Digital Circuits and Systems

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Lecture - 2
Introduction to Digital Circuits

Okay in the last lecture we talked about analog systems and digital systems. analog is a natural thing occurring in most real life situations so we need to have analog signal processing capability. At the same time we saw that al systems are more reliable, cost effective and are easy to design and work with especially for storage and transmission. I said most of the real life systems try to push as much processing as possible into the digital domain still have an analog interface at the input and output because all naturally occurring systems most of the real life systems are having analog inputs.

So this is the block diagram if you want to think of it as a digital system then we have an analog interface (analog in) then we have the analog to digital converter ADC stands for analog to digital converter and then goes into the digital domain, I will explain here why I put one arrow here and set of arrows here, I will explain to you in a minute. the output is the digital system I have again has to be processed by a reverse process called digital to analog converter DAC, of course I am including all preprocessing filters as analog in, I am not talking about transducer conversion into electrical signal, mechanical to electrical transduction or sound to electrical transducer and all those things I am not including. I am just generally saying everything before you convert the signal into digital I put it as analog.

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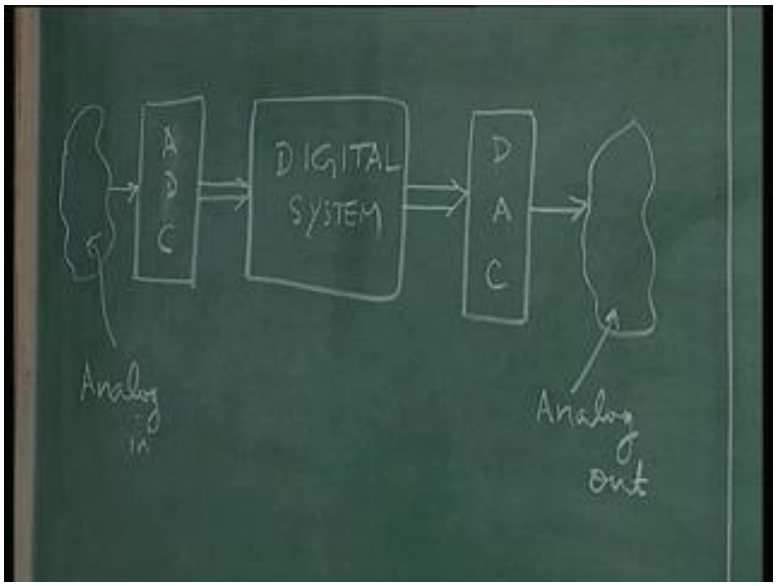

The details of this you will learn in analog course. Likewise once I have a digital output I need to have some filtering and all that. I will not show all that I will simply say it interfaces to the real analog world.

What is a digital system? That is what we are going to study in detail in this course as I said. What are the components of this digital system? What are the properties of these components? How do you analyze these components and how do you design these components for different applications? We may not be able to do all of it in single course especially in an introductory course like this but we will definitely get into many aspects of this, more complex designs and more complex analysis may be thirteen future courses more advance courses.

So what is a digital system? Are we familiar with any digital system and can some one give me idea what do you mean by a digital system. When somebody says digital system what comes to your mind? Computer, that's the most obvious thing anybody would think of, what else? Calculator is sort of a computer right? I will put a calculator I am not going to say no for you.

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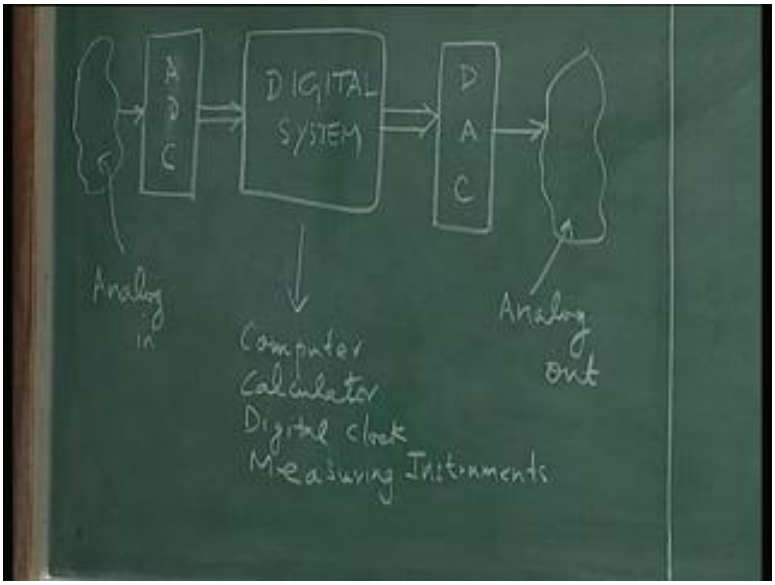

Something else? Watch, digital clock shall I call it because watch or clock depends on the size and you call something a watch or a clock depending on how big it is. If I wear it my hand I call it watch, and if it is on the wall I call it a clock, anything else? Digital voltmeter and I can say digital ammeter and I can say digital pressure meter so we can say instruments. Obviously these are some of the things especially computer is the first thing that comes in your mind. But you know in today's world the walkman if you have one there is a lot of digital component in it. Even though again the music finally that reaches your ear is analog but has lot of digital processing to improve the quality and equalizing at elevation the right type of notes and accentuation or improvement of the type of frequencies that you want to hear like that many things that you go along walking

on the road without your knowledge you will see many things you don't analyze them but most them are digital today.

