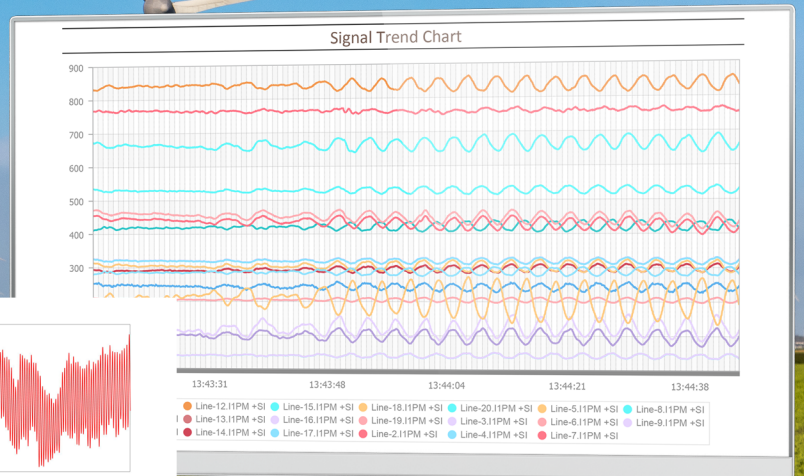


eGENS

Synchrophasor based comprehensive platform for **Grid Event Notifications**



Generator Model Validation

Event 1: March 23rd, 2019 13:52:22 PM

Number of Generators

Number of generator models validated	14
Number of good generator models	13
Number of questionable generator models	1

Summary of Validation Results

Generator	Result
G14	Questionable
G2	Good
G3	Good
G4	Good
G5	Good
G6	Good
G7	Good
G8	Good
G9	Good
G10	Good
G11	Good
G12	Good
G13	Good
G14	Good
G15	Good

Parameter Used for Quantifying Mismatch

Criteria	Threshold
Accumulated Error Ratio	0.02
First Swing Peak Value	0.3
First Swing Peak Time	0.05
Settling Time(s)	0.4

Validation Results for G1

Active Power (MW) Validation - Event 1

Reactive Power (MVar) Validation

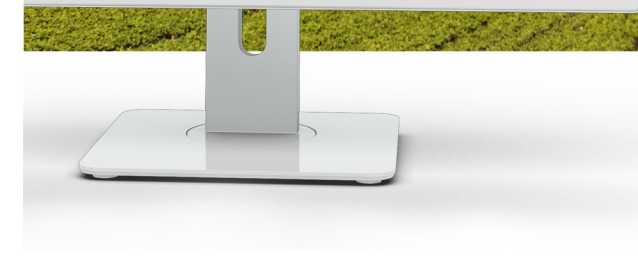
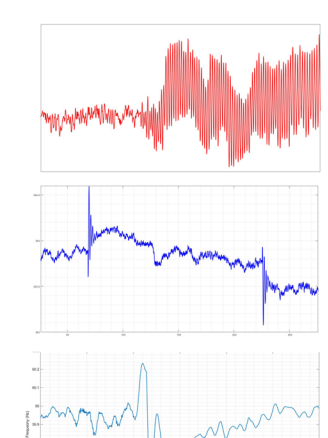
Figure 1. Active power & Reactive Power Comparison

Active Power Comparison

Criteria	PMU measurement	Simulated data
Accumulated Error	0.098927913	0.098927913
First Swing Peak Value	495.7075536	500.3981713
First Swing Peak Time	0.245	0.3
Settling Time	7.44489339	7.52695939

Reactive Power Comparison

Criteria	PMU measurement	Simulated data
Accumulated Error	0.144973111	0.144973111
First Swing Peak Value	399.3055053	426.6981556
First Swing Peak Time	0.055	0.065
Settling Time	8.64489339	13.3489339

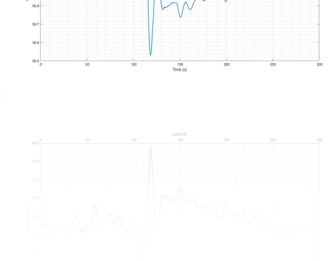


Electric Power Group

Parameter	Value
Accumulated Error Ratio	0.02
First Swing Peak Value	0.3
First Swing Peak Time	0.05
Settling Time(s)	0.4

