Power Events Analysis

Making facility Operations and Maintenance more Effective

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Agenda

1. Introduction: The challenges for critical facilities
2. The Tools for Power Events Analysis
3. Past, present and Future
4. Key takeaways

Introduction

Trends and Challenges faced by facility management and maintenance teams

- **Electrification**: More complex and critical electrical networks (DERs, EVs, backup systems, etc)
- **Fast Evolving Grid**: aging infrastructure, rapid integration of renewables and other technologies
- **Climate change:** More frequent and severe weather events
- **Digitalization:** Prevalence of digital technologies. Large amounts of data to interpret. More sensitive devices to electrical disturbances
- **Workforce challenges:** training and retaining new talent. Lost expertise (silver tsunami), remote work, etc

Problem Statement

A Power Event

- An outage takes down your electrical system, halting equipment and processes that cost $$$ per minute.
- Here's what you may find quickly:
  - The approximate time of the outage
  - The end systems that are affected
- Here's what you may not know:
  - What caused the outage?
  - What is the exact sequence in which things happened?
  - What equipment worked and what didn't?

Power Events Analysis

The What and How?

What (Definition):

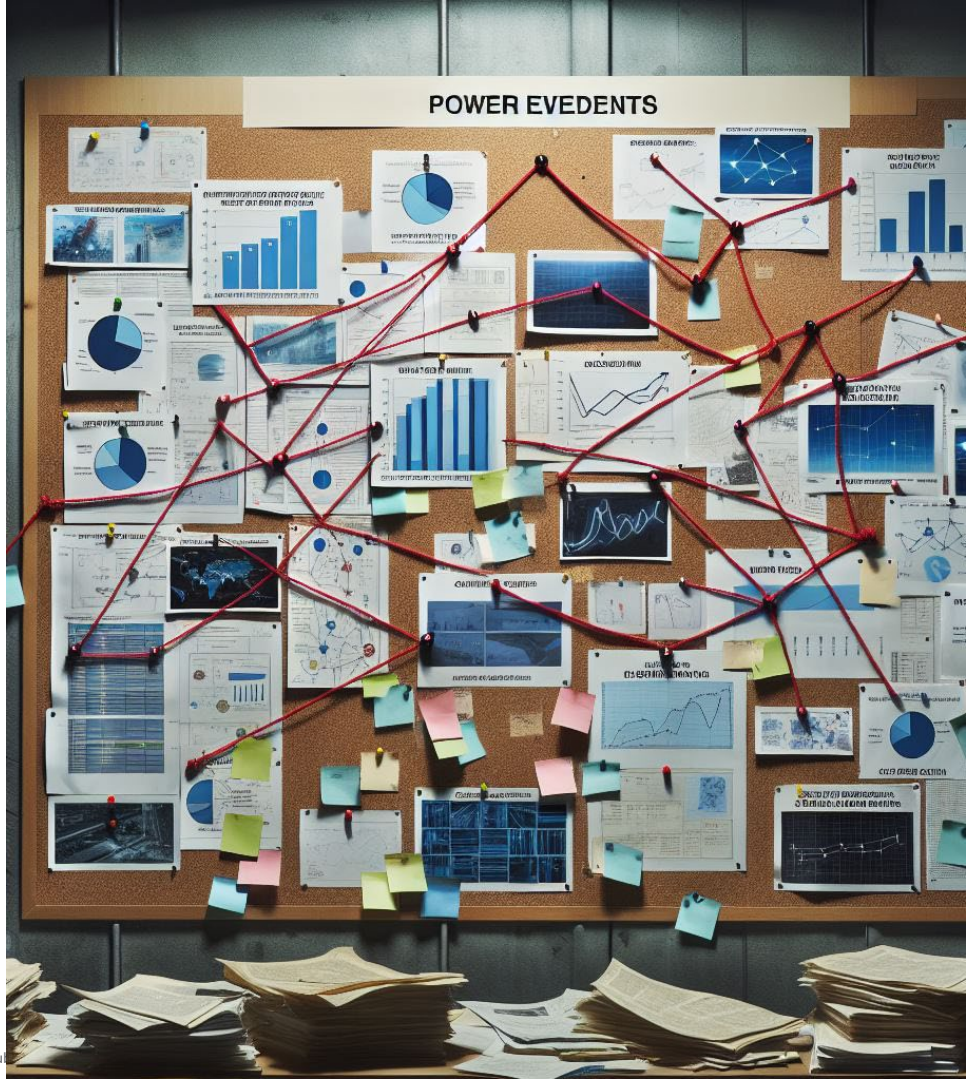
The process of identifying the origin, impact, and root cause of power disturbances. This often involves a detailed and time-consuming examination, including manual inspection and interpretation of waveforms captured by protection relays, circuit breaker trip units, and power quality monitoring devices

