Power Generation

Power Quality Solutions

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Flow of the presentation

- Company Overview
- Power Quality
- Power Quality Issues present in Industry
- Some Regulatory Drivers
- Case Study
- Requirements of effective mitigation solutions

Vision

"Making people's lives better by unleashing the Power of Cummins"

Mission

We unleash the Power of Cummins by:

- Motivating people to act like owners working together
- Exceeding customer expectations by always being first to market with the best products
- Partnering with our customers to make sure they succeed
- Demanding that everything we do leads to a cleaner, healthier, safer environment
- Creating wealth for all stakeholders

Values

Integrity
We strive to do what is right and we do what we say we will do

Corporate Responsibility
Serve and improve the communities in which we live

Innovation
Apply the creative ingenuity necessary to make us better, faster, first

Diversity
Embrace the diverse perspectives of all people and honor both with dignity and respect

Delivering Superior Results
Exceed expectations, consistently

Global Involvement
Seek a world view and act without boundaries

Cummins Inc.

Engine Business | **Distribution Business**

Power Generation Business


Power Generation


Generator Technologies

Components Business


Emission Solutions


Filtration


Turbo Technologies


Fuel Systems

HQ in Columbus, Indiana since 1919

37,800 employees worldwide

R&D:$329 million

Cummins Business Services

Operations in 190 Countries

50 manufacturing locations

550 distributor locations

5,200 dealer locations

Making people's lives better by unleashing the Power of Cumm


Power Generation

Power Quality

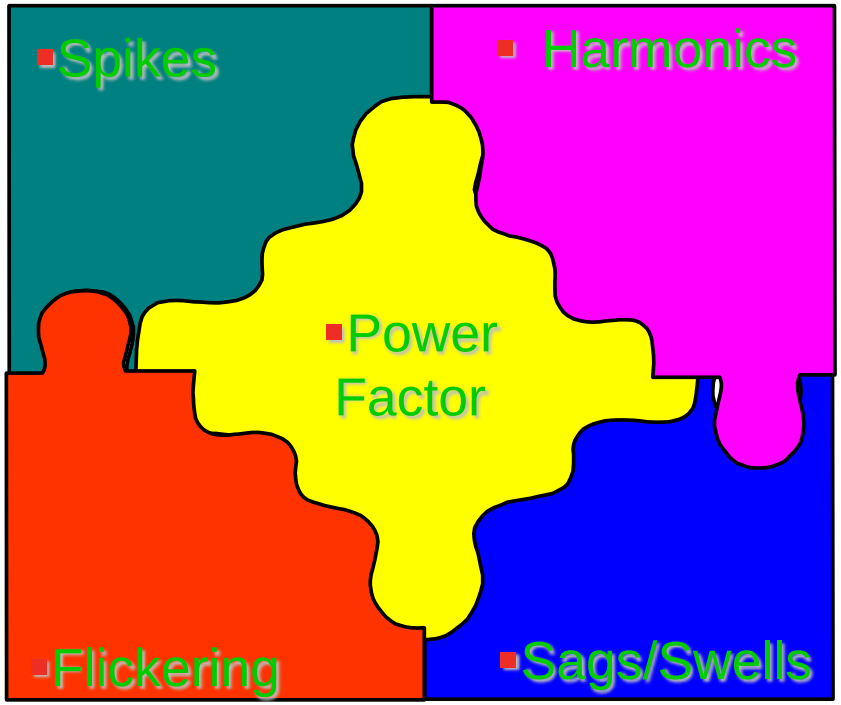
What is Power Quality?

Power Quality is no longer restricted to Input only, it can be load related as well

Non zero switching Causes Current Spikes

All of these cause Voltage Flicker…

In other words Power quality issues can be from Load End as well.



Non zero switching induces Harmonic Currents

Sudden tripping of Some major loads Cause voltage swell while switching On Heavy motors Cause sags

Generally Capacitors are switched on through APFC. While this helps improve power factor, non zero switching creates power quality issues.

Power Quality Issues Present in the Industry

Power Quality issues present in the industry

- In the past, either the DG is oversized or undersized resulting in High Fuel Consumption or DG not taking load.
- Cummins India Limited undertook a study across the country and met over 200 customers to understand the situation.

Power Quality issues present in the industry.. Continued

The survey highlighted the following:

- Modernization of Industries brought in lot of Electronic Controls. Almost all loads (which were hitherto linear became non linear).
- While they increase productivity it also brings with it increased Harmonic Levels.
- In order to maximize PF incentives, source side PF improvement is attempted through Fixed capacitors or through APFC or slow response Thyristorized systems.

Power Quality issues present in the industry.. Continued

- While this helped maximize PF Incentive , PF under low load, fast changing loads, unbalanced loads were found either low lagging or leading.

- In addition, improper method of capacitor switching is seen to generate Harmonics. We have case studies to support this.

- Predominant Harmonic orders are 3^{rd}, 5^{th} and 7^{th} . Rest of the harmonic orders are either absent or negligible. Treatment to these harmonic order will suffice to curtail THD levels.

Power Quality issues present in the industry.. Continued

- Unbalanced loading conditions are prevailing in the industry.
- We had noted that equally distributed single phase loads across three phases are not necessarily a balanced load.
- When one single phase load trips, the load becomes unbalanced calling for Unbalanced PF compensation. We have case studies supporting this.

Power Quality issues present in the industry.. Continued

In effect, following are the effects of High Harmonics

- Cable overheating in undersized cables.
- Cable line loss in oversized cables.
- Nuisance tripping of Breakers.
- Resonance blow up of Capacitors.
- Damage to Power Transformer.
- Malfunctioning of Electronic Controls and devices

Regulatory Drivers

Regulatory Drivers

- Some states in India moved to kVAH based Energy Billing. PF incentive is withdrawn.
- Consumers above 500 kVA contract demand will have to declare Harmonic Levels and their plans to mitigate them.(Position varies from State to State)
- In order to maintain Unity PF at source end under non linear load conditions, PF compensation mechanism will have to have Harmonic Filters.
- There is a proposal to levy penalty on High Harmonic Generating Consumers.

