Behavioral and Personal Finance
Prof. Abhijeet Chandra
Vinod Gupta School of Management
Indian Institute of Technology-Kharagpur

Lecture # 38
Dot Communication in Mutually Coupled Coils

Welcome to lecture number 38. And we are discussing about one of the very important problem in circuit analysis where there may be not only capacitor inductor but there may be coupled inductors having mutual inductance between 2 or more coils and then how to analyze such circuits.

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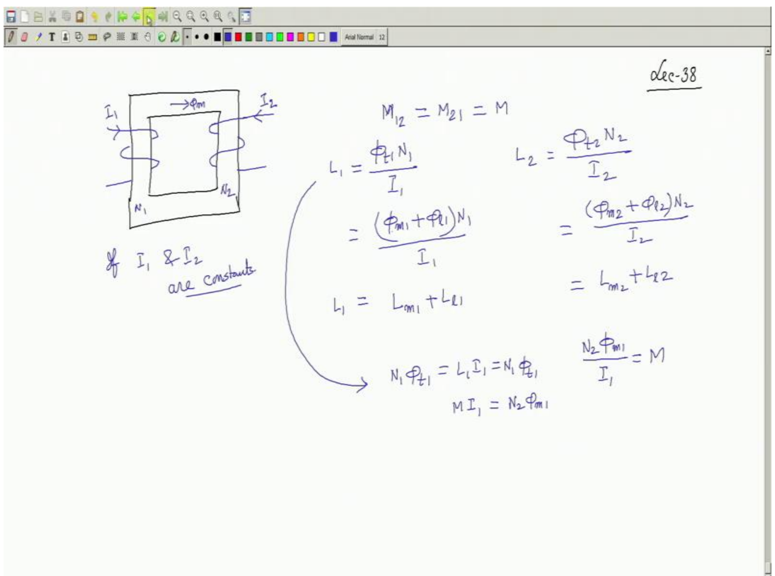

So, to do that we have to we have defined earlier we have been discussed in my earlier class, but I will quickly tell you what we did last time. Suppose we have got 2 coils with N1 and N2 turns wound on a common magnetic circuit like this and this is supposed into then we and this is coil number 1, this is coil number 2, then we showed that aim on to mutual inductance is equal to M 21 and we will call it M. And recall that L1 was defined as flux linkage when this coil get this current I1 total flux linkage that is I phi t1 into N1 flux linkage with coil 1 when 1 ampere flows through coil 1 that is per unit ampere.

Similarly, L2 was defined as phi t2 into N2 divided by I2 when second coil will be energized to current it that was all and then we told you that this phi t1 has got to component phi l1 and leakage component into N1 divided by I1. Similarly, this phi t2 will have 2 components the mutual flux + phi l2 divide into divided by I2. This was nothing and the mutual inductance between 1 and 2 was defined that is be due to I m1 and this part of the inductance first term I called as L m1 and this is leakage inductance.

Similarly as a L m2 magnetizing inductance + L l2 up to this we have done now if obviously you can see that this this inductance the total flux linkage from these for example, we can also say that total flux linkage is nothing but L1 into I1 got the point similarly flux linkage in coil to because of current in coil one will be phi N2 into phi m1 and is the flux linkage when coil 1 carries current I1 what is the flux linkage with coil 2 it will be N2 into phi m1. Because phi m1 is the mutual flux I m1 so N2 into phi m1 is the total flux linkage that divided by I1 so I was telling him to M21 and M12 but we have established that these are same, so M.

Therefore, also note that the flux linkage with second coil. So, L1 I1 will give you flux linkage a total flux linkage with the first coil and M into I1 will give you flux linkage with coil 2 when coil 1 carries current I1 and vice versa. So, inductance into current will give you flux linkage in this way. So this was the basis of the thing. Now if both the coils carry current if both the coils carry current and if I1 and I2 are constant then of course, there will be no voltage drop between these 2 points L1dI1 dt1 will be θ Similarly, the induced voltage in the other coil which will be M dI1 dt that will be also 0.

