Section 6

Capacitor Installations

Note: Amendments to the text made since the previous edition are underlined.

Service and Installation Rules of New South Wales
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6 Capacitor Installations

6.1 INTRODUCTION

Industrial and commercial loads require significant amounts of reactive power (kVArs) for the operation of motors, furnaces, electric discharge lighting and the like. The result is a low power factor. The low power factor can be improved by applying capacitors to supply this reactive power.

6.1.1 Minimum Power Factor

Clause 1.10.11 requires an electrical installation to have a power factor of 0.9 or greater lagging.

CAUTION
The power factor of the installation must not become leading at any time

6.1.2 What is Power Factor

Power Factor is all about the effective use of the electricity distributor's distribution system. It is a measure of how effectively you turn the electricity supplied to your business into actual productive power (i.e. light, heat, motive power). By improving your power factor you could reduce your energy costs if it is charged at a tariff incorporating a kVA demand component or a power factor penalty.

The costs of a kVA demand type tariff and a kWh tariff are not the same. There is a difference between the power supplied to your premises **Apparent Power** (measured in kVA) and the power consumed in your electrical equipment **Real Power** (measured in kW).

This difference is due to electromagnetic fields. **Reactive Power** (measured in kVAr) is required to establish electromagnetic fields which allow magnetic coils to operate. These coils are found in fluorescent and mercury vapour lighting, electric motors and many other types of equipment.

6.1.3 Expressing Power Factor

Commercial and industrial customers, by the very nature of their activities, require, in addition to real power, a significant proportion of reactive power.

Magnetic fields in motors, induction furnaces, transformers and discharge lighting are maintained by reactive current.

Reactive power is not seen by the kWh energy meters, but its presence causes a demand kVA to be significantly higher than the kW value, as shown below.

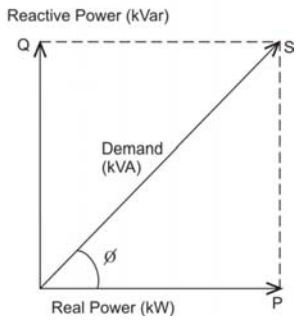
This relationship is represented mathematically by the cosine of the angle Ø between real power and apparent power.

Power Factor = kW/kVA = Cos Ø

Obviously, correction of the power factor to near unity (Cos Ø =1, Ø = 0 degrees), will minimise the kVA demand.

Connecting capacitors to an electrical installation achieves this.

Power Factor Relationship



6.1.4 Why Power Factor is Important to your Business

Improving your power factor can mean a significant benefit to your business.

It can achieve this in two ways:

(a) If you pay for electricity using a kVA demand tariff, a higher power factor would reduce your peak kVA demand and save money on your electricity account.

(b) If a kVA demand tariff is not your best tariff option and your main switchboard or service/consumers mains are loaded to capacity, an improvement in your power factor may provide the additional capacity you require at a lower cost than the replacement of your switchboard or upgrading of your service/consumers mains.

6.1.5 Power Factor Correction

A higher power factor for the installation can be achieved by reducing the total amount of reactive power required by your electrical installation.

In most cases power factor is best corrected by connecting capacitors at the load terminals, for example, at each motor or each luminaire. However, for economic reasons power factor correction usually takes place at the customer's main switchboard using switchable capacitor banks.

The cost of installing power factor correction capacitors can usually be recovered through reductions in your electricity costs.

6.1.6 Cost Savings

Significant savings can be achieved by controlling the electrical installation's overall power factor.

As an example, improving a power factor of 0.67 to 0.98 will result in a reduction of about 20% in the total demand charge. You could expect to get your money back on the cost of the associated power factor control equipment in 12 to 18 months.

Even with low levels of power factor correction, the savings can be worthwhile.

The sample calculation below demonstrates a method of estimating the cost benefits of correcting power factor.

In the sample calculation below, the required kVAr of capacitors needed to improve the power factor to 0.9 is calculated at 480 kVArs, and the resultant monthly saving in electricity charges is $1,650. With an estimated cost of $29,500 for the capacitors and associated control equipment, the pay-back period would be approximately 18 months.

SAMPLE CALCULATION

(Example using a kVA demand charge of $6.60/kVA/month. Use the applicable tariff costs when doing your calculations.)

