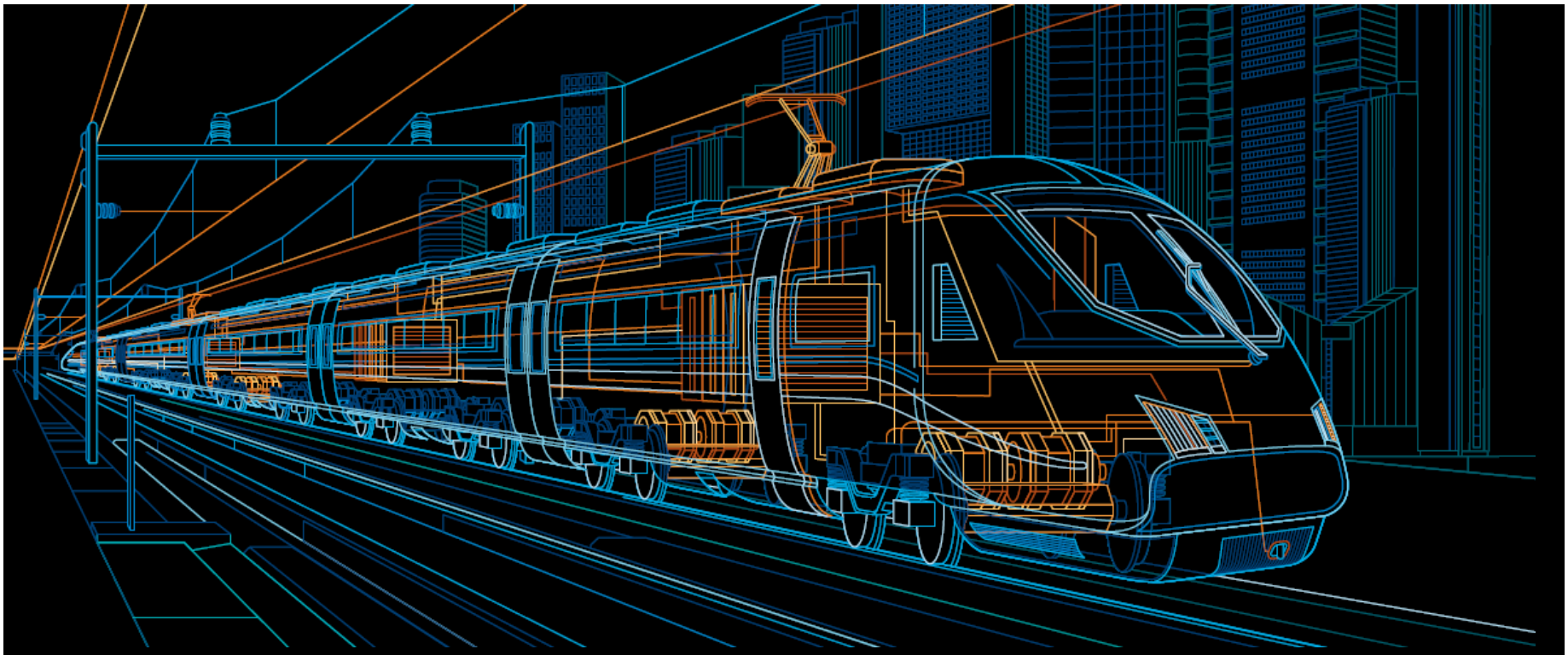


PGHVC, Railways presentation

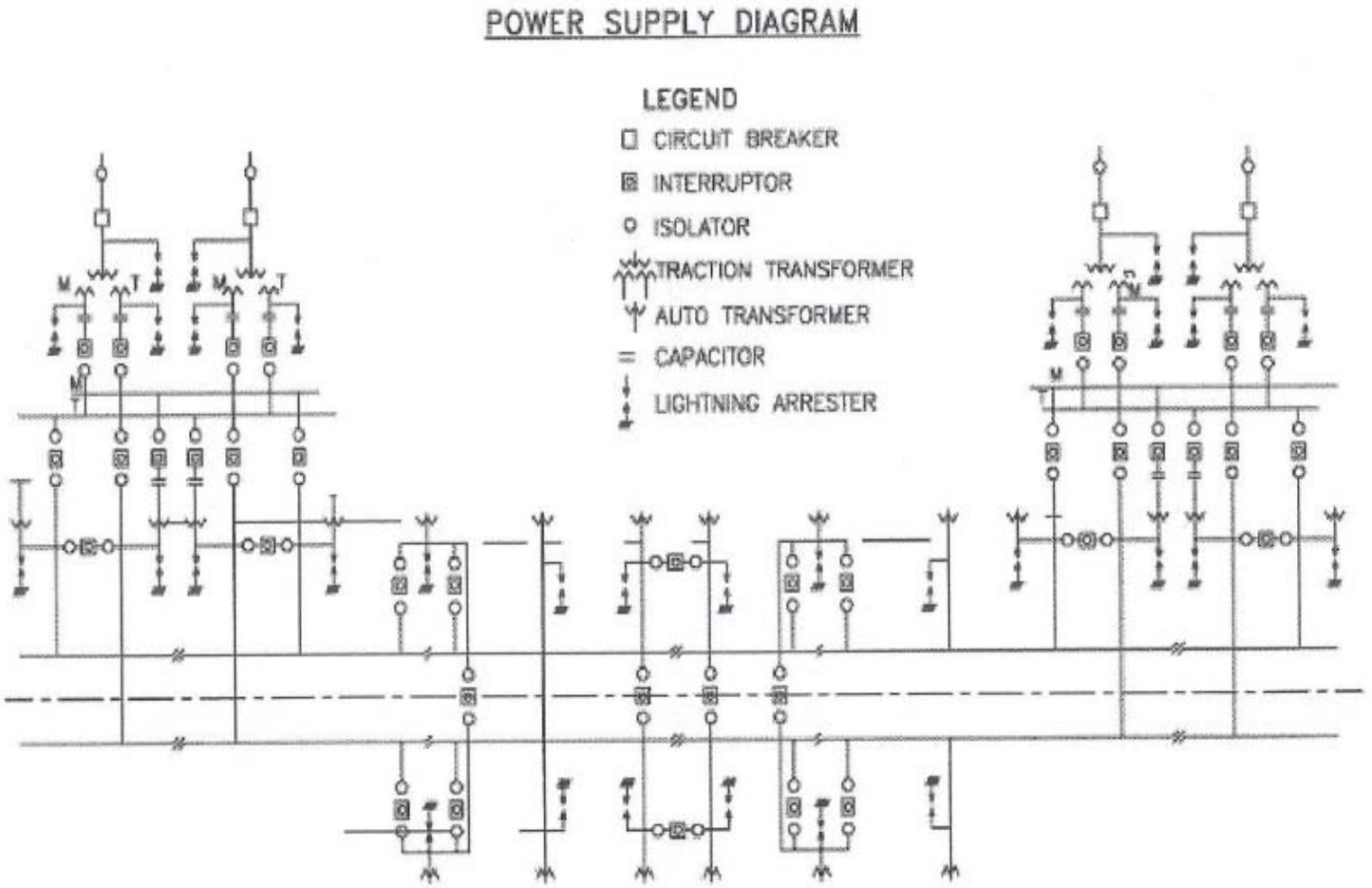
PQC STATCON

Instantaneous & Stepless Power Quality Compensation for Dynamic Reactive Power & Unbalanced loads

Railways
Traction Power Supply

- Railway load is a AC 50Hz 1-phase through 2 x 25 KV Auto Transformer (between CATENARY & FEEDER)
- Maximum harmonics recorded is 3rd Harmonic
- Railway supply voltage is 25KV AC
- Supply Voltage variation +/- 20%.
- Loads are frequent & rapidly varying in nature i.e varies from no load and overload.
-

