Digital Electronic Circuits
Prof. Goutam Saha
Department of E & EC Engineering
Indian Institute of Technology, Kharagpur

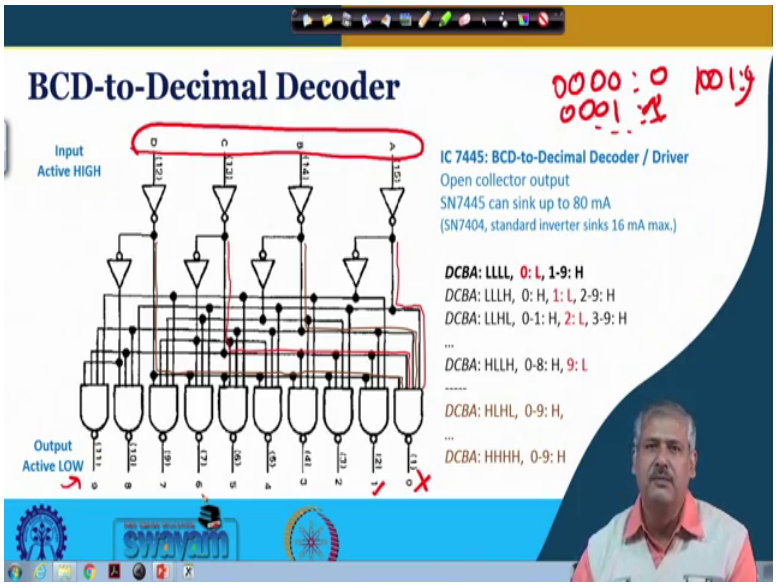
Lecture – 19
Decoder with BCD Input and Encoder

Hello everybody, in the last class we discussed demultiplexer and decoder ok. So, we have seen that how decoder can be demultiplexer can be also seen as a decoder by appropriate you know connection of the input, the data input and this strobe input. Now, we extend the discussion from there where we started the understanding how decoder works to decoding for BCD input and then we shall discuss encoder.

(Refer Slide Time: 00:47)

So, this is the concept that we shall covered in this particular class.

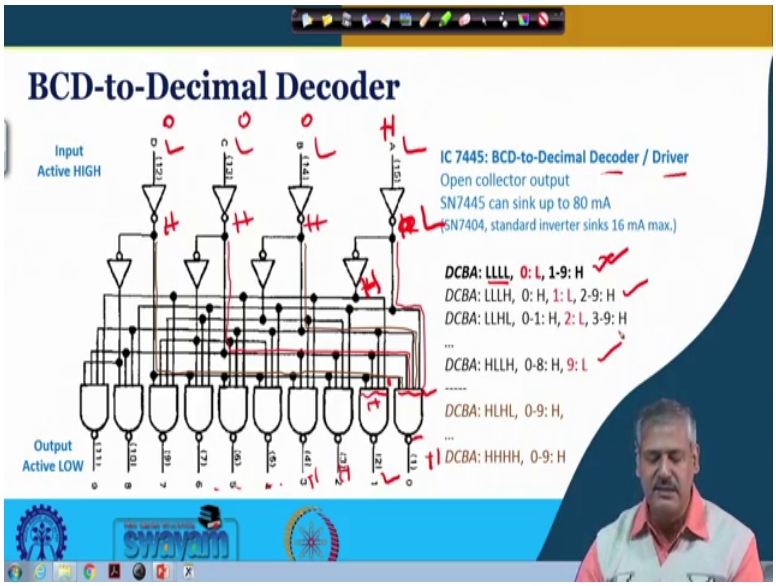
(Refer Slide Time: 00:51)



So, BCD to decimal decoder; so why what is BCD? BCD is Binary Coded Decimal. So, whenever we talk about you know decimal number 0 to say 9. So, decimal means based in so, 10 digits are there. So, in terms of binary coding so, we represent them as 0 0 0 0 that is your decimal number 0 to 1 0 0 1 ok. So, that is decimal number 9. So, this is the basic understanding that 0 0 0 0 is decimal 0 0 0 0 1 is decimal 1 right, 1 up to it goes on 1 0 0 1 is decimal 9 right. So, when we talk about BCD to decimal decoder so, the input will be a BCD number right and the output will be what about these BCD number represent ok. The corresponding output will be in a decoded ok.

