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The eGRID and WTDTF Electrical Grid Monitoring System

John McIntosh
Fellow Engineer
john.mcintosh@srnl.doe.gov

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Wind Turbine Drivetrain Testing Facility (WTDTF) Data Acquisition System

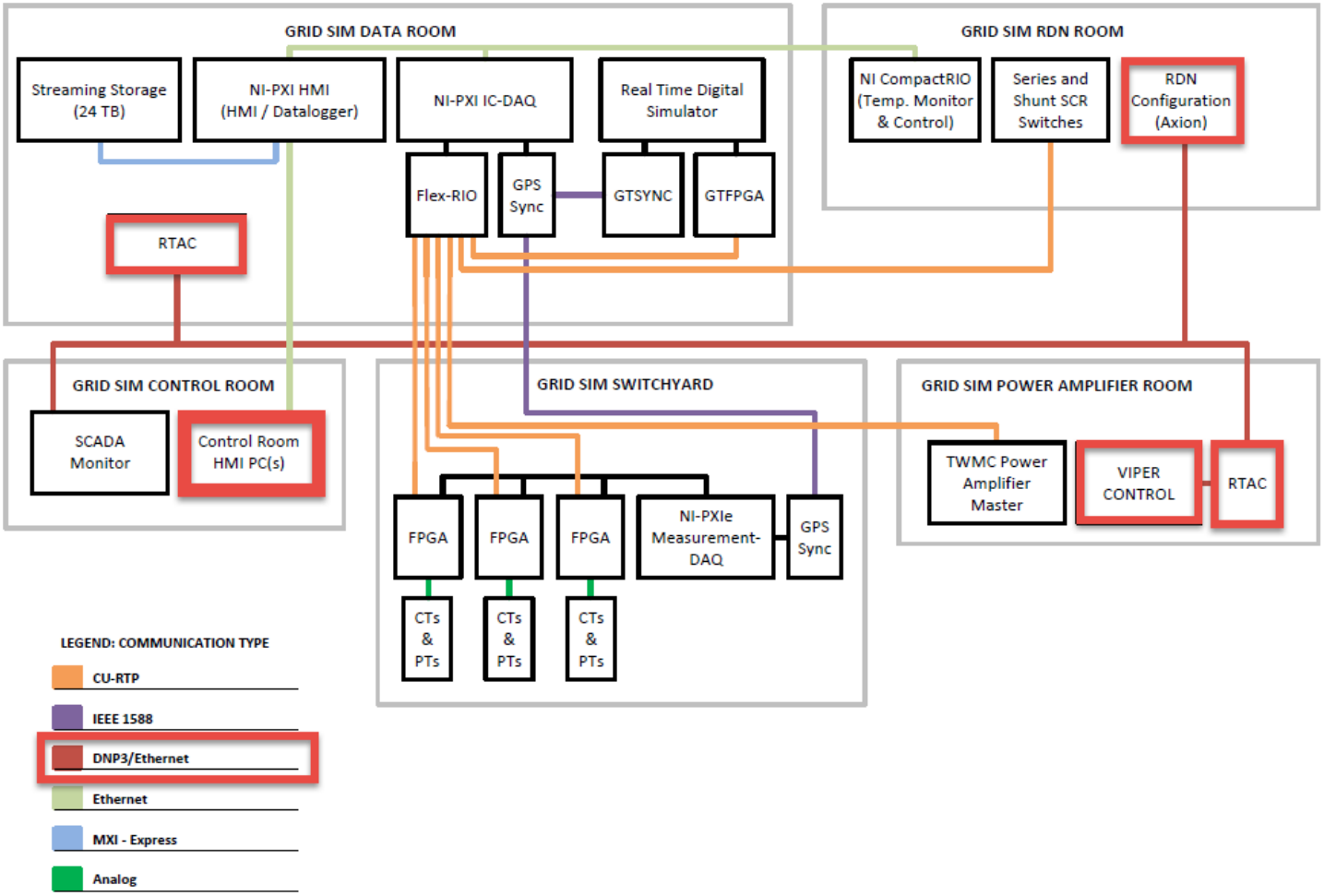
Components

- Temperature Monitoring System
- High Speed Data Acquisition
- Electrical Grid Monitoring
- Low Speed Voltages, Current, Facility Monitoring System
- Real Time Vibration Monitoring System

General Requirements

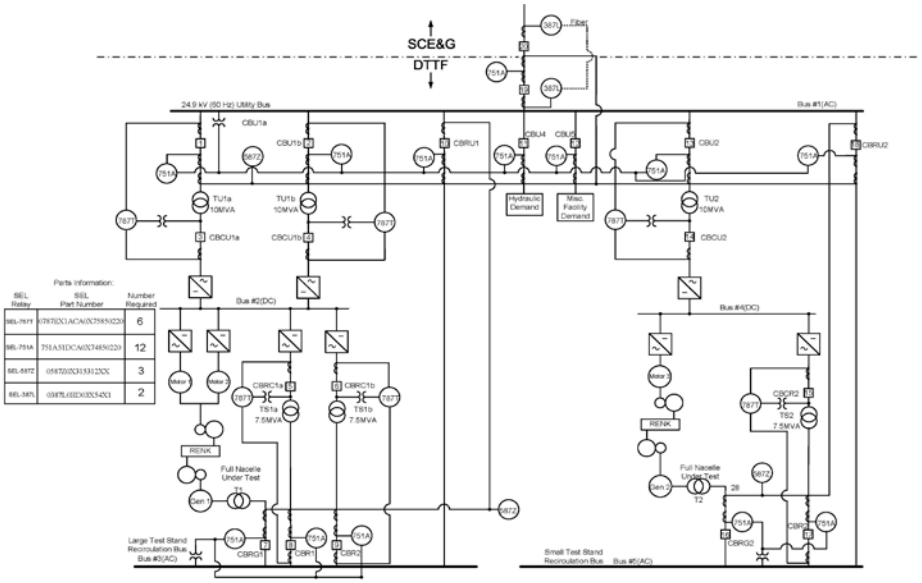
- Synchronization of data
- High (>2000 S/sec) and low speed (1 S/sec) data
- EMI/RFI noise immunity
- Secure yet accessible data

