Design and Simulation of DC-DC converters using open source tools

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Lecture – 15
Forward Converter with Lossless Core Reset

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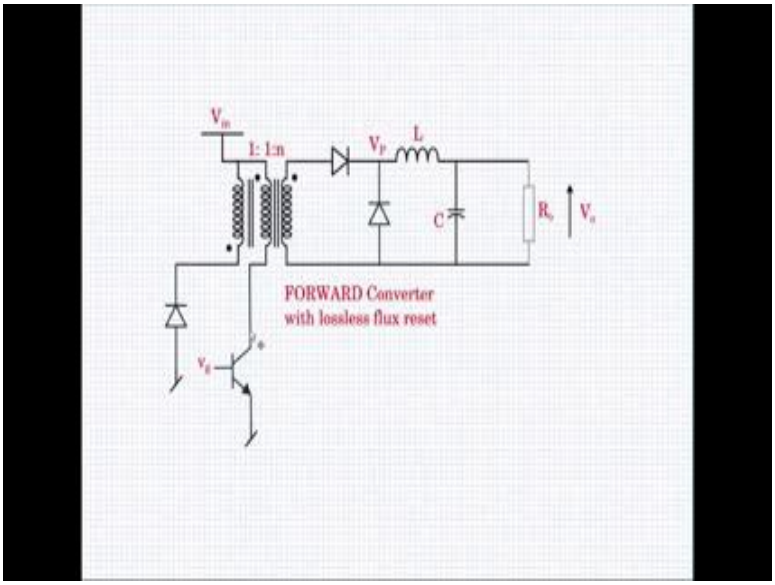

In this forward converter topology we saw that the core reset is done in this way, when the transistor switches of the magnetizing current will flow in this path and dissipating this resistant. Instead of dissipating in this resistor which is lossy we would like to put back that energy in to the source so that it can be used later, so there by increasing the efficiency. For that we would not to like to have the resistance here we will definitely have the diode, we need the diode but we will see the topology a little bit.

So, let me rearrange the topology is like the, and we would try to do the core resetting in magnetic way. Let me put one more additional winding like this here and showing this add additional winding, there all coupled discussion. One important change is the dock polarity. The dock polarity is them this direction and I am going to indicate the turns pressure relationship as 1. What it basically means is, you saw that primary to secondary it is 1 is to n, primary to this winding is called is 1 is to 1. Now this winding is called the

demagnetizing winding. As the main suggest it does just the job demagnetizing the core or resetting the core. Therefore, in the literature you see that is winding is called the magnetizing winding and it is having the same translate was the primary and in fact it is wound by (Refer Time: 02:50) together. That is both the primary and the demagnetizing winding stones are taken together and wound together so that the leakage induct has between these two is minimized.

Now, we have the diode and let us place the diode here and make the connections. So, after having made the connection you see that this is the demagnetizing position of the winding, the rest of the circuit is exactly same as the regular forward converter. We have changed only the position corresponding to core reset it part. The dilute is there the resistance has been replaced by another winding and then it is connected to the supply. Very important note that the dock polarity it is an opposite dock polarity with respect to the primaries dock polarity, which means that n this is positive, the end here is positive and when this is negative the end here is negative.

Now let us see how this functions. This particular type of topology is now called the lossless flux reset forward converter. So, we can say it is a forward converter with lossless flux reset. Now this particular converter, the forward direction operation is exactly same as or what we are discussed before. When the switch is on you will see dot is at V in with respect to the non not n, secondary is write becomes n V in, V p will be n V in induct terms will charge and during the (Refer Time: 04:58) brand BJT is off the non dot end becomes positive, the secondary portion is out of the picture, inductances prevailing and because the non dot end is positive here also in the demagnetizing winding the non dot end will be positive and it will pump the magnetic energy in this path.

So, you see that the magnetic energy will be put in to these sources. So, the source has to or sinking capability and it will go in this direction. So the voltage of this will rise correspondingly to term on this diode and allow for the prevailing path. In this way the code will reset and will be prop back to the original status and then the next cycle will start again. During the time when the code has resetting there is when there is a kind flow demagnetizing current flow during this you see that the divergence on and this end

is connected ground this and this connected to V in, so the voltage across this winding is V in. Which means the constant voltages apply the across V in and the code reset happens with the constant rate and that is V in by l of this particular winding or V in by n d what with the n d is the number of terms and this demagnetizing winding we can say V in by n d will be the rate at which the flux decreases to 0.

