Data Center Expert Day, September 29, San Francisco, CA

Data Center Expert Day
Intelligent data needs intelligent power
# Data Center Expert Day

## Agenda

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<td>Welcome</td>
<td>Brian Davis</td>
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<td>1:10-1:30</td>
<td>Technology advances for the future of the data center</td>
<td>Dave Sterlace</td>
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<td>Part 1: Next level monitoring and control for optimized operations</td>
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<td>Saving time and money with data center automation</td>
<td>Rich Ungar, Business Manager, Data Center Automation</td>
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<td>2:00-2:30</td>
<td>The missing piece – Operation Management</td>
<td>Chris Martinez, Industry Solutions Executive, Enterprise Software</td>
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<td>The key to uptime and reliability – Asset condition monitoring</td>
<td>Dinesh Sachdeva, Business Manager Director, Service</td>
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<td>3:00-3:15</td>
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<td>Part 2: Technology innovations for power quality, efficiency and safety</td>
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<td>Transformer design enhancements for safety and reliability</td>
<td>Jamie Ritter, Channel Manager, Transformers</td>
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<td>3:40-4:05</td>
<td>Benefits of the modular UPS to a data center</td>
<td>Joergen Madsen, Business Development Manager, Power Protection</td>
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<td>4:05-4:30</td>
<td>IEC 61850 GOOSE enabled innovations</td>
<td>Don Elliot, Product Manager, Medium Voltage</td>
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<td>4:30-4:45</td>
<td>Q&amp;A and Wrap Up</td>
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<td>4:45-6:45</td>
<td>Meet &amp; greet with the experts in Triple Alley on the field at AT&amp;T Park</td>
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<td>7:15</td>
<td>SF Giants vs. Colorado Rockies Baseball Game</td>
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© ABB
3-Oct-16
Dave Sterlace, Global Head of Technology, ABB

Internet of things, services and people
An ABB perspective
What do you need to know about IoT?

Unprecedented Scale

20B connected devices by 2025 per Gartner 50B per Cisco!
What do you need to know about IoT?

Wireless

100k cell sites in NYC in 2025 vs 3000 today
What do you need to know about IoT?

Latency

...will drive Edge
What do you need to know about IoT?

Security

...Target’s breach went in through HVAC “back door” in ‘12
What do you need to know about IoT?

Flexibility

...infrastructure must scale with IT loads
What do you need to know about IoT?

Visibility

...infrastructure must scale with IT loads
How the data will be analyzed and used is crucial, new business models emerge.

Devices and machines communicate with each other, deliver data for Big Data.

Humans remain in charge, program and control the activities of things.

How the data will be analyzed and used is crucial, new business models emerge.
Internet of Things, Services and People
Improves productivity, efficiency and reliability
Intranet of Things – Internet of Things

- Intelligent devices with sensors are providing large amounts of data
- Essential requirements remain (safety, reliability), cyber security and data privacy become more important

Internet of People

People will remain in control of the production process. People will be the decision makers

Internet of Services

- Services becomes more advanced through data analytics.
- Opportunities for new service models that build on collaboration.
Part 1

Next Level monitoring and control for optimized operations
Next level monitoring & control for optimized operations

1:40 – 2:05 PM - Saving time and money with data center automation
Rich Ungar, North America Business Manager, Data Center Automation
richard.t.ungar@ca.abb.com

2:05 – 2:30 PM - The missing piece – Operation Management
Chris Martinez, Industry Solution Executive, Enterprise Software
chris.Martinez@us.abb.com

2:30 – 2:55 PM - The key to uptime and reliability – Asset condition monitoring
Director, Business Development Service
dinesh.sachdeva@us.abb.com
Rich Ungar

Saving Time and Money with Data Center Automation
Learning from other industries is an opportunity

Data center industrialisation is inevitable
Data Center Automation takes industrial technologies and applies them to the data center

- Highly *available* infrastructure
- Super *efficient* industrial operations
- Automated workload management
Data center automation merges industrial monitoring, control systems and predictive analytics to optimize networked asset utilization, including virtual assets and services like the cloud, technology refresh, environmental conditions and even human workflow. At a functional level, controls deliver a highly reliable and secure machine-driven sequence of operations and repeatable processes. Thus, a data center infrastructure management system with controls provides intelligent, flexible, adaptable and ultimately autonomous control of the entire data center or fleet of data centers.”
’Islands of automation’ increase risk, cost, inefficiency
Eliminate the Silos

Converged DevOps and Management

All physical and virtual infrastructure as one

1. Power
   - Integrate all physical infrastructure monitoring, control, and automation
   - PMS, Substation, Switchgear, Utility Meter, Generators, Power Meters, UPS, BCM, PDU

2. Cooling
   - Enable optimal management of space, power, and cooling for the entire facility
   - BMS, Airflow, CRACs, VFDs, Chillers, Economisers, Pressure

3. White Space
   - Establish full IT workload management
   - Fire Control, Hotspots, Server Mon., VESDA, Plug in Strips

Comprehensive management of the 3 Cs in your data center:

Cost  Capacity  Control
Step 1 - Integrate all physical infrastructure monitoring, control and automation
CAPEX Benefits of One System

- One control technology
- One HMI to commission
- No system integrations
- No finger-pointing between controls vendors
- Reduce delays due to troubleshooting and rework
- Speed up commissioning time
- Less training required
- Fewer spares parts needed
What does an integrated Data Center Automation system look like?

- Common user interface
- Open hierarchical architecture with standardized integrations
- Use of high-availability designs and redundancy (when appropriate)
- Segmented networks and servers dedicated by system/area/function
- Common API for integration with 3rd-party applications
CAPEX Benefits of One Vendor

- One contract
- One site team, one project manager
- One wiring team, one set of controls wiring pathways
- One support contract
- One “neck to hug” (aka “throat to choke”)

Cost reductions through lower overhead & Coordinated construction activities
OPEX Benefits of a Data Center Automation Solution

- Know where your money is going
- Predict when expenses will occur
- Optimize your data center to reduce costs and improve performance
- Plan your future activities with accurate insight
- Better information means reduced risk
Reduced risk, cost and inefficiencies for data center operations and management teams by creating an Operational Management platform that provides real-time, high-reliability monitoring, control & automation.

