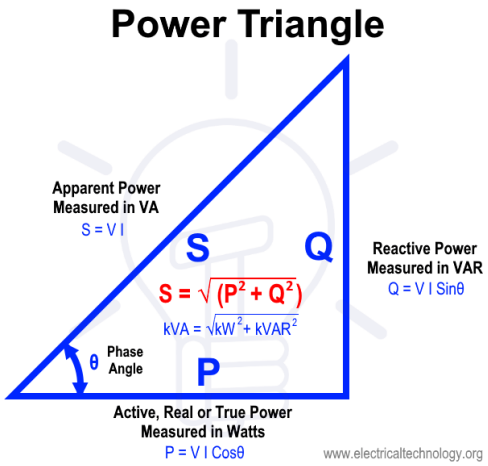
SUBJECT and GRADE	**Electrical Technology Grade 12**	
TERM 1	*Week 7*	
TOPIC	Three Phase Generation: lesson 3	
AIMS OF LESSON	This lesson is about the understanding of 3-phase generation with reference to: power in a 3-phase system, losses, efficiency, power factor correction, the watt meter, kWh meter, power factor meter as well as 3- and 2-watt meter connections.	
RESOURCES	***Paper resources***	***Digital resources***
	Electrical Technology textbook Grade 12 (pg. 99-107)	You-tube links and web pages for this lesson. See end of lesson for links
INTRODUCTION	• This lesson is about the understanding of 3-phase systems with reference to: power in a 3-phase system, losses, efficiency, power factor correction, the watt meter, kWh meter, power factor meter as well as 3- and 2-watt meter connections.	

CONCEPTS AND SKILLS

Power in a 3ph System

Electrical power consumed in an AC circuit can be represented by the three sides of a right-angled triangle, known commonly as a power triangle



Do you know?

- power in a 3-phase system, losses, efficiency, power factor correction, the watt meter, kWh meter, power factor meter as well as 3- and 2-watt meter connections.

Real, True or Active power

This is the capacity of the circuit for performing work in a particular time. The power dissipated by a load is referred to as true power. True power is symbolized by the letter P and is measured in the unit of Watts (W)

Power per phase = I_{phase} x V_{phase}. Cos Θ and

Total power =3x I_{phase}e x V_{phase}. Cos Θ = 3 IL VL / √3 CosΘ

The equation for both delta and star connections are the same and can be written as:
$P = \sqrt{3}\, I_L\, V_L \cos\Theta$ in Watts

Reactive power
We know that reactive loads such as inductors and capacitors dissipate zero power, yet the fact that they drop voltage and draw current gives the misleading impression that they do dissipate power
Reactive power is simply transferred backwards and forwards between the supply and the inductor or capacitor and perform no real work.
This "phantom power" is called reactive power, and it is measured in a unit called Volt-Amps-Reactive (VAR), rather than watts.
The mathematical symbol for reactive power is the capital letter Q.
Reactive power is calculated by**: $Q = \sqrt{3}\, I_L\, V_L \sin\Theta$ in VAR**

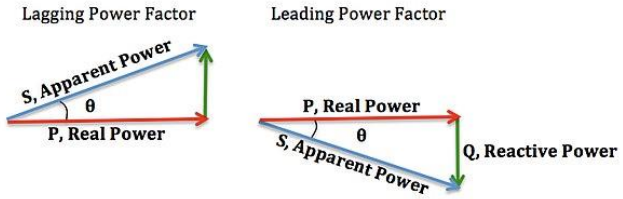
Apparent power
The combination of reactive power and true power is called apparent power, and it is the product of a circuit's voltage and current, without reference to phase angle.
Apparent power is measured in the unit of Volt-Amps (VA) and is symbolized by the capital letter S.
Apparent power is calculated by**: $S = \sqrt{3}\, I_L\, V_L$ in VA**

Losses
In power transmissions, the line losses are caused by the current through the line resistance given by I^2R. To reduce losses, the transmission lines are supplied by a star connection, because the currents are less, hence thinner conductors are needed.

Efficiency
The efficiency of a three-phase system is the ratio of the output power to the input power. It is usually expressed as a percentage.

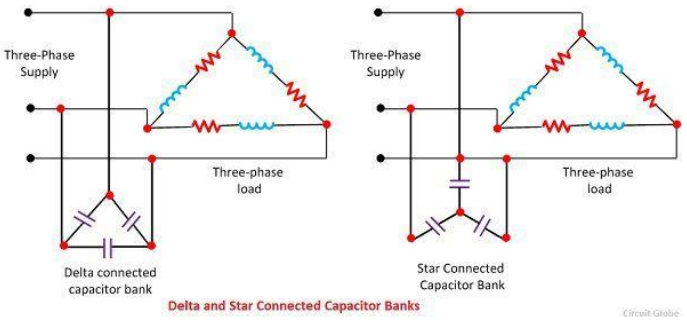
Efficiency η = output/input x 100%

Power factor correction
Power factor is defined as the ratio of the real power flowing to the load to the apparent power in the circuit. The power factor in large industries is important, because the power factor determines how efficient the electric power is used.
The low power factor is usually caused by inductive loads of consumers.
Inductive loads cause lagging currents.
The supply line voltage is fixed, which means that the power factor is directly related to the current



The process of introducing reactive components to improve the power factor is called 'power factor correction'
The aim is to get the power factor as close as possible to unity (1).

