Electrical Measurement And Electronic Instruments
Prof. Avishek Chatterjee
Department of Electrical Engineering
Indian Institute of Technology, Kharagpur

Lecture - 16
Ohmmeters - I

Welcome back. In this video we shall talk about Ohmmeters. In our last video we talked about voltmeters and ammeters. So, this is the time for ohmmeters.

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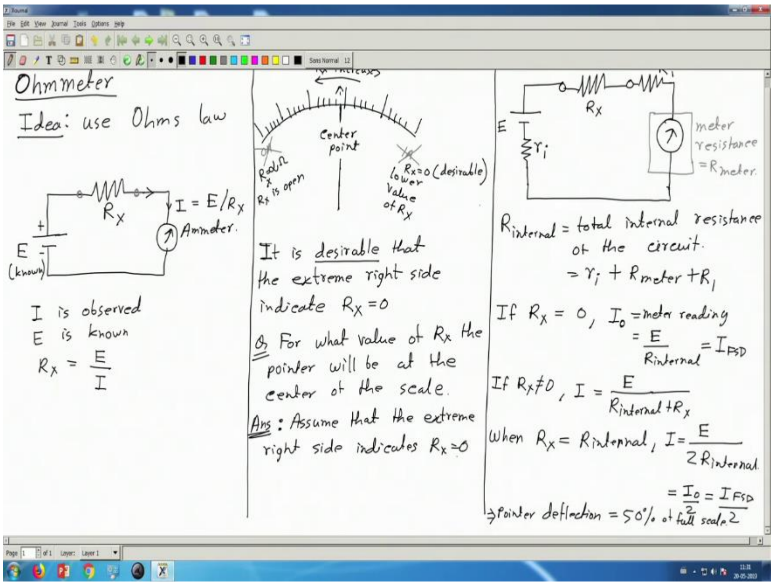

So, as you can expect ohmmeters will be used for measuring resistance and we will use say simple PMMC or may be some other type of meters to make this ohmmeter ok. So, the idea is very simple, the idea is to use Ohms law ok. So, suppose I have resistance call it R X; X stands for unknown. So, R X is a unknown resistance. So, what I can do; I can connect this resistance in series with battery, with known emf and nanometer may be an ammeter ok. So, this can be an ammeter any type of ammeter you like and this E is known or X is unknown.

Now, according to Ohms law the current that will flow through this circuit; that means, through the ohmmeter this current I is given by $\frac{E}{R_x}$. Now, I is observed; that means, by looking at the pointer position of the ammeter we can find the value of I; E it is already known. So, R X can be found as E by I. So, this will be the value of R X ok. So, this is the simple scheme of an ohmmeter ok.

Now, that is the idea. Now, let us talk about this circuit in more detailed let us consider various aspects above of the circuit ok. So, first thing we will discuss is how would the scale of this meter look like once it is marked in terms of resistance or ohms ok; so, this scale of this meter. So, say this is an ammeter.

So, that means the left side within decayed low value of current. So, maybe I write this as the 0 ampere and maybe this is some high value of current maybe just call it 1 ampere. So, this is the behaviour of this meter as an ammeter ok. So, this side should be low current, this side should indicate some higher value of correct.

Now, when we mark this scale in terms of the unknown resistance, because you want to measure resistance with the circuit so, let me erase this and let me put the value of resistances. Now, when R X is infinite if R X is infinite they; that means, R X is open so, then no current flows in this circuit. So, I will be 0. So, I will be 0 when R X is infinite. So, this side; that means, current equal to 0 can be marked as resistance equal to infinite. So, R is equal to infinite ohm this side will be R equal to infinite ohm.

And, this side, so, as I go from the left to the right the current value is increasing which means the resistance is definitely decreasing ok. So, this side will have a lower value of R R X lower this is lower value of R X and this is the higher value of R X. So, this is how this scale of this meter should look like ok. So, this side should have higher value of R X and this is actually infinite because; that means, open circuit R X is open; that means, we remove R X from here. So, we can remove it like this. So, then this point will indicate R X is equal to infinite ok.

Now, what should be the value at the extreme right? So, we may we may desire we may we would like it is desirable that the extreme right of this meter, this is desirable I mean this also logical I mean make ammeter it is convenient to have one side indicating 0 value of the quantity; that means, the resistance that we are measuring. So, this is desirable ok.

So, you remember that this is a desirable condition of this meter this is I mean if you may choose not to maintain this condition because of some other reason you may have, but in general we would like to have this side indicating R X equal to 0 ok. So, this side should be R X equal to 0 in bracket I write desirable ok.

