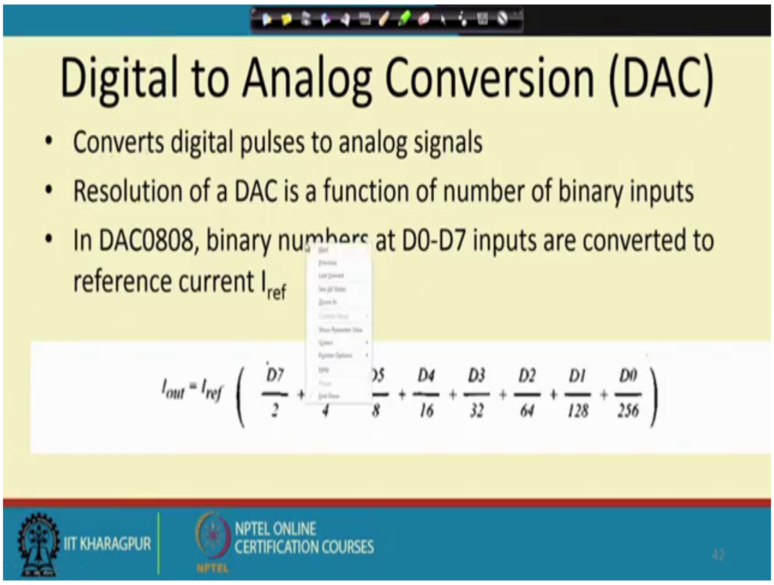
Microprocessors and Microcontrollers
Prof. Santanu Chattopadhyay
Department of E & EC Engineering
Indian Institute of Technology, Kharagpur

Lecture-57
Interfacing (Contd.)

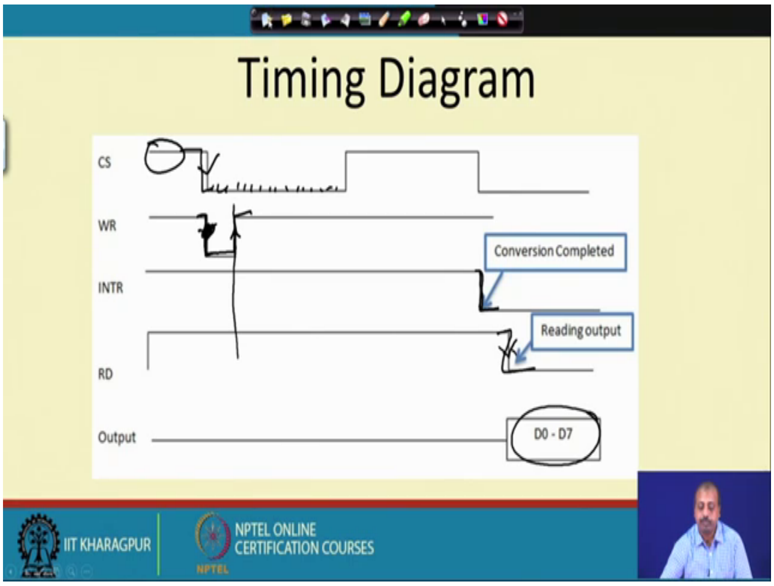
Having looks at the timing diagram for the operation of this ADC. So, this is self explanatory like this CS line.

(Refer Slide Time: 00:23)



$$I_{out} = I_{ref}\left(\frac{D7}{2} + \frac{D6}{4} + \frac{D5}{8} + \frac{D4}{16} + \frac{D3}{32} + \frac{D2}{64} + \frac{D1}{128} + \frac{D0}{256}\right)$$

(Refer Slide Time: 00:29)