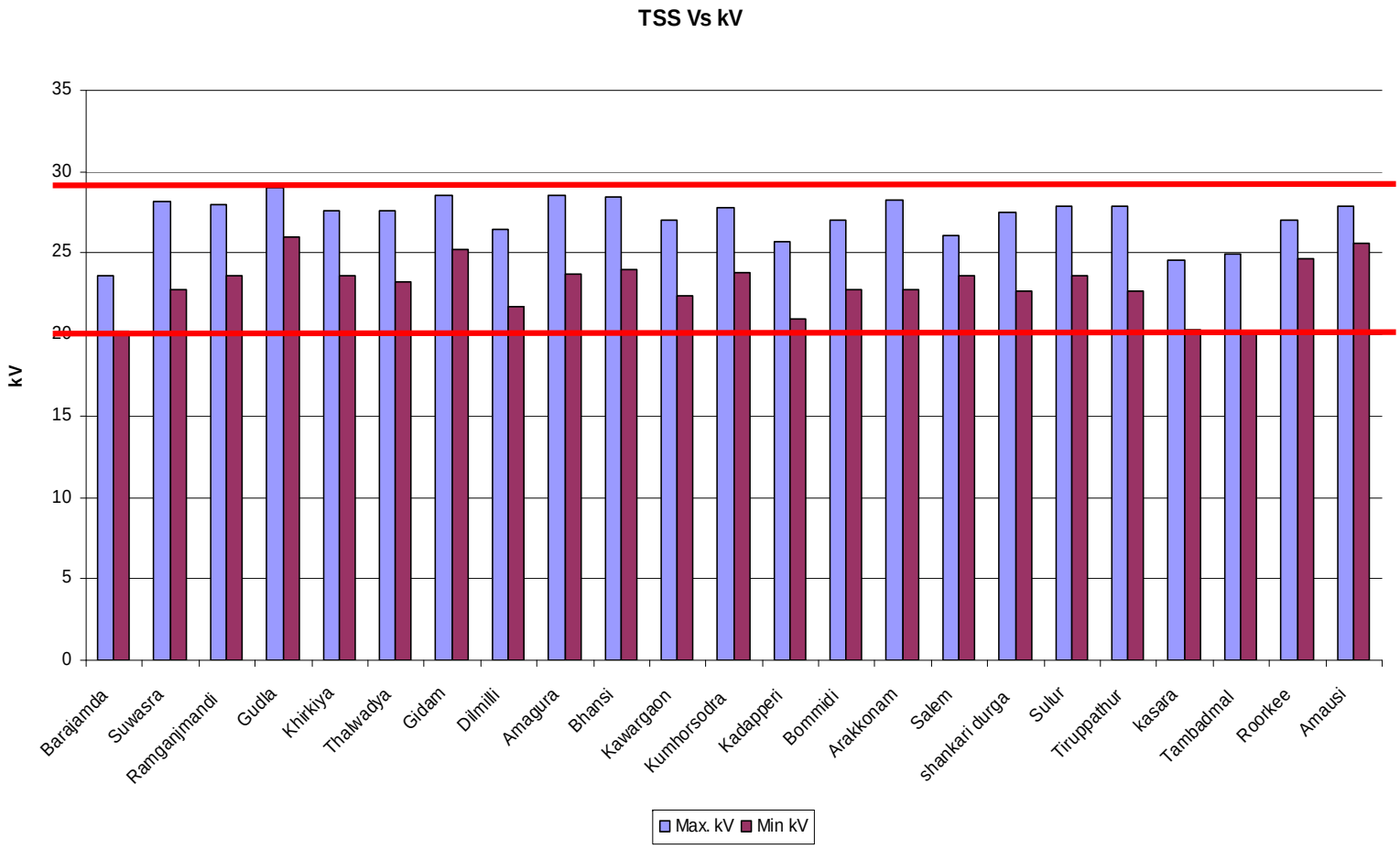
Railways
Typical TSS SLD



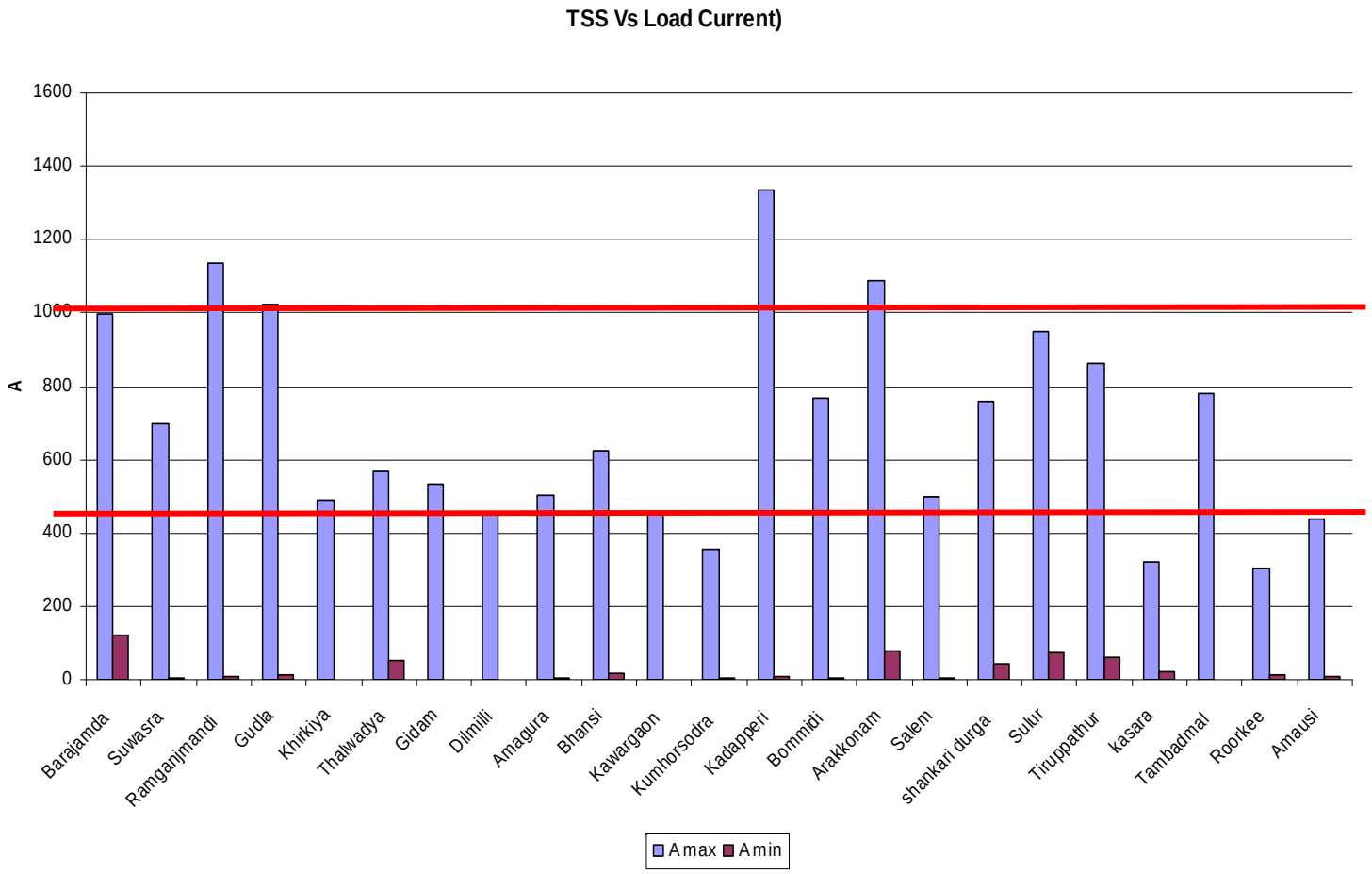
Railways
Technical requirement

- Power Factor Correction.
- Power Quality Improvement.
- Harmonic Reduction (below IEEE 519 limit).
- Improving of voltage profile
- Improving System performance or Enhancing system capability.

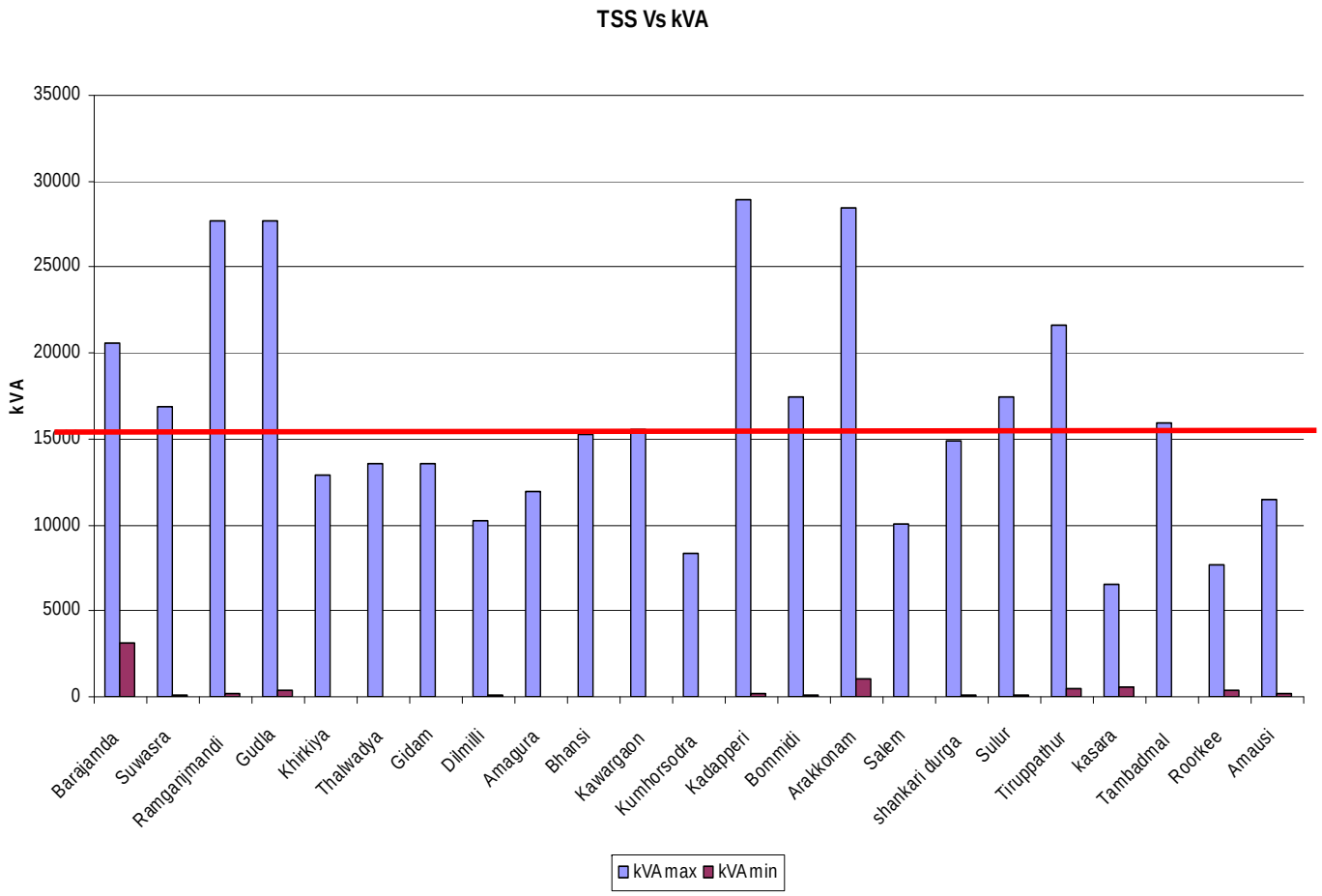
Railways TSS
Supply Voltage variations > 20%



