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

Lecture – 47
Input-output relationship

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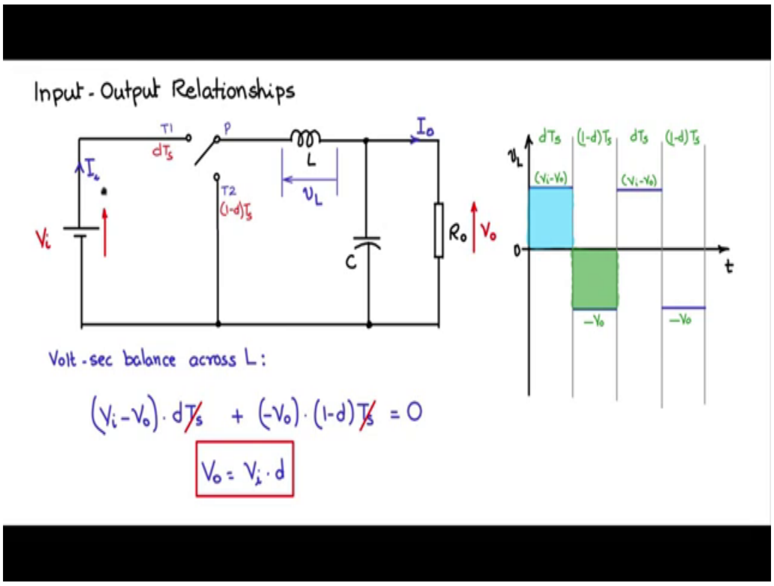

Input - Output Relationships

Volt - sec balance across L:

$$(V_i - V_o)\cdot d\cancel{T_s} + (-V_o)\cdot(1-d)\cancel{T_s} = 0$$

$$\boxed{V_o = V_i \cdot d}$$

Now, I will demonstrate to you for the circuit that we had discussed till now, how to get the Input output relationship by application of the volt second balance. So, let us take this buck converter circuit which we have discussed and let me mark this current I naught; I naught is the output current that flows through the output load register R naught, the voltage across the output is V naught V i is the voltage of the unregulated input. Now the inductor, so when you want to apply the volt second balance you have to look for the inductor or the coil in the circuit and take the voltage across that coil.

So, you go to the inductor take the voltage across that and mark that vL look at the way I have put the arrow what it basically means is that when you are making a measurement using a physical device or virtually you are to mentally keep the common of the probe here and the measurement probe on the side that is what the arrow mark indicates. So, I could as well now use the arrow mark on this fashion which means that, if the arrow is pointing on to the right then you keep the common of the probe on the left and make them use the measurement probe on the right. But here what I am doing is I am keeping the common probe here and the measurement probe here.

So, let us also mark the time periods for which P T1 is on and time period for which P T2 is on or P T1 is off which is 1 minus dTs. Let us also put a graph here indicating that will indicate the wave shape of the voltage waveform the inductance and let us divide the time scale in this fashion I will call this period as dTs time period during which P T1 is ON 1 minus dTs time period during which P T2 is ON dTs again the second cycle starts and 1 minus dTs, so these are the time periods. Now let us look at the voltage waveform across the inductor. So, during the dTs period the pole is connected to T1 and V P is equal to V i on this side of the inductor in the steady state this is V naught.

So, in the steady state the capacitor would have charged up we are talking of steady state conditions only because we want to have the steady state input output relationship and during that time we know the volt second balance occurs across the inductor voltage. So, this is V naught here and this is Vi here during the dTs period, so therefore I will say it is constant Vi minus V naught during that time the voltage across the inductor.

Then during the time 1 minus dTs P is connected to T2, so this is grounded the inductor is freewheeling so let us say the voltage here is 0 V P is 0. But V naught is there V naught does not discharge so quickly we are talking of the switching cycle, so minus V naught appears across the inductance. So, it has to be minus voltage here because then only volt second balance will occur, so you will see minus V naught appearing across that then again during the next cycle dTs P is connected to T1 you have V i minus V naught and during 1 minus dTs time when P is connected to T2 you have minus V naught appearing across the inductor.

