Fundamentals of Power Electronics
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Lecture – 95
Slope compensated current control

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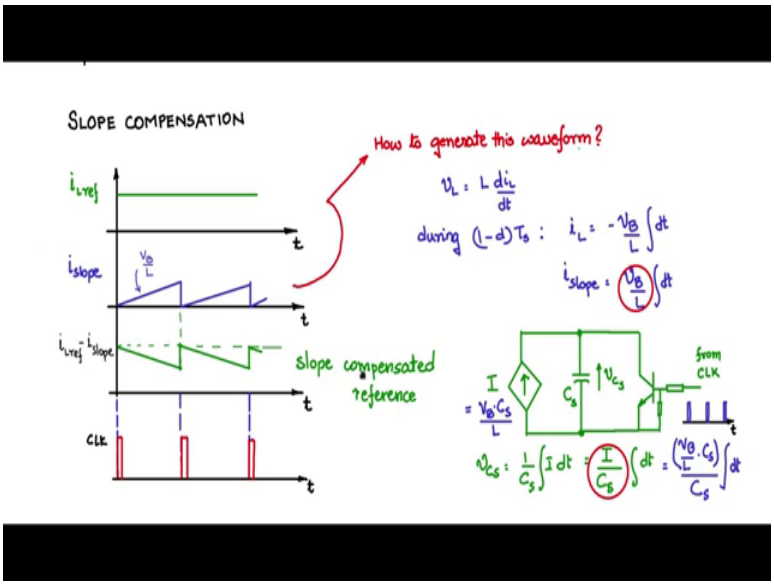

Let us now try to understand what slope compensation is and how to obtain the slope compensated reference waveform. Let us understand it with the help of some waveforms with respect to time, I will plot i L ref which is nothing but a constant dc value. So, the inductor current waveform is compared with this constant dc and then that is how the current controlled output is generated. But this has a problem for greater than 50 percent duty cycle where it will become unstable.

So, therefore, we need to generate a slope compensated waveform. Let me now draw this type of wave shape and this slope should be V B by L should have a magnitude of V B by L. So, this will have a magnitude of V B by L and this is called i slope let us say and the new reference will be i L ref minus i slope and that will look like this. So, this will be the new current reference that we need to use for doing the current control.

So, the inductor current should get compared with this slope compensated current reference. So, this will be the slope compensated reference that we will use. Now, how do we get this wave shape where the slope is same as V B by L that is the down slope of the inductor current waveform. So, the question, how to generate this waveform? So, if we look at the inductor current.

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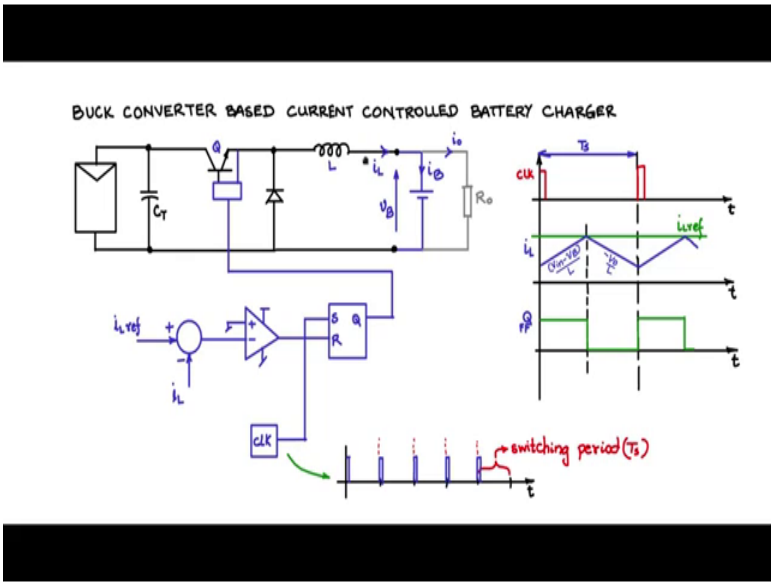

The inductor current here what we have drawn during 1 minus d T s period during the time when the switch is off, the slope of the inductor current is minus V naught by L or minus V B by L the magnitude of that slope is V B by L. So, this inductor by the Faraday equation the V L voltage across the inductor is given by L d i L by d t. Let us write that down V L is equal to L d i L by dt and during the 1 minus d T s period i L is minus V B by L integral dt. And i slope because here we are talking up of positive slope I remove the negative sign. Taking on considering only the magnitude of the slope will be V B by L the integral dt.

So, how do we obtain this current wave shape? How do we get this wave shape by implementation? So, what we can have is we can have a controlled current source like this and the controlled current source is connected to a capacitor like this. And let us say C S is the capacitance and then you can monitor the voltage V C S across here and then let us say there is a current I that you have decided for the current source. So, what is the voltage across the capacitance? So, the voltage of the capacitance is 1 by C S integral of I d t which is I by C S because I is a constant integral of dt.

