Intelligent Motor Control

A definition and benefits to process control

Sergio L. Gama & David C. Mazur, P.Eng., Ph.D.

IEEE

Speakers

Sergio L. Gama
Director Marketing Intelligent Motor Control

Rockwell Automation

David C. Mazur, P.Eng., Ph.D.
Global Technical Consultant

David received his B.S. EE degree summa cum laude and first in his class from Virginia Polytechnic Institute and State University, Blacksburg, VA in 2011. David graduated with his M.S. EE degree in 2012 for his work based on rotor angle measurement of synchronous machines from Virginia Polytechnic Institute and State University. He graduated with his Ph.D. in Mining Engineering in September 2013 for his work with the IEC 61850 standard. He is an active member of the IEEE IAS and serves as working group chair for the Communication-Based Protection of Industrial Applications Working Group. He also serves as a member of the Mining Industry Committee (MIC) as well as the Industrial and Commercial Power Systems Committee (I&CPS). David is also an active voting member of the IEEE Standards Association (SA).

Rockwell Automation

IEEE

Agenda

- The growing challenges of industrial and commercial power systems
- What is Intelligent Motor Control
- Intelligence—A Definition
- Benefits of using intelligent motor control
- Network Security
- Visualization
- Safety

IEEE

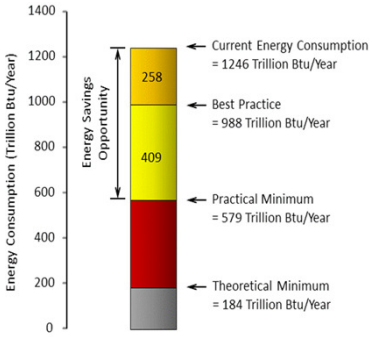
Agenda

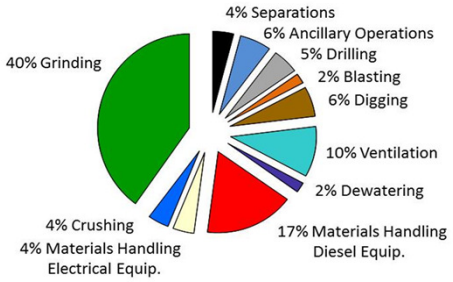
- Scalability
- SCADA
- Condition Monitoring
- Energy Management
- Adaptive Predictive Modeling Software vs. Continuous Emissions Modeling Systems
- Wrap Up and Questions

IEEE

Industrial and Commercial Power System Challenges

A Mining Example

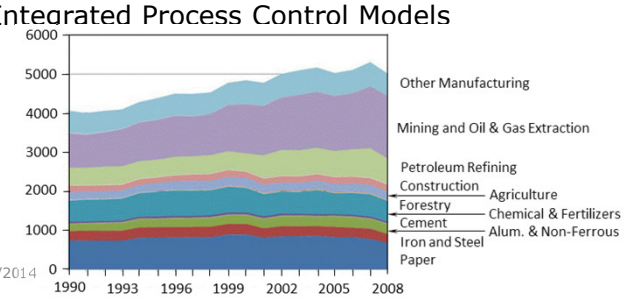




IEEE

Industrial and Commercial Power Systems Challenges

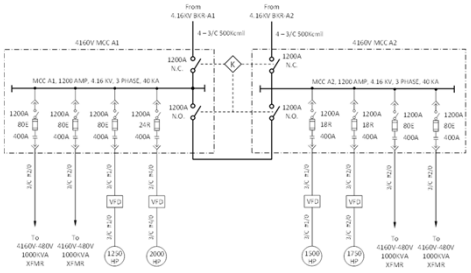
- Heavy Industries are amongst the largest consumers of electric power globally
- Opportunities
  - Energy Monitoring and Management
  - Increased Visibility of Control System
  - Integrated Process Control Models



IEEE

Industrial and Commercial Power System Challenges

- The electrical distribution and infrastructure systems of a I&CPS are not very well monitored
  - Need an easy way to gather information to maximize process yield and efficiency
  - Need to improve automation and control systems to better understand the "big picture" of industrial operations



IEEE

Why? And How?

- Industrial facilities are under increasing pressure to:
  - Reduce overall costs
  - Boost productivity and quality
  - Improve personnel safety
- Device level integration through digital communications boosted the practicality and affordability of complete plant level integration

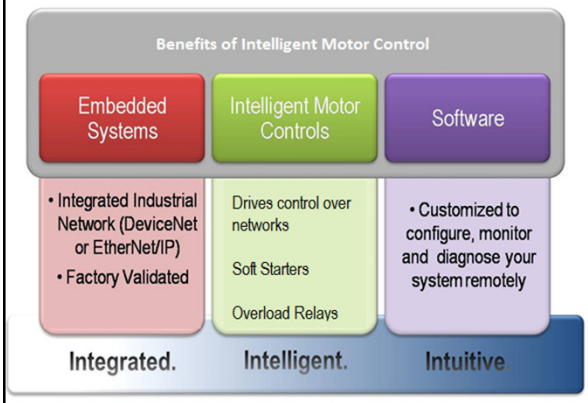
IEEE

History

- Motor Control Centres and Drives are now available with a comprehensive assortment of control and monitoring devices
  - Including
    - Networked Programmable Automation Controllers (PACs)
    - Electronic vacuum contactor control technology
    - Solid State Starters
  - Newer equipment includes
    - Advanced motor-protection and feeder-protection devices that include advanced methods such as optical arc-flash detection capabilities

IEEE

Overview of Intelligence



- Integrated, preconfigured network infrastructure
- Order specific, customized support materials
- Preconfigured user interface software for monitoring, diagnostics and configuration

EtherNet/IP™

Leverage benefits of IMC to enable & strengthen enterprise solutions

What is Intelligent Motor Control?

- When MCCs are used in combination with enhanced performance of MV and LV drives, a greater level of overall system control process capabilities can be achieved
  - This new breed is known as the Intelligent MCC (IMCC)
- These advanced technologies provide a significant amount of control and process data in each separate device, creating distributed data islands
  - Transforming these islands of data into useful information presents a major challenge for the process owner

IEEE

Benefits of Using Intelligent Motor Control

- Using both polled and diagnostic real-time information can provide the following efficiencies in process control and management:
  - Increased productivity
  - Minimized downtime
  - Efficient energy management
  - Preemptive and predictive maintenance modeling
  - Proactive condition monitoring
  - Enhanced quality controls
  - Improved level for personnel safety

IEEE

Value of Embedded Intelligence

- Faster Integration
  - Network is preconfigured (node number, IP address, baud rates, functionality verified)
- Faster installation compared to hardwired I/O
- Control and diagnostics
  - State of the art intelligent motor controls provide crucial feedback from motors
- Precise control with intelligent motor control devices
  - Wide array of device level components
- More information – where you need it when you need it
  - Enhances your plant asset management system
- Improved uptime
  - Warnings in advance of failure
  - Troubleshooting tools and information at your fingertips

IEEE

Ethernet Wiring inside the MCC

- Dual Ethernet Jacks and Dual 24V power jacks provide Unit connections in the Vertical Wire Way

