Electrical Machines - II
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Lecture – 05
A Single Conductor Generator and Motor

Now in today's unit we are ideally will be looking at some motor generator aspects not in rotating machine, but first to give you a glimpse of the things it is linear a linear generator or motor in its simplest form I will describe that. But before that I will just want to tell you one things very clearly, I expect that you know that, but very quickly I will tell for example, these are the two rules which will be often using.

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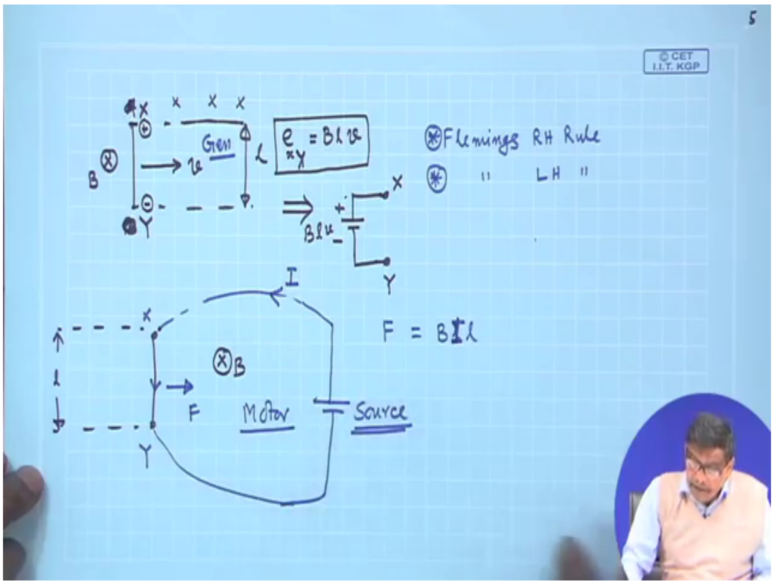

For example you if you have a conductor ok, title I will write slightly later. Suppose you have a straight conductor finite length and it is moving with some velocity v and let there be a magnetic field present, all along the plane of the paper whose strength is b into the paper. So, this crosses into the paper, velocities like this then what happens and the length of the conductor is suppose l l.

So, this is the conductor A B, let me avoid B X Y and it is moving along this direction then what happens between the two ends x and y a emf will be generated. The value of this emf will be B l v, where B is the flux density all along the paper it is there you imagine. How this can be created perhaps on the on above the paper there is the North

Pole and below the paper there is a South pole. So, lines of forces will be perpendicular to the plane of the paper.

And your conductor is on the plane of the paper and it is suppose moving with a velocity v and then between these two points there will be an induced emf whose value will be B lv ok. Now the question is what should be the polarity of these voltages. So, if you apply then you have to apply your right hand rule you recall that your forefinger always will denote B; thumb will denote the velocity and then this middle finger will give you, the tip of the middle finger will give you the plus sign of the voltage induced.

For example here it is like this is B. So, plane of the paper this is v in this way v. So, the polarity of the induced voltage will be this is the tip. So, this will be plus, this will be minus understood this. So, this is the tip of the middle finger, there I will write plus and below I will write minus. So, this voltage B l v is actually the potential of x with respect to y see always it is a good habit to write potential difference between two points. No point in telling e voltage at X with respect to what, that is very important.

So, potential of X with respect to Y put the numerical values here you will get some number that will be the voltage existing and I can say that this thing is equivalent to as if there is a battery here. Plus minus the value of the voltage is v l me this point is X this point is Y that is what I meant to say. If velocity is constant B is constant it will be a constant DC voltage product of all these things reverse; obviously, this also tells me many more things, suppose l of the conductor is finite fixed.

If you reverse the polarity of the magnetic field that is instead of cross into the paper if it is coming out then this will be become potential of x and y will become negative B l v indicating that y is really positive x is negative similarity is the velocity, if you reverse velocity similarly the polarity of the induced voltage will reverse. So, this is called emf equation, which will be often used in any machine analysis problem complicated machine.