So, if 0 0 0 0 present is there the 0 all 0's are present. So, this will be active and rest all will be inactive. If 0 0 0 1 is present this 1 will be active and rest all will be inactive. So, this is the understanding this is what we mean by BCD to decimal decoder. So, this is useful because in lot of cases this BCD numbers these is what we shall encounter in different applications ok. So, for that we have a in a standard IC integrates circuit is available chip is available which is IC 7445 ok. So, what is driver etcetera we shall see later.

(Refer Slide Time: 02:45)



So, first we look at the what is meant by you know what is done as decoding. So, when DCBA is all low 0 0 0 0 ok. So, what is happening here? So, you see this is the 1 example we have taken. So, this is low right so, this is all these are low right. So, this is the inverter output so, these are all high this are all high. So, this is this high is going here, this high is going here all this inputs of this NAND gate gets a high. So, for the NAND gate what will be the corresponding output ok. The output will be low at that time right. So, normal decoding operation we have seen that this bubble this inverter will not be present. So, here there is a inverter present.

So, output is made active low otherwise, if it is this inverter is not present active high at that time the output would have been high and for rest of the combinations one of the input would have been low. So, output would have been low. Now, since presence of this inverter at the output ok. So, all the outputs are made active low. So, in this situation when all the inputs are low ok; so, this output is low and all other outputs are high ok. All are other outputs are high, this is understand understood.

So, this is when this is low, low, low, high that means what is present here 0 0 0 1, we shall again see the connection.

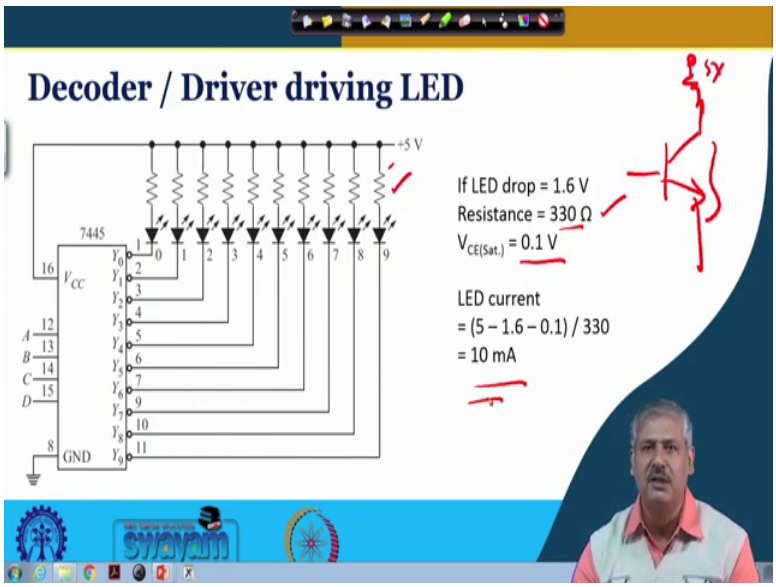
And, we can see that these 3 are high and this is high and this again this becomes low alright. So, sorry this is low, low, low high so this is high, so this is your low and this has become high. So, this high is connected here right and this is low right, so all this 4

becomes high. And, here one of them becomes low so, this output is high and this is low and all rest of them are high ok.

So, this is what is shown here. So, similarly it goes for every other cases. Now, with this 4 you know inputs we can have possible 16 combinations. But, since is it is we know for sure that the input is a binary coded decimal so, only 0 0 0 0 2 1 0 0 1 is expected. So, any other combination we are not bothered about, we do not care ok. So, for any other combinations right the output will be high actually this is we do not care about it ok. So, this is what we can see. Now, when you talk about this driver as I say this is enough when for specific purposes.