IEEE

Ethernet Wiring in MCC

- Easy connection from the Vertical Wire Way to the Unit mounted device

IEEE

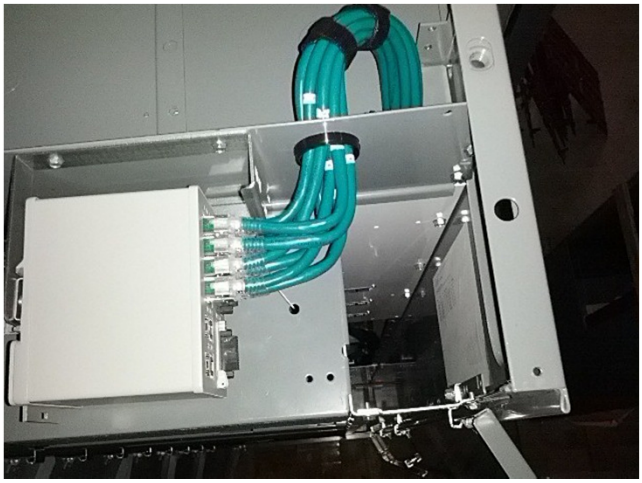
Mounting Ethernet Switches

- Switch mounted in the top or bottom Horizontal Wire Way

IEEE

Cable Routing

- Cables are routed through rear horizontal baffle to the Vertical Wire Way
- 8 cables / section distributed through the Vertical Wire Way



IEEE

Intelligent Motor Control Portfolio

- Fixed Speed Devices

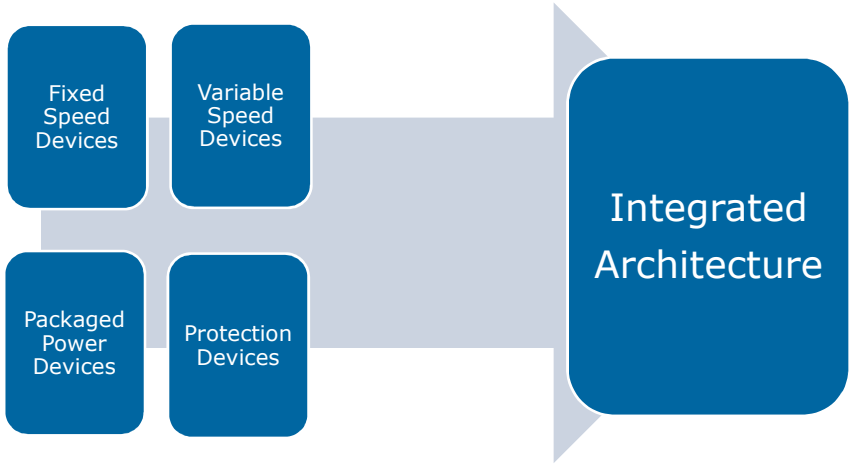
- Variable Speed Devices

- Packaged Motor Controls

- Protection Devices

IEEE

Combing These "Islands" of Information



IEEE

Integrated Architecture

- The combination of these systems forms a flexible, networked architecture platform and network topologies known as **Integrated Architecture (IA).**
- In the past controls designers had to implement controls systems for a specific architecture and network size
- The IA approach allows process owners a set of common automation components and tools
  - These tools make it easy to scale a solution for the entire range of applications, regardless of size or complexity

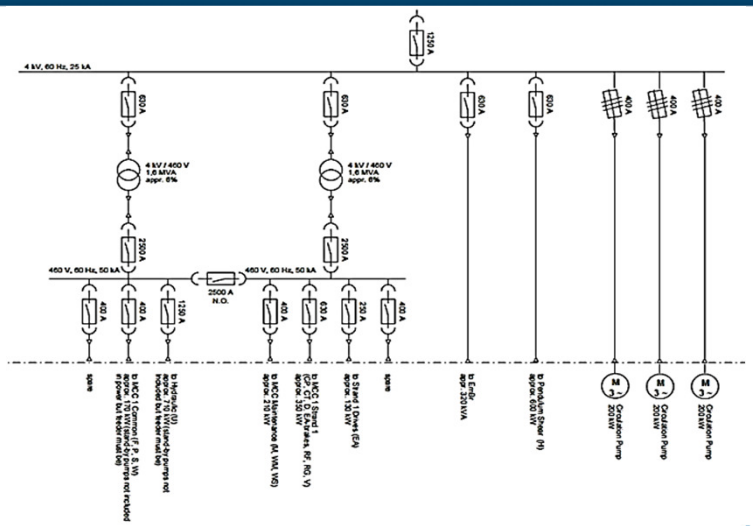
IEEE

IMC Benefits

- Integrated intelligent motor control improves important aspects of the industrial process, such as security, process visualization, safety, scalability, condition monitoring, and adaptive-predictive modeling
- **How do process owners implement improvements from available documentation?**
  - **One lines**
  - **P&ID**

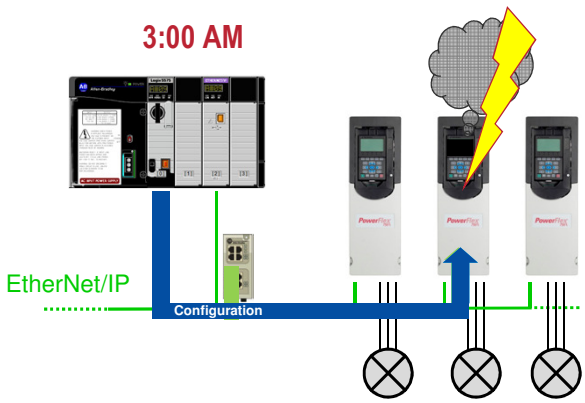
IEEE

IMC Benefits



IEEE

Automatic Device Configuration



Saves the End-User time / money by reducing down-time

Network Security

- Security is a major consideration in the design and operation of industrial control systems
- Good security practices reduce controls and system susceptibility to accidental or unauthorized activities that affect safety, operational integrity and data confidentiality

IEEE

Effective Security

- Effective security requires layers of multiple controls
  - Methods and techniques that work together to help protect system assets, operations, and those who depend upon safe, reliable operations
- Technical controls including physical and electronic mechanisms compensate for security risks
  - These controls should be accompanied and balanced with non-technical controls such as company policies, guidelines and procedures

IEEE

Effective Security

- To help protect key assets users should employ specific product-level security and protection features within a networked IA system

IEEE

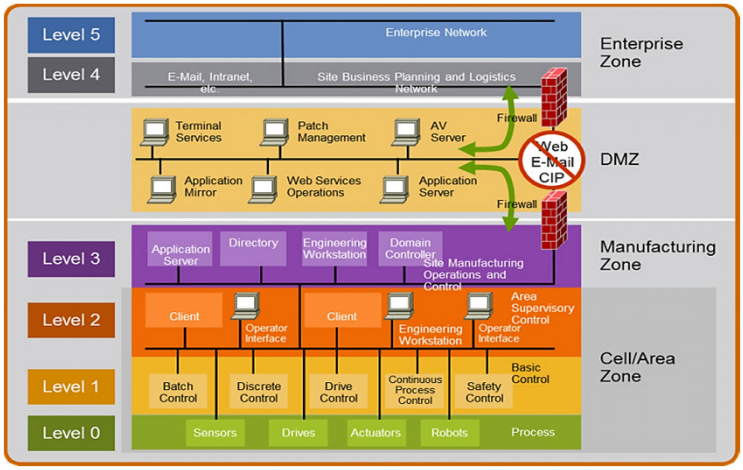
Cyber Security

- Cyber attacks against facilities are at an all-time high
- With use of intelligent devices, such as managed switches, process owners now have the ability to segment their networks into zones, thus mitigating the cyber threat

