Electrical Measurement And Electronic Instruments
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Lecture - 17
Ohmmeters - II

Welcome back. We are discussing Ohmmeters and particularly the skill of the ohmmeter.

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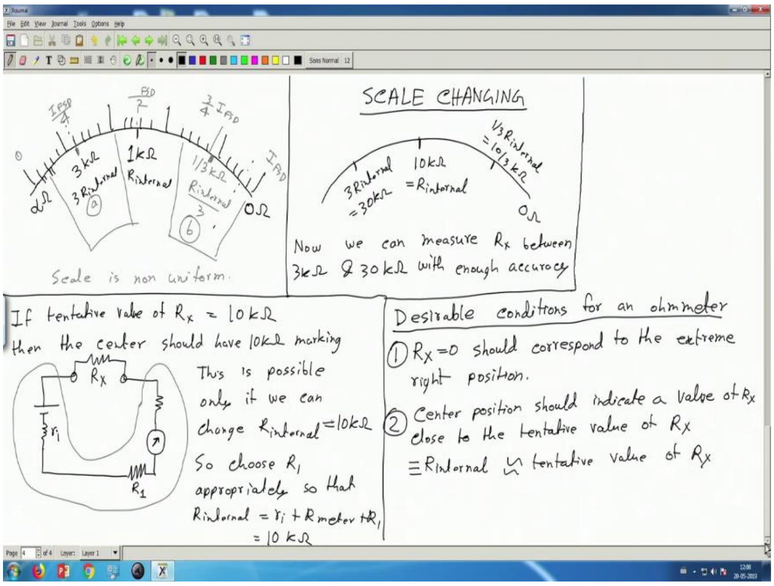

And in our last video you have seen that so, the scale of the ohmmeter is non uniform 0 on one side; infinite on the other side and the center of the scale correspond to the unknown resistance equal to the total internal resistance of the circuit. Now, and we also said that if the R internal is equal to 1 kilo ohm, then with this ohmmeter we can measured registers values which are which is say between one third of a kilo ohm and 3 kilo ohm quite accurately, but it is difficult to measure resistance value which is higher than 3 kilo ohm or much higher than 3 kilo ohm or which is close to 0 or lower than this one third of a kilo ohm.

Now, suppose I have a resistance which I know has a value of say 10 kilo ohm or around 10 kilo ohm then this ohmmeter is not good to measure that resistance or if I have a resisters whose value I know is about 100 ohm or 50 ohm, again then this particular ohmmeter is not good to measure that resistance. What can we do? We need another ohmmeter another ohmmeter whose skill will have the center point. So, this the center point equal to the tentative value of the unknown resistance that we are measuring ok.

So, if the tentative value of R X is equal to say 10 kilo ohm, then the center should have 10 kilo ohm marking. How is that possible? Because the center always correspond to the value of the total internal resistance. What is the total internal resistance? Let us draw the circuit once again. The battery then we have the X the unknown resistance then we have we may have everything else battery resistance r i then we may have the meter resistance everything. So, that is everything together is the total internal resistance. So, everything means everything here ok.

So, everything here is the total internal resistance and the center point always correspond to half of the sorry equal to the total internal resistance provided the extreme right position correspond to R X equal to 0, that is what we have seen ok. Now, we need the center point to have a value of 10 kilo ohm. This is only possible this is possible only if we can change R internal equal to 10 kilo ohm that is not difficult according to our previous example where we had R internal equal to say 1 kilo ohm.

Now, we can add serious resistance. So, let us add serious resistance here which may be 9 kilo ohm call it R 1. So, choose the value of R 1. So, that the total internal resistance becomes 10 kilo ohm then the scale of the meter will be altered. So, choose R 1 appropriately so that R internal which is same as r i plus R meter plus R 1 this should be equal to 10 kilo ohm or whatever value you desire or whatever is the value of tentative value of R X that you want to measure and therefore, the scale of this meter will be get altered like this. This side will be 0 ohm; this position will become 10 kilo ohm; once again this is same as R internal.

But, now we have changed the value of R internal by adding an appropriate series resistance in the circuit and this position will again correspond to 3 times R internal which will now be equal to 3 kilo ohm this position will equal to one third of R internal which is same as now 10 by 3 kilo ohm ok. So, now, we can measure any resistance between 3 kilo ohm and 30 kilo ohm with good enough accuracy. So, now, we can measure R X between 3 kilo ohm and 30 kilo ohm with enough accuracy ok.

And if I want to measure something like 1 mega ohm I have to add a higher value of R 1. So, that this becomes 1 mega ohm and so on. So, this is how we can change the scale of the ohmmeter. So, this topic that we are discussing today we can call it. So, let us give it a name scale changing or of an ohmmeter.

So, now let us write to desirable conditions for an ohmmeter in this desirable conditions for an ohmmeter. One of them we already have seen we already have mentioned is that R X equal to 0 should correspond to the extreme right position and the second thing is that the center position should indicate a value of R X close to the tentative value of R X unknown resisters. So, if I measuring an unknown resistance I generally will have an idea of the value of R X is it of the order of 10 ohms or 100 ohms or kilo ohms or mega ohms.

