**Electrical Measurement And Electronic Instruments**

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**Lecture - 13**
**Ammeter – I**

Hello and welcome. Today we are going to start our second chapter in this course of Electrical Measurements.

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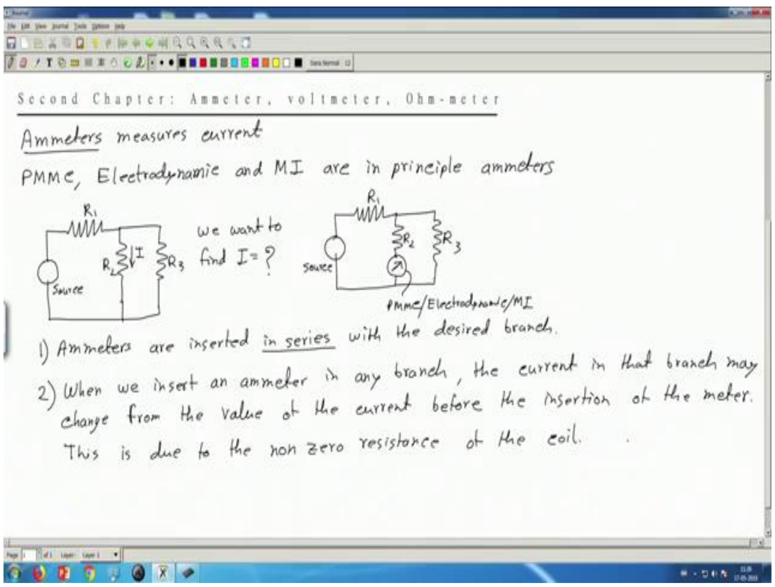


And this chapter is going to be on Ammeters, voltmeters and ohmmeters. So, let us a begin this talk with ammeters. Ammeters as you all know it measures current and so, far we have studied instruments like PMMC, electrodynamic, moving in moving iron. So PMMC, electrodynamic and moving iron.

So, this three types of instruments are inherently or in principle ammeters. Why I am saying so, because you know that if we pass any current through the coil or the coils of these instruments the pointer moves. So, the pointer responds directly to the current which is flowing through the coil or the coils of these instruments. So, these instruments are directly like ammeters. So, we can measure current with this any of these instruments. Now, suppose if I can have a circuit which can be very complicated.

But so, let me take circuit you can think of a very complicated circuit and see that I want to find the current in any of these branches say in this branch call it I. So, we want to find I equal to what, how much is this current? So, what do we have to do? We have to cut open this branch. So, we have to open this branch and insert ammeter here in series. So, this meter can be PMMC this can or electrodynamic or MI. So, this is this can be PMMC, can be electrodynamic or MI in principle.

So, the choice with the also depend on the type of this circuit may be AC, DC etcetera. So, right now let me just put a source without mentioning exactly what type of source it is ok. So, we have to insert this meter in this branch in series ok. So, the important thing to note or know about ammeters is that ammeters are inserted in series with the desired branch, where we want to measure the current ok. Now, this is one important fact which I believe all of you know; the next thing which we should know is that the. So, when we insert this ammeter in this branch the impedance of this branch will change.

So, this coil the coil of this instrument has some resistance. So, the resistance of this branch will increase and therefore, the current in this branch may decrease ok. So, the so, when we insert an ammeter in any branch of an electrical circuit, the current in that branch may change or will always actually change slightly so, will always change. So, this current in that branch may change from the value of the current before the insertion of the meter ok. So, this happens because of the resistance of the coil. So, this is due to the non-zero resistance of the coil of the meter ok.

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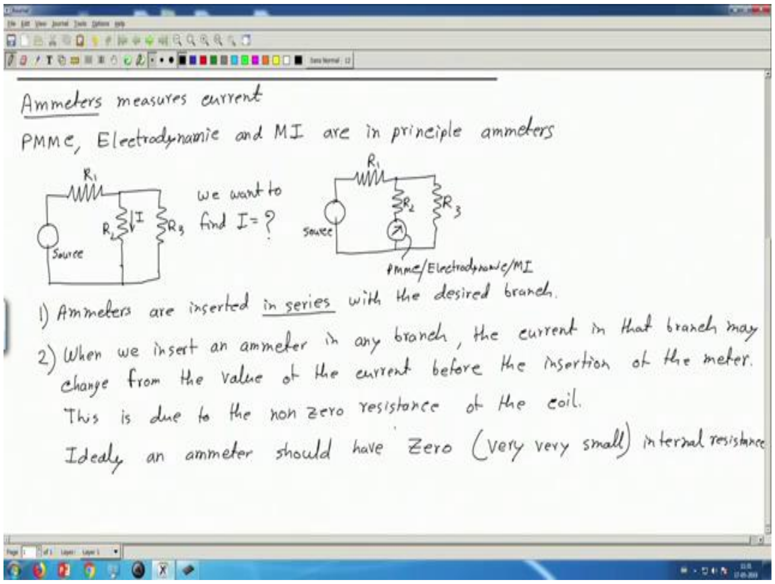


So, therefore, ideally what we would like to have is that the ammeter should have zero internal resistance, zero internal impedance. So, ideally we would like to have so, zero is never possible. So, practically we should write very small internal impedance or resistance. So, this is the second fact about the ammeters, we would like the ammeters to have very low internal resistance or internal impedance ok. Now, let us take an example.