Assume that with a load of 1800kW at 0.8 power factor, it is desired to correct the power factor to 0.9. What amount of kVAr correction will be required, what are the expected savings on a Demand Tariff, and what will be the anticipated pay-back period?

Quantity	Present Power Factor 0.8	Required Power Factor of 0.9
Real Power-kW	1800	1800
kVA = kW/power factor	1800/0.8 = 2250	1800/0.9 = 2000
kVAr = $\sqrt{kVA^2 - kW^2}$	$\sqrt{2250^2 - 1800^2}$ = 1350	$\sqrt{2000^2 - 1800^2}$ = 870
Correction kVAr		1350 - 870 = 480
Demand Charge @$6.60/kVA/Month	$14 850	$13 200
Monthly Savings		$1 650
Est. Cost of Correction Equipment		$29 500
Pay-Back Period Months		17.9

6.2 EQUIPMENT REQUIREMENTS

Power factor correction equipment may be located:

(a) In or connected to a distribution board for that part of the installation supplied by that distribution board.

(b) At the main switchboard for the whole of the installation.

(c) In individual electric discharge lighting circuits.

(d) In individual equipment such as induction furnaces, motors, lighting fittings, etc.

The kVAr value of capacitor banks you need to install to correct from an existing to a desired power factor for a particular kW load is set out in Table 6.1. Use this table as a guide when designing an installation.

Shunt capacitors must comply with publications AS 2897 ‘Power capacitors - Shunt - rated voltages above 660V AC.’ or IEC 60831-1 ‘Shunt power capacitors of the self-healing type for AC. systems having a rated voltage up to and including 1000V Part 1: General Performance, testing and rating - Safety requirements - Guide for installation and operation’ as appropriate’.

Application for the connection of power factor correction equipment must be made to the electricity distributor. An application is required for each connection except where fitted to individual items of equipment with low power requirements.

Obtain agreement from the electricity distributor before you commit funds or install the power factor correction equipment.

6.2.1 Capacitor Switching Steps

In addition to the above requirements the automatic control capacitors must be made in steps to not affect the ripple frequency. However, the electricity distributor may consider larger steps in the following circumstances:

(a) If the capacitors are switched with equipment as one unit, then there is no limit to the size of capacitors; or

(b) In exceptional or special circumstances where switching is not frequent, and either:

i) The installation is connected to a low impedance supply system (an example would be where the installation is in the proximity of, or directly connected to, an appropriate size of substation).

ii) Other conditions which make sure that the supply to other customers is not affected.

6.2.2 Equipment Design

The design of the power factor control system to meet the customers and the electricity distributor’s requirements is a complex matter.

Therefore:

(a) It is recommended you use a competent energy management consultant.

(b) Discuss the detailed aspects of the design of the power factor correction installation with the electricity distributor before it is manufactured.

(c) Submit any impedance improvement equipment for approval before connection. Impedance improvement equipment is necessary with power factor correction equipment to reduce the attenuation effect on the electricity distributor’s ripple control signal. Refer to clauses 6.6, 6.7 and 6.8.

6.2.3 Fluorescent Lighting Installations

In general, leading and lagging ballasts or power factor correction capacitors with series inductors are suitable for fluorescent lighting installations. Leading and lagging ballasts are available as a dual unit within the one fitting.

When leading and lagging ballasts are used in separate fittings, a leading ballast in one lamp for every two lamps satisfies the power factor and blocking requirements of clause 6.4. Table 6.2 illustrates the effect of different fluorescent lighting circuits.

Table 6.1: Power Factor Correction, Determination of kVArs Required

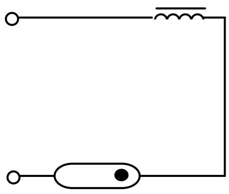
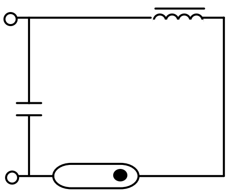
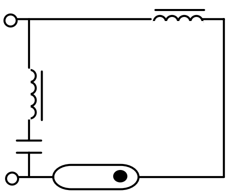
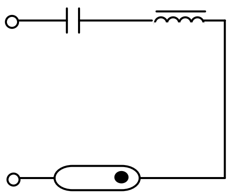
Method:

Select the cell where the Original Power Factor row intersects with the Corrected Power Factor column.

Multiply the table values x kW load = Number of kVArs needed to correct from existing to desired power factor.