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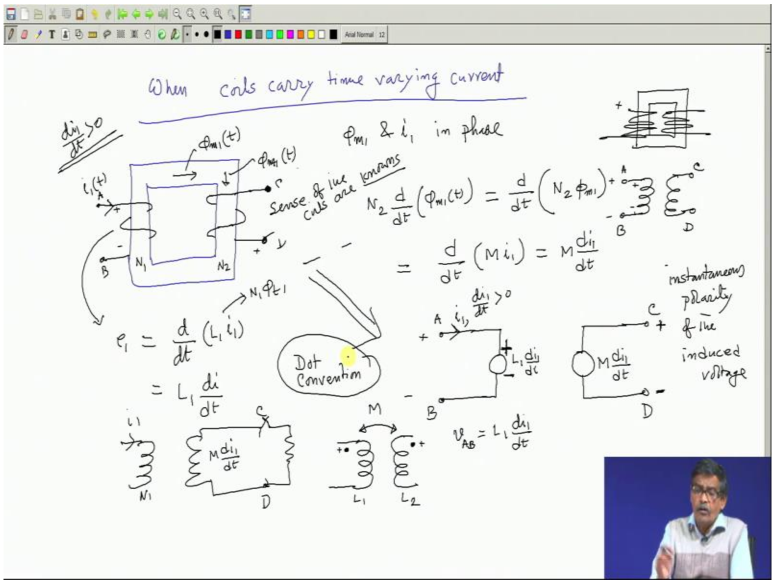

Therefore, now let us see what happens in time varying case when coil carry time varying current. So, the first coil consider first that the first coil is carrying current. So, these are the coils and this is the second coil and this is happening N2 turns and this is having N1 turns. Suppose, we pass some current in the first coil which is some time varying current I1t and the direction I have shown like that then this coil will produce a mutual flux, which is phi m1.

Which that to will be time varying when this current is maximum phi m1 will be maximum when this current is negative phi will be negative. So, this phi m1 and I1 in phase they will change therefore this flux which is going to link second coil is a time varying flux mutual flux. Therefore, we expect that there will be some induced voltage in the second coil is not that is what Faraday's law is that is the if in a coil perpendicular to its section if there is a time varying flux.

These 2 terminals will become a set of emf and the number of emf will be N2 and the rate of change of flux that is phi m1t this will be the induced voltage between these 2 points. So that is the thing. So phi m1t and this can be written as d / dt I will come about the polarity what will be the instantaneous polarity of the voltage but before that what I do I push the N2 which is constant inside. So, it is N2 into Phi m1 this will be the thing but N2 into Phi m1 is nothing but m into I1.

Therefore, I will write it as d / dt of M into I1 in terms of mutual inductance and the m is constant and this m can be taken outside and I can write this, got the point. Therefore, if there is a time varying current in the first coil, we immediately come to know that between these 2 points, there has to be an induced voltage. So, also there will be an induced voltage between these 2 points, how much will be the value of this voltage?

This if I call it e1, the induced voltage will be d / dt now I am writing in 1 stroke into N1 phi t1 if it is phi t1 it must be L1 i1 this is my new This is N1 into phi t1 for self-inductance total flux linkage, how it is varying across these 2 points that will be this 1 and these L1 being constant it is L1 di / dt. Now, so, if you see, let me call these 2 points as A B and these 2 terminals as C D as I told you earlier this this whole thing I will not now draw the diagram across A and B.

I will conclude that there is A and B as if a source of emf present and this is the direction of the I1 and the polarity of this voltage will be this side + this side - and the value of this voltage is L1 di / dt I mean the story is this second coil is not getting any current there is no current in the second coil, under that condition what is happening I am seeing, so, this is this 1 and then in the second coil also there will be an induced voltage M di / dt.

This 2 terminals will be C D. If your I1 is time varying, then this C D voltage available across C D must be also time varying which was picked to time it will change. Now, the question is that if I assume this current direction is I1 and di1 / dt is greater than 0, suppose current is increasing, then the induced voltage is such that in this slot tells us that the polarity of the induced voltage will be such that it will try to oppose the cause for which the current is due.

Now, for which current is due current is due because you must have applied some voltage of this polarity it is flowing in this direction and the polarity of this voltage L1 di / dt is positive. So, upper 1 must be + so that it will try to oppose the cause. So, that current increases di/ dt is positive. So, this only it can do it by making the upper terminal class and what terminal - therefore the polarity of the induced voltage in across this coil that is across A and B whatever assumed I1 is positive and di / dt is greater than 0.

These 2 things have I shown and then I will say polarity has to be like this, because current is trying to increase but the polarity of the voltage should be such it will oppose the cause current increasing means flux increasing because I want and I1 are in phase and so, the coil will try to see that the change of flux which is causing the induced voltage is not allowed that to keep that so, upper 1 + and lower 1 - that is nothing like this.

Similarly, the now the question is with this being known, I ask ourselves that is fine then how do I decide about the polarity of the induced voltage. So, V AB is equal to L1 di / dt that is fine. Similarly, here the voltage is M di / dt now, what should be the polarity assigned to C and D there are only 2 possibilities either C + D - or this is - this is + 1 of them is correct at the instant when A + B is -. At that time we ask ourselves whether C is + D is - or C is - D + that is what we have to decide upon.