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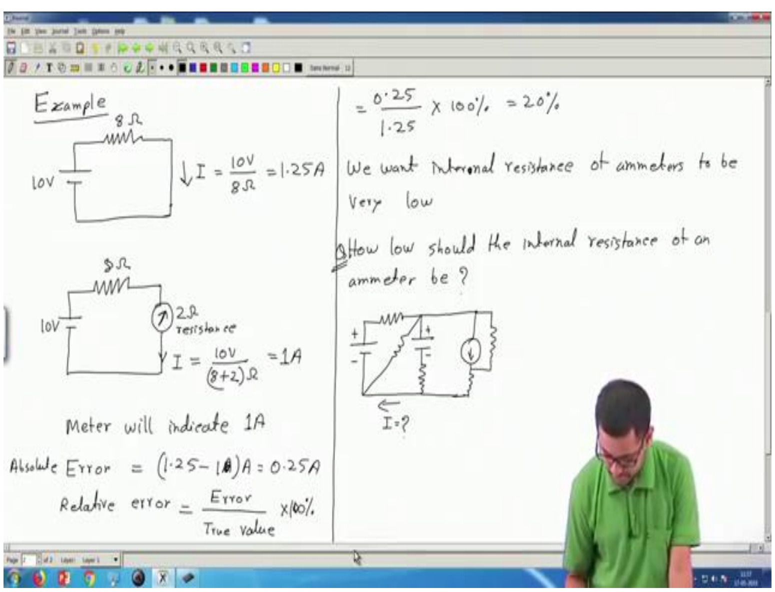

So, let us take a small example; suppose I have a circuit very simple circuit say a 10 volt source which has 8 ohm resistance in series and then some current is flowing in this branch. So, what will be this current? This current I will be equal to 10 volt divided by 8 ohm, this will be 1.25 ampere. Now, say I have an ammeter which has his internal resistance of 2 ohm for example, and I want to measure this current. So, I am inserting the ammeter 2 ohm resistance.

So, this is 8 ohm, this is 10 volt; now the current that will flow in this branch I this will become 10 volt divided by 8 plus 2 ohm which is 1 ampere and this 1 ampere is not same as 1.25 ampere. So therefore, we have a difference between the current that was actually flowing in the circuit and the current which is now flowing after the insertion of the meter. So, the meter will indicate 1 ampere whereas, if we are interested in the value of the current that was flowing actually in the original circuit that was different. So, therefore, we have an error ok. So, the error in this case is quite large error is therefore, we can write this as 1.25 minus 1 ampere.

This is like 0.25 ampere and this we call the absolute error and if we want to measure say relative error and we can define it as the error divided by true value. We can also define it as error divided by the measured value depending on the situation into 100 percent. So, this will come out to be 0.25 divided by true current was 1.25 so, this is like 1 over 5. So, this is 25 percent which is quite large in this case. So, ideally we would like to have the internal resistance of any ammeter very low ok. So, we want once again internal resistance of ammeters to be very low.

So, this is quite obvious now let us ask a more involved question which is to say how low is good enough; I mean how low is low enough for an ammeter ok. So, how low should the internal resistance of an ammeter be? So, this is the question we are asking now and the answer is actually right in front of us ok. So, we have seen a very simple circuit which is made up of a voltage source and resistance in series. But, if we had a complicated circuit any complicated circuit think of any complicated network.

So, think of very complicated network as a complicated as you can think of. So, let me also put some current sources and say then there is a branch in this circuit where we want to measure the current; say we want to measure the current in this branch.

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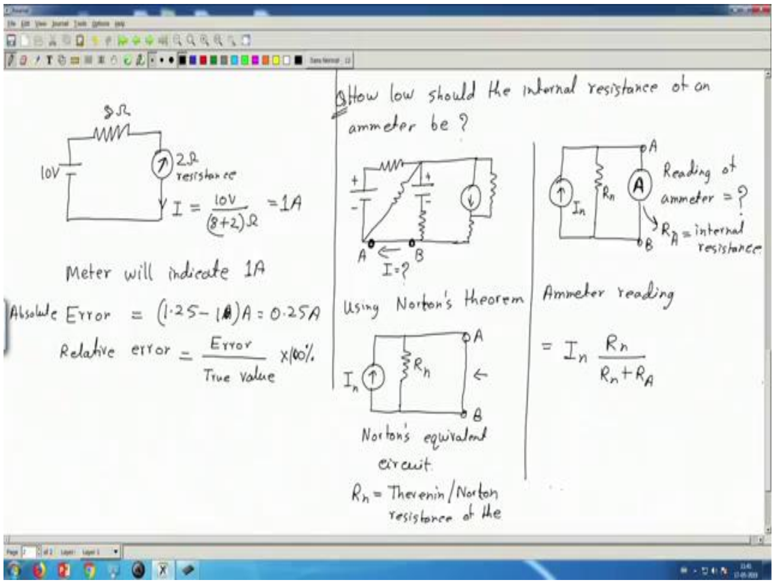


