Power Management Integrated Circuits
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Lecture – 82
Introduction to Buck- Boost Converter

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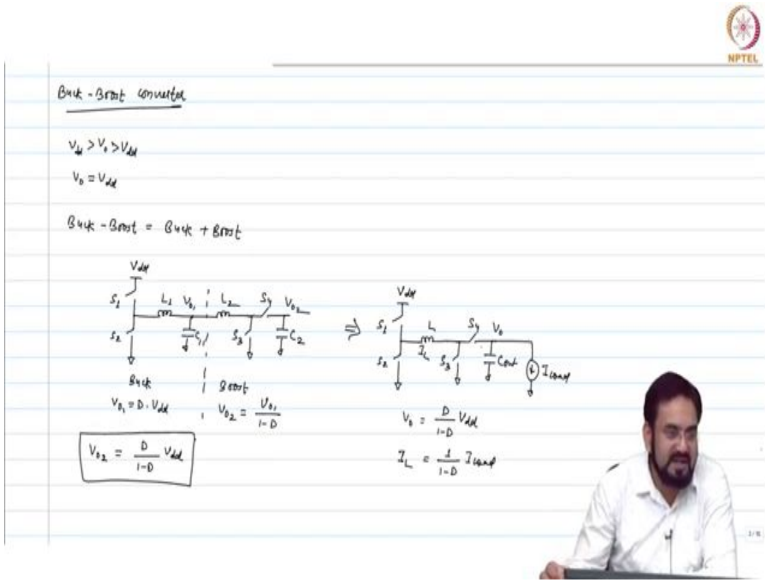

So, for the Buck-Boost converter we know for boost V out is greater than V dd and for buck it is less than Vdd. So, which means we need a converter which can do both like V out is greater than or less than V dd or in fact, it could be the same also ok. Or V out is Buck plus Boost. So, let us say I have this; I will call it S1, S2. What is this buck or boost?

So, what is V out here? If I call it V o1, D times V dd. Let us say I have L2. I will call it S3. What is this right hand side? Boost. Let us say I am operating with the same PWM where duty cycle is D, what will be V o2? V dd over 1 minus D. And what is V o1? D times V dd. So, effectively V o 2 is nothing, but D over 1 minus D times V dd ok. So, what is this capacitor doing C1?

Do we really need this? I mean we need to simply transfer the charge from one side to the other side and an inductor where you can do that. So, why do we need to store at C1? It is not required if I remove this it will do the same job. Ultimately I am only interested in V o2. I am not interested in V o1 at all, then I can remove that cap and now those inductors are in series, I can combine them and make them into a single inductor.

So let me just do this and make it C out and this is V out. So, we have saved one inductor and one capacitor and now you can apply the same volt-second balance and you will see you will get the same expression actually. So, you can do that.

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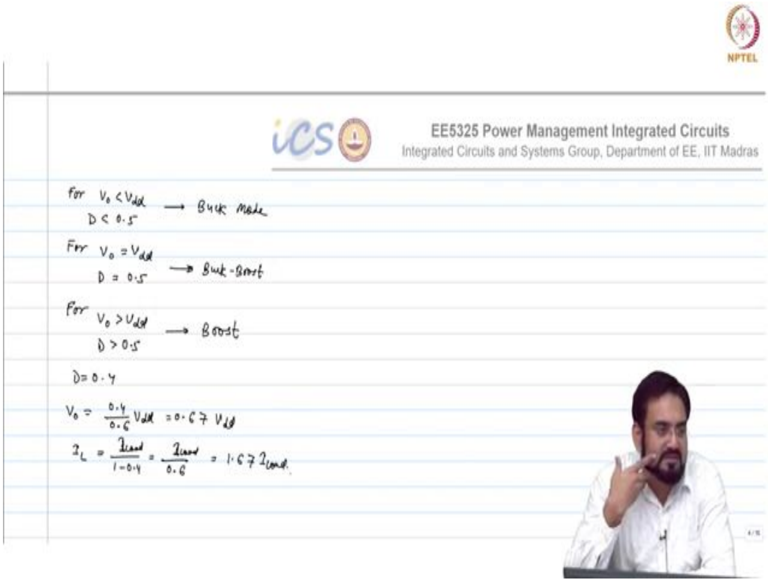

So, now for V out less than V dd what should be the duty cycle? What should be the range of duty cycle? Less than 0.5 and this is your Buck mode. For V out equal to V dd what is D? 0.5. This is what? This is Buck Boost. And for boost what should be D? Greater than 0.5, this is Boost. So, now if I make D equal to 0.5 by the way what will be the current? So, V out is D over 1 minus D V dd, but what about the current, what about I dd?

So, in the buck. D times and if you have a load here. I load what will be the current? 1 minus D upon? If you look at the left hand side figure what is the current in L 2? We talked about what is the current in boost. So, what will be the current in L 1? They are in series. Same current? So, your current will be driven my boost only here ok, because for buck the load is input current of the boost. And inductor current of the boost because for L1 your L2 basically is defining the current; correct and so your I dd will be. So, I mean think about what will be that. D equal to 0.5.

So, D equal to 0.5, what is the relationship between V in V out? V in equal to V out, but what about the current? Current is 2 x. So what will happen to the losses? They increase by 4x.

So, now let us say instead of that you operate only in buck and make D equal to 1 you will get the same thing? In the Buck if you made D equal to 1.You will get the same thing V out equal to V in and what about the current inductor current? I load. So, what about the losses there? How much difference in the loss, I square loss you are seeing? 4 times difference. So, why do we not do that actually? If I want V out equal to V in, why do I need this buck boost? Forget about the boost part. Now let us say I want my range to be only V out is less than or equal to V in. Do I still need a buck boost or I can do it with buck only?

Let us let us say I do not have even duty cycle saturation. You are allowed to make D equal to 1. Can I regulate my output to V dd? You cannot, that is the ideal condition. What about the I R loss V out equal to D times V in minus V loss. Under the condition of load, V loss will be finites. So, your V out will always be less than V in. You cannot make V out equal to V in. That is an ideal condition without any loss. The moment you have a loss you cannot make.

So, that is why you require buck-boost. Even if you want to achieve V out equal to V in, you cannot do with the buck. Even if you are allowed to make the duty cycle 100 percent ok. That is only true under no loss condition which means your load current should be 0 correct. So, let us say I want D equal to 0.9 what is your V out? 0.9 over 1 minus 0.9 into V dd. How much is this? Nine times V dd. And if D equal to 0.1?

Or let us say d equal to 0.4 take the other condition. 0.4 over 0.6 V dd. How much is this? 0.67 V dd, but what about this now and what will be the load current IL? I mean not the load, the inductor current 1 over 1 minus 0.4. 1 over 0.6 is how much? 1.67 times which is 67 percent more than your load but my output is much less than V dd and if I still need to do this and not incur lot of losses I can only operate in buck. So, which means controlling S1, S2, S3 and S4 with a single duty cycle does not make any sense here. We should independently control S1, S2 and S3, S4. This is by the way conventional Buck. If you look at any literature the conventional Buck Boost will be like this.