TARGET

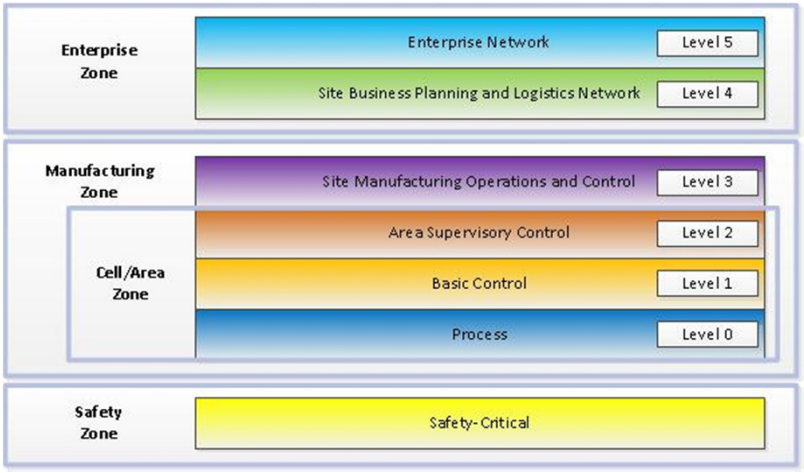
IEEE

The Purdue Network Model and ISA Standard 95



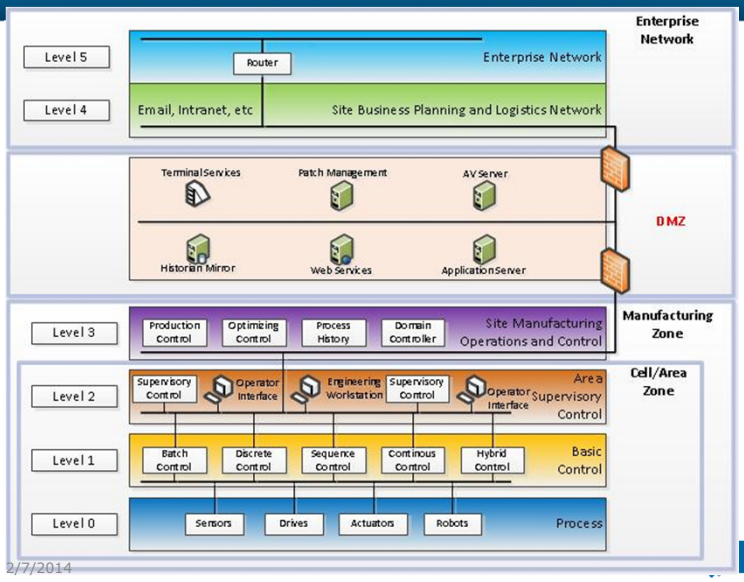
IEEE

A closer look at the Purdue Network Model



IEEE

A practical industrial control model



IEEE

Visualization

- Industrial process owners have various requirements for process visualization
- IA provides the data to visual presentation screens that aid operators in finding the most-efficient plant operating point
- With the development of more sophisticated human-machine-interface (HMI) displays, global objects have been introduced into automation graphics

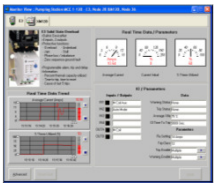
IEEE

Software Support

System Level Dashboard

- Virtual view of the MCC
- Simple dashboard presentation
- Customer configurable
- Exclusive functionality for MCCs

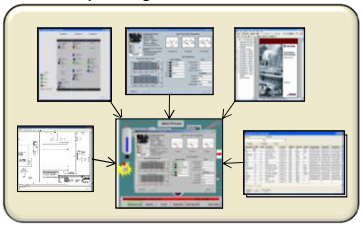
Component Configuration



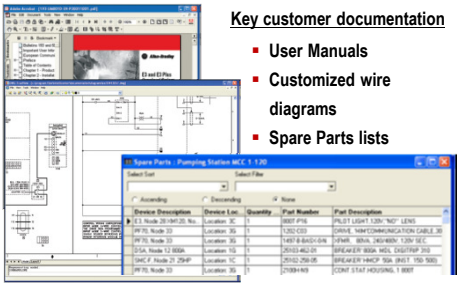
- Parameter Editor
- Device monitoring and configuration
- Remote diagnostic support
- Support for all IMC devices in the MCC
- Trending and event logging

HMI support

ActiveX and IMC faceplates provided
Enables simple integration with On-Machine HMIs



Asset Management



Key customer documentation

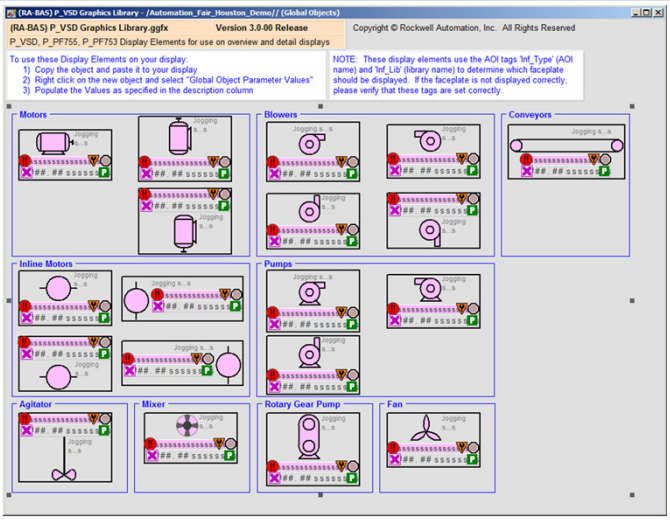
- User Manuals
- Customized wire diagrams
- Spare Parts lists

Faceplates—A definition

- The use of global objects, reusable images and icons, has enabled the creation of faceplates
- Faceplates are defined as reusable standard display objects
- The advantage of the faceplate is that is a standard, prebuilt object that can be implemented repeatedly and consistently
- Each faceplate has security levels built into the objects
  - Can be customized based on user requirements and applications

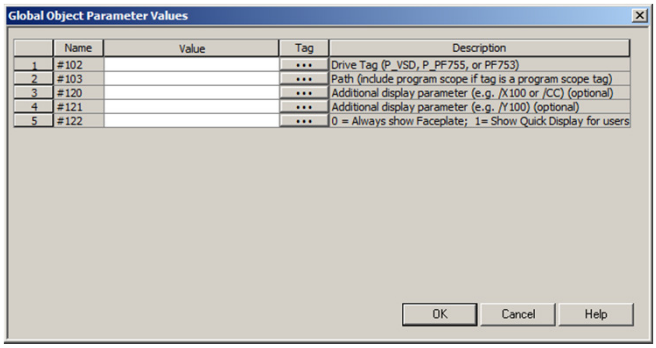
IEEE

Global Objects



IEEE

Backing Tags



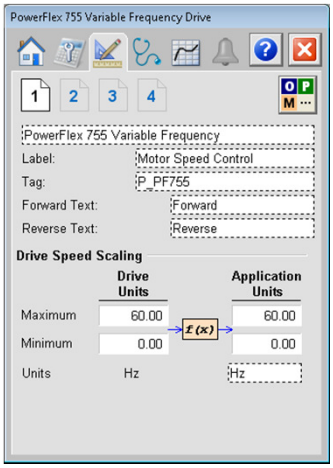
IEEE

Faceplates

- Designed to Support Various User Roles
  - Engineering
  - Maintenance
  - Operator
- Done through various modes of operation
  - Operator
  - Program
  - Override
  - Maintenance
  - Hand