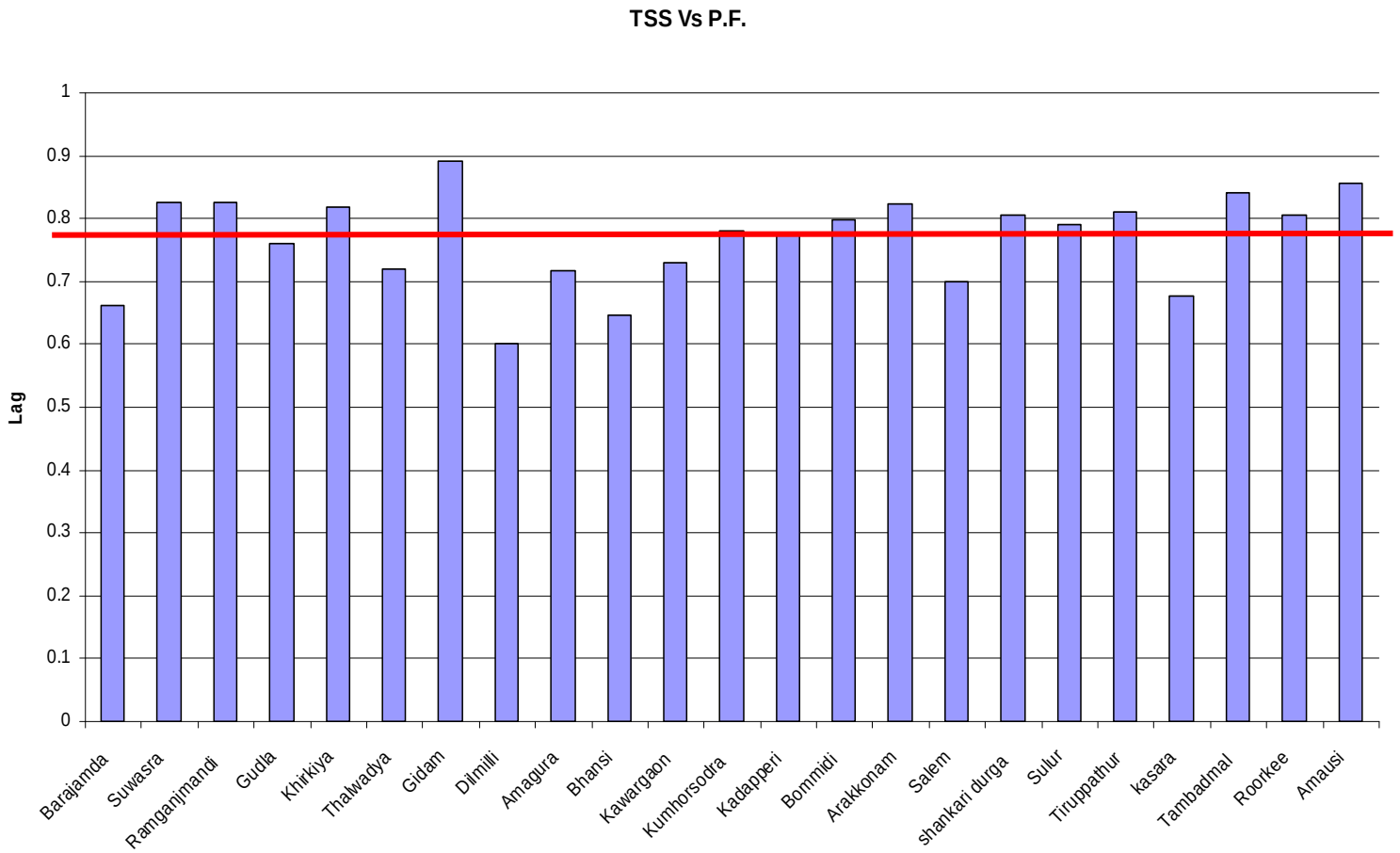
Railways TSS
Current Variations



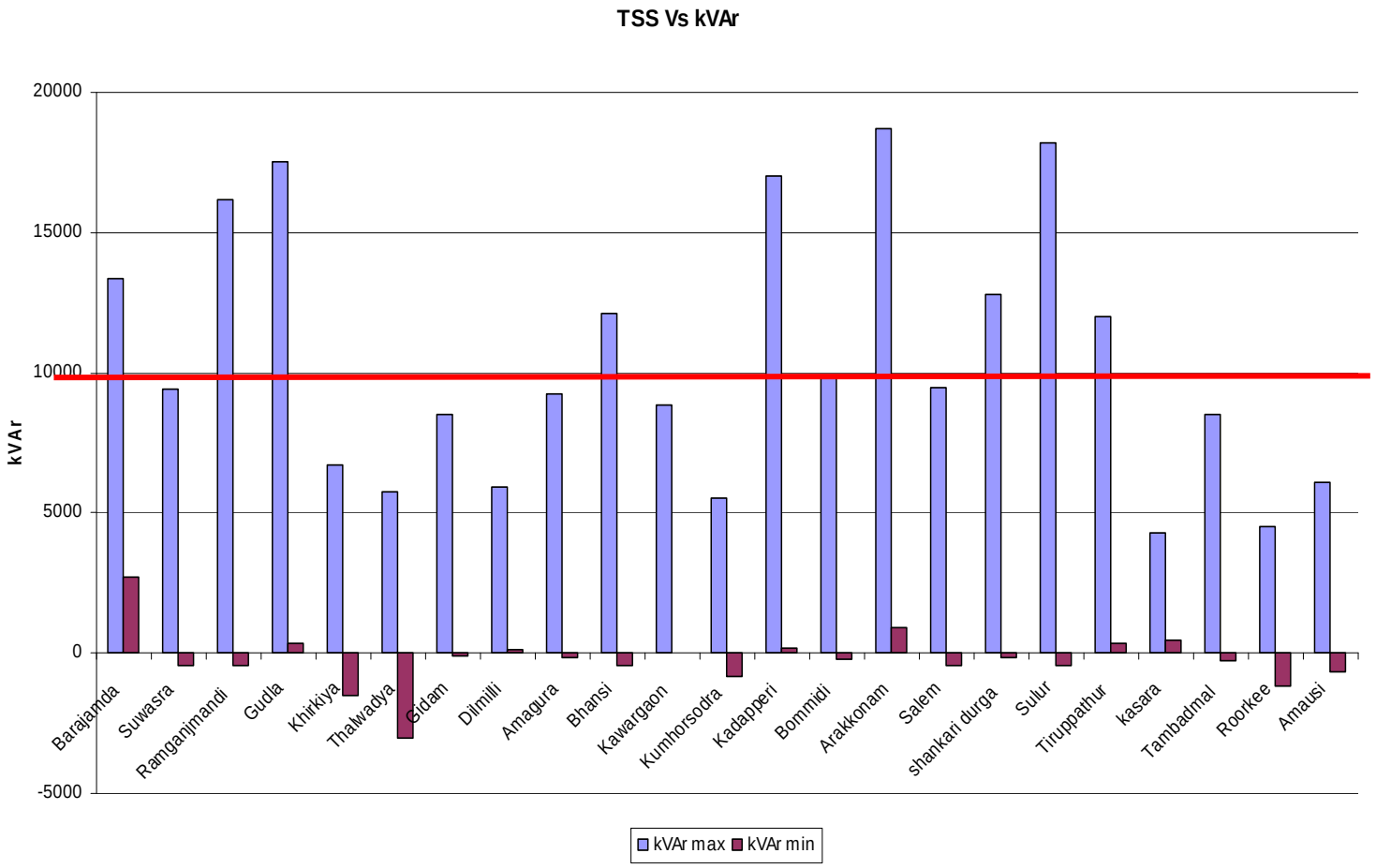
Railways TSS
Apparent Power Demand > 15 MVA



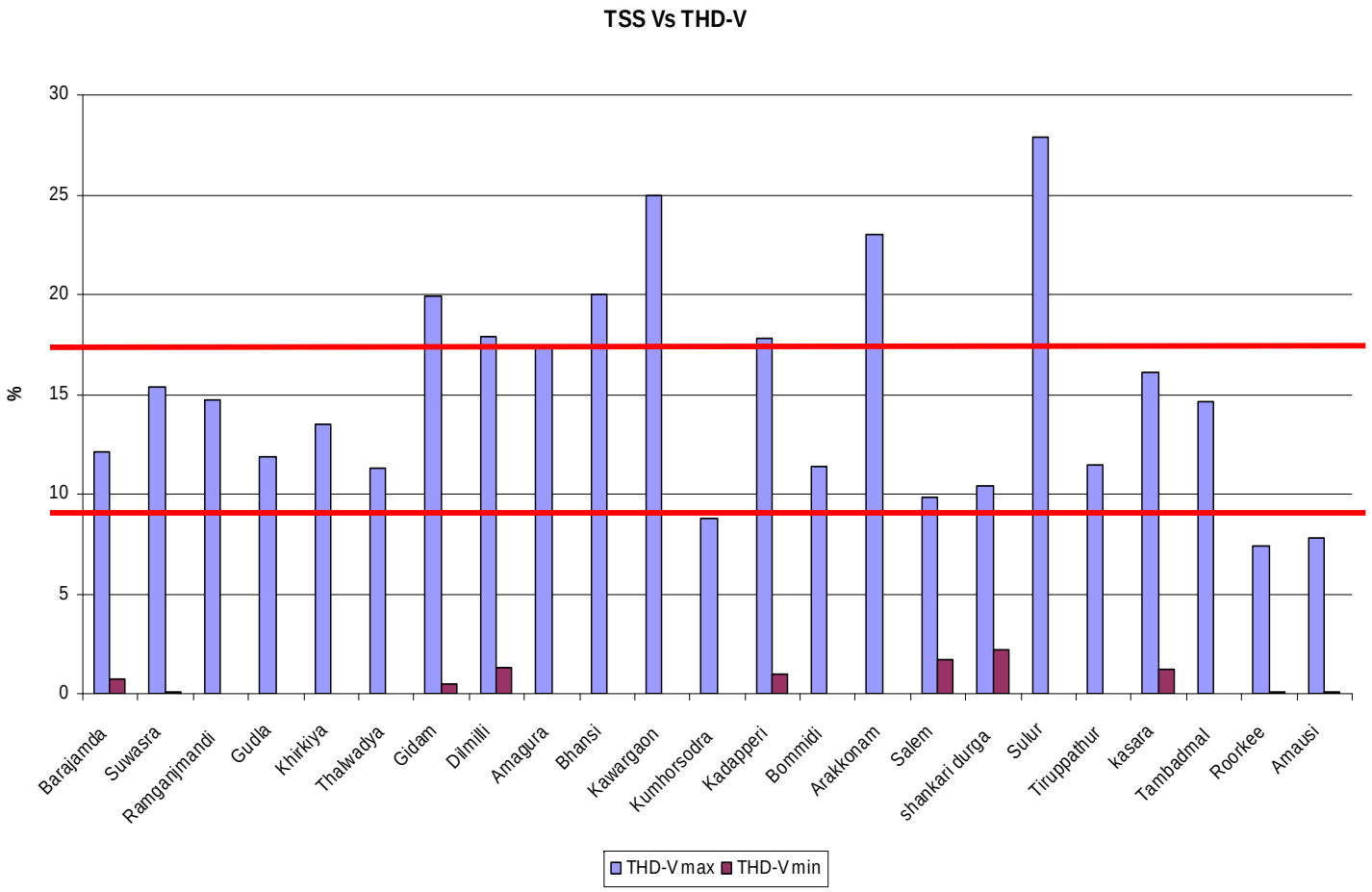
Railways TSS
Average Load PF < 0.8



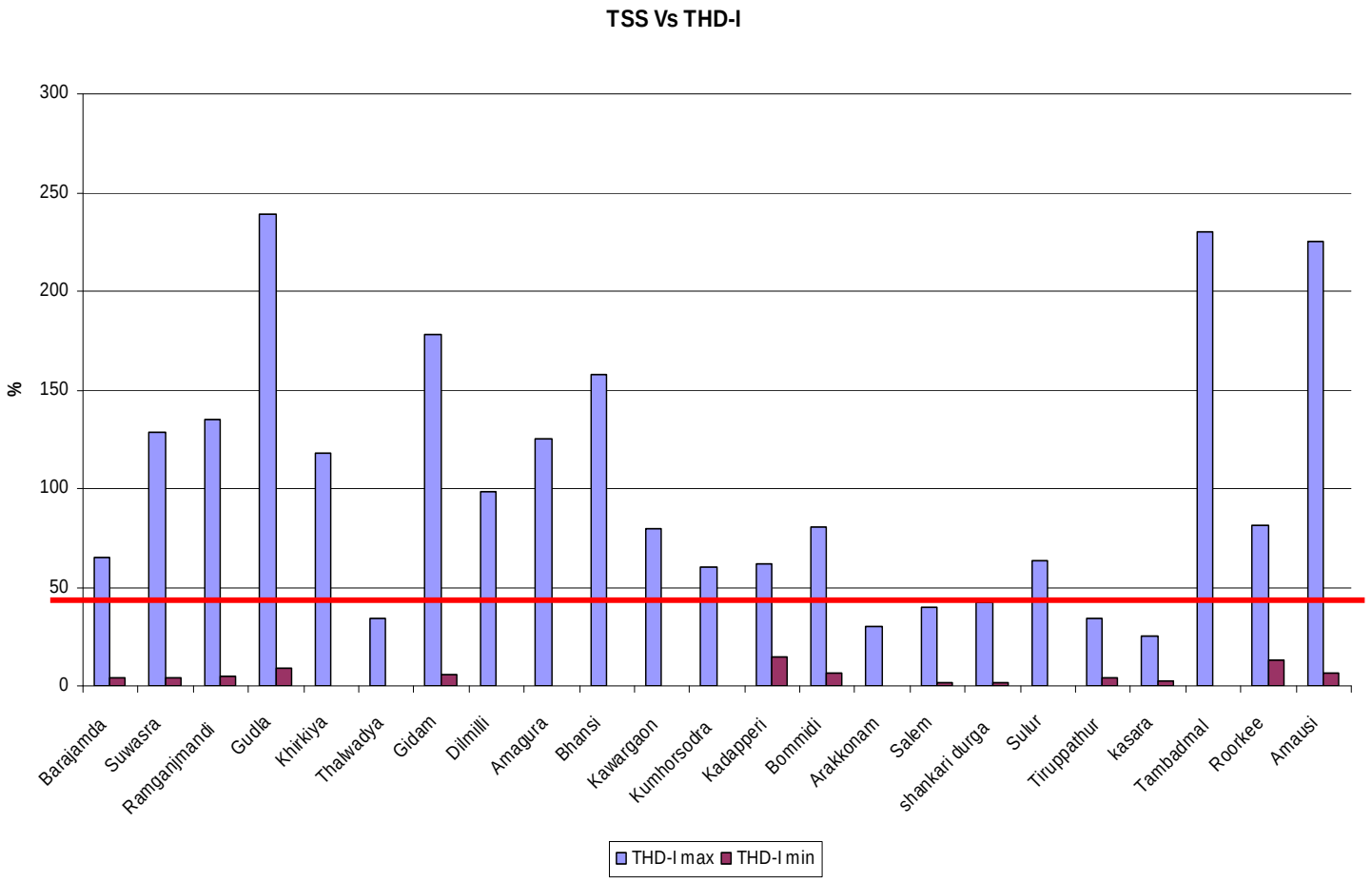
Railways TSS
Reactive Power Demand > 10 MVAR



