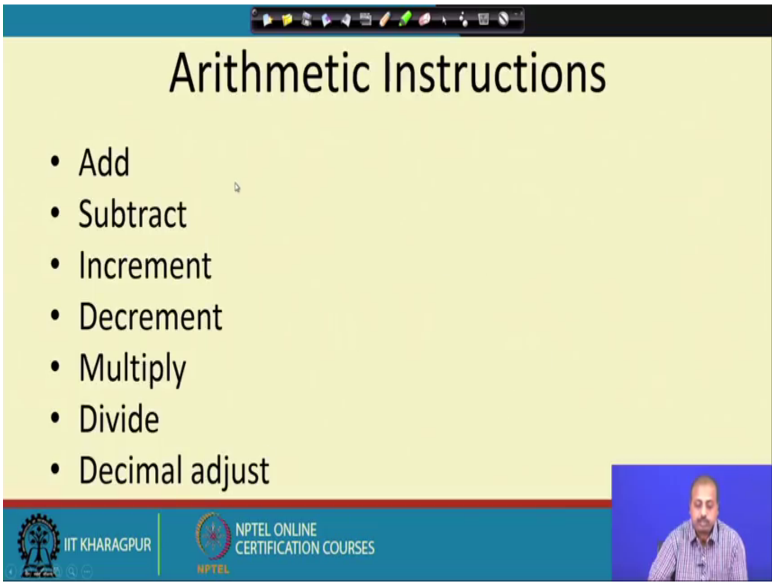

In 8 0 5 1 like add subtract increment decrement multiply divide decimal adjust. So, like that.

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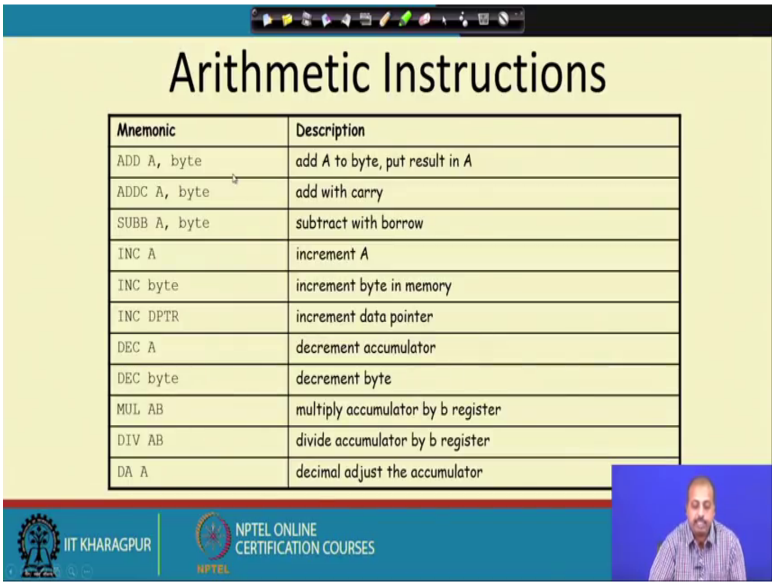

So, we can have like adequate instruction, like Add A comma byte Add A 2 byte and put the result in A register, Add C comma byte. So, Add C A comma byte. So, it will add with carry. So, it is a plus byte plus carry will be put into the A register, then subtract with borrow SUBB. So, that will be there. So, this way we can have a number of such instructions.

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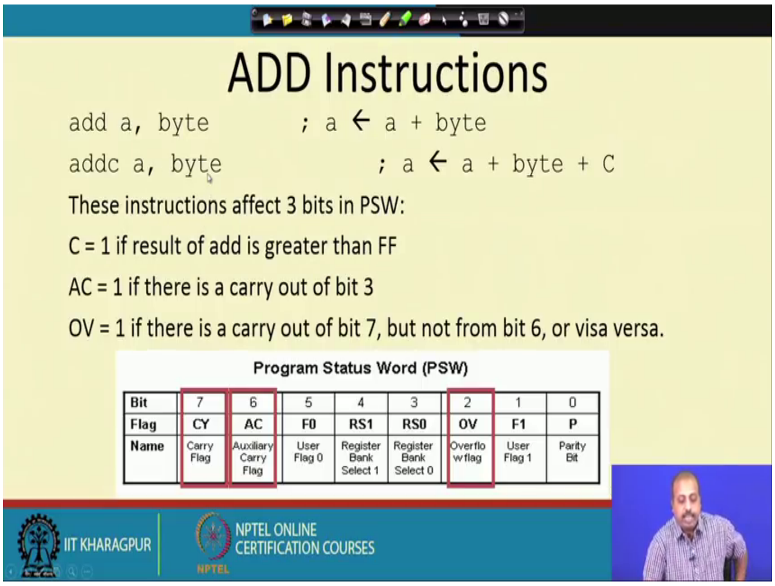

