**Fundamentals of Electrical Engineering**
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**Lecture - 50**
**Three Phase Circuits (Contd.)**

Ok we have back again.

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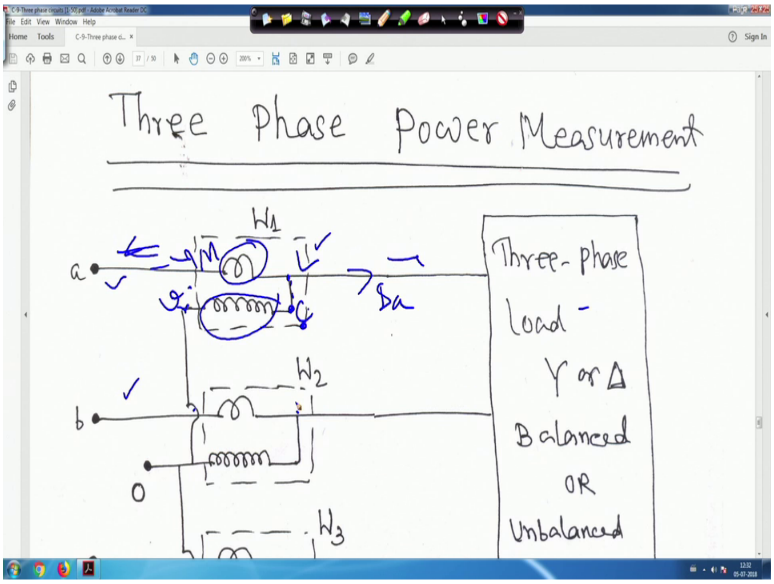


So, Three Phase Power Measurement, right; so, in this case, in this case your what will what your, what we have, we will do it that basically for Three Phase Power when to use to two wattmeter method. So, in this case, we have used three wattmeter is given. General in a wattmeter you have a current coil this is actually current coil right and this is I am sometimes we call phasor coil or voltage coil.

So, load may be Balanced or Unbalanced right and this side is your this side is your if, you see in your laboratory this sides when it will be in the (Refer time: 00:53) itself. You will see that this side is marked as M and this side is marked as an L right; M is the main side there is a supply side this is called main and M is the load side.

That means, this side that is why it is L, length L both are marked. And this point this point some, this point sometimes we mark c and this point marks as v and this is called phasor coil and voltage coil current coil has negligible resistance; basically, it to, current passing through all the current passing through this your what you call, your, this is the current coil.

And this phasor coil actually it is a voltage coil. So, it, basically, it is sees the voltage. So, suppose this is a and this is b and current flowing to these the phase a is I a and the voltage is actually it looks the voltage from here to here is your what you call, it is a your, c know it is connected we will see in the, in your next diagrams, right. So, basically it is sees the line to line voltage. So, whenever this, go for two wattmeter methods.

But in this diagram, in this diagram I have shown just one minute I have, shown this is your, three wattmeters, right.

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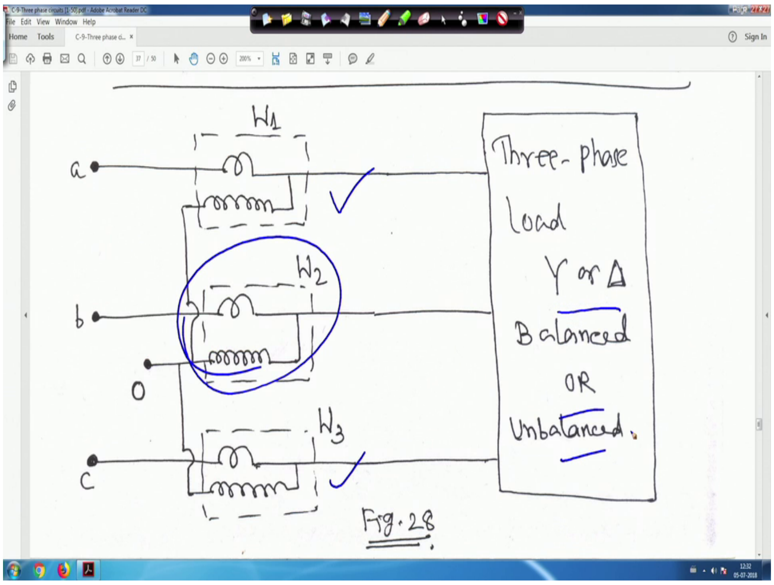


So, this one wattmeter is redundant it will measure 0, no need for three wattmeter. So, this connection I have given intentionally just you think yourself that this wattmeter will it basically, 0 if you go for a 3 wattmeter.

So, basically you need two wattmeter method for measuring the, load maybe star or delta Balanced or, Unbalanced does not matter. We measure power using two wattmeter method right and this is I am leaving up to you.

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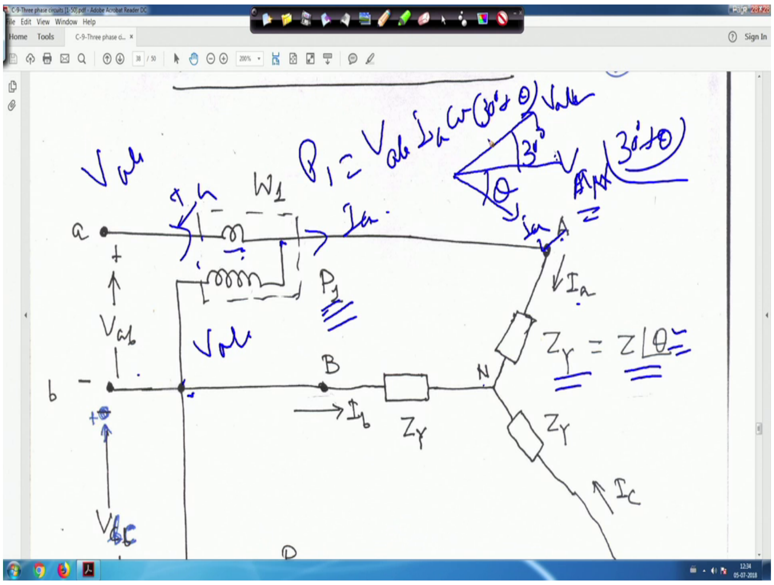

So, whenever you go for your two wattmeter two wattmeter method right. So, this is my, this is my your what you call that, watt this is my wattmeter and it measures the power P 1 and, load is taken as a star say.

So, if the angle is Z angle theta. So, current flowing through this actually, current flowing through this is your I a, this is your I a, this is the phasor at voltage measure this we write this voltage from here to here. So, voltage actually it will be V a v. Now, somewhat phasor diagram we have seen that if this is this is my A to N, this is my say your line current is equal to phase current. So, this is my V a n right; and current and this is the voltage in here I have taken capital A N instead of small a n.

So, here also we can write capital A N does not matter, and the current I actually is lagging while angle theta because these angle is theta right. So, this is angle is theta, so. So, now, this is the line voltage line voltage is V a b V a b leads the phase voltage by angle 30 degree. So, this is my V a b and this angle is, 30 degree right.

Therefore angle between this, and these wattmeter measures actually, looks the line voltage here because it is phasor coil is connected here it will V a b because right and the current flowing through this is I a. So, angle between V a b and I a is 30 degree plus theta right; that means, this reading of the wattmeter is P 1. Then P 1 will be is equal to it is magnitude V a b into I a into cos, 30 degree plus theta right. So, if you would similarly for other wattmeter we will come to that.

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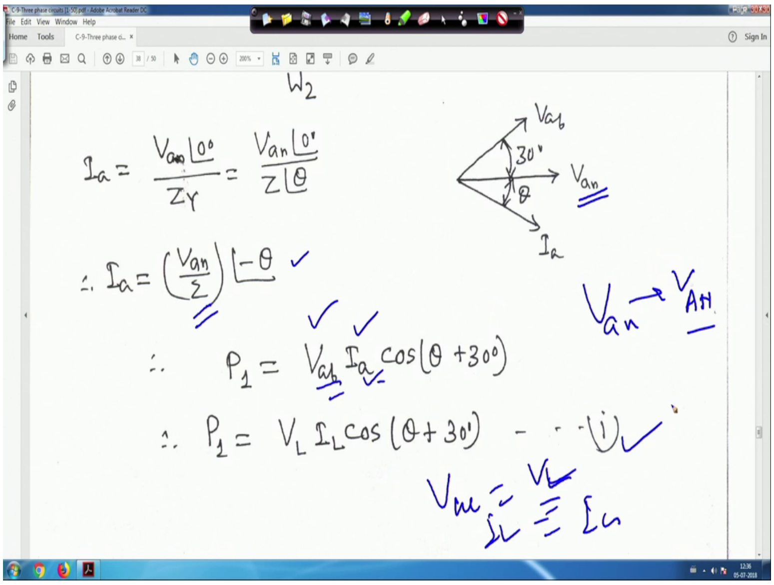


So, whenever you come to this one, that your this phasor diagram if, you see that V a b V a n it is 30 degree theta angle between V a b and I a is 30 degree plus theta. Now, I a is equal to your I a is equal to it will V a n actually, here it is at this diagram just hold on, this diagram, we know this, this is yeah I have marked it capital A N right. So, question is in between one, between your current coil is there.

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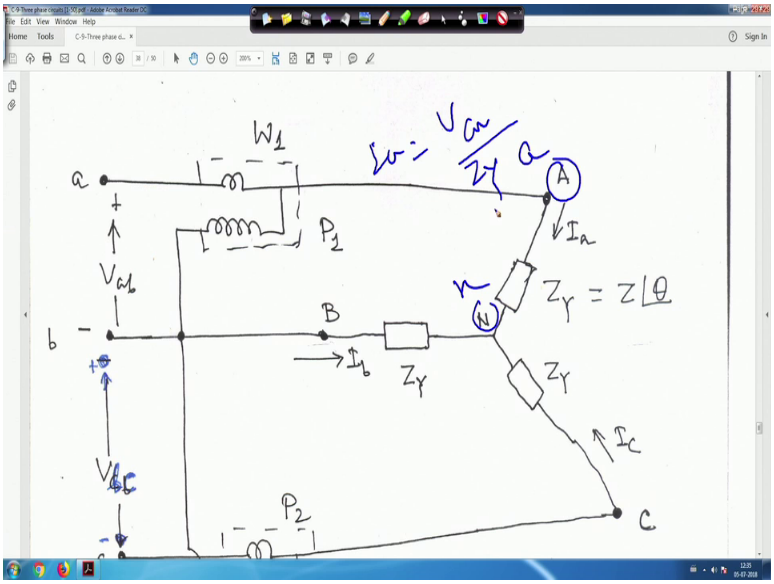


So, basically this is nothing, but your, you can fix small a and you can small n also right. So, current I a will I a actually is equal to your same actually V a n right divided by your

Z star not Z Y right. So, this is this way you can make it. So, here I have written capital N same thing same thing. So, ; that means, here V a n angle 0 upon Z star right.

Here also in the phasor diagram phasor diagram also it means your V a n V a n actually it is V A N same thing understandable right. So, this V a n angle is your also, Z Y is equal to Z angle theta. So, it will be I a will be V a n upon Z angle minus theta. Therefore, P 1 is equal to V a b I a cos theta plus 30 this is magnitude this is magnitude, but V a b actually is equal to a line voltage. So, it is V L right, it is a line voltage and I a l is equal to line current I a l is equal to I a it is the line current it is line voltage and line current.

So, it is V a b I a cos theta plus 30 degree or we can write V L I L cos theta plus 30 degree this is equation 1 this is the reading of the your wattmeter 1 right, now wattmeter 2. if you go to the diagram again, if, you go to the diagram again. So, in this case it is voltage is what you call a b, b c is marked if you move little bit upward, right.

