ABB’s Power Quality Solution

Setting a new level of efficiency & productivity for F&B industries

Ferdinand Sibarani, Product Specialist
What is the significance of power quality?

It’s the prerequisite to achieve system’s efficiency & productivity!
Utility / supply related power quality issues

- Utilities endeavor to supply reliable & consistent electric power, however many factors beyond control can cause voltage/power disturbances;

- Common causes:
  - lightning,
  - thunderstorm, high winds,
  - heavy rain,
  - traffic accidents,
  - construction works,
  - animals,
  - switching operation, etc.;
Power Quality Challenges

Modern F&B industries apply more sensitive equipment

- Dairy processing
- Packaging lines
- High speed bottling
- Batch process
- Climate control
- Dryer process
<table>
<thead>
<tr>
<th>Technically</th>
<th>Financially</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ waste of material / resources / work in progress;</td>
<td><strong>150 billion Euros per year!</strong></td>
</tr>
<tr>
<td>▪ uncontrolled / inconsistent product quality;</td>
<td><em>(European power quality survey in EU-25 countries, in 2003 -2004, among 62 companies from different industries &amp; service sectors)</em></td>
</tr>
<tr>
<td>▪ plant down time and delays in delivery time;</td>
<td><strong>188 billion Dollars per year!</strong></td>
</tr>
<tr>
<td>▪ increased wear / malfunction of electrical component;</td>
<td><em>(EPRI &amp; CEIDS survey in American industries in 2000)</em></td>
</tr>
<tr>
<td>▪ reduced life expectancy / premature aging of the equipment;</td>
<td></td>
</tr>
<tr>
<td>▪ additional labor (for product reworks, etc.);</td>
<td></td>
</tr>
<tr>
<td>▪ human health, safety, and productivity;</td>
<td></td>
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</tbody>
</table>
Utility / Supply Related Power Quality Issues

Voltage disturbances

- Voltage dip / sag
- Voltage surge / swell
- Voltage unbalance
- Voltage flicker
- Voltage phase angle error
What is the solution?
Traditional Solutions...

On Load Tap Changer (OLTC)
Motor based voltage stabilizer

- lack speed of response;
- have limited correction potential;
- usually do not offer imbalance and phase correction.

Uninterruptible Power Supply (UPS)

- very expensive;
- less efficient;
- high operational cost (battery, space, AC)
Modern Solution Available

Active Voltage Conditioner

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>• no energy storage required;</td>
<td>• extremely fast &amp; accurate;</td>
</tr>
<tr>
<td>• correction of under &amp; over voltage, even with regenerative loads;</td>
<td>• power electronic based;</td>
</tr>
<tr>
<td>• rugged overload capability;</td>
<td>• small dimensions / footprint;</td>
</tr>
<tr>
<td>• correction capabilities: 20% or 40%;</td>
<td>• high reliability;</td>
</tr>
<tr>
<td>• low voltage solution, size per unit 150 kVA to 3.6 MVA;</td>
<td>• high efficiency;</td>
</tr>
<tr>
<td>• integrated event log;</td>
<td>• operating temperature range 0°C–50°C;</td>
</tr>
<tr>
<td>• Ethernet connectivity;</td>
<td>• low cost of ownership;</td>
</tr>
<tr>
<td>• modular construction;</td>
<td>• commonality of spares;</td>
</tr>
<tr>
<td></td>
<td>• low maintenance.</td>
</tr>
</tbody>
</table>
No Protection Against Voltage Disturbances
PCS100 AVC Dip / Sag Protection

Utility Sag

Injection Transformer

Bypass

Rectifier and Inverter
PCS100 AVC Surge / Swell Protection

Utility Swell → Rectifier and Inverter

Injection Transformer → Bypass

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Slide 12
Utility / Supply Related Power Quality Issues

Power outage

- **Definition**: loss of electric power, could last momentarily or continuously;
- **Causes**: temporary or permanent disturbance, e.g.: auto-recloser operation, etc;
- **Effect**: electrical and electronic equipment to trip or malfunction;

