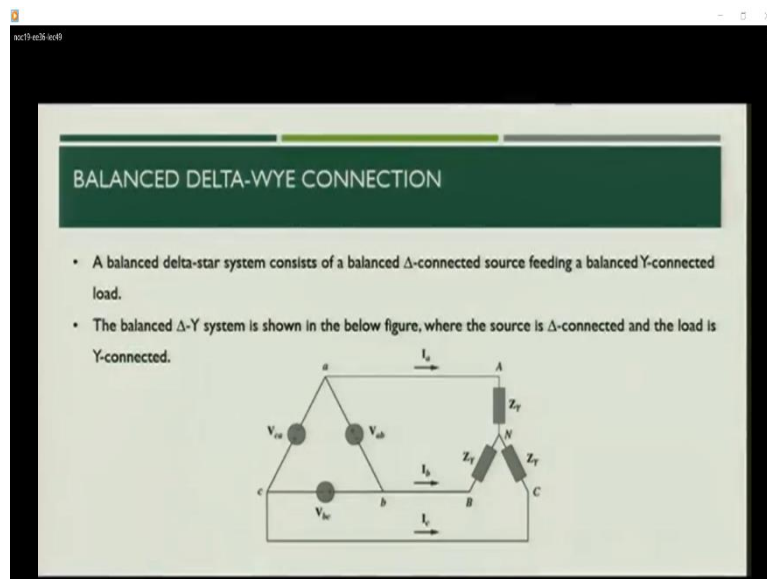


Basic Electric Circuits
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Module-10
Sinusoidal Steady State Analysis 2
Lecture-49

Balanced Delta-Wye Connections and Power in Balanced Three Phase System

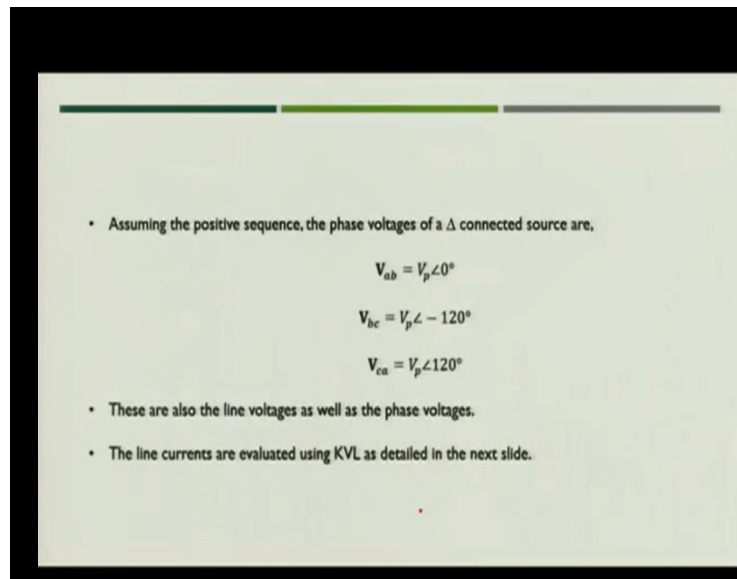
Namashkar, so in the last two sessions, we have discussed about three phase connections specially star star and then we discussed star delta connections and then in the last lecture we discussed about the Delta Delta connection. So today, we will start our session with delta star connection. You can also say Delta Wye connection where delta is the source and the star connected is the load and in the later part of the session, we will discuss about the energy for a three phased system. So, let us start our discussion.

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So basically, in case of Delta Wye connection or Delta Star connection, we have source delta connected and the load star connected. So, if you see in this figure, the source is connected in delta i.e. load is connected in star and the line currents are I_a , I_b , and I_c .

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• Assuming the positive sequence, the phase voltages of a Δ connected source are,

$$V_{ab} = V_p \angle 0^\circ$$
$$V_{bc} = V_p \angle -120^\circ$$
$$V_{ca} = V_p \angle 120^\circ$$

• These are also the line voltages as well as the phase voltages.

• The line currents are evaluated using KVL as detailed in the next slide.

Now as we discussed in the previous cases, in this case also we assume that the positive sequence is considered for the source and the phase voltage of delta connected source can be given as,


$$V_{ab} = V_p \angle 0^\circ$$

$$V_{bc} = V_p \angle -120^\circ$$

$$V_{ca} = V_p \angle 120^\circ$$

As you know, in case of delta connected source, the line voltage and phase voltages are same. Now let us apply KVL to find out the line current.

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The diagram shows a three-phase system with nodes a, b, and c. A loop is highlighted in red, labeled aANBba. The loop starts at node a, goes to node A, then to node B, then to node b, and back to node a. The voltage across the branch a-b is labeled V_{ab} . The current entering node a is I_a and the current leaving node b is I_b . The impedances of the branches A-N and B-N are both labeled Z_Y . The voltage across branch a-c is V_{ac} and across b-c is V_{bc} .