So, a conductor moving at a constant velocity v will be having an induced voltage provided it is placed in a magnetic field b and this b direction of B and v they are mutually perpendicular this is into the paper, velocity is this way and B is this way. They are mutually at perpendicular condition then only induced voltage will be there for example, if this conductor is moved vertically in presence of this B, no way there is no voltage.

Because you must have a perpendicular component of B with respect to v, if it exists then there will be some induced voltage across the point, B cross B they say v cross b anyway let us not make things complicated this you must understand ok. Similarly if you have this conductor, same conductor of length l meter all units are si unit this length is l and suppose once again you imagine on the top there is a north pole, below the pepper there is a south pole permanent magnets, lines of forces will be there and suppose it is present all along the place.

Then B symbolically I am just showing one line, but all the lines of its forces are present. So, suppose this length is l and what I will do now, I will to this end I will connect some wires, two wires I will connect flexible wires. And I will connect a battery outside source therefore; this will drive a current in this circuit ok. What will be the magnitude of the current? This voltage divided by the resistance of this path.

So, some current I inject into the conductor, conductor is X and Y. Now we are in a situation a conductor of length l is carrying a current and there is a magnetic field perpendicular to the direction of the current flow like this then what happens this conductor is going to experience some force. Now the question is what is the magnitude of the force and what is the direction of the force, like while we found out the voltage across X and Y, two question should be asked what is the magnitude of the voltage and what is the polarity of the voltage.

Similarly, when a conductor I am telling it is experiencing a force then I must say, what is the magnitude of the force and what is the direction of the force. And the magnitude and direction of the force is obtained by Flemings famous left hand rule it was Flemings right hand rule to find out the magnitude of the voltage and polarity of the voltage and this is Flemings left hand rule to find out the magnitude and force experienced by x y.

Because it is carrying a current and placed in a magnetic field, the magnitude of the force will be b i and l what is B? B is the flux density. What is I? I is this current that is in this case I and how to find out the direction? To find out the direction what you have to do, you have to apply left hand rule mind you. So, once again the forefinger is the direction of B that is into the paper this middle finger is the direction of the current that is this way and then thumb will give you the direction of the force.

So, magnitude of the force is B i l and it will be towards right understood therefore, these two rules that is Flemings right hand rule and Flemings left hand rule. Right hand rule is to be used to find out the polarity of the voltages, magnitude of the voltages and left hand rule is to be applied when you want to find out the force, when a conductor is carrying current placed in a magnetic field. So, three things are required a conductor is required in case you want to generate some voltage you require some velocity of that conductor and you require some magnetic field.

Absence of any of these three will not generate any voltage. Similarly to generate some force. So, this is called motoring as you can easily understand, somewhat like a motor you get some motion and this is somewhat like generator, you generate a electrical voltage between two points. So, this is the very fundamental thing, now after learning this, we will now go to a simple motor problem ok.

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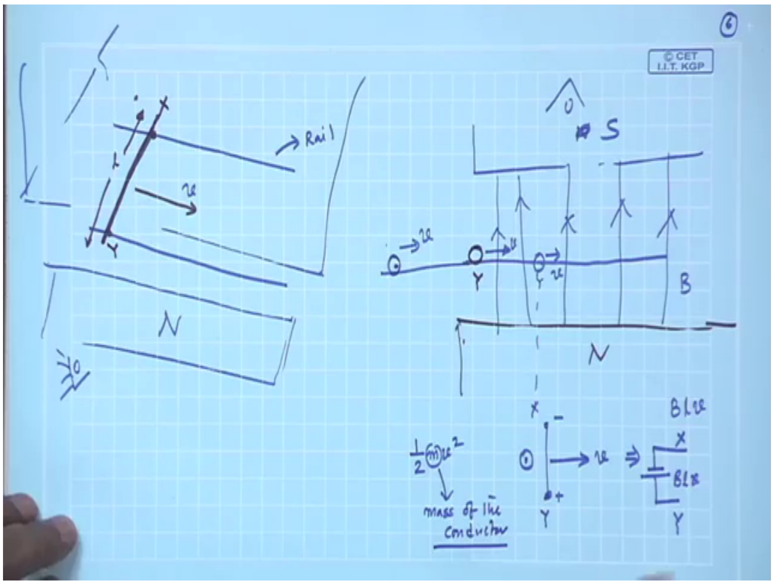

What is the motor the arrangement try to understand, suppose you have let me draw slightly in three dimension roughly, suppose you have got two dale's, rail; rail railway track frictionless and over which you have a finite length conductor and it is of course, there are rails this conducting bar of length l is resting on the pair of rails and therefore, it can move this way or that way, if you pull it will move to this.

