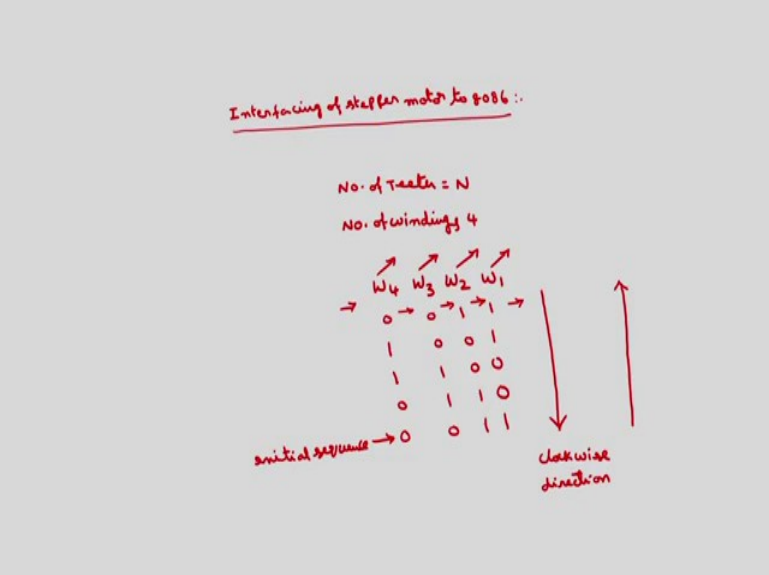
Microprocessors and Interfacing
Prof. Shaik Rafi Ahmed
Department of Electronics and Electrical Engineering
Indian Institute of Technology, Guwahati

Lecture - 22
Stepper motor, Liquid level control

In the last class we have discussed about the various high power devices, how to control the high power devices using Microprocessor. Today we will discuss about the Stepper motor Interface to the 8086.

(Refer Slide Time: 00:43)



So, stepper motor unlike the conventional motor, where the rotation will be continuous here will be having some steps. So, stepwise rotation will be there, because of that this stepper motor will be used in printers ok. So, if the number of teeth in the motor is N, you can choose the N depends upon your application and there will be 4 windings number of windings will be 4 motor windings. If I call this winding as W4, W3,W2 ,W1.

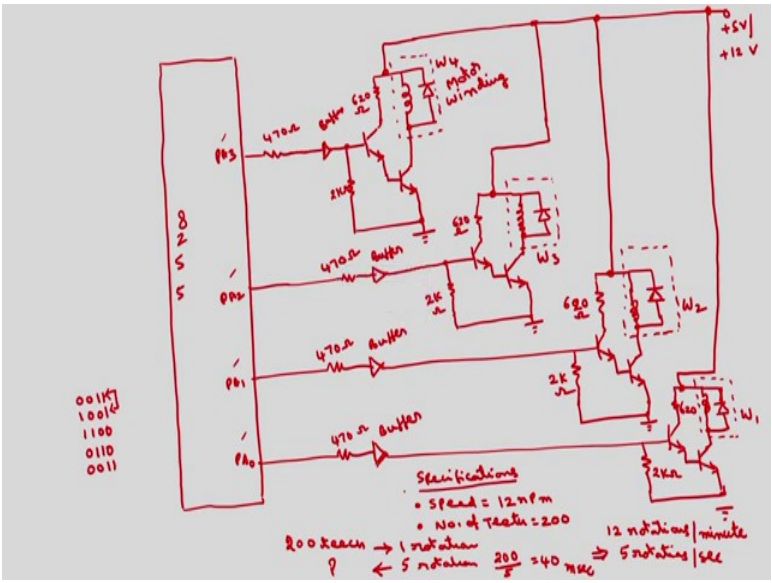
So, in order rotate the stepper motor, the sequence that has to be given to this windings will be 0011 we have to feed 11 in 2 windings, we have to I mean feed 0 in 2 windings. Then we have to rotate this to the right, if I rotate this this will come in front of this and this will move here this, this will move here, this will move here and so on. So, this becomes 1001 till we get the same first sequence we have to do this rotation, then the

next rotation 1100, next rotation 0110, next rotation is 0011 which is same initial rotation this is the initial sequence.