How (typically):

- Disparate sources of data
- Varying reliability & accuracy of data
- Different forensic tools
- Human expertise to piece together evidence and uncover root cause
- Action plans to avoid recurrence

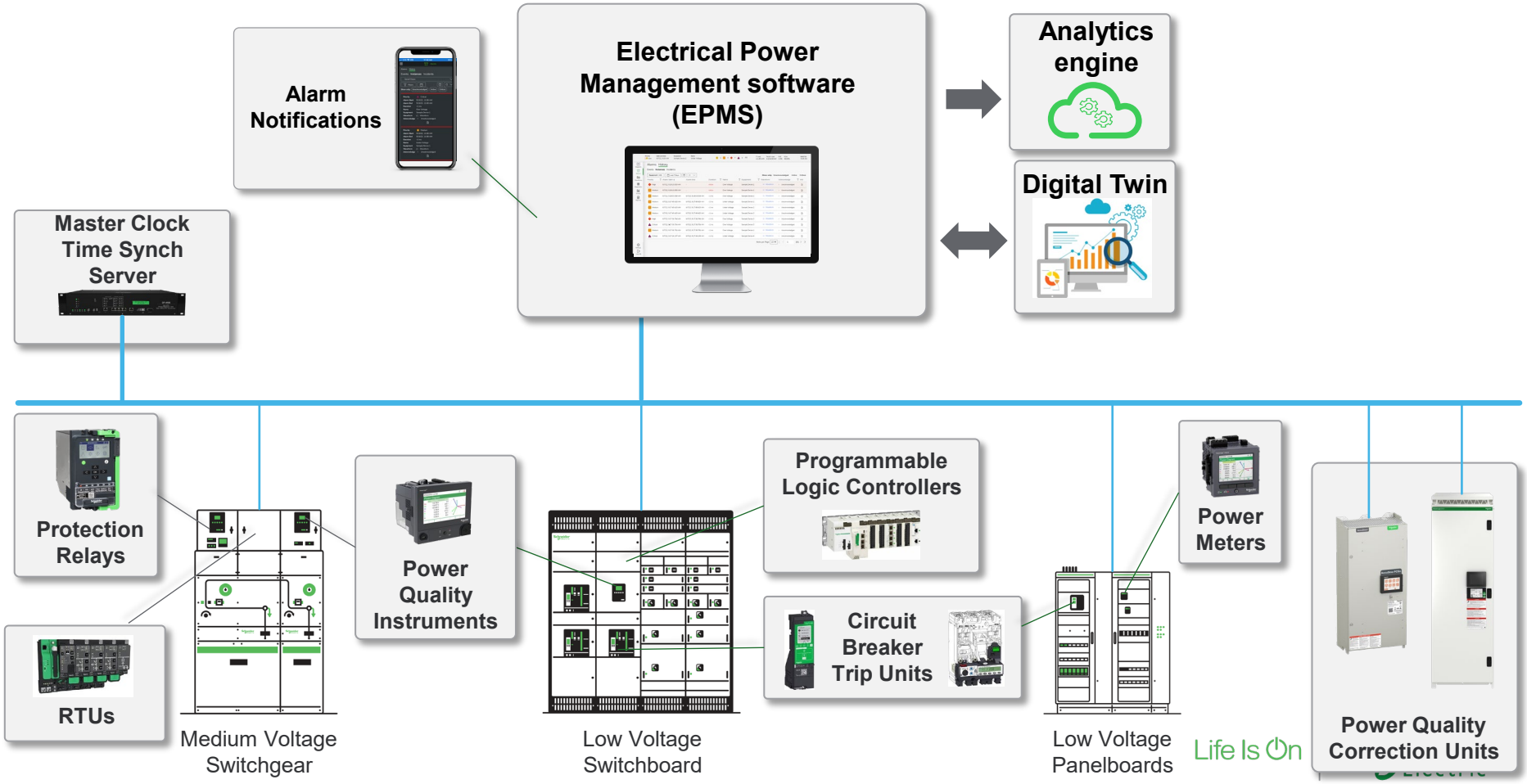
What if we get it wrong?

