PPHVC-Power Quality Solutions

PQC-STATCON
Instantaneous and stepless power quality compensation for dynamic reactive power and unbalanced loads

Power and productivity for a better world™

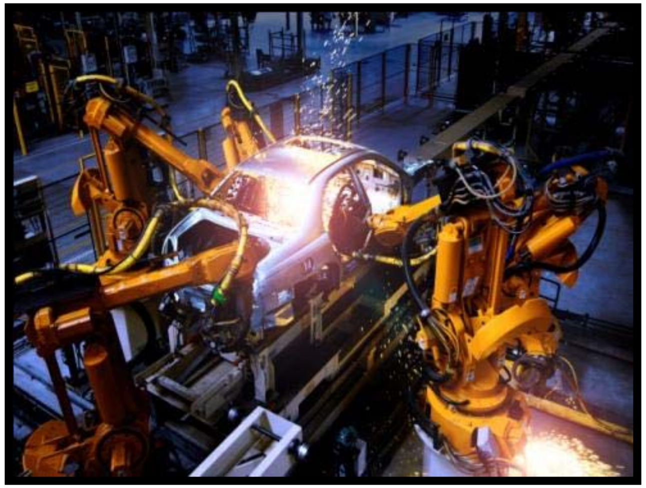
Contents

What is poor power quality?

Any event related to the electrical network that ultimately results in financial loss

- Power supply failures – “e.g :breakers tripping, blowing of fuses”
- Utility regulations and penalties
- System losses
- Equipment failure, malfunctioning and lifetime reduction, including
  - Equipment overheating (transformers, motors, etc)
  - Damage to sensitive equipment (PCs, UPS systems, drives)
- Capacitor problems due to resonance
- Electronic communication interference
- Personnel issues (illness, poor work efficiency, etc)

Key elements of poor power quality



Reactive power
Load imbalance
Harmonics

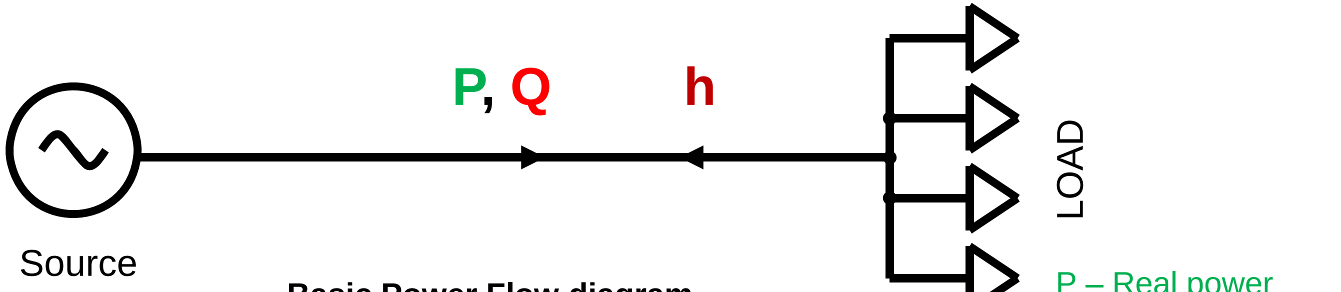
High running costs and failures

Reasons for investing in power quality solutions

Traditional reasons

- Technical problems leading to system downtime
  - Production loss
- Compliance with regulations (local/IEC/company standards)
  - Penalties if no compliance
  - No connection if no compliance
- Energy savings potential
  - Poor Power Quality results in higher system losses
  - A topic which is becoming more important due to increasing energy prices

Reactive power in a power system network



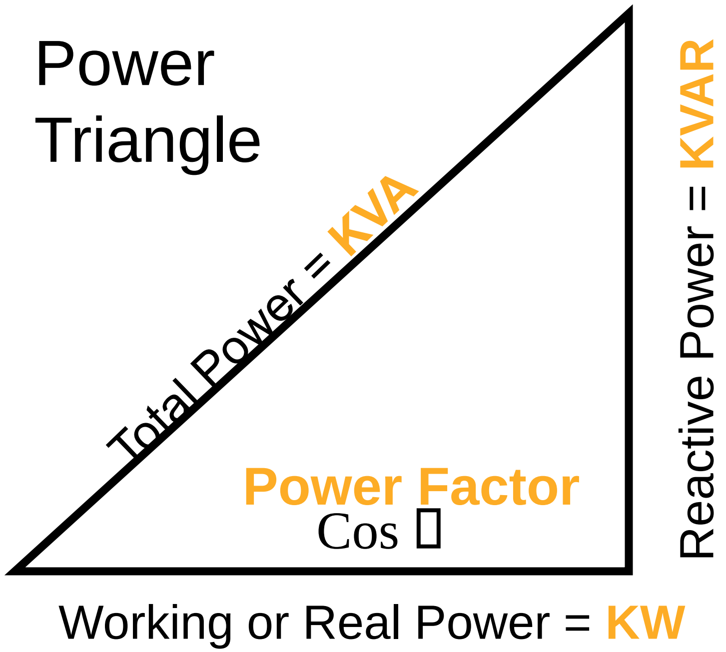
Basic Power Flow diagram

- Real power
  - Responsible for transfer of energy
- Reactive power
  - Enabler for conversion of real power
  - Not a form of energy
  - Flows back and forth, causes loss in the transmission/distribution system
  - Local supply of reactive power improves the system efficiency

Capacitor & PF

- Capacitors supply the reactive power component
- Power Factor is a measurement of how efficiently power is being used.
- PF is the cosine of the angle of phase displacement between current and voltage.
- Cos (phi) = P / S

Power factor vector relationship

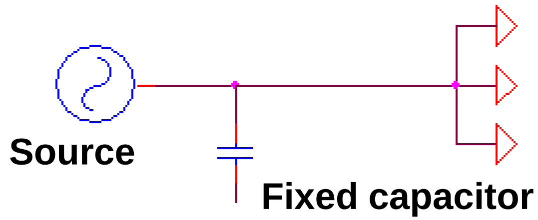


- kVA = kW ÷ PF
- kW = kVA x PF
- PF = kW ÷ kVA

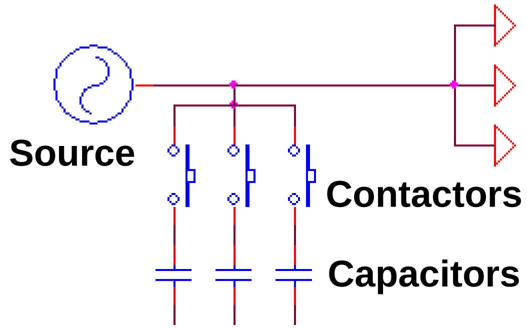
- kVA: Total Power required for a given load
- kW: Working Power required to produce work
- kVAR: Reactive Power needed to generate magnetic fields for inductive loads such as motors
- Power Factor: The relationship of real power (kW) and total power (KVA) consumed
  - Cosine of angle shown
  - Percentage or decimal expression

Reactive power in a power system network
Conventional solutions of reactive power compensation

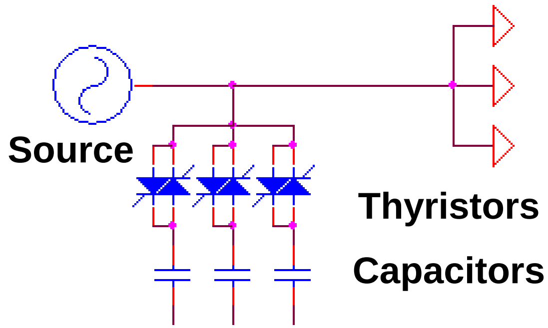
- FC (Fixed capacitor Bank)



- APFC (Automatic power factor corrector)
  - CSC (Contactor switched capacitor)



