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DYNAMIC POWER FACTOR CORRECTION PANEL

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INTRODUCTION

Majority of the loads in the industries are highly inductive in nature such as induction motors, AC/DC drives, welding machines, arc furnaces, fluorescent lightings, electronic controls and computers. There may be a few resistive loads for heaters and incandescent bulbs. Very rarely industries may have capacitive loads such as synchronous motors. Net industrial load is highly inductive causing a very poor lagging power factor. If this poor power factor is left uncorrected, the industry will require a high maximum demand from Electricity Board and also will suffer a penalty for poor power factor. These two factors of high kVA demand and penalty for poor factor will inflate the monthly Electricity Bill. Since power factor can be corrected to near unity there can be huge saving from the Electricity Bill. Standard practice is to connect power capacitors in the power system at appropriate places to compensate the inductive nature of the load. The relation between the different power parameters kW, kVA, kVAr, kWh, kVArh, average power factor and other basic details are given in the Appendix - 1.

DISADVANTAGES OF HAVING POOR POWER FACTOR ARE GENERALLY UNDERSTOOD AS FOLLOWS.

- More kVA demand for the given kW load and penalty for poor power factor - hence higher running cost (electricity bill).
- More line current for the given kW load and hence higher rated transformer, switchgears and cables are required - hence higher capital cost.
- More line current for the given kW load and hence higher losses at the transformer, switchgears and cables - hence higher running cost.
- More line current for the given kW load - Poor utilization of all electrical distribution network and hence poor return on investment.
- Higher voltage drops in the distribution network - hence poor performance of electrical equipments resulting in production loss.
- Higher voltage fluctuations - hence damage to electrical equipments resulting in production loss.

NEED TO CORRECT THE POOR POWER FACTOR:

Hence if we are able to correct the poor power factor to near unity on all occasions at all loads, we can bring down the kVA demand, line losses, increase the utilization of the distribution equipments, increase the performance of electrical equipments, avoid damages to electrical equipments and avoid production losses due to power related problems. Another major advantage is that near unity power factor not only avoids penalty, but also brings in incentive from Electricity Board for higher power factor. All the above savings in revenue expenditures improves the bottom line of the company directly adding to the profit. Hence the investment on a good power factor correction system will have an attractive pay back. Subsequently the return on the investment will be high.

VARIOUS METHODS OF POWER FACTOR CORRECTION SYSTEM

Using Power Capacitors, the poor power factor can be corrected in the following methods.

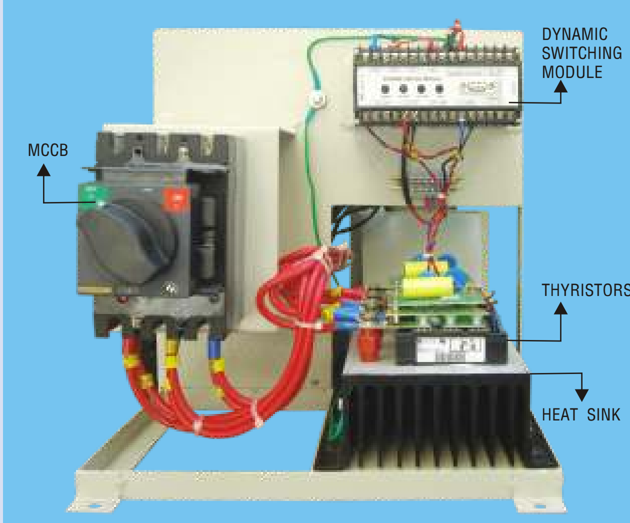
- By providing fixed value of capacitors to the distribution network at various points. They will be switched In/Out as per the load manually. This method is simple and cheap but effective correction not possible. Over compensation at lean loads result in high voltages, transients and leading Power factor which are detrimental to the system.
- Using APFC Panel at the various Points of the distribution network. Here automatic Power factor correction takes place with respect to load power factor with the help of Power factor controller and Power contactors. Here effective correction is reasonably possible. In both the methods high inrush currents are produced during switching ON/OFF of capacitors. Hence capacitors, contactors and switchgears are likely to fail.
- By Dynamic PFC panel with power factor controller and Thyristors instead of power contactors .4/6/8/12 steps of capacitor banks will be switched in/out as the power factor varies. Zero current switching of capacitors is possible with Thyristor switch.
- By Dynamic PFC Panel with detuned capacitor banks. Here instead of plain capacitor a detuning reactor is used in series with the capacitor. This method is recommended where the industrial loads are predominantly non linear and causing power harmonics more than that of the stipulated standards.