So, now how low should the internal resistance of the ammeter be to measure the current in this branch? The answer lies in the fact that according to Norton’s theorem any complicated circuit can always be reduced in a simple circuit, looking from; looking from the this bit looking from the perspective of this branch between so, where we want to measure the current.

So, using Norton’s theorem we can always find a simplified circuit called these two points as A and B. So, we can always find a simplified circuit with one current source and some series and some parallel impedance or resistance in this case, call it R n, call these current source as I n.

This is point A and this is point B, these two are connected joint by this branch which is a short circuit ok. I mean which is a zero resistance branch and we want to measure the current in this branch ok. So, this is the general scenario always. Now we will so, this is the equivalent circuit and this is the impedance R n as seen from the perspective of these two terminals A and B, as seen from this side ok. So, this is the internal resistance of this circuit R n Norton’s resistance is also same as Thevenin resistance ok. Now, we will put the ammeter there ok. So, this is the symbol of an ammeter and this is terminal A, terminal B, this is R n, this is I n.

Now, the question is what will be the reading of this ammeter? Now, the reading of this ammeter will be will depend on the internal resistance of this ammeter; say the internal resistance R i is the or call it R A is the internal resistance ok. Then the current that will flow through this ammeter that will be the ammeter reading,

$$\text{Ammeter reading } (I_A) = I_{sc}\,\frac{R_n}{R_n+R_A}$$

$$I_A \approx I_{sc} \qquad \text{when } R_A << R_n$$

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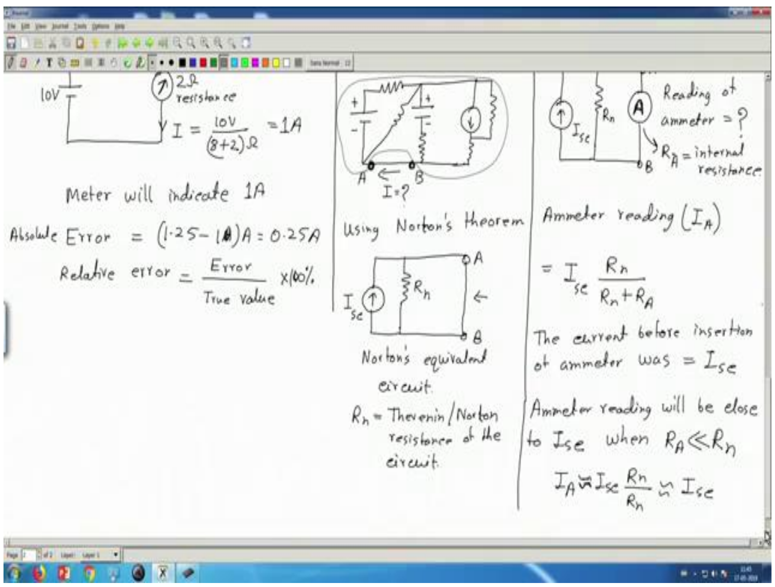


And so, this will be the ammeter reading, but the true current that was flowing in this branch before the insertion of the ammeter that was I n. So, this was the short circuit current ok. So, we can actually we often denote this as I short circuit I sc, this is I sc because this is this short circuit current as seen from as terminal A B ok. So, the current before insertion of ammeter was I sc. So, now the ammeter reading we want this to be close to I sc or same as I sc ideally and that will be true only if.

So, ammeter reading will be close to I sc that is the actual current that was flowing before the insertion of the meter when. So, ammeter reading will be close to I sc when this factor is close to 1. Now, when will this factor be close to 1? Only if R A is much less than R n, when R A is much much less than R n because then so, call this I A ammeter reading. Then I A will be I sc multiplied by R n by R n we can neglect R A because R A is much smaller than R n. So, this is approximately true and this will be equal to I sc.

So, this is the condition we want. So, we want the ammeter resistance to be much much smaller than the internal resistance of the actual circuit as seen from these two terminals. So that means, the internal resistance of so, the internal resistance of this circuit as seen from the terminal A B that is R n should be much higher than the ammeter internal resistance of the ammeter, then only our reading will be close to the correct value. So, in our next video we will talk about multi-range ammeters and we will stop in this video here.

Thank you.