Original Power Factor	Corrected Power Factor										
	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98	1
0.50	0.982	1.034	1.086	1.139	1.192	1.248	1.306	1.369	1.440	1.529	1.732
0.52	0.893	0.945	0.997	1.050	1.103	1.159	1.217	1.280	1.351	1.440	1.643
0.54	0.809	0.861	0.913	0.966	1.019	1.075	1.133	1.196	1.267	1.356	1.559
0.56	0.730	0.782	0.834	0.887	0.940	0.996	1.054	1.117	1.188	1.277	1.480
0.58	0.655	0.707	0.759	0.812	0.865	0.921	0.979	1.042	1.113	1.202	1.405
0.60	0.583	0.635	0.687	0.740	0.793	0.849	0.907	0.970	1.041	1.130	1.333
0.62	0.516	0.568	0.620	0.673	0.726	0.782	0.840	0.903	0.974	1.063	1.266
0.64	0.451	0.503	0.555	0.608	0.661	0.717	0.775	0.838	0.909	0.998	1.201
0.66	0.388	0.440	0.492	0.545	0.598	0.654	0.712	0.775	0.846	0.935	1.138
0.68	0.328	0.380	0.432	0.485	0.538	0.594	0.652	0.715	0.786	0.875	1.078
0.70	0.270	0.322	0.374	0.427	0.480	0.536	0.594	0.657	0.728	0.817	1.020
0.72	0.214	0.266	0.318	0.371	0.424	0.480	0.538	0.601	0.672	0.761	0.964
0.74	0.159	0.211	0.263	0.316	0.369	0.425	0.483	0.546	0.617	0.706	0.909
0.76	0.105	0.157	0.209	0.262	0.315	0.371	0.429	0.492	0.563	0.652	0.855
0.78	0.052	0.104	0.156	0.209	0.262	0.318	0.376	0.439	0.510	0.599	0.802
0.80	0.000	0.052	0.104	0.157	0.210	0.266	0.324	0.387	0.458	0.547	0.750
0.82		0.000	0.052	0.105	0.158	0.214	0.272	0.335	0.406	0.495	0.698
0.84			0.000	0.053	0.106	0.162	0.220	0.283	0.354	0.443	0.646
0.86				0.000	0.053	0.109	0.167	0.230	0.301	0.390	0.593
0.88					0.000	0.056	0.114	0.177	0.248	0.337	0.540
0.90						0.000	0.058	0.121	0.192	0.281	0.484
0.92							0.000	0.063	0.134	0.223	0.426
0.94								0.000	0.071	0.160	0.363
0.96									0.000	0.089	0.292
0.98										0.000	0.203

Table 6.2: Lighting Circuits

Circuits	Power Factor	Effect on ripple signal (see Note 2)	Compliance with Service Rules
1 	Low power factor approx. 0.4 lagging, known as a "lagging ballast"	No interference to ripple signal	Does not comply due to poor power factor
2 	High power factor. Depends on value of capacitor usually about 0.9 lagging.	The presence of the shunt capacitor appears as a low impedance to the ripple signal, hence reducing the voltage of the ripple signal.	Does not comply without the use of a "stopper" circuit in either the final subcircuit, submains or mains.
3 	High power factor. Depends on value of capacitor usually about 0.85 lagging.	Placing an inductor in series with the capacitor (where the combination is tuned to a frequency below that of the ripple signal) will not interfere with the ripple signal.	Satisfies the requirements
4 	A capacitor in series with the ballast is known as a "leading ballast", approx. 0.4 leading.	No interference to ripple signal	Satisfactory if used in combination with lagging ballasts as shown in Circuit 1.

Notes:

1. Tests have shown satisfactory results using "leading and lagging" ballasts in combination. The ratio of luminaires with leading ballasts to luminaires with lagging ballasts should be 1 to 1, i.e. 1 luminaire with leading ballast to 1 luminaire with lagging ballast. The "leading ballast" most successfully tested was a combination normal 36 watt lagging ballast in series with a 440V 3.1 microfarad capacitor giving a leading power factor of 0.4 for a ripple frequency of 1050 Hz.

2. This does not apply to areas which do not use ripple signals.

6.3 EXISTING INSTALLATIONS

Any additional load must comply with the minimum power factor requirements of clause 6.1.1.

