Many unscheduled downtime issues throughout the facility are caused by fluctuations in the quality of the power coming to the machine.

These fluctuations can also decrease the life of electrical components by adding heat and stress in the circuits.

Rockwell can provide a variety of solutions which can increase the life of your components and reduce downtime:

- **Using power correction devices**
  - DySC (Dynamic Sag Corrector), Buffer Module, and UPS
    - Benefits of each
    - Best use cases for each
    - Protect against facility level quality issues

- **24VDC N+1 Redundancy Circuits**
  - Protect against downtime caused by localized faults
Agenda

Power Quality Overview

Does Your Plant have Power Issues?

Protection of AC Circuits

Protection of DC Circuits

Summary
Power Quality Overview

Quality vs. Reliability and Why Does It Matter?
Power Quality vs. Power Reliability

- **Power Quality**: Related to fluctuations in electricity, such as momentary interruptions, voltage sags or swells, flickering lights, transients, harmonic distortion and electrical noise
  - Fewer such incidents indicate greater power quality
  - Events go mostly untracked by Utilities

- **Power Reliability**: Continuity of electric delivery measured by the number and duration of power outages (Zero voltage)
  - Outages are tracked by Utilities
  - Power can be as high as 99.999% reliable
  - Remaining 0.001% can take out a process as many as 20-30 times per year

The Grid is designed for Reliability, not Quality…
Legal Requirements of the Utility

- Wisconsin Public Service Commission
  - PSC 113.0703: Variations of voltage caused by action of the elements, equipment failure, infrequent or unavoidable fluctuations of short duration, normal operations, or other causes beyond utility control may cause: Interruptions, Sags, Swells, Transients
    - Customers having equipment or operations that are sensitive to such voltage fluctuations … may find it necessary to install, at their own expense, power conditioning equipment or other modifications …
  - The service voltage shall be reasonably constant within the following limits:
    - Residential: ±5%
    - Retail Power < 500kW: +5%, -10%
    - Retail Power > 500kW: ±10% (432V-528V for a 480V customer)

The utility is responsible for reliability, not quality of power….the customer is responsible for protecting their sensitive equipment at their own expense.
Causes of Power Quality Events

Facility Problems

- Starting of large loads – motors
- Poor electrical connections
- Accidents (Fork Trucks/Spilling Water)

Faults on the utility system

- Lightning
- Animal/bird/tree contact
- Cable failures
- Cable dig-ins & vehicle/airplane contact
- Recloser/fuse/breaker operations
- Equipment failure/contamination
**Events Overview**

- **EPRI (Electrical Power Research Institute)**
  - Monitored 300 sites for 2+ years.
  - 1993 study: 92% of all events were voltage sags under 2 seconds.
  - 1995 study: 96% of all events were voltage sags less than 2 seconds.

<table>
<thead>
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<th>Frequency of Occurrence</th>
<th>Typical Incident Cost</th>
</tr>
</thead>
<tbody>
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<tr>
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</table>

- **Unbalance** (Fluctuating)
- **Swell** (0.5 cycles – 60s)
- **Noise** (Constant)
- **Sag** (0.5 cycles – 60s)
- **Harmonics** (Constant)
- **Overvoltage** (>1 minute)
- **Notching** (Constant)
- **Transient** (<50 ns – 5 ms)
- **Undervoltage** (>1 minute)
- **Interruption** (0.5 cycles – >1 hr)
- **Overvoltage** (>1 minute)
- **Undervoltage** (>1 minute)
- **Sag** (0.5 cycles – 60s)
- **Transients** (<50 ns – 5 ms)
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- **Harmonics** (Constant)
- **Notching** (Constant)
- **Interruption** (0.5 cycles – >1 hr)
- **Overvoltage** (>1 minute)
- **Undervoltage** (>1 minute)

**Grid Related**

**Facility Related**
Power Issues Cause Downtime

- Sags and interruptions cause components to drop out
- Noise and Harmonics can cause devices to “act up” or provide incorrect feedback to PLC
- Many issues increase heat and wear down internal componentry
- Downtime issues are made worse by spending time trying to troubleshoot the cause without the proper devices in place to accurately monitor how power quality is affecting the devices
Voltage Sags Damage Equipment

When voltage returns, high current inrush can occur because the Soft-charge ckt. is bypassed RF Amplifiers; Gradient Amplifiers; Low Voltage Power Supplies and Variable Frequency Drives, subjected to repeated hits—Over Time Causes Failure.