MAIN FEATURES

- Control is very dynamic and follows the load fluctuations without any delay.
- Zero current switching technique is used, so there are no voltage transients or surge currents during switch IN/OUT - Hence improved life span of capacitor.
- Thyristors are used for switching-Hence there is no limit on number and frequency of switching.
- Dry type - soft resin - self healing - low loss - over pressure disconnected type reputed make capacitors are used. It gives compact and high safety construction.
- On customer request as well as depending on site condition heavy duty capacitors can be used to operate in continuous high voltage.
- Low loss reputed make detuned reactors are used as decided by the presence of harmonics in the system. (RPD 9530 Only)
- Schneider and GE switch gear components manufactured according to IEC standards are used in the panel.
- Micro controller based PF controller with 4 quadrant measurement and built in protections is used to select capacitor banks.
- Continuous display of instant power factor and other related data such as kVAr, required kVAr etc.
- Panel design is available for 1:1:1:1, 1:1:2:2, 1:2:2:2, 1:2:4:4, 1:2:4:8 capacitor steps. Hence smooth and accurate compensation is possible with minimum switching operations.
- Facility to operate in Auto/Manual mode.
- Customized panel construction is possible.
- Rating from 50 kVAr to 600 kVAr for 3 phase 415 V, 50 Hz applications.

OPTIONS

1) Digital ammeter for capacitor current
2) kVArh meter to show the kVArh pumped.
3) Harmonic Indicator and Load managers. (Grid as well as panel side)



TYPE RPD 9520

FAST PF REGULATOR

It is a high end power factor controller suitable for switching the Thyristors. It accepts voltage and current signals, computes kVAr of the load, requirement of the compensation as per the set point and activates the Thyristor switching modules to switch IN/OUT the capacitor banks. A special logic is written in the software for selection of required compensation.

DYNAMIC SWITCHING MODULES

This module consists of an electronic card to see the Thyristor switch in a capacitor with minimum voltage so that the switching current is near zero. This, hence prevents heavy in rush current in the capacitor and in the system. Even with phase reversal this module functions normally. This module switch OFF the capacitors during any phase failure condition.

POWER BLOCK

This is nothing but two Thyristors connected in antiparallel mode for use in AC system. Adequate dv/dt protection is provided by snubber circuit. Over current protection and isolation of the bank are achieved by MCCB. Thyristors are mounted on heat sinks with proper cooling arrangements.

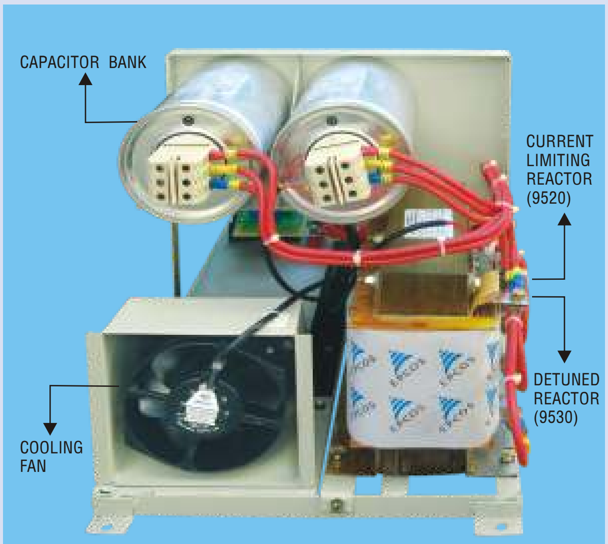
CURRENT LIMITING REACTOR

Suitable Iron core reactor is used in series with the capacitor for di/dt protection of Thyristors.

CAPACITOR

Dry type - soft resin - self healing - low loss - over pressure disconnected type reputed make capacitors are used. On customer request as well as depending on site condition heavy duty capacitors can be used to operate in continuous high voltage.

