Electrical Measurement And Electronic Instruments
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Lecture - 45
Flux density measurement with Ballistic Galvanometer

Welcome; today, we are going to start the last chapter of the Electrical Measurement parts and this will have several miscellaneous topics. One of them is magnetic measurement, where basically we will measure the Flux density or field intensity of a magnetic field.

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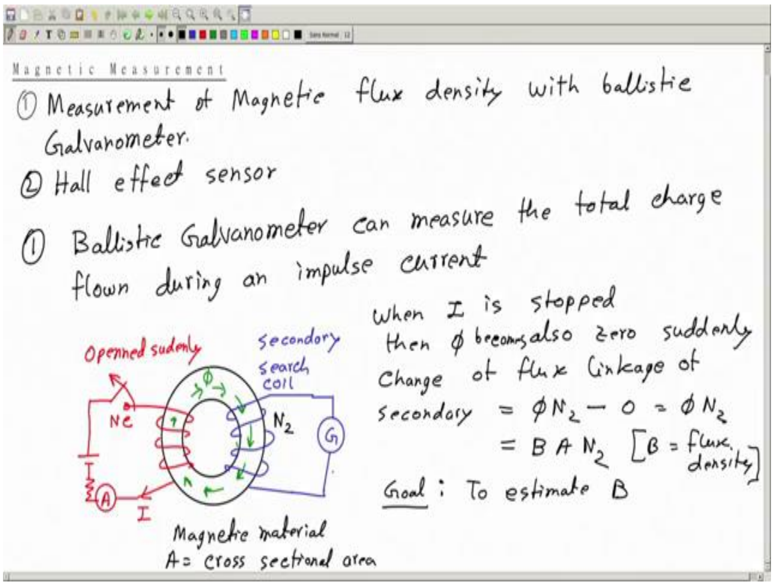

And here, we will see two small topics; one is Measurement of flux density Magnetic flux density in a code with ballistic galvanometer and the second thing we will study is a Hall effect sensor. So, let us start with this one that is flux density measurement with a ballistic galvanometer. So, let us recall what a ballistic galvanometer is. We have studied this I think in our first week.

So, ballistic galvanometer can measure the charge, the total charge flown during an impulse or impulsive current ok. So, if we have a very short duration current ah, but of high enough magnitude; but very short duration, the current last for very short duration. Then, some charge will flow within that duration and that charge can be measured with a ballistic galvanometer. Just recall what we have studied go back to your first our first week.

So, if we connect the ballistic galvanometer, in series with this impulsive current then the pointer of the galvanometer will get a throw will start to oscillate. The movement the current passes the pointer will be thrown like this it will be tilt and it will start to oscillate. The ballistic galvanometer does not have much friction; ideally no friction at all and the amplitude of this oscillation that means, from here to here this amplitude is proportional to the charge flown within that small time.

So, please revise that if you have forgotten. Now, suppose we have a magnetic material and we want to estimate it say BH characteristic. So, what do we have to do? So, we will first make say a small toroidal ring circular ring with that material which you want to test. So, this is a magnetic material under test and then, we will wound a coil with some number of turns and then, what we will do? We can we have we can do many different things. One possibility is taking a battery, connect an ammeter and take a switch.

The switch is normally closed; NC normally closed. So, initially closed and then, we will open it suddenly. So, open suddenly and when the switch is closed, we can measure this current, I using this ammeter and when this is opened suddenly this I will become 0 immediately right. So, therefore, the current here will become 0 instantaneously when we open this switch. Now, if we change this current, suddenly then the flux. So, the flux; so, the in this core is like this when the current is flowing this flux phi will also become 0, very soon very quickly as soon as you make this I equal to 0 by opening the switch. So, there will be a quick change of the flux.

Now, what we will do we will take a second coil. This is this will be wound here; this is like the secondary; his is also called the search coil. You can call it secondary and we will connect a ballistic galvanometer here. Now, if when I is when I is stopped suddenly, then phi is also phi also becomes 0; becomes also 0 suddenly. So, there will be a change of flux and a change of flux linkage of the secondary coil. So, if this number of turns is N 2, then the change of flux linkage of secondary or search coil is equal to how much. So, this will be initial flux linkage minus final flux linkage; initial flux linkage is phi times into multiplied by sorry minus 0 because final flux is 0.