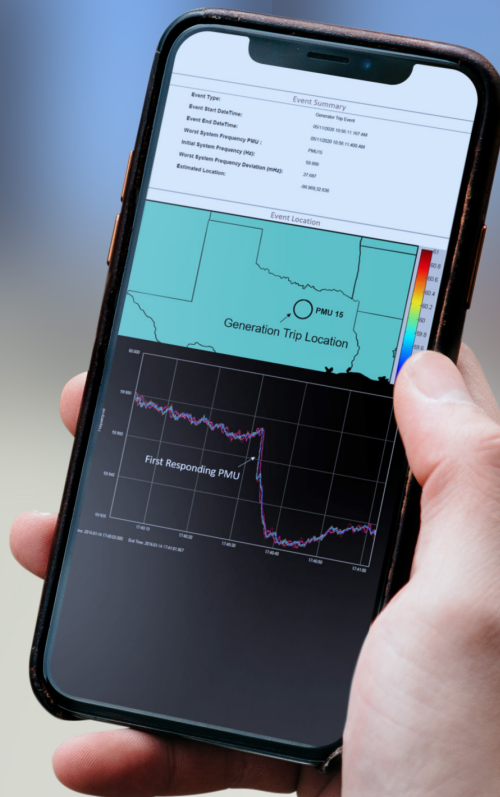
Electric Power Group

Criteria	PMU measurement	Simulated data
Accumulated Error	0.098927913	0.098927913
First Swing Peak Value	495.7075536	500.3981713
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eGENS

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Introduction

The electric power industry is rapidly adopting synchrophasor technology. Phasor Measurement Units (PMUs) provide high-resolution and time-synchronized data typically at 25 or 50 frames/second for 50 Hz systems and 30 or 60 frames/second for 60 Hz systems. This high resolution and time synchronized data provides unprecedented intelligence on power system dynamics that cannot be obtained from the traditional SCADA/EMS system. This intelligence is used in *e*GENS for:

1. Event Detection - line trips, generation trips, load trips and other events
2. Oscillation Detection and Source Location
3. Generator Model Validation
4. Dynamic Events linked to phase angle separations and other dynamic metrics

When major grid events occur, information needs to be available to operators, engineers and managers in and outside control room. During major events, gathering event information could take several hours and operators do not have time for information dissemination.

The *e*GENS platform (*enhanced* Grid Event Notification System) addresses this need by providing an automated notification which alerts authorized subscribers via email and mobile devices when events occur and provides key event intelligence including location, timing and severity with map-based visualization. *e*GENS specifically addresses utility needs for grid event source localization using data from PMUs, DFRs and other IEDs.

*e*GENS provides a simple, easy to use platform enabling event detection, oscillation source location, generator model validation as well as automated notifications, alarms and event intelligence dissemination via email and mobile devices

*e*GENS Platform Leverages Synchrophasor Data to Provide Timely Event Intelligence and Notifications.



eGENS is a software platform to detect events and notify operators, engineers and managers with automated event reports sent via emails and mobile devices in real time to alert users and enable timely mitigating actions. During major events, it may take several hours for the event information to be pieced together. eGENS automates the analysis and event notification, allowing the organizations to focus upon taking the mitigating or corrective actions.

eGENS platform is flexible and scalable. It is designed to address industry needs for timely event information on:

- Oscillation events and oscillation source location
- Frequency events including line trips, load drops, generator trips
- Automated Generator Model Validation when events are detected
- Dynamic Events via WAMS integration for all available alarms

eGENS is capable to send notifications in near real-time to the users and complements control room WAMS.

Some key features are:

- Platform for automated event driven notifications
- Easy to interpret information using maps and graphic displays
- Information at your fingertips – emails, mobile device notifications
- Easy installation with minimal IT infrastructure requirements
- Help in compliance fulfillment such as NERC MOD-26/27 and NERC IRO-002-6 WECC Regional Variance
- Notifications provide following key information
 - *Event Date and Time*
 - *Event Types - Oscillation, Line Trip, Generation Trip etc.*
 - *Affected Area(s)*
 - *Source of Events e.g. Oscillation Source Location*
 - *Geographical Map Based Visualization with heat maps/contours*
 - *Plots of Key Metrics Relevant to the event*
 - *Automated Recording of Event file for further analysis and investigation*