Knowing Everything About Your Data Center - NOW

Schematic based approach

Connect to everything

Rich visualisation & dashboards
Seeing the Truth Behind the Data

Advanced alarming and alarm diagnostic capabilities, for fast troubleshooting
Sophisticated reporting and analytics environment
Looking Into the Future

Condition-based monitoring and prognostics integrated with maintenance management tools
Step 2 - Enable optimal management of space, power and cooling for the entire facility
Monitoring, reporting and analytics of energy utilization including the optimization of the use of supply resources to meet the predicted consumption at minimum total cost.
Optimize space, power and cooling capacity through intelligent placement of IT assets. Perform modeling and what-if analyses and automate and manage workflow processes.
Operations Management

Provide a consistent, organized, and integrated approach to those activities that affect equipment configuration, system status, and data center operation.
Step 3 - Establish full IT workload management
The Industrialized Data Center
Fully Integrated Facility and IT

Power
- Substation
- Switchgear
- Utility Meter
- Generators
- Power Meters
- UPS
- BCM
- PDU
- PMS
- EMS

Cooling
- CRACs
- VFDs
- Airlow
- CMS
- BMS
- Chillers
- Economisers
- Pressure
- CRACs
- VFDs
- Pressure

White Space
- Security
- Fire Control
- VESDA
- BCM
- Hotspots
- Server Mon.
- Plug in Strips
- App. Mon.
- Network Mon.

IT
- Network Compute Data Services
The Industrialized Data Center
Fully Integrated Facility and IT

Collect data into one place.

Get end-to-end insight.

Simulate possibilities.

Put into action.


Collect data into one place.
Aggregate for full spectrum of machine knowledge. Full transparency.

Get end-to-end insight.
Analyze. Real-time KPIs and benchmarks. Data visualization.

Simulate possibilities.

Put into action.

Aggregate for full spectrum of machine knowledge. Full transparency.

Automate.
End-to-end intelligence.

Speed of business goes from weeks/months to minutes/hours – with total governance.
Conclusion: Learning from other industries is essential

“"This really is an innovative approach, but I’m afraid we can’t consider it. It's never been done before."
The missing piece
Operation Management
The missing piece – Operation Management

Agenda

- Outage Statistics
- Data Center Operations Overview
- Operations Management
- Operations Solution
- Summary
Outage statistics
Delta, Jet Blue, and Southwest have all recently encountered problems.

- Delta: Data Center Outage Cost the company $150M over 3 days
- While Southwest didn’t disclose the exact cost of the outage, CNN estimated it to have been at least $177M in lost passenger revenue, based on ratios Southwest did provide.

Data Center Knowledge September 8, 2016
What if?

- You can’t access the internet to help your kids with home work or research something pressing?
- You can’t pay your mortgage, utilities, insurance, or other critical items in your life due to system issues?
- You can’t call home when you need to?
- The doctor can’t access your loved ones medical records at a critical moment of time?
The average cost of a data center outage has steadily increased from $505,502 in 2010 to $740,357 today (or a 38 percent net change).

Poneman Institute Study January 2016
Root Causes of Unplanned Outages

- Water, heat or CRAC failure: 10% (2016), 12% (2013), 15% (2010)
- Generator failure: 4% (2016), 4% (2013), 5% (2010)
- IT equipment failure: 4% (2016), 4% (2013), 5% (2010)
- Other: 0% (2016), 2% (2013), 0% (2010)

Poneman Institute Study January 2016
The Uptime Institute, citing the Emerson work, adjusted the results to equal 100% to show **battery failure and human error being responsible for more than 50% of all outages.**
Human Error or lack of investment?

- Accidental / human error remained unchanged from 2013 to 2016. There has not been enough focus on reducing human error as a root cause of Data Center Outage.

- Ponemon’s reported high rate of human-caused downtime may be worse, as other industry watchers have argued that cyber crime and UPS system failures are ultimately caused by humans.

- According to a 2014 report from IBM, over 95 percent of cyber crimes had human error as a contributing factor.

- The human factor was recently illustrated by the three hours of data center downtime that forced delays for JetBlue airlines. That failure was blamed on a power outage at a Verizon data center.
Operations Overview
Data Center Operations

- Operations run 24 x 7
  - Usually 3 8 hour shifts that overlap by 30 minutes
  - Graveyard is typically a skeleton crew 1 maybe 2 people
  - Weekend coverage is on the lower side
- Two types of technicians work in a Data Center
  - Engineer
    - Responsible for the infrastructure, UPS, AC, Pumps, Battery, etc
  - IT technician
    - Responsible for the servers, networking, routers, etc
- Data Center Operations plays a key role in your customer satisfaction and company image....
Data Center Engineer – job description

- The Data Center Engineer position is an important part of our data center team. This position will focus on supporting the real-time operational activities of a 7×24 world class co-location facility. The engineer in this position will be responsible for monitoring and maintaining the Mechanical systems, HVAC systems, building electrical, building controls, automation systems and general facilities support.

Position Responsibilities:

- Operate and maintain mechanical systems including but not limited to cooling towers, pumps, CRAC units, and roof top AC package units.

- Operate and maintain critical power system generators, UPS, ATS, PDU, high voltage dual feed systems and battery monitoring equipment.

- Work with contracted vendors to insure equipment is serviced and maintained without impacting the operation of the data center.

- Monitor the mechanical and electrical systems for proper operation.

- Respond to alerts from the Building Management System and resolve issues as needed.
Data Center Engineer – cont’d

- Monitor the proper operation.
- **Track and respond to trouble tickets for Facilities issues.**
- Make recommendations for improving the reliability, availability, and serviceability of the mechanical and electrical systems.
- Maintain building lighting fixtures.
- Perform minor electrical work as needed.
- Perform general maintenance within and around the facility as directed.
- Maintain a service oriented environment focused on problem prediction, detection and resolution.
- **Perform all work in a safe manner.**
- Self-starter with the ability and motivation to work independently with minimal direction.
- **Deliver status and communications on all issues.**
- Write procedures as may be needed.
- Participate in a rotating On-Call support schedule.
The Datacenter Technician is responsible for the daily operations and maintenance of the Datacenter. Performs or delegates all tasks associated with the installation, acceptance and maintenance of a variety of Telecommunication equipment. Responsibilities range from installation of cabinets, equipment, cross-connects, performing remote hands requests, and managing vendor maintenance of all critical infrastructure equipment. Project installation, testing and troubleshooting of Telecommunication infrastructure components including but not limited to Ladder rack, Fiber Guide, MDF, IDF, switches, routers and related cabling.

Expert working knowledge of copper (UTP, Cat5e, Cat6, Cat6a) and fiber optic media types, (MMF, SMF, 50 micron, 62.5 micron), industry standards and applications, and use cases (e.g., Ethernet, Fiber Channel, SONET, TDM).