So, I may have a tentative idea and accordingly I should have the scale of the meter somehow. I have to add just the scale of the meter so that the center position is has a value which is close to the tentative value of the R X and this condition we can also write as that R internal because the center position indicates R internal and we want this value to be close to the tentative value of the unknown resistance which means R internal should be approximately close to the tentative value of R X ok.

So, depending on what value of R X or what range of R X I want to measure I should be able to change the R internal and I also need a provision for adjusting the so that the extreme light position here corresponds to R X equal to 0 ok.

So, far we have assumed that the first fact is true, I mean and we have not said how to achieve this and the other requirement the second requirement this we already have indicated that by choosing the value of the series resistance R 1 we can make this second criteria fulfilled ok. So, now, let us talk about how we can adjust the circuit so that R X equal to 0, correspond to extreme right position.

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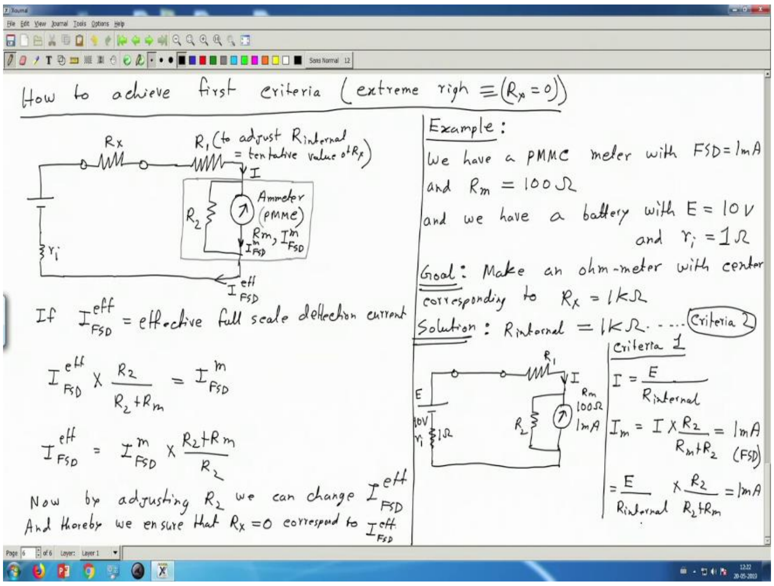

So, how to achieve fast criteria that means, extreme right correspond to R X equal to 0. So, how to achieve that? And so, how we will do it? So, this will be done by; so, let me draw this the draw the circuit. So, I am drawing these terminals because R X is an external element that will connect to the circuit and everything else is internal to the circuit internal to the ohmmeter ok.

Now, the so, here we will have the R 1 in series and then we will have the meter. So, this can be a PMMC meter for example, this R 1 we will need this is primarily to adjust R X not R X R internal is equal to tentative value of R X and we will put a shunt call it R 2 R 1 and R 2. So, we will put a shunt with this ammeter. So, this is an ammeter; this can be a PMMC meter for example and we will put as a shunt just like ordinary ammeters and what is the purpose of this shunt? This shunt will bypass some amount of current which flows in the main circuit.

If this current is I only a fraction of this current will flow through this meter and the remaining part will go through R i and thereby this will alter the effective full scale deflection current of this combination R 2 and the meter in parallel. So, the effective full scale deflection current of this arrangement will get increased. For example, say if I call for this meter say for this meter the internal resistance is R m. So, the meter has a in turn call resistance you can say call resistance of R m and the full scale deflection current of this meter is I FSD. So, let us call it I FSD m; m for meter ok.

Then the effective I full scale deflection current will be how much? Say so, if I call it FSD effective ok; that means, the current which flows in this main circuit I effective full scale deflection current if this is the effective full scale deflection current, then the current that goes through the meter is sufficient to bring the pointer to the extreme right ok. So, then when by this I mean when this amount of current is flowing through the main circuit the pointer goes to the extreme right which means at that could moment this current will be same as I FSD; I FSD of m ok.

So, we can write

$$I_{FSD}^{eff} \text{ x } \frac{R_2}{R_2+R_m} = I_{FSD}^{m}$$

$$I_{FSD}^{eff} = I_{FSD}^{m} \; x \; \frac{R_2 + R_m}{R_2}$$

Now, by adjusting R 2 we can change effective full scale deflection current ok.

Now, and therefore and thereby we can and thereby we ensure we can ensure that R X equal to 0 correspond to the effective full scale deflection current. So, by choosing a proper value of R 2 along with a proper value of R 1, we can change the effective full scale deflection current so that the so that when R X equal to 0 the current that flows will bring the pointer to the full scale position ok. So, I think this will be more clear if we take some example ok. So, let us take an example numeric example ok.

