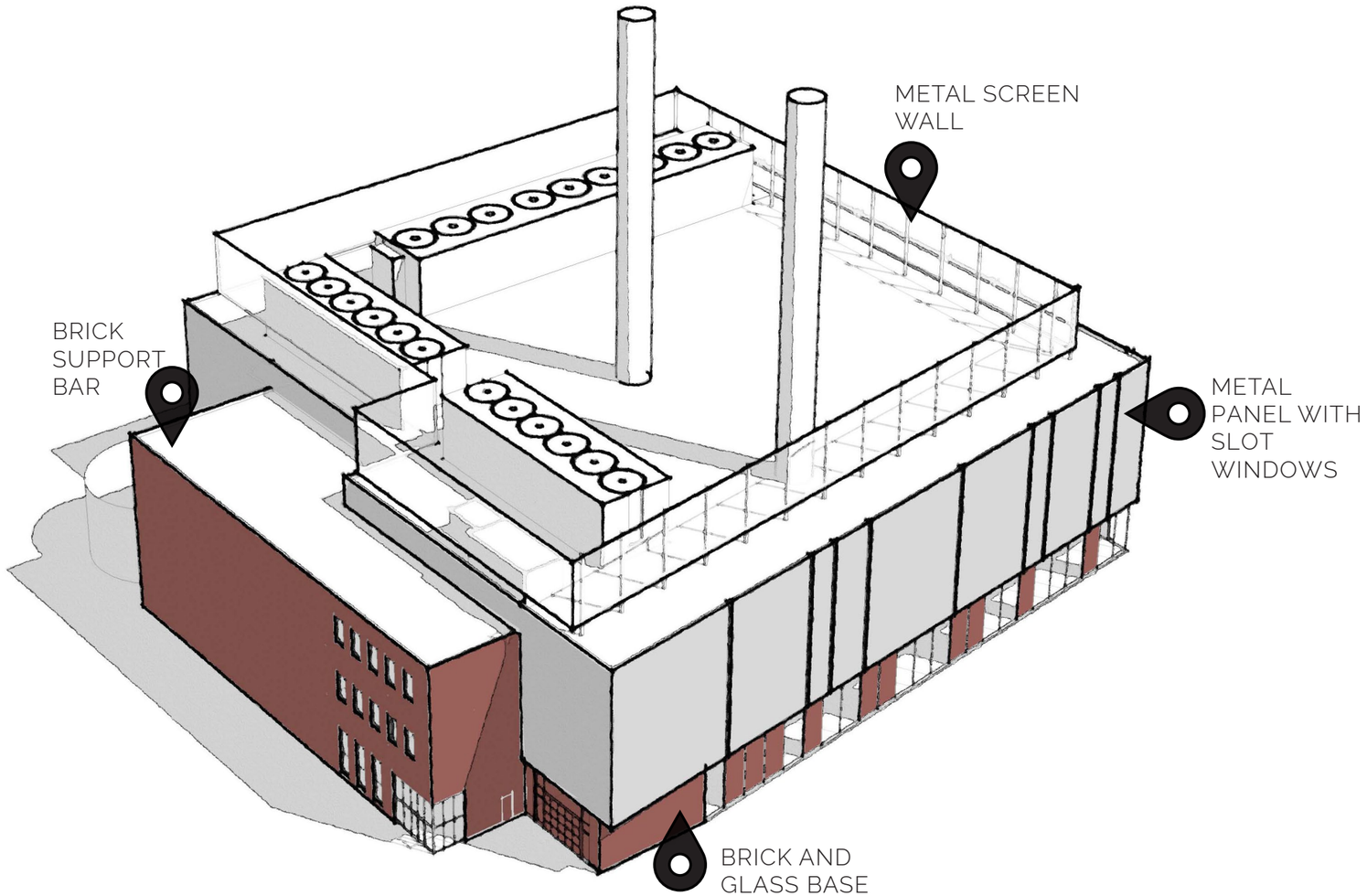
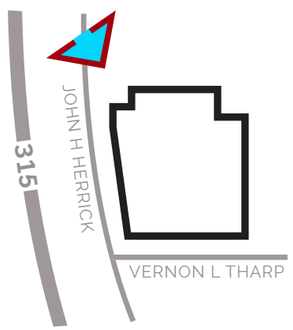
EXHIBIT D: CHP Preliminary Architectural Design





METAL SCREEN WALL

METAL PANEL WITH SLOT WINDOWS

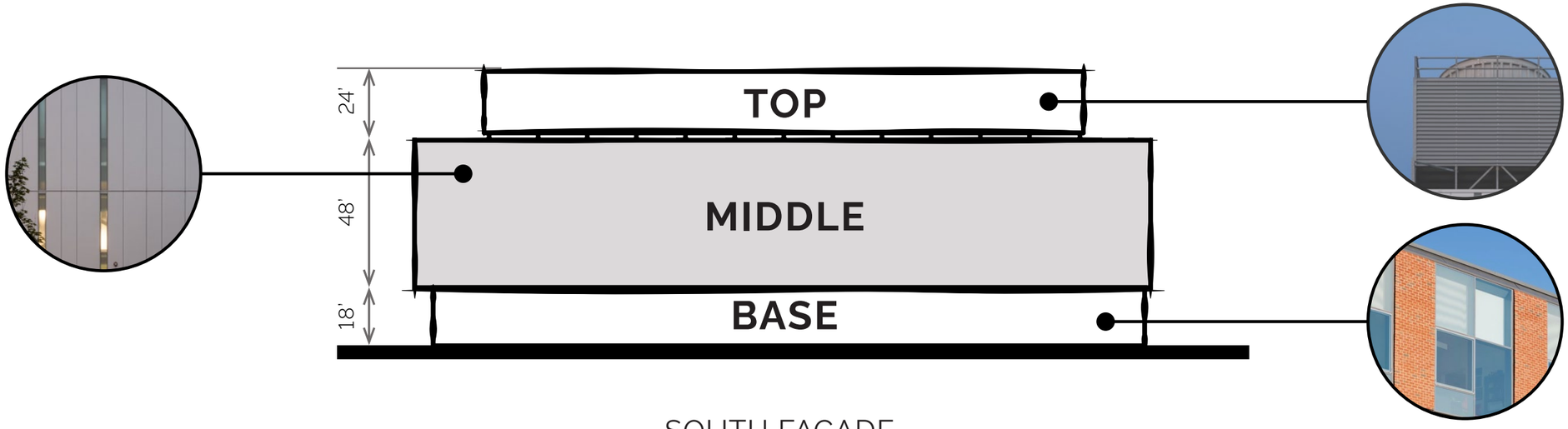
BRICK AND GLASS BASE - **BRICK PRECEDENT FROM ADJACENT VETERINARY MEDICAL COMPLEX**

NORTHWEST CORNER AERIAL 3D VIEW

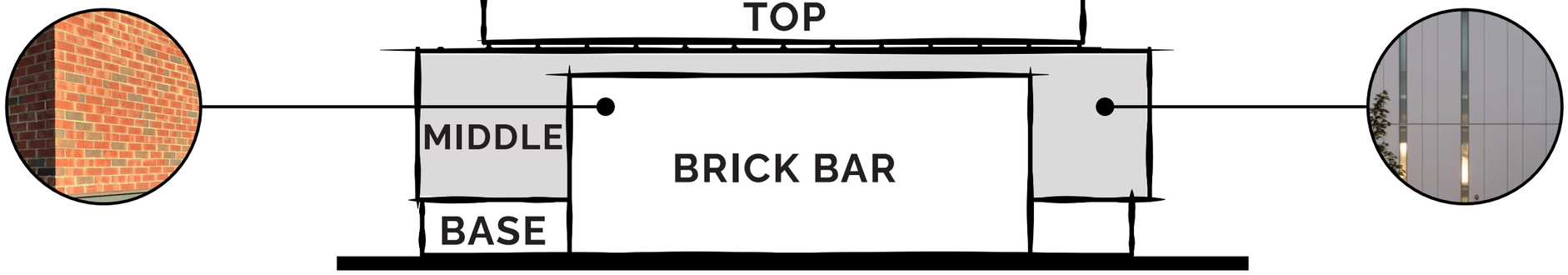
ENGIE CHP PLANT

OCTOBER 2019

ENGIE OHIO STATE ENERGY PARTNERS DESIGNGROUP

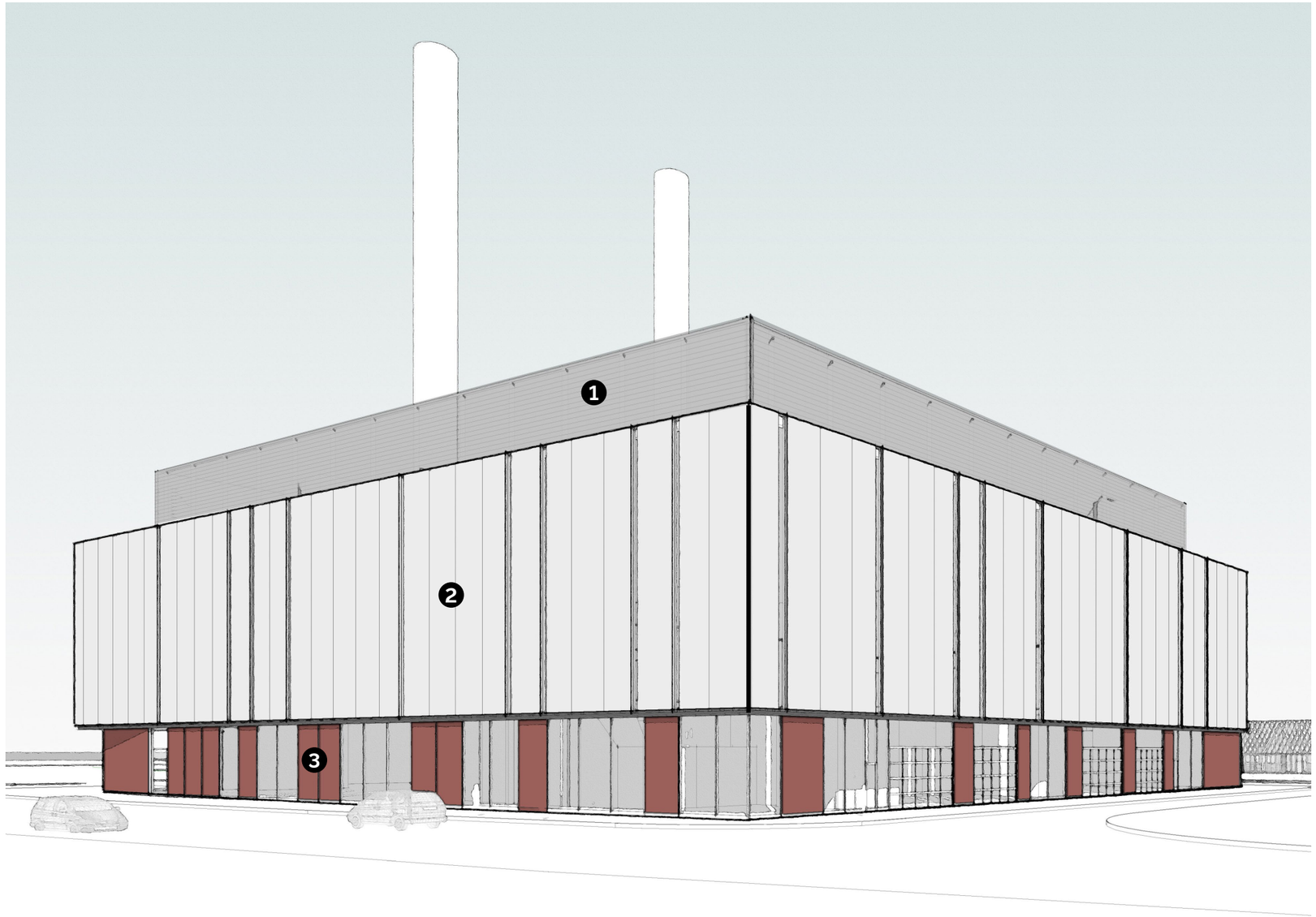


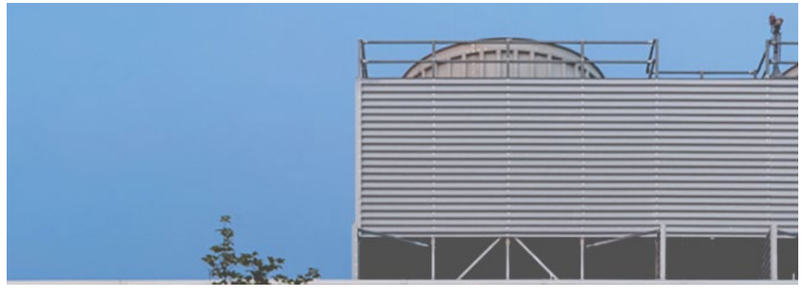
SOUTH FACADE



NORTH FACADE

COMPOSITIONAL DIAGRAM
ENGIE CHP PLANT
OCTOBER 2019



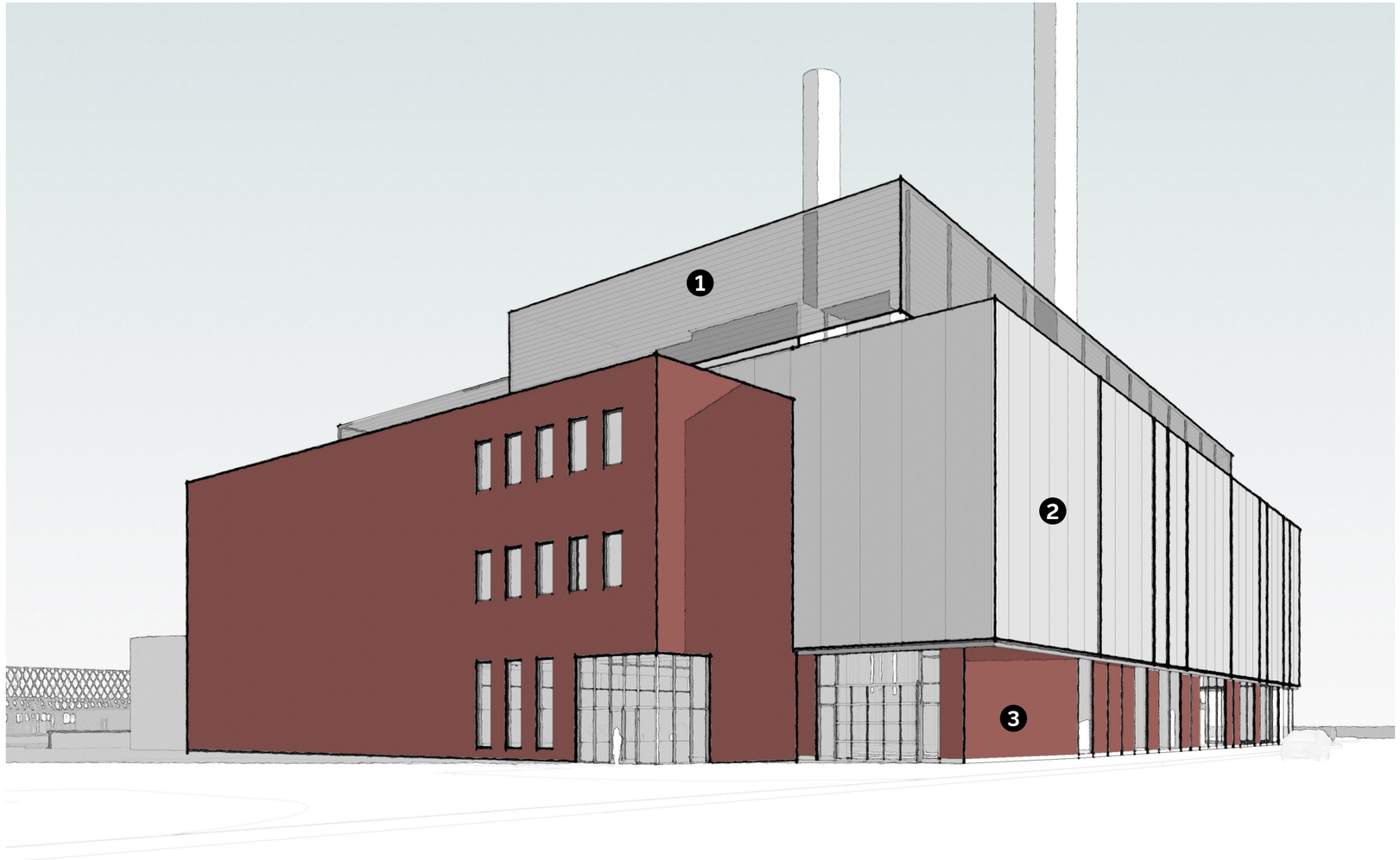


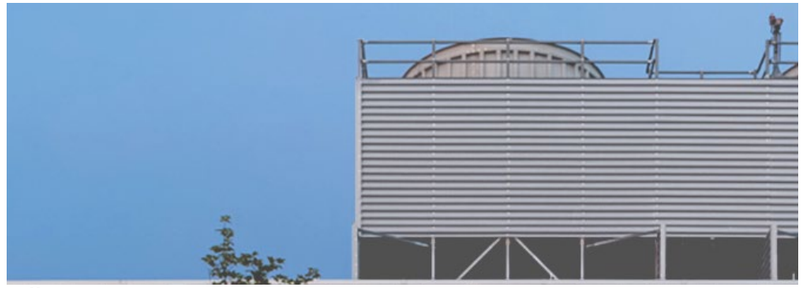
1 METAL SCREEN WALL

2 METAL PANEL WITH SLOT WINDOWS

3 BRICK AND GLASS BASE - **BRICK PRECEDENT FROM ADJACENT VETERINARY MEDICAL COMPLEX**

SOUTHWEST CORNER
ENGIE CHP PLANT
OCTOBER 2019





1 METAL SCREEN WALL

2 METAL PANEL WITH SLOT WINDOWS

3 BRICK AND GLASS BASE - **BRICK PRECEDENT FROM ADJACENT VETERINARY MEDICAL COMPLEX**

NORTHWEST CORNER
ENGIE CHP PLANT
OCTOBER 2019

EXHIBIT E: American Electric Power Short Form Application

AEP OHIO
An AEP Company
BOUNDLESS ENERGY

APPLICATION FOR INTERCONNECTION OF GENERATION EQUIPMENT 20 MEGAWATTS OR LESS (Standard Form Application)

A Short Form Application is available for inverter-based systems (25 kW or less).

An Application is a complete application when it provides all applicable and correct information required below. Additional information to evaluate a request for interconnection may be required pursuant to the application process after the Application is deemed complete.

Applications for Interconnection meeting Level 2 qualifying criteria are subject to an application fee of $50 + $1/kW. Applications for Interconnection meeting Level 3 qualifying criteria are subject to an application fee of $100 + $2/kW.

Customer

Legal Name: _____

Mailing Address: _____

City: _____ State: _____ Zip: _____

Phone: (614) _____ Phone: (____) _____

E-mail address: _____

Alternate Contact

Name: _____

Mailing Address: _____

City: _____ State: _____ Zip: _____

Phone: (614) _____ Phone: (____) _____

E-mail address: _____

Facility Location

Street Address: _____

City: _____ Zip: _____

Service Information

Electric Service Account Number: _____

Existing Electric Service: Capacity: _____ Amperes Voltage: _____ Volts

Service Character: ☐ Single Phase ☑ Three Phase

Site Maximum Demand: _____ kW Annual Energy Consumption _____ kWh

Requested Point of Interconnection: _____

Location of Utility Accessible Lockable Disconnect Switch: _____

(e.g. West wall next to utility meter)

Requested In-Service Date: _____

Consulting Engineer or Contractor

Name: ENGIE Buckeye Operations c/o Jason Jones

Address: 1990 Post Oak Blvd. Suite 1900

City: Houston State: Texas Zip: 77056

Phone: (713) 636-1982 Phone: (716 994-9566 E-mail: jason.jones@engie.com

Generator Qualifications

Energy Source: ( ) Solar ( ) Wind ( ) Hydro: type (e.g. run-of-river) _____

( ) Diesel ( ) Natural Gas ( ) Fuel Oil ( ) Other: (specify) Natural Gas

Type of Generator: ☐ Inverter-Based ☑ Synchronous ☐ Induction

Generator Nameplate Ratings: 2x33800, 1x50500 kW 13800 Volts Connected: ☑ Wye ☐ Delta

Number of Generators: 3 Service Character: ☐ 1 Phase ☑ 3 Phase Power Factor: _____%

Inverter AC Ratings: _____ kW _____ Volts Number of Inverters _____

Number of Solar PV Modules: _____ DC Rating: _____ watts

Maximum Net Export Capability: 0 kW Estimated Annual Energy Production: 495000000 kWh

This Generating Equipment is intended to be used to:

☐ Emergency/Standby – Operated when AEP service is not available. Paralleling is for short durations.

( ) Peak Shaving – Operated during peak demand periods. Paralleling is for extended times.

☑ Base Load Power – Operated continuously at a pre-determined output. Paralleling is continuous.

☑ Cogeneration – Operated primarily to produce thermal energy. Paralleling is extended or continuous.

( ) Renewable non-dispatched – Operated in response to an available renewable resource. Paralleling is for extended times.

( ) Other – Describe: The CHP will run in parallel to the AEP system and the intended use is to completely offset the university's load at all times. The control and protection will be designed to ensure that there is NO real power injection into the AEP system.

List components of the generation equipment that are currently certified by a nationally recognized testing and certification laboratory (NRTL) and/or listed by the Underwriters Laboratory:

	Equipment Type	UL Listing or certifying NRTL Certification
1.		
2.		
3.		
4.		

Generation Equipment Technical Information

Attach electrical one-line diagram showing the configuration of all generating facility equipment, transformers, switchgear, switches, circuit breakers, fuses, current and potential transformers, and protection and control schemes. (This diagram must be signed and stamped by a licensed Professional Engineer if the facility is larger than 50kW).

Attach site documentation that indicates the precise physical location of the proposed generating facility and location of protective interface equipment, disconnect switch, and utility electric meter (e.g. USGS topographic map or other diagram or documentation).

Attach technical specifications literature for inverters, photovoltaic modules, wind turbines, other generation equipment, battery systems, transformers, switches, or other interface devices and documentation that describes and details the operation of all protection and control schemes.

Attach UL 1741 documentation or installation test procedures for all the tests required by IEEE 1547 and the periodic maintenance schedule recommended by the equipment manufacturer.

Attach "Certificate of Liability Insurance" or proof of insurance sufficient to meet construction, operating and liability responsibilities.

I hereby certify that, to the best of my knowledge, all the information provided in the Interconnection Application is true and correct.

CUSTOMER'S SIGNATURE: _____

TITLE: _____

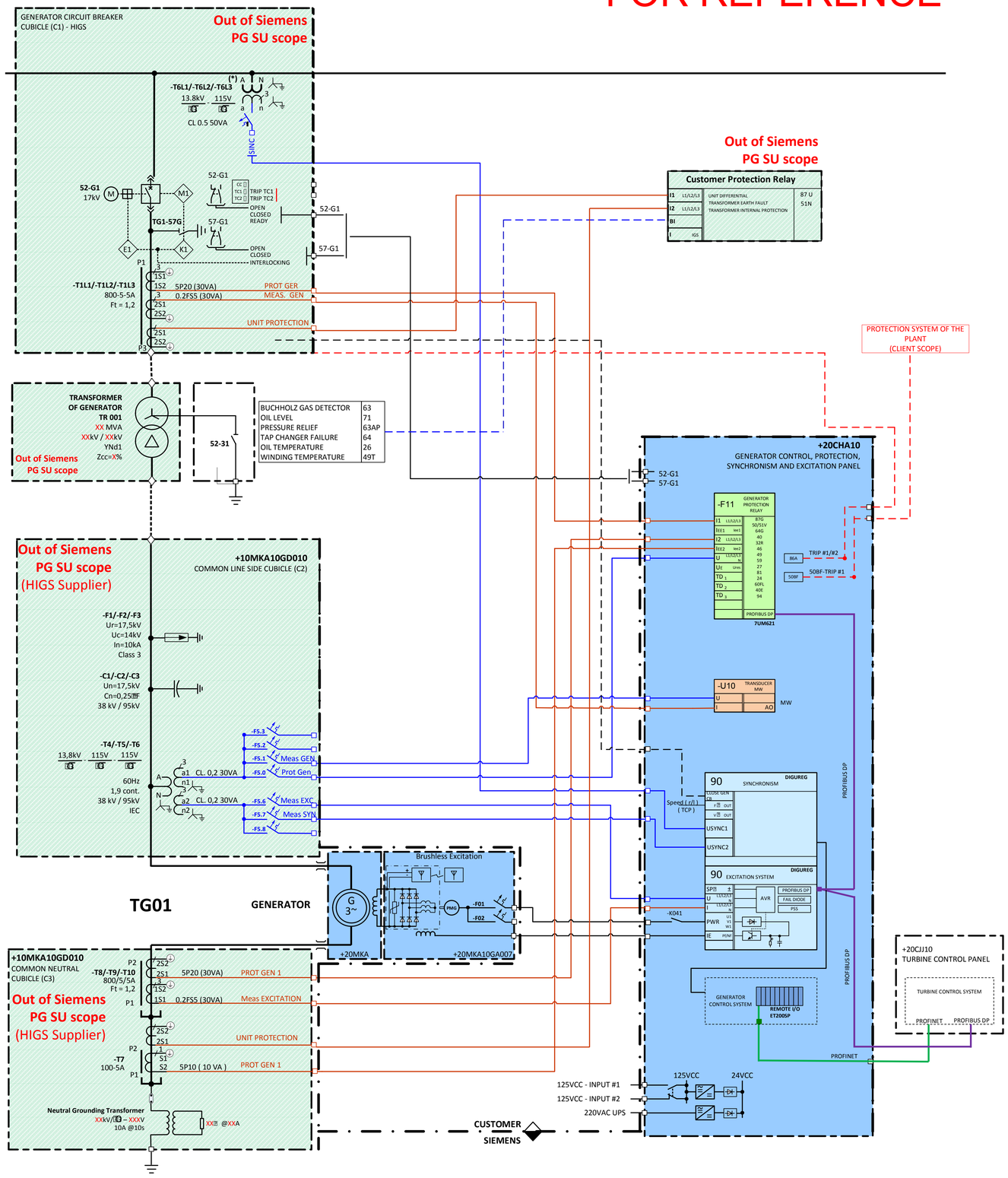
DATE: _____

Return Completed Application to:

AEP Ohio
Attn: DG Coordinator
700 Morrison Road
Gahanna, Ohio 43230-6605
614-883-6775
dgcoordinator-ohio@aep.com

SINGLE LINE DIAGRAM – STEAM TURBOGENERATOR

FOR REFERENCE



FUNCTION	DESCRIPTION
-F11	MULTIFUNCTION PROTECTION DEVICE
21	DISTANCE PROTECTION
24	VOLTS-PER-HERTZ / OVERFLUXING / OVEREXCITATION PROTECTION
25A	SYNCHRONIZING DEVICE – AUTOMATIC
27	GENERATOR UNDERVOLTAGE PROTECTION
27/50	GENERATOR ACCIDENTAL ENERGIZATION PROTECTION
32R	REVERSE POWER PROTECTION
40	GENERATOR LOSS OF FIELD PROTECTION
46	GENERATOR UNBALANCED LOAD PROTECTION
49	GENERATOR OVERLOAD PROTECTION / THERMAL OVERLOAD PROTECTION
50BF	GENERATOR CIRCUIT-BREAKER FAILURE
51	GENERATOR INVERSE TIME OVERCURRENT PROTECTION
52	AC CIRCUIT-BREAKER
59	GENERATOR OVERVOLTAGE PROTECTION
64S	GENERATOR STATOR GROUND PROTECTION
67	GENERATOR DIRECTIONAL OVERCURRENT PROTECTION
81O	GENERATOR OVERFREQUENCE PROTECTION
81U	GENERATOR UNDERFREQUENCE PROTECTION
87G	GENERATOR DIFFERENTIAL PROTECTION
90	VOLTAGE REGULATING DEVICE (AVR – AUTOMATIC VOLTAGE REGULATOR)
A/B/C/N	PHASE IDENTIFICATION
CB	CIRCUIT-BREAKER
GCP	GENERATOR CONTROL, PROTECTION, EXCITATION AND SYNCHRONIZATION PANEL
NGR	NEUTRAL GROUNDING RESISTOR
PMG	PERMANENT MAGNET GENERATOR
U10	ACTIVE POWER TRANSDUCER
S52GA	CIRCUIT-BREAKER 52GA COMMAND SWITCH
S52GB	CIRCUIT-BREAKER 52GB COMMAND SWITCH

Remark: Table based on IEEE Std C37.2-2008 – "IEEE Standard for Electrical Power System Device Function Numbers, Acronyms, and Contact Designations"

SYMBOL DESCRIPTION

- SYNCHRONOUS GENERATOR
- GROUNDING TRANSFORMER
- GROUNDING RESISTOR
- STEP-UP TRANSFORMER
- CONDENSER AGAINST OVERVOLTAGE
- SURGE ARRESTER
- VOLTAGE TRANSFORMER
- CURRENT TRANSFORMER
- ELECTRICAL CABLE – VOLTAGE TRANSFORMER
- ELECTRICAL CABLE – CURRENT TRANSFORMER
- GENERATOR
- ELETRICAL CABLE – TRIP SIGNAL
- ELETRICAL CABLE – CIRCUIT BREAKER CLOSE/OPEN COMMAND
- ELECTRIC POWER CABLE
- MEDIUM VOLTAGE CIRCUIT-BREAKER
- MOTORIZED DISCONNECTOR SWITCH
- MEDIUM VOLTAGE CABLE TERMINAL
- AUXILIARY POWER TRANSFORMER
- TRANSDUCER
- DIODE
- MECHANICAL INTERLOCK
- MECHANICAL INTERLOCK KIRK TYPE
- ELECTRICAL INTERLOCK
- GENERATOR
- SIEMENS PG SU SCOPE OF SUPPLY
- OUT OF SIEMENS PG SU SCOPE OF SUPPLY

REMARKS:

1) CUSTOMER TO CONFIRM IF WILL BE APPLIED IN THIS PROJECT EARTHING SWITCH ON ONE SIDE OR BOTH SIDES OF CIRCUIT-BREAKER (UPSTREAM AND DOWNSTREAM) FOR MAINTENANCE AS WELL AS FOR GENERATOR CAPACITANCE DISCHARGE. IF SUCH DEVICES WILL BE APPLIED, THEN WILL BE NECESSARY FOLLOWING
SAFETY INTERLOCKS:
- MECHANICAL INTERLOCK ("M") BETWEEN EARTHING SWITCH AND CIRCUIT-BREAKER;
- ELECTRICAL INTERLOCK ("E1") FOR EARTHING SWITCH BETWEEN GENERATOR AND BREAKER, CONSIDERING EXCITATION OFF (PERMISSIVE CONDITION);
- ELECTRICAL INTERLOCK ("E2") FOR EARTHING SWITCH BETWEEN BREAKER AND STEP-UP TRANSFORMER, CONSIDERING BREAKER ON STEP-UP TRANSFORMER PRIMARY SIDE OPEN AND GENERATOR EXCITATION OFF (PERMISSIVE CONDITIONS);
TO BE EVALUATED ALSO THE USE OF LOCK "KIRK" TYPE ("K1" AND "K2", DEPENDING ON SUBSTATIONS DISTANCES AND OPERATIONAL REQUIREMENTS).

2) MEDIUM VOLTAGE DUCTS / CABLES, VOLTAGE CABLES, CURRENT TRANSFORMER CABLES, CONTROL AND INTERCONNECTING CABLES BETWEEN CONTROL CABINETS ARE OUT OF SIEMENS PGSU SCOPE OF SUPPLY;

3) SIEMENS DOESN'T RECOMMEND HIGH-VOLTAGE FUSES ON PRIMARY SIDE OF VOLTAGE TRANSFORMERS, JUST MINI-CIRCUIT-BREAKERS ON SECONDARY SIDE, DUE FOLLOWING REASONS:
- SHORT-CIRCUITS ON HIGH-VOLTAGE SIDE DOES NOT AFFECT VT;
- SHORT-CIRCUITS ON SECONDARY SIDE WILL BE PROTECTED BY MCB ON LOW VOLTAGE SIDE. REFLECTED CURRENT ON HIGH VOLTAGE SIDE ARE TOO SMALL TO BURN HV FUSES (APP. 1.0A). THIS CURRENT CAN ALSO EXPLODE THIS FUSE DUE THERMAL EFFECT;
- HV FUSES ARE ADDITIONAL POINTS OF FAILURE;

4) SIEMENS GENERATOR PROTECTION SHALL TRIP BREAKER 52-GB

5) THE BREAKERS SHOULD HAVE TWO TRIP SECURITY COIL (TC1-TRIP COIL # 1 AND TC2-TRIP COIL # 2);

6) ALL BREAKER STATUS CONTACT SHALL BE DRY TYPE (POTENTIAL FREE). 1NO AND 1NC CONTACT (MAINTAINED) SHALL BE PROVIDED.

7) THE CLOSING COILS OF THE SYNCHRONIZABLE SWITCHES (CC - CLOSING COIL) SHOULD HAVE DOUBLE SECURITY, FOR SAFETY;

LKZ : CZ
ECCN : N
AL : N
Goods labeled with "AL" not equal to "N" are subject to European or Czech export authorization when being exported out of the EU.
Goods labeled with "ECCN" not equal to "N" are subject to US reexport authorization. Even without a label, or with label "AL:N" or "ECCN:N", authorization may be required due to the final end-use and destination for which the goods are to be used.

				Date	18.08.2017	FOR REFERENCE ONLY	SIEMENS	Document title: SINGLE LINE DIAGRAM STEAM TURBINE FOR REFERENCE ONLY
				Drawn	V. ALVES		PG SU AM BRA EN EC	INITIAL ISSUE
0	First issue	18.07.2017		Checked	J. PIOTTO		Brazil - Jundiaí	Language EN
Rev.	Text	Date		Approved	A. CASSOLATO	Machine no.: XXXX		Format A2
							Document no. FOR REFERENCE ONLY	Rev. 0
								Sheet no. 1
								Next sheet 0

TECHNICAL SPECIFICATION FOR BRUSHLESS SYNCHRONOUS GENERATOR

CLIENT : Siemens
PROJECT : Siemens Brazil
TYPE : AMS 1250ALM 4L BS
OUR REFERENCE : BRT15460-18
DRIVEN EQUIPMENT : Steam turbine
DATE : 2016-02-22
SERIALNUMBER : 0

INDEX

1. Technical Specification

ABB type AMS 1250ALM 4L BS brushless synchronous Generator rated
Power =61147 kVA,
PF =0.85 (Overexcited),
PF =0.9 (Underexcited),
Voltage =13800 V,
Frequency =60 Hz,
Speed =1800 rpm,
for installation in safe area.Designed for Steam Turbine.
Designed according to NEMA MG1.

2. Included accessories

2.1 Standards and Site Conditions

- UBC4 earthquake zone classification.

2.2 Main Mechanical Data

- Clockwise direction of rotation at drive end, facing shaft end.
- Cooling arrangement: IC8 A1W7. Self circulated inner air circuit cooled by built-on water-air heat exchanger.
- Protection of machine IP54
- Temperature rise, rotor within class B
- Temperature rise, stator within class B

2.3 Excitation

- Main brushless exciter type GLC 600 for DC excitation complete with diode bridge, thyristors, RC-circuits and control box.
- Mini circuit breaker - PMG over current protection.
- PMG

2.4 Cooling System

- 2x67 % Water cooler redundancy
- Air-to-water single tube cooler with ANSI flanges (Design/Test pressure 0.6/0.9MPa)
- Customer water analysis required
- Safety valve on water cooler
- Safety valve on water cooler
- Water cooler connection at left side of machine facing DE
- Water cooler counter flanges
- Water cooler counter flanges

- Water cooler material: Tubes: Stainless steel, Tube end plates: Stainless steel, Water box: Rilsan coated steel, Plate fins: Aluminium

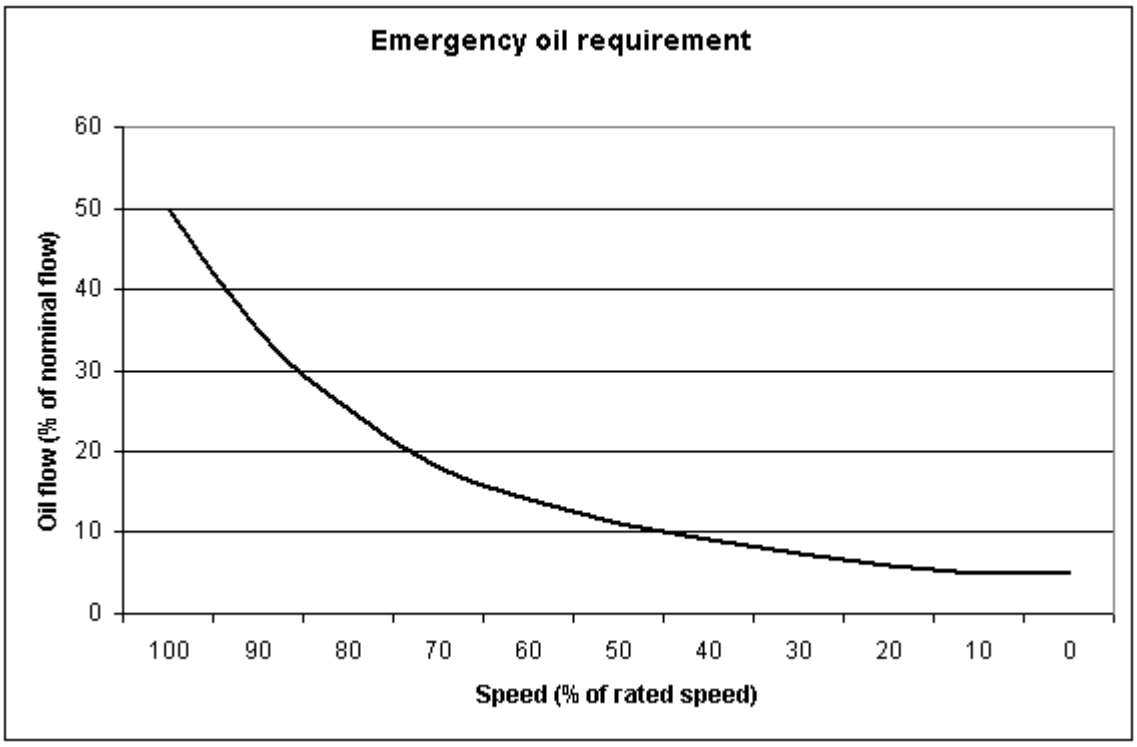
2.5 Shaft Extensions

- Flange diameter 648 mm
- Flanged shaft end with internal spigot in DE

2.6 Bearings

- Bearing size GL397
- Bearings prepared for jacking oil
- Forced lubricated sleeve bearing.
- Lockable oil pressure reducing valve in brass.
- Oil connections at left side of machine seen from DE, locations close to machine edges.
- Oil inlet flange: DIN, DN 20 PN16
- Oil outlet flanges: DIN, DN 65 PN16
- Oil pressure measurement by manometer without contact.
- Separate oil connections at both bearings, stainless in- and outlet, DIN
- The lube oil drain pressure must be less than or equal to the machine ambient pressure. An oil drain pressure of 200-1000 Pa lower than the bearing ambient is recommended.

Bearings not equipped with oil ring



2.7 Main Terminal Boxes and Related Accessories

- Main terminal box located on the right side, seen from DE
- MTB supply cable entry from below. Gland plate is removable, undrilled and of non magnetic material.
- Standard large air insulated Main Terminal Box
- The main terminal box is delivered as a loose item, assembly on site is not included in ABB's scope of supply.
- The main terminal box needs to be supported from beneath. Supports are not included in ABB's scope of supply.

2.7.1 Line side

- 3 Current Transformers, 3 core, mounted in MTB, metering accuracy class 0.3 B 2.0 (ANSI) and relaying accuracy C400.
- 3 Surge Arrestors
- 3 Surge Capacitors single phase
- 3 Voltage Transformers

2.7.2 Neutral side

- 1 Current Transformer for NGTR (1 core)
- 3 Current Transformers, 3 core, mounted in MTB, metering accuracy class 0.3 B 2.0 (ANSI) and relaying accuracy C400.
- LV-Contactor for Neutral Grounding Resistor (NGTR)
- Neutral Grounding Transformer with secondary Resistor (10 A for 10 sec)

2.8 Monitoring and Protection Accessories

RTD's according to IEC 60751, class B
- Provision for proximity transducers
- 1x RTD in warm machine air, duplex (Pt100), 3 wire, unshielded.
- 1x RTD per bearing in oil outlet pipe, single (Pt100), 3 wire unshielded
- 2x RTD in cold machine air, duplex (Pt100), 3 wire, unshielded (mounted at NDE + DE)
- 2x RTD per Bearing Shell, duplex (Pt100), 3 wire, unshielded
- 6+3 spare x RTD's in stator windings, single (Pt100), 3 wire, unshielded, safe and hazardous area
- BN 3300XL keyphasor
- Generator not prepared for MACHsense-R (later installation impossible)
- Heaters in both main machine and exciter, safe area, 480 VAC 1 phase supply. The heaters should always be connected during stand still to avoid condensation.
- Prepared for bonding
- Rotor earth fault brush mounted at NDE
- Shaft earthing brush mounted at DE.
- Stainless steel junction boxes provided with undrilled gland plates. Located at left side of machine facing DE.
- Water leakage detector, float switch, Safe area.
- Vibration control, velocity type BN 330500 (1 probe in horizontal direction per bearing), hazardous area.

2.9 Foundation and Installation

- Long sole plates kit (ABB std)
- Mounting shims in black steel, total thickness 2 mm for each machine foot.

2.10 Special Design and Accessories

- Burnishing shaft hub surface for proximity type of vibration probes, maximum combined electrical and mechanical run out 23 µm (0.91 mils) peak-to-peak.
- Noise reduction -3 dB(A) acc. to ISO 3744
- Rotor sliding tool - RST 1 (one covering all identical units)
- Stainless steel bolts (M12 or smaller) on external covers.

Rotor sliding tool, RST 1
Sliding plates for rotor removal of rotor by sliding,
requires one hook lifting with a capacity which can handle the rotor weight,
the hook motion must be along the shaft. No slings, lifting jack or rotor storage support included.

2.11 Painting and corrosion protection

- ABB blue colour (NCS 4822-B05G)
- Standard industrial coating acc. to ISO 12944 C3

2.12 Packing and Transportation

- Long term storage (heater included)
- Seaworthy wooden case packing.

2.13 Spare Parts & services

- 10: Operational spare parts package ABB bearing (one covering all identical units)
- 11: 6 pc Diodes, 2 pc Thyristors & 1 pc Control pulse unit (one covering all identical units)
- 13: 4 pc Bearing liners, 4 pc Air filters (one covering all identical units)
- 14: 1 pc Earth fault brush set (one covering all identical units)
- 1A: 1 pc Grounding brush set (one covering all identical units)

2.14 Special components

- 1 extra water leakage detector

3. Position notes, Specification comments and Validation notes

4. Documentation

- Installation and maintenance manual in Portugese language. Language for other documents is English.
- Standard documents for Machine according to MDD 3AAM100439
- User's manual on CD, (1 copies)

5. Tests and Certificates

- Final inspection of complete machine, unwitnessed
- Routine and Type test according to ABB standard procedure

5.1 Routine tests

- Air gap measurement, unwitnessed
- Dielectric test, unwitnessed
- Magnetic neutral pos., axial play in bearing and distance shaft-end to footplate, unwitnessed
- Measurement of insulation resistance before and after dielectric test, unwitnessed
- No-load characteristics, unwitnessed
- Overspeed test, unwitnessed
- Phase sequence and terminal marking, unwitnessed
- Resistance measurement, unwitnessed
- Settings list for machine protection, unwitnessed
- Short-circuit characteristics, unwitnessed
- Vibration measurement during retardation or acceleration, unwitnessed
- Vibration measurements, unwitnessed
- Visual inspection of complete machine, unwitnessed

5.2 Type tests

- Determination of efficiency at rated P.F. and 100, 75, 50 and 25% load, unwitnessed (one covering all identical units)
- Determination of rated excitation current, unwitnessed (one covering all identical units)
- Determination of reactance Xd, Xd', Xd'' and time-constant Ta, Td', Td'', unwitnessed (one covering all identical units)
- Determination of timeconstant (Td0'), unwitnessed (one covering all identical units)
- Heat run at P.F. = 0, unwitnessed (one covering all identical units)
- Sudden three -phase short-circuit test, unwitnessed (one covering all identical units)
- Waveform analys TIF, unwitnessed (one covering all identical units)

5.3 Special tests

- Control of leak water detector, unwitnessed
- Control of proximity vibration units, unwitnessed
- Control of seismic vibration units, unwitnessed
- Functional control and adjustment of oil flow measurement system, unwitnessed
- Measurement on burnish surface at rotor shaft with rotor journaled in vee-block, unwitnessed
- PMG, Output voltage and frequency, unwitnessed

- Shaft voltage measurement, unwitnessed
- Test of main terminal box, unwitnessed

5.4 Certificates

- Declaration of Incorporation for partly completed machinery
- Pressure test of water cooler

A. Rated data

at cooling water temperature 32 °C/ 89.6 F		
Machine type		AMS 1250ALM 4L BS
Output	kVA	61147
Power factor (overexcited)		0.85
Voltage	V (±5.0 %)	13800
Frequency	Hz (±5.0 %)	60
Speed	rpm	1800
Current	A	2558
Exciter type		GLC 600
Excitation	V / A	78 / 10
Power factor (underexcited)		0.90
Output (underexcited)	kVA	57750
Active output (underexcited)	kW	51975
Current (underexcited)	A	2416
PMG ratings:		
- Voltage AC	V	173
- Power factor		0.5
- Current	A	11.8
- Frequency	Hz	300
- Poles		20
- Phases		3

B. Standards

Applicable standards		NEMA
Insulation class stator and exciter		F
Insulation class main rotor		H
Temperature rise, stator within class		B
Temperature rise, rotor within class		B
Increased safety, Standards/Form		

C. Other performance data

Guaranteed efficiency at P.F. 0.85 and		
100 / 75 / 50 / 25 % load	%	98.39 98.18 97.63 95.66
Guaranteed efficiency at P.F. 1.0 and		
100 / 75 / 50 / 25 % load	%	98.70 98.51 98.04 96.35
Reactances:		
- X_d	(±15) %	154.5
- X_d' unsat/sat	" %	23.9 / 20.5
- X_d'' unsat/sat	" %	14.8 / 12.6
- X_q unsat/sat	" %	72.3 / 67.4
- X_q'' unsat/sat	" %	22.1 / 18.8
- X_0	%	5.9
- X_2	%	14.8
- X_L	%	10.8
Time constants:		
- T_d'	s	0.934
- T_d''	s	0.022
- T_{d0}'	s	7.090
- T_{q0}''	s	0.109
- Ta	s	0.202
Sub-transient short circuit current Ik''	(±15) %	796.2
Generator inertia constant		

- H	s	1.28
Excitation main machine:		
- voltage no load	V	96
- voltage full load	V	214
- current no load	A	232
- current full load	A	516
Excitation exciter:		
- voltage no load	V	35
- voltage full load	V	78
- current no load	A	4
- current full load	A	10
Sudden short circuit current (peak)	kA	58
Short circuit ratio	%	69
Max. field forcing for 10 seconds	%	200
Sustained short circuit, stator current for 10 seconds at symmetrical conditions	%	309
Max. permissible overspeed (<2 min)	rpm	2160
Output with one cooler element out of service	%	67
Max. continuous negative sequence current	%	10
Fault condition capability $(I_2/I_N)^2t$	s	40
Voltage regulation acc. to IEEE 100, seventh edition		
- Regulation = (Et - E) / E	%	141
Overcurrent capability $(I^2 - 1)$ t	s	37.5
this relationship shall apply for values of t between	s	10 - 60

Allowed current harmonic content, with base 61150 kVA

Harmonic	Amplitude [p.u]
5	0.02
7	0.017
11	0.012
13	0.011
17	0.01
19	0.01
23	0.009
25	0.006

If the current harmonic content is higher than above values, the temperature of the machine may rise above the specified limits

Permissible output at diff. temp.				
Cooling water temperature	°C/F	15/59	27/81	41/106
Output	kVA	63000	62160	55500
Power factor		0.85	0.85	0.85
Stator current	A	2636	2601	2322
Exciter output	kVA	115	113	97
Exciter excitation	V / A	80 / 10	79 / 10	73 / 9
Efficiency at				
100 % load	%	98.40	98.40	98.33
75 % load	%	98.20	98.19	98.07
50 % load	%	97.68	97.65	97.44
25 % load	%	95.77	95.72	95.27

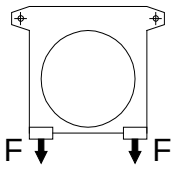
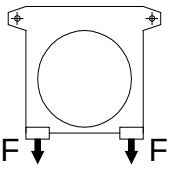
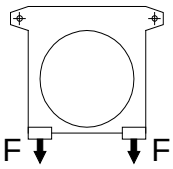
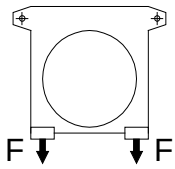
D. Site conditions

Ambient temperature range	°C	0 - 41	F	32 - 106
Altitude	m a.s.l.	1000	ft.a.s.l.	3281
Water temperature range	°C	10 - 32	F	50 - 90
Hazardous area classification		Non hazardous area		
Seismic zone		Acc. to UBC, Zone 4		

F. Installation data

Protection form/cooling form		IP54 TEWAC		
Cooler location/No of coolers		Top / 2+2 vertical cooler elements, air in series		
Water cooling:				
- Required cooling water flow	m³/h	128.0	gpm	563.6
- Cooling water temperature (rated)	°C	32	F	90
- Temperature rise cooling water	K	5.2	F	9.3
- Pressure drop cooling water	kPa	25	psi	4
- Fouling factor	m² °C/W	0.000090	hr-ft2-°F/Btu	0.000511
Heat losses:				
- Cooling water	kW	757		
- Lubrication oil at 65 °C	kW	39.0		
Arrangement form		IM 1005		
Shaft end according to drawing				
Sleeve bearings:				
- Max. axial play towards D-end	mm	10.0	in.	0.394
- Max. axial play towards N-end	mm	10.0	in.	0.394
- Max. permissible axial thrust	kN	0	lbf	0
- Min. barring speed	rpm	45		
- Min. barring speed with jacking oil activated	rpm	0		
- Rotor break away torque	Nm	12539		
- Rotor break away torque with jacking activated	Nm	100		
- Required oil flow to bearings (Total)	l/min	74	gpm	19.6
- Oil temperature range to bearings	°C	40 - 65	F	104 - 149
- Required oil pressure at 65 °C	kPa	200	psi	29
- Supply oil pressure		To be advised by customer*)		
*)For setting of pressure reduction valve/orifice				
Default oil pressure*)	kPa	240	psi	34.8
*)Used if no value received from customer before FAT				
- Max supply oil pressure	kPa	500	psi	72.5
- Type of oil		ISO VG 46		
- Degree of purity for oil		17/15/12 acc. to ISO 4406:1999		
Weights (estimated):				
- Total (complete machine, excluding terminal box)	kg	78800	lb	173600
- Stator	kg	38900	lb	85700
- Rotor	kg	25800	lb	56800
Rotor inertia ($J=m*r_m^2$)	kgm²	4394	lb-ft²	104268
First lateral critical speed	rpm	>2070		
Direction of rotation (at drive end, facing		Clockwise		

shaft end) Noise level (at 1m, rated speed and no load acc.to ISO 3744)	dB(A)	82, Tol. +3 dB(A)

Forces on the foundation per stator side			
Static  F = 386.1 kN F = 86798 lbf	Rated torque  F = 386.1 kN ± 107.7 kN F = 86798 lbf ± 24213 lbf	2-phase short circuit  F = 386.1 kN ± 1202.7 kN F = 86798 lbf ± 270367 lbf	3-phase short circuit  F = 386.1 kN ± 1118.6 kN F = 86798 lbf ± 251464 lbf
Forces on each inner foot (2 inner feet/side)*)			
F = 96.5 kN F = 21700 lbf	F = 96.5 kN ± 53.9 kN F = 21700 lbf ± 12107 lbf	F = 96.5 kN ± 601.3 kN F = 21700 lbf ± 135184 lbf	F = 96.5 kN ± 559.3 kN F = 21700 lbf ± 125732 lbf
Forces on each outer foot (2 outer feet/side)*)			
F = 96.5 kN F = 21700 lbf	F = 96.5 kN F = 21700 lbf	F = 96.5 kN F = 21700 lbf	F = 96.5 kN F = 21700 lbf
*)The foundation shall be dimensioned to withstand the maximum force at all feet positions.			

Airgap torque equation - 3-phase short circuit

$T_e(t) = M_0 \, e^{-t/\tau_0} \sin \omega t + M_1 \, e^{-t/\tau_1}$

$M_0 = 8.89$; $M_1 = 1.83$; $\tau_0 = 0.129$ s ; $\tau_1 = 0.128$ s ; $\omega = 377$ rad/s

Maximum value of torque 10.4 * T_N, when t = 4.1 ms

Airgap torque equation - 2-phase short circuit

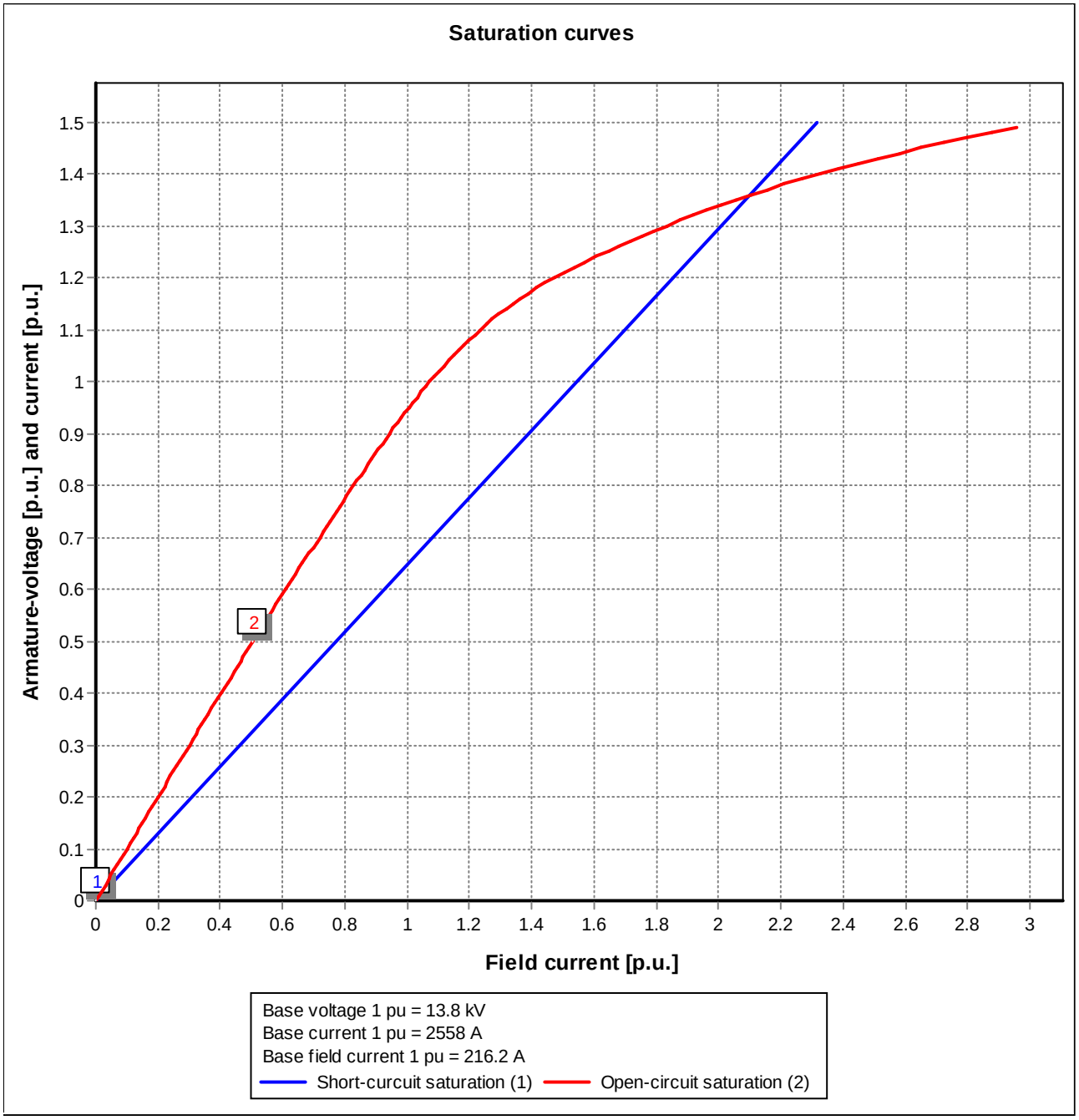
$T_e(t) = M_0 \, e^{-t/\tau_0} \sin \omega t - M_1 \, e^{-t/\tau_1} \sin 2\omega t + M_2 \, e^{-t/\tau_2}$

$M_0 = 7.25$; $M_1 = 3.64$; $M_2 = 1.96$; $\tau_0 = 0.223$ s ; $\tau_1 = 0.505$ s ; $\tau_2 = 0.304$; $\omega = 377$ rad/s

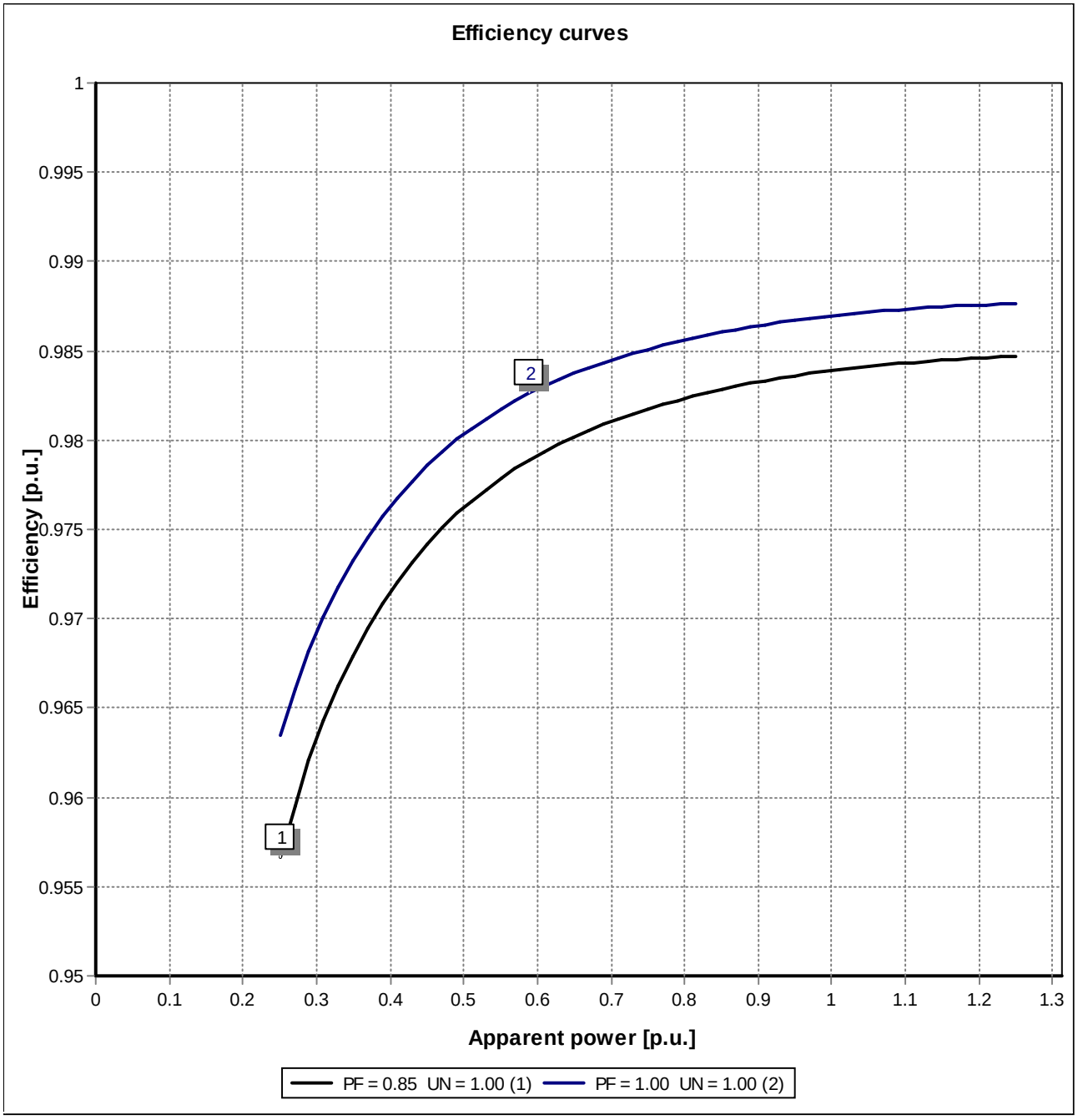
Maximum value of torque 11.2 * T_N, when t = 5.55 ms

Rated torque $T_N = 280$ kNm

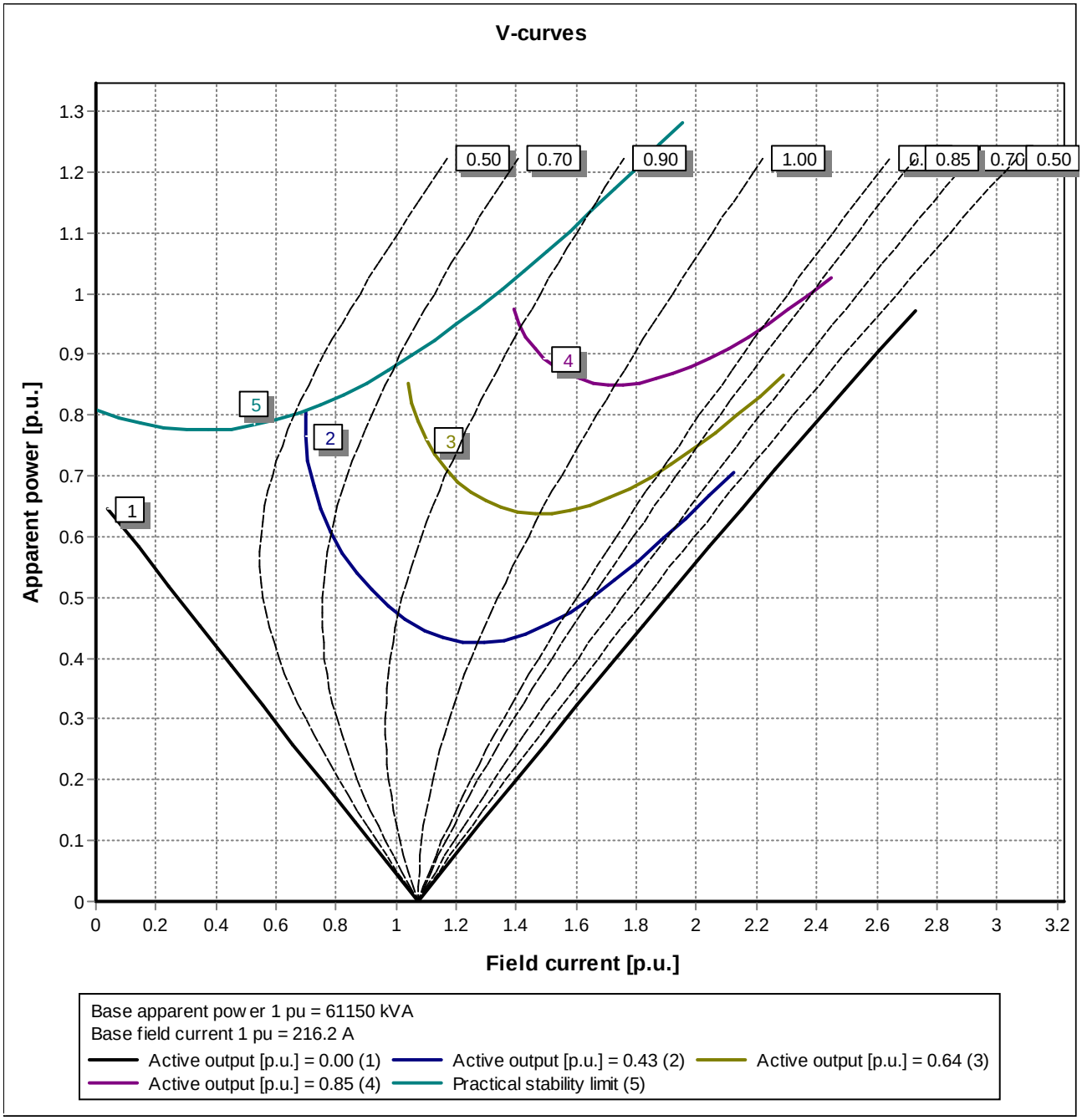
Generator type code: AMS 1250ALM 4L BS



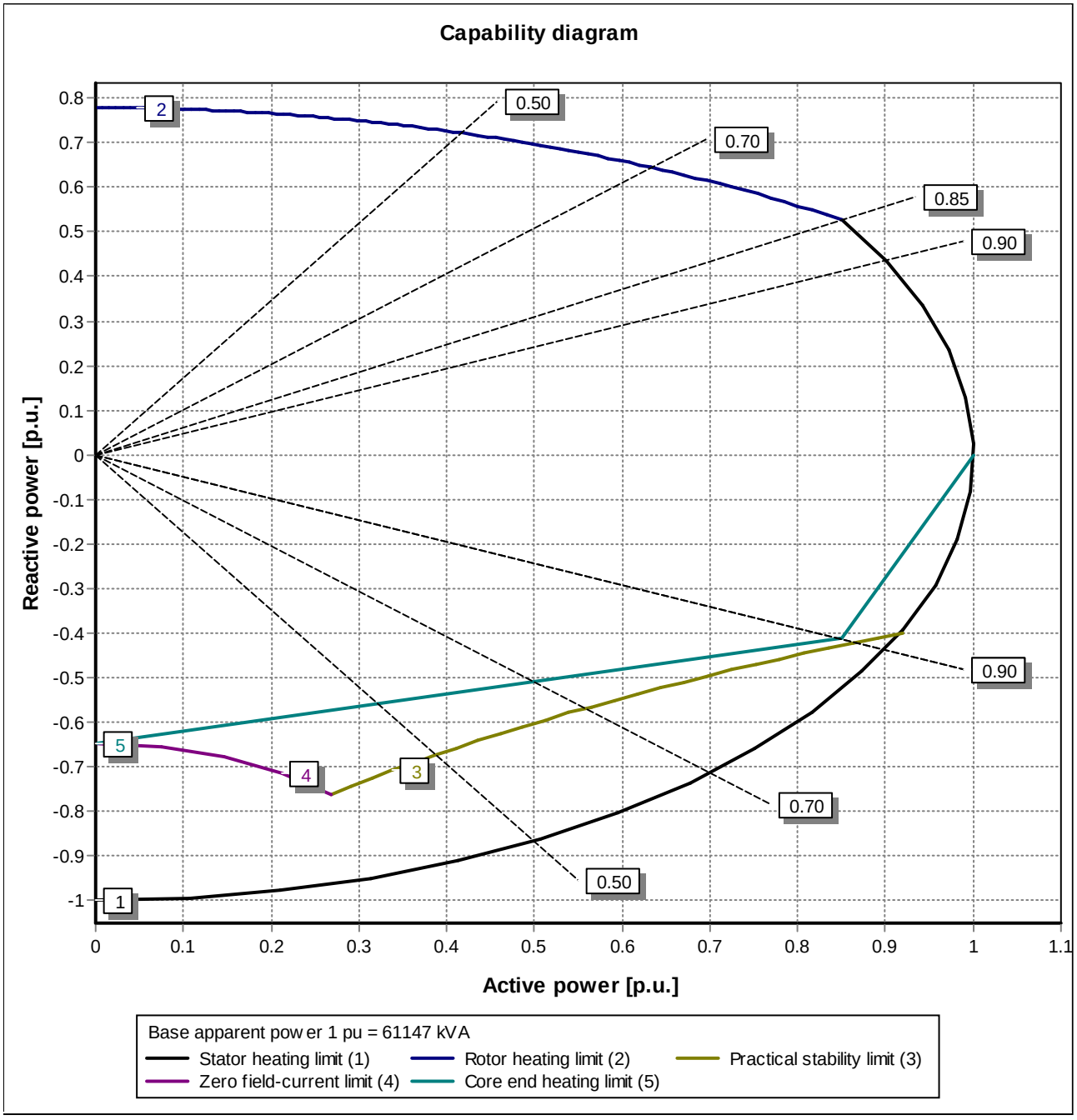
Generator type code: AMS 1250ALM 4L BS



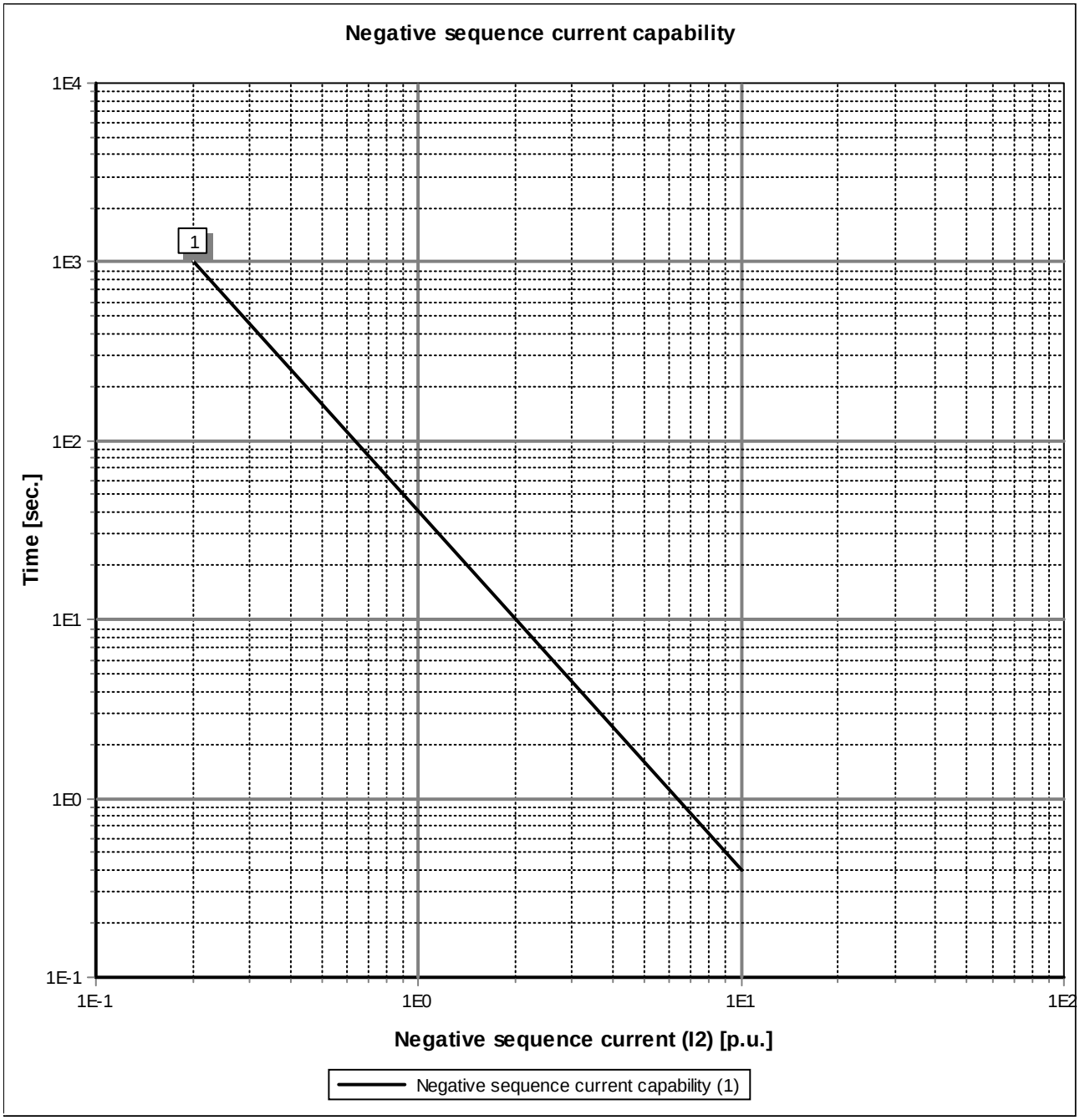
Generator type code: AMS 1250ALM 4L BS



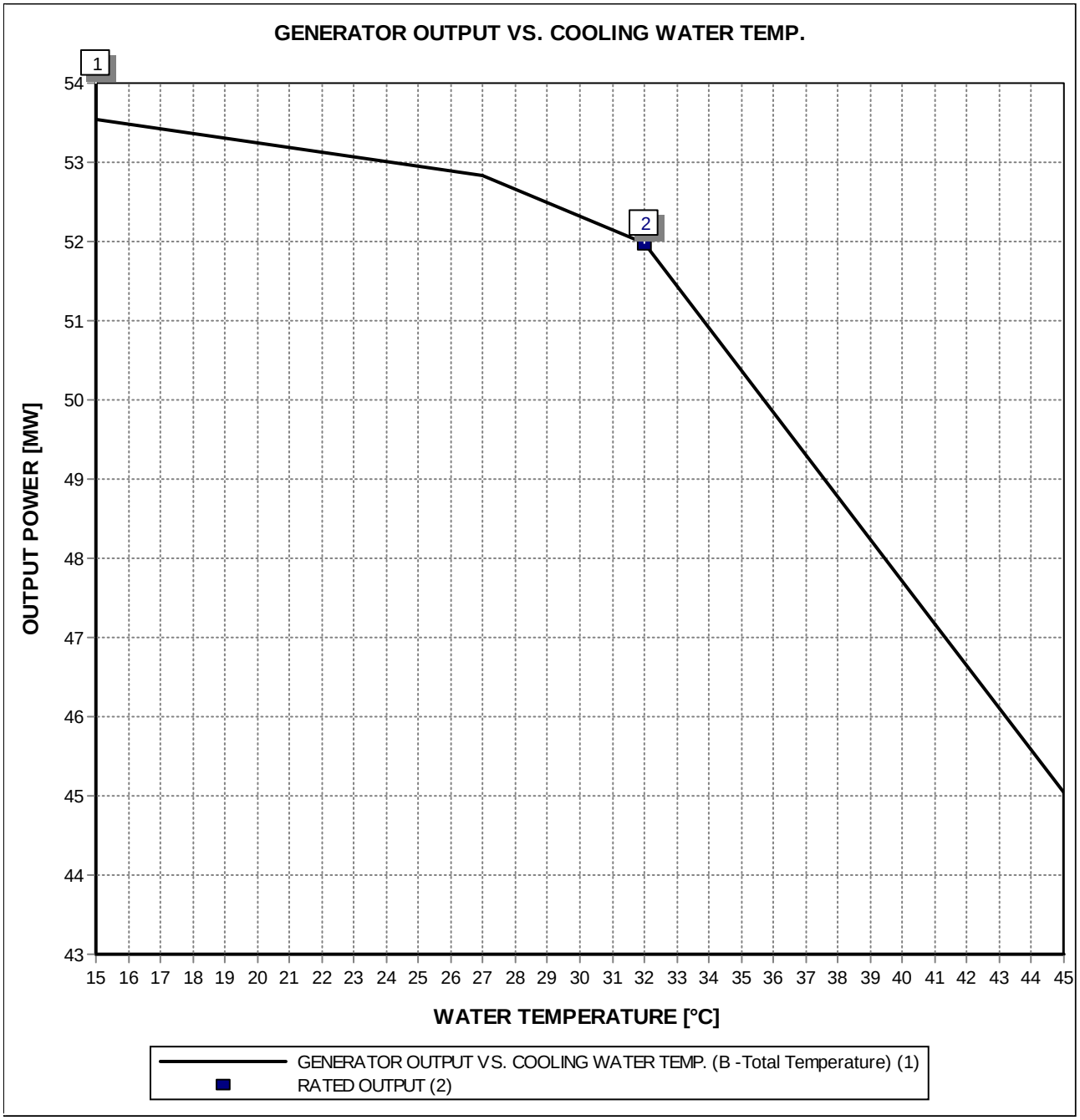
Generator type code: AMS 1250ALM 4L BS



Generator type code: AMS 1250ALM 4L BS



Generator type code: AMS 1250ALM 4L BS



TECHNICAL SPECIFICATION FOR BRUSHLESS SYNCHRONOUS GENERATOR

CLIENT : Siemens Industrial Turbomachinery AB
PROJECT : Ohio State University
TYPE : AMS 1250SE 4L BS
OUR REFERENCE : SET18281-02
DRIVEN EQUIPMENT : Gas turbine
DATE : 2018-09-13

INDEX

1. Technical Specification

ABB type AMS 1250SE 4L BS brushless synchronous Generator rated
Power =35000 kVA,
PF =0.85 (Overexcited),
PF =0.9 (Underexcited),
Voltage =13800 V,
Frequency =60 Hz,
Speed =1800 rpm,
for installation in safe area.Designed for Gas Turbine.
Designed according to NEMA MG1.

2. Included accessories

2.1 Standards and Site Conditions

- UBC4 earthquake zone classification.

2.2 Main Mechanical Data

- Cooling arrangement: IC8 A1W7. Self circulated inner air circuit cooled by built-on water-air heat exchanger.
- Counter clockwise direction of rotation at drive end, facing shaft end.
- Protection of machine IP54
- Temperature rise, rotor within class B
- Temperature rise, stator within class B

2.3 Excitation

- Main brushless exciter type GLB 600C for DC excitation complete with diode bridge, thyristors, RC-circuits and control box.
- Mini circuit breaker - PMG over current protection.
- PMG

2.4 Cooling System

- 2x70% Water cooler redundancy
- Air-to-water single tube cooler with ANSI flanges (Design/Test pressure 1.0/1.5MPa)
- Customer water analysis required
- Ethylene glycol as water cooler anti-freeze (40 %).
- Water cooler connection at right side of machine facing DE
- Water cooler material: Tubes: Cu 90%/Ni 10%, Tube end plates: Naval brass, Water box: Rilsan coated steel, Plate fins: Aluminium

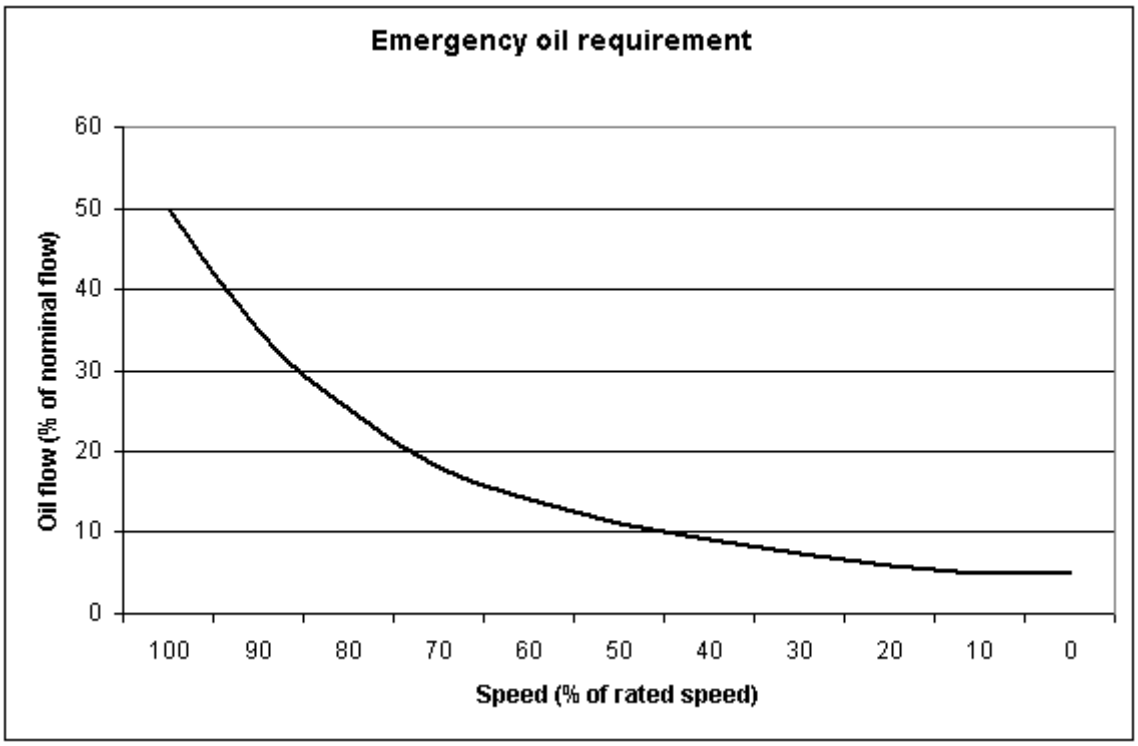
2.5 Shaft Extensions

- Flange diameter 548 mm
- Flanged shaft end with internal spigot in DE

2.6 Bearings

- Bearing size GL355
- Bearings prepared for jacking oil
- Complete bearing oil connection system to common point, stainless in- and outlet, ANSI
- Forced lubricated sleeve bearing.
- Oil connection at left side of machine seen from DE, location at DE.
- Oil inlet flange: ANSI 3/4" Cl 150
- Oil outlet flange: ANSI 3" Cl 150
- Orifice in fitting for reduction of oil pressure
- The lube oil drain pressure must be less than or equal to the machine ambient pressure. An oil drain pressure of 200-1000 Pa lower than the bearing ambient is recommended.

Bearings not equipped with oil ring



2.7 Main Terminal Boxes and Related Accessories

- Heaters in main terminal box, safe area, 480 V single phase supply
- Main terminal box located on the left side, seen from DE
- MainTerminal Box supply cable entry from below. Gland plate is removable, undrilled and of non magnetic material.
- Standard large air insulated Main Terminal Box

- The main terminal box is delivered as a loose item, assembly on site is not included in ABB's scope of supply.
- The main terminal box needs to be supported from beneath. Supports are not included in ABB's scope of supply.

2.7.1 Line side

- 3 Current Transformers, 3 cores, accuracy class C200 (ANSI)
- 3 Surge Arrestors
- 3 Voltage Transformers

2.7.2 Neutral side

- 3 Current Transformers, 3 core, accuracy class C200 (ANSI)
- Neutral Grounding Resistor NGR, 10 A, 10 sec.

2.8 Monitoring and Protection Accessories

RTD's according to IEC 60751, class B
- 1x RTD in warm machine air, duplex (Pt100), 3 wire, unshielded.
- 1x RTD per Bearing Shell, duplex (Pt100), 3 wire, unshielded
- 2x RTD in cold machine air, duplex (Pt100), 3 wire, unshielded (mounted at NDE + DE)
- 12x RTD's in stator windings, single (Pt100), 3 wire, unshielded, safe and hazardous area
- Heaters in both main machine and exciter, safe area, 480 VAC 1 phase supply. The heaters should always be connected during stand still to avoid condensation.
- Painted carbon steel junction boxes with glands. Located at right side of machine facing DE.
- Prepared for bonding
- Shaft earthing brush mounted at DE.
- Water leakage detector, float switch, Safe area.
- Vibration control, velocity type BN 330500 (3 probes(2oo3) in horizontal direction per bearing), safe area.

2.9 Special Design and Accessories

- Noise reduction -3 dB(A) acc. to ISO 3744
- Vibration level according to ABB standard (MDD 3AAM100425)

2.10 Painting and corrosion protection

- Standard gray colour (RAL 7032)
- Standard industrial coating acc. to ISO 12944 C3

2.11 Packing and Transportation

- Shrink film packing.