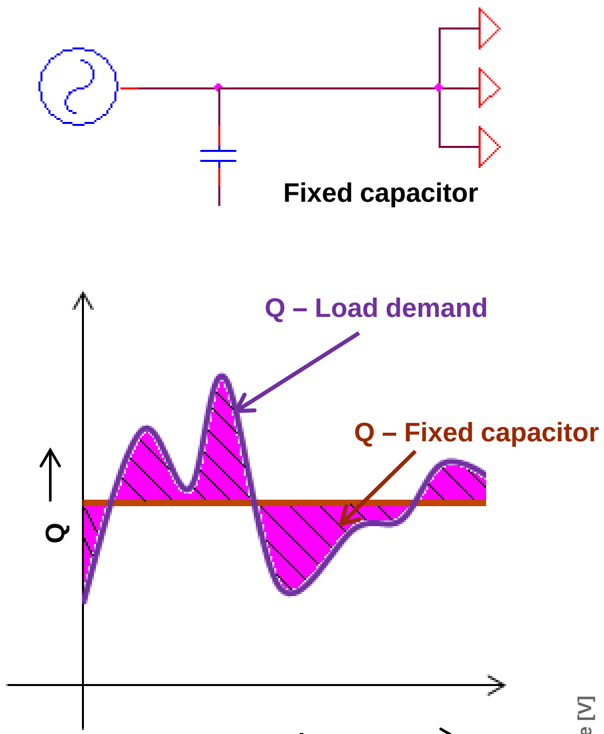
  - TSC (Thyristor switched capacitor)



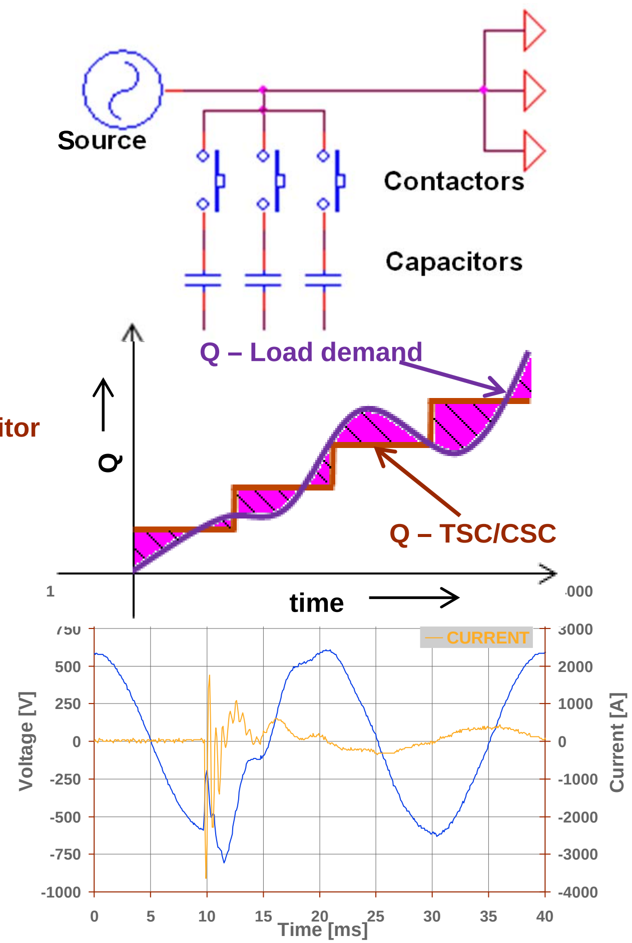
Classical reactive power compensation techniques

Reactive power in a power system network
Limitation with conventional schemes

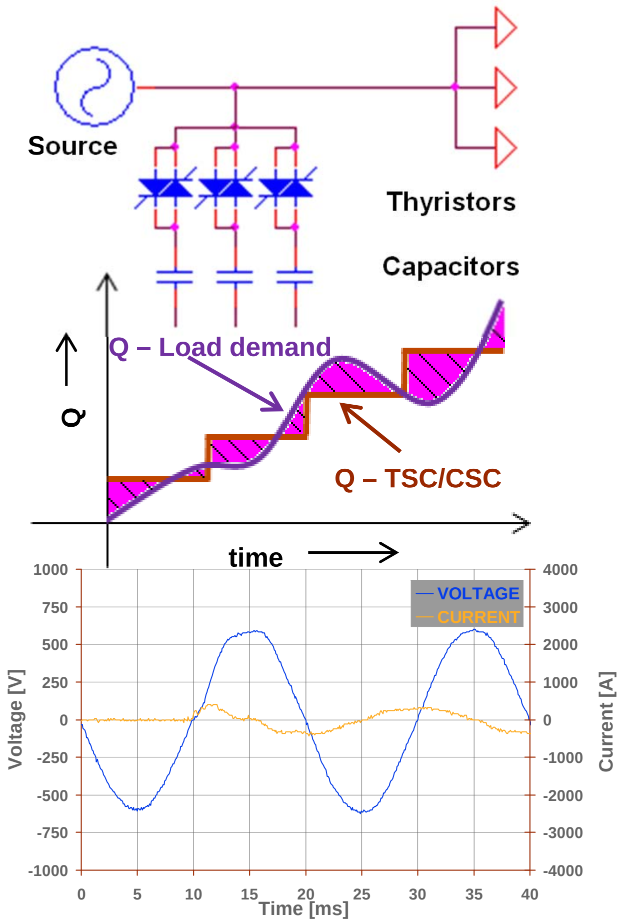
Fixed capacitor (FC)



Contactor switched capacitor (CSC)



Thyristor switched capacitor (TSC)

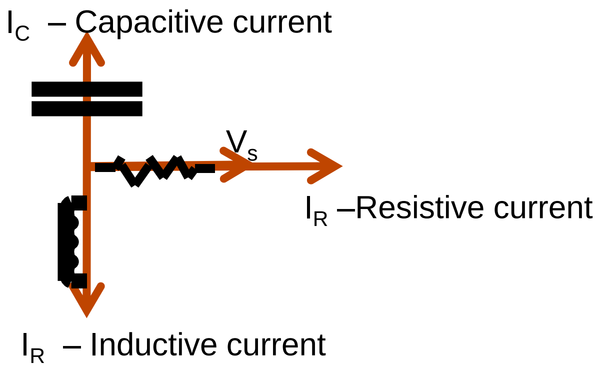


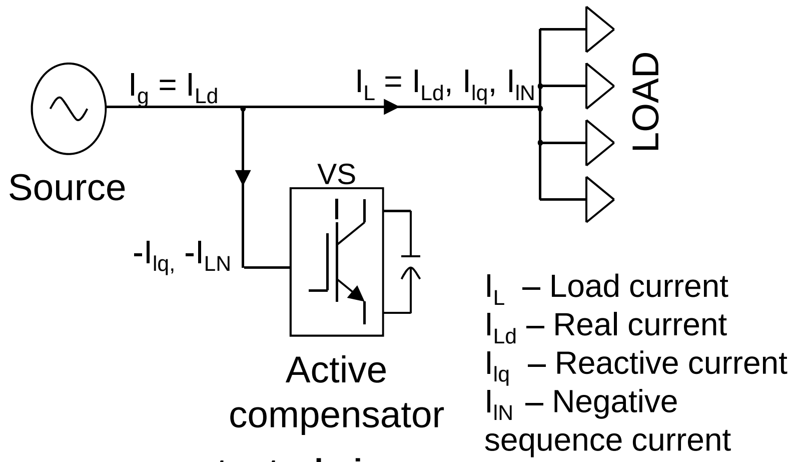
Instantaneous stepless compensation

What is better power quality?