Now so, this side is infinite resistance, this side is 0 resistance and all the other values will be from here to here. So, R X increases from right to left. So, this is so, let me write like this R X increases from right to left unlike voltmeters and ammeters this ohmmeter will have this opposite characteristic and nowadays this is not a very common the analogue multimeters, but if you have seen in analogue multimeter in your lab.

So, analogue multimeter means which has a pointer and you can use it as voltmeter or ohmmeter or ammeter then we will see that the scale for voltage and current has a 0 on the left side and higher value on the right side. But, the resistance scale is opposite 0 on the on this right side and higher value on the left side ok. So, this is how ohmmeter scale look like.

Now, next thing next question is so, consider the center point ok. So, this is the center point all the scale ok. So, what will be the value of R X for which the pointer will be here at the center ok? So, the question is for what value of R X the pointer or the indicator will be at the center of the scale ok. So, to answer this question so, we will assume that the right side the extreme right side indicates R X equal to 0. Suppose I have made this circuit; that means, I have chosen this value of say everything this emf the different parameters of this ammeter such that the right side the extreme right side indicates R X equal to 0 which is a desirable condition.

So, let us say we have this condition this desirable condition fulfilled ok. If so, then what will be the value of the resistance for which the pointer will be at the centre? So, let me draw this circuit once again with bit more details. So, this is the emf E known, so, this that we can have some internal resistance may be r i. So, we are putting more details in this diagram now then here I have the meter and say the internal resistance have this meter. So, this is an ammeter and the meter resistance call it call it R meter ok. So, which can be the coil resistance and if it is an ammeter it can some shunt resistance.

So, the total combination of all the resistances so, that means, between these two points here and here is R meter ok. Now, the unknown resistance R X will be connected between these two terminals. So, this is R X and now let us call R internal equal to total internal resistance of the circuit total internal resistance of the circuit ok. So, which means in this diagram this is equal to r i plus R meter and if I have anything else I am also including conductor resistance that may be negligible, but and if I have anything else in series.

So, let me just put any other resistance which I may have or may not have depending on the requirement. So, if I put any other resistance in this circuit called R 1 so, R 1; so, all this together is called the total internal resistance of this circuit ok. Now, this is R internal; now if R X is equal to 0, then the current that will flow I through this meter that are the meter reading ok.

If $R_x = 0$, $I = \frac{E}{R_{internal}}$

If $R_x \neq 0$, $I = \frac{E}{R_{internal} + Rx}$

So, R internal is all these resistances and R X is here. So, they are in series. So, if add them I get the total circuit resistance and if I divide E with the total resistance I get the meter reading current I ok.

When $R_x = R_{internal}$ $I = \frac{E}{2\, R_{internal}}$

Now, let me denote this as I 0 this one this particular current now this current is the current when R X is equal to 0. So, this is the current I 0 which is for R X equal to 0 and this is also same as I can write this is also same as I FSD of the meter full scale read current of this meter. Why because we have assumed we have assumed that the R X equal to 0 corresponds to the extreme right side extreme right position of the pointer ok. So, when that means, when R X equal to 0 the pointer goes to the extreme right; that means, when R X equal to 0 the full scale deflection current flows through this meter ok. So, this I can also write as I FSD.

If so, now, from here when R X is equal to R internal then I can write this

$$I = I_0 /2 = \frac{I_{FSD}}{2}$$

that means, when R X is equal to R internal the current that will flow through the meter is half of the full scale deflection current which means the pointer deflection will be equal to the 50 percent of the full scale 50 percent of full scale; that means, the pointer will be here at the center ok. So, if I choose R X equal to the total same as the total internal resistance then under that situation the pointer will be here at the center ok. So, you can also so, you can ok.

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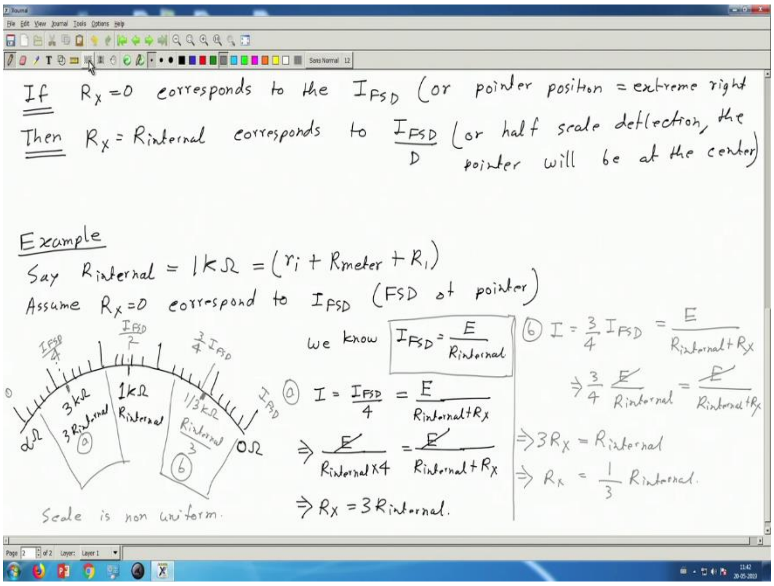