3. Position notes, Specification comments and Validation notes

4. Documentation

- Installation and maintenance manual in English language. (one covering all identical units)
- Standard documents for Machine according to MDD 3AAM100439
- User's manual on CD, (1 copies) (one covering all identical units)

5. Tests and Certificates

- Routine and Type test according to ABB standard procedure

5.1 Routine tests

- Air gap measurement, unwitnessed
- Bearing heat run, unwitnessed
- Dielectric test, unwitnessed
- Magnetic neutral pos., axial play in bearing and distance shaft-end to footplate, unwitnessed
- Measurement of insulation resistance before and after dielectric test, unwitnessed
- No-load characteristics, unwitnessed
- Overspeed test, unwitnessed
- Phase sequence and terminal marking, unwitnessed
- Resistance measurement, unwitnessed
- Settings list for machine protection, unwitnessed
- Short-circuit characteristics, unwitnessed
- Vibration measurement during retardation or acceleration, unwitnessed
- Vibration measurements, unwitnessed
- Visual inspection of complete machine, unwitnessed

5.2 Type tests

- Determination of efficiency at rated P.F. and 100, 75, 50 and 25% load, unwitnessed
- Determination of rated excitation current, unwitnessed
- Determination of reactance Xd, Xd', Xd" and time-constant Ta, Td', Td", unwitnessed (one covering all identical units)
- Determination of timeconstant (Td0'), unwitnessed (one covering all identical units)
- Heat run at P.F. = 0, unwitnessed (one covering all identical units)
- Sudden three -phase short-circuit test, unwitnessed (one covering all identical units)
- Waveform analys TIF, unwitnessed (one covering all identical units)

5.3 Special tests

- Adjustment of pressure reducing valve/orifice plate, unwitnessed
- Balancing of rotor complete, unwitnessed
- Control of leak water detector, unwitnessed
- Control of seismic vibration units, unwitnessed

- Dissipation factor (tan delta) measurement on complete winding, unwitnessed
- PMG, Output voltage and frequency, unwitnessed
- Radial bearing clearance, unwitnessed
- Shaft voltage measurement, unwitnessed
- Sound level measurement, unwitnessed (one covering all identical units)
- Test of main terminal box, unwitnessed
- Voltage and current balance, unwitnessed

5.4 Certificates

- Declaration of Incorporation for partly completed machinery
- Material check of blank for rotorbody
- Material check of blank to pole tips
- Pressure test of water cooler

A. Rated data

at cooling water temperature 35 °C/ 95 F		
Machine type		AMS 1250SE 4L BS
Output	kVA	35000
Power factor (overexcited)		0.85
Voltage	V (±5.0 %)	13800
Frequency	Hz (±2.0 %)	60
Speed	rpm	1800
Current	A	1464
Exciter type		GLB 600C
Excitation	V / A	103 / 7
Power factor (underexcited)		0.90
Output (underexcited)	kVA	33056
Active output (underexcited)	kW	29750
Current (underexcited)	A	1383
PMG ratings:		
- Voltage AC	V	166
- Power factor		0.6
- Current	A	8.9
- Frequency	Hz	300
- Poles		20
- Phases		3

B. Standards

Applicable standards		NEMA
Insulation class stator and exciter		F
Insulation class main rotor		H
Temperature rise, stator within class		B
Temperature rise, rotor within class		B
Increased safety, Standards/Form		

C. Other performance data

Guaranteed efficiency at P.F. 0.85 and		
100 / 75 / 50 / 25 % load	%	97.95 97.65 96.90 94.31
Guaranteed efficiency at P.F. 1.0 and		
100 / 75 / 50 / 25 % load	%	98.32 98.06 97.42 95.19
Reactances:		
- X_d	(±15) %	138.7
- X_d' unsat/sat	" %	22.5 / 19.3
- X_d'' unsat/sat	" %	14.2 / 12.1
- X_q unsat/sat	" %	67.2 / 62.9
- X_q'' unsat/sat	" %	21.4 / 18.2
- X_0	%	5.8
- X_2	%	14.2
- X_L	%	10.6
Time constants:		
- T_d'	s	0.951
- T_d''	s	0.023
- T_{d0}'	s	6.863
- T_{q0}''	s	0.109
- Ta	s	0.138
Sub-transient short circuit current Ik''	(±15) %	825.9
Generator inertia constant		

- H	s	1.56
Excitation main machine:		
- voltage no load	V	45
- voltage full load	V	94
- current no load	A	325
- current full load	A	675
Excitation exciter:		
- voltage no load	V	49
- voltage full load	V	103
- current no load	A	3
- current full load	A	7
Sudden short circuit current (peak)	kA	34
Short circuit ratio	%	77
Max. field forcing for 10 seconds	%	160
Sustained short circuit, stator current for 10 seconds at symmetrical conditions	%	256
Max. permissible overspeed (<2 min)	rpm	2160
Output with one cooler element out of service	%	70
Max. continuous negative sequence current	%	10
Fault condition capability $(I_2/I_N)^2t$	s	40
Voltage regulation acc. to IEEE 100, seventh edition		
- Regulation = (Et - E) / E	%	138
Overcurrent capability $(I^2 - 1)$ t	s	37.5
this relationship shall apply for values of t between	s	10 - 60

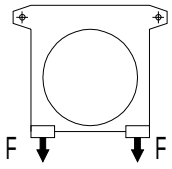
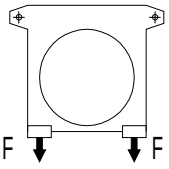
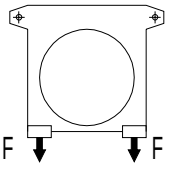
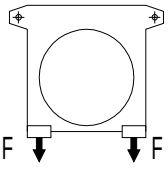
D. Site conditions

Ambient temperature range	°C	0 - 40	F	32 - 104
Altitude	m a.s.l.	1000	ft.a.s.l.	3281
Water temperature range	°C	10 - 35	F	50 - 95
Hazardous area classification		Non hazardous area		
Seismic zone		Acc. to UBC, Zone 4		

F. Installation data

Protection form/cooling form		IP54 TEWAC		
Cooler location/No of coolers		Top / 2+2 vertical cooler elements, air in series		
Water cooling:				
- Required cooling water flow	m³/h	61.1	gpm	268.9
- Ethylen glycol	%	40.0		
- Cooling water temperature (rated)	°C	35	F	95
- Temperature rise cooling water	K	8.6	F	15.6
- Pressure drop cooling water	kPa	31	psi	5
- Fouling factor	m² °C/W	0.000090	hr-ft2-°F/Btu	0.000511
Heat losses:				
- Cooling water	kW	549		
- Lubrication oil at 65 °C	kW	26.8		
Arrangement form		IM 1005		
Shaft end according to drawing				

Sleeve bearings:					
- Max. permissible axial play towards D-end	mm	15.0	in.	0.591	
- Max. permissible axial play towards N-end	mm	15.0	in.	0.591	
- Max. permissible axial thrust	kN	0	lbf	0	
- Min. barring speed	rpm	45			
- Min. barring speed with jacking oil activated	rpm	0			
- Rotor break away torque	Nm	8335			
- Rotor break away torque with jacking activated	Nm	67			
- Required oil flow to bearings (Total)	l/min	60	gpm	15.8	
- Oil temperature range to bearings	°C	40 - 65	F	104 - 149	
- Required oil pressure at 65 °C	kPa	200	psi	29	
- Supply oil pressure		To be advised by customer*)			
*)For setting of pressure reduction valve/orifice					
Default oil pressure*)	kPa	240	psi	34.8	
*)Used if no value received from customer before FAT					
- Max supply oil pressure	kPa	500	psi	72.5	
- Type of oil		ISO VG 46			
- Degree of purity for oil		17/15/12 acc. to ISO 4406:1999			
Weights (estimated):					
- Total (complete machine, excluding terminal box)	kg	56300	lb	124100	
- Stator	kg	25000	lb	55200	
- Rotor	kg	19200	lb	42300	
Rotor inertia ($J=m*r_m^2$)	kgm²	3072	lb-ft²	72890	
First bending lateral critical speed	rpm	>2070			
Direction of rotation (at drive end, facing shaft end)		Counter-clockwise			
Noise level (at 1m, rated speed and no load acc.to ISO 3744)	dB(A)	85 dB(A)			

Forces on the foundation per stator side			
Static	Rated torque	2-phase short circuit	3-phase short circuit
			
F = 275.9 kN F = 62027 lbf	F = 275.9 kN ± 61.9 kN F = 62027 lbf ± 13919 lbf	F = 275.9 kN ± 700.9 kN F = 62027 lbf ± 157568 lbf	F = 275.9 kN ± 658.1 kN F = 62027 lbf ± 147953 lbf
Forces on each inner foot (2 inner feet/side)*)			
F = 69 kN F = 15507 lbf	F = 69 kN ± 31 kN F = 15507 lbf ± 6959 lbf	F = 69 kN ± 350.4 kN F = 15507 lbf ± 78784 lbf	F = 69 kN ± 329.1 kN F = 15507 lbf ± 73976 lbf
Forces on each outer foot (2 outer feet/side)*)			

F = 69 kN F = 15507 lbf	F = 69 kN F = 15507 lbf	F = 69 kN F = 15507 lbf	F = 69 kN F = 15507 lbf
*)The foundation shall be dimensioned to withstand the maximum force at all feet positions.			

Airgap torque equation - 3-phase short circuit

$T_e(t) = M_0\, e^{-t/t_0} \sin wt + M_1\, e^{-t/t_1}$

$M_0 = 9.21$; $M_1 = 1.86$; $t_0 = 0.103$ s ; $t_1 = 0.0947$ s ; $w = 377$ rad/s

Maximum value of torque 10.6 * T_N, when t = 4.08 ms

Airgap torque equation - 2-phase short circuit

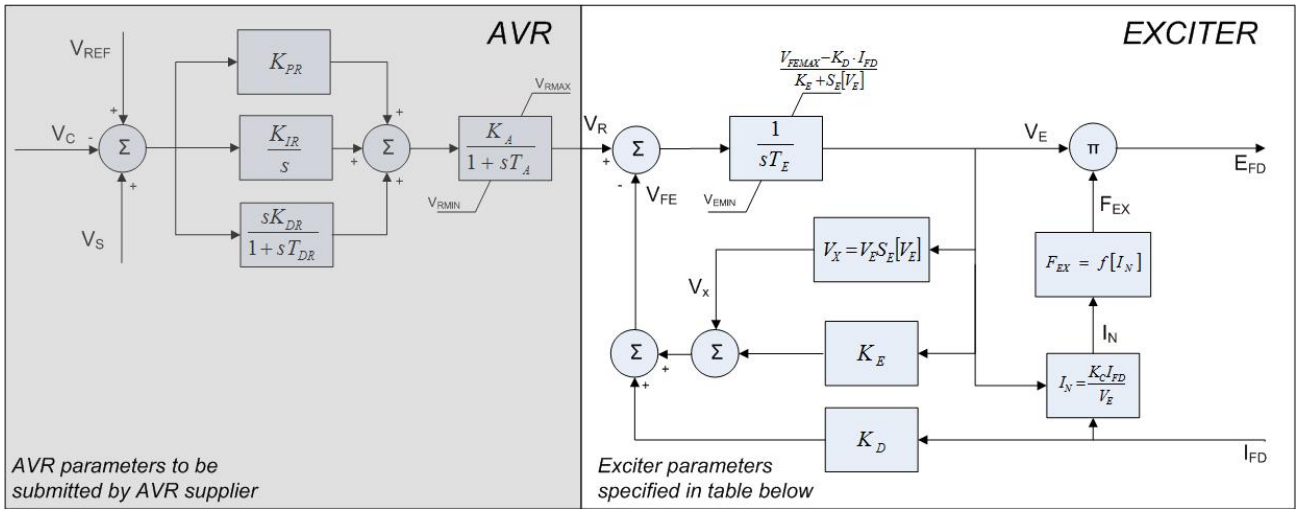
$T_e(t) = M_0\, e^{-t/t_0} \sin wt - M_1\, e^{-t/t_1} \sin 2wt + M_2\, e^{-t/t_2}$

$M_0 = 7.45$; $M_1 = 3.74$; $M_2 = 1.91$; $t_0 = 0.166$ s ; $t_1 = 0.53$ s ; $t_2 = 0.29$; $w = 377$ rad/s

Maximum value of torque 11.3 * T_N, when t = 5.55 ms

Rated torque $T_N = 161$ kNm

TRANSFER FUNCTION FOR BRUSHLESS AC EXCITER MACHINE WITH RECTIFICATION (IEEE STD. 421.5)
Excitation system for synchronous machine type: AMS 1250SE 4L BS
Exciter: GLB 600C



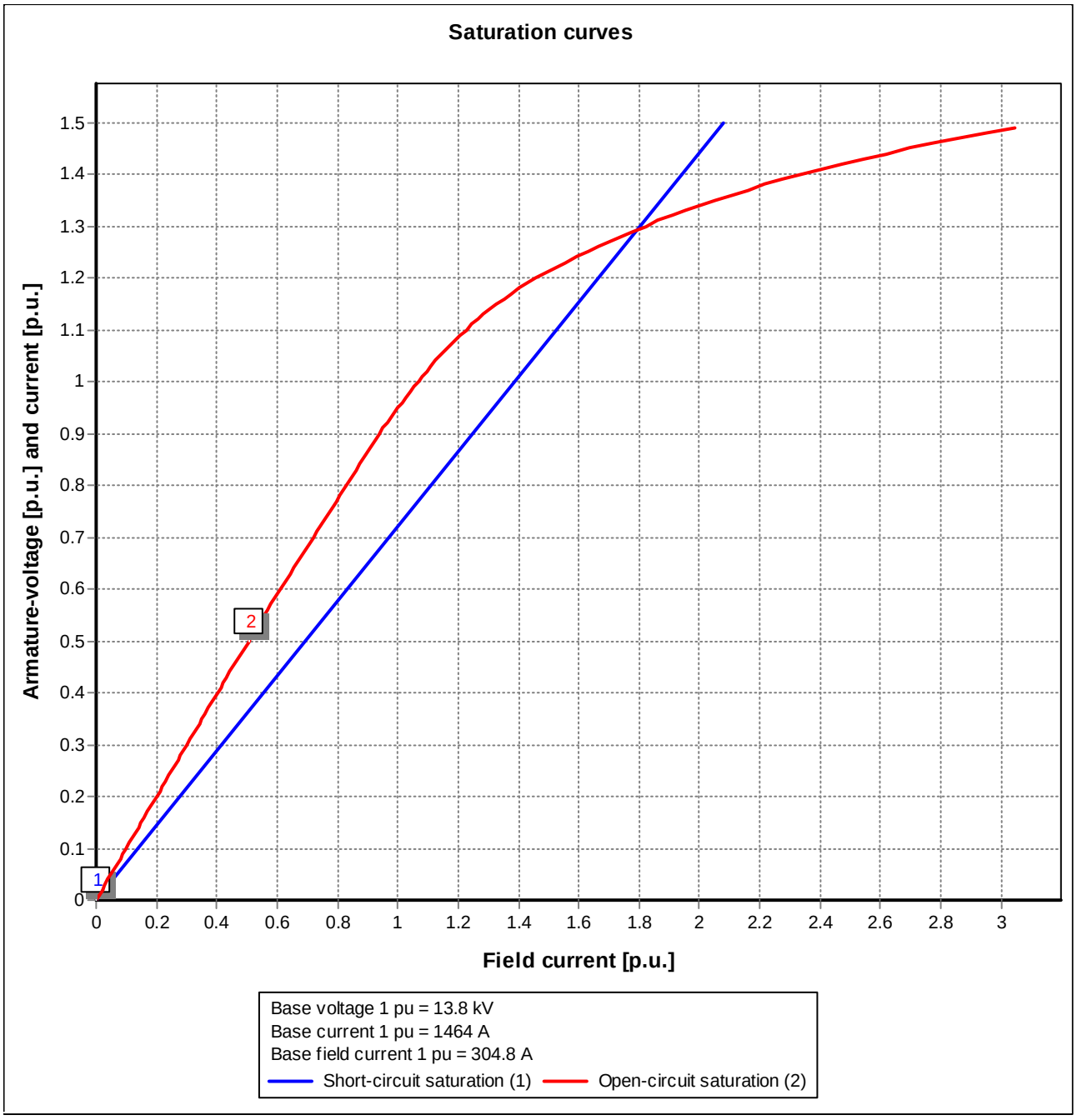
IEEE Std. 421.5 Type AC excitation system model. The illustrated model is Type AC8B.

The table below provides a computer representation of the brushless AC exciter with rectification in accordance with IEEE Std. 421.5.
Note that the AC exciter with rectification only constitutes one part of a complete AC excitation system model, as shown in the figure above.

IEEE 421.5 Type AC Model Parameter	Unit	Value
K_C		0.93
K_D		0.39
K_E		1.00
T_E	s	0.275
SE (VE1 = 5.6 p.u.)		0.0220
SE (VE2 = 3.5 p.u.)		0.0219
VEMIN	p.u.	0
VFEMAX	p.u.	19.21
Exciter Machine Base Values		
VRBASE	V	23.09
EFDBASE	V	42.44
IFDBASE	A	304.80

Note
The function $F_{EX} = f(I_N)$ describes the rectifier voltage drop due to commutation and phase retard. For the definition of $f(I_N)$, refer to IEEE Std. 421.5-2005, annex D.

Generator type code: AMS 1250SE 4L BS



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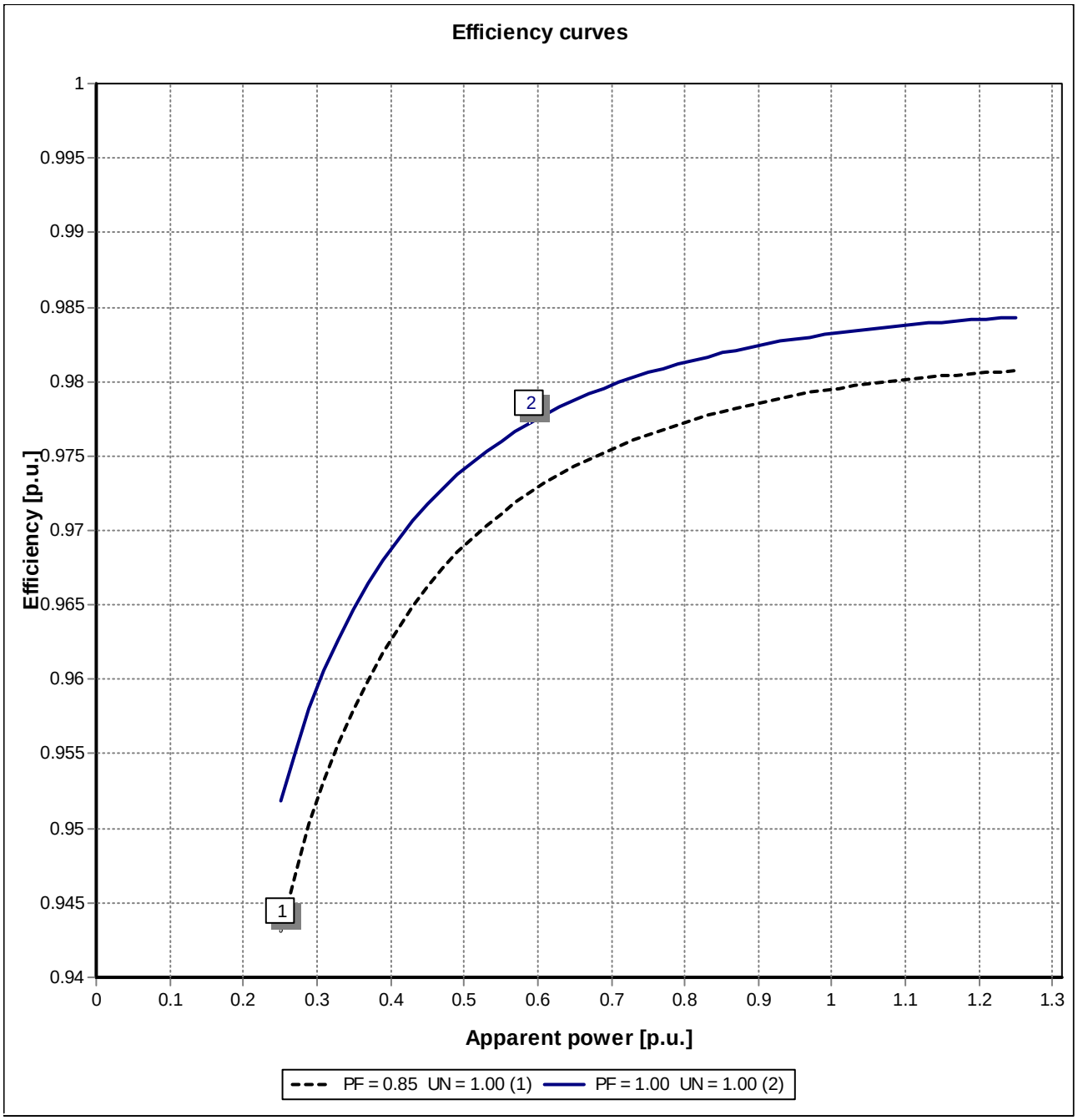

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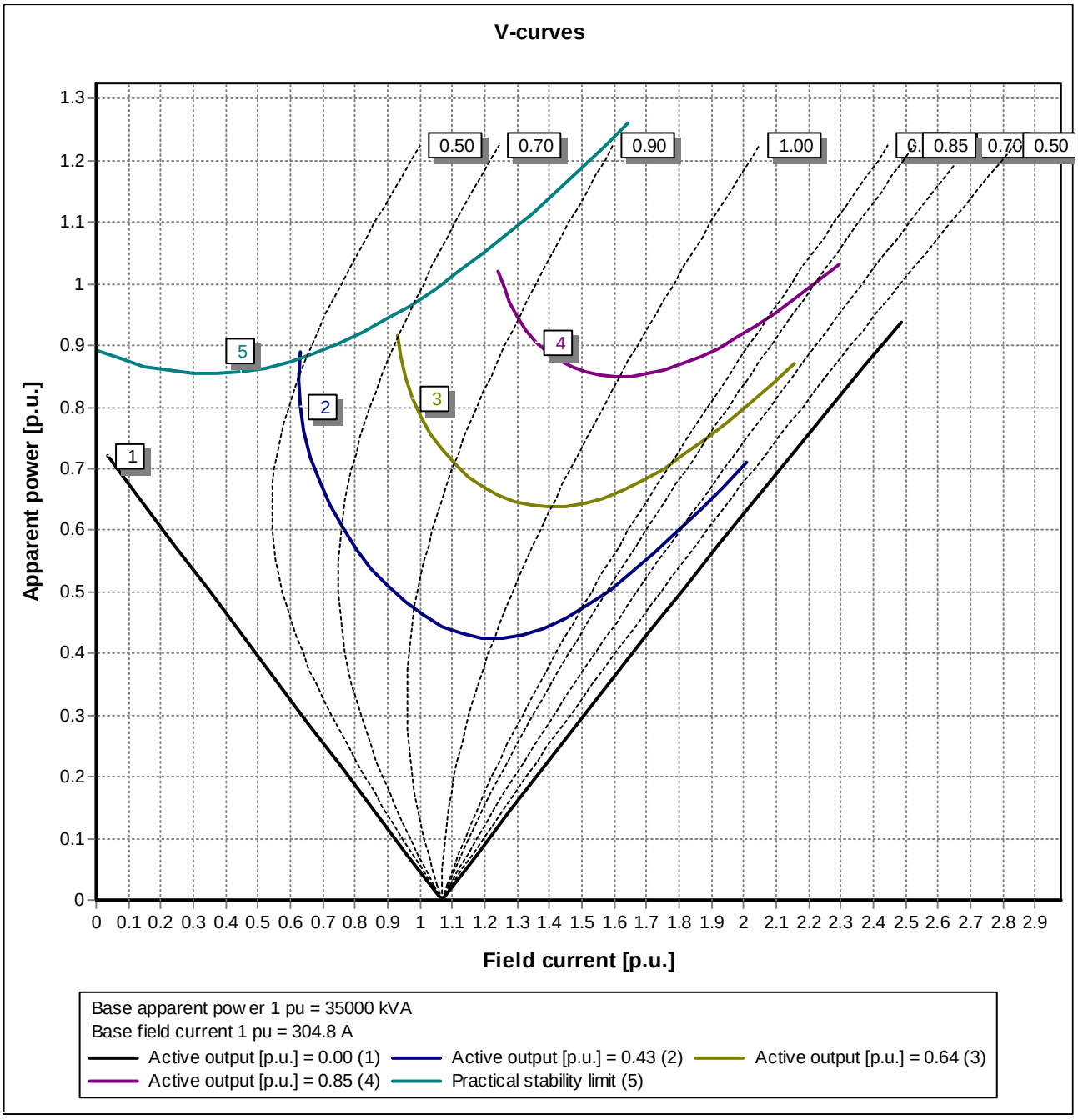

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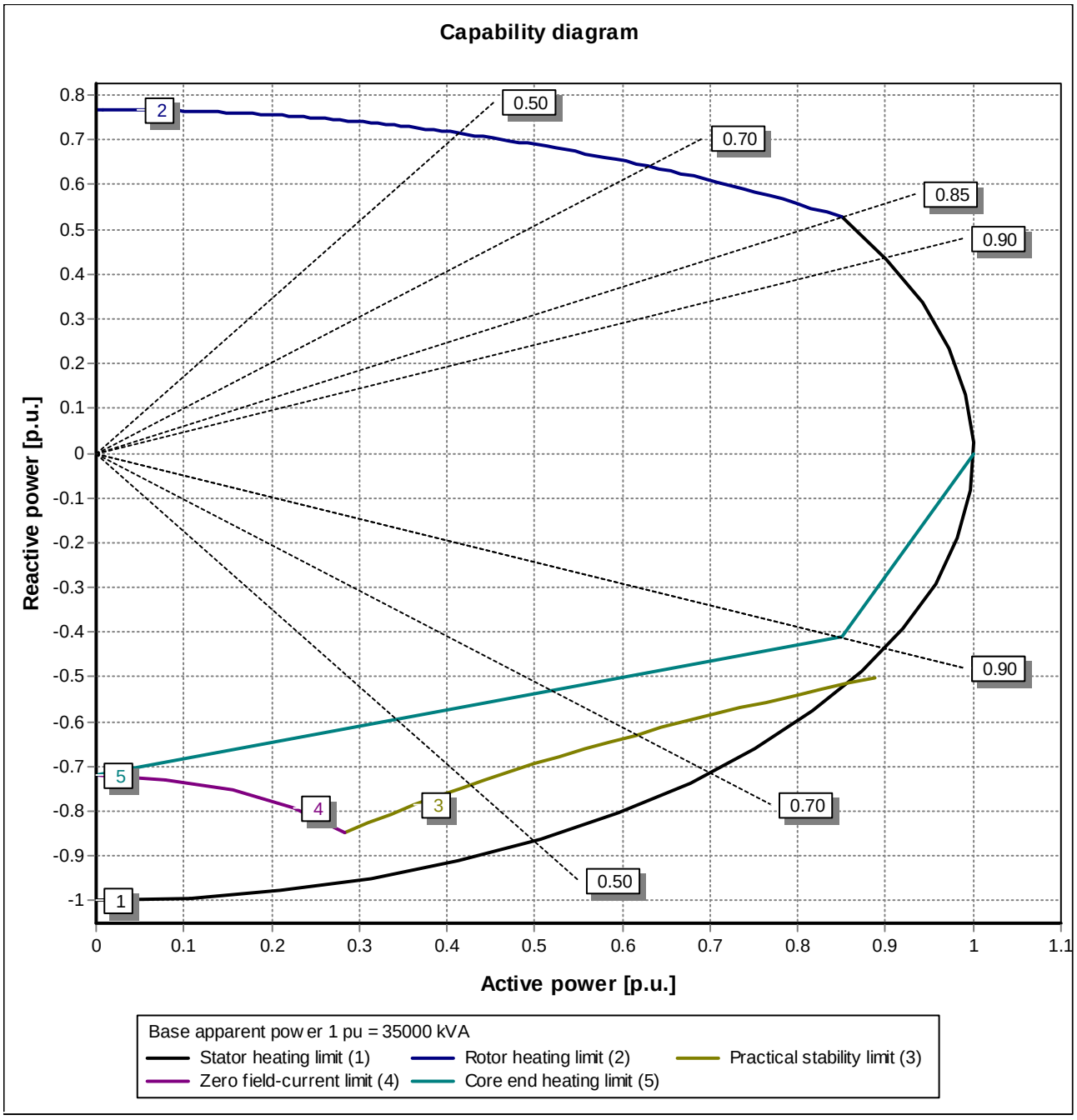

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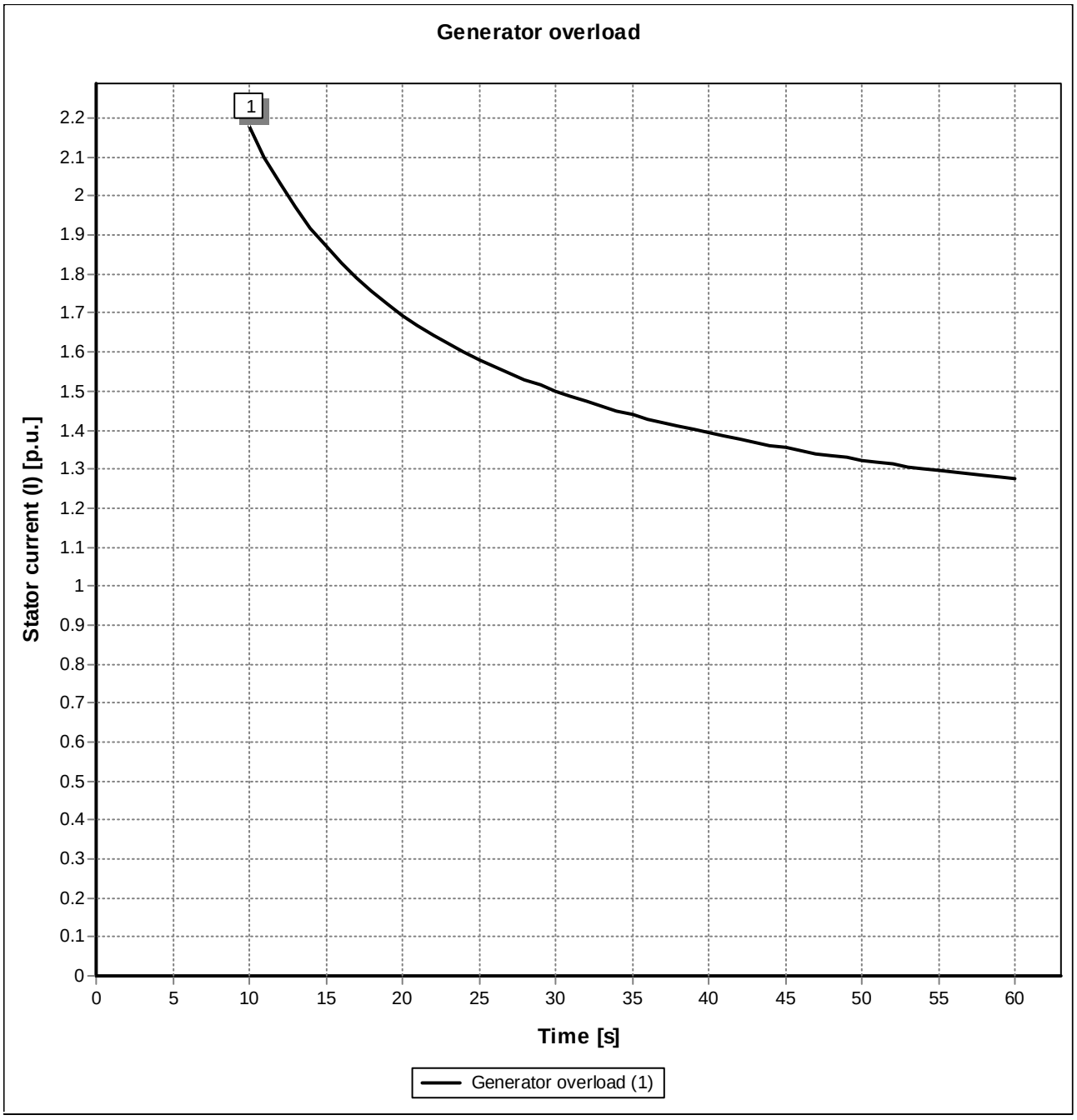
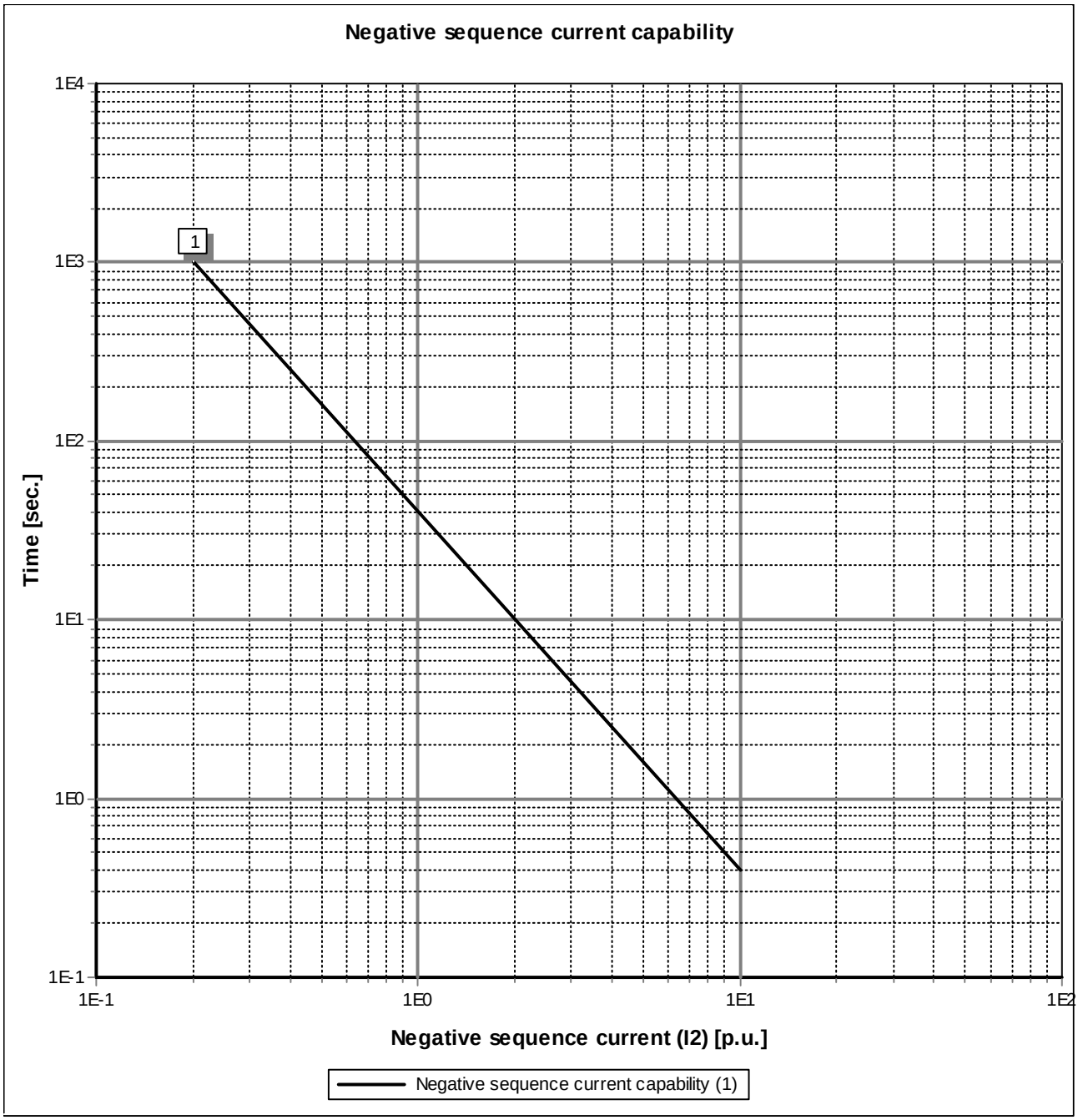
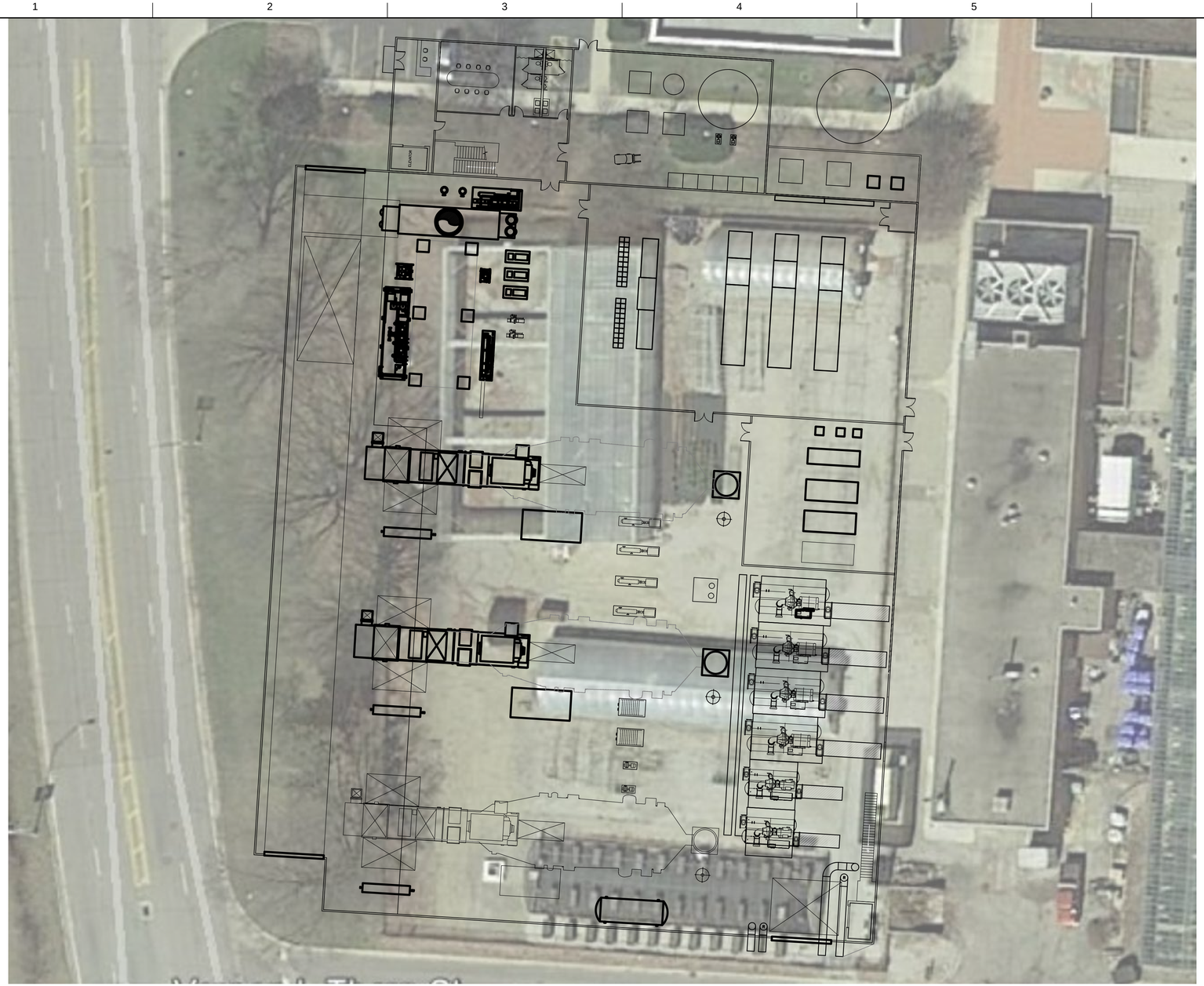


Generator type code: AMS 1250SE 4L BS



A

Site Layout



N

PLAN

SCALE: 1" = 20'-0"

20' 10' 0 20' 40' 60'

ISSUE	DATE	DESCRIPTION	DRAWN	ENGINEER	CHECKED	APPROVED
C	09/10/2018	FOR REVIEW	J_B	JPK	AWS	
B	08/30/2018	FOR REVIEW	J_B	JPK	AWS	
A	08/03/2018	FOR REVIEW	J_B	JPK	AWS	

NOT FOR CONSTRUCTION

OHIO STATE ENERGY PARTNERS

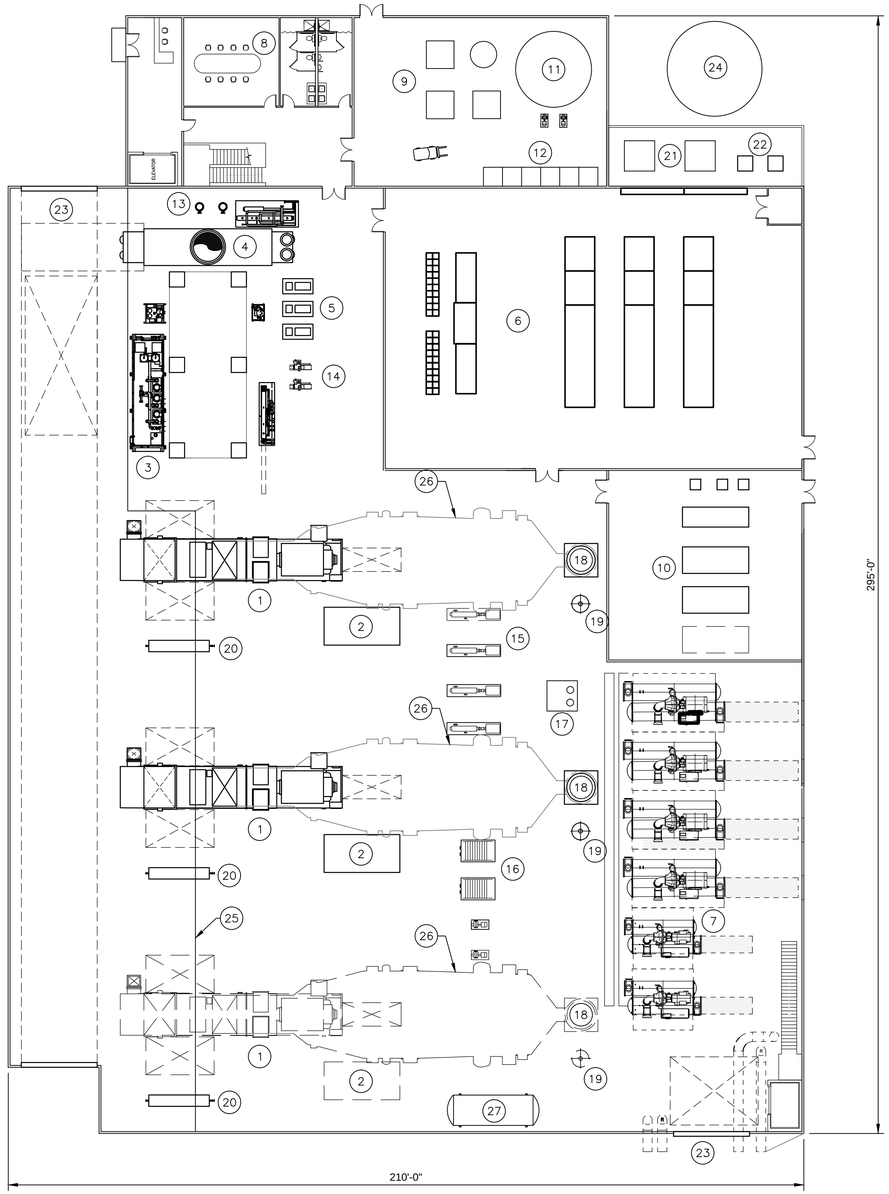
OHIO STATE ENERGY PARTNERS
CHP / DHC PLANT
3x1 OPTION
CONCEPTUAL SITE PLAN

FILENAME 10125564-OGA-C101.dwg

SCALE 1"=20'-0"

SHEET **10125564-0GA-C201**

9/10/2018 2:54:44 PM, jbrzys



FACILITY LEGEND

1. CTG
2. CTG - ELECTRICAL / CONTROL ENCLOSURE
3. STG - LUBE OIL AND EHC SKID
4. CONDENSER
5. CW PUMPS
6. ELECTRICAL AND I&C ROOM
7. CHILLERS
8. ADMINISTRATION AND BREAK ROOM
9. WATER TREATMENT
10. GAS TREATMENT AND COMPRESSORS
11. DEMIN TANK
12. CHEMICAL STORAGE TOTES
13. CONDENSATE PUMPS
14. VACUUM PUMPS
15. FEEDWATER PUMPS
16. CCCW PUMPS AND HEAT EXCHANGERS
17. HRSG SUMP
18. HRSG STACK SUPPORT
19. HRSG BLOWDOWN TANK
20. CTG - FIRE SUPPRESSION SKID
21. 4160V TRANSFORMERS
22. 480V TRANSFORMER
23. OVERHEAD DOOR (MAJOR EQUIPMENT TRUCK ACCESS)
24. SERVICE WATER TANK
25. EDGE OF OPEN SPACE (NO 2ND FLOOR ABOVE / ACCESS AREA)
26. OUTLINE OF HRSG (ABOVE) (FOR REFERENCE)
27. UREA STORAGE

NOTES

1. TOTAL BUILDING SIZE IS APPROXIMATELY 62,000 SQ. FT.
2. THIRD CT/HRSG IS FUTURE AND SHOWN FOR REFERENCE.

N

PLAN – 1st FLOOR

SCALE: 1" = 20'-0"

20' 10' 0 20' 40' 60'

ISSUE	DATE	DESCRIPTION	DRAWN	ENGINEER	CHECKED	APPROVED
C	09/10/2018	FOR REVIEW	J_B	JPK	AWS	
B	08/30/2018	FOR REVIEW	J_B	JPK	AWS	
A	08/03/2018	FOR REVIEW	J_B	JPK	AWS	

NOT FOR CONSTRUCTION

OHIO STATE ENERGY PARTNERS

OHIO STATE ENERGY PARTNERS
CHP / DHC PLANT
3x1 OPTION
CONCEPTUAL BUILDING PLAN - 1st FLOOR

FILENAME	10125564-OGA-M101.dwg
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SHEET

10125564-0GA-M201

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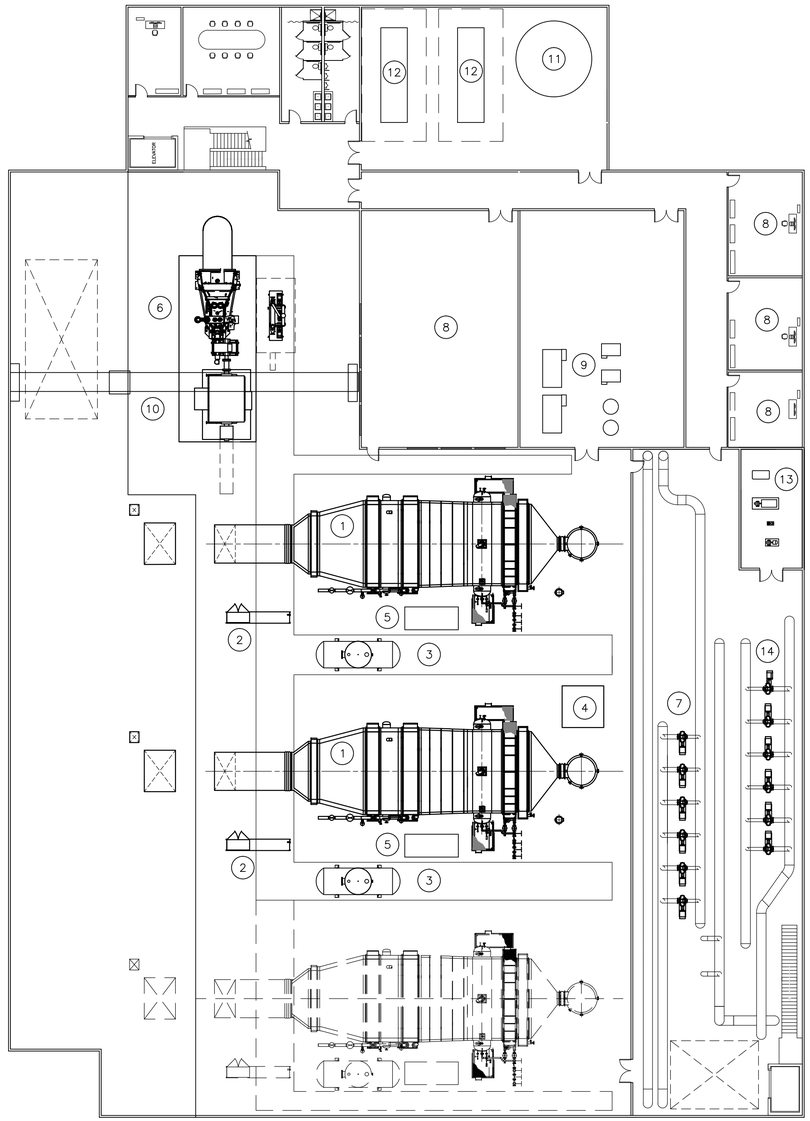

FACILITY LEGEND

1. HRSG
2. HRSG - FUEL GAS SKID
3. DEAERATOR
4. CEMS
5. AMMONIA INJECTION SKID
6. STG
7. HOT WATER PUMPS
8. CONTROL ROOM / OFFICES
9. COMPRESSED AIR EQUIPMENT / STORAGE
10. OVERHEAD CRANE
11. DEMIN TANK
12. RO SKIDS
13. FIRE PUMP ROOM
14. CHILLED WATER PUMPS

NOTES

1. TOTAL BUILDING SIZE IS APPROXIMATELY 90,000 SQ. FT.
2. THIRD CT/HRSG IS FUTURE AND SHOWN FOR REFERENCE.

N

PLAN – 2nd FLOOR

SCALE: 1" = 20'-0"

20' 10' 0 20' 40' 60'

ISSUE	DATE	DESCRIPTION	DRAWN	ENGINEER	CHECKED	APPROVED
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B	08/30/2018	FOR REVIEW	J_B	JPK	AWS	
A	08/03/2018	FOR REVIEW	J_B	JPK	AWS	

NOT FOR CONSTRUCTION

OHIO STATE ENERGY PARTNERS

OHIO STATE ENERGY PARTNERS
CHP / DHC PLANT
3x1 OPTION
CONCEPTUAL BUILDING PLAN - 2nd FLOOR

FILENAME 10125564-0GA-M101.dwg
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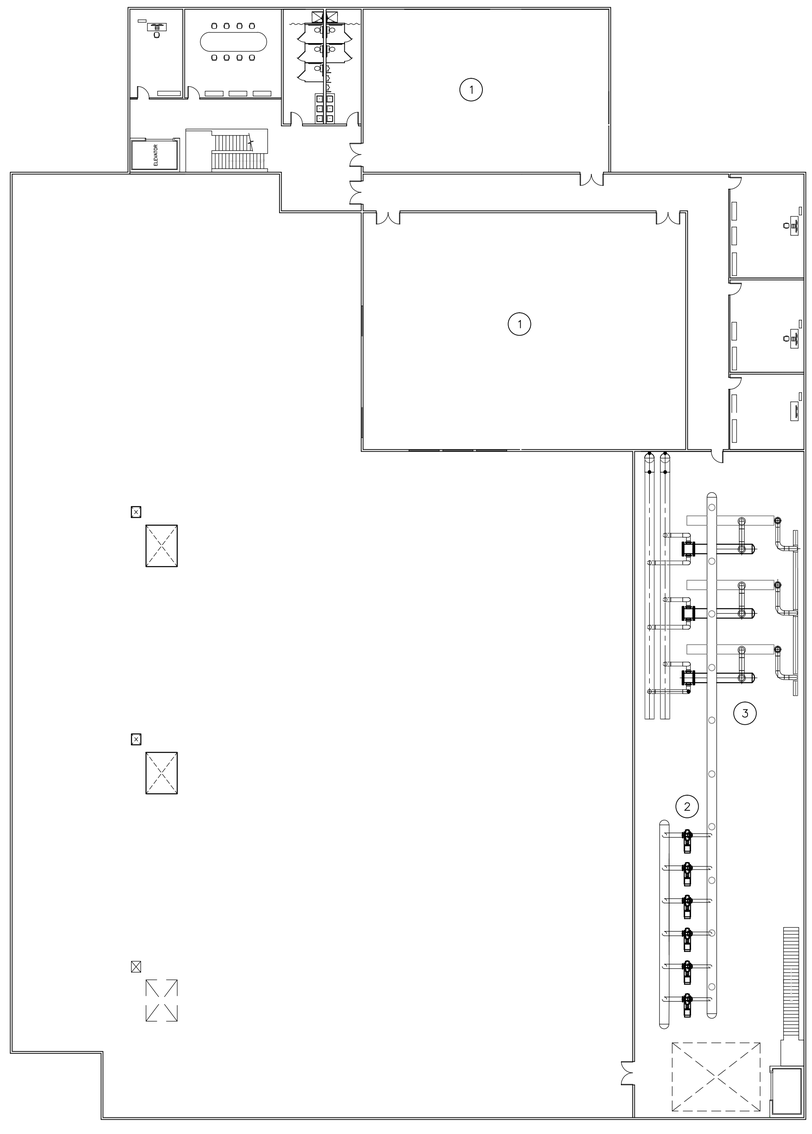

FACILITY LEGEND

1. STORAGE
2. CONDENSER WATER PUMPS
3. STEAM TO HOT WATER HEAT EXCHANGERS

NOTES

1. TOTAL BUILDING SIZE IS APPROXIMATELY 62,000 SQ. FT.
2. THIRD CT/ HRSG IS FUTURE AND SHOWN FOR REFERENCE.

N

PLAN – 3rd FLOOR

SCALE: 1" = 20'-0"

20' 10' 0 20' 40' 60'

ISSUE	DATE	DESCRIPTION	DRAWN	ENGINEER	CHECKED	APPROVED
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B	08/30/2018	FOR REVIEW	J_B	JPK	AWS	
A	08/03/2018	FOR REVIEW	J_B	JPK	AWS	

NOT FOR CONSTRUCTION

OHIO STATE ENERGY PARTNERS

OHIO STATE ENERGY PARTNERS
CHP / DHC PLANT
3x1 OPTION
CONCEPTUAL BUILDING PLAN - 3rd FLOOR

FILENAME	10125564_OGA_M101.dwg
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SHEET
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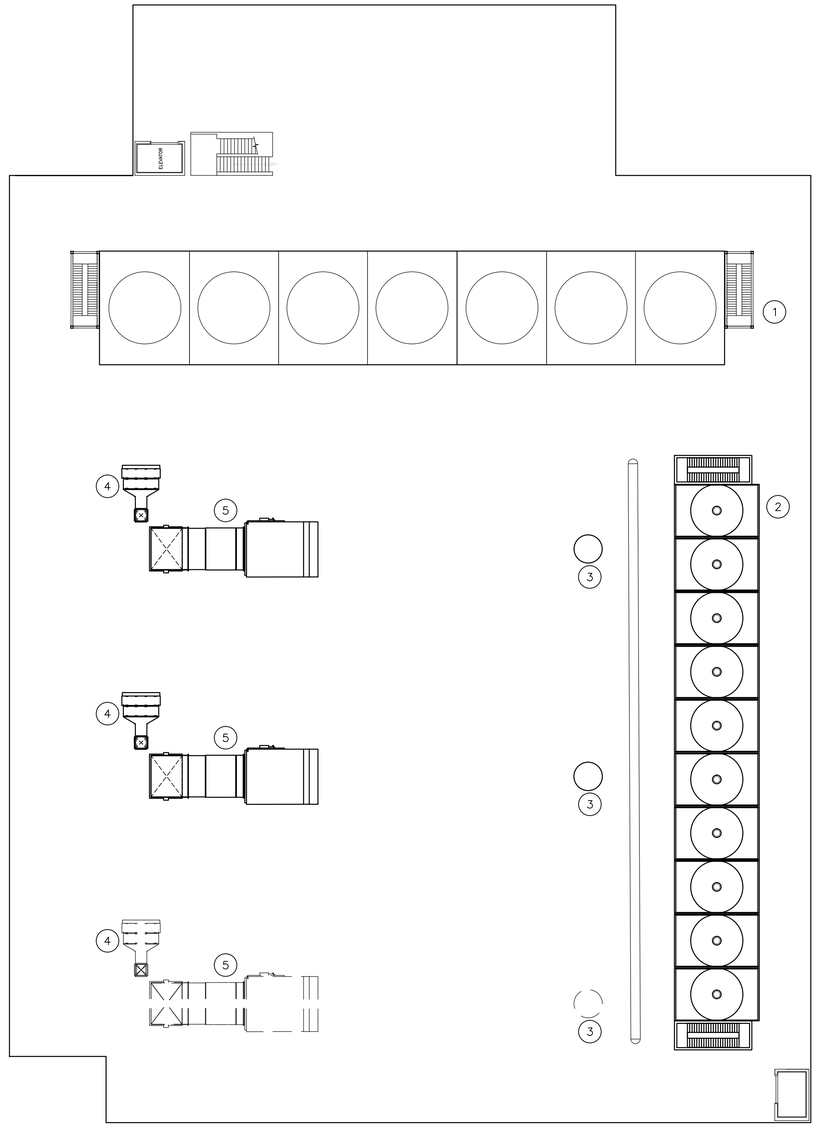
9/10/2018 2:52:25 PM, jbrzyk



FACILITY LEGEND

1. STG COOLING TOWER
2. DHC COOLING TOWER
3. HRSG EXHAUST STACK
4. CTG INLET AIR (MOUNTED BELOW ROOF LEVEL)
5. CTG VENTILATION AIR (MOUNTED BELOW ROOF LEVEL)

NOTES

1. TOTAL BUILDING SIZE IS APPROXIMATELY 62,000 SQ. FT.
2. THIRD CT/ HRSG IS FUTURE AND SHOWN FOR REFERENCE.

N

PLAN – ROOF

SCALE: 1" = 20'-0"

20' 10' 0 20' 40' 60'

ISSUE	DATE	DESCRIPTION	DRAWN	ENGINEER	CHECKED	APPROVED
C	09/10/2018	FOR REVIEW	J_B	JPK	AWS	
B	08/30/2018	FOR REVIEW	J_B	JPK	AWS	
A	08/03/2018	FOR REVIEW	J_B	JPK	AWS	

NOT FOR CONSTRUCTION

OHIO STATE ENERGY PARTNERS

OHIO STATE ENERGY PARTNERS
CHP / DHC PLANT
3x1 OPTION
CONCEPTUAL BUILDING PLAN - ROOF

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10125564-0GA-M204

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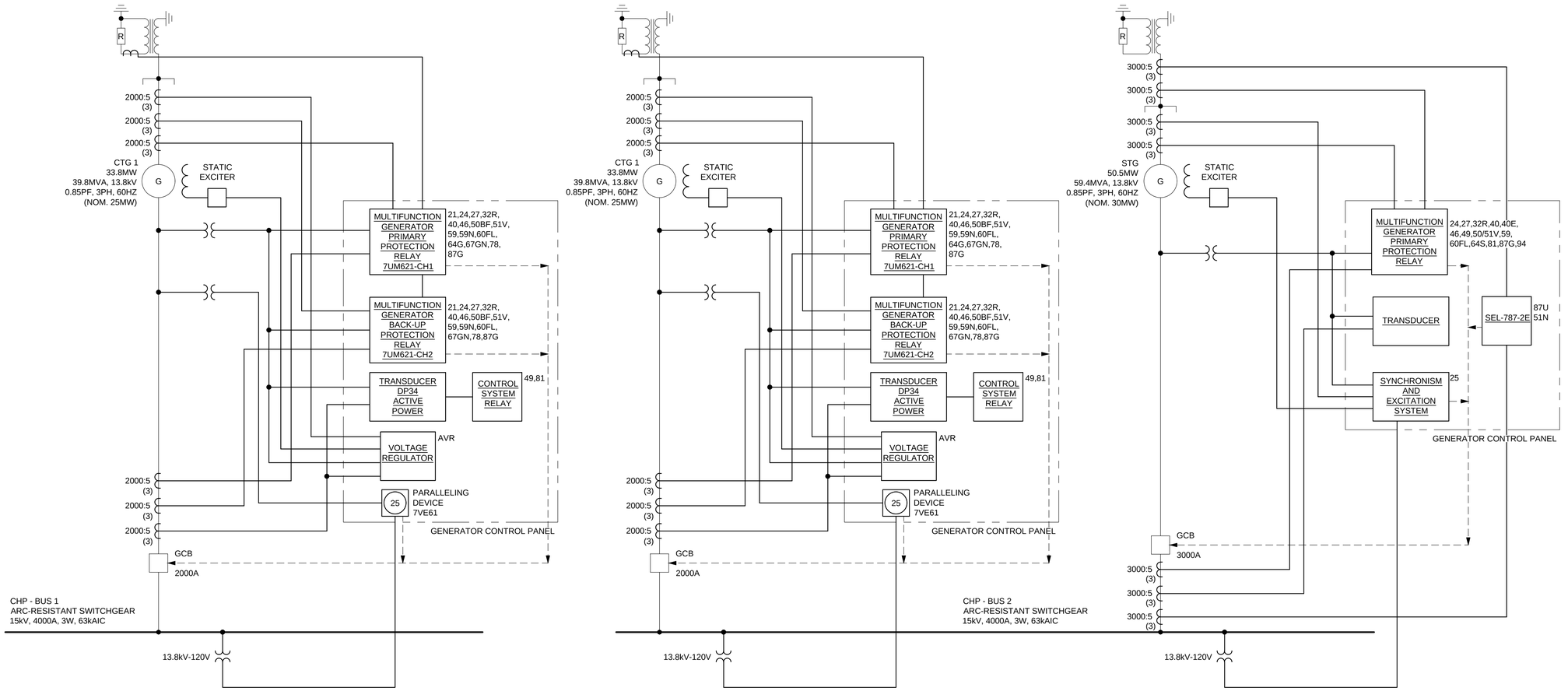

LEGEND:

* - PROPOSED SEL-787-2E OR EQUIVALENT AS BACK-UP PROTECTION FOR STG.

ISSUE	DATE	DESCRIPTION	DRAWN	ENGINEER	CHECKED	APPROVED
A	06/03/2019	FOR CLIENT REVIEW	REB	SAS	JBP	

NOT FOR CONSTRUCTION

CHP / DMC PLANT

GENERATOR PROTECTION ONE-LINE DIAGRAM

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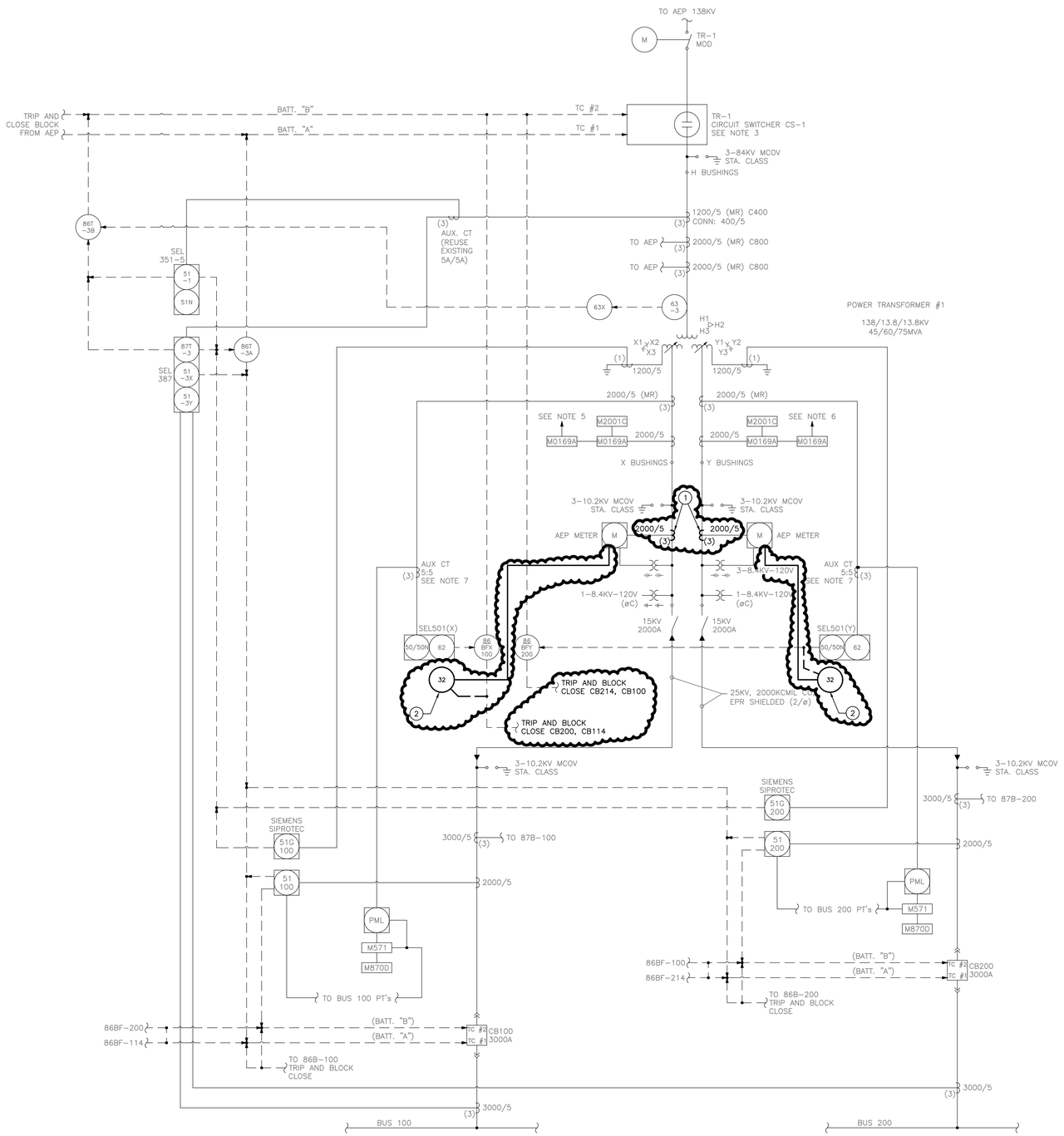

LEGEND

- SURGE ARRESTER
- HOOK STICK OPERATED SWITCH
- M — MOTOR OPERATOR
- TC #2 / TC #1 — CIRCUIT BREAKER WITH DUAL TRIP COILS
- VOLTAGE (POTENTIAL) TRANSFORMER (VT)
- CURRENT TRANSFORMER
- SF6 CIRCUIT SWITCHER
- M — METER
- PML — ION PML METER (IN SWITCHGEAR)
- M2001C — BECKWITH LTC CONTROL (IN LTC PANEL)
- M0169A — BECKWITH AUX CT (IN LTC PANEL)
- M571 — BITRONICS M571 TRANSDUCER (IN SWITCHGEAR, SHIPPED LOOSE BY PANEL VENDOR FOR INSTALLATION BY CONTRACTOR)
- M870D — BITRONICS M870D REMOTE DISPLAY (IN LTC PANEL)
- POWER CONDUCTOR/BUS
- — — — RELAYING AND CONTROL

NOTES

1. SEE SPECIFICATIONS FOR PROTECTION, CONTROL, AND INSTRUMENTATION EQUIPMENT TO BE FURNISHED BY OSU.
2. TEST SWITCHES NOT SHOWN FOR CLARITY.
3. INTERLOCK THE CIRCUIT SWITCHER (CS-3), CB314 AND CB114 TO OPEN CB314 AND CB114 IF CS-3 IS OPEN AND BLOCK THE CLOSURE OF CB314 AND CB114 OF CS-3 IS OPEN. INTERLOCK THE MOTOR OPERATED SWITCH TO BLOCK OPENING OF SWITCH UNLESS CS-3 IS OPEN AND BLOCK THE CLOSURE OF SWITCH UNLESS CS-3 IS OPEN.
4. NOT USED
5. THIS CURRENT CIRCUIT PROVIDES THE CIRCULATING CURRENT TO M2001C ON TR 2X(NORMAL) OR TR 1Y(SUSTAINED ALTERNATE) DEPENDING ON BREAKER STATUS.
6. THIS CURRENT CIRCUIT PROVIDES THE CIRCULATING CURRENT FROM M2001C ON TR 1X(NORMAL) OR TR 2Y(SUSTAINED ALTERNATE) DEPENDING ON BREAKER STATUS.
7. AUXILIARY CT's SHALL BE FURNISHED, INSTALLED, AND WIRED BY INSTALLATION CONTRACTOR. MOUNTING PROVISIONS IN RELAY PANELS SHALL BE PROVIDED BY INSTALLATION CONTRACTOR.

RELAY POWER SUPPLY/COIL SOURCES

SEL 351 – BATTERY "B"
SEL 387 – BATTERY "A"
SEL 501XY – BATTERY "B"
SIEMENS SIPROTEC 51G-114/314 – BATTERY "A"
SIEMENS SIPROTEC 51-114/314 – BATTERY "B"
86BFX314 COIL – BATTERY "B"
86BFY114 COIL – BATTERY "B"
86T-3A COIL – BATTERY "A"
86T-3B COIL – BATTERY "B"

REVISION NOTES:

1. REPLACE WITH DIRECTIONAL CT's.
2. REVERSE POWER PROTECTION RELAY, MODEL NUMBER .... TBD.

NOTE:

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ISSUE	DATE	DESCRIPTION	DRAWN	ENGINEER	CHECKED	APPROVED
A	06/03/2019	FOR CLIENT REVIEW	REB	SAS	JBP	

NOT FOR CONSTRUCTION

CHP / DMC PLANT
OSU SUBSTATION
TRANSFORMER #1
RELAYING SINGLE DIAGRAM

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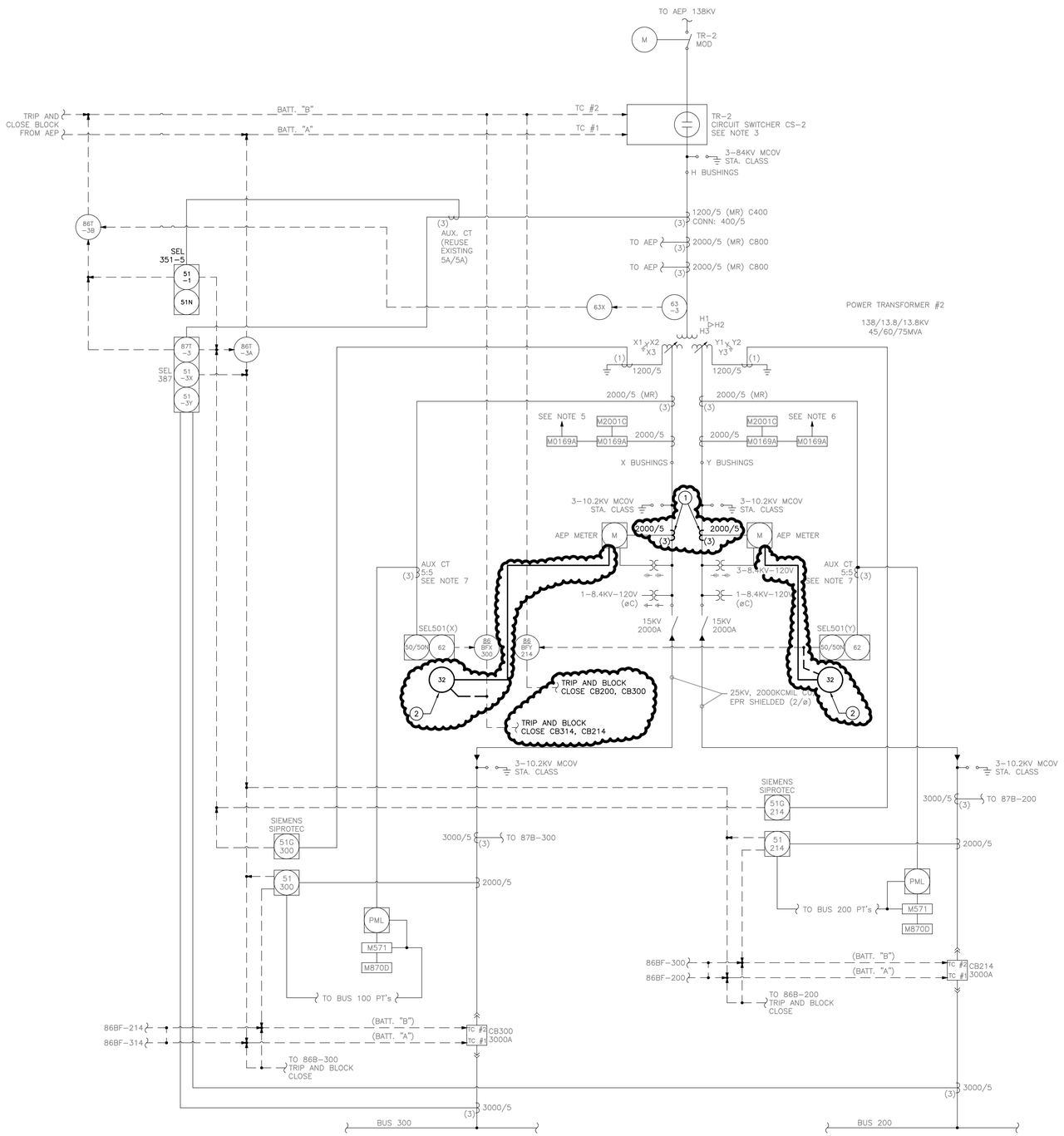

LEGEND

- SURGE ARRESTER
- HOOK STICK OPERATED SWITCH
- M — MOTOR OPERATOR
- TC #2 / TC #1 — CIRCUIT BREAKER WITH DUAL TRIP COILS
- VOLTAGE (POTENTIAL) TRANSFORMER (VT)
- CURRENT TRANSFORMER
- SF6 CIRCUIT SWITCHER
- M — METER
- PML — ION PML METER (IN SWITCHGEAR)
- M2001C — BECKWITH LTC CONTROL (IN LTC PANEL)
- M0169A — BECKWITH AUX CT (IN LTC PANEL)
- M571 — BITRONICS M571 TRANSDUCER (IN SWITCHGEAR, SHIPPED LOOSE BY PANEL VENDOR FOR INSTALLATION BY CONTRACTOR)
- M870D — BITRONICS M870D REMOTE DISPLAY (IN LTC PANEL)
- POWER CONDUCTOR/BUS
- — — — RELAYING AND CONTROL

NOTES

1. SEE SPECIFICATIONS FOR PROTECTION, CONTROL, AND INSTRUMENTATION EQUIPMENT TO BE FURNISHED BY OSU.
2. TEST SWITCHES NOT SHOWN FOR CLARITY.
3. INTERLOCK THE CIRCUIT SWITCHER (CS-3), CB314 AND CB114 TO OPEN CB314 AND CB114 IF CS-3 IS OPEN AND BLOCK THE CLOSURE OF CB314 AND CB114 OF CS-3 IS OPEN. INTERLOCK THE MOTOR OPERATED SWITCH TO BLOCK OPENING OF SWITCH UNLESS CS-3 IS OPEN AND BLOCK THE CLOSURE OF SWITCH UNLESS CS-3 IS OPEN.
4. NOT USED
5. THIS CURRENT CIRCUIT PROVIDES THE CIRCULATING CURRENT TO M2001C ON TR 2X(NORMAL) OR TR 1Y(SUSTAINED ALTERNATE) DEPENDING ON BREAKER STATUS.
6. THIS CURRENT CIRCUIT PROVIDES THE CIRCULATING CURRENT FROM M2001C ON TR 1X(NORMAL) OR TR 2Y(SUSTAINED ALTERNATE) DEPENDING ON BREAKER STATUS.
7. AUXILIARY CT's SHALL BE FURNISHED, INSTALLED, AND WIRED BY INSTALLATION CONTRACTOR. MOUNTING PROVISIONS IN RELAY PANELS SHALL BE PROVIDED BY INSTALLATION CONTRACTOR.

RELAY POWER SUPPLY/COIL SOURCES

SEL 351 – BATTERY "B"
SEL 387 – BATTERY "A"
SEL 501XY – BATTERY "B"
SIEMENS SIPROTEC 51G-114/314 – BATTERY "A"
SIEMENS SIPROTEC 51-114/314 – BATTERY "B"
86BFX314 COIL – BATTERY "B"
86BFY114 COIL – BATTERY "B"
86T-3A COIL – BATTERY "A"
86T-3B COIL – BATTERY "B"

REVISION NOTES:

1. REPLACE WITH DIRECTIONAL CT's.
2. REVERSE POWER PROTECTION RELAY, MODEL NUMBER .... TBD.

NOTE:

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ISSUE	DATE	DESCRIPTION	DRAWN	ENGINEER	CHECKED	APPROVED
A	06/03/2019	FOR CLIENT REVIEW	REB	SAS	JBP	

NOT FOR CONSTRUCTION

CHP / DMC PLANT
OSU SUBSTATION
TRANSFORMER #2
RELAYING SINGLE DIAGRAM

FILENAME 10161576-SK-E004.dwg
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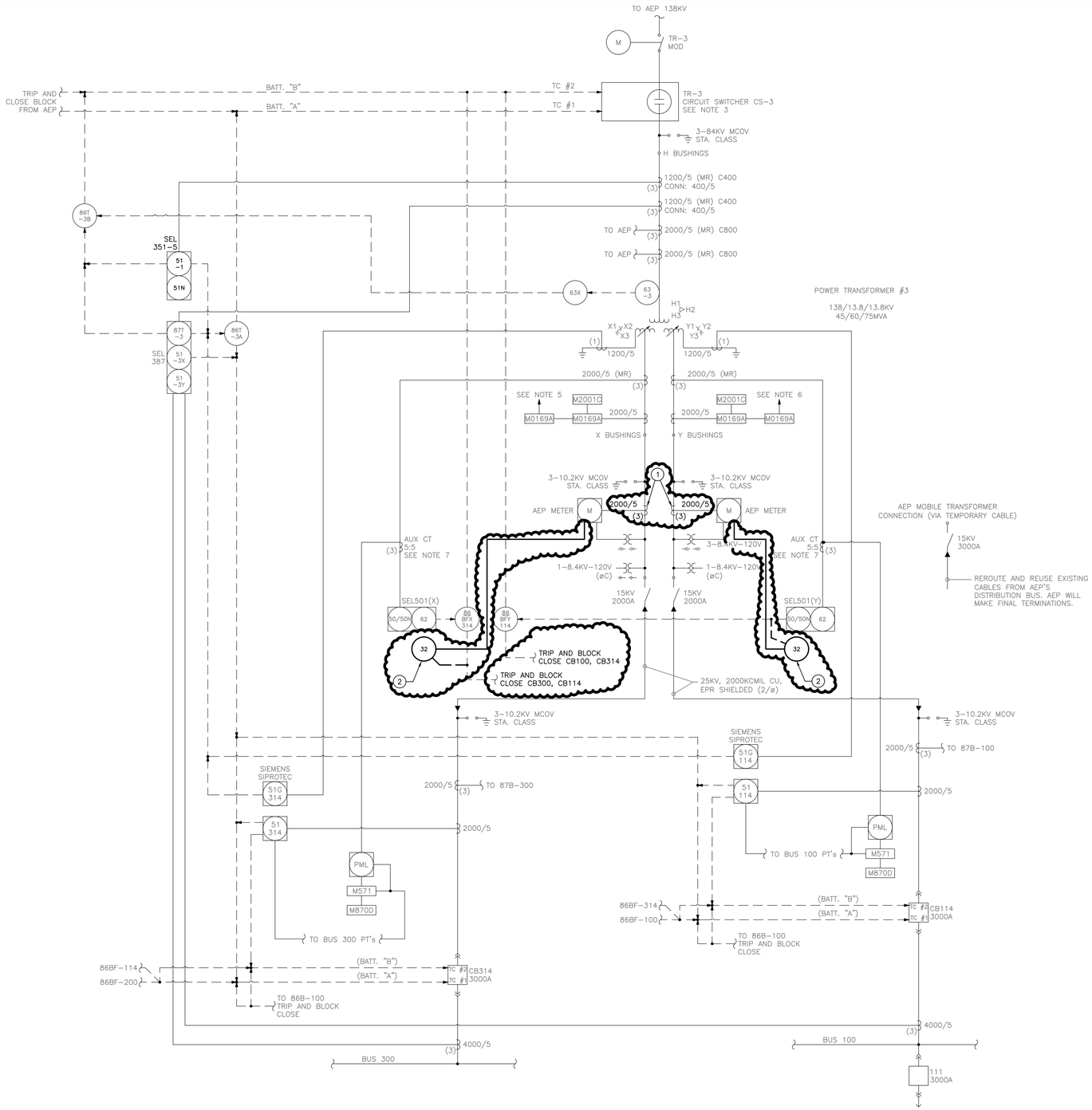
SHEET 10161576-SK-E004



LEGEND

- SURGE ARRESTER
- HOOK STICK OPERATED SWITCH
- M — MOTOR OPERATOR
- TC #2 / TC #1 — CIRCUIT BREAKER WITH DUAL TRIP COILS
- VOLTAGE (POTENTIAL) TRANSFORMER (VT)
- CURRENT TRANSFORMER
- SF6 CIRCUIT SWITCHER
- M — METER
- PML — ION PML METER (IN SWITCHGEAR)
- M2001C — BECKWITH LTC CONTROL (IN LTC PANEL)
- M0169A — BECKWITH AUX CT (IN LTC PANEL)
- M571 — BITRONICS M571 TRANSDUCER (IN SWITCHGEAR, SHIPPED LOOSE BY PANEL VENDOR FOR INSTALLATION BY CONTRACTOR)
- M870D — BITRONICS M870D REMOTE DISPLAY (IN LTC PANEL)
- POWER CONDUCTOR/BUS
- RELAYING AND CONTROL

NOTES

1. SEE SPECIFICATIONS FOR PROTECTION, CONTROL, AND INSTRUMENTATION EQUIPMENT TO BE FURNISHED BY OSU.
2. TEST SWITCHES NOT SHOWN FOR CLARITY.
3. INTERLOCK THE CIRCUIT SWITCHER (CS-3), CB314 AND CB114 TO OPEN CB314 AND CB114 IF CS-3 IS OPEN AND BLOCK THE CLOSURE OF CB314 AND CB114 OF CS-3 IS OPEN. INTERLOCK THE MOTOR OPERATED SWITCH TO BLOCK OPENING OF SWITCH UNLESS CS-3 IS OPEN AND BLOCK THE CLOSURE OF SWITCH UNLESS CS-3 IS OPEN.
4. NOT USED
5. THIS CURRENT CIRCUIT PROVIDES THE CIRCULATING CURRENT TO M2001C ON TR 2X(NORMAL) OR TR 1Y(SUSTAINED ALTERNATE) DEPENDING ON BREAKER STATUS.
6. THIS CURRENT CIRCUIT PROVIDES THE CIRCULATING CURRENT FROM M2001C ON TR 1X(NORMAL) OR TR 2Y(SUSTAINED ALTERNATE) DEPENDING ON BREAKER STATUS.
7. AUXILIARY CT's SHALL BE FURNISHED, INSTALLED, AND WIRED BY INSTALLATION CONTRACTOR. MOUNTING PROVISIONS IN RELAY PANELS SHALL BE PROVIDED BY INSTALLATION CONTRACTOR.