So, whenever this numbers are there and this in a corresponding number will or LED will glow or some number display will be there. So, you need to send little bit of more current than normal logic circuit operations ok. So, the output here is through open collector which can sink much larger current then the normal TTL ok. So, this is useful for as I said displays and other things where, this binary coded decimal and corresponding display is connected in tandem. So, this is the meaning of decoder driver. So, the output stage of it; output stage of it will be open collector. So, we can see one example.

(Refer Slide Time: 06:17)

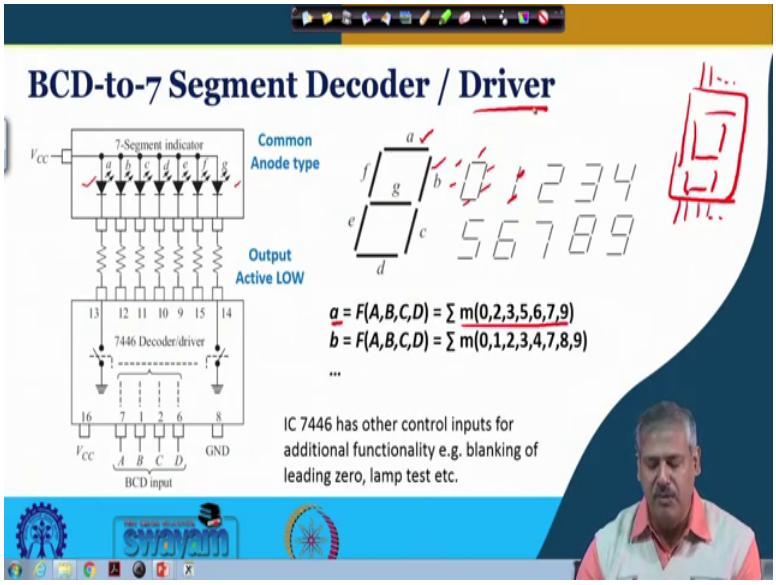


The example is a so, this is a decoder driver right. So, here we are putting a what is it called LEDs are connected. So, if the LED drop here we consider as 1.6 volt right. This

resistance current limiting resistance is 330 ohm and the open collector output we know the open collector output how does it work alright. So, this is output stage.

So, here it remains open basically you are connecting it through a resistance, this is resistance you are talking about to 5 volt supply right. So, this is in saturation. So, if we consider saturation voltage is 0.1 volt ok; so, then LED current here is 10 milliampere ok. So, this is the way we can calculate. So, for any other value of the résistance another you know current will be. So, LED will be brighter or little less bright clear, we can do simple calculation around it.

(Refer Slide Time: 07:17)



Now, another important application of this is BCD to 7 segment decoder driver ok. So, what do you mean by that? So, often this BCD numbers are displayed. So, 0 to 9 is to be displayed in a 7 segment display. So, 7 segment display how does it look like? So, if you have seen any; so, basically there will be 7 such segments a b c d e f g and when 0 0 0 0 is presented here 0 0 0 0 is presented here right. So, these are all LEDs these are all individual LEDs. So, this is the corresponding LEDs a b c d e f g that you see over here ok.

But, there addend in a package, where it would look something like this. So, there are you know this pins are there, this pins are there right and this is the package where this LEDs are present. So, 7 LEDs are there. So, this whenever 0 0 0 0 is presented. So, which LED is will glow? So, this LED, this LED, this LED, this LED, this LED and this

