IDEAL ELECTRIC

Specifying and Using

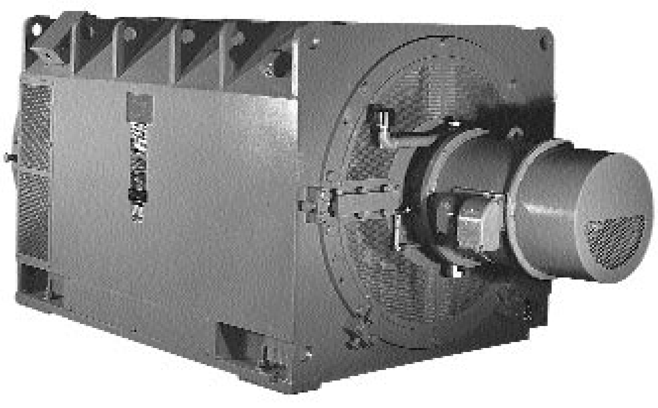
Synchronous Condensers

for

Power Factor Correction

and

Voltage Support



1000 KVAR To Over 100 MVAR Systems

System Harmonics Can Cause Capacitor Failures — Rotating Synchronous Condensers are Better

The use of rotating synchronous condensers, common through the 1950s, is now making a comeback as an alternative (or a supplement) to capacitors for power factor correction. Because of the problems that have been experienced with harmonics causing capacitor overheating and catastrophic failures, more power users are realizing how effective synchronous condensers can be for power factor improvement.

Synchronous condensers are also very good for supporting voltage in situations such as starting large motors, or where power must travel long distances from where it is generated to where it is used, as is the case with power wheeling.

Power Factor

With a purely resistive load the current and voltage remain exactly in phase and the power factor is 1.0 (unity power factor). As inductive loads are added (primarily motors and transformers), the current begins to lag the voltage, and the power factor is lowered.

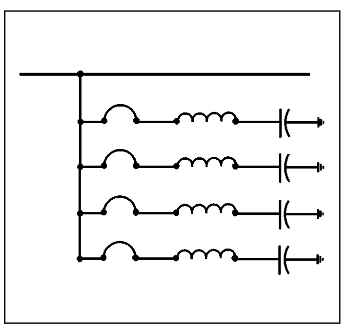
A higher power factor reduces line losses and allows more KW to be available on the network. This is important in mills and manufacturing facilities because a low power factor can cause equipment to operate poorly. Transformers and motors will run hotter at low power factors and arc furnaces will not be able to maintain the consistent temperatures required to manufacture high quality steel.

Power Factor Correction Options

There are several methods available for power factor correction, including fixed capacitors, switched capacitors, static VAR compensators, and rotating synchronous condensers.

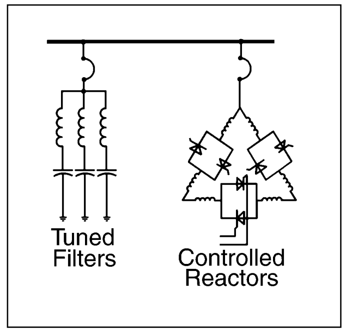
Fixed capacitors have a single MVAR rating. They are primarily used to correct a relatively constant, low PF.

Switched Capacitors are used if there are some changes in the plant power factor correction requirements. Unfortunately, this system adds the capacitors in steps which can develop over voltages. In addition to the abrupt system changes, switched capacitors cause voltage transients on the electrical system during these switching steps.



Switched Harmonic Filters

If there is a significant content of harmonics on the electrical network, capacitors are susceptible to failures from overheating and electrical resonances. It is generally recommended to add tuned inductors with the switched capacitors to form switched harmonic filters which reduce harmonic problems.



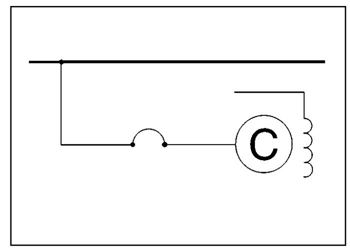
Static VAR Compensator

A newer technology is the static VAR compensator. A static VAR system is basically a power rectifier (SCR) bridge which directs the VARs from a capacitor bank onto the electrical system, or dissipates VARs across a set of inductors as necessary to maintain a set-point system power factor. This system has very fast response and is infinitely variable, but it is very expensive. The maintenance, installation and physical space requirements are similar to the disadvantages of high HP, medium-voltage, variable frequency drives.