So you see the way and you have to I mean give the sequence, if want to rotate stepper motor in clockwise direction. If want to rotate in anti-clock wise direction we have to give in a reverse manner, you start with 0011 then you give this 0110 and so on. So, we know how to I mean control this motor windings they require the I mean larger currents.

So, I will draw now the interfacing circuitry between microprocessor and stepper motor. So, correspond to each winding I will connect to one of the ports of 8255 through the control circuitry. So, the interfacing diagram of the stepper motor to 8086 is as follows.

(Refer Slide Time: 03:50)



So, this is 8255 we have 4 windings as I have told. So, we have to connect through the buffer, this is the bootstrap as we are discussed in the earlier classes. This will be used to increase the current capacity of the circuit. This is the winding this is to one winding let us call this one as W4. So, these values is going to decide means something like 470 ohms, 620 ohms, 2 kilo ohms. Similarly, we will be having correspond to W3, W2 ,W1.

So, this is one of the I mean configuration that I have discussed to increase the current capacity, similarly third one and fourth one. So, there are 4 windings correspondingly the four control circuitry. So, this 2 transistors will be used for increasing the current capacity this will be connected to the motor winding. So, these are values are same as in

the previous 2K, 620, 470 ohms, this one is winding W4, this is W3, this is 620 ohms, 2 kilo ohms. So, this points will be grounded this is W2, this is W1 they are called motor windings.

In the last class we have discussed about how to control the motor winding also this is the circuit that we have to discussed and this points we have to connect to plus 5 volts or plus 12 volts depends upon the specifications of the motor. We can have 12 volt operated motors also and we have 5 volts operated motors also, this will be given to common plus 5 volts or plus 12 volts. This is the complete circuitry which has to be connected to the windings of the stepper motor, the other side we have to use 8255.

So, these are all called buffers, there are 4 buffers. So, we know the buffer increases the current capacity. So, this I am going to connect to 8255 one of the ports of 8255 only 4 pins of 8255 is enough. So, is up to you I am going to connect this W1 to PA0, PA1, PA2, PA3. So, I will assume the same address is port a address is FCH, port b is FD, port c is FE and a control word is FFH. So, what will be the control word corresponding to this one? I am using only port a and I have to program as output port.

So, in order to I mean program all the ports as output port 80 h is the control word ok. So, if I want to write the program here. So, the program procedure is so I want to operate this motor, it is speed of these are the specifications. So, we have to first decide the specifications before writing the program interfacing is same ok. How much delay is required between two consecutive sequences, as I have discussed that so the sequences that you have give is 0 0 1 1.

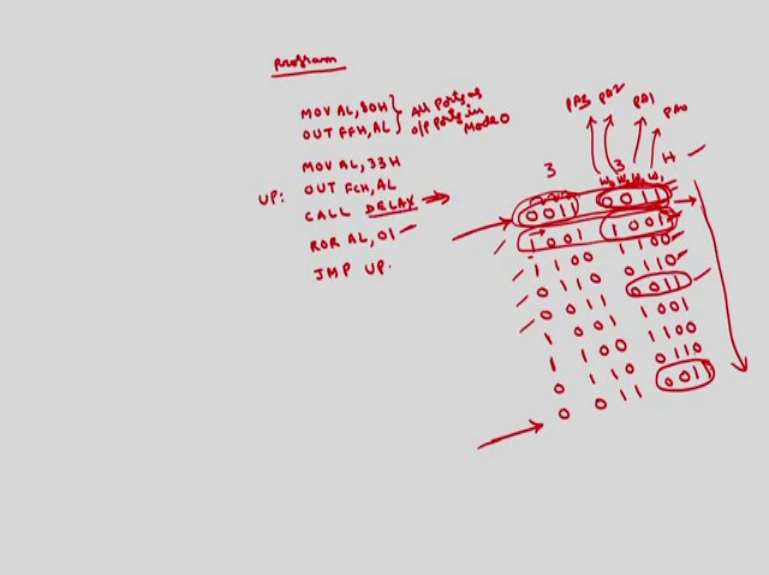
So, then 1 0 0 1, 1 1 0 0, 0 1 1 0, 0 0 1 1 like that you have repeat the sequence. In between the two consecutive sequences what should be the delay, that depends upon the speed. So, specifications of this speed I want to use a speed of this depends upon the application say 12 rpm revolutions per minute or rotations per minute. I want to rotate this say number of teeth will be say N is equal to 200; number of teeth is 200.

