**Electrical Measurement And Electronic Instruments**
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**Lecture - 18**
**Rectifier based Voltmeters and Ammeter – 1**

Hello and welcome. So, we are continuing with our second chapter which is on ammeter, voltmeters and ohmmeters. And, in this particular video we will talk about Rectifier based Voltmeters and Ammeters so that we can measure AC as well.

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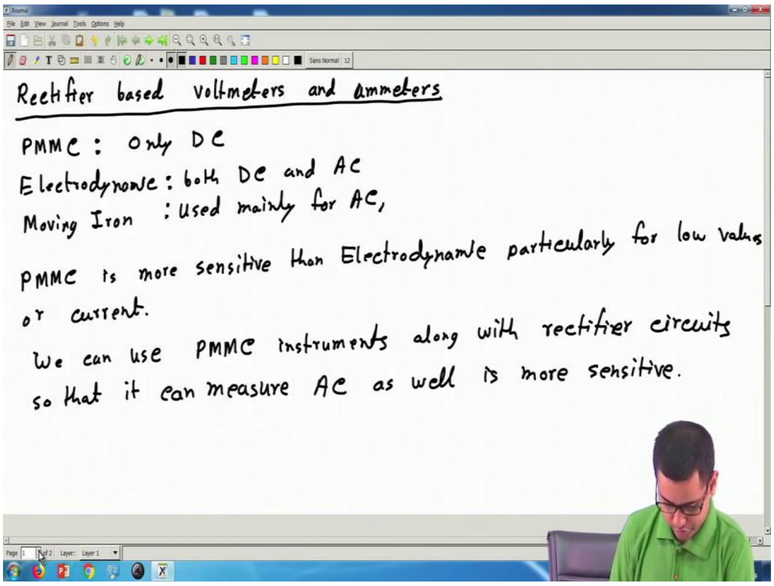


So, the reason we are considering this is, let us recall what are the instruments that we have studied? We have studied PMMC instruments, we have studied electro dynamic and moving iron instruments ok. And, we know that PMMC can measure only DC and this can measure either DC or AC in principle.

So, in principle this can measure both DC and AC also this can measure both DC and AC, but generally as we have seen generally this instrument is not used for measuring DC ok. So, this is used mainly for AC. In principle it can measure DC, but we do not use this for DC measurement because of the retentivity or residual magnetism problem which we have discussed before ok. So, this is mainly for used mainly for AC.

And, now if we compare PMMC and electro dynamic recall that we have said that PMMC is more sensitive than electro dynamic particularly for low values of current or maybe voltage ok. This is because PMMC has a permanent magnet; this does not have a permanent magnet and the magnetic field in this instrument is again created by the unknown current. Therefore, if the current is low in this instrument electro dynamic both the magnetic field and current both of them becomes low. So, the torque becomes lower.

Here at least the magnetic field flux density b e is not changing. So, b e is always same; current is low for low currents. So, this is not the torque in this instrument is not as low as electro dynamic instruments. Therefore, PMMC instruments have some advantages like this is more sensitive to low value of the current, but it cannot measure AC.

Now, we can use PMMC so, which is a DC meter instruments in conjunction with or along with rectifier circuits so that it can measure both AC, I mean it can measure AC as well as is more sensitive particularly when we are measuring low values of current ok. So, therefore, in this video we will talk about rectifier based meters.

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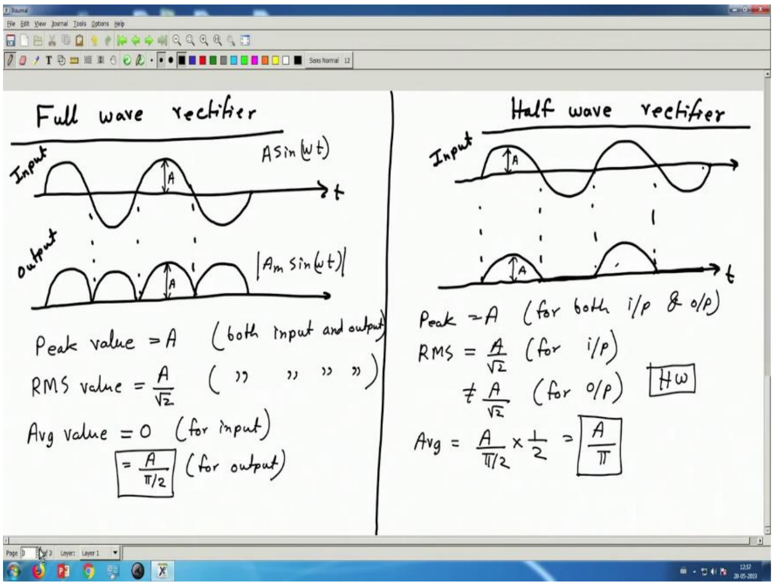


Now, rectifier you may already have studied rectifiers in your first year or maybe in your earlier courses, but let us recall it ok. So, generally we can have two types of rectifiers which you call as full wave rectifier and half wave rectifier ok. So, we will come to the circuit in a while till then let us see what they does.