So, you will see some of them like add a, comma byte a gets a plus byte and a dc add CA comma byte a gets a plus by plus C. These instructions will affect 3 bits of PSW like it will affect this carry bit CY auxiliary carry bit and the overflow bit.

So, if C equal to one if the result of add is greater than FF. So, the carry is generated then the carry flag will be set this they auxiliary carry will be 1, if there is a carry from bit 3 to bit 4. So, if there is a carry then the after the after the nibble if there is a carry, then this bit will be set to one and this overflow will be set if there is an overflow carry coming out of bit 7, but not from bit 6. So, there is a carry out of bit 7, but not from bit 6 or vice versa then if the overflow flag will be set.

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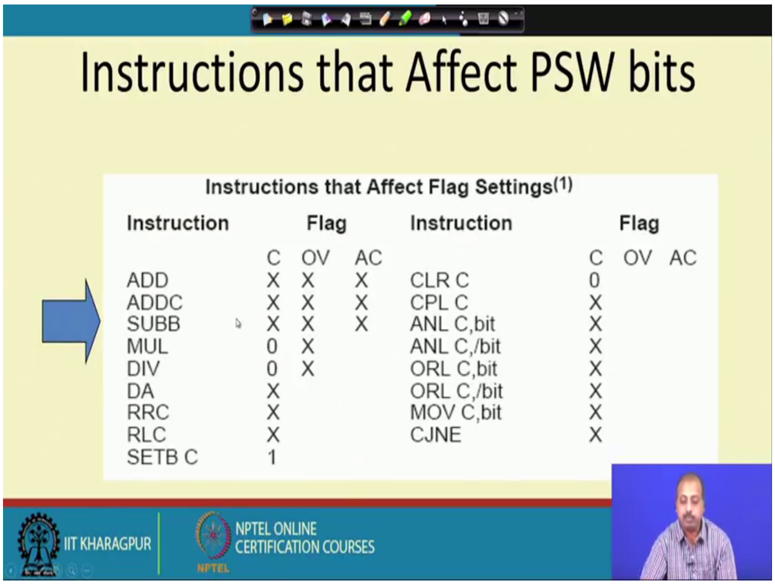

So, these are the instructions that will affect the PSW register like the add affects C carry overflow and auxiliary carry add C again affects all of them.

Now, some of the interesting things that we have got is molly multiply instruction that will set the carry to 0 and the overflow is affected, but not the other one. Similarly division so, this will set the carry flag to 0 and it will not affect the it will affect the overflow, but not the accumulator then SETB carry. So, as the name suggests the carry should be set to one say bit carry. So, this carry is set to one similarly clear carry will make the carry bit 0 complement carry. So, whatever be the current value of the carry bit. So, that will be complemented then we have got n logical C bit.

So, this is so, this will be ending the bit with the carry. So, that may be if this bit is 0. So, it is clear carry. So, if this bit is one. So, this will be some the previous will continue. So, you can position you can mention some bit number with which the carry will be ended then we have got this move C. So, we will see these instructions.

