Electrical Machines - II
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Lecture –27
Winding Table 3 –Phase Distributed Winding (Contd.) With Examples (Contd.)

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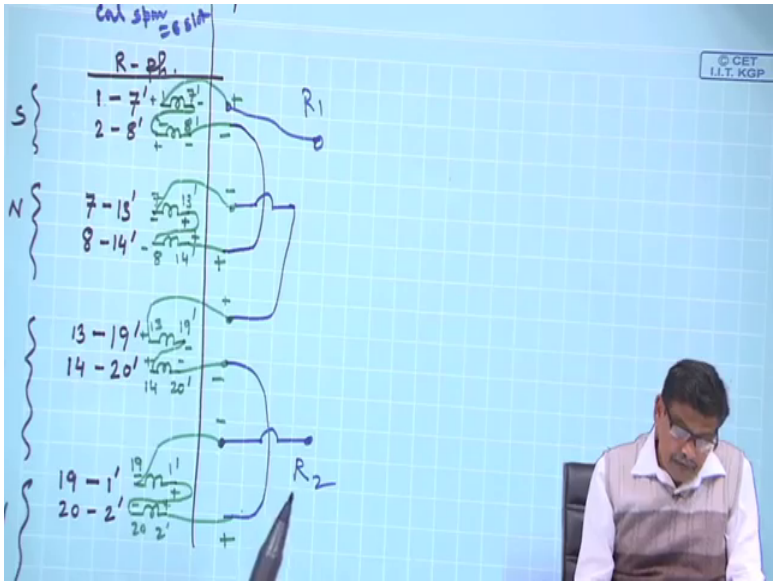

Welcome to this next lecture on Electrical Machines and we were discussing about how to make a balance 3 Phase Winding, when this specifications are that total number of slots is 24 and number of poles is 4, this time I have taken that is that is this was the specification 24 slots and 4 poles machine double layer winding I want to do full pitched and I have decided that under each pole there are 6 slots 2 slots will be allotted to R phase for distribution.

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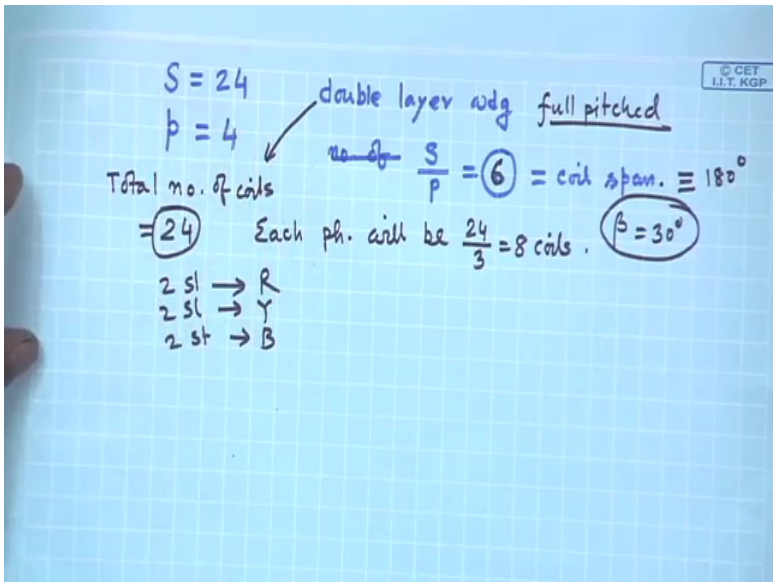

And 2 slots will be allotted to Y phase and 2 slots will be allotted to B phase. So, as usual I conclude first before doing anything that there are total of 24 coils will be there because its slot houses 2 coil sides and 2 coil sides make a coil therefore, their must be total of 24 coils and it is a balanced 3 phase winding we want to do therefore, at the end there must be 8 coils belonging to R phase 8 to Y phase and 8 to B phase. So, that was the thing.

