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

Lecture – 21
Multiplexed 7-segment Display Interface

So ok, in the last class, we have discussed about the Interfacing of 7 segment display to 8086. We have discussed about only single digit. If you want a multiple digit display system to be connected to 8086, then we need many 7447s. So, in order to avoid that we can time multiplex this displays and we can use only one 7447. How you can time multiplex this displays? Now I am going to discuss Multiplexing of 7-Segment Displays.

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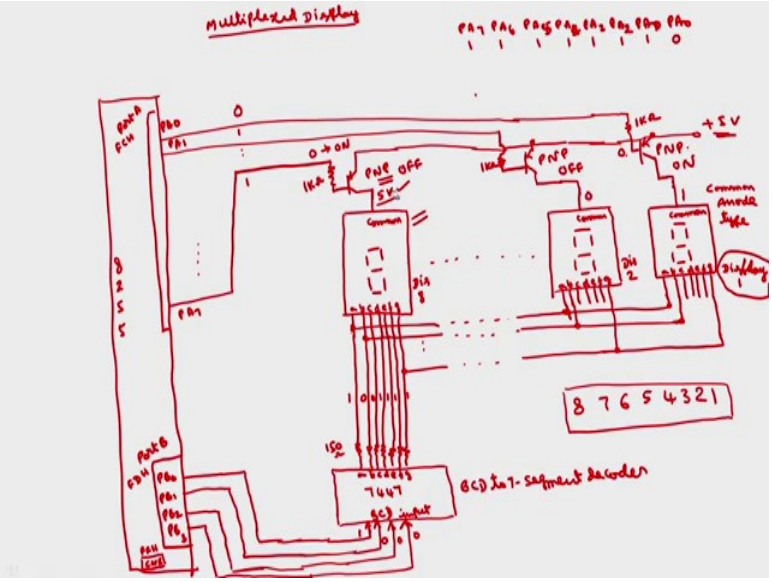

Multiplexed 7-segment Display Interface: Let us assume we want to connect eight 7 segment displays. So, starting with here one 7 segment display; this will be having a, b, c, d, e, f, g, h and there will be one common signal also. This is common signal; this is a, b, c, d, e, f, g. Let us assume that all displays are common anode type. Now we have one more display; a, b, c, d, e, f, g common signal like that suppose, we have up to 8 displays, this is common signal. Now instead of using eight 7447s, I will use only one 7447 and I will connect to all the 8 displays and assuming that this is display 1, display 2, display 8.

So, I will take one 7447 which is BCD 7 segment decoder this is 7447 which is called BCD to 7 segment decoder. The input BCD value will be given by the port, this is BCD input and outputs will be 7 segments a b c so on up to this. a to a you have to connect through 150 ohm resistor. As you have discussed in the last class; a we have to connect to a, b to b, c to c and so on. So, these are all 100 and 50 ohm resistors which are called current limiting resistors. This is segment a, b, c, d, e, f, g. This I will connect to the port 8255 port.

So, I will take here 8255 to 8255. I will connect to one of the ports; let us assume that this is port B. So, I am going to connect this to PB0, PB1, PB2, PB3, port B whose address is FD H and inside this there is a control word register whose address is FF H. And then we have port A whose address is FC H. Now we have to connect this port A to the common signals of this eight 7 segment displays ok. So, I will connect this to PA0, PA1, PA2 and so on.

I will remove this and I will write at the top of this. So, this common signal through transistors. we will take first this signal, I will connect through transistor to. Similarly, we connect this. So, we are taking PNP transistors; all these emitters we are going to connect to +5 volt supply and base is connected through ports.

This will be connected to port A and this will be connected to port B, PA0 then PA1 and so on. So, this is PA0, this is PA1 and this is PA7. Totally, I am connecting eight 7 segment displays. So, this I mean; emitters we have connected to common plus 5 volt supply and here we are going to connect 1 kilo-ohm resistors. So, this is the complete setup.

So, where we can connect? Eight 7 segment displays to 1 single 7447. Now we are going to connect a's of all this to common a. a will be connected to a of all these segments, a of this, b to b, c to c and so, on up to g to g. So, single 7447 is going to control eight 7 segment displays, display 1 to display 8 ok. Now the procedure here is what we are going to do is; first I will send a logic 0 on PA0 and the remaining I will make as 1. I will send a logic 0 here, the remaining all be this will be 1 ok.

