Architectural Design of Digital Integrated Circuits
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Lecture - 01
Introduction

Hello everyone, welcome to the course on Architectural Design of ICs. So, this is the introductory video myself Dr. Indranil Hatai, I am an assistant professor, in the school of VLSI technology IIEST Shibpur.

So, today we will see; that means, why we need to known about this architectural designs of ICs and what is what are the; that means, what are the phases it goes through whenever we are developing one ICs; that means, ICs means integrated circuits. So, why do I need to need to learn this course, how it will help you to improvise or to improve your skills, when you are designing or you are associated with designing any integrated circuit.

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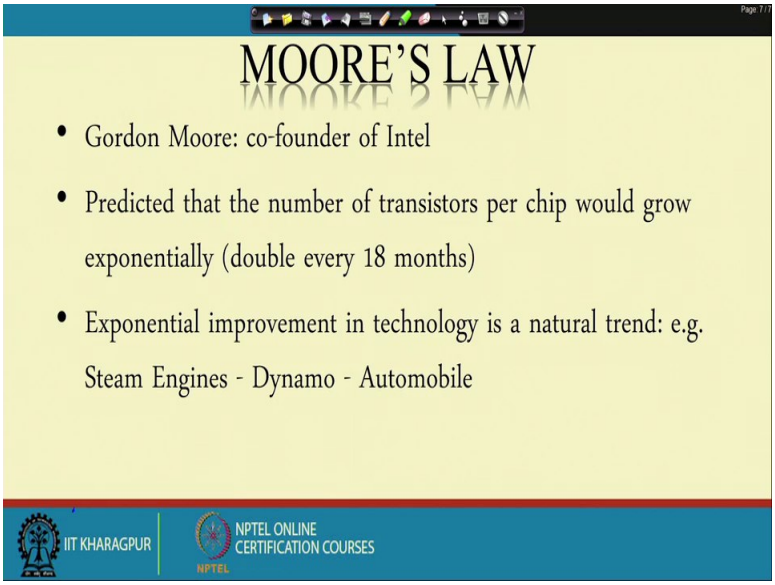

So, the first the thing is that, Gordon Moore the co founder of Intel, he predicted that initially in the earlier phase he predicted that the number of transistor per chip would grow exponentially; that means, it would be double in each 18 months. So, we can actually in the present days if we see the scenario we can see; that means, in the technology their exponentially improvement like if we see; that means, the in the

automobile application. So, how it basically evolve from one generation to the another generation; the same things happen if you see; that means, the wireless communication it has started with 1G then now it is; that means, the era of 4G and now it is; that means, it is trying to move on to the 5G.

So, what are; that means, what are the changes or what are the need for that? That means, the users need more data to be accessed ok. So, that is why every day basically people or the researchers are trying to; that means, increase the data rate by founding newer algorithm then algorithm to its architecture and which architecture is basically helping the to make the hardware for that so, that the users can use it for their purpose ok. So, if you see this IC products ok.

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So, it has been; that means, everywhere you can find this integrated circuit like this processors, processors are used in CPU, DSP controllers, then if we use memory chips there is RAM, ROM or electrically erasable proms then programmable and what are this programmable and all those things we will come later to this lecture. Then programmable PLA FPGA and then embedded system; embedded system is basically it is used in cars, factories, network cards then latest trends is this system on chip. So, this is basically the part of the VLSI ok. So, and in VLSI what we do basically.

Suppose we have one concept ok. So, that concept should be we have to make that concept into reality ok; that means, that should be working and that working phase that

will be used by the user. So, how do I do that? Using or by making the integrated circuits only or making the hardware for that basically integrated circuit means we are building the hardware. So, that hardware building is basically passes through several phases ok.

You can implement there are different; that means, implementation platforms where you can implement your hardware and then what are the things you need to know about that implementation platform that we will cover in this introductory lecture; that means, in the this introductory lecture is all about; that means, what is there or what are the phases which basically passes for one VLSI design and then after this introduction, we will see whenever we are passing through this particular VLSI design phases.