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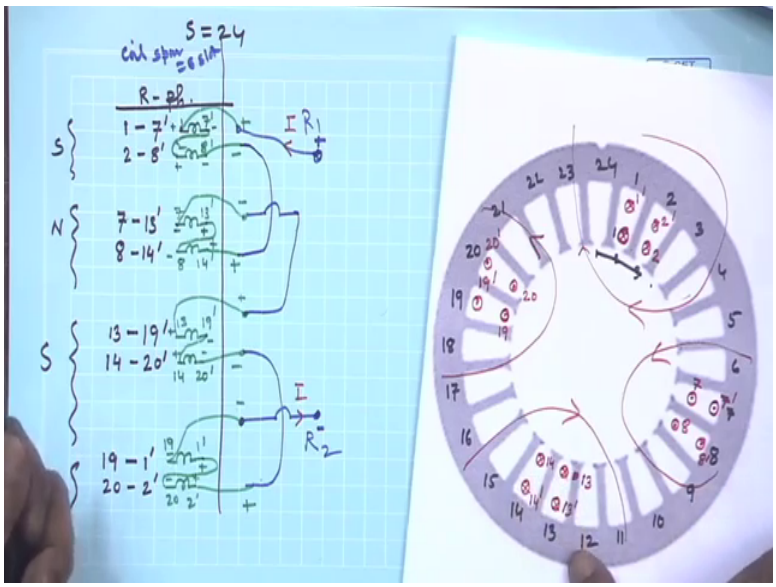

Now, I was telling that actual machine is this one, these are the slots I have already numbered 1 to 24, but I will not go to this fast what I will do, I will make this table first,

because I now know the rules. So, coil Spanish 6 slots. So, for R phase I have completed. So, if it starts from 1 plus 6 7 dashed than immediately 2 slots I will allot so, 2 2 8 dashed so coil span is 6 slots; coil span is 6 slots that is why 6 is added and this 2 coils we will make group 1 of R phase; group 1 of R phase. Similarly group 2 under the next pole it will therefore, start from if it has started from 1 under South Pole it must start at 7, because 6 is the pole pitch therefore, 1 plus 6 7 7 13 dashed 8 14 dashed then 7 plus 13.

So, it just becomes number you just write them then to give a physical picture to this I have drawn the what this 1 dashed 7 dashed mails it means a single coil with terminals 1 7 dashed available to you. So, this is this one and then I have shown the polarity suppose it. So, happens that coil side one has plus and 7 dashed minus and it is full pitched coil. Similarly this is plus this is minus, but; however, the start of the second group 7 13 dashed must have opposite polarity like this and this way I completed and I got all the 8 coils of R phase, then of course, the interconnection of this phases are necessary and for doing that one should be careful.

One cannot just go on blindly add them in series a with due regard to polarity one should add them. So, that they become all the additive and ultimately two terminals you will get in which all the coils will be in series and then ultimately this is R phase this is minus off Y phase. Now let us do the Y phase before doing Y phase let me cancel it the R phase here now in this diagram ok, let us see how it translates R phase. So, red phase I will use red color it possible.

So, you see here is the first coil and this is 1 and this is 1; this is 1 then its returned will be at 7 dashed you see 1 7 dashed. So, it will be 7 dashed and this time you notice it is not diametrically opposite to make a coil and this I know because it is a 4 pole machine so, 90 degree mechanical if you go you have gone by 180 degree electrical. So, this things we will now come out nicely so, this is 1 coil. Second coil is 2 8 dashed so this is 2 and 8 dashed is here is not these are the 2 coils, then you have 7 13 dashed. So, 7 and 13 dashed this is 7 and 13 dashed is here.

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Which one.

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Below I have drawn. So, this is 7 dashed I have so 13 will be here. So, 1 7 correct 2 7 dashed this is correct, then I want to do this coil that is 7 13 dashed I want to make. So, if this is 7 13 dash should be shown here is not this is 1. I am sorry 7 13 dashed and then 8 14 dashed so 8 and 14 dashed 14 dashed 8 14 dashed, then you have 13 9 dashed. So, 13 is where 13 is here this is 13 13 and 19 dashed 19 dashed is here below 19 dashed 13 19 dashed and then you have 14 20 dashed. So, 14 is here and 20 dashed is here.