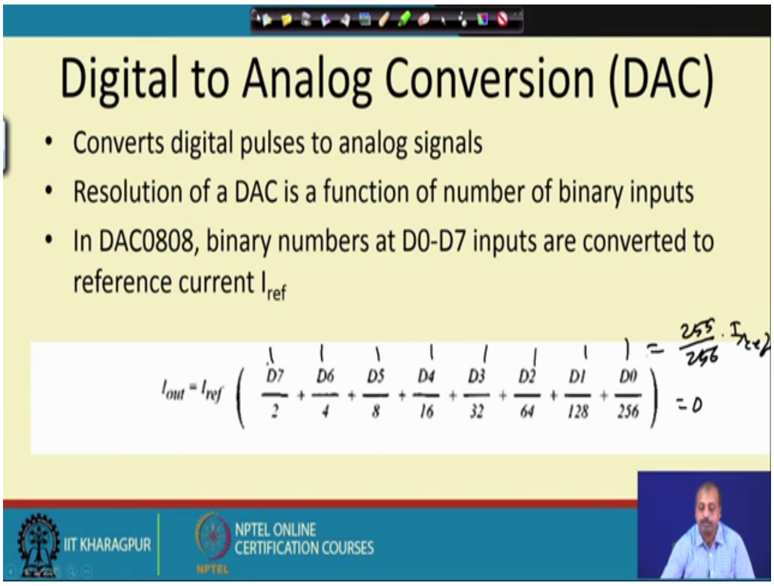


So, this CS line is initially this CS line is initially 0 initially high then after sometime it becomes low. So, this high to low transition so, this ships decline should be low for the operation of the ADC then we give a pulse on this right line. So, it makes a transition from high to low. So, this transition, so at that time whatever be the analog value so, that will be sampled and that will be taken for conversion and then it will do that it will do the conversion and then after that it generates when the conversion is over.

So, it generates this INTEL line, this interrupt line makes a transition from low to high to low. So, that way the conversion is complete then the processor gives this read bar line. So, it makes a transition from high to low. So, this read bar line is given. So, this line is this transit is given and then the data is available on the data bar, so it can read. So, write bar lines. So, we need to give a pulse, if you see that this is a I have said this is a high to low trans low high transition that is required for starting the conversion. So, the conversion start point is not here, so conversion start point is this one.

So, from this point onwards the conversion will start so there is a low to high transition on that line. So, next, so next we will look into another very important data converter which is known as digital to analog converter.

(Refer Slide Time: 01:54)

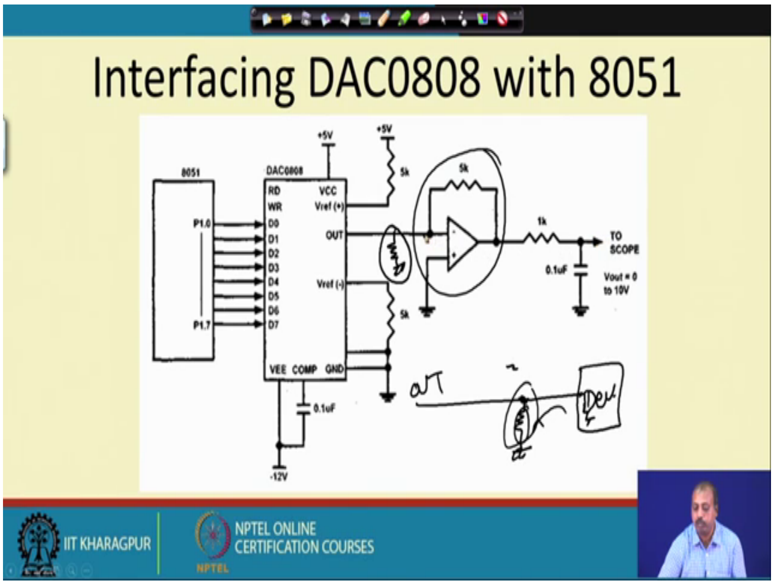


So, so far whatever we had seen this analog to digital converter. So, they are useful for doing this conversion of analog data to digital. So, that is basically acting as the input part of the input part of the interface, sometimes we want to control some output device for example, if there is a fan that is rotating and you want to control the speed of fan. So, digitally if you want to do this.

So, microcontroller or microprocessor so it can produce some digital value and that digital value is actually corresponding to some, some voltage that should be fed to the fan for its rotation. So, that way we can have different type of activities by which this digital signal needs to be converted into the corresponding analog value. So, that it can be fed to the, this analog world. So, this ads DAC s are digital to analog converter. So, they convert digital pulses to analog signals and resolution of a DAC is a function of number of binary inputs. So, the same thing that is we they this so it has got says s 8 bit DAC.

So, the resolution will be one upon 2 power 8. So, in DAC the 0808 the example that will take in our discussion so, it has got binary numbers at d 0 to d 7 inputs and that will be converted into a reference current I ref and I out is I ref so, with respect to reference current.