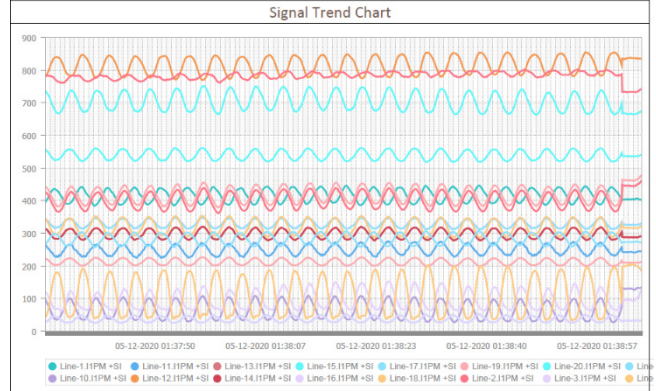


eGENS for Oscillation Source Location (OSL)

eGENS is designed for oscillation detection, source location and provides notifications, reports and alarms in near-real time to provide the relevant event information:

- Early detection of oscillation events due to root causes such as:
 - Generator PSS, AVR, controller issues*
 - Wind/ Solar controller issues*
 - System resonant conditions*
 - HVDC/FACTS device controller issues*
- Pinpoint the oscillation source to a generating plant/unit
- Area-wise identification of source location
- Help in identifying event root cause
- Event severity in terms of oscillation energy and affected areas
- Provide oscillation frequency
- List of locations with highest oscillation energies
- Plots of key metrics relevant to the event
- Helps in complying with NERC IRO-002-6 WECC Regional Variance

Event Summary	
Event Start Timestamp (Local Time):	05-12-2020 01:39:04
Band:	2
Oscillation Frequency:	0.25
Highest DEF Line:	Line-5.11PM +SI
Oscillation Source:	Area-2 is the source



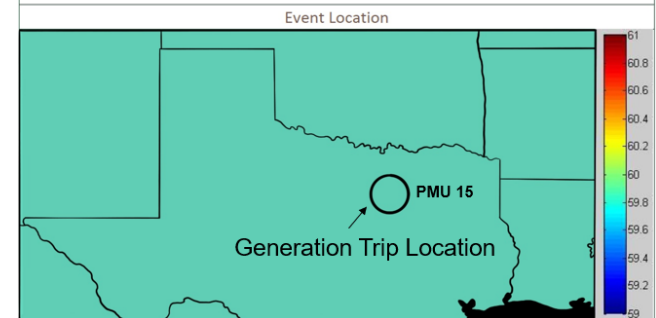
Dissipating Energy (DE) Flow Pattern		
	DE Flow Directions on Interties	In/Out of the area
Oscillation Source Interpretation	Outside the Area	Inside the Area

eGENS for Frequency Events

eGENS is designed for frequency event detection, location and provides notifications, reports and alarms in near-real time to provide the most relevant event information :

- Event detection such as:
 - Line Trip*
 - Generation Trip*
 - Load Trip*
 - Pumped Storage Trip*
- Event location on geographical map with heat maps/contours
- Event date and time
- Affected Area(s)
- Plot of key metrics relevant to the event
- Automated recording of event file for archiving and further analysis