Typical Rectifier Circuit diagram:
How Voltage Sags Damage Equipment

Example: Inrush current measured for 1kVA electronic load

**Normal inrush**:
- Peak inrush: 10A
- Soft-charge circuit is active

**Inrush after Sag**:
- Peak inrush: 50A
- Soft-charge circuit bypassed

Note the scale change necessary to get the sagged results on the same page!
Does Your Facility have Power Issues?

Strategies and Components to Understand Power in Your Plant
Strategies to Understand Power in Your Plant

- **Step 1** – Install a monitoring device to capture power quality events and related downtime
- **Step 2** – Analyze the data from the monitoring and the manufacturing processes
- **Step 3** – Implement a mitigation plan
Strategies to Understand Power in Your Plant

- Step 1 – Install a monitoring device to capture power quality events and related downtime
  - Listen
- Step 2 – Analyze the data from the monitoring and the manufacturing processes
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- Step 1 – Install a monitoring device to capture power quality events and related downtime
  - Listen
- Step 2 – Analyze the data from the monitoring and the manufacturing processes
  - Think
- Step 3 – Implement a mitigation plan
  - Solve
Listen: i-Sense Voltage Monitor

- Easy to use and install
- Virtually maintenance-free
- Voltage-only monitor:
  - 1-Phase, 3-Phase or dual 3-Phase measurement
  - 26 User configurable voltages between 100V and 480V
  - 50/60 Hz Auto-sensing
- Connected to the i-Grid Network

Think: i-Grid Monitoring Network

- Ethernet and global modem capability
- 1-year subscription included with purchase of monitor
- Over 5 Years of data, over 2 million events captured
- Linked to national weather database
- Corroboration notifications: transmission event or local distribution
Power Monitor 5000 / E300

- Install PM 5000 on your Factory Talk network and program it for PQ event and wave capture
- Energy Management
  - FT Energy Metrix
  - Shadow Billing
- E300 can monitor voltage, current, ground fault, & energy (on one single load or upstream of a small process)
- Get notifications for power events via Studio or embedded web server
Single Event Detail: What Just Happened?

- Monitor Number, Time, Duration
- Min / Max RMS, Worst Case RMS as % of Nominal
- Waveform of each phase (4 cycles at beginning and 4 cycles at end of event)
- RMS – Every ½ cycle throughout event

Use this information to correlate unexplained downtime with power quality events
Summary of Events: What is the Long-term Trend in My Facility?

Event Overview by duration and severity

Monthly Summary

RMS plots

Understand the long-term impact on a facility or multiple facilities
Value of Power Quality Data

Rockwell Automation / Distributor

- Installed Base:
  - Currently ~90+% in US & Can
  - Longest installed customer dates back to 2002
- Direct line-of-sight into customers for resource-based troubleshooting assistance
- Insight into local, regional, national, global power quality trends

Customer

- Short-term: Diagnose downtime quickly
- Long-term: Power Quality trends
  - Random issues are tough to quantify without continuous monitoring
  - OEM: Warranty protection
  - Are customers providing quality power to my machine / product?
Protection of AC Circuits
Provide Clean, Steady Power to the Panel
Rockwell Automation Power Event Correction

• Dynamic Sag Corrector – DySC®
  • Product Overview
  • DySC® Technology Overview & Capabilities
  • Product Features

• UPS
  • Power Events & UPS Products
  • UPS Technology Overview
  • UPS Product Portfolio
DySC® (Dynamic Sag Corrector)

- DySC® (pronounced “Disk”) is an adaptive power supply that optimizes the remaining power during a sag by using patented inverter technology to compensate for the sag thereby maintaining an uninterrupted flow of optimal power to the load thus maximizing uptime, minimizing inventory loss and reducing maintenance costs.

- Up to 5 seconds of ride through.