- Lost time in root cause analysis, chasing time-stamps and piecing together evidence
- Incorrect conclusions and guessing games on sequence of mis-operating equipment.
  - Was the relay mis-coordinated?
  - Was the breaker stuck?
  - Did the transfer switch operate within tolerance?
  - Did the inrush current on the motor cause the false breaker trip?
- No action plan on preventing recurrence
- Impact on uptime, loss of reputation & relationships with erroneous conclusions
- No accurate records for
  - concrete proof of proper equipment operation
  - insurance & warranty



2. System Components

Tools for Power Events Analysis


Alarm Notifications
Electrical Power Management software (EPMS)
Analytics engine
Digital Twin
Master Clock Time Synch Server
Protection Relays
RTUs
Medium Voltage Switchgear
Power Quality Instruments
Low Voltage Switchboard
Programmable Logic Controllers
Circuit Breaker Trip Units
Low Voltage Panelboards
Power Meters
Power Quality Correction Units
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Intelligent Electronic Devices (IEDs)

Field Data Collection

According to Wikipedia: In the electric power industry, an intelligent electronic device (IED) is an integrated **microprocessor-based** controller of power system equipment, such as circuit breakers, transformers and capacitor banks.

- Non-volatile memory for storing timestamped events onboard the device
- High sampling rate (samples per cycle)
- Millisecond timestamp resolution for event logging
- Time-synchronizable, high-precision onboard clock

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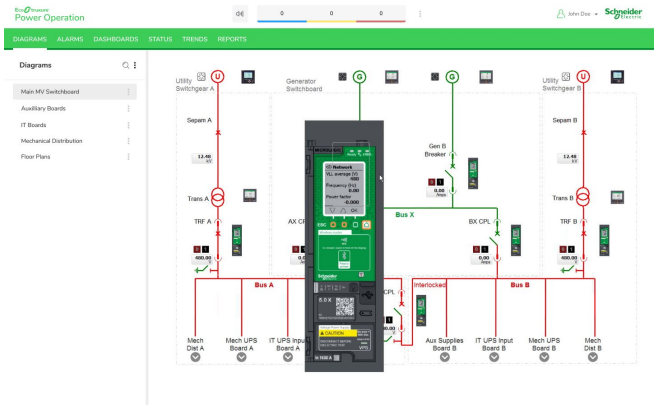
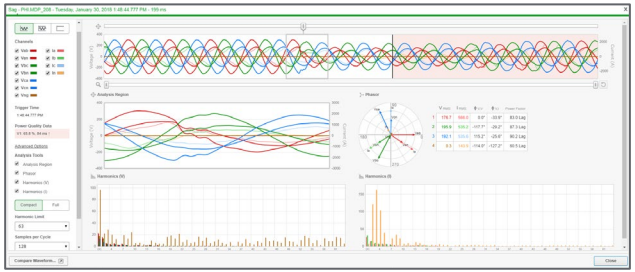
Electrical Power (and energy) Management System

Aggregation, analysis and presentation

Electrical power monitoring system is a Purpose-built software that measures power and energy usage and provides insights into the health and stability of an electrical network. Dedicated tools for the job:

- Device onboard timestamped data and event collection
- Ad-hoc alarm & event viewers – Incident aggregation
- Sequence of events and timeline analysis tools
- Waveform visualization and analysis tools
- Precalculated analytics and standard compliance reports