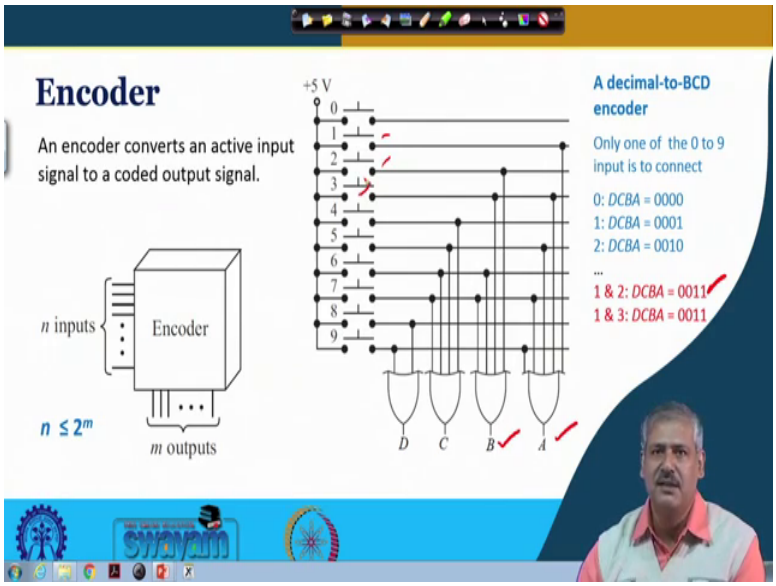
LED the corresponding LED these are the LEDs that will go; that means, a b c d e f g will not glow right. So, when 1 is present; that means, 0 0 0 1 is present which LED will glow b and c, b and c will glow. So, similarly for rest of the cases; similarly for rest of the cases; now you can understand that a will glow for the cases when at the input 0, 2, 3, 5, 6, 7 these are present right.

And b will glow when these are present. So, what you can do? You can generate all the you know this possible cases and then this minterms and you can just simply sum them up; this is one way of in a generating circuit. So, basically this is what is you are you know looking for when you are generating a BCD to 7 segment decoder. And, since we are trying to light up LED which will glow and will you know. So, we are also considering a driver.

So, this driver is again a open collector kind of you know output ok. And, we are telling saying that this is a common anode type where, because V CC is connected to this diode, the positive side of it they are not it is in earlier context it is called anode ok. And if you get connected the common so, basically the output was going to each of these inputs and the ground part is this is connected to the ground that is common that would have been a common cathode type.

And this IC 744 6 this particular IC which is the decoder driver other than the basic concept that we have discussed here, it has got additional functionality like blanking of leading zero, lamp test and other things ok. So, that we are not discussing that you can think about when you make a try to get an application around it.

(Refer Slide Time: 10:41)



So, having discussed decoder we would like to take up encoder also encoding operation how and what would be the circuit for a encoder. So, what does encoder do? It is just opposite to decoder and encoder converts and active input signal to a coded output signal; coded output signal. So, here is an example. So, in this case this is a decimal to BCD encoder. So, the possible are 0 to 9 ok. So, these are the input that are present and the corresponding outputs are 0 0 0 0 to 1 0 0 1; so, the encoded one.

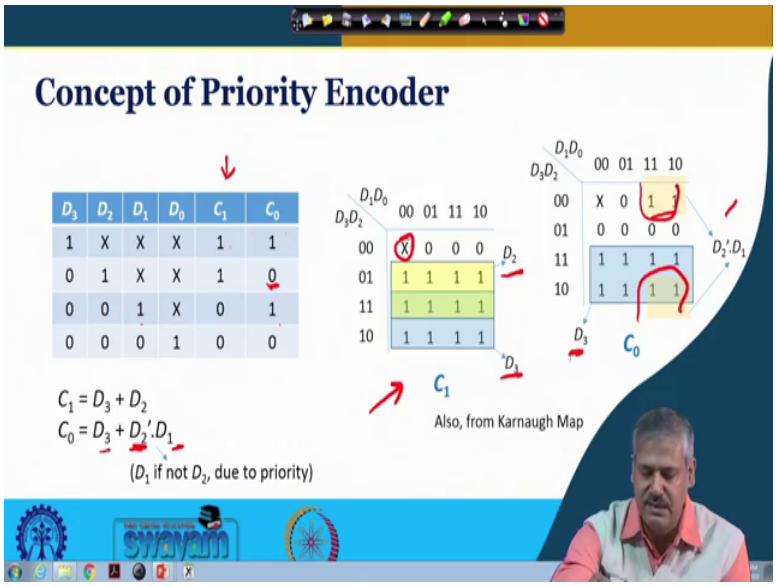
So, one simple linear arrangement that you can see whenever 0 is to be you know sent coded. So, you just connect this one and you can see that this has got connection with none of these OR gate output. So, OR gate outputs will be 0 0 0 0 in such a situation. So, idea here is there is no enable input to begin with or in a strobe kind of thing which we shall see later. So, that one of the input is always present, one of the input decimal input is always present right.