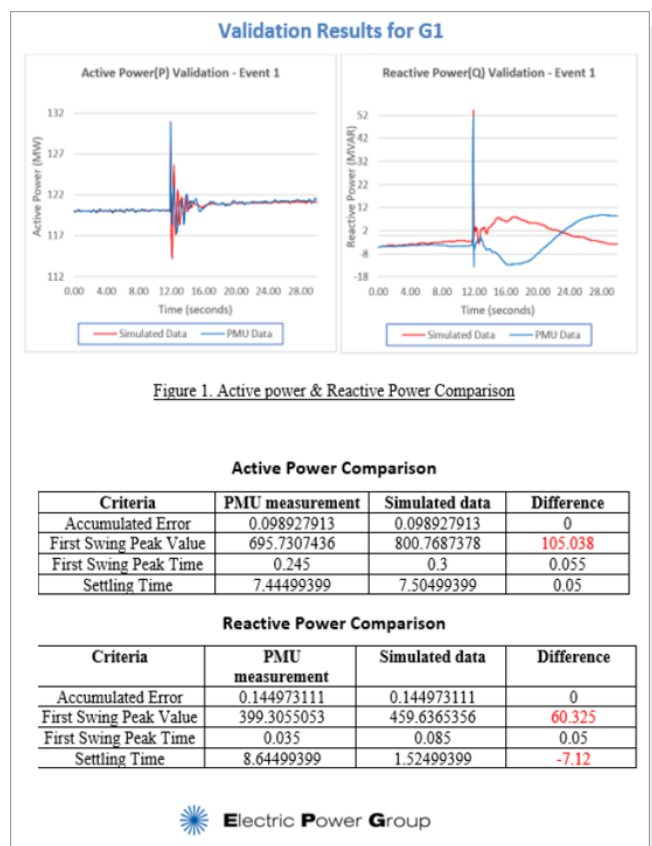
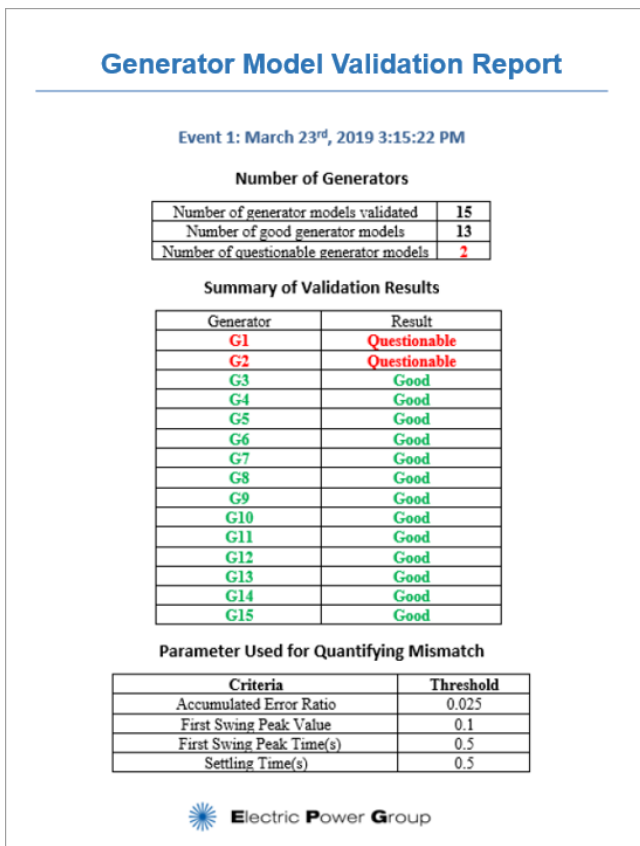
Event Summary	
Event Type:	Generator Trip Event
Event Start DateTime:	05/11/2020 10:56:11.167 AM
Event End DateTime:	05/11/2020 10:56:11.400 AM
Worst System Frequency PMU :	PMU15
Initial System Frequency (Hz):	59.999
Worst System Frequency Deviation (mHz):	27.887
Estimated Location:	-96.969,32.636



eGENS for Generator Model Validation

eGENS includes capability to validate generator models and provide validation reports in real-time to provide the most relevant event information:

- Automated system to perform model validation after significant events
- Validates multiple events
- Validates multiple generators
- Identifies good vs questionable model parameters (programmatically not visually)
- Automated report generation and email
- Compliance with NERC MOD-26, 27



eGENS for Dynamic Events

eGENS is also designed to integrate with EPG's RTDMS WAMS software that is used in major control centers. An adaptor integrates all the dynamic event alarms that are available in RTDMS WAMS systems such as phase angles, oscillation detecting and damping, voltage stability index and notifies engineers and operators, including those who are not in the control room to stay abreast of events as they occur.