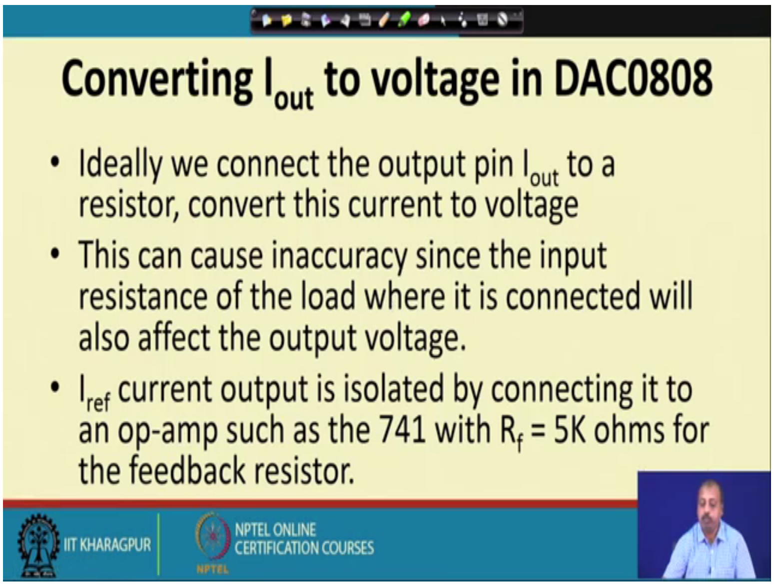
(Refer Slide Time: 03:34)



So, depending upon the setting of depending upon the setting of those bits d 0 to d 7 we can understand that we will be getting a different current like if all these bits are equal to 1. So, you are getting a current which is close to I ref. So, that will be 255 or 256 of I ref. So, if all of them are one. So, you are getting 255 by 256 into I ref. So, that is very close to the full I ref value, on the hand if all these bits are 0. So, the I out will be equal to 0 and some intermediary values of this d 0 to d 7 gives some intermediary output for the current and that current when you convert to voltage. So, you will be getting the corresponding digital voltages. So, this is, this is done by this structure ok. So, we have got this DAC 0808. So, it has got these digital inputs some read write lines are there and then we have got this ports p 1.0 to 1.7. So, those themes are there by which you are feeding the data bits for this DAC and then the, we are.

So, output is available as a current so then that current needs to converted into a voltage. So, that conversion is done by this opamp circuitry. So, this will become multiplied by this 5 this current will be having here will be multiplied by 5 k voltage value 5 k resistance value. So, you will get the voltage value here and that you can put to a oscilloscope and see what type of current what type of voltage is coming here so, that we can plot on to the oscilloscope. So, this way we can use this DAC for this digital to analog conversion ok.

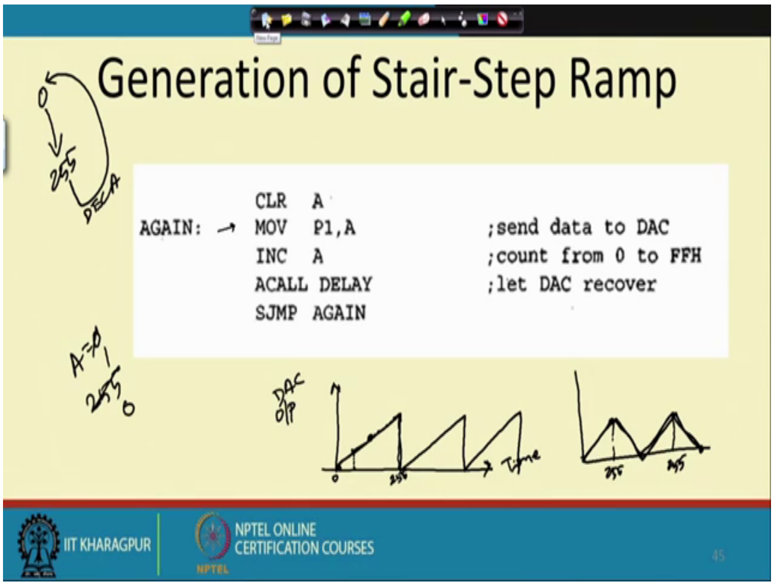
(Refer Slide Time: 05:28)



So, ideally we connect the output pin I out to a resistor and to convert this current to voltage; however, this can cause inaccuracy since the input resistance of the load where it is connected will also affect the output voltage, the point I want to mention is. So, this is the current this is the current that we sorry. So, this is the, at this point so we have got some current I out. So, this I out when it is when this I out is. So, ideally I should connect directly a resistance here and see what is the voltage. So, we should we should measure the voltage across, but the problem that we have is that this I outlines this outline when it is going. So, I am I am connecting a resistance here like this plus it is going to drive some other point in the circuits. So, it is to it is connected to some other device also and as a result. So, that device is input resistance.