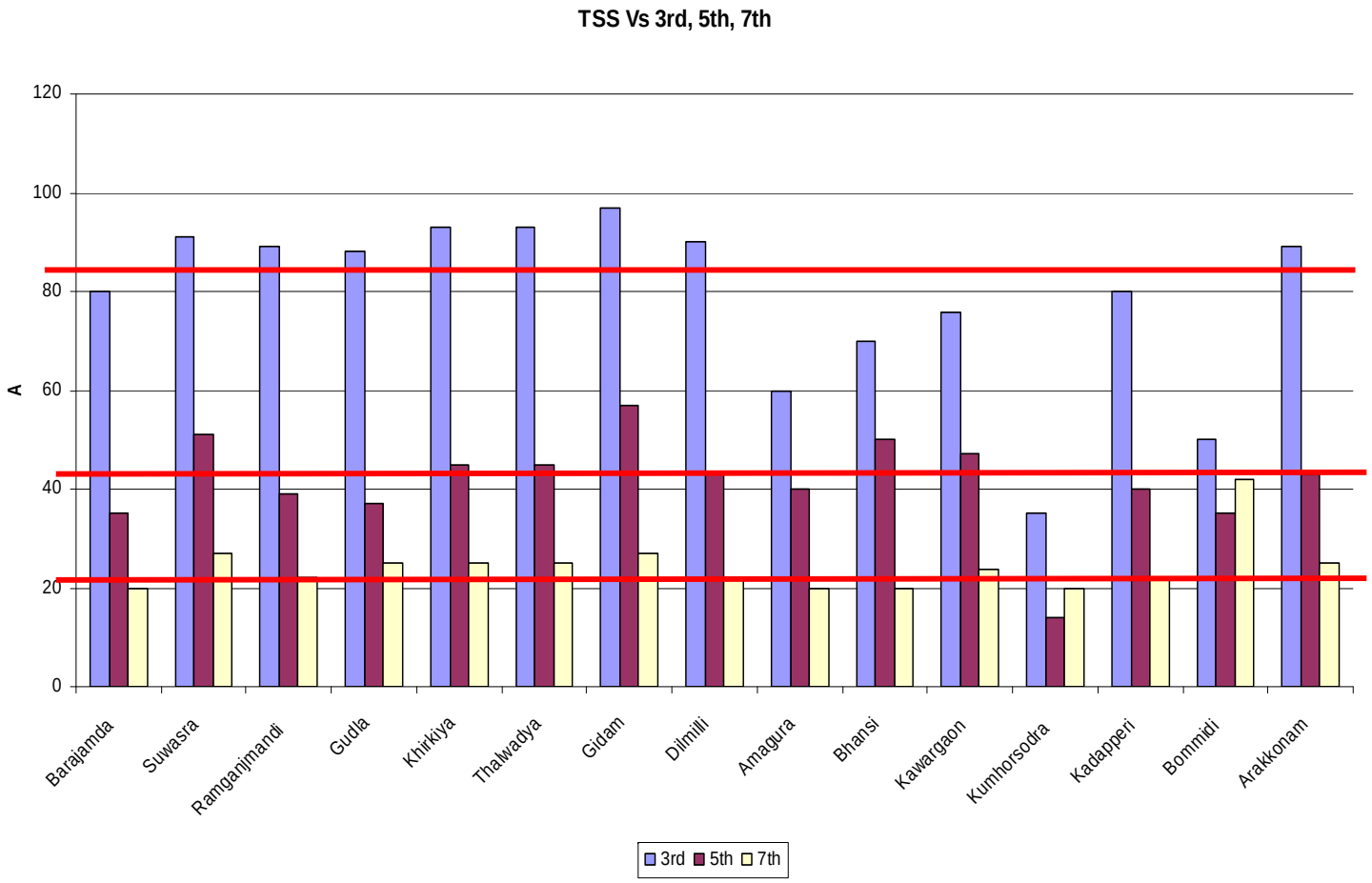
Railways TSS
Voltage THD



Railways TSS
Current THD



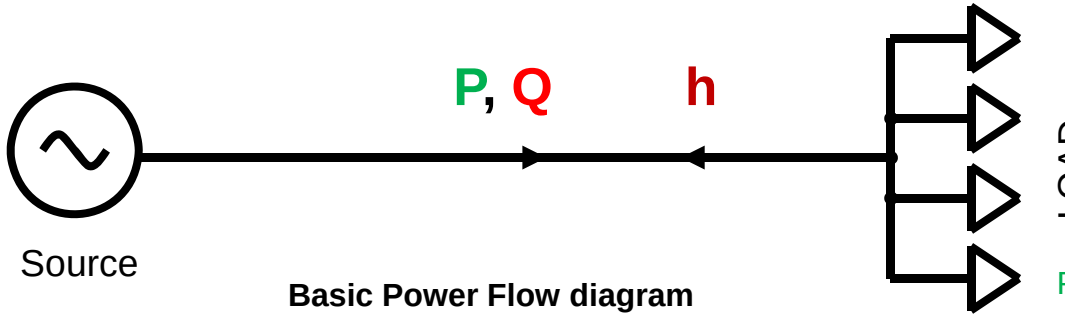
Railways TSS
Individual Current THD



Railways TSS
Power Quality Issues

- Recorded huge amount of 3rd & 5th Harmonics currents and excessive THDV and THDI !!!
- Recorded very high and fast reactive Power demand.
- Various problem associated in TSSs caused due to above two basic requirements,
  - Frequent nuisance feeder tripping
  - Transformer heating / Insulation failure
  - Caused O/V and U/V tripping
  - O/C caused due to excessive fast reactive power demand
  - Harmonic amplification / resonance

Reactive power in a power system network



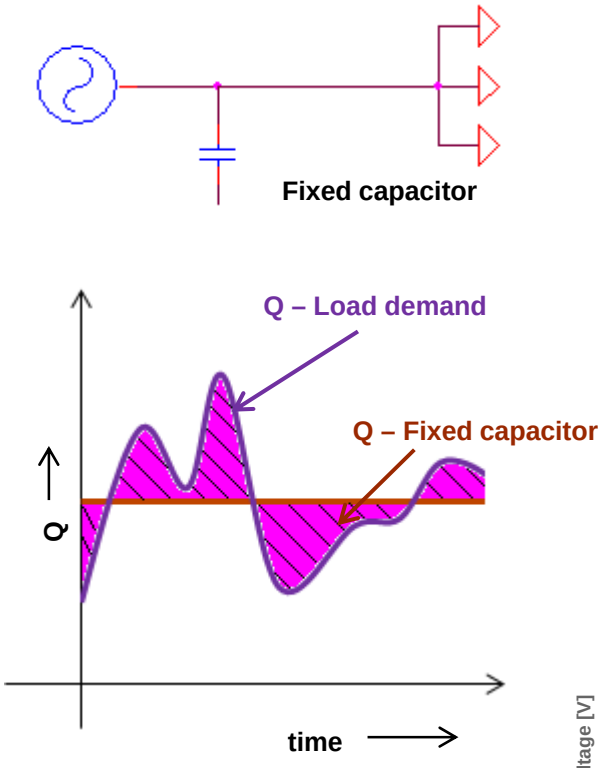
Basic Power Flow diagram

P – Real power
Q – Reactive power
h – Harmonics

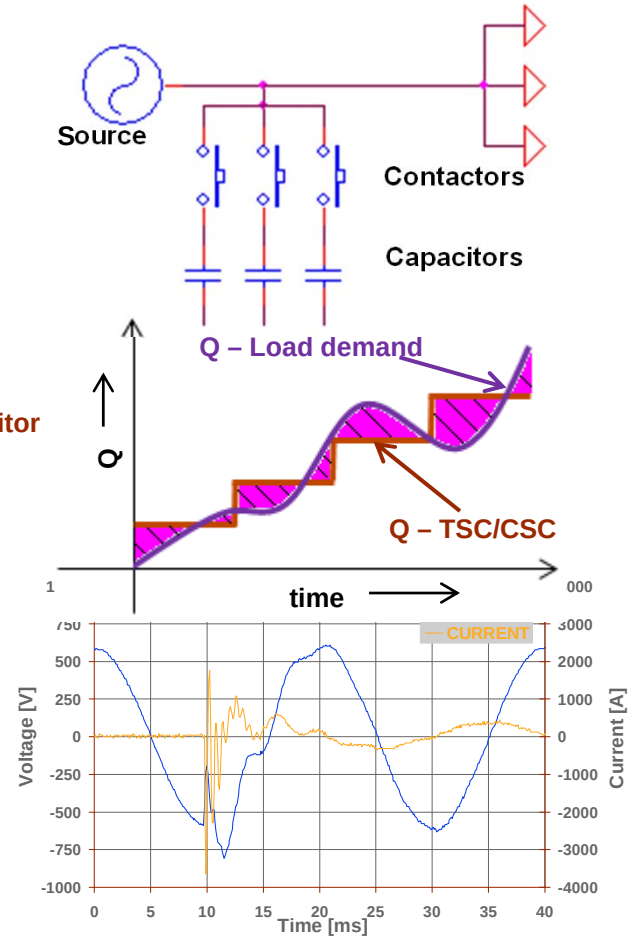
- Active/Real power
  - Responsible for transfer of energy
- Reactive power
  - Enabler for conversion of real power
  - Not a form of energy
  - Flows back and forth, causes loss in the transmission/distribution system
  - Local supply of reactive power improves the system efficiency
- Apparent power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

Reactive power in a network
Limitation with conventional schemes

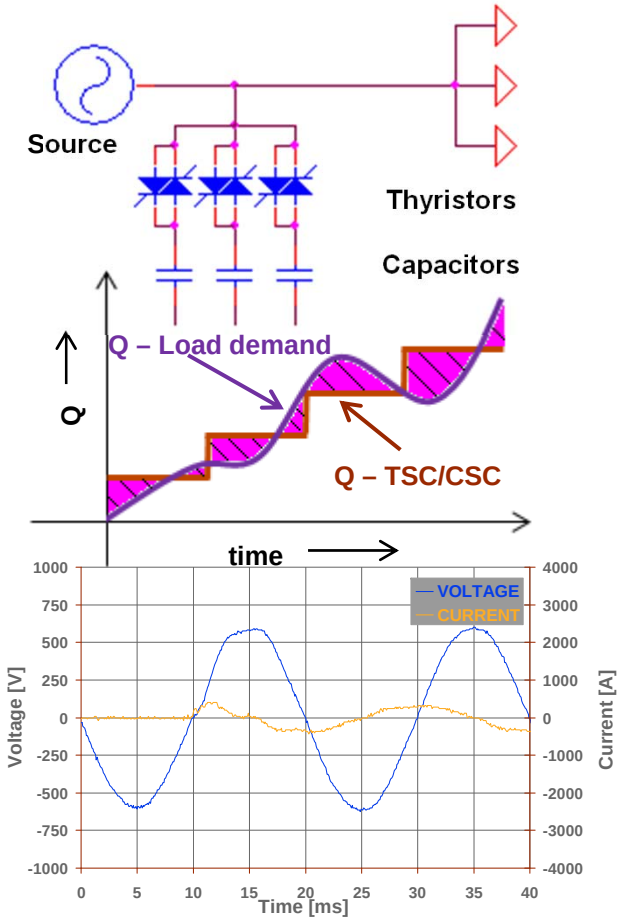
Fixed capacitor (FC)