You see that when the transistor studies on V in by n p is the rate at which the flux increases and when the transistor goes of V in by n d is the rated which it comes down. And as we are saying that n d and n p are same number of terms once to one then the rate at which it increasing the rate at which you falls as same. Therefore the maximum duties I call that you can offer for this type of converter is 50 percent duty cycle, because at 50 percent the flux would have reached particular level and you should allow remaining 50 percent of time or it to come back to 0.

When then 50 percent of problem because the off time is greater than the on time and it will definitely come back to 0. So, these are going limitation or this converter it has a maximum duty cycle of 50 percent. Now all the waveforms are exactly similar as the previous except the demagnetizing waveform. It was exponential in the earlier case exponential decaying to 0. In this case it will linearly decrease to 0, because the voltage across this winding is constant. Let us have a look at this waveform by simulating the circuit and probably you can also do the simulation and find out the waveforms of other parts go circuit and ensure that they work similar to the lossy flux reset type of followed converter also.

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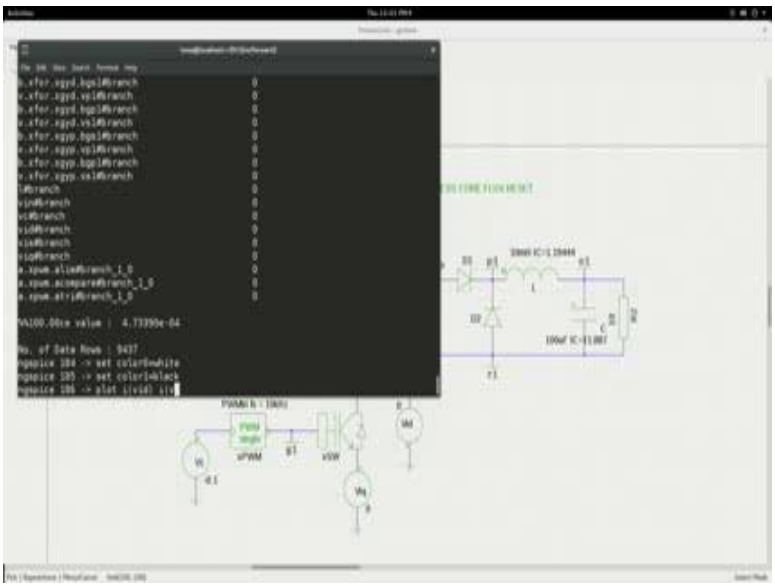

I shall bring to show to you the lossless reset forward converter that we just discussed and see how we can do the simulation of that one. So, I have created another folder call forward two which I have copied from the lossy forward converter circuit and I have modified the schematic to include the demagnetizing winding that we just the focus. Let me explain this point. So, you see all the part of the forward converter you exactly same here to it is same the get by portion, there was diverted resistor or core reset. Now that portion we have removed and we have included one more winding.

This is the new component which I have picked from the library here. So, what I have actually picked is the transformer for forward converter which is having three windings. And observe the dot polarities. The primary and the secondary have the same sense of dot polarity, and the demagnetizing minding is opposite sense of dot polarity and exactly that is for we are using. And do the (Refer Time: 09:55) winding and have connected in diode. And last before I have connected the 0 voltage sources to has current sensors v i could v i s we saw the last simulation, and I have put v i d along with this diode and ask the current direction is going in this direction as the arrow is moving I have put the plus sin here such that the current enters the cosine.

Now, we can look at the currents here and see to the demagnetizing winding is just try

what we have discussed trays on the circuital remain the same. We go back to the terminal and let me do the net list. And I have the net list as created NG spice or going to cir. So, that is loaded in to the spice run these simulation, observe that I have you may initial condition you are just like from last time so that the simulation is very quick and you will be able to see there is as quickly. So set I will give the background color equal white set we color, now the foreground to black and plot the current of (Refer Time: 11:30) demagnetizing winding current of you switch and the current through the secondary.