IEEE

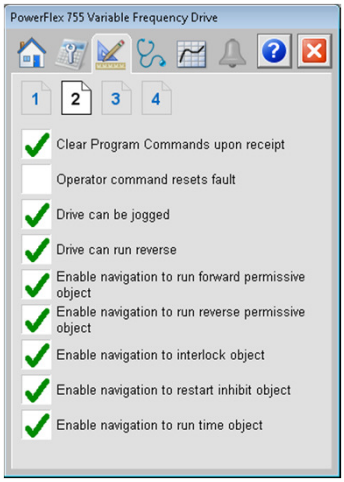
Engineering View



- Allow for Engineers to configure device
  - Set points
  - Control Strategies
  - Naming Conventions

IEEE

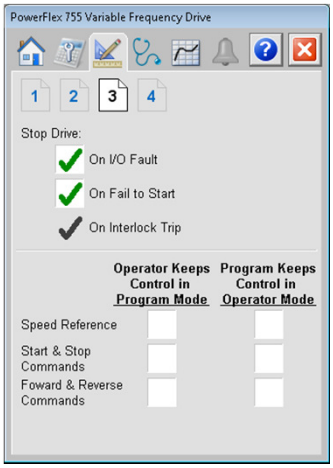
Engineering View



- Select permissions for operators
- Both graphical and control

IEEE

Engineering View

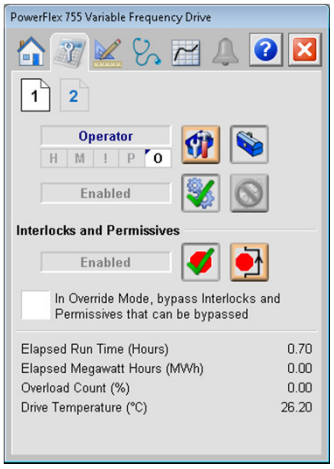


- Configure fail to safe configuration state

IEEE

Maintenance View

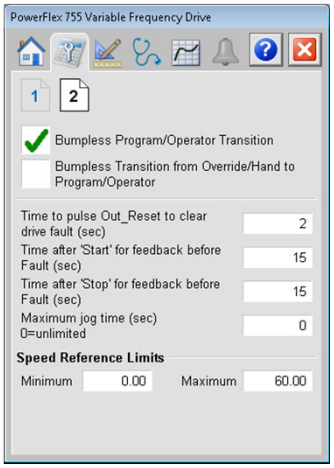
- Enable interlocking and permissive within the control strategy
- Provided with basic runtime information
  - Temperature
  - Uptime



IEEE

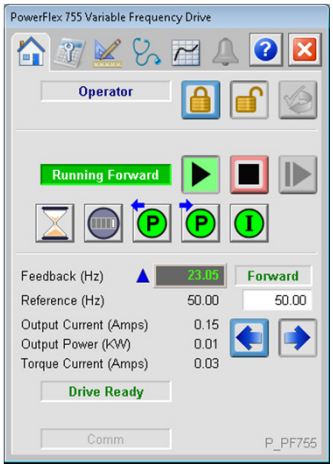
Maintenance View

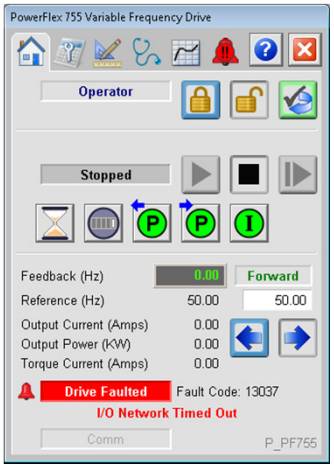
- Configure timing between faults and permissive for restart



IEEE

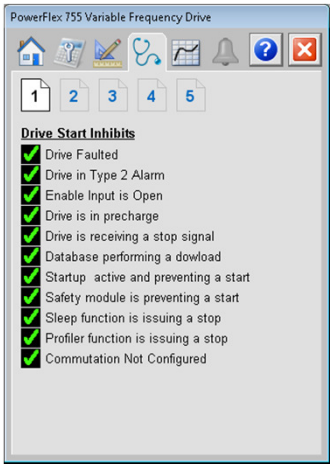
Operator View

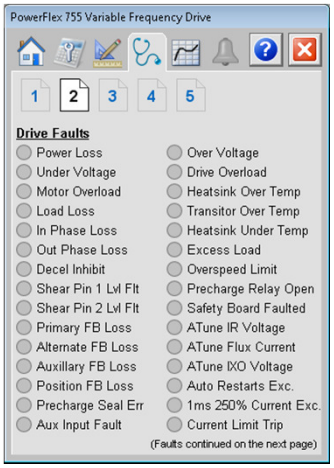




IEEE

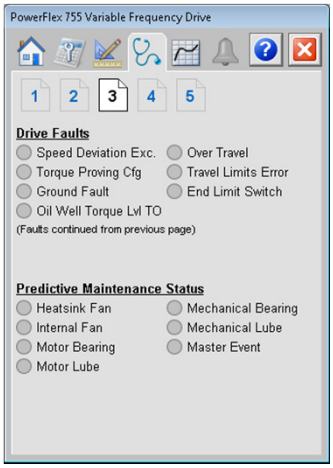
Diagnostic Information

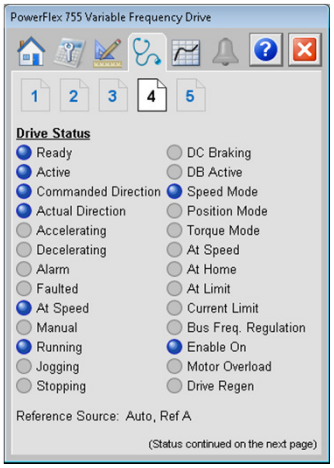




IEEE

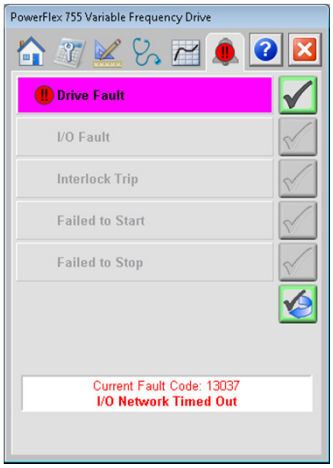
Diagnostic Information





IEEE

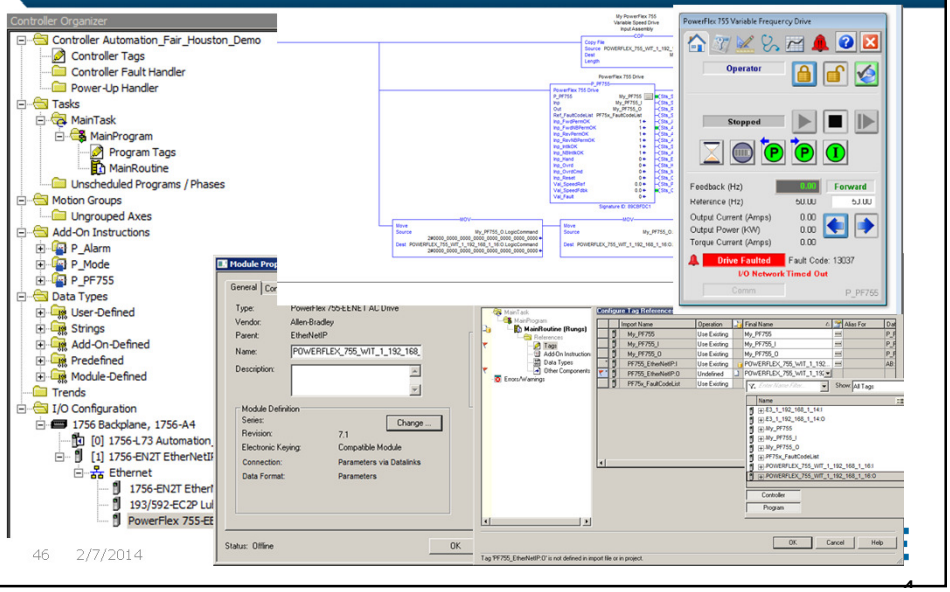
Alarm Indicators



- Linked to the Alarm and Events Database for each device
- Provide a visual indication of alarms associated with device
- Breadcrumbs provide operators easy navigation of faceplate to locate the issue