ABB

Power electronics based compensator
Instantaneous stepless reactive power compensation

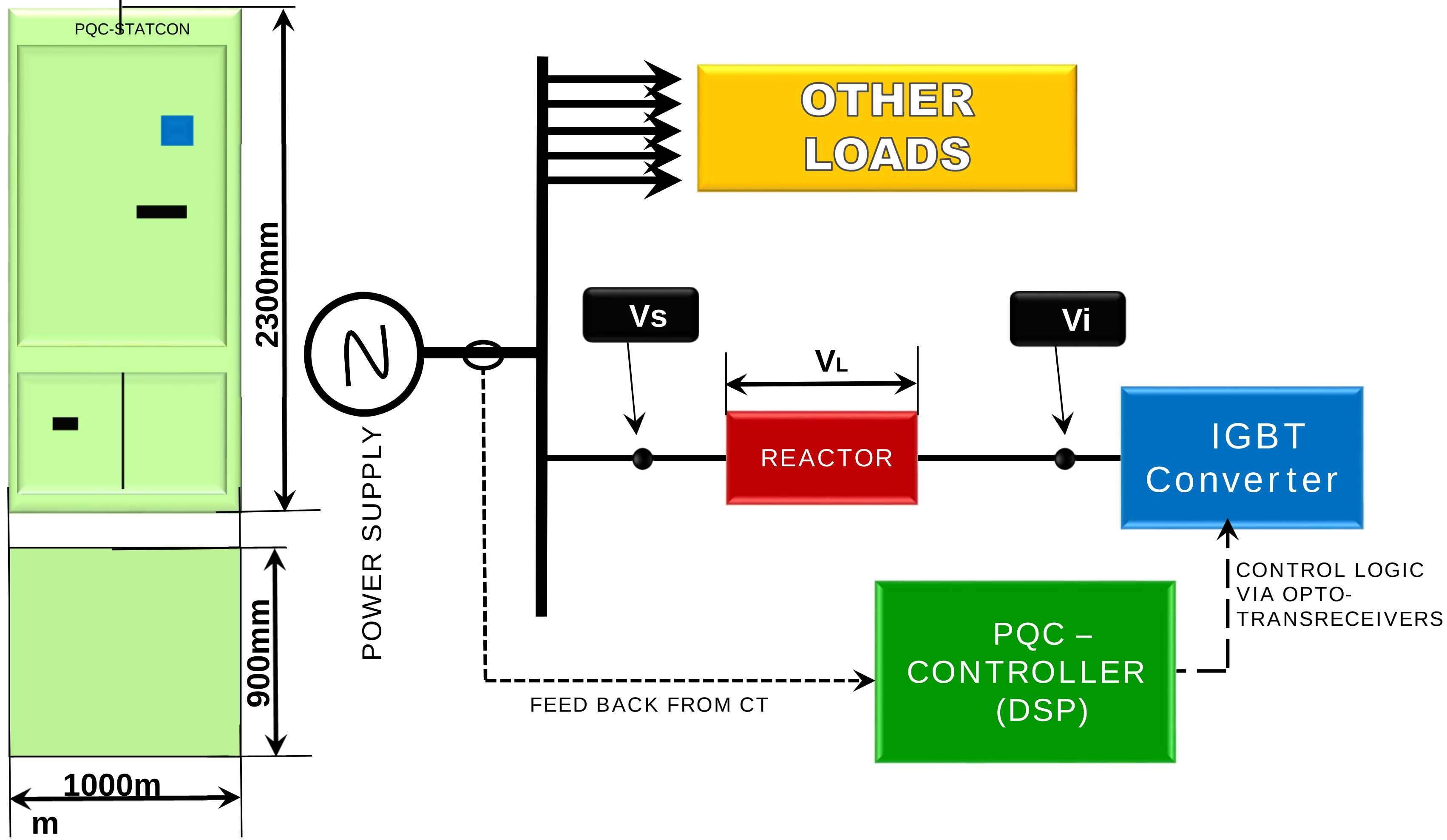




Active compensator based reactive power compensator technique

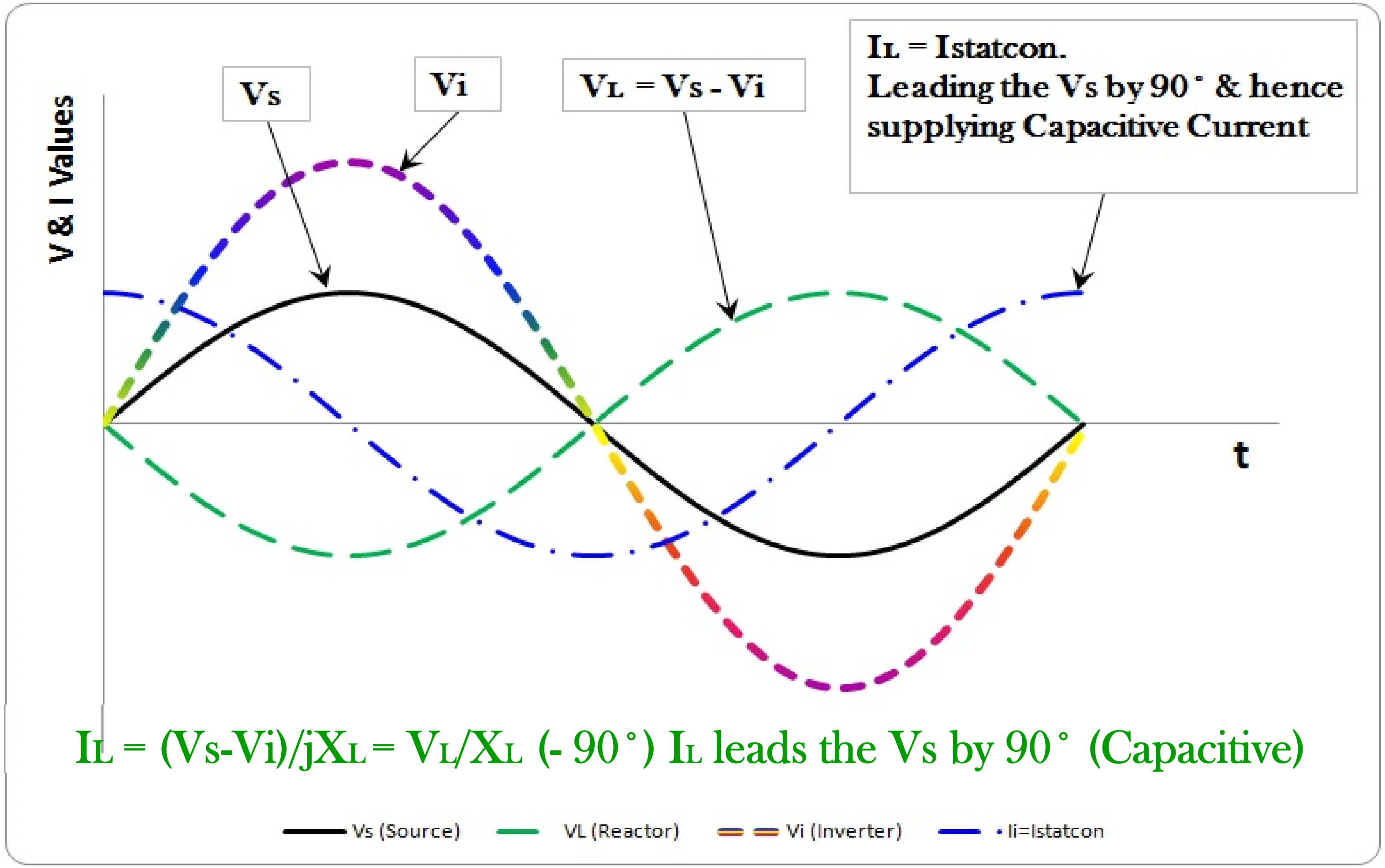
- IGBT based power electronic current source
- Fast dynamic response
- Smooth and step-less
- Inductive/capacitive reactive power operation
- Unbalance compensation
- Operates in shunt with loads

