Design and Simulation of DC-DC converters using open source tools
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Lecture – 17
Inductor Design

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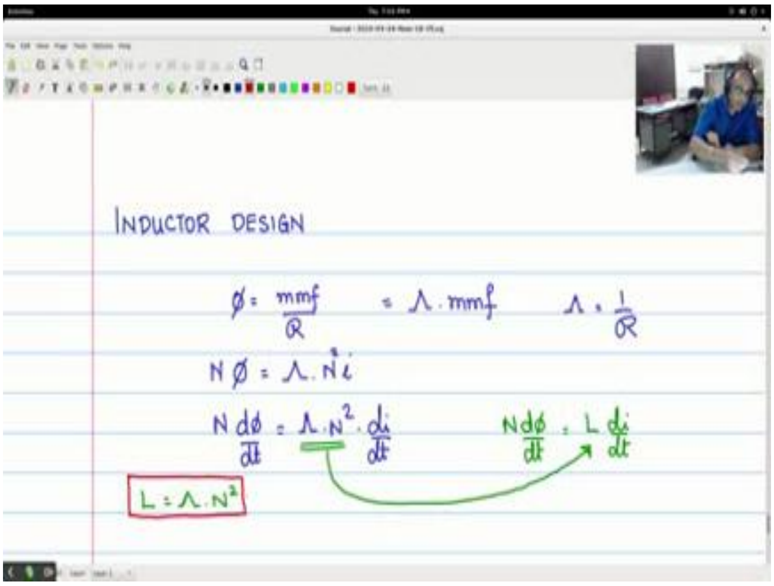

The inductor design is also along similar lines as we discussed for the transformer with few minor variations. Now, let me start in this fashion, we know that flux is equal to m m f by reluctance, now this is equal to permeance into m m f; permeance is nothing but 1 by reluctance. This is basic equation which you would have studied during your B E, it is just a recall, just go back into your old notes and the text books and you will see that, these relationships are valid. Now m f is nothing but n i, so the flux phi is equal to i will say lambda, permeance into n into i. Now i will multiply both sides by n and this becomes square, now I differentiate, so n d phi by d t equals permeance into n square into d i by d t. We know the Faraday law, I am going to use the Faradays law; n d phi by d t is equal to L d i by d t.

So, recall this and by comparison you have L equals permeance into n square, this is a very important relationship in the development of the inductance design.

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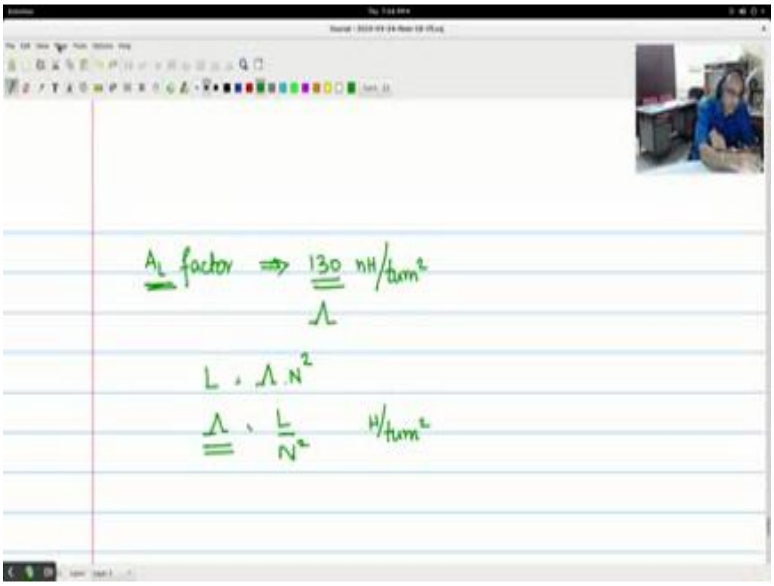

Now going a bit further on that, now when you go to the market to purchase cores, there is something called A L factor which is written on the cores. Now this A L factor is something given as 130; just giving some number which I will find on typical cores, nano, henry per tones square something like that. So, what it basically means is, this is nothing, but the permeance value, the permeance; you saw that L is equal to permeance into n square or permeance itself it is nothing, but L by n square.

So this is actually henry per tones square, so in the market what is available to you is the permeance in nano henry per tones square and then they call that one has the A L factor. So, do not get confused when you look at the data sheets or some of the core material or when you go to the market and then see A L factor that is nothing, but the permeance you can purchase given permeance for the inductor. Now along the similar lines like we did in the for the transformer, inductor however goes on the energy storage, the size of the inductor is depend on the energy and the energy is equal to half L i max (Refer Time: 04:12) square.