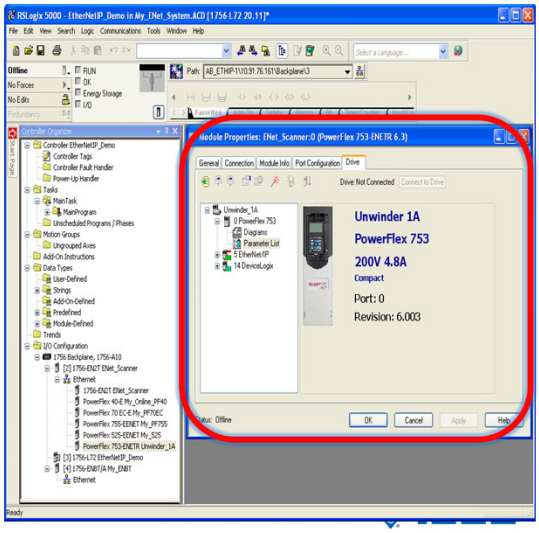
IEEE

Seamless Integration



Integrated Architecture Benefits

- Easy to add to integrated architecture via Add-On Profile
  - Device parameters automatically mapped to controller tags in software
  - Configure and program all intelligent motor control devices in software



Safety

- Continually changing and increasing requirements for electrical safety has caused process owners to invest more resources in systems and methods that increase safety for their personnel and that promote equipment longevity
- IMC provides an alternative to augmenting present site safety practices
- Equipment can be remotely interrogated, reset, and reconfigured directly from the associated HMI screens by operators and maintenance personnel

IEEE

Protective Relay Safety

- Protective relaying devices combine control and protection capabilities with arc-sensing technologies to facilitate the detection of arc-flash events
- These types of integrated devices can provide a coordinated solution for controlling the level of incident energy at various points within the distribution network

IEEE

Scalability

- Common automation components and tools enable the process owner to scale a solution for the entire range of applications regardless of size or complexity
- IMC offers the flexibility of finding the best fit through a range of components and tools
  - Controllers, motion information, inputs/outputs, visualization screens, and safety
- Systems that provide layers of scalability reduce total cost of ownership

IEEE

Scalability

- The use of common system components reduces plant complexity
- A less-complex process saves money by reducing maintenance costs, lowering overall training requirements, minimizing spare parts inventory, and lowering mean time to repair (MTTR)

IEEE

SCADA

- Supervisory control and data acquisition (SCADA) systems have been implemented for some time
- The first SCADA systems were panels, meters, and lights
  - The operator would manually exercise supervisory control by adjusting control knobs
- These systems remain to perform the supervisory control and data acquisition of plants, factories, and power generating stations
  - As control systems become more distributed today, the need and role of SCADA systems plays a larger role in process efficiency and yield

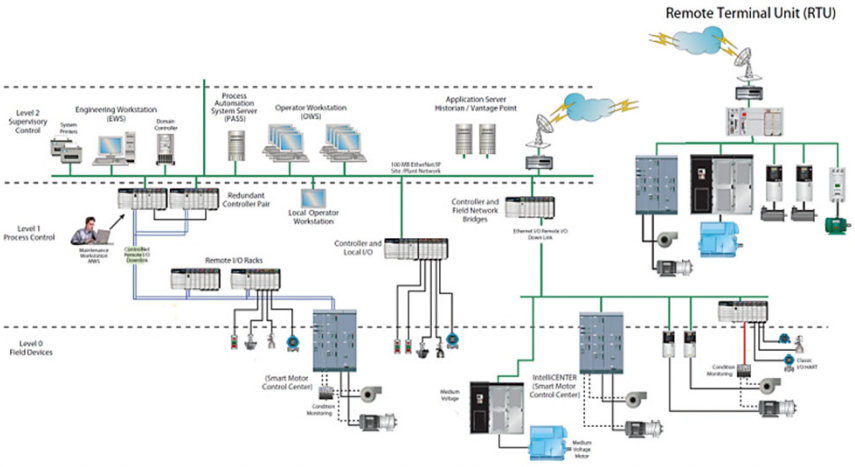
IEEE

SCADA Benefits

- Information can be served from I/O or field IEDs to PACs both periodically and upon event, thus providing the process owner with more data, both real-time and historical diagnostic information to better control the process
- Both variable-frequency drives and IMCCs act as IEDs on the process network
- Important electrical and mechanical parameters can be acquired by the industrial SCADA system

IEEE

SCADA Model



IEEE

SCADA Model

- Typically, SCADA systems are divided into various levels
- Level zero typically represents the process-system peripherals (or field devices) including motors, pumps, drives, motor control centers, and various IEDs.
  - These devices communicate over a fieldbus such as the Highway Addressable Remote Transducer (HART) protocol.

IEEE

SCADA Model

- Level one represents the control portion of a facility.
  - Equipment that resides at this level includes devices that have processing and decision-making capabilities such as PACs and local-operator workstations where command and control is available.

IEEE

SCADA Model

- Level two has control devices
- These devices display a "big picture" view of the system and typically consist of engineering work stations (EWSs), system servers, networked operator workstations (OWSs), and historian/trending applications.
  - Putting intelligent devices on the process network, including motor drives and MCCs, gives enterprise and supervisory control systems the ability to interrogate these devices for meaningful electrical, mechanical, and process parameters

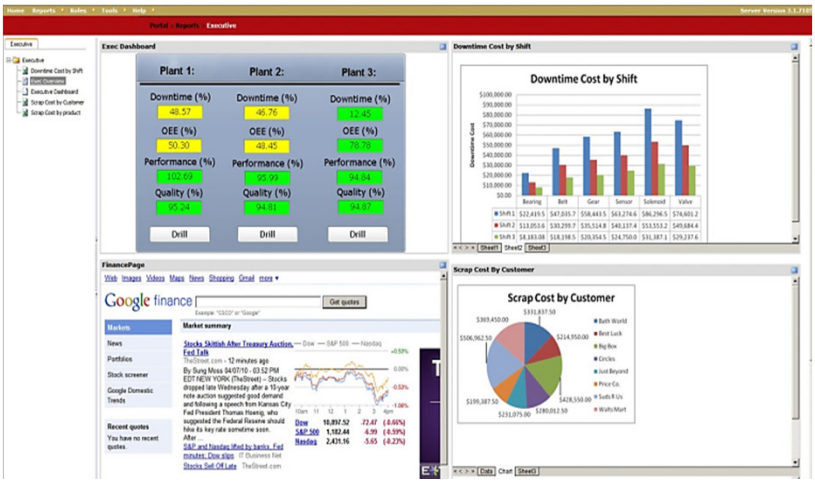
IEEE

SCADA and Historian

- With smarter, more-secure, network configurations, this trended information can be served to anyone with the proper security credentials anywhere in the world from an internet browser
- The historian presents these data to a user in an easy-to-read format
- Historian software is also capable of taking process data and constructing data reports to provide operations management with a visual representation of facility performance