So, that will also come with this one. So, that way the measure for this voltage that you are getting so, may not be due to this resistance alone may be due to some other loading with some other resistance also, that way the inaccuracy may come in that is why this op amp circuitry has been introduced. So, that we do we can decouple the next device the, this point we can decouple this point from this point ok. So, that way this circuitry is used so. So, I ref output current is isolated by connecting it to an op amp for example, IC 741 op amp with a feedback resistance of 5 kilo ohms for the. So, therefore, for the, that way it will be isolating the output stage from the DAC output. So, this is helpful for getting proper outputs, the program for is very simple.

(Refer Slide Time: 07:28)



Like if you want to generate some stair step type of ramp then what we do see the we want to generate. So, let us trace this program. So, initially the we have got clear if A equal to 0, initially A equal to 0 and then MOV P 1 comma A. So, MOV P 1 comma a so this statement will be putting this a output on to this a a output will be put on to this input to the 0808. So, it will be converting into a digital value. So, you will get a 0 at the output.

So, you will get a 0 at the output and then after that. So, at this point I have a equal to 0 and then we have got this a equal to. So, a value will be increasing. So, a value will become equal to 1 A equal to 0. So, when this a equal to 0 is output. So, if I just look into the, of form the DAC output. So, this output will be 0 here and then am implementing this a by 1. So, a becomes equal to 1 and after some delay am jumping to this point again. So, as a result this one will be output to these to give into the DAC. So, DAC will put the corresponding a voltage output.

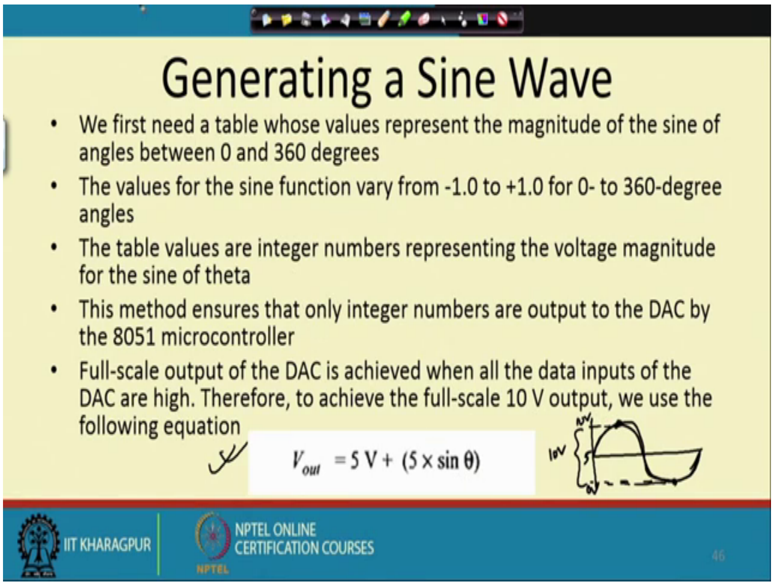
So, this may be the voltage corresponding to the digital value 1. So, this side I have got say time and this side I have got the DAC output ok. So, I will get something like this here time after sometime after that one delay time I have data output like this. So, after 2 delay time the output will be increasing so it will be something like this. So, this way it will go. So, after say 256 after 256, 250 type 255 times. So, I will see at the maximum this is 255 this is time 0.

So, I will be at this maximum then what will happen the content of the a register is 255 and then if you increase it further. So, this value will get reset to 0. So, as the of form I will find that it will go up to this then it will fall like this, then again it will go like output like this then it will fall like this go out output like this then it will fall like this, every 256 cycle. So, it will be coming down to 0 otherwise it will be increasing. So, this type of output so very easily you can be obtained using this particular DAC operation ok.

So, this is stair case type of output that may be useful. So, you can just use it for some other type of input as well for example, you can use it for if you do it like this that once the value reaches from 0 to 255. So, if you say that after that instead of increasing I will start decrementing. So, decrement it till it becomes 0 so, but this is not a single step. So, this is DAC there it there will be a de decrement instruction. So, DCA that will be decrementing the count and then that way I will be going to a going back to 0. So, in that case so you can very easily generate say triangular wave form.

So, from 0 it will go like this. So, once you reach the point to the count value 255, once you reach the count value 255 now you start decreasing it. So, you will get something like this then from this will be again. So, when it comes down to 0 again you start implementing it again you start decrementing it. So, again another 255 count so, you start decrementing it. So, that is why you can very easily generate a triangular wave also, different type of waves can be gen generated using the DAC. So, if you are having these wave form generator to be designed. So, we can use this DAC as a put initial candidate for the same.