Installs, provisions, tests, and maintains DS0 thru OC12 services, and equipment in support of network and customer requirements. Diagnoses, troubleshoots and repairs customer and network circuits.
Data Center Technician – cont’d

- Working knowledge with Data Center Network Hardware (Ethernet, Fiber Channel interfaces)

- Working knowledge of pertinent ISO Standards associated with Data Center Cable Infrastructure including ANSI-942, ANSI-568

- Expert working knowledge with Cable Management Systems (e.g., Cabinet, Ladder Rack, Iron Work, Cable Sewing)

- Responsible to lead the troubleshooting process and repairs in case of events or equipment failure providing recommendations to prevent reoccurrence of such events

- Monitors and responds to security, environmental, equipment monitoring systems

- Participate in regular facilities audits

- Participate in facilities post incident reviews as required
Challenges Requiring Investment in Operations Management

- Balancing Safety with operational efficiency
- Integration of plant processes to increase accuracy of execution
- Regulatory requirements affecting Operations Management
- Access to near real-time field information to enhance decision making

Supporting Data Center safety while enhancing reliability and productivity of Operations Management
The Cost of Inefficient Work Execution

Managing complex operations, there is no room for compromises or short cuts

...plus other considerations:

- Work crew safety
- Compliance, Audit Reporting
- Company reputation
- Overall system reliability
When Operations Management processes are weak ...

Rely on human experts to pull everything together in high pressure work environment

- Supporting Data Center activities online and during outages
- Equipment configuration control for worker safety
- Gathering field information for timely Decision making
- Needed data in multiple systems & formats
- Tracking operations status to regulatory requirements
- Logging operation activities
Value of Operations Management Solutions
The Value of an Operations Management Solution

Improve worker safety, equipment performance, work effectiveness, and regulatory compliance

- Know that worker safety is not compromised while increasing plant efficiency
- Know that the work is done right with quality and safety
- Know that your plant is operating at peak performance
Logbooks (accurate, real-time, collaborative)

Operations Management solution combines:

1. **Expertise**
   - Functional Activity Logs
   - Limiting Condition of Operations
   - Notice of Change Logging
   - Mobility
   - Enhancing knowledge sharing of activities while effectively tracking required limits for operation

2. **Analysis**
   - A set of functions that helps ensure process standardization and integration with plant operational requirements

3. **Actions**
   - Expanded and more timely dissemination of information to operations shifts and the entire organization

4. **Results**
   - Higher visibility of plant activities
   - Track and model operational requirements
   - Efficiency of field workers
**Rounds and Inspections (routine automation)**

Operations Management solution combines:

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<th>Expertise</th>
<th>Analysis</th>
<th>Actions</th>
<th>Results</th>
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<td>Rounds Performance</td>
<td>Decision Making</td>
<td>Allows the greatest opportunity to effectively utilize resources to integrate field monitoring with work execution activities</td>
<td>Timely access to physical plant conditions</td>
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<tr>
<td>Alerts, Limit Checks, Exception Logging</td>
<td>Evaluate</td>
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<td>Standardization of operational processes</td>
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<tr>
<td>Data Management</td>
<td>Optimize</td>
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<tr>
<td>Mobility</td>
<td>Plan</td>
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<td>Reduced operations costs</td>
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Enhancing the integration of operations related tasks while maximizing field level data entry.

A solution that ensures that field monitoring activities can translate to real-time decision making.

Allows the greatest opportunity to effectively utilize resources to integrate field monitoring with work execution activities.

Timely access to physical plant conditions.

Standardization of operational processes.

Reduced operations costs.
Clearances (focus on safety and compliance)

Operations Management solution combines:

1. Expertise
   - Clearances
   - Lineups
   - Work Management Support
   - Mobility
   
   A complete solution for managing the status of equipment for worker safety and work management

2. Analysis
   - Analyze
   - Evaluate
   - Optimize
   - Plan
   
   Ability to gather related items associated with work during all modes of Operations Management

3. Actions
   - Track and manage equipment status and work execution to effectively balance worker safety and work efficiency

4. Results
   - Worker safety
   - Work process Integration
   - Higher plant operational performance

ABB
Key Benefits: Operations Management

Improve worker safety, equipment performance, work effectiveness, and regulatory compliance with comprehensive Operations Management.

<table>
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<tr>
<th>Top benefits</th>
<th>How we can help</th>
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<tr>
<td>Improved workforce safety</td>
<td>Automate Permits to Work. Ensure safety checks actually performed and consider the conditions.</td>
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<td>Reduce shutdown duration</td>
<td>Efficient turnarounds with optimized tagging to eliminate overruns and minimize downtime</td>
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<td>Empower your workforce to make better decisions</td>
<td>Availability and visibility of key plant data, functional logs, shift turn-over information and regulatory requirements</td>
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<td>Improve consistency of work</td>
<td>Operations processes are being followed consistently while providing tools and templates which adjust to suit work conditions.</td>
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<td>Improve process efficiency</td>
<td>Information system integration for plant data management and correlation of plant activities</td>
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<tr>
<td>Improve equipment Performance</td>
<td>Higher quality information and trends showing equipment status and operational history</td>
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Key to Uptime and Reliability
Asset Condition Monitoring
Maintain aging assets while under increasing pressure to hold or reduce operations and maintenance spend while increasing uptime and reliability.

Asset Health (ACM) is a method for asset intensive Data Centers to assess critical assets based on the combination of the criticality and risk of failure.

Asset Condition Monitoring System that combines operational and information technologies, along with product and diagnostic expertise.
Integration of OT and IT
Asset Health Management End-to-End Process

Operations Technology (OT)  
Information Technology (IT)

Apparatus & Service  
Sensors & Monitoring  
Substation Gateway  
Asset Database  
Analytics & Performance Models  
Work & Asset Management

DC product, systems, service & expertise

Transformers
Breakers
Batteries
HVDC & FACTS
Switches
Reclosers
Switchgear
Transformer monitors
Circuit Breaker monitors
Battery monitors
Relays (IED’s)
Instrumentation/sensors
Substation Automation
Data Concentration
Communications
Equipment spec
Failure data
Test results
Service records
Performance models based on embedded T&D equipment intelligence
Decision Support:
1. Operations Impact
2. Optimized Maintenance
3. Lifecycle Management
4. Recommended Work Execution
Work Management
Inventory
Crew Deployment

Transformers
Breakers
HVDC/FACTS
GridGuard switch
GridShield recloser
Switchgear
Transformer (TEC)
Circuit Breaker Sentinel (CBS)
GridSync Sensor
Relion family of relays
Excount-II surge arrester monitor
Decathlon
MicroSCADA
COM600
SYS 600C
TRU560
cpmPlus Data Historian
SecureMesh/Trillian
SCADA Historian
Ellipse (EAM)
Asset Health Center
using the Local IT platform and Business Intelligence modules
Service Suite
Ellipse (EAM)
Asset Health Solution