So, if 1 is present 1 is pressed right. So, then what happen only this one is getting output. So, DCBA so, 0 0 0 0 1 will be the output. If 2 is pressed only you can see that 2 is connected here to this one. So, only B will be getting the 5 volt one here and rest all are 0. So, it will be 0 0 1 0. When 3 is pressed what will happen, you see that this is getting connection and this is getting connection alright; so, B and A so, 0 0 1 1. So, that way it will you know go on and we can have a encoded version of this. So, instead of you know 10 signal sent we can send only 4 such a signal in the encoded from which will carrying

the information of this 4 right. So, this is the idea right. So, with m outputs we can send up to 2 to the power m number of input in a encoded form ok.

Now in this particular example what you can see that when both I mean as I said here there is a condition, a constant that one of the input is always you know present always pressed. Now, if more than one input is present in a pressed what will happen? For example, we take the examples say 1 and 2, if 1 and 2 are simultaneously pressed, simultaneously present 1 and 2 both are simultaneously present what will happen. So, this will become high and this will also become high. So, the output will become 0 0 3 1 1. So, it will appear that to the external world that input 3 is present in state which is erroneous ok. So, in these case we need to think of a different kind of you know mechanism to achieve encoding.

(Refer Slide Time: 13:55)



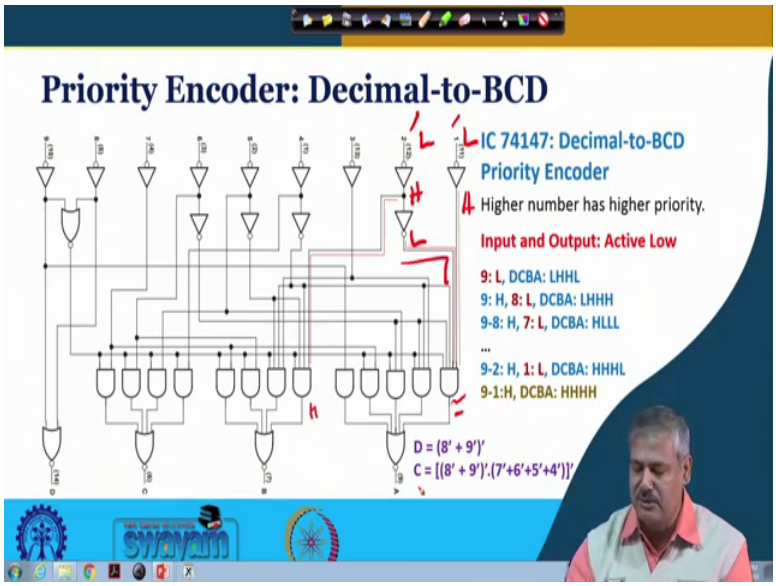
And then there comes the concept of priority encoding ok. So, what is that? So, here we take an example. So, in this example we take 4 inputs only 4 inputs which I have can extend later. So, D 3 D 2 D 1 and D naught and in this we assign higher priority to highest priority to D 3, then to D 2 then D 1 and then D naught D naught has the lowest priority. So, and this the these are the 4 inputs. So, the encoded we need to outputs which will encode this 4 inputs right. So, we are naming them C 1 and C naught. So, because D 3 has got highest priority, when D 3 is 1 D 3 is active irrespective of other inputs the outputs are according to D 3 which is 1 1.

We are you know that is the way we are designating it D 3 1 1. When D 3 is 0 ok, if D 2 is 1 irrespective of the other input, if D 1 is present D naught is present we do not care about it. So, the output will represent D 2 only and we designate D 2 as 1 0, we encode D 2 as 1 0. Similarly, if D 3 and D 2 are 0 then D 1 will be seen in the output irrespective of D naught is simultaneously pressed or not pressed and finally, D naught. So, that is 0 0 ok. So, this is what how what we see as the truth table ok. Now, see if we look at this you know the C 1, how we can you get the you know realization of the C 1. One way of course, is we know just looking at the combination and all and figuring out that C 1 is D 3 plus D 2, you can see the D 3 and plus D 2 right; the other one is C naught is D 3.