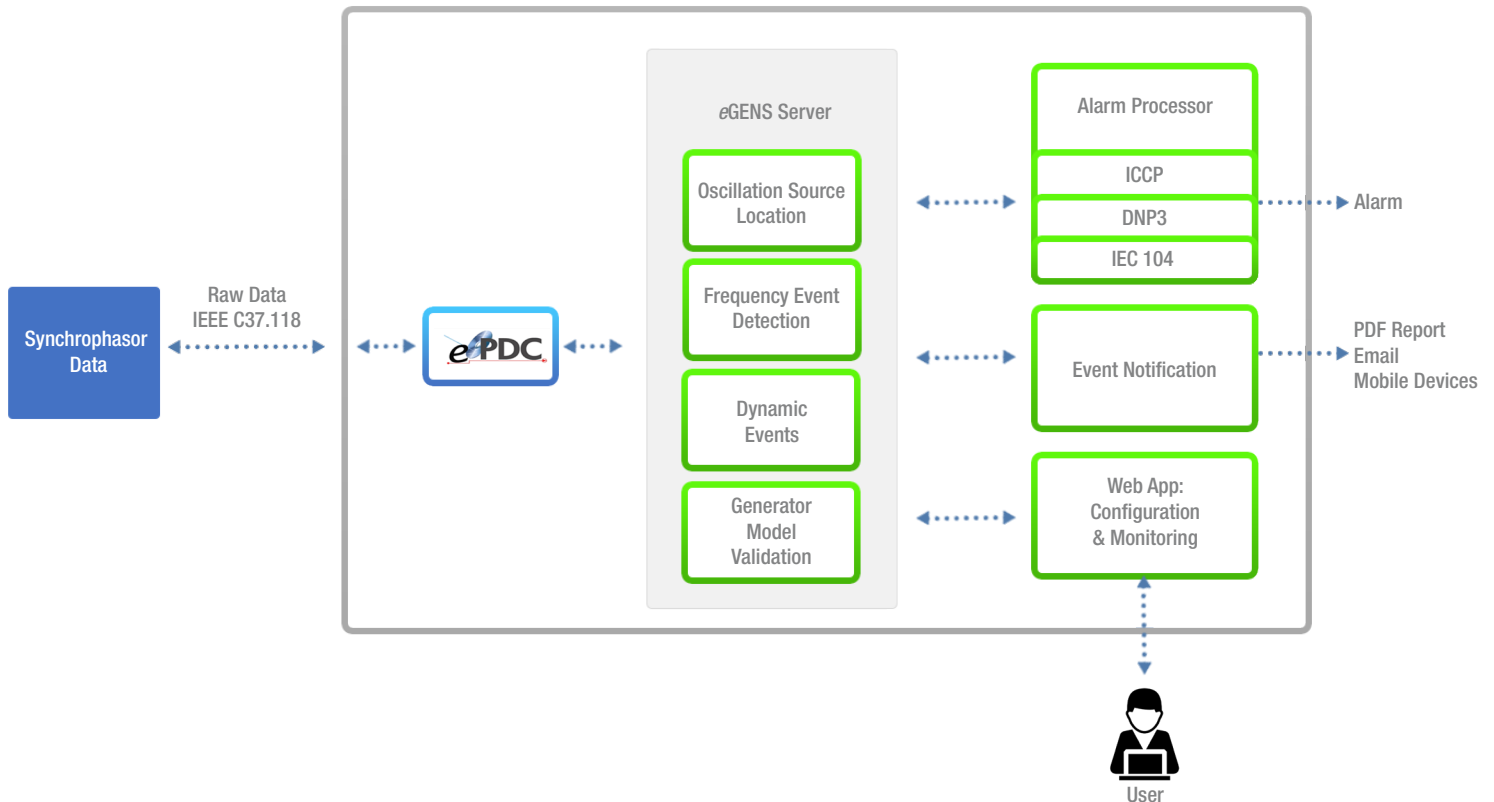
Architecture and Data Flow

*e*GENS application can receive the synchrophasor data from any device which supports IEEE C37.118 format such as PMUs, Phasor Data Concentrators (PDCs), DFR devices etc. *e*GENS application has four subsystems:

- **Server:** A Windows Service to subscribe sub-second data from the substation devices, perform calculations for the 4 *e*GENS modules - oscillation source localization, frequency event detection, dynamic events and generator model validation, and provide data sink interfaces for the results and alarms.
- **Web App:** A web application hosted by Microsoft Internet Information Service (IIS) to configure *e*GENS Server and monitor the results and alarms.
- **Event Notification:** Event Notification subsystem sends a real time notification and report to the subscribed list upon detection of an event.
- **Alarm Processor:** The application is capable to send alarms locally to the substation or to a central control room. The Alarm Processor is compatible with industry standard communication protocols such as ICCP, DNP3 and IEC 104.

*e*GENS also has a feature of archiving the event data for detailed engineering analysis.