For example, automobile today if you take an automobile it has lots of digital features. The ignition control of an engine has lots of digital processing in it because précised timing for fuel efficiency and there may be other control circuitry which turns on turns off things at the right moment. Even the car radio that you have or car tapes, deck as you call it in the car there is a lot of digital in it because again the same processing I told you about the walkman the tape that you insert into the tape deck may be an analog magnetic tape but then the pick up and the processing has a lot of digital involved so that you have noise free reception in a car which goes at very high speed in highways with so much ambient noise externally as well as internally generated by engine in spite of that you are able to hear, listen a very good audio that is because of lot of processing and again finally it will be turned into analog for you to hear through a speaker. But in between that there is a lot of digital processing.

Toys, control equipment at home you have a washing machine may be the precise timing of the cycles especially in Chennai which is a water starved city we should not waste water so to what level should you fill your washing machine and when should the water flow stop and when should rinsing start turning whatever you call it in the washing machine are precisely controlled. You take for granted all the gimmicks you see on the TV screen. Earlier we used to have a person in front of a camera like this classroom here and then it is an analog signal and television picks up light intensity modulation and intensity modulation is converted into electrical modulation and electrical modulation is sent to the receiver where it is demodulated as again a light variation which will appear in the picture tube.

But today you can see lots of things. But nowadays you can have multiple things, you can have my lecture in the corner of the screen and rest of the screen you have the classroom and part of it they can have a subtitle running underneath all these different gimmicks are possible because the studio people are able to store the image and manipulate it, you would have seen all these videos in television programs, in movies and things like that and there is so much more.

I cannot exhaust all the possibilities, measuring instruments, I will put one simple word 'control systems' and simply I will say audio and video processing. So it is alright that you wanted to push as much as this processing into the digital domain as possible for the reasons of cost, reliability and design but how complex is the system going to be depends on the application that is what I am trying to say. Obviously today's computer we talk of Pentium P3 or P4 or whatever it is called all these different versions running at Giga hertz clock speeds.

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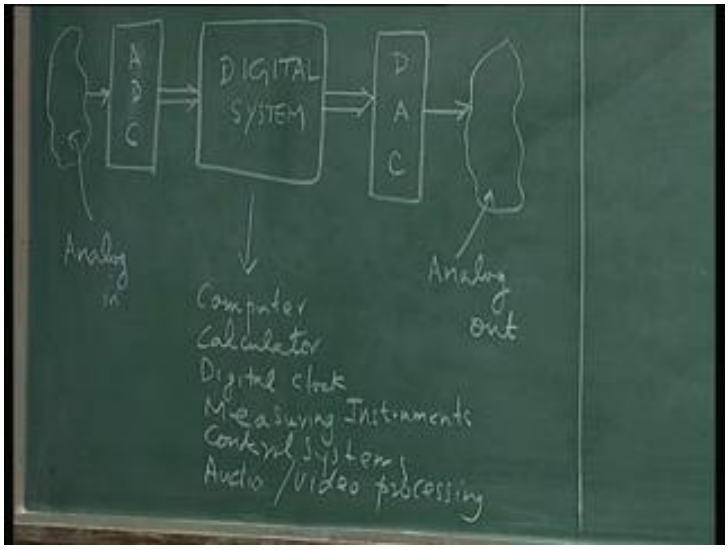

The complexity of the circuitry inside is enormous. On the other hand you have a simple washing machine control I said or a mixer that is used in domestic kitchen all you have to do is to time it for a particular cycle or whatever it is and control the on and off switch. So depending on the application the complexity varies. So you cant be overwhelmed, how can I learn in one class, how to design a computer of course you are not going to learn to design a computer in this class but we can get well into that because the other thing I told you about digital system the other day in the introduction lecture is it has a repetitive nature as I said improvement in accuracy can be done easily by adding more blocks in digital system which are almost identical or similar whereas in analog an improvement in accuracy or improvement in performance comes with a great effort at the cost of great effort being put in design. So improve the performance in analog system the design efforts are not proportional to the improvement is much more where as digital system is depends on efforts proportional to the effort so that is one thing.

So it is possible to design complex systems because if you know how to design simple systems then for complex systems there is lot of work. Of course I am making it too trivial because there is lot of control features and how to combine all these various blocks into a complex system this is not a trivial task it is a non trivial task but still it is not as complicated as or formidable as you think. So basically a digital system design becomes easier because it consists of building blocks. Any digital system can be broken down to blocks.

Let us take an example of a computer again. What are the things we have in a computer as far as you know? You all use computers, there is a CPU Central Processing Unit which does all your computations even though today you use computers for more non computing purposes than computing purposes like internet and email is that not what we use eighty percent of the time and 80% of the people including me of course. I am not going to pretended I am doing high performance computing in my computer it is all the same, may be my computer is little faster than your computer because the faculty is given

better computers than what you see in the labs. But these are all the same. But the Central Processing Unit which processes, let us not worry too much whether it is computing or processing, manipulation of data is also processing, storing and retrieving at the right time file management or whatever we will call it processing so be non controversial about it so CPU and then what all do you have? Memory? Memory is required in a computer to store program and data. I need to have a program to run so I need to store it somewhere and I need data for input and output and then it would be stored. And then what? Input output unit, how am I going to put the input into the computer how am I going to get the output of the computer, so input output units.

