Dynamic PF compensation Systems:

Major Criteria for determining the Dynamic PF compensation Systems Configuration:

- Load kVAr changing Pattern. (Load Variation v/s Time for load variation)
- Supply system Harmonics and Transients.
- Efficiency of the Dynamic PF correction system. (Watt Loss factor in the system).
- Load pattern with regards to Phase unbalances, Transformer No load current.
- Type of supply system: viz. Feedback from HT side CT/PT, Supply system with duel source (Mains & Generator), System with minimum base loading etc.
- Other auxiliary requirements like Data Logging, Maximum Demand Controlling, GSM Communication for Load management SCADA etc. as well as Auto / Manual switching option for complete redundancy to the Auto PF controller relay.
- Site Conditions: Depending on site physical condition. Factors like Dust, metal particles, Humidity, Temperature etc.
- Maintenance Requirements: Here the issues like module standardisation, Spares requirements, Panel construction (draw out type modules) etc.

Load kVAr changing Pattern. (Load Variation v/s Time for load variation)

Assuming Target PF requirement is 0.990 lag.

Sr.No.	50% load variation time.	Recommended Configuration.
1	5min & higher	Contactorised Switching.
2	0.5min (30sec) to 5min	Thyristorised or Thy+Cont Hybrid system. No special discharge devices.
3	1sec to 30sec.	Thyristorised with 2thyristor blocks in 2 lines configuration and with faster Discharge resistances. (DISR modules)
4	60mS to 1000mS (1sec)	Thyristorised with 3thyristor blocks inside delta arms of capacitors. Here single cell capacitors required and usage of special discharge devices (inductors) (DISI modules)
5	20mS to 60mS	Statcon.

For detailed note on Discharge Devices, please refer to the “Application Notes” folder on TAS-CD. This gives the theory and the calculation formula for these Discharge devices.

Supply System Harmonics and Transients:

Type of Loads:

• With current THD-F less than 10% and/or line to line voltage THD-F less than 2.5%.

• With current THD-F more than 10% and/or line to line THD-F more than 2.5% but no zero sequence harmonic components. (Zero sequence harmonic components causes Neutral currents to flow).

• With current THD-F more than 10% and/or line to line or line to Neutral THD-F more than 2.5% and zero sequence harmonics are present.

• With current THD-F less than 10% but transient currents with high harmonics and / or transient spike current type of loads. Mainly commercial installations or the loads like SMPS, DC rectifier or DOL starters with fixed capacitors connected etc.

With all the four type of loads, the respective suggestions for configuration are.

• Use the thyristorised system with 0.2% reactors or contactor system with suppression coils.

• Use the 7% detuned reactors.

• Use the 14% detuned reactors.

• Use 0.96% detuned reactors with fixed bank of about 5% of total KVAr without reactor.

Efficiency of the Dynamic PF correction system. (Watt Loss factor in the system).

With the existing solutions available in PF correction systems, the “Correction Time” factor and “System Efficiency” factor act against each other.

Following chart shows the typical figures that are seen with various type of systems.
The figures shown are for per KVAr compensation in terms of “watt”. (Note that these are just a typical figures for guidelines, actual figures may vary depending on the actual system configurations)

Sr.No.	Type of PF correction System	Per KVAr watt loss.
1	Contactorised System.	2watt
2	Thyristorised + contactorised (Hybrid) System	2.5watt
3	Thyristorised System with DISR modules (1sec to 30sec)	5watt
4	Thyristorised System with DISI modules (60mS to 1Sec)	5watt
5	Statcon system (using IGBT based inverter in 3 ph configuration)	7.5watt
6	Statcon system (using per phase push-pull inverter configuration)	9watt

The figures above shows that usage of Thyristorised switching or Statcon where the response time requirements are not stringent, would add to un-necessary watt loss as well as increase in the price of the system.
Thus selecting the right system for the specified application is important.

Load pattern with regards to Phase unbalances, Transformer No load current.

Normal Dynamic PF correction uses Delta connected capacitor banks that offers equal compensation all the three phases.
This is OK if the unbalance loading between the phases is less than 50%. (50% between maximum loaded phase and minimum loaded phase). In case of unbalance is too high, then compensation that is to be provided should be for “Individual Phase”.

For unbalance between the phases that is between 15% to 50%, its important that compensation kVAr should be based on the “MEAN KVAR” requirement. Under such case, the PF sensing/correction relay should be three phase sensing relay that offers the compensation based on mean of the three phases.

Keeping in mind the above specified points, following table gives the system requirements based on phase unbalances.

Sr.No.	Max to Min phase unbalance.	System Configuration.
1	Less than 15%	Capacitors Delta, Relay type- LCPF-15 or LCPF-02
2	15% to 50%	Capacitors Delta, Relay type- SPF-03.
3	More than 50%	Single phase capacitors, Relay type LCPF-02 X 3No.

For HT supply consumers, transformer magnetising current can cause some worry. Under such condition, the system should be designed with some fixed minimum bank permanently inserted into the system. The size of the bank will depend on the transformer characteristics but as a thumb-rule it can be considered as 3.5% of transformer kVA rating in terms of kVAr. i.e. 100kVA transformer should be connected with 3.5kVAr fixed capacitor bank to take care of its magnetising current.