Clemson eGRID Control and Data Acquisition System

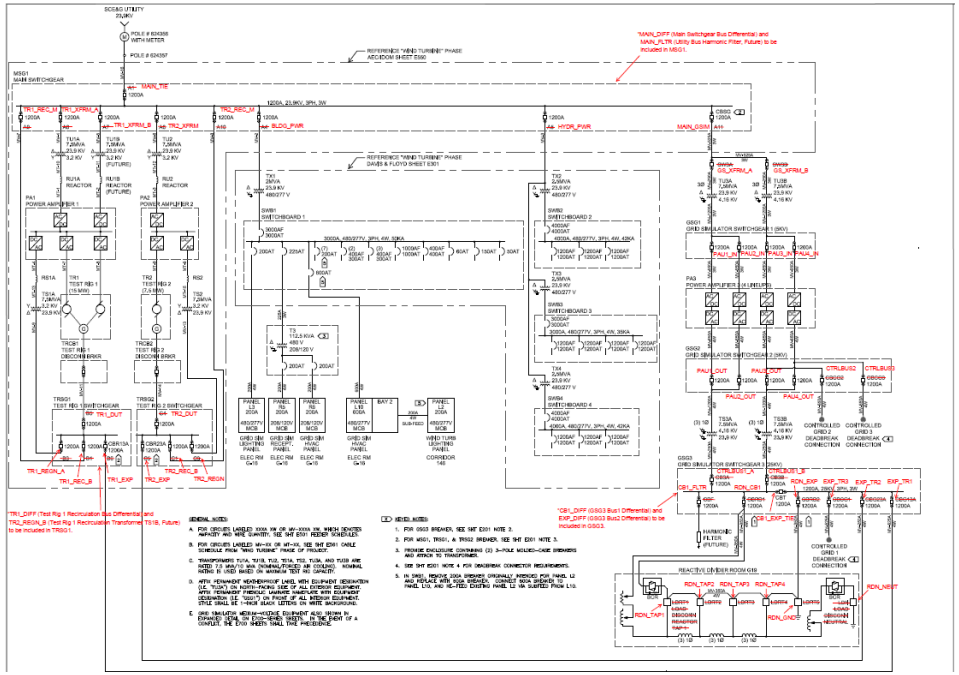


- Low speed grid monitoring data acquisition supplemental to real time systems
- Control of switchgear via a HMI integral to facility testing setup and execution

Facility Electrical Design



Early Single Line



Near Final Design

- Number of switchgear components increased significantly with the addition of the eGRID facility
- Final design includes: 29 Feeder Protection Relays, 5 Transformer Protection Relays, 3 High Impedance Differential Relays, 7 Advanced Reclosers, 9 Overcurrent Protection Systems

Electrical Grid Monitoring and Control Design

Requirements

- Full control of facility relays via remote HMI using Ethernet communication
- Continuous electrical data available e.g. Volts/Amps/Frequency/ Status-Open/Closed/Fault
- Ability to obtain high speed data from a relay for analysis
- Although relays are “shared” in the facility, independent information needed to be available to the three control rooms: Large Test Rig, Small Test Rig, eGRID

Vendor Selected

Schweitzer Engineering Laboratories (SEL) in Charlotte

Collaboration

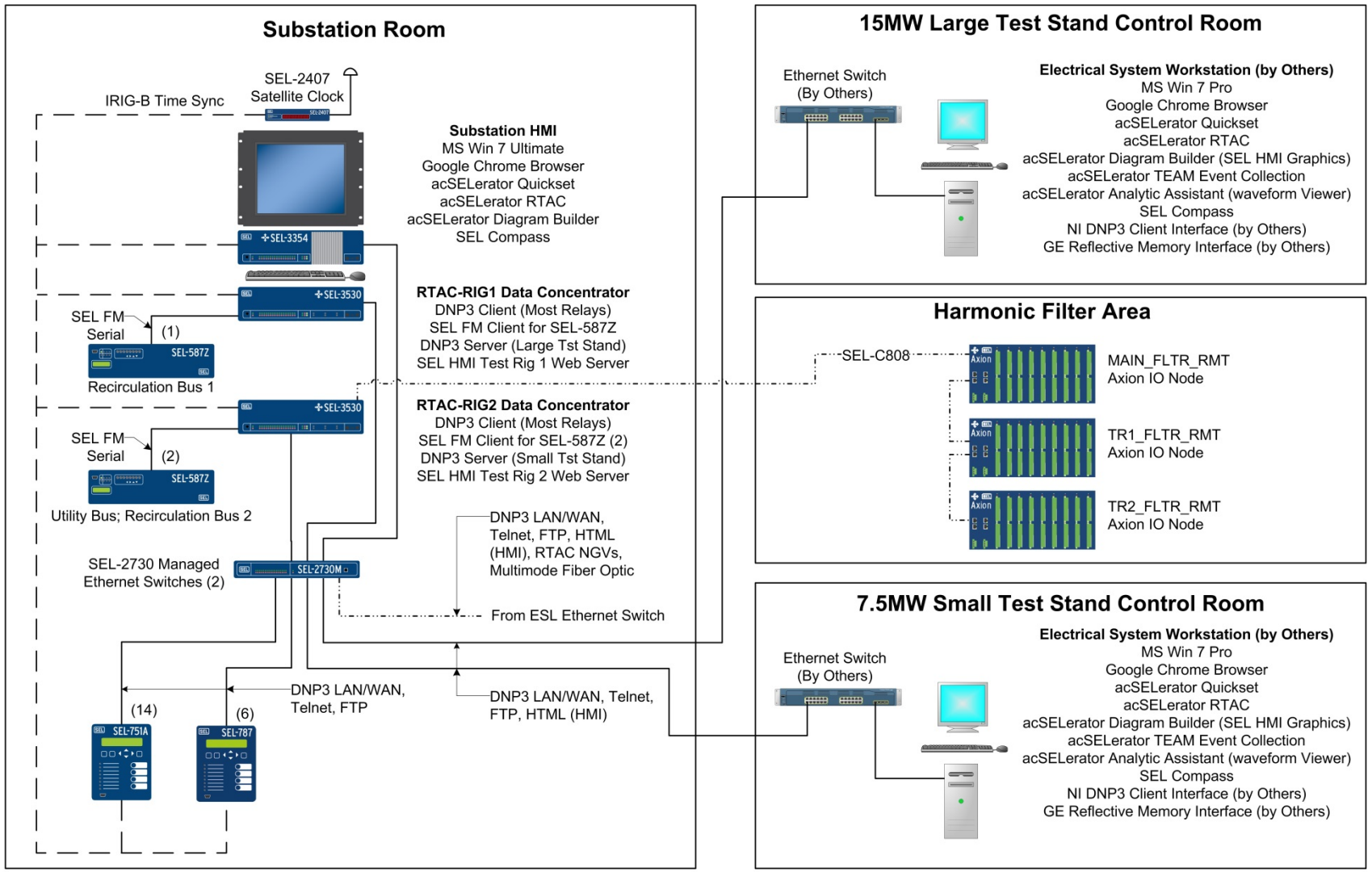
- Clemson University – facility electrical design
- Savannah River National Laboratory – data acquisition requirements and system design
- National Instruments – data transfer coding design
- Schweitzer Engineering Laboratories – SEL hardware design and HMI design/implementation

