Electrical Measurement And Electronic Instruments
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Lecture – 31
Connection of Energy Meter, Wattmeter, and Three Phase Supply

Hello. So in last couple of classes we have studied wattmeter and energy meters ok. So, in this video in this class we will talk about Connection of Wattmeter and Energy Meter, in Three Phase lines ok. So, this will we will also do some recapitulation ok. So, essentially energy meter and wattmeter they have some common commonality between them.

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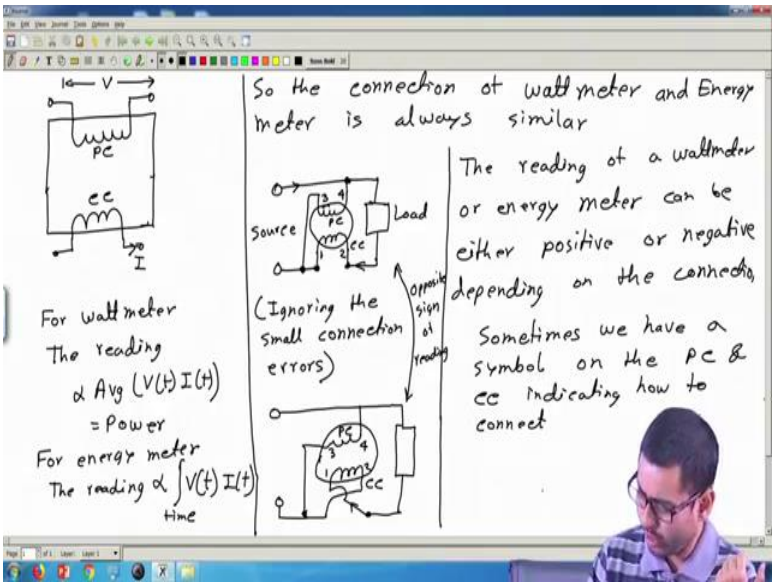

So, energy meter or a wattmeter is functionally a black box, which will have two inputs ok. So, a voltage input ok, it can. So, this can be the voltage input, so we call this the pressure coil. And so you have to connect the voltage, I have to apply some voltage across it and there will be another coil, which will sends some current I, this will call the current coil. And this is common for both energy meter and wattmeter. For energy meter, ok; first for wattmeter, the reading; the reading of the wattmeter is proportional to the average value of the product of this current and this voltage ok. So, if I apply a voltage V ok. Then the current that will flow through this is V divided by the impedance of this circuit.

And if we pass some current I,

For wattmeter

Reading α Avg [V(t) I(t)] = power

For energy meter

Reading $\alpha \int V(t)\, I(t)$

So, essentially both of them are quite similar, the only difference between them is that so, both of them take the product of V and I. The wattmeter after taking the product calculates the average and the energy meter after taking the product calculates the sum. This calculates the average, this calculates the sum, that is the difference.

So, the connection of a wattmeter or an energy meter will therefore, be similar. So, the connection of wattmeter and energy meter is always similar ok. So, if I have a single phase let us recall. So, if I have a single-phase supply with us load ok. Then if I want to measure the power consumed by this load or delivered by this source ok. We will take the wattmeter or the energy meter; if you want to measure power, then wattmeter else energy meter.

So, it will have two coils just like this ok. Now this current coil these you connect in series and this you connect across like this ok. Ignoring the small error due to this the fact that; the voltage measured by this is right now the sum of this voltage; this voltage drops plus this voltage drop.

So, for now let us ignore the small drops or the errors that we have discussed in detail. So, for now ignore that. So, for that we can have compensating mechanism compensating wattmeter. So, this is ignoring for now, ignoring the small connection errors ok. So, for now, for the ease of understanding you are ignoring small errors, but those are there definitely there ok.

Now, suppose I have ok; this is PC pressure coil ok. Now suppose I have a 3 phase supply and that 3 phase load ok. Before k; this is an another important another important thing I must mention which is the reading of a wattmeter or an energy meter, can be either positive or negative depending on the connection ok.

So, for example, if in this if this same circuit ok I connect it. So, let me just give us some names called this terminal 1, 2, 3 and 4 ok. This is terminal 1, terminal 2, terminal 3 and

terminal 4. Now if I had connected possibly like this. So, this is the wattmeter, this is terminal 3, 4, 1, 2, this is pressure coil, this is the current coil ok.

