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The eGRID and WTDTF Electrical Grid Monitoring System

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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



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

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

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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



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

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eGrid Overview One-Line





eGrid Reactive Divider Network Controls





Example Relay Information

OPC Server Tags

RELAY: SEL-7	'51A				CEPServerEX	- Runtime								_ @ X
DNP					<u>File Edit View</u>	Tools Runtime	Help							
Type Index	Point ID	Description	Units	Value Type		2	<u> m ~ a us cs</u>	▲ 1000		[a	10.01	1	[m	
AI 0000	IA MAG	A-Phase Line Current	Amps	REAL	E- T SEL-T	DNP Master SEL-TR2		AI_0000_TR2_XFMR_751A_IA_MAG	30.5.0.Value	Float	1000	None	Description	
AI 0001	IB MAG	B-Phase Line Current	Amps	REAL	E	R2_DA5_Map_DN	P	AI_0001_TR2_XFMR_751A_IB_MAG	30.5.1.Value	Float	1000	None		
AI 0002	IC MAG	C-Phase Line Current	Amps	REAL				AL_0002_TR2_XFMR_751A_IC_MAG	30.5.2.Value 30.5.3 Value	Float	1000	None		
AL 0003		Neutral Current	Δmns	REAL				AI_0004_TR2_XFMR_751A_IARMS	30.5.4.Value	Float	1000	None		
AI 0004		Residual Current	Δmns	REAL				GAI_0005_TR2_XFMR_751A_IBRM5	30.5.5.Value	Float	1000	None		
AL 0005		Average Line Current	Amps	REAL				AI_0006_TR2_XFMR_751A_ICRM5	30.5.6.Value 30.5.7.Value	Float	1000	None		
AL 0005	LIPI	Current Unhallanco	0/	PEAL				AI_0008_TR2_XFMR_751A_VA_MAG	30.5.8.Value	Float	1000	None		
AI 0000		A Phase RMS Current	70 Amns	DEAL				AL 0009_TR2_XFMR_751A_VB_MAG	30.5.9.Value 30.5.10.Value	Float	1000	None		
AI 0007		P. Phase RMS Current	Amps	DEAL				AI_0011_TR2_XFMR_751A_VAB_MAG	30.5.11.Value	Float	1000	None		
AI 0008	IDRIVIS		Amps	REAL				AI_0012_TR2_XFMR_751A_VBC_MAG	30.5.12.Value	Float	1000	None		
AI 0009	ICRIVIS	C-Phase RMS Current	Amps	REAL				AI_0013_TR2_XHMR_/51A_VCA_MAG	30.5.13.Value 30.5.14.Value	Float	1000	None		
AI 0010	INRMS	Neutral RMS Current	Amps	REAL				AI_0015_TR2_XFMR_751A_VARMS	30.5.15.Value	Float	1000	None		
AI 0011	VA_MAG	A-Phase to Neutral Voltage	Volts	REAL				AL_0016_TR2_XFMR_751A_VBRMS	30.5.16.Value	Float	1000	None		
AI 0012	VB_MAG	B-Phase to Neutral Voltage	Volts	REAL				AL_0018_TR2_XFMR_751A_SA	30.5.18.Value	Float	1000	None		
AI 0013	VC_MAG	C-Phase to Neutral Voltage	Volts	REAL				GAI_0019_TR2_XFMR_751A_SB	30.5.19.Value	Float	1000	None		
AI 0014	VAB_MAG	A to B Phase Voltage	Volts	REAL				AL_0020_TR2_XFMR_751A_5C	30.5.20.Value 30.5.21.Value	Float	1000	None		
AI 0015	VBC_MAG	B to C Phase Voltage	Volts	REAL				AL_0022_TR2_XFMR_751A_PA	30.5.22.Value	Float	1000	None		
AI 0016	VCA_MAG	C to A Phase Voltage	Volts	REAL				AI_0023_TR2_XFMR_751A_PB	30.5.23.Value	Float	1000	None		
AI 0017	VAVE	Average Voltage	Volts	REAL				AI_0024_TR2_XPMR_751A_PC	30.5.29. value 30.5.25. Value	Float	1000	None		
AI 0018	UBV	Voltage Unbalance	%	REAL				AI_0026_TR2_XFMR_751A_QA	30.5.26.Value	Float	1000	None		
