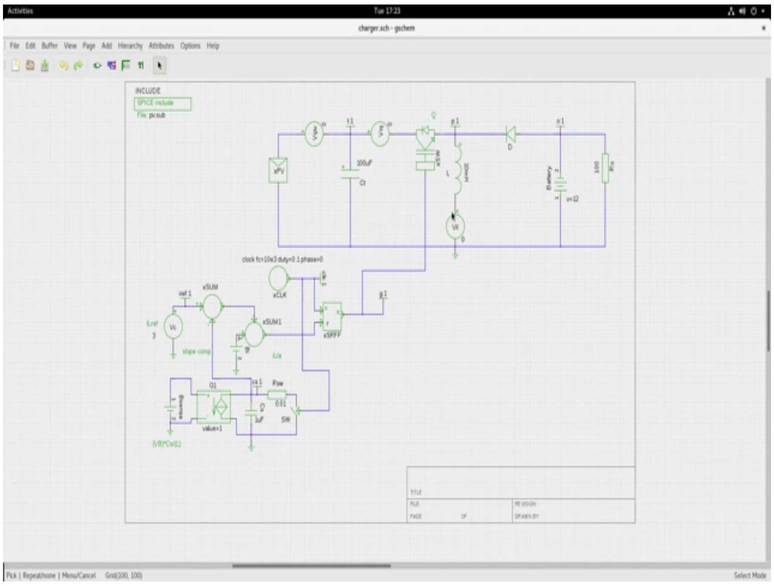
**Fundamentals of Power Electronics**
**Prof. L. Umanand**
**Department of Electronics Systems Engineering**
**Indian Institute of Science, Bengaluru**

**Lecture – 96**
**Simulation of current control**

Let us now see how we go about simulating the battery charger circuit with current control with slope compensated current control. So, let me open this charger schematic in gschem.

(Refer Slide Time: 00:51)

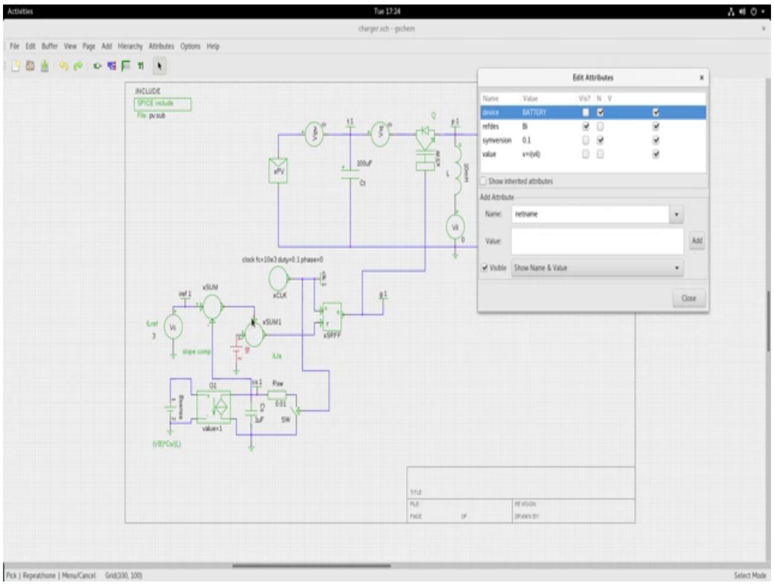


So, this is the schematic that I have for you; pv dot sub I think you are now familiar with how to include the sub circuit file now this is the schematic. I discussed while discussing in theory, I discussed about the buck converter, but here in the implementation I thought we will use the buck boost converter.

This is the buck boost converter circuit so; that you will get familiarized with the one more convertor in doing current mode control. So, we have this photovoltaic source it is the same source that we had modeled earlier a short circuit current of 2 amps voltage scale factor of 20. And, then I am having a buffer capacitor C t this V i PV with value 0 V i q with value 0 or the current sensing voltage sources have a switch here; this is the inductor current inductor current measurement sensor a diode D at the battery. Observe there is a battery is put in a position where here it is plus one is plus, two is minus.

Because the buck boost circuit you will have a negative voltage coming across the output and therefore, you have to appropriately connect the battery terminals and of course, the load. Now, how are we getting the PWM signals for duty cycle control? This is the SR latch we have discussed about that, now there is this summing junction where I am having i l measured. So, I m using the sense there is this source here and I am sensing it from their source.