So, in port a we are going to send PA7, PA6, PA4, PA3, PA2, PA1 and PA0. I will send all 1 s except PA0. PA7, PA6, PA5, PA4, PA3, PA2, PA1 and PA0. Then what happens is here because, this is PNP transistor; if I apply 0 here, this particular PNP transistor

will be on. So, it will acts as short circuit this 5 volts will be applied here. So, because this is common anode type to activate this particular display a 5 volts signal has to be applied to the common signal ok.

So, here only this particular latched display will receive logic 0. So, that this will be on and the remaining all will be off because, we are going to send logic 1. So, logic 1 means; this will acts as open circui. Now the last digit display 1 will be selected. Suppose, if I have to display say the same digit 1, 2 and display 1, I want to display 1 and display 2 2, display 3 3, 4, 5, 6, 7, 8. So, I want to display simultaneously, 8, 7, 6, 5, 4, 3, 2, 1 on this eight 7 segment displays. So, I want to display here 1; means, we can send here 0001, 0001 this is BCD corresponding to 1.

So, it will generate the corresponding code to display the 1 which is BCD will be 1 1. So, this will be because, this is common anode type 0 will hit the corresponding this. So, this will be 1001111. Of course, this pattern is common to all the 7 segment displays, but for the first 7 7 segment displays, the common point is connected to 0 because of that they will be off. So, only here the common point is connected to 0, this is 1. Only this point will be connected to 1, this all remaining will be connected to 0.

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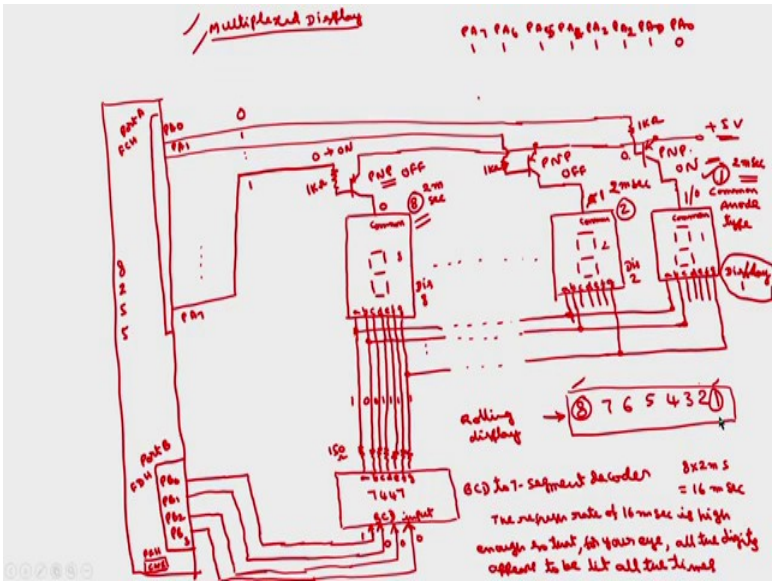

So, because of that only this 1 will be displayed on first common cathode type display. Now, you allow some time after that you send 0 on all the signals means; this also you make as 0. So, that all will be off, then you select this, this 0 you replace with 1 and you

send a 2 on code corresponding 2 on this display again you call some delay. So, like that you proceed and you go up to this digit 8 here.

Then after this 8, again you come back here and you display 1 here and you repeat this process ok. So, this is for revision of this process. Actually, what happens is here so, you keep this 1 for 2 milliseconds. After 2 milliseconds so, this will be displays 1 and after 2 milliseconds you display 2 on this. After another 2 milliseconds, you display 3 on the third display.

So, like that another 2 milliseconds you display 8 on the 8th display. After this again, you go back to this one. So, what is the time taken to come to same 1 starting with this 1, so what is the time taken to come back to again 1 is this is 2 plus 2 plus 2 plus 2, 8 x 2 milliseconds which is equal to 16 milliseconds. After 16 milliseconds; again you are displaying 1 here, 2 here, 3 here and so on up to 8 here. So, this 16 milliseconds; the refresh rate which is called refresh rate; the refresh rate is high enough. The refresh rate of 16 milliseconds is high enough. So, that for your eye, all the digits appears to be lit all the times, appears to be lit all the times. This is the logic behind the multiplexed display .