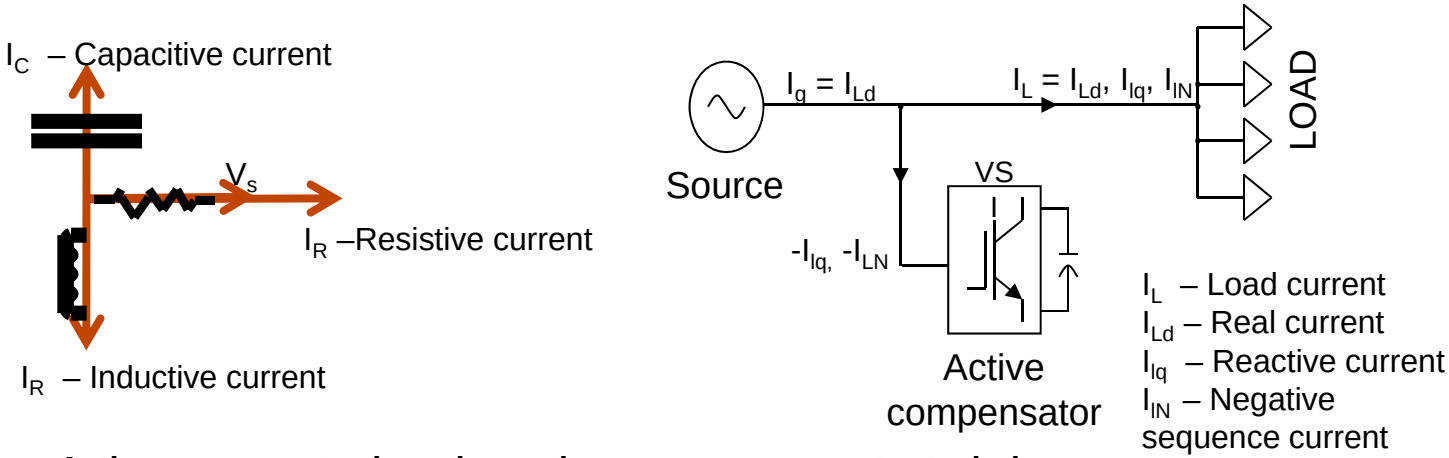
Contactor switched capacitor (CSC)



Thyristor switched capacitor (TSC)



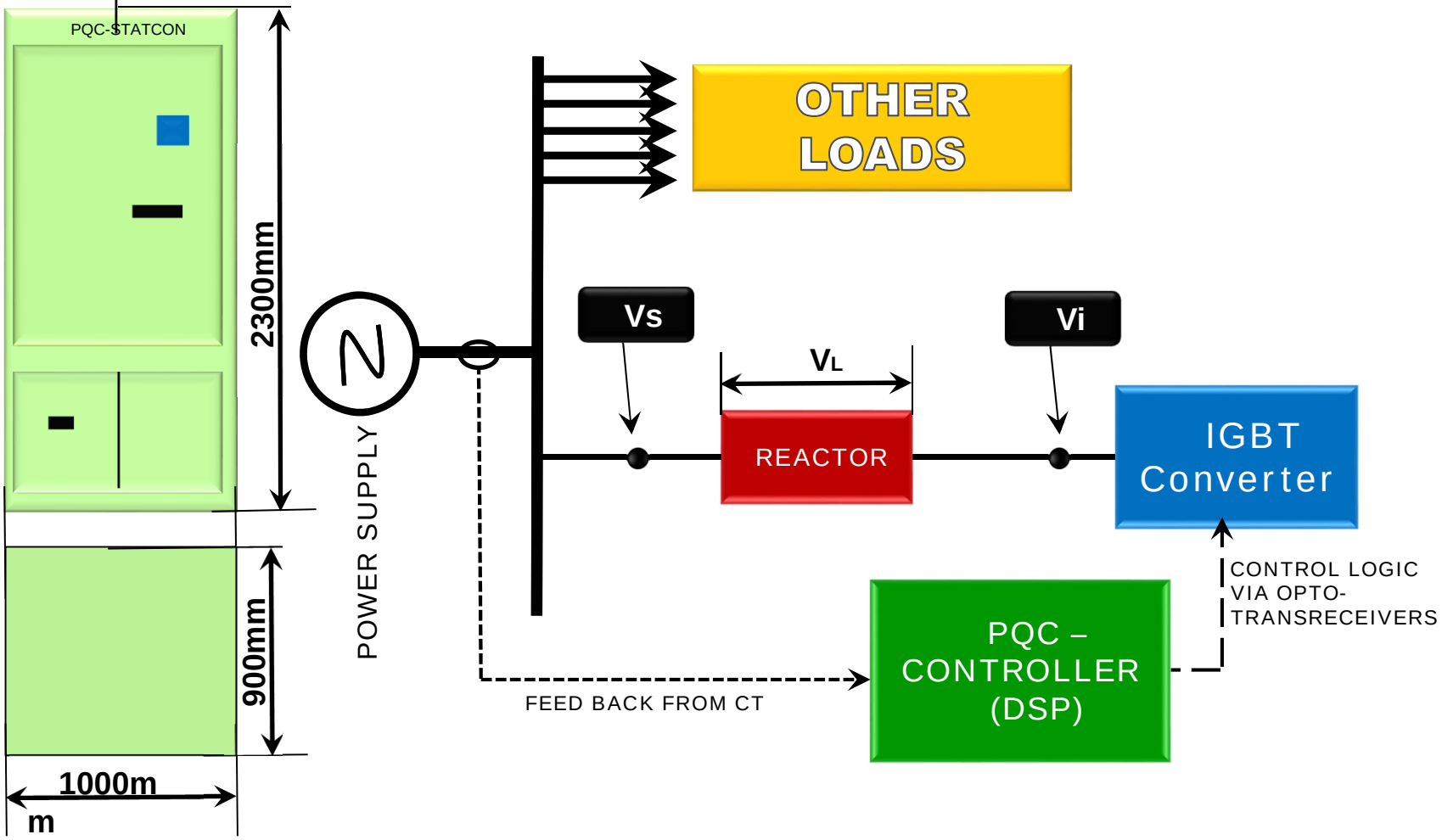
Power electronics based compensator
Instantaneous stepless reactive power compensation



Active compensator based reactive power compensator technique

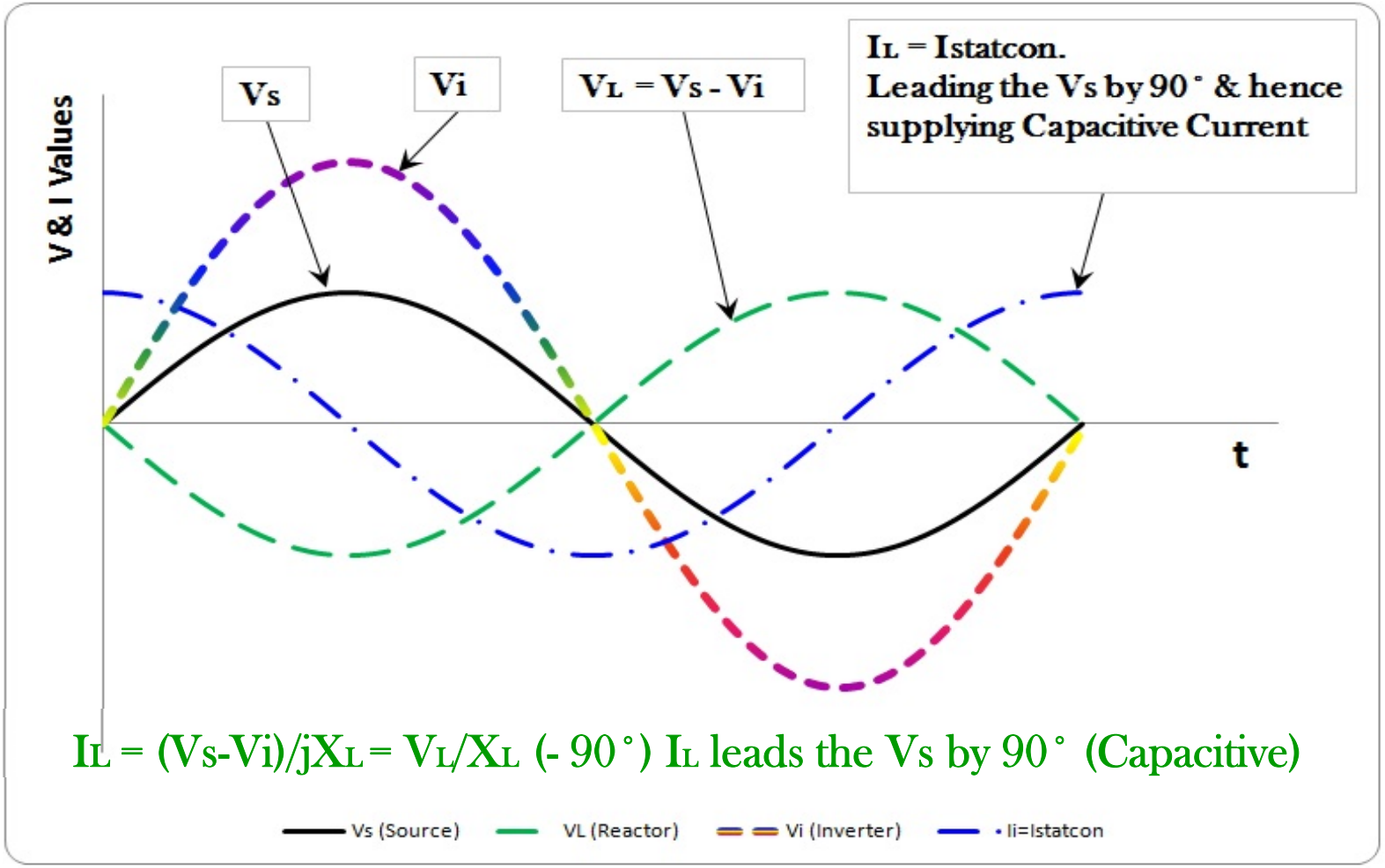
- IGBT based power electronic current source
- Fast dynamic response
- Smooth and step-less
- Inductive/capacitive reactive power operation
- Unbalance compensation
- Operates in shunt with loads