DNP3 vs. Modbus

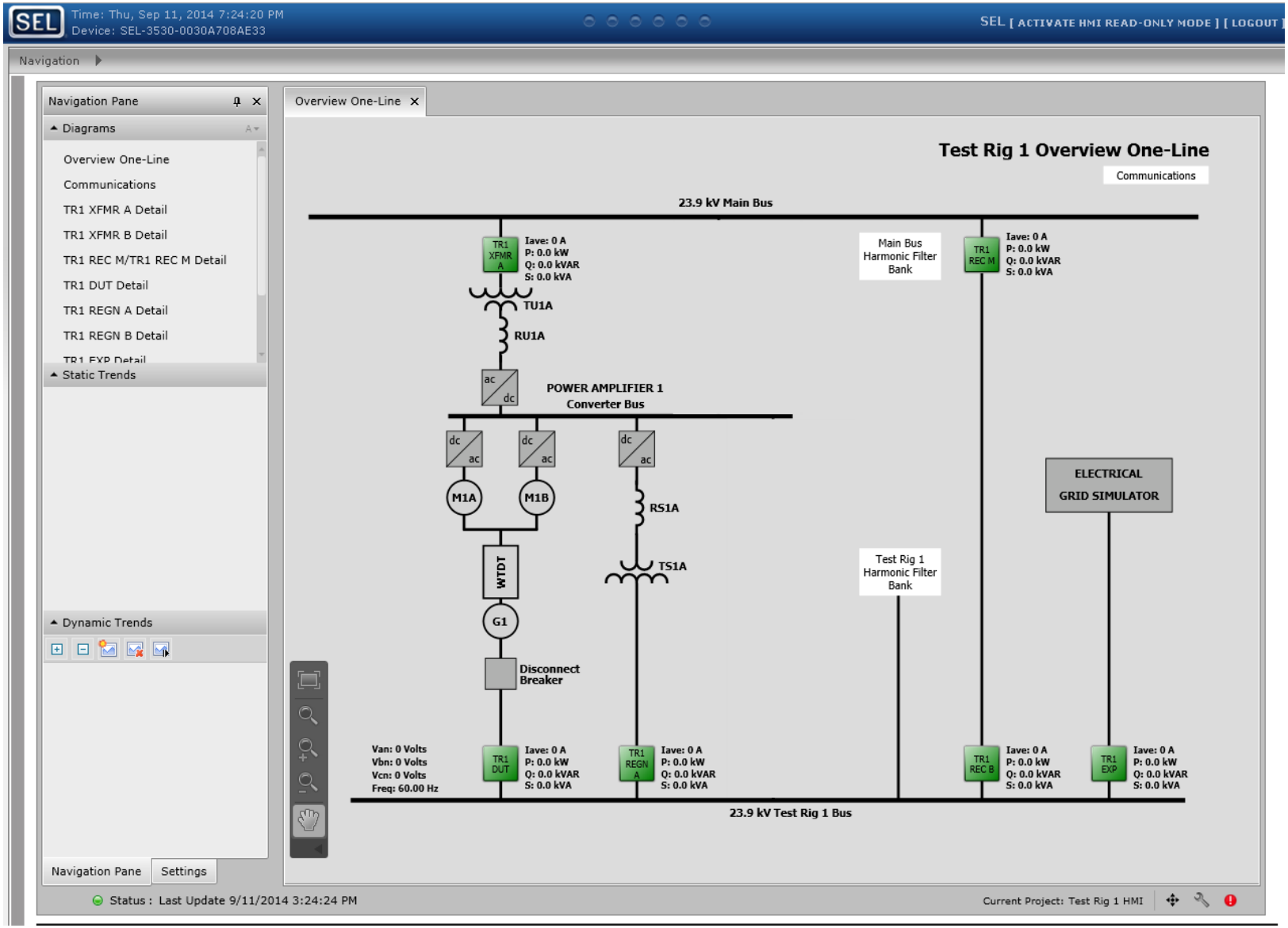
- SEL hardware includes a “Real Time Automation Controller” (RTAC) which handles all communication with SEL equipment
- Two ways the RTAC can transfer data to external systems is via a DNP3 (Distributed Network Protocol) or Modbus protocol.
- DNP3 is a Utility industry data protocol that requires a server to direct data to a custom data acquisition system
- Modbus is a common serial communication protocol that can stream data to a custom data acquisition system
- Although DNP3 data communication is more complicated than Modbus it has advantages in security, expandability and comprehensive data functionality

Clemson University Wind Turbine Drive Train Test Facility
Electrical Grid Monitoring System Communication Diagram
SEL Project 0P4585.000.00, Rev. 7