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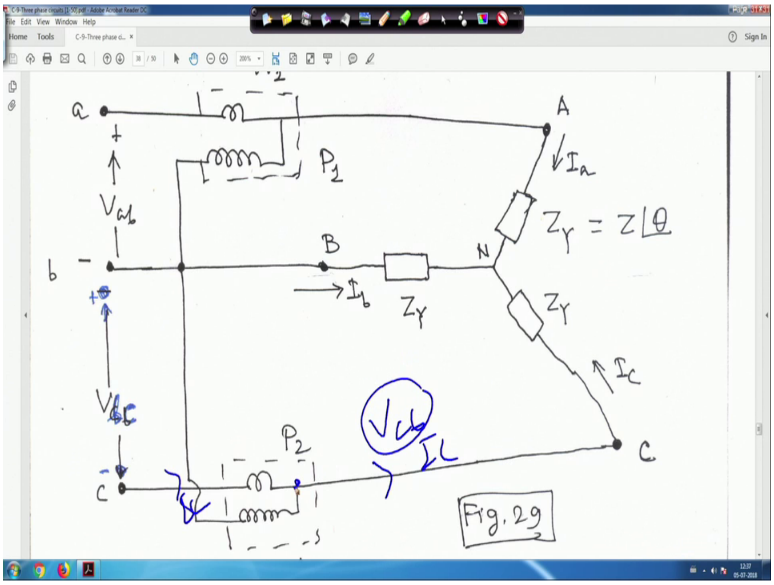


So, in this case your, current is here it is I c this current is your I c right, this current is I c right the, wattmeter is placed here. So, line current is I c, yeah and your voltage it looks at the a b c, it looks at voltage c b right although b to c, V b c, V a b, V b c b c is given, but it will be V c b because this is the phase c and this is connected to b. So, voltage should be V c b it means it is see the voltage V c b, but not V b c right.

So, and the current is I c. So, if you draw the complete phasor diagram, right, if you draw the complete phasor diagram so, this is the diagram.

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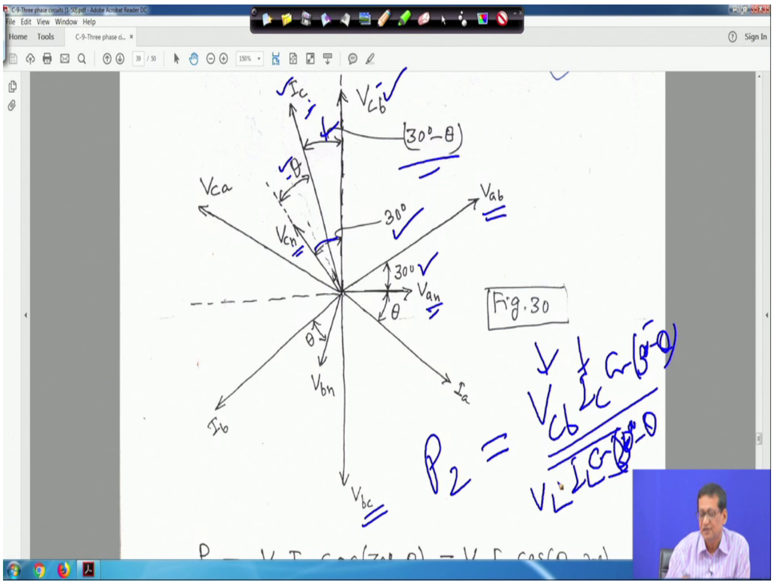


So, in this case, earlier we have seen this is V a b this is your V a n; this angle is 30 degree this is already we have seen before and this is I a right. So, I a lag from V a n by theta.

Similarly, this is your what you call I b, this is your I b right yeah just little move little bit upward, just little move. So, so this is your, this is your I b, right; I b also lags from V b n by angle 30 degree. Similarly if you see the I c I c also lags from V c n by, sorry, I I b lag from V b n by theta and I c is also lags from this one your what you call your, by an angle theta.

Right now, this is let me clear it, now actually diagram is, hold on hold on I will reduce the zoom just hold on. So, in this case just hold on. So, in this case you are this is my V b c if I want V c b just 180 degree phase shift just make other way opposite way this is my V c b right.

Now, you we want the angle should be in between V c b I c and V c b. So, this angle that angle between your V c b right and this v look at V a your what you call V a b and V a n is thirty degree and similarly your V your what you call b V c, V c a right here it is V a b and V a n similarly here it is V c a and V c n angle your what you call will be 30 degree like this. So, if you look into that that this is my V c n right this is my V c n and this is my I c.

So, angle between V c n and I c is theta, because I c actually current is lagging from this one because it is balance say you have taken balance. So, this is angle theta, right and angle between this thing that you are V c n and V c b is 30 degree, like your V a b and V a n is 30 degree just you have taken the opposite right V c b. So, this angle is 30 degree so; that means, this angle will be 30 degree minus theta.

So, this angle is 30 degree minus theta then watt wattmeter reading from that second wattmeter reading is P 2 is given P 2 should is equal to it is V c b then your I c, then your cosine, 30 degree minus theta right. So, this is my V c b, but this is a magnitude this is also magnitude. So, V c b is equal to V L, I c is equal to I L it will be cos 30 degree minus theta right. So, this is the reading of the second wattmeter right. So, let me clear it. So, let me increase the zoom.

So, this is what, this is what you are reading of the second wattmeter. So, it should be V c b into I c into cos 30 degree minus theta right.

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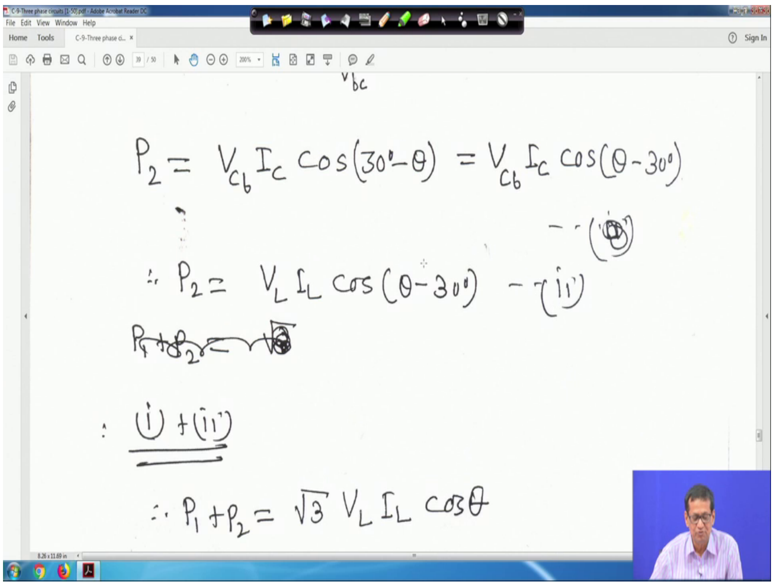


So, that is that is what has been made here P 2 is equal to V c b, I c into cos your, your cos minus theta is equal to cos theta. So, it is written cos 30 degree minus theta is equal to cos theta minus 30 degree right; or we can write P 2 is equal is a magnitude only line to line voltage.

So, V c b is equal to V L I L cos theta minus 30 degree this is equation 2, then total wattmeter reading.

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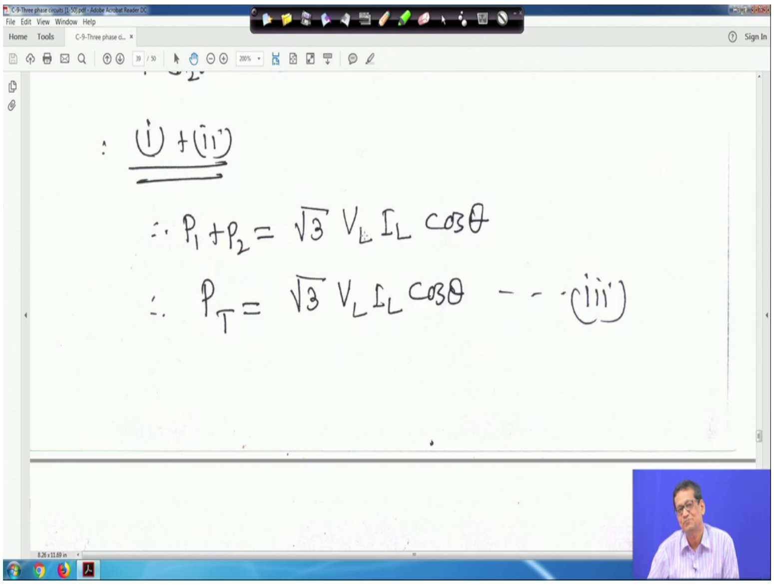


Add equation 1 and 2 if, you do. So, P 1 plus P 2 and simplified, you will see it will become root 3 V L I L cos theta, and total that means, P T is P T actually is a total power. So, it will be root 3 V L I L cos theta this is your equation 3 this is the we your, whatever mathematically whatever we have derived wattmeter is reading the same thing it is reading the same thing right.

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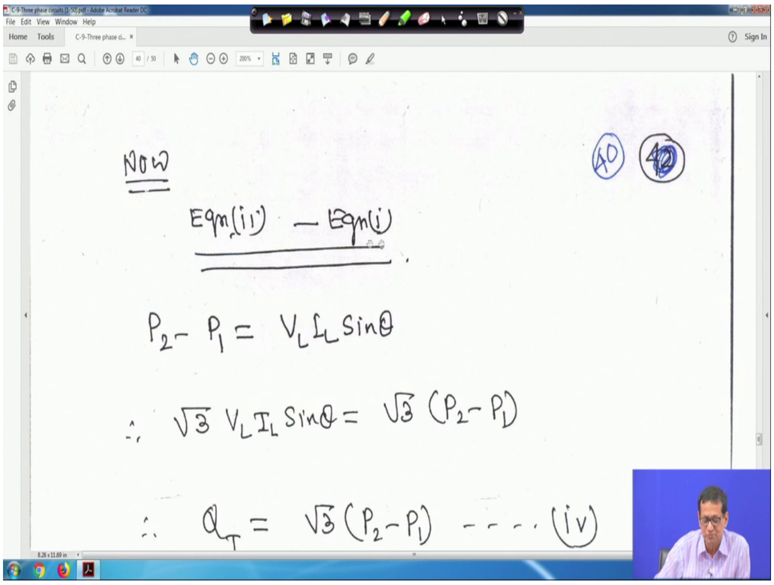


Similarly, if you subtract equation 1 from equation 2 right; that is, equation 2 minus equation 1, you will get P 2 minus P 1 is equal to V L I L sin theta right or if, you multiply both side by root 3 then root 3 V L I L sin theta is equal to root 3 into P 2 minus P, minus P 1 right.

Therefore Q T is equal to root 3 into P 2 minus P 1 because this is my total reactive power root 3 V L I L sin theta. So, that is my q t is equal to root 3 P 2 minus P 1 this is equation 4, right. Therefore, root 3 V L I L cos theta is equal to P 1 plus P 2 and root 3 V L I L sin theta is equal to root 3 P 2 minus P 1.

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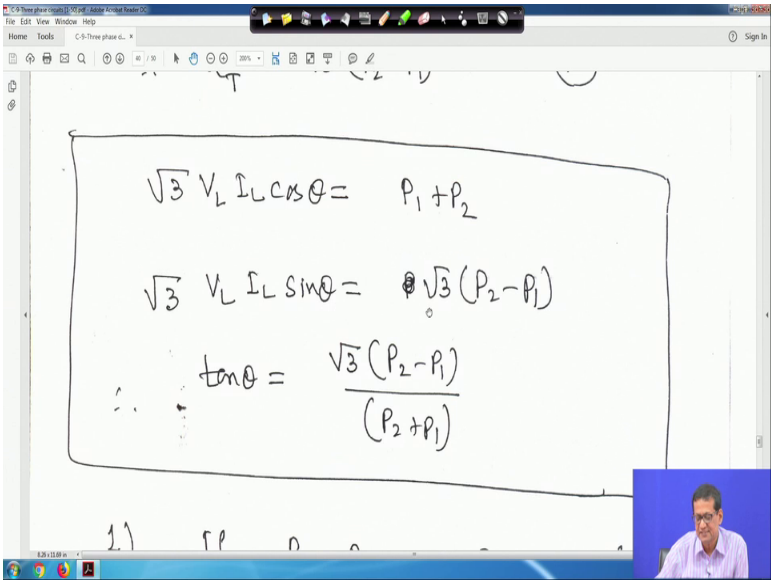


So, divide the divide this one your, this one by this one if you do then it will be tan theta is equal to root 3 P 2 minus one upon P 2 plus 1. Now, if theta is positive then it is inductive; that means, if P 2 greater than P 1 loading inductive if P 2 less than P 1 loading capacity right if P 2 minus P 1 positive means loading inductive.