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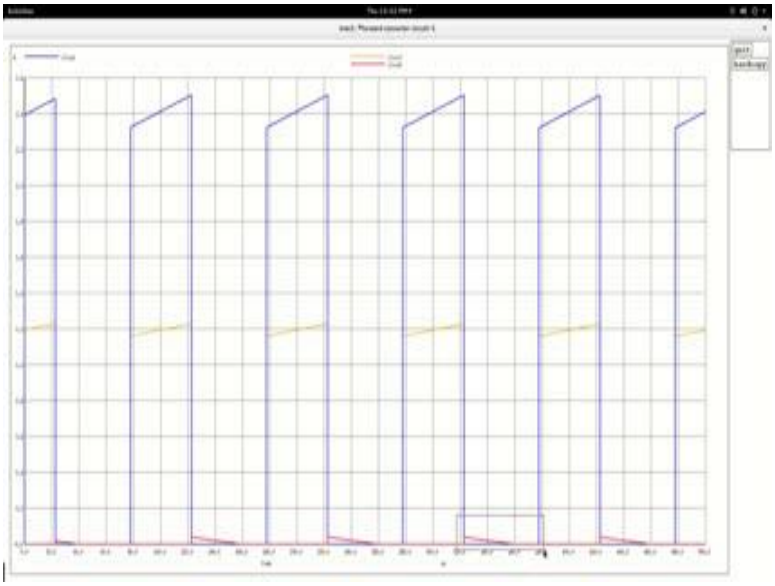

So, you are now able to see the blue one is the current of the switch and this flat equal to flat top value with be two times i naught, these will be i naught, this is n i naught, 2 in this case and you see here the demagnetizing winding let me explode that a bit zoom in and you see it is linear.

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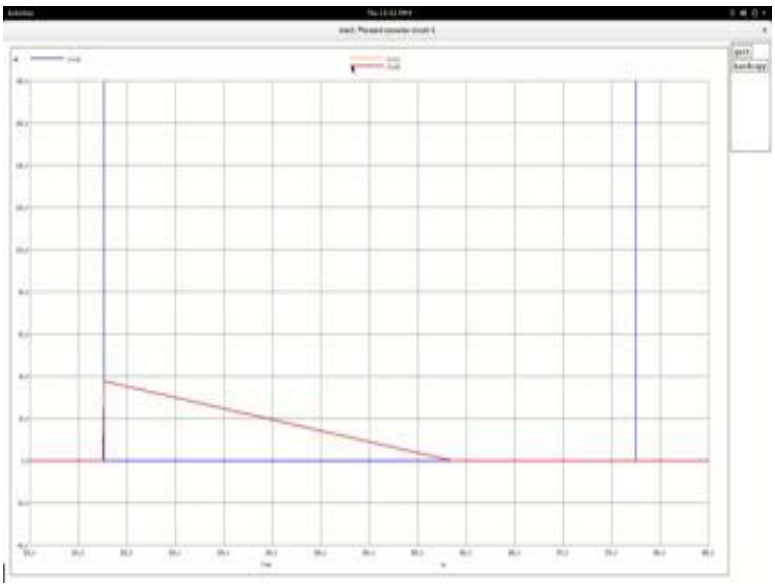

So, you see that it would be having a linear slope. The forward slope is also linear; the falling slope is also linear, because the voltage across the winding is text constant. Now if are decayed and because this is a less than 50 percent duty cycle this would have taken the same time to come down to 0.

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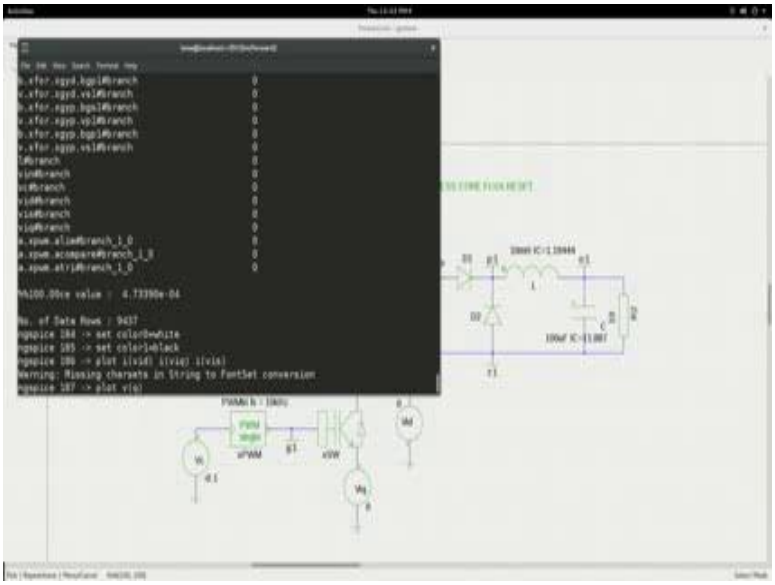

Now, let me also show one more change in the lay form that will occur is the wave shapes across v i q across the switch. There will not be the exponential portion which we observed in the lossy flux we said call that converter. When this switch is of these diode is conducting, there is a V in coming across here which will get reflected on to this. This is positive V in this would be positive V in for the V in here and the V in there, so that will two times V in coming across this. So, let us see that waveform to plot v q.