So, this is the inductor current wave shape and during this time what is the volt second this is a rectangular voltage no need to do integral you can find out the area just by the height into the time width, so we have V i minus V naught into dTs. So, let us calculate the volt second balance across the inductor, so during this time V i into V naught into dTs is the area of this rectangle. Now the other rectangle is this which is minus V naught into 1 minus d T s.

So, that is minus V naught into 1 minus dTs now that should be equal to 0 these 2 should add up to 0 or basically what it means is these 2 should cancel each other. So, here I can remove this T s T s so the remaining portions if I simplify you see V naught into d and you have a minus V naught 1 minus d if you take it to the other side they become V naught into d plus 1 minus d. So, basically it becomes 1 and in the side you are having V i into d, so if you do the algebra in simplification you will get V naught is equal to V i into d and that is the input output relationship.

Now, to get the input output current relationship you can use the amp second balance average current flowing through C is equal to 0, but for that you have to understand the waveforms the currents that go through which we have not yet come to that point. However, you can do the amp second balance. Later on I will show you how the amp second balance also work, but I have an easier method for you right now.

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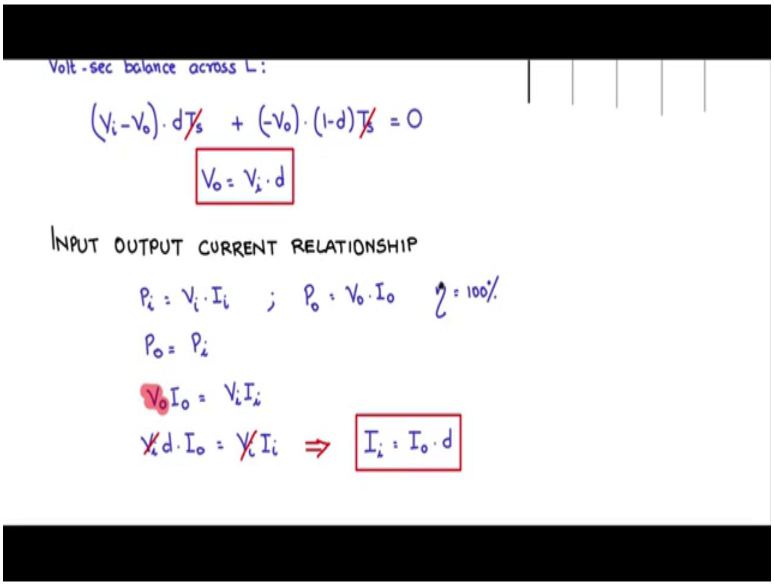

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INPUT OUTPUT CURRENT RELATIONSHIP

$$P_i = V_i \cdot I_i \quad ; \quad P_o = V_o \cdot I_o \qquad \eta = 100\%$$

$$P_o = P_i$$

$$V_o I_o = V_i I_i$$

$$\cancel{V_i} d \cdot I_o = \cancel{V_i} I_i \Rightarrow \boxed{I_i = I_o \cdot d}$$

So, let us say I will define this as I and let us find the input output current relationship. So, to find the output input current relationship I will make use of the fact that the efficiency of the circuit is 100 percent meaning there is no lossy component within. So, Pi is V i into I into i and P naught is V naught into I naught and I must being efficiency is 100 percent no loss within. So, in such a case P naught is equal to Pi or V naught I naught is equal to V i I i.

Now, I know the input output voltage relationship here, so let me apply it here V naught I will replace it by V i into d. So, you have V i into d into I naught equals V i into I i, so remove V i they cancel of and you have I input current is equal to I naught into d. So, this is the input output current relationship you can get it through the capacitances amp second balance also, but that is sometime later after we know how the waveform current waveform is through the capacitor.

But for now you can use the power relationship or the power balance relationship knowing that there are no dissipative components switch is either OFF or ON no dissipation here the ideal sense inductance is a energy storage device, no dissipation capacitance is a storage device potential storage device no dissipation again.

So, all these components or dissipation less devices in the ideal sense, therefore if I take 100 percent efficiency I will get this input output current relationship knowing the input output voltage relationship. So, this is the formal way of using the volt second balance across the inductor to get the input output voltage relationship you can use it for any circuit however complex it is.