So, this is Ø N 2 and this we can write as B A N 2. What is B? B is the flux density. What is A? A is the cross-sectional area of this core. So, A is cross sectional area and B is flux density and we say want to measure this B ok. The goal of the experiment is to measure to estimate this flux density B that was present when this current was flowing; when this current I was flowing ok. So, we want to estimate this B. How we will do this? We will is do that using galvanometer. How? Ok.

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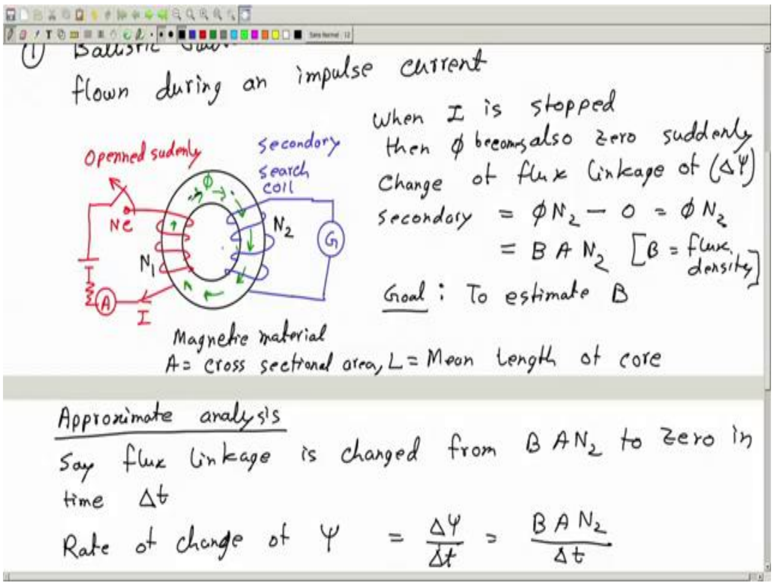

So, the change of flux linkage calls it dφ is given by this quantity and if we assume so approximately. So, let us do this analysis first approximately for ease of understanding. Then, if time permits, we will do it more accurately. So, approximate analysis say flux linkage is changed from this value B A N 2 to 0 in time very small-time dt.

Rate of change of $\varphi = \frac{\Delta\varphi}{\Delta t} = \frac{BAN2}{\Delta t}$

EMF induced in secondary = $\frac{BAN2}{\Delta t} = E$

So, let us call that delta t, let me call everything delta divided by delta t. This is the rate of change of flux linkage. So, how much emf will be generated in this secondary search coil. So, emf induced in secondary will be equal to this rate of change of flux linkage according to Faradays law.

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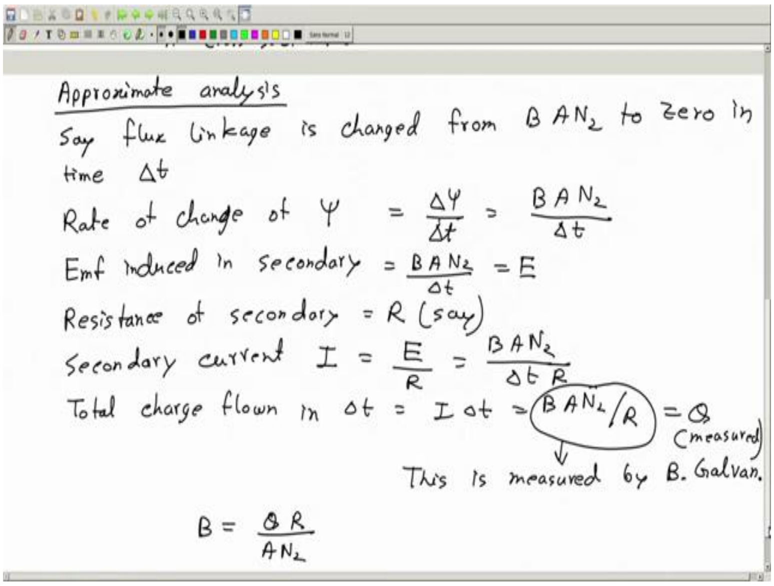

So, this is the current. Now, this current will flow only as long as this emf is there; that means, only as long as this flux linkage is changing and the flux linkage changes within a time of delta t approximately assuming ok.