The electricity distributor may also require the entire installation to comply with minimum power factor requirements of clause 6.1.1.

6.3.1 Power Factor Problems in Non-Domestic Multi-Tenanted and Large Installations

In multi-tenanted installations where power factor is poor for the total installation, any additional load may require uprating of the supply facilities.

The premises should have its poor power factor corrected if the power factor of the entire installation is less than 0.9 and power factor correction would cater for the increased load required. The customer will avoid the cost of an uneconomic extension to supply, i.e. additional facilities.

This may be achieved by:

(a) Installing the power factor correction equipment within the metered house services section of the premises electrical installation.

(b) If this is not possible because the house services load is small when compared to the total site, the electricity distributor may allow the correction equipment to be connected to the line side of the meters of all customers, i.e. at the unmetered main switchboard. This would be unmetered, and its consumption would need to be estimated.

Do not seal the power factor correction equipment as it would be impracticable for maintenance of fuses, contactors and other equipment.

Label the section with unmetered supply to highlight it. The unmetered section should also be labelled with total power losses at 100% utilisation of the power factor correction equipment at rated voltage.

6.4 RIPPLE CONTROL AND HARMONIC BLOCKING

Ripple control signals are used as a load control system for the switching of water heaters, street lighting and meter equipment. Where it is agreed that power factor correction capacitors are to be installed and the electricity distributor uses ripple control, the customer must install additional equipment to block the electricity distributor's ripple control signals. The areas where ripple control is used are available from the electricity distributor.

The frequencies used depend on the region within the electricity distributor's area. The frequencies used by each electricity distributor are detailed in Table 6.3.

At audio signal frequencies, capacitors present an impedance of some 10 to 21 times less than at 50Hz. This can result in a significant portion of the signal being absorbed or lost to the system. The effect on the signal voltage of the control system is variable, depending upon the size and number of capacitors and their distribution in the high and low voltage network.

In the worst case the capacitor impedance may approach or equal the inductive reactance of the distribution transformer(s), to form a series resonance combination and a virtual short-circuit on the ripple system. Avoid this undesirable and unacceptable condition by connecting blocking inductors in the capacitor circuit.

Shunt capacitors used for power factor correction are likely to cause significant loss to the ripple control signal. Their impedance to the frequency must be increased by connecting either BLOCKER, REJECTER or STOPPER CIRCUITS to a value which will prevent interference to the electricity distributor's ripple control system.

The designer of the power factor correction equipment should also be aware that harmonics may either be created by the installation itself or exist on the supply network. These harmonics may harm the capacitors, and the capacitors should be protected by suitable harmonic blocking.

Note: Although electricity distributors permit the use of any methods stipulated in the following clauses it should be emphasised that the preferred method is through the use of detuning reactors. (A detuning reactor is a reactor selected to tune the resonant frequency below any likely harmonics).

It is often difficult to attain the required level of impedance using other methods, and it should be noted that the full costs of re-inspection due to failure to meet impedance levels will be borne by the customer.

In addition, the electricity distributor may, in future, require improved shunt impedance due to the need for powerline carriers. In this event, further blocking would be required of customers utilising capacitor banks without detuning reactors.

Customers not providing detuning reactors shall install suitable equipment to prevent switching spikes.

The use of power factor correction without detuning reactors greatly increases the risk of damage from harmonics and the incidence of litigation from other customers due to damage. Although detuning reactors will not nullify these risks, they will be significantly reduced.

Typical single line diagrams representing various arrangements are shown in clauses 6.6, 6.7 and 6.8.

Table 6.3: Ripple Frequencies by* Electricity Distributor *(as at 1/06/05)

Electricity Distributor	Former area	Signal Frequency (Hz)
EnergyAustralia	Upper Hunter	492 & 750
	Hunter Valley	1050 & 750
	Hunter other areas	1050
	Central Coast	1050
	Manly/Warringah Mackellar	1050
	St George	492
	Sydney – other areas	750
Integral	Thirroul to Kiama	750
	Kandos Area	396
	Nowra	283
	Western Sydney	1050
Country Energy	Broken Hill City Council	500
	Central West	492 & 206
	Macquarie	217
	Ophir	283
	Southern Mitchell	317
	Ulan	217
	Murrumbidgee	297 & 225
	Finley	750
	Albury	500
	Northern Riverina	760 & 270
	Southern Riverina	580 & 270
	Southern Tablelands	183
	Tumut River	168
	Namoi	217
	New England	317
	North West	167
	Nambucca	750 & 217
	Tweed	12500 & 217
	Coffs Harbour, Grafton & Lismore	297 & 217
	Taree & Port Macquarie	750 & 217
	Kempsey	435 & 217
	Peel Cunningham	217

6.4.1 Blocking System

The customer is responsible for the design of blocking systems. Blocking should be effective under all required conditions, including where sequential steps of capacitor switching are employed.