So, 12 revolutions per minute per second how many revolutions 12 revolutions or 12 rotations per minute implies 60 seconds will be 1 minute. So, in 1 second how many rotations we want? So we want 5 rotations per second. And number of teeth is 200, so means 1 rotation will be have to rotate 1 complete rotation is 200 teeth; 200 teeth is

equivalent to. So, 5 rotations per second 1 rotation means 1 by 5 th second, it has to get 5 teeth in 1 by 5 rotations 200 teeth, has to be completed in 1 rotation.

So, 5 rotations for 5 rotations how much time is required 5; 5 rotations, what is the time required? Will be 5 by 1 into 200 which is equal to 200 by 5, this is equal to 40. So, 40 milliseconds is the time required between 2 consecutive states. So, I have to write for this particular delay. So, we know how to write the delay programs. Now, if I come from this overall main program of this stepper motor the program part.

(Refer Slide Time: 13:49)



First, we have to program all the ports as output ports for that. So, initialization of data segment that are not writing now MOV AL , 80 H. OUT FFH ,AL these two instructions are used for programming the all the ports as output ports in mode 0.

Then the sequence that have to give is so I want only is 0011 sequence first initially 0011, the logic that I am going to use here is so I will write 0011 also again. I will repeat this, this is nothing but 33 H hexadecimal I want to go into enter into AL ok. So, after each rotation what happens we are going to rotate this to the right by 1 bit position through carry. So, after the first rotation what happens this will becomes1001 1001. So, this bit will come here, this bit will come here, this bit will come here like that. So, this bit last bit will goes to the first bit.

So, this one will be comes to here, so this will be the sequence after the first rotation. So, after the second rotation in a similar manner, so this bit one will come here 1 the remaining all this bits will be shifted to the right by 1 bit position. So, what will be this 1100, 1100 this will be after the next rotation next in similar manner 0110, 0110 next will be 0011, 0011.

So, next one will be 1001 1001 , next one will be 1100 1100 , the next one will be 0110, 0110. So, the next one will be 0011 0011 this is same as the initial sequence this two are same, means after the 8 rotation so we will get again 33 H you take 33 H in AL register you goes on rotating 8 times, after the 8 th rotation again we will get the same 33 H ok. That is why I am going to take this 33 H MOV AL, 33 H. OUT port a because I have to give this I am connected this to W4 ,W3, W2, W1.

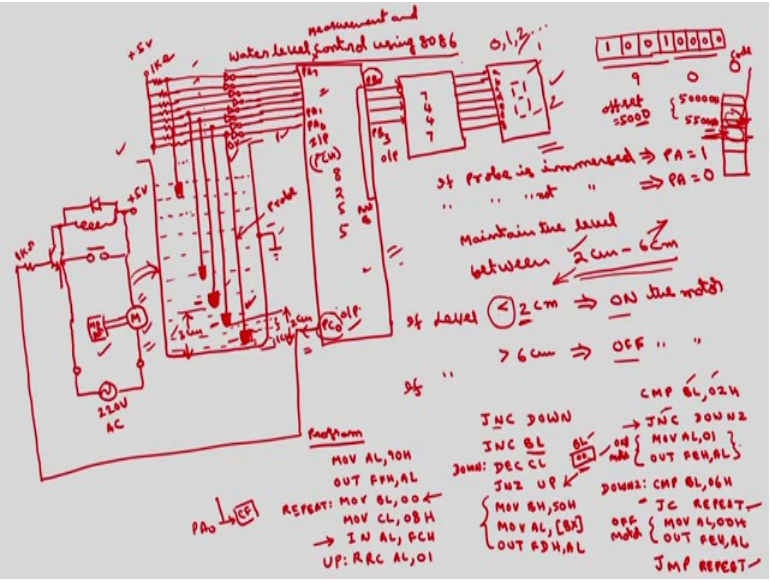
So, the sequence that have to give is 0011100 is this again this is same as this, again here this is same as initial. So, this sequence will be repeatedly comes. So, how to output this on to the because this W1 is connected to PA0 this is connected to PA1, this is connected to PA2 this is connected to PA3. So, if out on to the port A whose address is FC H, AL. What happened the first sequence is given, so it will rotate then we have to give this sequence in the order between the 2 consecutive rotations we have to call some delay. The delay which we have computed earlier called delay this depends upon this speed that we want.