Otherwise if P 2 minus P 1 negative mean loading capacity right.

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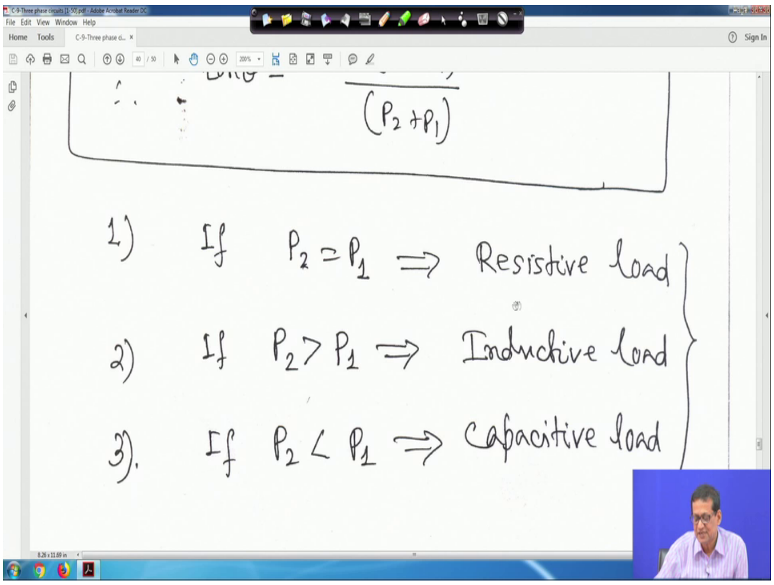

So, here it is given if P 2 is equal to P 1 Resistive load that mean theta is equal to 0 right, that mean resistive load if P 2 greater than P 1 it is Inductive load if P 2 less than P 1 it is capacitive load. So, from there you can determine right.

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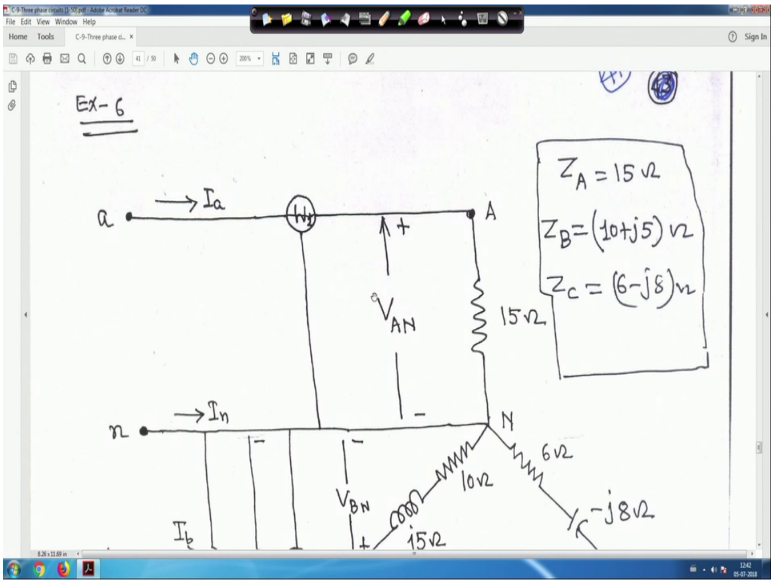


Now, after this, you take one example. This is example 6 that wattmeter is something i have connected like this.

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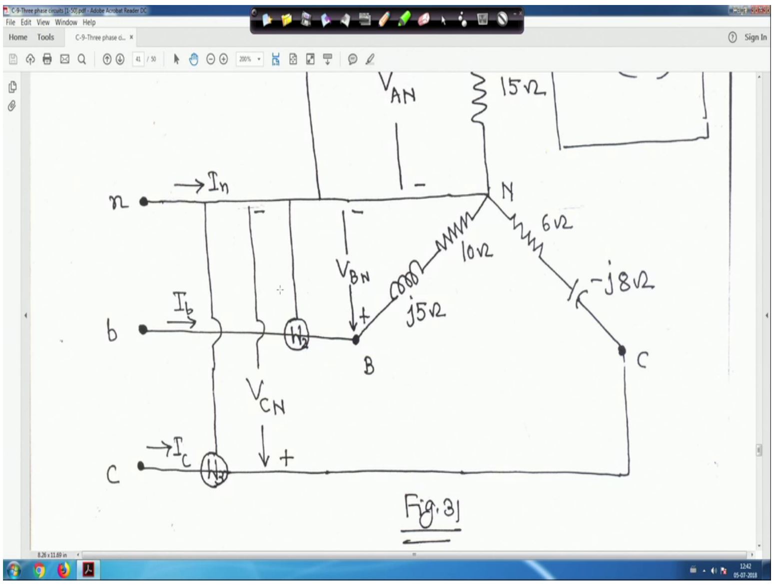


W 1 W 2 and W 3 and interesting thing this thing, you have intentionally taken the this load is Unbalanced because Z a is simply 15 ohm, similarly Z b is 10 plus j 5 ohm and Z

6 minus j 8 ohm. So, you are what where to do if we have to measure the park phase basis right.

So, here it is un, Unbalanced thing is given and the intentionally I have taken this example right intentionally I have taken this example, and this is 15 ohm, this is your 6 minus j 8 ohm that is your Z c and this side I will show you the diagram and this side is your Z b 10 plus j 5 watt wattmeter is connected like this. Similarly another wattmeter is carried your what you call, connected like this right.

So, in this case your, what you call at this is a neutral. So, we want to measure your, what you call the park phase power park phase basis right. So, this is the current I a this is I b this is I c and, some current is flowing through the neutral and, right and this is your what you call unbalanced thing you have taken. Now, in this case, you are predict the wattmeter readings find the total power absorbed rights.

So, it is Unbalance you have taken. So, in this case, you are what you call that you find out your first I a I b and I c you find out.

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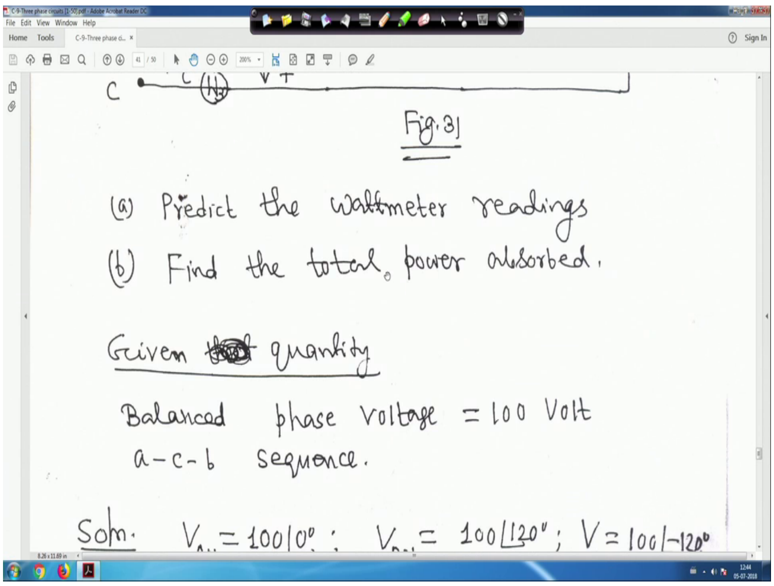


So, if then, it is your what you call it is given a c b sequence a c b sequence; that means, balance phase voltage is 100 volt right. If you look into that, it is given that balance phase voltage it is given that is your hundred volt.

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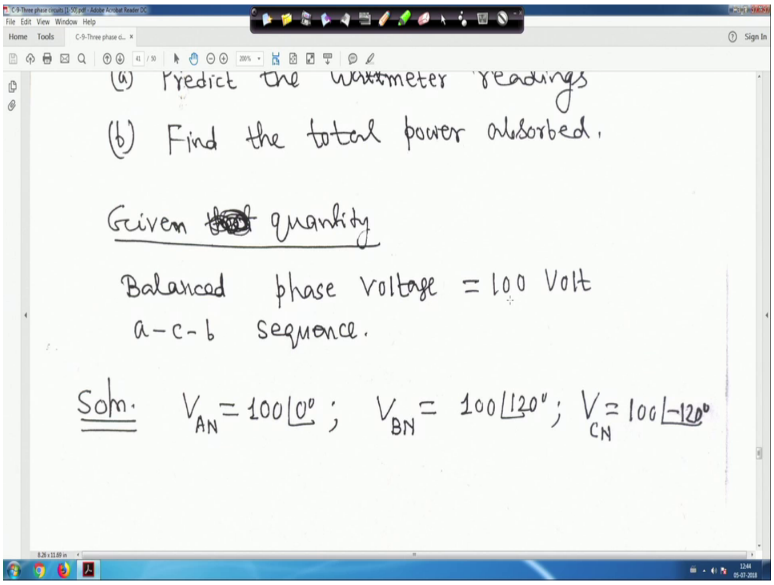


That the phase voltage is Balanced if the, a c b sequence, but load is Unbalanced load is unbalanced.

So, V a n is taken hundred angle 0 and as it is a c b sequence. So, V c n is 100 angle minus 120, and V b n is equal to 100 angle 120 degree right.

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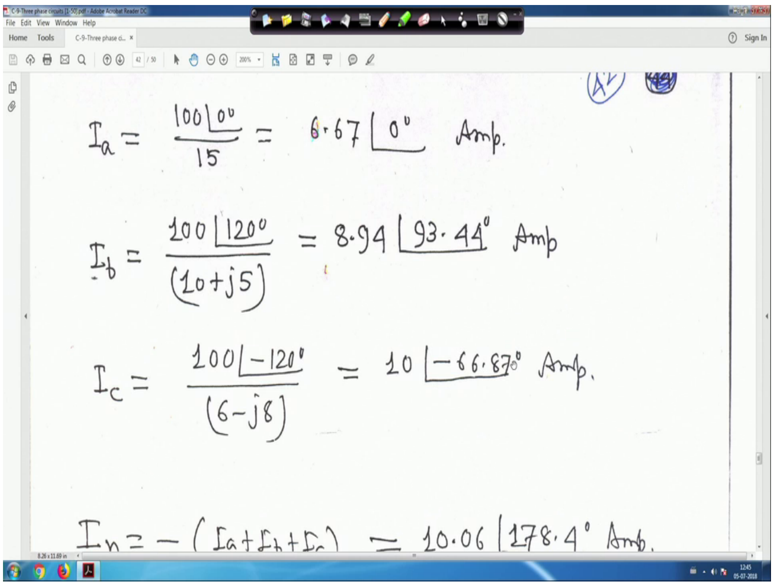


Now, I a is equal to for your phase a 100 angle 0 by 15 it is 6.67 angle 0 degree Ampere. Similarly upper phase b, it is 100 angle 120 divided by 10 plus j 5 which is 8.94 angle 93.44 degree Ampere.

Similarly, for phase c 100 angle minus 120 divided by 6 minus j 8. It will be 10 angle minus, 66.87 degree ampere here it is, right. So, this is your find out, I a is equal to V a n upon this one, similarly for your I b is equal to V b n upon this one, similarly for I c n is equal to V c n upon this one similarly you can find out the phase wise right.

So, once you do this, now I n is equal to minus of I a plus I b plus I c. So, if you do your I a plus I b plus I c right all figure some.