*e*GENS Data Flow



Features and Functionalities

Overall

- Event Detection such as Oscillations, Generator Trip, Load Trip, Line Trip etc.
- Event Location and Source information to guide corrective actions
- Event Notification and Reports to authorized email list and mobile devices
- Generator Model Validation and automated event reporting
- Event Notification and Reports for dynamic events
- Generate Alerts and Alarms
- Visualize data on variety of charts and displays - Trends, Geographical Maps
- Record Event Data for engineering analysis
- Add-on module for developing custom algorithms using SDS (Synchrophasor Distribution Service)

Comprehensive Input Configurations

Input Communication Modes

- TCP
- UDP/UDP
- TCP/Broadcast
- TCP/Multicast
- TCP/Unicast
- Spontaneous Broadcast
- Spontaneous Multicast
- Spontaneous Unicast
- Serial through Ethernet Converter
- Variable Input Data Rate (up to 100 samples/sec or 120 samples/sec)

Input Data Formats

- C37.118
- C37.118 B
- C37.118 Draft6
- Macrodyne 1 (M)
- Macrodyne 2 (G)
- PDC Stream
- FNet
- C37.118.2
- ICCP
- Optional Add On Modules
 - *DNP3*
 - *IEC 104*

Security (NERC CIP Compliance)

- Role based access control (admin definable roles)
- Settable Timeout
- Screen Lock
- Definable password characteristics (Caps, Numbers, Special Chars, Length etc.)
- Password expiration
- User management utility
- Active Directory integration

System Requirements

Operating System:	64 bit Microsoft Windows 2008 R2 or later 64 bit
	Microsoft Windows 7 or later
Processor Speed:	2.8 GHz or higher
Processor Cores:	Dual Intel Processors (8 cores total or greater)
Memory:	8 Gigabytes or greater
I/O Ports:	1 Network Interface Card (NIC) supporting 1 Gbps
Hard Disk Storage:	100 GB Minimum

Substation Deployment can be on a PC or a hardened PC



About EPG

Electric Power Group (EPG) was established on June 24, 1999 and began operations in 2000. EPG is led by technical, management, and executive level personnel with extensive utility power systems experience in planning, operations, transmission, protection with specialization in use of synchrophasor technologies and advanced applications for analytics, real-time operations and grid monitoring technologies. EPG's research in the use of synchrophasor measurements led to the development of the first of its kind wide-area real-time performance monitoring system for electric grids, referred to as Real Time Dynamics Monitoring System (RTDMS®); the first prototype was installed at California ISO in 2003. EPG's RTDMS® application for Wide Area Situational Awareness and other synchrophasor applications are in use at many of the leading ISOs and utilities in North America for real time and off-line analytics as well as real time wide area situational awareness and monitoring in control centers. EPG applications using SCADA data are installed at North American Electric Reliability Corporation (NERC) for reliability monitoring.

EPG is a leading provider of synchrophasor technology solutions with more than 32 customers in USA, Canada, Middle East, India and Dominican Republic. EPG specializes in working with transmission companies, utilities and ISOs in the areas of power systems planning, analysis, reliability technologies, control center operations, research and development, and development and implementation of synchrophasor technology applications. EPG has been working with synchrophasor technology since 2001 and has extensive first-hand knowledge and experience with addressing the challenges that ISOs and utilities face in making use of synchrophasor applications by operators, reliability coordinators, operating engineers, and planners.

EPG experience covers all components of synchrophasor technology networks and use of synchrophasor technology data for reliability management including – data collection, synchronization, data validation and conditioning, data archiving, linear state estimation, real-time streaming to applications, real-time monitoring and offline analysis applications for use in control room, engineering environments, substations, universities and technology centers.

EPG WAMS and Substation Applications

PHASOR DATA MANAGEMENT

Collection and Synchronization



Storage



Integration



Validation and Conditioning



Algorithms / Models

REAL-TIME ANALYTICS, MONITORING, NOTIFICATIONS & REPORTS



Analytics and Monitoring



GridSmarts Reports



enhanced Grid Events Notification System

OFFLINE ANALYTICS PLATFORM

Phasor Grid Dynamics Analyzer



Phasor Data Extractor

AUTOMATED Event Miner

Big Data Analytics

GRID RESILIENCY



PhasorNxt

LINEAR STATE ESTIMATION



enhanced Linear State Estimation

GRID PERFORMANCE

GRID PERFORMANCE ASSESSMENT SERVICE

SUBSTATION APPLICATIONS



Intelligent Transmission Alert Monitor



enhanced Grid Events Notification System



Generator Model Validation

PhasorSmart

WAMS Package for Substations



Phasor Simulator for Operator Training



Synchrophasor Training Courses

for further information on all EPG products and services please visit us at www.electricpowergroup.com



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