Rotating Synchronous Condensers

A rotating synchronous condenser is fundamentally a synchronous motor that is not attached to any driven equipment. It is started and connected to the electrical network. It operates at full leading power factor and puts VARs onto the network as required to support a system's voltage or to maintain the system power factor at a specified level. The condenser's installation and operation are identical to large electric motors.

Condensers provide a proven, low cost alternative for many applications and should be considered for any power factor correction or voltage support applications.



Synchronous Condenser

A synchronous condenser provides step-less automatic power factor correction with the ability to produce up to 150% additional MVARs. Condensers can be installed inside or outside and are relatively small in size. The system produces no switching transients and is not affected by system electrical harmonics (some harmonics can even be absorbed by condensers).

Condensers will not produce excessive voltage levels and are not susceptible to electrical resonances. Because of the rotating inertia of the condenser, it can provide voltage support even during a short power outage.

Condensers are also very reliable, require little maintenance and have low spare parts costs. A condenser's initial cost is comparable to switched capacitors and is considerably less than static VAR compensators.

Comparison of Power Factor Correction Options

	Fixed Capacitors	Switched Capacitors	Static VAR Compensators	Synchronous Condensers
First Cost	Low	Medium	High	Medium
Installation Cost	Low	Medium	High	Low
Harmonic Problems	Yes	Yes	Yes	No
Voltage Transients	No	Yes	Yes	No
Infinitely Adjustable	No	No	Yes	Yes
Physical Size	Small	Medium	Large	Medium
Overload Capability	No	No	No	Yes
Outage Ride-Through	No	No	No	Yes
Maintenance	Easy	Easy	Complex	Easy
Install Outdoors	No	No	No	Yes

Condenser Payback

A significant portion of industrial power bills is the demand charge which is based on KVA. With a better power factor the KVA is reduced and the bill is significantly lowered. Many utilities charge additional large penalties for low power factors. By reducing power bills, many companies have had less than a two year payback when installing condensers.

A recent plant expansion required 21MVAR to be added to the system on an adjustable basis. Because of existing background harmonics, inductors would have had to be added to switched capacitors to avoid electrical resonances and possible capacitor overheating. The synchronous condenser had the clear benefit of providing step-less control without creating voltage transients. The hardware costs for the synchronous condensers was $400,000 less than switched harmonic filters. An additional $75,000 was saved because the condenser could be installed on an outdoor foundation, while the switched filters would have required a new building.

The cost comparison charts on page 4 of this brochure will help you determine when rotating synchronous condensers are the most cost-effective alternative.

Condensers in Combination

Despite the many advantages of rotating synchronous condensers, they may not provide an optimized solution for every application. Often, a combination of approaches is the best solution.

For a refinery or paper mill, a fixed bank of capacitors tuned to be a harmonic filter may be chosen to correct the continuous need for VARs while a condenser provides the variable and peak requirements.

For an arc furnace at a steel mill, a 50%/50% system of condensers and static VARs may be the best choice. The static VAR would meet the need for fast response to sudden demand for voltage support while the condenser would provide an adjustable amount of VARs continuously and contribute up to 150% during peak demand.

Voltage Support — Power Wheeling

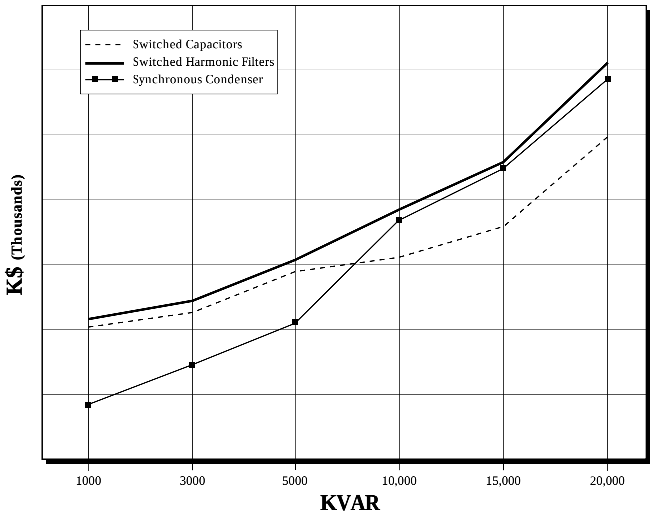
Power wheeling is a significant new trend in power generation. It holds great promise for maximizing the output of existing power generation facilities and meeting peak power demand needs while reducing the cost of power in remote locations. However, if power wheeling is to succeed, either the producer or the user is going to have to compensate for the drop in voltage that occurs as power is transmitted over long distances. Just as gas and oil pipelines require "boosting stations" to maintain flow, many power wheeling applications will require voltage support along the line. This can be accomplished inexpensively through the use of rotating synchronous condensers. These simple systems provide exactly what is required for power wheeling: a low cost, reliable way to maintain the system voltage.