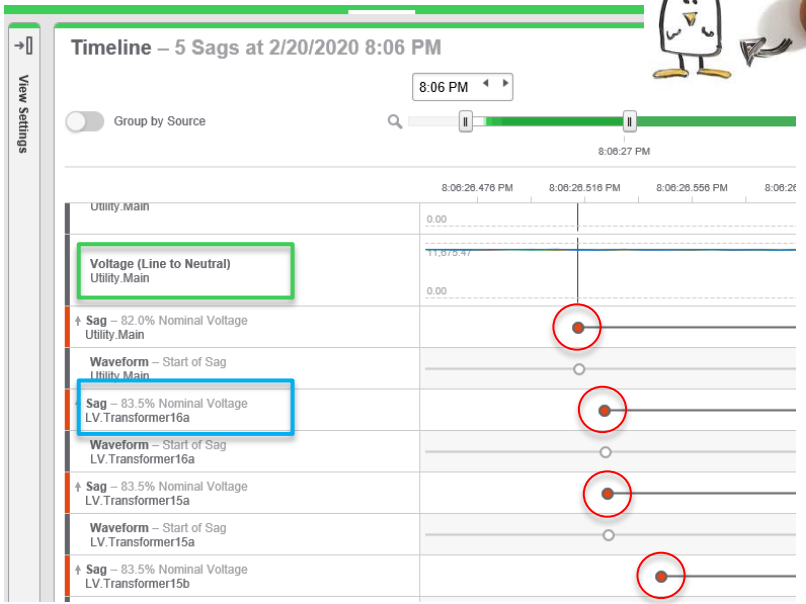


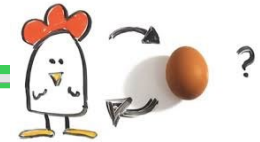
Time Synchronization

Often overlooked

When diagnosing power-related problems, it is important to know the precise sequence of events, especially when you consider how quickly disturbances can travel through an electrical network

- Time horizon = 1-5 sec, **resolution/accuracy** = 1-10 ms., time criticality = high
- Choice of time **synchronization architecture** – NTP, PTP, IRIG-B etc. with ms. or µs time accuracy.
- **NOTE**: Not all devices are capable of recording status changes with high accuracy and resolution. Critical statuses must be connected to devices I/Os with accurate (<= 1 ms.) time-stamping (breaker status, ATS switch status etc.)





"A man with a watch knows what time it is. A man with two watches is never sure"

Segal's law

3. Past, Present and Future

System Components and Analysis Tools

The three-step process of Power Events Analysis

1 Detect

When an unexpected event or series of related events occurs, specialized monitoring devices capture high-resolution, timestamped event and power quality data and EPMS software automatically uploads the information.

2 Diagnose

Analyze the sequence of events to determine origin, impact and probable cause of the incident and understand what equipment or processes have been affected and in what way.

3 Respond

Make informed decisions about what action(s) to take to address the problem and return the state of the electrical system to pre-incident operating conditions or better, as quickly and safely as possible.

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Power Events Analysis - **15 YEARS AGO**

1 Detect

Automatic

- High speed PQ event detection
- Millisecond accurate timestamps
- Waveform capture
- Automatic upload to EPMS

2 Diagnose

Software-assisted

- Event viewer applications provided a chronological list of all timestamped events.
- Graphical user interfaces for PQ waveform analysis
- Software could send event notifications to personnel

Manual

- Manual inspection of many events from multiple devices to confirm if events are related to same incident
- Manual correlation of events was necessary to determine if PQ disturbance had an impact and load was lost.
- Waveform analysis needed to confirm PQ event details

3 Respond

Manual

- Personnel form hypothesis of the root cause and make decisions based on limited information available to them
- Changes to operations or equipment were made based on the hypothesis and staff would hope changes prevent future disturbances

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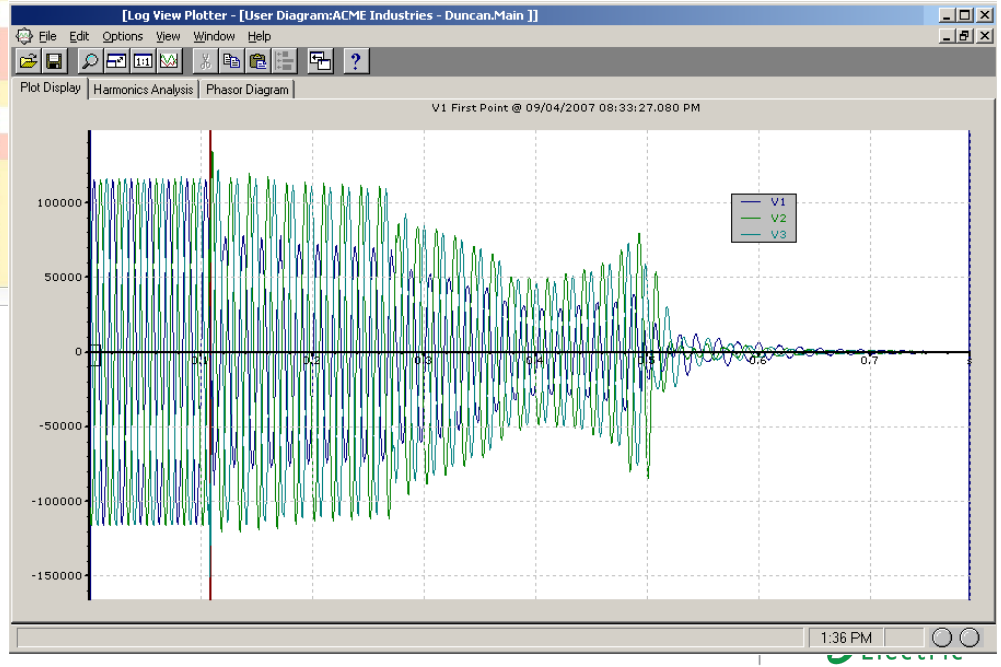
Alarms | Events