(Refer Slide Time: 11:36)



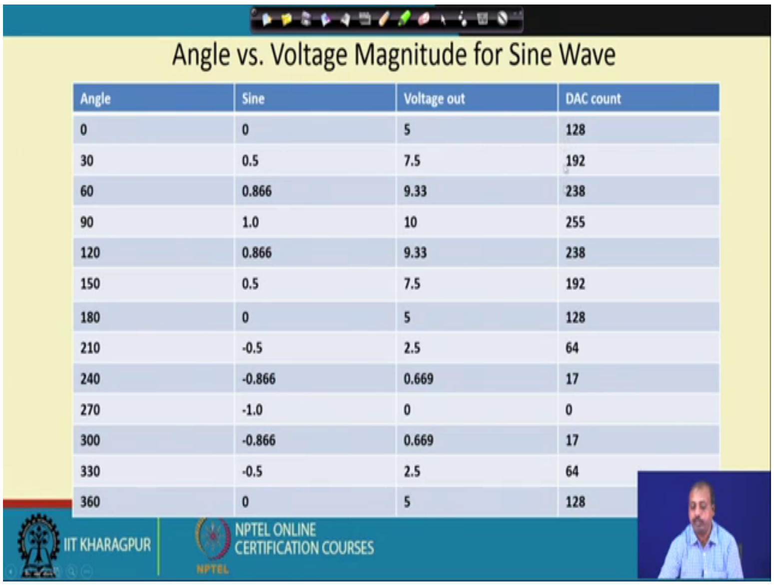
So, we will take a slightly more complex example of generating a sine wave ok so, for calculating for generating a sine wave. So, what you have to do is that for different sine value. So, you have to feed the current corresponding count to the input of DAC. So, that it is converted in to the equivalent voltages. So, we first need a table whose values will represent the magnitude of the sine of angles between 0 and 360. So, you can make a table by hand.

So, you can for different sine values what are the corresponding magnitudes that you can calculate, now if you are this values in the sine wave sine quantity. So, this will have vary in the range of minus 1 to plus one in the 0 to 360 degree range the sine angle sine value will carry from minus 1 to plus 1. So, in that table we will store the integer numbers only. So, we will take only those values of sine where the voltage value will become an integer number because we assume that our table is not able to sort, our circuitry not able to use this floating point number.

So, it will be using only integer numbers. So, so we will be having this thing like if I say that the next thing to be decided is the full scale value of the DAC the of this sine waves. So, you if you if you think that I have full range of this sine wave should be 10 volt so, that is you are looking for if this is the ideally say if I am looking for something like this and this range is say plus 5 to minus 5. So, this range is 10 volt. So, you have got so these increment point is 5 volt this is this minimum point is 0 volt and this maximum point is 10 volt.

So, you have got a dc of set of 5 volts. So, with that we are generating this 10 volt magnitude sine wave ok. So, if you are trying to do something like this then I should follow this particular equation that the v out is 5 volt plus, 5 into sine theta because sine theta will be in the range of minus 1 to plus 1. So, where it is minus 1 so you will get the 0 and when it is plus on so you will get the value 10, 5 plus 5 10. So, this is what we are going to do.

(Refer Slide Time: 14:03)