6.4.2 System Harmonic Blocking

Remember that this equipment will be installed in a power system environment where natural harmonics of 50Hz exist in varying magnitudes depending on location and time of day. In general, the magnitude of the harmonics tends to diminish as the number increases, the 3rd and 5th tend to be “strong” while the 17th and 19th are “weak”. Signal frequencies in common use, are positioned in the upper region of this frequency spectrum.

In many electricity distributor’s systems significant levels of 650Hz (i.e. 13th harmonic) are present at some locations and steps are taken in 750Hz installations to minimise the harmful effects of 650Hz.

The series resonance frequencies required are therefore designed to both increase the impedance of shunt capacitors at the signal frequency and avoid introducing low impedance sinks to system harmonics which may overload equipment.

The required tuning frequency should not be close to any harmonic frequency and still provide a sufficient increase in impedance at the signal frequency.

6.4.3 Low Frequency Ripple Systems

Experience in the industry shows that any effects due to capacitance will be negligible for a ripple frequency less than 400 Hz. However, sufficient space for the installation of harmonic filters should be provided. Nevertheless, each individual application must still be checked and verified by the customer.

6.4.4 Ripple Control Blocking

Although the design of the blocking systems is the responsibility of the customer, in general there are three types of circuit commonly used to increase the impedance of shunt connected capacitors at the signal frequency are known as Blocker, Rejecter and Stopper circuits. Refer to clauses 6.6, 6.7 and 6.8.

Only the Blocker circuit, which acts as a general low pass filter, is not frequency specific. The Rejecter and Stopper circuits use parallel resonance and are tuned to a specific frequency.

6.5 LABELLING

The power factor equipment must have a nameplate securely fixed to it in an accessible position. The label must include the following information:

(a) Maker’s name.

(b) Type, serial number (rejecter coils and stopper circuits only).

(c) System voltage rating.

(d) Rated 50Hz current.

(e) Rated capacitor value (inductors only).

The complete equipment assembly should also be labelled for:

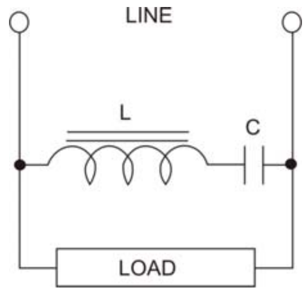
i) Series resonant frequency (series inductors and rejector coils only).

ii) Parallel resonant frequency (rejecter coils and stopper circuits only).

6.6 BLOCKER CIRCUITS

BLOCKER CIRCUIT

An inductor L in series with the capacitor bank C can be used to increase the signal frequency impedance of single or 3-phase capacitors. Commonly used in individual discharge lighting fittings.



Choose the inductance of the series inductor, (also called a blocking inductor) so that the series resonant frequency does not coincide with a strong harmonic of the mains frequency (eg 5th harmonic, 250Hz and 7th harmonic, 350Hz). The series resonance frequency is fixed by the inductance of the inductor and the capacitance of the shunt capacitor to be blocked.

The required value of tuned frequency must be at least 50% below the ripple frequency plus or minus 5%. For example, in a system where a 750 Hz ripple frequency is used, a value of 190 Hz or 320 Hz ensures that harmonic currents and resultant overvoltages on the capacitor are minimised, at the same time providing adequate blocking to the signal frequencies.

The whole installation should present a predominantly inductive impedance within plus or minus 10% of the ripple frequency.

Successful blocking of the harmonics depends on accurate values of inductance and capacitance.

Note: The inductance value should not vary, with up to 200% of the inductors current. There may be considerable difference between the nameplate value and the actual value of capacitance.

Series or blocking inductor circuits are a cost effective and satisfactory method of raising the impedance to signal frequencies, particularly where the capacitor is a single unit, such as in a fluorescent lighting installation.