So, I have just reversed the terminal 1 and 2 ok. So, now, if previously the current was like this. So, it was flowing from terminal 2 to terminal 1. Now this current is flowing from terminal 1 to terminal 2. So, in the current coil, the direction of the current is changed. So, therefore and this current is in this same direction. This current is in the opposite direction, this current is in the same direction. So, the torque deflecting torque will be in the opposite direction.

And therefore, if this reading is positive, then this reading will be negative or if this reading is negative, then this will be positive. So, the these two will have opposite signs will have opposite sign of reading ok. So, sometimes we may have a wattmeter which whose dial whose pointer can move say only in one direction ok. It cannot go to the other direction, because the other that there may not be any room for the pointer to move to the other direction. It can move only in one direction. Then if we connect the coils in a manner so, that the reading is negative the pointer will indicate 0 ok. And in that case we have to reverse the connection. So, that the pointer now indicates positive reading only ok. So, that is important.

And so sometimes we the pointer cannot go to the negative side and there is no place to go to the negative side and then the pointer it gives only 0. And therefore, we have to reverse the connection of either the current coil or the pressure coil. Sometimes we have a symbol. So, sometimes we have a symbol on this pressure and current coil, indicating how to connect and this symbol and convention this can vary. Different instruments have different conventions.

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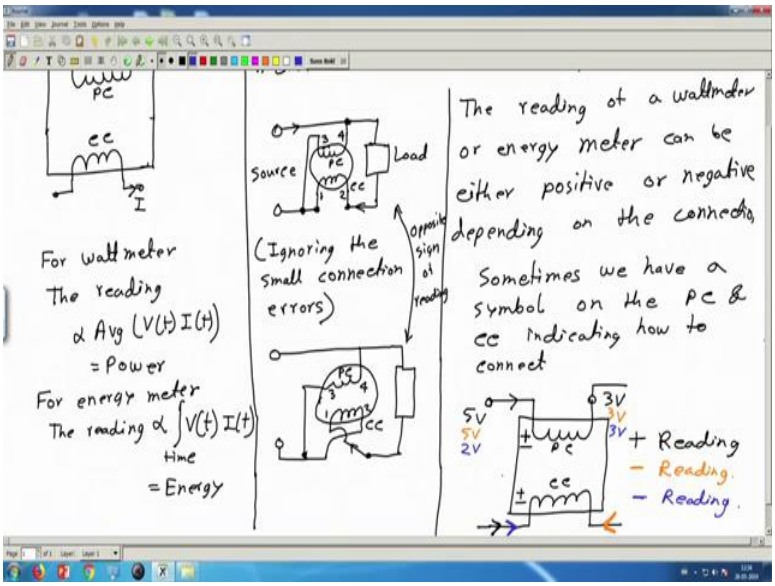

So, do not memorize this thing this is only for our knowledge and common sense. The most important thing I was saying in engineering common sense is common sense ok. So, sometimes I am just giving an example do not memorize it ok. So, wattmeter can have marking like this. So, if these are the two coils; pressure coil and current coil. So, they may have a plus minus sign, on this side on one side of the pressure coil and a plus minus side on the on one side of the current coil. Indicating that if you apply a higher voltage on this side compared to this ok.

So, if this voltage says if this point is at 5 volts, this DC for ease of understanding, this point is at 3 volts then; that means, current is actually flowing like this. And at the same time if you connect this coil in such a way that current also flows through the plasma; I mean entering through this symbol leaving through the other terminal. And here this symbolled marked side is positive. Then read it; so, with this connection the reading will be positive, the reading is positive.

So, if you connect this meter in an opposite way such that you have 5-volt, 3 volts, but now the current is going in the opposite direction in this coil, entering through this side and leaving through this symbol side, then we will have minus negative reading ok. So, if this is 5 volt this is 3 volt what current is entering through this, we will have negative reading.

Similarly, say if we have, if we connect like this. So, that this current is entering through this. So, I am using now blue color and say this side is at 2 volt and this side is at 3 volt ok; that means, this is at higher potential. Then this will give negative reading.

So, sometimes this type of conventions is this type of symbols are used. Once again do not at all try to memorize this thing the I will what I will suggest you is that, whenever you see a new instrument; in your lab or in your workplace. Try to see are there any symbols, is there any manual go and read the manual if there is any symbol apply your common sense and try to understand what they may mean. Do some small experiment, apply some known voltage and current. And see whether the pointer is moving to the positive direction or to the negative side.

Do some small experiments before you put that in use or if you are in a job you are so you have other people who also use the same instrument, go and ask them. What is the convention how to connect it, so that it gives positive reading, do not memorize anything apply your common sense. Read the manual ask other people to your seniors, to your instructor like that, but have the common sense that is important ok. So, now let us move to 3 phase wattmeter connection.