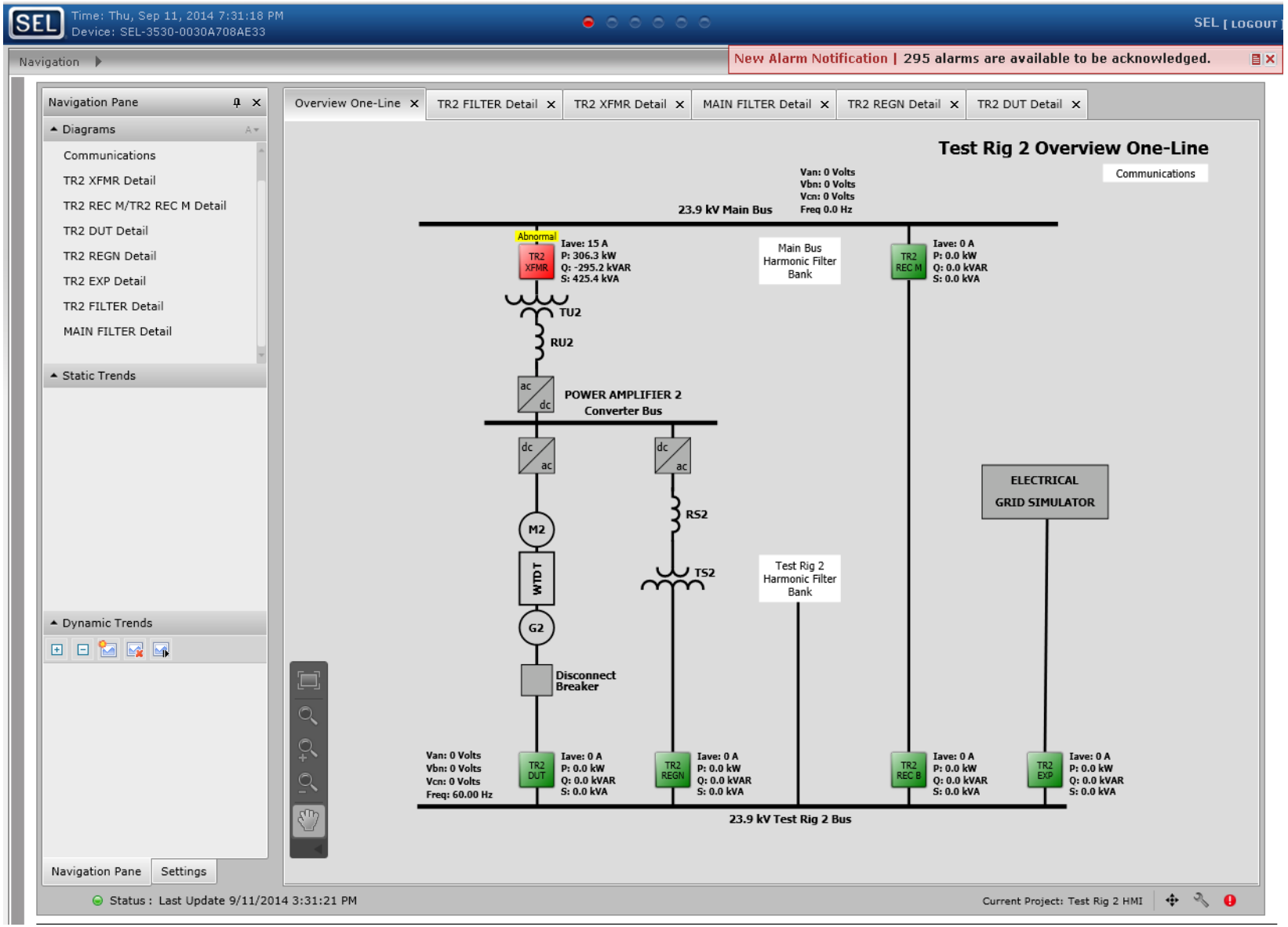
Thursday, September 26, 2013



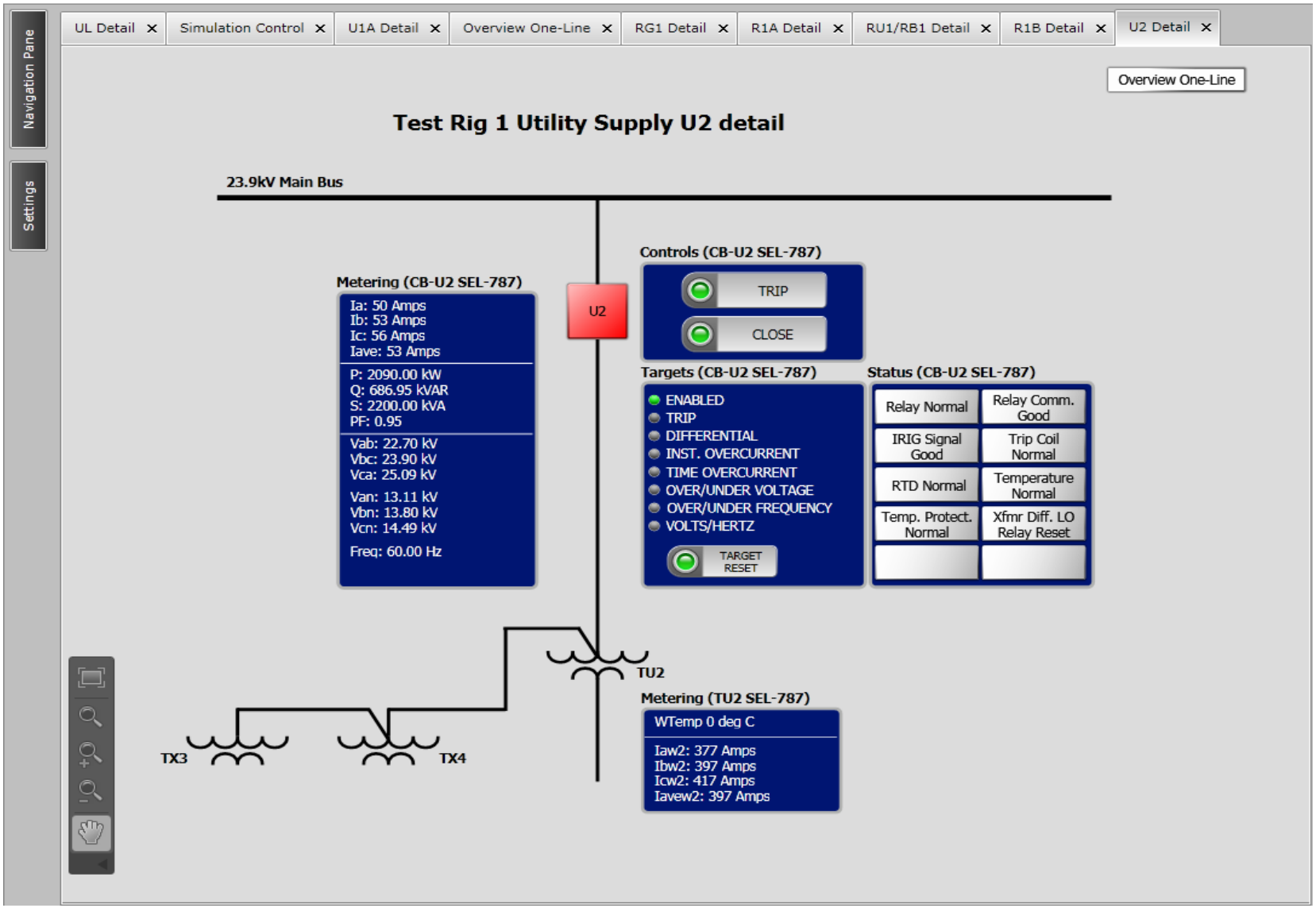
Test Rig 1 (15MW) Overview One-Line



Test Rig 2 (7.5 MW) Overview One-Line



Example Relay Interface



Features of the SEL Systems

- Relays independently monitor multiple input variables and automatically provide the data to the RTAC
- Data is time stamped using a IRIG-B GPS satellite clock
- Distributed control and integration platform, Axion, allows for eGrid control and monitoring of 3rd party equipment
- The “tags” for DNP3 data are easily set up and transferred to the data acquisition program using a Kepware OPC server
- High speed incident data is automatically recorded and is accessible through utilities independent of the DNP3 data stream or HMI control software
- There are embedded multiple layers of security: software and hardware
- Product line includes managed switches with FO connections for long runs
- All hardware is rated for high temperature and high reliability