So, these are rails, rails it can be moved. Now you imagine above this track, railway track above this track you have a permanent north south pole, permanent south pole magnet I do not know how to sketch it is like this some south pole magnet is above it and below it there is a north pole magnet understood. So, this diagram if you look from this engineers way if you want to draw look from this end it will then look like this what I want to tell.

There is a north full south pole above it and this track you can see then only a line railway track and the conductor is section of the conductor that is X Y, this is the Y side this is the X side, Y side you can see if you if I look from this end it will be Y this is south pole. And what I am telling below this I have kept a north pole such that the lines of forces exist all along the track and what is the width of the magnets? Width of the magnet is the track length ok.

North Pole all about the track south pole and below the track it is there and this is your conductor. So, so it goes like this, B I mean this same thing I have drawn here in this example this way; now as I have told you suppose I want to move this conductor with a velocity v from left to right. So, this velocity will look like this it will be moving and suppose the magnetic field starts from here, before that the this conductor which is on the track was here still moving velocity v length of the conductor perpendicular to the paper.

Will there be any induced voltage? No way no in this voltage v is their length of the conductor is there, but there is no B, the moment it enters into this magnetic field region then when it comes here for example, it moves with a velocity v with this end Y the other end I cannot say that is X at the other side it is like this moving. So, now the length of the conductor is this B is this, velocity is this. So, polarity of the induced voltage B l v will be there definitely and if you apply this rule if you look from the top the conductor length you can see here, is Y X at this point.

If you look from the top plan of this view and it is moving with velocity v and then b it is dot here is not. So, if you look from the top you will see lines of forces going up in this case the voltage induced here will be B l v. Now the, what will be the polarity of the voltage? Polarity of the voltage to find it out this is B, this forefinger is B in this diagram B this is v and middle finger they are mutually perpendicular these three things.

Tip of the swan this will become plus this will become minus v l v, and this thing is equivalent to selling telling that the voltage is like this and the magnitude of the voltage is this B l v. Now let us imagine that this conductor is moving on a railway track where there is absolutely no friction nothing therefore, tell me if this conductor I would say that is moving with a constant velocity v how much force you need to keep the motion alive with constant velocity v.

The answer is 0 that is what Newton says that to move a thing against any friction with a constant velocity no force is needed, if some force is applied it will like that accelerate or decelerate that is different issue. But to move a body on a frictionless track no force is needed it will move initially you have to give that push whatever velocity it acquires it will continue to move uninterrupted, unless somebody apply some opposite force it will perhaps start decelerating and so on.

Therefore a generator and it does not violate anything, no no laws of physics is violated because work done by this conductor now is 0 and you do not require any work to be done either. Although this bar conducting length is having a kinetic energy associated with it and the value of the kinetic energy will be half mv square where m is the mass of that conductor ok, this is the thing. Therefore, that is a simplest generator.