The speed at which you want to operate the stepper motor and I explain the procedure to compute this delay, then after this we have to send this sequence. For that we have to rotate this value to the right by 1 bit position. So, for that you write the expression for ROR AL,01. So, this last bit will come to the first bit, then again you output the same sequence. So, for that unconditional JMP to UP if I write UP here. So, in the first I mean instant this is the sequence. So, after this rotate instruction this is the sequence ok, if you go some given the sequences, you will get this this this.

So, here after this 4 signals you will get the initial state again after another 4 you will get the same as this initial also, this is infinite loop. So, this will be continuously sends this sequence of 0011 1000 1001 1100 0110 to the 4 windings, there by the motor will rotate at the speed that is decided by this delay this is about the program to I mean rotate the

stepper motor through 8086. So, next we will discuss about how to I mean measure the water level and how to control the level of a water in a tank.

(Refer Slide Time: 20:04)



Water level control using in many of the industrial applications this type of control is required. So, in the previous stepper motor control we have driven this motor winding, now we will discuss about how to control the motor. So, here we can have this different ways to I mean measure this level. So, this setup that I am going to use here is this is the tank where I want to control the level. So, this tank is grounded and we have the water level up to this point, inside this you have to insert a probes. So, you have to insert probes through the resistor values.

So, here we have 5 volts you take the resistor values. If I use 8 probes this we have to connect to the inverters, through inverters I am going to connect to the ports of 8255. So, what is the need of inverter I will explain. I am going to use one complete I mean port of 8255, this is your 8255 in order to assume that this point is connected to a probe here, this point is connected to another level.

So, I am going to measure here 8 different levels at equal distance, this to another level this to another level and so on. This I will connect to PA0, PA1 so on up to PA7. So, this is the minimum change in the level that is required to detect, this is the this should be same ok. So, we can display the level as well as we can control the motor also ok.

So, in order to control the motor something like this is connected to 220 volts AC this is motor, this will be also controlled by 8255 port I am using port PC0. So, this motor will be on or off using this PC0 there by it will pump the water in to the this tank.

Now, we can send this value to the another port I am using port B to send the data to the display through BCD to 7 segment decoder. We can use 4 pins of port B lower order four bits PB0, PB1, PB2, PB3 this is 7447 which we have discussed in earlier classes. BCD to 7 segment decoder this 7 segments will be connected to the each segment of 7 segment decoder of course through resistors. Here I am assuming that the water level is only a single digit, it can be 1 centimeter 2 centimeter, so on up to it can count up to 8 centimeter for the sake of simplicity.

We can extend the same logic to connect to I mean multiple digit values also. So, the basic assumption here will be now suppose a particular probe these are call probes these are all probes. If a probe is inserted into the water what will be the voltage level? Is immersed. So, what happens there will be a connection from this water to the tank which is connected to ground point.

So, suppose if this probe is dipped or immersed into the water, here the voltage will be 0 volts. So, even if we have connected this 5 volts through some resistor values say some 1 k or 2 k, so this voltage here will be 0. So, if we want to directly connect this voltage to PA0 this will is negative logic, to convert this negative logic into positive logic we have connected through inverter so this will be 1. So, whenever this probe is inserted here this will be 1, if this probe is not inserted this probe is inserted inside implies the port value PA will be having value of 1. Because before the inverter it is 0 after the inverter it will be 1, if probe is not inserted or not immersed implies that port value will be 0 that is the logic.