In fact, at any time you are going to select only 1 display only. But the refresh rate is so fast that which is 16 milliseconds, means; 40 times in a second you are going to refresh this. This is so high that for our eye. We cannot I mean; interpret that change for our I it seems to be all the displays are lit all the times. So, this is the idea behind multiplexed display ok. So, now, how to display this 1 to 8 what is the program required to display 1 to 8 on eight 7 segment displays? I will discuss the program.

Suppose, if I want to I mean display this 1 for some time and if you want to rotate this 1 here, 2 here so, like that we can extend this program to a rolling display. You might have seen it in many a places, there will be some rolling display. There are some advertisements which are going to be rolled with a some rate ok. So, you can extend the same logic to design a rolling display also ok. Now first I will write the program to display 1 to 8 on the eight 7 segment displays following the procedure that I have explained.

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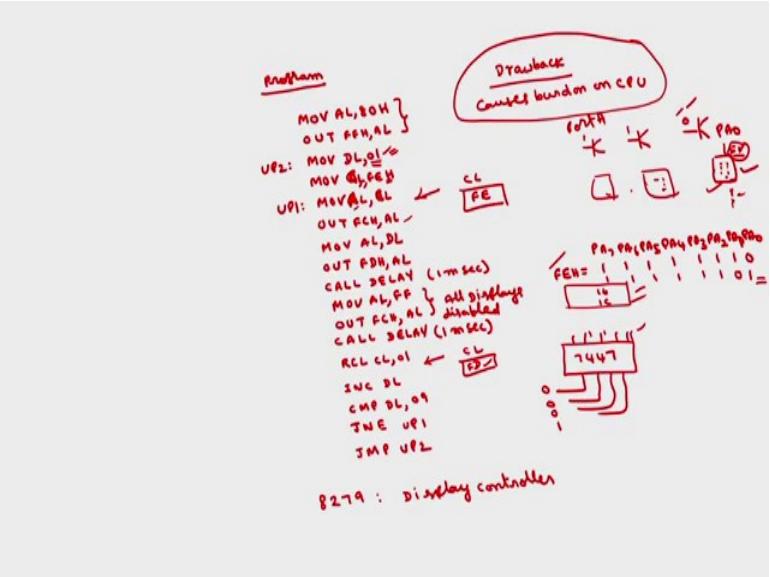

So, initially, you have to program the port A and port B as output ports. Because, you are using 2 ports; 1 port, port A is used to apply the signal to the base of all the transistors which drives common point of all the displays and second a port, port B. We are going to use to apply BCD signal to the BCD to 7 segment decoder ok. So, for that, we need 2 ports to be programmed as output ports.

So, in order to program; all the ports as output ports in mode 0, we have derived the control word as A T H. MOV A L, AT H, OUT control word register address is FF H then AL. So, this instruction will clear or will program all the ports as output ports in mode 0 ok. Now what is the next step? You have to select the last display. The last display and you have to display a 0 on this.

So, for that this is connected to this common point is connected to PA0 through this PNP transistor. So, in order to on this PNP transistor and apply a 5 volts to a common signal so, you have to send a 0 on base of this. If I send a 0 here, this will be 5 volt; there by this will be selected. So, you send a 0 on this 1 and the remaining displays, you send a 1. So that the remaining displays will be disabled, this will be disabled, only this will be enabled; then you send a code corresponding to 1 here to display 1 here ok.

So, you have to first send a 0 on PA0 and 1 on the remaining bits of the ports. So, PA7, PA6, PA5, PA4, PA3, PA2, PA1, PA0. Ah First send 11111110 which is equal to FE. So, we take this FE out of this one, before that I will initialize MOV D L with 0 1,

because I want to display 1 on this particular display. That 1 I am taking this is BCD code, if I apply this 1 to the BCD to 7 segment decoder, it will display 1 on this display. So, I am taking this 01 into DL. Then, I am taking MOV AL with FE H. So, I am storing this AL because, all the times I have to use A L in out instructions.

So, I am saving this FE content in MOV CL also. In the CL, I am storing this FE, because at the later stage I have to rotate this because, in the next stage I have to make this as 0 so, that the second display will be selected and so on. So, to do that, I have taken this FEH into AL as well as CL also. Now I can use AL for OUT instructions then OUT, so because this is connected to port A. The address of the port A is FCH, AL.