So, say we the problem is we have a PMMC meter with full scale deflection current is equal to say 1 milliampere and the call resistance say R m. So, this is the meter resistance let us call this 100 ohm and we also have and we have a battery with say EMF is equal to 10 volt and say r i internal resistance equal to 1 ohm. And the goal is to make so make an ohmmeter with centered corresponding to R X equal to 1 kilo ohm.

So, that means, this means we want to make a ohmmeter which will measure resistances near 1 kilo ohm ok. So, how to attach this? So, solution; so, first requirement is that R internal ok; so, total the internal resistance must be equal to 1 kilo ohm because we want to measure unknown resistance which is close to 1 kilo ohm. So, the total internal resistance should be 1 kilo ohm ok.

Now, if so, let us draw the circuit and this is also an R i; 1 ohm; this is 100 ohm and I FSD is 1 milliampere ok. Now, so, this is the point these are the terminals between which I will connect the external resistance unknown resistance. Now, we want when this is equal to 0; that means, a short circuit like this the pointer should go to the extreme right full scale deflection that is what you want. Now, when this is equal to 0 so, according to condition 1 or criteria 1 so, we can write here. So, this is e equal to 10 volt. So, according to the criteria 1, when we have a short circuit here, then the current that flows through the meter should be 1 milliampere.

Now, how much current will flow through the meter? Before that what will be this current I? This current I the total current through this short circuit I will be equal to E by I can write it as R internal total internal resistance including this R i the comparable combination of R 2 and R m, then R 1 everything together is R internal. This current is the current through the unknown resistance or this short circuit ok.

Now, according to criteria 1,I should have meter current let us write it I m

$$\frac{10V}{1kohm} \text{ x } \frac{R_2}{R_2+R_m} = 1\text{mA}$$

$$10\ R_2 = R_2 + R_m$$

$$R_2 = R_m/9$$

$$R_2 = \frac{100}{9} ohm$$

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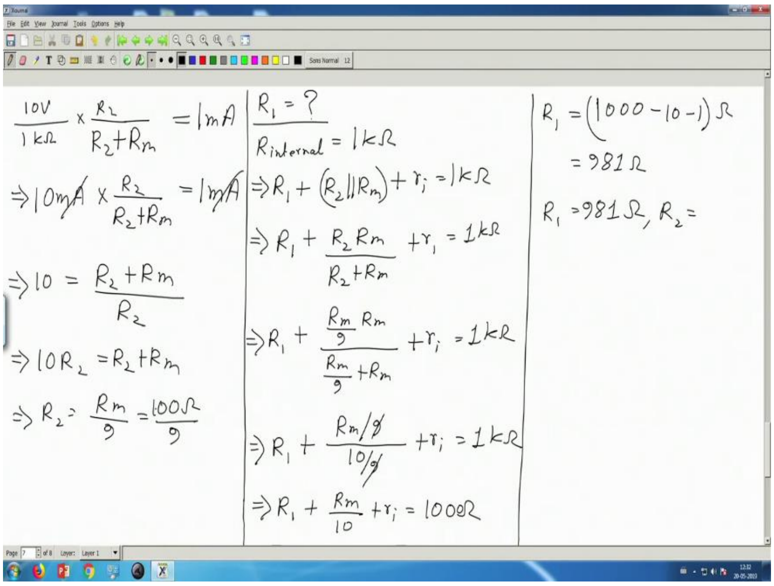

So, this way we can find the value of required value of these unregisterd R 2. Now, once we know the value of R 2. Let us find the value of R 1 ok. Now, so, R 1 is equal to what? So, this is the question next question ok. So, let us go back to this circuit. We know the total internal resistance is 1 kilo ohm and so, right let us write R internal is equal to 1 kilo ohm.

$R_1 + (R_2 \parallel R_m) + r_i = 1\text{k ohm}$

$R_1 + \frac{R_2 R_m}{R_2 + R_m} + r_i = 1\text{k ohm}$

$R_1 + \frac{R_{m/9}\, R_m}{R_m/9 + R_m} + r_i = 1\text{k ohm}$

$R_1 + R_m/10 + r_i = 1000 \text{ ohm}$

$R_{1=}$ 1000-10-1

$R_1 = 981$ ohm , $R_2 = 100/9$ ohm

Number 1; one side of this scale that is the right side should indicate zero resistance and the second condition is that the center part where we have higher accuracy of measurement because here these scale is spread out enough ok. So, the center part should have a value equal to the tentative value of the unknown resistance.

So, these are the two conditions we would like to have in an ohmmeter before we design ohmmeter circuit and to fulfill two conditions we need two controls ok. Always if I need if I have two criteria to meet I need two flexibilities two controls and these two controls come to me in the form of R 1 and R 2. I can change the value of R 1; I can change the value of R 2 to get two condition satisfying.

This R 2 as a bypass resistance will control the full scale deflection effective full scale deflection current of this arrangement, thereby ensuring that the extreme right position of the meter correspond to R X equal to 0. And by changing the value of R 1 I can change the total internal resistance of the circuit they are by ensuring the center part of the scale correspond to the tentative unknown resistance ok.

So, thank you. That is all about ohmmeters.