![Power outage diagram]
What is the solution?
## Industrial UPS vs Commercial UPS

<table>
<thead>
<tr>
<th>Description</th>
<th>Commercial UPS</th>
<th>Industrial UPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical load</td>
<td>IT (computer, server), sensor, meter, control system, etc.</td>
<td>IT &amp; Industrial e.g.: motors, drives, transformers, production tools, etc.</td>
</tr>
<tr>
<td>Topology</td>
<td>Double conversion</td>
<td>Single conversion</td>
</tr>
<tr>
<td>Maximum efficiency</td>
<td>95.5%</td>
<td>99.5%</td>
</tr>
<tr>
<td>Static switch design</td>
<td>Hybrid – electro mechanical</td>
<td>Full electronic</td>
</tr>
<tr>
<td>Failure in static switch power supply and / or microprocessor</td>
<td>May drop critical loads</td>
<td>Static switch fails to bypass source</td>
</tr>
<tr>
<td>Battery life time</td>
<td>2 years</td>
<td>10 years</td>
</tr>
<tr>
<td>Product / system life time</td>
<td>5 – 7 years</td>
<td>15 – 25 years</td>
</tr>
</tbody>
</table>
ABB’s Commercial Stand Alone UPS

**PowerValue 11 RT**
- Parallelable up to 2 units
- System power 20 kVA
- Single-phase rack or tower convertible

**PowerScale**
- Parallelable up to 20 units
- System power 1000 kVA
- 3 different cabinets and configurations
- Three-phase standalone tower

**PowerValue 11/31 T**
- Parallelable up to 4 units
- System power 80 kVA
- Single in/three-phase out standalone tower

**PowerWave 33**
- Parallelable up to 10 units
- System power 5000 kW
- 10 different cabinets and configurations
- Three-phase standalone tower
ABB’s Commercial Modular UPS

DPA UPScale ST
- Parallelable up to 20 modules
- System power 400 kW
- 5 different cabinets and configurations

Conceptpower DPA
- Parallelable up to 30 modules
- System power 1500 kVA
- 2 different cabinets and configurations

DPA UPScale RI
- System power 80 kW
- Rack-independent UPS system
- 7 different subracks and configurations

Conceptpower DPA 500
- Parallelable up to 30 modules
- System power 3000 kW
PCS100 UPS-I (Industrial UPS – Low Voltage)

- single conversion;
- industrial grade, suitable for motors, pumps, compressors, drives, transformers, production tools, etc.;
- modular design with advanced redundancy;
- very high fault current capacity;
- ultra-capacitor or battery storage;
- generator walk-in algorithm;
- Capacity 150 kVA to 3 MVA and voltage 208 V to 480 V
- highest reliability;
- long lifetime energy storage;
- small footprint;
- highest efficiency (>99%) and availability;
- the lowest total cost of ownership;
- easy serviceability & maintenance.

Features

Benefits
PCS100 UPS-I (Industrial UPS)

Single line diagram
PCS100 UPS-I (Industrial UPS)

Utility voltage within limit

- Inverters → off, but synchronized with the utility voltage;
- Float charger → maintains the battery or ultra-capacitor storage.
Utility disturbance occurs

Utility Disconnect → commutated off instantaneously with ABB’s commutation technique
PCS100 UPS-I (Industrial UPS)

Utility disturbance occurs

Utility Disconnect → commutated off instantaneously with ABB’s commutation technique
Utility voltage returns

PCS100 UPS-I (Industrial UPS)

UPS-I → synchronizes and closes the Utility Disconnect;
UPS-I → softly transfer the load to the utility or generator;
UPS-I → energy storage is then rapidly recharged.
PCS120 MV UPS (Industrial UPS – Medium Voltage)