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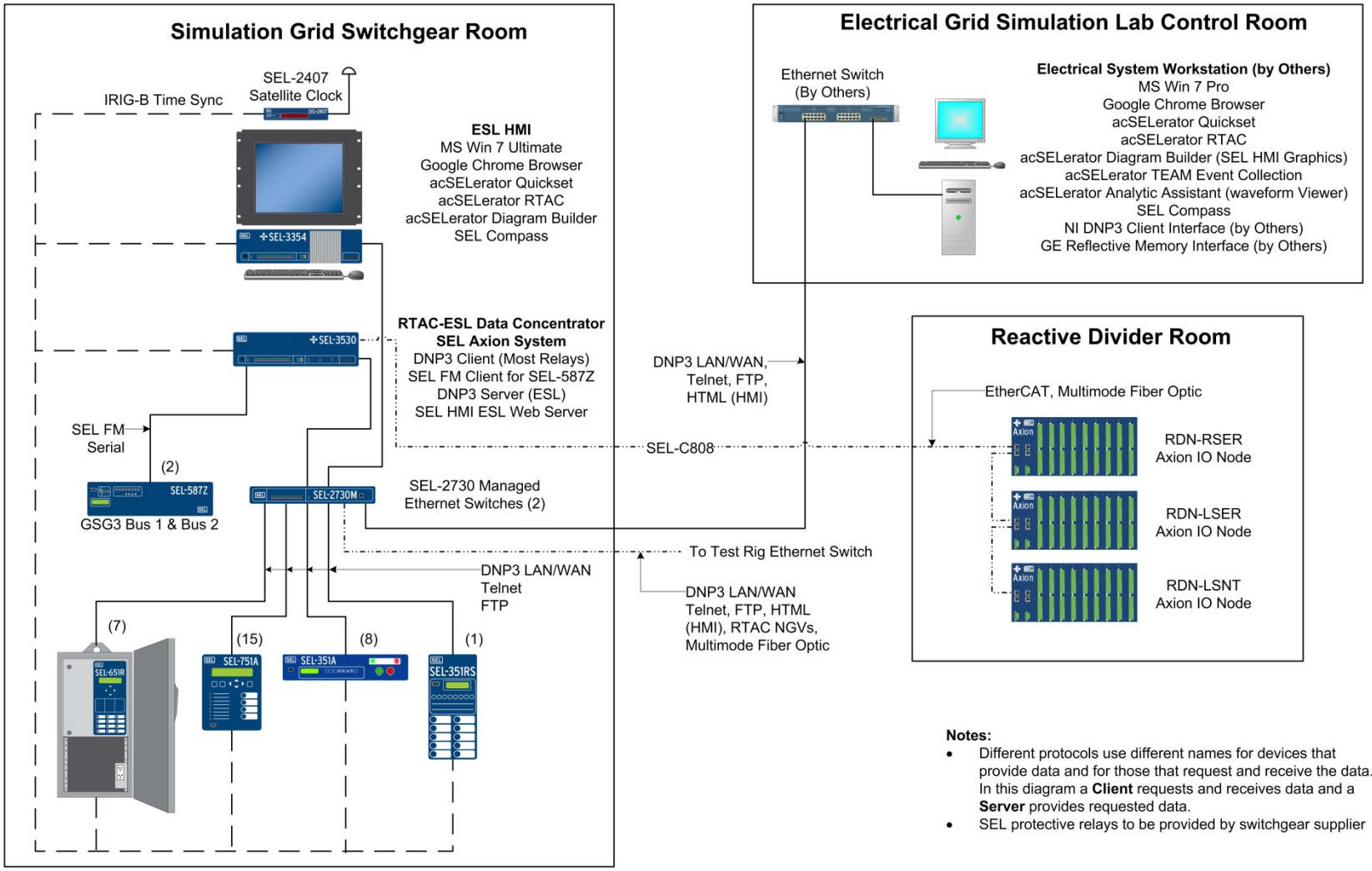
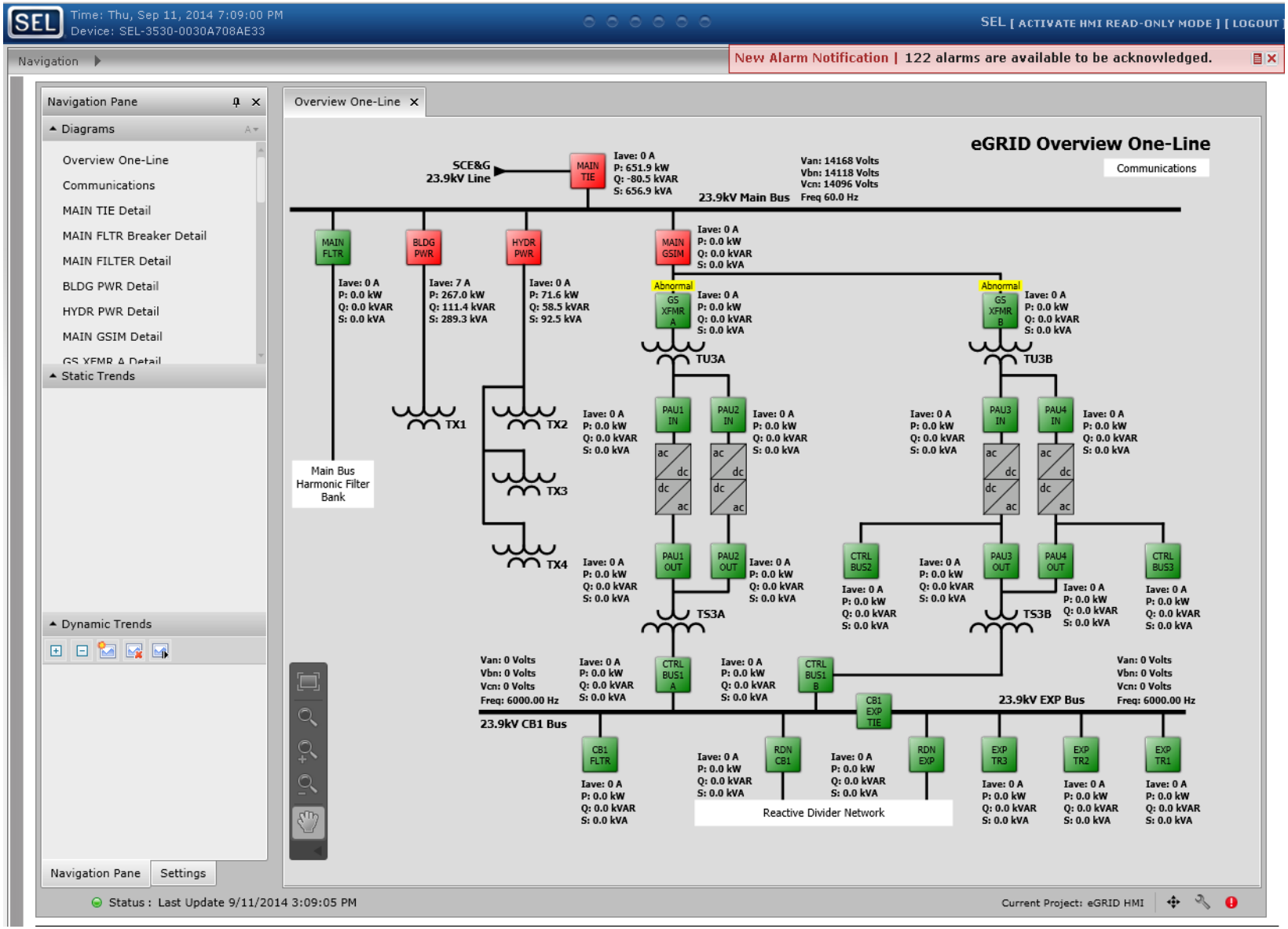