IEEE

SCADA and Historian



IEEE

Condition Monitoring

- Condition monitoring and maintenance management are multidisciplinary systems that encompass electrical engineering, mechanical engineering, economics, instrumentation, information technology, and detection, and real-time prediction of faults and failures
- It has been clearly demonstrated that using condition monitoring systems yields improvements in efficiency and direct profitability

IEEE

Condition Monitoring

- In 1993 the subcommittee "TC 108/SC 5 Condition monitoring and diagnostics of machine systems" was formed by the International Organization for Standardization (ISO)
  - Its mandate is standardization of the procedures, processes and equipment requirements related to condition monitoring and machine-system diagnostics
  - The standards specify measuring and recording methods for the purpose of reducing, analyzing, comparing and displaying data and information
  - The ultimate purpose of using this interim result is to support decisions related to the operation and maintenance of the machine system

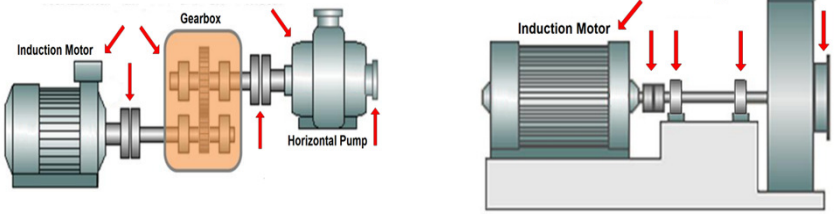
IEEE

Condition Monitoring

- A condition monitor system catalogs vibration, bearing temperatures, flow rates, valve positions and pressures, equipment performance, thermo-graphic data and ultrasonic measurements
- These data are collected, interrogated, and filtered into real-time reports that detect operating anomalies as well as processes that are moving outside their nominal tolerance band
- Then, corrective and preventive maintenance can be appropriately planned, instead of suffering equipment failure that causes an unplanned outage

IEEE

Condition Monitoring



IEEE

Energy Management

- With real-time data, the process user makes management decisions based on real-time reporting from the system and process control components
- With the aid of energy-management tools, parts of the process are optimized to reduce energy consumption with data from actual loading parameters and material loading profiles
- Adjustments to the loading profiles within specific portions of the overall process can be monitored and then manipulated to maximize the overall process quality and flow rate

IEEE

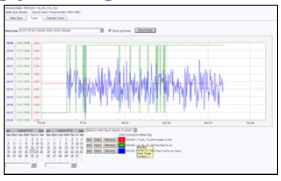
Energy Management

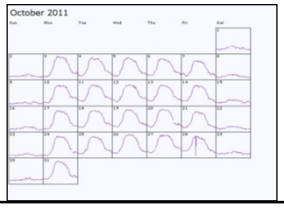
- Optimizing the overall process facilitates the ability to shed specific loads within the process line that typically are left running although these processes are intermittent
- With the inclusion and application of IEC 61850 communications, within IMC there is efficient control, monitoring, and protection of process-level devices

IEEE

Energy Support

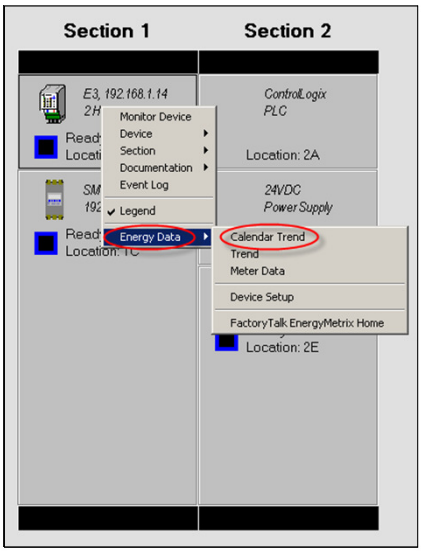
- Real-time energy consumption and historical trending down to the device level, all across the network!
- Ability to monitor and manage energy usage for substantial cost savings

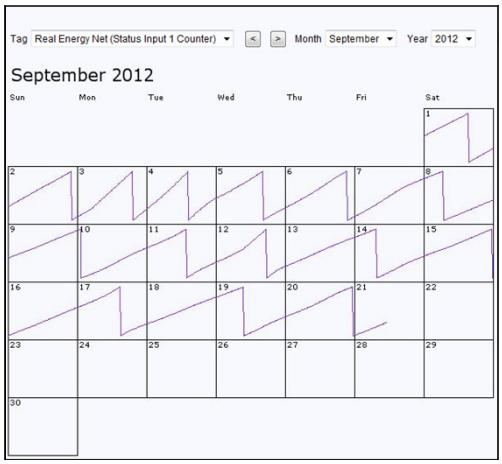




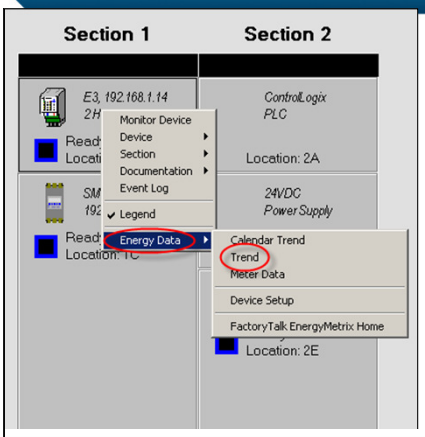
IEEE

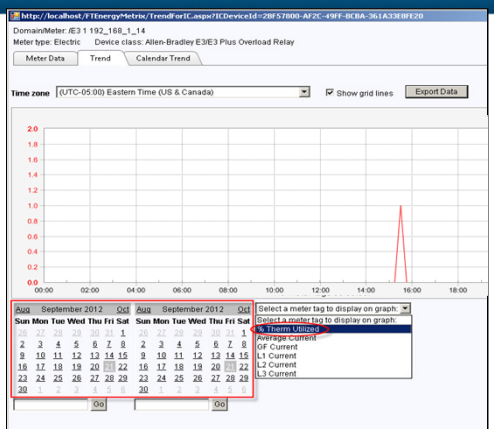
Energy Calculations





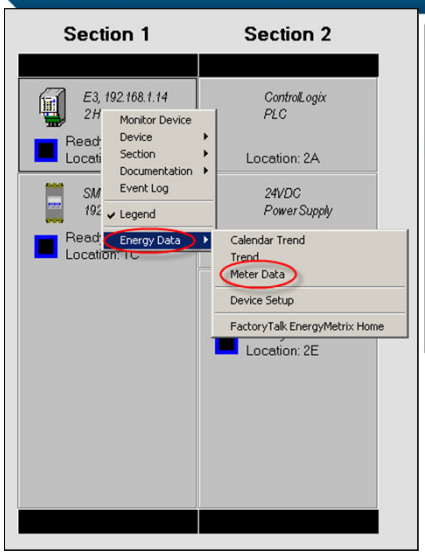
Energy Management

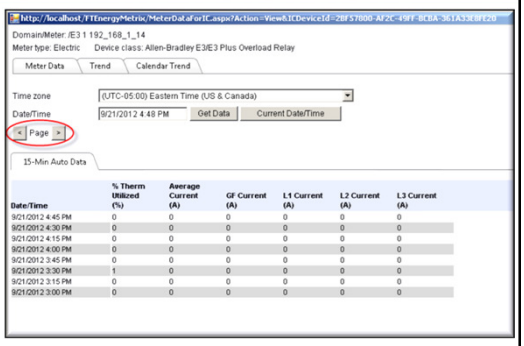




Collect data for any time period (hourly, daily, weekly, monthly, etc.)
Trend key parameters simultaneously
Export data for recordkeeping or further analysis.