And still you have to add another 2 coils 19 1 dashed. So, where is 19 19 so this is 19 upper take 19 and 1 dashed vacancy will be there appropriately as you can see 19 1 1 dashed and 22 dashed. So, this is 20 and this is 2 dashed and there are now 8 coils drawn. And the coils are distributed and this is what I expect, because if you connect them in series and if you suppose pass a DC current let us see how 4 poles are produced. So, this current is entering through 1 2 through so, 1 2 and you can easily see current is all also entering through 1 dashed and 2 dashed.

So, this all carry cross current similarly this all will carry dot current, this will carry cross current you can easily verify and this will carry dot current. So, how 4 poles are produced cross so this will be the thing these are dot this will be the thing these are cross this will be the thing and these are dot this will be the thing.

Therefore, for this one this this part 1 quarter will become South Pole flux is entering and this quarter this this quarter flux are coming out and it will the North Pole, this will be South Pole this will be North Pole. So, this is R phase Y phase will be exactly saying, but this whole patterned will be shifted by 120 degree alone apart from this. So, this I am not drawing I will only make the winding table here you can practice it and verify yourself indeed it will be shifted by 120 degree that is the most important thing therefore, this is the thing.

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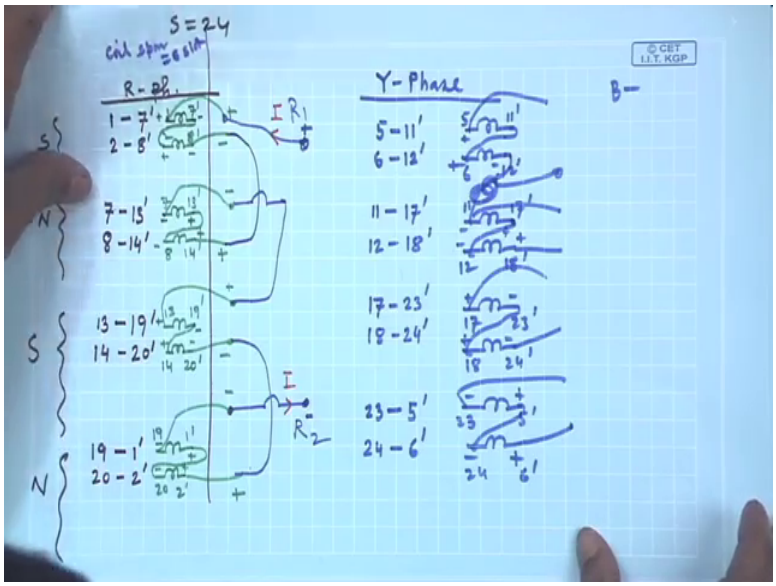

Now let us do it for Y phase so, R phase is over so Y phase all though I am using blue color, but it does not matter Y phase something I will do. Now, for this I neither required this slots that is the advantage if you have understood it properly, only thing is Y phase starting slot number must be 120 degree electrical apart. 120 degree means what 6 slots correspond to 120 degree so, angel is 30 degree between this slot so 4 slots therefore, it must start from 5. So, this way from this to this 4 120 degree apart after you get 5 then it is 6 because each coil is identical with the others so, 5 I will write 11 dashed is not.

Then next slot also I will give to go so, it will b 12 dashed this is first group under South Pole. So, then this one 7 plus 4 that is 11 and then plus 6 17 dashed and then 12 18 dashed, then South Pole 13 plus 4 17 and then plus 6 17 plus 6 is 23. So, 23 dashed and then 18 24 is their 24 dashed hopefully things are correct, then this one 11 plus 6 17 17 plus 6 23, but 23 is not I have 23 is there 23.