6.6.1 Series Resonant Frequency

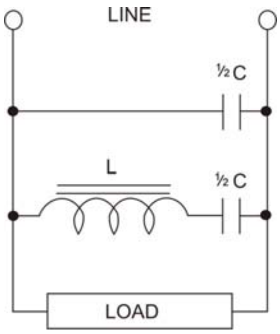
Inductors must be designed so that when they are connected in series with the actual capacitor(s) they will be used with, the series resonant frequency of the combination will be at least 50% below the ripple frequency within ±5%. The voltage of the superimposed frequency is 2% of the mains voltage.

Note: The operating conditions of the combination can combine to cause a considerable increase in the RMS current through the capacitor over its normal 50Hz current as determined by the mains voltage and reactance. The voltage rating of the capacitor must be such that it can withstand these conditions in compliance with AS 2897.

6.7 REJECTER CIRCUITS

REJECTER CIRCUIT

Used where the capacitor installation can be divided into two approximately equal banks. Frequently the most cost effective method for fixed capacitor banks up to 450kVars. On site adjustment to tune the circuit is required



For large correction currents, and where the shunt capacitor bank can be split into two equal sections, the inductor is placed in series with one half of the bank. The inductor then only has to carry half of the 50Hz correction current. These are called Rejecter circuits. They are suitable for fixed capacitor banks up to 450kVar.

Tune the parallel combination of one half of the capacitor bank and one inductor, with the other half of the capacitor bank to parallel resonance at the signal frequency. This offers a high impedance to the control signal.

Tune the inductor on site by air gap adjustment to achieve the required rejection of harmonics and signal frequency.

6.7.1 Signal Frequency Impedance

The overall impedance of the capacitor installation with rejecter coils installed must not be less than 75 per cent of the 50Hz reactance of the capacitors within the frequency range used by the electricity distributor in that location, + 1% - 2%. This must be measured with a signal voltage equal to 2% of the 50Hz mains voltage across the terminals of the input capacitor(s).

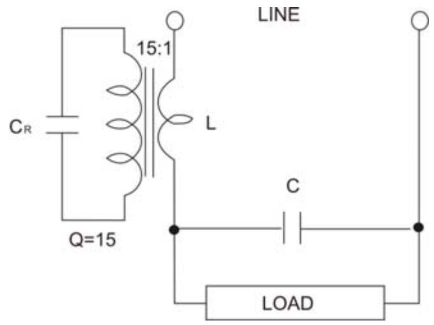
6.7.2 Series Resonant Frequency

The series resonant frequency of the inductor and the capacitor(s) on the side of the inductor remote from the supply must not be less than 500Hz.

6.8 STOPPER CIRCUITS

STOPPER CIRCUIT

Used for installations with stepped banks of shunt capacitors or where capacitors are located at various sites throughout the installation. Particularly suitable for automatically controlled systems.



Stopper circuits consist of a self contained inductor/capacitor unit inserted in series with either the capacitor bank or the line feeding the capacitor bank and the load. Tune the elements to parallel resonance for the signal frequency to be blocked. A series impedance of about ten times the impedance of the inductor or tuning capacitance alone will be the result.

6.8.1 Signal Frequency Impedance

The impedance of the stopper circuit alone within the range used by the distributor in that location, + 1% - 2% must not be less than 75% of the impedance of the capacitor alone at 50Hz. A stopper circuit carrying load current in addition to capacitor charging current, must not be less than 120% of the 50Hz impedance of an equivalent load determined by the current rating. The impedance of this equivalent load must be determined by dividing the mains voltage by the rated current of the stopper circuit.

In the case of switched or variable capacitor banks the 50Hz impedance must be the maximum possible capacitance connected at any time. Further, the overall impedance of the stopper circuit and capacitor in any switched position of capacitance must not be less than 50% of the 50Hz impedance of the maximum possible capacitance connected at any time.

The impedance at the electricity distributor's ripple frequency must be measured at rated 50Hz current and with a signal voltage applied equal to 2% of the mains voltage.

6.8.2 Series Resonant Frequency

The series resonant frequency of the stopper and capacitor combination must be at least 25% below the ripple signal frequency and at a minimal even harmonic of 50Hz, eg 10th harmonic. In the case of switched or variable capacitors the series resonant frequency with the maximum capacitance connected must not be within 10% of the ripple signal frequency.