View: **All Unacknowledged Alarms**

Alarms Displayed: 1,161 Unacknowledged Alarms: 1,161 Acknowledge Select Columns

Drag a column here to group by that column

Active	Start Time	Device	Type	Priority	Value	Acknowledge
	12/4/2012 8:37:12.850 AM	Victoria_Keating.main_Training	Dist Direction Detection 1		DDD Analysis Done	Acknowledge
	12/4/2012 8:37:12.850 AM	Victoria_Keating.main_Training	Voltage Disturbance State		Disturbance Start	Acknowledge
	12/4/2012 8:35:21.096 AM	Victoria_Keating.PNL_B	Voltage Disturbance State		Disturbance Start	Acknowledge
	12/4/2012 8:35:20.934 AM	Victoria_Keating.PNL_Q	Voltage Disturbance State		Disturbance Start	Acknowledge
	12/4/2012 8:35:20.896 AM	Victoria_Keating.PNL_K	Voltage Disturbance State		Disturbance Start	Acknowledge
	12/4/2012 6:11:42.000 AM	Victoria_Keating.main_Training	PF Limit		-88.106	Acknowledge
	12/3/2012 6:11:39.000 AM	Victoria_Keating.main_Training	PF Limit		-89.497	Acknowledge
	12/3/2012 5:21:14.466 AM	Victoria_Keating.main_Training	Dist Direction Detection 1			
	12/3/2012 5:21:14.466 AM	Victoria_Keating.main_Training	Tran V3 Max			
	12/3/2012 5:21:14.466 AM	Victoria_Keating.main_Training	Tran V2 Max			
	12/3/2012 5:19:23.257 AM	Victoria_Keating.PNL_B	Tran V2 Max			
	12/2/2012 6:49:17.290 AM	Victoria_Keating.main_Training	Dist Direction Detection 1			
	12/2/2012 6:49:17.290 AM	Victoria_Keating.main_Training	Tran V1 Max			
	12/2/2012 6:47:26.161 AM	Victoria_Keating.PNL_Q	Tran V1 Max			
	12/1/2012 11:36:59.000 PM	Victoria_Keating.main_Training	PF Limit			
	12/1/2012 6:11:34.000 PM	Victoria_Keating.main_Training	PF Limit			
	12/1/2012 1:07:00.000 AM	VIP.SPM7DEMO	HVAC kwh TM			
	12/1/2012 1:06:00.000 AM	VIP.SPM7DEMO	kw this month			



Power Events Analysis – 5 Years Ago

1 Detect

Automatic

- High speed PQ event detection
- Millisecond accurate timestamps
- Waveform capture
- Automatic upload to EPMS

2 Diagnose

Automatic

- Many related events intelligently aggregated into individual “incidents”
- PQ disturbances are automatically classified, and their origin determined
- The probable cause and impact of a disturbance are determined using analytics