1. **Data Acquisition:** Data from a variety of sources ranging from
   - Real time data (condition, EMS-SCADA, monitors and sensors, Decathlon)
   - Near real time data (GIS, mobility, Historian, EAM)
   - Enterprise Data (EAM data warehouse, market databases, ERP etc)

2. **Data Aggregation and Analytics:** Leveraging ABB Experts, Statistics, and Condition Assessments
   - Analytics, Algorithms and Engineering best practices determine total risk
   - Mechanical risk
   - Thermal risk
   - Dielectric Risk
   - Accessory risk
   - Miscellaneous risk

3. **Decision Support:** KPIs and Workflows to Prioritize Investment and Maintenance Work
   - KPI Dashboards
   - Packaged Analytics
   - Notifications & Reports
   - Adhoc capabilities

4. **Results and Communications:** Actionable; Integrated into Work and Asset Management
   - Digital Dashboards
   - Field Inspections/Communications & Work Notifications
   - Work and Asset Management – Work Orders
Transformer Aging & Failure Model

Thermal aging
Temperature
Chemical aging
Moisture
Oxygen
Acids

Mechanical aging
Overstressing
Vibration / Nr. of operation

Electrical aging
Overvoltage
Overcurrent
Harmonics

Operational Life

Fault Occurs
Retrofit
End of Life
With Retrofit

Strength
Margin
Life Extension
End of Life
Without Retrofit

Stress
Operational Life
Transformers Life Extension Options & Considerations
Risk Of Failure Determination

Input Data
- Nameplate Information
- Application Information
- Loading History
- Service Record
- Mechanical Design Information
- Electrical Design Information
- Thermal Design Information
- Through-Fault History
- Site Inspection Information
- Bushing type and Diagnostic Data
- Conservator type and Condition
- Load Tap Changer Type and Diagnostics
- Cooling Equipment Type and Condition
- DGA and Oil Quality Data
- Electrical Test Data (PF, Resistance, PD.)
- Maintenance History
- Failure History of Similar Units
- Leaks and Environmental Concerns
- Relative Importance to System

Risk Categories
- Short-Circuit Risk
- Thermal Risk
- Dielectric Risk
- Accessory Risk
- Miscellaneous Risk

ROF
High/Medium Voltage Breakers
Asset Health Solution

Data Acquisition;
Data from a variety of sources ranging from

- Alarms
- Maintenance Procedures
- Maintenance Records
- Nameplate
- Observation
- Operation Counter
- Operational Check
- Test Results
- Visual Inspection
- IED Inputs

Analytics, Algorithms and Engineering best practices determine total risk

- Mechanical risk
- Thermal risk
- Dielectric risk
- Protective risk
- Electrical Auxiliaries risk
- Equipment Safety
- Misc Observations

Risk Group Criteria - Mechanical

- Age
- Service Interval
- % Rated Operations
- # of Fault Current Ops.
- Lubricant Type
- Mechanism Type
- Manufacture
- Ambient Temp.
- Environmental
- Other Defects
- Timing
- Additional Tests
- Operating Voltage Range
Overview of the Asset Health Orientated Application for Circuit Breaker

Malfunction information:
**Name:** Loss of stored interruption energy due to leaks
**Degradation level:** 60%
**Consequence:** High
**Failure Characteristics:** Pneumatic mechanisms generally lose energy over at least several minutes
**Monitoring Points:** Pressure of SF6
**Maintenance Suggestions:** Fix the leak; adding more SF6 to restore pressure
Battery Monitoring and Alarms

Float Current Monitoring

Input

- AC and DC floating current measurements
- Thresholds presetting
- Ambient temperature

Output

- Battery condition level based on AC/DC floating current measurement

Note: Float current measurement needs correction based on temperature

Battery condition evaluation and alarm with following parameters

- Float current
- Float voltage
- Temperature
- AC/DC resistance or conductance
- Electrolyte level (where available)

Battery Risk of Failure calculation

Reference: IEC TR62060
Asset Health Center
Information Flow & Analysis

Transformers
Circuit Breakers
Batteries

SF6 Gas System
Electrical Controls & Auxiliaries

Interupter Wear
Mechanical System
Asset Health Center
Information Flow & Analysis

Data Sources
Databases, Historians, SCADA
Offline Data; Excel, CSV, Paper etc...

ETL & Performance Models

Advanced BI Solution
BIM

Actionable Intelligence
Continuous Feedback

EAM Solution

Packaged SME
Thermal Winding Risk
Short Circuit Risk
Dielectric failure Risk
Etc.

SME Support

Transformers
Circuit Breakers
Batteries
Asset Health Center – Information Flow & Analysis

- **Trxf. fingerprint**
- **Events, alarms**
- **Load**
- **Top Oil**
- **T. amb**
- **Tap pos.**

**Online Sensors**
- Gas Sensor
- H₂O Sensor
- Bushing
- LTC
- PD
- FRA/Transients

**Expertise**
- ABB

**Equations**

**Performance Models**

**Statistics**

**Computation**

**MTMP Risk of Failure**

- **Off line DGA**
- **Off line SOT, Furans**
- **Routine tests**
- **FRA, DFR, Z, etc**
- **Maintenance actions**

**Offline Databases**

- **SCADA**
  - Kelman Minitrans
  - Hydran M2
  - Kelman Transfix

- **Static data or information**
- **Dynamic data/information**
- **On going development**

- **Trxf. 1**
- **Trxf. 2**
- **Trxf. 3**
- **...**
- **Trxf. n**
Expected Benefits

- Consolidated data on asset condition available to stakeholders in a timely fashion
  - Providing situational awareness
  - Support for making maintenance and capital replacement decisions
- Decreased reliance on specific local knowledge
  - Deployment of advanced decision support tools
- Early warning signals of potential failures
  - Make operational decisions with actionable intelligence
- Improved asset utilization
  - major maintenance is performed less frequently on healthy assets
- Workforce efficiencies
  - Specific tasks at the right time
- Clear path to Condition Based Maintenance
Technology innovations for power quality, efficiency and safety
Technology innovations for quality, efficiency & safety

3:10 – 3:40 PM - Transformer design considerations for safety & reliability
James Ritter. Channel Manager, OEM Sales, Transformers
james.ritter@us.abb.com

3:40 – 4:10 PM - Benefits of the modular UPS to a data center
Joergen Madsen, Director, Business Development, Power Protection
joergen.Madsen@us.abb.com

4:10 – 4:40 PM - IEC 61850 GOOSE enabled innovations
Don Elliott, Product Management, Medium Voltage
don.r.elliott@us.abb.com
Transformer design enhancements for safety and reliability
Keys to proper transformer selection
Transformer considerations for data centers