RELAY POWER SUPPLY/COIL SOURCES

SEL 351 – BATTERY "B"
SEL 387 – BATTERY "A"
SEL 501XY – BATTERY "B"
SIEMENS SIPROTEC 51G-114/314 – BATTERY "A"
SIEMENS SIPROTEC 51-114/314 – BATTERY "B"
86BFX314 COIL – BATTERY "B"
86BFY114 COIL – BATTERY "B"
86T-3A COIL – BATTERY "A"
86T-3B COIL – BATTERY "B"

REVISION NOTES:

1. REPLACE WITH DIRECTIONAL CT's.
2. REVERSE POWER PROTECTION RELAY, MODEL NUMBER .... TBD.

NOTE:

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ISSUE	DATE	DESCRIPTION	DRAWN	ENGINEER	CHECKED	APPROVED
A	06/03/2019	FOR CLIENT REVIEW	REB	SAS	JBP	

NOT FOR CONSTRUCTION

CHP / DMC PLANT
OSU SUBSTATION
TRANSFORMER #3
RELAYING SINGLE DIAGRAM

FILENAME: 10161576-SK-E005.dwg
SCALE: NO SCALE
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Distrbuted Generation Facility IEEE 1547.1 Testing Matrix

Facility Name	Smart[E] Campus
Facility Location	Ohio State University Campus
Total Generation	117.6MW
DG Type	CTG, STG

Line	IEEE 1547.1 ID	IEEE 1547.1 Test	Type/Production Test	Field Test	Not Applicable	Device under test	Referenced Document	Notes
1	5.1.2.1	Operational Temperature Test						
2	5.1.2.2	Storage Temperature Test						
3	5.2.1.2	Test for overvoltage magnitude		X		SEL 751, SIPROTEC 7UM621(CTG), SIPROTEC 7UM621(STG), SEL 787	D	To be tested per IEEE 1547.1 test procedure. Field test report to be provided by others after testing completed.
4	5.2.1.3	Test for overvoltage trip time		X		SEL 751, SIPROTEC 7UM621(CTG), SIPROTEC 7UM621(STG), SEL 787	D	To be tested per IEEE 1547.1 test procedure. Field test report to be provided by others after testing completed.
5	5.2.2.2	Test for undervoltage magnitude		X		SEL 751, SIPROTEC 7UM621(CTG), SIPROTEC 7UM621(STG), SEL 787	D	To be tested per IEEE 1547.1 test procedure. Field test report to be provided by others after testing completed.
6	5.2.2.3	Test for undervoltage trip time		X		SEL 751, SIPROTEC 7UM621(CTG), SIPROTEC 7UM621(STG), SEL 787	D	To be tested per IEEE 1547.1 test procedure. Field test report to be provided by others after testing completed.
7	5.3.1.2	Test for overfrequency magnitude	X			SEL 751, SIPROTEC 7UM621(CTG), SIPROTEC 7UM621(STG), SEL 787	C	Per supplied manufacturer's spec sheet
8	5.3.1.3	Test for overfrequency trip time	X			SEL 751, SIPROTEC 7UM621(CTG), SIPROTEC 7UM621(STG), SEL 787	C	Per supplied manufacturer's spec sheet
9	5.3.2.2	Test for underfrequency magnitude	X			SEL 751, SIPROTEC 7UM621(CTG), SIPROTEC 7UM621(STG), SEL 787	C	Per supplied manufacturer's spec sheet
10	5.3.2.3	Test for underfrequency trip time	X			SEL 751, SIPROTEC 7UM621(CTG), SIPROTEC 7UM621(STG), SEL 787	C	Per supplied manufacturer's spec sheet
11	5.4.1.2	Synchronization Method 1 Variation 1	X			SIPROTEC 7VE61, STG PARALLELING DEVICE	D	To be tested per IEEE 1547.1 test procedure. Field test report to be provided by others after testing completed.
12	5.4.2.2	Synchronization Method 1 Variation 2		X		SIPROTEC 7VE61, STG PARALLELING DEVICE	D	To be tested per IEEE 1547.1 test procedure. Field test report to be provided by others after testing completed.
13	5.4.3.2	Synchronization Method 1 Variation 3		X		STG PARALLELING DEVICE	D	To be tested per IEEE 1547.1 test procedure. Field test report to be provided by others after testing completed.
14	5.4.4.2	Synchronization Startup current measurement (Method 2)			X			
15	5.5.1.2	Protection from electromagnetic interference (EMI) test	X			SEL 751, SIPROTEC 7UM621(CTG), SIPROTEC 7UM621(STG), SEL 311L	C	Per supplied manufacturer's spec sheet
16	5.5.2.2	Surge withstand performance test	X			SEL 751, SIPROTEC 7UM621(CTG), SIPROTEC 7UM621(STG), SEL 311L	C	Per supplied manufacturer's spec sheet
17	5.5.3.2	Dielectric test for paralleling device			X			
18	5.6.2	Limitation of dc injection for inverters without interconnection transformers			X			
19	5.7.1.2	Unintentional Islanding test			X			
20	5.7.2.2	Unintentional Islanding test for synchronous generators			X			
21	5.8.1.2	Reverse power for unintentional islanding			X			
22	5.8.2.2	Reverse power time test			X			
23	5.9.2	Open phase test						
24	5.10.2	Reconnect following abnormal condition disconnect test						
25	5.11.1.1	Harmonics test for inverters			X			

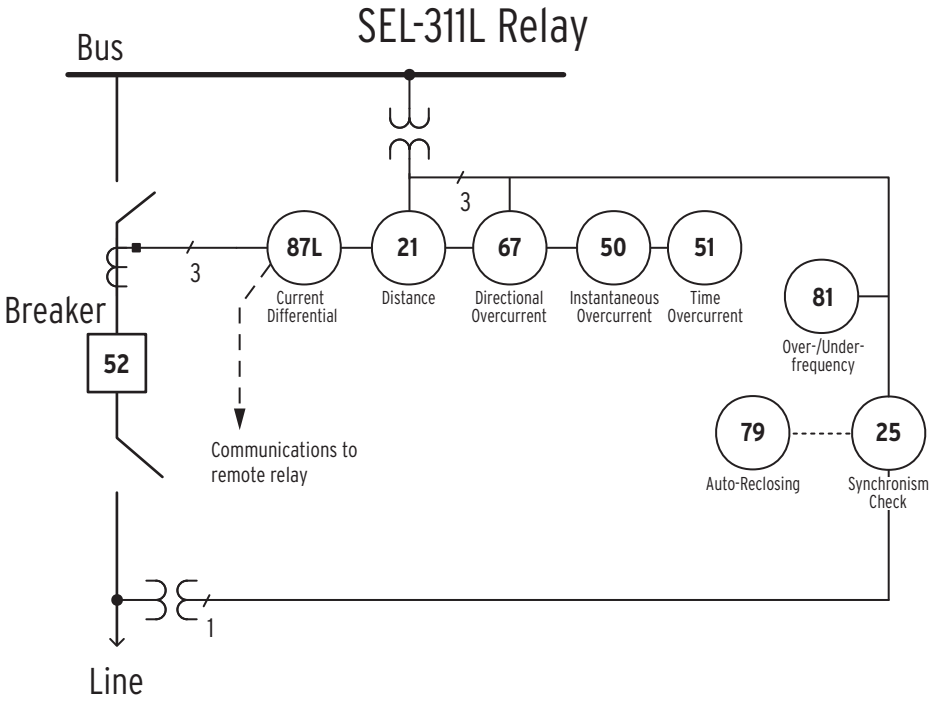
SEL-311L Line Current Differential Protection and Automation System

Differential Relays With Alpha Plane Restraint Provide Superior Security, Speed, and Sensitivity

Major Features and Benefits

- **Synchrophasors.** Improve operator awareness of system conditions. Use real-time data to view load angles, improve event analysis, and provide state measurements.
- **Security and Reliability.** Provide security for CT saturation and channel asymmetry by using the Alpha Plane restraint characteristic.
- **Protection Sensitivity.** Provide sensitivity without sacrificing security during external faults through use of negative-sequence current differential and Alpha Plane restraint.
- **Protection Speed.** Subcycle operating times at only four times minimum pickup for phase elements.
- **Single-Pole Tripping.** Improve system stability with optional single-pole tripping by differential and Zone 1 distance elements.
- **Full-Featured Backup Protection.** Standard backup protection includes: four zones of distance protection, directional overcurrent elements, and a four-shot reclose logic system.
- **Easy to Apply.** Select CT ratios and channel ID and the relay is ready to be used on most differential applications. Use application settings for simplifying setting requirements.
- **Communication Security.** True hot standby communications for no loss or degradation in protection during single channel failure. Isolation of 1.5 kV on electronic differential communication circuits. IEEE C37.94 fiber to multiplexer compatible. Multiple channel paths do not require the same baud rate or channel delay.
- **Three-Terminal Application.** Apply the SEL-311L on three-terminal lines without compromising protection even on loss of a single differential channel.
- **Mismatched CTs.** Set the CT ratio for all connected terminals. The Alpha Plane restraint characteristic prevents misoperation due to mismatched characteristics such as voltage class or burden.
- **Automation.** Equip the SEL-311L with optional dual fail-over Ethernet communications for Telnet, FTP, read-only web server, and IEC 61850 communications support.

Functional Overview



- Advanced SELOGIC® Control Equations
- Event Reports With Oscillography
- Sequential Events Recorder
- Breaker Wear Monitor
- Station Battery Monitor
- DNP3 Level 2 Slave Protocol*
- MIRRORED BITS® Communications and Advanced Scheme Logic
- Synchrophasors
- Remote and Local Control Switches
- Local Display
- Fault Locator
- CCVT Transient Overreach

*Optional Function

Figure 1 Functional Diagram

Protection Features

The SEL-311L contains an advanced line current differential system that is easy to set and apply, while still giving subcycle operation and superior fault resistance coverage. It is suitable for protection of any transmission line or underground cable where digital communications, in the form of either a 56/64 kb channel or a dedicated fiber-optic interface is available. Enable as many as four zones of phase and ground mho distance backup elements plus four zones of ground quadrilateral distance elements. These distance elements, together with overcurrent functions, may be applied in communications-assisted and stepped-distance protection schemes (see *Figure 1*).

Predefined configurations for typical applications are included in the relay settings. These configurations allow for greatly reduced settings for many line configurations, with or without potential transformers.

Protection Elements

The SEL-311L differential elements compare phase and sequence components from each line terminal, as illustrated in *Figure 2*. Because line charging current has a very low negative-sequence component, negative-sequence current differential protection allows for high sensitivity without compromising security. The phase elements provide high-speed protection for severe or balanced faults. This allows high-speed operation even under heavy load flow conditions when system stability may be critical.

The innovative differential protection in the SEL-311L checks the vector ratio of the local ($\vec{I_L}$) and remote ($\vec{I_R}$) currents in a complex plane, known as the Alpha Plane, as shown in *Figure 3*, *Figure 4*, *Figure 6*, and *Figure 7*. For load and external faults, with no CT or communication errors, the vector ratio of remote current to local current will be –1 or $1\angle 180°$. Errors introduced from CTs or nonequal communications path delays cause the ratio to appear at different locations within the complex ratio plane. The SEL-311L restraint characteristic improves on prior systems. The SEL-311L restraint region surrounds the ideal external fault and load current point allowing for errors in both magnitude and phase angle. CT saturation, channel asymmetry, and other effects during faults outside the protected zone produce shifts in the magnitude and angle of the ratio. The restraint characteristic provides proper restraint for these conditions and still detects high-impedance faults and "outfeed" faults that occur within the protected zone. The restraint region is adjustable both in angular extent and radial reach.

The differential protection algorithms are insensitive to CT saturation effects due to different CT characteristics at the line ends or remnant CT flux. This prevents tripping on through faults and allows the use of existing CTs at each line end. The SEL-311L current connections add very little burden, which allows line current differential protection to be added to multiuse CTs without degradation of accuracy (see *Figure 5* and *Figure 6*).

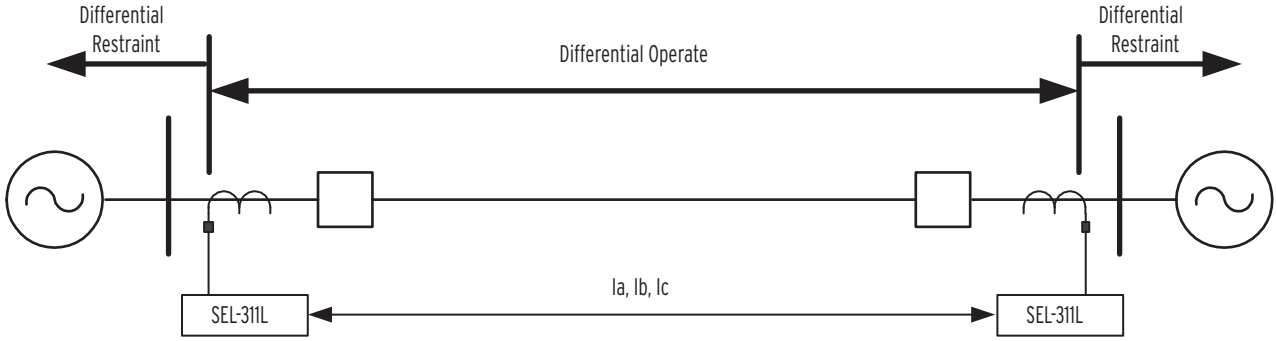


Figure 2 Differential Element Operate and Restraint Regions

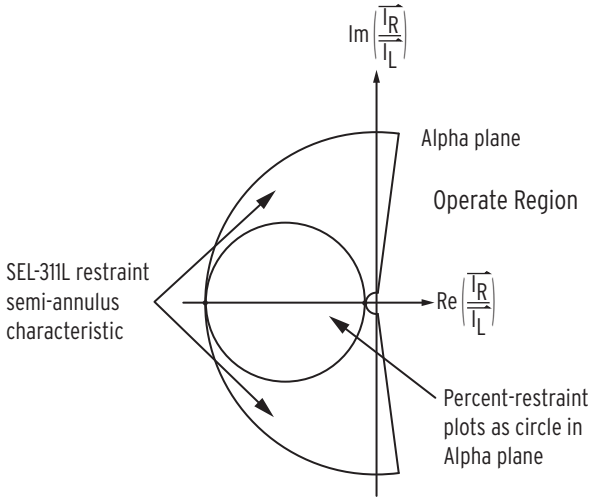


Figure 3 Operate and Restraint Regions in the Alpha Plane

For characteristics with the same sensitivity, SEL-311L Relays have greater security than percent-restraint, as seen in this Alpha Plane comparison.

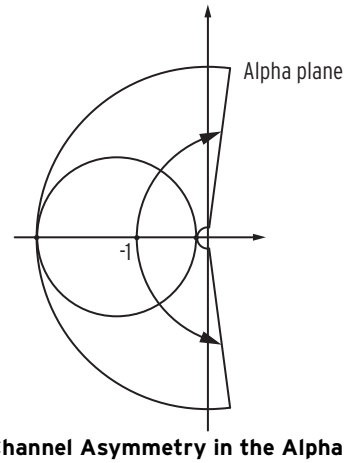


Figure 4 Channel Asymmetry in the Alpha Plane

Communications channel asymmetry causes errors in angle, and is easily handled by the SEL-311L semi-annular restraint characteristic. Percent-restraint is less secure.

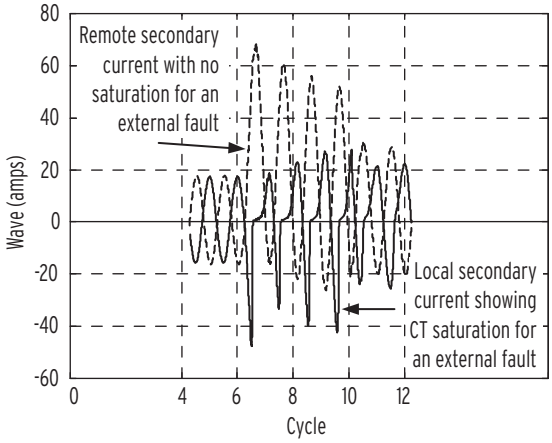


Figure 5 Effect of Current Transformer Saturation in Wave Form

Secondary CT currents resulting in false differential current due to CT saturation at one end of the protected line.

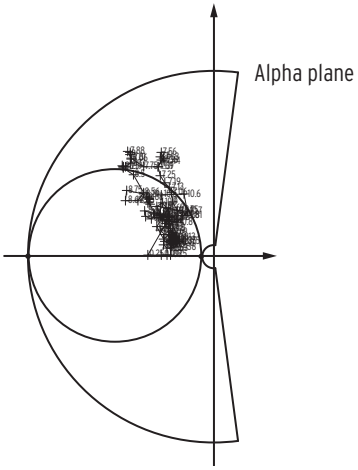


Figure 6 Effect of Current Transformer Saturation in Alpha Plane

For the CT saturation shown, the current-ratio trajectory plots outside the percent-restraint circle while remaining securely inside the SEL-311L semi-annular restraint characteristic. Percent-restraint could misoperate for this fault.

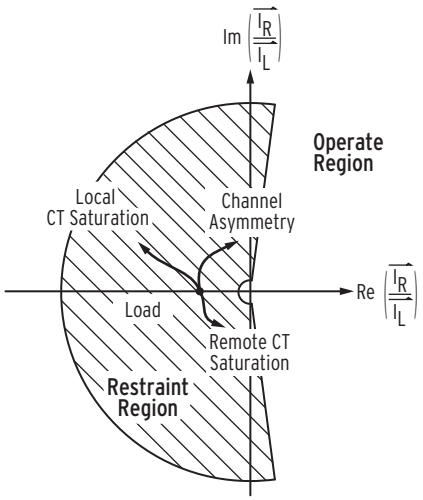


Figure 7 System Conditions in the Alpha Plane

Alpha Plane Restraint Provides Security, Even With CT Saturation

The SEL-311L restraint characteristic advances the state of the art in transient security for differential relays. CT saturation during external faults moves the remote to local current ratio plot in the Alpha Plane. The restraint characteristic accommodates a large degree of CT saturation.

The following equation gives the CT selection criteria for a two-terminal application:

$$150 \geq (X/R + 1) \bullet I_F \bullet Z_B$$

where:

- X/R is system X/R ratio
- I_F is secondary fault current, per unit of nominal secondary current
- Z_B is CT burden, per unit of rated secondary burden

To avoid CT saturation entirely, select and apply the CT such that

$$20 \geq (X/R + 1) \bullet I_F \bullet Z_B$$

Notice that the SEL-311L remains secure even when the CT is over-burdened 7.5 times worse than the case which avoids all CT saturation.

Sensitivity and High Speed

The SEL-311L provides sensitive negative- and zero-sequence differential elements, as well as high-speed phase current differential elements. Set negative- and zero-sequence differential elements below load or line charging current without risk of misoperation. The graph in *Figure 9* shows the average operate time, including high-speed outputs, for the phase differential units. For improved security on uneven pole operation, the sequence units operate approximately 2 cycles slower.

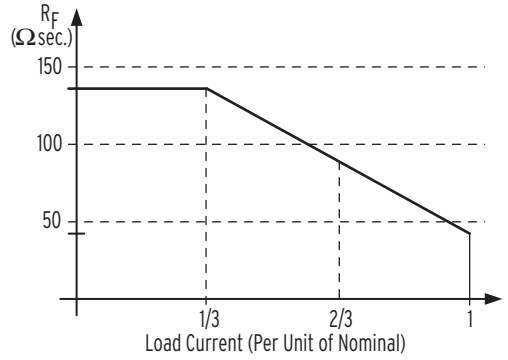


Figure 8 Ground Fault Sensitivity

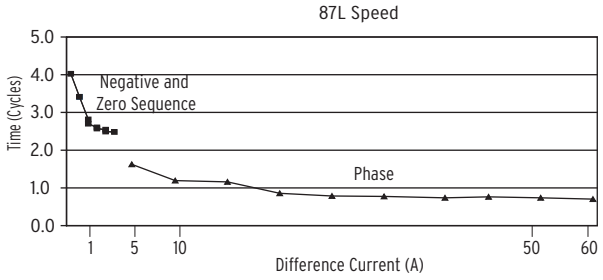


Figure 9 Current Differential Element Trip Times

Single-Pole Tripping

In this example two-line system (*Figure 10*) we can look at the stability curve to see the power transfer capability under different system conditions. In cases where systems must operate near stability limits, it is clear that the optional single-pole tripping capability of the SEL-311L will improve the transient stability.

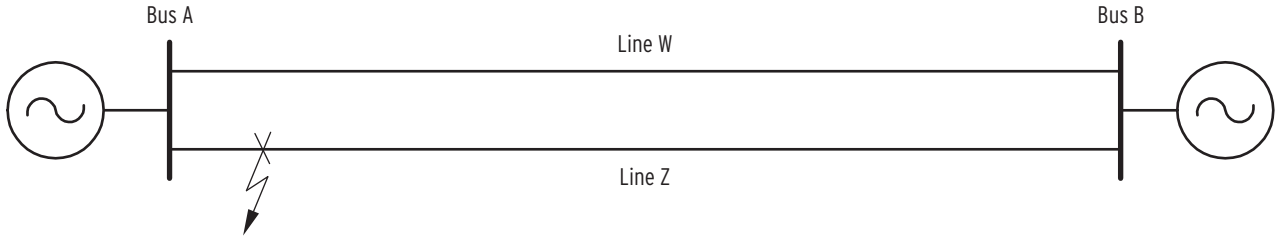


Figure 10 Single-Pole Tripping Diagram

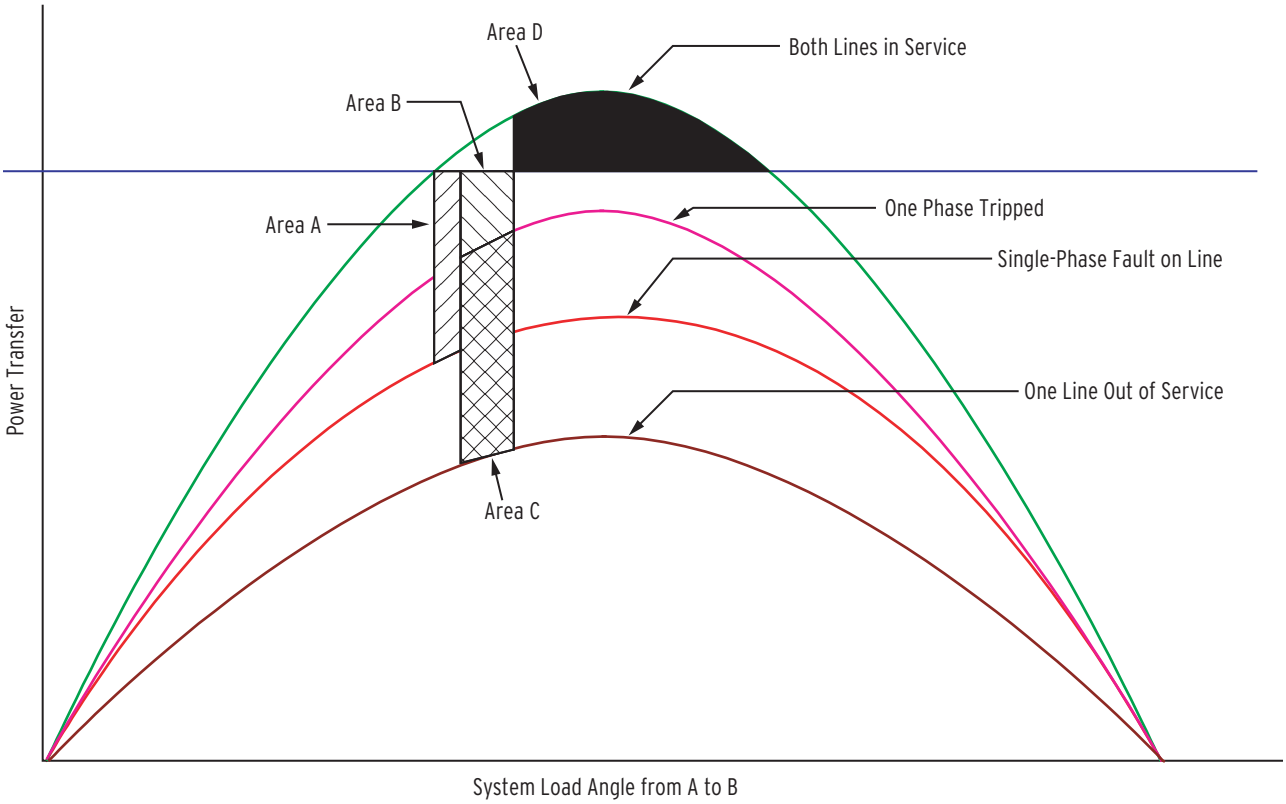


Figure 11 Equal Area Curve

Single-pole tripping improves stability as illustrated by the difference between Area B (for single-pole trips) and Area B + C (for three-pole trips) (*Figure 11*). The difference in these two areas is the extra stabilizing momentum available when single-pole tripping is used as compared to three-pole tripping.

The high-speed tripping of the SEL-311L complements the single-pole tripping by minimizing the size of Area A. The operating time of the SEL-311L, including output time, is approximately 0.75 cycles for a severe fault.

Full-Scheme and/or Current-Only Backup Protection

Full-Scheme Backup Protection

The SEL-311L includes all of the protection elements in the SEL-311C Relay. A complete and independent distance and directional overcurrent system is included for use if potential transformers are available (see *Figure 12*). These elements run on a separate processor platform using separate contacts and firmware. Failure of either the 87L channel or processing hardware does not affect backup protection. Both step-distance and communications-assisted protection are available. Transmit the permissive trip, direct trip, or block trip signal using the current differential channel, MIRRORED BITS® communications on a separate serial port, or via contact to channel equipment.

Backup protection maintains excellent sensitivity using patented Best Choice Ground Directional™ protection. All the features of the SEL-311C, such as load-encroachment, out-of-step, loss-of-potential detection and blocking, and CCVT transient detection are also included.

Current-Only Backup Protection

Apply phase and ground overcurrent backup protection elements in the SEL-311L. When the "Current-Only" Application Setting is used, these are the only backup elements that will be displayed for setting.

Three steps of phase and four steps of ground and negative-sequence instantaneous/definite time-overcurrent protection are included. Inverse-time phase, ground, and negative-sequence overcurrent elements are also included. If desired, backup elements can be enabled only after communication failure.

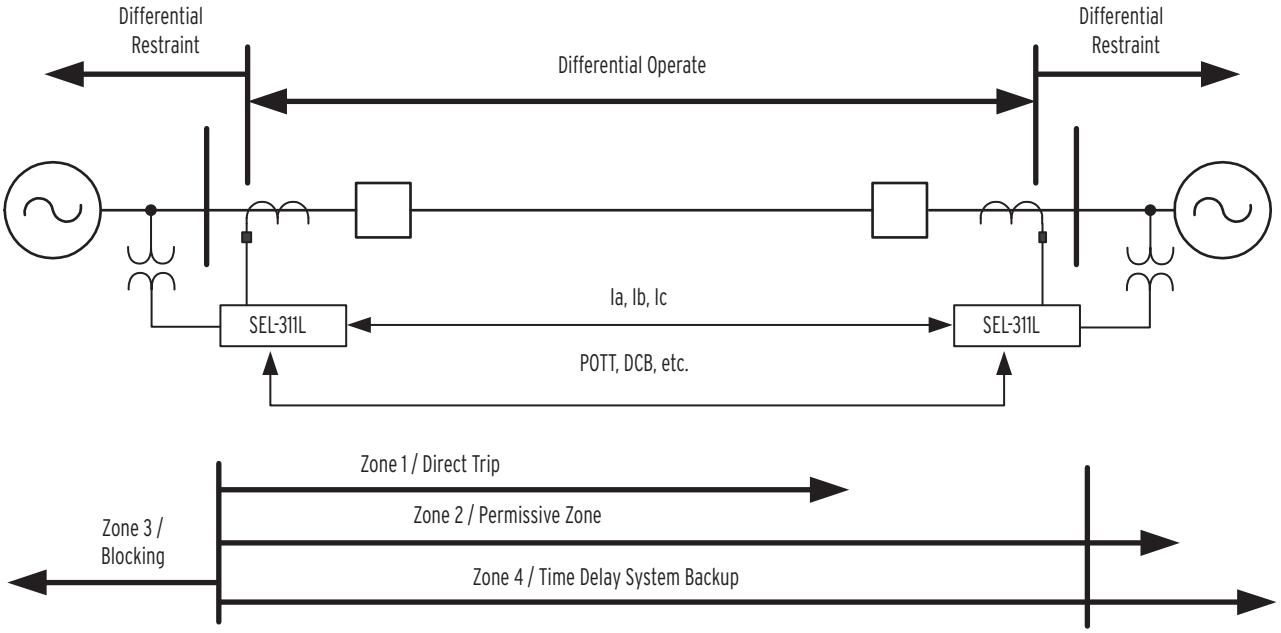


Figure 12 Full Scheme Backup Protection

Synchrophasors

The SEL-311L now includes phasor measurement technology that provides synchrophasor measurements throughout a power system. This technology in a protective relay reduces or eliminates incremental installation and maintenance costs while leaving system reliability unaffected. Incorporate present and future synchrophasor technology control applications without much effort into the same devices that protect and control the power system.

High-Speed Trip Contacts Interrupt Trip Current

Six high-speed, high-current interrupting contact outputs are controlled directly by the line current differential processor. These contacts can interrupt trip currents should the breaker auxiliary contacts fail to open. Backup protection can use the same high-speed contact outputs, passing backup trip decisions through the current differential processor (see *Figure 13*).

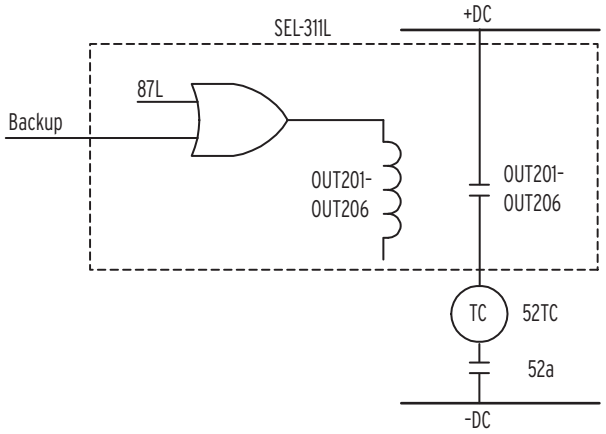


Figure 13 Combined Distance and Current Differential Protection

To maintain backup protection independent of line current differential protection, use standard contacts (eight included) controlled by the backup protection processor for backup tripping (see *Figure 14*).

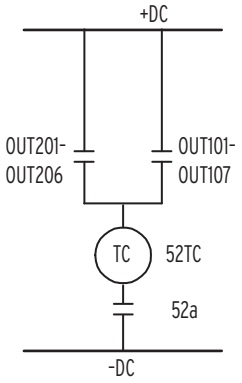


Figure 14 Segregated Differential and Backup Tripping

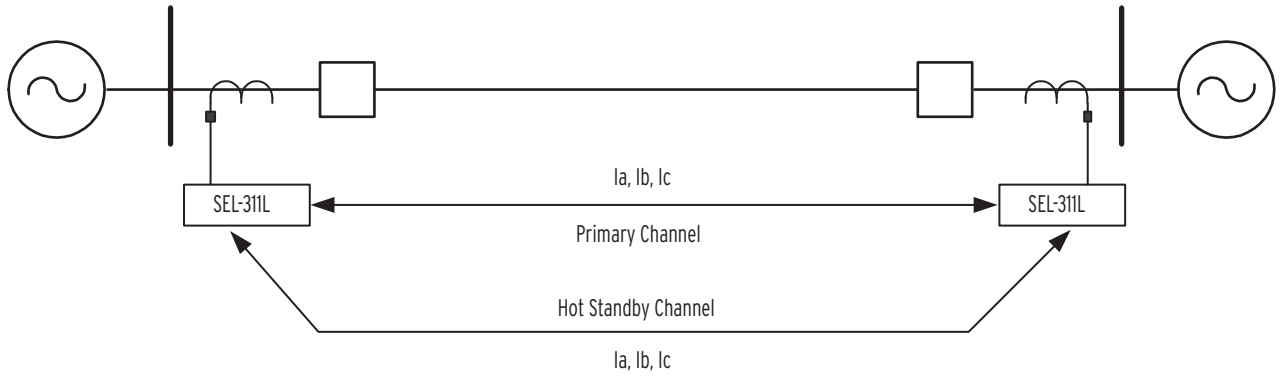


Figure 15 Dual Channel Hot Standby Communications

Dual Channel, Hot Standby Communications

Use one or two current differential communications channels between the line ends. For a two-terminal line, the redundant channel is in hot standby mode until the primary channel fails (see *Figure 15*). There is no interruption of protection or delay in tripping, even if a fault occurs simultaneously with the loss of one communications channel (see *Figure 16*).

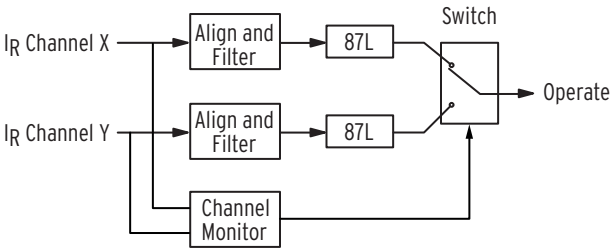


Figure 16 True Hot Standby

Dual Communications and Dual Differential prevent loss or degradation of protection during channel failure.

The relay continuously monitors both channels for correct data transmission and channel delay. Channel quality reports available from the relay include short and long term unavailability, and round trip channel delay. Use this information to accurately assess protection and communications system reliability and make appropriate changes for maximum system reliability.

Channel Requirements

The SEL-311L has options for the following channel interfaces (select one or two):

- G.703 codirectional to multiplexer
- EIA-422 to multiplexer for a 64 kbps or 56 kbps channel
- 1300 nm single-mode (120 km) fiber
- 1550 nm single-mode (120 km) fiber
- IEEE C37.94-compatible multimode fiber to multiplexer
- IEEE C37.94-compatible modulated 1300nm single-mode fiber to multiplexer

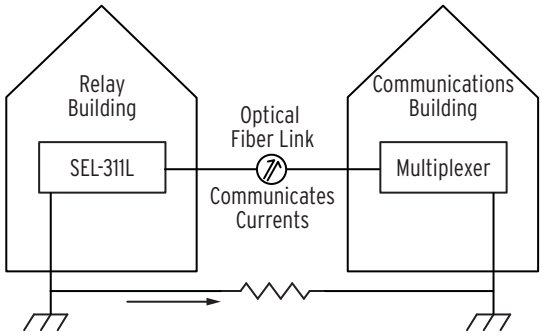


Figure 17 IEEE C37.94-Compatible

The SEL-311L Relay with an IEEE C37.94-compatible standard fiber interface. It provides a direct fiber-optic interface between the relay and multiplexer to prevent communication errors, equipment damage, and hazardous conditions due to ground potential rise.

```
=>>COMM Y L <Enter>
SEL-311L                          Date: 05/26/01    Time: 09:27:03.269
EXAMPLE: BUS B, BREAKER 3

FID=SEL-311L-R100-V0-Z001001-D20010625       CID=BAFD
Summary for 87L Channel Y
Channel Status Alarms
    ROKY = 1    DBADY = 0    RBADY = 0    AVAY = 0

For 05/24/01 13:37:01.631 to 05/26/01 09:27:04.248

    COMMUNICATION LOG SUMMARY        COMMUNICATION STATISTICS
    # of Error records  29          Last error          Data Error
    Data Error          20          Longest failure            4.685 sec.
    Dropout              9          Lost Packets, prev. 24 hours      407
    Test Mode Entered    0          One Way Delay (Ping-Pong) 0.4 msec.

    Error                   Recovery
#   Date     Time           Date     Time           Duration  Cause
  1 05/26/01 09:23:54.041   05/26/01 09:23:54.042      0.001  Data Error
  2 05/26/01 09:23:53.888   05/26/01 09:23:54.040      0.152  Dropout Error
  3 05/26/01 09:23:53.885   05/26/01 09:23:53.888      0.003  Data Error
  4 05/26/01 09:23:53.882   05/26/01 09:23:53.885      0.003  Dropout Error
  .
  .
  .
 27 05/24/01 13:37:04.688   05/24/01 13:37:04.689      0.001  Data Error
 28 05/24/01 13:37:00.003   05/24/01 13:37:04.688      4.685  Dropout Error
 29 05/24/01 13:37:00.000   05/24/01 13:37:00.003      0.003  Data Error

=>>
```

Figure 18 COMM Command Report

The SEL-311L Relay communications monitor reports performance of all 87L channels and MIRRORED BITS communications channels. Review these reports to optimize communications.

Tapped Load Application

The SEL-311L coordinates with tapped loads. A difference-current ANSI or IEC overcurrent protection curve, as shown in *Figure 19*, coordinates with the tapped load protection. This prevents loss of the line for cases of a fault on the tap, while still providing differential measurements of the protected line to give the fastest operation possible. Implement either fuse-saving or trip-saving schemes. For example, select high-speed, sensitive protection for the initial shot and then delayed tripping on a subsequent reclose operation to allow a fuse on the tapped line to blow if the fault is still present. This can be modified to accommodate the user's operation practices and provide the best possible service for the end customers. This feature is applicable to two- and three-terminal lines.

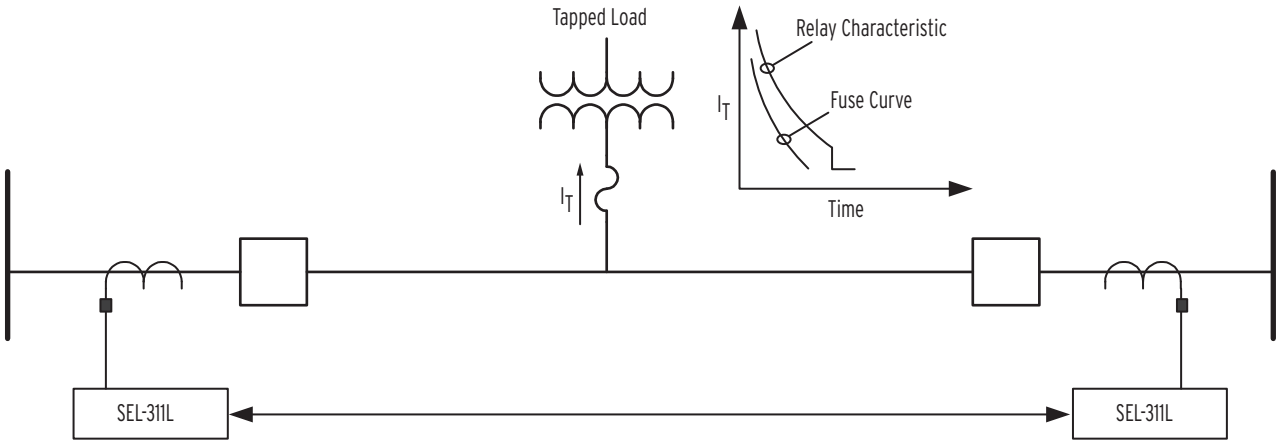


Figure 19 Tapped Load Coordination

Relays determine current at the tap point. Overcurrent elements use that current to coordinate with tap protection. Use phase current, negative-sequence current, and zero-sequence current for optimal protection.

Three-Terminal Lines

The SEL-311L protects three-terminal lines in either a peer-to-peer configuration using two channels connected to each relay, as shown in *Figure 20*, or in a leader-remote arrangement when only one relay is connected to two channels. The leader relay has line current information from all terminals. It sends a trip signal to the remote units when it determines there is a fault on the line.

Reclosing

The SEL-311L includes a four-shot recloser. Internal element status or external inputs can condition the recloser to match your practice:

- Reclose initiate (e.g., breaker status, fault type, trip).
- Drive-to-lockout or last shot (e.g., input from manual or SCADA open).
- Skip shot (use 27/59 elements, fault current magnitude).
- Stall open-interval timing.
- Separate times to reset from cycle or lockout.

The recloser shot counter can control which protective elements are used in each reclose interval for fuse-saving or fuse-coordination of tapped or downstream loads. Front-panel LEDs track the recloser state: Reset (**RS**) and Lockout (**LO**).

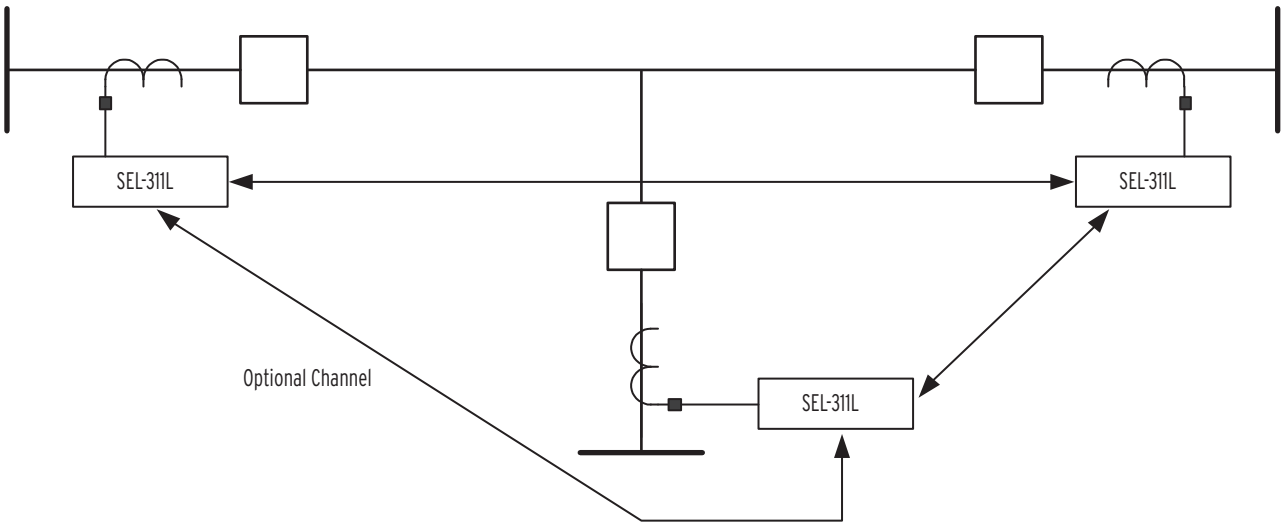


Figure 20 Three-Terminal Line Protection Communications Connections

Bus Stub Logic

Bus stub protection is enabled by input or SELOGIC control equation.

- ➤ No analog data are sent to the remote terminal
- ➤ Analog data received from the remote terminal are ignored
- ➤ Differential transfer trips are disabled

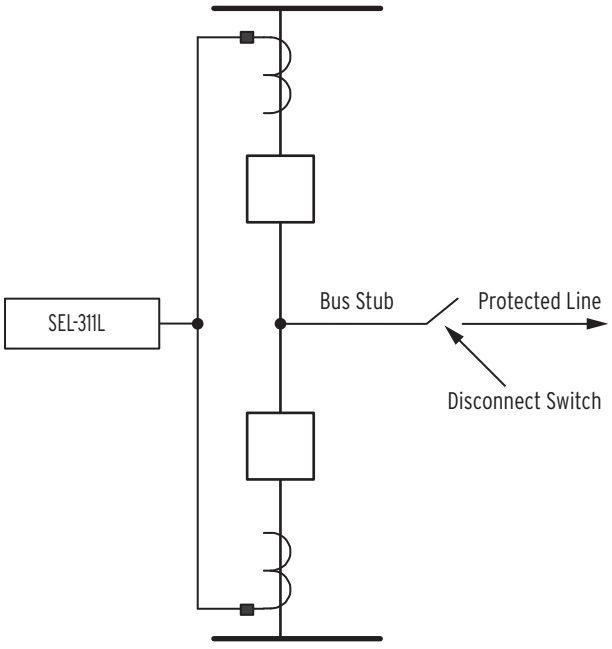


Figure 21 Automatic Bus Stub Protection

Fault Locator

If potentials are applied, the SEL-311L provides an accurate fault location calculation even during periods of substantial load flow. The fault locator uses fault type, replica line impedance settings, and fault conditions to calculate fault location without communications channels, special instrument transformers, or prefault information. This feature contributes to efficient dispatch of line crews and fast restoration of service.

The relay provides fault location information on the front panel, in the event reports, and in event summaries.

Six Independent Setting Groups

The relay stores six groups of settings. Select the active setting group by contact input, serial port or front-panel command, or other programmable conditions. Use these setting groups to cover a wide range of protection and control contingencies. Selectable setting groups make the SEL-311L ideal for applications requiring frequent setting changes and for adapting the protection to changing system conditions. Selecting a group also selects logic settings.

Program group selection logic to adjust settings for different operating conditions, such as station maintenance, seasonal operations, emergency contingencies, loading, source changes, and adjacent relay setting changes.

Relay and Logic Settings Software

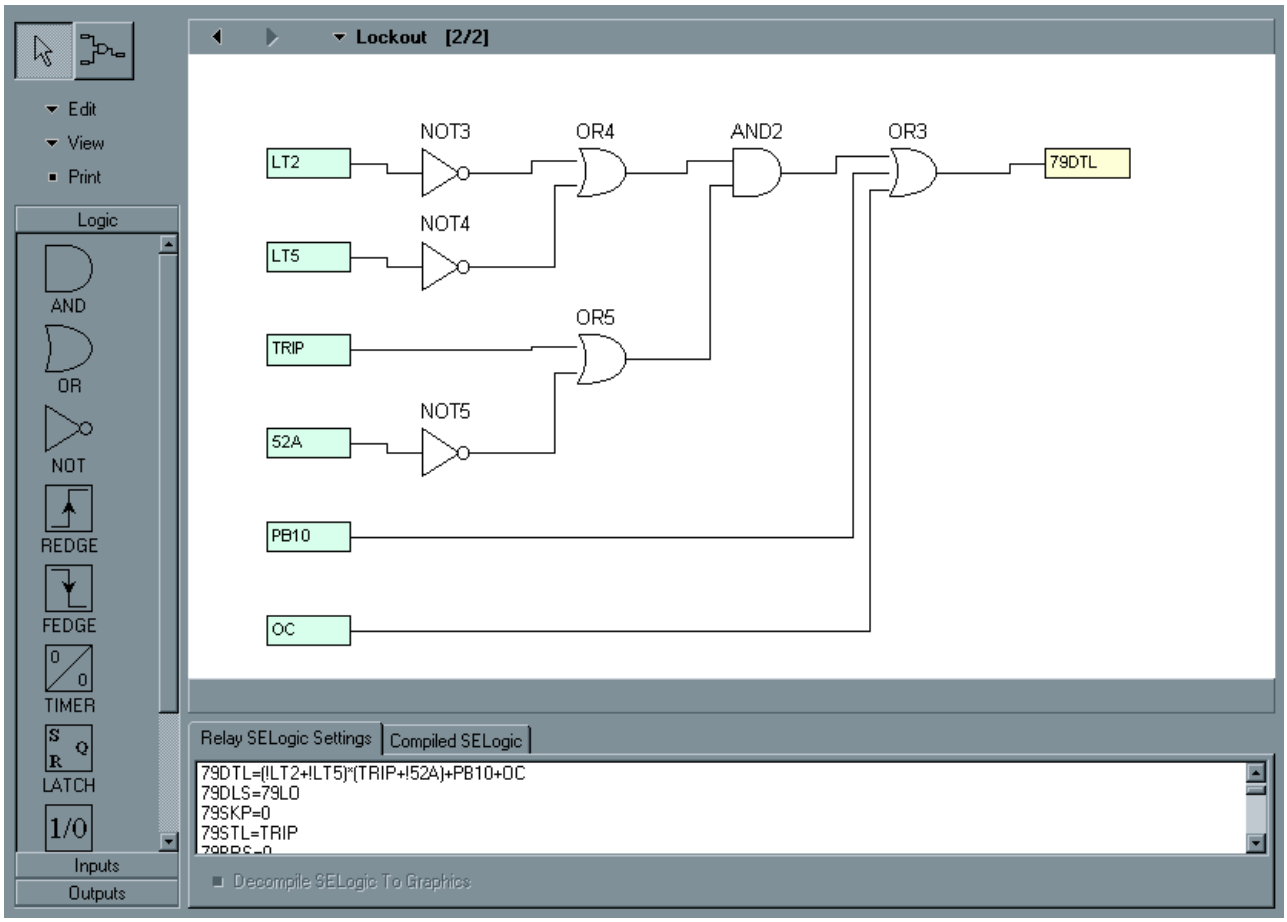


Figure 22 ACSELERATOR® QuickSet SEL-5030 Software Screen

The ACSELERATOR QuickSet SEL-5030 software program uses the Microsoft® Windows® operating system to simplify settings and provide analysis support for the SEL-311L.

Use ACSELERATOR QuickSet to create and manage relay settings:

- Develop settings off-line with an intelligent settings editor that only allows valid settings.
- Create SELOGIC control equations with a drag and drop graphical editor and/or text editor.
- Use on-line help to assist with configuring proper settings.
- Organize settings with the relay database manager.
- Load and retrieve settings using a simple PC communications link.

Use ACSELERATOR QuickSet to verify settings and analyze events:

- Use the logic simulator to test setting schemes with user or event report input stimulus. (Use for training, too!)
- Analyze power system events with the integrated waveform and harmonic analysis tools.

Use ACSELERATOR QuickSet to aid with monitoring, commissioning, and testing the SEL-311L:

- Use the Human Machine Interface (HMI) to monitor meter data, Relay Word bits, and output contacts status during testing.

Use the PC interface to remotely retrieve breaker wear, voltage sag/swell/interruption reports, and other power system data.

Metering and Monitoring

Table 1 Metering Capabilities

Quantities	Description
Currents (local) $I_{A,B,C,pol}$, I_1, $3I_2$, $3I_0$	Individual phase, polarizing, and sequence currents for local relay terminal.
Currents (remote and difference) $I_{A,B,C}$, I_1, $3I_2$, $3I_0$	Individual phase and sequence currents for remote relay terminal and difference currents.
Voltages $V_{A,B,C,S}$, V_0, V_1, V_2	Individual phase voltages for wye-connected PTs, and positive-, negative-, and zero-sequence voltages.
Power $MW_{A,B,C,3P}$, $MVAR_{A,B,C,3P}$	Single-phase and three-phase megawatts and megavars available for wye-connected PTs.
Energy $MWh_{A,B,C,3P}$, $MVARh_{A,B,C,3P}$	Single-phase and three-phase megawatt and megavar hours available for wye-connected PTs.
Power Factor $PF_{A,B,C,3P}$	Single-phase and three-phase power factor; leading or lagging.

Advanced Metering Capabilities

The SEL-311L provides extensive metering capabilities, as shown in *Table 1*. Metering accuracies are provided in the *Specifications on page 1.23*. Metering information is displayed on the relay front panel or is available via communications over the serial port.

Use the current differential meter to verify line charging current. Compare local and remote currents to detect CT connection errors or CT ratio setting errors at any terminal.

If voltages are supplied to the relay, power and energy quantities are also available.

Event Reporting and Sequential Events Recorder (SER)

Event Reports and Sequential Events Recorder simplify post-fault analysis and improve understanding of simple and complex protective scheme operations. They also aid in testing and troubleshooting relay settings and protection schemes.

Eleven 60-cycle, twenty-two 30-cycle, or forty-one 15-cycle oscillographic event reports provide 4 or 16 samples per cycle resolution for remote and differential phase currents, each local analog channel, system frequency, dc system voltage, contact I/O, and many relay elements. Use the local and remote current oscillography to completely reconstruct complex system disturbances, and check local and remote CT connections during commission testing from a single report (see *Figure 23*).

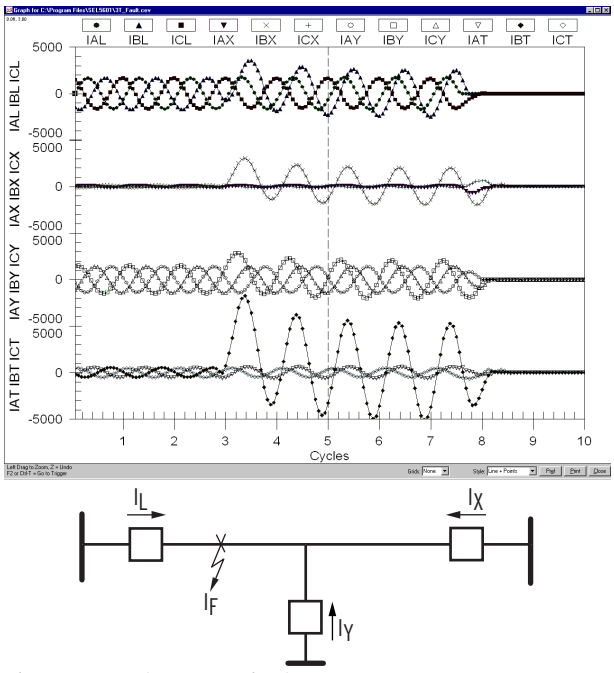


Figure 23 Three-Terminal Oscillograph From Any Terminal

The SEL-311L Sequential Events Recorder records the last 512 event entries, which may include contact inputs, internal relay conditions, relay setting changes, and relay power-up.

The IRIG-B time-code input synchronizes the SEL-311L Relay SER time stamps to within ±5 ms of the time-source input. A convenient source for this time code is the SEL-2032, SEL-2030, or SEL-2020 Communications Processor (via Serial Port 2 on the SEL-311L). Line current differential protection does not rely on IRIG-B time synchronization, nor on any other external source of time synchronization.

To simplify event analysis following an operation, relay settings are appended to the bottom of each event report.

Flexible Event Analysis

Examine line currents from two or three line ends in the same event report. Use the SEL-5601 Analytic Assistant to help visualize power system disturbances. *Figure 23* shows phase currents from the local relay, from the relay connected to Channel X, from the relay connected to Channel Y, and difference currents for an internal ground fault on a three-terminal line. Trigger event reports using any programmable condition.

Figure 24 shows the corresponding negative-sequence Alpha Plane plot, showing the prefault current inside the restraint region and the fault current outside the restraint region.

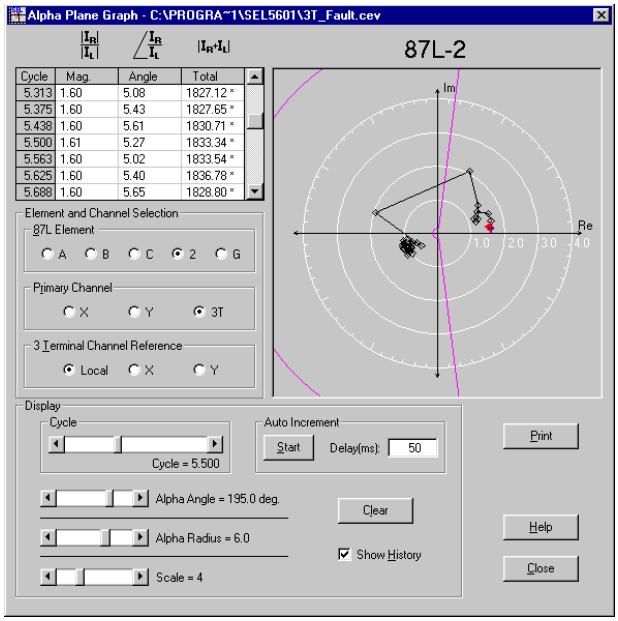


Figure 24 Alpha Plane Display

Event Summary

Each time the relay generates a standard event report, it also generates a corresponding Event Summary (see *Figure 25*). This is a concise description of an event that includes the following information:

- Prefault and fault, local and remote phase, zero- and negative-sequence currents
- Status of each 87L channel
- Phase voltages
- Fault type at time of trip
- System frequency at time of trigger
- Recloser shot count at time of trigger
- Relay identification
- Event date and time
- Event type
- Fault location
- ALARM status
- Status of all MIRRORED BITS and 87L channels
- Trip and close time tags
- Breaker status (open/close)

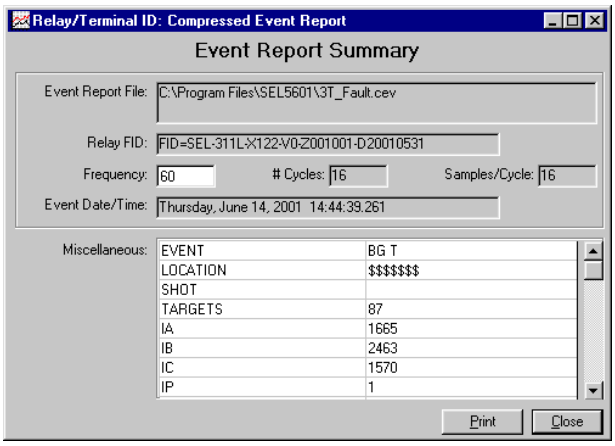


Figure 25 Example Event Report Summary

The relay automatically sends an Event Summary to all serial ports set as "AUTO" each time an event report is triggered.

The relay gives each Event Summary a unique identifier. This allows an automated event system, such as the SEL-5040, to acknowledge triggered events, and to retrieve the associated oscillographic report reliably.

Synchrophasor Measurements

Upgrade System Models

Send synchrophasor data using SEL Fast Message protocol to SEL communications processors, or to SEL-5077 SYNCHROWAVE Server phasor data concentration software, or to an SEL-3306 Synchrophasor Processor. Data rates of as much as one message per second with an accuracy of ±1 electrical degree provide for real-time visualization.

The SEL-5077 SYNCHROWAVE Server software and the SEL-3306 Synchrophasor Processor time correlate data from multiple SEL-311 relays and other phasor measurement and control units (PMCUs). Then, the SEL-5077 sends the concentrated data to visualization tools, such as the SEL-5078 SYNCHROWAVE Console, for use by utility operations.

Use SEL-2032 or SEL-2030 Communications Processors to collect synchrophasor data from multiple SEL-311 relays and incorporate the data into traditional SCADA and EMS systems. Traditional power system models are created based on measurements of voltages and power flows at different points on the system. The system state is then estimated based on a scan of these values and an iterative calculation. The state estimation includes an inherent error caused by measurement inaccuracies, time delays between measurements, and model simplifications. Synchrophasor measurements reduce error and change state estimation into state

measurement. The time required for iterative calculation is minimized, and system state values can be directly displayed to system operators and engineers.

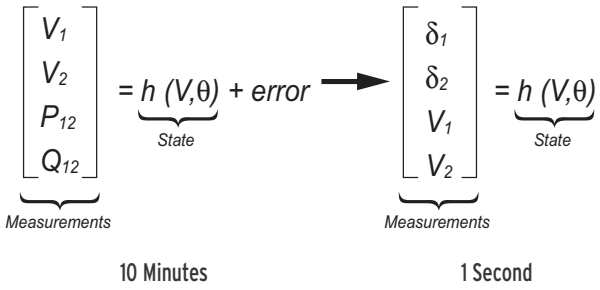


Figure 26 Synchrophasor Measurements Turn State Estimation Into State Measurement

Improve Situational Awareness

Provide improved information to system operators. Advanced synchrophasor-based tools provide a real-time view of system conditions. Use system trends, alarm points, and preprogrammed responses to help operators prevent a cascading system collapse and maximize system stability. Awareness of system trends provides operators with an understanding of future values based on measured data.

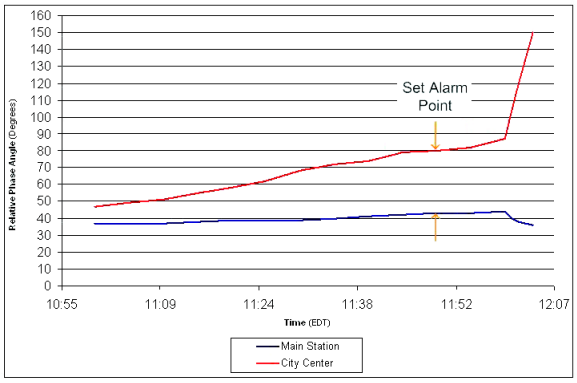


Figure 27 Visualization of Phase Angle Measurements Across a Power System

- Increase system loading while maintaining adequate stability margins.
- Improve operator response to system contingencies such as overload conditions, transmission outages, or generator shutdown.
- Advance system knowledge with correlated event reporting and real-time system visualization.
- Validate planning studies to improve system load balance and station optimization.

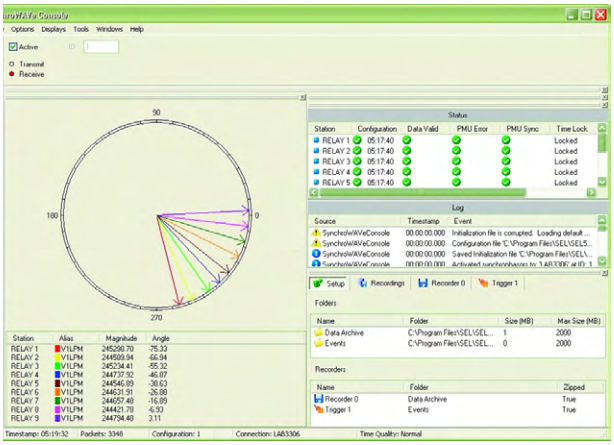


Figure 28 SEL-5078 SYNCHROWAVE Console Real-Time Wide-Area Visualization Tool

IEC 61850 Communications (SEL-311L-1 and SEL-311L-7)

IEC 61850 Ethernet-based communications provides interoperability between intelligent devices within the substation. Logical nodes using IEC 61850 communications allow standardized interconnection of intelligent devices from different manufacturers for monitoring and control of the substation. Reduce wiring between various manufacturers' devices and simplify operating logic with SEL-311L relays equipped with IEC 61850. Eliminate system RTUs by streaming monitoring and control information from the intelligent devices directly to remote SCADA client devices.

The SEL-311L-1 or SEL-311L-7 can be ordered with embedded IEC 61850 communications operating on dual fail-over 100 Mbps Ethernet interfaces. Use IEC 61850 communications for relay monitoring and control functions, including:

- As many as 16 incoming GOOSE messages. The incoming GOOSE messages can be used to control as many as 32 control bits in the relay with <10 ms latency from device to device. These messages provide binary control inputs to the relay for high-speed control functions and monitoring.
- As many as eight outgoing GOOSE messages. Outgoing GOOSE messages can be configured for Boolean or analog data. Boolean data are provided with <10 ms latency from device to device. Use outgoing GOOSE messages for high-speed control and monitoring of external breakers, switches and other devices.
- IEC 61850 Data Server. SEL-311L relays equipped with embedded IEC 61850 communications provide data according to predefined logical node objects. As many as six simultaneous client associations are supported by each relay. Relevant Relay Word bits are available within the logical node data, so status of relay elements, inputs, out-

puts, or SELOGIC control equations can be monitored using the IEC 61850 data server provided in the relay.

Use the ACSELERATOR Architect SEL-5032 Software to manage the logical node data for all IEC 68150 devices on the network. This Microsoft Windows®-based software provides easy-to-use displays for identifying and binding IEC 61850 network data between logical nodes using IEC 61850-compliant CID (Configured IED Description) files. CID files are used by ACSELERATOR Architect to describe the data that will be provided by the IEC 61850 logical node within each relay.

Telnet, FTP, and Read-Only Web Server

Order the SEL-311L-1 or the SEL-311L-7 with Ethernet communications and use the built-in Telnet and FTP (File Transfer Protocol) that come standard with Ethernet to enhance relay communication sessions. Use Telnet to access relay settings, metering, and event reports remotely using the ASCII interface. Upload IEC 61850 CID files to the relay via the high-speed Ethernet port using FTP.

Enable the integrated read-only web server and browse the relay with any standard web browser to safely read settings, verify relay self-test status, inspect meter reports, read relay configuration, and more. The web server allows no control or modification actions, so users can be confident that an inadvertent button press will have no adverse effects.

Substation Battery Monitor for DC Quality Assurance

The SEL-311L measures and reports the substation battery voltage presented to its power supply terminals. The relay includes two programmable threshold comparators and associated logic for alarm and control. For example, if the battery charger fails and the measured dc voltage falls below a programmable threshold, operations personnel are then notified before the substation battery voltage falls to unacceptable levels. Monitor these thresholds with the SEL Communications Processor. Use the SEL Communications Processor to trigger messages, initiate telephone calls, or take other actions.

The measured dc voltage is reported in the METER display via serial port communications, on the LCD, and in the event report. Use the event report data to see an oscillographic display of the battery voltage. You can see how the substation battery voltage drops during trip, close, and other control operations.

Breaker Monitor Feature Allows for Intelligent Breaker Maintenance Scheduling

Circuit breakers experience mechanical and electrical wear every time they operate. Effective scheduling of breaker maintenance takes into account the manufacturer's published data of contact wear versus interruption levels and operation count. The SEL-311L breaker monitor feature compares the breaker manufacturer's published data to the interrupted current.

Every time the breaker trips, the interrupted current is added to its previous value. When the result of this addition exceeds the threshold set by the breaker wear curve (*Figure 29*), the relay can alarm via serial port, output contact, or the front-panel display. With this information, breaker maintenance is scheduled in a timely, economical fashion.

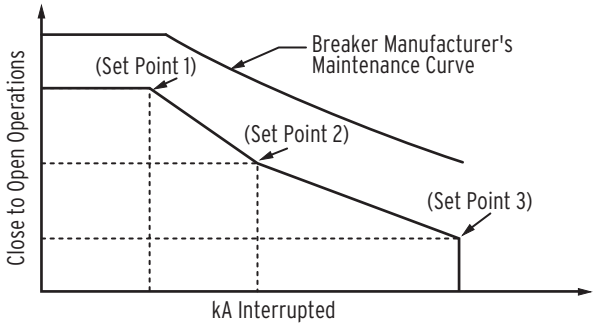


Figure 29 Breaker Contact Wear Curve and Settings

Automation

Flexible Control Logic and Integration Features

Use the SEL-311L control logic to:

- ➤ Replace traditional panel control switches.
- ➤ Replace traditional indicating panel lights.
- ➤ Replace traditional latching relays.
- ➤ Eliminate RTU-to-relay wiring.

Eliminate traditional panel control switches with 16 local control switches. Set, clear, or pulse local control switches with the front-panel pushbuttons and display. Program the local control switches into your control scheme via SELOGIC control equations. Use the local control switches to trip test, enable/disable reclosing, trip/close the breaker, etc.

Eliminate RTU-to-relay wiring with 16 remote control switches. Set, clear, or pulse remote control switches via serial port commands. Program the remote control

switches into your control scheme via SELOGIC control equations. Use remote control switches for SCADA-type control operations: trip, close, settings group selection, etc.

Replace traditional latching relays for such functions as "remote control enable" with 16 latching control switches. Program latch set and latch reset conditions with SELOGIC control equations. Set or reset the latch control switches via optoisolated inputs, remote bits, local bits, or any programmable logic condition. The latch control switches retain their state when the relay loses power.

Replace traditional indicating panel lights with 16 programmable displays. Define custom messages (e.g., REMOTE BREAKER OPEN, REMOTE BREAKER CLOSED, RECLOSER ENABLED) to report power system or relay conditions on the LCD. Control which messages are displayed via SELOGIC control equations using any logic point in the relay.

Serial Communications

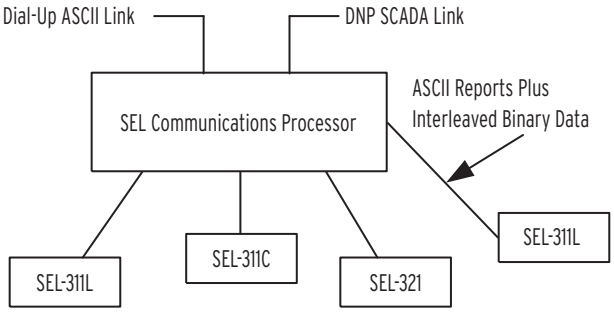


Figure 30 Example Communication System

Three EIA-232 serial ports and one isolated EIA-485 serial port each operate independently of the other serial ports.

- ➤ Full access to event history, relay status, and meter information from the serial ports.
- ➤ Settings and group switching have password control.
- ➤ DNP3 Level 2 protocol with point mapping (optional).
- ➤ Open communications protocols (see *Table 2*).

The relay does not require special communications software. ASCII terminals, printing terminals, or a computer supplied with terminal emulation and a serial communications port is all that is required. SEL manufactures a variety of standard cables for connecting this and other relays to a variety of external devices. Consult your SEL representative for more information on cable availability.

Table 2 Open Communications Protocols

Type	Description
Simple ASCII	Plain language commands for human and simple machine communications. Use for metering, setting, self-test status, event reporting, and other functions.
Compressed ASCII	Comma-delimited ASCII data reports. Allows external devices to obtain relay data in an appropriate format for direct import into spreadsheets and database programs. Data are checksum protected.
Extended Fast Meter, Fast Operate, and Fast SER	Binary protocol for machine-to-machine communications. Quickly updates SEL-2032/2030/2020, RTUs, and other substation devices with metering information, relay element, I/O status, time-tags, open and close commands, summary event reports, and sequence of events records. Data are checksum protected. Binary and ASCII protocols operate simultaneously over the same communications lines so control operator metering information is not lost while transferring an event report.
Distributed Port Switch Protocol	Enables multiple SEL devices to share a common communications bus (two-character address setting range is 01–99). Use this protocol for low-cost, port-switching applications.
DNP3 Level 2 Slave	Certified Distributed Network Protocol. Includes capability for settings-based DNP events, full-point remapping, individual scaling and dead-band thresholds for analog inputs.
IEC 61850	Ethernet-based international standard for interoperability between intelligent devices in a substation.

Relay-to-Relay Digital Communications (MIRRORED BITS)

In addition to the differential channels, the SEL-311L includes MIRRORED BITS communications which can operate simultaneously on any two serial ports for three-terminal operation. The SEL patented MIRRORED BITS technology provides bidirectional relay-to-relay digital communications (see *Figure 31*).

This bidirectional digital communication creates eight additional outputs (transmitted MIRRORED BITS) and eight additional inputs (received MIRRORED BITS) for each serial port operating in the MIRRORED BITS mode. These MIRRORED BITS can be used to transfer information between line terminals to enhance coordination and achieve faster tripping or to provide additional contact I/O with the SEL-2505. MIRRORED BITS also help reduce total pilot scheme operating time by eliminating the need to close output contacts and debounce contact inputs. Use the dual-port MIRRORED BITS capabilities for high-speed communications-assisted schemes applied to three-terminal transmission lines.

Advanced SELOGIC Control Equations

Advanced SELOGIC control equations put relay logic in the hands of the protection engineer. Assign the relay inputs to suit your application, logically combine selected relay elements for various control functions, and assign outputs to your logic functions.

Programming SELOGIC control equations consists of combining relay elements, inputs, and outputs with SELOGIC control equation operators. Any element in the Relay Word can be used in these equations.

The SELOGIC control equation operators include the following: OR, AND, invert, parentheses, and rising and falling edges of element state changes.

In addition to Boolean-type logic, 16 general-purpose SELOGIC control equation timers eliminate external timers for custom protection or control schemes. Each timer has independent time-delay pickup and dropout settings. Program each timer input with any desired element (e.g., time-qualify a voltage element). Assign the timer output to trip logic, reclose logic, or other control scheme logic.

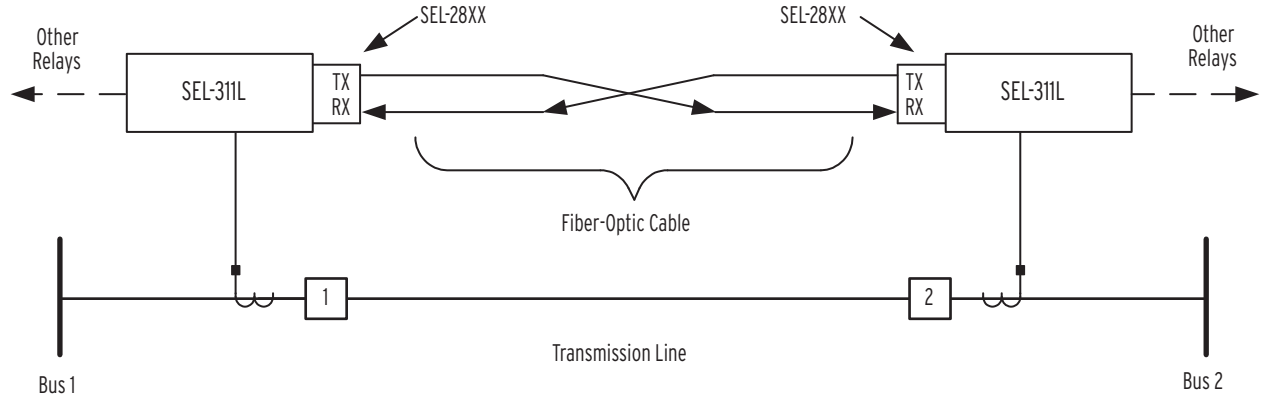


Figure 31 Integral MIRRORED BITS Communications Provides Secure Protection, Monitoring, and Control

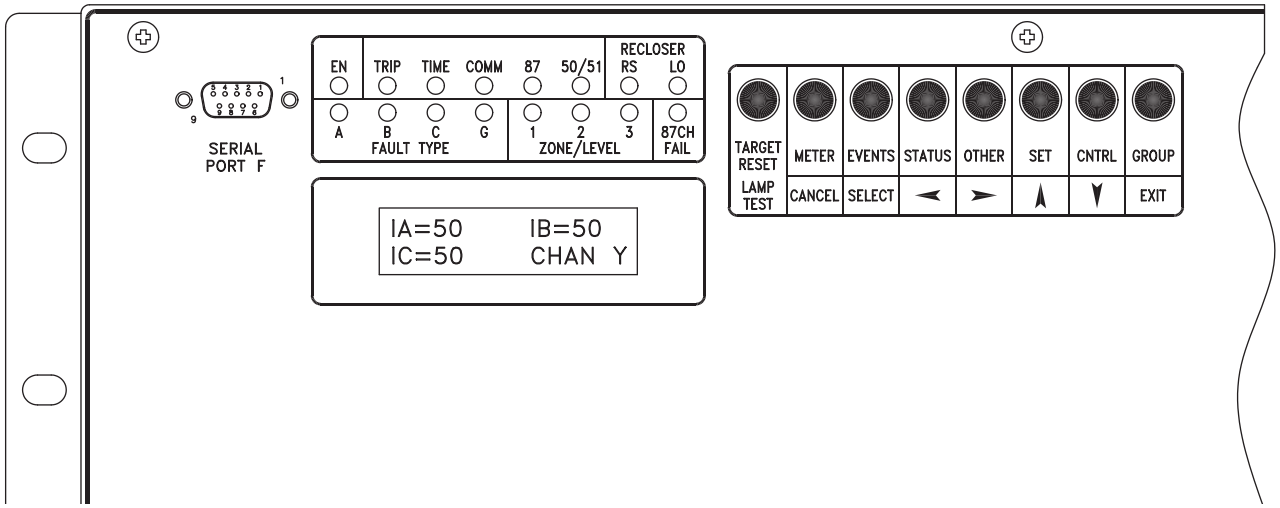


Figure 32 Status and Trip Target LEDs, Front-Panel Display, and Pushbuttons

Front-Panel User Interface

Status and Trip Target LEDs, Front-Panel Display, and Pushbuttons

Figure 32 shows a close-up view of the user interface portion of the SEL-311L front panel. It includes a two-line, 16-character LCD, 16 LED status and target indicators, and 8 pushbuttons for local communication. *Table 3* explains the front-panel LEDs.

The LCD shows event, metering, setting, and relay self-test status information and allows relay settings changes without the need for a data terminal.

The LCD is controlled by the pushbuttons, automatic messages the relay generates, and user-programmed Display Points. The default display scrolls through any active, nonblank Display Points. If none are active, the relay scrolls through four two-line displays of the A-, B-, and C-phase local and remote currents in primary quantities. Each display remains for two seconds, before scrolling continues. Any message generated by the relay due to an alarm condition takes precedence over the normal default display. The **{EXIT}** pushbutton returns the display to the default display, if some other front-panel function is being performed.

Error messages such as self-test failures are displayed on the LCD in place of the default display when they occur.

Table 3 Description of Target LEDs

Target LED	Function
EN	Relay powered properly and self-tests okay
TRIP	Indication that a trip occurred
TIME	Time-delayed trip
COMM	Communications-assisted trip
87	Line current differential trip
50/51	Instantaneous and time-overcurrent trip
RECLOSER	
RS	Ready for reclose cycle
LO	Control in lockout state
FAULT TYPE	
A, B, C	Phase(s) involved in fault
G	Ground involved in fault
ZONE/LEVEL	
1–3	Trip by Zone 1–3 distance elements and/or Level 1–3 overcurrent elements
87CH FAIL	Failure of active differential channel

Contact Inputs and Outputs

The SEL-311L includes six high-speed/high-interrupting outputs as well as eight standard duty output contacts and six optoisolated inputs. Assign the contact inputs for control functions, monitoring logic, and general indication. Except for a dedicated alarm output, each contact output is programmable using SELOGIC control equations.

