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Reactive loads and the effect on the installation and the Power Authority.

Calculating loads, demand management, fault current and earth fault loop impedance.

The importance of AS3000 and AS3008 in cable management.

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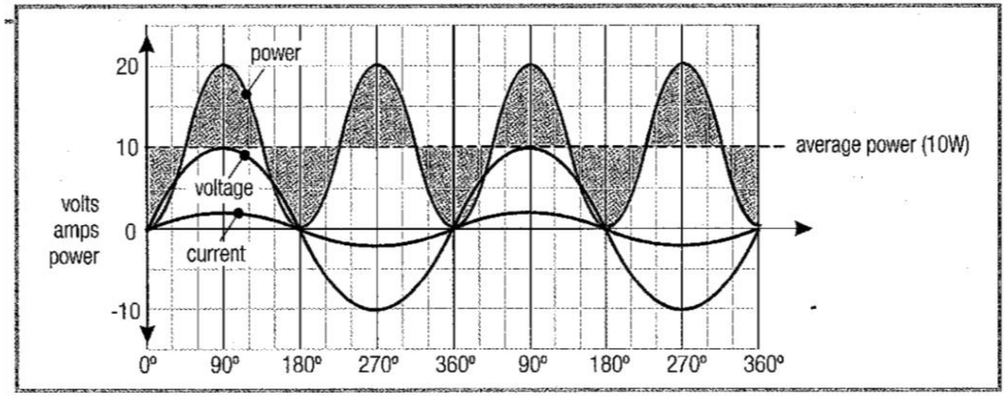
To understand about reactive loads first we must talk about resistive loads

- Listing just a few examples of an AC circuit in which the load is pure resistance includes;

1) Lighting circuits with incandescent lamps
2) Power circuits for stoves
3) Power circuits for ovens and for heaters

Resistive loads

- Such loads do not have a phase shift between the voltage and the current.
- Due to this lack of phase shift the relationship between Voltage and Current is such that the power produced will do 100% useful work at the load.
- Diagram from Phillips Electrical Principles 2nd edition page 360 below to explain