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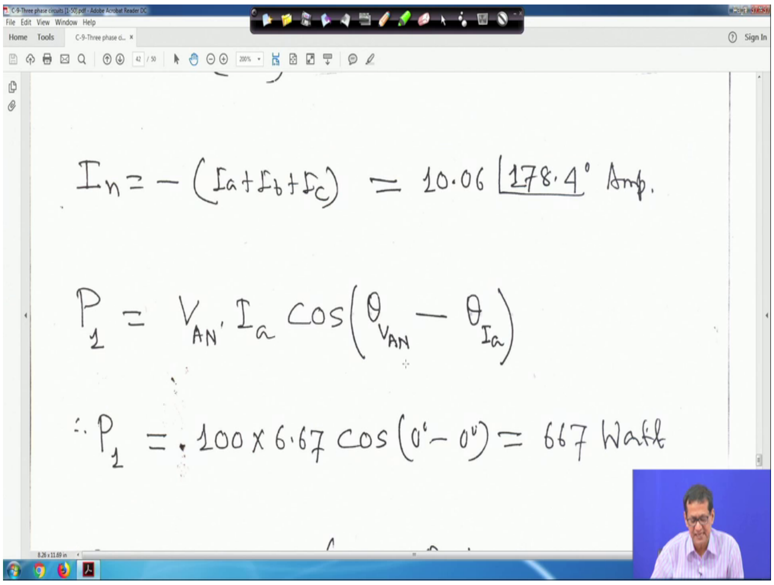


If, you do it will become 10.06 angle, 178.4 degree Ampere, right, and for wattmeter reading power P 1 it will be V A N I a into cos theta V A N minus I a; that means, your for this wattmeter it is connected here.

It is it is connected in this thing and between this one and this neutral it is connected right.

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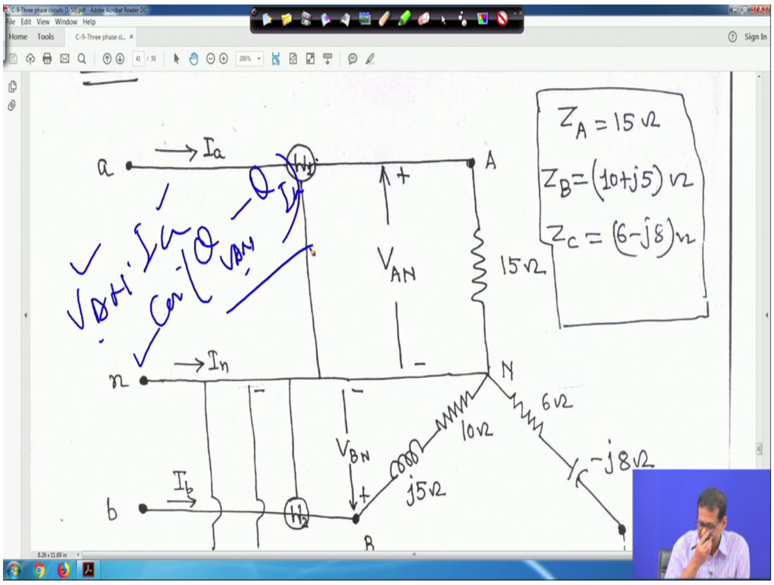


So, it will what it will do that voltage V A N magnitude will take V A N then you will take the current I a, then angle between this, voltage that is your I write cosine of theta V A N that is the angle of V A N, minus theta of I a right, this way it is written just for easy understanding right. Therefore, if you if you see this, if you see this that your, P 1 is equal to V A N A I a cosine theta V A N minus theta I a, theta V A N is 0 reference one and theta I a also 0.

So, it is becoming 667 Watt; similarly for P 2 it will be V B N, into I b just look at the diagram.

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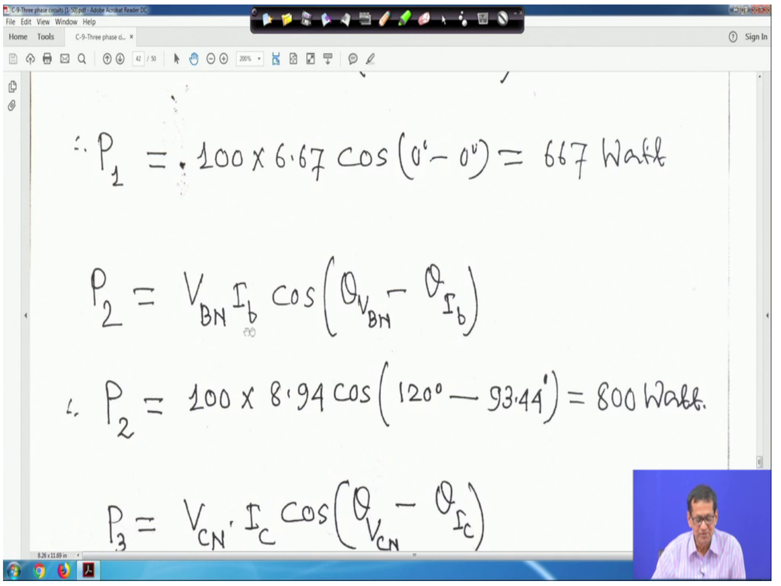


And just write it, cosine of it is angle of theta V B N is 120 degree, and angle of I b is 93.44 degree. This is a power factor angle actually difference is the power factor angle. So, it is 8 800 Watt.

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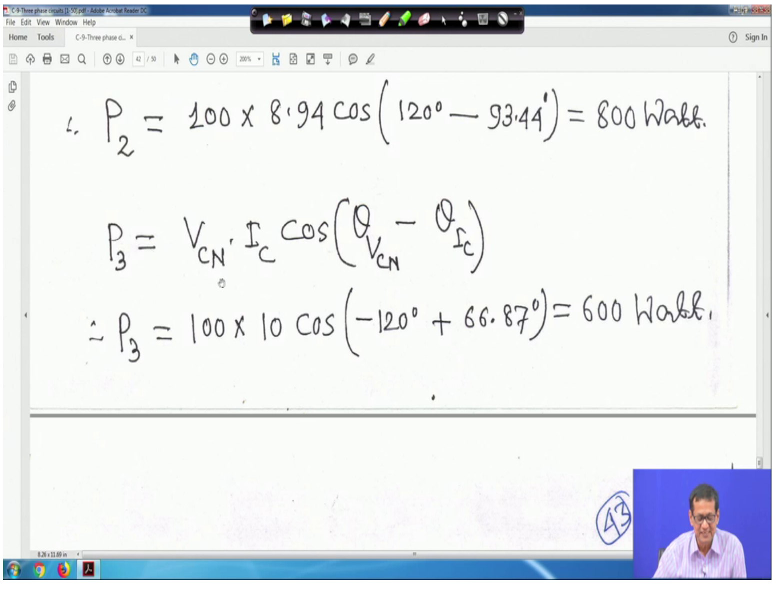


Similarly, for P 3 V C N I c into cos theta this is the angle of your what you call that V C N is minus 120, and angle of your I c it will be minus 66.87. So, in this flux right. So, it will become 600 Watt right.

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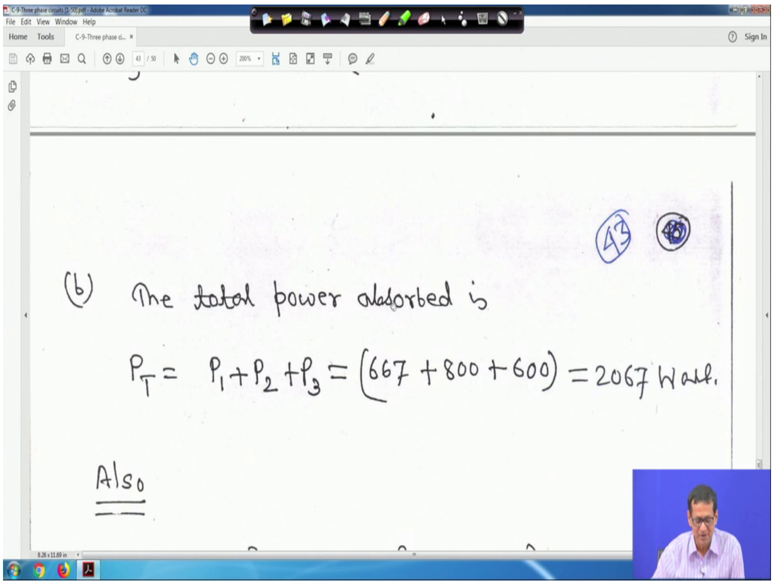


Therefore the total power absorbed is P T is equal to P 1 plus P 2 plus P 3.So, 2000 your 67 Watt this is the answer right.

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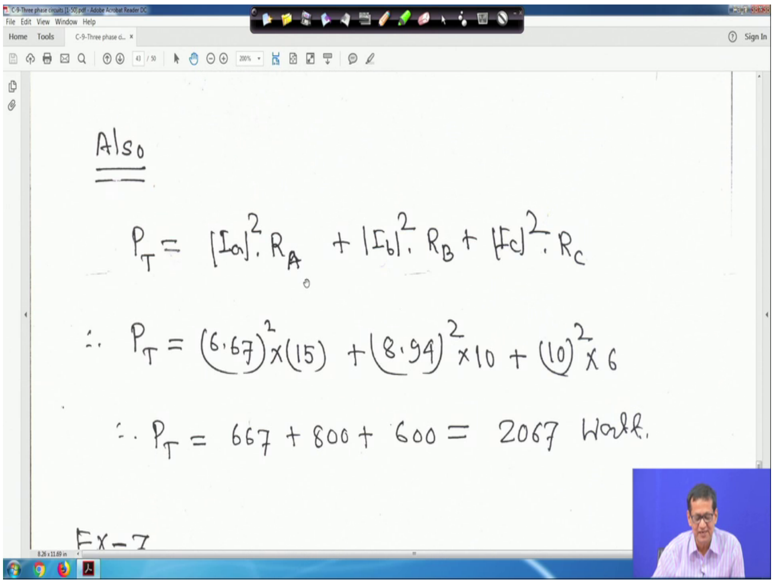


Now, another thing is P T is equal to I a square into R A resistance of the phase a R A is your, plus I b square R B the resistance of your phase b, then I c square R C right. If you just make all magnitude right I just. So, if you just put all these values from the magnitude of this current and the resistive value , you will get 2067 Watt here also 2067 watt. So, it is matching right. So, answers are correct some of you have understood this right.

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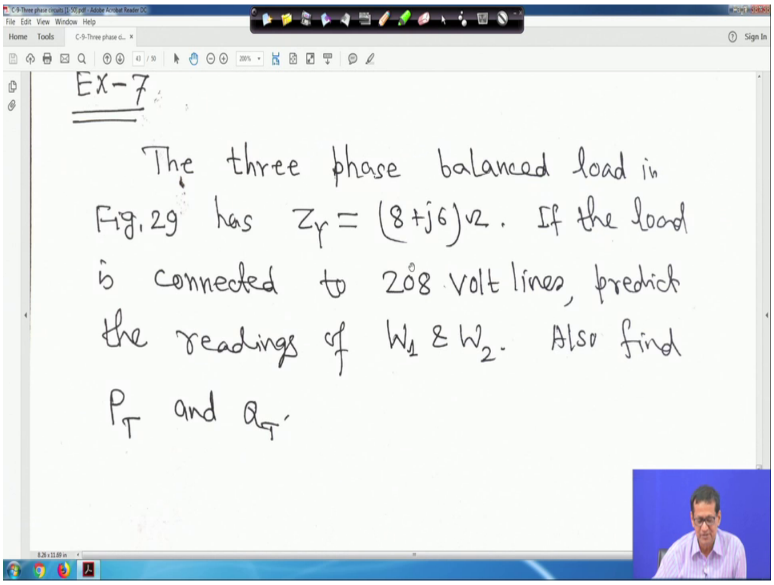


So, example another example you take. The three phase balanced load in figure 29 has your Z star is equal to 8 plus j 6 ohm. If the load is connected to 208 volt, a 208 volt lines, predict the readings of W 1 and W 2 also find P T and Q T right. So, it is actually figure 29.