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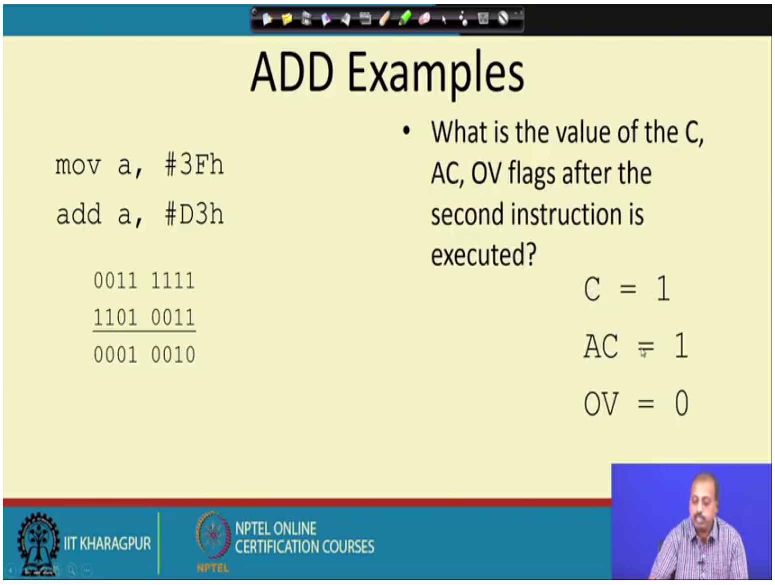

Now like this addition example like move a comma 3 FX and then at a comma has D 3. So, what will be the value of this? So, if we do this addition. So, it will be like this. Now, so, the a the affect the things that are affected is carry equal to 1 is equal to 1 and OV equal to 0.

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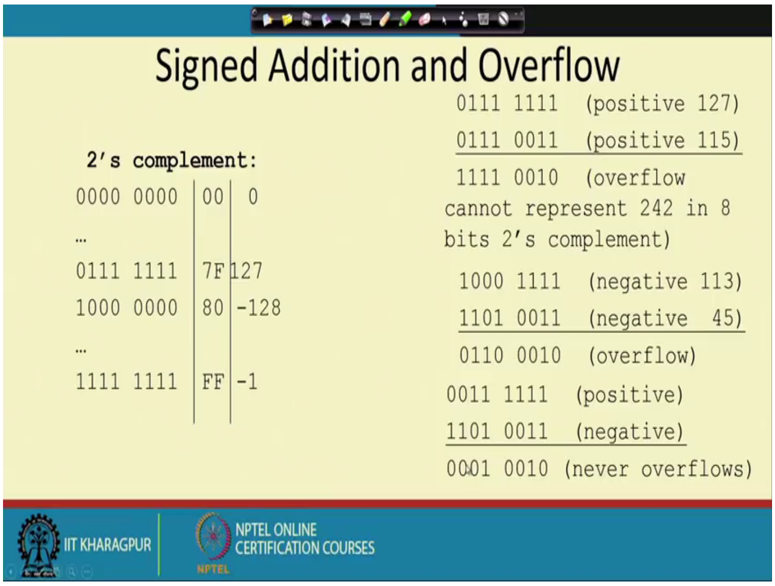

Then if you is so, 2's complement notation. So, we have got these since this number it is 7 F and this is 8 0.

So, 8 0 is minus 1 20 8 and this number is 7 f is 127, if you do the addition then the result it should be minus 1. So, in the binary notation if we do the additions 1 1 or so, these the auxiliary single equivalent is FF, which is minus 1.

So, similarly if this is 127 there so, this is number 127 this is 115. So, if you add it then there will be an overflow, because this value 2 4 2 cannot be represented in 8 bit twos complement format. So, there is an overflow and similarly we have got say negative of 1 1 3. So, this is coded like this negative of 45 coded like this again there will be an overflow, because we cannot represent the number there, but if we do it say this is positive and this is negative. So, after doing the addition there is no overflow.

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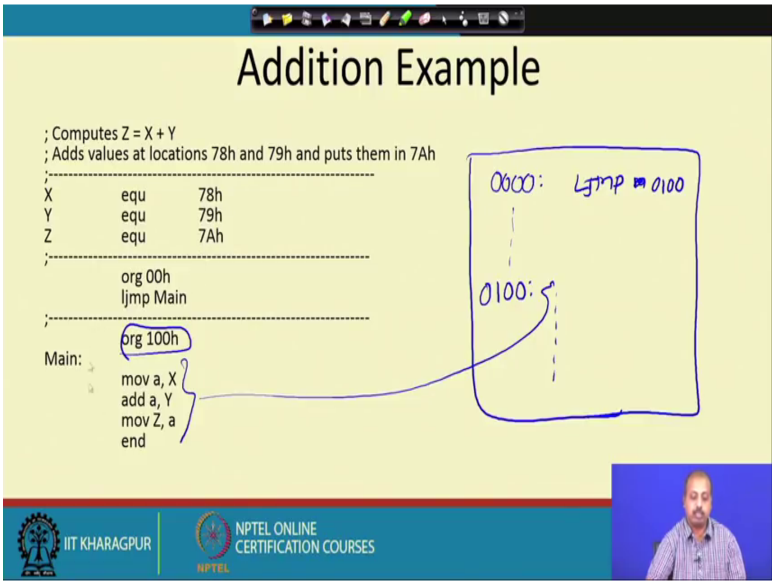

So, that way we can have different addition results affecting the carry auxiliary carry overflow flags. Now suppose we are writing a program that will be doing this Z equal to X plus Y. So, it will add the contents of locations 78 hex and 79 hex and put them in the register into the memory location 7 A.

