Electrical Machines - I
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Lecture - 03
Ideal Transformer, dot Convention and Phasor Diagram

Welcome to lecture 3. So, in my last class, I was talking about the magnetizing current necessary to create a flux.

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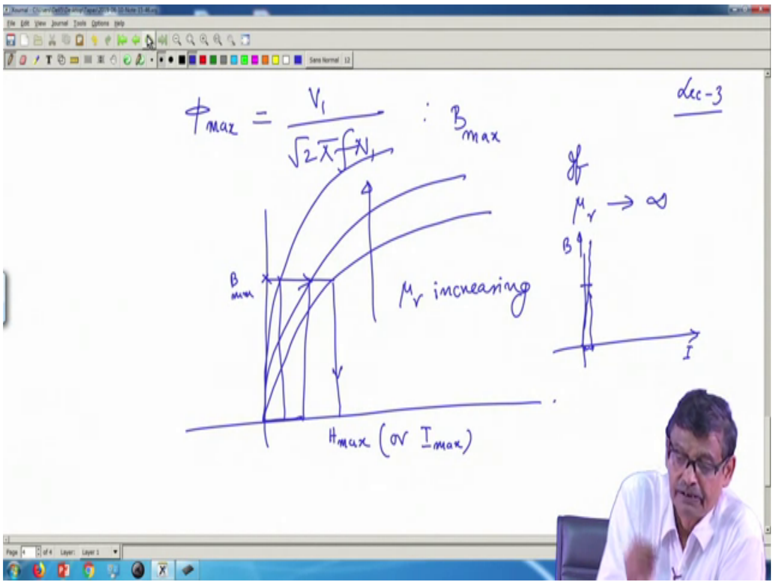

The flux is decided by the supply voltage and I will be writing many a times this. So, that you also become a accustomed with this one. So, this is the thing. So, phi max gets fixed and then from this I will be able to calculate B max and from B max then I will say, where is your B H curve? What is the core material? B H curve is like this suppose then corresponding to B max, you read H max. This axis can be for a given value of number of turns and magnetic length l, this can be also treated as I H max or I max. Is not? I can always do that because N by l come as a constant.

So, corresponding to this B max, you get H max, hence I max hence the current drawn from this supply and the another important thing I told if you have better and better magnetic material another material, then the current needed will be only this much not this much have another better material current will be needed this much. So, essentially this mu r is increasing mu r increasing ok. Now, I will be telling you about the ideal transformer ok. Therefore, if the magnetic material is very highly permeable, if mu r tends to infinity very large that is this curve will become almost like a vertical line, then to create a flux current needed will be vanishingly small to establish the flux ok.

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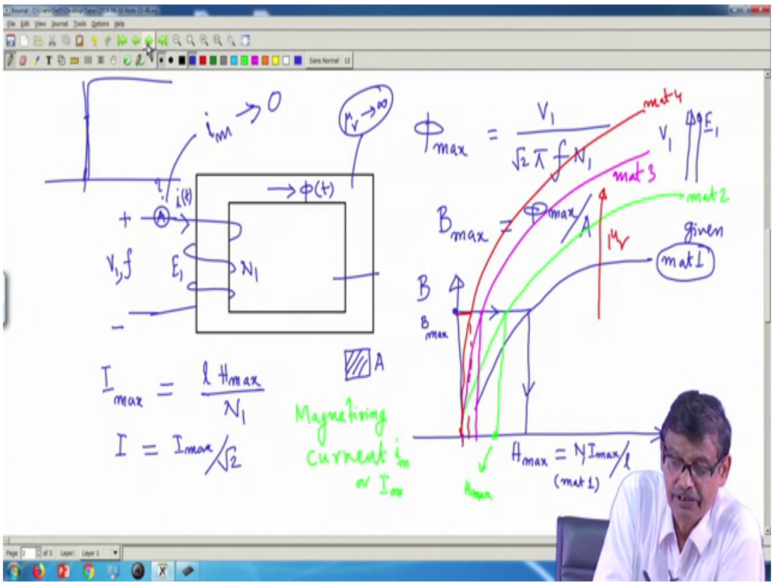

Therefore, we can say that, if this material mu r tends to infinity what will be the ammeter reading? You think a bit. Ammeter reading will be vanishingly small some finite current is necessary, but that current you can make it as small as possible provided you do not have any restriction on using better and better magnetic material.