- Applying KVL around the loop aANBba gives,
$$-V_{ab} + Z_Y I_a - Z_Y I_b = 0$$
- or
$$Z_Y (I_a - I_b) = V_{ab} = V_p \angle 0^\circ$$
- Therefore,
$$I_a - I_b = \frac{V_p \angle 0^\circ}{Z_Y}$$

Let us consider the figure which we saw in the first slide. Now we will apply Kirchhoff voltage law around the loop aANBba. This will be the loop in which we will apply the Kirchhoff voltage law. So if we apply,

$$-V_{ab} + Z_Y I_a - Z_Y I_b = 0$$

or

$$Z_Y (I_a - I_b) = V_{ab} = V_p \angle 0^\circ$$

Therefore,

$$I_a - I_b = \frac{V_p \angle 0^\circ}{Z_Y}$$

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• But I_b lags I_a by 120° , i.e.,

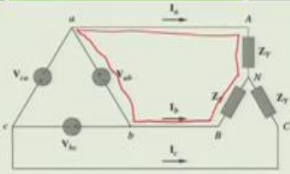
$$I_b = I_a \angle -120^\circ$$

• Hence,

$$I_a - I_b = I_a(1 - 1 \angle -120^\circ)$$

$$= I_a \left(1 + \frac{1}{2} + \frac{j\sqrt{3}}{2} \right) = I_a \sqrt{3} \angle 30^\circ$$

• Therefore,

$$I_a = \frac{V_p \angle 0^\circ}{\sqrt{3} Z_Y}$$


• Applying KVL around the loop $aANBba$ gives,

$$-V_{ab} + Z_Y I_a - Z_Y I_b = 0$$

or

$$Z_Y (I_a - I_b) = V_{ab} = V_p \angle 0^\circ$$

• Therefore,

$$I_a - I_b = \frac{V_p \angle 0^\circ}{Z_Y}$$

Now as we know,

$$I_b = I_a \angle -120^\circ$$

Hence,

$$I_a - I_b = I_a(1 - 1 \angle -120^\circ)$$

$$= I_a \left(1 + \frac{1}{2} + \frac{j\sqrt{3}}{2} \right) = I_a \sqrt{3} \angle 30^\circ$$

Therefore,

$$I_a = \frac{\frac{V_p}{\sqrt{3}} \angle -30^\circ}{Z_Y}$$

In this way you can calculate the line current for delta star connected system.

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Another way to obtain the line currents is to replace the delta connected source with its equivalent Y connected source as shown below.

We had already discussed that the line-line voltages of a wye-connected source leads their corresponding phase voltages by 30 degree and is $\sqrt{3}$ times in magnitude as well.

Now another way to obtain the line current is that you replace the delta connected source into its equivalent star connected or Y connected source. So when you convert, let us say that the phase voltages are V_{an} , V_{bn} and V_{cn} and we have already discussed that line line voltage of Wye connected source leads their corresponding phase by 30 degree and root 3 times the magnitude.

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Therefore, the equivalent Y connected source has the phase voltages,

$$V_{an} = \frac{V_p}{\sqrt{3}} \angle -30^\circ$$

$$V_{bn} = \frac{V_p}{\sqrt{3}} \angle -150^\circ$$

$$V_{cn} = \frac{V_p}{\sqrt{3}} \angle 90^\circ$$

If the delta connected source has a source impedance of Z_s per phase the wye-connected source will have a source impedance of $Z_s/3$ per phase.

Once the source is transformed to Y the circuit becomes a Y-Y network and can be solved using the single phase analysis as discussed previously.

So, in that case what you can write,

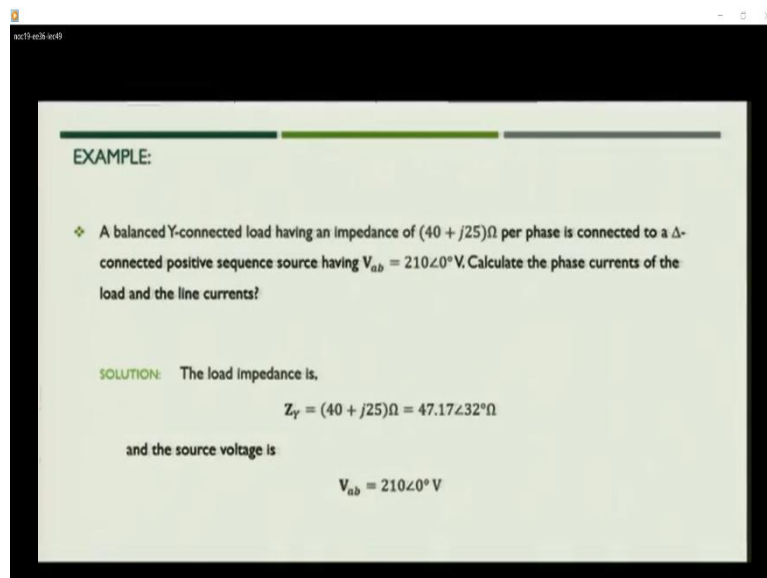
$$\mathbf{V}_{an} = \frac{\mathbf{V}_p}{\sqrt{3}} \angle -30^\circ$$