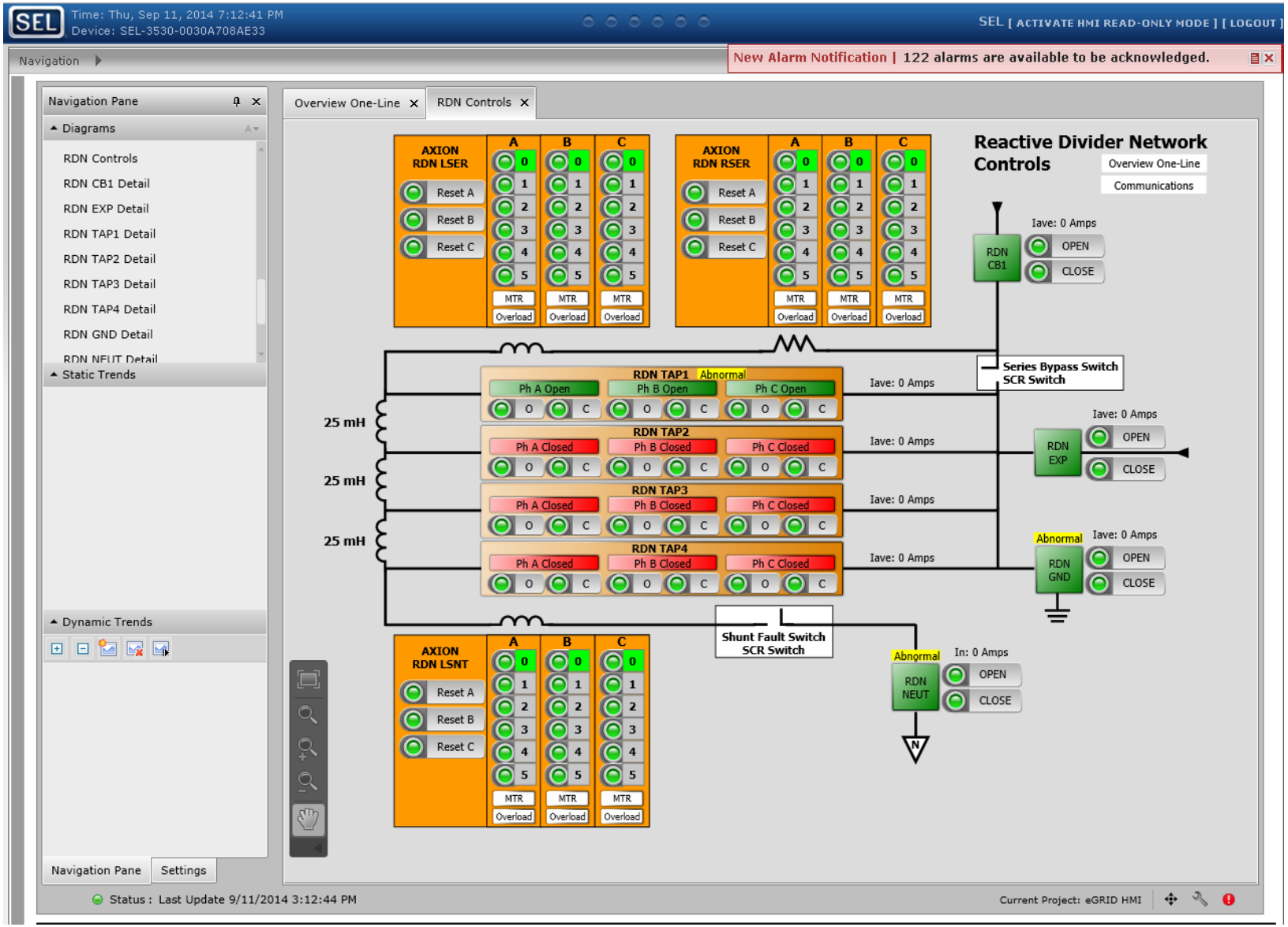
Notes:

- Different protocols use different names for devices that provide data and for those that request and receive the data. In this diagram a **Client** requests and receives data and a **Server** provides requested data.
- SEL protective relays to be provided by switchgear supplier