So, at that time how this architectural designs of ICs that will help in each of this phases. In each of this phases means each of these phases it is; that means, the out of this course that is that the whole phase will not be covered into this particular course, but how you can achieve the optimization in architectural design or this logic design logic; that means, logic optimization phases that will be covered in this particular course ok.

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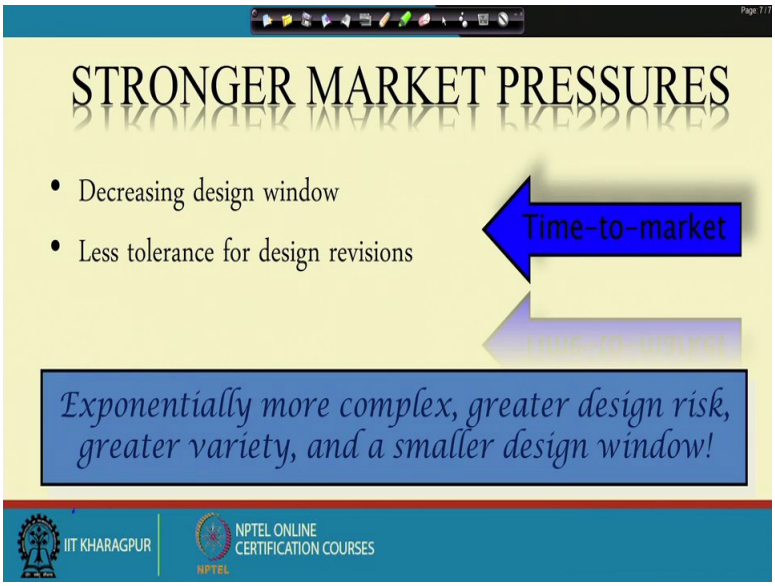

So why; that means, why I need to know or what is; that means, what is the intention for learning or to; that means, know about this architectural designs of ICs why because, there is a stronger market pressures. So, stronger market pressures means what? Basically if you see; that means, nowadays every 3-4 months your cell phones are basically changing; cell phones are changing means it is coming with newer features;

that means, the company who will come with; that means, who will come with a product which has unique feature. So, he will get the maximum; that means, market capture in other terms if I say he can capture most of the money from the market ok.

So, the companies perspective is that; that means, if you know the and; that means, the faster you develop the chip you release to the market you get the market and make the money ok. So, that is the; that means, primary intention of the companies ok. So, this basically this needs basically put the pressures on the engineers or the researchers who are building the ICs and whenever we are. So, that is why you can see that these basically decreasing the design window.

So, design window means for making one chip from concept to the reality, it takes some time. So, whether that should be 3 months 4 months 6 months 1 year 2 year. So, there should be one fixed time. So, that time is basically reducing day by day. As the market needs become becoming day by day that is basically becoming more and more greedy so, that basically decreasing the design window ok.

And the second point is that that is less tolerance for design revisions. So, less tolerance for design revision means. So, whenever you are building one ICs at that time it has So, much of it associated with so much of cost. So, cost in terms of ah; that means the researcher or the workers who are basically developing the ICs then the fabrication cost along with that so, many other costs there which are associated with one particular IC whenever I am making.

So; that means, if I design one faulty IC. So, at that time all the money or all the effort which are associated for building that particular IC that all are in vain ok. So, that is why whenever you are designing one IC particular IC. So, at that time you must be more cautious about that it is fault free; that means whatever specification or whatever; that means whatever design you want to do the circuit which you have realized, that also working or that performance of the particular IC that are same where from you have started ok.

So; that means, in each of the phase you have to do the revision; that means, in each of the phase you have to check whether that design is working fine or not. So, when your design window or design time that is reduced so, at that time you are not getting that much of time for doing the revisions ok. So, that is why this stronger pressure market it

is not only decreasing the design window, it also creates the problem of reducing the time for design revision ok. So that means, the fault checking that is not that much rigorous so that you must has a engineer or as a researcher or as a designer you must be more cautious whenever you are designing the ICs.