- Reduced cost (less current – less copper – less cable);
- Increased efficiency (less current – less losses);
- Performance → IEC 62040-3 Class 1;
- Modular & redundant architecture (n + n);
- Voltage → 6.6kV; 11kV, 20kV (IEC)
  → 15kV (UL)
- Capacity → 2.25MVA - >50MVA
PCS120 MV UPS

Z-Impedance Isolated Static Converter (ZISC) Architecture
PCS120 MV UPS

Power Conditioning Mode

Utility Supply

Protected Load

Active Power

Reactive Power

Reactive Power

Input voltage

Output voltage

April 1, 2019
PCS120 MV UPS

Independent Mode

Utility Supply

Input voltage

Output voltage

Protected Load

Active Power

Reactive Power
# Industrial UPS vs Diesel Rotary UPS

<table>
<thead>
<tr>
<th>Description</th>
<th>Diesel Rotary UPS</th>
<th>Industrial UPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topology</td>
<td>Electro-mechanical, not modular</td>
<td>Fully electronics, modular, redundant</td>
</tr>
<tr>
<td>Reliability</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Maximum efficiency</td>
<td>90%</td>
<td>99.5%</td>
</tr>
<tr>
<td>Maintenance cost</td>
<td>Very high</td>
<td>Much lower</td>
</tr>
<tr>
<td>Component failure rate</td>
<td>Very high / frequent</td>
<td>Very low</td>
</tr>
<tr>
<td>Product life time</td>
<td>&lt; 10 years</td>
<td>20 – 25 years</td>
</tr>
<tr>
<td>Noise &amp; vibration</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Air pollution</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Load Related Power Quality Issues
Load Related Issues

True power factor

Displacement Power Factor / Reactive Power

\[ \text{Displacement PF} = \cos \varphi = \frac{P}{S} \]

Distortion Power Factor / Harmonic

\[ \text{Distortion PF} = \frac{1}{\sqrt{1 + (\text{THD}_i)^2}} \]
(Assuming THD < 10%)

True power factor = displacement power factor x distortion power factor
Load Related Issues

Regenerative load

PF lagging

$V_{\text{Sag}}$ 80% Utility

$S = P + Q$
Voltage $\rightarrow$ 80% nominal

Load consuming power

PF leading

$V_{\text{Swell}}$ 110% Utility

$S = P - Q$
Voltage $\rightarrow$ 110% nominal

Load regenerating power
Load Related Issues

Dynamic load

**Definition:** load which draws high inrush current during start-up, and fast changing reactive current during operation;

**Effect:** power quality events e.g.: voltage sag / dip, voltage fluctuation / variation;

**Examples:** motor starting, welders, cranes, press, crusher, variable frequency drives (VFD);
Background
Load / current imbalance

Root cause: single phase or line to line loads;
Effect: heating on motors, trip or malfunction on VSDs;

If supply is balanced, current waveform has double pulse per half cycle shape;

If supply is imbalanced, current deviates to a single pulse, causes more stress to diodes, and lead to tripping (DC-undervoltage) or malfunction (diodes, DC-caps.)
What is the solution?
Traditional Solutions…?

Capacitor bank:
• can only fix displacement power factor (reactive power);
• can only fix “lagging” power factor, but NOT “leading” power factor;
• vary in number of steps with delay (not suitable for dynamic load);
• reluctant to harmonics due to resonance effect;
• cannot fix current imbalance;
• cannot / very limited capability to stabilize voltage;
• require large space;

Harmonic filter:
• can only fix distortion power factor (harmonics);
• cannot fix current imbalance;
• cannot / very limited capability to stabilize voltage;
• require large space;
PQCR

- fix *displacement power factor* (reactive power), both leading and lagging;
- fix *distortion power factor* (harmonics);
- fix current imbalance;
- fix inrush generated dip/sag;
- fix voltage flicker;
- stabilize voltage (over & under voltage);
- compact dimension;
- long life time with minimum maintenance;
Reactive Power Conditioner