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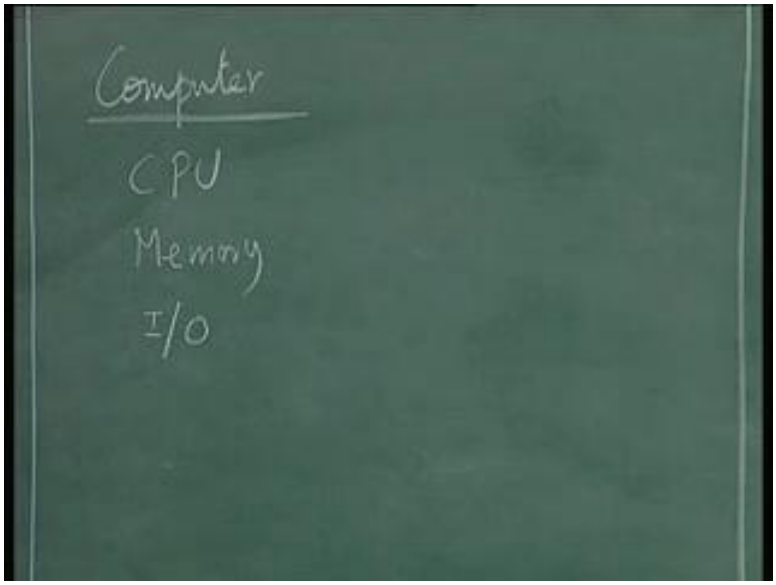

These are standard building blocks which you have been seeing from high school physics somewhere around down sixth or seventh grade in physics book you would have seen a block diagram of a computer, the CPU, the memory, IO and so on, I don't think it has changed. But we will know more about it, more and more functions and more and more complex things.

Now like this I can breakdown any digital system. I can now further divide the CPU into if I am interested arithmetic logic function and if I am further interested arithmetic functions and logic functions and even further interested an arithmetic function consists of add, subtract and multiply so adder, subtracter and multiplier and likewise from the overall view of any digital system down to the details I can define and all I need to do is to design these simple, simple building blocks I call them building blocks now.

So basically this can go into ALU, control logic and let us say register to store results, I am just giving you a very trivial picture but there is much more than this in a computer and you will learn this in the next course Computer Architecture course. But the point is again ALU can be made up of, ALU is not a black box, you know it has to do logic so what is a logic function what is an arithmetic function you can define so arithmetic

function can be adder or subtracter or multiplier so I can design each one of them and put them together so I can go on dividing the task partitioning the system into smaller and smaller subsystems so from systems I get subsystems these are all not standard definitions. Subsystems can be broken into modules or functional blocks if you want to call them and functional blocks can be down graded into basic units. I will not elaborate it this time because this is the first course and it doesn't have some of the background that you need. As an example I can say I can have a gate level implementation. A gate is concept. I have two inputs and an output so depending on the gate type the output is defined in terms of the input.

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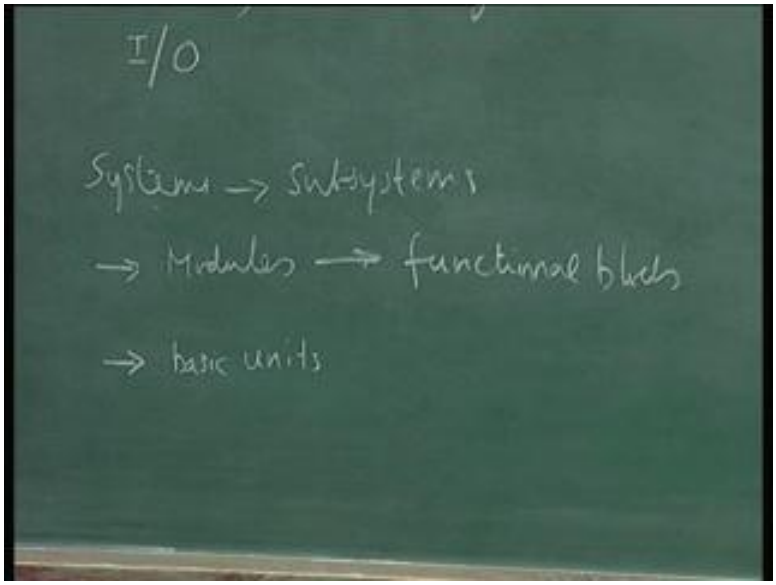

The gate is only a logical building block, but how do you realize it is you need transistors and capacitors. So it is from these basic units to actual circuits using active and passive elements. Now if you think of a computer like this it becomes a much more manageable task, like that I think of memory, like that I can think of IO. So any digital system can be broken down into subsystems, subsystems can be broken into modules and modules can be broken into functional blocks, functional blocks can be broken into logic units, logic units can be broken into circuits, circuits are made up of devices and components. But you don't need this but you didn't read it in your high school physics.