Case Study

Power Generation

Customer : Research Centre, South India

Source : 1600 Tr LT mains(11KV/433V)
: 2x 500 kVA + 1 x 625 kVA + 1 x 250 kVA Cummins DG sets (Run in parallel)

Application : Advanced Vacuum System Furnace (PID Controlled Temperature Cycle Profile)

Reported Plant Operational Problems

Plant Operational Problems

Discussions with Plant Officials revealed the existence of the following plant operation problems

- Existing DGs unable to get synchronized when running with furnace load.
- Very low Power Factor at EB Mains .
- Installed APFC of Rating 500 kVAr is not able to maintain PF to provide maximum incentive.
- Suspected Harmonic Problems

Analysis Objective

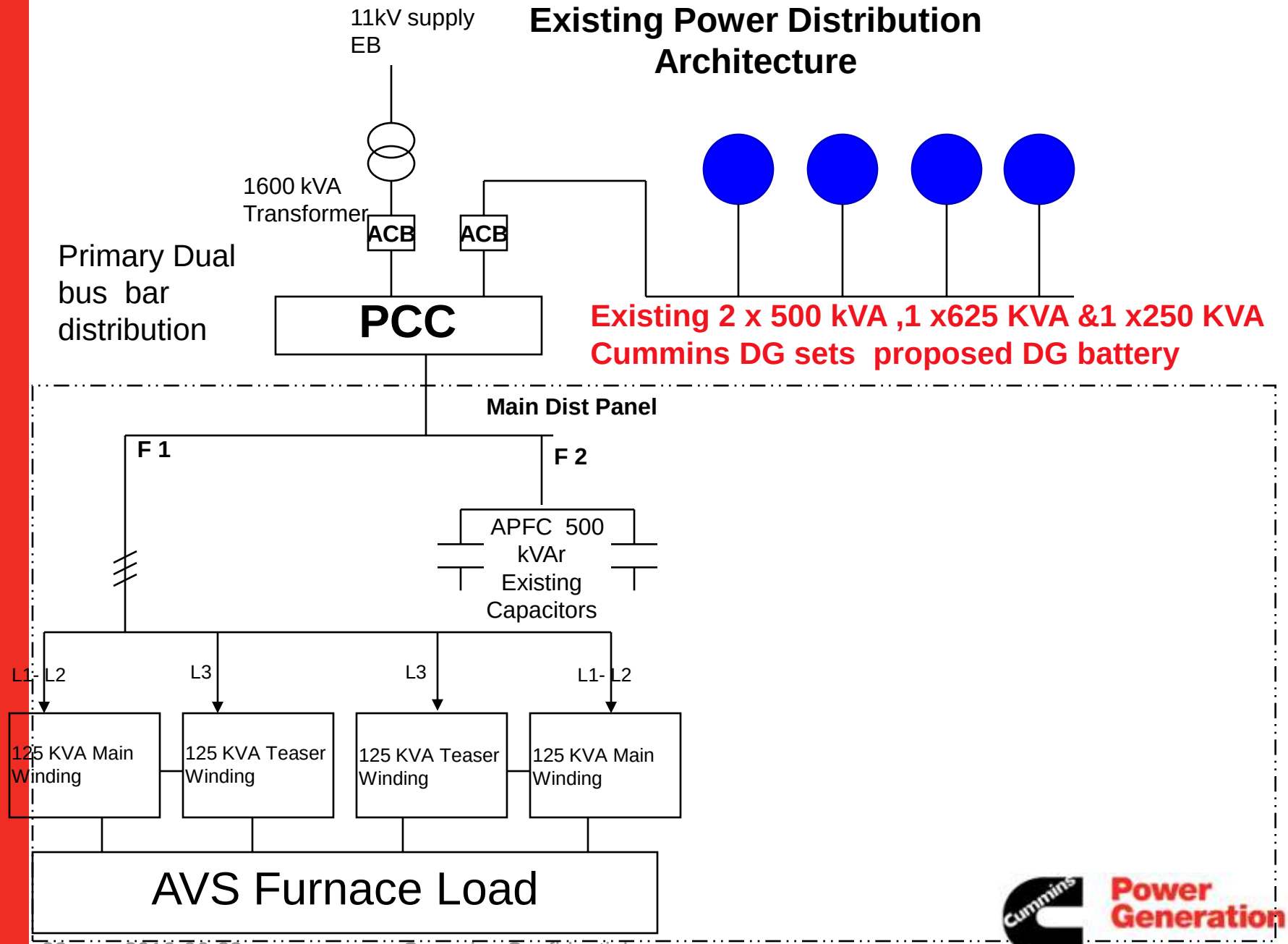
Customer : Research Center, South India

Analysis Objective:

- Profiling of AVS furnace system electrical parameters with respect to change in temperature/time PID controlled cycle.
- Identify Harmonic Levels and recommend suitable Harmonic Filtration System if required.
- Verification of DG sizing for captive power to power the above furnace and other loads and provide recommendations.

Existing Power Distribution Architecture.

Existing Power Distribution Architecture



Analysis Methodology

Analysis Methodology

In order to find out feasible solutions:

- Measurements were taken at Transformer LT mains for one number AVS furnace Load Cycle Profile.

- Measurements were also taken for harmonics

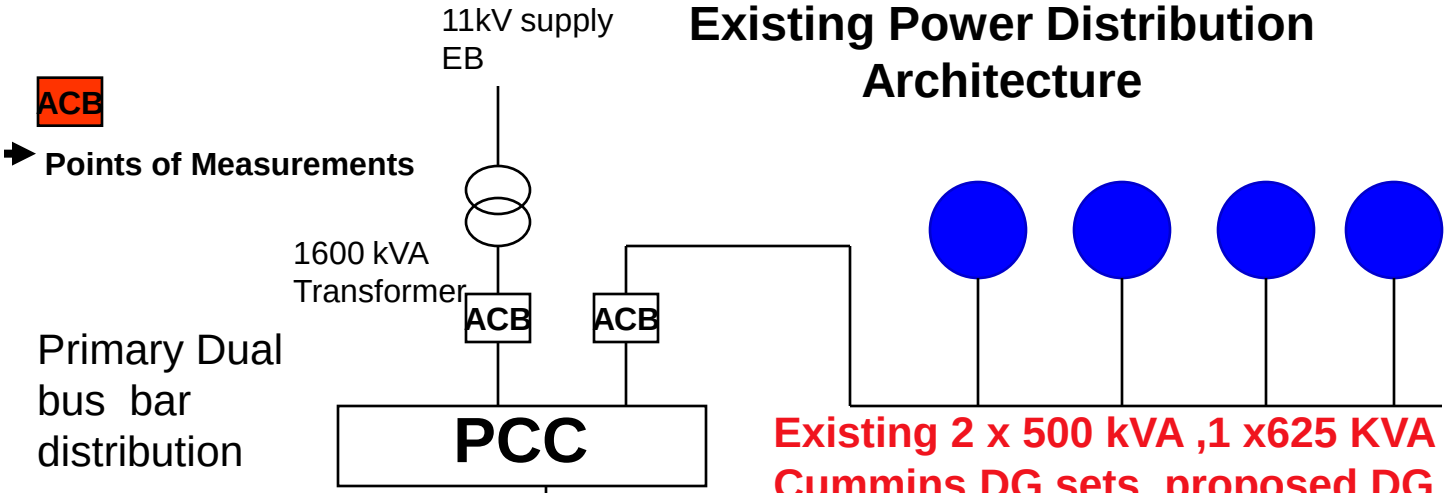
- Readings were analyzed for captive DG Capacity sizing at different temperature zones namely.
  - 75^{0}C to 750 ^{0} C
  - 750 ^{0}C to 1400 ^{0} C
  - 1400^{0}C to 1995^{0} C
  - 1995^{0}C to 2150^{0} C

Analysis Methodology Conti..