$$\mathbf{V}_{bn} = \frac{\mathbf{V}_p}{\sqrt{3}} \angle -150^\circ$$

$$\mathbf{V}_{cn} = \frac{\mathbf{V}_p}{\sqrt{3}} \angle 90^\circ$$

Now incase if you have a delta connected source with some source impedance \mathbf{Z}_Δ , in that case you can apply star delta transformation and find out the per phase source impedance for equivalent star connected source. In that case your source impedance will be become $\mathbf{Z}_\Delta/3$ as we have already seen when we were doing the star delta transformation. Now once the source is transformed into Y or star, these circuit becomes Y-Y network which can be easily solved using single phase analysis which we have already discussed.

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The image shows a presentation slide with a black border. At the top, it says "EXAMPLE:". Below that, a problem is stated: "A balanced Y-connected load having an impedance of $(40 + j25)\Omega$ per phase is connected to a Δ -connected positive sequence source having $\mathbf{V}_{ab} = 210\angle 0^\circ \text{ V}$. Calculate the phase currents of the load and the line currents?". Below the problem, the solution is given: "The load impedance is, $\mathbf{Z}_Y = (40 + j25)\Omega = 47.17\angle 32^\circ \Omega$ and the source voltage is $\mathbf{V}_{ab} = 210\angle 0^\circ \text{ V}$ ".

Now let us take one example. Suppose if balanced star connected load is having impedance of $(40 + j25)\Omega$ per phase is connected to delta connected positive sequence source having $\mathbf{V}_{ab} = 210\angle 0^\circ \text{ V}$. We need to calculate the phase currents and line currents.

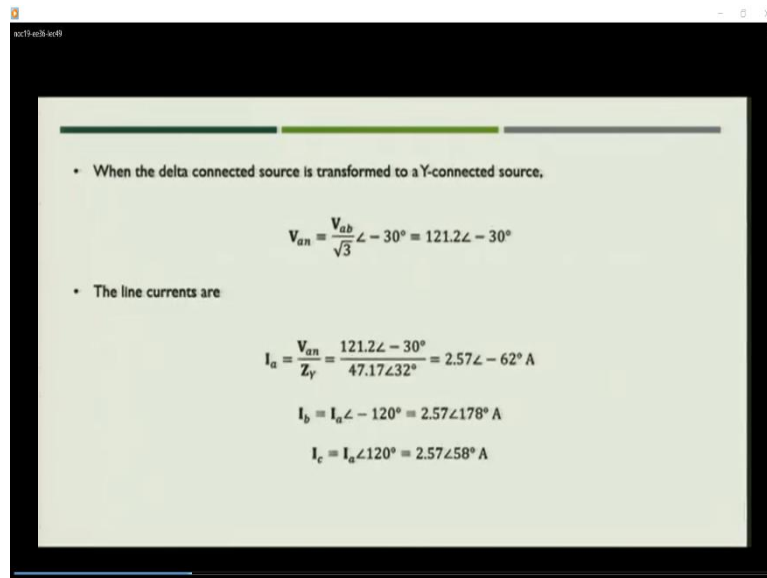
So, we have load impedance as given. We convert it to phasor format as,

$$\mathbf{Z}_Y = (40 + j25)\Omega = 47.17\angle 32^\circ \Omega$$

and the source voltage is,

$$\mathbf{V}_{ab} = 210\angle 0^\circ \text{ V}$$

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• When the delta connected source is transformed to a Y-connected source,

$$\mathbf{V}_{an} = \frac{\mathbf{V}_{ab}}{\sqrt{3}} \angle -30^\circ = 121.2\angle -30^\circ$$

• The line currents are

$$\mathbf{I}_a = \frac{\mathbf{V}_{an}}{\mathbf{Z}_Y} = \frac{121.2\angle -30^\circ}{47.17\angle 32^\circ} = 2.57\angle -62^\circ \text{ A}$$
$$\mathbf{I}_b = \mathbf{I}_a \angle -120^\circ = 2.57\angle 178^\circ \text{ A}$$
$$\mathbf{I}_c = \mathbf{I}_a \angle 120^\circ = 2.57\angle 58^\circ \text{ A}$$