If this particular probe is immersed, so I will assume that this is a for example. For the sake of simplicity 1 centimeter, if both are immersed first one and second one this is 1 plus 1, 2 centimeter this is total from here to here 2 centimeters and if third one is also immersed I will assume that this is say some 3 centimeters. So, like that I can display the values of this 1 centimeter, 2 centimeter on the 7 segment display. In addition so I am going to control the on and off of this particular motor also, say I want to I mean control I want to maintain the level between 2 centimeters to 6 centimeters. Means, so whenever

this level is less than or equal to 2 centimeters, implies I will ON the motor to pump the water ok.

So, between 2 to 6 centimeters we will not do anything, if this level is greater than or equal to 6 centimeters, then I want to maintain between 2 centimeters, 6 centimeters I will off the motor. So, I want to display this value on this 7 segment display, in addition I want to control on and off this one through this motor control using PC0. So, we see the hardware setup the connection from 8255 to 8086 we are not showing, because we know how to interface 8255 to 8086.

So, with this assumption how to program this what will be the program for this? Here in this we are using all the 3 ports; port B as output port, port C, of course only one pin only output port, port A input port. Let us assume that all I want to operate in mode 0. So, what is the control word register this is port C lower I want to ask output port 0 port B, I want the output port 0 mode selection for port B 0. I want to operate in this is port C upper I want as output port and port A, port A we have to operate as input port and mode selection for port a will be I want to operate in mode 0 and this will be one for bit set I mean control mode CD total with this one 9 this will be 0, 90 H.

So, the initialization of this stack pointer or data segment all these things I am not writing, because here we are going to call the sub routines. Wherever sub routines is called we have to initialize the stack segment and for any program you have to initialize the data segment and whenever you want I mean subroutine we have to also initialize the stack pointer also. Stack segment stack pointer in case if you write the subroutines and data segment for all the programs that I am skipping here.

So, initially we have to set this 90 H into the control word register of 8255 the instructions are MOV AL , 90 H. OUT FFH , AL. So, with these two instructions the 8255 will set this port B and port C as output ports, port A as input port. Now, the next step is so we have to see which probes are inserted, total I am using 8 probes. Correspond to each pin each line we have 8 probes. So, which probe is inserted? So, in order to check this total 8 probes are there.

So, I will initialize MOV BL , 00. So, that I will start with whenever a probe is inserted I am going to increment this value, then MOV CL , 08 because total we have 8 probes, after each probe checking I will decrement this CL by 1. So, I have to check now the

contents of the AL, because this is connected to port A ok. So, IN AL , FCH, FCH is the address of the port A this is FCH. So, with this the status of all the probes will be available in AL. Now, we have to check the lower first PA0,PA0 is connected to lower order which is correspondence to 1 centimeter ok.

So, PA0 we check the PA0 is 0 or 1, rotate the accumulator contents to the right ROR this will be through carry AL , 01. So, take the contents of you can take or RRC, because I want the carry contents also we can use RRC. So, this PA0 contents; PA0 contents will goes to the carry as well as carry flag status as well as PA7 ok. So, I am going to check now carry jump not carry down. What does it mean not carry means? There is no carry means AL contents are greater ok.

So, RRC if jump not carry no carry means AL will be. So, the last PA0; PA0 is 0. So, PA 0 is 0 means no need to increment we have to go check for next PA1 and so on ok. If this is false jump not carry is false means PA0 is 1. So, we have to increment BC INC BL, because PA0 is 1 already 1 centimeter, similarly we have to check for PA1 if it is also 1 2 centimeters PA 2 is also 1 3 centimeters and so on.

So, we are incrementing the BL otherwise you have to go for the next down, at the down what you have to do without incrementing the BL, I have to go for the next term I mean rotation. So, which will be you have to decrement CL by 1, DEC CL jump not 0 UP. So, we have to check the next I mean probe. So, where that next probe checking will be done, again we have to rotate by one more bit. While this is coming out of the loop BL will be having the number of probe immersed into the PA. So, at the end of this loop what will be the contents of BL? BL contains the number of probes; number of probes immersed into the water. If only 1 probe will immersed 1 centimeter I am simplifying logic.