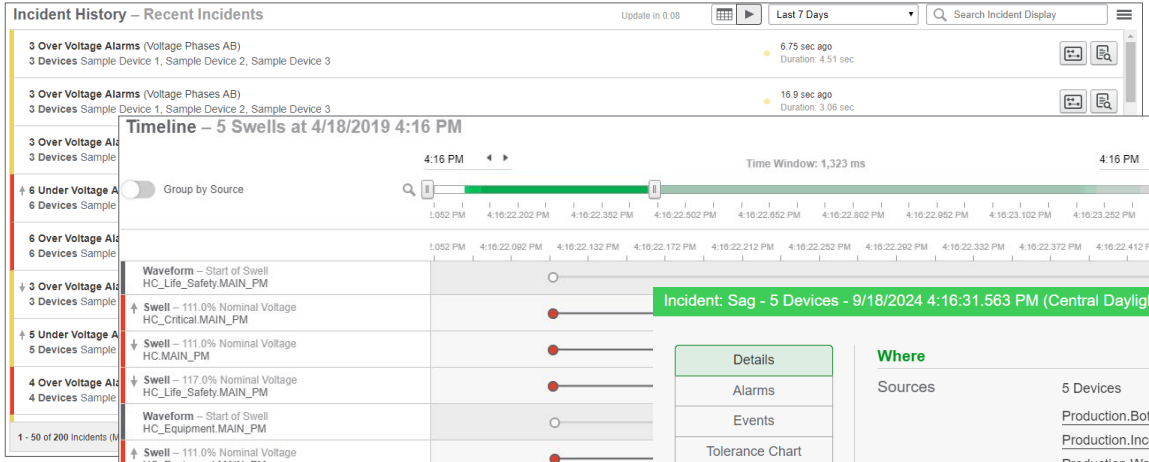
Software-assisted

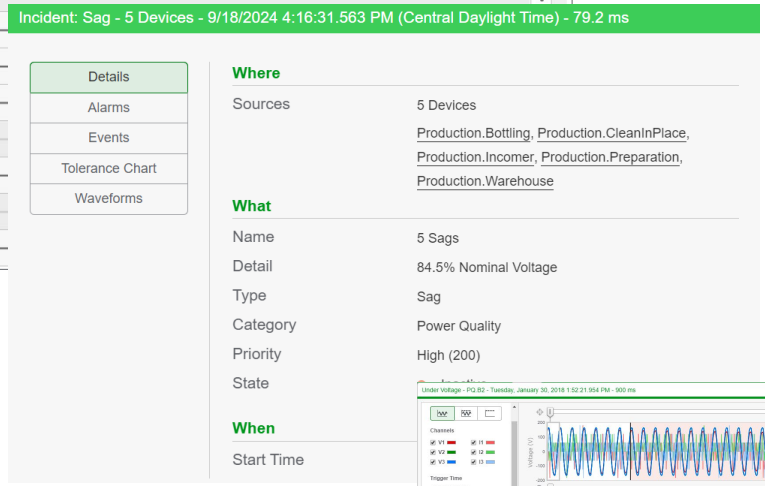
- Incident viewers replace event viewers to reduce information overload and improve alarm management
- Personalized incident views can be created, and alarms can be “shelved”
- Timeline analysis interfaces simplify event reconstruction and streamline diagnostics

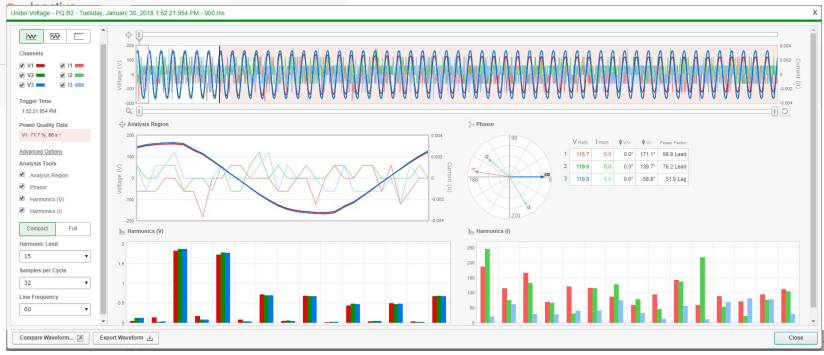
3 Respond

Manual

- Personnel make informed decisions based on detailed information about type, origin, impact and probable cause of all PQ disturbances
- Changes to operations and mitigation actions are made based on understanding of root cause and impact of power-related problems