MiniDySC® (Single-phase; 2 – 50 Amps)
<table>
<thead>
<tr>
<th></th>
<th>MiniDySC</th>
<th>ProDySC</th>
<th>MegaDySC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amp Range</td>
<td>1-50A</td>
<td>25-200A</td>
<td>400-2400A</td>
</tr>
<tr>
<td>Voltage Range</td>
<td>100-240V</td>
<td>208-480V</td>
<td>208-480V</td>
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<tr>
<td>Power Range</td>
<td>0.25-14kVA</td>
<td>10-165kVA</td>
<td>333-2000kVA</td>
</tr>
<tr>
<td>Mounting</td>
<td>Din rail / Panel</td>
<td>Panel/Floor</td>
<td>Floor</td>
</tr>
<tr>
<td>Phases</td>
<td>1 Phase</td>
<td>3 Phase</td>
<td>3 Phase</td>
</tr>
<tr>
<td>Ride Through</td>
<td>Up to 5 seconds</td>
<td>Up to 5 seconds</td>
<td>Up to 5 seconds</td>
</tr>
<tr>
<td>Applications</td>
<td>Controls, Component Level</td>
<td>Small Machine, Drives</td>
<td>Process, bus level</td>
</tr>
<tr>
<td>Batteries</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Energy Efficiency</td>
<td>99+%</td>
<td>99+%</td>
<td>99+%</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Minimal</td>
<td>Minimal</td>
<td>Minimal</td>
</tr>
<tr>
<td>Enclosure</td>
<td>NEMA 1 (IP20)</td>
<td>NEMA 1 (IP20)</td>
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</tr>
<tr>
<td>Temp Rating</td>
<td>0-40°C</td>
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Features and Benefits

- Lower cost of ownership than UPS:
  - Smaller size
  - Lower weight
  - Lower energy consumption
  - Easier to justify
- No HVAC required
- Protects to 0 volts
- Up to 5 Seconds of ride through
- True Sine Wave Output
- GREEN Solution

Typical Customer Drivers Towards DySC®

- Have power quality issues
- Batteries are not a realistic option (e.g. SEMI F47)
- Achieve quick ROI with a very long life (>20 years)
- Use a “GREEN” solution with minimal operating costs
- Retrofit without modifying the physical facility
- Ensure reliable product scheduling
- Minimize Service costs.
- Increase equipment “uptime” (approaching 100%)

Efficiency

Most facilities experience 20 - 30 voltage sags each year, lasting typically less than a 1/2 second. This means the DySC® power electronics run less than 30 seconds per year.
Rockwell Automation Power Event Correction

- Dynamic Sag Corrector – DySC®
  - Product Overview
  - DySC® Technology Overview & Capabilities
  - Product Features

- UPS
  - Power Events & UPS Products
  - UPS Technology Overview
  - UPS Product Portfolio
Power Events & UPS Products

- **Interruption**
  - Source: Utility
  - Duration: 0.5 cycles → 1 hour
  - Symptom: Equipment shutdown
  - Protection: Energy storage or self-generation

- Three different types of UPS Technology
  - Offline/Stand-By
  - Line Interactive
  - Double Conversion/Online

UPS products provide solution for power interruptions
Existing Product Line Overview

1609-B
- 600VA and 1kVA
- Multiple Voltages:
  - 120V, 208/230VAC
- Din rail or Panel/Floor Mount
- Dry Contacts
- Line Interactive
- Simulated Sinewave
- Integrated Remote On/Off
- Replaceable Surge protection
- USB Communication

1609-D
- Up to 1500VA
- Multiple Voltages:
  - 120V, 208/230VAC
- Panel or Floor Mount
- Expandable Batteries
- Dry I/O Contacts
- Remote On/Off
- Replaceable Surge Protection
- Line Interactive
- Pure Sinewave Communications
  - USB
  - SNMP(Webserver)
  - Ethernet/IP
DySC® and UPS Correction Capability

Magnitude vs. Duration Scatter plot

- Voltage Surge/Swell
- Normal Utility Operating
- UPS Protection
- On-Site Generation

DySC Protection

Remaining RMS Voltage vs. Duration (Seconds)
DySC® and UPS Best Use Cases

**DySC® Solution:**
- Voltage Sag Correction
- Runtime: 2-5 sec
- Faster reaction/correction time (compared to Standby or Line Interactive UPS)
- Lower total cost of ownership of compared to UPS
  - No Battery replacement
  - No Battery disposal

**UPS Solutions:**
- Surge/Filter Protection
- Automatic Voltage Regulation (AVR)
- Runtime: min - hrs
- Communication
- Remote On/Off
Panel Protection RA Solutions

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- **Sag (0.5 cycles – 60s)**: UPS, DySC
- **Undervoltage**: UPS, DySC
- **Overvoltage**: UPS, Surge
- **Noise (Filter)**
- **Harmonics (Constant)**
- **Swell (0.5 cycles – 60s)**
- **Notching (Constant)**
- **Transient (Surge)**
- **Grid Related**
- **Facility Related**
Protection of DC Circuits