Summary

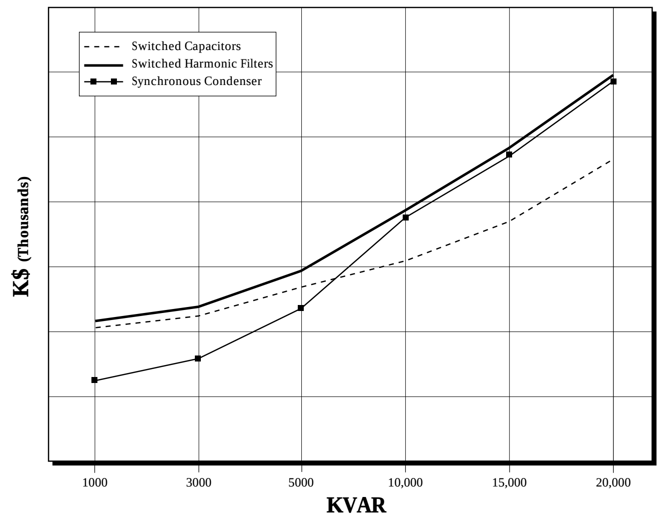
There are significant annual savings that can be realized by installing Power Factor correction devices. There are some potential harmonic and voltage transient problems associated with capacitors. Rotating synchronous condensers are reliable and very cost effective. When capacitors are operating in a system with harmonics, their life expectancy can be in the 3 to 5 year range (or less) while condensers have a life expectancy of 20 to 30 years (or more). Condensers offer many advantages that other options cannot provide. Considering condensers for power factor correction and voltage support is recommended.

Comparison of Initial Cost of Synchronous Condensers

Cost Comparison (4.0 KV)



Cost Comparison (13.8 KV)



Guide Specification

Condenser rating (MVAR): ______________ Voltage: ______________________________ Enclosure: ___________________________

System MVA: __________________________ Minimum plant PF: ____________________ PF desired: ___________________________

System short circuit MVA: ______________ Max. starting voltage drop: ____

The rotating synchronous condenser shall be designed to produce the MVAR rating indicated above with a 1.15 service factor on a continuous basis with a maximum of Class F temperature rise above a 40° C ambient temperature.

The stator shall include a sealed class F VPI insulation system. Stators rated over 5KV shall include a corona protection. Stator laminations shall be made of a low loss C5 coreplate. The stator shall include (6) 100 Ohm RTD's and space heaters.

The Condenser shall have split sleeve bearings which shall be self cooled or include a lube oil system. Each bearing shall included (1) 100 Ohm RTD. The Condenser shall be designed to have a maximum vibration level of 0.1 in/sec. If a shaft extension is brought out, it shall have a safety cover over it.

All interior and exterior metal surfaces shall be painted with an oxide primer, the exterior finish coat shall be a premium alkyd-polyurethane ANSI 61 grey paint.

Condensers 3 MVAR and over shall include differential current transformers, lightning arresters and surge capacitors. The Condenser shall include a brushless exciter rated at 150% current, a primary starter with a Multilin 269+ protection relay and all necessary controls. The Condensers and starter/control system shall be given a routine test which will be witnessed.

The following spare parts shall be included:

- upper and lower liners for DE and NDE bearings,
- an oil ring,
- front and rear inboard and outboard seals,
- a spare exitation controller,
- and 1 set of diodes, SCR's, fuses, and surge suppressors.

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For More Information…

If you need help selecting the proper size condenser, or if you have questions about your application, do not hesitate to contact your local Ideal Electric representative or Jim Clous, Ideal Electric's Sales and Marketing Manager, at 419-522-3611. Completed Specification Guides can be faxed to Ideal Electric at 419-522-9386.