Equipment used for power factor correction

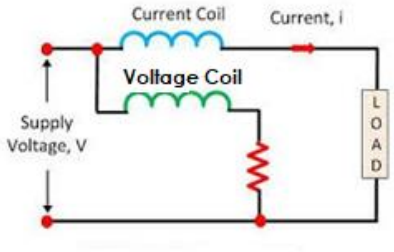


Delta and Star Connected Capacitor Banks

- **Static Capacitors**: Connecting static capacitors or capacitor banks in parallel with the load. Power factor correction is the process of compensating for the lagging current by creating a leading current by connecting capacitors to the supply. A sufficient capacitance is connected so that the power factor is adjusted to be as close to unity as possible.
- **Synchronous motors:** Synchronous motors draw leading currents on no load (over excited) and acts like a capacitor.
- **Phase advancers**: They are used to improve the power factor of induction motors and is mounted on the rotor and it makes the induction motor acts like a synchronous condenser(motor).

Watt meter

This is a meter used to measure the power consumed by an application. This meter has a current coil and a voltage coil. The current coil is connected in series with the circuit and the voltage coil connected in parallel to the circuit.



NB!! A Watt meter does not measure energy

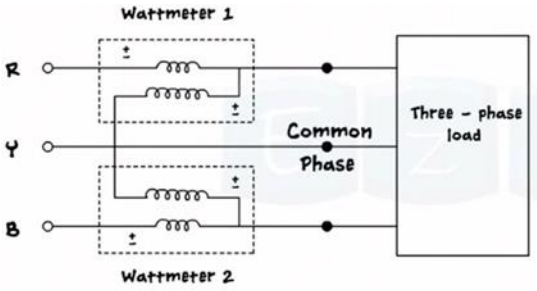
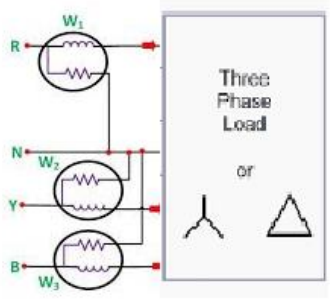
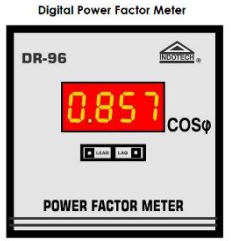
kWh Meter (energy meter)

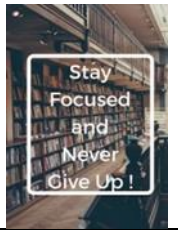
A kilowatt-hour meter or energy meter is a device that measures the amount of electric energy consumed, or the amount of power used over a certain time period.

NB!! A kWh meter does not measure energy over a period, energy is already as a measure of time.

Two wattmeter connections

Under balance conditions with a three-wire system, the power in all three phases can be measured by only using two-watt meters. This is called the "two-wattmeter method"

	This method gives the true power in the circuit. The sum of the two meters equal to the total real power in the system ie $P_T = P_1 + P_2$  **Three-watt meter connections** By connecting a watt meter in each phase of the three-phase system, the total power can be found. $P_T = P_{PH1} + P_{PH2} + P_{PH3}$  **Power Factor meter** As the name indicates, a power factor meter measures the power factor in a circuit by either using an analog or digital meter. Power factor is defined as the ratio of the true/real power to the apparent power. A power factor of less than 1, means the voltage and current is not in phase, reducing the instantaneous product of the two waveforms (V x I)   In electric power systems, a load with a low power factor draws more current than a load with a high-power factor for the same amount of useful power transferred. The high currents the thicker the conductor to be used.
ACTIVITIES/ ASSESSMENT	**NB:** It is important that you do all the questions on your own first before you consult any resources. Refer to end of chapter activity and do all the questions related to this section of the work. (pages 108-109) Time per question (1 mark = 1 minute)

CONSOLIDATION	• The work done in the lesson was about 3-phase generation with reference to: power in a 3-phase system, losses, efficiency, power factor correction, the watt meter, kWh meter, power factor meter as well as 3- and 2-watt meter connections. • Congratulations on completing this lesson 
VALUES	The understanding of how 3-phase electricity is generated, will help us understand electricity better as well as appreciating it more as an energy source.
YouTube links and web pages for this lesson	https://www.youtube.com/watch?v=oMFPK2JDp8g (Two watt meter method) https://www.youtube.com/watch?v=zYCt66SkrD8 (kWh connections) https://www.youtube.com/watch?v=SMPhh8gT_1E (Difference between Watts and kWh) https://www.youtube.com/watch?v=Tv_7XWf96gg (Power factor) https://www.youtube.com/watch?v=ADilk28vfj0 (Power factor correction) https://www.youtube.com/watch?v=Bo0MGZKhPrs (Power factor) https://www.solarquotes.com.au/blog/kw-and-kwh-what-is-the-difference/ (Difference between power and energy)