So, what we do? So, we define 3 constants X Y and Z and as I said that this e q u are equal. So, this is a assembler directive that tells the assembler that in my program wherever I am writing X you should replace it with 78. So, that is a constant number and r g 0 0 hex. So, this is this way this means that also this is the assembly will start at location 0 0 hex.

So, this the program when it is loaded. So, the first instruction LJMP main will be at location 0 0 hex. So, if you look into the memory map. So, it will be like this at location 0 0 0 0. So, it will put the instruction LJMP main now for main. So, this is before that we have got this org 100. So, this at location from 0 1 0 0 my actual program starts. So, there I have got this move X and all these codes they are starting from this point onwards. So, when we start the program the start the system. So, it should go to location 0 1 0 0.

So, the assembler when they are generating the object code so, it will do it like this that at location 0 0 0 0 it will put the instruction LJMP 1000 and at location 0 1 0 0 onwards. So, it will be putting the code for this this piece of program. So, when the program will actually be executed the PC, when we reset the processor the PC will be 0 0 00. So, it will come to this instruction and it will make this executed LJMP 0 1 0 0 as a result it will start executing from this point onwards.

So, what are we doing here? So, first we are moving the content of X move a comma 78 hex. So, content of memory location 78 will come to a then add a comma Y. So, content of memory location 79 will be added to a and then move Z comma a. So, content content of the accumulator will be saved into the memory location 7 a hex. So, this way this program will be executed and do the addition.

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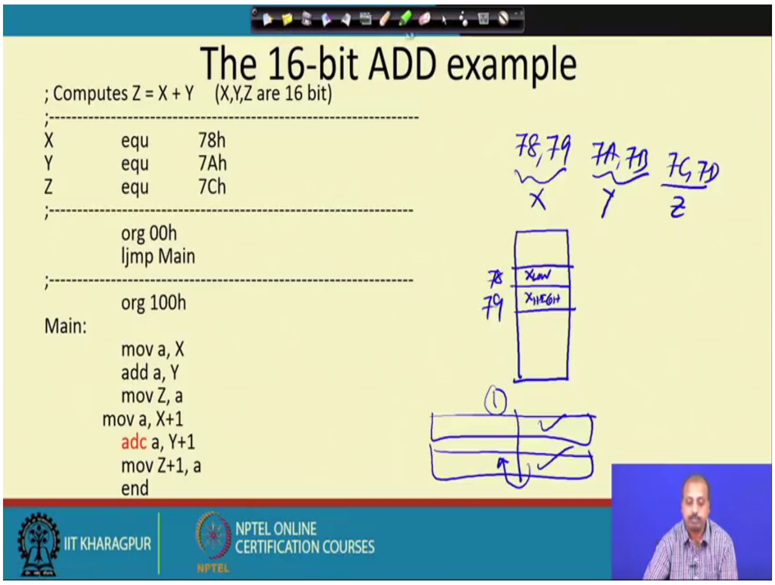

So, next we look into a slightly more complex version, where this XYZ these numbers are 16 bit numbers. So, instead of being 8 bit number they are 16 bit numbers, but 8 0 5 1 will do 8 bit addition only. So, we have to be careful that from 1 stage to the next stage. So, that carry has to be propagated.

So, what we do? So, now, individual 7 8 so, individual locations as 16 bit the number X is 16 bit. So, it is. So, we assume that at sorry we assume that at location 78 hex, we have got the number X. So, the location 78 a 7 8 and 7 9 they will hold the value of X and then 7 A and 7 B, they will hold the value of Y and these 7 C and 7 D they will correspond to the variables they will correspond to the variable Z. So, this X Y and Z we are defining their addresses as 78 7 7 8 7 a and 7 CX.

