Power Management Integrated Circuits
Dr. Qadeer Ahmad Khan
Department of Electrical Engineering
Indian Institute of Technology, Madras

Lecture – 35
Synchronous versus Non-Synchronous Switching Regulations, PWM Control Techniques

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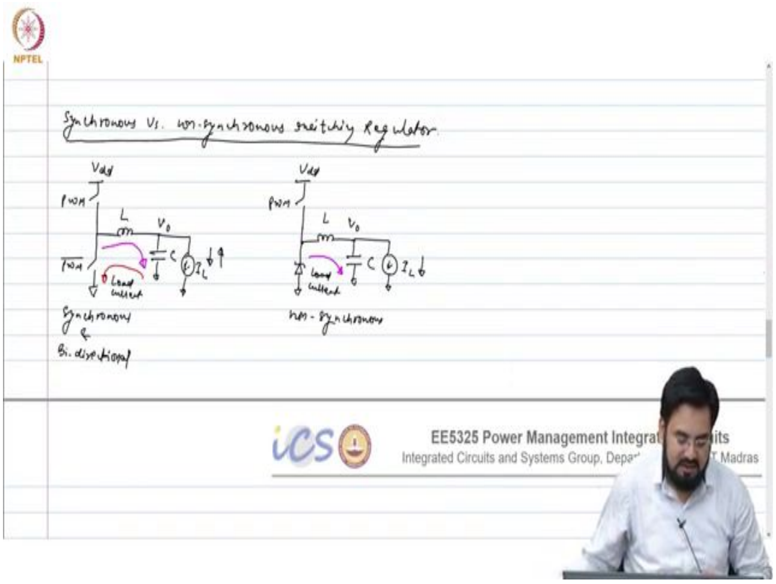

Synchronous versus Non-Synchronous. So, I am just ignoring the losses here. So, this is your synchronous because both the switches are driven by the clock. In this case and this is synchronous and bi-direction. So, it can sync the current and source the current both because this bottoms switch can conduct and it can draw the current from the output.

This could be another way to implement your buck converters and this is non-synchronous because the bottom switch is only this top switch is controlled by PWM and bottom you do not have any switch. So, your diode will conduct on its own. So, in this case current can flow in this direction and in this direction. So, when you are looking at this direction the current is basically anyway ok. So, current can go from V out to ground and V dd or as well as V dd and ground to V out.

In this case, current will only flow in one direction. So, if this is your load, load can go like this or this here load can always go like this ok. So, this is your. So, the disadvantage of having a bi-direction so, we talk about that later. So, in terms of efficiency which is better? Synchronous or non-synchronous? Go back to your losses, how do you calculate the losses?. So, for diode there is no R, you have to take the diode drop. So, let us say this is a normal diode, what will be the forward voltage?

0.7. So, 1 amp and 0.7; 0.7 your loss in multiplied by your 1 minus d. So, let us say even if you have a fifty percent duty cycle 350 milli what is lost in the diode itself and in the other case we were looking at total loss of only 50 millivolt in the switches and 50 millivolt was in the inductor. So, your non-synchronous will be lossy and that is why we do not use normal diode, but we use Schottky because Schottky has a lesser forward voltage.

So, even if you use a Schottky it will be 200 to 300 milli volt roughly. So, still in terms of efficiency your synchronous will perform better than non-synchronous. So, if your load current so, in case of non-synchronous when the inductor current goes negative this will not conduct; negative means from output to. So, reverse can if you are reverse current diode we cannot allow reverse current? It will just block it because it will get reverse biased.

And, that is the reason it is only unidirectional not the bi-directional, but here switch is a bi-directional current can flow from any direction source to drain or drain to source if you are using MOSFET and that is why this one is synchronous one is bi-direction. So, both have its own advantages and disadvantages, we will talk about that later in terms of efficiency at high load the synchronous is better, but at light load your non-synchronous may perform better compared to your synchronous. And, that is why we forcefully operate this synchronous in a non-synchronous mode at light load and will.

So, basically you convert this switch into a diode by using some kind of a logic and. So, I mean will look at those circuits later when we talk about your discontinuous conduction mode and all those.

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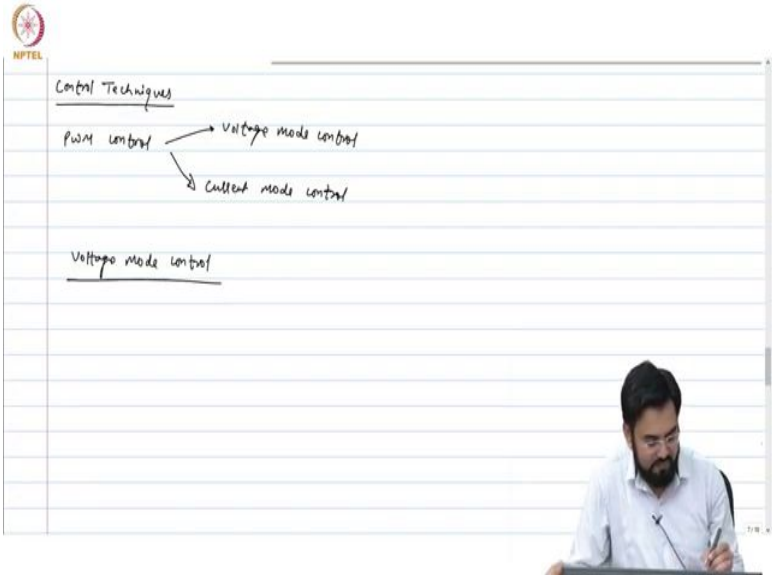