With this instruction; so, only this particular common pin of this display will be 5 volts, the remaining all display will be disabled. Then you have to send A1 on this one. So, then you have to send 1 this BCD to BCD to 7 segment decoder which is connected to port B right.

So, you take MOV A L, DL. OUT port B is FDH ,AL. So, that 1 will be applied to this BCD to 7 segment decoder. This is 7447 here, you are going to apply this 01 means; last digit will be 0001 ok so, that this will generate a code corresponding to 1. So, this will be BC will be 11. So, as a result of that the display that is connected to here will display b and c 1 will be displayed.

Of course, these lines are common to all this 8 displays, but only the last display will be enabled, remaining all display will be disabled. As a result of that; 1 will be displayed on the last display ok. Now you call a delay. This delay will be of, the order of 1 millisecond then before you are sending the second digit to second display; that is 2 to second display.

So, you make sure that all the displays are off ok. So, I am going to off all the displays. How to off the all the displays? So, you make MOV AL , FF, OUT port A, FCH. So, with these 2 instructions; all the displays will be disabled. Initially, you have enabled the last display, then after 1 millisecond you have disabled all the displays ok. This also you call for one more milli second.

We know how to write the delay program, so I am not discussing that here ok. Then, so you have to I mean; send 2 we have to display 2 on display 2. So, for that I am

incrementing DL by 1 and before that because, I have to I mean select the second display. The code corresponding to second display is this should be 11111101.

So, for that I am rotating the contents of CL. Rotate contents of C L, R C L left C L. In CL, we have initially this FEH. Now if I rotate the 1 bit this CL contents. Now, so this is your F, FDH ok. This FDH code is corresponding to selection of the second display ok. Then you have to increment DL, because I have to display 2 on that particular display INC DL. Totally, how many digits we have to display is 8 ok.

So, you have to compare with 9. Yesterday also I used this logic compare D L , 0 9. Jump not equal, means; up to 8, this not equal will be true so it will go to UP 1. Then it will display a 2 on the second display because, we have already selected a second display here. So, where should be this UP 1 now? UP 1 should be here MOV the contents of A L to CL then OUT this contents of A L on this, this will be UP 1.

So, that in AL, we have here this is AL, FF is there, you take this as CL and you make this CL to AL. Same thing, but because you are changing this CL, so you have to take CL here and AL here; this is CL and this is CL, this is AL. In CL we have the code corresponding to F D. So, which I am taking into AL then I am going to output this.

After that D becomes 2 3 4. So, like that 8 will displayed on eighth display. 1 on first display, 2 on second display like that 8 will be displayed on eighth display. So, after that this will be false, then we have to do unconditional jump to UP 2. So, that I want to repeat the same process ok.

So, where should be this UP 2? UP 2 should be again you have to take DL with 0 1. So, that the last segment will be selected and again you have take FE to send logic 1 corresponding to this I mean first display, so UP 2 will be here. So, this is the program. So, which will continuously displays 1 to 8 on 8 displays ok. For our eye it seems to be it appears to be all the I mean displays are lit all the times because that rate is 16 milli seconds.

So, this is how you can interface 8 displays to the 8086 using only single 7447 ok. Still there are some drawbacks of this multiplexer display also. One of the drawback is it will actually it will be burden on the CPU. It causes burden on CPU. If CPU is performing some important task then, so after displaying the first I mean digit. So, before coming for

the second digit so, if this CPU is I mean; busy with some other important task, then what happens is only the first I mean display will be enabled all the times the remaining all will be disabled.

So, this means actually this is burden on CPU. So, in order to avoid this, we can use directly IC there is one IC called 8279 which is called display controller. So, this using display controller, we can directly connect multiple displays to the 8086. So, this is about the 7 segment display interface. Now we will discuss how to connect high power devices to the 8086.