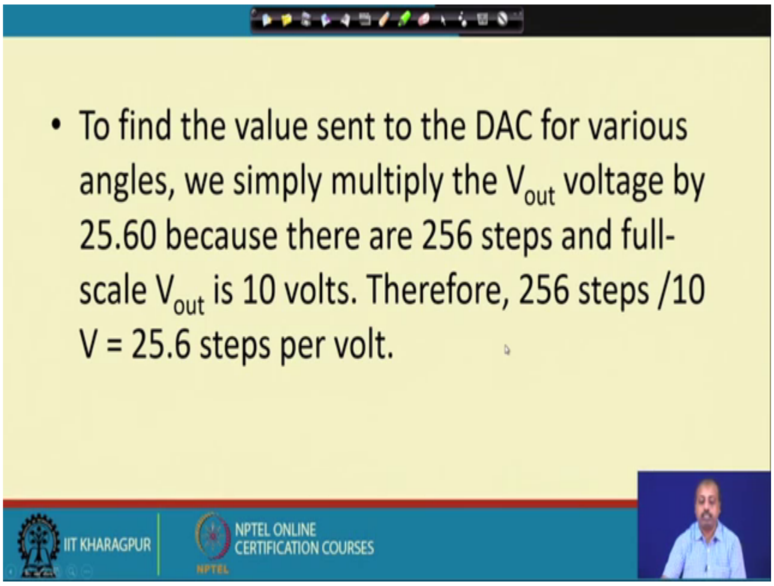


Angle	Sine	Voltage out	DAC count
0	0	5	128
30	0.5	7.5	192
60	0.866	9.33	238
90	1.0	10	255
120	0.866	9.33	238
150	0.5	7.5	192
180	0	5	128
210	-0.5	2.5	64
240	-0.866	0.669	17
270	-1.0	0	0
300	-0.866	0.669	17
330	-0.5	2.5	64
360	0	5	128

So, first of all we write down this sine table ok. So, we take the values at 30 degree difference is 0, 30, 60, 90 like that and then we corresponding sine values are like this. So, voltage that is outputed if you consult the previous equation then when it is 0 so, it is 5 volt when it is 0.05, output is 7.5 volt when it is 60 degree 0.866 voltage out is 9.33. So, what you do is you can you can find out the corresponding DAC count because 5 volt will be at the may at the middle. So, if it is at the middle. So, I should output the half of the full range or full range is of the DAC is 0 to 255. So, it will be somewhere it should be somewhere in the middle.

So, DAC will be outputting a 128 value. So, when you are. So, DAC value should be 128. So, that the DAC will put a value of 5 volt close to 5 volt in the output. So, if you are putting say next time you want the output value to be 7.5 volt corresponding to 30 degree sine value. So, you can put the DAC count as 192. So, that be will be converting it to 7.5 volt output. So, this way I can just after sometime this sine value becomes negative and for negative if you consult the corresponding corresponding formula. So, the voltage out is 2.5 volt and for that the DAC count needed is 2 point is 64 that is half of this 128, 64.

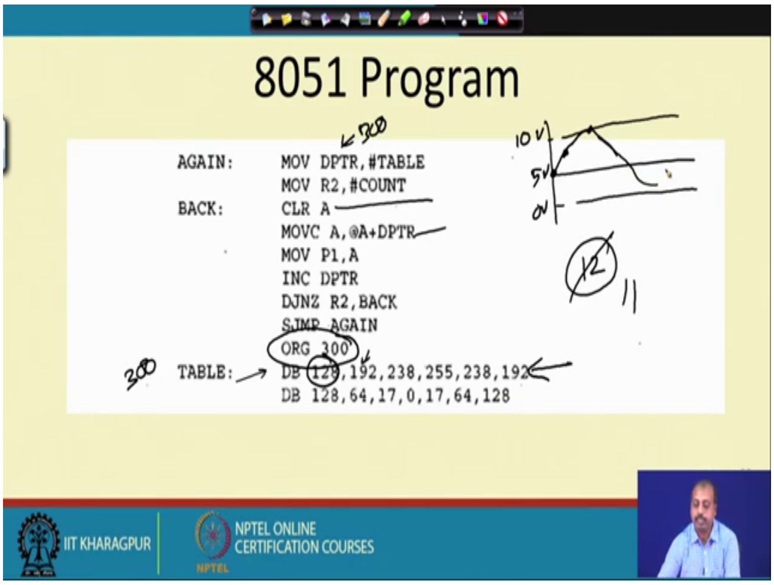
(Refer Slide Time: 15:40)



So, this way we can do this thing we can count find out the count value. So, this the way we compute it like to find value sent to the DAC for various angles we multiply v out voltage by 25.60 why? Because there are 256 steps that will be covering the full 10 volt range that is 256 covering 10 volts. So, for each steps you will be covering 25 point each volt will be covering 25.6 steps ok. So, each 25.6 step change so, this will be converted into 1 volt change in the output. So, that way you can simply multiply this v out voltage by 25.6 in the previous table that we have got. So, v out multiplied by 20.6 will give me this DAC out DAC count.

So, that way in everything if take the closest integer. So, that DAC output will be that much of integer. So, this way we can convert this DAC values to the corresponding voltage and this is the corresponding program for the sine wave generation.