Energy Software





View all key energy values for a particular device on a single screen

IEC 61850

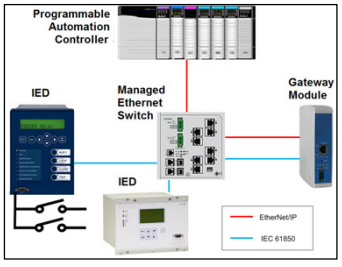
- IEC 61850 provides many benefits using a standard industrial Ethernet network. These include the capability of high-speed device-to-device communications
- This standard offers peer-to-peer communication of both digital and analog values, and consistent control and monitor capabilities using reusable and common visual interactive display windows
- It also provides for a common database naming format and structure that simplifies data collection for analysis and archiving

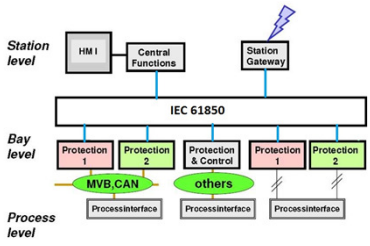
IEC 61850

- There are many practical applications for IEC 61850 over an Ethernet communications network such as zone-interlocking protection schemes, bus-transfer schemes, load-shedding schemes, process-optimization information, energy management, and client-server communication
- IEC 61850 in the industrial facility also provides the benefits of reduced device-to-device wiring, component cost reduction, simple configuration and reconfiguration