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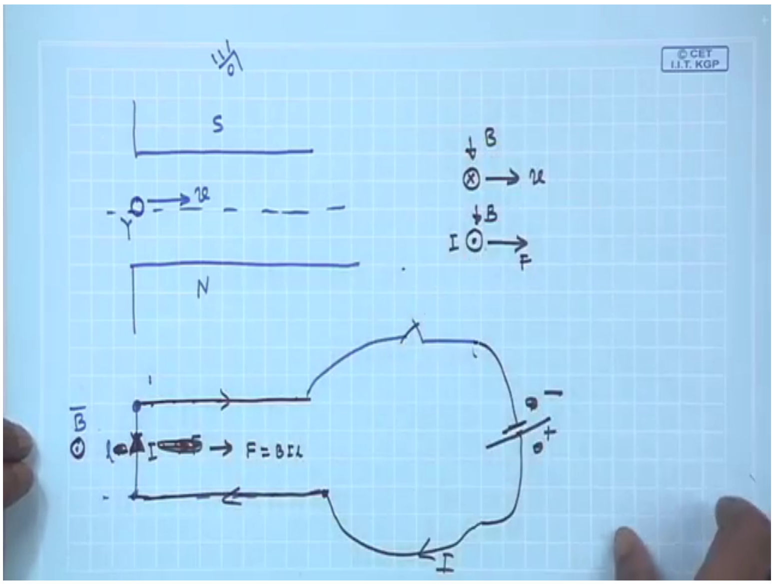

So, once again I draw it and write down this, this is suppose South Pole continues forever; this is suppose North Pole continues forever. What is the width? Width is perpendicular to the paper that is finite width equal to the separation of the two rails. So, and this conductor is on the rail it is moving with a velocity v and here you will see the end Y the other side you will see the end X and there will be induced voltage in it ok.

Now, let us see the other operation for example, what I you will do in this diagram which is not a very neat diagram, but you try to have the field what I am telling. Now suppose I have this conductor moving on the tracks presenting a magnetic field you get a induced voltage. Now what I will do is this it will be present in that magnetic field, but I will pass some current through this conductor by external means ok.

So, this is the conductor if you see from the top this is the conductor you can see the total length of the conductor if you look from the top, this is l length and where are the middle lines also you will be able to see in this view, from the top if you look at you will see v and v is of course, dot all along the track. Now, what I will do this track here I will connect a switch here with a flexible wire leave the track and this is track and I will connect a battery, this is B and I want to pass current so that movement will be this way.

So, now let us see what happens. So, if you connect a battery to this rails, rails always contact with the rails. So, circuit will be completed, if this is the polarity of the battery then you are passing some current like this I through the conductor. Then if this is the current this is the field you see you have to apply left hand rule to know the direction of the force, it will be this way force will be acting. B B is coming out of the paper O, B B is coming out and I is going like it will be like this way.

So, what I will make it I will make the polarity like this plus minus this is I, then this is B this is B, this is I and then the force will be acting like this is that clear. So, B is coming out of the paper I is going like this and it will move in this direction. What is the magnitude of the force? Magnitude of the force is B I l therefore, conductor was stationary in presence of a magnetic field you pass some current I it will flow like this through this flexible where it will complete its butt and then it will experience a force BIl.

Now, as it starts moving. So, what happens if you apply some force to a mass? It will accelerate. So, it will go on accelerating velocity will change, but anyway it will move with a velocity, but one point must be understood very clearly if it starts moving the magnitude of the current I am not sure whether this e divided by total r of the circuit will be the magnitude of the current.

Because what happens the moment this fellow starts moving, I know that a conductor moving in a magnetic field with some velocity will have some induced voltage in the edges therefore, did this conductor itself will become another seat of emf. Therefore, to find out the currents in this circuit not only this emf will be acting when this conductor has started moving, but also another emf which will be generated across the two points of this conductor. These two together divided by the impedance or resistance of the circuit should decide what will be the current in this circuit.

Therefore in this unit you what I have done is this if there is a magnetic field if it is moving with a velocity v there will be some induced voltage in it, polarity of the induced voltage how can you show this is v. So, this will be cross; cross means it is like this is not so B v and it will be cross means the other end of the conductor will have plus sign. And if you have a conductor carrying some current I in this direction and if it is having a B like this then it will experience a force the value of which I will get it from left hand rule.

So, B I l this is the direction of the force and so in this lecture a single conductor moving in a magnetic field what will be the induced voltage we have discussed and we have discussed how to decide about the polarity of the voltage. Similarly if a conductor which carries current and it is placed in a magnetic field then it will experience some force, the direction of the force can be obtained by using left hand rule and the magnitude of the force is BI l. So, in our next unit we will further carry on with this.

Thank you.