We will convert delta connected source into star connected. So in that case, per phase voltage for equivalent star connected source will be

$$\mathbf{V}_{an} = \frac{\mathbf{V}_{ab}}{\sqrt{3}} \angle -30^\circ = 121.2\angle -30^\circ$$

Now what will be the line currents? Line currents will be,

$$\mathbf{I}_a = \frac{\mathbf{V}_{an}}{\mathbf{Z}_Y} = \frac{121.2\angle -30^\circ}{47.17\angle 32^\circ} = 2.57\angle -62^\circ \text{ A}$$

$$\mathbf{I}_b = \mathbf{I}_a \angle -120^\circ = 2.57\angle 178^\circ \text{ A}$$

$$\mathbf{I}_c = \mathbf{I}_a \angle 120^\circ = 2.57\angle 58^\circ \text{ A}$$

Since the load is balanced so the magnitude of currents i.e. line currents will remain the same. The only change will be the angle value.

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POWER IN A BALANCED SYSTEM

- We now consider the power in a balanced three-phase system.
- To find the instantaneous power absorbed by the load, the analysis needs to be done in the time domain.
- For a Y-connected load, the phase voltages are

$$v_{AN} = \sqrt{2}V_p \cos \omega t$$
$$v_{BN} = \sqrt{2}V_p \cos(\omega t - 120^\circ)$$
$$v_{CN} = \sqrt{2}V_p \cos(\omega t + 120^\circ)$$

where the factor $\sqrt{2}$ is necessary because V_p has been defined as the rms value of the phase voltage.

Now let us discuss the power in the balance three phase system. To find the instantaneous power absorbed by any load in case of the three phased system, we will do the analysis in the time domain. So, what we will do we will assume that we have the load as star connected. The phase voltage in that case, you can say

$$v_{AN} = \sqrt{2}V_p \cos \omega t$$

$$v_{BN} = \sqrt{2}V_p \cos(\omega t - 120^\circ)$$

$$v_{CN} = \sqrt{2}V_p \cos(\omega t + 120^\circ)$$

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- If $Z_Y = Z \angle \theta$, the phase currents lag behind their corresponding phase voltages by θ .
- Thus,

$$i_a = \sqrt{2}I_p \cos(\omega t - \theta)$$
$$i_b = \sqrt{2}I_p \cos(\omega t - \theta - 120^\circ)$$
$$i_c = \sqrt{2}I_p \cos(\omega t - \theta + 120^\circ)$$

where I_p is the rms value of the phase current.

Now, if load is $\mathbf{Z}_Y = Z\angle\theta$. The phase currents will lag their corresponding phase voltages in that case by angle theta. We can write the currents as,

$$i_a = \sqrt{2}I_p(\cos \omega t - \theta)$$

$$i_b = \sqrt{2}I_p \cos(\omega t - \theta - 120^\circ)$$

$$i_c = \sqrt{2}I_p \cos(\omega t - \theta + 120^\circ)$$

where I_p is the rms value of the phase current.

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• The total instantaneous power in the load is the sum of the instantaneous power in the three phases, i.e.,

$$p = p_a + p_b + p_c = v_{AN}i_a + v_{BN}i_b + v_{CN}i_c$$

$$= 2V_p I_p [\cos \omega t \cos(\omega t - \theta) + \cos(\omega t - 120^\circ) \cos(\omega t - \theta - 120^\circ) + \cos(\omega t + 120^\circ) \cos(\omega t - \theta + 120^\circ)]$$

• Applying the trigonometric identity

$$\cos A \cos B = \frac{1}{2} [\cos(A + B) + \cos(A - B)]$$

Now total instantaneous power in the load, you can say the total instantaneous power will be the sum of individual phase instantaneous powers. So, we can write total instantaneous power,

$$p = p_a + p_b + p_c = v_{AN}i_a + v_{BN}i_b + v_{CN}i_c$$

$$= 2V_p I_p [\cos \omega t \cos(\omega t - \theta) +$$

$$\cos(\omega t - 120^\circ) \cos(\omega t - \theta - 120^\circ) +$$

$$\cos(\omega t + 120^\circ) \cos(\omega t - \theta + 120^\circ)]$$

Applying the trigonometric identity

$$\cos A \cos B = \frac{1}{2} [\cos(A + B) + \cos(A - B)]$$

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• The above identity transforms the instantaneous power equation as follows,

$$p = V_p I_p [3 \cos \theta + \cos(2\omega t - \theta) + \cos(2\omega t - \theta - 240^\circ) + \cos(2\omega t - \theta + 240^\circ)]$$

• Let $\alpha = 2\omega t - \theta$

$$p = V_p I_p [3 \cos \theta + \cos \alpha + \cos \alpha \cos 240^\circ + \sin \alpha \sin 240^\circ + \cos \alpha \cos 240^\circ - \sin \alpha \sin 240^\circ]$$

$$= V_p I_p \left[3 \cos \theta + \cos \alpha + 2 \left(-\frac{1}{2} \right) \cos \alpha \right] = 3 V_p I_p \cos \theta$$

• Thus the total instantaneous power in a balanced three-phase system is constant—it does not change with time while the instantaneous power of each phase does change.