IEEE

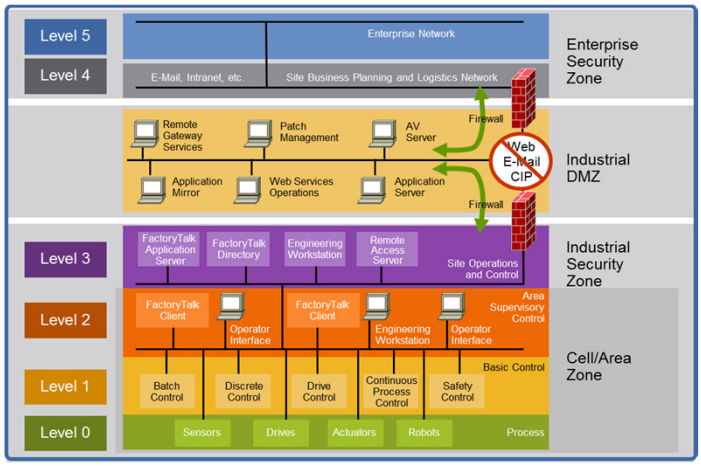
IEC 61850





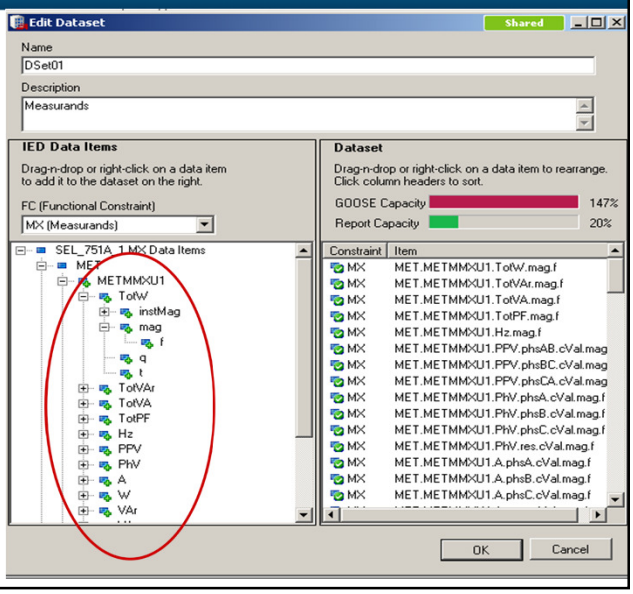
IEEE

IEC 61850



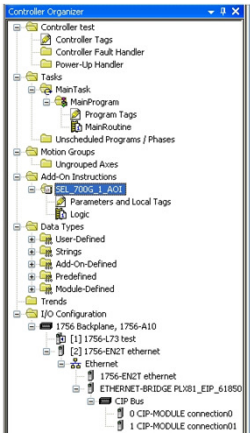
IEEE

IEC 61850 Object Model

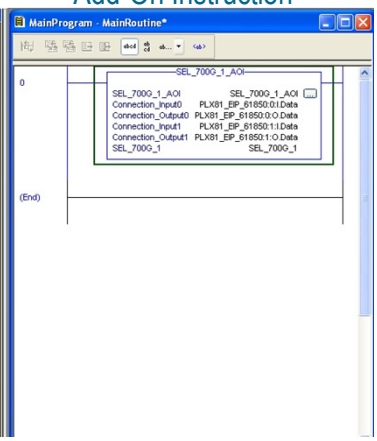


Integration Process

I/O Tree



Add-On Instruction



PlantPAx HMI Faceplate

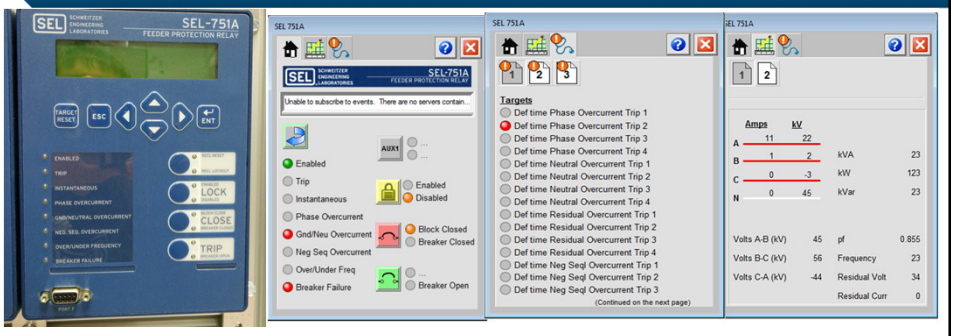
IEEE

Data Table

Name	Value	Style	Data Type
SL_700G_1	{...}		SL_700G_1
SL_700G_1.MVGGIO12_MX_AnIn01_instMag_f	0.0	Float	REAL
SL_700G_1.MVGGIO12_MX_AnIn01_mag_f	0.0	Float	REAL
SL_700G_1.MVGGIO12_MX_AnIn01_q	0	Decimal	INT
SL_700G_1.MVGGIO12_MX_AnIn01_t	DT#1969-12-31-16:00:00.0000...	Date/Time	LINT
SL_700G_1.MVGGIO12_MX_AnIn02_instMag_f	0.0	Float	REAL
SL_700G_1.MVGGIO12_MX_AnIn02_mag_f	0.0	Float	REAL
SL_700G_1.MVGGIO12_MX_AnIn02_q	0	Decimal	INT
SL_700G_1.MVGGIO12_MX_AnIn02_t	DT#1969-12-31-16:00:00.0000...	Date/Time	LINT
SL_700G_1.MVGGIO12_MX_AnIn03_instMag_f	0.0	Float	REAL
SL_700G_1.MVGGIO12_MX_AnIn03_mag_f	0.0	Float	REAL
SL_700G_1.MVGGIO12_MX_AnIn03_q	0	Decimal	INT
SL_700G_1.MVGGIO12_MX_AnIn03_t	DT#1969-12-31-16:00:00.0000...	Date/Time	LINT
SL_700G_1.MVGGIO12_MX_AnIn04_instMag_f	0.0	Float	REAL
SL_700G_1.MVGGIO12_MX_AnIn04_mag_f	0.0	Float	REAL
SL_700G_1.MVGGIO12_MX_AnIn04_q	0	Decimal	INT
SL_700G_1.MVGGIO12_MX_AnIn04_t	DT#1969-12-31-16:00:00.0000...	Date/Time	LINT
SL_700G_1.MVGGIO12_MX_AnIn05_instMag_f	0.0	Float	REAL
SL_700G_1.MVGGIO12_MX_AnIn05_mag_f	0.0	Float	REAL

IEEE

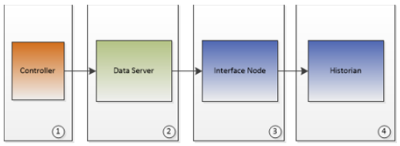
Faceplate



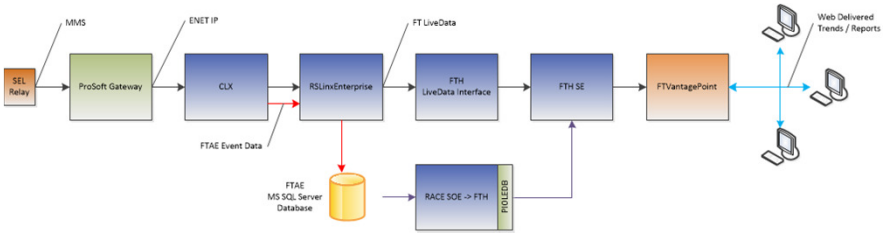
- PlantPAx faceplate available to pull all data from custom .cid file for SEL equipment
- Faceplate ties directly to tag values defined in ProSoft generated Add-On Instruction and User-Defined data type

IEEE

IMC Enhancing Process Historians



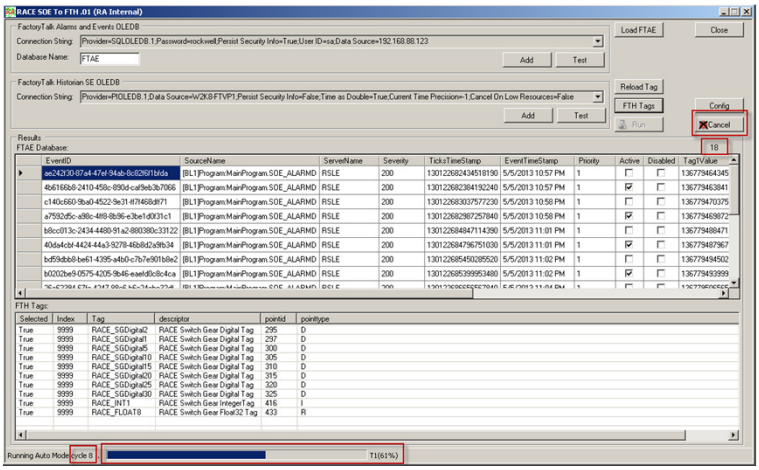
Traditional Historian Repository Data Flow



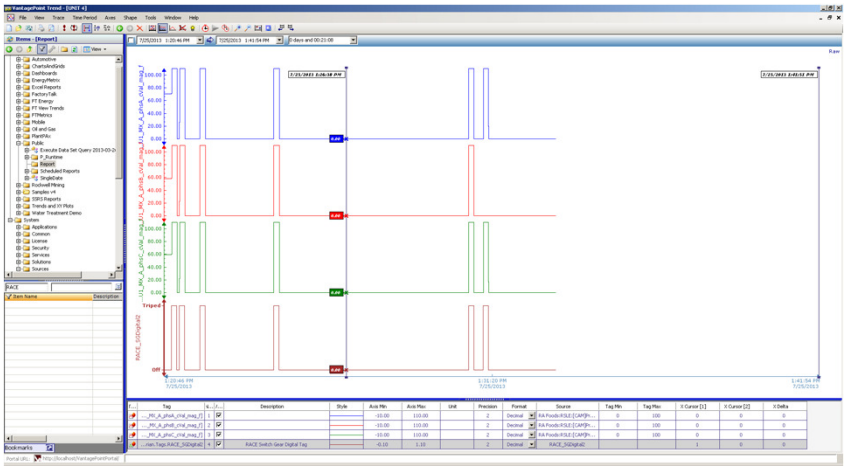
Modified Data Path 61850 Solution

IEEE

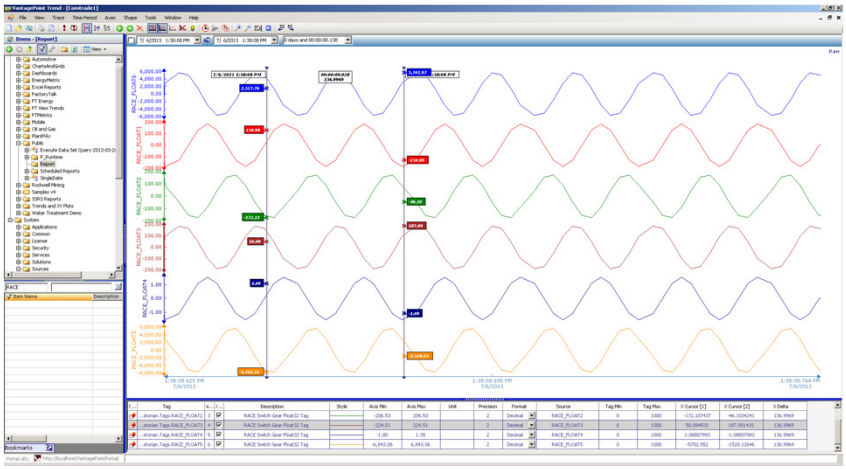
Software Developed



Value Added Results (SoE)



Value Added Benefits—Waveform Capture



IEEE

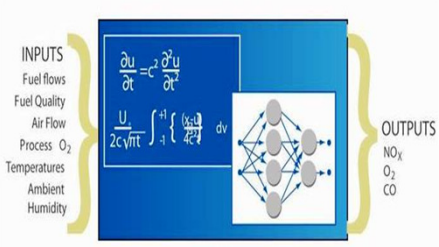
Adaptive Predictive Modeling

- Industry has the responsibility to account for environmental impact
- Traditionally emissions systems were managed by discrete hardware and expensive sensors
  - Known as Continuous Emissions Monitoring (CEMs)
- Today, non-linear hybrid predictive models (PEMs) are used to meet the imposed performance criteria for regulatory certification

IEEE

Adaptive Predictive Modeling

- A predictive model uses various inputs including fuel flows and quality, airflow, process oxygen, temperature measurements, and humidity measurements
- Values are run through model to predict NOx, O2, and CO for a process
- These models are implemented in furnaces, kilns, and boilers to optimize performance



IEEE

Conclusions

IEEE

Questions