Then you add plus 6 to 8 this is the coil span so 29 but 29 does not exist maximum is 24. So, 29 minus 24 is 5 so, it will be 5 dashed and then you know 24 and 6 dashed this will be your Y phase and if you want to show it as coils show it 5 11 dashed. So, everything is accounted for all this slots 6 12 dashed and then 11 17 dashed and then 12 18 dashed and then 17 23 dashed and this is 18 24 dashed.

And then once again plus minus, plus minus under note pole, then this is minus plus minus plus on that say North Pole this is South Pole this is once again plus minus

alternately it comes like that plus minus plus minus, because South Pole and then this will be minus plus minus plus and the numbering you can do 5 dashed etcetera 25, I am not going to draw for B phase that you do yourself. So, similar thing and then once again connect them in series this is one group why no this is one group and then this is another group two two this is another group and you add them in series you get another one over.

Now how to get that total voltage in terms of phasor and what should be the value of m, let us see first thing is I will now state away draw suppose there are 4 voltages 8 voltages are to be added. So, I will take a news space news space.

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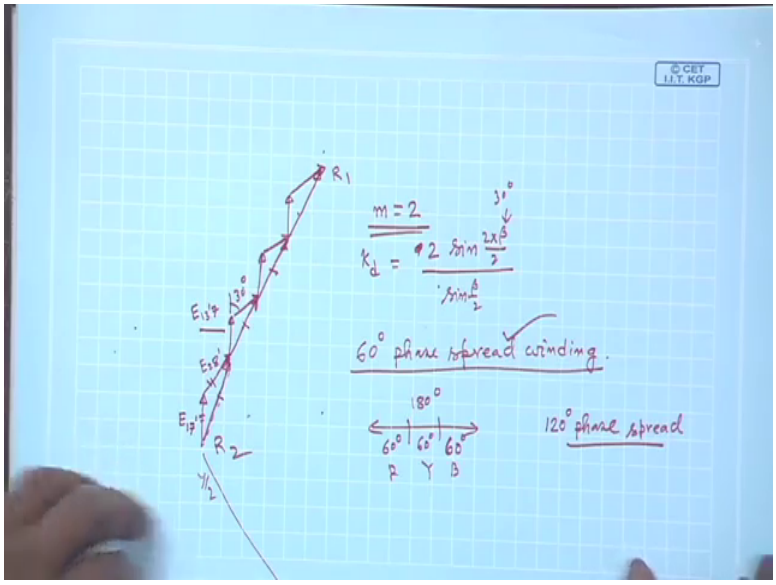

So, suppose I start with this voltage keep it here. So, this is E 1 7 dashed to this you have to add E 2 8 dashed, but there is a slot angle difference between 1 and 2 its start happens after 30 degree. So, you add this 30 degree lagging that is E 2 8 dashed after it is over we have to add this voltages, but reversed so, what happens is this another 2 voltages are added but this voltage is not E 7 13 dashed I should write it has E 13 dashed 7 reversed. And this way you will get this and another 2 voltages 1 2 3 and another 8 coils are there 1 2 3 4 5 6 and then 7 8.

Note that this lens will be collinear this because by the all lens are equal and their equally shifted in this case by 30 degree. So, this will be your R 1 R 2 similarly the Y phase if you sketch the whether you will see that a capital Y 1 Y 2 will be shifted by 120 degree Y 1 Y 2 etcetera, that I am not doing and you can easily show that. But to calculate the

distribution factor what should be the value of m see to calculate the value of m you need not go the whole length to understand that.

Because these things are in series I will of equal length in phase therefore, a k d should be calculated with m equal to 2 that is all you calculate distribution factor from this that is if this 2 are distributed, they are not distributed they would have been collinear higher. So, k d will be m that is 2 sin m beta by 2 beta is 30 degree divided by m; m sin beta by 2 by sin beta by 2 this will be the value of k d. So, this way it can be easily calculated therefore, I hope you have understood what is a double layer winding?