Basic operating principle Of PQC – STATCON



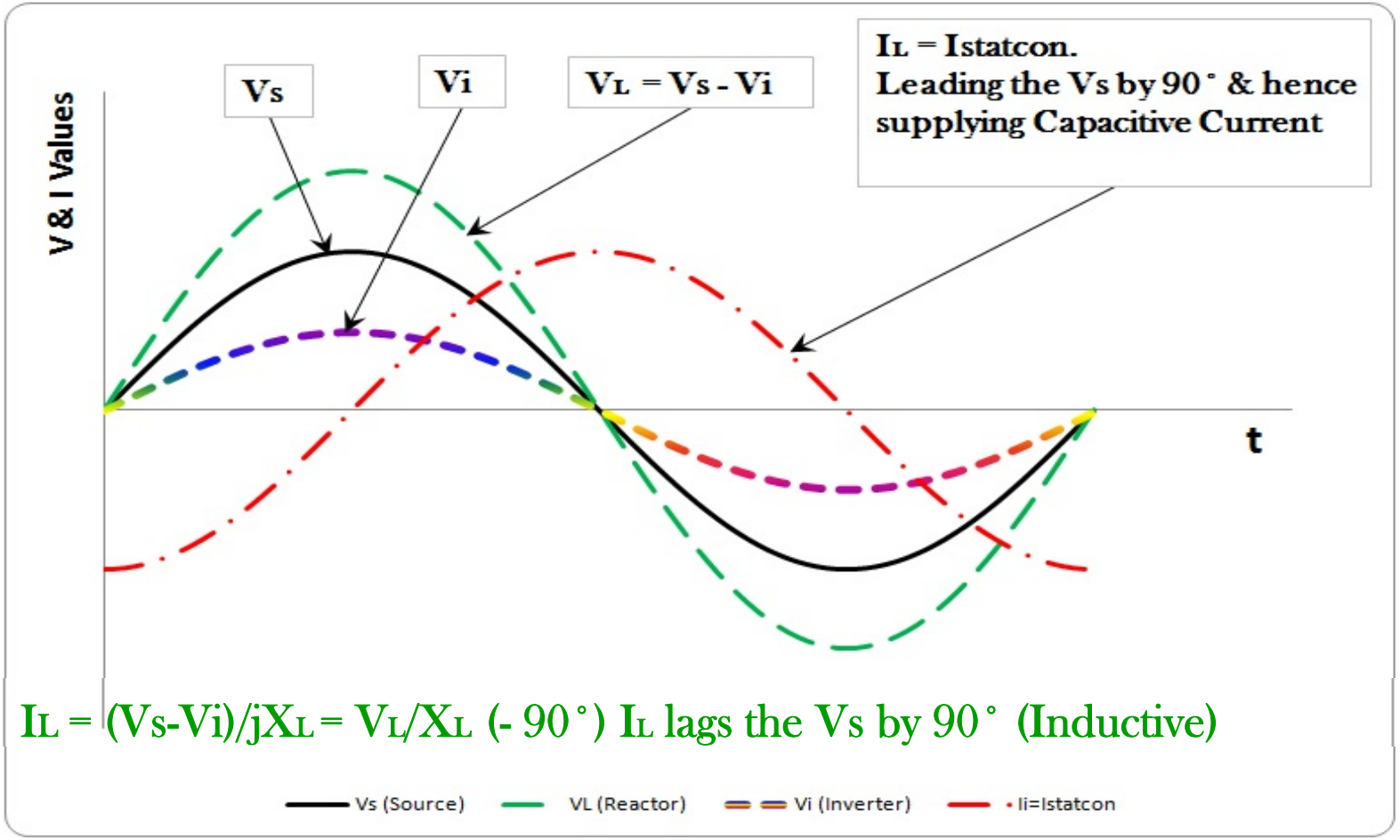
Reactive Power Compensation(RPC) by STATCON:

CASE-1: When Vi > Vs



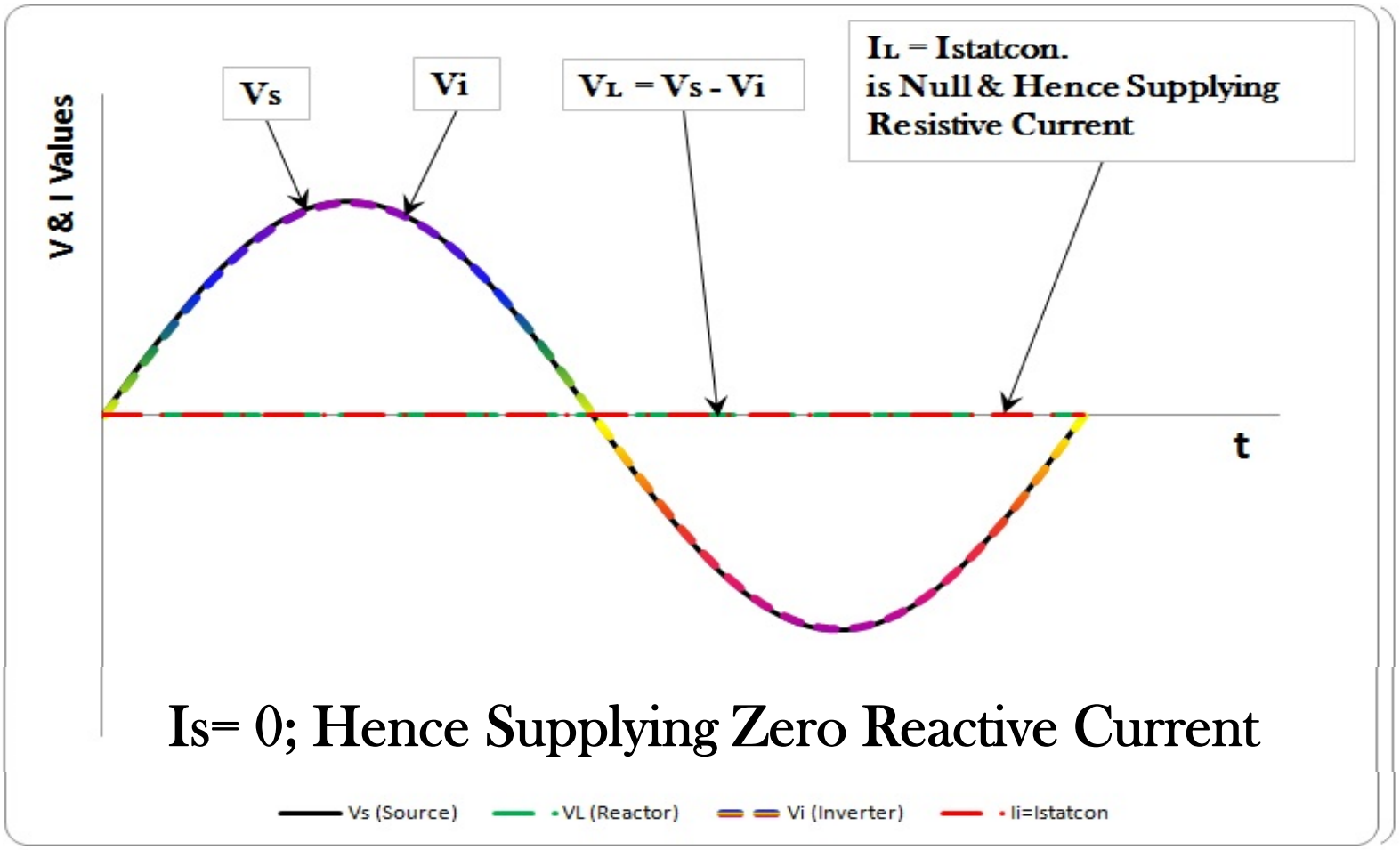
RPC BY STATCON:

CASE-2: When Vi < Vs



RPC BY STATCON:

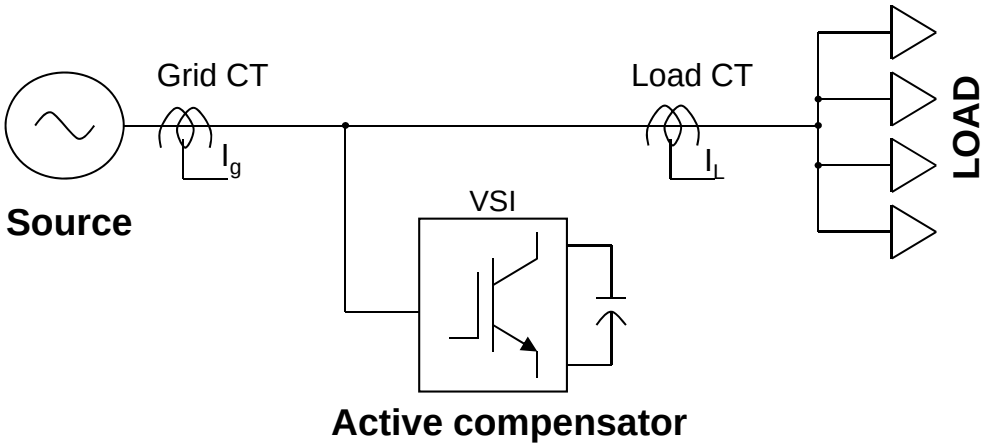
CASE-3: When Vi = Vs



PQC-STATCON
Key benefits

- Improves power factor & 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

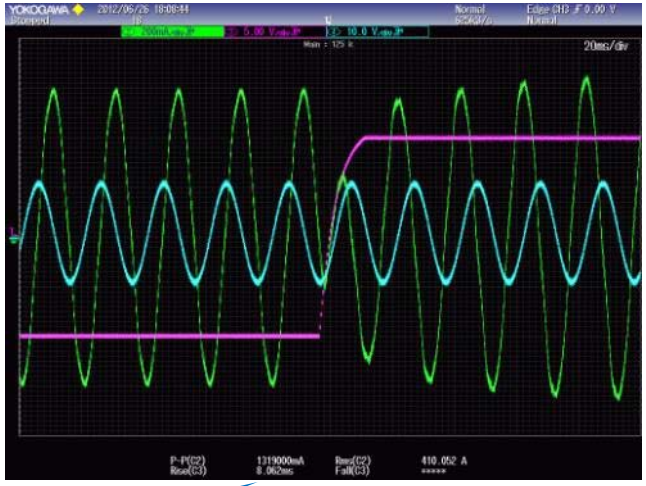
Multiple STATCONs in parallel can share the same CT feedback

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

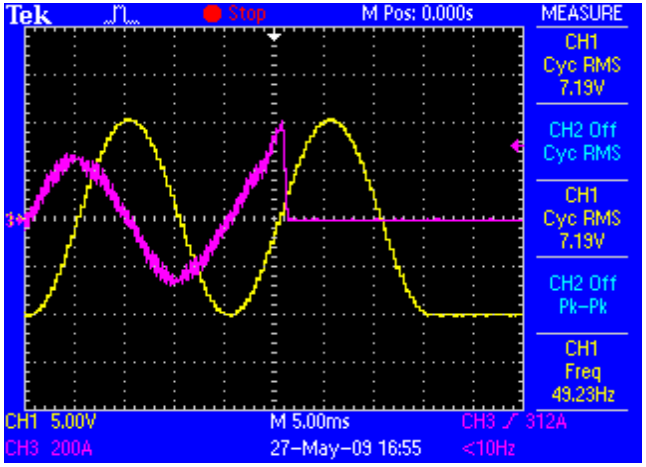
PQC-STATCON technology and features
Energy efficient operation