Resistance of secondary = R

Secondary current = I = E/R = $\frac{BAN2}{\Delta t\ R}$

Total charge flown in Δt = I Δt = $\frac{BAN2}{R}$ = Q

B= $\frac{QR}{A\ N2}$

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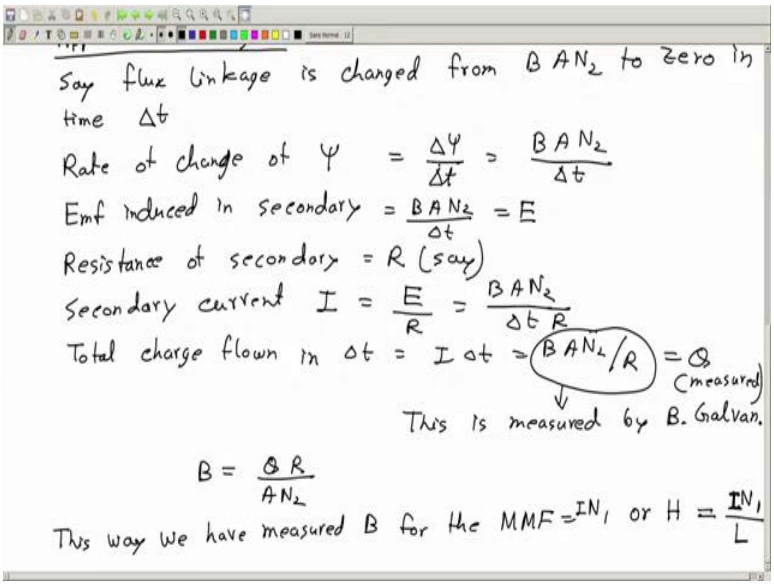

So, this way; o, this way we have measured B for the MMF produced by the primary current. What is the that how much is that? If this current is I and this is N1. Then, MMF was or H ok. So, they so the MMF was I times N1 for the MMF equal to I times N1 or H; H is equal to what, h is equal to MMF I N1 divided by l what is L? L is this length mean length of the core this length. So, this is the mean length of core.

Now, I is observed N1 is known; this mean length can also be known. So, H is known. So, therefore, H is known. B is measured and this way we can measure B for different values of H by selecting different initial currents here and then, we can plot a curve for different values of H, we can plot the values of B and we can get a BH curve. We can also sometimes do a slight variant of this experiment.

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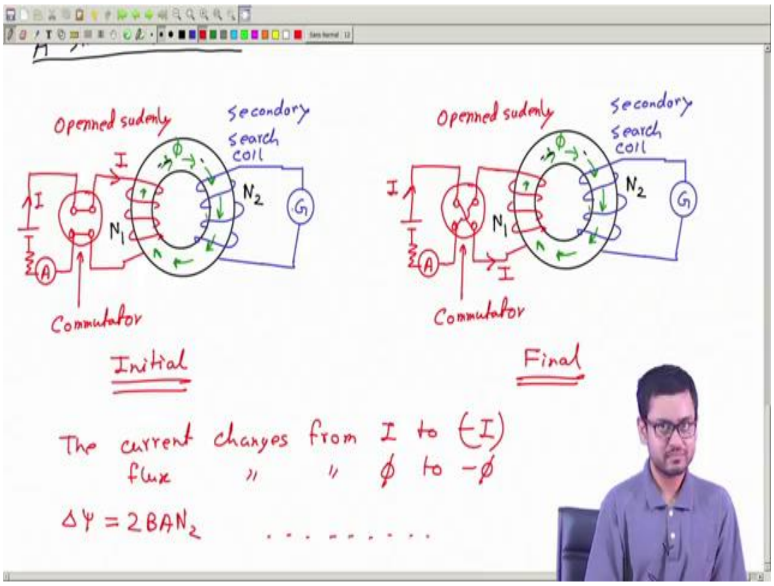

So, which is like this; so, a small variation, so, what we can do is this, we can connect a commutator. I am not good at drawing this commutator. What is this commutator? The commutator means we will say initially say we initially we will have this connected like this ok. Then, current I; this current I is flowing in this direction ok. So, this is initial situation and then, we will suddenly change this switch position like this. This is the final position; then, this current I will now flow in the opposite direction.

So, the current changes from I to (-I); so, total change is double, so, flux will also change from Ø to (-Ø).

$$\Delta\varphi = 2BAN_2$$

you can do the same calculation, but now you have more flux change. So, definitely more emf will be created. So, you will have more current and more charge flown through this. So, the sensitivity of the measurement is increased. So, that is how we can measure flux density.

Thank you.