Note: This clause does not apply to stopper circuits carrying load current in addition to capacitor charging current.

For transformer coupled stopper circuits, with 1.3 times the rated 50Hz current flowing in the primary winding, the temperature rise of the secondary winding after 4 hours in still air, measured by the winding resistance method, must not exceed 50°C.

6.9 POWER FACTOR CORRECTION EQUIPMENT INSTALLATION

Power factor correction equipment is sometimes added after the initial switchboard installation. The equipment is often in a separate cubicle, wired back to the main switchboard. Most of the cable requirements below will not apply for the few instances where the correction equipment is part of the main switchboard.

Where the power factor correction equipment is installed as part of the main switchboard then the provisions of the AS/NZS 3000 will apply.

6.9.1 Electrical and Mechanical Protection of Supply Conductors

Normally a main switchboard is located in its own dedicated switchroom or an allocated area of a plant room or floor. If there is a lack of space in this switchroom or switchboard area the correction equipment may be located remote from the switchboard. In this instance, the interconnecting cables should have electrical protection and isolation devices located on the main switchboard.

The cabling should be clamped in accordance with the AS/NZS 3000, to withstand the forces due to fault current. Each individual cable must be adequate to carry the fault current if the cables between the switchboard and the power factor correction cubicle are paralleled and the cables are not protected (where the correction equipment is located in the switchroom). To achieve this each cable's current rating must be no less than 25% of the setting of the upstream protection.

6.9.2 Isolation of Equipment

You must be able to isolate the correction equipment by a fault make, capacitive load break switch. It is not acceptable to use a fuse link or the power factor controller to operate capacitor contactors to provide isolation. Each consecutive stage of correction will have a time delay before its introduction, so the power factor controller will not provide instantaneous isolation. A circuit breaker or combined switch fuse (CFS unit) is acceptable isolation if it is suitable for switching capacitive currents.

The isolation and protection equipment must be rated for a fault level of 25kA. The electricity distributor may nominate a higher fault level if:

(a) The customer is situated close to the substation supply, or

(b) The substation supplying the customer has multiple transformers in parallel.

Labelling of the protection and isolation devices on the main switchboard should show the identity and location of the power factor correction equipment.

6.9.3 Clearances around Equipment

Maintain adequate clearances where the power factor correction equipment is installed. If metering equipment is installed nearby you must still have the minimum clearances nominated. If the metering location is a problem it is often more cost effective to relocate the metering than to find an alternative location for the power factor correction equipment. If required, the electricity distributor may relocate the metering equipment at the customer's cost.

6.9.4 Frequency Rejection Equipment

In ripple signal areas the equipment must be designed for the ripple frequency or have ripple frequency rejection fitted. Frequency rejection is necessary because the capacitors would otherwise appear as a low impedance to the ripple signal. The equipment must also be labelled with the designed rejection frequency.

Electricity distributor inspectors will check that this frequency matches the ripple frequency of the area in which the equipment is installed. Frequency rejection is necessary to limit the current spread of poor signal sectors within ripple areas. The equipment supplier should test the supply for harmonic content to establish whether harmonic rejection is required to protect the power factor correction equipment. This significantly increases the cost of the correction equipment and need only be installed where necessary.

6.9.5 Oil Filled Capacitors

If oil filled capacitors are used they should be manufactured in accordance with AS 2897. Other capacitors are manufactured to IEC 60831-1. If the supplier has used oil filled capacitors with a flashpoint of less than 250ºC and with total oil volume of greater than 50 litres, then the capacitor housing or mounting area should have adequate drainage installed, to prevent the spread of oil as specified in the AS/NZS 3000.

6.9.6 Labelling of Equipment

The correction equipment should be labelled as specified in clause 6.5.

6.9.7 Power Factor Monitoring

The current transformer (CT) used to monitor the installations power factor should be mounted where it will accurately reflect the power factor detected by the electricity distributor's metering. Mounting the power factor correction CT close to the electricity distributor's CTs is acceptable, provided that it does not interfere with the removal of the electricity distributor's CT. The CT should be on the line side of the connection point of the power factor correction capacitors. The electricity distributor must approve the location.

6.9.8 The Power Factor Controller

One power factor correction controller is often installed for two or more services. In these situations the power factor correction controller should make sure that no one service has a leading power factor. If the controller fails, it should give the installation a lagging power factor.