Technical comparison

2MVA transformer (6% impedance), feeding 400V bus with mixed reactive & harmonic industrial loads of 1.5MVA:

<table>
<thead>
<tr>
<th></th>
<th>No Compensation</th>
<th>VAR only (capacitor bank)</th>
<th>Harmonics only (active filter)</th>
<th>PQCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement PF</td>
<td>0.85</td>
<td>0.99</td>
<td>0.85</td>
<td>1.00</td>
</tr>
<tr>
<td>5\textsuperscript{th} harmonic current</td>
<td>30%</td>
<td>30%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>7\textsuperscript{th} harmonic current</td>
<td>12%</td>
<td>12%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>11\textsuperscript{th} harmonic current</td>
<td>5%</td>
<td>5%</td>
<td>0%</td>
<td>5%</td>
</tr>
<tr>
<td>13\textsuperscript{th} harmonic current</td>
<td>2%</td>
<td>2%</td>
<td>0%</td>
<td>2%</td>
</tr>
<tr>
<td>THDi</td>
<td>33%</td>
<td>33%</td>
<td>0%</td>
<td>5%</td>
</tr>
<tr>
<td>Distortion PF</td>
<td>0.950</td>
<td>0.950</td>
<td>1.000</td>
<td>0.999</td>
</tr>
<tr>
<td>Total PF</td>
<td>0.808</td>
<td>0.941</td>
<td>0.850</td>
<td>0.999</td>
</tr>
<tr>
<td>Load Voltage</td>
<td>389 V</td>
<td>397 V</td>
<td>389 V</td>
<td>400 V</td>
</tr>
<tr>
<td>Transformer Loading</td>
<td>93%</td>
<td>80%</td>
<td>88%</td>
<td>75%</td>
</tr>
</tbody>
</table>
Frequency related power quality issues
The World’s Frequency Map

- 50 Hertz
- 60 Hertz
- 50 / 60 Hertz
Tradational Solutions...?

Grid frequency converter
- this is a modified UPS;
- not modular, less reliable;
- less efficient, needs large space & air conditioner;
- capacity per unit is 500 kVA only.

Variable speed drive
- high harmonic (no harmonic filter);
- output voltage varies, depends on the input;
- no bi-directional & synchronize capability.

Rotary converter
- less efficient;
- difficult & costly maintenance;
- output frequency varies, depends on the input;
- high MTTR (e.g. bearing replacement);
- require large space;
- very high noise;
**Modern Solution**

PCS100 Static Frequency Converter

- Marine certified!
- Specifically designed to convert frequency of 60Hz to 50Hz, or vice versa;
- Convert input voltage to a different output voltage if required by the load;
- Proven power electronics (IGBT) technology - no moving elements - low maintenance;
- Modular & redundant architecture – high reliability;
- Capacity: 125 kVA to 2000 kVA per unit or higher;
- Built-in synchronizer, and power control functions;
Modern Solution

PCS100 Static Frequency Converter

- Compact design – small footprint - high power density;
- Precise output frequency & voltage generation, independent of input fluctuation;
- Bi-directional power flow – industrial & heavy duty grade;
- Excellent Mean Time To Repair (MTTR) – a few minutes to replace broken module;
- Remote monitoring and control through Ethernet, Modbus-TCP/IP protocols;
PCS100 Static Frequency Converter

Industrial application

SFC to power relocated 50Hz / 60 Hz machinery in a 60Hz / 50 Hz country
ABB’s Local Engineering & Technical Support

✓ Pre-purchase engineering;
✓ Installation and commissioning;
✓ Technical support;
✓ Training;
✓ Preventive and corrective maintenance and maintenance spare parts kits
✓ Retrofit and refurbishment;
✓ Globally available, supported by regional service hubs and operating in more than 100 countries
✓ Spare part availability and stocking
✓ On-site repairs
✓ 24 x 365 local support line
Project References
PCS100 AVC
South Kalimantan - Indonesia