(Refer Slide Time: 16:50)



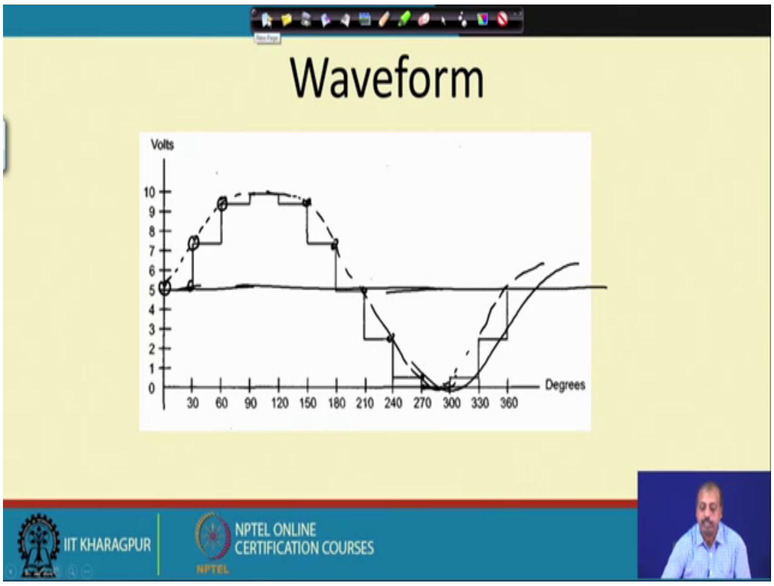
So, assume that this table is the stored from address 300. So, this table is stored from address 300 here and then am storing all the value 128 192. So, so it is 0 to all 30 degree then all those angles. So, that way it is stored and then for each of them I have to output the corresponding wave. So, what do I do?

So, in the R 2 register we put the count value. So, that we can stay like how many steps it will go like count value is the number of steps that we have like here it is 1, 2, 3, 4, 5, 6, 7, 8, 9 total is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and again 13 will be coming back there. So, it is 12. So, R 2, R 2 so, that will be holding the count value now we clear the register A and move c A comma at the rate a plus d PTL. So, DPTL is holding the address of these table. So, if the table is which is by this only 300 statement this table will be stored from the memory address 300. So, DPTR by the statement DPTR has got 300 and this a register is cleared.

So, when I do this. So, I get the first value 128 onto the a register. So, these value we put on to the port p 1 and as a result it will be it will be getting that it will be outputting that 5 volt that DAC, the DAC will get the count 128 as a result the DAC will be outputting that 5 volt. So, on your that of form chart so you will be somewhere here 0 fine this is the 5 volt, this is the 0 and this is the 10 ok. So, you will be somewhere here, we will be somewhere here then after that what we are doing we are decrementing these dz and z. So, r 2 r 2 is decremented in becomes 11 and then we are going back here. So, we have incremented at DPTR. So, DPTR is now point this in to this. So, by the again by the same statement so now, it will be outputting that next sine wave value that we have. So, that is your. So, if you look into this table now we want to output this 192. So, 192 will be outputted. So, when so next value is 192 when it is outputted. So, we are getting that sorry. So, in this 192 is outputted. So, we are getting the next voltage level that 7.5 volt. So, it will be somewhere here. So, it will be it will be rising like this. So, this way it will grow. So, it will become it will come to this point. So, it is step like this.

So, we will try to approximate this sine wave. So, in successive step so it will both this 10 volt and then it will start coming down in successive step that the approximation will be done. So, if you look into the typical wave form that you get after doing all these thing will be something like this.

(Refer Slide Time: 20:17)



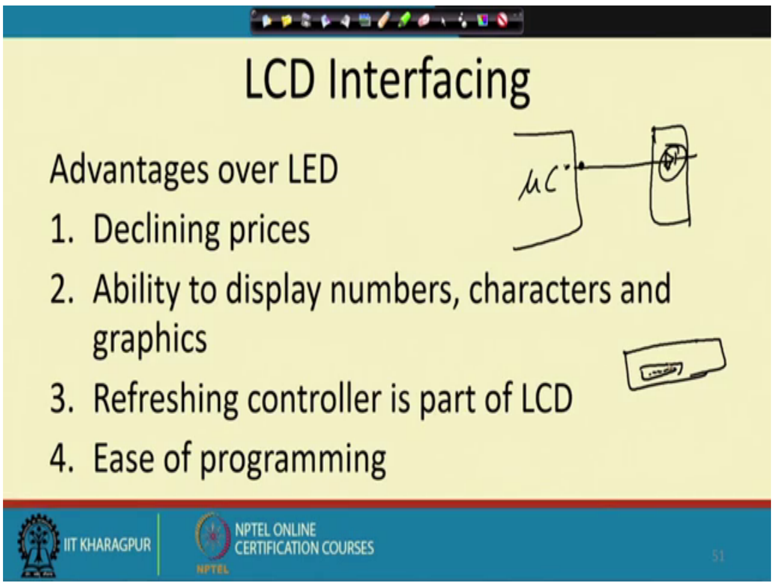
I do not, I do not know whether it looks sine wave or not, but ideally it more or less. So, because for 0 you have got this as the output for 30 degree you have got this as output ok, at 60 degree you have got this as the output. So, I so ideally is addressing the wave form like this, replacing the wave form like this. So, it is retrieving going up like this. So, so if you look if you take this 5 volt line as your 0 point of your sine wave. So, this is a some sort of a sine wave ok. So, that way we can get an approximation of the sine wave. So, of course, you can better job by making your step size better. So, you can you can take the step size to be you can take the step size to be less than 30 degree.