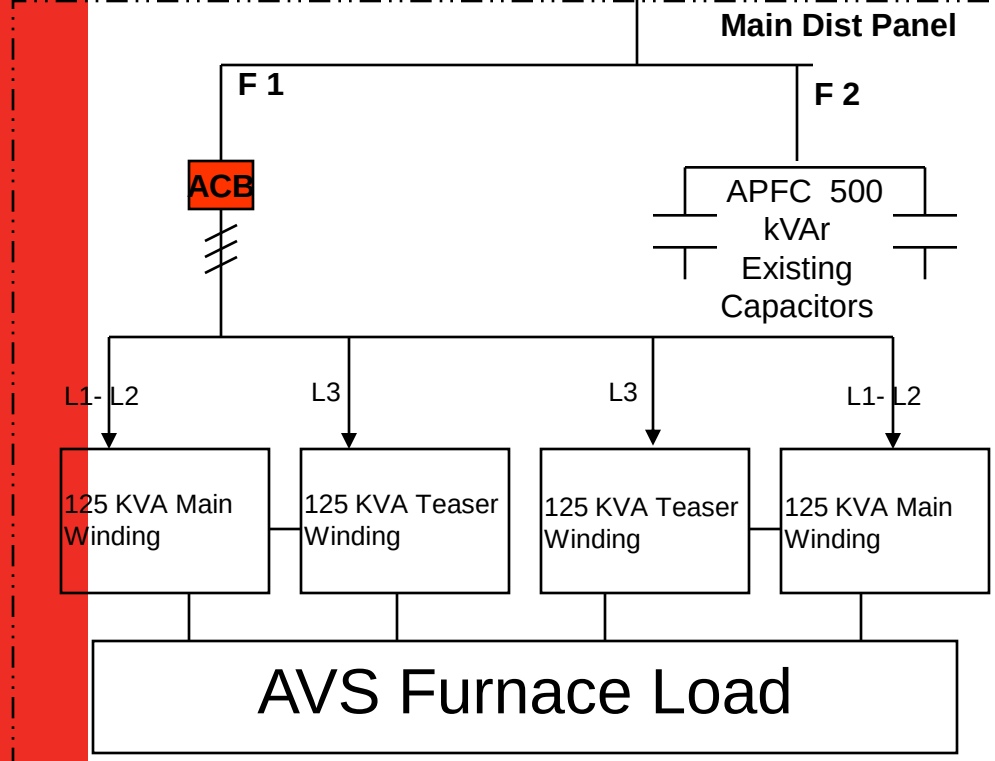
- Harmonic Levels present in Load current are quantified at different Temperature Zones.
- Impact of Harmonics on Source is evaluated.
- Final Recommendation is then arrived at for RTPFC and DG Sizing .

Measurement Location

Existing Power Distribution Architecture



Existing 2 x 500 kVA ,1 x625 KVA &1 x250 KVA Cummins DG sets proposed DG battery



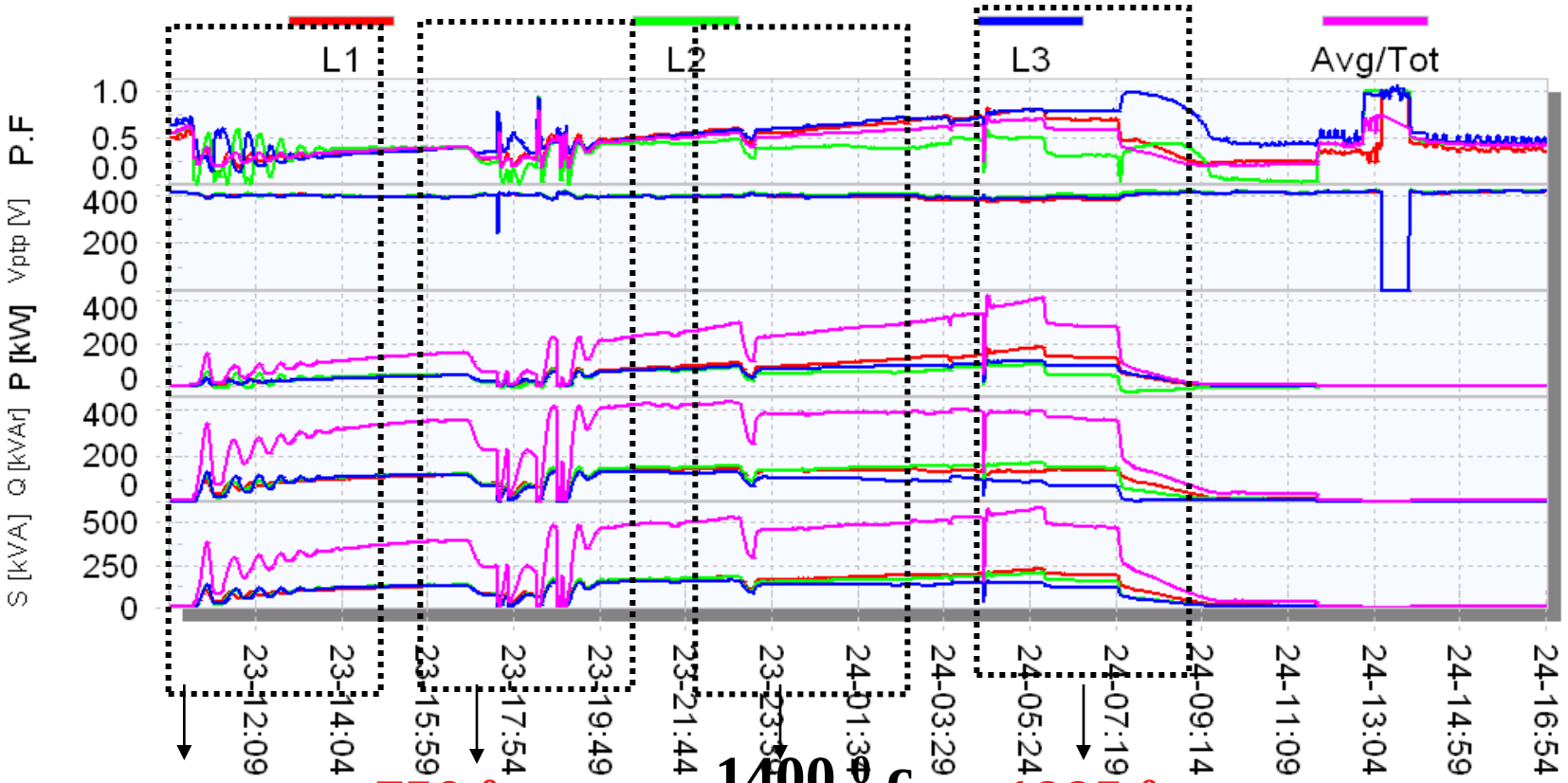
Readings were taken at :