We can use other logic also for some complicated problems 2 probes are inserted 2 centimeters 3 probes are inserted 3 centimeter and so on. Now, I can go up to the centimeters. So, those values will be present in BL, BL is 00 means no probe is inserted 01 means 1 probe is inserted and so on. Let us assume that there is a lookup table, I am maintain a lookup table here, lookup table say starting address of this data segment is 50000 H.

And with a offset of 5000 H means 55000 H, this offset is 5000. I will store here a code correspond to display 0 on this 7 segment display in 55001, I will store a code correspond to value which displays 1 on the 7 segment display. In the next location 55002 code correspond to display on 7 segment display and so on. Now at the end of this loop BL will be having either 00 means the corresponding 00 location we have the 0 code, if it is having 01 in corresponding 01 location, we have 01 code and so on.

Means simply the contents of this has to be outputted onto this port, port B. So, that that corresponding value will be displayed on 7 segment display. For that what is the logic? BL is already having this last digit last 2 digits of this offset, then you represent BH with 50. Now, what will be the BX? BX will be having this offset value if none of the probe is inserted BL will be having 00 means 50 offset value. If first probe is inserted offset value become 5001, if 2 probes are inserted 5002 so each location is having corresponding code.

So, this you read on to the AL, MOV AL , contents of BX out onto the port B OUT port B address will be FDH , AL. So, this program will display if no probe is inserted 0 here first only 1 probe is inserted 1, 2 probes are inserted 2 and so on. So, this is about measurement of level. Now, to control this I have to check whether the measure level is in between 2 centimeters to 6 centimeters or not, if it is below 2 centimeters I will on the motor, if it is above 6 centimeters I will off the motor ok.

For that the program will be now BL contents you check the BL contents which with compare BL , 02 H, jump not carry what does it mean BL will be having already larger value means it is greater than or equal to 2. Greater than or equal to two means no need to on the motor, if it is less than 2 centimeters we have to on the motor. Jump not carry so you go for down already one have down I have written write down 2. If this is false it will go here means I will it will check for the upper limit.

Now, lower limit has been checked, if not if this is false what does it mean? BL contents are less than 2, that means level is less than 2 centimeters. So, in that case this is jump not carry not carry means even 2 is also it is not carry, this is only now less than 2 equal just only less than, this is also greater than 6. So, here what we have to do? We have to write the program to on the motor. So, in order to on the motor PC0 is connected simply

this is very simple program MOV AL , 0 1. So, the last bit will be 1 out on to port C port C address is FEH , AL.

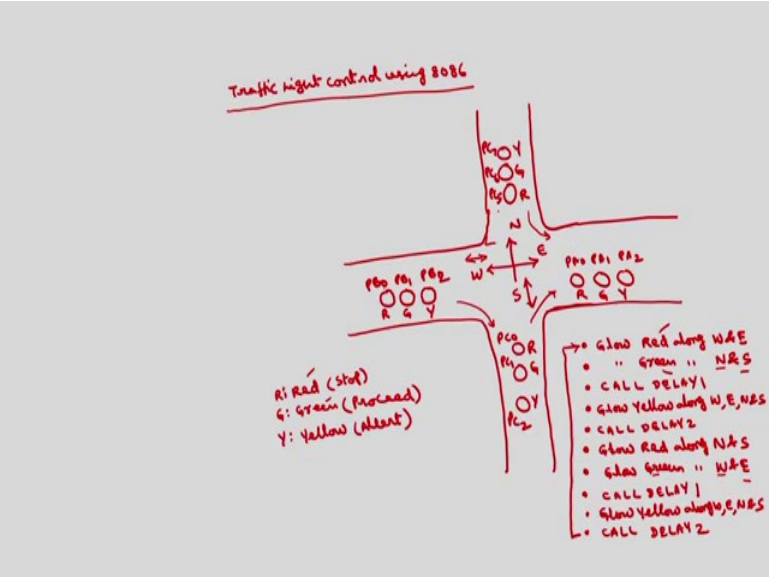
So, this will be executed whenever the level is less than 2 centimeters it will on the motor. If this is I mean not true then you have to go for down 2, where you have to check for the upper limit. So upper limit is 6, so compare BL , 0 6. Now, if it is greater than 6 I have to off the motor. So, for that you have to a jump on carry, because here I have to check the less than condition here I have to check the greater than condition. So, I have to write jump on carry; jump on carry means BL is less than 6 no problem I have to go for the repeat.