So if we use this in the above expression, what we can write,

$$p = V_p I_p [3 \cos \theta + \cos(2\omega t - \theta) + \cos(2\omega t - \theta - 240^\circ) + \cos(2\omega t - \theta + 240^\circ)]$$

Let $\alpha = 2\omega t - \theta$

$$p = V_p I_p [3 \cos \theta + \cos \alpha + \cos \alpha \cos 240^\circ + \sin \alpha \sin 240^\circ + \cos \alpha \cos 240^\circ - \sin \alpha \sin 240^\circ]$$

$$= V_p I_p \left[3 \cos \theta + \cos \alpha + 2 \left(-\frac{1}{2} \right) \cos \alpha \right] = 3 V_p I_p \cos \theta$$

Now if you will see this expression, what you can observe, you can observe that the total instantaneous power in a balanced three phase system is constant. That means that there is no time factor coming in this expression. So even your instantaneous power of each phase will change with respect to time. The three phased power will remain constant.

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- Since the total instantaneous power is independent of time, the average power per phase for the delta or wye connected load is $p/3$
$$P_p = V_p I_p \cos \theta$$
- The reactive power per phase can be given by,
$$Q_p = V_p I_p \sin \theta$$
- The apparent power per phase is,
$$S_p = V_p I_p$$
- The complex power per phase is, therefore,
$$S_p = P_p + jQ_p = V_p I_p^*$$

where V_p and I_p are the phase voltages and phase currents with magnitude V_p and I_p , respectively.

Now since the total instantaneous power is independent of time, you can say the average power per phase for the delta or star connected load will be $p/3$. So per phase, real power you will get

$$P_p = V_p I_p \cos \theta$$

The reactive power per phase is given by,

$$Q_p = V_p I_p \sin \theta$$

The apparent power per phase is given by,

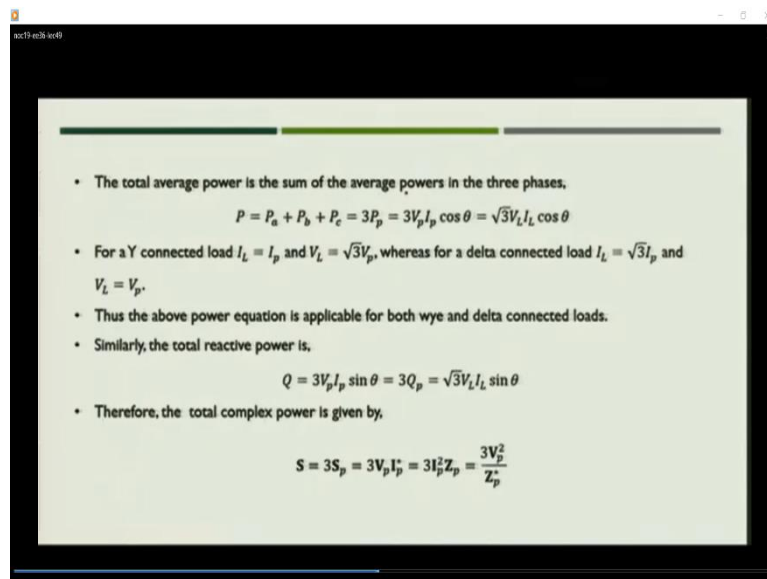
$$S_p = V_p I_p$$

The complex power per phase is given by,

$$S_p = P_p + jQ_p = V_p I_p^*$$

where V_p and I_p are the phase voltages and phase currents for with magnitude V_p and I_p , respectively.

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Now for three phase system, total power,

$$P = P_a + P_b + P_c = 3P_p = 3V_p I_p \cos \theta = \sqrt{3} V_L I_L \cos \theta$$

Now in case you have star connected load, $I_L = I_p$ and $V_L = \sqrt{3} V_p$ whereas for delta connected load, $I_L = \sqrt{3} I_p$ and $V_L = V_p$. So what we can say, irrespective of the load, whether it is star connected or delta connected, your total power will remain equal to $\sqrt{3} V_L I_L \cos \theta$.