Now, once again the decision is taken on the basis of the slot tells me that the polarity of the induced voltage in this coil also will be such that, if it is allowed to act upon the emf the consequent current that is going to flow through the second coil should be such that will it will try to oppose the increase in flux. Because I assume d / dt is greater than 0 that means flux is increasing with time. There will be it try to see the weather + or - or - or + that I will decide that if that emf circulate some current when you connect some external circuit it will try to oppose that change in flux.

Now, how it can do it got the point. So, I will just draw simply like this, this is N1 and I1 here it is flow. Now there is quite to what I am telling this magnitude of the voltage is known as M di1 / dt but only thing i want to know that this is C D. So, for that what I am telling if this emf it is ready with that emf, whether you draw current from it or not, but the polarity of the induced voltage will be such that. If you happen to connect some say load across CD imagine that resistance is connected then it will circulate some current in the second coil and this current should oppose this flux I m1 at that instant.

Now, as I told you there are only 2 possibilities either this 1 is + or this 1 is -, let us assume that maybe this the instantaneous polarity of the induced voltage across C D is like this suppose, and if this voltage at that instant is allowed to act upon some circuitry are connected here. It will circulate current like this it will circulate current through some resistance like this and the direction of the current here will be like this and if this is the direction look here the direction of the flux produced by the second coil will be in the opposite direction your thumbs through you apply.

So, wrap the direction of the current, so, it will be like this this way and therefore, it will try to oppose this phi m1. This is the flux created by the second coil. Therefore, it opposes the flux. So, this must be the polarity the other 1 cannot be that also I will tell suppose the other 1 true. So, if the other 1 is true this is + this is - the polarity of the induced voltage across this then the current would have flown like this. And direction of the current will be then just opposite in the coils and the direction of the flux will be then from top to bottom and we will be in the same direction of I m1.

So, then it is going to stand in the flux is that clear. So, polarity of the induced voltage of that which terminals is + which terminal is - and I have explained to you how to find this out. Therefore, with this idea in mind, I will say that this I will cross out there is only 1 answer uniquely if this is + at any instant of time this is - and di / dt is positive, the polarity of the induced voltage will be this is + this is - clear. So, A and C terminals will add same polarities after some time this will become + this will become - because you are applying a say time varying voltage.

So, also at that time D will become + C will become - so, this is instantaneous polarity induced warping instantaneous polarity of the induced or the induced. Now, 1 important thing you just try to understand this I remove it, even if you don't connect that load you while arguing this thing to decide upon the polarity imagine there is some now current here in this direction, which will ensure this is +, then you can come to the same conclusion, but what I am now trying to tell that if in this diagram, the core is drawn and then the coil is drawn on with their senses, how in which sense the coils are only you can feel he can easily understand instead of drawing like this.

For example, somebody draws coil draws coil like this, I mean, somebody has to draw calls like this, from the diagram, I will not be able to tell at least on pen and paper, it is very difficult to say, if this is + this is which 1 is this is + this, because I am not a whereas, drawn these coils he has not shown the sense of the drawing I understand very clearly what does it must be first go to the front and then to the back then from then towards the back it comes out.

So, this is called the sense of the coil are known both primary and secondary, then on pen and paper, I know what is the instantaneous polarity or suppose somebody draws the coils they draw without showing henceforth in fact will not draw the magnetic core what is the point, but if you draw coils like these 2 coils with terminals A and B and this is C and D and if at any instant this is + - from the supply voltage I know the polarity I know this is + this is binary, but here also it will be difficult for me to tell at that instant which one is C with a C + or C - it will be difficult.

Although there will be only 1 terminal + at that instant and that I can decide provided I know this sense of the winding understood this point anyway So, this is the thing now henceforth, so, people what people do is this why showing the mutually coupled coins they will draw coils in this way and put 2 dots here like this and these dots indicates that if at any instant of time this is + the other one will become +. It also means at any instant of time if this is - at that instant it will be - but how these dots have been arrived it for the first time you must know the sense of the varying the time and so on will show you later how by doing experience.

You can also determine the very simple experiments 1 has to do to find out to put the dark markings and people really write like this, this is self-inductance I1, this is self-inductance I2 and mutual inductance between the coils is M. So, dot convention is the very important dot convention which conveys to us that instantaneous polarities of the input side voltage, primary side voltage and secondary side voltage first coil and second oil they will vary with ignition + + - - like that.