Now, the program that we write is like this that first, we get the content of X into the a register. So, first byte 78 the bytes the memory location 78 content comes to the a register. So, if this is the location 78 and this is the location 79, now since intel follows the convention that the higher order byte will be at higher order address.

So, here I have got the X the lower part of it and at the next location I will have the higher part of it. So, first the lower bytes are to be added. So, the 78 content of memory location 78 comes to a and then add a comma Y. So, this will add the content of memory location 7 A with accumulator.

And the whatever be the result. So, that we are storing at location 7 C hex and then content of memory location X plus 1 that is X is 78 so, 78 plus 179. So, content of memory location 79 will come to a and then we will be adding the content of memory location Y plus 1 that is 7 b, with that a and here instead of using add we are using add C, because previously some carry would have been generated and that carry has to be added now because. So, we have got 16 bit numbers. So, 2 16 bit numbers so, we just added this lower lower order byte now from here there may be one carry generated. So, that carry has to be added in the next phase.

So, that is why this adc is used. So, this adc is instruction. So, this will be adding a and Y plus 1 and the carry will also be added. And the result will be stored at memory location Z plus 1 that is the location 7 7 D that is higher order byte. So, it will go to the higher order address ok.

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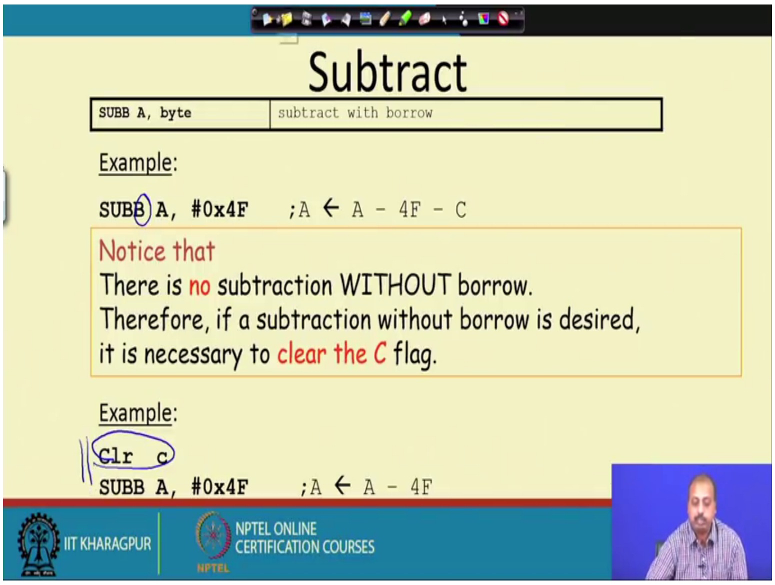

So, next you see the subtract instruction SUBB subtract with borrow. So, subtract with borrow. So, this will be doing like say a comma SUBB a comma hash 0 X 4 F. So, what it will do. So, accumulator will get a minus 4 F minus C, but we do not have any sub instruction. So, there is no instruction where this b is not there. So, this you do not have any instruction where this b is absent though we for add we have got add and add C, but here we do not have anything only.

So, whenever you are doing a subtraction. So, we have to be careful that we clear the carry first. So, whenever before doing any subtract operation, we have to clear the carry first and then we have to say like subtract with borrow a comma whatever subtraction we are interested in since so, that way we have to do it?

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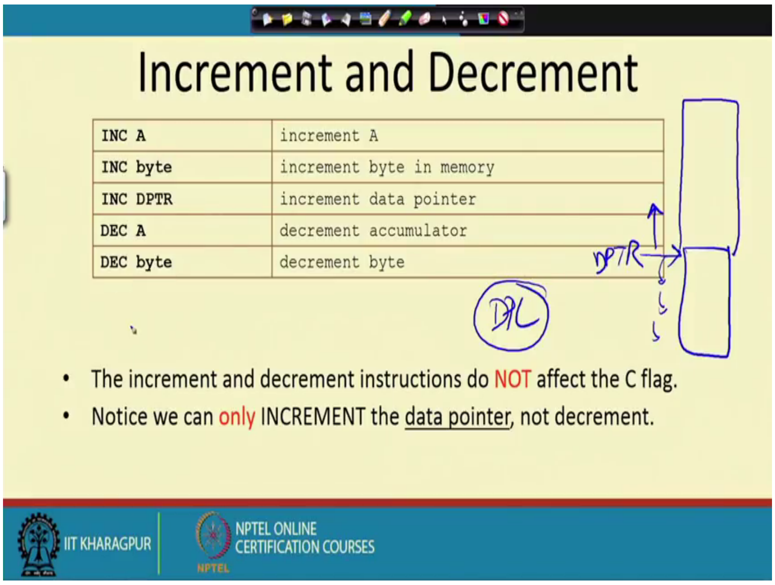