Now observe this and this, the coefficients of integral d t V B by L and I by C S. Now comparing these two; comparing these two we can write I as V B by L into C S. Now let us make I here V B by L into C S divided by C S; divided by C S into d t would be the voltage across this capacitance. So, the voltage across this capacitance will follow in this wave shape.

So, voltage equivalent value of i slope will follow this wave shape with this exact slope V B by L because C S C S will cancel. Now this was an integrator and as long as a current here is constant this will keep on integrating, it will not come down to 0 so, there has to be a reset mechanism. So, let us connect across this a switch. So, the current source I will set it at V B C S by L.

Now, I will connect a switch there across the capacitance and drive that switch on or off from the clock. So, whenever there is a clock so that will switch this on it will discharge this capacitance bring it to 0. So, during that period of clock duty cycle this will come down to 0, then again it starts integrating and then at this point clock will come into the picture this will come down to 0. The clock waveform looks like this, we have seen this earlier it is a set of narrow pulses occurring at every t s period; at the beginning of every t s period is the very very narrow duty cycle pulse and it is during the very narrow duty cycle. It will turn on this switch short circuit the capacitance the capacitance discharge through this one.

You can put a resistance in series, a small resistance in series to probably limit the current. Now, this if you place it along with these set of waveforms it will look in this fashion so let me draw so, these are the positions when the clock will appear. So, you will see the clock signal. So, a very narrow duty cycle pulse occurring at the start of every t s period, it will reset the capacitance and then bring it to 0.

Then the capacitor will keep integrating it will build up and at the occurrence of the next clock it will reset to 0. Again it will start integrating and the occurrence of the next clock starting on the t s period it will reset to 0 so, this will keep happening. So, in this way we can generate this i slope waveform and use it for obtaining the slope compensated reference.

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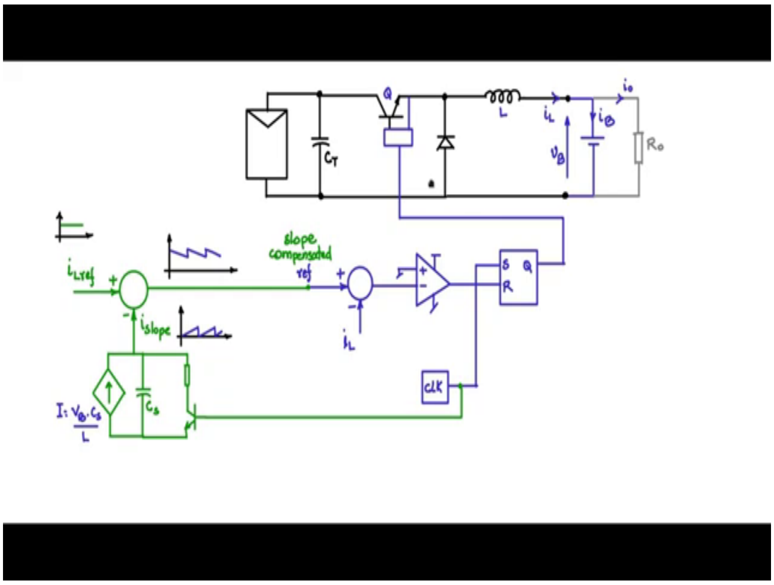

Now, let us take our current controlled converter charger circuit earlier we had i L ref directly here, i L ref here was a constant dc value. So, we will replace it with this slope compensated reference. So, what we will do is that we will remove i L there and I will say that this point we are going to give a slope compensated reference. Now, how do we generate that? Let us how i L ref here shifted back a bit and I will compare it with this I slope. So, let me have a controlled current source.

This controlled current source will have a current value i which is dependent on the sensed value of V B divided by L into C S. So, put a capacitance there and across the capacitance I will put a switch and the switch I will turn on based on this clock signal. So, whenever the clock gives a high this will also turn this on reset this capacitor and then when this goes off this will start integrating.

This resistance is put here just to limit the current and it will also put in a time constant C S into our time constant into picture, but it will be a small time constant which will reach five times time constant by the time the clock duty cycle a duty cycle pulse finishes.

So, this value what you would be giving there is i slope and you subtract it from i L reference and give this as the compensated slope compensated reference. Now if you look at this wave shape, this wave shape is just the dc and what about this wave shape? So, let us first set the current reference here the current value is V B into C S by L, observe that V B is the sensed value. So, the current reference here will change according to the output voltage here and if you do that then here you will get a positive slopes sawtooth waveform like this; i L reference minus this will give you a sawtooth waveform like this. And this will form the slope compensated reference that you will provide to this controller.

So, now, i L whenever it is greater than the slope compensated value then the error here will go negative and this will go positive and reset the S R latch. So, this is how the slope compensated current controlled converter will work and charge the battery.