So, if I give an input which is sinusoidal; so, this is input. For full wave rectifier the output will be like this; but for half wave rectifier for the same input it will look like this. So, rectifier is a circuit which takes sinusoidal input and gives output which is like this for full wave rectifier and for half wave rectifier it will be like this; positive halves will remain unchanged, negative halves will become 0. So, positive half as it is negative half is it is going to be 0 here as well and in this case positive halves are unchanged negative halves are reversed ok. So, this is what a full wave rectifier and a half wave rectifier does.

Now, let us call this waveform as say this waveform is $V_m$ sin ($\omega$t) ok. So, $V_m$ is what is the peak value of the voltage or current ok; so, let me call it A m because it can be voltage it can be current in general, so, let me call it A m. So, A m is this much and here again this will be A m. This output you can write it as possibly mod of A m sin omega t. In this circuit also this is A m peak value ok. So, this is the peak value and let me just use A for simplicity ok, see here also it will be A ok.

So, the peak value is equal to A for both input and output ok. Now, the RMS value root mean square value will be $\frac{A}{\sqrt{2}}$ once again this is true for both input and output. So, I guess you know how to find the RMS value of a sinusoidal wave. And, the average value so, for input 0 because it is positive for half of the times, negative for half of the times. So, for input and for output this will be $\frac{A}{\pi/2}$ for output ok. Once again I am assuming that you know how to find the average value by integrating over a complete cycle or half cycle you can do it.

So, in this case peak is once again if peak is A then RMS will be how much? It will not be equal to ok. So, peak is A for both input and output RMS is equal to $\frac{A}{\sqrt{2}}$ for input, but will not be equal to $\frac{A}{\sqrt{2}}$ ok. So, exercise what will be the value ok, homework. Find out the value of the RMS for half wave rectifier waveform ok.

And, then average this will be $\frac{A}{\pi/2}$ it was for this full wave rectified waveform and now, in this case we see that half of the times the waveform is absent like here it was present here it is absent. So, the average will definitely will be reduced by a factor of 2. So, this will become half of this. So, this will be $\frac{A}{\pi}$ ok. So, these relationships you should be able to derive it on your own and you should remember it always throughout this course ok. So, particularly important relationships are this average value equal to this for this is for full wave; this is for half wave. You must always know this.

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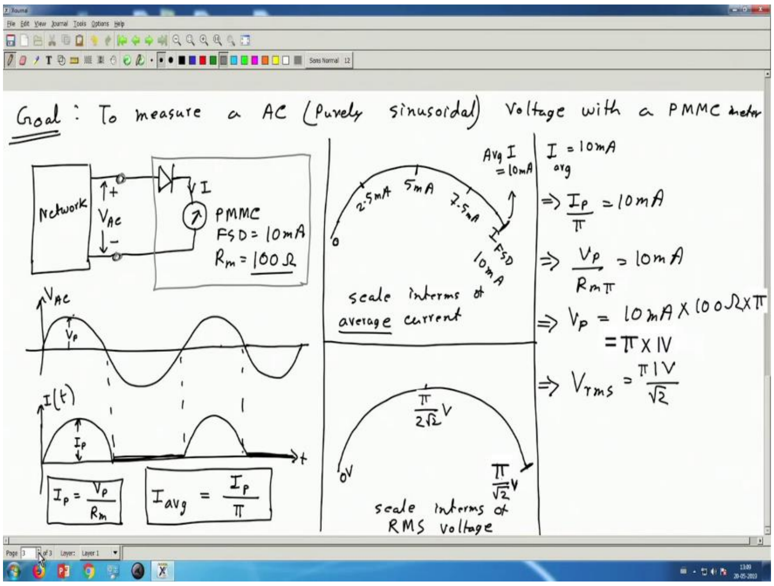


Now, say I want to measure a AC voltage. So, next the goal is to measure AC sinusoidal purely sinusoidal to me there is AC voltage with a DC meter PMMC meter with a PMMC meter ok. So, this is the goal. How can we do that? We just need a diode. So, now, let us draw the circuit. Suppose, I have a complicated network which I am trying like a box and it has two terminals between which I want to measure. So, I want to measure the voltage between these two terminals. What do I do? I generally connect a voltmeter.

So, now we have to connect a DC voltmeter which can measure an AC voltage. So, this voltage is AC. So, this voltage is AC purely sinusoidal we have to measure it ok. So, how we will do it? We will take a PMMC meter ok. Now, if we if we connect it like this. So, the voltage is positive for half of the time negative for other half; that means, the current which will flow through this meter is positive in for half of the time; negative for other half of the time and therefore, the torque will be towards the maybe towards the right for one half of the time and towards the left for another half they and the average torque will be 0.