And, it is not plus you know D 1 when it is present because, if D 2 is present D 2 is present D 2 has got higher priority at that end this should be 0. So, if D 2 is not present right then if D 1 is present, it will be high ok. So, this is what we can see I mean just by looking at the you know truth table; otherwise we have got our conventional way of working out through Karnaugh map. So, D 3 D 2 D 1 D naught if we put it into the Karnaugh map ok, this is what we shall see. And, this is one term we are getting here and another term over here.

And similarly for C naught if we just put it in the in to the map this is what we shall see this is 1 D 3 and this 1 1 and this 1 1 can be group together. So, this is giving you D 2 prime D 1. So, this is the way also you can get it ok. So, when you realize it you will get a priority encoding; that means, when both 1 and 2 are pressed ok. So, it will not be giving you 3 the earlier case that was seen. So, it will give you only 2 right 1 0 as the encoded output clear. And one thing one more thing that this is met cross because 0 0 0 0 case will never appear that is the understanding .

(Refer Slide Time: 17:27)

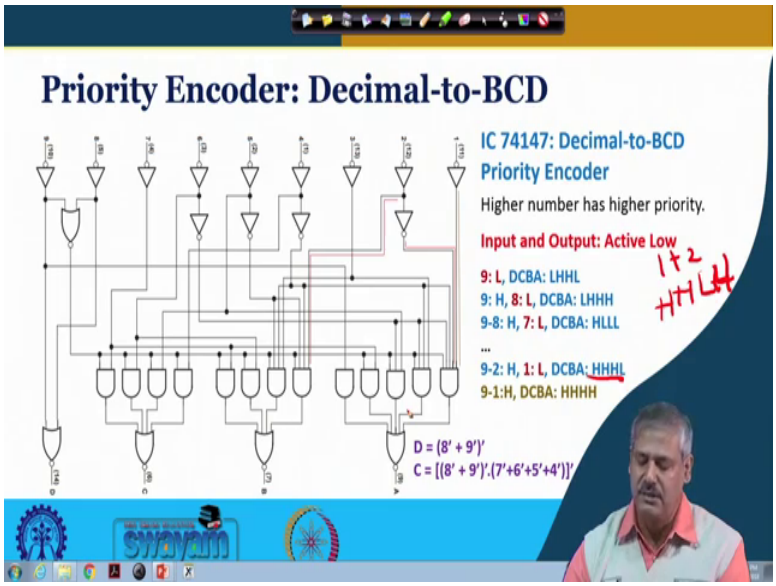


Now, let us look at one you know practical circuit where this priority encoding is happening. So, this is decimal to BCD priority encoding ok. So, in this case the higher number has got higher priority, this similar to what we had discussed during the development of the concept for priority encoding. And will look at the example where 1 and you know 2 pressed simultaneously let us see what happens. So, when 1 and 2 pressed simultaneously we shall see that this 2 over here right.

So, if this is your all this things are your this is your active low right. So, if this is your low and this is your low, this is high and this is high and this is your low is it ok. So, this low will go over here and even if this is present; so, this will make this output low is it clear and where is this high will continue and this will make this output high because, of the presence of the other combinations. So, this is what actually is making even if both are simultaneously present in a placed this one inactive and you know the corresponding output will be there.