Keys to proper transformer selection

- What is the installation environment
  - Will the transformers be located indoors or outdoors
  - Are there environmental concerns, sensitive areas – close to water

- What is the application
  - Transmission or Distribution step down
  - Secondary unit substation
  - VFD / VSD isolation transformer
  - Rectifier input transformer
  - General purpose distribution

- Are there loss evaluations (A&B Factors)
  - What is load profile
  - What is cost of energy

- Are there dimensional or weight restrictions
- Are there any other considerations
Transformer considerations for data centers

Typical locations of transformers in data centers

1. Substation
2. Isolation transformers
3. Internal distribution transformers
4. HVAC solutions
5. General Purpose
6. Power generation
7. Internal distribution transformers
8. Data center services

- Transformers
- Medium-voltage switchgear
- Generators
- Power quality assessments
- HV UPS
- Low-voltage switchgear
- Input transformers
- Rectifiers
- UPS
- Power generation
- Step up and collector transformers
- Isolation transformers
- Remote power panels
- Remote monitoring
- Data center services
- Remote monitoring
Transformer considerations for data centers
MV distribution transformers – liquid or dry?

- Flammable / Non-Flammable
- Environmental Considerations
- Integrated Solutions
- Lead-times, Product & Drawings
- Complexity of Coordination's
- Additional Containment
- UL, FM, NEMA, ANSI, IEC, etc.
- Efficiencies
- Maintenance & Commissioning
Transformer considerations for data centers
Dry-type transformers

Cast Coil / RESIBLOC
- 112.5-30,000 kVA
- 69 kV Primary
- 34.5 kV Secondary
- LTC’s

Open Wound VPI
- 112.5-15,000 kVA
- 34.5 kV Primary
- 15 kV Secondary
Transformer considerations for data centers
Liquid filled transformers

**SUBSTATIONS**
- 750-75,000 kVA
- 138 kV Primary
- 34.5 kV Secondary
- LTC’s

**UNIT SUBSTATIONS**
- 112.5 - 20,000 kVA
- 69 kV Primary
- 34.5 kV Secondary
- LTC available

**PADMOUNTS**
- Up to 20,000 kVA
- 46 kV Primary
- 15 kV Secondary
Transformer considerations for data centers

Location considerations

- Typical convention
  - Dry type inside
  - Liquid filled outside

- Reality is that dry type are used outdoors and liquid filled are used indoors

- High temperature dielectric fluids are classified less flammable
  - Additional fire suppression systems may be required

- Liquid filled units sometimes leak
  - Additional fluid containment may be required
Transformer considerations for data centers
Location considerations continued

- Transformers generate heat
- Advantages for locating units outside
  - Reduce HVAC costs
  - Reduce floor space
  - Reduce utility bills
- Disadvantages for locating units outside
  - Adds cost of bus duct
  - Can create voltage regulation issues for sensitive equipment, across the line motor starters
  - Increased security for MV outside
Transformer considerations for data centers
Location – costs of primary containment

- NEC® requires containment for all indoor liquid-filled transformer applications
- Containment may take the form of complete room containment or:
  - (door sills, dikes, curbing, or transformer containment pans)
- Custom-made containment pans, paint and drain plugs require custom design work to ensure that its tailored to fit, which can be costly

Up to $5000 option
Transformer considerations for data centers
Location – costs of secondary containment

- Dry-type transformers do not require Oil Pollution prevention measures
- Liquid transformers must comply with the latest spill prevention control and countermeasures that are put into place
- The EPA mandates that secondary containment is needed for oil storage of transformers in a combined volume of 1,320 gallons
- 1x 2000 KVA liquid filled indoor transformer has roughly 550 gallons of Natural Ester Fluid
Transformer considerations for data centers
Location – fire rating

- Alternative dielectric fluids (seed oil / FR3) are used in today’s liquid filled transformers, however:
  - Max. flash point of 320°C still exists
  - Max. fire point of 350°C still exists
- Dry-type offers the highest fire rating
  - Non-flammable & self-extinguishing
  - Inherently less risk of fire due to materials in construction and flash point is 350°C
Transformer considerations for data centers
Location – fire rating continued

- Burnable materials for 1000 kVA oil and dry distribution transformers

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Oil</th>
<th>Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid Burnable</td>
<td>160 lbs</td>
<td>500 lbs</td>
</tr>
<tr>
<td>Liquid Burnable</td>
<td>3,300 lbs</td>
<td>N/A</td>
</tr>
<tr>
<td>Total Weight</td>
<td>3,460 lbs</td>
<td>500 lbs</td>
</tr>
</tbody>
</table>

- In case of external fire:
  - Heat released: Oil transformer = 7 x Dry transformer
  - Dry Benefits:
    - Minimal combustible fuels
    - Self extinguishing / does not burn easily
    - Increases safety for people and property
Transformer considerations for data centers
Choice of mineral or ester oils

- Ester oil is very resilient against fire, however fire point of 350\(^\circ\)C still exists
  - 3 things required to ignite:
    - 1) consistent temps above 400-500\(^\circ\)C
    - 2) Oxygen
    - 3) Ignition source
- Small amounts of ester oil will biodegrade, but gallons need to be contained / remediated
- Mineral oil has much lower flash / fire point
- EPA does not allow for a distinction b/w ester or mineral in the event of a spill
- Ester oil solidifies at -10 to 0\(^\circ\)C, requiring additional startup procedures / options. Mineral oil does not solidify until -40\(^\circ\)C
Transformer considerations for data centers
NEC insulation exceptions for installations

- Per NEC, dry-type transformers are exempt from fire rated vaults due to their insulation class of $\geq 155^\circ C$ and lack of combustible material.

- Oil immersed units are subject to vaults reinforced by 4in thick concrete, minimum total kVA within electrical rooms, extended space separations of equipment, fire resistant barriers and automatic fire suppression systems.