If the frequency is high enough then the pointer will not move at all. So, this meter will not work. So, that was a quick recapitulation why PMMC meter does not work with AC. But, what we will do now we will put a diode in this circuit like this. So, now, what happens? So, if this is the input, this is the input voltage this plus minus does not mean this is DC. This is only the waveforms direction for drawing the waveform ok. So, I am measuring the potential of this point with respect to this point and the waveform looks like this.

And, now the current which will flow through this meter I ok; so, this is the voltage call it V. So, this is V AC sinusoidal the current which I which will flow through this meter will be positive here in the positive cycle; current will flow as it is. So, the current will be proportional to the voltage as you mean the meter is resistive. So, the unlimited resistance is R m. So, meter is resistive. So, the internal impedance of this meter is like a pure resistance with the value of R m. So, this current I will be; so, if I call this as V peak then this value $I_p = \frac{V_p}{R_m}$

So, this is sinusoidal and the peak of this sinusoid is V peak by R m V by I; here it will be 0, here it will be positive again and again here it is 0, 0 like that ok. So, if so, now how should I calibrate or mark this scale of this meter? So, say how should I calibrate this meter? Now so, if I assume this is the scale of the meter and so, this is a PMMC meter which I can for which I can mark the scale in terms of current say this current is 0 left side right side is as will be as per the notation IFSD full scale deflection current.

And, let us assume that full scale deflection current is equal to 10 milliampere and say R m let us say FSD full scale deflection current is 10 milliampere for this meter and R m is equal to say 100 ohm ok. So, that means, this point corresponds to 10 milliampere and this point corresponds to 0 milliampere. So, this is a PMMC meter; that means, the scale will be linear. So, this point corresponds to half of FSD; that means, 5 milliampere; this point is 2.5 milliampere, this point is 7.5 milliampere and so on.

But, now I want to mark the scale in terms of the voltage unknown voltage ok. So, this is scale in terms of the current ok. So, I want to mark this scale the same scale I want to mark in terms of the voltage so that by looking at the pointer position I can find the value of this voltage directly ok. So, this point 0 current means definitely the voltage must also be 0. So, this point I can write it as 0 voltage ok.

Now, what should be the value here in terms of voltage? So, let us do the calculation. So, here the current that is flowing is IFSD or 10 milliampere ok. So, current is 10 milliampere and this current is so, this is what? This is actually the average current because this meter is it is a PMMC meter so, this will indicate the average value of current. So, here we can write this point at this point average current is equal to 10 milliampere ok. So, I average here is 10 milliampere.

Now, what is the value of the current actual current? This is a time varying current I t and this I t looks like this and therefore, if the peak of this current is I p, then I average we can write how much will it be? This will be I peak divided by pi just recall from the previous slide. It is half wave rectified ok. So, this is I average. Now, here I avarage is 10 milliampere which implies $I_{avg}= \frac{I_p}{\pi}$ is equal to 10 milliampere here. Now, what is I peak? I peak is equal to V peak by R m this is equal to 10 milliampere ok.

$$\frac{I_p}{\pi} = 10mA$$

$$\frac{V_p}{R_m \pi} = 10 \text{ mA}$$

$$V_p = 10mA\ X\ 100\ ohmX\ \pi = \pi\ V$$

$$V_{rms} = \frac{\pi}{\sqrt{2}}\ V$$

So, therefore, this position I should mark it as root 2, whatever the value is. It is like 0.707 or so. This will be V volt ok.

So, this is the value or scale in terms of voltage. What kind of voltage? RMS voltage, very important; this is not in terms of peak voltage. This is in terms of RMS voltage and you probably know that when talking about AC particularly sinusoidal AC; RMS quantities generally what we use to mention it. So, this scale is in terms of RMS voltage this scale was in terms of current ok; to be more accurate this was in terms of the average current ok. So, this is in terms of average current, this is in terms of RMS voltage and if so the half of it. So, this center point I can definitely mark it as at 2 root 2 volt and so on.

So, this is how the skill should be marked and this is how the circuit should look like this is a half wave rectifier based voltmeter ok. So, we will call this thing together as my voltmeter because I will have the terminals here where I will connect the unknown voltage. So, this is AC voltmeter which is made up of our diode and PMMC meter.