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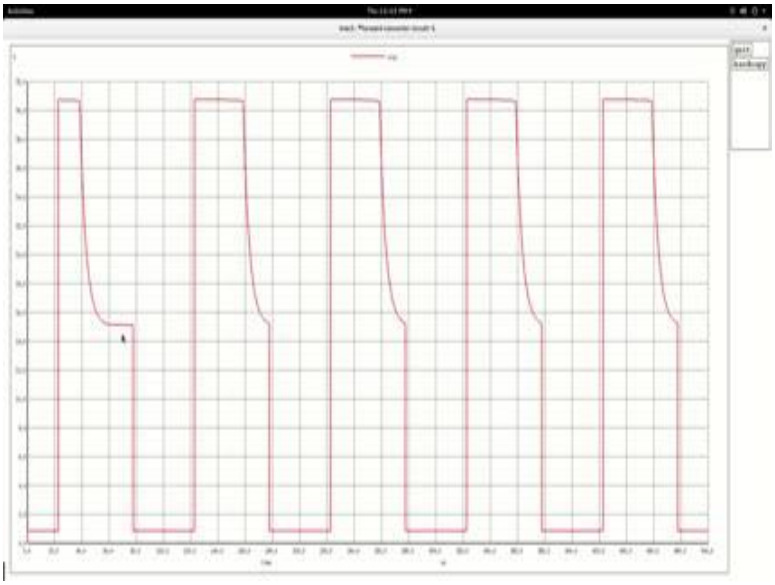

So, you see that this is the V in value. Now up to this point we see that there is study decay in the linear decaying the magnetizing plots and thought value is two times V in this value is V in, this is 15 volts V in and this is on 30 plus the diode drops and then at this point diode drops conducting and this exponentially drops to 0 and this is the voltage potential that it will finally settlement.

It should in effect ideally drop to 0 directly, but because the switches are not ideal switches you see that it will drop to 0 in finite time. This way you time simulate and learn more about the circuit type playing around with that part.

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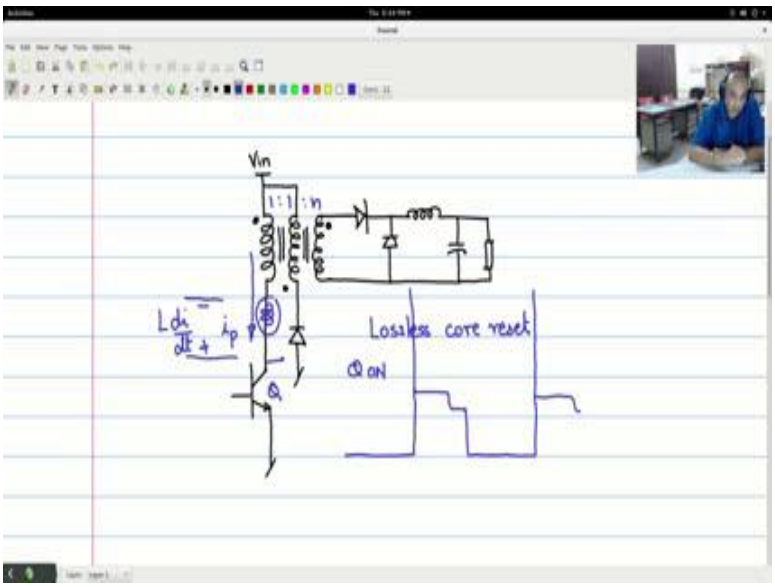

So, as you we can see this is the lossless core reset type of forward converter. There is one problem in this and that is we issue of leakage inductance. So, there will be some leakage inductance here. Leakage inductance means that that portion of the flux that is not coupled across between the two points and we mentioned and we discussed that this will be 1 is to 1 is to n and both the primary and the demagnetizing winding will be tightly coupled.