Computer users today don't even know what is inside a computer for them it is the computer turn on and then type in the keyboard and should get the message they want and then they say the computer is not working it is broken they call the person and yell at the fellow, what kind of computer you have given me, it doesn't work and all that thing that's all they do.

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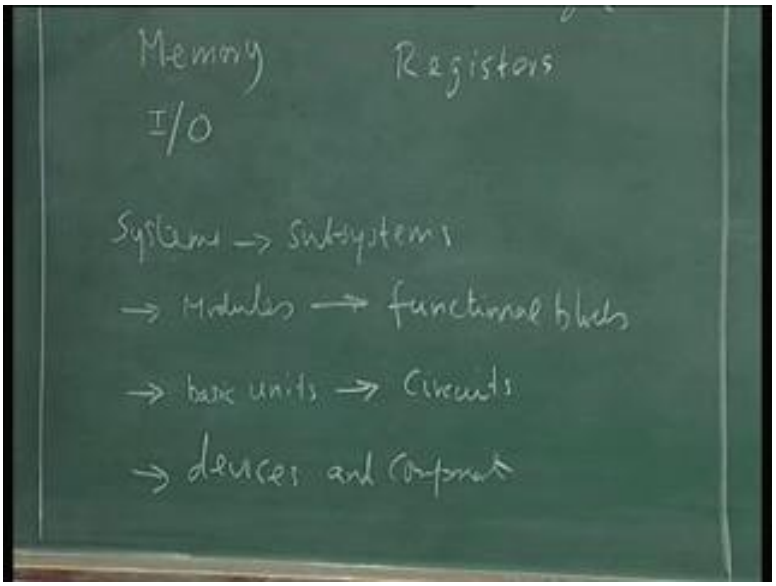

So we are little more than that we are supposed to be designing these things electronics, electrical engineers, we are domain specific people, we have to design these things so that is why we are having this course digital systems what does the basic digital system consists of, what are the units and so on.

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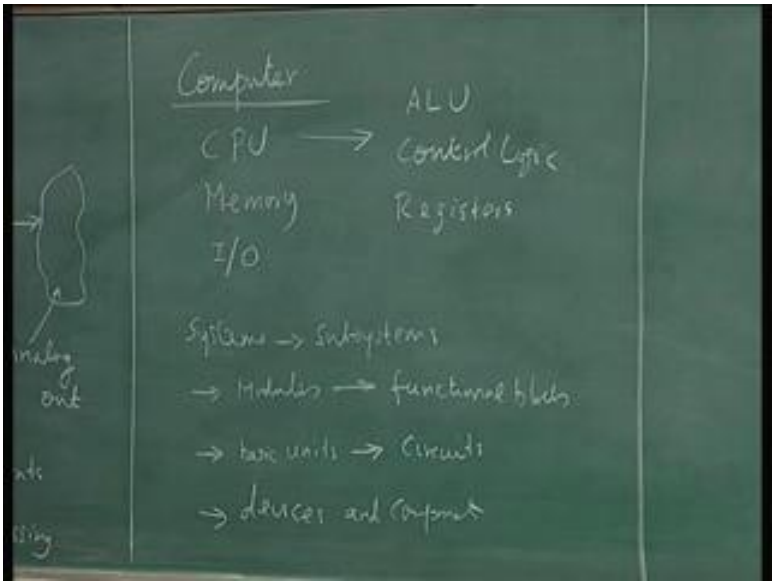

So in this first course obviously you cannot start from here and go down, I have to start from here and go as far as possible but at the same time we will always have this goal in mind so that at any point we will be able to expand into different schemes.

Of course again I will not go into devices and components for two reasons one is that we have a course called electric magnetic circuits and we have a course on analog circuits

these are the things which will be covered in more detail. So we will probably start with basic units, functional blocks and modules and possible subsystems and may be give one or two examples of a system design also at the end but need not be a computer, computer is only a concept. Any digital system has a same type of hierarchy as you want to call it. From top to bottom, from system to circuits to devices to components the same hierarchy is there whatever the system is.

Now everything is a computer in one sense. if you think of computer for a moment not as a machine which computes as I said many us do not use a computer for computing today, we don't need computers in our work, many people don't need computers in their work, for people in offices, in banks of course banks may add and subtract I don't know about that but there are many applications where computing is not required to be done by a computer. it controls data, it keeps data, it acts as a memory, database it gives out information when needed.

So when you think of a computer for a moment just forget the fact that it computes. Any function that you want to implement will need a Central Processing Unit that process may not be computing it may be a control function it may be just storing and releasing data at the appropriate time, whatever it is it is a control function Central Processing Unit, it processed the data that you give. Just keeping it and releasing it at the right time also called as processing to a certain extent and then any system needs a memory to store the program.

Let us say you are analyzing the railway reservation. Railway reservation all of us know it uses computers. All of us go we stand in front of a line in each window there is a computer the follow keeps punching in numbers in a keyboard. So for anybody including us the so called electrical engineers it is a computer he is working on, more so far a person who is not related to electrical engineering or even engineering but is he really doing any computation there, he finds out the availability of seat in a particular train that you want and allocates a seat for you in that train and says that seat is taken and that information is stored so when the next person comes the same seat is not allotted to that person.