Basic operating principle Of PQC – STATCON



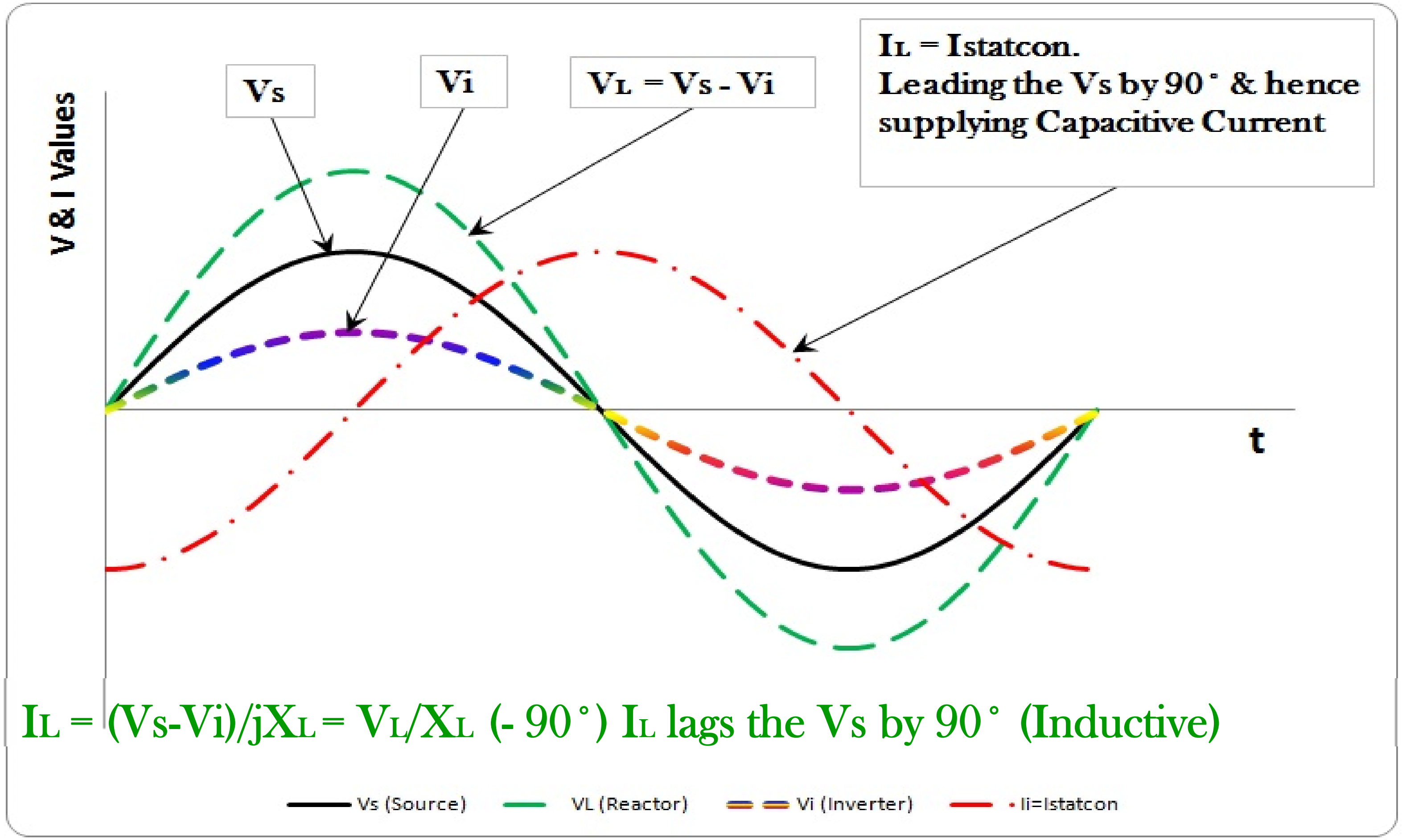
Reactive Power Compensation(RPC) by STATCON:

CASE-1: When Vi > Vs



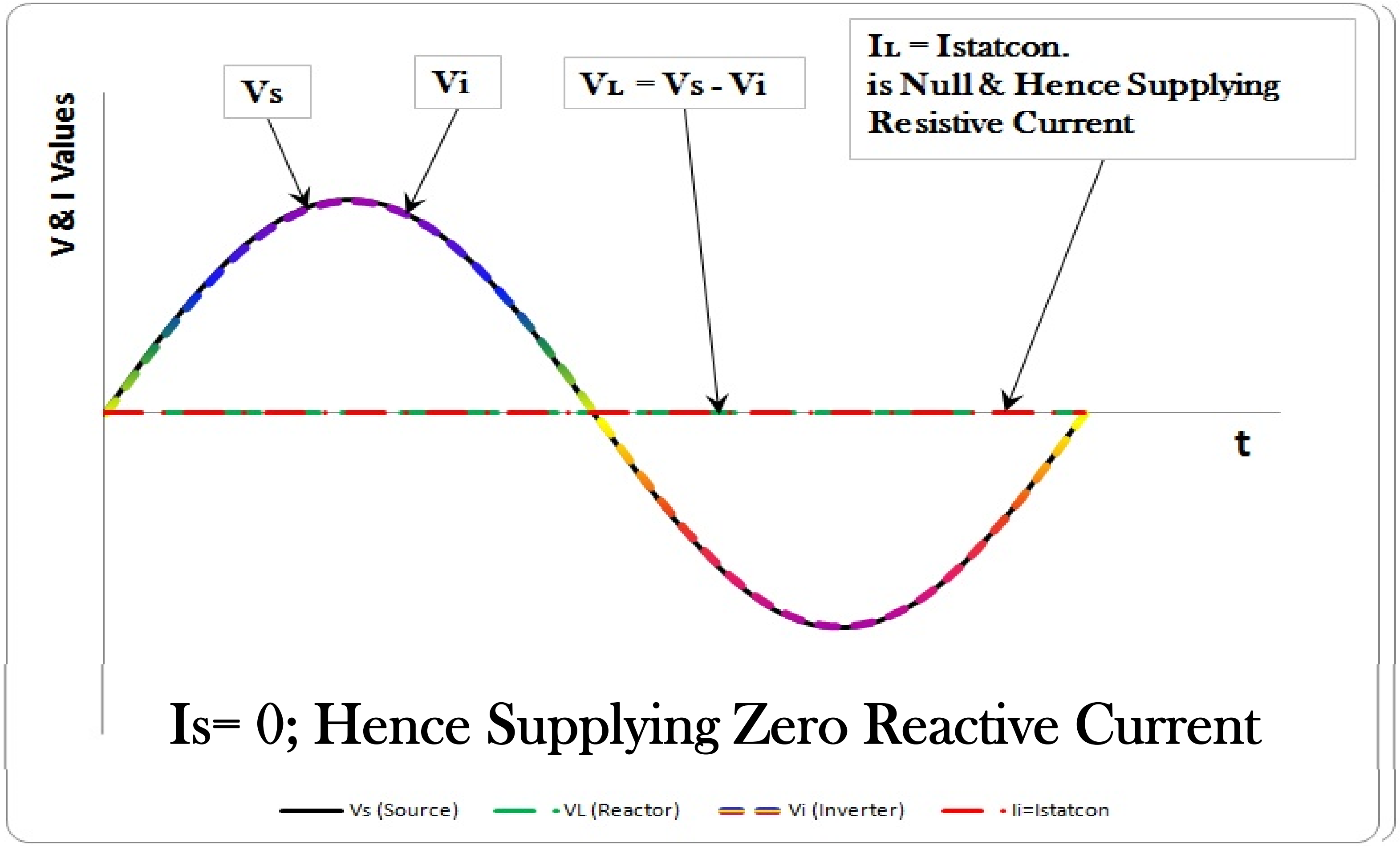
$I_L = (V_S - V_i)/jX_L = V_L/X_L\ (-90^\circ)$ I_L leads the V_S by 90° (Capacitive)