(Refer Slide Time: 02:55)



So, you see that this is a B source which is giving a voltage equivalent of the current which is flowing in the inductor. So, voltage is equal to I current flowing through the V i l voltage source. So, here basically I have a voltage equivalent of the inductor current and I have the I l reference coming in here which is I l ref minus the slope compensated sawtooth waveform.

Now, I have interchange the plus and minus here if I zoom in, you will see that I have made this plus I have made this minus this is used to make a simulation block simpler. We have put a comparator here with a minus and plus with an inversion here and this comparator block I have removed and then did a sign change here itself minus and plus. The inversion caused by the comparator is brought forward and I have inverted the sign here.

Because, there is a Schmitt comparator at the input to the SR latch itself. So, that is the only change then if you go to the slope compensation thing now here I am having a B source. And, B source I am getting a voltage equivalent of v naught by l; l is 10 milli Henry this one micro farad is coming because of this VB into CS by L. So, that is the formula that I have used that we have discussed.

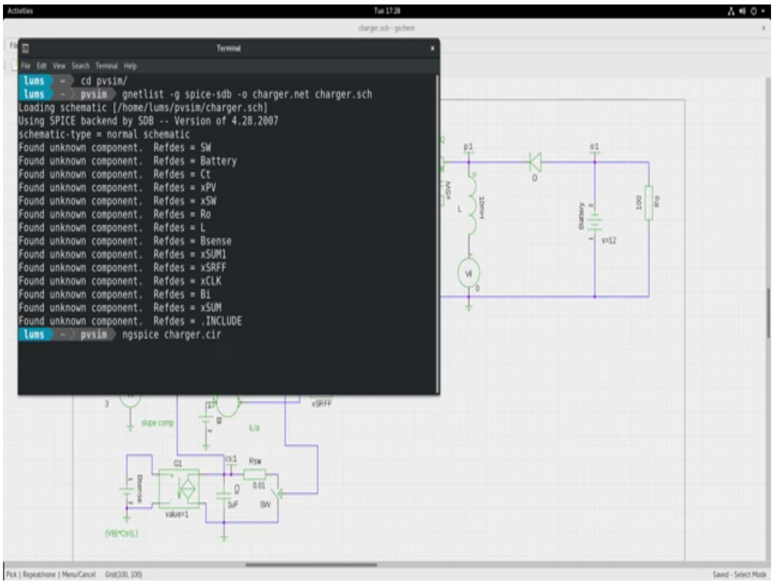
So, inductor value is 10 milli Henry that is what I have used. So, this is the formula. Now, this voltage will drive this voltage controlled current source. So, there will be a current that is coming out through this and then it will be charging up this capacitor. And if we monitor the potential here you will get the voltage equivalent of I slope.

And, the every time there is a clock giving a pulse, it will also reset the switch short circuiting the capacitor and discharging the capacitor. So, you will get a sawtooth waveform, this sawtooth waveform subtracts from the reference waveform and that is what is given as reference slope compensated reference.

So, this is exactly the block schematic that we are simulating and here this VC in the case of MPPT case it will come from the output of the MPPT controller and we will define the i ref. So now, let us simulate this. Here a point that you need to note is that this SR latch is introduced now the sub circuit of this SR latch is included in PV dot sub.

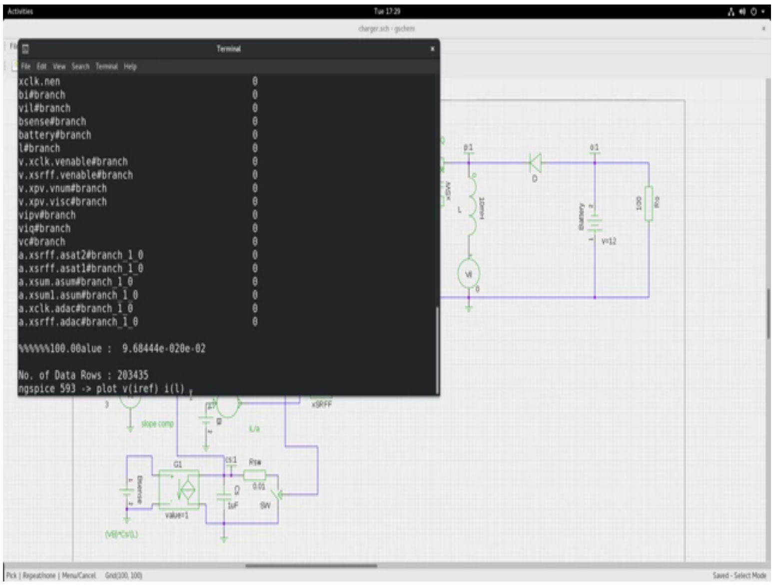
And the symbol file for this is also included in the set of a files and folders which had provided as resource in the last weeks session. This is a Voltage Controlled Current Source: VCCS and it is a spice simulation block itself. So, the rest all you are familiar with and let us simulate this.