1600KVA 11/0.433KV Transformer LT mains feeder (incomer for AVS furnace)

Measurement Snapshots of All Primary Parameters Pre Analysis

Typical Furnace Load

Abmient to 75-750-1400-1995-2150-800-Ambient Deg C Temp total Cycle.
per min



75 to 750 ^{0} c

750 ^{0} c to 1400 ^{0} c

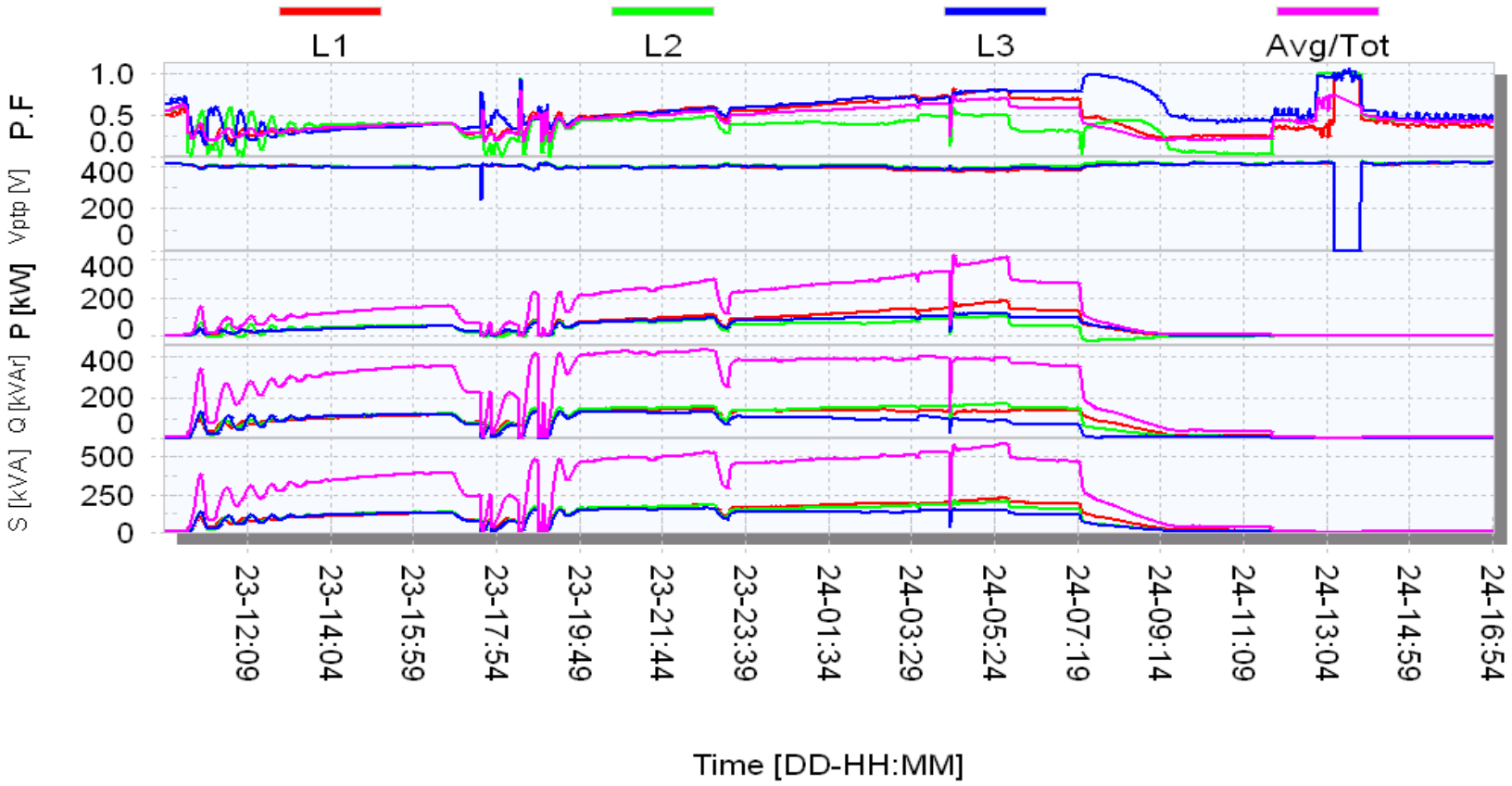
1400 ^{0} c to 1995 ^{0} c

1995 ^{0} c to 2150 ^{0} c

Measurement Snapshots of All Primary Parameters Pre Analysis On EB side

Typical Furnace Load

Abmient to 75-750-1400-1995-2150-800-Ambient Deg C Temp total Cycle.
per min



Overall Analysis

- The incomer voltage is low and needs correction on line.
- In the temperature zone 75 ^{0} C– 750 ^{0} C and 750 ^{0} C to 1400 ^{0} C the transient loading causes unbalanced kVAr resulting in unbalanced PF across three phases. Other Zones are fairly stable.
- DG paralleling during these transient conditions will encounter difficulty.
- Though the trials were not taken on DG, it is anticipated that there will be voltage drop during the transient loading conditions
- The 500 kVAr APFC will not be able to maintain power factor under during these transient loading conditions