So, if you come back to figure 29 it is here, this is the, just hold on, is just the same figure where you have derive the formula right this is the figure 30 and this is your this is the figure in this figure right. So, this is the figure you take this figure and data are given there right. So, we will come back to this. So, here so, impedance is given star connected load that is 8 plus j 6 ohm and line to line voltage is 208 volt right we have to find out W 1 and W 2 and P T and Q T.

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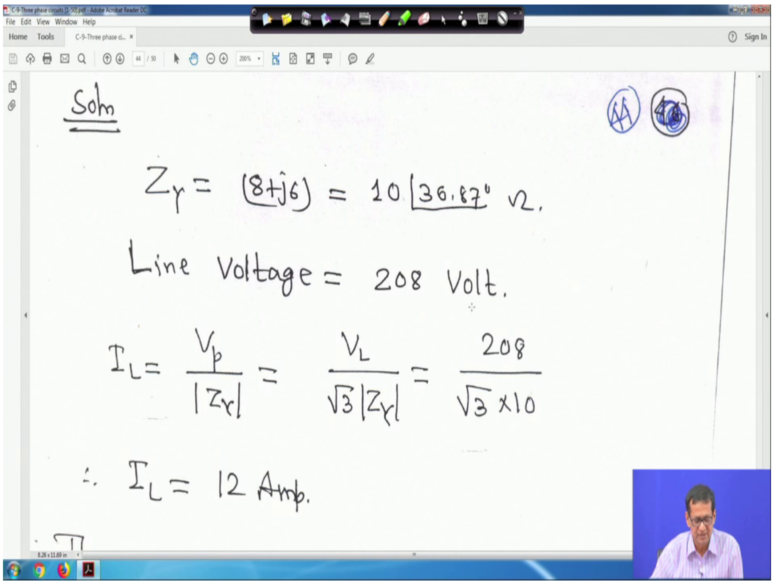


So, we know Z star 8 plus j 6 will 10 angle thirty 6.87 degree ohm right, line voltage is 208 volt therefore, line current will be just, your it is your star connected. So, your V P upon Z Y right. So, that is your V P phase voltage because it is line 2, is your what you call that, your line to Line voltage is given, 208.

So, phase voltage will be line voltage by root 3 magnitude Z Y just you are making the magnitude. So, it is given 208. So, root 3 into 10 magnitude here, it is 10 impendence is 10. So, I L magnitude is 12 Ampere right.

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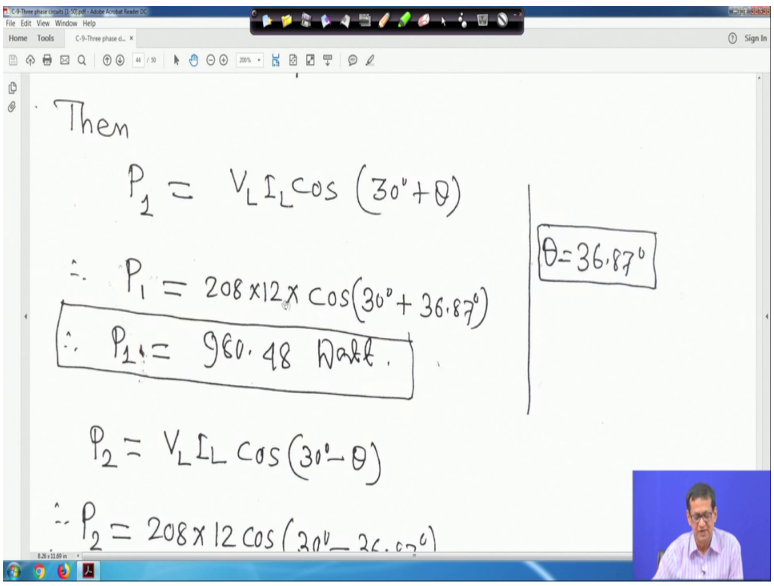

Therefore P 1 is equal to V L I L cos 30 degree plus theta and this theta is equal to 36.87 degree.

So, this is your theta is equal to here it is written here 36.87 degree. Therefore, P 1 is equal to 208 current magnitude is I L line current we got to all right into cosine thirty plus 36.87 degree. So, P 1 is equal to 980.48 Watt. Similarly, P 2 is equal to V L I L cosine 30 degree minus theta.

So, it will be P 2 V L is 208, I L we have got 12 30 minus 36.87 degree.

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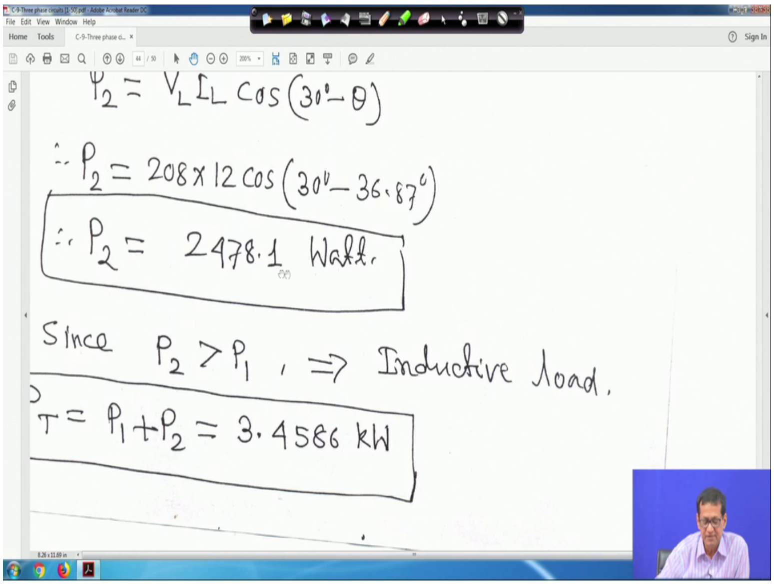


So, it is 2478.1 Watt. Now, now you can see the P 2 greater than P 1 means; it is Inductive load because already we have seen it is Inductive only. So, P 2 greater than P 1 and total power P T is equal to this is P T total power is equal to P 1 plus P 2. If you add this it will be actually 3.4586 Kilo Watt. You add on we might by 1000 you will get it kilowatt right.

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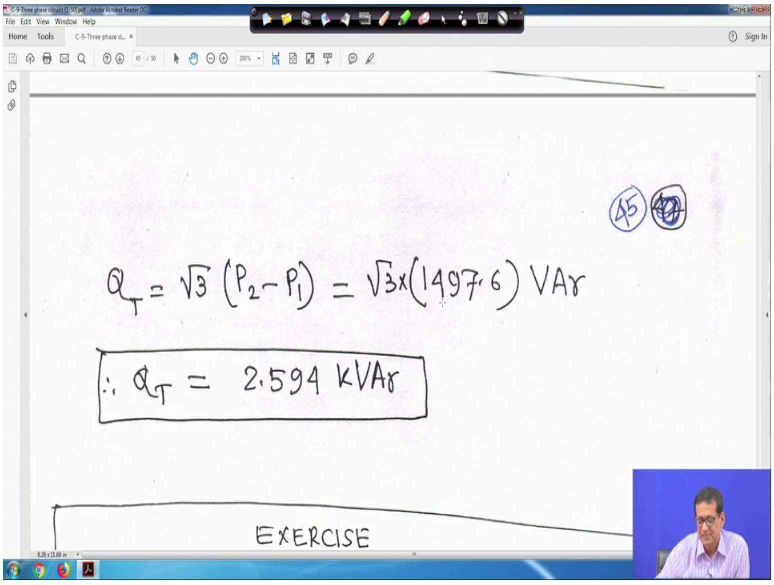


Now, Q T is equal to root 3 into P 2 minus P 1 it is root 3 into P 2 minus P 1 will become one 497.6 because you have got P 2 you with P 2 minus your P 1 right; you will get the directly I have write in 1497.6 VAr. So, it is actually 2.594 kVAr right.

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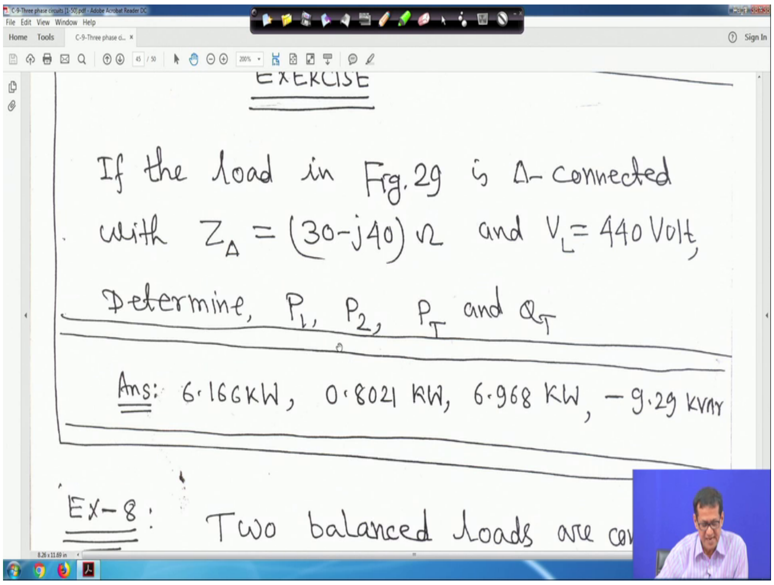


And this is one exercise for you will do it answers are given this exercise you will do it for you right.

You have, and you have it is load is delta right then it is capacity. So, you solve it, answers are also given. So, you can verify.

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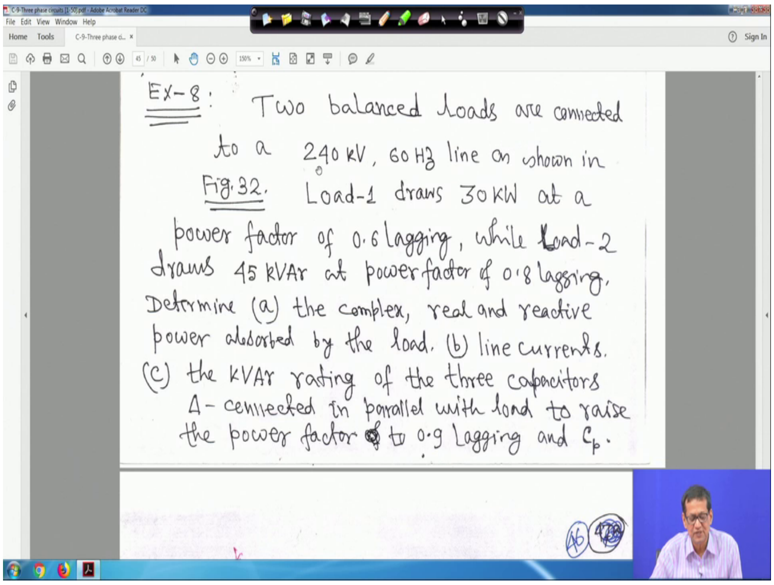


Now, this is a very interesting problem. So, just tell let me let me reduce the zoom little bit right.

So, in this three problem, that Two balance loads are connected to a 240 kV, it is frequency 60 hertz line as shown in figure 32 while. So, your figure 32, Load-1 draws 30 KW at a power factor of 0.6 lagging in 30 KW is given. So, from this power factor you can find out also is reactive power absorb right load reactive power also because power factor is given.

While, Load-2 draws 45 kVAr at power factor of 0.8 lagging, it is problem here it is twisted. So, here it is give it 45 kVAr, but power factor is when 0.8 ; that means, here you have to find out P and for the V A r you have to find out the Q right, and therefore, you have to determine, first one, the complex, real and reactive power absorbed by the load, and b) the line currents and c) the kVAr rate you have the your what you call three capacitors, which are, can delta connect in parallel with load right that, I will show you to raise the power factor to 0.9 lagging and also the value of C P right.

So, this is the thing now question is the let us go to the your what you call that diagram.