So let us look at the so, control techniques. So, it is a PWM control that we already know and usually we define it as voltage mode control, current mode control.

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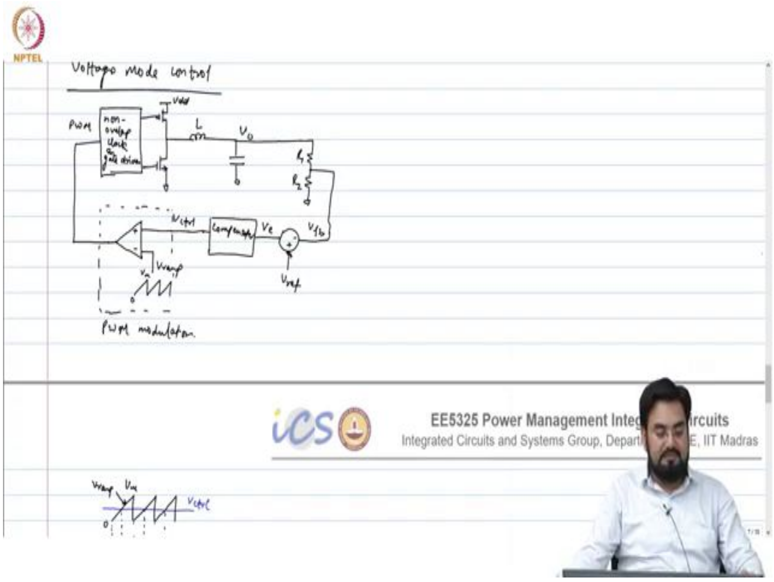

So, what do you have is your L C. So, usually that is how you implement your switches you can use bipolar also, but since we use MOSFET technology. So, we just use mos. So, for high side you use PMOS for low side use NMOS and these MOSFETs are quite big. So, you mostly you usually use gate drivers which has non-overlapping clock. So, gate driver is nothing, but it is a buffer and you fit PWM here. So, it generates two clocks with the non over lapsing basically they are non-overlap in the same polarity because one is PMOS and NMOS.

So, when this is high this should also be high to turn it off when this is low PMOS gate will also be low. So, it will turn on PMOS, but there will be not so. Non-overlapping is basically also called “break before make” which means before you turn on the other switch you first turn off (or break) the current switch and only then you turn on (or make) switch. And, this comes from PWM comparator minus plus and this gets a sawtooth waveform some control voltage; compensator, V ref. So, let us have a feedback resistor just like we had in case of LDO, this is your V ref ok.

So, this is your voltage mode control if this is going to 0 to let us say V m. So, what happens when you take the feedback and compare it with the V ref. So, it will generate your error signal V and that error goes into the compensator. So, the compensator you can assume it has amplifier and some R and C just like you have in case of LDO; so, it is a error amplifier. So, and this error will get converted into a control voltage and this control voltage will settle to get the desired duty cycle here at PWM.

So, now let us see how your duty cycle is getting generated here.

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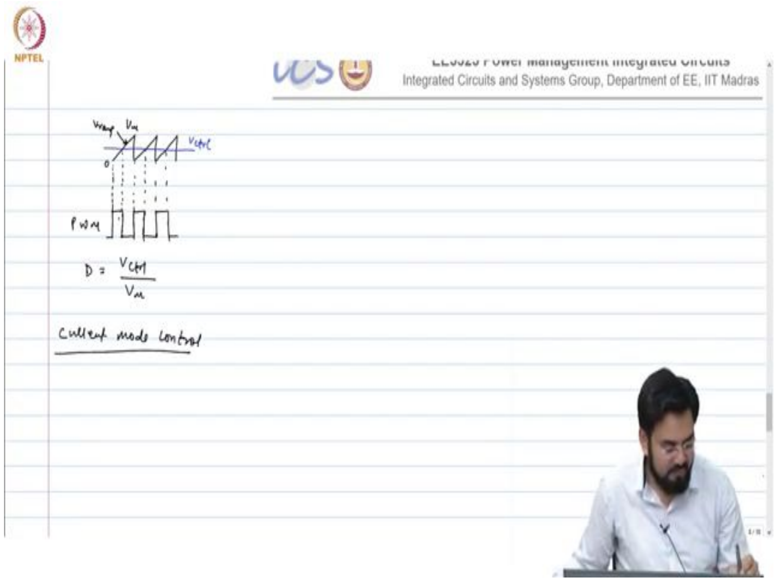

So, now, this is your saw tooth going 0 to V m; if this is my control voltage so, how will your PWM look like? So, V ctrl let us say greater than 0 and this is going 0 to V m. So, whenever you reset to 0, what will happen to the PWM? And, this let us say I call it V ramp. So, this is your. So, when V ramp is 0 V control is more than 0. So, PWM will be high ok? And, at this point what is happening?