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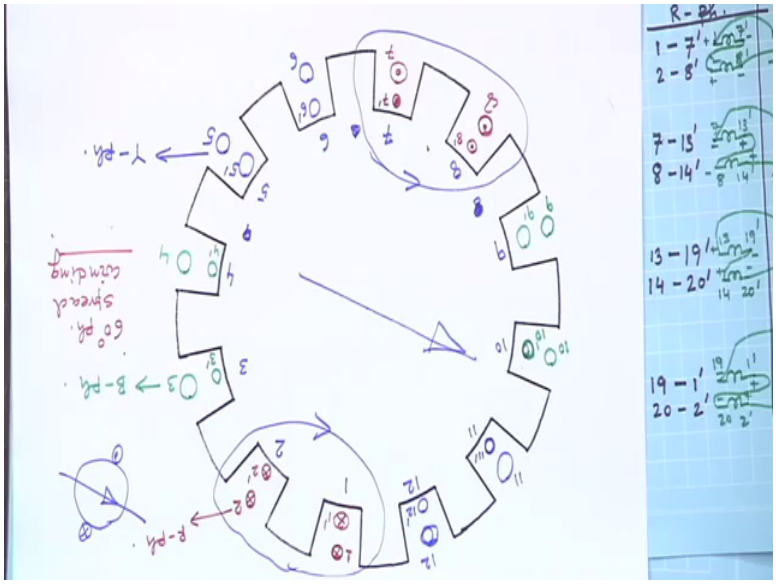

Why double layer winding then you are using this slots with more conductors. See the size of a machine depends upon the amount of copper you are utilizing and amount of iron you are utilizing ok. And whenever you use iron or copper you must see their used to their maximum possible limits therefore, it was found that you have to accommodate only 2 coil tone. So, better instead of using a single layer winding which can also be done for small machines, but it is always better to use a double layer winding like this.

Incidentally this winding when you use so, B phase you complete yourself and make a nice diagram not as clumsy as it appears in my case have a nice paper draw, it as I told you it is simple number games horizontal moment from R to Y phase it is actually 120 degree electrical apart, corresponding number of slot is to be added. This vertical movement from this to this and this movement is slot pitch like this ok. Now this sort of

winding is called 60 degree phase spread winding 60 degree phase spread winding name I am not used till now, it simply means that that one pole that is 180 degree 180 degree 60 degree 60 degree 60 degree 60 degree each I am allotting to R phase Y phase and B phase.

That is why it is called a 60 degree phase spread winding ok, there is a another type of winding which is called 120 degree phase spread winding this is very popular ok, 120 degree phase spread winding now what is phase spread, phase spread means how many coils immediately you are connecting in series over what angle this distribution takes place, that is a measure of phase spread to what extent of a 180 degree your are R phase winding is there or Y phase winding is their that is called phase spread ok.

So, in this case the phase spread is 60 degree because R phase winding over a pole you see only 2 slots 30 30 60 between this to this 30 30 60 so, that 120 degree phase spread I will tell you next time. But before that I already told you that it may be necessary not to use full pitched coil all the full pitched coil should be used no doubt, if you have a perfect B distribution sinusoidal B distribution nothing is better than that, but as I told you the B distribution may content some harmonics.

And therefore, instead of using a full pitched coil, you will use short pitch coil. The angle epsilon by which the a coil is short pitched is chosen by the designer; designer will tell me for this machine B distribution maybe third harmonic is very large and you short pitch these by 1 slot or 2 slot, that I gave you some hints how to decide about that epsilon short pitched coil. In this case what I will do is this I will specify the angle by which the coil is short coiled.