Recommendations

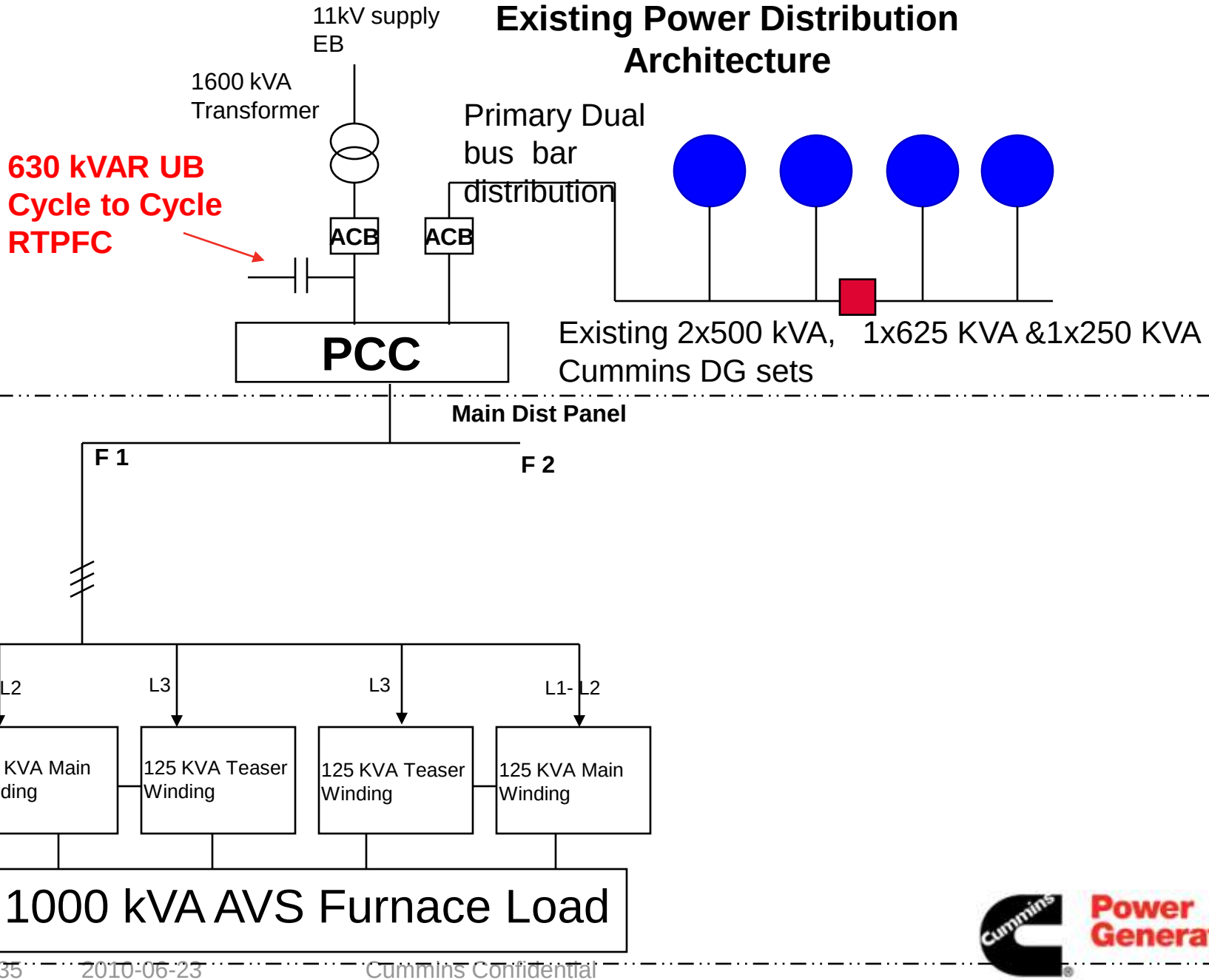
- In order to improve and maintain the incoming voltage, it is recommended to install OLTC for on line correction of Voltage.
- In order to maintain Power Factor and provide real time Reactive Power Compensation during transient and steady state load conditions, it is recommended to install 1 x 627 kVAr Unbalanced RTPFC to provide Phase to Phase, Cycle to Cycle compensation for DG compatibility.
- Existing 500 kVAr APFC will have to be disconnected.

contd...