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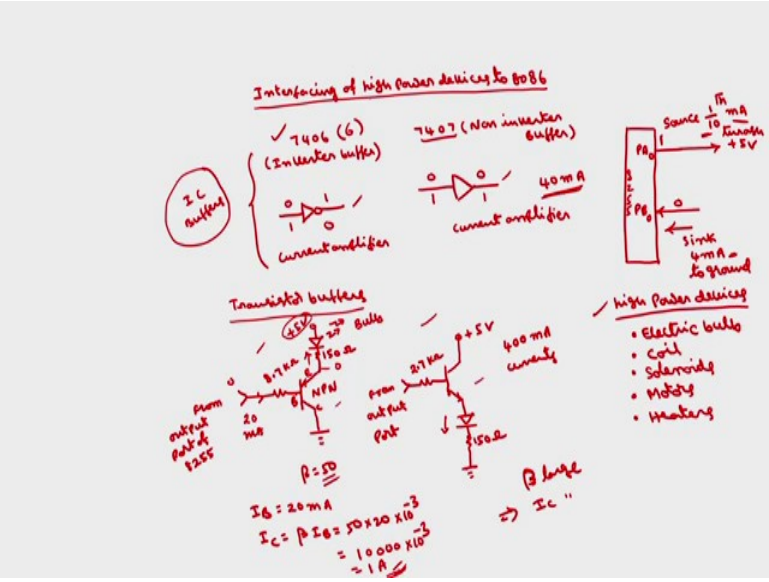

Because, the 8254 ports can carry. So, if you take the 8254 ports, this is say for example, PA0. If I program this as the output port; it can source a current of the order of one tenth of milli amp, means; 0.1 milli amp of the order of 0.1 milli amps.

Source means; whenever this is high. Why this is going to source? And if I connect say PB0 as input port. So, this can sink this is 0, this can sink this will be source through 5 volts of the supply. This can sink of the order of 4 milli amps to ground, but this much small currents may not be enough to drive high power devices such as, what are the high power devices? Such as electric bulb or you can have 1 set of the coils, solenoids, motors, you can have heaters also even.

While the microprocessor will be used in many of the industrial applications so, where we need to control this high power devices such as electric bulbs, coils, solenoids, motors, heaters ok. If I take 8255 alone; the current capacity of this one is this income source capacities are of the order of milli amps ok. So, this milli amps currents are not enough to drive high power devices.

So, in order to I mean drive this high power devices we need some sort of the buffers is nothing but current amplifiers. So, if we take a simple buffer, there are 2 ICs, IC buffer 7406 and 7407. This is non inverted buffer and you know this is inverted buffer. The symbol for this non inverted buffer is this. If you have a logic 0 here, the output also logic 0 only; if you have logic 1 here, output is also logic 1.

So, in terms of the voltage is same, but this is going to amplify the current. This will acts as current amplifier whereas, in case of inverting type buffer logic 0 means logic 1, logic 1 means logic 0, but the current capacity will be more. This will also acts as current amplifier.

So, here I call IC buffers, Integrated Circuit buffers. So, this 7406 IC, inside this; we have 6 such inverters. So, inside this also we will be having 6 such buffers ok. So, this current amplifier by using these current amplifiers you can get the currents of the order of 40 milli amps also. This you can drive a little bit moderately high power devices ok.

So, if you want still more currents. So, we have to go for transistor buffers ok. These are IC buffers and we have some transistor buffers also. So, we can construct the transistor buffer using either PNP transistor or NPN transistor. So, if I use this NPN transistor; the circuitry will be something like this we have to give from port, this is ground and here we have to connect replace 5 volt.

This you have to connect 150 ohms and this will be 8.7 kilo ohms, this is from output port. This you can connect to the LED or even you can connect here electric bulb also. This is connected to plus 5 volts. Now the advantage of this setup is; this is using I mean, NPN transistor.

If it is PNP also similar type of configuration will be there. Only the register values will be different and the connections are somewhat different. Collector is connected to plus 5

volts, emitter is connected to LED, this is 150 ohms, this is also from output port, this resistor value will be 2.7 kilo ohms.

So, now this will acts as buffers means; if input is 0 output is also 0. If input is 1 output is also 1. But the thing is here they are going to amplify the currents. So, this current passing through this LED will be more. Even LEDs can be replaced with a bulb also. In that case accordingly you have take this voltages. Bulb means, we require the larger voltages.

So, the current capacity of these buffers is 40 milli amps. Whereas, using this transistor buffers, we can go up to the 400 milli amps currents. From this port, we know that this is going to give only current of the order of 40 milli amps of suppose if I take this 1 as 20 milli amps. So, now, this 40 milli amps will be after buffers.

So, here this will be of the order of one tenth of the milli amps. So, I am taking this as 20 milli amps ok. And if the beta of the transistor is say 50. This I_B is base current, this is base current this is base collector emitter. So, if I take this base current as 20 milli amps. We know that collector current will be equal to beta times I_B. Simple is, what is I_B?