Wiring Diagram

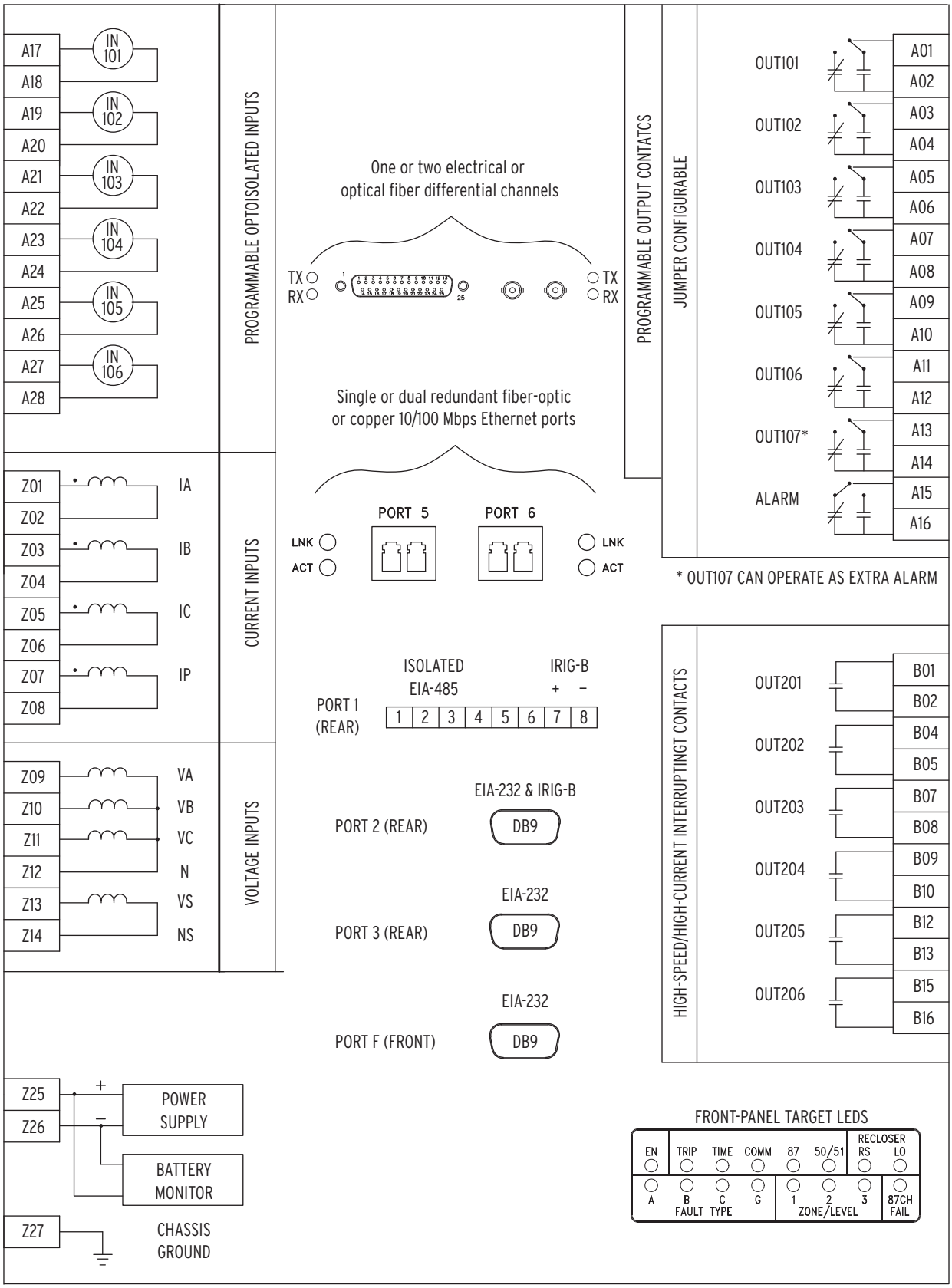
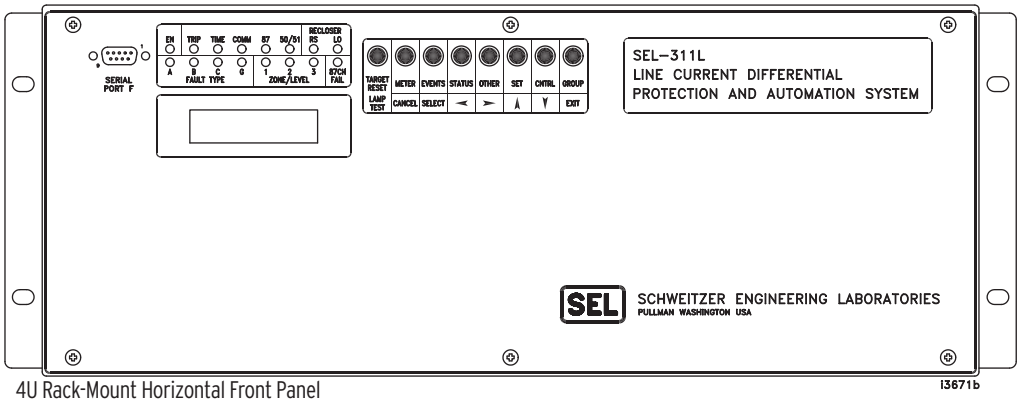
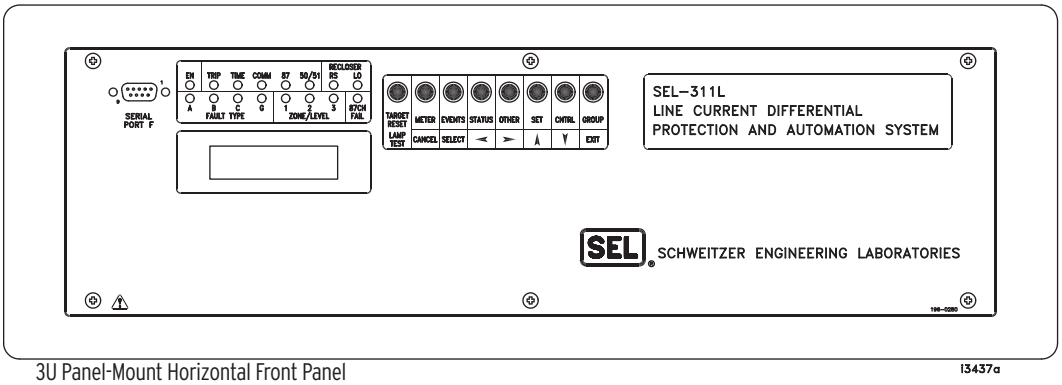


Figure 33 SEL-311L Inputs, Outputs, and Communications Ports

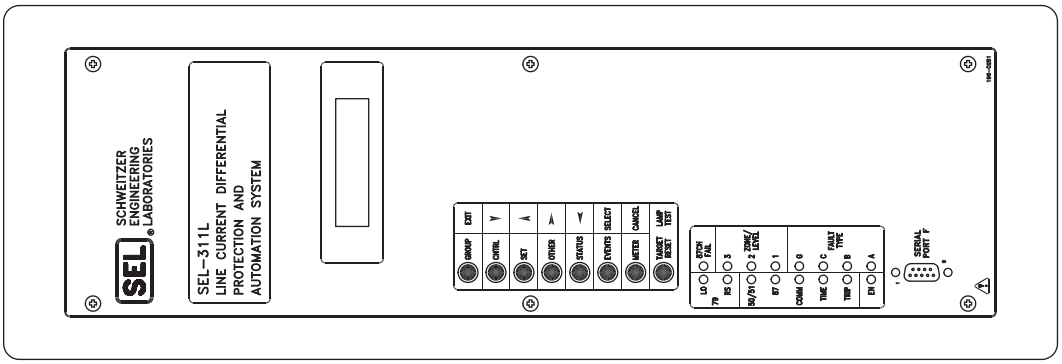
Front- and Rear-Panel Diagrams



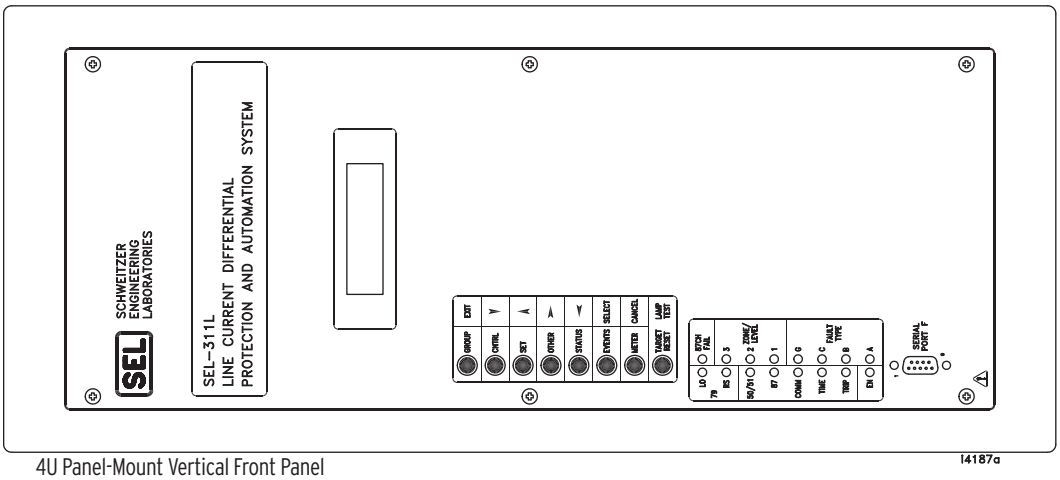
4U Rack-Mount Horizontal Front Panel



3U Panel-Mount Horizontal Front Panel

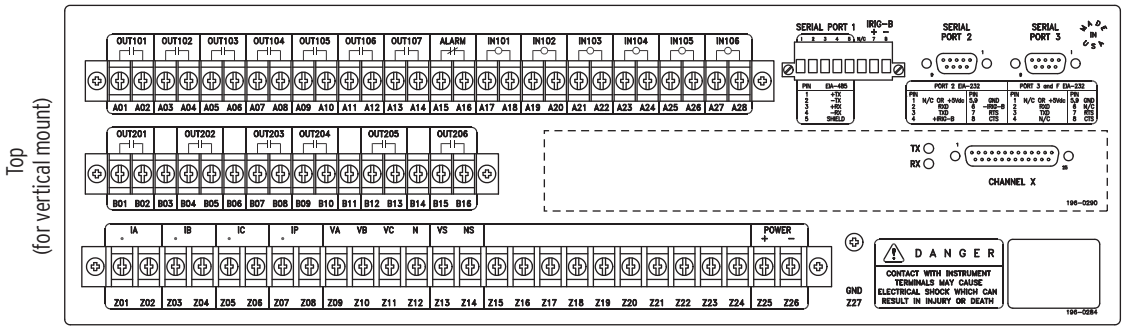


3U Panel-Mount Vertical Front Panel

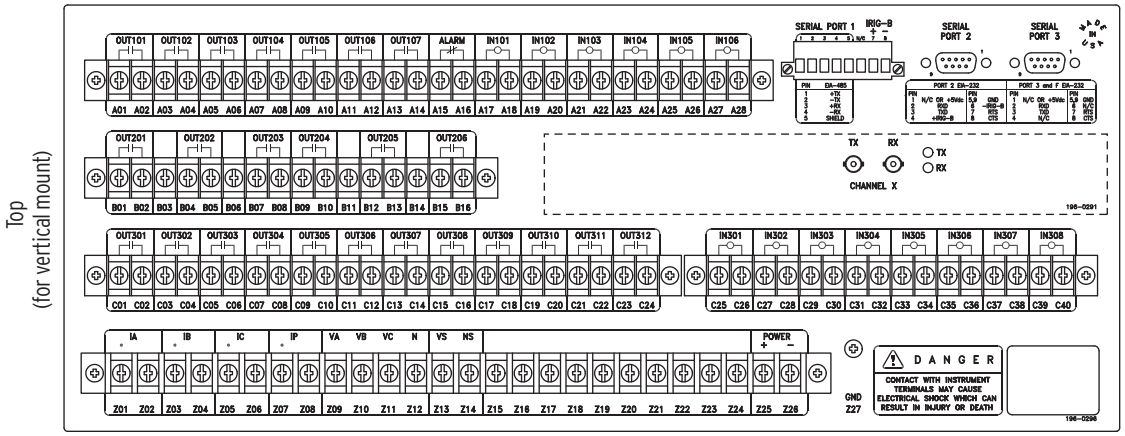


4U Panel-Mount Vertical Front Panel

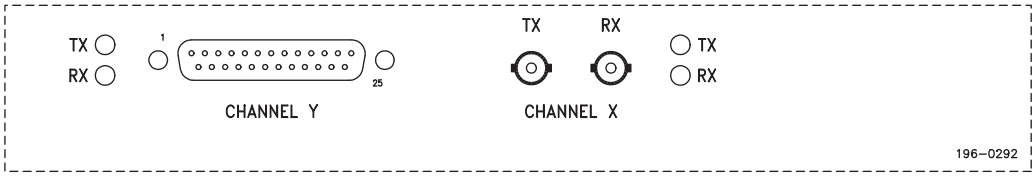
Figure 34 SEL-311L Horizontal and Vertical Front-Panel Diagrams



3U Rear Panel–Differential Channel Option With DB-25 Connector Outlined



4U Rear Panel–Differential Channel Option With Fiber-Optic Connectors

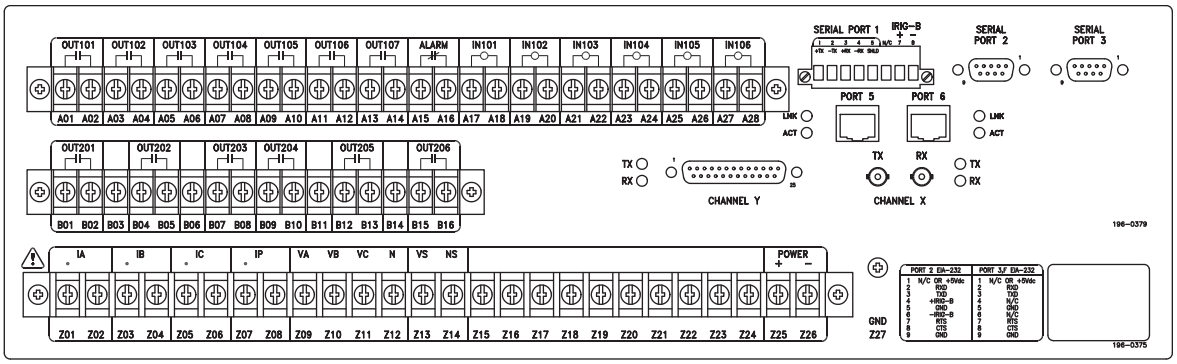


Differential Channel Option With DB-25 and Fiber-Optic Connectors

Differential Channel Option With 2 DB-25 Connectors

Differential Channel Option With 2 Fiber-Optic Connectors

Figure 35 SEL-311L Rear-Panel Diagrams Showing Differential Channel Options



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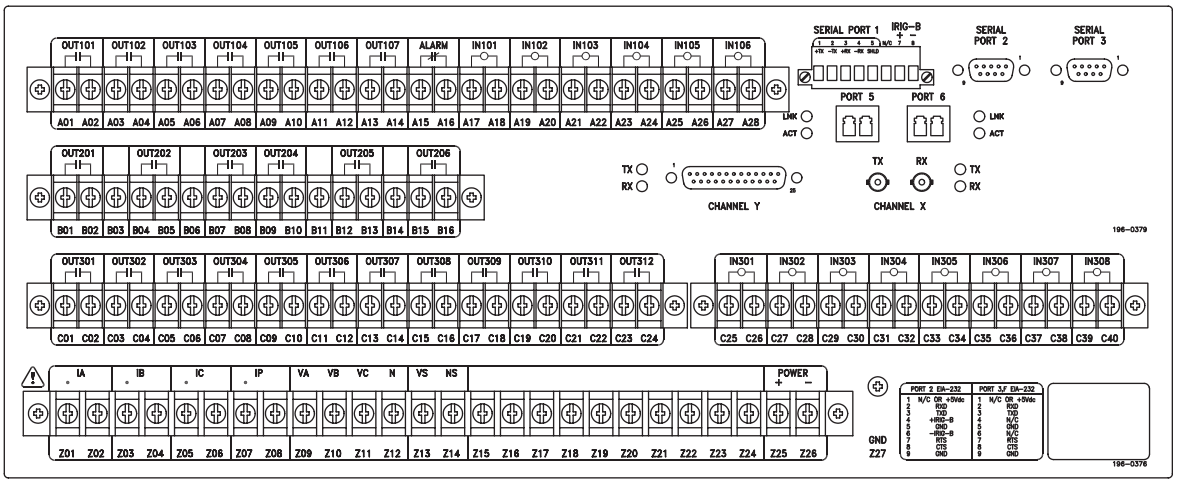

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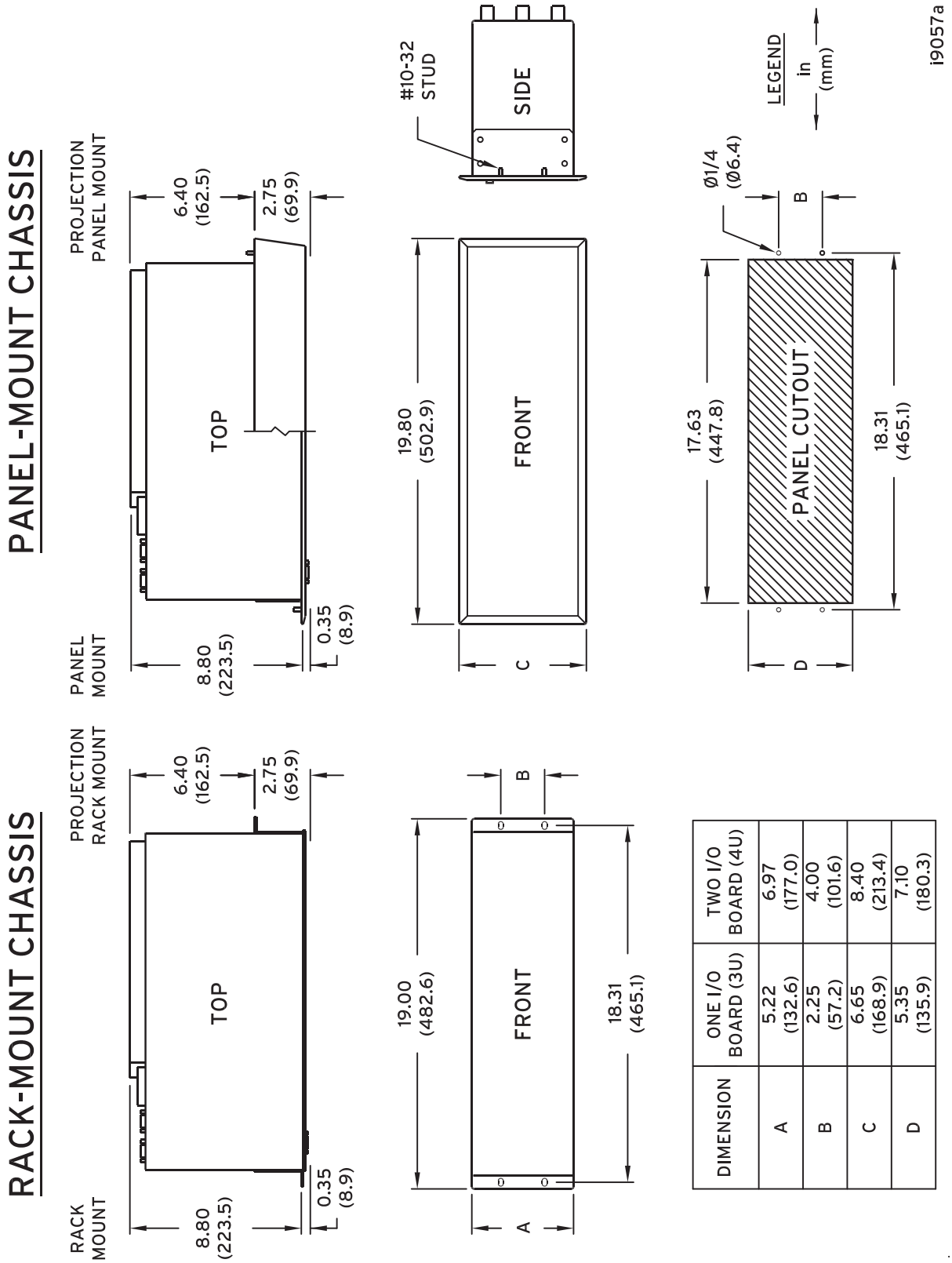
Figure 36 Typical Rear-Panel Diagrams Showing Dual 10/100BASE-T and Dual 100BASE-FX Ethernet

Relay Dimensions



DIMENSION	ONE I/O BOARD (3U)	TWO I/O BOARD (4U)
A	5.22 (132.6)	6.97 (177.0)
B	2.25 (57.2)	4.00 (101.6)
C	6.65 (168.9)	8.40 (213.4)
D	5.35 (135.9)	7.10 (180.3)

For projection rack mounting, brackets must be reversed.

Figure 37 SEL-311L Dimensions for Rack- and Panel-Mount Models

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system
UL Listed to U.S. and Canadian safety standards (File E212775; NRGU, NRGU7)
CE Mark
RCM Mark
Class 1 Laser Product

General

Terminal Connections

Rear Screw-Terminal Tightening Torque:

Minimum:	9-in-lb (1.1 Nm)
Maximum:	12-in-lb (1.3 Nm)

Terminals or stranded copper wire. Ring terminals are recommended. Minimum temperature rating of 105°C.

AC Current Input

Nominal:	5 A
Continuous:	15 A, linear to 100 A symmetrical.
Thermal Rating:	500 A for 1 second. 1250 A for 1 cycle.
Measurement Range:	0.5–96 A (DC offset for 1.5 cycles @ X/R = 10)
Burden:	0.27 VA at 5 A 2.51 VA at 15 A
Nominal:	1 A
Continuous:	3 A, linear to 20 A symmetrical.
Thermal Rating:	100 A for 1 second. 250 A for 1 cycle.
Measurement Range:	0.1–19.2 A (DC offset for 1.5 cycles @ X/R = 10)
Burden:	0.13 VA at 1 A 1.31 VA at 3 A

AC Voltage Inputs

Nominal:	67 V_{L-N} three-phase four-wire connection.
Continuous:	150 V_{L-N} (connect any voltage up to 150 Vac).
Measurement Range:	365 Vac for 10 seconds.
Burden:	0.13 VA at 67 V 0.45 VA at 120 V

Power Supply

Input Voltage

Rated:	125/250 Vdc or Vac
Range:	85–350 Vdc or 85–264 Vac
Rated:	48/125 Vdc or 125 Vac
Range:	38–200 Vdc or 85–140 Vac
Rated:	24/48 Vdc
Range:	18–60 Vdc polarity dependent
Power Consumption:	<25 W

Control Outputs

Standard

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1s Rating:	50 A
MOV Protection (maximum voltage):	270 Vac, 360 Vdc, 40 J
Pickup/Dropout Time:	<5 ms

Breaking Capacity (10,000 operations):

48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

Cyclic Capacity (2.5 cycles/second):

48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

Hybrid (High Current Interrupting)

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1s Rating:	50 A
MOV Protection (maximum voltage):	330 Vdc, 130 J
Pickup/Dropout Time:	<5 ms

Breaking Capacity (10,000 operations):

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Cyclic Capacity (4 interruptions/second, followed by 2 minutes idle for thermal dissipation):

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Note: Make per IEEE C37.90-1989; Breaking and Cyclic Capacity per IEC 60255-23:1994.

Fast Hybrid (High Current Interrupting)

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1s Rating:	50 A
MOV Protection (maximum voltage):	330 Vdc, 130 J
Pickup/Dropout Time:	<10 µs; <8 ms, typical

Breaking Capacity (10,000 operations):

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Cyclic Capacity (4 interruptions/second, followed by 2 minutes idle for thermal dissipation):

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Note: Make per IEEE C37.90-1989; Breaking and Cyclic Capacity per IEC 60255-23:1994.

Optoisolated Inputs

250 Vdc:	Pickup 200–300 Vdc; dropout 150 Vdc
220 Vdc:	Pickup 176–264 Vdc; dropout 132 Vdc
125 Vdc:	Pickup 105–150 Vdc; dropout 75 Vdc
110 Vdc:	Pickup 88–132 Vdc; dropout 66 Vdc
48 Vdc:	Pickup 38.4–60 Vdc; dropout 28.8 Vdc
24 Vdc:	Pickup 15–30 Vdc

Note: 24, 48, 125, 220, and 250 Vdc optoisolated inputs draw approximately 5 mA of current; 110 Vdc inputs draw approximately 8 mA of current. All current ratings are at nominal input voltages.

Frequency and Rotation

System Frequency:	50 or 60 Hz
Phase Rotation:	ABC or ACB
Frequency Tracking:	40.1–65 Hz

Serial Communications Ports

EIA-232:	1 Front, 2 Rear
EIA-485:	1 Rear, 2100 Vdc isolation
Baud Rate:	300–38400 (Port 1 Baud Rate 300–19200)

Ethernet Communications Ports (SEL-311L-1 and SEL-311L-7)

Application Protocols

FTP to Card:	1 server session (supports IEC 61850 CID files)
Telnet to Card:	1 server session (supports SEL ASCII)
Telnet to Host:	1 server session (supports SEL ASCII, SEL Compressed ASCII, Fast Meter and Fast Operate)
IEC 61850:	6 MMS sessions 16 incoming GOOSE messages 8 outgoing GOOSE messages
Web Server:	3 simultaneous read-only server sessions to host

Protocol Stacks

TCP/IP

OSI

Physical Layer Options (**PORT 5** and **PORT 6**)

10/100BASE-T:	10/100 Mbps, RJ45 connector
100BASE-FX:	100 Mbps, LC connector

Indicators (**PORT 5** and **PORT 6**)

Link:	Green LED is on when the link is operational.
Activity:	Red LED blinks when there is transmit or receive activity.

Differential Communications Ports

Fiber Optics—ST Connector

1550 nm Single Mode:

Tx Power:	–18 dBm
Rx Min. Sensitivity:	–58 dBm
Rx Max. Sensitivity:	0 dBm
System Gain:	40 dB
Distance Limitations:	120 km

1300 nm Multimode or Single Mode:

Tx Power:	–18 dBm
Rx Min. Sensitivity:	–58 dBm
Rx Max. Sensitivity:	0 dBm
System Gain:	40 dB
Distance Limitations:	*x* km
where:	*x* = 30 for multimode *x* = 80 for single mode

1300 nm Single Mode (IEEE C37.94-Compatible Modulated):

Tx Power:	–24 dBm
Rx Min. Sensitivity:	–37.8 dBm
Rx Max. Sensitivity:	0 dBm
System Gain:	13.8 dB
Distance Limitations:	15 km

850 nm Multimode, IEEE C37.94-Compatible:

Tx Power:	50 µm: –23 dBm; 62.5 µm: –19 dBm
Rx Min. Sensitivity:	50 µm: –32 dBm; 62.5 µm: –32 dBm
Rx Max. Sensitivity:	50 µm: –11 dBm; 62.5 µm: –11 dBm
System Gain:	50 µm: 9 dB; 62.5 µm: 13 dB
Distance Limitations:	2 km

Electrical

EIA-422:	56 or 64 Kbps synchronous; Isolated to 1500 Vac
CCITT G.703:	64 Kbps synchronous, codirectional

Time-Code Input

Relay accepts demodulated IRIG-B time-code input at Port 1 or 2. Relay time is synchronized to within ±5 ms of time-source input.

Synchronization (specification is with respect to the accuracy of the time source)

Synchrophasor:	±10 µs
Other:	±5 ms

Current differential protection does not require external time source.

Dimensions

Refer to *Figure 37* for relay dimensions.

Operating Temperature

–40° to +85°C (–40° to +185°F)

Note: LCD contrast impaired for temperatures below –20°C

Weight

3U Rack Unit: 6.9 kilograms (15.2 pounds)

4U Rack Unit: 8.3 kilograms (18.3 pounds)

Type Tests

Electromagnetic Compatibility Emissions

	EN 55011: 1998 + A1:1999 + A2:2002
Product Specific Emissions:	IEC 60255-25:2000

Electromagnetic Compatibility Immunity

Conducted RF Immunity:	IEC 60255-22-6:2001 Severity Level: 10 Vrms
Radiated Radio Frequency Immunity:	IEC 60255-22-3:2007 Severity Level: 10 V/m IEC 61000-4-3:2010 Severity Level: 10 V/m
Radiated Digital Radio Telephone RF Immunity:	ENV 50204:1995 Severity Level: 10 V/m at 900 MHz and 1.89 GHz

Electrostatic Discharge Immunity:	IEC 60255-22-2:2008 Severity Level: 2, 4, 6, 8 kV contact; 2, 4, 8, 15 kV air IEEE C37.90.3-2001 Severity Level: 2, 4, and 8 kV contact; 4, 8, and 15 kV air
Fast Transient/Burst Immunity:	IEC 60255-22-4:2008 Severity Level: 4 kV, 5 kHz on power supply, 2 kV, 5 kHz on I/O, signal, data, and control lines IEC 61000-4-4:2011 Severity Level: 4 (4 kV on power supply), 3 (2 kV on inputs and outputs)
Power Supply Immunity:	IEC 60255-11:2008
Radiated Radio Frequency Immunity:	IEEE C37.90.2-2004 Severity Level: 35 V/m
Surge Withstand Capability Immunity:	IEC 60255-22-1:2007 Severity Level: 2.5 kV peak common mode, 1.0 kV peak differential mode IEEE C37.90.1-2002 Severity Level: 2.5 kV oscillatory, 4 kV fast transient waveform

Environmental

Cold:	IEC 60068-2-1:2007 Severity Level: 16 hours at –40°C
Dry Heat:	IEC 60068-2-2:2007 Severity Level: 16 hours at +85°C
Damp Heat, Cyclic:	IEC 60068-2-30:2005 Severity Level: 25°C to 55°C, 6 cycles, Relative Humidity: 95%
Vibration:	IEC 60255-21-3:1993 Severity Level: Class 2 (Quake Response) IEC 60255-21-1:1988 Severity Level: Class 1–Endurance, Class 2–Response IEC 60255-21-2:1988 Severity Level: Class 1–Shock withstand, Bump, and Class 2–Shock Response

Safety

Product Safety:	EN 50263:1999
IP Code:	IEC 60529:2001 + CRGD:2003 Severity Level: IP30 for Category 2 equipment
Insulation Coordination:	IEC 60255-5:2000 Severity Level: 5 kV Impulse on DI, DO, AI, and Power Supply; 2.2 kV on IRIG-B, EIA-485 and Ethernet. 2.5 kVac Dielectric on DI, DO, and AI; 3.1 kVdc on Power Supply; 2.2 kVdc on EIA-485; 1.5 kVac on Ethernet. Type tested for 1 minute.
Laser Safety:	IEC 60825-1:2007 Product Class: Class 1 21 CFR 1040.10 Product Class: Class 1 ANSI Z136.1-2007 Product Class: Class 1
Product Safety:	IEC 60255-6:1988

Processing Specifications

AC Voltage and Current Inputs

16 samples per power system cycle, 3 dB low-pass filter cut-off frequency of 560 Hz.

Digital Filtering

One-cycle full cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.

Current Differential Processing

16 times per power system cycle for line current differential protection and tripping logic.

Backup Protection and Control Processing

4 times per power system cycle

Relay Elements

Line Current Differential (87L) Elements

87L Enable Levels (Difference or Total Current)

Phase Setting Range:	OFF, 1.00 to 10.00 A, 0.01 A steps
Negative-Sequence Setting Range:	OFF, 0.50 to 5.00 A, 0.01 A steps
Zero-Sequence Setting Range:	OFF, 0.50 to 5.00 A, 0.01 A steps
Accuracy:	±3% ±0.01 I_{NOM}

Restraint Characteristics

Outer Radius

Radius Range:	2 to 8 in steps of 0.1 (unitless).
Angle Range:	90–270° in steps of 1°
Accuracy:	±5% of radius setting ±3° of angle setting
Operate Time (for bolted fault):	See operate time curves in *Section 3* of the Instruction Manual.

Note: Refer to *Current Differential Elements* in *Section 3* of the Instruction Manual for the definition of terms and terminology listed above.

Difference Current Alarm Setting

Setting Range:	OFF, 0.5 to 10.0 A, 0.1 A steps
Accuracy:	±3% of ±0.01 I_{NOM}

Substation Battery Voltage Monitor Specifications

Pickup Range:	20–300 Vdc, 1 Vdc steps
Pickup Accuracy:	±2% ±2 Vdc of setting

Timer Specifications

Reclosing Relay Pickup:	0.00–999,999.00 cycles, 0.25-cycle steps (reclosing relay and some programmable timers)
Other Timers:	0.00–16,000.00 cycles, 0.25-cycle steps (some programmable and other various timers)
Pickup/Dropout Accuracy for All Timers:	±0.25 cycle and ±0.1% of setting

Mho Phase Distance Elements

Zones 1–4 Impedance Reach

Setting Range:	OFF, 0.05 to 64.00 Ω secondary, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 320.00 Ω secondary, 0.01 Ω steps (1 A nominal)

Note: Minimum sensitivity is controlled by the pickup of the supervising phase-to-phase overcurrent elements for each zone, load encroachment, OSB, and supervisory directional logic.

Accuracy:	±5% of setting at line angle for 30 ≤ SIR ≤ 60 ±3% of setting at line angle for SIR <30
Transient Overreach:	<5% of setting plus steady-state accuracy

Zones 1–4 Phase-to-Phase Current Fault Detectors (FD)

Setting Range:	0.5–170.0 A_{P-P} secondary, 0.01 A steps (5 A nominal) 0.1–34.0 A_{P-P} secondary, 0.01 A steps (1 A nominal)
Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal)
Transient Overreach:	<5% of pickup
Max. Operating Time:	See pickup and reset time curves in *Section 4* of the Instruction Manual.

Mho and Quadrilateral Ground Distance Elements

Zones 1–4 Impedance Reach

Mho Element Reach:	OFF, 0.05 to 64.00 Ω secondary, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 320.00 Ω secondary, 0.01 Ω steps (1 A nominal)
Quadrilateral Reactance Reach:	OFF, 0.05 to 64.00 Ω secondary, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 320.00 Ω secondary, 0.01 Ω steps (1 A nominal)
Quadrilateral Resistance Reach:	OFF, 0.05 to 50.00 Ω secondary, 0.01 Ω steps (5 A nominal) OFF, 0.25 to 250.00 Ω secondary, 0.01 Ω steps (1 A nominal)

Note: Minimum sensitivity is controlled by the pickup of the supervising phase and residual overcurrent elements for each zone, and supervisory directional logic.

Accuracy:	±5% of setting at line angle for 30 ≤ SIR ≤ 60 ±3% of setting at line angle for SIR <30
Transient Overreach:	<5% of setting plus steady-state accuracy

Zones 1–4 Phase and Residual Current Fault Detectors (FD)

Setting Range:	0.5–100.0 A secondary, 0.01 A steps (5 A nominal) 0.1–20.0 A secondary, 0.01 A steps (1 A nominal)
Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal)
Transient Overreach:	<5% of pickup
Max. Operating Time:	See pickup and reset time curves in *Section 4* of the Instruction Manual.

Undervoltage and Overvoltage Elements

Pickup Range:	OFF, 0.00–150.00 V, 0.01 V steps (various elements) OFF, 0.00–260.00 V, 0.01 V steps (phase-to-phase elements)
Steady-State Pickup Accuracy:	±1 V and ±5% of setting
Transient Overreach	<5% of pickup

Instantaneous/Definite-Time Overcurrent Elements

Pickup Range:	OFF, 0.25–100.00 A, 0.01 A steps (5 A nominal) OFF, 0.05–20.00 A, 0.01 A steps (1 A nominal)
Steady-State Pickup Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal)
Transient Overreach:	<5% of pickup
Time Delay:	0.00–16,000.00 cycles, 0.25-cycle steps
Timer Accuracy:	±0.25 cycle and ±0.1% of setting
Max. Operating Time:	See pickup and reset time curves in *Section 4* of the Instruction Manual.

Time-Overcurrent Elements

Pickup Range:	OFF, 0.25–16.00 A, 0.01 A steps (5 A nominal) OFF, 0.05–3.20 A, 0.01 A steps (1 A nominal)
Steady-State Pickup Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal)
Time Dial Range:	0.50–15.00, 0.01 steps (US) 0.05–1.00, 0.01 steps (IEC)
Curve Timing Accuracy:	±1.50 cycles and ±4% of curve time for current between 2 and 30 multiples of pickup.

Synchronism-Check Elements

Slip Frequency Pickup Range:	0.005–0.500 Hz, 0.001 Hz steps
Slip Frequency Pickup Accuracy:	±0.003 Hz
Phase Angle Range:	0–80°, 1° steps
Phase Angle Accuracy:	±4°

Definite-Time Overfrequency or Underfrequency (81) Elements

Pickup Range:	41.00–65.00 Hz, 0.01 Hz steps
Pickup Time:	32 ms at 60 Hz (max)
Time Delays:	2.00–16,000.00 cycles, 0.25-cycle steps
Maximum Definite-Time Delay Accuracy:	±0.25 cycles, ±1% of setting at 60 Hz
Steady-State plus Transient Overshoot:	±0.01 Hz
Supervisory 27:	20.0–150.0 V, ±5%, ±0.1 V

Metering Accuracy

Voltages

V_A, V_B,V_C, V_S, V_1, V_2, $3V_0$:	±2% (33.5–150 V)

Currents

I_A, I_B, I_C, I_P (Local):	±1% (0.5 to 100.0 A) (5 A nominal) ±1% (0.1 to 20.0 A) (1 A nominal)
I_1,3 I_0, $3I_2$ (Local):	±3% (0.25 to 100.0 A) (5 A nominal) ±3% (0.05 to 20.0 A) (1 A nominal)
I_A, I_B, I_C, $3I_2$, $3I_0$, I_1 (Remote):	±3% (0.25 to 100.0 A) (5 A nominal) ±3% (0.05 to 20.0 A) (1 A nominal)
I_A, I_B, I_C, $3I_2$, $3I_0$, I_1 (Total):	±3% (0.25 to 100.0 A) (5 A nominal) ±3% (0.05 to 20.0 A) (1 A nominal)
Phase Angle Accuracy:	±1°
MW/MVAR:	±3%

Synchrophasor Accuracy

Note: Specification is with respect to **MET PM** command and SEL Fast Message Synchrophasor protocol.

Voltages:	33.5–150 V; 45–65 Hz
Magnitudes:	±2%
Angles:	±1.0°
Currents:	0.50–1.25 A; 45–65 Hz (5 A nominal) 0.10–0.25 A; 45–65 Hz (1 A nominal)
Magnitudes:	±4%
Angles:	±1.5° @ 25°C ±2.0° over the full temperature range
Currents:	1.25–7.50 A; 45–65 Hz (5 A nominal) 0.25–2.50 A; 45–65 Hz (1 A nominal)
Magnitudes:	±2%
Angles:	±1.0° @ 25°C ±1.5° over the full temperature range

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PDS311L-01

SEL-351A Protection System

Optimize Protection, Automation, and Breaker Control

SEL-351A Protection System shown with front-panel USB port and SafeLock® trip/close pushbuttons with high-visibility breaker status LEDs.

Major Features and Benefits

The SEL-351A Protection System provides an exceptional package of protection, monitoring, control, and fault locating features. The SEL-351A-1 Protection System offers an economical, yet impressive feature subset of the SEL-351A. The SEL-351A-1 offers the same functionality as the SEL-351A, except without directional elements, second-harmonic blocking, synchronism checking, load-encroachment, station battery monitoring, and sensitive earth fault elements.

Protection Functions

- Second-harmonic blocking secures relay during transformer energization (SEL-351A only).
- Phase, negative-sequence, residual-ground, and neutral-ground overcurrent elements with directional control optimize radial and looped network protection for lines and equipment. Load-encroachment logic provides additional security to distinguish between heavy load and three-phase faults.
- Under- and overfrequency and under- and overvoltage elements and powerful SELOGIC® control equations help implement load shedding and other control schemes.
- SELOGIC control equations permit custom programming for traditional and unique protection and control functions.
- Four levels of rate-of-change-of-frequency elements help detect rapid frequency changes to initiate load shedding or network decoupling.

Automatic Reclosing and Synchronism Check

- Program as many as four shots of automatic reclosing with two selectable reclose formats.
- Control reclosing schemes for trip saving or fuse saving, and inhibit reclosing for hot-line maintenance.
- Supervise manual or automatic reclosing with synchronism-check and voltage condition logic.

Synchrophasors

- Improve operator awareness of system conditions with standard IEEE C37.118-2005 Level 1 synchrophasors at as many as 60 messages per second.
- Synchronize 128 sample-per-cycle oscillography and event reports to the microsecond to reconstruct complex disturbances. Synchronize meter reports to verify proper phasing.
- Use the "MRI of the power system" to replace state estimation with state measurement.

Metering and Monitoring

- Eliminate expensive, separately mounted metering devices with built-in, high-accuracy metering and harmonic metering functions.
- Improve maintenance scheduling using circuit breaker contact wear and substation battery voltage monitors (SEL-351A only). Record relay and external trips and total interrupted current for each pole.
- Use alarm elements to inhibit reclosing and provide local and remote alarm indication.
- Analyze oscillographic and Sequential Events Recorder (SER) reports for rapid commissioning, testing, and post-fault diagnostics.
- Use unsolicited SER protocol to allow station-wide collection of binary SER messages with original time stamp for easy chronological analysis.
- Synchronize all reports with IRIG-B on the standard rear-panel BNC or on serial Port 2, from Simple Network Time Protocol (SNTP) on the standard or optional Ethernet connections, or via DNP serial or Ethernet protocols. Connect all possible time sources and the relay automatically selects the best.

Fault Locator

- Reduce fault location and repair time with built-in impedance-based fault locator and faulted phase indication.
- Efficiently dispatch line crews to quickly isolate line problems and restore service faster.

Operator Interface and Controls

- Standard target LEDs annunciate trip and status indication and fault type.
- Two-line, large font rotating LCD display provides added operator information with programmable display points.
- Optional SafeLock® trip/close pushbuttons with high-visibility breaker status LEDs eliminate expensive panel-mounted breaker control switches and position indicating lights. The breaker status LED clusters are bright and easy to see from all viewing angles.

Communications Protocols

- Optional IEC 61850 MMS and GOOSE. As many as 6 MMS sessions, guaranteed GOOSE performance with 24 subscriptions and 8 publications.
- Standard Modbus® with label-based map settings (serial and Ethernet—as many as three sessions).
- Standard DNP3 Level 2 with label-based map settings (serial and Ethernet—as many as six sessions).
- IEEE C37.118-2005 synchrophasor protocol (serial and Ethernet).
- ASCII, SEL Fast Meter, SEL Fast Message, SEL Unsolicited SER, SEL Fast Operate, and SEL Distributed Port Switch (LMD) serial protocols are all standard.
- Standard Telnet and integrated web server on Ethernet.
- Parallel redundancy protocol (when supported by hardware).

Communications Hardware

Two 10/100BASE-T Ethernet ports with RJ45 connector included.

- One or two 10/100BASE-FX Ethernet ports with LC multimode fiber-optic connectors optional.
- One 10/100BASE-T Ethernet port and one 10/100BASE-FX Ethernet port with LC multimode fiber-optic connectors optional.
- Front-panel high-speed USB Type-B port included.
- Front-panel EIA-232 DB-9 serial port included.
- Two rear-panel EIA-232 DB-9 ports included.
- One optional rear-panel EIA-485 port with five-position compression terminal block.
- One optional SEL-2812-compatible fiber-optic serial port.

Single-Phase or Three-Phase Wye- or Delta-Connected Voltage Inputs

- Settings allow either single-phase or three-phase wye or three-phase delta voltage inputs.
- Single-phase voltage input permits phantom phase voltage for balanced three-phase metering and other limited voltage-dependent functions.
- The VS voltage input (SEL-351A only) can be used for either synchronism-check or broken-delta (zero-sequence) voltage connection to the relay.

Other Features and Options

Table 1 SEL-351A/SEL-351A-1 Feature Comparison (Sheet 1 of 2)

SEL-351A Features	Standard SEL-351A	Nondirectional, Three Voltage Input SEL-351A-1
SELOGIC Control Equations	Yes	Yes
Event Report	Yes	Yes
Sequential Events Recorder (SER)	Yes	Yes
Breaker Wear and Operate Time Monitor	Yes	Yes
Station Battery Monitor	Yes	No
DNP3 Serial LAN/WAN Outstation (Slave)	Yes	Yes
Modbus RTU and TCP	Yes	Yes
High-Accuracy Metering	Yes	Yes
Remote and Local Control Switches	Yes	Yes
Wye or Delta Voltage Connection	Yes	Yes
Synchrophasor Measurements	Yes	Yes
Fault Locator	Yes	Yes
Fast SER Protocol	Yes	Yes
Directional/Definite-Time Overcurrent Elements	Yes	No
Number of Residual-Ground Time-Overcurrent Elements	2	1
Number of Frequency Elements	6	3
Rate-of-Change-of-Frequency Elements	Yes	Yes
Sensitive Earth Fault Protection and Directional Protection for Various System Grounding Practices	Yes[a]	No
Second-Harmonic Blocking	Yes	No
Load-Encroachment Logic	Yes	No

Table 1 SEL-351A/SEL-351A-1 Feature Comparison (Sheet 2 of 2)

SEL-351A Features	Standard SEL-351A	Nondirectional, Three Voltage Input SEL-351A-1
Synchronism Check	Yes	No
ACSELERATOR QuickSet Compatible	Yes	Yes

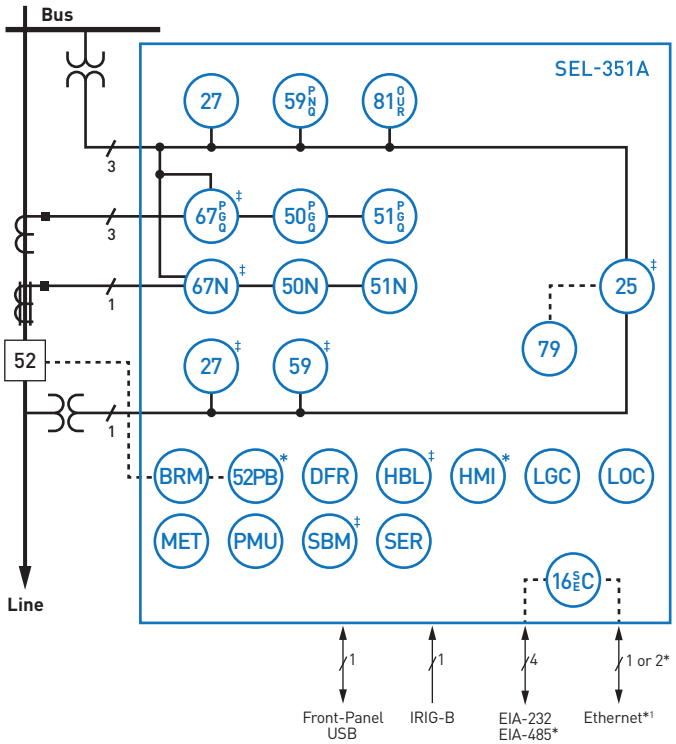
[a] Ordering option.

- Available 750 KB of on-board storage space for ACSELERATOR QuickSet® SEL-5030 Software settings file, ACSELERATOR QuickSet design template, or anything else you choose.
- Nominal 5 A or 1 A current inputs: 5 A phase, 5 A neutral; 5 A phase, 1 A neutral; 1 A phase, 1 A neutral; 0.05 A neutral for nondirectional sensitive earth fault (SEF) protection (SEL-351A only); or 0.2 A neutral for directional ground protection on low-impedance grounded, ungrounded, high-impedance grounded, and Petersen Coil grounded systems (SEL-351A only).

Note: The 0.2 A nominal channel can also provide nondirectional SEF protection. The 0.05 A nominal neutral channel IN option is a legacy nondirectional SEF option.

Functional Overview

Figure 1 shows the device numbers associated with the protection and control functions available on the SEL-351A Protection System, along with a list of the standard and optional monitoring and communications features.



ANSI NUMBERS/ACRONYMS AND FUNCTIONS	
16 SEC	Access Security (Serial, Ethernet)
25	Synchronism Check‡
27	Undervoltage
50G	Best Choice Ground‡
50N	Neutral Overcurrent
50 (P, G, Q)	Overcurrent (Phase, Ground, Neg. Seq.)
50/51	Adaptive Overcurrent
51N	Neutral Time-Overcurrent
51 (P, G, Q)	Time-Overcurrent (Phase, Ground, Neg. Seq.)
52PB	Trip/Close Pushbuttons*
59	Overvoltage‡
59 (P, G, Q)	Overvoltage (Phase, Ground, Neg. Seq.
67N	Directional Neutral Overcurrent‡
67 (P, G, Q)	Directional Overcurrent (Phase; Ground, SEF*; Neg. Seq.)‡
79	Autoreclosing
81 (O, U, R)	Frequency (Over, Under, Rate)
DFR	Event Reports
HMI	Operator Interface*
LGC	SELOGIC® Control Equations
MET	High-Accuracy Metering
PMU	Synchrophasors
SER	Sequential Events Recorder

ADDITIONAL FUNCTIONS	
BRM	Breaker Wear Monitor
HBL	Harmonic Blocking‡
LDE	Load Encroachment‡
LOC	Fault Locator
SBM	Station Battery Monitor‡
PPV	Phantom Phase Voltage

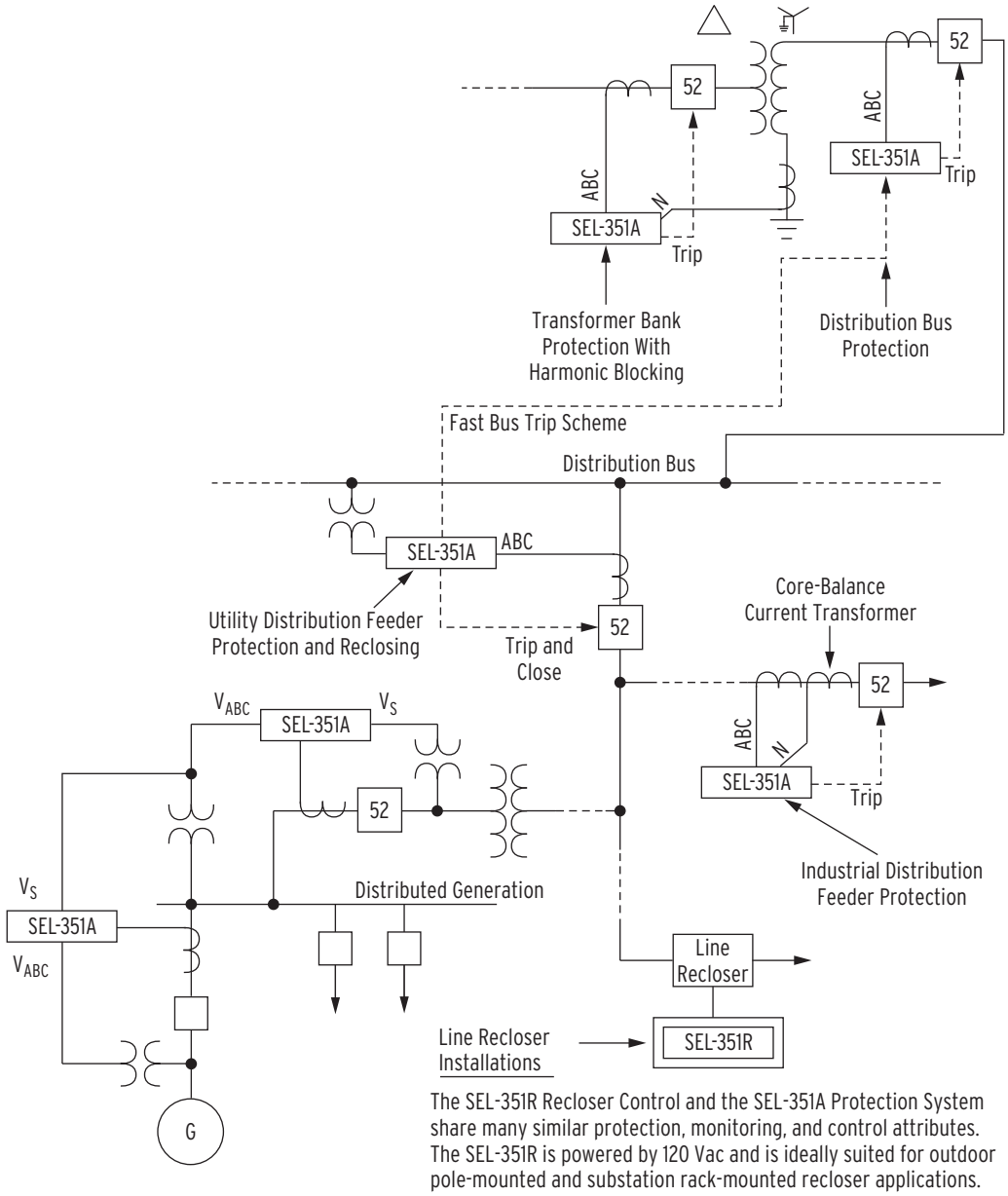
[1] Copper or Fiber Optic ‡ Available on the SEL-351A-0 * Optional Feature

Figure 1 Functional Diagram

Applications

The SEL-351A Protection System has many power system protection, monitoring, and control applications. *Figure 2* shows some of the typical protection applications that are well suited for the SEL-351A. The SEL-351A directional and nondirectional overcurrent functions can be used to protect virtually any power system circuit or device including lines, feeders, breakers, transformers, capacitor banks, reactors, and generators. Special relay versions can be ordered on the SEL-351A to provide nondirectional sensitive ground fault protection on high-impedance grounded systems, and directional overprotection ground fault protection on ungrounded, high-impedance grounded and tuned reactance (Petersen Coil) grounded systems. Over/underfrequency, over/undervoltage, rate-of-change-of-frequency and synchronism-check elements (SEL-351A only) are well suited for applications at distributed generation sites. Directional power elements in the SEL-351A model also make the relay suitable for utility/customer interface protection where customer generation is present.

Powerful SELOGIC control equations in the SEL-351A Protection System can be used to provide custom protection and control applications. SEL Application Guides and technical support personnel are available to help with many unique applications.



The SEL-351R Recloser Control and the SEL-351A Protection System share many similar protection, monitoring, and control attributes. The SEL-351R is powered by 120 Vac and is ideally suited for outdoor pole-mounted and substation rack-mounted recloser applications.

Figure 2 SEL-351A Protection Systems Applied Throughout the Power System

Protection Features

Overcurrent Elements

The SEL-351A includes numerous phase, negative-sequence, residual-ground, and neutral overcurrent elements, as shown in *Table 2*.

Table 2 SEL-351A Phase, Negative-Sequence, Residual-Ground, and Neutral Overcurrent Elements

Overcurrent Element Operating Quantity	Number of Elements	Directional Control	Torque Control	Definite-Time Delay
Maximum phase current (IA, IB, or IC)	1 inverse-time (51P)	Yes	Yes	NA
	6 instantaneous (50P1–50P6)	Yes, on first 4	Yes, on first 4	Yes, on first 4
Maximum phase-phase current (IAB, IBC, or ICA)	4 instantaneous (50PP1–50PP4)	No	No	No
Independent phase current	3 inverse-time (51A, 51B, 51C)	Yes	Yes	NA
Residual-ground current (3I0)	2 inverse-time (51G, 51G2)	Yes	Yes	NA
	6 instantaneous (50G1–50G6)	Yes, on first 4	Yes, on first 4	Yes, on first 4
Negative-sequence current (3I2)	1 inverse-time (51Q)	Yes	Yes	NA
	6 instantaneous (50Q1–50Q6)	Yes, on first 4	Yes, on first 4	Yes, on first 4
Neutral current (IN)	1 inverse-time (51N)	Yes	Yes	NA
	6 instantaneous (50N1–50N6)	Yes, on first 4	Yes, on first 4	Yes, on first 4

Inverse-time overcurrent element settings include a wide and continuous pickup current range, continuous time-dial setting range, and time-current curve choices from both US (IEEE) and IEC standard curves shown in *Table 3*.

Table 3 Inverse Time-Overcurrent Curves

IEEE	IEC
Moderately Inverse (U1)	Standard Inverse (C1)
Inverse (U2)	Very Inverse (C2)
Very Inverse (U3)	Extremely Inverse (C3)
Extremely Inverse (U4)	Long-Time Inverse (C4)
Short-Time Inverse (U5)	Short-Time Inverse (C5)

Use multiple inverse curves to coordinate with downstream reclose fast and delay curves. Sequence coordination logic is also included to provide coordination between fast and delayed curves on the SEL-351A and downstream reclosers. *Figure 3* represents an SEL-351A coordinated to a downstream SEL-351R Recloser Control. Inverse-time relay curve settings include a wide and continuous pickup current and time-dial (vertical multiplier) range.

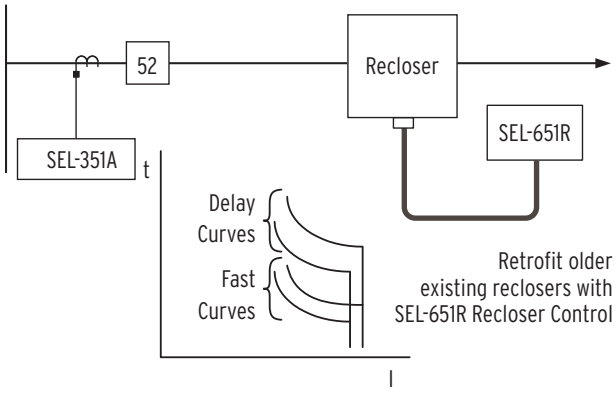


Figure 3 Coordinate Overcurrent Protective Devices

The SEL-351A Protection System inverse-time overcurrent relay curve settings offer two reset characteristic choices for each element. Setting EM Reset Delay = Y emulates electromechanical induction disc elements, where the reset time depends on the time-dial setting, the percentage of disc travel, and the amount of current. Setting EM Reset Delay = N resets the elements immediately if current drops below pickup for at least one cycle.

Overcurrent Elements for Phase Fault Detection

The SEL-351A Protection System provides the tools necessary to provide sensitive fault protection, yet accommodate heavily loaded circuits. Where heavy loading prevents the phase overcurrent elements from being set sufficiently sensitive to detect lower magnitude phase-to-ground faults, residual-ground overcurrent elements are available to provide sensitive ground fault protection without tripping under balanced heavy load conditions. Likewise, when heavy loading prevents the phase overcurrent elements from being set sufficiently sensitive to detect lower magnitude phase-to-phase faults, negative-sequence overcurrent elements are available to provide more sensitive phase-to-phase fault detection without tripping under balanced heavy load conditions. Phase overcurrent element pickup can be set high to accommodate heavy load, yet remain sensitive to higher magnitude three-phase faults. Block any element during transformer inrush with programmable second-harmonic blocking (SEL-351A only).

On extremely heavily loaded feeders, when phase overcurrent elements cannot be set to provide adequate three-phase fault sensitivity and also accommodate load, the SEL-351A load-encroachment logic (not available in the SEL-351A-1) adds security. This logic allows you to set the phase overcurrent elements below peak load current to see end-of-line phase faults in heavily loaded feeder applications. This load-encroachment logic uses positive-sequence load-in and load-out elements to discriminate between load and fault conditions based on the magnitude and angle of the positive-sequence impedance (*Figure 4*). When the measured positive-sequence load impedance (Z1) resides in a region defined by the load-encroachment settings, load-encroachment logic blocks the phase overcurrent elements. As *Figure 4* shows, when a phase fault occurs, Z1 moves from a load region to the line angle and allows the phase overcurrent elements to operate.

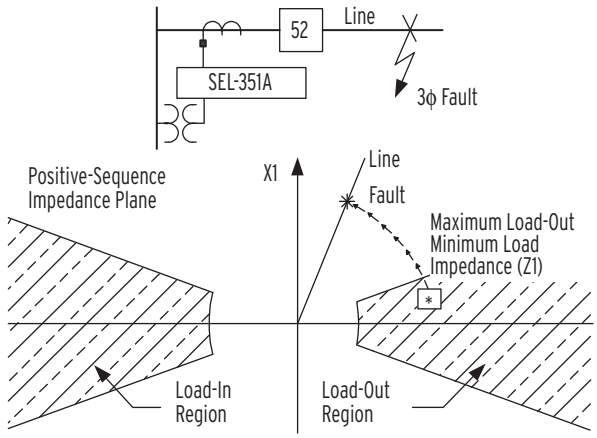


Figure 4 Load-Encroachment Characteristics

Overcurrent Elements for Ground Fault Detection

Residual-ground (I_G) and neutral (I_N) overcurrent elements detect ground faults. Increase security by controlling these elements using optoisolated inputs or the internal ground directional element. The SEL-351A Protection System includes patented Best Choice Ground Directional Element® logic, providing a selection of negative-sequence impedance, zero-sequence impedance, and zero-sequence current polarizing techniques for optimum directional ground element control.

Connect a Single-Phase Voltage Input or a Three-Phase Voltage With Wye or Open-Delta Connected Potential Transformers

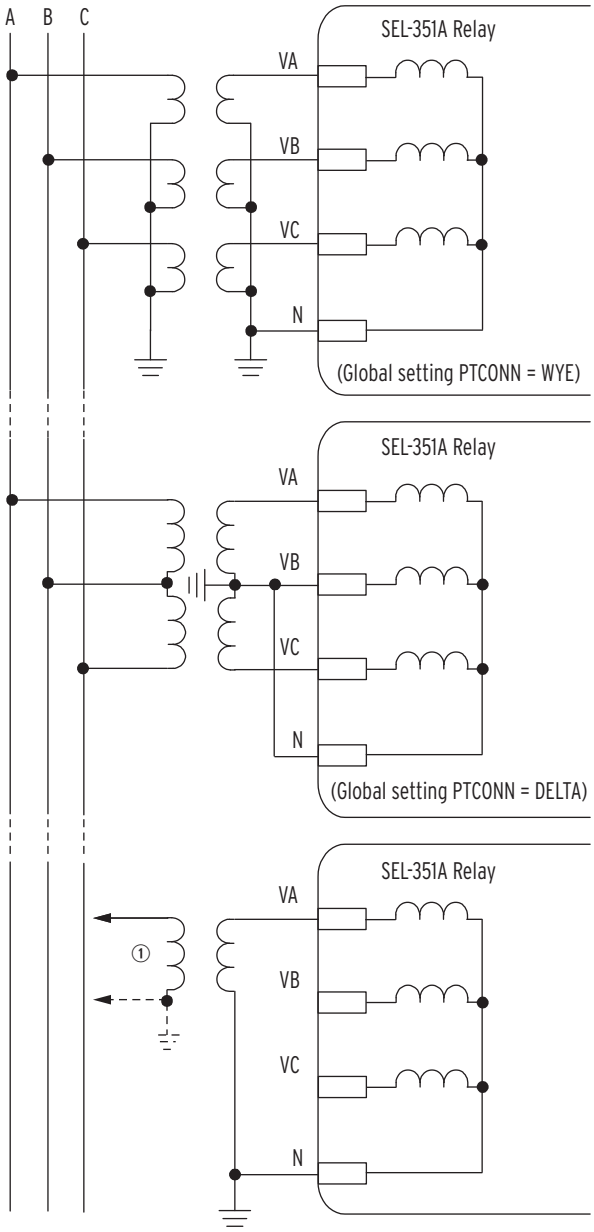
With a single-phase voltage input connected, the SEL-351A Protection System creates phantom phase voltages to emulate balanced three-phase voltages for metering. The single-phase voltage must be connected to VA and N, as shown in *Figure 5*, but can come from any phase or phase-to-phase voltage source. Make Global setting PTCONN = SINGLE and set PHANTV to the desired phase or phase-to-phase voltage to identify the single-phase voltage source for proper metering. Single-phase voltage input also permits some voltage-dependent protection functions. See *Table 4* for more details. Other nonprotection functions, including fault locating, are not available with only single-phase voltage connected.

Three-phase voltages from either wye-connected (four-wire) or open-delta-connected (three-wire) sources can be applied to three-phase voltage inputs VA, VB, VC, and N, as shown in *Figure 5*. You only need to make a Global setting (PTCONN = WYE or PTCONN = DELTA, respectively) and an external wiring change—no internal relay hardware changes or adjustments are required. Three-phase, wye-connected voltage inputs permit full use of voltage-dependent protection functions. Some limitations exist with delta-connected voltage inputs. See *Table 4* for more details.

Table 4 Voltage-Dependent Protection Function Availability Based on Voltage Source Connection

Voltage-Dependent Protection Functions	Voltage Source		
	Single-phase	Three-phase wye	Three-phase delta
Phase Over/Undervoltage	Yes	Yes	No
Phase-to-Phase Over/Undervoltage	No	Yes	Yes
Sequence Over/Undervoltage	No	Yes	Positive and negative
Over/Underfrequency	Yes	Yes	Yes
Load Encroachment	No	Yes	Yes
Phase and Negative-Sequence Directional Overcurrent	No	Yes	Yes
Ground Directional Overcurrent	Yes[a]	Yes	Yes
Communications-Assisted Trip Logic	No	Yes	Yes
Loss-of-Potential Logic	No	Yes	Yes

[a] Requires 3I0 current polarization on IN, or 3V0 voltage polarization on VS input.



① Connections / PHANTV =

Connections	PHANTV =
VA-G	VA
VB-G	VB
VC-G	VC
VA-B	VAB
VB-C	VBC
VC-A	VCA

Global settings:
PTCONN = SINGLE
PHANTV = (see ①)

A single-phase voltage can be connected to provide phantom three-phase voltages for metering.

Figure 5 Connect Wye or Open-Delta Voltage to SEL-351A Three-Phase Voltage Inputs or Connect any Single-Phase or Phase-to-Phase Voltage to VA and N

Connect to Synchronism-Check or Broken-Delta Voltage (SEL-351A Only)

Traditionally, single-phase voltage (phase-to-neutral or phase-to-phase) is connected to voltage input VS/NS for synchronism check across a circuit breaker (or hot/dead-line check), as shown in *Figure 22*.

Alternatively, voltage input VS/NS can be connected to a broken-delta voltage source, as shown in *Figure 6*. This broken-delta connection provides a zero-sequence voltage source (3V0)—useful when zero-sequence voltage is not available via the three-phase voltage inputs VA, VB, VC, and N, (e.g., when open-delta-connected voltage is applied to the three-phase voltage inputs—see *Figure 5*). Zero-sequence voltage is used in zero-sequence voltage-polarized ground directional elements and in the directional protection for Petersen Coil grounded systems.

Choosing between synchronism-check or broken-delta (3V0) voltage source operation for voltage input VS/NS requires only a Global setting (VSCONN = VS or VSCONN = 3V0, respectively) and an external wiring change—no internal relay hardware changes or adjustments are required. Therefore, a single SEL-351A model can be used in either traditional synchronism-check applications or broken-delta voltage applications.

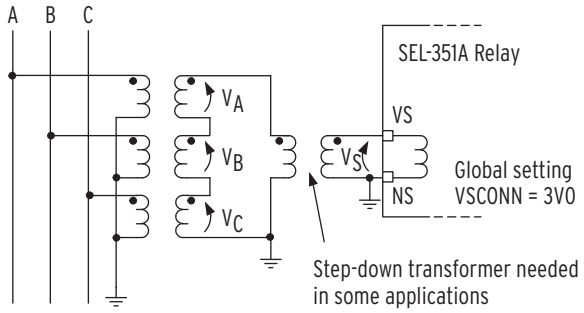


Figure 6 Broken-Delta Connection to SEL-351A Voltage Input VS/NS

Directional Elements Increase Sensitivity and Security (SEL-351A Only)

Phase and ground directional elements are standard. An automatic setting mode (E32 = AUTO) sets all directional threshold settings based on replica positive-sequence and zero-sequence line impedance settings (Z1MAG, Z1ANG, Z0MAG, and Z0ANG) for line protection applications. For all non-line protection applications, set E32 = Y to enable and set appropriate directional element thresholds.

Phase directional elements provide directional control to the phase- and negative-sequence overcurrent elements. Phase directional characteristics include positive-sequence and negative-sequence directional elements that work together. The positive-sequence directional element memory provides a reliable output for close-in, forward or reverse three-phase faults where each phase voltage is zero.

Ground directional elements provide directional control to the residual-ground and neutral overcurrent elements. The patented negative-sequence and zero-sequence impedance directional elements and the zero-sequence current directional element use the same principles proven in our SEL transmission line relays. Our patented Best Choice Ground Directional Element logic selects the optimum ground directional element based on the ORDER setting you provide.

Directional Protection for Various System Grounding Practices (SEL-351A Only)

Current channel IN, ordered with an optional 0.2 A secondary nominal rating, provides directional ground protection for the following systems:

- Ungrounded systems
- High-impedance grounded systems
- Petersen Coil grounded systems
- Low-impedance grounded systems

This optional directional control allows the faulted feeder to be identified on a multifeeder bus, with an SEL-351A on each feeder (*Figure 7*). Alarm or trip for the ground fault condition with sensitivity down to 5 mA secondary.

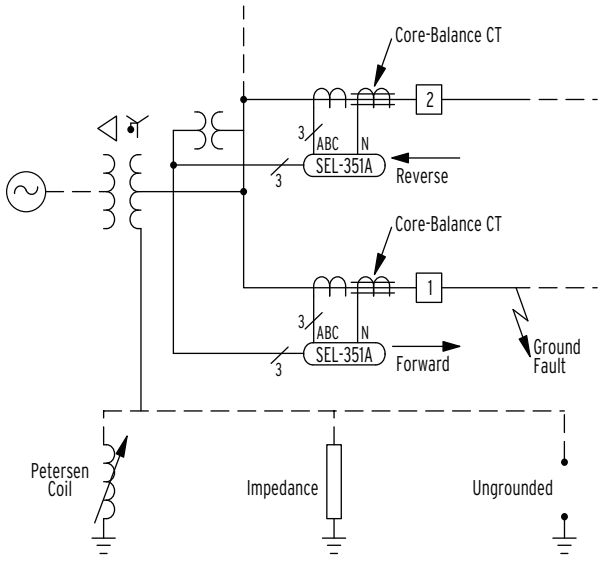


Figure 7 Apply SEL-351A Relays to Petersen Coil Grounded, Impedance-Grounded, and Ungrounded Systems for Directional Control

Loss-of-Potential Logic (SEL-351A Only) Supervises Directional Elements

Voltage-polarized directional elements rely on valid input voltages to make correct decisions. The SEL-351A includes loss-of-potential (LOP) logic that detects one, two, or three blown potential fuses. For an LOP condition, you can chose to disable all directional elements (set ELOP = Y), disable all reverse directional elements and enable forward directional elements as nondirectional (set ELOP = Y1), or chose not to affect the directional element operation with LOP logic (set ELOP = N).

This patented LOP logic is unique, as it does not require settings and is universally applicable. The LOP logic does not monitor the VS voltage input, nor does it affect zero-sequence voltage-polarized ground directional elements when a broken-delta 3V0 voltage source is connected to the VS-NS terminals. The LOP logic is not available when only single-phase voltage is applied to the relay.

Programmable Torque-Control Feature Handles Cold-Load Energization (SEL-351A Only)

When a feeder is re-energized following a prolonged outage, lost load diversity causes large phase currents (cold-load inrush). Avoid phase overcurrent element misoperation during cold-load inrush by programming cold-load block elements into the phase overcurrent element torque controls. One example of a cold-load block element is a time-delayed 52 status (long time-delay pickup and dropout timer with 52 as the input). An alternative is to detect the long outage condition (breaker open) automatically, and temporarily switch to a setting group with higher phase overcurrent element pickup thresholds.

Harmonic Blocking Elements Secure Protection During Transformer Energization (SEL-351A Only)

Transformer inrush can cause sensitive protection to operate. Use the second-harmonic blocking feature to detect an inrush condition and block selected tripping elements until the inrush subsides. Select the blocking threshold as a percentage of fundamental current, and optimize security and dependability with settable pickup and dropout times. Use the programmable torque-control equation to only enable the blocking element immediately after closing the beaker.

Voltage and Frequency Elements for Extra Protection and Control

Under/Overvoltage Elements

Phase (wye-connected and single-phase only) or phase-to-phase and single-phase undervoltage (27) and overvoltage (59) elements in the SEL-351A create the following protection and control schemes:

- Torque control for the overcurrent protection
- Hot-bus (line), dead-bus (line) recloser control
- Blown transformer high-side fuse detection logic
- Trip/alarm or event report triggers for voltage sags and swells
- Undervoltage (27) load shedding scheme. Having both 27 and 81U load shedding schemes allows detection of system MVAR- and MW-deficient conditions.
- Control schemes for capacitor banks

Use the following undervoltage and overvoltage elements, associated with the V_S voltage channel, for additional control and monitoring:

- Hot-line/dead-line recloser control
- Ungrounded capacitor neutrals
- Ground fault detection on delta systems
- Generator neutral overvoltage
- Broken-delta zero-sequence voltage (see *Figure 6*)

Sequence Voltage Elements

Independently set positive-, negative-, and zero-sequence voltage elements provide protection and control. Applications include transformer bank single-phase trip schemes and delta-load back-feed detection scheme for dead-line recloser control. Note that zero-sequence elements are not available when the relay is delta connected, and no sequence elements are available when only single-phase voltage is connected.

Under/Overfrequency Protection

Six (three in the SEL-351A-1) levels of secure under- (81U) or overfrequency (81O) elements detect true frequency disturbances. Use the independently time-delayed output of these elements to shed load or trip local generation. Phase undervoltage supervision prevents undesired frequency element operation during faults.

Implement an internal multistage frequency trip/restore scheme at each breaker location using the multiple under/overfrequency levels. This avoids the cost of wiring a complicated trip and control scheme from a separate frequency relay.

Rate-of-Change-of-Frequency Protection

Four independent rate-of-change-of-frequency elements are provided with individual time delays for use when frequency changes occur, such as when there is a sudden imbalance between generation and load. They call for control action or switching action such as network decoupling or load shedding. Each element includes logic to detect either increasing or decreasing frequency.

Operator Controls and Reclosing

Optional SafeLock Trip/Close Pushbuttons and Indicating LEDs

Optional SafeLock trip/close pushbuttons (see *Figure 8*) and bright indicating LEDs allow breaker control independent of the relay. The trip/close pushbuttons are electrically separate from the relay, operating even if the relay is powered down. Make the extra connections at terminals **Z15** through **Z22**. See *Figure 23* through *Figure 26* for front-panel and rear-panel views. *Figure 9* shows one possible set of connections.

The trip/close pushbuttons incorporate an arc suppression circuit for interrupting dc trip or close current to protect the internal electrical contacts. To use these pushbuttons with ac trip or close circuits, disable the arc suppression for either pushbutton by changing jumpers inside the SEL-351A. The operating voltage ranges of the **BREAKER CLOSED** and **BREAKER OPEN** indicating LEDs are also jumper selectable.

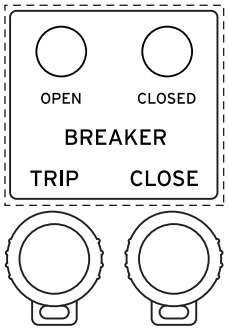


Figure 8 SafeLock Trip/Close Pushbuttons and Indicators

Note: The SafeLock trip/close pushbuttons and breaker status LEDs always have configurable labels. Dashed lines outline the configurable label area where text can be changed.

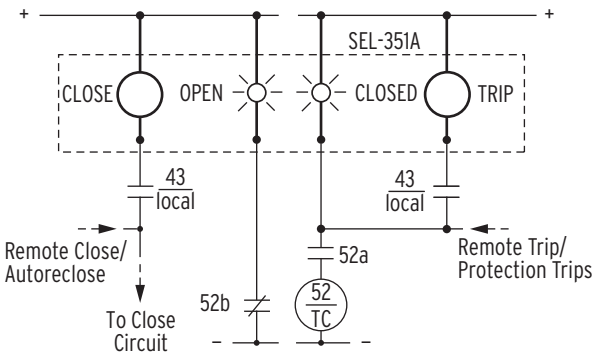


Figure 9 Optional SafeLock Trip/Close Pushbuttons and Indicating LEDs

Local and Remote Control

Under certain operating conditions, such as performing distribution feeder switching, it is desirable to temporarily disable ground fault protection. This is accomplished in a variety of ways using SELOGIC control equations with local and remote control. As shown in *Figure 10*, achieve remote disable/enable control using an optoisolated input or the serial communications port. The local control switch function handles local disable/enable control. Output contacts, serial ports and the local LCD display points indicate ground relay operating status. Local and remote control capabilities require programming SELOGIC control equations.

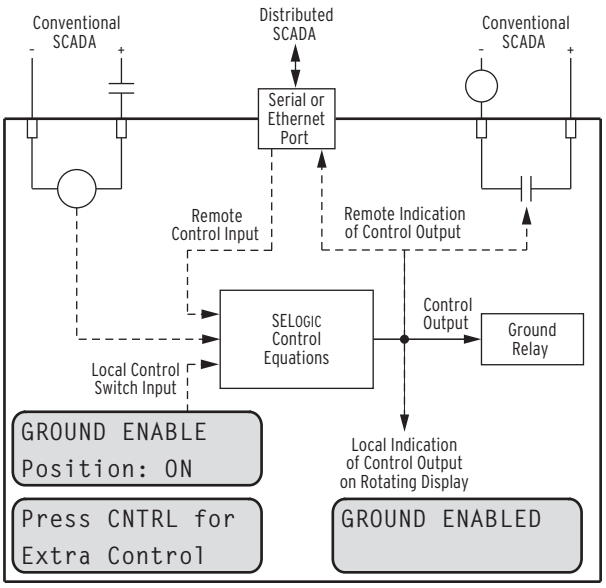


Figure 10 Local and Remote Control Using SELOGIC Control Equations (ground relay example)

Programmable Autoreclosing

The SEL-351A autoreclose flexibility allows many different reclosing strategies to meet traditional and custom requirements. Traditional applications include sequence coordination, fuse-saving, and trip-saving schemes. The SEL-351A can autoreclose a circuit breaker as many as four times before lockout. Use SELOGIC control equations to enable and disable reclosing, define reclose initiation and supervision conditions, shot counter advance and drive-to-lockout conditions, close supervision and close failure conditions, and open interval timer start and stall conditions. Separate time delays are available for reset-from-successful-reclose and reset-from-lockout conditions. The reset timer can be stalled if the relay detects an overcurrent condition after the breaker closes to prevent the recloser from resetting before the relay trips on a permanent slow-clearing fault.

Program the SEL-351A to perform unconditional reclose, conditional reclose using voltage check and synchrocheck functions, and even autosynchronizing when the two systems are asynchronous. Select from two recloser supervision failure modes: one drives to lockout, the other advances to the next available shot. The front-panel LEDs (**RESET**, **CYCLE**, and **LOCKOUT**) track the recloser state.

Relay and Logic Settings Software

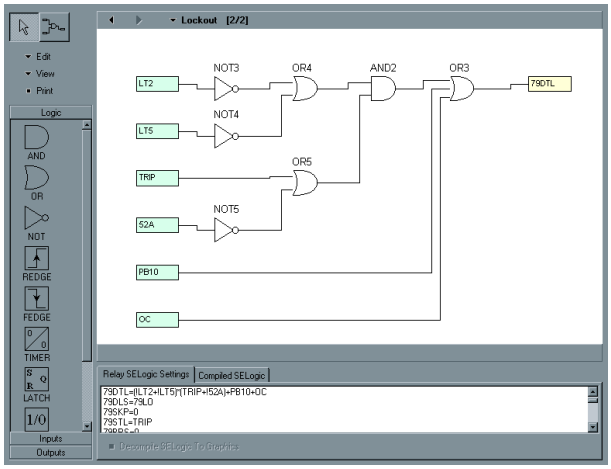


Figure 11 ACSELERATOR QuickSet Software Screen

The ACSELERATOR QuickSet software program uses the Microsoft® Windows® operating system to simplify settings and provide analysis support for the SEL-351A.

Use ACSELERATOR QuickSet to create and manage relay settings and analyze events:

- ➤ Develop settings off-line with an intelligent settings editor that only allows valid settings.
- ➤ Create SELOGIC control equations with a drag and drop graphical editor and/or text editor.
- ➤ Use online help to assist with configuring proper settings.
- ➤ Organize settings with the relay database manager.
- ➤ Load and retrieve settings using a simple PC communications link.
- ➤ Enter settings into a settings template generated with licensed versions of SEL ACSELERATOR QuickSet. Send resulting settings and the template to the relay with a single action. When reading settings from the relay, ACSELERATOR QuickSet also retrieves the template and compares the settings generated by the template to those in use by the relay, alerting you to any differences.
- ➤ Analyze power system events with the integrated waveform and harmonic analysis tools.

Use ACSELERATOR QuickSet to aid with monitoring, commissioning, and testing the SEL-351A:

- ➤ Use the human-machine interface (HMI) to monitor meter data, Relay Word bits, and output contacts status during testing.
- ➤ Use the PC interface to remotely retrieve breaker wear, voltage sag/swell/interruption reports, and other power system data.

Integrated Web Server

An embedded web server is included in every SEL-351A relay. Browse to the relay with any standard web browser to safely read settings, verify relay self-test status, inspect meter reports, and read relay configuration and event history. The web server allows no control or modification actions at Access Level 1 (ACC), so users can be confident that an inadvertent button press will have no adverse effects. *Figure 12* shows an example of a settings display web page.

The web server allows users with the appropriate engineering access level (2AC) to upgrade the firmware over an Ethernet connection. An Ethernet port setting enables or disables this feature, with the option of requiring front-panel confirmation when the file is completely uploaded.

The SEL-351A firmware files contain cryptographic signatures that enable the SEL-351A to recognize official SEL firmware. A digital signature, computed using the Secure Hash Algorithm 1 (SHA-1), is appended to the compressed firmware file. Once the firmware is fully uploaded to the relay, the relay verifies the signature using a Digital Signature Algorithm security key that SEL stored on the device. If the signature is valid, the firmware is upgraded in the relay. If the relay cannot verify the signature, it reverts back to the previously installed firmware.

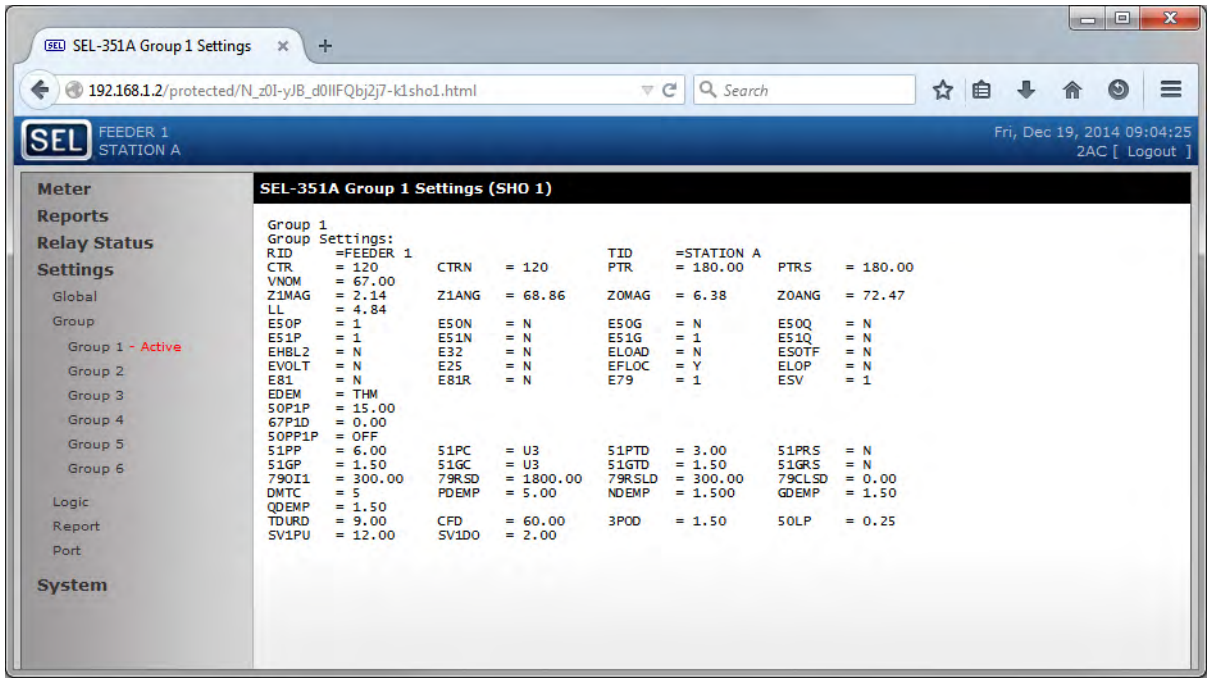


Figure 12 Settings Display Web Page

Metering and Monitoring

Table 5 Metering Capabilities[a] (Sheet 1 of 2)

Quantities	Description
Currents $I_{A,B,C,N}$, I_G	Input currents, residual-ground current ($I_G = 3I_0 = I_A + I_B + I_C$).
Voltages $V_{A,B,C}$	Wye-connected and single-phase voltage inputs.
Voltages $V_{AB,BC,CA}$	Delta-connected voltage inputs, or calculated from wye-connected voltage inputs.
Voltage V_S	Synchronism-check or broken-delta voltage input.
Harmonics and THD	Current and voltage rms, THD, and harmonics to the 16th harmonic.
Power $MW_{A,B,C,3P}$, $MVAR_{A,B,C,3P}$	Single-[b] and three-phase megawatts and megavars.

Table 5 Metering Capabilities[a] (Sheet 2 of 2)

Quantities	Description
Energy $MWh_{A,B,C,3P}$, $MVARh_{A,B,C,3P}$	Single-[b] and three-phase megawatt-hours and megavar-hours.
Power Factor $PF_{A,B,C,3P}$	Single-[b] and three-phase power factor; leading or lagging.
Sequence I_1, $3I_2$, $3I_0$, V_1, V_2, $3V_0$	Positive-, negative-, and zero-sequence currents and voltages.[c]
Frequency, FREQ (Hz)	Instantaneous power system frequency (monitored on channel V_A).
Power Supply Vdc	Battery voltage (not available in SEL-351A-1)
Demand and Peak Current, $I_{A,B,C,N,G}$, $3I_2$	Phase, neutral, ground, and negative-sequence currents
Demand and Peak Power, $MW_{A,B,C,3P}$, $MVAR_{A,B,C,3P}$	Single- and three-phase megawatts and megavars, in and out

[a] If single-phase or true three-phase voltage is not connected, voltage, MW/MVAR, MWh/MVARh, and power factor metering values are not available. With single-phase voltage connected and Global setting PTCONN = SINGLE, the relay measures the single-phase voltage and calculates other phase voltages and power measurements assuming balanced three-phase voltage.
[b] Note that single-phase power, energy, and power factor quantities are not available when delta-connected PTs are used.
[c] Sequence voltages are not metered with only single-phase voltage connected and Global setting PTCONN = SINGLE.

Complete Metering Capabilities

The SEL-351A provides extensive and accurate metering capabilities. See *Specifications on page 26* for metering and power measurement accuracies.

As shown in *Table 5*, metered quantities include phase voltages and currents (including demand currents); sequence voltages and currents; power (including demand), frequency, and energy; and maximum/minimum logging of selected quantities. The relay reports all metered quantities in primary quantities (current in A primary and voltage in kV primary).

The SEL-351A also includes harmonic meters, Total Harmonic Distortion (THD), and rms metering through the 16th harmonic.

```
=>MET H <Enter>

FEEDER 1                          Date: 11/13/09    Time: 13:19:22.102
STATION A

             Currents (A pri)                Voltages (kV pri)
             IA      IB      IC      IN      VA      VB      VC      VS
THD  (%)      19      22      11       0       2       4       2       2
RMS         35.40   41.79   38.60    0.00   21.61   21.54   21.50   21.50
Fund.       34.77   40.80   38.35    0.00   21.60   21.52   21.50   21.50

Harmonic
2    (%)       0       0       0       0       0       0       0       0
3    (%)       7      14       4       0       0       4       0       0
4    (%)       0       0       0       0       0       0       0       0
5    (%)       3      12       6       0       2       0       0       0
6    (%)       0       0       0       0       0       0       0       0
7    (%)      13       4       2       0       0       0       2       2
8    (%)       0       0       0       0       0       0       0       0
9    (%)       5       6       4       0       0       0       0       0
10   (%)       0       0       2       0       0       0       0       0
11   (%)       6       6       0       0       0       0       0       0
12   (%)       0       0       0       0       0       0       0       0
13   (%)       3       3       6       0       0       0       0       0
14   (%)       0       0       0       0       0       0       0       0
15   (%)       2       3       0       0       0       0       0       0
16   (%)       8       4       0       0       0       0       0       0

=>
```

Event Reporting and Sequential Events Recorder (SER)

Event Reports and the SER simplify post-fault analysis and improve understanding of simple and complex protective scheme operations. In response to a user-selected trigger, the voltage, current, frequency, and element status information contained in each event report confirms relay, scheme, and system performance for every fault. The Global setting LER determines if the relay stores 15-cycle, 30-cycle, or 60-cycle event reports. The relay stores the most recent eleven 60-cycle, twenty-three 30-cycle, or forty-four 15-cycle event reports in nonvolatile memory; a total of 11 seconds of oscillography. The relay always appends relay settings to the bottom of each event report.

The following event report formats are available:

- 1/4-cycle, 1/16-cycle, 1/32-cycle, or 1/128-cycle resolution
- Unfiltered or filtered analog
- ASCII or Compressed ASCII

The relay SER feature stores the latest 1024 entries. Use this feature to gain a broad perspective at a glance. An SER entry helps to monitor input/output change-of-state occurrences, element pickup/dropout, and recloser state changes.

The IRIG-B time-code input synchronizes the SEL-351A time to within 1 ms of the time-source input. A convenient source for this time code is an SEL communications processor (combining data and IRIG signals via Serial Port 2 on the SEL-351A) or an SEL GPS clock connected to the high-accuracy BNC IRIG-B connector on the SEL-351A rear panel. The optional SEL-2812-compatible fiber-optic serial port is also an IRIG-B source when paired with a compatible serial transceiver that transmits IRIG-B.

Synchrophasor Measurements

Send synchrophasor data using IEEE C37.118-2005 protocol to SEL synchrophasor applications. These include the SEL-3306 Synchrophasor Processor, SEL-3378 Synchrophasor Vector Processor (SVP), SEL-3530 Real-Time Automation Controller (RTAC), and the SEL SYNCHROWAVE® Central software suite. The SEL-3306 Synchrophasor Processor time correlates data from multiple SEL-351A relays and concentrates the result into a single output data stream. The SEL-3378 SVP enables control applications based on synchrophasors. Directly measure the oscillation modes of your power system. Act on the result. Properly control islanding of distributed generation using wide-area phase angle slip and acceleration measurements. With the SVP you have the power to customize synchrophasor control application based on the unique requirements of your power system. Then use SEL SYNCHROWAVE software to archive and display wide-area system measurements, which are precisely time-aligned using synchrophasor technology.

The data rate of SEL-351A synchrophasors is selectable with a range of one to sixty messages per second. This flexibility is important for efficient use of communications capacity. The SEL-351A phasor measurement accuracy meets the highest IEEE C37.118-2005 Level 1 requirement of 1 percent total vector error (TVE). This means you can use the low-cost SEL-351A in any application that otherwise would have required purchasing a separate dedicated phasor measurement unit (PMU).

Backward compatibility with the SEL Fast Message Protocol is maintained in the SEL-351A. Send data from one message per second to slower rates such as one message per minute using this protocol. The slow data rates are useful for integration into an existing SCADA scan rate. Use with the SEL communications processors, or the SEL-3530 RTAC, to change nonlinear state estimation into linear state estimation. If all necessary lines include synchrophasor measurements then state estimation is no longer necessary. The system state is directly measured.

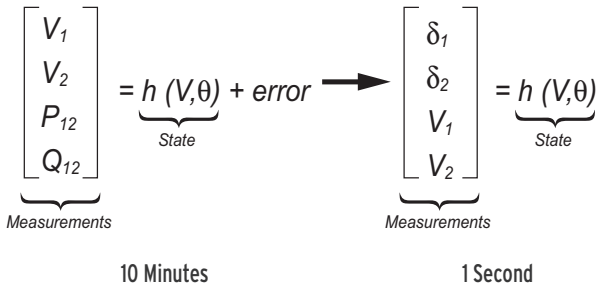


Figure 13 Synchrophasor Measurements Turn State Estimation Into State Measurement

Improve Situational Awareness

Provide improved information to system operators. Advanced synchrophasor-based tools provide a real-time view of system conditions. Use system trends, alarm points, and preprogrammed responses to help operators prevent a cascading system collapse and maximize system stability. Awareness of system trends provides operators with an understanding of future values based on measured data.

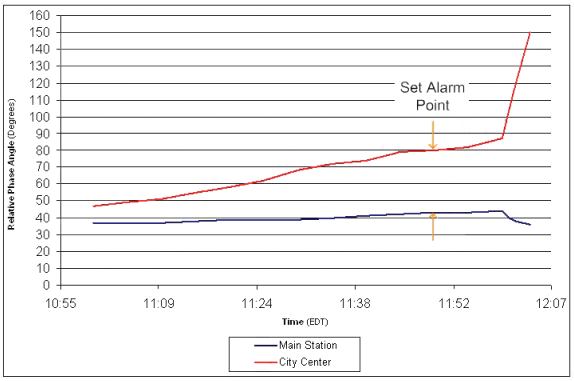


Figure 14 Visualization of Phase Angle Measurements Across a Power System

- Increase system loading while maintaining adequate stability margins.
- Improve operator response to system contingencies such as overload conditions, transmission outages, or generator shutdown.
- Advance system knowledge with correlated event reporting and real-time system visualization.
- Validate planning studies to improve system load balance and station optimization.

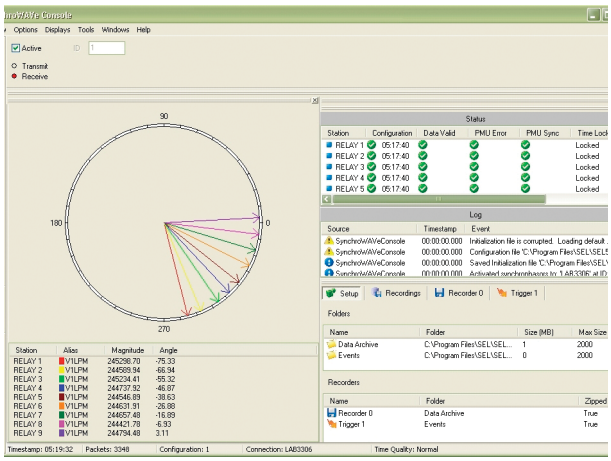


Figure 15 SEL-5078-2 SYNCHROWAVE Console Real-Time, Wide-Area Visualization Tool

Demand Current Threshold Alarm

Use overload and unbalanced current threshold alarms for phase, negative-sequence, neutral, and residual demand currents.