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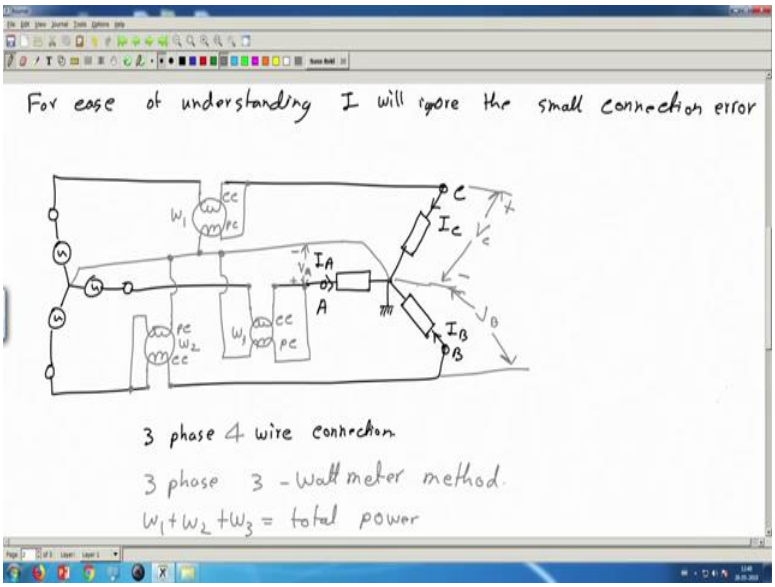

So, for now for ease of understanding, I will once again I will ignore the small connection errors which we discussed before due to nonzero current coil resistance and non-infinite

voltage coil resistance ok. So, those small errors we will ignore now. And we will also I may sometimes forget this plus minus convention etcetera.

So, ignoring these small facts, let us see 3 phase wattmeter connection. So, 3 phase wattmeters for that we need a 3 phase load and a 3 phase supply. Say this is a 3 phase supply and there is a 3 phase load which is like this. Let me take a star connected load it can also be a delta connected load ok. So, it will be connected like this supply to this phase this to this and this to this ok. So, this is a 3 phase supply ok. Let me also draw a generator, 3 phase generator and this is a 3 phase load.

Now, we want to measure the power consumed either by this load or supplied by this source. Which will be approximately equal; if we ignore the small losses elsewhere in the line, in the meters that will connect, so we will ignore the small losses ok. For now we will ignore. So, now, to measure this total power, what we have to measure we have to measure, the product of this volt voltage and this the current through this ok. So, let us give somes name phase A, phase B phase C ok. So, this current I will call I_C, this current I will call I_B and this current I_A and the voltage, so if this is the neutral a reference point ok.

So, this is the reference point. This is also you can think as the reference point ignoring the drops in the line etcetera. So this is a 3 phase, 3 wire, so this is a 3 phase, 3 wire connection ok. Now we can also have neutral, so this is the neutral line ok. So, let us start with this 3 phase, 4 wire first, 3 phase, 4 wire connection we want to measure this power ok. So, what we have to do once again this current time this voltage. Which voltage this voltage V_C and I can put a plus minus sign. So, this indicates the chosen reference for measuring this voltage ok.

So similarly this is V_B, between the neutral and the B phase. And similarly, we will have here V_A between the neutral and the line phase A this is plus side this is the reference minus sign ok. So, now, to measure these 3 powers I can use 3 wattmeters. So, let me take 3 wattmeters. So, this is wattmeter 1 and so with this I will measure say the power in this phase ok.

So, it will have two coils ok. So, I have to measure this current and this voltage. Now to measure this current I will disconnect this and put this current coil in series. So, this is the current coil CC and the fold for the voltage coil, let me put the voltage coil across this these life C phase and the neutral ok. Ignoring the small current going through this pressure

coil once again key ignoring the small errors and it ok. So, this is one wattmeter which will measure the power consumed by this call it W 1.

Similarly, I can have another word another wattmeter say W 2, it will have 2 coils once again, let this be the current coil. And I want to measure the power consumed by this. So, what I do? I open it connect it here like this and this is the pressure coil. So, I want to measure the voltage from here to here. So, I put one side to the neutral another side to this ok. It is now similarly I want to measure the power in this f s. So, let us take another wattmeter call this W 2 call this 1 W 3 ok.