(Refer Slide Time: 06:37)



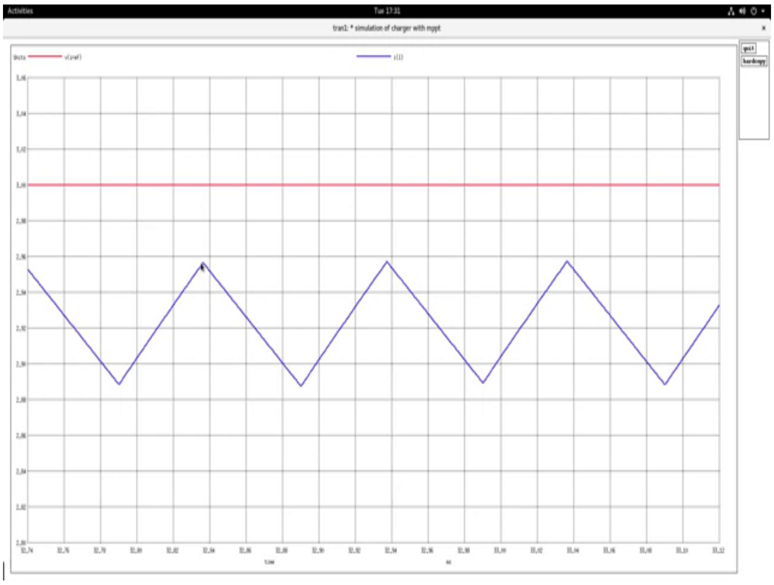

So, let me open the terminal window let me go to PV sin the folder, which contains all these files. I will generate the netlist first charger dot net by executing the g netlist and then now I will ngspicing ngspice charger dot c i r. So, it will start simulating.

(Refer Slide Time: 07:07)



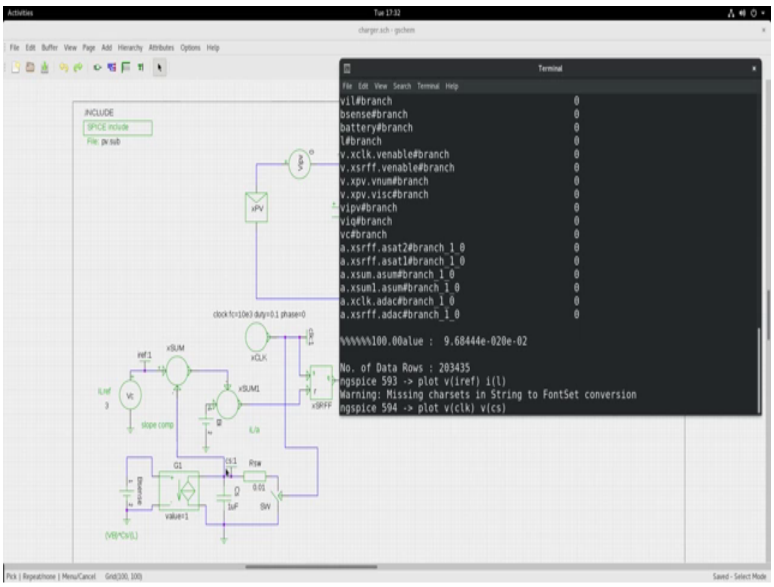

Let it simulate and after simulating we will look at some important waveforms.