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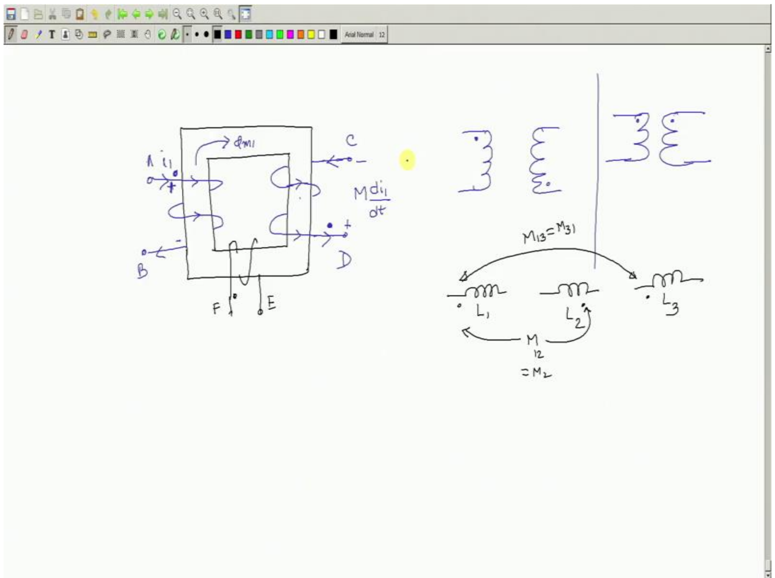

For example, let us draw another circuit another magnetic circuit itself did just to drawing on the same point, but it is very important people have lot of confusions, in understand suppose somebody draws coils like this sense of the windings unknown, but it is drawn in this way. Suppose I call this is A, this is B and this is C this is d in this case, if you say that it any instant of time the current is I1 is here they induced voltage in this will be M di / dt across C and D that is fine.

And I put a + sign here. I asked you where to put the dot + instantaneous + where should I put once again I go from by the basics if this is + suppose, you actually only 2 possibilities are there either this is + or this is -, suppose + if this is + and if this emf is allowed to pass some current through some secondary circuit then the direction of the current will be like this. If this is the direction of the current through the current must come out and this will be the direction of the current here of course, the direction of the current is known and the flux which is causing the induced voltage across C D it is in this direction at that instant.

Now, I find if this is + this is -, then the flux produced by the second coil will try to spend in this further which is not allowed by the legislature. This law tells that direction of the current in the second coil should be such that at any instant of time, that it will try to oppose the very cause for which the induced voltage is to you and these very causes fire 1 is increasing in this direction. Therefore, the polarity of this, this is wrong and it must be of this line.

That is polarity induced voltage should be this is + this is -, if this is the case then the current supplied by this coil to the load will be flowing like that and it through the coil has to be like this and then you can see the flux produced by this coil opposes this is not this time the flux is like this and it will try to oppose the flux and that is fine and if you say this + terminal you say this is taught, I must put this has taught one of them is taught.

Therefore, it is now clear that with the dot convention, we try to convey the instantaneous polarities. The voltages of the 2 coils so, henceforth, I will draw the coils just like that this is 1 coil this is 1 coil in this coil sense of winding is possible. No, but then I will ask that give me the dots, it could be like this also or it could be like that also depending upon the sense of the winding as I have shown for these 2 cases. So, it may be shown like this so, in the circuit did not draw when people did not prefer to draw the mega elaborate magnetic circuit coils.

These that only draw 2 coils and show the polarities and you must understand that there may be another coil here there could be another coil, E F is terminal. Here also the safe will be this is +. So, 3 majorly coupled coils dot, this will be dirt and this will be also dark sense of the winding is known. So, there may be a coil switch more number of coils and all of them will be coupled sharing a common magnetic circuit and it may be written as this is dot, you did not worry about that so, and it will be written as this is self-inductance L1 and this is self-inductance L2 to this is self-inductance L3.

And these 2 coils we have a mutually inductance between the M12 and M21 are same. Similarly, these 2 can have a mutual inductance of M 13 same as M31, here it is necessary not to write him because mutual inductance is may be different. So, this is how it will be indicated in the coil. Therefore, there may be many coupled coils. So, in today's lecture, in this lecture we have considered a very important phenomena that, how to decide about the instantaneous polarity of the induced voltage where coil will carry time varying current, because if the currents are constant then there is no induced voltage if I1 M di / dt will be 0 no induced voltage here. Therefore, we will continue with that in the next class. Thank you.