Now, will you call it a computer? Yes it is a computer, does it process? Yes it processes, what does it process? It processes the data the fellow gives in and gives out the proper response as an output all in terms of information in this case, information processing is also computing.

So if you now think of a computer is that most of the things you can relate to now as a computer. A traffic light controller can it be called a computer? Yes, it has to know which street has vehicles waiting, how long has this street been having a red light, is it time for the red to change to green in that road and release the traffic so that the other street where the traffic has been flowing for the last few minutes should now be stopped and green has to change into red there, so are these not processing of information? So anything can be related as a computer. If you think of the digital system as a Central Processing Unit in which your desired task is performed be it a computational task or a control function or

data, information processing or a data storage and retrieval whatever you want that system to do it is doing it so I will call it as Central Processing Unit and I need to know the program to do this for example traffic light controller cannot behave arbitrarily you have to program it, look at this street A, B, C, D four streets, look at street A see how many cars are waiting, how long it has been in red and based on that go and put street B as red release street A as green, this is a program so it needs a memory to store this program. So program memory is required in any digital system whether it is a computer or not and data has to be there in some form or the other. Sometimes it is trivial and sometimes in railway reservation data storage is a huge thing, how many trains, what are the timings and how much is the fare and how many seats have been given in GT express and some other system like traffic control there may not be much data to process, all it needs to process probably is the timing how long it has been on and how long it has been off.

So data memory is required, program memory is required, central processing is required. In the case of the railway reservation system input is the keep operator the output is the printing that he gets. In the case of traffic control the input is some sensor that you have somewhere to save how long it has been on or for some sensor somewhere you have to see how many cars are waiting and the output is the lights turning from red to green to yellow. So now if I think of this as a model of a digital system I can call everything a computer. A toy is a computer, a washing machine is a computer, the remote control of a TV is a computer, you did not think of a computer like this so far I think so, at least some of you might have but most of did not right, most of you did not know that you are working with ten to fifteen computers a day.

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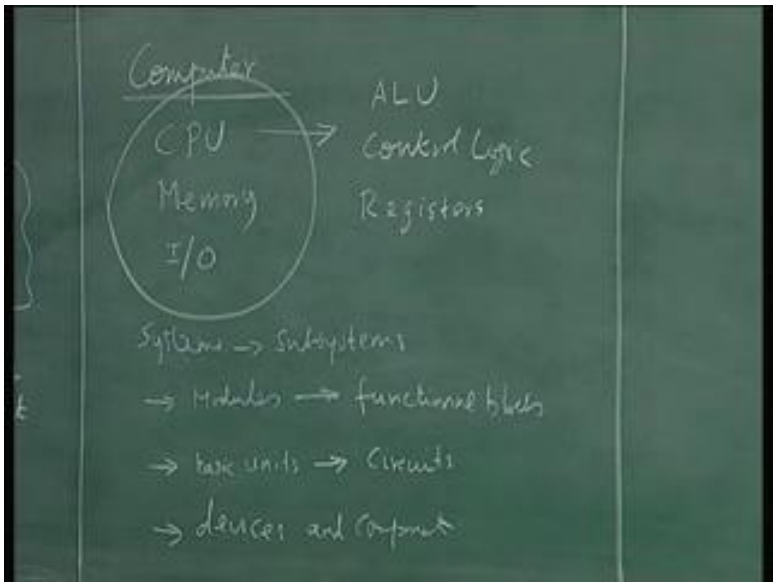

You all crib that you don't have enough computers in the department but each of you have fifteen computers, your cell phone is a computer, it has a program, it has a data memory to store the numbers, it has program memory, it has memory to charge so that

your parents can pay for it, it is a computer your cell phone is a computer, I would say cell phone is a computer how many of you disagree with me? Are you at least convinced that it is a computer now?

So when you are thinking of digital system design we are going to see how to build the systems to control it in a way to that you want a desired performance out of it. A chemical plant monitoring, temperature monitoring in a oven, air condition the right temperature to be set in, elevator, lift control going up and down which floor has a call button press which floor destination has been pressed, analyze, process and do the motor which takes the lift car up and down to operate it properly. When you press floor 4 you do not want the car to land in floor 5, you want the car to land exactly in floor 4, how does it do that? It is computing. Some books are named 'digital design' and some 'digital logic and computer design' but they both are same, so don't take computer in a more literal sense because nobody uses computer to compute nowadays.

Very few people in aerodynamics and all those people who write hundred equations with hundred parameters are the people who may be really using computers for computing but most of us do not. Rather we use it for control functions, information storage and retrieval functions. If you think of computing as that then all that you need to think of is what are the basic building blocks, how do you build these basic building blocks into the system which are useful to us like a traffic light controller, like an elevator controller. That way I will be able to do this also in our course.

We will probably start with the basic units as I said circuits and device level I will not do it because other people are going to do it more competently so from basic building blocks how do you define functions how do you make these functions into modules and how do you make these modules into sub systems and possibly this is because your traffic controller is one of the simplest systems we can think of so I can design it in the class at the end of the course probably let us see how far we go it is to early to say it all depends on how effectively I am able to transfer information how effectively I am able to absorb information.