RPC BY STATCON:
CASE-2: When Vi < Vs

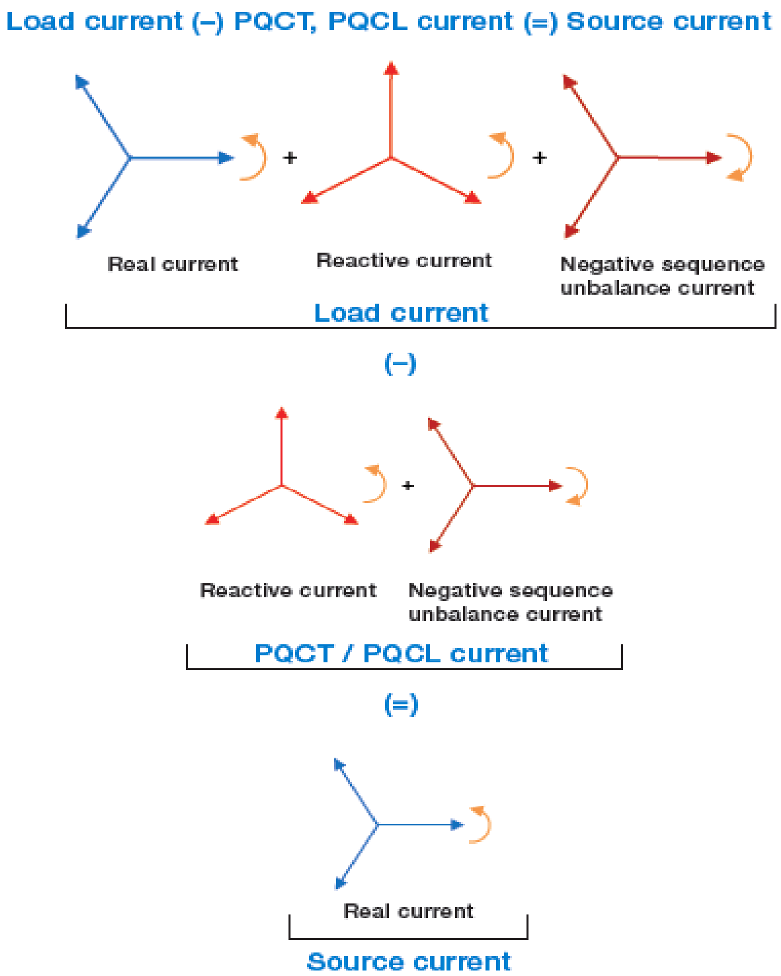


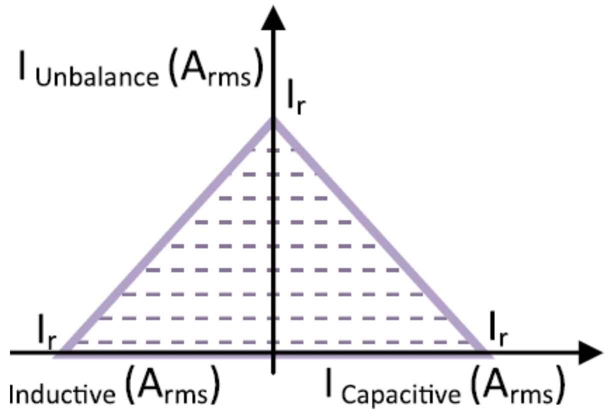
$I_L = (V_S - V_i)/jX_L = V_L/X_L\ (-90^\circ)$ I_L lags the Vs by 90° (Inductive)

RPC BY STATCON:
CASE-3: When Vi = Vs



Unbalance and reactive power compensation
Principle





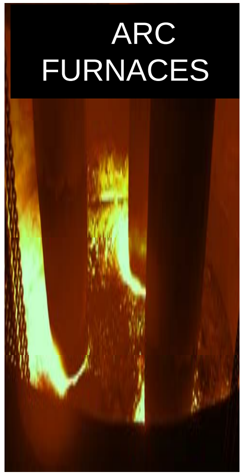
Operating boundaries of active compensator

PQC-STATCON
Applications

Instantaneous, stepless power electronics based dynamic compensator for reactive power (power factor) and unbalanced loads (<1 cycle response time)

- For inductive and capacitive loads
- For highly fluctuating loads e.g. welding loads, rolling mills etc.
- For industrial loads fed by weak networks , e.g. captive generators
- For three phase and single phase applications, e.g. railways
- Suitable for LV networks, and MV networks with step-up transformer

PQC–STATCON
Applications

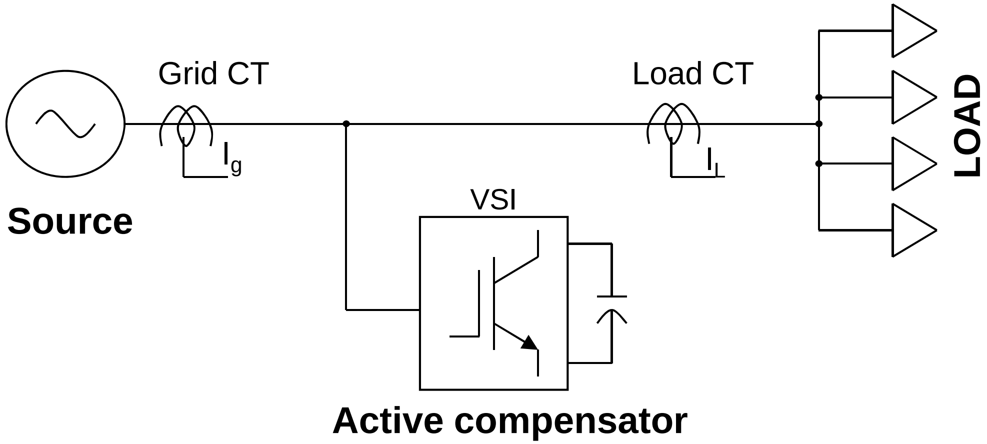


- Railway/ traction sub Stations
- Arc furnaces
- Automotive / welding plant
- Steel plants / rolling mills
- Airports / shipyards / ships
- Off-shore drilling
- Process industries
- Sky lifts / compressor loads
- Pulp & paper Industries
- Chemical plants
- Hydro plants
- Cement factories
- Water treatment plants
- Wind mills

PQC-STATCON
Key benefits

- Improves power quality
- Enhanced energy efficiency by reducing system losses
- Reduced Carbon footprint
- Improves the reliability of existing capacitor banks under dynamic condition
- Reduces maintenance need and enhances life of electrical Installations
- Easy installation & commissioning
- Easy and convenient operation with touch screen interface
- No risk of harmonic amplification

PQC-STATCON
Modes of operation



1. Dynamic compensation modes

   - Open loop (Load CT Mode)

   - Closed loop (Grid CT Mode), *Highest accuracy and the most recommended configuration*

2. Fixed Compensation Mode

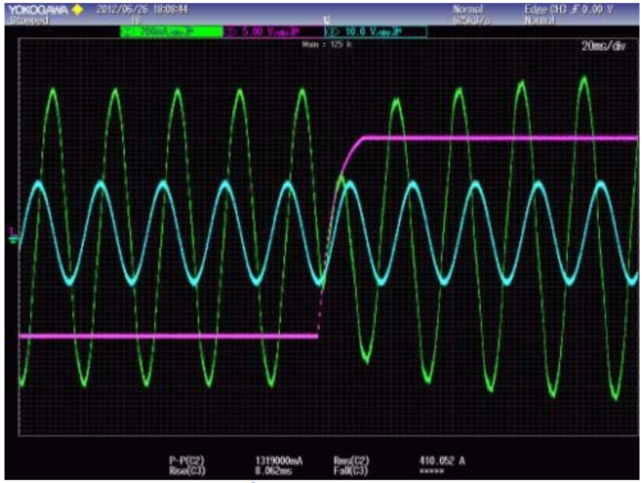
<u>Multiple STATCONs in parallel can share the same CT feedback</u>

PQC-STATCON technology and features
Instantaneous and precise control

Green
PQC-STATCON
Current

Blue
Supply Voltage

Magenta
Step Response



Response time: 8.062ms (Rise)

Response time: 8.002ms (Fall)

- Instantaneous reaction to step changes
- Fast dynamic response (< 1 cycle)
- Excellent steady state / transient stability
- Native closed loop operation, open loop operation is also possible
- Four cascaded control loops

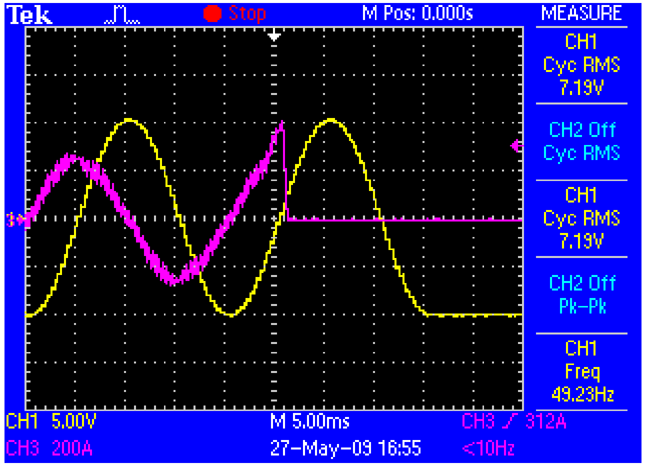
PQC-STATCON technology and features
Energy efficient operation