eGrid Overview One-Line



eGrid Reactive Divider Network Controls

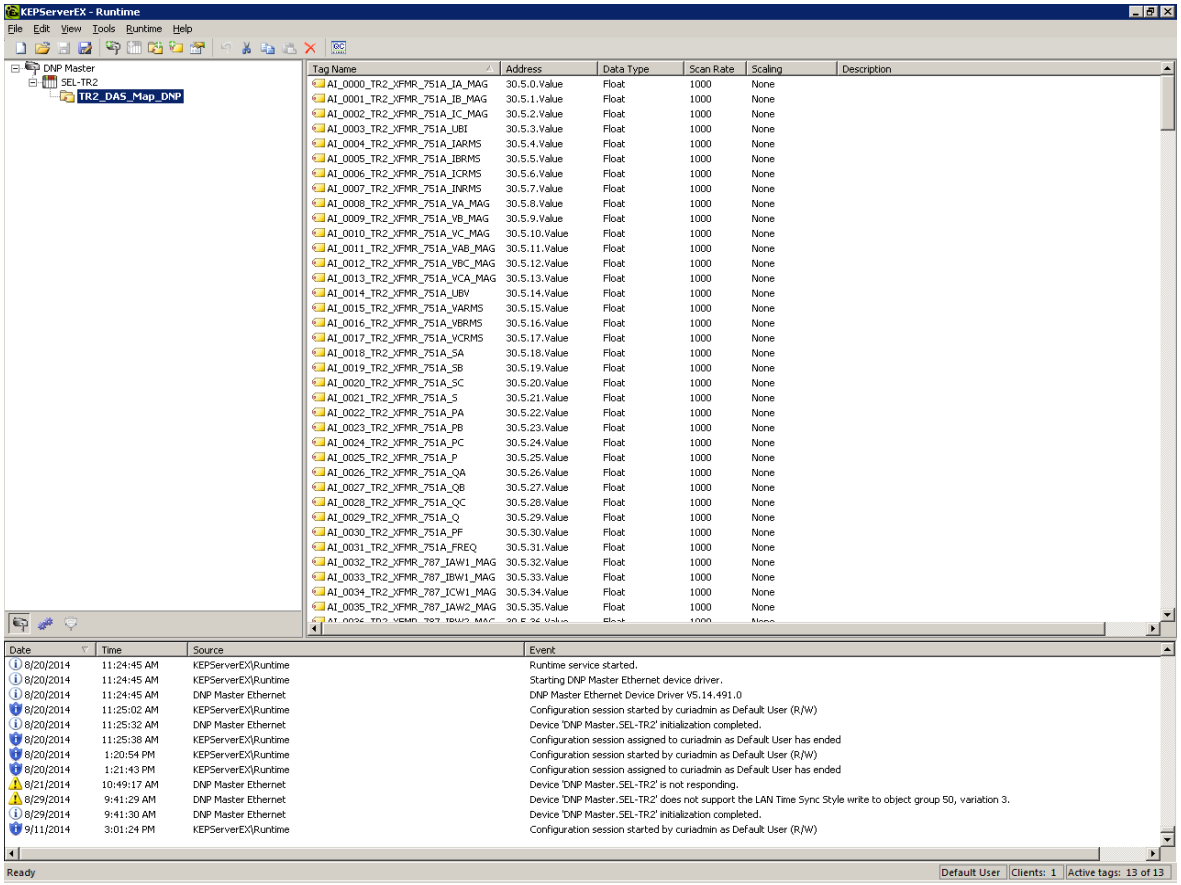


Relay Information and Data Server Tags

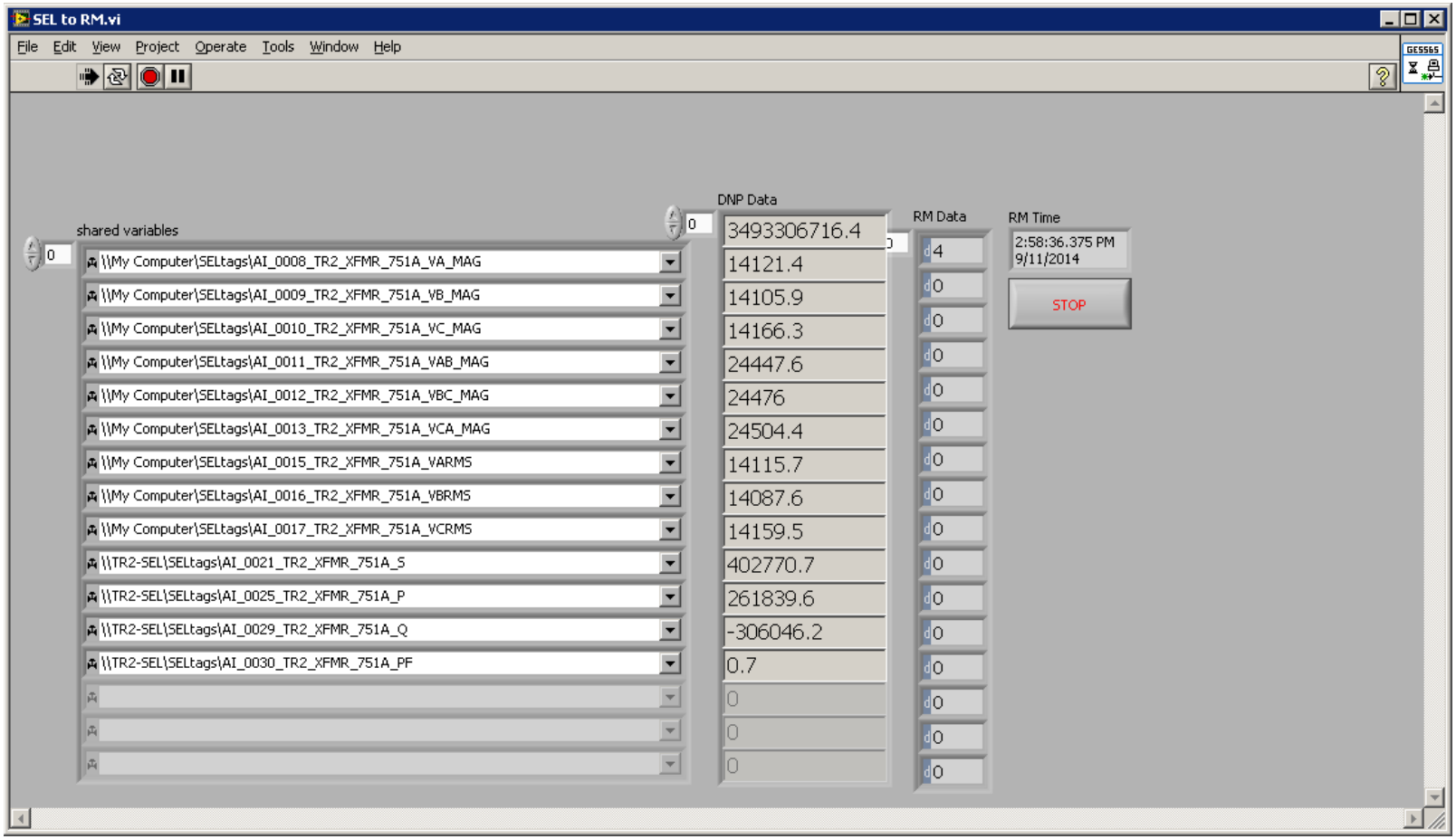
Example Relay Information

RELAY: SEL-751A					
DNP					
Type	Index	Point ID	Description	Units	Value Type
AI	0000	IA_MAG	A-Phase Line Current	Amps	REAL
AI	0001	IB_MAG	B-Phase Line Current	Amps	REAL
AI	0002	IC_MAG	C-Phase Line Current	Amps	REAL
AI	0003	IN_MAG	Neutral Current	Amps	REAL
AI	0004	IG_MAG	Residual Current	Amps	REAL
AI	0005	IAV	Average Line Current	Amps	REAL
AI	0006	UBI	Current Unballance	%	REAL
AI	0007	IARMS	A-Phase RMS Current	Amps	REAL
AI	0008	IBRMS	B-Phase RMS Current	Amps	REAL
AI	0009	ICRMS	C-Phase RMS Current	Amps	REAL
AI	0010	INRMS	Neutral RMS Current	Amps	REAL
AI	0011	VA_MAG	A-Phase to Neutral Voltage	Volts	REAL
AI	0012	VB_MAG	B-Phase to Neutral Voltage	Volts	REAL
AI	0013	VC_MAG	C-Phase to Neutral Voltage	Volts	REAL
AI	0014	VAB_MAG	A to B Phase Voltage	Volts	REAL
AI	0015	VBC_MAG	B to C Phase Voltage	Volts	REAL
AI	0016	VCA_MAG	C to A Phase Voltage	Volts	REAL
AI	0017	VAVE	Average Voltage	Volts	REAL
AI	0018	UBV	Voltage Unbalance	%	REAL
AI	0019	VARMS	A-Phase RMS Voltage	Volts	REAL
AI	0020	VBRMS	B-Phase RMS Voltage	Volts	REAL
AI	0021	VCRMS	C-Phase RMS Voltage	Volts	REAL
AI	0022	VABRMS	A to B Phase RMS Voltage	Volts	REAL