Important thing is flux is finite like this, mu r tending to infinity means that this ammeter reading i m magnetizing current will tend to 0 that is all, it only means that. No point in telling why 0 current how it can create flux it takes a current no matter how good your magnetic material is, it will definitely take a current, but that current is very small and will see that, it will be very small compared to the rated current of a transformer.

So, like that therefore, in a ideal situation; very ideal situation will say that as mu attains to infinity the current drawn that is I and this is B. This magnetizing current drawn can be made as small as possible. So, I will now we are now in a position to talk about ideal transformer ok.

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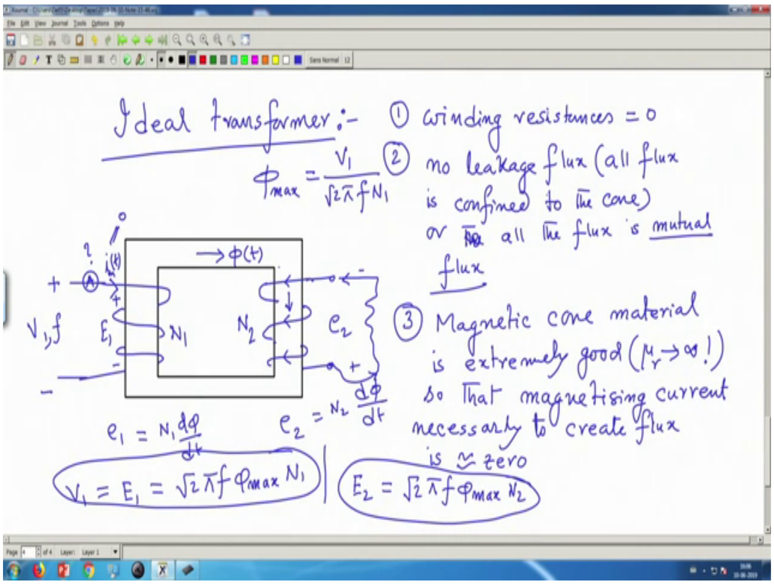

Now, for the first time I am writing this ideal transformer and if the concept of ideal transformer is clear, you can deal with any situation you can deal with a practical transformer very nicely, because the concepts are so interesting.

So, ideal transformer let us say that the first two conditions remains same winding or coil resistance are 0 winding resistances 0 2 no leakage flux, that is all the flux is confined to the core or all the flux or all the flux is mutual flux of course, this mutual flux what it is I will tell write now. And number 3 is magnetic core material is extremely good mu r tending to infinity I put a this mark also here means vanishingly small current extremely good.

So, that magnetizing current necessary to create flux is practically 0. These are the 3 properties. Now, it is I will now draw the core of the transformer from my previous diagram, which I have already drawn that is I come here and copy it and then please bear with me till that time, because and is the best; this is the thing. So, this was the thing. Now you see in this it is not a transformer a single coil. So, far I was discussing.

Now what I will do is this; I will draw another coil suppose here is another coil. So, on the magnetic circuit, now 2 coils are connected and this two terminals of this second coil I have not connected anything. Therefore, whatever I discussed in my previous lectures a single coil excited with a voltage V 1 from frequency f remains intact I mean, because this coil whether it is present or not no one bothers, because nothing have connected no current in this coil.

Therefore, you and suppose this has got a N number of turns N 2 is that clear? Therefore, you have created these then flux is created mind you although you require vanishingly small current, but phi max is finite and its strength is this one. That is what? But current needed magnetizing current, it will draw magnetizing current and this current is practically 0. If I assume the magnetic material is of very high quality having very large permeability and all the flux here is confined to the core.