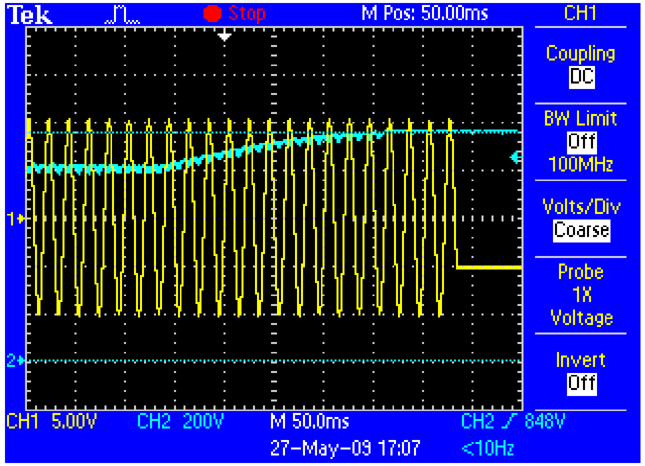
Energy save mode

- Programmable option
- IGBT converter is switched off after 30 s, during idle condition
- Cooling system is turned off, after 2 minutes
- POC-STATCON enters deep sleep mode
- Delivers rated kvar within 8 cycles(from sleep mode) of load demand

PQC-STATCON technology and features
Reliability is an important factor!

Rugged protections - PQC-STATCON



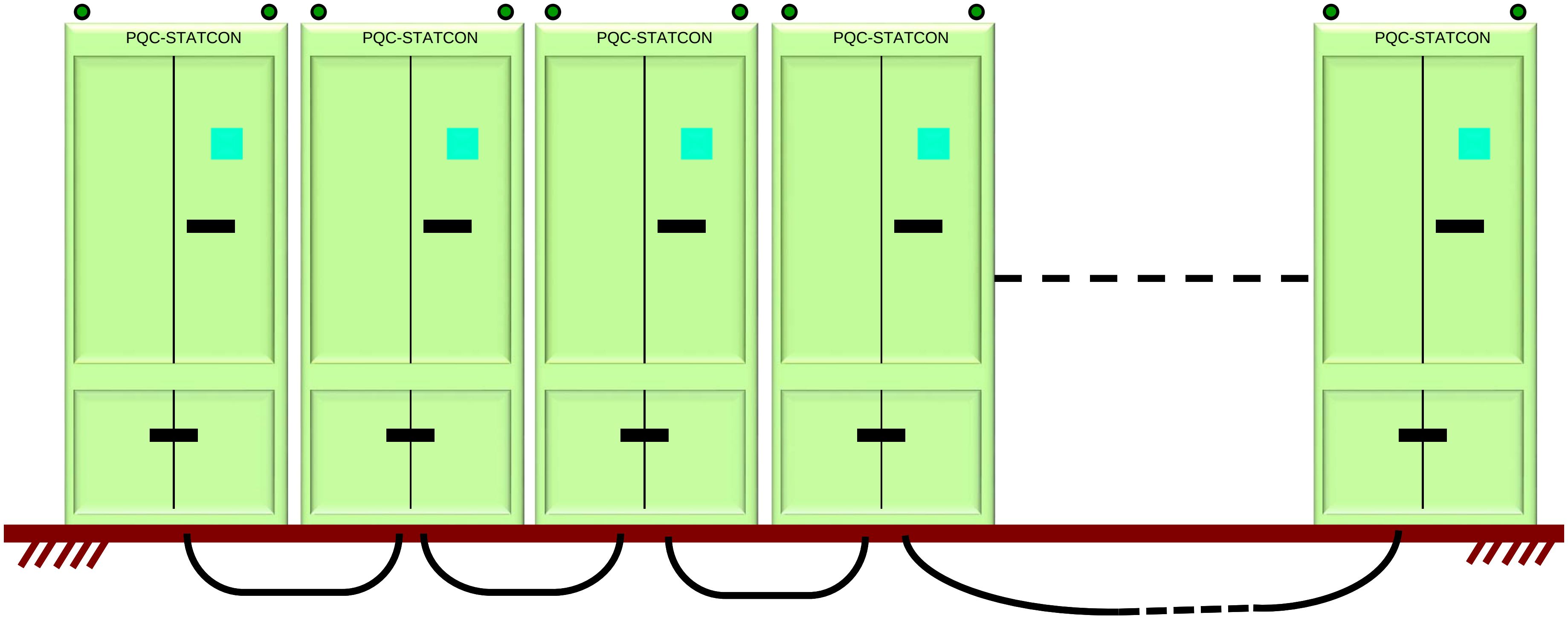


Protection

- Over current protection
- DC over voltage protection
- IGBT short circuit protection
- Over temperature protection
- Cooling system failure detection

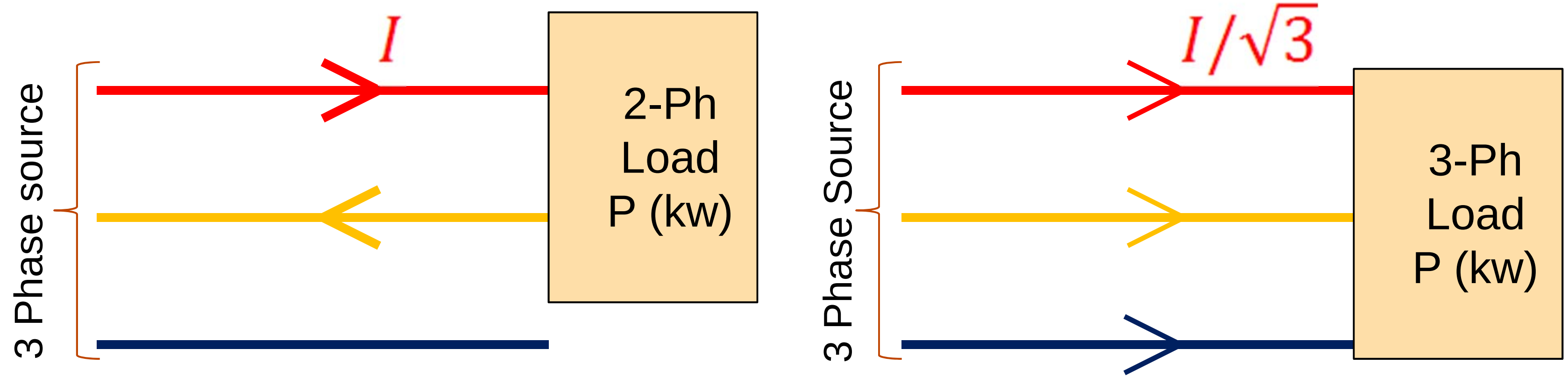
- IGBT stack failure detection
- Supply overvoltage/under voltage protection
- Switchgear acknowledgement feedback errors
- Unstable grid detection
- Door open detection

Unique advantages of PQC-STATCON
Parallel operation



In parallel system of PQC-STATCON, the system reliability will be increased by ‘X’ times, unlike other ONE MASTER-SLAVE systems where, in the event of master failure the total system gets to shutdown. In PQC-STATCON all individual PQC-STATCONs are capable of being a master and will take over as and when required.