Type of supply system: viz. Feedback from HT side CT/PT, Supply system with duel source (Mains & Generator), System with minimum base loading etc.

System with feedback from HT side CT/PT but kVAr compensation at LT level:
Here the PF correction relay should be able to accept the PT inputs with user defined PT ratio.
For load feedback through single CT (0 to 15% unbalance loading), LCPF-02 is capable of performing this.
For load feedback though three CTs, SPF-03 relay is ideally suited.
LCPF-02 and SPF-03 both are available with settable PT ratio with a single digit decimal point.

Supply System with duel source (Mains & Generator):
Number of HT consumers in India uses Generator as a back-up supply or a supply that is available due to byproducts. (e.g. Ba-gas used as fuel to generate electricity in Sugar factory or Bio-gas used as fuel to generate electricity with Sewerage treatment plant).
Under such case, single dynamic PF system should be able to compensate kVAr for either of the supply.
For this, summation CT / CTs usage is mandatory. Also usage of LCPF-02 or SPF-03 controllers can allow the separate target PF settings as well as separate CT primary ratio.

System with minimum base loading:
For taking care of Transformer magnetising losses or for taking care of minimum base load, a fixed capacitor bank is sometimes required to be in the system. But the protection to these banks against various faults cannot be provided if these banks are not controlled through PF correction relay.
LCPF-15, LCPF-02 or SPF-03 controllers are capable of declaring any banks as fixed.

Other auxiliary requirements like Data Logging, Maximum Demand Controlling, GSM Communication for Load management SCADA etc. as well as Auto / Manual switching option for complete redundancy to the Auto PF controller relay.

SPF-03 is the controller that comes with various more options. It comes in basic two models, one for contactorised switching and another with high speed thyristorised switching.
It has following additional optional features:

• 0.5class Load manager.

• Per phase Voltage, per phase source current, Neutral current and Capacitor current THD as well as odd harmonic coefficients up-to 15th harmonic measurements.

• 2MB / 4MB Flash memory for data logging. Factory settable user defined data logging structure.

• Six Aux. Outputs with kVA and kW maximum demand controller.

• RS-232, RS-485 communication with TAS and MODBUS protocols for SCADA connectivity. Additionally AT+ command sets for GSM communication modems for SMS enabled SCADA.

<u>Auto / Manual switching for redundancy of Auto PF controller relay:</u>

AMB-08 & AMB-16 modules are capable of giving a complete manual override and offer complete PF controller redundancy with manually switching of Capacitor banks ON/ OFF with pre-decided off delay timer for every capacitor bank.
This avoids usage of separate control circuit involving switches, control relays, off delay timers etc. In turn reduces the cost as well as maintenance problems.

Site Conditions: Depending on site physical condition. Factors like Dust, metal particles, Humidity, Temperature etc

Panel designing is dependent on the site physical conditions.
Dimensional Configuration is decided normally by the enclosure IP classes. In case of higher class of IP like IP-54 and above, removal of heat from the panel poses some challenge. Specifically with thyristorised systems and statcon.
Under such case usage of external Air ducts is the easiest solutions.

ZCTC and ZCCP thyristor switches and Combipack switches provides the ducting arrangement for such requirements.

Maintenance Requirements: Here the issues like module standardisation, Spares requirements, Panel construction (draw out type modules) etc.

For the contactorised system, the maintenance is normally high. This is because of following reasons:

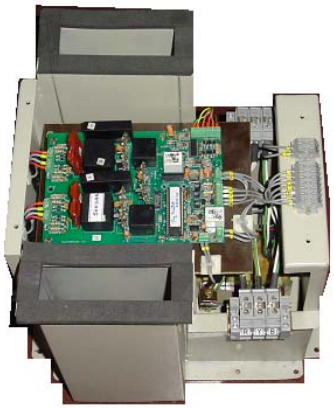
• Heavy inrush currents at the moment of switching ON of the capacitors causes the pitting / hot spots on the contactor contacts. This reduces the life of the contacts giving rise to regular maintenance.
• Regular ON / OFF with electromechanical contacts and thus the inrush currents causes the MPP capacitor values to deteriorate reducing its kVAr values. Also it reduces its life expectancy.

Under such case, if the maintenance is to be reduced, the usage of Thyristor + Contactor hybrid system is recommended.

Other maintenance requirements can be like standard rating of thyristor and capacitors used, Panel draw-out modular construction etc. This normally is defined by the final user of the system.

TAS Products for Thyristorised switching system.

ZCTC thyristor switch.
25kVAR to 100kVAR.



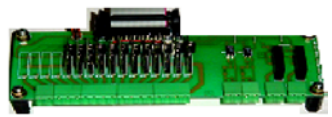
And thyristor Combi-packs
2in1 and 3in1 thyristor switches
with 5,10,12.5, 20, 25 kVAr.

Discharge Resistance
DISR module.

Switched Mode Power
Supply for Controls of
Thyristor switches.

LCPF-15 and LCPF-02
Auto PF correction relays.

SPF-03 Auto PF controller
+ Load Manager + Data Logger
+ MD controller + SCADA RTU
+ GSM / SMS communicator.



RLY module for
Switching of contactors /
Thyristor switches. To be
used with SPF-03.