Your negative terminal of this comparator this is nothing, but comparator is getting higher than V control. So, this will go to 0 and it will remain 0 until.

Again, gets reset then again will go high this should be higher. This is your PWM say in terms of V control and V m if I want to write the duty cycle what will be that duty cycle? So, if let us say V control becomes 0, what is the duty cycle? 0? ok. If V control becomes V m what is the duty cycle?

100 percent. So, it is a linear function of your V control. So, D is nothing, but V ctrl over V m, correct. So, that linear function will have this slope and the slope is nothing, but your gain. So, in terms of duty cycle it is this. So, when you model your PWM that is how you define the actually. So, the gain will be 1 over V m for that. So, we will try when we model the small signal then we see, we have to model each and every stage. We model the power stage and this PWM modulator or this PWM generator.

So, this is called PWM modulator. So, which means your duty cycle is controlled by the voltage here which is control voltage which is V ctrl. So, let us see what happens in the current mode?

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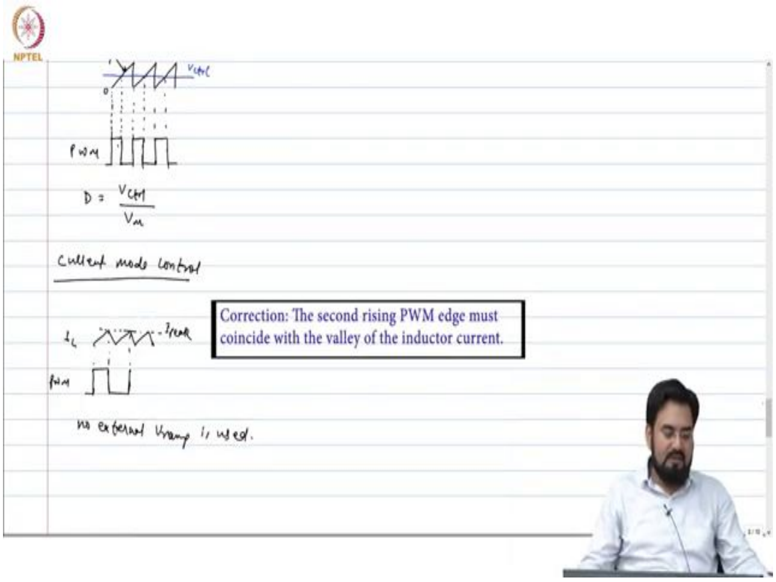

So, in the current mode control this is my I L, this is PWM. So, what you do actually you set your duty cycle at some clock reset clock. So, when PWM is high, the inductor current will rise and when it reaches a certain peak, let us say I peak you reset the duty cycle.

So, you are looking at the inductor current information rather than the voltage information. So, here we are not looking at the inductor current at all ok, but in this case current mode you look at the current. So, obviously, the compensator will be here and since what you do actually you take the current from here and add up in the control voltage ok. So, and then so, there is no ramp as such here. So, here you are comparing sort would be the control voltage and control voltage is DC.

Here what you do you keep resetting that duty cycle or setting the duty cycle. So, it will go to 1 as soon as you set and when the current reaches the peak some peak you reset it. So, there is no saw tooth in case of current because that ramp is basically current coming from the current itself because the inductor current is a shape of ramp ok. So, you do not require any saw tooth here. So, no external V ramp is used ok. So, theoretically we do not, but practically when you implement there is a small ramp we use for compensation purpose. So, when we look into this current mode in more detail then we will talk about that ok.

So, what we will do when we analyse this small signal and everything we will do everything for voltage mode control and we will talk about the current mode a little bit more detail later because for understanding purpose voltage mode is better compared to your current mode. Because the compensation and everything is a little bit complex for this because you use type 1, type 2, type 3 there are three different types of compensator we use here. But, in case of this current mode you do not use type 3 use only type 2; type 2 means use only one 0. In this case you require two 0s because you have three poles in the system, two poles coming from L C another pole comes from your integrator which is in the feedback amplifier ok.

So, we will look into more detail about the compensation everything considering the voltage mode control another reason is voltage mode control is widely used compared to your current mode because current mode has certain limitations some noise performance is not better and operating this at a very low current and very wider duty cycle range is not easy for current mode. But, voltage mode can easily be used for a wide range of load current and duty cycles. And, that is why we prefer voltage mode or current more over current mode for a wider range of duty cycle operation and wider range of load current.