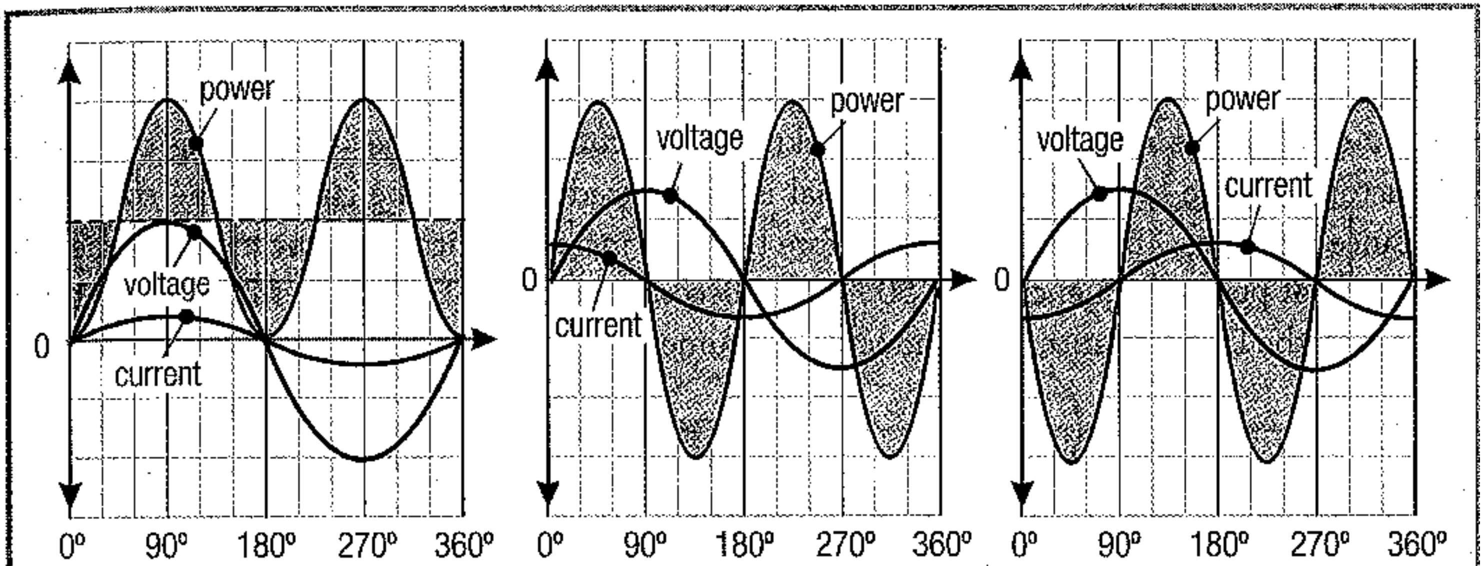


What is a reactive load?

- From Phillips Electrical Principles 2nd edition page 419 below
- For a purely *reactive load*, the voltage and current are 90 degrees out of phase. Thus for one quarter of a cycle, the reactive component takes power then returns it to the supply the next quarter cycle. The result, is on average, just as much energy that flows toward the load also flows back.

What is a reactive load?

- Diagram from Phillips Electrical Principles 2nd edition page 419 below



(a) resistive AC circuit consumes power

(b) capacitive AC circuit consumes no power

(c) inductive AC circuit consumes no power

What is a reactive load?

- From Phillips Electrical Principles 2nd edition page 419 below

- The result is, a purely reactive circuit does not consume true power even though current and voltage are present in the circuit. **Again I'll say, this is due to the reactive component taking power on one quarter of a cycle, then returning it to the supply the next.**
- Thus this reactive component or "reactive power", is due to the delay (90 degree phase shift) between voltage and current thus the reactive power cannot do any useful work at the load.

What is a reactive and a resistive load combination?

- Most AC circuits have a combination of reactance and resistance. Therefore, this type of circuit will take a certain amount of true power (the resistive component), and a certain amount of reactive power (the reactive component). Thus this circuit will consume some true power but also some reactive power.

What is a reactive and a resistive load combination?

- With this type of circuit, some of the power will be useful at the load and some will not.

Now we must talk about power factor

- Power factor is a way of describing the phase difference between the supply voltage and supply current.
- The value of the power factor in a circuit, therefore, depends on the phase difference between the supply voltage and current.

So why worry about power factor?

- The better the phase relationship is between voltage and current means less useless reactive power will be produced.
- Thus this also means the better use of electrical resources such as;

1) Busbars
2) Transformers
3) Power lines
4) Etc, etc.

Now we must talk about the inductive and capacitive reactance relationship between current and voltage

- Current lags voltage by 90 degrees in a purely inductive circuit.
- Current leads voltage by 90 degrees in a purely capacitive circuit.

So why do circuits go inductive?

- Because of coils.
- Like in motors.
- Like in transformers.
- Like in fluorescent lights.
- And the list goes on.

So how do we improve an inductive circuit?

- The phase relationship between the voltage and current can be brought closer together, or closer to unity, by introducing capacitance in to the circuit.

Now, to understand, we must talk about how we determine true power in a reactive/resistive circuit.

- Not only can true power be measured using a true power meter but it can be calculated.
- $P=V\times I\times \cos\theta$
- Where;
- P is true power
- V is voltage
- I is current
- Cos θ is the phase angle or Power Factor

So why is it important to impove power factor?

- If this power factor is closer to 1 (or unity), the better the true power will be.
- Thus the power produced will do more useful work at the load.

So why is it important to impove power factor?

- Since true power is a relationship between voltage, current and the phase angle. The type of circuit will have a direct effect on the electrical equipment that will supply the installation.
- In short, if you were allowed to get away with a bad power factor it would lead to more useless reactive power being produced. Since current is present, cables supplying the installation will have to be thicker, transformers will have to be larger. This leads to a very expensive installation for the contractor and for the power authority.

So why is it important to impove power factor?