I_B will be I_C by beta which is 20 milli amps by 50, which comes around 0.4 milli amps. This is I_C is equal to directly because I_B is given. So, this is equal to 50 times 20 milli amps. So, this will comes around root 10 to the power minus 3, which is equal to 1 amp. This is large enough to control moderately high power devices ok. This is how we can use this buffers to amplify the current. Thereby to drive the moderately high power devices ok.

If you want the further high currents; this is actually depends upon the beta. If beta value is large, beta is large basically, I_C is also large. If beta is large I_C is also large. So, in order to increase the beta instead of using a single transistor here we can use a Darlington pair.

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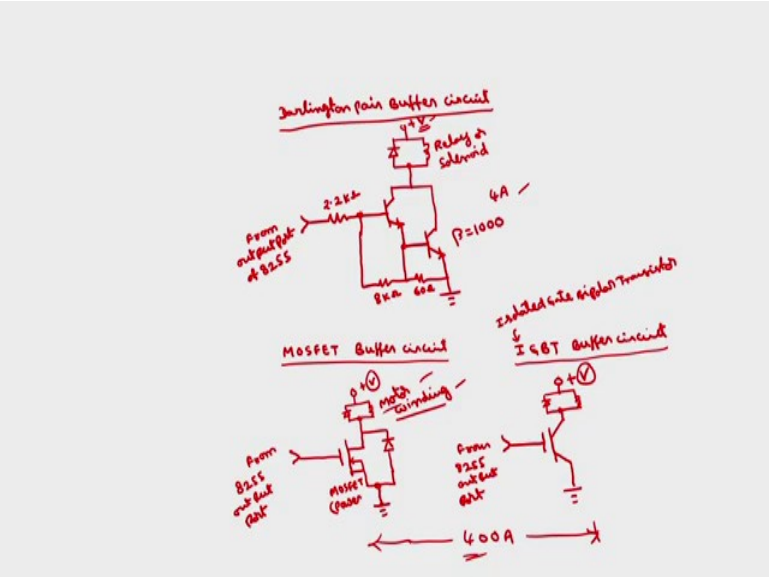

So, using that again we can increase the current capacity. Darlington pair buffer circuit. So, the basic idea is here I will introduce this all these things and I discuss how to connect the motor, stepper motor, which is one of the important device which will be used in many applications. So, how to connect the stepper motor to the 8086?

So, using Darlington pair; we can increase the current capacity because beta will be more. In order to increase the beta so, instead of connecting a single transistor, I am going to connect 2 transistors. So, in the manner, this will take from port. This will connect to the emitter will connect to the base of the other transistor. This will be connected to the ground.

So, I am not discussing about the design, I will directly take the values of this resistors. So, this can be either solenoid or coil. We will have a solenoid. So, we can support the relay the voltage that required for the relay, will choose this V. That is we have written this as V. This may not be 5 volts; you can actually take the more value also ok. This you have to take from output port of 8255.

So, using this configuration; this is called Darlington configuration. So, we can obtain the beta value of 1000, there by the current capacity is also more. Now, if you want to further increase the beta value and if you want the higher currents, we can go for MOSFET circuits. So, using this beta value, it can go up to some 4 amps.

So, the MOSFET circuit will be we will give from this output port to the gate of MOSFET. This will be plus V; this is motor winding which will require more currents. This will be from 8255, output port. This is MOSFET, power MOSFET. And also you can construct the same using IGBT Isolated Gate Bipolar Transistor, isolated gate bipolar transistor, this is called IGBT. IGBT buffer circuit; this we have to take from the output port of 8255, normally this is similar to the transistor only, but here the gate will be isolated.

So, this volts depends upon the capacity of this motor winding ok. Here also they are going to connect this to motor winding to the wire. Here also you are going to connect the motor winding. This is from 8255 output port. Using these 2 configuration; we can obtain the output currents of the order of 400 amps. Now, here you can go upto the 400 amperes.

So, which will be enough to drive the motors. We can use DC motor or stepper motor ok. Even if you want to further increase in this currents such as heater. Heater requires very high current ok, for that we can use another circuits using TRIAC, TRIAC based circuits.