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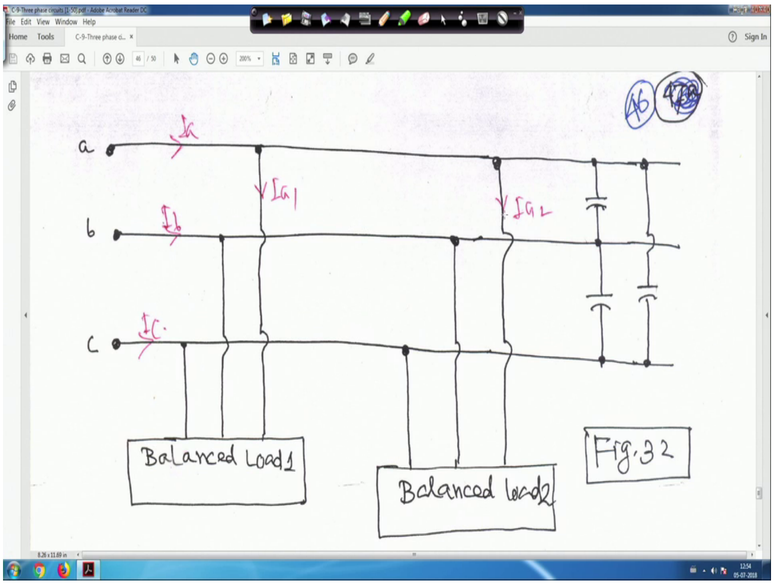


So, if you see the diagram actually this is the diagram. So, question is that that here little bit you have to understand right. So, loads are there. So, this is the three line a b c this is the, three lines are there right; and this loads are connected this is the Balanced Load 1 and this is the Balanced, 2 loads are connected.

So, this is without capacitor suppose it is connected; now, this capacitors are connected in delta form this is given just you see yourself that how actually things are connected right. So, now, in the here in the problem it is mentioned, that in the, problem it is mentioned that that you are the kVAr rating of the three capacitors delta connected in parallel the load to raise the power factor 0.9 lagging.

So, it is power factor you whatever combined power factor is given that different issue, but you have to raise the power factor right, at the power factor of the your what you call the first load is 0.6 lagging, and the for second load also it is your 0.8 lagging right.

So, this is all this is, what you call it is given. So, that is in the figure thirty 2 this is your figure 32. So, this capacitor thing will consider later. So, question is that, that this is my current I a this is I a I b. So, this I a then, this current is some part is going to I a 1 and going to I a 2. This we will see later this we will see later right.

So, question is and this is Balance Load 1, Balance Load 2. So, it is a basically parallel, circuit right, three phase it is a parallel circuit and this is the, your problem. So, now, very easy it is just see. So, ; that means, your I a is equal to I a 1 plus I a 2 and similarly I b I c that 120 degree phase shift you can easily make out because this is Balanced system.

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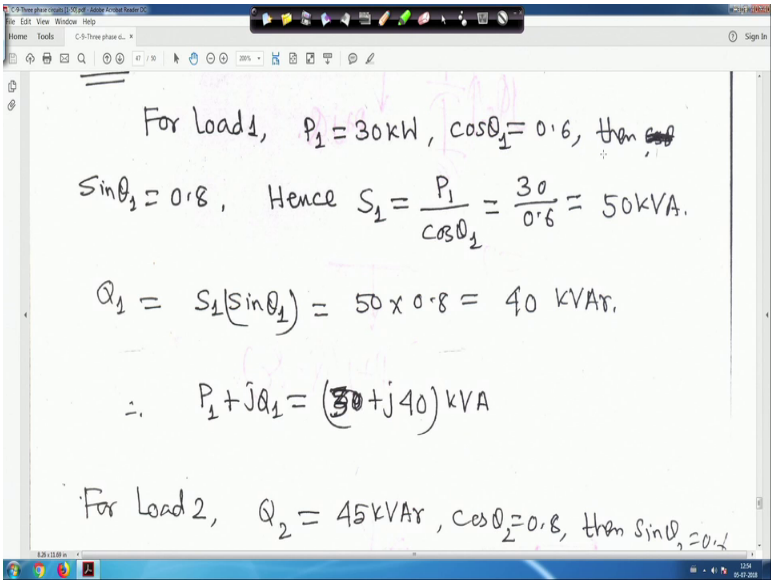


So, magnitude it will remain same, right. So, I a is equal to I a 1 plus I a 2 can case here right so; that means so; that means, if, Load 1 P 1 is equal to 30 KW cos theta 1.6; that means, sin theta one is equal to 0.8.

So, S 1 is equal to apparent power P 1 upon cos theta one it will be 50 KVA, right and Q 1 will be S 1 sin, theta one it will be 50 into 0.8 40 kVAr. Therefore, P 1 plus j Q 1 will be 30 plus j 40 Kilovolt Ampere right, in terms of K V A. Similarly, for Load 2 problem is twisted right, here it is q 2 is equal to 45 kVAr is given you have to obtain P. So, lagging power factor it is lagging means current is lagging. So, cos theta 2 is equal to 0.8 than sin theta 2 is equal to 0.6.

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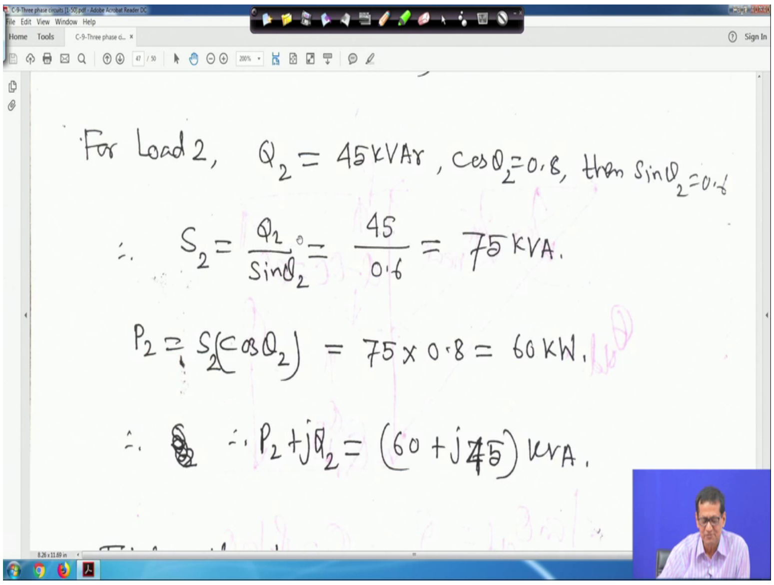


Therefore S 2 is equal to q 2 upon sin theta 2 that is 45 by 0.6 is equal to 75 KVA right. Therefore, P 2 is equals to S 2 cos theta 2 75 into 0.8 it was 60KW.Therefore, P 2 plus j Q 2 is equal to 60 plus j 45, in K V A right.

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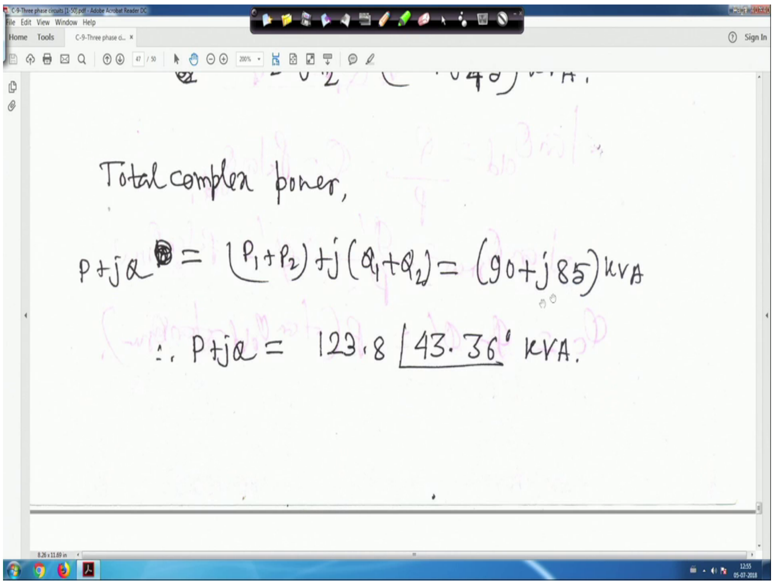


Now, total complex power P plus j Q will be P 1 plus P 2 plus j Q 1 plus Q 2; it will become 90 plus j 85 KVA right. therefore, P plus j Q will be you take the square root of 90 square plus 85 square you will get 123.8 and angle will be 43.36 degree KVA right so; that means, it is your, V i cos theta plus V b i sin theta form right.

So, now this is your, KVA and right 123.8KVA, the apparent power, now.

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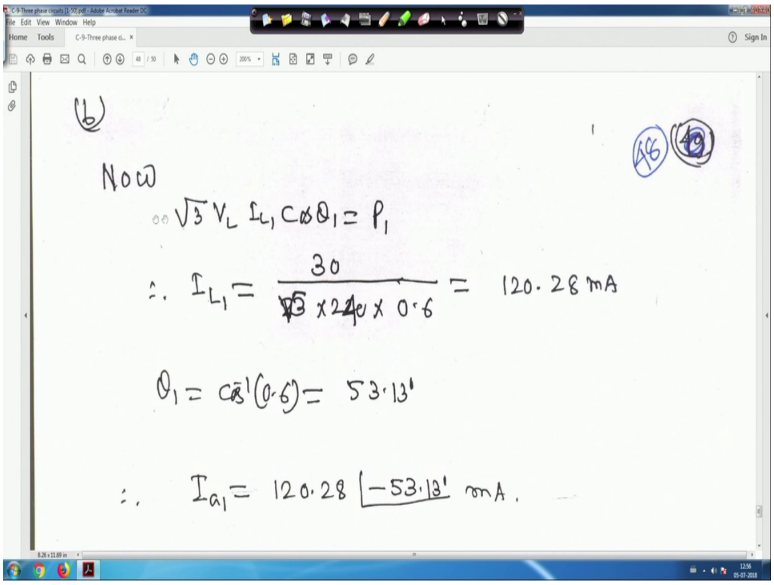

Now, question is now, the root 3 we know that root 3 V L I L 1 cos theta 1 is equal to P l P 1 right. So, I L 1 is equal to 30 you got, and this is in, kilowatt this is in kilowatt and this, your what you call the root 3 into 240 your kilovolt into 0.6 right.

So, it will become actually 120.28 milliAmpere, right this is you are written as kilowatt. So, it is also kilovolt right. So, if you solve it will be 120.28 milliAmpere, and theta 1 is equal to cos inverse 0.653.13 degree and current is lagging. Therefore, 120.28 angle minus 53.13 degree milliAmpere. So, current is lagging.

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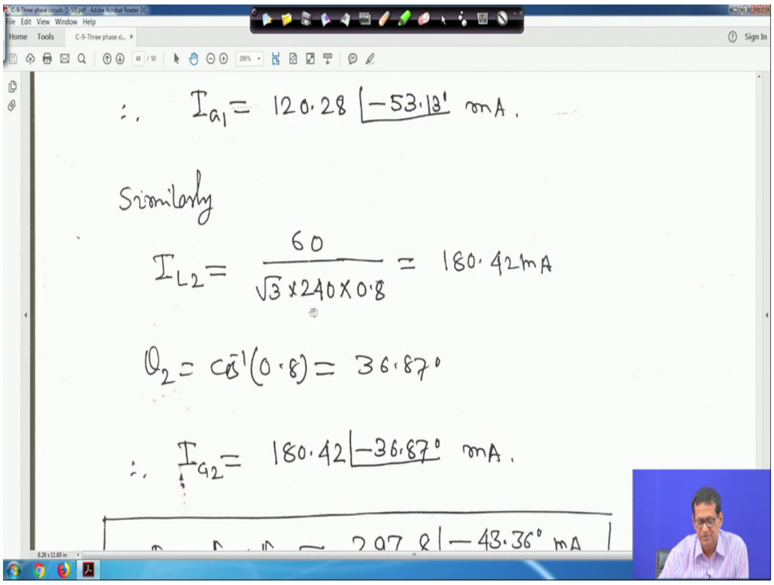


Similarly, for I L 2 it will be 60 upon root 3 into 240 into 0.8 it is milliAmpere, 180.42 milliAmpere, 60 is in kilowatt and this is in kilovolt.