So; that means, and how you will be more cautious? If you know what you have to achieve and if you know how you have to achieve. So, at that time; that means, if you are more proficient to do that so; obviously, you can you can cope up with this decreasing the design window as well as though the design revisions are time is less. So, we can cope up with both of these. So, exponentially as stronger market pressure basically that increases exponentially more, complex greater design risk, greater variety and smaller design window as I have already discussed this.

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So, VLSI design style; so, VLSI design styles are basically means there different styles where how you can implement your circuit. So, one a one of those is full custom design, then semi custom design or this application specific integrated circuit using programmable logic, that is PLD or this FPGA and then another thing is that that is system on a chip. So, these are the VLSI design styles; that means, or the implementation styles how you can build your ICs.

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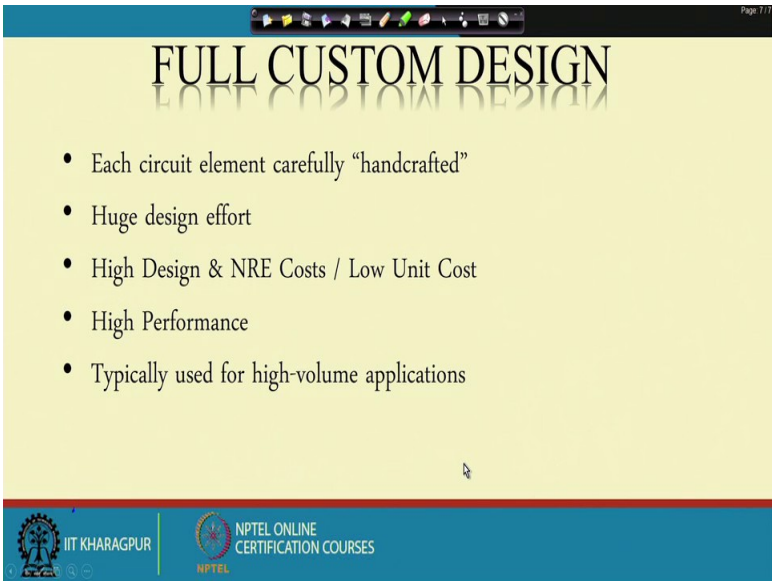

So, I will just brief about all these; that means, what are there in; that means, what does it does these full custom or these application specific integrated circuit (Refer Time: 12:10) FPGA means. So, I will just describe just I will brief briefly describe each of those.

So, full custom in full custom design each circuit element carefully handcrafted. So, handcrafted means here every element or every each of the circuit element you have to do it by yourself ok. So, no; that means, automation tool will help you to build your circuit ok. So, we will see how; that means, this is differs are what does it means this each circuit element carefully handcrafted, how what does it means. So, we will see later whenever we will see the examples at that time it will be much more clearer to you.

So, it cost with huge design effort, then high design end non recurring engineering cost high performance and typically used for high volume application. So, whenever I am doing each circuit element or each of this is handcrafted at that time, it needs lot of efforts. So, why I lot of effort? So; that means, I have to be more careful or I have to be more cautious whenever I am designing this particular circuit using this style.

So, at that time that is why it is requires huge design efforts, it requires huge cost and the time also for designing this if I follow this particular full custom design. So, at that time it requires more time also. So, but in terms of what? In terms of whenever you are doing these yourselves; that means, you are making you are following this full custom design. So, at that time it gives you the highest possible performance in any of these styles and

that is why it is basically used for high volume application so, that the cost per unit that becomes lesser. Otherwise if you for small volume application the cost this NRE cost this design cost that are so, much high; that means, per volume cost at that time it will be much more on the higher side. So, that is why if you require on high volume application at that time the cost per unit that will be lesser as it gives you the highest possible performance among all of this designs style.

