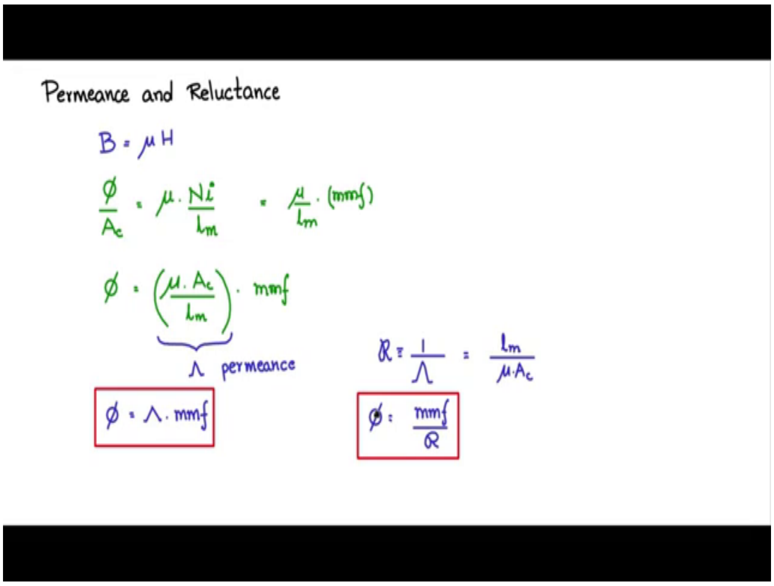
Fundamentals of Power Electronics
Prof. L. Umanand
Department of Electronics Systems Engineering
Indian Institute of Science, Bengaluru

Lecture - 63
Permeance

(Refer Slide Time: 00:27)

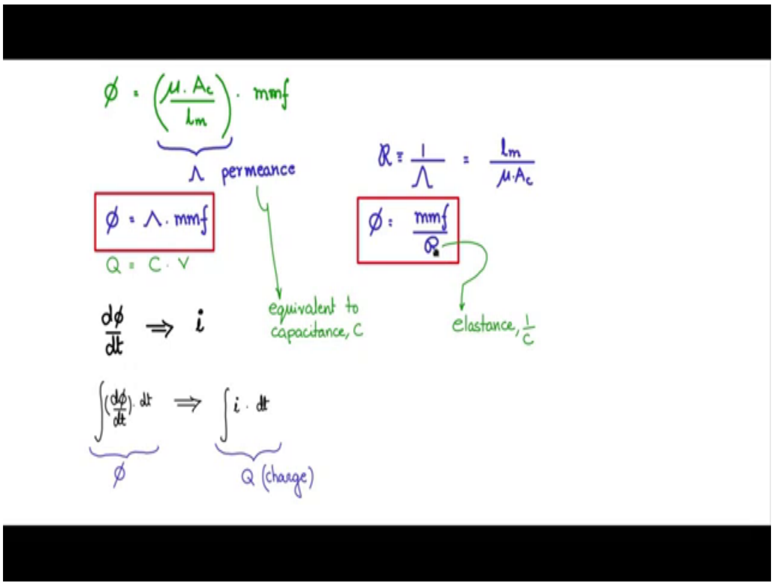


There are another couple of terms that you will come across whenever you are working with magnetics and that is Permeance is one of the term, another is Reluctance they are very well connected. And let us see what this permeance and reluctance means. Let us start with the basic equation B is equal to mu H, this is coming from the B H characteristic for the material. Flux density is equal to permeability mu into H field N i by l m. So, let us replace flux density by flux by area of cross section of flux density and this mu into H is Ni by l m; magnetic path length can be written as mu by l m in to N i is nothing but mmf.

So, flux can be written as mu into A c by l m into mmf. This this term here mu permeability into area of cross section by the magnetic path length is called permeance with this uppercase lambda here. So, it is called permeance and therefore, flux is equal to permeance into mmf this is one important relationship, it is as important as Ohm's law in the electrical domain. This is also written slightly in a different manner, there is another term called reluctance which is frequently used and it is defined basically as one by permeance inverse of the permeance. And therefore, this becomes reluctance is equal to l m by mu naught A c; mu A c. Now, if you if you reframe this you will see that, phi is equal to mmf this portion comes into the denominator into reluctance. So, phi is equal to mmf by reluctance this is also a popular way in which phi flux and mmf are related.

In fact, many of the literatures sometimes people confuse this with the Ohm's law in the electrical domain and call this as current, this is the potential and this equivalent to the resistance. Reluctance is not equal equivalent to the resistor, reluctance is not dissipative quantity and phi here is a not a kinetic term, d phi by dt is the kinetic term as we saw to have to conserve both the units and power it is d phi by dt which is the kinetic term in the magnetic domain and mmf is the potential term.