Two types of demand-measuring techniques are offered: thermal and rolling.

Select the demand ammeter time constant from 5 to 60 minutes.

Circuit Breaker Operate Time and Contact Wear Monitor

Circuit breakers experience mechanical and electrical wear every time they operate. Intelligent scheduling of breaker maintenance takes into account manufacturer's published data of contact wear versus interruption levels and operation count. With the breaker manufacturer's maintenance curve as input data, the SEL-351A breaker monitor feature compares this input data to the measured (unfiltered) ac current at the time of trip and the number of close to open operations.

Every time the breaker trips, it integrates the measured current information. When the result of this integration exceeds the breaker wear curve threshold (*Figure 16*) the relay alarms via output contact, serial port, or front-panel display. This kind of information allows timely and economical scheduling of breaker maintenance.

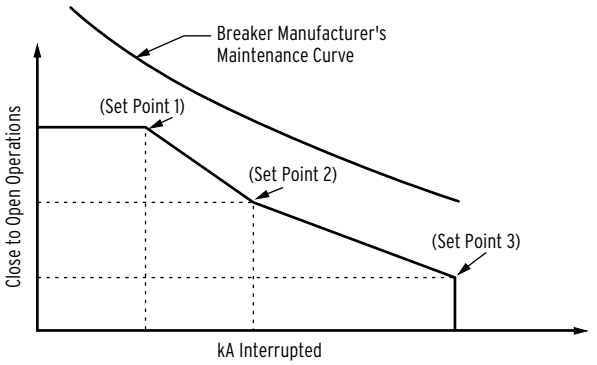


Figure 16 Breaker Contact Wear Curve and Settings

The relay monitors and records electrical and mechanical breaker operate times and minimum dc voltage for open and close operations. Use the settable alarm thresholds to issue warning alarms for slow mechanical or electrical trip or close operations. Inspect reports for the most recent operation, or gather trending data for as many as 128 previous operations. Retrieve breaker monitor reports through FTP or Manufacturing Message Specification (MMS) file transfer.

Substation Battery Monitor (SEL-351A Only)

The SEL-351A measures and reports the substation battery voltage connected to the power supply terminals. The relay includes two programmable threshold comparators and associated logic for alarm and control. For example, if the battery charger fails, the measured dc falls below a programmable threshold. The SEL-351A alarms operations personnel before the substation battery voltage falls to unacceptable levels. Monitor these thresholds with SEL communications processors and trigger messages, telephone calls, or other actions.

The measured dc voltage appears in the `METER` display and the `VDC` column of the event report. Use the event report column data to see an oscillographic display of the battery voltage. You can see how much the substation battery voltage drops during trip, close, and other control operations.

Fault Locator

The SEL-351A provides a valuable estimate of fault location even during periods of substantial load flow. The fault locator uses fault type, replica line impedance settings, and fault conditions to calculate fault location without communications channels, special instrument transformers, or prefault information. This feature contributes to efficient dispatch of line crews and fast restoration of service. The fault locator requires three-phase voltage inputs. Wye-connected voltages are required for phase and ground fault distance calculations. Only phase fault distance calculations are available with delta-connected voltages. The fault locator is not available when no voltage or single-phase voltages are connected. The fault locator also does not operate for ground faults on ungrounded, high-impedance grounded, or Petersen Coil grounded systems.

Automation

Flexible Control Logic and Integration Features

The SEL-351A Protection System is equipped with two 10/100BASE-T Ethernet ports on the rear panel, a front-panel USB port, and three independently-operated serial ports: one EIA-232 serial port on the front panel and two EIA-232 serial ports on the rear panel. Communications port ordering options include replacing the standard metallic Ethernet port with a 100BASE-FX optical Ethernet port, dual-redundant 100BASE-FX optical Ethernet ports, or with one 10/100BASE-T metallic and one 100BASE-FX fiber port. Additional options include an isolated EIA-485 rear-panel port or SEL-2812-compatible rear-panel fiber-optic port. The USB Type-B port on the front panel allows for fast local communication. A special driver required for USB communication is provided with the product literature CD.

The relay does not require special communications software. Use any system that emulates a standard terminal system. Establish communication by connecting computers, modems, protocol converters, data concentrators, port switchers, communications processors, and printers.

Connect multiple SEL-351A relays to an SEL communications processor, an SEL real-time automation controller (RTAC), and SEL computing platform, or an SEL synchrophasor vector processor for advanced data collection, protection, and control schemes (see *Figure 17*).

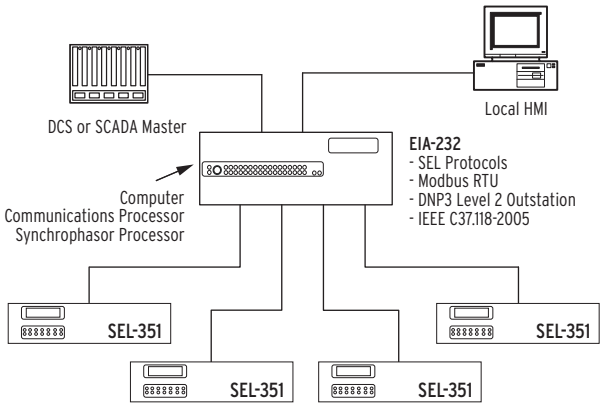


Figure 17 Typical Serial Communications Architecture

SEL manufactures a variety of standard cables for connecting this and other relays to a variety of external devices. Consult your SEL representative for more information on cable availability. The SEL-351A can communicate directly with SCADA systems, computers, and RTUs via serial or Ethernet port for local or remote communication (see *Figure 18*).

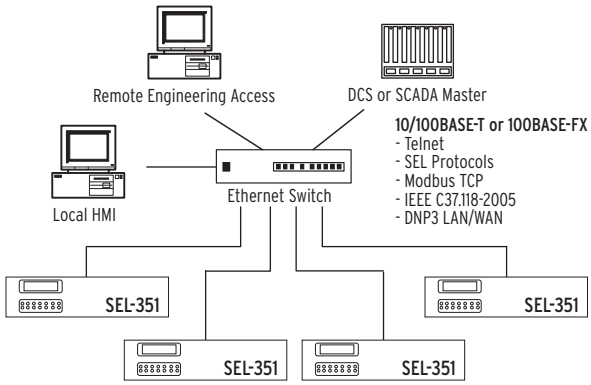


Figure 18 Typical Ethernet Communications Architecture

Dual-Port Ethernet Network Configuration Options

The dual-port Ethernet option increases network reliability and availability by incorporating the relay with external managed or unmanaged switches. Implement a self-healing ring structure with managed switches, or use unmanaged switches in a dual-redundant configuration (see *Figure 19* and *Figure 20*).

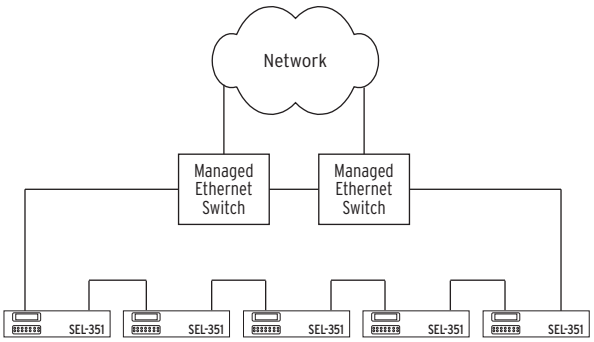


Figure 19 Self-Healing Ring Using Internal Ethernet Switch

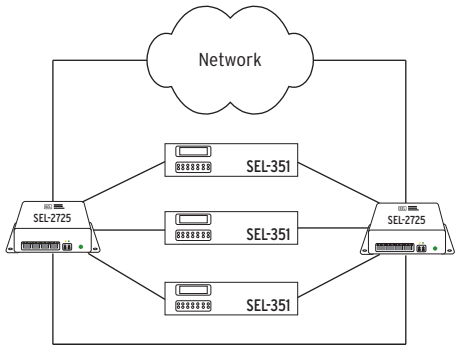


Figure 20 Failover Network Topology

Table 6 lists the communications protocols available on the SEL-351A for protection, monitoring, control, interrogation, setting, and reporting.

Table 6 Open Communications Protocols

Type	Description
IEC 61850	Ethernet-based international standard for interoperability between intelligent devices in a substation. Operates remote bits, breaker controls, and I/O. Monitors Relay Word bits and analog quantities. Use MMS file transfer to retrieve event and breaker monitor reports.
Simple ASCII	Plain language commands for human and simple machine communication. Use for metering, setting, self-test status, event reporting, and other functions.
Compressed ASCII	Comma-delimited ASCII data reports. Allows external devices to obtain relay data in an appropriate format for direct import into spreadsheets and database programs. Data are checksum protected.
Extended Fast Meter and Fast Operate	Serial or Telnet binary protocol for machine-to-machine communication. Quickly updates SEL communications processors, RTUs, and other substation devices with metering information, relay element and I/O status, time-tags, open and close commands, and summary event reports. Data are checksum protected. Binary and ASCII protocols operate simultaneously over the same communications lines so binary SCADA metering information is not lost while an engineer or technician is transferring an event report or communicating with the relay using ASCII communication through the same relay communications port.
SEL Distributed Port Switch (LMD) Protocol	Enables multiple SEL devices to share a common communications bus (two-character address setting range is 01–99). Use this protocol for low-cost, port-switching applications.
Fast SER Protocol	Provides serial or Ethernet SER data transfers with original time stamps to an automated data collection system.
Modbus RTU or TCP	Serial or Ethernet-based Modbus with point remapping. Includes access to metering data, protection elements, contact I/O, targets, relay summary events, and settings groups.
DNP3 Serial or LAN/WAN	Serial or Ethernet-based Distributed Network Protocol with point remapping. Includes access to metering data, protection elements, contact I/O, targets, SER, relay summary event reports, and setting groups.
IEEE C37.118-2005	Serial or Ethernet Phasor Measurement Protocol. Streams synchrophasor data to archiving historian for post-disturbance analysis, to visualization software for real-time monitoring, or to synchrophasor data processor for real-time control.

Control Logic and Integration

SEL-351A control logic improves integration in the following ways:

- **Replace traditional panel control switches.** As many as 16 local control switch functions (Local Bits LB1–LB16) can be programmed for operation through the **CNTRL** front-panel pushbutton (available on all SEL-351A-1 relays and on SEL-351A relays equipped with a front-panel LCD display). Set, clear, or pulse selected Local Bits and program the front-panel operator pushbuttons and LEDs and the Local Bits into your control scheme with SELOGIC control equations. Use the Local Bits to

perform functions such as turning ground tripping and autoreclosing on and off or a breaker trip/close.

- **Eliminate RTU-to-relay wiring.** Use serial or LAN/WAN communication to control as many as 32 remote control switches (Remote Bits RB1–RB32). Set, clear, or pulse selected Remote Bits over serial port or network communication using ASCII, DNP, or Modbus commands. Program the Remote Bits into your control scheme with SELOGIC control equations. Use Remote Bits for SCADA-type control operations such as trip, close, and turning autoreclose on or off.
- **Replace traditional latching relays.** Perform traditional latching relay functions, such as "remote control enable", with 16 internal logic latch control switches (Latch Bits LT1–LT16). Program latch set and latch reset conditions with SELOGIC control equations. Set or reset the nonvolatile Latch Bits using optoisolated inputs, remote control switches, local control switches, or any programmable logic condition. The Latch Bits retain their state when the relay loses power.
- **Replace traditional indicating panel lights.** Use 16 programmable rotating messages on the front-panel LCD display to define custom text messages (e.g., Breaker Open, Breaker Closed, and real-time analog quantities) that report power system or relay conditions. Use SELOGIC control equations to control which rotating display messages are displayed.
- **Eliminate external timers.** Provide custom protection or control schemes with 16 general purpose SELOGIC control equation timers. Each timer has independent time-delay pickup and dropout settings. Program each timer input with any desired element (e.g., time qualify a current element). Assign the timer output to trip logic, transfer trip communication, or other control scheme logic.
- **Eliminate settings changes.** Selectable setting groups make the SEL-351A ideal for applications requiring frequent setting changes and for adapting the protection to changing system conditions.

  The relay stores six setting groups. Select the active setting group by optoisolated input, command, or other programmable conditions. Use these setting groups to cover a wide range of protection and control contingencies.

  Changing setting groups switches logic and relay element settings. Program groups for different operating conditions, such as feeder paralleling, station maintenance, seasonal operations, emergency contingencies, loading, source changes, and downstream relay setting changes.

Fast SER Protocol

SEL Fast Sequential Events Recorder (SER) protocol provides SER events to an automated data collection system. SEL Fast SER protocol is available on any serial port. Devices with embedded processing capability can use these messages to enable and accept unsolicited binary SER messages from SEL-351A Relays.

SEL relays and communications processors have two separate data streams that share the same serial port. The normal serial interface consists of ASCII character commands and reports that are intelligible to people using a terminal or terminal emulation package. The binary data streams can interrupt the ASCII data stream to obtain information, and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communication (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering or SER data.

Added Capabilities

Status and Trip Target LEDs

The SEL-351A includes 16 status and trip target LEDs on the front panel to indicate if the relay is enabled (healthy), follow the reclosing relay state, and to latch in on various trip conditions. This combination of targets is explained in *Table 7* and shown in *Figure 21*.

Table 7 Description of Front-Panel LEDs (Sheet 1 of 2)

Target LED	Function
ENABLED	Relay powered properly and self-tests are okay.
TRIP	Trip occurred.
INST	Trip due to instantaneous overcurrent element operation.
COMM	Trip triggered by a direct transfer trip (DTT).
SOTF	Switch-onto-fault trip.

Table 7 Description of Front-Panel LEDs (Sheet 2 of 2)

Target LED	Function
50	Inst./def.-time overcurrent trip.
51	Time-overcurrent trip.
81	Underfrequency trip.
RECLOSING STATE	
RESET	Ready for reclose cycle.
CYCLE	Actively in trip/reclose cycle mode.
LOCKOUT	Reclosing relay is in lockout state.
FAULT TYPE	
A, B, C (fixed logic)	Involved phases latch in on trip.
G	Ground involved in fault.
N	Neutral element (channel IN) trip.

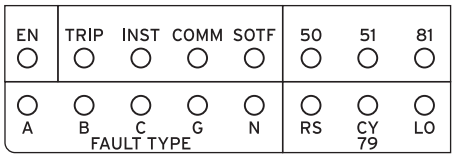


Figure 21 Status and Trip Target LEDs

Wiring Diagram

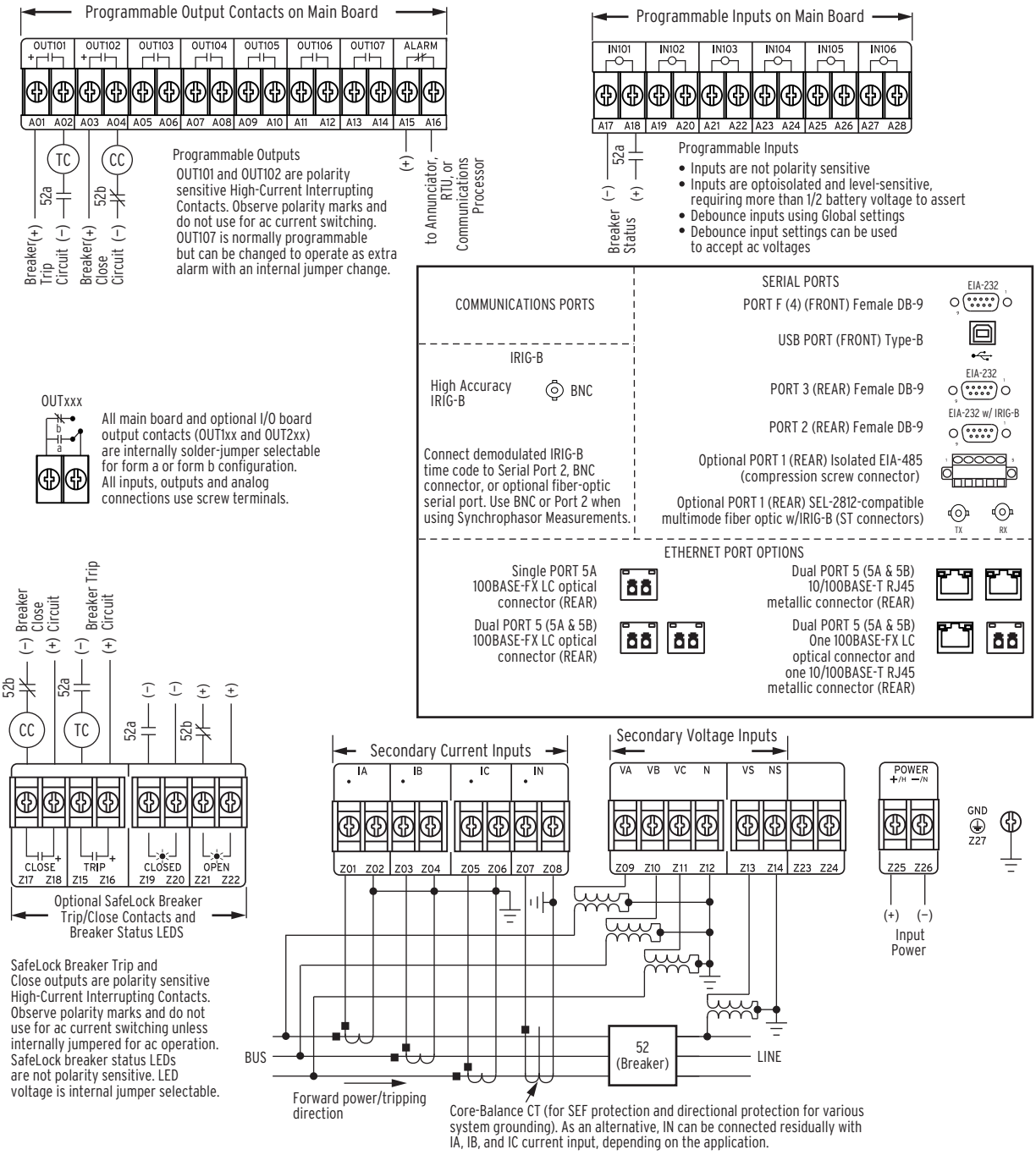
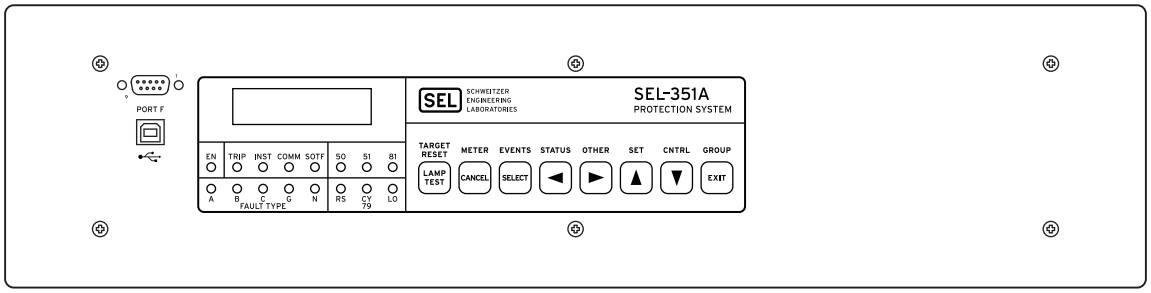
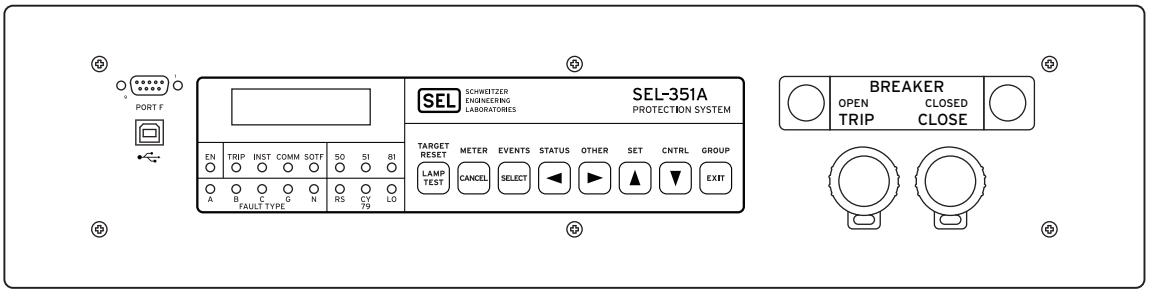


Figure 22 Example SEL-351A Wiring Diagram (Wye-Connected PTs; Synchronism-Check Voltage Input)

Mechanical Diagrams

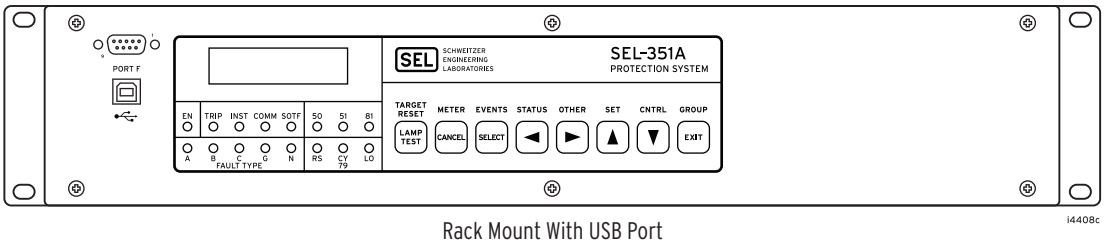


Panel or Projection Mount With USB Port

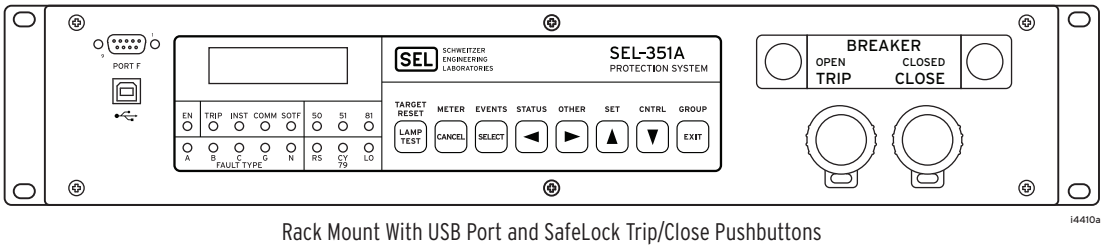


Panel or Projection Mount With USB Port and SafeLock Trip/Close Pushbuttons

Figure 23 SEL-351A Horizontal Panel-Mount Front-Panel Drawings (shown with LCD display and pushbuttons—optional on the SEL-351A and standard on the SEL-351A-1)

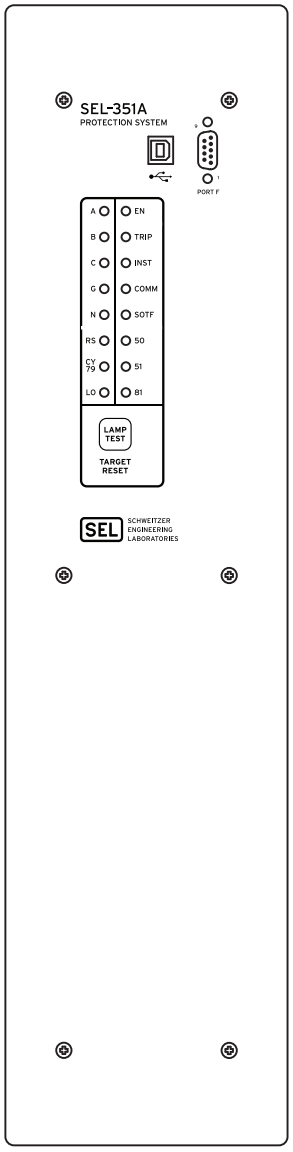


Rack Mount With USB Port

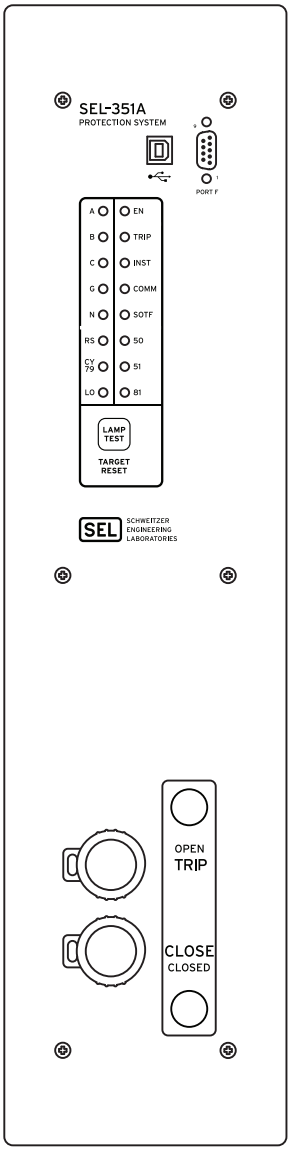


Rack Mount With USB Port and SafeLock Trip/Close Pushbuttons

Figure 24 SEL-351A Horizontal Rack-Mount Front-Panel Drawings (shown with LCD display and pushbuttons—optional on the SEL-351A and standard on the SEL-351A-1)

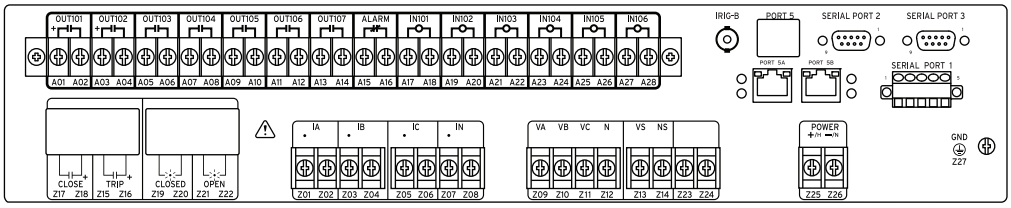


Panel Mount With
USB Port

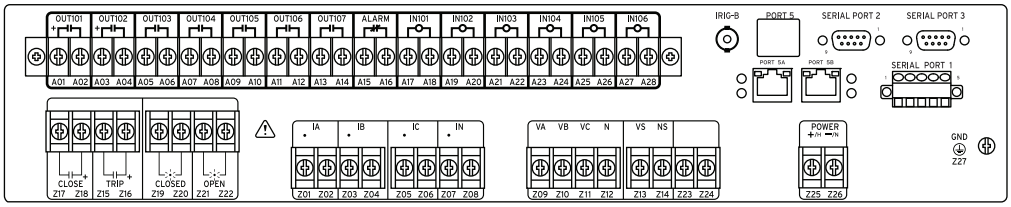


Panel Mount With
USB Port and SafeLock
Trip/Close Pushbuttons

Figure 25 SEL-351A Vertical Front-Panel Drawings (not available on the SEL-351A-1)



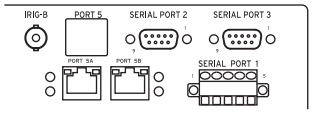
Standard



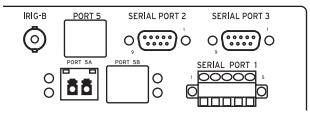
Optional SafeLock Trip/Close Pushbuttons

Vertical mount is identical to horizontal mount configuration rotated by 90 degrees counterclockwise.

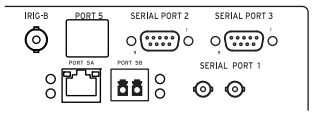
Figure 26 SEL-351A Horizontal Rear-Panel Drawings (refer to Figure 27 for port configurations)



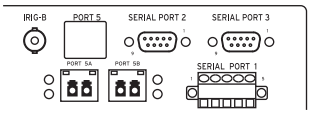
Dual-redundant 10/100BASE-T metallic Ethernet ports (5A and 5B) with EIA-485 serial Port 1



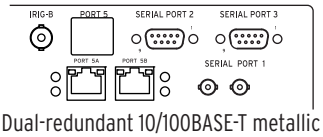
Single 100BASE-FX fiber Ethernet port (5A) with EIA-485 serial Port 1



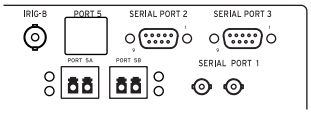
Dual-redundant 10/100BASE-T metallic and 100BASE-FX Ethernet ports (5A and 5B) with fiber-optic serial Port 1



Dual-redundant 100BASE-FX Ethernet ports (5A and 5B) with EIA-485 serial Port 1



Dual-redundant 10/100BASE-T metallic Ethernet ports (5A and 5B) with fiber-optic serial Port 1



Dual-redundant 100BASE-FX Ethernet ports (5A and 5B) with fiber-optic serial Port 1

Figure 27 SEL-351A Rear-Panel Communications Port Configurations

Relay Mounting

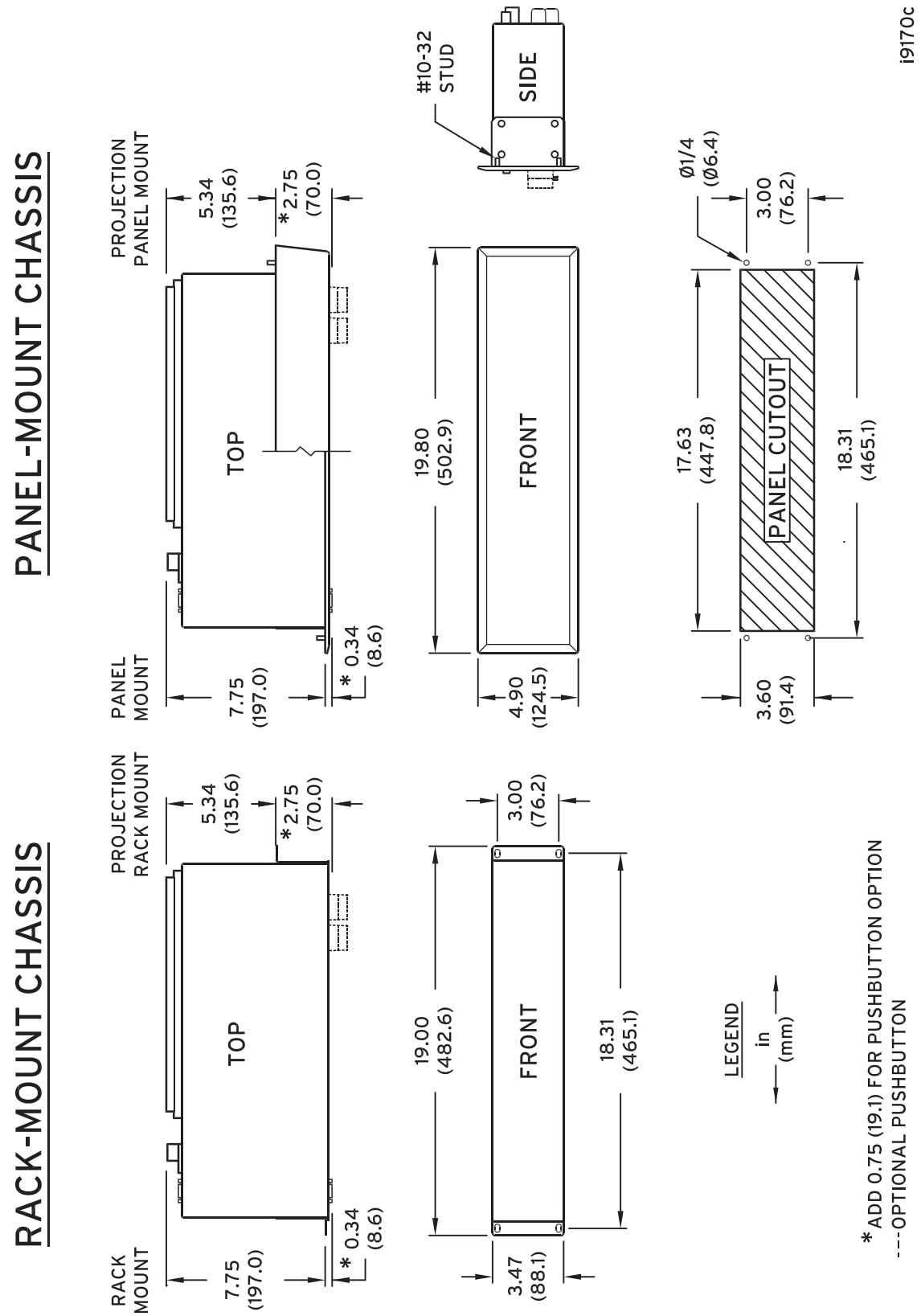


Figure 28 SEL-351A Dimensions and Drill Plan for Rack-Mount and Panel-Mount Models

Specifications

Important: Do not use the following information to order an SEL-351A. Refer to the actual ordering information sheets.

Compliance

Designed and manufactured under an ISO 9001 certified quality management system
UL Listed to US and Canadian safety standards (File E212775; NRGU, NRGU7)
CE Mark
RCM Mark

General

Terminal Connections

Note: Terminals or stranded copper wire. Ring terminals are recommended. Minimum temperature rating of 75ºC.

Tightening Torque

Terminals A01–A28 Terminals B01–B40 (if present):	1.1–1.3 Nm (9–12 in-lb)
Terminals Z01–Z27:	1.1–1.3 Nm (9–12 in-lb)
Serial Port 1 (EIA-485, if present):	0.6–0.8 Nm (5–7 in-lb)

AC Voltage Inputs

Nominal Range

Line to Neutral:	67–120 Vrms
Line to Line (open delta):	115–260 Vrms
Continuous:	300 Vrms
Short-Term Overvoltage:	600 Vac for 10 seconds
Burden:	0.03 VA @ 67 V; 0.06 VA @ 120 V; 0.8 VA @ 300 V

AC Current Inputs

IA, IB, IC, and Neutral Channel IN

5 A Nominal:	15 A continuous (20 A continuous at 55°C), 500 A for 1 s, linear to 100 A symmetrical, 1250 A for 1 cycle
Burden:	0.27 VA @ 5 A, 2.51 VA @ 15 A
1 A Nominal:	3 A continuous (4 A continuous at 55°C), 100 A for 1 s, linear to 20 A symmetrical, 250 A for 1 cycle
Burden:	0.13 VA @ 1 A, 1.31 VA @ 3 A

Additional Neutral Channel IN Options

0.2 A Nominal Neutral Channel (IN) Current Input:	15 A continuous, 500 A for 1 second, linear to 6.4 A symmetrical 1250 A for 1 cycle
Burden:	0.00009 VA @ 0.2 A, 0.54 VA @ 15 A
0.05 A Nominal Neutral Channel (IN) Current Input:	15 A continuous, 500 A for 1 second, linear to 6.4 A symmetrical 1250 A for 1 cycle
Burden:	0.000005 VA @ 0.05 A, 0.0054 VA @ 1.5 A

Note: The 0.2 A nominal neutral channel IN option is used for directional control on low-impedance grounded, Petersen Coil grounded, and ungrounded/ high-impedance grounded systems (see *Table 4.4*). The 0.2 A nominal channel can also provide nondirectional sensitive earth fault (SEF) protection.
The 0.05 A nominal neutral channel IN option is a legacy nondirectional SEF option.

Power Supply

Rated:	125/250 Vdc nominal or 120/230 Vac nominal
Range:	85–350 Vdc or 85–264 Vac
Burden:	<25 W
Rated:	48/125 Vdc nominal or 120 Vac nominal
Range:	38–200 Vdc or 85–140 Vac
Burden:	<25 W
Rated:	24/48 Vdc nominal
Range:	18–60 Vdc polarity dependent
Burden:	<25 W

Frequency and Rotation

Note: 60/50 Hz system frequency and ABC/ACB phase rotation are user-settable.

Frequency Tracking Range:	40–65 Hz (Zero-crossing detection method, preferred source: **VA-N** terminals. Backup source(s) **VB-N** or **VC-N**, depending on PT configuration).
Maximum Rate of Change:	~20 Hz/s (The relay will not measure faster-changing frequencies, and will revert to nominal frequency if the condition is maintained for more than 0.25 s)

Output Contacts

Standard

DC Output Ratings

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1s Rating:	50 A
MOV Protected:	270 Vac/360 Vdc/75 J
Pickup Time:	Less than 5 ms
Dropout Time:	Less than 5 ms, typical

Breaking Capacity (10,000 operations):

24 V	0.75 A	L/R = 40 ms
48 V	0.50 A	L/R = 40 ms
125 V	0.30 A	L/R = 40 ms
250 V	0.20 A	L/R = 40 ms

Cyclic Capacity (2.5 cycle/second):

24 V	0.75 A	L/R = 40 ms
48 V	0.50 A	L/R = 40 ms
125 V	0.30 A	L/R = 40 ms
250 V	0.20 A	L/R = 40 ms

Note: Make per IEEE C37.90-1989.
Note: Breaking and Cyclic Capacity per IEC 60255-0-20:1974.
Note: EA certified relays do not have MOV protected standard output contacts.

AC Output Ratings

Maximum Operational Voltage (U_e) Rating:	240 Vac
Insulation Voltage (U_i) Rating (excluding EN 61010-1):	300 Vac
Utilization Category:	AC-15 (control of electromagnetic loads > 72 VA)
Contact Rating Designation:	B300 (B = 5 A, 300 = rated insulation voltage)

Voltage Protection Across Open Contacts:	270 Vac, 40 J
Rated Operational Current (I_e):	3 A @ 120 Vac 1.5 A @ 240 Vac
Conventional Enclosed Thermal Current (I_{the}) Rating:	5 A
Rated Frequency:	50/60 ±5 Hz
Electrical Durability Make VA Rating:	3600 VA, cos ϕ = 0.3
Electrical Durability Break VA Rating:	360 VA, cos ϕ = 0.3

High-Current Interruption for OUT101, OUT102, and Extra I/O Board

Make:	30 A
Carry:	6 A continuous carry at 70°C 4 A continuous carry at 85°C
1 s Rating:	50 A
MOV Protection:	330 Vdc/145 J
Pickup Time:	Less than 5 ms
Dropout Time:	Less than 8 ms, typical

Breaking Capacity (10,000 operations):

24 V	10 A	L/R = 40 ms
48 V	10 A	L/R = 40 ms
125 V	10 A	L/R = 40 ms
250 V	10 A	L/R = 20 ms

Cyclic Capacity (4 cycles in 1 second, followed by 2 minutes idle for thermal dissipation):

24 V	10 A	L/R = 40 ms
48 V	10 A	L/R = 40 ms
125 V	10 A	L/R = 40 ms
250 V	10 A	L/R = 20 ms

Note: Make per IEEE C37.90-1989.
Note: Do not use high-current interrupting output contacts to switch ac control signals. These outputs are polarity dependent.
Note: Breaking and Cyclic Capacity per IEC 60255-0-20:1974.

SafeLock® Trip/Close Pushbuttons

Resistive DC or AC Load With Arc Suppression Disabled

Make:	30 A
Carry:	6 A continuous carry
1 s Rating:	50 A
MOV Protection:	250 Vac/330 Vdc/130 J

Breaking Capacity (10,000 operations):

48 V	0.50 A	L/R = 40 ms
125 V	0.30 A	L/R = 40 ms
250 V	0.20 A	L/R = 40 ms

Note: Make per IEEE C37.90-1989.

High-Interrupt DC Outputs With Arc Suppression Enabled

Make:	30 A
Carry:	6 A continuous carry
1 s Rating:	50 A
MOV Protection:	330 Vdc/130 J

Breaking Capacity (10,000 operations):

48 V	10 A	L/R = 40 ms
125 V	10 A	L/R = 40 ms
250 V	10 A	L/R = 20 ms

Note: Make per IEEE C37.90-1989.

Breaker Open/Closed LEDs

250 Vdc:	on for 150–300 Vdc;	192–288 Vac
125 Vdc:	on for 80–150 Vdc;	96–144 Vac
48 Vdc:	on for 30–60 Vdc;	
24 Vdc:	on for 15–30 Vdc	

Note: With nominal control voltage applied, each LED draws 8 mA (max.). Jumpers may be set to 125 Vdc for 110 Vdc input and set to 250 Vdc for 220 Vdc input.

Optoisolated Input Ratings

When Used With DC Control Signals

250 Vdc:	on for 200–300 Vdc;	off below 150 Vdc
220 Vdc:	on for 176–264 Vdc;	off below 132 Vdc
125 Vdc:	on for 105–150 Vdc;	off below 75 Vdc
110 Vdc:	on for 88–132 Vdc;	off below 66 Vdc
48 Vdc:	on for 38.4–60 Vdc;	off below 28.8 Vdc
24 Vdc:	on for 15–30 Vdc	

When Used With AC Control Signals

250 Vdc:	on for 170.6–300 Vac;	off below 106.0 Vac
220 Vdc:	on for 150.3–264.0 Vac;	off below 93.2 Vac
125 Vdc:	on for 89.6–150.0 Vac;	off below 53.0 Vac
110 Vdc:	on for 75.1–132.0 Vac;	off below 46.6 Vac
48 Vdc:	on for 32.8–60.0 Vac;	off below 20.3 Vac
24 Vdc:	on for 12.8–30.0 Vac	

Note: AC mode is selectable for each input via Global settings IN101D–IN106D and IN201D–IN216D. AC input recognition delay from time of switching: 0.75 cycles maximum pickup, 1.25 cycles maximum dropout.
Note: All optoisolated inputs draw less than 10 mA of current at nominal voltage or ac rms equivalent.

Time-Code Inputs

Relay accepts demodulated IRIG-B time-code input at Port 2, on the rear-panel BNC input, or through the optional SEL-2812-compatible fiber-optic serial port.

Port 2, Pin 4 Input Current:	1.8 mA typical at 4.5 V (2.5 kΩ resistive)
BNC Input Current:	4 mA typical at 4.5 V (750 Ω resistive when input voltage is greater than 2 V)
BNC Input Voltage:	2.2 V minimum
BNC Nominal Input Impedance:	≥ 1 kΩ

Synchronization Accuracy

Internal Clock:	±1 µs
Synchrophasor Reports (e.g., **MET PM**, **EVE P**, **CEV P**):	±10 µs
All Other Reports:	±5 ms

Simple Network Time Protocol (SNTP) Accuracy

Internal Clock:	±5 ms

Unsychronized Clock Drift

Relay Powered:	2 minutes per year typical

Communications Ports

EIA-232:	1 front, 2 rear
EIA-485:	1 rear with 2100 Vdc of isolation, optional
Fiber-Optic Serial Port:	SEL-2812-compatible port, optional
Wavelength:	820 nm
Optical Connector Type:	ST
Fiber Type:	Multimode
Typical TX Power:	–16 dBm
RX Min. Sensitivity:	–24 dBm
Fiber Size:	62.5/125 µm

Per Port Data Rate Selections:	300, 1200, 2400, 4800, 9600, 19200, 38400, 57600
USB:	1 front (Type-B connector, CDC class device)
Ethernet:	2 standard 10/100BASE-T rear ports (RJ45 connector) 1 or 2 100BASE-FX rear ports optional (LC connectors) Wavelength: 1300 nm Optical Connector Type: LC connector Fiber Type: Multimode fiber Typical TX Power: –15.7 dBm RX Min. Sensitivity: –30 dBm Fiber Size: 62.5 µm Internal Ethernet switch included with second Ethernet port.

Dimensions

Refer to *Figure 2.1*.

Weight

15 lb (6.8 kg)—3U rack unit height relay

Operating Temperature

–40° to +185°F (–40° to +85°C)
(LCD contrast impaired for temperatures below –20°C.)
Note: Temperature range is not applicable to UL-compliant installations.

Type Tests

Electromagnetic Compatibility Emissions

Emissions:	IEC 60255-25:2000

Electromagnetic Compatibility Immunity

Conducted RF Immunity:	IEC 60255-22-6:2001 Severity Level: 10 Vrms IEC 61000-4-6:2008 Severity Level: 10 Vrms
Digital Radio Telephone RF Immunity:	ENV 50204:1995 Severity Level: 10 V/m at 900 MHz and 1.89 GHz
Electrostatic Discharge Immunity:	IEC 60255-22-2:2008 Severity Level: 2, 4, 6, 8 kV contact; 2, 4, 8, 15 kV air IEC 61000-4-2:2008 Severity Level: 2, 4, 6, 8 kV contact; 4, 8, and 15 kV air IEEE C37.90.3-2001 Severity Level: 2, 4, and 8 kV contact; 4, 8, and 15 kV air
Fast Transient/Burst Immunity:	IEC 60255-22-4:2008 Severity Level: Class A: 4 kV at 5 kHz, 2 kV at 5 kHz on comm ports IEC 61000-4-4:2004 + CRGD:2006 Severity Level: 4 kV, 5 kHz
Power Supply Immunity:	IEC 60255-11:2008 IEC 61000-4-11:2004 IEC 61000-4-29:2000
Radiated Radio Frequency Immunity:	IEC 60255-22-3:2007 Severity Level: 10 V/m IEC 61000-4-3:2008 Severity Level: 10 V/m IEEE C37.90.2-2004 Severity Level: 35 V/m
Surge Withstand Capability Immunity:	IEC 60255-22-1:2007 Severity Level: 2.5 kV peak common mode, 1.0 kV peak differential mode IEEE C37.90.1-2002 Severity Level: 2.5 kV oscillatory; 4.0 kV fast transient

Environmental

Cold:	IEC 60068-2-1:2007 Severity Level: 16 hours at –40°C
Damp Heat, Cyclic:	IEC 60068-2-30:2005 Severity Level: 25°C to 55°, 6 cycles, Relative Humidity: 95%
Dry Heat:	IEC 60068-2-2:2007 Severity Level: 16 hours at +85°C
Vibration:	IEC 60255-21-1:1988 Severity Level: Class 1 Endurance, Class 2 Response IEC 60255-21-2:1988 Severity Level: Class 1—Shock withstand, Bump, and Class 2—Shock Response IEC 60255-21-3:1993 Severity Level: Class 2 (Quake Response)

Safety

Dielectric:	IEC 60255-5:2000 Severity Level: 2500 Vac on contact inputs, contact outputs, and analog inputs. 3100 Vdc on power supply. Type Tested for 1 minute. IEEE C37.90-2005 Severity Level: 2500 Vac on contact inputs, contact outputs, and analog inputs. 3100 Vdc on power supply. Type Tested for 1 minute.
Impulse:	IEC 60255-5:2000 Severity Level: 0.5 Joule, 5 kV IEEE C37.90:2005 Severity Level: 0.5 Joule, 5 kV
IP Code:	IEC 60529:2001 + CRDG:2003 Severity Level: IP30
Product Safety:	C22.2 No. 14 - 95 Canadian Standards Association, Industrial control equipment, industrial products UL 508 Underwriters Laboratories inc., Standard for safety: Industrial control equipment

Processing Specifications and Oscillography

AC Voltage and Current Inputs

128 samples per power system cycle, 3 dB low-pass filter cut-off frequency of 3 kHz

Digital Filtering

Digital low-pass filter then decimate to 32 samples per cycle followed by one-cycle cosine filter.
Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.

Protection and Control Processing (Processing Interval)

4 times per power system cycle

Oscillography

Length:	15, 30, or 60 cycles
Total Storage:	11 seconds of analog and binary
Sampling Rate:	128 samples per cycle unfiltered 32 and 16 samples per cycle unfiltered and filtered 4 samples per cycle filtered
Trigger:	Programmable with Boolean expression
Format:	ASCII and Compressed ASCII Binary COMTRADE (128 samples per cycle unfiltered)

Time-Stamp Resolution:	1 µs when high-accuracy time source is connected (**EVE P** or **CEV P** commands). 1 ms otherwise.
Time-Stamp Accuracy:	See *Time-Code Inputs on page 27*.

Sequential Events Recorder

Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy (with respect to time source):	±5 ms

Relay Element Pickup Ranges and Accuracies

Accuracy of cycle-based timers is specified for steady-state frequency.

Instantaneous/Definite-Time Overcurrent Elements

Pickup Range:	0.25–100.00 A, 0.01 A steps (5 A nominal) 1.00–170.00 A, 0.01 A steps (5 A nominal—for phase-to-phase elements) 0.050–100.000 A, 0.010 A steps (5 A nominal—for residual-ground elements) 0.05–20.00 A, 0.01 A steps (1 A nominal) 0.20–34.00 A, 0.01 A steps (1 A nominal—for phase-to-phase elements) 0.010–20.000 A, 0.002 A steps (1 A nominal—for residual-ground elements) 0.005–2.500 A, 0.001 A steps (0.2 A nominal neutral channel (IN) current input) 0.005–1.500 A, 0.001 A steps (0.05 A nominal neutral channel (IN) current input)
Steady-State Pickup Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal) ±0.001 A and ±3% of setting (0.2 A nominal neutral channel (IN) current input) ±0.001 A and ±5% of setting (0.05 A nominal neutral channel (IN) current input)
Transient Overreach:	±5% of pickup
Time Delay:	0.00–16,000.00 cycles, 0.25 cycle steps
Timer Accuracy:	±0.25 cycle and ±0.1% of setting

Note: See pickup and reset time curves in *Figure 3.5* and *Figure 3.6*.

Breaker Failure Current Detectors and Logic

Pickup Range:	0.5–100.00 A, 0.01 A steps (5 A nominal) 0.1–20.00 A, 0.01 A steps (1 A nominal)
Steady-State Pickup Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal)
Transient Overreach:	±5% of pickup
Reset Time:	≤1 cycle
Pickup Time:	≤1 cycle for current greater than 2 multiples of pickup
Time Delay:	0.00–16,000.00 cycles, 0.25 cycle steps
Timer Accuracy:	±0.25 cycle and ±0.1% of setting

Time-Overcurrent Elements

Pickup Range:	0.25–16.00 A, 0.01 A steps (5 A nominal) 0.10–16.00 A, 0.01 A steps (5 A nominal—for residual-ground elements) 0.05–3.20 A, 0.01 A steps (1 A nominal) 0.02–3.20 A, 0.01 A steps (1 A nominal—for residual-ground elements) 0.005–0.640 A, 0.001 A steps (0.2 A nominal neutral channel (IN) current input) 0.005–0.160 A, 0.001 A steps (0.05 A nominal neutral channel (IN) current input)
Steady-State Pickup Accuracy:	±0.05 A and ±3% of setting (5 A nominal) ±0.01 A and ±3% of setting (1 A nominal) ±0.005 A and ±3% of setting (0.2 A nominal neutral channel (IN) current input) ±0.001 A and ±5% of setting (0.05 A nominal neutral channel (IN) current input)
Time-Dial Range:	0.50–15.00, 0.01 steps (US) 0.05–1.00, 0.01 steps (IEC) 0.10–2.00, in 0.01 steps (recloser curves)
Curve Timing Accuracy:	±1.50 cycles and ±4% of curve time for current between 2 and 30 multiples of pickup ±1.50 cycles and ±4% of curve time for current less than 1 multiple of pickup ±3.50 cycles and ±4% of curve time for current between 2 and 30 multiples of pickup for 0.05 A nominal neutral channel (IN) current input ±3.50 cycles and ±4% of curve time for current less than 1 multiple of pickup for 0.05 A nominal neutral channel (IN) current input

Second-Harmonic Blocking Elements

Pickup Range:	5–100% of fundamental, 1% steps
Steady-State Pickup Accuracy:	2.5 percentage points
Pickup/Dropout Time:	<1.25 cycles
Time Delay:	0.00–16,000.00 cycles, 0.25 cycle steps
Timer Accuracy:	±0.25 cycle and ±0.1% of setting

Under- and Overvoltage Elements

Pickup Ranges	
Wye-Connected (Global setting PTCONN = WYE):	0.00–200.00 V, 0.01 V steps (negative-sequence element) 0.00–300.00 V, 0.01 V or 0.02 V steps (various elements) 0.00–520.00 V, 0.02 V steps (phase-to-phase elements)
Open-Delta Connected (when available, by Global setting PTCONN = DELTA):	0.00–120.00 V, 0.01 V steps (negative-sequence elements) 0.00–170.00 V, 0.01 V steps (positive-sequence element) 0.00–300.00 V, 0.01 V steps (various elements)
Steady-State Pickup Accuracy:	±0.5 V plus ±1% for 12.5–300.00 V (phase and synchronizing elements) ±0.5 V plus ±2% for 12.5–300.00 V (negative-, positive-, and zero-sequence elements, phase-to-phase elements)
Transient Overreach:	±5% of pickup

Synchronism-Check Elements

Slip Frequency Pickup Range: 0.005–1.000 Hz, 0.001 Hz steps

Slip Frequency Pickup Accuracy: ±0.003 Hz

Phase Angle Range: 0–80°, 1° steps

Phase Angle Accuracy: ±4° when |slip frequency| ≤ 0.4 Hz
±10° when 0.4 Hz < |slip frequency| < 1.0 Hz

Under- and Overfrequency Elements

Pickup Range: 40.10–65.00 Hz, 0.01 Hz steps

Steady-State *plus* Transient Overshoot: ±0.01 Hz

Pickup/Dropout Time:
Maximum instantaneous element response time to a step change in frequency (dF)

dF ≤ 0.3 Hz	NFREQ = 50 Hz	NFREQ = 60 Hz
|81DnP-Initial Frequency| ≤ 0.5 |dF|	45 ms	40 ms
|81DnP-Initial Frequency| > 0.5 |dF|	60 ms	50 ms
dF > 0.3 Hz	**NFREQ = 50 Hz**	**NFREQ = 60 Hz**
|81DnP-Initial Frequency| ≤ 0.5 |dF|	75 ms	60 ms
|81DnP-Initial Frequency| > 0.5 |dF|	85 ms	70 ms

Time Delay: 2.00–16,000.00 cycles, 0.25-cycle steps

Timer Accuracy: ±0.25 cycle and ±0.1% of setting

Undervoltage Frequency Element Block Range: 25.00–300.00 V_{LN} (wye) or V_{LL} (open delta)

Rate-of-Change-of-Frequency Element

Pickup Range: 0.10–15.00 Hz/sec, 0.01 Hz/sec steps

Dropout: 95% of pickup

Pickup Accuracy: ±100 mHz/s and ±3.33% of pickup

Pickup/Dropout Time: See *Equation 3.1*.

Pickup Time Delay: 0.10–60.00 seconds, 0.01 second steps

Dropout Time Delay: 0.00–60.00 seconds, 0.01 second steps

Timer Accuracy: ±6 ms and ±0.1% of setting

Timers

Pickup Ranges: 0.00–999,999.00 cycles, 0.25-cycle steps (reclosing relay and some programmable timers)
0.00–16,000.00 cycles, 0.25-cycle steps (some programmable and other various timers)

Pickup and Dropout Accuracy for all Timers: ±0.25 cycle and ±0.1% of setting

Substation Battery Voltage Monitor

Pickup Range: 20–300 Vdc, 1 Vdc steps

Pickup accuracy: ±2% of setting ±2 Vdc

Fundamental Metering Accuracy

Accuracies are specified at 20°C, at nominal system frequency, and voltages 67–250 V unless noted otherwise.

V_A, V_B, V_C: ±0.2% (67.0–250 V; wye-connected)
±0.4% typical (250–300 V; wye-connected)

V_{AB}, V_{BC}, V_{CA}: ±0.4% (67.0–250 V; delta-connected)
±0.8% typical (250–300 V; delta-connected)

V_S: ±0.2% (67.0–250 V)
±0.4% typical (250–300 V)

$3V_0$, V_1, V_2 ($3V_0$ not available with delta-connected inputs): ±0.6% (67.0–250 V)
±1.2% typical (250–300 V)

I_A, I_B, I_C: ±4 mA and ±0.1% (1.0–100 A) (5 A nominal)
±6 mA and ±0.1% (0.25–1.0 A) (5 A nominal)
±1 mA and ±0.1% (0.2–20 A) (1 A nominal)
±2 mA and ±0.1% (0.05–0.2 A) (1 A nominal)
Temperature coefficient: $[(0.0002\%)/(°C)^2] \bullet (\_\_°C - 20°C)^2$

I_N: ±4 mA and ±0.1% (1.0–100 A) (5 A nominal)
±6 mA and ±0.1% (0.25–1.0 A) (5 A nominal)
±1 mA and ±0.1% (0.2–20 A) (1 A nominal)
±2 mA and ±0.1% (0.05–0.2 A) (1 A nominal)
±1.6 mA and ±0.1% (0.005–4.5 A) (0.2 A or 0.05 A nominal channel IN current input)

I_1, $3I_0$, $3I_2$: ±0.05 A and ±3% (0.5–100 A) (5 A nominal)
±0.01 A and ±3% (0.1–20 A) (1 A nominal)

Phase Angle Accuracy

I_A, I_B, I_C: ±0.5° (1.0–100 A) (5 A nominal)
±3° (0.25–1.0 A) (5 A nominal)
±0.5° (0.2–20 A) (1 A nominal)
±5° (0.05–0.2 A) (1 A nominal)

V_A, V_B, V_C, V_S (wye-connected voltages): ±0.5°

V_{AB}, V_{BC}, V_{CA}, V_S (delta-connected voltages): ±1.0°

MW/MVAR
(A, B, C, and three-phase; wye-connected voltages)
MW/MVAR
(three-phase; open-delta connected voltages; balanced conditions)

Accuracy (MW/MVAR)	**at load angle**
for phase current ≥ 0.2 • I_{NOM}:	
0.35% / –	0° or 180° (unity power factor)
0.40% / 6.00%	±8 or ±172°
0.75% / 1.50%	±30° or ±150°
1.00% / 1.00%	±45° or ±135°
1.50% / 0.75%	±60° or ±120°
6.00% / 0.40%	±82° or ±98°
– / 0.35%	±90° (power factor = 0)

Energy Meter

Accumulators: Separate IN and OUT accumulators updated once every two seconds, transferred to nonvolatile storage once per day.

ASCII Report Resolution: 0.01 MWh

Accuracy: The accuracy of the energy meter depends on applied current and power factor as shown in the power metering accuracy table above. The additional error introduced by accumulating power to yield energy is negligible when power changes slowly compared to the processing rate of twice per second.

Synchrophasor Accuracy

Maximum Data Rate in Messages per Second

IEEE C37.118 Protocol:	60 (nominal 60 Hz system) 50 (nominal 50 Hz system)
SEL Fast Message Protocol:	1
IEEE C37.118-2005 Accuracy:	Level 1 at maximum message rate when phasor has the same frequency as phase A voltage, frequency-based phasor compensation is enabled (PHCOMP = Y), and the narrow-bandwidth filter is selected (PMAPP = N). Out-of-band interfering frequency (Fs) test, 10 Hz ≤ Fs ≤ (2 • NFREQ).
Current Range:	(0.1–2) • I_{NOM} (I_{NOM} = 1 A or 5 A)
Frequency Range:	±5 Hz of nominal (50 or 60 Hz)
Voltage Range:	30 V–250 V
Phase Angle Range:	–179.99° to 180°

Harmonic Metering Accuracy

Voltages V_A, V_B, V_C, V_S (Wye or Single-Phase); V_{AB}, V_{BC}, V_S (Delta)

Accuracies valid for THD < 100%, 30 V < fundamental < 200 V sec, 50 Hz or 60 Hz

RMS and Fundamental Magnitude:	±5%
THD Percentage:	±5 percentage points
02 Through 16 Harmonic Percentage:	±5 percentage points

Currents I_A, I_B, I_C, I_N

Accuracies Valid for THD < 100%, fundamental voltage < 200 V, 50 Hz or 60 Hz

5 A Nominal:	0.25 A < fundamental current < 5 A sec
1 A Nominal:	0.05 A < fundamental current < 1 A sec
0.2 A and 0.05 A Nominal (IN channel only):	0.01 A < fundamental current < 1A sec
RMS and Fundamental Magnitude:	±5%
THD Percentage:	±5 percentage points
02 Through 16 Harmonic Percentage:	±5 percentage points

Power Element Accuracy

Single-Phase Power Elements

Pickup Setting 0.33–2 VA (5 A nominal), 0.07–0.4 VA (1 A nominal):	±0.05 A • (L-N voltage secondary) and ±10% of setting at unity power factor for power elements and zero power factor for reactive power element (5 A nominal) ±0.01 A • (L-N voltage secondary) and ±10% of setting at unity power factor for power elements and zero power factor for reactive power element (1 A nominal)
Pickup Setting 2–13000 VA (5 A nominal), 0.4–2600 VA (1 A nominal):	±0.025 A • (L-N voltage secondary) and ±5% of setting at unity power factor (5 A nominal) ±0.005 A • (L-N voltage secondary) and ±5% of setting at unity power factor (1 A nominal)

Three-Phase Power Elements

Pickup Setting 1–6 VA (5 A nominal), 0.2–1 VA (1 A nominal):	±0.05 A • (L-L voltage secondary) and ±10% of setting at unity power factor for power elements and zero power factor for reactive power element (5 A nominal) ±0.01 A • (L-L voltage secondary) and ±10% of setting at unity power factor for power elements and zero power factor for reactive power element (1 A nominal)
Pickup Setting 6–39000 VA (5 A nominal), 1–7800 VA (1 A nominal):	±0.025 A • (L-L voltage secondary) and ±5% of setting at unity power factor for power elements and zero power factor for reactive power element (5 A nominal) ±0.005 A • (L-L voltage secondary) and ±5% of setting at unity power factor for power elements and zero power factor for reactive power element (1 A nominal)

The quoted three-phase power element accuracy specifications are applicable as follows:

- Wye-connected voltages (PTCONN = WYE): any condition
- Open-delta connected voltages (PTCONN = DELTA), with properly configured broken-delta 3V0 connection (VSCONN = 3V0): any condition
- Open-delta connected voltages, without broken-delta 3V0 connection (VSCONN = VS): balanced conditions only

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SEL-501 Dual Universal Overcurrent Relay

Major Features and Benefits

- Features two three-phase, current-based relays in one complete package.
- Protects feeders, buses, transformers, motors, breakers, and other apparatus.
- Is easily set from the front panel or communications port.
- Includes metering, self-testing, alarm, and event reporting.
- Saves two full reports and twenty summaries in nonvolatile memory.
- Makes redundant protection practical—ideal for stacked breaker switchgear.
- Includes low-level test interface.
- Supports ASCII, SEL LMD, Modbus®, and Square-D SY/MAX protocol.

Features

Dual Relay Concept

The SEL-501 Dual Universal Overcurrent Relay provides two complete and independent groups of protection functions in one compact unit. The unit contains Relay X and Relay Y, each having separate optoisolated inputs, output contacts, and three-phase current inputs.

Table 1 Relay I/O and Current Inputs

	Input	Output Contacts	Current Inputs
Relay X	XIN	XOUT1, XOUT2	IAX, IBX, ICX
Relay Y	YIN	YOUT1, YOUT2	IAY, IBY, ICY

Five Relay Functions

Select the relay functions independently for Relays X and Y. Choose from five relay functions.

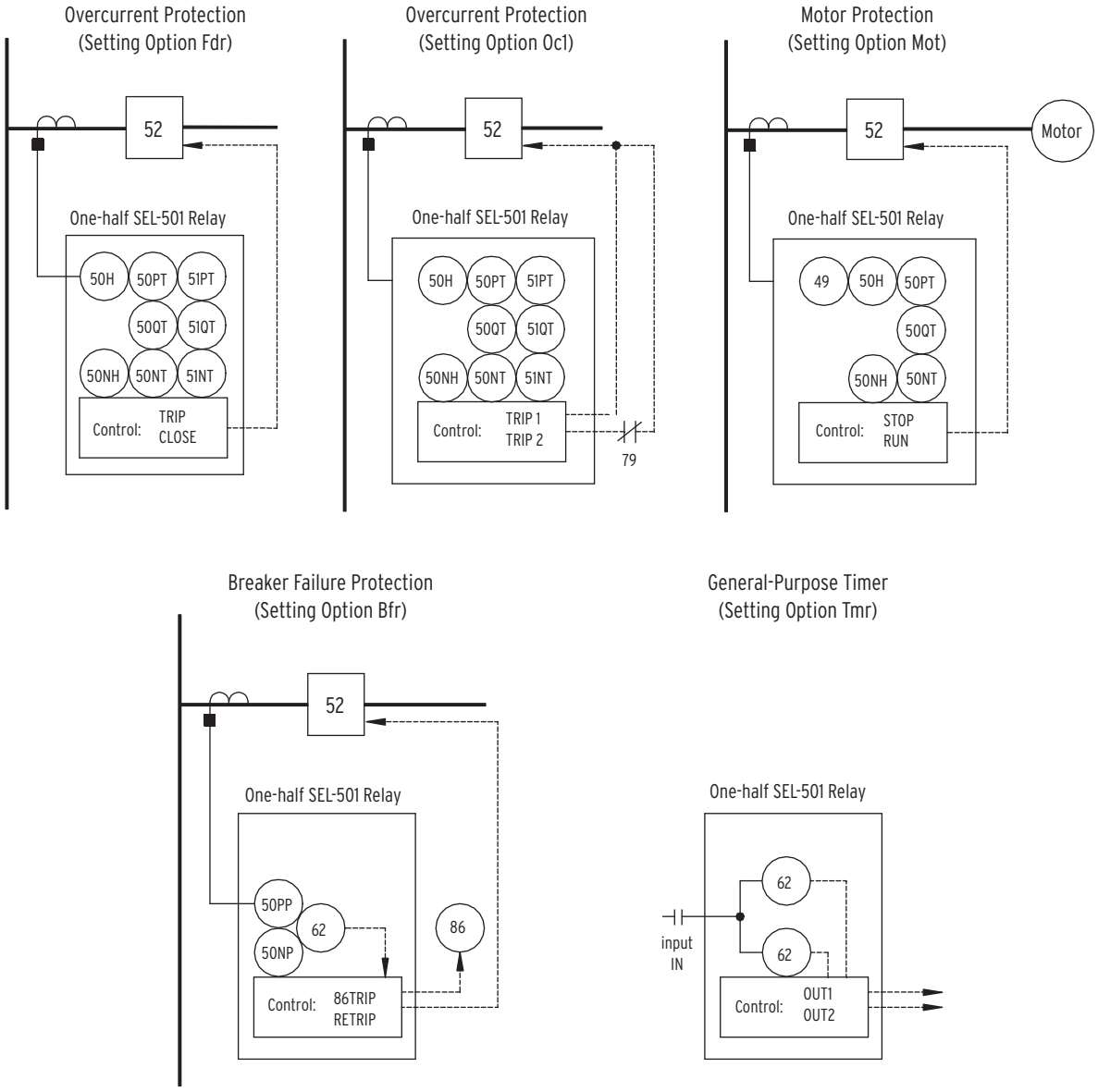
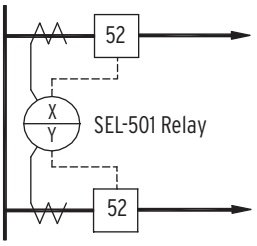


Figure 1 Relay Application Single-Line Diagrams

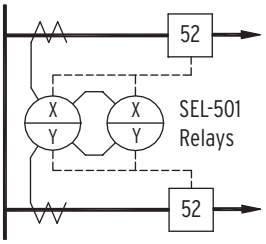
SEL-501 Dual Relay Applications

Protect Two Feeders



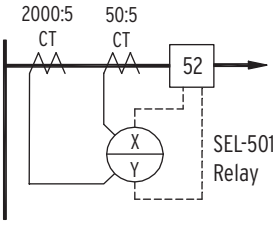
- Complete overcurrent and simple breaker failure protection for two feeders.
- Settable time delay on trip output contact provides simple breaker failure protection.
- Low-cost, compact protection.

Two Relays + Two Feeders = Full Redundancy



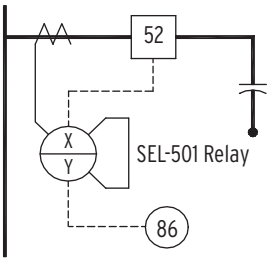
- Ideal for two-high switchgear.
- Front-panel control eliminates the need for manual control switches.
- Includes negative-sequence overcurrent protection for sensitive, fast phase-phase fault coverage.

Cover a Wide Range of Fault Currents



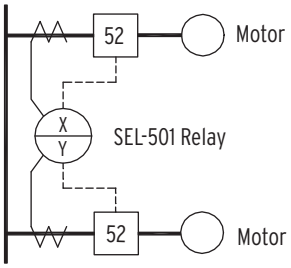
- 2000:5 CT covers fault up to 32,000 amps (5 A Model).
- 50:5 CT meters load accurately, and covers faults down to 5 amps primary (5 A Model).

Capacitor, Reactor, and Breaker Failure Protection



- Protects capacitors, reactors, and bus sections.
- Provides breaker failure protection.

Protect Two Motors



- Complete protection for two motors.
- Ideal for compact motor control centers.
- Stop and start motors from relay front panel.

Figure 2 Example SEL-501 Dual Relay Applications

Overcurrent Protection

The SEL-501 has two overcurrent protection setting options: FDR or OC1. Both options use the same overcurrent elements, but differ in input and output contact functions.

Table 2 Overcurrent Settings and Ranges

Eight Overcurrent Elements	Instantaneous	Definite-Time	Inverse-Time
Phase (Ia, Ib, and Ic)	50H	50PT	51PT
Negative-Sequence (IQ = 3 • I2)		50QT	51QT
Residual (IR = Ia + Ib + Ic)	50NH	50NT	51NT
Ranges (A secondary)			
5 A Model:	0.5–80 A, 0.1 step	0.5–80 A, 0.1 step	0.5–16 A, 0.1 step
1 A Model:	0.1–16 A, 0.1 step	0.1–16 A, 0.1 step	0.1–3.2 A, 0.1 step
Definite-Time Delay		0–16,000 cycles	US and IEC curves

Table 3 Overcurrent Contact Functions

Setting	Input	Output Contacts
FDR	52A	TRIP (OUT1)—select any elements CLOSE (OUT2)
OC1	Programmable—select one	Both trips have time-delay pickup timers, settable 0–16,000 cycles.
	EN—Enable user-selected elements	
	BLK—Block user-selected elements	TRIP1 (OUT1)—select any elements
	ET—External Trigger of event reports	TRIP1 (OUT2)—select any elements

Motor Protection

Table 4 Motor Protection Settings and Ranges

Elements	Instantaneous	Definite-Time
Phase (Ia, Ib, and Ic)	50H	50PT
Negative-Sequence (IQ = 3 • I2)		50QT
Residual (IR = Ia + Ib + Ic)	50NH	50NT
Ranges (A secondary)		
5 A Model:	0.5–80 A	0.5–80 A
1 A Model:	0.1–16 A	0.1–16 A
Definite-Time Delay		0–16,000 cycles

Thermal Model (49) provides locked-rotor, unbalance and overload protection.

Motor operation monitors include load-jam trip, load-loss trip, and a starts per-hour limit.

Input	Output Contacts
52A	TRIP (OUT1) CLOSE (OUT2)

Breaker Failure Protection

Table 5 Breaker Failure Protection Settings and Ranges

Instantaneous Overcurrent Elements		Breaker Failure Timer (62FC)
Phase (Ia, Ib, and Ic)	50PP	0.25–63.75 cycles
Residual (IR = Ia + Ib + Ic)	50NP	
Ranges (A secondary)		**Breaker Retrip Timer (62FC)**
5 A Model:	0.5–80 A	0–63.75 cycles
1 A Model:	0.1–16 A	
Maximum Reset Time	0.75 cycles	
Input	**Output Contacts**	
BFI—Breaker Failure Initiate	86TR—Breaker Failure Trip (OUT1) RETRIP—Breaker Retrip (OUT2)	

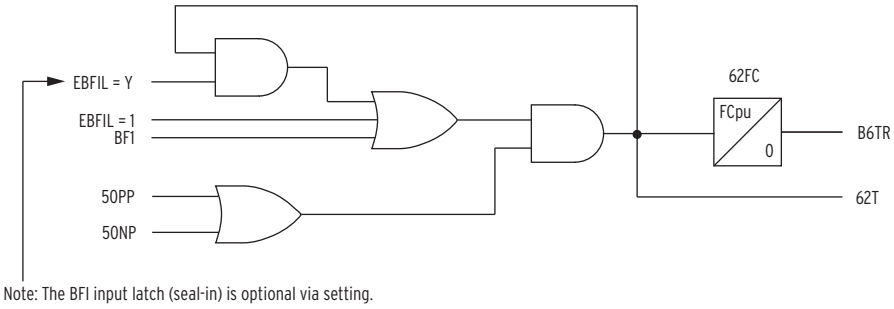


Figure 3 SEL-501 Relay Breaker Failure Logic

General-Purpose Timer

Timer Ranges (62 Device)
Pickup: 0–16,000 cycles
Dropout: 0–16,000 cycles

The timers are completely independent of the relay current inputs.

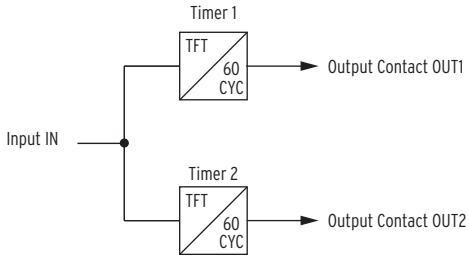


Figure 4 SEL-501 Relay General-Purpose Timer

Operation, Metering, and Communications

- Complete operation from front-panel controls or rear-panel serial port.
- Full access to event history, relay status, and meter information.
- Instantaneous, demand, and peak demand currents metered.
- Settings and control have passcode protection.
- One serial port for two relays cuts communications burden in half.
- Modbus RTU protocol supports direct integration, via appropriate gateways, into SCADA or DCS systems.

Event Reporting

- Relay stores twelve reports: newest two are in non-volatile memory.
- Reports have fifteen-cycle duration and quarter-cycle resolution.
- Unique event headers for each application.

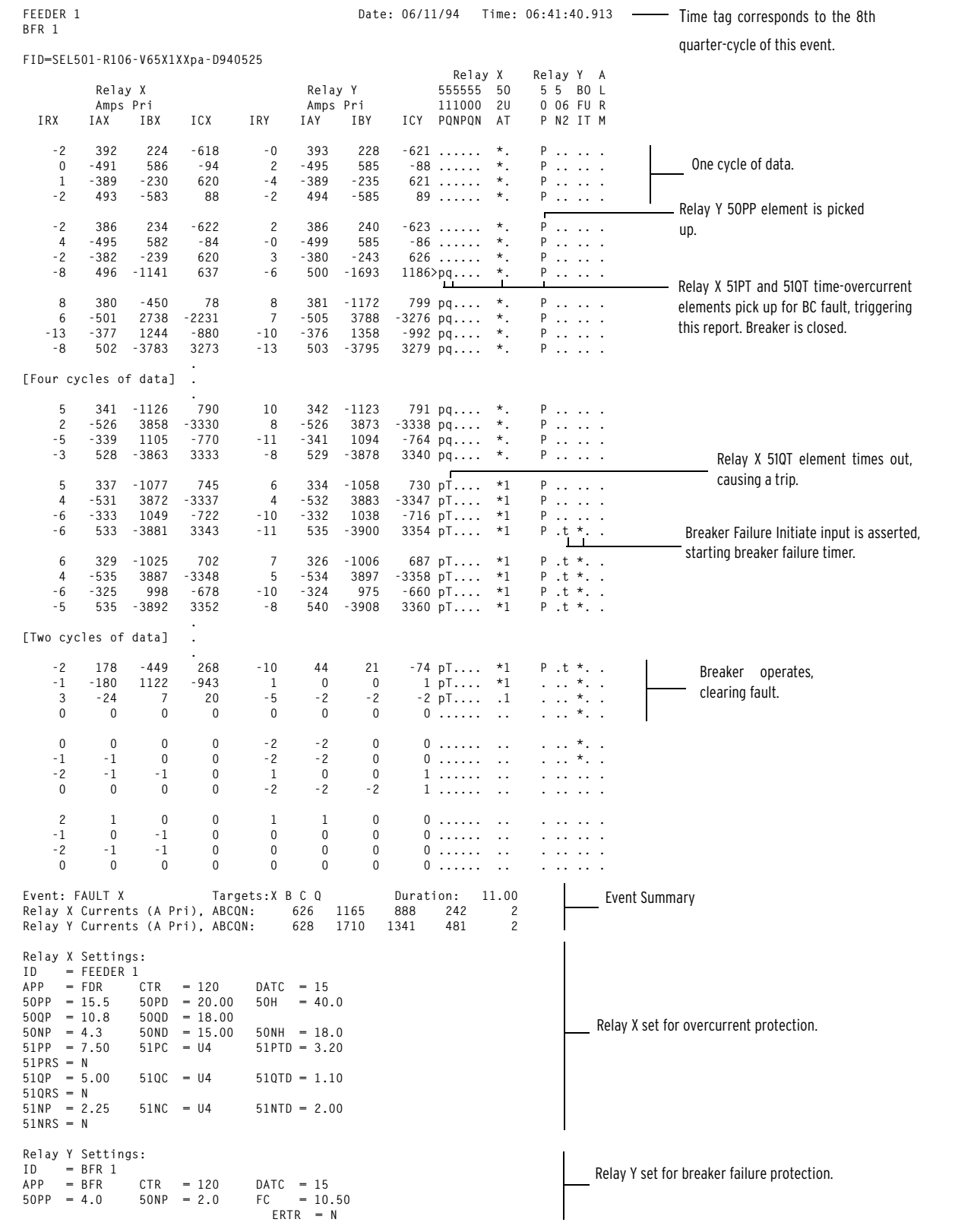


Figure 5 Example Event Report

Two Rear-Panel Options

Conventional Terminal Blocks

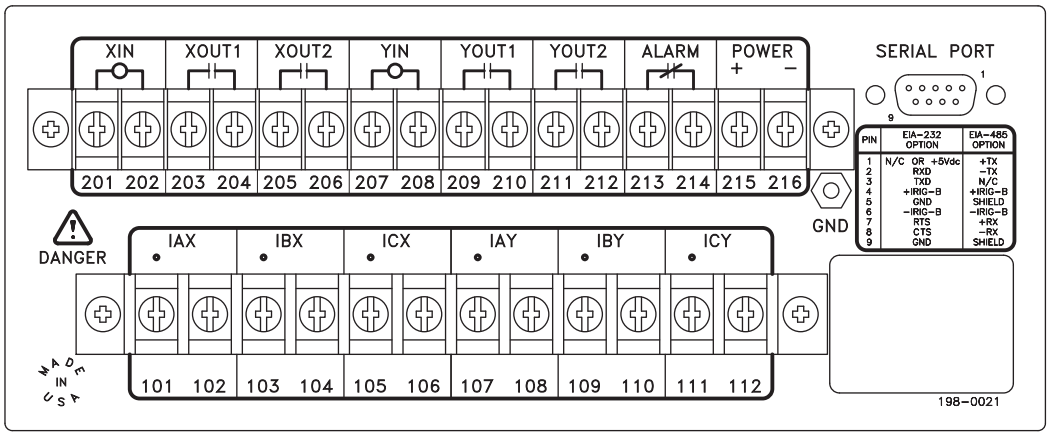


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Figure 6 SEL-501 Relay Rear Panel (Conventional Terminal Block Option)

Output contacts **XOUT1**, **XOUT2**, **YOUT1**, **YOUT2**, and **ALARM** are not polarity dependent.

Optoisolated inputs **XIN** and **YIN** are not polarity dependent.

All screws are size #6-32.

Connectorized Relay (Plug-In Connectors)

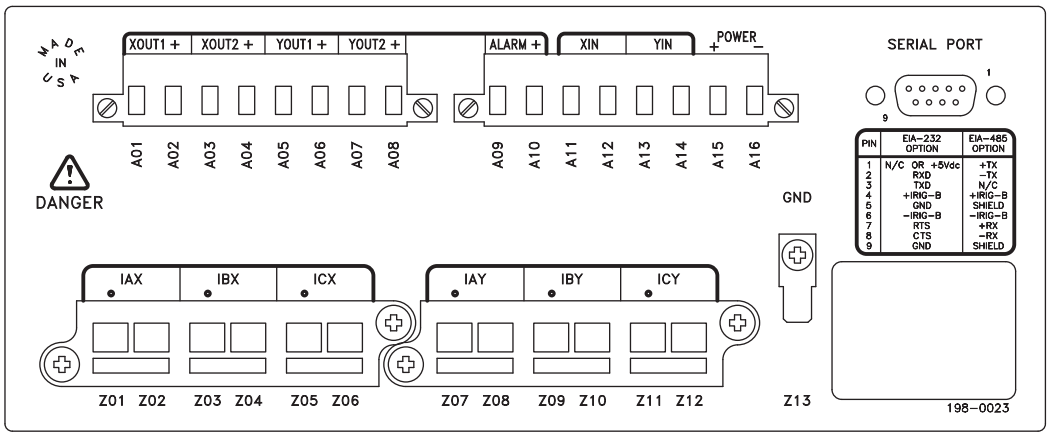

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Figure 7 SEL-501 Relay Rear Panel (Plug-In Connectors Option)

Important: Improvements in Connectorized® SEL-501 relays (Plug-In Connectors) resulted in part number changes.

The current transformer shorting connectors for current channel inputs **IAX**, **IBX**, **ICX**, and **IAY**, **IBY**, **ICY** have been made more robust. This improvement makes the new connector design incompatible with the old design. Thus, new Connectorized SEL-501 relays with this improved connector have a new part number (partial part numbers shown):

Old	New
0501xJ	0501xW

The respective wiring harness part numbers for these old and new Connectorized SEL-501 relays are (partial part numbers shown):

Old	New
WA0501xJ	WA0501xW

Figure 7 shows the rear panel for new models 0501xW. Because all terminal/numbering remains the same between the new and old relays, these figures can also be used as a reference for old model 0501xJ. Only the connectors and part numbers have changed.

Connector terminals **A01**–**A16** accept wire size AWG 24 to 12 (install wires with a small slotted screwdriver).

Output contacts **XOUT1**, **XOUT2**, **YOUT1**, **YOUT2**, and **ALARM** are polarity dependent (note the **+** above terminal **A02**, **A04**, **A06**, **A08**, and **A10**).

See *Specifications on page 14* for high current interrupting output contact ratings.

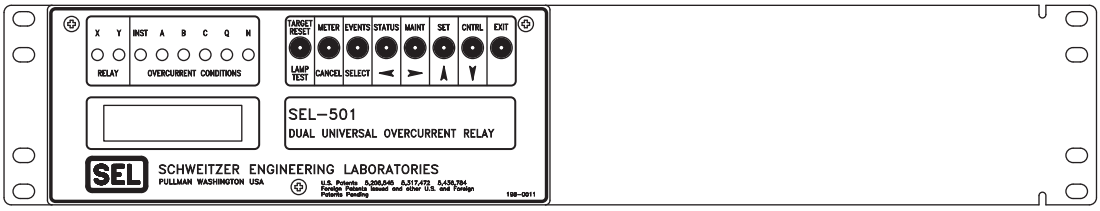
Optoisolated inputs **XIN** and **YIN** are not polarity dependent.

Current input connector (terminals **Z01**–**Z12**):

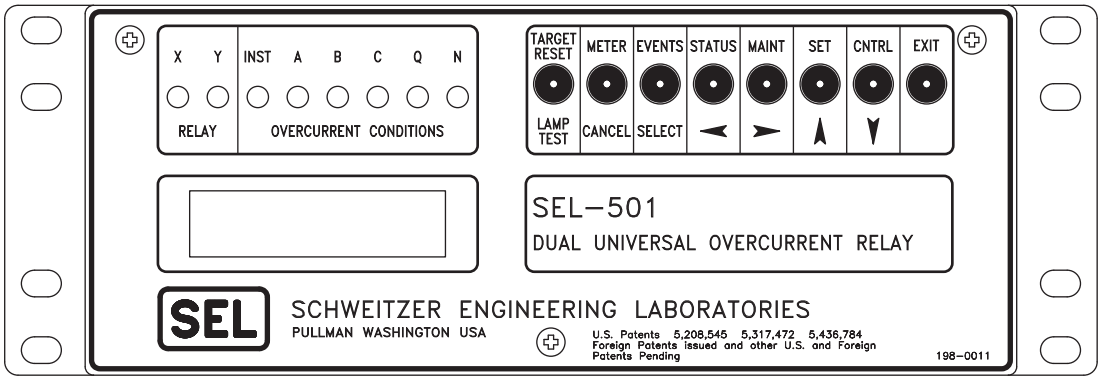
- ➤ Contains current transformer shorting mechanisms
- ➤ Accepts wire size AWG 16 to 10 (special tool required to attach wire to connector)
- ➤ Can be ordered prewired

Ground connection (terminal **Z13**): tab size 0.250 inch • 0.032 inch, screw size #6-32.