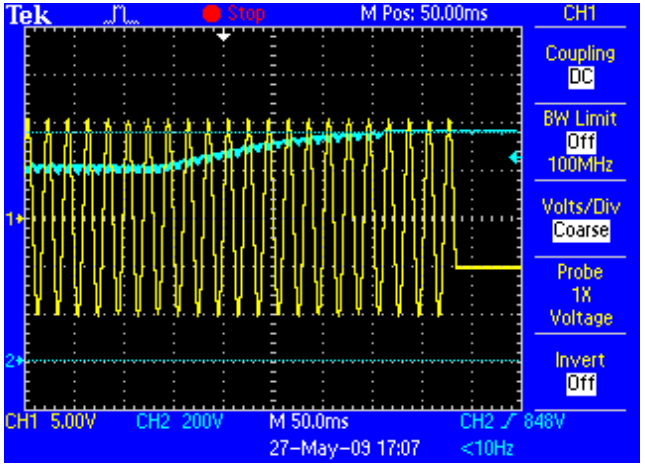
Energy save mode

- 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

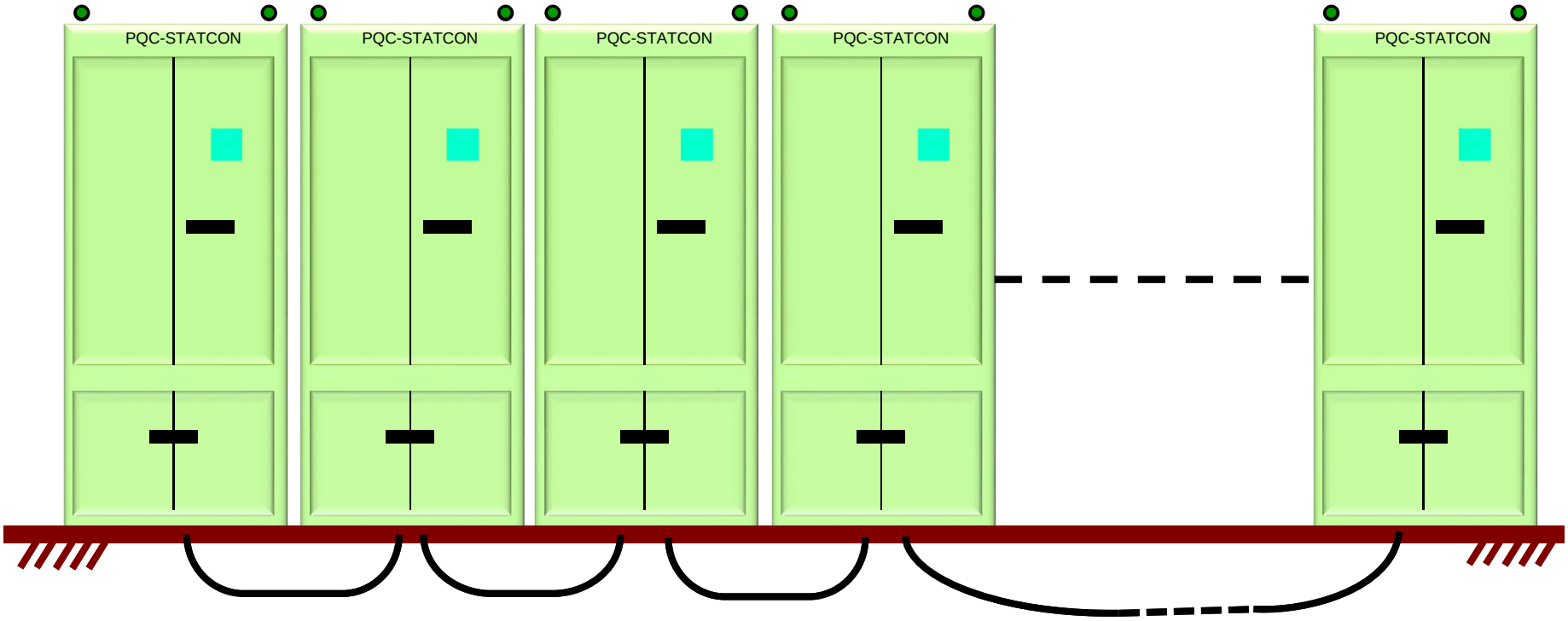




Protection

- 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

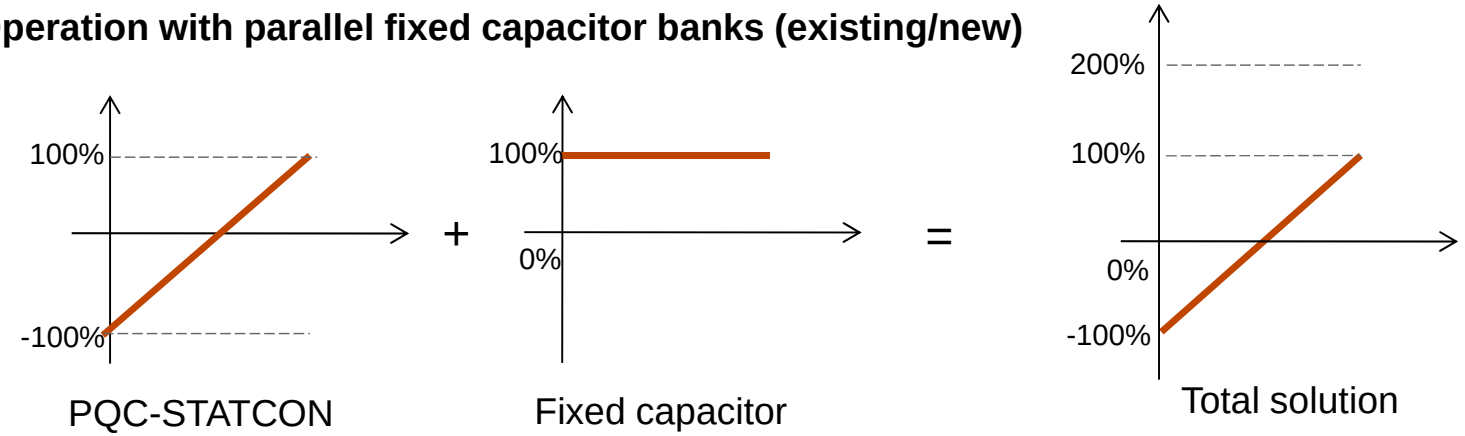
Unique advantages of PQC-STATCON
Parallel operation



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.

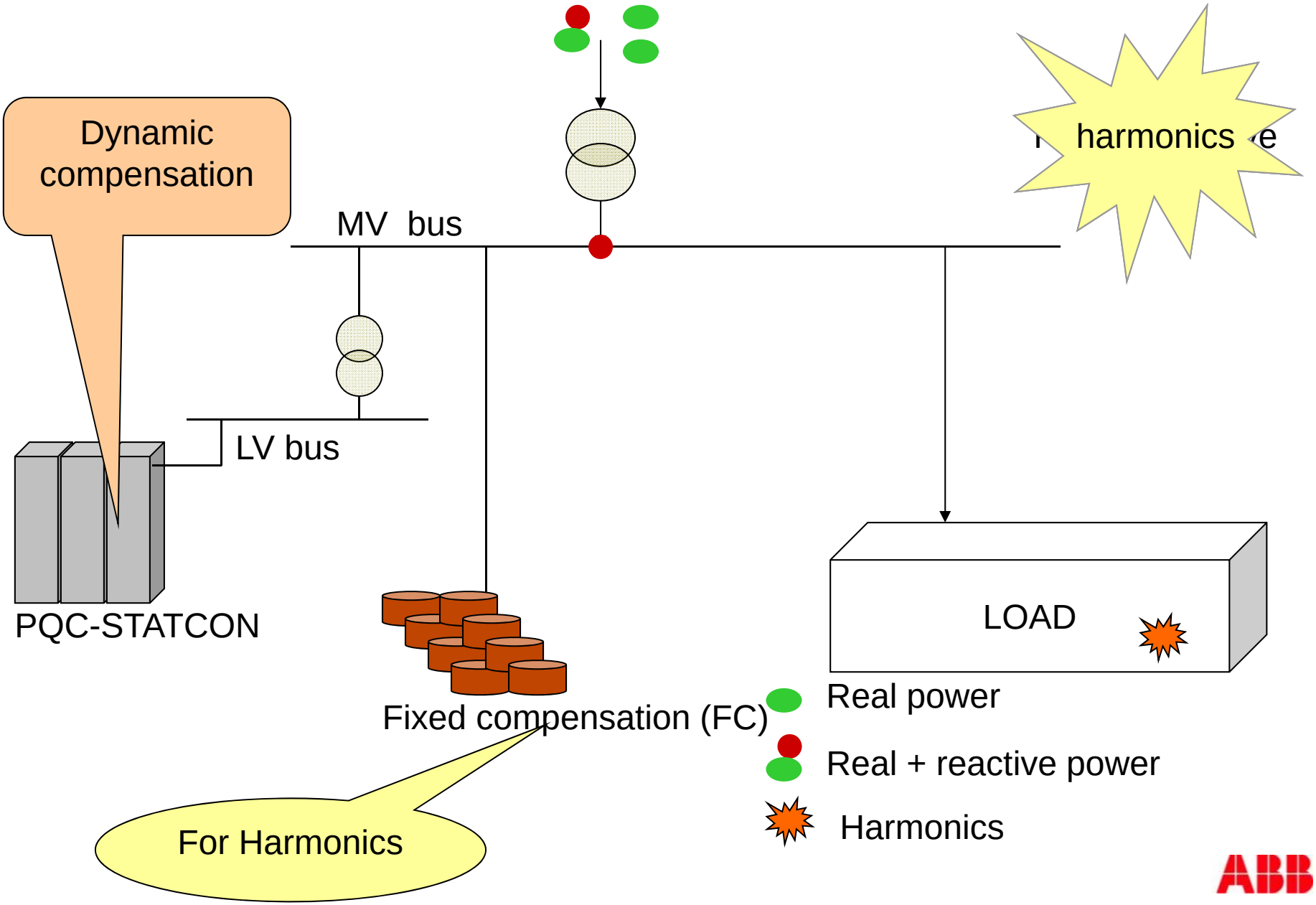
Operation with parallel fixed capacitor banks
Cost effective - more kvar / $

Operation with parallel fixed capacitor banks (existing/new)