In this model Effective correction is possible as Thyristors can be operated as many times as required. Inrush currents while switching can be contained to a very low level as zero current switching logics are employed for each step. This method is very much adequate, if the power harmonics are within the limits stipulated by the standards. Otherwise, power harmonics will get amplified due to resonance.



EFFECTS OF HARMONICS ON CAPACITORS

Capacitor reactance Xc decreases with the increase of frequencies. Xc = 1/(2pfc). Hence it offers low impedance for harmonic frequency. So even smaller amplitudes of the harmonic voltages result into higher current through the capacitor which are detrimental to them.

More critical is the capacitor may cause parallel resonance with transformer impedance at harmonic frequencies. At resonance high current flow between the capacitor and transformer and voltage magnification takes place which is harmful to the system.

TYPE RPD 9530

One of the better solution for improving power factor under harmonic conditions is by employing de-tuned capacitor banks.

De-tuned capacitor bank consists of a series circuit of capacitor and a specific filter circuit reactor. The resonance frequency of the de-tuned bank does not match close to any of the existing harmonic frequency, it is normally lower than the lowest harmonic frequency present in the system, usually 5th harmonic.

The main purpose of the de-tuned filter is to avoid resonance condition of the capacitor with transformer inductance and to prevent amplification of original harmonics. More or less harmonic currents will be sucked from the grid depending on the de-tuning frequency. Very common is a de-tuning to a frequency of 189 Hz (7%) with reduction of harmonics approximately 30 – 50%.

At the fundamental frequency (50 Hz), which is well below the resonant frequency, the de-tuned filter is capacitive and it produces capacitive reactive power. Above the resonant frequency the de-tuned filter is inductive and it cannot amplify the typical harmonic frequencies such as the 5th, 7th, 11th, 13th, and so on.

DE-TUNED REACTOR

ICD will make a study of power harmonics present in the system and suitably select the de-tuned reactor according to the harmonics present and the mitigation of harmonics required.

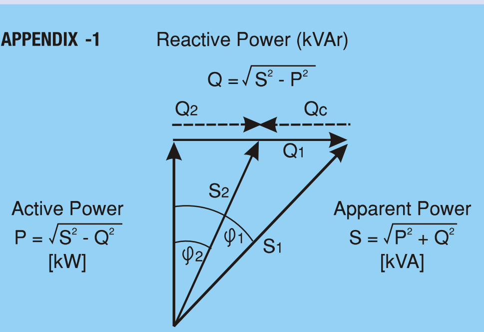
Dynamic PFC Panel using Thyristors employing de-tuned capacitor banks is an excellent solution for the power factor correction at all conditions of load whether it is fluctuating or it contains power harmonics. Power harmonics are mitigated with this system and power factor is corrected to the desired level without any amplification of power harmonics. With this system power quality will be much better and the performance of electrical equipments will have their normal function with minimum damages. Investment on this system will see a very good return and add directly to the profit of the industry.