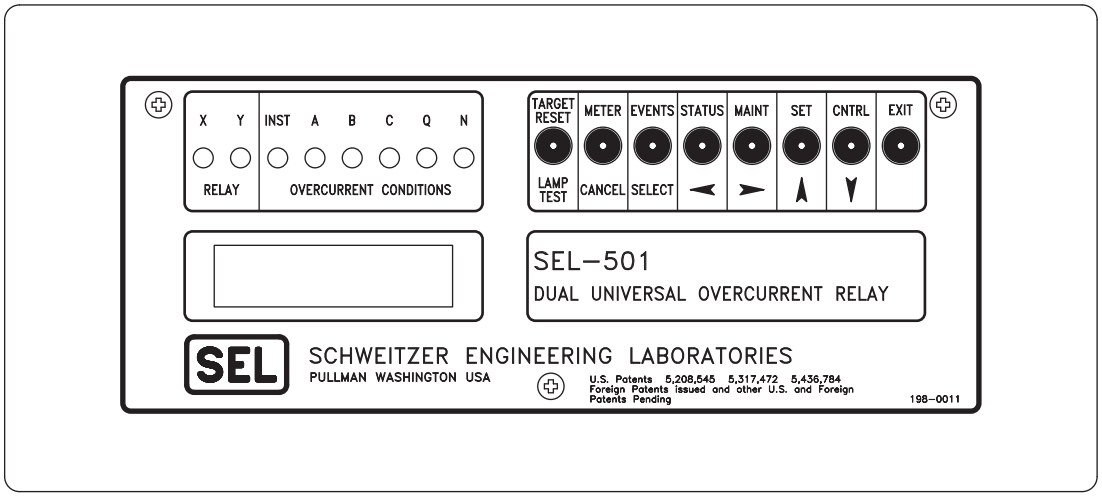
Front- and Rear-Panel Diagrams



SEL-501 Relay Fitted With Mounting Bracket (SEL P/N 9100) for Mounting in 19-Inch Rack

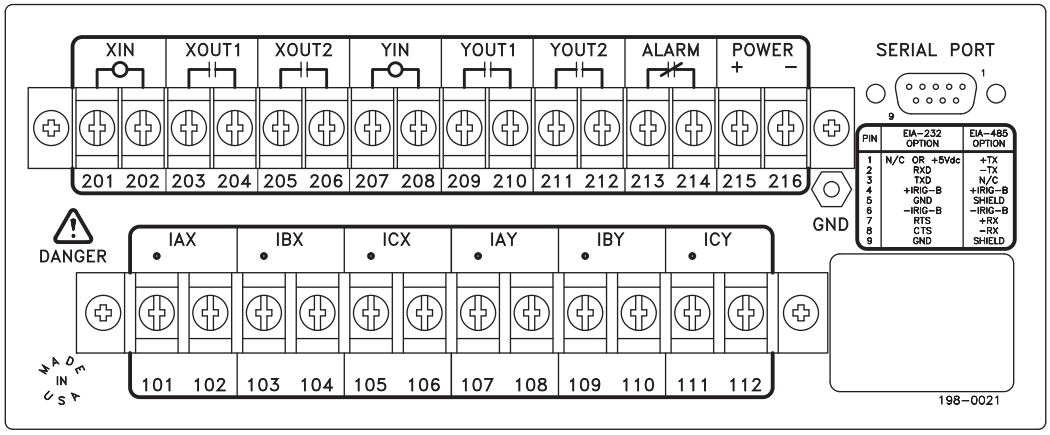


SEL-501 Relay Front Panel, Rack-Mount Version (Half-Rack Width)



SEL-501 Relay Front Panel, Panel-Mount Version

Figure 8 SEL-501 Front Panels



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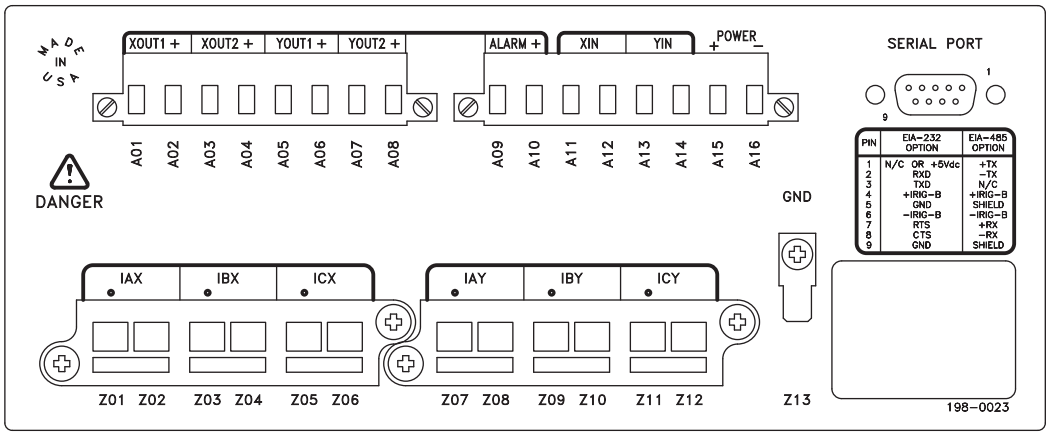
SEL-501 Relay Rear Panel (Conventional Terminal Blocks Option)



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SEL-501 Relay Rear Panel (Plug-In Connectors Option)

Figure 9 SEL-501 Rear-Panel Diagrams

Relay Dimensions

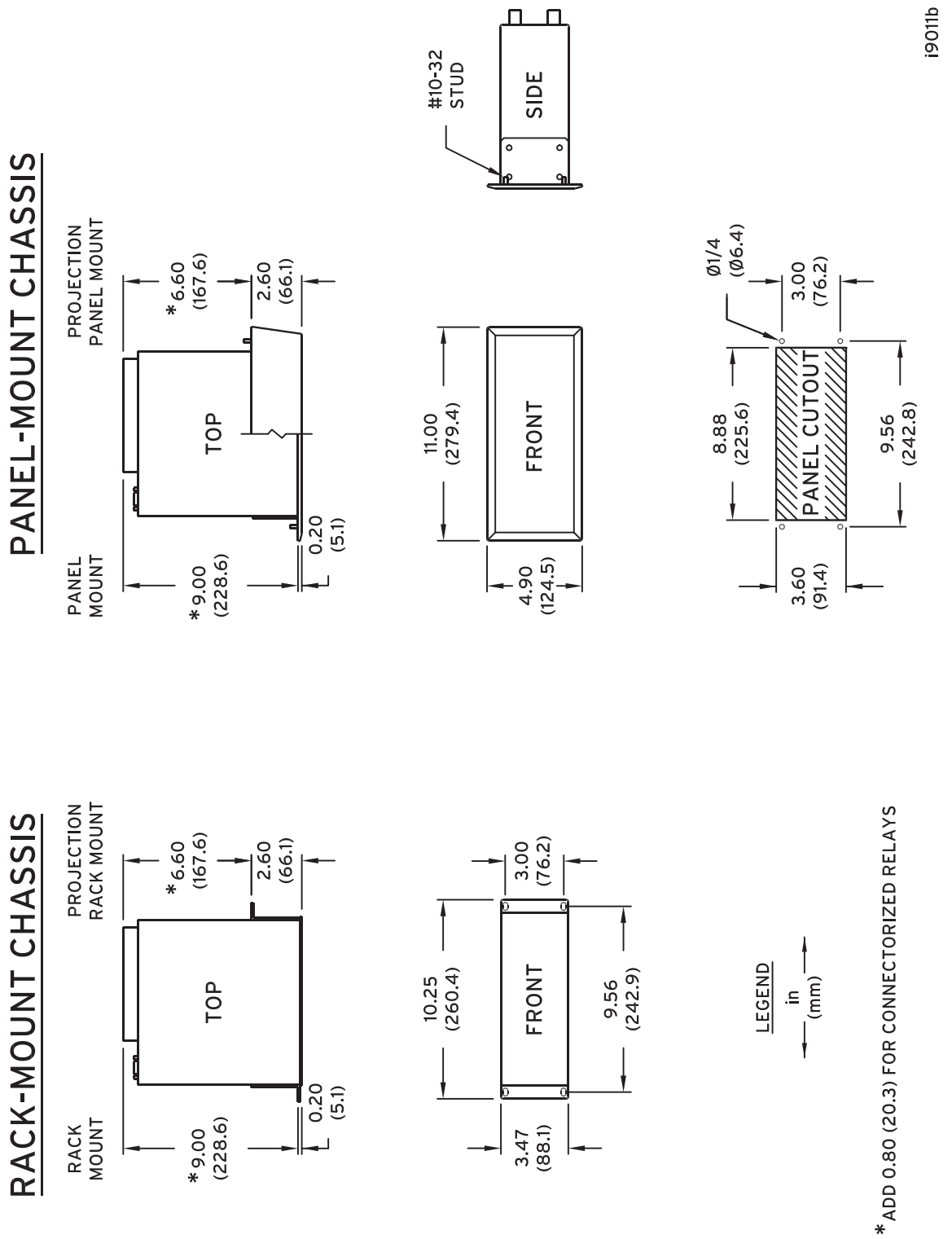

Figure 10 SEL-501 Dimensions and Drill Plan for Single Rack-Mounted Relay

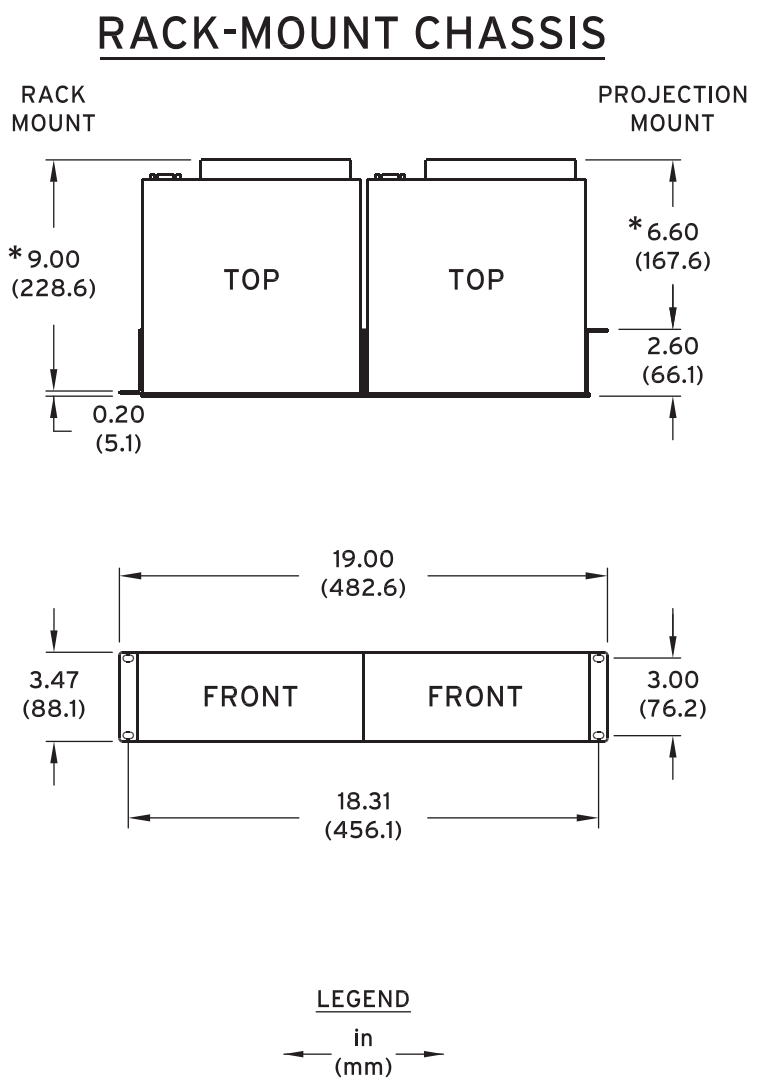

Figure 11 Relay Dimensions and Drill Plan for Mounting Two SEL-500 Series Relays Together Using Mounting Block (SEL P/N 9101)

RACK-MOUNT CHASSIS

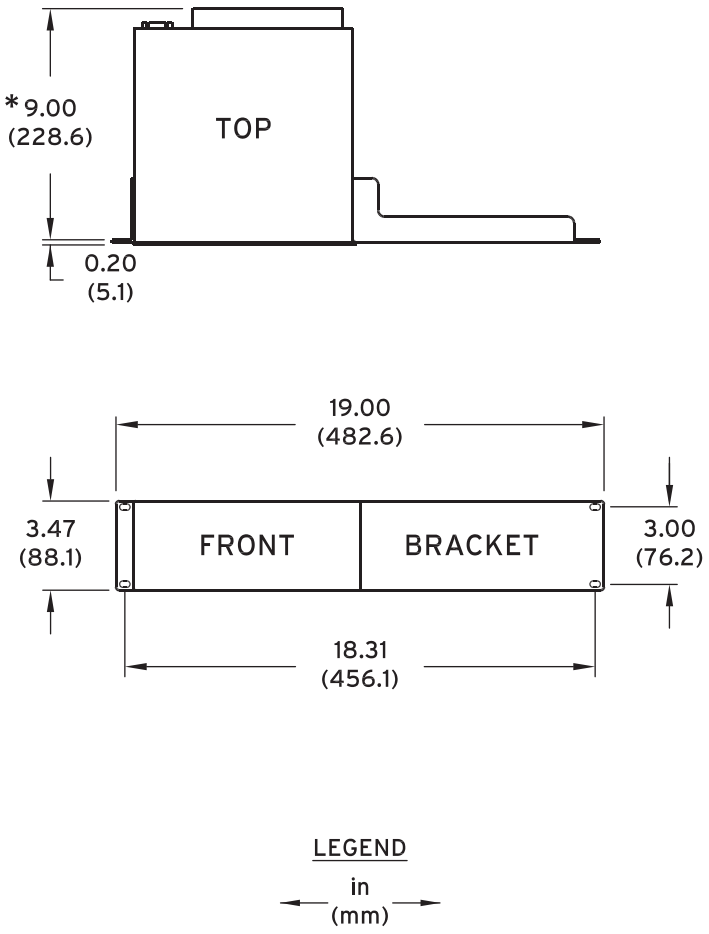

Figure 12 Relay Dimensions and Drill Plan for Mounting an SEL-501 Relay with Rack Mount Bracket 9100 (bracket on right side front view)

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

UL Listed to US and Canadian safety standards (File E212775; NRGU, NRGU7)

CE Mark

RCM Mark

General

Terminal Connections

Terminals or stranded copper wire. Ring terminals are recommended. Minimum temperature rating of 105°C.

Tightening Torque

Terminal Block

Minimum:	1.1 Nm (9-in-lb)
Maximum:	1.3 Nm (12-in-lb)

Connectorized

Minimum:	0.6 Nm (5-in-lb)
Maximum:	0.8 Nm (7-in-lb)

AC Current Inputs

5 A nominal:	15 A continuous, 500 A for 1 s, linear to 100 A symmetrical. 625 A for 1 cycle (sinusoidal waveform)
Burden:	0.16 VA at 5 A 1.15 VA at 15 A
1 A nominal:	3 A continuous, 100 A for 1 s, linear to 20 A symmetrical. 250 A for 1 cycle (sinusoidal waveform)
Burden:	0.06 VA at 1 A 0.18 VA at 3 A

Note: 60/50 Hz system frequency and ABC/ACB phase rotation are ordering options.

Power Supply

125/250 Vdc or Vac

Range:	85–350 Vdc or 85–264 Vac
Burden:	<5.5 W
Interruption:	100 ms at 250 Vdc
Ripple:	100%

48/125 Vdc or 125 Vac

Range:	36–200 Vdc or 85–140 Vac
Burden:	<5.5 W
Interruption:	100 ms at 125 Vdc
Ripple:	5%

24 Vdc

Range:	16–36 Vdc polarity dependent
Burden:	<5.5 W
Interruption:	25 ms at 36 Vdc
Ripple:	5%

Note: Interruption and Ripple per IEC 60255-11[IEC 255-11]:1979.

Output Contacts

The output type is dependent on the rear-panel terminal type. Output ratings were determined with IEC 60255-0-20:1974, using the simplified method of assessment.

Standard (Conventional Terminal Block Option)

Make:	30 A
Carry:	6 A continuous carry
1 s Rating:	100 A
MOV Protection:	270 Vac/360 Vdc
Pickup Time:	<5 ms
Dropout Time:	<5 ms

Breaking Capacity (10000 operations):

24 V	0.75 A	L/R = 40 ms
48 V	0.50 A	L/R = 40 ms
125 V	0.30 A	L/R = 40 ms
250 V	0.20 A	L/R = 40 ms

Cyclic Capacity (2.5 cycle/second):

24 V	0.75 A	L/R = 40 ms
48 V	0.50 A	L/R = 40 ms
125 V	0.30 A	L/R = 40 ms
250 V	0.20 A	L/R = 40 ms

High Current Interrupting (Plug-In Connectors Option)

Make:	30 A
Carry:	6 A continuous carry
MOV Protection:	330 Vdc
Pickup Time:	<5 ms
Dropout Time:	<8 ms, typical
Update Rate:	1/8 cycle

Breaking Capacity (10000 operations):

24 V	10.0 A	L/R = 40 ms
48 V	10.0 A	L/R = 40 ms
125 V	10.0 A	L/R = 40 ms
250 V	10.0 A	L/R = 20 ms

Cyclic Capacity (4 cycles in 1 second followed by 2 minutes idle for thermal dissipation):

24 V	10.0 A	L/R = 40 ms
48 V	10.0 A	L/R = 40 ms
125 V	10.0 A	L/R = 40 ms
250 V	10.0 A	L/R = 20 ms

Note: Do not use high-current interrupting output contacts to switch ac control signals. These outputs are polarity dependent.
Note: Make per IEEE C37.90-1989; Breaking and Cyclic Capacity per IEC 60255-23 [IEC 255-23]:1994.

Optoisolated Inputs

The input type is dependent on the rear-panel terminal type. "Level-sensitive" inputs differ from "standard" jumper-selectable inputs in that they are guaranteed to deassert below a certain voltage level and they are not user-settable. The inputs are not polarity dependent. With nominal control voltage applied, each input draws approximately 4 mA of current.

Jumper-Selectable (Conventional Terminal Blocks Option):
The conventional terminal block model is equipped with jumper-selectable inputs. Both inputs may be individually user-configured to operate on any of the following nominal voltages.

24 Vdc: on for	15–30 Vdc
48 Vdc: on for	30–60 Vdc
125 Vdc: on for	80–150 Vdc
250 Vdc: on for	150–330 Vdc

Level-Sensitive (Plug-In Connectors Option)
The plug-in connectors model is equipped with fixed "level-sensitive" inputs. Both inputs are factory-configured to the control voltage specified at time of ordering. Please note that the 24 Vdc option is not available as "level-sensitive."

24 Vdc: on for	15–30 Vdc
48 Vdc: on for	38.4–60 Vdc; off below 28.8 Vdc
125 Vdc: on for	105–150 Vdc; off below 75 Vdc
250 Vdc: on for	200–300 Vdc; off below 150 Vdc

Serial Communications

Rear Panel:	9-pin sub-D connector
Baud Rate:	300–38400 baud Settable baud rate and data bit protocol

Protocols

Serial Port Protocols:	ASCII Distributed Port Switch Protocol (LMD) Modbus RTU (baud rate limited to 192000; only available in SEL-501 Relay) SY/MAX (only available in SEL-501-1 Relay)

Metering Functions

Instantaneous and Demand Ammetering functions.
Measurement Accuracy: ±2%

Breaker Monitor

Relay counts trip operations and accumulates interrupted current on a pole-by-pole basis.

Routine Dielectric Test

Current inputs:	2500 Vac for 10 s
Power supply, optoisolated inputs, and output contacts:	3000 Vdc for 10 s

The following IEC 60255-5:1977 dielectric test is performed on all units with the CE mark:

2500 Vac for 10 seconds on analog inputs.
3100 Vdc for 10 seconds on power supply, optoisolated inputs, and contact inputs.

Operating Temperature

–40° to +85°C (–40° to +185°F)

Dimensions

8.81 cm x 21.59 cm x 23.37 cm (3.47" x 8.5" x 9.2") (H x W x D)

Weight

2.6 kg (5 lb, 12 oz)

Type Tests

Environmental Tests

Cold:	IEC 60068-2-1:1990 [EN 60068-1-1:1993] Test Ad; 16 hr at –40°C
Damp Heat, Steady State:	IEC 60068-2-3:1969 Test Ca; 96 hours at +40°C, 93% RH
Damp Heat, Cyclic	IEC 60068-2-30:1980 Test Db; 25° to 55°C, 6 cycles, 95% humidity
Dry Heat:	IEC 60068-2-2:1974 [EN 60068-2-2:1993] Test Bd: 16 hr at +85°C

Dielectric Strength and Impulse Tests

Dielectric:	IEC 60255-5:1977 IEEE C37.90-1989 2500 Vac on analogs, contact inputs, and contact outputs; 100 Vdc on power supply; 2200 Vdc on EIA-485 communications port
Impulse:	IEC 60255-5:1977 0.5 J, 5000 V

Electrostatic Discharge Test

ESD:	IEC 60255-22-2:1996 IEC 60801-2:1991 Level 4

RFI and Interference Tests

Fast Transient Burst:	IEC 60801-4:1988 Level 4 (4 kV on power supply, 2 kV on inputs and outputs)
Fast Transient Disturbance:	IEC 60255-22-4:1992 IEC 60801-2:1991 Level 4
Radiated EMI:	IEC 60255-22-3:1989, 10 V/m
Surge Withstand:	IEEE C37.90.1-1989 3.0 kV oscillatory; 5.0 kV fast transient

Vibration and Shock Tests

Shock and Bump:	IEC 60255-21-2:1988 Class 2 IEC 60255-21-3:1993 Class 2
Sinusoidal Vibration:	IEC 60255-21-1:1988 Class 2

Object Penetration

Object Penetration:	IEC 60529:1989 IP3X

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2350 NE Hopkins Court • Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.332.1890 • Fax: +1.509.332.7990
selinc.com • info@selinc.com

PDS501-01

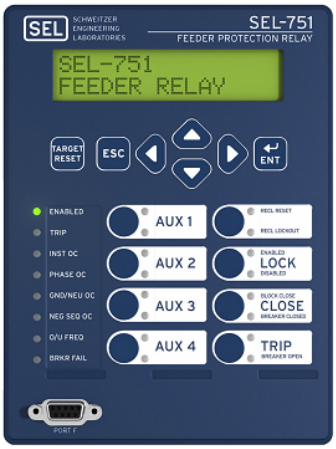
SEL-751 Feeder Protection Relay

Directional Overcurrent, Arc-Flash Detection, and High-Impedance Fault Detection

Five-Inch, Color Touchscreen Display Model With Four Pushbuttons

Five-Inch, Color Touchscreen Display Model With Eight Pushbuttons

Two-Line Display Model With Four Pushbuttons



Two-Line Display Model With Eight Pushbuttons

New Features

- A new front-panel layout option with a 5-inch, color, 800 x 480-pixel touchscreen interface to navigate the screens, folders, and applications. The new touchscreen display layout allows bay control. You can also view metered quantities and perform HMI functions including viewing and editing settings, event summaries, target status, SER, etc. This option is available with four or eight pushbuttons, with or without a fiber-optic serial port, or with or without ac voltage inputs.
- Added an ac currents only model (no voltages) that can be configured with four pushbuttons, four ac current inputs, and without a fiber-optic serial port.
- Increased the maximum number of GOOSE subscriptions to 64.

Major Features and Benefits

The SEL-751 Feeder Protection Relay provides a comprehensive combination of protection, fault-locating features, monitoring, control, and communication in an industrial package.

The SEL-751 protection features depend on the model selected. The models are configured with specific current/voltage input cards. *Table 1* shows current (ACI) and voltage (AVI) card selections for the SEL-751 models.

Table 1 Current (ACI) and Voltage (AVI) Card Selection for SEL-751 Models

Model Description	Slot Z Card Option (MOT String Digital Number 14, 15)	Slot Z Inputs	Slot E Card Option (MOT String Digits Number 12, 13)	Slot E Inputs
Base SEL-751 AC Currents Only	4 ACI (A1, A2, A3, A5, A6, A7)	IA, IB, IC, IN	None (0X)	None
SEL-751 With AC Voltages (300 Vac)	4 ACI/3 AVI (81, 82, 83, 85, 86, 87)	IA, IB, IC, IN, VA, VB, VC	None (0X)	None
SEL-751 With LEA AC Voltages (8 Vac)	4 ACI/3 AVI (L1, L2, L3, L5, L6, L7)	IA, IB, IC, IN, VA, VB, VC	None (0X)	None
SEL-751 With AC Phase Voltages (300 Vac), Vsync (300 Vac), Vbat (300 V) Input, and 4 Arc-Flash Detections Inputs	4 ACI/3 AVI (81, 82, 83, 85, 86, 87)	IA, IB, IC, IN, VA, VB, VC	2 AVI/4 AFDI (70)	VS, VBAT, AF1, AF2, AF3, AF4
SEL-751 With LEA AC Phase Voltages (8 Vac), LEA Vsync (8 Vac), Vbat (300 V) Input, and 4 Arc-Flash Detection Inputs	4 ACI/3 AVI (L1, L2, L3, L5, L6, L7)	IA, IB, IC, IN, VA, VB, VC	2 AVI/4 AFDI (L0)	VS, VBAT, AF1, AF2, AF3, AF4

The SEL-751 offers an extensive variety of protection features, depending on the model and options selected. *Table 2* lists the protection features available in each model.

Table 2 SEL-751 Protection Elements (Sheet 1 of 2)

Protection Element		Slot Z 4 ACI Card (Current Only Model) With 1 A or 5 A Neutral Channel	Slot Z 4 ACI/3 AVI Card With 1 A or 5 A Neutral Channel	Slot Z 4 ACI/3 AVI Card With 200 mA Neutral Channel
50P	Max. Phase Overcurrent	X	X	X
67P	Max. Phase Overcurrent With Directional Control		X[a]	X[b]
50Q	Neg.-Seq. Overcurrent	X	X	X
67Q	Neg.-Seq. Overcurrent With Directional Control		X[a]	X[b]
50G	Residual Overcurrent	X	X	X
67G	Residual Overcurrent With Directional Control		X[a]	X[b]
50N	Neutral Overcurrent	X	X	X
67N	Neutral Overcurrent With Directional Control			X[b]
51*m*P	Phase Time Overcurrent (*m* = A, B, C)	X	X	X
51P	Max. Phase Time Overcurrent	X	X	X
51P	Max. Phase Time Overcurrent With Directional Control		X[a]	X[b]
51G	Residual Time Overcurrent	X	X	X
51G	Residual Time Overcurrent With Directional Control		X[a]	X[b]

Table 2 SEL-751 Protection Elements (Sheet 2 of 2)

Protection Element		Slot Z 4 ACI Card (Current Only Model) With 1 A or 5 A Neutral Channel	Slot Z 4 ACI/3 AVI Card With 1 A or 5 A Neutral Channel	Slot Z 4 ACI/3 AVI Card With 200 mA Neutral Channel
51Q	Neg.-Seq. Time Overcurrent	X	X	X
51Q	Neg.-Seq. Time Overcurrent With Directional Control		X[a]	X[b]
51N	Neutral Time Overcurrent	X	X	X
51N	Neutral Time Overcurrent With Directional Control			X[b]
SEF	Sensitive Earth Fault			X
HBL	Second- and Fifth-Harmonic Blocking	X	X	X
FLOC	Fault Locator		X	X
27	Undervoltage (Phase, Phase-to-Phase, Vsync)		X	X
59	Overvoltage (Phase, Phase-to-Phase, Seq., Vsync)		X	X
27I	Inverse Time Undervoltage		X	X
59I	Inverse Time Overvoltage		X	X
60LOP	Loss of Potential		X	X
32	Directional Power		X	X
49T	IEC Thermal (line/cable)	X	X	X
55	Power Factor		X	X
78VS	Vector Shift		X	X
81	Over- and Underfrequency	X	X	X
81R	Rate-of-Change of Frequency		X	X
81RF	Fast Rate-of-Change of Frequency		X	X
25	Synchronism Check		X[c]	X[c]
BF	Breaker Failure	X	X	X
49RTD	RTDs	X[d]	X[d]	X[d]
79	Reclosing	X[d]	X[d]	X[d]
HIF AST	High-Impedance Fault Detection With Arc Sense Technology		X[d]	X[d]
AFT	Arc-Flash Detection	X[d]	X[d]	X[d]

[a] Available when ordered with the directional option. The 1 A/5 A neutral channel is suitable for solidly grounded systems and also impedance-grounded systems, depending on the available fault current level.
[b] Available when ordered with the directional option. The 200 mA neutral channel is suitable for ungrounded, low-impedance grounded, high-impedance grounded, and Petersen coil grounded applications.
[c] Available with the 2 AVI/4 AFDI card in Slot E.
[d] Available as ordering options.

The SEL-751 offers four front-panel HMI layouts that are front-panel option dependent. *Table 3* lists the HMI options for the SEL-751 front panel.

Table 3 SEL-751 Front-Panel Options

Model/Display Description[a]	Front-Panel Option (MOT String Digit Number 16)	Number of Pushbuttons	LED Type
SEL-751With Two-Line Display (2 x 16 characters)	0	8	Tricolor
SEL-751 With Two-Line Display (2 x 16 characters)	1	4	Tricolor
SEL-751 With Touchscreen Display (5-inch, color, 800 x 480 pixels)	A	8	Tricolor
SEL-751With Touchscreen Display (5-inch, color, 800 x 480 pixels)	B	4	Tricolor

[a] For ordering options, refer to the SEL-751 MOT.

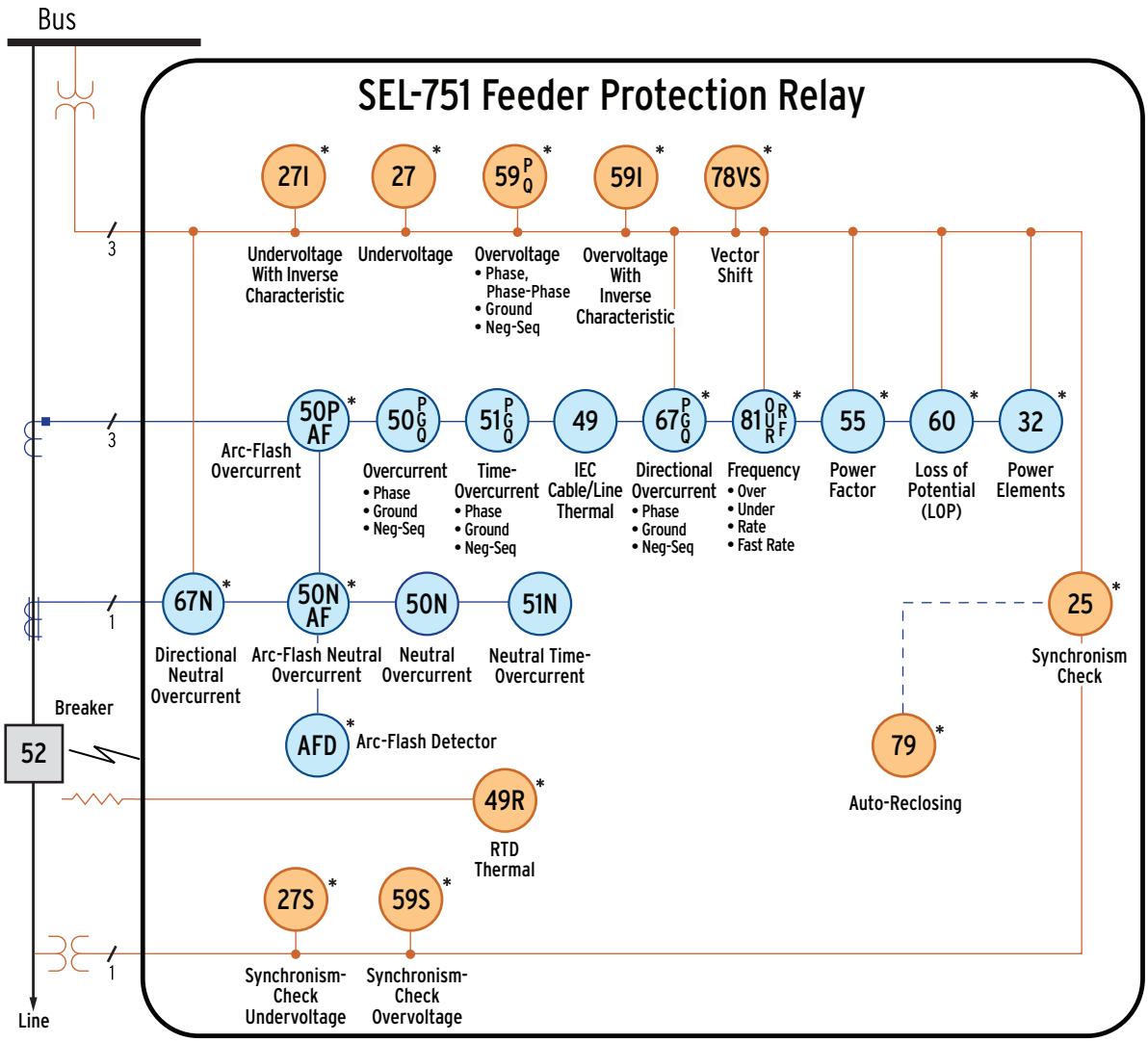
- **Standard Protection Features.** Protect lines and equipment with an extensive range of protection elements, including overcurrent elements, over- and underfrequency elements, rate-of-change-of-frequency and fast rate-of-change-of-frequency elements, definite-time and inverse-time over- and undervoltage elements, directional power elements, second- and fifth-harmonic current blocking (inrush blocking), load encroachment, demand metering elements, and breaker failure protection. Implement load shedding and other control schemes with under- and overfrequency elements, under- and overvoltage elements, and powerful SELOGIC® control equations. Also protect and control equipment with cable or line thermal elements that conform to the IEC 60255-149 standard and with vector shift elements that aid in islanding detection.
- **Optional Directional Control.** Use overcurrent elements with directional control to optimize radial and looped network protection for lines and equipment. Best Choice Ground Directional Element® logic optimizes directional element performance and eliminates the need for many directional settings.
- **Optional High-Impedance Fault Detection.** Use the high-impedance fault (HIF) detection element to operate for small current ground faults typically resulting from downed conductors on ground surfaces such as earth, reinforced concrete, or other poorly conductive materials. HIF event data are available in COMTRADE or Compressed ASCII format.
- **Optional Arc-Flash Protection.** Reduce or eliminate damage from arc-flash events with the optional four- or eight-channel fiber-optic arc-flash detector inputs and protection elements. Settable arc-flash phase and neutral overcurrent elements combined with arc-flash light detection elements provide secure, reliable, and fast arc-flash event protection.
- **Optional Low-Energy Analog (LEA) Voltage Inputs.** Measure voltages as low as 8 Vac rms.
- **Optional Synchronism Check and DC Station Battery Monitor.** Check single-phase voltage across a circuit breaker; measure dc voltage levels in the substation battery.
- **Operator Controls and Reclosing.** Trip and close the breaker easily with eight programmable front-panel pushbuttons, each with two tricolor LEDs. Implement remote and local control functions, and selectively reclose with synchronism and voltage checks.
- **Relay and Logic Settings Software.** Reduce engineering costs by using ACSELERATOR QuickSet® SEL-5030 Software for relay settings and logic programming. Tools in QuickSet make it easy to develop SELOGIC control equations.
- **Metering and Monitoring.** Use built-in metering functions to eliminate separately mounted metering devices. Analyze Sequential Events Recorder (SER) reports and oscillographic event reports for rapid commissioning, testing, and post-fault diagnostics. Unsolicited SER protocol allows station-wide collection of binary SER messages.
- **Fault Location.** Reduce fault location and repair time with built-in impedance-based fault location and faulted phase indication.
- **Wye or Delta Voltage Inputs.** Connect voltage inputs that are wye-connected, open-delta-connected, or single voltage.

- **Additional Standard Features.** Improve your feeder protection with these additional standard features in every SEL-751: Modbus RTU; Event Messenger support and MIRRORED BITS® communications; load profile and breaker wear monitoring; support for 12 external RTDs (SEL-2600); IRIG-B input; advanced SELOGIC; and IEEE C37.118-compliant synchrophasor protocol to provide real-time measurement data.
- **Additional Optional Features.** Select from a wide offering of other optional features, including IEC 61850 Edition 2; IEC-60870-5-103; DNP3 serial and LAN/WAN; Modbus TCP/IP; Simple Network Time Protocol (SNTP); parallel redundancy protocol (PRP) with dual Ethernet ports; ten internal RTDs; expanded digital/analog I/O; additional EIA-232 or EIA-485 communications ports; and single or dual, copper-wire or fiber-optic Ethernet ports, and an ac currents only model (no voltages) with no fiber-optic serial port and four programmable pushbuttons.
- **Supported Languages.** Multiple language support with English and Spanish options.

Intertie Standards and Compliance

The SEL-751 Feeder Protection Relay offers an extensive variety of protection and control features depending on the model and options selected. The SEL-751 Relay can be configured to meet or exceed the protection and control requirements specified in the ANSI/IEEE Std 1547-2014, *Standard for Interconnecting Distributed Resources with Electric Power Systems*.

Functional Overview



- Low-Energy Analogs (LEA) for AC Voltage Inputs (8 Vac RMS)*
- Sequential Events Recorder
- Event Reports and Load Profile
- SEL ASCII, Modbus RTU, Ethernet*, Modbus TCP*, IEC 61850 Edition 2*, DNP3 LAN/WAN*, DNP3 Serial*, SNTP*, Telnet*, IEC 60870-5-103*, PRP*, FTP*, and DeviceNet Communications*
- Event Messenger Compatible
- Front-Panel Tricolor LED Programmable Targets
- Two Inputs and Three Outputs Standard
- I/O Expansion*—Additional Contact Inputs, Contact Outputs, Analog Inputs, Analog Outputs, and RTD Inputs
- ST Fiber-Optic Communications Port*
- Single or Dual Ethernet, Copper or Fiber-Optic Communications Port*
- Battery-Backed Clock, IRIG-B Time Synchronization
- Instantaneous Metering
- Four or Eight Programmable Front-Panel Pushbuttons and Tricolor LED Indicators
- Advanced SELogic® Control Equations
- 32 Programmable Display Messages
- Station Battery Monitor*
- Breaker Wear Monitoring
- Synchrophasor Protocol (IEEE C37.118)
- Arc-Flash Protection*
- Peak Demand, Demand Metering
- Load Encroachment
- High-Impedance Fault Detection*
- Fault Locator
- Directional Protection*
- Touchscreen Display (5-inch, color, 400 x 800 pixels)*

*Optional

Figure 1 Functional Diagram

Protection Features

Overcurrent Elements

The SEL-751 includes a robust set of phase, negative-sequence, residual, and neutral overcurrent elements. Each element type has four levels of instantaneous protection with individual torque control and definite-time delay settings. Each element type has two inverse-time overcurrent elements (except negative-sequence, which has one time-overcurrent element). *Table 4* lists the curves available in the SEL-751.

The SEL-751 has two reset characteristic choices for each time-overcurrent element. One choice resets the elements if current drops below pickup for at least one cycle. The other choice emulates electromechanical induction disc elements, where the reset time depends on the time dial setting, the percentage of disc travel, and the amount of current.

Table 4 Inverse-Time Overcurrent Curves

US	IEC
Moderately Inverse	Standard Inverse
Inverse	Very Inverse
Very Inverse	Extremely Inverse
Extremely Inverse	Long-Time Inverse
Short-Time Inverse	Short-Time Inverse

Overcurrent Elements for Phase Fault Detection

The SEL-751 Relay provides the tools necessary for sensitive fault protection while accommodating heavily loaded circuits. Where heavy loading prevents sufficiently sensitive setting of the phase overcurrent elements to detect lower magnitude phase-to-ground faults, residual-ground overcurrent elements are available to provide sensitive ground fault protection without tripping under balanced heavy load conditions. Similarly, when heavy loading prevents sufficiently sensitive setting of the phase overcurrent elements to detect lower magnitude phase-to-phase faults, negative-sequence overcurrent elements are available to provide more sensitive phase-to-phase fault detection without tripping under balanced heavy load conditions. You can set phase overcurrent element pickup sufficiently high to accommodate heavy load while retaining sensitivity to higher magnitude three-phase faults.

On extremely heavily loaded feeders, SEL-751 load-encroachment logic adds security in cases when you cannot set phase overcurrent elements to provide adequate three-phase fault sensitivity while also accommodating load. With this logic, you can set the phase overcurrent elements below peak load current so that the relay can detect end-of-line phase faults in heavily loaded feeder applications. This load-encroachment logic uses positive-sequence load-in and load-out elements to discriminate between load and fault conditions based on the magnitude and angle of the positive-sequence impedance. When the measured positive-sequence load impedance (Z1) is within a region the load-encroachment settings define, load-encroachment logic blocks the phase overcurrent elements. As *Figure 2* shows, a phase fault causes Z1 to move from a load region to the line angle and leads to operation of the phase overcurrent elements.

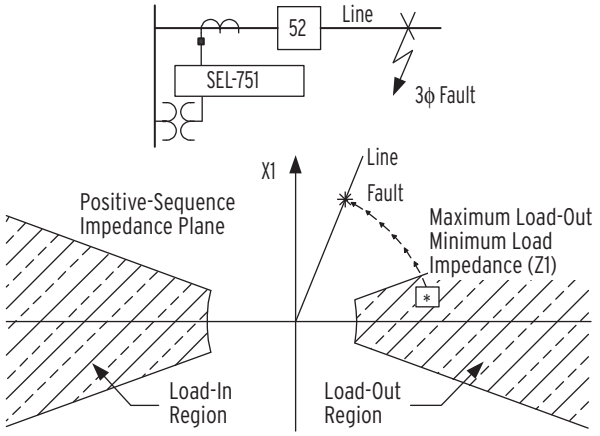


Figure 2 Load Encroachment Characteristics

Overcurrent Elements for Ground Fault Detection

Residual-ground (I_G) and neutral (I_N) overcurrent elements detect ground faults. Increase security by controlling these elements using optoisolated inputs or the internal ground directional element. The SEL-751 protection system includes patented Best Choice Ground Directional Element logic, providing a selection of negative-sequence impedance, zero-sequence impedance, and zero-sequence current polarizing techniques for optimum directional ground element control.

Directional Elements Increase Sensitivity and Security

Phase and ground directional elements come standard in an SEL-751 with the directional control option. An automatic setting mode (EDIR = AUTO) sets all directional threshold settings according to replica positive-sequence and zero-sequence line impedance settings (Z1MAG, Z1ANG, Z0MAG, and Z0ANG) for line protection applications. For all non-line protection applications, set EDIR = Y to enable and set appropriate directional element thresholds. Phase directional elements provide directional control to the phase- and negative-sequence overcurrent elements.

Phase directional characteristics include positive-sequence and negative-sequence directional elements working together. The positive-sequence directional element memory provides a reliable output for close-in, forward, or reverse three-phase faults where each phase voltage is zero.

Ground directional elements provide directional control to the residual-ground and neutral overcurrent elements. Patented negative-sequence, zero-sequence impedance directional elements, and the zero-sequence current directional element use the same principles proven in our SEL transmission line relays. Our patented Best Choice Ground Directional Element logic selects the best available ground directional element for the ORDER setting you provide.

Directional Protection for Various System Grounding Practices

Current channel IN, ordered with an optional 0.2 A secondary nominal rating, provides directional ground protection for the following systems:

- ➤ Ungrounded systems
- ➤ High-impedance grounded systems
- ➤ Petersen coil-grounded systems
- ➤ Low-impedance grounded systems

This optional directional control allows the faulted feeder to be identified on a multifeeder bus with an SEL-751 on each feeder (*Figure 3*). Alarm or trip for the ground fault condition with sensitivity down to 5 mA secondary.

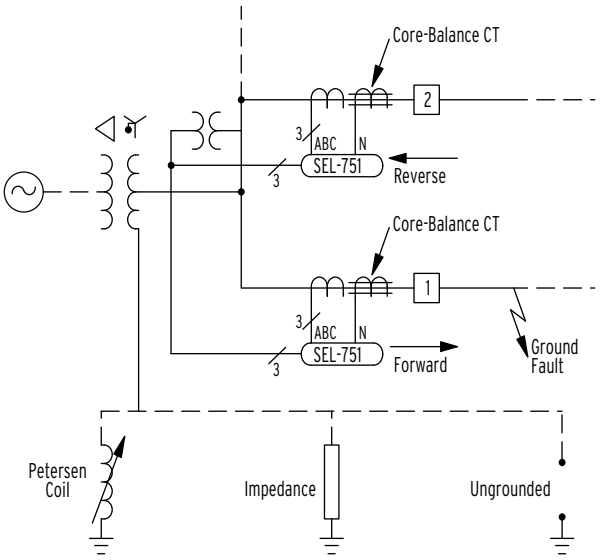


Figure 3 Apply SEL-751 Relays to Petersen Coil-Grounded, Impedance-Grounded, and Ungrounded Systems for Directional Control

Line/Cable Thermal Elements

Power lines and cables are designed to operate under a certain temperature range. Because the trend in power system operations is for equipment to be used as close to the operating limits as possible, the importance of protecting equipment against thermal overloads becomes more critical. The thermal overload protection element is used to protect the overhead lines and cables against thermal damage (including insulation degradation and loss of equipment life) and to monitor the thermal state of the overhead lines and cables. The temperature is calculated using a thermal model according to IEC 60255-149.

Wye or Open-Delta Voltages

You can apply wye-connected (four-wire) voltages or open-delta-connected (three-wire) voltages to three-phase voltage inputs VA, VB, VC, and N, as shown in *Figure 4*. You only need to make a global setting (DELTA_Y = WYE or DELTA_Y = DELTA) and an external wiring change—no internal relay hardware changes or adjustments are necessary. Thus, a single SEL-751 model meets all your distribution protection needs, regardless of available three-phase voltages.

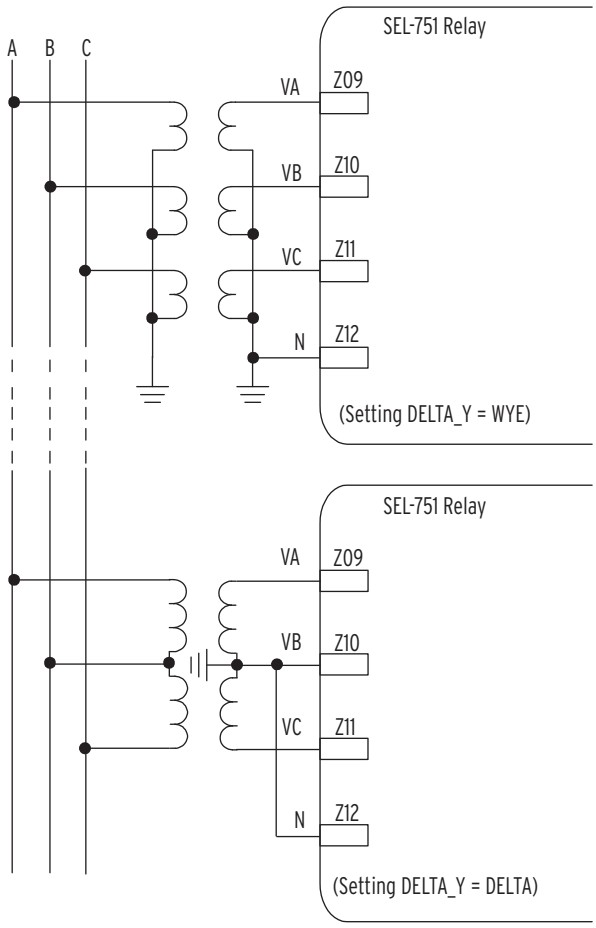


Figure 4 Connect Wye or Open-Delta Voltages to SEL-751 Three-Phase Voltage Inputs

Figure 5 shows the connections for a 3V0 broken delta input.

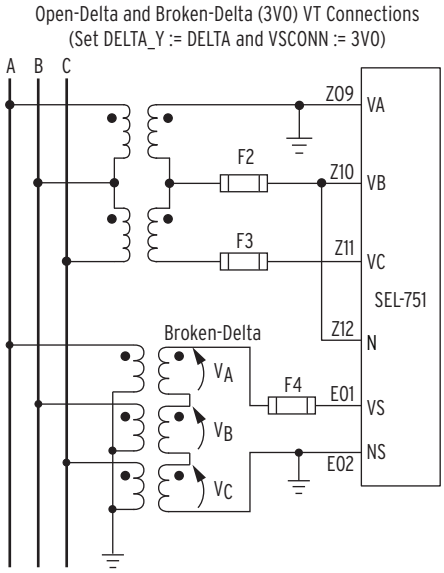


Figure 5 Broken-Delta Connections

In addition, the SEL-751 supports single voltage input. For customers with a single PT input, the SEL-751 will assume balanced voltage input for all protection and metering functions.

Loss-of-Potential Logic

The SEL-751 includes loss-of-potential (LOP) logic that detects one, two, or three blown potential fuses. This patented LOP logic is unique because it does not require settings and is universally applicable. The LOP feature allows the blocking of protection elements to add security during fuse failure.

Synchronism Check

When you order the Vsync, Vbat Voltage Input and 4 Arc-Flash Detection Inputs card (SELECT 2 AVI/4 AFDI), single-phase voltage (phase-to-neutral or phase-to-phase) is connected to voltage input VS/NS for synchronism check across a circuit breaker (or hot/dead line check). You can use synchronism-check voltage to coordinate reclosing with the optional recloser control.

Voltage and Frequency Elements for Extra Protection and Control

Over- and Undervoltage Elements

Phase-to-ground, phase-to-phase, negative-sequence, and residual overvoltage (59) and phase-to-ground or phase-to-phase undervoltage (27) elements in the SEL-751 can be used to create the following protection and control schemes.

- Trip/alarm or event report triggers for over- and undervoltage conditions.
- Undervoltage (27) load shedding scheme (having both 27 and 81U load shedding schemes allows detection of system MVAR- and MW-deficient conditions).

Inverse-Time Over- and Undervoltage Elements

Custom programmable, IEC equation-based inverse-time overvoltage (59I) and undervoltage (27I) elements in the SEL-751 add flexibility in voltage protection and control schemes.

Over- and Underfrequency Protection

Six levels of secure overfrequency (81O) or underfrequency (81U) elements detect true frequency disturbances. Use the independently time-delayed output of these elements to shed load or trip local generation. The SEL-751 uses the voltage input to make frequency measurements; it switches automatically to current input when voltages are insufficient.

Implement an internal multistage frequency trip/restore scheme at each breaker location using the multiple over- and underfrequency levels. This method avoids the cost of wiring a complicated trip and control scheme from a separate frequency relay.

Rate-of-Change-of-Frequency Protection

Four independent rate-of-change-of-frequency elements are provided with individual time delays for use when frequency changes occur, for example, when there is a sudden imbalance between generation and load. The elements can call for control action or switching action such as network decoupling or load shedding. Each element includes logic to detect either increasing or decreasing frequency and above or below nominal frequency.

Fast Rate-of-Change-of-Frequency Protection for Aurora Vulnerability Mitigation

The fast rate-of-change-of-frequency protection, 81RF, provides a faster response compared to frequency (81) and rate-of-change-of-frequency (81R) elements. Fast operating speed makes the 81RF element suitable for detecting islanding conditions. The element uses a characteristic (see *Figure 6*) based on the frequency deviation from nominal frequency (DF = FREQ – FNOM) and the rate-of-change of frequency (DF3C) to detect islanding conditions.

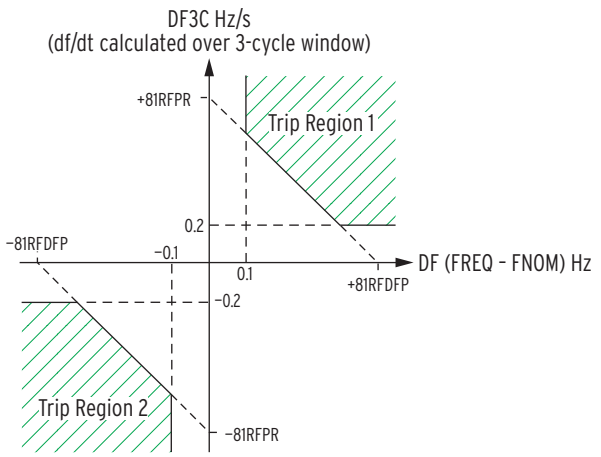


Figure 6 81RF Characteristic Power Element Protection

A time window of three cycles is used to calculate the value of DF3C. Under steady state conditions, the operating point is close to the origin. During islanding conditions, depending on the islanded system acceleration, the operating point enters Trip Region 1 or Trip Region 2 of the characteristic. 81RFDFP (in Hz) and 81RFRP (in Hz sec) are the settings used to configure the characteristic.

Vector Shift (78VS) Protection

When distributed generators (DG) are connected in the utility network, the vector shift (78VS) element is used to detect islanding conditions and trip the DG. Failure to trip islanded generators can lead to problems such as personnel safety, out-of-synchronization reclosing, and degradation of power quality. Based on the change in the angle of the voltage waveform, the islanding condition can be detected by the vector shift function.

Use the vector shift element with the 81RF element as a backup for fast and secure islanding detection. The vector shift element operates within three cycles, which is fast enough to prevent reclosing out-of-synchronism with the network feeders to avoid generator damage.

Harmonic Blocking Elements Secure Protection During Transformer Energization

Transformer inrush can cause sensitive protection to operate. Use the second- and fifth-harmonic blocking feature to detect an inrush condition and block selected tripping elements until the inrush subsides. Select the blocking threshold as a percentage of fundamental current, and optimize security and dependability with settable pickup and dropout times. Use the programmable torque control equation only to enable the blocking element immediately after closing the breaker.

Power Element Protection

The SEL-751 provides two power elements for detecting real (watts) or reactive (VARS) positive- or negative-power flow levels for the feeder application. Each power element has a definite-time delay setting.

High-Impedance Fault (HIF) Detection

High-impedance faults are short-circuit faults with fault currents smaller than what a traditional overcurrent protective relay can detect. The main causes of HIFs are tree branches touching a phase conductor; dirty or failing insulators that cause flashovers between a phase conductor and the ground; or downed conductors touching the ground. The SEL-751 with Arc Sense™ technology (AST) option, includes logic that can detect HIF signatures without being affected by loads or other system operation conditions. A running average provides a stable prefault reference, and adaptive tuning learns and tunes out feeder ambient noise conditions. Decision logic differentiates an HIF condition from other system conditions such as switching operations and noisy loads. The relay stores as many as 20 minutes of high-impedance fault activity in 2-cycle resolution Compressed ASCII and COMTRADE formats and it stores a summary of HIF activity that you can access through the use of ASCII commands.

Arc-Flash Protection

An arcing short circuit or a ground fault in low- or medium-voltage switchgear can cause serious equipment damage and personal injury, resulting in prolonged and expensive downtime.

The best way to minimize the impact of an arc-flash event is to reduce the detection and circuit breaker tripping times. Conventional protection may need several cycles to detect the resulting overcurrent fault and trip the breaker. In some cases, there may not be sufficient current to detect an overcurrent fault. Tripping may be delayed hundreds of milliseconds for sensitivity and selectivity reasons in some applications.

The arc-flash detection-based (AFD) protection can act on the circuit breaker in a few milliseconds (2–5 ms). This fast response can limit the arc-flash energy, thus preventing injury to personnel and limiting or eliminating equipment damage.

The arc-flash protection option in the SEL-751 Relay adds four- or eight-channel fiber-optic AFD inputs and protection elements. Each channel has a fiber-optic receiver and an LED-sourced fiber-optic transmitter that continuously self-tests and monitors the optical circuit to detect and alarm for any malfunction. There are two types of applications supported by the SEL-751: point-sensor applications and fiber sensor applications.

Point Sensor Application

The arc is detected by transmitting the arc-flash light captured by the optical diffuser (located appropriately in the switchgear) over a 1000 µm plastic fiber-optic cable to the optical detector in the relay. The relay performs sensor loopback tests on the optical system using an LED-based transmitter to transmit light pulses at regular intervals to the point-sensor assembly (through a second fiber-optic cable). If the relay optical receiver does not detect this light, the relay declares a malfunction and alarms. *Figure 7* (top) shows a diagram for the point sensor application.

Fiber Sensor Application

A second option for AFD uses a clear-jacketed 1000 µm plastic fiber-optic cable located in the switchgear equipment. One end of the fiber is connected to the optical detector in the relay and the other end is connected to the LED transmitter in the relay. The LED transmitter injects periodic light pulses into the fiber as a sensor loopback test to verify the integrity of the loop.

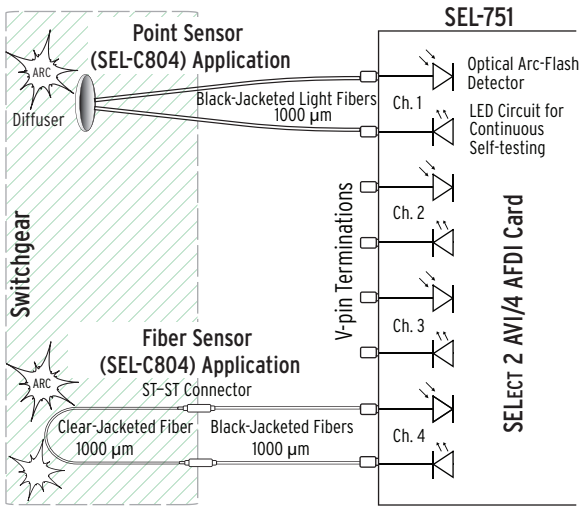


Figure 7 SEL-751 Arc-Flash Detection System

The relay detects and alarms for any malfunction. *Figure 7* (bottom) shows a diagram for the clear-jacketed fiber sensor application.

The SEL-751 AFD system provides four or eight channels per relay that can be configured for the point sensor or the clear-jacketed fiber sensor applications. The optional fast hybrid outputs (high-speed and high-current) of the relay provide fast-acting trip outputs to the circuit breaker (less than 50 µs). The fast breaker tripping can prevent serious damage or personal injury in case of an arc-flash event. The relay also provides light metering and light event capture to aid in setting the relay and capturing the arc-flash event for records and analysis.

Settable arc-flash phase and neutral overcurrent elements are combined with arc-flash light detection elements to provide secure, reliable, and fast acting arc-flash event protection.

RTD Thermal Protection

When the SEL-751 is equipped with either an optional 10 RTD input expansion card or an external SEL-2600 RTD Module with as many as 12 RTD inputs, you can program as many as 12 thermal elements in the relay for two levels of thermal protection per element. Each RTD input provides an alarm and trip thermal pickup setting in degrees Celsius, open and shorted RTD detection, and is compatible with the following three-wire RTD types:

- PT100 (100 Ω platinum)
- NI100 (100 Ω nickel)
- NI120 (120 Ω nickel)
- CU10 (10 Ω copper)

Operator Controls and Reclosing

Operator Controls Eliminate Traditional Panel Control Switches

Four or eight conveniently sized operator controls, each with two programmable tricolor LEDs, are located on the relay front panel (see *Figure 8*). You can set the SER to track operator controls. You can also change operator control functions using SELOGIC control equations. The following operator control descriptions are for factory-set logic.

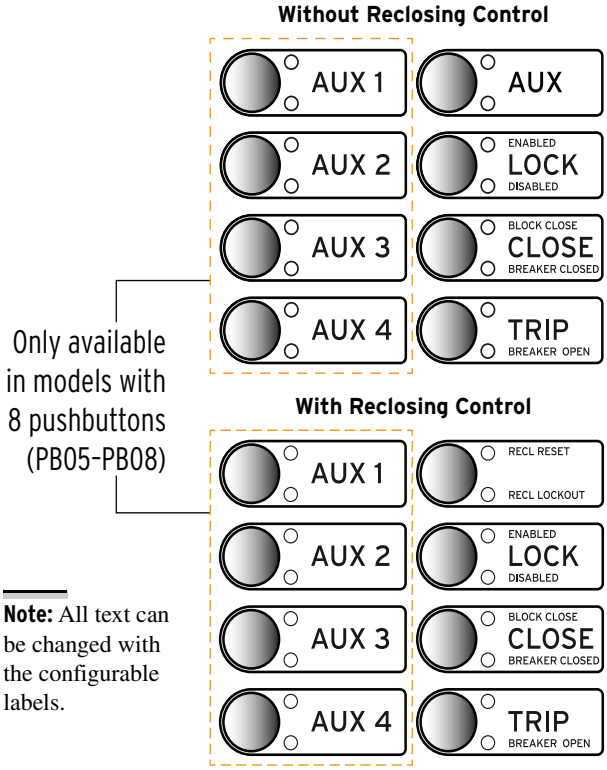


Figure 8 Operator Controls for Standard Model and Optional Reclosing Control Model

In the non-reclosing control SEL-751, you can program the top right operator control and its corresponding two LEDs. When the SEL-751 is ordered with optional reclosing, the two LEDs are programmed to give the status of the reclosing. The two LEDs, **RECL RESET** and **RECL LOCKOUT**, indicate whether the recloser is in the Reset or Lockout state.

The **LOCK** operator control blocks selected functions. Press it for at least three seconds to engage or disengage the lock function. While locked in position, the following operator controls cannot change state if pressed, **TRIP** and **CLOSE**.

Use the **CLOSE** and **TRIP** operator controls to close and open the connected circuit breaker. Program with intentional time delays to support operational requirements for breaker-mounted relays. This allows the operator to press the **CLOSE** or **TRIP** pushbutton, then move to an alternate location before the breaker command is executed.

In the SEL-751 with the touchscreen display, you can use the front-panel operator control pushbuttons to jump to a specific screen while using them for LOCK/OPEN/CLOSE operations, etc. You can program the selectable operator pushbutton screen settings under the touchscreen setting category in QuickSet and map the button to the specific screen.

Programmable Autoreclosing

When ordered with optional reclosing, the SEL-751 can autoreclose a circuit breaker as many as four times before lockout. Use SELOGIC control equations to program the SEL-751 to perform the following reclosing functions.

- Allow closing, e.g., when the load-side line is dead, or when the two systems are in synchronism (optional).
- Advance the shot counter without tripping, e.g., when another protective relay clears a fault, also known as sequence coordination.
- Initiate reclosing, e.g., for particular protection trip operations.
- Drive-to-lockout, e.g., when an optoisolated input is deasserted.
- Delay reclosing, e.g., after a trip caused by a close-in, high-duty fault.
- Flexible reclose supervision failure scheme that allows going to lockout or moving to the next available shot.

The reclosing shot counter controls which protective elements are involved in each reclose interval. Applications include fuse- and trip-saving schemes. The front-panel LEDs (**RECL RESET** and **RECL LOCKOUT**) track the reclosing state.

Relay and Logic Settings Software

QuickSet Software simplifies settings and provides analysis support for the SEL-751. With QuickSet you have several ways to create and manage relay settings:

- Develop settings offline with an intelligent settings editor that only allows valid settings.
- Create SELOGIC control equations with a drag-and-drop text editor.
- Configure proper settings using online help.
- Organize settings with the relay database manager.
- Load and retrieve settings using a simple PC communications link.

With QuickSet you can verify settings and analyze events; and analyze power system events with the integrated waveform and harmonic analysis tools.

Use the following features of QuickSet to monitor, commission, and test the SEL-751.

- The PC interface remotely retrieves power system data.
- The human-machine interface (HMI) monitors meter data, Relay Word bits, and output contacts status during testing. The control window allows resetting of metering quantities, arc-flash sensor testing and diagnostics, and other control functions.
- Bay control allows you to design new bay screens and edit existing bay screens by launching ACSELERATOR Bay Screen Builder SEL-5036 Software for SEL-751 relays with the touchscreen display.

ACSELERATOR Bay Screen Builder SEL-5036 Software

The SEL-751 Relay with the touchscreen display layout option provides you with the ability to design bay configuration screens to meet your system needs. You can display the bay configuration as a single-line diagram (SLD) on the touchscreen. You can use ANSI and IEC symbols, along with analog and digital labels, for the SLD to indicate the status of the breaker and disconnects, bus voltages, and power flow through the breaker. In addition to SLDs, you can design the screens to show the status of various relay elements via Relay Word bits or to show analog quantities for commissioning or day-to-day operations. You can design these screens with the help of Bay Screen Builder in conjunction with QuickSet. Bay Screen Builder provides an intuitive and powerful interface to design bay screens to meet your application needs.

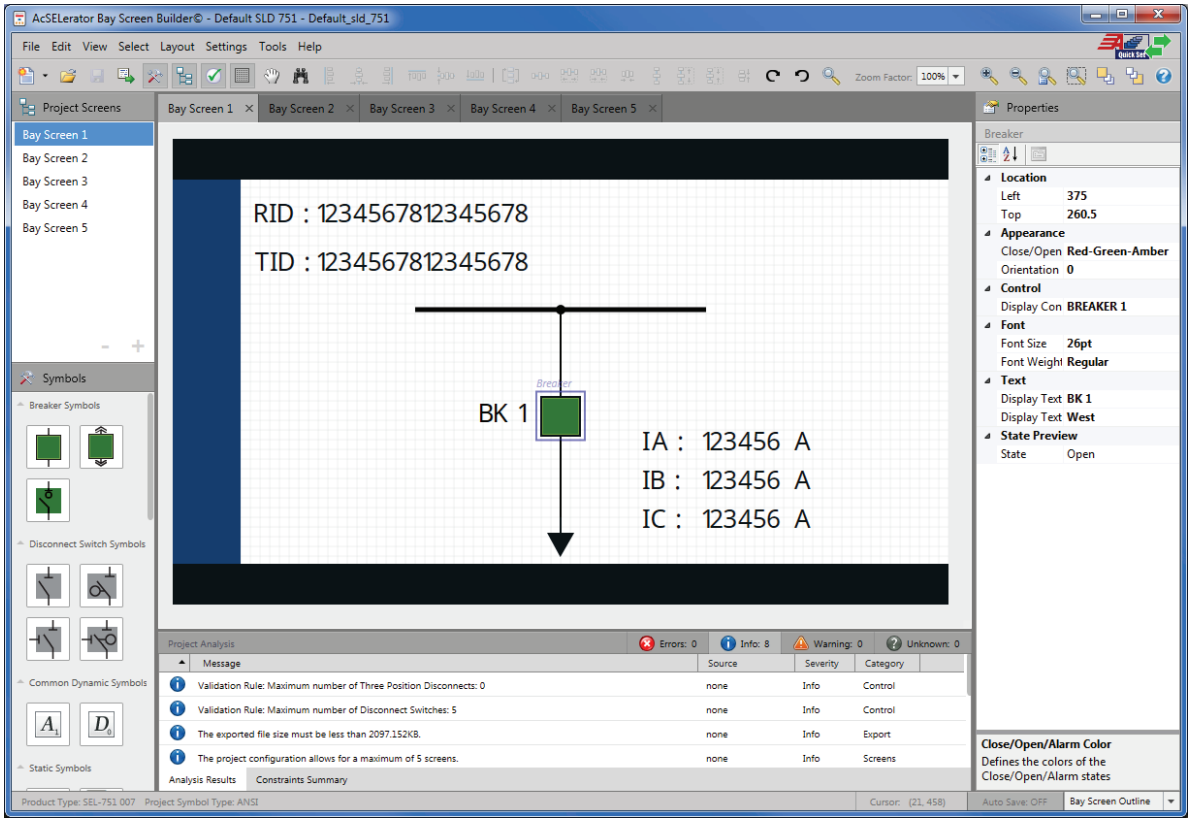


Figure 9 Bay Screen Builder

Metering and Monitoring

The SEL-751 provides extensive metering capabilities. See *Specifications on page 30* for metering and power measurement accuracies. As shown in *Table 5*, metered quantities include phase voltages and currents; sequence voltages and currents; power, frequency, and energy; and maximum/minimum logging of selected quantities. The relay reports all metered quantities in primary quantities (current in A primary and voltage in V primary).

Table 5 Metering Capabilities

Types of Metering			
Instantaneous	Light	Analog Inputs	Energy
Math Variables	RMS	Remote Analogs	Thermal
Demand and Peak Demand	Synchrophasors	Max/Min	HIF (High-Impedance Fault)

Quantities[a]	Description
Currents IA, IB, IC, IN, IG	Input currents, residual ground current (IG = 3I0 = IA + IB + IC)
Voltages VA, VB, VC	Wye-connected voltage inputs
Voltages VAB, VBC, VCA	Delta-connected voltage inputs
Voltage VS	Synchronism-check voltage input
Power $kW_{A,B,C,3P}$	Single and three-phase kilowatts, kilovars, and kilovolt-amps
$kVAR_{A,B,C,3P}$	
$kVA_{A,B,C,3P}$	
Energy MWh3P,	Three-phase megawatt-hours, megavar-hours, and megavolt-amp-hours
MVARh3P-IN,	
MVARh3P-OUT,	
MVAh3P	
Power Factor $PF_{A,B,C,3P}$	Single and three-phase power factor (leading or lagging)
Sequence I1, 3I2, 3I0, V1, 3V2, 3V0	Positive-, negative-, and zero-sequence currents and voltages
Frequency, FREQ, FREQS (Hz)	Instantaneous relay frequency, synchronism-check voltage frequency
Voltage VDC	Station battery voltage
Light Intensity (%) LS1–LS8	Arc-flash light inputs in percentage of full scale
AI*x*01–AI*x*08	Analog Inputs
MV01–MV32	Math Variables
RA001–RA128	Remote Analogs
Thermal Element *x*	Element *x* pu current level, thermal capacity, time to trip, and time to reset values, where *x* = 1, 2, or 3
Current THIEQ*x* pu	
TCU THTCU*x*%	
Trip Time THTRIP*x* s	
Release Time THRLS*x* s	
RTD1–RTD12	RTD temperature measurement (degrees C)

[a] Single-phase power, energy, and power factor quantities are not available when delta-connected PTs are used.

Load Profile

The SEL-751 features a programmable Load Data Profile (LDP) recorder that records as many as 17 metering quantities into nonvolatile memory at fixed time intervals. The LDP saves several days to several weeks of the most recent data depending on the LDP settings (6500 entries total).

Synchrophasor Measurements

Use IEEE C37.118-2005 protocol to send synchrophasor data to such SEL synchrophasor applications as the SEL-3373 Station Phasor Data Concentrator (PDC), the SEL-5073 SYNCHROWAVE® PDC, the SEL-3378 Synchrophasor Vector Processor (SVP), the SEL-3530 Real-Time Automation Controller (RTAC), and the SEL SYNCHROWAVE software suite.

The SEL-3373 Station PDC and the SEL-5073 SYNCHROWAVE PDC correlate data from multiple SEL-751 Relays and concentrate the result into a single output data stream. These products also provide synchrophasor data archiving capability. The SEL-3378 SVP enables control applications based on synchrophasors. Directly measure the oscillation modes of your power system and then act on the result. Use wide-area phase angle slip and acceleration measurements to properly control islanding of distributed generation. With the SVP, you can customize a synchrophasor control application according to the unique requirements of your power system.

The data rate of SEL-751 synchrophasors is selectable with a range of 1–60 messages per second. This flexibility is important for efficient use of communication capacity.

The SEL-751 phasor measurement accuracy meets the highest IEEE C37.118-2005 Level 1 requirement of 1 percent total vector error (TVE). This means you can use any SEL-751 model in an application that otherwise would require purchasing a separate dedicated phasor measurement unit (PMU).

Use the SEL-751 with SEL communications processors, or the SEL-3530 RTAC, to change nonlinear state estimation into linear state estimation. If all necessary lines include synchrophasor measurements then state estimation is no longer necessary. The system state is directly measured.

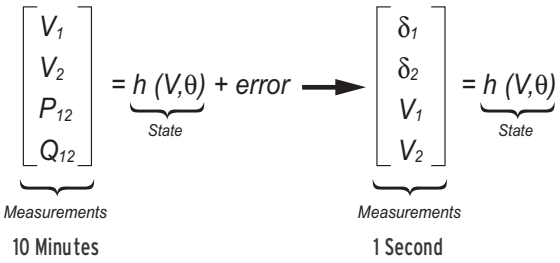


Figure 10 Synchrophasor Measurements Turn State Estimation Into State Measurement

Improve Situational Awareness

Provide improved information to system operators. Advanced synchrophasor-based tools produce a real-time view of system conditions. Use system trends, alarm points, and preprogrammed responses to help operators prevent a cascading system collapse and maximize system stability. Awareness of system trends provides operators with an understanding of future values based on measured data.

- Increase system loading while maintaining adequate stability margins.
- Improve operator response to system contingencies such as overload conditions, transmission outages, or generator shutdown.
- Advance system knowledge with correlated event reporting and real-time system visualization.
- Validate planning studies to improve system load balance and station optimization.

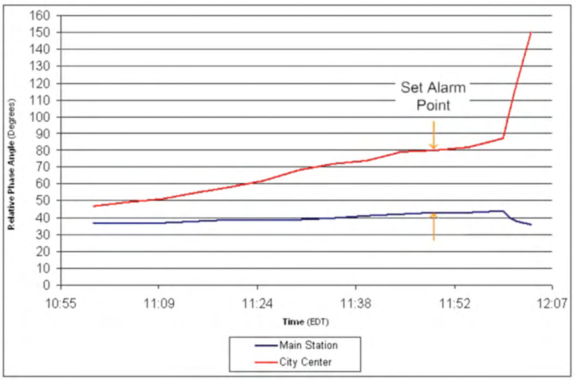


Figure 11 Visualization of Phase Angle Measurements Across a Power System

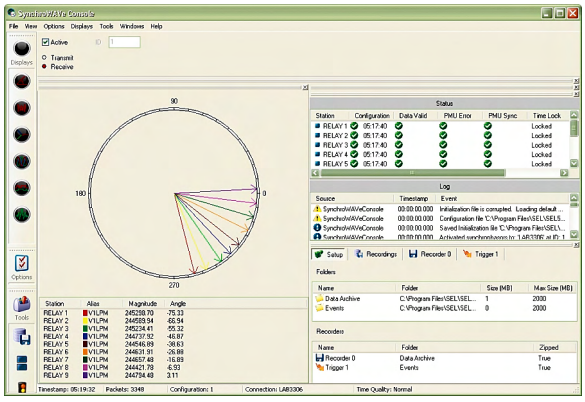


Figure 12 SEL-5078 SYNCHROWAVE Console Real-Time, Wide-Area Visualization Tool

Event Reporting

Event reports and the SER simplify post-fault analysis and improve understanding of simple and complex protective scheme operations. In response to a user-selected trigger, the voltage, current, frequency, and element status information contained in each event report confirms relay, scheme, and system performance for every fault. Decide how much detail is necessary when you request an event report (e.g., 1/4-cycle or 1/32-cycle resolution and filtered or raw analog data).

The relay stores as many as 6 of the most recent 180-cycle, 17 of the most recent 64-cycle, or 70 of the most recent 15-cycle event reports in nonvolatile memory. The relay always appends relay settings to the bottom of each event report.

The following analog data formats are available:

- 1/4-cycle or 1/32-cycle resolution, unfiltered or filtered analog, ASCII or Compressed ASCII reports
- 1/32-cycle resolution COMTRADE reports

The relay SER feature stores the latest 1024 entries. Use this feature to gain a broad perspective at a glance. An SER entry helps to monitor input/output change-of-state occurrences and element pickup/dropout.

The IRIG-B time-code input synchronizes the SEL-751 internal clock time to within ±1 µs of the time-source input. Convenient sources for this time code are the SEL-2401 Satellite-Synchronized Clock, the SEL communication processor, or the SEL Real Time Automation Controller (RTAC) (via Serial Port 2 or 3 on the SEL-751). For time accuracy specifications for metering, synchrophasors, and events, see *Specifications*.

Substation Battery Monitor

The SEL-751 relays that include the enhanced voltage option with the monitoring package measure and report the substation battery voltage connected to the VBAT terminals. The relay includes two programmable threshold comparators and associated logic for alarm and control. For example, if the battery charger fails, the measured dc falls below a programmable threshold. The SEL-751 alarms to alert operations personnel before the substation battery voltage falls to unacceptable levels. Monitor these thresholds with an SEL communications processor and trigger messages, telephone calls, or other actions.

The measured dc voltage appears in the meter display and the Vdc column of the event report. Use the event report column data to see an oscillographic display of the battery voltage. This display shows how much the substation battery voltage drops during trip, close, and other control operations.

Circuit Breaker Contact Wear Monitor

Circuit breakers experience mechanical and electrical wear every time they operate. Intelligent scheduling of breaker maintenance takes into account a manufacturer's published data of contact wear versus interruption levels and operation count. With the breaker manufacturer's maintenance curve as input data, the SEL-751 breaker monitor feature compares this input data to the measure (unfiltered) ac current at the time of trip and the number of close-to-open operations.

Every time the breaker trips, it integrates the measured current information. When the result of this integration exceeds the breaker wear curve threshold (see *Figure 13*) the relay alarms via output contact, communications port, or front-panel display. This kind of information allows timely and economical scheduling of breaker maintenance.

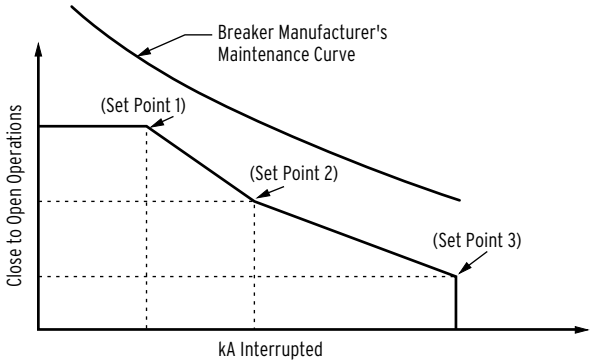


Figure 13 Breaker Contact Wear Curve and Settings

Fault Locator

The SEL-751 provides a valuable estimate of fault location even during periods of substantial load flow. The fault locator uses fault type, replica line impedance settings, and fault conditions to calculate fault location. This feature, which operates without the use of communications channels, special instrument transformers, or prefault information, contributes to efficient dispatch of line crews and fast restoration of service. The fault locator uses three-phase voltage inputs. Wye-connected voltages are necessary for phase and ground fault distance calculations.

Only phase fault distance calculations are available with delta-connected voltages. The fault locator is unavailable in the absence of voltage or single-phase voltage connections.

Touchscreen Display

You can order the SEL-751 Feeder Protection Relay with an optional touchscreen display (5-inch, color, 800 x 480 pixels). The touchscreen display makes relay data metering, monitoring, and control quick and efficient. The touchscreen display option in the SEL-751 features a straightforward application-driven control structure and includes intuitive and graphical screen designs.

The touchscreen display allows you to:

- View and control bay screens
- Access metering and monitoring data
- Inspect targets
- View event history, summary data, and SER information
- View relay status and configuration
- Control relay operations
- View and edit settings
- Enable the rotating display
- Program control pushbuttons to jump to a specific screen

You can navigate the touchscreen by tapping the folders and applications. The folders and applications of the **Home** screen are shown in *Figure 14*. Folders and applications are labeled according to functionality. Additional folder and application screens for the SEL-751 touchscreen display option can be seen in *Figure 15* through *Figure 23*.

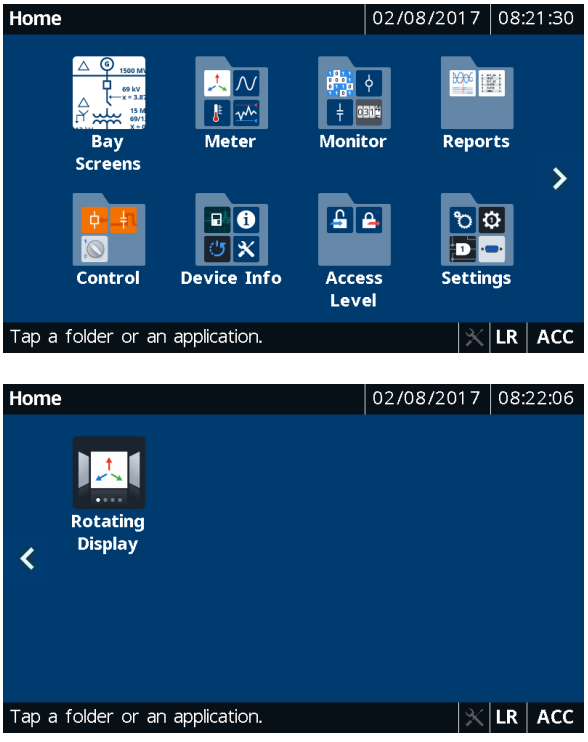


Figure 14 Home (Default FPHOME Screen)

Bay Screens Application

The SEL-751 Relay with the touchscreen display option provides you with the ability to design bay configuration screens to meet your system needs. The bay configuration can be displayed as an SLD on the touchscreen. You can create as many as five bay screens with one controllable breaker and as many as five monitor-only disconnects. ANSI and IEC symbols, along with analog and digital labels, are available for you to create detailed SLDs of the bay to indicate the status of the breaker and disconnects, bus voltages, and power flow through the breaker. *Figure 15* shows the default SLD for the touchscreen display option.

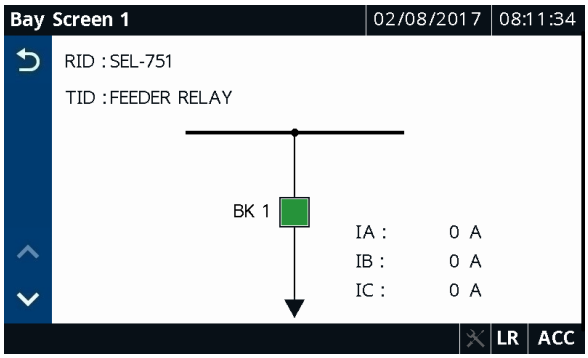


Figure 15 Default Bay Screen

Meter Folder Applications

The applications in the **Meter** folder are part-number dependent. Only those metering applications specific to your part number appear in the **Meter** folder. Tapping an application in the **Meter** folder shows you the report for that particular application. Tap the **Phasor** application to view the current and voltage phasors (see *Figure 16*).

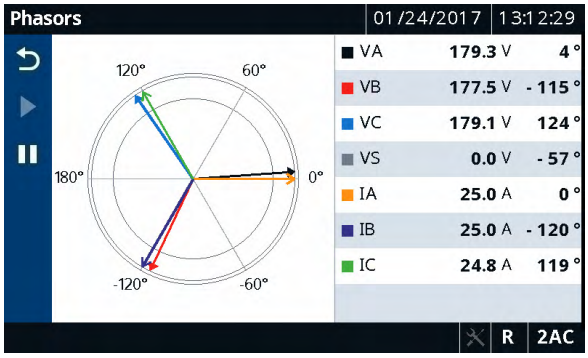


Figure 16 Meter Phasors

Tap the **Energy** application to view the energy metering quantities (see *Figure 17*). A reset feature is provided for the **Energy**, **Max/Min**, **Demand**, and **Peak Demand**

applications. Tap the **Reset** button (see *Figure 17*) to navigate to the reset confirmation screen. Once you confirm the reset, the data are reset to zero.

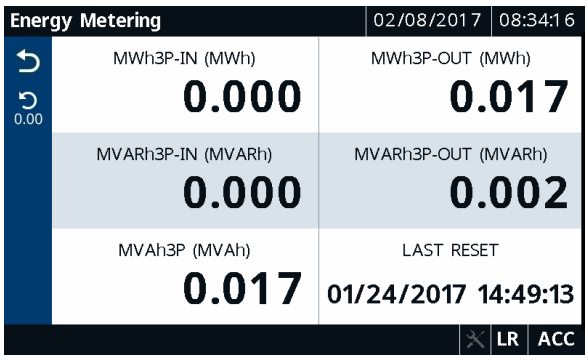


Figure 17 Meter Energy

Reports Folder Applications

Tapping the **Reports** folder navigates you to the screen where you can access the **Events**, **HIF Events** (if available), and **SER** applications. Use these applications to view events and SERs. To view the event summary (see *Figure 18*) of a particular event record, you can tap the event record on the **Event History** screen (for **Events** and **HIF Events**).

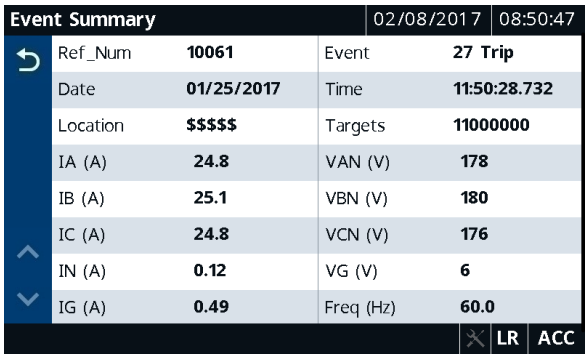


Figure 18 Event Summary

Tap the **Sequential Events Recorder** application to view a history of the SER reports (see *Figure 19*).