Incident History – Recent Incidents
Update in 0:08
Last 7 Days
Search Incident Display
3 Over Voltage Alarms (Voltage Phases AB)
3 Devices Sample Device 1, Sample Device 2, Sample Device 3
6.75 sec ago
Duration: 4.51 sec
3 Over Voltage Alarms (Voltage Phases AB)
3 Devices Sample Device 1, Sample Device 2, Sample Device 3
16.9 sec ago
Duration: 3.06 sec
Timeline – 5 Swells at 4/18/2019 4:16 PM
4:16 PM
Time Window: 1,323 ms
4:16 PM
Group by Source
Waveform – Start of Swell
HC_Life_Safety.MAIN_PM
Swell – 111.0% Nominal Voltage
HC_Critical.MAIN_PM
Swell – 111.0% Nominal Voltage
HC.MAIN_PM
Swell – 117.0% Nominal Voltage
HC_Life_Safety.MAIN_PM
Waveform – Start of Swell
HC_Equipment.MAIN_PM
Swell – 111.0% Nominal Voltage
HC_Equipment.MAIN_PM
Waveform – Start of Swell
HC_Non_Essential.MAIN_PM
Swell – 111.0% Nominal Voltage
HC_Non_Essential.MAIN_PM


Incident: Sag - 5 Devices - 9/18/2024 4:16:31.563 PM (Central Daylight Time) - 79.2 ms
Details
Alarms
Events
Tolerance Chart
Waveforms
Where
Sources
5 Devices
Production.Bottling, Production.CleanInPlace, Production.Incomer, Production.Preparation, Production.Warehouse
What
Name
5 Sags
Detail
84.5% Nominal Voltage
Type
Sag
Category
Power Quality
Priority
High (200)
State
When
Start Time



Power Events Analysis – **TODAY**

1 Detect

Automatic

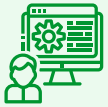
- High speed PQ event detection
- Millisecond accurate timestamps
- Waveform capture
- Automatic upload to EPMS

2 Diagnose – Train and Optimize

Automatic

- intelligently aggregated “incidents”
- PQ disturbances automatically classified, and origin determined
- Probable cause and impact of a disturbance determined

Software-assisted



- Incident viewers
- Personalized incident views can be created, and alarms can be “shelved”
- Graphical timeline analysis

Train & Optimize

- Digital twin to run what-if scenarios and simulate before operate
- Operator training with real system simulated data.
- Analytics to continuosly optimize and improve alarm management (ISA 18.2)

3 Respond

Manual

- Personnel make informed decisions based on detailed information about type, origin, impact and probable cause of all PQ disturbances
- Changes to operations and mitigation actions are made based on understanding of root cause and impact of power-related problems

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Load Loss 12% **8 Sag/Swell (Voltage) Alarms** (Nominal Voltage: 8,069.8 volts)

5 min 50 sec ago

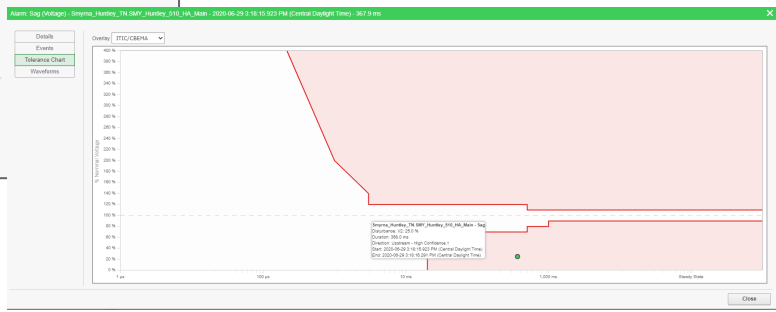
Duration: 30.3 sec

4 Devices

Waveform Analysis Information	
Source Name	cluster_pso AP.MV.Intake_A_PM
Probable Cause	Downstream Three-Phase Fault
Load Loss	12.25%
Max Voltage	1.0267 pu
Min Voltage	0.7952 pu
Max Current	3,615.24 A
Min Current	318.46 A
Load Change	-1,001.26 KW
Load Change	-12.25%
RMS Duration	15.18 cyc

Waveform Analysis Information	
Source Name	cluster_pso AP.HV.Utility_B_PM
Probable Cause	Downstream Load Start
Load Gain	19.12%
Max Voltage	1.0093 pu
Min Voltage	0.8528 pu
Max Current	24.19 A
Min Current	12.14 A
Load Change	626.58 KW
Load Change	19.12%
RMS Duration	3.94 cyc

Waveform Analysis Information	
Source Name	cluster_pso AP.MV.Intake_B_PM
Probable Cause	Upstream Voltage Sag
Load Gain	4.26%
Max Voltage	1.0113 pu
Min Voltage	0.8499 pu
Max Current	199.21 A
Min Current	118.80 A
Load Change	169.42 KW
Load Change	4.26%
RMS Duration	2.37 cyc