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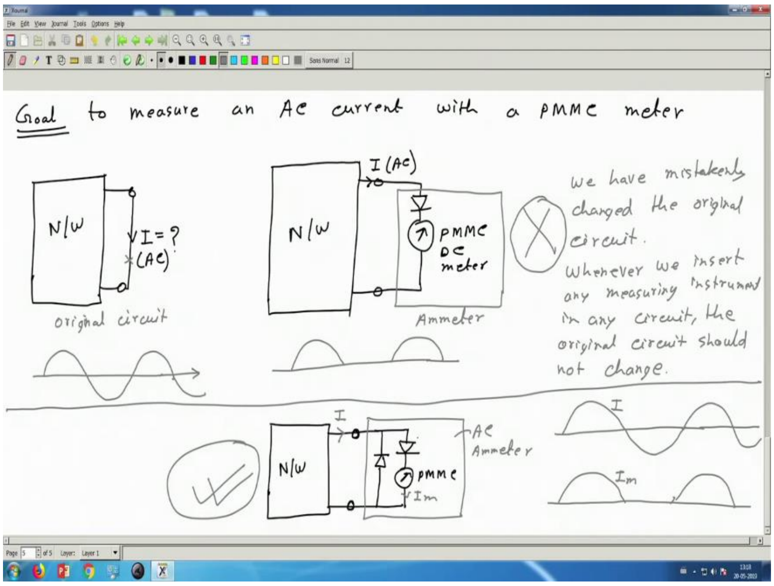


Now, suppose let us take a next new problem new question where the goal of our goal is now to measure say an AC voltage and sorry an AC current with a PMMC meter. So, I have a network in short N W in which I have a particular branch and some current is flowing through it call this current as I and I want to find out the value of I. This is AC and purely sinusoidal ok.

Now, so to measure this current I have to insert a PMMC meter. Why PMMC because PMMC we know is more sensitive than other types of meters. So, we connect a PMMC meter just one small note is that this symbol where we have an arrow inside a circle please do not think that this is a current source. This is also we use the same symbol for meters often, but the only difference it is generally when talking about meters we indicate the pointer at an angle generally. But, for current source we generally write it we draw it like this.

So, this is current source. So, please do not get confused this is generally a meter. So, this is I mean this is bit confusing we use the same symbol for both of the elements. I guess the meaning of the symbol will be clear evident form from the context or it is always better if we write what it is beside it. So, this is a PMMC meter; that means, it is a DC meter. Of course, this is a DC meter and we are measuring a AC current this current is AC.

So, the deflection will be 0, if I connect it like this because half of the times current is positive half of the times it is negative. So, half of the time torque is positive, half of the time it is negative, average torque will be 0, pointer will not move at all if the frequency is high enough. So, the solution is put R diode in this circuit just like the voltmeter circuit we used previously and then the current will flow for half of the time and the meter can indicate some non-zero value.

Now, this circuit is wrong. This circuit, if I call this circuit an ammeter this as an ammeter is absolutely wrong ok. Never make an ammeter like this. Why? Because this was the original circuit original circuit and here the current was flowing like this it was flowing for both positive and negative halves. This is the circuit where we have cut open this branch and inserted an ammeter and this ammeter is allowing the current to flow only for one half of the time. It is not allowing the current to flow for the other remaining time.

So, the original network is changed is disturbed because in the original network the current was flowing always, but now in this circuit when we are trying to measure something we have changed this circuit completely. So, we have changed mistakenly changed the original circuit ok. So, whenever we measured, whenever we insert any instrument in any measuring instrument in any circuit the original circuit should not change ok. So, if you want to measure something we should not change that itself ok.

So, this is true for any measuring instrument, electrical engineering in any other discipline everywhere. If we are trying to measure something we should not change that while measuring it, but in this circuit we are doing that ok. So, therefore, this is a wrong circuit. The correct circuit should look like this. So, if this is the network this is my meter I will put a diode in the opposite direction like this and this will be my AC ammeter, this will be this is my AC ammeter.

So, now what happens, this current I can flow always half of the time it flows through the meter half of the time it flows through this diode, but it can flow always. So, here this I will flow always therefore, the original circuit is not changed, but the meter gets current only for half of the time. So, I is continuous; this is I, but if I call this current as I m; I m flows only here this is I m. So, therefore, the average value of the meter current is non-zero because negative current does not flow through the meter. So, meter will indicate some value, but this circuit is not disturb. This is the correct circuit, correct ammeter. This is a wrong ammeter never make an ammeter like this.

For voltmeter so, previously for the voltmeter circuit we did lend put the put a diode in the opposite direction that is not so necessary because volt meters are ideally not supposed to draw any current. So, ideally very little amount of current flows through this in the positive cycle and the lower the amount, is better.

We know the voltmeter should have very high resistance very high impedance and in the negative cycle no current flows, no problem because in the original circuit as well no current was flowing between this. So, for volt meters the diode in the opposite direction is not that important, but for ammeters definitely we need it ok.

So now, we will take a break in this video. We will continue with this topic and we will discuss about more about say full wave rectifiers, full wave rectifier based circuits we will deal with more problems, examples in coming videos.

Thank you.