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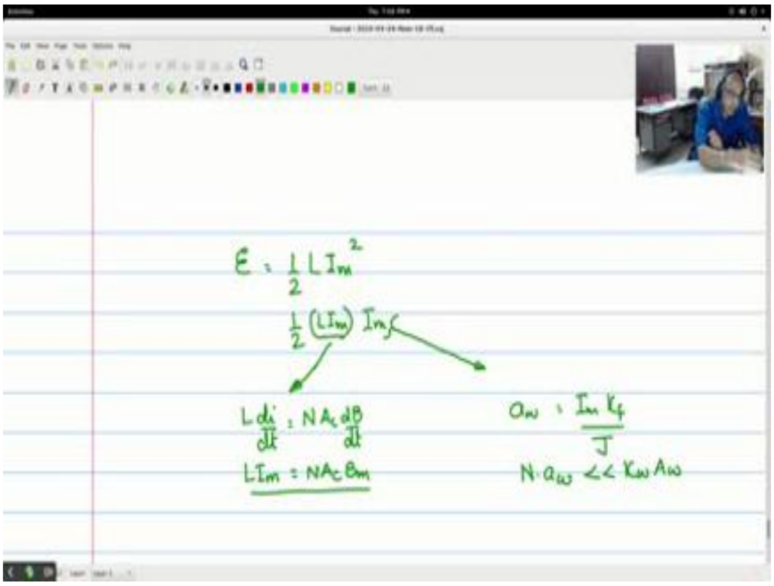

So, let us say this is split into two parts half L I m, this is 1 I m and I I m into I m, now one of this you can bring the relationship about from L d i by d t is equal to n a c; d b by d t and because the current is linear (Refer Time: 04:47) increasing, b also linearly increase, in current increases from 0, then I will say L i m equals n a; c b m, this is a nice relationship with relates i m and a c or L i m and a c, so it relates this; then another relationship to related with window area; use like has before the wire conception area equal i r ms or i m into k f by j, this will relate the wire cross section area and m into a w should be less than k w; a w. Now this would relate the a w with i m, now putting all this together you will see this as a c and this as a w and they are multiplied together that gives you a product and that the area product, so let me after simplification the area product for the inductor.

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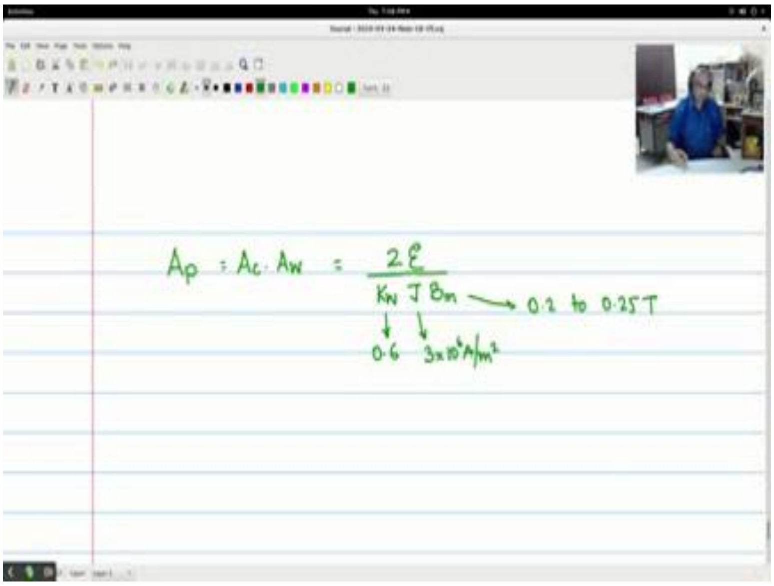

So, the area product a p is equal to a c into a w and is given by for the inductor 2 into energy divide by k w j b m. So, you can take k w as 0.6 for the inductor, this you can go at 3 into 10 to the power of 6 and per meter square and this at 0.2 to 0.25 decimal, that is how energy you calculate from the half L i m square from the circuit, from the electrical perspective and once you have done that, we can do the design of the inductor in a very simple way. So, now let us summarize a list on the steps involved in designing the inductor.

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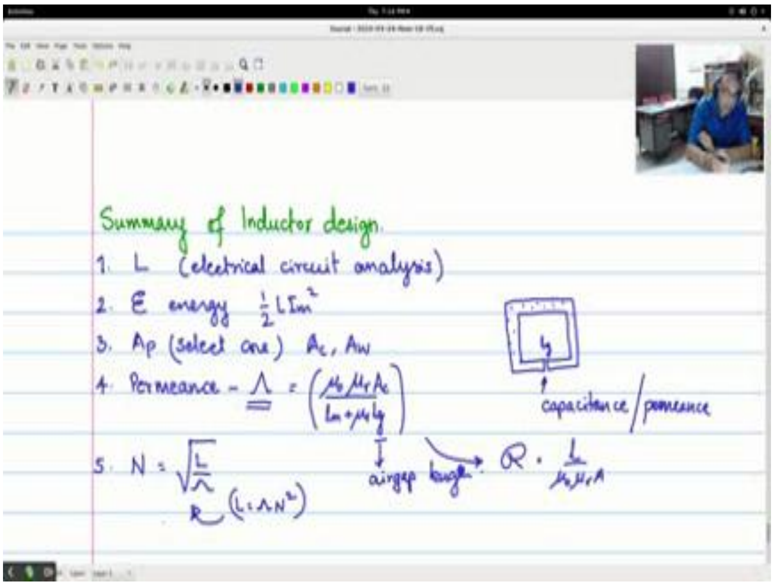