So, ultimately it will it, ultimately it will be ampere from that you write in milliAmpere from, it will be one, 8.42 milliAmpere and theta 2 will be 36.86 degree is lagging. Therefore, I a 2 will be 180.42 angle minus 36.87 degree milliAmpere right. Therefore, total current the K C L I told you apply, I a will be equal to I a 1 plus I a 2.

So, it will be, simplify it will be 297.8 angle minus 43.36 degree milliAmpere right. Therefore, I b is equal to just 120 degree phase shift I a angle minus 120 degree. It will become 297.8 angle 163.36 degree milliAmpere.

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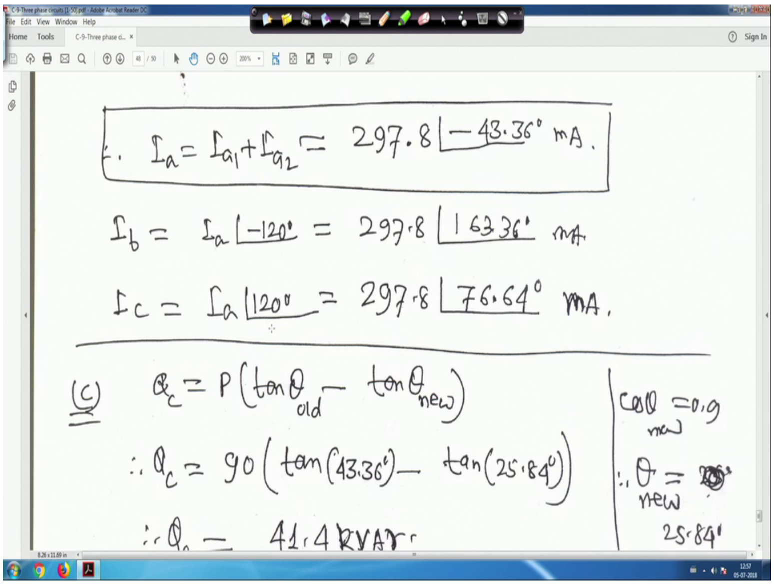

Similarly, I c is equal to, I a angle 120 degree, it will become 297.8. So, angle 76.6 degree a 64 degree milliAmpere. So, here you have got your what you call, that, your I a you got this I a here and here you substitute you are getting the magnitude is remain same right.

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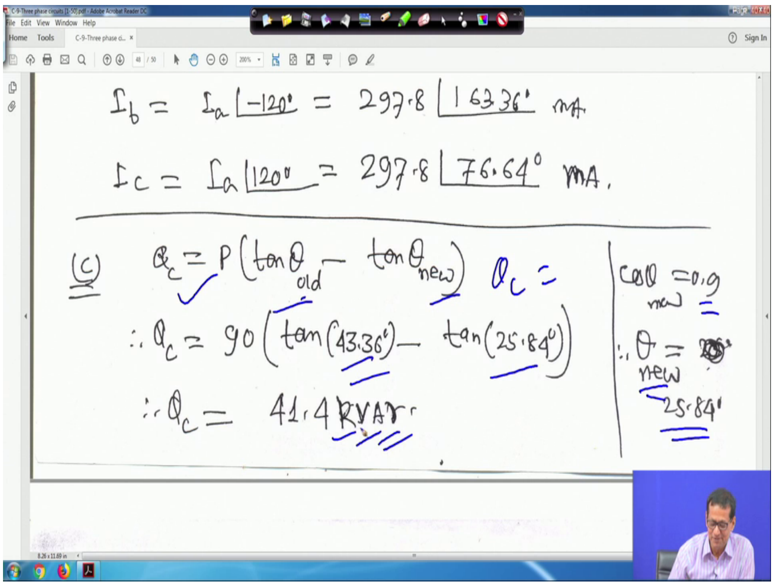

Now, Q c is equal to this one, this one is a very simple thing, that Q c will be P tan theta old a P into tan theta old minus tan theta new. So, this one how we have got in this is, your cos theta ; we want to improve the power factor to 0.9 therefore, theta new is equal to 25.85 degree right, and this we got it this is a small exercise I am leaving up to you please do it right you draw it triangle power triangle.

And from there you find out the expression of Q c right you draw a power triangle and you do yourself. So, this one I am leaving up to you right. So, Q c will be 41.4kVAr, and another thing is there the capacitor C P value not computed here, it is a delta connected capacitor from this also you try to find out what is the value of C P right a capacity in micro farad that answer is not given here, but I suggest you please do it and this one is very simple thing you do it up to your own right.

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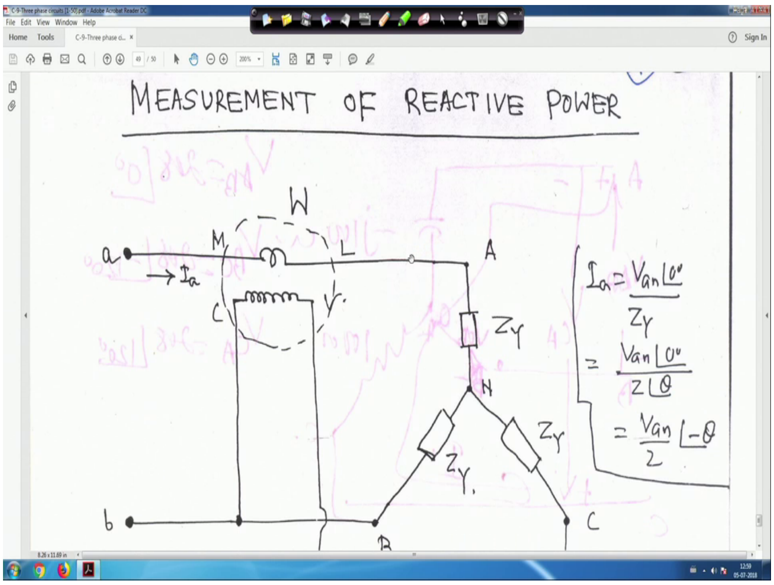


Next is the Measurement of Reactive Power using the same wattmeter, right, I mean, using the your same wattmeter you measure the your what you call the, your Reactive Power. In this case let me let me reduce the zoom little bit.

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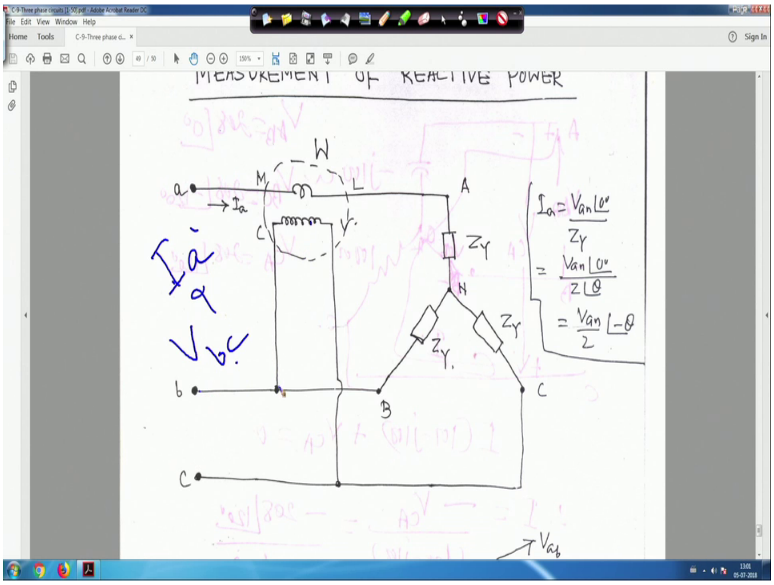


In this case what happened, that your sometimes you will finds sometime you will find this is, that current coil should be put in one phase and phasor coil should be connected across other phase right.

Sometimes we write that you your what you call wattmeter like m. So, m l then this is your mean side this is your load side C and V sometimes you write like this, but at the resistance in very high. So, whatever current will flowing here almost current will be same current will be flowing here right, but anyway. So, this current your what you call, this here to measure the reactive power using the same wattmeter you put the current coil in one phase.

Suppose in phase a I have put the current coil, which sees the current I a, and the phasor coil that is C V, it is connected to your what you call that other two phases that is b and c right. Then this will actually give you the reactive for the question, you have to find out how.

So, this is my Z Y Z Y Z Y right this is A N A same thing this is actually it is same thing it is small a, this is your small c, and this is your small b, same thing. So, I a the same current is flowing here I a is equal to V a n angle 0, this is your V a n and this is a new small n same thing right same, I will meaning is same. So, that should not be any confusion right. So, I n will be V a n angle 0 by Z Y this is your, V a n angle 0 then divided by say z theta. So, it will be V a n angle Z angle your minus theta this is your I a right.

Similarly, for I v n I c, the question is, how it will be, if, you to connect this, how it what is the value of then Reactive Power; however, doing it then, in this case you draw the phasor diagram.

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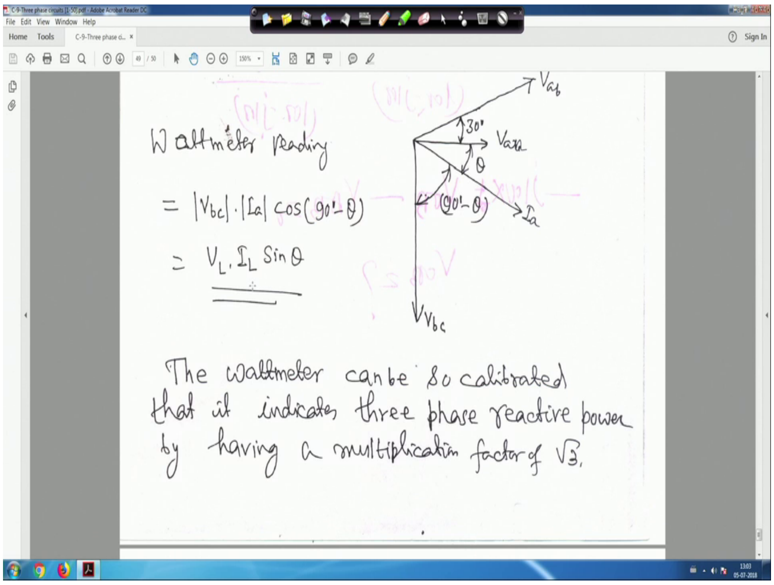


Now, suppose this is your, this is your V a b this is your V a b right; and this is my V a n right and current lag from V a n by angle theta.

But wattmeter actually, if therefore, your, this thing, for this diagram if you look into that wattmeter sees actually, that current I a, current I a and it is, sees the voltage your what you call V b c, and it will take angle between V b c and I a right, because it is, b this phasor coil as connected at b c. So, it measures the voltage V b c and the I a and the angle between the I a and V b c that we need.

So; that means, ; that means, here in the phasor diagram this is my V a b this is my V a n right and I L lags by theta and this is V b c V a b angle between V a b and V b c is 120 degree you know. So, this your what you call between V a n and V b c angle is ninety degree this angle is theta. So, this angle is ninety degree minus theta, right; therefore, that wattmeter reading will be the magnitude, of the v b c and magnitude of the current I a I have put I b, occasionally, I have put bar sometimes does not, put bar didn't put bar.

But I told you this long run cost that angle between I a and V b c is 90 degree minus theta. So, cos 90 degree minus theta, let me wattmeter, reading will be V L I L sin theta right, but our Reactive Power is root 3 V L I L sin theta, then this reading has to be multiplied by root 3 to get the connect reading right. So, this way watt same wattmeter, you can used for Measuring the Reactive Power right.