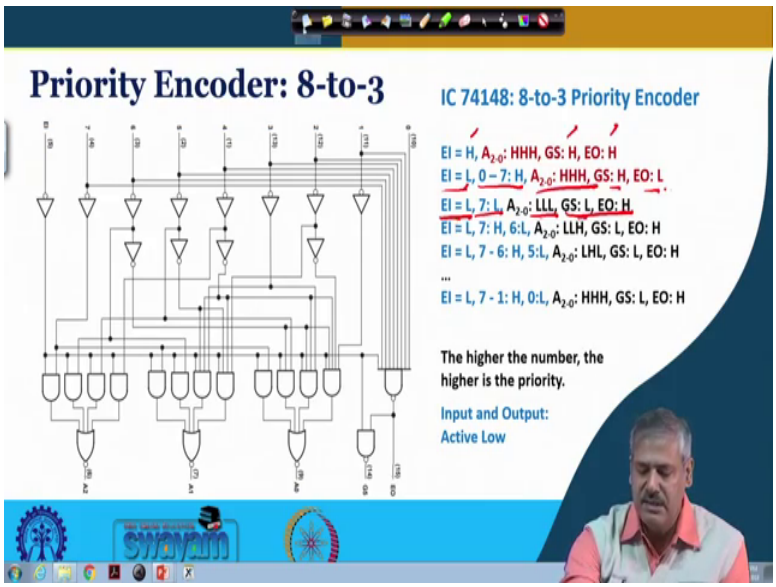
So, what is happening here looking at the other aspect of it when 9 is low right, the DCBA this output will be low, high, high, low. So, you can just look at the following circuit and you can see it is it clear. So, when 1 is present so, it will be low, high, high, high, low, right sorry, yes this is when 1 is present.

(Refer Slide Time: 19:25)



This is the case that is what will see right, 2 is present will see high, high, low, high, right, but when 1 and 2 simultaneously is you know pressed you will see H H L L when 1 plus 2. That is the priority encoding sorry H H L H ok, that is you know included in this particular circuit.

(Refer Slide Time: 19:25)



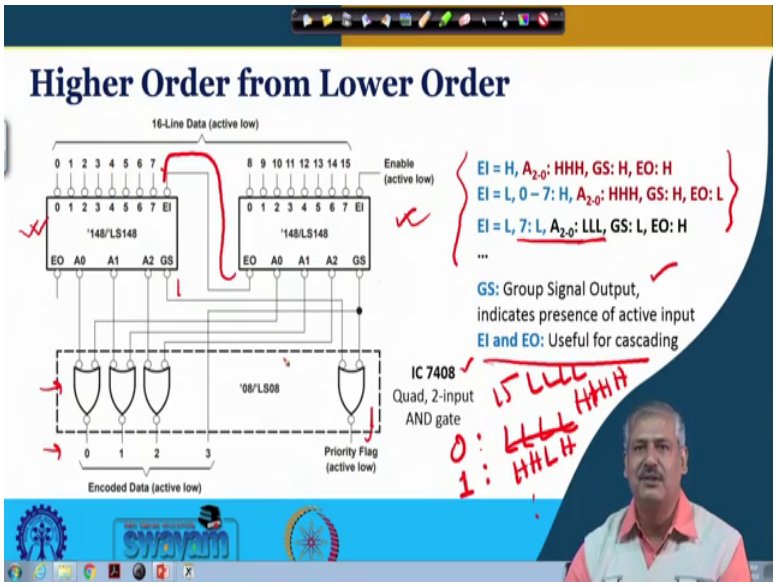
Similar thing for 8 to 3 priority encoder ok; so, this is 7 4 1 4 8 again this is an IC where you can see the same concept. But, we have taken up this one to make you understand the how you know cascading etcetera is done in case of you know encoding operation as

well. So, here other than the basic circuit you have got 2 you know 1 input here enable input. And, 2 outputs are there this is group select a data and this is enable output right. So, what you can see then when this enable input is high at that time this GS is high and enable output is also high right. And when EI enable input is low and none of the input is present 0 to 7 is present 0 to 7 is 8 to 3.

So, 0 to 7 are the corresponding inputs. So, none of them are present means you know active low. So, low it is low then all the outputs are high at that time GS is high and enable output is low. So, basically this is this low is making this low. And finally, when enabled input is low and one of the input is low, one of the input is active right. So, at that time the corresponding out will be there if it is 7 then you know it is L L L that is 0 0 0. Because, it is active low that is another part of it the encoding part of it and what you see at that time if data is present GS will become low ok. So, that a group data in this particular group it is present that is what it is saying and enable output will go high ok.

So, this is the 2 control inputs, 2 control outputs and 1 control input is associated with this circuit and rest of the thing are similar rest of the thing as that seen before. So, if you know 7 is low output is L L L low low low 0 0 0, if 6 is low alright, 6 is low then the output will be low low high because it is active low. So, this is conceder as active the so, this is 0 it will go on. And, here also there will be higher the number higher is the priority and input output we have seen to the active mode.