(Refer Slide Time: 07:27)



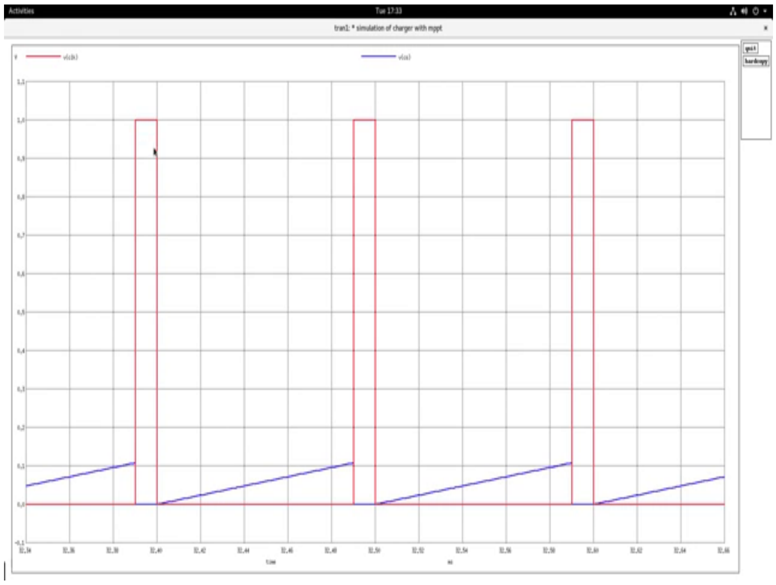
Let us plot the i l ref and the inductor current and we will see. So, the red one is i l ref which is at 3 amps, and let me expand it. So, and the blue one is the inductor current. Now, you see that the inductor current is not reaching up to i l ref the reason is that we have a slope compensated modified reference which is falling down from i l ref value. And, when it is falling down from i l ref value the inductor current will cross it over somewhere lesser than i l ref value, and the change state and then start in to the down slope mode.

(Refer Slide Time: 08:27)



Let us observe the clock waveform and the voltage across the c s capacitance. The voltage across the c s capacitance is supposed to be like a sawtooth waveform with a positive slope. Let us compare them and see if we are getting waveform like we studied in theory. So, let us plot voltage of the clock and the voltage across the c s node.

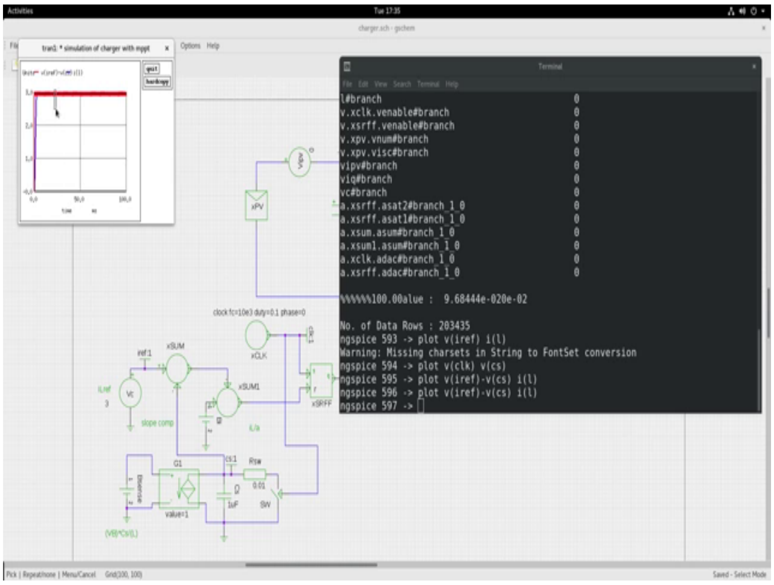
(Refer Slide Time: 09:05)




So, let me expand that let me select a very small narrow region and you will see that this red pulse is the clock pulse very small duty cycle. So, whenever red pulse comes, there is a reset of the voltage across the capacitance c s and then it rises and again and then starting of the next year cycle clock pulse comes reset and then rises and so on.