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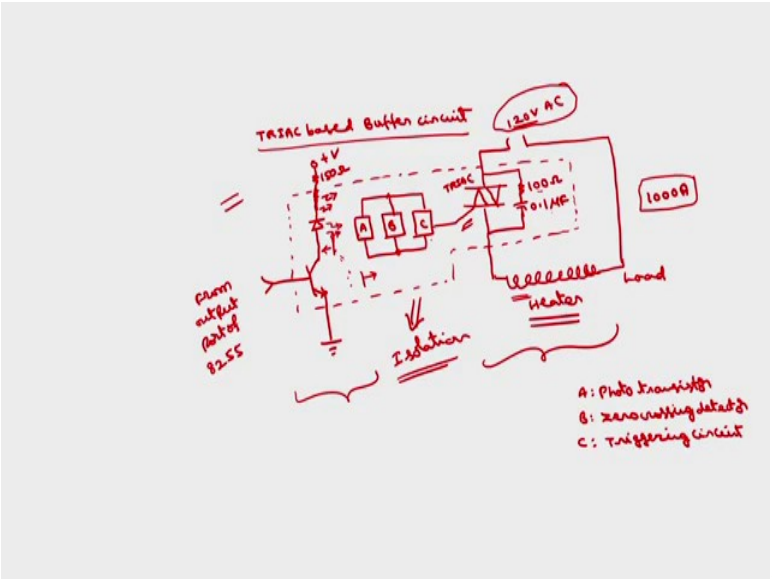

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So, in this circuit; so, you have to take this again same from 8255 port. You have to connect to base of the transistor, this you have to ground, this will be connected to plus V depends upon the voltage that is required for the load 150 ohms. You have to connect to the LED. This will emit the light and we require three circuits called; one is

phototransistor. I am not drawing the entire circuit just I am noting as block A, block B, block C.

So, these three are connected in cascade. So, this C is going to control the TRIAC, actual TRIAC. This is the symbol of TRIAC. This TRIAC will be connected to the load. So, this voltage here will be high voltage of the order of 120 volts AC, Alternating Current and the load here will be heater. This will acts as a load heater.

So, this is you can take this one as a block inside. So, there is some sort of isolation here. This side is high voltage how I connect the circuit. This is this side is microprocessors which operates with only 5 volt ok. If you do not have the proper isolation here what happens is? This high voltage sometimes may burn the ICs that are present this side ok. So, because of that we have to provide the isolation. There is no physical contact, you can observe that. So, this is this transistor part from here to here is. This is connected to the microprocessor and this part is connected to the high power device, there is no connection here at all here ok.

Now, how the coupling will be takes place here? Through this LED ok. This LED, whenever if I apply this is from output port of 8255. So, whenever this LED glows, then what happens is? This is A will acts as photo transistor, B is 0 crossing detector and C is actually this triggering circuit.

So, this whenever this LED is on, this is going to emit the light. That light will be converted into current by using this phototransistor that current will be transferred to 0 crossing detector. So, that it will convert into unipolar, then this will be given to the triggering circuit which will trigger the TRIAC, this is TRIAC. So, this TRIAC will acts as on off switch thereby, so it will allow this 120 volts to connect to this heater through this switch.

So, this control circuit is required 100 ohms and 0.1 microfarads ok. So, this is how you can drive this current or this one is very large. So, we can have up to even 1000 amperes also. So, it depends upon the capacity of the heater that we are going to use here, we can design the circuitry to give that much current.

So, as the current value increases the demand of this load is more. We are going to incorporate one of these circuits. So, we started with simple IC buffer, the current

capacity is somewhat less than to increase that we went to the transistor buffer then using single transistor the current capacity is still low.

So, we used 2 coupling transistor Darlington pair to further improve the current; we went to the MOSFET and IGBT to further improve the current, we can you use the TRIAC. So, these are the various circuits which will produce more currents. Thereby, you can drive the high power devices ok. So, with this background we can interface a stepper motor to the microprocessor. Stepper motor finds lot of applications. In printers; mostly stepper motors will be used.

So, stepper motor as the name implies it is unlike continuous time motors which rotates continuously stepper motor rotate in steps ok. That type of step moment is required in many applications such as printer, where the paper will be moves step by step ok. So, in that case we have to use stepper motor ok. So, how to connect this stepper motor to the 8086? So, now, to drive that stepper motor for that we require this circuitry. So, interfacing of the stepper motor we will discuss in the next class.

Thank you.