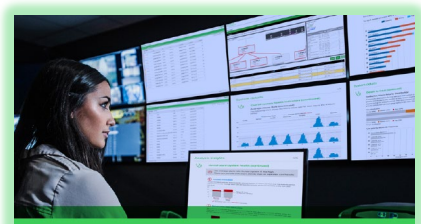
Alarm Analytic Digital Services

Measure
Alarm Health KPIs

- Average Alarm Rate KPI
- Peak Periods KPI

Detect Nuisance Alarms and Provide Recommendations

- Chattering / Fleeting Alarms
- Stale Alarms
- Alarm Floods
- Frequent Alarms



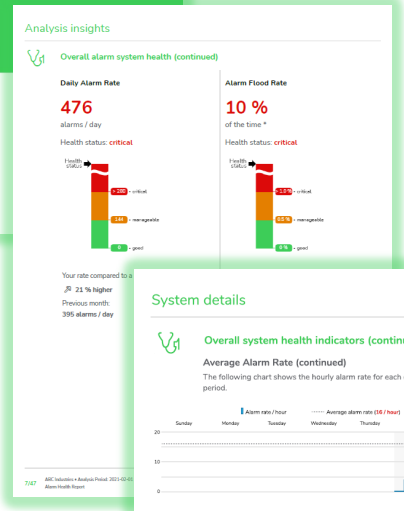
Power Advisor

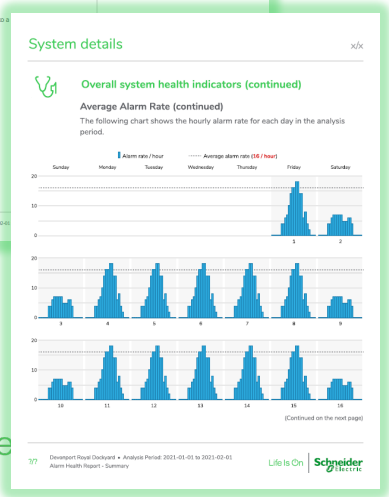
Alarm Health Report

ABC Industries
Analysis Period: 2021-02-01 to 2021-02-28

Created On
Wednesday, July 28, 2021

www.se.com

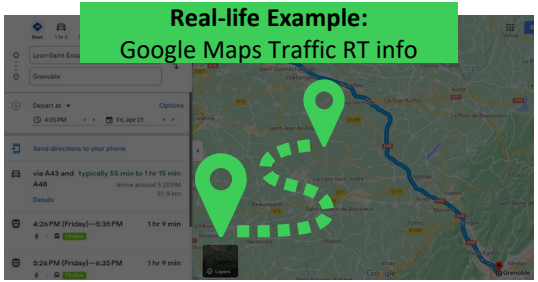




Digital Twin

Empowering operators and facility managers to make accurate choices

1. Predictive Simulation



What: Online Simulation

Persona: Power System Engineer

Intent : run simulations based on real-time data to secure design & investment decision

Criteria to select target :
- Site extension – secure investment.
- ED modifications / Equipment sizing
- Electrical studies / Operational plans Review

2. Operator Training Simulator

What: SCADA Training Simulator

Persona: Operator

Intent: train operators over a multitude of scenarios such as contingency plans or sequence of operation

Criteria to select target:
- Staff is multipurpose
- High turnover of the team
- Outage occurrence due to an operator's mistake

3. Simulate Before Operate

What: Risks notification

Persona: Operator

Intent: notify operators of the risks before they take the action

Criteria to select target :
- Production sites – high cost of outage due to operator's missteps
- Idem Operator Training Simulator

4. Key Takeaways

Food for Thought

Key Takeaways

- **More Complex Electrical systems:** both grid and demand side systems are becoming increasingly complex
- **Rising number of Power Events**: Increasing power quality (PQ) issues, climate related events, and human errors impacting operations
- **Challenges in Diagnosing Power Events**: Disparate sources of data, varying reliability & accuracy of data and Different forensic tools
- **Advancements in EPMS Software**: Modern EPMS software provides intelligent diagnostics and Power Events Analysis tools, simplifying the identification and resolution of power events.
- **Digital Twin and Analytics:** Take power events analysis to the next level. Simulation and analytic tools to reduce human errors and optimize the amount of information operators need to process

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