Then we have got the increment and decrement instructions like in ins INC A it it increments a then INC byte it increments byte INC DPTR it increments the data pointer similarly you have got decrement a decrement by type of instruction. So, the increment and decrement instructions they do not affect the carry flag. So, this is one difference compared to say 8 0 8 5 where they were affecting the carry flag, but they will affect the 0 flag, but they will not affect the carry flag. So, the only another interesting thing that we have is that we can only increment that data pointer we cannot decrement the data pointer.

So, if you if you have an array and in your external storage and if you have an array in your external storage and you say that. So, DPTR is pointing to this then for accessing successive locations. So, you can increase the DPTR well, but if you want to go upward, that is not possible so, you cannot decrement the DPTR value. So, for that purpose you have to use that DPL register. So, you have to use the DPL register. So, you can increment decrement the DPL, but when you are you are using a pair whenever you are using a pair. So, you cannot do this thing. So, it you have to write into DPTR is always increment only.

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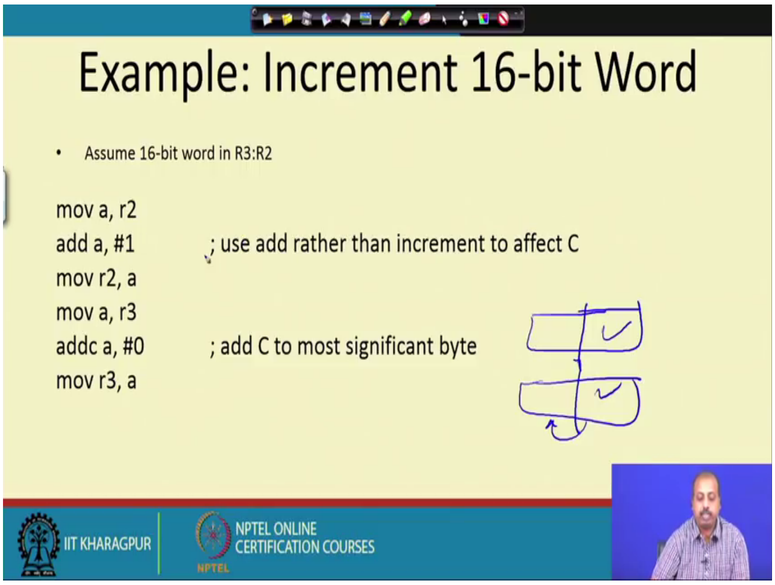

So, next we look into an example of implementing a 16 bit word. So, move. So, assume that the 16 bit word is stored in the pair r 3 r 2. So, r 3 has got higher order byte r 2 has got the lower order byte. So, first we get the content of r 2 into a register with add a comma hash 1. So, rather than increment because if we if I you I can I could have used increment here, but if I use increment instruction then the carry flag will not get affected, but since it is a 16 bit addition we want that the from that that the carry should be generated. So, when this addition is done? So, when you are adding these to this carry should be generated so, that this carry can be propagated to the next stage of addition.

So, that is why instead of doing this the increment we use this add one then the result we are storing in the r 2 register and the r 2 register value is incremented and then we have to. So, it may generate some carry. So, then r 3 value is moved on to this a register then add C a comma has 0. So, this will be a we already have r 3 and if some carry has been generated. So, that carry will get added and since r 2 is already added.

So, we do not have this r 2 to be added again. So, this is 0. So, that that way we get this ultimately this a value has to be moved to r 3. So, so this r 2 r 3 pair is incremented and r 2 is incremented by 1, if a carry has been generated that carry gets added with the content of r 3 that is how this program is executing?

So, these ways if you are have if you are doing 16 bit operation. So, many a times instead of using the increment decrement instruction, we have to use this add instruction or subtract instruction to make the program carry.