Unbalance & reactive power compensation
Eliminating unbalance - energy efficiency perspective



(Assuming line Resistance is R)

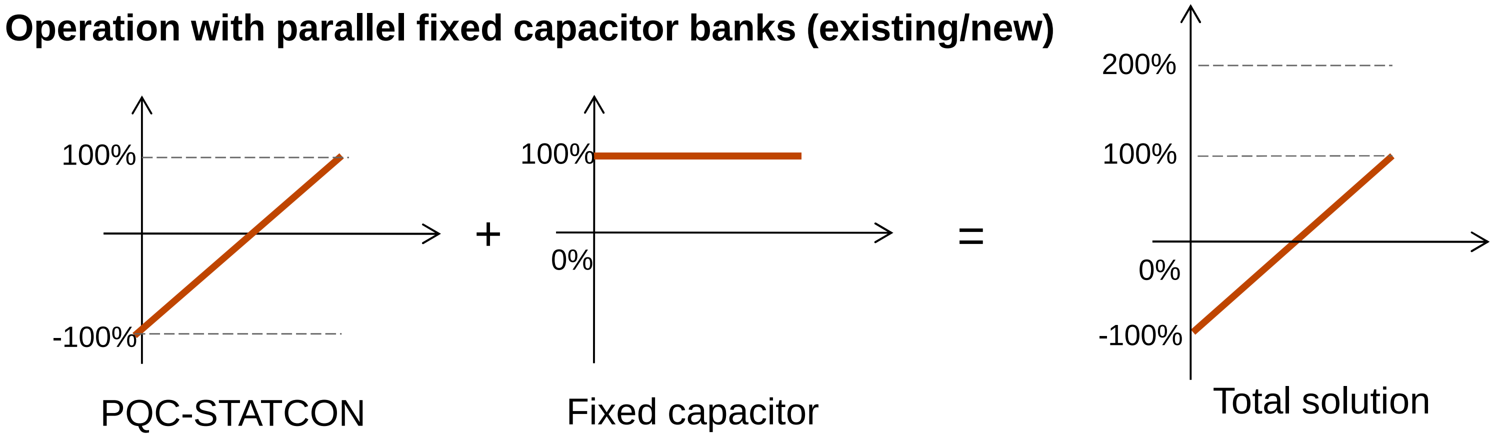
System losses comparison with balance / unbalance loads

$$Line\ Losses = 2\ x\ I^2\ x\ R \qquad Line\ Losses = 3\ x \left(\frac{I}{\sqrt{3}}\right)^2\ x\ R$$

$$= I^2\ x\ R$$

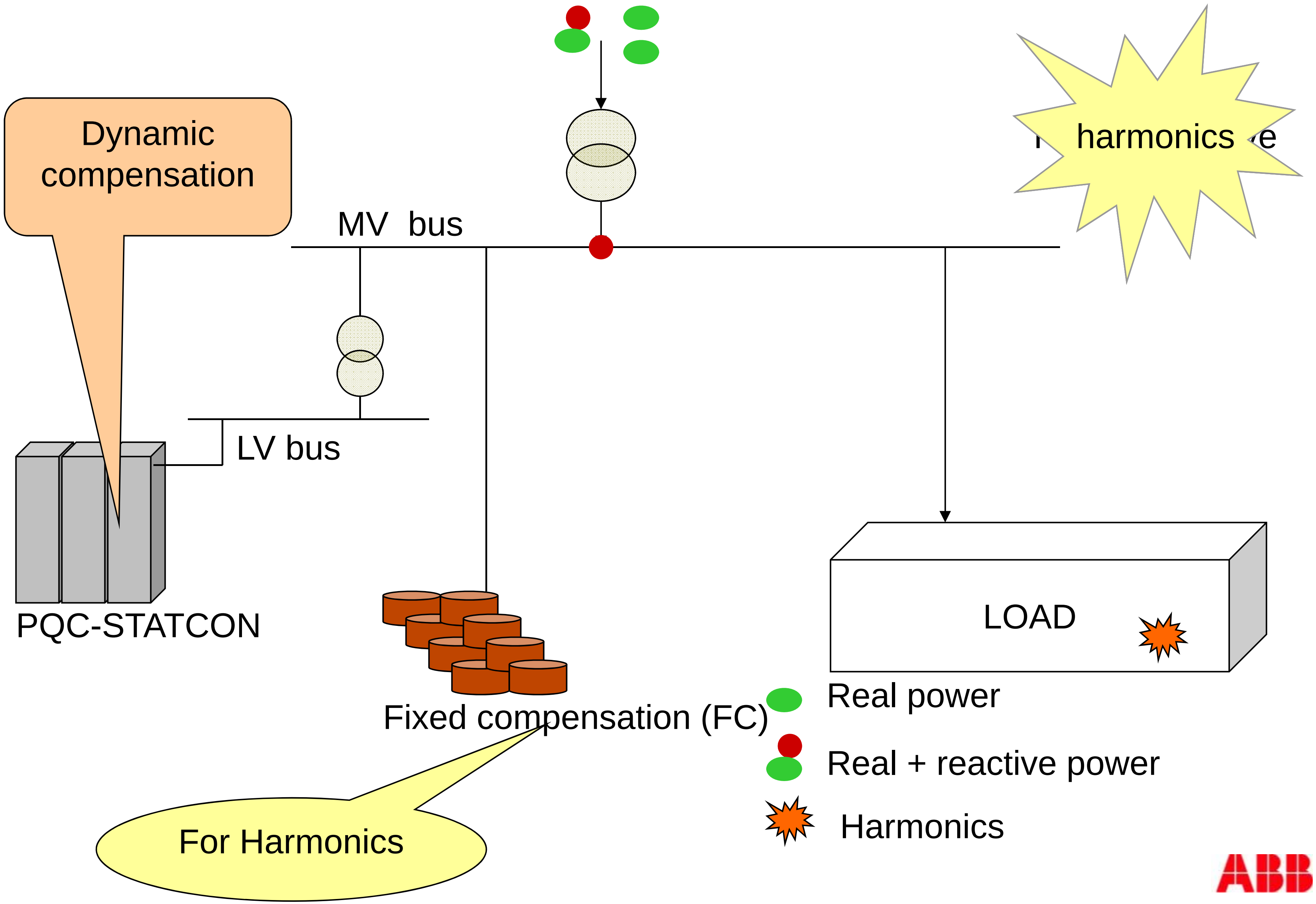
50 % Lower line losses

Operation with parallel fixed capacitor banks
Cost effective - more kvar / $



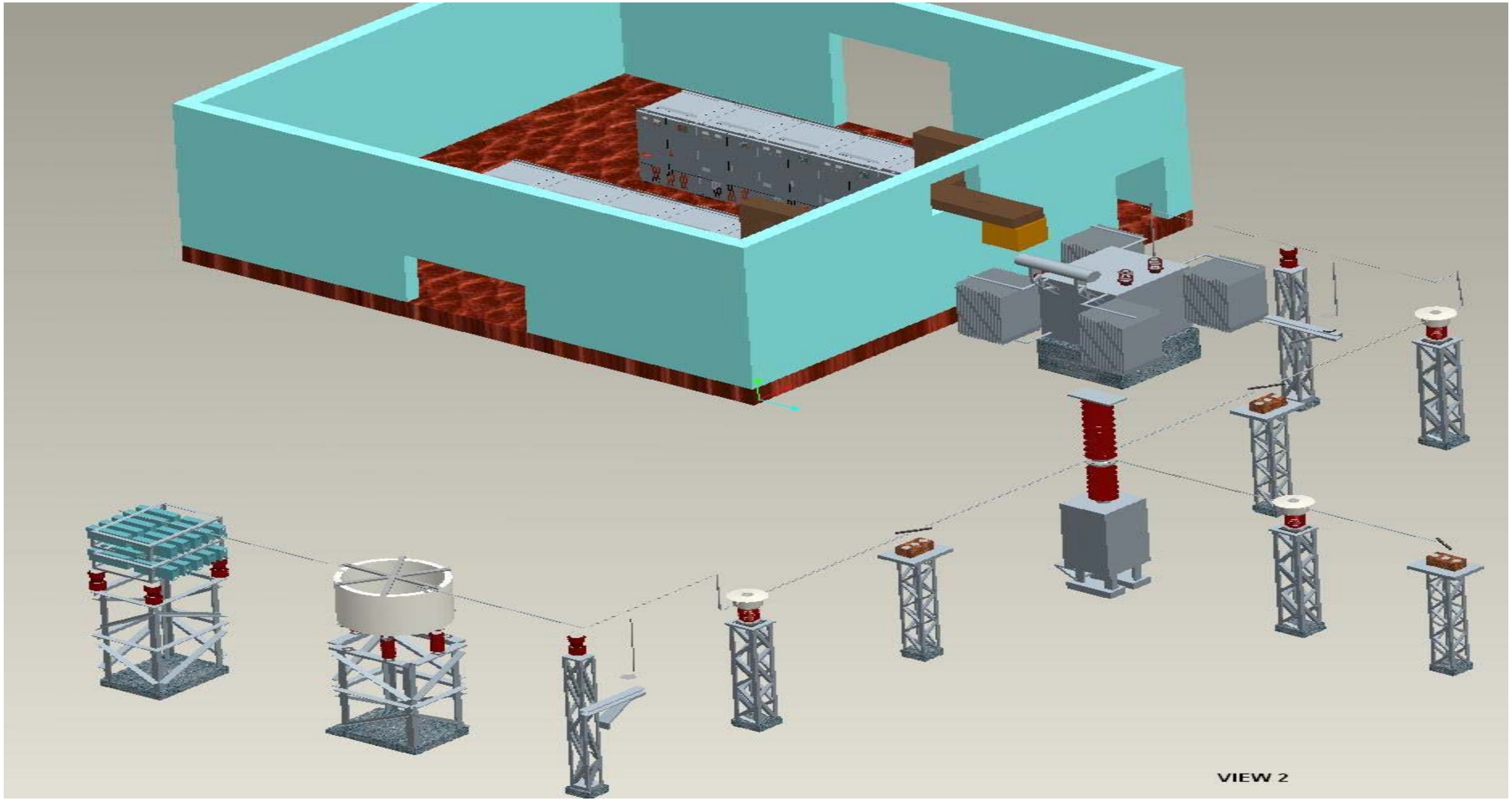
- **PQC-STATCON doubling the dynamic compensation range with parallel capacitor banks.**