- Per NEC, for outdoor applications, liquid filled substations must comply with Type 1 & 2 fire rated building construction (1-4 hour fire resistance) and meet confinement distances either by construction code or by the listing of the liquid.
Transformer considerations for data centers

Location – infrastructure costs for indoor

- Wet pipe systems (code minimum)
- Dry pipe systems
- Pre-action systems
- Water mist systems
- Raised floors
- Complex smoke detection

- Combustible liquids require extensive & costly fire suppression systems
- The power distribution rooms in Datacenters are considered Tier II hazards and require extensive containment
- Determined by the impact, special fire walls and vaults may be required
Transformer design considerations in datacenter applications
Transformer considerations for data centers
Application considerations - Harmonics

- Static rectification devices - AC to DC power conversion devices - current is drawn only during a controlled portion of the waveform.
- Single phase sources include computers and lighting ballasts.
- Three phase sources include motor drives and uninterruptible power supplies.
- Harmonics are fed back into the power system from these loads.
- Harmonic can drive higher K factor ratings
- Harmonics can create neutral grounding issues
Dry-types are generally larger and 15% - 20% heavier than liquid-filled units.
Transformer considerations for data centers

Sound levels

- Dry-type units are generally louder than liquid filled because of the inherent dampening offered by fluid
- Industry standards allow for this difference
- Newer technologies and materials can be used to lower sound levels for both types of transformers

<table>
<thead>
<tr>
<th>3P Power (kVA)</th>
<th>Dry-Type AA Sound Level</th>
<th>Liquid OA Sound Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>64 dB</td>
<td>58 dB</td>
</tr>
<tr>
<td>2500</td>
<td>68 dB</td>
<td>62 dB</td>
</tr>
<tr>
<td>5000</td>
<td>71 dB</td>
<td>65 dB</td>
</tr>
<tr>
<td>7500</td>
<td>75 dB</td>
<td>67 dB</td>
</tr>
<tr>
<td>10000</td>
<td>79 dB</td>
<td>68 dB</td>
</tr>
<tr>
<td>15000</td>
<td>82 dB</td>
<td>70 dB</td>
</tr>
</tbody>
</table>
Transformer considerations for data centers

Overloading

- Loading beyond the limitations of either liquid or dry units can shorten the insulation life of either type of transformer, but can be made possible under certain conditions.

- Forced air (FA) cooling is a common accessory that can increase the loading of both types of transformers. (25% max for liquids, 50% max for dry medium size transformers)
Transformer considerations for data centers
Seismic/Vibration withstand

- Both liquid and dry transformers can be braced to withstand sudden or long term vibration forces.
- Dry-type transformer are historically used for ship-board or nuclear 1E applications because of no threat of a leakage or fire during an extreme vibration event.
- Obtained seismic certified through shake-table testing per IBC 2009 and ICC-ES AC 156. Additionally, can be supplied to stringent OSHPD seismic locations up to 3 MVA.
### Transformer considerations for data centers

**Transformer maintenance**

<table>
<thead>
<tr>
<th>MAINTENANCE</th>
<th>FREQUENCY</th>
<th>OIL</th>
<th>DRY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil Level</td>
<td>monthly</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Porcelain Insulator Cleaning</td>
<td>annually</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Surface Cleaning</td>
<td>annually</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Connections (Tighten)</td>
<td>annually</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Painting State</td>
<td>annually</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Oil Analysis (Dielectric Test)</td>
<td>annually</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>SILICAGEL (Verify and Replace)</td>
<td>annually</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Accessories to Check</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure Guage/Relief</td>
<td>Monthly</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Buzcholz</td>
<td>annually</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Over-Pressure Relay</td>
<td>annually</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Oil Level</td>
<td>annually</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>WTI</td>
<td>annually</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

- Oil filled transformers are suspect to coking and sludging, requiring fluid analysis and ultimately change-out
- Dry = air cooled (ventilated) which isn’t subject to breaking down
- Over the life, oil filled units may have issues/symptoms that require insulating fluid analysis, metals analysis, dissolved gas analysis, furan analysis, etc.
- Dry = sealed and requires only periodic surface cleaning
Transformer considerations for data centers
Commissioning

- Dry-type transformers are less complicated to commission. They are shipped and stored fully assembled and have no major pre-commission test requirements.

- Liquid immersed units require consideration for the liquids whether it is in the lifting, or in onsite filling, oil testing, or pre-commission testing.

- Additional assembly may be required with liquid filled units due to disassembled radiators and/or containment pans. However, if needed, dry-types can be disassembled in place and moved as component parts.
Design / product considerations for contending with VCB’s
Transformer considerations for data centers
Vacuum circuit breakers – switching & bypass

- Vacuum circuit breakers can create over voltages on inductive equipment
- This is a system issue that needs to be analyzed taking the breaker device, cable, distance between devices and transformer into consideration
- Factor into design up front
- Results are breaker manufacture specific
- Add protection only when and where needed
Transformer considerations for data centers
Need for development

What was known:

- Vacuum circuit breakers (VCB) can produce very fast transients that cause high over voltages in transformers; some leading to failures.
- The global trend for circuit breakers is toward vacuum for its arc-quenching medium.
- Current market solutions are still susceptible to VCB switching or cost ineffective.

What was unknown:

- What was the true event occurring and to what levels.
- Which system characteristics caused the largest threat to transformers.
The rise time ($\Delta t$) is less than 0.1 $\mu$s and the rate of rise is about 600kV/$\mu$s

- 10x faster than impulse wave and occurs 30+ times in ~ 0.5 ms
- Overvoltages also stress the *middle* of the winding; opposed to a lightning impulse that stresses the external and ends of the winding

168 kV peak terminal voltage on 125 kV BIL design
Transformer considerations for data centers
Two types of winding stress; must protect from both

- Voltages spikes due to reignitions
  - Occurs when the voltage potential across the poles of the circuit breaker are still high enough to cause a spark across the terminals
  - Chance to occur during every switching event at load (seen on previous slide)

- Voltage rise due to resonance amplification
  - Occurs when sustained current (ex. short circuit) is interrupted and the wave frequency matches the natural frequency of the windings
  - Rare event but needs to be protected from for a total solution
Transformer considerations for data centers
Current market solutions – Line surge arresters

- Simply not enough protection
  - It does reduce peak overvoltages to ground, but overvoltages inside winding can still be very high
- Field recorded failure cases
Transformer considerations for data centers
Current market solutions – RC snubber circuit

- Adds as much as $20 kUSD to total price and 2’ box extension in any direction placed
- Monitoring to record and suggest when to replace components
- Field cases of end-users putting containment around dry-type transformers with RC snubber circuit because of oil capacitors
- No field recorded failure cases
Transformer considerations for data centers
Current market solutions – liquid hardened transformers

- Higher line-end capacitance and BIL resistance to provide more linear distribution of voltage across windings, reducing but not eliminating the effect of high internal voltage

- Increased protection still does not guarantee the survival in all system configurations; does not limit overvoltages to controlled levels

- Arcing may still occur during switching, creating gas

- Recorded field failure cases of liquid filled transformers due to VCB switching

- Still must handle the challenges of oil; worsened when placed indoors
Transformer considerations for data centers