Customer
PT Indonesia Bulk Terminal
- Indonesia’s mining and energy group;
- ADARO group of companies;

Issue
Power quality events:
- Voltage dips & swells;
- Continuously fluctuated supply;

ABB’s solution
- 1 x PCS100 AVC-30, 600 kVA;
- COD: 28 April 2014;
PCS100 AVC
Port Moresby – Papua New Guinea

Customer

The Government of PNG
– At Taurama Aquatic Center & Indoor Sport Complex, for the 15th Pacific Games;

Issue

Power quality events
– Protection against unstable / fluctuated supply for sensitive loads within the stadium;

ABB’s solution

– 2 x PCS100 AVC-30, 600 kVA;
– COD: 04 July 2015;
PCS100 AVC & PCS100 UPS-I (Industrial UPS)

Yogyakarta - Indonesia

Customer

PT Sarihusada Generasi Mahardhika
- Indonesia’s largest milk powder producer;
- DANONE group of company;

Power quality events
- Voltage dips & swells;
- Unstable / fluctuated supply;
- Short term power outages;

ABB’s solution
- 1 x PCS100 AVC-40, 150 kVA;
- 1 x PCS100 UPS-I, 150 kVA;
- COD: 18 January 2017;
**PCS100 AVC - Active Voltage Conditioner**

Cikedokan, West Java - Indonesia

**Customer**

PT Coca Cola Amatil Indonesia
- Major bottling partner of the Coca Cola Company;
- The largest Australian investment business in Indonesia;

**Issue**

- Voltage regulation for new coating, and blow molding machine;
- Unstable / fluctuated supply

**ABB’s solution**

- 1 x PCS100 AVC-20, 500 kVA;
- COD: 07 March 2017
**PCS100 SFC – Static Frequency Conditioner**

Tenau, Flores - Indonesia

### Customer

PT PELINDO 3
- State-owned enterprise in port services & operation

### Issue

- 50 / 60 Hz conversion for container crane auxiliaries;
- Unstable / fluctuated supply

### ABB’s solution

- 1 x PCS100 SFC, 250 kVA;
- COD: 18 October 2017
PCS100 SFC – Static Frequency Conditioner
Surabaya, East Java - Indonesia

Customer
PT PELINDO 3
– State-owned enterprise in port services & operation

Issue
– 50 / 60 Hz conversion for container crane auxiliaries;
– Unstable / fluctuated supply

ABB’s solution
– 1 x PCS100 SFC, 250 kVA;
– COD: 13 April 2018
PCS100 AVC - Active Voltage Conditioner

Pekanbaru, Riau – Indonesia

Customer

PT PLN (Persero) Pembangkitan
Sumatera Bagian Utara,
Sektor Pembangkitan Pekanbaru,
Pusat Listrik Balai Pungut

Issue

- Unstable / fluctuated supply for fuel feeder pump of the diesel / gas engine power plants;

ABB’s solution

- 1 x PCS100 AVC-40, 150 kVA;
- COD: 14 May 2018
PCS100 AVC - Active Voltage Conditioner

Port Moresby – Papua New Guinea

Customer

The government of PNG
– Star Mountain Plaza project;
– Including 5 star hotel, convention center, apartment & malls;

Issue

– Unstable / fluctuated utility supply;
– Dynamic & highly inductive loads;

ABB’s solution

- 1 x PCS100 AVC-20, 1000 kVA;
- 1 x PCS100 AVC-20, 1500 kVA;
- 1 x PCS100 RPC, 416 kVAr;
- COD: 25 July 2018
PQCR – Reactive Power Compensation

Kendari, South East Sulawesi - Indonesia

Customer

PT PELINDO 4
– State-owned enterprise in port services & operation

Issue

– Highly dynamic regenerative loads (lagging & leading power factor);
– Load imbalance;

ABB’s solution

– PQCR: 2000 kVA;
– COD: in progress
For inquiry, please contact:

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So let’s talk