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So, then this application specific integrated circuit or this also you can call as semi custom design. So, here semi custom design means, in the first point you can see this constraint design using predesigned component. That means, here in full custom what I we have seen that each of the element; that means, it start starts with as you might be knowing this in VLSI design, you have to there are several ah; that means, steps there like you can start from circuit level; that means, you transistor level, then you can start from gate level or above that you have; that means, each of the component basic components like adder, multiplier, this then divider something like these.

So, you can start from transistor level you can start from reg gate level or you can start from the upper level which is this basic components. So, in semi custom sorry in full custom or you have to start with transistor level. So, in application specific or semi custom design you have to start from the gate level; that means, some of the predesigned component or this gates or are already predesigned and you can use those; that means,

whenever you are designing one particular circuit. So, at that time those gates will automatically be you can use in your design ok.

So, that is why it is basically known as semi custom not full custom so, semi custom. So, here cad tools; cad tools means this design automation tool. So, cad tools greatly reduce the design effort and this load it; that means, gives you this low design cost, high non high this non recurring cost and the per unit cost is also low, but then what whenever actually there is that is the natures law, that whenever you are gaining something at the time you have to loose somewhere. So, as I am; that means, gaining and here another advantage is that, as I am starting from one level higher than the full custom design at that time the time for requiring the time which is required to design your particular circuit that becoming lesser than the in compare with full custom design.

So, but I am achieving this low cost per unit and this time to market is also reduced ok. So, then where I am loosing I am gaining these things, but I have to lose somewhere where I am losing? The performance; in performance wise it is lower than the full custom design ok. So, this is the semi custom design style.

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Then another design style is there this programmable logic. So, it is known as that pre manufactured component with programmable inter connect. And CAD tools greatly reduced design effort. here also low design cost low non recurring engineering cost and then lower performance also; that means, as a I said and one point is missing that is

advantage is that it requires much lower time than; that means, the design time is much more lower than the full custom and the semi custom.

So here you see this non recurring engineering cost that are high and here this low it this programmable logic, it requires low non recurring engineering cost. why so? Because in semi custom design or full custom design, you have to whenever you are you have; that means, you have build your chip; that means, you made the circuit then you made the layout, and then this layout information that you sent to the foundry for fabricating it, so; that means, it requires some of the cost for particular fabrication also ok. So, that is why this full custom semi custom that requires higher cost. But here in programmable logic you have one prebuilt chip that are basically comes with this pre manufactured component with programmable interconnects.

So, the difference is that in application specific or this semi custom or full custom, whenever the design is fixed you send it to the foundry, you cannot change. Once it fabricated it got fabricated you cannot change its functionality, but in programmable logic what you can do? You have the option to reconfigure it; that means, whether whenever you have; that means, after the manufacture you found that that; that means, some where you made the mistake or the design is somewhere it is faulty. So, you have the scope to revise it, but incase of semi custom and full custom you do not have the option or you do not have the scope to revise it ok.

So, that that is why basically this programmable logic in the initial design phase that is a better choice. That means, to validate your algorithm to validate your architecture or you use programmable logic. So, once everything is fixed then you can go for the full custom or semi custom design styles, but what is; that means, where I am losing here in this particular; that means, I am gaining in time to market and then cost wise also I am gaining, but here what I am losing it gives you lower performance than this full custom as well as semi custom ok.