- In fact, in Queensland, the power factor of an installation is not allowed to be any lower than 0.8.
- In ENERGEX and in other power authority substations, capacitor banks to improve power factor even further have been installed.
- A synchronous machine can also be used to improve power factor.

So I guess that capacitor in that induction motor is important after all?

- Certainly.
- That induction motor capacitor is improving the power factor of the installation.
- Removal of that capacitor can negatively effect the amount of true power being created, thus resulting in a greater demand of current on the installation.
- If the capacitor needs to be replaced, the same size capacitor should be reinstalled.

Why do we calculate loads?

- To use a scenario
- AS/NZS 3000:2007 Table C1 says
- Socket outlets not exceeding 10 Amps.
- With permanently connected electrical equipment not exceeding 10 Amps
- In a single domestic electrical installation
- Will have a maximum demand of 10 Amps for 1 to 20 points.
- Plus 5 Amps for each additional 20 points or part thereof.

Why do we calculate loads?

- AS/NZS 3000:2007 C2.1 says;
- The current in a circuit must not exceed the current rating of the circuit protective device.
- Which in turn, must not exceed the current carrying capacity of the circuit conductors.

So why bother with demand management?

- For a possible scenario, we have
- From AS/NZS 3000:2007 Table C1
- A maximum demand of 10 Amps for 1 to 20 socket outlet points.
- 5 amps for lighting.
- 20 Amps for a Hot Water Service
- And 15 Amps for an Air Con
- On a 3 phase supply
- What should we do in relation to this?

So why bother with demand management?

- Split the load as evenly as possible over the 3 phases.
- This distributes demand over the 3 phases, thus 1 or 2 phases is/are not doing the bulk of the work of the 3 phase installation.
- Also this enables all 3 windings of the supplying transformer to work evenly.

Why bother with fault current?

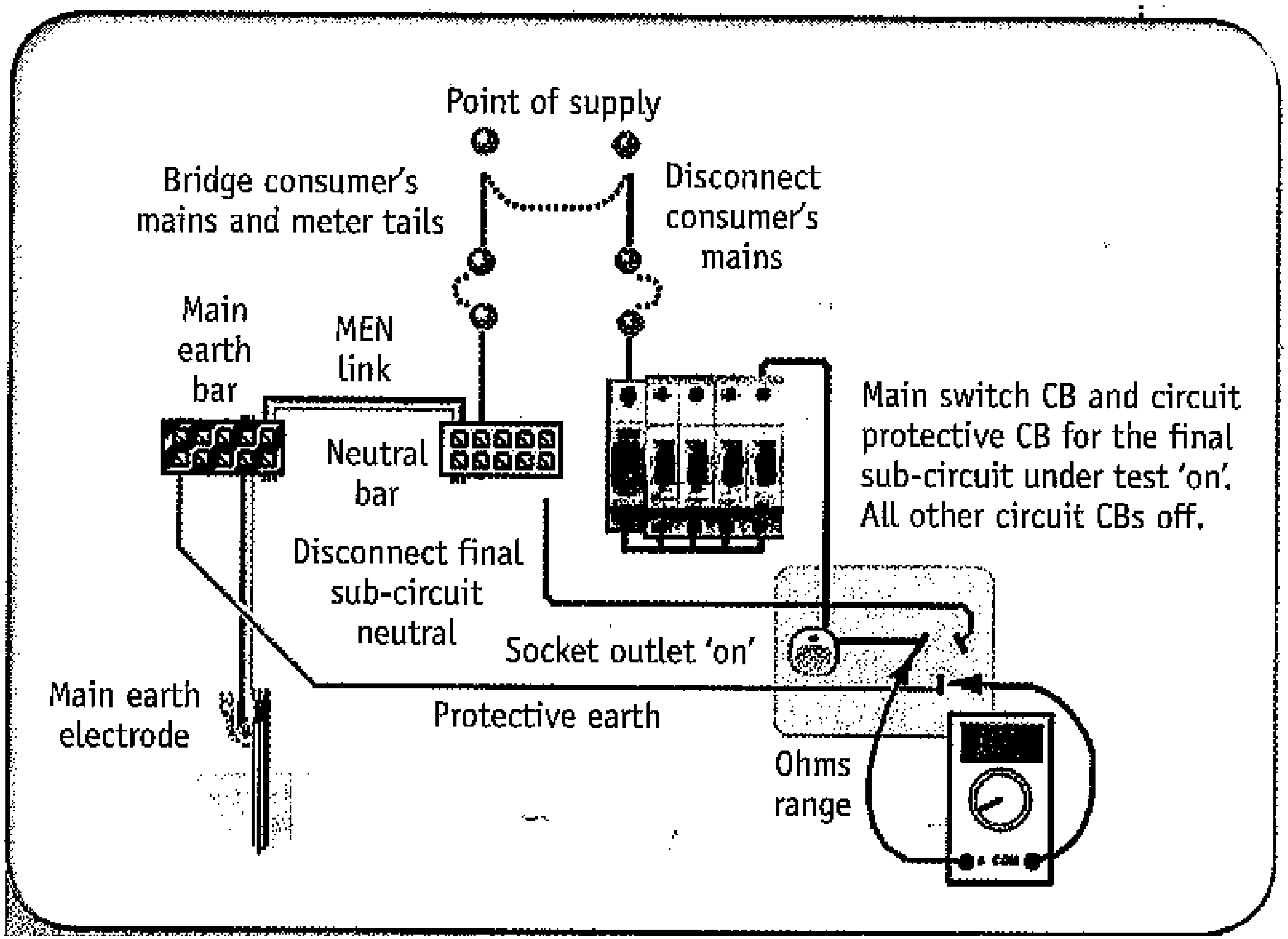
- Jeffery Hampson says in Electro Technology Practice 2nd edition page 416 says;
- One of the most severe problems in an electrical installation is the short circuit current. During a fault, the short circuit current might increase up to 100 times its nominal value and cause irreversible damage to cables and connected equipment