TECHNICAL SPECIFICATIONS

DETAILS	RATING			
	100 kVAr	200 kVAr	400 kVAr	600 kVAr
System Voltage	3 Phase 415V -20% to 10%	3 phase 415 V -20% + 10%	3 Phase 415V -20% +10%	3 Phase 415V -20% +10%
Frequency	50 Hz +/-3%	50 Hz + /- 3%	50 Hz +/-3%	50Hz +/-3%
Capacitor/Reactor - Make*	EPCOS	EPCOS	EPCOS	EPCOS
PF Controller - Make*	ICD	ICD	ICD	ICD
Operation Steps**	8 In Step of 12.5 kVAr	16 In Step of 12.5 kVAr	8 In Step of 50 kVAr	12 In Step of 50 kVAr
Capacitor Bank in kVAr**	1x50, 1x25 and 2x12.5	3x50, 1x25 and 2x12.5	8x50	12x50
Thyristor ratings for Capacitor Bank	Suitable rating as per CAP. Bank	Suitable rating as per CAP. Bank	Suitable rating as per CAP. Bank	Suitable rating as per CAP. Bank
Incomer Rating - MCCB	200 Amps	400 Amps	800 Amps	1200 Amps
Incomer MCCB - Make*	Scheneider	Scheneider	Scheneider	Scheneider
Bank Protection	100A, 63A and 32A MCCB	100A, 63A and 32A MCCB	100A	100A
Protection when Voltage sensing fails	Included	Included	Included	Included
Alarms with relay output	OC, OV,Over/Under Compensation	OC, OV,Over/Under Compensation	OC, OV,Over/Under Compensation	OC, OV,Over/Under Compensation
Tolerance in kVAr	± 8.75	± 8.75	± 37.5	± 37.5
Corrected PF	0.99	0.99	0.99	0.99
Auto Manual Selection	Through keypad in PFC	Through keypad in PFC	Through kepad in PFC	Through keypad in PFC
kVAr/Current meter for Capacitor	Optional - ICD Make	Optional - ICD Make	Included - ICD Make	Included - ICD Make
Parameter settings by keypad	Included	Included	Included	Included
Display of set / actual values	PF and kVAr	PF and kVAr	PF and kVAr	PF and kVAr
Panel Type	Floor Mounted	Floor Mounted	Floor Mounted	Floor Mounted
Panel Dimensions	2200(H) x 750(W) x 500(D) mm	2200(H) x 1300(W) x 600(D) mm	2200(H) x 1500(W) x 600(D) mm	2200(H) x 2000(W) x 600(D) mm
Panel Temperature Rise	20° C above ambient	20° C above ambient	20° C above ambient	20° C above ambient
Ambient	45° C, Rh-90% @25	45° C, Rh-90% @25	45° C, Rh-90% @25	45° C, Rh-90% @25
Panel Enclosure	IP20, Force Cooled	IP20, Force cooled.	IP20, Force Cooled	IP20, Force Cooled

*For all these items refer to the respective product manuals for detailed specifications. **Alternatively customers specifications can be adopted - 1:1:1:1 – 1:2:4:8

APPENDIX -1



$\cos\varphi = P/S$

$\sin\varphi = Q/S$

$Q = S\sin\varphi$

$Q = P\tan\varphi$

φ = Phase displacement angle

S_1 = Uncompensated apparent power

S_2 = Compensated power with capacitors for compensation

Active (Real) power : $P = \sqrt{3}\,VI\cos\varphi$

Reactive power : $Q = \sqrt{3}\,VI\sin\varphi$

Apparent power : $S = \sqrt{3}\,VI$

$Qc = Vc.\dfrac{Vc}{Xc}$

$Xc = \dfrac{1}{\omega.C} = \dfrac{1}{2\Pi.f.C}$

$Qc = V^2c.\omega.C = V^2c\ 2\Pi.f.C$

Power Factor = $\dfrac{\text{Active (Real) power}}{\text{Apparent power}} = \dfrac{P}{S}$

Required capacitor for compensation $Qc = P(\tan\varphi_1 - \tan\varphi_2)$

In Electricity Bills, generally the power factor is calculated for the month with the ratio between active energy and apparent energy that is $= \dfrac{kWh}{kVAh}$. This is known as the average power factor for the month. This power factor is taken for calculating penalty / incentive.

Approximate Power Factor of Different Kind of Loads:

- Induction Motor - 0.1 to 0.8 from no load to full load
- AC Drives - 0.95
- DC Drives - 0.1 to 0.8 depending upon the output voltage
- Fluorescent Light - 0.5
- Arc Welding Machines - 0.3 to 0.4
- Synchronous Motor - 0.8 lag to 0.8 lead depending upon the excitation
- Arc Furnace, Induction Heating - 0.85, Induction Furnace - 0.60

Details of the power factor will be available with the data sheet of the load

Please Provide The Following Details Along with Enquiry:

- Full Load capacity in kW
- Average Power Factor of last 2 months
- Power Factor to be achieved
- Types of load steady and fluctuating like Motors, Welding, Cranes, Press, Furnace, Rolling Mills, Forging, Stone Crusher, Cutting Machines etc.,
- Total required kVAr for compensation and number of steps
- Whether field study required.

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Note: Specifications are subject to change without prior notice due to continuous improvement in product development.