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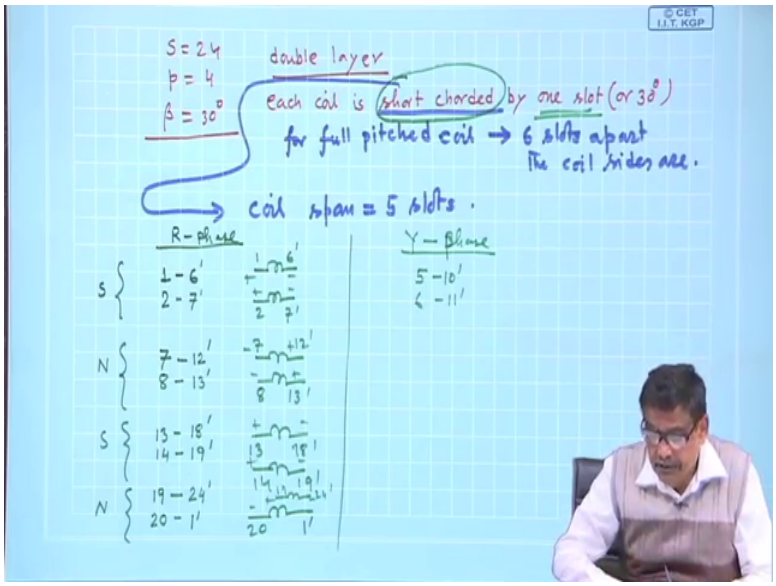

For example the same problem S equal to 24 p is equal to 4 double layer, but coils each coil all coils are identically each coil is short chorded by one slot.

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Or 30 degree.

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So because this problem we have discussing beta is 30 degree for this machine, then how to make the winding table, very simple see coil span for full pitched the same problem I am carrying on with, but I this time I want to be short chorded coil. For full pitched coil it should be a the coil side should be 6 slots apart has we have seen 6 slots apart the coil sides are.

Now, I am telling each coil span should not be 6 it is less by one slot therefore, in this case for when you have short chorded like this coil span, I am declaring it is 5 slots so, how things will change in the winding table. So, let me try here only for R phase at least 2 R phase nothing essentially we will change except that earlier it was 1 7 dashed is not, now it should be 1 6 dashed that is the first coil.

And all coils will have 5 slots separation coil sides for a particular coil. So, second one must be 2 7 dashed this will be the first group say under South Pole under North Pole of

course, the start of second group first coil side should be 1 pole pitch apart that is it should be 7 no doubt, but its written should be plus 5 that is 12 dashed. And this is 8 and 8 plus 5 13 dashed, then once again south 1 plus 6 7 7 plus 6 that should be 1 pole pitch apart second coil third coil so, 7 plus 6 13.

And 13 plus 5 18 dashed then 14 and 19 dashed and another north is there and that should be 13 plus 6 19 and 19 plus 5 24 dashed and this should be 20 and 25 dashed 25 dashed does not exist 1 dashed this is the R phase. And the coils I will show exactly similar I mean nothing new in this only thing the separation between the 2 coil sides of a coil is not 6 slots, but 5 slots because I am looking for a winding which is short chorded by 1 slots.

So, for full pitched it would have been 6 slots, but I am telling make it 5 slots. So, that is the thing so, 2 7 dashed in the same way and this is 7 12 dashed and 8 13 dashed and this is 13 18 dashed and this is 14 19 dashed and finally, this is 21 dashed. And polarity once again is decided by this way plus minus this will become minus plus minus plus plus minus plus minus alternate pole polarity reverses south is plus and then minus why oh I missed 1 here there is a another coil 19 24 dashed you get the idea plus minus like that.

And then once again connect them in series appropriately and get the. Now similarly only thing I will just tell you about the beginning of the Y phase, Y phase see you have short chorded no doubt, but you I looking for a balance rephrase winding therefore, Y phase must start after 120 degree that does not change only thing changes is the coil span this one. So, it should be that 4 slots apart that is 1 plus 4 5 and then 10 dashed and then this is 6 11 dashed once you get this number you did not look here then proceed.

So, this is how the Y phase and B phase I will request you on your own that is very important you try to complete this table. And next time I will of course, complete this table, but before that you do it on your own and also calculate the distribution factor k d for this particular machine. So, next time we will also discuss about 120 degree phase spread winding.

Thank you.