Why bother with fault current?

- Jeffery Hampson says in Electro Technology Practice 2nd edition page 416 says;
- Very fast response times for FCL (fault current limiters including circuit breakers) are necessary to protect equipment.
- AS/NZS 3000:2007 Table B1 considers the potential fault current of an installation, when instructing what type Circuit Breaker (Type B, C or D) and size to use in a given scenario.

So why bother with earth fault loop impedance?

Diagram from Hampson Electro Technology Practice 2nd edition page 419



So why bother with earth fault loop impedance?

- 2 examples
- AS/NZS 3000:2007 Table 8.2 says;
- A 2.5mm^2 conductor
- Protected by a 20 Ampere type ‘C’ Circuit Breaker
- Can have a maximum resistance value of 0.98 ohms phase to earth.
- For a type ‘D’ circuit breaker the maximum resistance value is 0.58 ohms phase to earth.

So why bother with earth fault loop impedance?

- In short we should bother with earth fault loop impedance to ensure the Overcurrent/Earth fault protection will operate when required!!!

Importance of AS3000 and AS3008 in cable management

- AS3008.1.1:2009 table 14 says;
- For 3 and 4 core copper flexible 10mm^2 cable.
- Exposed to the sun.
- Has a current carrying capacity of 52 Amps unenclosed.
- Why is this important?
- Installation conditions effect the cable’s current carrying capacity.

Importance of AS3000 and AS3008 in cable management

- If a cable is enclosed in a conduit, with 5 other cables. Perhaps 2 metres deep, those conditions effect that cable's current carrying capacity too.
- So in short, AS3000 and AS3008 are vital in cable management. They both consider the size, type and installation conditions to ensure the cable will operate efficiently, but most of all, safely!!!!

Questions?

List of references

- Australian/New Zealand Standard 2007, *AS/NZS 3000:2007,* Standards Australia, Standards New Zealand, Sydney
- Australian/New Zealand Standard 2009, *AS/NZS 3008.1.1:2009,* Standards Australia, Standards New Zealand, Sydney
- Hampson J 2011,*Electro Technology Practice 2nd Edn,* Pearson Australia, Sydney
- Phillips P 2012, *Electrical Principles 2nd Edn,* Cengage Learning, Melbourne