Current market solutions – ABB’s TVRT™

- The TVRT™ uses strategic, proprietary arrangements of varistors to enhance ABB’s vacuum cast coil technology
  - The varistors act as a surge limiter, preventing overvoltages inside the coil from growing beyond known levels
- With the peak voltage known, the internal windings are designed to withstand the transient
- This solution works in ALL system configurations because it addresses the right problem
Transformer considerations for data centers
Current market solutions – ABB’s TVRT™

Coil varistors – limit internal voltage peaks to below winding insulation levels
Line surge arresters – limit voltage to ground stress
Transformer considerations for data centers
The ultimate solution – TVRT™

No protection

168 kV peak

RC snubber circuit (with internal resistors)

250 Hz oscillation, 85 kV peak amplitude

TVRT™

40 – 45 kV (hf transients up to ≈ 65 kV)

Worst case system switching results. All other variables held constant.
Transformer considerations for data centers

TVRT™ in Summary

- The TVRT™ uses strategic, proprietary arrangements of varistors to enhance ABB’s vacuum cast coil technology
- With the peak voltage known, then the internal windings are designed to resist

**Benefits include:**

- Fully Dry-type solution
- Same enclosure sizes to unprotected SUS
- Simpler and more robust than traditional “snubber” circuits (does not require the use of resistors or capacitors)
- Varistors require no maintenance or monitoring and carry same life expectancy as the transformer
- Damage due to VCB interaction covered under standard warranty
- No transient / system analysis needed
Benefits of the modular UPS to a data center
Data centers and UPSs

Why UPS?

Critical load requiring constant uninterrupted power
Mission critical applications require high power availability

Availability ↔ TCO
Agenda

- UPS History
- Current UPS Topologies
- Market Drivers
- Technology Trends
- UPS Configurations & Architecture
- Application Trends/Future
Data centers and UPSs
First UPS systems

Motor/Generator set ~1950’s
Motor (DC or Synchronous AC)
Flywheel
Generator

Electrical ► mechanical ► electrical
Simple
Reliable
Inefficient
Limited ride through times
Still available today

Motor (DC or Synchronous AC)
Flywheel
Generator
Data centers and UPSs
Traditional North American UPS system

Transformer based static UPS
- SCR Rectifier converting AC to DC feeding inverter and charging Battery
- Inverter converting DC to AC generating clean AC power for critical load
- Energy Storage, traditionally lead acid battery
- Static Switch to support critical load with direct utility power in case of high overload or UPS failure (lately also utilized for Economy mode operation)
- Transformers to ensure safe operating voltage for semiconductors (and provides galvanic isolation)
Market Drivers
Total cost of ownership (TCO) – drivers

TCO drivers
- $$... bottom line
- Cost savings – eliminate losses
- Financial incentives
- Political
- Green profile
- Lobbying
- Legislation

LEED
- Platinum
- Silver
- Gold

U.S. Green Building Council (USGBC)

GREENPEACE

PUE..
WUE..
CUE...
Technology trends
Inverter - SCR -> IGBT topology

Static UPS SCR -> IGBT
- Higher voltage rating eliminates need for transformer
- Higher switching frequency allows reduction of filter size
- High efficiency
- PWM control -> excellent dynamic performance

SCR
- Step wave
- 2-Level PWM
- 3-Level PWM

IGBT
- Advanced PWM
Technology trends
TCO – technology drivers

Technology drivers – history

- IGBT based inverter and rectifier
- Reduced switching and filter losses
- Online efficiency > 96%
- Efficiency optimized at typical load level
- Eco-mode efficiency up 99%

UPS efficiency – Eco-mode

- ECO-Mode 98% – 99%
- Transformer-less UPS 2nd Generation 96% – 97%
- Transformer-less UPS 1st Generation 90% – 95%
- IGBT UPS 85% – 90%
- Transistor UPS 80% – 85%
- SCR UPS 75% – 80%
UPS configurations and architecture
Availability is King!
No downtime requirement – parallel /redundant UPSs

Need for higher availability

- Continuous uptime
- Single → parallel configuration
- Parallel for redundancy or capacity
- N+1, N+2 ….
- 2(N+1) w/ STS or dual corded load
- Tier level classification
New modular UPS designs
Monolithic vs. Modular – addressing CapEx

- Scalable – pay as you grow
- Rightsizing
- Eliminate stranded capacity
- Availability – integrated redundancy
- Serviceability – low MTTR
- Flexibility – easily scalable to fit current power/redundancy need
Modular UPS – centralized design

Centralized Modular UPS

- Traditional modular UPS design
- All control logic, static switch etc., centralized in UPS frame
- UPS frame is system control cabinet (SCC)
- Several single points of failure

Diagram showing:
- Bypass input
- Battery
- Rectifier input
- Power module
- Control logic
- Shared parts
- DISPLAY
- Output to critical load
Modular UPS – decentralized design
Decentralized parallel architecture (DPA)

- All control logic, static switch etc., in each power module
- Active power module is a complete UPS
- Passive frame design
- High availability
- Eliminates single points of failure
- Perfect load sharing
- Any UPS can be the logic leader (multimaster system)
Modular UPS – decentralized design
Conceptpower DPA UPS

**Vertical scalability**
1 – 5 modules in one single cabinet

**Parallel configurations**
- Scalable – vertically and horizontally
- 100kW to 3MW, 480V
- Online-swap modularity (OSM)
- Serviceability – low MTTR

**Horizontal scalability**
Cabinets in parallel configuration
Applications trends/future
480V with 208V/120V distribution vs. 415V/240V

Traditional US Datacenter Design
- Utility Service MV (15kV)
- Transformer 15kV to 480V
- 480V Distribution Switchgear
- 480V UPS
  - Battery
  - PDU Transformer 480V to 208V/120V
- Critical (IT) Load 120V

High efficiency 415V/240V Datacenter Design
- Utility Service MV (15kV)
- Transformer 15kV to 415V/240V
- 415V Distribution Switchgear
- 415V/240V UPS
  - Battery
  - Critical (IT) Load 240V

Combined 480V/415V Datacenter Design
- Utility Service MV (15kV)
- Transformer 15kV to 480V
- 480V Distribution Switchgear
- PDU Transformer 480V to 415V/240V
  - 415V/240V UPS
    - Battery
  - Critical (IT) Load 240V

October 3, 2016
MV UPS

Utility Service
MV (??kV)

