Basic Electrical Circuits
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Lecture – 11

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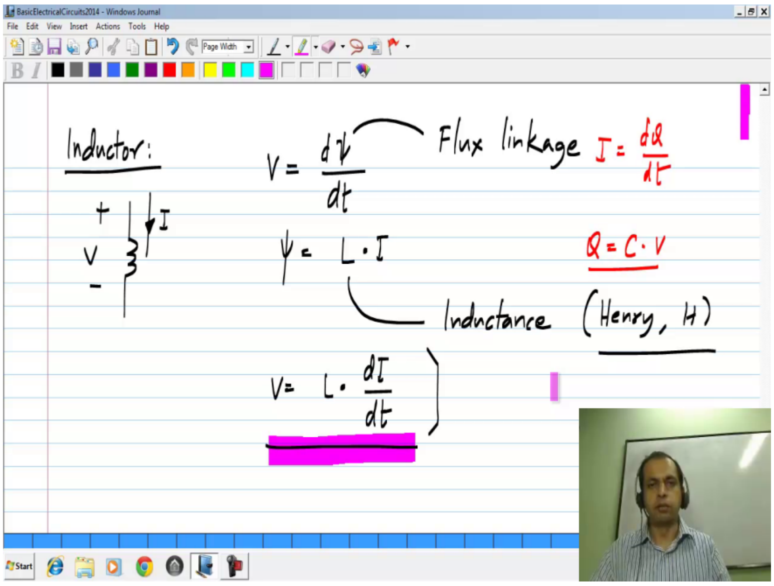

The next basic element is the inductor. It is given by this symbol, which resembles a coil, this is rigorous inductors are frequently implemented as coils of wire. And again we defined V and I using passive sign convention. Now, it turns out that a voltage across an inductor is related to the flux linkage stored in the inductor. It is given by this relationship where this psi is the flux linkage, and psi itself is proportional to I, through a proportionality constant, which is known as the inductance. So, the inductance is measured in Henry or H.

Now, you can see that this relationship is analogous to charge being proportional to voltage here the flux linkage is proportional to current. And the current was rate of change of charge, whereas, the voltage is rate of change of flux linkage. So, you can make this kind of analogy between quantities in a capacitor and then in a inductor, but this flux linkage is little more abstract quantity than a charge and I would not go into the details of it, but form the geometry of the inductor, and the current flowing in the inductor, you can see find the flux linkage, but again we do not have to go into all those complications, because as I have emphasize repeatedly, we are interested only in the terminals characteristics so that is the relationship between V and I. And for that we can eliminate this flux linkage and get a relationship which is V is L - the inductance times the rate of change of current. So, this is the defining relationship of an inductor, where again V is defined with this polarity and I with that polarity; so the inductance as I mentioned earlier is measured in Henry.

So, what does this relationship says if the current is increasing at the rate of one ampere per second and if the inductance is 1 Henry, the voltage across the inductor will be a constant which is equal to 1 volt. So, one point I would like to caution about here is that all of you would familiar with lenses law from physics, and you would know that the induced voltage across an inductor is in direction such that it opposes the change in flux and so on. And it is common to see relationships like V is minus L dI by dt. Now, do not be confused by that this is the correct relationship with this particular sign convention, now it turns out that in most of the physics books, the current would be considered in the other direction and that is why you get a minus sign in that expression. Now, if you have V like this and I define this way, this is the relationship and this is the induced voltage which opposes the change in magnetic flux linkage inside the inductor.

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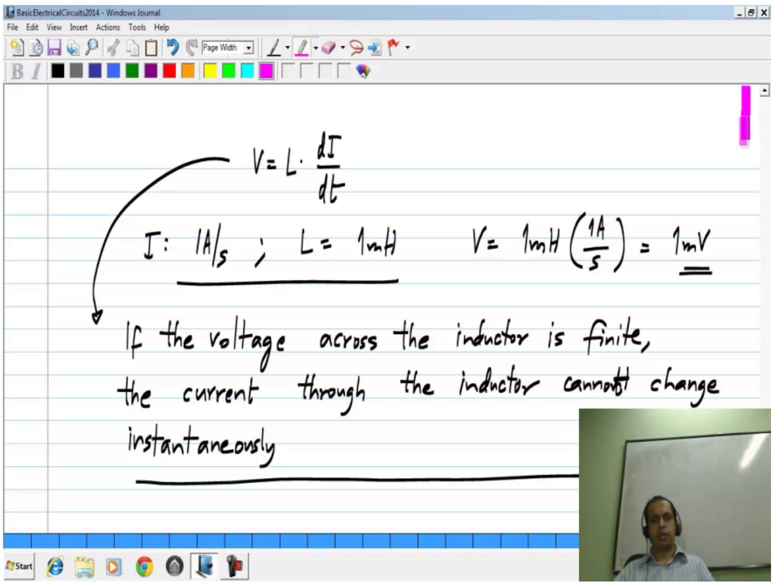

So, what does this say, V is L times dI by dt; and if I changing at let say 1 ampere per second and if the inductance is 1 milli Henry, clearly voltage induced across it is 1 milli Henry times 1 ampere per second, which is 1 milli volts. So, the voltage across the inductor is 1 milli volts. Now, this also says another thing, it says that if the voltage across the inductor is finite, the current through the inductor cannot change instantaneously. So, clearly that is the parent from this relationship; if the current changes instantaneously, the time derivative is infinity and the voltage would have to be infinite as well. So, this is the analogous to the voltage in a capacitor, which also cannot change instantaneously if the current through it is finite.

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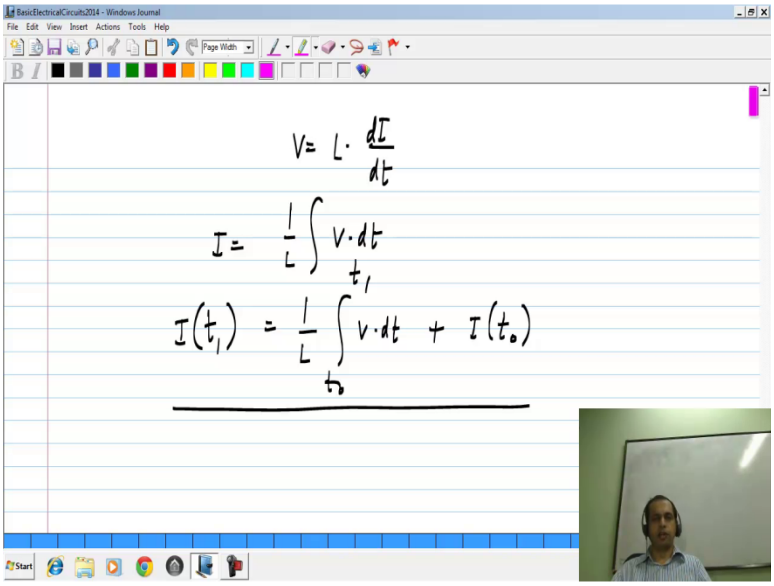

Now, we have V is L dI by dt, which says that I is 1 over L integral of the voltage with respect to time and I at a time t 1 is given by this integral plus I at time t 0 so; that means, that, the difference in current at time t 1 and time t 0 is given by the integral of the voltage, the area under the voltage curve divided by the inductance of the inductor. So, this again analogous to the relationship we saw earlier with the capacitor. Now, clearly the current in an inductor at a given instant depends not only on the voltage at that instant, but on voltages at all previous instants. So, again just like the capacitor, an inductor is also an element with memory, the capacitor stores charge and inductance stores flux.