(Refer Slide Time: 03:49)

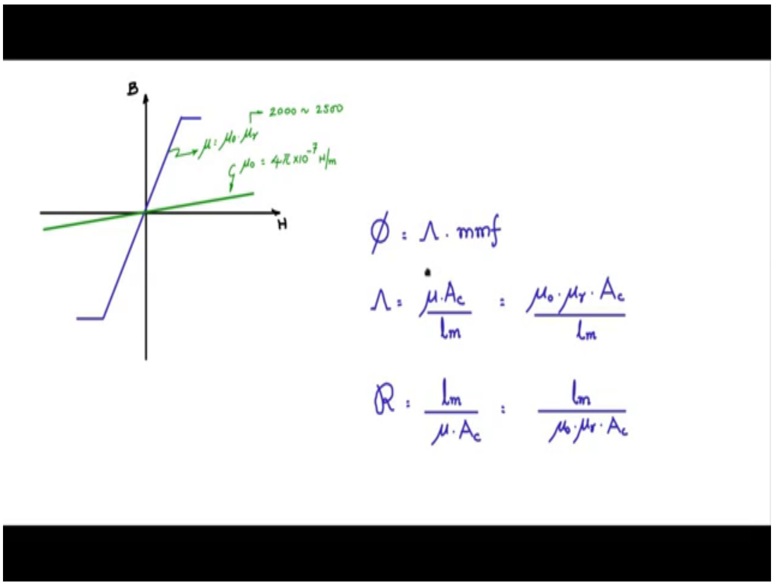


So, let us try to understand this a bit further, we know d phi by dt; d phi by dt we know is the kinetic term or the kinetic variable in the magnetic domain and it is same as the kinetic it is similar to the kinetic term in the electric domain which is current i. So, if I integrate both the kinetic terms, integral of d phi by dt with respect to time and integral of i dt with respect to time, what we get. We know integral of i dt is nothing but charge and second so, this term is nothing but charge Q and what is this term? d phi by dt integrate with respect to t is nothing but integral of d phi or integral which is nothing, but phi. So, this is phi or the flux.

So, if you see the phi the flux is linked more with the charge in the electrical domain you substitute there in this equation, you see how well they fall in place. Now for phi i will replace it with charge Q and with permeance I will put it A c and mmf is; Q is equal to C V V. This is a well founded relationship in the electrical domain and you see the equivalent relationship in the magnetic domain phi is equal to permeance times mmf.

So, permeance is actually behaving like equivalent to the capacitance and in fact, it is so in fact, the energy storage within the magnetic domain is happening in the permeance it is happening in the equivalent capacitance in the magnetic domain. So, what is reluctance? Reluctance is one by capacitance and nothing but elastance ah. Normally the permeance is a much more visualizable term than the elastance; so, elastance is 1 by C. We will be using permeance and the term reluctance in our design of the magnetics frequently therefore, let us just expand this terms a bit more.

(Refer Slide Time: 06:20)



Let me draw the BH BH curve, straight line like this and the saturation parts; now, this is the BH curve of a core. Now, what will be the BH curve of free space, no core in it. So, the slope will be very very low, almost horizontal, but I will show it zoomed with a finite slope like this.

Now, this is the character of free space and it has a value mu naught, we will call that an as mu naught the permeability of free space and it is a constant, it is 4 pi into 10 to the power of minus 7 it has units Henry per meter. Now, this is a constant, universal constant it is the permeability of free space.

Now the moment I introduce a core, we will see that the slope jumps to a very high value and that is mu. Now this mu is having mu naught slope of free space into some correction factor mu r, mu r is the relative permeability it is a numberless; it is a unit less quantity it is just a number. So, this for ferrites varies normally between 2000 to 2500.

What it basically means is that, if this is the slope of free space; the slope of the BH curve in ferrites will jump by a factor of 2000 to 2500 and therefore, it becomes almost vertical. So, this is the relative permeability. So, mu is having two parts, the permeability of free space and that of and that constant part are unit less part which is the scaling factor which scales the free space permeability to get you the permeability of that in the core.

So now if you take this equation phi which is equal to permeance into mmf, permeance is given by mu A by l m that is what we saw here. Permeance is nothing but mu A c by l m and mu gets expanded into mu naught into mu r, mu naught that of free space 4.10 power minus 7 into mu r relative permeability of that particular core which I have going to use area of cross section of the core by the mean magnetic path length lm for the core.

Likewise reluctance is one by permeability which is l m by m u Ac as we saw here and mu can be expanded l m by mu naught mu r Ac. So, this is the relationship between reluctance and the core cross section permeability and the path mean path length and so, also between permeance and the core cross section permeability and the mean path length.