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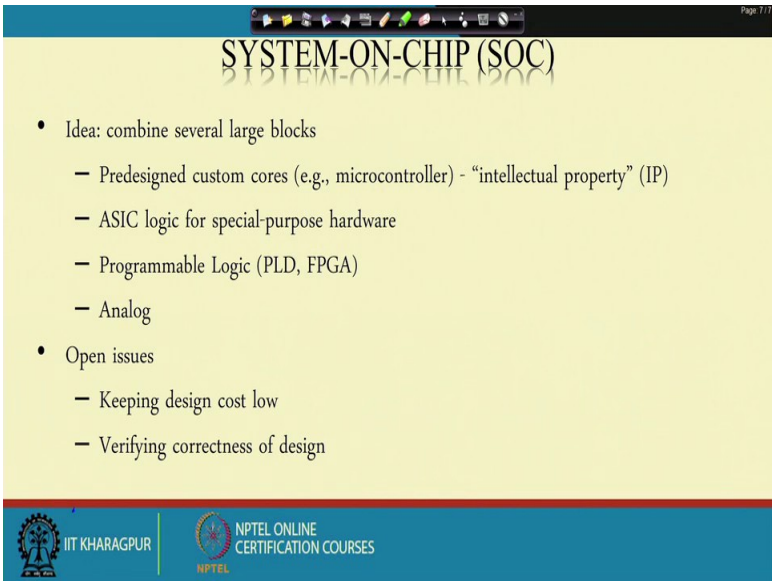

So, then this system on chip. So, system on chip what is the idea behind this system on chip? Combine several large blocks. So, now-a-days if you if you see; that means, everywhere like if you see one air conditioner, if you see one refrigerator, if you see one washing machine, if you see dish washer machine, if you see cellphone. So, everywhere there is one; that means, micro controller and there are some other controller which is basically used for different different application or different different features ok.

So; that means, more the number of features in particular products, more the number of controller you need in that particular system. So, if you see one; that means, cell phone nowadays one cell phone if you see it has camera (Refer Time: 23:04); that means, one very good camera sensor. It has this; that means, Wi-Fi connection with high speed it has to support 4G connection so; that means, several blocks you have to use for different different purpose. you can see you can access the internet you can see the TV everything you can do in cellphone.

So; that means, you need several things or several components as you are providing more number of features to the users. So, more number of features you provide to the users more the popular that particular product is in the market so; that means, in the companies perspective you are making more money. So, as designer whenever you are designing at that time your company is making the money. So, company is happy means you are also

happy. So, in system on chip what is what is the idea behind this system on chip is that, combines several large blocks.

So, as the day by day there is time to market that has been reduced. So, instead of; that means, starting from the scratch to build the whole system, it requires lots of time. So, instead of doing that block wise if I see if I; that means, in particular system if I need 10 blocks and each of the blocks let us consider each of the block consumes one thousand transistor. So, if I follow this semi custom or full custom design. So, at that time I have to; that means 10 into; that means 1000. So, 10000 transistors I have to deal with whenever I am following this as this full custom or semi custom or this two.

So, in system on chip of that what I am doing I am just picking one; that means, this 10 ten blocks are there I will only consider about this 10 blocks what are there inside this 10 blocks I will not consider ok. So, here the thing is that, you see this predesigned custom core; that means, this microcontrollers or the controllers for the camera or the controllers for the; that means, the hardware for the this Wi-Fi or the hardware for the for the 4G volte support. So, all these I have to just collect these from other third party vendors or I will just build this particular block previously I will just use it in my system.

So; that means, I have to provide one unique features. So, if one third party vendor is basically developing that particular controller. So, I will buy it and I will use it into my system ok. So, that is the main idea behind this system on chip; that means, this core wise or; that means, one level higher from this semi customer design which is this that gate level design. So, here I am component level design. So, I will collect those components and I will be using to my system to reduce the time to market.

So, here the another thing is that that ASIC logic for special purpose hardware programmable logic analogue, the issues are that is dealt with this system on chip is it that you need to keep the design cost very low, and verifying the correctness of the design. So, verifying the correctness of the design means as you are in the higher level; that means, you do not know about the you are using the cores; cores means you are using the intellectual properties. Somehow that is the controller which has been designed by some other person.

So, at that time this how you can check as the design has been made by some other; that means, researcher or other people. So, at that time whenever you are integrating those

IPs different from different vendors. So, at that time verifying the correctness of the design that becomes very much challengeable, whenever you are using or you are following this system on chip design step ok. So, for today for today's lecture this is it and next day, again we will see some interesting things on this particular course.

Thank you.