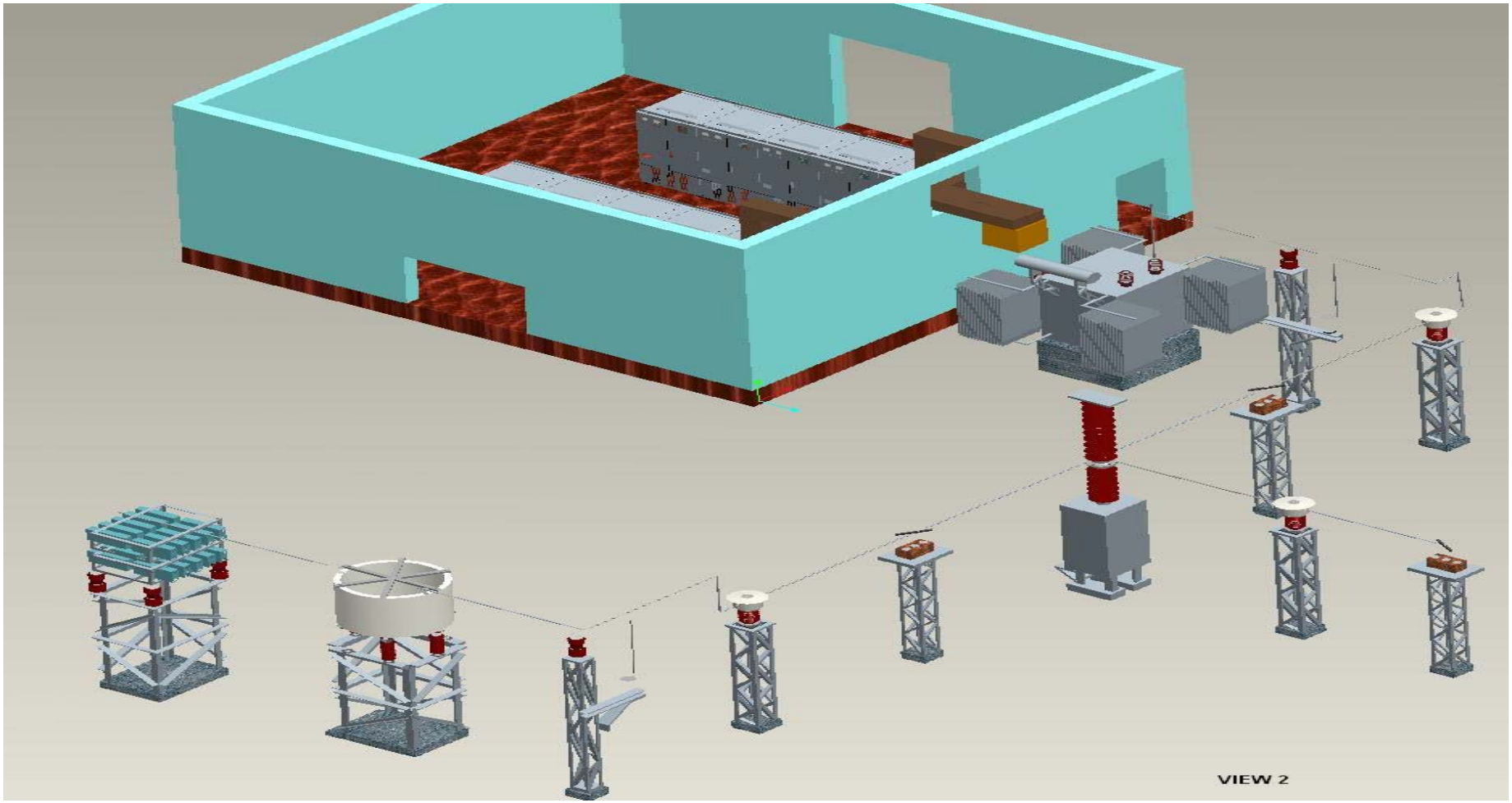
- **PQC-STATCON doubling the dynamic compensation range with parallel capacitor banks.**

Power quality solutions with PQC-STATCON + FC



Typical STATCON SOLUTION

Typical HV/MV Applications



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

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

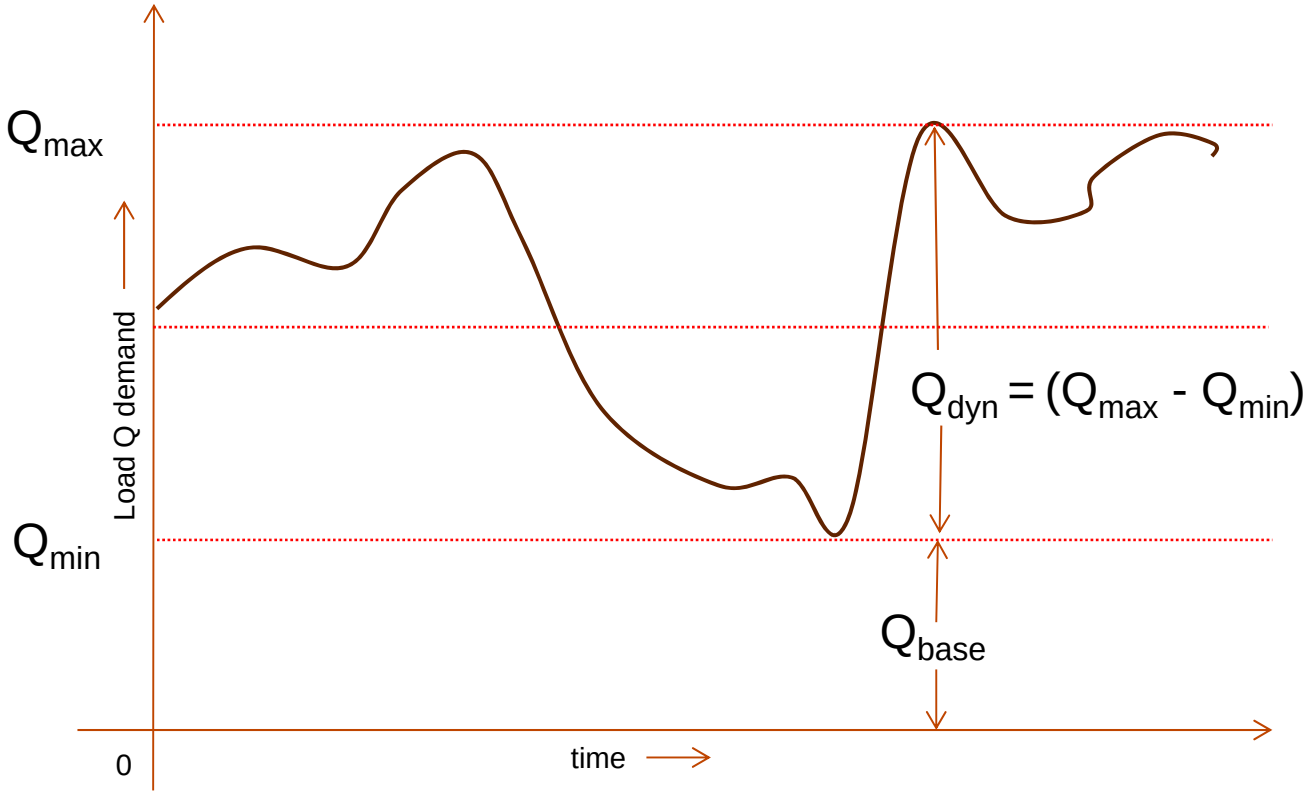
Calculate the required capacity for fixed capacitor based compensation, which is the sum of base compensation requirement and half of the total dynamic compensation requirement.

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

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.

Proposed Scheme for Railways

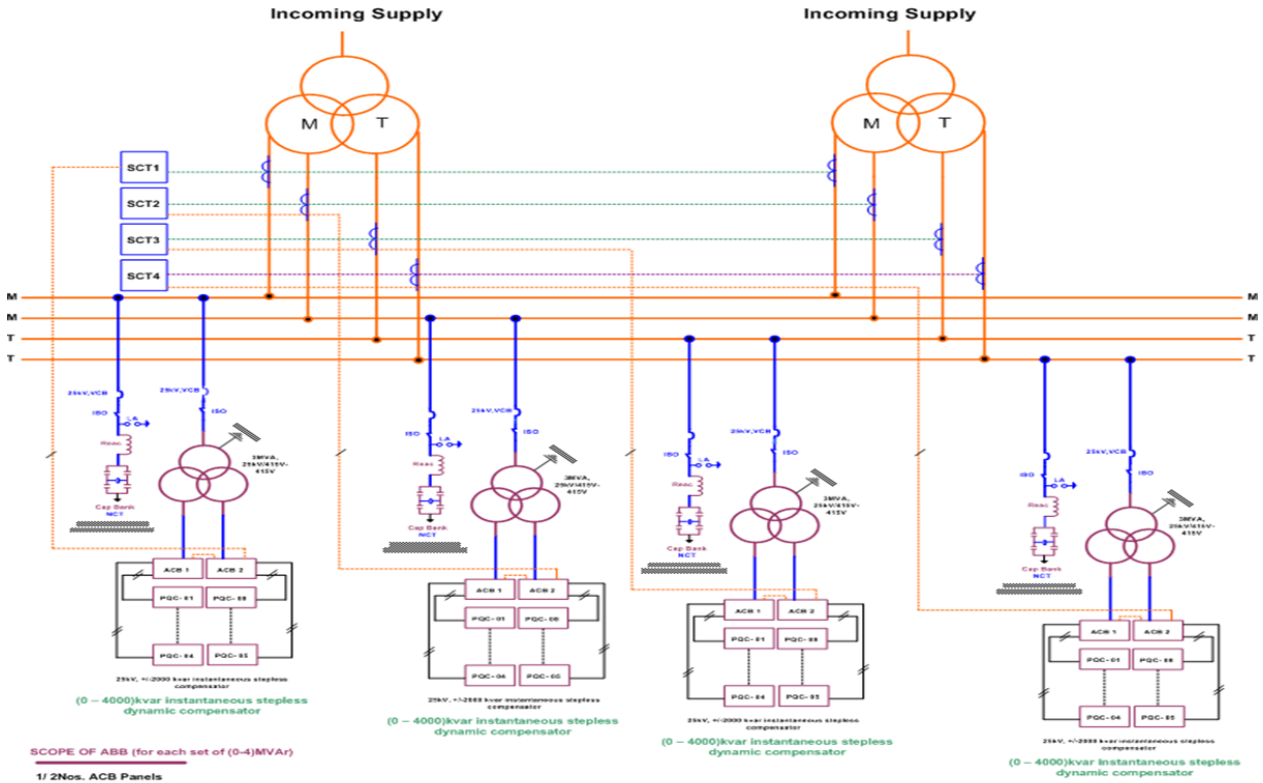


ABB STATCON Reference List
Indian Railways

Sr. no.	Railway & Division.	TSS Name	Statcon Installed rating	Fixed Capacitor
1	Central Railway Bhusawal Division	Lasalgaon	+/- 1200 KVAr	1800KVAR
2	Central Railway Bhusawal Division	Pimperkhed	+/- 1200 KVAr	1800KVAR
3	Central Railway Nagpur Division	Multai	+/- 1700 KVAr	2400KVAR
4	Central Railway Nagpur Division	Betul	+/- 1700 KVAr	2400KVAR
5	Central Railway Nagpur Division	Pandhurna	+/- 1100 KVAr	1500KVAR
6	Central Railway Nagpur Division	Ghoradongri	+/- 1200 KVAr	1900KVAR
7	Central Railway Wadibunder Division	Kasara	+/- 2400 Kvar	2400KVAR
8	Central Railway Wadibunder Division	Tambadmal	+/- 2400 Kvar	2400KVAR
9	Southern Railway Salem Division	Bommidi	+/- 1800 Kvar	Nil
10	Southern Railway Chennai Division	Tambaram	+/- 1800 Kvar	2400KVAR
11	East Coast Railway Vizag Division	Dilimili	+/- 1200 Kvar	1500KVAR
12	East Coast Railway Vizag Division	Gidam	+/- 2400 Kvar	2400KVAR
13	West Central Railway Kota Division	Ramganjmandi	+/- 2400 Kvar	3600KVAR
14	Northern Railway Lucknow Division	Amausi	+/- 2100 Kvar	-
15	West Central Railway Bhopal Division	Gulabganj	+/- 2400 Kvar	2400KVAR
16	Northern Railway Lucknow Division	Basai	+/-2100 Kvar	7700 KVAR+9900KVAr
17	Northern Railway Lucknow Division	Datia	+/-1200 Kvar	5500KVAr
18	RVNL, kolkata	Balichak	+/-3000	4000KVAr+3500KVAr

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for a better world™