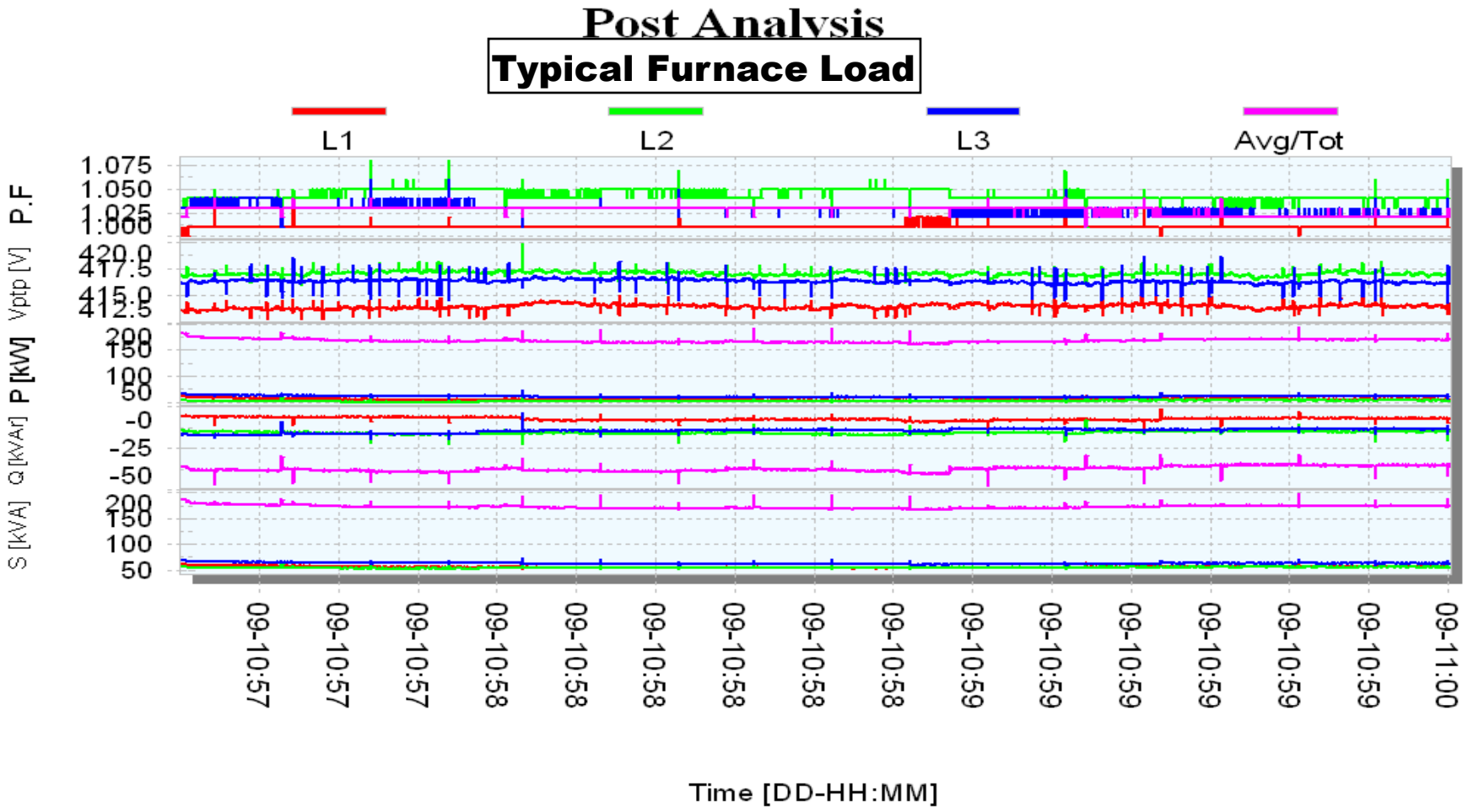
Recommendations

- Retrofit Cummins Power Command Control on existing 2 x 500 kVA DG sets to enable ensure transient Governor Response
- With implementation of the above recommendations, 2 X 500 kVA DG sets in parallel will be able to take the load.

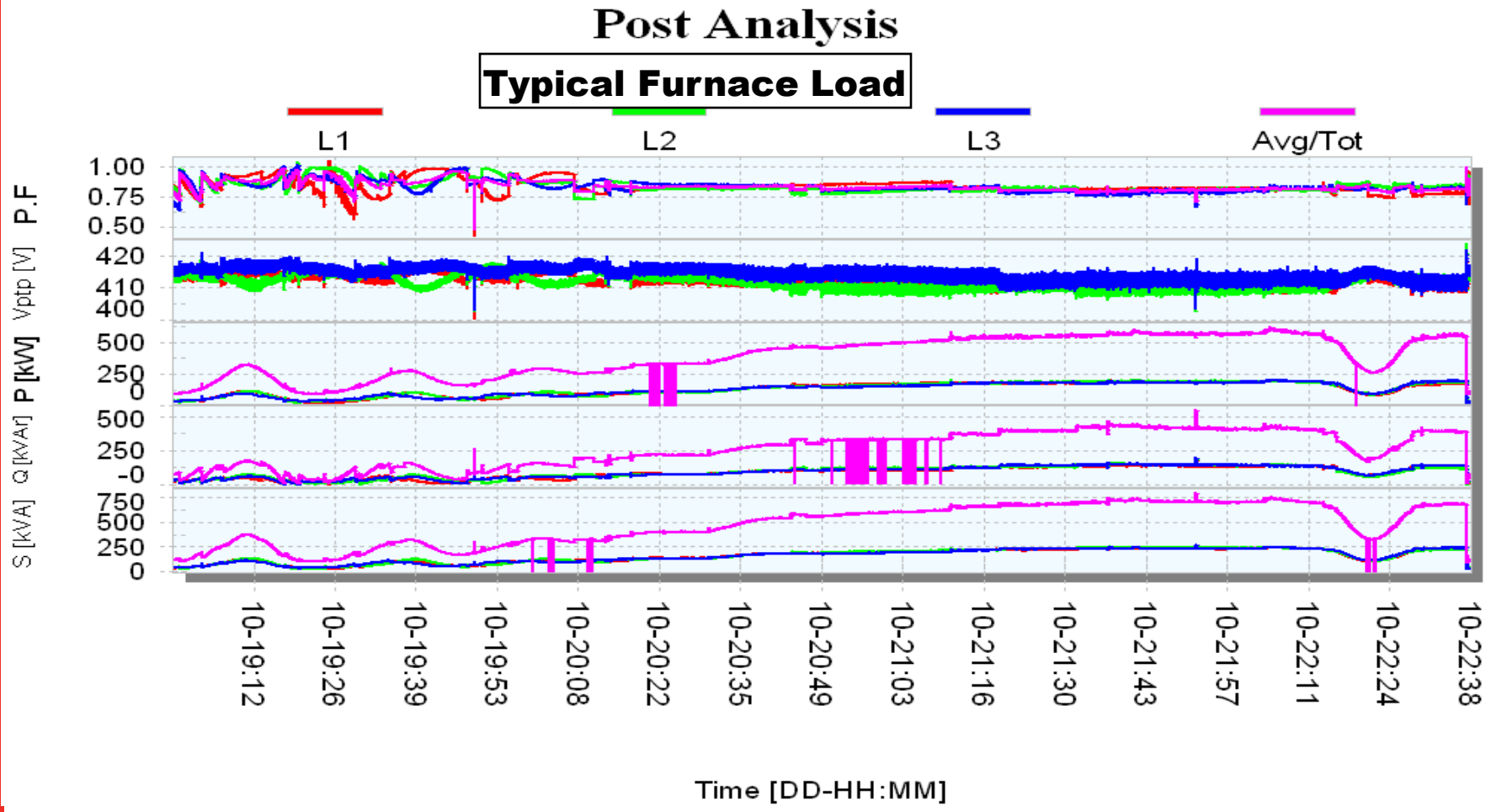
Existing Power Distribution Architecture