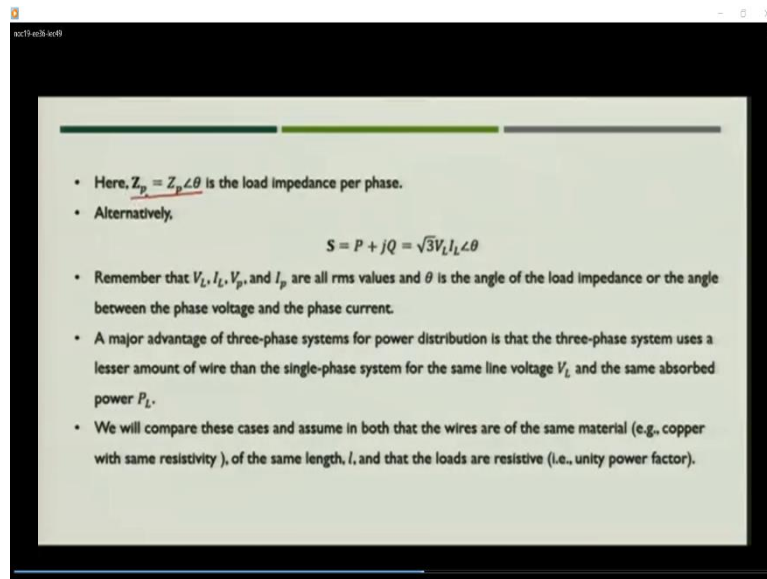
Similarly, the reactive power will also be,

$$Q = 3V_p I_p \sin \theta = 3Q_p = \sqrt{3} V_L I_L \sin \theta$$

The total complex power is given by,

$$S = 3S_p = 3V_p I_p^* = 3I_p^2 Z_p = \frac{3V_p^2}{Z_p^*}$$

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- Here, $Z_p = Z_p \angle \theta$ is the load impedance per phase.
- Alternatively,
$$S = P + jQ = \sqrt{3}V_L I_L \cos \theta$$
- Remember that $V_L, I_L, V_p,$ and I_p are all rms values and θ is the angle of the load impedance or the angle between the phase voltage and the phase current.
- A major advantage of three-phase systems for power distribution is that the three-phase system uses a lesser amount of wire than the single-phase system for the same line voltage V_L and the same absorbed power P_L .
- We will compare these cases and assume in both that the wires are of the same material (e.g., copper with same resistivity), of the same length, l , and that the loads are resistive (i.e., unity power factor).

Now if $Z_p = Z_p \angle \theta$, you can simply represent the complex power as,

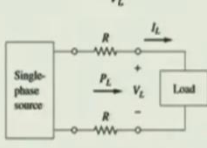
$$S = P + jQ = \sqrt{3}V_L I_L \cos \theta$$

The major advantages of three phase system for power distribution is that the three-phase system uses lesser amount of wire than the single-phase system for same line voltage V_L and the same absorbed power P_L . How? Let us try to find out and justify that the three-phase system for power distribution will use less amount of wire when we compare with single phase system which is having the same line voltage and the same power being fed to the load.

So, what we will do? We will first assume that in both systems one is three phase and the other is single phase system, in both of these systems we are using the same material that means copper with the same resistivity and same length of the wire is being used, let us say that the length of the wire is l and for simplicity we will assume that the loads are resistive that means the load is having unity power factor.

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• For the two wire single phase system, shown in the figure below,

$$I_L = \frac{P_L}{V_L}$$


• The power loss in the two wires is,

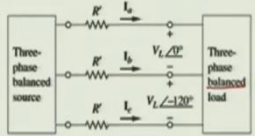
$$P_{loss} = 2I_L^2 R = 2R \frac{P_L^2}{V_L^2}$$

Now, in case of single-phase system what will happen we will have two wires to create the single-phase system where one single phase source will be supplying power to the load. Let us say that the power being supplied to the load is P_L and the voltage across the load is V_L and the current which is flowing in the load is I_L , R is the resistance of the transmission wire. So what will happen? The power loss in two wires because we are having 2 wires to create this single-phase circuit. Loss in the transmission will be,

$$P_{loss} = 2I_L^2 R = 2R \frac{P_L^2}{V_L^2}$$

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• For the three wire three phase system, shown in the figure below,