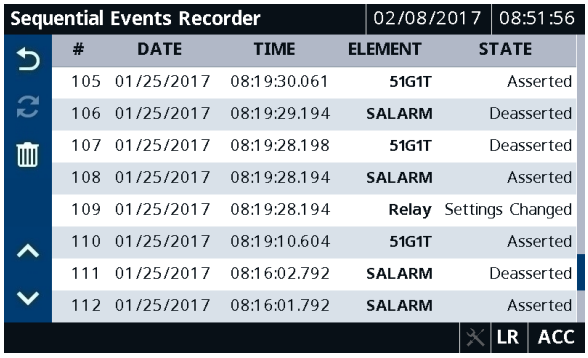


Figure 19 Sequential Events Recorder

Tapping the **Trash** button, shown in *Figure 18*, on the **Event History**, **HIF Event History**, and **Sequential Events Recorder** screens and confirming the delete action removes the records from the relay.

Control Folder Applications

Tapping the **Control** folder navigates you to the screen where you can access the **Breaker Control**, **Output Pulsing**, and **Local Bits** applications. Use the applications to perform breaker control operations, pulse output contacts (*Figure 20*), and control the local bits (*Figure 21*).

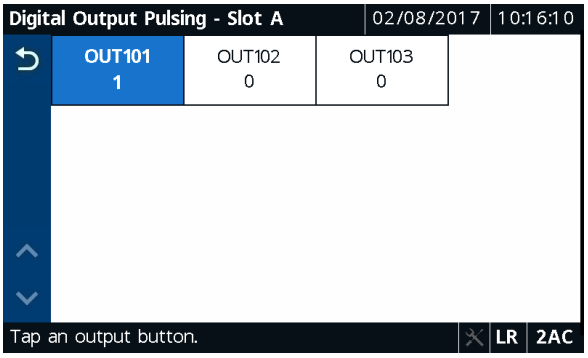


Figure 20 Digital Output Pulsing-Slot A

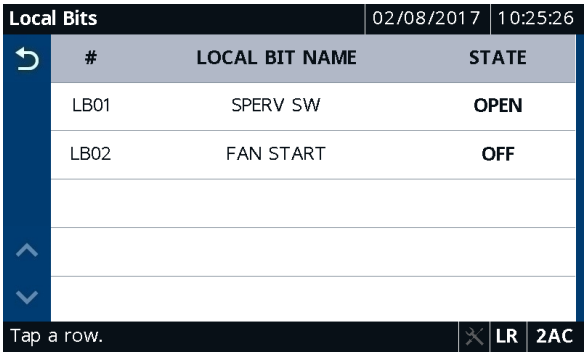


Figure 21 Local Bits

Device Info Folder Applications

Tapping the **Device Info** folder navigates you to the screen where you can access specific device information applications (**Status**, **Configuration**, **Arc-Flash Diagnostics**, and **Trip & Diag. Messages**) and the **Reboot** application.

Tap the **Status** application to view the relay status, firmware version, part number, etc. (see *Figure 22*).

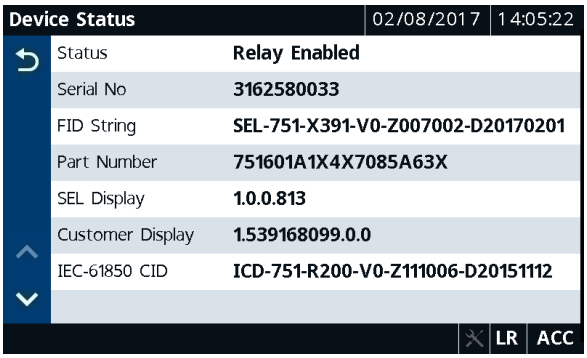


Figure 22 Status

To view the trip and diagnostic messages, tap the **Trip & Diag. Messages** application (see *Figure 23*). When a diagnostic failure, trip, or warning occurs, the relay displays the diagnostic message on the screen until it is either overriden by the restart of the rotating display, or the inactivity timer expires.

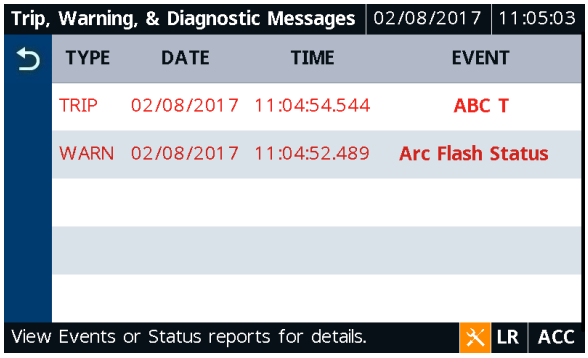


Figure 23 Trip and Diagnostics

Automation

Flexible Control Logic and Integration Features

The SEL-751 can be equipped with as many as four independently operated serial ports:

- EIA-232 port on the front panel
- EIA-232 or EIA-485 port on the main board in the rear
- EIA-232 fiber-optic port on the main board in the rear
- EIA-232 or EIA-485 port on the optional communications card in **Slot C** in the rear

Optionally, the relay supports single or dual, copper or fiber-optic Ethernet ports. The relay does not require special communications software. You can use any system that emulates a standard terminal system. Establish communication by connecting computers, modems, protocol converters, printers, an SEL real-time automation controller (RTAC), SEL communications processor, SEL computing platform, SCADA serial port, or RTUs for local or remote communication. Refer to *Table 6* for a list of communications protocols available in the SEL-751.

Table 6 Communications Protocols (Sheet 1 of 2)

Type	Description
Simple ASCII	Plain language commands for human and simple machine communications. Use for metering, setting, self-test status, event reporting, and other functions.
Compressed ASCII	Comma-delimited ASCII data reports. Allows external devices to obtain relay data in an appropriate format for direct import into spreadsheets and database programs. Data are checksum protected.
Extended Fast Meter and Fast Operate	Binary protocol for machine-to-machine communications. Quickly updates SEL communications processors, RTUs, and other substation devices with metering information, relay elements, I/O status, time-tags, open and close commands, and summary event reports. Data are checksum protected. Binary and ASCII protocols operate simultaneously over the same communications lines so control operator metering information is not lost while a technician is transferring an event report.
Fast SER Protocol	Provides SER events to an automated data collection system.
Modbus	Serial- or Ethernet-based Modbus with point remapping. Includes access to metering data, protection elements, contact I/O, targets, SER, relay summary event reports, and setting groups.
DNP3	Serial or Ethernet-based DNP3 protocols. Provides default and mappable DNP3 objects that include access to metering data, protection elements, Relay Word bits, contact I/O, targets, SER, relay summary event reports, and setting group selection.
IEC 61850 Edition 2	Ethernet-based international standard for interoperability between intelligent devices in a substation. Operates remote bits and I/O. Monitors Relay Word bits and analog quantities.
Synchrophasors	IEEE C37.118-compliant synchrophasors for system state, response, and control capabilities.
Event Messenger	The SEL-3010 allows users to receive alerts sent directly to their cell phone. Alerts can be triggered through relay events and can include quantities measured by the relay.

Table 6 Communications Protocols (Sheet 2 of 2)

Type	Description
DeviceNet	Allows for connection to a DeviceNet network for access to metering data, protection elements, contact I/O, targets, and setting groups.
SNTP	Ethernet-based protocol that provides time synchronization of the relay.
IEC 60870-5-103	Serial communications protocol—international standard for interoperability between intelligent devices in a substation.

Apply an SEL communications processor as the hub of a star network with a point-to-point fiber or copper connection between the hub and the SEL-751 (see *Figure 24*).

The communications processor supports external communications links including the public switched telephone network for engineering access to dial-out alerts and private line connections of the SCADA system.

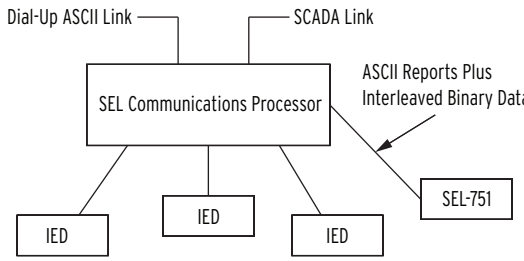


Figure 24 Example Communication System

SEL manufactures a variety of standard cables for connecting this and other relays to a variety of external devices. Consult your SEL representative for more information on cable availability.

SEL-751 control logic improves integration in the following ways.

- **Replaces traditional panel control switches.** Eliminate traditional panel control switches with 32 local bits. Set, clear, or pulse local bits with the front-panel pushbuttons and display. Program the local bits into your control scheme with SELOGIC control equations. Use the local bits to perform functions such as a trip test or a breaker trip/close.
- **Eliminates RTU-to-relay wiring with 32 remote bits.** Set, clear, or pulse remote bits using serial port commands. Program the remote bits into your control scheme with SELOGIC control equations. Use remote bits for SCADA-type control operations such as trip, close, and settings group selection.
- **Replaces traditional latching relays.** Replace as many as 32 traditional latching relays for such functions as "remote control enable" with latch bits. Program latch set and latch reset conditions with SELOGIC control equations. Set or reset the nonvolatile latch bits using optoisolated inputs, remote bits, local bits, or any programmable logic condition. The latch bits retain their state when the relay loses power.
- **Replaces traditional indicating panel lights.** Replace traditional indicating panel lights with 32 programmable displays. Define custom messages (e.g., `Breaker Open`, `Breaker Closed`) to report power system or relay conditions on the front-panel display. Use advanced SELOGIC control equations to control which messages the relay displays.
- **Eliminates external timers.** Eliminate external timers for custom protection or control schemes with 32 general purpose SELogic control equation timers. Each timer has independent time-delay pickup and dropout settings. Program each timer input with any desired element (e.g., time qualify a current element). Assign the timer output to trip logic, transfer trip communications, or other control scheme logic.
- **Eliminates setting changes.** Selectable setting groups make the SEL-751 ideal for applications requiring frequent setting changes and for adapting the protection to changing system conditions.

The relay stores three setting groups. Select the active setting group by optoisolated input, command, or other programmable conditions. Use these setting groups to cover a wide range of protection and control contingencies.

Switching setting groups switches logic and relay element settings. You can program groups for different operating conditions, such as feeder paralleling, station maintenance, seasonal operations, emergency contingencies, loading, source changes, and downstream relay setting changes.

Fast SER Protocol

SEL Fast SER provides SER events to an automated data collection system. Fast SER is available on any rear serial port. Devices with embedded processing capability can use these messages to enable and accept unsolicited binary SER messages from SEL-751 relays.

SEL relays and communications processors have two separate data streams that share the same serial port. The normal serial interface consists of ASCII character commands and reports that are intelligible to people using a terminal or terminal emulation package. The binary data

streams can interrupt the ASCII data stream to obtain information, and then allow the ASCII data stream to continue. This mechanism allows a single communications channel to be used for ASCII communications (e.g., transmission of a long event report) interleaved with short bursts of binary data to support fast acquisition of metering or SER data.

Ethernet Network Architectures

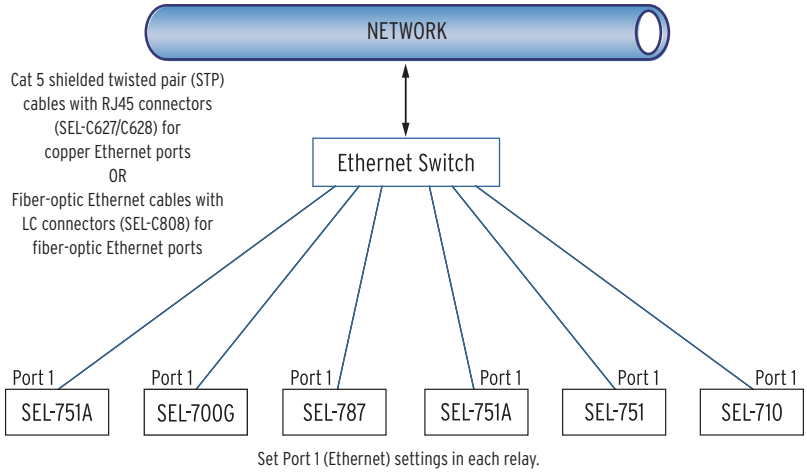


Figure 25 Simple Ethernet Network Configuration

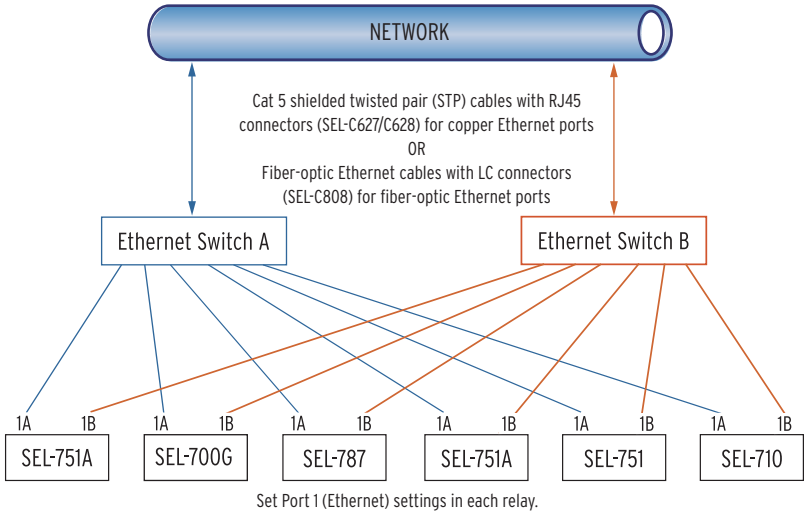


Figure 26 Ethernet Network Configuration With Dual Redundant Connections (Failover Mode)

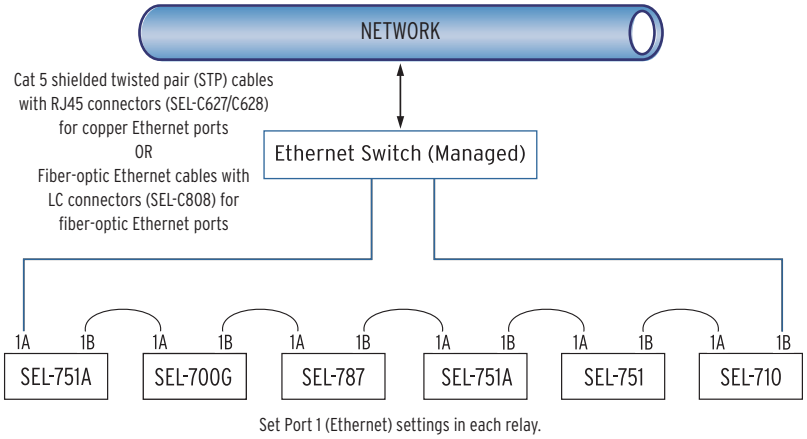


Figure 27 Ethernet Network Configuration With Ring Structure (Switched Mode)

Additional Features

MIRRORED BITS Relay-to-Relay Communications

The SEL-patented MIRRORED BITS communications technology provides bidirectional relay-to-relay digital communications. MIRRORED BITS can operate independently on as many as two EIA-232 rear serial ports and one fiber-optic rear serial port on a single SEL-751.

This bidirectional digital communication creates eight additional virtual outputs (transmitted MIRRORED BITS) and eight additional virtual inputs (received MIRRORED BITS) for each serial port operating in the MIRRORED BITS mode (see *Figure 28*). Use these MIRRORED BITS to transmit/receive information between upstream relays and a downstream recloser control (e.g., SEL-351R) to enhance coordination and achieve faster tripping for downstream faults. MIRRORED BITS technology also helps reduce total scheme operating time by eliminating the need to assert output contacts to transmit information.

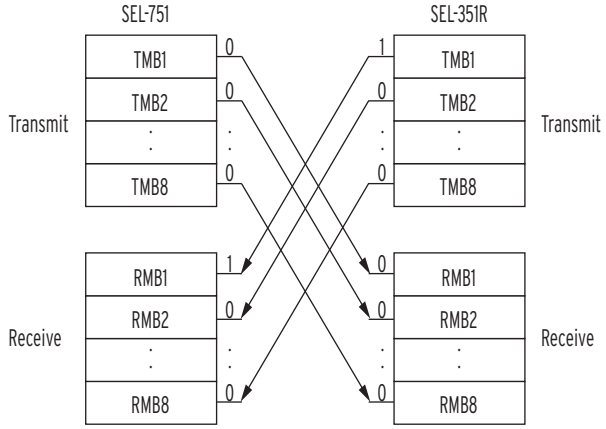


Figure 28 MIRRORED BITS Transmit and Receive Bits

Status and Trip Target LEDs

The SEL-751 includes 24 status and trip target tricolor LEDs on the front panel. When shipped from the factory, all LEDs are predefined and fixed in settings. You can reprogram these LEDs for specific applications. This combination of targets is explained and shown in *Figure 31*. Some front-panel relabeling of LEDs may be needed if you reprogram them for unique or specific applications (see *Configurable Labels*).

Event Messenger Points

The SEL-751, when used with the SEL-3010 Event Messenger, can allow for ASCII-to-voice translation of as many as 32 user-defined messages, along with analog data that has been measured or calculated by the relay. This combination can allow the user to receive voice messages on any phone for alerts to transition of any Relay Word bits in the relay.

Verbal notification of breaker openings, fuse failures, RTD alarms, etc. can now be sent directly to your cell phone through the use of your SEL-751 and SEL-3010 (must be connected to an analog telephone line). In addition, messages can include an analog value such as current, voltage, or power measurements made by the SEL-751.

Configurable Labels

Use the configurable labels to relabel the operator controls and LEDs to suit the installation requirements. This feature includes preprinted labels (with factory-default text), blank label media, and a Microsoft® Word template on CD-ROM. This allows you to create quick, professional-looking labels for the SEL-751. Labels may also be customized without the use of a PC by writing the new label on the blank stock provided.

The ability to customize the control and indication features allows specific utility or industry procedures to be implemented without the need for adhesive labels. All of the figures in this data sheet show the factory default labels of the SEL-751, including the standard model shown in *Figure 31*.

Relay Dimensions

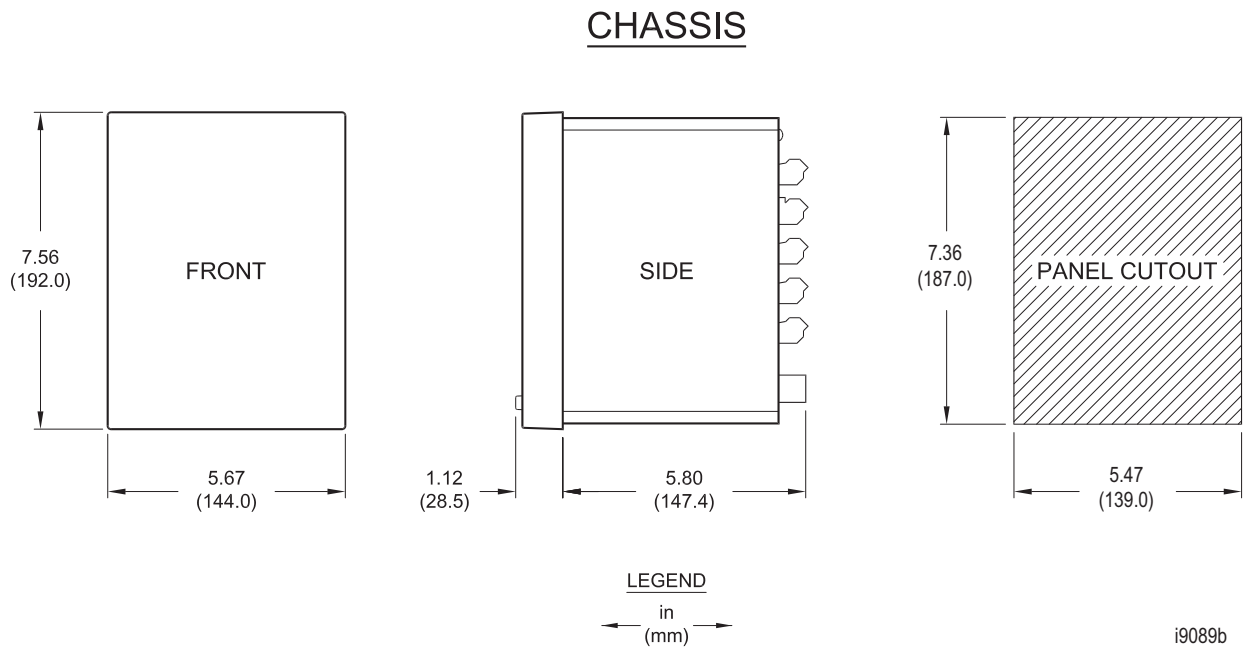


Figure 29 SEL-751 Dimensions for Rack- and Panel-Mount Models

Hardware Overview

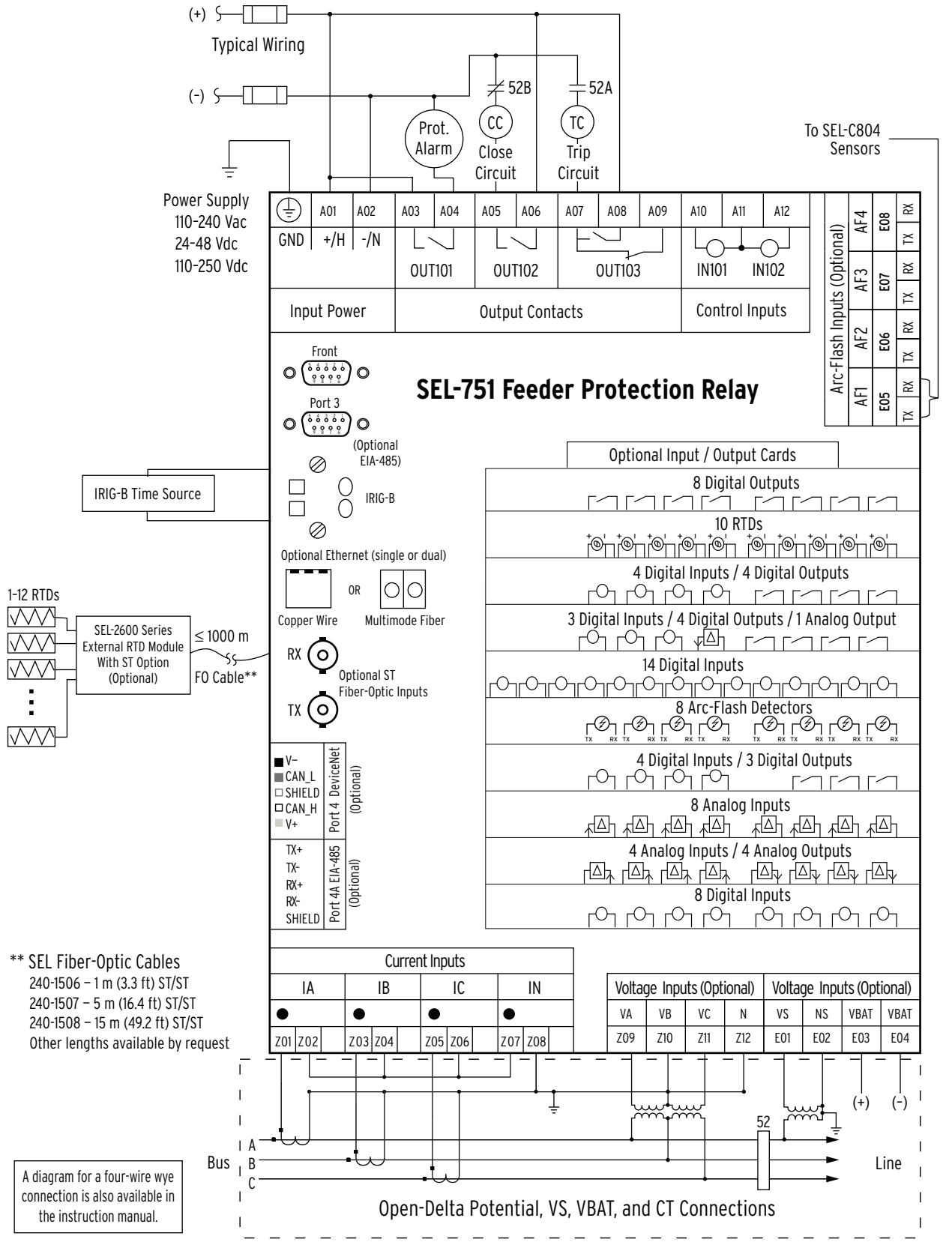


Figure 30 Wiring Diagram SEL-751

Relay Panel Diagrams

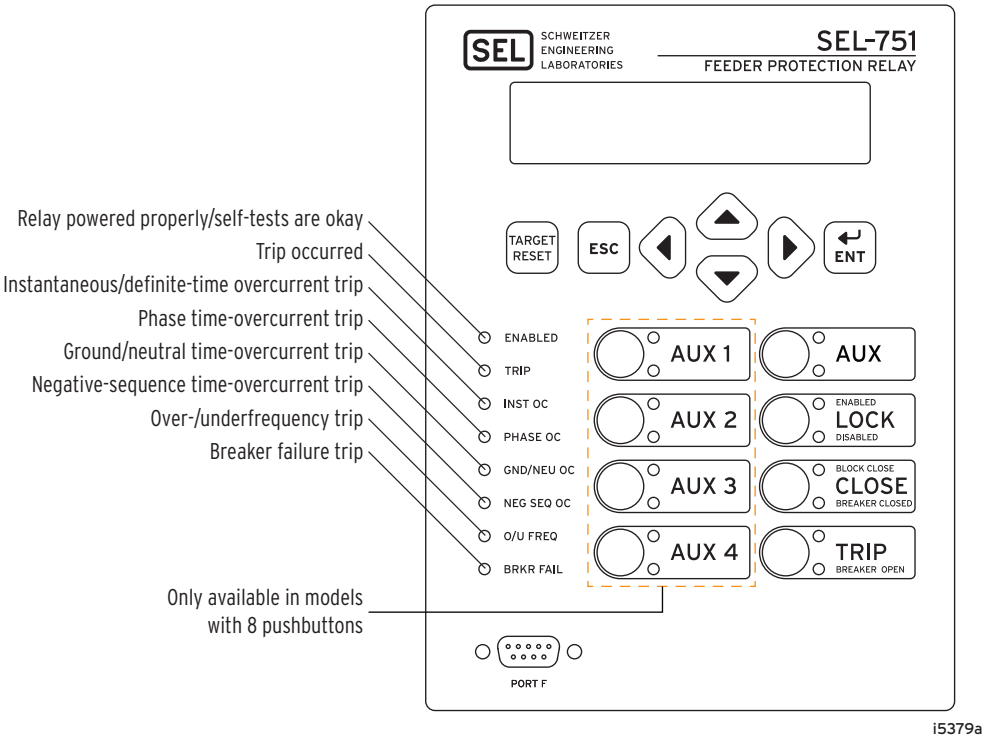
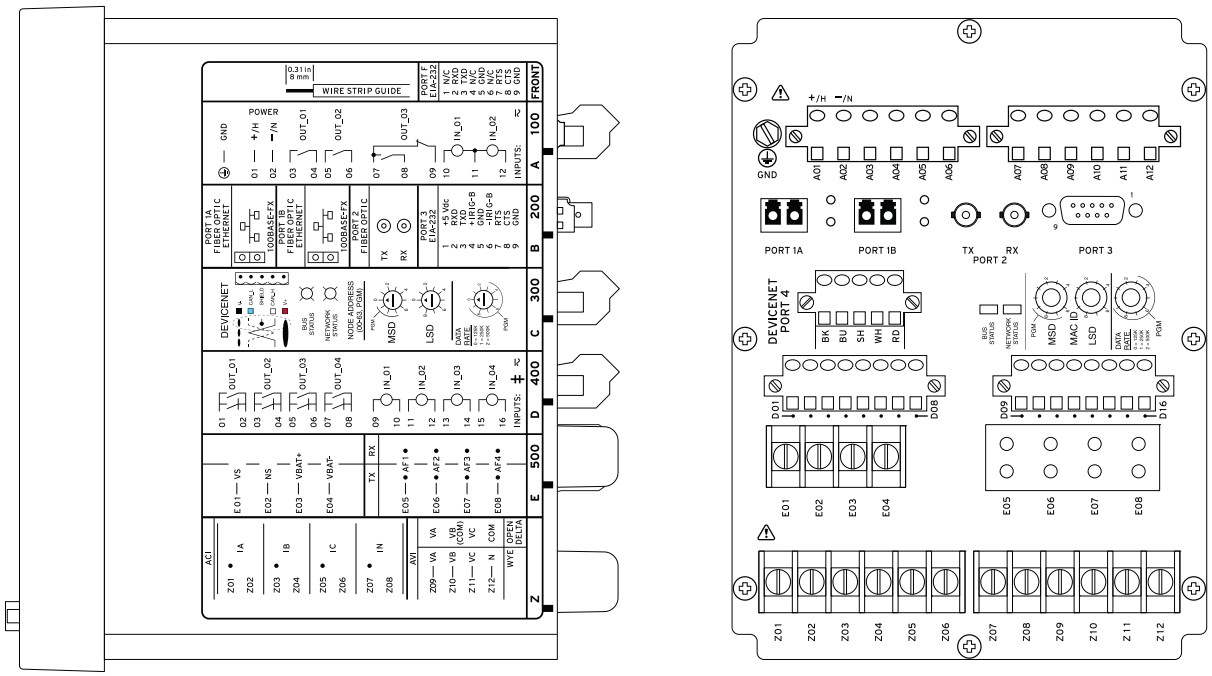


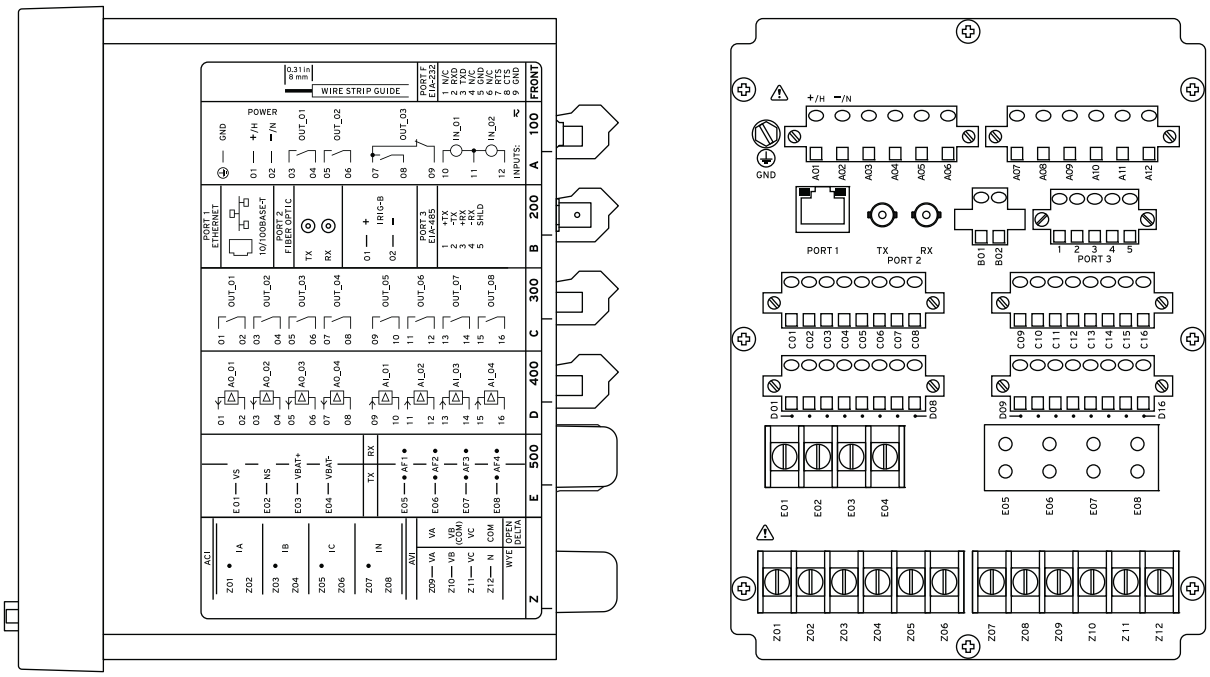
Figure 31 Front Panel With Default Configurable Labels in Base Relay



(A) Side-Panel Input and Output Designations

(B) Rear-Panel Layout

Figure 32 Dual Fiber Ethernet With 2 AVI/4 AFDI Voltage Option With Arc-Flash Detector Inputs, DeviceNet Card, and Fast Hybrid 4 DI/4 DO Card (Relay MOT 751501AA3CA70850830)

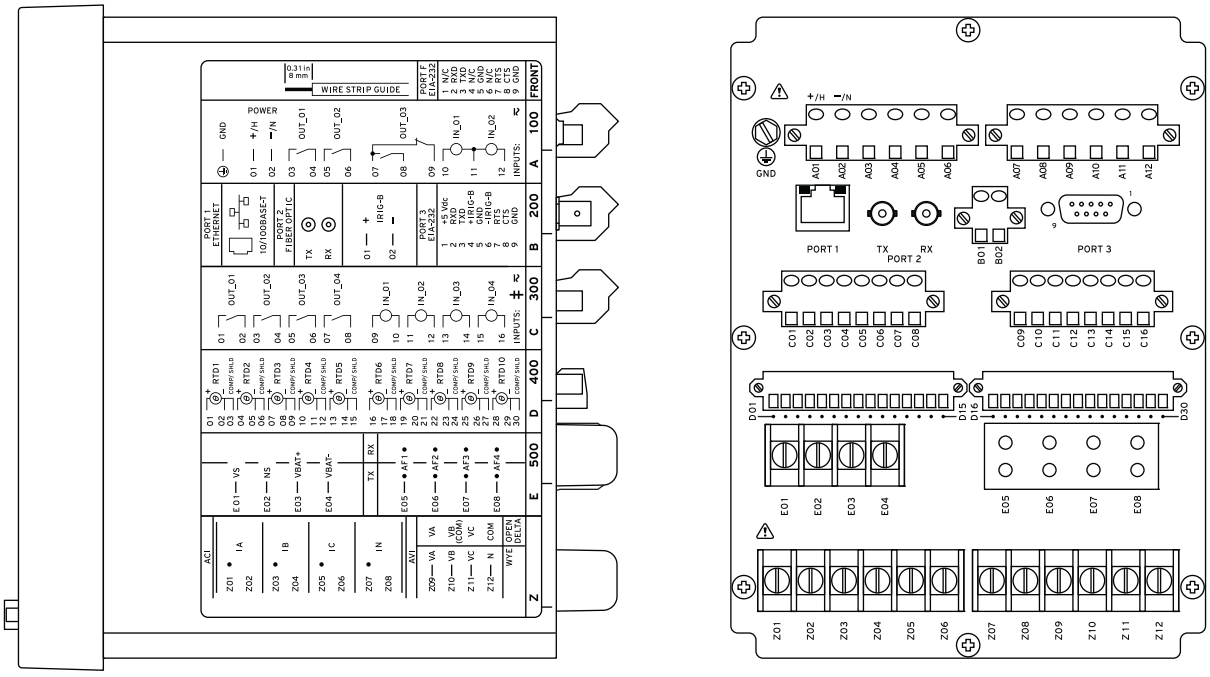


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) Side-Panel Input and Output Designations

(B) Rear-Panel Layout

Figure 33 Single Copper Ethernet, EIA-485 Communication, 8 DO (Form A) Card, 4 AI/4 AO Card, and 2 AVI/4 AFDI Voltage Option With Arc-Flash Detector Inputs (Relay MOT 751201A2A6X70810320)

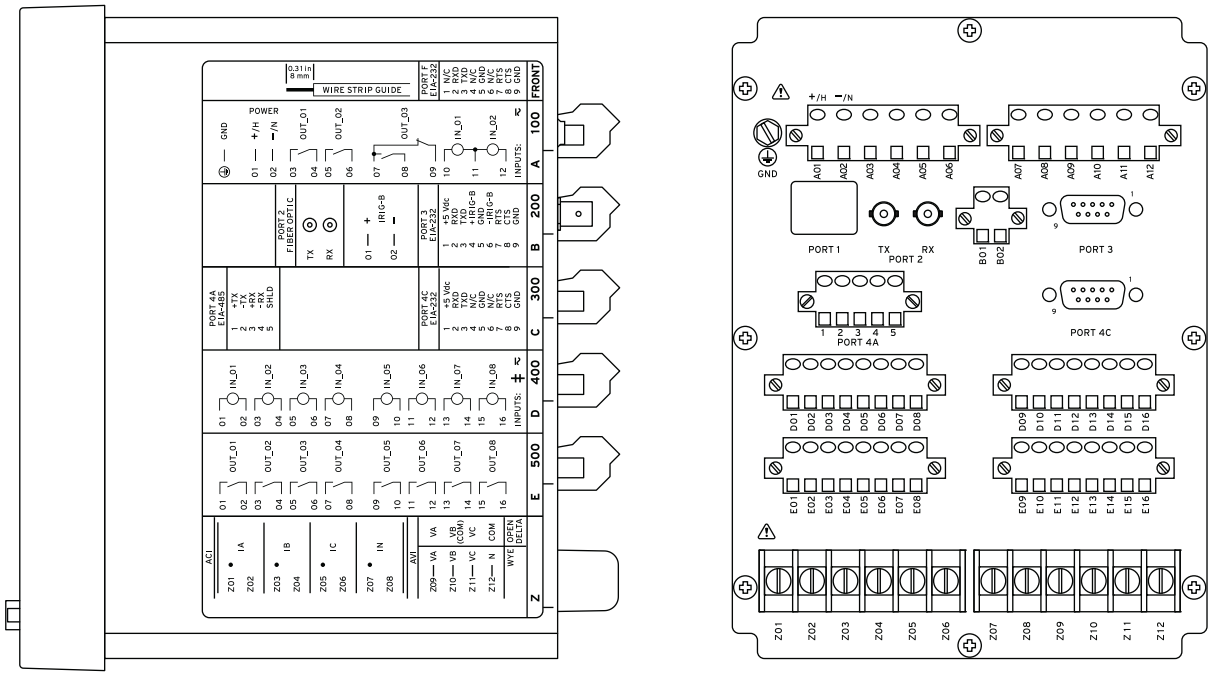


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) Side-Panel Input and Output Designations

(B) Rear-Panel Layout

Figure 34 Single Copper Ethernet With EIA-232 Communication, 10 RTD Card, 4 DI/4 DO Card, and 2 AVI/4 AFDI Voltage Option Card With Arc-Flash Detector Inputs (Relay MOT 751501A1A9X70850230)

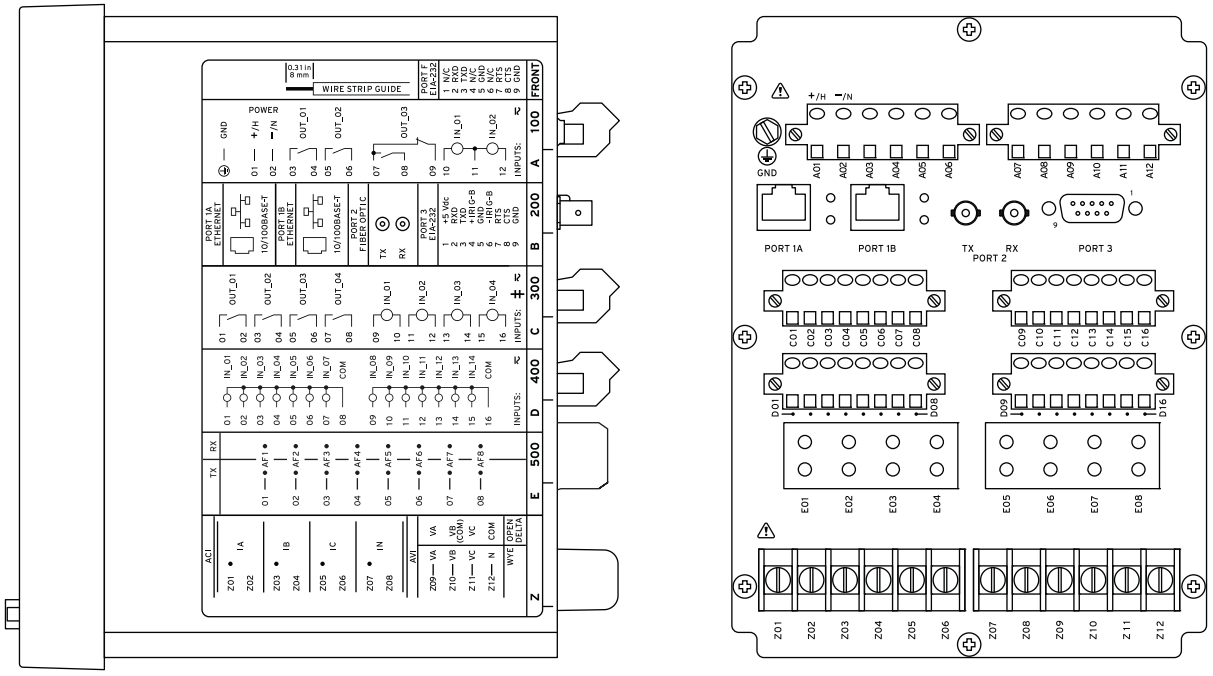


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) Side-Panel Input and Output Designations

(B) Rear-Panel Layout

Figure 35 No Ethernet, EIA-232 Serial Communications, EIA-232/EIA-485 Communications Card, 8 DI Card, and 8 DO Card (Form A) (Relay MOT 751401AA03A2A850000)

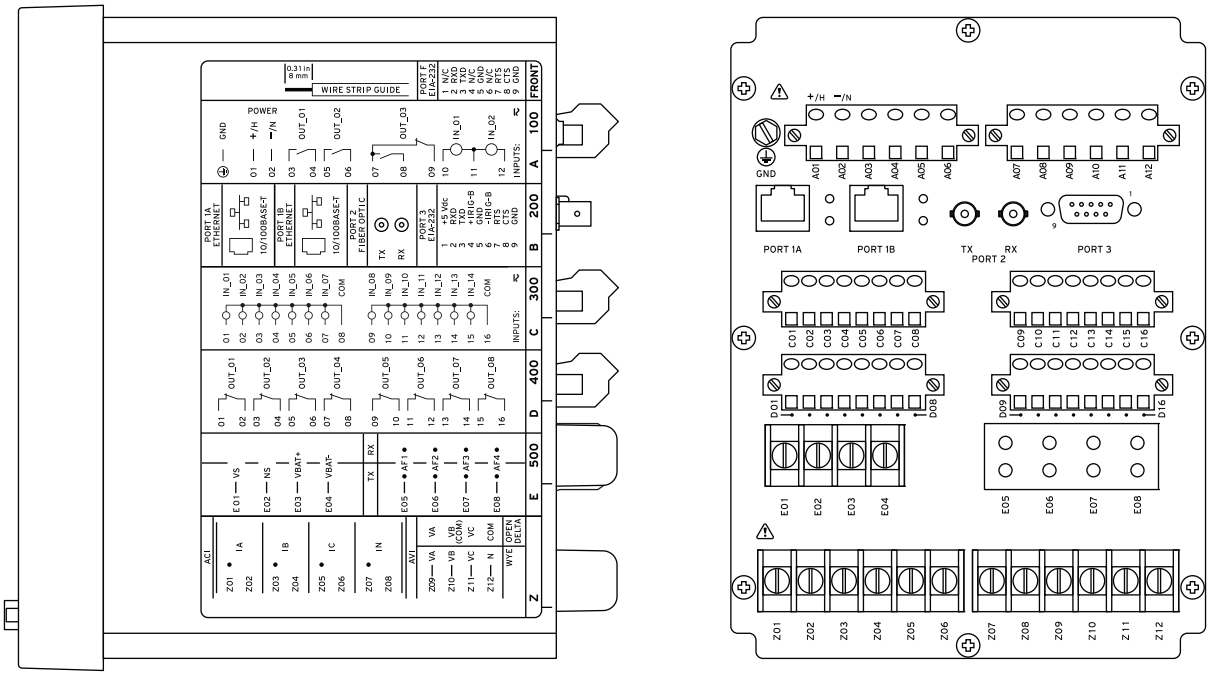


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) Side-Panel Input and Output Designations

(B) Rear-Panel Layout

Figure 36 Dual Copper Ethernet, 4 DI/4 DO Card, 14 DI Card, 8 AFDI Card With Arc-Flash Detector Inputs, 4 ACI/3 AVI Card With 5 A Phase, 200 mA Neutral, and 3-Phase AC Voltage Inputs (300 Vac) (Relay MOT 7515S1A1A4A77870671)

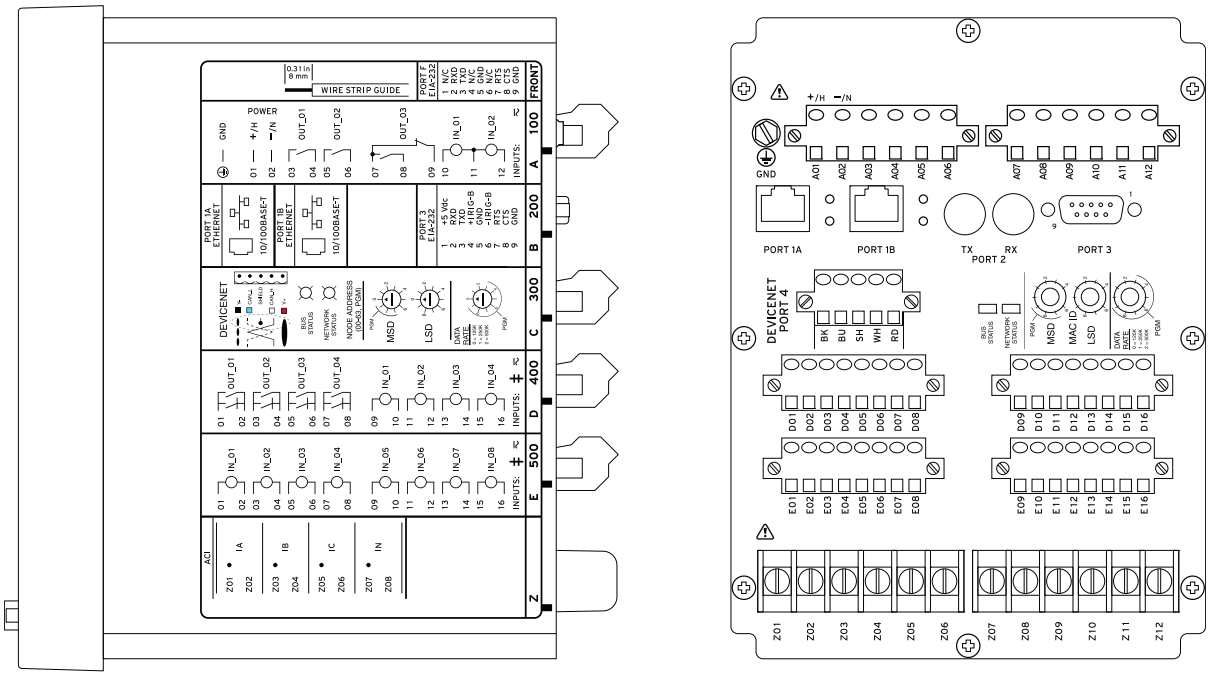


‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) Side-Panel Input and Output Designations

(B) Rear-Panel Layout

Figure 37 Dual Copper Ethernet, 14 DI Card, 8 DO (Form B) Card, 2 AVI/4 AFDI Card With LEA Vsync, Vbat Inputs, and 4 Arc-Flash Detection Inputs, 4 ACI/3 AVI Card With 5 A Phase, 200 mA Neutral, and 3-Phase LEA Voltage Inputs (8 Vac) (Relay MOT 751501A4A2BL0L70671)



‡ SEE DOCUMENTATION FOR INPUT VOLTAGE RATING

(A) Side-Panel Input and Output Designations

(B) Rear-Panel Layout

Figure 38 Dual 10/100 Base-T Ethernet, EIA-232 Rear Port, Without Single Multimode ST Fiber-Optic Serial Port Rear, With DeviceNet Card, Fast Hybrid 4 DI/4 DO Card, 8 DI Card, and 4 ACI Card (No Voltage Inputs) (Relay MOT 751001AA3CA3AA50F30)

Applications

Figure 39 shows some typical protection applications for the SEL-751. You can use the SEL-751 directional and non-directional overcurrent functions to protect virtually any power system circuit or device including lines, feeders, transformers, capacitor banks, reactors, and generators. Over- and underfrequency, over- and undervoltage, vector shift elements, rate-of-change-of-frequency elements, and synchronism-check elements are well suited for applications at distributed generation sites. Directional power elements make the relay suitable for utility and customer interface protection in applications with customer generation. IEC cable/line thermal elements can be used to prevent insulation damage.

Special relay versions can be ordered to provide sensitive earth fault (SEF) protection on high-impedance grounded systems, and directional overcurrent ground fault protection on ungrounded, high-impedance grounded and tuned reactance (Petersen coil) grounded systems.

You can use powerful SELOGIC control equations in all SEL-751 models for custom protection and control applications. SEL application guides and technical support personnel are available to help with unique applications.

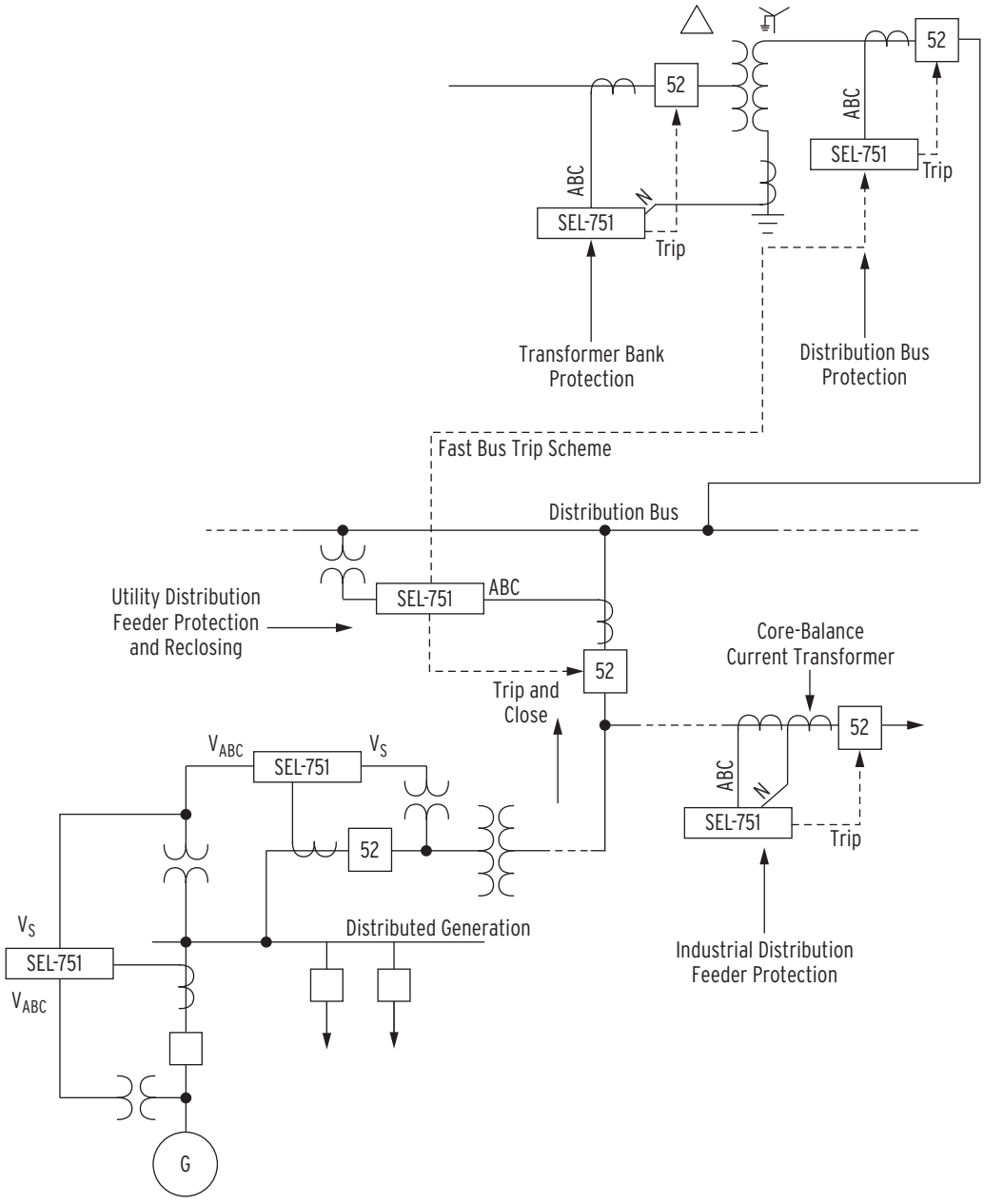


Figure 39 SEL-751 Feeder Protection Relay Applied Throughout the Power System

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

47 CFR 15B, Class A

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

UL Listed to U.S. and Canadian safety standards (File E212775, NRGU, NRGU7)

Note: UL has not yet developed requirements for products intended to detect and mitigate an arc flash; consequently, UL has not evaluated the performance of this feature. While UL is developing these requirements, it will place no restriction on the use of this product for arc-flash detection and mitigation. For test results performed by an independent laboratory and other information on the performance and verification of this feature, please contact SEL customer service.

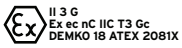
CE Mark

RCM Mark

Hazardous Locations

UL Certified for Hazardous Locations to U.S. and Canadian standards (File E470448)

EU



EN 60079-0:2012 + A11:2013, EN 60079-7:2015, EN 60079-15:2010, EN 60079-11:2012

Note: Where so marked, ATEX and UL Hazardous Location Certification tests are applicable to rated supply specifications only and do not apply to the absolute operating ranges, continuous thermal, or short circuit duration specifications.

General

AC Current Input

Phase and Neutral Currents

I_{NOM} = 200 mA, 1 A, or 5 A secondary, depending on model.

I_{NOM} = 5 A

Continuous Rating:	3 • I_{NOM} @ 85°C, linear to 100 A symmetrical 4 • I_{NOM} @ 55°C, linear to 100 A symmetrical
1-Second Thermal:	500 A
Burden (per phase):	<0.1 VA @ 5 A

I_{NOM} = 1 A

Continuous Rating:	3 • I_{NOM} @ 85°C, linear to 20 A symmetrical 4 • I_{NOM} @ 55°C, linear to 20 A symmetrical
1-Second Thermal:	100 A
Burden (per phase):	<0.01 VA @ 1 A

I_{NOM} = 200 mA

Continuous Rating:	4 A, linear to 4 A symmetrical
1-Second Thermal:	500 A
Burden (per phase):	<0.01 VA @ 0.2 A
Measurement Category:	II

AC Voltage Input

V_{NOM} (L-L) Setting Range:	20–250 V (if DELTA_Y := DELTA) 20–480 V (if DELTA_Y := WYE)

300 Vac Voltage Inputs

Rated Continuous Voltage:	300 Vac (phase-to-neutral)
10-Second Thermal:	600 Vac (phase-to-neutral)

	Burden	Input Impedance (Per Phase)	Input Impedance (Phase-to-Phase)
Vphase	0.008 VA @ 120 Vac	2 MΩ	4 MΩ
Vbat/Vs	0.003 VA @ 120 Vac	5 MΩ	

Low-Energy Analog (LEA) Voltage Inputs

Rated Continuous Voltage:	8 Vac (phase-to-neutral)
Nominal LEA Voltage:	0.5–6.8 Vrms (phase-to-neutral)
Input Range:	±12 V_{peak}
10-Second Thermal:	300 Vac (phase-to-neutral)
Burden:	0.0001 VA
Input Impedance:	2 MΩ single-ended (phase-to-neutral) 4 MΩ differential (phase-to-phase)

Power Supply

Relay Start-Up Time:	Approximately 5–10 seconds (after power is applied until the **ENABLED** LED turns on)

High-Voltage Supply

Rated Supply Voltage:	110–240 Vac, 50/60 Hz 110–250 Vdc
Input Voltage Range (Design Range):	85–264 Vac 85–300 Vdc
Power Consumption:	<50 VA (ac) <25 W (dc)
Interruptions:	50 ms @ 125 Vac/Vdc 100 ms @ 250 Vac/Vdc

Low-Voltage Supply

Rated Supply Voltage:	24–48 Vdc
Input Voltage Range (Design Range):	19.2–60.0 Vdc
Power Consumption:	<25 W (dc)
Interruptions:	10 ms @ 24 Vdc 50 ms @ 48 Vdc

Fuse Ratings

Low-Voltage Power Supply Fuse

Rating:	3.15 A
Maximum Rated Voltage:	300 Vdc, 250 Vac
Breaking Capacity:	1500 A at 250 Vac
Type:	Time-lag T

High-Voltage Power Supply Fuse

Rating:	3.15 A
Maximum Rated Voltage:	300 Vdc, 250 Vac
Breaking Capacity:	1500 A at 250 Vac
Type:	Time-lag T

Output Contacts

General

The relay supports Form A, B, and C outputs.

Dielectric Test Voltage:	2500 Vac
Impulse Withstand Voltage (U_{IMP}):	5000 V
Mechanical Durability:	100,000 no-load operations

Standard Contacts

Pickup/Dropout Time:	≤8 ms (coil energization to contact closure)

DC Output Ratings

Rated Operational Voltage:	250 Vdc
Rated Voltage Range:	19.2–275 Vdc
Rated Insulation Voltage:	300 Vdc
Make:	30 A @ 250 Vdc per IEEE C37.90
Continuous Carry:	6 A @ 70°C 4 A @ 85°C
1-Second Thermal:	50 A
Contact Protection:	360 Vdc, 115 J MOV protection across open contacts

Breaking Capacity (10,000 Operations) per IEC 60255-0-20:1974:

24 Vdc	0.75 A	L/R = 40 ms
48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

Cyclic (2.5 Cycles/Second) per IEC 60255-0-20:1974:

24 Vdc	0.75 A	L/R = 40 ms
48 Vdc	0.50 A	L/R = 40 ms
125 Vdc	0.30 A	L/R = 40 ms
250 Vdc	0.20 A	L/R = 40 ms

AC Output Ratings

Maximum Operational Voltage (U_e) Rating:	240 Vac
Insulation Voltage (U_i) Rating (excluding EN 61010-1):	300 Vac
1-Second Thermal:	50 A
Contact Rating Designation:	B300

B300 (5 A Thermal Current, 300 Vac Max)			
	Maximum Current		Max VA
Voltage	120 Vac	240 Vac	—
Make	30 A	15 A	3600
Break	3 A	1.5 A	360
PF < 0.35, 50–60 Hz			

Utilization Category: AC-15

AC-15		
Operational Voltage (Ue)	120 Vac	240 Vac
Operational Current (Ie)	3 A	1.5 A
Make Current	30 A	15 A
Break Current	3 A	1.5 A
Electromagnetic loads > 72 VA, PF < 0.3, 50–60 Hz		

Voltage Protection Across Open Contacts:	270 Vac, 40 J

Fast Hybrid (High-Speed, High-Current Interrupting)

DC Output Ratings

Rated Operational Voltage:	250 Vdc
Rated Voltage Range:	19.2–275 Vdc
Rated Insulation Voltage:	300 Vdc
Make:	30 A @ 250 Vdc per IEEE C37.90
Carry:	6 A @ 70°C 4 A @ 85°C
1-Second Thermal:	50 A
Open State Leakage Current:	<500 µA
MOV Protection (maximum voltage):	250 Vac/330 Vdc
Pickup Time:	<50 µs, resistive load
Dropout Time:	<8 ms, resistive load

Breaking Capacity (10,000 Operations) per IEC 60255-0-20:1974:

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

Cyclic Capacity (4 Cycles in 1 Second, Followed by 2 Minutes Idle for Thermal Dissipation) per IEC 60255-0-20:1974:

48 Vdc	10.0 A	L/R = 40 ms
125 Vdc	10.0 A	L/R = 40 ms
250 Vdc	10.0 A	L/R = 20 ms

AC Output Ratings

See *AC Output Ratings* for *Standard Contacts*.

Optoisolated Control Inputs

When Used With DC Control Signals

Pickup/Dropout Time:	Depends on the input debounce settings
250 V:	ON for 200.0–312.5 Vdc OFF below 150 Vdc
220 V:	ON for 176–275 Vdc OFF below 132 Vdc
125 V:	ON for 100.0–156.2 Vdc OFF below 75 Vdc
110 V:	ON for 88.0–137.5 Vdc OFF below 66 Vdc
48 V:	ON for 38.4–60.0 Vdc OFF below 28.8 Vdc
24 V:	ON for 15–30 Vdc OFF below 5 Vdc

When Used With AC Control Signals

Pickup Time:	2 ms
Dropout Time:	16 ms
250 V:	ON for 170.6–312.5 Vac OFF below 106 Vac
220 V:	ON for 150.2–275 Vac OFF below 93.3 Vac
125 V:	ON for 85–156.2 Vac OFF below 53 Vac
110 V:	ON for 75.1–137.5 Vac OFF below 46.6 Vac
48 V:	ON for 32.8–60 Vac OFF below 20.3 Vac
24 V:	ON for 14–30 Vac OFF below 5 Vac

Current Draw at Nominal DC Voltage:	2 mA (at 220–250 V) 4 mA (at 48–125 V) 10 mA (at 24 V)
Rated Impulse Withstand Voltage (U_{imp}):	4000 V

Analog Output (Optional)

	1 A0	**4 A0**
Current:	4–20 mA	±20 mA
Voltage:	—	±10 V
Load at 1 mA:	—	0–15 kΩ
Load at 20 mA:	0–300 Ω	0–750 Ω
Load at 10 V:	—	>2000 Ω
Refresh Rate:	100 ms	100 ms
% Error, Full Scale, at 25°C:	<±1%	<±0.55%
Select From:	Analog quantities available in the relay	

Analog Inputs (Optional)

Maximum Input Range:	±20 mA ±10 V Operational range set by user
Input Impedance:	200 Ω (current mode) >10 kΩ (voltage mode)
Accuracy at 25°C	
With User Calibration:	0.05% of full scale (current mode) 0.025% of full scale (voltage mode)
Without User Calibration:	Better than 0.5% of full scale at 25°C
Accuracy Variation With Temperature:	±0.015% per °C of full-scale (±20 mA or ±10 V)

Arc-Flash Detectors (Optional)

Multimode fiber-optic receiver/transmitter pair

Fiber Type:	1000 µm diameter, 640 nm wavelength, plastic, clear-jacketed, or black-jacketed
Connector Type:	V-pin

Frequency and Phase Rotation

System Frequency:	50, 60 Hz
Phase Rotation:	ABC, ACB
Frequency Tracking:	15–70 Hz

Time-Code Input

Format:	Demodulated IRIG-B
On (1) State:	$V_{ih} \geq 2.2$ V
Off (0) State:	$V_{il} \leq 0.8$ V
Input Impedance:	2 kΩ
Synchronization Accuracy Internal Clock:	±1 µs
Synchrophasor Reports (e.g., **MET PM**):	±10 µs
All other reports:	±5 ms
Simple Network Time Protocol (SNTP) Accuracy Internal Clock:	±5 ms
Unsynchronized Clock Drift:	2 minutes per year typical

Communications Ports

Standard EIA-232 (2 ports)

Location:	Front Panel Rear Panel
Data Speed:	300–38400 bps

EIA-485 Port (optional)

Location:	Rear panel
Data Speed:	300–19200 bps

Ethernet Port (optional)

Single/Dual 10/100BASE-T copper (RJ45 connector)
Single/Dual 100BASE-FX (LC connector)

EIA-232 Multimode Fiber-Optic Port (Optional)

Location:	Rear panel
Data Speed:	300–38400 bps

Fiber-Optic Ports Characteristics

Port 1 (or 1A, 1B) Ethernet

Wavelength:	1300 nm
Optical Connector Type:	LC
Fiber Type:	Multimode
Link Budget:	16.1 dB
Typical TX Power:	–15.7 dBm
RX Min. Sensitivity:	–31.8 dBm
Fiber Size:	62.5/125 µm
Approximate Range:	~6.4 km
Data Rate:	100 Mbps
Typical Fiber Attenuation:	–2 dB/km

Port 2 Serial

Wavelength:	820 nm
Optical Connector Type:	ST
Fiber Type:	Multimode
Link Budget:	8 dB
Typical TX Power:	–16 dBm
RX Min. Sensitivity:	–24 dBm
Fiber Size:	62.5/125 µm
Approximate Range:	~1 km
Data Rate:	5 Mbps
Typical Fiber Attenuation:	–4 dB/km

Channels 1-8 Arc-Flash Detectors (AFDI)

Diagnostic Wavelength:	640 nm
Optical Connector Type:	V-pin
Fiber Type:	Multimode
Typical TX Power:	–12 dBm

Point Sensor

Minimum Receive Sensitivity:	–52.23 dB
Point Sensor Diagnostic Worst Case Loss:	–28 dB
Link Budget:	12.23 dB
Black-Jacketed Fiber Worst Case Loss:	–0.19 dBm
Black-Jacketed Fiber Typical Loss:	–0.17 dBm

ST or V-Pin Connector Splice Loss:	–2.00 dB
Approximate Range:	As much as 35 m

Fiber Sensor

Minimum Receive Sensitivity:	–29.23 dB
Link Budget:	17.23 dB
Clear-Jacketed Fiber Worst Case Loss:	–0.19 dBm
Clear-Jacketed Fiber Typical Loss:	–0.17 dBm
ST or V-Pin Connector Splice Loss:	–2.00 dB
Approximate Range:	As much as 70 m

Optional Communications Cards

Option 1:	EIA-232 or EIA-485 communications card
Option 2:	DeviceNet communications card

Communications Protocols

SEL, Modbus, DNP3, FTP, TCP/IP, Telnet, SNTP, IEC 61850 Edition 2, IEC 60870-5-103, PRP, MIRRORED BITS, EVMSG, C37.118 (synchrophasors), and DeviceNet

Operating Temperature

IEC Performance Rating:	–40° to +85°C (–40° to +185°F) (per IEC/EN 60068-2-1 and IEC/EN 60068-2-2)

Note: Not applicable to UL applications.
Note: The front-panel display is impaired for temperatures below –20°C and above +70°C.

DeviceNet Communications Card Rating:	+60°C (+140°F) maximum
Optoisolated Control Inputs:	As many as 26 inputs are allowed in ambient temperatures of 85°C or less As many as 34 inputs are allowed in ambient temperatures of 75°C or less As many as 44 inputs are allowed in ambient temperatures of 65°C or less

Operating Environment

Insulation Class:	1
Pollution Degree:	2
Overvoltage Category:	II
Atmospheric Pressure:	80–110 kPa
Relative Humidity:	5%–95%, noncondensing
Maximum Altitude Without Derating (Consult the Factory for Higher Altitude Derating):	2000 m

Dimensions

144.0 mm (5.67 in) x 192.0 mm (7.56 in) x 147.4 mm (5.80 in)

Weight

2.7 kg (6.0 lb)

Relay Mounting Screw (#8-32) Tightening Torque

Minimum:	1.4 Nm (12 in-lb)
Maximum:	1.7 Nm (15 in-lb)

Terminal Connections

Terminal Block

Screw Size:	#6
Ring Terminal Width:	0.310-inch maximum

Terminal Block Tightening Torque

Minimum:	0.9 Nm (8 in-lb)
Maximum:	1.4 Nm (12 in-lb)

Compression Plug Tightening Torque

Minimum:	0.5 Nm (4.4 in-lb)
Maximum:	1.0 Nm (8.8 in-lb)

Compression Plug Mounting Ear Screw Tightening Torque

Minimum:	0.18 Nm (1.6 in-lb)
Maximum:	0.25 Nm (2.2 in-lb)

Product Standards

Electromagnetic Compatibility:	IEC 60255-26:2013 IEC 60255-27:2013 UL 508 CSA C22.2 No. 14-05

Type Tests

Environmental Tests

Enclosure Protection:	IEC 60529:2001 + CRDG:2003 IP65 enclosed in panel (2-line display models) IP54 enclosed in panel (touchscreen models) IP50 for terminals enclosed in the dust-protection assembly (protection against solid foreign objects only) (SEL Part #915900170). The 10°C temperature derating applies to the temperature specifications of the relay.
Vibration Resistance:	IEC 60255-21-1:1998 IEC 60255-27:2013, Section 10.6.2.1 Endurance: Class 2 Response: Class 2
Shock Resistance:	IEC 60255-21-2:1998 IEC 60255-27:2013, Section 10.6.2.2 IEC 60255-27:2013, Section 10.6.2.3 Withstand: Class 1 Response: Class 2 Bump: Class 1
Seismic (Quake Response):	IEC 60255-21-3:1993 IEC 60255-27:2013, Section 10.6.2.4 Response: Class 2
Cold:	IEC 60068-2-1:2007 IEC 60255-27:2013, Section 10.6.1.2 IEC 60255-27:2013, Section 10.6.1.4 –40°C, 16 hours
Dry Heat:	IEC 60068-2-2:2007 IEC 60255-27:2013, Section 10.6.1.1 IEC 60255-27:2013, Section 10.6.1.3 85°C, 16 hours
Damp Heat, Steady State:	IEC 60068-2-78:2001 IEC 60255-27:2013, Section 10.6.1.5 40°C, 93% relative humidity, 10 days
Damp Heat, Cyclic:	IEC 60068-2-30:2001 IEC 60255-27:2013, Section 10.6.1.6 25° to 55°C, 6 cycles, relative humidity

Change of Temperature:	IEC 60068-2-14:2009 IEC 60255-1:2010, Section 6.12.3.5 –40° to +85°C, ramp rate 1°C/min, 5 cycles

Dielectric Strength and Impulse Tests

Dielectric (Hi-Pot):	IEC 60255-27:2013, Section 10.6.4.3 IEEE C37.90-2005 1.0 kVac on analog outputs, Ethernet ports 2.0 kVac on analog inputs, IRIG 2.5 kVac on contact I/O 3.6 kVdc on power supply, IN and VN terminals
Impulse:	IEC 60255-27:2013, Section 10.6.4.2 0.5 J, 5 kV on power supply, contact I/O, ac current, and voltage inputs 0.5 J, 530 V on analog outputs IEEE C37.90:2005 0.5 J, 5 kV 0.5 J, 530 V on analog outputs

RFI and Interference Tests

Electrostatic Discharge Immunity:	IEC 61000-4-2:2008 IEC 60255-26:2013; Section 7.2.3 IEEE C37.90.3:2001 Severity Level 4 8 kV contact discharge 15 kV air discharge
Radiated RF Immunity:	IEC 61000-4-3:2010 IEC 60255-26:2013; Section 7.2.4 10 V/m IEEE C37.90.2-2004 20 V/m
Fast Transient, Burst Immunity[a]:	IEC 61000-4-4:2011 IEC 60255-26:2013; Section 7.2.5 4 kV @ 5.0 kHz 2 kV @ 5.0 kHz for comm. ports
Surge Immunity[a]:	IEC 61000-4-5:2005 IEC 60255-26:2013; Section 7.2.7 2 kV line-to-line 4 kV line-to-earth
Surge Withstand Capability Immunity[a]:	EN 61000-4-18:2010 IEC 60255-26:2013; Section 7.2.6 2.5 kV common mode 1 kV differential mode 1 kV common mode on comm. ports IEEE C37.90.1-2002 2.5 kV oscillatory 4 kV fast transient
Conducted RF Immunity:	IEC 61000-4-6:2008 IEC 60255-26:2013; Section 7.2.8 10 Vrms
Magnetic Field Immunity:	IEC 61000-4-8:2009 IEC 60255-26:2013, Section 7.2.10 Severity Level: 1000 A/m for 3 seconds 100 A/m for 1 minute; 50/60 Hz IEC 61000-4-9: 2001 Severity Level: 1000 A/m IEC 61000-4-10:2001 Severity Level: 100 A/m (100 kHz and 1 MHz)
Power Supply Immunity:	IEC 61000-4-11:2004 IEC 61000-4-17:1999 IEC 61000-4-29:2000 IEC 60255-26:2013, Section 7.2.11 IEC 60255-26:2013, Section 7.2.12 IEC 60255-26:2013, Section 7.2.13

EMC Emissions

Conducted Emissions:	IEC 60255-26:2013 Class A FCC 47 CFR Part 15.107 Class A ICES-003 Issue 6 EN 55011:2009 + A1:2010 Class A EN 55022:2010 + AC:2011 Class A EN 55032:2012 + AC:2013 Class A CISPR 11:2009 + A1:2010 Class A CISPR 22:2008 Class A CISPR 32:2015 Class A
Radiated Emissions:	IEC 60255-26:2013 Class A FCC 47 CFR Part 15.109 Class A ICES-003 Issue 6 EN 55011:2009 + A1:2010 Class A EN 55022:2010 + AC:2011 Class A EN 55032:2012 + AC:2013 Class A CISPR 11:2009 + A1:2010 Class A CISPR 22:2008 Class A CISPR 32:2015 Class A

Processing Specifications and Oscillography

AC Voltage and Current Inputs:	32 samples per power system cycle
Frequency Tracking Range:	15–70 Hz
Digital Filtering:	One-cycle cosine after low-pass analog filtering. Net filtering (analog plus digital) rejects dc and all harmonics greater than the fundamental.
Protection and Control Processing:	Processing interval is 4 times per power system cycle (except for math variables and analog quantities, which are processed every 25 ms). Analog quantities for rms data are derived from data averaged from the previous 8 cycles.
Arc-Flash Processing:	Arc-Flash light is sampled 32 times per cycle Arc-Flash current, light, and 2 fast hybrid outputs are processed 16 times per cycle

Oscillography

Length:	15, 64, or 180 cycles
Sampling Rate:	16 samples per cycle unfiltered 4 samples per cycle filtered
Trigger:	Programmable with Boolean expression
Format:	ASCII and Compressed ASCII Binary COMTRADE (32 samples per cycle unfiltered)
Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy:	±5 ms

Sequential Events Recorder

Time-Stamp Resolution:	1 ms
Time-Stamp Accuracy (With Respect to Time Source):	5 ms

Relay Elements

Instantaneous/Definite-Time Overcurrent (50P, 50G, 50N, 50Q)

Pickup Setting Range, A Secondary:

5 A models:	0.25–100.00 A, 0.01 A steps
1 A models:	0.05–20.00 A, 0.01 A steps
200 mA model:	0.01–4.00 A, 0.01 A steps (50N)

Accuracy:	±3% plus ±0.02 • I_{NOM} A secondary (steady state) ±5% plus ±0.02 • I_{NOM} A secondary (transient) ±6% plus ±0.02 • I_{NOM} A secondary (transient for 50Q)
Time Delay:	0.00–400.00 seconds, 0.01 seconds steps 0.1–400.0 seconds, 0.1 second steps (50Q)
Pickup/Dropout Time:	<1.5 cycles

Arc-Flash Instantaneous Overcurrent (50PAF, 50NAF)

Pickup Setting Range, A Secondary:	
5 A models:	0.50–100.00 A, 0.01-A steps
1 A models:	0.10–20.00 A, 0.01 A-steps
Accuracy:	0 to +10% of setting plus ±0.02 • I_{NOM} A secondary (steady state pickup)
Pickup/Dropout Time:	2–5 ms/1 cycle

Arc-Flash Time-Overlight (TOL1–TOL8)

Pickup Setting Range, % of Full Scale:	3.0–80.0% (point sensor) 0.6–80.0% (fiber sensor)
Pickup/Dropout Time:	2–5 ms/1 cycle

Inverse-Time Overcurrent (51P, 51G, 51N, 51Q)

Pickup Setting Range, A Secondary:	
5 A models:	0.25–24.00 A, 0.01 A steps
1 A models:	0.05–4.80 A, 0.01 A steps
200 mA models:	10.00–960.00 mA, 0.01 mA steps (51N)
Accuracy:	±5% of setting plus ±0.02 • I_{NOM} A secondary (steady state pickup)
Time Dial	
U.S.:	0.50–15.00, 0.01 steps
IEC:	0.01–1.50, 0.01 steps
Accuracy:	±1.5 cycles, plus ±4% between 2 and 30 multiples of pickup (within rated range of current)

IEC Thermal Element (49IEC)

Setting Range:	Trip pickup, 1%–150% Alarm pickup, 1%–100%
Pickup Accuracy:	±2% (for $I \geq I_{NOM}$) ±5% (for $0.4 \bullet I_{NOM} < I < I_{NOM}$)
Time to Trip/Reset Accuracy:	±5% plus ±0.5 s of the calculated value

Undervoltage (27P, 27PP, 27S)

Setting Range:	OFF, 2.00–300.00 V (phase elements, phase-to-phase elements with delta inputs or synchronism voltage input) OFF, 2.00–520.00 V (phase-to-phase elements with wye inputs)
Accuracy:	±1% of setting plus ±0.5 V
Time Delay:	0.00–120.00 seconds, 0.01-second steps
Pickup/Dropout Time:	<1.5 cycles

Overvoltage (59P, 59PP, 59G, 59Q, 59S)

Setting Range:	OFF, 2.00–300.00 V (phase elements, phase-to-phase elements with delta inputs or synchronism voltage input) OFF, 2.00–520.00 V (phase-to-phase elements with wye inputs)
Accuracy:	±1% of setting plus ±0.5 V
Time Delay:	0.00–120.00 seconds, 0.01-second steps
Pickup/Dropout Time:	<1.5 cycles

Inverse-Time Undervoltage (27I)

Setting Range:	OFF, 2.00–300.00 V (phase elements, positive-sequence elements, phase-to-phase elements with delta inputs or synchronism-check voltage input) OFF, 2.00–520.00 V (phase-to-phase elements with wye inputs)
Accuracy:	±1% of setting plus ±0.5 V
Time Dial:	0.00–16.00 s
Accuracy:	±1.5 cyc plus ±4% between 0.95 and 0.1 multiples of pickup

Inverse-Time Overvoltage (59I)

Setting Range:	OFF, 2.00–300.00 V (phase elements, sequence elements, or phase-to-phase elements with delta inputs or synchronism voltage input) OFF, 2.00–520.00 V (phase-to-phase elements with wye inputs)
Accuracy:	±1% of setting plus ±0.5 V
Time Dial:	0.00–16.00 s
Accuracy:	±1.5 cyc plus ±4% between 1.05 and 5.5 multiples of pickup

Harmonic Blocking

Pickup Range (% of fundamental):	5%–100%
Pickup Accuracy (A secondary):	
5 A models:	±5% plus ±0.10 A of harmonic current
1 A models:	±5% plus ±0.02 A of harmonic current
Time Delay Accuracy:	±0.5% plus ±0.25 cycle

Vector Shift (78VS)

Pickup Setting Range:	2.0°–30.0°, 0.1-degree increment
Accuracy:	±10% of the pickup setting, ±1 degree
Voltage Supervision Threshold:	20.0%–100.0% • VNOM
Pickup Time:	<3 cycles

Power Elements (32)

Instantaneous/Definite Time, Three-Phase Elements Type:	+W, –W, +VAR, –VAR
Pickup Setting Range, VA Secondary:	
5 A models:	1.0–6500.0 VA, 0.1 VA steps
1 A models:	0.2–1300.0 VA, 0.1 VA steps

Accuracy:	±0.10 A • (L-L voltage secondary) plus ±5% of setting at unity power factor for power elements and zero power factor for reactive power elements (5 A nominal) ±0.02 A • (L-L voltage secondary) plus ±5% of setting at unity power factor for power elements and zero power factor for reactive power elements (1 A nominal)
Time Delay:	0.0–240.0 seconds, 0.1-second steps
Pickup/Dropout Time:	<10 cycles

Power Factor (55)

Setting Range:	OFF, 0.05–0.99
Accuracy:	±5% of full scale for current ≥ 0.5 • I_{NOM}
Time Delay:	1–240 seconds, 1-second steps

Frequency (81)

Setting Range:	Off, 15.00–70.00 Hz
Accuracy:	±0.01 Hz (V1 >60 V) with voltage tracking ±0.05 Hz (I1 >0.8 • I_{NOM}) with current tracking
Time Delay:	0.00–240.00 seconds, 0.01 second steps
Pickup/Dropout Time:	<4 cycles

Rate-of-Change of Frequency (81R)

Setting Range:	OFF, 0.10–15.00 Hz/s
Accuracy:	±100 mHz/s, plus ±3.33% of pickup
Time Delay:	0.10–60.00 seconds, 0.01 second steps

Synchronism Check (25)

Pickup Range, Secondary Voltage:	0.00–300.00 V
Pickup Accuracy, Secondary Voltage:	±1% plus ±0.5 V (over the range of 2–300 V)
Slip Frequency Pickup Range:	0.05 Hz–0.50 Hz
Slip Frequency Pickup Accuracy:	±0.02 Hz
Phase Angle Range:	0°–80°
Phase Angle Accuracy:	±4°

Load-Encroachment Detection

Pickup Setting Range

5 A Model:	0.10–128.00 Ω secondary, 0.01 Ω steps
1 A Model:	0.50–640.00 Ω secondary, 0.01 Ω steps
Forward Load Angle:	–90° to +90°
Forward Load Angle:	+90° to +270°

Accuracy

Impedance Measurement:	±5% plus ±0.5 Ω
Angle Measurement:	±3°

Station Battery Voltage Monitor

Operating Range:	0–350 Vdc (300 Vdc for UL purposes)
Pickup Range:	20.00–300.00 Vdc
Pickup accuracy:	±2% of setting plus ±2 Vdc

Timers

Setting Range:	Various
Accuracy:	±0.5% of setting plus ±1/4 cycle

RTD Protection

Setting Range:	Off, 1°–250°C
Accuracy:	±2°C
RTD Open-Circuit Detection:	>250°C
RTD Short-Circuit Detection:	<–50°C
RTD Types:	PT100, NI100, NI120, CU10
RTD Lead Resistance:	25 Ω max. per lead
Update Rate:	<3 s
Noise Immunity on RTD Inputs:	As high as 1.4 Vac (peak) at 50 Hz or greater frequency
RTD Trip/Alarm Time Delay:	Approx. 6 s

Metering

Accuracies are specified at 20°C, nominal frequency, ac currents within (0.2–20.0) • I_{NOM} A secondary, and ac voltages within 50–250 V secondary (1.33–6.67 V secondary with 8 V LEA option), unless otherwise noted.

Phase Currents:	±1% of reading, ±1° (±2.5° at 0.2–0.5 A for relays with I_{NOM} = 1 A)
Three-Phase Average Current:	±1% of reading
IG (Residual Current):	±2% of reading, ±2° (±5.0° at 0.2–0.5 A for relays with I_{NOM} = 1 A)
IN (Neutral Current):	±1% of reading, ±1° (±2.5° at 0.2–0.5 A for relays with I_{NOM} = 1 A) ±1.6 mA and ±1% (0.04–4.0 A) (0.2 A nominal channel IN current input)
I1 Positive-Sequence Current:	±2% of reading
3I2 Negative-Sequence Current:	±2% of reading
System Frequency:	±0.01 Hz of reading for frequencies within 15–70 Hz (V1 > 60 V)
Line-to-Line Voltages:	±1% of reading, ±1° for voltages
Three-Phase Average Line-to-Line Voltage:	±1% of reading for voltages within 24–264 V
Line-to-Ground Voltages:	±1% of reading, ±1° for voltages within 24–264 V (0.64–7.04 V for LEA inputs)
Three-Phase Average Line-to-Ground Voltages:	±1% of reading for voltages within 24–264 V (0.64–7.04 V for LEA inputs)
Voltage Imbalance (%):	±2% of reading
V1 Positive-Sequence Voltage:	±2% of reading for voltages within 24–264 V (0.64–7.04 V for LEA inputs)
3V2 Negative-Sequence Voltage:	±2% of reading for voltages within 24–264 V (0.64–7.04 V for LEA inputs)
Real Three-Phase Power (kW):	±3% of reading for 0.10 < pf < 1.00
Reactive Three-Phase Power (kVAR):	±3% of reading for 0.00 < pf < 0.90
Apparent Three-Phase Power (kVA):	±3% of reading
Power Factor:	±2% of reading
RTD Temperatures:	±2°C

Energy Meter

Accumulators:	Separate IN and OUT accumulators updated once per second, transferred to nonvolatile storage 4 times per day
ASCII Report Resolution:	0.001 MWh
Accuracy:	The accuracy of the energy meter depends on applied current and power factor as shown in the power metering accuracy specifications above. The additional error introduced by accumulating power to yield energy is negligible when power changes slowly compared to the processing rate of once per second.

Synchrophasor Accuracy

Maximum Message Rate

Nominal 60 Hz System:	60 messages per second
Nominal 50 Hz System:	50 messages per second

The voltage accuracy specifications are only applicable for the model options with standard voltage inputs (not applicable to LEA option).
The current accuracy specifications are applicable for all 1 A and 5 A options.
Note: For the SEL-751 current only model, the accuracy specifications for currents are only applicable when the applied signal frequency equals FNOM.