Let us say there is a goal at least some of those things we will do. This is the crux of this course. That means it starts with this basic units what are the basic units of the building blocks of this. Now, before doing that we have to do a little bit of change of gears. If you remember in the introductory class we talked of digital system as a system in which discrete levels are defined for the quantity you are considering either voltage or current. For most part of this course let us stick with the levels of voltage levels it's also being a current logic.

So let us talk of voltage which is 0 to 5V I gave you the example of 0 to 5V that day. In analog system a system or any variable of the system can take any value from 0 to 5 continuously. In a digital system I said there are only certain discrete levels between 0 and 5 which are allowed to be taken by the parameters is that not what we said about the difference between analog, discrete and digital the other day?

In an analog system time varies continuously, the variable varies continuously and within the parameters within the limits any value is allowed. In discrete parameter can take any value but we only look at it as discrete data systems discrete time systems. In digital systems we will look at this only at discrete times and also we will only recognize certain values of the parameters as allowed values and any value in between to be rounded off to one of those values allowed. Was that not the definition I gave you?

Now on one hand we say we can have accuracy, improvement, easy to improve resolution but I say only certain values are allowed. That means the question is how do you make a system more accurate if you want to?

For example, this class let us say with all these exams, quizzes and final exam the total mark is for 100 you know 100 and grade you. So can I have those who get less than 50 fail and those who get above 50 pass no grades or else those above 50 getting S grade and those who get less than 50 is in U grade if I say will you agree? If you say 10 above is S and less than 10 is U then you will agree. But if I put it this way supposing I say those who get above 80 then S and those who get below 80 will be U will you agree? So this is digital system only two values are allowed between 0 and 100, 1 is 0 and the other is 80.

The part of the class mapped between 0 to 80 will be called 0 marks people and people who got between 80 and 100 will be mapped as 80 marks people so 80 mark people get S and 0 mark people get U. But I want to improve the resolution, you don't want this, it is unfair you will say then nobody will register for my course next semester. So I will have to at least have different grades 20, 40 if possible 15, anyway 20, 40, 60, 80 reasonable more reasonable fellow he is, even though I would like to have S he has got at least A for me. So I want to improve the resolution. That means I have to have more levels. But I said only two levels are allowed for variables because only discrete levels are available for variables.

So voltage is 0 to 5V how do you represent what it is? Because as I said the storage and transmission is more reliable in digital because we know the data is one of the values which is allowed only is being transmitted, if the value received at the output is not the same as what has been transmitted we know what could have been the value assuming a reasonable error. I gave you an example I try to pass 1.25V and I got it as 1.28V in all probability say this fellow tried to put 1.25V some noise got added and it became 1.28 so I will correct it to 1.25 you will say. Similarly you will try to set 1.25V and you received 1.22V you know this fellow tried to send 1.25 and some voltage got dropped in the line so I got .03V less it is only 1.22 but I am sure that this fellow has spent 1.25V.

So I want to improve the resolution at the same time I have only a fixed level. That means I have more number of digits. In a digital system where we are used to number system we have these digits 0 to 9. Depending on the accuracy supposing I want to have ten levels I can use to 0 to 9 levels, I can't have 20 levels with two digits I can have 20 but it is of inefficient use, with two digits I am going to use then I can even have hundred levels 0 to 99. So, as I increase the number of digits allowed to be used by me I can represent the quantities more and more accurately more and more precisely.

Now you translate to digital system I want to have this physical device this basic unit circuits and functional blocks to recognize discrete levels, if it is only two levels then no problem 0 or 5 as I said u or s then I need two voltages 0V is 0 and 5V is pass. 0V is fail and 5V is pass and in between means nothing you don't want that so I want to have more levels that means how do you have more levels in electrical circuit because after all the whole thing is finally electrical circuits.

You have to give voltages as inputs and measure voltages as outputs. It can also be current but as I as said I will stick to voltages in this course. Whatever is the electrical parameter even non-electrical parameter or pressure it can be, it can be temperature, it can be anything but I need to have a way of representing more than two levels or any number of levels in my system. That means my circuit should be able to represent 0V or 5V fine, if I have 0V I will show it as 0 and 5V I will show it as1 that means I have a switch. If the switch is open I will say low voltage is passing through so it is a 0 and if the switch is close the entire 5V is passing through so it is 5 so I can have two levels.

If you want four levels I need to have two switches operating together if both the switches are on I may have one possibility and if one is on the other is off I have another possibility so I have four combinations now. So this is what is known as number representation.

Before I go to the basic units and define them I would like to tell you a little bit about number representation. All of you know this I just want to make it a very simple presentation, most of it you can read it by yourself in any standard book and all of you might know all these by now through your so called computer sciences course in your high school. What I mean is we have only two levels let us first make some assumption in this course unless otherwise stated we work with voltages. The voltage levels are 0 and 5, range is 0 to 5V.

Now we have only a two level representation like pass or fail. I can have pass as 5V fail as 0V no problem. How do I do it? I should do it by means of electrical switches. a switch can be open to indicate a condition and close to indicate another condition, on or off of switch or if you want non electrical representation I can have a flag here so if the flag is up you are pass each person comes to me I will give grades today is the grade day, come to me I will raise my flag if I pass I will make the flag go fail.