Measurement Snapshots of All Primary Parameters Post Analysis On EB side



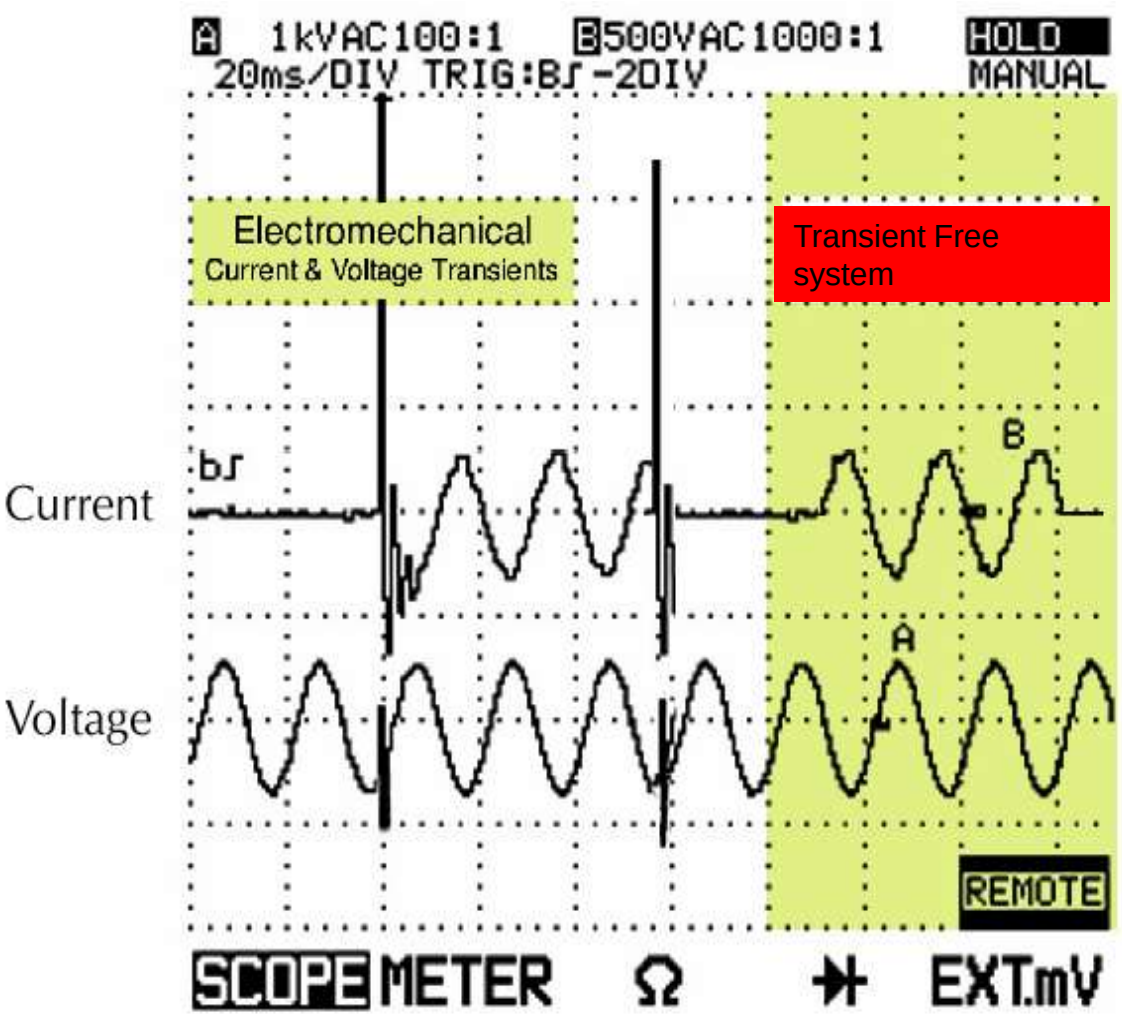
Measurement Snapshots of All Primary Parameters Post Analysis On DG side



Requirements of Mitigation Solutions

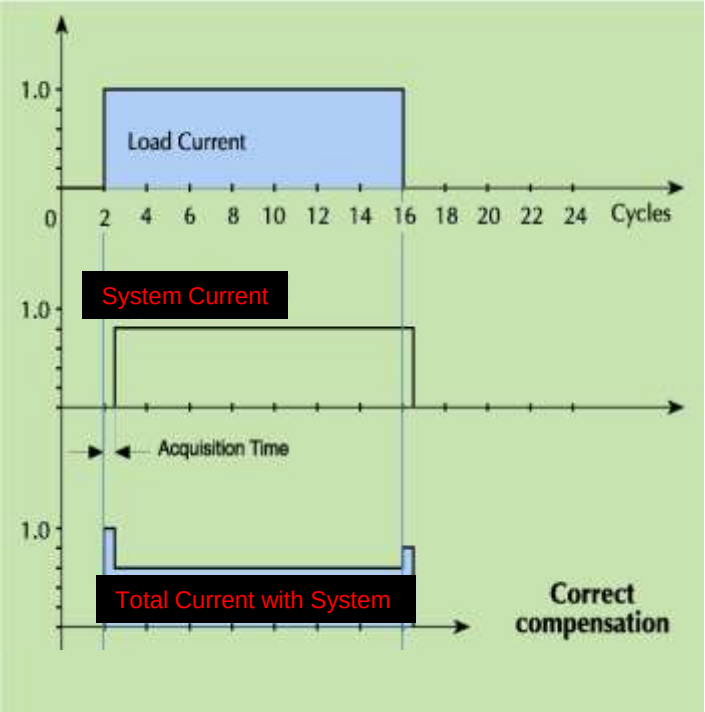
Power Generation

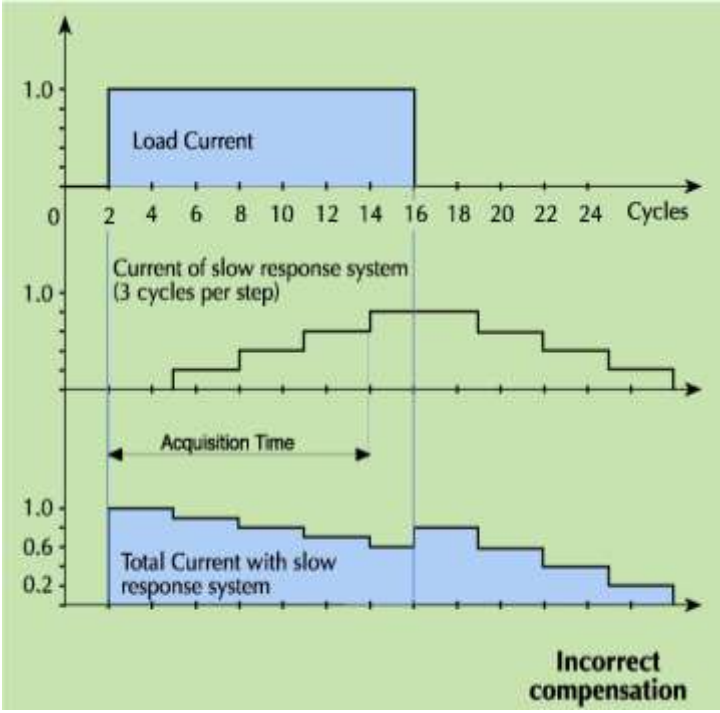
Electronic Switch Advantages



Power Generation

Cycle to Cycle Compensation - Quasi Real Time





In order to address issues related to Ultra Fast Changing Load Demands, Cycle to Cycle compensation is must.

Technology Ladder in PF comp+ Harmonics Mitigation

RTPFC + Harmonic Filtration (UNBALANCED) 20 milliseconds response time

RTPFC + Harmonic Filtration (Balanced) 20 milliseconds response time

RTPFC + Harmonic Filtration (Balanced) Slow response

RTPFC (Few cycles Response)

RTPFC (Few seconds response time)

Thyristorized APFC

APFC

Fixed Capacitors

Can maintain Unity PF under RAPID CHANGING load conditions. Zero Cross issues are addressed with 20 milliseconds response time to provide mirror image compensation under UNBALANCED load conditions. Cycle to Cycle, Phase to Phase compensation.