$$I'_L = |I_a| = |I_b| = |I_c| = \frac{P_L}{\sqrt{3}V_L}$$


• The power loss in the three wires is,

$$P'_{loss} = 3(I'_L)^2 R = 3R' \frac{P_L^2}{3V_L^2} = R' \frac{P_L^2}{V_L^2}$$

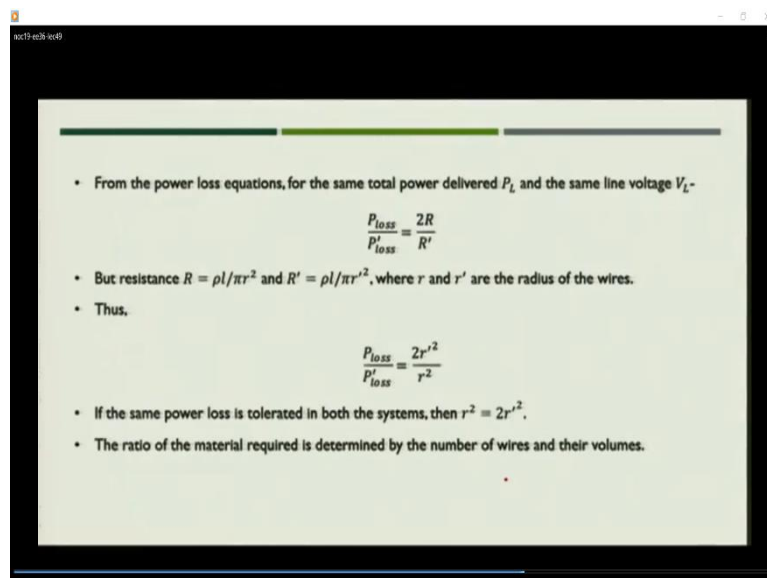
Now let us take the 3 wire three phase system. In this let us assume that I'_L is the current which is going to the load. Here the amount that is magnitude of all line currents will be we are considering as same and because we are considering that the load is balanced.

$$I'_L = |I_a| = |I_b| = |I_c| = \frac{P_L}{\sqrt{3}V_L}$$

So, in that case the power loss in three wires because for the three-phase system will have three wires. Let us assume that the resistance of each wire is R' so the power loss in the case of three phase system will be,

$$P'_{loss} = 3(I'_L)^2 R' = 3R' \frac{P_L^2}{3V_L^2} = R' \frac{P_L^2}{V_L^2}$$

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Now from these 2 equations, we can say,

$$\frac{P_{loss}}{P'_{loss}} = \frac{2R}{R'}$$

P_{loss} is for single phase P'_{loss} is for three phase system. Now resistance of the wire in case of single-phase system is $R = \frac{\rho l}{\pi r^2}$. Similarly, $R' = \rho l / \pi r'^2$ where r and r' are the radii of the wires. So, if you put these values in this, you will get,

$$\frac{P_{loss}}{P'_{loss}} = \frac{2r'^2}{r^2}$$

Now, if the same power loss is being tolerated in both of the systems means whether it is single phase or three phase system, the total loss in this system is same that means P_{loss} will be equal to P'_{loss} which means $r^2 = 2r'^2$.

Now the ratio of material required is determined by the number of wires and their volumes. So what we will try to find out. We will try to find out how much material is required to create the single-phase system as well as three phase system.

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This can be expressed mathematically as,

$$\frac{\text{Material for single phase}}{\text{Material for 3 phase}} = \frac{2(\pi r^2 l)}{3(\pi r'^2 l)} = \frac{2r^2}{3r'^2}$$

• But $r^2 = 2r'^2$,

• Therefore the above equation reduces to,

$$\frac{2r^2}{3r'^2} = \frac{2}{3}(2) = 1.33$$

• This shows that the single-phase system uses 33 percent more material than the three-phase system, alternatively, three-phase system uses only 75 percent of the material used in the equivalent single-phase system.

• In other words, considerably less material is needed to deliver the same power with a three-phase system than is required for a single-phase system.

So, material for single phase means since we have 2 wires in the single phase, you can write 2 times of the wire, we are having wires as cylindrical in shape so the total volume will be,

$$\frac{\text{Material for single phase}}{\text{Material for 3 phase}} = \frac{2(\pi r^2 l)}{3(\pi r'^2 l)} = \frac{2r^2}{3r'^2}$$

But $r^2 = 2r'^2$,

Therefore, the above equation reduces to,

$$\frac{2r^2}{3r'^2} = \frac{2}{3}(2) = 1.33$$

You can observe that the single phase system will use 33 percent more material than the three phase system to supply the same amount of power and to incur the same loss in the transmission system or you can write alternatively that the three phase system will use only 75 percent of the material as compared with the equivalent single phase system.

This shows that in case of three phase system, we need considerably less material to deliver the same power when we compare with the three-phase system and the single-phase system.

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EXAMPLE:

For the circuit given below determine the total average power, reactive power, and complex power at the source and at the load?

SOLUTION: It is sufficient to consider one phase as the system is balanced.

- Considering phase a

$$V_p = 110\angle 0^\circ, \quad I_p = 6.81\angle -21.8^\circ$$
- Thus at the source the complex power absorbed is,

$$S_s = -3V_p I_p^* = -3(110\angle 0^\circ)(6.81\angle 21.8^\circ) = -2247\angle 21.8^\circ = -(2087 + j834.6)\text{VA}$$
- Therefore, the real or average power absorbed at the source is -2087 W and the reactive power absorbed is -834.6 VAR.
- At the load end $Z_p = 10 + j8 = 12.81\angle 38.66^\circ$ and $I_p = I_a = 6.81\angle -21.8^\circ$
- Hence, the complex power absorbed is

$$S_L = 3|I_p|^2 Z_p = 3(6.81)^2 \cdot 12.81\angle 38.66^\circ$$

$$= 1782\angle 38.66^\circ = 1392 + j1113 \text{ VA}$$
- The real power absorbed is 1392 W and the reactive power absorbed is 1113 VAR.