(Refer Slide Time: 22:43)



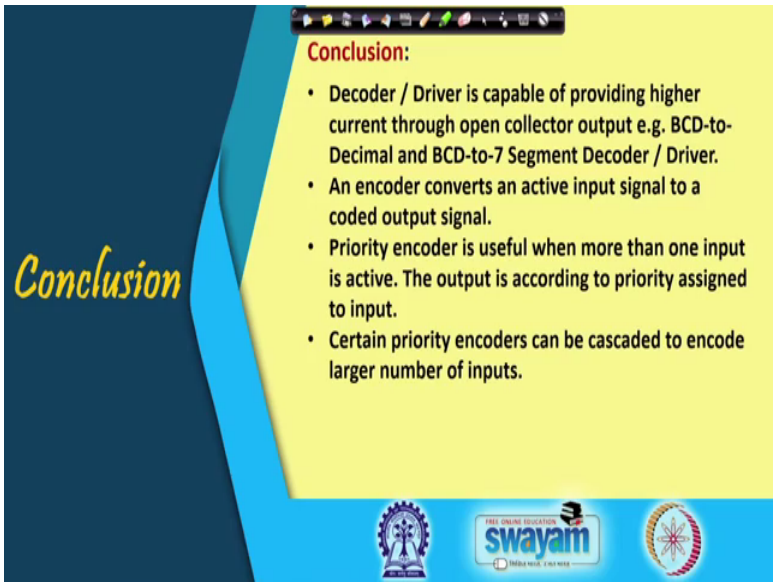
And finally, we see that how this can be used for enhancing the size of the encoder. So, this is higher order from lower order for IC 7 4 0 8. So, this EI and EO Enable Input and Enable Output are useful for cascading. So, this is what we have seen, this is the corresponding connection. So, these are essentially AND gate is this bubbles are present and then there is a bubble over here; so, in this making a essentially AND gate. So, basically it is realized by IC 7408. So, IC 7408 we have seen before it is a quad 2 input AND gate. So, this so, each one is having a 8 to 3 so, this is also 8 to 3. So, put together this is 16 to 1. So, this EO is connected to EI over here ok. This GS Group Signal output we have seen the truth table before the description on the truth table before. So, this GS and the GS these are coming together right.

And this is mentioning that the priority flag that is the priority is being you know provided here and the other the outputs now because it is 16. So, encoding will be done by 4 outputs. So, these are the 4 outputs and these are the AND gates this 3 AND gates and this is coming directly from GS. So, if you just look at the corresponding truth table and their description, we will see if you place the data and the check the output you will find that if say 0 is present here. So, it will be low low low low it is activated, if one is activated it will be low low then the EO this is EO you have seen.

So, basically when we see 0 being activated and when you see 1 being activated we shall see that, sorry 0 is high high or H H H H, because it is active low and when 1 H H L H. So, this the EO it will go on right and only when this was this is up to 7 here. So, here it will go up to 15 so, it will become H L L L L alright. So, this part look at it carefully how it is done because, it is active low and this is active low need to be very careful.

So, what is active high and what is active low how the output descriptions plan out. So, when 7 is present low. So, this is L L L this is a thing that you have to remember. You might get confused; so, you should be careful that you do not get confused about it.

(Refer Slide Time: 26:11)



Now, to conclude decoder driver is capable of providing higher current through open collector output. As for example, BCD to decimal and BCD to 7 segment decoded driver ok. And this is useful for display devices of an this BCD numbers are displayed.

And encoder converts an active input signal to a coded output signal. And priority encoded is useful when more than input is active. The output is according to the priority assign to the inputs. So, we have seen the examples where higher number was given a higher priority, but you can change the priority as per your requirement and accordingly the design would be done. And certain priority encoders can be cascaded to encode larger number of inputs.

So, you saw the example of IC 74148 which has got group select output and enable input and enable output which can be put judiciously. And from 8 to 2 such 8 to 3 encoder 74148 we can get 16 to 4 encoder, you know made ok.

Thank you.