Now, during the time when the switch is on, when Q is on there will be current flow through the switch like this and I will call this has primary i p and i p contains the reflected component from the secondary and also the magnetizing part. Now the moment the switch goes of the reflected part anyway cuts off, the magnetizing part cuts off to 0. Now across this leakage (Refer Time: 16:08) which is not coupled to the demagnetizing winding. We will see a sudden cut in the cut and therefore I use di by d t. But the coupled part of the magnetizing current will through very flow through this demagnetizing winding in to the supply and then back, so it will free with through this and then decay that we have see. But the uncoupled part there will be one leakage inductance and that will give arise to and L di by dt crop.

Now, this drop would have a reversal of popularity this would plus and this would be

minus because the current has got from positive to 0, so it is a negative slope huge negative slope because in a short time it cuts out to 0. And that drop will thus we will come across the Q. So, you would see where at the transistor goes off it should normally go like this. But do not the time I switches off because of this leakage in the times you can expect very huge spike repetitively occurring and (Refer Time: 17:46) like this depending upon the level of the leakage inductance energy that is stored in that leakage inductance.

So, this can blow the transistor Q and that is undesirable that should be taken care of that should be addressed. So, to take care of that what we do is that and stay continuity be lossless we use one more transistor.

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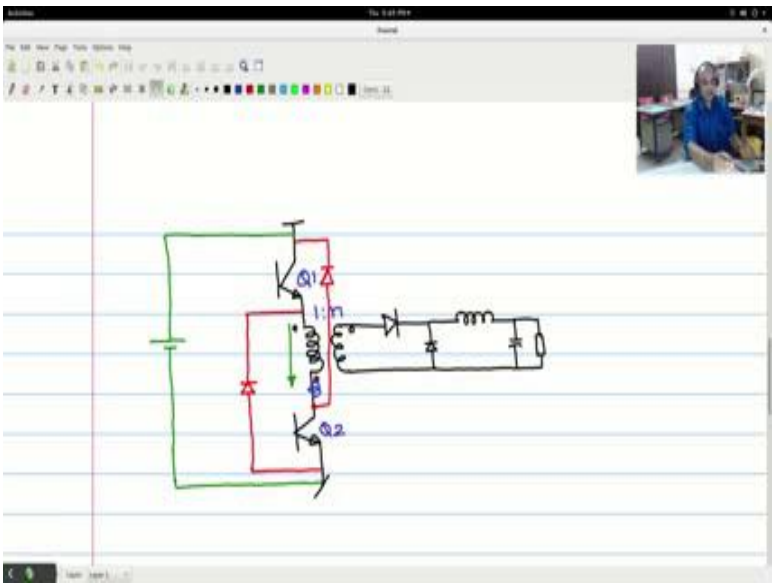

I will show how we consist that topology shortly and address the issue of this leakage inductance. Consist the topology like this with Q1 and Q2 are in series with be primary like this. This is a forward converter the dot polarities, note dot polarities and also see that the secondary side is the typical buck converter circuit.

Now, whenever you operate both Q1 and Q2 are turned on together. The mo moment Q1 and Q2 are turned on together there is a current flow through the primary like this, the

dot end to the primaries connected to re end the non dot end is connected to ground V in appears across primary n b n appears across the secondary, normal forward converter operation happens. Now let us say we have leakage inductance and we also have to incorporate core reset. So, they will input to more devices in this, so let us say Q1 and Q2 are been turned on there is a current flow in this direction, as shown by the greener.

Now at this movement Q1 and Q2 both or turned off together. Now current flows along has shown here then at this point Q2 is off we in take a branch out here and push it to the supplying to this diode and another diode here. Recall that may be sub battery which is capable of sinking current connected here and that is important for the operation of these types of circuits.

If we look at this circuit now, so Q1 and Q2 are on there is a current flow in this direction as showed by these pointer. And now Q1 and Q2 are suddenly switched off. The current continuous to playing the same direction in the inductor and the leakage inductance, then in form was this diode path into the supplying charges of the supplying into the ground back up through this diode and entrance the inductor the same direction.

So, you see that the inductor current continuous to flow in the same direction and even if there is leakage present it will not hurt or it will not result in a spike, because you are not breaking the current conduction path. And therefore there is no high l b i by dt voltage develop across the leakage in that terms. This way the voltage drop across both the transistors will the contained and when the switches are off they this will this point is connected to ground and the other points connected to be in these will see V in and this points connected to V in and therefore Q2 will also see overall drop of V in; so both should have a voltage which standing capability of V in.

So, this is a diode transistor of forward converter very interesting circuit, it is lossless and it can also handled leakage inductance issues, so it is the converter that you can practical try on.