So, let me just write a conclusion saying that if the R X equal to 0 corresponds to the full scale deflection current I FSD; that means, or the pointer movement to the extreme right or pointer position is equal to extreme right then. So, this is if and then R X equal to R internal will be will corresponds will corresponds to full half scale deflect half of the full FSD current or half scale deflection; that means, the pointer will be at the center ok.

Now, let us take an example a small numerical example say R internal is equal to 1 kilo ohm ok. So, this is basically you know this R internal is r i that are resistance per plus meter resistance plus R 1 etcetera anything everything ok. So, say this is equal to 1 kilo ohm. Now, and assume this condition that R X equal to 0 correspond to I FSD full scale deflection or full scale deflection of the pointer full scale deflection of pointer. Now, what we want? We want to mark the or calibrate the different positions on the scale ok.

Now, we know that R X equal to 0 corresponds to the full scale deflection current. So, here we can write 0 ohm; this side we will write infinite ohm R X actually open circuited that means, no current flows and the center point here we will write it as R internal R internal is 1 kilo ohm. Because, when R X will be equal to 1 kilo ohm then half of the full scale deflection current will flow and the pointer will be here. So, this point is 1 kilo ohm position ok.

Now, considered say this position say here which is like a three fourth from the right. So, this is. So, this position is three fourth from the right or you can say one fourth one fourth from the left ok. So, that means so, write it as I_{FSD} /4 ok. So, here if the pointer is here; that means, full scale deflection current flows; if pointer is here no current flows; if the pointer is here at the center; that means, half of the full scale deflection current flows; if it is here that means, one fourth of the full scale deflection current flows.

Now, what we will be the value of the resistance that I should put here on the scale. So, this is the question and let us find out the answer ok. So, we know the current is I_{FSD} /4 ok. So, if the pointer is here then the current that is flowing is equal to I_{FSD} /4 and this current is nothing, $I = \frac{E}{R_{internal} + Rx}$ this is equal to I_{FSD} /4.

Now, for what value of R X this is true?

$$I = \frac{I_{FSD}}{4} = \frac{E}{R_{internal} + Rx}$$

$$\frac{E}{4\, R_{internal}} = \frac{E}{R_{internal} + Rx}$$

$$4\, R_{internal} = R_{internal} + Rx$$

$$R_X = 3\ R_{internal}$$

what will be this position say three fourth of FSD say this position which is I FSD multiplied by three fourth ok. So, what will be this value of resistance. So, let us find that out ok. So, this is for position. So, this calculation was for position a.

Now, now for position b, let us do the similar calculation once again it will also be our practice. So, for this position I is equal to three fourth of full scale deflection current and this is same as

$$I = \frac{3\, I_{FSD}}{4} = \frac{E}{R_{internal} + Rx}$$

$$\frac{3\,E}{4\,R_{internal}} = \frac{E}{R_{internal} + \mathrm{Rx}}$$

$R_X = 1/3\ R_{internal}$

when R internal is 1 kilo ohm then this value will be 1 by 3 kilo ohm. So, let us put the value. So, this is 1 by 3 kilo ohm same as R internal by 3 in general. So, this is position b. So, this is the position b this is position a ok. So, that is how you can find mark all other positions on the scale.

And, now you observe that this scale is non uniform non-linear. So, scale is non-uniform show from 0 to one third of a kilo ohms this is like theta 333 ohm this region is here, then here I have one third kilo ohm to 3 kilo ohm here I have everything from 3 kilo ohm to infinite ok. So now, next question we will ask is this.

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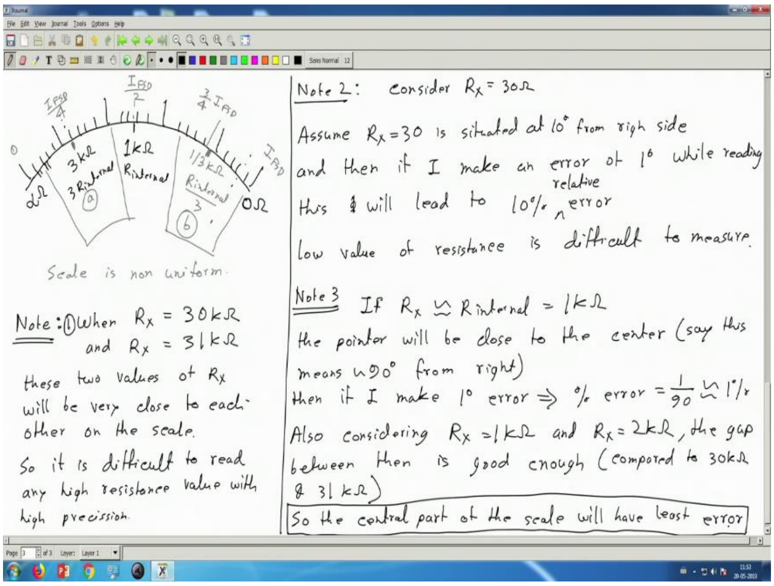