So, what is mutual flux that is what I have to tell you mutual flux is the flux which is common to both N 1 and N 2 turns. So, mutual flux will be the flux, which is confined to the core ok. Therefore, same flux will be linking both the primary coil, this I will call now primary and in this coil no source is connected, this flux is also changing with respect to time therefore, with respect to I mean applying Faraday's law I will then also conclude that these two will become a seat of emf.

So, e 1 is N 1 d phi d t e 2 will be equal to N 2 d phi d t is not same flux. Rms value of the induced voltage, see polarity of that voltage I have found it out without I mean thinking so, much about that negative sign. I have applied physical (Refer Time: 11:58) and told that if supply voltage at any time is increasing, then flux is increasing this terminal has to become plus and minus so far as even is concerned.

Similarly, and E 1 is equal to root 2 rms value phi max N 1, which of course, happens to be equal to V 1, because kvl is to be satisfied. Similarly, in the second one; if I say induced voltage in the second coil E 2 in which way it will be different same flux only N 2 comes in therefore, it will be equal to root 2 pi f phi max into N 2 that is all. Is not I am not deriving once again differentiating and trying to write. This is going to be what else. So, rms value of the induced voltage in the primary, which happens to be equal to V 1, because there is no resistance, no leakage flux, V 1 is equal to E 1.

On the second side this will be this one. Now I should not of course, jump to the conclusion that, this is plus, this is minus will see now that one. So, at a particular instant, if this is plus this is minus, what will be the polarity of this induced voltage e 2 here; e 2 here, whether, this is plus this is minus or this is minus this is plus, that I have to decide ok. The polarity of the induced voltage will be such that, it will try to oppose the very cause for which it is due, I am repeating the same statement. Means what this flux about this flux, what I told the flux is positive and it is increasing.

Now, there are only two possibilities, either this is plus this is minus or this is minus this is plus, either of one of this is true correct, that way if you think. Suppose I say that, I am not sure, suppose this has happened, when this is plus this is minus this has become plus this is minus; suppose, let us assume it is like that. Now let us verify whether this assumption is correct or not [FL] it has become a seat of emf.

Now you imagine that, this e 2 I will allow it to act; e 2 as it is open circuited nothing happens no current etcetera, only thing it has become a seat of EMF and somebody says this is plus this is minus. Now I am telling you that, if it e 2 is allowed to act on a circuit, then it will deliver current at that instant and what will be the direction of this current? If you imagine that you have connected some loads; some resistance here I will connect it some resistance here.

Then at that instant current supplied by the coil will be like this is not it will go this is the source like a battery current will go like this and the direction of the current in the windings will be like this. Now this is what in accordance with Lenz's law the answer is no why? Because the cause of the voltage induced is that phi was increasing is not? Phi was positive and increasing d phi d t was positive that was our assumption.

Now I find at that instant if current flows the flux in the core produced by this current will be; flux produced by core in this coil will be also in this same direction; are you getting? This was the flux created by i m, it was going up in this direction now also flux. So, the flux is strengthened, the cause for which it is due is strengthened, but that is not in accordance with Lenz's law.

It will try to oppose the very cause for which it is due. What is the very cause? Phi from top to bottom was increasing. So, the polarity of this induced voltage we will be such that, if this e 2 is allowed to act, it should pass current through this winding in such a direction, that it will try to oppose this flux that is what has to be. That is therefore, it looks like this is not correct no. So, this cannot be like this, what is the other possibilities? Other possibilities is this has become plus, this has become minus.