So, let us summarize the inductor design steps, so as a first step we find out the value of L, this come from the electrical circuit analysis which we have already done and we know how to calculate the value of L and next you calculate the energy using the half L i m square.

We know the current flowing through the inductor and we know the p current flowing through inductor, half L i m square you can calculate. Then estimate the area product, then choose up, select the core and you know a c and a w from the data sheet. Then after that, the permeance we need to one thing that you need to understand, I will just put a core like this; the energy in the core is stored in the air gap, air gap is actually like a capacitance; capacitance and permeance or (Refer Time: 09:13) I would say. So, most of the energy gets stored in the air gap and sometimes they will give an air gap here if you do not get any other core and you have to use a regular transformer core of very high permeance.

And therefore, a paper or minor sheet is introduced to provide air gap where the energy can be stored. Otherwise you will have to go and request from the shops and buy specific A L value or permeance core, which has a lower permeance what would be done is; at the time centering itself there will be air pockets here and that will actually be used for storing the energy and it would be a smoothly distributed throughout the core, this will bring down the permeance value which means it can handle more energy, so you have to choose core of a particular permeance. If you do not have a core of a particular permeance, you can calculate it mu knot; mu r divided by l m; plus l m plus mu r l g and an a c.

So this is the permeance formula, again (Refer Time: 11:04) from the basic formulas, L m plus mu r l g is the equivalent length of the magnetic and you know that from here the reluctance is given by l by mu knot, mu r a; that is inverse of that one, where the L m plus mu r l g is the equivalent permeance; l g is the air gap length and you do not need to bother too much about this because you may not be using this formula. You will be going and buying, purchasing core with a specific A L factor or permeance, once you know that; you know that this is nano (Refer Time: 11:53) square or l by turn. So, using that relationship n is equal to root of l by lambda per permeance, so this has come basically from the relationship L is equal to lambda n square, from here we can calculate the number of turns.

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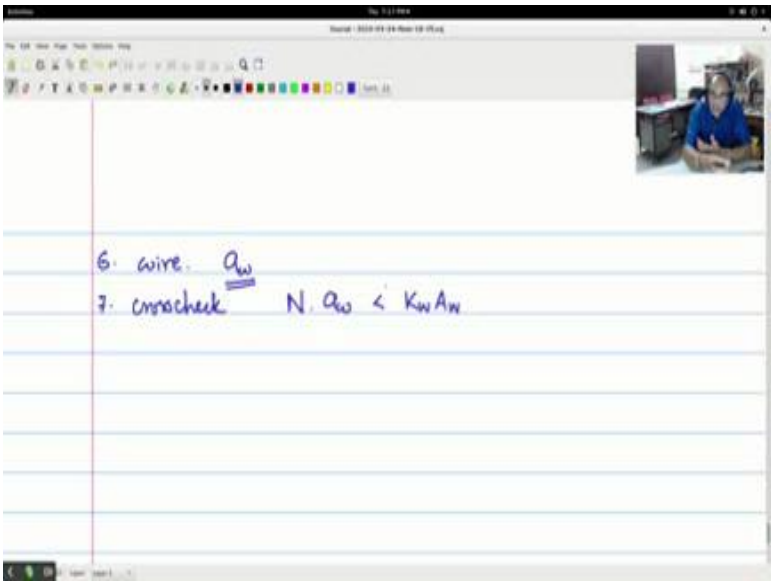

Now after we calculate number of turns, the wire gauge find out the wire cross section area again using the r m s value by j the current density three (Refer Time: 12:43) m square, find out from standard wire table and appropriately select a proper wire cross section area. Then after that you need to do a cross check and what is the cross check, n is the number of turns into the wire cross section area should be less than k w into a w; if this agrees then your design will work and you can stop there, if he does not agree go and choose the next size core, change the value of a c and a w according to data sheet and repeat the process.

I shall also put in the obtained m files as examples for you to look at how the transformer is designed for the forward converter and the inductor that will give you some idea of how it is done and what are the various equations actually used, so that you do not make a mistake, go through those m files that will give you some insight and help you go design their other course and inductors.