AI 0019	VARMS	A-Phase RMS Voltage	Volts	REAL				AI_0027_TR2_XFMR_751A_QB	30.5.27.Value	Float	1000	None		
AI 0020	VBRMS	B-Phase RMS Voltage	Volts	RFAL				AI_0029_TR2_XFMR_751A_Q	30.5.29.Value	Float	1000	None		
AI 0021	VCRMS	C-Phase BMS Voltage	Volts	RFAI				AI_0030_TR2_XFMR_751A_PF	30.5.30.Value	Float	1000	None		
AL 0022	VARRMS	A to B Phase BMS Voltage	Volts	REAL				AI_0031_TR2_XHMR_/51A_FREQ	30.5.31.Value 30.5.32.Value	Float	1000	None		
AI 0022	VADINING	R to C Rhase RMS Voltage	Volts	DEAL				AI_0033_TR2_XFMR_787_IBW1_MAG	30.5.33.Value	Float	1000	None		
AI 0023	VCADME	C to A Dhase RMS Voltage	Volts	DEAL				AI_0034_TR2_XFMR_787_ICW1_MAG	30.5.34.Value	Float	1000	None		
AI 0024	VCARIVIS	C to A Phase Rivis Voltage	VUILS	REAL	🔊 🥓 🕤			AT 0024 The VEMD TOT TOWS MAC	20 E 24 Value	Float	1000	None		_ _
AI 0025	SA	A-Phase Apparent Power	KVA	REAL		- [[[e .					
AI 0026	SB	B-Phase Apparent Power	kVA	REAL	1) 8/20/2014	11:24:45 AM	KEPServerEX\Runtime		Runtime ser	vice started.				-
AI 0027	SC	C-Phase Apparent Power	kVA	REAL	1 8/20/2014	11:24:45 AM	KEPServerEX\Runtime		Starting DN	P Master Ethernet o	levice driver.			
AI 0028	S	3-Phase Apparent Power	kW	REAL	(1) 8/20/2014	11:24:45 AM	DNP Master Ethernet		DNP Master	Ethernet Device Dr	iver V5.14.491.0	6		
AI 0029	PA	A-Phase Real Power	kW	REAL	1 8/20/2014	11:25:32 AM	DNP Master Ethernet		Device 'DNP	Master.SEL-TR2' in	itialization comple	ed.)	
AI 0030	PB	B-Phase Real Power	kW	REAL	120/2014	11:25:38 AM	KEPServerEX\Runtime		Configuratio	n session assigned	to curiadmin as D	efault User has	ended	
AI 0031	PC	C-Phase Real Power	kW	REAL	8/20/2014	1:20:54 PM	KEPServerEX\Runtime		Configuratio	n session started b	y curiadmin as De to curiadmin as P	efault User (R/W) Infault User bas i) ended	
AI 0032	Р	3-Phase Real Power	kW	REAL	1 8/21/2014	10:49:17 AM	DNP Master Ethernet		Device 'DNF	Master.SEL-TR2' is	not responding.	ordale opor map		
AI 0033	QA	A-Phase Reactive Power	kVAR	REAL	1 8/29/2014	9:41:29 AM	DNP Master Ethernet		Device 'DNF	Master.SEL-TR2 d	oes not support t	he LAN Time Syn	c Style write to object group 50, variation 3.	
AI 0034	QB	B-Phase Reactive Power	kVAR	REAL	1 8/29/2014 9/11/2014	9:41:30 AM 3:01:24 PM	DNP Master Ethernet KEPServerEX\Runtime		Configuration	Master.5EL-TR2' in in session started b	itialization comple v curiadmin as De	ited. sfault User (R/W))	_
AI 0035	00	C-Phase Reactive Power	kVAR	RFAL							,		, 	
AI 0036	0	3-Phase Reactive Power	kVAR	REAL	Ready								Default User Clie	nts: 1 Active tags: 13 of 13
AI 0037	PF	3-Phase Power Factor	Perlinit	REAL										pretire tags 15 0115
AL 0039	EREO	Frequency	н ст оппс µ7	REAL										
AL 0030		Prosker Wear A Phase	0/	DEAL										
AI 0039	WEARA		<i>%</i>	REAL										
AI 0040	WEARB	Breaker Wear, B-Phase	%	KEAL										
AI 0041	WEARC	Breaker Wear, C-Phase	%	REAL										



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	A \\My Computer\SELtags\AI_0010_TR2_XFMR_751A_VC_MAG	•	14166.3	0		
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1st data point is the timestamp which is synchronized with other data acquisitions in the facility with a GPS timestamp







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