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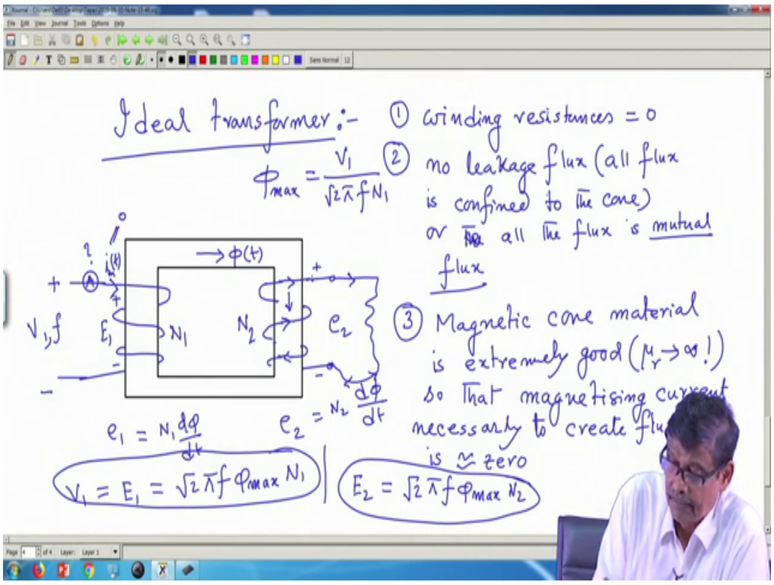

Let us see, whether this will be consistent mind you this is the continuous thing I have been only corrected no.

Student: Ok.

What is the other possibility? This is plus this is minus is it consistent? Let us see, if this emf is allowed to act on its own to an external circuit like r you have connected, then at that instant it will try to send current in this way. Because this is battery it is the source, current comes current goes current goes current goes like this current goes. So, this coil, when it delivers current it will create flux in a direction opposite to these phi t which has been created by this one.

So, it is trying to oppose the very cause for which it is due. Therefore, at a given instant of time, if this terminal is plus this terminal is also plus. Let me repeat this point in a Nicer diagram; it is like this.

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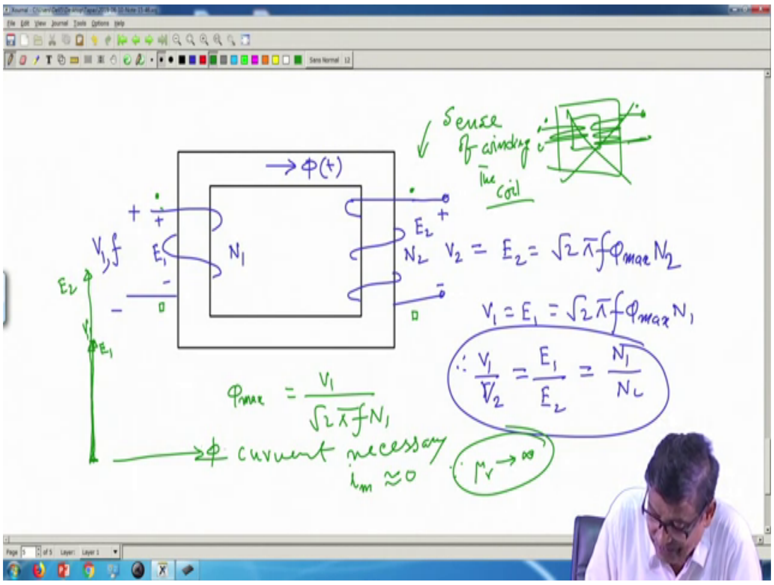

So, let me sketch it that will be faster. So, I sketch because let us spend some time on this; sorry, I have not selected I will cut it out. See so, let us do it like this, suppose this is your. Now I had got 2 coils let me repeat this point emphasize this point. This is suppose one coil have been N 1turns, this is suppose another coil with N 2 turns, you have applied I will not just simply say that you have applied V 1 rms voltage of frequency f with this is plus this is minus.

E 1 has appeared here, it will have polarity like this here also I applied the Lenz's law and the flux in the code is phi t. Then this two terminals also become a seat of emf. The value of this voltage V 2 is nothing, but E 2 only V 2 is the terminal voltage there is no distinction between E 2 and V 2 right now.