Accuracy for Voltages

Level 1 compliant as specified in IEEE C37.118 under the following conditions for the specified range.

Conditions

- At maximum message rate
- When phasor has the same frequency as the positive-sequence voltage
- Frequency-based phasor compensation is enabled PHCOMP := Y)
- The narrow bandwidth filter is selected (PMAPP := N)

Range

Frequency:	±5.0 Hz of nominal (50 or 60 Hz)
Magnitude:	30 V–250 V
Phase Angle:	–179.99° to 180.00°
Out-of-Band Interfering Frequency (Fs):	10 Hz ≤ Fs ≤ (2 • FNOM)

Accuracy for Currents

Level 1 compliant as specified in IEEE C37.118 under the following conditions for the specified range.

Conditions

- At maximum message rate
- When phasor has the same frequency as the positive-sequence voltage
- Frequency-based phasor compensation is enabled (PHCOMP := Y)
- The narrow bandwidth filter is selected (PMAPP := N)

Range

Frequency:	±5.0 Hz of nominal (50 or 60 Hz)
Magnitude:	(0.4–2) • I_{NOM} (I_{NOM} = 1 A or 5 A)
Phase Angle:	–179.99° to 180.00°
Out-of-Band Interfering Frequency (Fs):	10 Hz ≤ Fs ≤ (2 • FNOM)

[a] Front port serial cable (non-fiber) lengths assumed to be <3 m.

Notes

SCHWEITZER ENGINEERING LABORATORIES, INC.
2350 NE Hopkins Court • Pullman, WA 99163-5603 U.S.A.
Tel: +1.509.332.1890 • Fax: +1.509.332.7990
selinc.com • info@selinc.com

PDS751-01

Distrbuted Generation Facility IEEE 1547.1 Testing Matrix

Facility Name	Smart[E] Campus
Facility Location	Ohio State University Campus
Total Generation	117.6MW
DG Type	CTG, STG

Line	IEEE 1547.1 ID	IEEE 1547.1 Test	Type/Production Test	Field Test	Not Applicable	Device under test	Referenced Document	Notes
26	5.11.2.1	Harmonics test for synchronous generators						
27	5.11.3.1	Harmonics test for induction generators			X			
28	6.1.2	Response to abnormal voltage						
29	6.2.2	Response to abnormal frequency						
30	6.3.1.1	Synchronization production test		X		SIPROTEC 7VE61, STG PARALLELING DEVICE	D	To be tested per IEEE 1547.1 test procedure. Field test report to be provided by others after testing completed.
31	6.3.2.1	Optional test for equipment with synchronizing disable function			X			
32	7.2	Verifications and inspections		X		SEL 751, SEL 311, SEL 787, SIPROTEC 7UM621	D	To be performed per IEEE 1547.1 procedure. Field inspection report to be provided by others after testing completed.
33	7.4.1	Reverse power or minimum power test		X		32 Reverse Power Relay TBD	D	To be performed per IEEE 1547.1 procedure. Field inspection report to be provided by others after testing completed.
34	7.4.2	Non-island functionality test			X			
35	7.4.3	Other unintentional islanding test methods			X			
36	7.5.1	Cease to energize functionality test			X			

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY): 10/19/2018

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must have ADDITIONAL INSURED provisions or be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER
Marsh USA Inc.
500 Dallas Street, Suite 1500
Houston, TX 77002

CN115354100--GAWUP-18-19 .

CONTACT NAME:
PHONE (A/C, No, Ext): **FAX (A/C, No):**
E-MAIL ADDRESS:

INSURER(S) AFFORDING COVERAGE	NAIC #
INSURER A : Liberty Mutual Fire Ins Co	23035
INSURER B : ACE Property & Casualty Insurance Company	20699
INSURER C : Liberty Insurance Corporation	42404
INSURER D : Berkley Assurance Company	39462
INSURER E :	
INSURER F :	

INSURED
ENGIE Holdings Inc.
And their subsidiaries
1990 Post Oak Blvd., Suite 1900
Houston, TX 77056

COVERAGES **CERTIFICATE NUMBER:** HOU-003309300-12 **REVISION NUMBER:** 30

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSD	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS		
A	X **COMMERCIAL GENERAL LIABILITY** [ ] CLAIMS-MADE [X] OCCUR GEN'L AGGREGATE LIMIT APPLIES PER: [ ] POLICY [X] PRO-JECT [ ] LOC OTHER:			TB2-641-443605-038	07/01/2018	07/01/2019	EACH OCCURRENCE DAMAGE TO RENTED PREMISES (Ea occurrence) MED EXP (Any one person) PERSONAL & ADV INJURY GENERAL AGGREGATE PRODUCTS - COMP/OP AGG	$ $ $ $ $ $	2,000,000 100,000 10,000 2,000,000 4,000,000 2,000,000
A	**AUTOMOBILE LIABILITY** X ANY AUTO [ ] OWNED AUTOS ONLY [ ] SCHEDULED AUTOS X HIRED AUTOS ONLY X NON-OWNED AUTOS ONLY			AS2-641-443605-028	07/01/2018	07/01/2019	COMBINED SINGLE LIMIT (Ea accident) BODILY INJURY (Per person) BODILY INJURY (Per accident) PROPERTY DAMAGE (Per accident)	$ $ $ $	2,000,000
B	X **UMBRELLA LIAB** X OCCUR **EXCESS LIAB** [ ] CLAIMS-MADE [ ] DED [ ] RETENTION $			G27614814 004	07/01/2018	07/01/2019	EACH OCCURRENCE AGGREGATE	$ $	20,000,000 20,000,000
C	**WORKERS COMPENSATION AND EMPLOYERS' LIABILITY** ANYPROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? Y / N: N **(Mandatory in NH)** If yes, describe under DESCRIPTION OF OPERATIONS below	N / A		WC7-641-443605-018	07/01/2018	07/01/2019	X PER STATUTE [ ] OTH-ER E.L. EACH ACCIDENT E.L. DISEASE - EA EMPLOYEE E.L. DISEASE - POLICY LIMIT	 $ $ $	 2,000,000 2,000,000 2,000,000
D	Contractor's Professional Liability			PCAB-5004975-0718 SIR: $250,000	07/01/2018	07/01/2019	Each Incident Aggregate		5,000,000 5,000,000

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (ACORD 101, Additional Remarks Schedule, may be attached if more space is required)
Evidence Only.

CERTIFICATE HOLDER

ENGIE Holdings Inc.
1990 Post Oak Blvd., Suite 1900
Houston, TX 77056

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE of Marsh USA Inc.

Freeman M. Wade

ADDITIONAL REMARKS SCHEDULE

AGENCY	NAMED INSURED
Marsh USA Inc.	ENGIE Holdings Inc. And their subsidiaries 1990 Post Oak Blvd., Suite 1900 Houston, TX 77056
POLICY NUMBER	
CARRIER / NAIC CODE	EFFECTIVE DATE:

ADDITIONAL REMARKS

THIS ADDITIONAL REMARKS FORM IS A SCHEDULE TO ACORD FORM,

FORM NUMBER: 25 **FORM TITLE:** Certificate of Liability Insurance

Property:
Policy No.: 1041445
Carrier: Factory Mutual Insurance Company
Limit: $2,000,000
Deductible: $25,000

EXHIBIT F: Copies of Adjacent Property Owners Notification Letter, List of Adjacent Landowners, and Newspaper Advertisement

CALFEE

Calfee, Halter & Griswold LLP
Attorneys at Law

1200 Huntington Center
41 South High Street
Columbus, Ohio 43215-3465
614.621.1500 **Phone**
Calfee.com

September 3, 2019

Via First Class U.S. Mail

«Owners»
«Street»
«City», «ST» «Zip»

Re: Case No. 19-1641-EL-BTX
In the Matter of the Application of **The Ohio State University** for a Certificate of Environmental Compatibility and Public Need for a Combined Heat and Power Major Unit Facility in Franklin County, Ohio on the Campus of The Ohio State University

Dear «Salutation»:

Introduction

As the attorney representing The Ohio State University (Ohio State) before the Ohio Power Siting Board ("Board"), I am sending this letter as required by Ohio Administrative Code Rule ("OAC") 4906-3-03(B)(2). This letter is being sent to property owners and affected tenants to a proposed Combined Heat and Power ("CHP") major unit facility on the Ohio State campus in Clinton Township, Franklin County, Ohio. You are receiving this letter because your property is contiguous to the planned project area parcel. OAC Rule 4906-3-03(B)(2) requires the applicant to notify all property owners and affected tenants contiguous to the planned project area.

Background

Ohio State is committed to continuing to make a world-class education both accessible and affordable. At the same time, Ohio State is driven to continually improve the environmental sustainability of campus operations. As we add new academic, research, and medical facilities to campus, our energy demands grow accordingly. To reduce Ohio State's energy costs and improve the campus' carbon emissions impact on the environment, Ohio State is proposing to install a CHP facility on campus.

The proposed CHP facility will reduce the amount of electric power Ohio State must purchase from the electricity markets. Additionally, producing electricity on campus using highly efficient natural gas-fired generators will reduce the total carbon dioxide emissions associated with the campus.

Ohio State examined several possible locations for the proposed CHP facility. The proposed site is on the corner of John Herrick Drive and Vernon Tharp Street.

Description of Facility

The CHP facility will produce thermal energy powered by natural gas while introducing electricity generation on campus. The general purpose of the project is for the CHP facility to be a primary source of heating and electricity to the Columbus campus.

The proposed CHP major unit facility site is located on 1.35 acres on an area previously disturbed for the Howlett Greenhouse operations on campus. The site is on the corner of John H. Herrick Drive and Vernon L. Tharp Street adjacent to the Galbreath Equine Center, Parker Food and Science Technology Building, Howlett Greenhouses, and Howlett Hall. The proposed site is currently a gravel lot within a

chain link fence that contains lightweight plastic sheeting greenhouses and related structures (e.g. composting bins).

The CHP facility will include the installation of two natural gas combustion turbine generators and one steam turbine generator. The turbines nameplate output capacity will be 105.5 megawatts in summer and 85.1 megawatts in winter. The nameplate maximum heat input is 314.8 million Btu per hour (Higher Heating Value).

"Associated facilities" as defined by the Board rules will consist of buried lines except where the utility line(s) will be attached underneath a new bridge crossing the Olentangy River just south of Ohio Stadium. The new bridge will replace the existing bridge in that location which currently has utility lines attached to it. The buried lines will be located on the Ohio State campus in previously disturbed areas through lawns, streets, roads, sidewalks and parking lots within the urbanized area developed for the campus.

Description of the Certification Process

In order to construct, operate, and maintain the CHP facility, Ohio State must obtain permission from the Board. That permission is provided in the form of a Certificate.

In the near future, Ohio State will submit to the Board an Application for a Certificate of Environmental Compatibility and Public Need to construct, operate, and maintain the CHP facility. Once the application is submitted, the Board will preliminarily review the application to determine whether it is complete and contains all necessary requirements. No later than 60 days after the application is filed, the Chairman of the Board will notify Ohio State whether the application was complete and contains all necessary requirements. The docket number which has been assigned to this matter is: 19-1641-EL-BTX.

Assuming the application is found to be complete, the Board is required to promptly fix dates for public hearings: one, a non-adjudicatory, local public hearing to be held nearby in Franklin County; and also an adjudicatory hearing to be held at the offices of the Public Utilities Commission of Ohio, 180 East Broad Street, Columbus, Ohio 43215-3793.

Prior to the hearings, however, the application will be investigated by the Board staff. The investigation must be completed, and the staff must submit a written report to the Board, not less than fifteen days prior to the date of the hearings and no more than 75 days from the date the application is deemed complete. The report will set forth the nature of the investigation and contain recommended findings with regard to the criteria the Board must use to review the application. A copy of the report will be made available to any person upon request.

The criteria the Board must use to review the application are as follows:

(1) the basis of the need for the facility;
(2) the nature of the probable environmental impact;
(3) that the facility represents the minimum adverse environmental impact, considering the state of available technology and the nature and economics of the various alternatives, and other pertinent considerations;
(4) in the case of an electric transmission line, that the facility is consistent with regional plans for expansion of the electric power grid of the electric systems serving this state and interconnected utility systems and that the facility will serve the interests of electric system economy and reliability;
(5) that the facility will comply with Chapters 3704, 3734, and 6111 of the Revised Code and all rules and standards adopted under those chapters and under Sections 1501.33, 1501.34 and 4561.32 of the Revised Code;
(6) that the facility will serve the public interest, convenience, and necessity;

(7) the impact on the viability as agricultural land of any land in an existing agricultural district established under Chapter 929 of the Revised Code that is located within the site (route) and alternative site (route) of the proposed major utility facility (pipeline);
(8) that the facility incorporates maximum feasible water conservation practices as determined by the Board, considering available technology and the nature and economics of the various alternatives.

After the public hearings are completed, recent Board practice is that the Board directs the administrative law judge who presides over the hearings to prepare a draft order for its review and consideration. The Board will issue a final decision within a reasonable time after conclusion of the hearings. If a party is not satisfied with the Board's decision, an application for rehearing can be submitted and if the Board denies the rehearing application, the party can appeal to the Ohio Supreme Court.

Parties who are interested in this application may file a petition to intervene in the adjudicatory hearing or they may ask the Board to send them notices. Petitions to intervene will be accepted by the Board up to 30 days following the publication of the newspaper notice setting the date for the hearing, or later, if good cause is shown. However, the Board strongly encourages interested persons who wish to intervene in the adjudicatory hearing to file their petitions as soon as possible. Petitions should be addressed to the Ohio Power Siting Board, 180 East Broad Street, Columbus, Ohio 43215-3793 and cite the above-listed Case No. 19-1641-EL-BTX.

You may access all the filings in this case at the PUCO website at http://www.puc.state.oh.us/ and then click on "Docketing Information System (DIS)" in the second section, middle column; once the Docket Information System screen appears, type the case number for the CHP facility application, Case No. 19-1641-EL-BTX, and follow the instructions to retrieve copies of all filings in the case.

The Board's address is 180 East Broad Street, Columbus, Ohio 43215-3793; its telephone number is 1-866-270-6772, its website is http://www.opsb.ohio.gov/opsb/, and its email is opsb@puco.ohio.gov. The applicant's project website is https://buildingthefuture.osu.edu/combined-heat-and-power-plant.

Community Informational Meeting Date

Ohio State has arranged for a public community open house to be held on September 26, 2019 on the Ohio State campus at the Fawcett Center, 2400 Olentangy River Rd, Columbus, OH 43210 between the hours of 5:30 and 7:30 pm. Free parking will be available. The meeting format will be an open house with poster stations arranged throughout the room. Each station will have information about various aspects of the CHP project, including maps of the project area. Representatives from Ohio State and the university's utility systems manager, Ohio State Energy Partners LLC, will be in attendance to answer questions. Those who attend the meeting may write comments that the applicant will summarize and include in its application.

Conclusion

We expect that the Board will conclude, as we believe, that the CHP facility will benefit the community and the region. If you have any questions regarding the open house you may contact Ohio State's energy management office at (614) 292-0357 or email at potter.138@osu.edu.

Sincerely,

Steven D. Lesser

PARCELID	Land Use	Site Address				Owner Name 1	Owner Name 2	Owner Address			
010-207716	CONDOMINIUM UNIT	364 W LANE AV	UNIT 100	COLUMBUS OH	43201	RIVERWATCH TOWER	ASSOCIATION INC	OHIO EQUITIES LLC		605 S FRONT ST STE 200	COLUMBUS OH 43215-5777
010-207717	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 101	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207718	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 102	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		CORELOGIC		3001 HACKBERRY RD	IRVING TX 75063-0156
010-207719	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 103	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207720	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 104	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207721	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 105	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207722	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 106	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207723	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 107	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207724	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 108	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207725	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 109	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207726	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 110	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207727	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 111	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207728	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 112	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207729	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 113	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207730	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 114	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207731	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 115	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207732	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 116	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207733	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 117	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207734	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 118	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207735	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 119	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207736	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 120	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207737	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 121	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207738	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 122	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121

010-207739	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 123	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207740	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 124	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207741	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 125	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207742	EXEMPT PROPERTY OWNED BY STATE OF OHIO	364 W LANE AV	UNIT 126	COLUMBUS OH	43201	STATE OF OHIO FBO-OSU		OSU	LEASE ADMINISTRATOR	1534 N HIGH ST	COLUMBUS OH 43201-1121
010-207743	CONDOMINIUM UNIT	364 W LANE AV	UNIT 201	COLUMBUS OH	43201	LEONG KENNETH		KENNETH LEONG		8354 NUTHATCH WAY	COLUMBUS OH 43235-1480
010-207744	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 202	COLUMBUS OH	43201	MVP 364RW LLC		MVP 364 W LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207745	CONDOMINIUM UNIT	364 W LANE AV	UNIT 203	COLUMBUS OH	43201	HALDAR FRANCES L		FRANCES L HALDAR		7201 N CHESTNUT LN	VAN NUYS CA 91405-5479
010-207746	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 204	COLUMBUS OH	43201	MVP RIVERWATCH LLC		MVP RIVERWATCH LLC	ATTN ACCT DEPT	230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207747	CONDOMINIUM UNIT	364 W LANE AV	UNIT 205	COLUMBUS OH	43201	JARRELL SUSAN K		SUSAN K JARRELL		8428 COUNTY ROAD 107	PROCTORVILLE OH 45669-843
010-207748	CONDOMINIUM UNIT	364 W LANE AV	UNIT 206	COLUMBUS OH	43201	YERKEY MATTHEW R TR		MATTHEW R YERKEY TR		1750 SHADY LN	SALEM OH 44460-1240
010-207749	CONDOMINIUM UNIT	364 W LANE AV	UNIT 208	COLUMBUS OH	43201	DAUGHERTY WILLIAM L TR	DAUGHERTY BEVERLY A TR	WILLIAM L DAUGHERTY TR	BEVERLY DAUGHERTY TR	1470 CARDIFF RD	COLUMBUS OH 43221-3954
010-207750	CONDOMINIUM UNIT	364 W LANE AV	UNIT 209	COLUMBUS OH	43201	RIVERWATCH INVESTMENTS	LLC	RIVERWATCH INVESTMENTS LLC		8931 WHITNEY DR	LEWIS CENTER OH 43035-710
010-207751	CONDOMINIUM UNIT	364 W LANE AV	UNIT 210	COLUMBUS OH	43201	BESHRIDA OSAMA N		CORELOGIC		3001 HACKBERRY RD	IRVING TX 75063-0156
010-207752	CONDOMINIUM UNIT	364 W LANE AV	UNIT 212	COLUMBUS OH	43201	MOSER PAUL J	MOSER LUANNE K	FIRST FEDERAL COMMUNITY BANK		119 S SANDUSKY AVE	BUCYRUS OH 44820-2220
010-207753	CONDOMINIUM UNIT	364 W LANE AV	UNIT 213	COLUMBUS OH	43201	LIU LEAH		LEAH LIU		11530 JOHNSTOWN RD	NEW ALBANY OH 43054-8551
010-207754	CONDOMINIUM UNIT	364 W LANE AV	UNIT 215	COLUMBUS OH	43201	FRITTS CHRISTOPHER M		CHRISTOPHER FRITTS		7503 WINDSOR DR	DUBLIN OH 43016
010-207755	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 217	COLUMBUS OH	43201	WANG HUA		HUA WANG		690 RIVERVIEW DR APT 105	COLUMBUS OH 43202-3240
010-207756	CONDOMINIUM UNIT	364 W LANE AV	UNIT 218	COLUMBUS OH	43201	MCP RIVERWATCH LLC		MCP RIVERWATCH LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207757	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT 219	COLUMBUS OH	43201	JIANG TIANLU	LIN IVY RONG	TIANLU JIANG		5940 TARRIN CT	DUBLIN OH 43016-6125
010-207758	CONDOMINIUM UNIT	364 W LANE AV	UNIT 220	COLUMBUS OH	43201	BENEDICT JASON		JASON BENEDICT		364 W LANE AVE APT 220	COLUMBUS OH 43201-1096
010-207759	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 222	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948

010-207760	CONDOMINIUM UNIT	364 W LANE AV	UNIT 223	COLUMBUS OH	43201	EAGLE PEAK LLC		EAGLE PEAK LLC		2176 OAKMOUNT RD	COLUMBUS OH 43221-1230
010-207761	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 224	COLUMBUS OH	43201	KARNITIS CHARLES I	LAIMA E	CHARLES I KARNITIS	LAIMA E KARNITIS	724 CHAFFIN RDG	COLUMBUS OH 43214-2954
010-207762	CONDOMINIUM UNIT	364 W LANE AV	UNIT 225	COLUMBUS OH	43201	SIITAM ALEK T		ALEK T SITAM		1201 WESTPHAL AVE	COLUMBUS OH 43227-1744
010-207763	CONDOMINIUM UNIT	364 W LANE AV	UNIT 226	COLUMBUS OH	43201	JPC OF COLUMBUS LTD		JPC OF COLUMBUS LTD		6619 S PATSBURG ST	AURORA CO 80016-4394
010-207764	CONDOMINIUM UNIT	364 W LANE AV	UNIT 228	COLUMBUS OH	43201	KAMEL MOUHAMED K		MOUHAMED K KAMEL		6871 CHILLINGSWORTH CIR NW	CANTON OH 44718-1571
010-207765	CONDOMINIUM UNIT	364 W LANE AV	UNIT 229	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		239 HURONVIEW BLVD	ANN ARBOR MI 48103-2947
010-207766	CONDOMINIUM UNIT	364 W LANE AV	UNIT 231	COLUMBUS OH	43201	MCFADDEN TERRY		TERRY MCFADDEN		730 ERIN ST	LEWIS CENTER OH 43035-844
010-207767	CONDOMINIUM UNIT	364 W LANE AV	UNIT 235	COLUMBUS OH	43201	STAHL BRADLEY T	STAHL ALICIA K	BRADLEY T STAHL	ALICIA K STAHL	703 HAWTHORNE DR	MARSHALL IL 62441-1976
010-207768	CONDOMINIUM UNIT	364 W LANE AV	UNIT 237	COLUMBUS OH	43201	REPP CLIFFORD M & RUTH A		CLIFFORD M REPP	RUTH A REPP	PO BOX 2699	MANSFIELD OH 44906-0699
010-207769	CONDOMINIUM UNIT	364 W LANE AV	UNIT 239	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207770	CONDOMINIUM UNIT	364 W LANE AV	UNIT 301	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207771	CONDOMINIUM UNIT	364 W LANE AV	UNIT 302	COLUMBUS OH	43201	SGL ENTERPRISES LLC		SGL ENTERPRISES LLC		5917 GROVE CITY RD	GROVE CITY OH 43123-8925
010-207772	CONDOMINIUM UNIT	364 W LANE AV	UNIT 303	COLUMBUS OH	43201	DKJ INVESTMENTS LLC		DKJ INVESTMENTS LLC		7650 INNBROOK PL	COLUMBUS OH 43235-1640
010-207773	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 304	COLUMBUS OH	43201	WANG HUA		HUA WANG		688 RIVERVIEW DR APT 50	COLUMBUS OH 43202-1659
010-207774	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 305	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207775	CONDOMINIUM UNIT	364 W LANE AV	UNIT 306	COLUMBUS OH	43201	HO TSING-CHIANG	HO SHIU-FAN	TSING-CHIANG HO		1961 DREW AVE	COLUMBUS OH 43235-7412
010-207776	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 308	COLUMBUS OH	43201	KARNITIS CHARLES I	LAIMA E TRUST	CHARLES I KARNITIS	LAIMA E KARNITIS TRUST	724 CHAFFIN RDG	COLUMBUS OH 43214-2954
010-207777	CONDOMINIUM UNIT	364 W LANE AV	UNIT 309	COLUMBUS OH	43201	ZHANG HAIBO		HAIBO ZHANG		4001 POTTER ST APT 28	EUGENE OR 97405-4566
010-207778	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT 310	COLUMBUS OH	43201	CHONG PUI YEE KALINE	CHIANG JON	JON CHIANG		17025 NW MADRONE ST	PORTLAND OR 97229-1427
010-207779	CONDOMINIUM UNIT	364 W LANE AV	UNIT 312	COLUMBUS OH	43201	EAGLE PEAK LLC		KATHLEEN HARPER		2176 OAKMOUNT RD	COLUMBUS OH 43221-1230
010-207780	CONDOMINIUM UNIT	364 W LANE AV	UNIT 313	COLUMBUS OH	43201	SJ INTERNATIONAL LTD		SJ INTERNATIONAL LTD		1690 ARDWICK RD	COLUMBUS OH 43220-4416
010-207781	CONDOMINIUM UNIT	364 W LANE AV	UNIT 315	COLUMBUS OH	43201	JPC OF COLUMBUS LTD		JPC OF COLUMBUS LTD		6619 S PATSBURG ST	AURORA CO 80016-4394

010-207782	CONDOMINIUM UNIT	364 W LANE AV	UNIT 317	COLUMBUS OH	43201	ZOLLER D TIM	ZOLLER MARILYN S	D TIM ZOLLER		18854 STATE ROUTE 676	MARIETTA OH 45750-6321
010-207783	CONDOMINIUM UNIT	364 W LANE AV	UNIT 318	COLUMBUS OH	43201	COCKERILL CURTIS A		CURTIS COCKERILL		364 W LANE AVE APT 318	COLUMBUS OH 43201-4300
010-207784	CONDOMINIUM UNIT	364 W LANE AV	UNIT 319	COLUMBUS OH	43201	SINHA NIRMAL K	TRIPTI	NIRMAL K SINHA	TRIPTI SINHA	6470 MEADOWBROOK CIR	WORTHINGTON OH 43085-28
010-207785	CONDOMINIUM UNIT	364 W LANE AV	UNIT 320	COLUMBUS OH	43201	SAIDUDDIN JAMU		JAMU SAIDUDDIN		8825 BIRGHAM CT N	DUBLIN OH 43017-9718
010-207786	CONDOMINIUM UNIT	364 W LANE AV	UNIT 322	COLUMBUS OH	43201	DESAI FAMILY TRUST		DESAI FAMILY TRUST		124 SCARBOROUGH VILLAGE DR	DAYTON OH 45458-1104
010-207787	CONDOMINIUM UNIT	364 W LANE AV	UNIT 323	COLUMBUS OH	43201	XU CHARLES E		CHARLES E XU		364 W LANE AVE APT 323	COLUMBUS OH 43201-4300
010-207788	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 324	COLUMBUS OH	43201	KARNITIS CHARLES I	LAIMA E CO-TR	CHARLES I KARNITIS	LAIMA E KARNITIS CO-TR	724 CHAFFIN RDG	COLUMBUS OH 43214-2954
010-207789	CONDOMINIUM UNIT	364 W LANE AV	UNIT 325	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207790	CONDOMINIUM UNIT	364 W LANE AV	UNIT 326	COLUMBUS OH	43201	LEE SHIRLEY PEI-CHI		SHIRLEY PEI-CHI LEE		2065 STRATHSHIRE HALL LN	POWELL OH 43065-9439
010-207791	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 328	COLUMBUS OH	43201	KARNITIS CATHERINE SOPHIA		CATHERINE KARNITIS		PO BOX 2892	TAOS NM 87571-2892
010-207792	CONDOMINIUM UNIT	364 W LANE AV	UNIT 329	COLUMBUS OH	43201	ST JEAN CHARLES	ST JEAN KATHERYN	CHARLES ST JEAN		1645 N STATE ROUTE 61	SUNBURY OH 43074-7504
010-207793	CONDOMINIUM UNIT	364 W LANE AV	UNIT 331	COLUMBUS OH	43201	KOO OLIVER TAIT	LIU PEI-YANG	OLIVER TAIT KOO	PEI-YANG LIU	191 PRENTISS ST	MUNROE FALLS OH 44262-15
010-207794	CONDOMINIUM UNIT	364 W LANE AV	UNIT 335	COLUMBUS OH	43201	SIITAM ALEK T		ALEK T SIITAM		1201 WESTPHAL AVE	COLUMBUS OH 43227-1744
010-207795	CONDOMINIUM UNIT	364 W LANE AV	UNIT 337	COLUMBUS OH	43201	WISEMAN BRITT T		CORELOGIC		3001 HACKBERRY RD	IRVING TX 75063-0156
010-207796	CONDOMINIUM UNIT	364 W LANE AV	UNIT 339	COLUMBUS OH	43201	ST JEAN CHARLES	ST JEAN KATHRYN S	CHARLES ST JEAN		1645 N STATE ROUTE 61	SUNBURY OH 43074-7504
010-207797	CONDOMINIUM UNIT	364 W LANE AV	UNIT 401	COLUMBUS OH	43201	MCKITRICK ROBERT L	MESCAL E	ROBERT L MCKITRICK		7304 RIVERHILL RD	OXON HILL MD 20745-1031
010-207798	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT 402	COLUMBUS OH	43201	WENG XIN		XIN WENG		334 SILVER MAPLE DR	BLACKLICK OH 43004-8426
010-207799	CONDOMINIUM UNIT	364 W LANE AV	UNIT 403	COLUMBUS OH	43201	DICK DUANE E TR		DUANE E DICK TR		5681 LONDON WEST RD	SHELBY OH 44875-9228
010-207800	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 404	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207801	CONDOMINIUM UNIT	364 W LANE AV	UNIT 405	COLUMBUS OH	43201	RYAN THOMAS E		CORELOGIC		3001 HACKBERRY RD	IRVING TX 75063-0156
010-207802	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 406	COLUMBUS OH	43201	WANG HUA		HUA WANG		690 RIVERVIEW DR APT 105	COLUMBUS OH 43202-3240
010-207803	CONDOMINIUM UNIT	364 W LANE AV	UNIT 408	COLUMBUS OH	43201	SHIH CHUNG N & MEI C		CHUNG N SHIH	MEI C SHIH	1986 BRAEMAR DR	COLUMBUS OH 43220-3026

010-207804	CONDOMINIUM UNIT	364 W LANE AV	UNIT 409	COLUMBUS OH	43201	EMI PROPERTIES LLC		EMI PROPERTIES LLC		24 KESWICK CMNS	NEW ALBANY OH 43054-8231
010-207805	CONDOMINIUM UNIT	364 W LANE AV	UNIT 410	COLUMBUS OH	43201	DU YANG	XIN LIPING	YANT DU	XIN LIPING	179 SANBRIDGE CIR	WORTHINGTON OH 43085-35
010-207806	CONDOMINIUM UNIT	364 W LANE AV	UNIT 412	COLUMBUS OH	43201	DENNISON ASSOCIATES	PROPERTY MANAGEMENT LLC	DENNISON ASSOCIATES	PROPERTY MANAGEMENT	2398 KENSINGTON DR	COLUMBUS OH 43221-3770
010-207807	CONDOMINIUM UNIT	364 W LANE AV	UNIT 413	COLUMBUS OH	43201	SJ INTERNATIONAL LTD		SJ INTERNATIONAL LTD		1690 ARDWICK RD	COLUMBUS OH 43220-4416
010-207808	CONDOMINIUM UNIT	364 W LANE AV	UNIT 415	COLUMBUS OH	43201	LEE JEFFREY W TR	LEE MONICA M TR	JEFFREY W LEE TR	MONICA M LEE TR	PO BOX 37	CRYSTAL BEACH FL 34681-003
010-207809	CONDOMINIUM UNIT	364 W LANE AV	UNIT 417	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207810	CONDOMINIUM UNIT	364 W LANE AV	UNIT 418	COLUMBUS OH	43201	JPC OF COLUMBUS LTD		JPC OF COLUMBUS LTD		6619 S PATSBURG ST	AURORA CO 80016-4394
010-207811	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 419	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207812	CONDOMINIUM UNIT	364 W LANE AV	UNIT 420	COLUMBUS OH	43201	LUSTRE OSCAR TR	LUSTRE DALISAY TR	OSCAR E LUSTRE	DALISAY M LUSTRE	1651 REGAL MIST LOOP	TRINITY FL 34655-4975
010-207813	CONDOMINIUM UNIT	364 W LANE AV	UNIT 422	COLUMBUS OH	43201	SAHNI VEENA	SAHNI SANJAY K	VEENA SAHNI		5660 JANET BLVD	SOLON OH 44139-1963
010-207814	CONDOMINIUM UNIT	364 W LANE AV	UNIT 423	COLUMBUS OH	43201	JIANG TIANLU		TIANLU JIANG		4837 WINTERSET DR	COLUMBUS OH 43220-3138
010-207815	CONDOMINIUM UNIT	364 W LANE AV	UNIT 424	COLUMBUS OH	43201	GUTHRIE WILLIAM R TR		WILLIAM R GUTHRIE		2080 SHARON RD	WINTER PARK FL 32789-1517
010-207816	CONDOMINIUM UNIT	364 W LANE AV	UNIT 425	COLUMBUS OH	43201	PAN LEO		LEO PAN		364 W LANE AVE APT 912	COLUMBUS OH 43201-4345
010-207817	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 426	COLUMBUS OH	43201	JMG HOMES LLC		JMG HOMES LLC		141 NAVIGATOR DR	AUSTIN TX 78717-4938
010-207818	CONDOMINIUM UNIT	364 W LANE AV	UNIT 428	COLUMBUS OH	43201	PRABHA LLC		PRABHA INC		2600 BRYTON CT	POWELL OH 43065-7428
010-207819	CONDOMINIUM UNIT	364 W LANE AV	UNIT 429	COLUMBUS OH	43201	DUTTA-CHOUDHURY TAPU	JYOTIRMOY	TAPU DUTTA-CHOUDHURY	JYOTIRMOY DUTTA-CHOU	38 SKYLINE DR	MORRISTOWN NJ 07960-621
010-207820	CONDOMINIUM UNIT	364 W LANE AV	UNIT 431	COLUMBUS OH	43201	SARO LLC		SARO LLC		5077 GRASSLAND DR	DUBLIN OH 43016-4318
010-207821	CONDOMINIUM UNIT	364 W LANE AV	UNIT 435	COLUMBUS OH	43201	RINEHART PAULETTE J		PAULETTE J RINEHART		508 WASHINGTON AVE	BELLEFONTAINE OH 43311-18
010-207822	CONDOMINIUM UNIT	364 W LANE AV	UNIT 437	COLUMBUS OH	43201	EMI PROPERTIES		EMI PROPERTIES LLC		24 KESWICK CMNS	NEW ALBANY OH 43054-8231
010-207823	CONDOMINIUM UNIT	364 W LANE AV	UNIT 439	COLUMBUS OH	43201	ZELEK JARED		CORELOGIC		3001 HACKBERRY RD	IRVING TX 75063-0156
010-207824	CONDOMINIUM UNIT	364 W LANE AV	UNIT 501	COLUMBUS OH	43201	LEE EUSEBIO		EUSEBIO LEE		4409 SCISSORTAIL LOOP	WESTERVILLE OH 43081-372

010-207825	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT 502	COLUMBUS OH	43201	MVP RIVERWATCH LLC		MVP RIVERWATCH LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207826	CONDOMINIUM UNIT	364 W LANE AV	UNIT 503	COLUMBUS OH	43201	LINDA WAY PROPERTIES LLC		LINDA WAY PROPERTIES LLC		1182 STANHOPE DR	COLUMBUS OH 43221-2331
010-207827	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 504	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207828	CONDOMINIUM UNIT	364 W LANE AV	UNIT 505	COLUMBUS OH	43201	TIMMERMAN PATRICIA A		PATRICIA A TIMMERMAN		9322 CHATTANOOGA DR	SAN ANTONIO TX 78240-287
010-207829	CONDOMINIUM UNIT	364 W LANE AV	UNIT 506	COLUMBUS OH	43201	RWATCH LLC		RWATCH LLC		610 HAVENS CORNERS RD	COLUMBUS OH 43230-3112
010-207830	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 508	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207831	CONDOMINIUM UNIT	364 W LANE AV	UNIT 509	COLUMBUS OH	43201	CHIANG KUN YEH	CHONG PUI YEE KALINE	JON CHIANG		17025 NW MADRONE ST	PORTLAND OR 97229-1427
010-207832	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT 510	COLUMBUS OH	43201	WENG XIN		XIN WENG		334 SILVER MAPLE DR	BLACKLICK OH 43004-8426
010-207833	CONDOMINIUM UNIT	364 W LANE AV	UNIT 512	COLUMBUS OH	43201	SCALES FRONISTA LTD		SCALES FRONISTA LTD		8969 ADAMS RD	DAYTON OH 45424-4037
010-207834	CONDOMINIUM UNIT	364 W LANE AV	UNIT 513	COLUMBUS OH	43201	DU YANG	XIN LIPING	YANG DU	LIPING XIN	179 SANBRIDGE CIR	WORTHINGTON OH 43085-35
010-207835	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT 515	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207836	CONDOMINIUM UNIT	364 W LANE AV	UNIT 517	COLUMBUS OH	43201	RWATCH LLC		RWATCH LLC		610 HAVENS CORNERS RD	COLUMBUS OH 43230-3112
010-207837	CONDOMINIUM UNIT	364 W LANE AV	UNIT 518	COLUMBUS OH	43201	MAHAFFEY MARY S		MARY S MAHAFFEY		5502 QUEENS PARK DR	DUBLIN OH 43016-7250
010-207838	CONDOMINIUM UNIT	364 W LANE AV	UNIT 519	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207839	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 520	COLUMBUS OH	43201	KARNITIS CHARLES I TR	KARNITIS LAIMA E TR	CHARLES I KARNITIS TR		724 CHAFFIN RDG	COLUMBUS OH 43214-2954
010-207840	CONDOMINIUM UNIT	364 W LANE AV	UNIT 522	COLUMBUS OH	43201	LIN WILL	WENG XIN	WILL LIN	XIN WENG	334 SILVER MAPLE DR	BLACKLICK OH 43004-8426
010-207841	CONDOMINIUM UNIT	364 W LANE AV	UNIT 523	COLUMBUS OH	43201	SJ INTERNATIONAL LTD		SJ INTERNATIONAL LTD		1690 ARDWICK RD	COLUMBUS OH 43220-4416
010-207842	CONDOMINIUM UNIT	364 W LANE AV	UNIT 524	COLUMBUS OH	43201	NOGGLE KERRY	NOGGLE XIAOXIAO	KERRY NOGGLE	XIAOXIAO NOGGLE	5176 LAKE POINT DR	CARMEL IN 46033-7212
010-207843	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 525	COLUMBUS OH	43201	WANG HUA		HUA WANG		688 RIVERVIEW DR APT 50	COLUMBUS OH 43202-1659
010-207844	CONDOMINIUM UNIT	364 W LANE AV	UNIT 526	COLUMBUS OH	43201	YERKEY MATTHEW R TR		MATTHEW R YERKEY TR		1750 SHADY LN	SALEM OH 44460-1240
010-207845	CONDOMINIUM UNIT	364 W LANE AV	UNIT 528	COLUMBUS OH	43201	HRELIC DAREN	HRELIC DARKO	DAREN HRELIC		4794 CORDOBA ST	HILLIARD OH 43026-8902

010-207846	CONDOMINIUM UNIT	364 W LANE AV	UNIT 529	COLUMBUS OH	43201	GIBSON MICHAEL P		MICHAEL P GIBSON		4000 BAUGHMAN GRANT	NEW ALBANY OH 43054-8933
010-207847	CONDOMINIUM UNIT	364 W LANE AV	UNIT 531	COLUMBUS OH	43201	GRANATO SAMUEL C	MORATO-GRANATO SUSY	SAMUEL C GRANATO	SUSY MORATO-GRANATO	1005 S CASSINGHAM RD	COLUMBUS OH 43209-2433
010-207848	CONDOMINIUM UNIT	364 W LANE AV	UNIT 535	COLUMBUS OH	43201	KORI ARUN S TR	KORI MAMTA M TR	ARUN S KORI	MAMTA M KORI	4277 MACKENZIE CT	MASON OH 45040-4664
010-207849	CONDOMINIUM UNIT	364 W LANE AV	UNIT 537	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207850	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 539	COLUMBUS OH	43201	KARNITIS CHARLES I	LAIMA E CO TRS	CHARLES I KARNITIS	LAIMA E KARNITIS CO-TRS	724 CHAFFIN RDG	COLUMBUS OH 43214-2954
010-207851	CONDOMINIUM UNIT	364 W LANE AV	UNIT 601	COLUMBUS OH	43201	STROVILAS CRIST G TR		CRIST G STROVILAS TR		812 N 4TH ST	TORONTO OH 43964-1626
010-207852	CONDOMINIUM UNIT	364 W LANE AV	UNIT 602	COLUMBUS OH	43201	SAIDUDDIN JAMU		JAMU SAIDUDDIN	SHAFI SAIDUDDIN	8825 BIRGHAM CT N	DUBLIN OH 43017-9718
010-207853	CONDOMINIUM UNIT	364 W LANE AV	UNIT 603	COLUMBUS OH	43201	STROVILAS JACQUELINE C TR		JACQUELINE C STROVILAS TR		812 N 4TH ST	TORONTO OH 43964-1626
010-207854	CONDOMINIUM UNIT	364 W LANE AV	UNIT 604	COLUMBUS OH	43201	BALEN ALAN	BALEN MARK	MARK BALEN	ALAN BALEN	8755 CARTER RD APT 29	FREELAND MI 48623-8768
010-207855	CONDOMINIUM UNIT	364 W LANE AV	UNIT 605	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		364 W LANE AVE	COLUMBUS OH 43201-4362
010-207856	CONDOMINIUM UNIT	364 W LANE AV	UNIT 606	COLUMBUS OH	43201	DESAI MANOJ TR	DESAI PRIYA TR	MANOJ DESAI CO-TR	PRIYA DESAI CO-TR	124 SCARBOROUGH VILLAGE DR	DAYTON OH 45458-1104
010-207857	CONDOMINIUM UNIT	364 W LANE AV	UNIT 608	COLUMBUS OH	43201	GARGASZ RONALD L	GARGASZ SHARON L	RONALD L GARGASZ		19 TANGLEWOOD LN	BOWLING GREEN OH 43402-4
010-207858	CONDOMINIUM UNIT	364 W LANE AV	UNIT 609	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		364 W LANE AVE	COLUMBUS OH 43201-4362
010-207859	CONDOMINIUM UNIT	364 W LANE AV	UNIT 610	COLUMBUS OH	43201	STUMP VIOLET P		VIOLET P STUMP		4205 NAVAJO TRL	JAMESTOWN OH 45335-1331
010-207860	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 612	COLUMBUS OH	43201	KARNITIS CHARLES I	LAIMA E TRS	CHARLES I KARNITIS	LAIMA E KARNITIS TRS	724 CHAFFIN RDG	COLUMBUS OH 43214-2954
010-207861	CONDOMINIUM UNIT	364 W LANE AV	UNIT 613	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207862	CONDOMINIUM UNIT	364 W LANE AV	UNIT 615	COLUMBUS OH	43201	BALDESSARI HECTOR A	ESTHER N	HECTOR A BALDESSARI	ESTHER N BALDESSARI	5513 CRESTONE CIR	BOULDER CO 80301-3518
010-207863	CONDOMINIUM UNIT	364 W LANE AV	UNIT 617	COLUMBUS OH	43201	HART RICHARD D & TERESA S		RICHARD D HART	TERESA S HART	2405 UNIVERSITY AVE NW	CANTON OH 44709-3941
010-207864	CONDOMINIUM UNIT	364 W LANE AV	UNIT 618	COLUMBUS OH	43201	MCKITRICK ROBERT L	MESCAL E	ROBERT L MCKITRICK	MESCAL E MCKITRICK	7304 RIVERHILL RD	OXON HILL MD 20745-1031
010-207865	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 619	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948

010-207866	CONDOMINIUM UNIT	364 W LANE AV	UNIT 620	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207867	CONDOMINIUM UNIT	364 W LANE AV	UNIT 622	COLUMBUS OH	43201	KELLEY-JARRELL SUSAN		SUSAN KELLEY-JARRELL		8428 COUNTY ROAD 107	PROCTORVILLE OH 45669-843
010-207868	CONDOMINIUM UNIT	364 W LANE AV	UNIT 623	COLUMBUS OH	43201	SRIPAN MARTIN		MARTIN SRIPAN		1799 W 5TH AVE # 153	COLUMBUS OH 43212-2322
010-207869	CONDOMINIUM UNIT	364 W LANE AV	UNIT 624	COLUMBUS OH	43201	PAREKH AMI M		AMI M PAREKH		3495 SEABROOK ISLAND RD	JOHNS ISLAND SC 29455-6052
010-207870	CONDOMINIUM UNIT	364 W LANE AV	UNIT 625	COLUMBUS OH	43201	YEHASKUL DEBBIE		DEBBIE YEHSAKUL		6347 TANERA MORE CT	DUBLIN OH 43017-9579
010-207871	CONDOMINIUM UNIT	364 W LANE AV	UNIT 626	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207872	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 628	COLUMBUS OH	43201	KARNITIS CHARLES I	LAIMA E TRUST	CHARLES I KARNITIS	LAIMA E TRUST	724 CHAFFIN RDG	COLUMBUS OH 43214-2954
010-207873	CONDOMINIUM UNIT	364 W LANE AV	UNIT 629	COLUMBUS OH	43201	SAVIA JONATHAN J	SAVIA JAMES J	JONATHAN J SAVIA	JAMES J SAVIA	2593 NORTON PL	BELLMORE NY 11710-5428
010-207874	CONDOMINIUM UNIT	364 W LANE AV	UNIT 631	COLUMBUS OH	43201	BELL STEVEN D	BELL GLENNA J	STEVEN D BELL	GLENNA BELL	20209 BARKER RD	MARYSVILLE OH 43040-9160
010-207875	CONDOMINIUM UNIT	364 W LANE AV	UNIT 635	COLUMBUS OH	43201	WRE DE LLC		DENNISON ASSOCIATES	PROPERTY MANAGEMENT	2398 KENSINGTON DR	COLUMBUS OH 43221-3770
010-207876	CONDOMINIUM UNIT	364 W LANE AV	UNIT 637	COLUMBUS OH	43201	ZHAO XUEYANG		XUEYANG ZHAO		5526 VILLAGE PSGE	HILLIARD OH 43026-7995
010-207877	CONDOMINIUM UNIT	364 W LANE AV	UNIT 639	COLUMBUS OH	43201	RYAN MARK A	RYAN ANNE D	CORELOGIC		3001 HACKBERRY RD	IRVING TX 75063-0156
010-207878	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 701	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207879	CONDOMINIUM UNIT	364 W LANE AV	UNIT 702	COLUMBUS OH	43201	LIN SHIOW HWA		SHIOW HWA LIN		4103 174TH ST SE	BOTHELL WA 98012-7625
010-207880	CONDOMINIUM UNIT	364 W LANE AV	UNIT 703	COLUMBUS OH	43201	LIN WILL		WILL LIN		342 JOSHUA CT	HANOVER PA 17331-7430
010-207881	CONDOMINIUM UNIT	364 W LANE AV	UNIT 704	COLUMBUS OH	43201	EMI PROPERTIES LLC		EMI PROPERTIES LLC		24 KESWICH CMNS	NEW ALBANY OH 43054-8231
010-207882	CONDOMINIUM UNIT	364 W LANE AV	UNIT 705	COLUMBUS OH	43201	COVELLI ANTHONY P		ANTHONY P COVELLI		1326 WINDHAM RD	COLUMBUS OH 43220-3963
010-207883	CONDOMINIUM UNIT	364 W LANE AV	UNIT 706	COLUMBUS OH	43201	LIU LIYUAN		LIYUAN LIU		5176 LAKE POINT DR	CARMEL IN 46033-7212
010-207884	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 707	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207885	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 708	COLUMBUS OH	43201	KARNITIS CHARLES I TR	KARNITIS LAIMA E TR	CHARLES I KARNITIS		724 CHAFFIN RDG	COLUMBUS OH 43214-2954
010-207886	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 709	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948

010-207887	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT 710	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		364 W LANE AVE	COLUMBUS OH 43201-4362
010-207888	CONDOMINIUM UNIT	364 W LANE AV	UNIT 711	COLUMBUS OH	43201	SRIPAN SUTHATIP	SRIPAN MARTIN	MARTIN SRIPAN		1799 W 5TH AVE # 153	COLUMBUS OH 43212-2322
010-207889	CONDOMINIUM UNIT	364 W LANE AV	UNIT 712	COLUMBUS OH	43201	LOW THIAM GAIK	PENG SHANNON GIN-TI	THIAM GAIK LOW	SHANNON GIN-TI PENG	1926 PARKLAND CT	LEWIS CENTER OH 43035-606
010-207890	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT 713	COLUMBUS OH	43201	YEHSAKUL DEBBIE S	YEHSAKUL PHONGSAK D, YEHSAKUL DAVID CW, YEHSAKUL ALEXANDER H	DEBBIE S YEHSAKUL		6347 TANERA MORE CT	DUBLIN OH 43017-9579
010-207891	CONDOMINIUM UNIT	364 W LANE AV	UNIT 715	COLUMBUS OH	43201	CROWELL NANCY E		NANCY CROWELL		888 VERNON HEIGHTS CIR	MARION OH 43302-6504
010-207892	CONDOMINIUM UNIT	364 W LANE AV	UNIT 717	COLUMBUS OH	43201	KITTSONMILLER LLC		KITTSONMILLER LLC		RR 1 BOX 732	SUGAR GROVE OH 43155-966
010-207893	CONDOMINIUM UNIT	364 W LANE AV	UNIT 718	COLUMBUS OH	43201	JPC OF COLUMBUS LTD		JPC OF COLUMBUS LTD		6619 S PATSBURG ST	AURORA CO 80016-4394
010-207894	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 719	COLUMBUS OH	43201	THEADO MICHAEL J		CORELOGIC		3001 HACKBERRY RD	IRVING TX 75063-0156
010-207895	CONDOMINIUM UNIT	364 W LANE AV	UNIT 720	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207896	CONDOMINIUM UNIT	364 W LANE AV	UNIT 721	COLUMBUS OH	43201	FOLEY MICHAEL V	FOLEY MARY B	CORELOGIC		3001 HACKBERRY RD	IRVING TX 75063-0156
010-207897	CONDOMINIUM UNIT	364 W LANE AV	UNIT 722	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		364 W LANE AVE	COLUMBUS OH 43201-4362
010-207898	CONDOMINIUM UNIT	364 W LANE AV	UNIT 723	COLUMBUS OH	43201	LOCK SZE-WAI PETER	WAI KA-YEE GRACE	SZE WAI & PETER LOK	KA-YEE GRACE WAI	1776 DREW AVE APT 122W	COLUMBUS OH 43235-7423
010-207899	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 724	COLUMBUS OH	43201	KARNITIS CHARLES I TR	KARNITIS LAIMA E	CHARLES I KARNITIS TR		724 CHAFFIN RDG	COLUMBUS OH 43214-2954
010-207900	CONDOMINIUM UNIT	364 W LANE AV	UNIT 725	COLUMBUS OH	43201	MQ5936 LLC		LI Q ZHANG	M&Q REALTY LLC	PO BOX 1479	POWELL OH 43065-1479
010-207901	CONDOMINIUM UNIT	364 W LANE AV	UNIT 726	COLUMBUS OH	43201	CAV364 LANE I LLC		CAV364 LANE I LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207902	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT 727	COLUMBUS OH	43201	HSIU-LAING CHIANG WEI		CHIANG WEI HSIU-LAING		4103 174TH ST SE	BOTHELL WA 98012-7625
010-207903	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 728	COLUMBUS OH	43201	KARNITIS CHARLES I	KARNITIS LAIMA E	CHARLES I KARNITIS	LAIMA EVE KARNITIS	724 CHAFFIN RDG	COLUMBUS OH 43214-2954
010-207904	CONDOMINIUM UNIT	364 W LANE AV	UNIT 729	COLUMBUS OH	43201	SIITAM ALEK		ALEK SIITAM		1201 WESTPHAL AVE	COLUMBUS OH 43227-1744
010-207905	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT 731	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207906	CONDOMINIUM UNIT	364 W LANE AV	UNIT 733	COLUMBUS OH	43201	KARNITIS CHARLES	KARNITIS EVE	CHARLES KARNITIS	EVE KARNITIS	724 CHAFFIN RDG	COLUMBUS OH 43214-2954
010-207907	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 735	COLUMBUS OH	43201	MVP RIVERWATCH LLC		MVP RIVERWATCH LLC	ATTN ACCT DEPT	230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948

010-207908	CONDOMINIUM UNIT	364 W LANE AV	UNIT 737	COLUMBUS OH	43201	PHILLIPS ERIC A					
010-207909	CONDOMINIUM UNIT	364 W LANE AV	UNIT 739	COLUMBUS OH	43201	LUCIA KERRY ANN		KERRY ANN LUCIA		254 GLENWORTH CT	POWELL OH 43065-9118
010-207910	CONDOMINIUM UNIT	364 W LANE AV	UNIT 801	COLUMBUS OH	43201	YOUNG BARBARA	YOUNG JOHN	BARBARA YOUNG	JOHN YOUNG	41 STEWART AVE	COLUMBUS OH 43206-2549
010-207911	CONDOMINIUM UNIT	364 W LANE AV	UNIT 802	COLUMBUS OH	43201	RWATCH LLC		RWATCH LLC		610 HAVENS CORNER RD	COLUMBUS OH 43230-3112
010-207912	CONDOMINIUM UNIT	364 W LANE AV	UNIT 803	COLUMBUS OH	43201	LEE SHIRLEY PEI-CHI		SHIRLEY LEE		2065 STRATHSHIRE HALL LN	POWELL OH 43065-9439
010-207913	CONDOMINIUM UNIT	364 W LANE AV	UNIT 804	COLUMBUS OH	43201	SGL ENTERPRISES LLC		SGL ENTERPRISES LLC		5917 GROVE CITY RD	GROVE CITY OH 43123-8925
010-207914	CONDOMINIUM UNIT	364 W LANE AV	UNIT 805	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		239 HURONVIEW BLVD	ANN ARBOR MI 48103-2947
010-207915	CONDOMINIUM UNIT	364 W LANE AV	UNIT 806	COLUMBUS OH	43201	SARO LLC		SARO LLC		5077 GRASSLAND DR	DUBLIN OH 43016-4318
010-207916	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 807	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207917	CONDOMINIUM UNIT	364 W LANE AV	UNIT 808	COLUMBUS OH	43201	MATTHEWS CHARLES W JR LTD		CHARLES MATTHEWS		2861 HALSTEAD RD	COLUMBUS OH 43221-2915
010-207918	CONDOMINIUM UNIT	364 W LANE AV	UNIT 809	COLUMBUS OH	43201	JPC OF COLUMBUS LTD		JPC OF COLUMBUS LTD		6619 S PATSBURG ST	AURORA CO 80016-4394
010-207919	CONDOMINIUM UNIT	364 W LANE AV	UNIT 810	COLUMBUS OH	43201	SAIDUDDIN JAMU	SAIDUDDIN SHAFI	JAMU SAIDUDDIN	SHAFI SAIDUDDIN	8825 BIRGHAM CT N	DUBLIN OH 43017-9718
010-207920	CONDOMINIUM UNIT	364 W LANE AV	UNIT 811	COLUMBUS OH	43201	SARO LLC		SARE LLC		5077 GRASSLAND DR	DUBLIN OH 43016-4318
010-207921	CONDOMINIUM UNIT	364 W LANE AV	UNIT 812	COLUMBUS OH	43201	BILLETT ANTHONY E		ANTHONY E BILLETT		9725 COUNSELLOR DR	VIENNA VA 22181-3252
010-207922	CONDOMINIUM UNIT	364 W LANE AV	UNIT 813	COLUMBUS OH	43201	RWATCH LLC		RWATCH LLC		610 HAVENS CORNERS RD	COLUMBUS OH 43230-3112
010-207923	CONDOMINIUM UNIT	364 W LANE AV	UNIT 815	COLUMBUS OH	43201	SAIDUDDIN JAMU	SAIDUDDIN SYED	JAMU SAIDUDDIN	SYED SAIDUDDIN	8825 BIRGHAM CT N	DUBLIN OH 43017-9718
010-207924	CONDOMINIUM UNIT	364 W LANE AV	UNIT 817	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207925	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 818	COLUMBUS OH	43201	RWATCH LLC		RWATCH LLC		610 HAVENS CORNERS RD	COLUMBUS OH 43230-3112
010-207926	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 819	COLUMBUS OH	43201	CAO ZHENGTING		ZHENGTING CAO		401 VAN BUREN ST	SYRACUSE NY 13244-2732
010-207927	CONDOMINIUM UNIT	364 W LANE AV	UNIT 820	COLUMBUS OH	43201	LAHOTI RUKMANI J		RUKMANI J LAHOTI		207 GRANGE HALL DR	GAITHERSBURG MD 20877-43
010-207928	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 821	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948

010-207929	CONDOMINIUM UNIT	364 W LANE AV	UNIT 822	COLUMBUS OH	43201	WRE DE LLC		WICKFIELD PROPERTIES		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207930	CONDOMINIUM UNIT	364 W LANE AV	UNIT 823	COLUMBUS OH	43201	BIEDENHARN JUDY H		EDWARD BIEDENHARN	JUDY H BIEDENHARN	3954 LARCHMERE DR	GROVE CITY OH 43123-8738
010-207931	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 824	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207932	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 825	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207933	CONDOMINIUM UNIT	364 W LANE AV	UNIT 826	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207934	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 827	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207935	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 828	COLUMBUS OH	43201	KARNITIS CHARLES I	KARNITIS LAIMA E	CHARLES I KARNITIS		724 CHAFFIN RDG	COLUMBUS OH 43214-2954
010-207936	CONDOMINIUM UNIT	364 W LANE AV	UNIT 829	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		1695 HARVARD CT	OXFORD MI 48371-5970
010-207937	CONDOMINIUM UNIT	364 W LANE AV	UNIT 831	COLUMBUS OH	43201	CHOI GARY		GARY CHOI		6528 SADDLE RIDGE LN	TOLEDO OH 43615-2440
010-207938	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 833	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207939	CONDOMINIUM UNIT	364 W LANE AV	UNIT 835	COLUMBUS OH	43201	7594 SUGAR DRIVE LLC		7594 SUGAR DRIVE LLC		7594 SUGAR CREEK DR	YOUNGSTOWN OH 44512-57
010-207940	CONDOMINIUM UNIT	364 W LANE AV	UNIT 837	COLUMBUS OH	43201	DENNISON ASSOCIATES	PROPERTY MANAGEMENT LLC	DENNISON ASSOCIATES	PROPERTY MANAGEMENT	2398 KENSINGTON DR	COLUMBUS OH 43221-3770
010-207941	CONDOMINIUM UNIT	364 W LANE AV	UNIT 839	COLUMBUS OH	43201	JJM RENTALS LLC		JJM RENTALS LLC		7707 WINDING WAY S	TIPP CITY OH 45371-9246
010-207942	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 901	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207943	CONDOMINIUM UNIT	364 W LANE AV	UNIT 902	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207944	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT 903	COLUMBUS OH	43201	SGL ENTERPRISES LLC		SGL ENTERPRISES LLC		5917 GROVE CITY RD	GROVE CITY OH 43123-8925
010-207945	CONDOMINIUM UNIT	364 W LANE AV	UNIT 904	COLUMBUS OH	43201	CHIANG CONWAY		CONWAY CHIANG		4103 174TH ST SE	BOTHELL WA 98012-7625
010-207946	CONDOMINIUM UNIT	364 W LANE AV	UNIT 905	COLUMBUS OH	43201	SINGH GIRIDHAR	SINGH SHOBA RANI	GIRIDHAR SINGH	SHOBA RANI SINGH	6174 ENKE CT	DUBLIN OH 43017-9517
010-207947	CONDOMINIUM UNIT	364 W LANE AV	UNIT 906	COLUMBUS OH	43201	KANG JUN		XINLU LIU		5217 VAN HORN ST	ELMHURST NY 11373-4348

010-207948	CONDOMINIUM UNIT	364 W LANE AV	UNIT 907	COLUMBUS OH	43201	SINHA NIRMAL K	TRIPTI	NIRMAL K SINHA	TRIPTI SINHA	6470 MEADOWBROOK CIR	WORTHINGTON OH 43085-28
010-207949	CONDOMINIUM UNIT	364 W LANE AV	UNIT 908	COLUMBUS OH	43201	SZCZUREK MICHAEL J		MICHAEL J SZCZUREK		2680 WARREN BURTON RD	SOUTHINGTON OH 44470-97
010-207950	CONDOMINIUM UNIT	364 W LANE AV	UNIT 909	COLUMBUS OH	43201	THEADO MICHAEL J		CORELOGIC		3001 HACKBERRY RD	IRVING TX 75063-0156
010-207951	CONDOMINIUM UNIT	364 W LANE AV	UNIT 910	COLUMBUS OH	43201	WOLFE HERMAN P TR	WOLFE CARYOLYN J TR	HERMAN P WOLFE	CAROLYN J WOLFE	10062 HOBBY HORSE LN	MENTOR OH 44060-6824
010-207952	CONDOMINIUM UNIT	364 W LANE AV	UNIT 911	COLUMBUS OH	43201	RYAN THOMAS E		CORELOGIC		3001 HACKBERRY RD	IRVING TX 75063-0156
010-207953	CONDOMINIUM UNIT	364 W LANE AV	UNIT 912	COLUMBUS OH	43201	LIN WILL		WILL LIN		364 W LANE AVE APT 912	COLUMBUS OH 43201-4345
010-207954	CONDOMINIUM UNIT	364 W LANE AV	UNIT 913	COLUMBUS OH	43201	OSBORN JED E & MARY L		JED E OSBORN	MARY L OSBORN	2634 ROAD 8	LEIPSIC OH 45856-9261
010-207955	CONDOMINIUM UNIT	364 W LANE AV	UNIT 915	COLUMBUS OH	43201	LIU XIAOXIAO		XIAOXIAO LIU		5176 LAKE POINT DR	CARMEL IN 46033-7212
010-207956	CONDOMINIUM UNIT	364 W LANE AV	UNIT 917	COLUMBUS OH	43201	GOINGS FOREST		FOREST GOINGS		364 W LANE AVE APT 917	COLUMBUS OH 43201-4345
010-207957	CONDOMINIUM UNIT	364 W LANE AV	UNIT 918	COLUMBUS OH	43201	SGL ENTERPRISES LLC		SGL ENTERPRISES LLC		5917 GROVE CITY RD	GROVE CITY OH 43123-8925
010-207958	CONDOMINIUM UNIT	364 W LANE AV	UNIT 919	COLUMBUS OH	43201	KORI ARUN S TR	KORI MAMTA M TR	ARUN S KORI	MAMTA M KORI	4277 MACKENZIE CT	MASON OH 45040-4664
010-207959	CONDOMINIUM UNIT	364 W LANE AV	UNIT 920	COLUMBUS OH	43201	VERHOFF AMANDA J	VERHOFF THEODORE J, VERHOFF SUSAN M	AMANDA J VERHOFF	THEODORE VERHOFF	19894 ROAD S	FORT JENNINGS OH 45844-91
010-207960	CONDOMINIUM UNIT	364 W LANE AV	UNIT 921	COLUMBUS OH	43201	KRESKE SHIRLEY SU TR		SHIRLEY KRESKE		1033 LIVE OAK CIR	PORT CHARLOTTE FL 33948-2
010-207961	CONDOMINIUM UNIT	364 W LANE AV	UNIT 922	COLUMBUS OH	43201	XU LONGYA	ZHAO AILAN	LONGYA XU	AILAN ZHAO	7511 HEATHERWOOD LN	DUBLIN OH 43017-8229
010-207962	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT 923	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		364 W LANE AVE	COLUMBUS OH 43201-4362
010-207963	CONDOMINIUM UNIT	364 W LANE AV	UNIT 924	COLUMBUS OH	43201	BENEDICT JOSEPH W		JOSEPH W BENEDICT		PO BOX 30846	COLUMBUS OH 43230-0846
010-207964	CONDOMINIUM UNIT	364 W LANE AV	UNIT 925	COLUMBUS OH	43201	CHIANG CONWAY		CONWAY CHIANG		4103 174TH ST SE	BOTHELL WA 98012-7625
010-207965	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 926	COLUMBUS OH	43201	MVP RIVERWATCH LLC		MVP RIVERWATCH LLC	ATTN ACCT DEPT	230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207966	CONDOMINIUM UNIT	364 W LANE AV	UNIT 927	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207967	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 928	COLUMBUS OH	43201	KARNITIS CHARLES I	LAIMA E TRS	CHARLES I KARNITIS	LAIMA E KARNITIS TRS	724 CHAFFIN RDG	COLUMBUS OH 43214-2954
010-207968	CONDOMINIUM UNIT	364 W LANE AV	UNIT 929	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948

010-207969	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT 931	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207970	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 933	COLUMBUS OH	43201	SCHERER BARBARA E		BARBARA E SCHERER		528 HARTFORD DR	ELYRIA OH 44035-2906
010-207971	CONDOMINIUM UNIT	364 W LANE AV	UNIT 935	COLUMBUS OH	43201	RWATCH LLC		RWATCH LLC		610 HAVENS CORNERS RD	COLUMBUS OH 43230-3112
010-207972	CONDOMINIUM UNIT	364 W LANE AV	UNIT 937	COLUMBUS OH	43201	KANG JUN		JUN KANG		3750 87TH ST APT 4F	JACKSON HEIGHTS NY 11372-
010-207973	CONDOMINIUM UNIT	364 W LANE AV	UNIT 939	COLUMBUS OH	43201	RWATCH LLC		RWATCH LLC		610 HAVENS CORNERS RD	COLUMBUS OH 43230-3112
010-207974	CONDOMINIUM UNIT	364 W LANE AV	UNIT 1001	COLUMBUS OH	43201	WILSON CURTIS D	WILSON KRISTINE N	CURTIS D WILSON		399 HICKORY LN	WESTERVILLE OH 43081-3082
010-207975	CONDOMINIUM UNIT	364 W LANE AV	UNIT 1002	COLUMBUS OH	43201	POPS HOLDING LLC		POPS HOLDING LLC		1925 EDGEMONT RD	COLUMBUS OH 43212-1049
010-207976	CONDOMINIUM UNIT	364 W LANE AV	UNIT 1003	COLUMBUS OH	43201	VKCONDOLLC		VKCONDO LLC		PO BOX 892	DUBLIN OH 43017-6892
010-207977	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT 1004	COLUMBUS OH	43201	WENG XIN		XIN WENG		334 SILVER MAPLE DR	BLACKLICK OH 43004-8426
010-207978	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 1005	COLUMBUS OH	43201	LIU LIYUAN		LIYUAN LIU		5176 LAKE POINT DR	CARMEL IN 46033-7212
010-207979	CONDOMINIUM UNIT	364 W LANE AV	UNIT 1006	COLUMBUS OH	43201	BENEDICT JASON ANDREW		JASON BENEDICT		364 W LANE AVE APT 220	COLUMBUS OH 43201-1096
010-207980	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 1007	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207981	CONDOMINIUM UNIT	364 W LANE AV	UNIT 1008	COLUMBUS OH	43201	KAPADIA PURNIMA K TR		PURNIMA K KAPADIA		3417 WATERPOINT DR	COLUMBUS OH 43221-4951
010-207982	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 1009	COLUMBUS OH	43201	LIU LIYUAN		LIYUAN LIU		5176 LAKE POINT DR	CARMEL IN 46033-7212
010-207983	CONDOMINIUM UNIT	364 W LANE AV	UNIT 1010	COLUMBUS OH	43201	YEHSAKUL DEBBIE S	YEHSAKUL PHONGSAK D	DEBBIE S YEHSAKUL		6347 TANERA MORE CT	DUBLIN OH 43017-9579
010-207984	CONDOMINIUM UNIT	364 W LANE AV	UNIT 1011	COLUMBUS OH	43201	HALL GARNETT J		GARNETT HALL	C/O NANCY HALL DURNIN	3877 FRENCH FIELDS LN	HARRISBURG NC 28075-9695
010-207985	CONDOMINIUM UNIT	364 W LANE AV	UNIT 1012	COLUMBUS OH	43201	ANSARI MUHAMMAD K & NIDA		MUHAMMAD K ANSARI	NIDA ANSARI	8801 WILDBROOK CT	WEST CHESTER OH 45069-320
010-207986	CONDOMINIUM UNIT	364 W LANE AV	UNIT 1013	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207987	CONDOMINIUM UNIT	364 W LANE AV	UNIT 1015	COLUMBUS OH	43201	MOHAMMED KASHEED	JEANNETTE R	KASHEEED MOHAMMED	JEANNETTE R MOHAMME	2318 WICKLIFFE RD	COLUMBUS OH 43221-1834
010-207988	CONDOMINIUM UNIT	364 W LANE AV	UNIT 1017	COLUMBUS OH	43201	YERKEY MATTHEW R TR		MATTHEW R YERKEY TR		1750 SHADY LN	SALEM OH 44460-1240
010-207989	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 1018	COLUMBUS OH	43201	MVP RIVERWATCH LLC		MVP RIVERWATCH LLC	ATTN ACCT DEPT	230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948

010-207990	CONDOMINIUM UNIT	364 W LANE AV	UNIT 1019	COLUMBUS OH	43201	GIANGARCELLA JOHN P		JOHN P GIANGARCELLA		4664 CHERRY GLEN DR	POWELL OH 43065-7464
010-207991	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 102(	COLUMBUS OH	43201	KAWECKI DENNIS		CROSSCOUNTRY MORTGAGE		6850 MILLER RD	BRECKSVILLE OH 44141-3222
010-207992	CONDOMINIUM UNIT	364 W LANE AV	UNIT 102	COLUMBUS OH	43201	SIITAM ALEK		ALEK SIITAM		1201 WESTPHAL AVE	COLUMBUS OH 43227-1744
010-207993	CONDOMINIUM UNIT	364 W LANE AV	UNIT 102	COLUMBUS OH	43201	LOCKWOOD GARY R TR		GARY R LOCKWOOD TR		1720 STRINGTOWN RD NE	LANCASTER OH 43130-8203
010-207994	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 102	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207995	CONDOMINIUM UNIT	364 W LANE AV	UNIT 102	COLUMBUS OH	43201	RUFF PAUL D & SHERRI L		PAUL D RUFF	SHERRI L RUFF	2695 STRINGTOWN RD NW	LANCASTER OH 43130-9192
010-207996	CONDO 20-39 RENTAL UNITS	364 LANE AV	UNIT 102	COLUMBUS OH	43201	WENG XIN		XIN WENG		334 SILVER MAPLE DR	BLACKLICK OH 43004-8426
010-207997	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT 102	COLUMBUS OH	43201	CHONG MANDY M		MANDY M CHONG		4758 MIDDLETOWNE ST UNIT A	COLUMBUS OH 43214-1972
010-207998	CONDOMINIUM UNIT	364 W LANE AV	UNIT 102	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-207999	CONDOMINIUM UNIT	364 W LANE AV	UNIT 102	COLUMBUS OH	43201	RATLIFF KIMBERLY S	WEATHERHEAD JAMES E	CORELOGIC		3001 HACKBERRY RD	IRVING TX 75063-0156
010-208000	CONDOMINIUM UNIT	364 W LANE AV	UNIT 102	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		364 W LANE AVE	COLUMBUS OH 43201-4362
010-208001	CONDOMINIUM UNIT	364 W LANE AV	UNIT 103	COLUMBUS OH	43201	CHONG PUI YEE KALINE		PUI YEE KALINE CHONG		17025 NW MADRONE ST	PORTLAND OR 97229-1427
010-208002	CONDOMINIUM UNIT	364 W LANE AV	UNIT 103	COLUMBUS OH	43201	SCOTT PATICE LLC		SCOTT PATICE LLC		6041 WOODSBORO DR	COLUMBUS OH 43228-9263
010-208003	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT 103	COLUMBUS OH	43201	MVP RIVERWATCH LLC		MVP RIVERWATCH LLC	ATTN ACCT DEPT	230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-208004	CONDOMINIUM UNIT	364 W LANE AV	UNIT 103	COLUMBUS OH	43201	CHIANGWEI HSIULAING		HSIU LAING	CHIANG WEI	4103 174TH ST SE	BOTHELL WA 98012-7625
010-208005	CONDOMINIUM UNIT	364 W LANE AV	UNIT 103	COLUMBUS OH	43201	SARO LLC		SARO LLC		5077 GRASSLAND DR	DUBLIN OH 43016-4318
010-208006	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT P1	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-208007	CONDOMINIUM UNIT	364 W LANE AV	UNIT P2	COLUMBUS OH	43201	TRACY EILEEN		EILEEN TRACY	C/O KERRY LUCIA	254 GLENWORTH CT	POWELL OH 43065-9118
010-208008	CONDOMINIUM UNIT	364 W LANE AV	UNIT P3	COLUMBUS OH	43201	KARNITIS CHARLES I	KARNITIS LAIMA EVE	CHARLES I KARNITIS	LAIMA EVE KARNITIS	724 CHAFFIN RDG	COLUMBUS OH 43214-2954

010-208009	CONDOMINIUM UNIT	364 W LANE AV	UNIT P4	COLUMBUS OH	43201	JPC OF COLUMBUS LTD		JPC OF COLUMBUS LTD		6619 S PATSBURG ST	AURORA CO 80016-4394
010-208010	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT P5	COLUMBUS OH	43201	RWATCH LLC		RWATCH LLC		610 HAVENS CORNERS RD	COLUMBUS OH 43230-3112
010-208011	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT P6	COLUMBUS OH	43201	WANG HUA		HUA WANG		688 RIVERVIEW DR APT 50	COLUMBUS OH 43202-1684
010-208012	CONDOMINIUM UNIT	364 W LANE AV	UNIT P7	COLUMBUS OH	43201	SIITAM ALEK T		ALEK T SIITAM		1201 WESTPHAL AVE	COLUMBUS OH 43227-1744
010-208013	CONDOMINIUM UNIT	364 W LANE AV	UNIT P8	COLUMBUS OH	43201	JENKS FRANCIA D		FRANCIA D JENKS		1341 BRIARMEADOW DR	COLUMBUS OH 43235-1612
010-208014	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT P9	COLUMBUS OH	43201	MVP RIVERWATCH LLC		MVP RIVERWATCH LLC	ATTN ACCT DEPT	230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-208015	CONDOMINIUM UNIT	364 W LANE AV	UNIT P10	COLUMBUS OH	43201	RWATCH LLC		RWATCH LLC		610 HAVENS CORNERS RD	COLUMBUS OH 43230-3112
010-208016	CONDOMINIUM UNIT	364 W LANE AV	UNIT P11	COLUMBUS OH	43201	WRE DE LLC		WICKFIELD PROPERTIES		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-208017	CONDOMINIUM UNIT	364 W LANE AV	UNIT P12	COLUMBUS OH	43201	KIMBALL BRUCE A		BRUCE A KIMBALL		14 WOODHAVEN RD	WABAN MA 02468-1622
010-208018	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT P15	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-208019	CONDOMINIUM UNIT	364 W LANE AV	UNIT P17	COLUMBUS OH	43201	LAL VIKAS K		VIKAS K LAL		12729 OAK FARMS DR	HERNDON VA 20171-4217
010-208020	CONDOMINIUM UNIT	364 W LANE AV	UNIT P18	COLUMBUS OH	43201	NICHOLS JOSEPH E	NICHOLS LISA M	JENNINGS DEVELOPMENT CO		5830 US HIGHWAY 42	OSTRANDER OH 43061-9343
010-208021	CONDOMINIUM UNIT	364 W LANE AV	UNIT P19	COLUMBUS OH	43201	ARSHAD MUHAMMAD & SHUA		MUHAMMAD ARSHAD	SHUA ARSHAD	71 FORGE VILLAGE RD	GROTON MA 01450-2047
010-208022	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT P20	COLUMBUS OH	43201	PAUSCH JERRY B TR		JERRY B PAUSCH TR		PO BOX 413	LEESBURG OH 45135-0413
010-208023	CONDOMINIUM UNIT	364 W LANE AV	UNIT P21	COLUMBUS OH	43201	CHIANG CONWAY		CONWAY CHIANG		4103 174TH ST SE	BOTHELL WA 98012-7625
010-208024	CONDOMINIUM UNIT	364 W LANE AV	UNIT P22	COLUMBUS OH	43201	MCCASLIN KENNETH	MCCASLIN LEE ANN	KENNETH MCCASLIN	LEE ANN MCCASLIN	1885 ROSE AVE	CRIDERSVILLE OH 45806-214(
010-208025	CONDOMINIUM UNIT	364 W LANE AV	UNIT P23	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-208026	CONDOMINIUM UNIT	364 W LANE AV	UNIT P24	COLUMBUS OH	43201	HUEY INVESTMENTS LLC		HUEY INVESTMENTS LLC	C/O JOHN M KLAUSING	11953 BOCKEY RD	DELPHOS OH 45833-8869
010-208027	CONDOMINIUM UNIT	364 W LANE AV	UNIT P25	COLUMBUS OH	43201	ZIMMERS STEVEN L	ZIMMERS KYM H	STEVEN L ZIMMERS	KYM ZIMMERS	710 CLINTON SPRINGS AVE	CINCINNATI OH 45229-1345
010-208028	CONDOMINIUM UNIT	364 W LANE AV	UNIT P26	COLUMBUS OH	43201	CHONG HOI YEE JOEY		HOI YEE JOEY CHONG		532 HIGHLAND CREEK CT	HOLLAND OH 43528-9812
010-208029	CONDOMINIUM UNIT	364 W LANE AV	UNIT P27	COLUMBUS OH	43201	LIN SHIOW-HWA		SHIOW HWA LIN		4103 174TH ST SE	BOTHELL WA 98012-7625

010-208030	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT P28	COLUMBUS OH	43201	KARNITIS CHARLES I	LAIMA E CO-TRS	CHARLES I KARNITIS	LAIMA E KARNITIS CO-TRS	724 CHAFFIN RDG	COLUMBUS OH 43214-2954
010-208031	CONDOMINIUM UNIT	364 W LANE AV	UNIT P29	COLUMBUS OH	43201	CHIANG KUN YEH	CHONG PUI YEE KALINE	JON CHIANG		17025 NW MADRONE ST	PORTLAND OR 97229-1427
010-208032	CONDOMINIUM UNIT	364 W LANE AV	UNIT P31	COLUMBUS OH	43201	BOSCO NANCY L		NANCY BOSCO-JOSEPH		11230 BAYSIDE LN	FORT MYERS BEACH FL 33931
010-208033	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT P33	COLUMBUS OH	43201	LEE SHIRLEY PEI-CHI		SHIRLEY PEI-CHI LEE		2065 STRATHSHIRE HALL LN	POWELL OH 43065-9439
010-208034	CONDO 20-39 RENTAL UNITS	364 W LANE AV	UNIT P35	COLUMBUS OH	43201	WRE DE LLC		WRE DE LLC		230 HURONVIEW BLVD	ANN ARBOR MI 48103-2948
010-208035	CONDOMINIUM UNIT	364 W LANE AV	UNIT P37	COLUMBUS OH	43201	BOMBOLIS NICHOLAS G		CORELOGIC		3001 HACKBERRY RD	IRVING TX 75063-0156
010-208036	CONDOMINIUM UNIT	364 W LANE AV	UNIT P39	COLUMBUS OH	43201	CASBARRO PATRICK J	CASBARRO KATHRYN R	PATRICK J CASBARRO	KATHRYN CASBARRO	5946 MORGANWOOD SQ	HILLIARD OH 43026-7175
010-208037	CONDO 4-19 RENTAL UNITS	364 W LANE AV	UNIT P41	COLUMBUS OH	43201	KARNITIS CHARLES I TR	KARNITIS LAIMA E TR	CHARLES I KARNITIS TR		724 CHAFFIN RDG	COLUMBUS OH 43214-2954

EXHIBIT G: Decommissioning Plan

Smart Campus^{E} Facility Project

Decommissioning Plan

ENGIE Buckeye Operations

Columbus, OH

REVISION 0

OCTOBER 21, 2019

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1. INTRODUCTION

The CHP facility is designed to serve the energy needs of the University at least until year 2050. However, the technical life of the CHP can be extended with routine maintenance and upgrades for necessary equipment. The Ohio State University has the authority to decide when to retire and decommission the CHP facility, at which time the University will instruct the Ohio State Energy Partners to initiate this decommissioning plan.

It should be noted that the CHP plant building also houses the central chillers and heating hot water heat exchangers which provide cooling and heating sources, respectively, for the University's campus on the west side of the Olentangy River. The CHP plant decommissioning plan considers the removal of all equipment related to combined heat and power operations while maintaining the building itself intact with the chilled water system, heating hot water system, and related auxiliary equipment.

2. ASBESTOS AND OTHER POTENTIAL HAZARDS

The CHP plant is being designed and will be built asbestos-free.

The CHP plant's hazardous materials log, which will initially be based on the construction bill of materials, will be used as the reference when detailed decommissioning plans are being developed.

The decommissioning plan shall include, if applicable, abatement plan for any hazardous materials that may be present when the plant is considered for decommissioning.

3. SEGREGATION OF CHP BUILDING

In addition to the combined heat and power generation equipment, the CHP plant building houses a central control room, electrical switchgear room, the central chillers along with heating hot water heat exchangers, distribution pumps, and associated auxiliary equipment including cooling towers. The decommissioning plan will be based on removing the CHP Generation Equipment (listed below) while maintaining the integrity of the building, the cooling and heating equipment, and associated auxiliaries.

CHP Generation Equipment

- The two Siemens STG-700 combustion turbines and auxiliaries[1]
- The Siemens SST-400 steam turbine generator and auxiliaries[2]
- The heat recovery steam generators (HRSGs) and auxiliaries[3]
- HRSG exhaust stacks
- Selective Catalytic Reduction (SCR) system including urea hydrolyzer
- The water-steam cycle equipment and auxiliaries[4]
- Electrical and controls systems for the equipment listed above

[1] Combustion turbine generator auxiliaries include the air inlet filters and duct work, electrical switchgear and controls room, fuel gas compressors and delivery system, lube and control oil systems, the exhaust duct, the combustion turbine and generator enclosures, and other minor auxiliary equipment.

[2] The steam turbine generator auxiliaries include the steam turbine control and stop valves, drain systems, and enclosures

[3] The HRSG structure including all internal piping and heat exchangers, drains, fans, and pumps, safety valves, vents, and silencers

[4] The water-steam cycle equipment includes the steam condenser and condensate pumps, cooling towers, feedwater pumps, all steam piping between the HRSGs and the steam turbine, gland seal system, steam turbine vacuum system, chemical dosing system, vents, drains, and silencers

Following the decommissioning of the CHP plant, a new heat source – based on best available technology available at the time of CHP decommissioning - will be installed for the heating hot water district heating system.

4. DECOMMISSIONING

A tower crane will be utilized to dismantle and remove the HRSG stacks, the steam condenser cooling towers, and all related vents and silencers from the roof of the HRSG building.

The Siemens SGT-700 gas turbines and their generators, and the Siemens SSG-400 steam turbine and its generator are skid-mounted units which can be disconnected and rigged using the turbine hall bridge crane in the CHP building, and loaded on flatbed trucks.

The HRSGs will be dismantled using a telescoping or crawler crane after the combustion and steam turbine generators and associated equipment are removed from the CHP building.

Other smaller equipment, such as controls, electrical equipment, pumps, and fans, can be removed using smaller cranes or forklifts.

Two lanes along John H. Herrick drive and a single lane on Vernon L. Tharp street along the west and south side of the CHP building would be closed during decommissioning as construction zone. Dismantled equipment would be loaded on flatbed trucks in-situ and taken off site.

5. FINANCIAL CONSIDERATIONS

a. Cost of decommissioning

Using 2019 US dollars, the cost of decommissioning and removal of the CHP equipment is considered to be approximately $2 million. This estimate is based on a recent demolition experience executed by ENGIE (as the owner of the plant) at the Mt. Tom coal-fired power plant in Holyoke, Massachusetts.

b. Revenues from decommissioning

Any equipment that has a value to be re-purposed, such as the combustion turbine and steam turbine generators, shall be sold to the market. Most other metals, such as copper, steel, and iron, will be sold at respective junk metal value. As price of junk metal fluctuates, it is not possible to make an accurate estimate today for revenues from junk metal sales in 2050. However, it generally considered to be very close to the cost of decommissioning and dismantling of the CHP equipment.

c. Funding sources

The term for The Long-Term Lease and Concession Agreement for The Ohio State University Utility System (the "Concession Agreement") extends to year 2067. At the time of this decommissioning plan, the CHP is planned to operate until year 2050 and decommissioned then. Consequently, the existing funding mechanism where Ohio State Energy Partners provides the funds for capital projects and the University pays OSEP through the Variable Fee mechanism over a long-term period (20-yr is default) would apply to the decommissioning of the CHP.

Summary: Application Application Part 11 of 17 - Exhibits D-G electronically filed by Ms. Kari D Hehmeyer on behalf of Alexander, Trevor Mr. and THE OHIO STATE UNIVERSITY