XP Power

XPerts in Power – Module 5
Real & Apparent Power

Les Chant

What is Power?

- Power is the rate at which work is done

- In an electrical system, the more power in the system the more electrical work can be done (over a set period of time)

  – Power (W) = Work (J) / Time (seconds) or
  – Work (J) = Power (W) * Time (seconds)

  – Power (W) = Volts (V) * Amps (A)
  – I.e. you have more power when you have electrons pushing with more force (higher voltage) and also when you have more of them per period of time (higher current).

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Real, Reactive and Apparent Power

- This is defined as the active power dissipated into the load – i.e. the useful power.

- Real, Reactive and Apparent power is symbolised by P and is measured in Watts (W)

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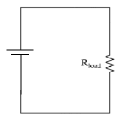
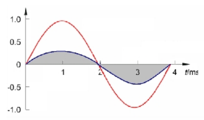
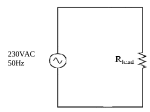
Real Power







Reactive Power

- Reactive power is stored in the load and then returned to the source - it is not dissipated
- It is symbolised by the letter Q and measured as Volts-Amps-Reactive (VAr)

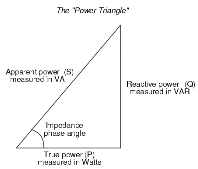
Apparent Power

- Total power in a circuit, both dissipated and reactive is referred to as apparent power
- It is symbolised by the letter S and is measured in Volt-Amps (VA)

Three Types Of Power

- Trigonometrically related to each other.

- In a right angled triangle
  - P (real) is adjacent length
  - Q (Reactive) is opposite length
  - S (Apparent) is hypotenuse length



- The opposite angle is equal to the impedance of the circuit - The Cosine of this impedance gives the "Power Factor"

What is Power Factor?

- Power Factor is a characteristic of AC circuits

- Always a number between 0 and 1: the closer to 1, the better the power factor

- Power Factor = Real Power/Apparent Power

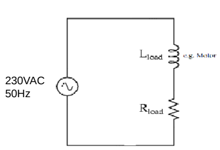
- Practical equations are;
  - VA = W/PF
  - W = VA*PF

- The Power Factor is affected by Phase Shift & Harmonics

Inductive Loads

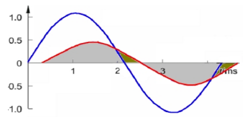
- Here is a simple circuit showing an inductive load

- In real components there is also a resistive component to the load hence R load is shown



Out Of Phase Current and Voltage - Motor Load

- Application with inductive load (motor)
- Here we can see that the current is lagging behind the voltage by a certain angle
- The Grey area shows "Real Power" and the green shows "Reactive power"
- This angle represents the phase shift - this directly relates to the PF



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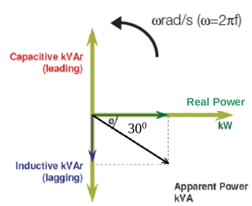
Phasor Angle Real and Reactive (Apparent)

- Here the load shows an inductive characteristic
- It is said to be lagging by phase angle Theta (q)
- The apparent power exceeds the Active power
- CIVIL – capacitive current before voltage, inductive current after voltage



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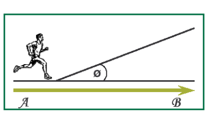
Efficiency of Power Transfer

- Runner analogy



Cosine ø (30°) = 0.87

or Power Factor = 0.87

or Efficiency = 87%

In other words, only 87% of the energy burned is being used to move the runner in the horizontal direction of B, and so extra energy will be required to achieve the same objective.

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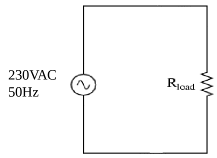
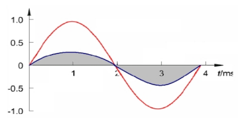
Resistive Loads

- This shows a simple lamp load circuit
- There is no reactive (capacitive or Inductive) component
- The lamp represents a simple resistive load



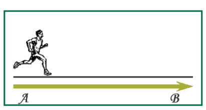
In Phase Voltage and Current - Lamp Load

- Typical application resistive load like a light bulb
- There is no phase shift between the voltage and the current
- The grey indicates real power being delivered
- Therefore Cos q = 1
- PF = 1



Efficiency of Power Transfer

- Runner analogy



When the running surface is flat, then angle ø is zero degrees (0°)

Cosine ø (0°) = 1.00

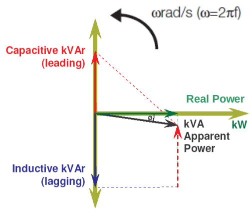
or Power Factor = 1.00

or Efficiency = 100%

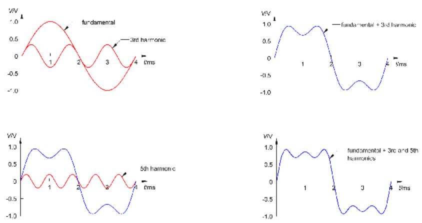
In other words, 100% of the energy burned is being used to move the runner from A to B.

Phase Angle Correction (Addition of Capacitive Component)

- When a capacitive element is added the apparent and real powers are brought closer together.
- This is seen typically in Power Factor corrected loads
- An inductive element would need to be added if the apparent power were to be leading the real power.

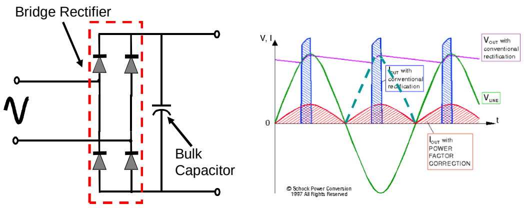


What is a Harmonic



Any waveform that is not sinusoidal has a harmonic content

Power Supply Harmonic Distortion



Better power factor = Lower harmonics because waveforms are cleaner

Why is Harmonic Distortion a Problem?

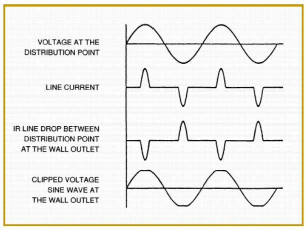


FIGURE 16
Waveforms illustrating the peak flattening effect that the narrow current pulses impose on the mains voltage

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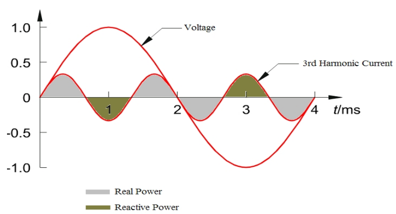
Harmonic Currents and Reactive Power



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Main Effects of Low Power Factor

- Mains Voltage Distortion
- Oversizing of conductors
- Overheating of Neutral conductors
- Electromagnetic load failures
- Circuit Breakers Tripping
- Must take into account when working out efficiency

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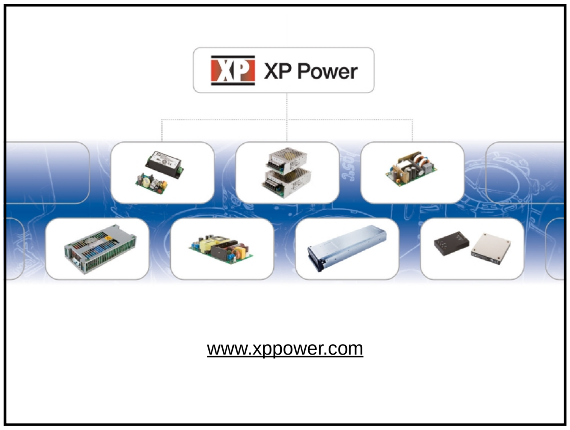
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