So, another wattmeter this is current coil, let this be the pressure coil, this is W 3. Now the current coil are the in certain series to measure the current I_A and this I will insert in parallel. So, one side to the life another side to the neutral ok. So, I can connect it here or maybe here to this neutral side ok. This is the neutral line. So, this is the 3 phase 3 wattmeter method ok. Now there is another method which is called 3 phase 2 wattmeter method ok.

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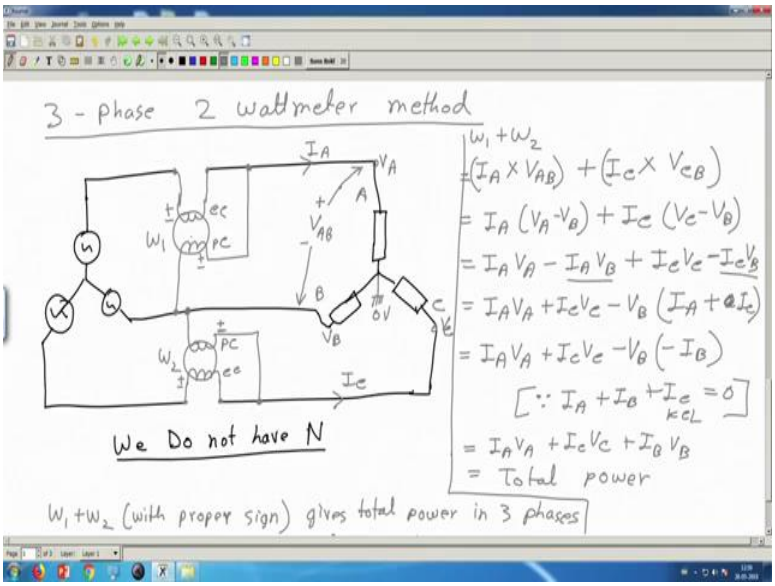

Now let us see another method, which we will call 3 phase 2 wattmeter method. So, let me draw a once again, the source 3 phase. So, this is the 3 phase source and let me draw a 3 phase load. Now this time we should not have the neutral ok, we do not have the neutral line. So, this is important, this is very important we should not have this neutral line in this method and now the way to connect the 2 wattmeters is as follows ok.

So, we will have 2 wattmeters. Now the 2 wattmeters are like this they will have their current coils and the voltage coils call this current coil voltage coil, current coil voltage coil ok. So, what we have to do, we have to measure the current of current in 2 phases ok. So, there are 3 phases, 3 lines we have to measure two line currents ok. So, you have to measure two line currents. So, say we are going to measure this two line currents this one and this one.

So, you are measuring this two line currents, call it I_A and if this is A, this is B, this is C ok. Because then this is I_C. So, you are measuring I_A and I_C with 2 wattmeters and the voltage coil they will measure the voltage between the corresponding say line. So, this is measuring line current in phase, so C line current C. So, we will measure the voltage between C and the unused which is the B, the unused line. So, this will measure the voltage between the corresponding line and the unused one the corresponding line means here it C the current coil is in C phase. So, and the pressure coil therefore, will go between C and B which is not used.

Similarly, here also this two this should be connected to this, one side to the corresponding line, another side to the unused line B ok. This is how to connect, so this is a 2 wattmeter to get the power measured in this 3 phases. So, now, if I call this W 1 and this W 2, then W 1 + W 2 with appropriate sign, with proper sign ok. They are reading can be negative, gives total power in 3 phases ok.

So, previously in the 3 wattmeter method to get the total power we needed W 1 + W 2+ W 3. So, here W 1 + W 2 + W 3 this was the total power. Now in this new circuit W1+ W2 this will give the total power. How? Is it not surprising the previous one was quite obvious, because this wattmeter was directly measuring this voltage into this current, this was also measuring this voltage into this current. So, they were measuring individual phase powers. So, that this was quite obvious.

But, now how is it so that W 1 + W 2 is the total power what this wattmeter is measuring this is measuring this current multiplied by this voltage what does it give, I mean what is what this is equal to ok. So, let us understand how is it true that W 1 + W 2 is equal to the total power.

=W1+W2

= Ia x Vab +Ic x Vcb

= Ia (Va-Vb) + Ic (Vc-Vb)

=Ia Va - Ia Vb + Ic Vc -Ic Vb

= Ia Va + Ic Vc – Vb (Ia + Ic)

= Ia Va + Ic Vc – Vb (-Ib) [Ia+Ib+Ic=0]

= Ia Va + Ic Vc + Vb Ib

So, remember how to connect the 2 wattmeters, this is something you have to remember ok. There are some things that you have to remember, how to connect it? Connect 2 current coils in any two lines, any two lines and connect the two voltage coils between those two lines and the other unused remaining line. So, this is; so remember how to connect it? And then this derivation is straightforward ok. So, this is called 3 phase 2 wattmeter method.