So, V 2 is equal to E 2 is equal to root 2 pi f phi max into N 2 and also I know V 1 is equal to E 1 is equal to root 2 pi f phi max, this is N 2 sorry and this is N 1 and it is easy to show that V 1 by 2 is equal to E 1 by E 2 is equal to N 1 by N 2. This is one famous formula ok. So, that is the thing, but I was discussing about the polarity of this induced voltage instantaneous polarity.

If at any instant of time this is plus this terminal as to become plus no way; the other possibility that at that instant this is plus this is minus will violate Lenz's law and this ratio of this voltage is this one and from this many things can be told it is merely the ratio of N 1 by N 2 manipulating this ratio N 1 by N 2 you can step up the voltage this is called secondary coil or step down the voltage depending upon, whether N 2 is greater than N 1 or N 1 is greater than N 2 depending on that.

But anyway, this is the thing. Now people use you know some dot marking to communicate this particular important aspect of a transformer by using known as dot convention. It merely tells you that any given instant of time, if the polarity of this induced voltage is this is plus, induced voltage in the other coil instantaneous polarity will be also this is plus and this is done by dot convention.

Now I must also point out see, I have drawn the core material and drew the coils primary coils and the secondary coils rather carefully. What do I mean by carefully; that you can draw suppose you have a magnetic circuit like this as a you draw the coils like these. It is for better than this, what I mean to say that this coils I have drawn. So, that you know what is the sense of the winding, you take the coil this way then turn it like that, but from this sense you cannot figure out, how this coils went somebody draws like this.

Then of course, you cannot point out if this is dot which one is dot this side. No out of question you cannot do that. Perhaps by doing some experiments you will be able to do, but as such on pen and paper you cannot predict ok, this is plus this will be plus that you can only do provided you know the sense of the winding; sense of winding the coil. If that is meticulously shown, then you can figure out. [FL] Before I tell some more interesting thing; also you note that if these two are dots after some time; you know because it is after all AC supply, it will be better if we say dot terminals are those terminals which have like polarities of the induced voltage.

For example if you say this is plus this will be plus, you rub this off for the same transformer I am talking this point you listen, suppose this dot I remove if somebody says no this is dot. Then also he is correct are you getting like terminals, if it is minus that will be minus whenever it will become plus because polarity reverses this will be also plus.

In other words, what I am telling no point in showing so many dotteds it is understood that, wherever you have shown dots; good enough other two terminals are also like terminals you can put some square brackets to indicate that. They are like terminals they are like, whenever this is plus this will be plus, whenever this is plus this will be plus, whenever this is minus this will be minus and so on like that.

So, we have we had discussing about ideal transformer and the ideal transformer is that transformer, who which requires vanishingly small magnetizing current to create a finite flux of strength V 1 by root 2 pi f N 1 is not current necessary, that is magnetizing current is vanishingly small 0.

Since, mu r is infinitely large, that is the idea. Apart from the fact that all flux is confined to the core there is no winding resistance, which allows me to write V 1 is equal to E 1 RMS values is equal to root 2 pi f phi max N 1 and the last thing I will tell in this class, then if I draw the phasor diagram, what should I draw this is the applied voltage is not?

Let me just draw it give you some idea, then the current drawn; magnetizing current drawn although vanishingly small it will be lagging 90 degree. So, magnetizing current will be along this line, because after all pure inductance it has got only inductance; inductance value is very large if mu r is tending to infinity we have shown wrote some expression for inductance, if mu r goes to infinity inductance goes to infinity, you can now interpret the things from different angle inductance point of view very large mu r, but the current drawn from the supply will be 90 degree laggin and this length is pretty small 0, so, this V 1.

So, primary current is this where is E 1? E 1 will be also like this same as these one and where will be E 2 same, because same N d phi d t. So, E 2 will be also like this, all voltages induced voltages, applied voltages this is V 1 they will be all in time phase and this is the direction of phi. Why phi? Because phi is proportional to i m although i m is vanishingly small, but it creates a finite flux. So, flux phasor will be along this line. We will continue with this in the next lecture.

Thank you.