So, here the problem came because we are taking a putting the output at the range of 30 degrees x y we have got some sort of the output that will see on the oscilloscope will be some sort of stair case of thing, but if you reduce this if you if you reduce this angle. So, instead of 30 degree so if you take say at 2 degree intervals of, say if you take the take it at 2 degree intervals.

So, you have got the large number of values outputted and then it will be following your sine wave more closed fashion in a more closed fashion. So, that way this may be useful while you are going for this sine wave generation or any arbitrary wave form generation. So, you can try out not only this sine waves wherever it is repetitive in nature wherever the wave form is repetitive in nature. So, you can store some of the sample values in the memory of the microprocessor or microcontrollers output those values to the DSP pins.

So, it will be outputting the corresponding analog value and you will be able to get that output on to the scope or any other device that you are looking for. So, this way we can connect it the in devices the so we can connect this DAC to the micro control microcontroller, microprocessor. So, similarly we can gain the same thing you can have a different range of this micro controller this ad DAC chips that are available some of them are doing better resolution the speed is one of the important factor ok. So, that way we can have different type of configurations like next will look into another.

(Refer Slide Time: 23:00).



Ah very nice interfacing device which is known as LCD or liquid crystal display.

So, this is they are better than led is because the led s the problem is that we have got. So, they are the, you do not have much flexibility, in the sense that led with led you can have certain fixed patterns only. So, you cannot have any arbitrary pattern displayed on the, this led ok. So, this certain only some of the digits and some of the figures some of the numbers can be some of the characters they can put on to the led display, but this LCD it is placed they are much better. So, you can put some graphics to it so this is general selecting the proper lines putting the corresponding bids on.

So, that way you can get some LCD interfacing which will be better than led and also the price of this LCD they are coming down. So, we can have this. So, we talking about LCD. So, this LCD prices are also coming down. So, that it is better. So, it can it has the ability to display numbers, characters and graphics. So, all the different types of things we can put on to the in display and refreshing controller is part of LCD. So, LCD another important thing is that you need to replace the display like in led also if you turn on any led then after some time so, if that the microcontroller which is controlling it. So, if that is going off like say this is the microcontroller which is controlling the led panel, if this is the led panel now this particular led pin the led bid that I have.

So, this has to be continually driven by this line. So, if this microcontroller is doing something else like if you if it is if it is as you know that most of the bids are this microcontroller port so they multiplexed in different functions. So, if it happens that microcontroller is using this particular pin for some other purposes, this particular bid if formed other purpose as a result this display will also get effected for example, the port p 0 which acts as these multiplexed address database.

So, that is if you are using it for displaying some LED module then their content the content of the led module may be problematic when some of the I have output of some pattern and after that we are trying to axis some memory location. So, that way the content becomes a problem the content will get modified of that led panel also. So, that is the problem in case of LCD what happens is that there will be dedicated register inside the LCD.

So, there will be some register inside the LCD where it will hold the petal that you want to display and as a result the microcontroller is a relieved of updating of continually beneficing the LED panel ok. So, these are display panel. So, this is once it is written on to the register that we have in the LCD. So, it will be using for that way for that purpose. So, you do not need to do anything. So, this refreshing controller is part of LCD and a programming is also very simple, only if some of the some of the bids are to be same some of the registers are to be same and then it will continually display the content.

So, that is why LCD interfacing is becoming very popular and there are again same thing that there are many LCD panel looks that are available that they were with varying capacities and all that we will look into some such panel some example panel and do and try to see how they can be programmed for displaying some particular pattern on to the display.