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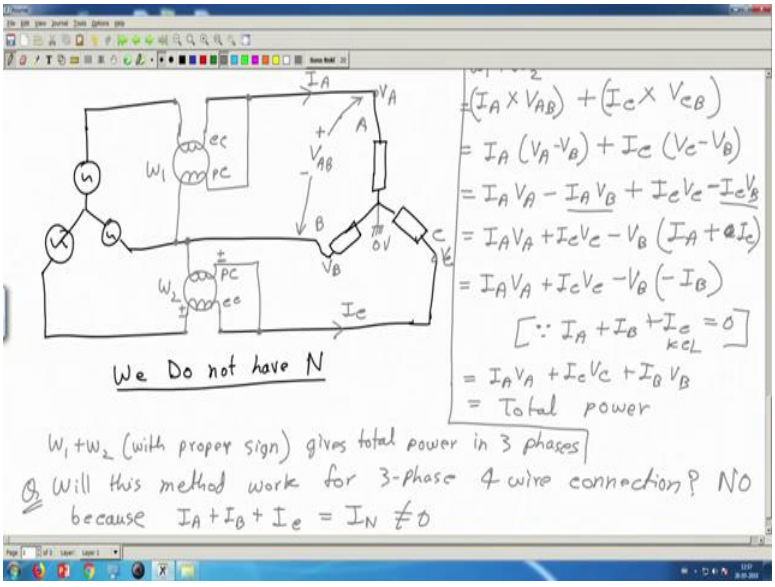

And will this method work, if we have the neutral line. So, question will this method work for 3 phase, 4 wire connection think and now I am giving you the answer. The answer is no. Why? Because, if I have the fourth wire, if I have a fourth wire ok. Then Ia+ Ib+Ic will

be same as the I N. The neutral current which need not be equal to 0 not necessary that this is 0.

If I have a fourth wire, if I do not have the fourth wire, then there is no fourth current. So, then this is of course, 0 then this derivation is true, but if I have A fourth wire then this is not true, but yes of course, you may say that if the load is perfectly balanced. Then even if we have a neutral wire then yes, then this that this method will work, but if there is any unbalanced load any unbalanced between these loads then with 4 wire with the fourth wire, this method will not work ok.

Now, of course, last small thing before I conclude, but this is once again a bit more detailed more detail which you may ignore, but this is required in practice. So, let us go back to this convention of plus minus. So, suppose if these meters have plus minus signs beside they are current and voltage coil, then how should we connect it?. So, we should connect it in such a way, so, that if the plus minus side is here ok. Then I should have the plus minus sign here ok. Because I am measuring see this current in this derivation also you see I am measuring this current, and the voltage V A minus; sorry this is for this wattmeter. So, I am measuring this I C and V C - V B ok.

So, if I C is now positive you also see this V C - V B is also taken like this I mean. So, if I have this plus minus sign here let me repeat in a different language. If I have the plus minus sign here then this is measure this coil is measuring this voltage minus this voltage which is V C - V B.

And similarly if I have this plus minus sign here, it is measuring this current I C if I by mistake had the plus minus sign here, then it is actually measuring minus I C. So, the reading of W 2 will be opposite than expected ok. So, this should be here. Similarly think of it, if I have say the plus minus sign here ok.

So, the current is entering through the plus minus sign according to the chosen reference here also I should have the plus minus side on this side ok from this to this. So, that this is measuring V A - V B. Why this is so important? Because in 2 wattmeter methods as I already have mentioned this W 1+ W 2 with proper sign with appropriate sign only gives the total power ok.

So, the reading of this meters can come out to be negative ok. If you connect in this way the reading of this meter can come out to be negative. That will depend on a lot of things like the angle of; the load angle of these loads ok. So, this can be negative if it is negative you have to add W 1 with that negative value only ok. So, you will take some examples in another class.

So, therefore, the this plus minus side is important. How I have decided this plus minus sign summarizing again I am taking here W 1 to be I A (V A - V B) and if I choose I A in this direction ok. From left to right then I should have plus minus here and V A - V B. So, I should have plus minus on the V A side positive side and nothing on the other side ok.

So, we can have other symbols instead of this plus minus. So, think of this and as I do I put the reference six amps from which you need to study these things in the book. So, in the book also you check this symbol conventions and this more details.

Thank you.