Power quality solutions with PQC-STATCON + FC



ABB

Typical STATCON SOLUTION
Typical HV/MV Applications



PQC-STATCON
Product portfolio

PQCS - Single Phase Compensator

- Reactive power compensation – PF improvement
- Main/Auxiliary PF setting (supports Utility/Generator sources)

PQCT & PQCT-Light(PQCL) –

Three Phase Compensator

- Reactive power compensation – PF improvement
- Main/Auxiliary PF setting (supports Utility/Generator sources)
- Unbalance compensation – Reduction of negative sequence components
- Priority configuration – Reactive power/Unbalance compensation

PQC-STATCON
Product portfolio

PQCS

S. No	Type No.	Application	Voltage	kVAr	Amp (Ir)
1	PQCS-50-V240	1-Ph	240	50	210
2	PQCS-100-V240	1-Ph	240	100	420
3	PQCS-100-V415	1-Ph	415	100	240
4	PQCS-150-V415	1-Ph	415	150	360
5	PQCS-250-V415	1-Ph	415	250	600

PQCT

S. No	Type No.	Application	Voltage	kVAr	Amp (Ir)
1	PQCT-100-V415	3-Ph	415	100	140
2	PQCT-150-V415	3-Ph	415	150	210
3	PQCT-250-V415	3-Ph	415	250	350
4	PQCT-300-V415	3-Ph	415	300	420

PQCT-Light (PQCL)

S. No	Type No.	Application	Voltage	kVAr	Amp (Ir)
1	PQCL-70-V415	3-Ph	415	70	100

For MV applications:
PQC-STATCON supports operation through step-down transformer

PQC-STATCON
Sizing for reactive power and imbalance

To quickly calculate the size of a PQC-STATCON based reactive power compensation system,

Calculate the required capacity for dynamic compensation through PQC STATCON, which is half of the total dynamic compensation requirement

$Q_{PQC\text{-}STATCON}^{*} = Q_{dyn}/2 = (Q_{max} - Q_{min})/2$

Calculate the required capacity for fixed capacitor based compensation, which is the sum of base compensation requirement and half of the total dynamic compensation requirement.

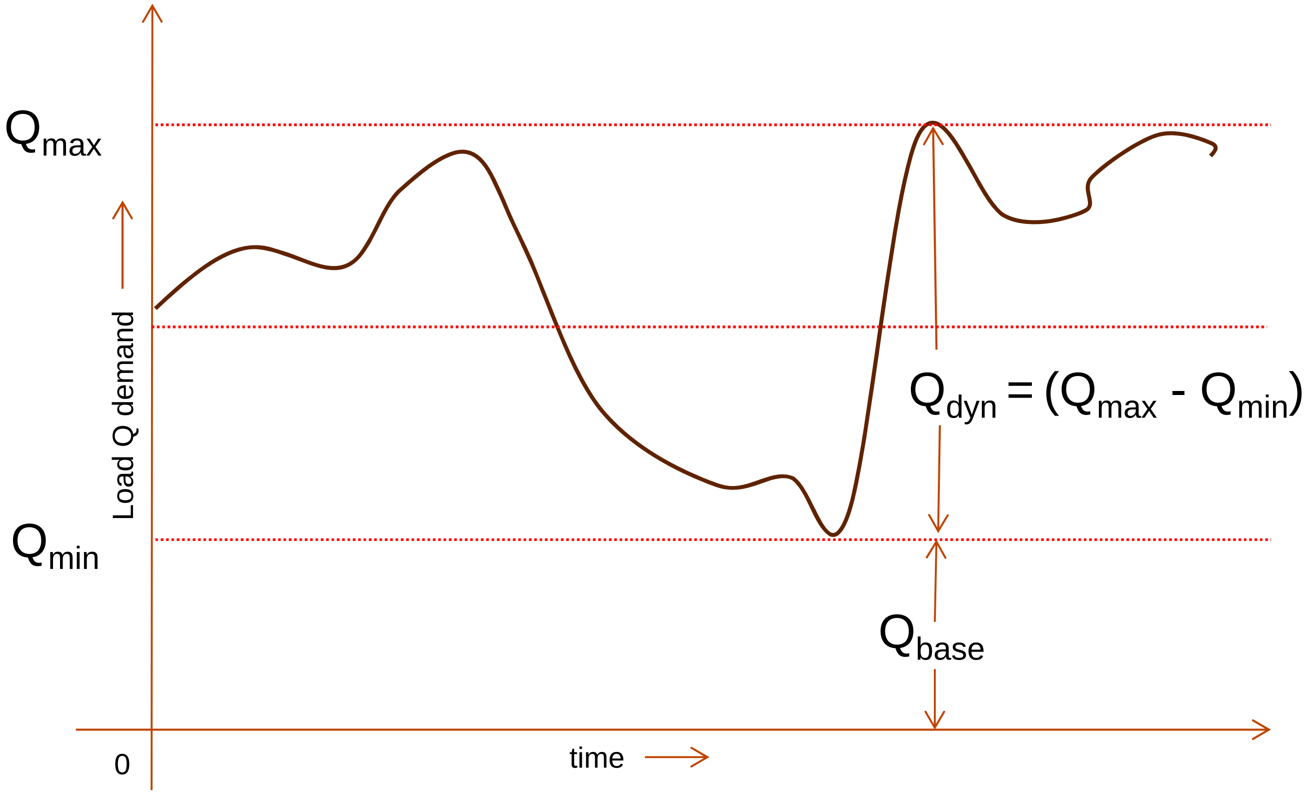
$Q_{capacitor} = Q_{base} + Q_{dyn}/2 = Q_{base} + (Q_{max} - Q_{min})/2$

Note:

- To perform load balancing, add the negative sequence demand of load

PQC-STATCON

Sizing for reactive power and imbalance



$$Q_{capacitor} = Q_{base} + (Q_{dyn}/2)$$

$$Q_{PQC\text{-}STATCON}{}^{*} = Q_{dyn}/2$$

Note:

* To perform load balancing, add the negative sequence demand of load.

ABB

Conclusions

- Talk to us for expert advice on solving your power quality problems

ABB

- Has complete range of power quality solutions
- Has vast amount of experience in instantaneous stepless compensation for reactive power and unbalanced loads (Example: Automobile, rolling mills, railways and furnaces etc.,)

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