Small Changes Can Have a Big Impact
Buffer Modules

- When your application requires sub-second runtime
  - e.g. 670ms at 10A load for 1606-XLSBUFFER24
- Statistics show that 80% of all power source faults/ouages last less than 200ms
  - These outages (voltage dips and drops or inrush spikes, etc.) are completely bridged by the buffer unit and will have no influence on the DC power, increasing the reliability of the system as a whole
- Service-free electrolytic capacitors are used for storing the energy
- The buffer unit does not require any changes to your control wiring, it can be added parallel to the load circuit at any given point
- Clear status indication by status LED, Control, and signaling terminals
- Provides additional power for short and heavy peak loads
- Any number of units can be installed in parallel to increase power buffer or back-up time

Outcomes/Benefits of Buffer Modules:

Buffer module bridges short-duration voltage dips with its electrolytic capacitors and reliably preserves interruption-free operation
DC UPS (battery-less)
EDLC (Electrochemical Double Layer Capacitors)

- When your applications require Sub-minute backup runtime
- Built-in capacitors as energy source, EDLC
- Wide temperature range: -40…+60 °C (-40…+140 °F)
- Typically >10 years operational lifetime expectancy
- Regulated output voltage in Buffer mode
- No ventilated cabinets required, no generation of hydrogen as valve-regulated lead-acid (VRLA) batteries do
- Active balancing for longest life and buffer times
- Short charging time, unit is rapidly back in Ready mode
- Output is decoupled from the input to separate load circuits into buffered and non-buffered sections
- Supports PC-mode function
- Expensive solution with lowest TCO

Applications of EDLC:
- Controlled shut-down of a system
- Communication Devices (Stratix)
- Industrial Computers (support PC-Mode function)
Parallel Use for Longer Buffer Times with DC-UPS (EDLC)

- DC-UPSs can be paralleled to extend the buffer time
Traditional DC-UPS with Batteries

- Most versions requires only One 12V Battery for a 24V Output
- 10A & 20A rated current and additional 50% Power Reserve
- Stable Output Voltage in Buffer Mode
- Superior Battery Management for Longest Battery Life
- Comprehensive Diagnostic and Monitoring Functions
- Replace Battery Signal Included
- Electronically Overload and Short Circuit Protected
- Selectable Buffer Time Limiter
Summary of High Available Systems

- **Buffer Modules**
- **DC UPS (EDLC)**
- **DC UPS (Battery)**

Run Time:
- 0 1 2 ..... seconds
- 40 45 60 seconds
- 1....30....60....180... minutes...hours...days

Product Type:
- Buffer Modules
- DC UPS (EDLC)
- DC UPS (Battery)
Redundancy

- Why can’t I just put two power supplies in Parallel?

Need to have a Diode or MOSFET to prevent a fault from cascading.
Hence the need for Redundancy!
Redundancy

- To produce redundant applications (reliable VDC system)
- To decouple power sources from each other as well as from the loads e.g. separation of sensitive loads from the power bus, design buffered branches, block reverse power.

Outcomes/Benefits of Redundancy:

- Fault tolerant VDC system for high availability
- External to Power Supply DC-OK monitoring
  - Protection during battery charging
- Blocking of energy which is fed backwards from a decelerating motor (back emf)
- Saving energy in buffered (Buffer Modules/EDLCs) branches

Two types of Redundancy modules:
- 2 Inputs and 1 Output
  - 1606-XLSRED$40HE
- 1 Input and 1 Output
  - 1606-XLSRED$40HF
- It allows replacing the power supply or the redundancy module while the system is running
Summary

Listen, Think, Solve
Don’t forget…

- Power issues have a large impact
  - Energy cost,
  - Equipment life due to excess heat and stress on components
  - Reliability
  - Reliable products save downtime costs (scrap, loss of production, clean-up time, etc.)
Improve Quality and Uptime

- **Listen**
  - Most facilities experience 20-30 power events each year
  - A better understanding of what you experience will allow you to create an effective plan to mitigate

- **Think**
  - Using the data gained a proper mitigation plan can be created to specifically address your needs

- **Solve**
  - Rockwell Automation offers a broad array of products to meet your needs, no matter how big or small they may be
Thank You!