Simple, but you are not happy. You want to know whether you passed with s grade or a grade or b grade so I need more flags. Passed with 'a' I will have one extra flag, passed with 'b' I have another flag so as I go on more and more but then these flags are the same or switches are same I can't make a switch half closed. Can I make a switch half closed or half open? No, so I should have more switches to do the job is it not. So with these two assumptions I am going to do if I only have to represent two numbers 0 as 0V, 1 I will call a symbol it is not a number, in this case this is a symbol so 1 is 5V, 1 is on = off of absence of a flag of the switch being off, flag being absent or anything else you can imagine.

I want two symbols I say. You can have a red shirt and a green shirt. If I wear green shirt today you are pass. After all we want representation, how does it matter? 1 is ON of the switch that shows the presence of the signal. But as long as I have two numbers there is no problem. But the problem comes when I want to have more than two, I want to improve the levels, I want to have 10 levels, I want to have 100 levels. Now in the case of binary numbers only two positions are possible 0 and 1.

Fortunately for us we don't have to go from 10 to 100 to 1000 there are decimal numbers each digit is 9 so only one digit I have, I can represent 0 to 9, if I have two digits I can represent 0 to 99, and if I have three digits I can represent from 0 to 999 so in case if I have decade by, one decade they call it, in a binary fortunately I have two levels, if I have one switch I can use two levels where by a combination of these two switches I can indicate four levels 2 power 2, if it is three switches I can indicate a combination of 8 levels so depending on the number of levels I can represent these by different switches.

So, for example if I want to have 4 levels I can have 0 0, 0 1, 1 0, 1 1 as I said these are symbols, don't think of them as numbers 0 and 1, 0 symbol and one symbol, that means I can have switches which are off and off, I will have two switches both are off I will say this as 0, if it is off and on, on and off, switch 1, this is 0 (Refer Slide Time: 44:04), switch 0 is off, switch one is off number is 0 0, both switches one is on the other is off it is 0 1, and then both are on it will be the fourth level so 0 and 2 so two switches can give you four levels.

Therefore in terms of this that means any number can be represented. I can now increase the range or the accuracy or the precision or whatever you want to call it, I want only two levels, I want four levels the discrete parameter the digital parameter the voltage or current I said mostly voltage but whatever parameter I am monitoring which can take only discrete values can now be allowed to vary over a wide range. If I did not have this and if I had only one switch it can only take a value of 0 or one or 0V or 5V or symbolically speaking 0 or 1.

If I have two switches now the same parameter is allowed to take four discrete values namely 0 0, 0 1, 1 0, 1 1. If you transfer it into voltages it will be 0V 1.25V, 2.55, 2.5V, 3.75V. So this 0 to 5V can be mapped as 0V and 5V with one bit with one switch and with two switches it can take 0, 1.25, 2.25, 3.75 and with three switches it can take whatever, divide by 8, 5 divided by 8 as I told you in the beginning you can increase the number of the representation to be more accurate by simply having more switches.

Suppose a switch has been designed by a circuitry using a transistor then it need not be an on off switch. Now all I need to do is two times I have to do it, three times I have to do it, ten times I have to do it. If have 10 times 10 switches I have 2 power 10 levels, 4 switches means I have 2 power 4 levels, 3 switches means I have 2 power 3 levels and 7 switches means I have 2 power 7 levels but they are identical switches. So my job of improving the accuracy or representation of the number becomes easy. This is called binary representation of number. Now you know all of these about binary representation

so I am going to make it as a reading assignment I don't want to spend lot of time on this binary number systems.

Is there any one in the class who does not what a binary number is? All of you know binary systems? There is any body tell me because even then I am going to teach you I can tell you where to read this. So now I have a decimal number and a corresponding binary equivalent binary representation. Now 0 will be 0, 1 will be 1, 2 will be 1 0, 3 will be 1 1 so with the two binary digits, binary digit is called a bit, 1 bit will do 2 bits, 4 is 100, (Refer Slide Time: 48:16) a bit stands for a binary digit, like that I can go on writing any number.

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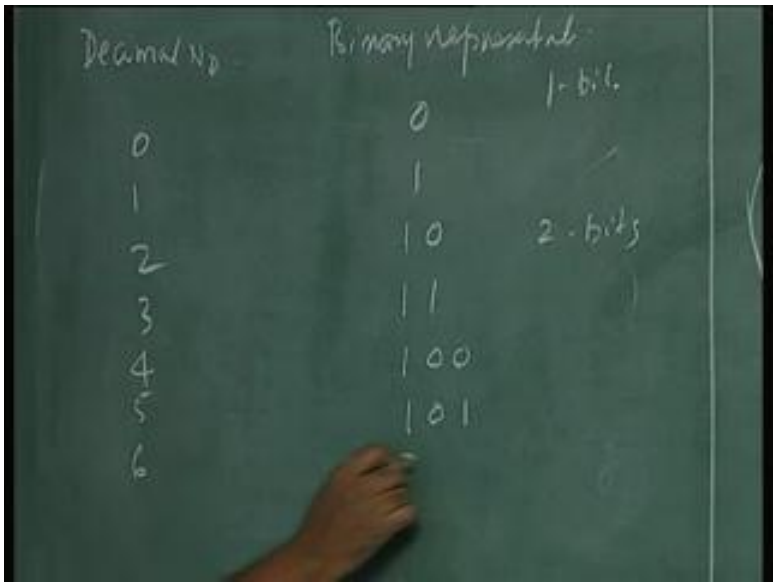

So depending on how many discrete values I want my parameter to take in the given range of 0 to 5V I can define the number of bits I will use to represent that number, that's all.