Can maintain Unity PF under Rapid changing load conditions. Zero Cross issues are addressed AND provide 20 milliseconds response and mirror image compensation for balanced load conditions. Good Harmonic Relief. DG Compatible.

Can maintain unity PF at peak load conditions

Can maintain PF under variable load conditions but create harmonics due to zero cross switching. Not effective for fast load changes. Not DG compatible.

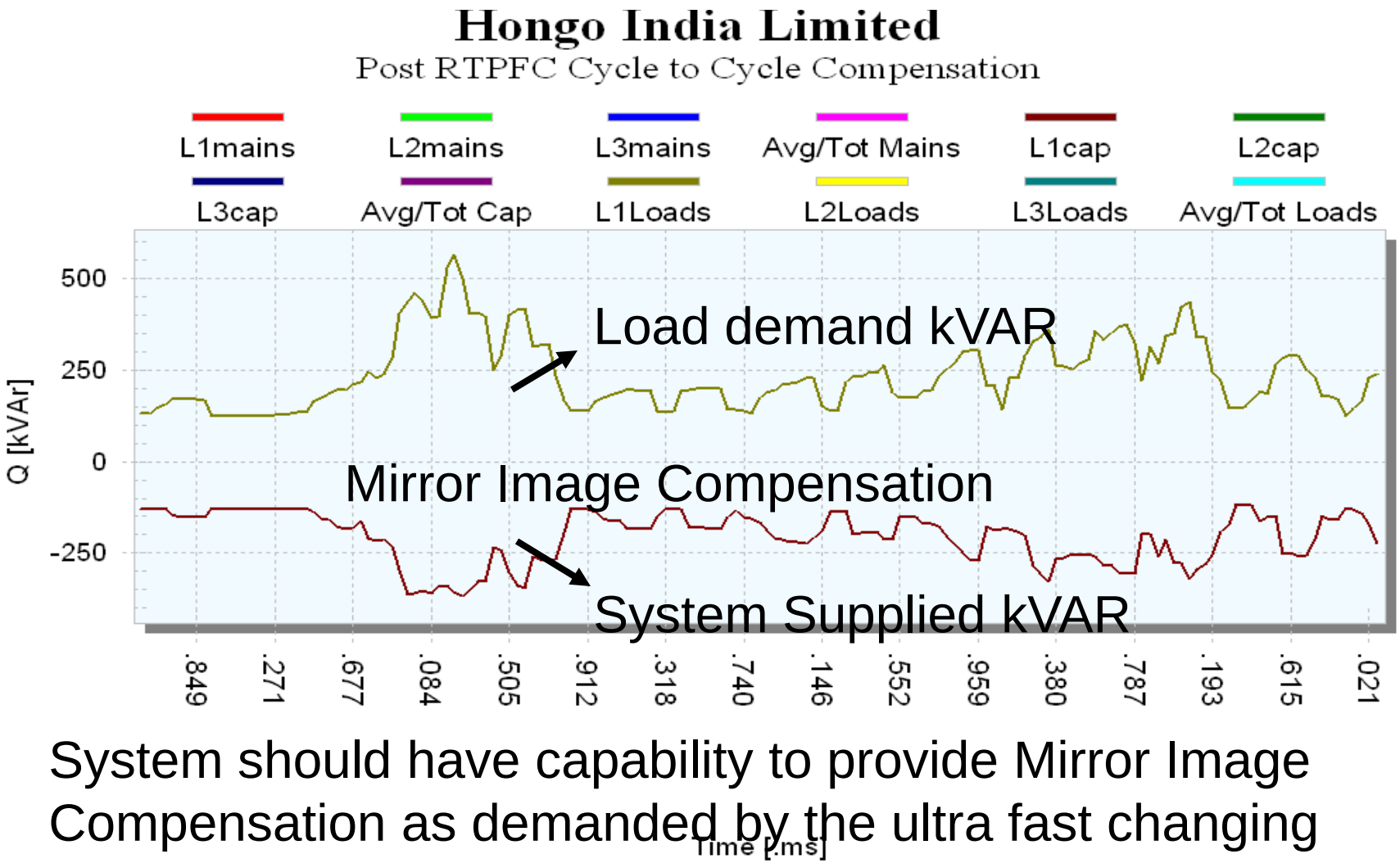
Can maintain PF under variable load conditions. Zero cross issues are addressed but not fast enough to provide compensation for rapid changing loads. Marginal Harmonic Relief. Not DG Compatible.

Can maintain PF under variable load conditions. Zero Cross issues are addressed but not fast enough to provide compensation for rapid changing loads. Does not assist reduction of Harmonics. Not DG compatible.

Good Harmonic Relief. DG Compatible.

These technologies address most of Power quality issues under all loading conditions

MIRROR IMAGE COMPENSATION



System should have capability to provide Mirror Image Compensation as demanded by the ultra fast changing loads

The Solution should provide

➔Cycle to Cycle Compensation In 20 milliseconds

➔Transient free switching,

➔Curtailing harmonics to desired levels

➔Compatible to run on both **DG and EB supply.**

➔Maintain Unity Power Factor under Unbalanced loading conditions

Power Generation

System Features/Benefits

- Cycle-by-cycle reactive power compensation (total acquisition time of 5-20mSec)
- Transient-Free Solid-state Capacitors Switching
- Energy Savings
- Compatible to both EB and DG
- Enhancement of local generation capacity (i.e., diesel generators and windmills)
- Harmonic Filtration
- Prevention of Voltage drops
- Reduction of Voltage Flickering
- Comprehensive Power Quality Analyzer
- Self testing and comprehensive reporting feature

Power Generation

Standards & Quality Assurance

Quality Assurance

- ISO 9001 (The New Revision - 2000)

EMC

- EN 50081-2
- EN 50082-2
- EN 55011
- EN 61000-4-2/3/4/5
- ENV50204
- ENV50141

- CE Mark
  - Low Voltage Directive 73/23/EEC am. 93/68
  - Machinery Directive 98/37/EC art. 4(2)
- Safety Standards
  - EN 61010-1
  - EN 60439-1
  - EN 60204
  - UL 508

SOURCE AND LOAD SHOULD WORK IN HARMONY….

Load

EB/DG

EB/DG

Load

….POWER QUALITY ASSESSMENT AND CORRECTION ENSURES THIS OBJECTIVE.

Contact Us:

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Thank You

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