Now, let us take one example to understand what we have discussed in relationship with the power. Let us see there is one circuit as we see in the figure. We need to determine the total average power, reactive power and complex power at the source and at the load. So here if you see, the source is star connected, the per phase voltage is $110\angle 0^\circ$ for Phase A, for phase B it is $110\angle -120^\circ$ and for phase C it is $110\angle -240^\circ$. $5 - j2$ ohm is the impedance of the transmission line and it is the same in all the three phases. Load we can see that it is star connected again where the per phase impedance of the load is $10 + j8$ ohm. Now from this figure, you can observe that the system is balanced.

So, in that case, if calculate the value of the current I_p , what you can do, you can simply use Kirchhoff Voltage Law in the loop and find out the value of current I_p .

So when you solve it, you will get this, anyways it is given in the question that $V_p = 110\angle 0^\circ$, $I_p = 6.81\angle -21.8^\circ$ This will be your per phase current.

Now when you have V_p and I_p calculated, you can find out the complex power absorbed at the source. Now since you know that source generally supply power to the load so if you are asked to find out the power absorbed that means that you will have negative sign in that. So total complex power absorbed by the source will be equal to,

$$S_s = -3V_p I_p^* = -3(110\angle 0^\circ)(6.81\angle 21.8^\circ) = -2247\angle 21.8^\circ = -(2087 + j834.6)\text{VA}$$

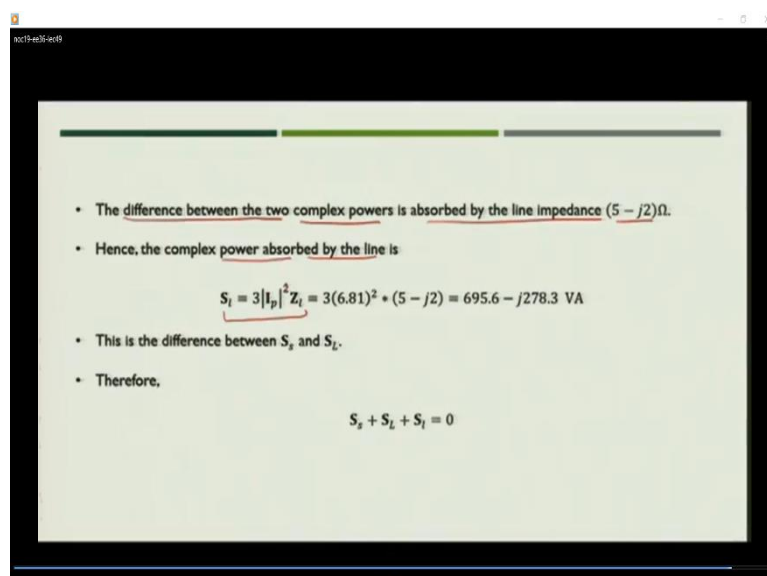
Now at the receiving end means at the load end $Z_p = 10 + j8 = 12.81\angle 38.66^\circ$ and $I_p = I_a = 6.81\angle -21.8^\circ$. I_p is also the line current also because in case of star connected phase current is equal to line current.

So complex power absorbed by the load, you can simply calculate by this particular formula

$$\begin{aligned} S_L &= 3|I_p|^2 Z_p = 3(6.81)^2 * 12.81\angle 38.66^\circ \\ &= 1782\angle 38.66^\circ = 1392 + j1113 \text{ VA} \end{aligned}$$

So what you can write the real power absorbed by the load is 1392 Watts and the reactive power absorbed by the load is 1113 VAR.

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Now the difference between the two complex powers is absorbed by the line impedance that means the power supplied by the source minus the power absorbed by the load. So what we will do? We will first find out the value of power absorbed by the line with the help of this formula that is

$$\mathbf{S}_l = 3|\mathbf{I}_p|^2 \mathbf{Z}_l = 3(6.81)^2 * (5 - j2) = 695.6 - j278.3 \text{ VA}$$

This will be the amount of power lost in the transmission which will be nothing but the difference between the source power minus the power absorbed by the load.

In a nutshell, what you can say that sum of the total power that is source power plus load power plus power absorbed by the transmission line will be equal to 0.

So, with this, we can close our today's session. In this session we discussed about the last combination that is delta star combination for the three-phase circuit and also discussed about the balanced three phase power. In the next session, we will discuss unbalanced three phase system and the calculation of power for the unbalanced three phase system. Thank you.