So, let me copy this diagram ok. So, now, let us ask another question. Which region is good to use in a sense that I mean for what value of the R X in this meter we can measure it with better accuracy better appreciation ok. Say now ok. So, note when say R X is equal to say 30 kilo ohm and another situation R X is equal to say 31 kilo ohm.

The these two conditions so, this two values of R X will be very close to each other on this scale will be very close to each other on the scale ok. Say this is 3 kilo ohm, maybe 30 kilo ohm will be somewhere here and 31 kilo ohm will be very close to it and therefore, is difficult to read the difference between these two because the pointer will be so close for R X is equal to 30 and 31 is very difficult to distinguish between these two values.

And, you see all high values of R X that in a very small region within this 25 percent of the scale we have everything from 3 kilo ohm to infinite. And, then say for example, now if I have 1 mega ohm and 2 mega ohm, those two will also be very close and we cannot distinguish easily between those two positions ok. So, it is very difficult to read resistances values which are very of very high value ok. So, it is difficult to distinguish or let us say it is difficult to read the read the read any high value of resistance with say high precession ok.

Similarly, so, this is true for high value of resistance. So, this is say note 1. Now, similarly, say another note 2 consider low value of resistance ok; consider very low value of resistance. See consider R X equal to say this is this point is around 300 ohm. So, let us consider something like R X equal to say 30 ohm and so, so what will happen the pointer will be somewhere here almost close to 0 ok.

So, here also if like I make say a small a dot in reading the pointer position see I make an error of due to say parallel x error, I make an error of say may be 1 degree. And, this 1 degree will correspond to a high relative error say because say this position R X is R X is equal to 3 30 ohm is say here at 10 degree.

So, assume R X equal to 30 degree is situated at 10 degree from right from the from right side and then if I make an error of see 1 degree while reading at noting the value of the value of a pointer then this will lead to; so, this is like 1 degree out of 10 degree. So, this will lead to 10 percent error in a 10 percent relative error or percent error you can say a 10 percent error in measured resistance and 1 degree error I can say make due to parallax error.

So, once again conclusion is a low value of resistance is difficult to measure and finally, say if R X is close to R internal; see in this case this is equal to 1 kilo ohm, then you see the pointer see quite far from the extreme right ok. So, maybe this angle is almost 90 degree ok. So, then this position is almost 90 degree I even if I make 1 degree error. So, one out of 90 is almost like 1 percent ok. So, so if R X is equal to R internal the pointer will be close to the center and say this means 90 degree is approximately, see this is 90 degree from the right.

Then, if I make 1 degree error this will lead to a percentage error of 1 over 90, approximately how much it will be I mean this approximately 1 percent much less than this and also so, this is 1 kilo ohm. Now, consider the value of 1 kilo ohm and 2 kilo ohm also considering R X equal to 1 kilo ohm and R X equal to 2 kilo ohm the gap between then is good enough ok.

So, 1 kilo ohm is here when 2 kilo ohm will be somewhere here between 1 and 3. So, we will have a sufficient gap between 1 and 2, compared to say 30 and 31 which have very close to each other. So, this gap between them is good enough compared to 30 kilo ohm and 31 kilo ohm ok. So, it is difficult to distinguish 30 and 31 kilo ohm, but it is easy to distinguish 1 and 2 kilo ohm ok.

So, this central part is most ideal region is the best region where the precession of our measurement will be most it is accuracy will be most. So, the conclusion is so, the central part of the scale will have best precession or accuracy right now we have not defined this terms formally 8 we will do that later. So, let me write we will have least error we will have. So, this is the important observation.

Now, next what we should do? Therefore, depending on the value of the resistance that we want to measure we should alter the markings of this scale ok. So, if we want to measure say 10 kilo ohm resistance or a resistance which is close to 10 kilo ohm then we should somehow change the circuit. So, that 10 kilo ohm comes at the center ok. So, this will be the focus of our next video. So, let us continue with ohmmeter in our next video. Thank you.

Thanks for watching.