So, that; that means, the wattmeter can be. So, calibrated that it indicates three phase Reactive Power by having a, multiplication factor of root 3, that if you want same wattmeter reading, that wattmeter has to be calibrated, by multiplying factor root three; that means, that is the scale is there know, that those all this thing has to be multiplied by root 3. So, whatever reading you get you just multiplied by root 3 you will get your what you call that your Reactive Power right.

So, this is the, that is why this is the connection of the wattmeter for getting your what you call, that your, Reactive Power same wattmeter you can use.

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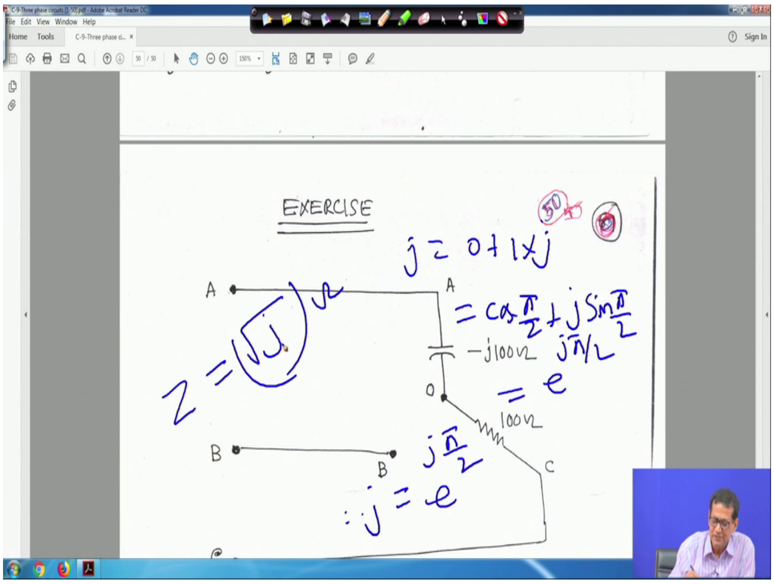


So, with this, this exercise is one exercise given this problem I have got from some book. So, suppose this a b c all of a sudden this, your this phase is open right. So, this is minus j 100 ohm this is one 100 ohm and A B C all these things are given you have to find out V O B that what is the voltage b open circuit voltage V O B.

So, find V O B given that the system is 208 volt and A B C is equal 208 volt means it is line to line right.

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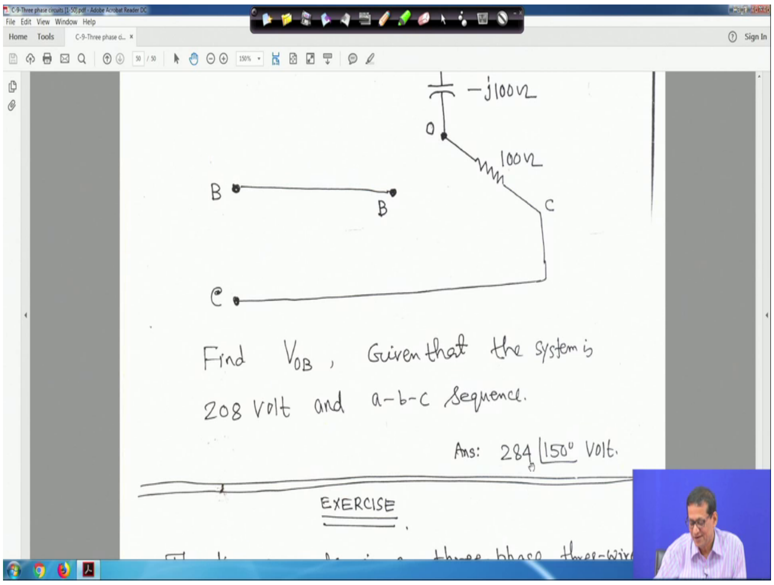


And the answer is given 284 angle 150 degree volt answer is correct you try to find out very simple problem, but very interesting problem, right.

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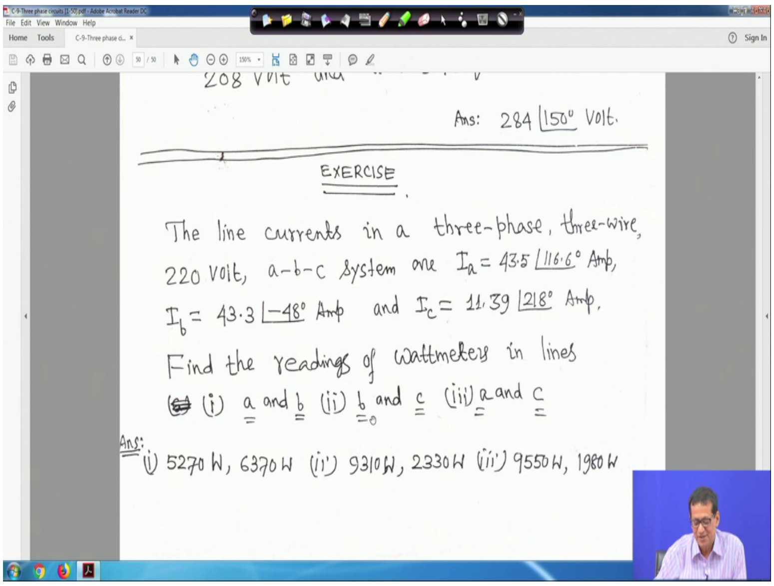


Another exercise is this, line current in a three-phase, three-wire 220 Volt a-b-c system, the I a is equal to is given I b is given I c is given.

Find the readings of wattmeter in lines 1 a and b and the readings also, if, you put wattmeter in b and c and a c having, you connect the wattmeter in line a and b and find out the reading; you connect the wattmeter b and c, find out the reading you connect the wattmeter a and c find out the reading and all these answers are given all the and you are what you call and you find out why this readings are different right.

Now, before they before you are, closing this three phase circuit one or two things I will tell you I will here itself I am telling you. Suppose sometimes is given suppose if it is given that impedance of a circuit, suppose if it is given that Z is equal to say root j, a ohm it is given then what is the value of r what is the value of x right. So, if it is given then what is r what is x suppose this is given and somebody ask you that the impedance is root over j.

So, what is the what will be the your what you call that R value and X value look, j is equal to you can write, 0 plus 1 into j this we write; that means, 0 is equal to you can write cos pi by 2, right and 1 you can write j this j is there j sin pi by 2 right.

That means you can write this one actually e to the power, j pi by 2 right; that means, my j is equal to, your e to the power j pi by 2 this is plus 11 complex number right. Therefore, root j means and j; that means, j is equal to e to the power j pi by 2 let me clear it.

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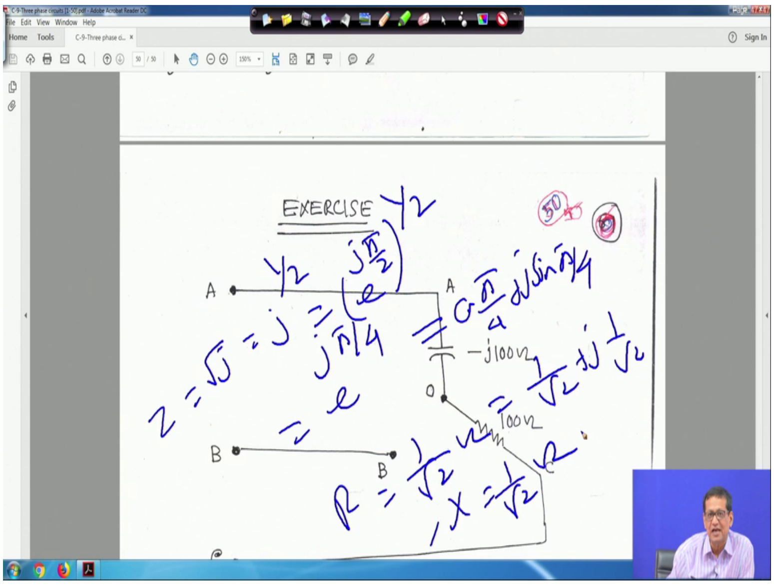

That means; that means, your z is equal to root j is equal to j to power half. So, j is equal to e to the power your, j pi by 2 to the power half right, is equal to e to the power j pi by 4 right is equal to it is cos pi by 4 plus j, sin pi by 4 right is equal to, 1 upon root 2 plus j, 1 upon root 2; that means, your R is equal to 1 upon root 2 ohm, and your X is equal to also, 1 upon root 2 ohm right. So, this is how calculate now another thing is.

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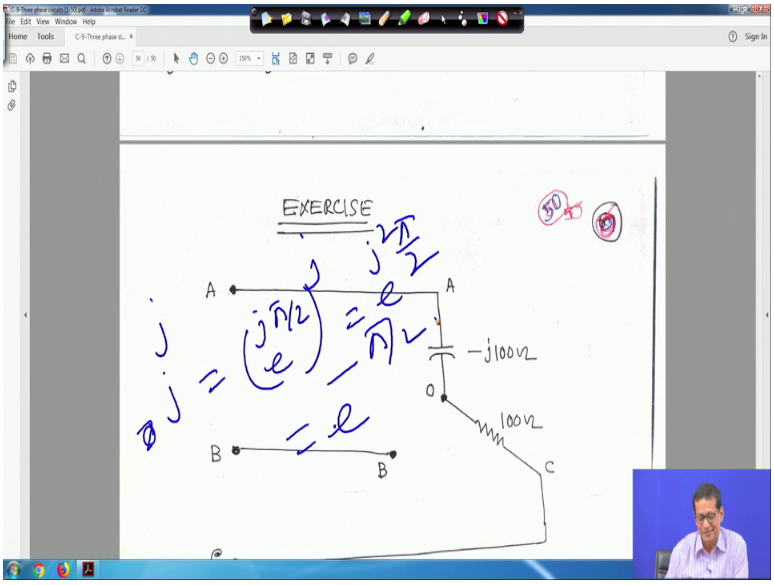


Another thing is with that only suppose if somebody ask you, that your what is the value of j to the power j, j we have seen, just now we have seen j is equal to e to the power j pi by 2 to the power j; that means, e to the power, j square pi by 2 right that that is equal to actually j square is minus 1. So, e to the power minus pi by l it is a real number right.

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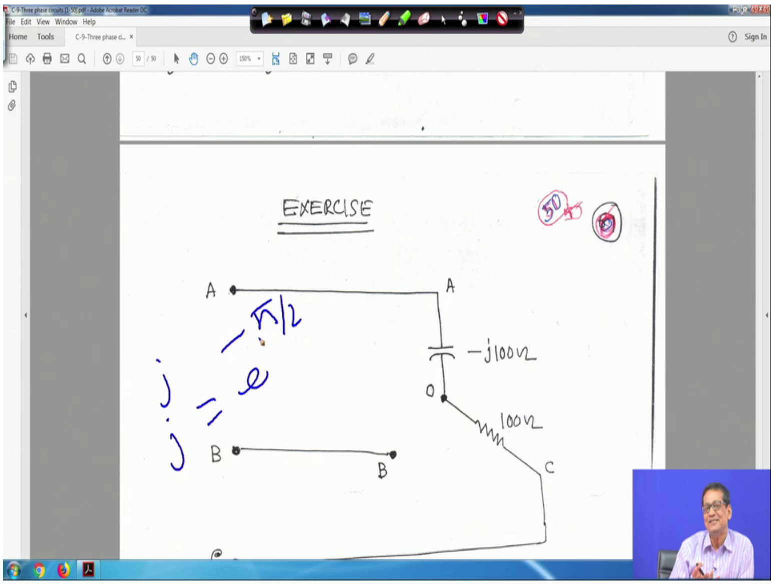


That means; that means, my j to the power j to the power j, is a real number it is e to the power minus pi by 2 right. So, little bit, little bit a your, I mean, mathematical thing, just I have told you right. So, with these thank you very much the three phase, three phase your A C circuit part is over. Next we will take the magnetic circuits and after that a little bit of single phase transformer and little bit of three phase induction machines and d c machines so.

Thank you very much.