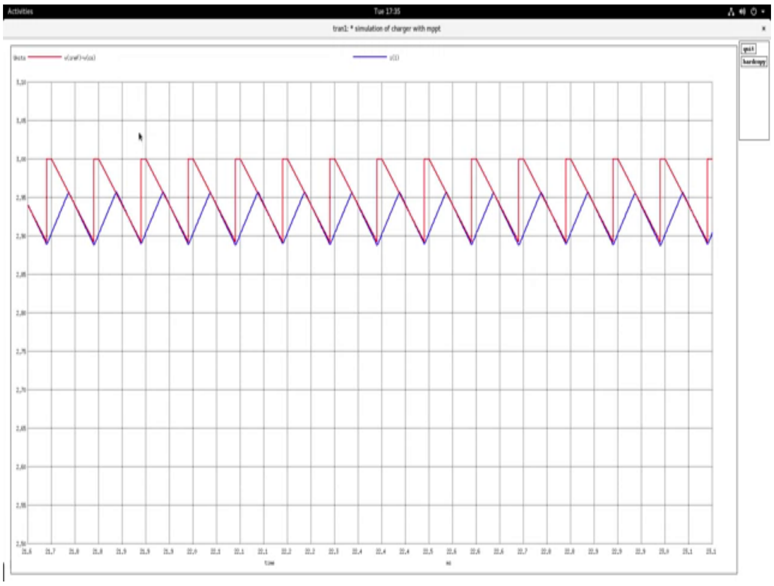
You have control on deciding the duty cycle of the clock. So, this is as per what we are expecting. Let us now see this modified i l reference that is the slope compensated reference here which is the i l ref minus i slope and compare it with the inductance current i l so, plot.

(Refer Slide Time: 10:01)




So, let me plot the difference between these two and the i l. So, it will appear something like that let us take a very narrow region so that we will be able to zoom it like that.

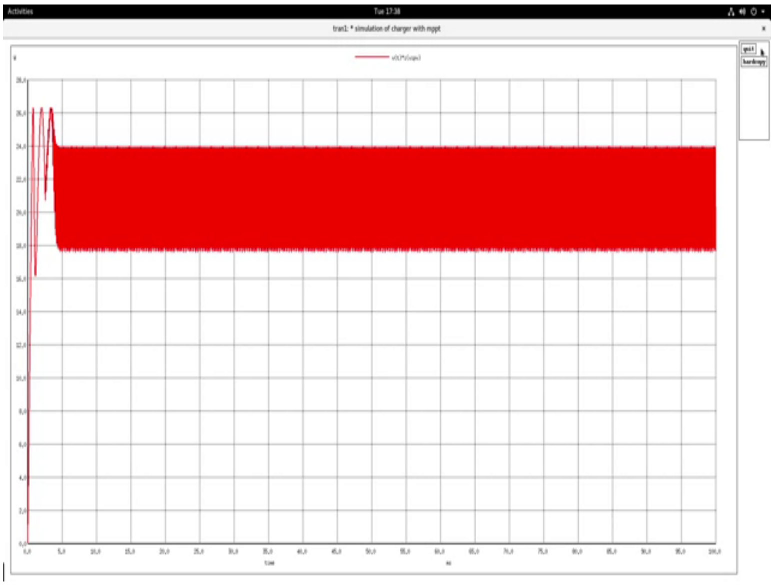
(Refer Slide Time: 10:21)



Now, here you see the blue line is i l and the red line is the modified or the slope compensated reference. So, you see with the falling whenever the clock comes in here then it starts falling subtracting again rises back, the i l ref was at 3 amps and from 3 amps it starts falling down, with the same slope as the inductor down slope. And so, the inductor current the moment it hits this or the down slope the SR latch change the state switches of that device and then the inductor is falling so, on it keeps going.

So, this is also behaving exactly like what we anticipated and you see that the inductor current is controlled to whatever value that you set. Now, let us see the voltage across the PV panel and the current through the PV panel and just check how much amount of power is being transferred to the load to charge the battery and the load.

(Refer Slide Time: 11:39)



So, if we check the power drawn from the PV panel see that it is hovering at around 24 close to the p power operating point. So therefore, you see that adjusting this i l ref value plays a role in actually deciding the amount of power that is being drawn from the PV panel.

Because the battery potential is more or less fixed more or less constant at around 12 volts. So, in this way this buck regulator, buck boost regulator that we have used here can be used as a slope compensated current controlled charger for the battery, drawing power at maximum power from the PV source. So, I will let you to explore this simulation on yourself and try to gain more insight from this simulation schematic.