AI	0023	VBCRMS	B to C Phase RMS Voltage	Volts	REAL
AI	0024	VCARMS	C to A Phase RMS Voltage	Volts	REAL
AI	0025	SA	A-Phase Apparent Power	kVA	REAL
AI	0026	SB	B-Phase Apparent Power	kVA	REAL
AI	0027	SC	C-Phase Apparent Power	kVA	REAL
AI	0028	S	3-Phase Apparent Power	kW	REAL
AI	0029	PA	A-Phase Real Power	kW	REAL
AI	0030	PB	B-Phase Real Power	kW	REAL
AI	0031	PC	C-Phase Real Power	kW	REAL
AI	0032	P	3-Phase Real Power	kW	REAL
AI	0033	QA	A-Phase Reactive Power	kVAR	REAL
AI	0034	QB	B-Phase Reactive Power	kVAR	REAL
AI	0035	QC	C-Phase Reactive Power	kVAR	REAL
AI	0036	Q	3-Phase Reactive Power	kVAR	REAL
AI	0037	PF	3-Phase Power Factor	Per Unit	REAL
AI	0038	FREQ	Frequency	HZ	REAL
AI	0039	WEARA	Breaker Wear, A-Phase	%	REAL
AI	0040	WEARB	Breaker Wear, B-Phase	%	REAL
AI	0041	WEARC	Breaker Wear, C-Phase	%	REAL

OPC Server Tags

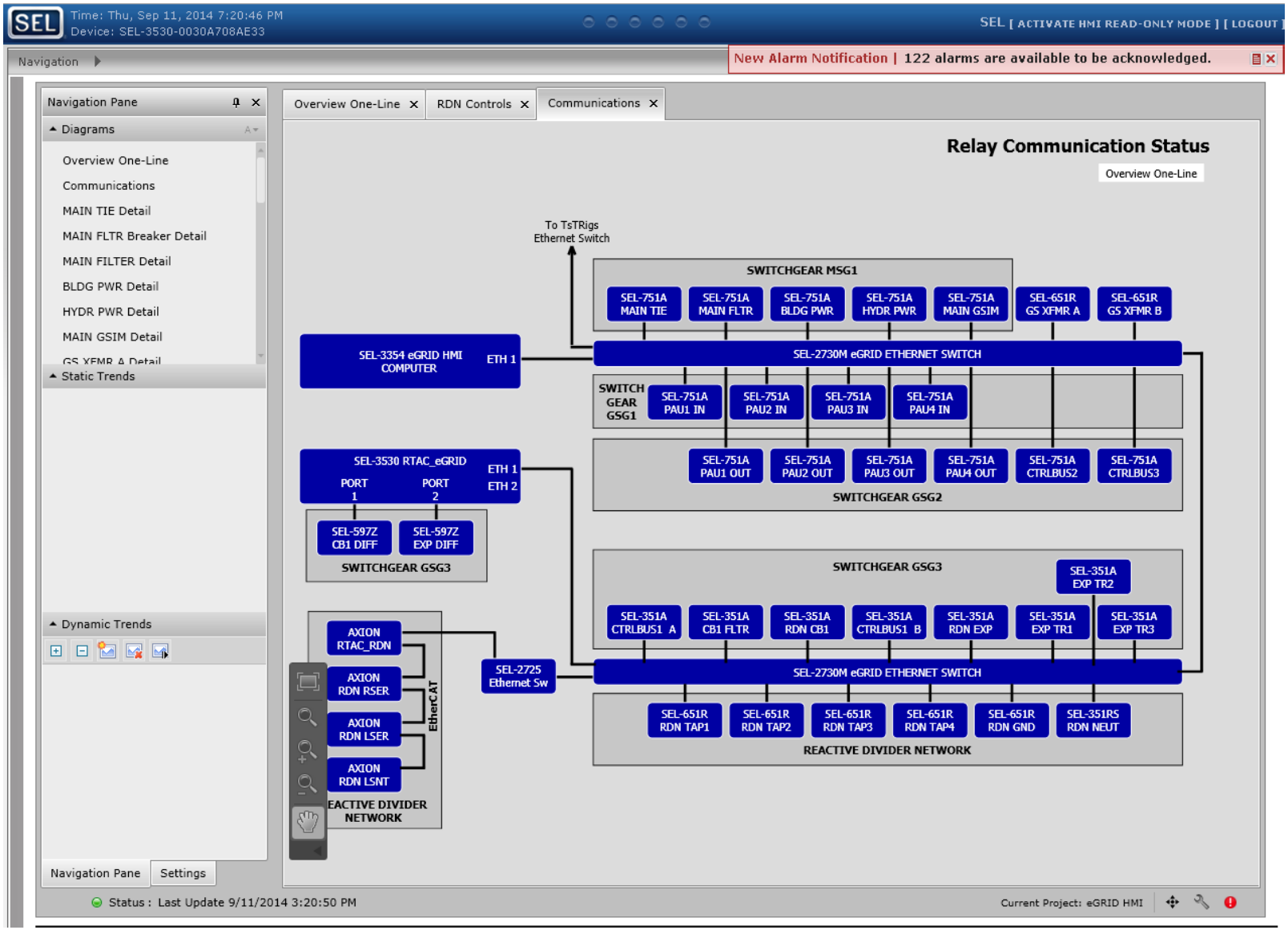


LabView Program Reads Data From Kepware and Transfers to the Data Acquisition System



1st data point is the timestamp which is synchronized with other data acquisitions in the facility with a GPS timestamp

Relay Communication Status



Primary Team Members

Clemson University – Dr. Curtiss Fox (fox8@clemson.edu)

Savannah River National Laboratory – Joe Cordaro (joe.cordaro@srnl.doe.gov)

National Instruments – Jeff Tipps (jeff.tipps@ni.com)

Schweitzer Engineering Laboratories – Gary Pederson (Gary_Pederson@selinc.com)