Transformer
??kV to 15kV

15kV Distribution
Switchgear

15kV UPS

Battery

Transformer
15kV to 415V/240V

Critical
(IT) Load
240V
Summary

- Online double conversion with full VFI operation is still the dominating UPS design – primarily transformerless design, due to higher efficiency.
- After several years of efforts to increase efficiency, now up to 98% online efficiency with SiC based semiconductors, very little room for further improvement.
- Economy mode – the market has been very reluctant to adapt, and with very high online efficiency – limited gains.
- “Exotic” voltages and configurations not likely to gain significant traction – do not offer significant benefit over current solutions (code, hardware availability, and safety issues).
- Future (and current) focus on “Rightsizing” – solutions that can eliminate/limit stranded capacity – to lower Cap-Ex and maintenance cost – need for scalable solution that easily adapt to ever changing load conditions – flexibility is key.
- Trend towards increased use of MV UPS in hyper scale data centers, due to savings on installation cost.
Digital Switchgear and IEC 61850
Increase Speed, Reliability and More

- Agenda
  - Industry requirements
  - Definition of Digital Switchgear
  - Key Digital Switchgear Components
  - Digital Switchgear Benefits
  - IEC 61850 with GOOSE
  - Discussion
Distribution networks are getting more complex
Increasing demands on MV switchgear

- Be simple
- Be "smart"
- Be on time
- Be flexible
- Be environmental friendly
- Be future proof
- Be efficient
- Be safe
- Be easy
- Be reliable
- Be on time
- Be future proof
Digital Switchgear
New concept for MV switchgear

- Digital Switchgear is not only new products, it is a new concept in protection, control, automation
Digital Switchgear
Advanced Measurement Solution

Current sensors

Voltage sensors

<table>
<thead>
<tr>
<th>MV sensors</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Sensor</td>
<td>• IEC 60044-8 (2002)</td>
</tr>
<tr>
<td></td>
<td>Electronic current transformers</td>
</tr>
<tr>
<td>Voltage Sensor</td>
<td>• IEC 60044-7 (1999)</td>
</tr>
<tr>
<td></td>
<td>Electronic voltage transformers</td>
</tr>
</tbody>
</table>
Digital Switchgear
Current sensors

- Rogowski coil sensor
  Us=150 mV for 50 Hz
  Us=180 mV for 60 Hz
- Proven technology which brings many benefits in various applications
- Output voltage is proportional to the derivative of primary current
- Output voltage is integrated by IED
- Accuracy up to class 0.5
- Complies with IEC 60044-8

No Saturation!
Digital Switchgear
Current sensors

- Secondary output
- Saturation level
- Primary current

- ABB sensor
  \( U_s \)

- Standard CT
  \( i_s \)
Digital Switchgear
Current Sensors – combined accuracy class 0.5/5P630
Digital Switchgear
Voltage sensors

- Resistive voltage divider sensor
- 10,000:1 transformation ratio
- Accuracy up to class 0.5
- Passive element
- Complies with IEC 60044-7

![Voltage Divider Diagram]

\[ U_S = \frac{R_2}{R_1 + R_2} U_P \]

No ferroresonance!
Digital Switchgear
Voltage Dividers - combined accuracy class 0.5/3P

Protection accuracy limit class 3P

Metering accuracy limit class 0.5

Continuous voltage measurement
Digital Switchgear

- Current sensor
- Voltage sensor
- Adapter
- IED (Intelligent Electronic Device)

Almost no analog wiring in the switchgear – increases reliability

IED must have LEA (Low Energy Analog) inputs compatible with the Rogowski coil and RVD sensors.
Digital Switchgear Technology for better switchgear

Capacity
- Integrated voltage measurement within insulator reduces space requirements
- Current sensor located in monoblock reduces space requirements

Safety
- Low energy analogue sensors
- Fewer wires to install, commission, maintain

Quality
- Better sensor accuracy and range of measurement improves protection & control
Digital Switchgear
Technology for better switchgear

- **Efficiency**
  - Lower operating cost (sensors consume less power)
  - Later configuration during manufacture (fewer wires to design and install)

- **Sustainability**
  - Universal standards (IEC61850) enable future system expansion
  - Lower environmental impact during operation

- **Reliability**
  - Fewer parts to fail
Digital Switchgear

Digital solution:

- Changing loads does not require changes in hardware like instrument transformers
  - Saves time and money during planning and execution
- Improved accuracy and range of current and voltage measurement for metering, protection and control
- Meets latest cybersecurity and communication performance standards
  - Manufacturer independant communication standard
  - Ready for easy SCADA integration
Digital Switchgear
Future proof solution based on IEC 61850

- Based on worldwide accepted standard ensuring long term sustainability
- Ready to be connected to Remote Control systems
- Available IEC 61850 features:
  - vertical communication
  - horizontal GOOSE communication
  - process bus
Digital Switchgear
Sensors and IEC 61850 communication
Digital Switchgear

Reduced losses during operation

- Lower sensor losses
- Saving potential of up to 250 MWh over 30 years (sample switchgear with 14 frames & 42 CTs)

Improved equipment reliability

- Fewer live parts, fewer failure opportunities reducing outage potential and troubleshooting costs

Solution that requires less space

- Complete transformer compartments eliminated
- Reduced space means lower installation costs
Digital Switchgear

- Solution has reduced weight
  - You can do away with the PT compartment!
  - Save frames (reduces frame count)
  - Greater flexibility in configurations.
- Solution does not require extra frames for instrumentation.
- Greatly reduced wiring

Conventional approach
Wiring between devices must be done individually per signal

Communication Network (Ethernet)
Horizontal GOOSE communication
Number of interconnections is equal to number of devices
UniGear Digital
Quick delivery time from order to operation

30% shorter delivery time!
This solution eliminates the trouble of defining details like CT/VT data...

- For all applications/relays?
  - No, but for nearly all of them! Reduced engineering and easier configuration selection. Reduces project administration and engineering costs

This solution supports minimized time to receive the project documentation

- CT/VT data not required
- Flexible towards last-minute changes
- Most changes are simply realizable within the IED’s logic, only minor changes in wiring and schematics (if any)
Digital Switchgear
Lower environmental impact
Digital Switchgear
Lower environmental impact

Digital Switchgear:
- Solutions that use less material
  - Less steel, less copper, less epoxy, …
- Solutions with reduced losses
  - Lower energy required to operate the gear
- Digital switchgear can save a significant level of CO₂
Distribution networks are getting more complex
Increasing demands on MV switchgear

Be simple
Be reliable
Simplified wiring

Be “smart”
Possibility of late customization

Be on time

Be flexible
Measurement devices with high accuracy over an extended range. Can deal with varying load flows.

Be environmental friendly

Be efficient
Significant energy savings

Be easy
Space & weight saving

Be future proof

Digital switchgear is the solution.
Questions?
Meet & Greet

- 4:45 p.m. Meet & greet with the experts in Triple Alley
- 7:15 SF Giants vs. Colorado Rockies Baseball Game
Power and productivity for a better world™