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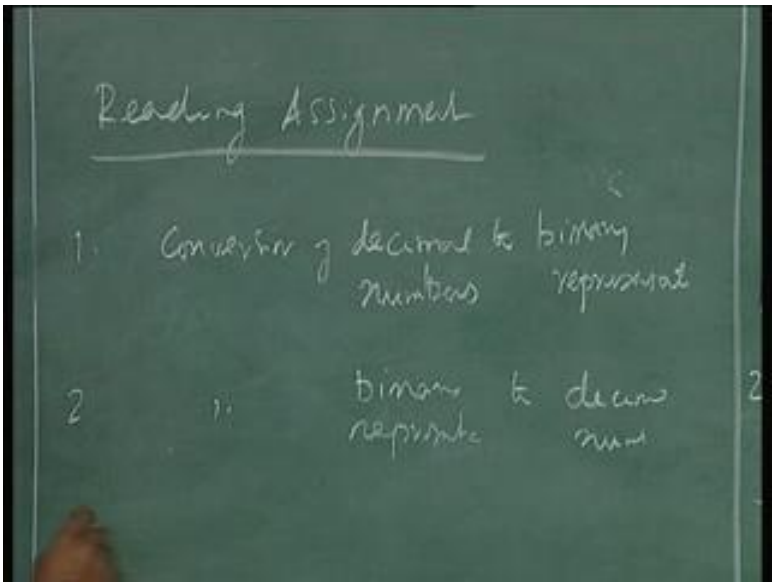

So I can decide on the number of bits which will be used to represent that quantity but still it is discrete. Even if it is 10 bits 0 to 1023, 10 bits is 2 power 10 – 1 so it is 0 to 1023. 0 to 5V can be divided into 1024 steps. Starting from 0V but all of them are discrete in between those discrete steps the parameter cannot take the value. But it is good enough for me I am not going to have more accuracy than that depending on the system.

As I said train coming or not flag will do, if there is marks in a class there are grades in a class there may be 5 levels may do, eight levels may do.

If I want to represent the number of people in this class a finite number of bits will do. So if I want to count my money some finite number of bits will do. Depending on the application the population of this country how many bits are required. So, for every application there is a finite number of bits required and that will decide my precision or the accuracy of my digital system and all of them are reproduced identically. So the improvement of the accuracy or precision of the digital system is not at all difficult because all I do is to replicate as I call it, duplicate, actually replicate, do it one more time that is called replication.

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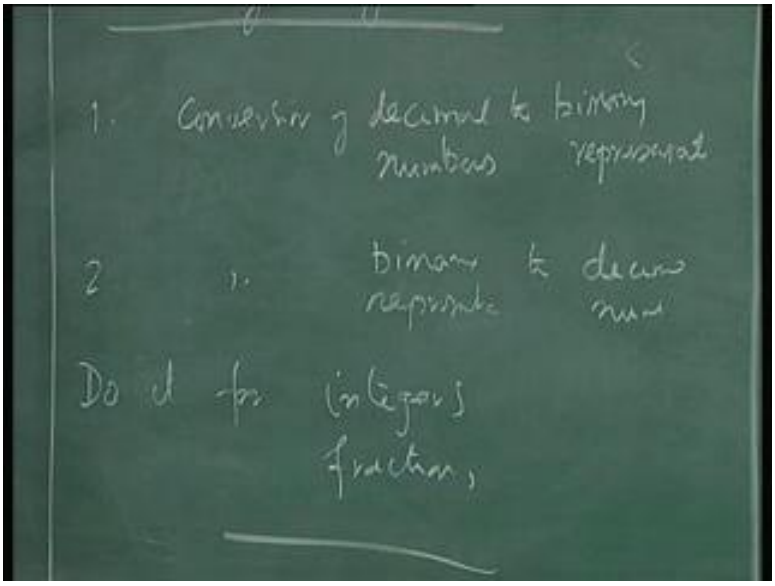

So I will leave it as an exercise to you, as a reading assignment to you to do the following things.

Reading assignment:

1) Conversion of decimal to binary decimal numbers to binary representation that is right way of saying it
2) Conversion of binary representation to decimal numbers.

Do this for integers and fractions.

I am not going to talk about this topic further, I will assume that all of you know it because these topics are being taught these days in schools, there is no point in repeating things we already know. But any of you have any questions you can ask me and as I said we will have discussion class in which you can also ask me. So you practice these things that's all, you take any number I don't need to give you any homework on this. you take any arbitrary numbers or conversion to binary or take any arbitrary to binary string and try to convert it into decimal, what will happen you need a fraction also that is integer and fraction and combined mixed number also that is real number both integer and fraction together in one representation. That will now give me that means I will only deal with two levels of any variable but by repeating these different bit positions I can get better resolution of my system that is what I am saying. That way I don't have to worry about my digital, I have only two levels, four levels how can I accurately do the processing that I want using computers.

Okay we will stop here. In the next class we will start looking at the basic building blocks of the digital systems.