So, I have to repeat the entire process. If this is false means no carry means BL is greater than 6. So, in that case I have to off the motor, I have to write the program here to off the motor. How to off the motor basically you take MOV AL , 00 out on to port C; out port C will be FEH, AL this will off the motor. Then after that we have to JMP to repeat, this process has to continuously performed. So, JMP unconditional JMP to repeat this repeat and this repeat both are same.

If it is maintained between 2 centimeters I mean 6 centimeters nothing to be done, you have to goes on monitoring the program. If it is less than 2 or greater than 6 I have to on and off the motors and where should be this repeat now? Repeat will be here. So, this is how we can here we are doing two task; one is we are displaying the value, means we are measuring the level and second one is we are controlling the motor also. So, this is water level control measurement and control also we can call this as water level measurement and control; water level measurement and control using 8086.

So, like that if you have I mean plenty of applications of this 8086 any other microprocessor if I use the 8255 IC. I will give you another example where the traffic light can be controlled.

(Refer Slide Time: 46:07)



Traffic light control using 8086. I will take a simple problem, so based on this logic you can extend to some complex routes also. This is four way I want to I mean control the traffic in a four way junction. Let us assume that this is North direction, this will be South, this will be East, this will be West.

So, I am going to arrange 3 lights, Red represents stop, amber or Yellow represent alert, Green represents proceed, I am going to use 3 color lights. So, one is R G Y, R is Red which indicates stop, G is Green which indicates proceed, this will indicate stop this will indicate proceed and Y represents alert Yellow. So, before going into the Red or Green I will make alert Yellow ok. Similarly, here also I am going to connect three lights R G Y, here also three lights R G Y, here also three lights R G Y.

Now, we have to connect each I mean light to one of the ports of 8255 it is up to you. Suppose if I want to connect this to PA0, PA1, PA2, if I want to connect this to PB0 you can write PB2 in similar order PB1, PB0. If I want to connect this PC0, PC1, PC2, then we can use the higher order ports also I can if I can use here PC7, PC6, PC5. So now, what will be procedure here is first we have to make. So, the procedure here is first glow R Red along any 2 directions say West and East. Then simultaneously what we have to do? Glow Green along North and South, now the vehicles can move in these directions ok.

So, the other direction is from West to East or East to West will be stopped, then you are allow sometime CALL DELAY. This delay depends upon the traffic condition, density of the traffic and all. Then I want to change the now condition I want to make this Red to Green this Green to Red, before that I will place Yellow along all the directions along all the 4 directions West, East, North and South.

So, that people will alert the people who are moving from North to South and South to North they will alert that they are going to be stopped and the people want to move from West to East or East to West they will alert to proceed, again you call a delay. Normally delay 2 will be less than delay 1, because Yellow will be there for only small amount of time. Then we have to reverse the procedure, glow Red along North and South glow Green along West and East again delay 1. Because this delay from North to South and South to North it should be equal to West to East and East to West, so CALL DELAY 1 only.

Then we have to glow Yellow along all the directions W,E,N and S, CALL DELAY 2, then we have to reverse the procedure. So, you have to repeat this problem and how to go this from here to, again you have to this you are I mean sending the Green on West and East. Now, we have to Green, send the Green on North and South. So, from here again we have to repeat this step and this is infinite loop. So, this will moves in a infinite loop.

So, here I am not considering the passage from here to here or here to here. So, we can write the program for data also. So, here I am considering the only flow between North to South and West to East. So, the corresponding program for this we will write in the next lecture.

Thank you.